the neutrino telescope ANTARES

ERLANGEN CENTRE
FOR ASTROPARTICLE
PHYSICS

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ICFP2012,
Crete, June 2012

Friedrich-Alexander-Universität
Erlangen-Nürnberg

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for astroparticle
physics

ANTARES

Cosmic Rays and Neutrinos

The origin of cosmic rays remains unknown.

The observation of cosmic neutrinos could help to identify cosmic ray sources:

- Unambiguous signature of hadronic acceleration

- Not deflected by magnetic fields

- Can escape from regions of high matter density
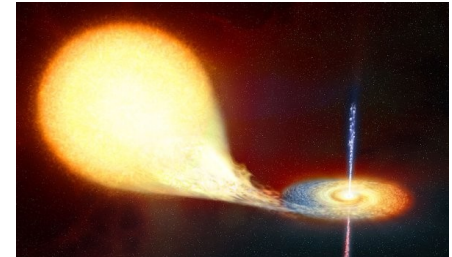
- Can be time correlated with optical signals
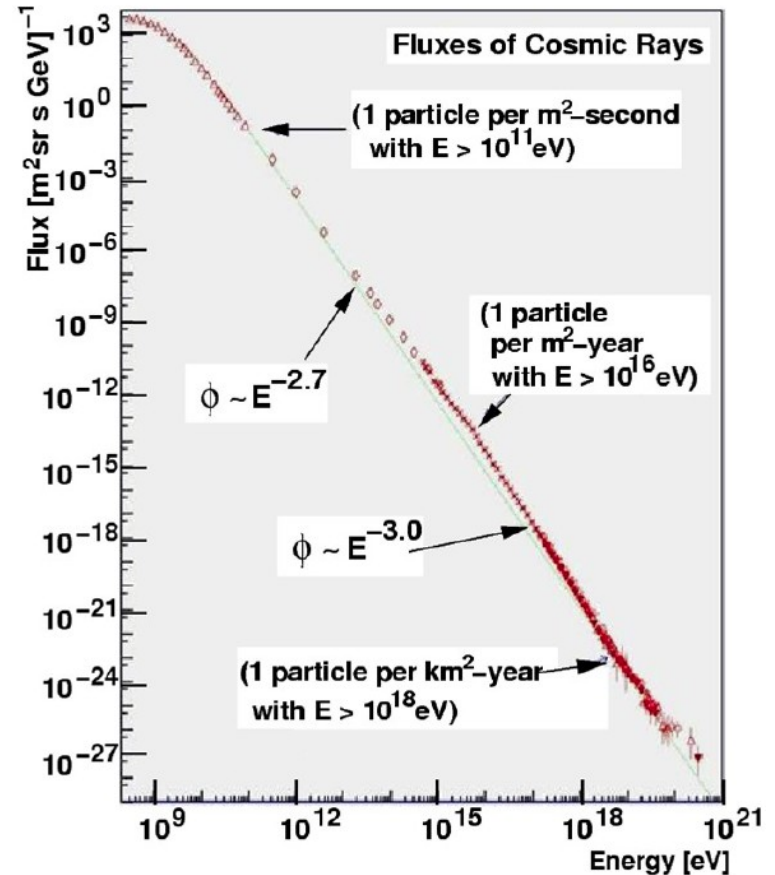
Physics with a Neutrino Telescope

- Search for point sources

  galactic:

  - supernova remnants

  - micro quasars

  extragalactic

  - active galactic nuclei

  - gamma ray bursts

- Search for diffuse fluxes

- Search for Dark Matter
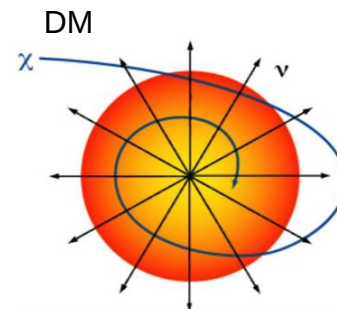
- ...

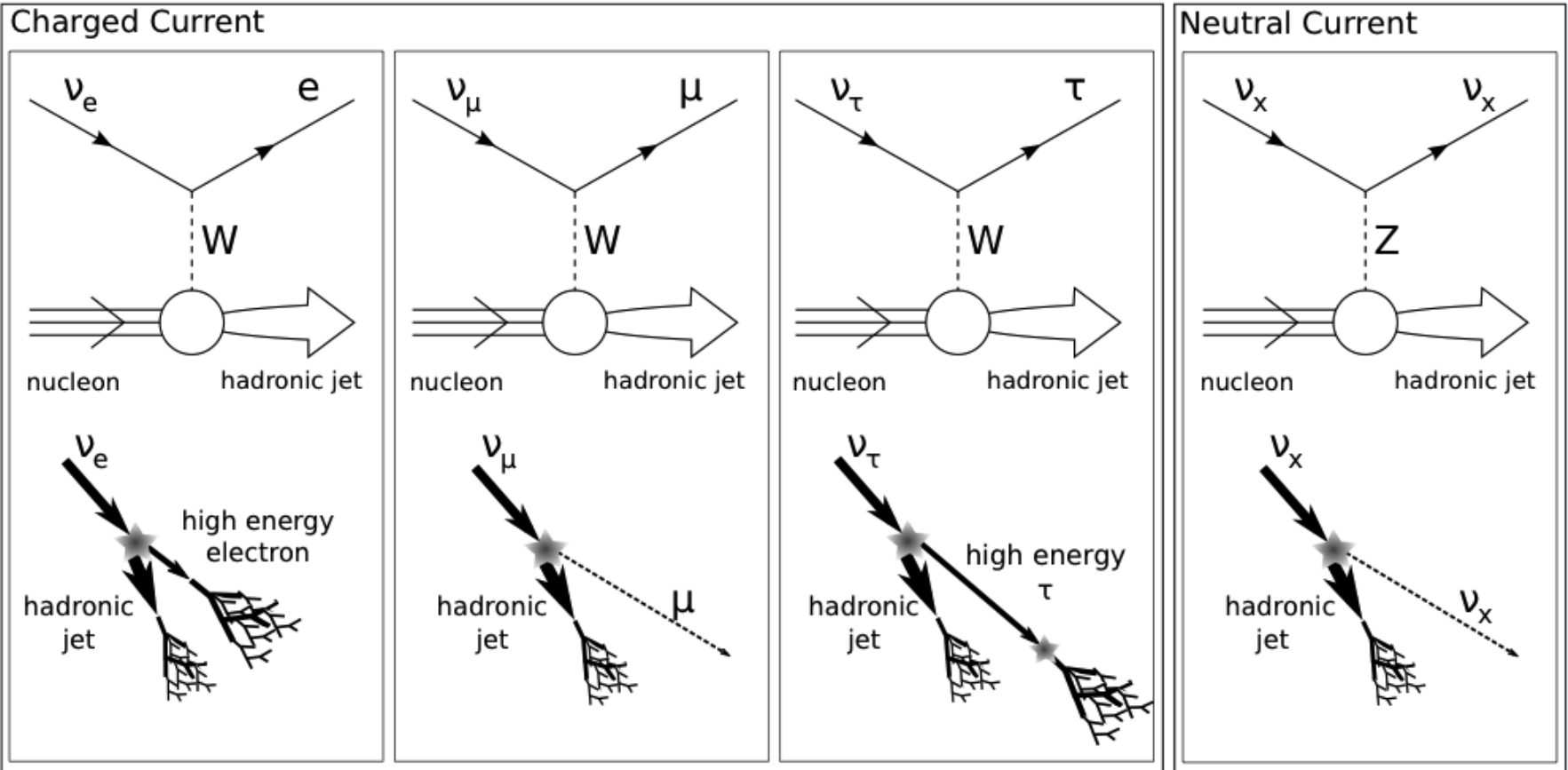SNR (SN1006, optical, radio, x-ray)

