



Astroparticle Physics European Consortium

**European Astroparticle
Physics Strategy
2017-2026**

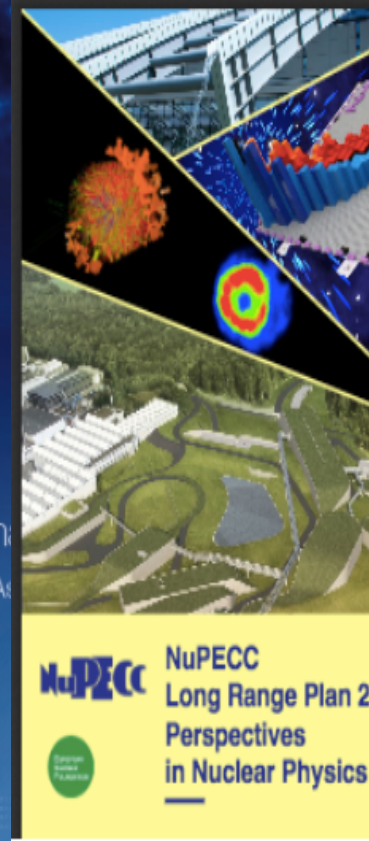


**Towards the EU Coordination
of the CMB programme
Sept. 20-21, 2018 Florence, Italy**

**Presentation of the
EU Astro-Particle
Physics Strategy
2017-2026**

*Antonio Masiero
INFN and Univ. of Padova
Chairman of the
APPEC General Assembly*

European roadmaps in fields of science



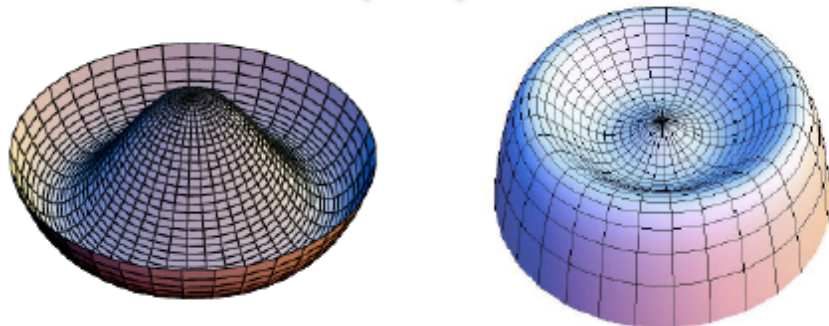
resource aware

- PARTICLE STANDARD MODEL**

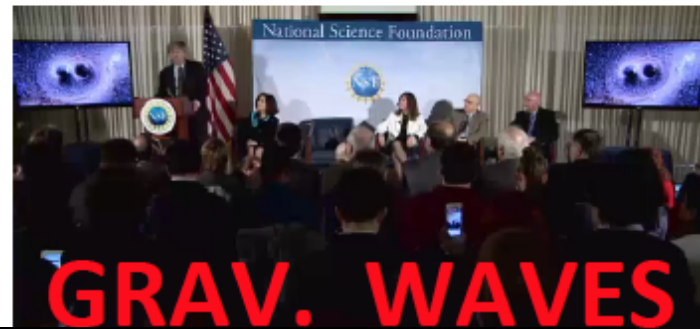
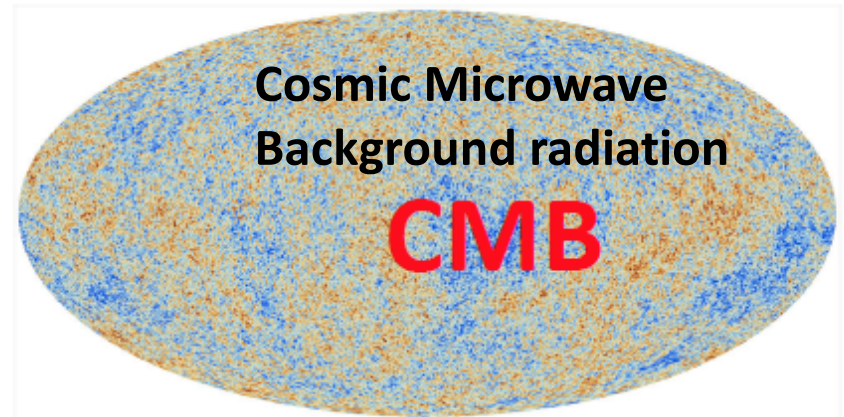


The **Higgs boson** and the destiny of the Universe

STABILITY ↔ **INSTABILITY**

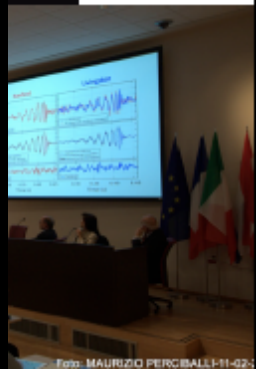
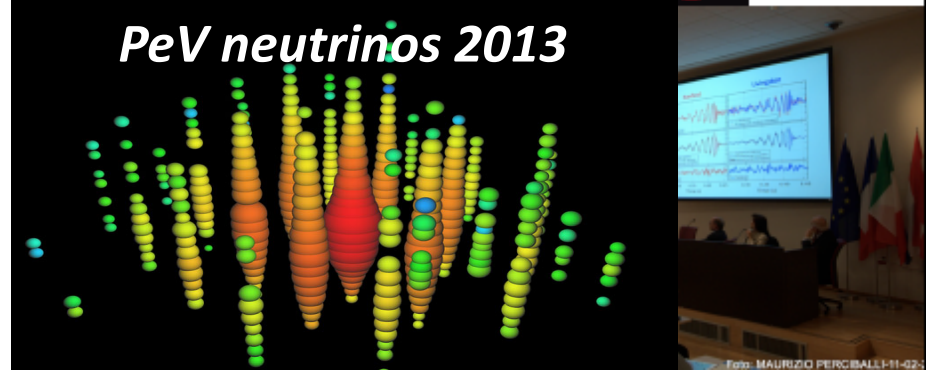


