IPPOG Workshop high school cosmic ray experiments,
Centro Fermi, Rome, Feb. 15, 2017

AstroParticle Physics European Consortium

Antonio Masiero – chair of APPEC

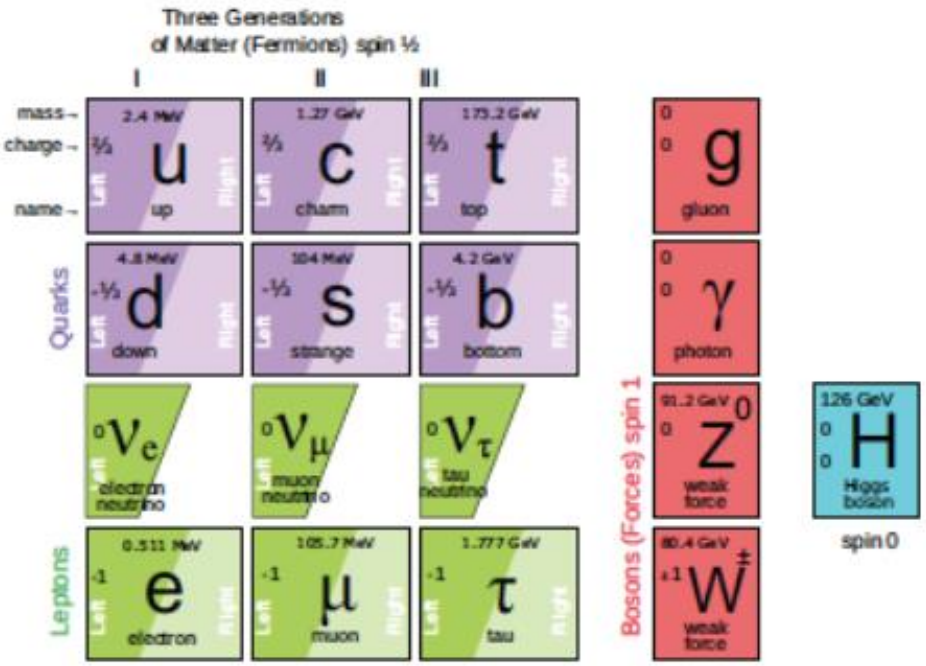
INFN and Univ. of Padova

- 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.]