micro quasars (artist impression)
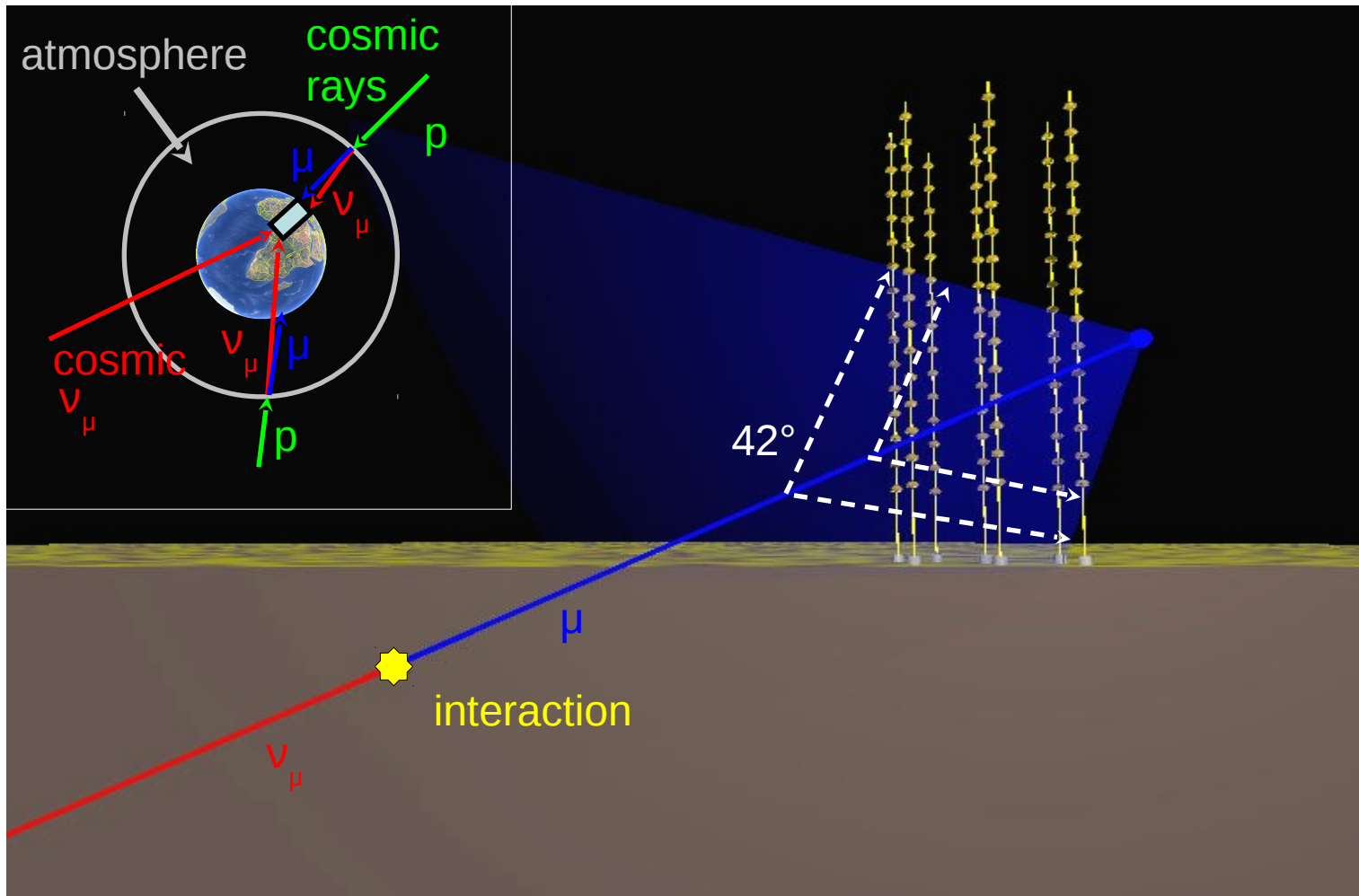

GRB (GRB 080319B, x-ray, SWIFT)

AGN (artist impression)

DM

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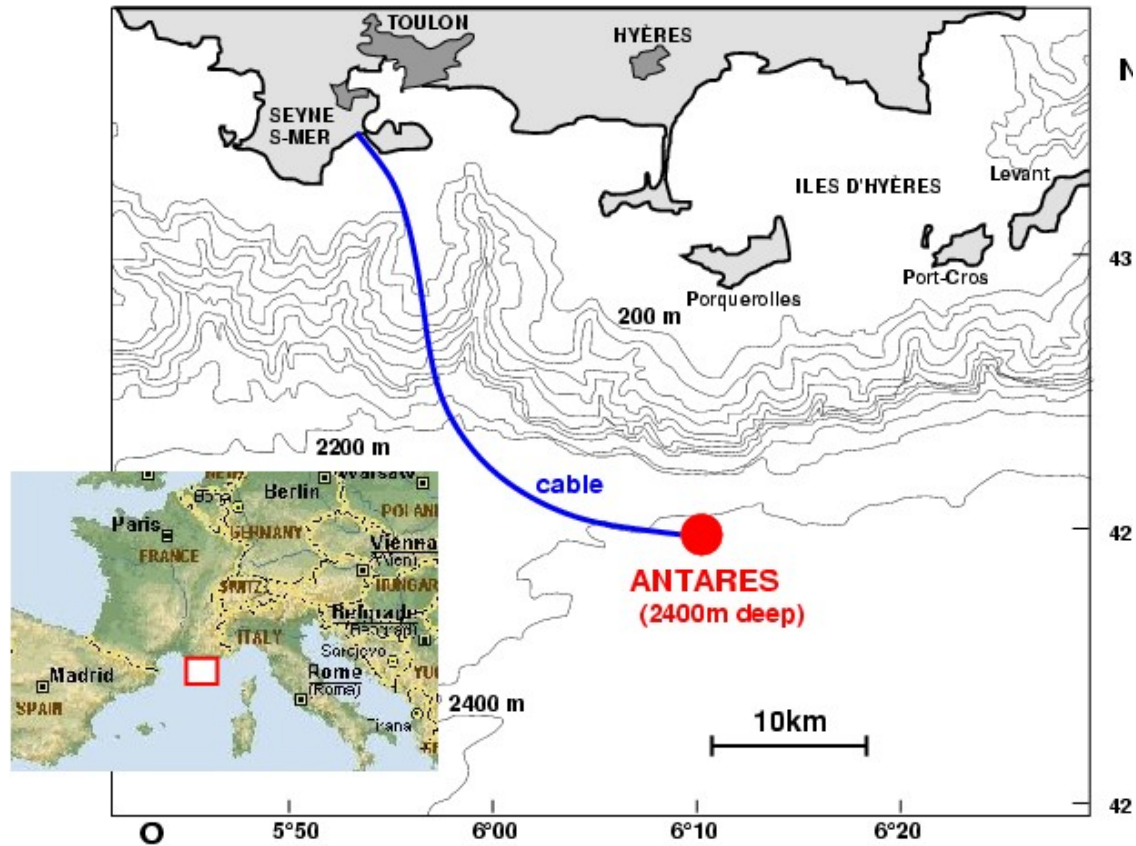PHYSICS

