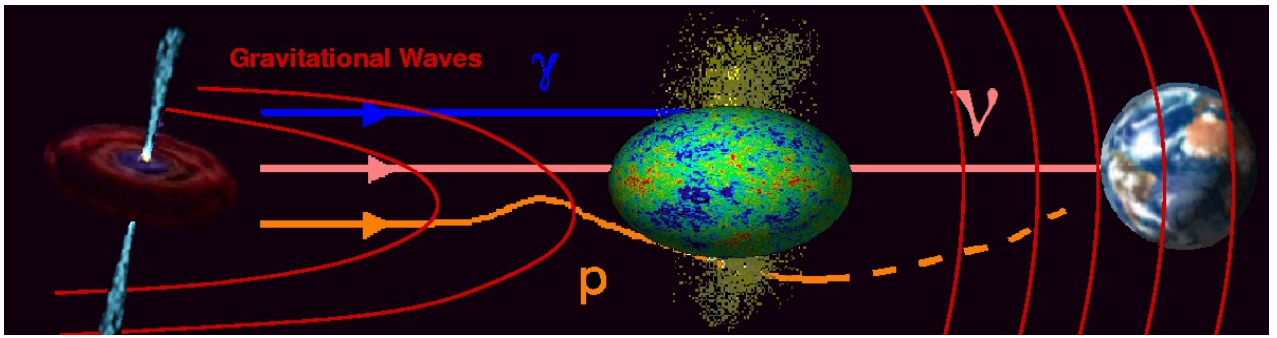
ANTARES: un télescope à neutrinos

Laura Core
(Centre de Physique des Particules de Marseille)
au nom de la collaboration ANTARES

Why neutrinos?

→ Flux not attenuated over cosmological distances ;

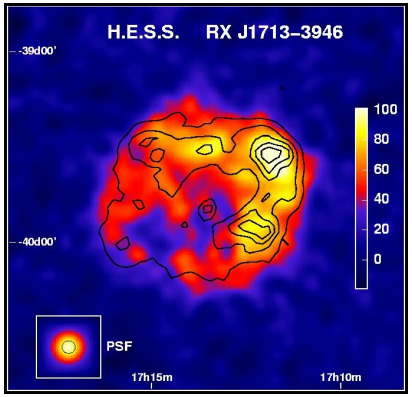


Neutrinos produced in CRs interaction with CMB and interstellar gas

→ Trajectory not deflected by magnetic fields;

→ They could indicate the presence of hadronics process in cosmic accelerator mechanisms.

Supernovae



Nature 432 (2004) 75

AGN

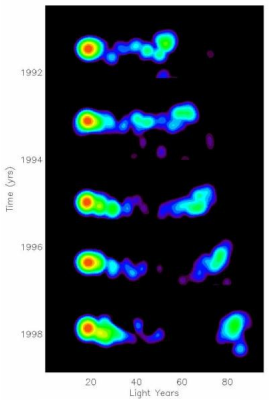


Image courtesy of NRAO/AUI

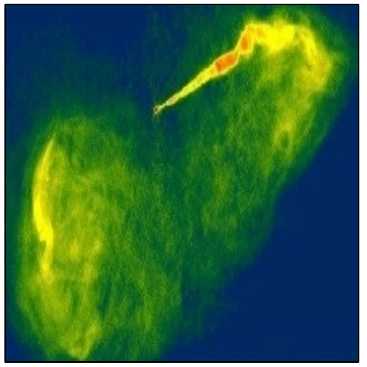
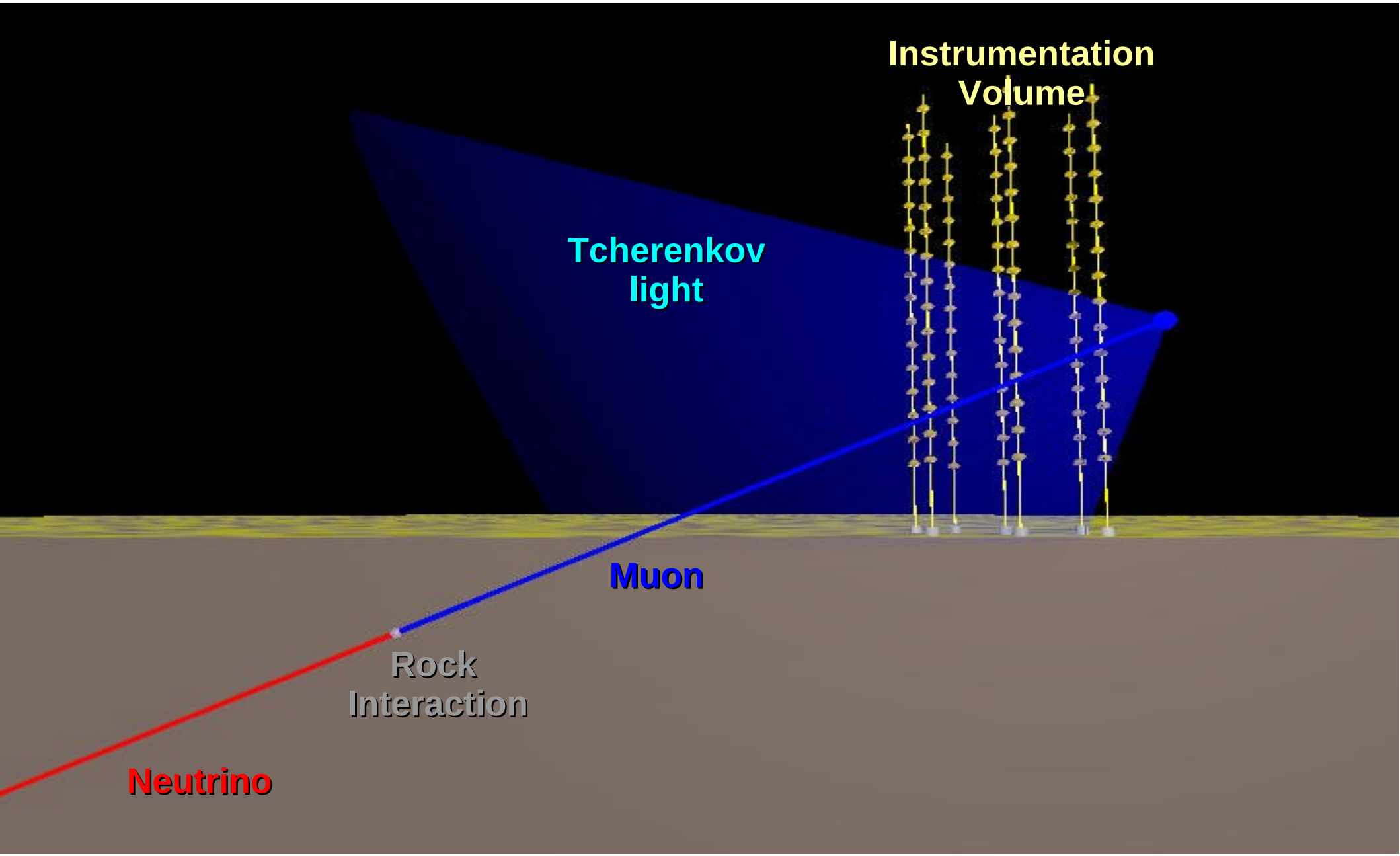


