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

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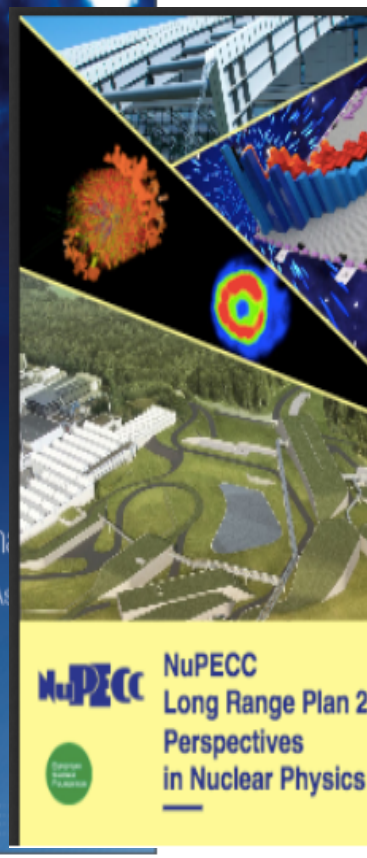
INFN and Univ. of Padova
Chairman of the APPEC General Assembly

European roadmaps in fields of science



APPEC Roadmaps

2008

2011

2017

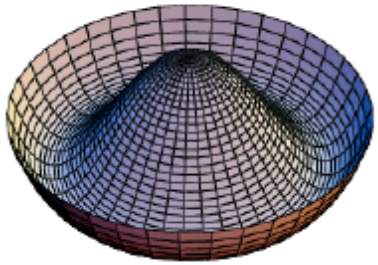
resource aware

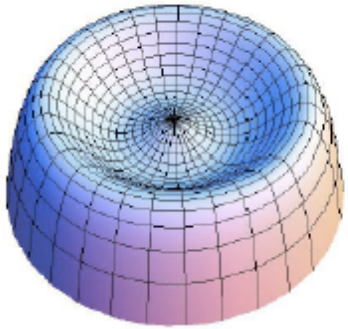
MICRO-COSMOS

- **PARTICLE STANDARD MODEL**

The Higgs boson and the destiny of the Universe

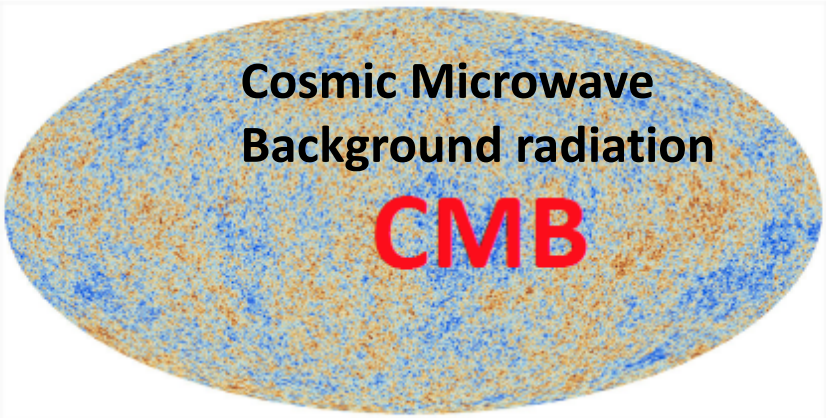
STABILITY ⟺ INSTABILITY

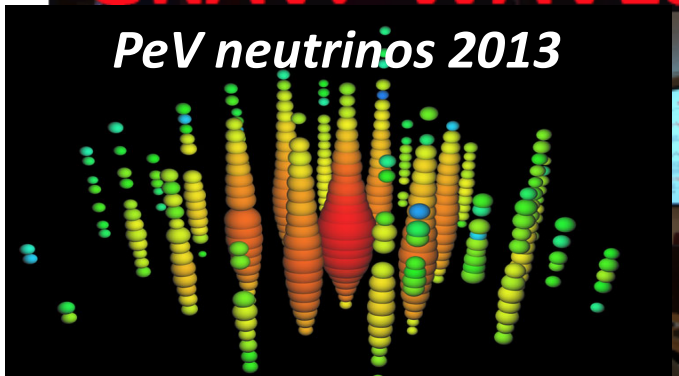




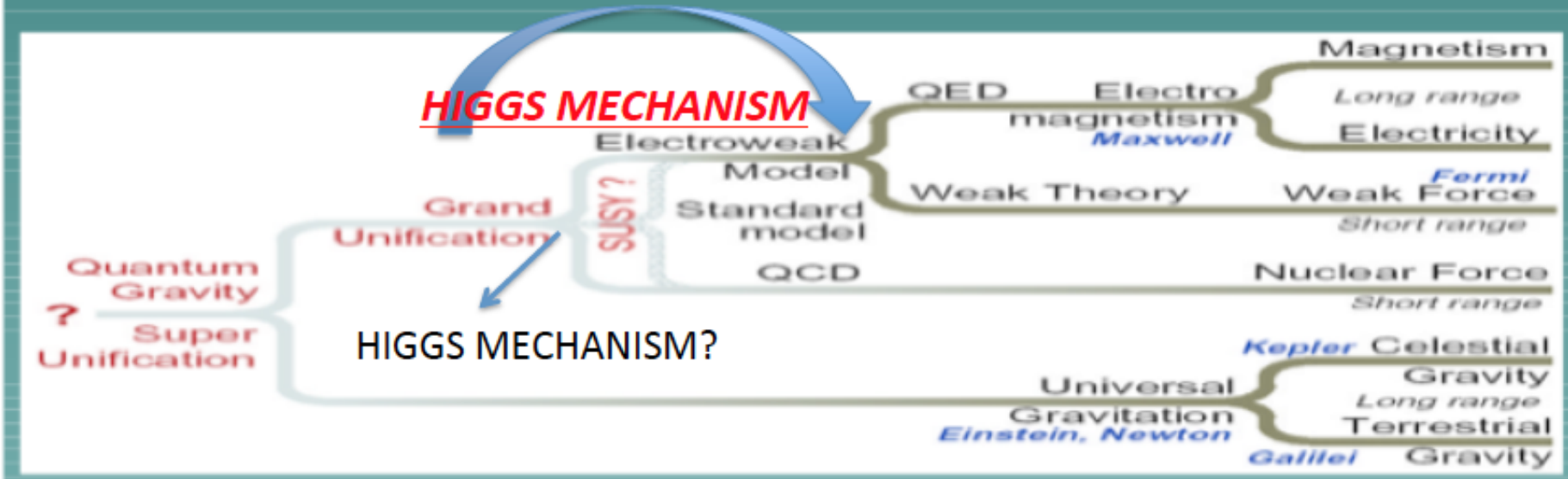
MACRO-COSMOS

