Finanziato dall'Unione europea
NextGenerationEU

MUR

Ministero dell'Università e della Ricerca
Direzione generale dell'internazionalizzazione e della comunicazione

Avviso pubblico per la presentazione di proposte progettuali per *"Rafforzamento e creazione di Infrastrutture di Ricerca"* da finanziare nell'ambito del PNRR

Missione 4, *"Istruzione e Ricerca"* - Componente 2, *"Dalla ricerca all'impresa"* -
Linea di investimento 3.1, *"Fondo per la realizzazione di un sistema integrato di infrastrutture di ricerca e innovazione",*
finanziato dall'Unione europea - NextGenerationEU

REFORMS AND INVESTMENTS UNDER THE RECOVERY AND RESILIENCE PLAN
NextGenerationEU

Call for proposals

Intervention field 6: Investment in digital capacities and deployment of advanced technologies
DESI dimension 4: Integration of digital technologies + ad hoc data collections
055 - Other types of ICT infrastructure (including large-scale computer resources/equipment, data centres, sensors and other wireless equipment)

Mission 4 – "Education and Research"
Component 2: from research to business
Investment 3.1: "Fund for the realisation of an integrated system of research and innovation infrastructures
Action 3.1.1 "Creation of new research infrastructures strengthening of existing ones and their networking for Scientific Excellence under Horizon Europe

Annex B

Full Proposal template for 2022CALL_PNRR:M4/C2/L3.1.1 (technical annex), pursuant to Article 9 paragraph 10 of the call for proposals

(To be provided in English only)

Annex B

All information that are requested in this part of this document must be provided ONLY online (https://www.gea.mur.gov.it/Bandi/IR)

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

1 Legal name; Tax code; VAT number, Legal address

Legal Name	*INAF - Istituto Nazionale di Astro Fisica*	Tax code	*97220210583*
VAT number	*06895721006*	Legal address	*Viale del Parco Mellini 84, 00136 ROMA RM*

2 Legal representative: personal data and contacts

First Name	*Marco*	Last Name	*Tavani*
Gender	*Male*	TAX Code	*TVNMRC57R05H501I*
Birth date	*05/10/1957*	Birth place	*ROMA*
Phone number	*0635533310*	e-mail	*presidente@inaf.it*

3 Management and reasearch structure

INAF is the Public Research Institution aimed to carry out scientific and technological research in the fields of Astrophysics, to disseminate its results and to foster technological transfer to industry, pursuing excellence at international level. It has legal personality under the public law and operates in full autonomy. The action of INAF is compliant with the European Charter for Researchers (recommendation n. 2005/251/CE).

INAF counts on 1118 employees (source PTA 2021-2023) of which 549 researchers, 213 technologists, 226 technicians and 128 administration staff. A variable number of short-term contract researchers and technologists, Post-docs and graduated students are also working in INAF Research Structures (RS) under the supervision of INAF employees. INAF has 16 RS distributed all over the Country, coordinated by the Headquarter in Rome.

INAF operates several Research Infrastructures around the world (many of them listed as high or medium priority in PNIR 2021) in autonomy, in collaboration with international partners or as representing entity in international organizations.

INAF is governed by the President, the legal representative of the Institute nominated by MUR, and the Administration Council (CdA). The Council consist in four members nominated by MUR, two of which indicated by INAF employees through public elections. The long term scientific plan is maintained by an elected Scientific Council and researchers are represented in the governance through elected National Scientific Committees (CSN).

INAF has two apical executive officers: the Director General (DG), responsible for administration and personnel matters, and the Science Director (DS), responsible for research related matters. DG and DS are proposed by the President and nominated by CdA. The Offices of the DG and DS are structured in divisions and areas.

INAF will set-up a specific temporary RS to carry out PNRR activities.

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

4 Financial Management System

INAF adopts the financial and accounting principles of Italian public research authorities. The Institute has full scientific, financial, accounting and organizational autonomy, and is subject to the supervision of the Ministry of University and Research (MUR).
Regarding the Financial Management System of INAF activities the Institute is organized in "Administrative Responsibility Centers" (CRA) at different levels, intended as the organizational structures in charge of making decisions regarding the management of human, financial and instrumental resources. The unique first level CRA is the General Direction of the institute, which has the responsibility for the entire administrative management of INAF. Then we have many different second level CRA distributed throughout the national territory and managed by appointed Directors.
INAF has a "Board of Auditors" nominated by the "Ministry of Economy and Finance" (MEF) and by MUR which supervises, in accordance with current legislation, the compliance with the laws, verifies the regularity of management and the correct application of accounting and tax rules. INAF also applies effective and efficient internal control to all its fundings. Management verifications are an integral part of the INAF internal control system, properly implemented in order to contribute to the prevention and detection of fraud. The internal management control has the task to verify, through comparative assessments of costs and yields, the achievement of objectives as well as the correct and economic management of its resources.
INAF is able therefore to guarantee all the management and administrative-accounting controls needed by national legislation and to ensure the regularity of the procedures and expenses before reporting them to the Ministry, as well as the traceability of the expenses to the project admitted to funding on the PNRR.
The Financial management system uses a complex and complete software through which INAF is able to manage and verify all the institute fundings, which are around 150-200 millions euros per year. With this system, INAF is able to deal also with complex activities, like those originated by programs of size and complexity comparable to the PNRR. For instance, INAF has recently managed a national call (called PON) of about 18 million euros, which is regulated by the same rules and procedures similar to those expected for PNRR. The system is able to manage all the CRA and also every single project and program, regardless of its size, can be managed separately if needed or in groups, sorted with a tree structure. All the financial data can also be seen and analyzed as a whole, in order to provide single INAF budget reports. The system manages Analytical accounting as well, in order to pursue the aim of guiding decisions according to criteria of economic convenience, favoring the efficient and effective use of resources to achieve institutional purposes.
This specific project will be part of the INAF accounting system in order to exploit its full potential, but will also maintain an independent management so as to facilitate control and reporting. Furthermore, in case the infrastructures subject to this intervention carry out both economic and non-economic activities, the costs, financing and revenues of the two types will be clearly separated; moreover, in case of distributed infrastructures the separation will be both at the level of the single site and at the aggregate level.
Regarding procurement, INAF procedures are compliant with all national and European rules and respect all principles of equal treatment. The negotiation activity is carried out in compliance with UE provisions, in accordance with the principles of fairness, impartiality, competitiveness, transparency, efficiency, effectiveness and cost-effectiveness of the proceedings.

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

5 Specific skills of the applicant with respect to this proposal

INAF is the main Institute for the research in astronomy in Italy, spanning all sectors and wavelengths ranges. In the context of STILES, INAF is the obvious choice to advocate the need to develop optical and radio astronomy. Indeed, INAF directly owns and manages all the main Italian facilities at these wavelengths, and leads Italian participation in main international organisations.

In the optical range, INAF owns the Telescopio Nazionale Galileo (TNG), which is mostly dedicated to the search and characterization of exo-planets. INAF has a 25% participation in the LBT, one of the most advanced 8m telescopes in the world, that has been the testbed of several INAF-borne technologies in Adaptive Optics. It also built the VLT Survey Telescope, a 2.5 telescope that will be fully available to the Italian community from late 2022. INAF built and commissioned several instruments for TNG, LBT and ESO. Currently INAF researchers have major responsibilities in two Extreme AO instruments for LBT (Shark-VIS and Shark-NIR) as well as instruments for ESO VLT (the CUBES spectrograph, the AO module ERIS, the AO wide field imager/spectrograph MAVIS). Finally, INAF leads the construction of 2 out of the 6 instruments planned for ELT: MAORY and ANDES, formerly known as HIRES.
Similarly, INAF owns major radio observing facilities in Italy: the 64m single-dish SRT antenna, in Sardinia, and other antennas in Noto and Medicina. INAF is one of the founders of the SKA international organisation, and has played a leading role in the design and development of its SKA-LOW antennas, receivers and signal acquisition chain, and is now actively involved in the deployment and commissioning of the first prototype stations (AAVS2) in Australia.
INAF scientists form a vibrant community of about 1000 scientists who actively utilise these and other facilities to address the most important open questions in modern astrophysics.

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*OAR*	OU Name	*Osservatorio Astronomico di Roma*
OU Type	*Department*		

Address

Region	*Lazio*	Province	*ROMA*
Municipality	*MONTE PORZIO CATONE*	ZIP Code	*00078*
Address	*Via Frascati*	Street Number	*33*

Contact Person

First Name	*Angelo*	Last Name	*Antonelli*
Phone number	*0694286475*	e-mail	*angelo.antonelli@inaf.it*

6.2 OU Osservatorio Astronomico di Roma - Scientific-technological expertise and experience

The Astronomical Observatory of Rome (OAR) is one of the 16 INAF research institutes, working on several astrophysical topics, including solar astrophysics, stellar and extragalactic astronomy, cosmology, computational astrophysics, gamma-ray astronomy.
Within the framework of the present proposal, INAF-OAR is involved in the technological research applied to astronomical instrumentation with particular attention on the development of detectors for optical astronomy and Adaptive Optics, and development of Machine Learning and advanced software for astronomical analysis.
Website: https://www.oa-roma.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [2] - Name, location, and contact person

General Information

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

OU Short Name	*OAA*	OU Name	*Osservatorio Astrofisico di Arcetri*
OU Type	*Department*		

Address

Region	*Toscana*	Province	*FIRENZE*
Municipality	*FIRENZE*	ZIP Code	*50125*
Address	*Largo Enrico Fermi*	Street Number	*5*

Contact Person

First Name	*Sofia*	Last Name	*Randich*
Phone number	*0552752258*	e-mail	*sofia.randich@inaf.it*

6.2 OU Osservatorio Astrofisico di Arcetri - Scientific-technological expertise and experience

The Astrophysical Observatory of Arcetri (OAA) is one of the 16 INAF research institutes, working on several astrophysical topics. Overall, the Arcetri technological team is composed of around 40 members with a variety of expertise: from radio waves to visible light, from ground-based telescopes to satellite observing instruments. Skills in the team include: design and development of single components and complex systems; prototyping and experimental characterization in the Arcetri laboratories; monitoring and measurement of atmosphere parameters; developments of electronic systems and software for monitoring and control purposes; firmware for digital signal processing.
Within the framework of the present proposal, INAF-OAA is involved in technologies for adaptive optics, radio astronomy and advanced software.
Website: http://www.arcetri.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [3] - Name, location, and contact person

General Information

OU Short Name	*OACN*	OU Name	*Osservatorio Astronomico di Capodimonte*

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

OU Type	*Department*		
Address			
Region	*Campania*	Province	*NAPOLI*
Municipality	*NAPOLI*	ZIP Code	*80131*
Address	*Salita Moiariello*	Street Number	*16*
Contact Person			
First Name	*Marcella*	Last Name	*Marconi*
Phone number	*0815575505*	e-mail	*marcella.marconi@inaf.it*

6.2 OU Osservatorio Astronomico di Capodimonte - Scientific-technological expertise and experience

The Astronomical Observatory of Capodimonte (OACN) is one of the 16 INAF research institutes, working on several astrophysical topics. In 1812 the first stone of the Royal Astronomical Observatory of Capodimonte was laid. The work ended in 1819 and the astronomers, led by Carlo Brioschi, began to make the first observations. Today, engaged in various research activities and international collaborations, over 70 people work in the observatory, including researchers, students and contract staff. Moreover, about 40 units of the technical and administrative staff contribute to the functioning of the institute and to the promotion of knowledge of Astronomy in schools and in society.
Within the framework of the present proposal, INAF-OACN is involved in the development of astrophysical instrumentation and R&D in control systems, data science and machine learning paradigms applied to the astrophysical domain.
Website: http://www.oacn.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [4] - Name, location, and contact person

General Information			
OU Short Name	*OAPA*	OU Name	*Osservatorio Astronomico di Palermo*
OU Type	*Department*		

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

Address

Region	*Sicilia*	Province	*PALERMO*
Municipality	*PALERMO*	ZIP Code	*90134*
Address	*Piazza del Parlamento*	Street Number	*1*

Contact Person

First Name	*Fabrizio*	Last Name	*Bocchino*
Phone number	*091233422*	e-mail	*fabrizio.bocchino@inaf.it*

6.2 OU Osservatorio Astronomico di Palermo - Scientific-technological expertise and experience

The Astronomical Observatory of Palermo (OAPA) is one of the 16 INAF research institutes, working on several astrophysical topics, and has a long tradition in space astrophysics. Its researchers have active roles and cover responsibilities in a number of ground- and space-based infrastructures relevant for the present proposals. They have significant expertise in developing sophisticated algorithms for data analysis and modeling, with particular attention to the study of exo-planetary atmospheres including laboratory experiments. On the technological point of view, INAF-OAPA is also committed to the development of opto-mechanical devices for ground based astronomical instrumentation.
INAF-OAPA researchers work in strong synergy with the Physics and Chemistry Department of the Palermo University.
Website: http://www.astropa.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [5] - Name, location, and contact person

General Information

OU Short Name	*OAS*	OU Name	*Osservatorio di astrofisica e scienza dello spazio*
OU Type	*Department*		

Address

Region	*Emilia Romagna*	Province	*BOLOGNA*

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

Municipality	*BOLOGNA*	ZIP Code	*40129*
Address	*via Gobetti*	Street Number	*93/3*

Contact Person

First Name	*Andrea*	Last Name	*Comastri*
Phone number	*0516357357*	e-mail	*andrea.comastri@inaf.it*

6.2 OU Osservatorio di astrofisica e scienza dello spazio - Scientific-technological expertise and experience

The Astrophysics and Space Science Observatory of Bologna (OAS) is one of the 16 INAF research institutes, working on several astrophysical topics.
Within the framework of the present proposal, INAF-OAS is involved in programs of research and development for astronomical instrumentation in particular for large, ground based, telescopes. In particular, it hosts the INAF Integration National Facility recently refurbished. The overall dimension (17.4mx11m with a height of 12 m) and the presence of support laboratories (optical and electronic), made it well suited for the integration of large size instruments as the new generation of instruments for the ELT Telescope. The Bologna Integration Hall is the largest INAF integration facility and it will be the reference facility for the integration of all INAF instrumentation that require a large integration facility in the coming decades.
Website: https://www.oas.inaf.it/it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [6] - Name, location, and contact person

General Information

OU Short Name	*IASF-Mi*	OU Name	*Istituto di Astrofisica Spaziale e Fisica cosmica*
OU Type	*Department*		

Address

Region	*Lombardia*	Province	*MILANO*
Municipality	*MILANO*	ZIP Code	*20133*

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

Address	*Via Alfonso Corti*	Street Number	*12*

Contact Person

First Name	*Bianca*	Last Name	*Garilli*
Phone number	*0223699313*	e-mail	*bianca.garilli@inaf.it*

6.2 OU Istituto di Astrofisica Spaziale e Fisica cosmica - Scientific-technological expertise and experience

The Institute for Space Astrophysics and Cosmic Physics of Milan (IASF-Milano) is one of the 16 INAF research institutes, working on several astrophysical topics in the fields of Observational Cosmology and High Energy Astrophysics. Specifically, IASF-Milano has been a leading institute in Italy and in Europe on the development of data-handling pipelines and large astronomical surveys management software.
Within the framework of the present proposal, INAF-IASF is involved in a virtual laboratory aiming to collect and share expertise, software, and astronomical spectroscopy data.
Website: https://www.iasf-milano.inaf.it/it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [7] - Name, location, and contact person

General Information

OU Short Name	*OAB*	OU Name	*Osservatorio Astronomico di Brera*
OU Type	*Department*		

Address

Region	*Lombardia*	Province	*MILANO*
Municipality	*MILANO*	ZIP Code	*20121*
Address	*Via Brera*	Street Number	*28*

Contact Person

First Name	*Roberto*	Last Name	*Della Ceca*
Phone number	*0272320333*	e-mail	*roberto.dellaceca@inaf.it*

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

6.2 OU Osservatorio Astronomico di Brera - Scientific-technological expertise and experience

The Astronomical Observatory of Brera (OAB) is one of the 16 INAF research institutes. INAF-OAB research activity spans a broad range of topics in astronomy, and includes instrumental and technological developments. On the technological side, INAF-OAB is specialized in the development of basic technologies related to manufacturing and characterisation of devices and mirrors for X-ray astronomy, and is strongly involved in gamma ray astronomy applications with particular focus on the Cherenkov telescope Array. Within the framework of the present proposal, INAF-OAB is involved in the optomechanical design and realization of devices for ground based telescopes and instrumentation. The group has delivered instruments for several telescopes (TNG, NTT, VLT,) and is nowadays involved in the design of ELT class instrumentation (Maory and ANDES). The research activity is focused on the development of new technologies and techniques to improve the performances of new instrumentation for astronomy.
Website: http://www.brera.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [8] - Name, location, and contact person

General Information

OU Short Name	*OATS*	OU Name	*Osservatorio Astronomico di Trieste*
OU Type	*Department*		

Address

Region	*Friuli Venezia Giulia*	Province	*TRIESTE*
Municipality	*TRIESTE*	ZIP Code	*34143*
Address	*Via G. B. Tiepolo*	Street Number	*11*

Contact Person

First Name	*Fabrizio*	Last Name	*Fiore*
Phone number	*0403199240*	e-mail	*fabrizio.fiore@inaf.it*

6.2 OU Osservatorio Astronomico di Trieste - Scientific-technological expertise and experience

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

The Astronomical Observatory of Trieste (OATS) is one of the 16 INAF research institutes, working on several astrophysical topics.
Within the framework of the present proposal, the INAF-OATS Instrumentation Control Group has a long experience in the field of design, implementation and integration of software and control electronics for state-of-the-art astronomical instrumentation, both in the optical and radio domain (8-m class telescopes and beyond, attached focal plane instrumentation and millimetric/submillimetric instrumentation).
Website: https://www.oats.inaf.it/index.php/it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [9] - Name, location, and contact person

General Information

OU Short Name	*OAAB*	OU Name	*Osservatorio Astronomico d'Abruzzo*
OU Type	*Department*		

Address

Region	*Abruzzo*	Province	*TERAMO*
Municipality	*TERAMO*	ZIP Code	*64100*
Address	*Via Mentore Maggini*	Street Number	*s.n.c.*

Contact Person

First Name	*Enzo*	Last Name	*Brocato*
Phone number	*0861439708*	e-mail	*enzo.brocato@inaf.it*

6.2 OU Osservatorio Astronomico d'Abruzzo - Scientific-technological expertise and experience

The Astronomical Observatory of Abruzzo (OAAB) is one of the 16 INAF research institutes, working on several astrophysical topics.
Since 2013 INAF-OAAB has been involved in several International projects for the implementation of new generation scientific instrumentation, based on Adaptive Optics, for the current and future large/extremely large telescopes. INAF-OAAB is also responsible for the maintenance plan and the development of monitoring and control solutions for the Square Kilometer Array (SKA) .

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

control solutions for the Square Kilometer Array (SKA) .
Website: http://www.oa-abruzzo.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [10] - Name, location, and contact person

General Information

OU Short Name	*OAC*	OU Name	*Osservatorio Astronomico di Cagliari*
OU Type	*Department*		

Address

Region	*Sardegna*	Province	*CAGLIARI*
Municipality	*SELARGIUS*	ZIP Code	*09047*
Address	*Via della Scienza*	Street Number	*5*

Contact Person

First Name	*Emilio*	Last Name	*Molinari*
Phone number	*070711801*	e-mail	*emilio.molinari@inaf.it*

6.2 OU Osservatorio Astronomico di Cagliari - Scientific-technological expertise and experience

The Astronomical Observatory of Cagliari (OAC) is one of the 16 INAF research institutes, working on several astrophysical topics. INAF-OAC operates the Sardinia Radio Telescope (SRT), one of the four existing national radio facilities. The SRT regularly takes part in the observations of international VLBI networks. INAF-OAC headquarters are located in Selargius (Cagliari). Laboratories and research infrastructures are also present at the SRT site (San Basilio, Cagliari). INAF-OAC is actively involved in the development of radio technologies for national and international radio facilities, including the SKA and its precursors.
Within the framework of the present proposal, INAF-OAC is involved in the development of state-of-the-art electronics, technology systems, software for the realization of radio telescopes and related instrumentation, as well as dedicated data analysis pipelines.
Website: https://www.oa-cagliari.inaf.it/

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [11] - Name, location, and contact person

General Information

OU Short Name	*OACT*	OU Name	*Osservatorio Astrofisico di Catania*
OU Type	*Department*		

Address

Region	*Sicilia*	Province	*CATANIA*
Municipality	*CATANIA*	ZIP Code	*95123*
Address	*Via Santa Sofia*	Street Number	*78*

Contact Person

First Name	*Isabella*	Last Name	*Pagano*
Phone number	*0957332220*	e-mail	*isabella.pagano@inaf.it*

6.2 OU Osservatorio Astrofisico di Catania - Scientific-technological expertise and experience

The Astrophysical Observatory of Catania (OACT) is one of the 16 INAF research institutes, working on several astrophysical topics. OACT operates the observing station M.G. Fracastoro (Serra La Nave, Etna). OACT actively collaborates with IRA, OAC and OAA in the development of radio technologies for national and international radio facilities, including the SKA and its precursors.
Within the framework of the present proposal, INAF-OACT is involved in the development of state-of-the-art optical and infrared astronomical instrumentation, as well as electronics and software for the realization of radio telescopes and related instrumentation. OACT is also actively involved in the development of radio interferometry data analysis pipelines.
Website: https://www.oact.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [12] - Name, location, and contact person

General Information

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

General Information

OU Short Name	*IRA*	OU Name	*Istituto di Radioastronomia*
OU Type	*Department*		

Address

Region	*Emilia Romagna*	Province	*BOLOGNA*
Municipality	*BOLOGNA*	ZIP Code	*40129*
Address	*Via Piero Gobetti*	Street Number	*101*

Contact Person

First Name	*Tiziana*	Last Name	*Venturi*
Phone number	*0516399370*	e-mail	*t.venturi@ira.inaf.it*

6.2 OU Istituto di Radioastronomia - Scientific-technological expertise and experience

The Institute for Radio Astronomy (IRA) is one of the 16 INAF research institutes, working on several astrophysical topics. IRA operates three national radio facilities: the Northern Cross interferometer in Medicina (Bologna) and two 32-m dish antennas, in Medicina and Noto (Siracusa). The INAF-IRA 32-m antennas regularly take part in the observations of international VLBI networks. INAF-IRA headquarters are located in Bologna. Laboratories and research infrastructures are also present at the radio telescopes sites. INAF-IRA is actively involved in the development of radio technologies for national and international radio facilities, and has leads the design and construction of the SKA low frequency array.
Within the framework of the present proposal, INAF-IRA is involved in the development of state-of-the-art electronics, technology systems, software for the realization of radio telescopes and related instrumentation, as well as dedicated data analysis pipelines.
Website: http://info.ira.inaf.it/

6 Operating Unit(s) (OU(s)) directly involved in the project

6.1 OU [13] - Name, location, and contact person

General Information

OU Short Name	*OAPD*	OU Name	*Osservatorio Astronomico di Padova*

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

			Padova
OU Type	*Department*		
	Address		
Region	*Veneto*	Province	*PADOVA*
Municipality	*PADOVA*	ZIP Code	*35122*
Address	*Vicolo Osservatorio*	Street Number	*5*
	Contact Person		
First Name	*Roberto*	Last Name	*Ragazzoni*
Phone number	*0498293517*	e-mail	*roberto.ragazzoni@inaf.it*

6.2 OU Osservatorio Astronomico di Padova - Scientific-technological expertise and experience

The Astronomical Observatory of Padova (OAPD) is one of the 16 INAF research institutes, working on several astrophysical topics. The Padova Observatory technological team is composed of about 40 members, divided into several research fields, ranging from ground-based telescopes, to satellite astronomical systems, to instrumentation for solar-system probes. Skills in the team include: design and development of single components and complex systems, prototyping activities, including technology transfer, and development of control software.
Within the framework of the present proposal, INAF-OAPD has a consolidated responsibility in telescope and instrumentation control SW, together with the leading role in a variety of Adaptive Optics issues (AO), including wide field AO techniques test and validation, real time computing, and scientific exploitation of AO data (simulations and PSF reconstruction).
Website: https://www.oapd.inaf.it/

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

7 National and international collaboration

A set of recent surveys from Nature regarding collaboration among scientific institutes ranked INAF among the most collaborative institutes worldwide: INAF ranked 2nd in the 2015 worldwide list of "overall collaborators" scientific institutions and 12th among institutions "with high affiliation articles in physics and astronomy" in 2019. These simple numbers demonstrate the number and quality of the links that INAF researchers have established with researchers around the globe. INAF collaborates with ESO, IAC, GMT for the construction of big optical telescopes, with SKA and MeerKAT and LOFAR collaborations for the development of radio arrays, with ESA, NASA and many other space agencies for the development of satellites at every wavelength, and with all major and small universities in the world. In this project, in particular, we benefit from tight collaborations with the University of Marseille and Grenoble, the Max Planck Institutes in Heidelberg and Munich, the Universities of Oxford and Leeds in UK and of Galway in Ireland, just to mention the most obvious. A full list of international collaborators is given in all the Actions presented in Part2.

INAF closely collaborates with all Italian Universities where astronomy courses are held, directly co-funding PhD schemes and supporting teaching activities. This is clearly revealed by the numerous Universities that participate in STILES.

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

8 Scientific coordinator of project

8.1 Personal data and contacts

First Name	*Adriano*	Last name	*Fontana*
Gender	*Male*	TAX Code	*FNTDRN62S29H501G*
Birth date	*29/11/1962*	Birth place	*ROMA*
Phone number	*0694286456*	e-mail	*adriano.fontana@inaf.it*

8.2 Digitally signed CV

(See documents attached)

8.3 Appointment letter as scientific coordinator of the project

(See documents attached)

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

9 Financial Officer in charge of the project

9.1 Personal data and contacts

First Name	*Chiara*	Last name	*Guccione*
Gender	*Female*	TAX Code	*GCCCHR72T66G273H*
Birth date	*26/12/1972*	Birth place	*PALERMO*
Phone number	*0635533341*	e-mail	*chiara.guccione@inaf.it*

9.2 Digitally signed CV

(See documents attached)

9.3 Appointment letter as scientific coordinator of the project

(See documents attached)

a) APPLICANT

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

10 Manager of the infrastructure as per Article 1 of the call for proposals, provide

10.1 Duties, expected profile and specific requirements

The Research Manager (RM) has the task and responsibility to manage the project in terms of schedule and budget. She/he shall coordinate all the processes identified to procure and deliver the expected products or results as defined in the program WPs.The RM shall plan, coordinate and monitor the progress of the project in order to meet the objectives and she/he shall also act as contact point between the Project leaders and all the players in its development,

The RM shall create a project plan in conformity to the proposal as approved or modified by MUR. Such a project Plan, encompassing scope, schedule and cost-baseline, will be the reference document against which the Project Performance will be measured. The Project Plan shall also cover programmatic aspects concerning quality, resources, communication and risks management.

The RM shall set up a Project Team to manage the project.The Project Team shall include a PA/QA expert to manage the quality and a Configuration Manager to take care of the project technical and administrative documentation through the definition of an appropriate configuration control process and through the implementation of a Documentation Management System (DMS) updated in real time. The DMS will be central in the project activity because it will contain all the documentation to be audited by MUR and by the European Union.

The RM will be also responsible for: a) changes management, b) Budget Control, c) Schedule Management, d) Team building and Team coordination, e) Risk management, f) Deliverable acceptance (intermediate and final). The RM will be hired by the Centralize PNRR managing Office at INAF Headquarters and will functionally respond its Director.

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

11 Legal name; Tax code; VAT number, Legal address

Legal Name	*Università degli Studi di Catania*	Tax code	*02772010878*
VAT number	*02772010878*		

Legal address

Region	*Sicilia*	Province	*CATANIA*
Municipality	*CATANIA*	ZIP Code	*95131*
Address	*Piazza Università*	Street number	*2*

12 Legal representative: personal data and contacts

First name	*Francesco*	Last name	*Priolo*
Gender	*Male*	TAX Code	*PRLFNC61S25C351E*
Birth date	*25/11/1961*	Birth place	*CATANIA*
Phone number	*0953785401*	e-mail	*rettorato@unict.it*

13 Management and research structure

Founded in 1434, the University of Catania (UNICT) is the oldest university in Sicily. Currently it has more than 42.000 students, 1.034 professors, 216 researchers and 1.125 administrative staff. UniCT educational system is run and overseen by 17 Departments, a Medical School and 2 other educational units, respectively located in the city of Ragusa - as far as Modern Languages are concerned - and in Syracuse for the School of Architecture.

Another special unit is the Scuola Superiore di Catania, which offers innovative courses at the highest level: preundergraduate additional teaching, Masters, Advanced Post-graduate and Ph.D. courses. The University of Catania governance is made up of a Rector, an academic senate, a board of directors and auditors, an evaluation body and a director general. The Central Administration is made up of 12 Administrative Divisions, each of them deals with a particular sphere of activity. Specifically, the Research Division is organized to provide professors and researchers with the administrative, organizational and managerial assistance in their scientific activities. It works closely with all other administrative offices involved in the management of the research projects both at central and departmental level. The University of Catania carries out its research activities both in departments and in research centers. Departments promote, coordinate and manage the research activities and they are in charge for the relations with external institutions. Research centers manage scientific

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

manage the research activities and they are in charge for the relations with external institutions. Research centers manage scientific initiatives by cooperating with professors coming from several departments. Noteworthy is the Services Center for Research and Innovation in Bio and Nano technology (B.R.I.T). The Center was set up with the ambitious mission of using high-end scientific equipment of great complexity, providing a highly qualified interdisciplinary service to the departments of the University of Catania and Italian public and private bodies.

14 Financial Management System

University of Catania uses an Economic-patrimonial accounting (or accrual accounting) that leads to obtaining:
a) a clear view of the single financial statements;
b) consolidated financial statements of the university;
c) the preparation of a budget and a financial accounting report, in compliance with the rules adopted pursuant to article 2, paragraph 2, of law no. 196 (on the basis of accounting principles and financial statements established and updated by the Ministry, in agreement with the Ministry of the Economy and of finance, after consulting the Conference of Rectors of Italian Universities – CRUI);
d) adoption of a three-year economic ¬ financial plan in order to guarantee the sustainability of all the activities of the university.
Drawing up a new balance sheet, the U.P.B. (Unità Previsionali di Base) are the main articulations into which the revenues and expenditures are divided. For each basic forecasting unit, the following data are indicated:
- the presumed amount of residual assets or liabilities at the end of the previous year;
- the revenues that are expected to be ascertained and the expenses that are expected to be committed;
- the revenue that is expected to be collected and the expenses that are expected to be paid.
The units are identified so that each of them corresponds to a single administrative responsibility center, which is entrusted with their management.

15 Specific skills of the applicant with respect to this proposal

The activities of University of Catania in this project will be conducted in the structures of the Department of Electric Electronic and Computer Engineering (DIEEI). DIEEI is responsible for research and education in
Electronics, Informatics, Telecommunications, Energy engineering and, in general, in the ICT domain. The
expertise of the professors and researchers at DIEEI (presently, 79 faculty members) covers several engineering areas. DIEEI is involved in a large number of national and international research projects, as well as international educational projects and an international Ph.D. program on "Systems, Energy, Computer and Telecommunications Engineering". Furthermore, University of Catania through DIEEI is one of the members of IUNET, the National Interuniversity Consortium for Nanoelectronics.
DIEEI has several facilities and well-equipped laboratories. Among these, there is the Microelectronic Lab
dedicated to the research on integrated circuits (IC). The Microelectronic Lab is made up of two Units one for the low frequency and digital electronics, the other for the high frequency electronics. The high frequency Lab Unity takes advantage of an area of 270 square

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

meters on loan for use in the premises of the L7 building of STMicroelectronics (ST). It includes a Design Lab equipped with CAD tools such as Keysight (ADS), Ansys (HFSS), Cadence, etc. and a Measurement Lab equipped with test benches for measurements of on-package assembled ICs and a Cascade Microtech probe station for on-wafer characterization. The Labs are connected to the ST server network and take advantage of periodic multi-project wafer runs with ST technologies. The Microelectronic Lab also exploits European technologies and software CAD tools thanks to the association to Europractice.

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

16.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*UNICT*	OU Name	*Department of Electrical Electronic and Computer Engineering - Università degli Studi di Catania*
OU Type	*Department*		

Address

Region	*Sicilia*	Province	*CATANIA*
Municipality	*CATANIA*	Address	*Viale Andrea Doria*
ZIP Code	*95125*	Street Number	*6*

Contact Person

First name	*Giuseppe*	Last name	*Palmisano*
Phone number	*0957382305*	e-mail	*giuseppe.palmisano@unict.it*

16.2 OU Department of Electrical Electronic and Computer Engineering - Università degli Studi di Catania - Scientific-technological expertise and experience

The Electronics Group is the research group at the University of Catania involved in the Project. It has a long and recognized scientific expertise in the field of integrated circuit (IC) design, which extends from the base-band to the mm-wave IC design (i.e., from dc to 100 GHz), also including ultra-low power and battery-less transceivers, RF and microwave front-ends, galvanically isolated switching power applications, power amplifiers, etc. using CMOS, BiCMOS, BCD and GaN technologies. The technical expertise of the Electronics Group covers the skills of circuit and system design, passive component design and modelling, electromagnetic simulations, layout and test-board design, and experimental characterization for both on-wafer and on-package circuits.
As far as the Project is concerned, the Electronics Group has a renowned experience in the modeling and design of ICs for Single-Photon Avalanche Diodes (SPAD) and Silicon Photo Multipliers (SiPM), semiconductor-based photosensors, addressing the challenge of low-light detection down to the single-photon for weak optical signals. The research activity has been mainly aimed at designing ICs for quenching and reset, and front-end electronics for SiPM readout. Moreover, accurate modeling of the photomultiplier device has been developed, also exploiting the Verilog-a behavioral language, suitable for transistor-level circuit simulations. This activity has been

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

conducted also in collaborations with INAF, INFN and STMicroelectronics.

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

17 National and International collaboration

The University of Catania pays great attention to research and a remarkable part of its resources is allocated, every year, to fund research projects in all scientific fields according to the merit. It also supports scientific activity of young researchers in the departments by providing, each year, about 200 research grants to young fellows. Moreover, UNICT is strongly committed to implement EU policies for the development of scientific careers and, in particular, the principles of the European Charter of Researchers and the Code of conduct for recruitment. To this end, its Research Division hosts one of the 18 Italian Mobility Centers participating to the EURAXESS network, created by the European Commission to support international mobility and careers' development of researchers. The University of Catania has also an intensive collaboration with research organizations and enterprises present on the territory, which has led to many joint research projects. Great attention is paid to the exploitation of research results through the management of its patents and the creation of "spin-offs". The University of Catania has a long experience of participation, both as coordinator and/or partner, to international, European and Italian projects. It is currently participating to many projects funded by Horizon 2020, Horizon Europe and many other Italian and European research and training programs, related to several scientific fields. In the last 5 years, about 300 projects have been funded, with a total financial contribution of about € 47.000.000,00. Specifically, the Department of Electric Electronic and Computer Engineering and, in particular, the Electronics Group involved in this Project actively cooperates with several research institutions in Europe such as the University of Sevilla and the University of Navarra, Spain, the National University of Singapore, the University of Shizuoka, Japan, the Eindhoven University of Technology, Netherlands.

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

18 Principal investigator for the co-applicant

18.1 Personal data and contacts

First Name	*Giuseppe*	Last name	*Palmisano*
Gender	*Male*	TAX Code	*PLMGPP56A09E431J*
Birth date	*09/01/1956*	Birth place	*LAMPEDUSA E LINOSA*
Phone number	*0957382305*	e-mail	*giuseppe.palmisano@unict.it*

18.2 Digitally signed CV

(See documents uploaded)

18.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Catania

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

19 Administrative contact for the co-applicant

19.1 Personal data and contacts

First Name	*Giuseppe*	Last name	*Caruso*
Gender	*Male*	TAX Code	*CRSGPP62L04C351Y*
Birth date	*04/07/1962*	Birth place	*CATANIA*
Phone number	*0957307279*	e-mail	*giuseppe.caruso@unict.it*

19.2 Digitally signed CV

(See documents uploaded)

19.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

11 Legal name; Tax code; VAT number, Legal address

Legal Name	*Università degli Studi di Roma Tor Vergata*	Tax code	*80213750583*
VAT number	*02133971008*		

Legal address

Region	*Lazio*	Province	*ROMA*
Municipality	*ROMA*	ZIP Code	*00133*
Address	*Via Cracovia*	Street number	*50*

12 Legal representative: personal data and contacts

First name	*Orazio*	Last name	*Schillaci*
Gender	*Male*	TAX Code	*SCHRZO66D27H501W*
Birth date	*27/04/1966*	Birth place	*ROMA*
Phone number	*0682598753*	e-mail	*rettore@uniroma2.it*

13 Management and research structure

Tor Vergata University of Rome is a non-economic, public university, governed by Public Law, and the Rector is the Legal representative of the University. The Rector appoints a Prorector (Prorettore vicario) who acts as his substitute in case of absence or impossibility to exercise his functions. The other Central bodies involved in the decision-making processes are the Academic Senate, the Board of Directors, the Board of Auditors, the Evaluation board and The General Director. The mission of Tor Vergata University is to provide higher education, research and third mission activities to domestic and international stakeholders. The Central Governing Bodies, the "Presidio di Qualità" and the "Nucleo di Valutazione" oversee and implement quality Management at the university.

http://pqa.uniroma2.it/normativa-e-documentazione-di-riferimento/documentazione-ateneo/

Description of some Research Labs, Centers and Research Units
Centro interdipartimentale Nanoscienze & Nanotecnologie & Strumentazione (NAST): Space sciences, cultural heritage, materials, ICT, health care, energy and environment;

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

ICT, health care, energy and environment;
Centro di Ricerca Interdipartimentale per le TeleInFrastrutture (Center for TeleinFrastructure);
Centro autonomo della Scuola per l'Istruzione a Distanza (IAD) Online education;
Centro di Ateneo per il Calcolo nella Scienza e nella Tecnica (CAST) Low-dimensional excitons, Opto-electronics and energy storage, Topological Properties of Matters, Protein Conformation Diseases (PCD's); Multi-level simulations; proteins sealed by metal ions;
The National Consortium for Space Physics: promotion of the participation of the associated institutions - currently the University of Milan, L'Aquila, Rome La Sapienza, Rome Tor Vergata, Turin, Trieste and the National Institute of Astrophysics - in the scientific and experimental activities of the space research in the fields of Astrophysics, Physics of the solar system and Interplanetary Plasma.

14 Financial Management System

The University of Tor Vergata is a public entity and must therefore abide to Italian laws and regulations for public universities, under the principles of transparency, efficiency and legitimacy, in compliance with the relevant European legislation. The University of Rome Tor Vergata is structured in 6 Schools (Economics; Law; Engineering; Humanities and Philosophy; Medicine and Surgery; Mathematics, Physics and Natural Sciences) which are organised in 18 Departments and the central Administration. The financial management of projects/actions is carried out at department level of the corresponding principal investigator, who is responsible of the related project/action.
The Organisation uses an "accruals accounting" system and the accounting software used by our organisation is called "EASY". The EASY software allows an integrated management of the general accounting for the purposes of the University's budget and the analytical accounting for each project or action for the preparation of the University budget and the disaggregated budgeting and reporting of each project via UPB (basic budgeting units assigned to each project). This system allows to maintain a separate accounting system for all transactions relating to an operation, making all documents available for inspection, providing information on the onset and completion of operations and providing all data required for the purpose of monitoring activities. The documents supporting the declared costs for each project/action are electronic. The internal accounting procedure normally assigns also a CUP (Unique Project Code) to each project.
Then, the University is also compliant with the national rules, in particular Law n. 190/2012, implementing every 3 years a plan for the implementation of strategies for the purpose of transparency and preventing and combating corruption and illegality.

15 Specific skills of the applicant with respect to this proposal

At central level the Management Unit II Research and Third Mission provides the expertise supporting the application phase preparing the proposal, then the management phase in case of positive results, are carried out by the department/s involved where academic and administrative expertise are available. The central administration guarantees anyway the support coordinating the action during all the phases of the life cycle of the action itself, ensuing a common approach at institutional level. The university has a Technical Service for the design, construction, maintenance and works for systems, technologies and construction. The office reports directly to the University's General Manager.

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

16.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*UniTV*	OU Name	*Department of Physics, University of Rome "Tor Vergata"*
OU Type	*Department*		

Address

Region	*Lazio*	Province	*ROMA*
Municipality	*ROMA*	Address	*Via della Ricerca Scientifica*
ZIP Code	*00133*	Street Number	*1*

Contact Person

First name	*Pasquale*	Last name	*Mazzotta*
Phone number	*0672594503*	e-mail	*mazzotta@roma2.infn.it*

16.2 OU Department of Physics, University of Rome "Tor Vergata" - Scientific-technological expertise and experience

The University of Rome Tor Vergata (UniTV), with the supporting offices of the International Research Division, aims at strengthening the internationalization process through a series of activities that involve researchers and administrative staff. The major actions focus on: project proposal, supporting with: Identification of funding opportunities; Proposal preparation and budget drafting; Online submission; Agreement negotiation; management and reporting; research collaboration: Promoting collaboration with international Universities and Research Centers Bilateral programmes for joint scientific cooperation; Drafting Consortium Agreement, Collaboration Agreement, Partnership Agreement, Memorandum of Understanding; Intellectual property and know-how protection and confidentiality issues: Non-disclosure Agreement, Data Transfer agreement, Material Transfer Agreement; Dissemination, Audit Internal audit: close monitoring of project's ongoing financial dynamics and possible deviations from the budget, Administrative and accounting coordination for external audit, Contact point for Auditors.

The main source of funding for the international research of UniTV comes from the European programmes, in particular Horizon 2020 (closed 2020) and Horizon Europe. The trend of successful proposals is positive in the recent year: Horizon 2020 funded n. 116 research projects for a total of Euro 46M.3 Euro. UniTV has already been

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

assigned also 4 projects within Horizon Europe. Currently UniTV has more than 110 research projects ongoing, including also those funded by international organisations extra UE as NIH, WFP and private funding association as National Geographic and Bill Gates.

The Physics Department is consistently ranked in the top 20% of the departments of physics worldwide and among the top Physics departments in Italy. The research activity involves the construction of large and complex experimental facilities operating at major research laboratories in the world and several hundred scientific publications per year on the most prestigious international journals. The Physics Department hosts a division of the National Institute for Nuclear Physics (INFN) and cooperates with the major national research centers, such as the Astrophysics National Institute (INAF) and ENEA, and international such as CERN, ESO, ESA the European Gravitational Observatory, the Massachusetts Institute of Technology, and NASA. Research spans topics in Astrophysics, Space science, Material science, Physics of fundamental interactions, Physics of complex systems, theoretical physics. The Department of Physics: i) promotes the scientific research and teaching in the field of experimental and theoretical studies of physical phenomena; ii) promotes and coordinates the applications in physical sciences and new technologies, the development of new teaching and learning methods, advanced instrumentation; iii) exploits the competences and professional qualification of its core staff, as well as the human and infrastructural resources assigned to it. The technical and administrative staff supports the activities of the organisation in its mission. In particular, in addition to the administrative secretariat and the doctoral secretariat, the department houses the following technical services: Computing Center, Teaching Laboratories, Electronics Laboratory, Mechanical Laboratory.

Finally, the proposers have a long-term experience in designing UHV systems, setting up and exploiting instrumentation for experiments in surface science, by using photoemission and optical spectroscopy, Scanning probe microscopies (STM and AFM), in ultra-high-vacuum and in liquid environment. They have proposed and performed experiments at synchrotron radiation sources. They have a long-standing experience in clean surfaces of semiconductors, metals and oxides, metal/semiconductor interfaces, thin and ultrathin organic layers deposited on solid substrates in vacuum and in liquid.

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

17 National and International collaboration

At national level, the main research collaborations are carried out across the different actions launched by the Ministry of University and Research (MUR), in which the university system participate to plan and enhance the scientific-technological research. The most relevant program to which Tor Vergata participates with large-scale projects is the Italian National Plan for Research (PRIN). This allows a wide collaboration among Tor Vergata and other Italian universities.
For the promotion of industrial innovation and the enhancement of patents, the University collaborates with the MISE, while for the implementation of projects aimed at achieving results of effective interest for regional companies, the main organization is the Lazio Region. As regards the implementation of the priority research development objectives in strategic sectors such as the study of drugs, rare diseases and oncological pathologies, health protection, the reduction of accidents, major collaborations can be referred, for example, to AIFA, Ministry of Health, INAIL, Telethon and AIRC. Other research agreements are related to applied research, for example in space and aerospace fields: ASI (Italian Space agency) in the fields of engineering, biomedicine and space applications. Collaborations with ENEA also focus on issues of common interest, ranging from energy efficiency to technologies for cultural heritage, earthquake protection, food safety and climate change. The interaction with the MIPAAF, on the other hand, concerns the implementation of projects responding to the priority themes of Research and Innovation identified in the "National strategic plan for the development of the organic system". The Physics Department is involved in international collaborations with several top-level institutions and research centers, such as the California Institute for Technology (USA), CERN (Switzerland), the European Gravitational Observatory (Italy), the Massachusetts Institute of Technology (USA).

