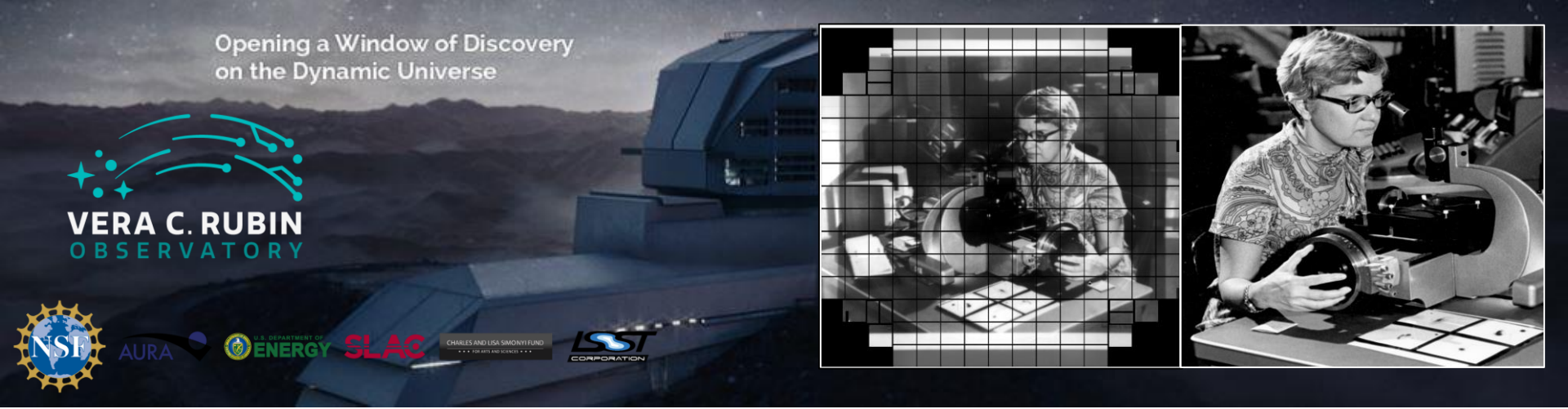


LSST
Legacy Survey of Space and Time

Program Rubin-LSST@Italy

Scienza e Partecipazione italiana al progetto Rubin-LSST

M. Brescia, I. Musella, M. Dall'Ora, R. Bonito, A. Bongiorno, C.M. Raiteri
on behalf of the Italian Team

INAF ISTITUTO NAZIONALE DI ASTROFISICA

In-kind program - Updates

As known, the Italian participation to Rubin-LSST is based on the in-kind contribution program.

After a 6-month (painful) negotiation phase, **a preliminary INAF-LSSTC agreement has been reached in January**. LSSTC provided us with a letter of support, which unblocked the INAF funds and ensured that all in-kind contributions, given before the official agreement, would be considered for data rights return.

20 contributions already accepted and approved (on a total of 24). They include SW development, legacy photo/spectro data, nights and data from LBT/SOXS and Commissioning contributions. The other contributions are just suspended waiting for confirmation about the VST availability.

Contributions related to Rubin Commissioning already started their activities.

The negotiated policy foresees data rights for senior researchers (PIs) and Junior Associates (JAs). A researcher, regardless the specific professional role, is considered JA if time(PhD) ≤ 10 years.

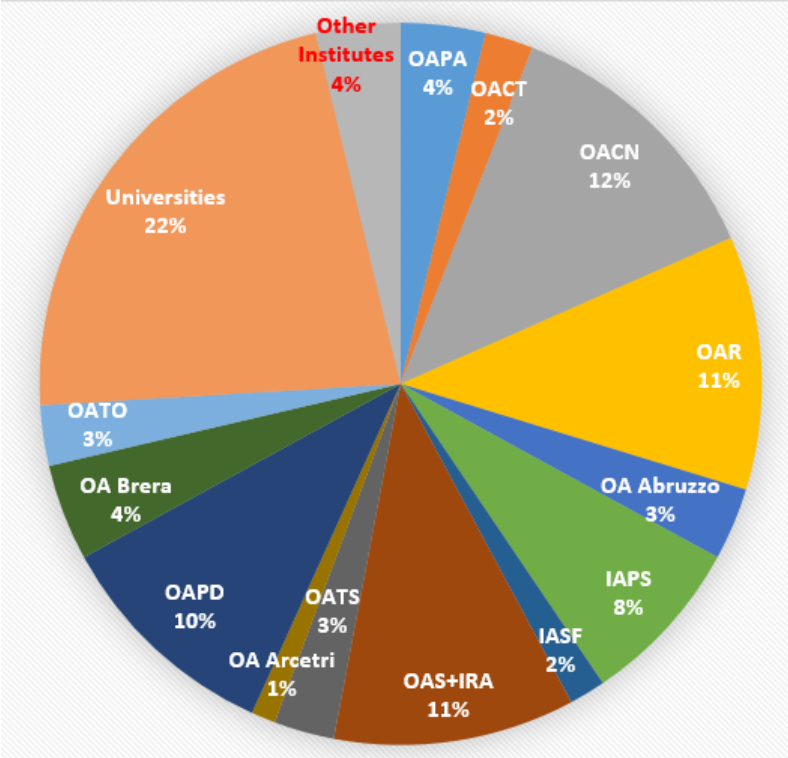
For the approved contributions (including management), we are going to invest **45 FTEs from researchers + 48 FTEs from new dedicated contracts in 15 years, obtaining a return of 81 data rights (PIs) + 324 data rights (JAs).**

By considering also the suspended contributions, we would reach **a total investment of 52.85 FTEs from researchers + 53 FTEs from new contracts in 15 years, with a total return of 104 data rights (PIs) + 416 data rights (JAs).**