- **COSMOLOGY STANDARD MODEL**





Big Bang			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			Astronomia→



Theories:

STRINGS? RELATIVISTIC/QUANTUM CLASSICAL

What the SM does not account for...

neutrino masses
dark matter
baryogenesis
inflation

→ OBSERVATIONAL REASONS

$M_{HIGGS} / M_{PLANCK} \sim 10^{-16}$

$E_{VACUUM}\,(DE) / M_{HIGGS} \sim 10^{-14}$

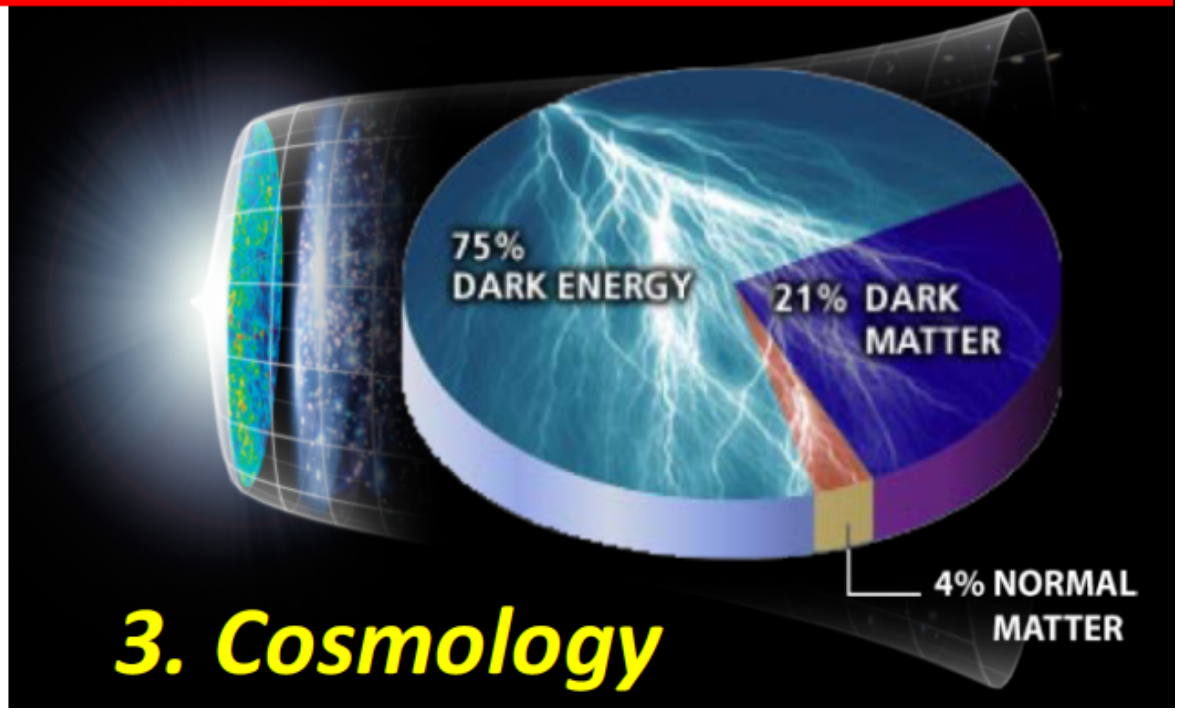
$\Theta_{CPV\ in\ STRONG\ INTERAC.} < 10^{-9}$

→ THEOR. REASON

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

1. High-energy Universe: multi-messengers

2. Neutrino's



3. Cosmology

J. de Kleuver

Promising – *bright* – future ahead!

