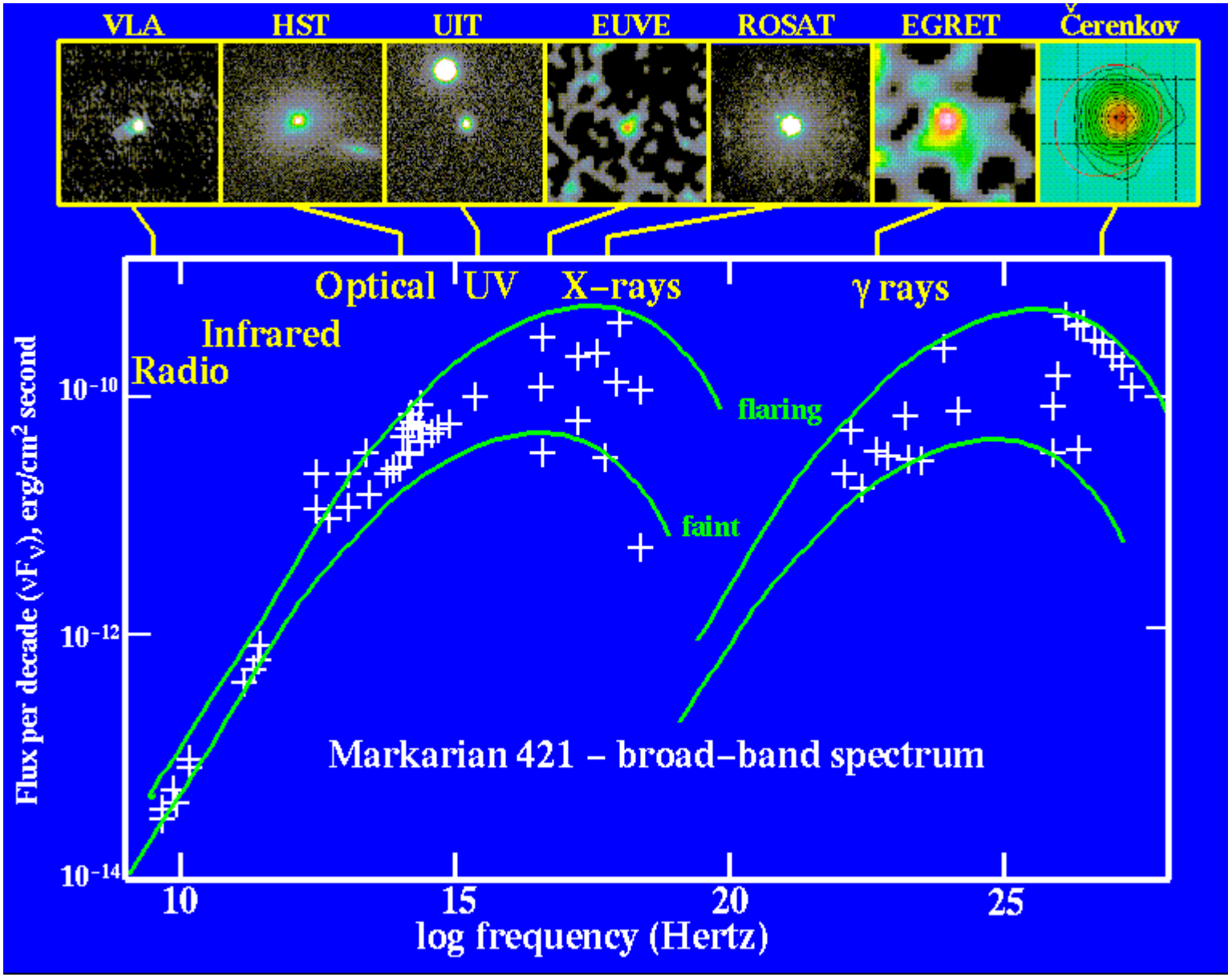
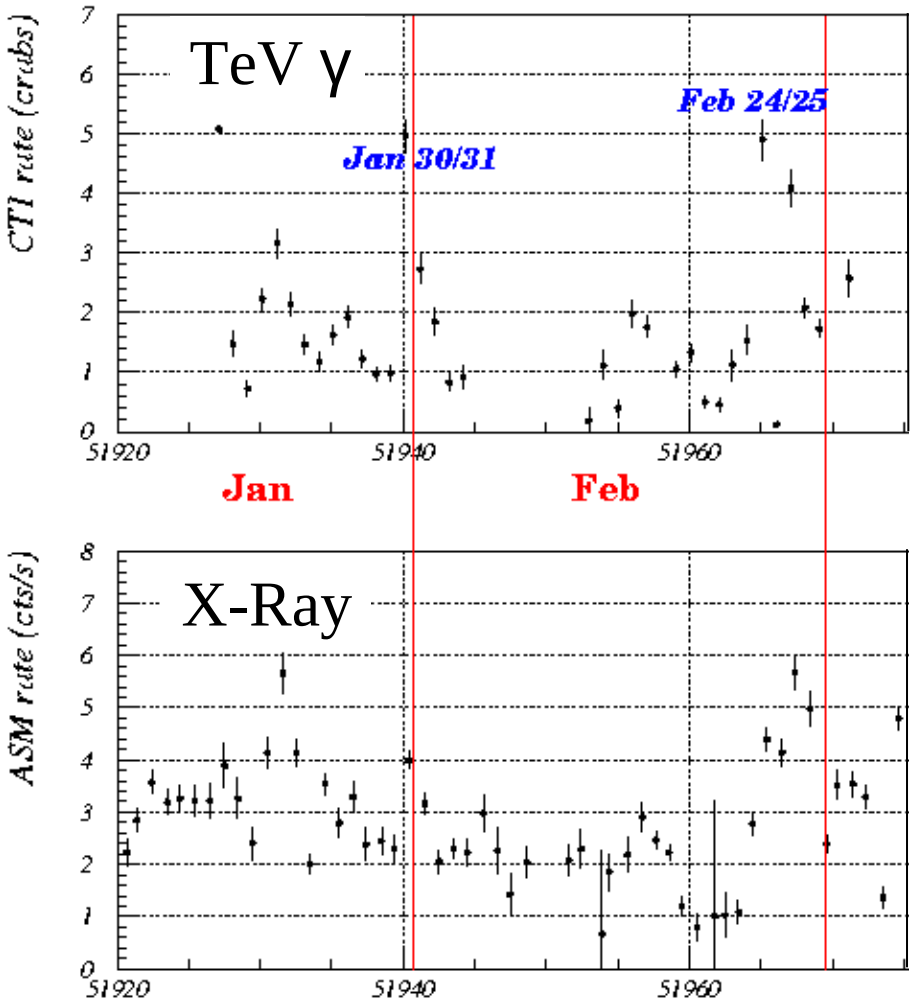
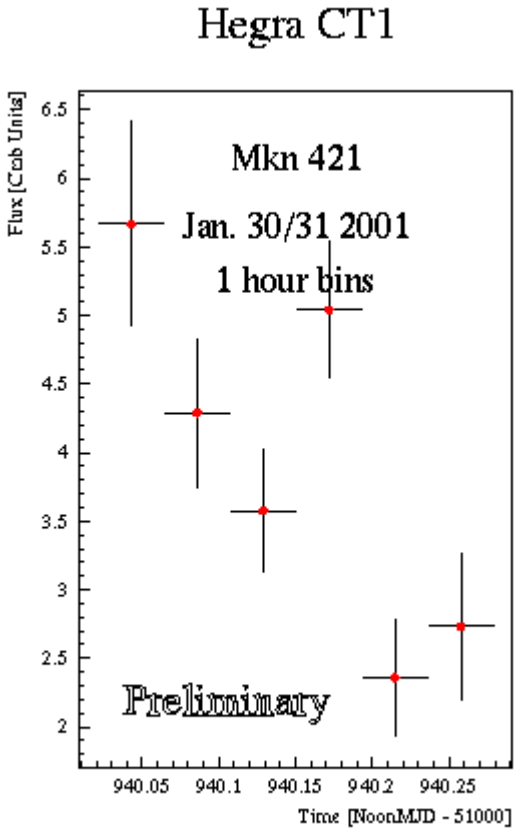
Markarian 421: a Blazar



