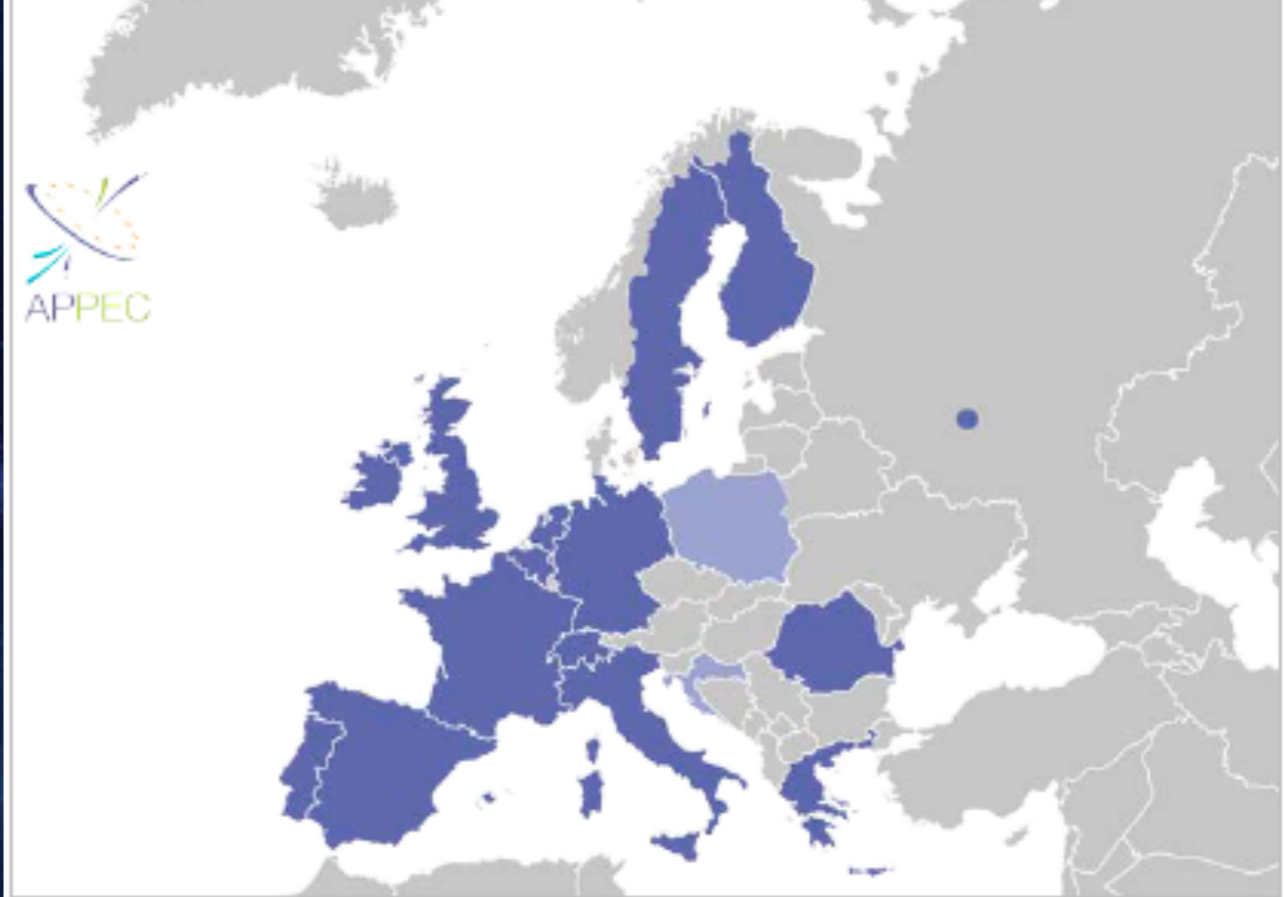




# European Astroparticle Physics Strategy 2017-2026



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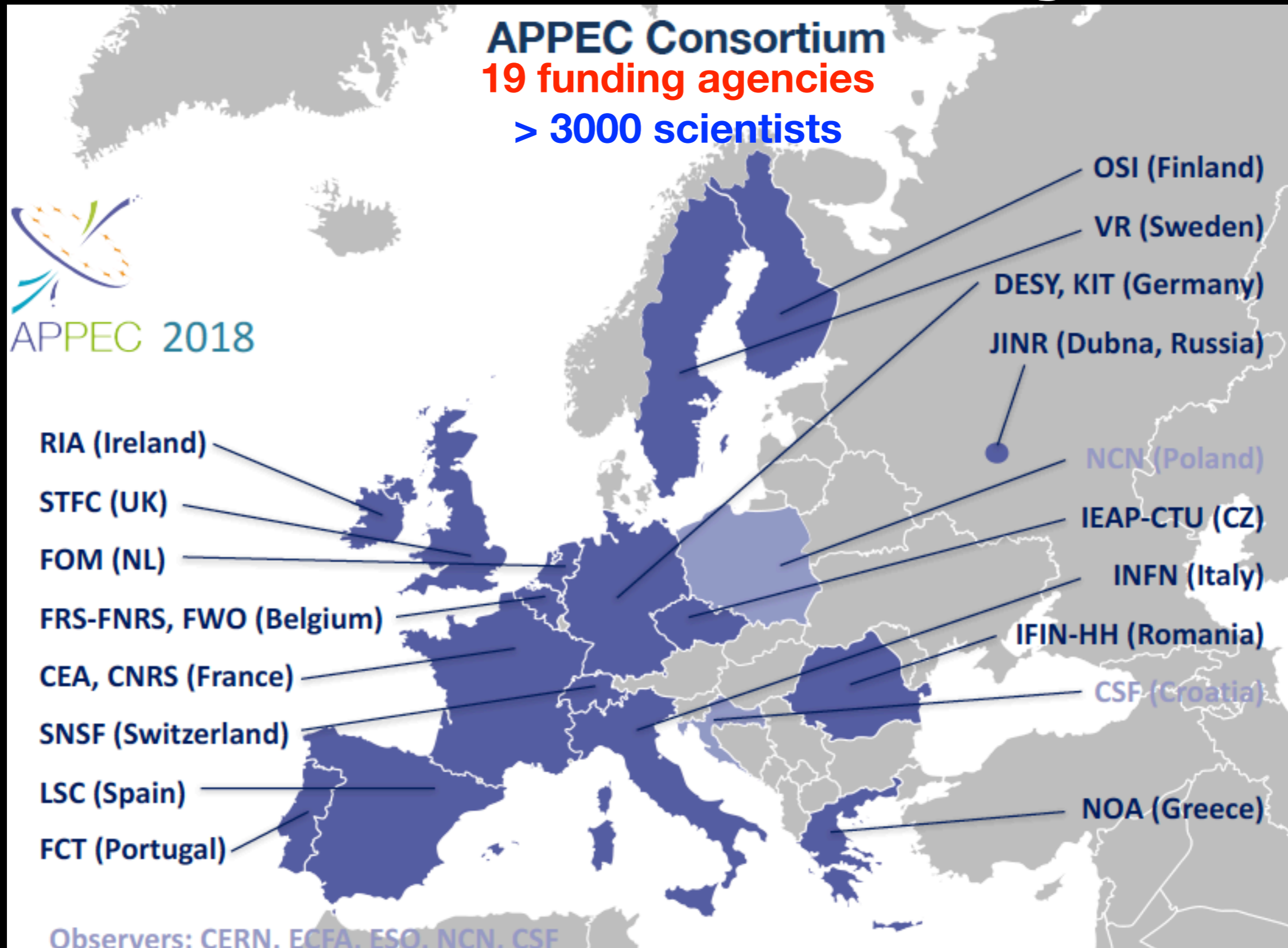
Astroparticle Physics European Consortium

