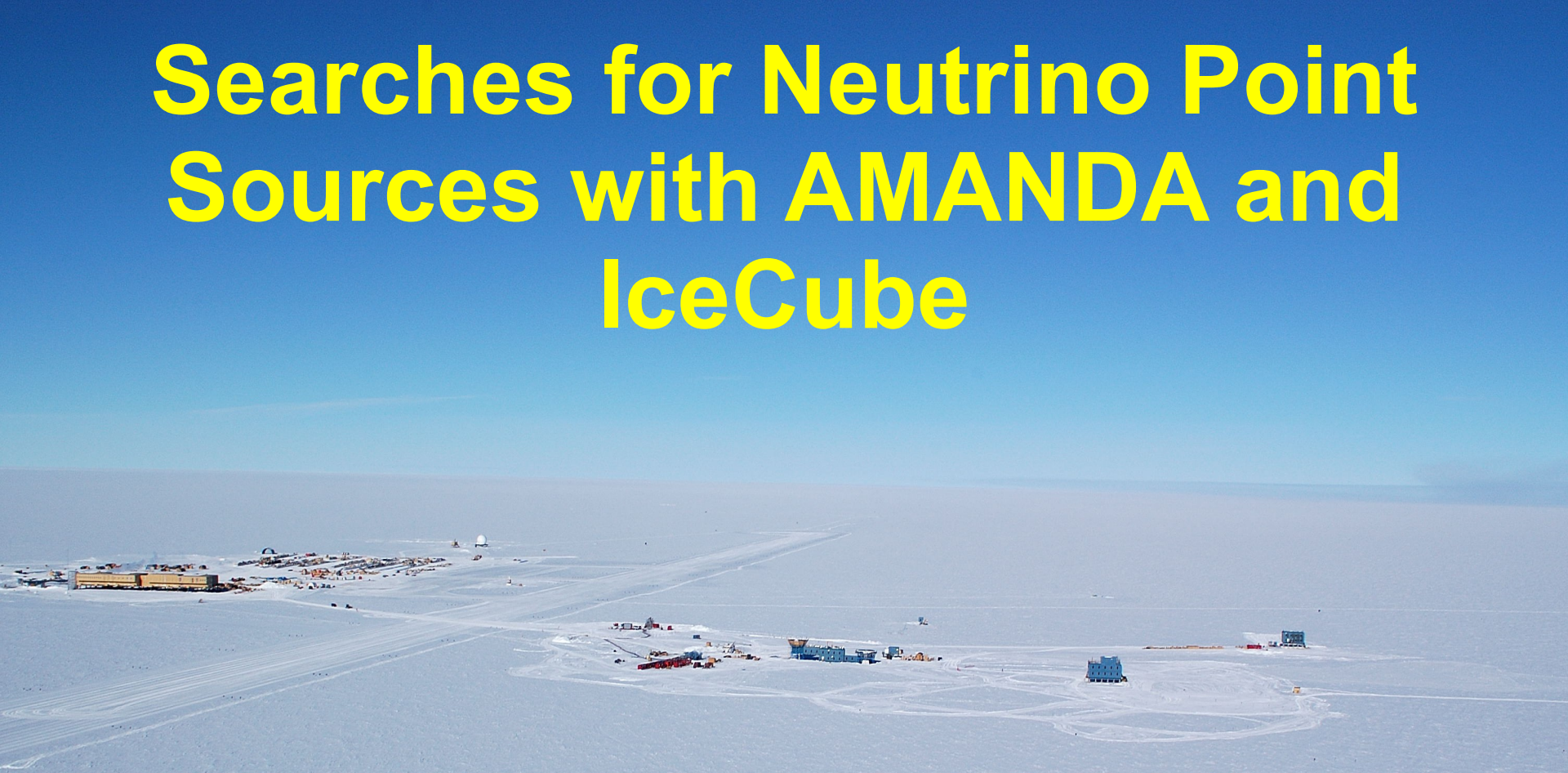
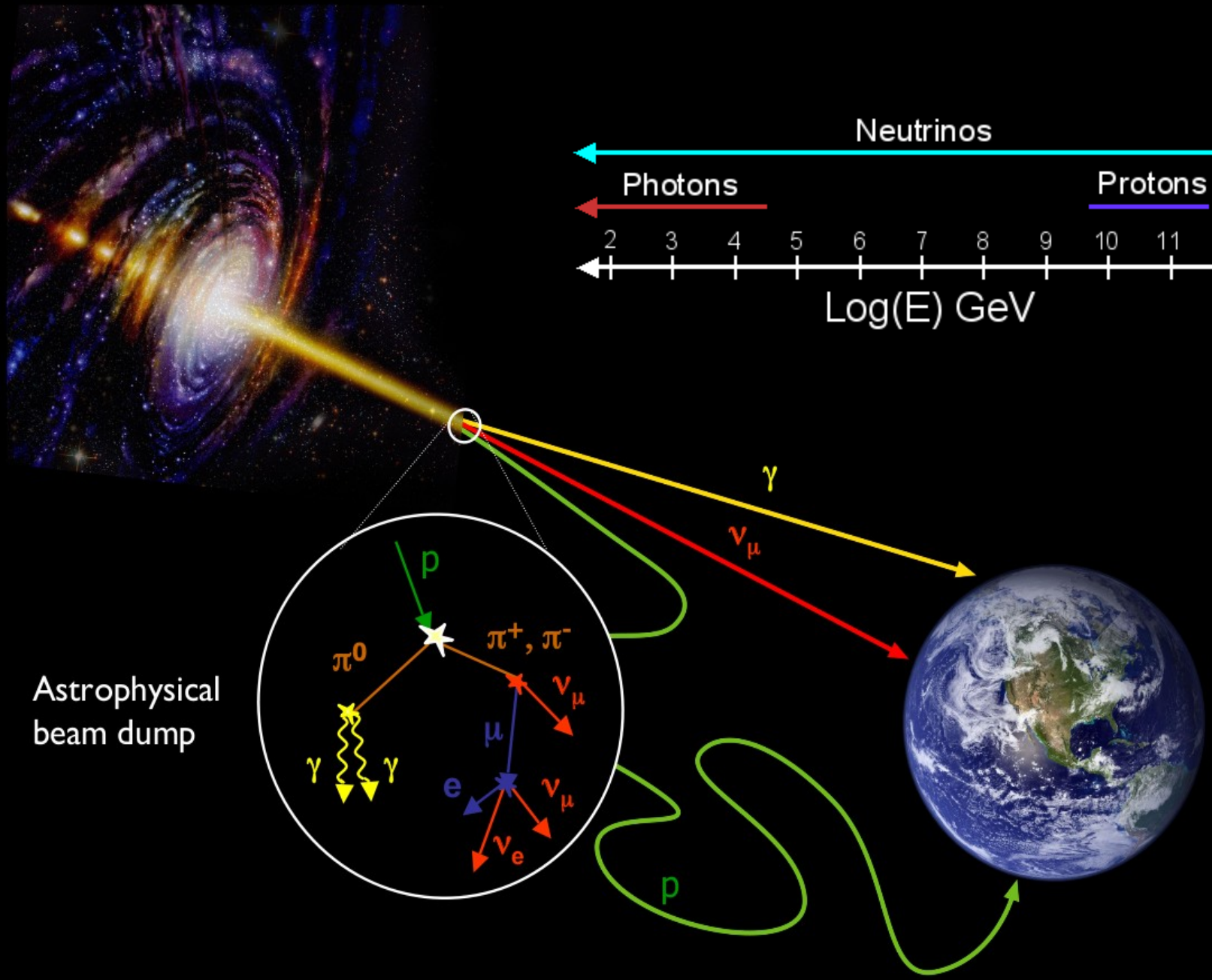
Searches for Neutrino Point Sources with AMANDA and IceCube