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

18 Principal investigator for the co-applicant

18.1 Personal data and contacts

First Name	*Claudio*	Last name	*Goletti*
Gender	*Male*	TAX Code	*GLTCLD61R26D612K*
Birth date	*26/10/1961*	Birth place	*FIRENZE*
Phone number	*0672594288*	e-mail	*claudio.goletti@roma2.infn.it*

18.2 Digitally signed CV

(See documents uploaded)

18.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Roma Tor Vergata

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

19 Administrative contact for the co-applicant

19.1 Personal data and contacts

First Name	*Giorgio*	Last name	*Di Giorgio*
Gender	*Male*	TAX Code	*DGRGRG56T09H501L*
Birth date	*09/12/1956*	Birth place	*ROMA*
Phone number	*0672592518*	e-mail	*giorgio.di.giorgio@uniroma2.it*

19.2 Digitally signed CV

(See documents uploaded)

19.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

11 Legal name; Tax code; VAT number, Legal address

Legal Name	*Università degli Studi di Milano*	Tax code	*80012650158*
VAT number	*03064870151*		

Legal address

Region	*Lombardia*	Province	*MILANO*
Municipality	*MILANO*	ZIP Code	*20122*
Address	*Via Festa del Perdono*	Street number	*7*

12 Legal representative: personal data and contacts

First name	*Elio*	Last name	*Franzini*
Gender	*Male*	TAX Code	*FRNLEI56E19F205V*
Birth date	*19/05/1956*	Birth place	*MILANO*
Phone number	*0250312000*	e-mail	*ricerca@unimi.it*

13 Management and research structure

The governance at the University of Milan (UNIMI) is composed by 17 committees, headed by the Rector. The most important are:
Administration Council: strategy definition and management
Academic senate: supervision and verification in the field of teaching & research
Patent Committee: Reviews patent applications
Research Observatory: collects and analyzes information on University research findings.
With a teaching staff of about 2.200 tenured professors and with almost 60.000 students, is the largest university in Italy. Research activities are conducted in 33 Dep and 53 Research centers, with around 8500 scientific publications in the last year, more than 300 patents and 12 active spin-off. UNIMI's researchers occupy leading positions in numerous research programmes at national and international level. 4 technological platforms equipped with next-gen instrumentation are available for implementing research activities: COSPECT (spectroscopic, spectrometric and diffractometric analysis- spectroscopy), INDACO (computing power and data storage), NOLIMITS (imaging – light, confocal and electron microscopy) e OMICs (proteomic and metabolomics). The protection and exploitation of the scientific productivity is a strategic focus of UNIMI. Several patent applications, in co-ownership with partners, have

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

exploitation of the scientific productivity is a strategic focus of UNIMI. Several patent applications, in co-ownership with partners, have been filed to protect such results. This is achieved through a close collaboration among the Research Services Division (deals with all types of grants at national and international level) and the Innovation and Knowledge Valorization Division (oversees all Intellectual Property issues and exploitation of results).

14 Financial Management System

The economic accounting at Università degli Studi di Milano is organized in two integrated systems:

• Analytical accounting

• General accounting

The analytical accounting is based on responsibility centres and on linked cost centres, profit centres, investment and project management and it is fed by results of the annual forecast budget. Thus, we maintain a separate accounting system for all transactions relating to each project.

Financial statements on accrual basis of accounting include information not only on past transactions, but also on obligations to pay and money to be received in the future. Also risks and losses of the accounting year have to be noted in the balance sheet, or eventually in the accounts or provisions, even if they occur after the end of the accounting year. The definition of the annual result implies a procedure of identification, measurement and correlation of revenues and costs for each accounting year.

In general, revenues have to be acknowledged when the following conditions occur:

1. The good and services production process has been completed;

2.The substantial (not formal) transfer of title has already been completed. This phase is represented by the shipment or when the services have been delivered and can be invoiced.

Costs have to be correlated to accounting year revenues:

1. With a causal association between costs and revenues;

2. With transactional profit split on a systematic and rational basis (for example the depreciation)

3. With the direct allocation of costs to the profit and loss account when: a) the costs incurred in the financial year terminate their economic benefit in the same financial year; b) their economic benefit cannot be evaluated in the future; the causal association and the systematic transactional profit split are not useful.

The economic accounting is an integrated process of quantitative registration, allowing to systematically monitor and control all the economic and financial transactions.

15 Specific skills of the applicant with respect to this proposal

UniMI has an established reputation as one of the institutions most strongly committed to basic and applied research in Europe. EU programs represent a major source of funding for the University of Milan, which has signed 147 grants under the 7th Framework Programme (2007-2013), for a total value of € 50,344,153, and 52 grants up to May 2016 under the Horizon 2020 Programme

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

(including 9 JPI), for a total value of more than € 14,000,000. UniMI has also built relationships with different third parties such as industries, non-profit organizations, institutional entities, SMEs.

UniMI is constantly developing projects in cooperation with some of the most relevant international research groups, often acting as activities coordinator. The University supports researchers in accessing EU funds, in the achievement and exploitation of innovative results in different ways, including: Monitoring official EU programs websites on a daily basis; Providing information on funding opportunities through newsletters, web pages, ad hoc events, helpdesk; Supporting proposal drafting; Facilitating the grant application process; Negotiating research-related contracts and agreements; Advising on Intellectual Propriety Rights issues; Supporting University and Divisional research-related planning; Promoting the responsible conduct of research activities and compliance with regulatory requirements; Supporting Intellectual property protection of innovative results; Promoting exploitation of research results; Supporting negotiation with third parties aimed to licensing of IPR; Assisting and supporting establishment of new innovative enterprise (i.e. spin-off).

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

16.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*UNIMI*	OU Name	*Dipartimento di Fisica - Università degli Studi di Milano*
OU Type	*Department*		

Address

Region	*Lombardia*	Province	*MILANO*
Municipality	*MILANO*	Address	*Via Celoria*
ZIP Code	*20133*	Street Number	*16*

Contact Person

First name	*Marco*	Last name	*Bersanelli*
Phone number	*0250317264*	e-mail	*marco.bersanelli@fisica.unimi.it*

16.2 OU Dipartimento di Fisica - Università degli Studi di Milano - Scientific-technological expertise and experience

The Department of Physics at University of Milano hosts research activities in most of the forefront fields in fundamental and applied Physics, including a strong and lasting activity in Astrophysics and Cosmology. Our Cosmology group, in particular, has wide experience in Cosmic Microwave Background (CMB) projects, covering instrumentation, observations and data analysis. We played a leading role in ESA Planck mission and currently also scientific responsibilities in LSPE, QUBIC, two ground-based CMB experiments currently under development, as well as in LiteBIRD, a JAXA-led project for a space mission to be launched in the late 2020's.

Planck – For over 20 years we covered leading roles in the design, development, calibration, and data analysis of the Low Frequency Instrument (LFI) on board the satellite. The LFI is a radiometer array operating at 30, 44 and 70 GHz based on cryogenic low noise HEMT amplifiers. Planck was successfully launched on 14 May 2009, and has provided 4 years of uninterrupted cosmological data of excellent quality. Our group has been deeply involved also in the post-launch activities on LFI, such as in-flight calibration, analysis and removal of systematic effects, support of the LFI data processing pipeline, scientific exploitation of the data.

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

LSPE – The LSPE is a combined ground (Strip) and balloon-borne (SWIPE) experiment to measure the polarization of the CMB at large angular scales. We have the leadership of the LSPE/Strip instrument, which invoves several Institutes in Italy, Spain and UK. ON the H/W side, we have integrated and tested the modules composing the feed-horn focal plane at 43 GHz, including mechanical verification, RF performance verification. We have completely designed and assembled the small anechoic chamber as a dedicated RF facility to test the LSPE Q-band feed horn antennas.

QUBIC – The Q&U Bolometric Interferometer for Cosmology (QUBIC) is a CMB is composed of interferometer modules operating at three different frequencies (97, 150 and 220 GHz). Our mechanical workshop and μwave-lab developed the platelet photo-etching technique to produce the large focal plane of 400 back-to-back corrugated feed-horns for the dual-band (150 and 220 GHz) QUBIC module.

LiteBIRD - We contribute to the RF and optical design and breadboard testing of the medium-high frequency telescope of the LiteBIRD mission. We are currently working on the measurements of refractive systems to investigate Furthermore, we contribute to the software development for simulations, analysis of systematic effects (in particular optical effects due to sidelobe pickup) and to the planning of the overall RF and optical calibration of the instruments.

Our radio-microwave laboratory integrates various capabilities and skills, from design and manufacturing of hardware components, to simulations, to data analysis and scientific computing. The lab includes two anechoic chambers equipped with high quality instrumentation, as well as a near-field system, for testing and calibration of passive and active systems.. The “small” one has sizes 122 x 122 x 305 cm, operated at frequencies > 20 GHz, Max load on RX: 30 kg, five CNC axes (Two linear, one azimuth, two polarizations), Equipped with a HP® 8785D scalar network analyzer with power sensors up to 50 GHz. The “large” chamber has dimensions 400 x 330 x 840 cm, max load on RX: 9000 kg, four axes (One linear, one azimuth, two polarizations – ordered not yet in house), equipped with an Anritsu® VectorStar MS4647B vector network analyzer with broadband test-set Anritsu® 3739C up to 330 GHz (with VDI extension modules). We have direct access to the department machine shop. While our core business remains astrophysics and cosmology, we have developed a number of synergic collaborations with small-medium enterprises and other external partners for mutual interest and benefit.

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

17 National and International collaboration

UNIMI is constantly developing projects in cooperation with some of the most relevant international research groups. It is the only Italian member among the prestigious Universities of the League of European Research Universities (LERU).
EU programmes represent a major source of funding for UNIMI, which has signed 182 grants under the Horizon 2020 Programme. During the period 2014-2021 it has also signed additional 60 grants under other funding programmes and initiatives. Up to now, UNIMI is participating in around 45 COST Actions.
UNIMI is part of the 4EU+ Alliance with the Sorbonne in Paris, the Charles University in Prague, and the Universities of Copenhagen, Heidelberg and Warsaw.
It is actively promoting its internationality with English being the official language in the 31 PhD programmes, and the only language in one Bachelor programme and 10 Master. Other courses are partially held in English. Exchanges of students, scientists and professors are also encouraged and promoted through exchange programmes (e.g. Erasmus+, Lifelong Learning, Socrates, Business Exchange and Student Training, Fulbright, Galileo, Vinci, Vigoni), and several specific international agreements.

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

18 Principal investigator for the co-applicant

18.1 Personal data and contacts

First Name	*Marco*	Last name	*Bersanelli*
Gender	*Male*	TAX Code	*BRSMRC60A29F205J*
Birth date	*29/01/1960*	Birth place	*MILANO*
Phone number	*3355426941*	e-mail	*marco.bersanelli@unimi.it*

18.2 Digitally signed CV

(See documents uploaded)

18.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Milano

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

19 Administrative contact for the co-applicant

19.1 Personal data and contacts

First Name	*Fortunato*	Last name	*Laface*
Gender	*Male*	TAX Code	*LFCFTN62C04F112K*
Birth date	*04/03/1962*	Birth place	*MELITO DI PORTO SALVO*
Phone number	*0250317402*	e-mail	*fortunato.laface@unimi.it*

19.2 Digitally signed CV

(See documents uploaded)

19.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

11 Legal name; Tax code; VAT number, Legal address

Legal Name	*Alma Mater Studiorum - Università di Bologna*	Tax code	*80007010376*
VAT number	*01131710376*		

Legal address

Region	*Emilia Romagna*	Province	*BOLOGNA*
Municipality	*BOLOGNA*	ZIP Code	*40126*
Address	*Via Zamboni*	Street number	*33*

12 Legal representative: personal data and contacts

First name	*Giovanni*	Last name	*Molari*
Gender	*Male*	TAX Code	*MLRGNN73R11A944J*
Birth date	*11/10/1973*	Birth place	*BOLOGNA*
Phone number	*0512099966*	e-mail	*segrettore@unibo.it*

13 Management and research structure

Alma Mater Studiorum – Università di Bologna (UNIBO) is one of the largest and most active Italian universities in research and innovation. UNIBO is organized in a multi-campus structure (Bologna, Cesena, Forlì, Ravenna and Rimini), with 32 Departments and 5 Schools. It offers 232 Degree programmes (a.y. 2020/2021) of which 84 international ones, and 68 delivered in English and 48 PhD programmes (approx. 1500 candidates). The total number of enrolled students is 87.590 (A.Y. 2019/2020), of which 6.725 are international. The UNIBO community is composed of 5778 people, of which 2842 are dedicated to teaching and research, and 2936 to services.

In research, UNIBO is very active in research in all research domains, with outstanding results in attracting research competitive funding at both European and national level: in Horizon2020, UNIBO was involved in 350 research projects (more than 150 M€ financial contribution), of which 98 coordinated, with more than 2300 partners involved, of which 1000 from the private sector. At national level, UNIBO is currently involved in about 200 PRIN projects, (30 M€ funding), of which 62 as national coordinator. At Regional level, UNIBO accounts for more than 214 funded projects (33 M€).

UNIBO is also very active in innovation and technology transfer, with 520 patented titles, 37 spinoffs and 12 start-ups, 8

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

UNIBO is also very active in innovation and technology transfer, with 520 patented titles, 37 spinoffs and 12 start-ups, 8 Interdepartmental Centres for Industrial Research (CIRI), a large number of agreements and collaborations with industry. Research activities are carried out in Departments and Inter-departmental Centres, all staffed with research manager profiles. At central level, the Research Services Division (ARIC) oversees activities related to institutional research and competitive funding, including aspects such as open science, ethics, research integrity. The Industrial Relations, Third Mission and Communication Division (ARTEC) oversees processes related to collaboration with industry, knowledge transfer, exploitation of research results.

14 Financial Management System

UNIBO has an economic-asset accounting system, in compliance with relevant national and EU regulations. The accounting system is sound in providing adequate information for monitoring and internal auditing functions, as well as precise valorisation of the wealth produced or consumed. The system allows tracking all transactions related to a single project and the provision of data and documents for monitoring purposes. Furthermore, the system is structured so as to clearly identify economic and non-economic operations.
Financial management is carried out at the Dept. level, strictly following the applicable legislation, under the supervision of central Divisions (e.g. Finance, Procurement, etc.) having instruction, support and monitoring functions. A Board of auditors carries out regular audits on the different organisational Structures of the University.
Grant management is supported - in its legal, financial and administrative aspects - by a research manager at the Dept. level, in collaboration with the Research Service Division. The latter supports compliance with the specific rules applied within competitive programmes and projects, providing instructions, training and assistance in all phases of the project. It also ensures alignment of internal practices and procedures in collaboration with the other competent Divisions at central level (i.e.: Accounting Division, Knowledge Transfer Office, DPO etc.). Results of 2nd level audits carried out in the last years on competitive projects at regional (e.g. ERDF), national (e.g. FIRST funds) and European level (Framework Programmes for R&I) confirm soundness of the set management and control procedures.
UNIBO adopted a strategy to prevent and disadvantage behaviors, as well as a Corruption Prevention Plan, an Ethical Code of Behaviour, attached to the Corruption Prevention Plan and a Research integrity policy.

15 Specific skills of the applicant with respect to this proposal

The Department of Physics and Astronomy "Augusto Righi" (DIFA) was established in 2012 following the merging of the two separate Departments of Physics and Astronomy of the University of Bologna. DIFA is a big structure with about 130 scientific staff members achieving a level of excellence in Research and Teaching. At the new Navile headquarters, Astrophysics section of DIFA shares the location with two structures of Istituto Nazionale di Astrofisica (INAF: Osservatorio di Astrofisica e Scienza dello Spazio di Bologna and OAS, Istituto di Radioastronomia - IRA) and with Headquarters of Cherenkov Telescope Array (CTA) Observatory, establishing one of Europe main research centres in Astrophysics and Cosmology. The DIFA Astrophysics group has specific skills in theoretical, computational and observational astrophysics, and astronomical and space technology. The staff is involved in several

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

international projects with world-class observing facilities and space missions (e.g. Euclid, HST, ESO VLT, Chandra, XMM-Newton, Herschel, NuSTAR, ALMA, LOFAR, VLA/VLBI, Fermi, RadioAstron, ATHENA). The vast experience outlined above translates into a variety of specific skills that are essential for the general success of this project and the development of the Bologna Integration Hall. This facility will play a key role to expand the synergies between UNIBO-DIFA and INAF for the integration of the new generation of instruments for the ELT project, becoming the reference facility in the coming decades.
Last but not least, UNIBO-DIFA will play the unique role of providing the "training ground" where young scientists will acquire top-level expertise in the astronomical technology within the national and international environments. This will be achieved thanks to the Bachelor, Master, PhD and a professional Master courses in Astronomy, Astrophysics and Space Missions with more than 150 students enrolled every year.

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

16.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*UNIBO-DIFA*	OU Name	*Department of Physics and Astronomy "Augusto Righi"- Alma Mater Studiorum – University of Bologna*
OU Type	*Department*		

Address

Region	*Emilia Romagna*	Province	*BOLOGNA*
Municipality	*BOLOGNA*	Address	*Viale Berti Pichat*
ZIP Code	*40127*	Street Number	*6/2*

Contact Person

First name	*Andrea*	Last name	*Cimatti*
Phone number	*0512095817*	e-mail	*a.cimatti@unibo.it*

16.2 OU Department of Physics and Astronomy "Augusto Righi"- Alma Mater Studiorum – University of Bologna - Scientific-technological expertise and experience

The expertise and experience of the UNIBO-DIFA Astrophysics group rely on local observing facilities, regularly used by researchers and students, including two optical telescopes located in Loiano, and two radio telescopes: the Northern Cross, owned by the University of Bologna, and the INAF VLBI 32m parabolic antenna. Vast experience and expertise is also based on several ground- and space-based telescopes (e.g. ESO, HST, …) as well as on the development of space missions such as ESA Euclid. Computational activities benefit from a local parallel cluster owned and managed by DIFA and of close relations with CINECA and its supercomputing facilities. The training of students (from Bachelor to PhD levels) in astronomical instrumentation benefits from the courses and laboratory in Astronomical Optics and Astronomical Instrumentation.

The leadership of UNIBO-DIFA in this PNRR project is of strategic importance to strengthen the synergies in place with INAF OAS and to participate actively in the development of the technological sector, strongly growing at both local, national and international levels. Moreover, the scientific topics related to the instruments under development at INAF OAS (and that will make use of the instrumentation acquired in this activity) are of primary importance also for UNIBO-DIFA, allowing also scientific synergies.

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

This activity will be run at UNIBO-DIFA under the responsibility of Andrea Cimatti (DIFA director), with the technical supervision of Giuseppe Cosentino (UNIBO-DIFA), electronic expert and collaborator of the MAORY project since 2008. Moreover , this activity will be strongly supported by the INAF OAS staff Paolo Ciliegi (MAORY PI), Italo Foppiani (electronic expert) and Gabriele Rodeghiero (optical engineer).
Regarding management expertise, the Department of Physics and Astronomy (DIFA) currently runs 47 active projects (European, national, regional, university) and 11 third party contracts.

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

17 National and International collaboration

National and international collaborations of the DIFA Astrophysics group are numerous and synergic, and reflect its involvement in some of the forefront topics of modern astrophysics and related - existing or forthcoming - facilities (see also 15). Here we would like to focus on some of the major international, ESA-led space missions which are going to be operative in the next years (Euclid) or decade (Athena and LISA) and that will conceivably provide a quantum leap in astrophysics, also in strong synergy with ELT.

The Euclid mission is mainly focused on the understanding of the nature of the dark energy through the study of galaxy clustering and weak lensing. The adopted multi-tiered survey strategy will provide a huge catalog of galaxies of more than one billion entries. This will have an enormous impact in the astronomy community, making the legacy aspect of the Euclid mission for the next decades invaluable.

Athena is an X-ray mission that will open a new window in terms of technology (silicon pore optics solution for the mirrors) and detectors (by using a calorimeter coupled with the large collecting area of the mirrors). High-energy source population studies (e.g., demography, evolution, spectral and timing characterization) will be guaranteed up to high redshift by the wide-field imager, while the X-ray integral-field unit will allow, due to its high spectral resolution capabilities, a deep investigation of the source physical properties on a pixel-by-pixel basis.

LISA represents the first observatory in space designed to detect gravitational waves (GWs). While low-mass merging systems have been recently detected by the ground-based LIGO observatories, LISA is going to expand significantly our knowledge of the GW universe through GW detection from very massive merging black holes, as those of the center of galaxies. In this regard, LISA will complement traditional astronomical observations based on the electromagnetic spectrum

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

18 Principal investigator for the co-applicant

18.1 Personal data and contacts

First Name	*Andrea*	Last name	*Cimatti*
Gender	*Male*	TAX Code	*CMTNDR64L31A944Y*
Birth date	*31/07/1964*	Birth place	*BOLOGNA*
Phone number	*0512095817*	e-mail	*a.cimatti@unibo.it*

18.2 Digitally signed CV

(See documents uploaded)

18.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Alma Mater Studiorum - Università di Bologna

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

19 Administrative contact for the co-applicant

19.1 Personal data and contacts

First Name	*Maria Giovanna*	Last name	*Piazza*
Gender	*Female*	TAX Code	*PZZMGV73B46D704L*
Birth date	*06/02/1973*	Birth place	*FORLI'*
Phone number	*0512095257*	e-mail	*mariagiovanna.piazza@unibo.it*

19.2 Digitally signed CV

(See documents uploaded)

19.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

11 Legal name; Tax code; VAT number, Legal address

Legal Name	*Università degli Studi di Palermo*	Tax code	*80023730825*
VAT number	*00605880822*		

Legal address

Region	*Sicilia*	Province	*PALERMO*
Municipality	*PALERMO*	ZIP Code	*90133*
Address	*Piazza Marina*	Street number	*61*

12 Legal representative: personal data and contacts

First name	*Massimo*	Last name	*Midiri*
Gender	*Male*	TAX Code	*MDRMSM62C30G273M*
Birth date	*30/03/1962*	Birth place	*PALERMO*
Phone number	*09123893444*	e-mail	*rettore@unipa.it*

13 Management and research structure

The University of Palermo, officially founded in 1806, is at present an internationally acknowledged public research organization which covers almost all main fields of study, fostering an interdisciplinary approach.
The academic structures include: 16 Departments, 1 School of Medicine, 21 libraries, 3 decentralised premises (Agrigento, Trapani, Caltanissetta), the Museum System, the Language Centre, ITASTRA - Italian school for foreign students, the Guidance Centre.
To promote the quality of scientific research and teaching, the University ensures access to funding, the use and modernization of infrastructures and technical equipment for its teachers and all personnel engaged in research, also for the purpose of allow mobility and foster the international dimension of research. The University promotes the dissemination of research results, also by encouraging related publications.
Article 43, paragraph 1, of the Statute identifies in the Management Centers the organizational units called to answer for the correct management of the assigned resources, as well as for the achievement of the planned objectives.
At the organizational level, the management centers are centers of responsibility. The Management Centers corresponding to the Central Administration Structures are distinguished from the Management Centers corresponding to the Decentralized Structures such as

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

Administration Structures are distinguished from the Management Centers corresponding to the Decentralized Structures such as Departments, Schools and Poles.
The Department is a functionally homogeneous structure for research purposes and methods, which promotes the scientific activity of its teachers, ensures the didactic activity of its own competence, and carries out the activities related to the outside or ancillary to them, including technology transfer. The department's activities are aimed at pursuing scientific and didactic quality and improving the level of internationalization.

14 Financial Management System

The administrative-accounting management of the University is implemented through management centers, which are the structures to which the single budget of the University assigns a budget. We distinguish the Centers similar to the Central Administration Structures, from the Management Centers similar to the Decentralized Structures such as Departments, Schools and Poles.
The Management Centers are called to answer for the correct management of the resources assigned, as well as for the achievement of the planned objectives. The Management Centers inform their activities on criteria of effectiveness and efficiency and an approach of a collaborative and interactive approach between the Offices, also through the consultation of common databases. The management centers have managerial and administrative autonomy; hold an economic budget and an annual authorization investment budget in line with the single University budget for the annual authorization forecast, as well as an economic budget and a three-year unauthorized investment budget in line with the single budget of the 'Three-year forecast university; The responses of the efficiency and effectiveness of the resources available to them and of the achievement of the programmed objectives.
The information-accounting system detects events by nature through the general accounting and reflects the organizational structure of the University through the definition of the entity of attribution of the results of economic and asset management; it also notes the allocation of costs by destination through analytical accounting.
The governance of the management and verification processes of economic-asset, general and analytical accounting, is attributed to the Economic-Financial Area of the Central Administration, within the limits of the responsibilities of the Management Centers; the preparation of the accounting summary documents is attributed to the General Manager.
The University information system allows the Management Centers to view and monitor the relevant accounting information flows.
For accounting management, the University uses Cineca's U-GOV application.
For the management and reporting of projects, which identify temporally defined initiatives with assigned financial and human resources and objectives, there is a further module on the U-Gov platform, U-Gov PJ, which integrates the Accounting module. A code is assigned for each project.
All accounting entries are managed in analytical accounting by taking the availability from the budget assigned to individual projects during the Budget Change phase approved by the Board of Directors.
All the entries in addition to taking the budget in analytical accounting determine a cost / revenue in general accounting and consequent printable reports from the U-Gov-PJ module.
All the expenses related to each project, including the expenses of the personnel hired, except for the expenses of the personnel already structured at the Entity, are directly recorded and reported on the specific project created and are verifiable by the Ugov-PJ form reporting.

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

structured at the Entity, are directly recorded and reported on the specific project created and are verifiable by the Ugov-PJ form reporting.

15 Specific skills of the applicant with respect to this proposal

The Physics and Chemistry Department (hence after DIFC) hosts and coordinates the research activities in the fields of astrophysics, theoretical physics, experimental solid-state physics, applied physics, chemical physics, and computational chemistry of the University of Palermo. The role of DIFC staff involved in the project is twofold: training and research. There is a longstanding collaboration between INAF and DIFC in both areas. The DIFC astrophysics teams, active in the fields of exoplanetary physics, stellar and solar physics, high energy astrophysics, work in strict collaboration with INAF. The DIFC hosts the international PhD course in physical and chemical sciences. The course is done in collaboration with the Universities of Turku and of Tuebingen and of INAF. Indeed, INAF cosponsors on a regular basis PhD grants and INAF staff members take part of the PhD course board being PhD supervisors.
This specific research project will extend the range of scientific collaboration between DIFC and INAF thanks to the involvement of the quantum technology group and the computational chemistry group whose expertise will be described in detail below.

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

16.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*UniPA*	OU Name	*Dipartimento di Fisica e Chimica – Emilio Segrè - Università degli Studi di Palermo*
OU Type	*Department*		

Address

Region	*Sicilia*	Province	*PALERMO*
Municipality	*PALERMO*	Address	*Via Archirafi, 36*
ZIP Code	*90123*	Street Number	*36*

Contact Person

First name	*Gioacchino Massimo*	Last name	*Palma*
Phone number	*09123891739*	e-mail	*massimo.palma@unipa.it*

16.2 OU Dipartimento di Fisica e Chimica – Emilio Segrè - Università degli Studi di Palermo - Scientific-technological expertise and experience

The DIFC research teams involved in the present project are the quantum technology group and the computational chemistry group.

The quantum technology group is one of the first European team working, since 1992, in the field of quantum computation and quantum information theory. Such research activity has been founded by several national and European research grants and in collaboration with the CNR – NANO institute for nanoscience. Its research focus is on the dynamics of open quantum system, mesoscopic systems, quantum thermodynamics as well as foundations of quantum information theory. In the past years the QT team has been working in the field of machine learning applied to quantum task and of quantum reservoir computing. Two new team staff members have specific expertise in the fields of quantum neural networks and quantum machine learning, and of simulation of systems of physical and chemical interest with ab initio techniques. Of particular relevance for the present project is the new collaboration between the QT team and Amazon Web Service to access its quantum computing service Amazon Bracket.

The computational chemistry group at UNIPA has more than twenty years of experience in the field of

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

computational catalysis and has been involved in important European projects oriented to the study of catalysis with a view to increasing process sustainability. The group has always been characterized by a broad spectrum of interests in the field of computational chemistry, ranging from the application of highly accurate post-Hartree-Fock methods for the calculation of molecular spectroscopic constants to the use of semiempirical approaches for systems of large sizes and great complexity, passing through the development and maintenance of original codes. In particular, techniques related to density functional theory, multilevel and not, on molecular systems, clusters and periodic systems are considered, by the group, as the ones of choice in catalytic investigations. These concern both the structural studies - with the consequent energetic, thermodynamic, conformational and spectroscopic information and implications - and the kinetic analysis of reaction pathways also of considerable complexity.

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

17 National and International collaboration

The research activity of the quantum technology and the computational chemistry teams are carried on in collaboration with several national and international research institutions within the framework of research networks and projects.
The quantum technology group works in strict collaboration with the Queen's University Belfast, the University of Turku, the University of Baleares, the ICFO – Barcelona, the Scuola Normale Superiore, Pisa, the University of Milan, The University of Rome- La Sapienza, within the the currently running PRIN "taming complexity with quantum strategies: a hybrid integrated photonics approach" and thenks to the recently expired EU Collaborative Project "TherMiQ: Thermodynamics of Mesoscopic Quantum Systems" and "QuProCS Quantum Probes for Complex Systems". The team leader is research associate with the CNR – NANO institute for nanoscience.
The computational chemistry team works in strict collaboration with the Institut Català de Nanociència i Nanotecnologia - ICN2 and the University of Turku. Department of Chemical and Biological Engineering University of Wisconsin-Madison, University of Twente, B.T.G. Biomass Technology Group Bv. Several of those research teams were partners of the EU project SUSFUELCAT

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

18 Principal investigator for the co-applicant

18.1 Personal data and contacts

First Name	*Gioacchino Massimo*	Last name	*Palma*
Gender	*Male*	TAX Code	*PLMGCH63E12C286J*
Birth date	*12/05/1963*	Birth place	*TRAPANI*
Phone number	*09123891739*	e-mail	*massimo.palma@unipa.it*

18.2 Digitally signed CV

(See documents uploaded)

18.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Palermo

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

19 Administrative contact for the co-applicant

19.1 Personal data and contacts

First Name	*Antonella*	Last name	*Pennolino*
Gender	*Female*	TAX Code	*PNNNNL66L43G273L*
Birth date	*03/07/1966*	Birth place	*PALERMO*
Phone number	*09123865601*	e-mail	*antonella.pennolino@unipa.it*

19.2 Digitally signed CV

(See documents uploaded)

19.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Napoli Federico II

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

11 Legal name; Tax code; VAT number, Legal address

Legal Name	*Università degli Studi di Napoli Federico II*	Tax code	*00876220633*
VAT number	*00876220633*		

Legal address

Region	*Campania*	Province	*NAPOLI*
Municipality	*NAPOLI*	ZIP Code	*80138*
Address	*Corso Umberto I*	Street number	*40*

12 Legal representative: personal data and contacts

First name	*Matteo*	Last name	*Lorito*
Gender	*Male*	TAX Code	*LRTMTT61C08H703V*
Birth date	*08/03/1961*	Birth place	*SALERNO*
Phone number	*0812537003*	e-mail	*rettore@unina.it*

13 Management and research structure

The University is articulated in 4 Schools and 26 Departments, the latter mainly responsible for organizing and supporting the research activity. It also has 23 interdepartmental centers and 17 inter-university centers, useful for enhancing collaborations and interdisciplinarity.

Chief executive of the University is the Rector, who promotes all the main policies of the University, including the research policies, and is responsible for their actual implementation. The regulation and ultimate decision power is vested in the Academic Senate and the Board of Governors, two collegial bodies which elaborate the development strategies of the University, including in the area of research. The Rector also appointed a group of research delegates and a coordinating delegate for research, who are charged with supporting the Rector in his duties in the area of research, in close collaboration with the administrative structures responsible for the delegated matters.

Other research-related bodies are the University "Task Forces", which coordinate and promote interdisciplinary research collaborations to achieve interdepartmental synergies.

At the Department level, a key role in the management of research is that of the Department Directors, who promote and coordinate research and teaching activities of all groups and faculty members, while respecting the academic freedom of all individuals and their right

b) CO-APPLICANT - Università degli Studi di Napoli Federico II

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

research and teaching activities of all groups and faculty members, while respecting the academic freedom of all individuals and their right to seeking direct access to research funding.

14 Financial Management System

The University Director-General, the Board of Auditors and the Board of Governors are the main University bodies responsible for the financial management of the University. While the Director-General is the chief administration officer, responsible for the overall management of all services, instrumental resources and administrative technical personnel, the other bodies collaborate to ensure effective economic and financial management. The Board of Auditors, in particular, is responsible for compliance to National financial regulations, while the Board of Governors has ultimate decision-making responsibility.

The current financial management system complies with the relevant European legislation. In particular, it is pursuant to the provisions set out in point 20 of the Communication from the Commission 2014/C198/01 and the provisions of Article 71 of Regulation (EU) no. 1303/2013, and with the inter-ministerial Decree No. 18/2012 and Ministerial Decree 19/2014.

Using the current financial management system, the University of Naples Federico II will maintain a separate accounting system for all transactions relating to the financed activity and will make all documents available for inspection. The University will provide information on the onset and completion of operations and all data required for the purpose of monitoring activities.

The University of Naples Federico II manages assets, income and expenses using the Cineca Consortium's Information-Technology support. In fact, Cineca provides software applications to manage the financial management process reducing accounting errors, maintaining audit trails and ensuring compliance with applicable accounting standards.

15 Specific skills of the applicant with respect to this proposal

UNINA research activities involve, among other aspects, architectures, programming models, techniques and tools for high-performance computing (HPC), design methodologies oriented to complex accelerators and Systems-on-Chip, particularly hardware/software co-design approaches and integration/programming of acceleration technologies like FPGAs and GPUs, as witnessed by the active participation in several H2020 research projects related to the HPC domain. Unina is also working on hybrid computer systems; hybrid networks (simultaneous Ethernet/Infiniband); data analysis via NVLink-connected GPUs, and high speed serial links/optical links for fast data acquisition at high rate. In the area of Smart Cities, the UNINA research groups address a broad spectrum of research topics involving edge/IoT technologies, digital twins and modelling, smart grids, wireless radio planning, predictive maintenance, and infrastructure monitoring.

With respect to the proposal, the Principal Investigator for UNINA has been Archive Scientist" for the Hubble Space Telescope, working for both ESA And NASA.

b) CO-APPLICANT - Università degli Studi di Napoli Federico II

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

16.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*UNINA*	OU Name	*Department of Physics, Università Federico II*
OU Type	*Department*		

Address

Region	*Campania*	Province	*NAPOLI*
Municipality	*NAPOLI*	Address	*Via Cintia*
ZIP Code	*80126*	Street Number	*26*

Contact Person

First name	*Guido*	Last name	*Russo*
Phone number	*3381384466*	e-mail	*guido.russo@unina.it*

16.2 OU Department of Physics, Università Federico II - Scientific-technological expertise and experience

UNINA is a very strong attractor of national and international funds for advanced and complex research projects. UNINA has participated as partner in 114 projects financed by the European Commission within the H2020 framework, 23 of which coordinated by UNINA, with an average of 13 international partners and a total financial contribution of over 47 million euros from the EU. In the same time frame, UNINA has participated in 23 international projects other than H2020 ones, 6 of which coordinated by UNINA. UNINA currently runs several hundred projects funded by the Italian Ministry for Research under the National Interest Research Projects program (PRIN) and several tens of applied-research grants financed under the Operative National Program (PON) and Operative Regional Program (POR), with a total financial contribution of several tens of million euros. UNINA has been the host institution for 16 grants of the European Research Council (ERC) and UNINA faculty members have been principal investigators for 27 ERC grants (11 of which hosted by other research institutions with which UNINA has a permanent agreement).

UNINA has held over the last decade a significant role in some of the most important scientific research project, leading a large group with specific responsibilities; in particular for high energy physics: the ATLAS, CMS and NA62 experiments at CERN, and the Belle and Belle II experiments at KEK, Japan, since the construction phase, and in the Monte Carlo simulation, and then the data analysis, with a total of over 30 physicists. The amount of financial resources managed is of the order of 100 million euros in this field, for the Napoli local unit. But UNINA also

b) CO-APPLICANT - Università degli Studi di Napoli Federico II

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

worked on the VIRGO gravitational wave antenna, where we leaded the construction of the mirror locking system and the scientific data analysis with about 10 physicists and engineers, with an overall budget of 20 million euros. Several scientific projects on seismology, astrophysics, and theoretical physics involved dozens of researches and 10 million euros.

The personnel of the UNINA research unit has also had a leading role in important large-scale projects at the national level (PRIN program) and international level (FP7, H2020 program), including HPC-targeted actions like H2020 project "MANGO - exploring Manycore Architectures for Next-GeneratiOn HPC systems", ID 671668, H2020-FETHPC-2014 call, and "RECIPE - REliable power and time-ConstraInts-aware Predictive management of heterogeneous Exascale systems", ID 801137, H2020-
FETHPC-2017 call. The UNINA research unit is also actively involved in numerous projects relevant for the area of smart cities and digital society, such as MITIGO “Mitigazione dei rischi idrogeologico e sismico per i collegamenti viari e per le strutture strategiche” as well as the Relius network of the University Laboratories of Seismic Engineering.

b) CO-APPLICANT - Università degli Studi di Napoli Federico II

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

17 National and International collaboration

UNINA has several existing and fully formalized collaborations in the field of scientific projects and data analysis: the most relevant are the ones with INFN, CNR, INAF, ASI, CINECA, GARR, ENEA, CINI, SISSA in Italy; with CERN in Switzerland/France; with KEK in Japan; with ESO in Germany; with ESA in Europe; with CNRS in France, with MPI in Germany; and of course with most Italian Universities, including those of the present collaboration. The results reached in these collaborations have always been very positive: for the experimental apparatuses, they are now up and running; for the data analysis, they leaded to the biggest hardware infrastructure in south Italy, used in the worldwide collaboration and with hundredths of papers published. The personnel of the UNINA research unit has contributed to the creation of the CINI national laboratory on HPC Key Technologies and Tools, aimed at creating and exploiting synergies and cooperation across the Italian research community towards the evolution of HPC technologies. The activity of the UNINA research unit in the national laboratory will be directly relevant to the participation in the proposed PNRR CN. Furthermore, several UNINA research groups working in the area of smart cities have active collaborations and joint research initiatives with international and national players, such as the Euro-Mediterranean Centre for Climate Change, the University of Trento, the Polytechnical University of Bari, and many more.

b) CO-APPLICANT - Università degli Studi di Napoli Federico II

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

18 Principal investigator for the co-applicant

18.1 Personal data and contacts

First Name	*Guido*	Last name	*Russo*
Gender	*Male*	TAX Code	*RSSGDU53T02F839Y*
Birth date	*02/12/1953*	Birth place	*NAPOLI*
Phone number	*3381384466*	e-mail	*guido.russo@unina.it*

18.2 Digitally signed CV

(See documents uploaded)

18.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Università degli Studi di Napoli Federico II

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

19 Administrative contact for the co-applicant

19.1 Personal data and contacts

First Name	*Salvatore*	Last name	*Verdoliva*
Gender	*Male*	TAX Code	*VRDSVT69S07G813L*
Birth date	*07/11/1969*	Birth place	*POMPEI*
Phone number	*081676286*	e-mail	*salvatore.verdoliva@unina.it*

19.2 Digitally signed CV

(See documents uploaded)

19.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Sapienza Università di Roma

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

11 Legal name; Tax code; VAT number, Legal address

Legal Name	*Sapienza Università di Roma*	Tax code	*80209930587*
VAT number	*02133771002*		

Legal address

Region	*Lazio*	Province	*ROMA*
Municipality	*ROMA*	ZIP Code	*00185*
Address	*Piazzale Aldo Moro*	Street number	*5*

12 Legal representative: personal data and contacts

First name	*Antonella*	Last name	*Polimeni*
Gender	*Female*	TAX Code	*PLMNNL62R46H501K*
Birth date	*06/10/1962*	Birth place	*ROMA*
Phone number	*0649910292*	e-mail	*rettrice@uniroma1.it*

13 Management and research structure

Sapienza University of Rome is the largest university in Europe and the second in the world for number of students and the wide academic offer that includes over 250 degree programmes and about 80 PhD programmes. Sapienza plans and carries out important scientific investigations in almost all disciplines, achieving high-standard results both on a national and on an international level, thanks to the work of its 11 faculties, 63 departments and several centres devoted to scientific research.

The Research Area of Sapienza University of Rome (hereinafter called ASuR) supports his researchers scouting funding opportunities and exploiting the research results through a constant dialogue with territories, public administrations, enterprises and stakeholders at national and international level. ASuR copes with the scouting of funding opportunities, the mapping of internal competences, the matching for internal and external competences in competitive partnerships and the writing of project proposals, fostering the dissemination and exploitation of the research results. Moreover, the ASuR provides technology transfer services, as well as support to entrepreneurship, start-ups and spin-offs. The activities in this field concern, among others, the incubation and the development of research ideas, the pre-commercial exploitation of research results, and the provision of high-level education courses aimed at fostering and enhancing the relations between researchers and business communities, and at developing the entrepreneurship abilities of the young researches both singularly (spin off) and in partnership with industrial groups.

b) CO-APPLICANT - Sapienza Università di Roma

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

off) and in partnership with industrial groups.

14 Financial Management System

Starting from January 2012, Sapienza University has adopted the economic and asset accounting system. (UGOV CINECA – Economic accounting). The financial management system acts in compliance with the following legislation: Communication from the Commission 2014/C198/01, Regulation (EU) no. 1303/2013, Interministerial Decree No. 18/2012, Ministerial Decree 19/2014, Law 240/2010.
Sapienza University as beneficiary maintains a separate accounting system for all transactions relating to an operation, makes all documents available for inspection, provide information on the onset and completion of operations and provide all data required for the purpose of monitoring activities. The management system is compliant with the rules in terms of prevention of corruption (Regulation (EU, EURATOM) 2018/1046 and Regulation (EU) 2021/241); Sapienza University has adopted the Code of Conduct and the Ethics Code in order to ensure the prevention, detection and correction of fraud, corruption and conflicts of interests

15 Specific skills of the applicant with respect to this proposal

Over the past five years, Sapienza has strongly pushed an investment strategy aimed at establishing a university network consisting of laboratories equipped with large and medium-sized infrastructures to support research, innovation and technology transfer activities ("Sapienza Research Infrastructure").
With a deeply multidisciplinary vocation in line with the regional Smart Specialization Strategy (S3) and the Piano Nazionale Industria 4.0, the research facilities are configured as a unified platform at the service of external companies and institutes, with the clear goal of sharing technological resources and skills to actively foster a collaboration in support of growth, technological update, and internationalization.
More in particular, the Department of Statistical Sciences (DSS) at Sapienza hosts TeraStat2, an HPC infrastructure that provides a general-purpose, parallel supercomputing facility for solving large mathematical models on Big Data, whose upgrade will be key to the success of the project.
Beside the infrastructural aspects, the DSS carries out multidisciplinary research in the fields of Statistics, Statistical Machine Learning, Data Mining, Probability, Finance and Actuarial Sciences, Demography, Economics, Economic Statistics and Econometrics, Operational Research and Social Research.
DSS has also the direct organizational responsibility of the "Statistics" degree courses and the master's degree courses of "Statistical Sciences" and "Statistical, Actuarial and Financial Sciences" with a rich educational offer completed by research masters and doctorates in statistical sciences

b) CO-APPLICANT - Sapienza Università di Roma

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

16.1 OU [1] - Name, location, and contact person

General Information

OU Short Name	*UNIROMA1*	OU Name	*Department of Statistics - Sapienza Università di Roma*
OU Type	*Department*		

Address

Region	*Lazio*	Province	*ROMA*
Municipality	*ROMA*	Address	*Città Universitaria di Roma - Sapienza - Piazzale A. Moro*
ZIP Code	*00185*	Street Number	*5*

Contact Person

First name	*Pierpaolo*	Last name	*Brutti*
Phone number	*0649910561*	e-mail	*pierpaolo.brutti@uniroma1.it*

16.2 OU Department of Statistics - Sapienza Università di Roma - Scientific-technological expertise and experience

To effectively support the development and testing of the computational demanding algorithmic solutions for large-scale astronomical images planned within the project, a relevant part of the investment will be devolved to push a significant upgrade of TeraStat2, an HPC infrastructure backed by the Department of Statistical Science of Sapienza University (DSS) and hosted by the InfoSapienza IT center. TeraStat2 provides a general-purpose, massively parallel supercomputing facility for solving large mathematical models on Big Data. First introduced 10 years ago under the name TeraStat thanks to an initial funding by La Sapienza, since then, it has grown steadily with the help of grants and the contribution of several groups that have actively used the infrastructure over the years for a variety of R&D activities. In its current form, TeraStat2 includes about 2,300 compute units and over 5 Tb of physical RAM, making it the most powerful general purpose computing system available at Sapienza. TeraStat2's compute nodes are interconnected via a low-latency 40 Gbps Infiniband link, enabling high-speed communications required for high-throughput distributed applications. Basic access is provided free of charge to all Sapienza members, whereas external research groups currently pay a fee proportional to their usage. These funds are then in turn used to cover the costs of ordinary and extraordinary maintenance and provide a basis for future infrastructure expansion. To increase reliability and further improve uptime, the infrastructure was moved to the Sapienza Data Center last year.

b) CO-APPLICANT - Sapienza Università di Roma

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

There it can benefit from facilities such as a redundant power supply, a professional air conditioning system and an automatic fire extinguishing system. In addition, at its new location, the TeraStat2 infrastructure is directly connected to the GARR network via the Sapienza Point of Presence, thus benefiting from fast access times and low latencies for all connections originating from universities and research institutions of the GARR consortium. The infrastructure is developed and managed by the DSS thanks to the allocation of a full-time technical staff position for all tasks related to the management of the infrastructure and the allocation of a part-time administrative staff position for all administrative tasks, such as the acquisition of new hardware and software or the collection of access fees. These infrastructures are used both to conduct basic applied research activities as well as to accelerate the development of large-scale research initiatives involving the analysis of big data. A sample of the research initiatives that have been conducted using the TeraStat2 facility, include, but are not limited to, the analysis of compression techniques for omics data, network medicine-based machine learning and graph theory algorithms for precision oncology, deep learning applications to the memory forensic analysis, multi objective optimization for safety in local public transportation systems and HPC applications to molecular dynamics simulations and reverse docking.

b) CO-APPLICANT - Sapienza Università di Roma

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

17 National and International collaboration

Sapienza plays a leading role in several European and international networks, aimed at fostering collaborations and exchange of best practices between institutions in both education and research, as well as the development of new partnerships to effectively tackle the challenges and the opportunities offered by the relevant European projects and programs. More specifically, in 2020 Sapienza has formally adhered to the following networks: Association of Academic Health Centre (AAHC), Advances in Cleaner Production Network (ACPN), European University Association (EUA), Council Doctoral Education (CDE), Eurasian Universities Union (EURAS), International Association of Universities (IAU), M8 ALLIANCE Alliance of Academic Health Centers, Universities and National Academies, SGROUP European Universities' Network, TETHYS Consortium of Euro-Mediterranean Universities, UNICA Institutional Network of the Universities from the Capitals of Europe, Unione delle Università del Mediterraneo (UNIMED, UNI-ITALIA), Scholar at Risk International (SAR).