Neutrino Interactions
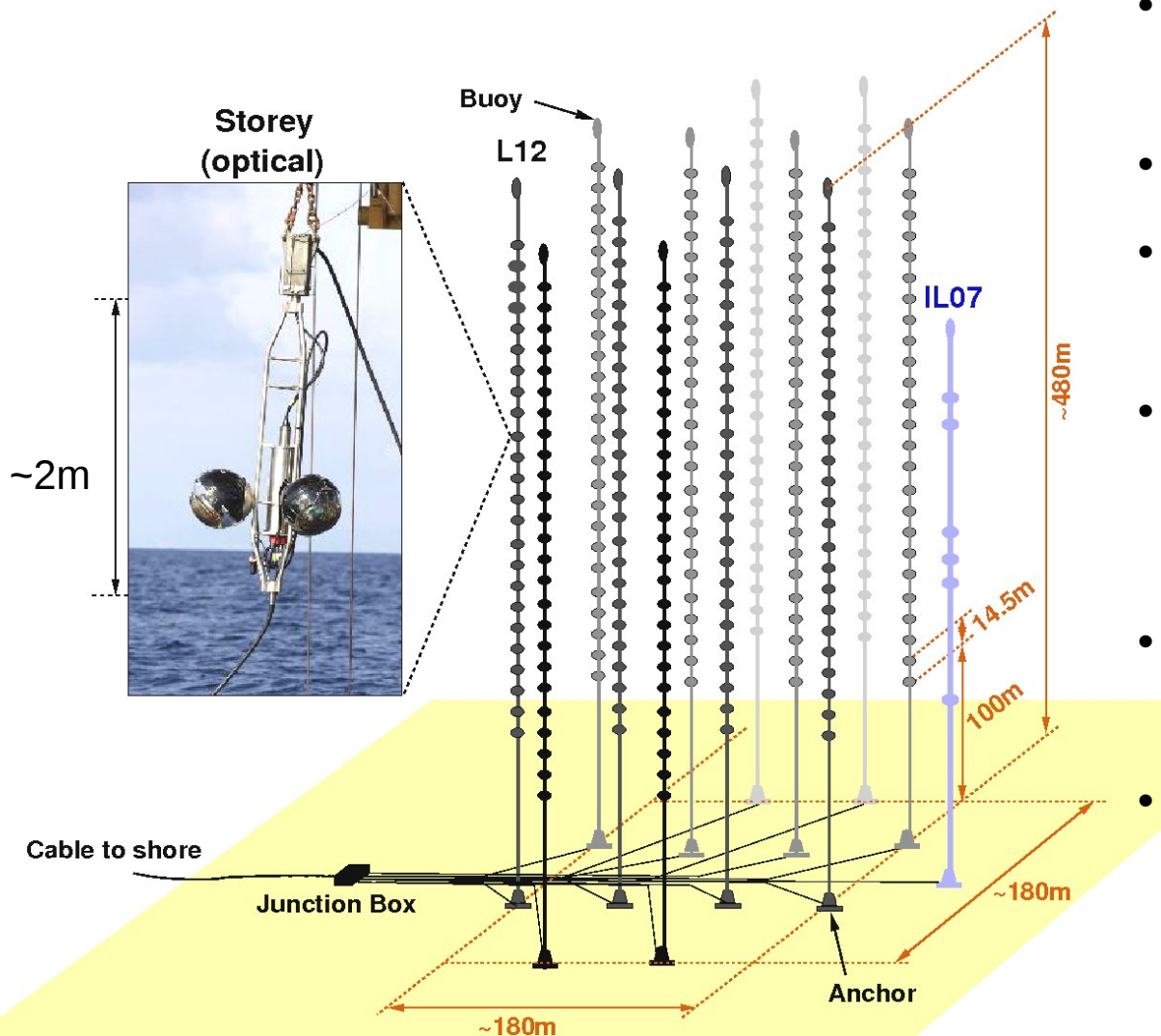
Detection of muon-neutrinos

ANTARES – collaboration members

France
Morocco
Russia
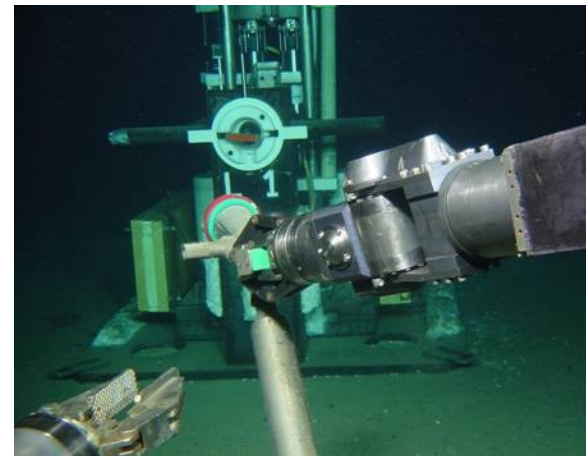Spain
Netherlands
Italy
Germany
Romania

The ANTARES site

The ANTARES Detector

- located in a depth of 2475 m
- 12 lines
- a total of 885 optical modules
- instrumented volume of about 0.01 km^3
- First data taking since Jan 2007
- completed in May 2008

ANTARES – deployment

Detector positioning
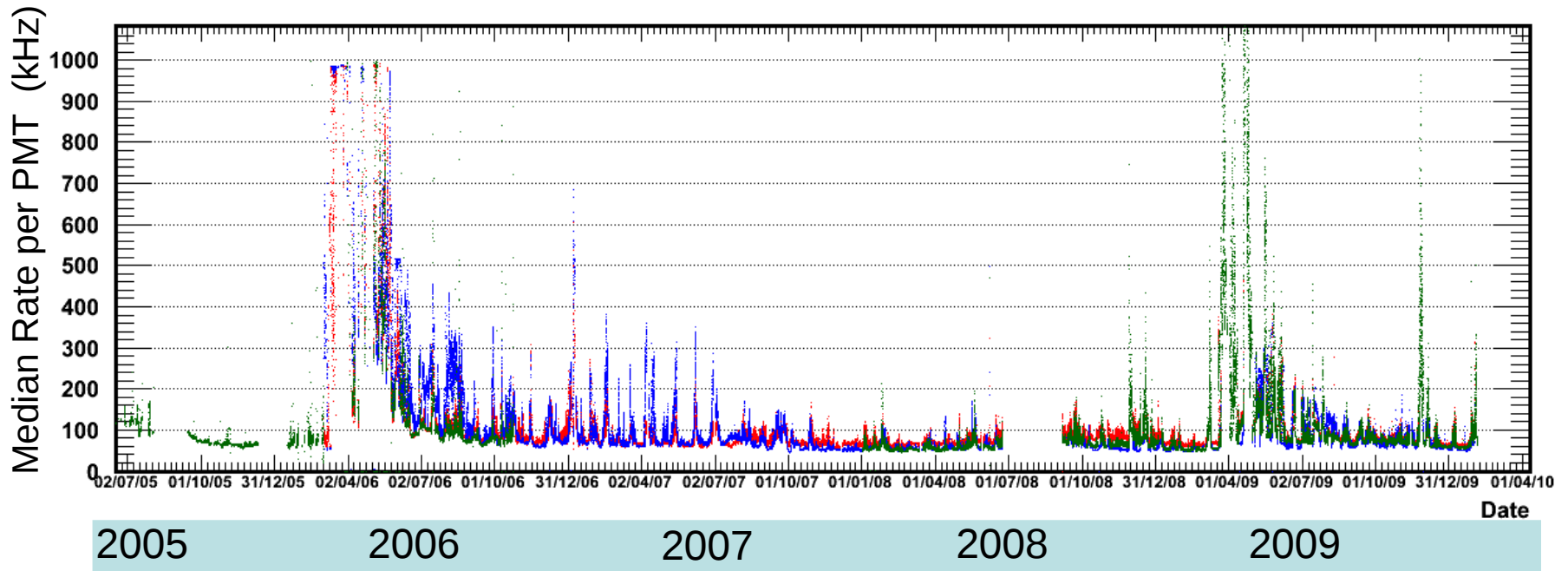
- Acoustic positioning system:

  1 emitter-receiver at each line socket

  5 receivers / line

- compass and accelerometer:

  1 compass / storey

  1 accelerometer / storey

- measurements taken every 2 minutes:

  acoustics: **travel time** sockets – receivers

  compass: **heading**

  accelerometer: **tilt**

- **travel time**, **heading** and **tilt** values are
  used to calculate the lineshape

Example for
Sea current
v= 25 cm/s
rmax = 22m

Z(m)

r(m)
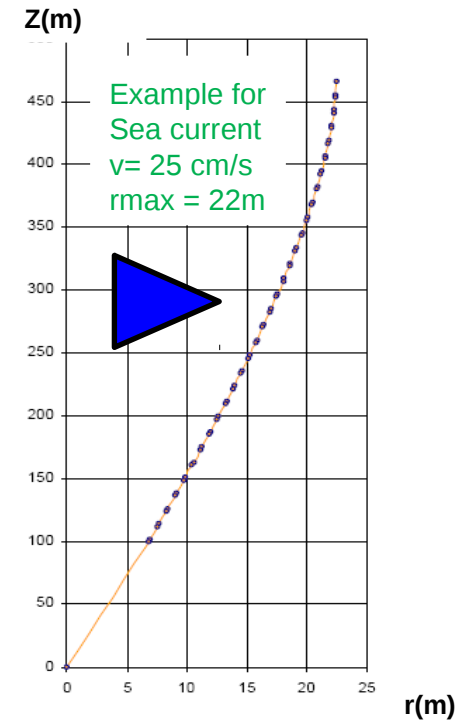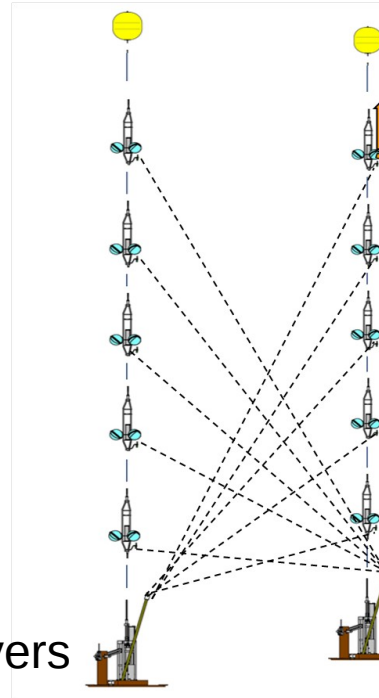
$$r = (a\,z - b\,\ln[1-cz]\,)\,v^2$$

precision of positioning: better than 10 cm

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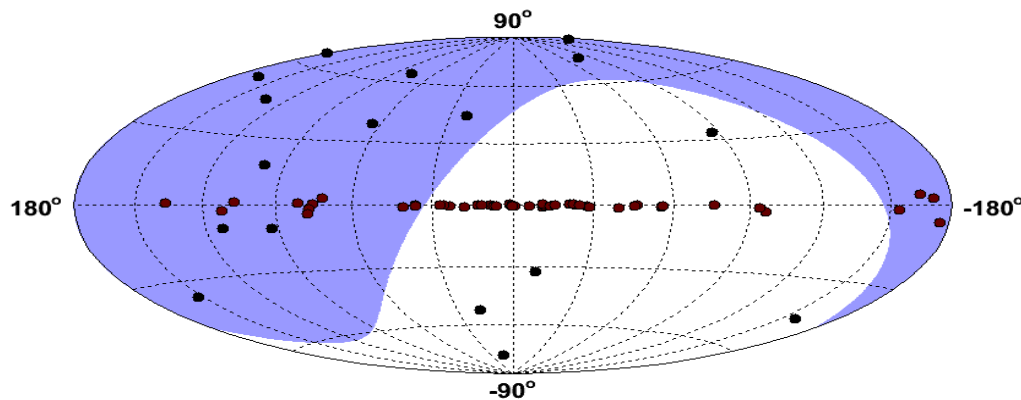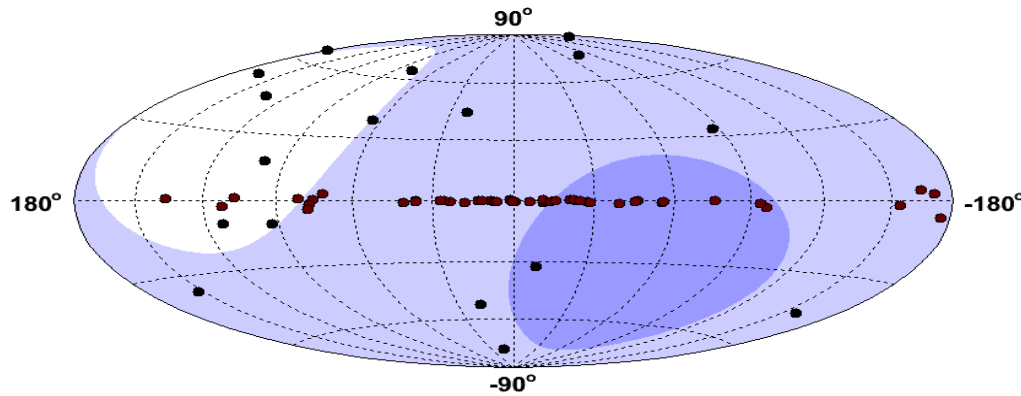
Optical Background

optical background

- ^{40}K-decay

- bioluminescense

- typical rate per PMT: 60-120 kHz
- additional short bursts and periods with higher rates

