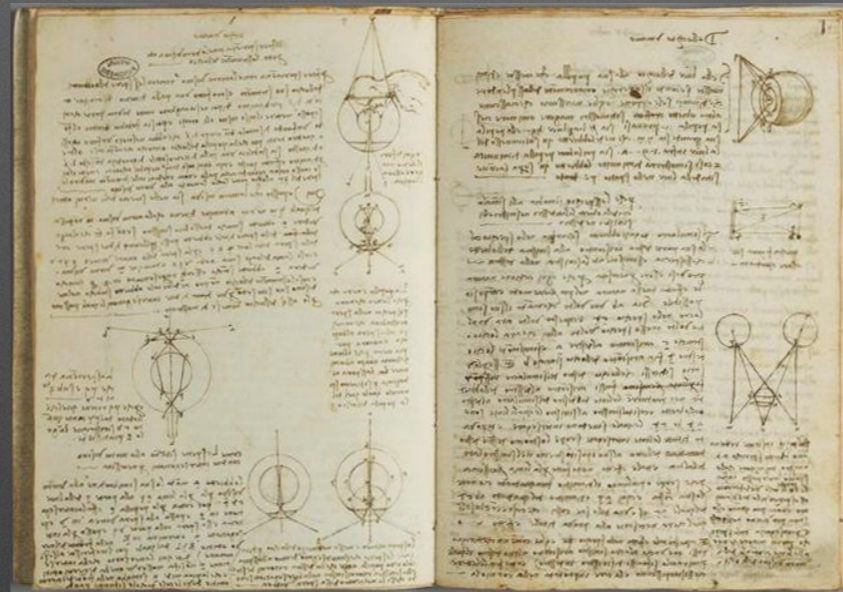


# Europe role in a global adventure

## A purely personal reflection

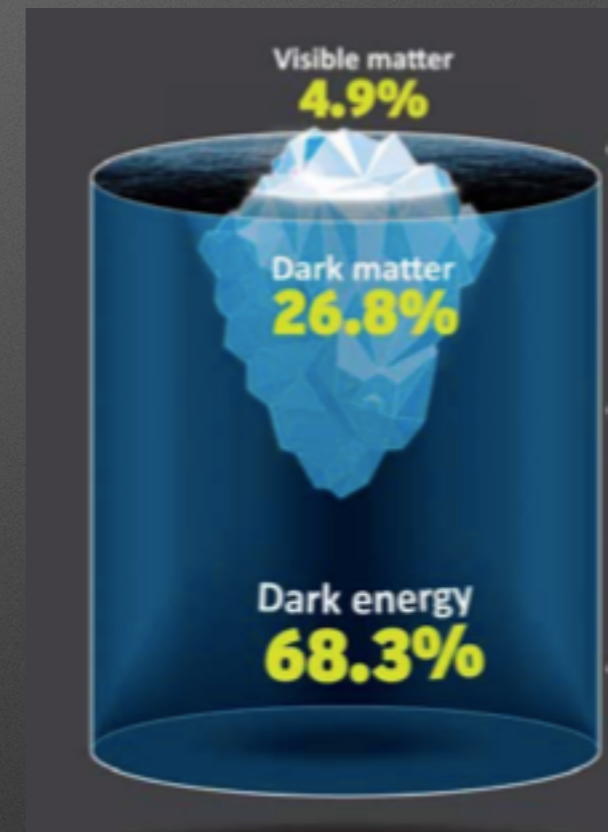


Fernando Ferroni  
Gran Sasso **Science** Institute & INFN



# The questions

- What our universe is made of ?
- Why had we a chance to be here ?



# The way to answer

- smashing particles
- listening to the voice of the universe

# The key to success

- Combining particle physics, astroparticle physics, astrophysics, cosmology
- an intellectual grand unification

# How Europe shall contribute

- Preserve its extraordinary successful laboratory - CERN- and designing the best possible future for it
- develop a coherent plan for contributing to the uproarious field of astroparticle physics

# Key words

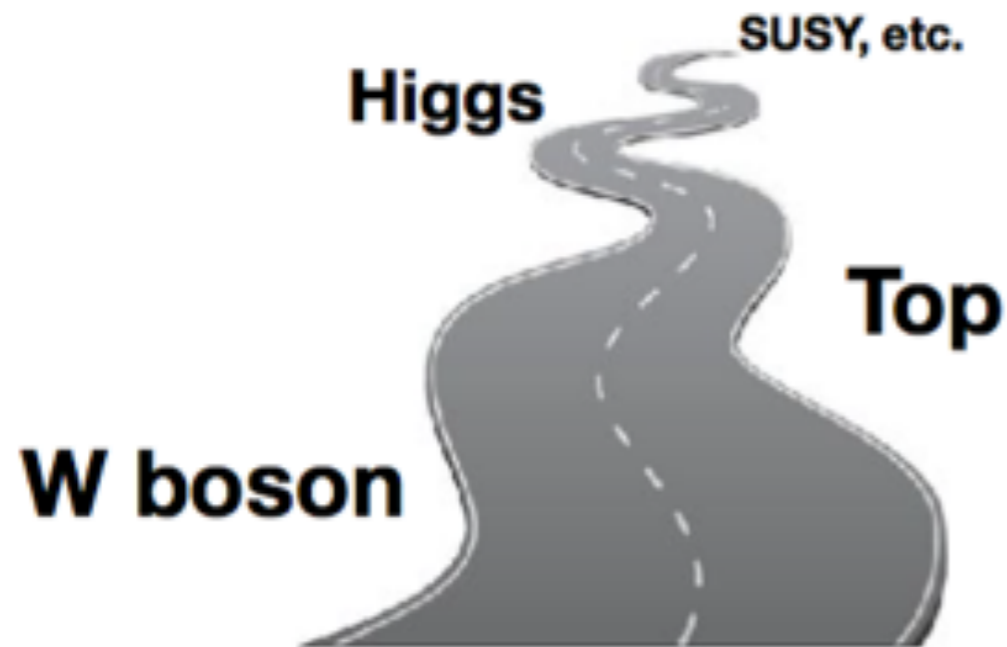
- Energy frontier
- Dark world
- Multimessenger physics

# Smashing particles

- LHC now (until sometime in the 30's)
- what next ?

