Astroparticle Physics

The European Strategy

Christian Spiering, DESY

Stockholm, Oct. 16, 2008

http://www.aspera-eu.org

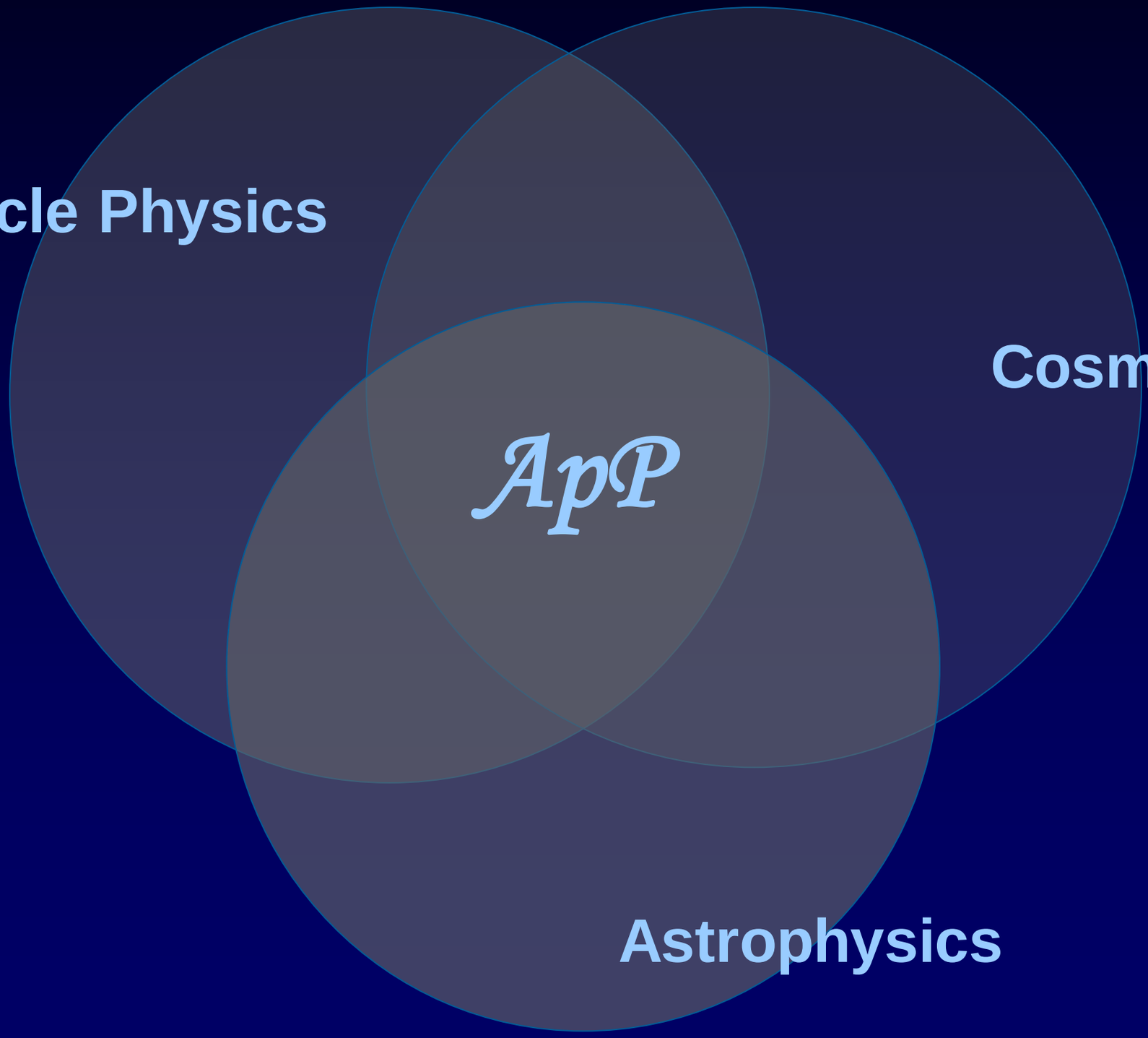
ASPERA

SIXTH FRAMEWORK PROGRAMME

Astroparticle Physics for Europe

ASPERA

Astroparticle Physics



Astroparticle Physics for Europe

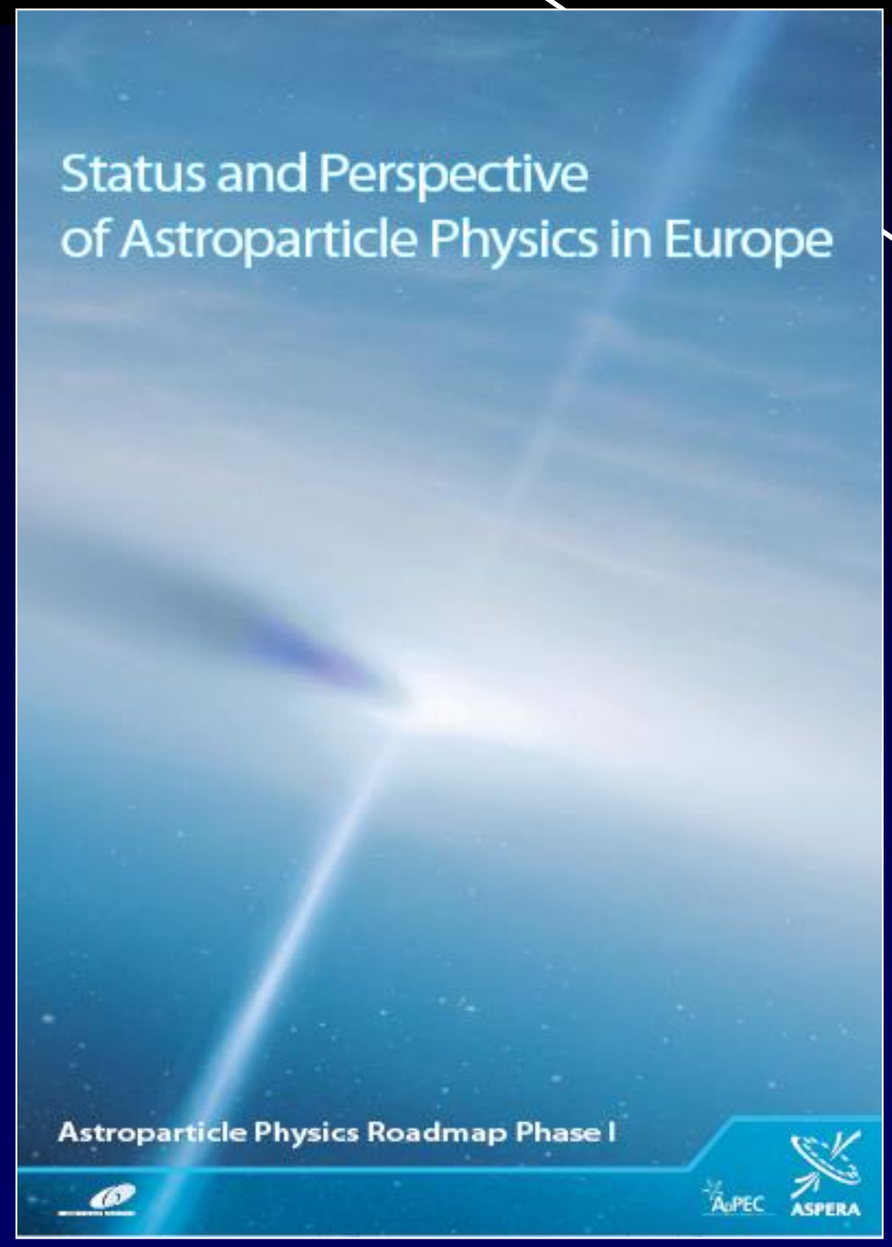
ASPERA

The Questions

- What is the Universe made of ?
  In particular: what is dark matter ?
- Do protons have a finite lifetime ?
- What are the properties of neutrinos ? What is their role in cosmic evolution ?
- What do neutrinos tell us about the interior of the Sun and the Earth, and about Supernova explosions ?
- What is the origin of cosmic rays ? What is the view of the sky at extreme energies ?
- What will gravitational waves tell us about violent cosmic processes and about the nature of gravity ?

Phases of Roadmapping

- **Phase I:**
  - Science case
  - Recommendations for convergence



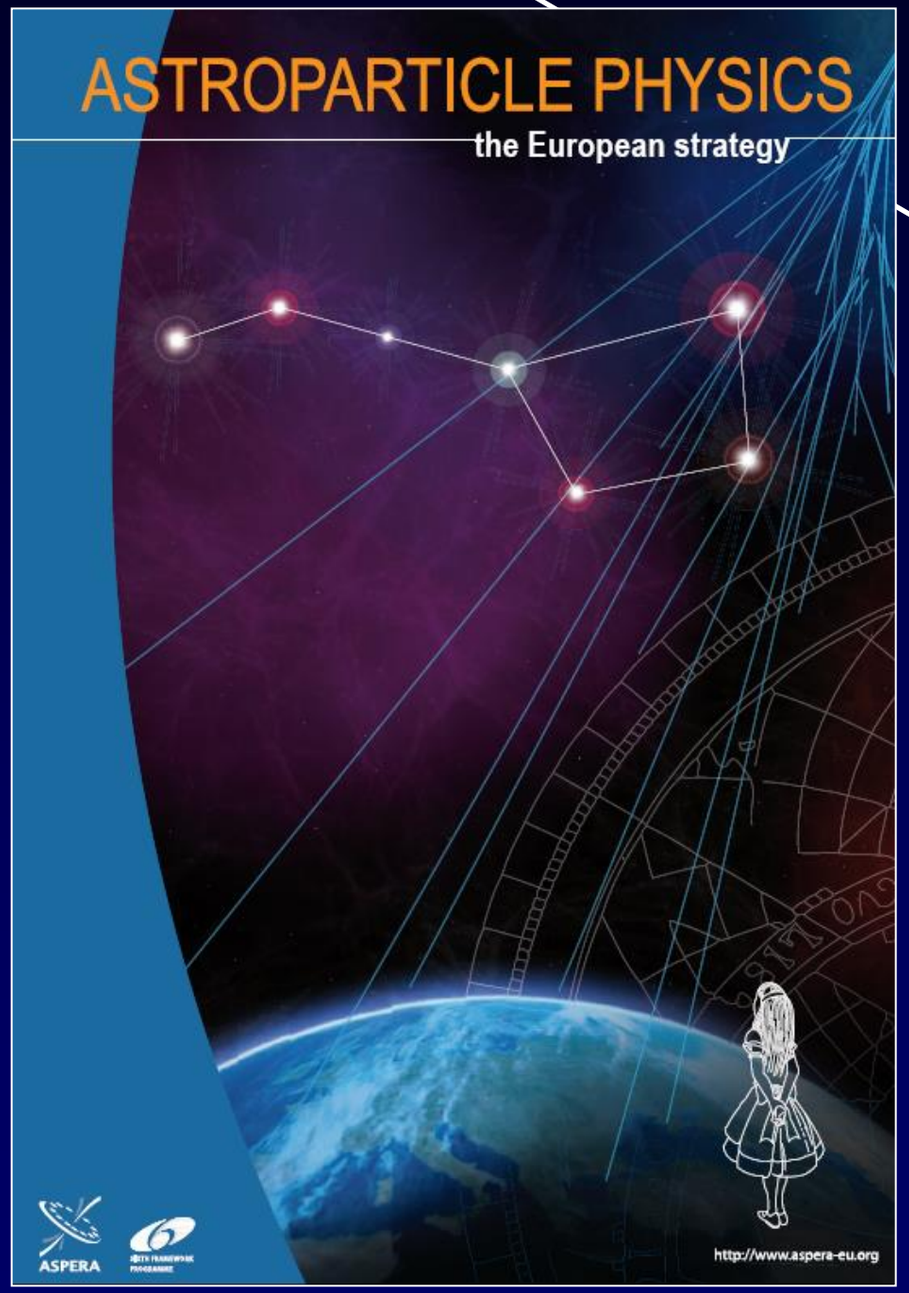
- **Phase II:**
  - Detailed data from experiments and agencies
- **Phase III:**
  - Critical assessment of plans
  - Calendar for milestones and decisions
  - Priorities

http://www.aspera-eu.org

Phases of Roadmapping

Astroparticle Physics

→ the European strategy



Astroparticle Physics for Europe

ASPERA

The Questions

- What is the Universe made of ?
  In particular: what is dark matter ?
- Do protons have a finite lifetime ?
- What are the properties of neutrinos ? What is their role in cosmic evolution ?
- What do neutrinos tell us about the interior of the Sun and the Earth, and about Supernova explosions ?
- What is the origin of cosmic rays ? What is the view of the sky at extreme energies ?
- What will gravitational waves tell us about violent cosmic processes and about the nature of gravity ?

Neutrino Astrophysics & p-decay

Astroparticle Physics for Europe

ASPERA

- What is the Universe made of ?
  In particular: what is dark matter ?
- Do protons have a finite lifetime ?
- What are the properties of neutrinos ? What is their role in cosmic evolution ?
- What do neutrinos tell us about the interior of the Sun and the Earth, and about Supernova explosions ?
- What is the origin of cosmic rays ? What is the view of the sky at extreme energies ?
- What will gravitational waves tell us about violent cosmic processes and about the nature of gravity ?

Proton Decay

Lifetime
in simplest GUTs
10^{29}-10^{32} years

Prefered
decay mode

$$p \rightarrow e^{+} + \pi^{0}$$
$$\hookrightarrow \gamma + \gamma$$

Proton Decay

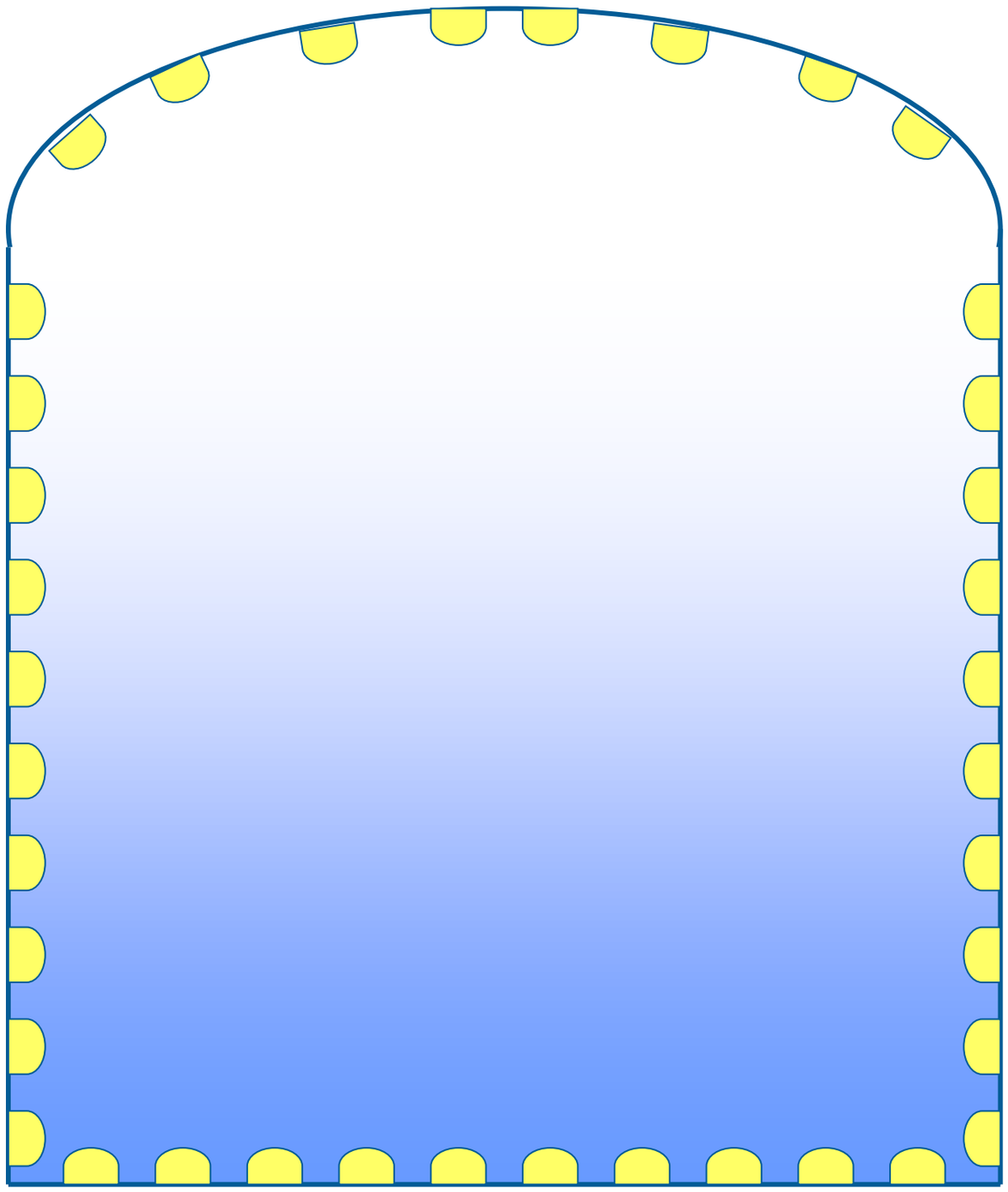
3000 tons water
(10^{33} protons)

Lifetime
in simplest GUTs
10^{29}-10^{32} years

Prefered
decay mode

$$p \rightarrow e^{+} + \pi^{0}$$
$$\hookrightarrow \gamma + \gamma$$

Proton Decay

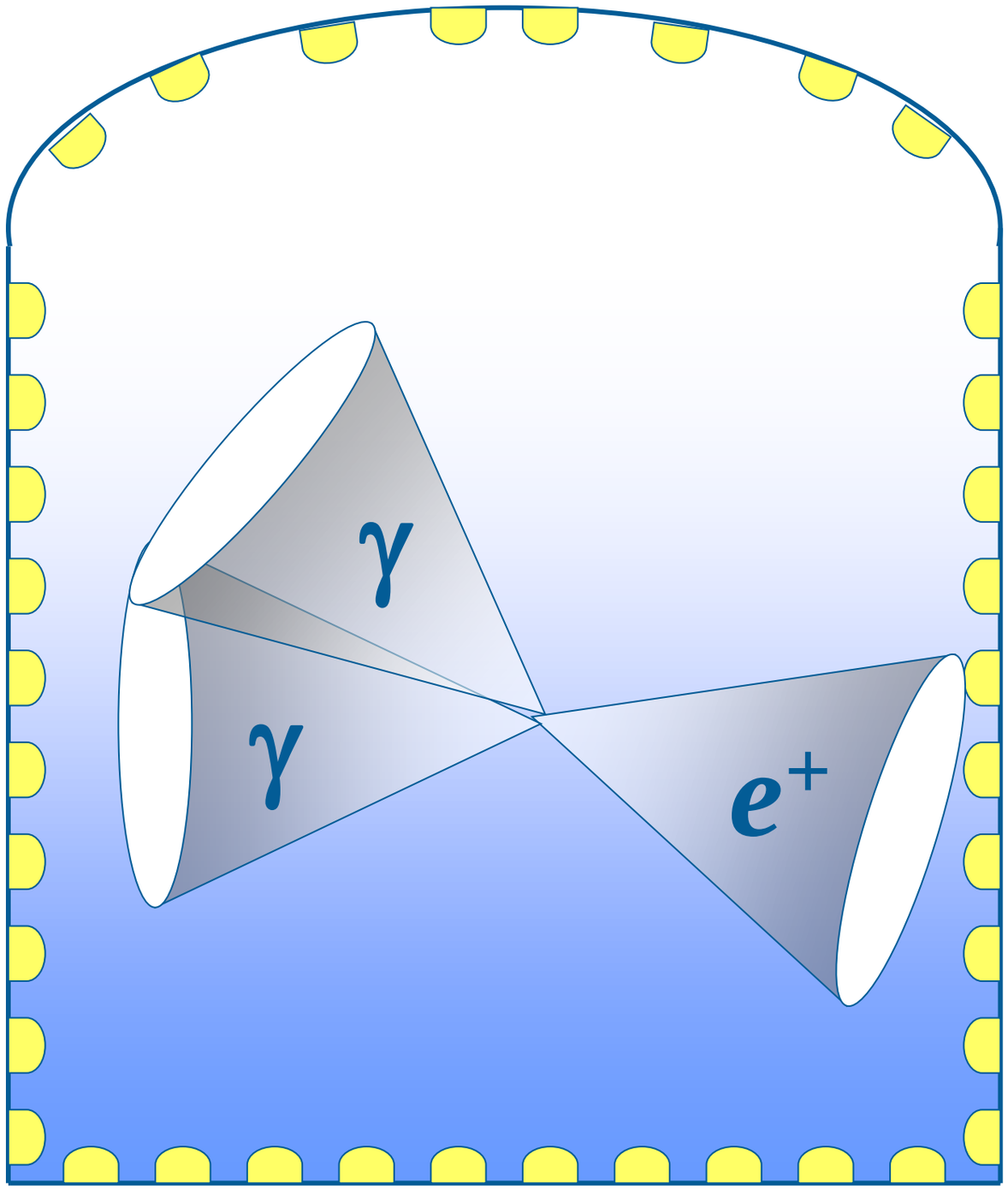


Lifetime
in simplest GUTs
10^{29}-10^{32} years

Prefered
decay mode

$$p \rightarrow e^{+} + \pi^{0}$$
$$\hookrightarrow \gamma + \gamma$$

Proton Decay



Lifetime
in simplest GUTs
10^{29}-10^{32} years

Prefered
decay mode

$$p \rightarrow e^{+} + \pi^{0}$$
$$\hookrightarrow \gamma + \gamma$$

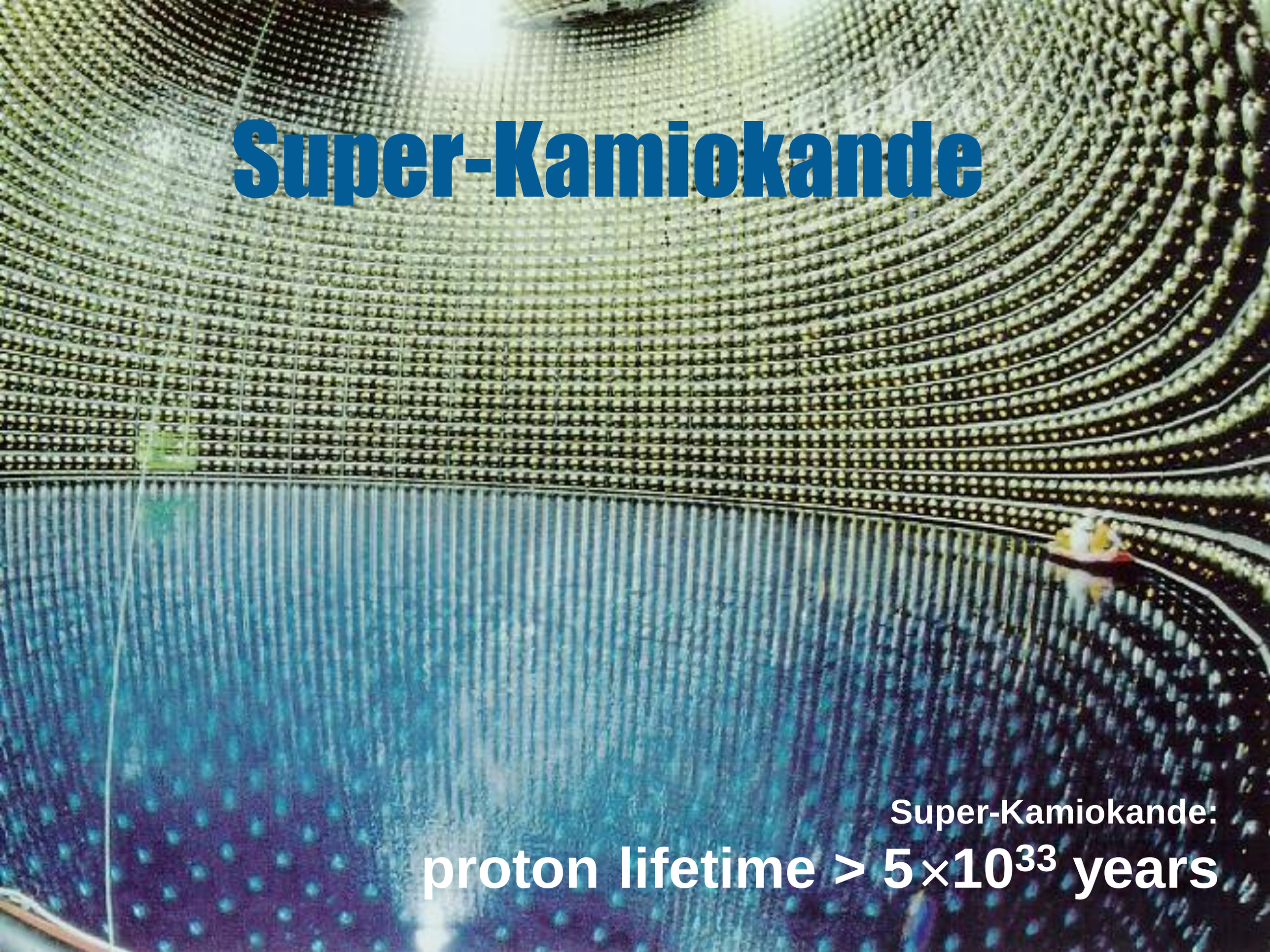
Proton Decay

Lifetime
in simplest GUTs
10^{29}-10^{32} years

Prefered
decay mode

$$p \rightarrow e^{+} + \pi^{0}$$
$$\hookrightarrow \gamma + \gamma$$

Super-Kamiokande



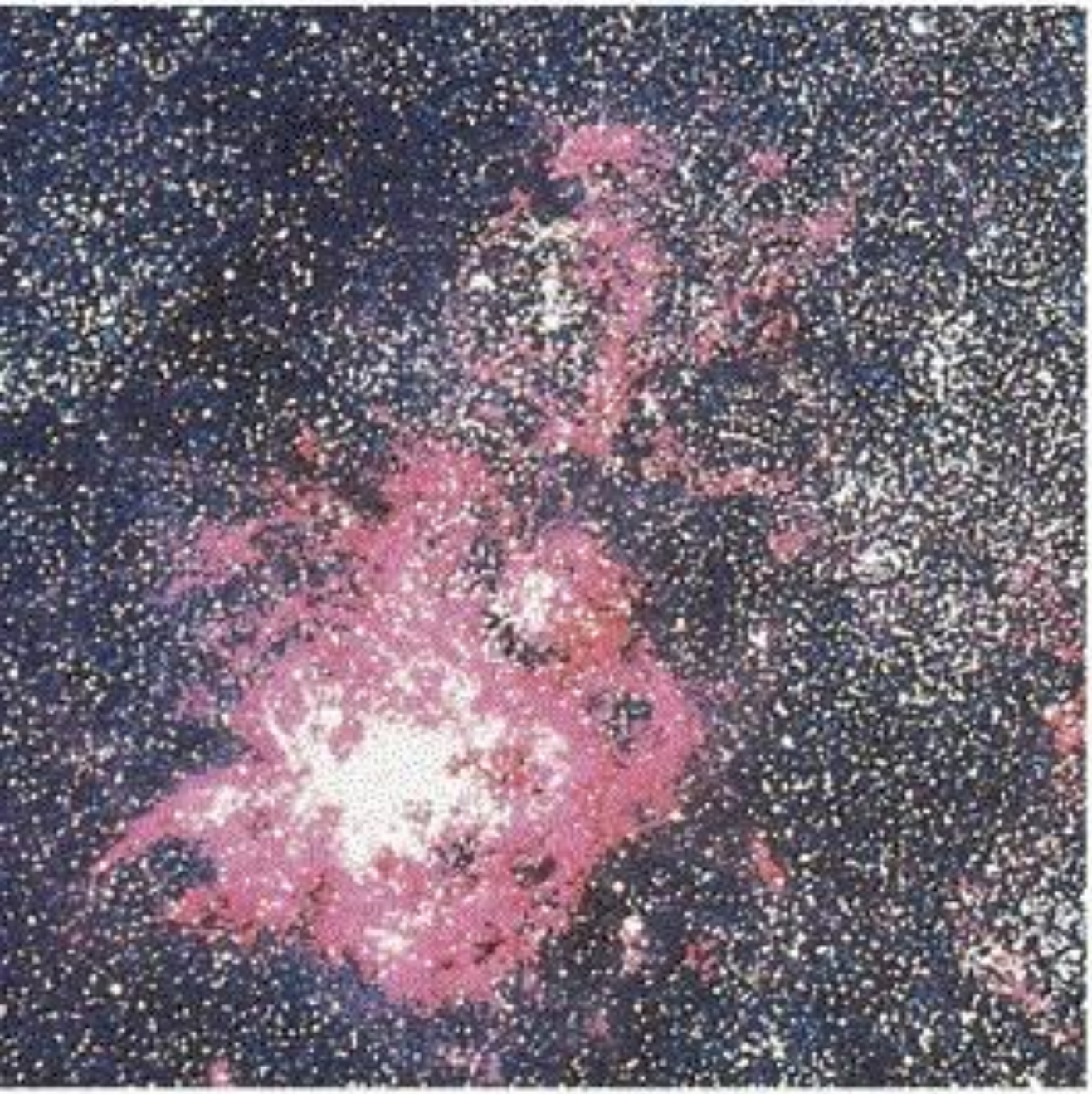
Super-Kamiokande:

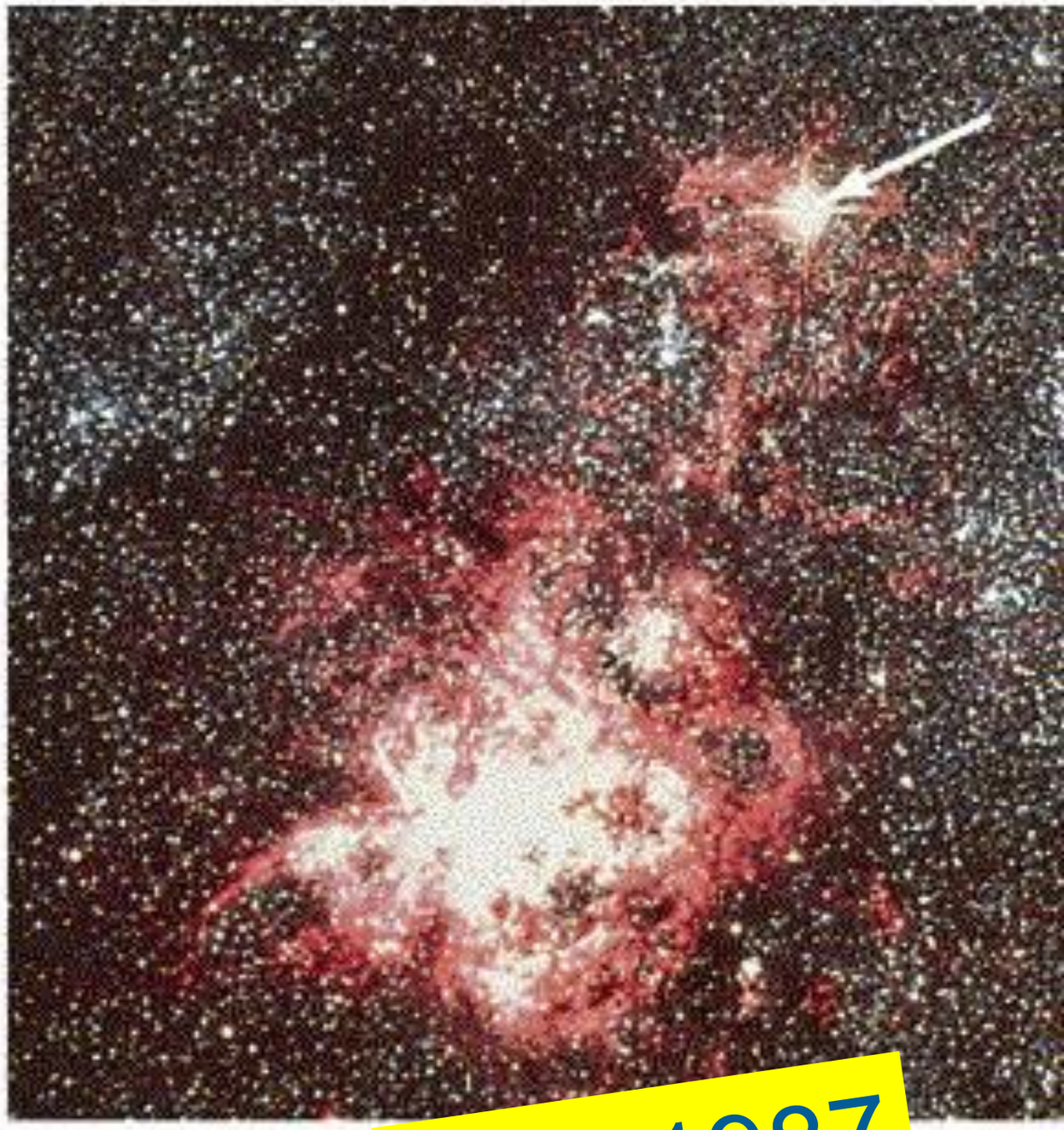
proton lifetime > 5×10^{33} years

Astroparticle Physics for Europe

ASPERA

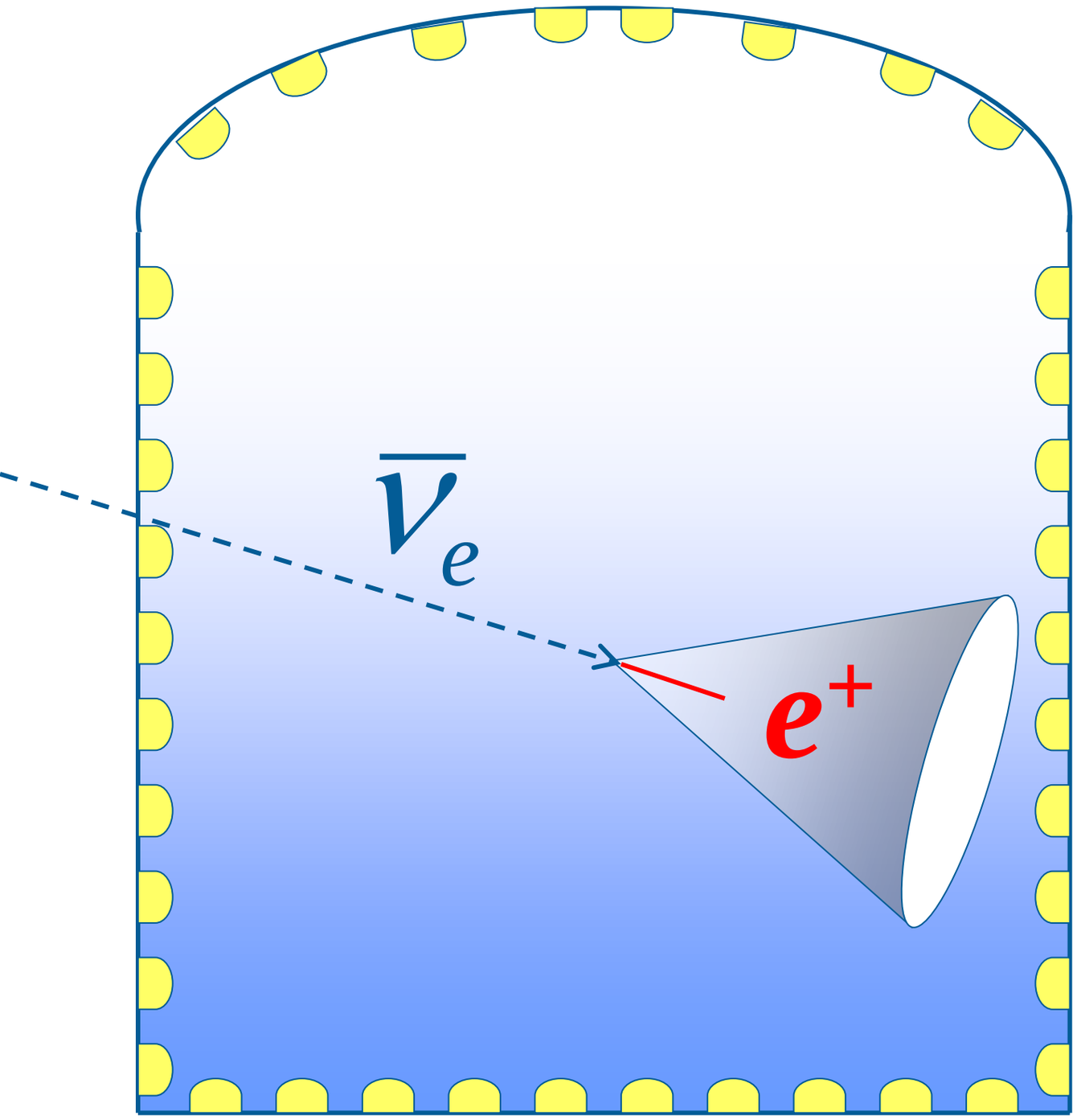
SN-1987



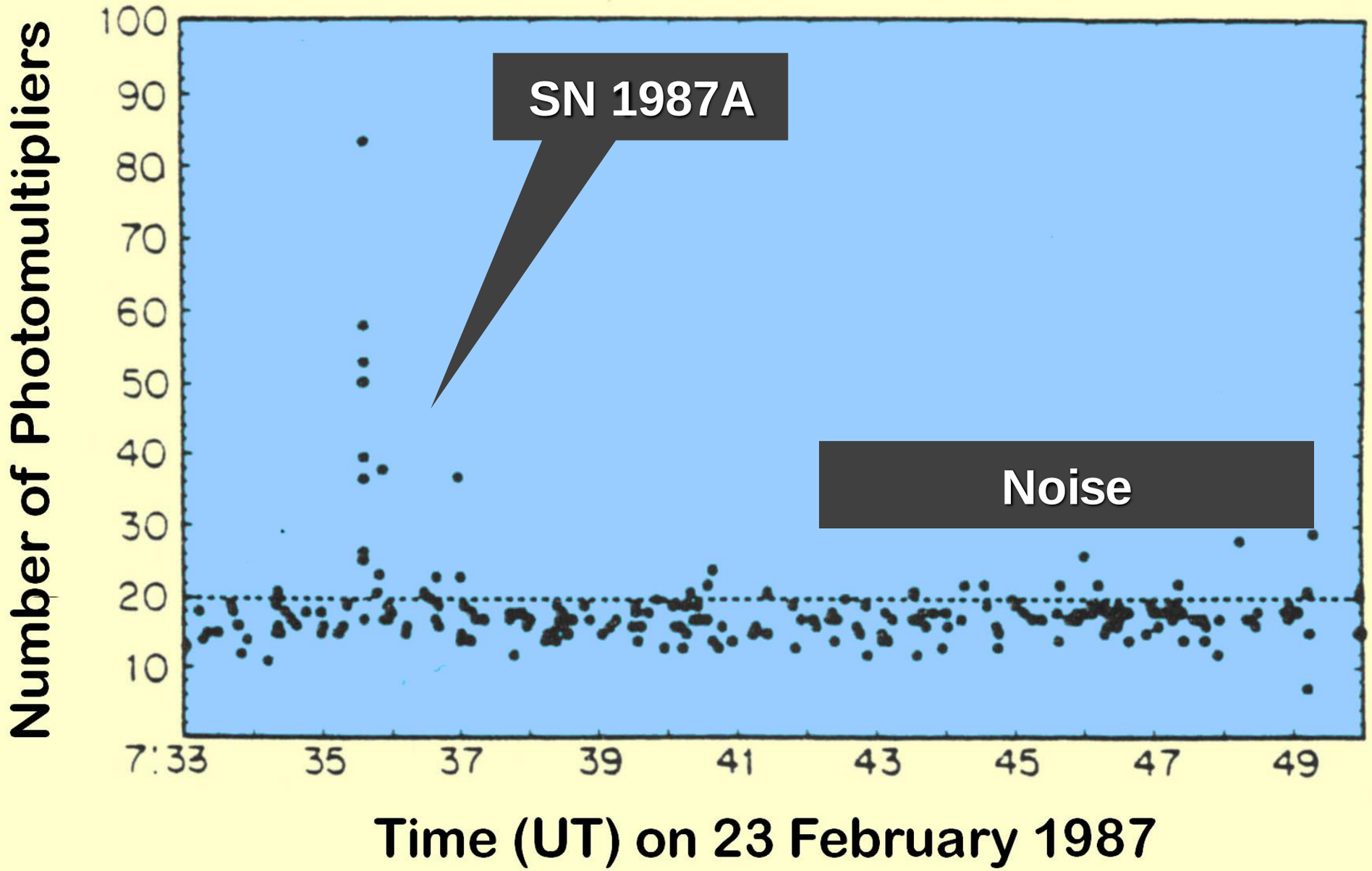


23.2.1987

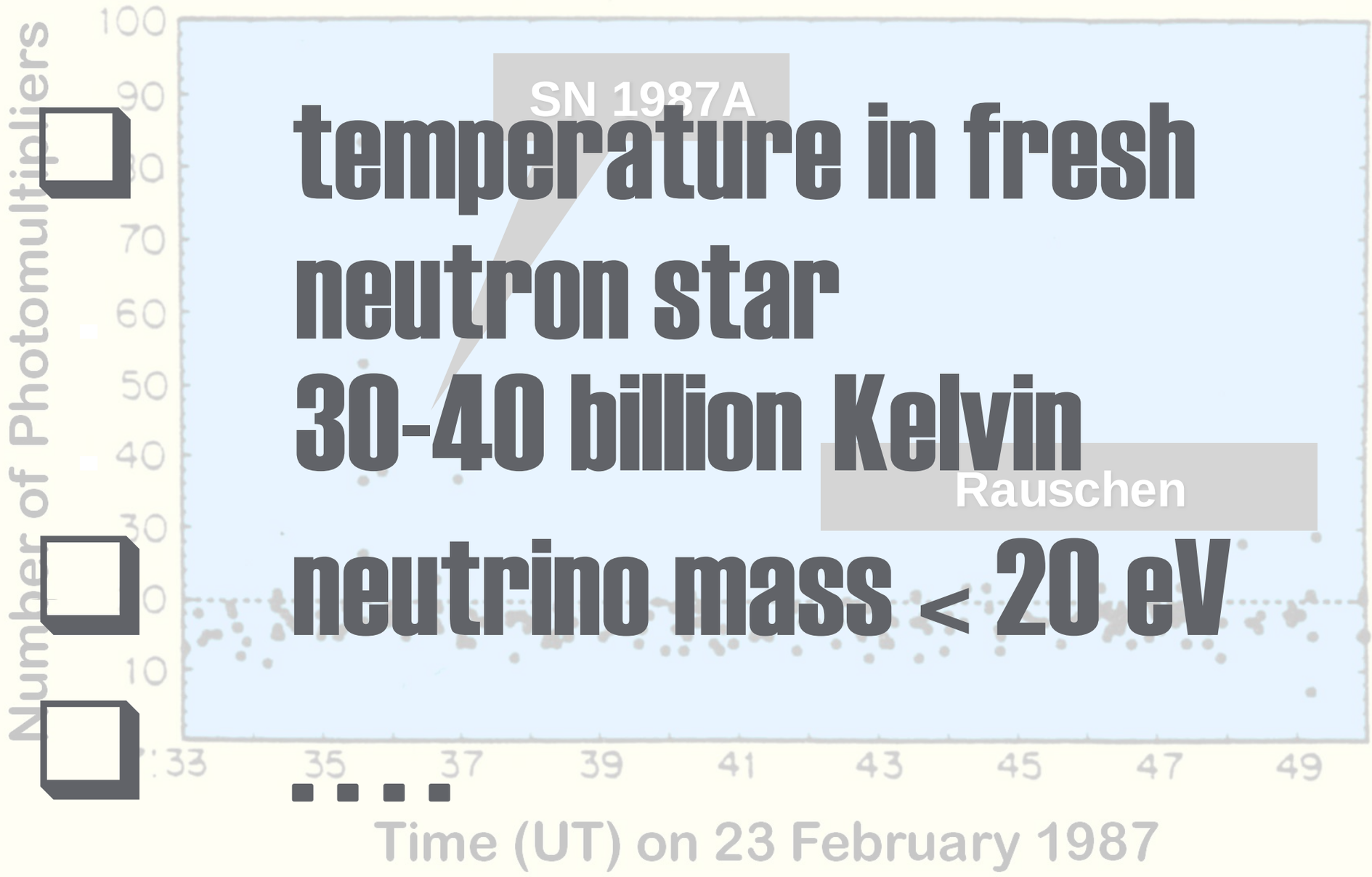
Neutrinos in Kamiokande



$$\bar{\nu}_e + p \rightarrow e^+ + n$$


SN 1987A
Noise
Number of Photomultipliers
100
90
80
70
60
50
40
30
20
10
7:33
35
37
39
41
43
45
47
49
Time (UT) on 23 February 1987

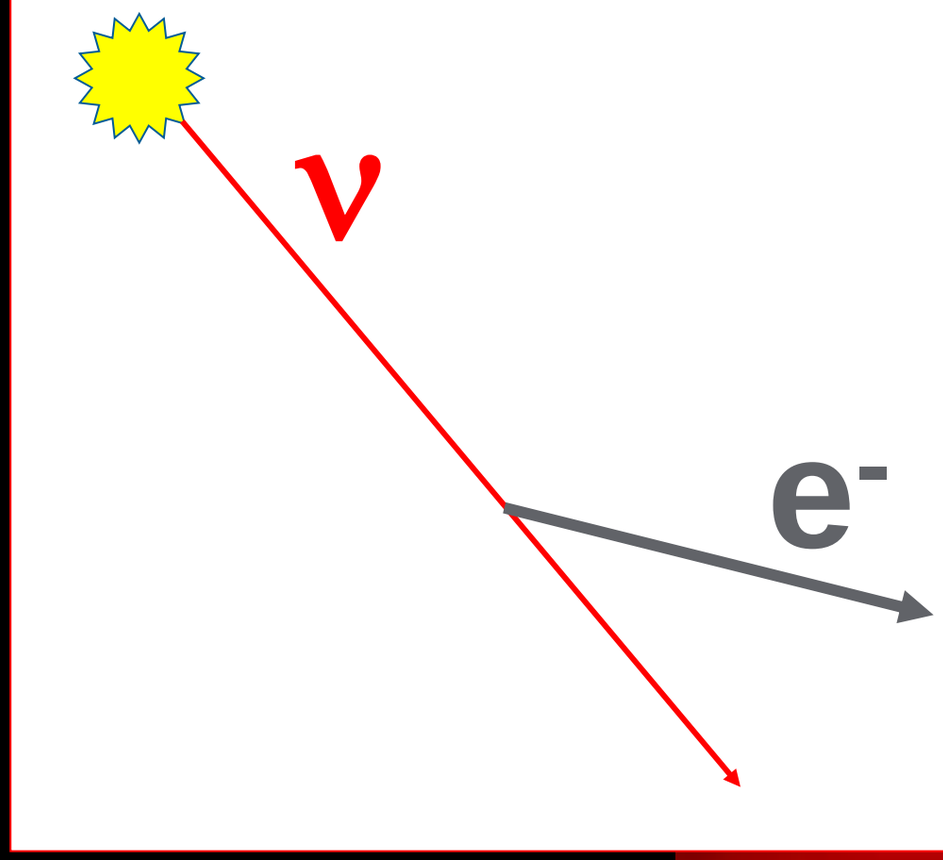
- temperature in fresh neutron star
  30-40 billion Kelvin
- neutrino mass < 20 eV
- ....

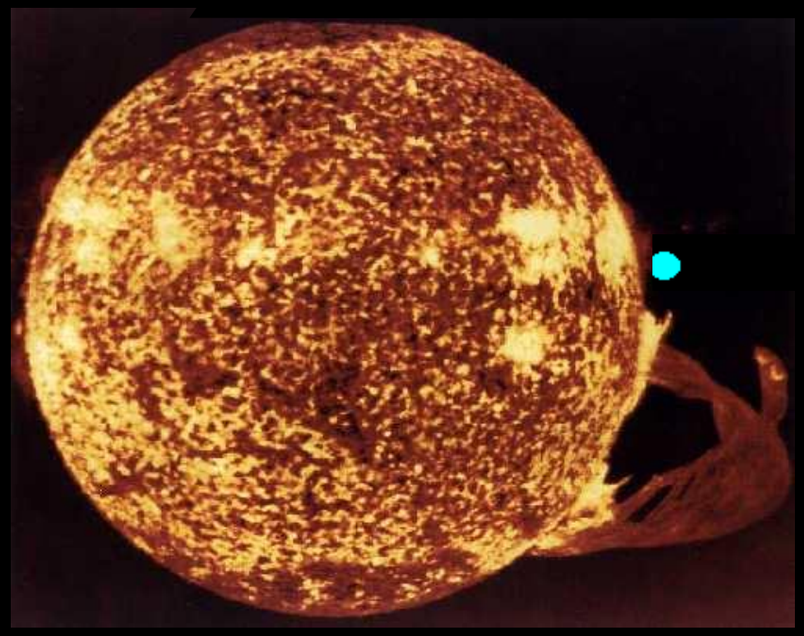


Astroparticle Physics for Europe

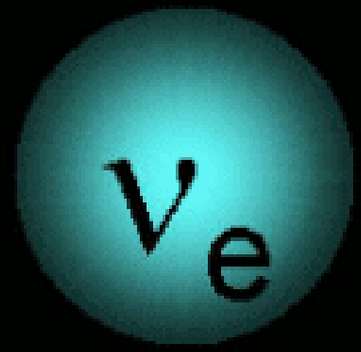
ASPERA

The Sun in Neutrinos





neutrinos change their type on their way from Sun to Earth



Cl-Ar (USA)
Sage (Russia)
Gallex (Italy)
SNO (Canada)
Borexino (Italy)

→ neutrinos have a rest mass

Astroparticle Physics for Europe

ASPERA

Science at the Megaton scale

- **Proton decay:** improve sensitivity by > factor 10 and test a new class of Supersymmetry models
- **Galactic Supernova:** 10^4- 10^5 events
  Incredibly detailed information on the early SN phase
- **Diffuse flux from past SN:** probe cosmological star formation rate
- **Solar neutrinos:** details of the Standard Solar Model determined with percent accuracy
- **Atmospheric neutrinos:** high statistics would improve knowledge neutrino mixing and provide unique information on the neutrino mass hierarchy
- **Geo-neutrinos:** improve understanding of the Earth interior
- **Indirect WIMP search**
- **Neutrinos accelerators** over a long baseline (also with dedicated smaller detectors): neutrino properties

Astroparticle Physics for Europe

LAGUNA

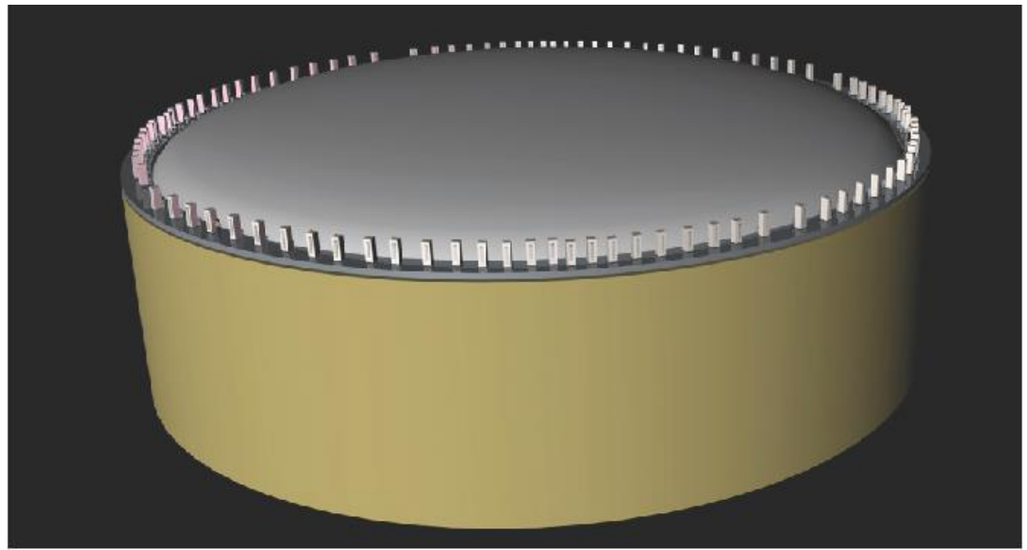
MEMPHYS

700 kton water

LENA

50 kt scintillator

50 m



GLACIER

100 kton liquid argon

- **Recommendation:**

We recommend supporting the work towards a large infrastructure for proton decay and low energy neutrino astronomy, possibly also accelerator neutrinos in long baseline experiments, in a worldwide context. Results of the LAGUNA FP7 design study are expected around 2010 and should be followed by work towards a technical design report. Depending on technology, site and worldwide cost sharing, construction could start between 2012 and 2015.

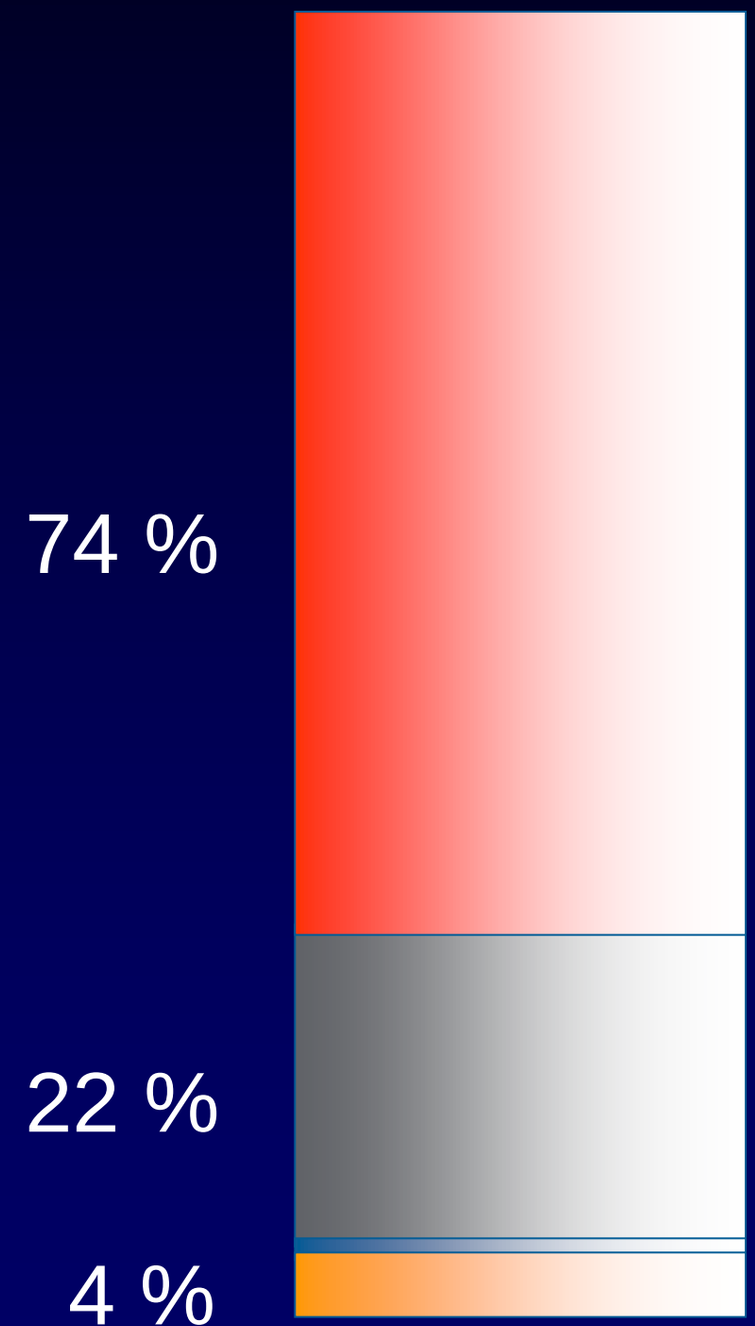
Astroparticle Physics for Europe

ASPERA

Dark Matter

- What is the Universe made of ?
  In particular: what is dark matter ?
- Do protons have a finite lifetime ?
- What are the properties of neutrinos ? What is their role in cosmic evolution ?
- What do neutrinos tell us about the interior of the Sun and the Earth, and about Supernova explosions ?
- What is the origin of cosmic rays ? What is the view of the sky at extreme energies ?
- What will gravitational waves tell us about violent cosmic processes and about the nature of gravity ?

