The background of the slide is a composite image of cosmic phenomena. At the top, a bright, glowing galaxy is visible. Below it, a colorful nebula with shades of blue, green, and orange is shown. In the bottom right corner, a portion of the Earth is visible, showing a satellite or space station orbiting the planet. The overall color palette is dominated by deep blues and purples, with bright highlights from the celestial objects.

**European Astroparticle
Physics Strategy
2017-2026**

**Prospettive della
Fisica Astroparticellare
in Europa 2017 -2026**

Antonio Masiero

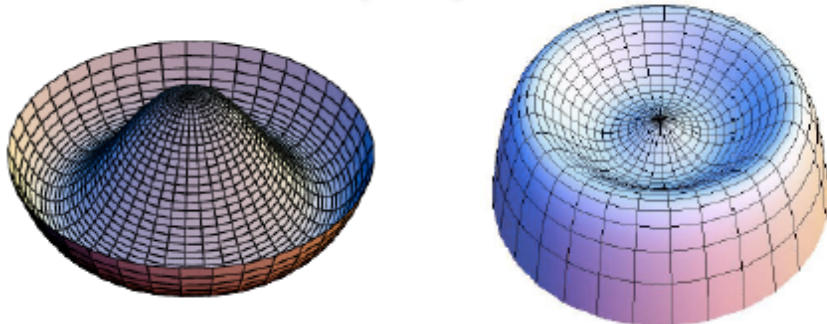
MICRO-COSMOS

- **PARTICLE STANDARD MODEL**



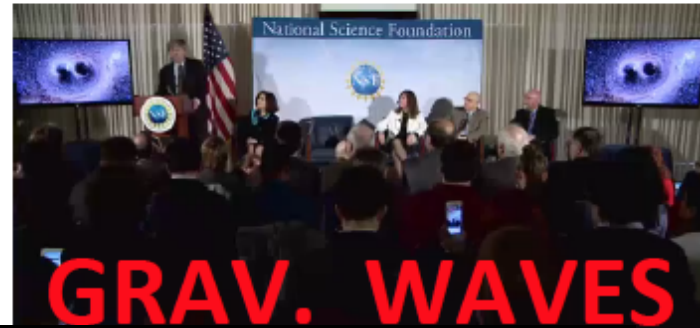
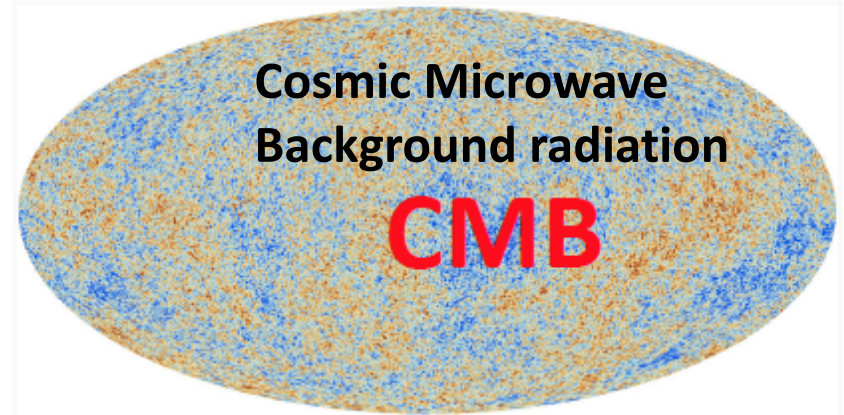
The **Higgs boson** and the destiny of the Universe

STABILITY ↔ **INSTABILITY**



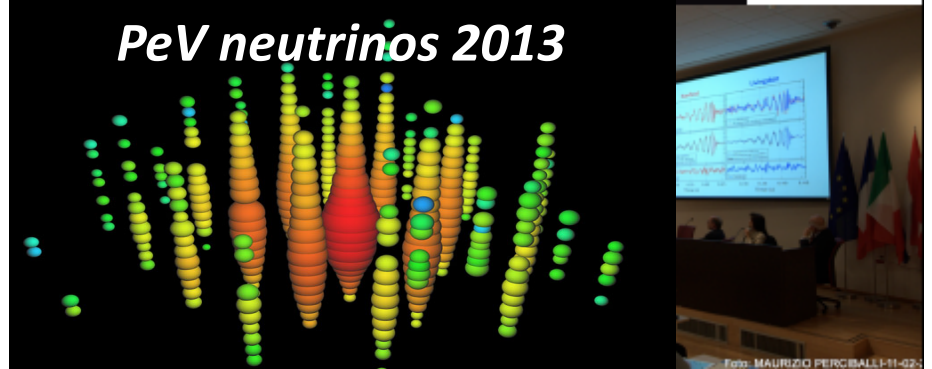
MACRO-COSMOS

- **COSMOLOGY STANDARD MODEL**



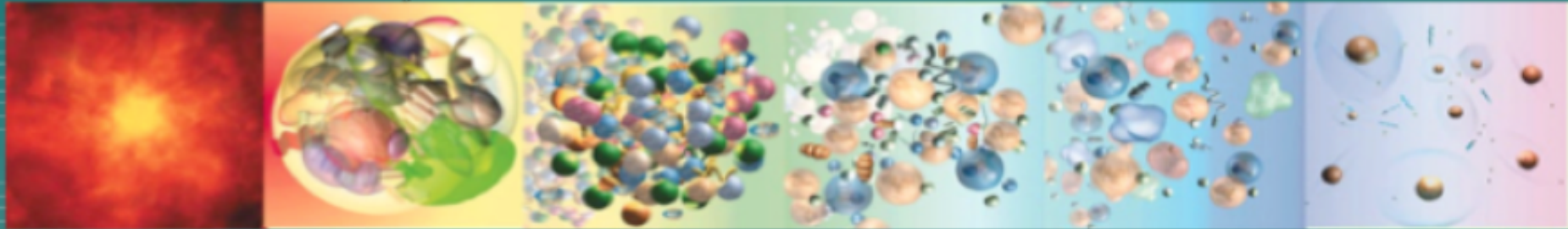
GRAV. WAVES

PeV neutrinos 2013



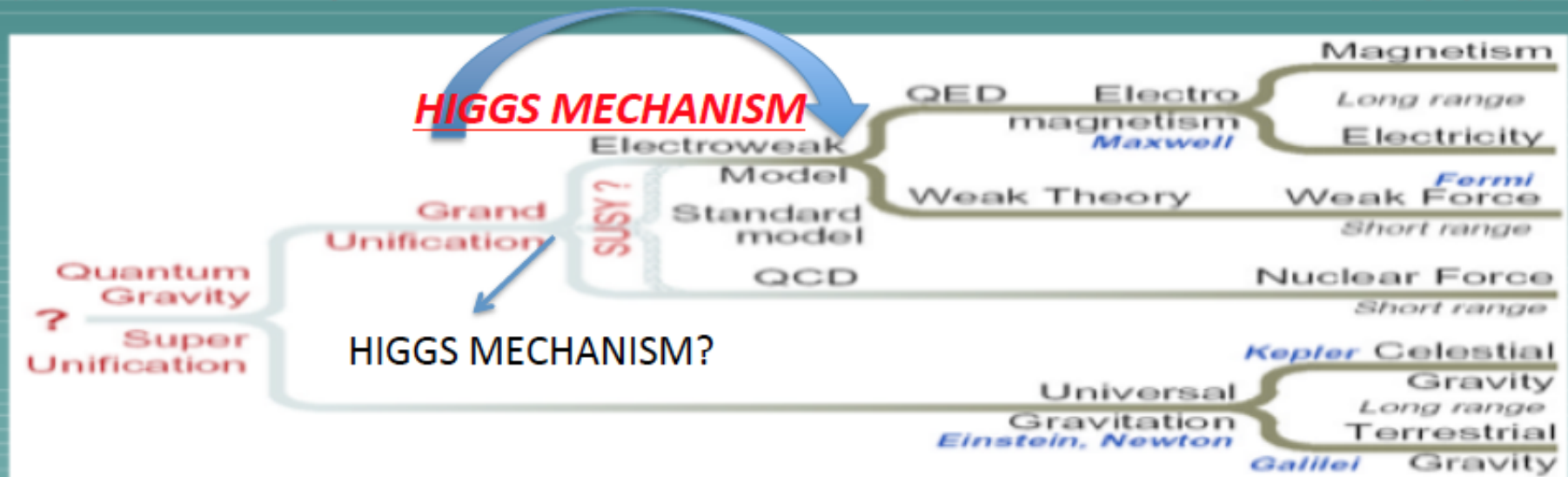
Big Bang Quark-Gluon Plasma Protoni e neutroni Protoni e Nuclei leggeri Atomi →Galassie →Molecole→DNA

