APPEC

Astroparticle Physics European Consortium

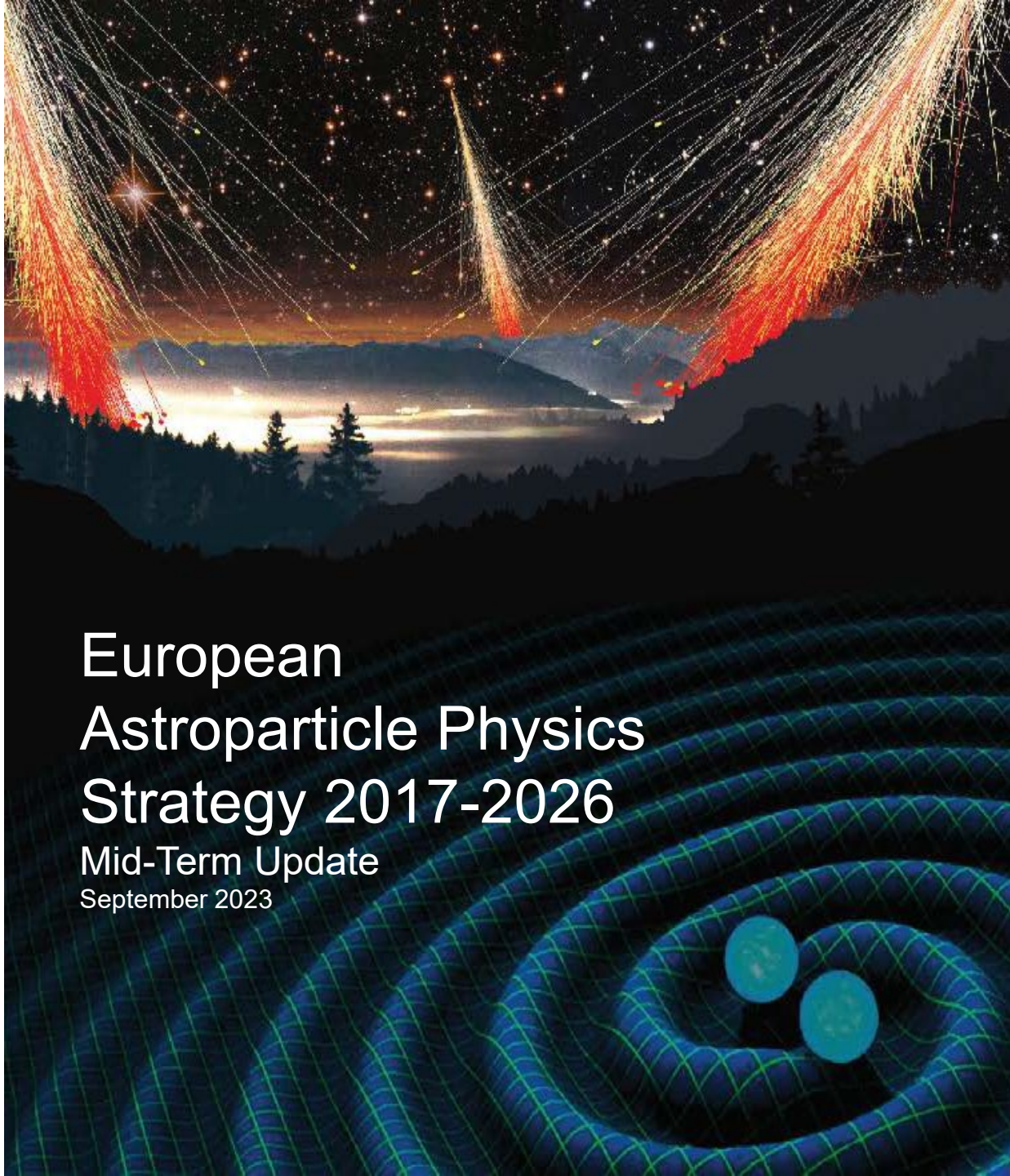
The Future of Astroparticle Physics

The European View

Andreas Haungs | KIT, APPEC

Pisa | 21-23 October 2024

KIT Karlsruhe Institute of Technology



Astroparticle Physics

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

Understanding

the Extreme Universe

- Multi-Messenger observations of cataclysmic events

the Dark Universe

- Exploring the nature of Dark Matter and Dark Energy

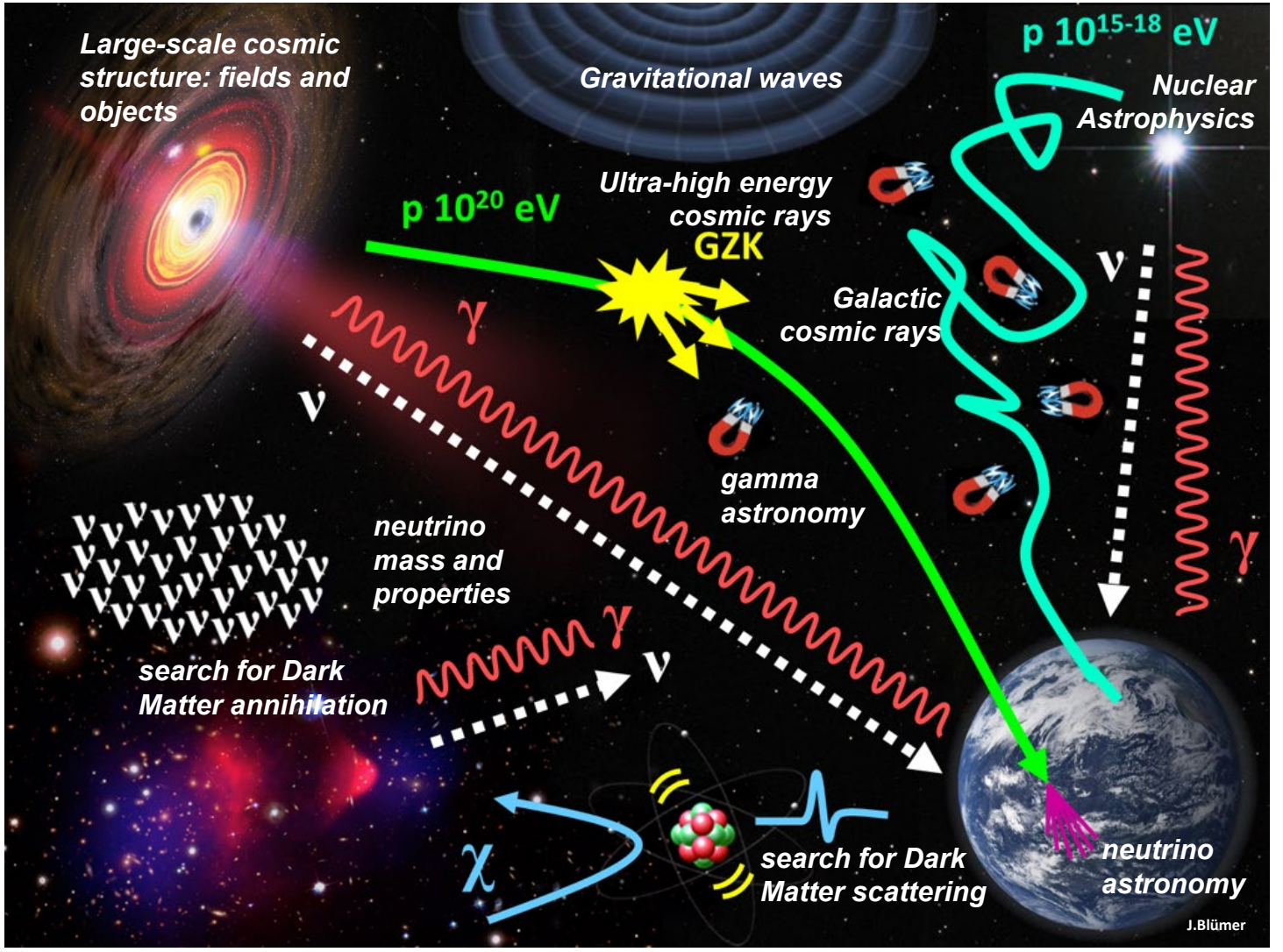
the Mysterious Neutrinos

- Measuring their properties und unveil their role in the universe