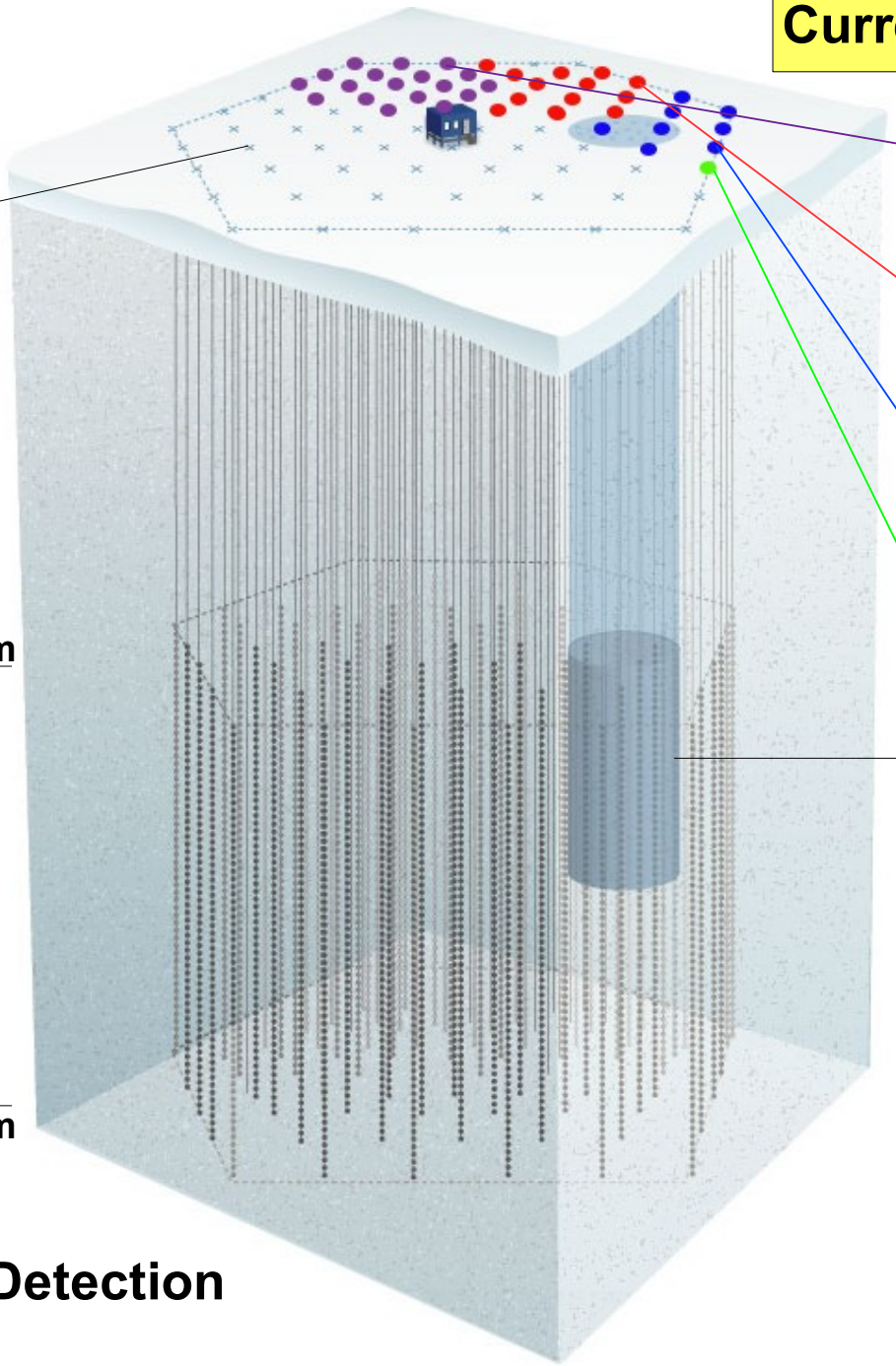
Jim Braun
IceCube Collaboration
University of Wisconsin – Madison, USA