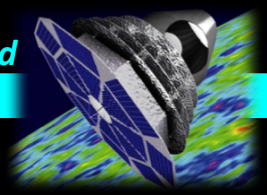
F. LINDE

COSMOLOGY

NEW

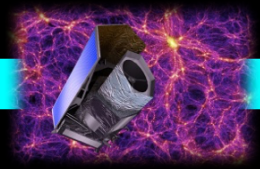
CORE++?
LiteBIRD

+ ground-based



CMB

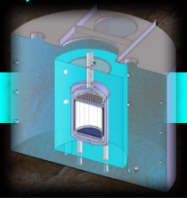
DESI, LSST
Euclid



DE

multi-ton
argon/xenon

+ other technologies



DM

2016 2018 2020 2022 2024 2026 2028 2030 2032 2034

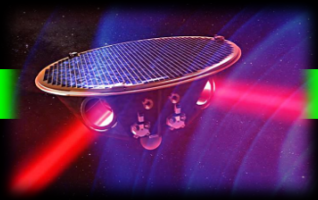
1t 0νββ
JUNO, ...
DUNE/HK

+ direct ν-mass ...

neutrino

ν

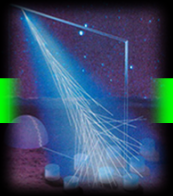
AdvVirgo/LIGO+
ET
LISA



GW