# No input to take the decision Neither now nor next

**HEP before the LHC**



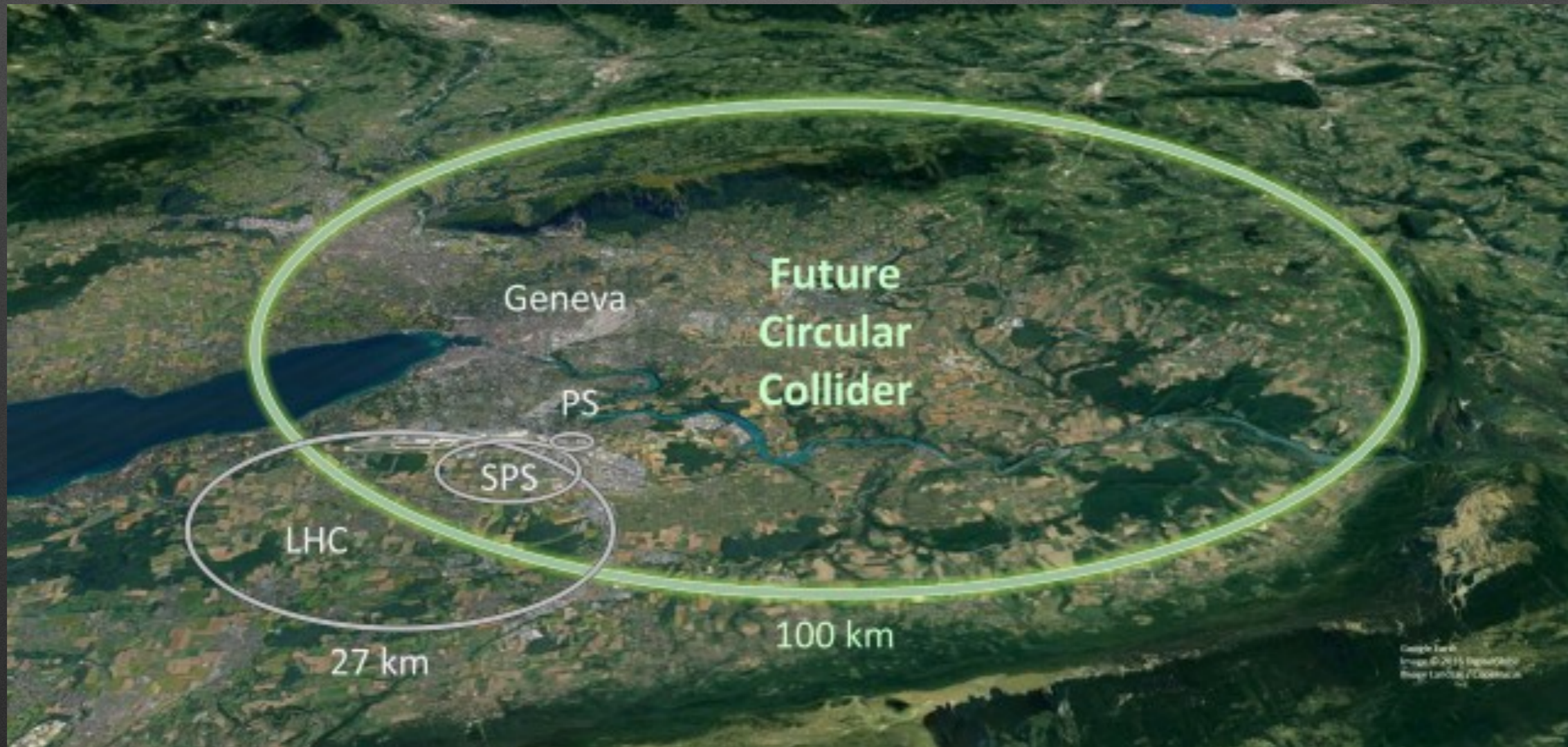
**HEP before the F.C.**



No way out, challenge the open sea



# CERN future (in my mind)



# the ideal way forward (amongst the many options)

- Find the money for the 100 km tunnel
- Hope that Asia take the challenge of the  $e^+e^-$  machine
- Fill the tunnel with 'degraded' and 'cheap' LHC dipoles
- Push the energy frontier to '45 +/-5 TeV'
- So that....

# in 20 years from now

- we will be studying the Higgs properties
- we will push the search for direct discover BSM physics

# and....

- skipping the 'extremely expensive and extremely difficult' step of 16 T Nb<sub>3</sub>Sn magnets
- we might concentrate on HTS technology (much requested from the market)
- so that the following round will be a machine at an energy in excess of 100 TeV

# I know the objection

- how can we justify the cost in front of politicians ?
- my answer is a mix of different elements:



**Preservation of leadership  
in this field by Europe**

CERN has gathered a  
community of 10k people  
No other machine could  
keep them at work

**developing HTS technology**

# However R&D on accelerator is also a must

- we need a revolution (sooner or later, better sooner)  
like the one of B. Touschek with AdA

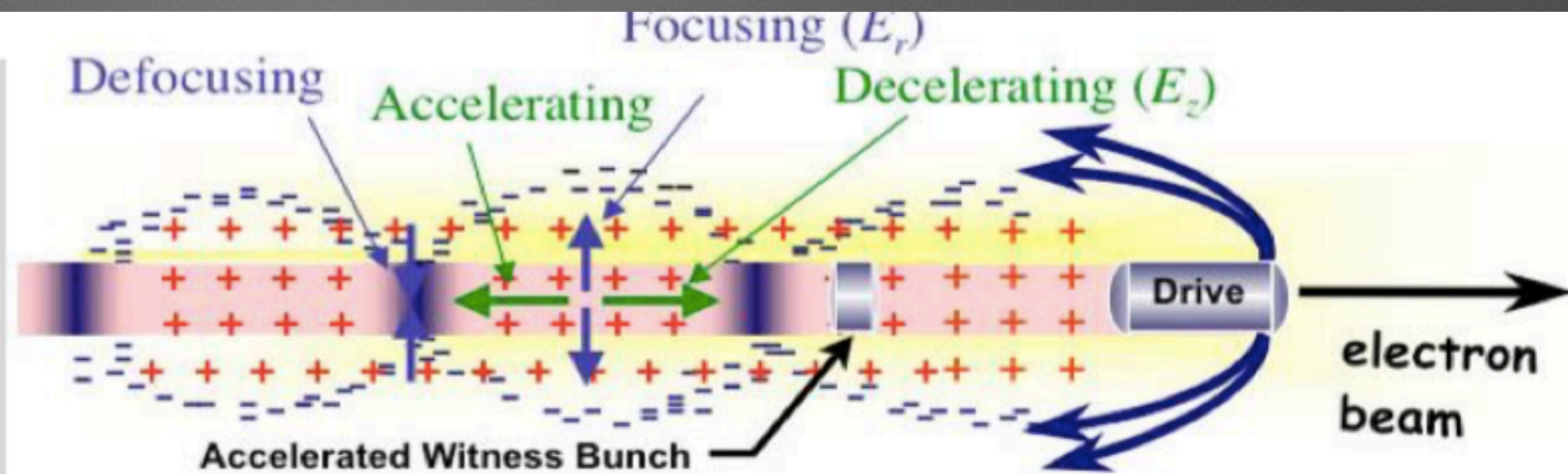
# PWFA

## Global effort

Mainly replace the main linac of linear colliders with novel technology acceleration

Plasma acceleration achieves very high gradients ( $> \text{GV/m}$ )

