

# Astroparticle Physics

## Relations to CERN



Christian Spiering, DESY



**CAST** search for solar axions

see the talks later this morning

**ISOLDE, n-TOF** ↔ nuclear  
astrophysics

see the talks of Huyse yesterday and others this afternoon

**NA-61** ↔ air showers

see the talks of Gazdzisky and Van Leuwen yesterday

... are examples for CERN experiments  
on astroparticle physics or closely related  
to astroparticle physics



<a href="#"><u>RE1</u></a>	(AMS) Alpha Magnetic Spectrometer (AMS) for Extraterrestrial Study of Antimatter, Matter and Missing Matter on the International Space Station
<a href="#"><u>RE3</u></a>	(AUGER PROJECT) The Pierre Auger Observatory Project
<a href="#"><u>RE5</u></a>	(EXPLORER) The Gravitational Wave Detector EXPLORER
<a href="#"><u>RE6</u></a>	(ANTARES) ANTARES: An Undersea Neutrino telescope
<a href="#"><u>RE7</u></a>	(GLAST) GLAST
<a href="#"><u>RE8</u></a>	(LISA) LISA
<a href="#"><u>RE9</u></a>	(NESTOR) NESTOR-Neutrino Extended Submarine Telescope with Oceanographic Research
<a href="#"><u>RE10</u></a>	(ICECUBE) IceCube
<a href="#"><u>RE11</u></a>	(MICE) Muon Ionization Cooling Experiment
<a href="#"><u>RE12</u></a>	(MEG) MEG: search for the $\mu e$ decay at PSI
<a href="#"><u>RE13</u></a>	(T2K) Neutrino Oscillation Experiment at JHF
<a href="#"><u>RE14</u></a>	(KATRIN) Tritium beta-decay experiment for direct measurement of the electron neutrino mass
<a href="#"><u>RE15</u></a>	(WARP) Search for cold dark matter using a cryogenic noble liquid detector
<a href="#"><u>RE16</u></a>	(HESS) High Energy Stereoscopic System
<a href="#"><u>RE17</u></a>	(MAGIC) MAGIC Major Atmospheric Gamma Imaging Cherenkov Telescope
<a href="#"><u>RE18</u></a>	(ArDM) ArDM: Search for Dark Matter in the Universe with Liquid Argon
<a href="#"><u>RE2B</u></a>	(PAMELA) Search for Antimatter in Space

This status is translated to reality on different levels:

- „essentially symbolic“
- Using CERN for meetings
- Using CERN as executive financial institution (e.g. Auger, Antares)
- Input from CERN experiments (e.g. NA-61 → Auger)
- Assembly and testing of detectors (e.g. AMS, ArDM)



Astroparticle Physics for Europe

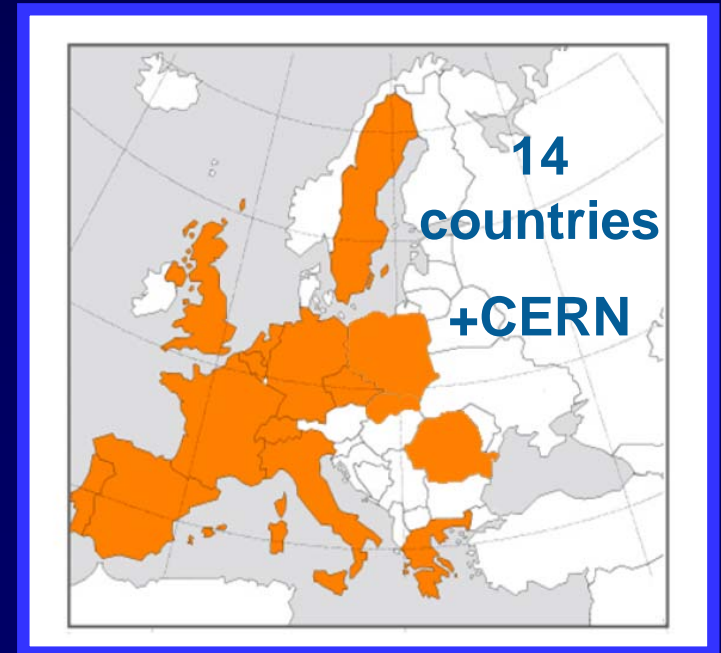
# Astroparticle Coordination in Europe

## ApPEC *Founded 2001*

- **Steering Committee** and **Physics Review Committee**
- Promote **cooperation** within European APP community
- Develop **long term strategies** for European APP, offering **advice to national funding agencies and EU**
- Improve links and **coordination** between European APP and the scientific programmes of organisations like **CERN, ESA, and ESO**
- Express views on APP in international forums, such as **OECD, UNESCO etc.**

## ASPERA *Launched 2006*

- The **ERA-Net** of Astroparticle Physics
- Funded by EU FP6 (**2.5 M€3yr** from July 2006)
- Phase 2 recently approved (July 2009 – 2012)
- Coordination with **ASTRONET** (the ERA-Net of astronomers) and also **CERN strategy bodies**
- **Roadmap for APP in Europe**



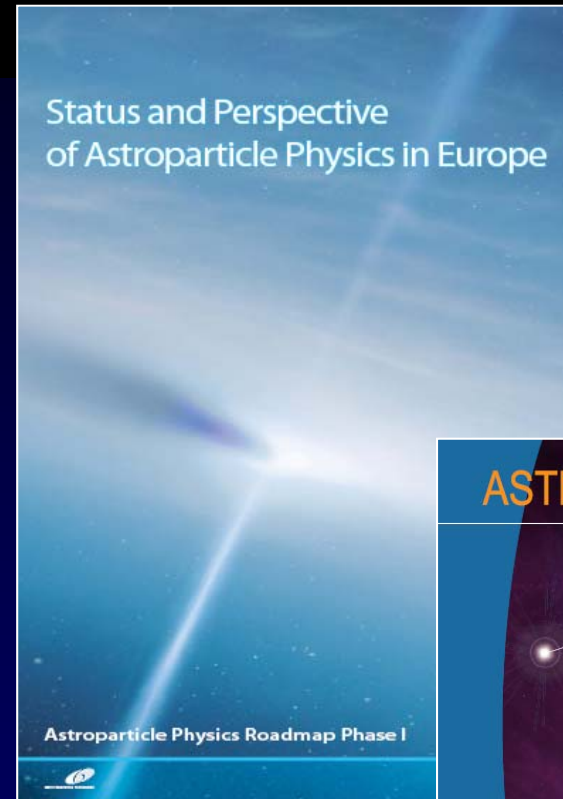


## 1 2007

- science case
- status: overview
- recommendations for convergence

## 2 2008

- Critical assessment of plans
  - Calendar for milestones and decisions
  - Input for ESFRI Roadmap
  - Coordinated with ASTRONET
- (Long write-up with detailed data and arguments in work)



# The Magnificent Seven

*Font size corresponds to realization time (not importance!)*

Einstein Telescope E.T.

Megaton (LAGUNA)

Ton-scale  
Double Beta

Ton-scale  
Dark Matter

Auger-Nord KM3NeT

CTA

# The Magnificent Seven

Particle Physics

Astrophysics

Double Beta Dark Matter LAGUNA KM3NeT Auger CTA E.T.

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# The Magnificent Seven

## Particle Physics

## Astrophysics

Double Beta

Dark Matter

LAGUNA

KM3NeT

Auger

CTA

E.T.

