

# The Future of Astroparticle Physics The European View

[RoadmapUpdate.pdf](#)

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ACME | Paris | 16-17 September 2024



## European Astroparticle Physics Strategy 2017-2026

Mid-Term Update  
September 2023



## Understanding

### the Extreme Universe

- Multi-Messenger observations of cataclysmic events

### the Dark Universe

- Exploring the nature of Dark Matter and Dark Energy

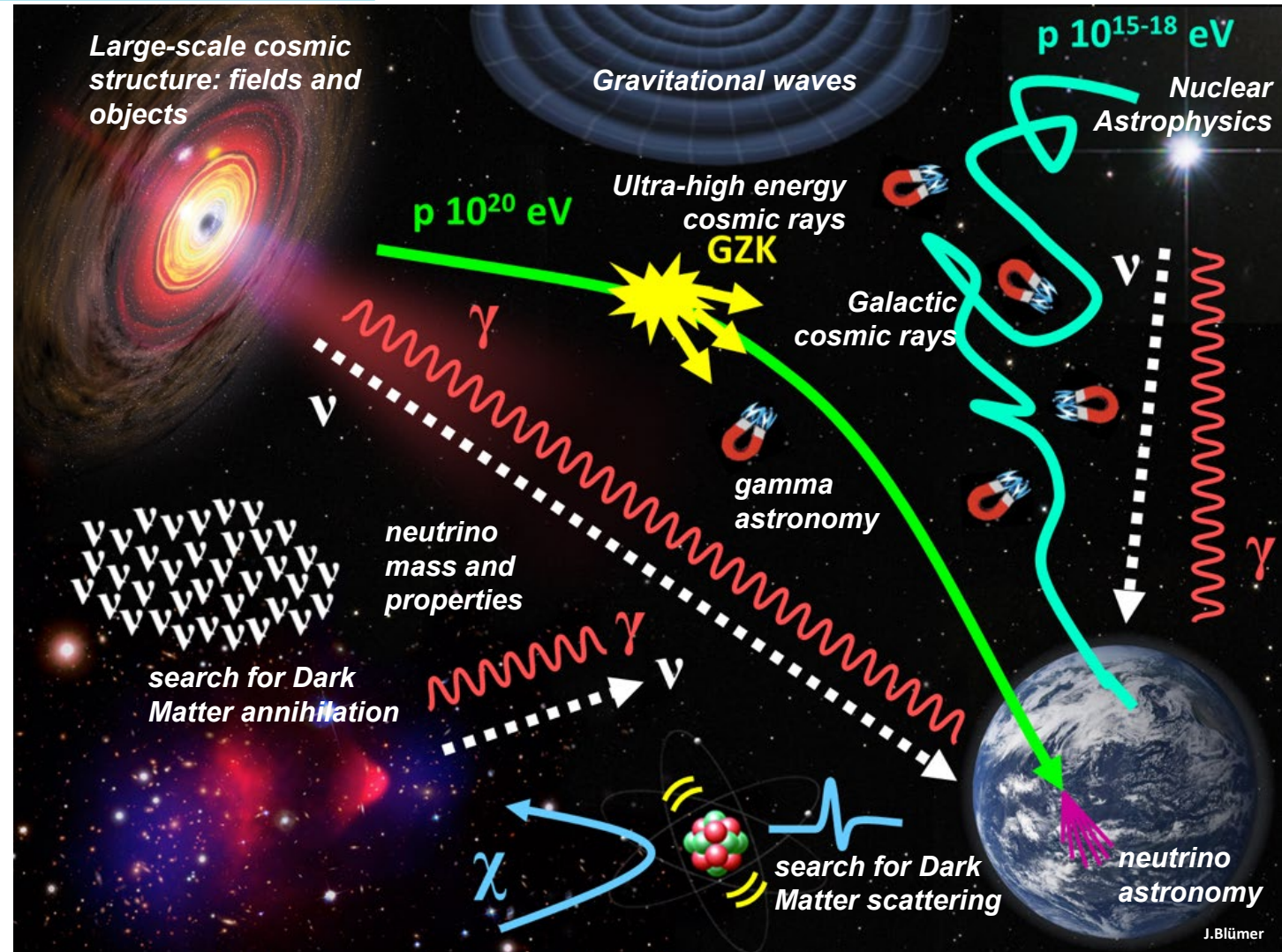
