ANTARES

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

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THE ANTARES EXPERIMENT

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

14.5m

25 storeys, 348 m

100 m

~70 m

- 40 km
- cable to
- shore

Junction Box

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

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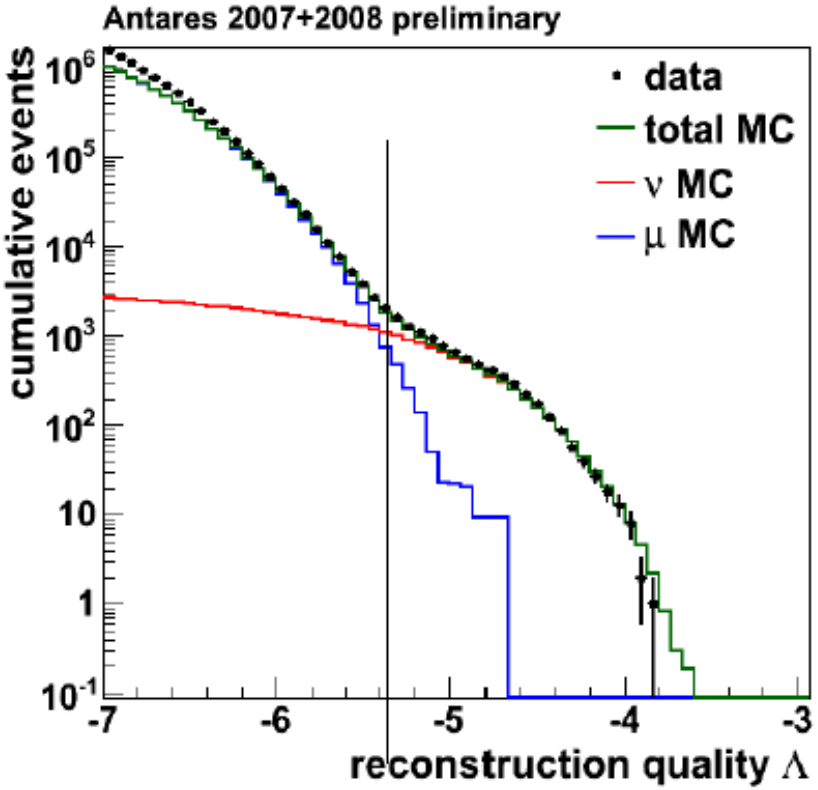
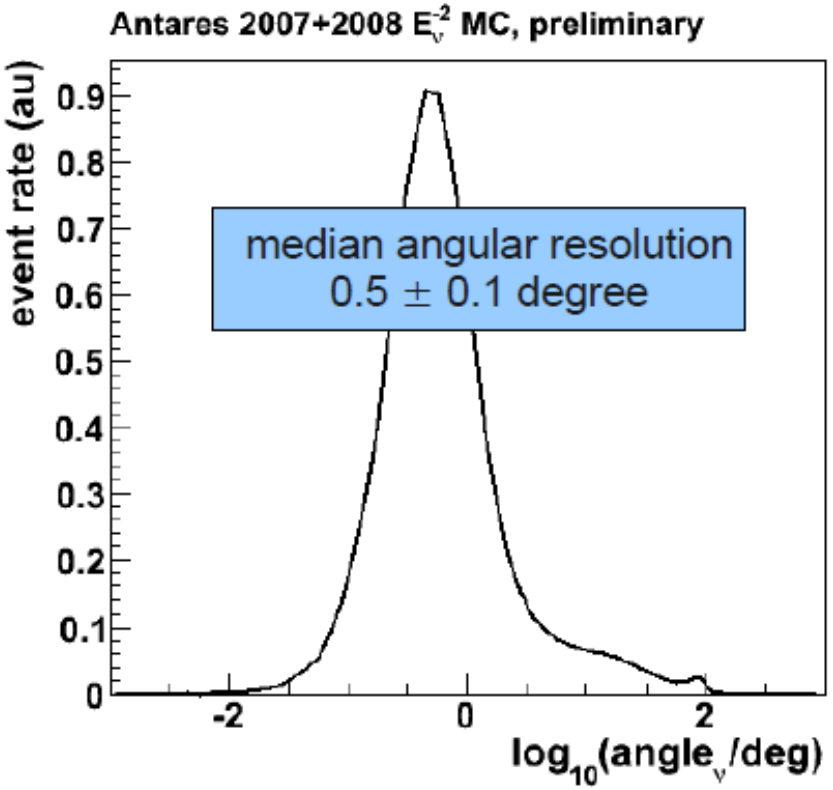
POINT SOURCES SEARCH





data from 5-line detector(2007) included.
loose selection for optimal sensitivity:

- error estimate < 1 degree
- reconstruction quality variable

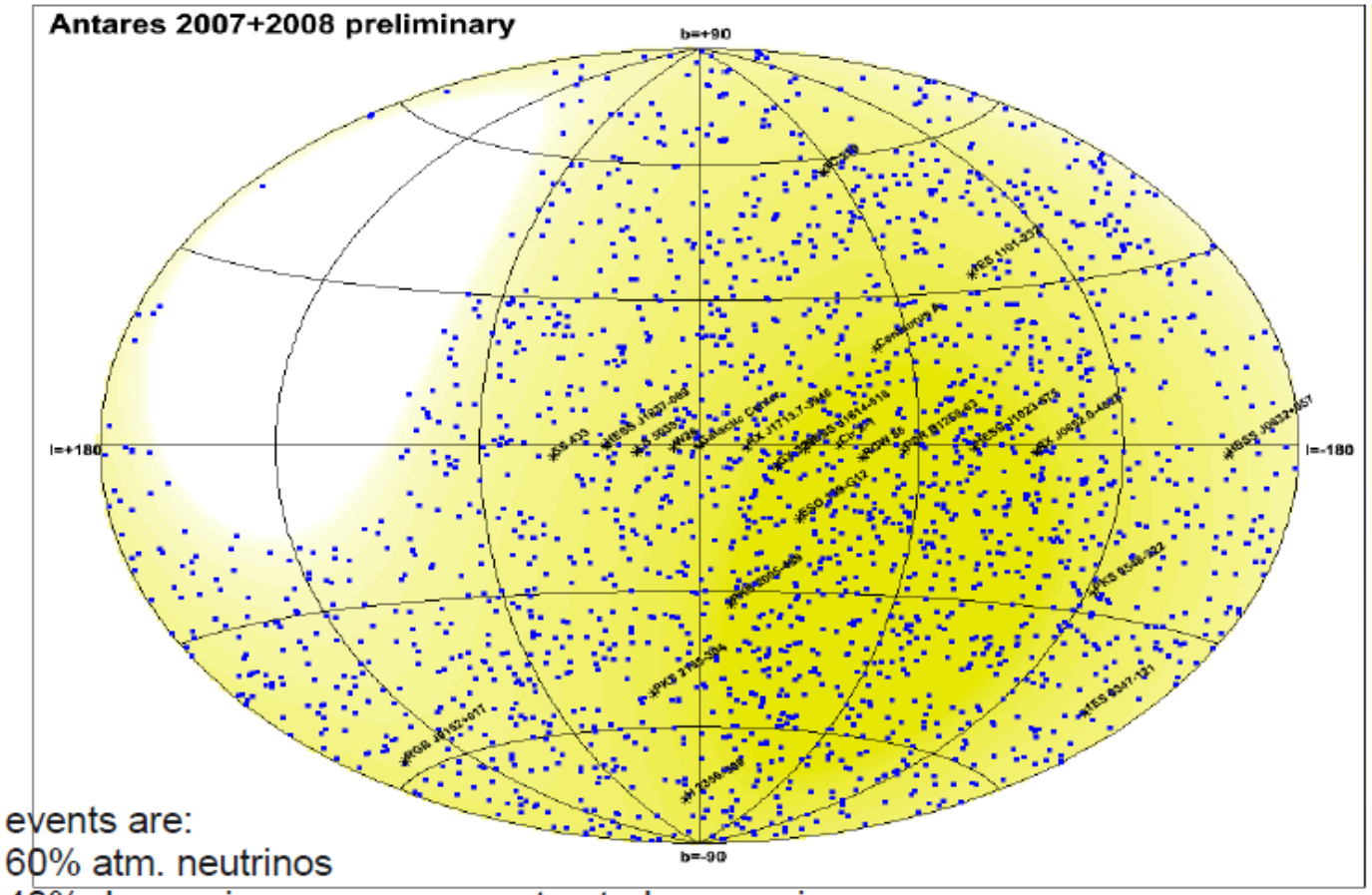
- Angular resolution estimated from MC, but constrained using data.
- comparable to IceCube, despite much smaller detector → advantage of water over ice.

