The ANTARES Neutrino Telescope Status Report

Antoine Kouchner
AstroParticle and Cosmology, Paris
for the ANTARES collaboration
µ well suited for HE detection
Both range and cross-section increase with energy
Large effective volume

Detection of Cherenkov light emitted by muons with a 3D lattice of PMT
Requires a large dark transparent detection medium

Time, position, amplitude of PMT pulses ⇒ µ trajectory (ν < 0.5 °)
Detection principle

µ well suited for HE detection
Both range and cross-section increase with energy
Large effective volume

Detection of Cherenkov light emitted by muons with a 3D lattice of PMT
Requires a large dark transparent detection medium

Intense background → deep ice/water shielding
Signal = upward muon

Time, position, amplitude of PMT pulses ⇒ µ trajectory (ν < 0.5 °)
HE ν production in astrophysical sources

- Cosmic ray interactions: \( p+A/g \rightarrow \text{mesons} \rightarrow n \)
- Decay of heavy particle
- DM (WIMP) annihilation: \( \text{DM} + \text{DM} \rightarrow \ldots \rightarrow n \)

Interdisciplinary Deep Sea Studies:
- oceanography, sea biology, seismology...
HE neutrino astronomy

- HE $\nu$ production in astrophysical sources
  - Cosmic ray interactions: $p+A/g \rightarrow \text{mesons} \rightarrow n$
  - Decay of heavy particle
  - DM (WIMP) annihilation: $\text{DM} + \text{DM} \rightarrow \cdots \rightarrow n$

- Interdisciplinary Deep Sea Studies:
  - oceanography, sea biology, seismology...
HE neutrino astronomy

- HE $\nu$ production in astrophysical sources
  - Cosmic ray interactions: $p+A/g \rightarrow$ mesons $\rightarrow n$
  - Decay of heavy particle
  - DM (WIMP) annihilation: $DM + DM \rightarrow \ldots \rightarrow n$

- Interdisciplinary Deep Sea Studies:
  - oceanography, sea biology, seismology...

Point-sources search, J.A. Aguilar, this session
HE neutrino astronomy

- HE $\nu$ production in astrophysical sources
  - Cosmic ray interactions: $p+A/g \rightarrow$ mesons $\rightarrow$ n
  - Decay of heavy particle
  - DM (WIMP) annihilation: $DM + DM \rightarrow \ldots \rightarrow n$

- Interdisciplinary Deep Sea Studies:
  - oceanography, sea biology, seismology...
HE neutrino astronomy

- HE $\nu$ production in astrophysical sources
  - Cosmic ray interactions: $p+A/g \rightarrow$ mesons $\rightarrow n$
  - Decay of heavy particle
  - DM (WIMP) annihilation: $DM + DM \rightarrow \ldots \rightarrow n$

- Interdisciplinary Deep Sea Studies:
  - oceanography, sea biology, seismology...

See talk from E. Falchini OG.2.5
ANTARES site

40 km submarine cable

-2475 m

ANTARES shore station

Astropart. Phys 23 (2005) 131-155 (Light transmission)
See talk from S. Escoffier, this session
The 12 string Antares Telescope

- 25 storeys / line
- 3 PMTs / storey
- 900 PMTs
The 12 string Antares Telescope

- 25 storeys / line
- 3 PMTs / storey
- 900 PMTs

Dimensions:
- 350 m
- 100 m
- ~70 m
- 14.5 m
- 40 km to shore
Basic detector element: storey

- **Titanium frame**: support structure
- **Optical Beacon** with blue LEDs: timing calibration
- **Optical Module**: 10” Hamamatsu PMT in 17” glass sphere photon detection
  - NIM A484 (2002) 369
  - NIM A555 (2005) 132
- **Local Control Module (Ti)**: Front-end ASIC, DAQ/SC, DWDM, Clock, tilt/compass, power distribution...
- **Hydrophone**: acoustic positioning
Basic detector element: storey

Titanium frame: support structure

Optical Beacon with blue LEDs: timing calibration

See poster by M. Circella (id 1290) HE.2.5

Local Control Module (Ti): Front-end ASIC, DAQ/SC, DWDM, Clock, tilt/compass, power distribution...

