



Astroparticle Physics European Coordination

European priorities for Astroparticle Physics

M. Spiro IN2P3/CNRS
AppEC Chairman

ASTROPARTICLE PHYSICS
the European strategy



<http://www.aspera-eu.org>

- **ApPEC created in 2001 by the national funding agencies of France, Germany, Italy, the Netherlands and UK.**
 - **Since then Spain, Belgium, Portugal, Greece, Switzerland and Poland have joined**
- **ApPEC aims to**
 - **Promote and facilitate co-operation within the European Particle Astrophysics (PA) community**
 - **Develop and promulgate long term strategies for European PA, offering advice to national funding agencies and EU**
 - **Assist in improving links and co-ordination between European PA and the scientific programmes of organisations such as CERN, ESA, and ESO**
 - **Express their collective views on PA in appropriate international forums, such as OECD, UNESCO etc.**

➤ **ApPEC operates**

- Strategically through its Steering Committee,
- Operationally through its Peer Review Committee

➤ **Steering Committee (SC):**

- **France:** M.Spiro, P.Chomaz, S.Katsanevas **Germany:** T. Berghöfer, R.Köpke, H. Bluemer, **Netherlands:** F. Linde, **UK:** D. Miller, J. Womersley, **Italy:** R. Petronzio B. Dettore, **Spain:** J. Fuster, A.Ferrer, **Switzerland:** M. Bourquin, **Belgium:** D. Bertrand, C. DeClerq, **Portugal** K. Gaspar **Greece:** D. Nanopoulos **Poland** S. Pokorski, **Romania** NV. Zamfir, **CERN:** D. Schlatter

➤ **Peer Review Committee (PRC)**

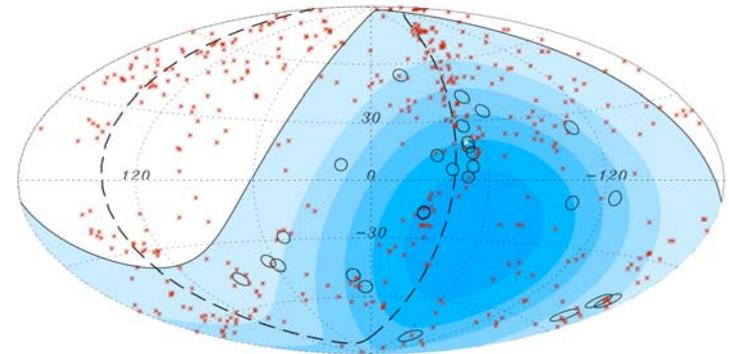
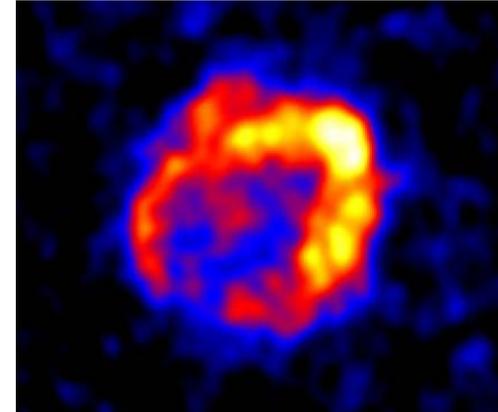
- Elena Aprile, Laura Baudis, Jose Bernabeu, Pierre Binetruy, Christian Spiering, Franz v. Feilitzsch, Enrique Fernandez, Andrea Giuliani, Werner Hofmann, Uli Katz, Paul Kooijman, Paolo Lipari, Manel Martinez, Antonio Masiero, Benoit Mours, Francesco Ronga, Sheila Rowan, Andre Rubbia, Subir Sarkar, Guenther Sigl, Gerard Smadja, Nigel Smith, Lucia Votano

- **ASPERA, 14 countries (ApPEC+ Czech republic +Sweden + CERN) funded by EU in 2006 for 3 years for coordination actions**
 - Coordinator S. Katsanevas IN2P3/CNRS, France
 - **EU funds its continuation for another 3 years 2009-2012**
 - Coordinator T. Berghoefer BMBF, Germany
 - **Actions of ASPERA-1:**
 - **Status of astroparticle funding in Europe:**
 - 2500 Full time researchers + 70 M€/year investment or 190 M€ total
 - **Linking of existing large infrastructures**
 - Linking of underground labs in progress
 - **Roadmap of infrastructures**
 - PRC, working groups and 3 workshops (... Amsterdam 2007, Brussels 2008)
 - **Launch a common call for support of design studies of the priority projects**
 - A 3,5 M€ grant on CTA and Dark Matter starting this March
-

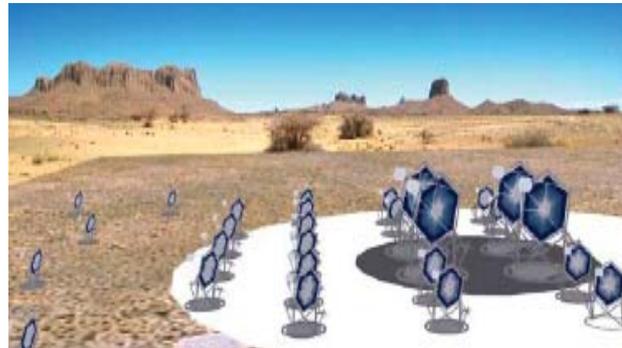
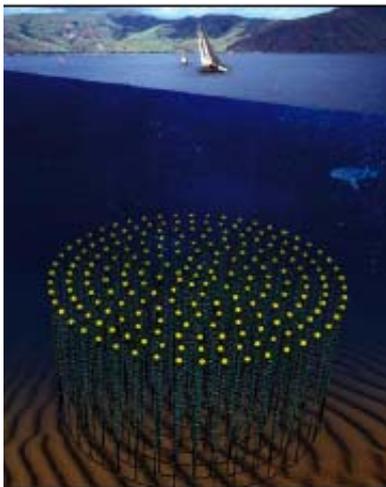
- ✓ A representative of the ApPEC SC attends in the European Strategy sessions of the CERN Council.
- ✓ A representative of the ApPEC PRC is a member of the scientific secretariat for the European Strategy sessions of the CERN Council.
- ✓ The “Working Group on the scientific and geographical enlargement of CERN” will include an ApPEC representative
- ✓ CERN asks ApPEC when Astroparticle Physics experiments ask the “recognised experiment” status from CERN.