Focusing our attention on the research side, Sapienza at large and the Department of Statistical Sciences in particular are constantly involved in national and international collaboration with several top-level institutions and research centers. Considering, for example, only the projects supported by the European program Horizon 2020, we see that, from 2014 to 2019, over 180 initiatives backed by Sapienza were funded, for a grand total of 84M Euro. Overall, Sapienza appeared as partner of more than 1.300 research institutes and universities -- 95% of which were spread over 68 different countries -- such as: Consiglio Nazionale delle Ricerche (CNR), Centre National de la Recherche Scientifique (CNRS); Fraunhofer-Gesellschaft zur Förderung der angewandten (Forschung); Commissariat à l'énergie atomique et aux énergies alternatives (CEA); Karlsruher Institut für Technologie (KIT); Politecnico di Milano.

b) CO-APPLICANT - Sapienza Università di Roma

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

18 Principal investigator for the co-applicant

18.1 Personal data and contacts

First Name	*Pierpaolo*	Last name	*Brutti*
Gender	*Male*	TAX Code	*BRTPPL77C03A462M*
Birth date	*03/03/1977*	Birth place	*ASCOLI PICENO*
Phone number	*0649910561*	e-mail	*pierpaolo.brutti@uniroma1.it*

18.2 Digitally signed CV

(See documents uploaded)

18.3 Appointment letter as principal investigator

(See documents uploaded)

b) CO-APPLICANT - Sapienza Università di Roma

(The information provided in this section will be evaluated with reference to criteria A.3 and A.5)

19 Administrative contact for the co-applicant

19.1 Personal data and contacts

First Name	*Antonella*	Last name	*Cammisa*
Gender	*Female*	TAX Code	*CMMNNL59A48H501P*
Birth date	*08/01/1959*	Birth place	*ROMA*
Phone number	*0649910745*	e-mail	*antonella.cammisa@uniroma1.it*

19.2 Digitally signed CV

(See documents uploaded)

19.3 Appointment letter as principal investigator

(See documents uploaded)

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

20 Project title and acronym

Project title	*STrengthening the Italian Leadership in ELT and SKA*	Project acronym	*STILES*

21 Duration of the project (in month)

Project duration	*30*

22 Project type

(i) Strengthening of an existing RI among those listed in NPRI with high priority

23 Research Infrastructure(s) targeted by the project

RI : E-ELT - Extremely Large Telescope

ESFRI domain	*PSE*	Capofila	*INAF*
RI Type	*Phisical Sciences and Engineering*	RI priority	*IR a priorità alta*

24 Proposal ESFRI domain

PSE

26 Free Keyword(s)

Astronomy, Astrophysics, optics, optomechanics, adaptive optics, radio frequency devices, HP computing, machine learning, astronomical instruments, optical telescopes, radio telescopes, laboratories

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

27 Publishable project abstract

STILES is a comprehensive program aimed at strengthening the Italian leadership in the exploration of the Universe by developing laboratories and instruments for the two largest ground-based telescopes of the next decades: the European Extremely Large Telescope (ELT) and the Square Kilometer Array (SKA).

STILES includes:

- Direct upgrades of ELT and SKA observational capabilities. We will build and use a suite of instruments on ELT and SKA, as well as on their precursors VLT/LBT and MeerKAT, respectively;

- Investments in Information Technology. They consist of HW and SW infrastructures that are fundamental to develop new instruments and analyse their data. They include a high-performance computing centre and machine-learning-based software tools for data analysis, and a Concurrent Design Facility and other infrastructures for instrument development.

- Development of laboratories to study exo-atmospheric conditions, which will allow us to investigate physical states that have never been observed on Earth, giving us crucial advantages in understanding and interpreting the data from ELT instruments.

- Development of R&D experiments and laboratories. The goal here is to invest in our laboratories to invent and explore new technologies in several fields (Adaptive Optics, optical detectors, and radio receivers) and apply them to the astronomical domain.

- National Testing Facilities. We propose to establish a network of facilities that are able to provide general services (like opto-mechanical design and manufacturing) as well as multi-purpose facilities for the characterisation of instruments and methods. These coordinated facilities will be available to all Italian and international technological groups.

- A unique scientific and educational program. The last pillar of our program is a coordinated PhD program and a nation-wide Post-doctoral program explicitly focused on science with ELT, SKA and their synergies, aimed at fostering the careers of young astronomers.

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

28 Extended abstract

Astronomy is on the verge of a great revolution. By the end of this decade, a new set of international facilities will enter into operation and transform the way we explore and understand the Universe. This is made possible mainly by the synergy between space- and ground-based telescopes. A fleet of new satellites (JWST, Euclid, Plato, Ariel, Spectrum/eRosita, IXPE, Einstein Probe, Athena and LISA) will exploit the unique opportunities (wavelength ranges and stability) that the space environment can offer. Conversely, ground-based radio and optical telescopes retain a unique power - their unmatched large collecting areas gather more photons (enabling the observations of fainter and/or more distant objects) and, through advanced techniques such as interferometry or Adaptive Optics (AO), can deliver sharper images than any spacecraft.

In this context, two ground-based future telescopes will dominate the astronomical landscape for the next decades: the Extremely Large Telescope (ELT) and the Square Kilometre Array (SKA).

ELT (https://elt.eso.org) is an optical/nearIR telescope with a 39m primary dish, the largest of its kind ever built or planned. ELT is being built by ESO, and will be located atop Cerro Armazones, a ~3000m peak in the Chilean desert. ELT will see its first light in 2027. ELT is designed to exploit the full power of AO, that removes atmospheric disturbances so as to reach the full resolution obtainable from the mirror. To this end, ELT will implement a fully adaptive deformable mirror (M4) in its optical train, and will host a number of instruments exploiting the AO correction. Thanks to these capabilities, ELT will deliver data 5 times sharper and deeper than even JWST will do from space.

The SKA Observatory (SKAO; www.skatelescope.org) will comprise two radio interferometers. The low frequency antenna array (SKA-Low) will reside in Western Australia and the mid-frequency dish array (SKA-Mid) will be hosted in South Africa's Karoo region. SKA-Low will be made of 512 stations, each hosting 256 dual-polarized Log-Periodic antennas, distributed over an area of 65 km in diameter and operating over the 50-350 MHz range. SKA-Mid will comprise 197 dishes distributed over a region of 150 km in diameter, operating at frequencies from 350 MHz to 15 GHz, and will include the dishes of the precursor facility MeerKAT. Once completed (2029-2030), the SKA arrays will provide an order of magnitude improvement in sensitivity, one to two orders of magnitude increase in survey speed over the state of the art, as well as unprecedented image fidelity.

It is important to stress that both facilities have a vast potential for upgrades and improvements during their entire operational phase, well within the 2040-ies. A second generation of instruments (MOSAIC and ANDES, formerly known as HIRES) has just been approved for development. Beyond that, 3rd generation instruments will further benefit from future improvements of AO capabilities. In particular, the concept of a Planetary Camera and Spectrograph (PCS) aimed to discover and obtain spectra of Earth-like extrasolar planets has been proposed to exploit the ultimate AO performances of the telescope. PCS requires crucial developments in AO technologies and can only be accomplished through intense research and development (R&D) efforts.

Similarly, the SKAO has established an Advanced Instrumentation Programme (AIP) to fund and promote R&D towards innovative technologies and solutions. Currently the AIP includes development activities focused on Phased Array Feeds (PAFs), Medium Frequency Aperture Arrays (MFAAs) and Wide Band Single Pixel Feeds (WBSPFs).

INAF and the entire Italian astronomical community are at the forefront of the development and exploitation of both of these facilities. INAF leads the construction of 2 out of the 6 instruments planned for ELT (MORFEO and ANDES), a unique effort at the European level. In addition to instrumentation, INAF is partnered with Italian small- and mid-size industries (PMI) for the design

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

European level. In addition to instrumentation, INAF is partnered with Italian small- and mid-size industries (PMI) for the design and realisation of the ELT M4 adaptive mirror, a key technological component of the ELT telescope. This engagement stems from the outstanding results obtained with the development of instrumentation (both AO and spectroscopic) at TNG, LBT and VLT in the last 10-20 years. In particular, INAF researchers and related industrial counterparts are worldwide leaders in the development of innovative AO instruments. Italian-led AO systems equip several telescopes around the world, including the next generation of US 30-m telescopes.

Similarly, INAF has played a leading role in the design and development of the SKA-Low antennas, receivers and signal acquisition chain, in collaboration with the Universities of Bologna, Florence and Ferrara and the CNR-Institute of Electronic, Information, Engineering and Telecommunications, and is now actively involved in the deployment and commissioning of the first prototype stations (AAVS2) in Australia. The Italian antenna design (SKALA4.1), developed in collaboration with the Italian manufacturer Sirio Antenne, was chosen over a competing one, after an extensive testing campaign on site. In addition INAF has introduced the so-called RFoF (RadioFrequency over Fibre) technology in the design of SKA-Low receivers, which allows antenna arrays to carry all signals in a central structure, and which has become a key element of AAVS2. INAF also led the design and development of the Local Monitor and Control (LMC) software for the SKA-Mid dishes, and is actively involved in the PAF AIP programme.

Thanks to the expertise gained in the framework of SKA-Low and SKA-Mid design and development activities, INAF has joined the two most sensitive SKA precursors: the International LOFAR Telescope (ILT) and the MeerKAT+ project. MeerKAT+, is an upgrade of MeerKAT in South Africa, improving the survey speed by a factor of 1.6 and its resolving power by a factor of 2. The INAF technological contributions to MeerKAT+ are twofold: the development of the antennas LMC software and the development of a digital correlator able to handle all 80 antennas.

In this context, STILES is an ambitious, comprehensive and transformational program with the ultimate goal of establishing a firm Italian leadership in the technological developments and scientific exploitation of ELT, SKA - and of their precursors on the path. STILES is conceived to attain these overarching goals:

1. Transform the capability of Italian laboratories (at INAF and in collaborating Universities) and related industries to perform R&D activities in ground-based astronomy, as a pathway to develop future groundbreaking astronomical instrumentation;

2. Directly provide ELT, SKA and their pathfinders with innovative instrumentation that will boost their scientific return, enabling Italian scientists to carry on highly innovative and rewarding scientific programs;

3. Train a new generation of scientists and engineers, with particular attention to gender equality, and give them the possibility of leading the scientific revolutions that these facilities will make possible.

4. Establish a closer relationship and networking between the Italian laboratories and industries, in order to boost their synergies and optimise the allocation of resources at the national level.

Before we translate these goals into definite objectives below, we want to stress the reason why we decided to design a single program covering two aspects - optical and radio astronomy, represented here by their champions ELT and SKA - that have been traditionally quite separated. We believe this is a crucial strength of our proposal.

First, there are clear scientific synergies between the two domains. The multi-frequency, multi-messenger approach is now a pillar of modern astronomy. Obvious examples that demand a multiwavelength approach are the study of the reionization epoch, of the galaxy-

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AGN co-evolution, of the nature of Dark Matter, of the birth of stars and planets and - ultimately - the search of habitable planets: they all need combined observations at all wavelengths, crucially including data from both radio and optical telescopes. In STILES, this is highlighted by a high-profile program of Post-doctoral grants explicitly designed to boost a combined radio-optical approach. Second, there are specific synergies that we want to pursue, to develop a cohesive network of research laboratories and facilities that share resources, expertise and methods. For instance, STILES will build common laboratories for radio/optical detector characterization, a shared Concurrent Design Facility, a shared Advanced Computing System, and trigger a joint science program.

STILES is designed to achieve six different General Objectives, all focused on ELT and SKA, each mapped onto a relevant WP, as detailed below.

1. Direct upgrades of ELT/SKA observational capabilities. The goal is to upgrade current instrumentation of ELT and SKA with facilities directly derived from our R&D activity. These improvements will boost the observational capabilities of ELT and SKA and open new pathways for their exploitation by Italian astronomers. The two pillars of this goal are: a) the design and delivery of an additional Deformable Mirror for MorfeoELT (which will become the first Multi Conjugate Adaptive Optics (MCAO) instrument operating with a 3-level cascade AO system), realising the ultimate ELT's wide-field AO capabilities; and b) the realisation and delivery of an entire suite of Band 5 (5-15 GHz) detectors for MeerKAT (to be integrated into SKA later), that will open a new window on astrophysical processes in distant galaxies and our own.

2. Investments in Information Technologies (IT). With astronomy rapidly becoming a science of Big Data, our goal here is to develop the computing facility and the analysis tools that are required to analyse data from ELT, SKA and other observatories, in synergy with the ESO archive and the SKA Regional Centres. A main objective will be to exploit Italian expertise for innovative data-mining techniques (generically referred to as Machine Learning) that have not yet become "standard tools" for data analysis.

3. Development of laboratories to study the physical properties of extraterrestrial atmospheres. Our goal is to develop innovative laboratories that will enable the study of exo-atmospheric conditions and give us crucial advantages in understanding and interpreting the data from future instruments.The data obtained with ELT and other future facilities, indeed, will explore physical states of matter that have never been observed on Earth in laboratories, and will be difficult to analyse properly. The most tantalising application is the study of extra-solar planet atmospheres, which ultimately may disclose the existence of non-terrestrial life - arguably among the greatest discoveries of mankind.

4. Development of R&D experiments and laboratories. Our goal here is to invest in our laboratories to invent and explore new technologies and apply them to the astronomical domain. This will be done by setting up dedicated "experiments", i.e laboratories dedicated to study specific problems and test various technological solutions to them. A typical case is the realization of laboratories dedicated to study options and solutions for Extreme or Wide Field AO, as well as a network of laboratories for radio detectors that will investigate new technologies for radio receivers (e.g cooled passive/active devices, materials and integrated systems, electronic boards for the monitoring of the receivers, ront end electronics at RFs, PAF). Other laboratories are going to be developed, to explore new optomechanical engineering approaches, including manufacturing of prototypes and actual hardware for next generation astronomical instrumentation.

5. National Testing Facilities. Here we plan to develop the "workhorses" of our strategy. We propose to establish a network of facilities that are able to provide general services (like optomechanical design and manufacturing) as well as multi-purpose facilities for

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the characterisation of instruments and methods.These facilities are coordinated at the national level, as they represent a non-redundant, complete set of facilities available to all Italian and international technological groups. Taken together they will form an invaluable asset to develop and characterise cutting-edge instrumentation at all wavelengths.

6. A unique scientific and educational program.This proposed effort would be useless without a new generation of scientists and engineers who can exploit it.The last pillar of our program is therefore an intense scientific and educational program aimed at fostering the careers of young astronomers.This will be based on a vast, coordinated PhD program scattered across several Universities and a high-profile, nation-wide Post-doc program focused on science with ELT and SKA, with particular emphasis on their synergies.

STILES will transform the landscape of Italian astronomy. The direct investment in laboratory equipment will be an order of magnitude greater than the integrated resources spent in the last years by INAF and universities. As a result, the capability of Italian labs to develop their own R&D programs and to participate with leading positions in major instrumental programs will be enormously increased. This would be the analog of the large funding obtained in the early 90's that enabled the Italian astronomical community to develop the technologies (Adaptive Secondaries and pyramid wavefront sensor) that are nowadays the key components of any 8m telescope and an integral part of the design of all instruments of the ELT. The same is true for the European FP6 SKADS and FP7 prepSKA funding, which paved the way to the Italian leadership in SKA.

STILES will also have a clear and direct impact on ELT, SKA and their pathfinders. First, we shall deliver new instrumentation that will boost their capabilities (improved AO performances for ELT and LBT; a brand new frequency range for MeerKAT, translating into enhanced high-frequency capabilities for the SKA). In the long term, the R&D activities enabled by STILES will target a number of open issues that still prevent ELT and SKA from reaching their ultimate performance. We shall analyse several avenues to guarantee the co-phasing of the ELT M4 adaptive mirror; develop new solutions for extreme and wide-field AO; develop a new manufacturing brench for large dispersing element (currently missing in Europe); and develop and test new wide-field receiver technologies (e.g., PAFs) and future generations of antennas and detectors for radio astronomy.

These developments will guarantee Italian astronomy an International leading role in the next decades not only in astronomical technologies but - more crucially - in the scientific exploitation of these facilities. They are indeed subject to a "fair return" policy that rewards with guaranteed observing time all the investments in hardware done by the partners. A leading role in the design and construction of the instrumentation therefore ultimately leads to new opportunities for the Italian community to lead extended and coordinated international programs..

As we describe more extensively in the "Impact" section below, STILES will strengthen the relationship between INAF, Universities and Italian and European industries, yield a direct return in terms of additional European and competitive grants, as well as of direct industrial contracts, and significantly contribute to the development of high-tech companies and scientific institutes in Southern Italian regions

In conclusion, reminding that this PNRR funding scheme is "aimed at consolidating the excellence of the Italian scientific community to reach the most challenging European and national objectives", we believe that STILES is the ideal approach to transform Italian astrophysical research.

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29 Objectives and ambition

STILES is designed to implement a set of facilities and laboratories dedicated to R&D and instrument characterization for optical and radio astronomy, design and procure instrumentation for ELT, SKA and their pathfinders, train the next generation of researchers and foster technology transfer and industrial collaboration with italian companies.

These goals are translated into six General Objectives that are also listed above and repeated here for simplicity:

- *Direct upgrades of ELT/SKA observational capabilities.*
- *Investments in Information Technologies.*
- *Developments of laboratories to study extraterrestrial atmospheres.*
- *Development of laboratories focused on R&D.*
- *Establish National Testing Facilities.*
- *A unique scientific and educational program.*

Before delving deeply into the details, we want to emphasise that we have refrained from adopting an apparently simpler organisation as could have resulted from splitting the WP between "optical" and "radio" laboratories. Indeed, this would not correspond to our intention to optimise synergies and develop facilities that are used for both radio and optical instruments - such as the refurbishment of shared laboratories, computing facilities or the development of a Concurrent Design Facility.

Moreover, the deliverables of most WPs consist of laboratory equipment or the refurbishment of existing facilities, which are largely independent and would not benefit from a different, more standard organisation. We believe instead that a list of WPs that is one-to-one mapped on the General Objectives allows us to remain more focused on the major goals and to present the activities in a more logical sequence.

The project is therefore organised in these Work Packages (WPs):

WP1000: Management. It is a standard management WP. It envisages the hiring of a dedicated Program Manager (PM) and two Project Managers and a lean and efficient structure for scientific supervision. It will be based on the adoption of best practices consolidated at international level, as formalized by leading Project Management organisations. It will also leverage the long experience accumulated by INAF in many international projects and available at the INAF central Project Management Office.

WP2000: Instruments for ELT and SKA. The goal of this WP is to deliver a set of instruments for ELT and SKA, or their pathfinders, and to support a unique scientific and educational program to exploit them. WP2000 includes five main deliverables: the 2nd Deformable Mirror for Morfeo, an extreme-AO cascade module for Sphere at VLT, an MCAO system operating at visible wavelengths for LBT, and two sets of receivers (UHF and Band 5) for the MeerKAT array. The goal of this WP is to build these instruments (or their main sub-components). In order to reduce the risks entailed by the strict limits on the project deadlines, we postpone their commissioning to a subsequent phase, jointly funded by INAF and our international partners. Therefore, our activities are essentially focused on the design, procurement and assembly of the instrument components. We also establish an ambitious PhD and Post-doc scientific program, focused on ELT and SKA science.

WP3000: Information Technology. This WP is devoted to deploy facilities (hardware and software) to support the activities necessary for the development and exploitation of new astronomical instrumentation. The main deliverables are a large computing centre dedicated to archiving and processing of optical and radio data (the latter in coordination with the SKA Regional Center) as well as the

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to archiving and processing of optical and radio data (the latter in coordination with the SKA Regional Center) as well as the development of data analysis tools exploiting innovative approaches to data mining. We also include here the support for instrument design and control software. The former is attained by the development of a INAF-wide Concurrent Design Facility, which will transform the way INAF develops its own instruments, the second by a network of facilities for prototyping of control software.

WP4000 ExoLabs. This is the first of three WPs aimed at the set-up of laboratories, serving different purposes. Here the focus is on three laboratories for the study of extraterrestrial atmospheres, in the broadest sense (stellar and planets atmosphere as well as other nebular media), including the conditions that may lead to the birth of life. Activities in this WP are primarily procurement of instruments and laboratory equipment.

WP5000: Labs for Research & Development. Here we include laboratories that are explicitly aimed at enabling specific investigations on new technologies with high gain/high risk. We stress that these labs are not "multi-purpose" but they are designed to test and develop specific new transformational technologies in view of ELT and SKA. In particular we highlight two labs for AO - one devoted to technologies needed to reach the ultimate AO performances of ELT, and the other on the opposite on studying new approaches to WideField AO corrections - as well as a network of laboratories focused on developing new radio receivers and receiver components (e.g. PAF).

Activities in this WP are primarily procurement of instruments and laboratory equipment.

WP6000: National Testing Facilities. We include in this WP a number of multi-purpose facilities meant to be of wider fruition, i.e. testing facilities and general services that will be available to the entire Italian astronomical community to routinely test instruments. Examples are a set of anechoic chambers that will be able to test radio receivers over a wide spectral range, equipment for high precision mechanical processing, radio and optical calibration facilities.

Activities in this WP are primarily procurement of instruments and laboratory equipment.

We stress once more that STILES is not aimed at doing research in astronomy or in astronomy-related technologies. STILES' goal is to enable future research by establishing an incredibly powerful network of laboratories and facilities. The synergies that we often mentioned in the scientific justification will enter in action once we finish STILES: here, WPs and Activities are primarily concerned with the procurement and set-up of laboratories which are largely independent and located in several sites. Each WP will have its own management system and a number of intermediate objectives that will allow us to keep track of their progress. Most Activities are independent resulting, crucially, in very few connections and dependencies between WPs. In order to reduce risks, we have carefully evaluated the procurement times and included in the program only items with a comfortable margin for delivery. As a result, there is no single item on the critical path that can affect the success of the entire program.

This translates into a simple hierarchy of activities, which is fully reported in the following WP descriptions.

Each WP includes a few sub-WP, each typically corresponding to a given objective, typically self-standing laboratories. In turn, these sub-WP are made of one or a few Activities which are fully described in the proposal. This is reflected into both the naming and the numbering scheme of WPs and Actions. Each Action number is uniquely identified with the format 'wdxx', where 'w' denotes the WP, 'd' is the sub-WP number in the WP and 'xx' are digits that identify the Actions therein.

For instance, in the WP "Information Technology" (WP3000) there is the sub-WP "AdvancedProcessingCenter" (3100) which is

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made of three Activities (3101, 3102, 3103) named AdvancedProcessingCenter_PowerCooling, AdvancedProcessingCenter_DataCenterHW and AdvancedProcessingCenter_DataCenterSW, respectively.

In conclusion, despite its breadth and complexity, we believe that STILES is organised in a simple, lean and effective manner, and we remain confident that it will be successful and lead to the transformation it was designed for.

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30 Project framework and main expected impact

We believe that STILES will literally transform Italian astronomy, have a wide impact on the industrial system in terms of investments and innovations, and will make new technologies available for a wide range of applications.
The impact on astronomy cannot be overestimated. The transformation of our laboratories and infrastructures will pave the way to the development of innovations that will have an impact for the next decades. Thanks to the new facilities and skills acquired with STILES, Italian scientists will lead the development of the next generation of astronomical instrumentation at International facilities. Immediate objectives are 2nd generation instrumentation for ELT and SKA.
For ELT, MORFEO's deformable mirror will largely improve resolution and sky coverage of ELT wide field instruments and grant additional GTO to the Italian community. The Extreme AO laboratories, and software tools for AO processing, hold the promise of reaching the ultimate diffraction limit of the 39m telescope. These and other developments will enable us to study the tiniest details of distant objects, including the first stars and galaxies, black holes, and earth-like planets around nearby stars.
Similarly, the installation of SKA Band 5 receivers (covering 4.6 – 15.3 GHz) onto the 64 MeerKAT antennas, that will enable MeerKAT sub-arcsecond resolution observations, providing a natural match to ALMA, JWST and ELT, adding leverage to joint multi-wavelength studies.
The investment on MeerKAT band 5 receivers will also have a long-lasting impact on SKA-Mid performances. The 64 extra receivers will significantly increase the sensitivity of SKA-Mid in Band 5 and, thanks to the additional short spacings provided by MeerKAT, will substantially enhance Band 5 image fidelity for extended emission.
Innovative AO methods and facilities will also be exploited to design and build instrumentation over a larger range of facilities, including space telescopes. For instance, it could position the Italian community very well in the R&D plan needed to design the NASA LUVOIR mission, the successor of HST and JWST, planned for the late 40s.

We expect that these investments will yield a direct return by making the Italian community much more effective in winning European and other competitive grants. We prudently estimate a return of 55M€ in the next 10 years, the inevitable result of the boosted R&D capabilities which are a prime goal of this proposal.

The impact on the industrial system is another key aspect of STILES.
There is a large set of extremely competitive high-tech Italian companies that are natural candidates for the contracts for the design and procurement of our laboratories. We estimate that about 50M€ out of 91M€ of the present proposal can eventually be the target of competitive offers from small and medium Italian industries.
Even more important, STILES will allow Italian companies to participate in our R&D efforts and help them develop and validate new technologies. In addition to those operating in the astronomical international market - for instance in the fields of AO deformable mirrors or low frequency antennas for radio astronomy - there is a large number of high tech Italian companies that will be both vendors and co-developers of new technologies, in fields like: circuits and RF components at high frequency, low noise working at cryogenics temperatures, anechoic chambers, clean rooms, precision optomechanics, development of SPAD and SCMOS detectors, cryogenics and vacuum technology, microwave precision mechanics, RF guidelines, stand-alone horns, low noise amplifiers, radiofrequency systems

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vacuum technology, microwave precision mechanics, RF guidelines, stand-alone horns, low noise amplifiers, radiofrequency systems (ASIC), precision optics and mechanics, custom mechanic, low-noise IR cameras, high quality large optics.
These developments will have a wider impact on technology and society. For instance, low noise cryogenic electronics and amplifiers and radio/microwave/mm-wave in general are adopted in remote sensing, radar, navigation, and satellite communications. Our testing facilities will certainly be a precious tool to validate new antennas when the transition to the 6G system (>100GHz) will be made. RF techniques are essential in the forthcoming automotive revolution, radar, and avionics.
Adaptive optics can have a range of applications, including optimization of solar panels. The proposed laboratory of line-resolved spectroscopy of highly ionised species (Activity #4301) will provide the atomic physics information necessary for the quantitative analysis of fusion plasmas, a diagnostic that is essential for the transition from ITER to DEMO.
This transformation will be conveyed to the Southern regions. With more than 46% of the total budget planned in these eight regions, where a vibrant network of local industries (mechanics, informatics, detectors) is connected to INAF institutes, STILES will significantly contribute to the development of high-tech companies and scientific institutes in Southern Italian regions.
STILES also offers a unique opportunity for the creation of new companies (start-up and spin-offs). The leading-edge technologies to be developed and improved in the project may foster the birth of small, highly specialised enterprises created by young technicians and scientists coming from existing firms or from academia. STILES is in synergy with the with the Line of investment 1.5 (Innovation eco-systems) and with the Line of investment 3.2 of the NRRP (Funding of Start-ups) that will allow the creation of 250 highly innovative SMEs with an investment of 700 M.
STILES will therefore provide an ideal framework for research-industry collaboration in high tech activities with very broad impacts for society. All these "spillovers" from STILES to Italian companies will be mediated by specific management activities that will favor intermediaries and startup companies devoted to specific technological transfer from research laboratories to industry.

The greatest value of STILES, however, is its legacy for the future generations. STILES will be a great opportunity to form a new generation of young scientists and engineers. We plan to hire as many as 90 of them (for a total of 161 person-year), in several fields of advanced technology: optics, photonics, mechanics, electronic, machine learning and advanced software. Some of them will find their way in academia, and will represent the new generation of scientists who will lead the technological research and innovations in astronomy in the 30's and beyond. The others will acquire an invaluable competence that will grant them a future brilliant career in high technology companies, reinforcing such companies in the international arena.
In this effort, STILES will attract brilliant scientists from abroad and facilitate movement of scientists across the entire country. With 35 (~40%) new hires in OU located in Southern regions, STILES will offer good options to local, brilliant graduates and will attract young scientists and engineers from other regions. This confirms the long-standing tradition of INAF: thanks to the world-class level of its research, INAF has always been able to attract young talented researchers from the entire world, as demonstrated by the recent "Astrofit" post-doctoral program (which is like the national program of science position that we include in STILES) that awarded about 30% of its final positions to international applicants.

In conclusion, STILES is more than a funding proposal. It encapsulates our vision for the future of astronomy in our country: a

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science that develops innovative technologies and solutions to study the Universe, building and sharing its knowledge with the most active actors in our society and industrial system. STILES will establish the framework of a firm Italian leadership in future Astronomy and will prepare the next generation of scientists that will make it real in the next decades. We can't think of a better way to exploit the unique opportunities of NPRR.

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31 Compliance/consistency with NRRP rules and constrains

31.1 Sustainability of the initiative

31.1.1 Awareness of project timing

STILES, as part of the NRRP, is strongly constrained by rigid time limits. All the work must be completed within 30 months, with only one extension of 6 months possible. This limitation is a threat for the project and a driving factor for the management of the initiative.

A solid Risk Management strategy has to be set-up since the beginning and followed during the entire project duration.

We will articulate the process on a series of interconnected activities:

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Risk Management Planning, at the beginning.

Risk Identification, to be done at the beginning and continued during the project.

Perform Qualitative Risk Analysis, evaluation of Likelihood and Impact of risks.

Perform Quantitative Risk Analysis, carried out only if needed, evaluation of risks in terms of schedule and budget.

Plan Risk Responses, mitigation actions to reduce likelihood/impact and contingency plan if the risk happens.

Implement Risk Responses, putting into action the measures planned in the previous point

Risk Management is an integral part of STILES Project Management and its results will be taken into account in all key strategic decisions.

The outputs of our Risk Management are:

- The Risk Management Plan establishes the guidelines, the methods and the metrics for STILES Risk Management.

- The Risk Report, within each Progress Report, showing the current status of risks together with statistics and relevant information.

- The Risk Register, managed as a separate document, will be an extended version of the list of risks contained in this proposal.

The Risk Management will be coordinated by the Research Manager with contributions from all main stakeholders: the Scientific Coordinator, the WP managers, the Co-Applicant managers and the INAF central office for NRRP.

We implement a continuous process with the following timing:

1. An internal Risk Review is held monthly. The core team (Research Manager, Scientific Coordinator and WP Managers) goes through the Risk Register and checks

a. if traced risks and their attributes (probability, impact, etc.) are still valid b.if new risks have arisen

c. if some risk is outdated and must be removed from the list

The Risk Register is thus updated correspondingly.

2.A risk review is held at each 2-month interval linked to reporting. The procedure of the Risk Review is the same as point 1, plus the preparation of a Risk Report inserted in the Progress Report, with statistics and trends.

3.Risks can be identified at any time during the project and inserted in the Risk Register asynchronously, on a need basis. Urgent measures can be taken to address these new risks.

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measures can be taken to address these new risks.
Our main aim in applying Risk Management to STILES will be to closely monitor all the possible events that could jeopardize the timely achievement of project objectives.

31.1.2 List of critical risks

Risk 1
Title: Availability of personnel
Description: It can be difficult to find adequate personnel to be hired in several domains (management, specific technical fields).
Likelihood: Medium.
Severity: High.
Mitigation measures: Start preliminary recruitment activities before project starting. Actively advertise the position through popular hiring channels.
Risk 2
Title: Limited timeframe for procurement
Description: The time limits imposed by the project could be not sufficient to complete the procurement, especially for complex technological elements.
Likelihood: Medium.
Severity: High.
Mitigation measures: Evaluate the possibility to start the procurement of long lead items as soon as possible. Divide the tenders into lots.
Risk 3
Title: Personnel resignations
Description: One or more persons hired with a fixed term contract could resign before the end of the contract.
Likelihood: Low.
Severity: Medium.
Mitigation measures: Hire new personnel (even from the existing list), or outsource the remaining activity. Load on INAF-Master staff members the remaining activity.
Risk 4
Title: Cost increase
Description: The increase of price of components could jeopardize the implementation of several components.
Likelihood: Low.
Severity: High.
Mitigation measures: Look for alternative components and, if needed, descope the project, limiting performances.
Risk 5
Title: Design not ready to start the procurement on time
Description: Due to the timeline of the PNRR programme the design of some components could be not mature enough to start procurement in due time.

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procurement in due time.
Likelihood: Low.
Severity: Medium.
Mitigation measures: Start design well before the start of PNRR programme; follow a controlled development process, including design reviews; avoid setting unnecessary goals.
Risk 6
Title: Quality of procured elements
Description: Some delivered elements could be of insufficient quality in terms of functions or performances, in some cases due to too demanding requirements.
Likelihood: Low.
Severity: Medium.
Mitigation: Follow a controlled development process, including design reviews; track progress and defects. If necessary, de-scope non-mandatory features, concentrate on core functionality. Avoid changes in requirements.
Risk 7
Title: Lack of internal staff for procurement and hiring
Description: Lack of administrative staff to devote for all tenders' procedures and for hiring personnel.
Likelihood: Medium.
Severity: High.
Mitigation measures: Evaluate the possibility to exploit an external specialized company.
Risk 8
Title: Delay in the delivery of externally procured elements
Description: Some elements, already subcontracted to external manufacturers, may have delay on the delivery.
Likelihood: Medium.
Severity: High.
Mitigation measures: Foresee proper penalties in the contract(s) for procurement.
Risk 9
Risk Title: Unsuccessful tenders
Description: Some tenders could remain not awarded, due to lack of appropriate offers or because nobody showed up to participate in the tender.
Likelihood: Low.
Severity: Medium.
Mitigation measures: Renew and publish the tender as soon as possible.
Risk 10
Title: Electronic circuits
Description: There could be problems in the delivery of some components due to global lack of availability of electronic circuits.
Likelihood: Medium.

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Likelihood: Medium.
Severity: Medium.
Mitigation measures: Allow for partial delivery, and give more time to complete delivery
Risk 11
Title: Delay in civil works
Description: Due to pandemic and over commitment of Italian construction companies some civil works may be delayed.
Likelihood: Medium.
Severity: Medium.
Mitigation measures: Divide the civil works in lots and start as soon as possible the procurement procedures.
Risk 12
Title: NirvanaVIS - LBT concurrent commissioning of other instruments
Description: The commissioning of other instruments at LBT could prevent or slow down on- site activities.
Likelihood: High.
Severity: Low.
Mitigation measures: Perform as many tests and characterization

31.1.3 Economic ad financial plan for the operation of the infrastructure(s) as resulting from the project, for at least ten years starting from the final payment

We present here the estimated financial plan for the next 10 years after the conclusion of the project. At that stage, all laboratories will be equipped, computing centres will be installed, and instruments will be on their way for commissioning and testing at their facilities.
Regarding the latter, the operational cost for their use and ordinary maintenance will be charged to the relevant facilities (ESO, LBT, MeerKAT) as long as they maintain the use of these facilities, such that INAF will not be charged for them and do not contribute to the cost presented here. We expect their operational life at these facilities to exceed 10 years, so we do not include maintenance costs either.
Running and maintenance costs have been evaluated for all the other laboratories by a careful analysis of each activity. We have included running costs (mainly electrical power and other utilities but also basic consumables) as well as the labour needed to maintain the structure from the administrative and technical point of view. Costs estimated for each Activity have been summed and are presented in 31.1.3.1.
Revenues are more difficult to estimate, of course, for research infrastructures. We have therefore tried to be quite conservative. We are confident that our facilities will become extremely competitive at the international level, and we therefore expect they will be able to attract significant funds from competitive calls: a prudent but realistic estimate is presented in the table below.
In "public endowments" we have included the funds that we shall receive from public bodies (including other research institutes) based on existing agreements, for which applicants (INAF primarily) will save resources thanks to the upgraded laboratories.
Finally, the "National Facilities" implemented thanks to this program will be able to collect funds by commercial contracts - for instance for the use of anechoic chambers or mechanical and optical metrology facilities. These have also been evaluated with a prudent approach and inserted below. The percentage of commercial activities will anyway be kept below the threshold of 20%, as required by point 20 of EC Communication 2014/C 198/01.
With obvious caveats about the uncertainty of this exercise, we remark that the facilities that we shall deploy with STILES will be able

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

With obvious caveats about the uncertainty of this exercise, we remark that the facilities that we shall deploy with STILES will be able to acquire significant revenues over the next decade, much superior to the running cost and somewhat comparable to the investments in the project.
For a pure research institute, we believe this is a great result and another excellent example of the ground-breaking nature of this program.

31.1.3.1 Managements Costs

(See documents uploaded)

31.1.3.2 Revenues

(See documents uploaded)

31.2 Brief analysis related to DNSH principle

STILES intends to achieve a significant breakthrough in Italian scientific capability through the creation of infrastructures, including the creation and refurbishing of existing buildings, research laboratories, computing centres as well as direct in-kind contribution to international research infrastructures. This represents a chance for STILES to become a demonstrator of sustainable resources. All investments will be made in accordance with the DNSH principle, ensuring that no activity that is not sustainable, either now or in the long run, will be supported.
More specifically STILES will procure new instrumentation to be contributed to operating infrastructure such as optomechanical elements to Optical telescopes or new receivers to radio-telescopes. It will also set-up new laboratories, in some cases in new or refurbished buildings, purchasing new instruments and facilities. It will also set up moderate size computing clusters in existing centres.
DNSH principles, as detailed in the Technical Guidance on the application of the "do no significant harm" under the Recovery and Resilience Facility Regulation (document 2021/C 58/01) with particular reference to: 1) Climate Change Mitigation, 2) Sustainable use and protection of water and marine resources, 3) Circular economy, including waste prevention and recycling, 4) Pollution prevention and control, 5) Protection and restoration of biodiversity andecosystems, willbeappliedtoensuresustainabilityinthelong-term,adoptfurthergreensolutionsand, possibly, contribute to circular economy.
STILES will refer to international benchmarking of energy costs and CO2 footprint for the new facilities, such as that defined for large accelerator in the CERN environmental report (to reduce by 28% the CO2 footprint by 2024) and derived from best practices suggested by scientific literature (e.g. Nature 561, pp. 163- 166, 2018) for reference values to be adopted in the project. No environmentally harmful activity will be carried out related to fossil fuels and disposal of untreated waste. Furthermore, STILES infrastructures and technologies will require intrinsically very low levels of power to be operated.
The INAF centralized PNRR management structure (described in WP1000) will incorporate a DNSH consulting figure, to suggest technologically and economically feasible alternatives with lower environmental impact to be adopted for the construction and refurbishment works. The DNSH consulting figure will provide the guidelines to Research Managers to carry out cost-benefit analysis in order to: a)

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(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

works. The DNSH consulting figure will provide the guidelines to Research Managers to carry out cost-benefit analysis in order to: a) evaluate the operating and accessibility costs by users, b) estimate the energy cost of the solutions adopted for the management of data and the activity of infrastructures and c) decommissioning costs where applicable.
The environmental impact will be shared and discussed with the Research Managers to demonstrate the compliance with DNSH principles and the adoption of the best available levels of environmental performance.

31.3 Brief analysis to FAIR principle

INAF endorses the values of Open Science by adhering to the principles of freedom of access to scientific literature and of the circulation of research results.
INAF has implemented a multi-level communication and dissemination policy to give visibility and access to its scientific activities. In 2013 the subscription of the "Position statement on open access to the results of scientific research in Italy", signed by all the University Rectors and by all the Public Research Institutions Presidents, the approval in 2018 of the "INAF Policy on open access to the results of scientific research" and in 2019 the realization of the institutional repository oa@inaf were the milestones that marked the direction of INAF towards open access.
Furthermore, INAF supported the creation of EOSC (European Open Science Cloud) the instrument through which the European Commission intends to build a competitive European knowledge economy, and in 2020 INAF became one of the first institutions members of the EOSC Association.
Since the beginning of the information age INAF has adopted a policy of opening up scientific data from the observations of Italian telescopes and is member of IVOA (International Virtual Observatory Alliance) since its foundation in 2000, whose target is to make accessible and interoperable all open astronomical data.
To best perform this INAF created in 2004 the IA2- Italian Center for Astronomical Archive. This infrastructure actively collaborates with IVOA and follows its standards now evolved in the wider FAIR (findable, accessible, interoperable, reusable) standards. IA2 has the goal to coordinate different national initiatives to improve the quality of astrophysical data services. IA2's main goals consist in data archiving systems and long-term preservation, including data hosting and data curation and preservation, data and metadata distribution over geographical sites, access services including publication within the Virtual Observer scenario. IA2 also provides services and tools to the community, like data sharing (owncloud), project management (redmine), software collaboration (git-lab) and has available a workflow manager (Yabi) for computational needs.
Data products are released to the public under a well-defined data policy and data access model with an attached data products license. INAF is working on a specific science portal in order to archive the high- level science data products. A global unique, persistent identifier will be assigned to each data product, creating a reproducible link between products and the related research outputs and publications. The INAF science archive will also make the public data available via other data services such as the IVOA registry or EOSC to promote wide accessibility and interoperability of the INAF data and compatibility of the attached metadata. All access to the data products is controlled and access regulations are followed according to INAF policies.
The INAF data products themselves follow international astronomical standards to ensure wide interoperability. The stewardship of data and methods to ensure its FAIR-ness is pervasive through all data levels from data acquisition to data processing, calibration, simulation, and storage to data curation of the high-level data products and their dissemination to the INAF users.

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

and storage to data curation of the high-level data products and their dissemination to the INAF users.
The presence within INAF of a consistent number of people and resources already devoted to the implementation of FAIR principles is reflected by the relatively small amount attributed to Open Access in the cost tables (point c.). The specific costs in STILES for Open Access and FAIR implementation are described in detail in the section of this document dedicated to project activities.