the Early Universe

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

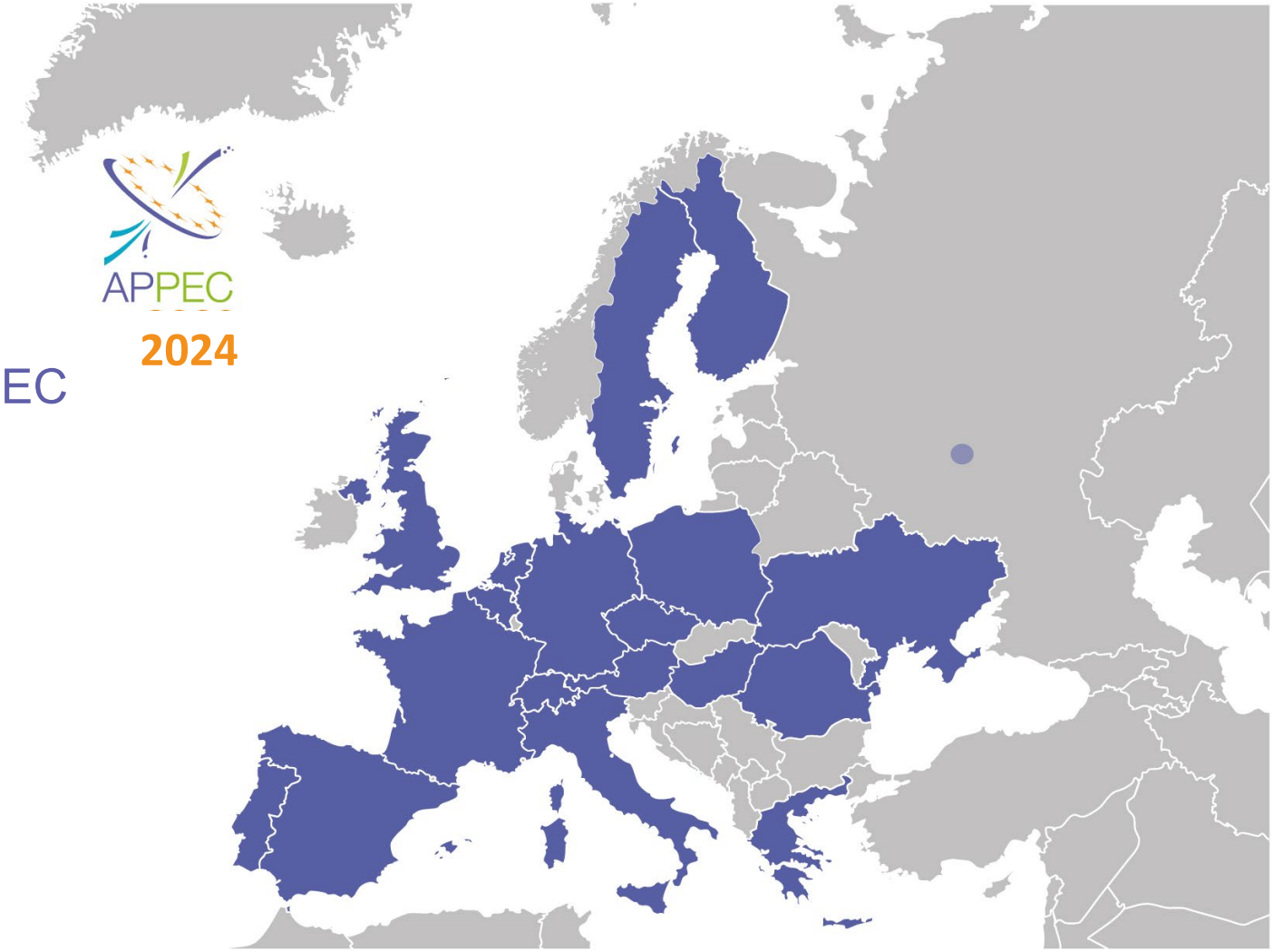
- Large-scale research facilities
- Interplay of theory with experiment
- Synergies with neighboring fields
- Connecting with society



www.appec.org

AstroParticle Physics European Consortium

- an international coordinating structure, founded in 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
  - In discussion with Denmark and Norway
- 3 bodies:
  - General Assembly with Observers
  - Scientific Advisory Committee;
  - Joint Secretary

