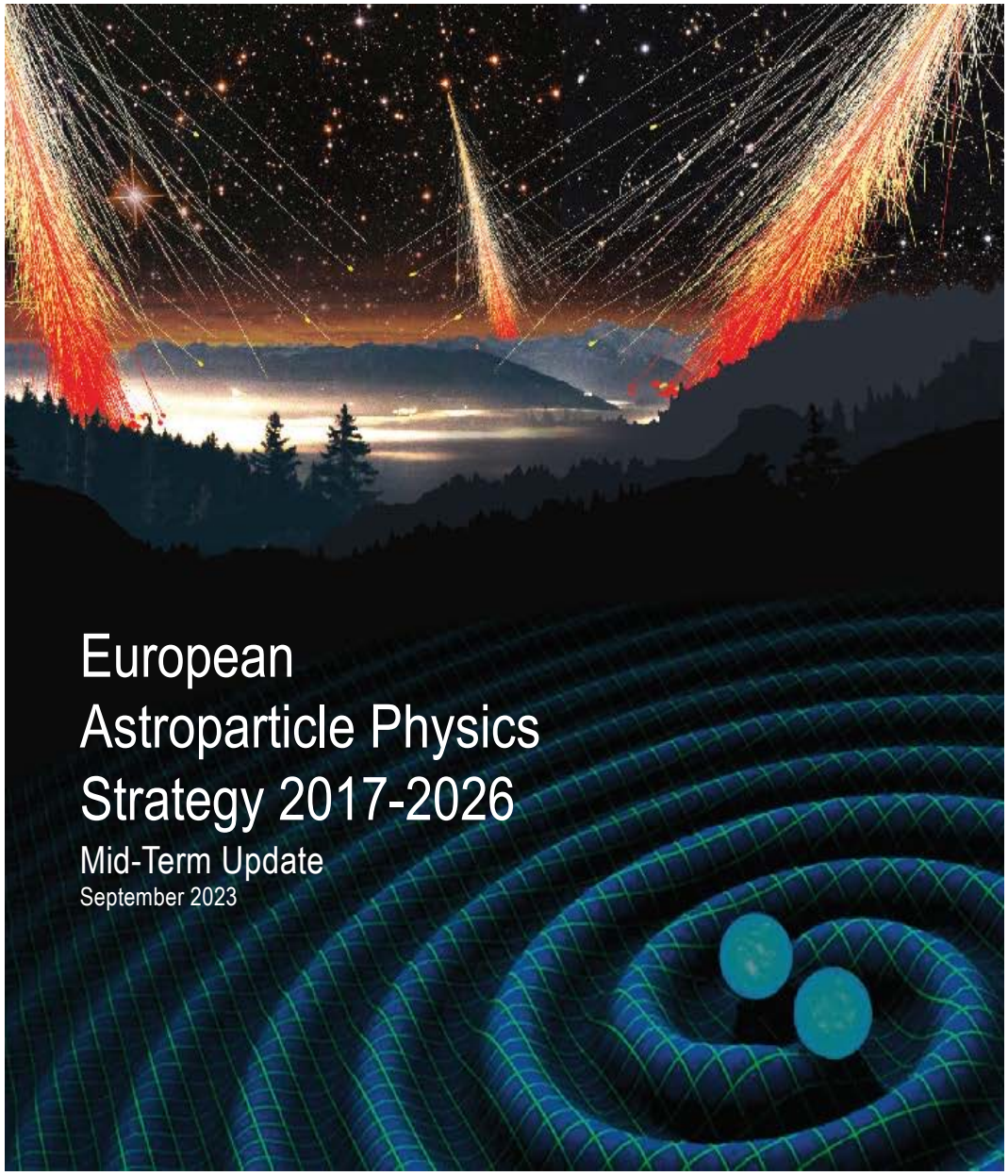
APPEC

Astroparticle Physics European Consortium

Report from APPEC



Aldo Ianni (INFN-LNGS), for the APPEC GA

114th ECFA meeting, Frascati 4-5 July 2024

Astroparticle physics

Understanding

the Extreme Universe

- **Multi-Messenger observations** of cataclysmic events
  - ✓ HE γ rays, neutrinos, cosmic rays, GW

the Dark Universe

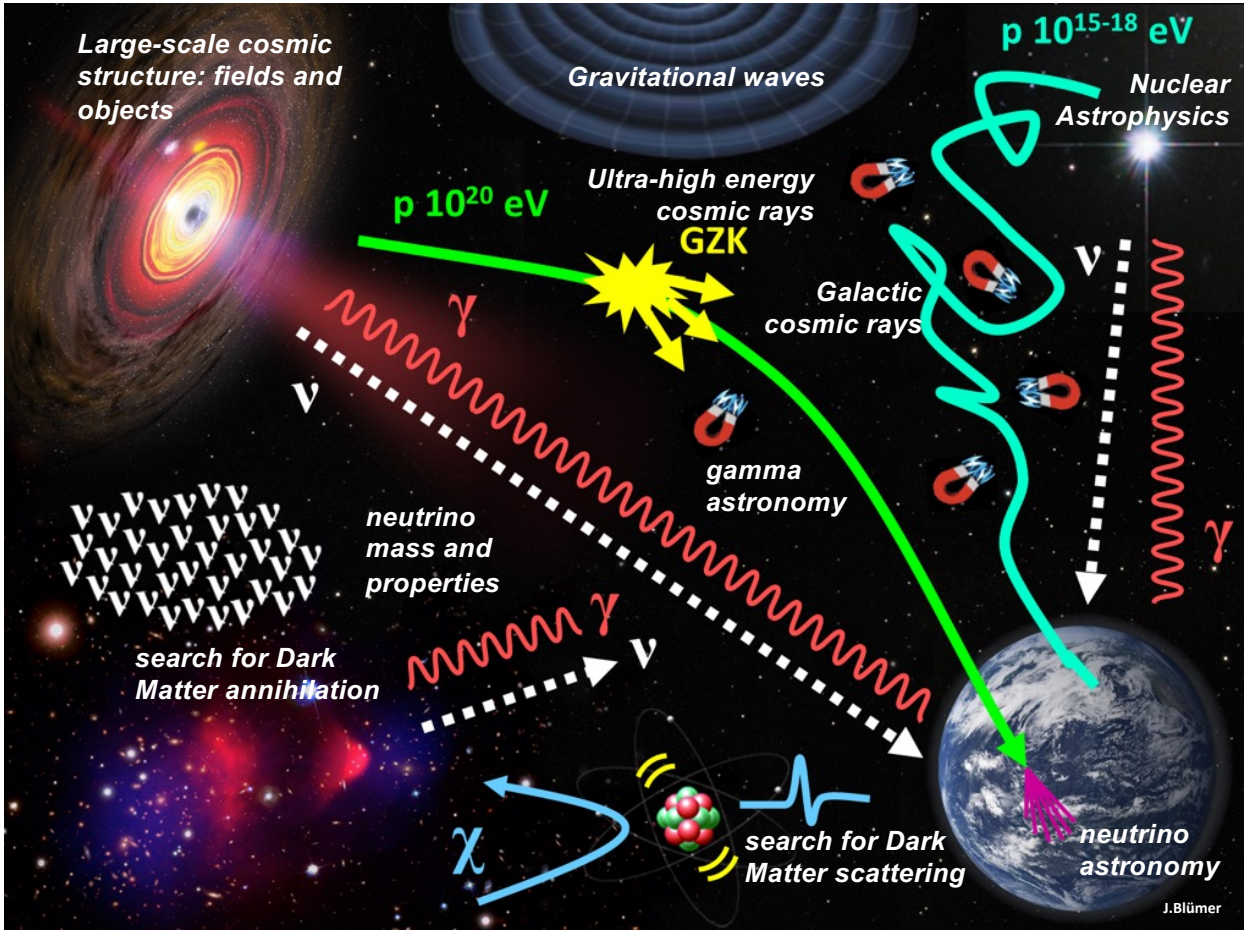
- Exploring the nature of **Dark Matter and Dark Energy**