31.4 Gender equality plan

INAF is committed to equal opportunity policies and is actively seeking to increase the number of women researchers. As a result, within INAF, the female representation in staff is about 36% and INAF policy is to recruit excellent scientists, independently of their gender, sexuality, ethnicity or any other background.
Within INAF there is an appointed Committee for Equal Opportunities (the so-called CUG) that collects and monitors each year gender-disaggregated data on personnel (at all career levels), finalized in a yearly report.
INAF has adopted specific measures against gender-based violence including sexual harassment (see INAF Ethical Code of Conduct) and is planning to adopt a Gender Equality Plan (GEP) as requested by the Horizon Europe Framework Programme (a working group to write a GEP for INAF is being finalized in these days).
Although gender is not a focus of the research questions this PNRR addresses, we plan to organize dissemination events that will allow a balanced and unbiased inclusion of participants, with special attention to under-represented groups, women, and girls, also to motivate all aspiring students, with special attention to young girls interested in STEM.

31.5 Synergies with other proposals within the recovery and resilience plan

From a general point of view this project can benefit from synergies with initiatives in the Line of Investment 3.2 of the NRRP (Funding of Start-ups), which could facilitate the creation of new companies as technological spin-offs. Also, the Line of investment 1.5 (Innovation eco-systems) can have a positive impact on STILES since the companies derived from the project could receive supporting services from one of the "R&D" territorial champions" that will be created in Italy.
This project is developed in coordination with other proposals within the resilience plan.
Within the same call, INAF is also applying for the upgrade of the Cherenkov Array Telescopes (CTA) in Chile - a program dubbed CTA+.
The links to this program are first scientific, as the ultimate goals of STILES are the realisation of observing capabilities in the multi-wavelength regime, that will be fundamental to study the high-energy sources that CTA+ will be able to discover in the Southern sky. In particular, the addition of the Large Size Telescopes (LST) in CTA is crucial to identify the low-energy gamma-ray sources associated with objects either in our Galaxy or at high redshift, and hence constitute ideal targets for southern-hemisphere telescopes like ELT and SKA.
The CTA+ program also includes instrumental upgrades that will enormously benefit from the laboratory upgrades that we shall carry on within STILES.

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

On a different level, we will also establish a strong logistical synergy with CTA+ and other programs with an INAF participation or leadership. INAF plans indeed to establish a dedicated office for the execution of all administrative actions needed during these programs, most notably for the execution of the call for tenders and procurement activities needed for them. Concentrating all needed skills and tools in a single, cohesive team will ensure prompt execution of these complex tasks and minimize the risks.

We also mention a promising development in collaboration with the ETIC proposal submitted by the IstitutoNazionale di Fisica Nucleare (INFN) under the same scheme, which aims at preparing the infrastructures to develop the future Einstein Telescope. Within this proposal, the INAF ADONI Unit will explore possible avenues to maintain the shape of reflective mirrors inside the ET cavity, making use of our experience in the field of Adaptive Optics - which is a central goal of this proposal.

Finally, STILES' activities in the field of Hyper Computing facilities are in strong synergies with similar initiatives carried on by INAF. INAF is participating to a proposal named "ICSC - Centro Nazionale HPC, Big data and Quantum Computing" in response to the call for proposals for "the strengthening of research structures and creation of R&D national champions" on some Key Enabling Technologies to be funded under the National Recovery and Resilience Plan (NRRP), Mission 4 Component 2 Investment 1.4.

These programs are nicely complementary, as the national HPC will not be able to sustain all the needs of the astronomical community, and those related to the processing and storage of data from optical telescopes, which are a key feature of the Advanced Processing Center that we propose in WP3000.

At the same time, the scientist and software engineers in the two projects will work in close collaboration to develop common tools, analyze similar problems, and avoid duplicating efforts.

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32 Total budget for the proposal

32.1 Entire project costs

COSTS (€) ENTIRE PROJECT			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	1.621.960,00	2.505.180,00	4.127.140,00
b. Scientific instrumentation and technological equipment, software licenses and patent	26.519.000,00	29.063.532,00	55.582.532,00
c. Open Access, Trans National Access, FAIR principle implementation	85.000,00	36.000,00	121.000,00
d. Civil infrastructures and related systems	2.367.446,00	2.344.000,00	4.711.446,00
e. Indirect costs, including running costs	2.156.042,20	2.423.396,80	4.579.439,00
f. Training activities	207.200,00	671.242,00	878.442,00
Total	32.956.648,20	37.043.350,80	69.999.999,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.2 For each Work Package (Specific Objective), as per the following table

COSTS (€) WORK PACKAGE [1000 - Management]			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	0,00	368.940,00	368.940,00
b. Scientific instrumentation and technological equipment, software licenses and patent	0,00	21.902,00	21.902,00
c. Open Access, Trans National Access, FAI principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	0,00	27.359,00	27.359,00
f. Training activities	0,00	0,00	0,00
Total	0,00	418.201,00	418.201,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.2 For each Work Package (Specific Objective), as per the following table

COSTS (€) WORK PACKAGE [5000 - R&D]			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	74.820,00	454.080,00	528.900,00
b. Scientific instrumentation and technological equipment, software licenses and patent	3.157.000,00	11.109.900,00	14.266.900,00
c. Open Access, Trans National Access, FAI principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	226.227,00	809.480,00	1.035.707,00
f. Training activities	0,00	0,00	0,00
Total	3.458.047,00	12.373.460,00	15.831.507,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.2 For each Work Package (Specific Objective), as per the following table

COSTS (€) WORK PACKAGE [3000 - InformationTechnology]			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	681.120,00	503.960,00	1.185.080,00
b. Scientific instrumentation and technological equipment, software licenses and patent	6.584.000,00	1.138.600,00	7.722.600,00
c. Open Access, Trans National Access, FAI principal implementation	80.000,00	36.000,00	116.000,00
d. Civil infrastructures and related systems	907.445,00	0,00	907.445,00
e. Indirect costs, including running costs	592.184,20	126.412,80	718.597,00
f. Training activities	207.200,00	127.342,00	334.542,00
Total	9.051.949,20	1.932.314,80	10.984.264,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.2 For each Work Package (Specific Objective), as per the following table

COSTS (€) WORK PACKAGE [4000 - ExoLabs]			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	213.280,00	170.280,00	383.560,00
b. Scientific instrumentation and technological equipment, software licenses and patent	2.470.000,00	895.800,00	3.365.800,00
c. Open Access, Trans National Access, FAI principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	187.829,00	74.626,00	262.455,00
f. Training activities	0,00	0,00	0,00
Total	2.871.109,00	1.140.706,00	4.011.815,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.2 For each Work Package (Specific Objective), as per the following table

COSTS (€) WORK PACKAGE [2000 - Instruments]			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	227.040,00	567.600,00	794.640,00
b. Scientific instrumentation and technological equipment, software licenses and patent	12.900.000,00	11.000.330,00	23.900.330,00
c. Open Access, Trans National Access, FAI principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	918.893,00	836.950,00	1.755.843,00
f. Training activities	0,00	388.500,00	388.500,00
Total	14.045.933,00	12.793.380,00	26.839.313,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.2 For each Work Package (Specific Objective), as per the following table

COSTS (€) WORK PACKAGE [6000 - National Testing Facilities]			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	425.700,00	440.320,00	866.020,00
b. Scientific instrumentation and technological equipment, software licenses and patent	1.408.000,00	4.897.000,00	6.305.000,00
c. Open Access, Trans National Access, FAI principal implementation	5.000,00	0,00	5.000,00
d. Civil infrastructures and related systems	1.460.001,00	2.344.000,00	3.804.001,00
e. Indirect costs, including running costs	230.909,00	548.569,00	779.478,00
f. Training activities	0,00	155.400,00	155.400,00
Total	3.529.610,00	8.385.289,00	11.914.899,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Applicants), as per the following table repeat the table for each Applicant and co-Applicant.

COSTS (€) **PARTICIPANT [INAF - Istituto Nazionale di Astro Fisica]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	1.281.400,00	1.994.340,00	3.275.740,00
b. Scientific instrumentation and technological equipment	19.299.800,00	26.240.732,00	45.540.532,00
c. Open Access, Trans National Access, FAIR principal implementation	5.000,00	36.000,00	41.000,00
d. Civil infrastructures and related systems	2.163.296,00	2.314.000,00	4.477.296,00
e. Indirect costs, including running costs	1.592.463,20	2.171.625,80	3.764.089,00
f. Training activities	0,00	438.142,00	438.142,00
Total	24.341.959,20	33.194.839,80	57.536.799,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Co-Applicants), as per the following table repeat the table for each Applicant and co-Co-Applicant.

COSTS (€) **PARTICIPANT [Università degli Studi di Catania]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	0,00	0,00	0,00
b. Scientific instrumentation and technological equipment	1.508.200,00	0,00	1.508.200,00
c. Open Access, Trans National Access, FAIR principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	105.574,00	0,00	105.574,00
f. Training activities	0,00	0,00	0,00
Total	1.613.774,00	0,00	1.613.774,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Co-Applicants), as per the following table repeat the table for each Applicant and co-Co-Applicant.

COSTS (€) **PARTICIPANT [Università degli Studi di Roma Tor Vergata]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	0,00	170.280,00	170.280,00
b. Scientific instrumentation and technological equipment	0,00	895.800,00	895.800,00
c. Open Access, Trans National Access, FAIR principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	0,00	74.626,00	74.626,00
f. Training activities	0,00	0,00	0,00
Total	0,00	1.140.706,00	1.140.706,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Co-Applicants), as per the following table repeat the table for each Applicant and co-Co-Applicant.

COSTS (€) **PARTICIPANT [Università degli Studi di Milano]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	0,00	170.280,00	170.280,00
b. Scientific instrumentation and technological equipment	0,00	1.612.000,00	1.612.000,00
c. Open Access, Trans National Access, FAIR principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	30.000,00	30.000,00
e. Indirect costs, including running costs	0,00	126.859,00	126.859,00
f. Training activities	0,00	0,00	0,00
Total	0,00	1.939.139,00	1.939.139,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Co-Applicants), as per the following table repeat the table for each Applicant and co-Co-Applicant.

COSTS (€) **PARTICIPANT [Alma Mater Studiorum - Università di Bologna]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	0,00	170.280,00	170.280,00
b. Scientific instrumentation and technological equipment	0,00	140.000,00	140.000,00
c. Open Access, Trans National Access, FAIR principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	0,00	32.597,00	32.597,00
f. Training activities	0,00	155.400,00	155.400,00
Total	0,00	498.277,00	498.277,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Co-Applicants), as per the following table repeat the table for each Applicant and co-Co-Applicant.

COSTS (€) **PARTICIPANT [Università degli Studi di Palermo]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	0,00	0,00	0,00
b. Scientific instrumentation and technological equipment	0,00	0,00	0,00
c. Open Access, Trans National Access, FAIR principal implementation	80.000,00	0,00	80.000,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	14.665,00	0,00	14.665,00
f. Training activities	129.500,00	0,00	129.500,00
Total	224.165,00	0,00	224.165,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Co-Applicants), as per the following table repeat the table for each Applicant and co-Co-Applicant.

COSTS (€) **PARTICIPANT [Università degli Studi di Napoli Federico II]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	340.560,00	0,00	340.560,00
b. Scientific instrumentation and technological equipment	5.711.000,00	0,00	5.711.000,00
c. Open Access, Trans National Access, FAIR principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	204.150,00	0,00	204.150,00
e. Indirect costs, including running costs	443.340,00	0,00	443.340,00
f. Training activities	77.700,00	0,00	77.700,00
Total	6.776.750,00	0,00	6.776.750,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

32.3 For each project participant (Applicant and co-Co-Applicants), as per the following table repeat the table for each Applicant and co-Co-Applicant.

COSTS (€) **PARTICIPANT [Sapienza Università di Roma]**			
	Costs included in the request for funding		
	To be located within the eight southern Regions	To be located outside the eight southern Regions	**Total requested grant**
a. Fixed term personnel specifically hired for the project	0,00	0,00	0,00
b. Scientific instrumentation and technological equipment	0,00	175.000,00	175.000,00
c. Open Access, Trans National Access, FAIR principal implementation	0,00	0,00	0,00
d. Civil infrastructures and related systems	0,00	0,00	0,00
e. Indirect costs, including running costs	0,00	17.689,00	17.689,00
f. Training activities	0,00	77.700,00	77.700,00
Total	0,00	270.389,00	270.389,00

c) PROJECT DESCRIPTION

(The information provided in this section will be evaluated with reference to criteria A.1, A.2, A.4, B.1-B.4)

PROPOSED PAYMENT PLAN

Bimester	Payment Amount	Cumulative Payment Amount
3	**5.097.267,00 €**	**5.097.267,00 €**
6	**10.503.031,00 €**	**15.600.298,00 €**
9	**10.882.518,00 €**	**26.482.816,00 €**
12	**16.495.690,00 €**	**42.978.506,00 €**
15	**27.021.493,00 €**	**69.999.999,00 €**

d) PROJECT WORK BREAKDOWN STRUCTURE - [1000 - Management]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

33 Timing of the different work packages: See documents uploaded

34 WP inter-relation with other WPs: See documents uploaded

35 Costs Scheduling according with the Intermediate Objectives:

Bimester	Title	Costs	**Cumulative Costs**
3	Team finalization and calls for tender	78.953,00	78.953,00
6	Conclusion of calls for tender	102.388,00	181.341,00
15	Final Management Report	236.860,00	418.201,00

36 WP title

Management

37 WP number

1000

38 Start month(relative to kick-off of the project) and **duration** (in month)

WP Start	1	WP Duration	30

39 OU(s) participating to the WP

OU Short Name	**OU Name**	**Applicant**
OAR	Osservatorio Astronomico di Roma	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

40 WP Leader

Manager of the Infrastructure (see "Applicant" section for duties, profile and requirements)

41 Summary of the activities envisaged in the WP

The project is complex and highly articulated with activities spanning several domains and many INAF local offices involved. In addition to complexity, a tight time frame exists that imposes a careful monitoring and control of the activities to avoid schedule slippages and possible difficulties in achieving the ambitious goals set in the proposal.
This WP collects the activities that are necessary to oversee the project and to ensure the smooth and well coordinated development of all the other WPs.
It comprises the activities described in the following:

1101 Research Management
This activity regards the coordination of the whole project and aims to ensure that all its expected objectives are reached on due time, within the foreseen budget and with the proper quality.

d) PROJECT WORK BREAKDOWN STRUCTURE - [1000 - Management]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

within the foreseen budget and with the proper quality.
The manager of this WP will be a professional of proven capacity, specifically hired with a fixed term contract. The expected profile, duties and specific requirements for this role are described in the "applicant" part of this proposal.
The activity is carried out in close contact with the WP managers, with the Scientific Coordinator, with the Financial Officer and with the INAF central services that will support the project.
The manager of this WP will interact with the National central administration in charge of the NRRP funds and with any other authorised entity or auditing body.
The Management of the project will be carried out in accordance with consolidated best practices of project management. Since the high-level objectives are well defined at the beginning of the project a waterfall lifecycle will be adopted at global level. However, at WP level a hybrid approach can be evaluated on a case-by-case basis, especially for SW development and for R&D activities.
Each WP will report regularly to the Research Manager, clearly indicating the progress of each activity, the intermediate results reached so far and the outlook for the successive period.
Any deviation shall be highlighted in due time, in order to be able to take all necessary corrective actions.
The detailed scheduling of activities and of costs will be the basis of project monitoring that will be carried out by means of Earned Value methodology.
The risk register, prepared at proposal time, will be updated during the project involving the key stakeholders. Mitigation strategies will be identified to reduce the probability and/or impact of each risk. Contingency plan will also be prepared in order to properly react if the risk turns into reality. The risks are then constantly monitored in order to keep updated their probability/impact and to detect signals of an imminent triggering.
The project manager will be supported by lower-level managers, acting as links to the WPs.
In order to optimise the resources while maintaining an adequate control over the project activities the following vice managers are foreseen:
- Technology manager, who will take care of WP 2000 (Instruments), WP 3000 (Information Technology), WP 4000 (ExoLab).
- Science manager, who will deal with WP 5000 (R&D), WP 6000 (Testing Facilities).
These intermediate managers will collect information on status, achievements and issues from the relevant WPs and will, in turn, flow down suggestions and recommendations.

Beside the management of project activities, aiming at the effective and timely execution of all foreseen tasks, this activity will have the objective to ensure scientific coordination. To achieve this goal it is foreseen the creation of the STILES Science Board.
The Science Board is in charge of the definition of the scientific targets and is engaged to maintain the scientific focus on those targets during the project lifetime and beyond. It thus aims at maximizing the scientific exploitation of the scientific results within INAF and in the astrophysical community at large.
The Science Board is composed of:
Adriano Fontana, Scientific Coordinator of STILES
- Isabella Prandoni, acting as deputy of Adriano Fontana, plus, by default,
- all WP managers
- the Science Leads of all Co-Applicants
The Science Board will also ensure the scientific coordination with the other INAF projects and with parallel initiatives at National and International level.

INAF intends to coordinate the management of all its NRRP projects by setting up a centralized office (PNRR Management Office) located at the INAF Headquarters in Rome. This office, acting at higher level than the single projects in a sort of programme office, will make available to NRRP projects:
- a Project Management Office, offering advice, tools and documentation,
- a Procurement Office, aiming to optimize the acquisition of instruments and services
- an Accounting Office, in charge of financial management and reporting.

42 WP inter-relation with other WWPP

This WP receives reports from all other WPs during the whole duration of the project and gives directions for the proper management of activities

43 Most relevant outcome:

d) PROJECT WORK BREAKDOWN STRUCTURE - [1000 - Management]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

43 Most relevant outcome:

The value that this WP brings to the project is the facilitation of the correct and timely development of all the other WPs in a well-orchestrated manner.
The asset on which the WP relies is the qualified personnel working in it.
This WP is thus based on the activities of the personnel specifically hired with fixed term contracts.
The professional figures that will carry out the work of this WP are the following:
- One Infrastructure Manager, as prescribed by this call, with a senior profile in project management and coordination of Research activities
- Two Mid-level Managers, with at least 5 years of experience in project management, preferably in the Research domain

44 List of WP deliverables that will be available according with the timing set by the Intermediate Objectives:

Title	Bimester	Deliverables
Team finalization and calls for tender	3	This IO is made of three deliverables, each documented in a relevant report: D1101 Report on team hiring It contains a summary of the hiring procedures and team composition D1102 Report on calls for tender It contains the list of calls for tender issued at the end of the period, and of those that are still to be issued, if there are.
Conclusion of calls for tender	6	DX201 Report on calls for tender It contains the list of calls effectively completed and assigned at the end of the period, and of those that are still to be assigned. DX202 Report on staffing It contains an update of the staff allocation within the WP.
Final Management Report	15	D1501 Report on Management

45 Objective, quantitative, and measurable indicators relevant to the monitoring and ex-post assessment of the expected results:

Title	Bimester	Objective, quantitative, and measurable indicators
Team finalization and calls for tender	3	-Number of team member hired and fraction over the total planned number. -Number of calls for tender issued and fraction over the total planned number
Conclusion of calls for tender	6	-Number of calls for tender completed and assigned, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Final Management Report	15	Overall success in management of the project, as compared to international best practices; Fraction of the staff that is hired, compared to planned.

d) PROJECT WORK BREAKDOWN STRUCTURE - [1000 - Management]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

46 WP Intermediate Objectives:

IO Title	*Team finalization and calls for tender*		
IO Bimestre	*3*	IO Costs	*78.953,00*

IO Desciption

This IO closes the first part of the project, where a) the hiring procedures are concluded and the team is assembled and b) calls for tender for instrumentation procurement are completed and released.

IO Title	*Conclusion of calls for tender*		
IO Bimestre	*6*	IO Costs	*102.388,00*

IO Desciption

This IO closes the second part of the project, where major calls for tender have been closed and the relevant contracts assigned. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Final Management Report*		
IO Bimestre	*15*	IO Costs	*236.860,00*

IO Desciption

We shall prepare a final report of the management activities held during the project and a full report of the staff engaged in the WP1000

47 WP budget description

Cost of fixed term personnel specifically hired for the project

Cost description:

This WP aims at the coordination of the whole project and at ensuring its link with the National NRRP authorities on the one side and with INAF central management office on the other.

As such, this WP involves the hiring of highly qualified personnel with a fixed term contract, according to the rules of the Call.
The following personnel is thus foreseen for WP1000:
- A Research Manager, a professional skilled in management of Research projects, hired for the whole duration of the project (30 months)
- Two Mid-level Managers, with at least 5 years of experience in Research projects, supporting the Research Manager in the interfacing with the various WP. Also these Managers are hired for 30 months.

The costs of the above personnel are reported in the specific section of this

d) PROJECT WORK BREAKDOWN STRUCTURE - [1000 - Management]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

The costs of the above personnel are reported in the specific section of this proposal.
It has to be noted that the hiring procedures could not be finished at Kick-Off time and the involvement of these professionals could be less than 30 months. Anyway we have considered the cost on the whole project duration, in order to keep a cost reserve.

Scientific instrumentation and technological equipment, software licenses and patent

Cost description: We include in the costs a small amount to provide with the project office with the IT infrastructure (server, laptops, printers) needed for the organization of the project, track of expenses and other activities.

Open Access, Transnational Access, FAIR principle implementation

Cost description: Not Applicable.

Civil infrastructures and related systems

Cost description: Not Applicable.

Indirect costs

Cost description: Indirect costs (7% of all direct costs) will be primarily dedicated to support the administrative activities related to the project. In particular, they will serve to hire specific personnel dedicated to issue and follow the many calls for tenders that will be needed to procure all the deliverables of the project.
Indirect costs will also be used to refund travels directly related to the specific project, consumables and other similar expenses.

Training activities

Cost description: Not Applicable.

48 Activity title

Research Management

49 Activity short name

1101

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

d) PROJECT WORK BREAKDOWN STRUCTURE - [1000 - Management]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OU short name	OAR	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The aim of this activity is to coordinate the project from an operational point of view, making sure that the objectives established at the beginning of the project are reached in the foreseen timeframe and with the expected quality.
Possible problems impacting the schedule will be highlighted immediately and recovery measures will be taken correspondingly. If needed, the project can be re-modulated in agreement with the funding authority, keeping unchanged the main objectives of the project.
This activity foresees several duties:
• definition and maintenance of the schedule
• verification of the achievement of the project milestones
• monitoring of project partners' activities
• preparation of the relevant documentation
• preparation and support to project meetings (physical or virtual according to the current needs)
• monitoring and control of project costs
• support to the scientific responsible for management aspects.
The manager of this activity will constantly keep in contact with the different WPs, with the help of mid-level managers, each dealing with a group of WPs, namely:
• Technology manager, overseeing WP 2000 (Instruments), WP 3000 (Information Technology), WP 4000 (ExoLab).
• Science manager, overseeing WP 5000 (R&D), 6000 (Testing Facilities).
The STILES Science Board, in charge of the scientific management of the project, acts in coordination with the Research Management team that carries out this activity.
On a monthly basis the Science Board meet with the Research Manager and the mid-level Managers in order to:
- verify the achievement of the project objectives foreseen for that period
- verify the alignment of the technical developments with the scientific strategic targets
- contribute to risk identification and update
- identify new issues and possible solutions within the current project baseline or propose changes to scope/schedule/cost.
The Research Management activity will be carried out in collaboration with all involved INAF structures.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

368.940,00 €

Cost description: Profile #1 Research Manager, skilled in management of research projects
Profile #2 Technology Manager, intermediate manager
Profile #3 Science Manager, intermediate manager

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

21.902,00 €

Cost description: None

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [1000 - Management]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

27.359,00 €

Cost description: General costs of the structure related to the activity.

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

33 Timing of the different work packages: See documents uploaded

34 WP inter-relation with other WPs: See documents uploaded

35 Costs Scheduling according with the Intermediate Objectives:

Bimester	Title	Costs	**Cumulative Costs**
3	Team finalization and calls for tender	1.434.703,00	1.434.703,00
6	Conclusion of calls for tender	2.445.789,00	3.880.492,00
9	Short Lead Items Delivery	6.969.214,00	10.849.706,00
12	Medium Lead Items Delivery	3.099.944,00	13.949.650,00
15	Long Lead Items Delivery	1.881.857,00	15.831.507,00

36 WP title

R&D

37 WP number

5000

38 Start month(relative to kick-off of the project) and **duration** (in month)

WP Start	1	WP Duration	30

39 OU(s) participating to the WP

OU Short Name	**OU Name**	**Applicant**
OAS	Osservatorio di astrofisica e scienza dello spazio	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
UNICT	Department of Electrical Electronic and Computer Engineering - Università degli Studi di Catania	CO-APPLICANT: Università degli Studi di Catania
OAB	Osservatorio Astronomico di Brera	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAC	Osservatorio Astronomico di Cagliari	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACN	Osservatorio Astronomico di Capodimonte	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OAS	Osservatorio di astrofisica e scienza dello spazio	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAR	Osservatorio Astronomico di Roma	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAB	Osservatorio Astronomico di Brera	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
IRA	Istituto di Radioastronomia	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAB	Osservatorio Astronomico di Brera	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAA	Osservatorio Astrofisico di Arcetri	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAA	Osservatorio Astrofisico di Arcetri	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAPD	Osservatorio Astronomico di Padova	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAR	Osservatorio Astronomico di Roma	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

40 WP Leader

Valentina Viotto

41 Summary of the activities envisaged in the WP

Work Package 5000 is devoted to R&D activities and its goal is to equip INAF with state-of -the-art laboratories, to boost the institute technological and instrumental capabilities and strengthen its position in the international context of R&D activities, promoting the already existing synergy within different INAF observatories, so as with other National and International Institutions.This will confirm INAF's key role in some technical aspects, related to the development of optical and radio infrastructures, especially exploited within ELT and SKA environments.
Adaptive Optics:
The teams involved in the proposal covered some leading and complementary roles in the development of new techniques, currently in use at the largest telescopes, including the Pyramid wavefront sensor and its exploitation in Extreme AO (XAO), and outlined several novel Multi-Conjugate AO (MCAO) schemes, like the Layer Oriented and the Multiple Field of View techniques. INAF AO teams are now involved in many worldwide collaborations, aimed at the validation of novel wavefront sensors, and in the Consortia of next generation AO systems for Large Telescopes and ELTs, such as ERIS, SOUL, SPHERE+, MAORY, MAVIS, NGWS-P for GMT, ELT-M4 and ANDES which cover wavebands from optical to IR, fields of view regimes from narrow field (XAO) to wide field AO (MCAO) and reference source including both natural and laser guide stars. ELT shows some peculiarities, never experienced before, that turn into challenges for the future AO. Even if this may seem just an upscaling of known properties (e.g. number of actuators), the optimal solutions for the AO design and control include new approaches and this WP aims at providing INAF with the capabilities to test and validate new solutions. The synergy between AO teams within INAF is supported by the ADaptive Optics National Italian laboratory (ADONI) that, since 2015, is promoting collaboration and expertise complementarity.
These activities are grouped in Sub-WPs:
- ExtremeAOLab: XAO systems focus on achieving high Strehl ratio on small fields of view. In the ELT context, XAO will face new issues, like the increasing number of actuators, and the optical sensing of the differential piston between the telescope mirror segments. This sub-WP aims at developing advanced laboratories at OAA and OAS, equipped with facilities allowing the research of ELT XAO specific aspects and enabling technology demonstrators, including SPHERE+ and LBT visible interferometer, on the road to ELT-PCS. The activities also include the creation/refurbishment of local infrastructures, equipped with the services and systems needed to make them responsive to scientific and environmental needs and safety parameters.
- LaserAOLab: this sub-WP focuses on the development of laboratories, devoted to research in the Laser AO framework. It aims at boosting INAF competitiveness in LGS AO systems, upgrading the existing LGS-AO laboratory at OAR, built to support the development of LGS technologies and LGS assisted instrumentation.
- WideFieldAOLab: this sub-WP is focused on exploring the wide field aspects of AO, setting up a dedicated laboratory at OAPD, to

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

- WideFieldAOLab: this sub-WP is focused on exploring the wide field aspects of AO, setting up a dedicated laboratory at OAPD, to serve as a testing facility for validation of novel MCAO approaches, open to collaborations within ADONI and with other national and international institutions. The facility's opto-mechanical design is meant to be as flexible and modular as possible, so as to cope with the needs of different AO techniques and to allow future upgrades.
Detectors development:
Other groups in the proposing team aim at confirming their experience in development and testing of detectors, from optical to radio regimes. Also in this branch, the proposing teams are complementary, filling the waveband spectrum with their pluri-decennial experience, ranging from promoting R&D activities on solid-state detectors and characterization of different families of electro-optical sensors from UV to NIR (OACT), also applied to the specific field of fast imaging and wavefront sensing at high frame rate and low photon flux (OAR) and high time resolution (OACT), to radio astronomy detectors development and characterization (IRA, OACT, UniCT, OAS) and design of new electronic boards for the monitoring and control of the receivers parameters (OAC) or front end electronics at RFs (OAC,OACT). These teams are still upgrading their expertise in many national and international collaborations, such as SRT, LBT, ELT, ALMA,SKA and its precursors (MeerKAT, ASKAP, LOFAR).
The development of laboratories, devoted to testing and characterization of detectors, will turn into a nation-wide network of facilities, aimed at R&D and optimization of low-noise detectors and front-end electronics. They will become a crucial resource within INAF, in the context of the ELT and SKA projects, but also for the development and characterization of new sets of detectors for national Radio Astronomy facilities (Medicina, Noto, SRT) committed for important world wide project as VLBI and space applications.
These activities are grouped in Sub-WPs:
- OpticalDetectorDevelopment: this sub-WP proposes the development of a facility, as a dedicated laboratory where researchers can test the performances of the detectors to be deployed in the ELT, expanding its capabilities and opportunities (AO systems, new generation photo-detectors).
- RadioDetectorDevelopment: this sub-WP aims to improve the national capabilities for testing, measuring and design at cryogenic temperature of passive and active devices, materials and integrated systems of interest for radio astronomy, at wavelengths from centimeter to millimeter, and in general electronics for front end and on-board processing devices.
Optomechanical components Prototyping and Manufacturing:
The teams involved are proposing to exploit their experience in the development of Optomechanical devices for ground-based astronomical systems. As non-exhaustive examples, INAF led implementation of a few Instruments for the VLT Observatory (X-Shooter, Sphere, Espresso), a variety of instruments for smaller telescopes (SOXS @ NTT, NTE @ NOT, …) and is currently involved in the development of the optomechanics for MAORY and ANDES for ELT. ELT's new challenges, in this context. require for a new optomechanical engineering approach, focusing on all the instrument phases and loads, including metrology. In this context, INAF's competence also covers a peculiar niche: the current baseline for the dispersing elements in low and mid-resolution spectrographs such as BlueMUSE for the VLT, and MOSAIC, HARMONI, ANDES for the ELT is represented by Volume Phase Holographic Gratings (VPHG). The capability of design and optimization of these devices is a uniquum of INAF in the World's Astronomical field. Improving this skill including manufacturing capabilities is a strategic driver for spectroscopy leadership of INAF in the European context.
These activities are grouped in Sub-WPs:
- OptomechPrototyping: this sub-WP aims to exploit and expand the experience achieved to develop new optomechanical devices, optimized in stiffness and lightweight, also acquiring means to manufacture prototypes with novel technologies enabling new materials and tighter tolerances. New alignment and metrology techniques will complete the capability to provide more complex and efficient optomechanical systems
- VPH: the aim of this sub-WP is the development of an infrastructure, at OAB, for the design and manufacturing of large size VPHGs for astronomical instrumentation and let INAF become the leader at the European level for this kind of strategic optical elements.
Those capabilities are complementary to the testing facilities described in WP 6000

42 WP inter-relation with other WWPP

This WP does not have dependencies with any other WP, as it is dedicated to the independent acquisition of equipment, software and labor.

43 Most relevant outcome:

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

The main outcome of the WP5000 is a complete and diffuse network of laboratories that provides coverage for a wide variety of enabling technologies for the next generation optical, IR and radio large telescopes and arrays, with particular reference to ELT and SKA. The access to these facilities will help INAF to fill some interesting niches that are currently missing in the international context. This is the case, for example, of the VPH laboratory, which will be a unique facility in Europe, with just few worldwide competitors. Something similar will happen also for the Adaptive Optics framework, in which INAF's leading role in concepts, simulations and instruments development will be extended to include means to provide laboratory demonstration for new techniques and hardware validation of a wide range of concepts.
Moreover, the ownership of high technology laboratory equipment, needed for the characterization of the detectors in the wide waveband range from UV to Radio, will place INAF as the European leader in the front-end instrumentation context and bring Italian Institutes at the level of US competitors, especially thanks to the cryogenic facilities and materials optimizations.
The technological products designed for astrophysics, in the production/content matrix are located so they have very high technological value but medium-low production volume; so the reference market for production is not always the big electronics companies, but small and medium-sized that have an interest in strongly improving their technological know-how and to grow their market capability.
These companies often do not have adequate laboratory equipment, since it is not justified by their costbenefit ratio: the same equipment is instead an added value for the Research Institution as INAF, that can create an extraordinary boost to their participation to scientific collaborations and high content industrial development opportunities, moreover when the industrial partners participate directly in research projects from the early design activities.
The sharing of patents and technological solutions represents not only the key to lead the construction of global infrastructures (ELT and SKA above all), but also a multiplier in improving the technological specialization of the industrial tissue, to attract capital and investments and man power on the territory: an example of all was the participation in the design of observation facilities of SKA (SKA-Mid and SKALow) from 2013 to now.
We shall also mention the financial return that INAF will collect in the future, as a result of the Laboratories development proposed in this WP. On one hand, some of the procured technologies (e.g. for what concerns in the components Prototyping and Manufacturing activities, to be held at OAB) will make our facilities appealing for commercial contracts, addressing an audience of potential users including, but not limited to, small and medium-sized enterprises, reinforcing the manufacturing network around the observatories. At the same time, the ability to provide in-house technologies optimization and development will allow INAF to save resources that would, instead, be devoted to outsourcing contracts for feasibility studies and technologies validation.

44 List of WP deliverables that will be available according with the timing set by the Intermediate Objectives:

Title	Bimester	Deliverables
Team finalization and calls for tender	3	This IO is made of three deliverables, each documented in a relevant report: D5101 Report on team hiring It contains a summary of the hiring procedures and team composition D5102 Final design of instrumentation It contains the final design for the instrumentation to be procured D5103 Report on calls for tender It contains the list of calls for tender issued at the end of the period, and of those that are still to be issued, if there are.
Conclusion of calls for tender	6	D5201 Report on calls for tender It contains the list of calls effectively completed and assigned at the end of the period, and of those that are still to be assigned.

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

		period, and of those that are still to be assigned. D5202 Report on staffing It contains an update of the staff allocation within the WP.
Short Lead Items Delivery	9	D5301 Report on SLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the remaining SLI items. D5302 Report on staffing It contains an update of the staff allocation within the WP.
Medium Lead Items Delivery	12	D5401 Report on MLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the SLI items which were not delivered at the end of IO3. It also includes an outlook of the procurement procedures for the Long Lead Items. D5402 Report on staffing It contains an update of the staff allocation within the WP.
Long Lead Items Delivery	15	D5501 Report on LLI procurement It contains the list of LLI effectively delivered, as well as of all other items that have been procured within the project D5502 Report on staffing It contains a final report about the team engaged in the WP.

45 Objective, quantitative, and measurable indicators relevant to the monitoring and ex-post assessment of the expected results:

Title	Bimester	Objective, quantitative, and measurable indicators
Team finalization and calls for tender	3	-Number of team member hired and fraction over the total planned number. -Number of instrument/laboratory design completed and fraction over the total planned number -Number of calls for tender issued and fraction over the total planned number
Conclusion of calls for tender	6	-Number of calls for tender completed and assigned, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Short Lead Items Delivery	9	-Amount of SLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Medium Lead Items Delivery	12	-Amount of MLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Long Lead Items Delivery	15	-Amount of LLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.

46 WP Intermediate Objectives:

IO Title *Team finalization and calls for tender*

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

IO Title	*Team finalization and calls for tender*		
IO Bimestre	*3*	IO Costs	*1.434.703,00*

IO Desciption

This IO closes the first part of the project, where a) the hiring procedures are concluded and the team is assembled; b) design phases of the instrumentation is completed and c) main calls for tender for instrumentation procurement are completed and released.

IO Title	*Conclusion of calls for tender*		
IO Bimestre	*6*	IO Costs	*2.445.789,00*

IO Desciption

This IO closes the second part of the project, where major calls for tender have been closed and the relevant contracts assigned. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Short Lead Items Delivery*		
IO Bimestre	*9*	IO Costs	*6.969.214,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Short Lead Items (SLI) that - by definition - can be purchased in a short time. We shall present a list of the SLIs obtained within the period, and of those which haven't been delivered yet. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Medium Lead Items Delivery*		
IO Bimestre	*12*	IO Costs	*3.099.944,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Medium Lead Items (MLI) that - by definition - are purchased in about one year. We shall present a list of the MLIs obtained within the period, and of those which haven't been delivered yet. We also include a final report on the delivery of SLI that were still pending at the end of IO3, and an outlook of the procurement procedures for the Long Lead Items. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Long Lead Items Delivery*		
IO Bimestre	*15*	IO Costs	*1.881.857,00*

IO Desciption

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

IO Desciption

This IO reports about the final procurement of the instrumentation, with an emphasis on Long Lead Items (LLI) that - by definition - are purchased by the end of the project. We shall present a list of the LLIs obtained within the period, as well as of all other items that have been procured within the project. We will also include a final report on the delivery of all items that were still pending at the end of IO4. We also provide a final report about the team.

47 WP budget description

Cost of fixed term personnel specifically hired for the project

Cost description:

The personnel cost includes the cost of fixed-term contracts (TD), needed to complete the existing teams, so to make them suitable, in terms of units and skills, to complete each of the activities, in the project timeframe.
The exhaustive list of TDs, divided for each Activity, is reported here after:

ATT5102: ExtremeAOLab_HpAOLabCascading
1 optical engineer, to be allocated to design and verification activities

ATT5103: ExtremeAOLab_HpAOLabPetalometer
1 AIV engineer, to be allocated to procurement, laboratory integration and verification

ATT5301: WideFieldAOLab_AOTestBench
1 engineer, to actively support the design and specification definition tasks, and the procurement

ATT5521: RadioDetectorDevelopment_OACElectronicsLab
1 technician, with electronical skills

ATT5701: LargeSizeVPHGsLab
1 optomech. technician for the design and realization of the holo labs

Scientific instrumentation and technological equipment, software licenses and patent

Cost description:

All the activities of WP 5000 include costs allocated to scientific instrumentation, in order to develop the laboratory equipment needed to complete their goals.
The exhaustive list of these costs, divided for each Activity, is reported hereafter:

ATT5101: ExtremeAOLab_OptIR&AOLab
Equipment for lab. and cleanroom
Cryocoolers, thermal control system and vacuum bench
Computers
Software licenses

ATT5102: ExtremeAOLab_HpAOLabCascading
Cascaded system (DMs)
Surfaces metrology equipment
High speed detectors (Pyr WFS) + a SWIR detector
Optomechanics

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

High speed detectors (Pyr WFS) + a SWIR detector
Optomechanics
Control and support HW

ATT5103: ExtremeAOLab_HpAOLabPetalometer
Opto-mechanics and electronics
Autocollimator
Fast interferometer
Segmented DM (6 flat petals, custom)
Absolute phasing sensor
Interferometric displacement sensors
Detectors

ATT5201: LaserAOLab_LaserGuideStarAOLab
Clear air laminar flow
Precision wavemeter
LGS-AO system
Optic metrology laboratory
Laser 30 mW, single frequency

ATT5301: WideFieldAOLab_AOTestBench
Reference sources module (DMs, SLMs, T/T mirrors, opto-mechanics, light sources)
Telescope simulator module (custom optics and mechanics)
MCAO correction module (DMs, opto-mechanics, detectors)
Sensing module (SLMs, opto-mechanics, pupil and focal planes detectors)
RTC
Workstations and other electronics
SW Licenses

ATT5401: OpticalDetectorDevelopment_DetectorAdvancedTestTrack
Automated alignment system
Sources (programmable spectrum sources, custom DLP projector, integrating spheres)
Optomechanics
Beam turbulence and jitter injector
Interferometer
Wavefront sensor
Custom control software for automated test procedure
Calibrated detectors

ATT5501: RadioDetectorDevelopment_CryogenicFacilityForMultiFrequencyCharacterization
RF equipment: supports/translation stages
RF equipment: isolators/tunable attenuators/test bench passive components
RF equipment (to test calibration loads): standard antennas, confocal telescopes. lenses
Materials Characterization Kits (MCK)
2 channels SMU Keithley B + SW (LNAs tests)
VNA extension heads
VNA calibration Kits

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

VNA extension heads
VNA calibration Kits

ATT5511: RadioDetectorDevelopment_CryoRXIntegrationLab
Jib Cranes
Cryogenic Compressor
Spectrum Analyzer
Frequency Synthesizer
Laboratory Server and equipment

ATT5521: RadioDetectorDevelopment_OACElectronicsLab
Mechanical PCB milling machine
FDM 3D Printer
Pick and place machine
Compact reflow oven for SMD soldering
Through hole electroplater
Press and laser machine for the PCB multilayer
Small clean room
RF Diagnostic Chamber

ATT5531: RadioDetectorDevelopment_CharacterizationFacilityCOLD+
VNA (1 a 110 GHZ), Tools
Probe station for 'on chip' measurements
Frequency counter
Microwaves Signal Generator, Spectrum Analyzer, Power Meter,components
Optical microscope station
2x PC acquisition and simulation workstation
Wide Band Oscilloscope
vacuum and cryogenic system

ATT5532: RadioDetectorDevelopment_IC design
Spectrum Analyzer
Frequency extenders
Arbitrary Wave and logic pattern Generators
Ultra-Wide Band Power Amplifier
Ball&wedge bonding machine
Climatic chamber
SO/DEsoldering and rework station
PCB prototyping machine
Pick&place semiautomatic

ATT5601: OptomechPrototyping_NewMaterial
"3D high performance polymer printer"
SW license
Optomechanical test facility

ATT5602: OptomechPrototyping_PrecisionManufacturing
Equipment #1 DMG Ultrasonic 65 Machine

ATT5603: OptomechPrototyping_MetrologyAndMonitoring
Metrology equipment and SW update
Laser tracker

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Metrology equipment and SW update
Laser tracker
Laser Line
Coupled single line system
Cryogenic laser tracker equipment
Improvement of CMM facility with PSD

ATT5701: LargeSizeVPHGsLab
Development of photopolymers for holography
Optics for large size VPHG setup
Opto-mechanics
Laser
Characterization setup (light sources, VPHG moving stages, detectors)
Photopolymers for holography
Deposition machine

Open Access, Transnational Access, FAIR principle implementation

Cost description: Not Applicable.

Civil infrastructures and related systems

Cost description: Not Applicable.

Indirect costs

Cost description: Indirect costs (7% of all direct costs) will be primarily dedicated to support the administrative activities related to the project. In particular, they will serve to hire specific personnel dedicated to issue and follow the many calls for tenders that will be needed to procure all the deliverables of the project.
Indirect costs will also be used to refund travels directly related to the specific project, consumables and other similar expenses.

Training activities

Cost description: Not Applicable.