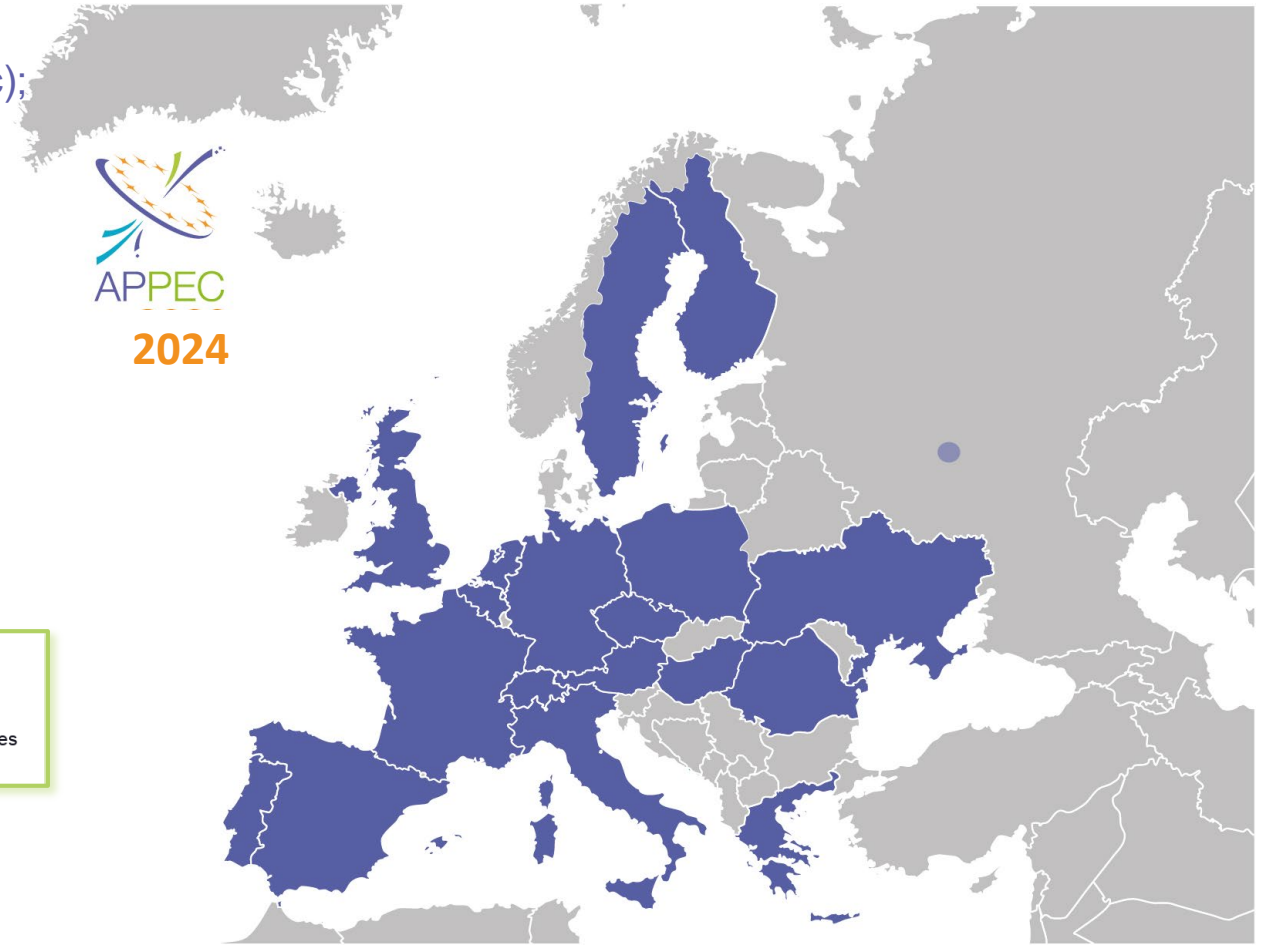


APPEC Bodies

- **General Assembly**
  - Strategic, decision making and supervisory body
  - Representatives of funding agencies
  - Chair: Andreas Haungs (KIT), Carlos Peña Garay (Canfranc);
  - Vice-Chair: Antoine Kouchner (APC)
- **Scientific Advisory Committee**
  - Advisory body
  - Chair: Aldo Ianni (LNGS) since 2024;
  - Vice-Chair: Mathieu de Naurois (CNRS) since 2024
- **Joint Secretariat (distributed office)**
  - Executive body chaired by the General Secretary
  - General Secretary: Julie Epas (APC) since 2024
- **Observer**
  - CERN (Joachim Mnich)
  - ECFA (Paris Sphicas)
  - NuPECC (Marek Lewitowicz)
  - Astronet (NN, Martin Giard)
  - ESO (Andy Williams)
  - EPS-HEPP (Ramon Miquel)
  - EuCAPT (Silvia Pascoli)

JENAA
Joint ECFA-NuPECC-APPEC Activities

www.appec.org



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

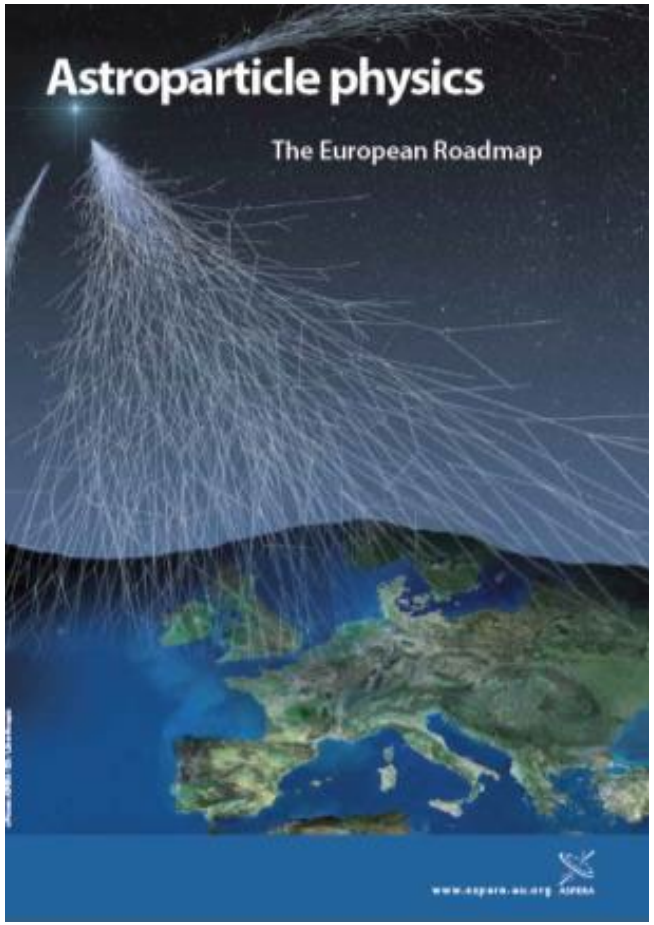
- **Helping in coordination of large-scale RI**
- **Helping in transition of mid-scale experiments to large-scale RI**
- **Helping in support of small-scale and R&D experiments**

APPEC Roadmaps

https://www.appec.org/roadmap

2008

2011



2017

APPEC roadmap - scientific topics

https://www.appec.org/roadmap

- 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

RoadmapUpdate.pdf

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

RoadmapUpdate.pdf

Horizon Europe
THE NEXT EU RESEARCH & INNOVATION PROGRAMME (2021–2027)