### the Mysterious Neutrinos

- Measuring their properties and unveil their role in the universe

### the Early Universe

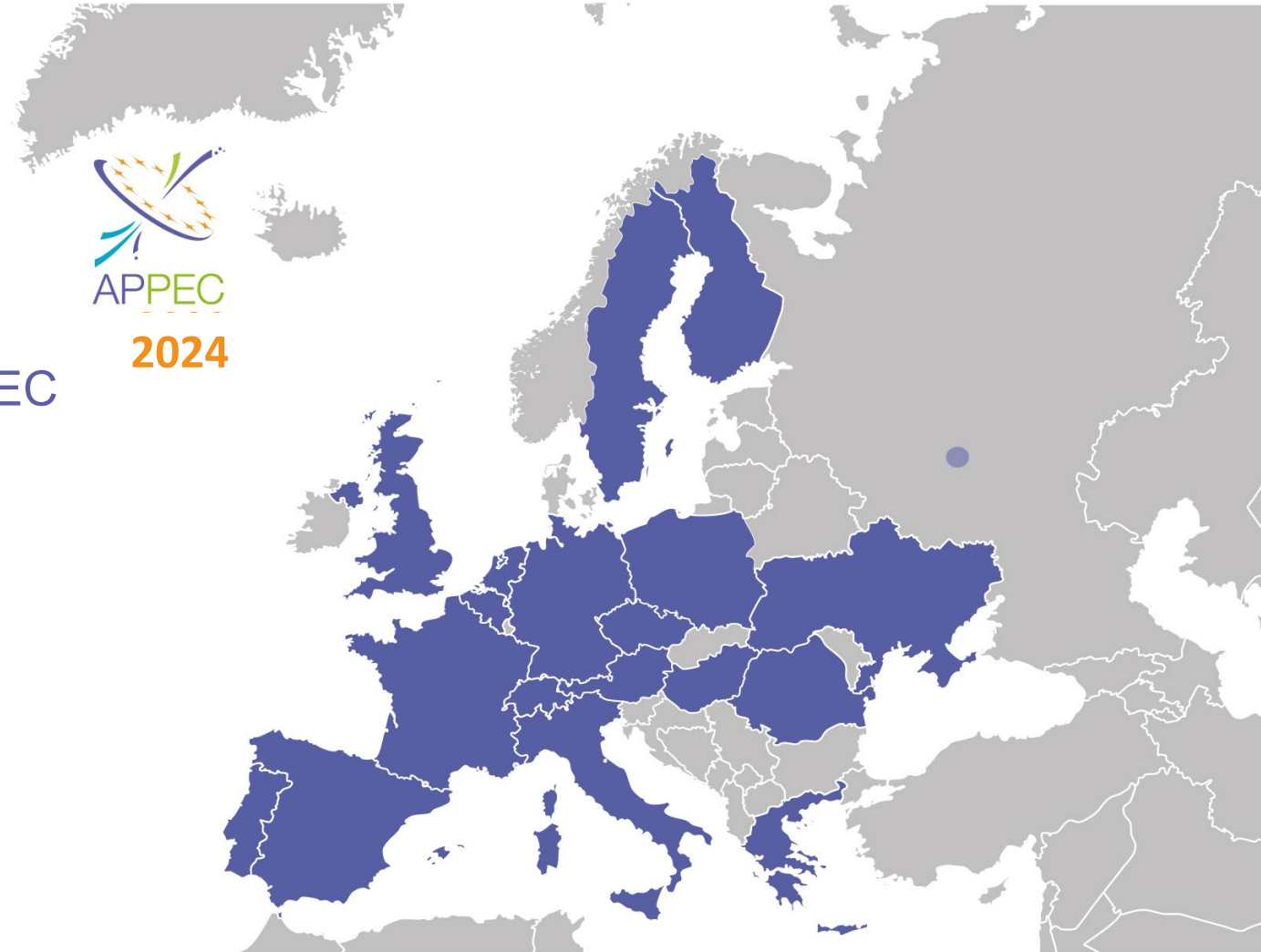
- Learning about the Big Bang, e.g. from CMB

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



## 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**

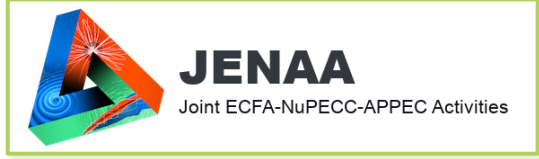
- Advisory body
- Chair: Aldo Ianni (LNGS) since 2024;
- Vice-Chair: Mathieu de Naurois (CNRS) since 2024