Study

- The origin of cosmic rays and in general non-thermal processes
- Access to energies beyond LHC
- Indirect search of dark matter annihilation
- Extreme phenomena serving as cosmological markers
- Probe the intergalactic space and/or the space-time fabric itself



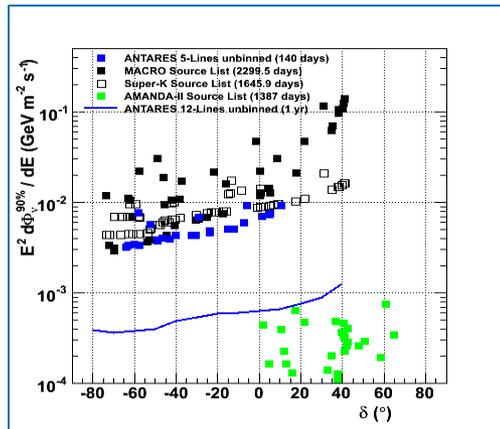
- ❑ Neutrino telescope in the Mediterranean (KM3Net)
- ❑ High Energy Gamma Ray Cherenkov Telescope Array (CTA)
- ❑ Beyond the Auger South Observatory (Auger-North)
- ❑ Einstein Telescope for gravitational wave detection (ET)
 - ❑ Complementary to a space program (FERMI, JEM-EUSO, LISA)



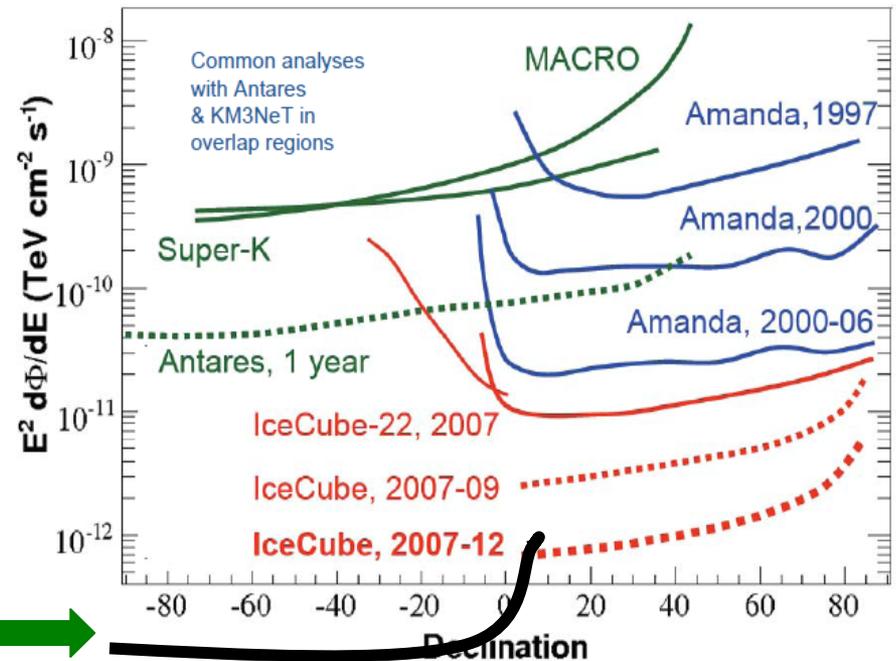
Possible designs

100fold progress in sensitivity in 15 years

- Antares completed R&D
- NEMO
- NESTOR



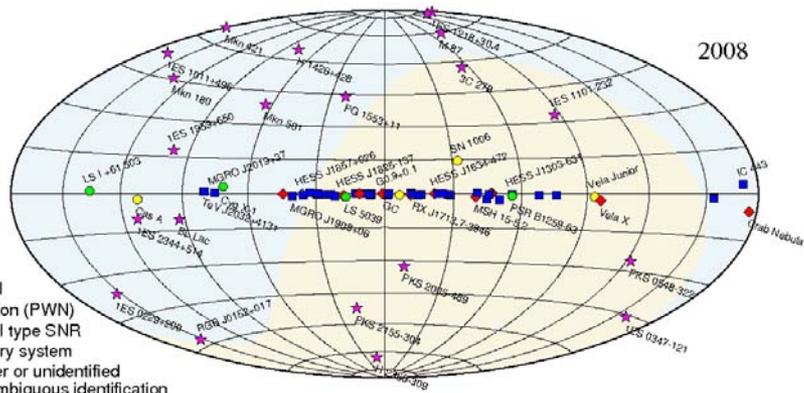
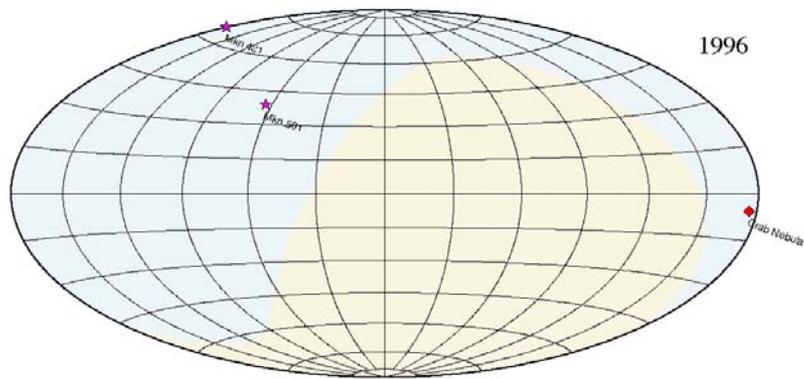
point source limits/sensitivities:



KM3net 3 years

- ICECUBE+ KM3net: full sky coverage
- KM3net points to GC
- Projected sensitivity and resolution
- x3 better than ICECUBE

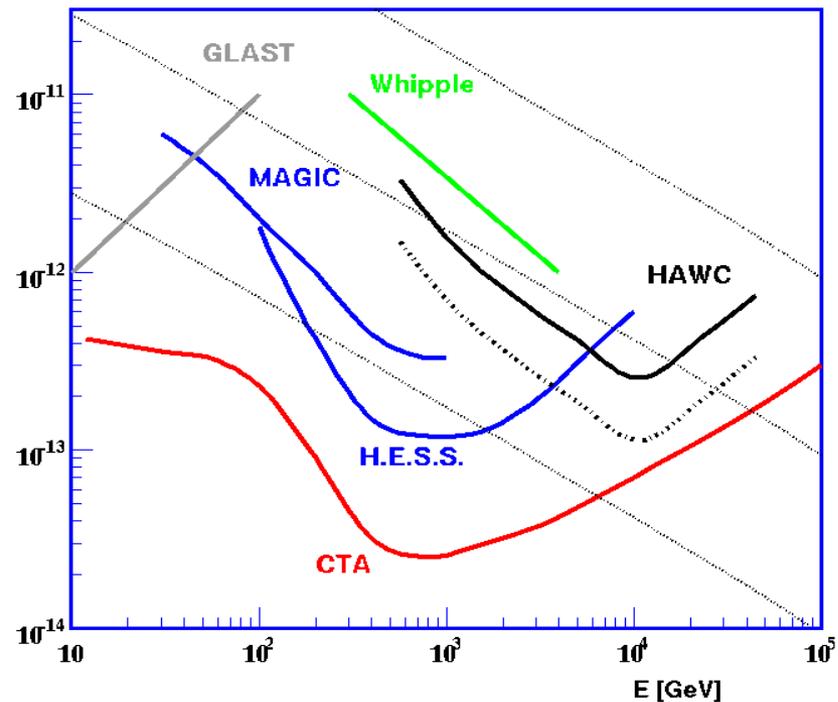
High Energy Gamma Rays



- ★ AGN
- ◆ Plerion (PWN)
- Shell type SNR
- Binary system
- Other or unidentified or ambiguous identification