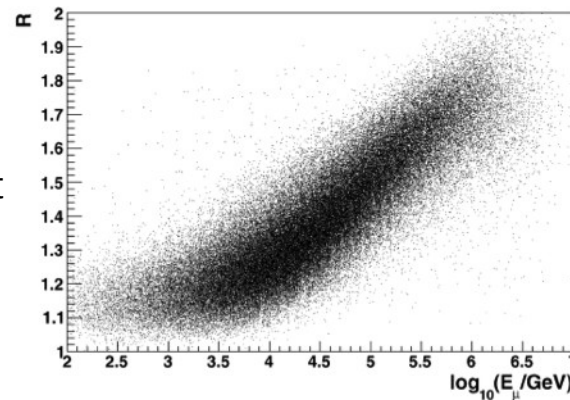# Sky Coverage

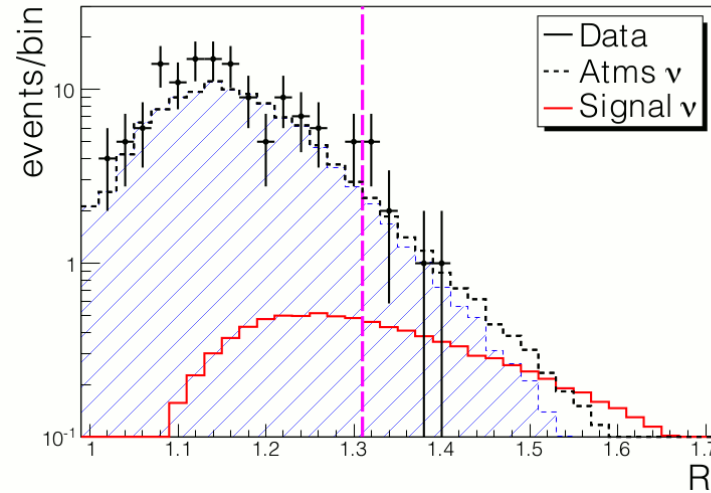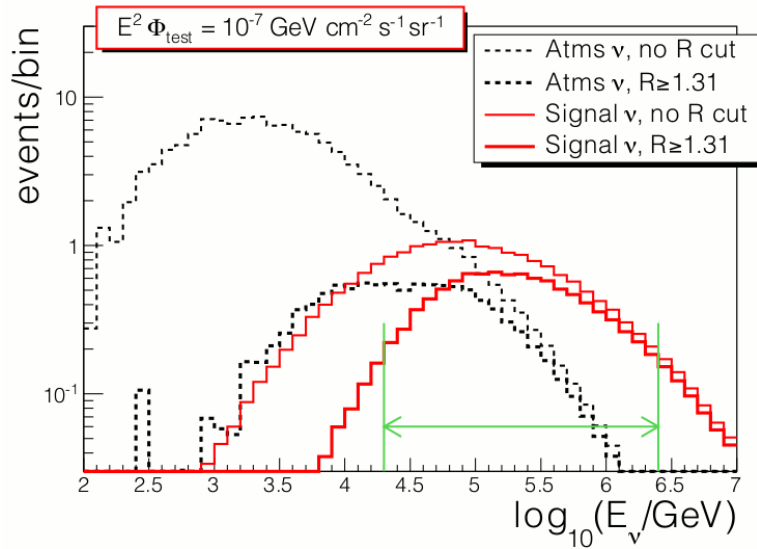ANTARES
- 🟦 > 75%
- ⬜ 25% – 75%
- ⬜ < 25%

TeV γ-Sources
- 🔴 galactic
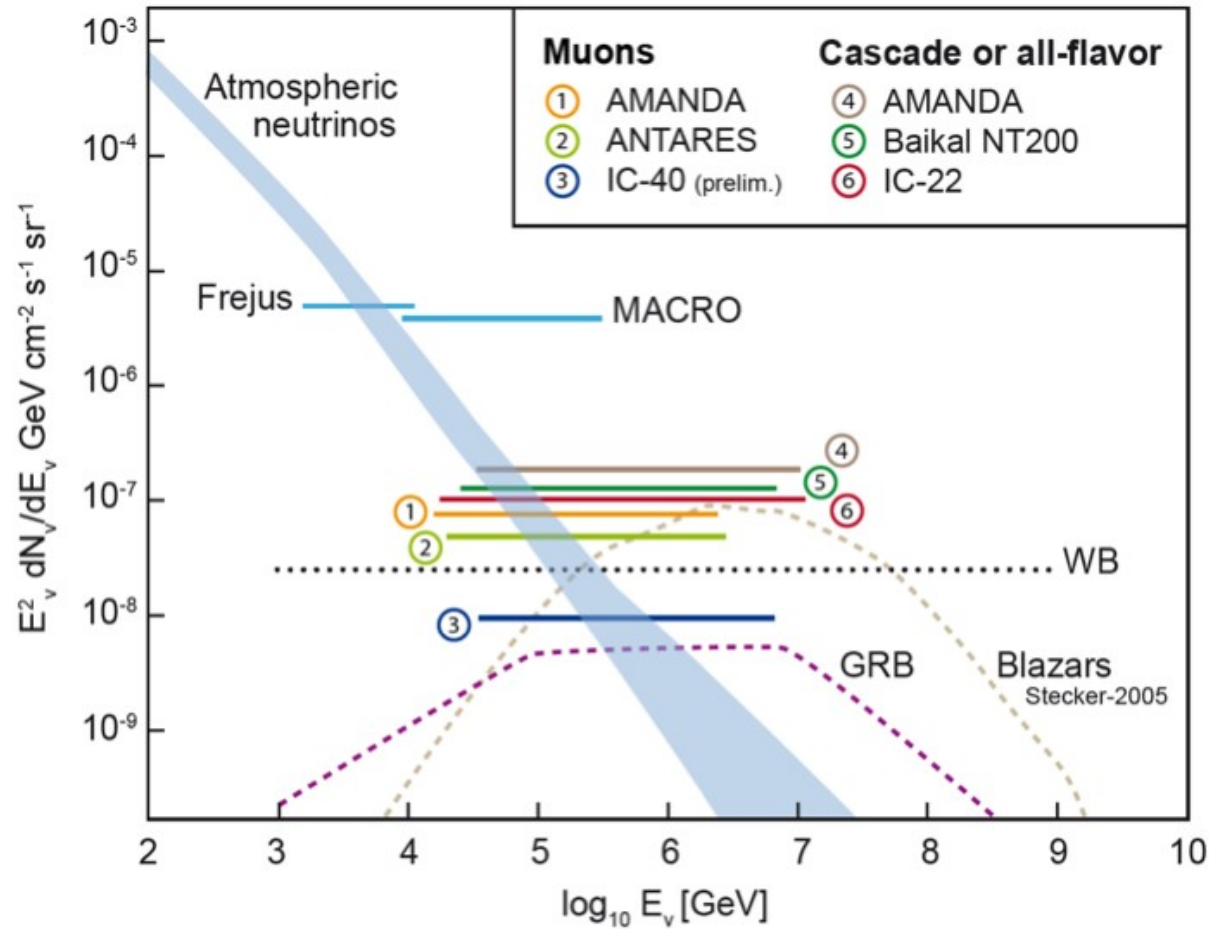- ⚫ extra-galactic