- Powered with beam or laser

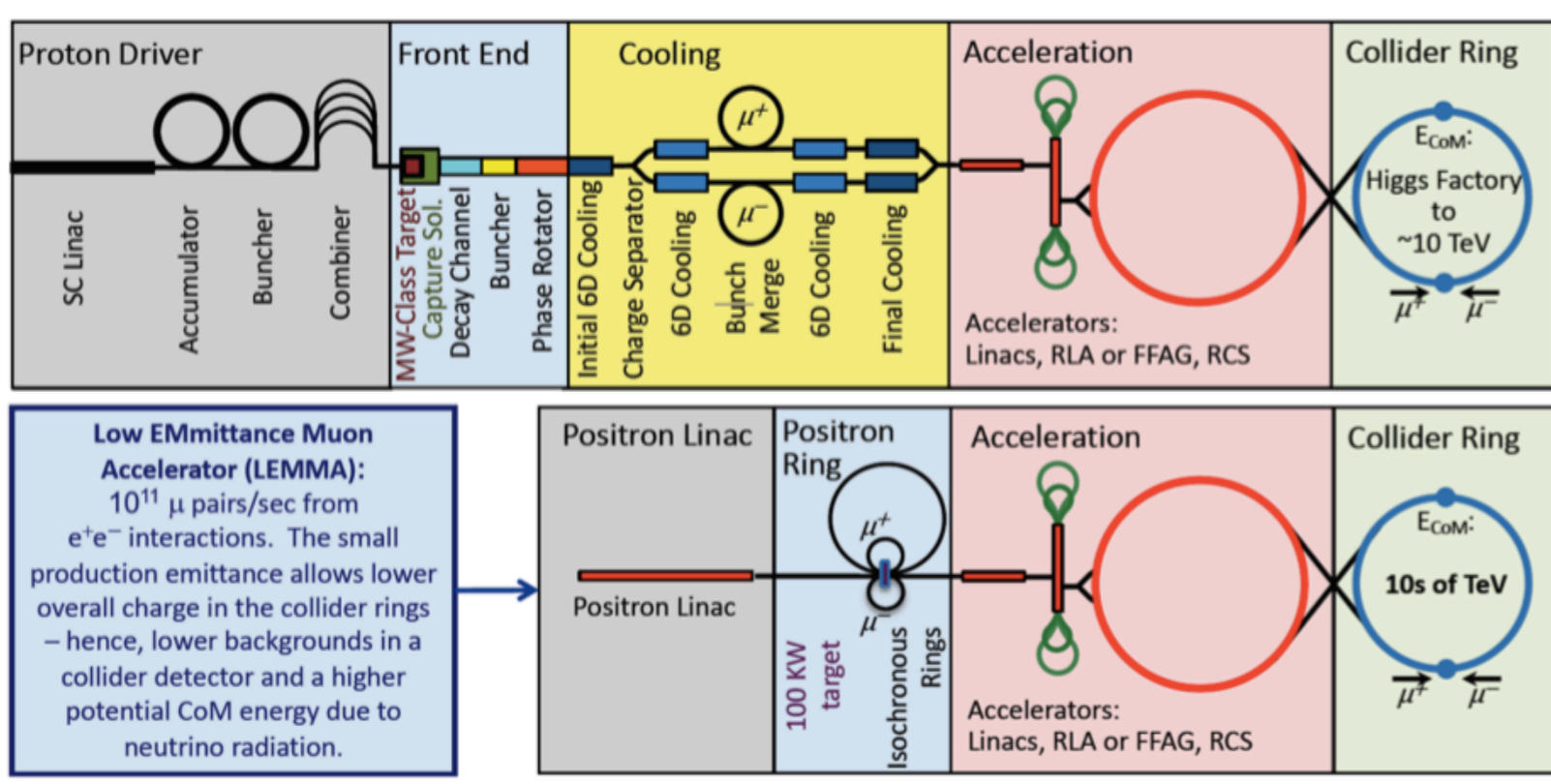


The EuPRAXIA Research Infrastructure:  
A Required Intermediate Step Towards Plasma Accelerators  
for the Energy Frontier

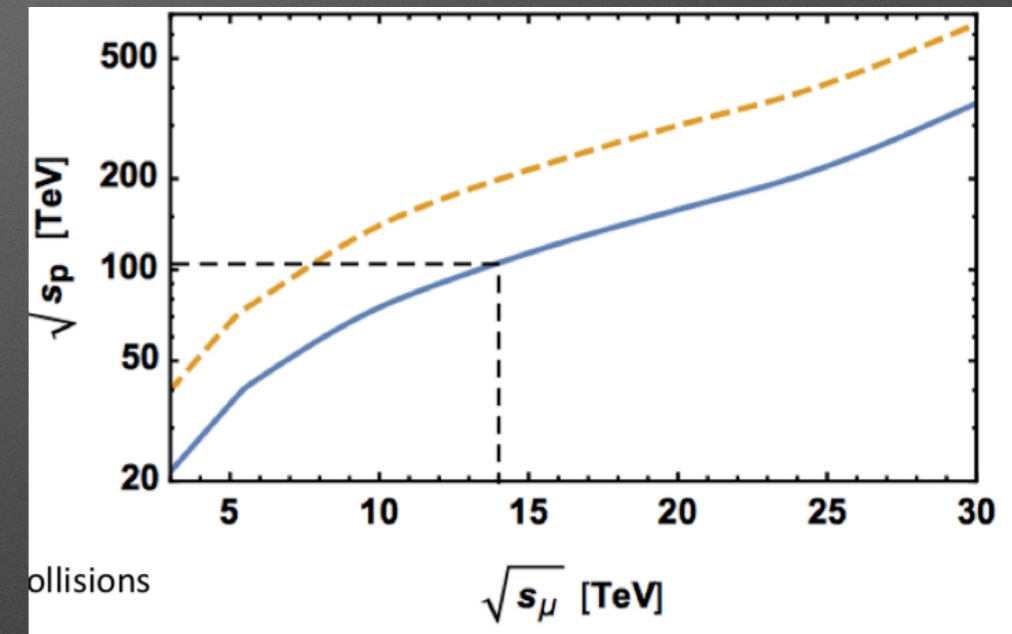
The road to colliders passes through first applications that need compact accelerators:

- Early HEP applications, FELs, Thomson scattering sources, medical applications, injection into next generation storage rings ...

