# Activities and Future Plans at the ET-CSIC RU













EINSTEIN TELESCOPE








# Carlos F. Sopuerta

## Instituto de Ciencias del Espacio (ICE-CSIC & IEEC)


Institute of Space Sciences

05 November 2026

# CSIC Institutes in the ET RU

- Institute of Space Sciences (ICE, CSIC and IEEC):
- Institute of Astrophysics of Andalucía (IAA, CSIC):
- Corpuscular Physics Institute (IFIC, CSIC and UV):
- Institute for the Structure of Matter (IEM, CSIC):
- Institute of Physics of Cantabria (IFCA, CSIC):

CSIC currently has 121 research institutes!

# CSIC Institutes in the ET RU







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# The ET-CSIC RU

CS

## CSIC

ETC | 36 members | Spain | Legacy FRTE (66)

CAD table (CSV) | CAD document (Word)

This Research Unit includes Research Institutes of the National Spanish Research Council (CSIC)

Edit RU details | History | Onboard a member | Offboard a member | RU-Leader instructions

**RU LEADER**

Carlos Fernández Sopuerta

carlos.f.sopuerta@csic.es

**OUTREACH RESPONSIBLE**

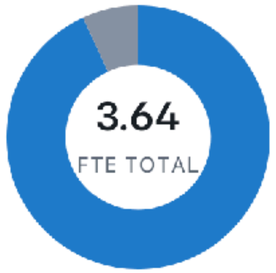
Jorge Rivero González

rivero@ice.csic.es

### PLEDGED FTE BY CP PART

3.64 FTE

Where this RU's pledged effort lands across the top-level Core-Program Parts. Board-Activity pledges without a CP link fall into the grey slice.




| | | |
|---|---|---|
| P-I | 3.39 | 93% |
| BA | 0.25 | 7% |

### PLEDGED FTE BY BOARD ACTIVITY

3.64 FTE

Where this RU's pledged effort lands across the top-level Board Activities. Archived activities are excluded. Hover a legend row for the full board name.



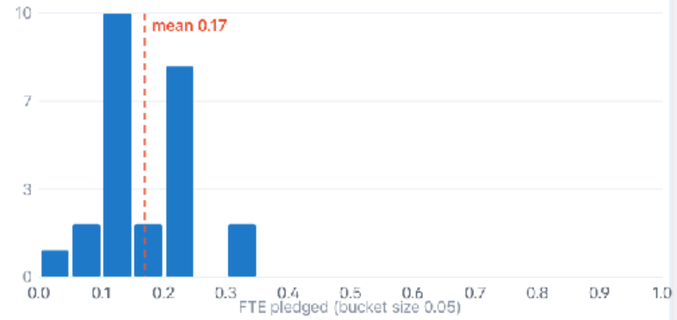

| | | |
|---|---|---|
| OSB | 3.39 | 93% |
| Governance | 0.15 | 4% |
| SSB | 0.10 | 3% |

### PLEDGE-SIZE DISTRIBUTION

25 pledges across 15 members

How many pledges fall in each 0.05-FTE band, across this RU's contributions. Toggle to *Members* to see the same distribution bucketed by each member's summed pledged FTE instead.

Pledges | Members



# The ET-CSIC RU

- Statistics of the CSIC-RU:  ICE, IEM, IFIC, IAA, IFCA

Number of people:  36 (22+3+5+4+2)

Permanent Staff: 19
Postdocs: 10 (1 RyCs; 1 AT)
PhD Students: 6
Engineers: 1

# CSIC Institutes in the RU

Institute of Space Sciences
CSIC IEEC

EXCELENCIA MARÍA DE MAEZTU

## ✳ Institute of Space Sciences (ICE, CSIC and IEEC):




- **Cosmology & Gravitational Waves: I**nvestigation of dark matter, dark energy, and the early universe. Foundational role in the LISA Pathfinder and LISA missions, leading the Spanish contribution, the high-precision science diagnostics subsystem. Key player in the DES, DESI, and Euclid, where it developed, with IFAE, the Near-Infrared Filter Wheel Assembly. ICE leads cosmological data simulations.

