



APPEC

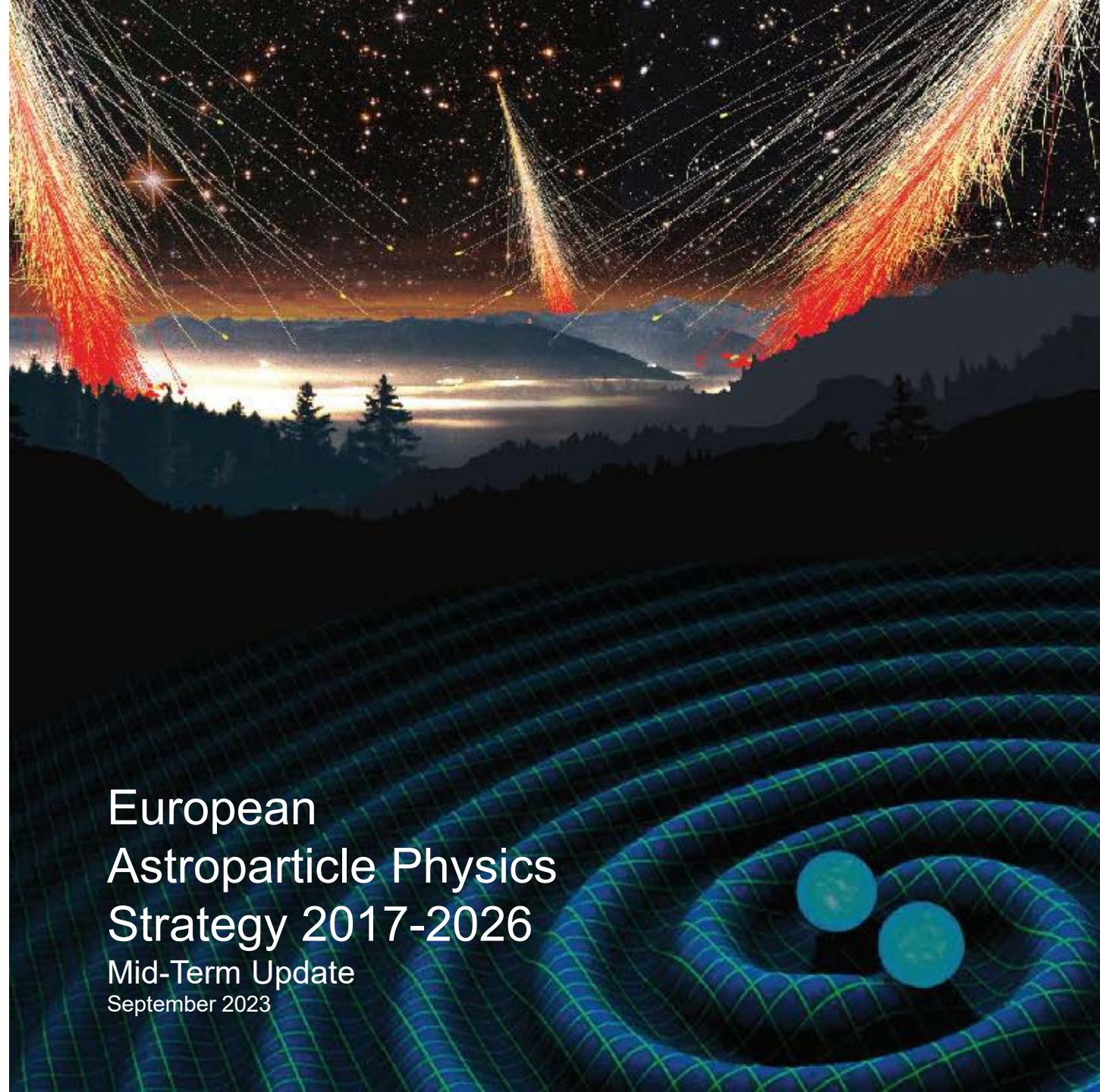
Astroparticle Physics European Consortium