# Muon Collider

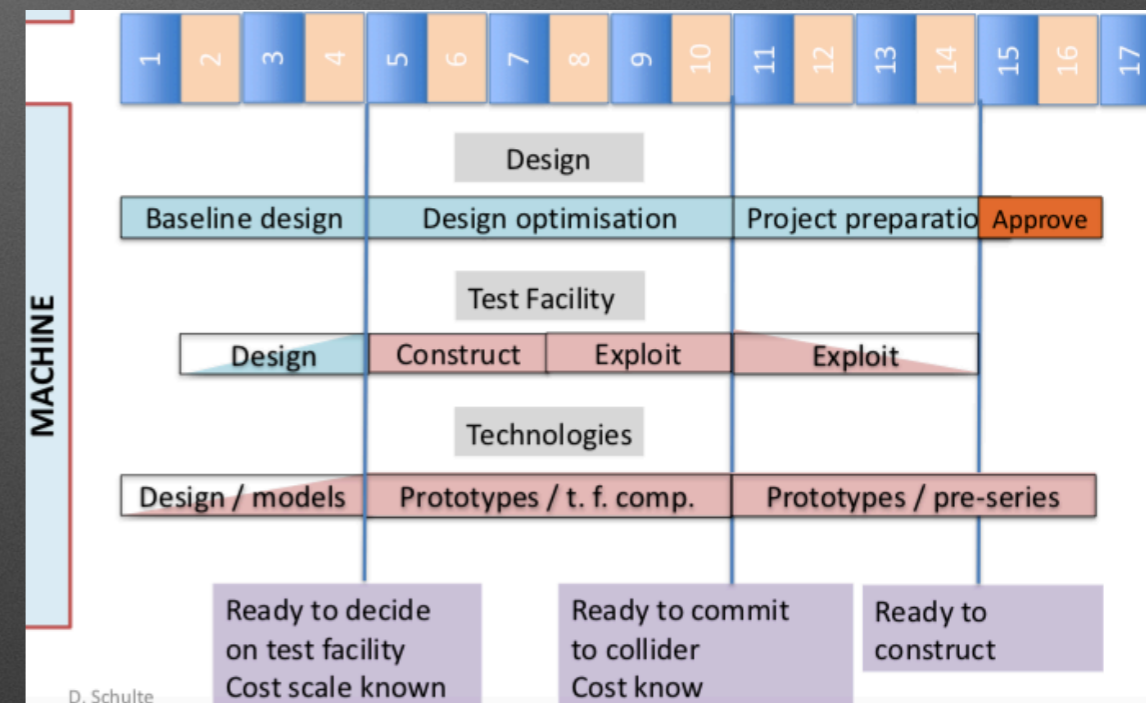
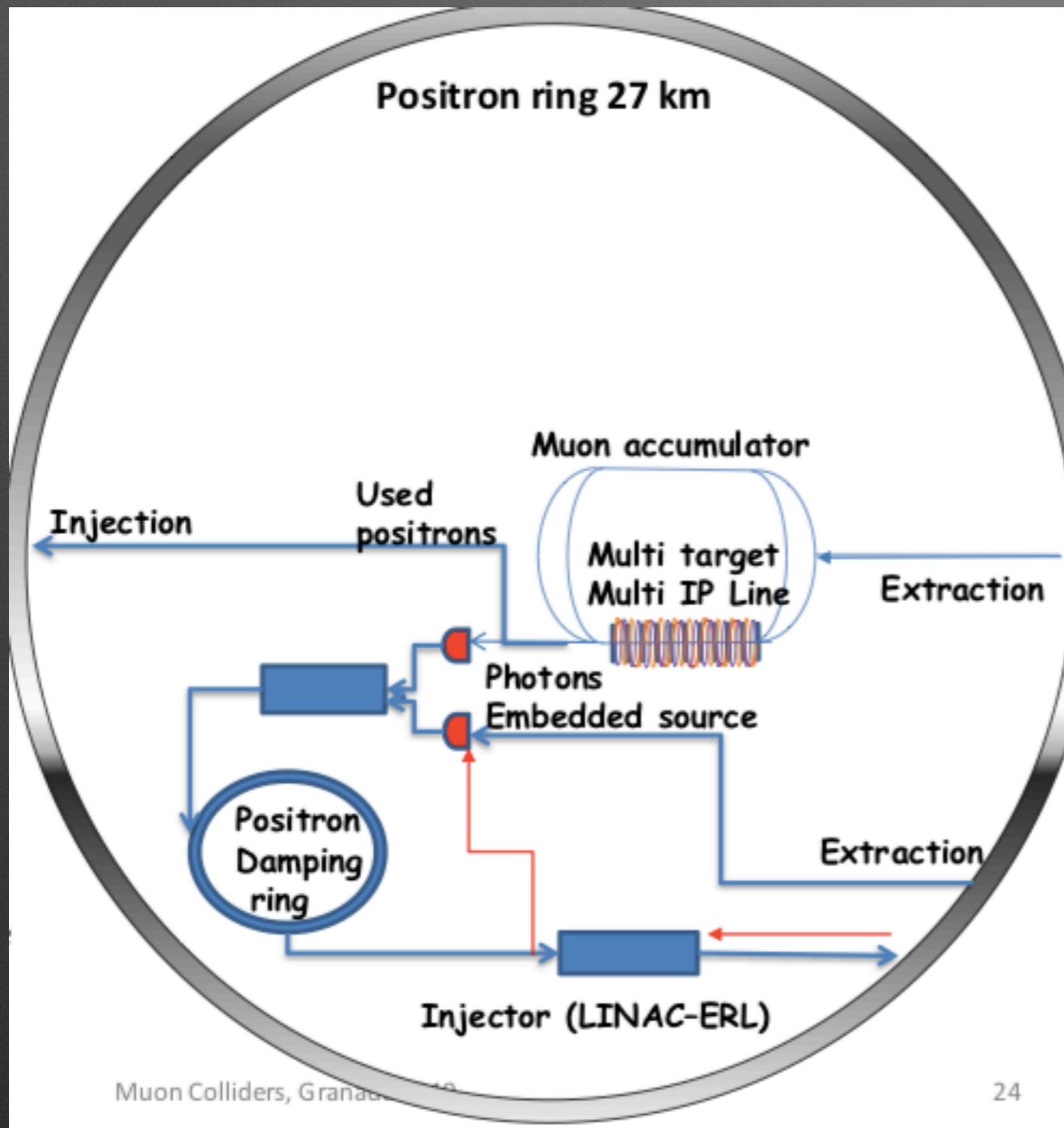


**Low EMittance Muon Accelerator (LEMMA):**  
 $10^{11}$   $\mu$  pairs/sec from  $e^+e^-$  interactions. The small production emittance allows lower overall charge in the collider rings – hence, lower backgrounds in a collider detector and a higher potential CoM energy due to neutrino radiation.





# LEMMA



Consolidate the positron driver scheme addressing specifically the target system, bunch combination scheme, beam emittance preservation, acceleration and collider ring issues.