Image courtesy of NRAO/AUI

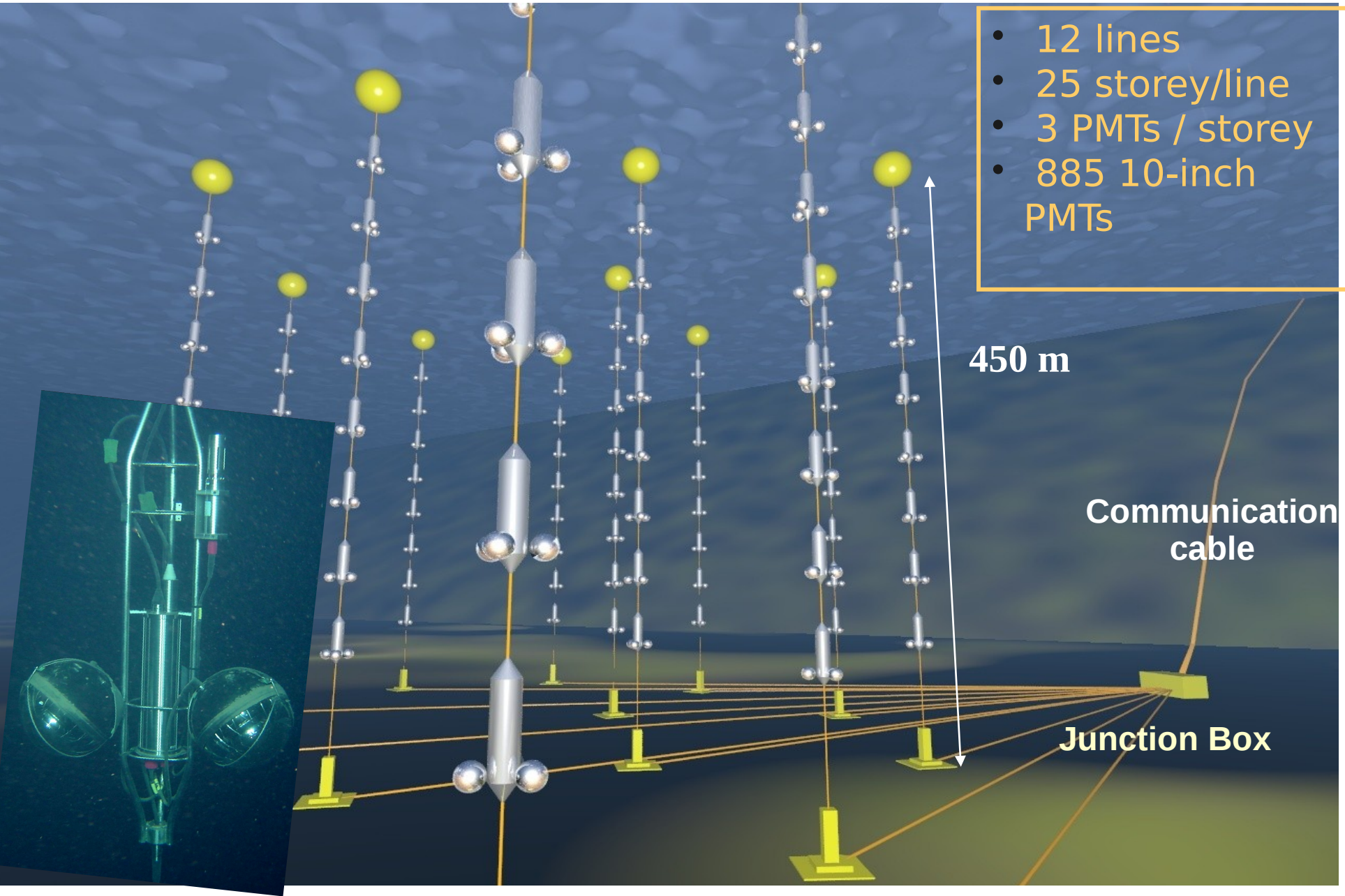
GRB

NASA/Swift/Stefan Immler

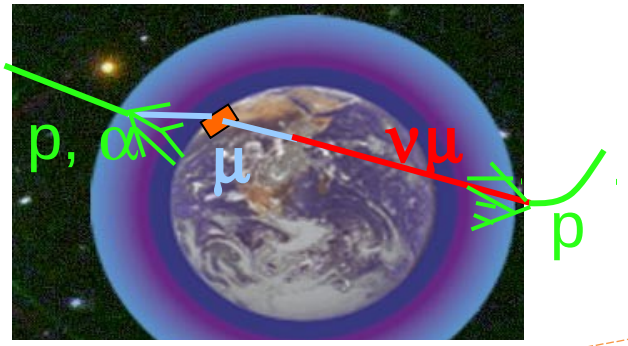
Detection principle



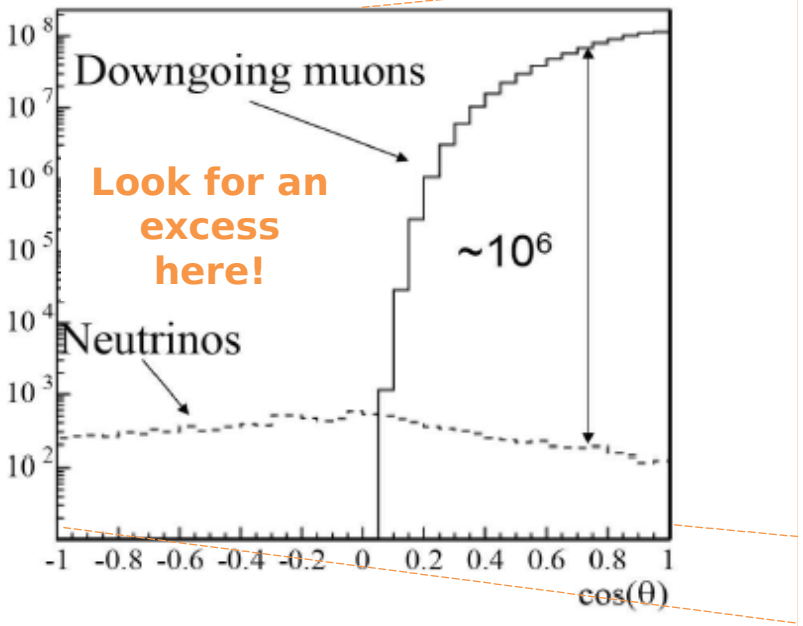
Detector layout

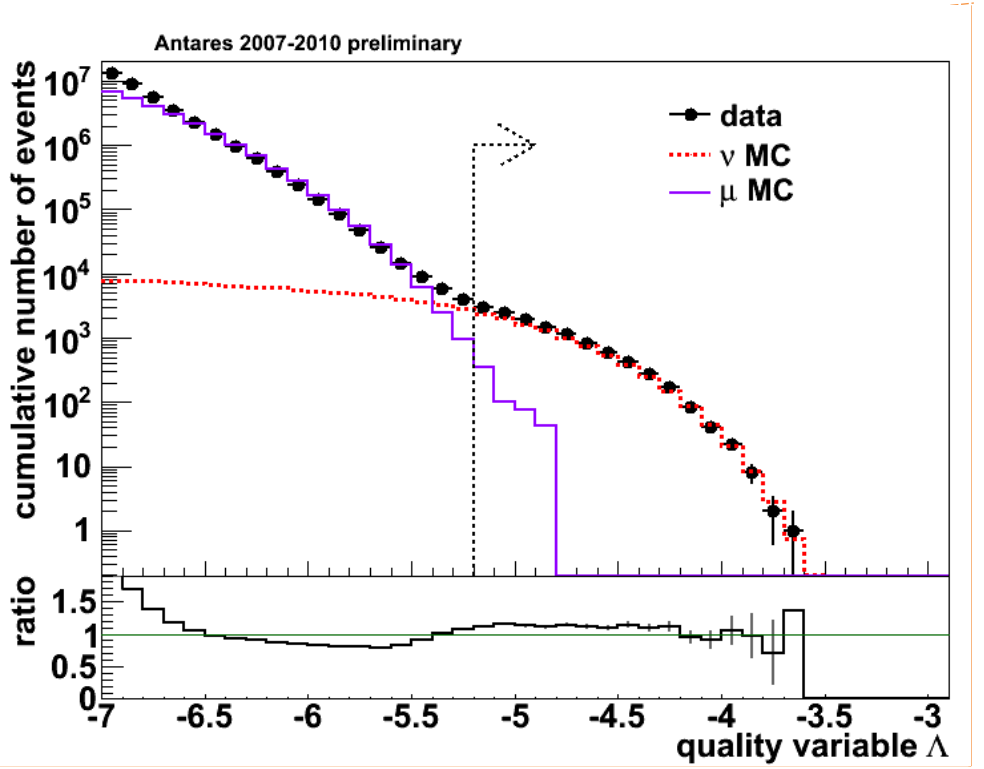