the Neutrinos

- Measuring **neutrino properties** und unveil their role in the universe
  - ✓ 0νDND, reactor, solar, SN, SN relic, and atmospheric ν

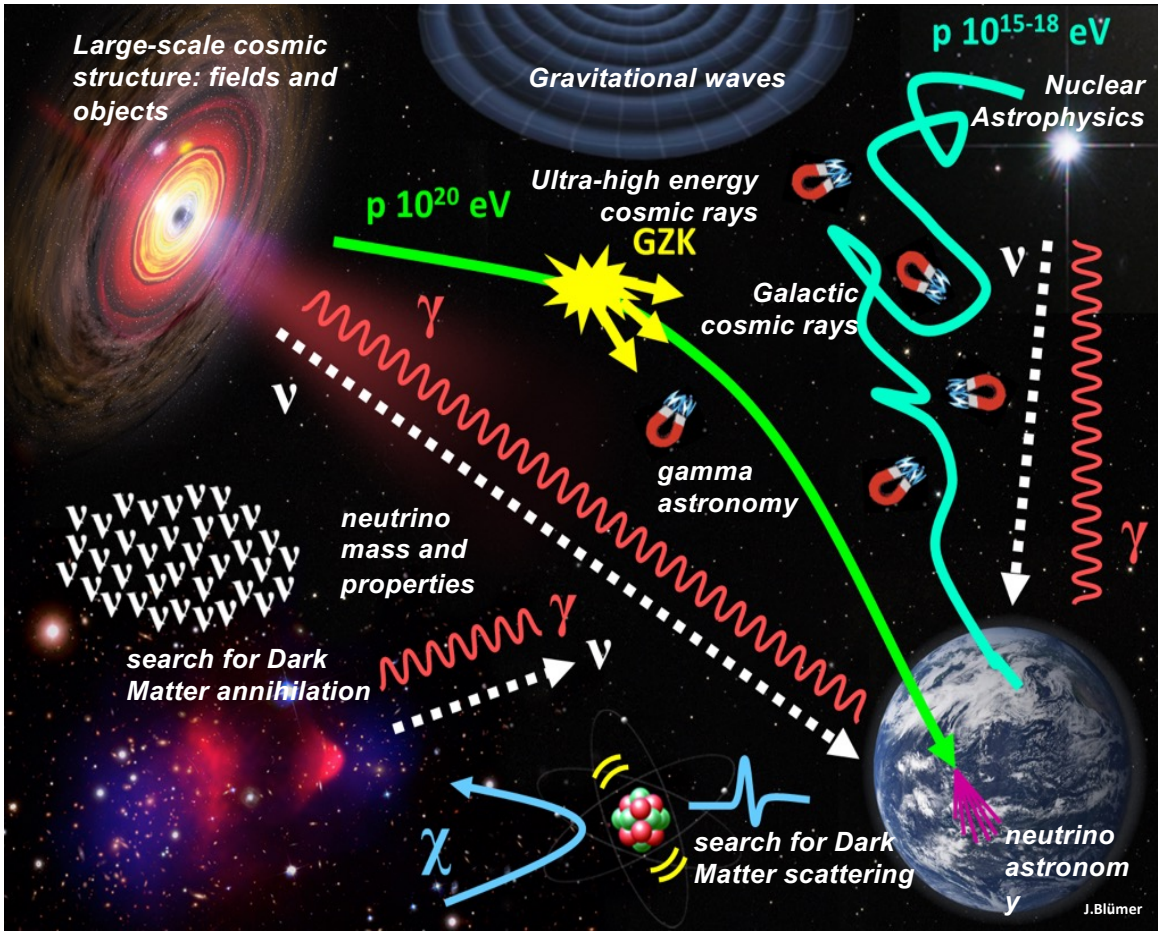
the Early Universe

- Learning about the Big Bang and early universe from **CMB**



Main questions

- Least-well-understood components of our universe
  - ❖ What is dark matter (WIMP-like, axion-like) ?
  - ❖ What is dark energy?
- What will gravitational waves teach us?
- What are the limitations of the current theory of gravitation?
- What will multi-messenger astronomy teach us?
- What are the different sources of high-energy neutrinos?
- What is the origin of cosmic rays?
- What is the physics of ultra dense matter?
- What caused our Universe to become dominated by matter and not anti-matter?
- Do we understand structures and stellar formation and their evolution?