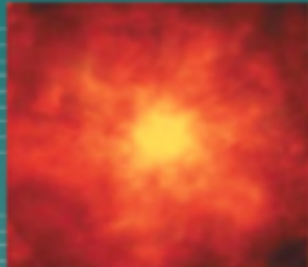

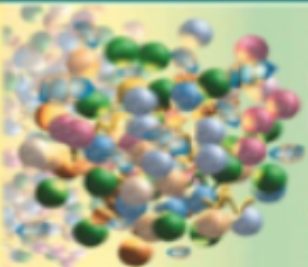

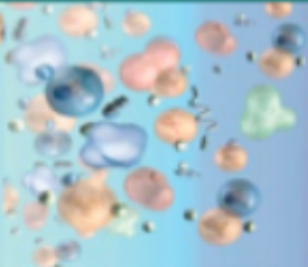

- COSMOLOGY STANDARD MODEL**

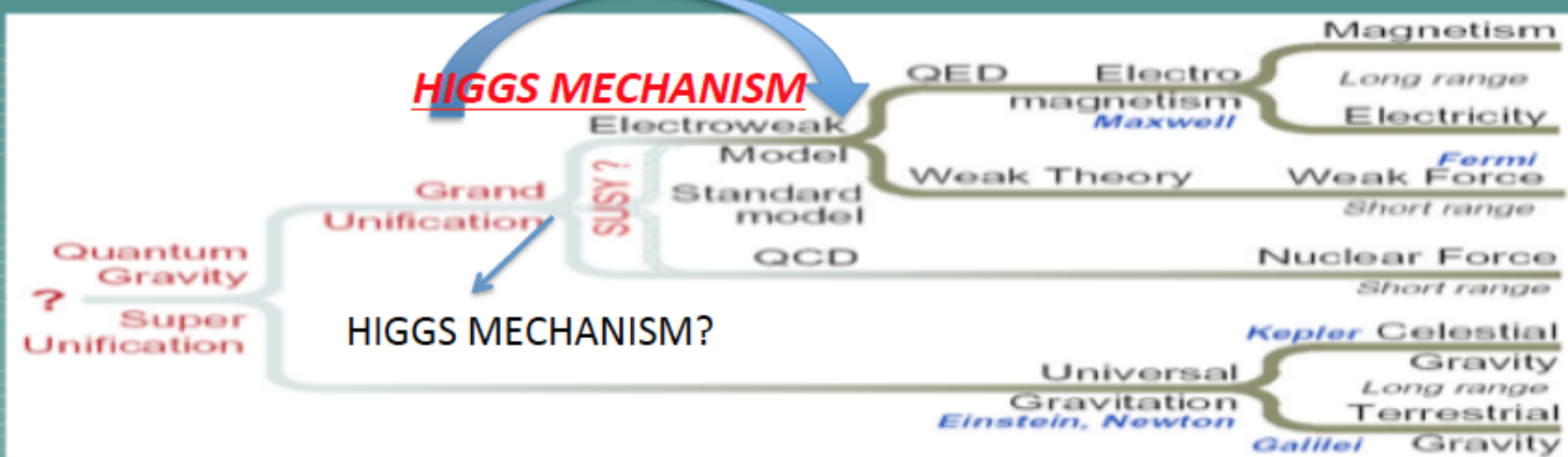


GRAV. WAVES

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

- By the end of the 20th century ...
**we have a comprehensive,
fundamental theory of all
observed forces of nature which
has been tested and might be
valid from the Planck length
scale [10^{-33} cm.] to the edge of
the universe [10^{+28} cm.]**