Majorana nature  
nu mass

Cosmology  
SUSY

Proton decay  
nu astronomy  
accelerator beam  
(oscillations)

nu astronomy  
nu oscillations  
indirect DM and  
other exotic particles

Astrophysics  
GZK physics

Astrophys.  
Indirect DM

Test Relativity  
Extreme objects

# The Magnificent Seven

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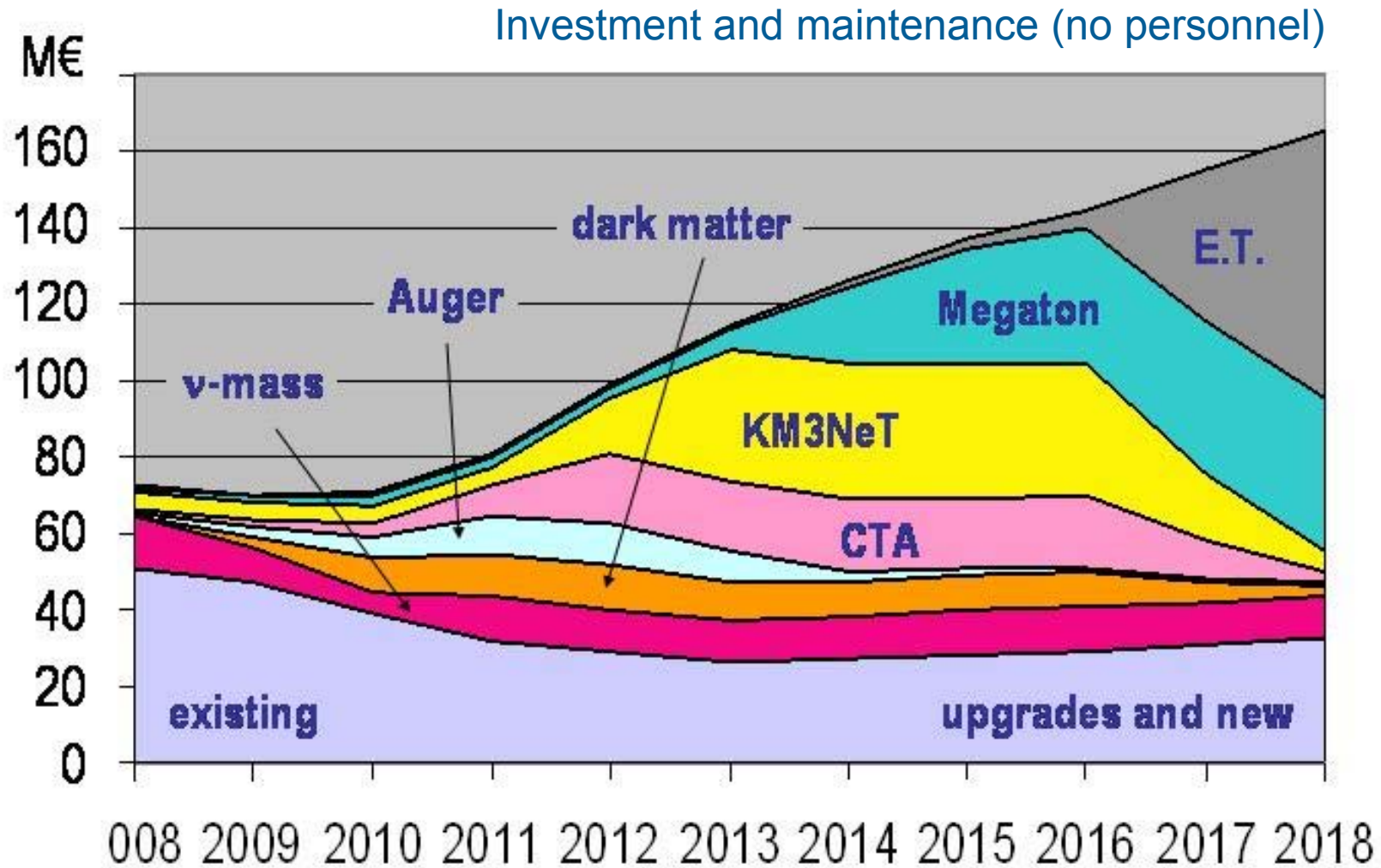
Test Relativity  
Extreme objects

closer to CERN

closer to ESO

# Timeline and the factor-2 scenario

Increase in personnel cost will be smaller !





- **Double Beta Decay** → see talk of L. Baudis
- **Dark Matter Search** → see talks of Baudis, Papaevangelou and Meissner

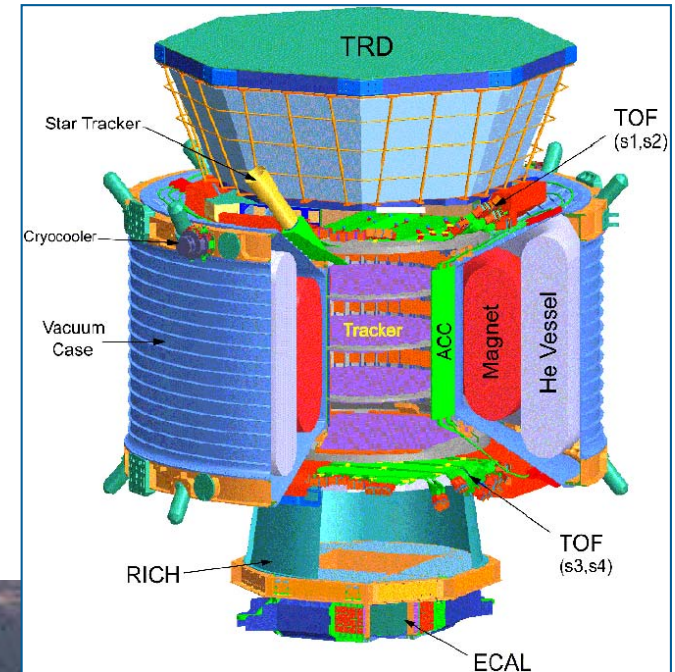
In the following:

- **AMS**
- **LAGUNA: Underground detector(s) on the 0.1-1 Megaton scale** → see also the talk of A. Rubbia yesterday
- **KM3NeT**
- **Astroparticle Theory**



- „Pamela King-Size“ at the ISS
- Search for dark matter
- Search for anti-matter
- Heavy primary nuclei
- Cosmic ray propagation
  - Geomagnetic effects
  - Solar modulation
  - ISM effects
- ...

3.5 m

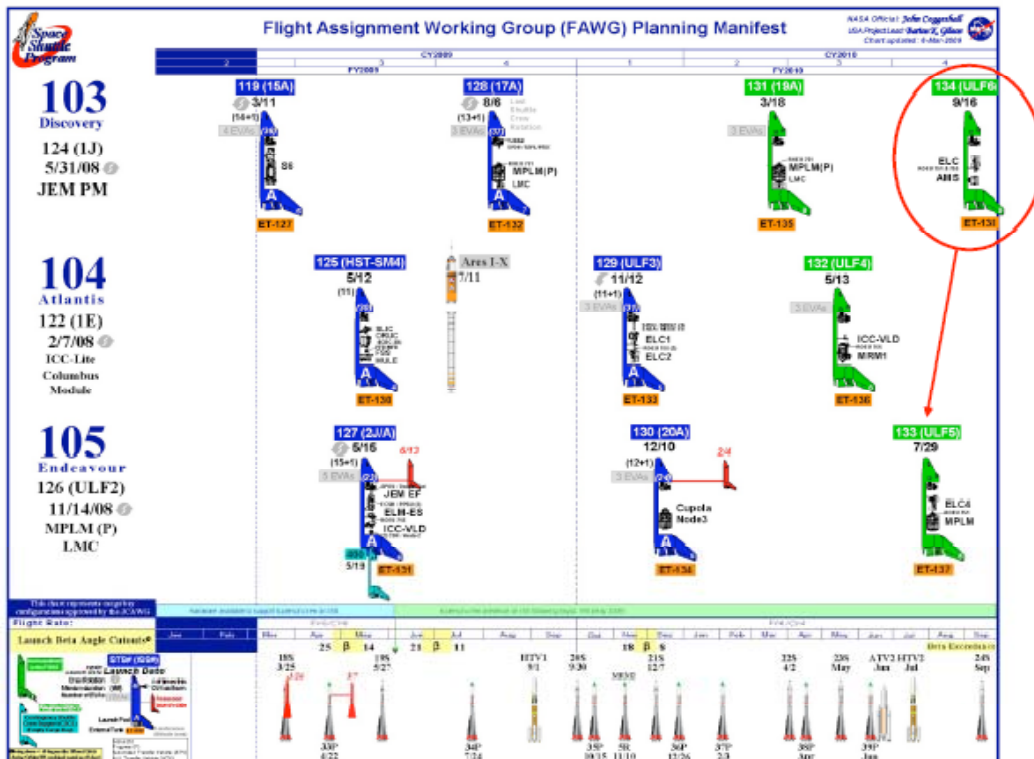
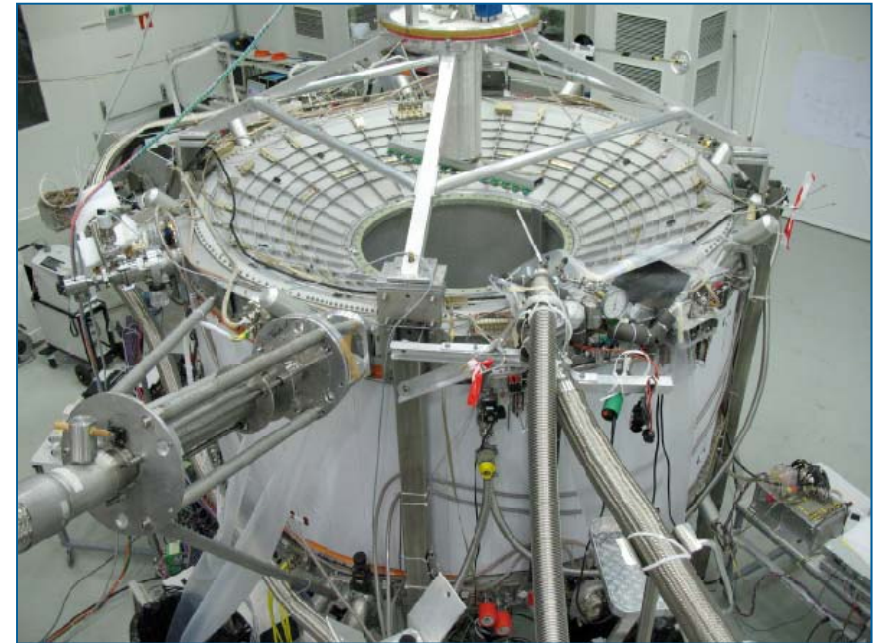