ACME
Astrophysics Centre for Multi-messenger studies in Europe

JENAA
Joint ECFA-NuPECC-APPEC Activities

Astronet

EuCAPT

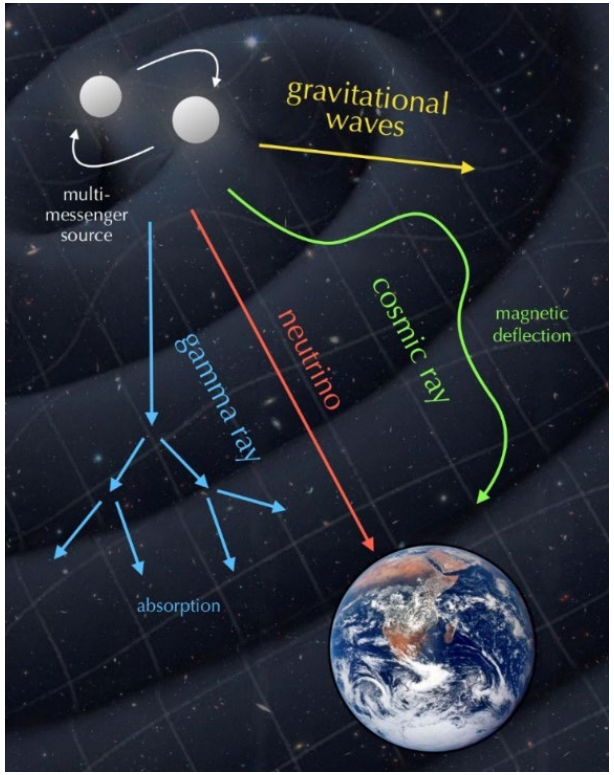
OPEN SCIENCE

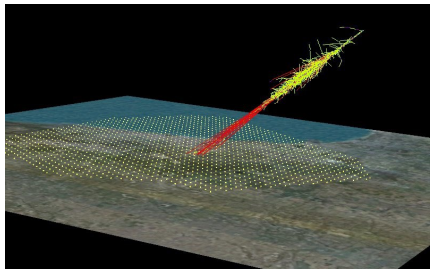
Findable Accessible Interoperable Reusable

United Nations SUSTAINABLE DEVELOPMENT GOALS

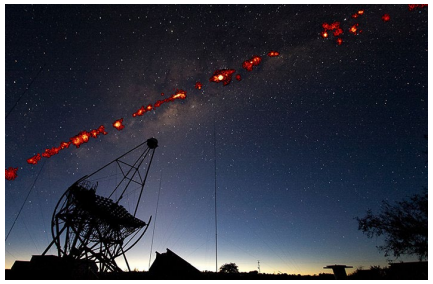
The High-Energy Universe: Multi-Messenger Astroparticle Physics

- 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!