- **Astrophysics & Extreme Matter:** Study of the life cycles of stars, supernovae, and compact objects like black holes and neutron stars. ICE contributes to major ground-based observatories, including the Cherenkov Telescope Array (CTAO) for gamma-ray astronomy.

- **Exoplanets & Star Formation:** Discovery and characterization of exoplanets. ICE is heavily involved in ESA's exoplanet missions, PLATO and ARIEL, and in the high-resolution spectrograph ANDES for the ELT.

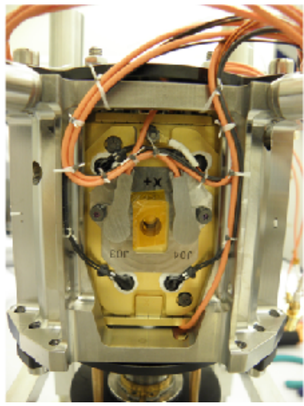
- **Earth Observation & Space Technology:** ICE uses satellite remote sensing (such as GNSS reflectometry) to monitor climate change, ocean states, and the water cycle. They design and build custom aerospace hardware and data systems for both Earth-monitoring satellites and international deep-space missions.

# The Science Diagnostics System

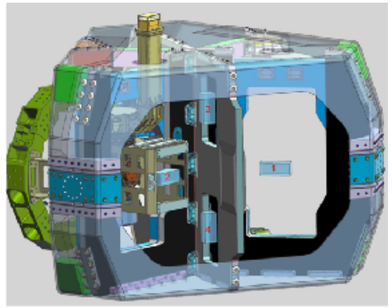
## (Heritage of the contribution to LISA Pathfinder)

✳ The primary goal of the **Science Diagnostics System** (SDS) is to generate scientific information during LISA operations to monitor and characterise the temperature, magnetic and the radiation environment on-board LISA.

| | | | |
|---|---|---|---|
| 144 | Temperature sensors | 3 | Radiation monitors |
| 12 | Magnetometers | 12 | Heaters |
| 3 | Audio band EM antennas | | |

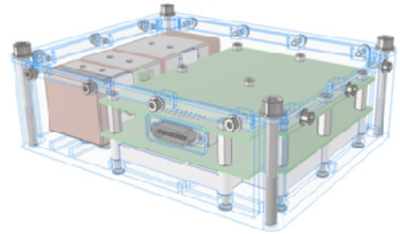


**Temperature fluctuations** can affect the mission in different ways. From temperature-induced forces in the test mass (radiation pressure, outgassing, etc) to thermo-optical distortions. The Temperature Diagnostics Subsystem will provide a network of high precision sensors to measure these fluctuations on-board (**in collaboration with UPC**).



**Magnetic fluctuations** and gradients on-board LISA can couple with the interplanetary magnetic field to produce magnetic-induced forces in the test mass. The SDS will use fluxgate magnetometers and search coils to monitor the magnetic fluctuations on-board.

The **background radiation** can induce charging in the free falling test masses potentially inducing noise in the LISA performance. The objective of the radiation monitor (**in collaboration with ICCUB**) is to characterise the incoming radiation flux in orbit.

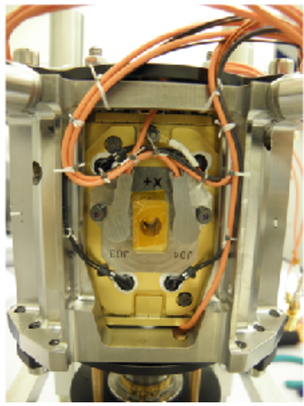


# The Science Diagnostics System

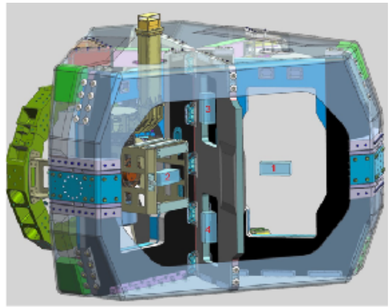
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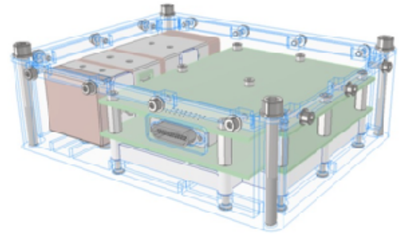