Inventory of the Universe



74 % Dark Energy

22 % Dark Matter

4 % Normal Matter

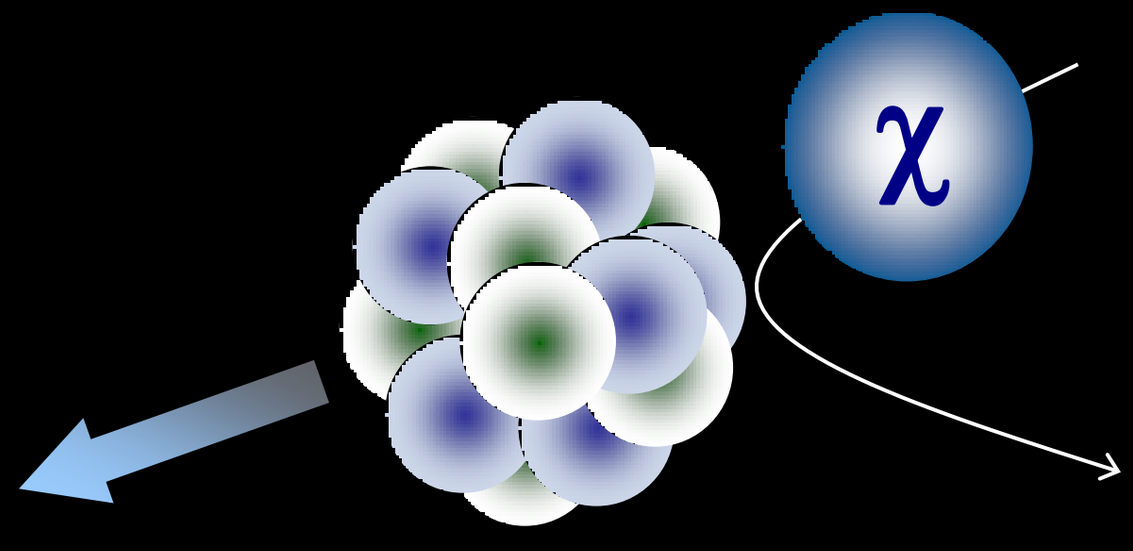
Neutrinos
0.1-1 %

Astroparticle Physics for Europe

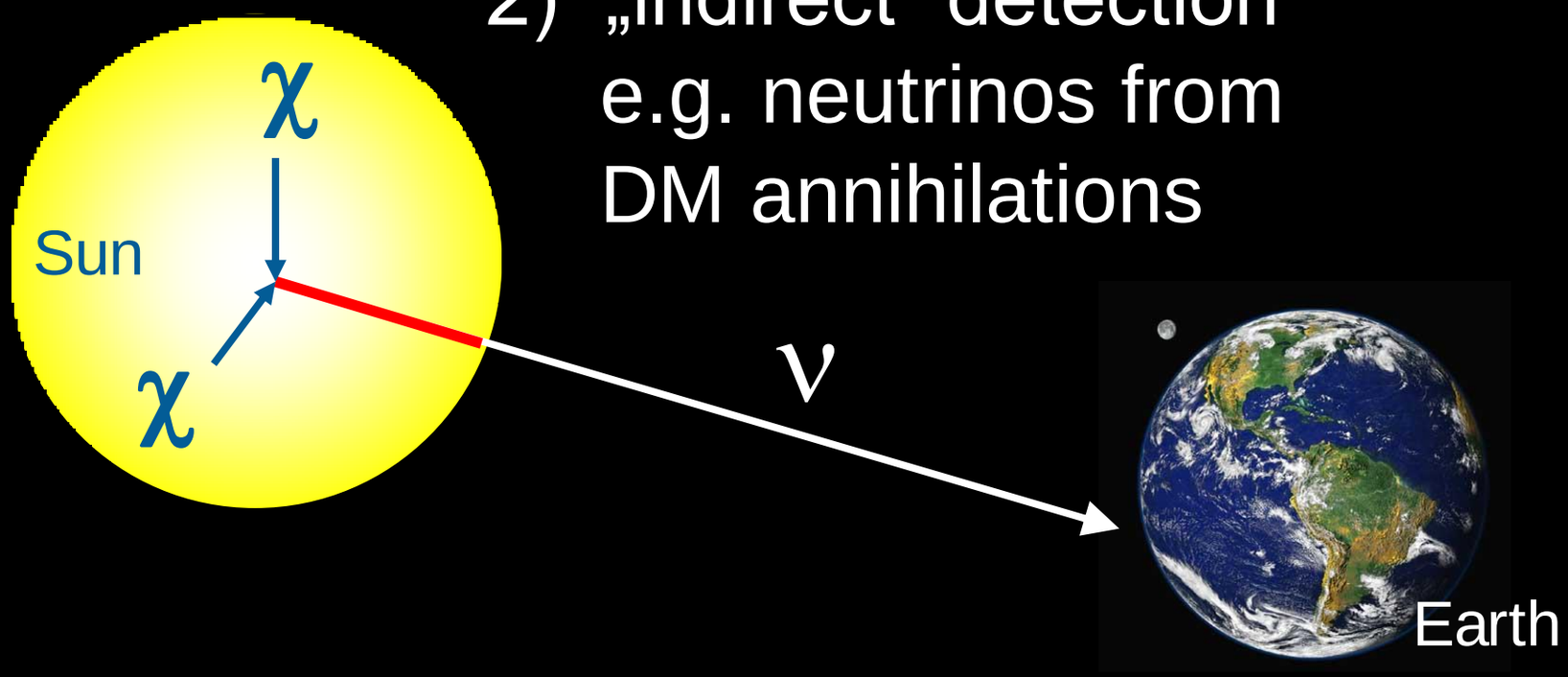
ASPERA

Dark Matter Searches

1) „direct“ detection of DM reactions deep underground



2) „indirect“ detection e.g. neutrinos from DM annihilations



3) Production of DM particles at the LHC

Dark Matter Searches

COUPP, PICASSO, SIMPLE

DRIFT I, II

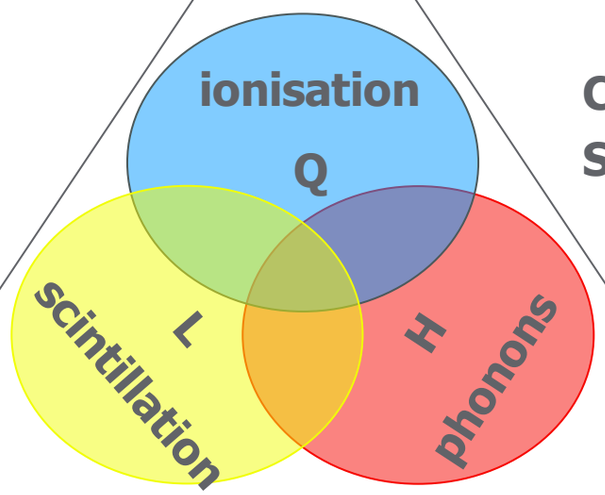
GENIUS,

IGEX,

NEWAGE

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

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



ArDM, SIGN, WARP, XENON10, ZEPLIN III , LUX, XENON-100, WARP-140

CDMS, EDELWEISS, SuperCDMS, EURECA

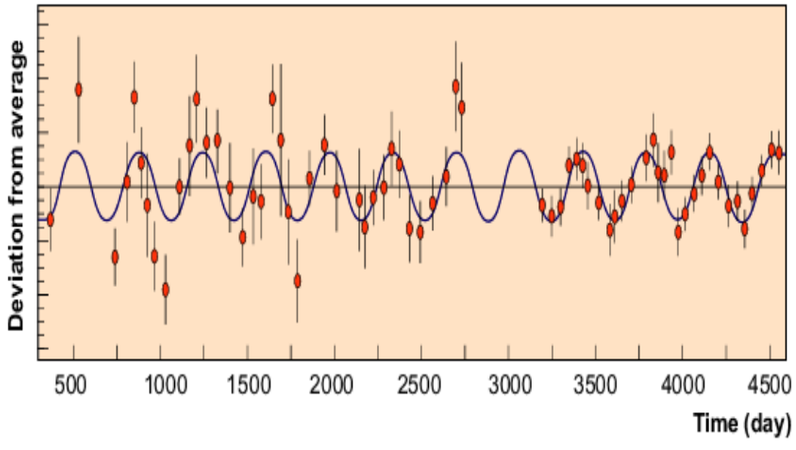
ANAIS, CLEAN, DEAP, KIMS, DAMA/LIBRA, NAIAD, XMASS, ZEPLIN I

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

CRESST II, ROSEBUD, EURECA

by T. Sumner updated by C.P.de los Heros and C.Spiering

DAMA annual modulation



Dark Matter Searches

COUPP, PICASSO, SIMPLE

DRIFT I, II

GENIUS,

IGEX,

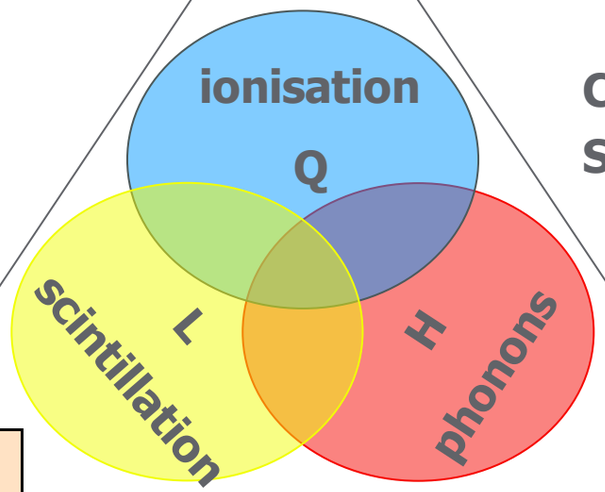
NEWAGE

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

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

ArDM, SIGN, WARP, XENON10, ZEPLIN III , LUX, XENON-100, WARP-140

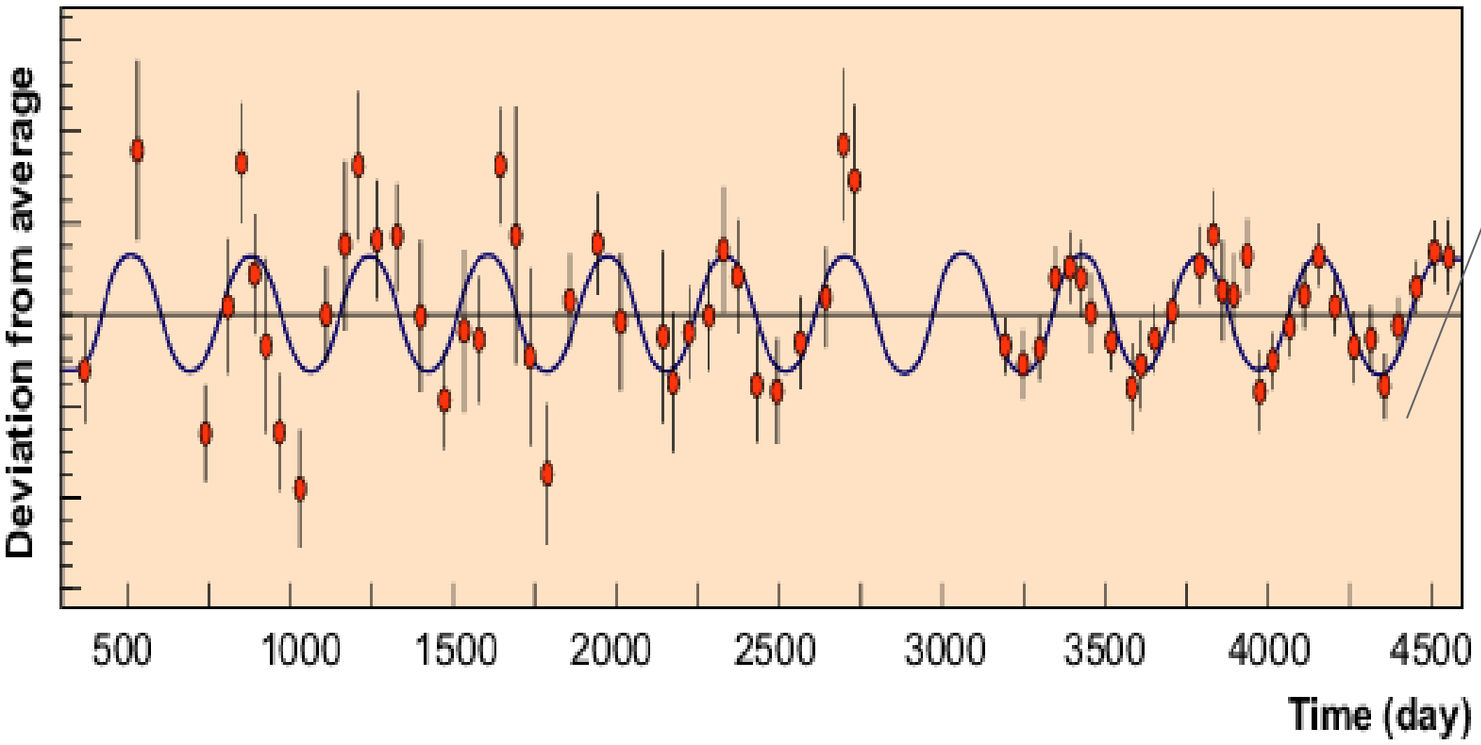
CDMS, EDELWEISS, SuperCDMS, EURECA



CRESST II, ROSEBUD, EURECA

by T. Sumner updated by C.P.de los Heros and C.Spiering

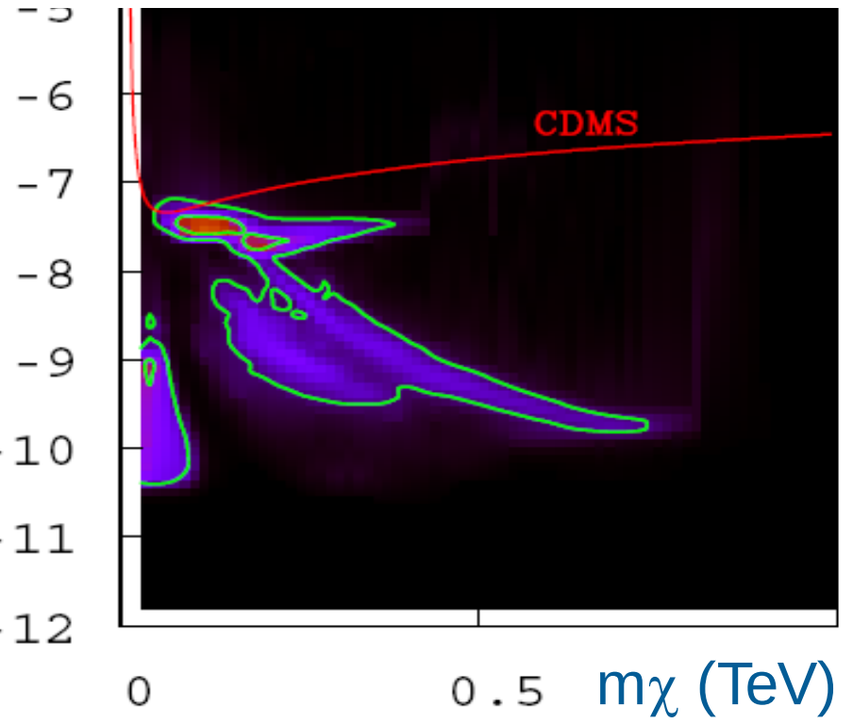
DAMA annual modulation



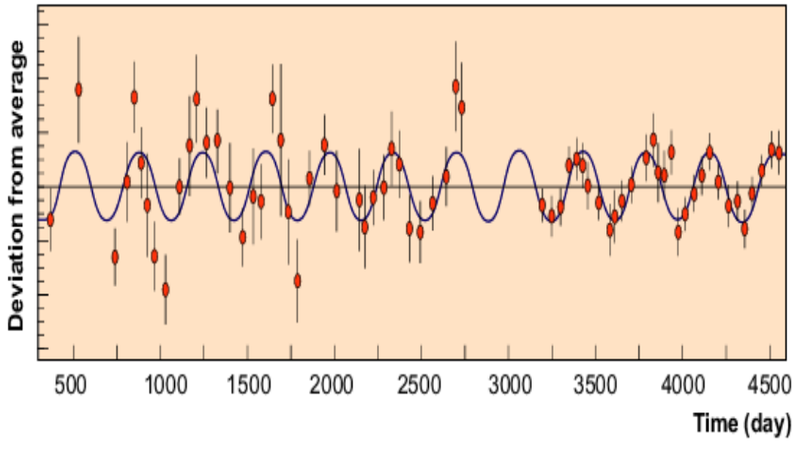
Dark Matter Searches

Astroparticle Physics for Europe

ASPERA



DAMA annual modulation



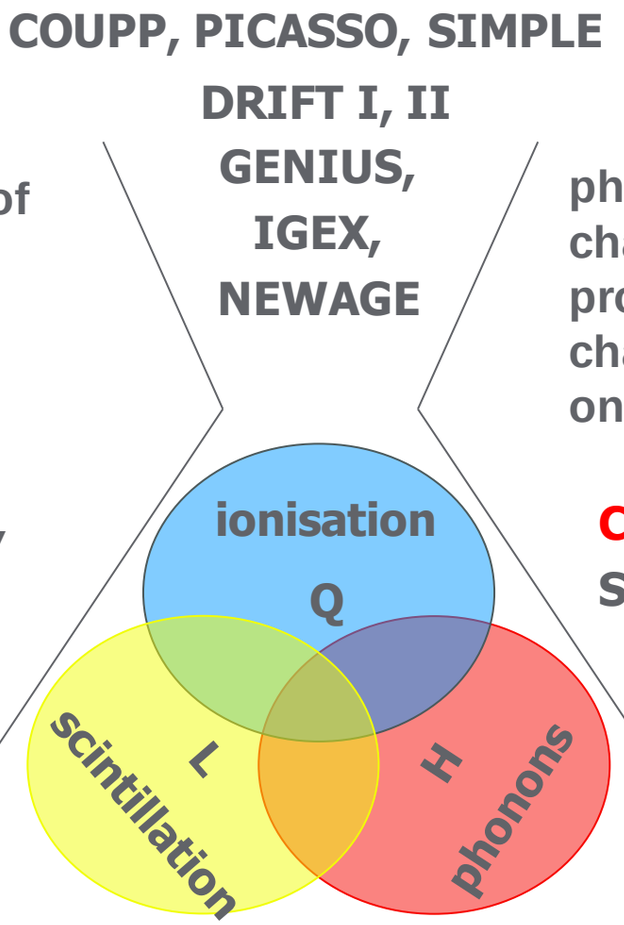
WIMP elastic nuclear recoils deposit < 50keV of energy at a rate 10^{-5} to 1 event/day/kg

ArDM, SIGN, WARP, XENON10, ZEPLIN III , LUX, XENON-100, WARP-140

ANAIS, CLEAN, DEAP, KIMS, DAMA/LIBRA, NAIAD, XMASS, ZEPLIN I

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

CRESST II, ROSEBUD, EURECA

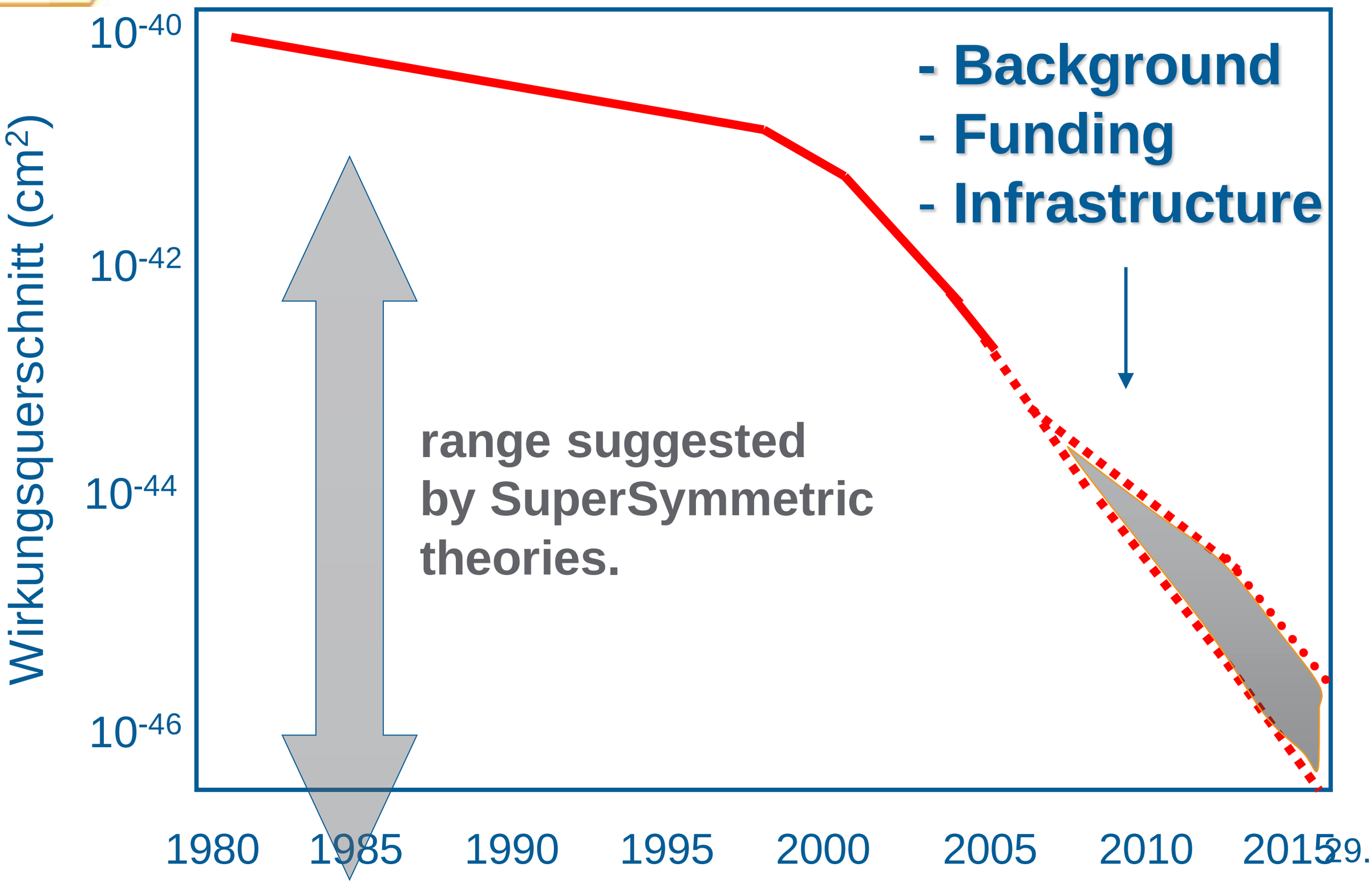


phonons, photons and charge whose relative proportions and /or characteristics depend on dE/dx ⇒ particle type

CDMS, EDELWEISS, SuperCDMS, EURECA

by T. Sumner
updated by
C.P.de los Heros
and C.Spiering

Dark Matter Searches



Dark Matter Searches

Towards 2 ton-scale zero-background detectors

Now: 10 kg scale 2009/11: 100 kg scale 2011-17: constr. ton scale

CRESST
Edelweiss

EURECA-100 → EURECA @ ton scale

modular expansion

LXe
LXe
LAr
LAr
...

XENON/LUX, WARP

Xe-100
Ar-100

→ Noble liquid @ ton scale

a possible convergence scenario, slide CS from one year ago.

Astroparticle Physics for Europe

ASPERA

Dark Matter Searches

We recommend the construction and operation of one – possibly two complementary – detectors on the ton scale or beyond with low background, capable of reaching a 10^{-10} pb sensitivity, with a European lead role or shared equally with non-European partners. We recommend a stepwise approach via 100 kg detectors, as present underway, and a prioritisation between different technologies around 2010. **We urge convergence of parallel worldwide efforts.**

The High Energy Universe

Astroparticle Physics for Europe

ASPERA

iverse made of ?

hat is dark matter ?

ve a finite lifetime ?

roperties of neutrinos ? What is

smic evolution ?

nos tell us about the interior of

the Sun and the Earth, and about Supernova explosions ?

- What is the origin of cosmic rays ? What is the view of the sky at extreme energies ?
- What will gravitational waves tell us about violent cosmic processes and about the nature of gravity ?

- **Gamma Rays**

  CTA

- **Neutrinos**

  KM3NeT

- **Charged Cosmic Rays**

  Auger North

European Priorities

ASPERA

SIXTH FRAMEWORK PROGRAMME

http://www.aspera-eu.org

primary particle

stratospheric balloon (40 km altitude)

~ 20 km altitude

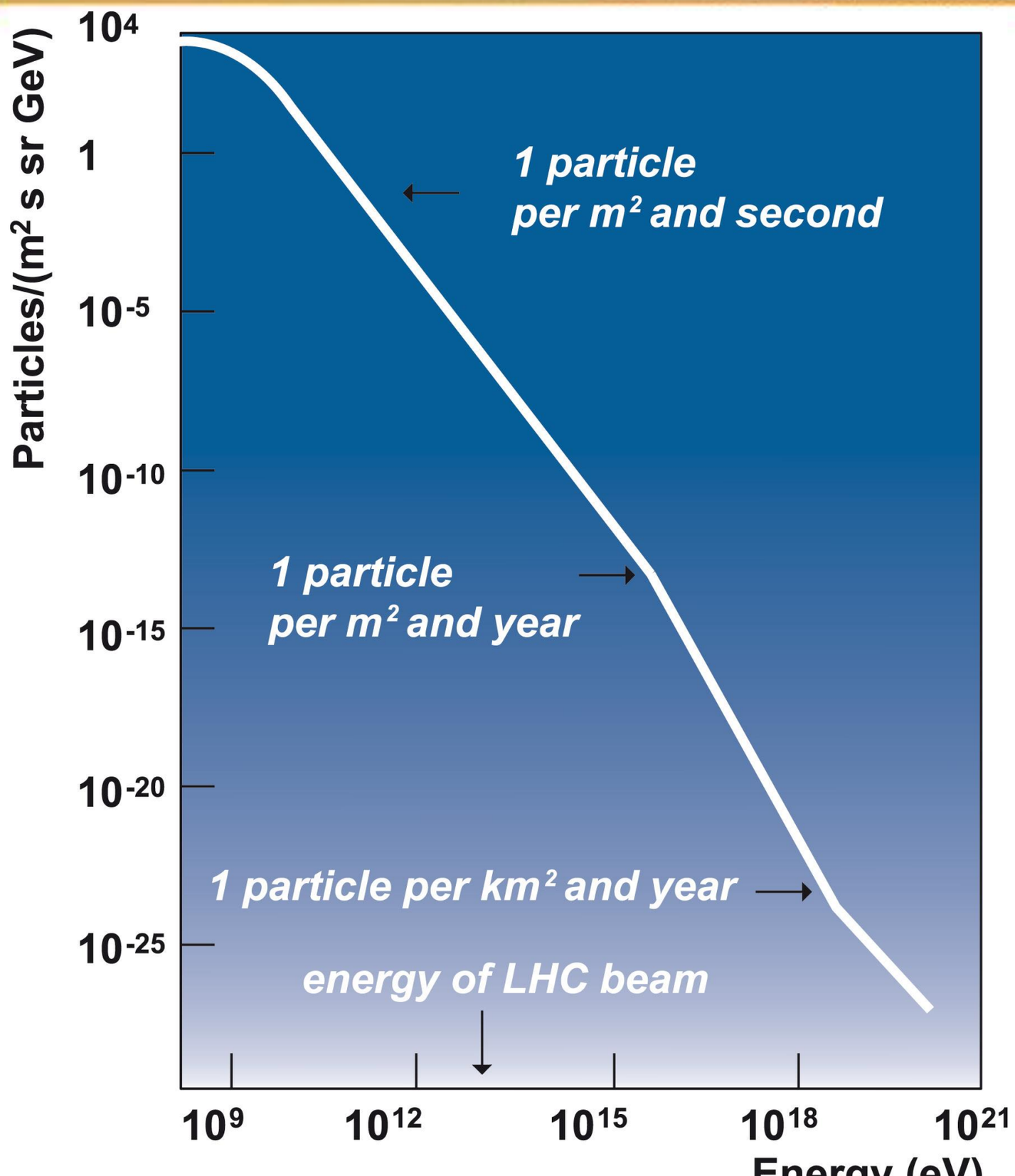
collision of primary particle

Hess‘ balloon (up to 5 km altitude)

fluorescence telescope

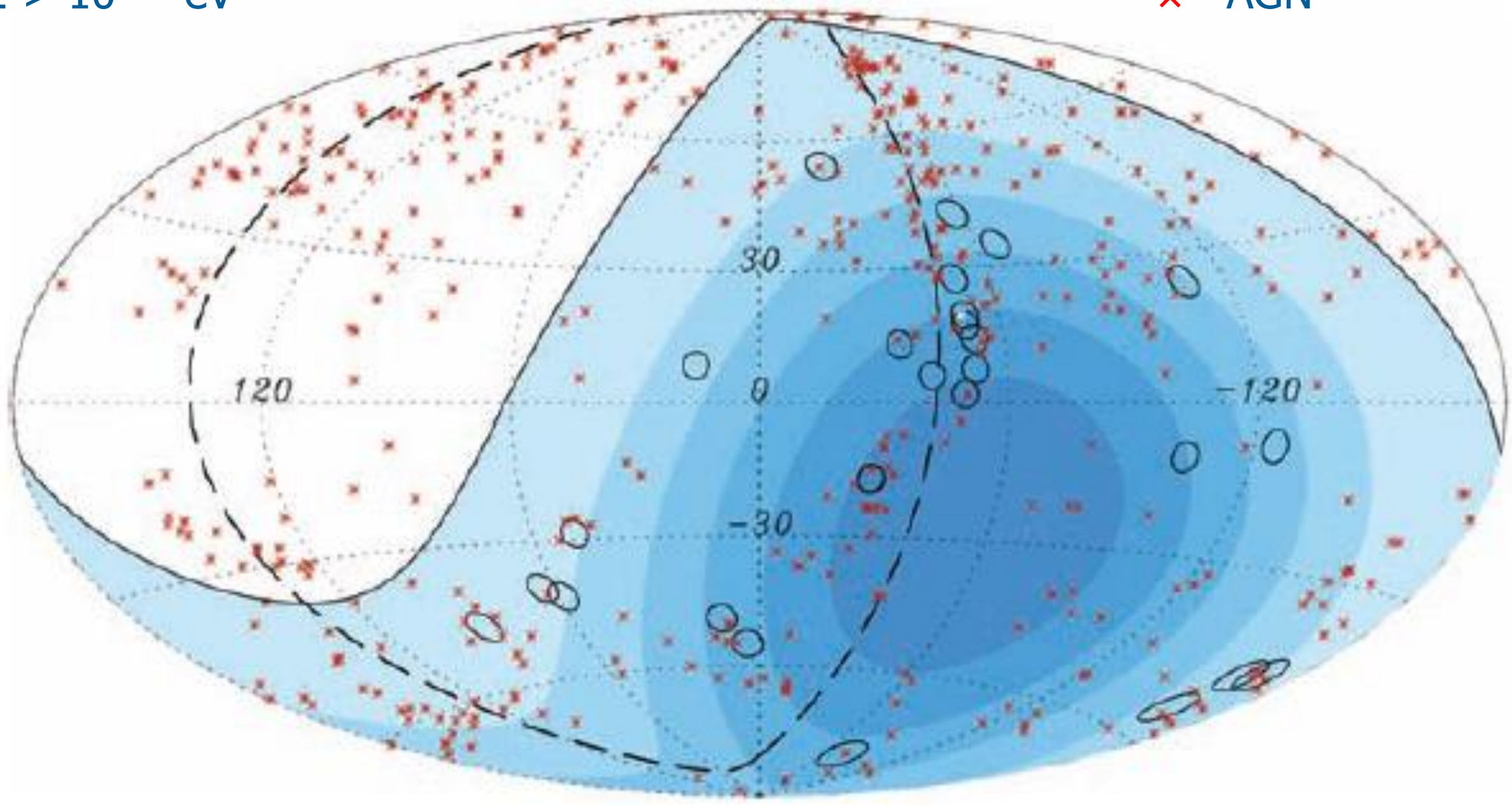
particle detectors

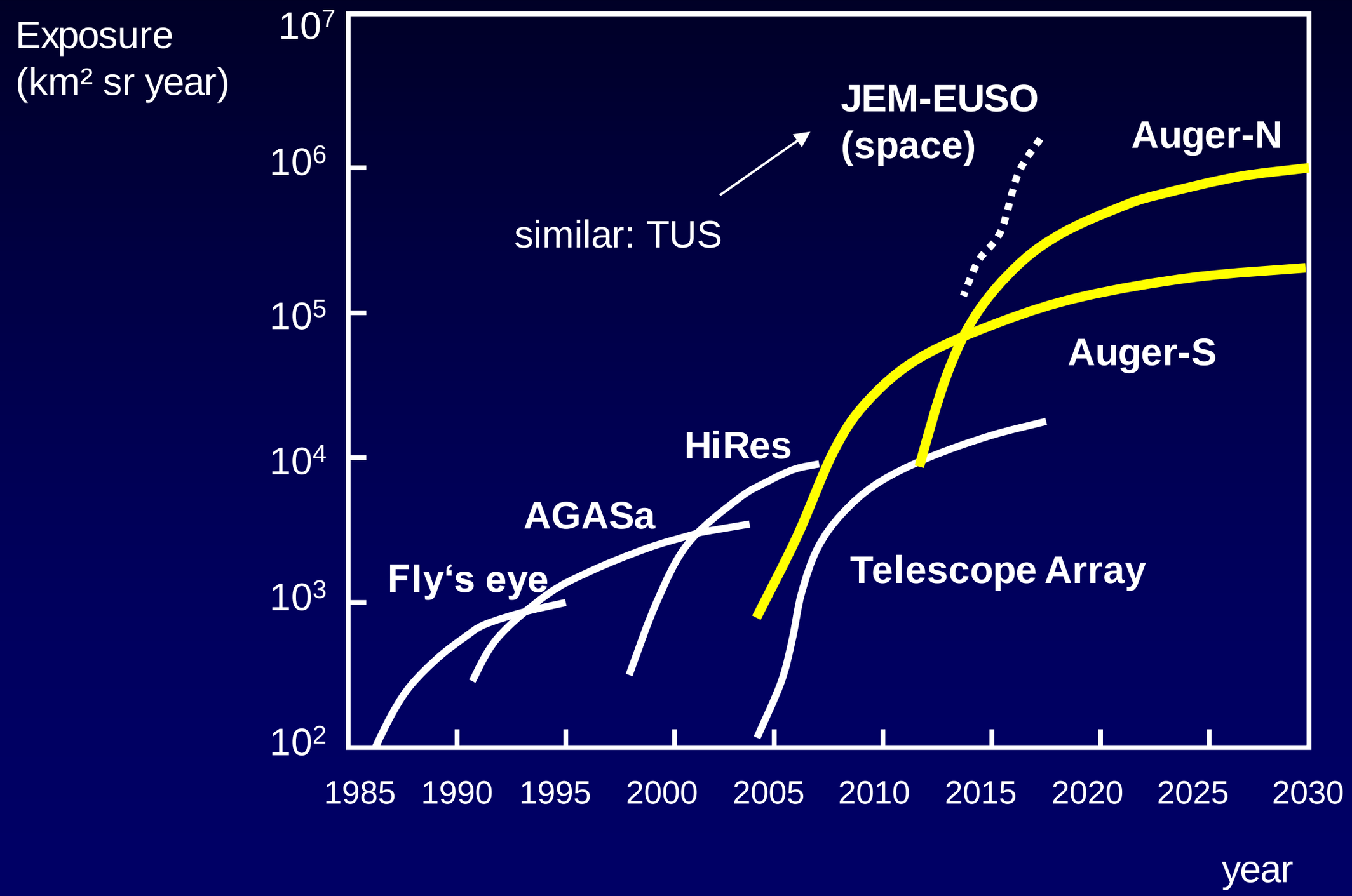
Charged Cosmic Rays



Auger skymap
$E > 10^{19.5}$ eV

o - Auger-Events
× - AGN




Exposure
(km² sr year)
10⁷
10⁶
10⁵
10⁴
10³
10²
JEM-EUSO
(space)
similar: TUS
Auger-N
Auger-S
HiRes
AGASa
Fly's eye
Telescope Array
1985
1990
1995
2000
2005
2010
2015
2020
2025
2030
year

Charged Cosmic Rays

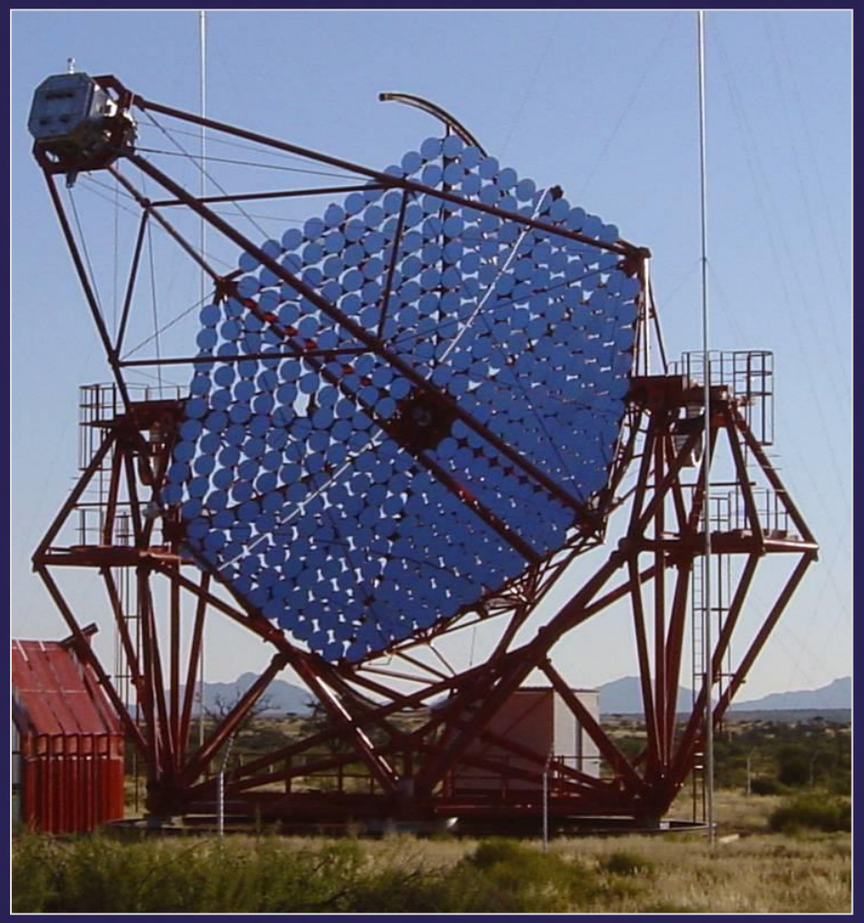
- High statistics astronomy
  → need a substantially larger array than Auger South
- Full sky coverage → need Northern site

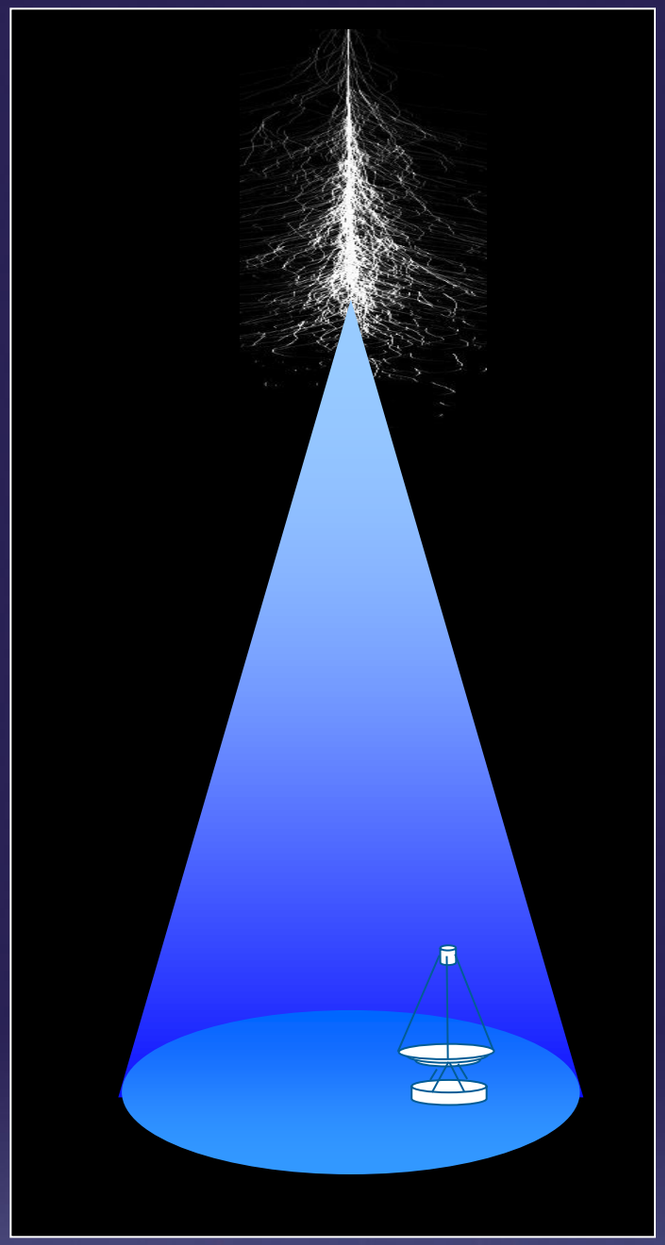
- Recommendation: The priority project for high energy cosmic ray physics is Auger. We encourage the agencies in different continents to work towards a common path for Auger-North. We recommend the construction of such a large array as soon as worldwide agreements allow.