Gravità Nucleare forte Nucleare debole



10^{-43} sec	10^{-32} sec	10^{-10} sec	10^{-4} sec	100 sec	300KY → 15GY
10^{-35} m	10^{-32} m	10^{-18} m	10^{-16} m	10^{-15} m	10^{-10} m
10^{19} GeV	10^{16} GeV	10^2 GeV	1 GeV	1 MeV	10 eV

??? LHC LEP As tronomia →



Theories:

STRINGS? RELATIVISTIC/QUANTUM CLASSICAL

5 numbers, 5 indications of physics beyond the Standard Models of Particle Physics and Cosmology: NEUTRINO MASSES, DARK MATTER, DARK ENERGY, ANTIMATTER and VACUUM ENERGY

◦ Stars and galaxies are only $\sim 0.5\%$

◦ Neutrinos are **$> 0.1\%$**

◦ Rest of ordinary matter

(electrons, protons & neutrons) are 4.4%

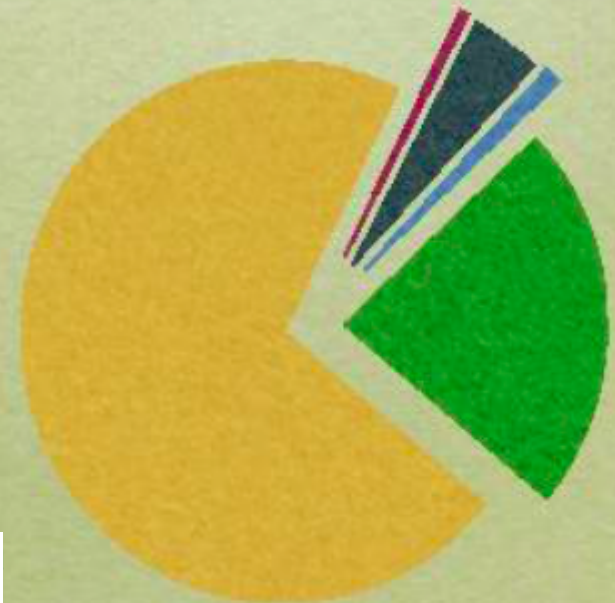
◦ Dark Matter **$\sim 27\%$**

◦ Dark Energy **$\sim 68\%$**

◦ Anti-Matter **0%**

◦ Higgs Bose-Einstein condensate

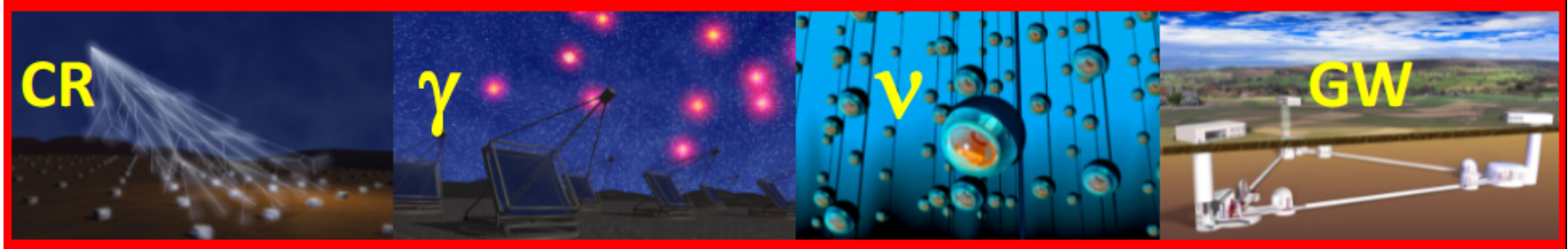
\sim **$10^{62}\%$** ??



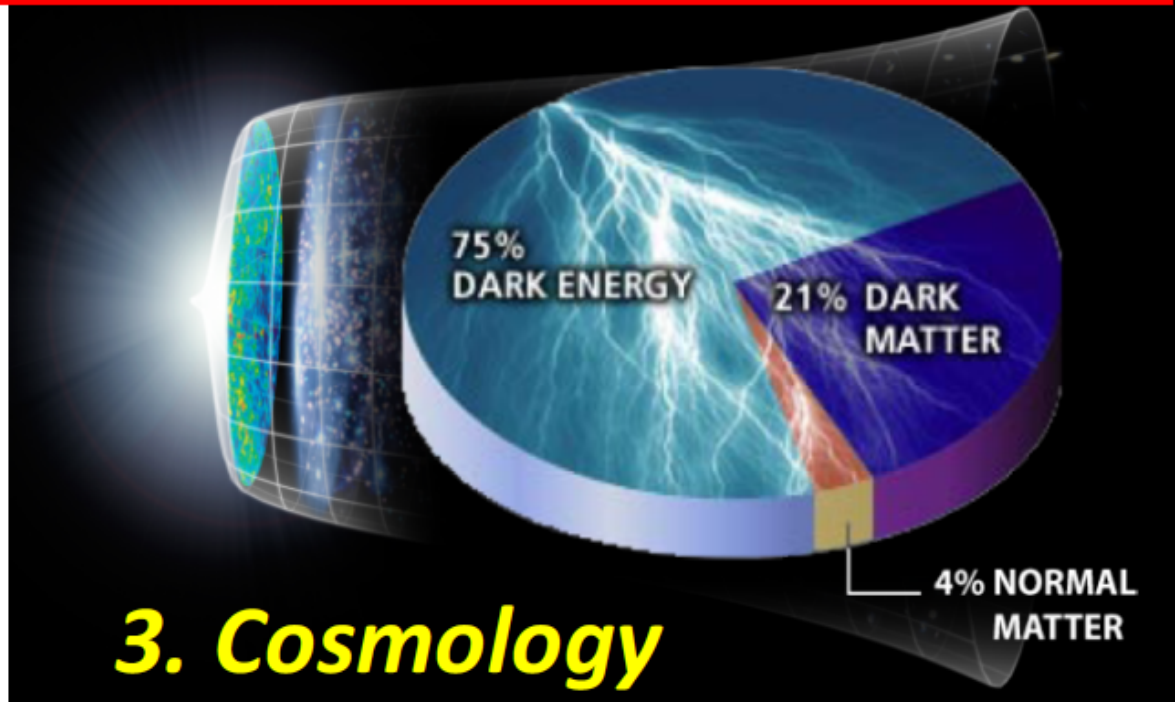
thanks to H. Murayama

Going beyond the physics Standard Models: the APP 3-pronged approach

1. High-energy Universe: multi-messengers



2. Neutrino's



ASTROPARTICLE PHYSICS

APPEC

F. LINDE

A
S
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M
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dark energy