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# The Science and Diagnostics System

ESA UNCLASSIFIED – For ESA Official Use Only – ESA-LISA-EST-BAM-PR-0002

LISA SDS PDR BOARD REPORT

## The LISA SDS Preliminary Design Review is declared successful!

| | |
|---|---|
| Prepared by | LISA Payload Team |
| Document Type | |
| Reference | ESA-LISA-EST-SDS-RP-0001 |
| Issue/Revision | 1 . 0 |
| Date of Issue | 03/03/2026 |
| Status | Draft |

ESA UNCLASSIFIED – For ESA Official Use Only ESA-LISA-EST-BAM-PR-0002



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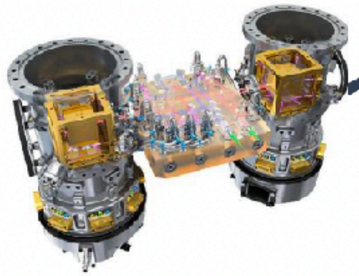
# The Science and Diagnostics System

## ILIADA: In-Orbit LISA Diagnostics Demonstrator

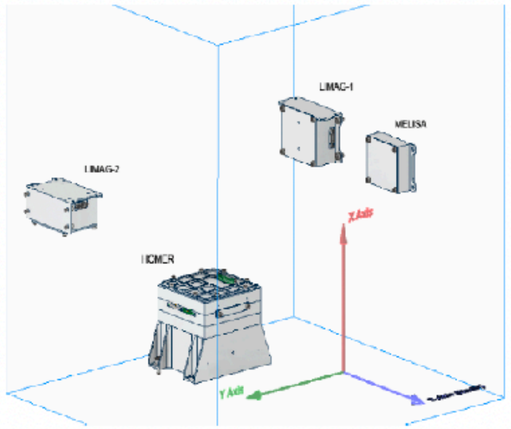
**LISA Pathfinder Diagnostics Subsystem (DDS)**

- 24 NTC temperature sensors
- 4 Fluxgate magnetometers
- 1 Radiation monitor (Si PIN)
- 16 Heaters
- 2 Coils

2015



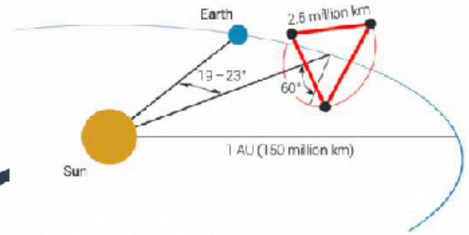
2026




**ILIADA is an in-orbit demonstrator for the LISA Science Diagnostics Subsystem (SDS).**

**To be flown in the Geneo-2 Earth Observation CubeSat with expected launch on Q1 2026 as part of the Generalitat de Catalunya NewSpace strategy**

2035




**LISA Scientific Diagnostics Subsytem (SDS)**

- 144 NTC/Pt temperature sensors
- 18 AMRs magnetometers
- 3 Radiation monitor (Si PM)
- 12 Heaters
- 6 Coils (audio band EM sensors)