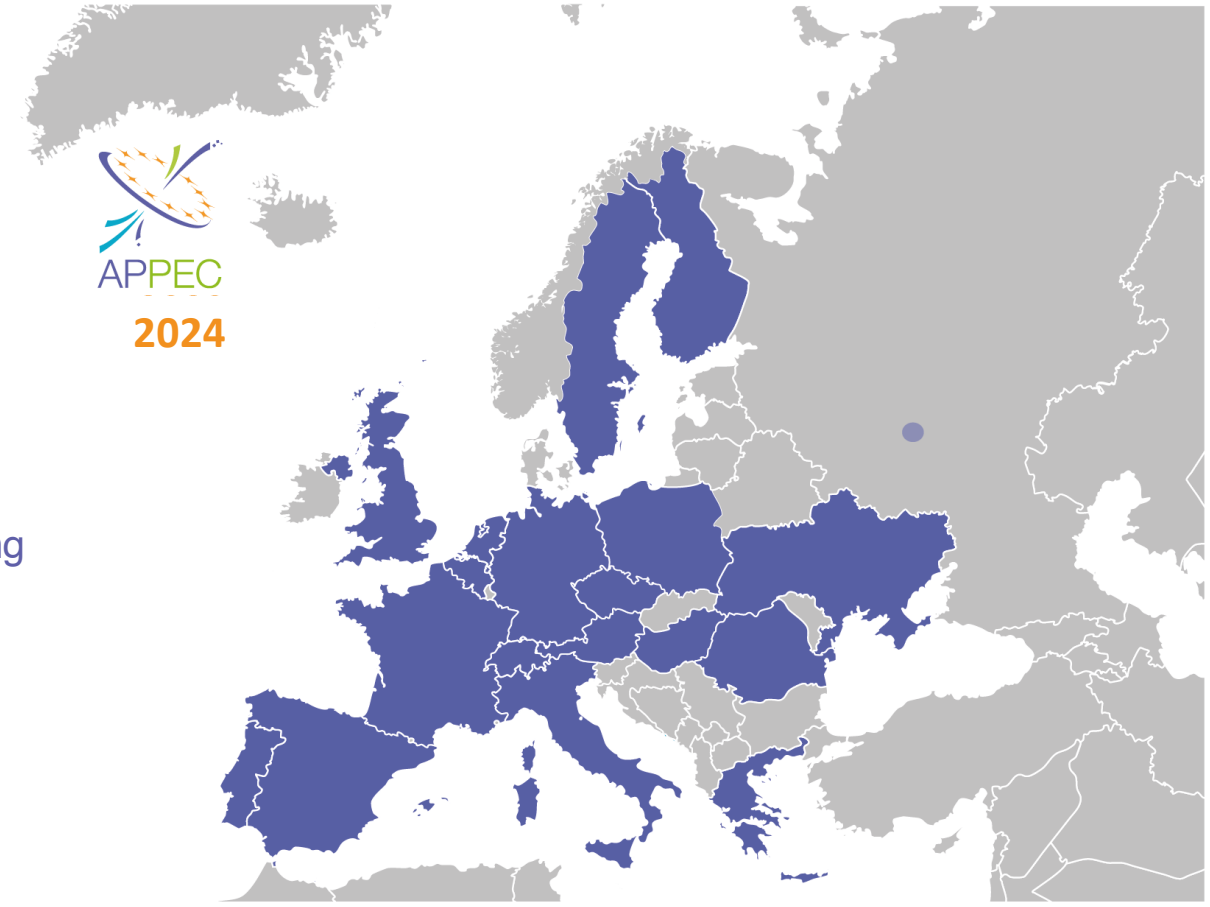


APPEC: what is it?

www.appec.org

AstroParticle Physics European Consortium

- An international coordinating structure, founded in 2001
  - ✓ European Strategy for Astroparticle Physics published in 2008
  - ✓ First roadmap with priorities in 2011
- Based on MoU by all partners and an APPEC Common Fund of order 70k€/year
- 18 (+1 suspended) member countries with 22 funding agencies
  - In discussion with Denmark and Norway
- 3 bodies:
  - **General Assembly** with Observers
  - **Scientific Advisory Committee**
  - **Joint Secretariat**