Background sources



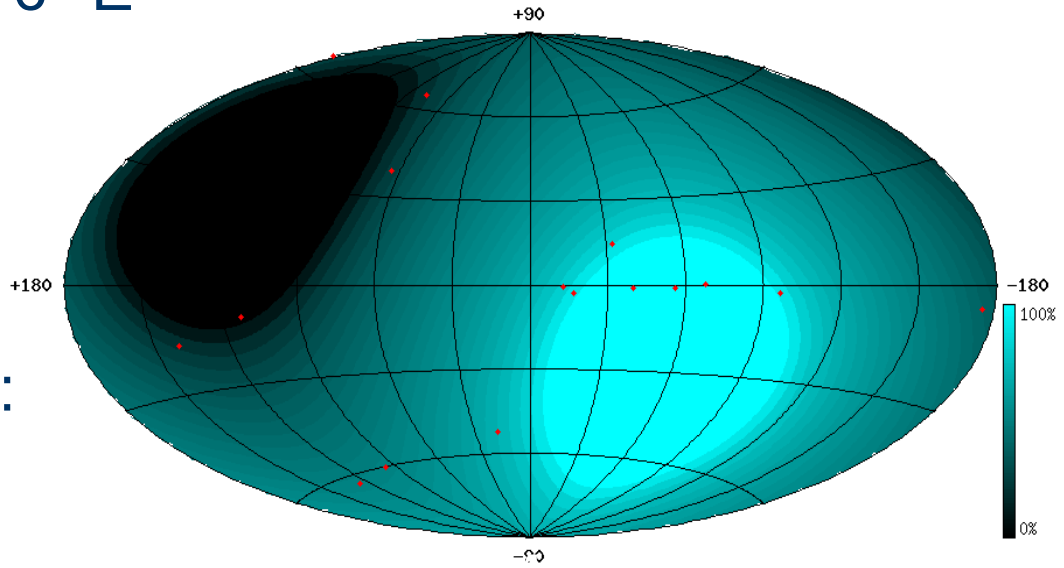
- Remove atmospheric muon background with zenith and quality cuts (20 muons per sec);
- CR neutrino background irreducible (5 neutrinos per day);





ANTARES performances

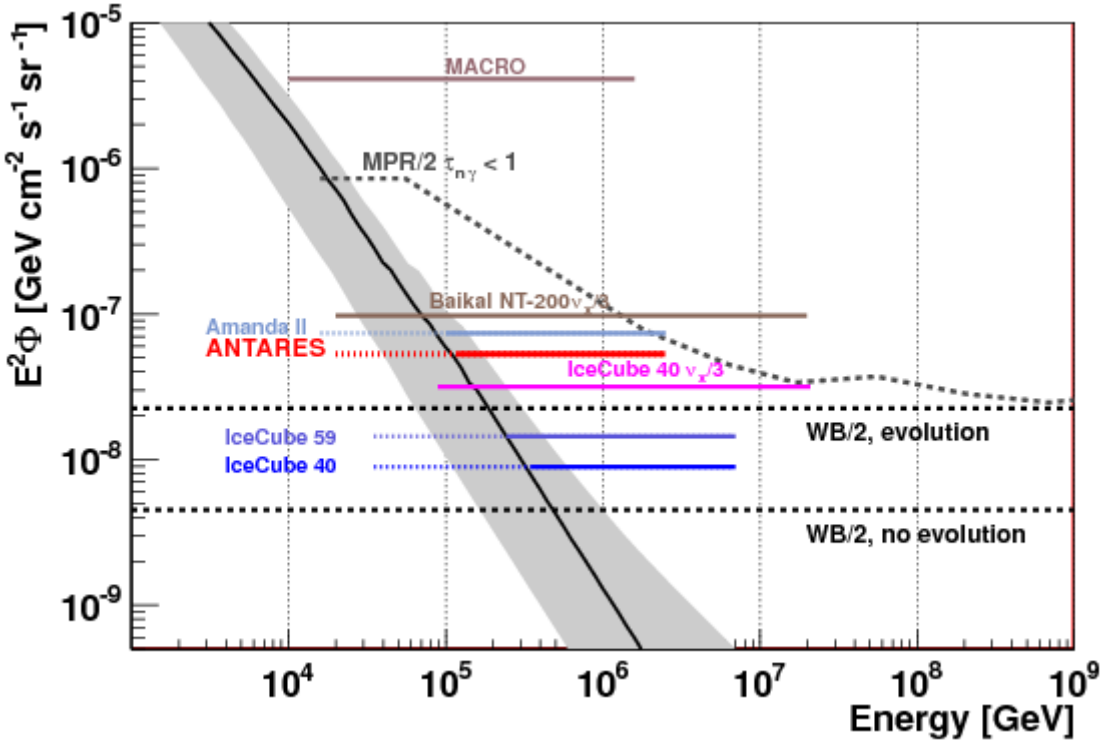
- ANTARES coordinates 43° N, 6° E
  Sensitive to Southern sky;
- Visibility: 3/4 of the sky
- Effective area 1 m^2 at 30 TeV
- Timing resolution of electronic:
  0.5 ns
- Positioning resolution: 10 cm
- Median angular resolution: 0.3°-0.4°



