Position for the Update of the European Strategy for Particle Physics provided by RENATA, MULTIDARK and REDONGRA thematic networks

The fields of multi-messenger astrophysics (using gamma ray, neutrino, charged particle and gravitational wave messengers), neutrino physics (neutrino properties from man-made accelerator, astrophysical and radioactive sources) and dark matter searches through direct detection have made remarkable progress in recent decades. They have produced major discoveries that challenge the standard models of particle physics and cosmology, providing invaluable approaches to uncovering new physics. This document summarizes the input provided by the Spanish astroparticle and neutrino physics community for the 2026 Update of the European Particle Physics Strategy.

In Spain, the astroparticle and neutrino physics community comprises about 400 FTEs covering both experimental and theoretical research activities. The scientific objectives and technological approaches are very diverse, with Spanish participation spanning more than 30 experimental projects. While recommendations on specific research lines are listed in the three subsections below, we provide here some general remarks, namely:

- CERN should continue to support astroparticle and neutrino physics projects not based at CERN through Recognized Experiment status. Among those, particularly strategic for us are the projects and infrastructures with Spanish participation included in the European Strategy Forum on Research Infrastructures (ESFRI) Landmarks and Projects, and in the Spanish Unique Science and Technology Infrastructures (ICTS).
- CERN should continue to support neutrino physics based at CERN, both theory and experiments, through its Neutrino Platform.
- International collaboration agreements between CERN and other particle physics laboratories around the world should continue and be strengthened, as we believe that they are beneficial not only for the current and future collider projects at CERN, but also for astroparticle and neutrino physics projects based elsewhere.

Dark Matter Direct Detection

While traditional dark matter (DM) candidates like WIMPs with masses above 1 GeV and QCD axions remain central to DM searches, new candidates have emerged that cover a vast range of mass scales. Covering the whole mass range will require a comprehensive and coordinated exploration program incorporating all available detection strategies (direct detection, indirect detection, production in colliders, astrophysical measurements, and simulations). Combining these approaches will maximize the chances of discovering new physics beyond the Standard Model. DM research in the coming years can be divided into three major groups: (1) heavy WIMPs, with masses on the order of 1 GeV–100 TeV; (2) light DM, with masses between 1 eV

and 1 GeV; and (3) wave-like DM, including axion-like particles or other ultra-light scalar or vector candidates with masses below 1 eV.

For heavy WIMPs, efforts should continue exploiting well-established direct detection technologies based on argon and xenon. These technologies are mature enough to explore the parameter space down to the so-called "neutrino fog", a region where neutrino backgrounds become significant, making detection challenging. Current limits on SI WIMP-nucleus interaction are set by xenon experiments, and the first observation of nuclear recoils from solar ^{8}B neutrinos by the XENONnT experiment via coherent elastic neutrino-nucleus scattering (CEvNS) was announced in summer 2024. At the same time, argon offers the best prospects in terms of electron recoil background rejection, and the experiments using liquid argon (LAr) detectors have joined in the Global Argon Dark Matter Collaboration, which includes participation from the Spanish community. The first detector of this collaboration, DarkSide-20k with 20-ton fiducial mass, is under construction at Gran Sasso Laboratory (Italy) and is projected to reach the 10^{-48} cm^2 scale in spin-independent (SI) interaction for 1 TeV WIMP mass. A third-generation experiment, ARGO (300-ton fiducial volume), is planned to be the ultimate dark matter experiment with a planned exposure of 3000 ton·y. The xenon community is also joining forces under the proposal of a third-generation large experiment, XLZD (XENON+LZ+Darwin, 60-ton liquid Xe). The complementarity between argon- and xenon-based techniques will be essential if a DM signal is discovered, as it will help to disentangle the specific type of interaction involved (e.g., spin-dependent or spin-independent interactions of WIMPs). Therefore, we strongly support progress in both technologies. While xenon is naturally radiopure, atmospheric argon (AAr) contains the cosmologically produced radioactive ^{39}Ar isotope. For future projects, it is essential to ensure the production of underground argon (UAr), where ^{39}Ar is depleted by three orders of magnitude. The UAr production involves three stages: extraction in a mine, purification, and quality control. The DArTinArDM detector, under construction at the Canfranc Underground Laboratory (LSC), will provide the required sensitivity in ^{39}Ar. The LSC is a Spanish ICTS, the only underground scientific facility in Spain, and the second largest underground laboratory in Europe in terms of size and characteristics. Maintaining the UAr production and control chain will be essential in future years, not only for Ar-based DM searches but also for other projects like LEGEND (a neutrinoless double beta decay search with Ge detectors in a LAr bath) or a potential future DUNE module.