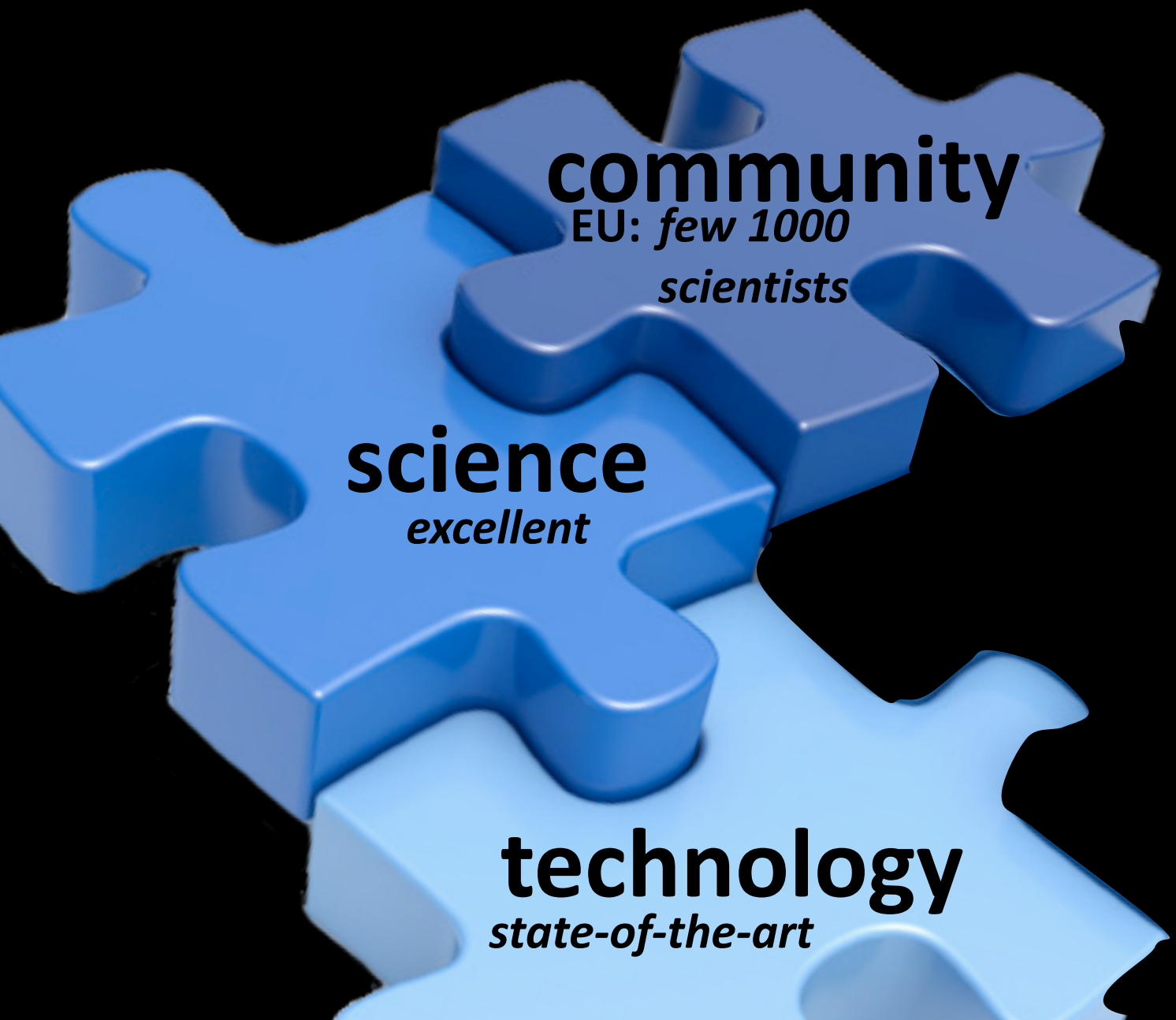
HEU

AugerPrime, TA
CTA
Icecube, KM3NeT, GVD

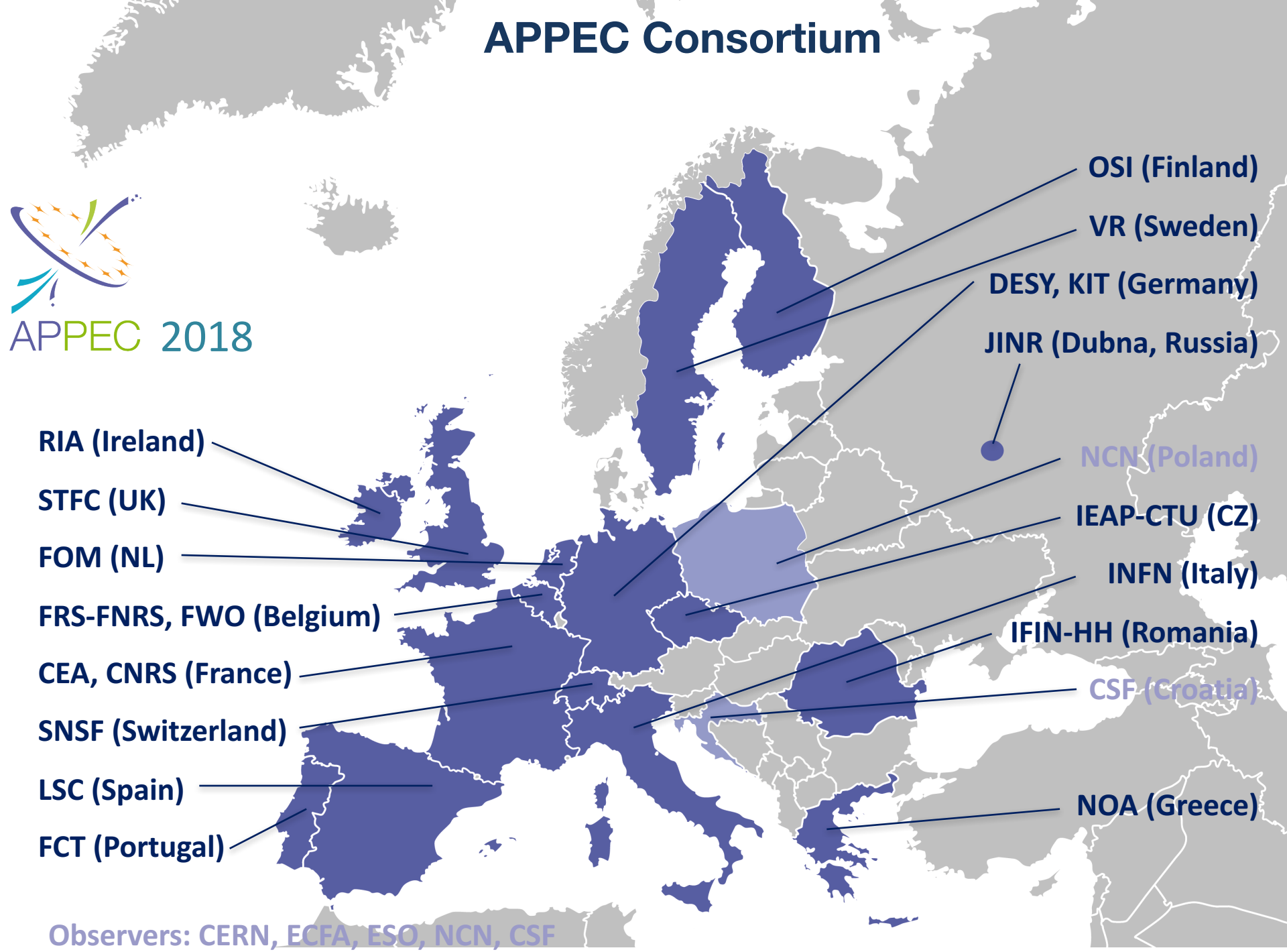


HE CR-, γ-, ν-observatories

Crucial ingredients



APPEC Consortium



APPEC 2018

Observers: CERN, ECFA, ESO, NCN, CSF

http://www.appec.org/roadmap

Scientific issues – 13×

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

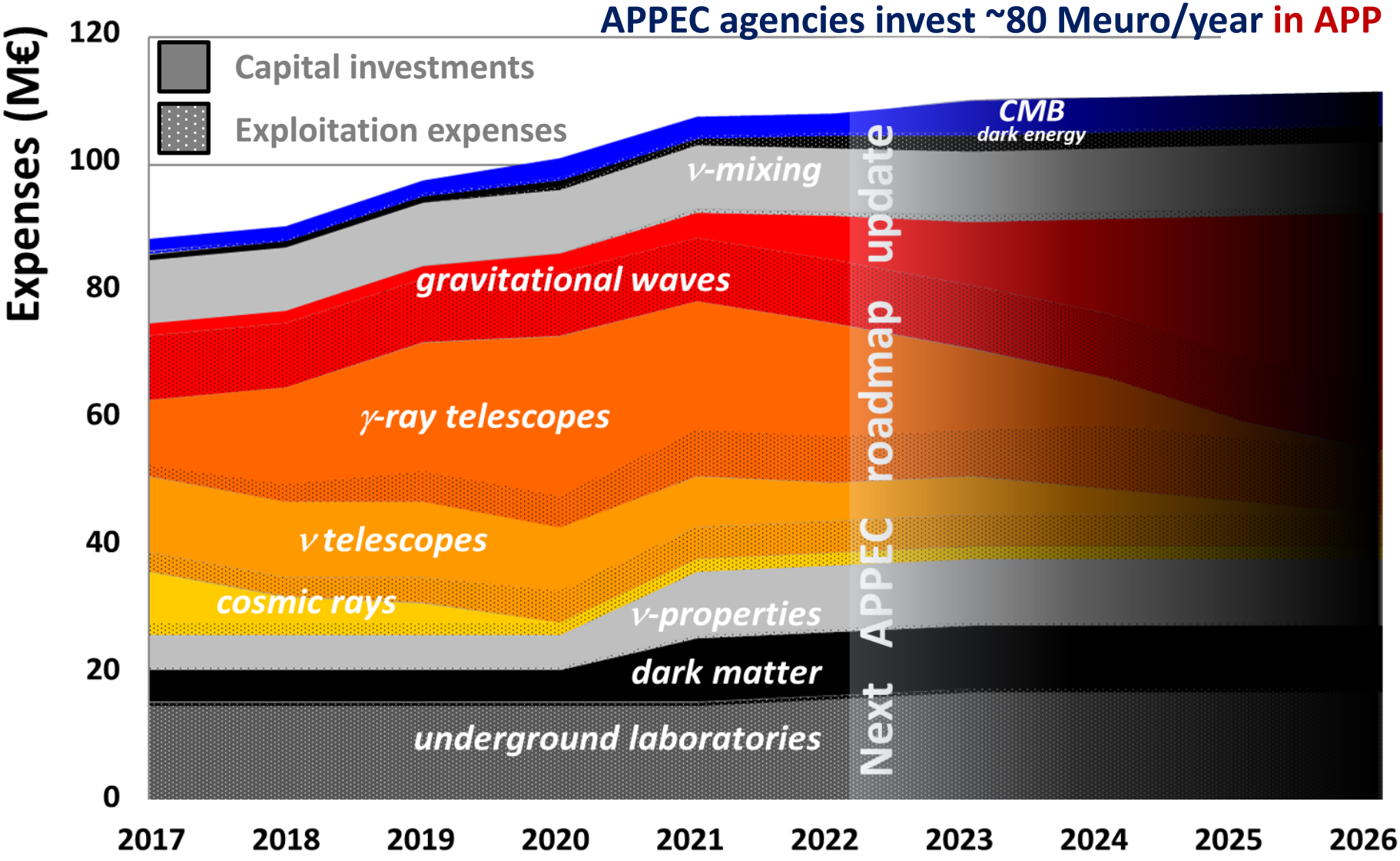
Organisational issues – 5×

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

Societal issues – 3×