Hydrophone: acoustic positioning

Optical Module: 10” Hamamatsu PMT in 17” glass sphere photon detection

NIM A484 (2002) 369

NIM A555 (2005) 132

astro-ph/0703355
ANTARES Construction Milestones

2001 – 2003:
- Main Electro-optical cable in 2001
- Junction Box in 2002
- Prototype Sector Line (PSL) & Mini Instrumentation Line (MIL) 2003
ANTARES Construction Milestones

2001 – 2003:
- Main Electro-optical cable in 2001
- Junction Box in 2002
- Prototype Sector Line (PSL) & Mini Instrumentation Line (MIL) 2003

2005 – 2006:
- Mini Instrumentation Line + Oms (MILOM) 12 April 2005 → 6 April 2007
- Line 1 running since 2 March 2006, first complete detector line
- Line 2 running since Sept 2006
ANTARES Construction Milestones

2001 – 2003:
- Main Electro-optical cable in 2001
- Junction Box in 2002
- Prototype Sector Line (PSL) & Mini Instrumentation Line (MIL) 2003

2005 – 2006:
- Mini Instrumentation Line + Oms (MILOM)
  - 12 April 2005 → 6 April 2007
- Line 1 running since 2 March 2006, first complete detector line
- Line 2 running since Sept 2006
ANTARES Construction Milestones

2001 – 2003:
- Main Electro-optical cable in 2001
- Junction Box in 2002
- Prototype Sector Line (PSL) & Mini Instrumentation Line (MIL) 2003

2005 – 2006:
- Mini Instrumentation Line + Oms (MILOM) 12 April 2005 → 6 April 2007
  
  
- Line 1 running since 2 March 2006, first complete detector line
- Line 2 running since Sept 2006
ANTARES Construction Milestones

2001 – 2003:
- Main Electro-optical cable in 2001
- Junction Box in 2002
- Prototype Sector Line (PSL) & Mini Instrumentation Line (MIL) 2003

2005 – 2006:
- Mini Instrumentation Line + Oms (MILOM) 12 April 2005 → 6 April 2007
- Line 1 running since 2 March 2006, first complete detector line
- Line 2 running since Sept 2006

2006 – now:
- Lines 3,4,5 connected January 2007
- Lines 6,7 deployed
ANTARES Construction Milestones

2001 – 2003:
- Main Electro-optical cable in 2001
- Junction Box in 2002
- Prototype Sector Line (PSL) & Mini Instrumentation Line (MIL) 2003

2005 – 2006:
- Mini Instrumentation Line + Oms (MILOM)
  12 April 2005 → 6 April 2007
- Line 1 running since 2 March 2006, first complete detector line
- Line 2 running since Sept 2006

2006 – now:
- Lines 3, 4, 5 connected January 2007
- Lines 6, 7 deployed

Full completion early 2008!
Detector Calibration
Detector Calibration

- Led Beacon
- Intense light:
  - PMT TTS
  - negligible
Detector Calibration
Detector Calibration

Timing resolution of electronics ~ 0.5ns
Detector Calibration

Timing resolution of electronics
\(~ 0.5\text{ns}\)
Detector Calibration

Timing resolution of electronics ~ 0.5ns

Positioning resolution < 10 cm
Detector Calibration

Timing resolution of electronics ~ 0.5ns

Positioning resolution < 10 cm

See poster by F. Fehr (id 481) OG.2.7
Event displays

Hits are plotted for each line: height (z) versus time (t)

⇒ Characteristic pattern depending on zenith angle and distance of closest approach

Several reconstruction strategies available 1D, 3D, $\chi^2$, ML
Event displays

Hits are plotted for each line: height (z) versus time (t)

⇒ Characteristic pattern depending on zenith angle and distance of closest approach

Several reconstruction strategies available 1D, 3D, $\chi^2$, ML

See poster by Y. Becherini (id 481) HE.2.3
Atmospheric muon tracks (L1)

Reconstruction with 1 line (poor sensitivity to azimuth):

Algorithm minimizes $\chi^2$ to find zenith angle of track

Run 21240 / Event 12505
Zenith $\theta = 101^\circ$
$P(\chi^2, ndf) = 0.88$
5 line detector displays
Atmospheric neutrino candidate

\[ \theta = 35^\circ \]
Nadir angle distribution

After quality cuts

5 lines 2007 data
No alignment

ANTARES
PRELIMINARY

number of events

$\mu$

$\cos \theta$
Conclusions and Outlook

- Major step forward during the last year

- Detector working well within design specifications:
  - Junction Box in operation since Dec. 2002
  - 5 lines delivering data on the site
  - All technical problems solved

- 12 lines detector complete early 2008:
  Operation for science ≥ 5 years

- Milestone towards a KM³ underwater detector
Conclusions and Outlook

- Major step forward during the last year

- Detector working well within design specifications:
  - Junction Box in operation since Dec. 2002
  - 5 lines delivering data on the site
  - All technical problems solved

- 12 lines detector complete early 2008: Operation for science ≥ 5 years

- Milestone towards a KM$^3$ underwater detector

Candidates for first undersea neutrino!!