# The Middle Earth

- Neutrinos might hold the key to both the mystery of the antimatter disappearance and the New Physics

Leptogenesis



Majorana mass

# CP Violation

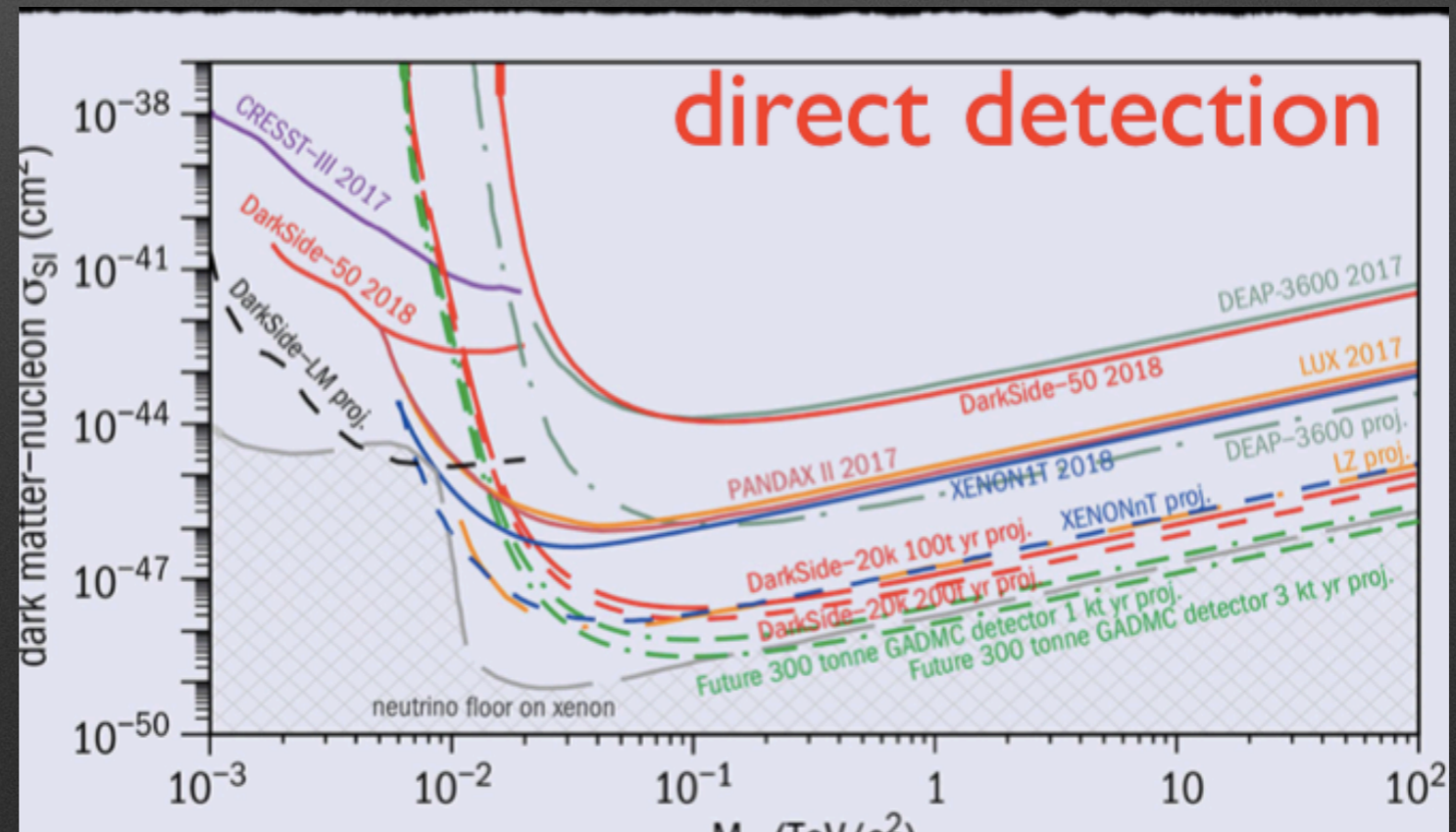
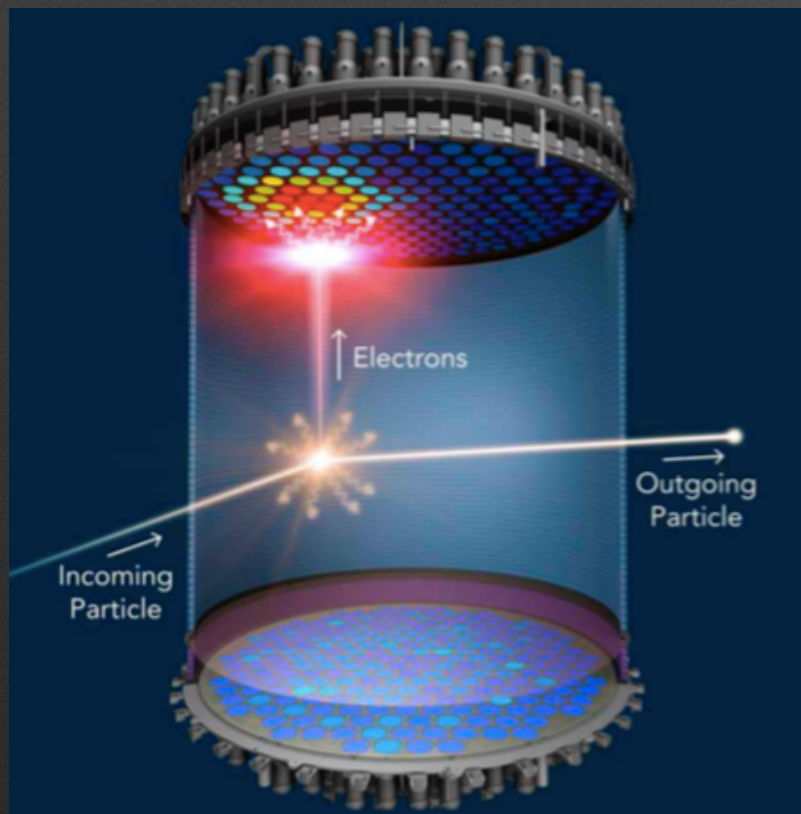
- Action far from Europe.
- Help with people, idea, technology.....
- Excitation for future result is motivated but remember than from a very precise knowledge of CKM we have not got much improvement in our knowledge of flavour mystery