Italian Team distribution

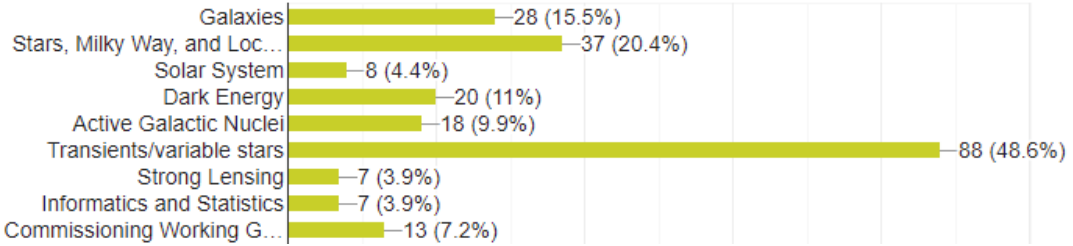
Total 185: 137 INAF members (+ 48 associates)

Internal census yearly updated

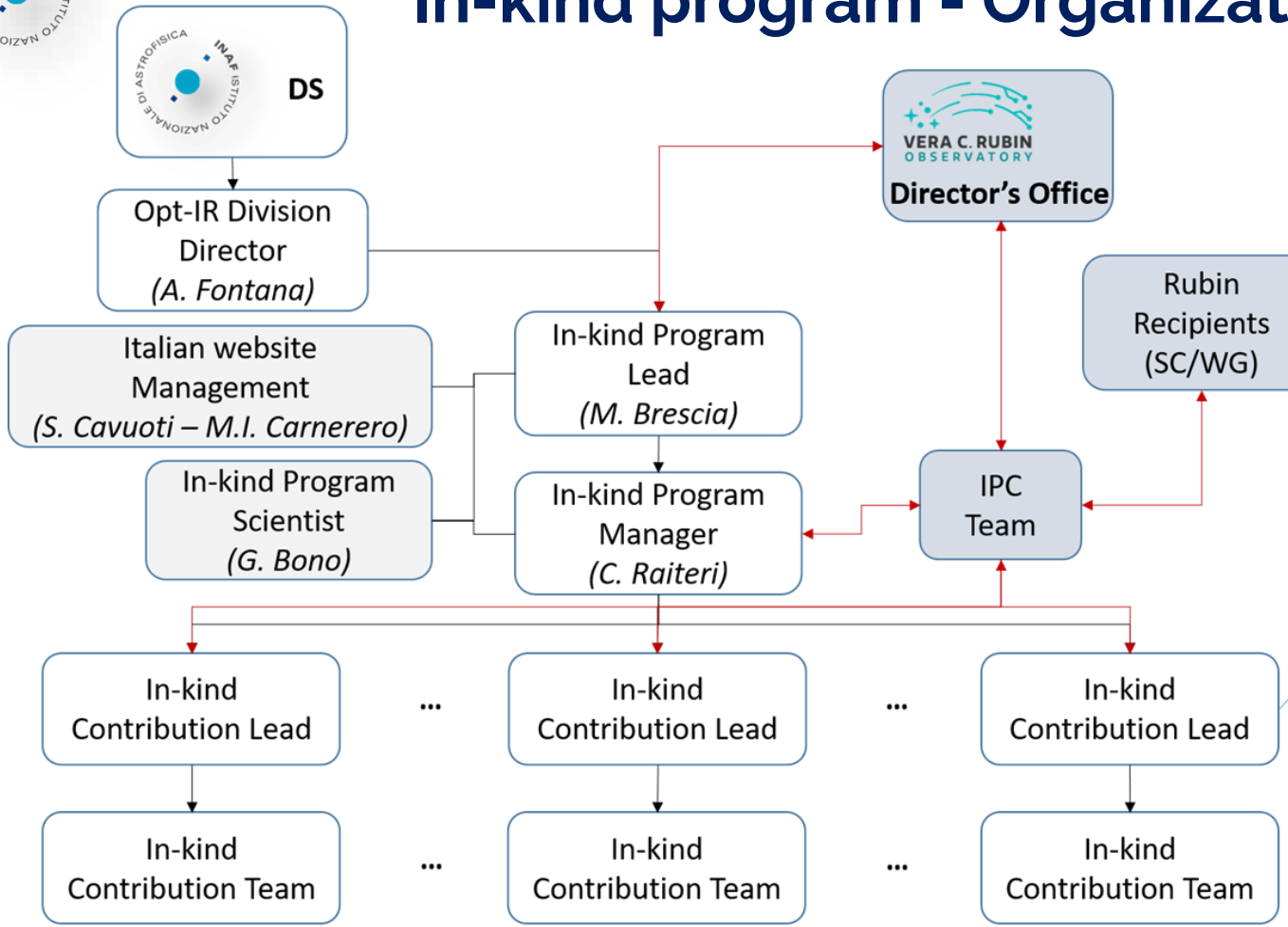


An internal national census has been organized to obtain an exhaustive and faithful list of interested people within our community. This initiative was extremely helpful to ensure a full inclusive policy adopted to distribute the data rights. **All in-kind and ex quintuplet teams, as well as external groups of interested people, are represented within the data right holders list**.