IceCube
- 🟦 100%
- ⬜ 0%

Search for a diffuse flux of HE neutrinos

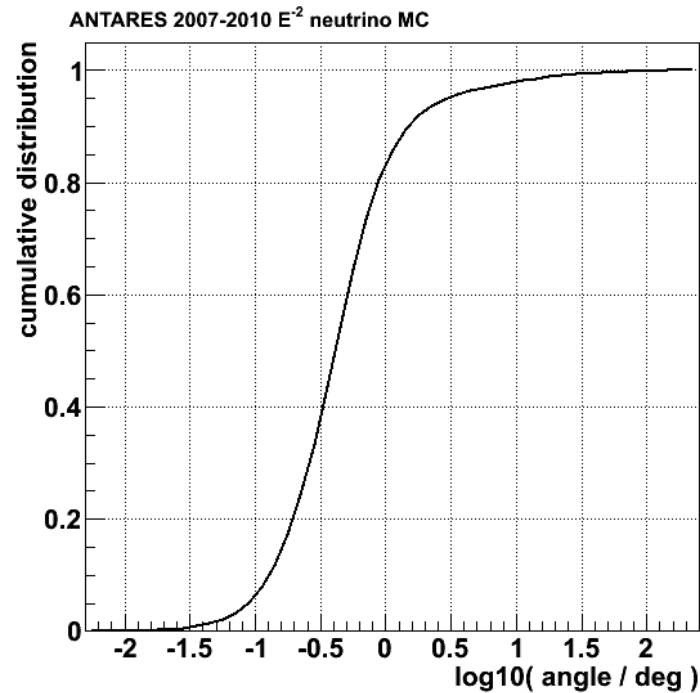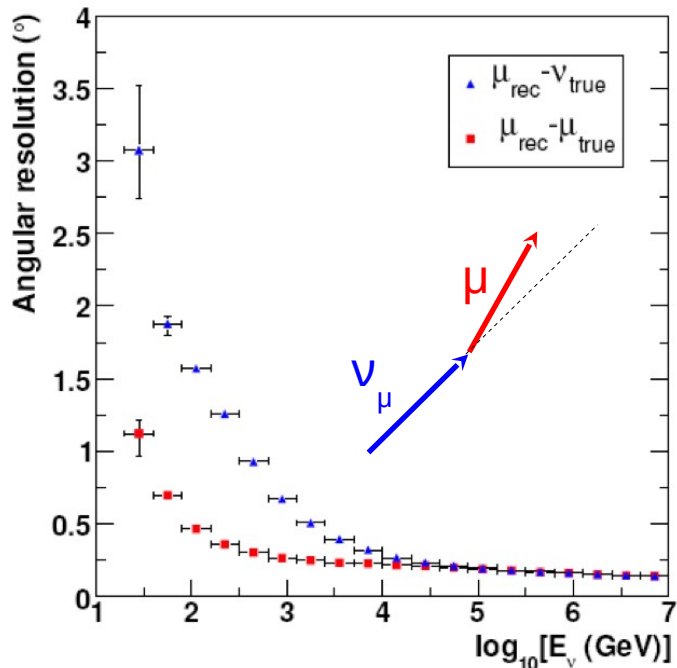R = mean number of hit repetitions within an event

Upper limit on diffuse flux of HE neutrinos

Angular resolution for the point source-search


ANTARES 2007-2010 E⁻² neutrino MC

Integrated distribution of the angular error for neutrino events that pass the selection cuts (assuming an E^{-2} spectrum). 50% of those events are reconstructed better than 0.46°.

Search for neutrino point sources
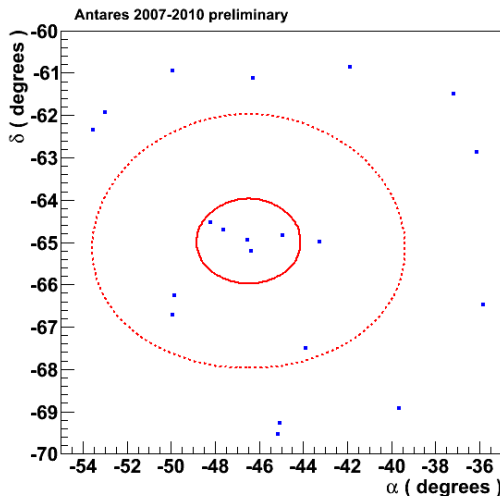
candidate-search

- 51 sources with hard gamma-ray spectrum

- source with highest significance:
  HESS J1023-575, p-value = 0.41

Antares 2007-2010, preliminary

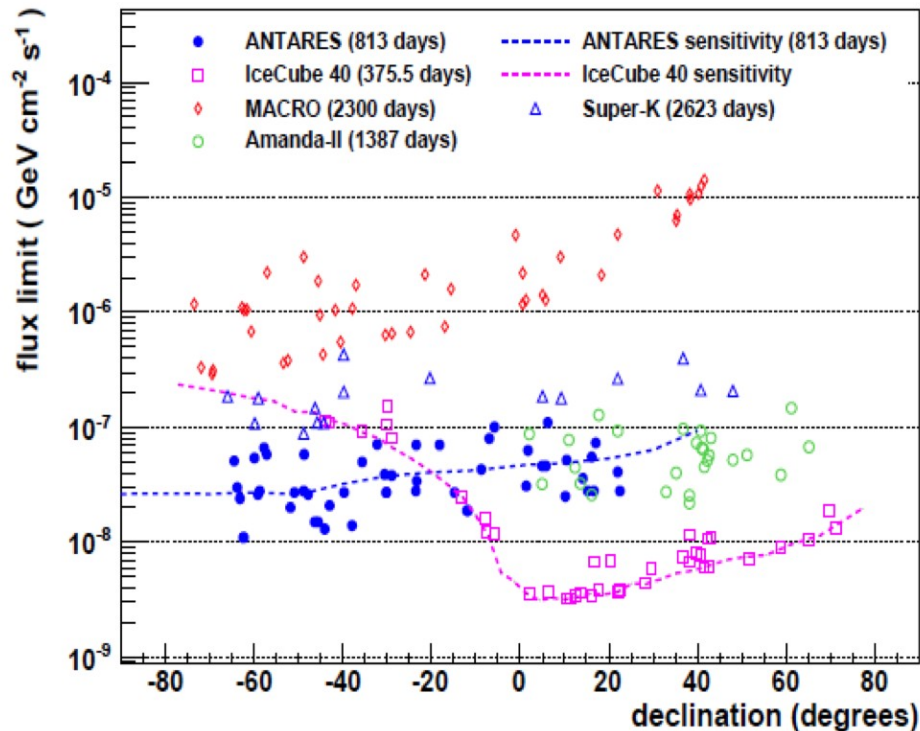Antares 2007-2010 preliminary
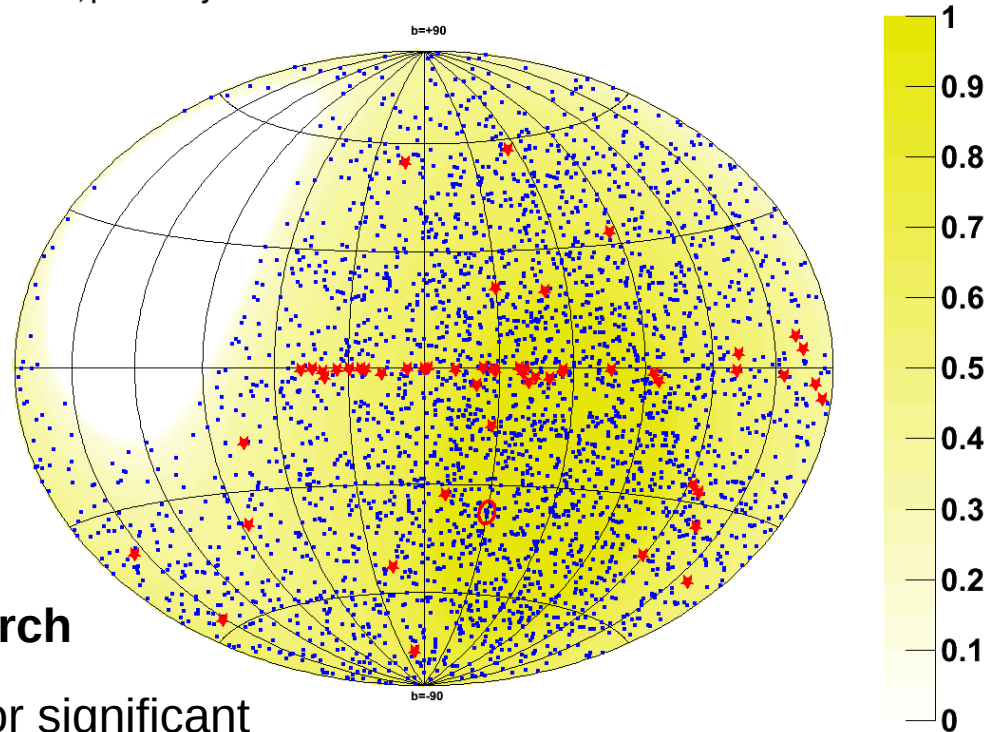
full sky search