- **Joint Secretariat (distributed office)**

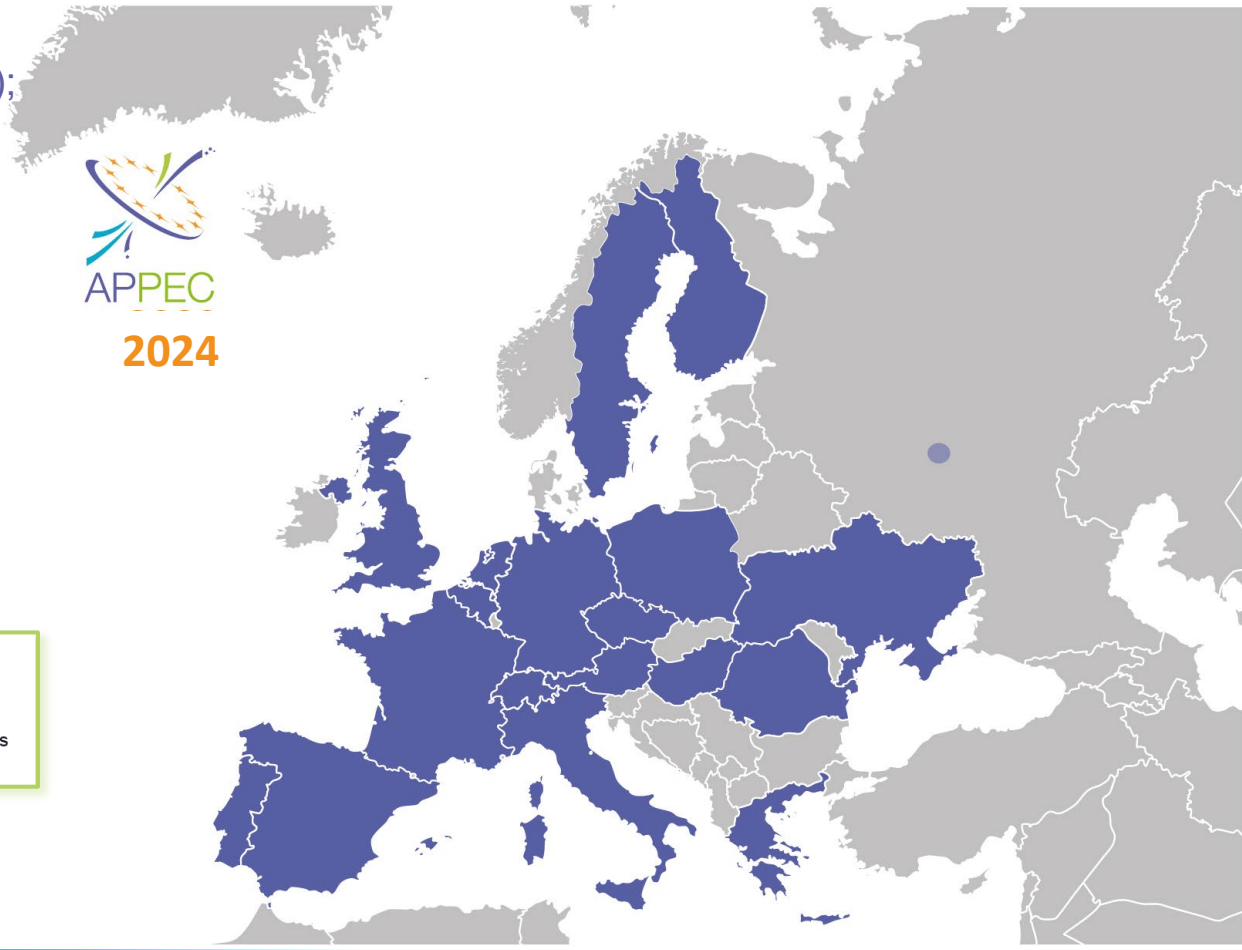
- Executive body chaired by the General Secretary
- General Secretary: Julie Epas (APC)

- **Observer**

- CERN (Joachim Mnich)
- ECFA (Paris Sphicas)
- NuPECC (Marek Lewitowicz)
- Astronet (NN, Martin Giard)
- ESO (Andy Williams)
- EPS-HEPP (Ramon Miquel)
- EuCAPT (Silvia Pascoli)



[www.appec.org](http://www.appec.org)



- 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

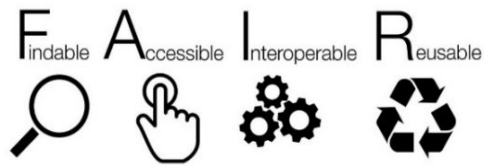
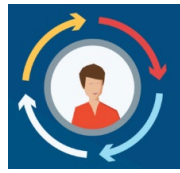
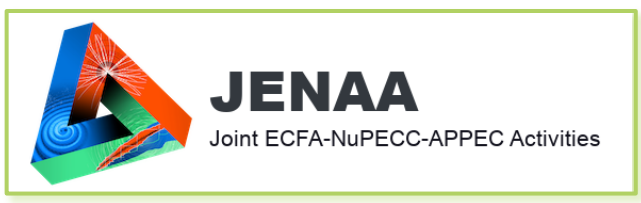
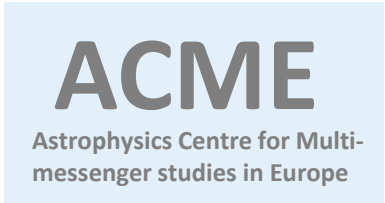
[RoadmapUpdate.pdf](#)