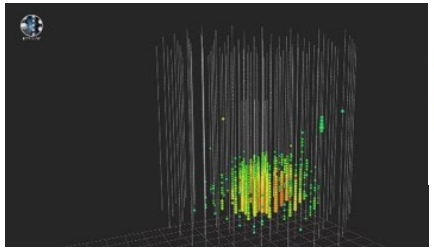




PIERRE AUGER OBSERVATORY



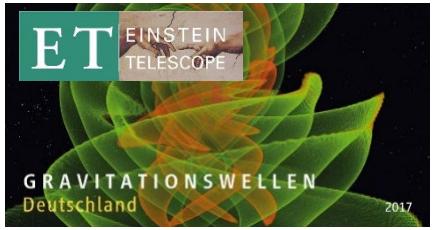
cta cherenkov telescope array



KM3NeT IceCube

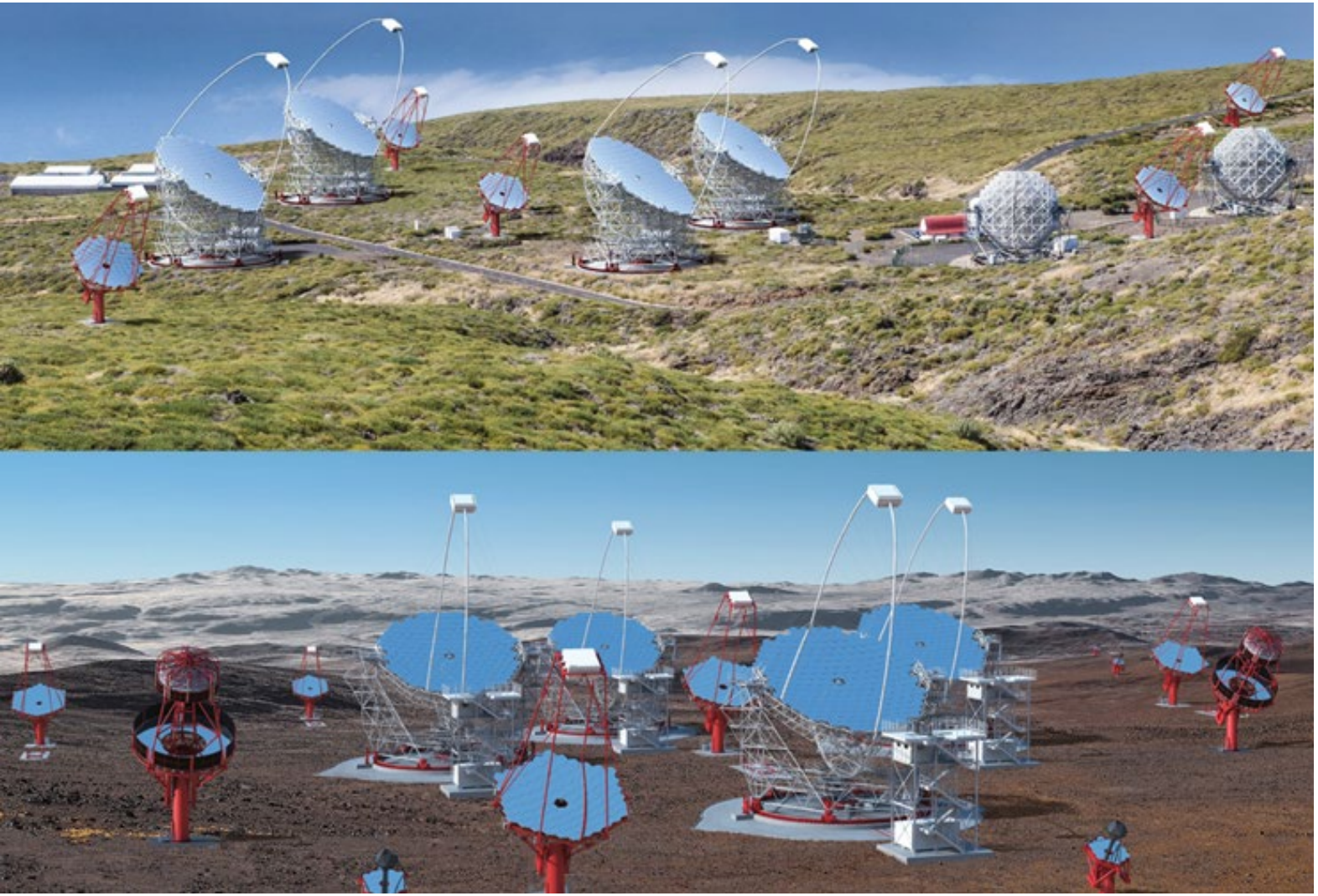
SKAO

+ instruments for multiwavelength astronomy



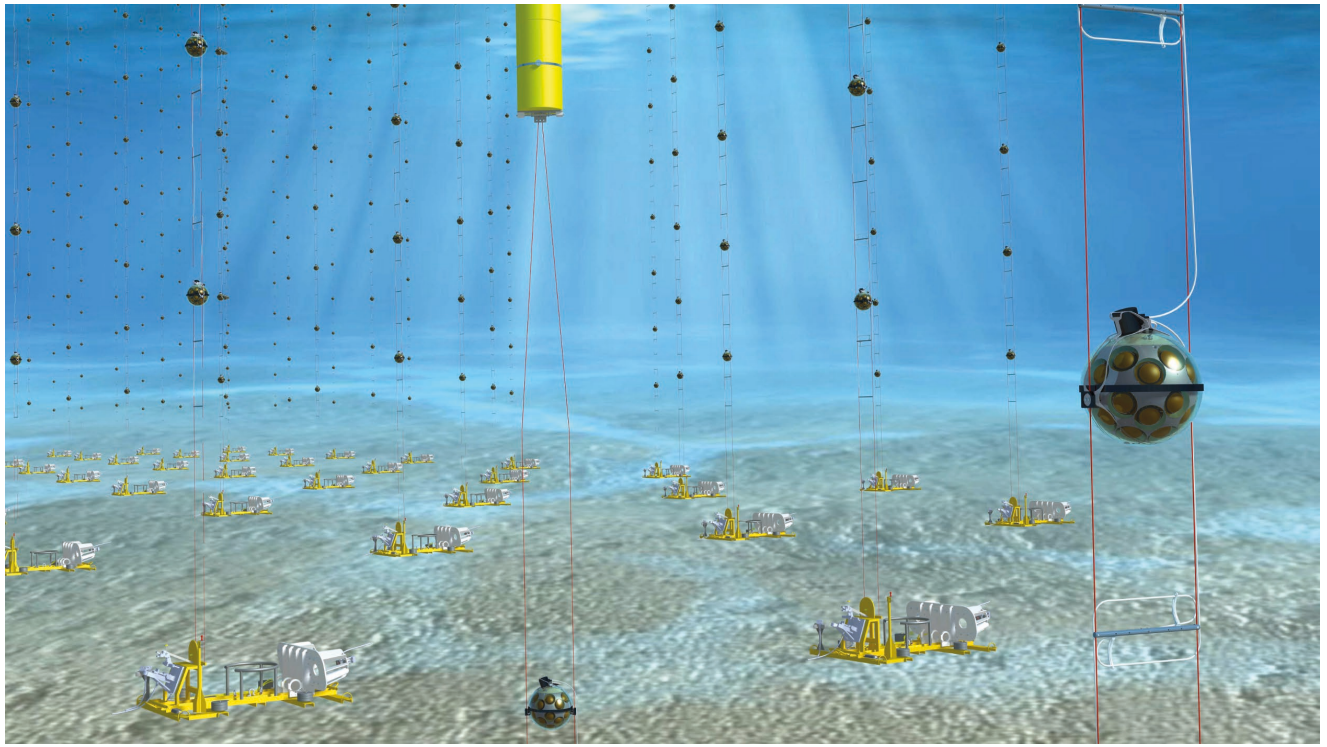
LIGO VIRGO

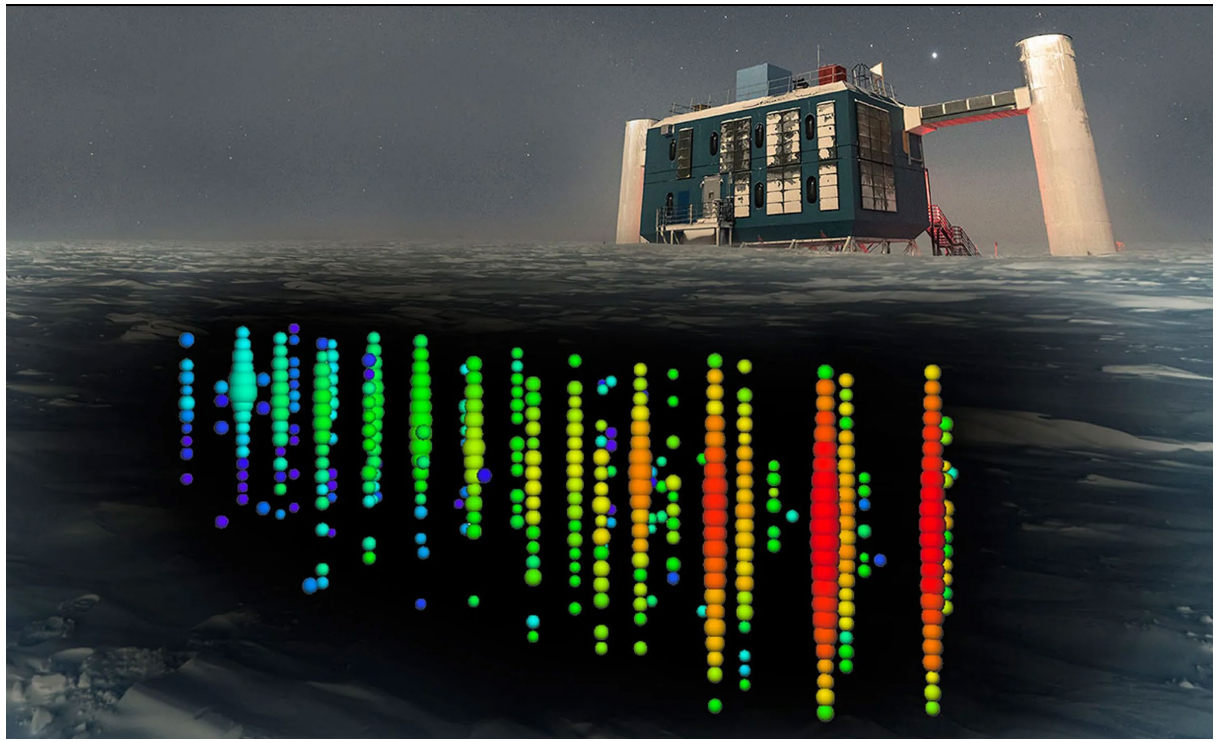
High-Energy Gamma Rays



APPEC fully endorses the construction and subsequent long-term operation of CTA in both the northern and southern hemispheres. APPEC supports work towards the selection of the mission concept THESEUS and the construction of SWGO. It urges the community to consider a replacement for the Fermi telescope.