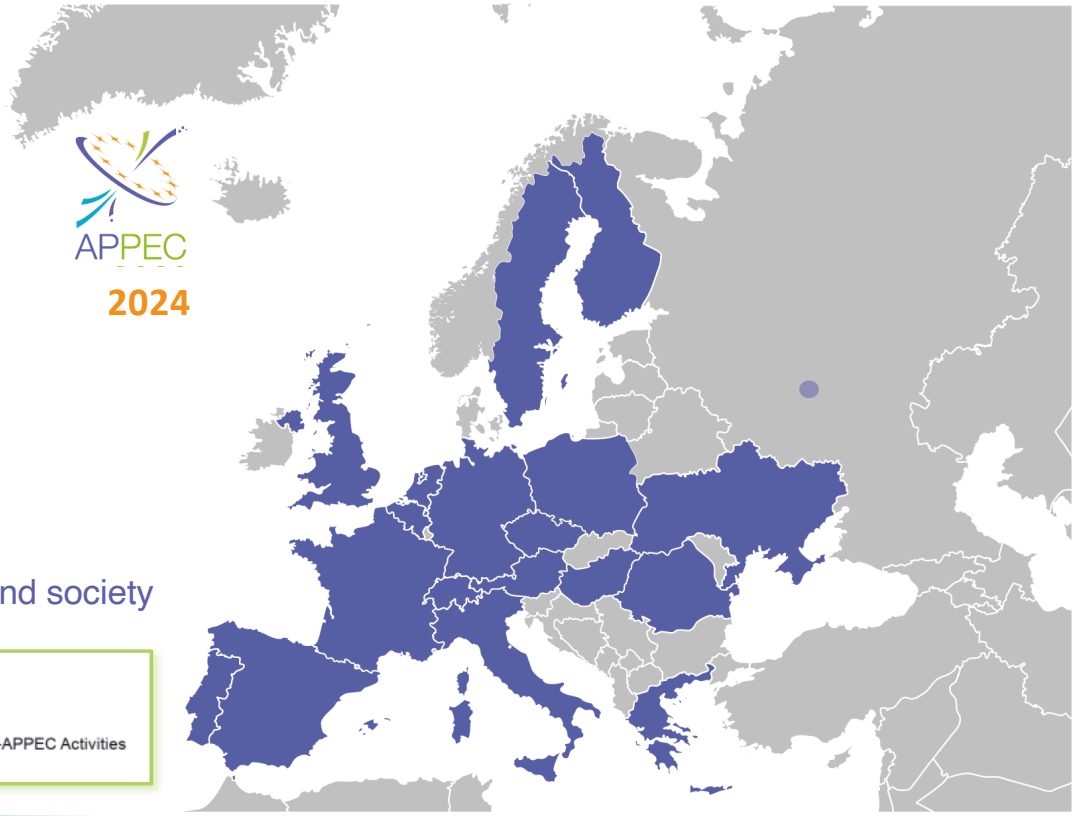


APPEC Bodies

- **General Assembly**
  - Strategic, decision making and supervisory body
  - Representatives of funding agencies
  - Chair: **Andreas Haungs** (KIT)
    - ✓ new elected chair: **Carlos Peña-Garay** (LSC) 2025-2026
  - Vice-Chair: **Antoine Kouchner** (APC) – new election in 2024
- **Scientific Advisory Committee**
  - Advisory body
  - Chair: **Aldo Ianni** (INFN-LNGS) since June 2024;
  - Vice-Chair: **Mathieu de Naurois** (CNRS) since June 2024
- **Joint Secretariat (distributed office)**
  - Executive body chaired by the General Secretary
  - General Secretary: **Julie Epas** (APC) since June 2024
- **Connections**
  - Nuclear, particle, and astroparticle physics communities (NuPECC, ECFA, APPEC, ESFRI) joining efforts for science and society
  - ESO (Andy Williams)
  - EPS-HEPP (Ramon Miquel)
  - EU Consortium for Astroparticle Physics Theory (EuCAPT, Silvia Pascoli)

JENAA
Joint ECFA-NuPECC-APPEC Activities

www.appec.org



APPEC tasks

Coordination link of European Astroparticle Physics in Europe between funding agencies and the community needs through:

- Structured scientific advising (SAC, dedicated panels to specific challenges)
- Development and update of roadmaps based on **scientific strategies** and **financial considerations**
- Establish relations with other bodies in companion fields
- Initiate activities within Horizon Europe
  - ✓ to encourage/support applications for grants:
    - **ACME** (Astrophysics Center for Multi-messenger studies in Europe) recently approved (better access to RI services)
    - **DEEPEN-STUDI** (coordination of EU DULs) recently submitted
- Organise Town meetings
  - ✓ to **engage the community**
- Support relevant meetings/schools of the community
- Organize TechFora and Open Calls
  - ✓ to **support R&D and engagement with industry**
- Engagement with society (Outreach, Education,...)

APPEC is

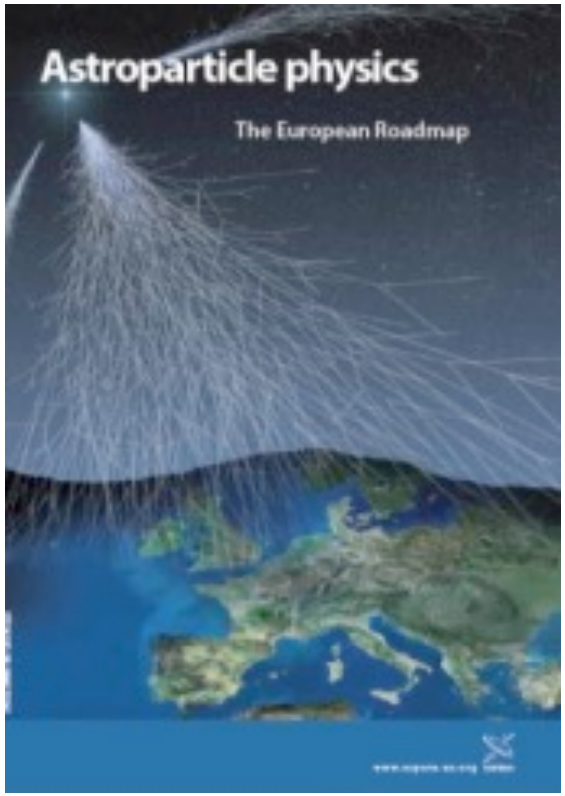
- **Helping in coordination of large-scale RI**
- **Helping in transition of mid-scale experiments to large-scale RI**
- **Helping in support of small-scale experiments and R&D projects**

Outcome: APPEC roadmaps

https://www.appec.org/roadmap

2008

2011



2017

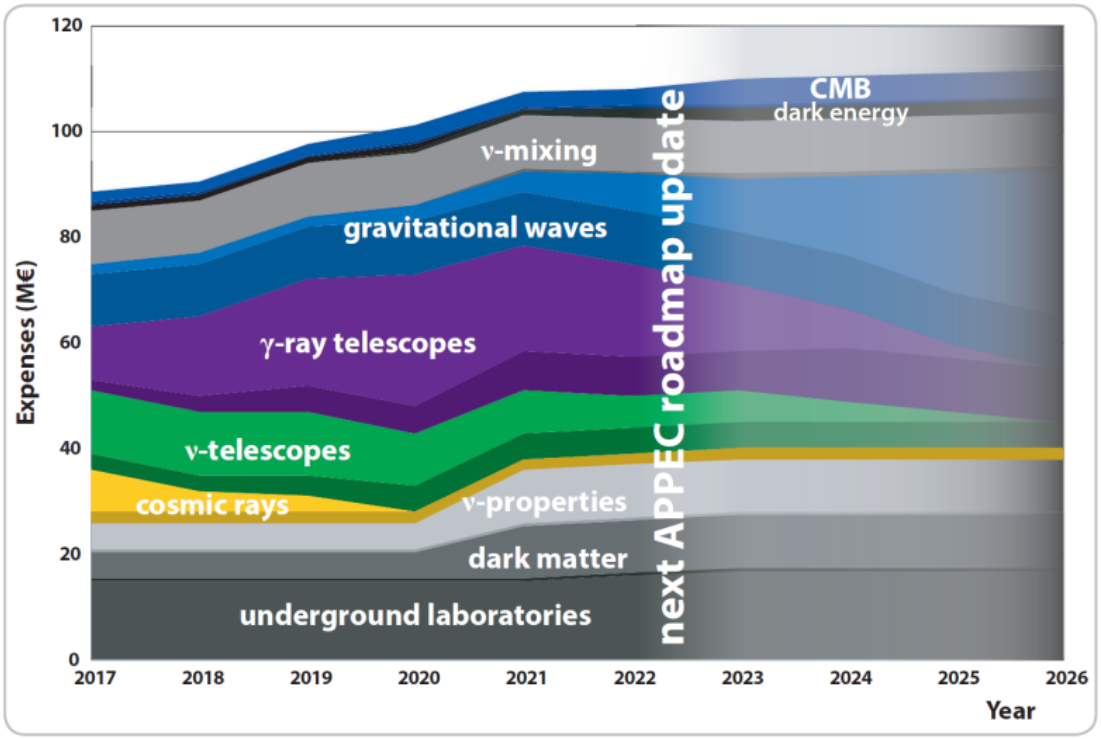
APPEC roadmap – scientific/technical topics