gravitational waves

CMB

HE neutrinos

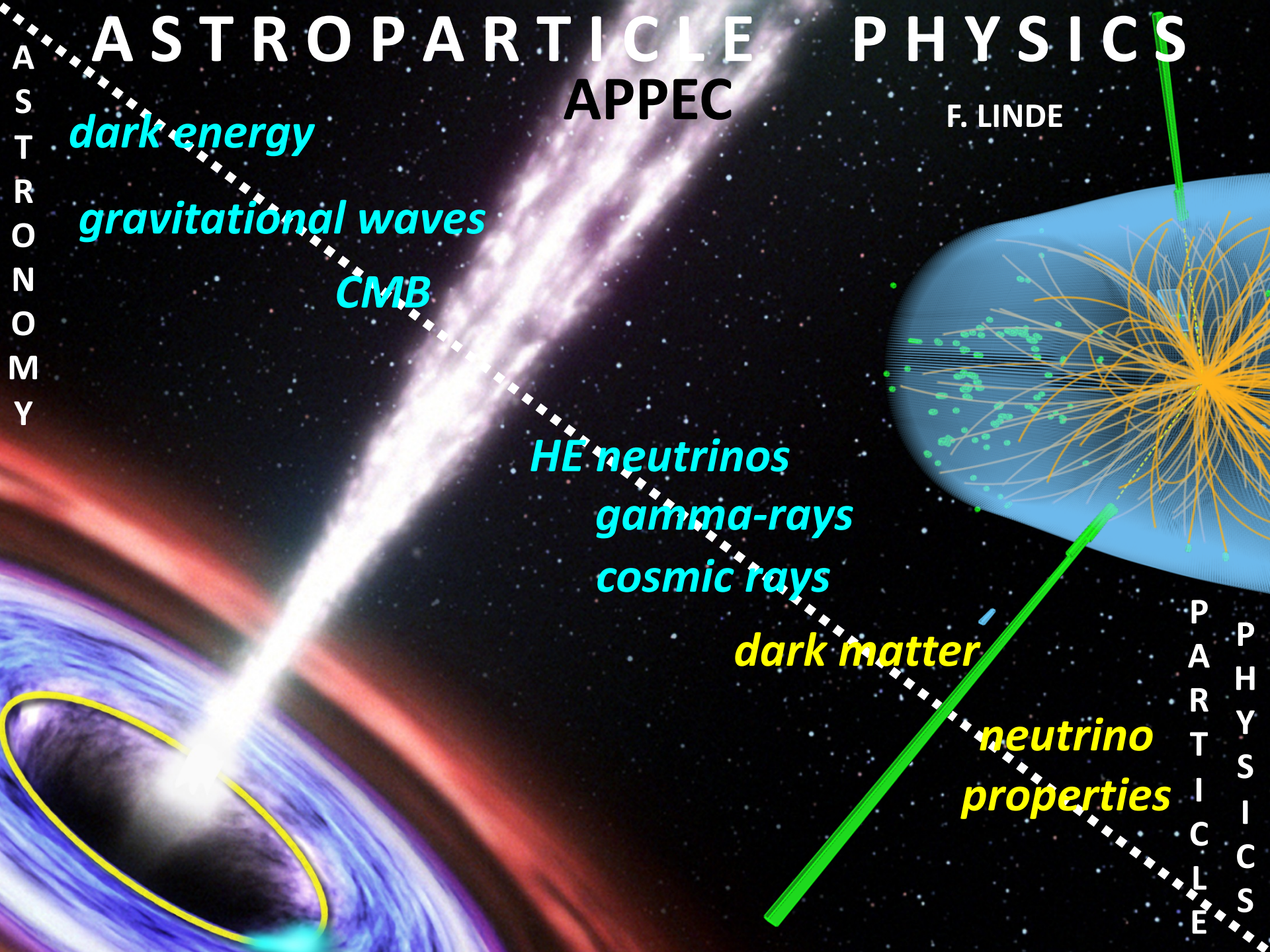
gamma-rays

cosmic rays

dark matter

*neutrino
properties*

P
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ASTROPARTICLE PHYSICS

APPEC

F. LINDE

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M
Y

dark energy

2011

gravitational waves

1993

CMB

1978

2006

HE neutrinos

gamma-rays

cosmic rays

1936

dark matter

neutrino

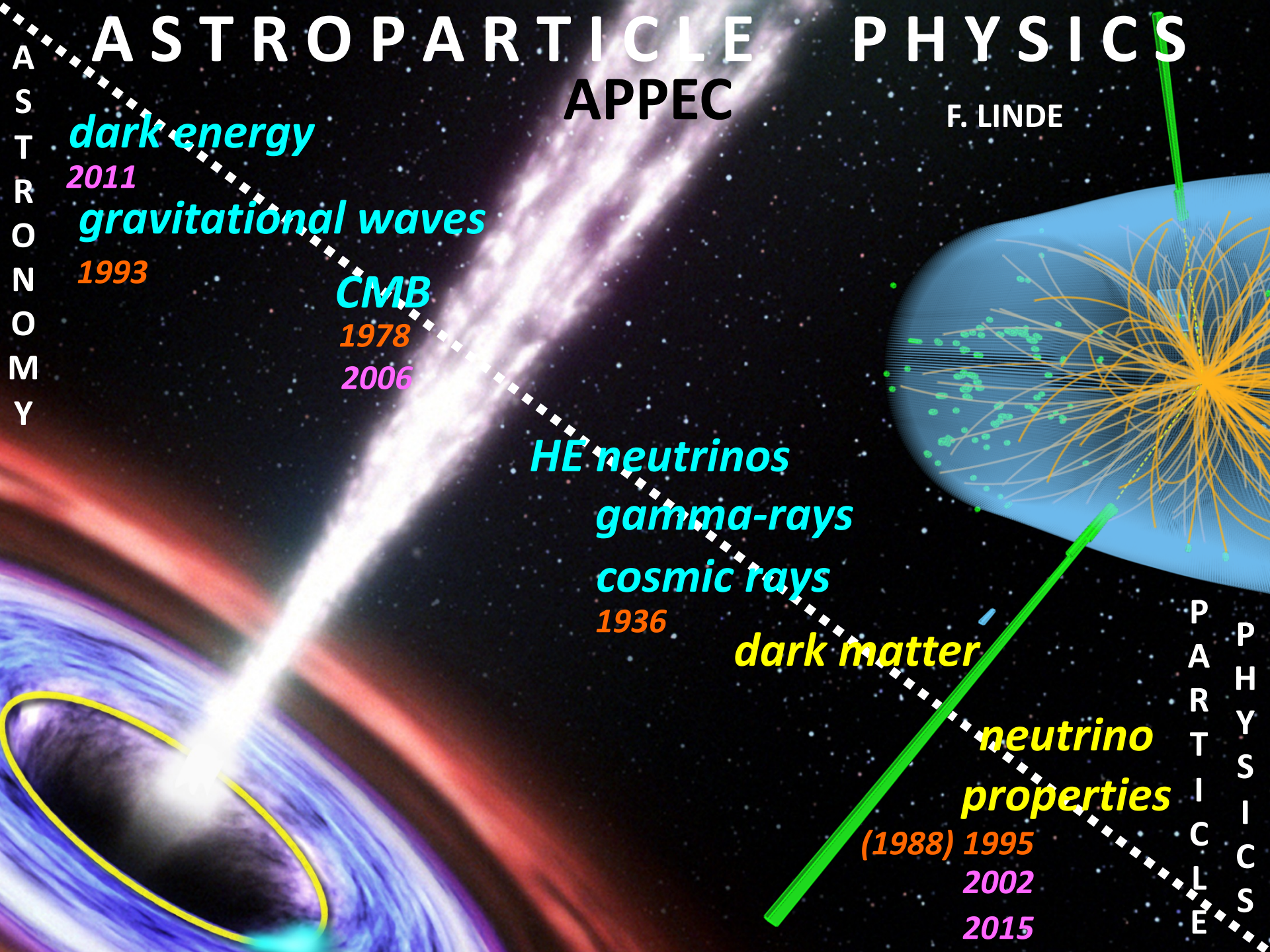
properties

(1988) 1995

2002

2015

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ASTROPARTICLE PHYSICS

APPEC

F. LINDE

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P
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C
L
E
S