D. Gross 2007

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%

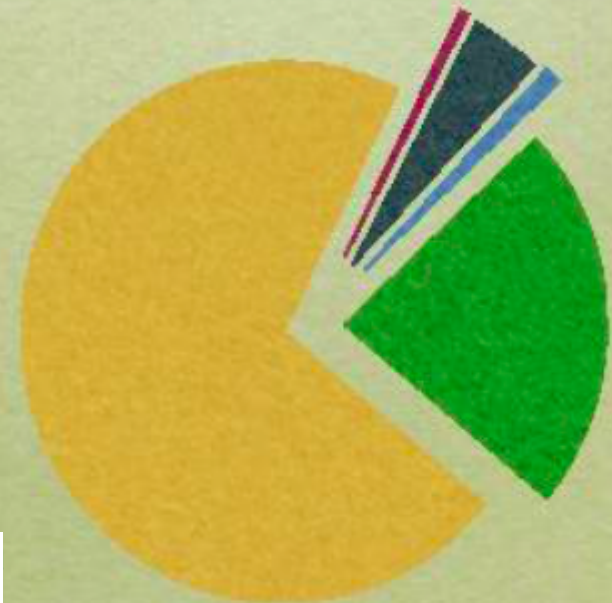
- Dark Matter **$\sim 27\%$**

- Dark Energy **$\sim 68\%$**

- Anti-Matter **0%**

- Higgs Bose-Einstein condensate

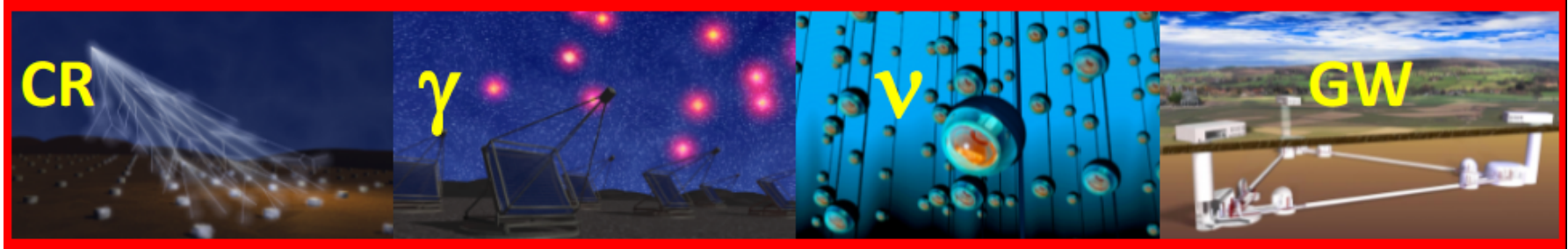
\sim **$10^{62}\%$** ??