IEEC

www.ieec.cat




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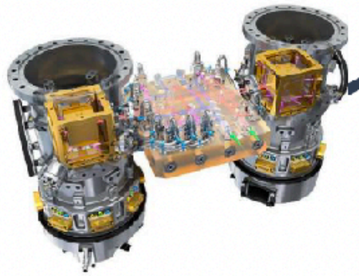
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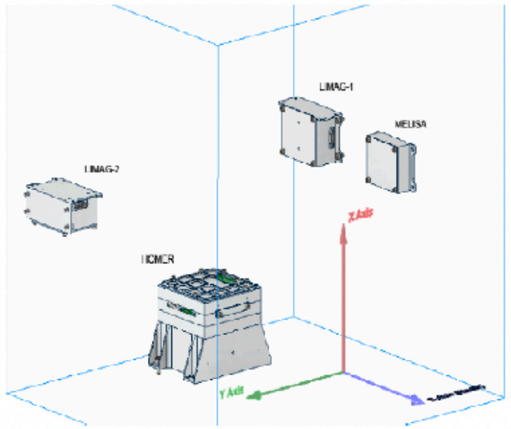
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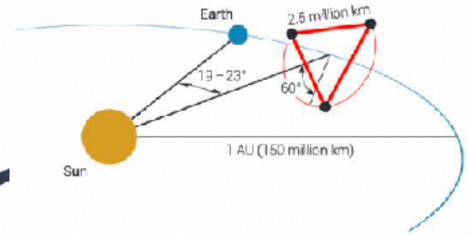
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# LISA Ground Segment and Scientific Operations

✳ Contributions to the LISA Ground Segment, as established in the Multi-Lateral Agreement (MLA) between ESA and member states:

**Spain**

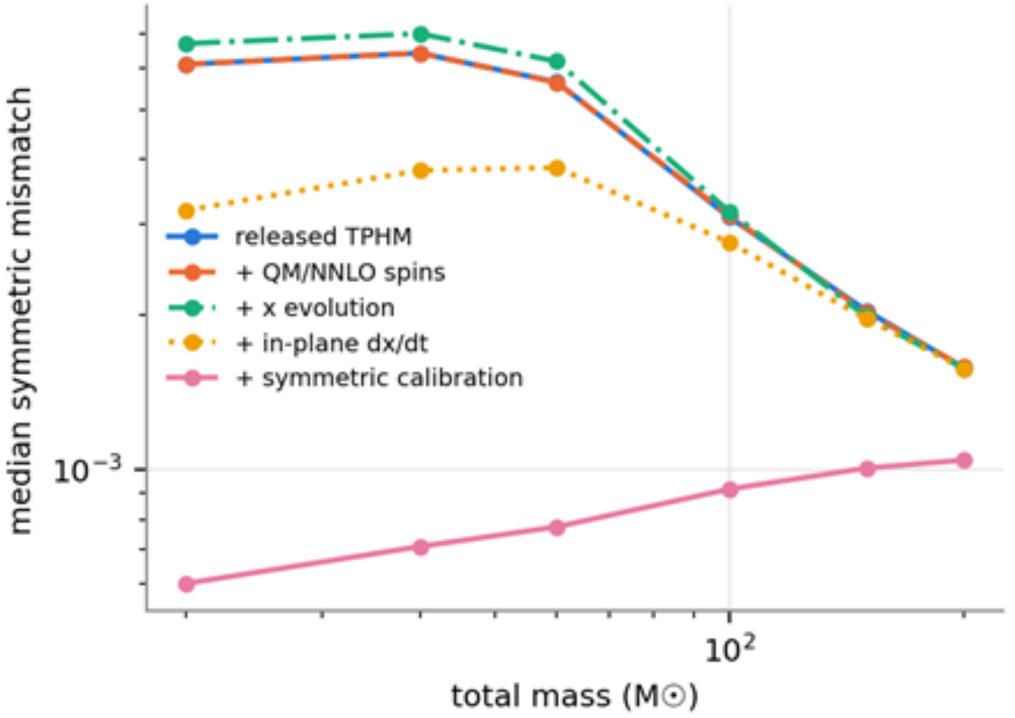
- Be responsible for the development of 1 instance of the following pipelines of the DDPC:
  - Global Fit Pipeline;
- Be responsible for the deployment in Spain of 1 DCC and contribute to the system engineering work packages;
- Contribute to the software and data processing (contribution to other work packages than listed before) of the SGS and to the operations.