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

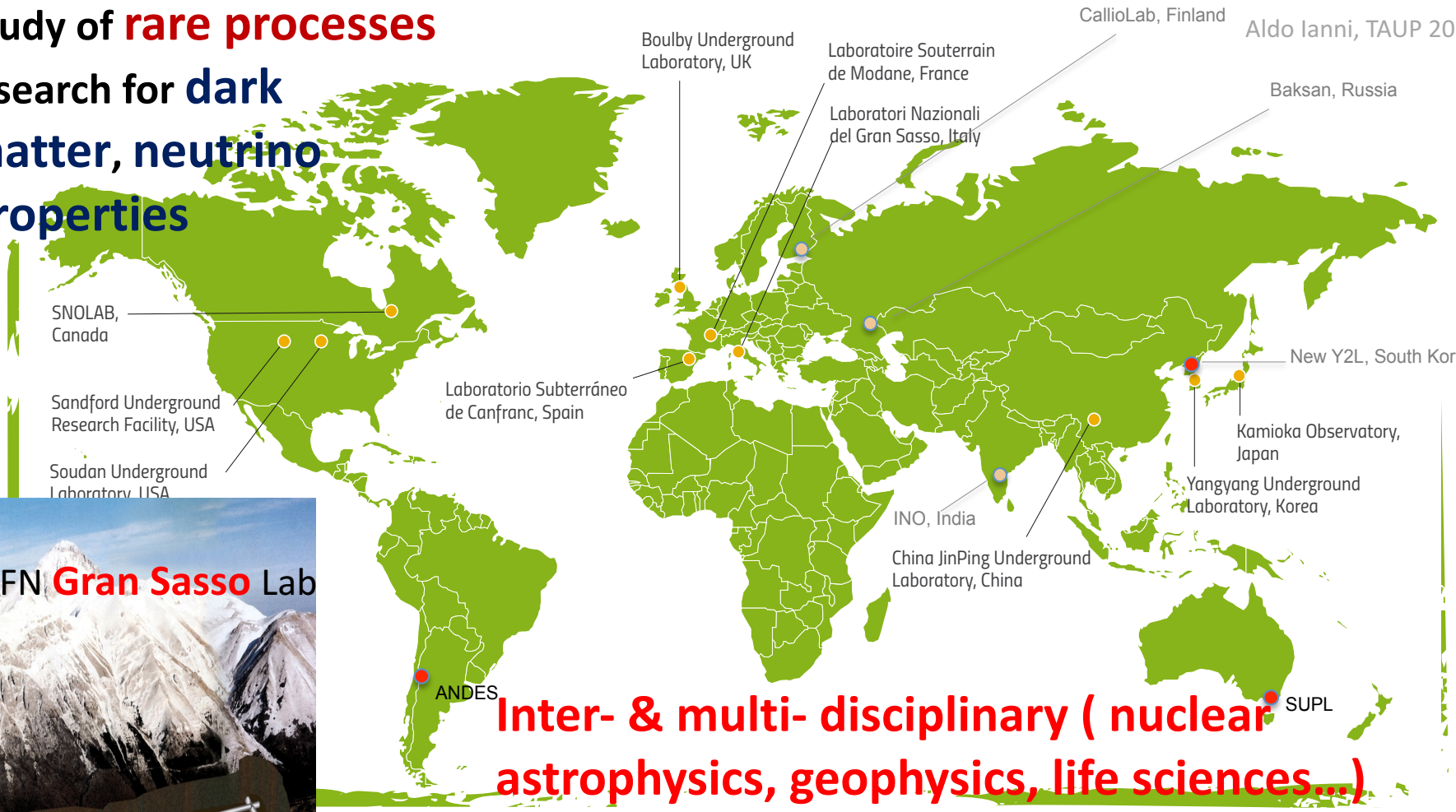
APPEC's 2017 strategy …



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

DEEP UNDERGROUND LABs

Study of rare processes – search for dark matter, neutrino properties



Inter- & multi- disciplinary (nuclear astrophysics, geophysics, life sciences…)

Surface: 17 800 m^2

Volume: 180 000 m^3

Worldwide largest underground lab in operation with easy accessibility

Challenges for next DM, ββ frontiers; Challenges for LNGS