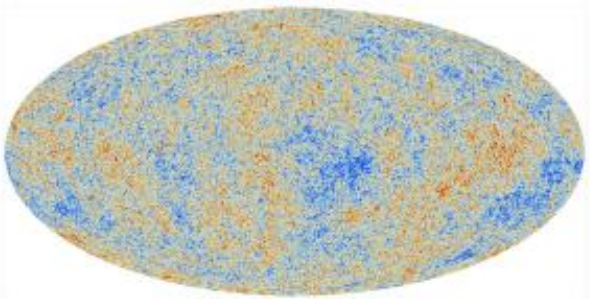
D. Gross 2007

2013 – 2016 : the triumph of the STANDARD

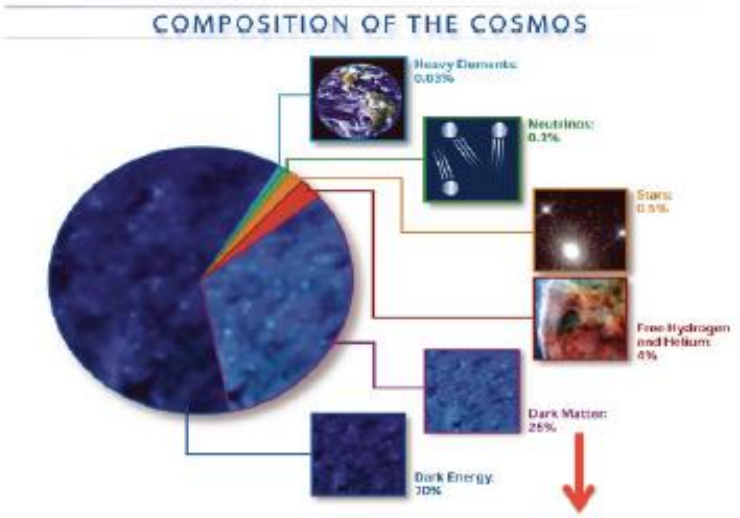
- **PARTICLE STANDARD MODEL**



- **COSMOLOGY STANDARD MODEL**

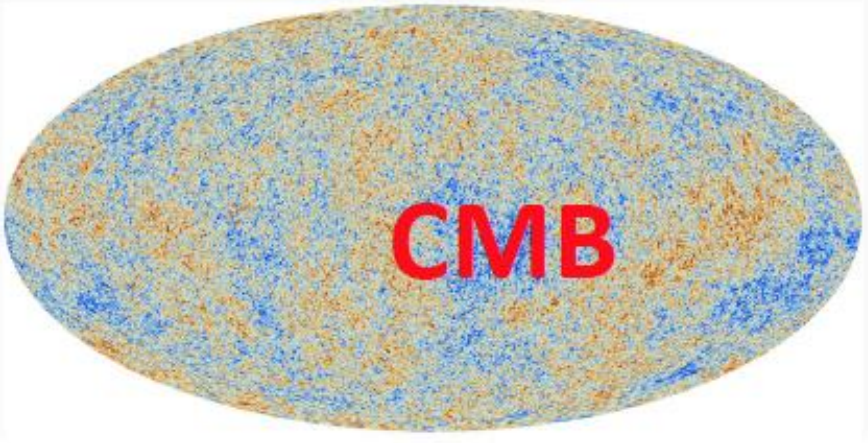


ΛCDM + "SIMPLE" INFLATION



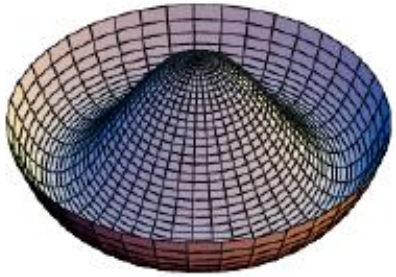
- **PARTICLE STANDARD MODEL**

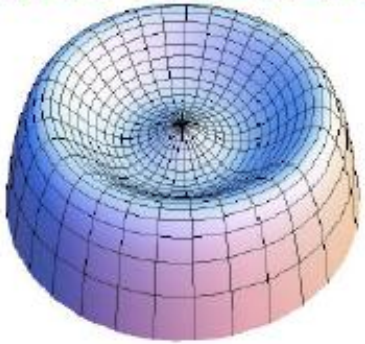
- **COSMOLOGY STANDARD MODEL**



The Higgs boson and the destiny of the Universe

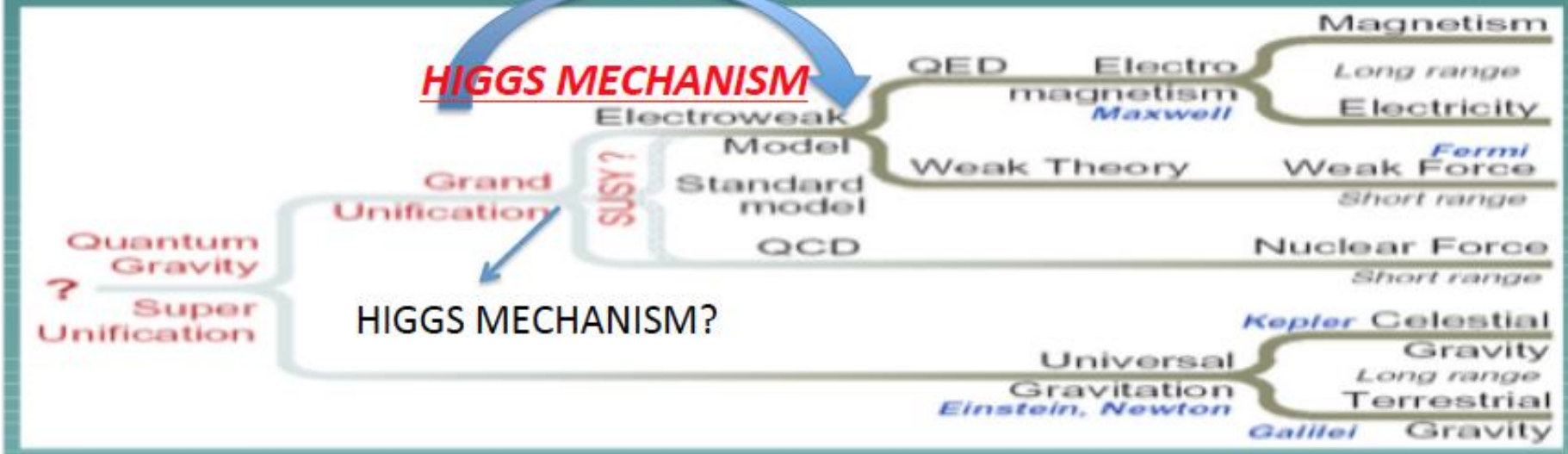
STABILITY ⟷ INSTABILITY





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			Astronomia→



Theories:

STRINGS? RELATIVISTIC/QUANTUM CLASSICAL

MICRO

GWS STANDARD MODEL

MACRO

HOT BIG BANG STANDARD MODEL

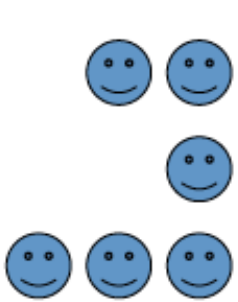
UNIVERSE EXPANSION +
WEAK INTERACTIONS **NUCLEOYINTHESIS**
1 sec. after BB

NUMBER OF BARYONS and OF NEUTRINO SPECIES → CONFIRMED FROM CMB **350000 YEARS** AFTER BB

Independent confirmation from the study of the CMB

BUT ALSO

FRICTION POINTS



-COSMIC MATTER-ANTIMATTER ASYMMETRY

-INFLATION ???

- DARK MATTER + DARK ENERGY

OBSERVATIONAL EVIDENCE OF NEW PHYSICS

BEYOND THE STANDARD

APPEC: *organisation*

S. KATSANEVAS at the
IN2P3 CS, Feb. 2-3, 2017

AstroParticle Physics European Consortium

GENERAL ASSEMBLY

Chair: A. Masiero (INFN)

General Secretary: Job De Kleuver (FOM)

Scientific Advisory Committee *+ CERN ESO*

APPEC *functional centers*

APC - Paris/F
Roadmapping, Common Calls, Interdisciplinary

DESY - Hamburg/D
Management, Computing & Industry

LNGS - L'Aquila/I
Networking, Theory, Graduate Schools

Coordination 2001-2006
ASPERA 2006-2012
Consortium 2012-....