**Spanish contribution to waveforms is going to be added in the revision of the LISA MLA! (ICE, UIB)**

# LISA Ground Segment and Scientific Operations

## Contributions to OBS DIV-8 (Waveforms)

- Division co-chaired by Husa.
- New developments for the time-domain IMRPhenom models (collaboration with UIB):
  - Improved dynamics for spin-precessing systems and co-precessing NR calibration (Estellés+,in-prep)
  - Addition of the dominant equatorial asymmetry (Kolitsidou+,in-prep)
  - Collaboration with Valencia+ - add eccentricity.
- Development of new time-domain baseline:
  - Coordinated between ICE and UIB
  - First production models expected on a 6-month timescale
  - Prototype, bridging the gap between comparable mass and high-mass-ratio systems almost ready (Yébana+, in-prep, co-supervised by Estellés)



# Contributions to OBS DIV-8 (Waveforms)

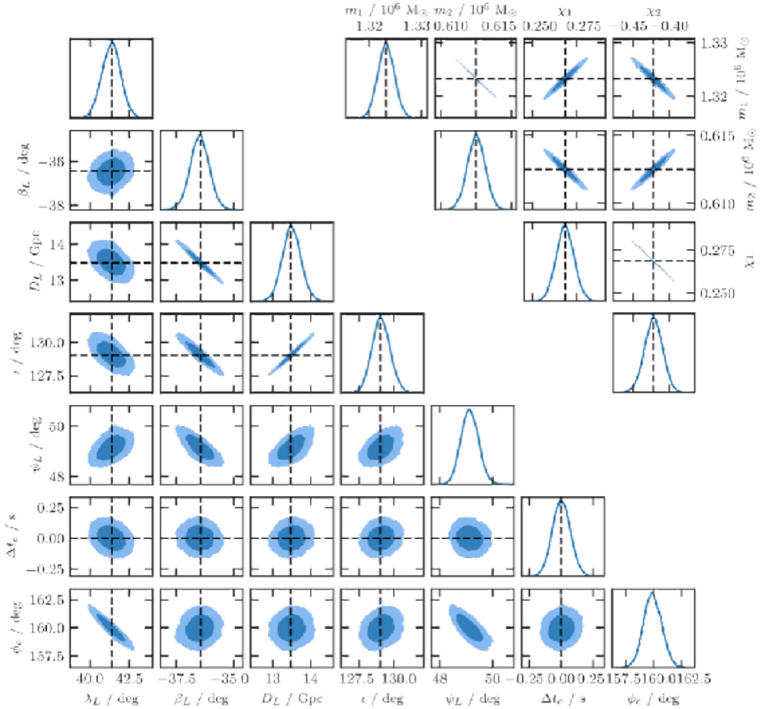
- Common tools for waveform systematic projects:
  - GWFitFactor (likelihood optimisation and unfaithfulness tool to compute parameter biases) (Brandoli+, in-prep)
  - Coordination with Common tools from LISA Consortium (Estellés project coordinator on the LISA side)
- Common waveform reviews:
  - Deep expertise from LVK waveform reviews during the last decade
  - Involvement in current waveform review activities for the LISA DDPC (Estellés review chair of pyseobnr; member of review team for phenomxpy and pyEFPE)
  - Goal to standarize review processes across collaborations to reduce human cost and accelerate readiness time of new waveform improvements