129 senior members (PIs)
56 Junior Associates (≤ 10 years from PhD)
> 40 DP0 Delegates



In-kind program - Organization



A. Antonelli	*L. Girardi*
A. Bongiorno	*L. Inno*
R. Bonito	*S. Lucatello*
M.T. Botticella	*E. Merlin*
I. Busà	*I. Musella*
S. Campana	*G. Riccio*
M. Cantiello	*P. Rosati*
G. Clementini	*A. Saro*
F. Cusano	*P. Schipani*
M. Dall'Ora	*M. Spavone*
G. Fiorentino	*V. Testa*
A. Fontana	*C. Tortora*

Critical aspects to maintain in-kind program

Italian participation to Rubin-LSST project - timeline of planned in-kind activities and contracts recruitment

YCs = contract annualities	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	DATA RIGHTS (Pis) estimated	DATA RIGHTS (Pis) granted	DATA RIGHTS (Pis) used	DATA RIGHTS (JAs) estimated	DATA RIGHTS (JAs) granted	DATA RIGHTS (JAs) used
Agreements with Rubin Corporation			MoA				in-kind proposed	informal acceptance																			
Participation to Science Collaborations	SC roadmap and observing strategies																										
Science, legacy and directable contributions								2 YCs	28 YCs													40	40		160	160	
HW/SW Infrastructure											2 YCs											13	0		52	0	
Legacy surveys and observing time at INAF facilities (VST/LBT/SOXS)										2 YCs												28	20		112	80	
Commissioning contributions								3 YCs	9 YCs													22	20		88	80	
Management										2 YCs												1	1		4	4	
TOTAL INAF YCs	48 YCs																					104	81	67	416	324	54

275 K€ financed
(includes quotes for missions and equipments)

Total estimated cost ~2.5 M€

\+ new contractors

Expected return last year: ~100 data right holders

This is a long-term program, articulated in multiple objectives and tasks, strongly dependent on resource availability.
The activities foresee the recruitment of an adequate amount of AdR postdocs, i.e. young researchers,
mostly SW/System Engineers and Astroinformaticians (data scientists with a background on Astrophysics)

Returns for INAF & italian community from Rubin-LSST in-kind program

63% of senior members actually with data rights and 100% coverage for junior associates

In perspective, an excellent investment for the formation of new generation of scientists

Internal re-use of all detection/classification/characterization methods and pipelines, developed as in-kind contributions, in all fields (from solar system to cosmology)

Opportunities for in-house science transfer (Rubin Science Platform, synergies with other survey projects and legacy data, combined exploitation of proprietary infrastructures)

Opportunities for in-house technology transfer (big data warehouse, data science)

Caveat

Potential +27% of data right holders if VST is available (81% of senior members coverage)

The recruitment of an adequate amount of AdR postdocs, i.e. young skilled researchers

Incoming LSST@Europe 4

Save the dates: October 24-28, 2022 @ Accademia Nazionale dei Lincei, Rome

https://sites.google.com/inaf.it/lssteurope4

MOVIE@LSST: Modeling and Observations of Variable stars as distance Indicators and stellar Evolution tracers in the Vera Rubin Observatory Legacy Survey of Space and Time (I. Musella)

Pulsating stars (RR Lyrae, Cepheids, Long Period Variables, and delta Scuti play) a fundamental role both as distance indicators and as tracers of different stellar populations. Indeed, different types of pulsating stars are characterized by different masses and belong to different evolutionary phases, allowing us to trace stellar generations with different ages and chemical compositions thus providing information on the star formation history of the host stellar system.

This project is part of a more general program (MOVIE), where multi-band time series data collected by Rubin-LSST, combined with its very accurate parallaxes measurements and adopting pulsational models (PULCINELLA), will provide a fundamental benchmark, extending Gaia's capabilities by five magnitudes, thus allowing us

- **to observe and characterize variable stars not only in the Milky Way, but also in Local Group galaxies**
- **To have the first statistical significative database for variable characterized by long and very long period (ULPs, LPVs)**

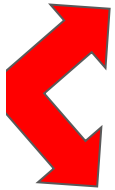
"Transient and Variable Stars" (TVS) Science Collaboration: M. Dall'Ora, M. Di Criscienzo, G. Fiorentino, S. Leccia, M. Marconi, I. Musella, V. Ripepi, G. Bono, M. Gatto, G. de Somma

- TVS SubGroups:
  - "Classification and Characterization": M. Dall'Ora, M. Di Criscienzo, I. Musella, V. Ripepi
  - "Distance Scale": M. Marconi (coordinator), M. Dall'Ora, M. Di Criscienzo, G. Fiorentino, I. Musella, V. Ripepi, G. de Somma
  - "Pulsating Variables": M. Dall'Ora, M. Di Criscienzo, G. Fiorentino, M. Marconi, I. Musella, V. Ripepi, G. de Somma
- TVS Task Forces:
  - "Stellar variability in crowded fields": M. Dall'Ora (coordinator), M. Di Criscienzo, G. Fiorentino, S. Leccia, I. Musella
  - "Data Preview 0": M. Dall'Ora, M. Di Criscienzo, S. Leccia, I. Musella
  - "Survey Strategy": M. Marconi, I. Musella
  - "Software": M. Marconi, I. Musella

"Stars, Milky Way and Locale Volume" (SMWLV) SC: M. Dall'Ora, M. Gatto, M. Marconi, I. Musella, V. Ripepi

- SMWLV Subgroup "Near Field Cosmology": M. Dall'Ora

"Dark Energy Science Collaboration" SC: M. Dall'Ora



In-Kind: Tools for the simulation of Pulsating Stars

Analysis Tool: Metric PulsatingStarRecovery.py

MOVIE@LSST: Modeling and Observations of Variable stars as distance Indicators and stellar Evolution tracers in the Vera Rubin Observatory Legacy Survey of Space and Time

IN-KIND: Directable software development effort in the general area of **Rubin data science analysis and exploration** in close collaboration with the TVS SC to develop an infrastructure based on extended model sets along with software tools to interpolate among grids of theoretical templates (e.g. light and radial velocity curves, periods, mean magnitudes and colors etc.....) for pulsating variables (Cepheids, RR Lyrae, Long Period Variables…), in order to:

1) simulate the behaviour of Rubin-LSST pulsating stars of various classes for classification and characterization purposes in the context of the TVS Scientific Collaboration, including training machine learning classification systems;
2) derive synthetic Rubin-LSST light or radial velocity curves for different parameter combinations;
3) train the developed tools on the extended and detailed model grids built by our team but also by other teams;

INITIAL STAGE: Development of theoretical framework in the Rubin-LSST filters (Marconi et al. submitted, Musella et al. in prep.) → **Implementation of the Database and Tools from the end of 2023 (Post-Doc with specific skills)**

Minigrant to develop theoretical framework for Ultra Long Period Cepheids "Are the ULPs cosmological standard candles?" (I. Musella)

ANALYSIS TOOLS: Metrics to analyze the performance of different LSST OpSim strategies to recover accurate periods, mean magnitudes and amplitudes for different types of pulsating stars characterized by different light curve shapes and ranges of period, absolute mean magnitude and amplitude (Type ab and c RR Lyrae, Cepheids, Long Period Variables, δ Scuti).

Application to: OpSim → Simulated Data (DP0.2) → Commissioning data (2 Data Release 23-24) → Rubin-LSST data (25)

- **Cadence Note** "Classical variable stars in different Galactic environments: pulsation behaviour recovery" (Musella et al.) to give recommendation to maximize the expected outcome for our science case.
- **PulsatingStarRecovery.py:** Rubin-LSST Metric Analysis Framework (Di Criscienzo, Braga, Leccia, Musella, et al.)
- **Paper:** "Light curve's recovery with Rubin-LSST: pulsating stars in Local Group dwarf spheroidals galaxies" (Di Criscienzo et al. in prep. for Astrophysical Journal Focus Issue on Rubin LSST cadence and survey strategy)

Minigrant to enable researcher exchange with Rubin team and to develop tools to maximize pulsating stars early science "MOVIE@LSST: Enabling early Science" (M. Di Criscienzo)

Stellar VARIability in the crOwded fields (Rubin-LSST-11) – RSN2, Coordinator: M. Dall'Ora

Goal: Investigation of the 3D structure, age, metallicity and reddening distributions of extremely crowded stellar environments, through high-precision photometry.

In-kind contribution: "Directable SW contribution for the SMWLV and TVS SCs: Software Tools for Stellar Populations in Crowded Fields" (PI: M. Dall'Ora). This contribution is focused on two complementary aspects:

1. **Technical contribution**: i) providing the Rubin-LSST Community at large a massive photometric reduction of the crowded stellar fields, based on the Allframe code. The Allframe approach is much more demanding than the forced photometry delivered by Rubin-LSST, and it potentially provides the more accurate results, especially at the faint end of the luminosity distribution; ii) providing a series of tools to detect and characterize the periodic variable stars (especially pulsating), and to derive structural parameters and photometric metallicities of the Galactic clusters (based on ML techniques) → **Deliverables: general catalogs and software**
2. **Scientific contribution**: provide one of the deepest and accurate photometric database of the Galactic Bulge so far, including the information on the stellar variability. This database will be invaluable for a series of astrophysical topics, about the Bulge structure, the stellar variability and the distance scale. → **Deliverables: extended Bulge catalogs (photometry, variability, individual distances, metallicities and reddenings - when applicable)**

2024 — – – – – – – – – – – – – – **2025** – – – – – – – – **2026** – – – – – – – – – – – **2028**

pipeline implementation and testing | first massive reductions | variability and ML contributions

Team: 13 researchers (9 INAF and 4 associates) in 6 institutes (4 INAF and 2 Univ) in SVARIO.
TOTAL FTE: 5.3
Additional contribution from 6 colleagues (from 2 INAF institutes and 1 Univ) involved for the associated in-kind activities (see also breaking news)

Funding: 2 Post-Doc positions (INAF) for the in-kind contribution

Criticalities: this project is critically dependent on the existence of an adequate calculus facility (not yet identified), and on the availability of two Post-Doc positions

Current status: a preliminary release of the reducing pipeline has been successfully tested on Bulge data and the results are being published (in collaboration with the Rubin-LSST Kickstarter Program, “Stellar Variability with Rubin-LSST”, PI M. Monelli, IAC, ES)

Breaking News: a project has been submitted to the INAF-PLEIADI computing facility, to massively reduce DECam Bulge data (start of the project: 2022, Sept. 15; end: 2023, Dec. 31). The technical goal is to fine-tune our reduction pipeline on a large scale. Requested 45k core/hours.

Rubin LSST: from young stars to the use of the Rubin Science Platform (Rubin-LSST-1) RSN2, Coordinator: Rosaria (Sara) Bonito

INAF - OAPa

Goal: constraining open issues related to the accretion process and its intrinsic variability, the stellar rotation evolution, the stellar magnetic activity, and accretion and inner disk geometries of young stellar objects (YSOs) investigating different time scales (from hours to years)

3D rendering/Inclusion:

From light curves to 3D models: printed kits used for inclusion of blind/visually impaired (BVI) researchers/students to address equity of accessibility; useful as well as for sighted astronomers for a deeper understanding of very complex systems with different components at work simultaneously, as in YSOs

Current status:

Transients & Variable Stars Science Collaboration

In-kind contribution:

Development of a software to classify variable stars

Leadership: Bonito:

chair Non Degenerate Eruptive Variables group; **chair** Science Platform Evaluation Task Force; **chair** Special Programs Task Force; **chair** Data Preview 0 Task Force; **chair** Justice, Equity, Diversity, and Inclusion group