Results

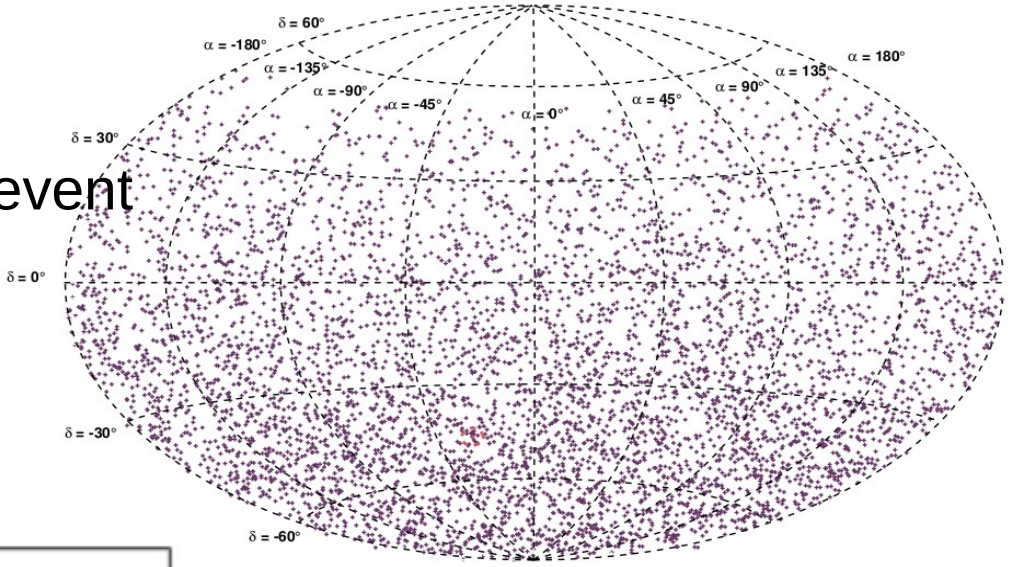
Neutrino diffuse flux search

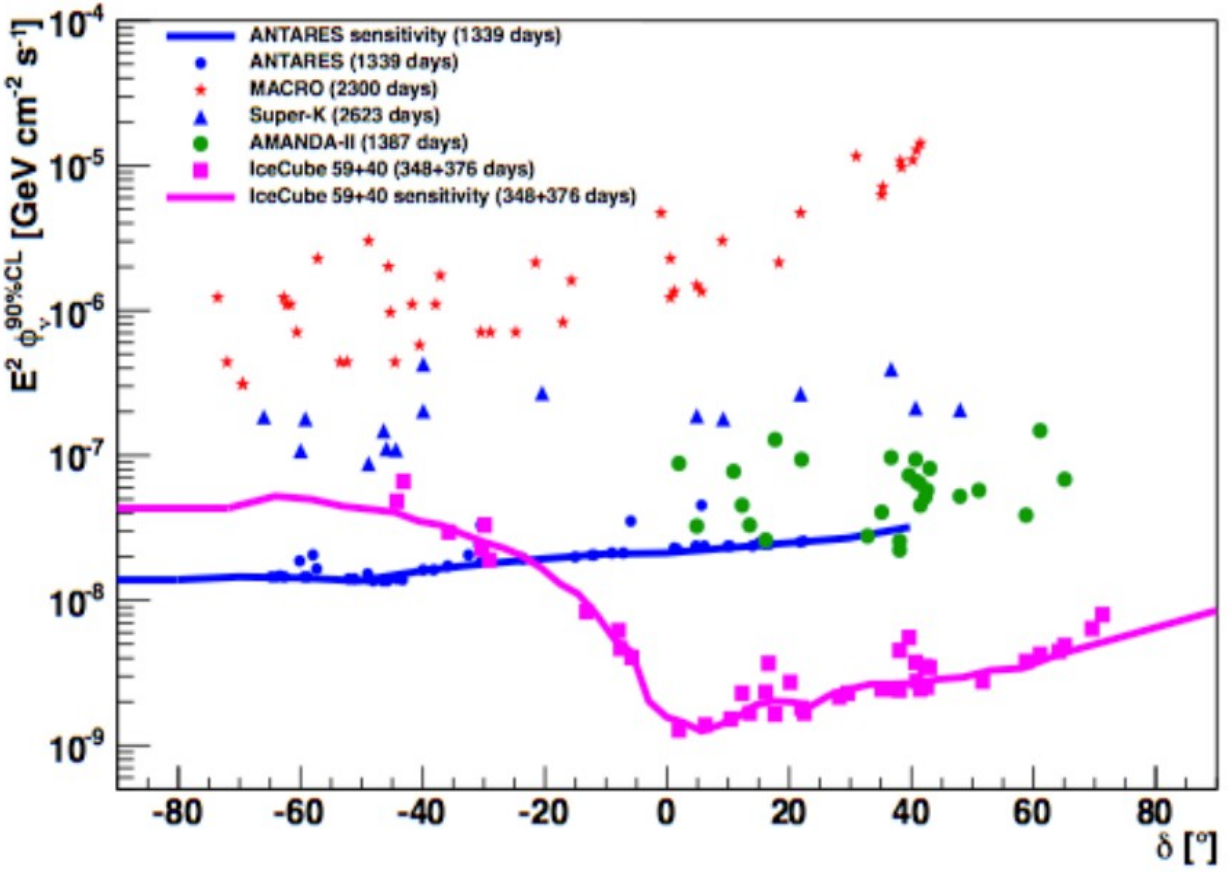
- Low muon contamination → upgoin tracks
- Neutrino energy → estimators (dE/dx)
- Search on 855 days of data taking:
  - Upper limit: $E^2\Phi = 5.9 \times 10^{-8}$ GeV $cm^{-2}s^{-1}sr^{-1}$ (45 TeV-10 PeV)
  - Result: 8 events compatible with background

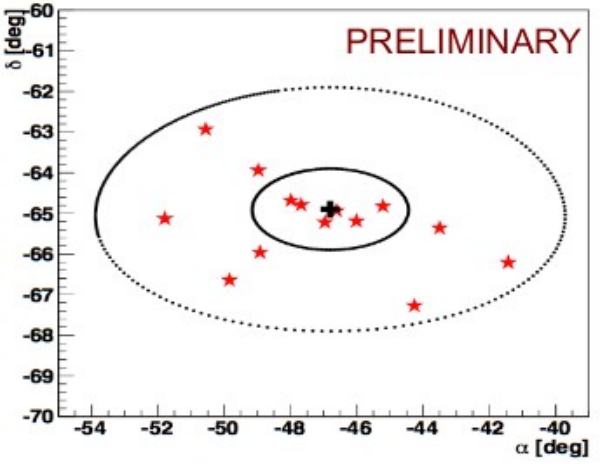


All sky point-source search

- Sky map in equatorial coordinates:
  - 2007-2012 data period, search for event clusters;
  - 5516 candidates after cuts;
  - 2 search: all sky and candidate list