- Attack and cover the IH region → 1-ton neutrinoless ββ
- WIMPS DM : Reach the neutrino background → n-ton (**n = 50 -200** ?

LNGS → largest ultra low-background facility …

LNGS → 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 → towards a GLOBAL COORDINATION (GRI – Global Research Infrastructure

Dark Matter

APPEC

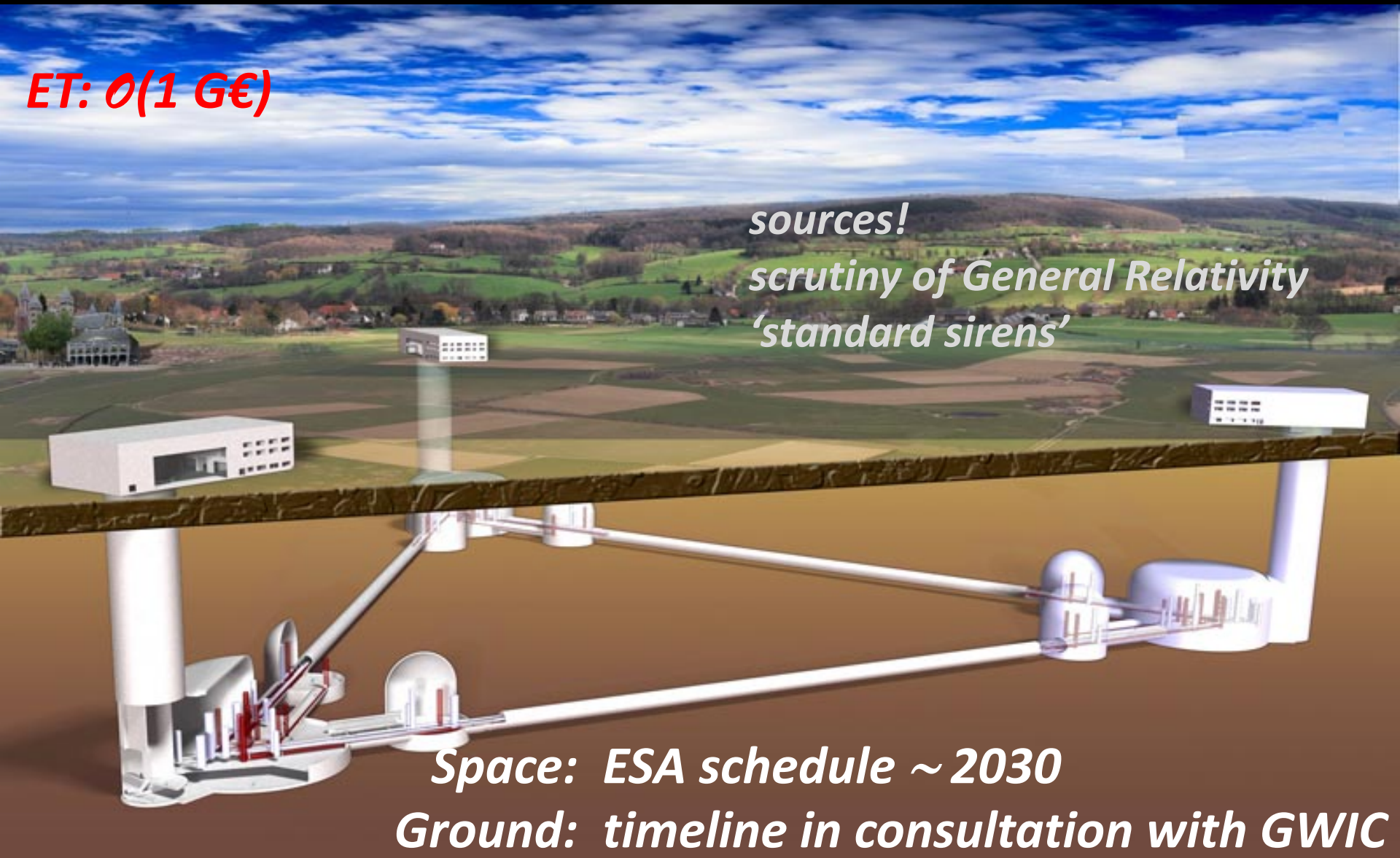
Elucidating the nature of Dark Matter is a key priority at the leading tip of astroparticle physics.