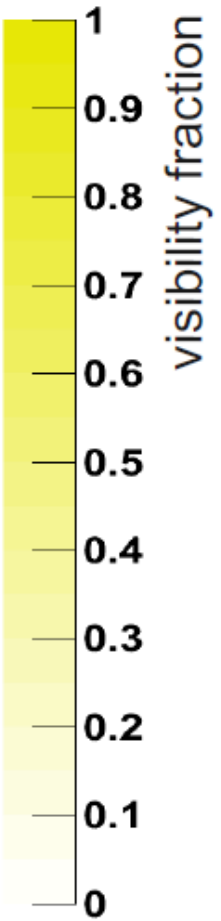
See poster C. Di Stefano on the moon shadow

POINT SOURCES SEARCH

Preliminary

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





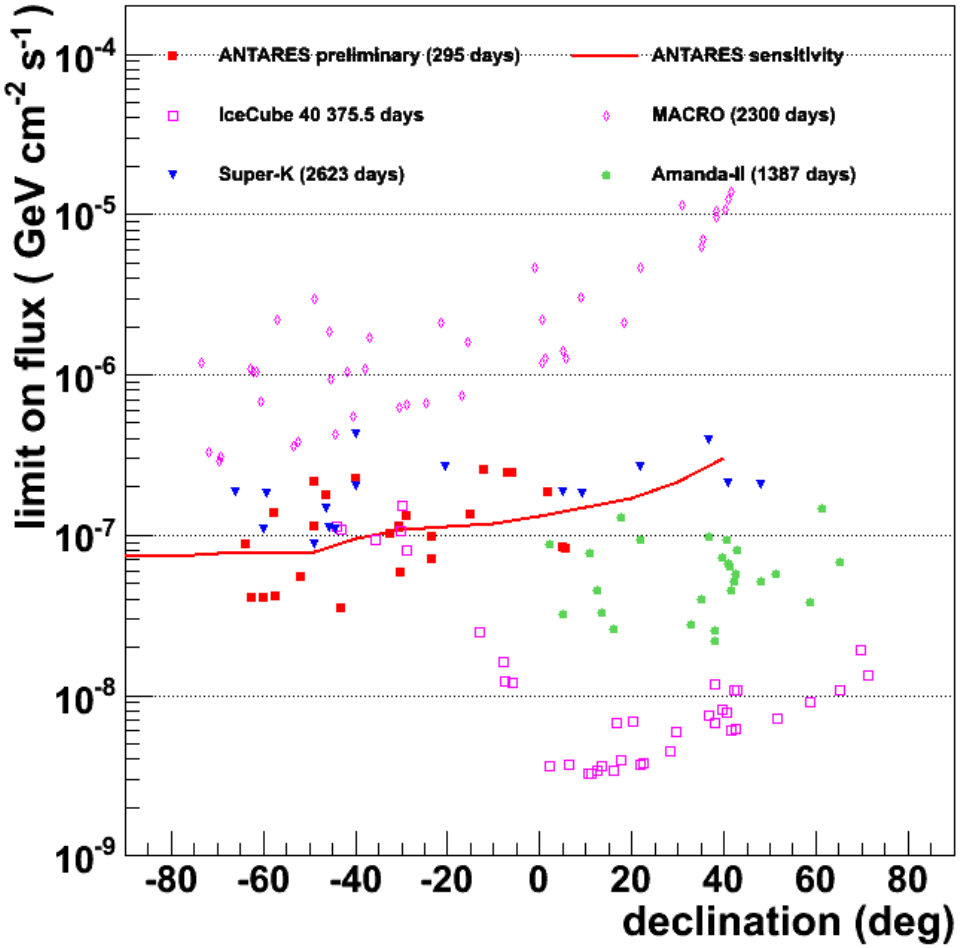
events are:
60% atm. neutrinos
40% downgoing muons, reconstructed as upgoing

source
HESS J1023-575
GX 339
RX J1713.7-3946
HESS J1837-069
1ES 0347-121
3C 279
Cir X-1
PKS 2005-489
Galactic Center
LS 5039
H 2356-309
RX J0852.0-4622
PKS 0548-322
PSR B1259-63
PKS 2155-304
HESS J1614-518
SS 433
HESS J0632+057
RCW 86
RGB J0152+017
Centaurus A
ESO 139-G12
W28
1ES 1101-232