dark energy

2015

LVC

gravitational waves

CMB



2017

IceCube

2013

PeV neutrinos

gamma-rays

cosmic rays

dark matter

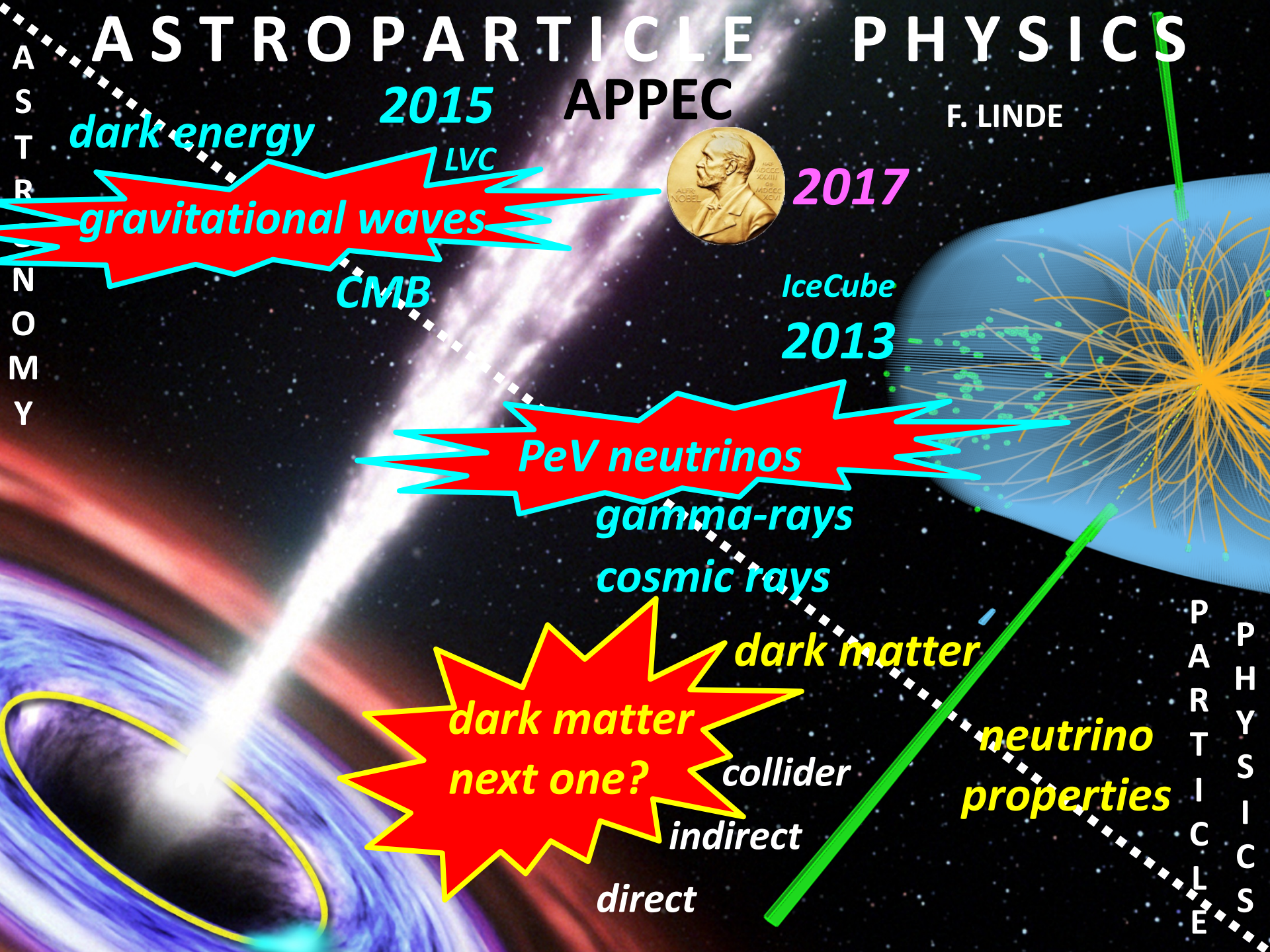
dark matter
next one?

collider

indirect

direct

neutrino
properties



ASTROPARTICLE PHYSICS

APPEC

F. LINDE

A
S
T
R
O
N
O
M
Y

dark energy

2015

LVC

gravitational waves



2017

CMB

? B-modes

IceCube

2013

PeV neutrinos

gamma-rays

cosmic rays

dark matter

dark matter
next one?

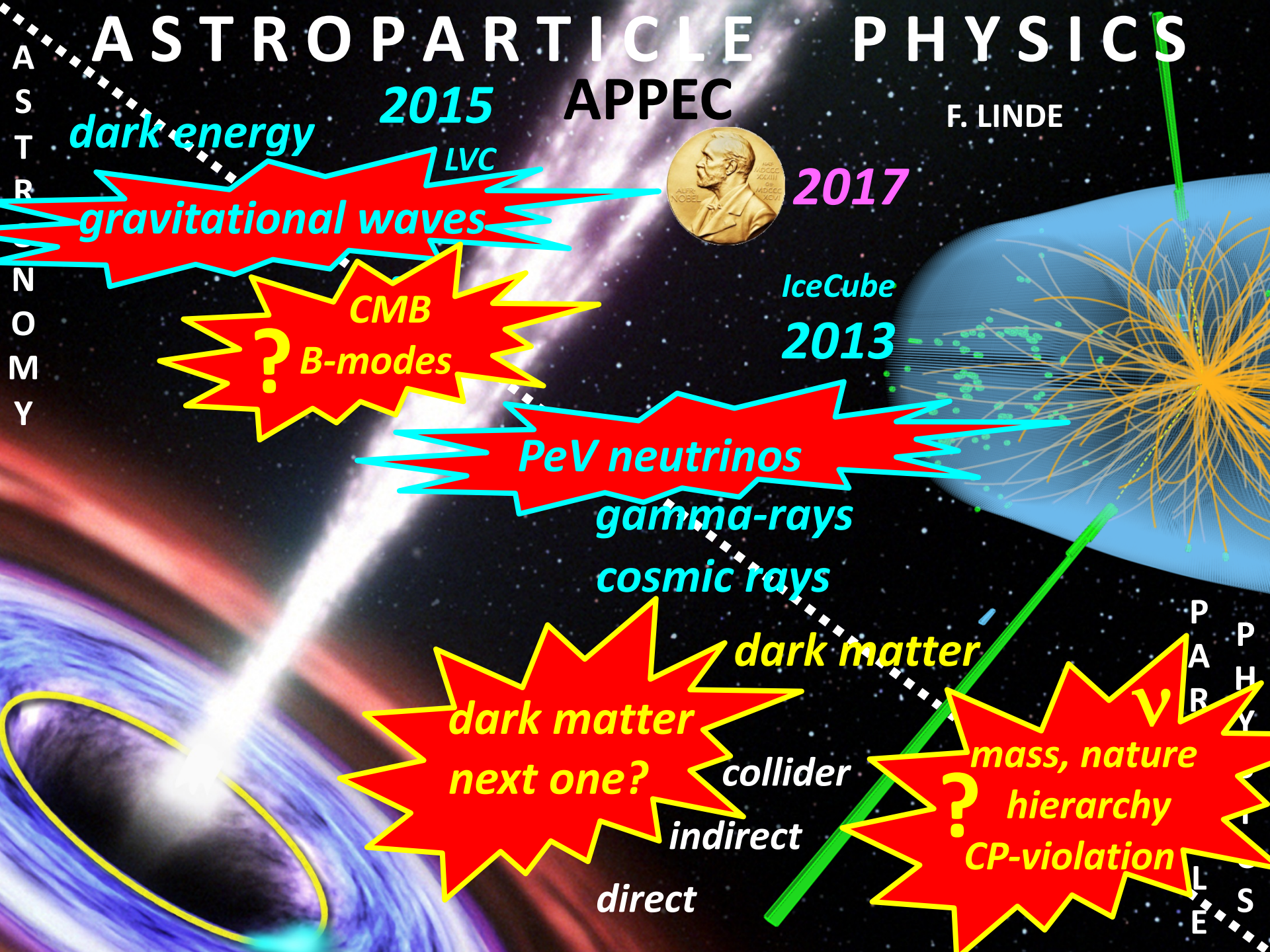
collider

indirect

direct

mass, nature
? hierarchy
CP-violation

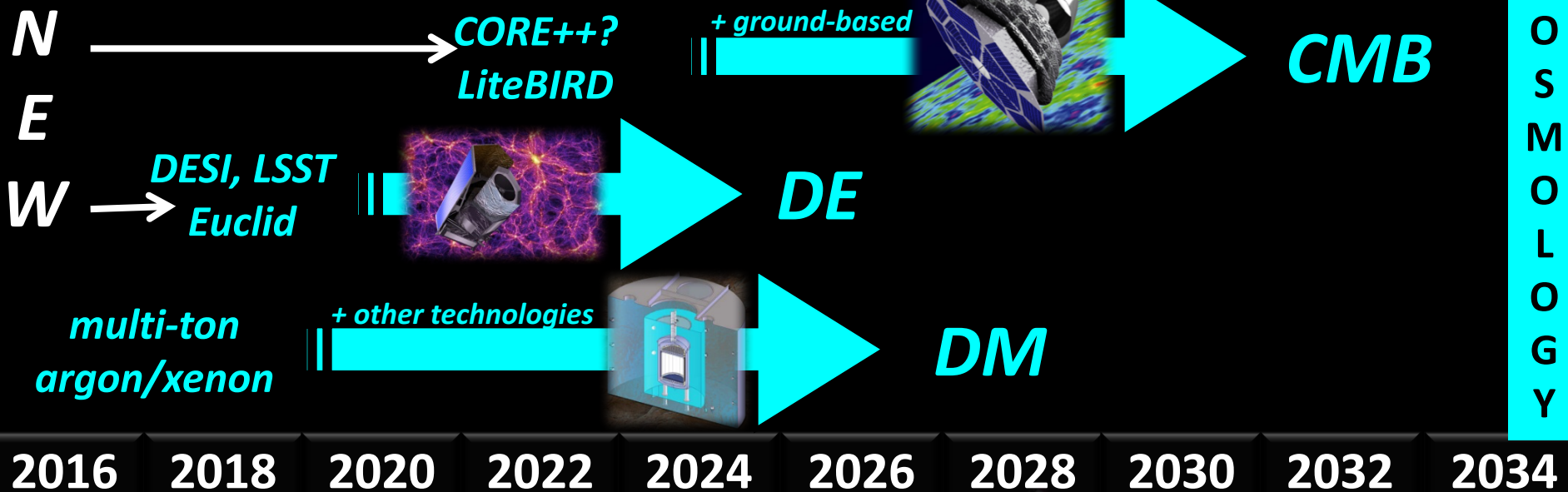
P
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S



Promising – *bright* – future ahead!