Team:

10 researchers (9 INAF and 1 associate) in 4 institutes (3 INAF and 1 Univ)

TOTAL FTE: 4.2

Some of the **papers** of the members of this **team**: Bonito & Hartigan et al. 2018; Prisinzano & Magrini et al. 2018; Feigelson, Bianco, Bonito 2018; Street, Bianco, Bonito et al. 2020; Bonito & Venuti et al. 2021; Prisinzano et al. 2021; Bellm et al. ApJS 2022; Bonito & Venuti et al. ApJS in prep.; Prisinzano et al. ApJS in prep.; Ustamujic et al. in prep.; Data Preview 0 delegates

Multi-band characterization of YSOs and their variability (team members involved in the Gaia-ESO Survey, JWST, Chandra,...see “schede” YSO-ALESA, PI Bonito, and e.g. Athena, 4MOST and WEAVE)

Funding:

Bonito: PI of 2 Kickstarter grants Rubin LSST (**ending in July 2022**)

Bonito: PI of the LSST Corporation grants for **Rubin LSST@Europe 4** meeting (Roma 2022)

meetings: LSST Special Programs workshop, Palermo, 2018 (Chair: R. Bonito);
Untangle the skein with Scarlet: LSST de-blending pipeline application (Chair: R. Bonito);
LSST TVS-SMWLV meeting, Delaware, 2019 (SOC: Bonito)

Criticalities:

1 year PostDoc (Kickstarter grant **Rubin LSST**/INAF-OAPa) **ending in Feb. 2023**

3 years PostDoc position (INAF) for the **in-kind** contribution **starting in 2026**

Univ. Palermo students (interships/Thesis)

Large-grant (PI: Prisinzano); mini-grant (Ustamujic)

High-z AGN as seen by Rubin-LSST (Rubin-LSST-16)

RSN1, Coordinator: Angela Bongiorno

Goal: collect and study the largest sample of high-z AGN selected from the Rubin-LSST survey

The project consists of two parts:

1) **In-kind contribution:**
   a) Build an **AGN mock catalog** which will be used as input, together with the galaxy mock catalog, to simulate **LSST images**
   b) Extract realistic photometric catalogues of sources (AGN and galaxies)

Images and catalogs + doc will be released as in-kind contribution.

1) **High-z AGN Selection and Analysis:**
   a) Select high-z AGN from the simulated catalogs using different techniques including machine learning tools and build a **sample of bona-fide high-z AGN**
   b) Perform a scientific analysis on the extracted simulated sample
   c) Repeat the selection and the analysis on the real data, once available.

Schedule:

year 1	year 2	year 3
1) in-kind contribution		
3) Acquiring Expertiese in ML	2) Simulated and real data Analysis	

Team:

16 researchers (11 INAF and 5 associates) in 8 institutes (5 INAF and 3 Univ)

TOTAL FTE: 5.2 (3.7 INAF and 1.5 Associates)

Funding:

2 years Post-Doc position (INAF) for the in-kind contribution

Criticalities:

1) The in-kind contribution is work we provide to have access to the Rubin-LSST data This is funded by INAF. **BUT** the full exploitation of the real data requires a big investment of FTE from INAF TI researchers and associates which is not supported by any funding.
2) miss the skills/knowledge and the computing power for machine learning techniques

- **Request for a mini-grant to acquire expertise and train students on ML techniques** which will be fundamental to successfully exploit the Rubin-LSST data once available.

Interest @INAF in Rubin-LSST

RSN 1

Rubin-LSST-**04**, **SBF** (**M. Cantiello**), *Surface Brightness Fluctuations: measurements and models beyond 2022*
Rubin-LSST-**12**, **LENS-ML** (**C. Tortora**), *LENses and Structural parameters with Machine Learning*
Rubin-LSST-**13**, **BlaRub** (**C. M. Raiteri**), *Blazars with Rubin-LSST*
Rubin-LSST-**14**, **TimeDomes** (**M. Paolillo**), *Time domain precursor studies for AGN science*
Rubin-LSST-**16**, **LSST-highzAGN** **(A. Bongiorno),** *High-z AGN as seen by Rubin-LSST*

RSN 2

Rubin-LSST-**01**, **Rubin-LSST-YSO** (**R. Bonito**), *Rubin LSST: from young stars to the use of the Rubin Science Platform*
Rubin-LSST-**05**, **GaLS** (**G. Clementini**), *Gaia-LSST Sinergy*
Rubin-LSST-**07**, **MOVIE@Rubin-LSST** (**I. Musella**), *Modeling and Observations of Variable stars as distance Indicators and stellar Evolution tracers in the Vera Rubin Observatory Legacy Survey of Space and Time*
Rubin-LSST-**08**, **popstar-LSST** (**L. Girardi**), *Population models of the LSST stellar content*
Rubin-LSST-**09**, **CRAM** (**I. Busà**), *Cosmic rays accelerators: in loco measurements*
Rubin-LSST-**11**, **SVARIO-LSST** (**M. Dall'Ora**), *Stellar VAriability On LSST crowded fields*
Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), *Study of Galactic and Extragalactic Novae*

RSN 3

Rubin-LSST-**06**, **CI-LSST** (**L. Inno**), *Vera Rubin LSST for Comet Interceptor*

RSN 4

Rubin-LSST-**10**, **GuRu** (**S. Piranomonte**), *The GuRu (GRAWITA using Rubin) project. Vera Rubin Observatory as a multi-messenger laboratory*

RSN 5

Rubin-LSST-**15**, **IQ4VRO** (**G. Fiorentino**), *Image quality for Vera Rubin Observatory commissioning*
Rubin-LSST-**03**, **Astroinformatics** (**G. Riccio**), *Data driven Science in Astrophysics*