Thanks to their increased sensitivity, these direct DM experiments are starting to observe solar neutrinos through CEvNS and electron interactions. This will not only allow to test the prediction from Solar models, but also to look for new physics in the neutrino sector in a complementary way to neutrino detectors. A better understanding of the uncertainties in neutrino fluxes and CEvNS cross section is needed to better disentangle a potential DM signal from neutrinos. We thus support further experimental and theoretical investigations in these areas, with Spanish groups actively contributing through both theoretical efforts (IFT/IFIC) and experimental projects (ESSCEvNS and GanESS at the European Spallation Source).

For light DM, small-scale or proof-of-concept experiments are currently setting limits in previously unexplored regions of the parameter. However, ensuring a continuous scale-up in experimental exposure is crucial to maximizing future coverage. Spain is involved in the development of a number of these experiments: among the mature technologies, SuperCDMS, using germanium

and silicon cryogenic detectors, is well-positioned to probe MeV-scale DM via electron scattering, as well as to detect eV-scale dark photons and ALPs through absorption; skipper-CCD technology has proven to be highly effective in reducing noise and achieving single-electron counting, allowing sensitivity down to 1 MeV for DM detection. We support scaling up current setups, such as the projected 10 kg OSCURA detector, a collaborative effort by DAMIC, DAMIC-M, and SENSEI. Several of these experiments have measured an excess at low energies over modeled backgrounds. The effort to resolve these unknown backgrounds, already underway through the EXCESS workshops, should be continued as a joint effort among different groups and technologies. We also endorse further development of small-scale experiments, such as TREX-DM (a Spanish project looking for low-mass WIMPs with a high-pressure Micromegas TPC) and ANAIS+ (NaI+SIPM, still in the R&D phase and also led by Spanish groups) with potential to explore SI and SD couplings for light WIMPs. Experiments focused on heavy WIMPs can also contribute in the low-mass regime, generally by switching off the nuclear vs electron recoil discrimination capability. This will be the case for DarkSide-LowMass, which is based on the demonstrated ultra-low threshold achieved with DarkSide-50. In addition, to fully explore light DM candidates and dark sector particles that may interact via new mediators, it is essential to support R&D across diverse experimental technologies. Quantum sensor technologies are of particular interest as an exciting new frontier for detecting DM.

Currently, stringent experimental limits on low-WIMP mass are established by assuming a low-probability ionization process driven by the recoiling nucleus (the MIGDAL effect), which has not yet been experimentally confirmed. The MIGDAL collaboration is actively working to assess this effect experimentally, and this effort should be supported.

We highlight the long-standing claim of a positive DM signal observed as an annual modulation in the low-energy data of the DAMA/LIBRA experiment at LNGS. This result is being strongly challenged in a model-independent way by the negative results of ANAIS-112 and COSINE-100. ANAIS-112, a Spanish experiment, is still collecting data at LSC and is projected to test the DAMA/LIBRA result with 5σ significance based on data accumulated until the end of 2025, having reached already with the analyzed six years data more than 4 sigma sensitivity. However, further work is needed to eliminate the main relevant systematic issue affecting the comparison: the response to nuclear recoils, which may differ from that of DAMA crystals. On the other hand, once the DAMA/LIBRA experiment has concluded the data taking, we believe it is essential to independently verify the result using the same DAMA crystals by a different research team. This is the goal of a collaborative proposal between SABRE, COSINE, and ANAIS and represents a unique opportunity to resolve a puzzle that has persisted for more than 20 years—a chance the community should not miss and we strongly support.

Continuous improvements in material radioassay and cleaning procedures, as well as in detector response modeling and validation of simulation tools like GEANT, FLUKA, or SRIM in the low-energy region, are essential for the future of DM searches. Of particular relevance for both DM and CEvNS experiments is the measurement and modeling of nuclear quenching factors. We strongly support future research in these instrumental areas and the establishment of a dedicated working group among the CERN Detector Research and Development collaborations. Finally, we

emphasize the importance of a commitment to open science and transparency in analysis protocols.