- Cosmic rays
- High-energy neutrinos
- High-energy photons
- Gravitational waves
- WIMP Dark Matter
- Non-WIMP Dark Matter
- Neutrino properties
- Cosmic Microwave Background
- Dark Energy
- Multi-messenger astroparticle physics
- Astroparticle theory
- Detector R&D
- Computing and data policies

- Ecological Impact
- Societal Impact
- Open Science and Citizen Science
- Human Talent Management
- Central Infrastructures
- European and Global Cooperation
- Interdisciplinary Opportunities

Recommendations are given for each topic

Resources



From Roadmap 2017: Projected annual capital investment

- **A resource aware roadmap**

  (darker colors also show M&O of RI)

- **Midterm Evaluation**: Preparation of roadmap update https://www.appec.org/mid-term-review
  - Direct Dark Matter working group
  - Double Beta Decay APPEC sub-Committee
  - Multi-messenger Discussion Workshops
  - Coordination workshop of Underground Labs
  - Town Meeting June 2022 https://indico.desy.de/event/25372/
  - Census / Survey of time and cost lines

- Goals
  - Identify new developments and new topics
  - Update recommendations
  - Update of time and cost line

Highlights since 2017

Mid-term update to account for relevant developments since 2017

- Multi-messenger observations: a new window to the universe
  - ✓ Multi-messenger event of a neutron star merger GW170817
  - ✓ Multi-messenger event by a neutrino alert from a blazar TX0506+056
- High Energy Gamma Rays: PeV sources in Milky Way
- Excess of neutrinos at E>1 TeV
  - ✓ galactic (1TeV<E<100TeV) and extra-galactic sources distinguishable
- Neutrino mass limit by direct measurements
- Improved neutrino oscillation matrix determination
- Direct dark matter search increased sensitivities
- …..

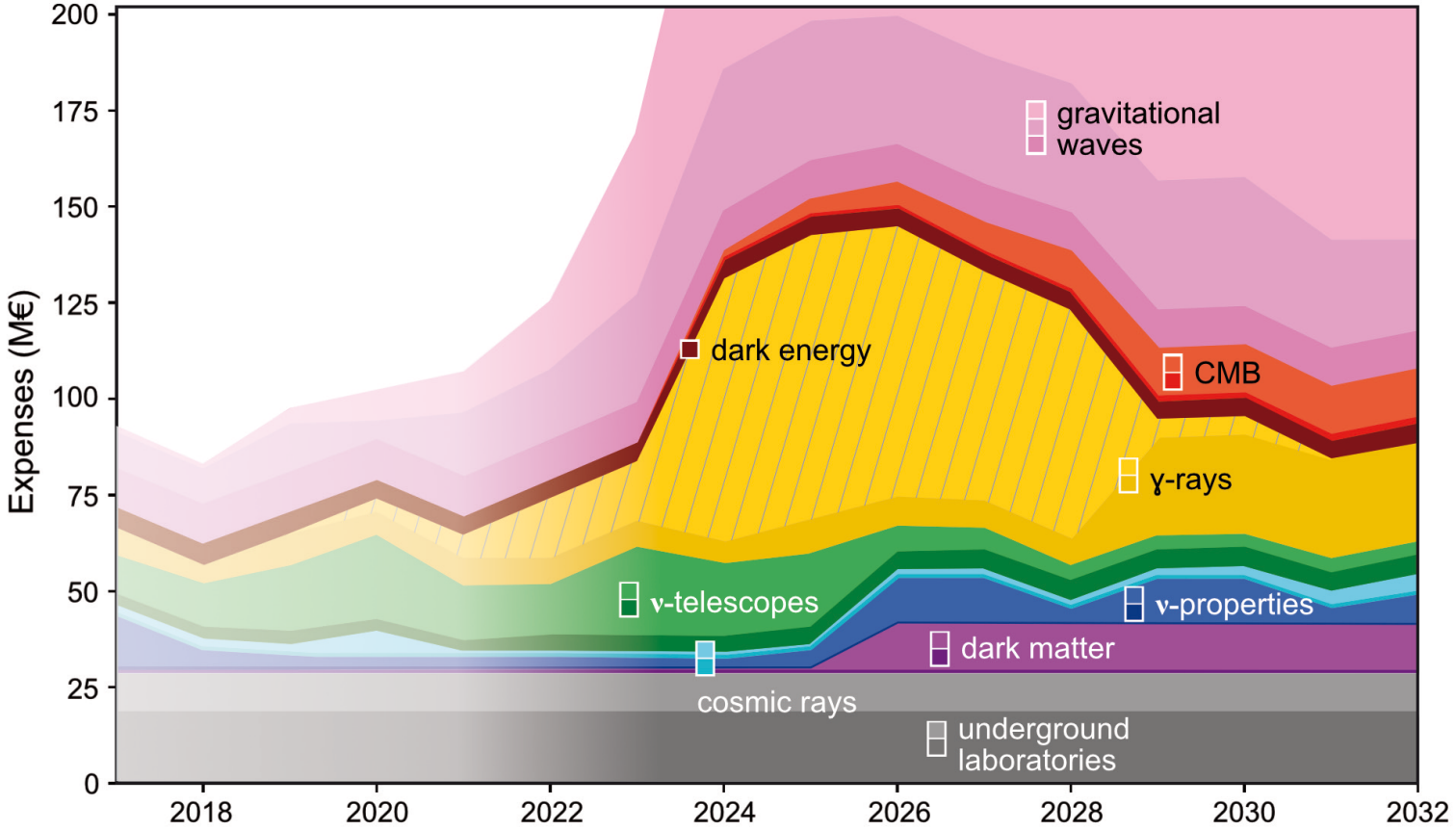
- Methodically we improved by:
  - Structured theory connection (EuCAPT, established in 2020)
  - Machine learning applications
  - Cooperation of underground laboratories
  - Closer cooperation with neighbouring fields and European Commission

Resources updated: survey from major experiments/projects

A resource aware roadmap
(darker colors show M&O of RI)

Observations:

- Predictions from 2017 (until 2022) were okay
- CTA-peak shifted to later years compared to 2017 roadmap
- CTA-investments funded
- HE Neutrinos: stretched
- ET peak has 3 colors: operation, instrument, infrastructure



Roadmap Update 2023: Projected annual capital investment

Roadmap in a nutshell

- **High-energy photons** (gamma astronomy):
  - support construction and long-term operation of CTA (10GeV-100TeV)
  - support work towards next-generation (THESEUS, SWGO)
- **High-energy neutrinos** (neutrino astronomy):
  - support operation of KM3NeT through ARCA and ORCA
  - support expansion of Ice-cube (x10) and precision neutrino astronomy
- **Cosmic rays**
  - Support completion of AugerPrime
  - Exploitation of Auger and TA sky coverage
- **Neutrino propertis**
  - Support EU in leading NLDBD research
  - Support mass ordering research in KM3NeT, DUNE, HyperK, direct mass measurements
- **Theory**
  - Support EuCAPT as a coordination centre
- **Gravitational waves**
  - Support EU participation in ET and reinforce EU leadership
- **Dark Matter**
  - Support EU leadership with one next-generation experiment with Argon or Xenon
  - Support cavity technology for axion search
- **CMB**
  - Encourage EU contribution to LiteBIRD mission, Stage4 and R&D for ground-based projects
- **Dark Energy**
  - Support Euclid mission and participation in ground-based projects (DESI, Rubin-LSST)
- **Multi-messenger**
  - Support coordination of multi-messenger observational strategies
- R&D, ecological impact, societal impact, open science, training young scientists

Enhance European Research Infrastructures

- A required path towards next-generation experiments
  - ✓ Support and development of EU RI
- Underground Laboratories offer a clear example
  - ✓ enhance a **trans-national access policy** and training programs for young scientists
  - ✓ support structured coordination
    - optimise use of facilities
  - ✓ reinforce connections between DULs and associated research institutes

ESFRI and APPEC RIs (landscape analysis 2024)

- APPEC RIs included in ESFRI roadmap
  - ✓ KM3NeT
  - ✓ CTA
  - ✓ ET
- DULs considered essential key RIs to Astroparticle Physics projects
- Underlined APPEC role and recommendations to support Astroparticle Physics advancement

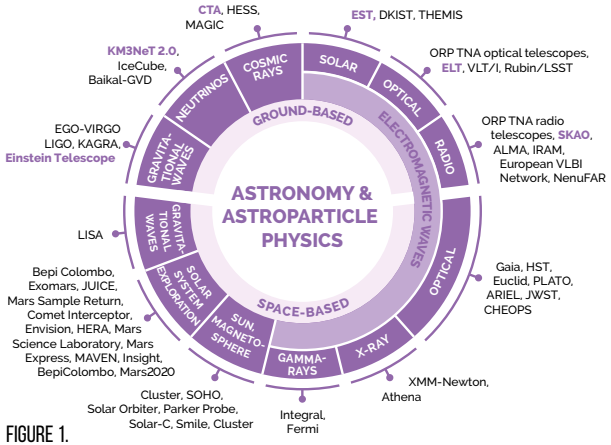


FIGURE 1.
The landscape of the Astronomy & Astroparticle Physics sub-domain

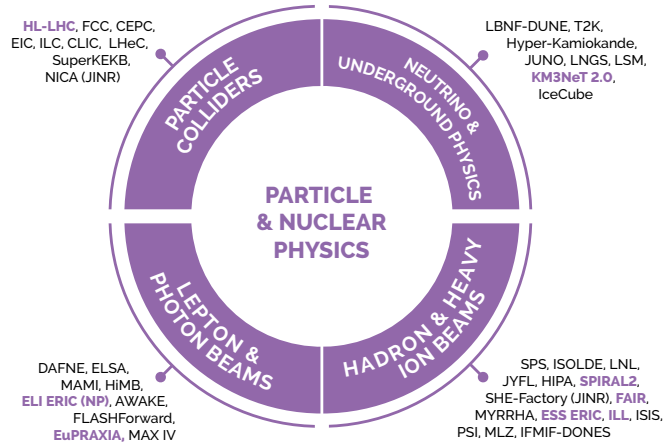
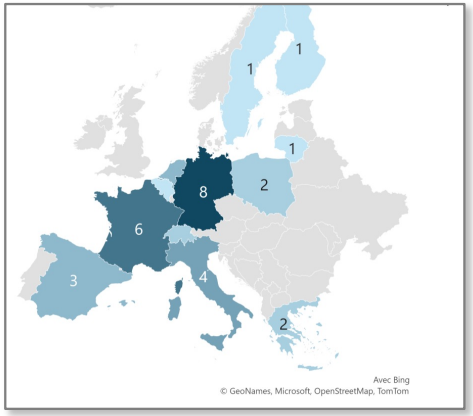


FIGURE 2.
The landscape of the Particle & Nuclear Physics sub-domain

ACME - Astrophysics Centre for Multi-messenger studies in Europe

HORIZON-INFRA-2023-SERV-01-02 (domain: Astronomy & Astroparticle physics)

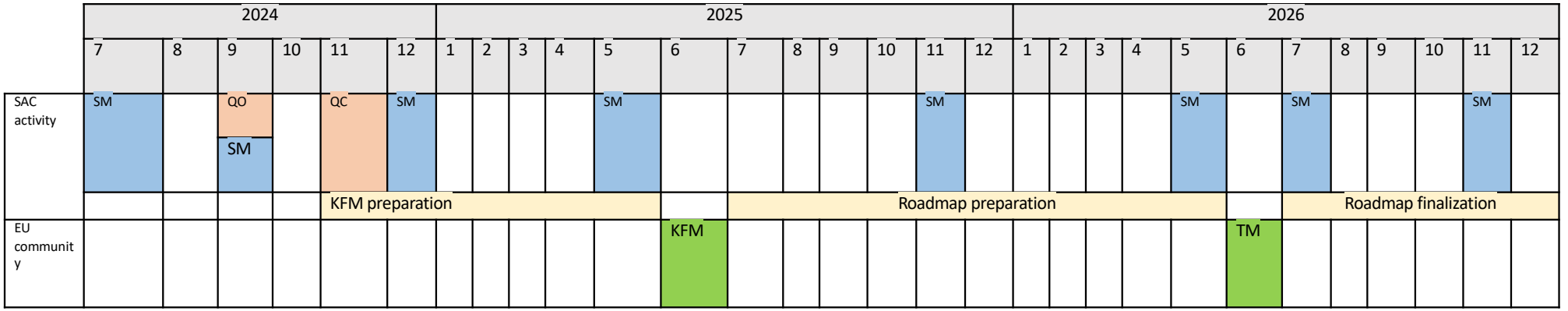
- Topic: **better access of users to RI services to advance frontier knowledge**
- **ACME is an ambitious coordinated European-wide optimization of the accessibility and cohesion between multiple leading RI, offering access to instruments, data and expertise.**
- Selected for funding by the European Commission: 14.5 M€ (in Feb 2024)
- Provides Transnational access (TA) and Virtual Access (VA) to RI
- Consortium: 41 partners, 15 countries, >30 research infrastructures
- Grant Agreement Preparation phase