F. LINDE

C
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H
E
U

Crucial ingredients

The image features three interlocking blue gears of varying sizes, set against a solid black background. Each gear is rendered with a slight 3D effect, showing highlights and shadows. The largest gear is at the bottom, the medium one is in the middle, and the smallest is at the top. Each gear contains text in a bold, sans-serif font, with a smaller, italicized font below it.

community

*EU: few 1000
scientists*

science

excellent

technology

state-of-the-art

Concerns

*coherent program
connected community*



*EU national funding alignment ...
(‘easy’ in USA, Japan, China)*



*Technical readiness & convergence
Realistic time schedules
(Exploitation costs!)*

F. LINDE

Bottom line: in EU we need to strengthen the APP organisation even further ...

Strategic objectives

- Coordination of European Astroparticle Physics
- Develop and update long term strategies (roadmap)
- Express collective views on APP in international fora

Implementation objectives

- Coordination between existing/developing national activities
- Convergence of future large scale projects/facilities
- Organisational advice for implementation of large facilities
- Launch common calls funded by a (virtual) common pot

APPEC Consortium



APPEC 2018

RIA (Ireland)

STFC (UK)

FOM (NL)

FRS-FNRS, FWO (Belgium)

CEA, CNRS (France)

SNSF (Switzerland)

LSC (Spain)

FCT (Portugal)

OSI (Finland)

VR (Sweden)

DESY, KIT (Germany)

JINR (Dubna, Russia)

NCN (Poland)

IEAP-CTU (CZ)

INFN (Italy)

IFIN-HH (Romania)

CSF (Croatia)

NOA (Greece)

Observers: CERN, ECFA, ESO, NCN, CSF



Astroparticle Physics European Consortium



General Assembly

Stavros Katsanevas 2012 – 2014
Frank Linde 2015 – 2016
Antonio Masiero 2017 –

Joint Secretariat

Thomas Berghöfer 2012 – 2016
Job de Kleuver 2017 –

Scientific Advisory Committee

Laura Baudis (chair), Michal Ostrowski, Mauro Mezzetto, Gisela Anton, Jocelyn Monroe, Petr Tiniakov, Jo van den Brand, Patrick Sutton, Ramon Miquel, Zito Marco, Andrea Giuliani, Felix Aharonian, **Pierre Binétruy**, Ignatios Antoniadis, Yifang Wang, Francis Halzen, Hank Sobel, A. Haungs, S.Katsanevas (APPEC)

Distributed responsibilities of the five APPEC Functional Centers



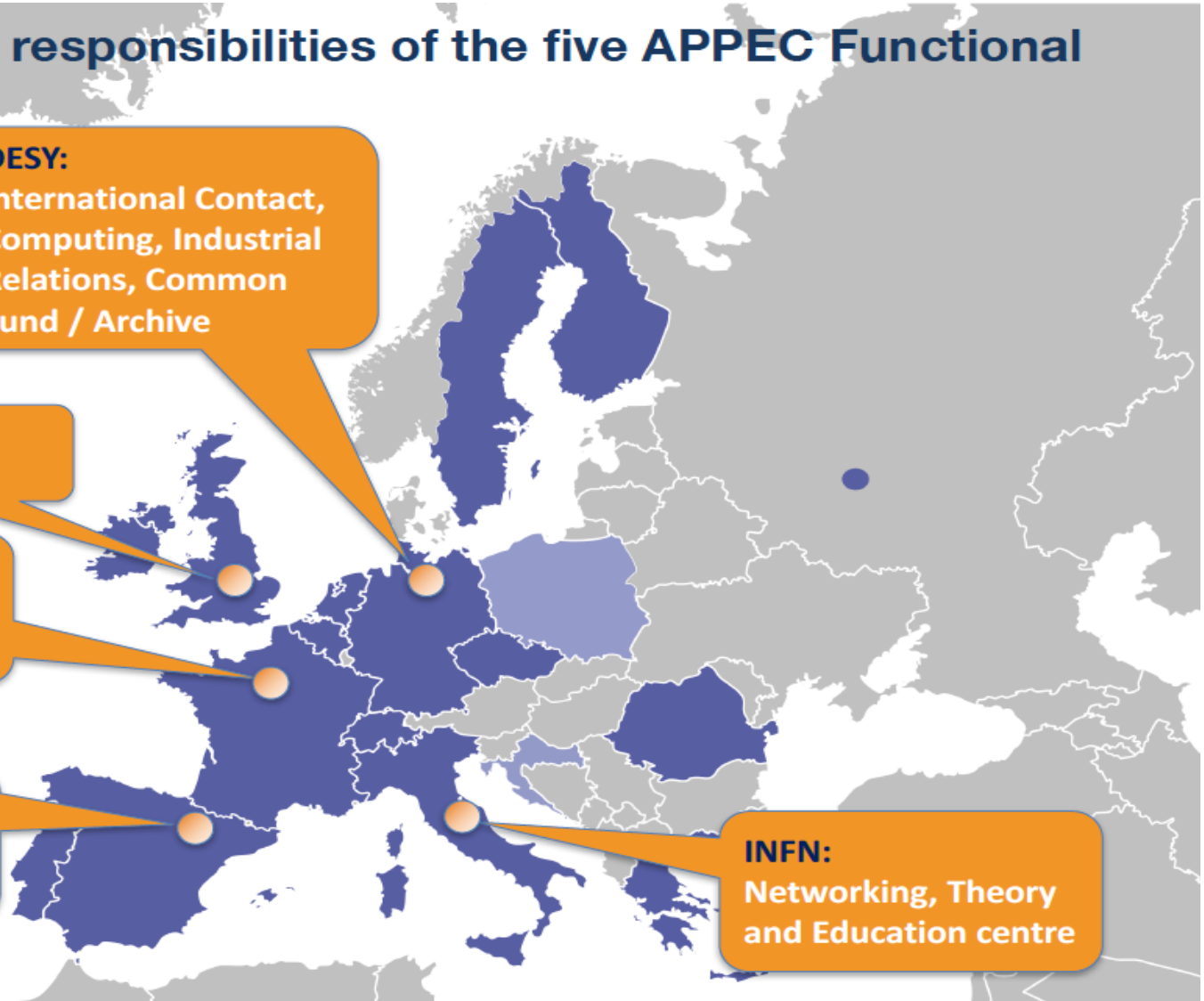
DESY:
International Contact,
Computing, Industrial
Relations, Common
Fund / Archive

STFC:
Outreach

APC:
Strategic Actions,
Interdisciplinarity

LSC:
Electronic Tools

INFN:
Networking, Theory
and Education centre

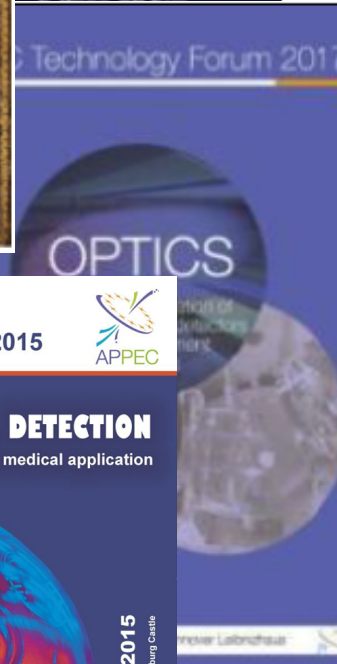
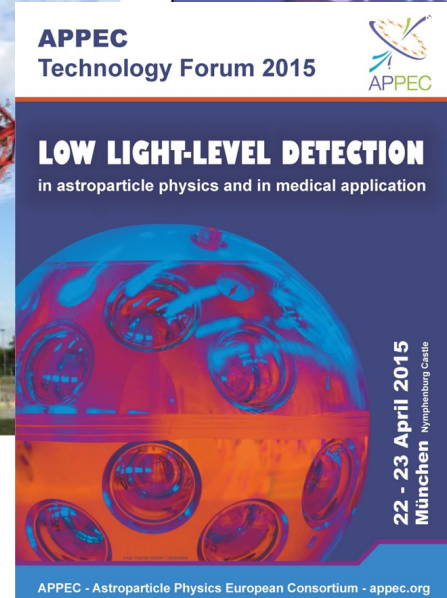


APPEC actions

- **Promotion of global and/or European strategies on specific topics** (for instance, global neutrino meetings, European CMB coordination in a global context; for the future : global strategy ofor integrated activities of large underground research infrastructures, global strategy for cosmic multi-messenger approach)
- **APPEC Technology Fora**
- **Stimulus for large astroparticle RI** (example strong help in the preliminary stage if the CTA project)
- **Calls for R&D on common projects** (ex. ET, DARWIN, etc.)