For axion searches, efforts should continue leveraging both experimental and theoretical advancements to probe unexplored regions of parameter space. The International Axion Observatory (IAXO) is the largest European collaboration in search for axions, with a strong Spanish leading contribution. As an axion helioscope, it will enjoy a 10(4-5) increase in signal-to-noise compared to the best current solar axion searches. Its pathfinder, BabyIAXO, under construction at DESY, will set the foundation for the full IAXO, and also explore additional physics cases, like the search for dark matter axions, supernova axions, or other feebly interacting particles that may be viable dark matter candidates. Should BabyIAXO detect a signal, IAXO would enable detailed axion studies and their astrophysical implications. The Relic Axion Detector Exploratory Setup (RADES) is testing novel detection concepts building on the axion haloscope concept in search for dark matter axions. Among other actions, the implementation of large RF-cavities inside the BabyIAXO magnet is contemplated, with very competitive sensitivity to low mass (1-2 microeV) axions. With the recently awarded ERC-SyG DarkQuantum, a substantial sensitivity step ahead will be unlocked by the use of quantum technologies, an activity with an important role of the Spanish community. Finally, The Canfranc Axion Detection Experiment (CADEx), a fully Spanish collaboration, uses advanced technology such as Kinetic Inductance Detectors (KIDs) to target high-mass DM axions, predicted in post-inflationary scenarios with large axion production from topological defects. These initiatives, particularly the use of quantum sensors, place Spain at the forefront of axion research.

At a European/international level, we strongly support the completion and scientific exploitation of BabyIAXO and the preparations towards the future full-scale IAXO, as a major strategic goal for the community. In addition, we support the realization of a diverse portfolio of smaller initiatives to explore novel concepts and connections, potentially ground-breaking, in particular those using quantum sensors. From a theoretical perspective, significant progress has been made in calculating the axion parameter space relevant for DM, particularly addressing the challenging contributions from topological defects. Spanish research groups are leading these efforts, contributing valuable insights into axion cosmology. Moreover, ongoing theoretical work is advancing our understanding of axion production from astrophysical sources especially (but not limited to) supernovae. Finally, new results from the Instituto de Astrofísica de Canarias (IAC), in particular observations from the MAGIC telescope, have provided important constraints on axions from observations of very high energy astrophysics phenomena. In this respect, there is considerable anticipation for the forthcoming Cherenkov Telescope Array (CTA). The complementarity and synergy between different experimental techniques, observational, and theoretical studies makes Spain a leading player in the modern axion investigation.

Neutrino Physics

The Spanish community has been actively working in neutrino physics for more than 20 years, to improve our understanding of neutrino properties; making relevant contributions in both

theoretical and experimental physics, and covering a wide field, from 0νββ decay detection to neutrino oscillation studies.

Despite remarkable progress, many open questions persist in neutrino physics. These include a detailed description of flavor oscillations, the absolute scale of neutrino masses and its origin, the fundamental nature of neutrinos, the potential existence of physics beyond the Standard Model, the determination of neutrino properties from cosmological measurements, and the accurate modeling of neutrino interactions with matter. Spanish research groups specializing in neutrino theory and phenomenology are actively working to address these challenges and are internationally recognized for their contributions, with two of the coordinators of the CERN Neutrino Platform - Theory Working Group coming from Spain. In the next years, Spanish research teams are well-positioned to make substantial advancements in neutrino theory and phenomenology. Examples include the continued development of Spanish-led global fits to extract neutrino mass and mixing parameters (see http://www.nu-fit.org/ and https://globalfit.astroparticles.es/), theoretical nuclear models and their implementation in neutrino event generators, new BSM searches using neutrino probes or neutrino detectors, the study of coherent elastic neutrino-nucleus scattering, and the calculation of nuclear matrix elements for 0νββ decay.

Regarding neutrino oscillations, the Spanish groups plan to continue participating in the near detector (ND) of T2K (Japan) and on the ND of the Short Baseline program at Fermilab (US), SBND. Both experiments are at the forefront of the most challenging neutrino oscillation quests: the three-flavour neutrinos oscillation and the unitarity of the neutrino oscillation mixing matrix. The technologies developed and used in these experiments are the starting point of the next generation of long baseline neutrino oscillation (LBNO) experiments in Japan and US, Hyper-Kamiokande and DUNE. These experiments will be able to measure the neutrino mass ordering and the CP violation phase, and make precise measurements of the three-flavour mixing parameters in the next decade. Spain is providing strong support for the construction of both experiments through European funds.

DUNE is a collaboration of more than 1,400 collaborators from 240 institutions worldwide, including CERN, and hosted in the US. DUNE Phase I is funded, and includes two (out of four) 17 kton liquid argon TPC modules for the Far Detector (FD), a broad-band neutrino beam, and the near detector complex. The excavation of the four large underground caverns at the far site have been completed in 2024, with the DUNE physics planned for 2029.