Flares from Markarian 421

Correlation of flares at different wavelengths

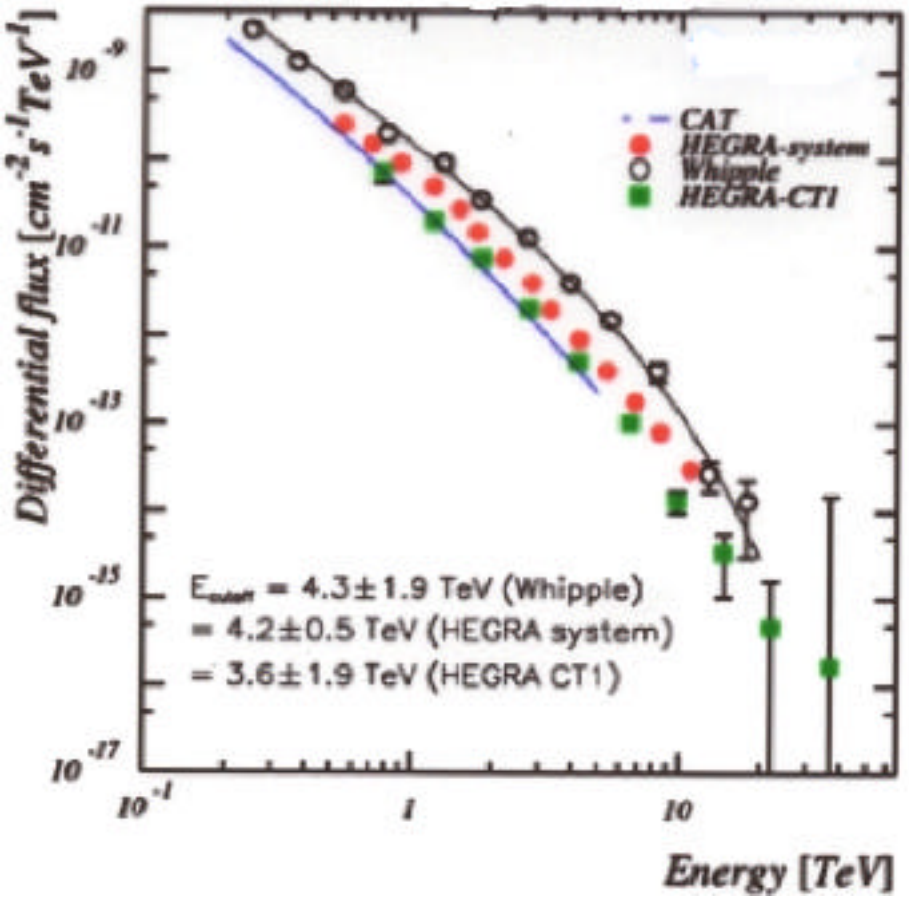




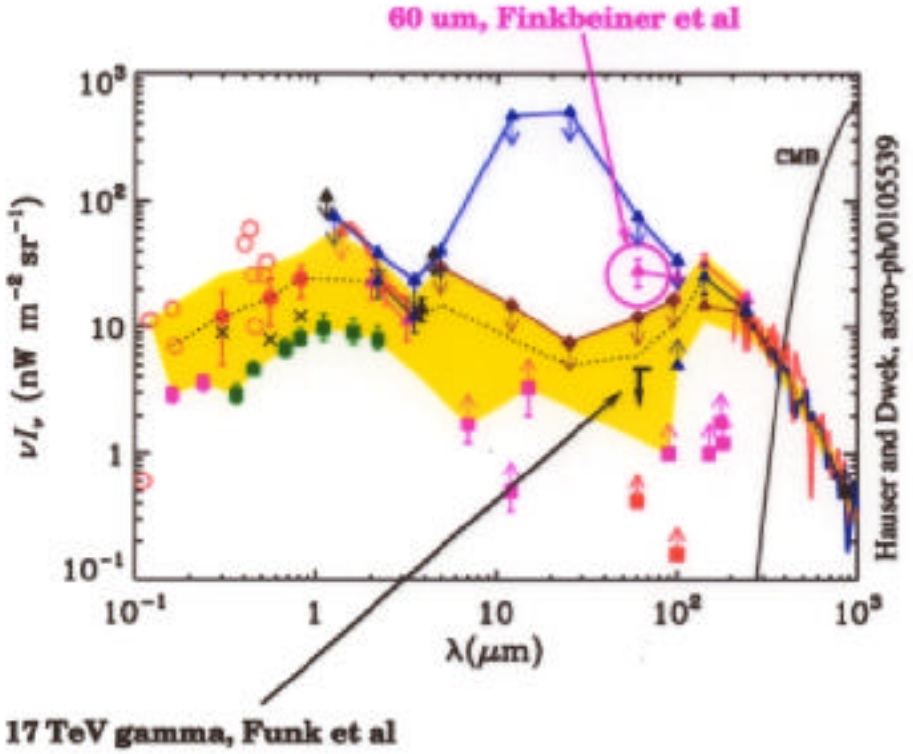
Timescale of flares indicate solar system dimensions of source