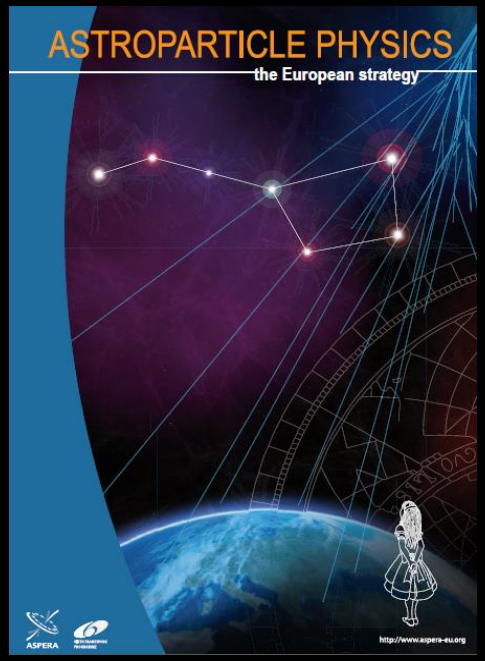
Outreach, Web pages

STFC – Swindon/UK

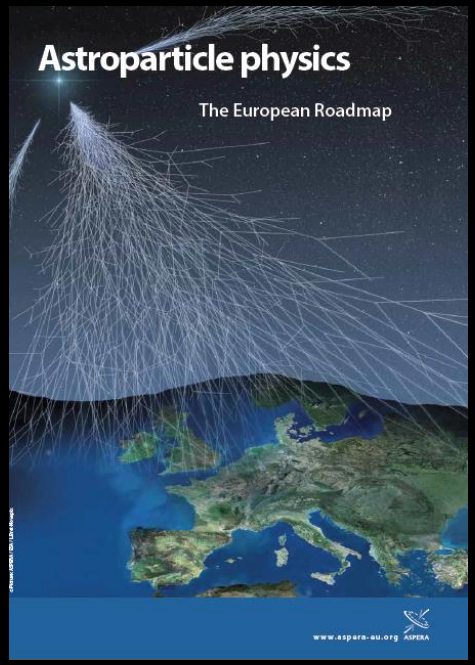
APPEC: *roadmapping*

From the Nature article

2008



2011



Magnificent 7

1. ***HE gammas***
2. ***HE neutrinos***
3. ***HE cosmic rays***
4. ***Gravitational waves***
5. ***Dark matter***
6. ***ν-mass***
7. ***ν-mixing & p-decay***

CMB

Dark Energy

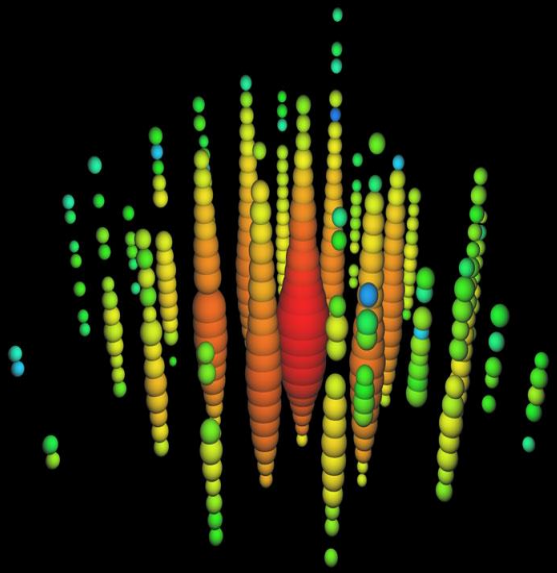
S. Katsanevas

nasty comment:

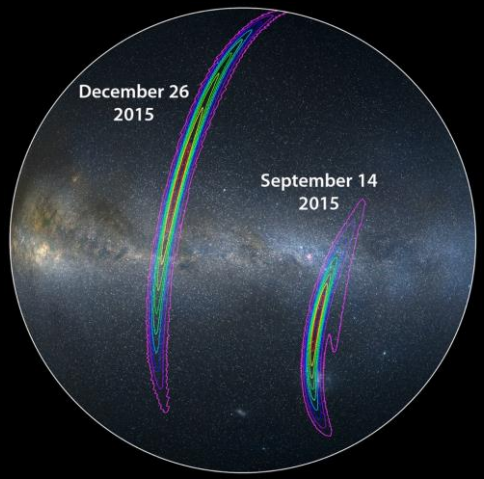
But… at least 4 -5 domains have not seen a signal yet

Well 2 of the domains have detected a signal in the first 3 years

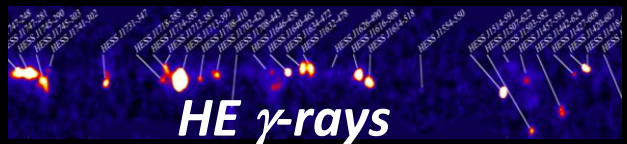
PeV neutrinos 2013



GW1509-2014



The search of point sources for HE cosmic-rays, neutrinos and GW (better pointing) ongoing