- search for significant accumulations

- most significant cluster:

  p-value = 0.026

Limits and Sensitivities

- assumes an E^{-2} spectrum for a potential signal
- ANTARES gives the most stringent limits for most sources of the Southern Sky
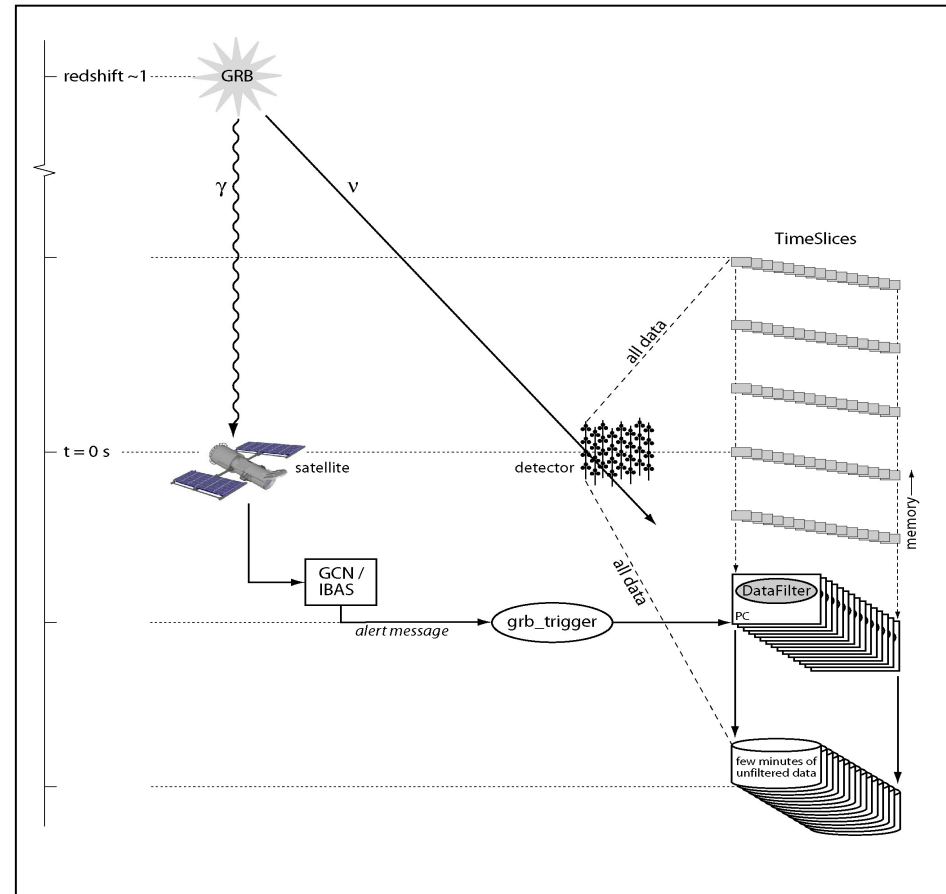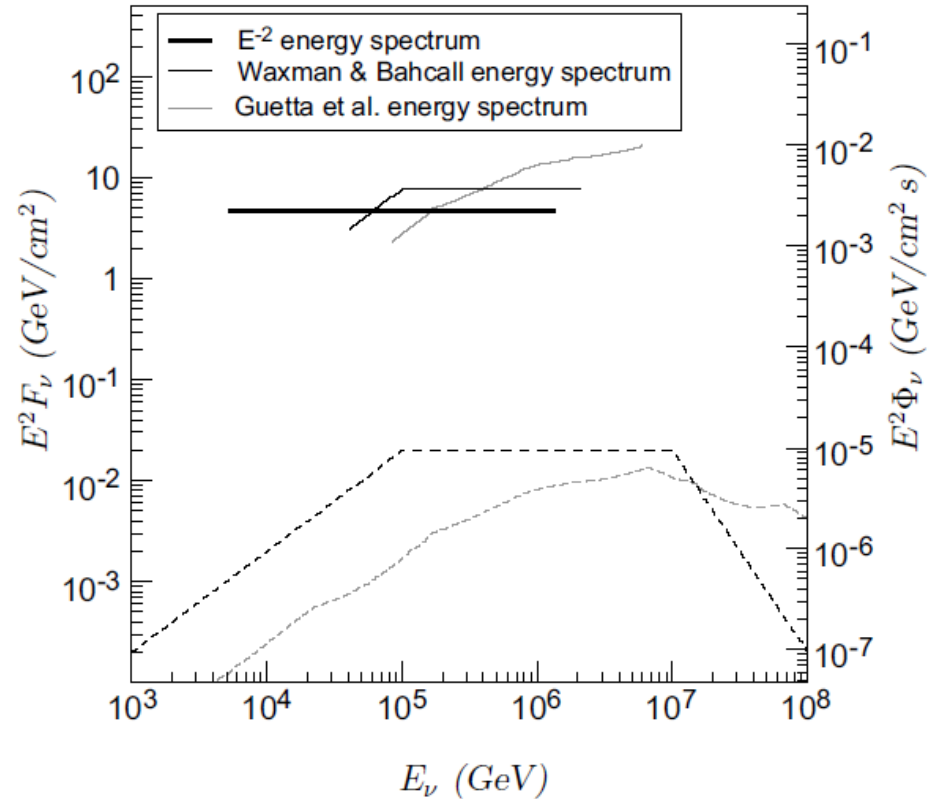
GRB search methods

Rolling search
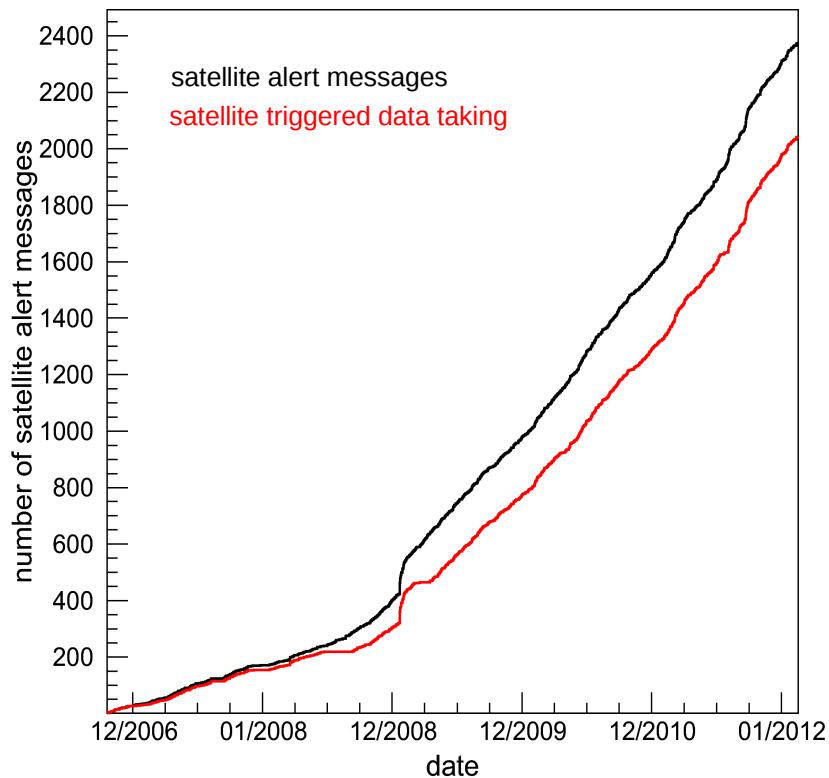
Search for neutrino events from the same direction within a short time window