ASPERA

Astroparticle Physics for Europe

High Energy Gamma Rays



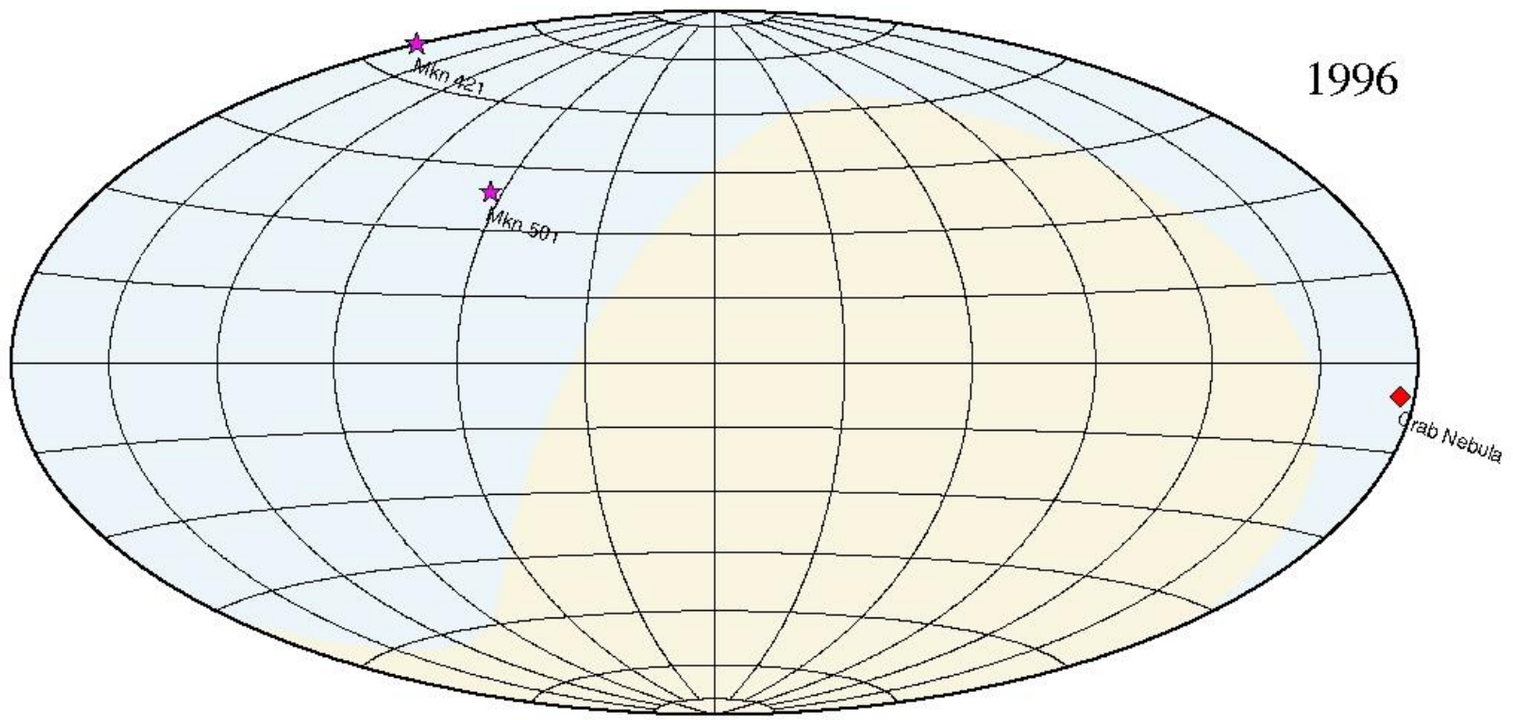


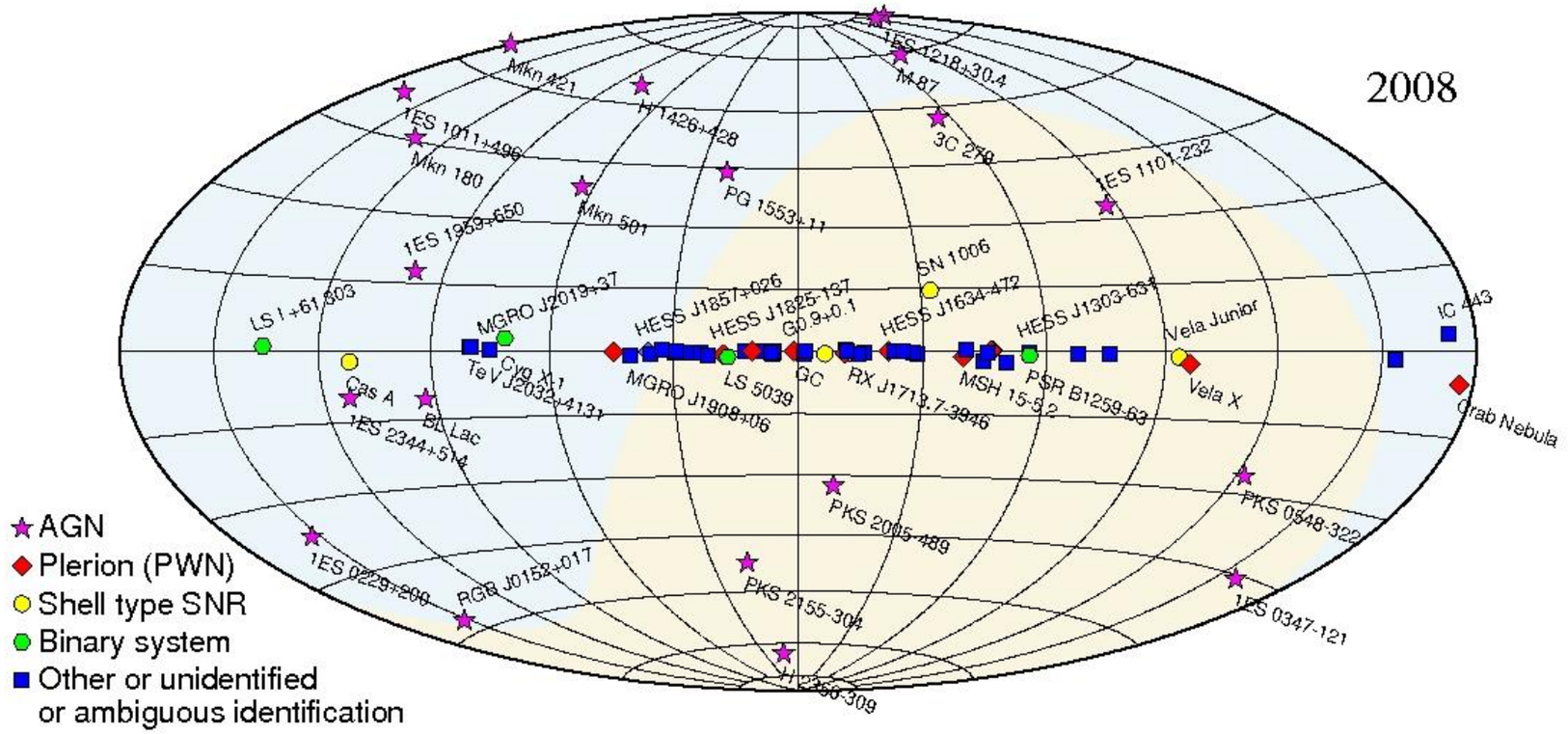
High Energy Gamma Rays

- Enormous progress over last 15 years

- 1989: first source (Crab)
- 1996: 3 sources
- 2006: ~ 40 sources
- 2008: ~ 75 sources

- H.E.S.S. (Namibia)
- MAGIC (La Palma)
- VERITAS (Arizona)





High Energy Gamma Rays

Astroparticle Physics for Europe

ASPERA

now

IACTs, Europe

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

operation — **H.E.S.S.** — four 11-m telescopes

construction → operation — **H.E.S.S.- II** — + one 25-m telescope

operation — **MAGIC-I** — one 17-m telescope

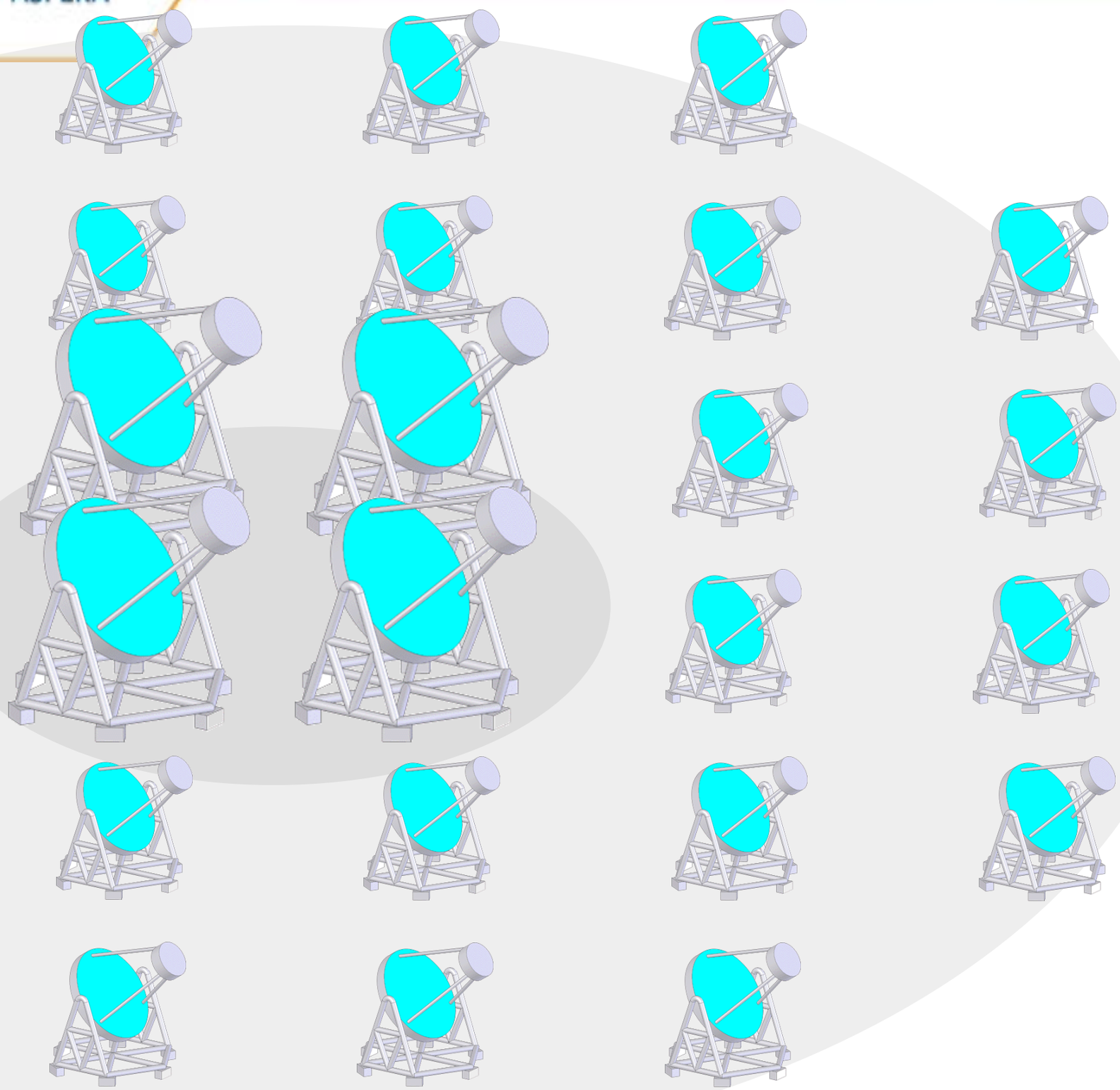
construction → operation — **MAGIC- II** — 2nd 17-m telescope

CTA

des… → …nstruction + operation → Oper.

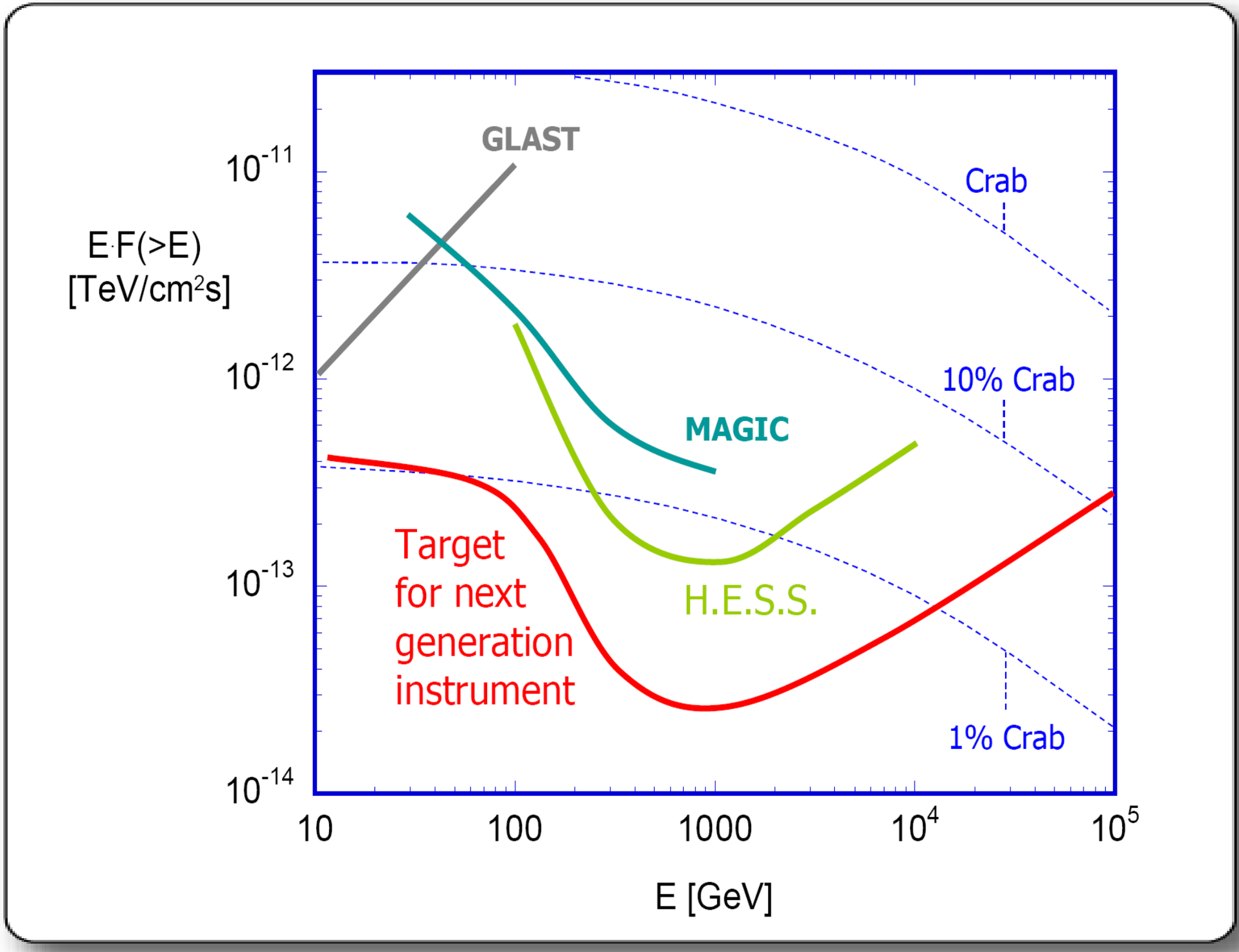
Coordination with USA, Japan, Australia

High Energy Gamma Rays



A possible CTA design

CTA sensitivity



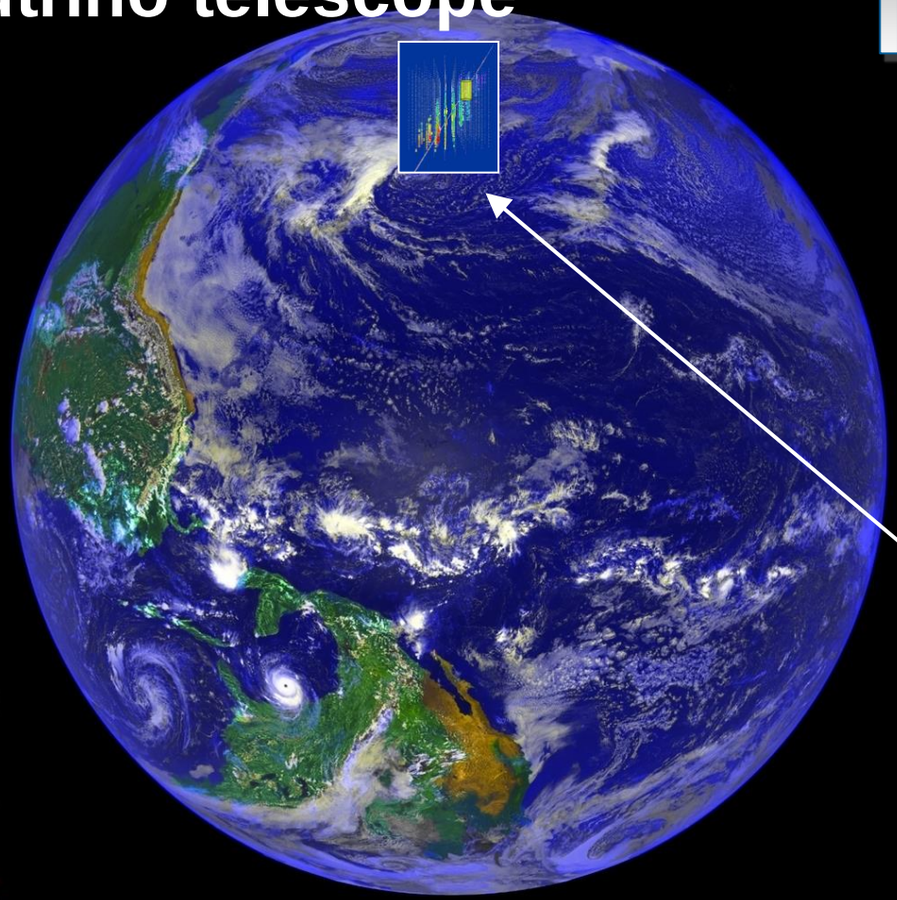
Expect ~1000 sources

High Energy Gamma Rays

- From “experiment” to “observatory”
- 10-fold improvement of sensitivity, extension of energy range, significant improvement in resolution
- Expect ~ 1000 sources, explore spatial structure and energy spectra.
- Ultimately, a Northern and a Southern CTA instrument, operated under a common framework, should provide full-sky coverage.
- Coordination with AGIS (USA) is underway. CTA is on the ESFRI list. Also listed as a priority entry in the ASTRONET infrastructure roadmap.

- **<u>Recommendation:</u> The priority project of VHE gamma astrophysics is CTA. We recommend design and prototyping of CTA and selection of site(s), and proceeding decidedly towards start of deployment in 2012.**

High Energy Neutrinos



ν

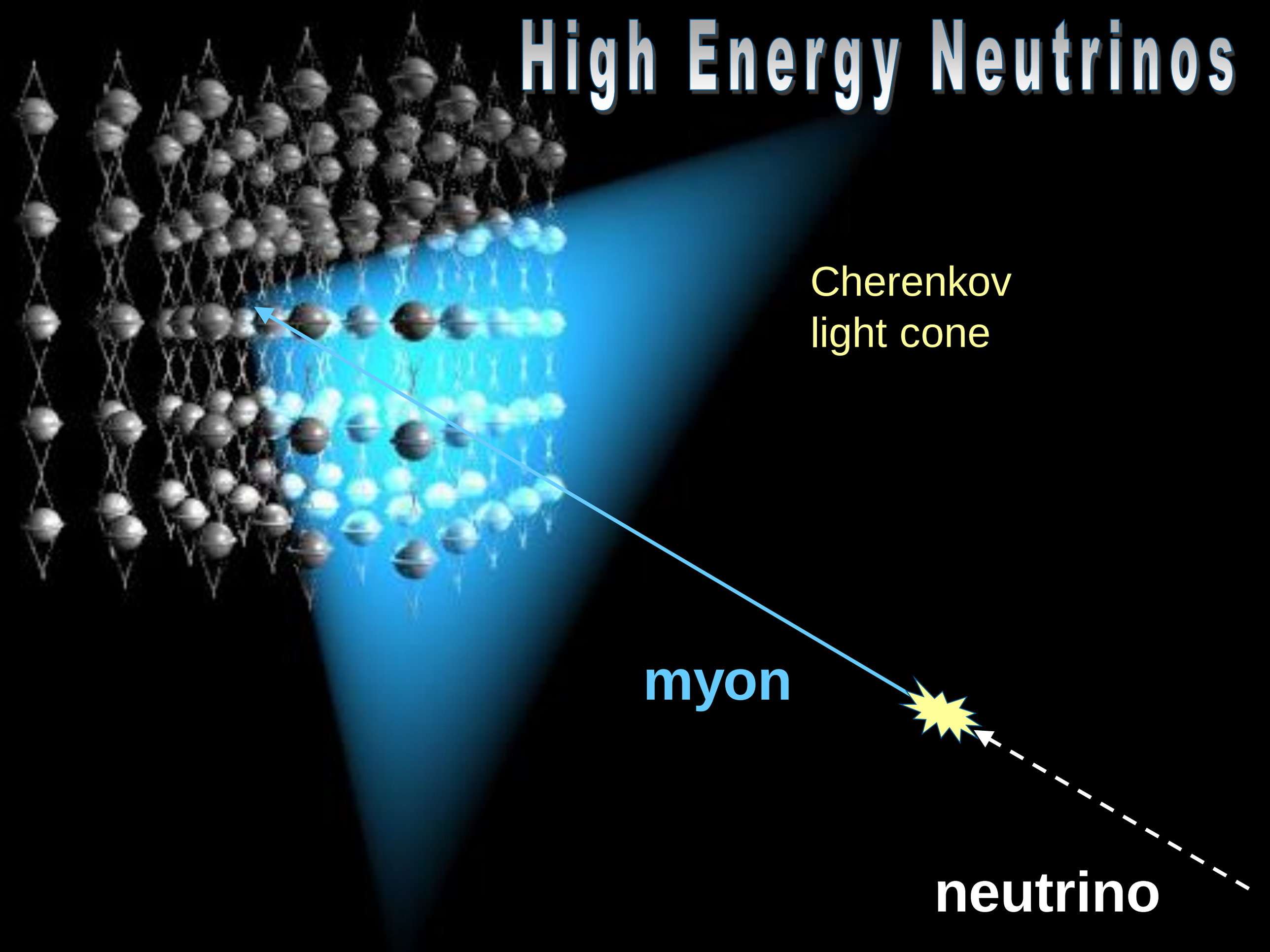
Only neutrinos can cross the Earth

→ for clear identification:

Look down !

(and use the Earth as filter)