Background colours indicating northern / southern sky

Graphics by Konrad Bernlöhr 2008



CTA:

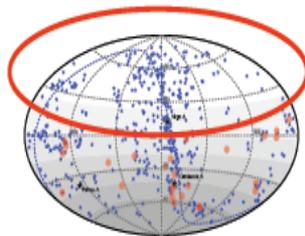
- sensitivity x10
- angular resolution x2-3

Charged Cosmic Rays

Science with Auger-North

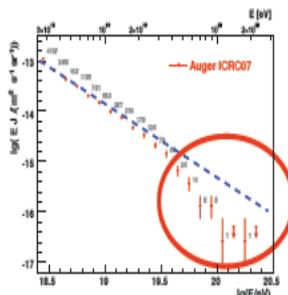
The sources of UHECR

- Anisotropy \Rightarrow correlations \Rightarrow source classes
- Study individual sources with spectra and composition on the whole sky



The acceleration mechanism

- Composition evolves from source to here
- Proton beam !? calibration !
- $E \gg 10^{20}$ eV still difficult; E_{\max} ?

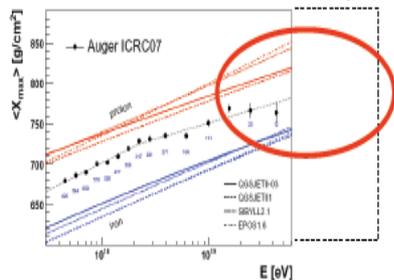


Propagation and cosmic structure

- Map galactic B-field
- Matter within 100 Mpc
- Extragalactic B-field small ?

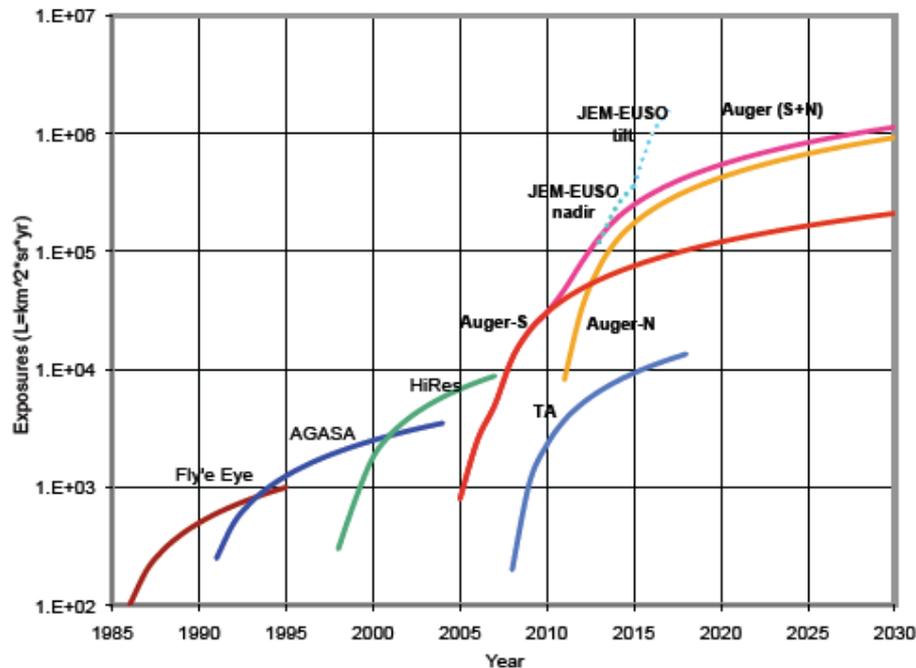
Particle physics at 350 TeV

- Mass and X_{\max}
- Had. interactions, cross sections ?
- New physics, Lorentz invariance



Multi-messenger astrophysics

- Combine the data from photons, neutrinos and charged particles !
- Sources within field of view of IceCube

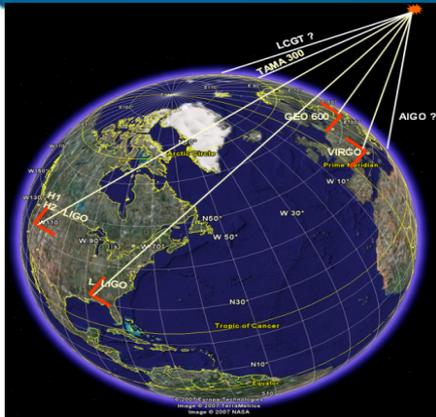


GSZ horizon



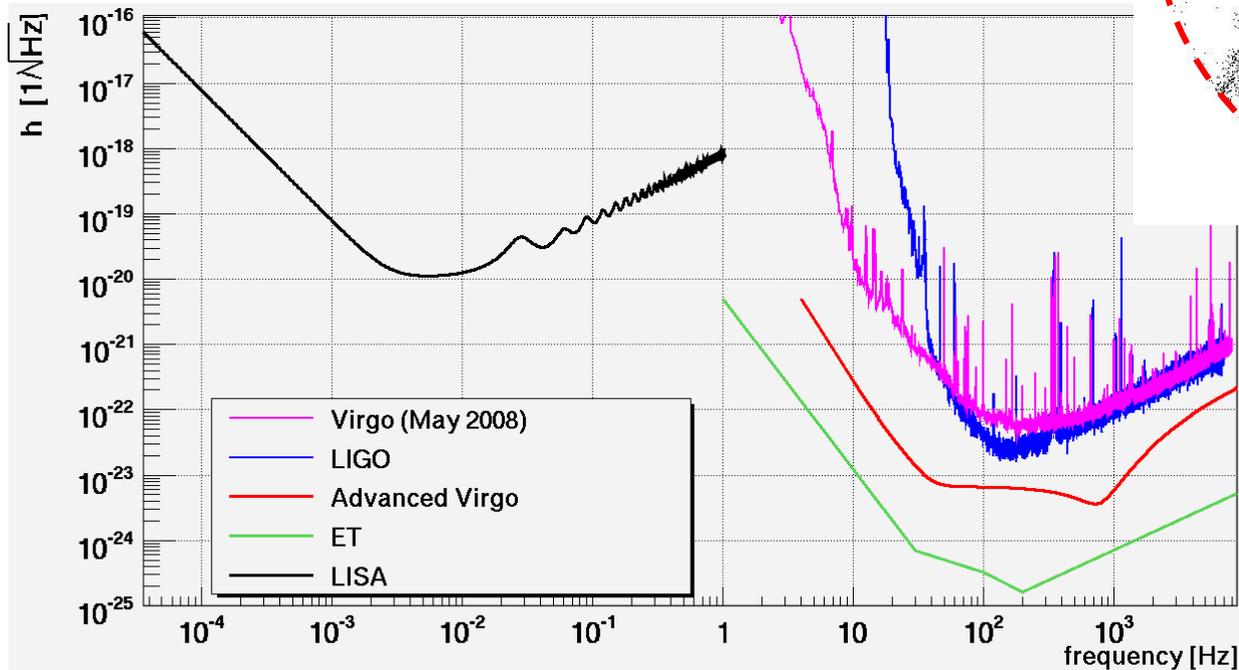
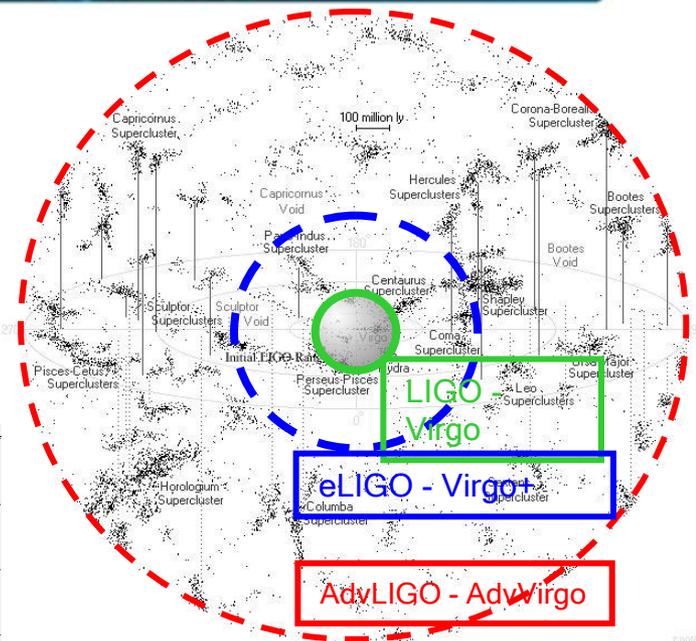
Thanks to R. Engel