Tev γ spectra ⇒ infrared photon background

Markarian 421, 2001 Flare

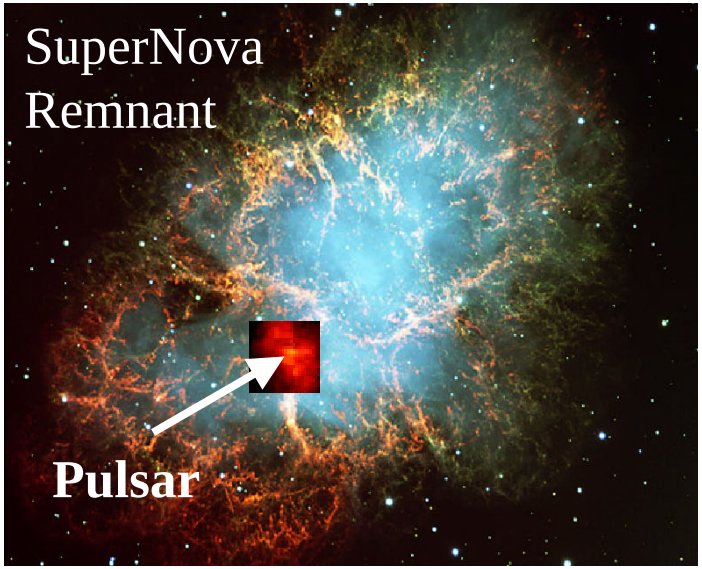


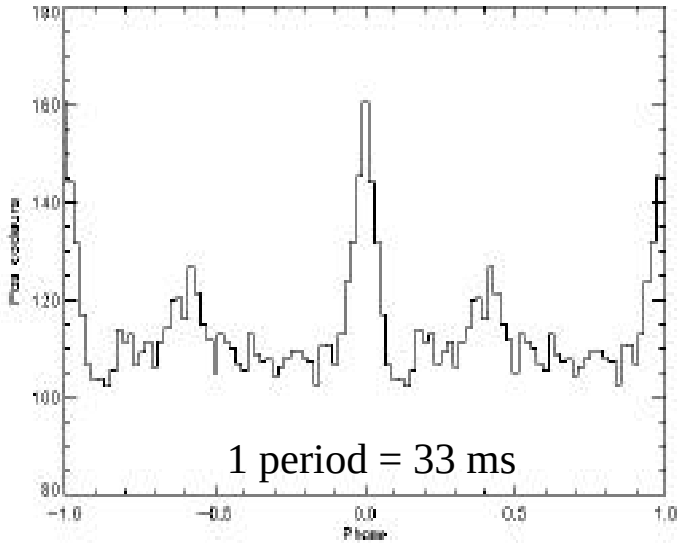
Infrared photon background

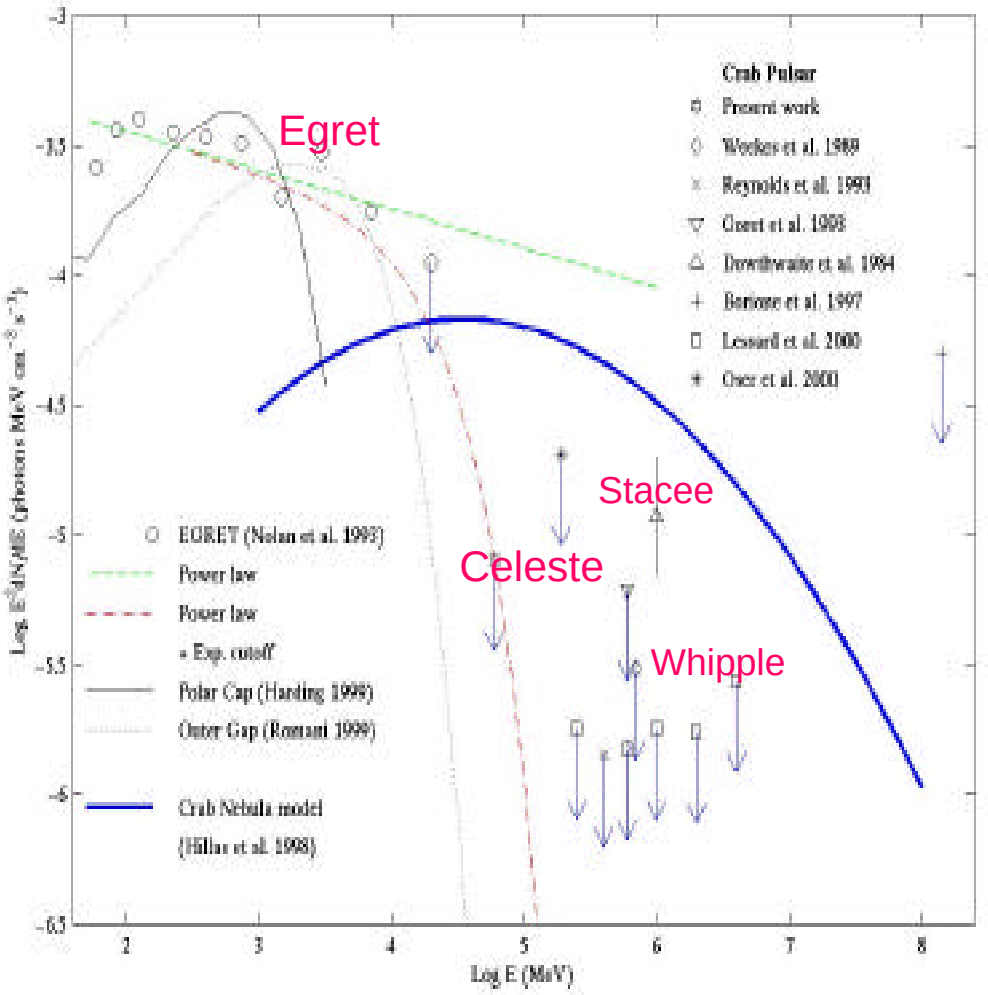


Observation of >10 TeV γ limit IR photon background field

Crab Pulsar



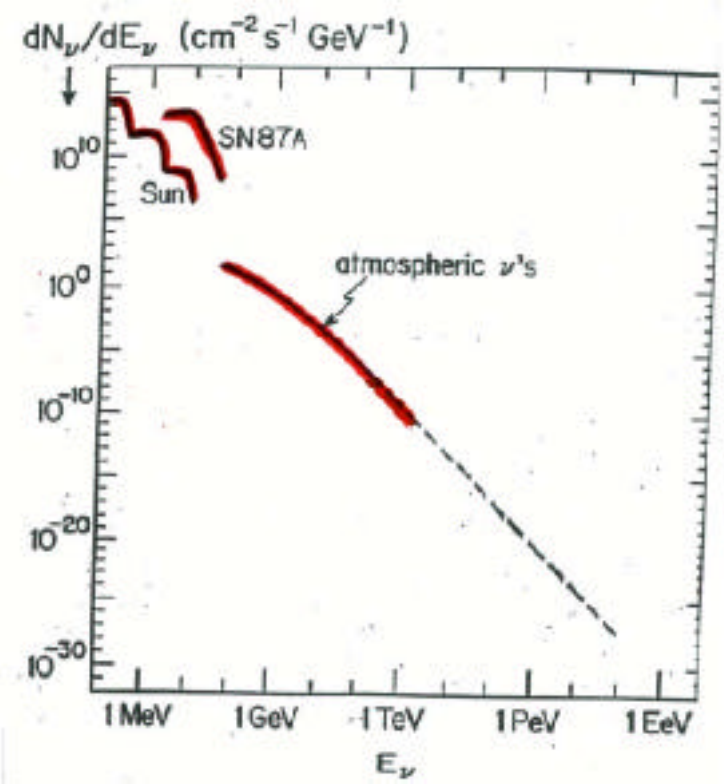




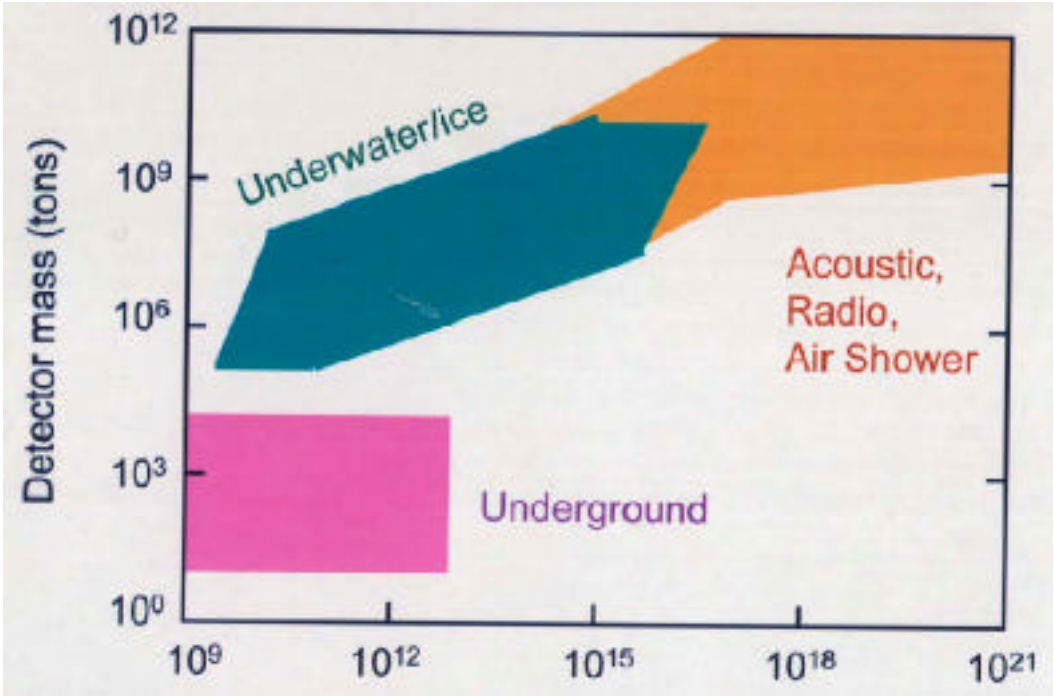
No pulsed signal above 10 GeV
high energy acceleration in SNR?