**Interplay of AMS science with CERN science**

**Interplay of AMS/space technologies with CERN particle technologies**



- SC Magnet now at 1.78 K (superfluid He temperature)
- This week: start of magnet charging
- Experiment integration to be completed by Oct. 2009



- After 4 months Thermo/ Vacuum test in ESTEC, AMS will be shipped to KSC for integration on the shuttle
- Planned launch July 2010



# LAGUNA

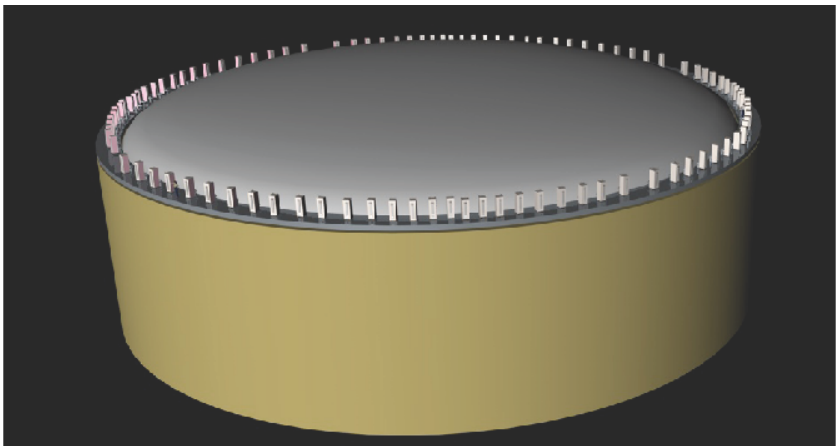
FP7 design study  
Common proposal in 2010  
Worldwide context

**MEMPHYS**  
700 kton water

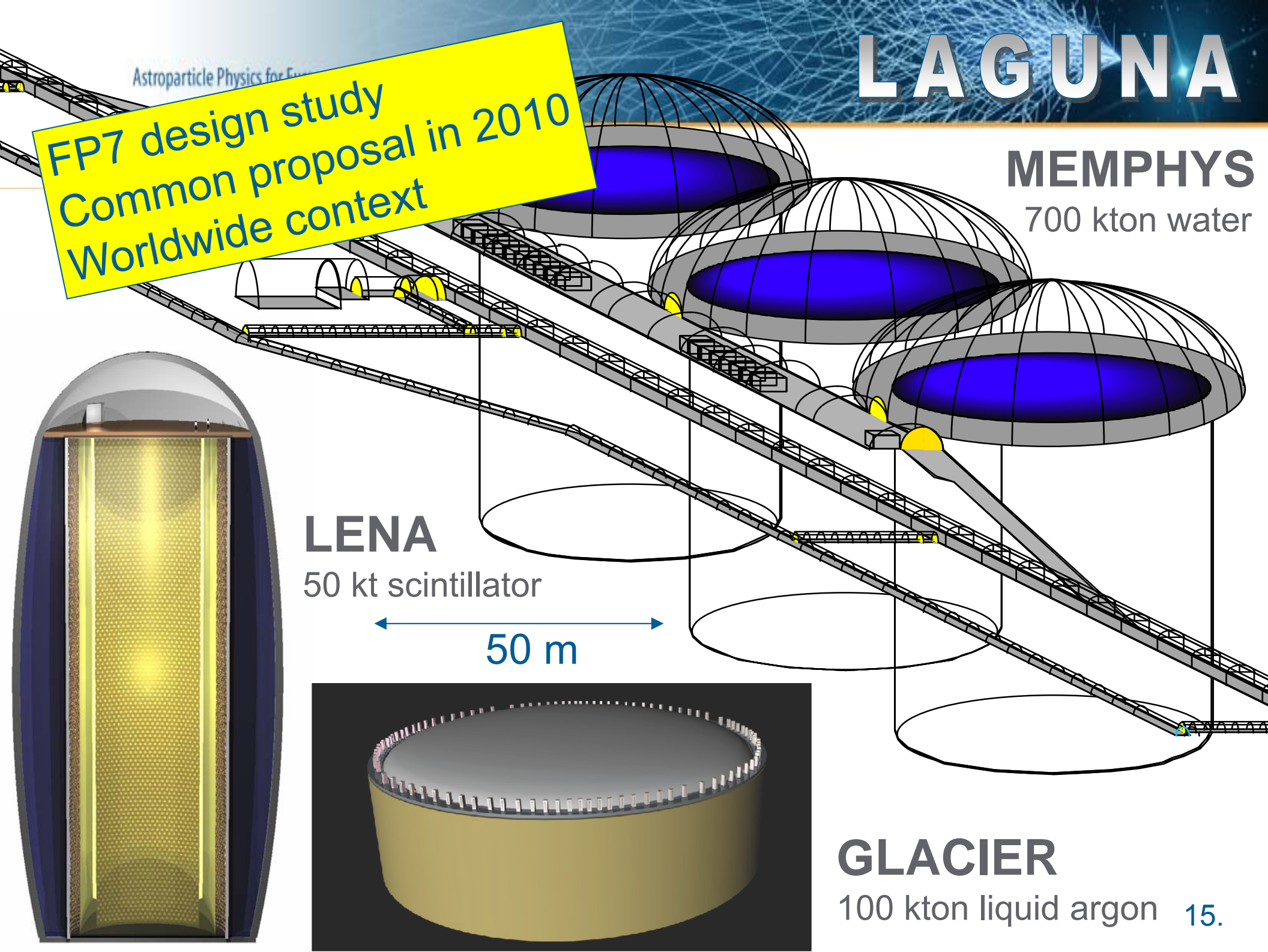


**LENA**  
50 kt scintillator

50 m



**GLACIER**  
100 kton liquid argon 15.



- **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 from accelerators** over a long baseline (also with dedicated smaller detectors): neutrino properties