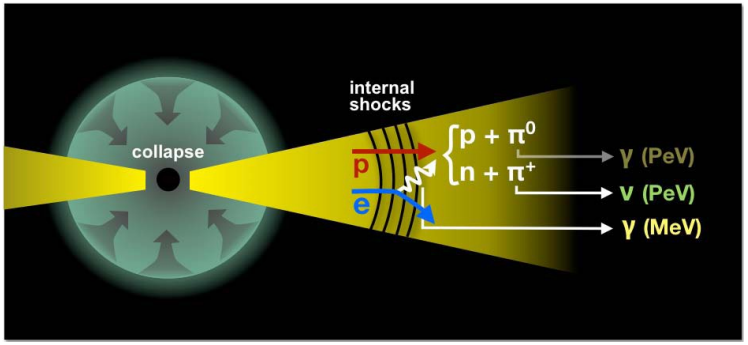




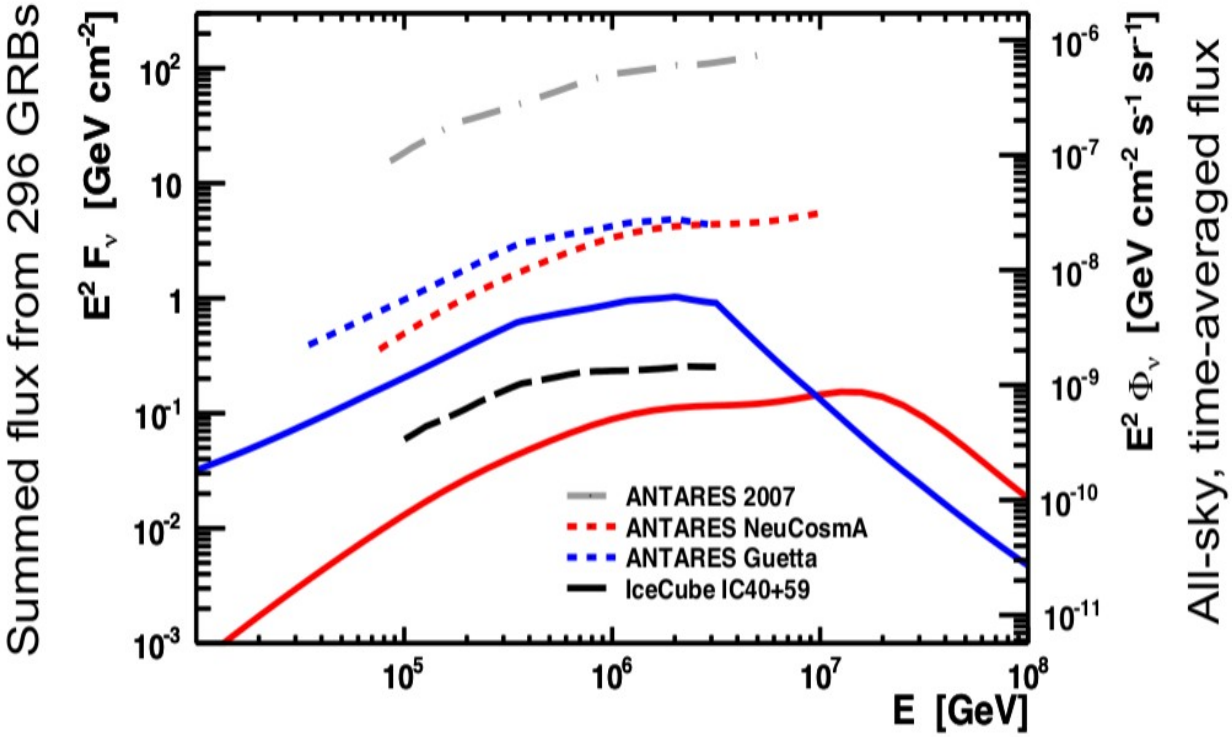
Search on 5 most signifcant sources (like SNR remants).

Neutrinos from GRB

- ‘Fireball’ model for GRBs



  - Predicts neutrinos with hadronic process.



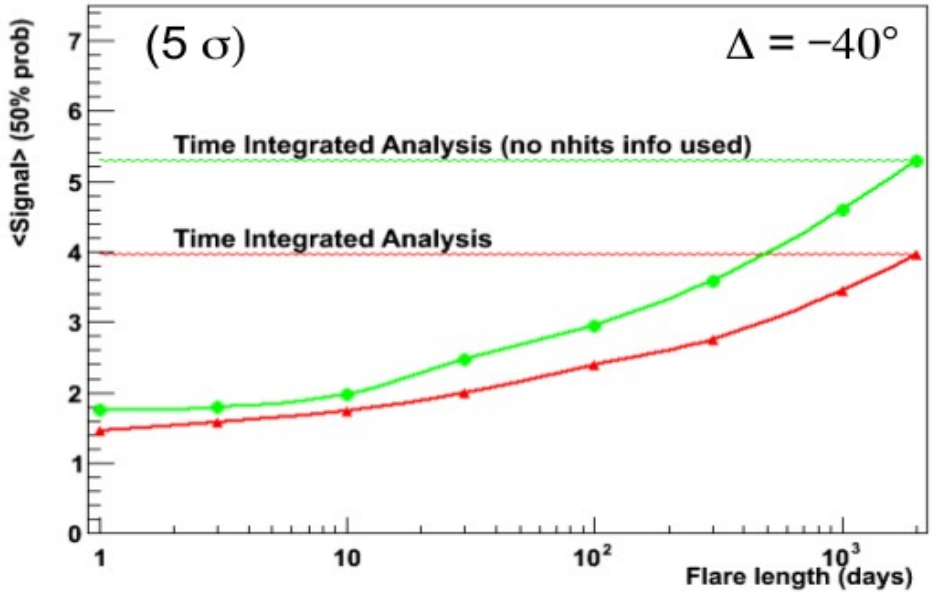
Search of time and space coincidence with 296 observed bursts (SWIFT, FERMI), 6.55 hours of total prompt emission;