Neutrino Astronomy

Neutrinos observed so far

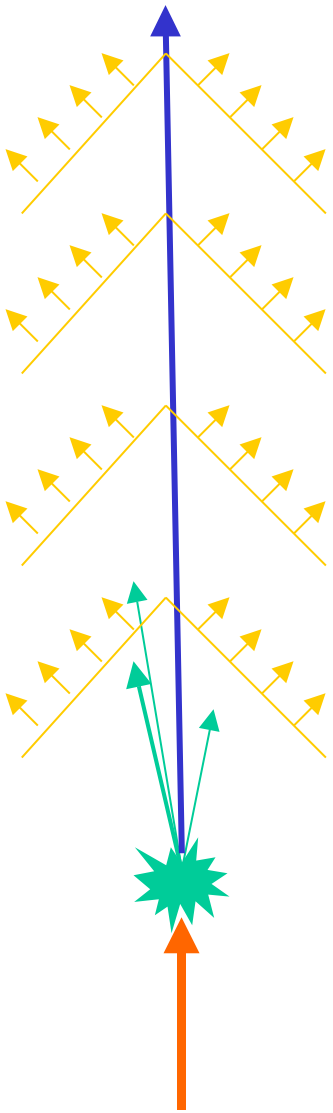


Methods to look further



Detection of neutrinos: Light and Sound

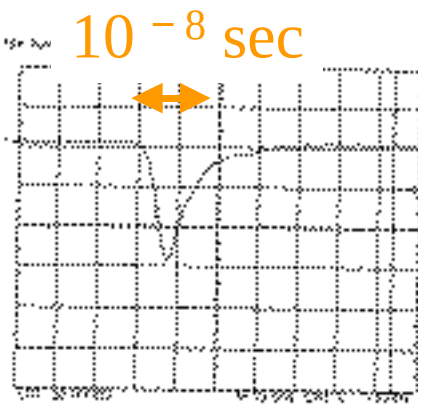
Cherenkov light



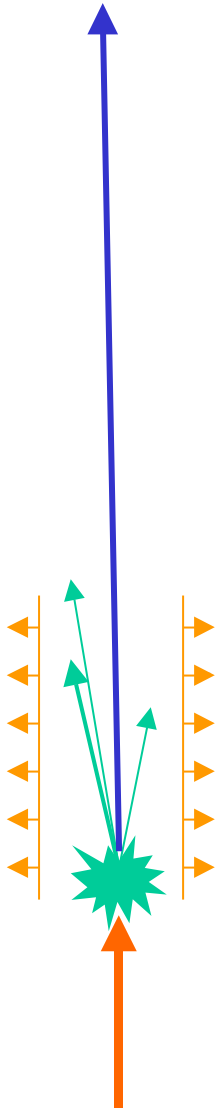
muon

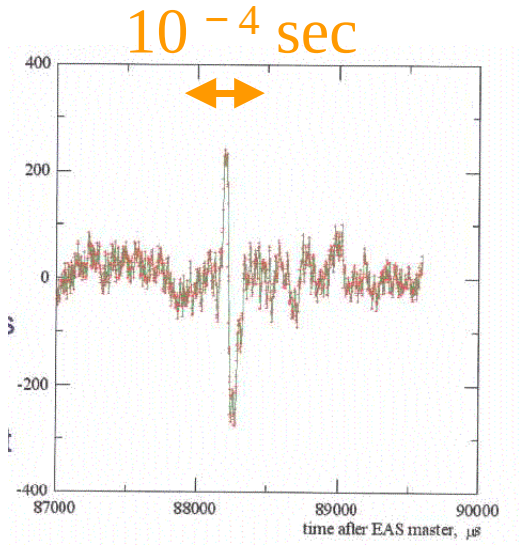
pion

neutrino



Sound

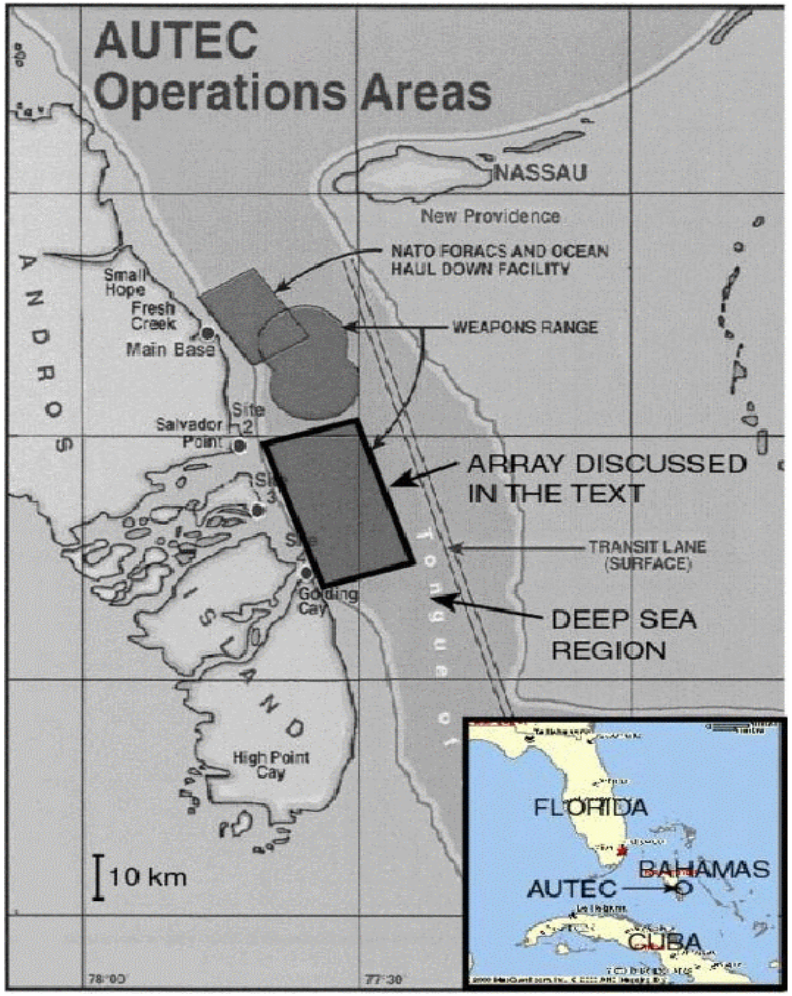




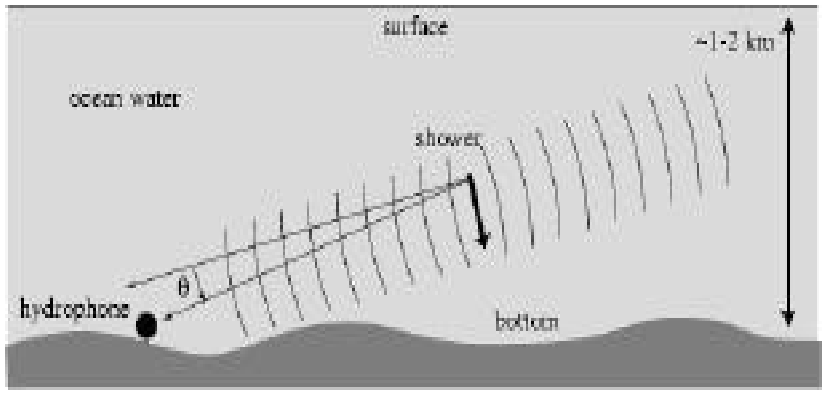
Ocean Acoustic Detection

Renewed efforts for GZK Neutrino Detection

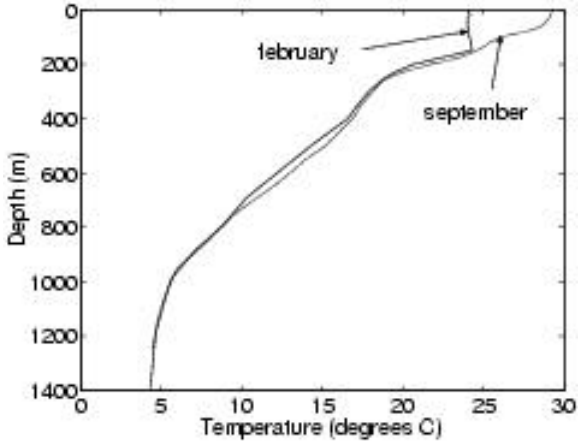
Stanford project to use US Navy array in Atlantic



pancake beam pattern



sound velocity depends on depth

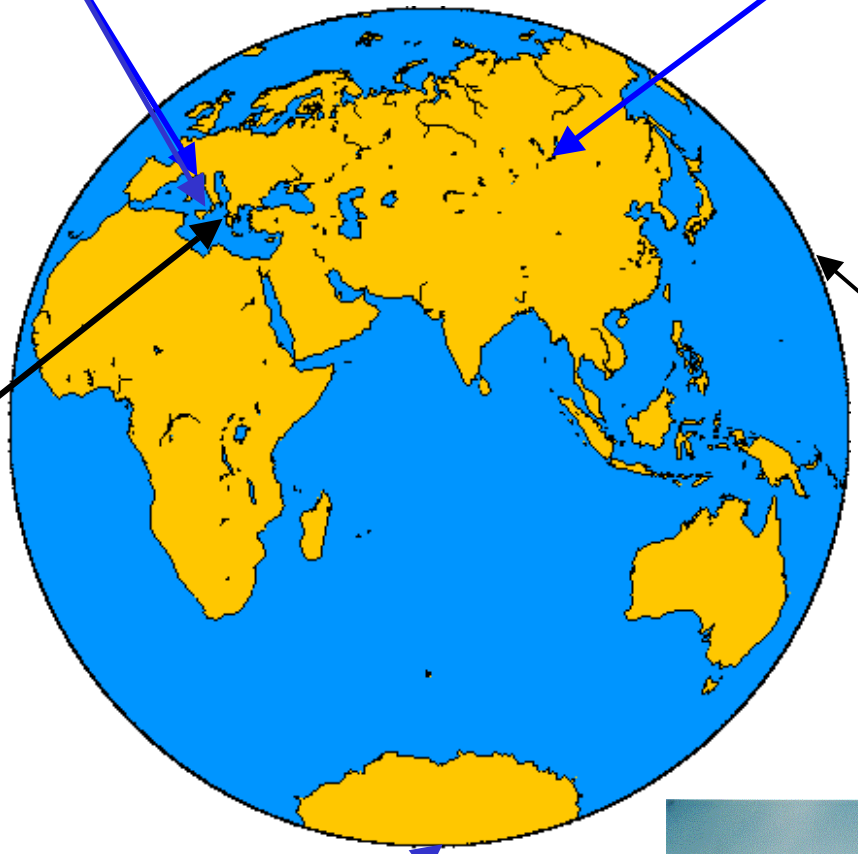


G.Gratta, atro-ph/0104033

Neutrino Telescope Projects

ANTARES La-Seyne-sur-Mer, France
(NEMO Catania, Italy)