# DBD or 'electrons creation'

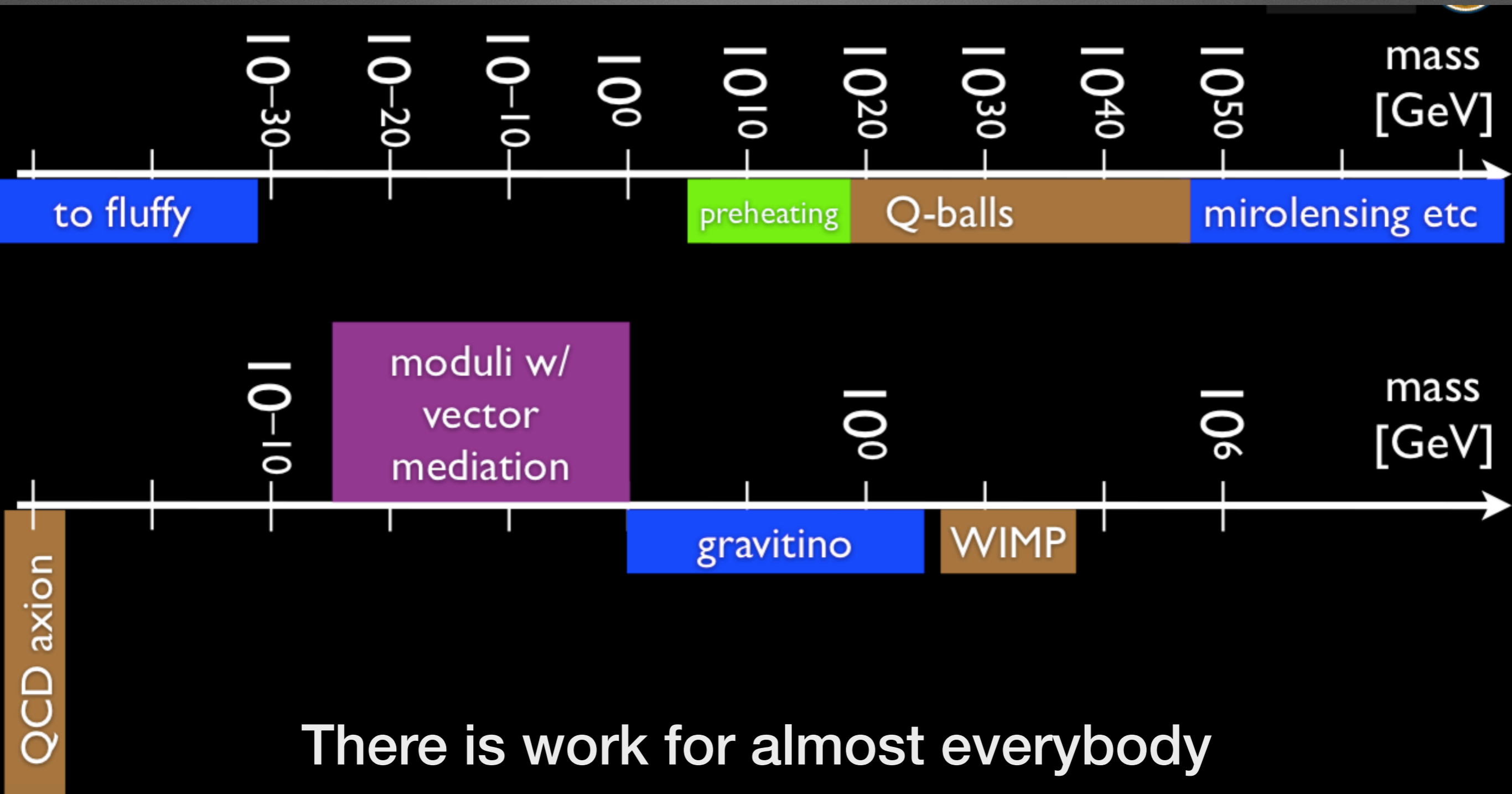
- Exploit LNGS experiment and their technology to the limit (GERDA/LEGEND and CUORE/CUPID)
- However.....if you need to reach a half life that requires masses of order 10-100-1000 tons this requires a change of technology
- Enrichment becomes prohibitive and in case of Xenon even the world total production would be a limitation

# Dark Matter as a substantial slice of the Universe pie

- A duty of bringing the existing lines of research at LNGS to their limit (get to the neutrino floor)
- Xenon nT
- Dark Side 20k (moving eventually to ARGO 300k)