Astronomical Messengers



IceCube

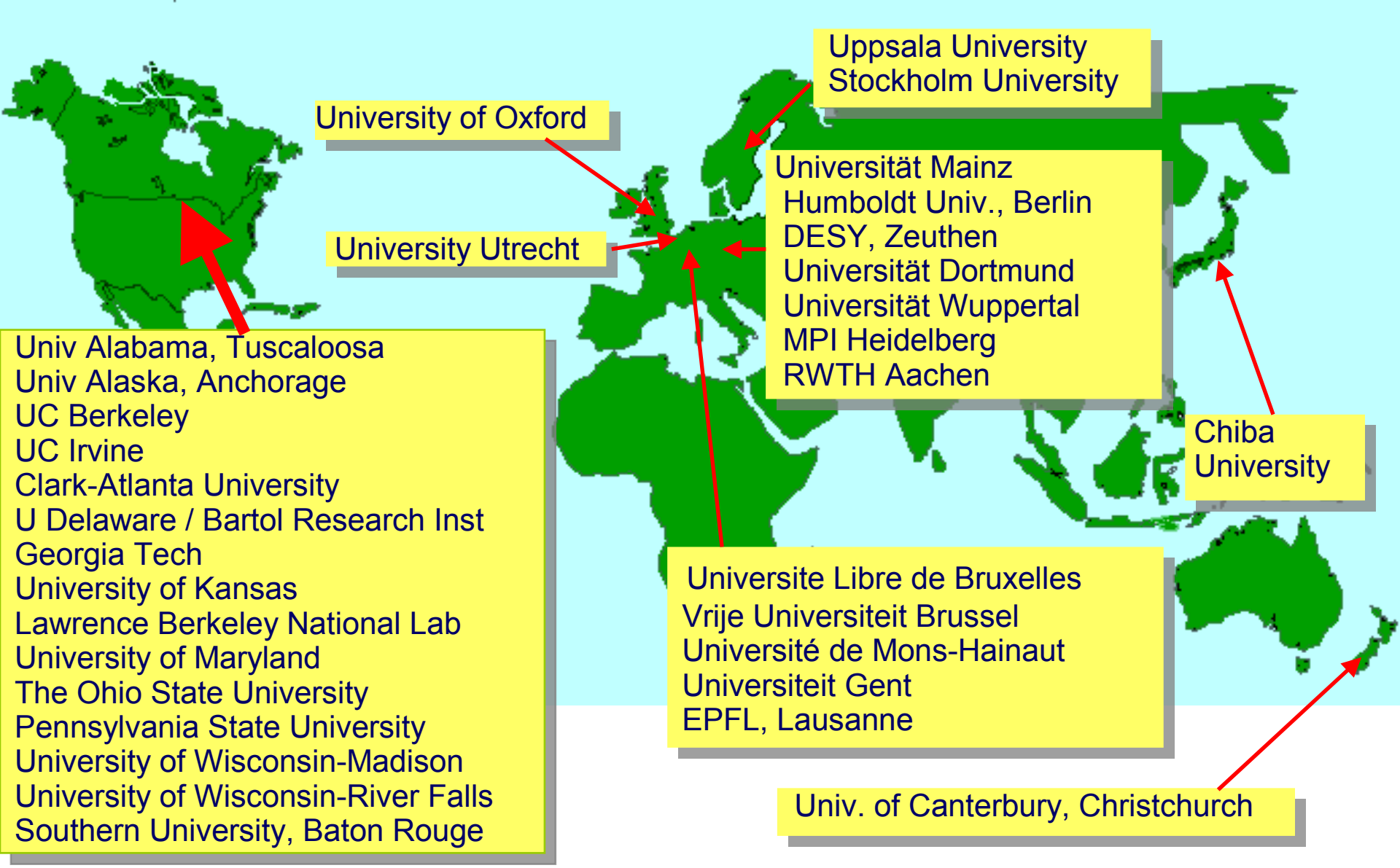
Currently 40 Strings



In-Ice Array

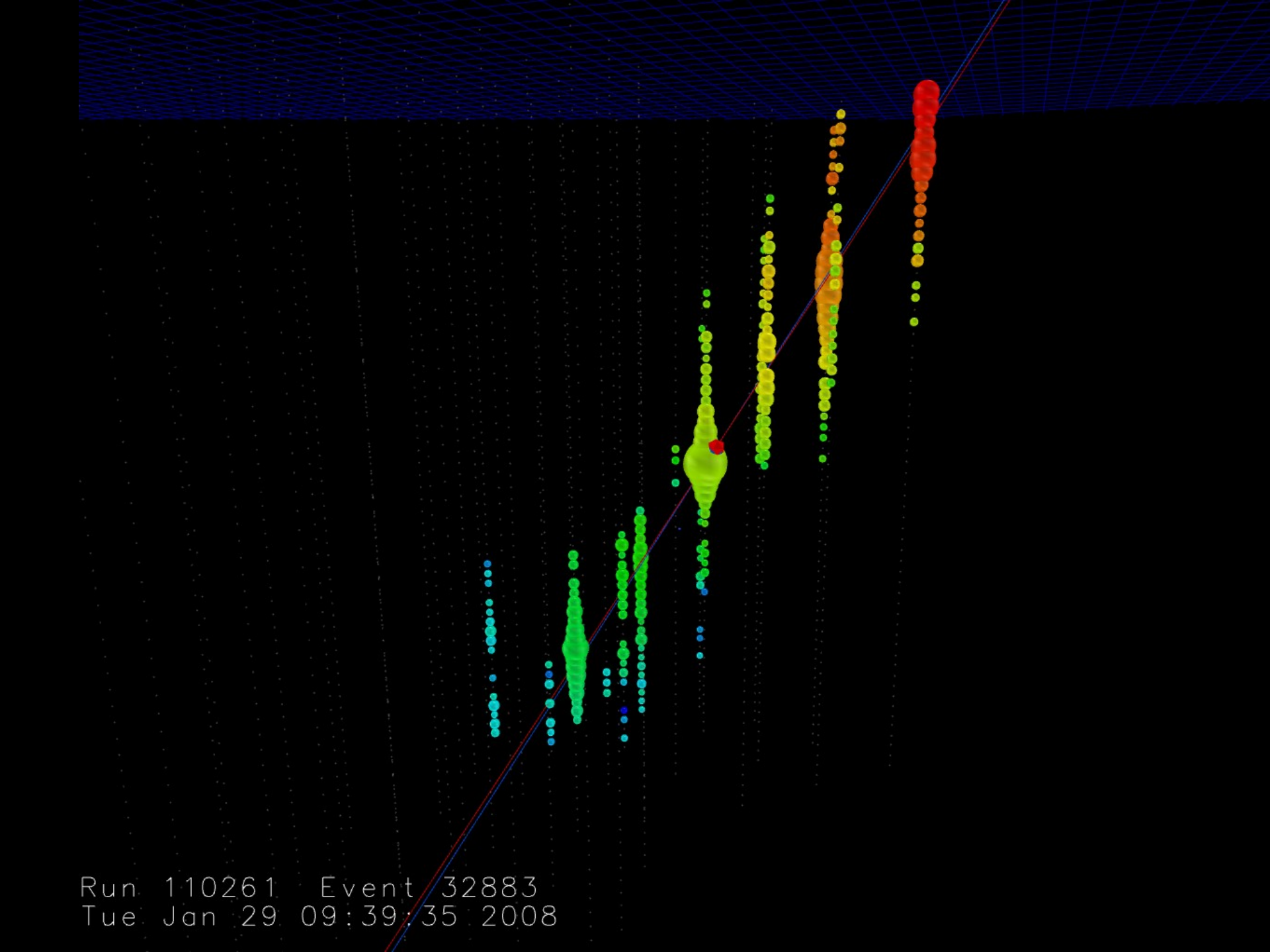
80 Strings
60 Modlues
17 m between modules

