Status of the ANTARES neutrino telescope

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The ANTARES Collaboration

More than 20 Institutes from 6 European countries

[Map showing institutes and locations]
Neutrino Detection Principle

The diagram illustrates the process of detecting neutrinos. Neutrinos interact with protons (p, α) to produce muons (μ). The muon then produces Cherenkov light, which travels through the water column towards the PMT (PhotoMultiplier Tubes) array. The 3D PMT array captures the light, allowing for the determination of the time, position, and energy of the neutrino interaction. The diagram shows the angle of 43° between the interaction point and the sea floor, which is crucial for accurately measuring the depth of the interaction. The Cherenkov light is indicated by the γ symbol, and the energy of the neutrino is represented by the energy level at the bottom of the diagram.
The ANTARES Neutrino Telescope

Hostile environment:
- Seafloor at 2500m depth (pressure up to 250 bar)
- Sea water (corrosion)

12 detection lines with 25 storeys each
Each line holds 75 PMTs
Basic detector element: storey

Optical Beacon for timing calibration (blue LEDs) 4 per line

Optical Module (OM):
17” glass sphere 10” PMT Ham. R7081-20

Local Control Module (in the Ti-cylinder)

Hydrophone Rx 5 per line
Expected performance

0.2°-0.3° angular resolution at E > 10 TeV – *limited by:*

- Light scattering + chromatic dispersion in sea water:
  $\sigma \sim 1.0\,\text{ns}$
- TTS in photomultipliers:
  $\sigma \sim 1.3\,\text{ns}$
- Electronics + calibration:
  $\sigma < 0.5\,\text{ns}$
- Position reconstruction of PMTs:
  $\sigma < 10\,\text{cm} (\leftrightarrow 0.5\,\text{ns})
ANTARES: Current Status

Line 1, first complete line in operation since 2 March 2006

Mini Instrumentation Line with Optical Modules (MILOM) in operation since 12 April 2005

Production of remaining lines in progress
12 lines are expected to be operating by end 2007
Time calibration with the MILOM

3 Optical Modules

Optical Beacon
36 LEDs + reference PMT

15 m

Time in OMs relative to reference PMT in OB

OM 1

OM 2

OM 3

\[ \sigma = 0.54 \]

\[ \sigma = 0.50 \]

\[ \sigma = 0.53 \]

\[ \delta t \text{ (ns)} \]

\[ \delta t \text{ (ns)} \]

\[ \delta t \text{ (ns)} \]

Timing resolution of electronics <0.5ns
Background from $^{40}$K and bioluminescence

OM counting rate from July 2005 (example)

Burst-fraction:
fraction of time when rate > baseline + 20%

Sept/Oct 2005
Water current measurements

Acoustic Doppler Current Profiler (ADCP)

MILOM data in 2005

- OM1
- OM2
- OM3

burst fraction (%) vs. water current (cm/s)
40K Coincidences

40K → 40Ca

40K → γ → Electron

40K coincidence rate from Gauss fit:

40K

13.0±0.5 Hz

13.0±0.5 Hz

10.5±0.4 Hz

Simulation: 12 Hz ± 4 Hz (sys)
Deployment of Line 1
Connection of Line 1
Reconstruction of Atmosph. Muon Tracks

Reconstruction with line1: Algorithm minimizes $\chi^2$ to find zenith angle of track.

- Run 21240 /
- Event 12505
- Zenith $\theta = 101^\circ$
- $P(\chi^2, \text{ndf}) = 0.88$

Antares preliminary
Reconstruction of Atmospheric Muons

Antares preliminary

- Time residuals
- \( \sigma = 7.8 \text{ ns} \)
**Data from Acoustic Positioning**

**Receivers (Hydrophones):**
- MILOM, Line 1

**Transmitters:**
- RxTx on BSS of MILOM, Line 1
- Autonomous Transponders

**First triangulation of hydrophone:**

**Z position vs time**

- 2 cm
- 12 h

**Resolution in x, y, z < 1 cm**
Position and orientation of each PMT have to be reconstructed:

Compass, tiltmeter in every storey (inside electronics container)
Conclusions and Outlook

- Currently two lines in operation at ANTARES site
  - Line 1 works as expected from design specifications
  - Excellent time resolution
  - Position reconstruction ongoing
    (individual measurements exceeding required precision have been performed)

- All 12 detection lines expected to be deployed and connected by end 2007