⇒ 2 searches: all-sky (unbiased) + candidate lists

POINT SOURCES SEARCH

ANTARES: Best limits for the Southern sky !



preliminary result:

⇒ no significant signal found

⇒ limits reported for few candidate neutrino sources

* interesting gamma/X-ray sources for which models predict neutrinos

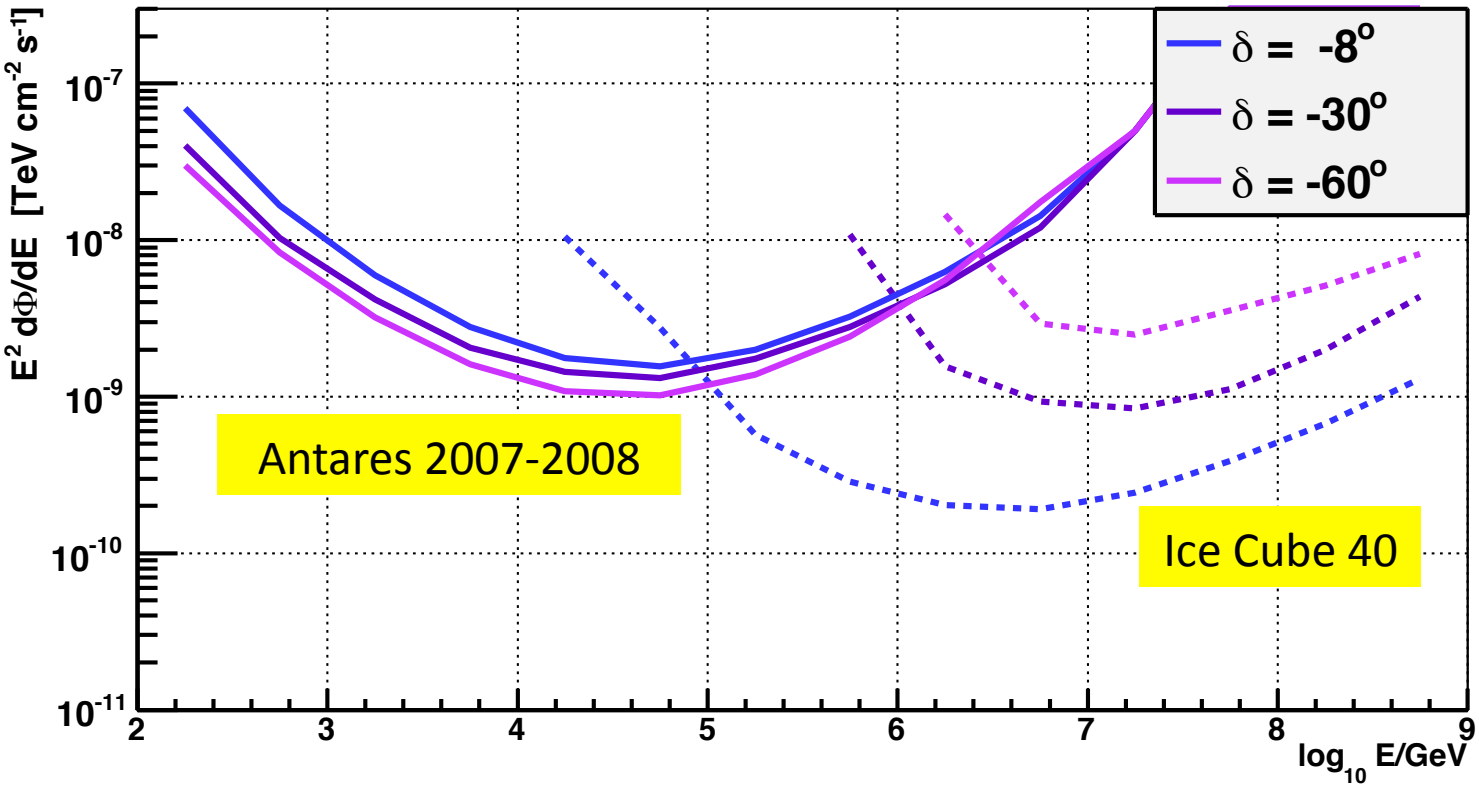
* galactic center: see no events within resolution

IceCube competitive, but energy range for decl<0 is very different.