Speakers
E. Lisi, J. Strait,
M. Neusi, T. Kobayashi,
S.K. Agarwalla, M. Diwan,
M. Shiozawa, A. Rubbia,
T. Ekelof, K. Long,
S. Ritz, J. Lesgourgues,
A. Szafron, A. McDonald,
P. Huber, T. Lasserre.



APPEC Roadmaps

2008

2011

2017



resource aware

European roadmaps in fields of science



APPEC: *Town Meeting* → *strategy*

Wednesday 6 April

Time	Topic	Speaker	Moderator
09:00-10:00	Registration - Welcome coffee		
10:00-10:15	Openning & Introduction	Antonio Masiere <i>APPEC SAC Chair</i>	Antonio Masiere <i>APPEC SAC Chair</i>
10:15-11:00	HE-Universe - Gamma	Felix Aharonian	Christian Spiering
11:00-11:45	HE-Universe - Neutrino	Gisela Anton	Stanislaus Bentvelsen
11:45-12:30	HE-Universe - Cosmic rays	Andreas Haungs	Johannes Bluemer
12:30-14:00 Lunch - Buffet			
14:00-14:30	Multimessenger study of the Universe - Theory	Roger Blandford	Antonio Masiere
14:30-15:00	Current problems in cosmology - Theory	Subir Sarkar	Lars Bergstroem
15:00-15:30	Current problems in neutrino - Theory	Eligio Lisi	Janet Seed
15:30-16:15 Coffee			
16:15-17:00	Neutrino parameters with large experiments (CP violation, mass hierarchy,...)	Mauro Mezzetto	Fernando Ferroni
17:00-17:45	Lepton number violation and basic neutrino properties	Andrea Giuliani	Stefano Ragazzi
17:45-18:30	Cosmology - Dark Matter	Jocelyn Monroe	Mario Martinez
18:30-18:45 Break			
18:45-19:30	T. Kajita public lecture	Takaaki Kajita	Stavros Katsanevas
19:15-20:15 Cocktail			

Thursday 7 April

Time	Topic	Speaker	Moderator
09:30-10:15	Cosmology - CMB	Francois Bouchet	Stavros Katsanevas
10:15-11:00	Cosmology - Dark Energy	Ramon Miquel	Reynald Pain
11:00-11:45 Coffee			
11:45-12:30	HE-Universe - Gravitational Waves	Patrick Sutton	Federico Ferrini
12:30-13:00	APP Computing	Volker Beckmann	Katharina Henjes-Kunst
13:00-14:30 Lunch - Buffet			
14:30-15:00	APP - Detector R&D, Industry	Jo v/d Brand	Teresa Montaruli
15:00-17:00	Round table with international agencies (CERN, ASTRONET, ESO, DOE, NSF, CANADA, CHINA, JAPAN)	F.Giannotti (CERN), R. Gilmozzi (ESO), K. Turner (DOE), J. Whitmore (NSF), T. Kajita (Japan), SN Zhang (China), N. Smith (Canada), C. Vincent (Astronet), M. Carena (Fermilab)	Stavros Katsanevas
17:00-17:45 Coffee			
17:45-18:15	Conclusions, APPEC, community, roadmap, funding alignment, international coordination	Frank Linde <i>APPEC Chair</i>	Frank Linde <i>APPEC Chair</i>

Paris, April 6-7, 2016

<http://www.appec.org/roadmap>



European Astroparticle
Physics Strategy
APPEC 2017-2026

Scientific issues – 13×

- *Large-scale: CTA, ν -telescopes, Auger, GW*
- *Medium-scale: Dark Matter, ν -mass, $0\nu\beta\beta$*
- *+PP: ν -mixing; +ASTRO: Dark Energy & CMB*
- *Base: theory, R&D, computing
deep-underground laboratories*

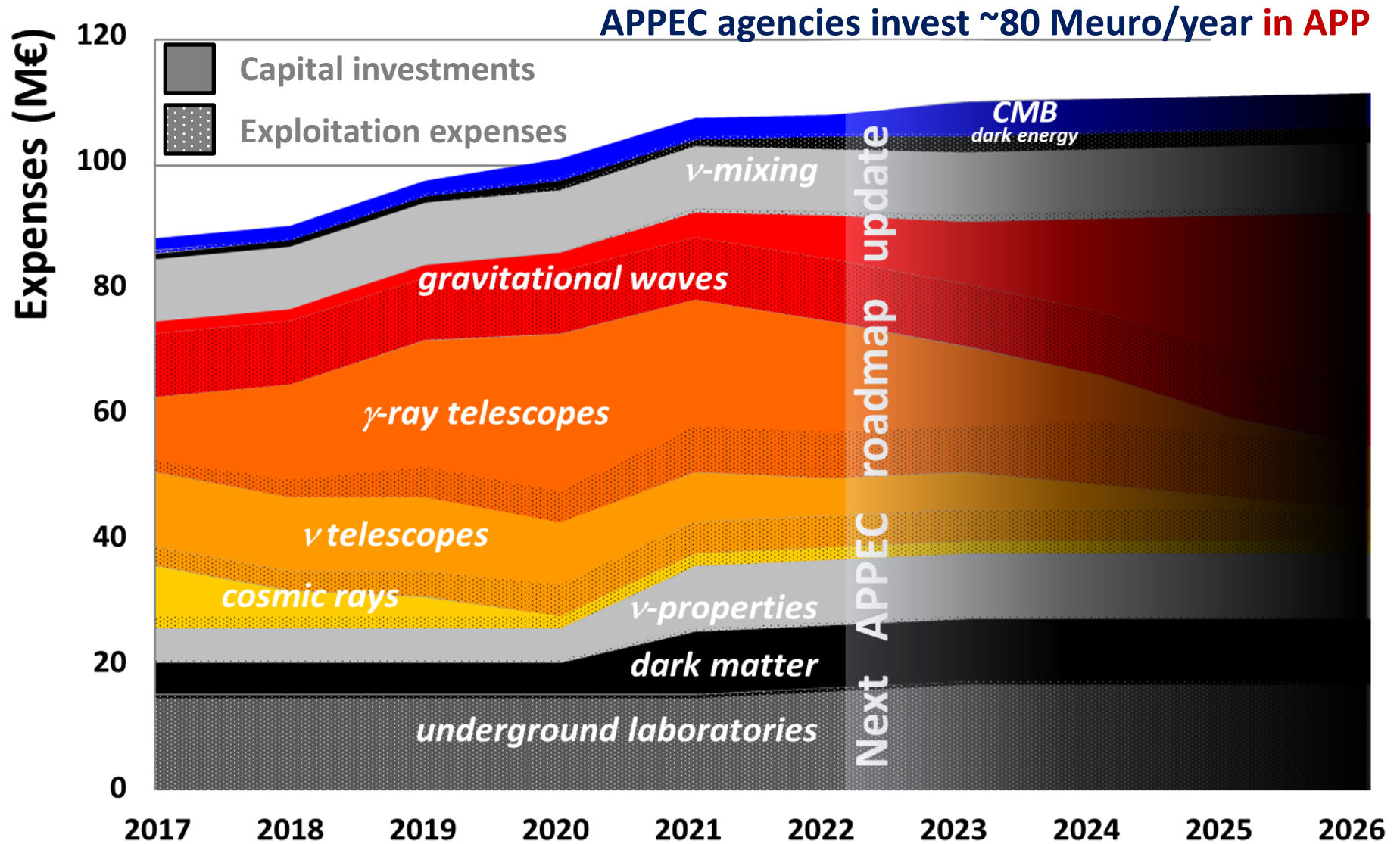
Organisational issues – 5×

- *European Commission*
- *European collaboration/coordination*
- *Global collaboration/coordination*
- *Particle physics & Astronomy*
- *Inter-disciplinary opportunities*

Societal issues – 3×

- *Gender balance*
- **Education & Outreach**
- *Industry*

APPEC's 2017 strategy ...