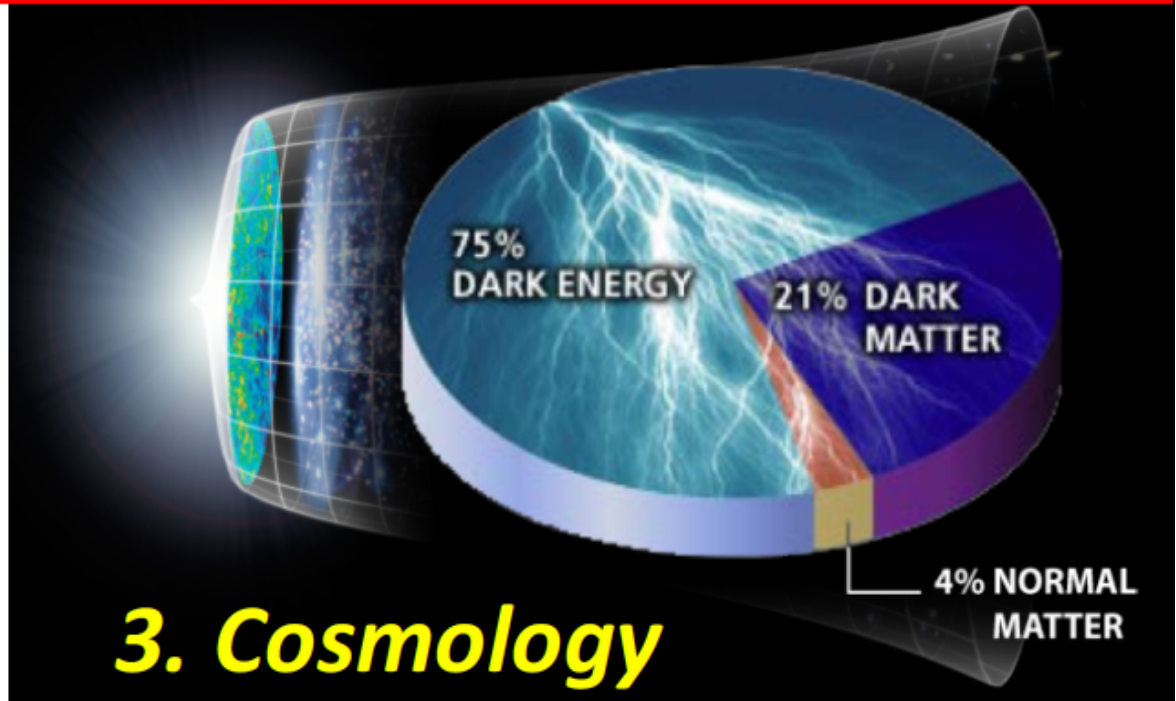
thanks to H. Murayama

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

1. High-energy Universe: multi-messengers

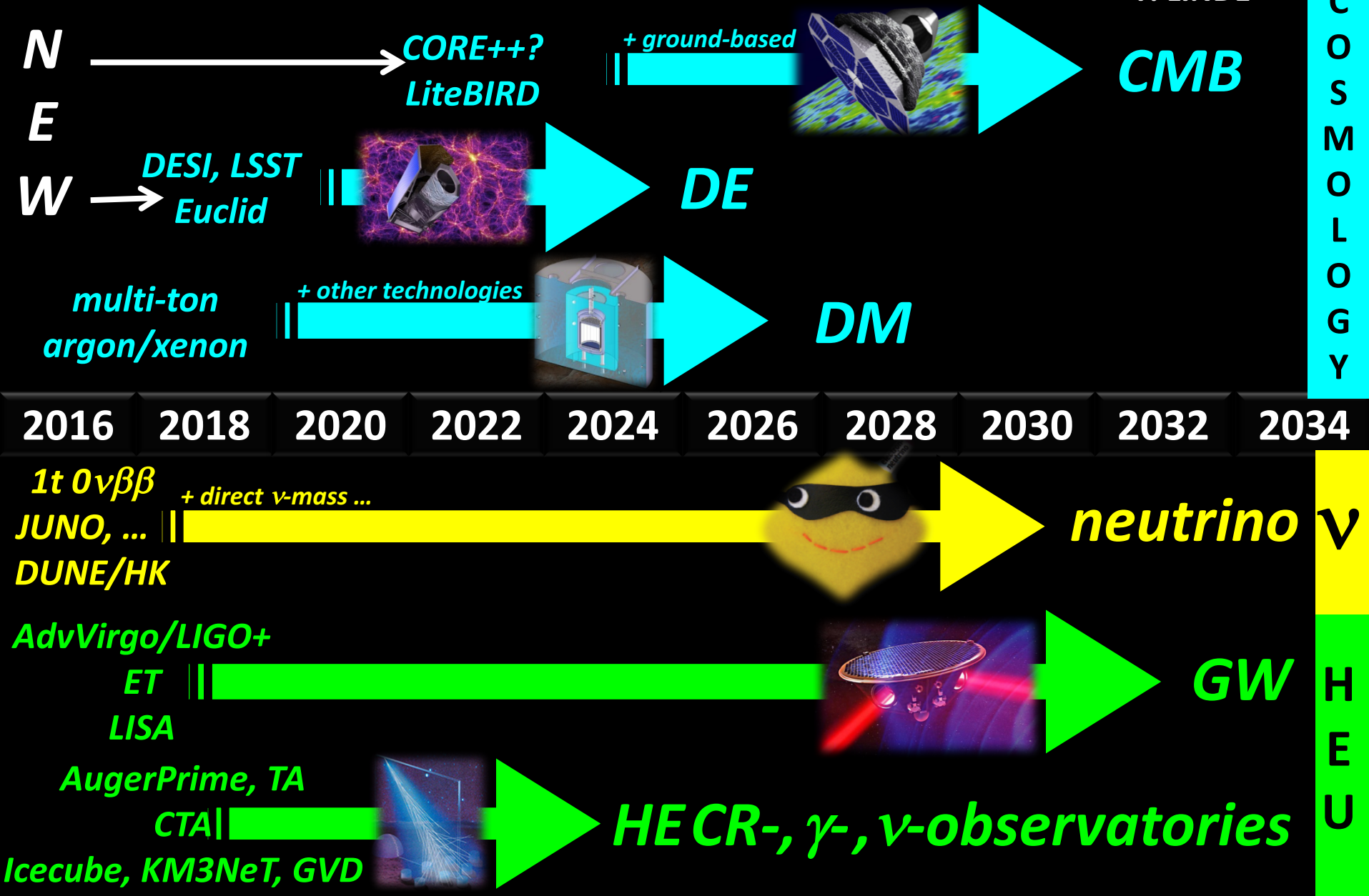


2. Neutrino's



Promising – *bright* – future ahead!

F. LINDE



Crucial ingredients



community

*EU: few 1000
scientists*

science
excellent

technology
state-of-the-art

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

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:

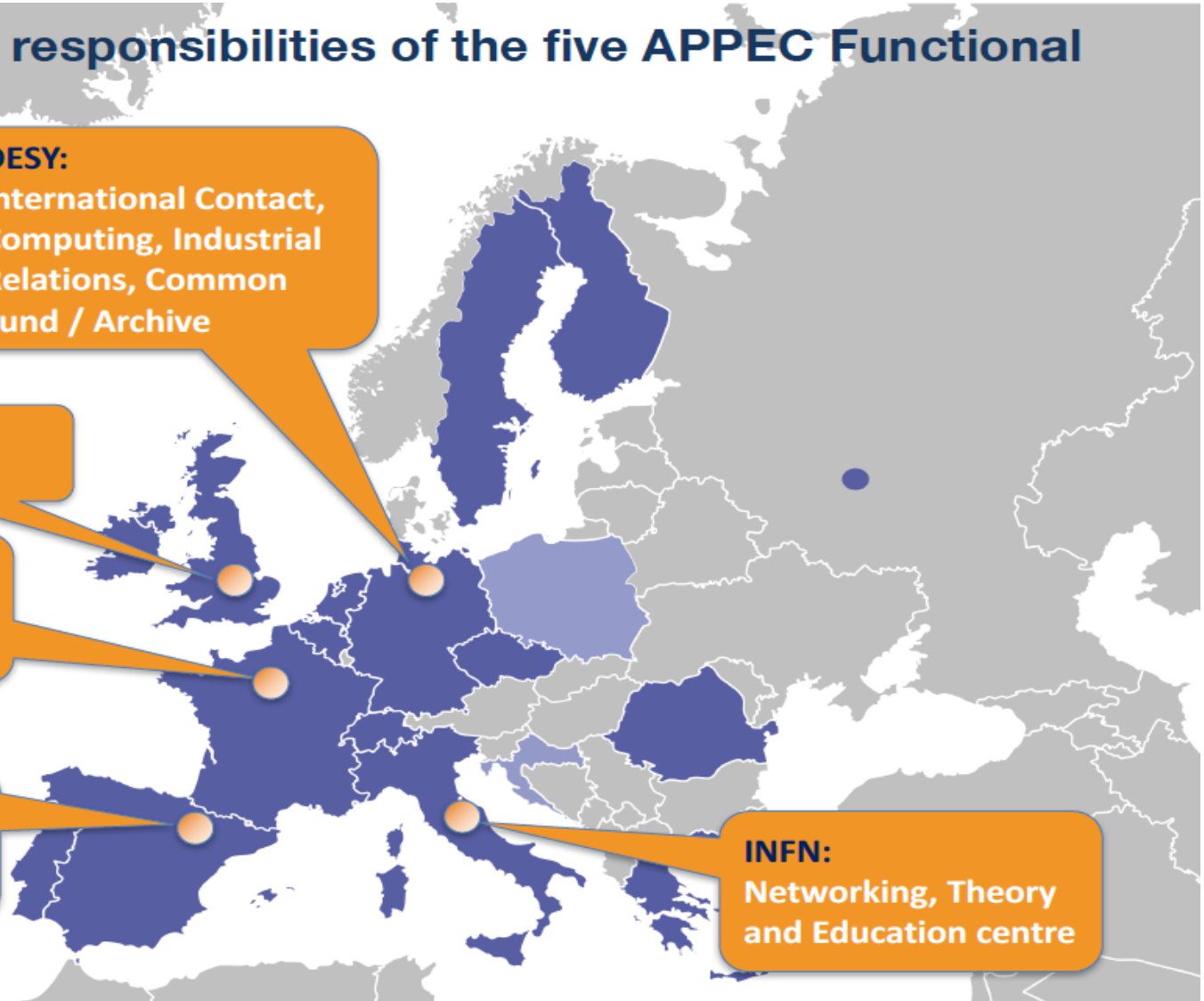
Strategic Actions,
Interdisciplinarity

LSC:

Electronic Tools

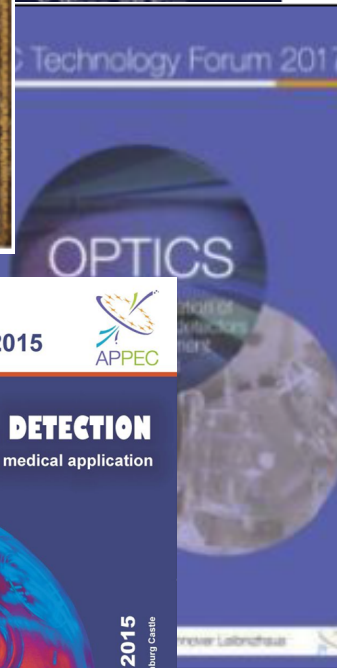
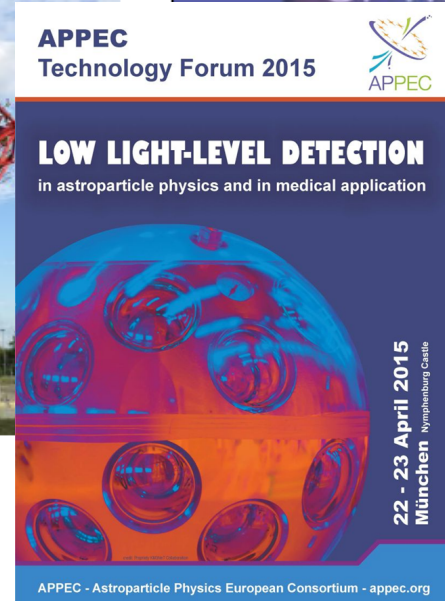
INFN:

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.)



- **APPEC Technology Forum 2018 – November, 12-13, Veldhoven (NL)**
 - Topic: **Active and passive stabilization systems and sensors**
 - Scientists and companies from different fields are invited to talk about a common challaning topic
 - Occasion for interdisciplinary discussions and new collaborations
 - GW-search, dark-matter experiments, particle physics, ... And more.

Sign up now!

<http://indico.desy.de/indico/e/ATF2018>





European Astroparticle
Physics Strategy
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*