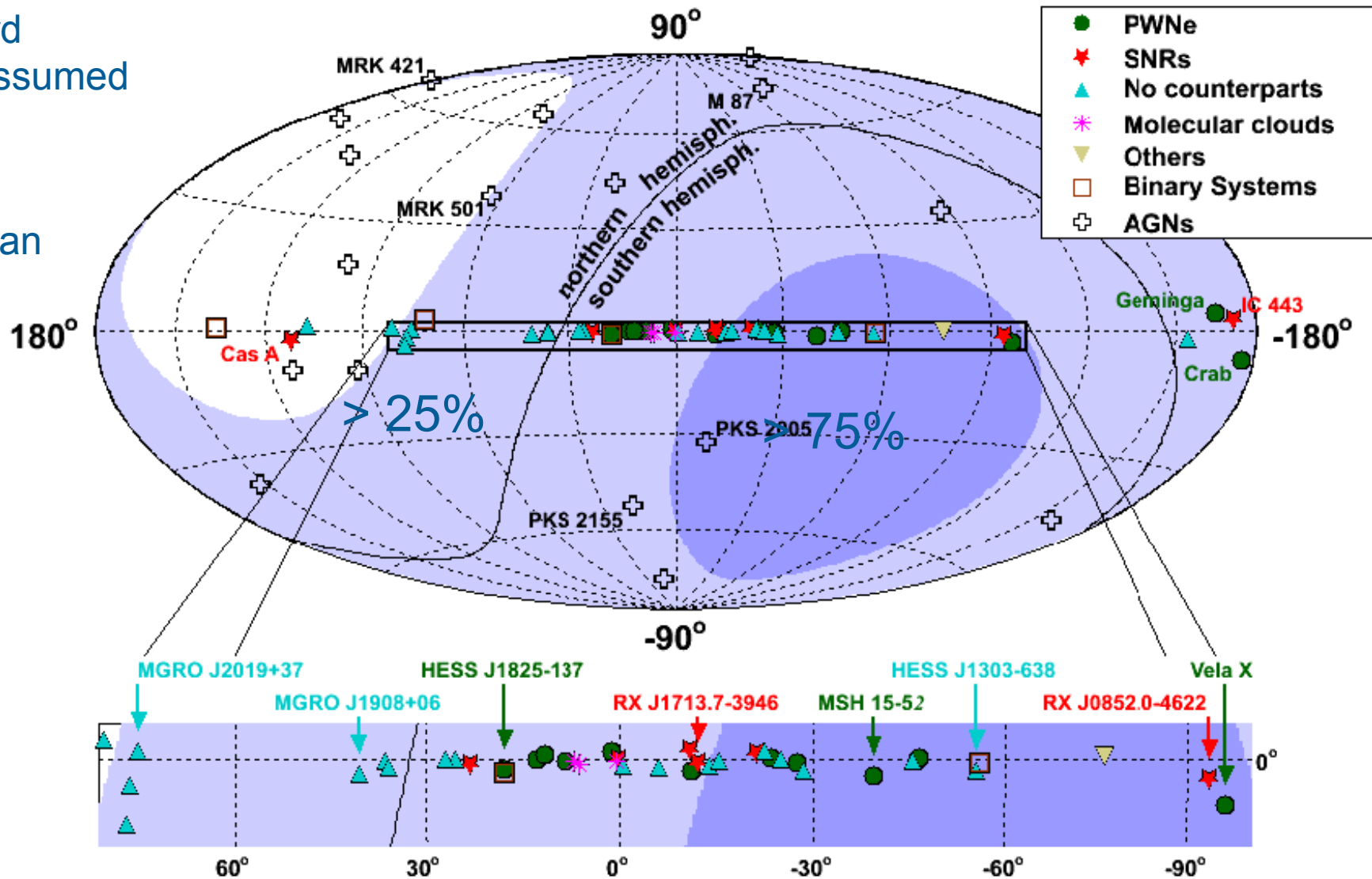




# The KM3NeT Field of View

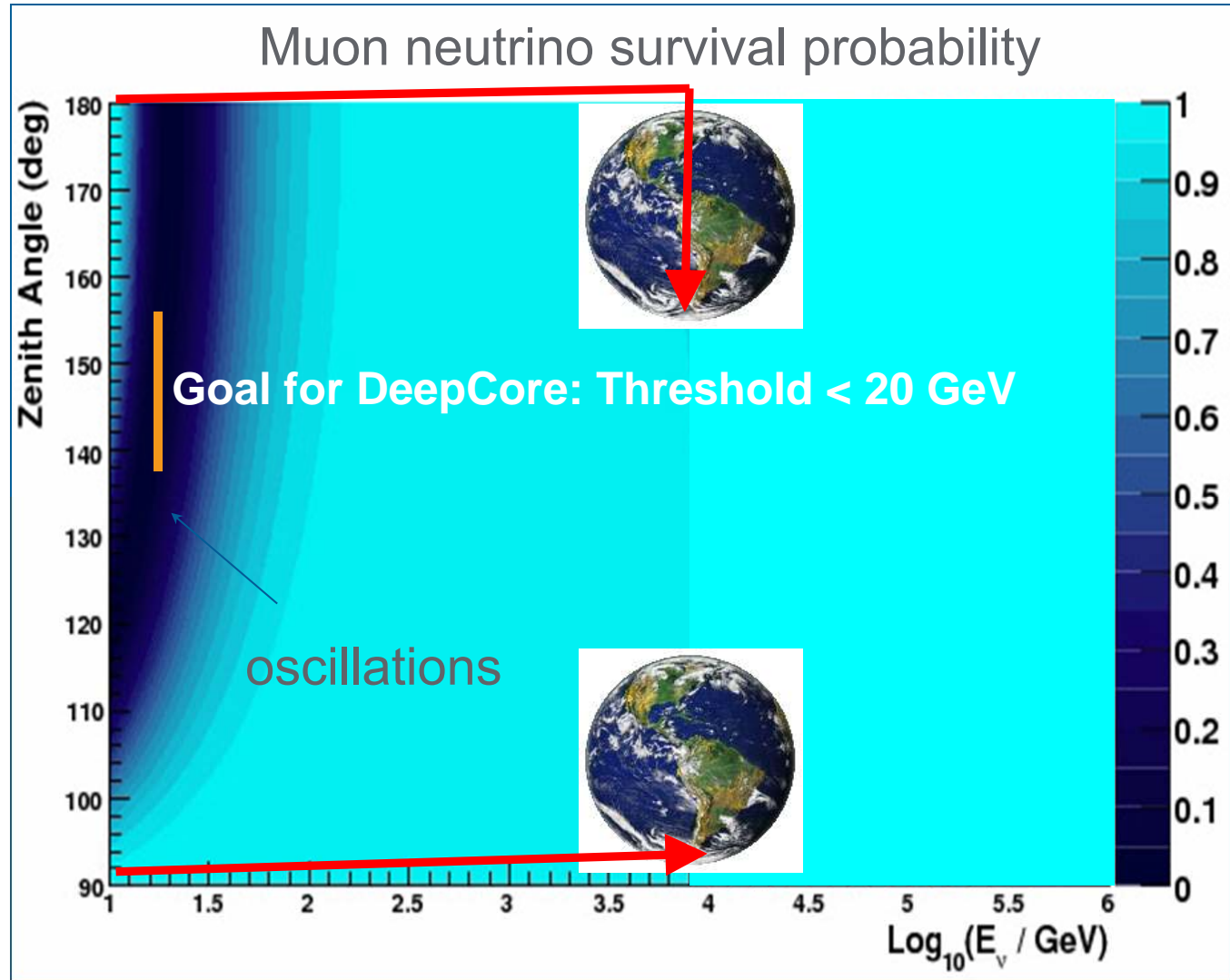
$2\pi$  downward sensitivity assumed

Located in Mediterranean  
 → visibility of given source can be limited to less than 24h per day



## Some illustrative results from AMANDA/IceCube

- Use large atmospheric neutrino sample, look for  $\nu_\mu$  disappearance and appearance of  $\nu_\tau$
- DeepCore will help peering into the oscillation region