# 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

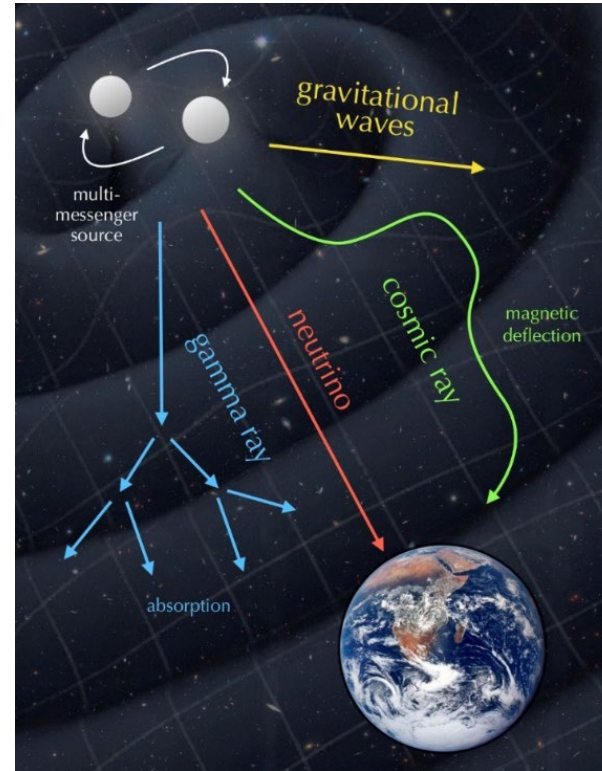
Recommendations are given for each topic

[RoadmapUpdate.pdf](#)



# The High-Energy Universe: Multi-Messenger Astroparticle Physics

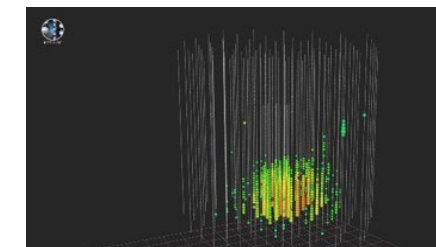
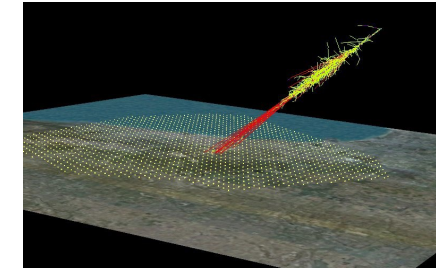
- Required to understand the sources of cosmic rays and the physics processes in the high-energy Universe
- Needs long-term operational observatories
- And a sophisticated Big Data management: Big Data Analytics; Research Data Management; Data Curation; Open Data..... preferably in real-time!



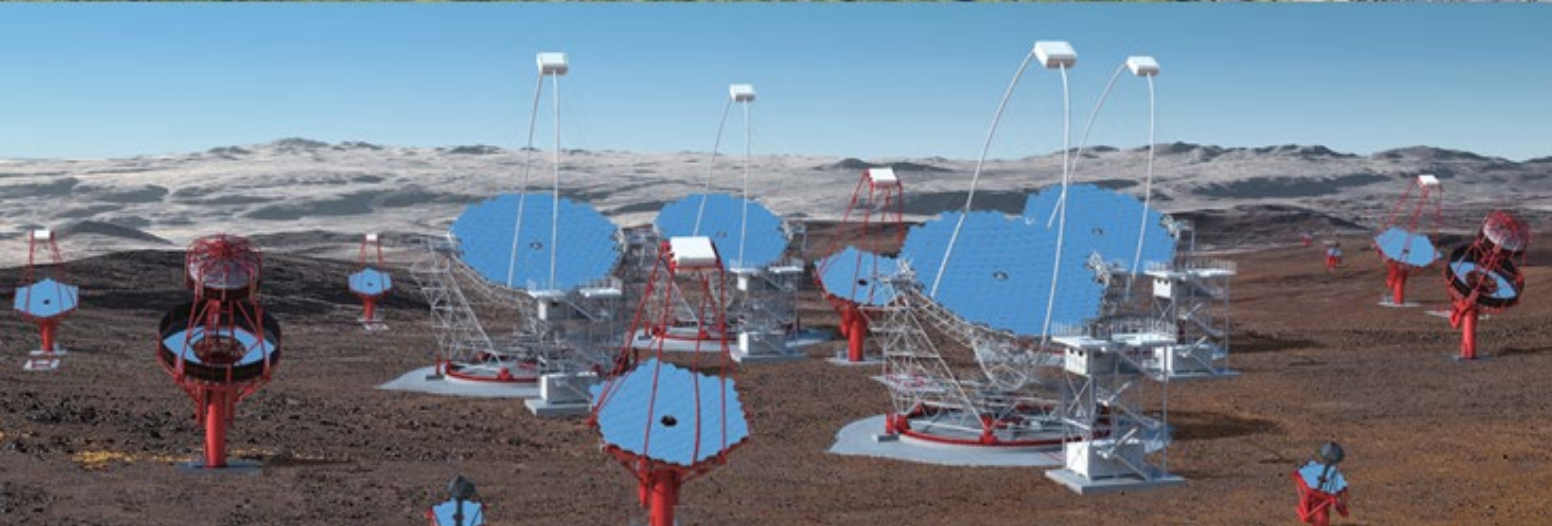
+ instruments for multiwavelength astronomy



