ANTARES

Searches for point sources of high energy cosmic neutrino with the ANTARES telescope

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THE ANTARES EXPERIMENT

14.5m

100 m

~70 m

25 storeys, 348 m

• String-based detector;
• Underwater connections by deep-sea submersible;
• Downward-looking PMTs, axis at 45° to vertical;
• 2475 m deep.

THE ANTARES EXPERIMENT

• 12 detection lines
• 25 storeys / line
• 3 PMTs / storey
• 885 PMTs

Junction Box

• 40 km
• cable to
• shore
POINT SOURCES SEARCH

Antares 2007+2008 preliminary

- data
- total MC
- $\nu$ MC
- $\mu$ MC

cumulative events

reconstruction quality $\Delta$

$10^5$

$10^4$

$10^3$

$10^2$

$10^1$

$10^0$

$10^{-1}$

$10^{-2}$

$10^{-3}$

Antares 2007+2008 $E_\nu^{-2}$ MC, preliminary

event rate (au)

$0.9$

$0.8$

$0.7$

$0.6$

$0.5$

$0.4$

$0.3$

$0.2$

$0.1$

$0$

$-2$

$-1$

$0$

$1$

$2$

log$_{10}$ (angle $\nu$/deg)

median angular resolution $0.5 \pm 0.1$ degree

data from 5-line detector (2007) included. Loose selection for optimal sensitivity:
- error estimate < 1 degree
- reconstruction quality variable

Angular resolution estimated from MC, but constrained using data.
- comparable to IceCube, despite much smaller detector $\rightarrow$ advantage of water over ice.

See poster C. Di Stefano on the moon shadow
POINT SOURCES SEARCH

Optimization in order to have the best sensitivity at 90% C.L.
(2190 selected events – 295 days 2007-2008 ANTARES data)

⇒ 2 searches: all-sky (unbiased) + candidate lists
preliminary result:
⇒ no significant signal found
⇒ limits reported for few candidate neutrino sources
  * interesting gamma/X-ray sources for which models predict neutrinos
  * galactic center: see no events within resolution

IceCube competitive, but energy range for decl<0 is very different.
Comparison of the 5σ discovery flux between the 2007-2008 ANTARES results (295 days) and the IceCube 40 results (375 days) in the Southern sky:

=> Very different energy range

IceCube data: 375 days (2008-2009 with IC40), ~14000 atm muon in South hemisphere, ~22000 atm neutrinos in North hemisphere (C. Finley MANTS 2009)
AUTO-CORRELATION

Looking for structure in the data:

• Same data sample as point source search (2007-2008)
• Number of pairs in a given angular bin

No significant excess found
TIME-DEPENDENT ANALYSIS

Use the time information provided by other multimessenger experiments (Swift, Fermi, HESS...) directly in the analysis:

* Space-time coincidences reduce effectively the background
* Improve the discovery potential over a time integrated search.

**ANTARES:**
→ Time dependant likelihood method
→ Analysis of 2008 (4 months)
→ Performance: number of events required for a $5\sigma$ discovery (90 % C.L.)
Search for signal from blazars AGN – candidate sources for UHECR
(p-γ or p-p \(\Rightarrow\) strong correlation between \(\gamma\)-ray and neutrino fluxes
+ Larger photon density + Larger magnetic field \(\Rightarrow\) enhancement of the
neutrino production)

Fermi LAT data: Identification of the flare periods on AGNs
1) \(\gamma\)-ray sources: Variable and energetic blazars
2) 1-day binned light curve (fit files from Fermi website)
3) Flare (\(\Leftrightarrow\) HE state) periods: robust and simple method
   - Extraction of a baseline + error
   - Prior: \((\text{flux-erflux})>(\text{baseline}+2*\text{sigma}) + \text{flux}>(\text{baseline}+3*\text{sigma})\)
   - Duration: add consecutive points to the prior \((\text{flux-erflux})>(\text{baseline}+\text{sigma})\)
     add +/- 0.5 day to each flare (1-day binned LC + uncertainties models)
SEARCH FOR FERMI BLAZARS

Analysis of 10 bright and variable Fermi LAT sources in 2008 data (61 days):
PKS0208-512, AO0235+164, PKS1510-089, 3C273, 3C279, 3C454.3, OJ287,
PKS0454-234, WComae, PKS2155-304

=> 1 neutrino compatible with the time/space distribution ($\Delta \alpha = 0.56^\circ$)
of 3C279 with probability 10 % after trials
Summary

- ANTARES complete since 2008
  Largest $\nu$ telescope in Northern hemisphere
- Technology proven (operating smoothly, understanding of detector)
- Data analysis progressing
  - nearly 3000 neutrino candidates selected
- Ready for next step with KM3NeT
  (see talk of Apostolos T.)

Exciting physics program in progress
Muons, neutrinos, dark matter, monopoles …
Diffuse flux search
Best limits for point sources in the Southern sky
More data (x2) already on disc.
Multi-messenger approaches strongly pursued
TAToO, GWHEN…