48 Activity title

RadioDetectorDevelopment_CryogenicFacilityForMultiFrequencyCharacterization

49 Activity short name

5501

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

51 OU in charge of the Activity

OU short name	OAS	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The scope is to design and set-up a microwave test facility operating from RT to CRYO temperature (350- 4K) allowing to characterize, at the typical temperatures (4-20K) at which instrumental noise is minimal, the key performance of passive (feedhorn, OMTs, waveguides, circulators) and active (LNAs) devices, of typical dielectric materials for microwave optics (lenses, filters) and RF calibration cryogenic loads. The frequency range covers many astronomical projects and instruments relevant to INAF. The true novelty consists in combining in a single general-purpose facility the wide range radiofrequency characterization and the cryogenic operating environment. Currently, INAF does not have a facility with these characteristics: such measures require onerous entrustment to external foreign companies, when existing. The proposed facility will undoubtedly have a unique character and an undeniable potential value.
Many benefits for INAF: possibility of carrying out measures and developing frontier verification methodology currently not accessible; in-house availability of a durable and state-of-the-art facility; to expand scientific collaborations; offering third-party services. The project will be fully developed at OAS, having a long time recognized experience in the areas of the design and V&V of cryogenic systems, RF components, cryogenic calibrators; it envisages the involvement of Italian companies of excellence both in the field of cryogenics and microwave precision mechanics. The planned duration is 30 months. The main objectives will be mostly pursued in parallel. They are in detail: design and manufacturing of the thermal vacuum chamber; procure the RF and thermal equipment to setup the room ambient and cryogenic temperature test bench; setup the control HW and develop the control SW (a fixed term contract is envisaged to attend this task); attend training courses.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

699.000,00 €

Cost description: - RF equipment: supports/translation stages
- RF equipment: isolators/tunable attenuators/test bench passive components
- RF equipment (to test calibration loads): standard antennas, confocal telescopes. lenses
- Materials Characterization Kits (MCK)
- 2 channels SMU Keithley B + SW (LNAs tests)
- VNA extension heads
- VNA calibration Kits

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

54.5 e. Indirect costs

48.930,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

RadioDetectorDevelopment_CharacterizationFacilityCOLD+

49 Activity short name

5531

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACT	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The activity aims to set-up a RF laboratory for the characterization of detectors (LNAs), passive almost microstrip and high temperature superconductor devices, operating at the typical radiofrequency SKA signals (50 MHz - 22 GHz) up to 100 GHz, at cryogenic conditions (20K).
A very important items is the study of package and assembly and calibration of operative conditions of radio frequency of active devices at different temperatures, and the study and design of integrating analog RF conditioning devices (filters, attenuators, amplifiers, mixers) with high speed digital ADC and programmable processors as FPGAs.
The key point of this laboratory is the connection with other activities in charge of Osservatorio Astrofisico di Catania, that share cryo-electronic instrumentation (signal generator, conditioning and processing) operating at different and complementary spectrum (Visible, UV) so that it would be possible to install a characterization wide multiband facility in the region of South Italy.
The boost for INAF would be the possibility to have a measurement facility not present now in Italy, in which would be possible to perform the first measurements stage for low noise environment for all the activity SKA related, with the collaboration of University of Catania and Companies (ST, Digital, etc) operating into the Micro and Nano System District.
This synergy is as added value component not only for the Italian participation as a lead role to the most important worldwide astrophysical projects (ELT, SKA) as demonstrated by OACT personnel as well in different project (SKA-Low, CTA, SKA-Mid),

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

but also for the reason of involving medium and small size companies into very high content technology challenge.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

982.000,00 €

Cost description: - Vector Network Analyzer da 1 a 67/110 GHZ
- VNA Tools and set equipment
- Probe station for on chip measurement
- Microwave spectrum analyezers
- Microwave signal generator
- Frequency Counters
- Microwave RF Power meter
- Optical microscope station
- PC acquisition and simulation workstation
- Mobile workstation laptop
- Project development and simulation
- Microwave components for test and measurement
- Electronic work bench an tools
- Cryocooler and vacuum system

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

68.740,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

48 Activity title

RadioDetectorDevelopment_IC design

49 Activity short name

5532

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UNICT	Participant	Università degli Studi di Catania

52 Activity description

The objective of UniCT in the Project is the strengthening of its Microelectronic Lab to better support the Lab mission in the IC electronic design research and effectively contribute with high-performance dedicated (ASICs) solutions to a National Lab Network for the research in astronomy and astrophysics. The Microelectronic Lab of UniCT is presently composed of two Units, one for the low-frequency analog/digital design and the other, called "Radio Frequency Advanced Design Center" (RFADC), is dedicated to RF and microwave IC design. The Microelectronic Lab takes advantage of an area of 270 square meters on loan for use in the premises of STMicroelectronics (ST), Catania site. It includes a Design Lab equipped with CAD tools (Keysight, Ansys, Cadence), etc., and a Measurement Lab equipped with test benches for on-package measurements and a Cascade Microtech probe station for on-wafer characterization. The Design Lab is connected to the ST server network and takes advantage of the periodic multi-project wafer runs with the ST technologies.
The Electronics Research Group of UniCT has a long experience and internationally recognized expertise in the area of analog, digital, and mixed-signal integrated circuit (IC) design, from low to microwave frequencies (as high as 77 GHz). As far as the Project is concerned, it has a renowned experience in the modeling and design of ICs for Single-Photon Avalanche Diodes (SPAD) and Silicon Photo Multipliers (SiPM), semiconductor-based photosensors, addressing the challenge of low-light detection down to the single-photon for weak optical signals. The research activity has been mainly aimed at IC designing for quenching/reset and front-end electronics for SiPM readout, and modeling of photomultiplier devices. Such works have been conducted also in collaborations with INAF, INFN, and STMicroelectronics.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

1.508.200,00 €

Cost description: - Vector Network Analyzer, 4 Ports, 10 MHz - 26.5 GHz
- Spectrum Analyzer 2 Hz-110 GHz

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

- *Spectrum Analyzer 2 Hz-110 GHz*
- *Frequency extender up to 110 GHz*
- *Digital Oscilloscope, 2 GHz, 5 Gsample/s, 4 channels*
- *Arbitrary Wave Generator, 2 x 250 MHz*
- *Spectrum Analyzer 5 Hz-3 GHz*
- *Logic pattern Generator/ Analyzer*
- *Ultra-Wide Band Power Amplifier 18GHz-40GHz*
- *10 to 50 GHz coaxial directional coupler*
- *10 to 50 GHz coaxial directional coupler*
- *Active probe for VNA*
- *Pico-Amp meter*
- *Nano-Volt/Micro-Ohm Meter*
- *Power supply, 20 V, 6 A, 120 W*
- *DC load , 80 V, 45 A, 600 W*
- *DC power analyzer*
- *LCR meter*
- *Server CAD*
- *Ball&wedge bonding machine*
- *Climatic chamber*
- *Desoldering and rework station*
- *Soldering station*
- *Optical microscope with display*
- *PCB prototyping machine*
- *Pick&place semiautomatic*
- *Pick&place semiautomatic*
- *Reflow oven*
- *DC to 120 GHz USB thermocouple power sensor*
- *DC to 120 GHz USB thermocouple power sensor*

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

105.574,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

48 Activity title

LargeSizeVPHGsLab

49 Activity short name

5701

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The aim of this activity is the realization of a holographic facility for the manufacturing and characterization of very large size VPHGs. The activity starts with the design of the holographic setup and the refurbishment of the laboratory that will host all the equipment. The holographic machine has a target clear aperture of 360 - 450mm (in diameter) according to a detailed analysis considering the astronomical requests, costs and system stability. After that, the procurement of the optics, optical benches and the laboratory refurbishment will be carried out in order to match the timescale of the project. In addition, the ancillary setups will be implemented/improved. In particular: i)the characterization setup for the measurement of the grating efficiency across the clear aperture in the UVVis- NIR range, the line density and fringe alignment; ii) the substrate preparation (deposition of the holographic material) and handling. In parallel, the development of the high-performance holographic material (photopolymer) will be performed.
A very large modulation of the refractive index and a large UV transparency are the two targets to make possible the realization of most of the VPHGs for ELT's spectrographs. Collaborations with holographic companies, especially COVESTRO AG, will be established: i) to support the material development; ii) to proceed with the industrial production; iii) to agree on a future procurement model of the holographic materials suitable for the astronomical market.
The possibility to establish an SME for the VPHG production for astronomy will be carried out. A business plan will be produced and analyzed. The different stakeholders will be contacted and a clear picture concerning the sustainability of a dedicated company will be provided.
The validation of the full holographic laboratory consists in the writing and characterization of VPHGs with requirements defined in this project framework.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Contract: TD Ricercatore/Tecnologo
Role description: A TD technician with skills in optomechanics for the design of holo setup
Duration: 24 months

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

1.130.000,00 €

Cost description: - Development of photopolymers for holography
- Componenti ottici di grosse dimensioni per setup olografico
- High power laser for holography
- Other optomechanical equipments (spatial filters, beam splitter,...)
- Characterization setup: light sources, VPHG moving stages, detectors,...
- Deposition machine (for laminating the photopolymer foil on the glass substrate)
- Optical benches with protecting cover

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

87.047,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

RadioDetectorDevelopment_NewOACElectronicLab

49 Activity short name

5521

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAC	Participant	INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

di Astro Fisica

52 Activity description

The goal of this proposal is to create a new facility for the realization and testing of electronic and microwave circuit board prototypes at the Electronic and Microwave laboratory of the Cagliari Astronomical Observatory. The facility will be available also for the realization of the prototypes developed by other INAF Institutes.
In the Cagliari Observatory laboratories, we design, realize and characterize parts and components of the radio astronomical receivers developed for example for the Sardinia Radio Telescope, SKA, ALMA and other radio astronomical infrastructures and facilities from ground and space. One of the principal activities is to design, realize and characterize electronic boards operating at low and high frequency, like for example the ones based on microcontrollers for the monitoring and control of the parameters of the receiver and for metrology applications. Another kind of boards very important for the design and construction of radio astronomical receivers, are the high frequency microstrip, coplanar and microwave circuits and devices. To construct these electronic and microwave circuits systems with the necessary resolution and accuracy, many operations need to be done in a well-equipped clean room and with a very advanced laser manufacturing machine. After realizing this, we need to measure the level of radio frequency interference emissions of the circuits in a diagnostic chamber to verify if they are in the permitted range. The electronic circuits and boards need to be installed in mechanical structures to be realized with a 3D printer.
For the production and characterization of the prototype boards we need some very specialized equipment proposed to be acquired in this project.
To realize this facility we need the support of some specialized technicians in electronics and mechanics and some accessory equipment like for example work benches, shelves, work cabinets.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

74.820,00 €

Cost description: Contract: TD Tecnico
Role description: Electronics Technician
Duration: 18 months

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

340.000,00 €

Cost description: Laser PCB machine
Mechanical PCB milling machine
FDM 3D printer
Pick-and-place machine
Compact reflow oven for SMD soldering
Throu-hole elctro-plater
Press machine for PCB multi-layer
Accessory equipments

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

29.037,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

OptomechPrototyping_NewMaterial

49 Activity short name

5601

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACN	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The activity is aimed at setting up a rapid prototyping station, using 3D printing technology with highperformance polymers. This technology integrates and supports the innovative and multidisciplinary design activities that are carried out at the INAF headquarters of the Capodimonte Astronomical Observatory.
Rapid prototyping allows very reliable feedback, for example on the integration and verification of future ELT instrumentation. In order to optimize the design flow, which today is mainly based on simulations and graphic prototyping, the possibility of producing artifacts makes it possible to identify potential aspects and criticalities of the design in a much shorter time, increasing the level of confidence and consequently the robustness of the design.
The production of prototypes is also preparatory to the dissemination activity, providing physical models in support of presentations dedicated to the public.
Rapid prototyping is also an additional source of collaboration with the university, both from the point of view of research activities and in the training of students, in particular undergraduates and trainees. The University of Naples Federico II, and in particular the Department of Industrial Engineering, has already expressed its interest in this regard.
Additive manufacturing is also well integrated into the Concurrent Design Facility proposal in OACN, allowing the rapid and shared

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Additive manufacturing is also well integrated into the Concurrent Design Facility proposal in OACN, allowing the rapid and shared validation of design choices according to the various design aspects.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

326.800,00 €

Cost description: - 3D high performance polymer printer
- Software of the manufacturing machine to cover the duration of the project phase
- Optomech test facility for in house test and verification
- Indirect costs, including running costs

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

22.876,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

ExtremeAOLab_OptIR&AO_Lab

49 Activity short name

5101

50 Activity Start month and duration

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAS	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

This activity is aimed at consolidating and expanding OAS facilities for the development of AO technologies, optical and infrared instrumentation, cryogenic instrumentation including environmental
testing. These facilities will be primarily used for SPHERE+, an enabling technology demonstrator for ELT PCS (activities 2301, 2302, 2303, 2304).
Actions include:
• maintenance and upgrade of OAS optical laboratory (to improve cleanliness level) and of OAS ISO7 clean room (to renovate the air treatment system);
• procurement and installation of equipment (optical benches, tools) and instrumentation (optical metrology and alignment, optical and opto-electronics components and equipment, measurement and support instrumentation) for the OAS optical/electronics laboratory and ISO7 clean room;
• procurement and installation of cryocoolers, thermal monitoring/control system and vacuum bench for the OAS large cryofacility;
• procurement of laptop and workstation computers;
• procurement of software licenses (optical design, mechanical design, thermal modelling);
• providing engineering, technical, managerial support to the SPHERE+ project-related activities.
Definition of procurement specifications is already in progress at the moment of writing.
The activity is done at OAS.
Staff participants are Emiliano Diolaiti, Fausto Cortecchia, Adriano De Rosa, Matteo Lombini, Gianluca Morgante, Filomena Schiavone, Laura Schreiber, Luca Terenzi.
A fixed-term personnel unit for the whole duration of the activity is planned to support this and all the SPHERE+ project-related activities.
The activity is carried out in the framework of the SPHERE+ collaboration, performed by a consortium of Institutes from different European Countries (Italy, France, Germany, The Netherlands, Switzerland) and ESO. The involved INAF institutes are: OAPD, OAS, OACN, OAB. Moreover, OAA and OAR will contribute to the scientific validation after installation at the VLT.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

484.000,00 €

Cost description: - Equipment and instrumentation for OAS optical/electronics laboratory and ISO7 clean room
- Cryocoolers, thermal monitoring/control system and vacuum bench for OAS large cryofacility

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

- *Cryocoolers, thermal monitoring/control system and vacuum bench for OAS large cryofacility*
- *Laptop and workstation computers*
- *Software licenses (optical design, mechanical design, thermal modelling)*

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

33.880,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

LaserAOLab_LaserGuideStarAOLab

49 Activity short name

5201

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAR	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The main goal is the upgrade of the current INAF-OAR LGS AO laboratory, allowing full assembly, integration and verification of LGS-AO systems, capable of serving INAF needs in projects with ESO, ESA and ASI.
We will increase the capability of the laserlab fast optical and electronics metrology for testing of lasers with and without the associated

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

We will increase the capability of the laserlab fast optical and electronics metrology for testing of lasers with and without the associated AO systems, with and without IR or VIS laser high power.
LGS AO Lab is currently involved in scientific projects in which INAF is a main partner, with national and international partners: CaNaPy (ESO+Durham University+IAC+ESA+INAF), ALASCA (ESA+EU SME); it also cooperates at different levels with projects like: INGOT (INAF OAP), MOF (INAF OAR), Lunar Ranging (INFN, ASI), Space debris (ASI).
The role played by INAF–OAR in these LGS-AO projects is mainly to be responsible of the AIV activities, the development of Instrument Control SW design and the design of dedicated technical solution for part of the projects opto-mechanical parts.
In particular, the activities of the LGS lab actually are creating the opportunity to acquire and develop knowledge in the fields of specific technologies needful to:
• Demonstrate and Optimize LGS uplink pre-compensation, for the smallest LGS size (implies pulsed laser)
• Close the LGS-AO loop with Pyramid WFS, in monostatic configuration
• Demonstrate operation and control also in non favourable seeing conditions (including daytime)
• Test the time delay method (Ragazzoni, 1999) for the measurements of tip-tilt from the LGS
• Test the candle-light method to have and use the sodium profile and its centroid during operations
• Evaluate the advantages of the uplink pre-compensation in monostatic mode, vs more standard bistatic LGS-AO configurations
• Manage macro-pulsed laser operation assessment in LGS-AO

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

390.000,00 €

Cost description: - Clear air laminar flow volume for the laboratory
- Precision wavemeter with stabilized wavelength reference laser
- Optical bench test with LGS-AO system for adaptive optics
- Class IV laser safety and security tools
- Optic metrology laboratory (Polarimeter, surface profilometer; Optical power measurement equipment, including pulsed and continuous - visible and infrared- lasers; test equipment for adaptive systems: sensors, digitizers)
- Laser 30 mW, single frequency, 589nm CW (low power laser)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

27.300,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

OptomechPrototyping_PrecisionManufacturing

49 Activity short name

5602

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

A key element of the efficiency of the Optomechanical system is the manufacturing tolerance that can be achieved. More precise optomechanics will reduce the alignment and integration time and will also make possible the achievement of better optical performances. Coupling then a precise manufacturing machine, like DMG Ultrasonic 65, to the rapid prototyping technologies will close the loop of the capability to create free form and precise optomechanics.
The flexibility design resulting from this great duality will have an enormous positive outcome in the definition of novel optomechanics. In addition, the possibility to work on the same machine (even not on the same time) with both ceramic and metallic material, will open new frontiers for glass based optomechanics. Increasing the number of automatic axes (5 against the current 3) will widen the complexity of feasible geometries. With these two improvements the design and assembling process will benefit in terms of precision, costs and realization time reducing typical criticalities coming by the different materials coupling (differential CTE, gluing, threading, …). Of course this machine needs to be inserted in a working existing workshop as a step forward, in order to really provide improved skills and capabilities. By purchasing this facility, the observatory will also be able to acquire the proper skills and knowledge to properly interact with the industry in order to obtain more efficient and cheap optomechanics. The capability to work on behalf of other small companies will reinforce the manufacturing network around the observatories.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

1.000.000,00 €

Cost description: Precise manufacturing machine

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

70.000,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

RadioDetectorDevelopment_CryoRXIntegrationLab_equipment

49 Activity short name

5511

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	IRA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Given the growing number of projects in which the staff of the Medicine RadioAstronomy Station is involved, given the upcoming implementation of the active surface that will allow the Medicine dish to work at high frequency and the corresponding growing number of receivers, the creation and integration of these complex systems require more suitable spaces for carrying out these activities. This laboratory does not constitute a duplication of existing facilities, but an optimization and improvement of a structure present only in Medicine and which would be inserted as a national reference for the implementation of receivers. The laboratory will be equipped with the necessary instrumentation to carry out the measurements and characterizations of the receivers developed before they are installed on the radio telescopes, a system for cryogenic cooling of the receivers, a "jib crane" for lifting heavy loads.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

755.000,00 €

Cost description: - Furniture
- Cryogenic Compressor
- Spectral Analyzer up to 26GHz
- RF Frequency Synthesizer
- Noise figure meter
- Server
- Other lab equipment

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

52.850,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

48 Activity title

OptomechPrototyping_Metrologyandmonitoring

49 Activity short name

5603

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

INAF Brera in the last 10 years has developed optomechanical alignment techniques purely based on mechanical metrology, such as Laser Tracker (LT) and Coordinate Measuring Machine (CMM). This technique was used with success in the alignment of ESPRESSO@VLT. This has granted the team a leading role in Europe. A good collaboration has been established with ESO by exchanging personnel and hardware.
The step forward to effectively use this technique for the ELT instrumentation requires the update of the existing hardware, and the acquisition of new and promising devices, called multiline systems, with a gain in accuracy of one order of magnitude. The observatory will acquire two multiline systems with different capabilities (modularity and flexibility), able to monitor the position of optomechanical components with nanometric accuracy. The two systems will be used in synergy, to exploit the maximum possible performances. Being the observatory deeply involved in MAORY, M4, and ANDES @ELT, it will be possible to embed this technology in the design of those systems, to properly monitor on-line the optomechanical alignment of those ELT instruments.
The existing collaboration with ESO (and a germinal one with CERN) is moving the research also on a new frame: the adoption of alignment and monitoring techniques in the cryogenic environment, of fundamental importance for IR instrumentation. The facilities released in Task 6701 will enable this possibility, empowering the leading role of INAF in this new frontier. In this respect, collaborations within INAF between Brera, Arcetri, and Padova observatories still provide a strong network.
Nowadays, these techniques employ mechanical references mounted on the optomechanics or the direct contact of the CMM probe on the optical surface, which may cause undesired damage. The coupling of the existing CMM with an optical probe to allow non-contact measurements will open the path to the alignment and integration of delicate optics.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

675.000,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: - Software for dataprocessing and equipment usage
- Metrology Equipment
- Laser tracker
- Laser Line
- Coupled single line system
- Cryogenic Laser tracker equipment
- Improvement of CMM facility with PSM

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

47.250,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

ExtremeAOLab_HpAOLabCascading

49 Activity short name

5102

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAA	Participant	INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

52 Activity description

The detection and characterization of exo-Earths is the goal of the ELT Planetary Camera and Spectrograph (PCS) and the visible interferometer of LBT. Both will require Extreme Adaptive Optics (XAO) a technology that aims to provide an "aberration-free" optical system by controlling 2 deformable mirrors in a cascade.
The key point of this activity is to produce a versatile test bench to move the research activity on XAO from computer-assisted simulations to the laboratory. Such facility will allow the Arcetri technological group to deepen the knowledge in all the aspects of the implementation and control of 2 AO systems in cascade, like:
• Advantages of synthetic vs optical calibrations
• Algorithms for Image quality estimation
The main actions we foresee to carry on are:
1. Purchase 2 optical tables to provide an area of 6.0x1.5m^2 for the optics installation.
2. Purchase 2 DMs: 1. a custom woofer based on the voice coil actuator technology, 2. an off-the-shelf high-order DM (e.g. ALPAO DM820).
3. Purchase equipment for optical surface metrology (e.g. fast frame rate interferometer, reference spheres, rails) to be used for the optical calibration of the hardware.
4. Manufacture the optomechanical components of the test bench. A ROM estimation for the costs have been made on the optical concept of the bench.
Investing in the development of this facility will also attract researchers worldwide allowing the Arcetri AO group to lead the research in XAO and strengthen its participation in the realization of future high-contrast instruments for ELT and LBT.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Contract: TD Ricercatore/Tecnologo
Role description: Optical designer
Duration: 24 months

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

1.170.000,00 €

Cost description: - Voice-coil DM
- Tweeter DM
- Optical metrology HW
- Optical Benches
- Detectors
- Optics
- Mechanics
- Control hardware
- Support equipment

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

54.5 e. Indirect costs

89.847,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

ExtremeAOLab_HpAOLabPetalometer

49 Activity short name

5103

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The goal of this activity is the realization of a testbed for sensors and techniques dedicated to ELT-M4 phasing.
Phasing the segmented primary and quaternary mirrors is a task of the utmost importance for any AOassisted instrument on the ELT and it still represents an open issue highly debated in the ELT community.
The most challenging aspect is the phasing of the 6 petals composing the quaternary mirror (M4) of ELT.
M4 is the adaptive component of the ELT optical train and will provide the first stage of atmospheric turbulence correction. Every instrument on ELT with AO mode will need to control not only the shape of every petal, but also their differential piston in order to preserve the coherence in the full aperture wavefront, exploiting the spatial resolution of the 39m pupil. Moreover, the control of the M4 petals is needed not only for the SCAO systems like HIRES, but also for any other kind of AO systems at ELT, like MAORY, where the wavefront sensors are not sensitive to the differential piston at all. Nowadays, the petalometer is an open challenge for the entire AO community working for ELT instruments.
The proposed activity consists in setting up a laboratory facility (Figure 8)aimed to test different wavefront sensors and phasing techniques for ELT-M4. The testbench will be equipped with a segmented mirror mimicking M4 petals and a reference metrology system to validate the petalometer measurements. The required actions are:
• Design the testbed facility

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

- *Define specifications for testbed components*
- *Procure and verify the single components*
- *Integrate the testbed in the laboratory refurbished by activity 5130*

The activity is carried out by the Arcetri Adaptive Optics Group (member of the ADONI national laboratory). The team has more than 20 years of demonstrated experience in adaptive optics and in particular is a pioneer in the wavefront sensing for phasing of astronomical segmented mirrors.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Contract: TD Ricercatore/Tecnologo
Role description: System design and procurement
Duration: 24 months

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

826.900,00 €

Cost description: - Optical bench
- Optomechatronics
- Light sources
- Autocollimator
- Interferometer
- Segmented Deformable Mirror
- Absolute Phasing Sensor
- Displacement Sensors
- NIR detector for petalometer
- Focal plane NIR camera

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

65.830,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

48 Activity title

WideFieldAOLab_AOTestBench

49 Activity short name

5301

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAPD	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

This activity is devoted to the design and procurement of the equipment to build a wide field AO test bench for the development of novel MCAO techniques, described in Figure 9. It is conceived to be flexible, thus it is divided in independent modules:
• Reference source module: produces atmosphere-perturbed reference beams. Both NGS and LGS can be simulated.
• Telescope simulator module: mimics the geometry of the beams in the lower atmosphere.
• MCAO correction module: simulates a variety of compensation schemes, combining three large DMs, that can conjugate at any equivalent distance.
• Sensing module: it simulates a variety of wavefront sensors. It allows positioning of sensing and perturbing elements in different optical positions.
The main tasks are:
• Optical design, optimization and tolerancing for each of the modules
• Identification of off-the shelf optical components or design of custom optics
• Identification of off-the shelf mechanical components suitable to provide the required mechanical performance
• Identification of specifications for the Real Time Computing device
• Identification of a suitable computer configuration, to drive all the devices, in any configuration
• procurement and acceptance of opto-mechanical, computer and RTC components
• integration of the components in a setup configuration and functional test
The expertise needed for the various tasks spreads in various engineering domains and the participants, at OAPD, shall cover it: R. Ragazzoni, V. Viotto, D. Greggio/D. Magrin, D. Vassallo/E.Carolo, L. Marafatto/J.Farinato,C. Arcidiacono, M. Bergomi/S.Chinellato, K. Radhakrishnan/S. di Filippo/M.Dima, A. Baruffolo.
The bench could be useful for testing of MCAO systems, like MAVIS or MAORY, in the form of a Telescope simulator. This kind of equipment is typically needed for validation of closed loop performance of AO systems, operating DMs included in the telescope optical path. Collaboration with the consortia of MCAO systems are expected

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

113.520,00 €

Cost description: Contract: TD Ricercatore/Tecnologo
Role description: Bench design and procurement
Duration: 24 months

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

2.824.000,00 €

Cost description: - Detectors
- Deformable mirrors
- Spatial light modulators
- Tip tilt mirrors
- Lenses
- Light sources
- Large custom optics
- Large optics custom mounts
- MotorDriven Precision Positioners
- Optical bench
- Real time computer
- Computers
- Other optics
- Other mechanics
- Other electronics
- SW licenses

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

205.626,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OpticalDetectorDevelopment_DetectorAdvancedTestTrack

49 Activity short name

5401

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAR	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Proponents:
OAR: F. Pedichini (lead), R. Piazzesi,
IAPS: G. Li Causi
OAB: M. Landoni
IASFMi: M. Uslenghi
OAPD: C. Arcidiacono
Future ELTs and current 8m telescopes need advanced detectors to achieve top performances for WFS and imaging. Detector development is fast, leading to quick obsolescence in a timescale shorter than that of the development of an astronomical instrument.
There is a need for a fast track detector test and selection process to avoid obsolescence of astrophysical instrumentation, keeping instrument design and development up to date with detectors.
The DATT (Detector Advanced Test Track) is an update of the current ADONI testbench at INAFOAR that aims to test new detectors in a few days with automated, reproducible procedures. As traditional electro-optical tests cannot always verify the compliance of a detector to its expected science goals, DATT tests will provide conditions as close as possible to the detector's final implementation at the telescope, creating target and telescope conditions, and using the data reduction pipelines of its final application.
The program also aims to acquire novel detector technologies from the market, to verify and validate them for ELTs and CTA/CTA+ in collaboration with INAF partners such as the Bruno Kessler
Foundation, and to generate "observatory-like" datasets that will help to optimize data reduction pipelines thanks to the availability of calibrated realistic targets.
DATT will provide:
- clean area ISO-7/8 of 25mq with stabilized optical bench and control room;
- easy mounting of DUTs within the test beam thanks to an automatic aligning interface;
- complete coverage of the visible spectrum with calibration in 4nm spectral bins from 350 to 900 nm;
- high-contrast/low-separation double sources, extended sources, flat field and background;
- residual atmospheric turbulence and image jitter;
- emerging detectors such as SPAD array and SCMOS with on pixel digitization.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [5000 - R&D]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

1.156.000,00 €

Cost description: - Procurement of a clean room ISO 7/8 with annexes and bridge crane
- Precision optomechanics tools and devices
- 3 x 1.5 m stabilized insulated and light shielded optical bench
- Test platform micrometric 200mm range automated alignment system
- Chromatiq programmable calibrated spectrum sources, 4 nm resolution
- Spectroscopic line sources
- Extended sources custom DLP projector
- Integrating spheres
- Piezo stages for secondary source relative movement
- Off-axis collimator, pupil diameter >25mm with 6 DOF holder
- 2 off-axis cameras for f# 10, 15 with 6 DOF holders
- Folding mirrors with 6DOF holders
- K-mirror and ADC
- Beam turbulence and jitter injector with control
- Zygo interferometer for optical test
- Wavefront sensor (Shack-Hartmann, 1000 apertures)
- Control computers
- Custom control software for automated test procedure
- Reference calibrated detectors for visible range
- Outsourced contracts for project development and engineering (ca 15% of total)
- Contract for advanced detector procurement

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

80.920,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

33 Timing of the different work packages: See documents uploaded

34 WP inter-relation with other WPs: See documents uploaded

35 Costs Scheduling according with the Intermediate Objectives:

Bimester	Title	Costs	**Cumulative Costs**
3	Team finalization and calls for tender	941.194,00	941.194,00
6	Conclusion of calls for tender	6.642.881,00	7.584.075,00
9	Short Lead Items Delivery	846.531,00	8.430.606,00
12	Medium Lead Items Delivery	1.843.017,00	10.273.623,00
15	Long Lead Items Delivery	710.641,00	10.984.264,00

36 WP title

InformationTechnology

37 WP number

3000

38 Start month(relative to kick-off of the project) and **duration** (in month)

WP Start	1	WP Duration	30

39 OU(s) participating to the WP

OU Short Name	**OU Name**	**Applicant**
OAR	Osservatorio Astronomico di Roma	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAPA	Osservatorio Astronomico di Palermo	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
UniPA	Dipartimento di Fisica e Chimica – Emilio Segrè - Università degli Studi di Palermo	CO-APPLICANT: Università degli Studi di Palermo
UNIROMA1	Department of Statistics - Sapienza Università di Roma	CO-APPLICANT: Sapienza Università di Roma
IRA	Istituto di Radioastronomia	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAC	Osservatorio Astronomico di Cagliari	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAAB	Osservatorio Astronomico d'Abruzzo	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAA	Osservatorio Astrofisico di Arcetri	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACN	Osservatorio Astronomico di Capodimonte	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAPD	Osservatorio Astronomico di Padova	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OATS	Osservatorio Astronomico di Trieste	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAR	Osservatorio Astronomico di Roma	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAPA	Osservatorio Astronomico di Palermo	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAR	Osservatorio Astronomico di Roma	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
UNINA	Department of Physics, Università Federico II	CO-APPLICANT: Università degli Studi di Napoli Federico II
UNINA	Department of Physics, Università Federico II	CO-APPLICANT: Università degli Studi di Napoli Federico II
UNINA	Department of Physics, Università Federico II	CO-APPLICANT: Università degli Studi di Napoli Federico II
OACN	Osservatorio Astronomico di Capodimonte	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAPD	Osservatorio Astronomico di Padova	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAS	Osservatorio di astrofisica e scienza dello spazio	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAB	Osservatorio Astronomico di Brera	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

40 WP Leader

Massimo Brescia

41 Summary of the activities envisaged in the WP

WP3000 is focused on a series of Information Technology activities and will provide STILES with infrastructures and services over a wide range of challenging scientific and technological objectives. WP3000 will provide the Italian community with a network of dedicated, multi-scale computing and storage facilities, with unique engineering solutions to design and operate new instruments, and will develop skills and tools for astronomical data analysis.
The WP is organized in four sub-WPs, the first two devoted to establish tools to support the analysis of astronomical data, the latter two dedicated to implement engineering processes for instrument design.
Modern astronomical instruments deliver huge amounts of data - images, spectra, catalogues. Well known cases are the forthcoming Rubin-LSST and Euclid survey, which will yield multi-epoch observations of the entire observable sky, identifying unique targets for immediate follow-up with other telescopes - including ELT and SKA once available. All such surveys will require PB-scale storage, a

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

immediate follow-up with other telescopes - including ELT and SKA once available. All such surveys will require PB-scale storage, a fast, massive computing system and conceptually new approaches to data analysis, based on ML/DL paradigms, to fully extract their full informational content, which are accomplished by sub-WPs 3100 and 3300, respectively, as described below.

sub-WP3100 - Advanced Processing Center
We propose to build and put in operation a Tier-2/3 computing center dedicated to the storage and treatment of data from both optical and radio facilities, able to process the computationally intensive algorithms of image and spectral analysis developed in sub-WP3300.
In the optical, storage capabilities are necessary for the archival of VST images, as it will fully transfer under INAF responsibility from late 2022, and also from AO facilities that are delivering large amount of data, like SHARK-VIS at LBT in the short term, and MICADO@ELT later (we remind that both LBT and VST are Italian Research Infrastructures eligible for this funding program).
In the radio, all the preparatory work for SKA, like the gathering and analysis of MeerKAT radio data, requires an archiving system able to maintain such huge volumes of data.
Crucially, the Advanced Processing Center (APC) will be installed at the University of Naples Federico II, which hosts a large computing facility and is a leading institute with widely recognized leadership roles in ML/DL solutions for multi-disciplinary scientific problems. The University is at the center of a lively network of high tech industries, including the only European Apple Development Center.
The APC will consist of 40 multi-core servers, each with 2GPUs and 10 PB of tape/disk storage. It will support a number of key functions: (i) multi-wavelength data storage and archiving systems, (ii) efficient cross-matching and visualization systems of large multidimensional catalogues, (iii) support for computing-intensive scientific and engineering analysis systems based on many-core computing, (iv) R&D in data science and ML/DL for the classification and prediction of sources/structures at different cosmological scales.
The realisation of the APC will fill a huge gap in the global resources available to the Italian community, and represents one of the major outcomes of the entire STILES program.

sub-WP3300 Advanced Software
Unsurprisingly, another effort is directed toward the realization of tools that exploit the most recent techniques to optimally analyse the data - and that will use the APC to its full capabilities. We leverage on the extended collaborations that already exist among researchers across the entire country: while we present them splitted in several actions, as requested by the program format, we stress that these activities are already being developed in close collaboration. All these activities will hire SW engineers to publicly deliver specific tools for immediate astronomical analysis.
Four activities (3301 to 3304) from the MASTER collaboration pursue the goal of producing an ensemble of SW tools for the scientific exploitation of AO data, focusing on the PSF-reconstruction for ELT, and delivering a new version of Starfinder, a AO-tailored SW largely used by the scientific community for the analysis of stellar fields.
Similarly, the collaboration between INAF-OAR and the University of Rome La Sapienza (3321 and 3322) is working on advanced ML/DL tools to lower the noise levels, increase the resolution, avoid spurious detections, and deblend sources in deep extragalactic surveys. These techniques promise to improve the depth and resolution of dithered images by major factors (1.5-2x) and will be fully tested on real and simulated data.
ELT instrumentation, complemented by other space-borne observing facilities, will deliver spectra of exoplanets with much higher S/N and resolution than any existing instrument. These data need to be corrected against systematic errors and interpreted using laboratory instruments that mimic the conditions of real planetary and stellar atmospheres. This is the goal of three activities (3311, 3312, and 3313) for understanding the origin and evolution of planetary atmospheres and the possible impact of biological processes, exploring also new tools that use quantum computing.
Finally, to exploit the full capabilities offered by the SKA precursors, and the investment in instrumentation for MeerKAT, we aim at upgrading existing radio interferometry data reduction and analysis tools, optimizing them for either low (UHF-band) and high (SKA Band5) frequency data. The aim of the Radio SW activities (3331, 3332, 3333) is to upgrade computing facilities, making them suitable to develop and test solutions for the analysis of MeerKAT radio data, in particular spectral line and time domain experiments, as well as full Stokes radio-continuum galactic and extragalactic surveys.

sub-WP3200 Concurrent Design Facilities
Concurrent engineering is a revolutionary approach that uses a set of infrastructures that allow engineering teams with different backgrounds to work together on all the aspects of the design in a "virtual" environment. This approach is implemented in a Concurrent Design Facility (CDF), i.e. a physical infrastructure where different specialised engineers can work together in a common environment,

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

Design Facility (CDF), i.e. a physical infrastructure where different specialised engineers can work together in a common environment, thus increasing the level of efficiency in all the design and implementation steps. The CDF initiative (Activities 3201, 3202) will create a network of CDFs across three different INAF institutes, the kernel of a potentially larger future system. The wider, central CFD will be located in Naples. This "distributed" CDF will transform the engineering of future instruments for the entire INAF. We also anticipate that this facility, especially the one in Naples, will be heavily used by industrial partners.
sub-WP3400 Control SW Infrastructure
INAF researchers and technologists have a consolidated responsibility for work-packages concerning control SW for SKA and ELT. Such systems are increasingly complex, consisting of many components executing in distributed and heterogeneous environments, often with strict synchronization requirements. In order to guarantee the quality and reliability of these SW systems it is necessary to have an adequate infrastructure for their prototyping, implementation, test and verification. The proposed activities (3401 to 3406), aim at strengthening the INAF infrastructure dedicated to the development of control SW for projects related to SKA and ELT. This will be used to prototype and develop SW for SKA and its precursors, ELT Instrumentation SW and Adaptive Optics Real Time Computers. It will also enable the development of real time pipelines for the detection of radio transients and novel AO control techniques based on Machine Learning.

42 WP inter-relation with other WWPP

This WP does not have dependencies with any other WP, as it is dedicated to the independent acquisition of equipment, software and labor

43 Most relevant outcome:

The initiatives related to image analysis, reconstruction and Adaptive Optics (AO), will guarantee not only the consolidation of the already recognized key and leading roles of the Italian Community within ELT project, but also a high scientific impact on all astrophysical projects in which the Community is involved. It will act as a decisive flywheel in the fields of image denoising, super-resolution, topological segmentation, light profiles reconstruction and combined analysis, all features that will be of great interest to exploit future ELT AO imaging data in combination with lower resolution data, to achieve a self-consistent mapping of the galaxy spectral energy distributions. Furthermore, the infrastructure in the MASTER collaboration proposals will support the INAF researchers in the forthcoming decade, offering software applications and computational support for the preparation and the post-processing of ELT AO observations, and AO-imaging in general.
The initiative devoted to the extraction and interpretation of the spectrum of an exoplanet in presence of systematic errors acquires particular relevance for the correct exploitation of observations from most of the future large telescopes, whose main scientific objectives include the observations of planetary atmospheres.
The initiative related to SKA project, while immediately applicable for the use of the new MeerKAT/+ band 5 and UHF receivers, will make the capabilities and acquired expertise crucial for elaborating the additional steps, which will be required to address the data analysis challenges imposed by the advent of SKA. Developing state- of-the-art radio-interferometry data analysis tools will favour the Italian community positioning in leadership roles in the upcoming selection of SKA legacy surveys. In addition, such tools will be of great value during the early phases of SKA scientific commissioning and science verification.
The consolidation and expansion of the infrastructure for prototyping, development and validation of control software for astronomical telescopes and instruments will allow INAF to take more prominent roles in projects related to SKA and ELT, ultimately leading to an increased scientific return in terms of guaranteed observing time.
The proposed Concurrent Design Facility (CDF) module will be replicated in other INAF institutes, with the aim of creating the first nodes of the network distributed over the national territory to connect working groups remotely and in real time. The design process will become accessible from every node of the CDF thanks to a dedicated data management tool, tailored to INAF needs. This way, activities can be moved forward in every facility, independently from the location.
Based on the resources of each institute, the CDF node can be expanded and characterized for specific needs. The facility will integrate a dynamic work environment with a versatile application, useful both for other research institutes (e.g. universities) and local design companies. With the addition of an Additive Manufacturing laboratory, it will also be possible to quickly realize, in relation to the technological possibilities, manufactured goods and

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it will also be possible to quickly realize, in relation to the technological possibilities, manufactured goods and samples to support concurrent design activities.
Moreover, it is worth emphasizing that, in the medium and long term, the extraordinary quality of the data and the massive use of machine/deep learning techniques, shared among the OU initiatives, could open unpredictable but fundamental discoveries of "unknown unknowns". Such an effort in technological and methodological innovation will therefore constitute the ideal humus in which to forge the knowledge of the new generations of scientists and engineers, as well as constitute an effective flywheel for the application of new methodological solutions to other international astrophysical projects in which the community Italian (and in particular the OU teams participating in this program) is involved at high levels of responsibility.

44 List of WP deliverables that will be available according with the timing set by the Intermediate Objectives:

Title	Bimester	Deliverables
Team finalization and calls for tender	3	This IO is made of three deliverables, each documented in a relevant report: D3101 Report on team hiring It contains a summary of the hiring procedures and team composition D3102 Final design of instrumentation It contains the final design for the instrumentation to be procured D3103 Report on calls for tender It contains the list of calls for tender issued at the end of the period, and of those that are still to be issued, if there are.
Conclusion of calls for tender	6	D3201 Report on calls for tender It contains the list of calls effectively completed and assigned at the end of the period, and of those that are still to be assigned. D3202 Report on staffing It contains an update of the staff allocation within the WP.
Short Lead Items Delivery	9	D3301 Report on SLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the remaining SLI items. D3302 Report on staffing It contains an update of the staff allocation within the WP.
Medium Lead Items Delivery	12	D3401 Report on MLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the SLI items which were not delivered at the end of IO3. It also includes an outlook of the procurement procedures for the Long Lead Items. D3402 Report on staffing It contains an update of the staff allocation within the WP.
Long Lead Items Delivery	15	D3501 Report on LLI procurement It contains the list of LLI effectively delivered, as well as of all other items that have been procured within the project D3502 Report on staffing

45 Objective, quantitative, and measurable indicators relevant to the monitoring and ex-post assessment of the expected results:

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of the expected results:

Title	Bimester	Objective, quantitative, and measurable indicators
Team finalization and calls for tender	3	-Number of team member hired and fraction over the total planned number. -Number of instrument/laboratory design completed and fraction over the total planned number -Number of calls for tender issued and fraction over the total planned number
Conclusion of calls for tender	6	-Number of calls for tender completed and assigned, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Short Lead Items Delivery	9	-Amount of SLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Medium Lead Items Delivery	12	-Amount of MLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Long Lead Items Delivery	15	-Amount of LLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.

46 WP Intermediate Objectives:

IO Title *Team finalization and calls for tender*

IO Bimestre *3* IO Costs *941.194,00*

IO Desciption

This IO closes the first part of the project, where a) the hiring procedures are concluded and the team is assembled; b) design phases of the instrumentation is completed and c) main calls for tender for instrumentation procurement are completed and released.

IO Title *Conclusion of calls for tender*

IO Bimestre *6* IO Costs *6.642.881,00*

IO Desciption

This IO closes the second part of the project, where major calls for tender have been closed and the relevant contracts assigned. We also keep reporting about the team, with an update about the staffing situation.

IO Title *Short Lead Items Delivery*

IO Bimestre *9* IO Costs *846.531,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Short Lead Items (SLI) that - by

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Short Lead Items (SLI) that - by definition - can be purchased in a short time. We shall present a list of the SLIs obtained within the period, and of those which haven't been delivered yet. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Medium Lead Items Delivery*		
IO Bimestre	*12*	IO Costs	*1.843.017,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Medium Lead Items (MLI) that - by definition - are purchased in about one year. We shall present a list of the MLIs obtained within the period, and of those which haven't been delivered yet. We also include a final report on the delivery of SLI that were still pending at the end of IO3, and an outlook of the procurement procedures for the Long Lead Items. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Long Lead Items Delivery*		
IO Bimestre	*15*	IO Costs	*710.641,00*

IO Desciption

This IO reports about the final procurement of the instrumentation, with an emphasis on Long Lead Items (LLI) that - by definition - are purchased by the end of the project. We shall present a list of the LLIs obtained within the period, as well as of all other items that have been procured within the project. We will also include a final report on the delivery of all items that were still pending at the end of IO4. We also provide a final report about the team.

47 WP budget description

Cost of fixed term personnel specifically hired for the project

Cost description:

The cost of personnel for the WP3000 is based on the specific need to equip the various teams of the participating OUs with highly specialized professionals in the management and orchestration of sophisticated distributed and high-performance computing infrastructures, scientific software development and systems control. Below, the complete list of fixed-term personnel costs for each activity is reported.

ATT3102 AdvancedProcessingCenter_DataCenterHW
hiring of 2 fixed term personnel
- system operation support personnel

ATT3103 AdvancedProcessingCenter_DataCenter_SW
hiring of 2 fixed term personnel
- DBMS manager
- system and SW manager

ATT3302 AdvancedSW_PSFReconstruction
hiring of 1 fixed term personnel
- SW engineer

ATT3304 AdvancedSW_PSFValidation

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

- SW engineer

ATT3304 AdvancedSW_PSFValidation
hiring of 1 fixed term personnel
- data scientist

ATT3311 AdvancedSW_ExoAtmoSp
hiring of 2 fixed term personnel
- Sw Engineers for exoplanet spectra extraction SW

ATT3312 AdvancedSW_ExoAtmoMod
hiring of 1 fixed term personnel
- SW Engineer for development of exoplanet spectra extraction SW

ATT3321 AdvancedSW_ImageAnalysis
hiring of 1 fixed term personnel
- data scientists for detection/photometry of galaxies in ELT images

ATT3331 AdvancedSW_SWRadioLine
hiring of 1 fixed term personnel
- HI line analysis expert and pipeline developer

ATT3332 AdvancedSW_SWRadioTime
hiring of 1 fixed term personnel
- 1 time-domain pipeline developers

ATT3406 CtrlSWInfra_OATs
hiring of 1 fixed term personnel
- IT specialist

Scientific instrumentation and technological equipment, software licenses and patent

Cost description:

The ambitious scientific and technological objectives of the WP3000 require a powerful infrastructure able to host sophisticated software and produce complex data analyses. It includes also state-of-the-art engineering design and active control system laboratories. Below, the complete list of HW/SW infrastructure costs for each activity is reported.