BAIKAL: Lake Baikal, Siberia



NESTOR : Pylos, Greece

DUMAND, Hawaii
(cancelled 1995)

AMANDA, South Pole, Antarctica

AMANDA

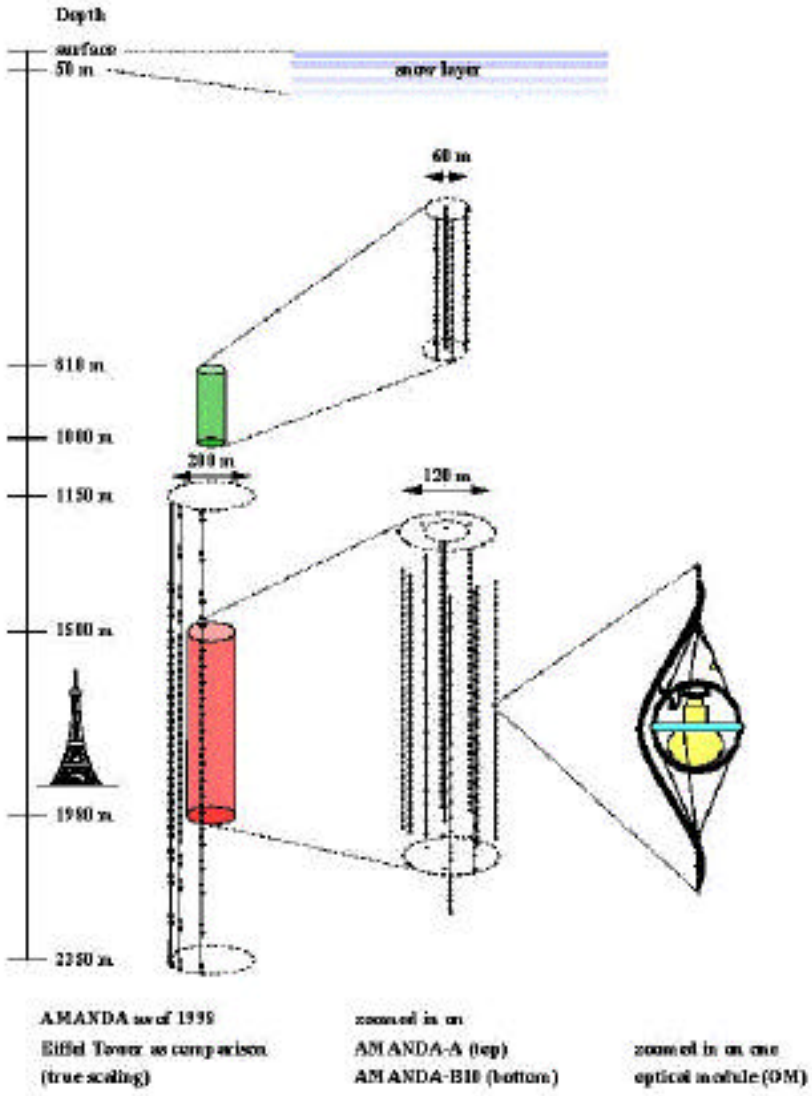
South Pole: glacial ice

1993 First strings AMANDA A
1998 AMANDA B10 ~ 300 Optical Modules

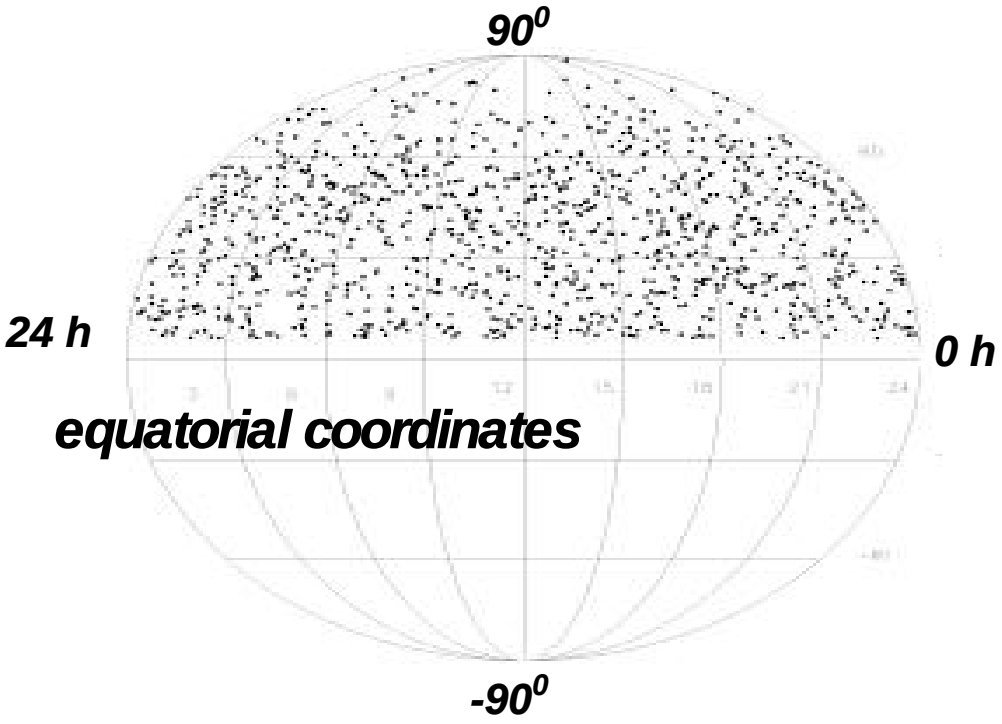
2000 ~ 700 Optical Modules

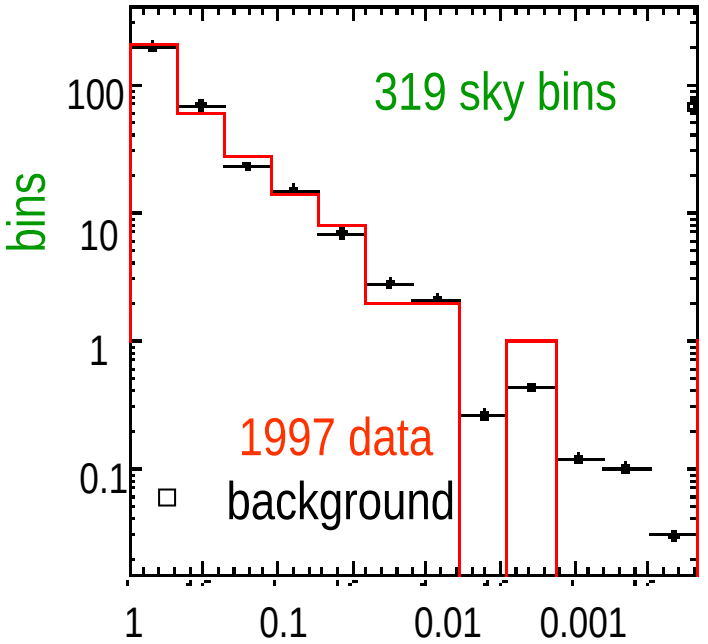
→ ICECUBE 8000 Optical Modules

AMANDA
ν > 50GeV



AMANDA: Search for Point Sources

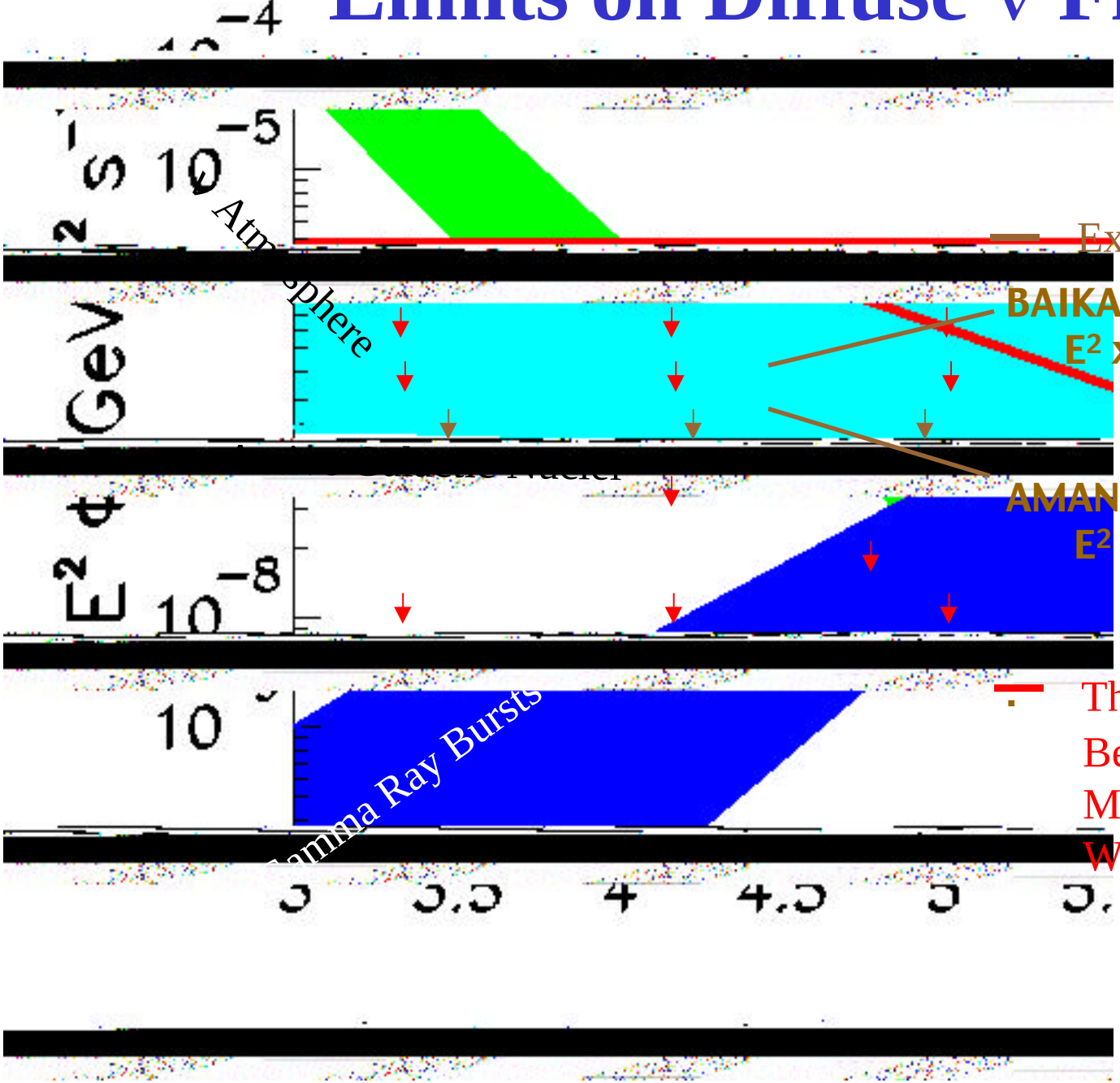




Flux (>10 GeV) < 10^{-7} cm^{-2} s^{-1} @90%

Angular resolution 3°

Limits on Diffuse ν Flux