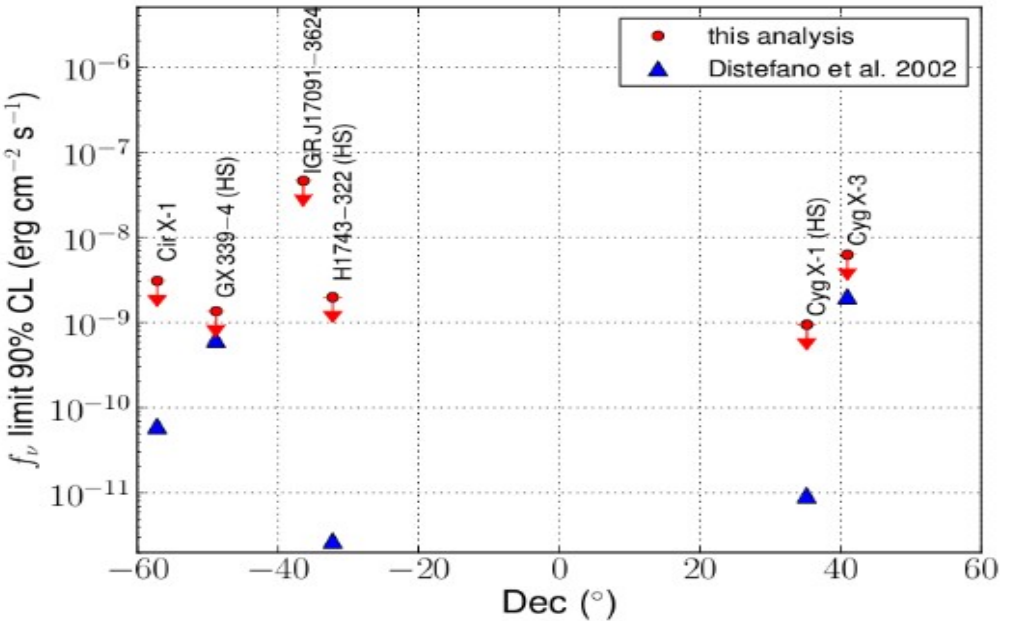
- Models: Guetta and NeuCosmA

No coincidence events observed, derived 90% C.L. upper limit on combined neutrino flux.

Neutrinos from flaring sources

- Search of signal from blazars and quasars;
- 40 blazars:
  - 2008-2011 data (750 days livetime), 86 flaring periods;
  - Improved likelihood with energy proxy;
  - Lowest p-value (12%) 3C279, compatible with background fluctuation;
- 6 microquasars with (x/γ)-ray outbursts:
  - 2007-2010 data set (813 days);
  - No events detected in coincidence with satellites.