# Data Analysis for Gravitational Wave Astronomy

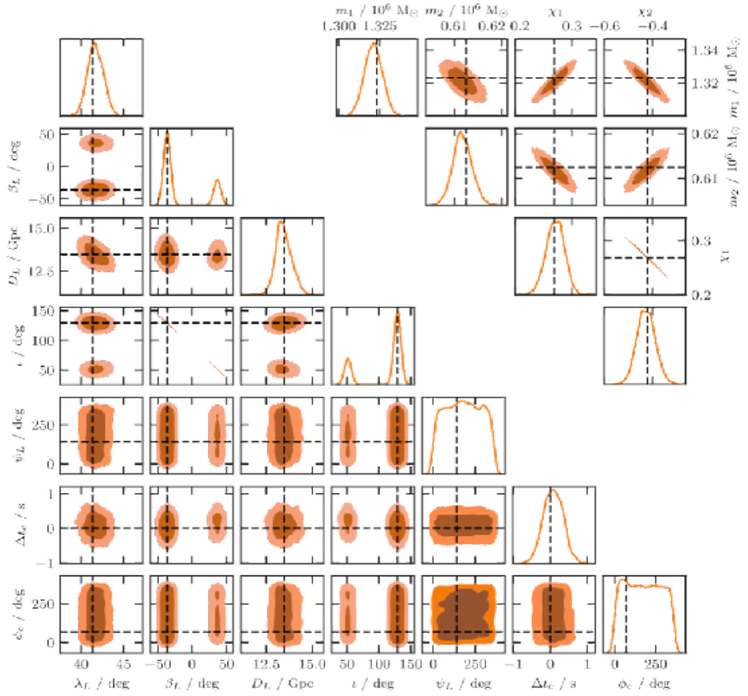
✳ **Practical Case:** Massive Black Hole Binary detection with LISA.

➡Some Results

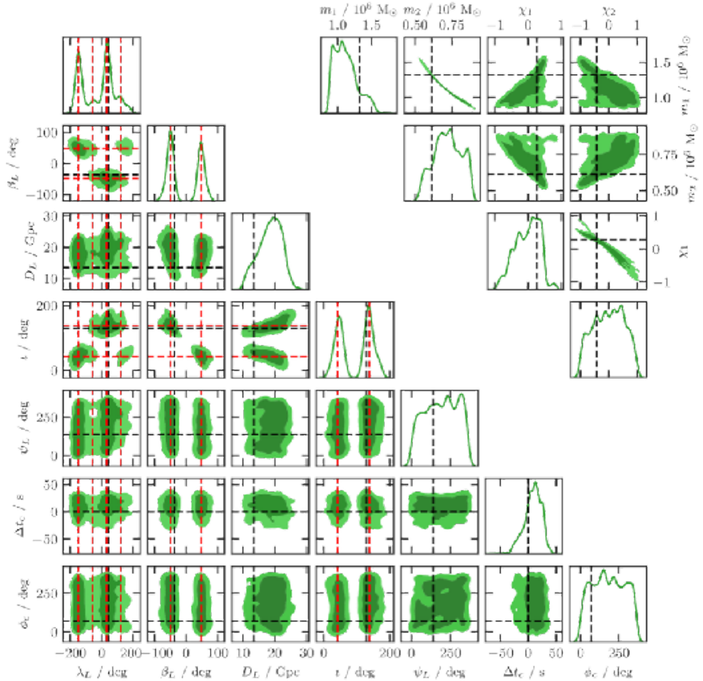
**Iván Martín Vílchez, CFS, JCAP 04(2025) 022, arXiv:2406.00565**



Erin (MCMC sampler)