# A bit of history

- APPEC in its present form was created in 2012.
- Comes from the Astroparticle Physics European Coordination Committee created in 2001.
- EU-funded ERANETs: ASPERA, ASPERA-2 (2006-2012).

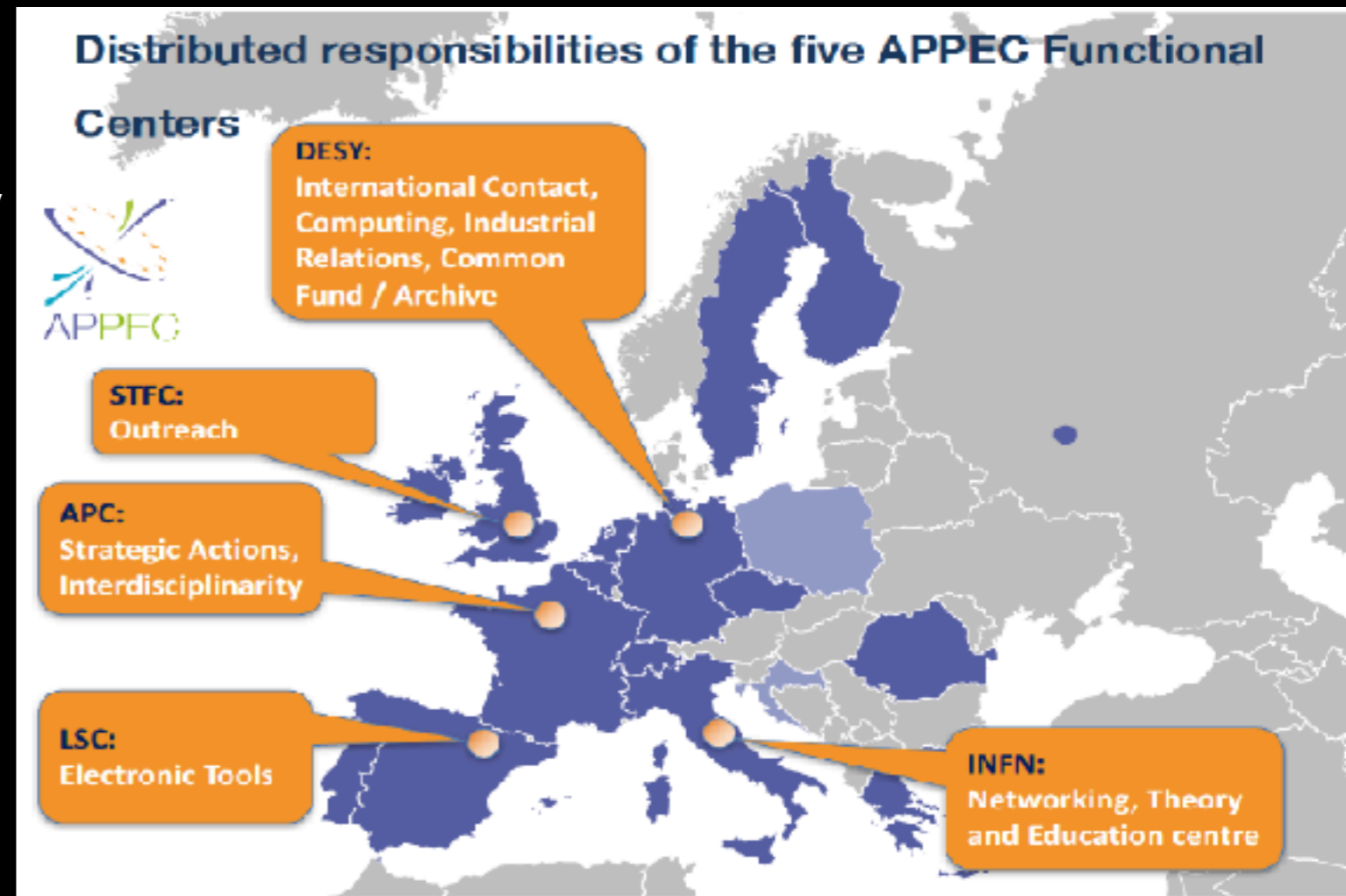


# APPEC nowadays



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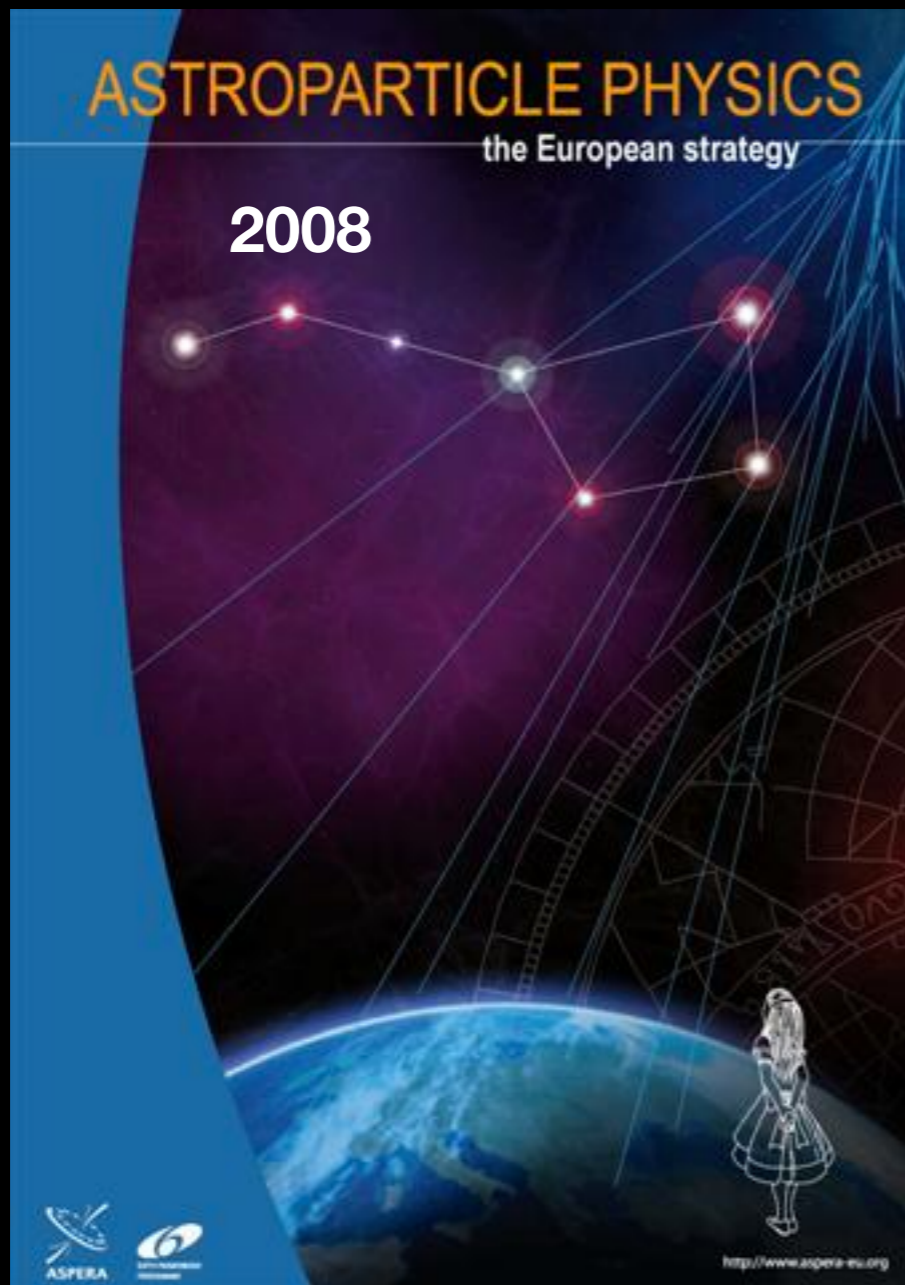
- **General Assembly:** decision making and supervisory body
  - **Chairman:** Antonio Masiero (Italy)
- **Joint Secretariat:** executive body
  - **General Secretary:** Job de Kleuver (The Netherlands)
- **Scientific Advisory Committee:** advisory body
  - **Chair:** Laura Baudis (Switzerland)
- **Functional Centres**