For masses in excess of a few GeV, the best sensitivity to WIMPs is reached with detectors that use ultra-pure liquid noble-gas targets; **such detectors include XENON1T (using 3.5 tons of xenon) and DEAP (using 3.6 tons of argon), which both started operating in 2016. Their sensitivity can be further enhanced by increasing the target mass. A suite of smaller-scale experiments is exploring, in particular, low-mass WIMPs and other Dark Matter hypotheses such as those based on dark photons and axions.**

Gravitational waves – *LVC, ET, LISA*

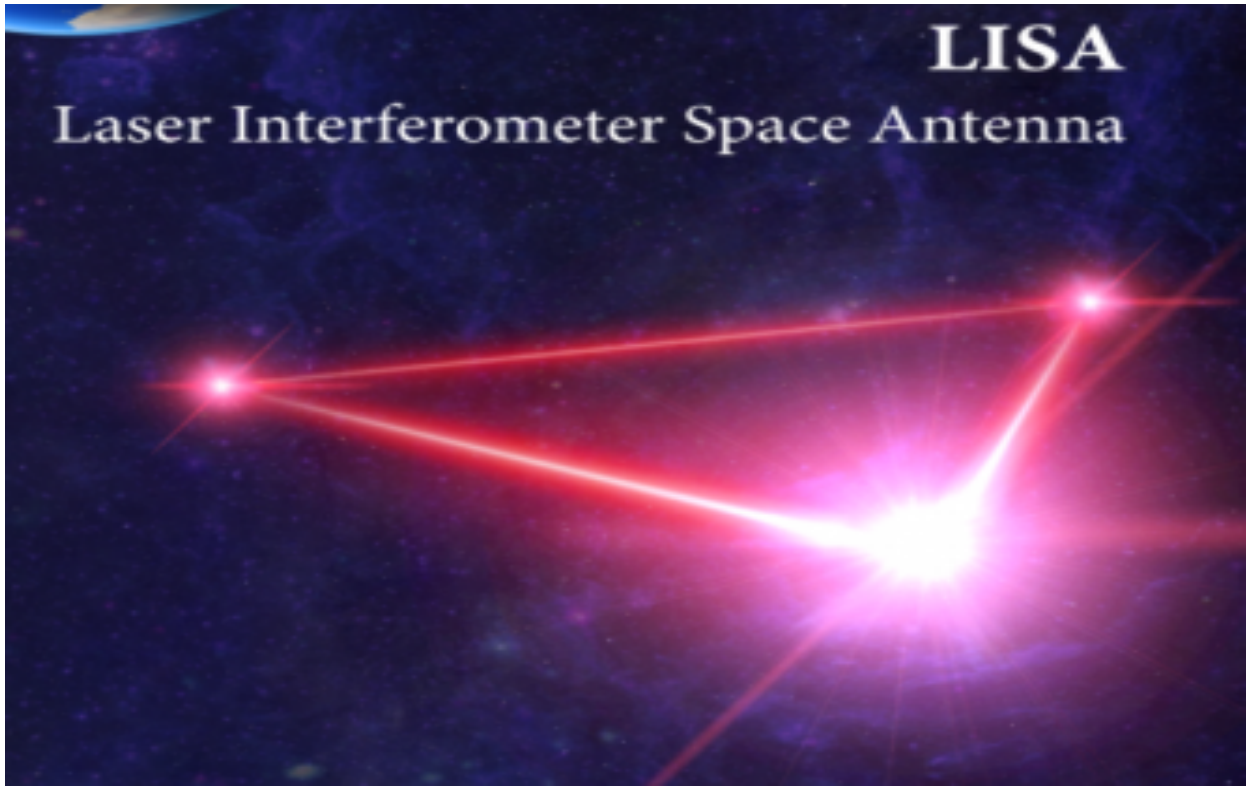
surface, underground, space GW interferometers