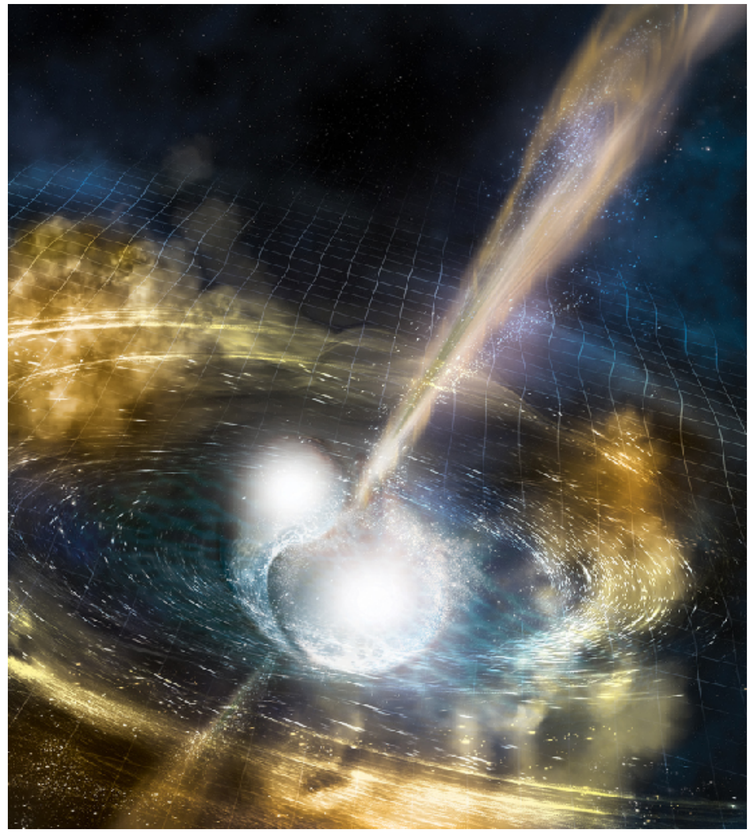
SNL-PCA



SNL-AE

# Nuclear Physics and Black Hole Populations

✳ The ICE-CSIC **nuclear physics group** (Laura Tolos, Cristina Manuel and collaborators) treats neutron stars and their mergers as laboratories for matter beyond nuclear density. They compute the microphysics, meaning the equation of state, transport coefficients and possible dark-matter components, that leaves a measurable imprint on the gravitational-wave signal.



✳ Mezcua and Izquierdo-Villalba work on where **massive black holes** come from and how they grow and pair up. Mezcua searches dwarf galaxies for “leftover” black hole seeds. Izquierdo-Villalba models the full population of massive black holes and their binaries across cosmic time, which predicts what **LISA** and **pulsar timing arrays** should detect.

# CSIC Institutes in the RU

✳ Institute of Astrophysics of Andalucía (IAA, CSIC):



- **Electromagnetic Counterparts to Gravitational Waves:** The High-Energy Transients and HESS (HETH) group is deeply involved in tracking the visible "counterparts" of gravitational wave events. They use a global network of telescopes to rapidly catch the optical, radio, and gamma-ray light (like kilonovae and supernovae) emitted when neutron stars or black holes collide.

- **Robotic Telescope Networks:** To support the rapid follow-up of fast gravitational wave triggers, the IAA has been a pioneer in developing autonomous and networked robotic observatories capable of reacting to cosmic alerts within minutes.

# CSIC Institutes in the RU

✳ Institute of Astrophysics of Andalucía (IAA, CSIC):



- **Flagship Space and Ground Instrumentation:** IAA has a large technology division that builds hardware for international astrophysics missions, including key instruments for ESA's JUICE (GALA/JANUS), PLATO mission, the Solar Orbiter, and major ground-based systems like the Calar Alto Observatory instrumentation (CARMENES-PLUS) and spectrographs for Europe's Extremely Large Telescope (ELT)

- **Fundamental Physics and Black Holes:** IAA has a large contribution to the Event Horizon Telescope (EHT). They are developing tests of the nature of black holes and gravity with gravitational waves (contribution to ET).

# CSIC Institutes in the RU

✳ Corpuscular Physics Institute (IFIC, CSIC and UV):




- **Experimental Particle Physics**: Involvement in the ATLAS and LHCb experiments at CERN's LHC.
- **Neutrino and Astroparticle Physics**: Leading roles in neutrino experiments (KM3NeT, DUNE, NEXT, and T2K).
- **Nuclear Physics**: Participating in accelerator facilities like FAIR (Germany) and n_TOF at CERN.

# CSIC Institutes in the RU

✳ Corpuscular Physics Institute (IFIC, CSIC and UV):




- **Theoretical Physics**: High-energy phenomenology, QFT, cosmology, black holes, quantum gravity. Predictions for Gravitational Wave backgrounds for LISA and ET (contribution).

- **Medical Physics & Computing**: Applying nuclear and particle technologies to advanced medical imaging (like PET/CT scans). Big contribution to GRID and e-Science distributed computing frameworks.