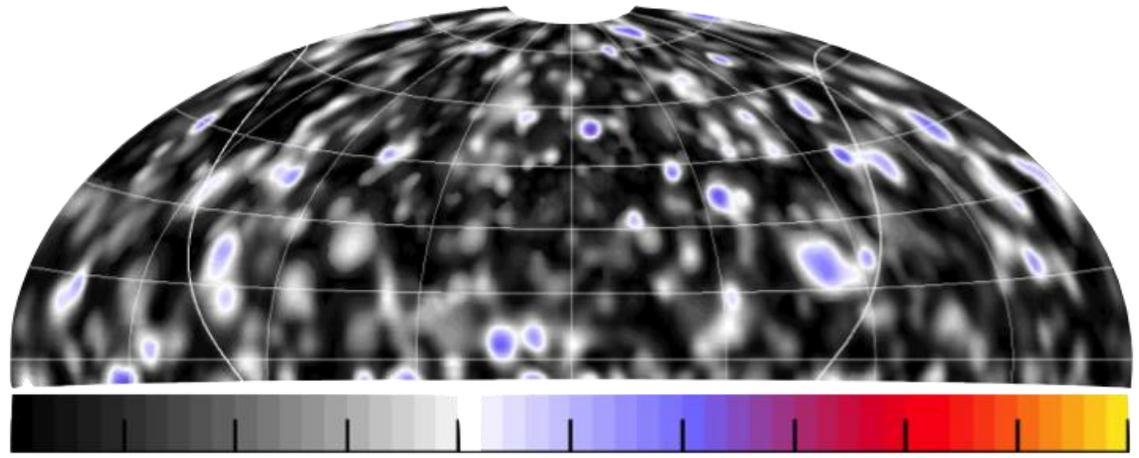
High Energy Neutrinos

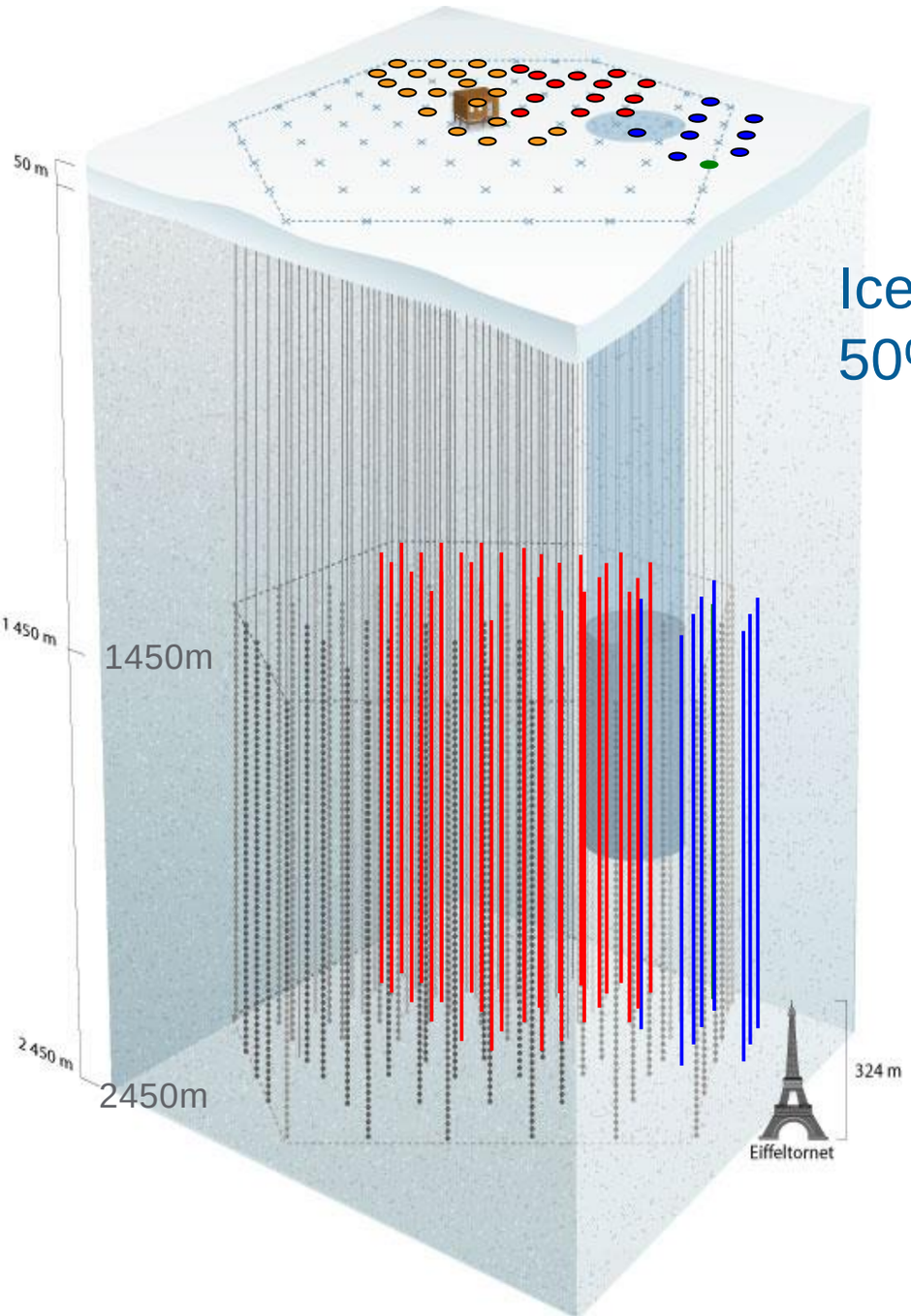


High Energy Neutrinos

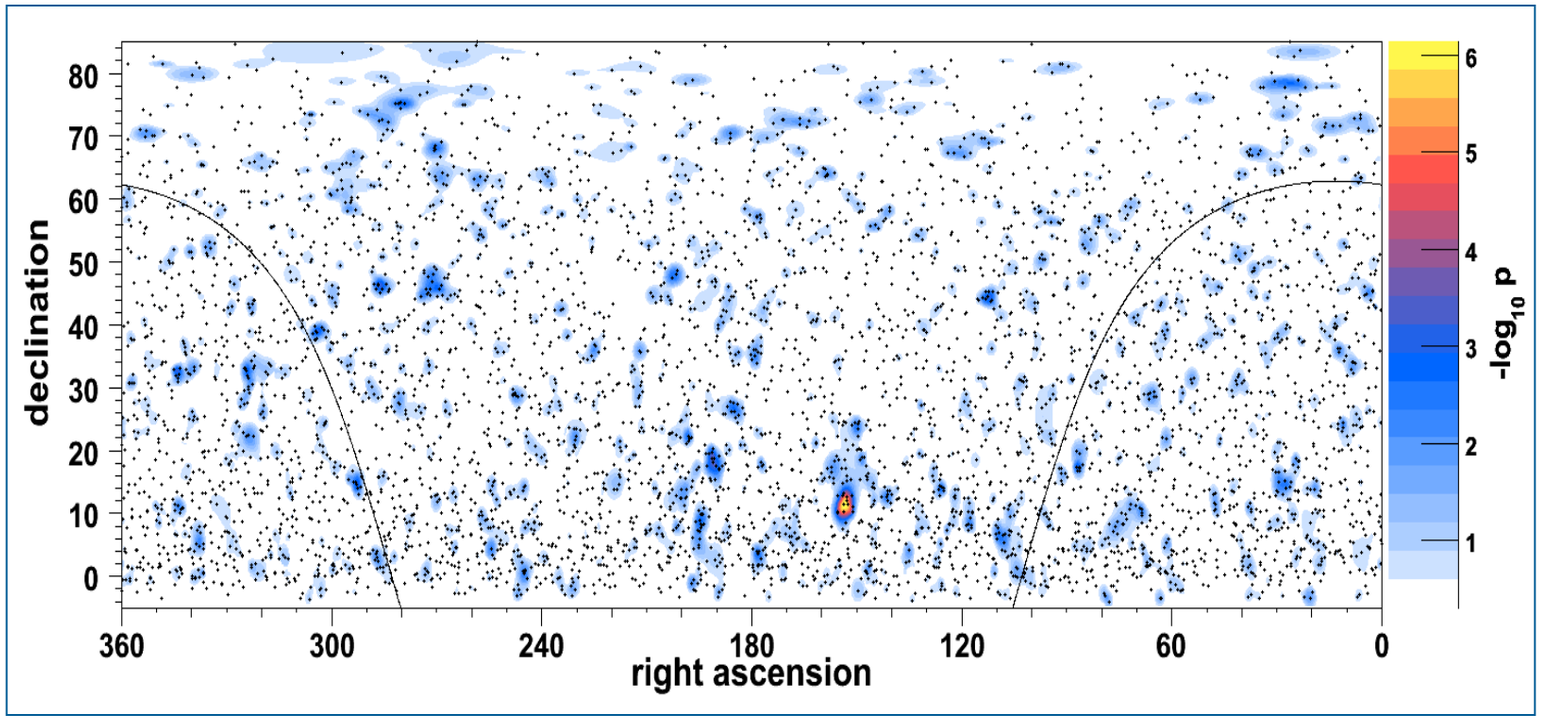
A fantastic year 2008

7 year skymap AMANDA





IceCube
50% complete

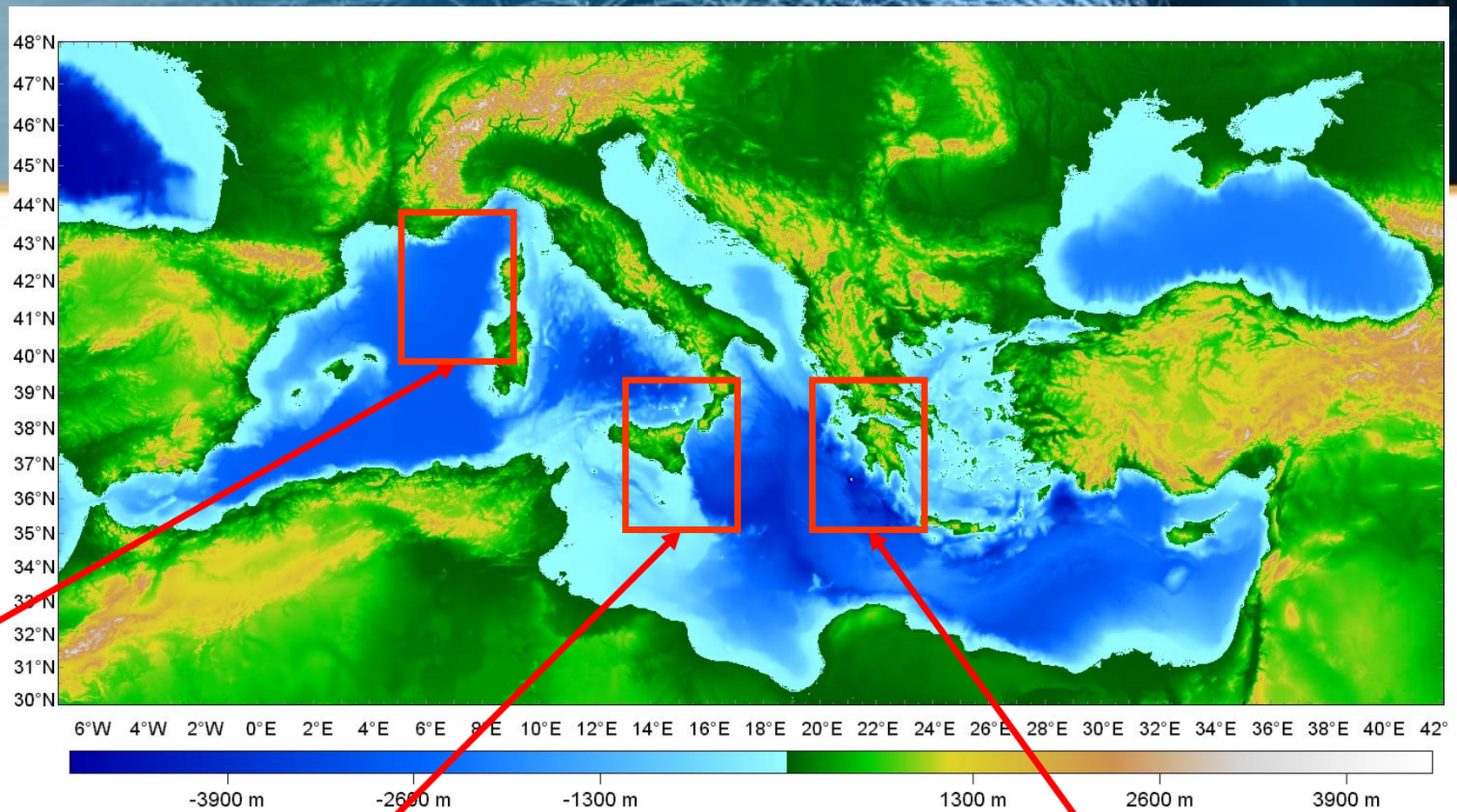


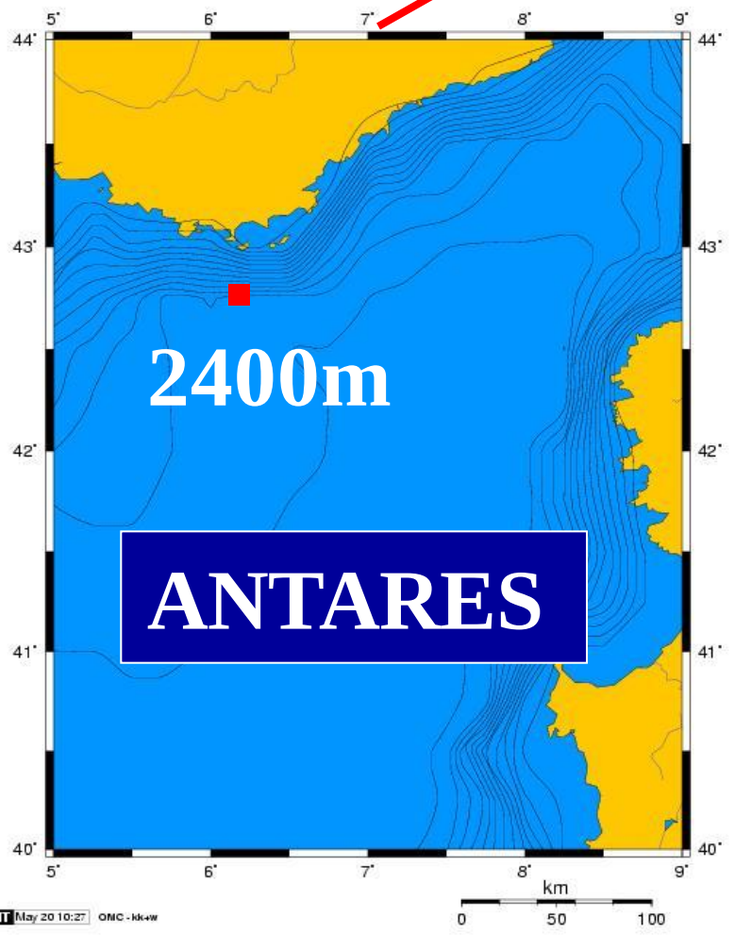
High-statistics sky-map IceCube

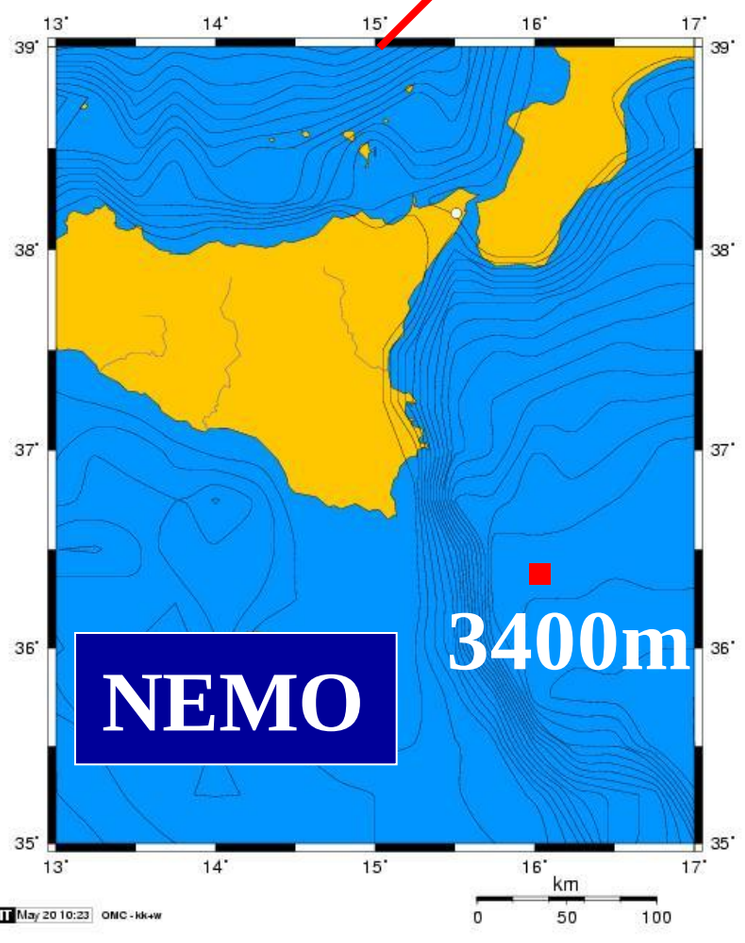
Astroparticle Physics for Europe

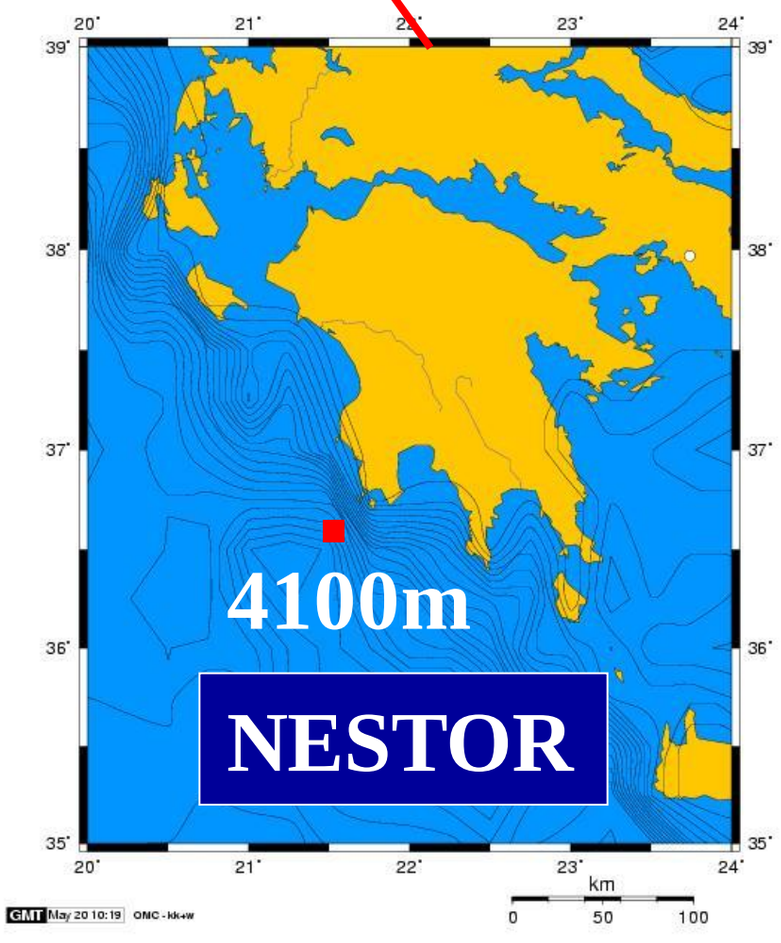
ASPERA

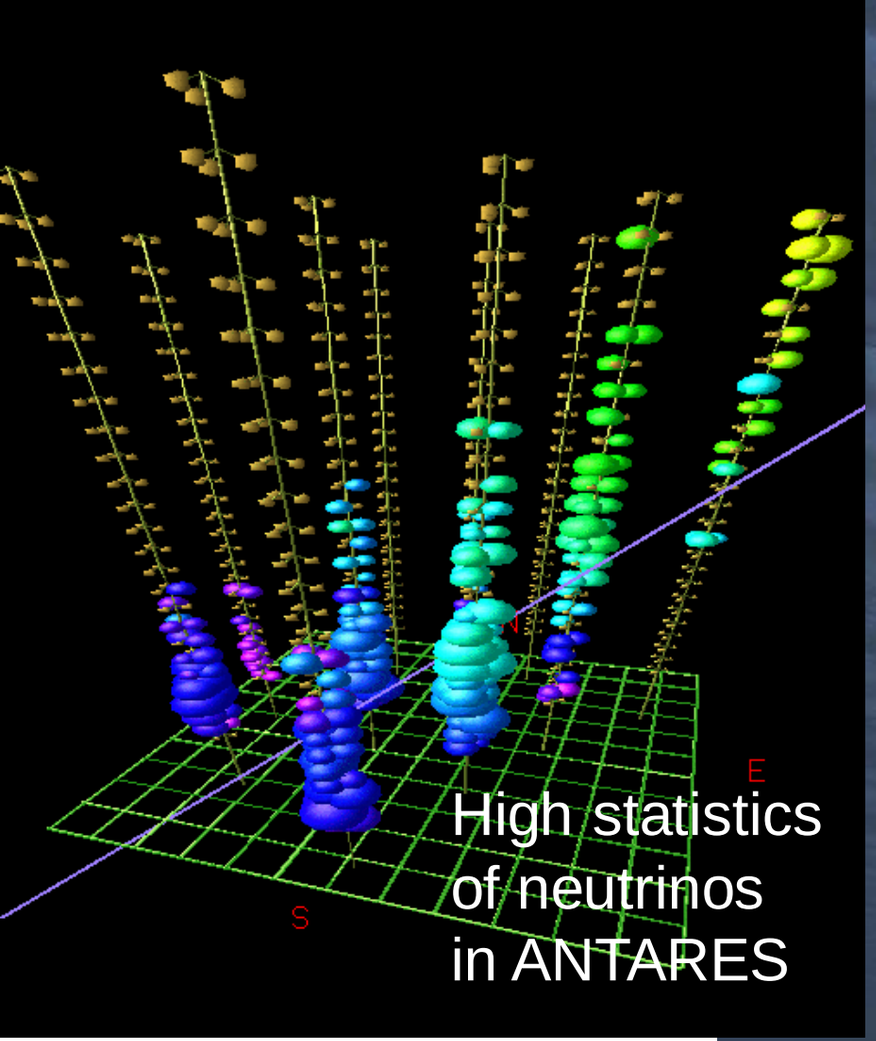
Projects in Mediterranean



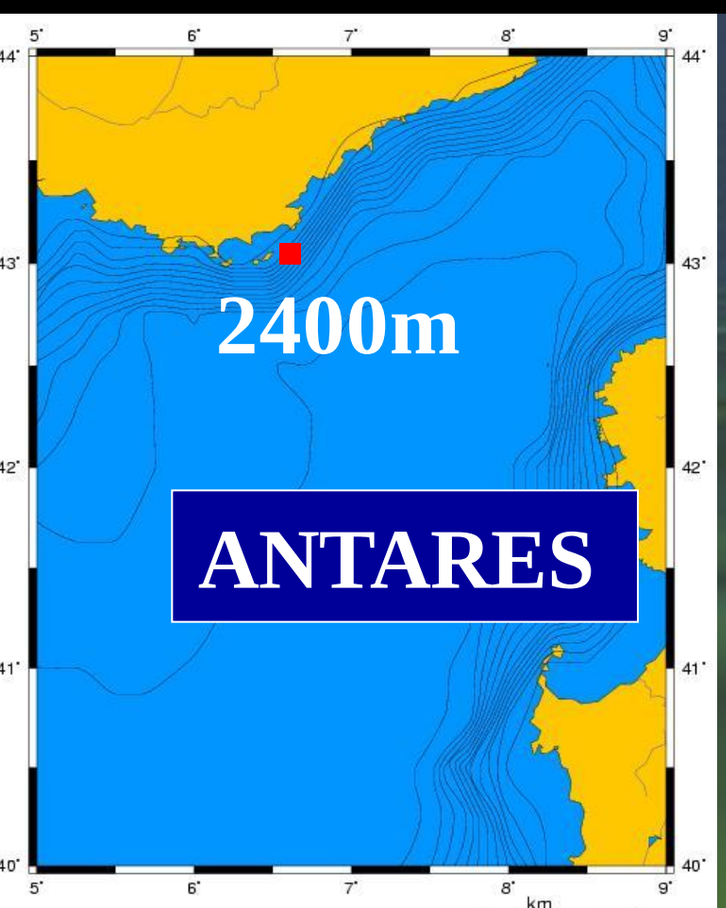


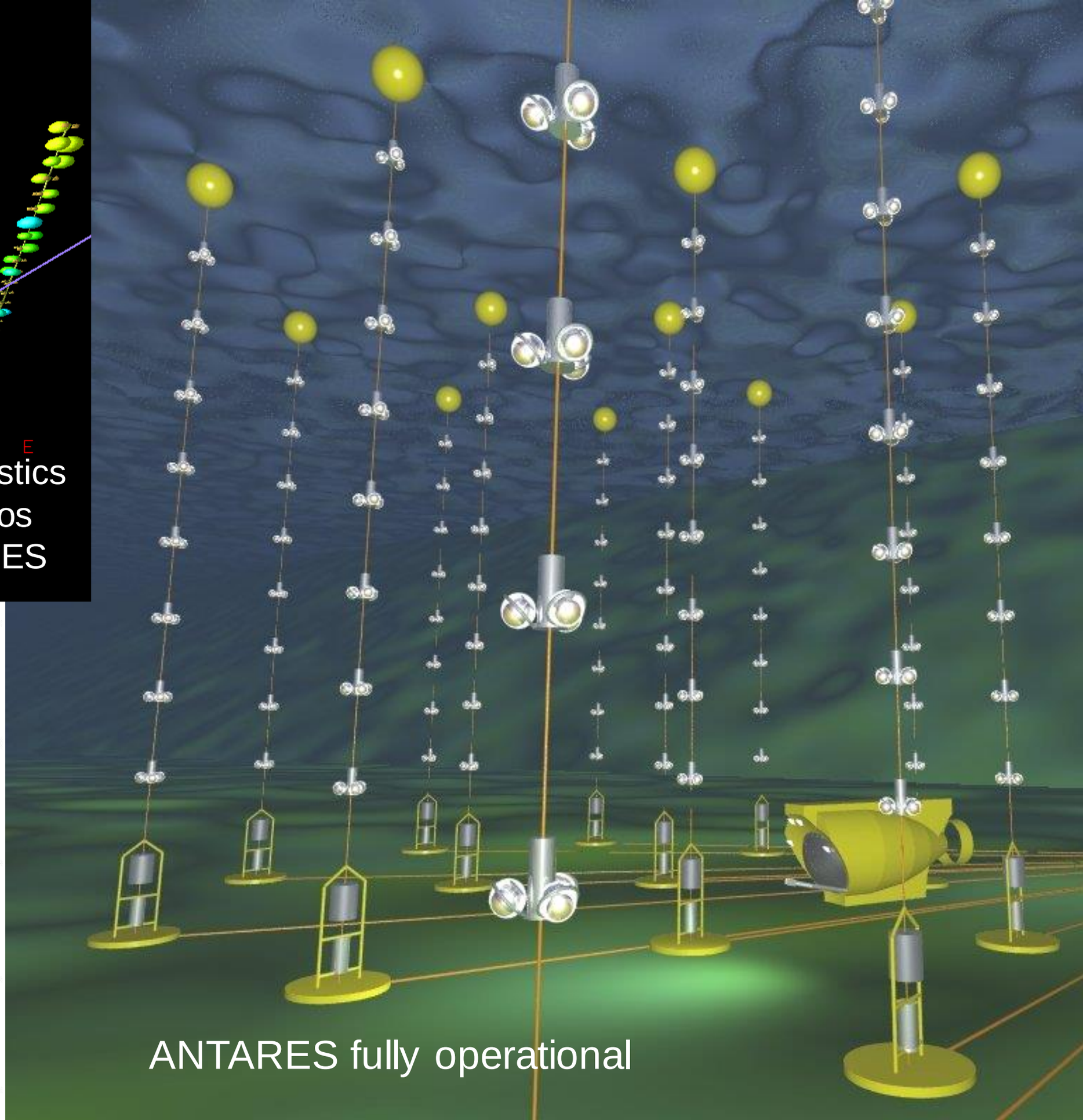






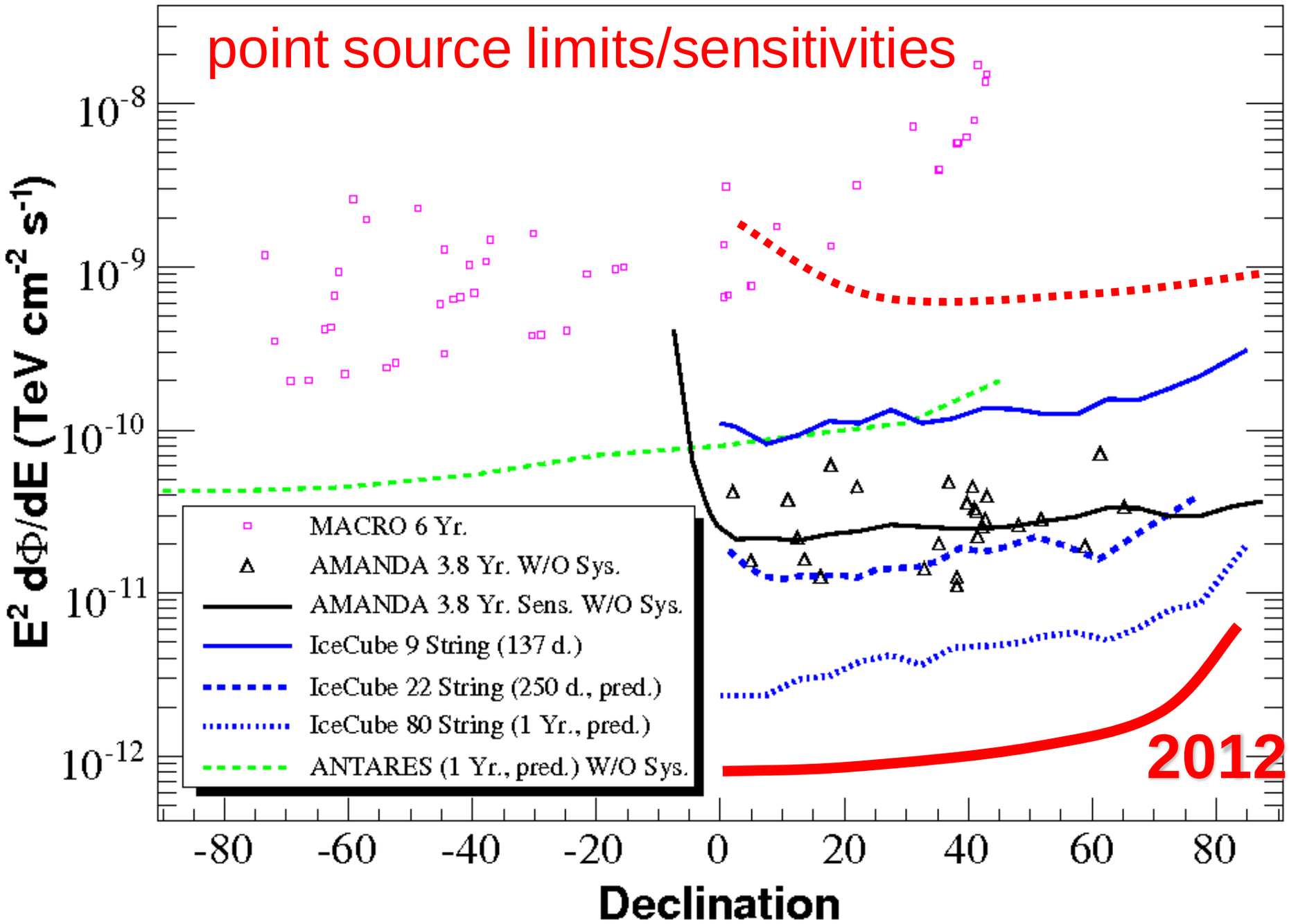
High statistics
of neutrinos
in ANTARES



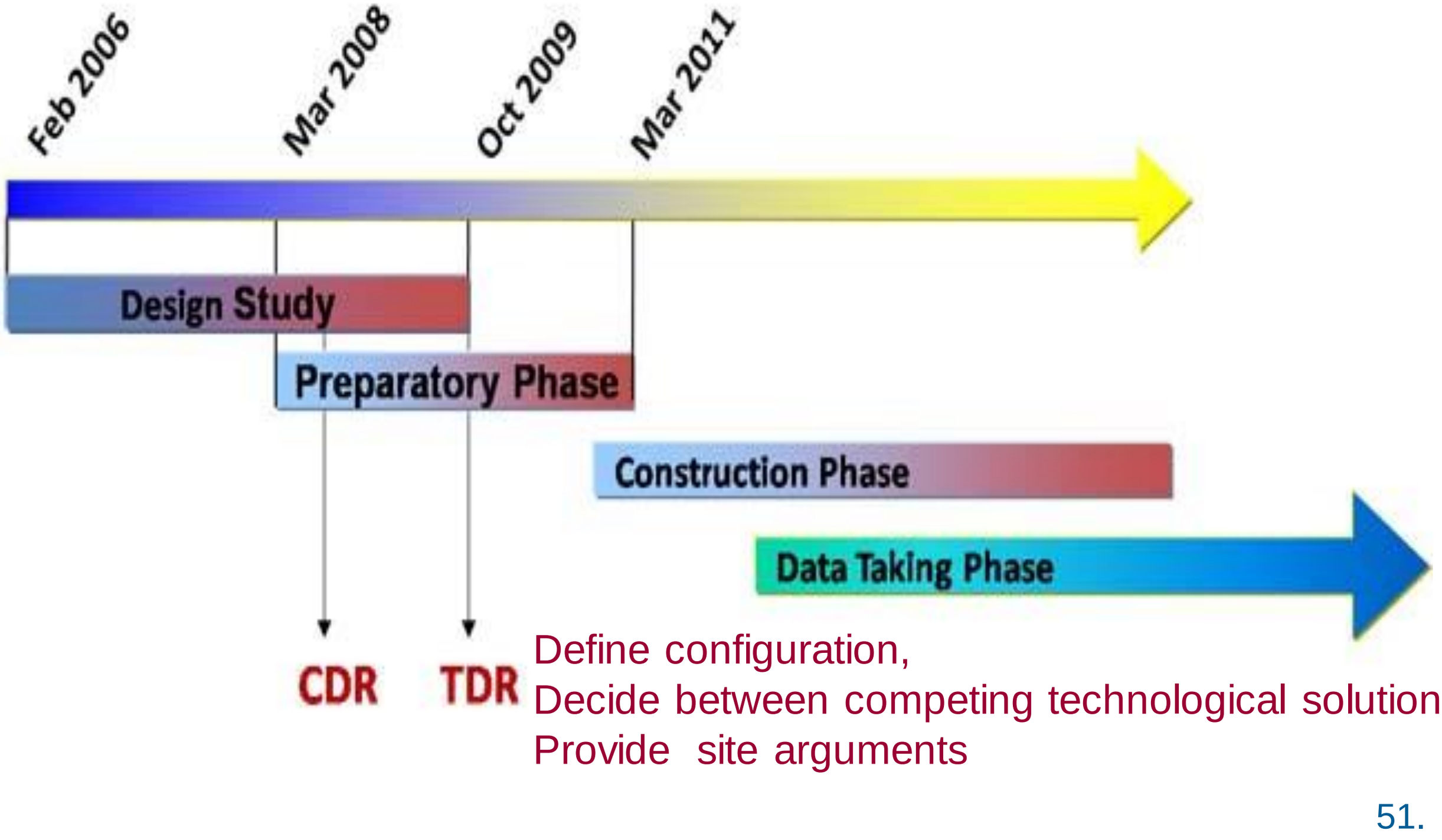


ANTARES fully operational

Tremendous progress in sensitivity over last decade



KM3NeT marching line



Define configuration,
Decide between competing technological solutions
Provide site arguments

High Energy Neutrinos

- Europeans play strong role in IceCube.
  Support for analysis!
- Broad European community works towards KM3NeT.
- **KM3NeT:**
  - is on ESFRI list
  - FP6 design study, started FP7 Preparatory Phase.
  - is one of the priority entries in ASTRONET infrastructure roadmap.