Optical Cherenkov Detection

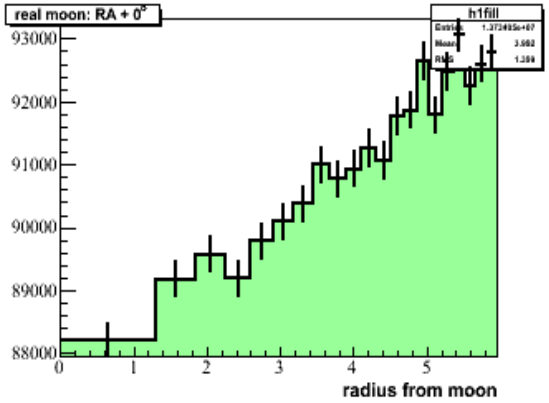


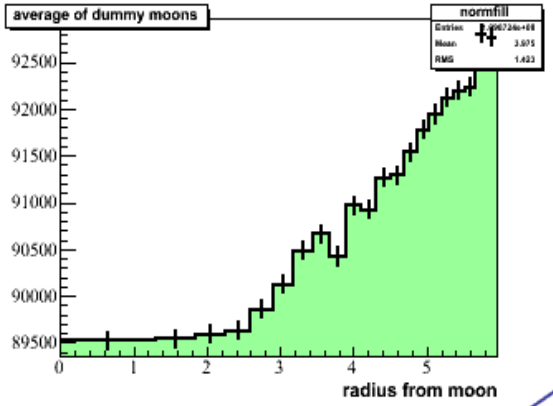
The IceCube Collaboration

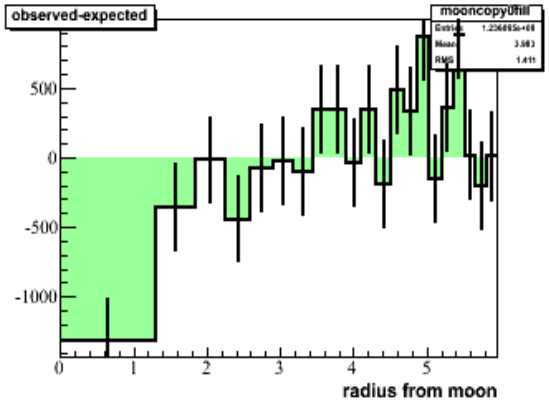
32 Institutions, ~250 members

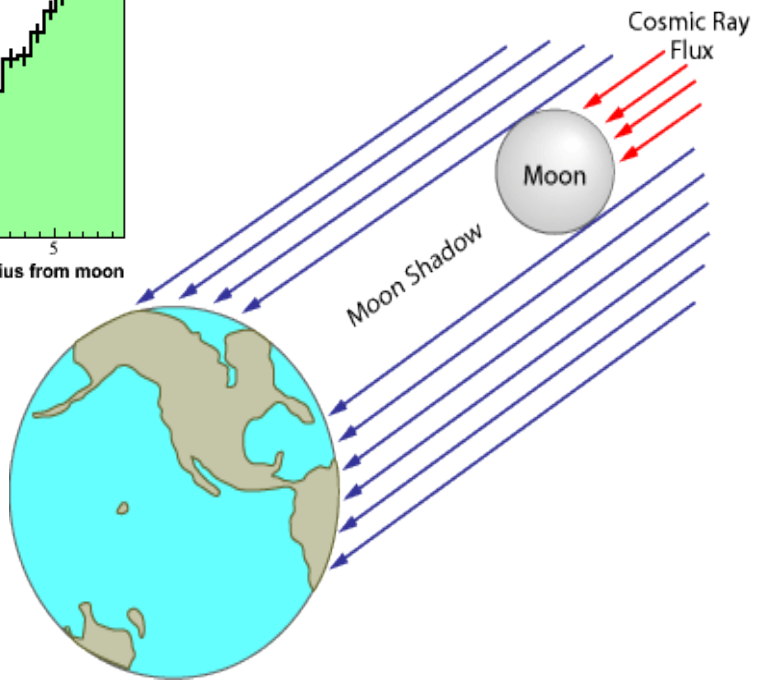

Run 110261 Event 32883
Tue Jan 29 09:39:35 2008

Moon Shadow





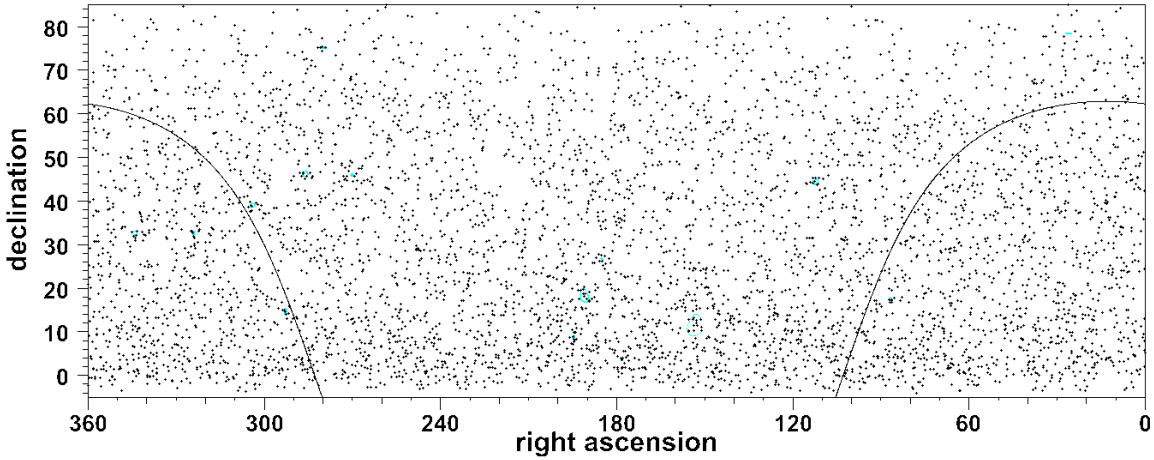




4.2σ deficit of events from direction of moon in the IceCube 40-string detector (3 months of data) confirms pointing accuracy

Calibration with moon ~monthly with completed IceCube detector

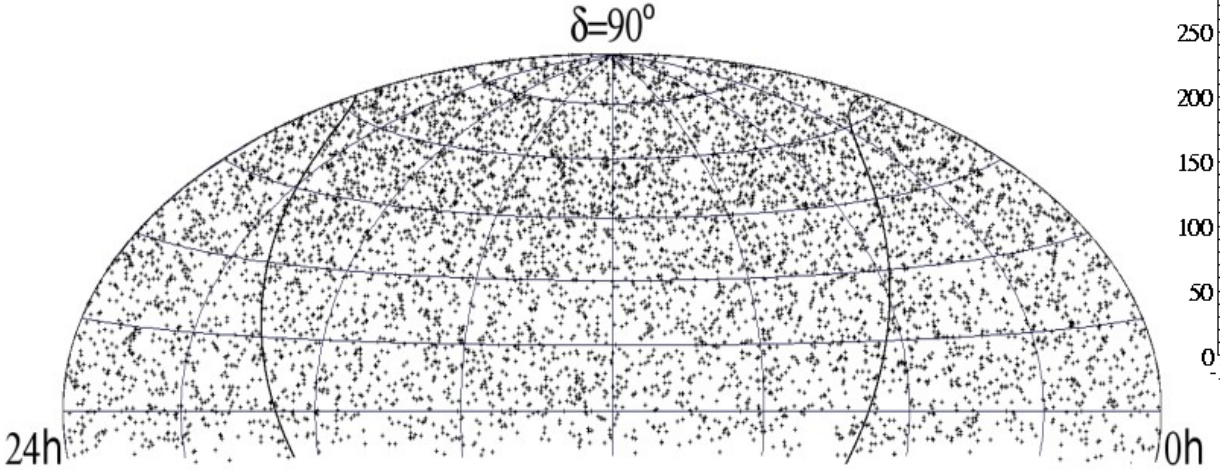
Upgoing Events

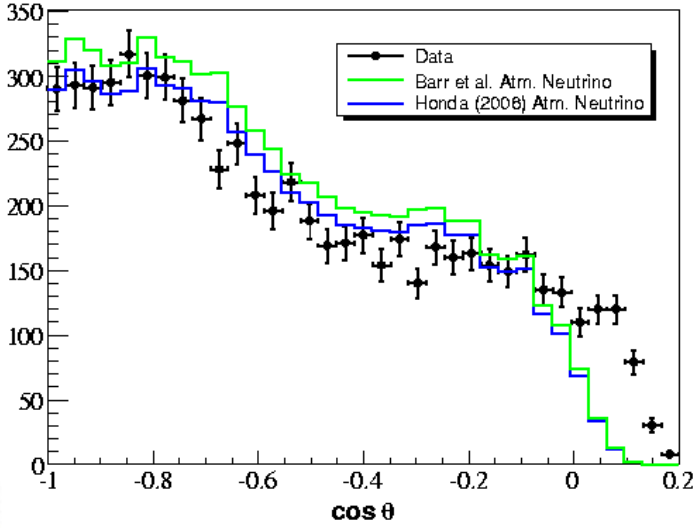


IceCube 22 String:

5114 neutrino candidates
in 276 days livetime

AMANDA: 6595 ν candidates in 3.8 live-years

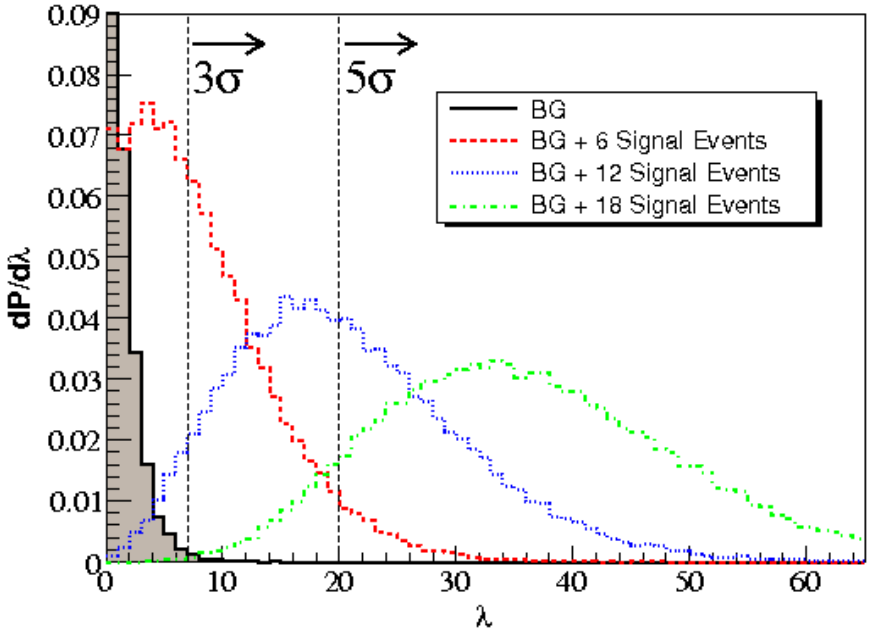


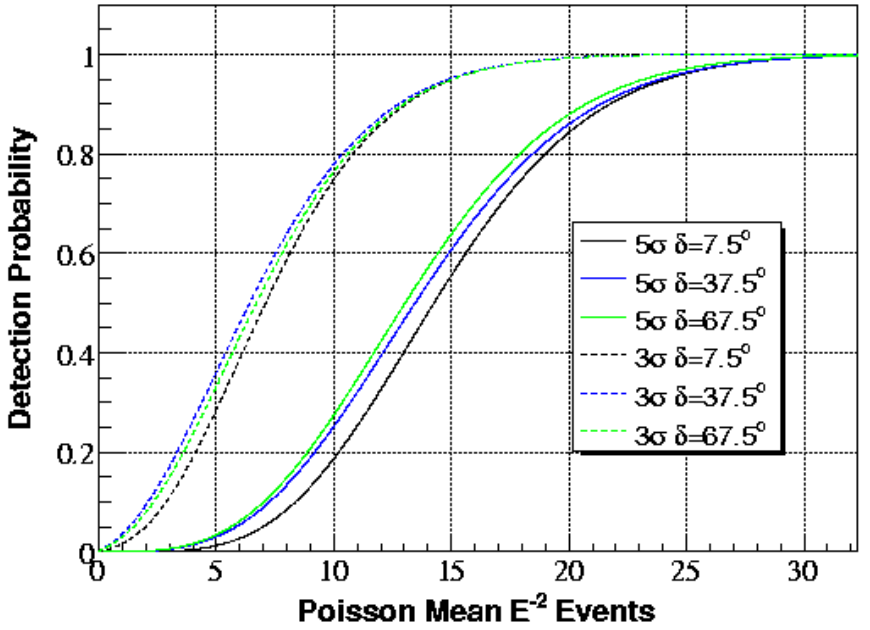


Search for Extraterrestrial Neutrinos

- Use unbinned maximum-likelihood search method
  - Incorporate event angular resolution and event energy estimate

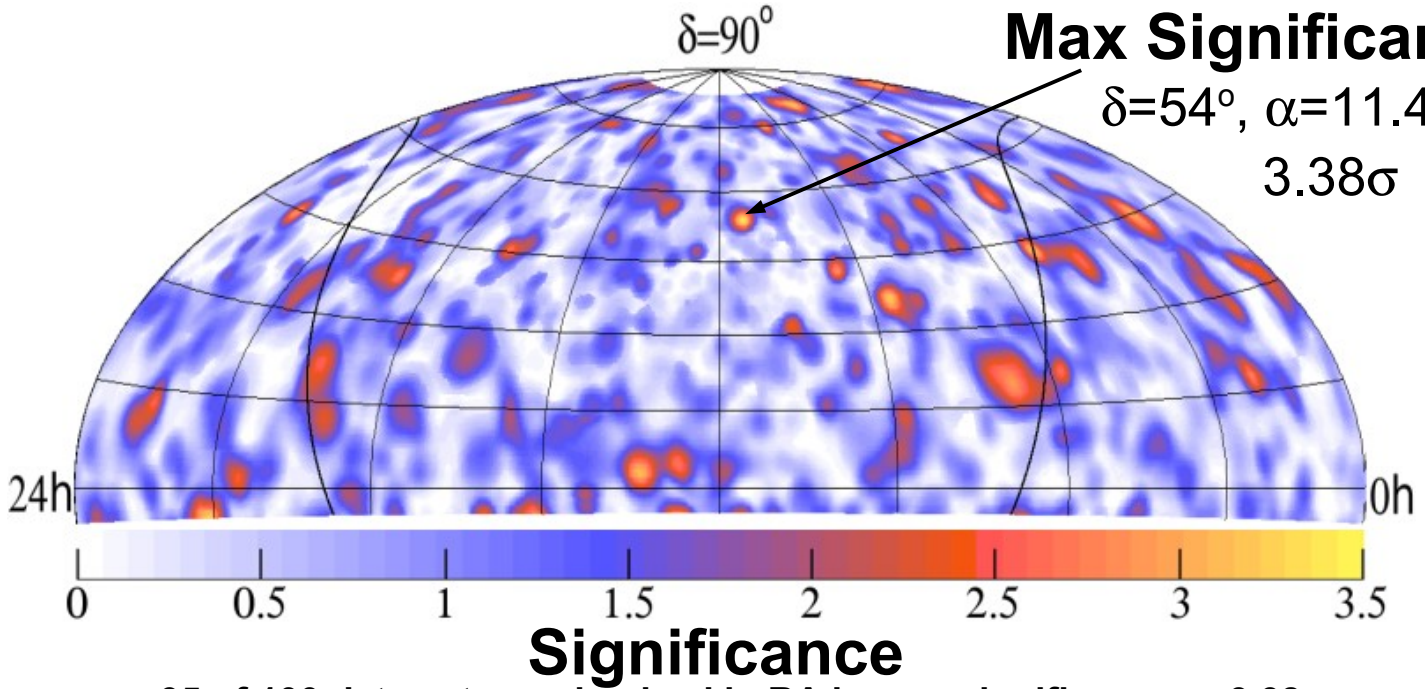
$$\mathcal{L}(\vec{x}_s, n_s, \gamma) = \prod_{i=1}^{N} \left(\frac{n_s}{N} \mathcal{S}_i + (1 - \frac{n_s}{N}) \mathcal{B}_i \right) \qquad \lambda = -2 \cdot sign(\hat{n}_s) \cdot log \left[\frac{\mathcal{L}(\vec{x}_s, 0)}{\mathcal{L}(\vec{x}_s, \hat{n}_s, \hat{\gamma})} \right]$$





Astropart. Phys. **29**, 299 (2008)

AMANDA All-Sky Search



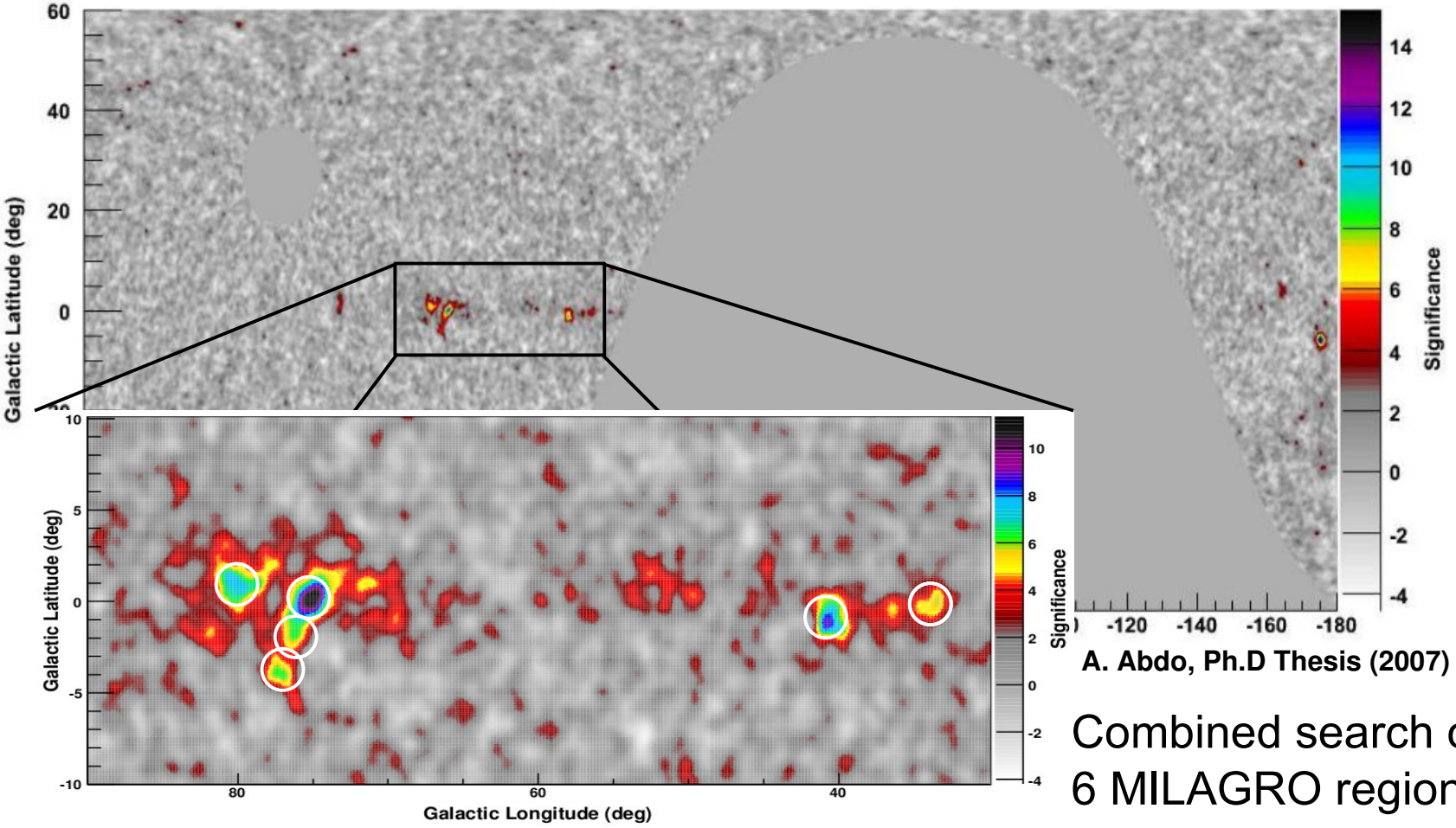
95 of 100 data sets randomized in RA have a significance ≥ 3.38σ