Experimental Limits

BAIKAL:
$E^2 \times \Phi(\nu_\mu) < 1.3$ to 1.8×10^{-6}

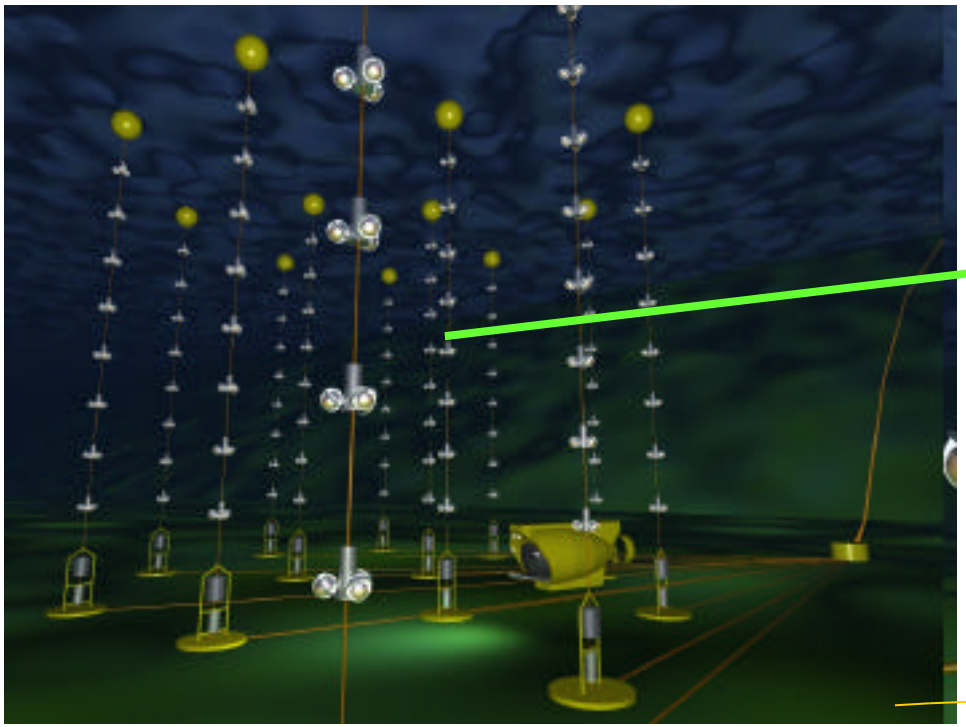
AMANDA :
$E^2 \times \Phi(\nu_\mu) < 0.9 \times 10^{-6}$
[GeV cm^{-2}s^{-1}sr^{1}]

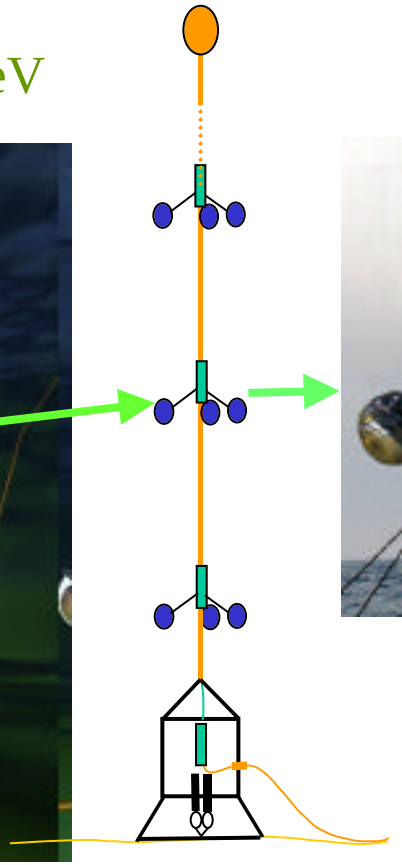
Theoretical Limits
Berezinsky
Mannheim et al.
Waxman and Bahcall

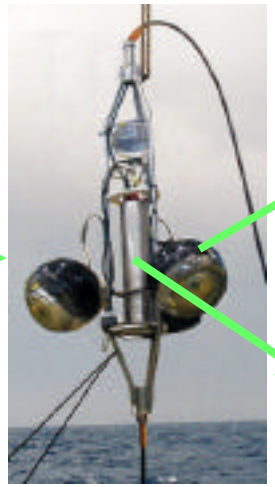
Future in ν telescopes: ANTARES

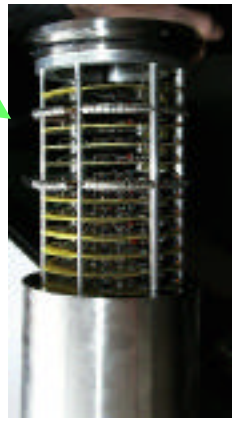
1996	Started
1996 - 2000	Site exploration and demonstrator line
2001 - 2004	Construction of 10 line detector, area ~0.1km^2 on Toulon site
future	1 km^3 in Mediterranean