Interested EU-countries: many



APPEC and Gravitational Waves

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



High-energy neutrinos – *KM3NeT/Icecube*

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

KM3NeT: O(200 M€)

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

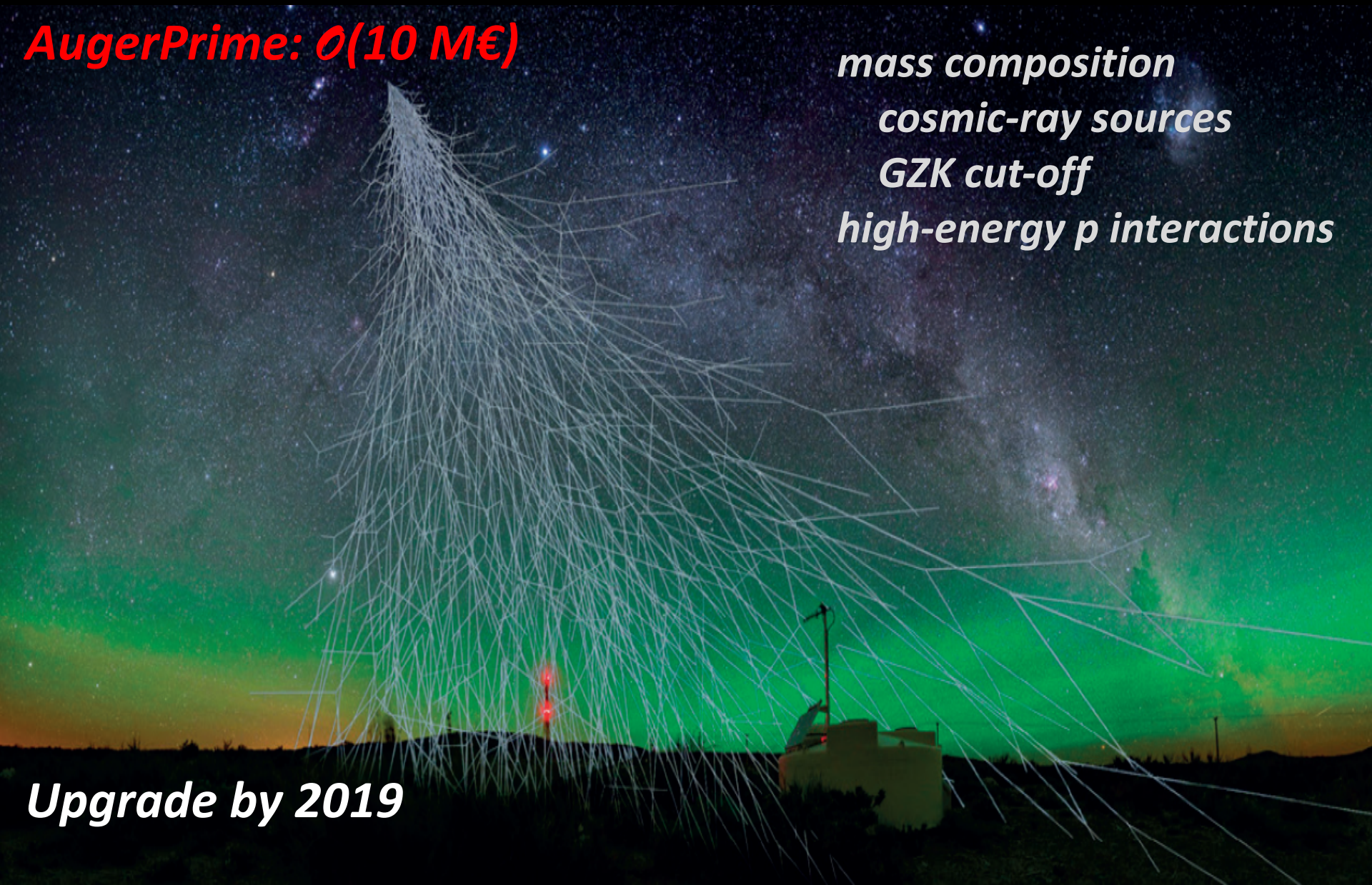
For the northern hemisphere (including Baikal GVD), APPEC strongly endorses the KM3NeT collaboration's ambitions to realise, by 2020: (i) a large-volume telescope with optimal angular resolution for high-energy neutrino astronomy; and (ii) a dedicated detector optimised for low-energy neutrinos, primarily 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

High-energy cosmic-rays – *AugerPrime*

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



AugerPrime: O(10 M€)

mass composition
cosmic-ray sources
GZK cut-off
high-energy p interactions

Upgrade by 2019

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**

Particle Physics community involvement in the astroparticle strategy

- **2 → 3**: **the BSM threefold way** [**the two traditional particle physics roads** (energy and intensity frontiers) **+** the **astroparticle road**] → more and more **from a virtual to a realistic (necessary) way of proceeding to explore BSM**

- **CERN and APP future**: the study, development and running of **astroparticle research infrastructures** [**neutrino physics** (LBN), **DM** (Argon technique), **GW** (Einstein Telescope)] **would strongly benefit of a major presence** (**technological support, more direct involvement**) **of the particle physics community.**