**SKAO**



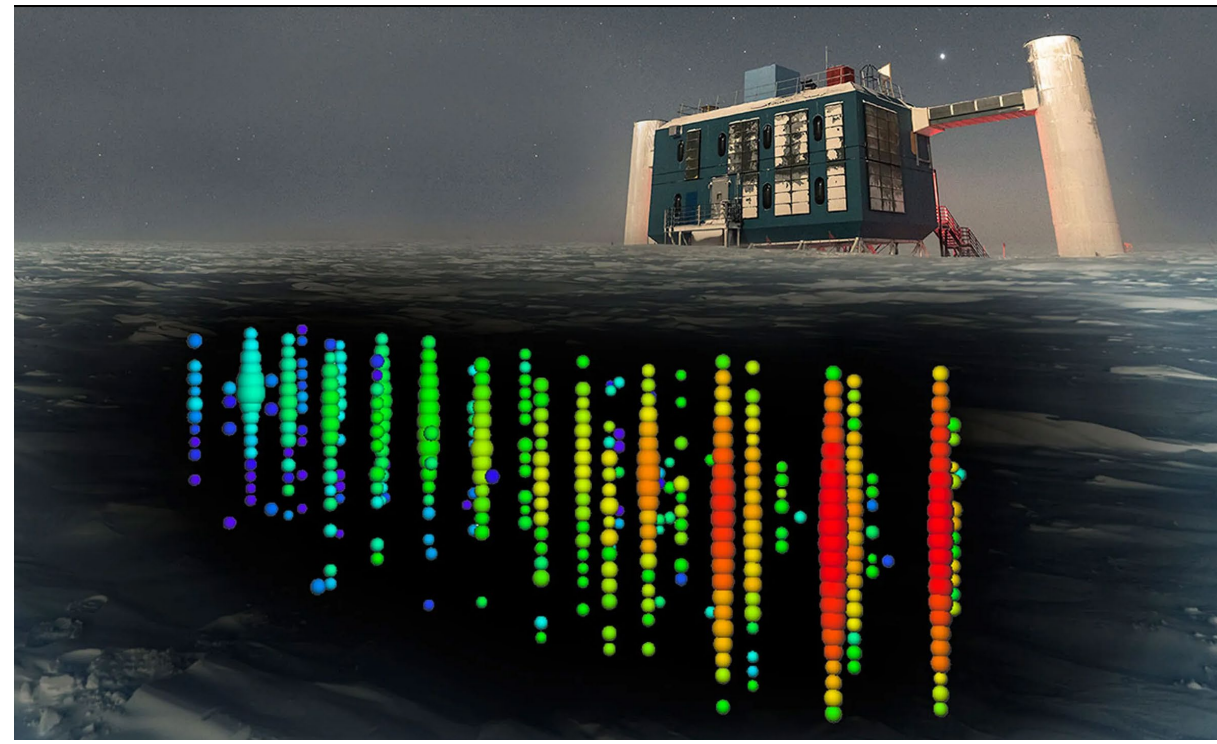
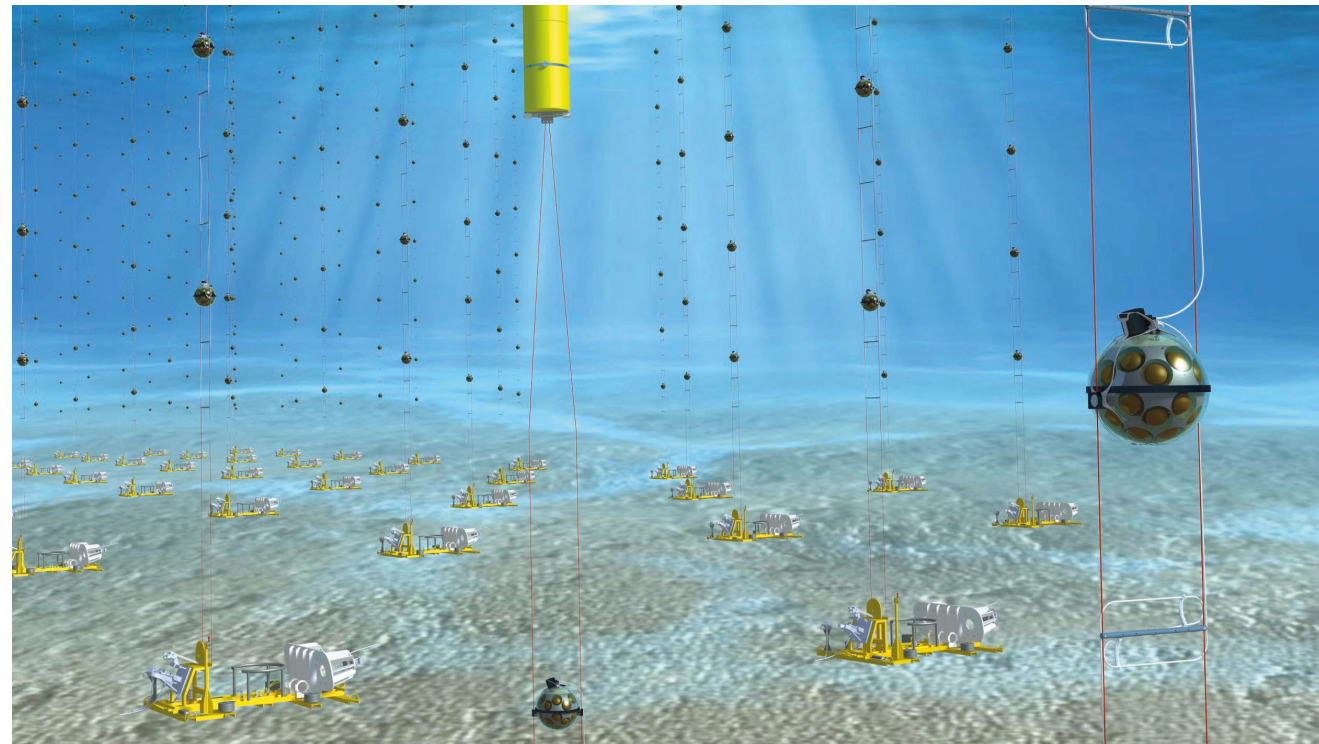
# High-Energy Gamma Rays