The Future of Astroparticle Physics The European View

Presentation of the European Astroparticle
Physics Strategy Mid-Term Update

Andreas Haungs | KIT & APPEC chair

Brussels | 16 November 2023



European
Astroparticle Physics
Strategy 2017-2026

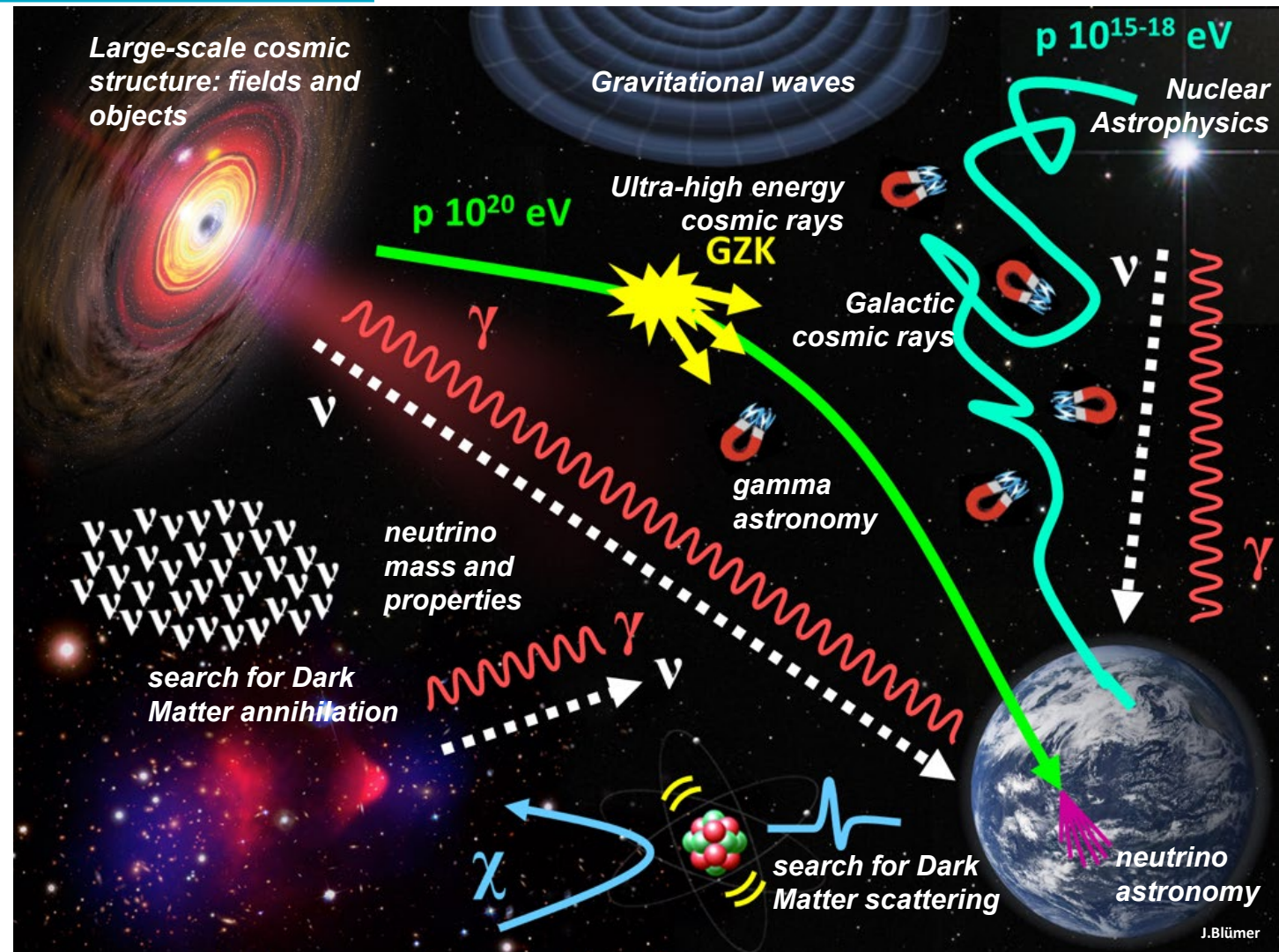
Mid-Term Update
September 2023

Astroparticle Physics

Astroparticle Physics is a branch of fundamental science embedded in environment and society!

Wikipedia:

While it may be difficult to decide on a standard 'textbook' description of the field of astroparticle physics, the field can be characterized by the topics of research that are actively being pursued.