# APPEC Actions

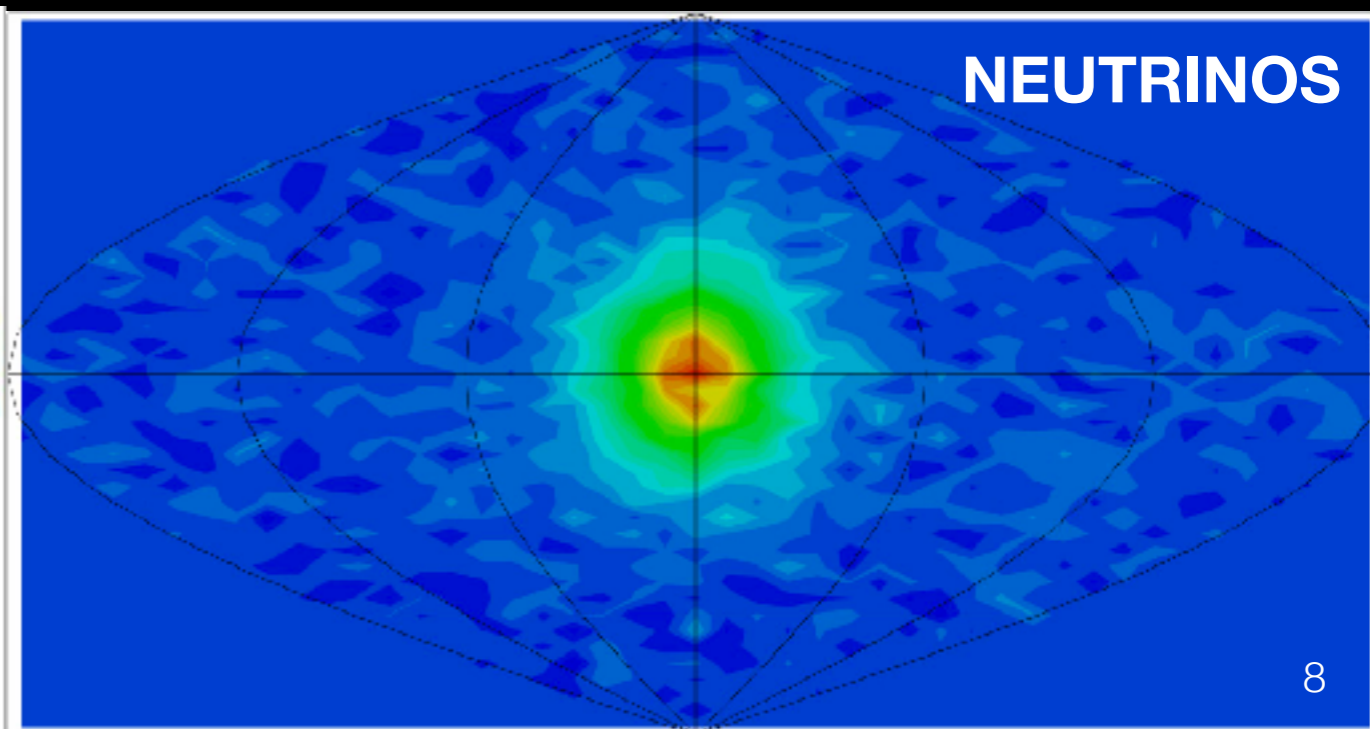
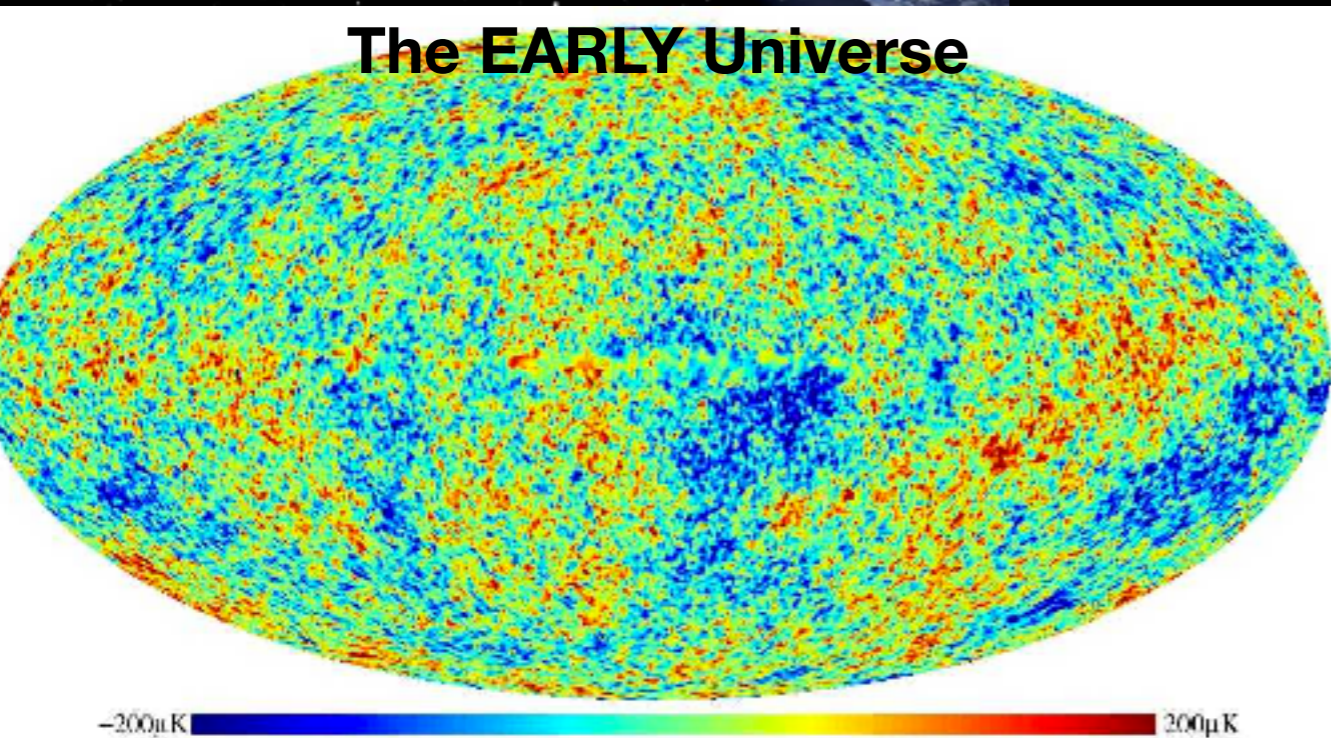
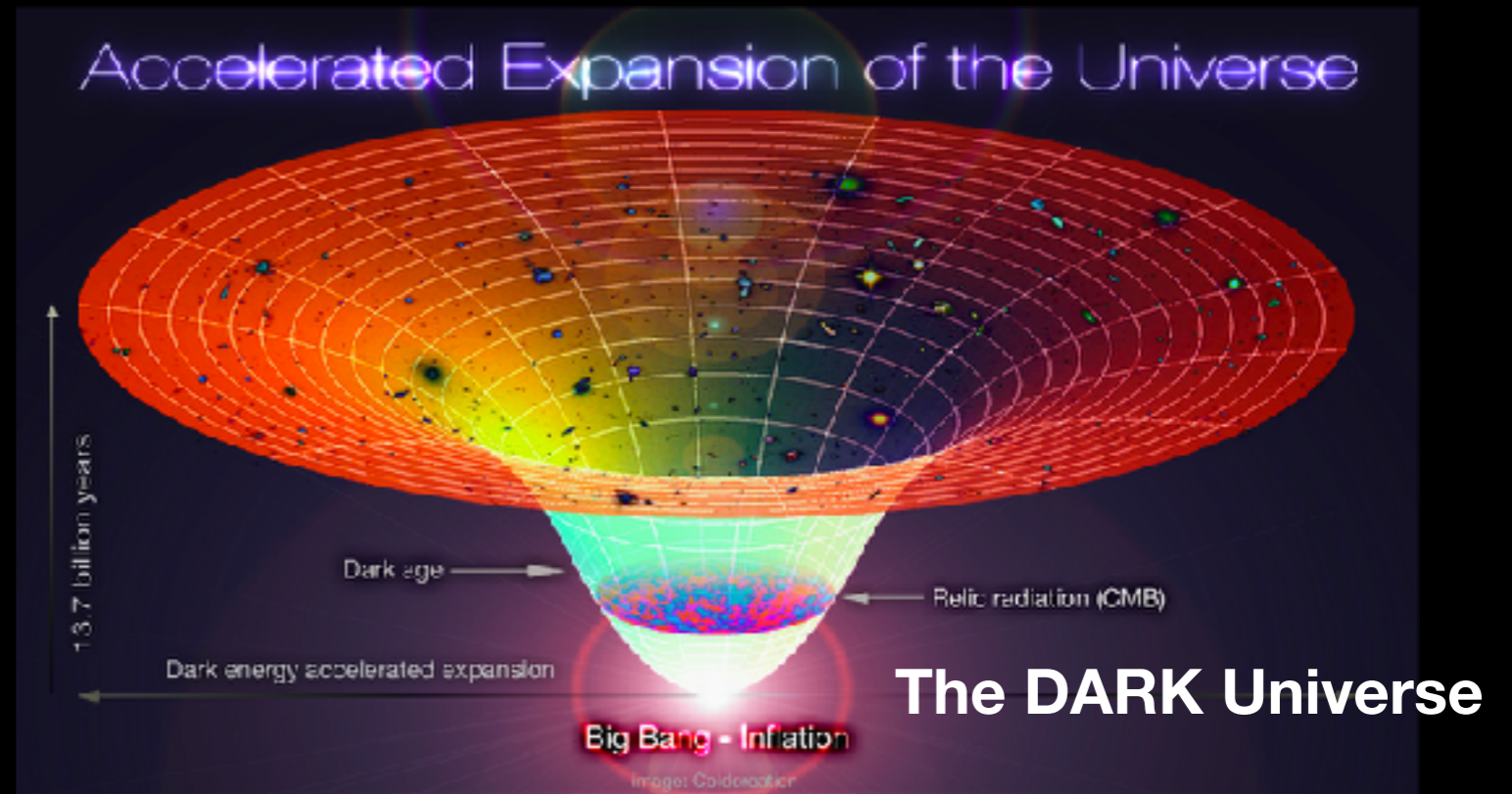
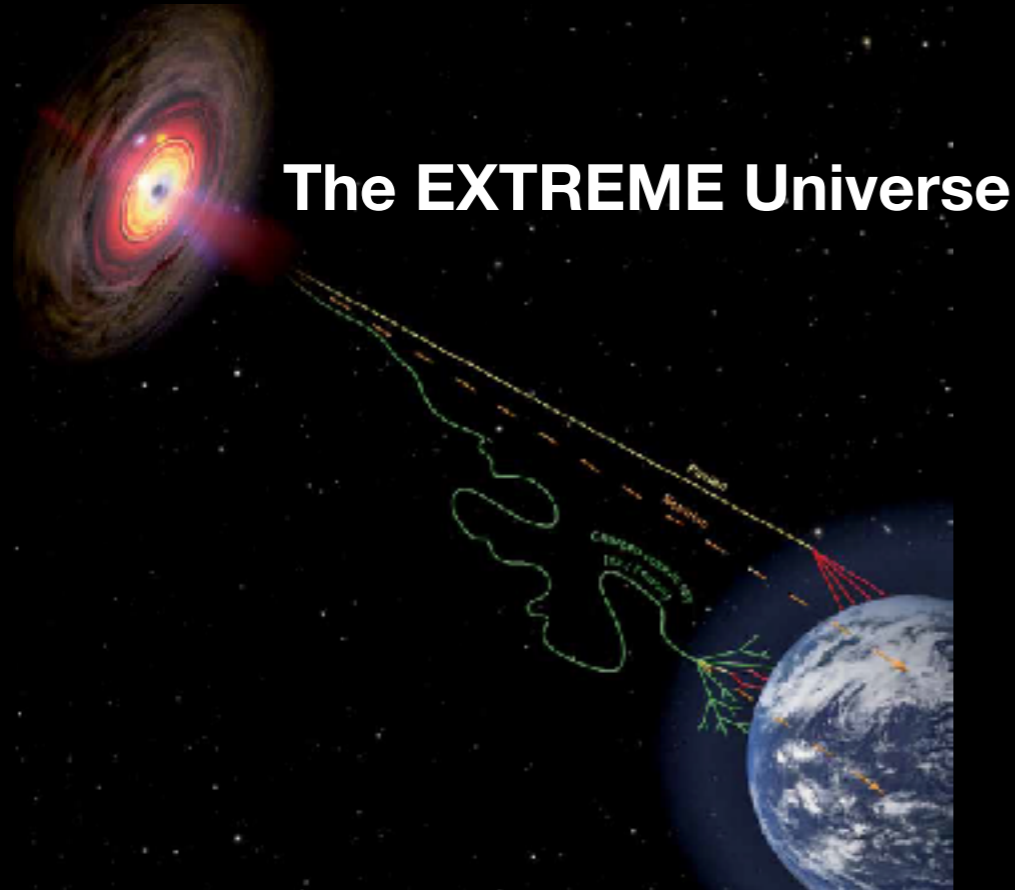
- Discussion forum for the coordination of Astroparticle Physics in Europe.
- **Develop and update long term strategies (roadmap).**
- Bolster coordination with organizations such as ESA, CERN, ESO.
- Develop a common action plan for convergence of large astroparticle infrastructures.
- Participate in European scientific strategy (ESFRI, EU Particle Physics Strategy, ...).
- Common calls for R&D proposals.