Gravitational Wave Antennas

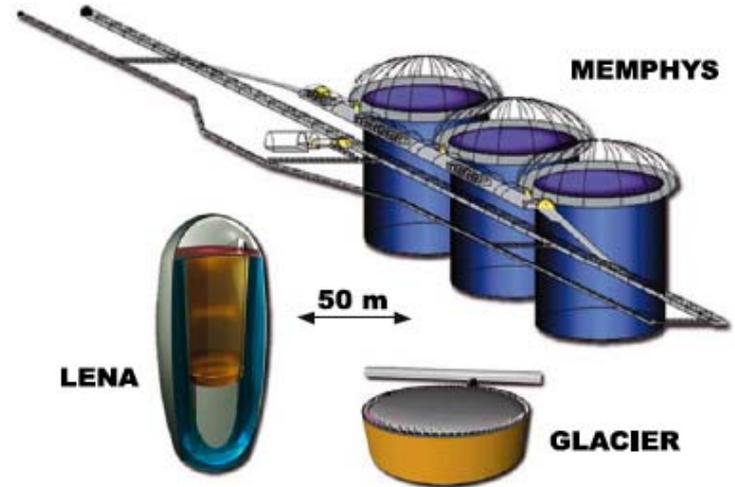
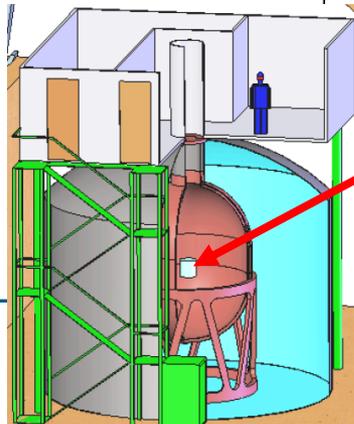
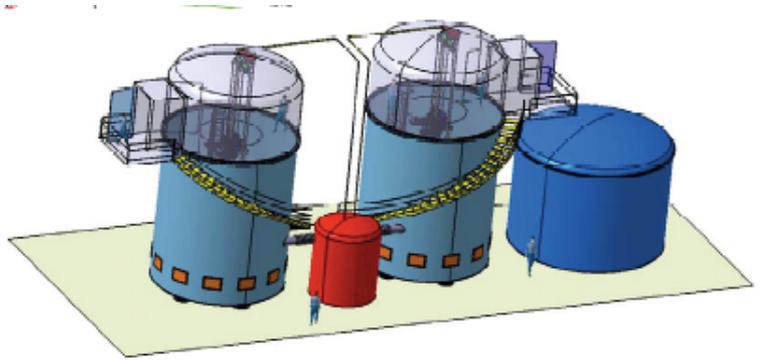