## Some illustrative results from AMANDA/IceCube

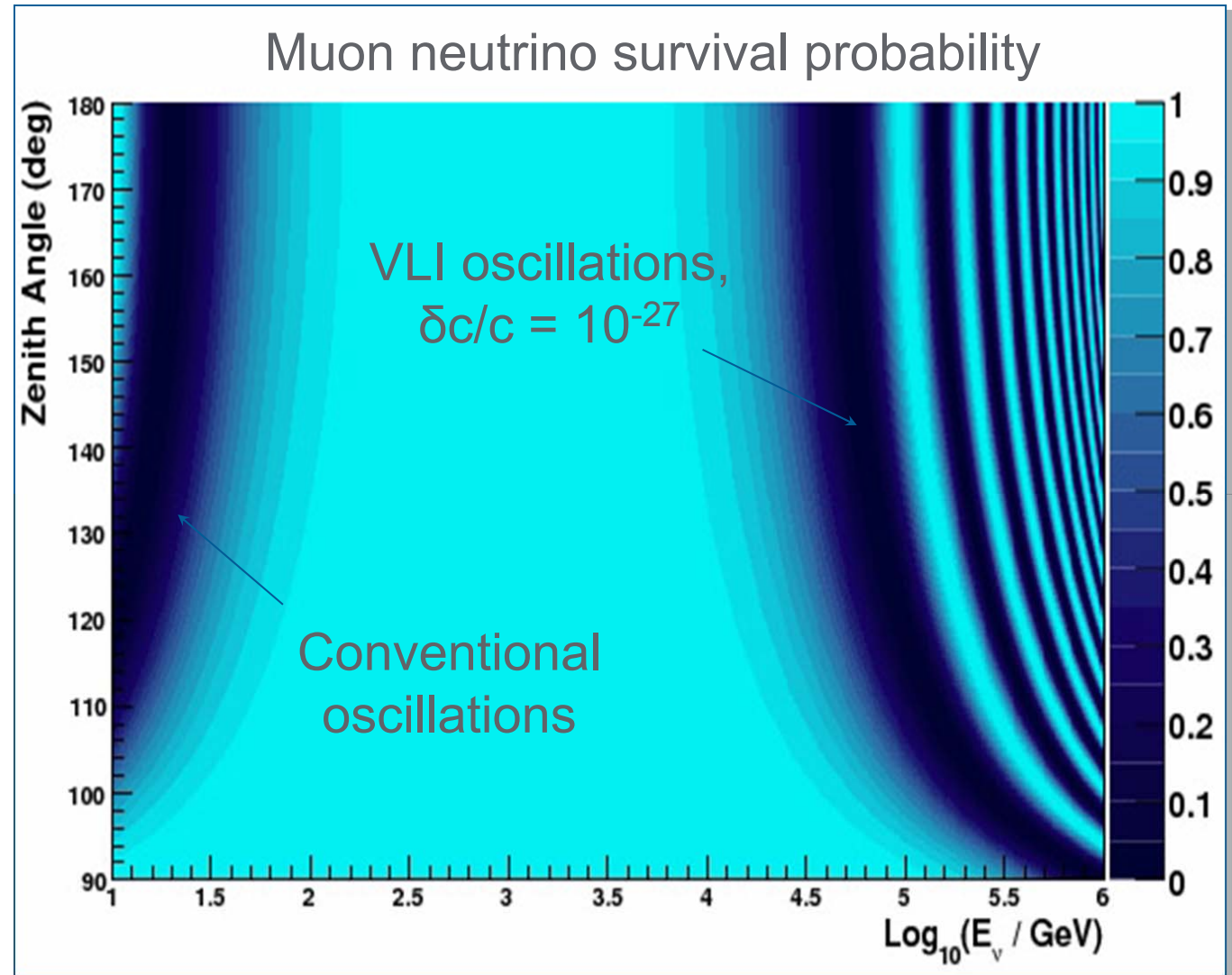
- Violation of Lorentz invariance
- Quantum decoherence
- (both appear in quantum gravity theories)

parameters of interest:

**VLI:**  $\delta c/c$ ,  $\sin 2\xi$ , phase  $\eta$

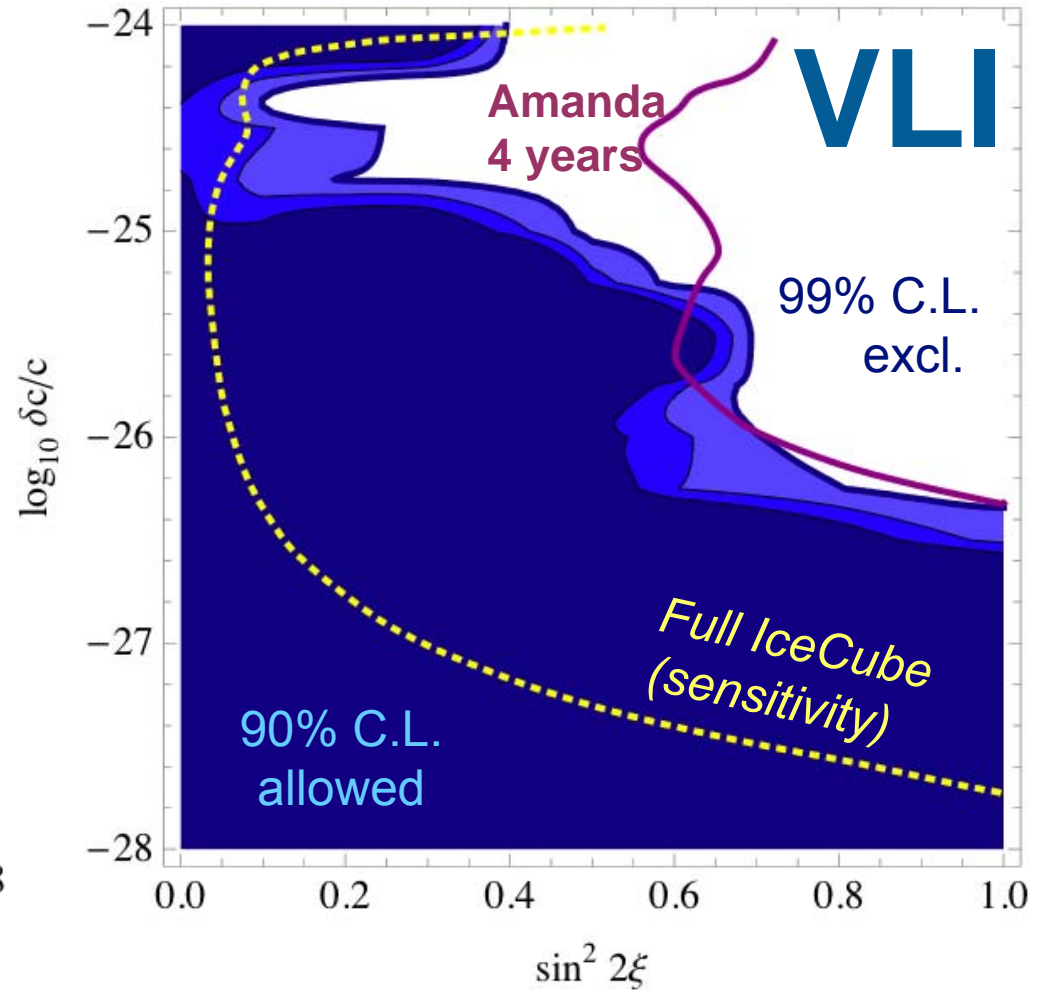
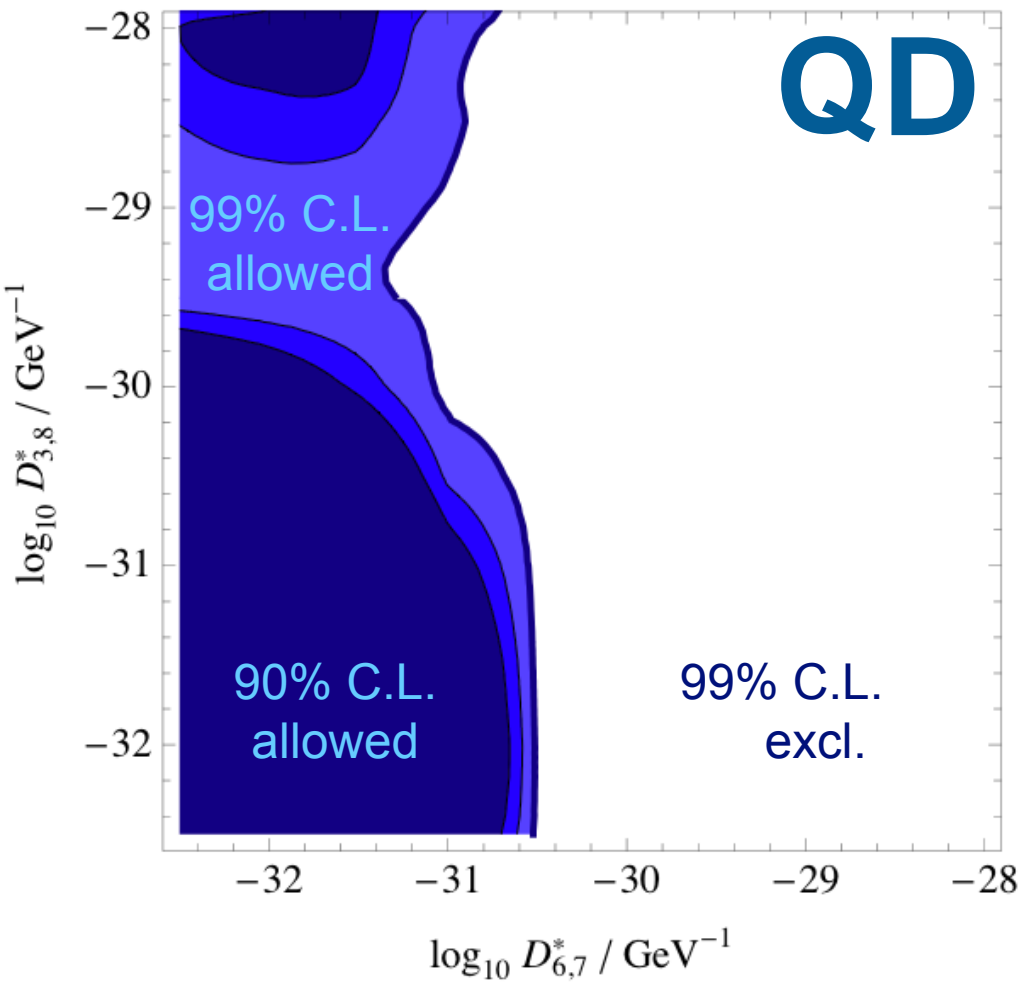
**QD:**  $D_3$  and  $D_8$ ,  $D_6$  and  $D_7$