High-Energy Neutrinos



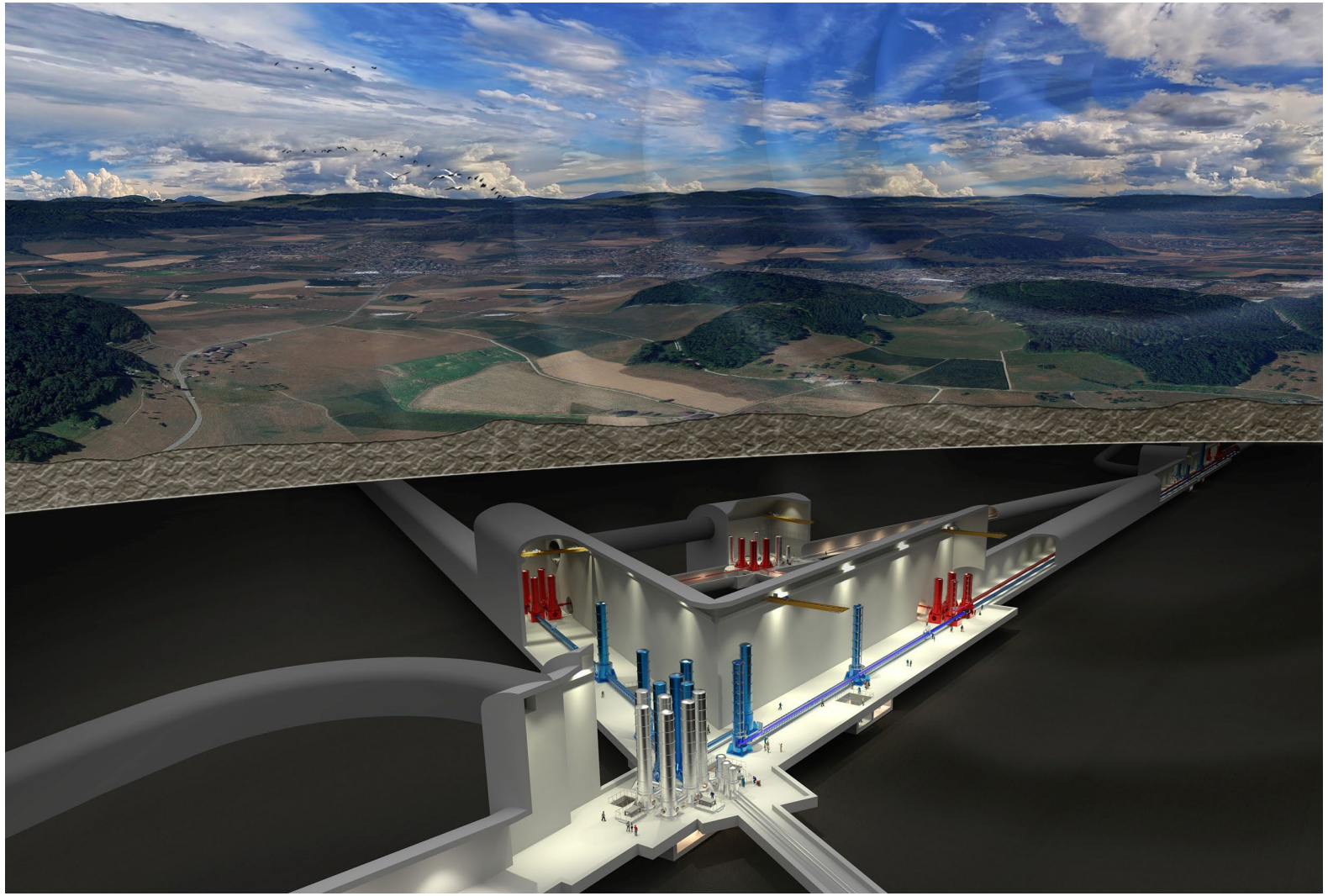


APPEC fully endorses the goal of the KM3NeT collaboration to complete the construction of the large-volume telescope optimised for high-energy neutrino astronomy ARCA, and the dedicated detector to resolve the neutrino mass hierarchy ORCA. APPEC strongly supports the construction of the IceCube Upgrade, and the ambition to build IceCube-Gen2 in the following decade.

High-Energy Cosmic Rays

APPEC fully endorses the completion of AugerPrime and strongly supports the exploitation of the combined Auger and TA full sky coverage by joint working groups. APPEC encourages continued R&D on new cost-effective detector technologies for a next-generation observatory. APPEC encourages theory efforts to understand air shower physics, physics at cosmic-ray sources and cosmic-ray propagation.

Gravitational Waves



APPEC strongly supports actions to enlarge European countries' participation in ET, acquire funds for ET construction and operations, and develop the ET scientific community. APPEC supports building the bridge between second and third-generation detectors to maintain European expertise and leadership in the field and the VIRGO observation capability up to when the ET will start observations. APPEC strongly supports the LISA mission.

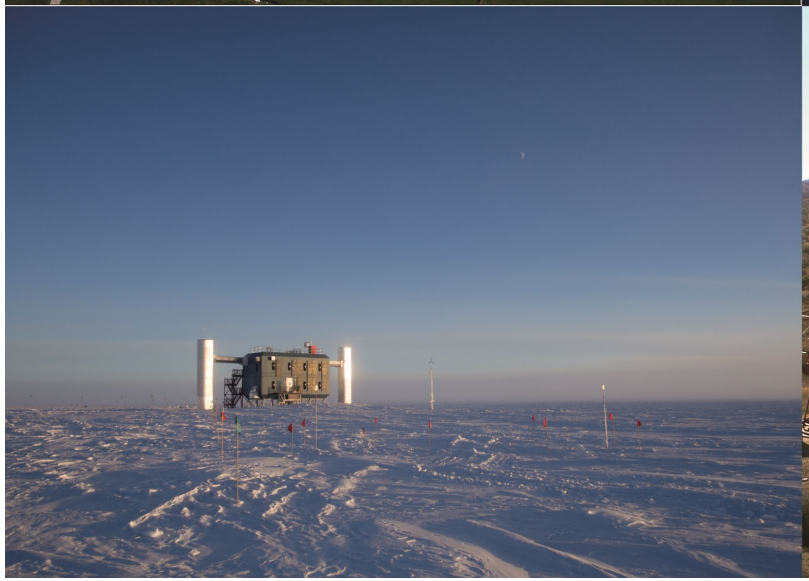
Multi-Messenger Astroparticle Physics

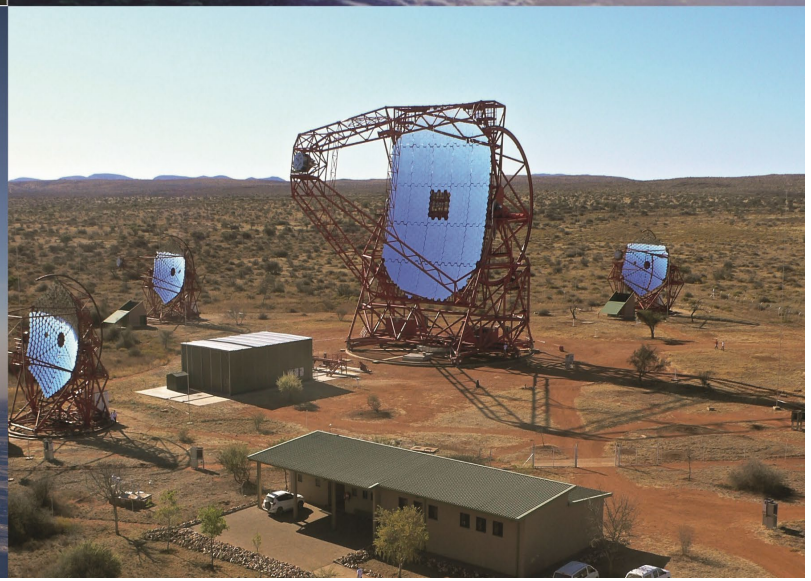
ACME
Astrophysics Centre for Multi-messenger studies in Europe