# APPEC Roadmaps





# New insights on fundamental enigmas





# Roadmap recommendations

## 21 grouped into three categories

- **Scientific issues (13)**
  - Large-scale infrastructures.
  - Medium-scale Dark matter and neutrino experiments.
  - Synergies with Astronomy, Particle Physics & Cosmology.
  - Foundations (theory, detector R&D, computing, deep underground labs).
- **Organizational issues (5)**
  - EC, European & Global collaboration/coordination.
  - Collaboration with astronomy & particle physics communities.
  - Interdisciplinary science.
- **Societal issues (3)**
  - Gender, Industry, Education & Outreach.

# Societal issues

## Gender balance

*Inspired by the H2020 project GENERA, APPEC will develop a gender balance policy for all of its activities and will urge projects to develop and implement Gender Equality Plans.*

## Education & Outreach

*Given the rapid expansion of the field of astroparticle physics, APPEC encourages (e.g. in cooperation with the IPPOG) the exchange of best practice in the sphere of outreach. At its frontier research facilities, APPEC will implement more structured organisation of dedicated astroparticle physics summer schools and studentships. APPEC will also enhance its presence on the web and social media.*

## Industry

*APPEC will increase its efforts to identify potential applications of astroparticle physics expertise for societal benefit. In parallel, APPEC will continue to organise its successful technology fora on targeted technologies and use these as a platform for discussion and collaboration involving industry and academia.*

# Organisational issues

## European Commission

*APPEC will continue to work with the European Commission in order to strengthen the EU's ability to capitalise on astroparticle physics technologies and ideas, as well as to make optimal use of the opportunities that already exist within various EU programmes in terms of advancing science and generating economic value.*

## European collaboration

*APPEC will explore ways of aligning the realistically available funding in Europe to maintain the excellent discovery potential of European scientists. Project governance, management, computing needs and running costs all require serious attention.*

## Global collaboration

*APPEC will continue to seek collaboration and coordination with its partners worldwide – scientists and funding agencies – to advance the design, construction, sustainable exploitation (including computing needs) and governance of the next-generation world-class large research infrastructures required to achieve the scientific discoveries of which we all dream.*

## Astronomy & Particle Physics communities

*APPEC will enhance its interactions with its present observers ESO and CERN in areas of mutual interest and will seek to engage with ESA in view of upcoming astroparticle-physics-oriented space missions. This will ensure scientific complementarity, where appropriate, and allow closer collaboration with our colleagues in the astronomy and particle physics communities. APPEC therefore welcomes ASTERICS, which serves as a platform for closer collaboration between the ESFRI-listed projects SKA, CTA, KM3NeT and E-ELT.*

## Interdisciplinary opportunities

*APPEC will further develop interdisciplinary workshops and will promote to the outside world – including both academia and industry – interdisciplinary access to its full research infrastructure.*

# APPEC meets CERN

- CERN is an observer inside APPEC.
- Crucial for scientific complementarity in areas of common interest.
  - Common calls for detector R&D.
  - Conversations to involve CERN in a future European Astroparticle Theory Center.
- **28 experiments listed as CERN Recognized Experiments.**
- Of those, **18** are part of the APPEC Roadmap.

Number	Experiment	First Recognized	valid until
RE 1	AMS	1997	31-DEC-2019
RE 2b	Pamela	1999	31-DEC-2018
RE 3	Auger	1998	31-DEC-2018
RE 6	Antares	1999	31 DEC 2019
RE 7	Fermi (former GLAST)	2000	31-DEC-2018
RE 8	LISA-P1	2000	31-DEC-2018
RE 10	IceCube	2005	31-DEC-2018
RE 14	Katrin	2007	31-DEC-2019
RE 17	Magic	2008	31 DEC 2017
RE 18	ArDM	2008	31-DEC-2017
RE 23	CTA PP	2011	31-DEC-2017
RE 26	Borexino	2012	31-DEC-2017
RE 27	NEXT	2013	31-DEC-2018
RE 28	Advanced Virgo	2013	31 DEC 2018
RE 30	KM3NeT Phase 1	2014	31-DEC-2019
RE 31	Euclid	2015	31-DEC-2018
RE 33	LIGO	2016	31-DEC-2018
RE 34	JUNO	2017	31-DEC-2019

# Scientific issues: Synergies with other fields

## CMB

*APPEC strongly endorses a European-led satellite mission (such as CORe) to map the CMB from space. APPEC will encourage detector R&D towards a next-generation ground-based experiment complementary to initiatives in the US. APPEC continues to contribute to global coordination of this field following the Florence CMB Workshop series that started in 2015.*

## Dark Energy

*APPEC supports the forthcoming ESA Euclid satellite mission, which will establish clear European leadership in space-based Dark Energy research. Because of their complementarity to Euclid, APPEC encourages continued European participation in the US-led DESI and LSST ground-based research projects. To benefit fully from the combined power of satellite-based and ground-based experiments, the exchange of data is essential.*

## Neutrino oscillations

*From a scientific perspective and as part of a global strategy, APPEC strongly endorses European participation in DUNE and Hyper-Kamiokande experiments – exploiting long-baseline neutrino beam facilities – as well as in the JUNO nuclear reactor neutrino experiment.*

*funding is likely to come from US and Asian agencies or from the European particle physics and astronomy communities.*

# Scientific issues: Foundations

## Theory

*APPEC supports an ambitious theory programme in the field of astroparticle physics, with special attention focused on adjacent disciplines such as particle physics, astronomy and cosmology. APPEC encourages the establishment of a centre for astroparticle physics theory in one of its member countries.*

## Computing

*APPEC requests all relevant experiments to have their computing requirements scrutinised. APPEC will engage with the particle physics and astronomy communities (e.g. within the context of EU-T0) to secure for the future a balance between available European computing resources and needs. Furthermore, APPEC encourages the use of data format standards to facilitate data access between experiments. APPEC supports the transition to Open Access publication strategies and encourages the making of data publicly available (as 'open data') to foster 'citizen science', for example.*