POINT SOURCES SEARCH

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

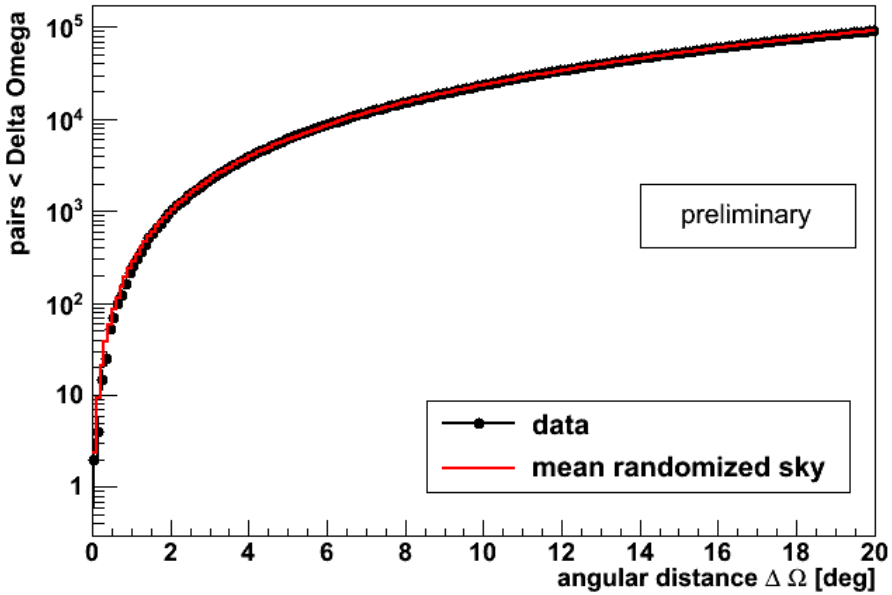


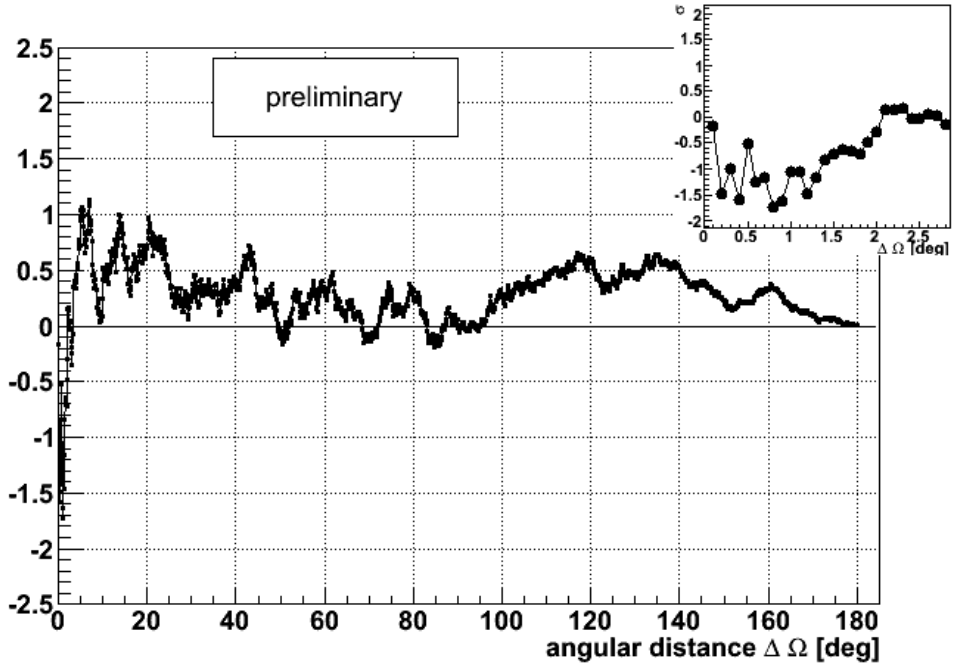
IceCube data: 375 days (2008-2009 with IC40), ~14000 atm muon in South hemisphere, ~22000 atm neutrinos in North hemisphere (C. Finley MANTS 2009)

AUTO-CORRELATION

Looking for stucture 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:

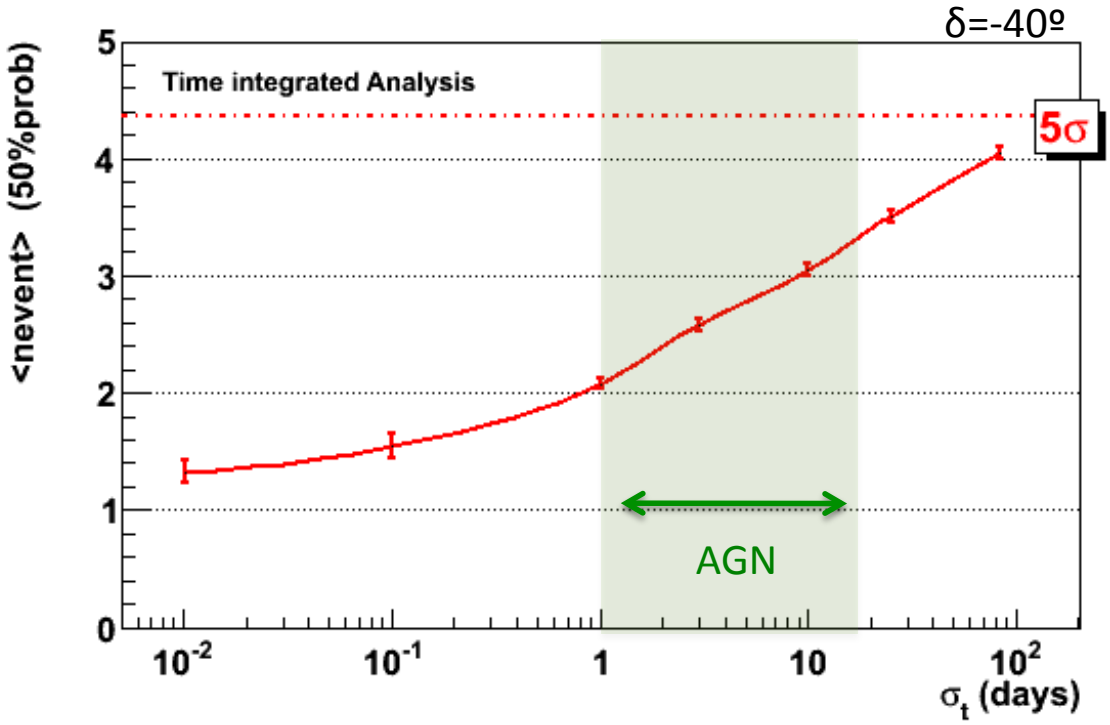
* Space-time coincidences reduce effectively the background
* Improve the discovery potential over a time integrated search.

ANTARES:

→ Time dependant likelihood method

→ Analysis of 2008 (4 months)

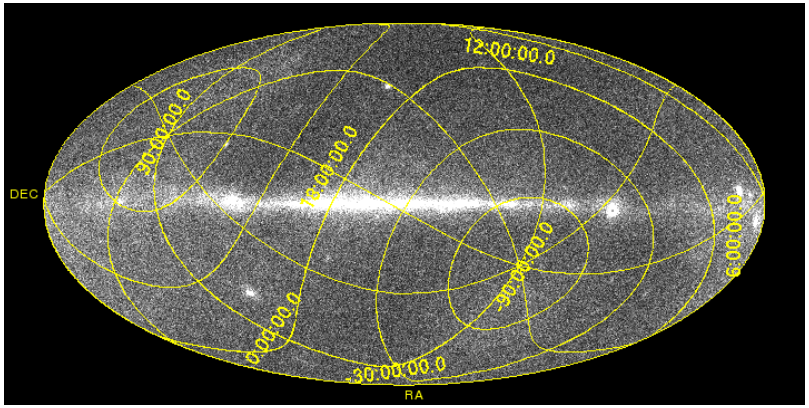
→ Performance: number of events required for a 5σ discovery (90 % C.L.)