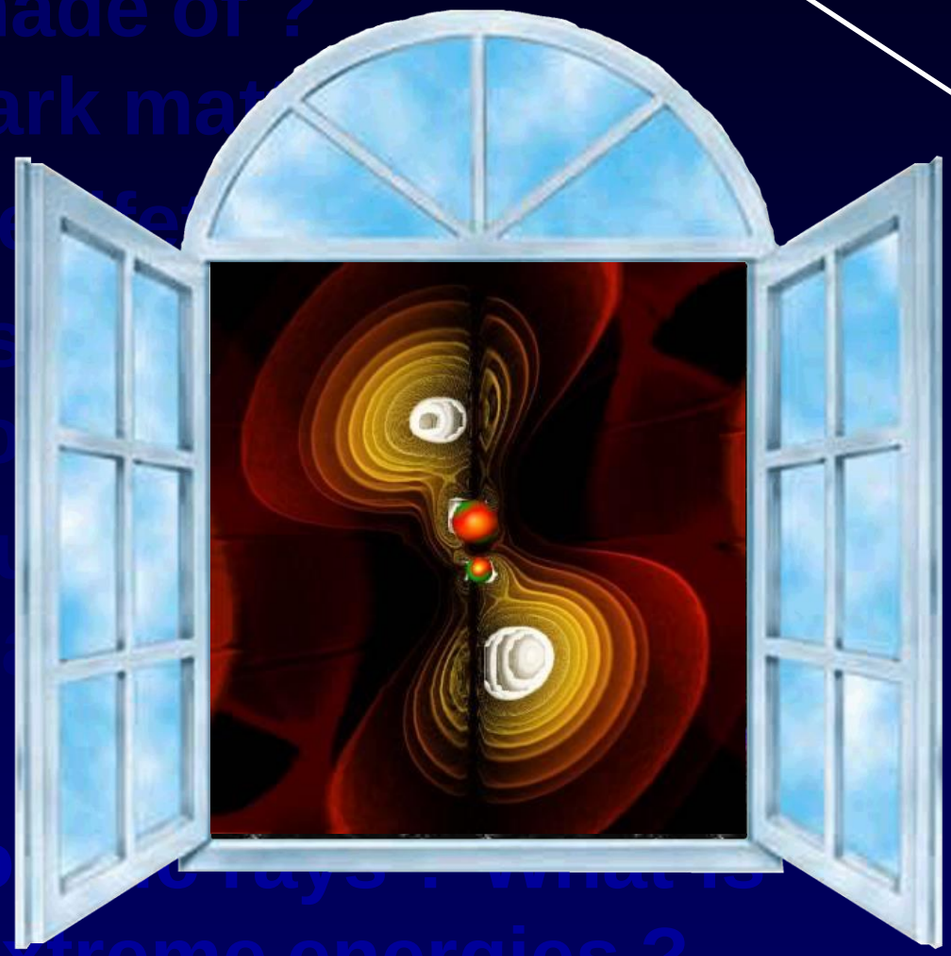
- **<u>Recommendation:</u> The priority project for high energy neutrino astronomy is KM3NeT. Encouraged by the significant technical progress of recent years, the support for working towards KM3NeT is confirmed. Resources for a Mediterranean detector should be pooled into a single optimised design for a large research infrastructure, with installation starting in 2012. The sensitivity of KM3NeT must substantially exceed that of all existing neutrino detectors including IceCube.**

Gravitational Waves

Astroparticle Physics for Europe

ASPERA

- What is the Universe made of ?
  In particular: what is dark mat
- Do protons have a finite
- What are the properties
  their role in cosmic evo
- What do neutrinos tell
  the Sun and the Earth,
  explosions ?
- What is the origin of co rays ? What is
  the view of the sky at extreme energies ?
- **What will gravitational waves tell us about violent cosmic processes and about the nature of gravity ?**



Gravitational Waves

Astroparticle Physics for Europe

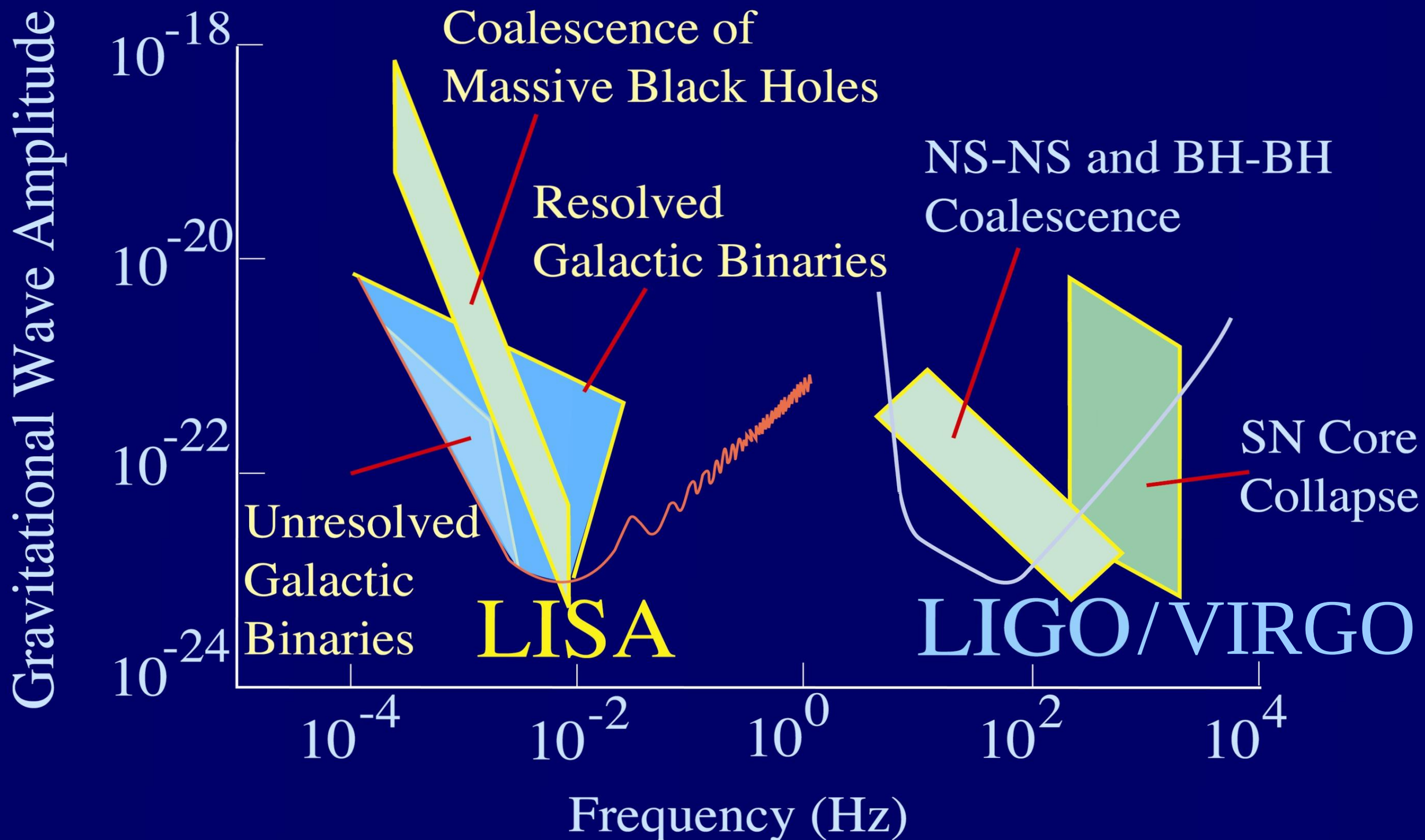
ASPERA

- **What is the Universe made of ?**
  In particular: what is dark matter ?
- **[illegible]**
- **[illegible]**
- **What is the origin of cosmic rays ? What is the view of the sky at extreme energies ?**
- **What will gravitational waves tell us about violent cosmic processes and about the nature of gravity ?**

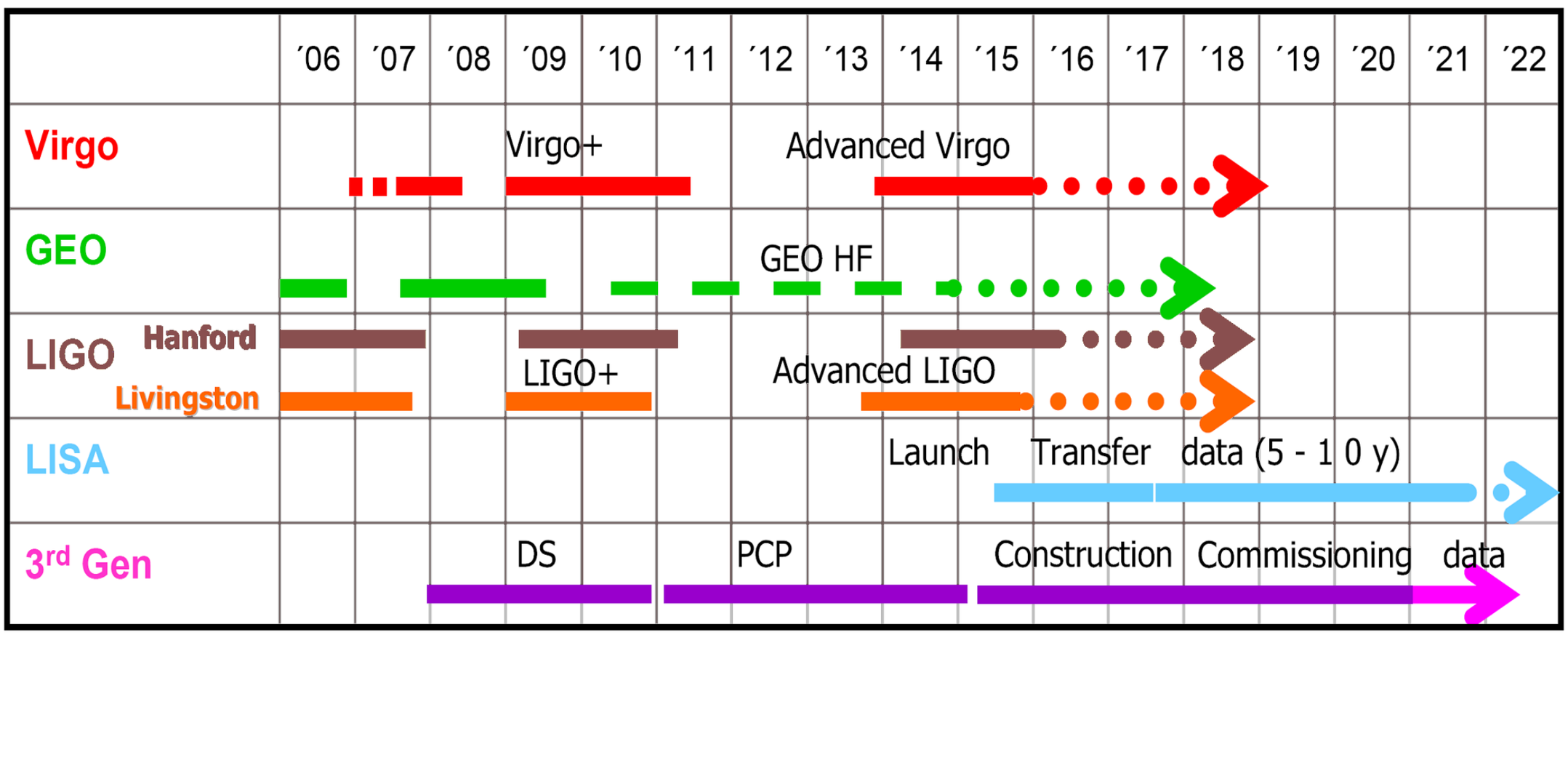
Interferometers
(here: GEO-600 in Germany)

Astroparticle Physics for Europe

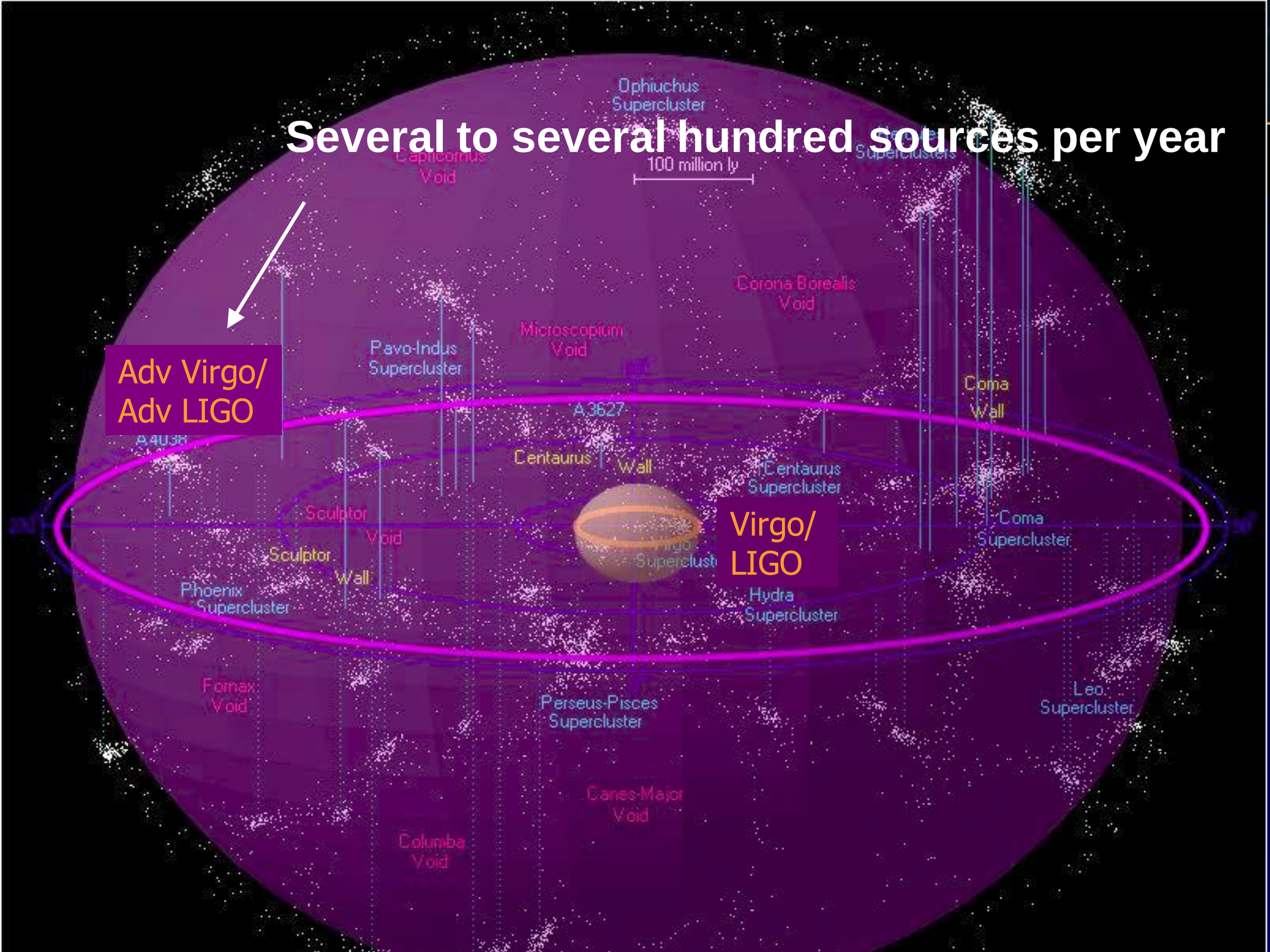
Gravitational Waves



Time Chart


´06
´07
´08
´09
´10
´11
´12
´13
´14
´15
´16
´17
´18
´19
´20
´21
´22
Virgo
Virgo+
Advanced Virgo
GEO
GEO HF
LIGO
Hanford
Livingston
LIGO+
Advanced LIGO
LISA
Launch
Transfer
data (5 - 1 0 y)
3rd Gen
DS
PCP
Construction
Commissioning
data

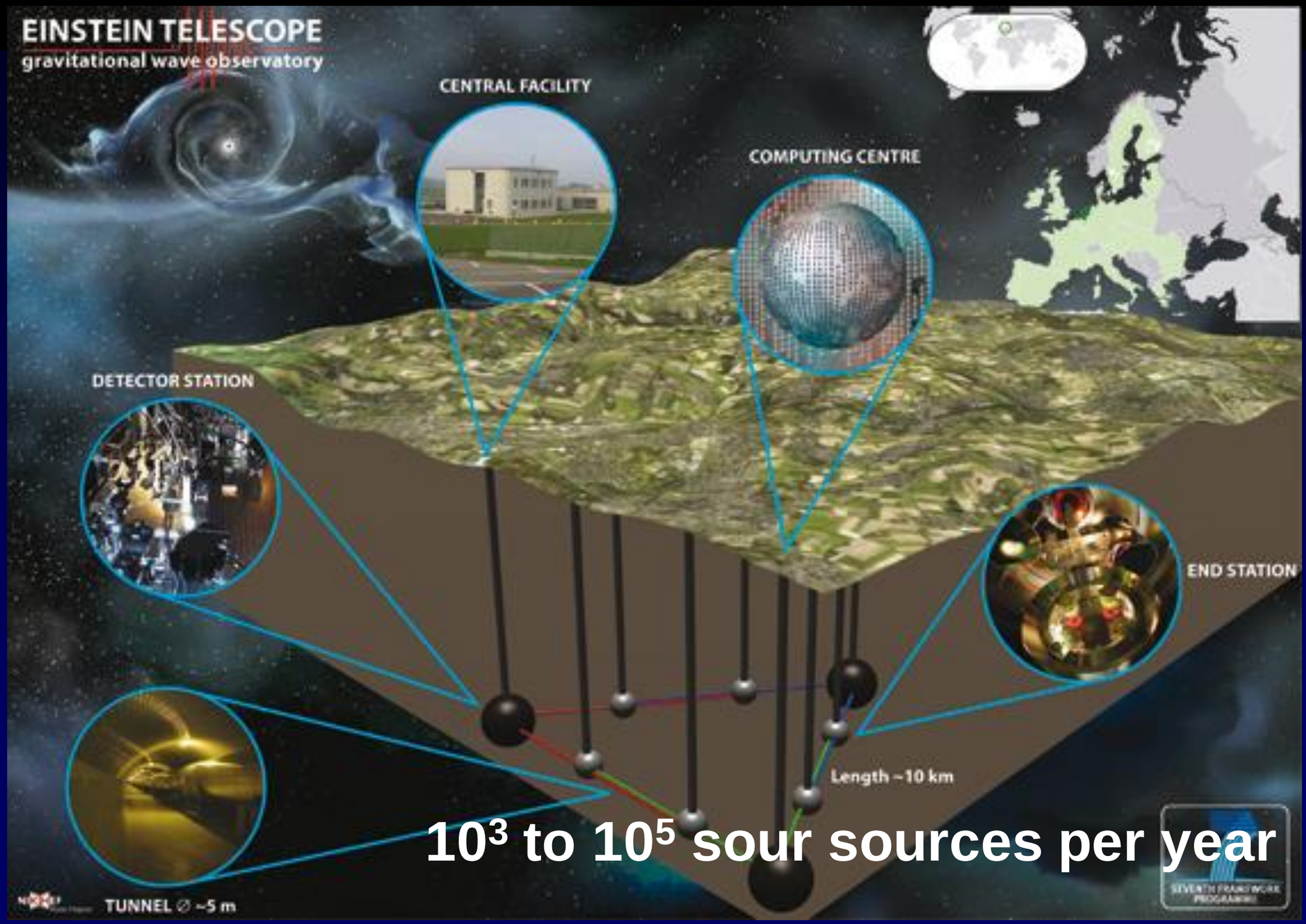
Several to several hundred sources per year



Astroparticle Physics for Europe

ASPERA

Gravitational Waves



Gravitational Waves

- **E.T. is the long-term future project of ground-based gravitational wave astronomy.**
- **Many thousands of events per year.**
- **FP7 Design Study, first technical design and associated costing expected in 2011, followed by a 'Preparatory Phase'.**
- **A decision on funding for the construction of E.T. will earliest after first detections with enhanced LIGO/Virgo but is most likely after collecting about a year of data with advanced LIGO/Virgo in approximately 2014/15. Targeted start of E.T. construction 2016 or 2017.**

- With European participation in upgraded versions of LIGO and GEO confirmed, full support for the VIRGO upgrade towards "Advanced VIRGO" still has to be secured. This would ensure the critical infrastructure for a coherent gravitational wave programme in Europe and lay the ground for E.T.

- At low frequencies: LISA (LISA-Pathfinder 2010)

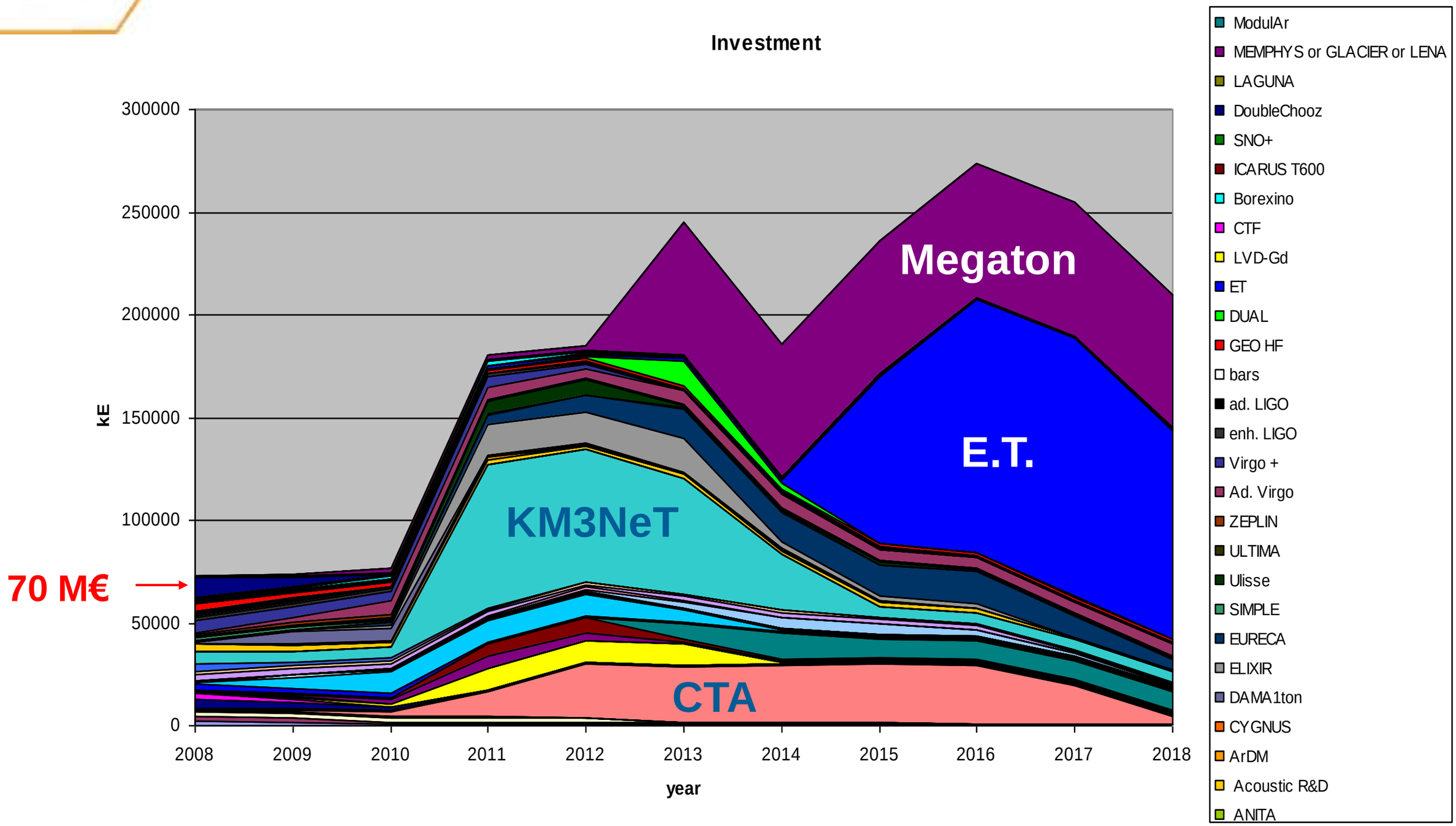
Cost

ASPERA

SIXTH FRAMEWORK PROGRAMME

http://www.aspera-eu.org

2007: Input from Aspera Working Groups

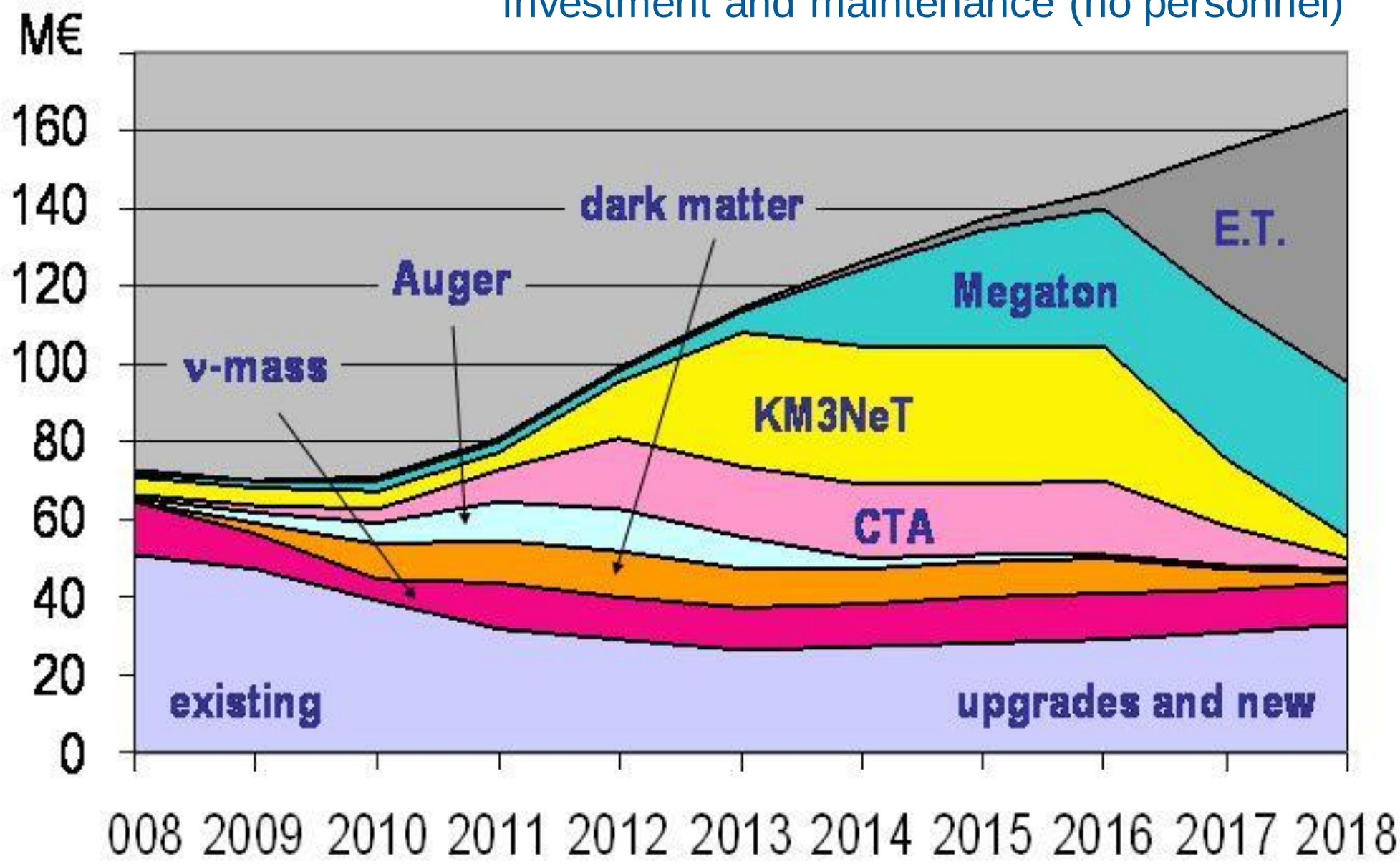


2011-2015: ~1000-1200 M€

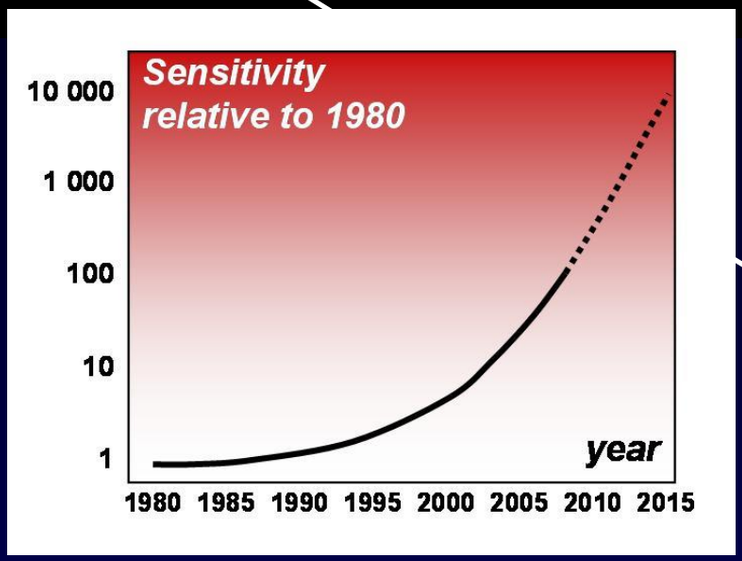
The factor-2 scenario

Increase in personnel cost will be smaller !

Investment and maintenance (no personnel)



Summary



- From infancy to maturity: the past 1-2 decades have born instruments methods for doing **science with high discovery potential.**
- **Accelerated increase in sensitivity** in nearly all fields.
- A lot of advanced, interesting world-class projects **Europeans lead in many fields**.
- **Physics harvest has started** (TeV gamma) or is in reach.
- Need a **factor-2 funding increase** over next decade.
- **Initiated radical process of convergence.**

ASPERA

Astroparticle Physics for Europe

The Magnificient Seven

Einstein Telescope
(LISA)

Megaton

Ton-scale
Double Beta

Auger-Nord

KM3NeT

Ton-scale
Dark Matter

CTA

Backups

Properties of Neutrinos

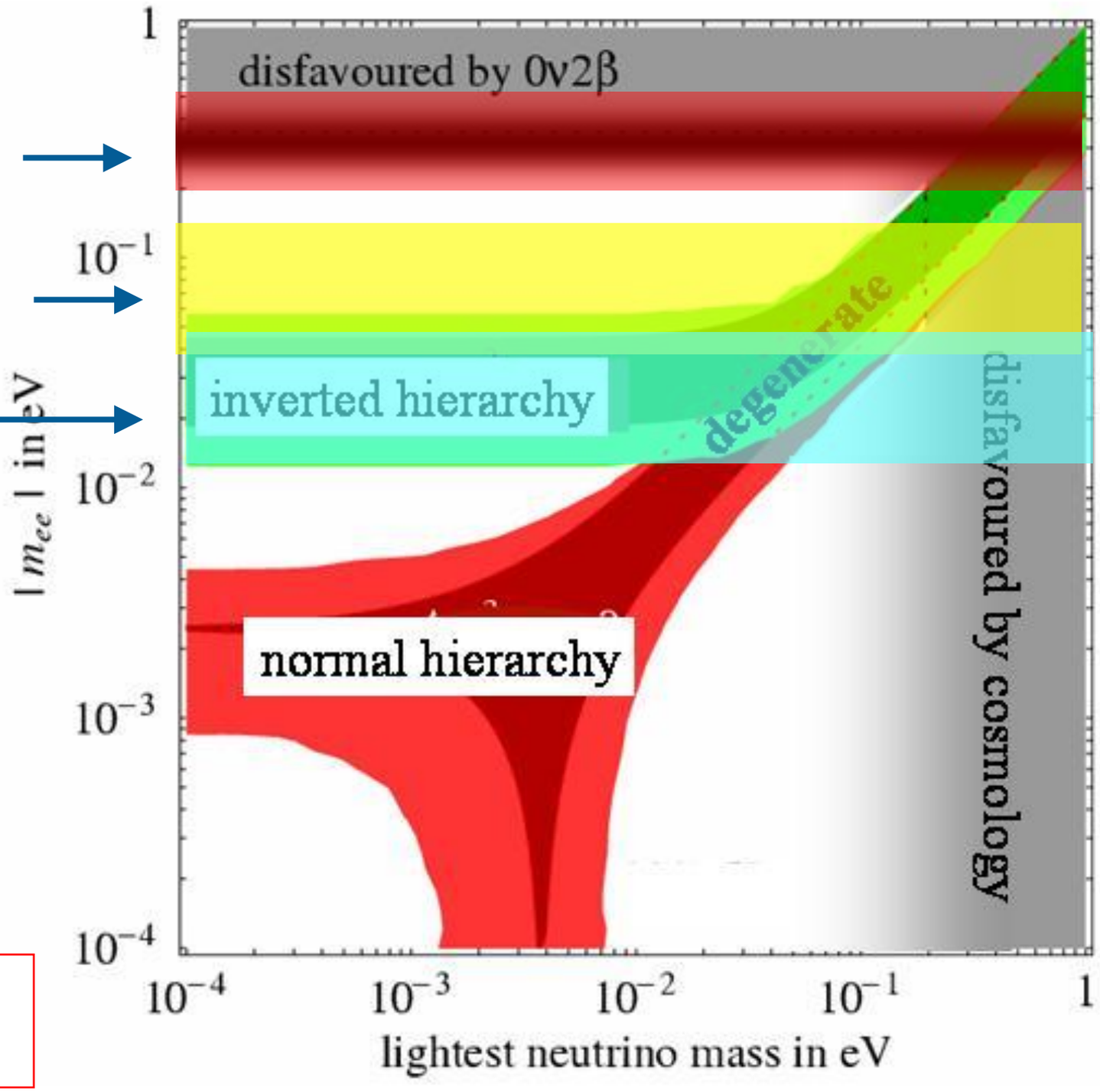
- **Direct Mass Measurements**
  - Present limit 2.3 eV
  - KATRIN, start 2011, down to 0.2 eV
  - Troitzk (Russia) start 2009, down to 0.8 eV
- **Double Beta Decay Experiments**
  - Cuoricino, Nemo-3
  - Gerda, Cuore, Super-Nemo
  - EXO
  - Cobra, NEXT, ….
- **Mixing Parameters**
  - Double CHOOZ
  - T2K
  - experiments with CERN beam (Opera, Modular, …)

Double Beta Decay

KKGH claim →

GERDA, EXO200 CUORE, SuperNEMO →

Ton-scale →



Price tag for ton-scale 50-200 M€.