Interest @INAF in Rubin-LSST

RSN 1

Rubin-LSST-**04**, **SBF** (**M. Cantiello**), *Surface Brightness Fluctuations: measurements and models beyond 2022*

Rubin-LSST-**12**, **LENS-ML** (**C. Tortora**), *LENses and Structural parameters with Machine Learning*

Rubin-LSST-**13**, **BlaRub** (**C. M. Raiteri**), *Blazars with Rubin-LSST*

Rubin-LSST-**14**, **TimeDomes** (**M. Paolillo**), *Time domain precursor studies for AGN science*, Rubin-LSST-14

Rubin-LSST-**16**, **LSST-highzAGN (A. Bongiorno),** *High-z AGN as seen by Rubin-LSST*

The "SBF with LSST" project concerns the **use of Rubin data for the estimation of distances for galaxies within ~100/150Mpc**. The most relevant aspects of this project are the **accuracy** of the distances obtained (likely ~ 5%), which is a key aspect for the numerous fields of application (cosmological parameters, black hole masses, dynamical time scales, age, etc.), and the **huge sample** of measurable sources (probably well above 10^4 galaxies). The criticality is the **need to develop new SBF measurement paradigms, to obtain measurements in times that are orders of magnitude smaller than the current times** (a measurement of SBF currently takes about 3-4 hours, in most simple cases). As part of the ongoing collaboration, our program is to **develop new codes** capable of addressing this measure in a shorter time, using precursor data of the LSST and other archival data.

Interest @INAF in Rubin-LSST

RSN 1

Rubin-LSST-**04**, **SBF** (**M. Cantiello**), *Surface Brightness Fluctuations: measurements and models beyond 2022*

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Rubin-LSST-**14**, **TimeDomes** (**M. Paolillo**), *Time domain precursor studies for AGN science*, Rubin-LSST-14

Rubin-LSST-**16**, **LSST-highzAGN (A. Bongiorno),** *High-z AGN as seen by Rubin-LSST*

Using machine learning, this proposal aims at complementing the ongoing effort of the Data Management division of the Rubin Observatory to **derive single Sérsic fitting of galaxies and expand this to multi-band and multi-component analyses** in a fast and efficient way, **contributing to the process of deblending sources and star/galaxy separation**. The production of galaxy-subtracted images will be implemented within the LSST strong lensing pipeline.

Interest @INAF in Rubin-LSST

RSN 1

Rubin-LSST-**04**, **SBF** (**M. Cantiello**), *Surface Brightness Fluctuations: measurements and models beyond 2022*
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Rubin-LSST-**16**, **LSST-highzAGN (A. Bongiorno),** *High-z AGN as seen by Rubin-LSST*

Main purpose of our team is the **study of the variability, census and environment of blazars,** active galactic nuclei with extreme variability properties. We participate to the activities of the Rubin-LSST Science Collaborations (TVS and AGN), in particular to **define the observation strategy** (see Raiteri et al. 2022, 'Blazar Variability with the Vera C. Rubin Legacy Survey of Space and Time', ApJS, 258, 3), and the **software and tools needed to better exploit the survey data through the Rubin Science Platform and brokers**.

Interest @INAF in Rubin-LSST

Rubin-LSST-**04**, **SBF** (**M. Cantiello**), *Surface Brightness Fluctuations: measurements and models beyond 2022*

Rubin-LSST-**12**, **LENS-ML** (**C. Tortora**), *LENses and Structural parameters with Machine Learning*

Rubin-LSST-**13**, **BlaRub** (**C. M. Raiteri**), *Blazars with Rubin-LSST*

RSN 1 Rubin-LSST-**14**, **TimeDomes** (**M. Paolillo**), *Time domain precursor studies for AGN science*, Rubin-LSST-14

Rubin-LSST-**16**, **LSST-highzAGN (A. Bongiorno),** *High-z AGN as seen by Rubin-LSST*

The ongoing and future activities **exploit the expertise acquired with VST surveys on AGN** and time-domain science and its application to LSST. The project also proposes to **perform additional VST surveys** in support to LSST science (before and during LSST operations) to be offered as an in-kind contribution from the italian community.

Interest @INAF in Rubin-LSST

Rubin-LSST-**04**, **SBF** (**M. Cantiello**), *Surface Brightness Fluctuations: measurements and models beyond 2022*
Rubin-LSST-**12**, **LENS-ML** (**C. Tortora**), *LENses and Structural parameters with Machine Learning*
Rubin-LSST-**13**, **BlaRub** (**C. M. Raiteri**), *Blazars with Rubin-LSST*

RSN 1

Rubin-LSST-**14**, **TimeDomes** (**M. Paolillo**), *Time domain precursor studies for AGN science*, Rubin-LSST-14
Rubin-LSST-**16**, **LSST-highzAGN** **(A. Bongiorno),** *High-z AGN as seen by Rubin-LSST*

The science goal is to exploit the voluminous and complex Rubin-LSST dataset to **collect and study the largest sample of high-z AGN** to date by using both standard and innovative methods. The project includes also the planned work for the approved in-kind contribution which consists in **creating an AGN+galaxy+star mock catalog** to be used as input for simulating images in the different (LSST +Euclid) bands and a realistic catalog-level simulated data extracted from them.