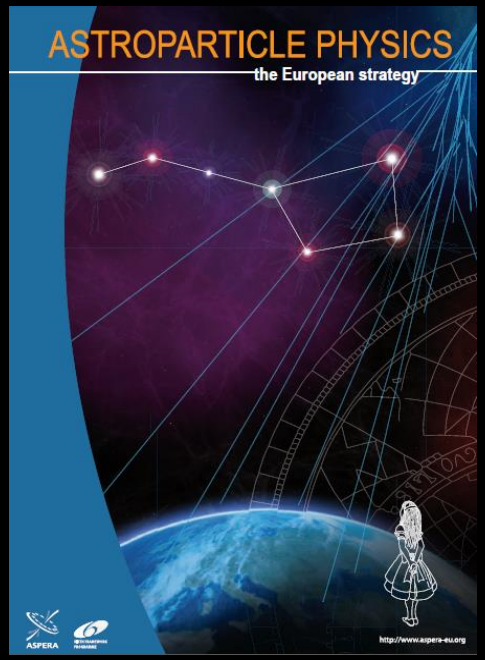


S. Katsanevas

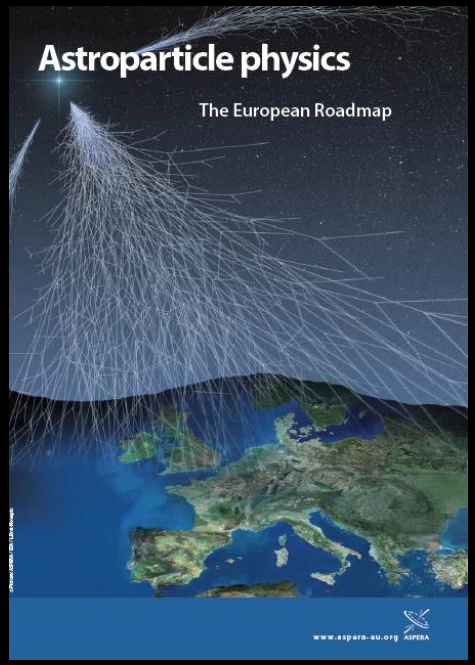
APPEC: *roadmapping*

S. Katsanevas

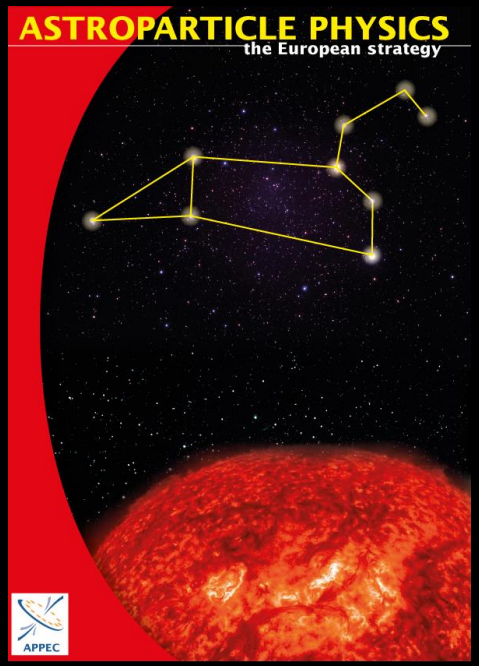
2008



2011



2017



resource aware

European Strategy for Astroparticle Physics
4 domains

S. Katsanevas

i. ***Extreme Universe***: *What can we learn about the cataclysmic events in our Universe by combining all messengers?*

ii. ***Dark Universe***: *What is the nature of Dark Matter and Dark Energy?*

iii. ***Neutrinos***: *What are the intricate properties of neutrinos and what can they tell us?*

iv. ***Early Universe***: *What else can we learn about the Big Bang from the cosmic microwave background?*