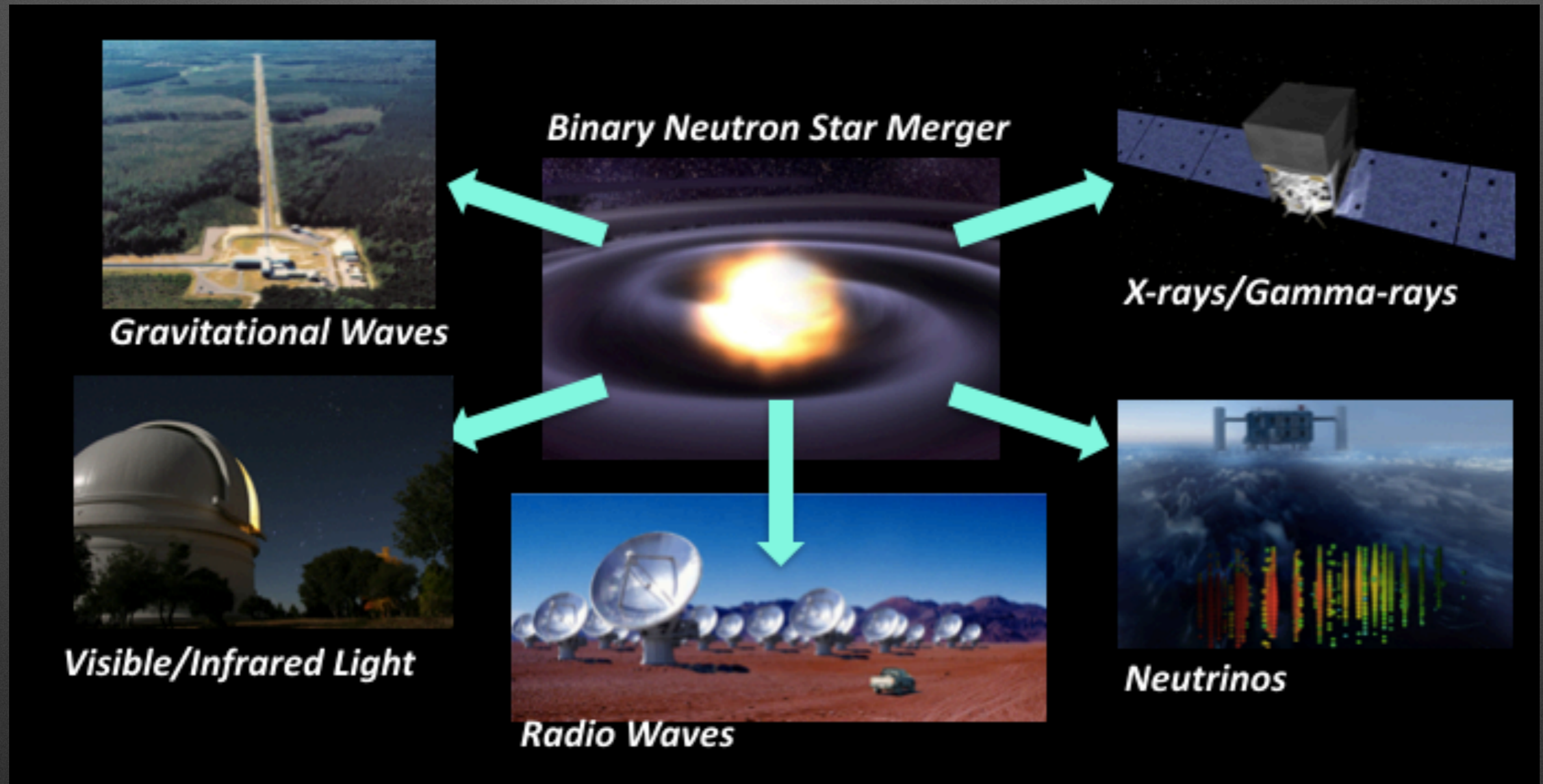


# However you better have an unbiased view of the landscape



There is work for almost everybody

# The emerging field of Multimessenger physics



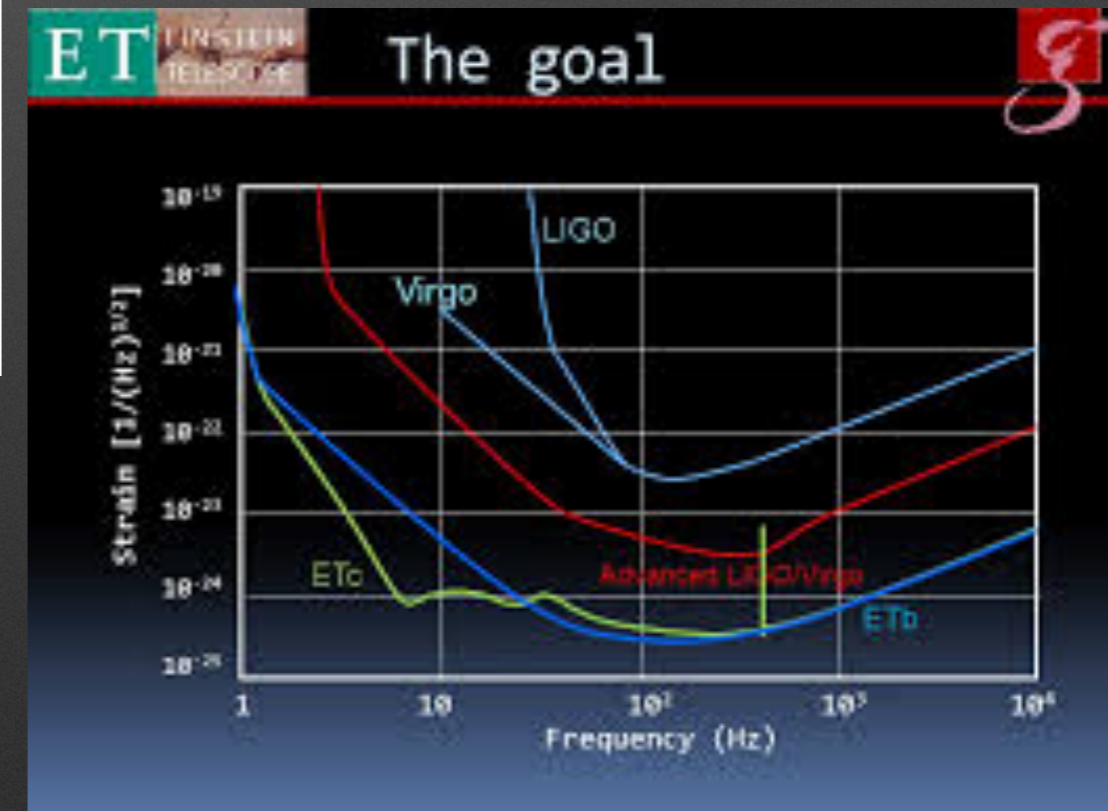
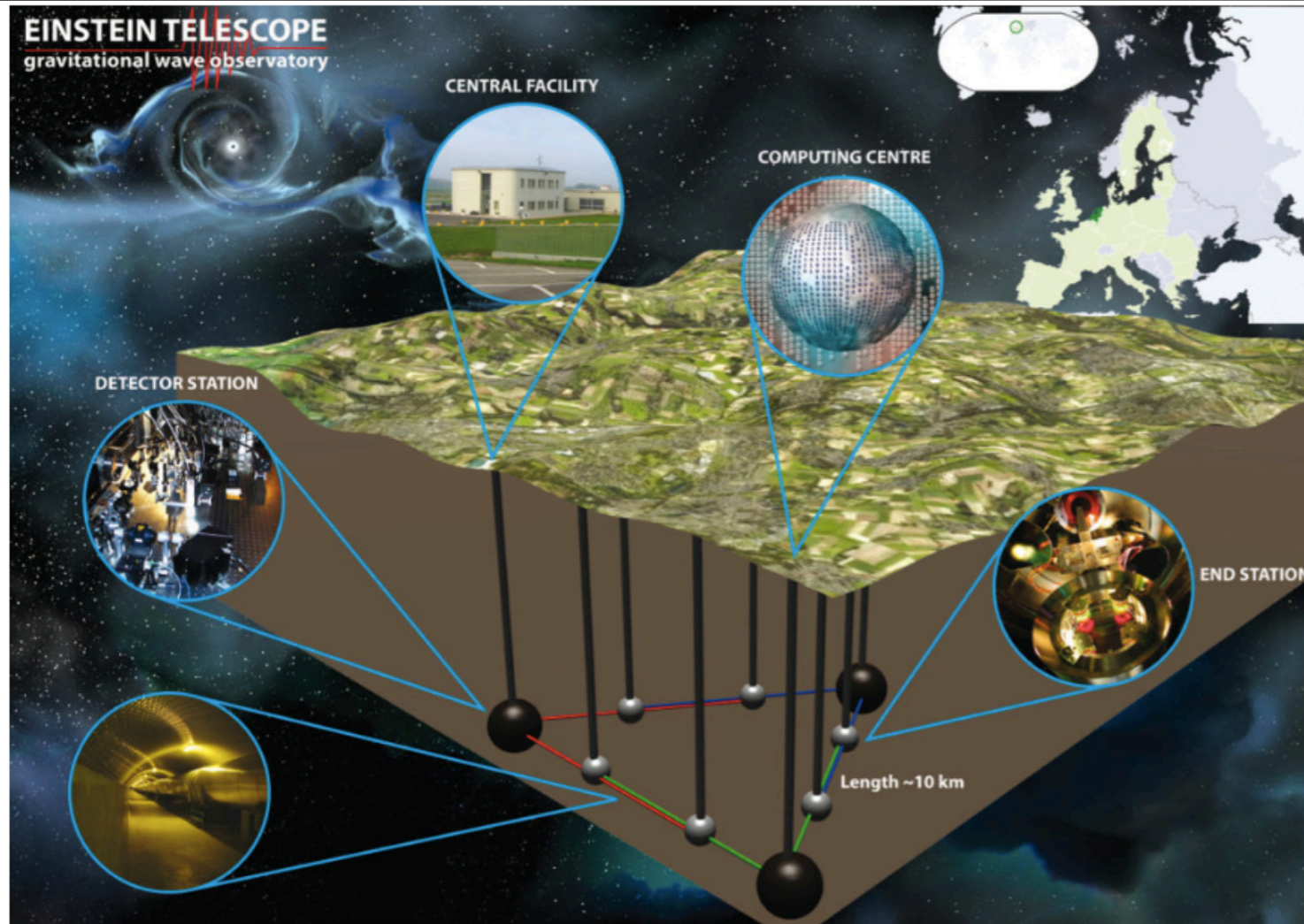
# a field of mandatory collaboration