A worldwide network

Towards a source detection in 2014-2015

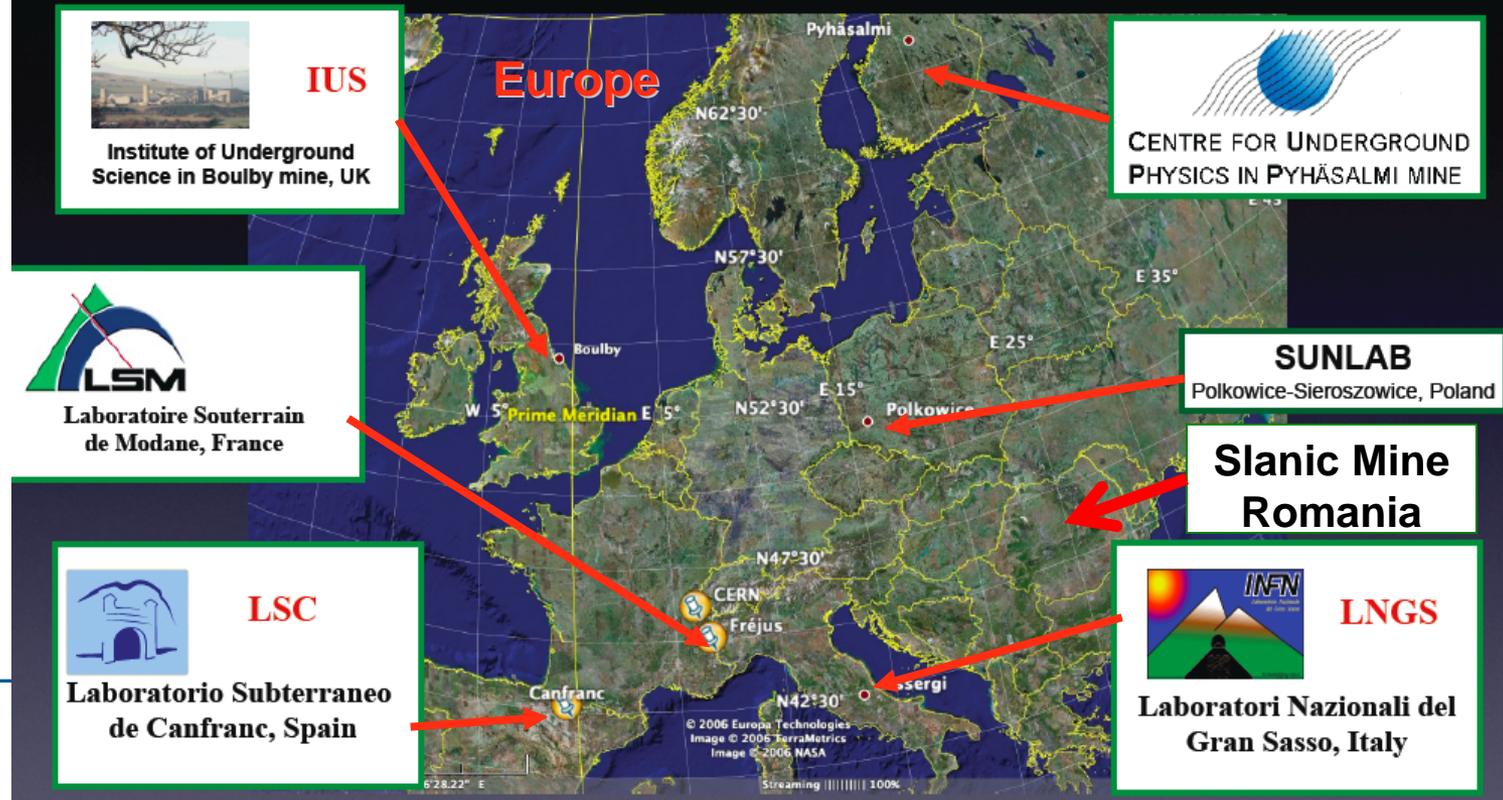


- ❑ Dark matter detectors towards the ton
- ❑ Neutrino mass detectors towards the ton
- ❑ Proton decay and neutrino (astro)physics towards the megaton

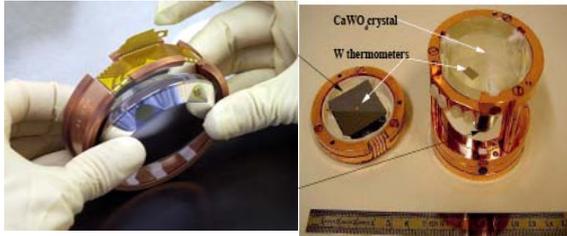


- 4 large laboratories (largest Gran Sasso) + 3 smaller ones. Support their coordination.

7 national underground science laboratories



Dark Matter Searches



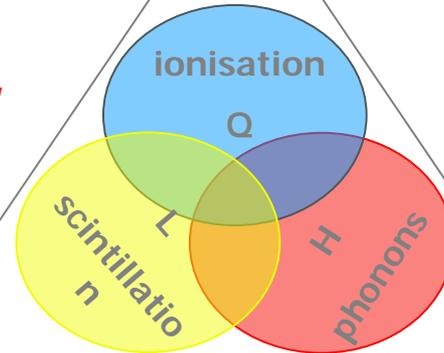
WIMP elastic nuclear recoils deposit $< 50\text{keV}$ of energy at a rate 10^{-5} to 1 event/day/kg

PICASSO/SIMPLE

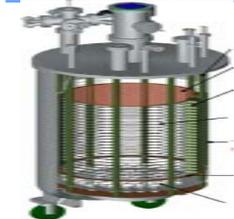
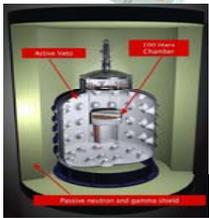
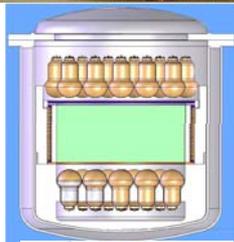
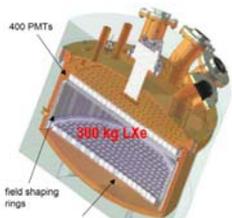
DRIFT I, II
GENIUS,

phonons, photons and charge whose relative proportions and /or characteristics depend on $dE/dx \Rightarrow$ particle type

ArDM, WARP,
XENON, ZEPLINI III, LUX,



EDELWEISS, EURECA



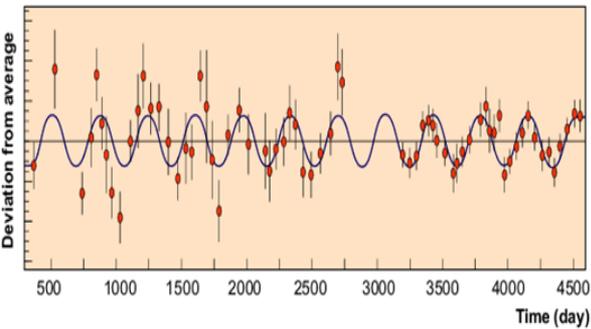
DAMA/LIBRA, ZEPLIN I

High efficiency particle identification requires compound information and/or large self-shielding mass