Improvement by a factor 2-3 compared to a standard analysis

SEARCH FOR FERMI BLAZARS

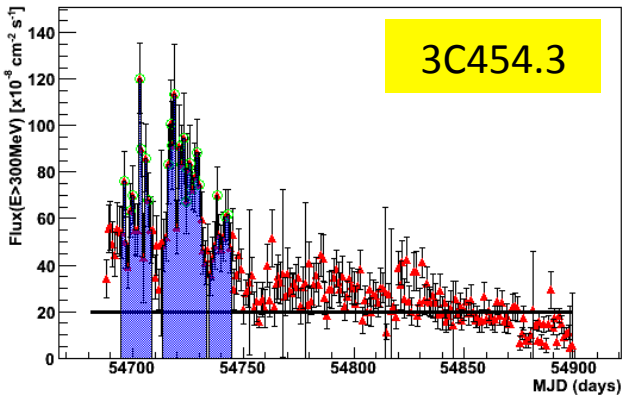
Fermi LAT data:
Many sources show important time variabilities at HE …



→ Search for signal from blazars AGN – candidate sources for UHECR
(p-γ or p-p ➔ strong correlation between γ-ray and neutrino fluxes
+ Larger photon density + Larger magnetic field => enhancement of the neutrino production)

Fermi LAT data: Identification of the flare periods on AGNs

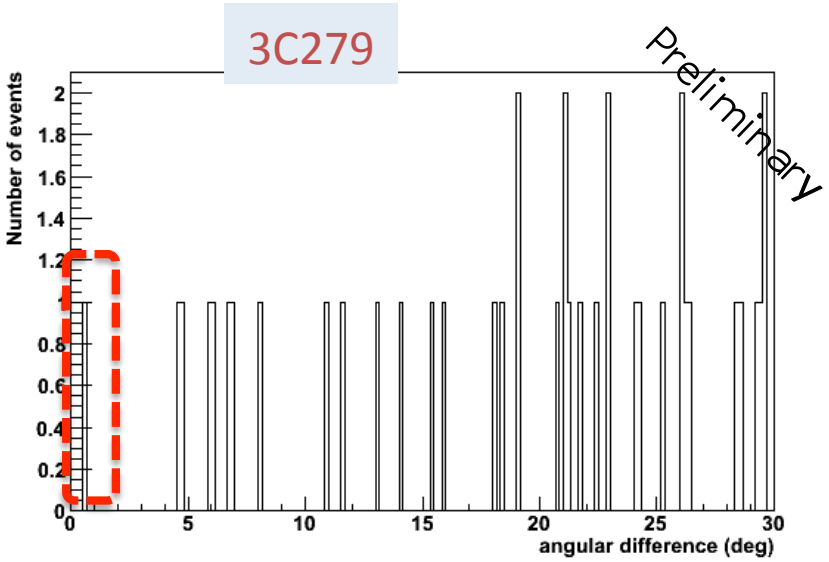
1) γ-ray sources: Variable and energetic blazars
2) 1-day binned light curve (fit files from Fermi website)
3) Flare (⇔ HE state) periods: robust and simple method
   - Extraction of a baseline + error
   - Prior: (flux-erflux)>(baseline+2*sigma) + flux > (baseline+3*sigma)
   - Duration: add consecutive points to the prior (flux-erflux)>(baseline+sigma)
     add +/- 0.5 day to each flare (1-day binned LC + uncertainties models)