Interest @INAF in Rubin-LSST

Rubin-LSST-**01**, **Rubin-LSST-YSO** (**R. Bonito**), *Rubin LSST: from young stars to the use of the Rubin Science Platform*

Rubin-LSST-**05**, **GaLS** (**G. Clementini**), *Gaia-LSST Sinergy*

Rubin-LSST-**07**, **MOVIE@LSST** (**I. Musella**), *Modeling and Observations of Variable stars as distance Indicators and stellar Evolution*

RSN 2

Rubin-LSST-**08**, **popstar-LSST** (**L. Girardi**), *Population models of the LSST stellar content*

Rubin-LSST-**09**, **CRAM** (**I. Busà**), *Cosmic rays accelerators: in loco measurements*

Rubin-LSST-**11**, **SVARIO** (**M. Dall'Ora**), *Stellar VAriability On LSST crowded fields*

Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), *Study of Galactic and Extragalactic Novae*

Focusing on young stellar objects (YSOs), the project will improve the expertise on the Rubin Science Platform (Chair of TVS TF: Bonito), develop tools for the **classification of YSOs variability** (Bonito et al. in-kind contribution), collaborate with the Project **to optimize the observing strategy** (Chair of TVS TF 2018: Bonito). Furthermore, the team will support the **organization of next Rubin LSST@Europe workshop** (Bonito is the PI of a LSST Corp. granted proposal) and will work to ensure a more inclusive environment in the context of the TVS Justice, Equity, Diversity, and Inclusion group (Chair: Bonito).

Interest @INAF in Rubin-LSST

Rubin-LSST-**01**, **Rubin-LSST-YSO** (**R. Bonito**), *Rubin LSST: from young stars to the use of the Rubin Science Platform*

Rubin-LSST-**05**, **GaLS** (**G. Clementini**), *Gaia-LSST Sinergy*

Rubin-LSST-**07**, **MOVIE@LSST** (**I. Musella**), *Modeling and Observations of Variable stars as distance Indicators and stellar Evolution*

RSN 2 Rubin-LSST-**08**, **popstar-LSST** (**L. Girardi**), *Population models of the LSST stellar content*

Rubin-LSST-**09**, **CRAM** (**I. Busà**), *Cosmic rays accelerators: in loco measurements*

Rubin-LSST-**11**, **SVARIO** (**M. Dall'Ora**), *Stellar VAriability On LSST crowded fields*

Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), *Study of Galactic and Extragalactic Novae*

Rubin-LSST will obtain astrometry and multiband time series data of southern hemisphere sources up to 5 magnitudes weaker than the Gaia limit (G ~ 20.7). The aim of GaLS is to **extend the study of pulsating stars as standard candles and stellar population tracers to the magnitude limits of LSST**. The much complete and improved **catalogues of pulsating stars** (Cepheids and RR Lyrae, in particular) that we will publish with **Gaia Data Release 3,** on 13 June 2022, **will be used as training sets for classification of the variable sources observed by LSST** .

Interest @INAF in Rubin-LSST

Rubin-LSST-**01**, **Rubin-LSST-YSO** (**R. Bonito**), *Rubin LSST: from young stars to the use of the Rubin Science Platform*

Rubin-LSST-**05**, **GaLS** (**G. Clementini**), *Gaia-LSST Sinergy*

RSN 2

Rubin-LSST-**07**, **MOVIE@Rubin-LSST** (**I. Musella**), *Modeling and Observations of Variable stars as distance Indicators and stellar Evolution tracers in the Vera Rubin Observatory Legacy Survey of Space and Time*

Rubin-LSST-**08**, **popstar-LSST** (**L. Girardi**), *Population models of the LSST stellar content*

Rubin-LSST-**09**, **CRAM** (**I. Busà**), *Cosmic rays accelerators: in loco measurements*

Rubin-LSST-**11**, **SVARIO** (**M. Dall'Ora**), *Stellar VAriability On LSST crowded fields*

Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), *Study of Galactic and Extragalactic Novae*

This project is part of a more general program, where multi-band time series data collected by Rubin-LSST, combined with its very accurate parallaxes measurements and adopting pulsational models (PULCINELLA), will provide a fundamental benchmark, extending Gaia's capabilities by five magnitudes, thus allowing us **to observe and characterize variable stars not only in the Milky Way, but also in Local Group galaxies.**

Interest @INAF in Rubin-LSST

Rubin-LSST-**01**, **Rubin-LSST-YSO** (**R. Bonito**), *Rubin LSST: from young stars to the use of the Rubin Science Platform*

Rubin-LSST-**05**, **GaLS** (**G. Clementini**), *Gaia-LSST Sinergy*

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Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), *Study of Galactic and Extragalactic Novae*

Our group is producing **extensive simulations of the stars** to be observed by Rubin/LSST. Our second simulation has now been provided to NOIRLab Datalab, and contains over **12 billion stars in all evolutionary stages from pre-main sequence to either white dwarfs or carbon ignition, in the Milky Way and in the Magellanic Clouds**, including interacting binaries, eclipsing binaries, Cepheids, long-period variables, etc. The stellar densities and luminosity functions are integrated in Rubin's Metrics Analysis Framework.

Interest @INAF in Rubin-LSST

Rubin-LSST-**01**, **Rubin-LSST-YSO** (**R. Bonito**), *Rubin LSST: from young stars to the use of the Rubin Science Platform*

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Rubin-LSST-**07**, **MOVIE@LSST** (**I. Musella**), *Modeling and Observations of Variable stars as distance Indicators and stellar Evolution*

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Rubin-LSST-**11**, **SVARIO** (**M. Dall'Ora**), *Stellar VAriability On LSST crowded fields*

Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), *Study of Galactic and Extragalactic Novae*

The goal is the **identification of new GCRs sources, by observing their effects through diffuse clouds**, that can contribute significantly to the total cosmic-ray luminosity at Earth. The team, in collaboration with Stars, Milky Way & Local Volume and Galaxies-LSB Science Collaborations is working on:

*Theoretical-observational **identification of optical indicators** (charge-exchange) for the passage of CRs in known sources of GCRs (SNRs) (work in progress)
***Tools** implementation (according the Rubin Science Platform RSP standards) for the automatic identification of LSST LSB extended sources (in-kind program)
***Tools** implementation for the automatic detection of optical charge-exchange indicators in diffuse clouds close to GCRs possible sources such as WR, Flare, mCP and LBV stars.