The Spanish groups are playing a leading role in the development and construction of DUNE's detectors and related physics program. They form a cohesive community that engages in a coherent and coordinated participation in DUNE. The national community supports the Spanish participation in the second phase of the DUNE project, that encompasses an enhanced 2.1 MW beam, a third and fourth far detector modules at SURF, and an upgraded near detector complex at FNAL.

CERN is currently constructing the first two of four cryostats for the DUNE detectors based on new technology and plays a central role in the development of the DUNE cryogenic facility. The

CERN involvement in the cryogenic infrastructure also for the third and fourth DUNE far detectors is critical to maintain the current high standards and should continue. Besides that, CERN should foster DUNE's physics programme with a strong contribution to computing resources.

HyperK is an LBNO experiment currently under construction in Japan. The collaboration has about 600 members from 104 institutions from 22 countries. The FD is a 190 kton Water Cherenkov detector. HyperK will start data-taking in 2027.

The Spanish groups have sole responsibilities for crucial FD components as the 20,000 PMT covers, the geomagnetic compensation system and the ventilation system. HyperK will profit from the recently completed upgrade of the ND280 detector of the T2K experiment, which will serve as ND. Spanish groups have leading roles in the organization to operate ND280 in the HyperK era. In addition, a second near detector, the Intermediate Water Cherenkov Detector (IWCD), complementary to ND280, will be constructed. A prototype for the IWCD was constructed at CERN with significant Spanish contributions and is currently taking data. The Spanish groups are exploring possible contributions to IWCD.

The Spanish community considers high priority for the next years to support and enhance the Spanish participation in DUNE and HyperK, given the high complementarity of their experimental techniques.

The CERN Neutrino Platform is a unique facility for the development of large-scale prototypes for next generation neutrino detectors. Europe and CERN should continue to support the Neutrino Platform and a dedicated low energy beam until at least 2030. The CERN DRD collaborations are a promising way to fund and articulate the R&D necessary for the upgrades of the long-baseline neutrino detectors, where Spain is already playing a leading role. These R&D demonstrators at CERN also enable world-leading physics opportunities in the short term, for example through the search for beam-produced, and long-lived, BSM particles.

Apart from the neutrino oscillation experiments based on neutrino beams, the Spanish community is involved in the study of the oscillation of atmospheric neutrinos within KM3NeT-ORCA experiment, the only one of its kind based on Europe, which should make a significant contribution to the resolution of the neutrino mass ordering in the next few years, prior to next-generation LBNO experiments. Spain is leading the NEXT experiment at the LSC (Spain), one of the major Europe-based experiments searching for $0\nu\beta\beta$. Scientific exploitation of the currently operating NEXT-100 detector will continue until the end of the decade. In parallel, R&D toward a next-generation tonne-scale detector, NEXT-HD, is underway, and will be validated via a NEXT-100 upgrade. Spanish physicists are also leading a new initiative to study coherent neutrino scattering (CEvNS) at the ESS and other neutron facilities, amply backed by the ESS program. The emerging area of CEvNS-based neutrino physics, whose detection was only established in 2017, provides many unexplored avenues for BSM searches and close collaboration between Spanish theorists and experimentalists.

In all these cases, the association to CERN as recognized experiment has been key for the development of technology and software, as well as benefiting from CERN know-how. In the

future, as the technological developments needed to increase the physics potential of the above experiment become even more challenging, the status of recognized experiment will become even more important.

The Spanish community is also interested in the novel application based on opaque liquid scintillator, the so-called LiquidO technology, to the detection of low-energy neutrinos, decay and CEvNS process. In particular, there is an important Spanish contribution within an EIC-Pathfinder project devoted to the exploration of LiquidO technology to use neutrinos as a direct probe into the functioning of industrial nuclear reactors.

Multi-messenger Astrophysics

This is an exciting era for astrophysics studies involving multiple cosmic messengers. In addition to traditional observational techniques based on collecting photons across the electromagnetic spectrum—particularly gamma rays for astroparticle physics—the advent of neutrino and gravitational wave observatories, as well as sensitive charged particle detectors, now enables a much more comprehensive view of cosmic phenomena across diverse astrophysical environments and scales.