Understanding

the Extreme Universe

- Multi-Messenger observations of cataclysmic events

the Dark Universe

- Exploring the nature of Dark Matter and Dark Energy

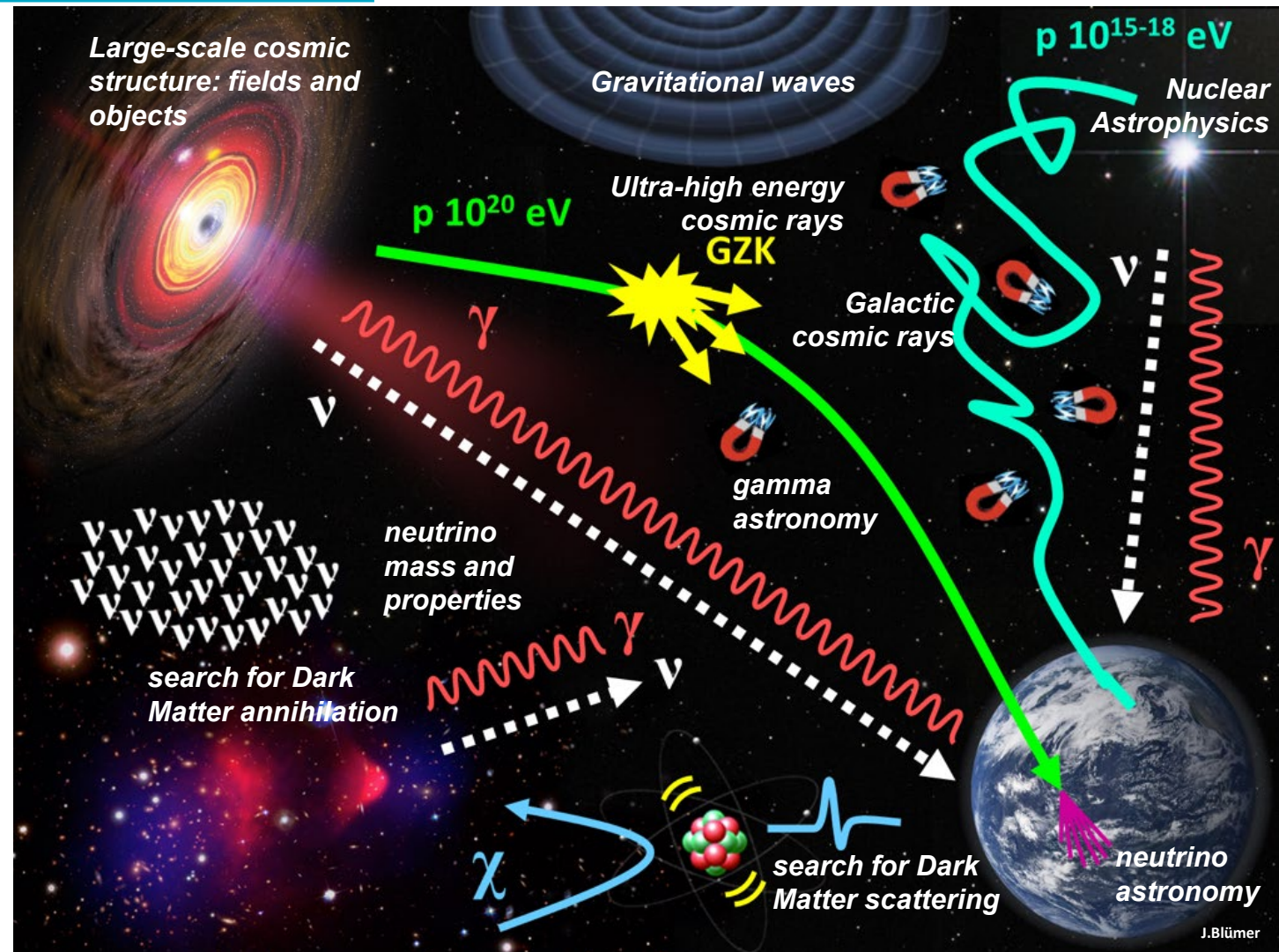
the Mysterious Neutrinos

- Measuring their properties and unveil their role in the universe

the Early Universe

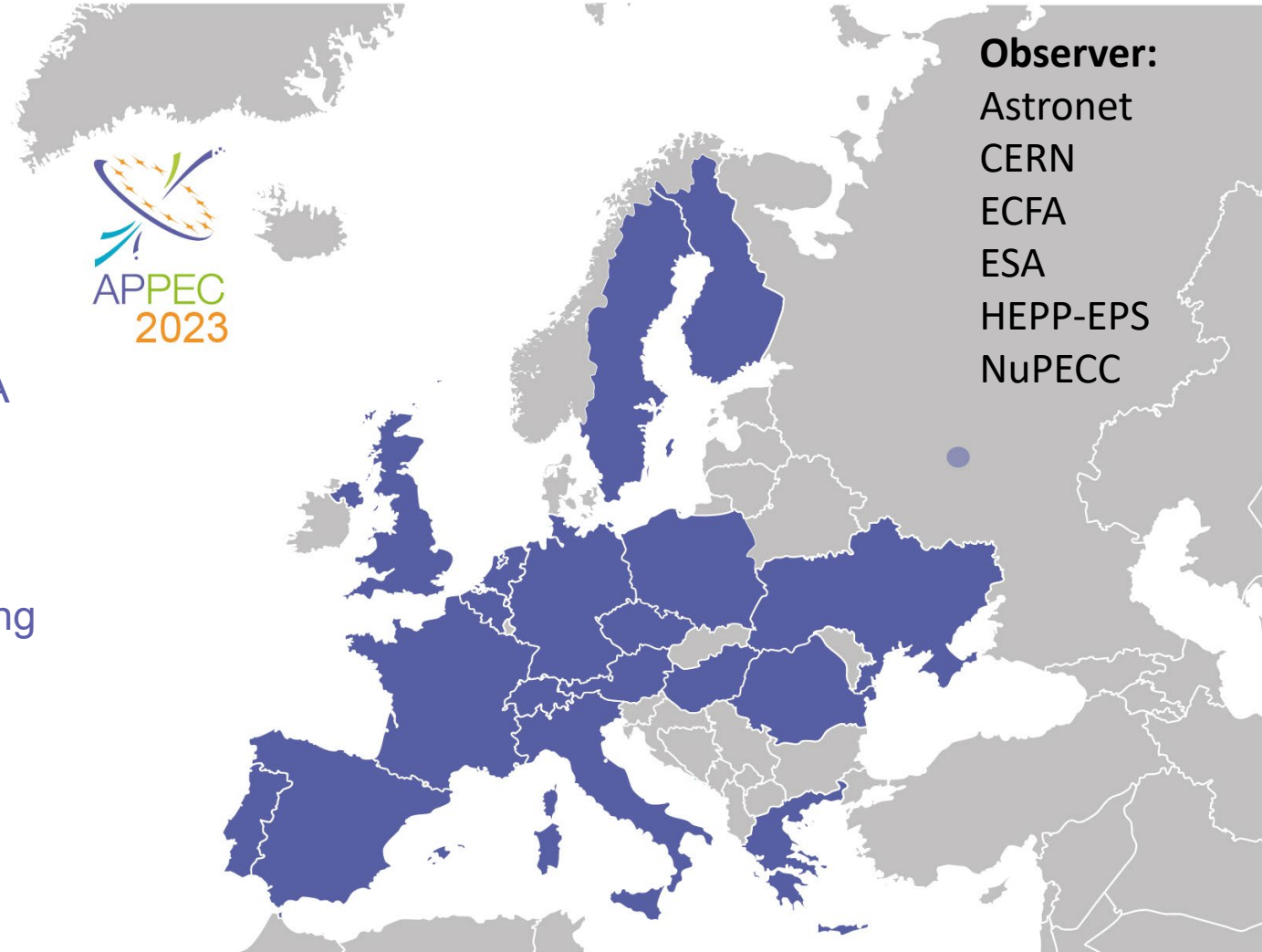
- Learning about the Big Bang, e.g. from the CMB

- Large-scale research facilities
- Interplay of theory with experiment
- Synergies with neighboring fields
- Connecting with society



AstroParticle Physics European Consortium

- Started as bottom-up initiative 2001 to establish an international coordinating structure (ApPEC)
- Current APPEC founded in 2012 as sustainable measure of an EU funding of the ERANET ASPERA (2006-2012)
- Based on MoUs by all partners and an APPEC Common Fund with c. 70k€/year
- 18 (+1 suspended) member countries with 22 funding agencies
- 3 bodies:
 - General Assembly with Observers
 - Scientific Advisory Committee;
 - Joint Secretary