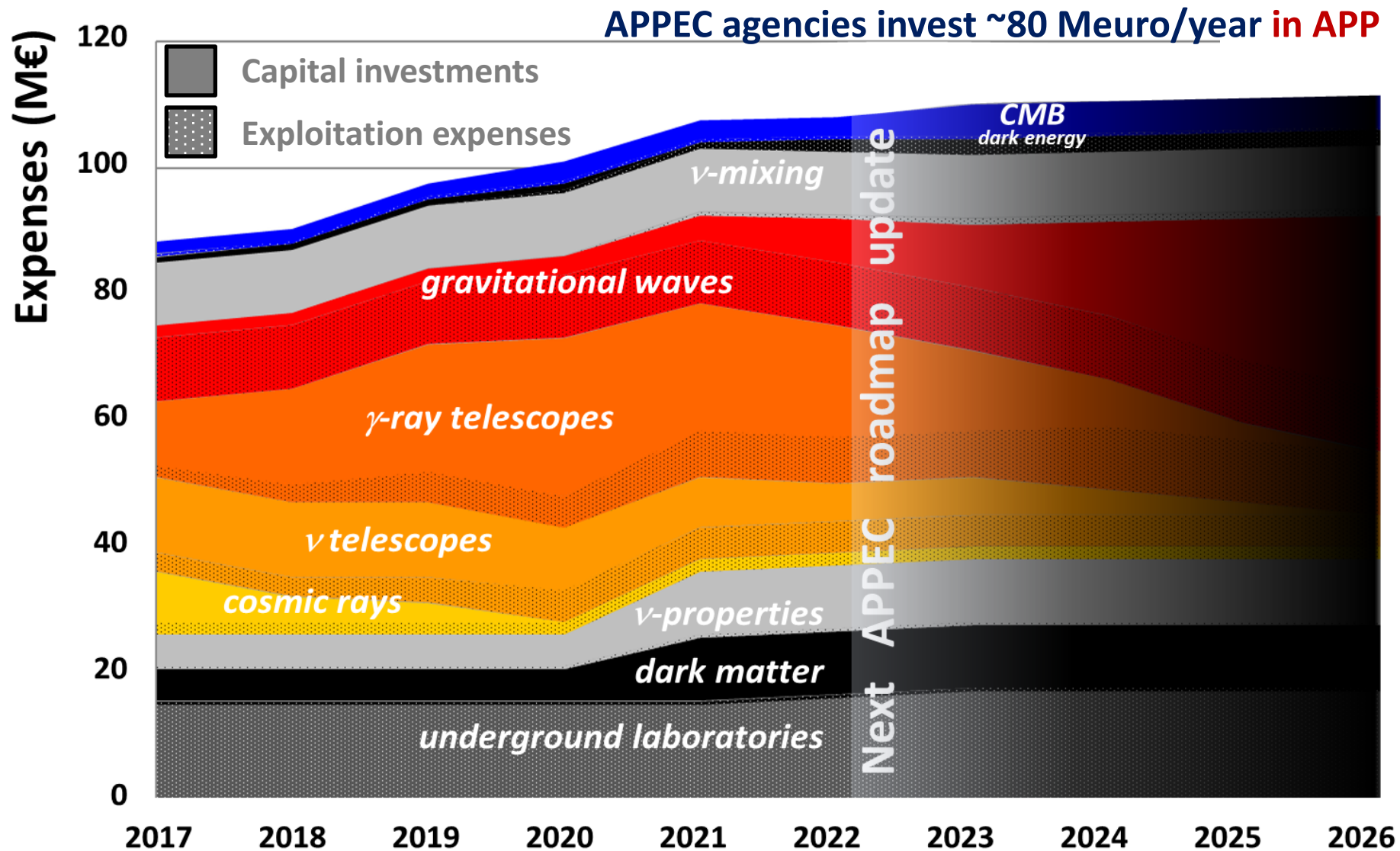
Organisational issues – 5×

- *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 ...

European *research infrastructures* roadmap: *ESFRI*

European Strategy Forum
on Research Infrastructures

ESFRI

STRATEGY REPORT
ON RESEARCH

CTA

Cherenkov Telescope Array

EST

European Solar Telescope

KM3NeT 2.0

KM3 Neutrino Telescope 2.0:
Astroparticle & Oscillations Research with Cosmics
in the Abyss



ROADMAP 2016

1

ESFRI PROJECTS

	NAME	Full Name	ESFRI REF (YHR)	OPERATION (YHR)	LEGAL STATUS (AGREEMENTS)	CONSTRUCTION COST (M€)	OPERATIONAL BUDGET (M€)
ENV	CCS-SEL	European Carbon Dioxide Capture and Storage Laboratory Infrastructure	2008	2016	ERIC under preparation	80-120	1M*
	EU-SOLARS	European SOLAR Research Infrastructure for Concentrated Solar Power	2010	2020*	ERIC under preparation	120	3-4
	MYRRHA	Multi-purpose Hybrid Reactor for High-tech Applications	2010	2024*		NA	100
	WindScanner	European WindScanner Facility	2010	2018*		45-60	8
	ACTRES	Aerocids, Clouds and Trace gases Research Infrastructure	2016	2025*		190	50
ENV	DAHURIUS-RI	International Centre for Advanced Studies on River-Sea Systems	2016	2022*		222	28
	ESFRI 2.0	ESFRI 2.0	2016	2022*		200	9
ENV	KM3NeT 2.0	KM3 Neutrino Telescope 2.0: Astroparticle & Oscillations Research with Cosmics in the Abyss	2016	2020*		92	3
	ESFRI 2.0	ESFRI 2.0	2016	2022*		4	5