Different to standard oscillations ( $\sim 1/E$ ), effects of QG oscillations go  $\sim E$

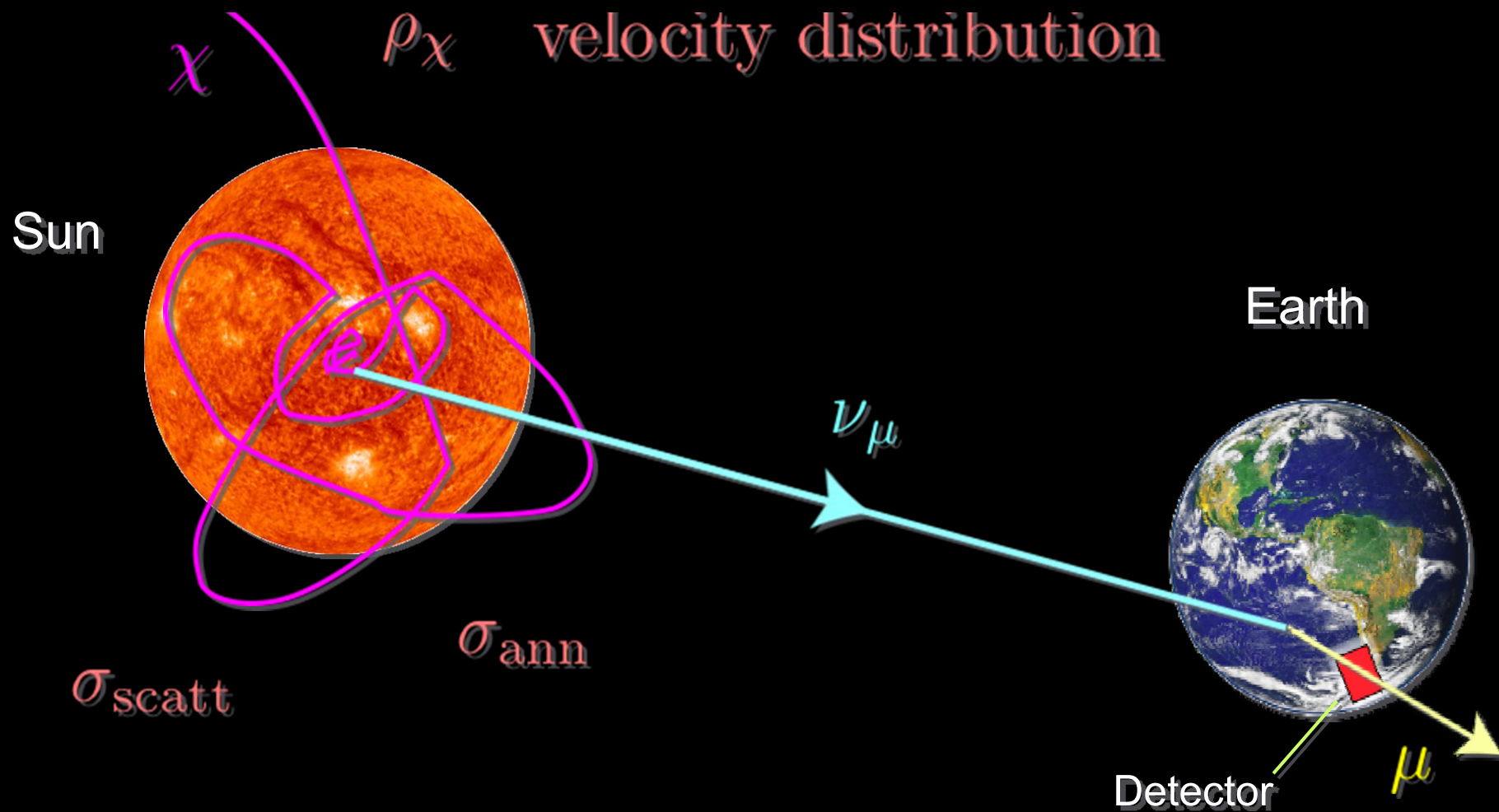




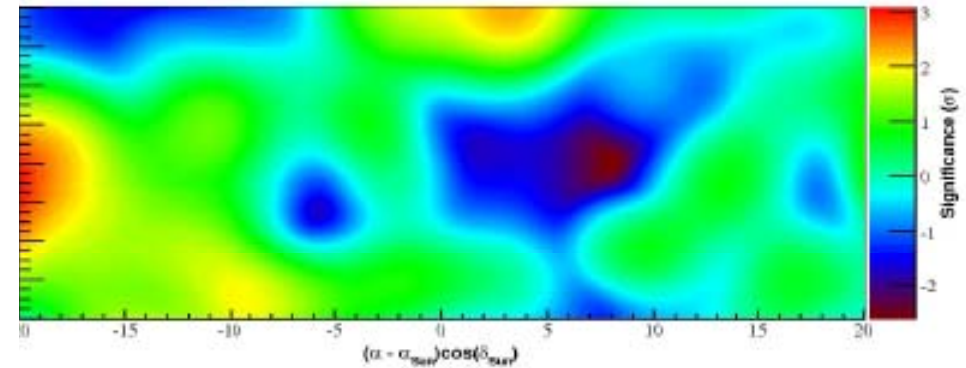
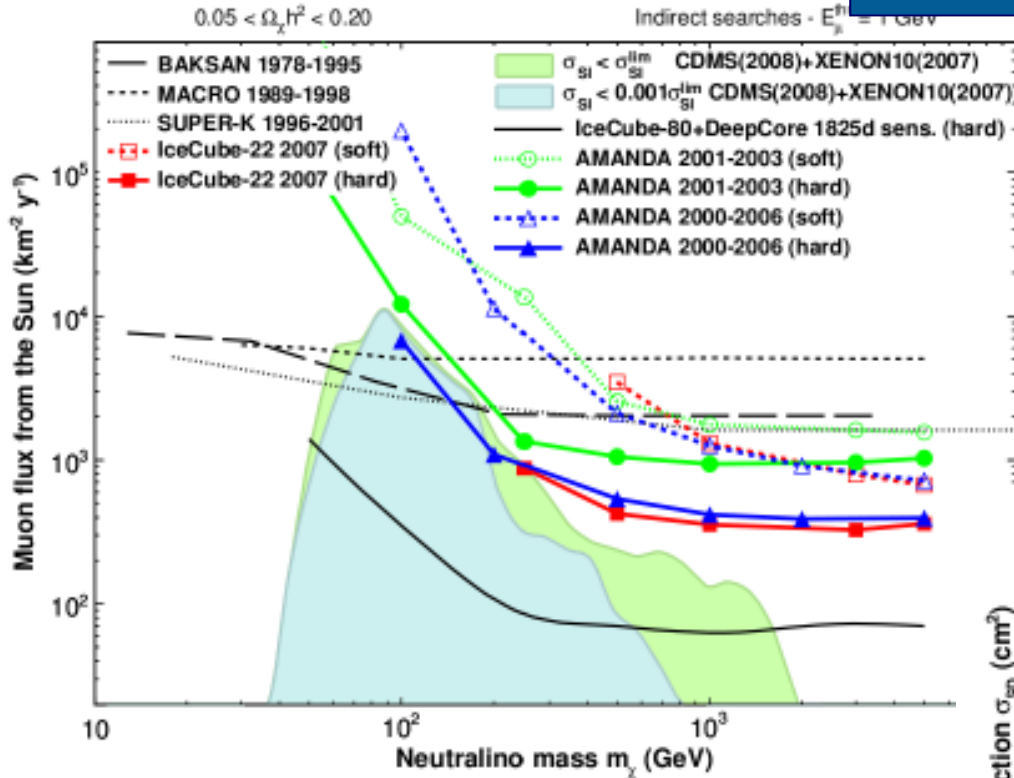
Some illustrative results from AMAMDA/IceCube



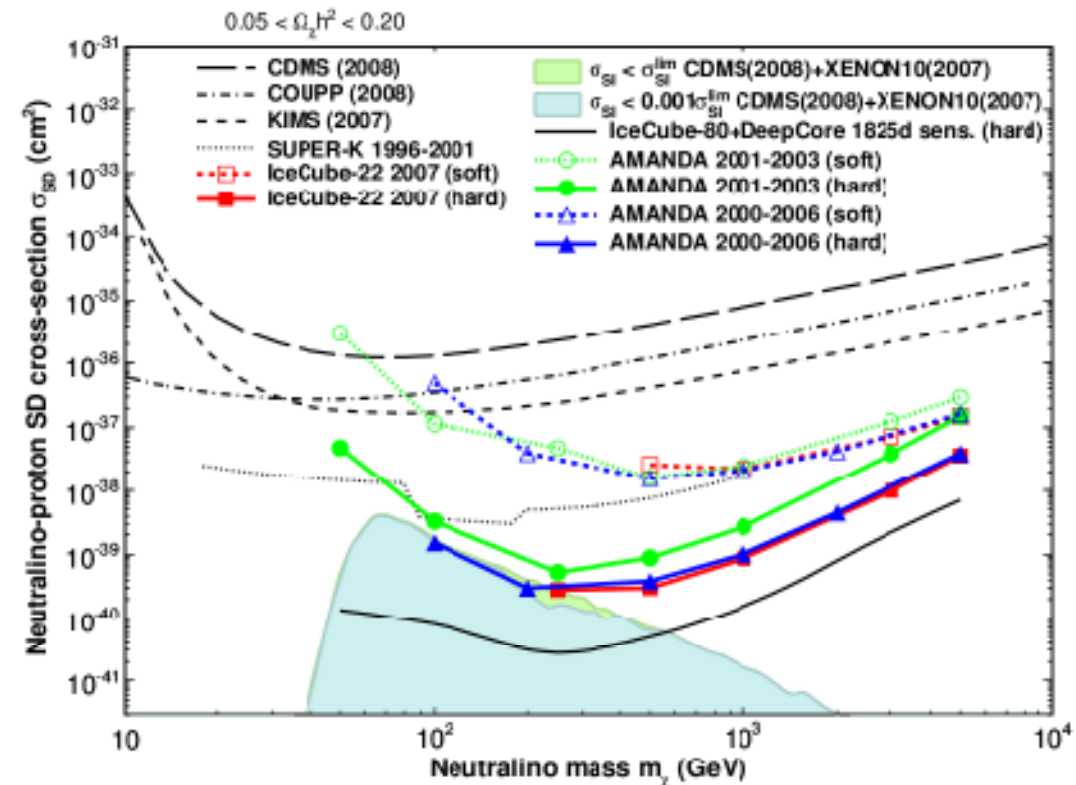