Gamma rays

Spain has a longstanding tradition and renowned expertise in the gamma-ray energy domain, especially in Imaging Atmospheric Cherenkov Telescopes (IACTs) from the ground. Starting with HEGRA in the 1990s and continuing with the MAGIC telescopes in the early 2000s—still operational today—the Spanish IACT community has consistently contributed to the field. For the years ahead, the top priority for this community will undoubtedly be the construction and operation of the Cherenkov Telescope Array Observatory (CTAO), with its northern site at a Spanish ICTS, the Roque de los Muchachos Observatory. The CTAO facility, an ESFRI Landmark, is expected to lead TeV multi-messenger astrophysics for decades. The first large-size telescope at the array center, LST-1, is already delivering scientific results, with additional telescopes (LST-2 to LST-4) set to be operational by the end of 2025. We strongly support Spain's ongoing commitment to CTAO, which has been instrumental in making this project a reality. The significant contributions and involvement of Spanish institutions have been key to the current construction efforts and the development of CTAO's scientific potential across various topics. It is crucial and strategic for Spain to finalize the hardware construction commitments and increase its dedication to software deliveries to prepare for the full scientific exploitation of the array even as its construction is finalized. Notably, CTAO's exceptional capabilities for studying transient sources and its prominent role in the multi-wavelength and multi-messenger astrophysics international arena deserve special attention. Additionally, CTAO is poised to become the leading instrument for searching for dark matter signals in the TeV mass range, a focus where Spanish institutions already play a leading role. Continuing and strengthening these contributions is essential and has our full support.

Complementing CTAO from space, the NASA Fermi Large Area Telescope (LAT) aboard the Fermi satellite operates at lower, GeV energies and is expected to continue its mission for many more years. After 16 years in operation, Fermi LAT remains in excellent condition, and no planned facility is expected to replace it in its energy range, ensuring its status as the leading instrument for GeV astrophysics for the foreseeable future. For this reason, we strongly support the Spanish community's involvement in Fermi LAT operations and scientific exploitation. While Spain is not formally a partner in the mission, several national research groups have historically held significant roles within the Fermi LAT Collaboration. Moreover, there is substantial overlap and synergy between the Fermi LAT and the much larger Spanish IACT community, which we strongly encourage strengthening. A collaborative IACT+LAT effort is already underway, addressing diverse scientific topics such as AGN physics, pulsars, cosmology, and dark matter research. Spanish researchers have been at the forefront of Fermi LAT's scientific production in several of these areas, and these efforts should continue and expand, especially with CTAO nearing the start of its operations. Early exploration and involvement on alternatives beyond Fermi LAT operations are also encouraged and have already started (e.g., HERD, COCOA).

Neutrinos

Spain has a strong and well-established reputation in neutrino astronomy as well. The significant involvement of many Spanish institutions in ANTARES—the proof-of-concept project for neutrino telescopes under seawater—not only provided international visibility to the Spanish neutrino community but also allowed the acquisition of invaluable expertise over the past decades. With ANTARES now decommissioned after 14 years of continuous operations, the national community's absolute priority is the ESFRI Project KM3NeT. Spanish contributions to KM3NeT are substantial, both in hardware development and scientific exploitation, as they were for ANTARES.

To date, 57 KM3NeT detector lines have been installed, producing competitive results while taking data, and additional lines will be deployed soon until the observatory is fully completed by 2028. The recent announcement of a neutrino event with the highest energy ever observed has garnered significant attention from the scientific community, highlighting KM3NeT's enormous potential for breakthroughs in the field. We strongly support Spain's heavy involvement during this critical construction phase, as well as its contributions to scientific studies on neutrino properties (mass ordering, neutrino oscillation parameters), neutrino astronomy and BSM searches (dark matter, neutrino NSIs, neutrino decay, heavy neutral leptons…). KM3NeT will be particularly significant for joint multi-messenger efforts, with neutrino alerts (<20 seconds) expected to begin by the end of 2024. We strongly encourage synergies with the Spanish gamma-ray and gravitational wave communities to maximize the potential of these collaborations. Maintaining Spain's well-recognized leading role in indirect dark matter searches and in studies on neutrino properties using neutrino telescopes is equally essential, and we fully support continued efforts in this area.

Cosmic rays

Cosmic-ray astrophysics is another field where the Spanish community has been particularly active over the years, despite being smaller in size compared to other areas. Two major experiments have concentrated most of Spain's efforts to date: AMS aboard the International Space Station (ISS) and the Pierre Auger Observatory in Argentina.