- Here particle physics, astroparticle physics and cosmology do intersect
- need everybody on board



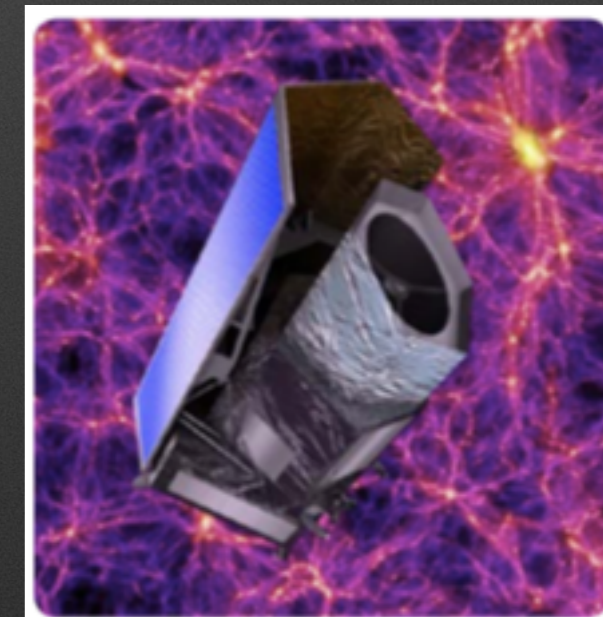
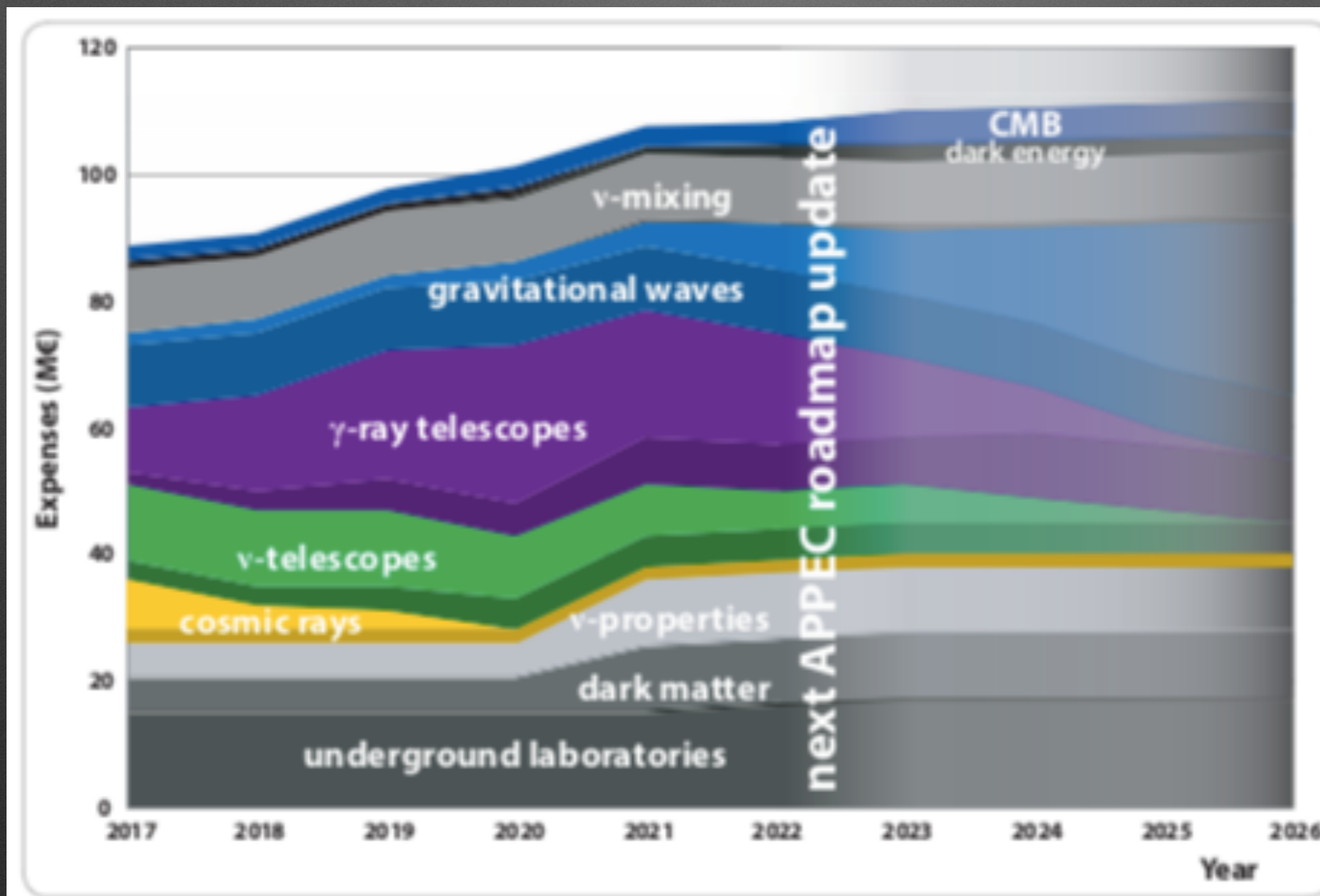
# ET

Based on VIRGO experience an ambitious project to be based somewhere in Europe



# European Astroparticle Physics Strategy 2017-2026

(Credit: Christian Reisswig, Luciano Rezzolla, Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut/AEI) Michael Koppitz, Max-Planck-Institut für Gravitationsphysik (Albert-Einstein-Institut/AEI)/Zuse-Institut Berlin) © AEI/ITP/ZIB)



# Conclusion

- Europe has a large impact on our field research
- CERN will be the flagship in any foreseeable future
- ET will be a landmark for the fascinating and complex field that intersects Gravity, Nuclear Physics, Astrophysics and Cosmology
- LNGS has a long way to go on both DBD and DM searches
- A growing attention to CMB/DarkEnergy sector
- All this in the frame of the Global Science



*Le seul véritable voyage ... ce ne serait pas d'aller  
vers de nouveaux paysages, mais d'avoir d'autres yeux*

*Marcel Proust*