Source	μ_{90}	P-value
Crab	9.27	0.10
MGRO J2019+37	9.67	0.077
Mrk 421	2.54	0.82
Mrk 501	7.28	0.22
LS I +61 303	14.74	0.03
Geminga	12.77	0.0086

$E^2\Phi < \mu 90 * 10^{-11}$ TeV cm^{-2} s^{-1}

The probability of obtaining p ≤ 0.0086 for at least one of the 26 sources is 20%

AMANDA Milagro Stacking Search

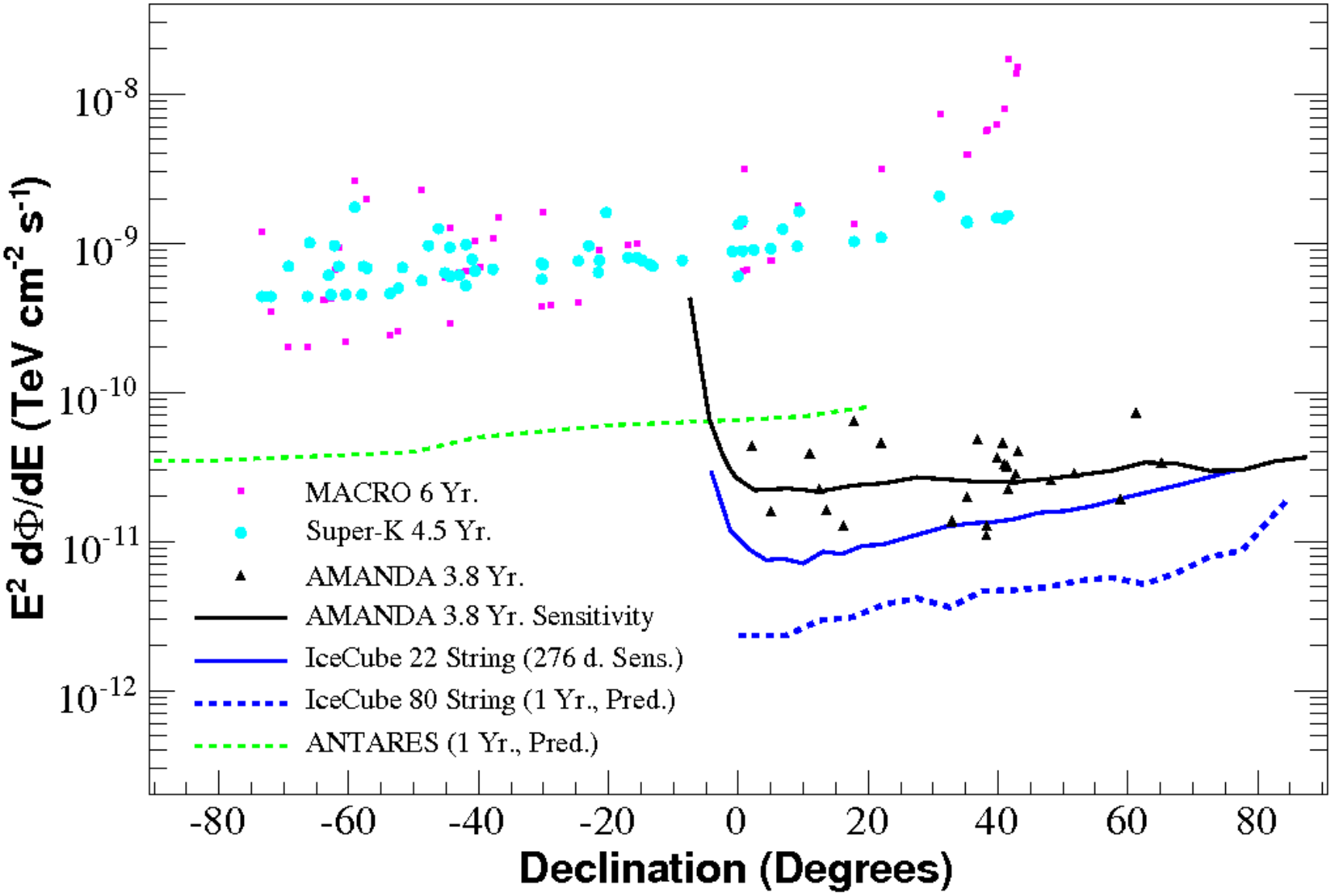


Combined search over 6 MILAGRO regions

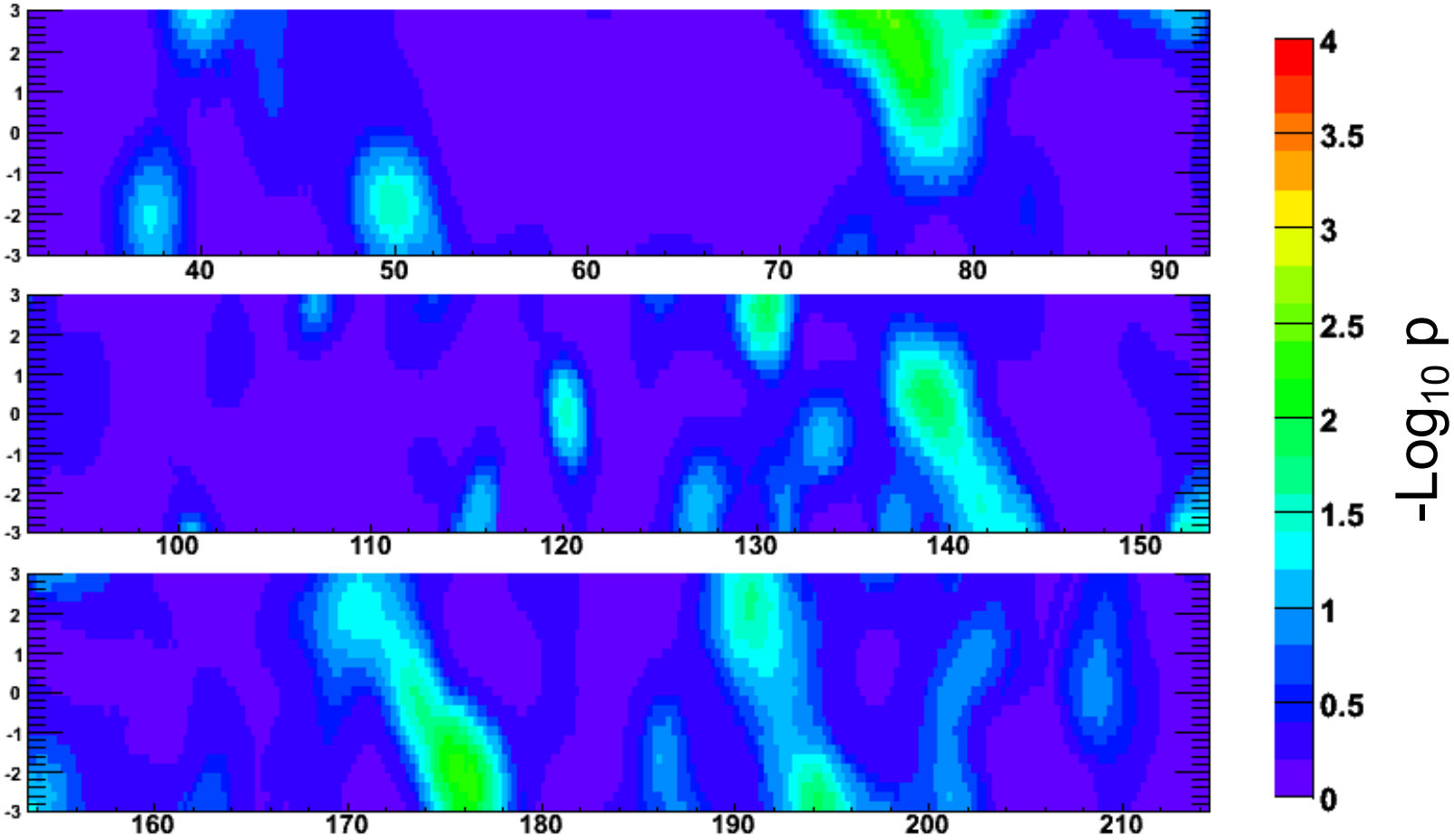
Improves per-source flux sensitivity and discovery potential by a factor of 4 compared to a fixed-point search for any of the six sources