ATT3101 AdvancedProcessingCenter_PowerCooling
Scientific instrumentation and technological equipment
- electrical cabling
- networking cabling
- UPS
- networking switches

ATT3102 AdvancedProcessingCenter_DataCenterHW
Scientific instrumentation and technological equipment (Tier2 and Tier3)
- HTC servers with GPUs
- Storage systems (tape/disks)
- monitoring system

ATT3103 AdvancedProcessingCenter_DataCenter_SW
Management and scientific software
- storage cluster handling SW
- long-term licenses per specific modelling and programming SW

ATT3201 ConcurrentDesignFacility_PrimaryNodeOACN
HW and SW for the CDF
- workstations, cloud servers, storage
- technical SW (mechanics, electronics, optics, PA/QA)
- videoconference tools
- VR/AR devices

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

- videoconference tools
- VR/AR devices

ATT3202 ConcurrentDesignFacility_AncillaryNodeOABR
Ancillary CDF equipment
- HW/SW for 5 concurrent workstations
- screens and A/V system for TLC
- VR/AR systems

ATT3301 AdvancedSW_PSFSimulations
HW and SW for the MASTER PSF-R simulation system
- server for intensive simulation analysis
- NAS 20TB
- rack and support
- laptop for fixed term personnel
- licenses for commercial SW

ATT3302 AdvancedSW_PSFReconstruction
HW and SW for the MASTER PSF-R system
- 24-months contract for outsourcing of a C++ library for PSF-R
- laptop for fixed-term personnel

ATT3303 AdvancedSW_PSFFitting
HW and SW for the prototyping of Starfinder system
- Laptop and Workstation
- IDE SW licenses

ATT3312 AdvancedSW_ExoAtmoMod
HW equipment for exoplanet spectra analysis
- 2 workstations (64core, 2x80GB GPU Tesla, 28TB RAID storage)

ATT3321 AdvancedSW_ImageAnalysis
HW equipment for local prototyping of SW for detection/photometry of galaxies in ELT images
- server for developing and testing (56core, 2x 32GB GPU Tesla V100, 16TB HDD)

ATT3322 AdvancedSW_TopologicalDataAnalysis
HW equipment for local prototyping of SW for topological analysis of ELT images
- server for developing and testing (14 nodes, 2x 4TB GPU, 250TB HDD)

ATT3331 AdvancedSW_SWRadioLine
HW equipment for the analysis of MeerKAT/+ spectral line data
- local network upgrade (1 switch and 10 cards)
- GPU fat processing station

ATT3332 AdvancedSW_SWRadioTime
HW equipment for MeerKAT data processing
- 2 servers (30cores, 2 GPUs, 36TB HDD)

ATT3333 AdvancedSW_SWRadioRC
HW equipment for processing and data storage of radio continuum data produced by MeerKAT
- MeerKAT data storage system
- server for data processing

ATT3401 CtrlSWInfra_OAAb
HW equipment for development and testing of monitoring and control solutions for both SKA and ELT AO-based instruments
- 2 servers Dell R7525 with GPU accelerators
- network components and storage units
- camera for fast image acquisition

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

- network components and storage units
- camera for fast image acquisition
- 2 FPGA modules
- 2.5y license BigML Lite

ATT3402 CtrlSWInfra_OAA
HW equipment for development and testing of the portion of SKA software we are committed to develop

- 2 servers with multiple GPU
- network components
- Redundant large capacity network storage server

ATT3403 CtrlSWInfra_OACt
HW equipment

- Server for running MeerKAT antenna monitoring and control system components

ATT3404 CtrlSWInfra_OACN
HW equipment to prototype and develop control software

- server for the prototyping and simulation of a RTC
- server for simulation of ELT control system
- control system equipment

ATT3405 CtrlSWInfra_OAPd
HW equipment for ELT prototyping, development, testing and validation of control SW

- ESO IT standard server
- 6 ELT IT servers for RTC applications
- 7 servers for real-time RTC
- ESO standard control system
- SW licenses for PA/QA and remote access SW

ATT3406 CtrlSWInfra_OATs
HW equipment for ELT prototyping, development, testing and validation of control SW

- Time reference and high-speed network system
- HW components for template instrument

Open Access, Transnational Access, FAIR principle implementation

Cost description:

The WP includes the following activity related to the FAIR principle.
ATT3301 AdvancedSW_PSFSimulations
Fair data for SW development

- Delivery of Fair versions of simulated training data

ATT3313 AdvancedSW_ExoAtmoQC
Fair computing time

- computing time on quantum computing service providers

Civil infrastructures and related systems

Cost description:

The Advanced Processing Center (activities 3101 to 3103) will take advantage of the SCoPE scientific Data Center of the Complex of Monte S. Angelo (UniNA). The entire existing computing infrastructure will be adapted to meet the electrical power and cooling requirements of the new resources.
In the area of the "Real Osservatorio Astronomico di Capodimonte" (OACN), belonging to INAF, in Naples, a historical building has been selected to be

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

belonging to INAF, in Naples, a historical building has been selected to be converted into a Concurrent Design Facility.
Below, the complete list of civil work costs for each activity is reported.

ATT3101 AdvancedProcessingCenter_PowerCooling
Civil Infrastructures and related systems
- chiller/generator automation
- refrigerated rack doors
- LCP update (air-water)

ATT3201 ConcurrentDesignFacility_PrimaryNodeOACN
CDF room requalification
- restoration of historical building
- reinforced concrete, insulation, sewage, water, electrical, TLC, fire system, landscaping
- equipment of technical control room

Indirect costs

Cost description:

Indirect costs (7% of all direct costs) will be primarily dedicated to support the administrative activities related to the project. In particular, they will serve to hire specific personnel dedicated to issue and follow the many calls for tenders that will be needed to procure all the deliverables of the project.
Indirect costs will also be used to refund travels directly related to the specific project, consumables and other similar expenses.

Training activities

Cost description:

Within the WP3000, the activities concerning training and academic specialization efforts are carried out by means of thematic research doctorate scholarships and courses/workshops. Below, the complete list of training costs for each activity is reported.
ATT3102 AdvancedProcessingCenter_DataCenterHW
training for 1 PhD
- training for ML/DL development

ATT3304 AdvancedSW_PSFValidation
PhD school
- PhD school for ELT use at OA Capodimonte (Napoli)

ATT3313 AdvancedSW_ExoAtmoQC
training of 2 PhDs for exoplanet analysis, simulations and hybrid QC
- co funded PhD for analysis and simulations in astrochemical research
- co funded PhD for hybrid quantum-traditional simulations

ATT3322 AdvancedSW_TopologicalDataAnalysis
training of 1 PhD for image analysis

48 Activity title

AdvancedSW_PSFValidation

49 Activity short name

3304

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

3304

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAR	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The INAF "MASTER" collaboration encompasses the activities 3301, 3302, 3303 and 3304 to jointly pursue the goal of producing an ensemble of software (SW) tools for the scientific exploitation of the data produced by Adaptive Optics (AO) equipped facilities. The WPs are based in several INAF departments and are respectively devoted to: Data simulations, PSF extraction SW tools, PSF fitting SW, PSF SW validation.
The "MASTER" collaboration looks forward to the application of such SW infrastructure in the view of ELT observations by providing validated software on specific data training sets and simulated observations.
GOALS: The 3304 activity aims at validating data processing using newly developed SW from 3303 and simulated images from 3301, including the use of PSF reconstructed from 3302. We will test SW performance using training AO datasets (already in hands). Using well known Globular Cluster data coming from AO instrumentation (SOUL, GEMS, MUSE) combined with Gaia and HST data, we will be able to test the precision and the accuracy of photometric and astrometric performance and to provide crucial input for data processing Integral Field Spectrographs (IFS). This will allow us to pave the road for ELT data processing and to give a solid basis for ERC advanced grant application.
We will also analyze ELT simulated images by using both PSFs extracted from the image and those coming from PSF-reconstruction techniques, thus providing a crucial validation to the PSFR performance.
ACTIONS: A 24-month TD will be hired to process real and simulated AO data.
A PhD student will be trained to deal with AO data from ELT. Advanced courses to train the next gen of Astronomers will be organized in Southern INAF Observatories (Naples).
PARTICIPANTS: Fiorentino (OAR). COLLABORATIONS: Univ. of Rome (Tor Vergata), European Southern Observatory (ESO), Dominion Astrophysical Observatory (DAO).

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Data Analysis on simulated ELT images and validation of AO dedicated software

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

0,00 €

Cost description: None

54.3 c. Open Access, Transnational Access, FAIR principle implementation

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

11.422,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

49.642,00 €

Cost description: PhD School

48 Activity title

AdvancedSW_ExoAtmoSp

49 Activity short name

3311

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAPA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

This action aims at the development of an integrated optimized system devoted to the extraction and interpretation of the spectra of exoplanets in presence of systematic errors. This goal is particularly relevant for the correct exploitation of observations of most of the present and future large telescopes, whose main scientific objectives include the observations of planetary atmospheres (i.e. HARPS-N@TNG, GIANO@TNG, HIRES@ELT, JWST, Ariel). A planetary spectrum is obtained from the subtraction of the spectra of the host star during a transit event or the secondary eclipse with an expected amplitude of the order of 10 parts per million of the stellar one. The recovery is critical when the noise is correlated and shows an amplitude larger than the searched signal. To overcome the issue, parametric and non-parametric methods can be employed, even simultaneously to validate the robustness of the results. To extract the planet's atmospheric signals from the data, the development of non-parametric methods, based e.g. on principal or independent component analysis, cluster analysis, Gaussian processes and deep learning are foreseen. Model-comparison approaches, for a physical understanding

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analysis, cluster analysis, Gaussian processes and deep learning are foreseen. Model-comparison approaches, for a physical understanding of the observations, will be developed as well, with a case-by-case selection of the algorithms and of the sampling optimization. Sets of numerical simulations will be implemented to test and validate the methods. These tools will allow the extraction of the exoplanets atmospheric spectra from space-based observations obtained with present and future instrumentation, supported by additional data useful to characterize both the planet and the host star. This activity will be coordinated by S. Benatti (INAF - OAPA) with the support of G. Micela (INAF - OAPA) and I. Pagano and G. Bruno (INAF - OACT). It will be held also in collaboration with the analysis working group of the Ariel Mission Consortium.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

170.280,00 €

Cost description: Development and optimization of the algorithms; Engineering of the tools

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

0,00 €

Cost description: None

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

11.919,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedSW_ExoAtmoQC

49 Activity short name

3313

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

3313

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UniPA	Participant	Università degli Studi di Palermo

52 Activity description

We will develop computational routines to carry out astrochemical research or molecular calculation on real or virtual quantum computers. This will be done integrating classical algorithms based on e.d. DFT with quantum ones e.g. Variational Quantum Eigensolver Algorithms. This will be made possible with the advent of commercial quantum computing devices in the NISQ (Noisy Intermediate-Scale Quantum) regime, which has paved the way to the integration between quantum computing algorithms with HPC, providing a promising platform to efficiently simulate quantum and classical complex systems. In our specific scenario the use of hybrid classical - quantum computational techniques could allow on the one hand for the efficient extraction of relevant information from large data and more importantly to simulate the astrochemistry of exoplanets. Indeed, hybrid quantum algorithms provide powerful tools for the correct description of strongly correlated and complex systems, which are the great challenge in current chemistry simulation.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

0,00 €

Cost description: None

54.3 c. Open Access, Transnational Access, FAIR principle implementation

80.000,00 €

Cost description: computing time on quantum computing service providers

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

14.665,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

129.500,00 €

Cost description: cofunding of PhD grant (30 months) Analysis and simulations of observations; cofunding of PhD grant (30 months) hybrid quantum - classical simulation of exoatmspheres

48 Activity title

AdvancedSW_TopologicalDataAnalysis

49 Activity short name

3322

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UNIROMA1	Participant	Sapienza Università di Roma

52 Activity description

Our work will be characterized by a close collaboration with the Extragalactic Astrophysics branch of INAF OAR to consolidate and advance our common research lines focused on the development and software implementation of innovative Topological Data Analysis (TDA) based tools aimed at segmenting, denoising and, more generally, statistically modeling large scale astronomical images. In a nutshell, with TDA we identify a rich set of statistical and machine learning techniques devoted to the study of the "shape" of data. In a recent Master's thesis, a promising new unsupervised segmentation method based on persistent homology in dim. 0 was designed and successfully tested by the participants, and will provide a solid starting point for the present project. More in particular, after the deployment of further computational refinements/optimizations of our original proposal, we will first explore the inclusion of information provided by persistent homology in dim. 1 or higher, and then we consider the extension of the "shallow" base model into a topology-aware deep network in order to amplify and leverage further nonlinearities in the segmentation process. As an additional step, we also plan to push the envelope on the uncertainty quantification side by adapting to the segmentation problem some recently introduced conformal prediction schemes in order to determine precise levels of confidence in the algorithm output. Finally, although TDA based methods have proved extremely effective in extracting scientifically relevant information from data, they also come at huge computational costs that limit their potential, especially in the analysis of large-scale astronomical images. With this in mind, the use of high-performance computing tools is essential and, for this reason, the upgrade of TeraStat2, the HPC infrastructure developed by the Dipartimento of Scienze Statistiche, is key to the success of the project. Participants: Bompiani, Brutti, Ferraro Petrillo, Tardella (Uni

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

175.000,00 €

Cost description: Computing facilities

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

17.689,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

77.700,00 €

Cost description: PhD scholarship

48 Activity title

AdvancedSW_SWRadioLine

49 Activity short name

3331

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	IRA	Participant	INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

di Astro Fisica

52 Activity description

The final aim of this activity is to design, develop and test an infrastructure for the analysis of MeerKAT/+ spectral line data. This work will build on the existing MeerKAT HI datacube pipeline (CARACAL) developed as part of a collaboration between INAF-OAC and the Inter-University Institute for Data Intensive Astronomy (IDIA) in South Africa. The aim is to optimise this pipeline for high-redshift HI-line surveys (taken in UHF band). We will also use simulated data to develop and test stacking algorithms exploiting optical spectroscopy information, to push
the analysis of HI galaxy properties below the HI detection threshold. The proposed activity is focused on the procurement, set-up and test of the HW infrastructure. The HW infrastructure will consist of a computing server, with multicore processors, large RAM, and powerful GPUs. To maximize the efficiency of the overall infrastructure, we also intend to upgrade the local network to 100 Gbit/s. Adequate storage (50 TB) is already available in house. We propose to hire dedicated personnel, with fixed-term contracts, joining the team to support the procurement, configuration, and initial operations of the infrastructure. The team is involved in some of the major legacy surveys currently running at MeerKAT, aimed at galaxy evolution studies (namely MIGHTEE and Fornax), and has a long-standing and internationally recognized expertise in radiointerferometry data analysis, gained over many decades of work in this domain. The team has leadership roles in major ongoing legacy surveys, like e.g. the ASKAP and LOFAR all-sky surveys and the eMERGE legacy survey at eMERLIN. The team has also established experience in data post-processing (source extraction, characterization and multi-wavelength classification). This activity will also count on the expertise of the Italian node of the ALMA Regional Center (hosted at IRA) in datacube analysis.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Profile #1: system manager/ pipeline developer; Profile #2: HI line analysis expert/pipeline developer

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

50.000,00 €

Cost description: GPU fat station for the processing of MeerKAT data; 100Gbit/s local network upgrade: 1 Switch and 10 boards QSFP28

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

11.446,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

11.446,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedSW_SWRadioTime

49 Activity short name

3332

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAC	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The final aim of this activity is to design, develop and test an infrastructure for the analysis of time-domain data, with particular emphasis on the high time resolution ones. The proposed activity is focused on the procurement and set up of an HW infrastructure, as well as the implementation on that infrastructure of data analysis solutions suitable to handle the processing of MeerKAT timedomain data. The hardware infrastructure will consist of 2 computing servers, with multicore processors, large RAM, 2 GPUs, and a large amount of disk space in order to host the very high volumes of the expected data. Pipelines of data analysis will be developed, aimed to: discover new isolated pulsars, new Fast Radio Bursts, new kinds of radio transients, discover binary pulsars in very tight orbits, improve the accuracy and precision in the determination of the times of arrival of the pulses as well as of the polarization properties of any observed pulsars. For some of these aims we will explore the use of Machine Learning. The team has leading roles in the two largest time-domain pulsar projects nowadays running at MeerKAT, namely TRAPUM and MeerTime, also involving several international collaborators from: MPIfR (Ger), Uni of Manchester (UK), CNRS (France), SARAO (SA), CSIRO (AUS), Swinburne Uni (AUS), and NRAO (USA). The team had a key role in many past pulsar experiments: the main result was the discovery of about 1000 pulsars, among which the still unique Double Pulsar. The team is also among the founders, and still deeply involved, in the EPTA (European Timing Array) collaboration, the focus of which is to detect long-period gravitational waves via observation of an array of pulsars. Furthermore, the team was among the founders of the Parkes experiment that confirmed the cosmic nature of the Fast Radio Burst and has built a relevant expertise also in using Italian facilities to investigate these sources.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

113.520,00 €

Cost description: Time-domain pipeline developers

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

50.000,00 €

Cost description: Servers for processing of MeerKAT data

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

11.446,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedSW_SWRadioRC

49 Activity short name

3333

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACT	Participant	INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

di Astro Fisica

52 Activity description

With the proposed activities, we aim at strengthening the computing infrastructure dedicated to the processing of radio continuum data produced by MeerKAT, particularly in the Galactic plane, paving the way for effective processing of SKA data on a longer term. We will procure and set up a HW infrastructure that can support the processing of MeerKAT data in view of future commissioning and survey data produced by the upgraded MeerKAT+. The infrastructure will consist of one or more computing servers, equipped with multicore processors, capable of running radio astronomical data reduction pipelines on MeerKAT raw or calibrated uv data, and post-processing software tools on imaging data products. Auxiliary equipment (e.g. storage server, or GPUs) are also foreseen for raw and processed data archiving, and for carrying out R&D activities. The involved team has established experience in the study of radio stars and their environments with the most sensitive interferometers (VLA, ATCA, GMRT, MERLIN, VLBI networks), as well as single dishes. The team is also involved in Galactic radio survey programs with SKA precursors, like e.g. the ASKAP/EMU and the MeerKAT-GPS collaborations. International collaborations are established with CSIRO/Western Sydney University, SARAO, University of Oxford and Malta. The team has so far developed expertise in: stellar radio astronomy, evolved stars, extended radio sources, solar-stellar connection and stellar activity, radio signature of the star-planet interaction, modelling of gyro-synchrotron radio emission, radio data imaging and post-processing (source extraction, characterization and multi-wavelength classification) at scale, through distributed computing and artificial intelligence techniques. We propose dedicated personnel to be hired, with fixed-term contracts, joining the team to support the procurement, configuration, and operations of the infrastructure.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

25.000,00 €

Cost description: Computing system: HD 5 TB SSD, RAM 256/512 GB, Cores 30-48, GPU 1 (RTX 6000/8000 or superior); Data storage system (50 TB)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

1.750,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

CtrlSWInfra_OAAb

49 Activity short name

3401

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

This activity covers SW infrastructure for the development and testing of monitoring and control solutions for both the Square Kilometer Array (SKA) and the Extremely Large Telescope (ELT) AO-based instruments. The SKA project is aimed to build the world's largest radio telescope. INAF obtained from SKAO a contract to develop a critical portion of CSP Local Monitoring and Control (LMC) and a web-based LMC interface. To properly develop the SKA M&C system based on the Tango framework, it is necessary to use a complex environment of interacting virtual machines under the control of an orchestrator. The ELT project is aimed to build the world's largest optical and infrared telescope that will be equipped with Adaptive Optics instrumentation like MAORY (lead by INAF) and MICADO. One of the most challenging aspects of the AO correction is related to operating fast, efficient and stable wavefront sensors. ML has been recently applied to AO to improve the compensation of instrumental effects and to simplify system complexity. Using supervised deep learning in a dedicated testbed, it will be possible to learn the mapping relationship between image distortions and wavefront aberrations, combined with the modal transport of the signal through optical fibers, and to explore the potential of this technique. The method will be extended to RT applications in a closed-loop setting, applying ML to the DM control to significantly increase the performance in a highly non-linear regime.
The overall infrastructure to achieve all these goals will consist of:
- *computing servers, equipped with multi-core processors and GPU devices, capable of running several virtual machines or containers, hosting the control system components*
- *auxiliary equipment (e.g. storage, network components)*
- *other devices for R&D activities (a camera for fast image acquisition, FPGAs)*
- *tools for SW development, testing, and infrastructure management.*

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

90.000,00 €

Cost description: Server with CPU and GPU-accelerators. Includes Installation and 2-years maintenance & support. Network components & storage units. FPGA module, e.g FlexRIO, PXIe-7976, Kintex-7 K410T, 28620 Kbit, 63550 logic blocks.

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

6.300,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

CtrlSWInfra_OACt

49 Activity short name

3403

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACT	Participant	INAF - Istituto Nazionale

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OU short name	OACT	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

MeerKAT, with its 64 operating antennas, is the largest and most sensitive SKA pathfinder for intermediate frequencies. The MeerKAT Plus project recently started with the aim of extending the current array with 20 SKA-compliant dishes, all equipped with SKA Band 2 and S-Band feed systems. In this context, INAF-OACT is responsible for the development of the local monitoring and control software (Dish LMC) of the MeerKAT Plus dishes. The proposed activity aims to set up a HW infrastructure that can support the development and testing of Dish LMC software, and integration activities with other MeerKAT/SKA components in view of the final deployment on site. The infrastructure will consist of computing servers, equipped with multi-core processors and GPU devices) capable of running several virtual machines or containers, hosting the control system components (including device simulators), auxiliary equipment (e.g. storage, or other device for R&D activities), tools for SW development, testing, and infrastructure management. We foresee three major actions to be taken during the project: 1) HW procurement; 2) HW setup at the INAF-OACT computing centre; 3) SKA/MeerKAT control system software setup and hardware testing. The proposed activities involve different participants from INAF-OACT (S. Riggi, C. Trigilio, A. Ingallinera, F. Schillirò), and interactions with several collaborators from the South African Radio Astronomy Observatory (SARAO) staff, in charge of the project management, system engineering and AIV activities, and various international public and industrial partners, providing the instrumentation to be monitored and controlled, such as the Max-Planck-Institut für Radioastronomie (MPIfR), MT Mechatronics (MTM), and EMSS Antennas. Software testing activities will be done in partnership with the Euro.Soft S.r.l. company, operating within the "Società Aerospaziale Mediterranea (SAM)" Consortium.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

20.000,00 €

Cost description: Computing server per sistema di controllo MeerKAT Plus.

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

1.400,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

CtrlSWInfra_OAA

49 Activity short name

3402

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The Square Kilometer Array (SKA) project is an international effort to build the world's largest radio telescope, with eventually over a square kilometer of collecting area. The scale of the SKA represents a huge leap forward in both engineering and research & development towards building and delivering a unique instrument. Every aspect of the design and development of such a large and complex instrument requires state-of-the-art technology and innovative approach. To properly develop the SKA monitor and control system, it is necessary to use a complex environment of many interacting virtual machines under the control of an orchestrator, Kubernetes. INAF obtained from SKAO a contract to develop a critical portion of LMC, the CSP Local Monitoring and Control and the webbased LMC interface, Taranta. Present day development requires tens of simulated servers, while the scale of deployment will enter soon in the hundred server areas. In a few years the full scale of SKA will be reached, requiring even more servers. The development of such projects will soon exceed the capacity of our present server, hence the necessity to build a network of servers to run the large quantities of such virtual servers. Our goal is to get a powerful network of servers able to sustain the development and testing of the portion of SKA software we are committed to develop. We will design such a computing network, identify a suitable source and proceed in its acquisition. The participants in the design and acquisition will be the members of the Italian SKA SW community, the Cream Team. The Cream Team also hosts participants from other nations belonging to the SKA community: Portugal, India and Switzerland. We also propose to hire a person, with a fixed-term contract, and train her/him in the installation, configuration, operation and use of the infrastructure described above.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

110.000,00 €

Cost description: External support, to be shared with Teramo, for the installation, configuration and operation of the computing infrastructure. The servers with multiple CPU properly configured. Redundant large capacity network storage server. Network components with speed at least of 10Gb/sec

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

7.700,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

CtrlSWInfra_OACN

49 Activity short name

3404

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACN	Participant	INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

52 Activity description

The TElescope and inSTrumentation for Astronomy group (TESTA) of Capodimonte observatory has been developing control software and systems for ground-based astronomy over the last decades and is highly involved in ESO projects like ELT-MAORY, where new challenges for the control software come from the requirements of a MultiConjugate Adaptive Optics system. The project aims at upgrading the existing infrastructure in order to be able to prototype and develop control software, which needs specialized and well specified computing resources and a hardware test bench to run. In fact, the ELT standards in terms of software and control hardware require new development software and new test benches for prototyping the control software. In the ELT future instruments, the software development must deal with demanding real-time operations, for measuring wavefront errors from natural and artificial guide stars, reconstruct 3d tomographic measurement of the wavefront and apply high-frequency corrections to actuators like deformable mirrors. Many other functions are implemented in ELT instruments, like e.g. any kind of motors and sensors. Developing control software within this context is possible only with dedicated machines respecting ELT requirements. The specific activity needs also a companion hardware test bench. The proposed activity is the upgrade of the laboratory by:
- purchasing a set of computing facilities and test equipments specifically dedicated to ELT devices control, following mandatorily the ESO standards whenever applicable;
- setting up the facility.
The new infrastructure will allow for the prototyping and development of a RTC (Real Time Computer) control system based on HPC computers, special purpose accelerators and an high speed network compatible with Real Time protocols (e.g. ESO MUDPI), as well as for developing non real-time controls within the ELT instrumentation standards.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

85.000,00 €

Cost description: Development servers for the simulation of the ELT control environment; these servers will be based on ESO ELT standards. Computing system for the development and simulation of a Real Time Computer; this system will be based on ESO ELT standards and will have special purpose computing units and an high speed network. Control Software development system.

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

5.950,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

CtrlSWInfra_OAPd

49 Activity short name

3405

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAPD	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Goal of this activity is to strengthen the infrastructure devoted to the prototyping, development, testing and validation of control SW for projects related to the ELT. The existing infrastructure at OA Padova has been built to support projects for the VLT and LBT. It now needs to be updated to the new demands and standards dictated by ELT and new development activities, e.g. Real-Time Computers for Adaptive Optics (RTCs for AO). Specifically, we propose to acquire:
- An ESO IT standard computer server capable of hosting several tens of virtual machines, supporting the ELT SW development environment as well as continuous integration/testing pipelines based on dynamic allocation of resources.
- Computer servers and accelerators for the development of RTCs for ELT AO modules. These are specialized systems, made of several high-performance machines, connected by a dedicated, high-speed network, processing camera sensor data at hundreds of Hz, supported by a co-processing cluster for monitoring and optimization.
- A network infrastructure based on ELT standard data transmission (10-100 GbE).
- Auxiliary equipment, like storage systems (NAS), high-precision time sources for the synchronization of network nodes, server computers dedicated to the generation and transmission of simulated (test) data.
- Hardware for prototyping of control system and/or machine vision adhering to ELT standards, based, e.g., on industrial PLCs and cameras providing a GigE-Vision interface.
- Software licenses for SW Quality Assurance and remote access tools.
We also propose to hire one person, with a fixed-term contract, for the installation and management of the infrastructure.
Participants: A. Baruffolo (PI), B. Salasnich, D. Fantinel, A. Petrella and D. Selvestrel, staff members of INAF OA Padova.
Collaborations: ESO (Germany), ANU (Australia), IPAG (France), INAF OAS Bologna, INAF OA Capodimonte, INAF OA Brera, INAF OA Abruzzo and INAF OA Arcetri.

54 Activity budget

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

270.000,00 €

Cost description: Control Software development system. Real-Time Computer development system (core). Real-Time Computer development system (performance). Control Hardware prototyping system. Software licenses

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

18.900,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

ATT3406 CtrlSWInfra

49 Activity short name

3406

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OU short name	OATS	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The INAF-OATs Instrumentation Control Group (ICG) has a long experience in the field of design, implementation and integration of software and control electronics for state-of-the-art astronomical instrumentation (both in the optical and radio domain). For this activity, the group uses a laboratory at the OATs that, however, is not currently equipped to adequately support long-term activities. This leads to a criticality especially in the phases of transitions between projects, limiting the possibilities of keeping up with technological evolution and extending the design and development phases at the beginning of new projects. In this context, the proposed activity aims to fill this gap by enhancing the existing laboratory infrastructure along two main lines:
- equip the laboratory with a high precision time reference system and high-speed network (10G) based on ELT and SKA standards
- purchase hardware components for a template instrument (ELT compliant industrial PLCs, motors of various typology, piezo systems, sensors, GigE Vision cameras, cabinets) with metrology and verification instruments and handling devices.
Participants include: Paolo Di Marcantonio (PI), Valentina Alberti, Veronica Baldini, Giorgio Calderone, Roberto Cirami, Igor Coretti, Antonio Sulich. It is intended to hire a person with fixed-term contracts. A successful upgrade of the laboratory structure will be of primary importance to foster existing and future national and international collaboration and to keep existing leadership roles, in particular for ESO CUBES, ESO FORSUp and ESO ANDES instruments and SKA.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

49.880,00 €

Cost description: IT specialist for installation, configuration and operation

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

65.000,00 €

Cost description: Time reference system (PtP Grandmaster clock, network interfaces, compliant network switches). Template instrument components, PLC, Motors, Cameras

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

8.041,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedSW_PSFReconstruction

49 Activity short name

3302

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAR	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The INAF "MASTER" collaboration encompasses the activities 3301, 3302, 3303 and 3304 to jointly pursue the goal of producing an ensemble of software (SW) tools for the scientific exploitation of the data produced by Adaptive Optics (AO) equipped facilities. The WPs are based in several INAF departments and are respectively devoted to: data simulations, PSF extraction SW tools, PSF fitting SW, Science validation. The "MASTER" collaboration looks forward to the application of such SW infrastructure in the view of ELT observations by providing specific data training sets and simulated observations. The 3302 aims to develop the "MASTER-PSF" C++ applicative SW for high-performance PSF-Reconstruction (PSF-R). A 24months 100% dedicated TD unit, hired as Software Expert, will build the deliverable MASTER-PSF SW. It performs PSF-R using telemetry data from AO systems. The TD will work on the integration of the high-level functions of the SW, linking functionalities embedded in several C++ libraries. One library will be in parallel outsourced to a company to implement functions as the PSF-R algorithms invented by the INAF staff and collaborators. Third-party support is the viable solution to avoid further contracting of TD personnel. We estimate that two/three additional SW-TDs would otherwise serve the scope of the PSF-R library release. This further TDs investment would not cope with the next decade strategy of the MASTER group, which focuses on scientific exploitation and algorithmic research (and not applicative SW), making outsourcing the way for cost reduction, mitigated risk, and improved efficiency. Also, timing is a point we considered since the training of a TD is demanding. The development of the MASTER-PSF will take profit from the server acquired within the WP3301 and its data products. Participants: OAR: Pedichini, Piazzesi; IAPS: Li Causi; OAPD: Grazian, Vulcani, Zanella; OAAB: Portaluri. Collaborations: ADONI, MICADO, MAORY, Univ Linz

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Software Expert (Required skills: strong expertise in C/Python/Matlab coding and code structure and implementation, with some astronomical background. He/She is dedicated to PSF-R software applicative. He/She has to supervise the forthcoming activities distributed in the PSF-Reconstruction working group of MICADO for the PSF-R applicative software implementation, define software interfaces with Linz part, follow the contract with the outsourcing company.

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

172.000,00 €

Cost description: Contract to a software company for the delivery of a C++ library including the PSF-Reconstruction tool components. This includes assistance for the developing of the non-AO and Calibration algorithms on top of the AO algorithms already. The contract will cover 24 months and will foresee milestone with SW and documentation delivery every six months. Laptops for TD.

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

19.986,40 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedSW_ExoAtmoMod

49 Activity short name

3312

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OU short name	OAPA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Design and development of softwares operating on hybrid architectures for the study of the chemical evolution of exo-planetary atmospheres in the radiation environment of parent stars, and the impact on planetary dynamics and climatology. The aim is the construction of an extended database containing observables and related physical and chemical profiles, that depending on the size (and it needs to be very big) relies upon specialized architectural, management, processing and maintenance procedures. Such a dedicated database, which is not available to date, would need to be indexed over a number of well-defined, physically motivated parameters quantitatively describing synthetic atmospheres. The underlying model is inherently 3D and time-dependent. It contains the description of the vector transport of radiation, the transport of fast particles and the deposition of energy, chemistry and photochemistry (including ionization), heat balance, pressure variations, vertical mixing, molecular diffusion, particulate condensation and calculation of optical properties, interaction with the planetary surface (thermal, dynamic and chemical exchanges), mass loss, and spectral synthesis. The activity will be coordinated by C. Cecchi Pestellini (INAF-OAPA), with the support of G. Micela (INAF-OAPA) and G. Aresu (INAF-OAC). The activity will benefit by collaborations with CNR-IPCF (Italy) for quantum chemistry, reactivity, and particulate optical properties, NCU (Taiwan) and INTA-CAB (Spain) for laboratory testing of optical properties, and UCL (UK) for chemical modeling.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

56.760,00 €

Cost description: Development and optimization of the algorithms; Model implementation, database population

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

150.000,00 €

Cost description: 2 workstations equipped with at least 2 latest generation GPU cards

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

14.473,20 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedSW_ImageAnalysis

49 Activity short name

3321

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAR	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

We will develop SW tools aimed at improving the detection and photometry of galaxies in ELT images. Detection: we will implement an efficient tool to apply recently tested techniques, including denoising algorithms (explored in our paper Roscani et al. 2020), super-resolution (exploiting iterative/Bayesian combination and interpolation of dithered images, following our early work in Castellano et al. 2015), and segmentation (completing the development of an innovative unsupervised detection method based on Topological Data Analysis begun in a recent Master Thesis). Photometry: we will finalize the development of a deep-learning VAE algorithm, currently under construction, to infer and reconstruct the shape of blended galaxy pairs, with the twofold goal of enhancing the accuracy of photometric and morphological measurements and of providing accurate priors for template-fitting; we will also improve our template-fitting code T-PHOT (Merlin et. Al. 2015) to exploit ELT AO imaging in combination with lower resolution data (e.g. HST, JWST, Euclid, LSST), considering bulge+disk prioring to model color gradients and morphology-dependent algorithms (also exploring machine-learning optimizations). Two TD data scientists (24 months each) with a solid background in astronomical data analysis and software development will be hired; one will focus on detection and the other (with additional expertise in ML methods) on photometry. Thoroughly testing the SW tools will require intensive MonteCarlo runs of image processing, catalogue extraction and training of neural networks, exploiting simulated data (from 3301) and real datasets. We will acquire a dedicated computing server with 56 cores, 2 GPUs and 256TB storage for the development phase, while production runs will be performed at the Processing Center of ATT3100. Participants: Merlin, Castellano, Paris (OAR). Collaborators: Brutti, UniROMA1; Huertas-Company, IAC / Un. Paris.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Data-scientist developing SW for detection topics: denoising, super-resolution, topological segmentation; Data-scientist developing SW for photometry topics: ML profile reconstruction, template-fitting

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

23.000,00 €

Cost description: Server for developing and testing SW

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

9.556,40 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedProcessingCenter_PowerCooling

49 Activity short name

3101

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UNINA	Participant	Università degli Studi di Napoli Federico II

52 Activity description

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Main goal of this activity is the readiness of racks for HW installation of servers and storage. In particular, we will have to prepare no.8 racks for the HW, with the following:
o 3x8 LCP Liquid Cooling Packages (Civil infrastructures);
o 1x8 refrigerated doors (Civil infrastructures);
o 1 diesel generator automation system (Civil infrastructures);
o 2x chiller automation system (Civil infrastructures)
o 8x electrical cabling (Scientific Instrumentation)
o 6x8 Power Distribution Units (Scientific Instrumentation)
o 8x networking cabling, fiber (Scientific Instrumentation)
o 1x UPS 400 kVA (Scientific Instrumentation)
o 2x network switches Ethernet (Scientific Instrumentation)
o 2x network switch Infiniband (Scientific Instrumentation)
Participants: G. Russo, G. Longo, A. Izzo, D. Michelino, D. Bottalico (UniNA)
National/international collaborations: coordination with CSI (Centro Servizi Informativi) of UniNA, which has the technical management of the Data center, and with INFN Napoli, which also uses the same Data Center, but with different racks.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

436.000,00 €

Cost description: Electrical cabling in the Data Center; Networking cabling (fiber) in the Data Center; UPS (modular) for the Data Center; Networking switches for the Data Center

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

204.150,00 €

Cost description: Chiller automation for the Data Center; Refrigeration for rack (liquid cooling) in the Data Center; Generator automation for the Data Center; LCP update for the Data Center

54.5 e. Indirect costs

44.811,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

48 Activity title

AdvancedProcessingCenter_DataCenterHW

49 Activity short name

3102

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UNINA	Participant	Università degli Studi di Napoli Federico II

52 Activity description

The objectives of the program require the provision of a centralized (Tier2) data center, with distributed (Tier3) smaller data centers, suitable to support a series of key functions: (i) multi-wavelength data storage and archiving systems, (ii) efficient cross-matching and visualization systems of large multi-dimensional catalogues, (iii) support for computing-intensive scientific and engineering analysis systems based on many-core computing, (iv) R&D in data science and machine/deep learning for the detection, deblending, reconstruction, classification and prediction of sources/structures at different cosmological scales, (v) prototyping, development, testing and validation of active control systems for telescope, optics and instruments. The HW requested concerns the Tier2 data center, chosen on the basis of similar experiences for high energy physics project (Atlas, Belle II) and consists of 40 servers (each with 2 CPUs, 48 core each, 2 GPUs, 2 TB RAM, 1 TB disk), 8 storage systems (1 PB each, with 4 front-end each, with rotative disks and SSD caching disks) and a tape library LTO-09 of 6 PB for long-term archiving, 1 monitoring system (2 servers with HW and SW to monitor all the infrastructure).
Participants: G. Russo, G. Longo, D. Michelino, D. Bottalico (UniNA).
National/international collaborations: coordination with CSI (Centro Servizi Informativi) of UniNA which has the technical management of the Data center, and with INFN Napoli, which also uses the same Data Center, but with different racks.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

141.900,00 €

Cost description: RTDA

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

5.190.000,00 €

Cost description: HTC servers with GPUs; Storage systems (disks, tape libraries); Monitoring system (hw and sw);

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

378.672,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

77.700,00 €

Cost description: PhD student

48 Activity title

AdvancedProcessingCenter_DataCenter_SW

49 Activity short name

3103

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UNINA	Participant	Università degli Studi di Napoli Federico II

52 Activity description

Since a decade astronomical instruments have become "big data" producers (in the multi PB regime) thus requiring large computing infrastructures for data storage, processing and interpretation. UniNA intends to prepare an infrastructure for computing, SW development and archiving of scientific data, at the service of the other WPs. In order to match the needs, the data center will host computers with adequate computing power for the analysis of data from various experiments with MPI and GPGPU paradigms, as well as specialized systems for storing and
managing large volumes of data. The archiving may concern both the original and unprocessed data (raw data), both legacy data and data coming from the analyses performed with specialized SW and through the use of Machine and Deep Learning paradigms. Mass storage

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

coming from the analyses performed with specialized SW and through the use of Machine and Deep Learning paradigms. Mass storage systems present in the Data Center and that will be made available to the community can also be used for medium-long term archiving. While most of "science dependent" SW will be contributed by the various participating WG after the prototyping phase, in order to perform properly, the infrastructure will require the acquisition of SW for: 1) the databases deployment (on premise) and management, 2) to monitor and manage the job queues 3) to evaluate, monitor and assess the data quality 4) to monitor the performances of the data center. Some of these SW will come with the HW or from an open source domain, but others need to be acquired (licenses for modeling and programming).
Participants: G. Longo, M. Paolillo, G. Covone, G. Acampora, M. Staiano (UniNA), M. Brescia (INAF OACN, UniNA)
National/international collaborations: coordination with CSI (Centro Servizi Informativi) of UniNA, which has the technical management of the Data center, and with INFN Napoli, which also uses the same Data Center, but with different racks. Coordination with ESO-ELT, Vera Rubin Telescope and SKA consortiums to define policies of data access.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

198.660,00 €

Cost description: Database Manager, Software implementation and testing

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

85.000,00 €

Cost description: software licenses

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

19.857,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

ConcurrentDesignFacility_PrimaryNodeOACN

49 Activity short name

3201

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACN	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

A historical building of INAF OACN, in Naples, will be converted into a Concurrent Design Facility, hosting a set of workspaces, advanced manufacturing tools and dedicated hardware to improve the engineering process. Two CDF facilities will be provided (see Figure 5). The main will host n.15 workstations, equipped with computers, HW accessories, videoconference tools and dedicated SW for each involved discipline. The auxiliary room will host n. 5 workstations for splinter meetings and dedicated design sessions. A concurrent engineering tool manages data from different SW's and allows the sharing of information and design steps with other facilities, including a cloud approach for licenses and data storage, according to the European framework Gaia-X Hub. Augmented and virtual reality are employed for better understanding of design concepts and critical aspects. Moreover, this activity will comprise the procurement, set-up and maintenance of all SW elements that support the management of the different WPs and the project at large. The foreseen supporting tools are industry standard and in current use in the main Institutions like ESO, ESA. The facility will act as the coordinating node of a CDF network distributed over the national territory, acting as cloud host for SW and storage, in accordance with European Gaia-X Hub Italia. Two other nodes of the network shall be installed in IRA (related to SKA activities) and OAS (related to ELT activities, like the OACN facility). Currently, the CDF will be the first facility of this kind in Southern Italy, with the aim of becoming a reference hub for the design activities of Research Institutes and companies of the area. The CDF will also prove useful for outreach purposes, training of personnel, and in consolidating the strong collaboration with the University of Naples Federico II, paving the way for new common research interests. E. Cascone, V. De Caprio, A. Di Dato, L. De Filippis (OACN).

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

453.000,00 €

Cost description: Hardware for concurrent engineering facility; Software: Product data management tool, Mechanical CAD, Electrical CAD, Optical CAD, PA/QA tool, DOORS, JAMA, Cameo, Atlassian Jira; Large projection screen/screens, A/V system for TLC and furniture; Hardware and software tools for virtual reality and augmented reality

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

703.295,00 €

Cost description: Excavation, demolition, backfill

54.5 e. Indirect costs

80.941,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AdvancedSW_PSFSimulations

49 Activity short name

3301

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAPD	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The INAF "MASTER" collaboration encompasses the activities 3301, 3302, 3303 and 3304 to jointly pursue the goal of producing an ensemble of software (SW) tools for the scientific exploitation of the data produced by Adaptive Optics (AO) equipped facilities. These activitiesare based in several INAF departments and are devoted to data simulations, PSF extraction SW tools, PSF fitting SW, Science validation. The "MASTER" collaboration looks forward to the application of such SW infrastructure in the view of ELT observations by providing specific data training sets and simulated observations. The 3301 aims to produce AO data sets needed for the development of the SW for scientific analysis. Pursuing this goal will:
a) install a computation server with dedicated storage for AO simulations to be performed in 2023-2025, and to be left as a legacy to the

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

a) install a computation server with dedicated storage for AO simulations to be performed in 2023-2025, and to be left as a legacy to the MASTER collaboration.
b) update of INAF-made numerical simulation tools;
c) produce and distribute simulated training data sets of several AO instruments up to the size of the ELT instrumentation.
d) advertise the advancements of this and related activities with an international workshop.
In a short time, we aim to install a server dedicated to simulating the AO data from an 8m telescope to ELT instruments. The simulated data will be used by related activities for SW development and by the WP3321. We will update the INAF tools MAO and PASSATA that make intensive memory allocation and use of the flops capacity. The power of the servers currently available within the MASTER collaboration limits the simulations, especially for the ELT case. These data require large GPU and RAM space able to host long temporal data series and dense PSF sampling. Participants: OAPD: Arcidiacono, Mesa, Simioni, Gullieuszik; OAA: Agapito. Collaborations: MAORY and MICADO consortia, INAF-ADONI.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

93.600,00 €

Cost description: NAS 20 TB. Tipo: Dell EMC ME4012 Storage Array[Dell EMC ME4012] SSD disks. Storage support for the server; Server, tipo DELL PowerEdge R750 Server, 1Tb RAM, RAID5 on 4Tb SSD, 2 GPU NVidia 48Gb, 80Cores Intel Platinum. The MAO and Passata tools intensively use GPU and CPU cores. The server type here specified match the goal of producing >30sec long exposures PSF, located over a grid of 5x5 points on the Field of View of the ELT; Rack and support flanges; Licenses for Commercial Software (2023-2024-2025); laptop,

54.3 c. Open Access, Transnational Access, FAIR principle implementation

36.000,00 €

Cost description: International workshop March 2025, Padova, High Spatial Resolution at the ELT instrument, software and science

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

9.072,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: None

48 Activity title

AdvancedSW_PSFFitting

49 Activity short name

3303

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAS	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The INAF "MASTER" collaboration encompasses the activities 3301, 3302, 3303 and 3304 to jointly pursue the goal of producing an ensemble of SW tools for the scientific exploitation of the data produced by Adaptive Optics (AO) equipped facilities. The activities are based in several INAF departments and are respectively devoted to: data simulations, PSF extraction SW tools, PSF fitting SW tools, PSF SW validation. The "MASTER" collaboration looks forward to the application of such SW infrastructure in the view of ELT observations by providing specific data training sets and simulated observations. The 3303 activity aims at releasing an open source SW for the deep analysis of stellar fields based on the INAF code Starfinder. Starfinder is largely diffused in the scientific community and it has been specifically designed for AO well-sampled images, characterized by a complex and highly structured Point Spread Function (PSF) variable across the Field of View. This SW will be fully compatible with PSF models obtained through the PSF-R technique. A 30 month fixed-term contract will be 100% dedicated to the improvement of Starfinder with two main objectives:
a) The optimization of the existing SW to allow a more efficient use in the presence of large format images (as expected from the ELTs instrumentation);
b) The translation of the SW into an open source language (Python) to drastically increase its catchment area. Even though Starfinder is already free and available to the community, it is written in IDL, which is not open source.
The release of the final SW will be openly distributed at T0+28(30), following the FAIR principle.
Participants: Schreiber, Diolaiti, TD (OAS). National/international collaborations: Institut de Planétologie et d'Astrophysique de Grenoble (IPAG), Laboratoire d'Astrophysique de Marseille (LAM).