*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



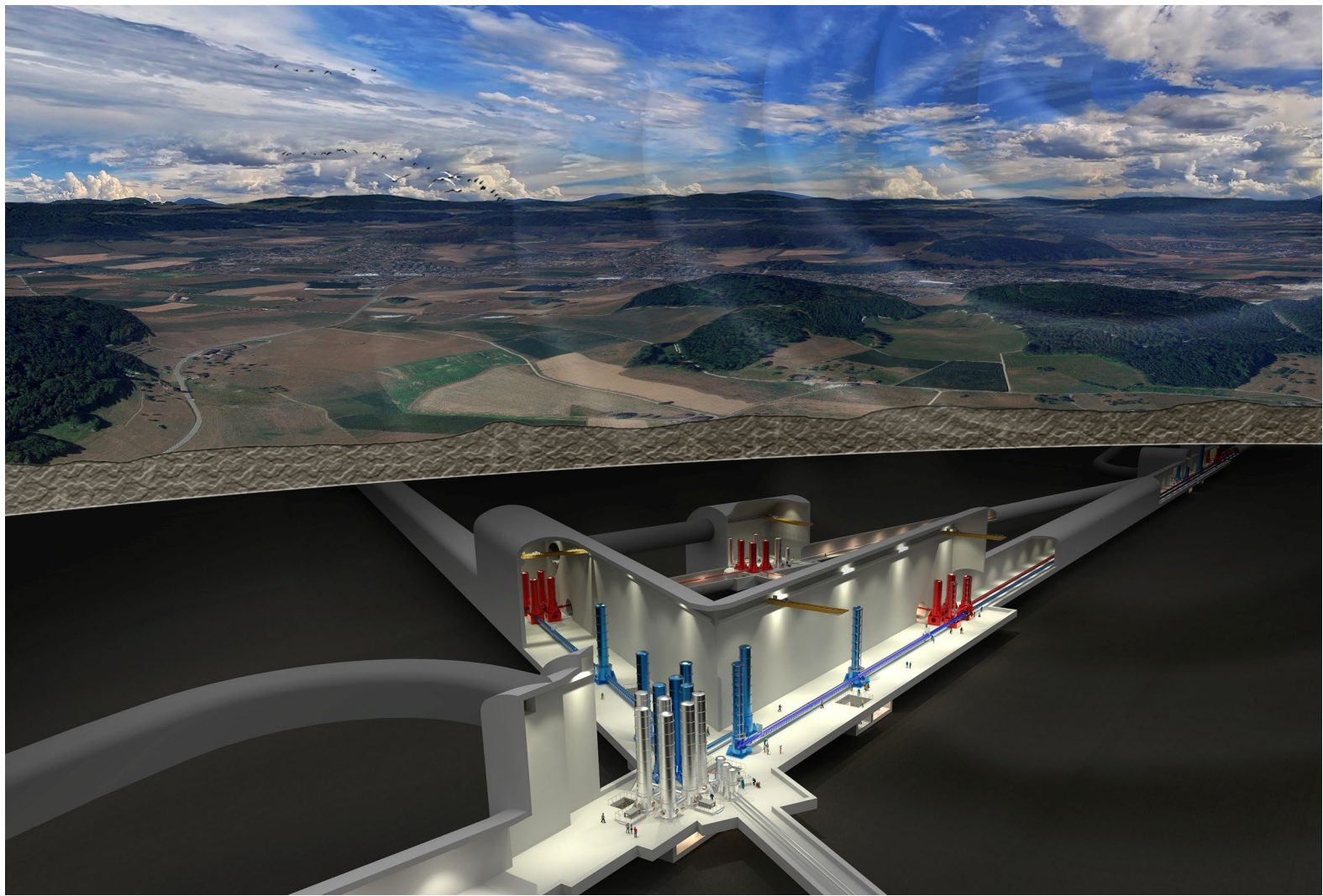
*APPEC fully endorses the goal of the KM3NeT collaboration to complete the construction of the large-volume telescope optimised for high-energy neutrino astronomy ARCA, and the dedicated detector to resolve the neutrino mass hierarchy ORCA. APPEC strongly supports the construction of the IceCube Upgrade,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