Funded by the European Union

APPEC

APPEC supports the further development and coordination of optimised multi-messenger observational strategies, common tools and data formats. Optimising future observatories for multi-messenger observations is strongly supported. APPEC encourages efforts to enhance collaboration among theorists, experimentalists, observers, and experts in data analysis and computing from different communities.





Computing and Data Policies

APPEC requests all relevant experiments to continue to have their computing requirements scrutinised. APPEC will engage with the particle physics and astronomy communities to secure a balance between available European computing resources and needs for now and into the future. Appropriate training in data science should be provided for astroparticle physicists.

Open Science and Citizen Science

APPEC encourages the use of data format standards to facilitate data access between experiments. APPEC encourages funding agencies and publishers to support coherent Open Access publication policies. APPEC encourages making data publicly available as much as possible according to the FAIR principles. APPEC encourages citizen science to engage the public, while at the same time increasing the scientific capabilities of experiments.

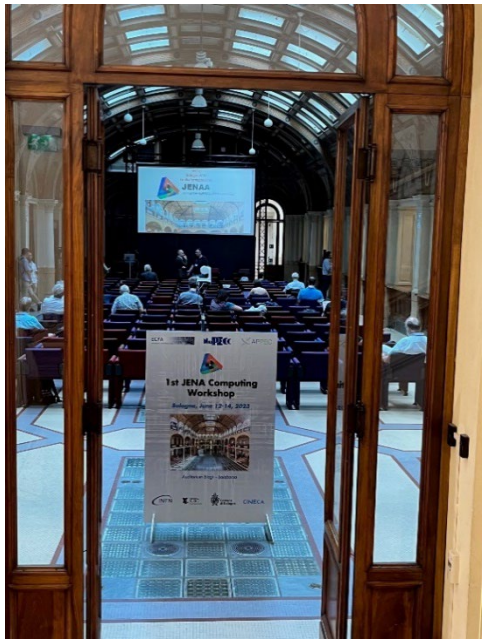
ACME – Astrophysics Centre for Multimessenger studies in Europe

JENA Computing Initiative

JENAA
Joint ECFA-NuPECC-APPEC Activities

APPEC

- 1st JENA Symposium: 14-16 October 2019 in Orsay, France https://jenas-2019.ijclab.in2p3.fr
- 2nd JENA Symposium: 3-6 May 2022 in Madrid, Spain https://indico.cern.ch/event/1040535
- 3rd JENA Symposium: 8-11 April 2025 at RAL, UK https://indico.cern.ch/event/1440480/



- **One Topic: Future European Federated Computing**

  Initiation started by workshop https://agenda.infn.it/event/34738/

  Target: European white paper on (ENA) computing as input for the next JENA Symposium 2025 to discuss with representatives of funding agencies

  Dedicated working groups (to look deeper) on five areas:

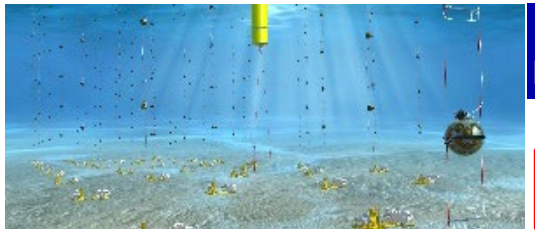
  - HPC: https://indico.scc.kit.edu/e/JENA_computing_wp1/
  - Software: https://indico.scc.kit.edu/e/JENA_computing_wp2/
  - Data Management: https://indico.scc.kit.edu/e/JENA_computing_wp3/
  - ML & AI: https://indico.scc.kit.edu/e/JENA_computing_wp4/
  - Training: https://indico.scc.kit.edu/e/JENA_computing_wp5/

APPEC Flagship Research Infrastructures

This is not a closed, but dynamic list…

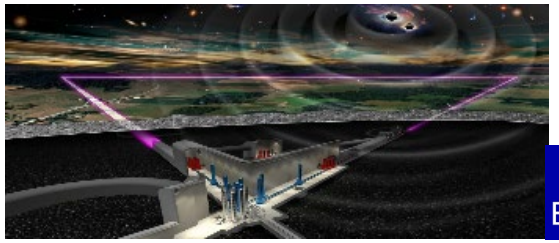
ESFRI=European Strategy Forum on Research Infrastructures

[construction KM3NeT 2020-2026; IceCube-Gen2]



ESFRI

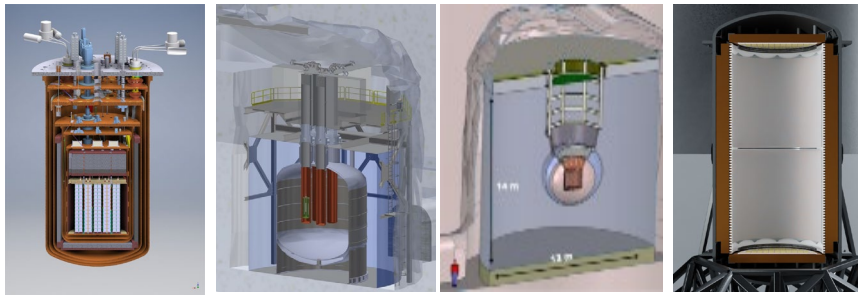
HE Neutrinos



ESFRI

[construction Einstein Telescope 2026-]