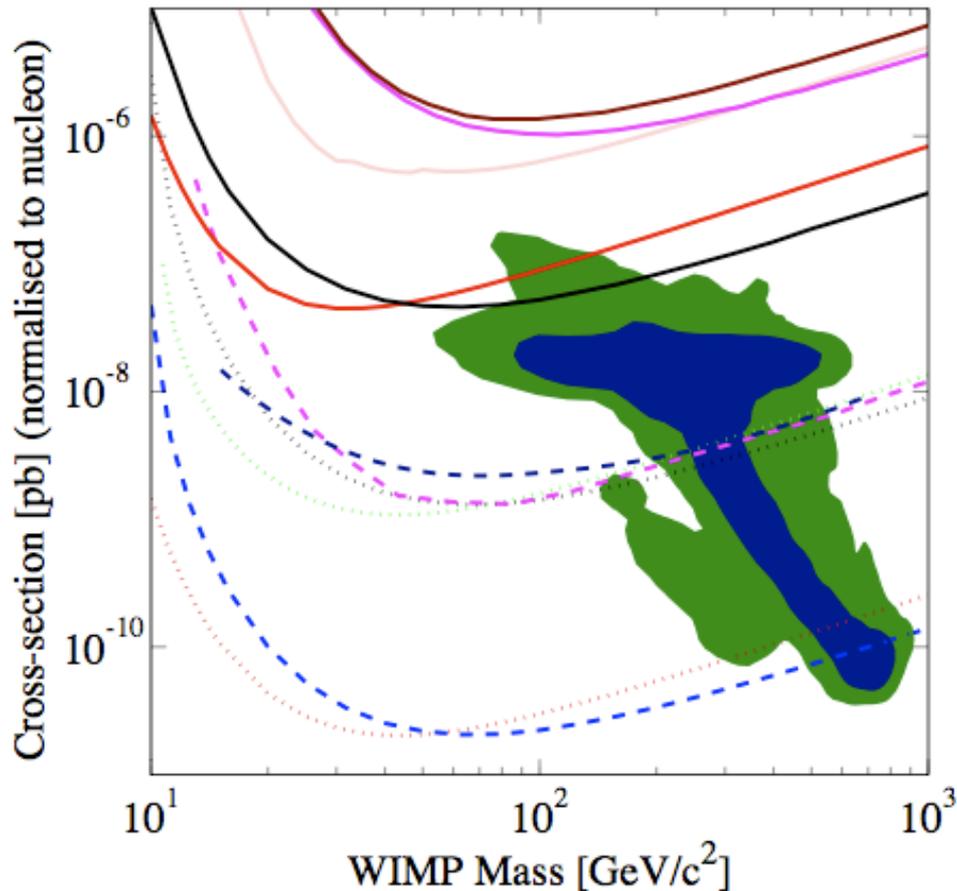
CRESST II,
ROSEBUD,
EURECA

Originally by T. Sumner

DAMA annual modulation



European or european participation projects only



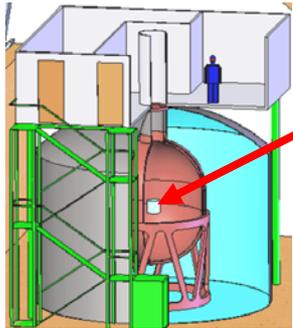
EDELWEISS, CRESST, WARP
2003

CDMS/XENON10
2007-2008

XENON100/WARP140EDELWEISSII/CDMS
2010-2011

1 ton Bolometer/Noble Liquide
2015-2016?

1 order of magnitude every 5 years ?



$0\nu\beta\beta$ decay: in operation CUORICINO, NEMO3

GERDA

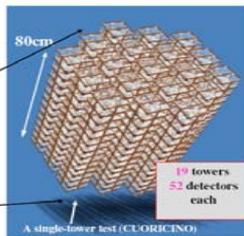
Ge diodes in liquid nitrogen
Implemented in phases

Single dilution refrigerator - 10 mk



for Rare Events

• $\beta\beta 0\nu$, Cold Dark Matter, Axion searches
proposal hep/ph 0501010



CUORE

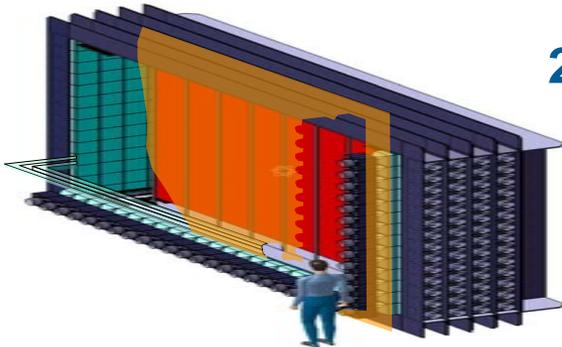
Bolometer of TeO_2
(^{130}Te 203 kg)
Operation 2011

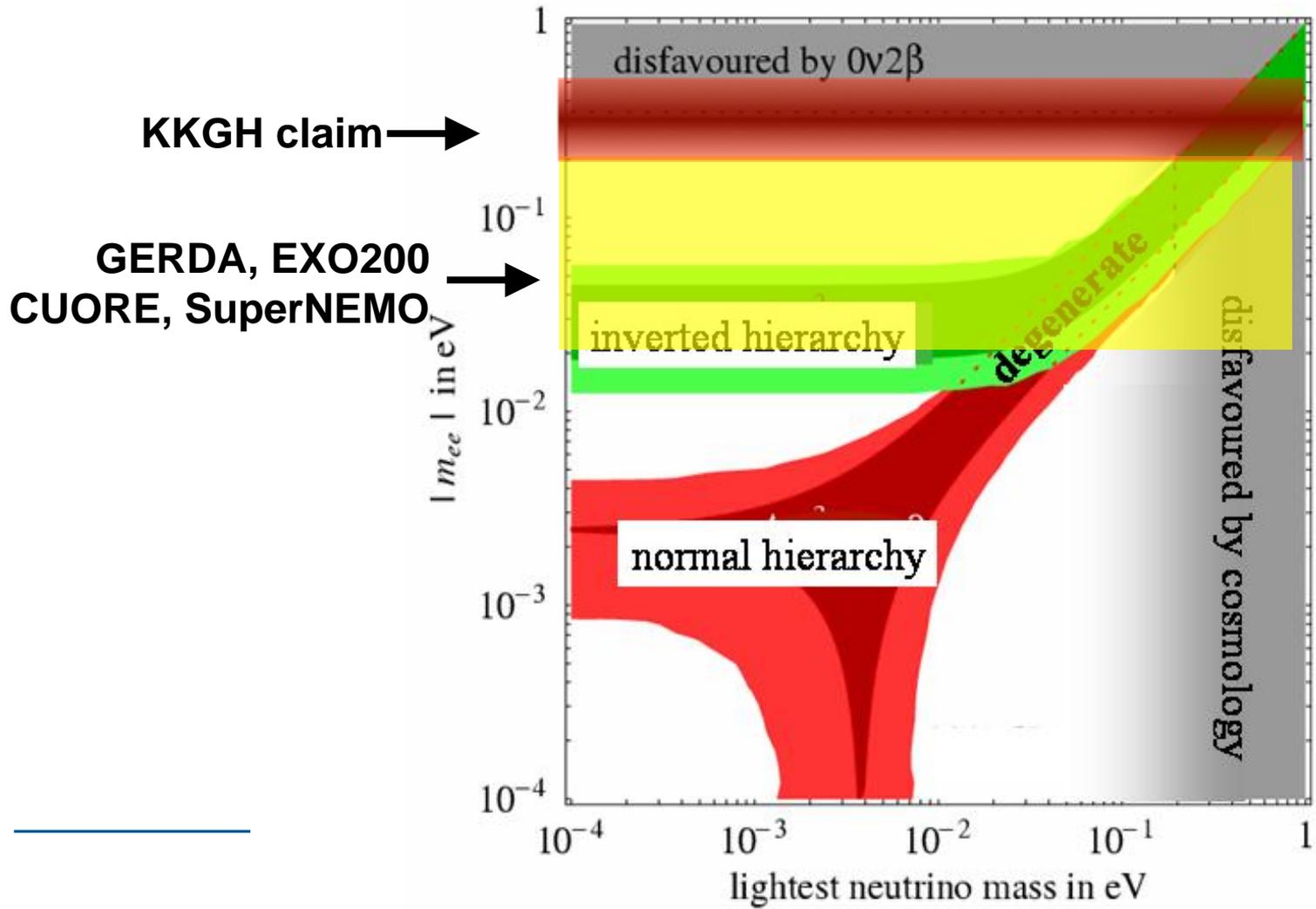


KATRIN β decay
Sensitivity 200 meV

SuperNEMO

20 modules of a tracko-calor, 100 kg of ^{82}Se or ^{150}Nd
First modules in 2011