APPEC tasks

Guarantee **Coordination** of European Astroparticle Physics in Europe between **funding agencies** and **visibility** at Ministry level 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**
- Express **collective views** on APP in international fora
- Organise **Town meetings**
- Support relevant **meetings/schools** of the community
- Organize **TechFora** and Open Calls
- Engagement with **society** (Outreach, Education,...)
- Contribute to **Working Groups** (R&D panel, Individual Recognition, Early Scientist career, Science WGs) and **Organisations** (EuCAPT...) and **JENA**

to support the **Astroparticle Physics** community

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 and R&D experiments**

2008



2011

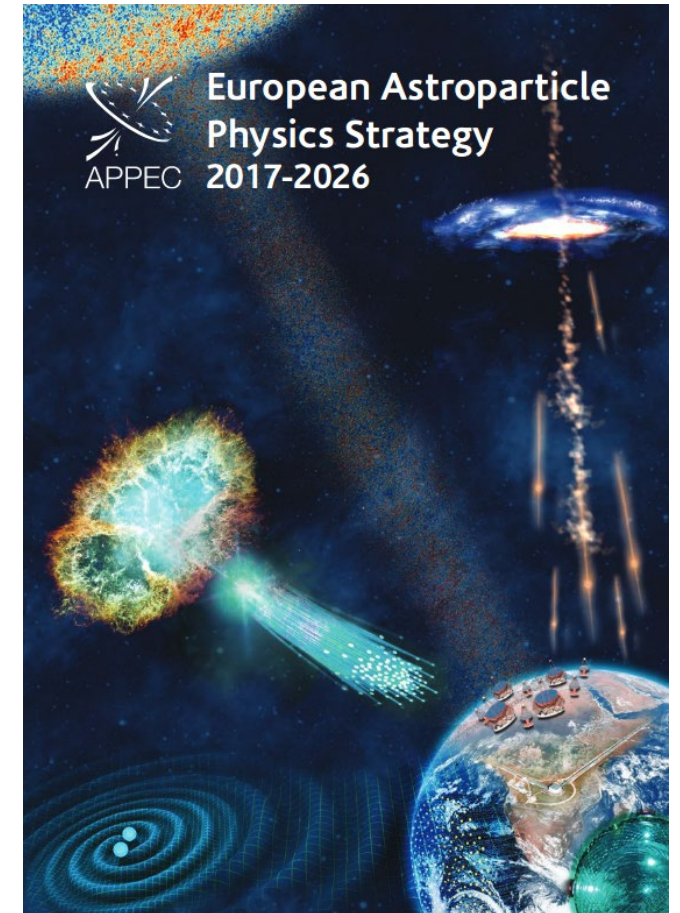


2017



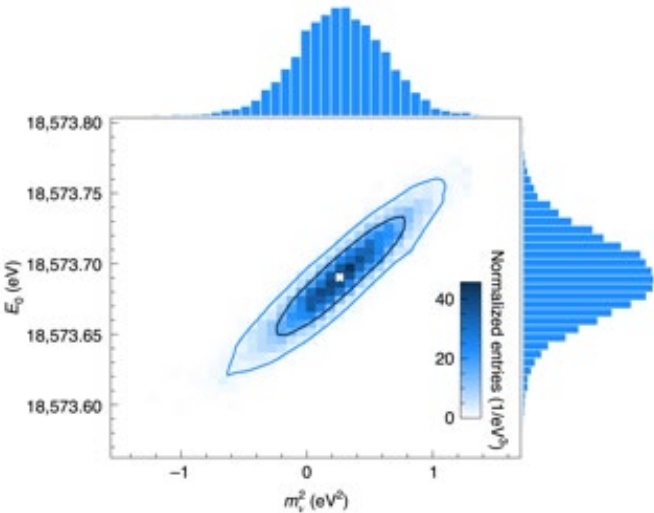
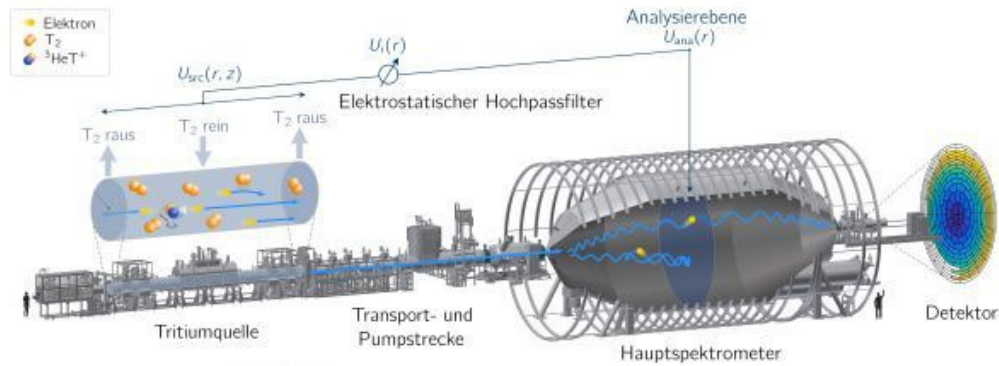
Highlights since 2017

- Multimessenger event of a neutron star merger GW 170817
- Multimessenger event by a neutrino alert from a blazar TX 0506+056
- High Energy Gamma Rays: PeV sources in Milky Way
- Neutrinos from the Milky Way
- Instep structure in spectrum of UHECR and anisotropy
- Neutrino mass limit by direct measurements (KATRIN)
- Combination of many experiments for improved neutrino oscillation matrix
- Direct dark matter search have dramatically increased sensitivities
-
- **Methodically we improved by:**
 - Structured theory connection (EuCAPT)
 - Machine learning applications
 - Federated computing
 - Realtime event and data exchange
 - Cooperation of underground laboratories
 - Closer cooperation with neighboring fields and European Commission