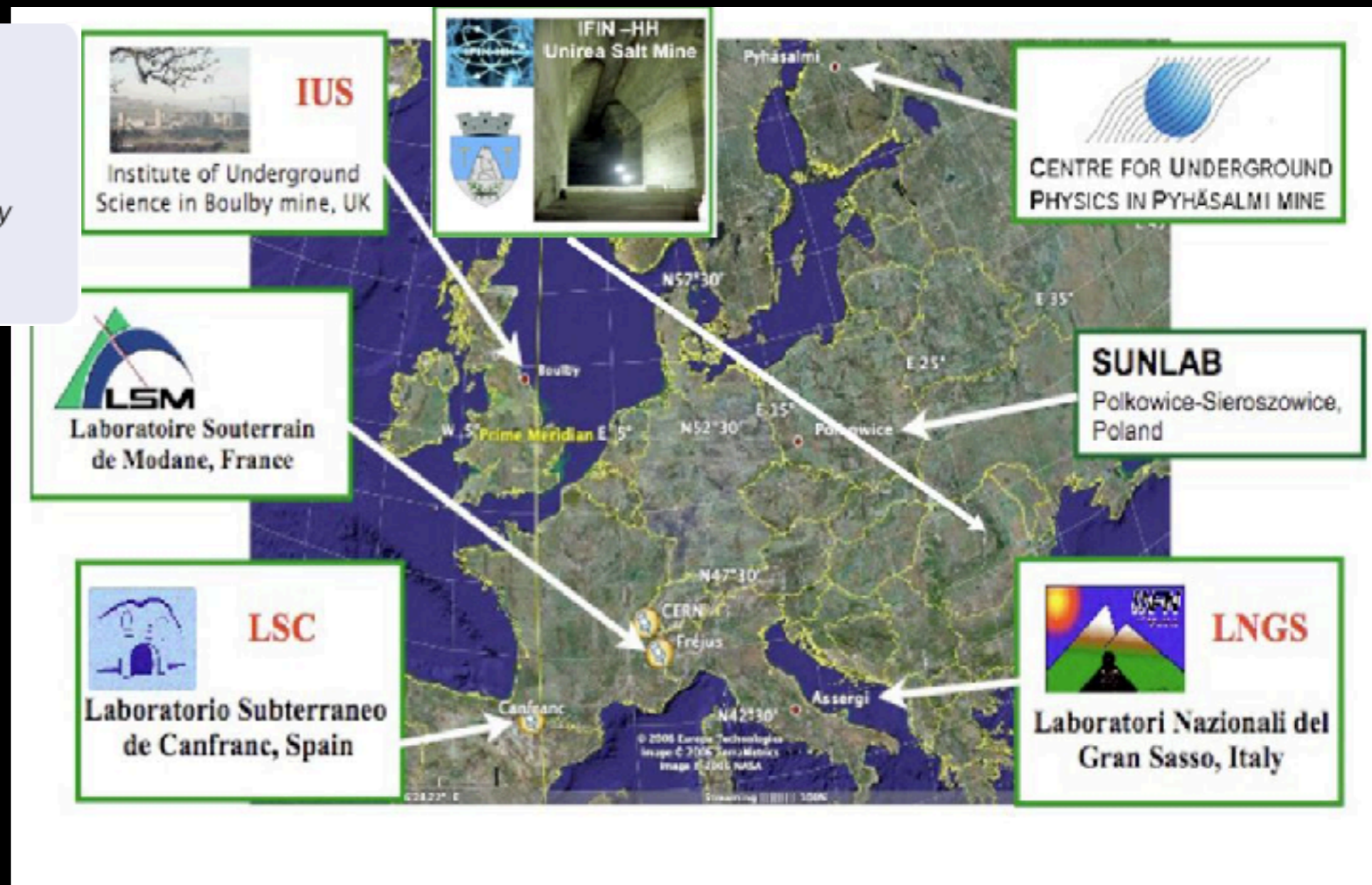
## Detector R&D

*APPEC stimulates and supports a range of detector R&D projects through targeted common calls and technology fora that bring scientists and industries together. APPEC encourages consortia to apply for EU (technology) grants such as those achieved by SENSE for low-level light-sensor technologies. APPEC welcomes the ATTRACT initiative, which aims to accelerate development of particle-radiation detector and imaging technologies for the science community and for the wider market.*

# Scientific issues: Foundations

## Deep underground laboratories

*With a view to maintaining a good match between available capacity and planned activities, APPEC fosters continued support for and cooperation between underground laboratories – as advocated, for example, by the DULIA (Deep Underground Laboratory Integrated Activity) initiative.*



# Scientific issues: Medium scale

## Dark Matter

*APPEC encourages the continuation of a diverse and vibrant programme (including experiments as well as detector R&D) searching for WIMPs and non-WIMP Dark Matter. With its global partners, APPEC aims to converge around 2019 on a strategy aimed at realising worldwide at least one 'ultimate' Dark Matter detector based on xenon (in the order of 50 tons) and one based on argon (in the order of 300 tons), as advocated respectively by DARWIN and Argo.*

## Neutrino mass & nature

*APPEC strongly supports the present range of direct neutrino-mass measurements and searches for neutrinoless double-beta decay. Guided by the results of experiments currently in operation and in consultation with its global partners, APPEC intends to converge on a roadmap for the next generation of experiments into neutrino mass and nature by 2020.*

searches must be pursued to the level of discovery, unless prevented by an irreducible background or an unrealistically high demand for capital investment.



# Scientific issues: Large scale

## High-energy gamma rays

*APPEC fully supports the CTA collaboration in order to secure the funding for its timely, cost-effective realisation and the subsequent long-term operation of this observatory covering both northern and southern hemispheres.*

## High-energy charged cosmic rays

*APPEC strongly supports the Auger collaboration's installation of AugerPrime by 2019. At the same time, APPEC urges the community to continue R&D on alternative technologies that are cost-effective and provide a 100% (day and night) duty cycle so that, ultimately, the full sky can be observed using very large observatories.*

## High-energy neutrinos

Confirmed messengers  
providing vital insight  
into the Universe

*For the northern hemisphere (including Baikal GVD), APPEC strongly endorses the KM3NeT collaboration's ambitions to realise, by 2020: (i) a large-volume telescope with optimal angular resolution for high-energy neutrino astronomy; and (ii) a dedicated detector optimised for low-energy neutrinos, primarily aiming to resolve the neutrino mass hierarchy. For the southern hemisphere, APPEC looks forward to a positive decision in the US regarding IceCube-Gen2.*