Proton decay and neutrino (astro)physics

ApPEC Astroparticle Physics European Coordination

LAGUNA

MEMPHYS

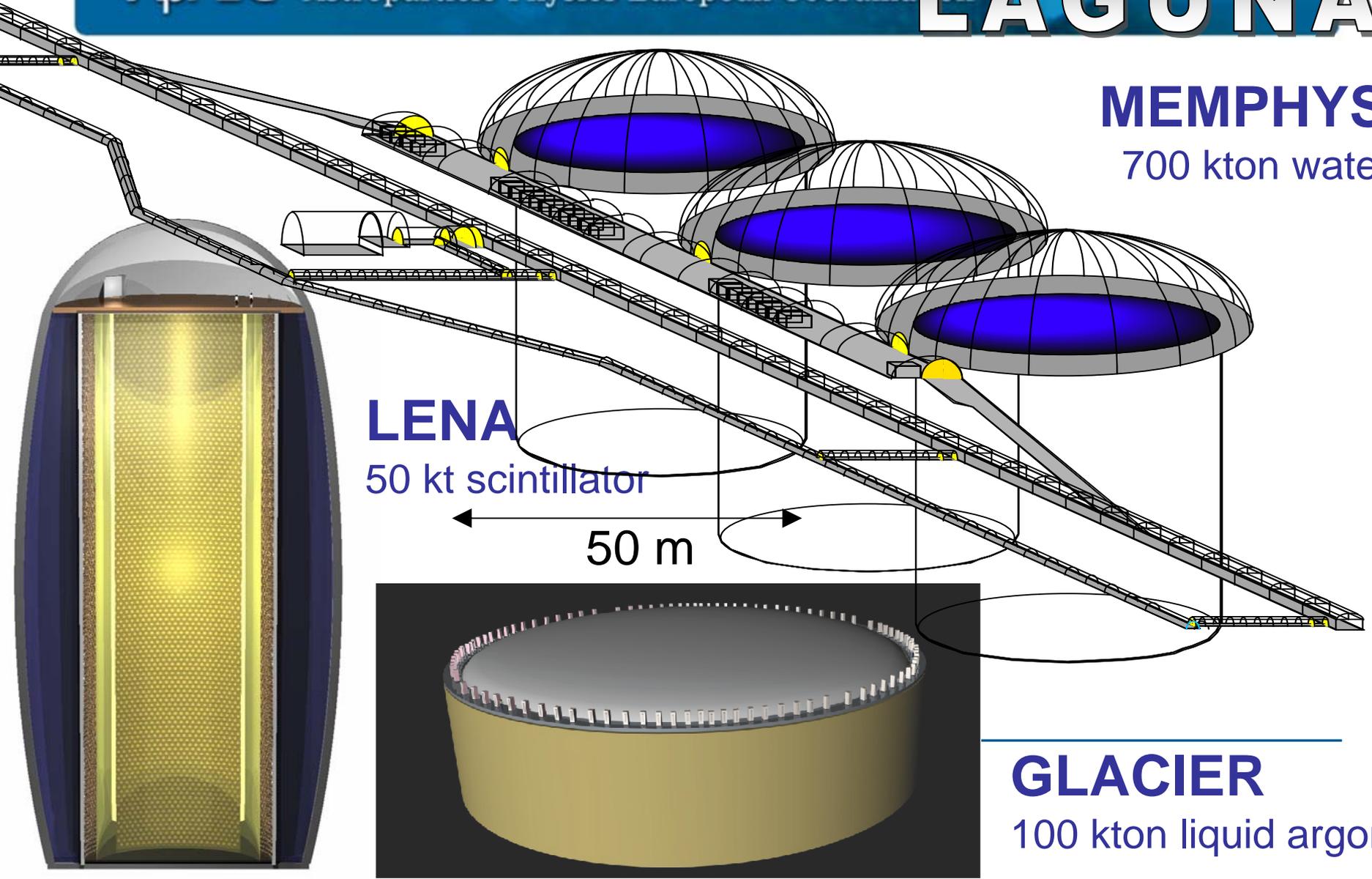
700 kton water

LENA
50 kt scintillator

50 m

GLACIER

100 kton liquid argon



- ❑ Not prioritised in the roadmap since DE depends also on other non-ApPEC agencies: (astrophysics, space) but important contributions of the astroparticle physics community to existing SNaE program (SCP, SNFS, SNLS)
- ❑ The APPEC/ASPERA roadmap supports participation to existing and future US programs:
 - ❑ On ground: DES, LSST
 - ❑ Support for a common US-EU dark energy mission
 - ❑ If sufficiently large and sufficiently complete with all 3 methods

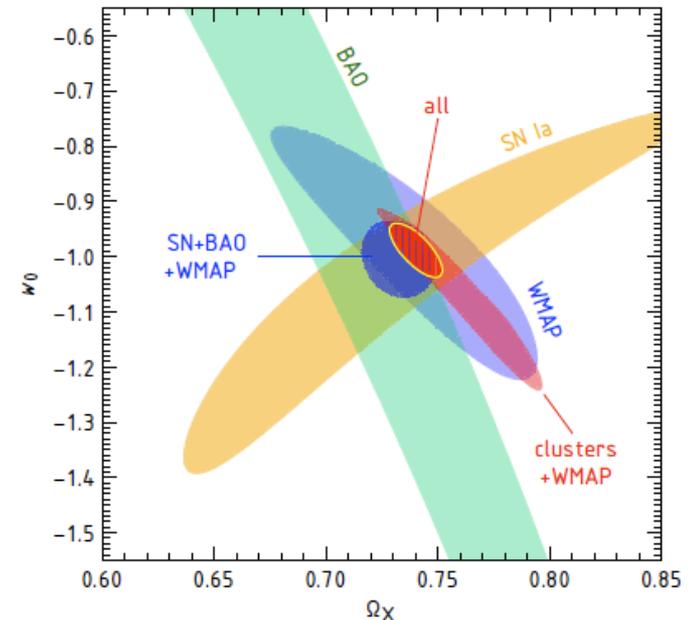
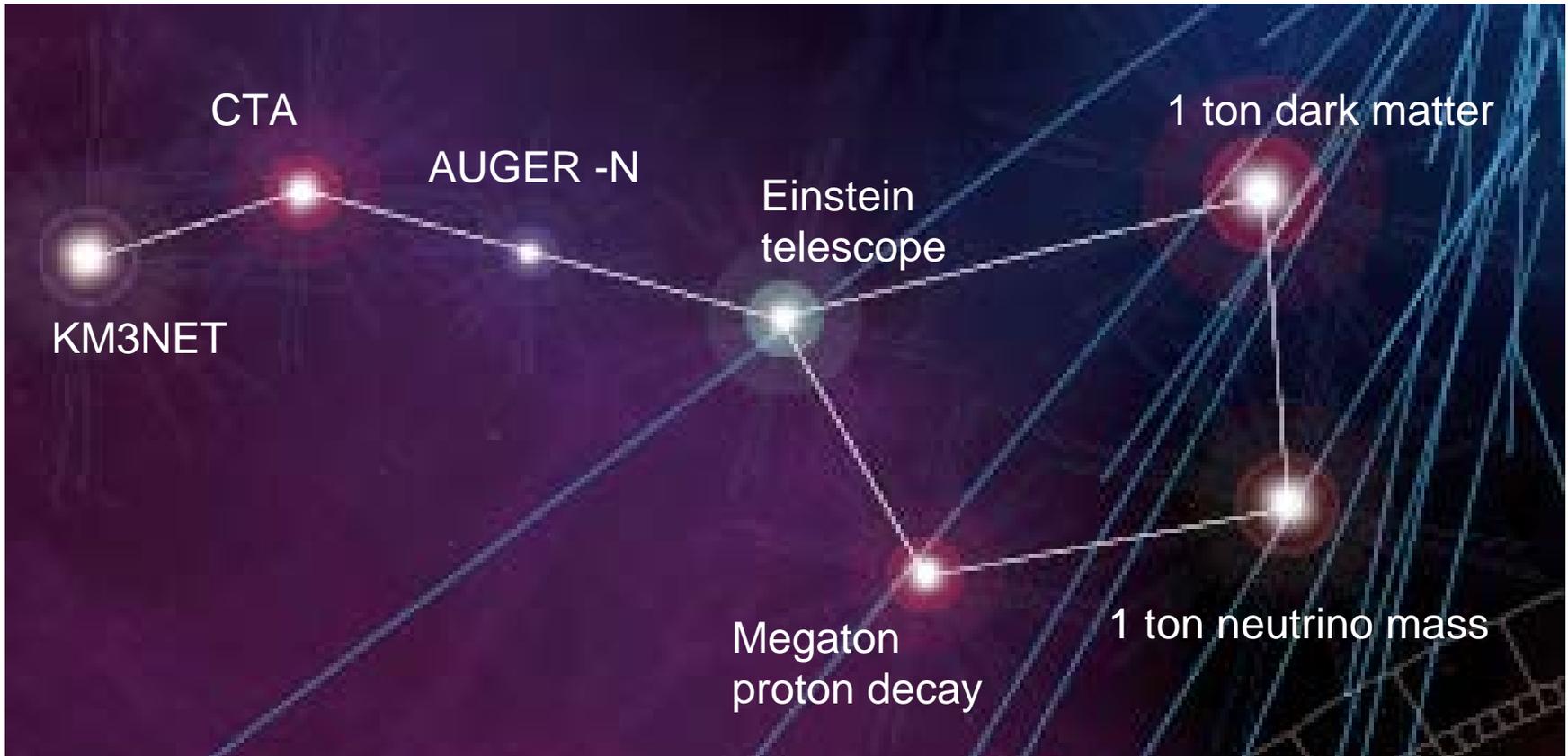