Highlights since 2017....examples

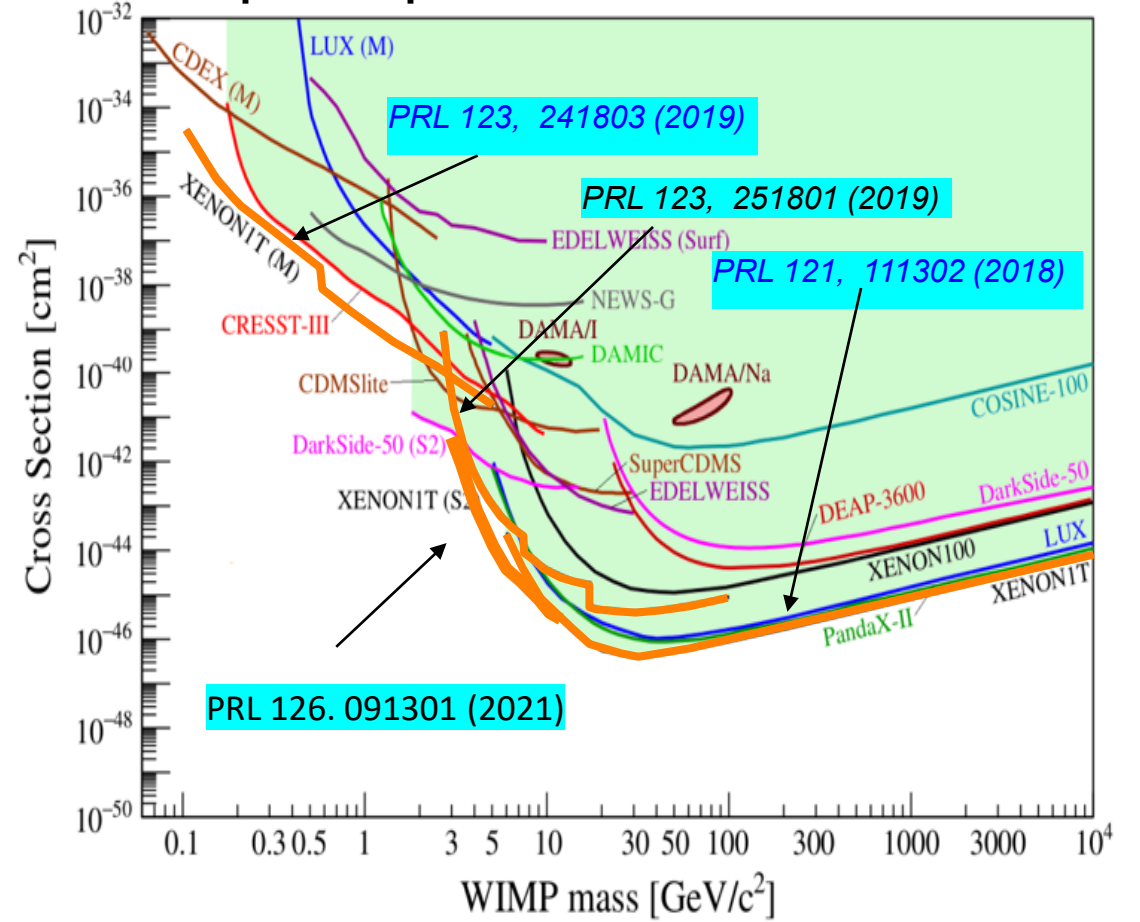
KATRIN neutrino mass limit



$m_\nu < 0.8 \text{ eV } c^{-2}$ at 90% CL [Nature Physics, 18, 160 \(2022\)](#)

Dark Matter WIMP limit

spin-independent WIMP-nucleon interactions



Highlights since 2017....examples

Multimessenger GW event

THE ASTROPHYSICAL JOURNAL LETTERS, 848:L12 (59pp), 2017 October 20
 © 2017. The American Astronomical Society. All rights reserved.

<https://doi.org/10.3847/2041-8213/aa91c9>

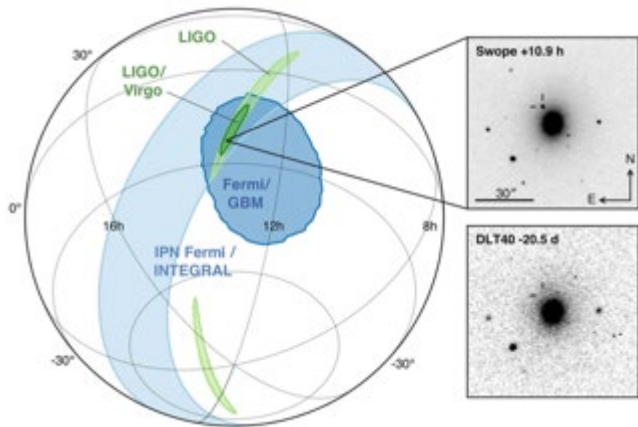
OPEN ACCESS



Multi-messenger Observations of a Binary Neutron Star Merger*

LIGO Scientific Collaboration and Virgo Collaboration, Fermi GBM, INTEGRAL, IceCube Collaboration, AstroSat Cadmium Zinc Telluride Imager Team, IPN Collaboration, The Insight-HXMT Collaboration, ANTARES Collaboration, The Swift Collaboration, AGILE Team, The 1M2H Team, The Dark Energy Camera GW-EM Collaboration and the DES Collaboration, The DLT40 Collaboration, GRAWITA: GRAVitational Wave Inaf TeAm, The Fermi Large Area Telescope Collaboration, ATCA: Australia Telescope Compact Array, ASKAP: Australian SKA Pathfinder, Las Cumbres Observatory Group, OzGrav, DWF (Deeper, Wider, Faster Program), AST3, and CAASTRO Collaborations, The VINROUGE Collaboration, MASTER Collaboration, J-GEM, GROWTH, JAGWAR, Caltech-NRAO, TTU-NRAO, and NuSTAR Collaborations, Pan-STARRS, The MAXI Team, TZAC Consortium, KU Collaboration, Nordic Optical Telescope, ePESSTO, GROND, Texas Tech University, SALT Group, TOROS: Transient Robotic Observatory of the South Collaboration, The BOOTES Collaboration, MWA: Murchison Widefield Array, The CALET Collaboration, IKI-GW Follow-up Collaboration, H.E.S.S. Collaboration, LOFAR Collaboration, LWA: Long Wavelength Array, HAWC Collaboration, The Pierre Auger Collaboration, ALMA Collaboration, Euro VLBI Team, Pi of the Sky Collaboration, The Chandra Team at McGill University, DFN: Desert Fireball Network, ATLAS, High Time Resolution Universe Survey, RIMAS and RATIR, and SKA South Africa/MeerKAT (See the end matter for the full list of authors.)