- *Two emergent characteristics of the present era :*

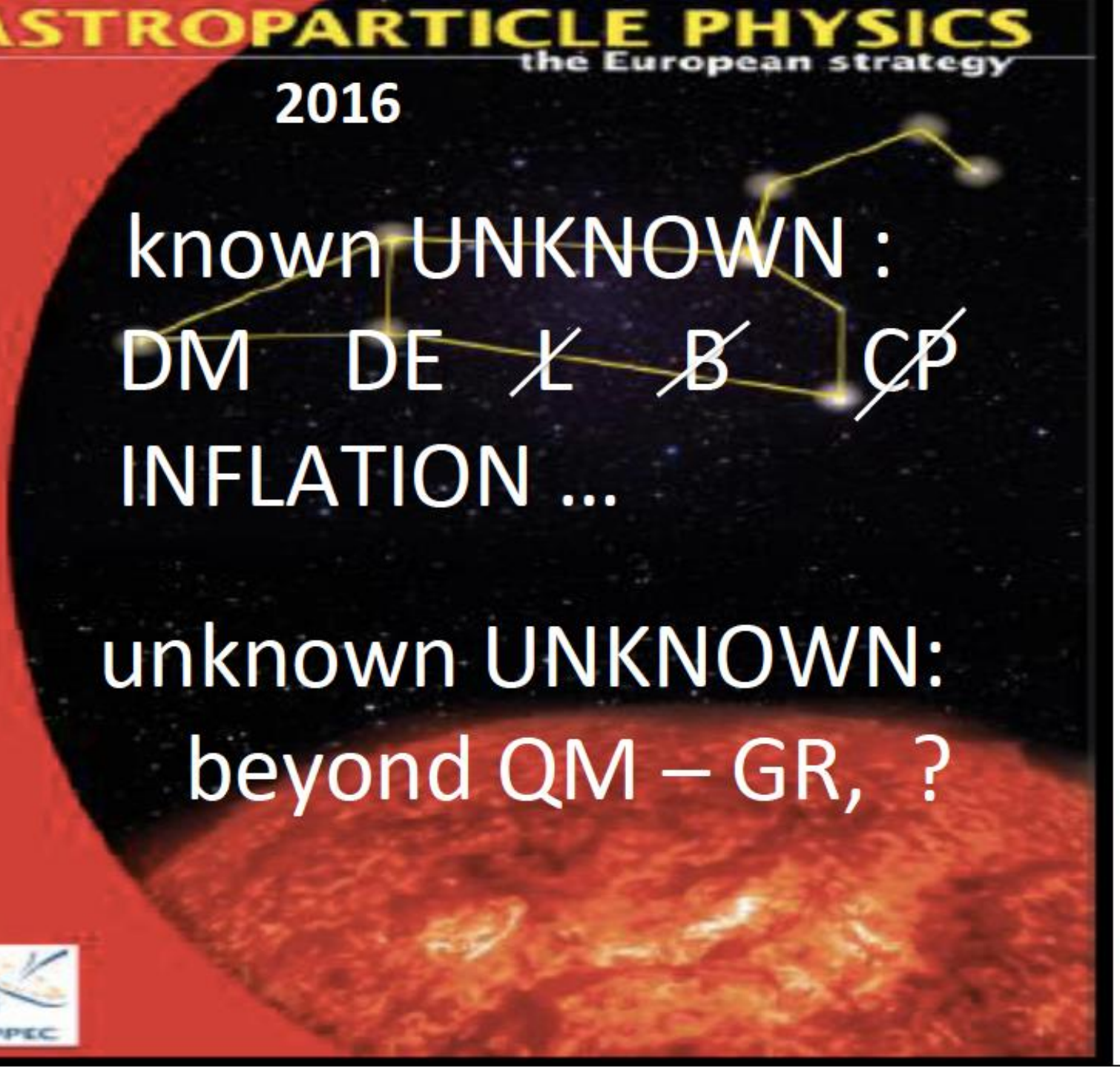
I. *We are at the* ***edge of multi-messenger detections involving high energy photons, neutrinos, high-energy charged particles and gravitational waves****, that will give us a deeper understanding of violent phenomena regulating structure formation in the Universe as well as eventually hints for new laws of physics*