Double Beta Decay

Astroparticle Physics for Europe

ASPERA

now

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

operation → **CUORICINO** bolometric 41 kg ^{130}Te

construction → operation → **CUORE** bolometric 740 kg ^{130}Te

operation → **NEMO-3** tracking 8 kg ^{130}Mo/^{82}Se

design study → construction → operation → **Super-NEMO** tracking 100 kg ^{150}Nd/^{82}Se

construction → operation → **GERDA** 18 → 40 kg ^{76}Ge

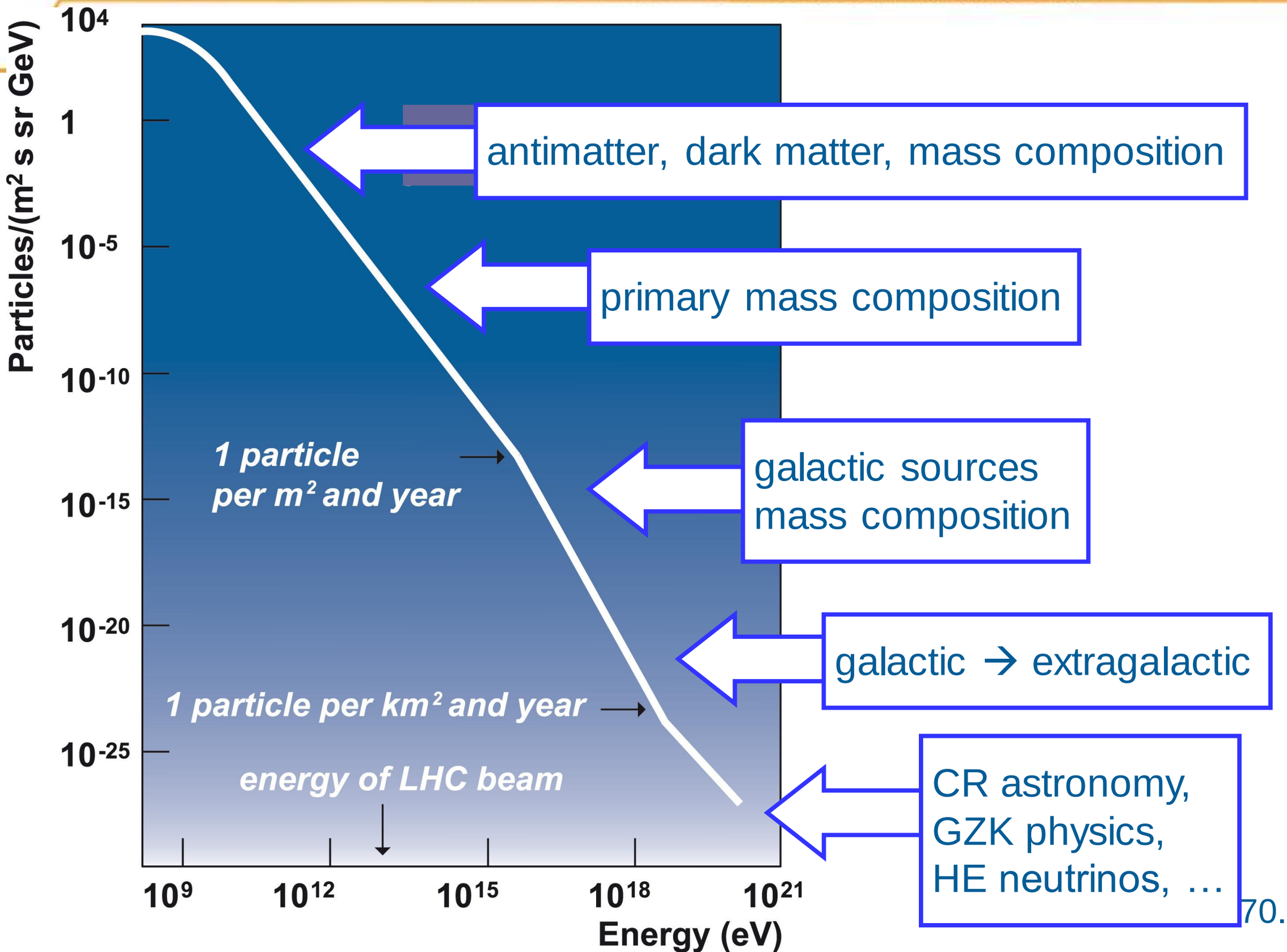
design study → construction → operation → **EXO (USA)** 200 kg ^{130}Xe

(Projects running, under construction or with substantial R&D funding)

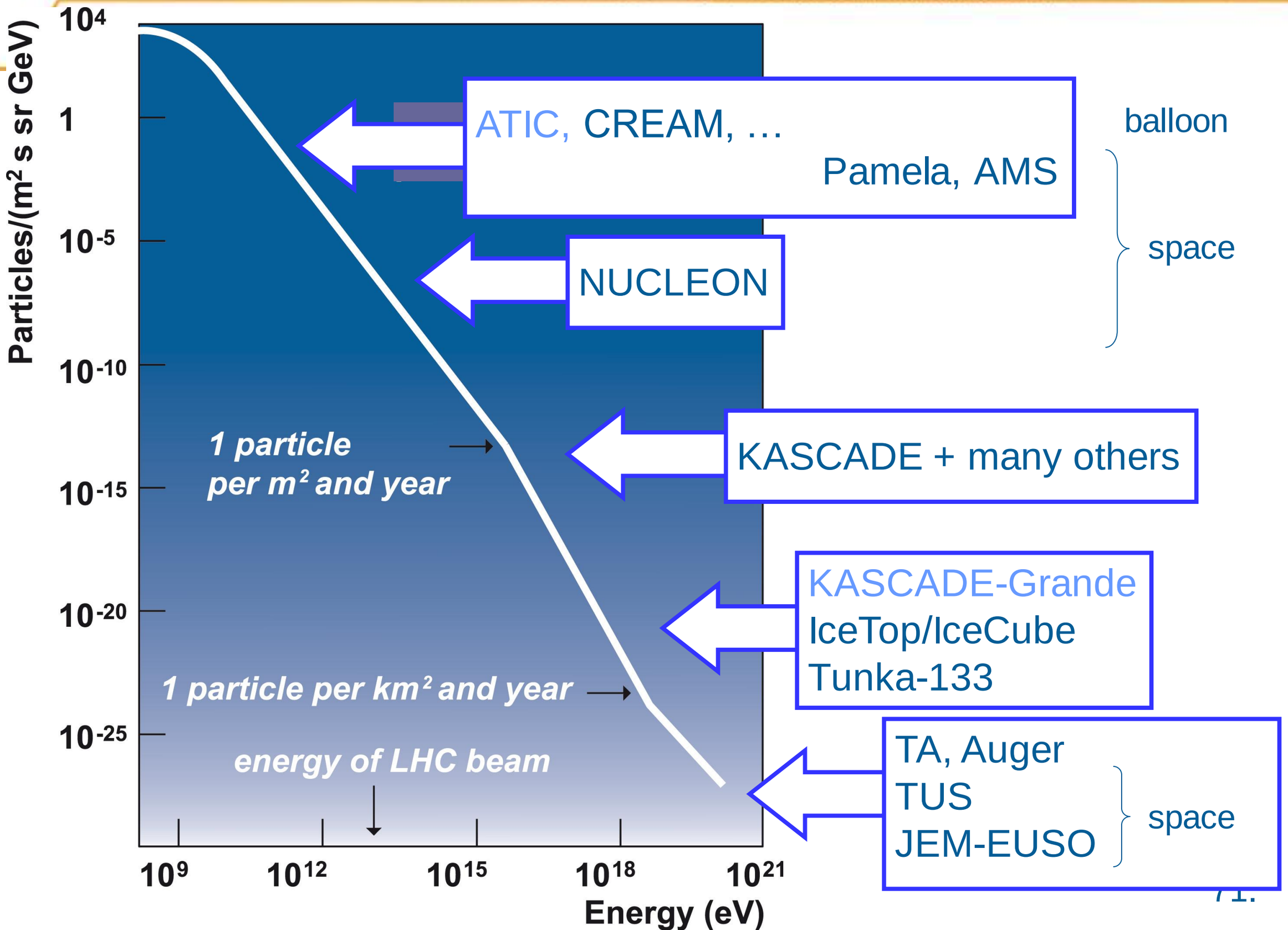
Double Beta Decay

- Priority to experiments starting operation within 5 years
  - **GERDA (phase I and II)**
  - **CUORE**
  - **Super-NEMO**
- Complementary nuclei/methods essential to judge any positive claim or upper limit.
- Will scrutinize the claimed evidence in ^{76}Ge, will touch the "inverted hierarchy" mass range and keep European leadership.
- Other methods may become competitive in the future.
- At the same time, envisage an experiment on the 1-ton-isotope scale, which will peer deep into the inverted hierarchy range. Two options discussed, both with worldwide cost sharing:
  - **GERDA III as merger of GERDA with Majorana (USA)**
  - **CUORE with enriched tellurium, USA participation.**
- Milestone: Decision on the isotopes/ techniques to be taken by 2012/13.

Charged Cosmic Rays



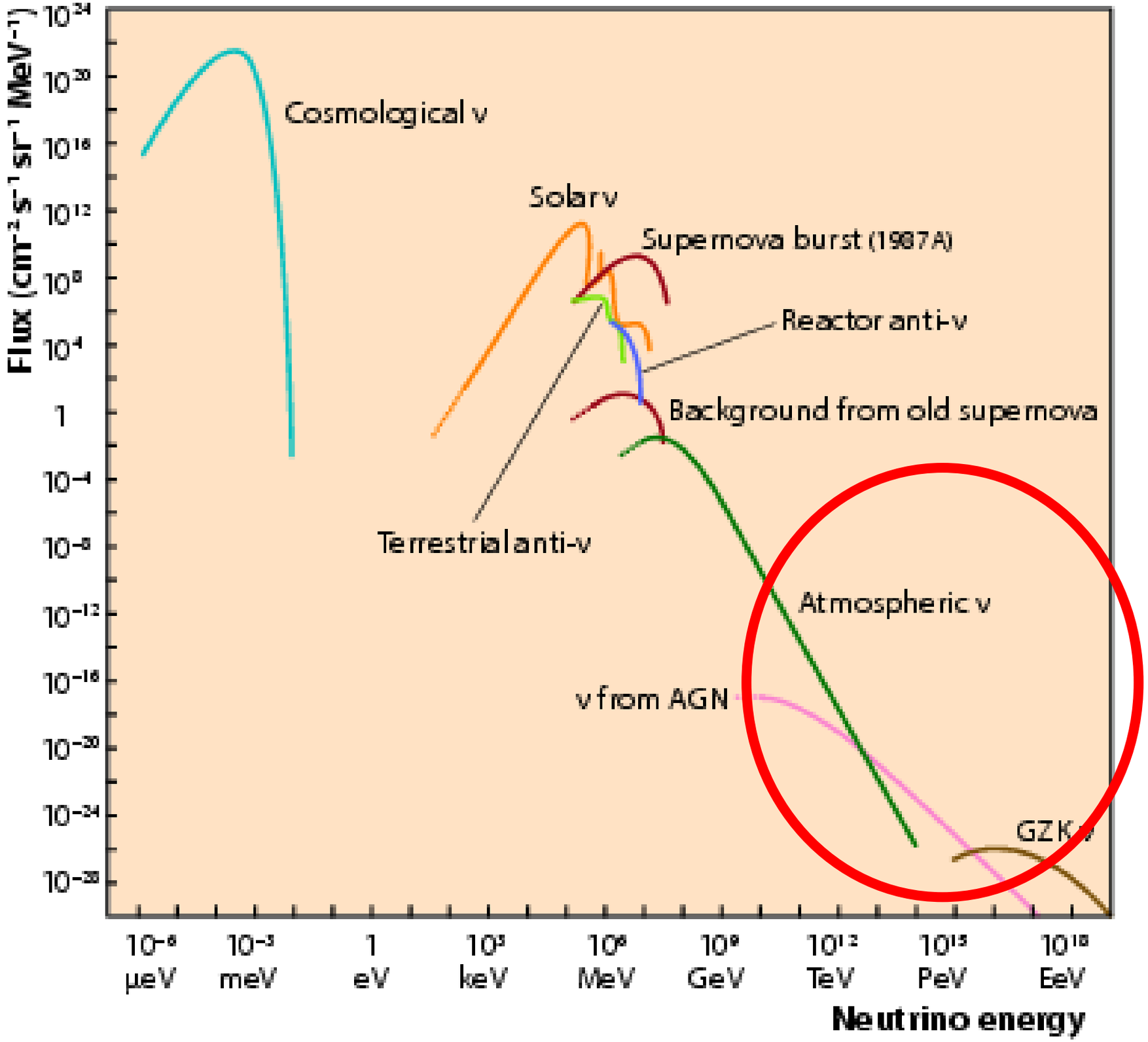
Charged Cosmic Rays



Astroparticle Physics for Europe

ASPERA

High Energy Neutrinos



Visions

ASPERA

SIXTH FRAMEWORK PROGRAMME

- Dark Matter:
  - LHC has discovered SUSY.
  - First direct searches with sensitivity <10^{-9} pb discover DM.
    → dramatically accelerated speed with other nuclei and methods for confirmation. Push directional methods.
  - *If DM not yet discovered:*
    → move on with 2 experiments to 10^{-10} pb or below

- Neutrino Properties
  - Double-CHOOZ, T2K and others have measured finite Θ_{13}
  - KATRIN measures neutrino mass > 0.2 eV
  - and/or: Gerda/Cuore measure mass > 0.1 eV
  - *If no sign for mass:*
    → move further on towards 1-2 DBD experiments with sensitivity 0.03 eV , see what MARE could do

Sensational: cosmology !

- Megaton-Detector
  - Technology ready, worldwide consensus, construction going to start
- High Energy Universe
  - >200 gamma sources from HESS-II and MAGIC-II
  - CTA under construction, first results from prototypes
  - Sky-map with clear sources from Auger-South, also chemical composition
  - Auger-North under construction
  - IceCube has discovered neutrino sources
  - KM3NeT under construction
    - *If no neutrino sources in IceCube until 2011:*

      → consequent re-design towards > 5 cubic kilometers for affordable price
  - Exciting multimessenger astronomy, including satellites (GLAST)

- Gravitational Waves
  - LIGO+, VIRGO+ and GEO have seen their very first event
  - Adv LIGO, adv VIRGO, GEO-HF have started operation
  - E.T. in preparatory phase
  - Lisa-Pathfinder successful, clear way towards LISA

- New Methods
  - Variety of methods called „new m… acoustics, COUPP-li… are being i…
  - Still, we hav… …erves for new „new methods“.

We have to keep reserves for new methods and approaches!

Visions

ASPERA

SIXTH FRAMEWORK PROGRAMME

- Dark Matter:
  - Several experiments are below 10^{-10} pb and have detected WIMP DM
  - Move from DM searches to DM studies
- Neutrino mass:
  - DBD measures neutrino mass 20-70 meV and proves inverted hierarchy
  - *If not: hm …. There is no idea how to reach < 20 meV*
- Megaton detectors:
  - First subdetector operates
  - **>10000 neutrinos from SN2018A** (Feb 22, 2018) (IceCube measure precise early time profile)
  - New precision results on solar physics