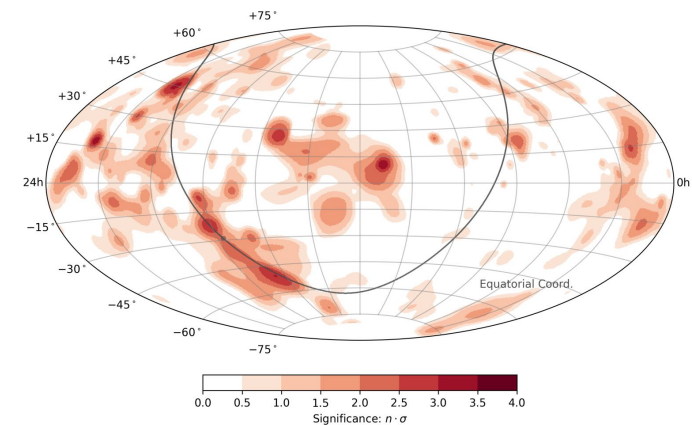
Received 2017 October 3; revised 2017 October 6; accepted 2017 October 6; published 2017 October 16



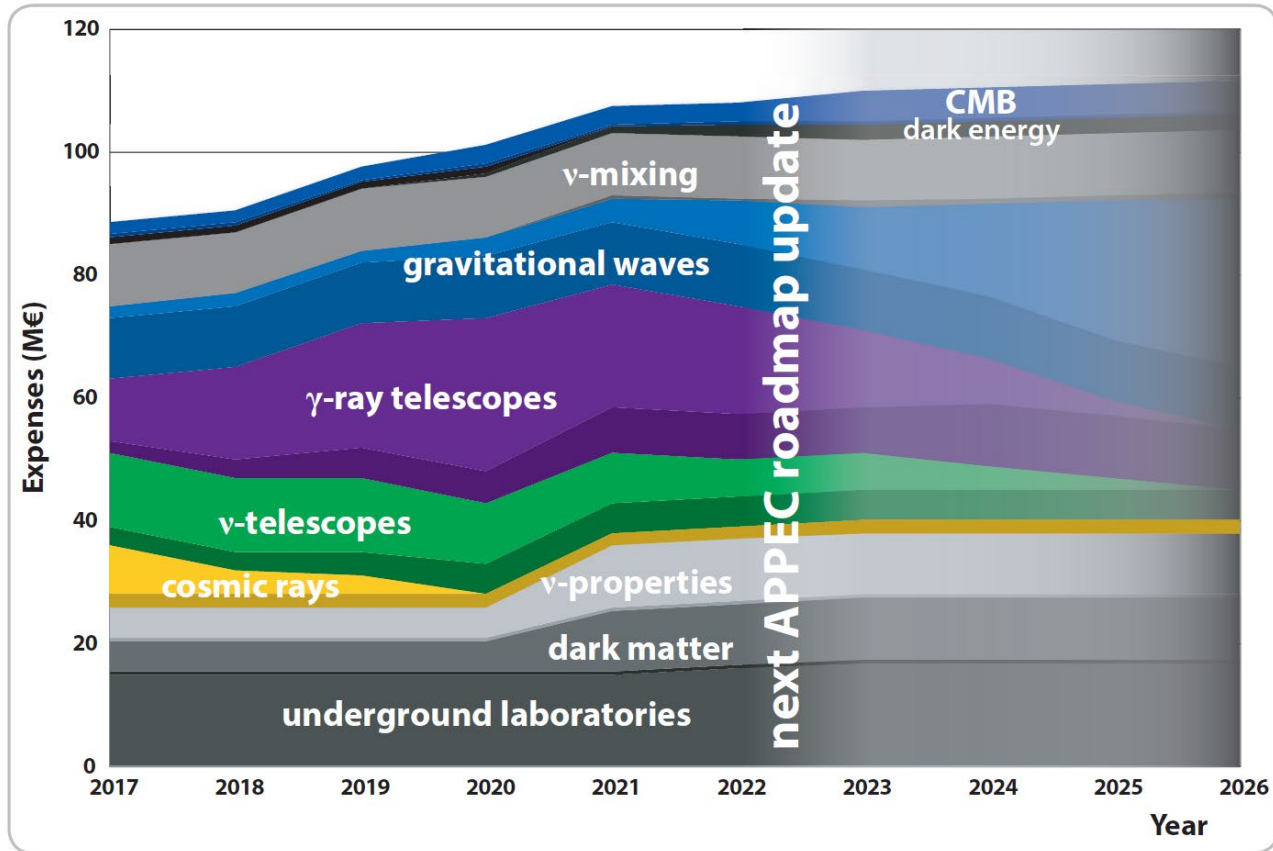
[The Astrophysical Journal Letters, Volume 848, Number 2](#)

LVK (2021): mass of graviton $m_g \leq 1.27 \times 10^{-23} \text{ eV}/c^2$, 90%CL

IceCube Neutrinos from the Milky Way



Midterm Evaluation and Update of the Roadmap



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



- ➔ An inspiring, lively and colourful event with a lot of debates and exchange!
- ➔ important input to the Roadmap update