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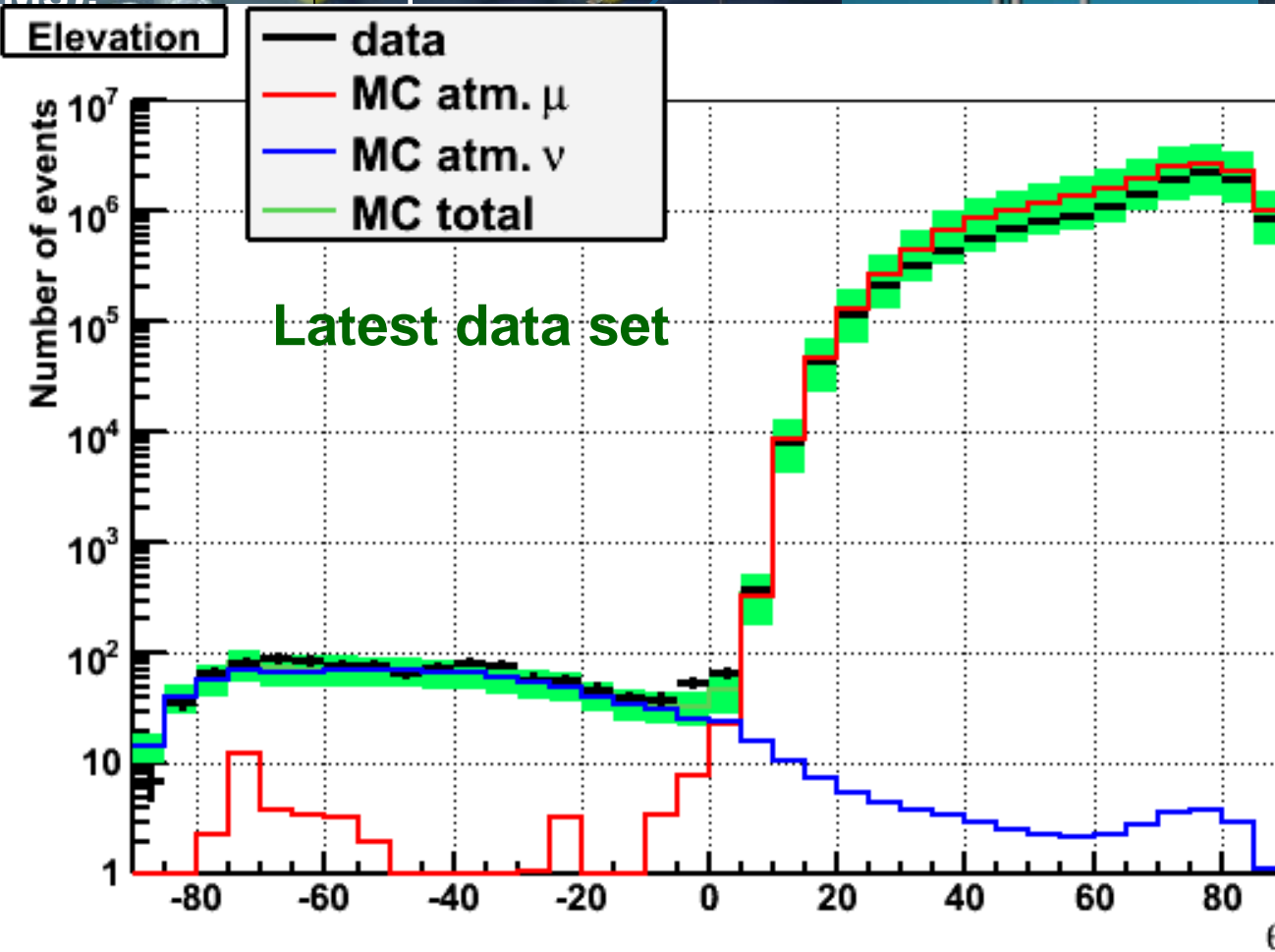
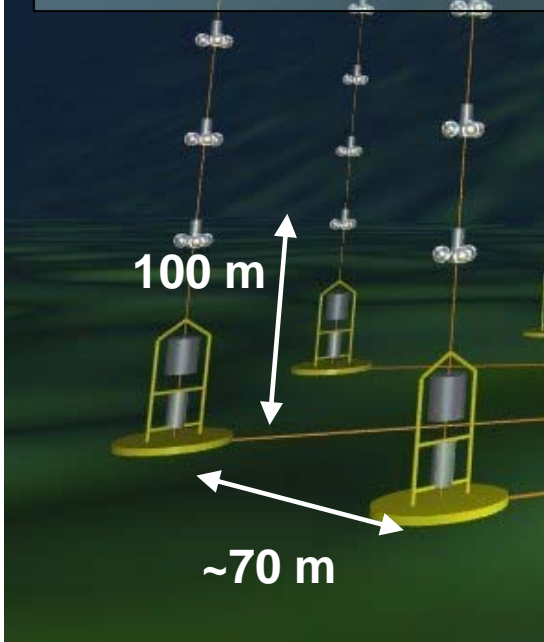
- Models with strong spin-dependent coupling are the least constrained by direct DM searches.
- W.r.t. spin-dependent coupling, underice/underwater detectors are  $\sim 100$  times more sensitive than direct search experiments (Sun is mostly hydrogen)