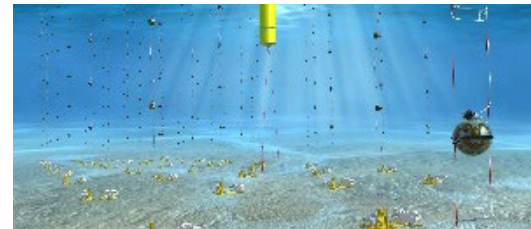


# APPEC Flagship Research Infrastructures

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

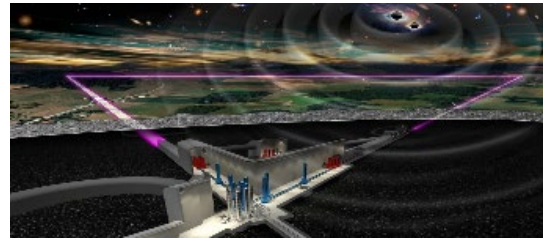
ESFRI=European Strategy Forum on Research Infrastructures

[construction KM3NeT 2020-2026; IceCube-Gen2]



ESFRI

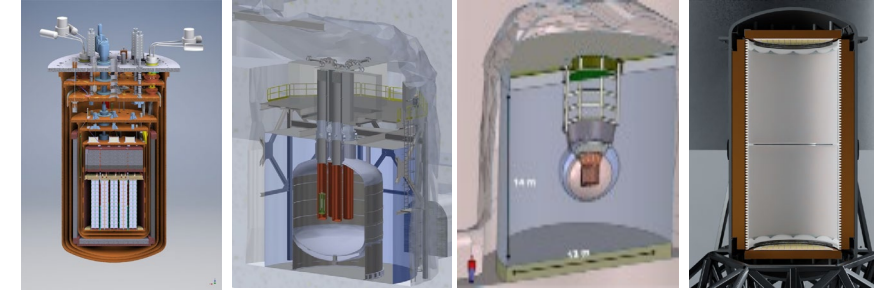
HE Neutrinos



ESFRI

[construction Einstein Telescope 2026-]

Gravitational Waves



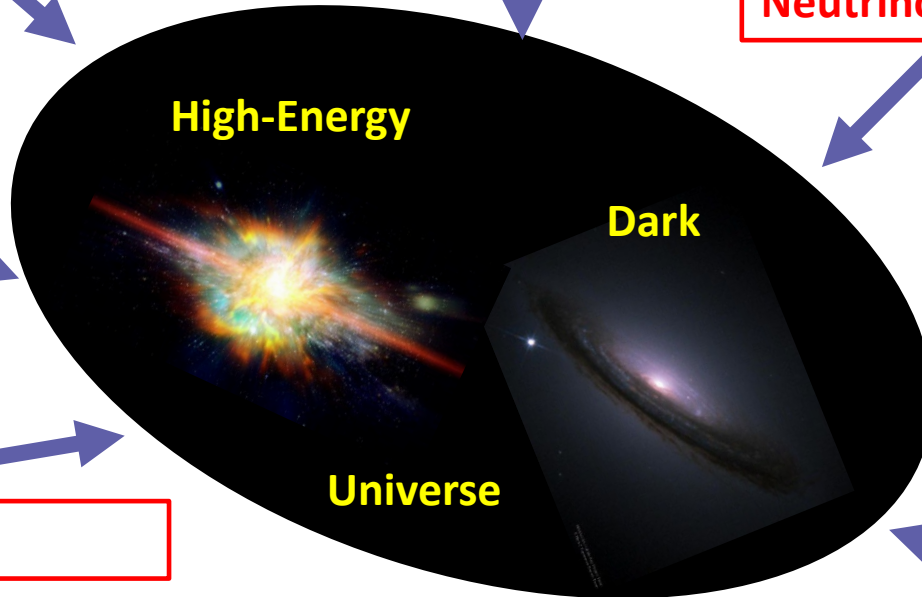
[construction LEGEND-1000 / nEXO 2023- ; ...]