Angular resolution <0.4° for E>10 TeV

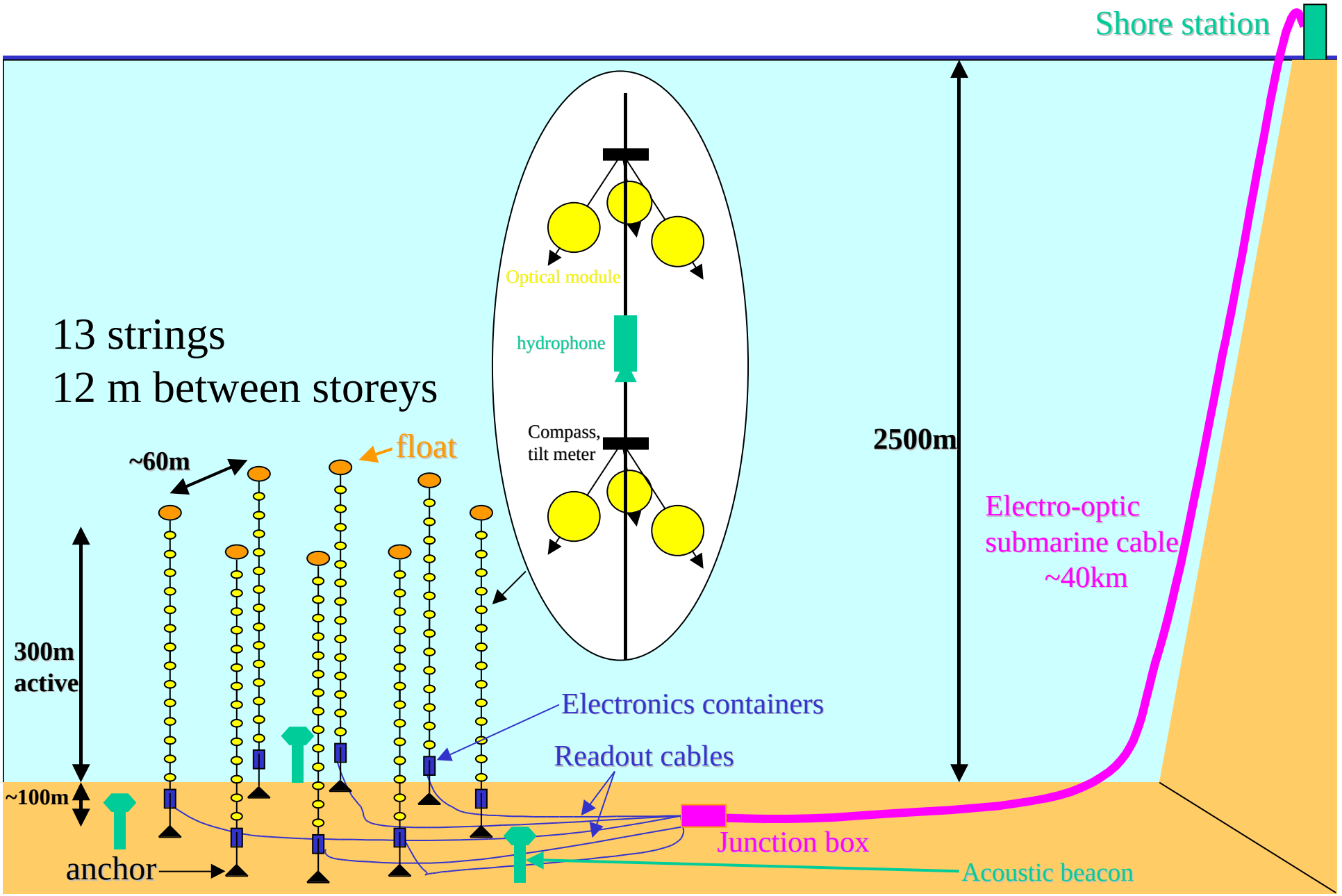




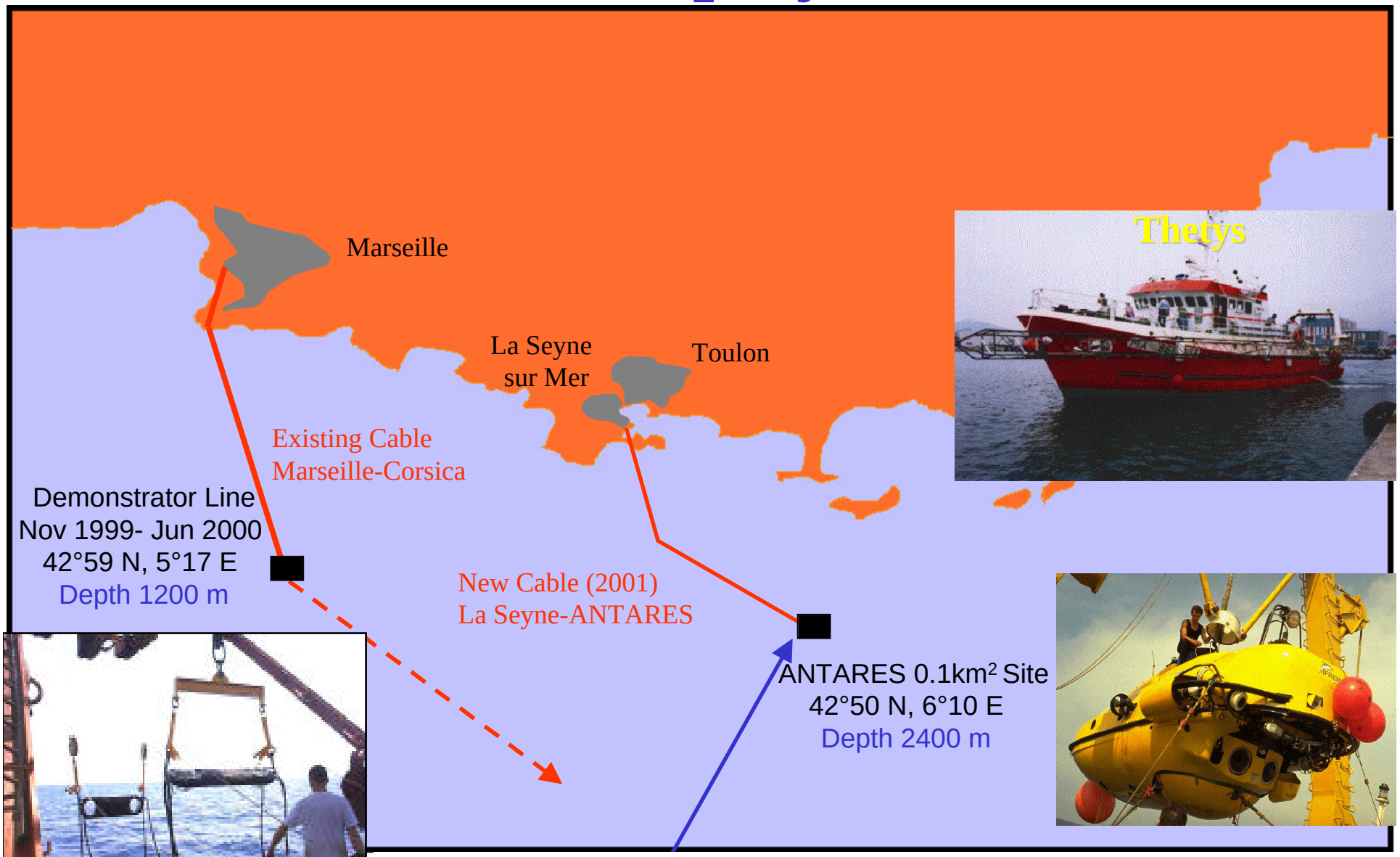




ANTARES 0.1km^2 Detector



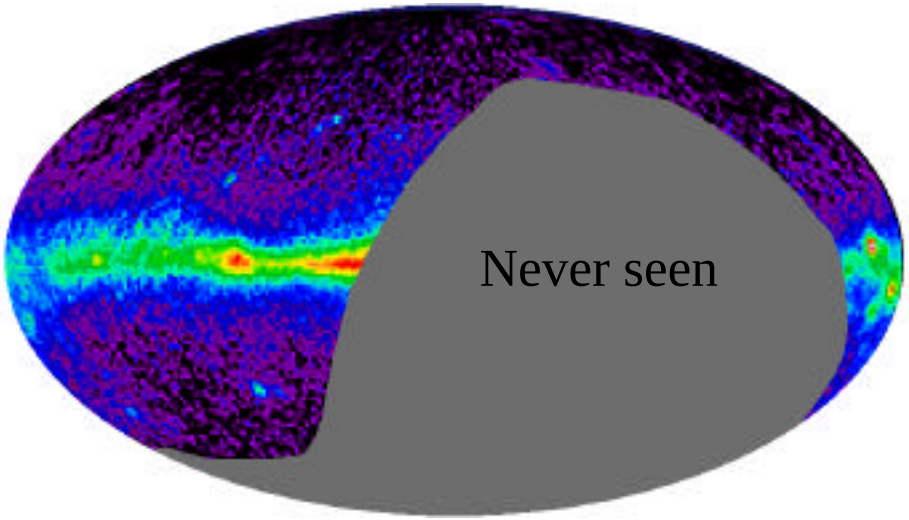
ANTARES Deployment Sites



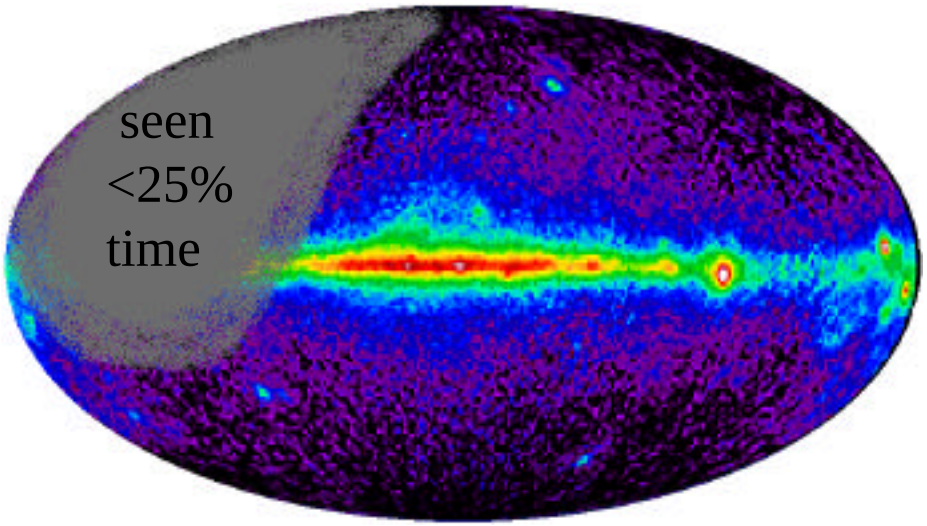
~ 40 deployments and recoveries of test lines for site exploration
0.1 km² Detector with 900 Optical Modules , deployment 2002- 200

Region of sky seen by Neutrino Telescopes

AMANDA (South Pole)



ANTARES (43° North)



Gamma ray flux >100 MeV observed by EGRET

EGRET Source Type	number of sources	seen by Antares	seen by Amanda
All	271	89%	43%
AGN	94	86%	52
Pulsars	5	100%	40%