*up to 2016

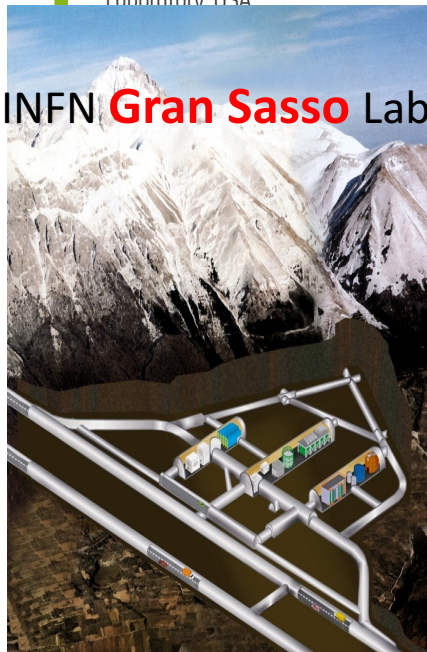
**for controlled access

NA: Not Available

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

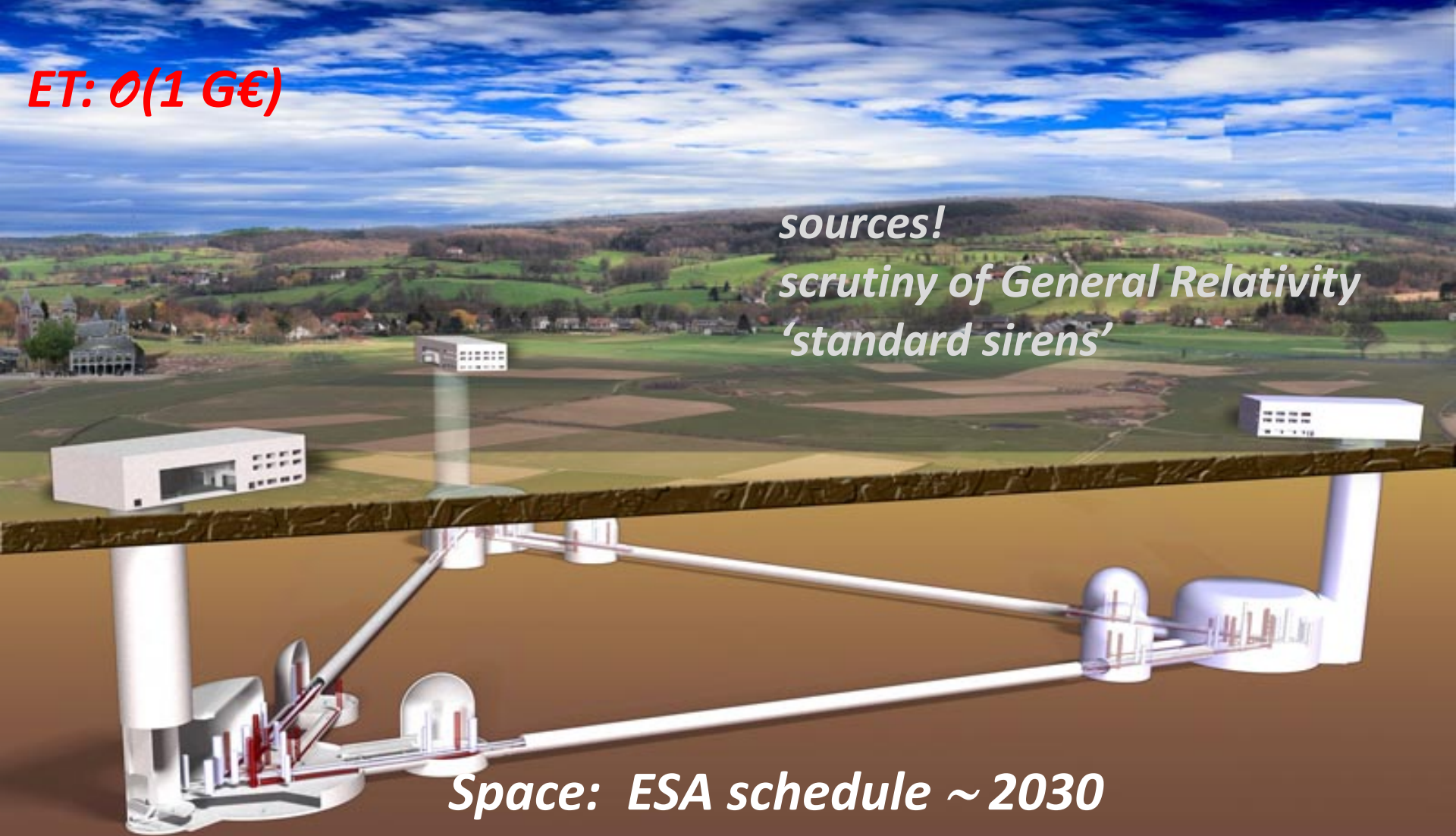
Gravitational waves – LVC, ET, LISA

surface, underground, space GW interferometers

Interested EU-countries: many

ET: 0(1 G€)