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

85.000,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Contract to a software company; Laptop and workstation equipment; Development tools software licenses (IDE)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

5.950,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

ConcurrentDesignFacility_AncillaryNodeOABR

49 Activity short name

3202

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The activity is based on the creation of a CDF node at INAF OABR. This structure will host a dedicated environment made up of 5 integrated design stations, each one equipped with specific hardware and software for concurrent multidisciplinary design. A further element of innovation is represented by the integration of virtual reality instrumentation, for the evaluation and validation of design choices. This infrastructure allows a coordinated and multidisciplinary effort in the design phase, during the feasibility study and the preliminary design phase, significantly optimizing development times and the quality of the contribution offered by all working groups

d) PROJECT WORK BREAKDOWN STRUCTURE - [3000 - InformationTechnology]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

preliminary design phase, significantly optimizing development times and the quality of the contribution offered by all working groups during all phases of the project. The OABR CDF is part of a network of CDFs distributed throughout the country, connected to each other through a process data management software system. The facility installed at OACN will act as the coordinating node of a CDF network distributed over the national territory. Actual collaboration with MEchanical and Aerospace Department of Politecnico di Milano will sustain the development of use of CDF and VR approach to design of various phases of instruments, like Virtual assisted integration procedure definition and or enhanced reality assisted Maintenance. The concept of modular slave node will be possibly expanded in future to other facilities within INAF; it will also enable the possibility to link the INAF web to other CDF existing nodes. Possible expansion in this field is identified thanks to the previously described collaboration with Politecnico di Milano.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

95.000,00 €

Cost description: Hardware and software for 2-5 concurrent engineering workstations; Large projection screen/screens and A/V system for TLC; VR/AR systems

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

6.650,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

33 Timing of the different work packages: See documents uploaded

34 WP inter-relation with other WPs: See documents uploaded

35 Costs Scheduling according with the Intermediate Objectives:

Bimester	Title	Costs	**Cumulative Costs**
3	Team finalisation and calls for tender	131.610,00	131.610,00
6	Conclusion of calls for tender	302.692,00	434.302,00
9	Short Lead Items Delivery	1.208.982,00	1.643.284,00
12	Medium Lead Items Delivery	158.028,00	1.801.312,00
15	Long Lead Items Delivery	2.210.503,00	4.011.815,00

36 WP title

ExoLabs

37 WP number

4000

38 Start month(relative to kick-off of the project) and **duration** (in month)

WP Start	1	WP Duration	30

39 OU(s) participating to the WP

OU Short Name	**OU Name**	**Applicant**
OAPA	Osservatorio Astronomico di Palermo	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
UniTV	Department of Physics, University of Rome "Tor Vergata"	CO-APPLICANT: Università degli Studi di Roma Tor Vergata
OACN	Osservatorio Astronomico di Capodimonte	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

40 WP Leader

Angela Ciaravella

41 Summary of the activities envisaged in the WP

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

41 Summary of the activities envisaged in the WP

Laboratory experiments simulating astrophysical environments play a key role in the interpretation of our universe. Filling some of the crucial gaps that hinder our capability to interpret observations of planetary atmospheres, highly ionized media and environments of astrobiological interest, is the common thread that binds the activities described in this WP. The needs for extremely accurate spectroscopic data are of particular relevance as ELT and future telescopes will provide detailed and sensitive observations with high resolution in a wide spectral range. Specifically, ELT will offer
- an unprecedented look at planetary atmospheres, which allows a significant increase in understanding how and what types of planets form, and what makes them habitable. The interpretation of the expected wealth of data requires the production of spectroscopic data, and a better insight into chemical reaction kinetics, both thermal and radiation-induced, at a broad range of temperatures, under conditions that may be totally at odds with the "familiar" characteristics of our own planetary system. The Exo-Atmosphere Laboratory will contribute to this framework.
- a view of currently inaccessible faint high-energy environments; these regions will be probed with spectrographs capable of very high resolution and large wavelength coverage. A test case highlighting the lack of atomic data for highly ionized species is provided by high temperature plasma in stellar atmospheres. The Laboratory Plasma Spectroscopy will produce spectroscopic measurements from UV to NIR of plasma emission with the ultimate goal of populating atomic databases.
- observations of solar system bodies from planets to moons, small primitive rocky and icy bodies such as asteroids and comets. Through these observations it will be possible to search and identify features of complex organics of prebiotic interest. ThePre-BioticLab_SurfLab and the laboratory at OACN will address this task providing robust signatures of biomolecules relevant to the origin of life.

42 WP inter-relation with other WWPP

This WP does not have dependencies with any other WP, as it is dedicated to the independent acquisition of equipment, software and labor.

43 Most relevant outcome:

The most relevant outcome of the WP4000 is the construction of three astrophysical laboratories and the upgrading of an existing one. These laboratories will produce a wealth of data for the interpretation of the future observations provided by ELT and space telescopes.

a) An Exo-Atmosphere Laboratory at OAPA will be designed and constructed to study the chemical and physical evolution of gas mixtures resembling exoplanetary atmospheres subjected to extreme-ultraviolet photons and X-rays, under a wide range of physical, chemical and environmental conditions. These spectral bands produce phenomena that cannot be caused in other lower-energy bands, regardless of their larger fluxes. An electron discharge system simulates lightning events inside the atmosphere. The laboratory will be embedded in a network of international laboratory facilities preparing for the expected enormous amount of exo-atmospheric data by the present and future telescopes.

b) A Laboratory Plasma Spectroscopy at OACT will be dedicated to the identification of spectral lines emitted by elements in high ionization states from UV to NIR. The goal is to fill the gaps in atomic databases, to provide a re-interpretation of past data, and a correct analysis of present and future spectroscopic data. The need for UV atomic data is related to the red-shifted objects observed with ELT spectrographs at the visible and near-infrared wavelengths. The laboratory will be the first one specialized in cataloguing and measuring spectral lines of highly ionized elements. These studies will make a step forward in atomic physics with a significant impact on high-energy astrophysics.

c) The new laboratory at the UniTV and the upgrading of the existing one at OACN will be dedicated to investigating the bonds between complex organic molecules (such as amino acids), and the role of the substrate onto which they are adsorbed under different physical and radiative conditions.
The goal is to verify if and under which conditions peptide bond formation may occur and study their interaction with minerals of astrophysical and astrobiological interest in spectral ranges compatible with ELT.

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

44 List of WP deliverables that will be available according with the timing set by the Intermediate Objectives:

Title	Bimester	Deliverables
Team finalisation and calls for tender	3	This IO is made of three deliverables, each documented in a relevant report: D4101 Report on team hiring It contains a summary of the hiring procedures and team composition D4102 Final design of instrumentation It contains the final design for the instrumentation to be procured D4103 Report on calls for tender It contains the list of calls for tender issued at the end of the period, and of those that are still to be issued, if there are.
Conclusion of calls for tender	6	D4201 Report on calls for tender It contains the list of calls effectively completed and assigned at the end of the period, and of those that are still to be assigned. D4202 Report on staffing It contains an update of the staff allocation within the WP.
Short Lead Items Delivery	9	D4301 Report on SLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the remaining SLI items. D4302 Report on staffing It contains an update of the staff allocation within the WP.
Medium Lead Items Delivery	12	- D4401 Report on MLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the SLI items which were not delivered at the end of IO3. It also includes an outlook of the procurement procedures for the Long Lead Items. - D4402 Report on staffing It contains an update of the staff allocation within the WP.
Long Lead Items Delivery	15	D4501 Report on LLI procurement It contains the list of LLI effectively delivered, as well as of all other items that have been procured within the project D4502 Report on staffing It contains a final report about the team engaged in the WP.

45 Objective, quantitative, and measurable indicators relevant to the monitoring and ex-post assessment of the expected results:

Title	Bimester	Objective, quantitative, and measurable indicators
Team finalisation and calls for tender	3	-Number of team member hired and fraction over the total planned number. -Number of instrument/laboratory design completed and fraction over the total planned number -Number of calls for tender issued and fraction over the total planned number
Conclusion of calls for tender	6	-Number of calls for tender completed and assigned, and fraction over the total planned number

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

calls for tender		planned number -Fraction of the staff that is hired, compared to planned.
Short Lead Items Delivery	9	-Amount of SLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Medium Lead Items Delivery	12	-Amount of MLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Long Lead Items Delivery	15	-Amount of LLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.

46 WP Intermediate Objectives:

IO Title *Team finalisation and calls for tender*

IO Bimestre *3* IO Costs *131.610,00*

IO Desciption

This IO closes the first part of the project, where a) the hiring procedures are concluded and the team is assembled; b) design phases of the instrumentation is completed and c) main calls for tender for instrumentation procurement are completed and released.

IO Title *Conclusion of calls for tender*

IO Bimestre *6* IO Costs *302.692,00*

IO Desciption

This IO closes the second part of the project, where major calls for tender have been closed and the relevant contracts assigned. We also keep reporting about the team, with an update about the staffing situation.

IO Title *Short Lead Items Delivery*

IO Bimestre *9* IO Costs *1.208.982,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Short Lead Items (SLI) that - by definition - can be purchased in a short time. We shall present a list of the SLIs obtained within the period, and of those which haven't been delivered yet. We also keep reporting about the team, with an update about the staffing situation.

IO Title *Medium Lead Items Delivery*

IO Bimestre *12* IO Costs *158.028,00*

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Medium Lead Items (MLI) that - by definition - are purchased in about one year. We shall present a list of the MLIs obtained within the period, and of those which haven't been delivered yet. We also include a final report on the delivery of SLI that were still pending at the end of IO3, and an outlook of the procurement procedures for the Long Lead Items. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Long Lead Items Delivery*		
IO Bimestre	*15*	IO Costs	*2.210.503,00*

IO Desciption

This IO reports about the final procurement of the instrumentation, with an emphasis on Long Lead Items (LLI) that - by definition - are purchased by the end of the project. We shall present a list of the LLIs obtained within the period, as well as of all other items that have been procured within the project. We will also include a final report on the delivery of all items that were still pending at the end of IO4. We also provide a final report about the team.

47 WP budget description

Cost of fixed term personnel specifically hired for the project

Cost description: The activities of the WP4000 include 3 units of personnel devoted to:
1)designing, assembling and testing the Exo Atmosphere Laboratory
2)designing, assembling and testing the Pre-BioticLab_SurfLab (UHV chamber, XPS/UPS)
3)opto-mechanical interface and installation of EBIT, FTS and laser-comb

Scientific instrumentation and technological equipment, software licenses and patent

Cost description: Exo Atmosphere Laboratory:
•Custom made vacuum chamber with pumping system and a gas temperature control system
•Sources: EUV source and monochromator, soft X-ray sources
•e- discharge power supply
•Diagnostics Instruments: IR Spectrometer (NIR-MIR), Mass/energy analyzer for ions, neutrals and radicals, Cavity ring-down system
•Valves, pressure gauges, UHV fittings.

Pre-BioticLab_SurfLab Laboratory:
UHV system including:
•a chamber for sample analysis (XPS/UPS/ARPES/AES measurements) with pumping units and pressure gauges.
Energy hemispherical analyzer for XPS, UPS, AES, SAM, ISS and LEIS.
X-ray source with monochromator
•A preparation chamber, with pumping system, introduction system of samples into the main chamber, evaporation cells, thickness monitor, with flange to couple with preparation cell in liquid. The chamber is equipped with a

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

into the main chamber, evaporation cells, thickness monitor, with flange to couple with preparation cell in liquid. The chamber is equipped with a quadrupole residual mass analyzer and a quartz microbalance
•UHV valves; windows; feedthrough for voltage, motion, fluids, flanges, gaskets.

Laboratory at OACN:
•UV-VIS-NIR fiber optic reflectance module (spectrometer + integrating sphere + accessories)
Reflectance system (reaction chamber + temperature controller + Praying Mantis and accessories) for Vertex 70v spectrometer.
•Pumping system for the NIR-MIR reflectance system (pumps, pump controllers, pressure sensors, valves, flanges and fittings).
•Small laboratory instrumentation/equipment/samples (standard samples and minerals for calibration and test experiments, spectrometer fittings, windows, optics, optomechanic items, gases.)

LaboratoryPlasmaSpectroscopy:
•Electron Beam Ion Trap complete of: vacuum system, cabinet with control system hardware, injection kit for element injection through volatile compounds (MIVoC), heating tent incl. temperature control, spare electron gun head, metal ion injection kit incl. quadrupole beam bender and liquid metal ion source (LMIS), X-ray spectroscopic equipment (detector, Be-window, time and energy resolved x-ray detection electronics TERX)
•High resolution Spectrograph calibrated in wavelength covering the 200-2500 nm range with Resolution larger than 100000
•Laser-Comb System for absolute calibration of Visible and Near-Infrared wavelengths
•Optomechanics, positioners, vacuum and cryogenics.

Open Access, Transnational Access, FAIR principle implementation

Cost description: Not applicable

Civil infrastructures and related systems

Cost description: Not applicable

Indirect costs

Cost description: Indirect costs (7% of all direct costs) will be primarily dedicated to support the administrative activities related to the project. In particular, they will serve to hire specific personnel dedicated to issue and follow the many calls for tenders that will be needed to procure all the deliverables of the project.
Indirect costs will also be used to refund travels directly related to the specific project, consumables and other similar expenses.

Training activities

Cost description: Not applicable

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

48 Activity title

ExoAtmoLab

49 Activity short name

4101

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAPA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Goal of the activity is the design and construction of an atmosphere simulator facility to explore the chemical and physical evolution of gas mixtures resembling exoplanetary atmospheres subjected to extreme ultraviolet photons and X-rays, under a wide range of physical, chemical and environmental conditions.
These spectral bands produce phenomena that cannot be caused in other lower-energy bands, regardless of their larger fluxes.
The facility consists of a chamber reaching a pressure of < 10-8 mbar before introducing the atmospheric gas. The working pressure ranges from 10-6 mbar to 1 bar. Two photon sources EUV and Xrays are used to mimic the high energy component of the parent stellar emission. An electron discharge system simulates lightning events inside the atmosphere. Diagnostic instruments such as IR and mass spectrometers provide monitoring of the atmosphere's evolution. A cavity ring-down system performs spectroscopic measurements of trace species in optically thin samples. The facility will produce an IR spectroscopic database which will contribute to the interpretation of exoplanetary atmospheric observations by ground based (ELT) and space telescopes (e. g. JWST and ARIEL).
Actions:
The facility will be built at the OAPA. The construction will be organized in 5 main steps:
finalizing the facility design and the hardware and the instruments;
acquisition of the hardware and instruments;
assembling the facility;
functioning tests and calibrations;
benchmark experiments and validation.
Participants: A. Ciaravella, A. Jimènez-Escobar, C. Cecchi Pestellini - OAPA
Collaborators: O. Maragò, M. G. Donato (IPCF, ME), Y-J Chen (NCU, Tw), G. M. Muñoz Caro (Centro de Astrobiología, Spain), N. Carrasco (UVSQ, France).

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

99.760,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: - 1 yr to design, test and calibrate the facility

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

430.000,00 €

Cost description: - Custom made vacuum chamber.
- Pumping system.
- Cavity ring-down system.
- Gas temp control system.
- UV/EUV source and monochromator.
- Soft X-ray source.
- e- discharge power supply.
- IR Spectrometer (NIR, MIR).
- Mass/energy analyser for ions, neutrals and radicals.
- Valves, windows and UHV fittings.

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: none

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: none

54.5 e. Indirect costs

37.083,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: none

48 Activity title

Pre-BioticLab_SurfLab

49 Activity short name

4201

50 Activity Start month and duration

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UniTV	Participant	Università degli Studi di Roma Tor Vergata

52 Activity description

Goals: The present project aims at setting up a laboratory to investigate the interactions between complex organic molecules of astrobiological interest (e. g., amino acids) and minerals, using the experimental methods of surface physics. The laboratory setup will provide a deep analysis of the conditions for the reactions and the properties of the formed molecule assembly. In detail, the deposition of molecules on mineral surfaces will be carried out in different, highly controlled environments. Then the properties of the molecule layers will be studied. The scientific final goal is to verify by the detection of a specific physical response if and under which conditions peptide bond formation may occur. The main goal is to set up a UHV system designed and assembled to investigate the evolution of bonding between simple biomolecules adsorbed onto solid surfaces, at different temperatures, in different environments (vacuum, liquid), under different pH conditions and sources of space weathering processing (e.g., electrons, ions). The lab will be provided with:
i) UHV chamber for sample characterization and analysis, in ultra-high vacuum conditions (< 10-10mbar), with XPS and UPS techniques to investigate the chemical bond between molecules and the eventual development of molecular bands after bonding;
ii) variable Temperature manipulator, to prepare the substrate and mimic a broad range of environments of astrophysical interest, from the Earth' surface to the low T of cosmic dust grains in dense clouds of the interstellar medium (15 K);
iii)ion gun and electron gun to mimic the effects of the solar wind onto aggregates of molecules.
Actions: Design of the complete UHV system; UHV chamber, XPS, UPS, and manipulator acquisition; Ion and electron gun acquisition; Installation and setting of the UHV system; Calibration and testing of the laboratory with samples of known proprieties. Testing of the laboratory using samples of astrobiological interest.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

170.280,00 €

Cost description: - 36 months researcher with UHV and photo-emission skills

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

895.800,00 €

Cost description: - UHV chamber
- Manipulator VT with Closed Cycle He Cooling
- X-ray source
- Pre-chamber UHV for sample introduction and preparation (equipped with manipulator , Knudsen source and ion gun).
- LEED system
- Energy hemispherical analyzer
- UHV fittings.

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: none

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: none

54.5 e. Indirect costs

74.626,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: none

48 Activity title

Pre-BioticLab_OptSpectrLab

49 Activity short name

4202

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACN	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

In trying to understand the origin of life, a promising scientific approach is to reproduce the conditions where chemical reactions lead to the formation of biomolecules. Among the still unanswered questions, one is the possible role of substrates (e.g. minerals on Earth and cosmic dust grains) which may have favored such reactions.
Activity (#4202) aims at upgrading the facilities present @OACN, to allow the UV-VIS-NIR and NIR-MIR analysis and characterization of minerals of astrophysical interest and their interactions with amino acids. The facilities existing @OACN will be upgrated by adding:
i) an UV-VIS-NIR fiber optic module (spectrometer plus integrating sphere plus accessories) that allows to acquire reflectance spectra in this spectral range. This remarkable upgrade will allow to work with thick samples, more common and easier to treat/handle in the laboratory. Calibration and testing activities will be performed within the project timeframe.

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

laboratory. Calibration and testing activities will be performed within the project timeframe.
ii) to the Vertex 70v spectrometer (NIR-MIR), a module (reaction chamber + accessories + pumping units) that allows to acquire spectra in reflectance and at temperatures above room temperature. This experimental upgrade will significantly expand the analytical characteristics of the instrument. Calibration and testing activities will be performed within the project timeframe.
Activity #4202 will be led by Dr. Daniele Fulvio, INAF-OACN, Naples (IT). His main field of research is laboratory astrophysics, with main expertise in UV-VIS-NIR and NIR-MIR spectroscopy.
Activity #4202 will also benefit of complementary expertise by the following collaborators:
- Prof. Claudio Goletti, Dept. of Physics, University of Rome Tor Vergata, Rome (IT);
- Prof. Adele Sassella, Dept. of Materials Science, University of Milano - Bicocca, Milan (IT);
- Prof. Thomas Henning, Director Max Planck Institute for Astronomy, Heidelberg (DE);

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: none

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

70.000,00 €

Cost description: - UV-VIS-NIR fiber optic reflectance module (spectrometer + integrating sphere + accessories).
- Reflectance system (reaction chamber + temperature controller + Praying Mantis and accessories) for Vertex 70v spectrometer.
-Pumping system for the NIR-MIR reflectance system (pumps, pump controllers, pressure sensors, valves, flanges and fittings).
-Small laboratory instrumentation/equipment/samples (standard samples and minerals for calibration and test experiments, spectrometer fittings, windows, optics, optomechanic items, gases.)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: none

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: none

54.5 e. Indirect costs

4.900,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: none

48 Activity title

LaboratoryPlasmaSpectroscopy

49 Activity short name

4301

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACT	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Goals: Implementation of the first Astrophysical laboratory dedicated to the spectroscopic identification and characterization of emission lines from highly ionized atoms in the UV, VIS and NIR ranges. The ultimate goal is an atomic database for the re-interpretation of past data and correct analysis of present and future data, in particular forthcoming ELT high-resolution spectroscopy.
We propose here a system made of selected state-of-the-art devices to collect spectra for a vast atomic database:
1) "Electron Beam Ion Trap" (EBIT) to produce and confine ionized atoms up to Xe46+,
2) Fourier Transform Spectrograph (200-2500 nm, R>100000), and 3) components to develop VIS+NIR laser-comb systems for absolute wavelength calibration and very fast Fourier Spectroscopy, that is mandatory to cover the extremely extended wavelength range.
Acquired data will be stored according to FAIR principles.
The UV data are fundamental to understanding the red-shifted objects observed at the visible and NIR wavelengths. The development of a new concept of Ultra-BroadBand Astrocomb (based on a highrepetition rate mode-locked microlaser frequency stabilized with respect to an atomic clock) will be applicable to TNG and ELT high-resolution spectrographs.
Actions:
EBIT acquisition;
FTS acquisition;
acquisition of components for laser frequency combs;
FTS+EBIT+Combs optical and SW interfaces.
Participants: F. Leone, I. Busà, G. Catanzaro, A. Frasca, M. Munari – (OACT)
Collaborators: G. Del Zanna (Cambridge University); E. Landi (University of Michigan); G. Galzerano (Ist. Fotonica CNR Milano); P. Laporta (Dip. Fisica del Politecnico Milano); M. Cecconi, R. Cosentino, A. Ghedina, A. Harutyunyan, E. Poretti – (TNG)

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [4000 - ExoLabs]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: - 1 yr TD will be in charge for procurement, opto-mechanical interface and Spectroscopy.

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

1.970.000,00 €

Cost description: - Plasma Source.
- FTS Spectrograph
- Broad-Band Laser Comb
- Optomechanics, positioners, vacuum and cryogenics
-CAD licenses

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: none

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: none

54.5 e. Indirect costs

145.846,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: none

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

33 Timing of the different work packages: See documents uploaded

34 WP inter-relation with other WPs: See documents uploaded

35 Costs Scheduling according with the Intermediate Objectives:

Bimester	Title	Costs	**Cumulative Costs**
3	Team finalization and calls for tender	83.139,00	83.139,00
6	Conclusion of calls for tender	295.705,00	378.844,00
9	Short Lead Items Delivery	1.210.555,00	1.589.399,00
12	Medium Lead Items Delivery	8.609.605,00	10.199.004,00
15	Long Lead Items Delivery	16.640.309,00	26.839.313,00

36 WP title

Instruments

37 WP number

2000

38 Start month(relative to kick-off of the project) and **duration** (in month)

WP Start	1	WP Duration	30

39 OU(s) participating to the WP

OU Short Name	**OU Name**	**Applicant**
OAS	Osservatorio di astrofisica e scienza dello spazio	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
IRA	Istituto di Radioastronomia	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAS	Osservatorio di astrofisica e scienza dello spazio	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAPD	Osservatorio Astronomico di Padova	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

40 WP Leader

Paolo Ciliegi

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Paolo Ciliegi

41 Summary of the activities envisaged in the WP

The goal of the WP2000 is an upgrade of most relevant instruments and facilities related to ELT and SKA in which INAF is currently involved. INAF has a long tradition of building ground based astronomical instruments, both in the radio and in the optical/near-infrared bands. The delivery by INAF of a large number of successful instruments to the suite of ESO telescopes and to the LBT, the construction of important national astronomical radio facilities (like the 32 m single dishes in Medicina (BO) and Noto, and the 64 m Sardinia Radio Telescope) testify the commitment and expertise of the entire INAF technology segment in this domain. These activities have naturally led to strong cooperation with various branches of national industry in the course of the last decades.
In some specific fields, such as adaptive optics in the optical and near infrared bands and design and development of radio antennas and detectors, internationally-recognized leadership has emerged not only for INAF but also for several Italian companies.

This technological leadership has led Italy to play a key role in the world-leading facilities operating in the radio and optical/near-infrared bands, such as VLT, LBT, ELT, LOFAR, MeerKAT, and SKA, also favouring scientific leadership. Currently INAF is strongly involved in the construction of the two ground based telescopes that will dominate the landscape in the next 50 years: ELT and SKA. This WP is devoted to strengthening Italian leadership through the upgrading of some of the key instruments and facilities in which INAF is currently involved. These upgrades will boost their scientific performance, by developing new solutions and methods for future generations of instruments in the domain of adaptive optics and radio detectors the instruments involved in this Work Package are MORFEO (formerly know as MAORY), SPHERE+, NIRVANA on the optical/near infrared side, and MeerKAT UHF and Band 5 receivers on the radio side. Moreover the WP is devoted to hiring fixed-term scientific positions to exploit the scientific capability of the upgraded instruments. For each activity, we report below a summary of the envisaged activities:

MORFEO2DM: the goal of this activity is to upgrade the MORFEO instrument, providing it with a second deformable mirror (DM). MORFEO is the adaptive optics module for ELT under construction by an international consortium led by INAF. There are 6 different INAF institutes inside MORFEO (OAS, OAA, OAB, OAPD, OACN, OAAB), one in France (IPAG Grenoble) and one in Ireland (NUIG Galloway) with more than 70 people involved and about 500 FTE planned to complete the project. The MORFEO project is funded by an agreement signed by INAF and ESO in December 2015. The agreement provides for the financing of the whole instrument but of only one DM inside MORFEO. We propose to finance the purchase of the second DM for the MORFEO instrument. This will allow the MORFEO instrument (and the ELT telescope in general) to make a great breakthrough, pushing the system toward maximal performance, increasing the stability under different conditions with an impressive impact on scientific productivity. It will also open the way for future generations of adaptive optics modules, being the first instrument in the world to work simultaneously with 3 deformable mirrors.

NirvanaVIS. Nirvana is a high resolution, near infrared imager operating at the LBT telescope. The instrument has been designed, constructed, installed and commissioned at the telescope by a German-Italian Consortium. The goal of this activity is to upgrade the NIRVANA imager into the visible range using a checker-board-array of detectors operation in the visible domain and implementing an adaptive optics assisted speckle holography technique. The INAF OAPD team proposing this upgrade was already part of the original consortium that built the instruments, ensuring the complete knowledge of the instrument and the necessary experience to complete the project. Opening a high spatial resolution window also in the optical domain will open new science opportunities in many different astronomical fields. Finally, although NirvanaVIS will upgrade an instrument already working on LBT, its implementation will constitute a pathfinder for the development of this technology for the next generation telescopes as ELT.

SPHERE+ The research of exoplanets is one of the key topics of astronomy in the coming decades. The Spectro-Polarimetric High contrast imager for Exoplanets REsearch (SPHERE) on the ESO's VLT Telescope is an instrument dedicated to the observation of exoplanets allowing imaging of young Jupiter-like planets in large orbits. The next generation of this kind of instrument will be the Planetary Camera and Spectrograph (PCS) for ELT which will allow direct observation of telluric planets (namely Super Earths) and to analyse the presence of Oxygen bands in their atmosphere. Achieving high contrast for Earth-like planet imaging translates in controlling the wavefront aberrations at unprecedented precision. As a consequence, PCS requires a breakthrough concept and techniques to correct for the atmospheric turbulence and various sources of aberrations on such a large telescope. These innovative techniques must be developed and tested before being implemented on ELT. In this context, SPHERE+ is an upgrade of the SPHERE instrument and an enabling technology demonstrator for the next generation of adaptive optics systems at ELT. The upgrade will be, in fact, realised

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

an enabling technology demonstrator for the next generation of adaptive optics systems at ELT. The upgrade will be, in fact, realised using innovative techniques (e.g., two stage AO approach) that are also candidate solutions for ELT PCS. SPHERE+ will boost the current performance of detection and characterization of exoplanets and disks and, at the same time, it will be a pathfinder for ELT PCS. The goal of this activity is to fund the upgrade from SPHERE to SPHERE+ in order to start the implementation phase, otherwise not fully funded at the moment, and to consolidate the INAF participation and role in the consortium.

MeerKAT Band5. MeerKAT, an array of 64 13.5 m antennas built to prove techniques and technologies ahead of SKA-Mid deployment, is proving to be one of the most sensitive radio arrays yet built. MeerKAT represents the premier radio facility in the southern hemisphere, and will remain so until it is integrated into the SKA-Mid core.
Unfortunately, due to funding constraints, MeerKAT is not equipped with receivers operating in the so-called SKA Band 5 (4.6–15.3 GHz), and the SKA Observatory has no plans to retrofit these receivers onto the 64 MeerKAT dishes, when incorporated in the SKA array. This means that the central core of the SKA will not be Band 5-capable for the foreseeable future. This limits the range of science that can be conducted with MeerKAT now and with the SKA in future.
The objective of this project is to extend the frequency coverage capability and improve the sensitivity of MeerKAT by installing 64 SKA Band 5 receivers in the 64 antennas of the array.
Deploying these receivers will enable high impact science with MeerKAT in the run up to SKA. The deployment of Band5 receivers will provide benefits also to the SKA, with a significant increase of sensitivity and substantial enhancement of image fidelity for extended emission. Moreover, these receivers will give the Italian community the chance to build technical and scientific expertise and leadership in view of the upcoming SKA surveys.

42 WP inter-relation with other WWPP

This WP does not have dependencies with any other WP, as it is dedicated to the independent acquisition of equipment, software and labor.

43 Most relevant outcome:

a) the design and delivery of an additional Deformable Mirror for MORFEO (which will become the first Multi Conjugate Adaptive Optics (MCAO) instrument operating with a 3-level cascade AO system), realising the ultimate ELT's wide-field AO capabilities
b) the realisation and delivery of an entire suite of Band 5 (5-15 GHz) detectors for MeerKAT (to be integrated into SKA later), that will open a new window on astrophysical processes in distant galaxies and our own.

44 List of WP deliverables that will be available according with the timing set by the Intermediate Objectives:

Title	Bimester	Deliverables
Team finalization and calls for tender	3	This IO is made of three deliverables, each documented in a relevant report: D2401 and D2501 Report on team hiring It contains a summary of the hiring procedures and team composition D2401 Final design of instrumentation It contains the final design for the instrumentation to be procured D2101 and D2301 Report on calls for tender It contains the list of calls for tender issued at the end of the period, and of those that are still to be issued, if there are.
Conclusion of calls for tender	6	D2101, D2201, D2301 and D2401 Report on calls for tender It contains the list of calls effectively completed and assigned at the end of the period, and of those that are still to be assigned. D2401 and D2501 Report on staffing It contains an update of the staff allocation within the WP.

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

		D2401 and D2501 Report on staffing It contains an update of the staff allocation within the WP.
Short Lead Items Delivery	9	D2201, D2301 and D2401 Report on SLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the remaining SLI items. D2401 and D2501 Report on staffing It contains an update of the staff allocation within the WP.
Medium Lead Items Delivery	12	D2101, D2201, D2301 and D2401 Report on MLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the SLI items which were not delivered at the end of IO3. It also includes an outlook of the procurement procedures for the Long Lead Items. D2401 and D2501 Report on staffing It contains an update of the staff allocation within the WP.
Long Lead Items Delivery	15	D2101, D2201, D2301 and D2401 Report on LLI procurement It contains the list of LLI effectively delivered, as well as of all other items that have been procured within the project D2401 and D2501 Report on staffing It contains a final report about the team engaged in the WP.

45 Objective, quantitative, and measurable indicators relevant to the monitoring and ex-post assessment of the expected results:

Title	Bimester	Objective, quantitative, and measurable indicators
Team finalization and calls for tender	3	-Number of team member hired and fraction over the total planned number. -Number of instrument/laboratory design completed and fraction over the total planned number -Number of calls for tender issued and fraction over the total planned number
Conclusion of calls for tender	6	-Number of calls for tender completed and assigned, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Short Lead Items Delivery	9	-Amount of SLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Medium Lead Items Delivery	12	-Amount of MLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Long Lead Items Delivery	15	-Amount of LLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.

46 WP Intermediate Objectives:

IO Title	*Team finalization and calls for tender*		
IO Bimestre	*3*	IO Costs	*83.139,00*

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

IO Bimestre	*3*	IO Costs	*83.139,00*

IO Desciption

This IO closes the first part of the project, where a) the hiring procedures are concluded and the team is assembled; b) design phases of the instrumentation is completed and c) main calls for tender for instrumentation procurement are completed and released.

IO Title	*Conclusion of calls for tender*

IO Bimestre	*6*	IO Costs	*295.705,00*

IO Desciption

This IO closes the second part of the project, where major calls for tender have been closed and the relevant contracts assigned. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Short Lead Items Delivery*

IO Bimestre	*9*	IO Costs	*1.210.555,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Short Lead Items (SLI) that - by definition - can be purchased in a short time. We shall present a list of the SLIs obtained within the period, and of those which haven't been delivered yet. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Medium Lead Items Delivery*

IO Bimestre	*12*	IO Costs	*8.609.605,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Medium Lead Items (MLI) that - by definition - are purchased in about one year. We shall present a list of the MLIs obtained within the period, and of those which haven't been delivered yet. We also include a final report on the delivery of SLI that were still pending at the end of IO3, and an outlook of the procurement procedures for the Long Lead Items. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Long Lead Items Delivery*

IO Bimestre	*15*	IO Costs	*16.640.309,00*

IO Desciption

This IO reports about the final procurement of the instrumentation, with an emphasis on Long Lead Items (LLI) that - by definition - are purchased by the end of the project. We shall present a list of the LLIs obtained within the period, as well as of all other items that have been procured within the project. We will also include a final report on the delivery of all items that were still pending at the end of IO4. We also provide a final report about the team.

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

end of IO4. We also provide a final report about the team.

47 WP budget description

Cost of fixed term personnel specifically hired for the project

Cost description: For the engineering activities related to the design and manufacturing of the instrumentation proposed in this WP, 2 (two) fixed term (TD) personnel will be hired. This two TD positions will be devoted to the following activities:

•procurement and testing of components for the 64 MeerKAT band 5 receivers and digitizers
•design and prototyping of the 64 MeerKAT band 5 Digitizers

To support the scientific activities associated with the instrumentation and facilities subject of this proposal, 5 TD personnel will be hired across the country.

Scientific instrumentation and technological equipment, software licenses and patent

Cost description: Instrumentation cost will be dedicated to:
•Design, manufacturing and delivery of the second deformable mirror for the MORFEO Instrument
•Design, manufacturing and delivery of the components needed to upgrade the LINC-NIRVANA imager into the visible range
•Purchase of the equipment for an optical laboratory and test workshop for SPHERE+
•Design, manufacturing and delivery of 64 MeerKAT Band5 receivers

Open Access, Transnational Access, FAIR principle implementation

Cost description: Not Applicable.

Civil infrastructures and related systems

Cost description: Not Applicable.

Indirect costs

Cost description: Indirect costs (7% of all direct costs) will be primarily dedicated to support the administrative activities related to the project. In particular, they will serve to hire specific personnel dedicated to issue and follow the many calls for tenders that will be needed to procure all the deliverables of the project.
Indirect costs will also be used to refund travels directly related to the specific project, consumables and other similar expenses.

Training activities

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description:	To support the scientific activities associated with the instrumentation and facilities subject of this proposal, 6 PhD students will be hired across the country.

48 Activity title

SPHERE+_SAXO+

49 Activity short name

2301

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAS	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The goal of this activity is the construction of the second-stage AO module (SAXO+) in the framework of the SPHERE+ upgrade. The module consists of two main sub-systems: an optical relay including an adaptive deformable mirror and a pyramid-based infrared wavefront sensor channel.
The end product, built within the PNRR initiative, will undergo extensive testing at INAF OAS; then it will be delivered to the SPHERE+ European Consortium for integration with the Real-Time Control System and, finally, it will be installed at the VLT for on-sky testing and demonstration of the two-stage AO approach which is also planned to be implemented in ELT PCS.
Actions include:
• project management and system engineering for this activity and for the Italian participation in the SPHERE+ consortium;
• procurement of components for the construction of SAXO+;
• optical engineering, design and implementation of SAXO+;
• thermal engineering of SAXO+;
• optical and environmental testing of components;
• Assembly, Integration and Test (AIT) of SAXO+.
Testing of components and AIT of SAXO+ are carried out using laboratories and facilities, to be refurbished and equipped with new instrumentation in the framework of activity 5101 "SPHERE+_OptIR&AO_Lab".
Management, engineering and design actions are already in progress at the moment of this writing.
Staff participants are Emiliano Diolaiti, Fausto Cortecchia, Adriano De Rosa, Matteo Lombini, Gianluca Morgante, Filomena Schiavone, Laura Schreiber, Luca Terenzi.
SPHERE+ is developed by a consortium of Institutes from different European Countries (Italy, France, Germany, The Netherlands, Switzerland) and ESO. The involved INAF institutes are: OAPD, OAS, OACN, OAB. Moreover, OAA and OAR will contribute to the scientific validation after installation at the VLT.

54 Activity budget

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

320.000,00 €

Cost description: SPHERE+ Adaptive Optics Module components

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

22.400,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

SciencePerspectives

49 Activity short name

2501

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OU short name	IRA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The investment in new instruments towards next-generation facilities like ELT and SKA would be useless without a new generation of scientists who can exploit it. The aim of this activity is to provide an intense scientific and educational program aimed at fostering the careers of younger astronomers. This will be based on a vast, coordinated wide PhD program scattered across several Universities and a high-profile, nation-wide Post-doctoral program explicitly focused on science with ELT, SKA and their synergies.
We intend to offer 5 fixed-term scientific positions across the country, 40% of them to be in Southern regions, as well as 5 PhD fellowships, 50% of which at universities located in Southern regions. Particular attention will be put on gender equality. The focus will be on scientific projects exploiting the instrumentation and observing facilities subject of this proposal. Emphasis will be given to synergic projects, exploiting a combined radio-optical approach. For the fixed-term positions we intend to offer benefits (traveling and HW equipment budget) that will allow us to attract brilliant scientists from abroad and that will facilitate movement of scientists across the country. We remark that INAF - thanks to the world-class level of its research - has a long tradition of hiring international staff. For instance, the recent 'ASTROFIT" post-doctoral program (which is similar to the national program of science positions that we propose here) has awarded about 30% of its final positions to international applicants. We expect to perform similarly, bringing new skill and competence to our Institutes.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

567.600,00 €

Cost description: 5 fixed-term scientific positions for two years across the country, 40% of them to be located in Southern regions. The focus will be on scientific projects exploiting the instrumentation and observing facilities subject of this proposal.

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

0,00 €

Cost description: None

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

66.927,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

388.500,00 €

Cost description: 5 PhD fellowships, 40% of which at universities located in Southern regions
The focus will be on scientific projects exploiting the instrumentation and observing facilities subject of this proposal. Emphasis will be given to synergic projects, exploiting a combined radio-optical approach

48 Activity title

MORFEO2DM

49 Activity short name

2101

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAS	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The MORFEO project (formerly know as MAORY) has just finished the preliminary design phase and it is entering in the final design phase. It is funded by an agreement signed by INAF and ESO in December 2015. The agreement provides for the financing of the whole instrument but of only one post focal deformable mirror inside MORFEO, with one post focal deformable mirror being possibly replaced by a rigid mirror.
An analysis of the 1DM versus 2DM photometric, astrometric and sky coverage performances was carried out. The presence of the second post focal DM increases the image quality and its stability under variations of the atmospheric conditions. In terms of scientific performance, the sensitivity will increase by 1 mag in K-band (equivalently 2 mag in H-band and over 3 mag in J-band). A 1 mag difference corresponds to a factor 6 reduction in telescope time to reach the same signal-to-noise on faint point sources. The fraction of targets for which a scientifically useful minimum Strehl Ratio can be achieved will increase by a factor 2-6 in K-band. Without the second post focal DM there will be a significant loss for science cases in all the astrophysical fields.
This activity is devoted to the design and procurement of the second DM for the MORFEO instrument. Given its complexity and size (1m class), the manufacturing will be commissioned to an external company under the supervision of P. Ciliegi (MORFEO PI) and in close cooperation with INAF experts (INAF OAA) during all phases (design, manufacturing, test and delivery), as scheduled for the first DM.
With the second DM inside MORFEO we will have, for the first time in the world, an MCAO system working simultaneously with 3 DM (considering also telescope's mirror M4). This will turn MORFEO into the world's most innovative working MCAO system, paving the way for future generations of instruments and further strengthening the worldwide INAF leadership in the adaptive optics field.