AMANDA: Minor upward fluctuation (p = 20%)

Experimental Limits



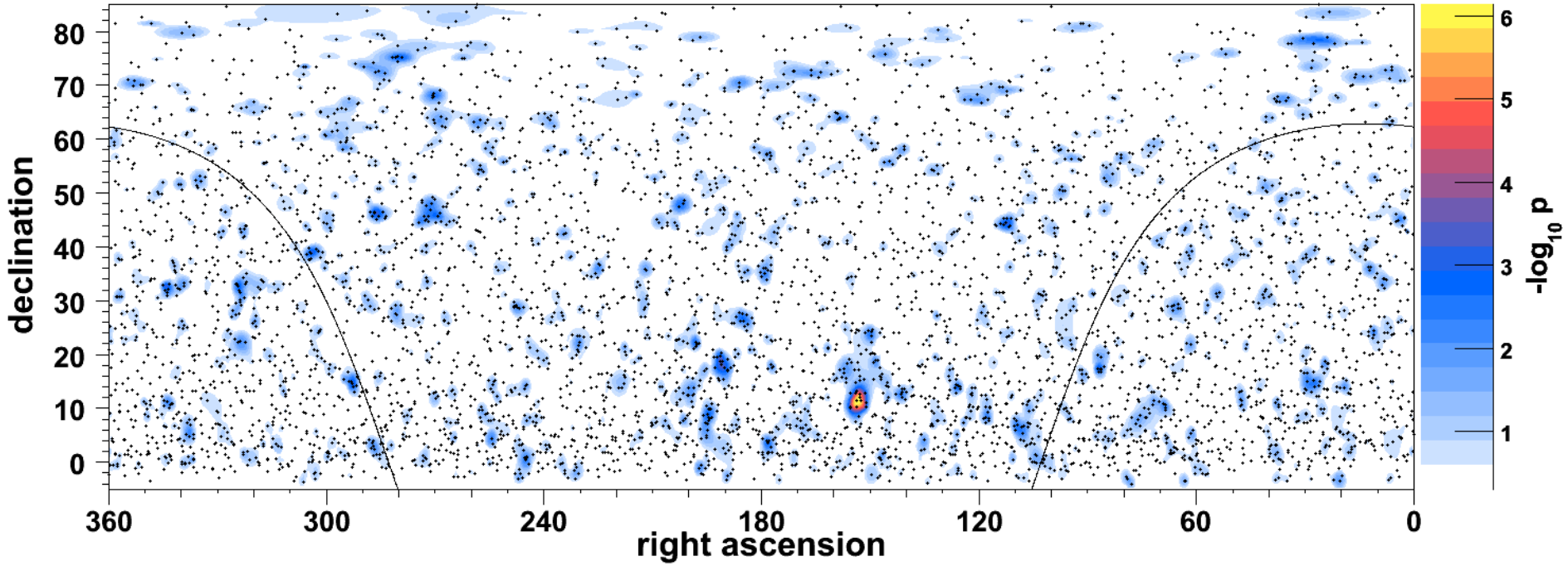
Search of the Galactic Plane with IceCube-22 + AMANDA



Optimized for low energy

No significant excess observed

IceCube 22 String

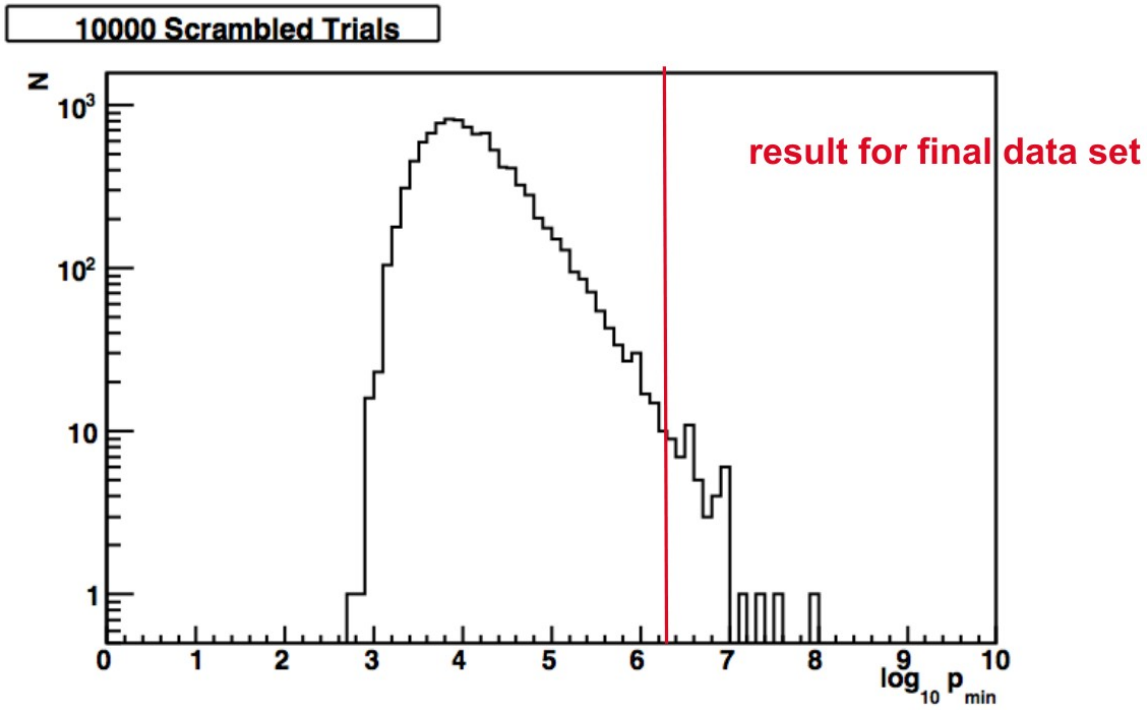


Hottest spot found at r.a. 153º , dec. 11º
pre-trial p-value: $7 \cdot 10^{-7}$ (4.8 sigma)
est. nSrcEvents = 7.7 est. gamma = 1.65

Accounting for all trials, p-value for analysis is 1.34% (2.2 sigma).