APPEC roadmap - scientific topics

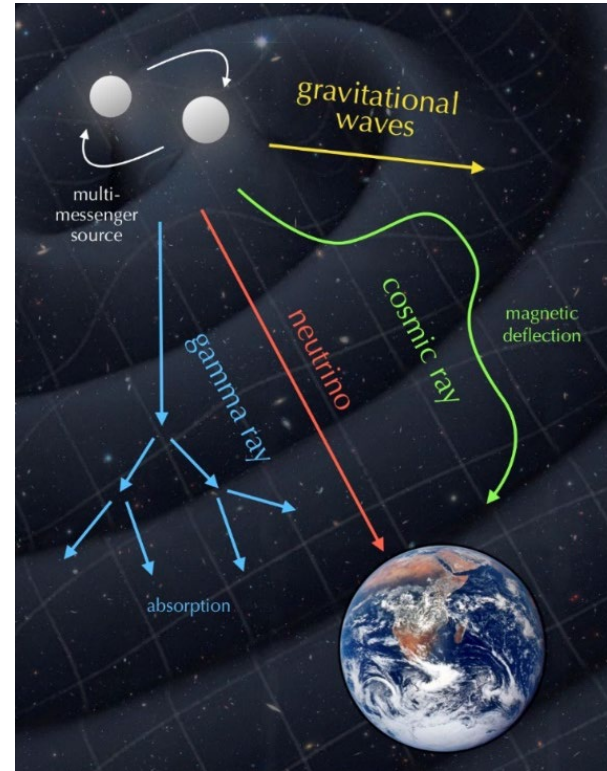
- High-energy gamma rays
- High-energy neutrinos
- High-energy cosmic rays
- Gravitational waves
- WIMP Dark Matter
- Non-WIMP Dark Matter
- Neutrino mass and nature
- Neutrino mixing and mass ordering
- Cosmic Microwave Background
- Dark Energy
- Multi-messenger astroparticle physics
- Astroparticle theory
- Detector R&D
- Computing and data policies



Recommendations are
given for each topic

The High-Energy Universe: Multi-Messenger Astroparticle Physics

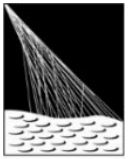
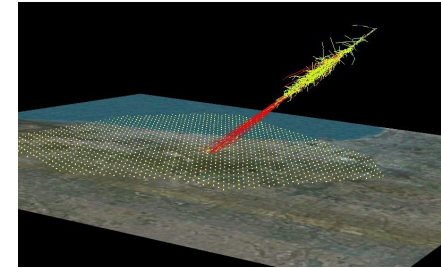
- Required to understand the sources of cosmic rays and the physics processes in the high-energy Universe
- Needs long-term operational observatories
- And a sophisticated Big Data management: Big Data Analytics; Research Data Management; Data Curation; Open Data..... preferably in real-time!



+ instruments for multiwavelength astronomy



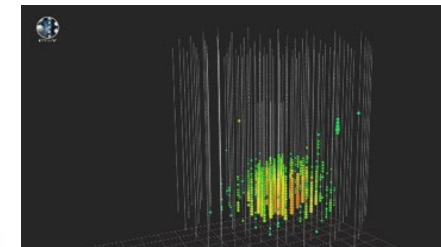
SKAO



PIERRE
AUGER
OBSERVATORY



cta
cherenkov telescope array



The Dark Universe: Underground Laboratories

- Experiments (often) require sophisticated Deep Underground Laboratories (DULs)
- R&D and prototyping also require DULs
- Community-overarching, synergetic research possible
- Needs long-term commitments for operation of Underground Labs.

➔ Structured Coordination of European Underground Activities and Infrastructures

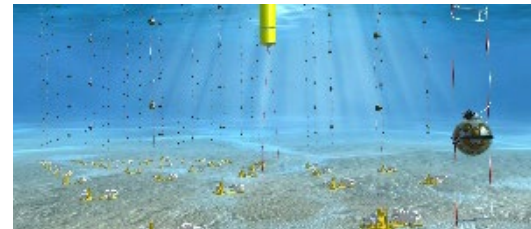


APPEC Flagship Research Infrastructures

This is not a closed, but dynamic list...

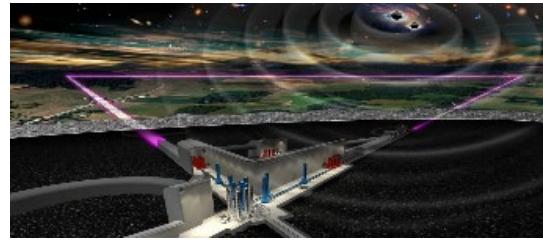
ESFRI=European Strategy Forum on Research Infrastructures

[construction KM3NeT 2020-2026; IceCube-Gen2]



ESFRI

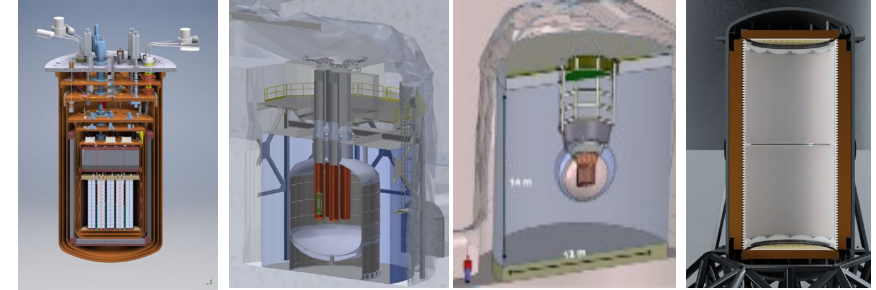
HE Neutrinos



ESFRI

[construction Einstein Telescope 2026-]