Triggered search

When alerted by CGN/IBAS, all raw data within several minutes is stored and later used for an extensive analysis

First results from the triggered GRB search

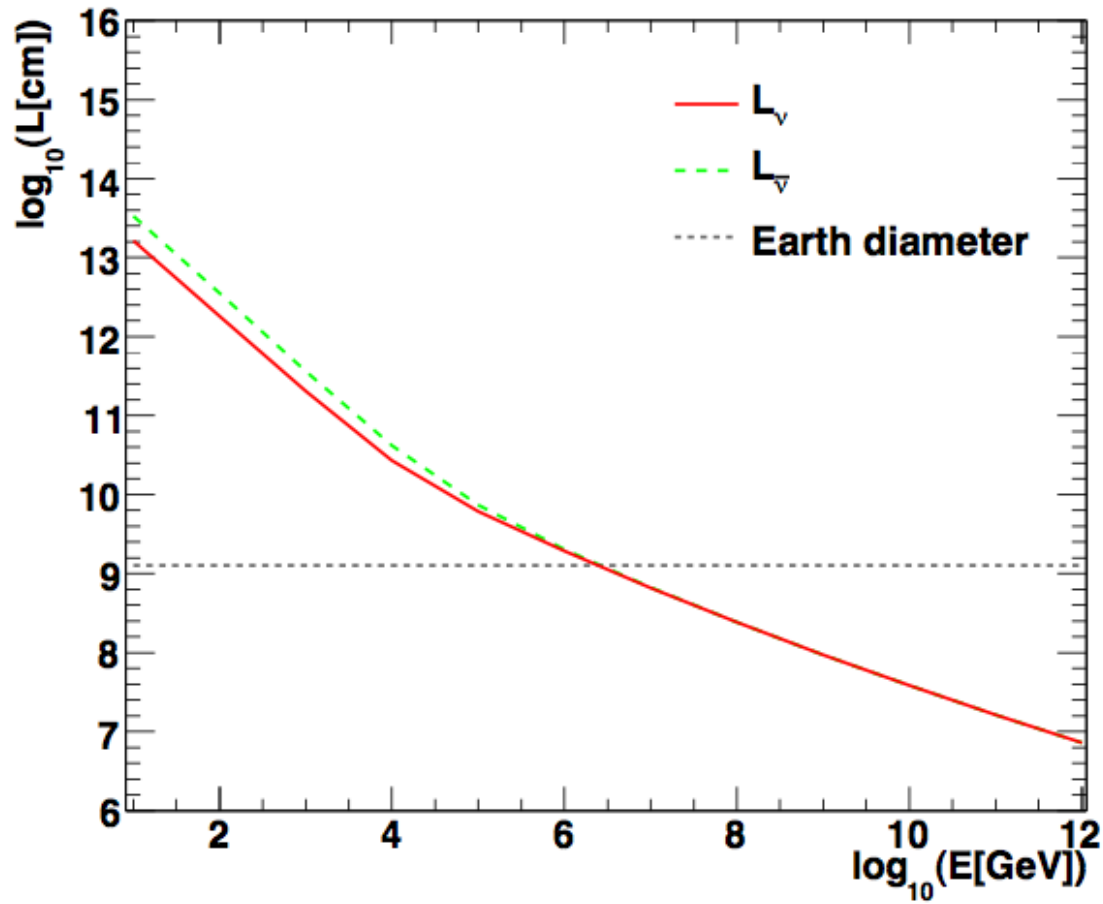90% CL upper limits on the fluxes of 40 selected GRBs

Summary and Outlook

ANTARES

- … is the only operating deep sea neutrino telescope

- … is the largest neutrino telescope in the northern hemisphere

- … has a broad physics program

- … has been continuously taking data since 2007

- … has determined the most sensitive upper limit on the flux on some of the galactic and extragalactic point sources

- … complements the sky coverage of IceCube

- … is an important testbed for KM3NeT

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Backup

Product Range
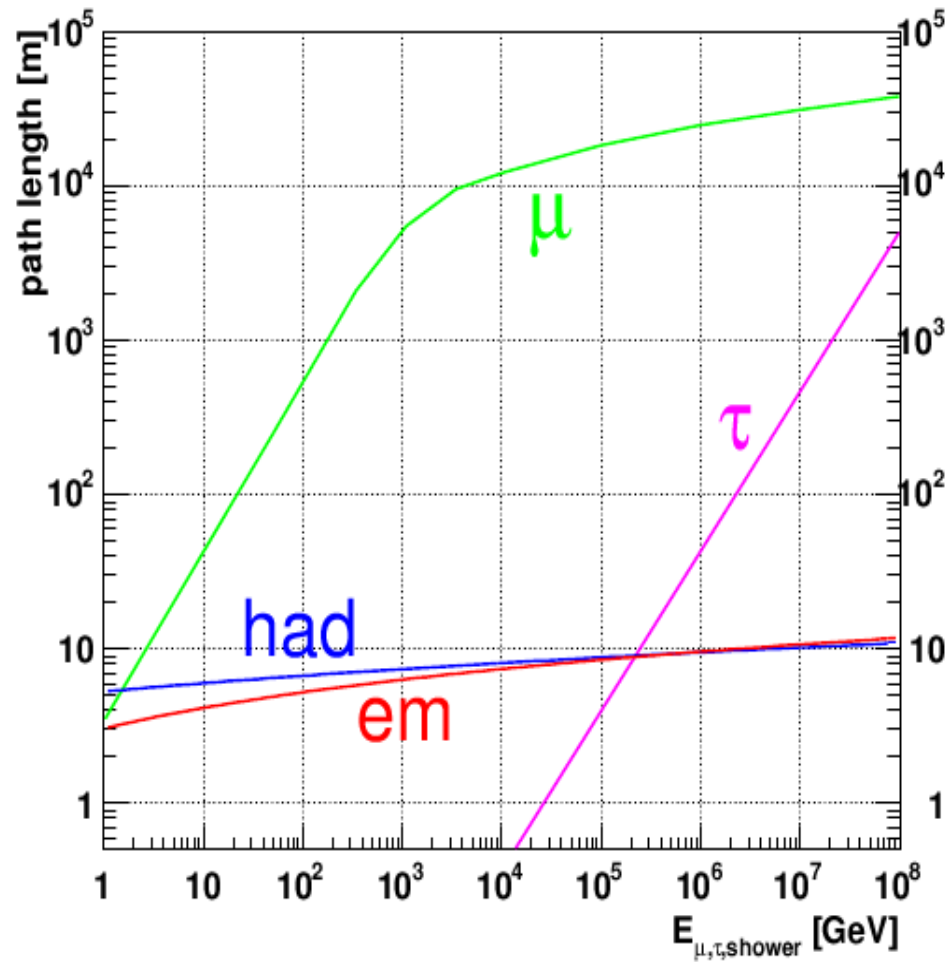
Mean free path length of neutrinos in water

Gain