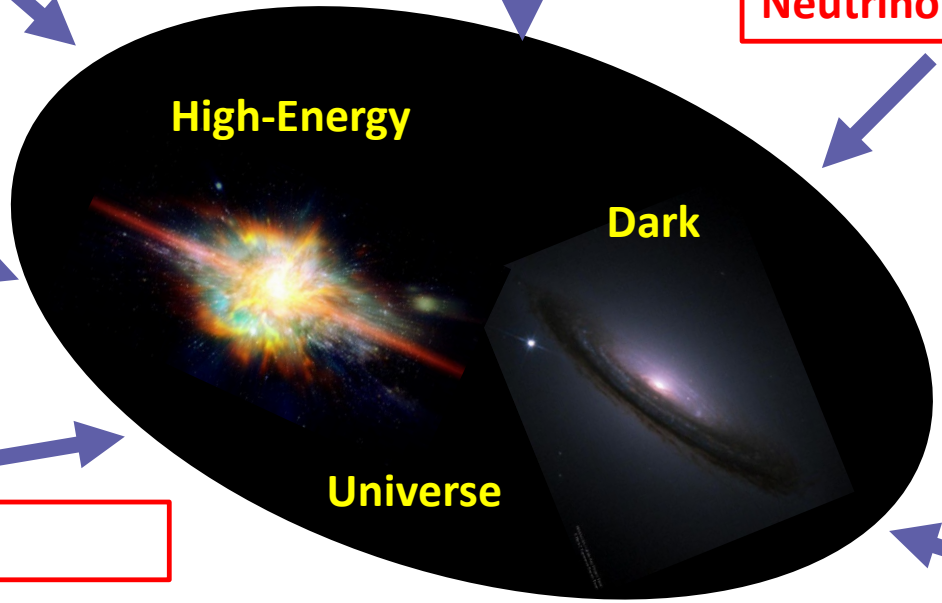
Gravitational Waves



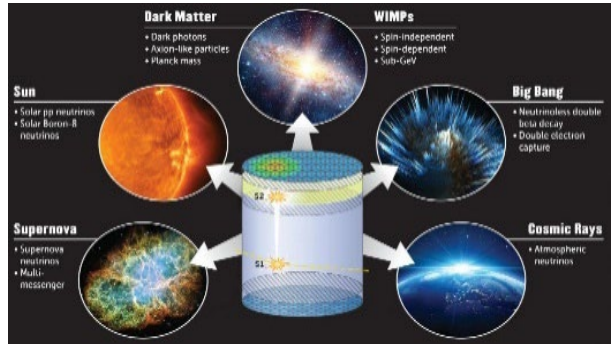
[construction LEGEND-1000 / nEXO 2023- ; …]

[construction AugerPrime 2019-2023]

HE Cosmic Rays

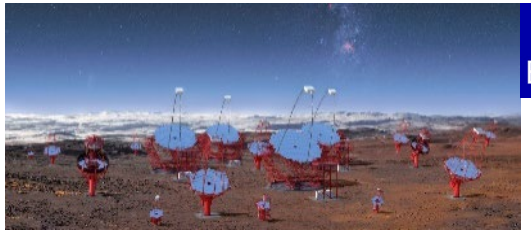


Neutrino Properties



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

[construction CTA 2021-]



ESFRI

HE Gamma Rays

Dark Matter

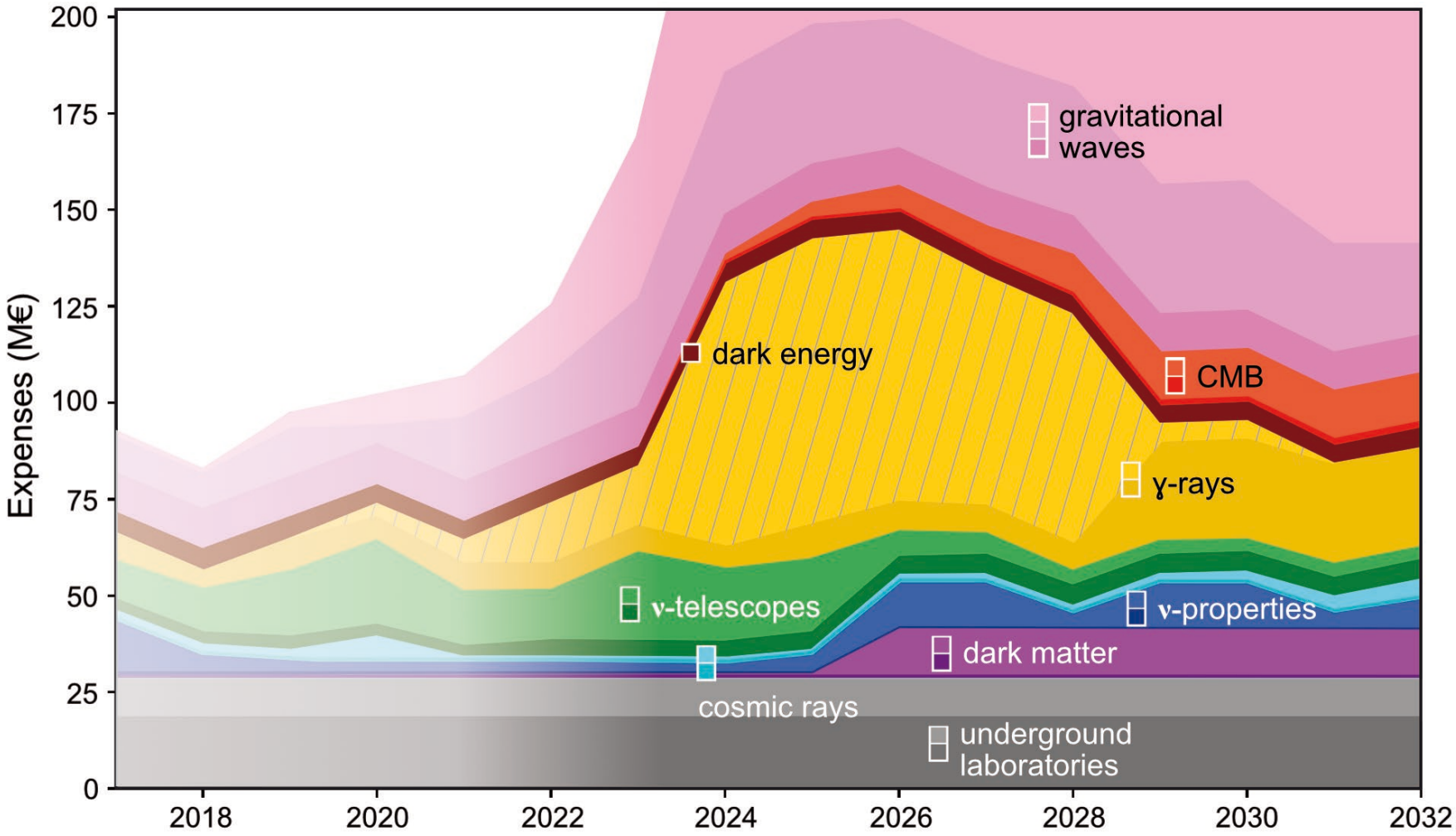
Ressources

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)

RoadmapUpdate.pdf



Roadmap Update 2023: Projected annual capital investment

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 starts now!
- Coordination of European Astroparticle Physics strategy…
- …in view of global developments in the field
- …in cooperation with neighboring fields
- …in concord with society

APPEC Newsletter:
https://www.appec.org/latest-news/newsletters

=> A big **thank you** to the community and the Funding Agencies to support APPEC

Thank You