II. *The visible Universe from the* ***CMB*** *to the present started to provide comparable constraints to the* ***standard models of cosmology*** *(inflation, dark energy)* ***and particle physics*** *(neutrino, dark matter)*

ASTROPARTICLE PHYSICS

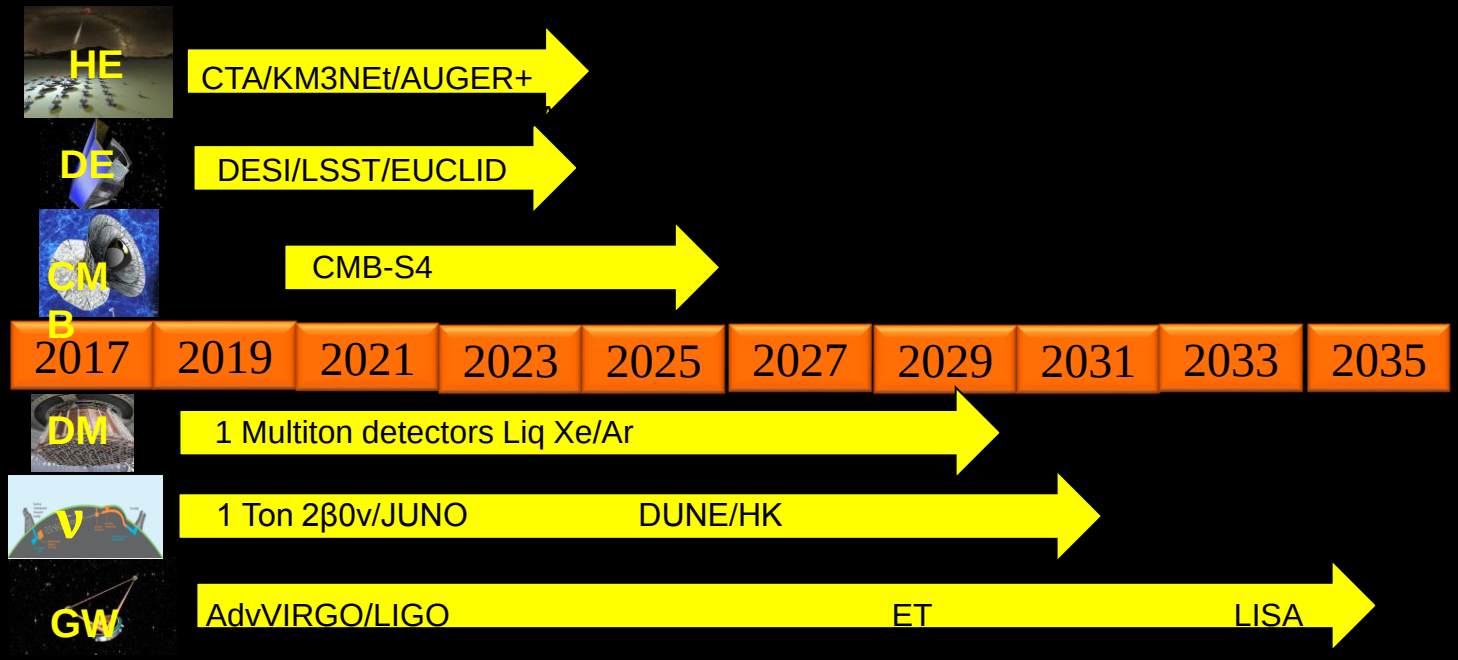
the European strategy

2016



APPEC

Astroparticle Physics and Cosmology the next 20 years



The importance of being **SMALL**

My recommendation: beware the temptation of going ONLY for LARGE enterprises

The protective shield of large, Big Science: too big to fail!