The path to the new roadmap (2027-2036)

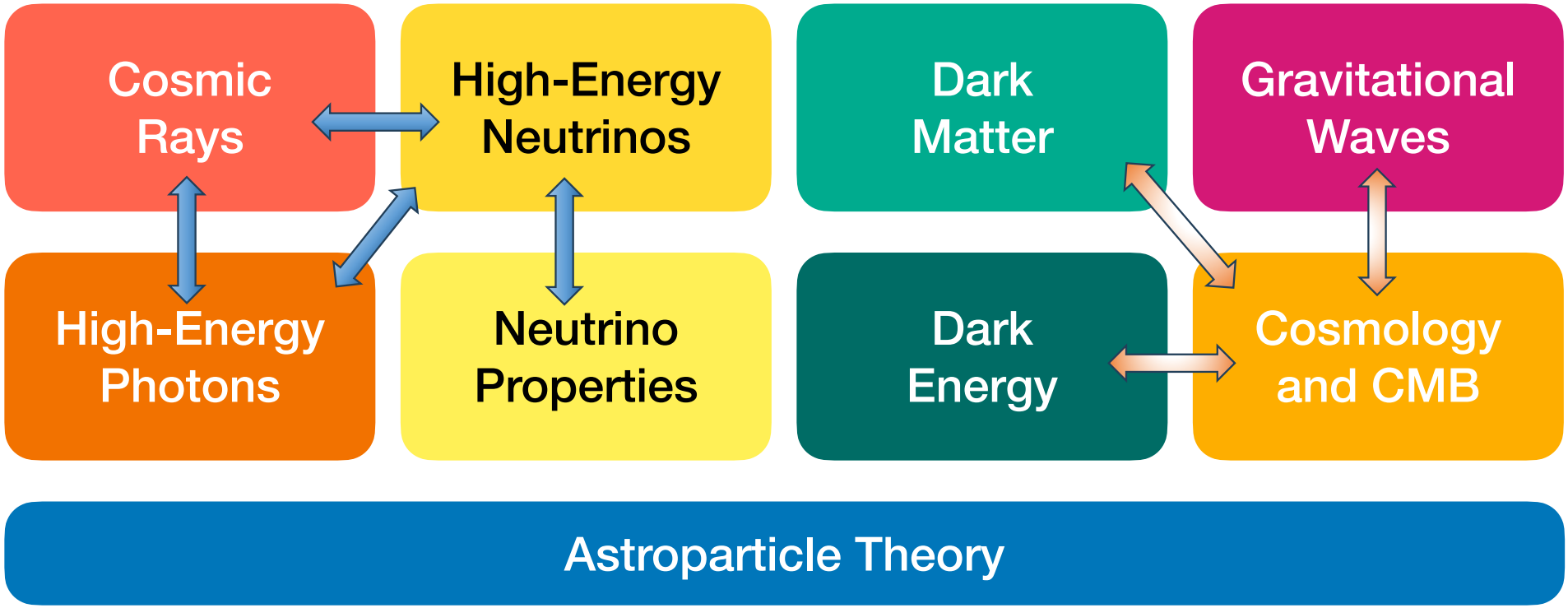
Strategy:

- science driven process
- community driven process: inputs from community and kick-off meeting
- crucial interaction with GA to properly benefit of European and national programs
- take into account the international landscape to develop synergy and optimise outcome of fundamental research
- acknowledge international cooperation, viability, and sustainability in projects planning



SM = SAC meeting; QO = questionnaire out; QC = questionnaire closing; KFM = kick-off meeting; TM = Town meeting

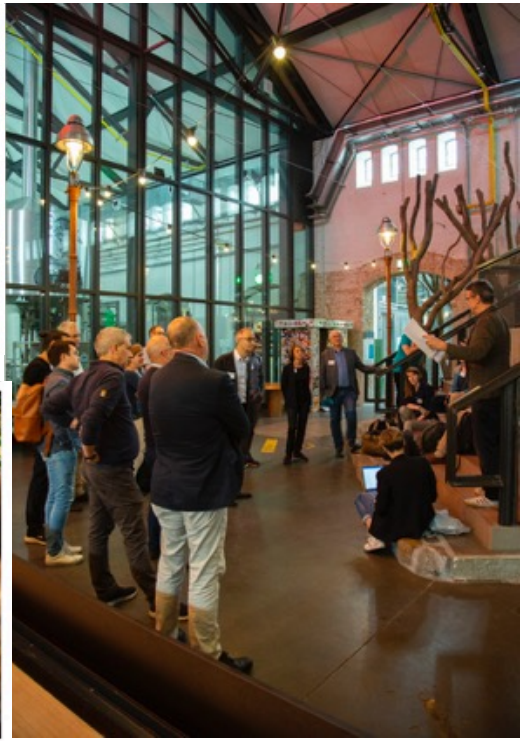
Astroparticle is a field full of connections



The path to the roadmap: Town Meeting

https://indico.desy.de/event/25372/

APPEC TOWN MEETING BERLIN 2022



➔ **An inspiring, lively and colourful event with a lot of debates and exchange!**
➔ **Active work tables on specific topics with summary reports in plenary session**
➔ **Important input to the Roadmap update**

Conclusions

Astroparticle physics is a reach field in science with multi-disciplinary opportunities

APPEC role:

- ✓ provide a coordinated EU effort to enhance Astroparticle Physics
- ✓ stimulate funding agencies to improve synergy
- ✓ engage community in the roadmap development
- ✓ support RIs connections
- ✓ enhance new ideas
- ✓ enhance connection with society