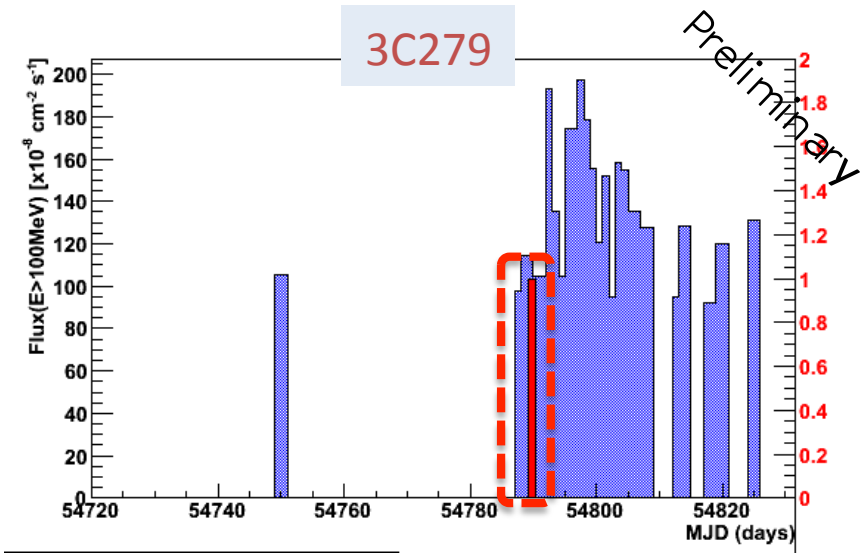


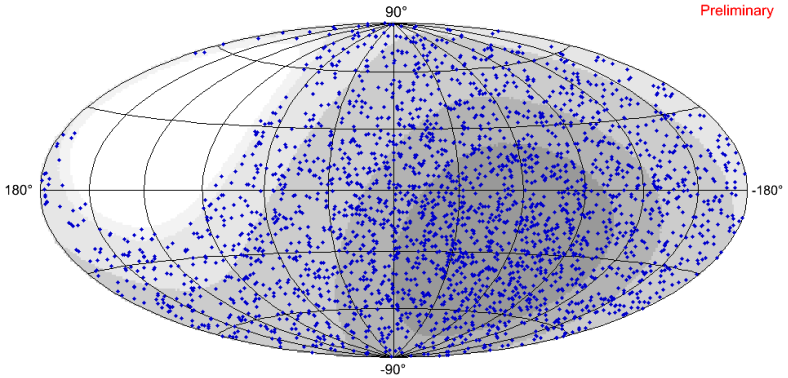
SEARCH FOR FERMI BLAZARS

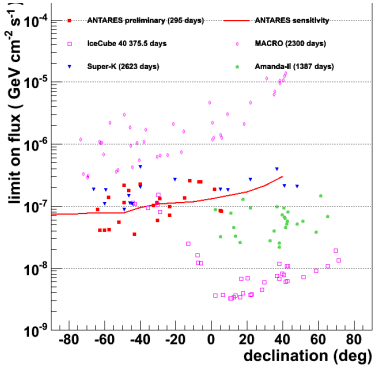
Analysis of 10 bright and variable Fermi LAT sources in 2008 data (61 days):
PKS0208-512, AO0235+164, PKS1510-089, 3C273, 3C279, 3C454.3, OJ287, PKS0454-234, WComae, PKS2155-304

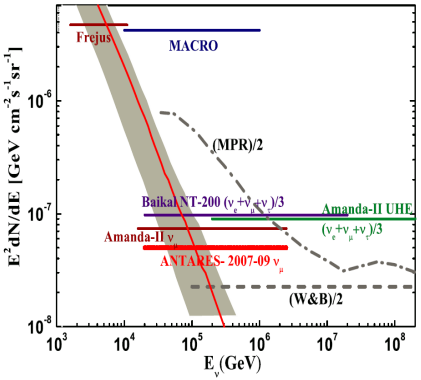
=> 1 neutrino compatible with the time/space distribution ($\Delta\alpha=0.56^{o}$) of 3C279 with probability 10 % after trials

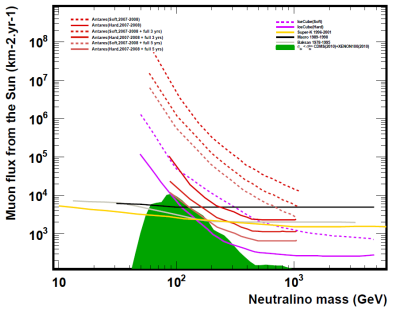


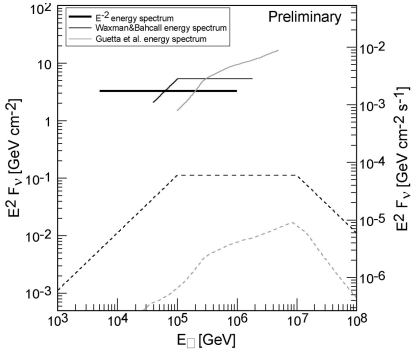


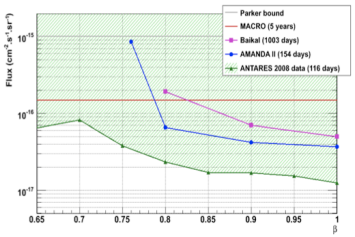


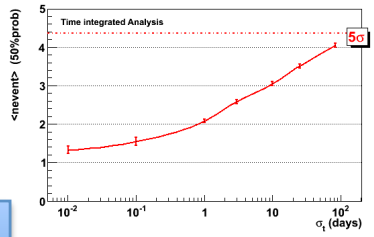












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Summary

- **ANTARES complete since 2008**

Largest ν 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…