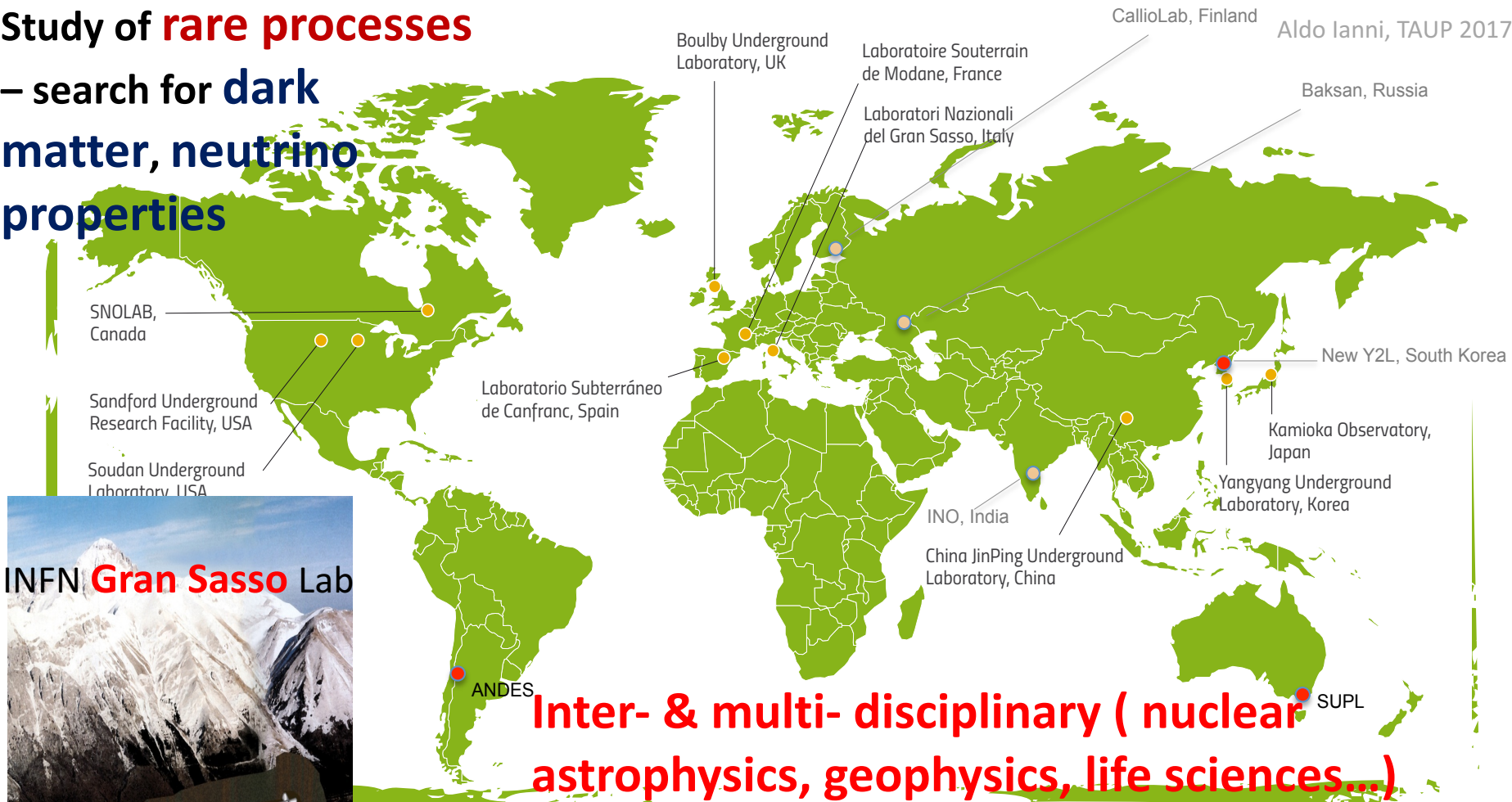


Excludes EU structural/regional, PP, ASTRO, non-EU funding ...

DEEP UNDERGROUND LABs

Study of **rare processes**

– search for **dark matter, neutrino properties**



Surface: 17 800 m²
Volume: 180 000 m³



Worldwide largest underground lab in operation with easy accessibility

Challenges for next DM, $\beta\beta$ frontiers; Challenges for LNGS

- Attack and cover the IH region \rightarrow 1-ton neutrinoless $\beta\beta$
- WIMPS DM : Reach the neutrino background \rightarrow n-ton (n = 50 -200) ?

LNGS \rightarrow largest ultra low-background facility ...

LNGS \rightarrow Need for a major infrastructural upgrade to meet the formidable challenges of next-generation exps. and to maintain the present leadership role among the underground RIs worldwide

Underground labs \rightarrow towards a **GLOBAL COORDINATION (GRI – Global Research Infrastructure)**

High-energy neutrinos – KM3NeT/Icecube

Participating EU-countries: BE, CH, CY, DK, ES, DE, FR, GR, IT, NL, PL, RO, RU, SE, UK, ...

KM3NeT: 0(200 M€)

High-energy ν sources
indirect Dark Matter
 ν -mass hierarchy

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.

KM3NeT: start operations in 2020

Icecube: USA in the lead

Substantial EU-APP funding: France, Italy, Netherlands, ...

Substantial **non**-APP funding: Italy, France

Gravitational waves – LVC, ET, LISA

surface, underground, space GW interferometers

Interested EU-countries: many

ET: 0(1 G€)

*sources!
scrutiny of General Relativity
'standard sirens'*



*Space: ESA schedule ~ 2030
Ground: timeline in consultation with GWIC*

Gravitational Wave GRI (Global Research Infrastructure)

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.

High-energy cosmic-rays – AugerPrime

Participating EU-countries: CZ, DE, ES, FR, IT, NL, PL, PO, RO, SI, ...

AugerPrime: 0(10 M€)