At this significance level, consistent with fluctuation of background.

IceCube 22 String

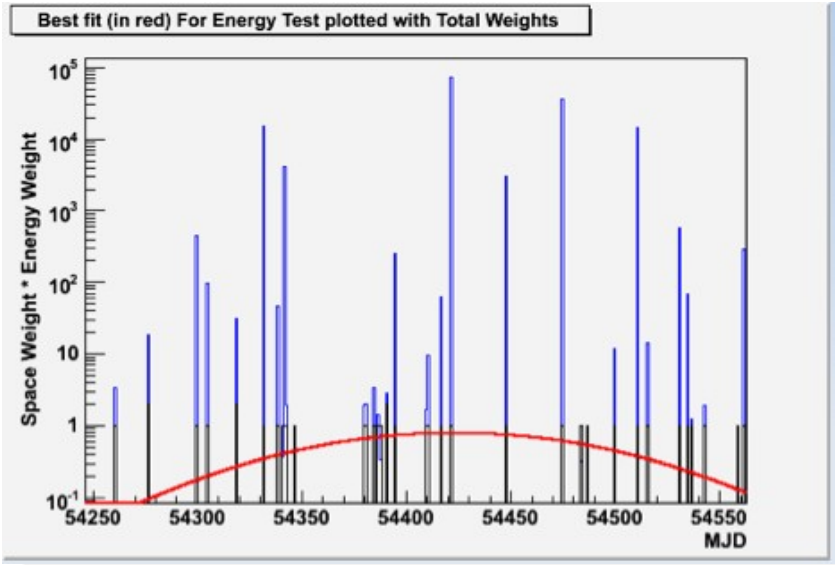


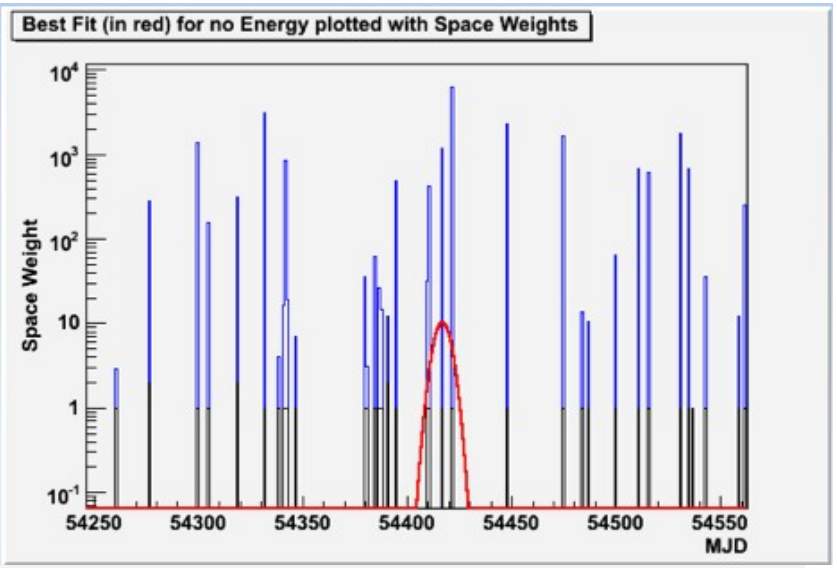
Out of 10,000 trials of scrambled data sets, 67 (0.67%) have a test-statistic (max llhRatio or p-value of hottest spot) more significant than that found in the data.

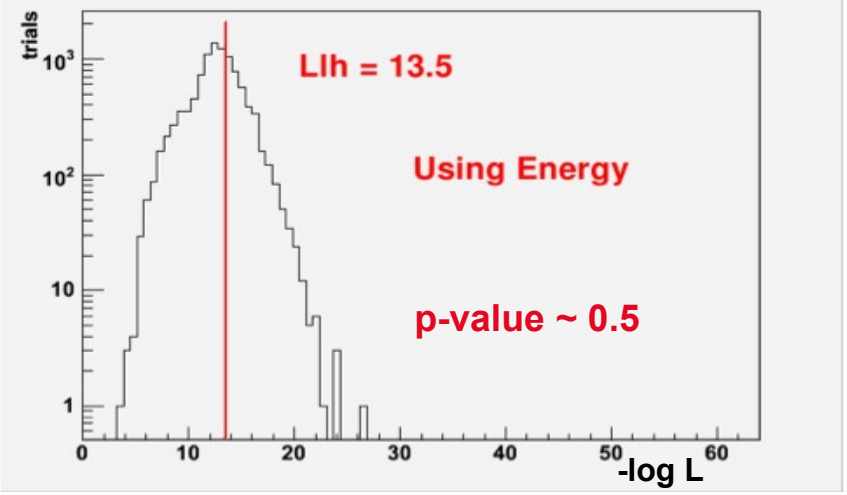
Including trial factor of two since the analysis with the a priori list was also performed, the **post-trials p-value is ~ 1.34%.**

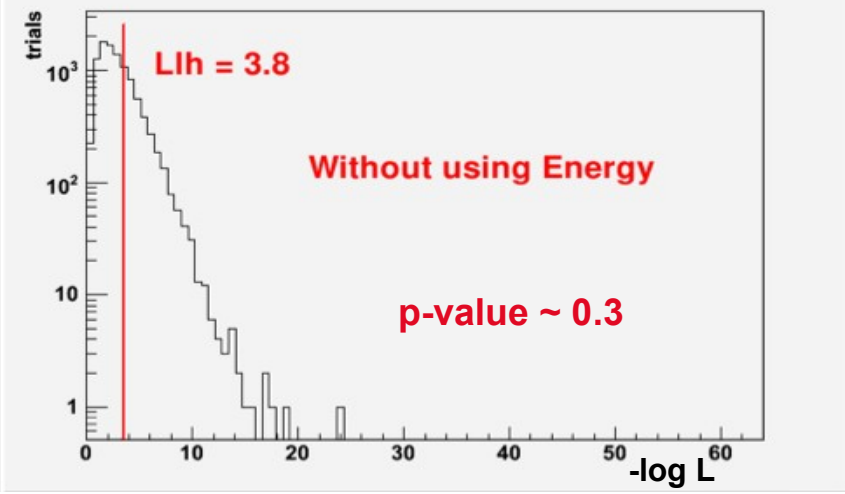
Future IceCube data will test the possibility that the hotspot is a source unless it is a **one-time occurrence**.

Time Analysis of Hotspot









- None of the events contributing most strongly to the hotspot are closer together than 10 days. Events are distributed roughly evenly in time over the year.
- Neither analysis finds any significant single cluster of events in time.

Conclusions

- New methodology and increasing detector size are improving the current neutrino point source sensitivity
- No evidence of neutrino point sources observed by AMANDA in 3.8 years of livetime.
- The hotspot observed by IceCube-22 will be tested with data from IceCube-40