54 Activity budget

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

9.975.330,00 €

Cost description: Acquisition of the second deformable mirror for the MORFEO instrument

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

698.273,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

MeerKAT-Band5

49 Activity short name

2401

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OU short name	OACT	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Goal of this Activity is to procure all the hardware necessary for the assembly of the 64 receivers in band 5, including design and realization of new digitalisers. A sample of them will be assembled ,shipped to the site of MeerKAT where they will be commissioned.
Collaborations: Oxford University developed the Band 5 receiver system for SKA. Its role is to lead receiver assembly & integration. To enhance Italian technological expertise, a INAF team would be sent to the UK to help with the receiver assembly, with the advantage of skills transfer from the UK to INAF and reinforce the collaboration Italy-UK in view of development of second-generation instruments for the SKA (i.e. Band 6).
South Africa Radio Astronomy Observatory (SARAO) operates MeerKAT. It will be involved in system engineering, fitting of the band5 feed in the indexer platform, interfaces, technology development of digitizer, installation and commissioning
Italian Companies: development and assembly with INAF supervision. Actions are:
Procurement. The components, that include cryostats, digitizer and control electronics, will be procured from companies. The Control modules could possibly be outsourced to Italy as a unit. INAF will be responsible for the purchasing and and testing the components in INAF laboratories prior to shipment to the UK for assembly
Design and prototyping of Digitizer. The SKA Band 5 design does not include a digitizer, which would be needed to interface to the MeerKAT system. INAF will develop and build the digitisers.
Assembly and installation of a first sample of Band 5 receivers in MeerKAT dishes, technical and scientific commissioning.
To complete all the actions, new fix-term personnel and travel in support of overseas deployment are necessary.Participants are from different INAF structures: OACT(OU), OACA, IRA, OAA.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

227.040,00 €

Cost description: Two TD positions that will be devoted to the following activities:
- *procurement and testing of components for the 64 MeerKAT band 5 receivers and digitizers*
- *design and prototyping of the 64 MeerKAT band 5 Digitizers*

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

12.900.000,00 €

Cost description: Acquisition of all the mechanical elements : feeds, dewars, electronic devices
Acquisition and assembling of all the electronic boards

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: None

54.5 e. Indirect costs

918.893,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

NirvanaVIS

49 Activity short name

2201

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAPD	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Upgrading the LINC-NIRVANA (LN) imager into the visible regime using adaptive optics assisted speckle holography technique, requires installing a "checkerboard" array of sensors at the "FP-20" focal plane of the instrument. This implementation will involve just one of the two sides of LN. Science quality CMOS sensors with the characteristics needed to satisfy the requirements in terms of fast readout, low dark current, 4k-class devices with 95% quantum efficiency, and sub-electron read noise (which significantly helps with single-exposure sensitivity) are currently available on the market. A matrix of such sensors (spaced apart by the physical size of the photo-receptive area), with the entire unit mounted on precision motorized stages, will allow imaging of the whole 2 arcminutes AO-corrected FoV field of view. We will realize a new opto-mechanical design enabling such a configuration.
Selection of the COTS CMOS sensors that can match our volume and structure requirements will be part of the work. Definition of SW, data reduction techniques and that of the computing power and storage unit able to cope with a high amount of data will need to be finalized. The procurement phase will include the preparation of the call for tenders.
INAF-OAPD will lead this project. The primary personnel involved are:
Maria Bergomi (lead and procurement), Luca Marafatto (AIV), Kalyan Radhakrishnan (CMOS selection and commissioning at the telescope), Carmelo Arcidiacono (Algorithms and computing units), Jacopo Farinato (AIV), Roberto Ragazzoni, and Davide Greggio (Optical design, selection of optical components).
It will be an international collaboration, given the participation of colleagues from MPIA in Heidelberg, including the PI of the LN instrument, and it will take advantage of the sharing of knowledge inside the ADONI network.

d) PROJECT WORK BREAKDOWN STRUCTURE - [2000 - Instruments]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

705.000,00 €

Cost description: C-MOS cameras
Optics, mechanics and high precision motorized stage
Computer, storage HDD, electronics
Cooling system

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

49.350,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

33 Timing of the different work packages: See documents uploaded

34 WP inter-relation with other WPs: See documents uploaded

35 Costs Scheduling according with the Intermediate Objectives:

Bimester	Title	Costs	**Cumulative Costs**
3	Team finalization and calls for tender	2.427.668,00	2.427.668,00
6	Conclusion of calls for tender	713.576,00	3.141.244,00
9	Short Lead Items Delivery	647.236,00	3.788.480,00
12	Medium Lead Items Delivery	2.785.096,00	6.573.576,00
15	Long Lead Items Delivery	5.341.323,00	11.914.899,00

36 WP title

National Testing Facilities

37 WP number

6000

38 Start month(relative to kick-off of the project) and **duration** (in month)

WP Start	1	WP Duration	30

39 OU(s) participating to the WP

OU Short Name	**OU Name**	**Applicant**
UNIMI	Dipartimento di Fisica - Università degli Studi di Milano	CO-APPLICANT: Università degli Studi di Milano
OAA	Osservatorio Astrofisico di Arcetri	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
IRA	Istituto di Radioastronomia	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
IRA	Istituto di Radioastronomia	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAB	Osservatorio Astronomico di Brera	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAA	Osservatorio Astrofisico di Arcetri	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAB	Osservatorio Astronomico di Brera	APPLICANT: INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OAB	Osservatorio Astronomico di Brera	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAPA	Osservatorio Astronomico di Palermo	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OACT	Osservatorio Astrofisico di Catania	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAAB	Osservatorio Astronomico d'Abruzzo	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAAB	Osservatorio Astronomico d'Abruzzo	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
OAS	Osservatorio di astrofisica e scienza dello spazio	APPLICANT: INAF - Istituto Nazionale di Astro Fisica
UNIBO-DIFA	Department of Physics and Astronomy "Augusto Righi"- Alma Mater Studiorum – University of Bologna	CO-APPLICANT: Alma Mater Studiorum - Università di Bologna

40 WP Leader

Pietro Bolli

41 Summary of the activities envisaged in the WP

The main goal of WP6000 is to strengthen the capabilities of INAF testing facilities therefore enabling innovative concepts and technologies. Having state-of-the-art laboratories equipped with the most updated instruments is key to maintaining, for the next decades, a leading role in new instrument developments.
INAF technological staff is employed throughout the entire development process of several scientific instruments. This process starts from the preliminary design for the proof of concept and ends to the delivery and integration of the instrument to the observing infrastructure. A fundamental phase of this long path is represented by the experimental activities performed in the INAF testing facilities for verification and acceptance before delivery.
The facilities distributed throughout the structures of INAF were originally built to serve the electronics, mechanical and optical needs of the instruments installed in the local observatories. Several generations of skilled personnel are grown in these laboratories and nowadays they represent one of the most important legacies of INAF.
After the establishment of INAF in 1999 and the starting of the new epoch of International projects, the local-scale laboratories have started to be reconfigured providing unique capabilities in a synergic approach of a National network. This has proven to be successful as demonstrated by the role that these laboratories have nowadays in the development of new instruments. An example of one of the most advanced testing facilities for optical instruments is the integration hall located at the premises of INAF-OAS (Bologna), which has been recently refurbished. The overall dimensions of the hall made it well suited for the integration of large size instruments as those required for ELT. As a result of this effort, this integration facility is recognized to be the reference facility for the integration of MAORY, foreseen in the period 2024 - 2028, and of potential interest for other instruments like ANDES (aka HIRES). It is worth noting, as a second example, the capabilities in optomechanical devices for ground-based astronomical telescopes and instrumentation developed in the lab of INAF-Brera (Milan), which contributed to instruments for VLT Observatory (X-Shooter, ESPRESSO, …) and is currently involved in the optomechanical design and implementation of instruments for ELT (MAORY and ANDES).
In the radio domain, at INAF-OAA (Florence) a large expertise in antenna characterization, mainly addressed to measure the feed patterns of radio astronomical receivers for the Italian radio telescopes and for ALMA mostly making use of anechoic chambers, exists since late eighties of the 20th century. Two generations of anechoic chambers have been designed/fabricated and equipped with controlled movement systems for alignment, pointing and shifting mechanical parts to measure the antenna patterns. Similarly, INAF-IRA in Medicina acquired valuable experience in the local laboratories to develop technologies in analog and digital electronics and optical links to transport RF signals. This was eventually recognized by the adoption in the SKA-Low radio telescope of many technological devices proposed by INAF staff, such as the antenna, the optical fibre link and the digital acquisition system.Besides equipping the labs with more powerful instruments, it is of primary importance for WP6000 to pursue two other goals: 1) the refurbishment or the construction of new buildings to host the labs and 2) the creation of a new generation of skilled personnel.
The construction of new buildings or the refurbishment of previous laboratories is fundamental to ensure proper dimensions, auxiliary

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

The construction of new buildings or the refurbishment of previous laboratories is fundamental to ensure proper dimensions, auxiliary offices, modern plants (conditioning system, electrical power distribution, data network infrastructure etc) and high quality standards in the environmental conditions to take up the future challenges. Wherever it will be possible, the new laboratories will be organised to be accessible, with safety and standards precautions, to the general public for dissemination and outreach on the activities conducted, with an original "open-laboratory" approach.
As far as the human resources are concerned, this project is a great opportunity to train new personnel to facilitate the start-up of the new laboratories. In particular, we intend to make an effort in terms of training and formation of young PhD students in this advanced technological field.
WP6000 includes eight main sub-WPs, each of them composed of one or more activities. The sub-WPs are either radio-oriented or optical-oriented. Some of them include transversal laboratories that can be efficiently exploited by both fields, such as mechanical workshops, thermal and vibrational testing facilities, electronic and photonic laboratories. As said, the long-term idea would be to make the testing facilities as transversal as possible to exchange competences between the two communities. However, for the sake of simplicity, we split here the testing facilities as those conceived for radio applications:
Sub-WP6200 (AnechoicChamber): INAF-OAA and the University of Milan are involved in a synergic way to acquire a larger and wider frequency band anechoic chamber and new systems for antenna characterization (compact range and near-field, equipped with vector network analyser)respectively.
Sub-WP6800 (LowFreqAcceptanceLab): INAF-IRA will refurbish a space inside the Medicina station to host a new laboratory addressed to test and verify the quality of analog, optical and digital electronics both in prototypes and in production.
and those intended for the optical domain:
Sub-WP6300 (TestingWFInstrumentOnSky): An innovative inertial platform for on-sky testing of wide field instrument concepts will be installed in a dismissed dome of the Serra la Nave station of INAF-OACT.
Sub-WP6400 (AOCalibrationFacility): The AOCalibrationFacility aims at strengthening the technological development and the innovation capacity of INAF-OAAB in the calibration of high-resolution Adaptive Optics instrumentation, by creating a national facility to support the Italian leadership in large international AO projects for the ELT, within the framework of the INAF-ADONI National Lab.
Sub-WP6500 (OpticalIntegrationFacility): The integration hall facility at INAF-OAS will be supplemented with two further laboratories devoted to optics and electronics activities. These laboratories, one of which under the coordination of the University of Bologna, are intended to carry out tests of components and subsystems in a controlled environment with the availability of specific equipment such as optical bench, laser, oscilloscope etc.
Sub-WP6600 (StrayLightFacility): A straylight laboratory is foreseen for the INAF-OACT to measure spurious reflections or scattering. Ultimately, this facility permits the characterization of straylight for instruments, operating at two levels: measurements of scattering properties of materials and surfaces plus straylight characterization of instruments or parts of instruments.
Sub-WP6700 (OptomechTesting): This concerns state-of-the-art laboratories at INAF-OAB and INAF-OAPA for optomechanical tests with capabilities to verify the newly developed systems in the proper environment, including vibration and thermal tests. The new lab will also include cryogenic precise mechanical metrology and a profilometer to accurately measure surfaces.
Finally, Sub-WP 6100 (OAAAbetti) is equally applicable to the two frequency domains, and it consists in renovating an existing building located in the Arcetri area. The building offer an excellent opportunity to host a new generation laboratory complex with office space to support technological developments.

42 WP inter-relation with other WWPP

This WP does not have dependencies with any other WP, as it is dedicated to the independent acquisition of equipment, software and labor.

43 Most relevant outcome:

The most relevant results are new state-of-the-art laboratories equipped with the most updated instruments. The laboratories will be devoted to radio and optical domains and will assure INAF, for the next decades, a leading role in new instrument developments.
This is a unique opportunity to face the challenges required by the future instrumentation needed for SKA and ELT, ensuring a leadership role in large technological projects in optical and radio wavelengths.
The laboratories involved in this project are both geographically spread among INAF structures and devoted to

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

The laboratories involved in this project are both geographically spread among INAF structures and devoted to different branches of experimental activity. In particular, seven INAF structures (three of them located in the South of Italy, namely Palermo, Catania and Teramo) and two Universities (Milan and Bologna) will benefit from this improvement of the capabilities of the laboratories, opening new frontiers and pushing the design of instruments to a further quality standard thanks also to the "improving by testing" technique.
These testing facilities will be an asset for INAF to qualify and independently verify most of the instrumentation that INAF is developing and consequently to allow cost savings towards manufacturing industries. Also they will consolidate technology reference centres and favour the transfer of technology to the territorial small and medium-sized enterprises, consequently profiting from this investment by providing external services.
Furthermore, having a centralised endeavour to update laboratories, as the one given by this project, is key to maximise efficiency and limit redundancies. Under this perspective, the synergy between SKA and ELT communities to propose, whenever possible, common testing facilities and to establish new collaborations between the different groups is a plus of this project.
INAF testing facilities will be equipped with advanced and sophisticated instruments which are rare around the world, often overbooked and limited in performances. Just to mention some of them, INAF will be equipped with: an inertial platform capable of testing novel wide field telescopes directly on the sky; a new testing facility for the calibration of high-resolution Adaptive Optics instrumentation; new instruments to characterize the straylight of optical instruments, parts of instruments and also surfaces and materials.

44 List of WP deliverables that will be available according with the timing set by the Intermediate Objectives:

Title	Bimester	Deliverables
Team finalization and calls for tender	3	This IO is made of three deliverables, each documented in a relevant report: D6101 Report on team hiring It contains a summary of the hiring procedures and team composition D6102 Final design of instrumentation It contains the final design for the instrumentation to be procured DX603 Report on calls for tender It contains the list of calls for tender issued at the end of the period, and of those that are still to be issued, if there are.
Conclusion of calls for tender	6	D6201 Report on calls for tender It contains the list of calls effectively completed and assigned at the end of the period, and of those that are still to be assigned. D6202 Report on staffing It contains an update of the staff allocation within the WP.
Short Lead Items Delivery	9	D6301 Report on SLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the remaining SLI items. D6302 Report on staffing It contains an update of the staff allocation within the WP.
Medium Lead Items Delivery	12	D6401 Report on MLI procurement It contains the list of SLI effectively delivered, and an update of the status of the procurement procedure for the SLI items which were not delivered at the end of IO3. It also includes an outlook of the procurement procedures for the Long Lead Items. D6402 Report on staffing It contains an update of the staff allocation within the WP.

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(The information provided in this section will be evaluated with reference to criteria C1-C5)

		D6402 Report on staffing It contains an update of the staff allocation within the WP.
Long Lead Items Delivery	15	D6501 Report on LLI procurement It contains the list of LLI effectively delivered, as well as of all other items that have been procured within the project D6502 Report on staffing It contains a final report about the team engaged in the WP.

45 Objective, quantitative, and measurable indicators relevant to the monitoring and ex-post assessment of the expected results:

Title	Bimester	Objective, quantitative, and measurable indicators
Team finalization and calls for tender	3	-Number of team member hired and fraction over the total planned number. -Number of instrument/laboratory design completed and fraction over the total planned number -Number of calls for tender issued and fraction over the total planned number
Conclusion of calls for tender	6	-Number of calls for tender completed and assigned, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Short Lead Items Delivery	9	-Amount of SLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Medium Lead Items Delivery	12	-Amount of MLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.
Long Lead Items Delivery	15	-Amount of LLI procured, and fraction over the total planned number -Fraction of the staff that is hired, compared to planned.

46 WP Intermediate Objectives:

IO Title *Team finalization and calls for tender*

IO Bimestre *3* IO Costs *2.427.668,00*

IO Desciption

This IO closes the first part of the project, where a) the hiring procedures are concluded and the team is assembled; b) design phases of the instrumentation is completed and c) main calls for tender for instrumentation procurement are completed and released.

IO Title *Conclusion of calls for tender*

IO Bimestre *6* IO Costs *713.576,00*

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

IO Bimestre	*6*	IO Costs	*713.576,00*

IO Desciption

This IO closes the second part of the project, where major calls for tender have been closed and the relevant contracts assigned. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Short Lead Items Delivery*

IO Bimestre	*9*	IO Costs	*647.236,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Short Lead Items (SLI) that - by definition - can be purchased in a short time. We shall present a list of the SLIs obtained within the period, and of those which haven't been delivered yet. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Medium Lead Items Delivery*

IO Bimestre	*12*	IO Costs	*2.785.096,00*

IO Desciption

This IO reports about the status of the procurement for the instrumentation, with an emphasis on Medium Lead Items (MLI) that - by definition - are purchased in about one year. We shall present a list of the MLIs obtained within the period, and of those which haven't been delivered yet. We also include a final report on the delivery of SLI that were still pending at the end of IO3, and an outlook of the procurement procedures for the Long Lead Items. We also keep reporting about the team, with an update about the staffing situation.

IO Title	*Long Lead Items Delivery*

IO Bimestre	*15*	IO Costs	*5.341.323,00*

IO Desciption

This IO reports about the final procurement of the instrumentation, with an emphasis on Long Lead Items (LLI) that - by definition - are purchased by the end of the project. We shall present a list of the LLIs obtained within the period, as well as of all other items that have been procured within the project. We will also include a final report on the delivery of all items that were still pending at the end of IO4. We also provide a final report about the team.

47 WP budget description

Cost of fixed term personnel specifically hired for the project

Cost description: Under WP6000, seven new fixed-term collaborators are needed to reach the objectives of the project. This is reflected in approximately half of the Activities of WP6000 requiring a new unit of personnel.

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

of WP6000 requiring a new unit of personnel.

There are, basically, two main profiles for the skills of the new personnel: one is a construction site manager to follow the civil works to construct new building or refurbish existing facilities. The second one is an engineer profile specialized in one of the technologies planned in the proposal; the latter could be engineers skilled in electromagnetics, electronics, control systems or opto-mechanics, which will support the team in the installation, integration, qualification and tests of the new instruments purchased in the project.

For the two main profiles of the collaborators, the Activities which require new staff are listed here after:

Construction site manager:
ATT6101 OAAAbetti_Building-renovation
ATT6401 AOCalibrationFacility_Building

Specialized engineer:
ATT6202 AnechoicChamber_HighFrequencyTestRanges
ATT6301 TestingWFInstrumentOnSky_Instrumentssetup
ATT6402 AOCalibrationFacility_Equipment
ATT6502 OpticalIntegrationFacility_ElectronicLab
ATT6702 OptomechTesting_WindAcoustic

Scientific instrumentation and technological equipment, software licenses and patent

Cost description:

Almost 60% (corresponding to ~6.3 M€) of the overall budget requested in WP6000 is addressed to equip the testing facilities with new instruments. Eleven activities out of the forteen of WP6000 plan to purchase equipment for their testing facilities. The new equipment can be grouped in three main categories: electronics; optics; mechanics and cryogenics.

The exhaustive list of these costs, divided for each Activity and for the three categories is reported hereafter:

Electronic instruments:
ATT6201 - AnechoicChamber_AnechoicChamber: Shielded anechoic chamber
ATT6202 - AnechoicChamber_HighFrequencyTestRanges: Dual reflector compact antenna test range; Near-field measurement system; microwave instruments
ATT6502 - OpticalIntegrationFacility_ElectronicLab: Electronic laboratory to support the Bologna Integration Hall
ATT6601 - StrayLightFacility_Scatterometer: Scatterometer to measure the scattering properties of surfaces or volumes of samples
ATT6802 - LowFreqAcceptanceLab_equipment: Electronic equipment

Optical instruments:
ATT6301 - TestingWFInstrumentOnSky_Instrumentssetup: Optical bench for inertial platform and service instruments
ATT6402 - AOCalibrationFacility_Equipment: Instrumentation equipment for the calibration facility
ATT6501 - OpticalIntegrationFacility_OpticalLab: Optical laboratory to support

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

the calibration facility
ATT6501 - OpticalIntegrationFacility_OpticalLab: Optical laboratory to support the Bologna Integration Hall

Mechanical and cryogenic equipment:
ATT6701 - Optomechanical Testing Thermomechanical: Cryogenic test facility, Vibration Test facility and Optomechanical metrology
ATT6702 - OptomechTesting_WindAcoustic: Facility for the numerical simulation and testing of opto-mechanical elements subject to dynamic stresses
ATT6703 - OptomechTesting_Profilometry: Profilometer and control software

Open Access, Transnational Access, FAIR principle implementation

Cost description: Within WP6000, only activity ATT6301 - TestingWFInstrumentOnSky_Instrumentssetup is requesting budget (15 k€) for open access activities. In particular, this aims to develop a mini ICT to host a webserver presenting the facility and its possible use, to manage access requests and to archive data collected for facility users and for dissemination to the community.

Civil infrastructures and related systems

Cost description: Civil infrastructures is the second item absorbing more resources in WP6000, with a request of ~3.8 M€. Four activities have allocated budget under this item for the requalification of spaces or the construction of new building to create the suitable infrastructures (in terms of space, safety, environment conditions, etc.) to host the new testing facilities. The list of these four activities is reported here after:

ATT6101 - OAAAbetti_OAAAbetti
ATT6202 - AnechoicChamber_HighFrequencyTestRanges
ATT6401 - AOCalibrationFacility_Building
ATT6801 - LowFreqAcceptanceLab_Building-renovation

Indirect costs

Cost description: Indirect costs (7% of all direct costs) will be primarily dedicated to support the administrative activities related to the project. In particular, they will serve to hire specific personnel dedicated to issue and follow the many calls for tenders that will be needed to procure all the deliverables of the project.
Indirect costs will also be used to refund travels directly related to the specific project, consumables and other similar expenses.

Training activities

Cost description: One activity (ATT6502 - OpticalIntegrationFacility_ElectronicLab) plans to train PhD students.

48 Activity title

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

AnechoicChamber_HighFrequencyTestRange

49 Activity short name

6202

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UNIMI	Participant	Università degli Studi di Milano

52 Activity description

This work package aims at upgrading the antenna test facility available at the University of Milano. The current facility is constituted by a "small" anechoic chamber (122 cm x 122 cm x 305 cm) coupled to a scalar network analyzer for measurements up to 50 GHz and a "large" anechoic chamber (400 cm x 330 cm x 840 cm) coupled to a vector network analyzer (VNA) for measurements up to 170 GHz, soon to be complemented by the 220-330 GHz band (already purchased). This chamber is also equipped with a dual-reflector compact antenna range that allows far-field measurements up to about 20 GHz. The UniMi team has more than 15 years of experience in the field of antenna measurements and characterization and the laboratory facilities have been exploited in the context of leading astrophysical and cosmological projects (Large Scale Polarization Explorer, SRT, Q-U-I Joint Tenerife Experiment, LiteBIRD) and in support of small-medium enterprises in the field of civil radio communication.
The purpose of this activity is to upgrade the capabilities of the UniMI facility, in synergy with the National network, by improving the measurement accuracy, the frequency range, and the variety of available test methods. Together with the complementary facility at INAF/Arcetri we will be able to test a wide range of antenna systems, including SKA elements and extending to the sub-mm range. The UniMI facility will be able to perform high precision tests on electrically large antennas in a Compact Antenna Test Range up to 600 GHz, as well as small and medium size antennas up to 750 GHz in the far- and near-field configuration, depending on system characteristics (directivity, physical size, etc.). This activity is organized along two main lines:
• Substitute the current compact antenna test range with a much-improved dual reflector compact range (up to 600 GHz);
• Install a thermally-controlled planar near-field antenna measurement system.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

170.280,00 €

Cost description: Antenna test engineer (36 months)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

1.612.000,00 €

Cost description: Dual-reflector Compact Antenna Test Range
Elevation and linear positioners
RF/mmW passive components

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Temperature & relative humidity control equipment
Eccosorb absorber for anechoic chamber upgrade
VNA extension modules in the range (75-750 GHz)
Microwave optics simulation software
VNA with broadband Test Set for near-field facility
Spectrum analyzer
RF passive components and harness for wiring
Polarization axis and alignment tools
Temperature & relative humidity control equipment
Optical table (vibration isolation)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

30.000,00 €

Cost description: Lab. rooms maintenance & carpentry

54.5 e. Indirect costs

126.859,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AnechoicChamber_AnechoicChamber

49 Activity short name

6201

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAA	Participant	INAF - Istituto Nazionale

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

OU short name	OAA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The AnechoicChamber activity aims to install a state-of-the-art anechoic chamber at the Arcetri Astrophysical Observatory (OAA) with the goal to cover the range from VHF/UHF to 110 GHz of the radio frequency spectrum.
The current anechoic chamber, equipped with controlled movement systems for alignment, pointing and shifting mechanical parts, antenna under test included, is able to operate down to 2 GHz, is about 4.5 x 3 x 3 (height) m in size. The relatively small size is the real bottle-neck for capability improvement to meet the antenna test requirements of current/future international-scale projects like SKA, ALMA, as well as INAF radio astronomical instruments.
On the OAA hill there are spaces available in old disused buildings both OAA owned and shared with other Institutions, currently planned to be restored to create new research facilities. In such a scenario, an adequate space of about 8 x 4 x 4 (height) m can be made available for the new anechoic chamber.
The planned actions for the anechoic chamber installation are:
• Retraining of available spaces at OAA for the anechoic chamber installation.
• Acquisition of a readily-operating turnkey-system shielded-anechoic-chamber.
• The refurbishment of a nearby mechanical workshop with state of the art tools to fabricate in house custom mechanical parts to serve anechoic chamber operation.
Participants are 2 staff technologists and 1 staff technician.
The activity is in synergic collaboration with UniMi, planning to equip an existing anechoic chamber with new facilities.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

425.000,00 €

Cost description: Anechoic chamber

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

29.750,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

TestingWFInstrumentOnSky_Instrumentssetup

49 Activity short name

6301

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OACT	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The present action is meant to procure of all instruments needed to develop the testing facility and the support assembly room. Necessary software purchased and installed where needed.
The instruments will be installed and tested. A mini ICT (Information and Communication Technologies) rack center will also be installed and prepared to present the facility and for the dissemination of results.
An optical engineer (2.5 year TD) will be hired to support the definition of the equipment to be procured, to take care of the procurement itself and of the installation of the instruments in the facility. A data scientist expert in optics (1.5 year TD) will be hired to support the testing of the facility.
Goals are the purchase of the instruments and necessary control systems:
- Inertial Platform
- 2x Optical transportable Benches for the inertial platform
- Custom flanges
- Optical Bench for Assembly room
- Service Detector
- XYZ stage (& controller)
- Computers
- Software License
- Mini ICT
Actions are: selection of the instruments to be procured; procurement, installation, and testing.
Staff participants are: Giuseppe Leto, Roberto Ragazzoni, Isabella Pagano, Valentina Viotto. The overall work will be supported by the two involved INAF institutes: OACT and OAPD.

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

the two involved INAF institutes: OACT and OAPD.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Optical Engineer (24 months)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

200.000,00 €

Cost description: Inertial Platform/Eq. #1
Optical Bench/Eq. #2
Custom flanges/Eq. #3
Assemblyroomoptbench/Eq. #4
ServiceDetector/Eq. #5
XYZstage/Eq. #6
Computers/Eq. #7
Software/Eq. #8

54.3 c. Open Access, Transnational Access, FAIR principle implementation

5.000,00 €

Cost description: Open Access #1 Mini ICT to host a webserver presenting the facility and its possible use; to manage access requests; to archive data collected for facility users and for dissemination to the community.

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

22.297,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

LowFreqAcceptanceLab_equipment

49 Activity short name

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

49 Activity short name

6802

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	IRA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

This activity is aimed to purchase and install all the furniture, to tender, purchase and install all the equipment/instruments necessary to populate the laboratory and finally to verify the adequacy and functioning of the laboratory created.
The new laboratory is the upgrade of a previous lab born from the need to create, test and verify the quality of prototype or production analog and digital electronics, deriving from any technological project oriented to the transport of RF signals in optical and high performance complex digital systems. The laboratory will be
specifically equipped with useful machines for the realization of RF / optoelectronic prototype devices and very accurate test tools for RFoF (Radio over Fiber) systems. The realization of these integrated systems, which include the optoelectronic device and all the RF electronics necessary for operation, fits perfectly into a regional
framework that has great experience in the characterization and testing of individual chips.
The acceptance laboratory will be operational for the Italian productions of the SKA project, a project of international importance for the construction of the largest radio telescope in the world and for the LOFAR2.0 radio telescope.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

833.000,00 €

Cost description: Arredamento
Upgrade PNAX
Analizzatore di Spettro
Materiale per allestimento laboratorio RFoF
Fresa per circuiti stampati
Camera climatica
Camera GTEM
2xCabinet termostatato
Equipaggiamento vario laboratorio

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

58.310,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

LowFreqAcceptanceLab_Building-renovation

49 Activity short name

6801

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	IRA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

This activity is aimed to realize the thermo-hydraulic systems for the building where the new laboratory will be hosted, to prepare the tender for building renovation and doing the works inside the area that will host the laboratory.
The new laboratory is the upgrade of a previous lab born from the need to create, test and verify the quality of prototype or production analog and digital electronics, deriving from any technological project oriented to the transport of RF signals in optical and high performance complex digital systems. The laboratory will be
specifically equipped with useful machines for the realization of RF / optoelectronic prototype devices and very accurate test tools for RFoF (Radio over Fiber) systems. The realization of these integrated systems, which include the optoelectronic device and all the RF

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

RFoF (Radio over Fiber) systems. The realization of these integrated systems, which include the optoelectronic device and all the RF electronics necessary for operation, fits perfectly into a regional framework that has great experience in the characterization and testing of individual chips.
The acceptance laboratory will be operational for the Italian productions of the SKA project, a project of international importance for the construction of the largest radio telescope in the world and for the LOFAR2.0 radio telescope.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

0,00 €

Cost description: None

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

910.000,00 €

Cost description: Rifacimento impianto termo-idraulico
Ristrutturazione edile

54.5 e. Indirect costs

63.700,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

OptomechTesting_Profilometry

49 Activity short name

6703

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

In order to allow a rapid optics manufacturing process, a precise and accurate metrological technique is needed.
Moreover, a versatile tool, which can be used from the grinding phase of the optic to the end of the polishing process, it is highly desirable to guide efficient fabrication. In general, standard metrological approach is based on interferometric set-up and has to be tailored on specific mirror designs. This is a huge limiting factor for a
cutting edge optics-manufacturing laboratory, like the one operational at INAF-OAB. Here, new and attractive free form optics can be realised starting from innovative optical designs. The finalisation of one of the largest European Ion beam facilities and the purchase of the dedicated robotic polisher machine, the IRP1200 by Zeeko, allow the manufacturing of large prototypes and advanced optical components up to few nanometres accuracy.
In this context, an adequate metrological device is of paramount importance for a complete production chain and to sustain the requests of an independent cross-check validation of freeform optics. We aim to realise a profilometer which may be used starting from the very first optics figuring phases or in all the cases when the surface roughness does not allow interferometry approaches. Moreover, thanks to the free-form design, it could allow the characterization of a wide range of optics both concave and convex, for spherical and aspheric mirrors, fulfilling the flexibility requirement of the laboratory and reducing the cost of ad-hoc systems. The design of the machine starts from a consolidated heritage of metrological tools, designed and realised with the substantial contribution of INAF-OAB staff, based on profilometric and deflectometric approach techniques. The implementation will be carried out thanks to external enterprise which may deliver the hardware and the control software. Data analysis software will be managed by INAF-OAB staff.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

750.000,00 €

Cost description: Profilometer

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

0,00 €

Cost description: None

54.5 e. Indirect costs

52.500,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

OAAAbetti_OAAAbetti

49 Activity short name

6101

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

This work package aims to renovate a number of buildings available spaces, and laboratories located on the Arcetri hill. This renovation offers an excellent opportunity to host a new generation laboratory complex, with different laboratories and office space for technologists; the lab complex would represent a key facility to support technological developments in the context of the ELT and SKA infrastructures. In particular, a building that used to be the home of the Observatory caretaker is available, plus some other laboratories and structures belonging to the Demanio (State Property) granted for permanent use to the Osservatorio Astrofisico di Arcetri that need important refurbishment for the civil structures, with new electrical and HVAC systems. The total amount of these areas is about 250 square-meters, where we could realise new laboratories for many of the future projects regarding AO systems, IR and radio instruments and SW development for ground based projects.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

99.760,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: TD - technician (24 months)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

0,00 €

Cost description: None

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

1.404.000,00 €

Cost description: Recupero e ristrutturazione del 'Villino Abetti'

54.5 e. Indirect costs

105.263,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

Optomechanical Testing Thermomechanical

49 Activity short name

6701

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAB	Participant	INAF - Istituto Nazionale di Astro Fisica

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

52 Activity description

The prototyping of Optomechanical device has to be completed with proper capability to identify and measure their performances. Essentially in the astronomical instrumentation, the main characteristics to be monitored and verified in order to assess the efficiency of the optomechanics are stability and survivability under mechanical and thermal loads. The activity is focused onto the realization of a testing facility able to:

- *measure dynamic performance of the devices (modal characterization),*
- *verify compatibility to dynamic loads (earthquake)*
- *Verify compatibility and performances under thermal loads (down to cryogenic environment).*

A vibration lab equipped with mechanical and electromagnetic shaker will grant the mechanical testing capability. The plan is to be able to test small Optomechanical system or large Optomechanical device by applying to them typical earthquake vibrations. The test facility will be able also to simulate space launch loads if required. The capability to make modal characterization will provide an enormous feedback to the Optomechanical design as it will enable the possibility to fine tune the Finite Element models that are today the only way used to predict the device performances. The models will be then more accurate and the design more efficient. A cryogenic chamber will be manufactured to enable the thermal tests onto optomechanical systems. Also in this case the retrofit to the Finite element models will improve the design capability. The chamber will be able to simulate the typical environment of Astronomical cryogenic system oriented to the NIR based astronomy. This activity will also provide the suitable environment for the development of novel alignment techniques which are described in the last activity. A demonstrative Optomechanical system will be deployed and tested within this activity to prove the capabilities.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

800.000,00 €

Cost description: Cryogenic chamber
Criogenic control Equipment
Thermal control equipment
Mechanical equipment
Optomechanical demonstrator
Mechanical load simulator
Modal analysis system

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.5 e. Indirect costs

56.000,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

OptomechTesting_WindAcoustic

49 Activity short name

6702

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAPA	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Facility for the numerical simulation and testing of opto-mechanical elements subject to dynamic stresses.
It includes a workstation dedicated to the FE Analysis necessary in the phase of design; a large area CNC milling machine high speed cutting dedicated to the realization of high precision mechanical parts; an electrodynamic shaker and a high-speed laser scanner vibrometer to dynamically characterize and test mechanical and optical parts subject to dynamic stress. A mobile clean room sized to host the shaker to handle parts needing a clean environment.
The set up activities need one researcher for 30 months dedicated to coordinate the project following all commissioning. Involvement of students in educational and research projects is foreseen. The facility will be employed for at least a decade, but presumably more after completion in that not only it will be a fundamental support to maintenance and future upgrades but it will also be used in other projects involving INAF, allowing in house fabrication and testing of parts and equipments with consequent saving of huge budgets. Furthermore the Southern Italy location of the facility makes it unique in a part of the nation lacking of this kind of support to local industries, opening it to possible services to external parties. The personnel to operate the facility is already available among the staff members of OAPA.
Among other projects that will benefit using the facility we mention INAF collaborations to Athena and eXTP missions, along with Università degli studi di Palermo, Max Planck Institute for Extraterrestrial Physics (MPE), Centre Spatial de Liège (CSL), Centre national d'études spatiales (CNES), Netherlands Institute for Space Research (SRON), Space Research Centre of Polish Academy of Sciences (CBK) e Institute of High Energy Physics (IHEP).

54 Activity budget

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.1 a. Cost of fixed term personnel specifically hired for the project

85.140,00 €

Cost description: Ingegnere Meccanico (18 months)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

465.000,00 €

Cost description: Workstation per simulazioni termiche e strutturali meccaniche FEM
CNC machine
Shaker and accessories
Clean room mobile
Laser scanner vibrometer and accessories

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

38.509,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

StrayLightFacility_Scatterometer

49 Activity short name

6601

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

51 OU in charge of the Activity

OU short name	OACT	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Goal of this activity is the acquisition and installation of a scatterometer plus the education of INAF personnel for its correct use.
A scatterometer is an instrument that measures the quantity of light scattered by a surface or volume sample when illuminated, in several position of the 3D space around the sample.
Data obtained may be used to derive a BSDF (Bidirectional Scattering Distribution Function), a function that fully characterizes the scattering properties of the material and that may be used to simulate it during an instrument design, to evaluate performances and possibly improve them.
Scatterometers are commercially available, in a wide range of performances and consequently prices, depending on multiple parameters and configurations (spectrum of radiations, size, position and orientation of sample and detector, use in transmission and in reflection); willing to create a facility that may satisfy the largest number of measurements needs, we propose to acquire a scatterometer having the possibility to work form UV to NIR, and do measurements in the complete 3D space with several angles of incidence of radiation on sample.
The presence of this instrument in INAF would allow to perform routinely measures of BSDF in an environment fully characterized and controlled, hence with a known error; measurements will be carried out on materials of interest for the instruments modelling and realization (optical smooth surfaces; diffractive elements; surfaces of mechanical elements; surfaces contaminated with dust or molecules, as it is typical for elements that go through a process of AIV/AIT.
INAF-OACT will be in charge of the activity performed by staff personnel.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

368.000,00 €

Cost description: Tavolo ottico Scatterometro

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.5 e. Indirect costs

25.760,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AOCalibrationFacility_Equipment

49 Activity short name

6402

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The design and development of advanced calibration systems for ELT instruments require very high level skills (photonics, precision mechanics, metrology, microelectronics, information technology and automation) and sophisticated equipment to guarantee the technological advancement in this field.
The CalibrationFacility_Equipment is a twofold activity that foresees both the acquisition of new equipment to setup experimental benches, and the recruitment of new personnel.
The sub-activities to be carried out are:
a. purchase of advanced equipment for optical and mechanical metrology, rapid prototyping, integration, alignment and verification of highly complex AO instrumentation.
b. set up a full test & verification bench devoted to the calibration and spectro-photometric characterization of ELT class AO instruments.
c. set up an advanced testbed to study innovative techniques of focal plane wavefront sensing, reconstruction and correction, training and validation of control algorithms based on Machine Learning.
The OAAb technology group will carry on the activities of the AOCalibrationFacility. Nevertheless, given the increased amount of work in the time-period of the proposal, new personnel is required to facilitate the startup of the facility:
- 1 TD to support the definition of requirements for the tender process, the procurement, the management, the installation and verification of the delivered equipment, the set up of measurement and experimental test benches.
International collaborations: ESO, MPIE, University of Galway, University of Grenoble, NASA.

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: System Engineer (24 months)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

375.000,00 €

Cost description: 3D Metrology arm for MORFEO-CU mechanical assembly
FT Spectrometer - VIS/NIR Spectro-photometric calibration, (calibration/characterization of artificial sources)
Mechanical Workshop equipment for MORFEO-CU (hydraulic lifters)
Fast dynamic Interferometer for MORFEO-CU AIV (thermal stability, optics deformation, small optics alignment and characterization)
Deformable Mirror, 1", 100 actuators class DM & control electronics
Network infrastructure (Router, servers, WLAN, etc.)
MORFEO-CU Electronics & Lab equipment (light sources, fibers, LGS mask, high accuracy beam profiler/analyzer)
MORFEO-CU Test Assembly (custom large 5DoF motorized assembly with IR camera)
Autocollimator for MORFEO-CU blocks alignment (MAT - Mount Alignment Telescope)
Large active optical bench for MORFEO-CU AIV, optics, mountings

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

34.197,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

AOCalibrationFacility_Building

49 Activity short name

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

49 Activity short name

6401

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAAB	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

The AOCalibrationFacility_Building has the objective to create a new building, where to transfer and expand all the technological activities of INAF-OAAB in the field of Adaptive Optics. The proposal arises from the urgency to set up larger spaces equipped with adequate and modern support systems and services, overcoming the infrastructural limitations due to the impossibility of expansion and adaptation of the current laboratories in the historic buildings (already affected and penalized by the seismic events in Central Italy in 2009 and 2016).
This national facility will therefore allow INAF to increase and strengthen R&D activities in Adaptive Optics, consolidating a reference center for Astrophysics in Abruzzo, in the Adriatic area, and favoring the transfer of advanced technologies to the territorial small and medium-sized enterprises.
It will follow the current regulations concerning sustainability (environmental and energy impact) being also equipped with a solar energy plant. It will include the following items:
• Optics and electronics laboratories (prototyping, optical tests, signal analysis, metrology and automation, spectro-photometric calibrations);
• Integration Area (ISO7 thermo-controlled cleanroom, hydraulic lifts and overhead crane, mechanical support structures, control room);
• Mechanical workshop and fab-lab (CNC, turning, mechanical components and precision assemblies, production and processing of materials, 3D printers);
• Offices (6 workstations) and IT services (server room);
• Technical rooms and warehouses (high acoustic noise devices, heat exchangers, raw materials, laboratory materials).
The investment will consolidate the role of INAF-OAAb in current collaborations with international partners (European Southern Observatory, Max-Planck Institute, University of Galway, University of Grenoble, NASA, etc.) and in large future technological projects for AO.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

113.520,00 €

Cost description: Site Construction Manager (24 months)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

1.460.001,00 €

Cost description: Design T0 (Final Design) - Relyes on financial availability of â,¬ 160.000 on May 2022.*
Call for tender (Full Financial availability of â,¬ 1.270.000 on May 2023)
Delivery #1 foundation (payment 1) - Construction site preparation, excavation, foundation slab
Delivery of bearing structure, floors and partitions (payment 2) - Bearing structure and partitions
Delivery of plants and systems, acceptance test and furniture (payment 3) - Plants and systems installation, furnitures, acceptance test

54.5 e. Indirect costs

110.146,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

48 Activity title

OpticalIntegrationFacility_OpticalLab

49 Activity short name

6501

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	OAS	Participant	INAF - Istituto Nazionale di Astro Fisica

52 Activity description

Two laboratories are specifically foreseen in support of the integration room at the premises of INAF OAS: one devoted to optics and one to electronics activities. These laboratories are of fundamental importance to carry out tests of components and subsystems in a devoted and controlled environments with the availability of specific equipment such as optical bench, laser, oscilloscope etc. Nevertheless these

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

controlled environments with the availability of specific equipment such as optical bench, laser, oscilloscope etc. Nevertheless these laboratories are crucial to cope with unexpected issues that could rise during the long periods of integration and testing of the instrument that, despite the huge design and engineering effort, remains somehow a prototype being a unique unit. However, while the refurbishment that began in 2016 covered all the construction works, the instrumentation in the support laboratories has not been renewed.
This activity is devoted to the procurement of the necessary equipment for the optical laboratories in order to have it ready for the next decades.
This activity will be run at INAF OAS under the responsibility of Paolo Ciliegi (ELT-MORFEO PI), in collaboration with Ugo Di Giammatteo (Project Manager), Italo Foppiani (electronic expert) and Gabriele Rodeghiero (optical engineer). Other INAF structures involved in the MORFEO project (OAA, OAB, OAPD, OACN, OAAB) will participate in this activity, by providing additional technical expertise.
However, the Bologna Integration Hall is a National Facility so the use of the support opto-electronic laboratories will be open to national and international research groups (with the necessary legal skills and qualifications) who will need to use these support laboratories during the periods when an instrument will be integrated into the integration room.

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

0,00 €

Cost description: None

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

337.000,00 €

Cost description: Acquisto strumentazione per laboratorio di Ottica a supporto della Sala di Integrazione a Bologna

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

23.590,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

0,00 €

Cost description: None

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

48 Activity title

OpticalIntegrationFacility_ElectronicLab

49 Activity short name

6502

50 Activity Start month and duration

Activity Start month	1	Activity Duration	30

51 OU in charge of the Activity

OU short name	UNIBO-DIFA	Participant	Alma Mater Studiorum - Università di Bologna

52 Activity description

Two laboratories are specifically foreseen in support of the integration room at the premises of INAF OAS: one devoted to optics and one to electronics activities.
These laboratories are of fundamental importance to carry out tests of components and subsystems in a devoted and controlled environments with the availability of specific equipment. Nevertheless these laboratories are crucial to cope with unexpected issues that could arise during the long periods of integration and testing of the instrument that, despite the huge design and engineering effort, remains somehow a prototype being a unique unit. However, while the refurbishment that began in 2016 covered all the construction works, the instrumentation in the support laboratories has not been renewed. This activity is devoted to the procurement of the necessary equipment for the electronics laboratory in order to have it ready for the next decades.
The leadership of UniBO-DIFA in this activity is of strategic importance. It allows UniBO-DIFA to strengthen the synergies in place with INAF OAS and to participate actively in the development of the technological sector, strongly growing at both local and national level.
Moreover, the scientific topics related to the instruments under development at INAF OAS (and that will make use of the instrumentation acquired in this activity) are of primary importance also for UniBO-DIFA, allowing also scientific synergies.
This activity will be run at UniBO-DIFA under the responsibility of Andrea Cimatti (DIFA director), with the technical supervision of Giuseppe Cosentino (UniBO-DIFA), electronic expert and collaborator of the MORFEO project since 2008. Moreover , this activity will be strongly supported by the INAF OAS staff Paolo Ciliegi (MORFEO PI), Italo Foppiani (electronic expert) and Gabriele Rodeghiero (optical engineer).

54 Activity budget

54.1 a. Cost of fixed term personnel specifically hired for the project

170.280,00 €

Cost description: TD A per collaborazione UNIBO INAF OAS (36 months)

54.2 b. Scientific instrumentation and technological equipment, software licenses and patent

140.000,00 €

d) PROJECT WORK BREAKDOWN STRUCTURE - [6000 - National Testing Facilities]

(The information provided in this section will be evaluated with reference to criteria C1-C5)

Cost description: Strumentazione scientifica per laboratorio ottica a supporto Bologna Integration Hall

54.3 c. Open Access, Transnational Access, FAIR principle implementation

0,00 €

Cost description: None

54.4 d. Civil infrastructures and related systems

0,00 €

Cost description: None

54.5 e. Indirect costs

32.597,00 €

Cost description: Travels, consumables, additional instrumentation and staff

54.6 f. Training activities

155.400,00 €

Cost description: 2 PhD students per collaborazione UNIBO INAF OAS (36 months each)

The Scientific Coordinator

(Digital Signature)

The legal representative for the applicant

(Digital Signature)