Dark Matter Searches

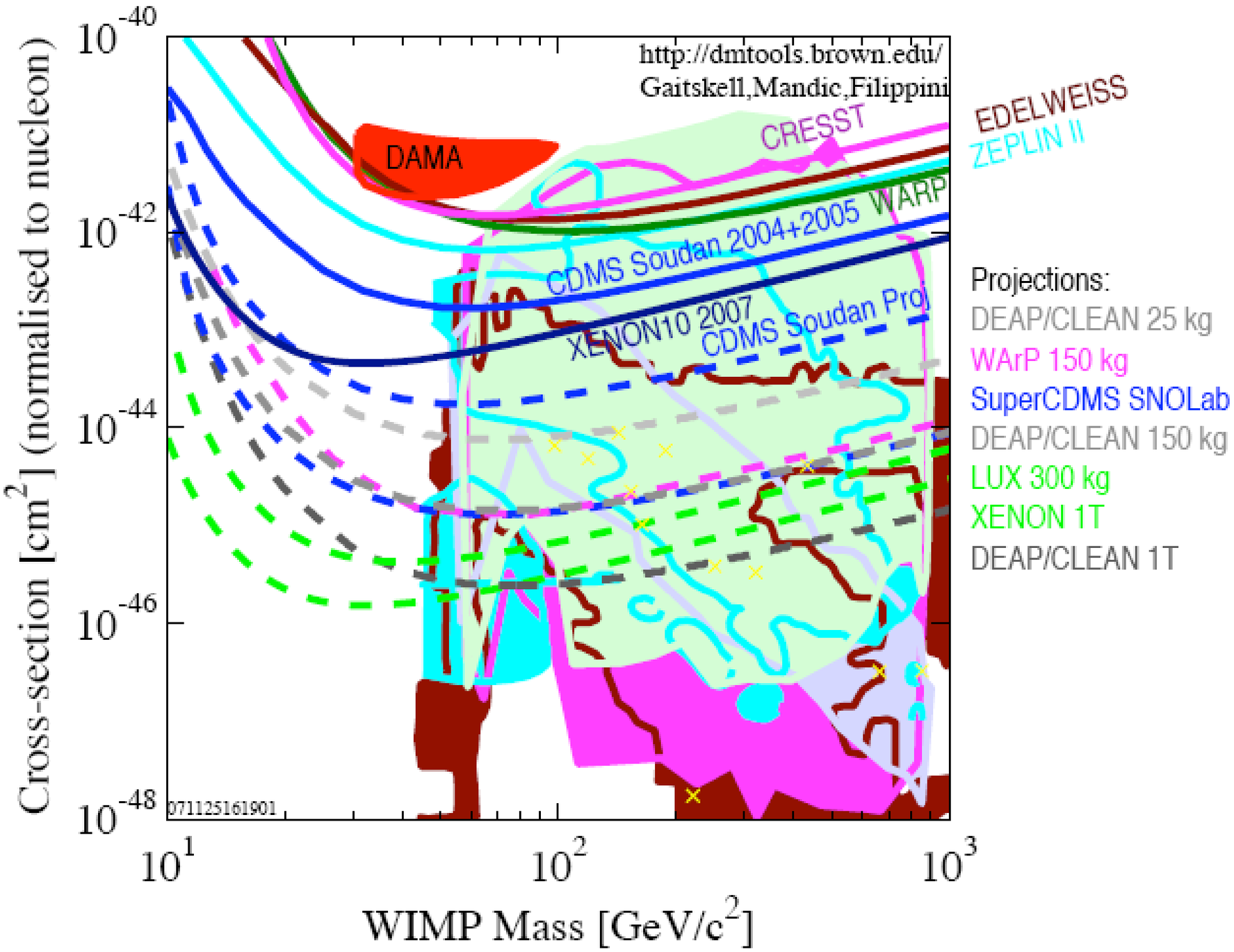
picobarn

10^{-6}

10^{-8}

10^{-10}

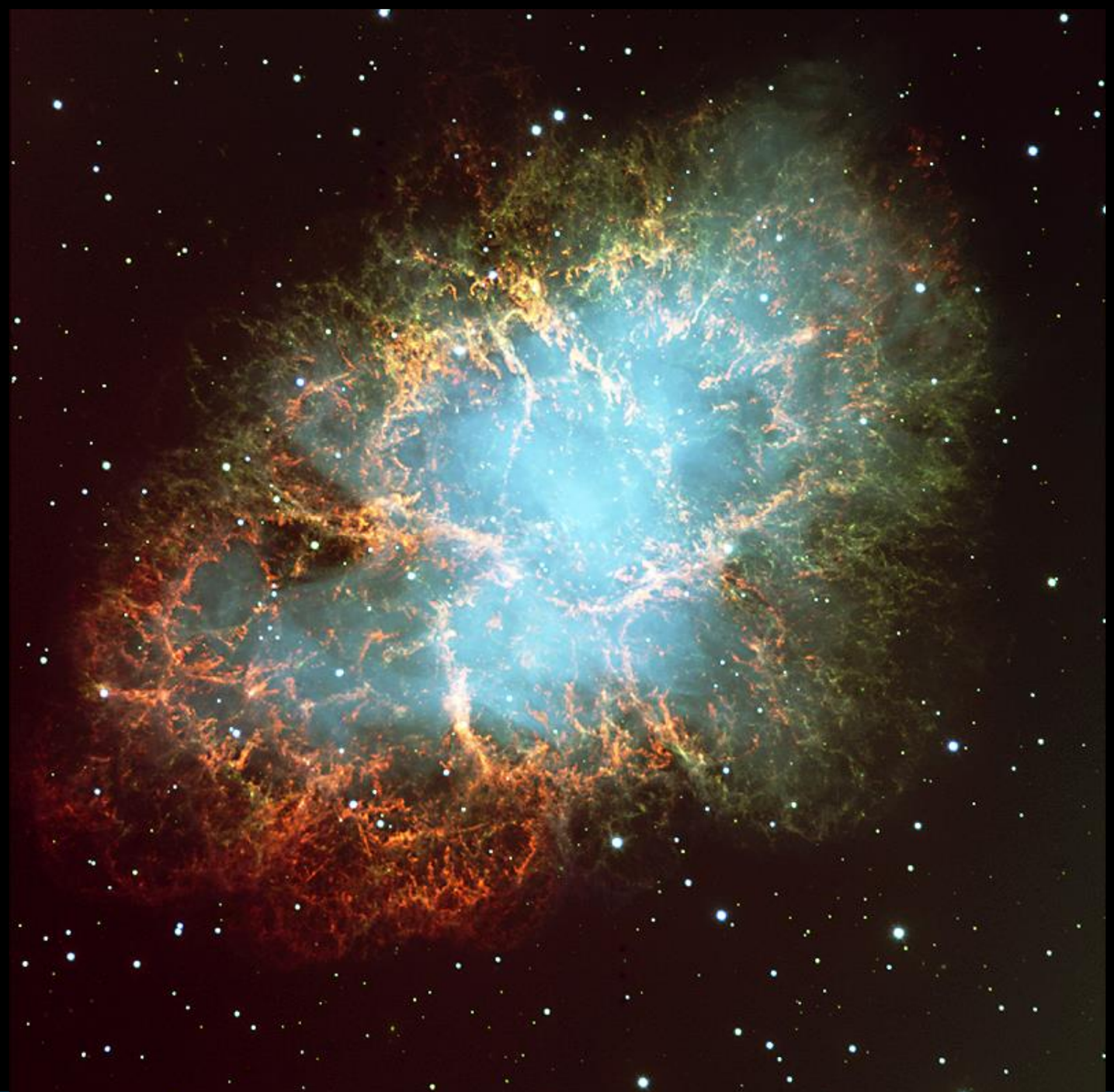
10^{-12}



Supernovae:
Stosswellen in interstellares Medium

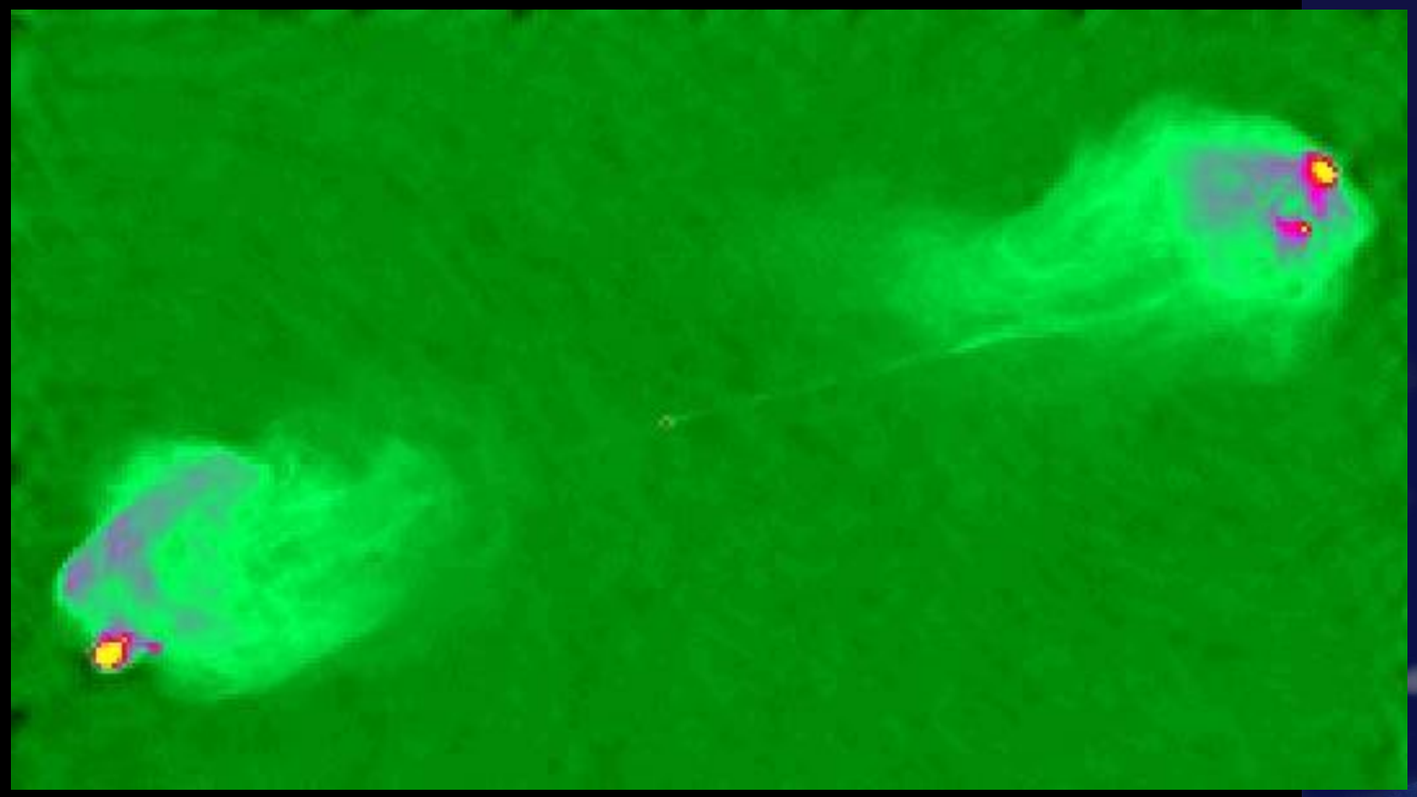
bis 10^{16} eV

Krebs-Nebel

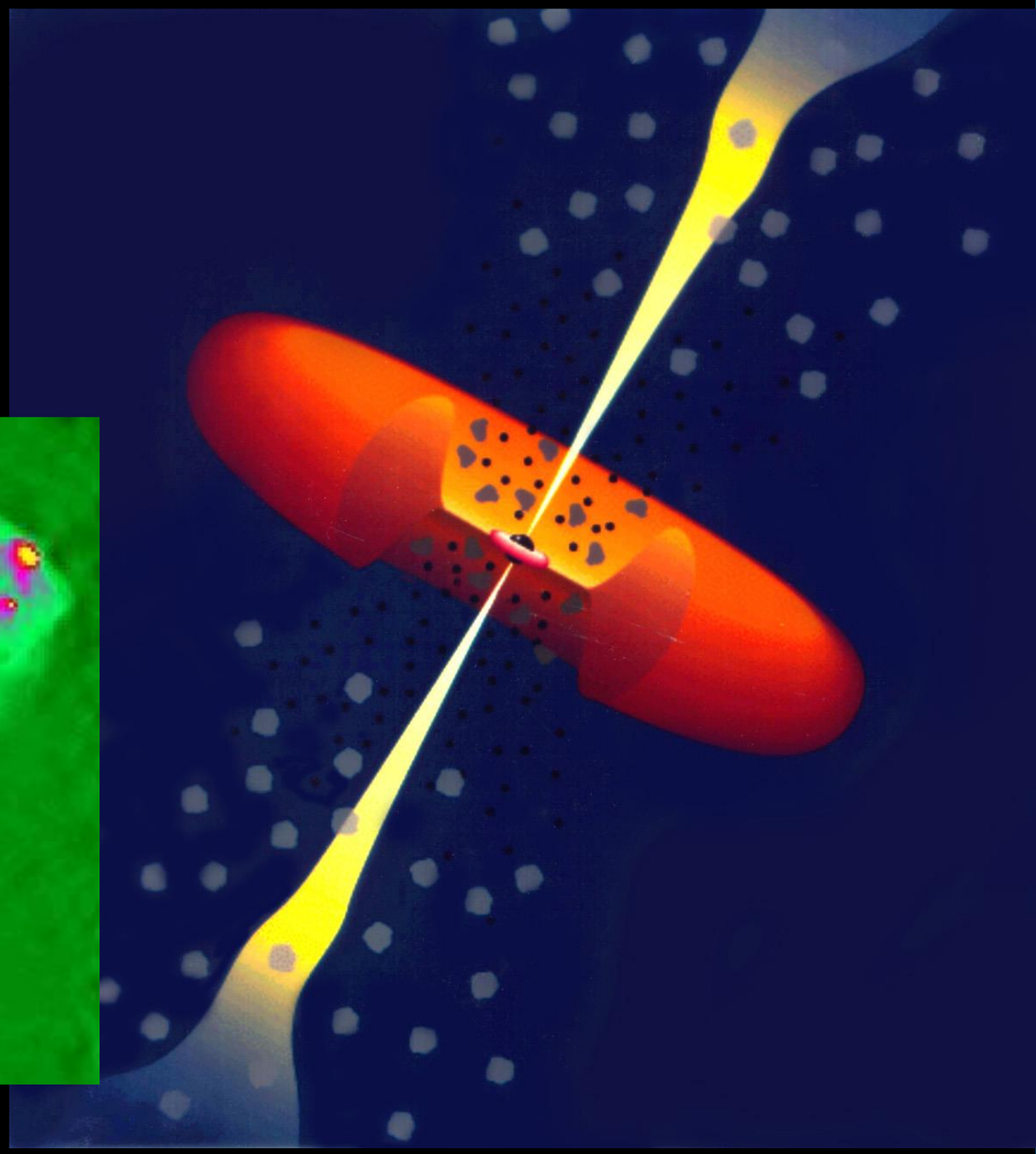


Aktive Galaxien: Akkretionsscheiben und Jets

bis 10^{20} eV

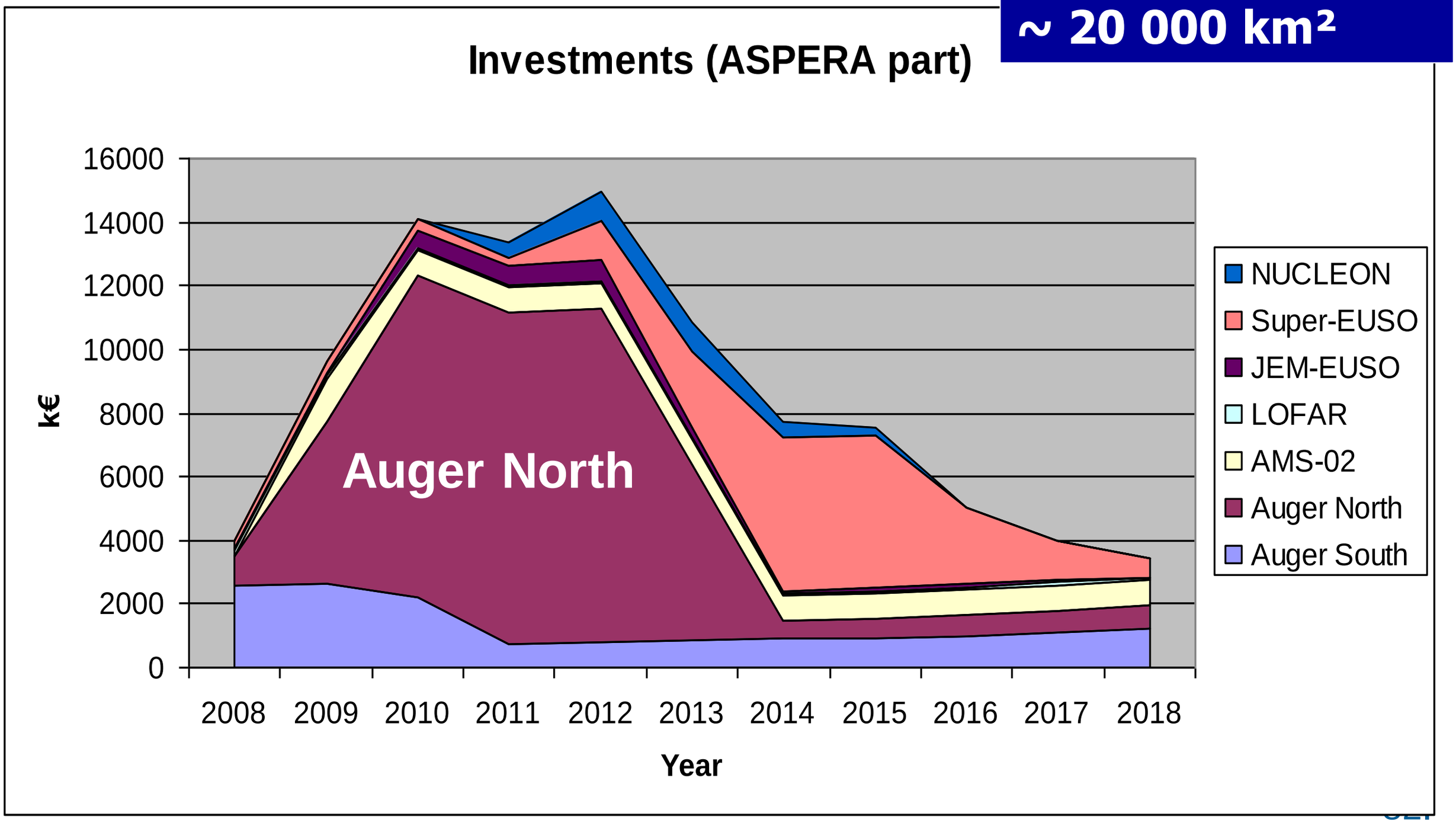


Radiobild von Cygnus A

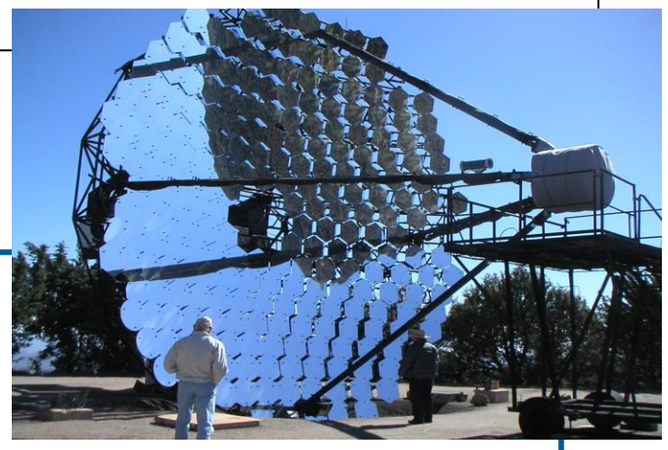


Klare Priorität: Auger-Nord

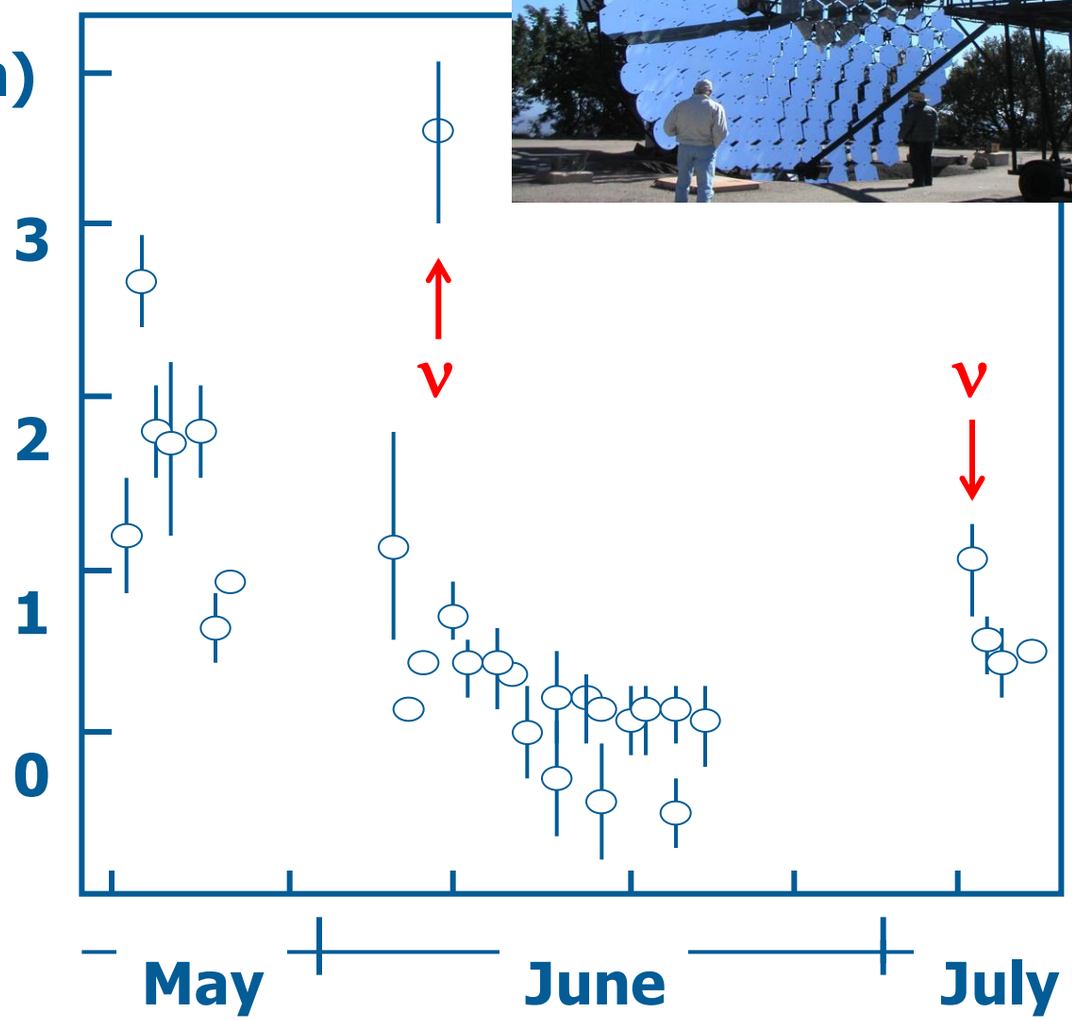
Trans-GZK-Physik
~ 20 000 km²



ES1959+650

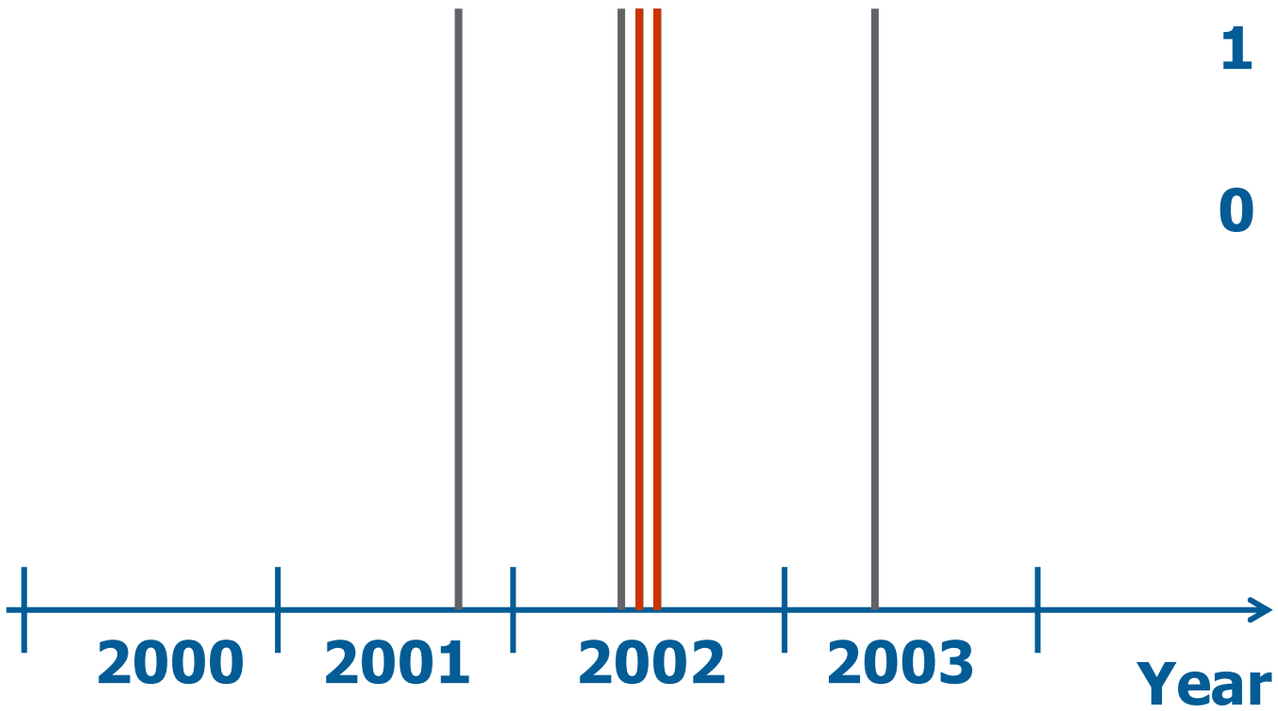


Fluss von TeV Photonen (willk. Einheiten)

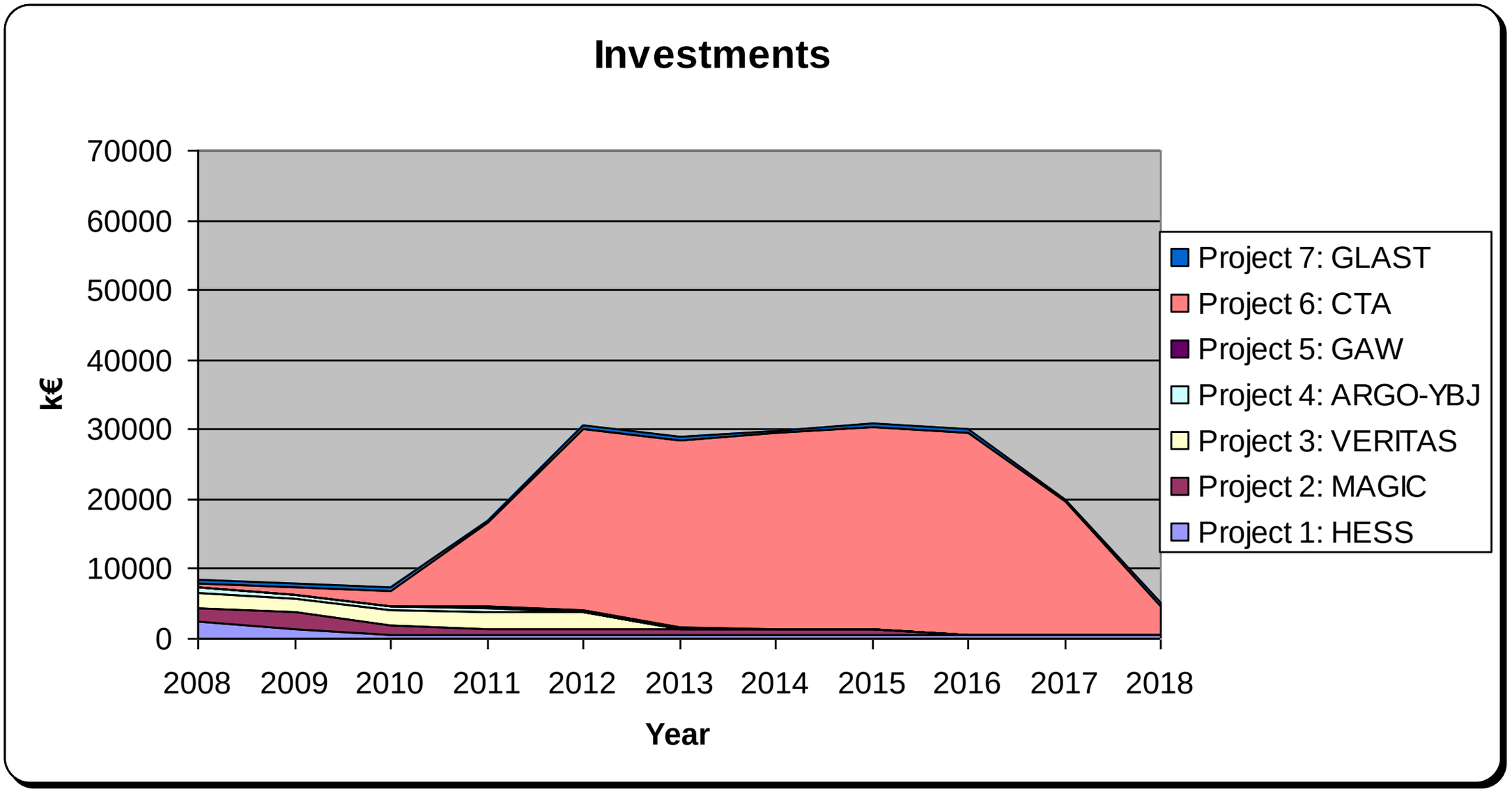


Gamma-Fluss aus der Richtung ES1959+650 im WHIPPLE-Teleskop

Ankunftszeit von „AMANDA-Neutrinos“ aus der Richtung der Aktiven Galaxie ES1959+650

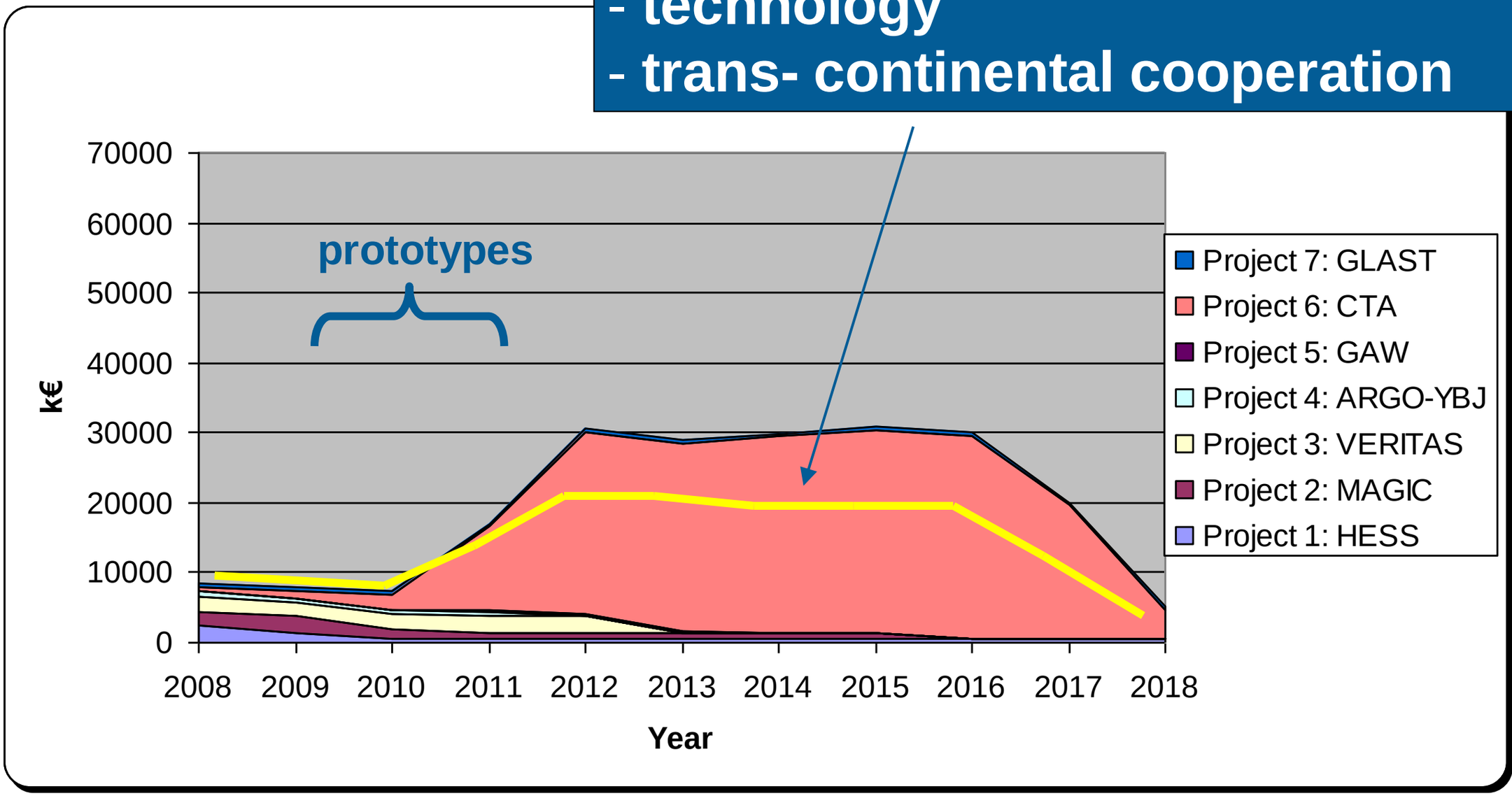


Result Working Group 2007

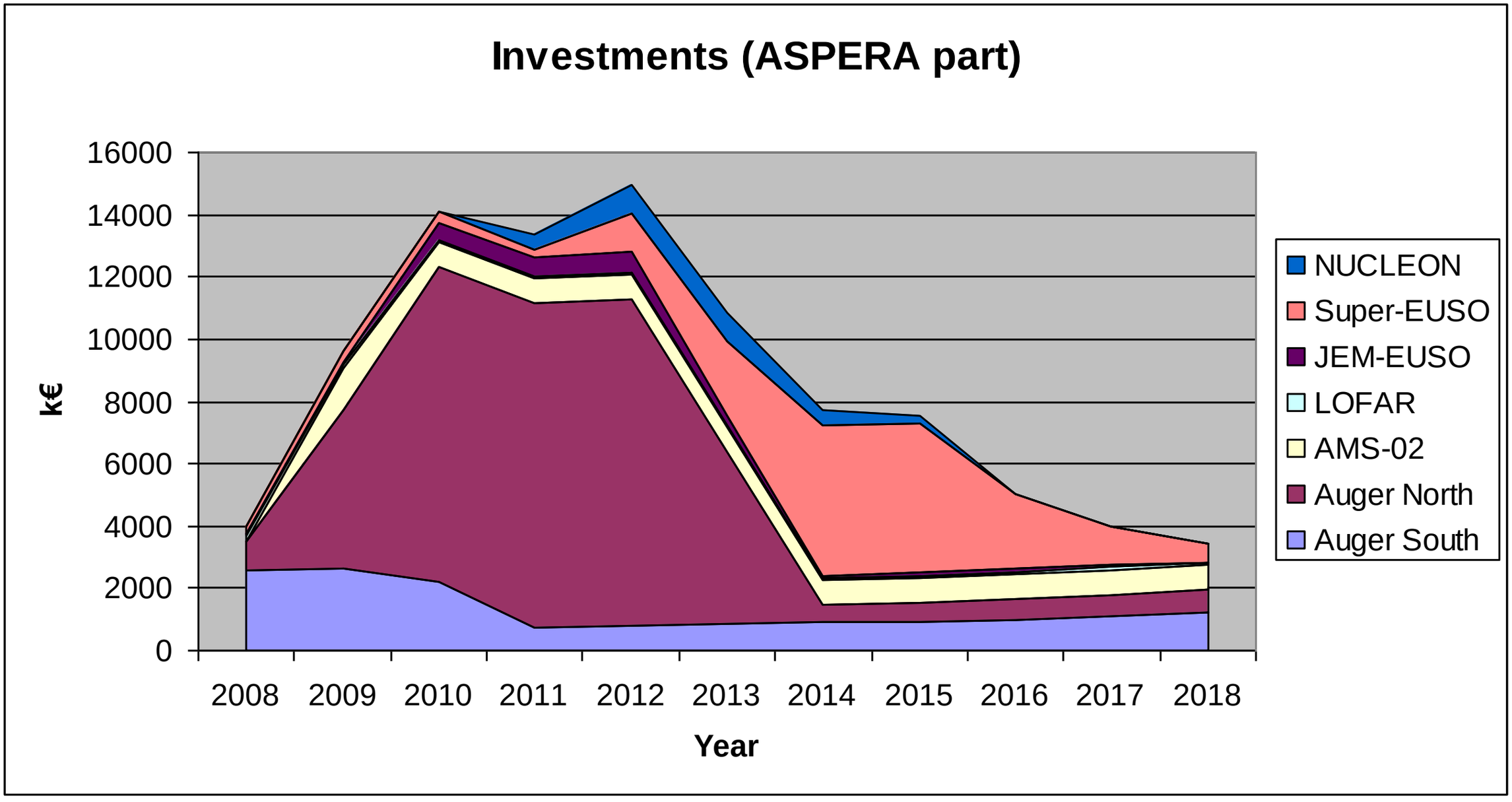


High Energy Gamma Rays

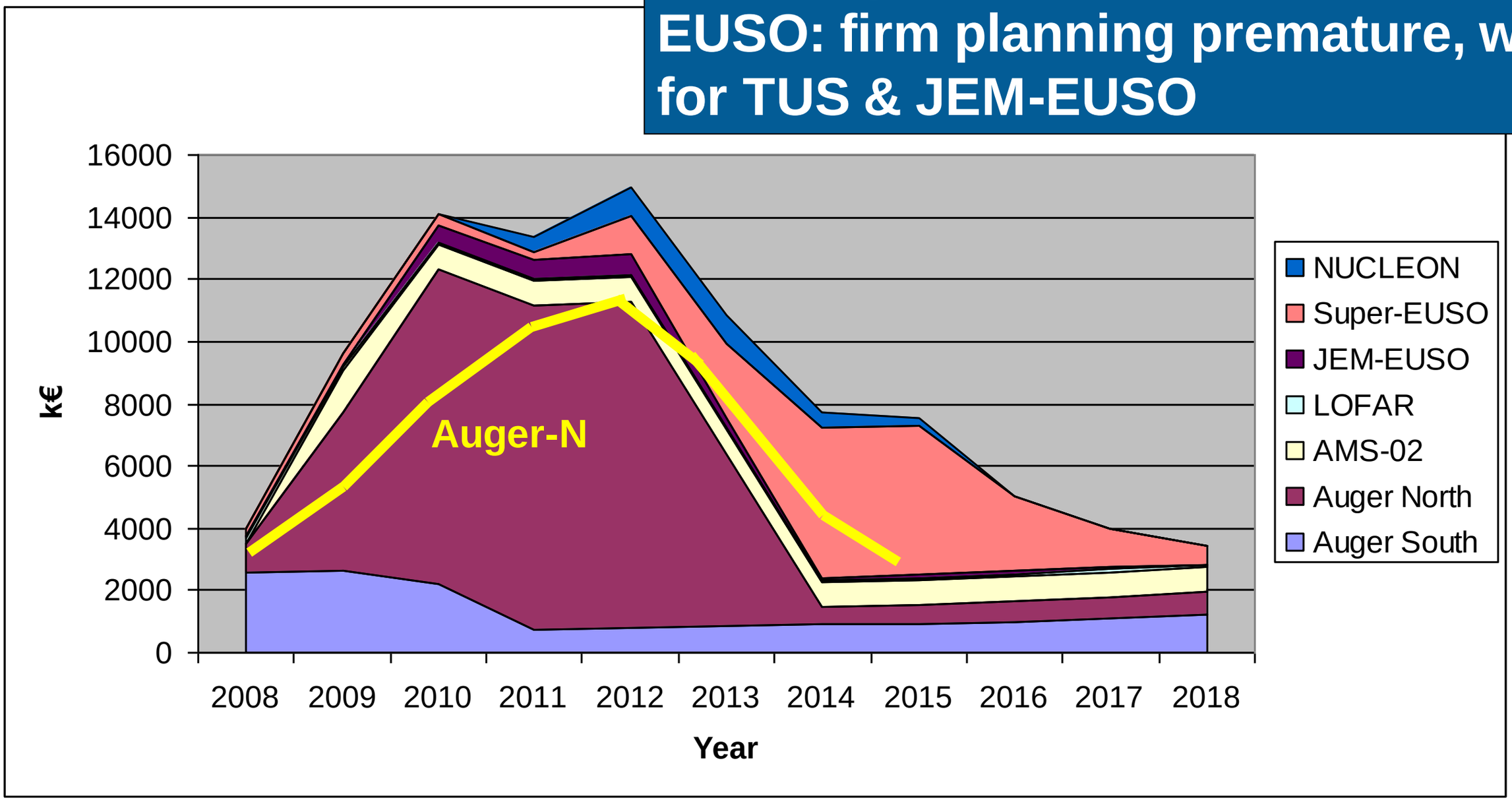
Roadmap:
Cost reduction from 170 to 120 M€
- technology
- trans- continental cooperation



Result Working Group 2007



Roadmap:
Shift Auger-North, no cost reduction
EUSO: firm planning premature, wait for TUS & JEM-EUSO



Dark Matter Searches

Astroparticle Physics for Europe

ASPERA

now

100 kg scale

ton scale

2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017

operation **ZEPLIN-II**

construction → operation **ZEPLIN-III** → construction → operation **LUX/ZEPLIN**

operation **XENON**

construction → operation **XENON-100** → construction → operation **XENON-1Ton**

liquid xenon

operation **WARP**

construction → operation **WARP-140**

Tests **ArDM**

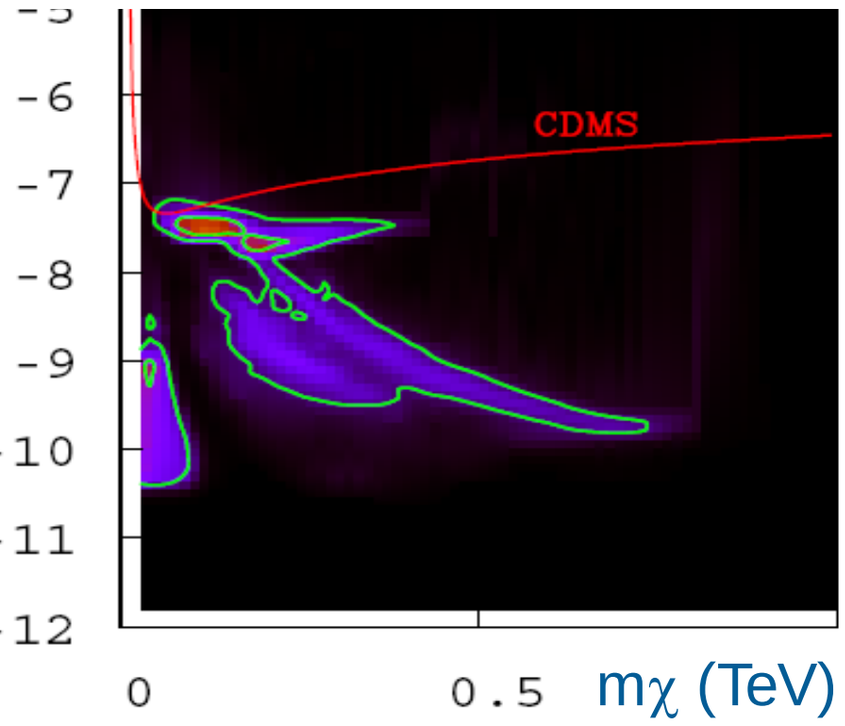
liquid argon

Noble liquid detectors with European participation

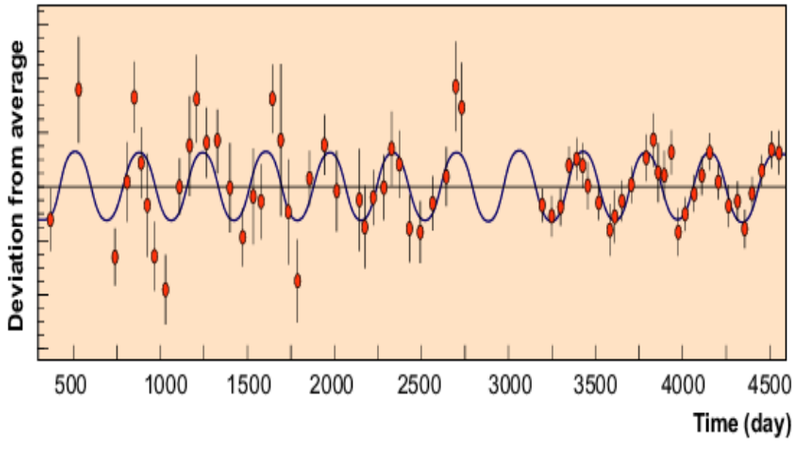
Dark Matter Searches

Astroparticle Physics for Europe

ASPERA



DAMA annual modulation



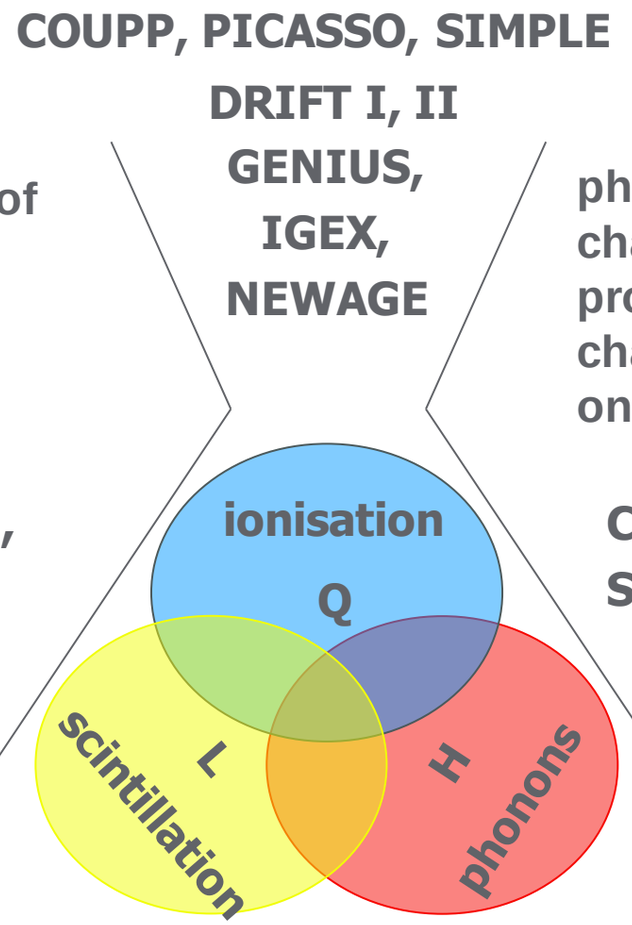
WIMP elastic nuclear recoils deposit < 50keV of energy at a rate 10^{-5} to 1 event/day/kg

ArDM, SIGN, WARP, XENON10, ZEPLIN III , LUX, XENON-100, WARP-140

ANAIS, CLEAN, DEAP, KIMS, DAMA/LIBRA, NAIAD, XMASS, ZEPLIN I

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

CRESST II, ROSEBUD, EURECA



COUPP, PICASSO, SIMPLE

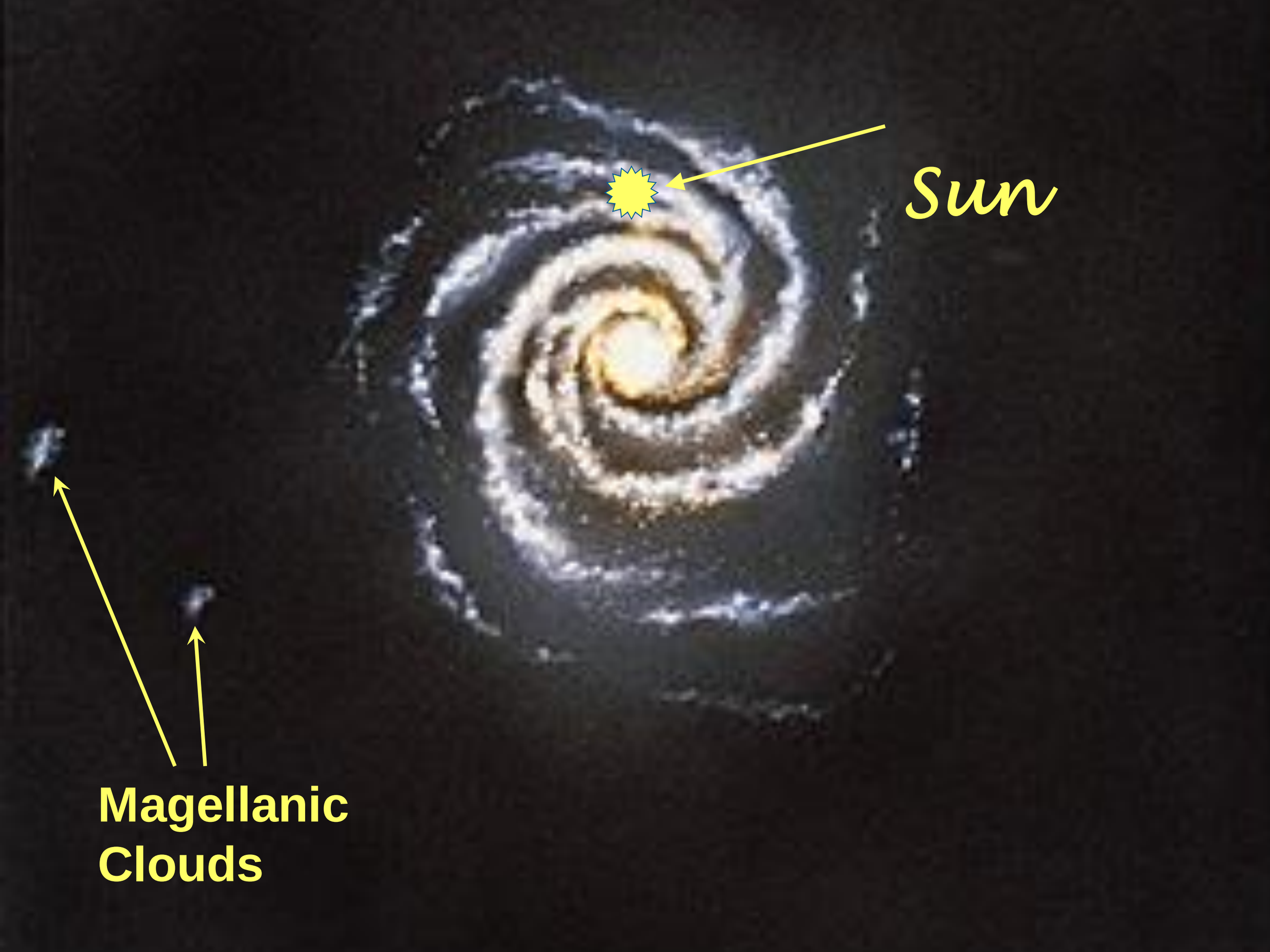
DRIFT I, II

GENIUS, IGEX, NEWAGE

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

CDMS, EDELWEISS, SuperCDMS, EURECA

by T. Sumner updated by C.P.de los Heros and C.Spiering


Sun
Magellanic
Clouds