## Gravitational waves

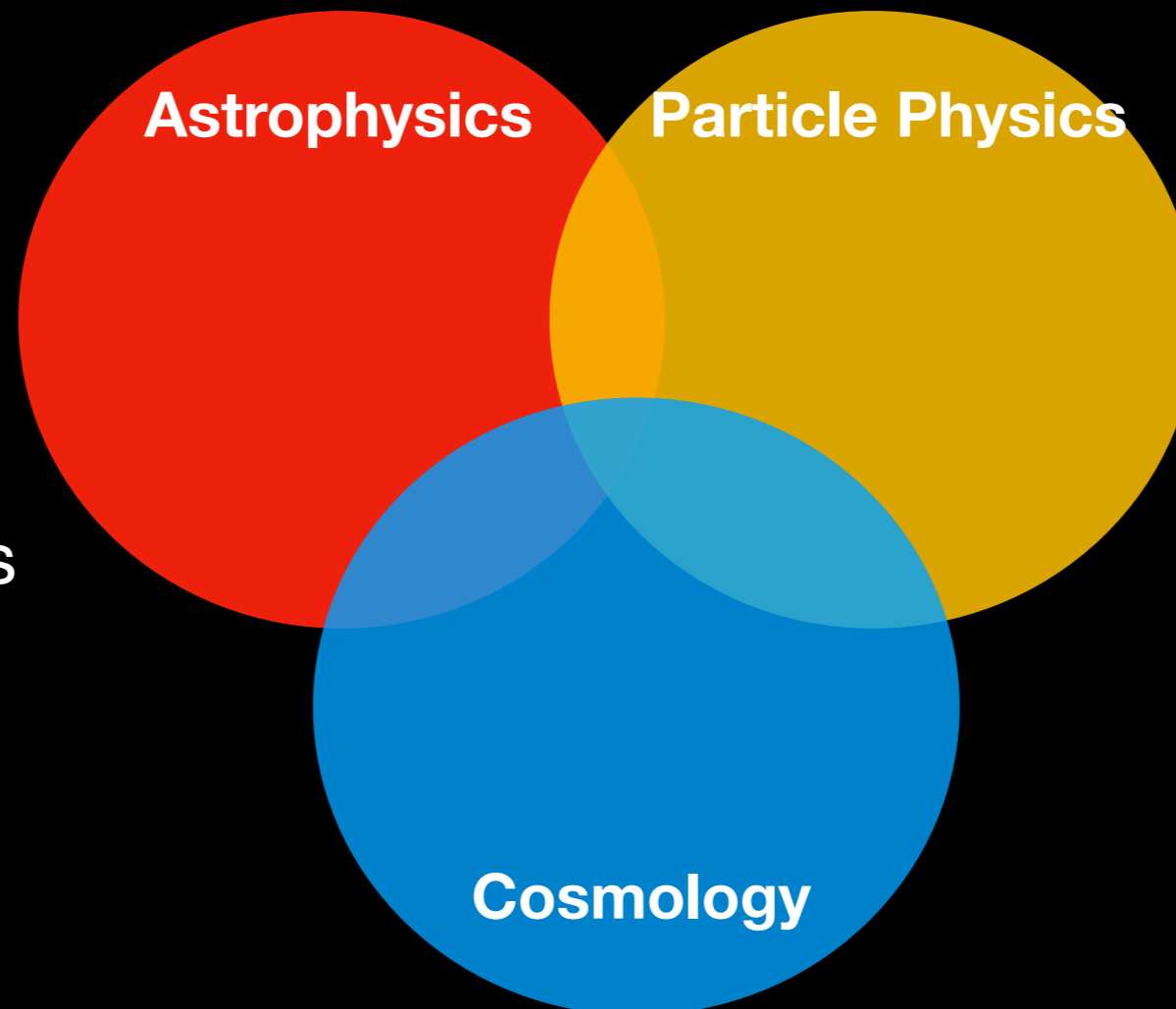
*With its global partners and in consultation with the Gravitational Wave International Committee (GWIC), APPEC will define timelines for upgrades of existing as well as next-generation ground-based interferometers. APPEC strongly supports further actions strengthening the collaboration between gravitational-wave laboratories. It also strongly supports Europe's next-generation ground-based interferometer, the Einstein Telescope (ET) project, in developing the required technology and acquiring ESFRI status. In the field of space-based interferometry, APPEC strongly supports the European LISA proposal.*

# Astroparticle Physics: Future Three Pillars

## II. PROPERTIES OF NEUTRINOS

## I. MULTI-MESSENGER

- Gravitational waves
- Gamma rays
- High-energy neutrinos
- Charged cosmic rays



## III. DARK SECTOR, PHYSICS OF BIG BANG

# Roadmap implementation

- **Coordination** of 19 national agencies.
- **Funding “alignment”** all across Europe.
- Astroparticle strategies “easier” to implement in:
  - USA (Gravitational Waves, Dark sector, Neutrinos)
  - Japan (Hyper-Kamiokande, Cosmic rays, ...)
  - China (JUNO, PANDAX, LHAASO, ...)

# Final remarks

- A **revolutionary, new era** on the way we approach the unsolved mysteries of the Universe (multi-messenger) **calls for an updated resource-aware strategy**.
- Foster top-level scientific and technical contributions of EU in the field of Astroparticle Physics.
- Coherent collaboration & cooperation to keep a high discovery potential.
- **Spanish astroparticles & the future**: coordination to make optimal use of resources (human, technical, funding)? critical review of the field to converge in a roadmap that sets priorities? new distinct Program to cope with the large investments required by the future research infrastructures?

# Back-up

# Projected annual costs

Projected annual capital investment (for instrument prototyping and construction, excluding manpower) and projected annual running costs (for consumables and employee expenses, i.e. travel and manpower; included in the shaded area) anticipated from the European astroparticle physics funding agencies and required to realise APPEC's 'European Strategy for Astroparticle Physics'. Costs related to actual scientific exploitation (data calibration, analysis, interpretation, publication etc.) are not considered in this projection. Also excluded are other, often substantial subsidies notably from regional and EU structural funds and from the European astronomy and particle physics research communities, and contributions from APPEC's non-European partners. The uncertainties in this projection increase rapidly with time.