Richness of small, “unorthodox” projects based more on clever ideas than on muscular, managerial strength!

APPEC roadmap: Education & Outreach

- *Given the rapid expansion of the astroparticle physics field,* ***APPEC encourages*** *(e.g. in cooperation with the International Particle Physics Outreach Group)* ***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****.*

Conclusions

- **In the last 30 years**, we have seen
  - the detection of Supernova 1987A and the Crab in HE γ 1989
  - 3 major paradigm-changing discoveries in the 90's
    - CMB fluctuations
    - Confirmation of neutrino oscillation and mass
    - Dark energy
  - In the 2010's Gravitational waves
- The longest series of Nobel prizes for an emerging domain

- **Bright expectations for the next 10-20 years**:
  1. The development of **multi-messenger astronomy**
  2. **Dark matter** sensitivities close to the parameter limits of our current theories, and ultimate precisions measurements in **inflation and dark energy,**
  3. A determination of the **neutrino masses, number and CP violation and their interplay with cosmology**

BACK-UP SLIDES

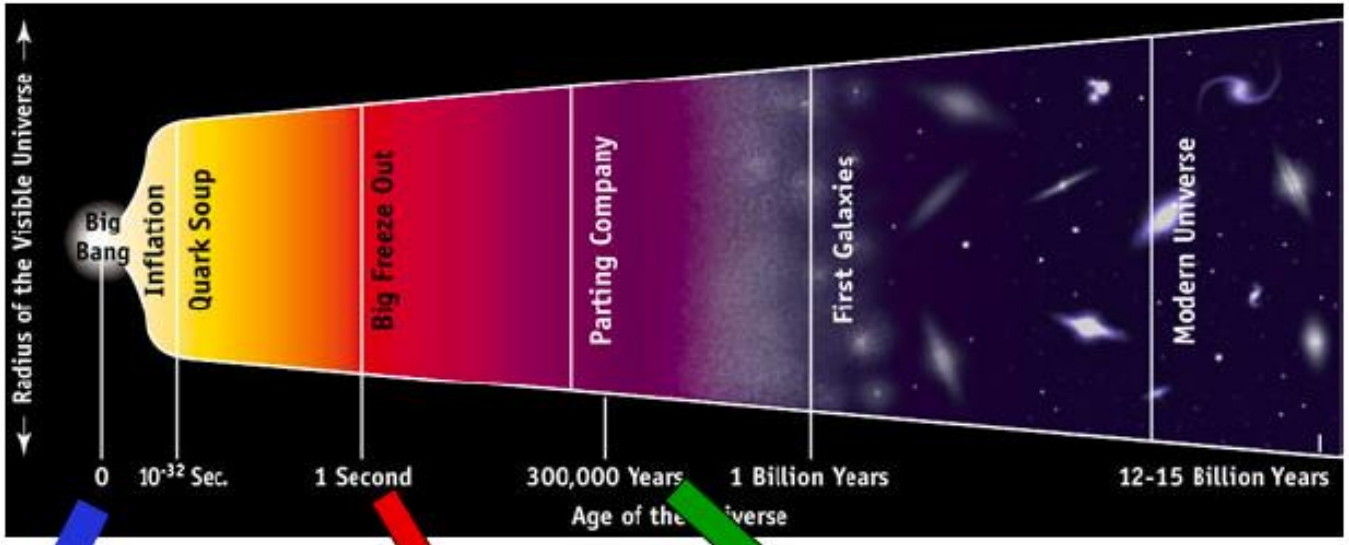
the two Standard Models are an extraordinary step forward in our knowledge of the Universe:

but, beware, Nature is rich of "unknown unknown"

→ after all Physics had already produced a "comprehensive, fundamental theory of all observed forces of nature" at the end of the XIX century…

Maybe the DM and the DE mysteries could represent the XXI century black-body and photoelectric problems

Relic Stochastic Background



Relic gravitons

Relic neutrinos

CMBR

- Imprinting of the early expansion of the universe
- Correlation of at least two detectors needed