Interest @INAF in Rubin-LSST

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Rubin-LSST-**11**, **SVARIO-LSST** (**M. Dall'Ora**), *Stellar VAriability On LSST crowded fields*

Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), *Study of Galactic and Extragalactic Novae*

The goal is **to reconstruct the structure of the Bulge** (and other critically crowded stellar fields), **using appropriate population/age/distance tracers**, with a special focus on the stellar variability. For this, it is necessary to implement adequate data reduction/analysis techniques, not extensively envisaged by the Rubin-LSST pipeline, because of the demanding resources needed. A pilot experiment has already been underway for three years, formalized in the activities of the joint SMWLV-TVS Crowded Stellar Fields Task Force.

Interest @INAF in Rubin-LSST

Rubin-LSST-**01**, **Rubin-LSST-YSO** (**R. Bonito**), *Rubin LSST: from young stars to the use of the Rubin Science Platform*

Rubin-LSST-**05**, **GaLS** (**G. Clementini**), *Gaia-LSST Sinergy*

Rubin-LSST-**07**, **MOVIE@LSST** (**I. Musella**), *Modeling and Observations of Variable stars as distance Indicators and stellar Evolution*

Rubin-LSST-**08**, **popstar-LSST** (**L. Girardi**), *Population models of the LSST stellar content*

RSN 2

Rubin-LSST-**09**, **CRAM** (**I. Busà**), *Cosmic rays accelerators: in loco measurements*

Rubin-LSST-**11**, **SVARIO** (**M. Dall'Ora**), *Stellar VAriability On LSST crowded fields*

Rubin-LSST-**17**, **SUDDEN** (**M. Della Valle**), Study of Galactic and Extragalactic Novae

This is a program that has been dealing with the **photometric and spectroscopic follow-up of galactic and extragalactic Novae for 30 years**. Observations extend **from NIR to X** in both low- and high-resolution imaging and spectroscopy. The program began with telescopes of the 2-4m class and with the IUE satellite and then continued with telescopes of the 8-10m class and with HST and satellites as Fermi, NuSTAR, Swift, AstroSAT, Gaia and the NICER camera on the International Space Station.

Furthermore, we interact and collaborate with the NOARS project for getting X spectroscopy of outbursting novae. In the immediate future, the **synergy between the spectrograph SOXS ("made in INAF") and LSST** will allow to study no less than ~20 objects/year. We expect important results on the **nucleosynthesis of the Milky Way and the Galaxies of the Local Universe** and on the **Distance Scale**.

Interest @INAF in Rubin-LSST

RSN 3 Rubin-LSST-**06**, **CI-LSST** (**L. Inno**), *Vera Rubin LSST for Comet Interceptor*

The science objective of our work is to **identify and characterize** from LSST images **long-period/interstellar comets early on their inbound orbit towards the inner Solar System**, including potential targets for the next ESA space mission **Comet Interceptor** (of which our team is co-I). In particular, we want to **quantify the dust emission rate** and **speed** of these objects by applying a status-of-the art **tail model developed within our team**, in order to assess the dust environment in which the spacecraft will operate. We are currently working i) on simulated LSST images in order to test our detection capabilities, ii) on real images (Asiago, TNG) of close, in-bound comets to test our model predictions (Fulle et al. MNRAS, in press).

Interest @INAF in Rubin-LSST

RSN 4 Rubin-LSST-**10**, **GuRu** (**S. Piranomonte**), *The GuRu (GRAWITA using Rubin) project. Vera Rubin Observatory as a multi-messenger laboratory*

Rubin-LSST will play a key role allowing us to study and identify the likely faint and rapidly fading electromagnetic counterparts of the **hundreds of gravitational wave (GW) events** expected by the 2nd generation GW detectors network at full sensitivity. It will operate in synergy with other multi-wavelength facilities available for our team GRAWITA (GRAvitational Wave Inaf TeAm) expressly dedicated to this project.
GuRu aims to optimize the response of the GRAWITA facilities in the context of the search for GW counterparts with Rubin-LSST providing means and opportunities to have a leading role in the GW and Time Domain Astronomy.

Interest @INAF in Rubin-LSST

RSN 5

Rubin-LSST-**15**, **IQ4VRO** (**G. Fiorentino**), *Image quality for Vera Rubin Observatory commissioning*

Rubin-LSST-**03**, **Astroinformatics** (**G. Riccio**), *Data driven Science in Astrophysics*

Our Image Quality team will support the Active Optics sanity check through the **study of the quality of science images**. We will analyse offline the **PSF shape** and the **geometric distortions across the image Field of View to constrain the Active Optics performance**. As a goal we plan to **develop a full procedure** to process science images in real-time and interfacing with the AO control system. As a further and independent analysis of the image quality, we will study how to **recover magnitudes for saturated stars**.

Interest @INAF in Rubin-LSST

RSN 5

Rubin-LSST-**15**, **IQ4VRO** (**G. Fiorentino**), *Image quality for VRO commissioning*

Rubin-LSST-**03**, **Astroinformatics** (**G. Riccio**), *Data driven Science in Astrophysics*

Main goal for LSST is **to automate commissioning and scientific data analysis**, by exploiting the so-called **"data driven science"** and the **machine learning** paradigms, thus permitting an efficient and proper exploration of its huge amount of multi-wavelength information and multi-dimensional parameter space.