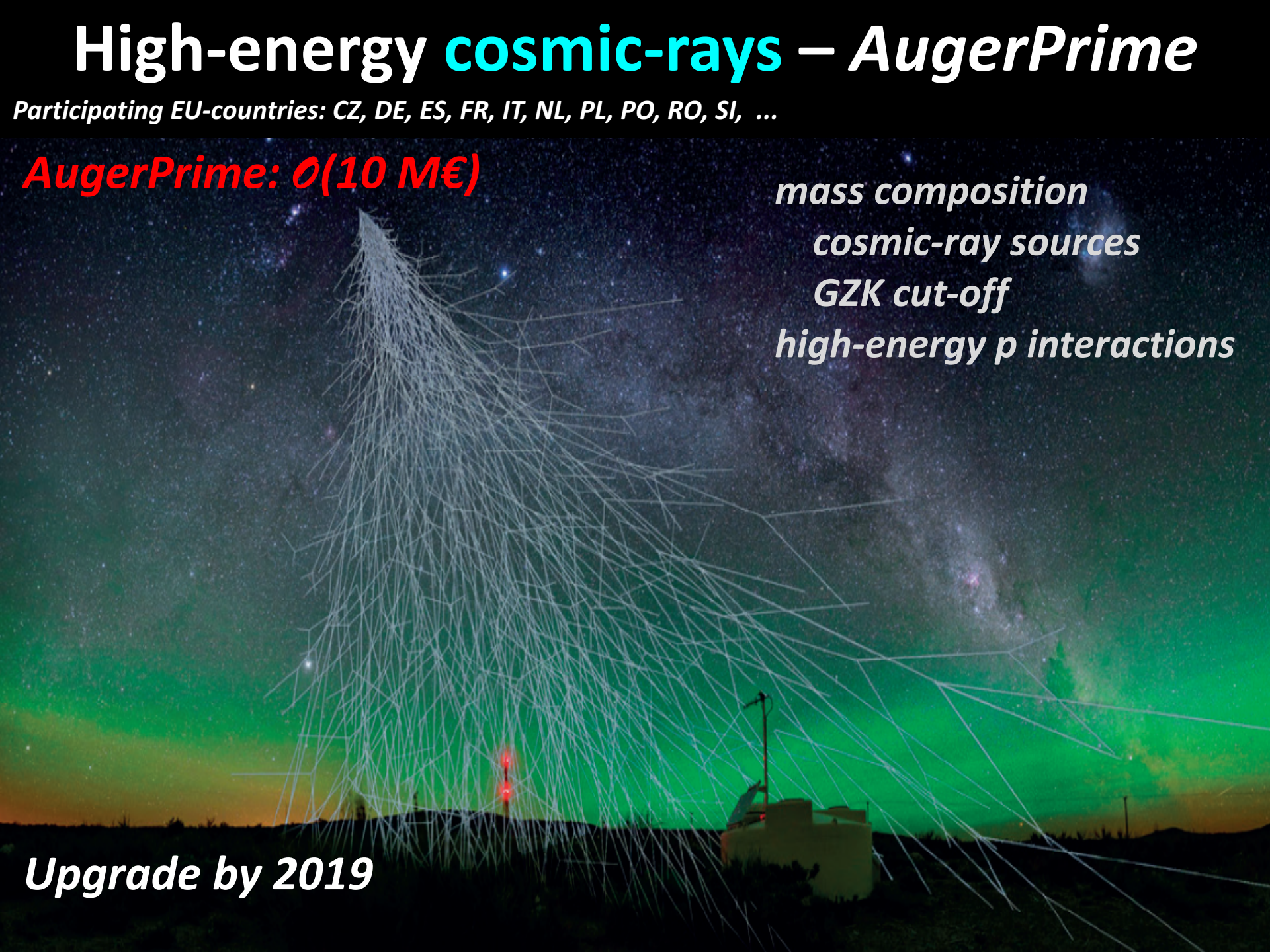
mass composition

cosmic-ray sources

GZK cut-off

high-energy p interactions

Upgrade by 2019



High-energy photons – CTA

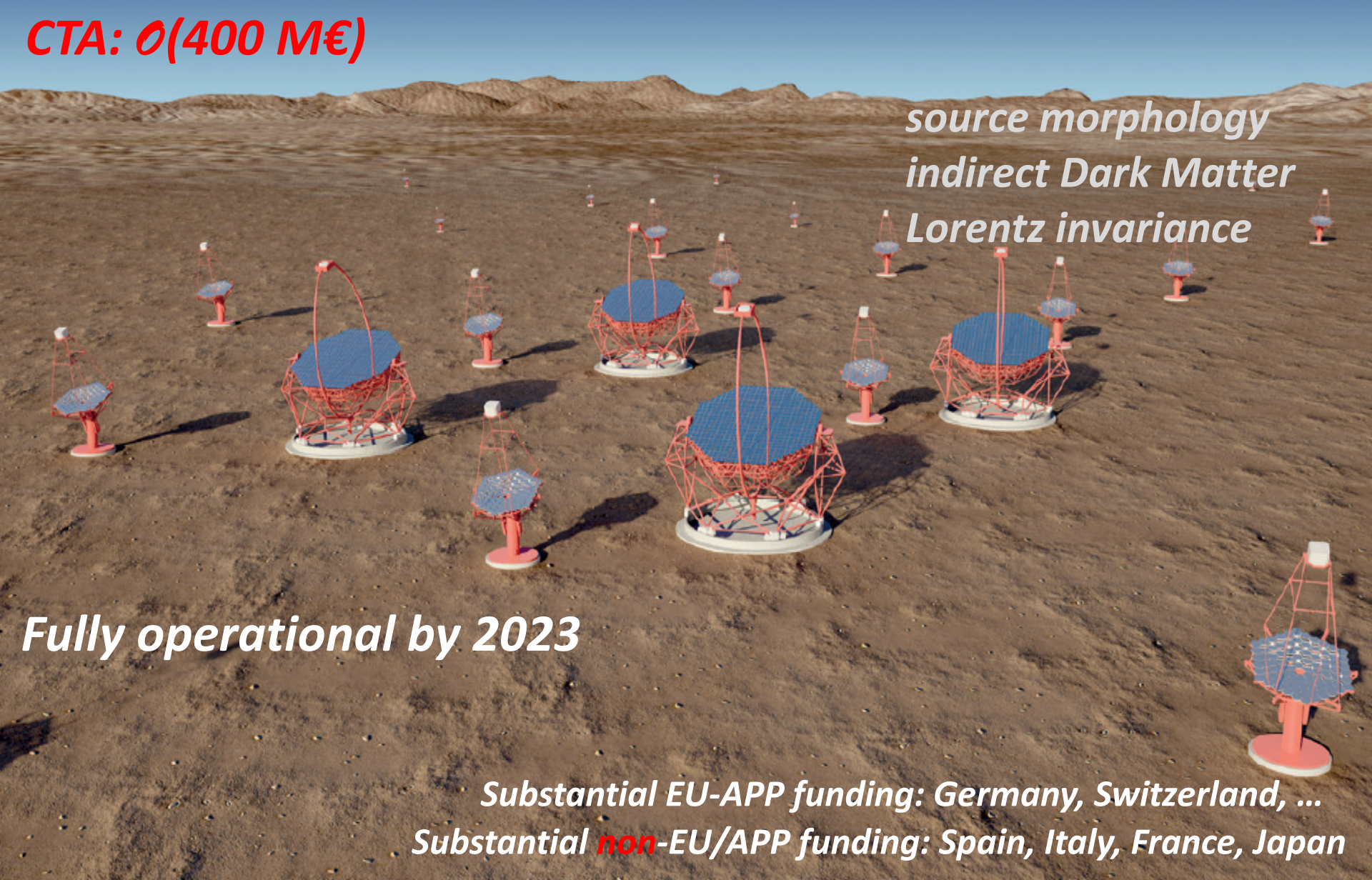
Participating EU-countries: AT, BG, CH, CZ, DE (coordinator), ES, FI, FR, HR, IE, IT, NL, NO, PL, SE, UA, UK, ...

CTA: 0(400 M€)

*source morphology
indirect Dark Matter
Lorentz invariance*

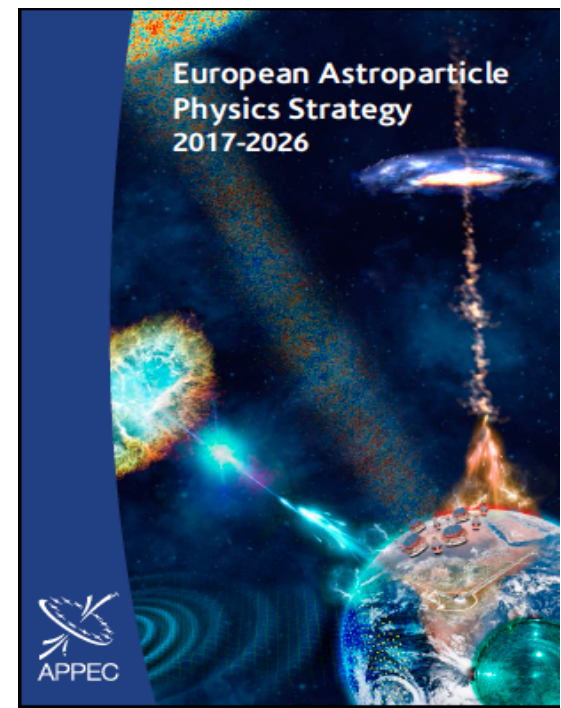
Fully operational by 2023

*Substantial EU-APP funding: Germany, Switzerland, ...
Substantial **non**-EU/APP funding: Spain, Italy, France, Japan*



final considerations

- APPEC is a key-factor to fully exploit the enormous **HUMAN, SCIENTIFIC, TECHNOLOGICAL** potential of European APP leading EU to play a top-level role in the global astroparticle landscape
- The success of the APPEC'S new resource-aware EU Astroparticle Strategy 2017-2026 relies on a **close cooperation between the APP scientific community with our various national governments and funding agencies, the EU Commission, our partners outside Europe, those working in the connected field of particle physics, astronomy and cosmology, and the strong pillars that these 3 research fields rely on – CERN, ESO and ESA**

The image is a vertical rectangular graphic with a dark blue background. It features a central illustration of a galaxy with a bright core, surrounded by a nebula and a bright blue laser beam. In the foreground, there is a depiction of Earth with a satellite orbiting it. The text 'European Astroparticle Physics Strategy 2017-2026' is located in the top left corner. The APPEC logo is in the bottom left corner.

European Astroparticle
Physics Strategy
2017-2026

APPEC

We are living in an
extraordinarily exciting time for
our comprehension of the
Universe from **its smallest to its
largest space and time scales**

With this roadmap APPEC intends to set a relevant program for the establishment and running of the planned APP RI's and an intense R&D for future RIs, hence **an overall RI area program** of potential high impact on the growth and innovation in EU.