FIG. 10.— Dark energy constraints in flat universe from combination of all cosmological datasets. We find $w_0 = -0.991 \pm 0.045$ (± 0.04 systematic) and $\Omega_\chi = 0.740 \pm 0.012$, see Table 2 and § 8.3.



❑ CTA and KM3

- ❑ High priority also in Astrophysics Roadmap
- ❑ Both in European project ESFRI roadmap
- ❑ KM3 advanced Design Study and Preparatory Phase work in progress
- ❑ Both could start construction by 2012

❑ Auger North

- ❑ Start of construction depends on US evaluation processes

❑ Dark matter and neutrino mass

- ❑ Continue with a few techniques at the 10-100 Kg scale
- ❑ By 2011-2012 decide on the technology(ies) of the ton scale detector(e)

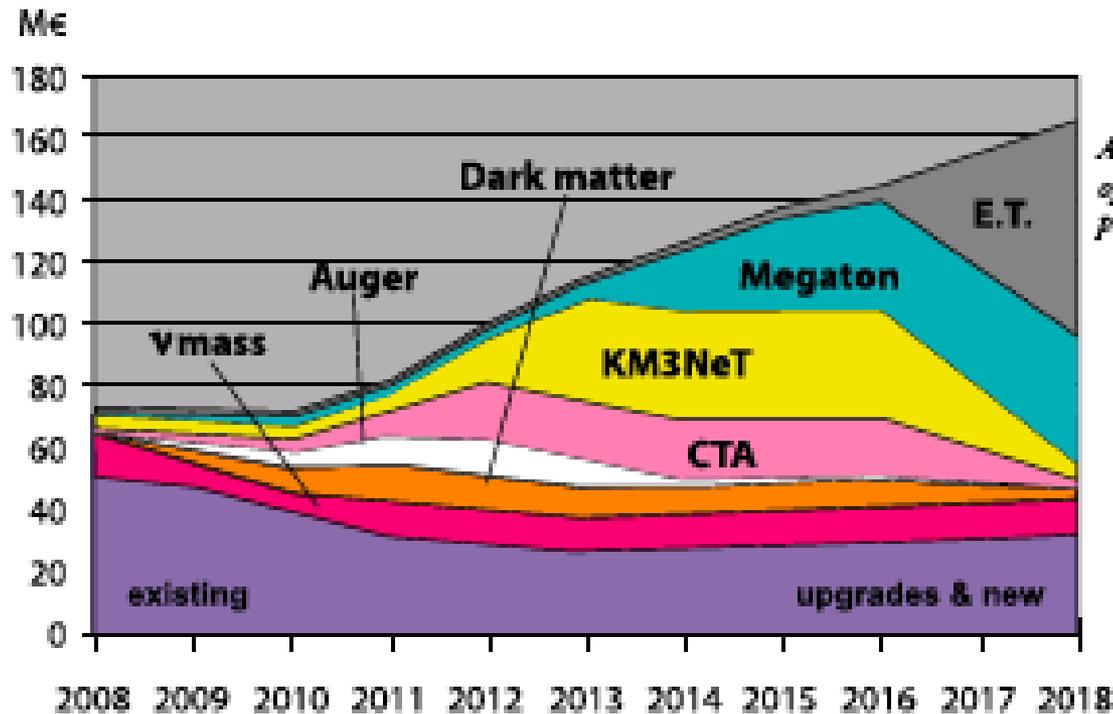
❑ Megaton scale for proton decay

- ❑ EU Design Study in progress (essentially cavern feasibility and costing)
- ❑ Decisions in 3-4 years for a start by mid-decade

❑ Einstein Telescope

- ❑ Decisions by 2016 and after advVRGO/LIGO detections

NB. Most projects would profit from coordination either of a distributed type (e.g. the VIRGO/LIGO network) or the creation of a global scale single infrastructure (e.g. Auger-South)



A scenario for investment and operation cost of astroparticle physics in the ASPERA countries.

The full program demands a 50% increase in the next 10 years (integrated)

- **European Astroparticle Physics after a long but fruitful process of coordination has prepared a phased priority roadmap that enjoys large acceptance by the agencies and the community.**
 - **Furthermore the discussion has started in Europe for the drafting of a more sustainable coordinating structure that would manage the realisation of the above program. Its eventual relationships to the existing pan European structures (CERN, ESO) are examined.**
 - **Complementarities and budget demand the generalisation of this process of coordination to other regions. This process that has started in the context of the OECD Global Science Forum (1st meeting in Paris 12-13 February 2009) and could continue in other bodies (e.g. FALC).**
 - **OECD GSF phase 1 (2009) perimeter, statistics and census of the field**
 - **OECD GSF phase 2 (2010) priority coordination ?**
 - (in synchronism with US decadal survey)
-