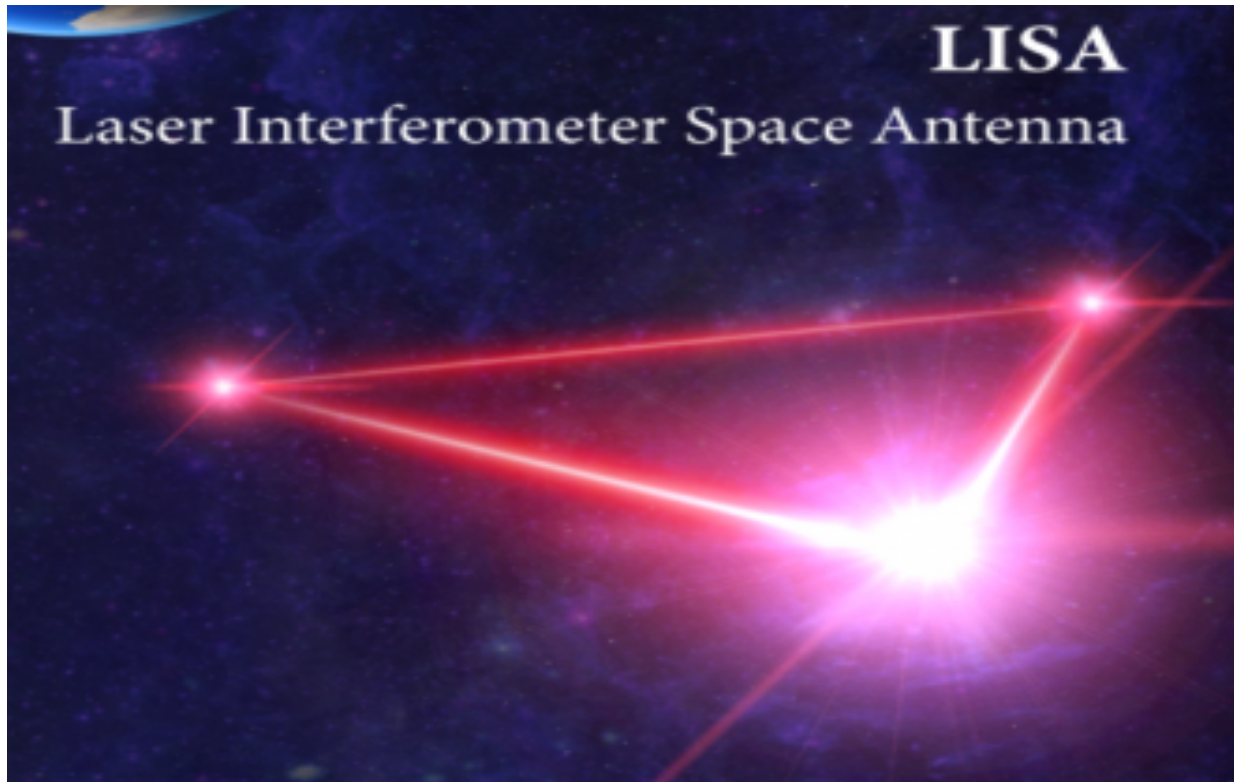
*sources!
scrutiny of General Relativity
'standard sirens'*



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

APPEC and Gravitational Waves

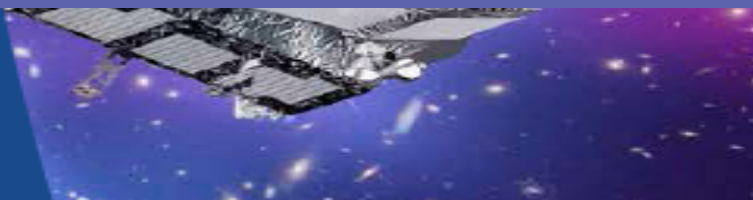
In the field of space-based interferometry, APPEC strongly supports the LISA proposal.



Dark Energy

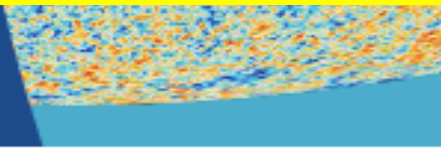
Together with Dark Matter, Dark Energy – the hypothetical form of energy behind the Universe's accelerated expansion – constitutes the least understood component of the cosmos. It is studied via large galaxy-survey campaigns (both satellite-based and ground-based) that combine spectroscopic, photometric and weak-lensing techniques to reconstruct the growth of cosmic structures.

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.



ESA's Planck satellite mission gave Europe a major role in space-based experiments in this field, while the US leads the way in ground-based experiments. Apart from better precision, the next generation of experiments primarily aims at trying to identify the tell-tale sign of cosmic inflation: the imprint of primordial gravitational waves on CMB polarisation modes.

- *APPEC strongly endorses the proposed European COrE satellite mission to map the CMB from space, and 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 initiation of the Florence CMB Workshop series in 2015.*



Info from Planck: Neutrino # and mass

$$\Sigma m_{\nu} < 0.23 \text{ eV (95\% CL)}$$

$$N_{\text{eff}} = 3.15 \pm 0.23$$

Planck + Lyman alpha

$$\Sigma m_{\nu} < 0.14 \text{ eV (C.L)}$$

Prospects for PLANCK + EUCLID

$$\Delta m_{\nu} \sim 0.03 \text{ eV} \ \& \ \Delta N_{\nu} \sim 0.08$$

final considerations on the APPEC roadmap

- 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**

- An exciting moment in fundamental physics: we have discovered, validated and (still partially) understood two crucial territories of our knowledge - **the SMs of particle physics and cosmology**
- We know that there must exist a **new land** – that of the “physics beyond the SMs” – but we don’t know where it is, what shape it may have → hence we’ve to proceed with **an open mind** and fully **exploiting the synergy of all possible** (and sometime even seemingly **impossible**) **ways to reach it – need for global coordination in our efforts, ex. Global Research Infrastructures**
- No doubt, **ASTROPARTICLE PHYSICS** is one of the most extraordinary ways to proceed in this fascinating journey towards the unknown!