Unidentified Gal. Plane	55	93%	36%
Unidentified off Gal. Plane	116	90%	40%

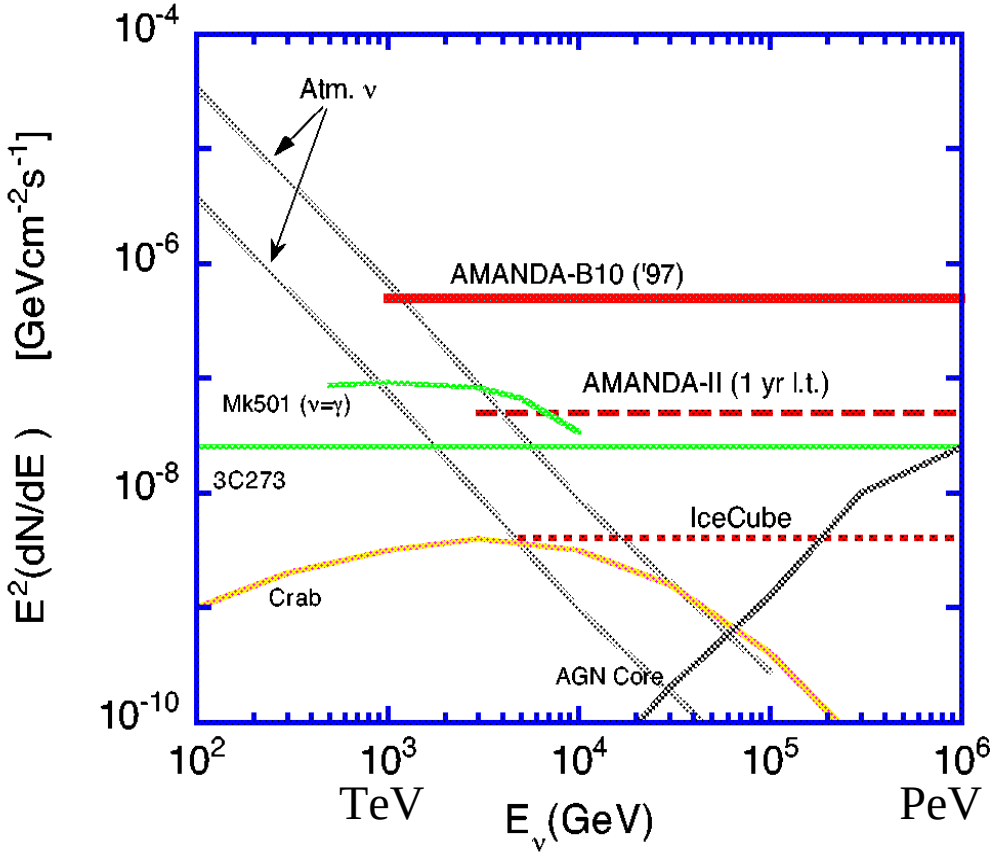
Indicative, assumes efficiency=100% for 2π downwards

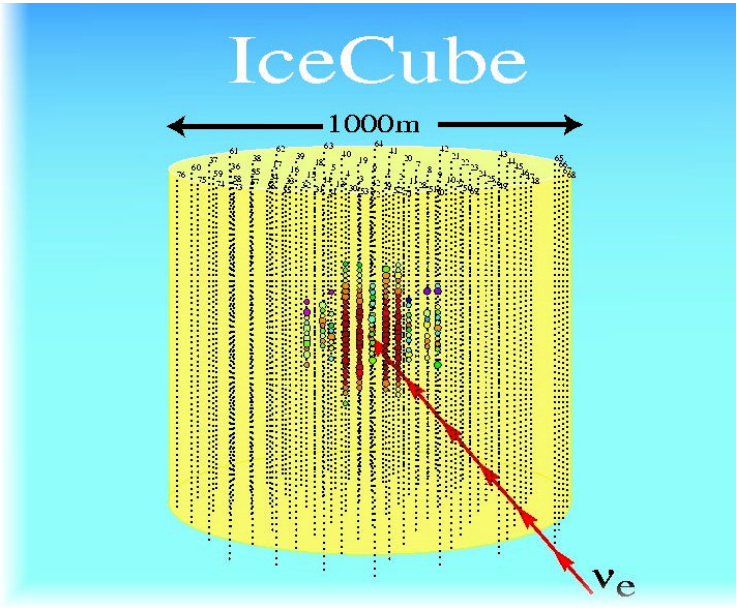
Complementary sky coverage, ANTARES sees Galactic Centre

Great hope for major discoveries

ICECUBE at South Pole

First Km^3 Neutrino Detector, ~2007





- **80 strings, 60 PM´s each; 4800 optical modules total**
- **V ≈ 1 km_, E_{th}~ 0.5-1TeV**

References

Book:
Particle Astrophysics, H.V. Klapdor-Kleingrothaus and K. Zuber
IOP Publishing Ltd, ISBN 0 7503 0549 5

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