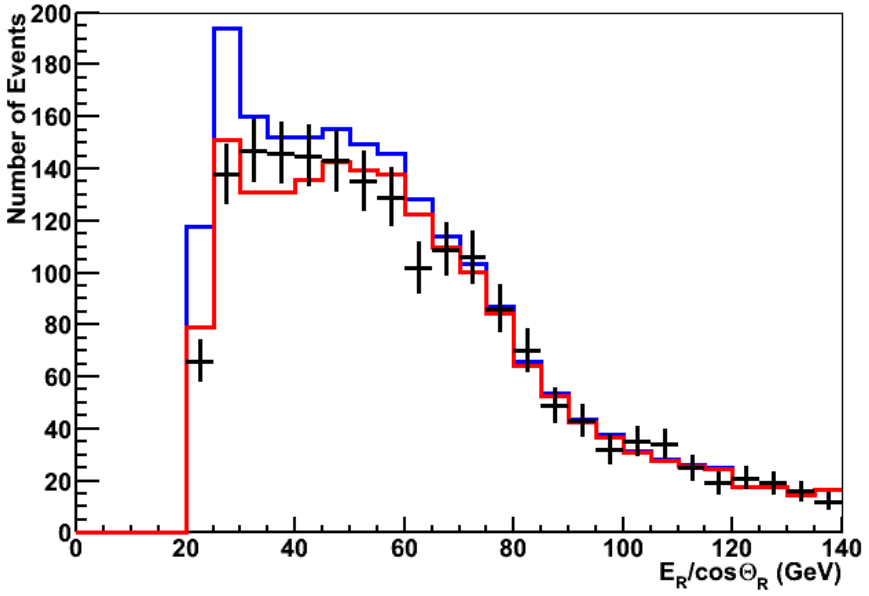
Neutrino Oscillation

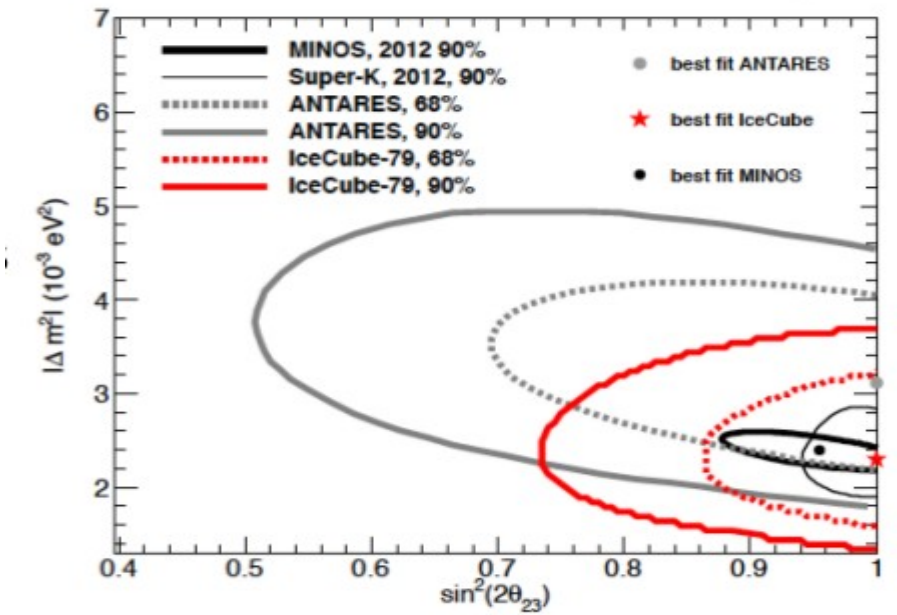
- Two-flavour mixing approximation:

$$P\left(\nu_\mu \to \nu_\mu\right) \approx 1-\sin^2\left(2\theta_{32}\right)\sin^2\left(\frac{1.27\Delta m^2_{32} L}{E_\nu}\right) = 1-\sin^2\left(2\theta_{32}\right)\sin^2\left(\frac{1.27\Delta m^2_{32} D_{Earth}\cos\Theta}{E_\nu}\right)$$

  - Measureable: $\frac{\cos\Theta}{E_\nu}$ 'Unknown': θ_{32}, Δm_{32}
  - World data: 1st minimum at $\cos\Theta = 1$, $E_\nu = 24$ GeV (120 m max muon range)

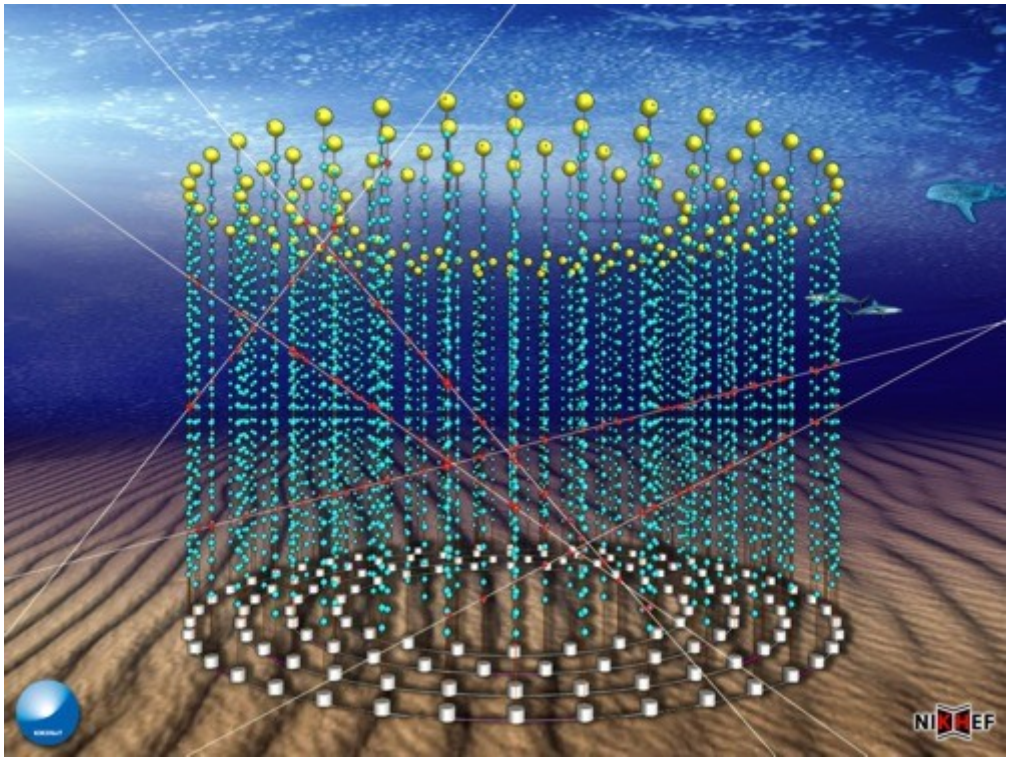
- Results for 863 days' data: » **Phys. Lett.B 714 (2012) 224**





The future KM3Net

- Project of km-scale detector in Norten Emispere, based on ANTARES experience;
- Implementation of the first phase since January 2013;
- First module deployed on April 16th!



Conclusions

- ANTARES underwater neutrino telescope:
  - Largest neutrino telescope in the Northern Hemisphere, with associated multi discliplinary observatory;
  - Proven ability to detect neutrino-induced muons;
  - Good performance in neutrino astrophysics;
  - Sensitivity optimised for the galactic centre region.

- Neutrino astrophysics:
  - First official results from diffuse flux, point sources analysis and transient sources;

- Diverse physics program:
  - Dark matter indirect search;
  - Neutrino oscillations;

- Entering ‘mature’ phase:
  - Analyses on 5+ years of 12-line data in progress;
  - More results on their way!