APPEC
Thank You
for your attention

Country	Cosmic rays	High-energy photons	High-energy neutrinos	GW	Neutrino properties	Dark Matter	Dark Energy	CMB	Theory
FR		Mathieu de Naurois		Edwige Tournefier			Stéphanie Escoffier	Sotiris Loucatos	
DE			Anna Nelles		Christian Weinheimer				Joachim Kopp
ES					Concha Gonzalez-Garcia				
IT				Marica Branchesi	Oliviero Cremonesi	Aldo Ianni			
FI									
SE			Chad Finley						
EL									
CZ									Fedor Simkovich
BE	Ioana Maris								
HU									
PL						Marcin Kuzniak			
PT									
RU									
CH									
UK		Paula Chadwick					Ofer Lahav		
AT									
NL	Sijbrand de Jong								
DK									Irene Tamborra

Chair: Aldo Ianni
Deputy chair: Mathieu de Naurois
Secretary: Nicola Rossi from LNGS

To be changed or re-discussed in 1yr

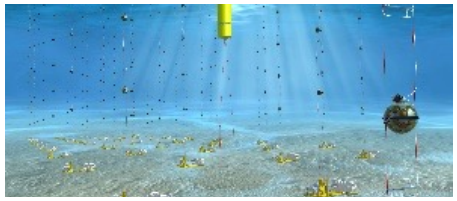
Enhance the future of Astroparticle Physics in Europe

Presentation of the European Astroparticle Physics Strategy Mid-Term Update

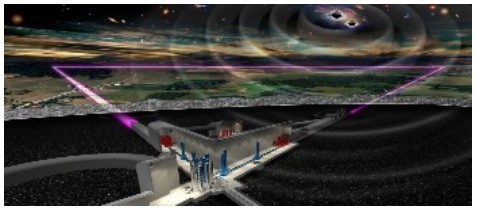
7/12/2023 14-18:00
https://indico.cern.ch/event/1339060/

APPEC Flagship Research Infrastructures

[KM3NeT; IceCube-Gen2]

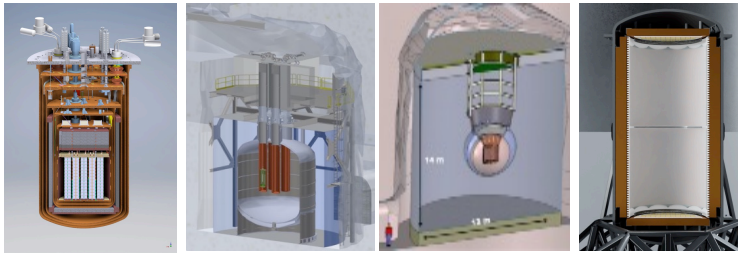


HE Neutrinos



[Einstein Telescope]

Gravitational Waves

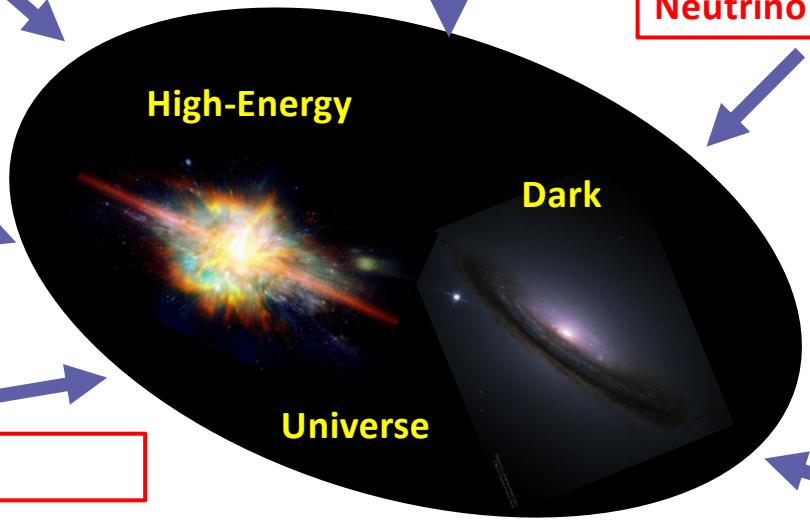


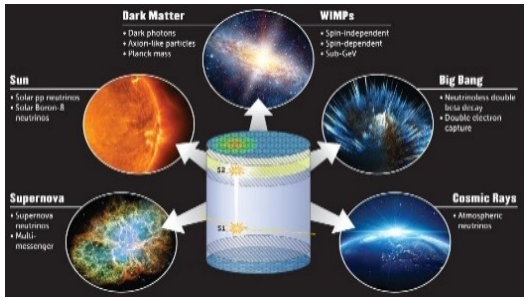
[construction LEGEND-1000 / nEXO 2026- ; …]

Neutrino Properties

[AugerPrime]

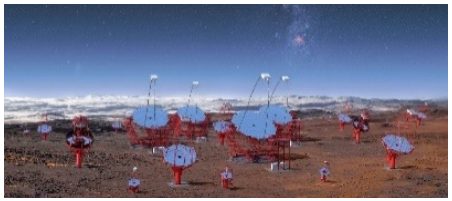
HE Cosmic Rays





[DARWIN; XLZD, ARGO, …]

[CTA]



HE Gamma Rays

Dark Matter

DEEPEN-STUDI - DevElopment of a EuroPEan Network for Science and Technology in deep UnDerground Infrastructures

- HORIZON European Programme

Key objectives

1. Develop a coordination model for European DULs
2. Advance technology
3. Enhance engagement
4. Foster accessibility and training
5. Develop synergistic DUL investment strategies to preserve Europe's leadership

- Coordinator node: LNGS

Participant No.	Participant organisation name	Country
1 (Coordinator)	Istituto Nazionale di Fisica Nucleare	Italy
2	Laboratorio Subterráneo de Canfranc	Spain
3	Centre Nationale de la Recherche Scientifique	France
4	United Kingdom Research and Innovation	United Kingdom
5	University of Oulu	Finland
6	CESKE VYSOKE UCENI TECHNICKE V PRAZE	Czech Republic
7	UNIWERSYTET JAGIELLONSKI	Poland

- WP1,2 management, exploitation and networking;
- WP3 new advanced technologies for cryogenic infrastructures and superconducting sensors in ultra-low background environments for quantum computing;
- WP4 innovative technology in radio-purity assay and low background detectors, new technology for Rn-free environments and application of additive manufacturing for rare events searches;
- WP5 biology in Cosmic Silence;
- WP6 safety, engineering, muography, and environment in Underground Laboratories;
- WP7, 8 Identity, involvement and engagement