# ANTARES (RE6): Proof of Feasibility

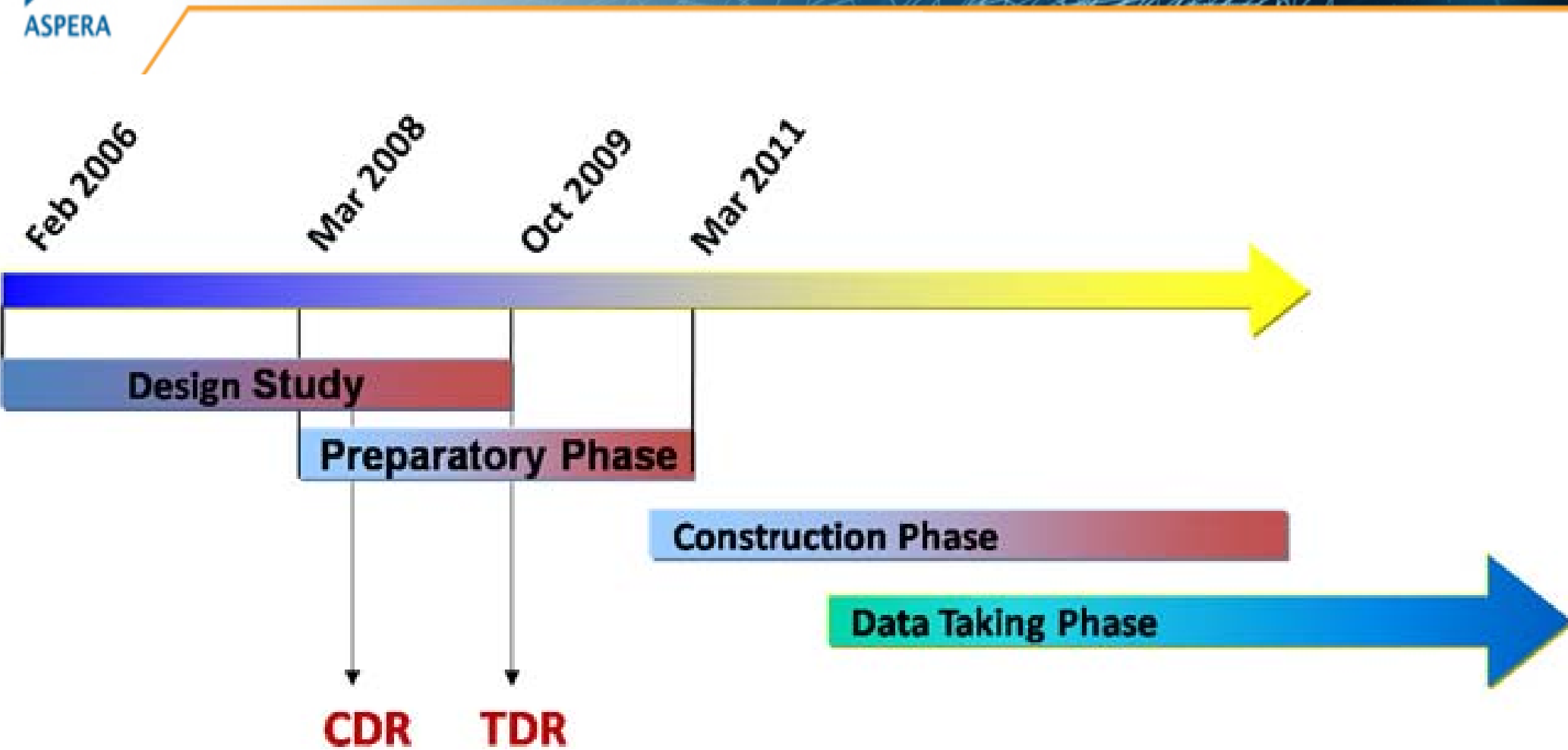
- String-based detector;
- Downward-looking photomultipliers (PMs) axis at  $45^\circ$  to vertical
- 2500 m deep.
- Currently taking data on 6 lines, completion in 2010



- Technical:
  - Design Study 2006-2009 (EU-funded with 9 M€)
  - Conceptual Design Report 2008
  - Technical Design Report 2009
- Political:
  - Pilot projects ANTARES and NESTOR are CERN RE's
  - High priority on ApPEC/ASPERA and ASTRONET roadmaps
  - On ESFRI 2006/08 roadmaps
  - Funding commitments (partly conditional to site)



# Timeline Towards Construction



Note: "Construction" includes the final prototyping stage



- Photo-sensors and optical modules
- Data acquisition, information technology and electronics
- Mechanical structures
- Deep-sea infrastructure
- Deployment
- Calibration
- Associated science infrastructure
- Prototyping, project planning & management
- Operation

fields of  
CERN expertise

Increasing intensity and impact



- Recognized experiment (RE)
- Structural support with limited resources (reviewing and advisory role)
- Structural support with moderate resources (consolidating role in technology and site choices, project organisation etc., member of consortium)
- Involvement with significant resources (contribution to preparation and construction, leading member of consortium)

# Astroparticle Theory & CERN

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## Particle Physics

## Astrophysics

Double Beta   Dark Matter   LAGUNA   KM3NeT   Auger   CTA   E.T.

- A **European Centre for Astroparticle Theory** could be established either in one of the European countries or at CERN. Given the synergy between LHC physics and astroparticle physics, CERN would be a natural host, particularly in view of several astroparticle experiments being CERN recognized experiments.