Gravitational Waves



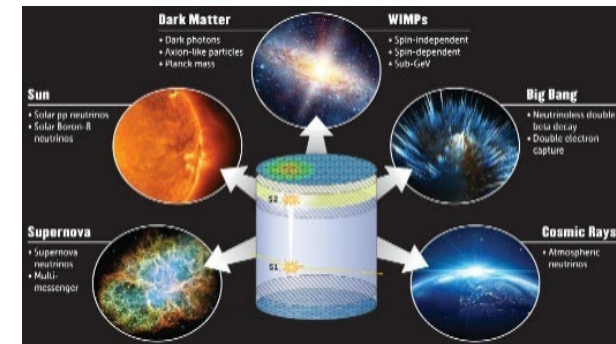
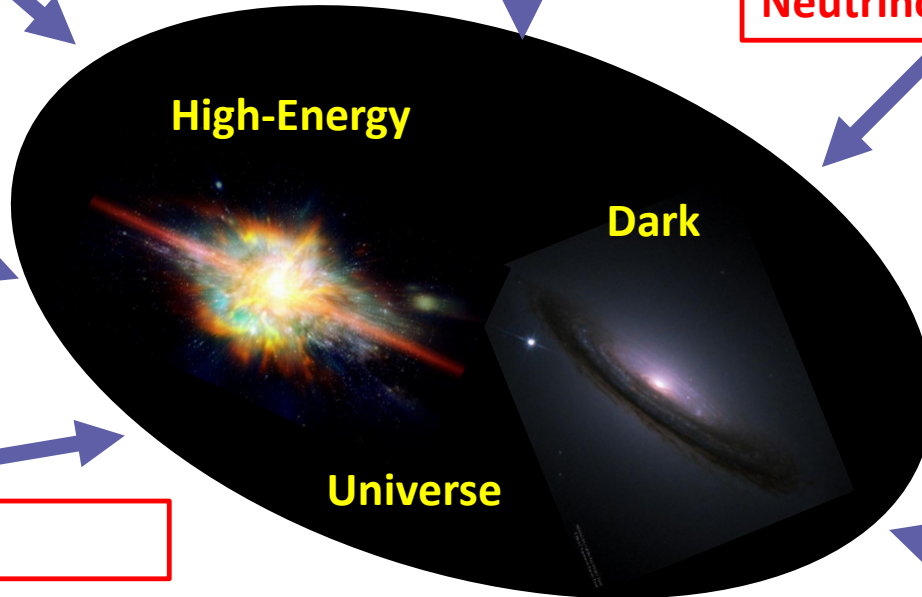
[construction LEGEND-1000 / nEXO 2023- ; ...]

Neutrino Properties

[construction AugerPrime 2019-2023]



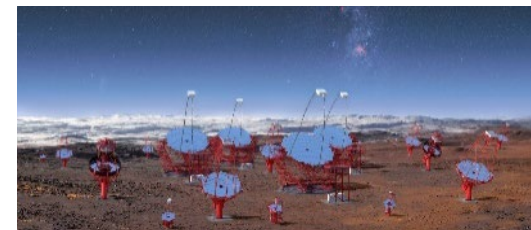
HE Cosmic Rays



[construction DARWIN 2024- ; XLZD, ARGO, ...]

Dark Matter

[construction CTA 2021-]



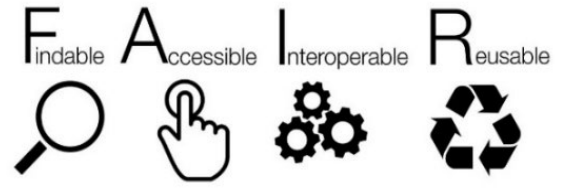
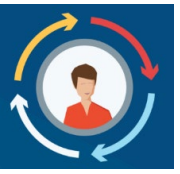
ESFRI

HE Gamma Rays

Roadmap - Connecting to Society and Organisation

- 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



JENA Computing Initiative

<https://agenda.infn.it/event/34738/>

• Workshop:

- JENA Computing Workshop in Bologna: 12-14 June 2023
- Motivation: JENAS 2022 → There is a need for a European coordination of (federated) computing
- Topics were all aspects of (federated) computing covering, e.g., HPC vs. HTC, software, data management, open data, sustainability

• Results:

- Preparation of a white paper on (ENA) computing as input for JENAS 2025
- Dedicated working groups on five areas:
 - HPC integration in the HTC federated infrastructures
 - Software and Heterogeneous Architectures
 - Data Management, Virtual Research Environments and FAIR/Open Data
 - Machine Learning and Artificial Intelligence
 - Training, Dissemination, Education

• Next:

- Building the working groups and prepare dedicated meetings

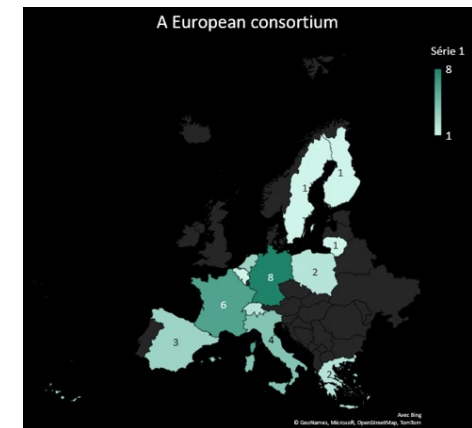


HORIZON-INFRA-2023-SERV-01-02

- Topic: **better access of users to RI services to advance frontier knowledge**, activities to improve and harmonize the access, and training for scientists.
- **ACME is set up to realize an ambitious coordinated European-wide optimization of the accessibility and cohesion between multiple leading RI, offering access to instruments, data and expertise.**
- Maximum EU contribution per project: 14.5 million euros.
- Scientific domain of interest: Astronomy & Astroparticle physics.
- Consortium: 41 partners, 15 countries, >30 research infrastructures
- Submission on March 9th, feedback in September → waiting list



Astronet



Summary

- Astroparticle Physics is a booming and blooming field
....in search of the wonders of the cosmos
- Plenty of opportunities for young scientists
- Plenty of opportunities for transdisciplinary science

APPEC Future:

- Sustainable consortium for the next >10 years
- Preparation of next decadal roadmap
- Coordination of European Astroparticle Physics strategy...
- ...in view of global developments in the field
- ...in cooperation with neighboring fields
- ...in concord with society

=> A large Thank you to the community and the Funding Agencies to support APPEC

APPEC Newsletter:

<https://www.appec.org/latest-news/newsletters>





Thank you