# CSIC Institutes in the RU

✳ Institute for the Structure of Matter (IEM, CSIC):



- IEM group is actively participating in the first LISA+ET Synergy project on parameter estimation of the gravitational-wave background using both LISA and ET.

- IEM contributes at the level of coding (a brand new Python code has been developed for the task), theoretical, simulations, and writing.

- IEM also engages in extensive theoretical analysis aimed at estimating quantum gravity effects that can be tested through tests of General Relativity.

- IEM researchers are in the process of getting more involved in the governance of the ET collaboration through the planned participation to committees.

# CSIC Institutes in the RU

✳ Institute of Physics of Cantabria (IFCA, CSIC):



- **Observational Cosmology & Lensing**: A major point is gravitational lensing across cosmic scales (such as strong-lensing analyses of galaxy clusters) to constrain dark matter properties and cosmological parameters.

- **Particle Physics Instrumentation**: IFCA has a Particle Physics and Instrumentation division. They specialize in silicon radiation detectors and advanced photodetectors. They are primary contributors to the development and hardware upgrades of massive detector components at CERN.

- **Advanced Computing & Big Data**: IFCA operates a Supercomputing and e-Science center. They utilize cutting-edge Grid Computing, Machine Learning, and Big Data infrastructures to handle massive data storage.

# Role in the support of Spain to ET for entry in ESFRI

- Instituto de Ciencias del Espacio (ICE, CSIC y IEEC): Institute of Space Sciences (CSIC IEEC) — Excelencia María de Maeztu
- Instituto de Astrofísica de Andalucía (IAA, CSIC): IAA Instituto de Astrofísica de Andalucía — CSIC — Excelencia Severo Ochoa
- Instituto de Física Corpuscular (IFIC, CSIC y UV): IFIC Instituto de Física Corpuscular — CSIC — Universitat de València — Excelencia Severo Ochoa
- Instituto de Estructura de la Materia (IEM, CSIC): IEM Instituto de Estructura de la Materia — CSIC
- Instituto de Física de Cantabria (IFCA, CSIC): IFCA Instituto de Física de Cantabria — Excelencia María de Maeztu
- Instituto de Física Teórica (IFT-CSIC/UAM): ift Instituto de Física Teórica UAM-CSIC — Excelencia Severo Ochoa

MINISTERIO DE CIENCIA E INNOVACIÓN

CSIC Consejo Superior de Investigaciones Científicas

Madrid, a 5 de febrero de 2020

Subdirección General de Internacionalización de la Ciencia y la Innovación
Ministerio de Ciencia e Innovación

**Asunto: CARTA DE APOYO INSTITUCIONAL A LA PROPUESTA Einstein Telescope-ESFRI**

Estimado Subdirector General:

Por la presente, nos complace comunicarles que la Agencia Estatal Consejo Superior de Investigaciones Científicas (CSIC) expresa su firme apoyo a la candidatura "**Einstein Telescope**", con el fin de ser incluida en la Hoja de Ruta 2021 del Foro Estratégico Europeo de Infraestructuras Científicas (ESFRI).

## POLITICAL SUPPORT

**Lead**
IT
**Prospective member**
BE, ES, NL, PL



# Plans for the short-medium term

✳ We are working on increasing of the involvement of the current CSIC institutes within the ET-CSIC RU and involve new ones connected with the science of ET, in particular in instrumentation and data analysis.

✳ CSIC commission for Large Scientific Infrastructures. We are reporting to them our involvement in ET.

✳ CSIC has institutes with experimental expertise in many areas of interest for ET. We have to investigate which ones can be compatible with the requirements for ET and ways to define realistic contributions to ET.

✳ We are going to apply to the CSIC "**Programa CSIC en Grandes Infraestructuras de Investigación Europeas**" (the annual INFRAS call) funds CSIC groups to strengthen their role in ESFRI infrastructures. Each year it awards about 4 grants of up to €100k each, lasting up to 48 months. It is renewed for 2025–2026 with €400k per year.