AMS is expected to continue operations at least until 2030, when the ISS will likely be deorbited. A significant instrumental upgrade is planned for 2026, involving new silicon tracker planes, which is anticipated to have a major impact on its scientific output. The Spanish contribution to AMS, consistently supported by the Spanish Space Program, has focused on the design and construction of the RICH detector, with Spain also responsible for its operation from CERN. We strongly support these important Spanish contributions to hardware, as well as ongoing and future scientific studies aimed at unraveling the origin of cosmic rays, the physics of dark matter and antimatter, and the abundances of primary and secondary particles.

Spanish groups have also been involved in the Pierre Auger Observatory for ultra-high energy cosmic rays (UHECRs; $E>10^{17}$ eV) for decades. With its 'Phase I' data collection completed (2004–2021), a new phase, 'AugerPrime,' is set to begin operations in 2025 and extend beyond 2035. Its primary goals are to deepen understanding of UHECR mass composition and improve statistics with higher-quality data. We fully support the small but influential Spanish presence in Auger, where members have played significant roles in scientific working groups, data processing, and analysis. Maintaining this expertise is critical to meeting the challenges of AugerPrime's Phase II.

Looking into the future, and beyond AMS and Pierre Auger, the Spanish community is becoming particularly interested in the HERD mission, which receives our full support. HERD is a spaceborne cosmic ray detector and gamma-ray observatory to be installed at the Chinese Spatial Station (CSS) by 2027 and with an expected lifetime of 10 years. Spain is currently involved in the HERD conceptual design, prototype validation, and scientific exploitation. HERD is expected to extend the energy range of direct cosmic-ray measurements, e.g. measuring cosmic-ray spectra and composition up to PeV energies, searching for dark matter signatures in the spectra of electrons and gamma rays up to 100 TeV, and contributing to the continuous monitoring of the gamma-ray sky.

Gravitational waves

Gravitational Wave (GW) Astronomy was inaugurated in 2015 after the first detection of the GW emission from a binary black hole (BBH) collision, worth the Physics Nobel prize of 2017. Developments in GW detectors can be traced back to the 1960s. Spanish groups got already involved in GW detection in the 1990s, in particular, in the operations of the first generation LIGO detectors (2002-2010; with Virgo joining in 2007) and later also in the development of the LISA Pathfinder technology demonstrator mission (ESA; starting in 2001) for the future LISA space-based GW detector.

The Spanish participation in ground-based detectors has been substantially increased in the 2nd-generation LIGO-Virgo detectors, including recent developments in instrumentation. The Spanish groups are deeply involved in aspects related to computational and theoretical challenges in GW astronomy: searches for GW events (compact binary coalescences, continuous GWs expected from rapidly rotating neutron stars, and burst signals from core collapse supernovae); Bayesian inference to identify sources (including machine learning techniques); source modelling based on high performance computing, mostly at European Tier-0 facilities, and characterisation of the detector noise, including works at the detector sites. There is a growing interest in: search for stochastic GW signals and their relation with the very early universe dynamics; compact objects (as e.g. boson stars); dark matter signatures; tests of General Relativity using GWs, and the search for multi-messenger counterparts, in particular EM radiation and high-energy neutrinos.

The Spanish GW community is getting strongly involved in the ongoing developments towards 3rd-generation GW detectors, in particular in the European project Einstein Telescope, which became an ESFRI Project in 2021 and is now in the preparatory phase, where a number of Spanish groups participate, and scientists from Spanish institutions are visible in top-level management positions. Most importantly, Spanish institutions are playing a key role in promoting the synergies with CERN on ET related R&D activities. We consider the support of GW research should be included as one of CERN's missions in the next EU strategy update.

On the other hand, the LISA mission, led by ESA and operating in the low-frequency band, has entered the implementation phase in 2024 with an expected launch in 2035. LISA is a CERN recognized experiment. Spain has a very important instrumental contribution and many Spanish groups actively participate in the LISA Consortium. In addition, Spain will provide a Distributed Data Center and participate in the development of a global fit pipeline for the analysis of the LISA data. There is also growing interest in the Spanish community in the Pulsar Timing Arrays operating in the very-low GW frequency band as well as in CMB polarisation detectors, which can infer GWs in the ultra-low frequency band. There is also interest in the very-high frequency band and in atom-interferometric detectors that will give access to the deciHertz band.

Since 2011, the GW Spanish groups are organised under the umbrella of the REDONGRA network, which is represented by 20 groups in the last proposal (2024), with the goal of expanding the GW community in Spain and reinforce its participation in the next generation experiments, ET and LISA, and in multi-messenger observations, taking full advantage of synergies between the field of GW astronomy and the existing community in cosmology, astroparticle and theoretical physics.