Neutrino Properties

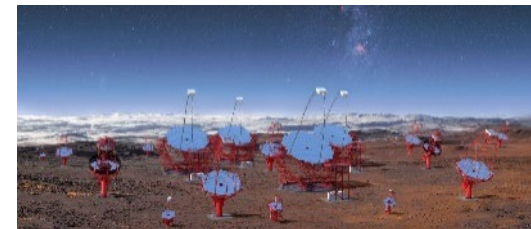
[construction AugerPrime 2019-2023]



HE Cosmic Rays

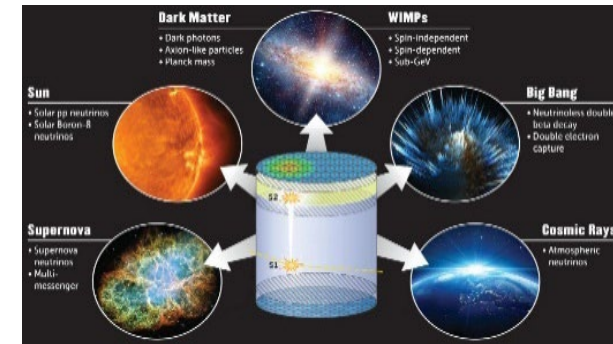


[construction CTA 2021-]



ESFRI

HE Gamma Rays



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

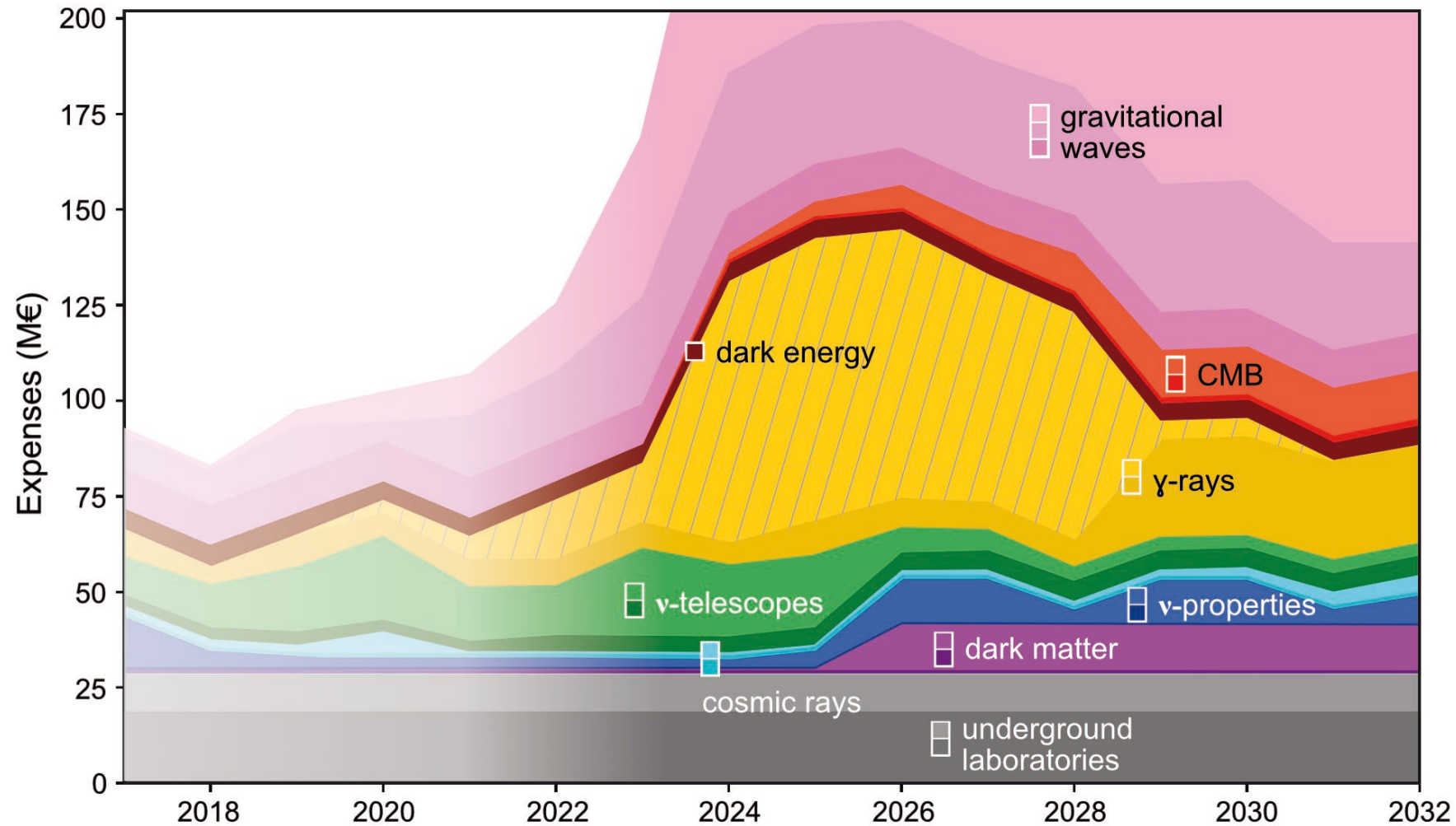
Dark Matter

## 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

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

APPEC Newsletter:

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





# Thank You