Recent IceCube Results

Josh Wood for the IceCube Collaboration

TeVPA 2018, August 27

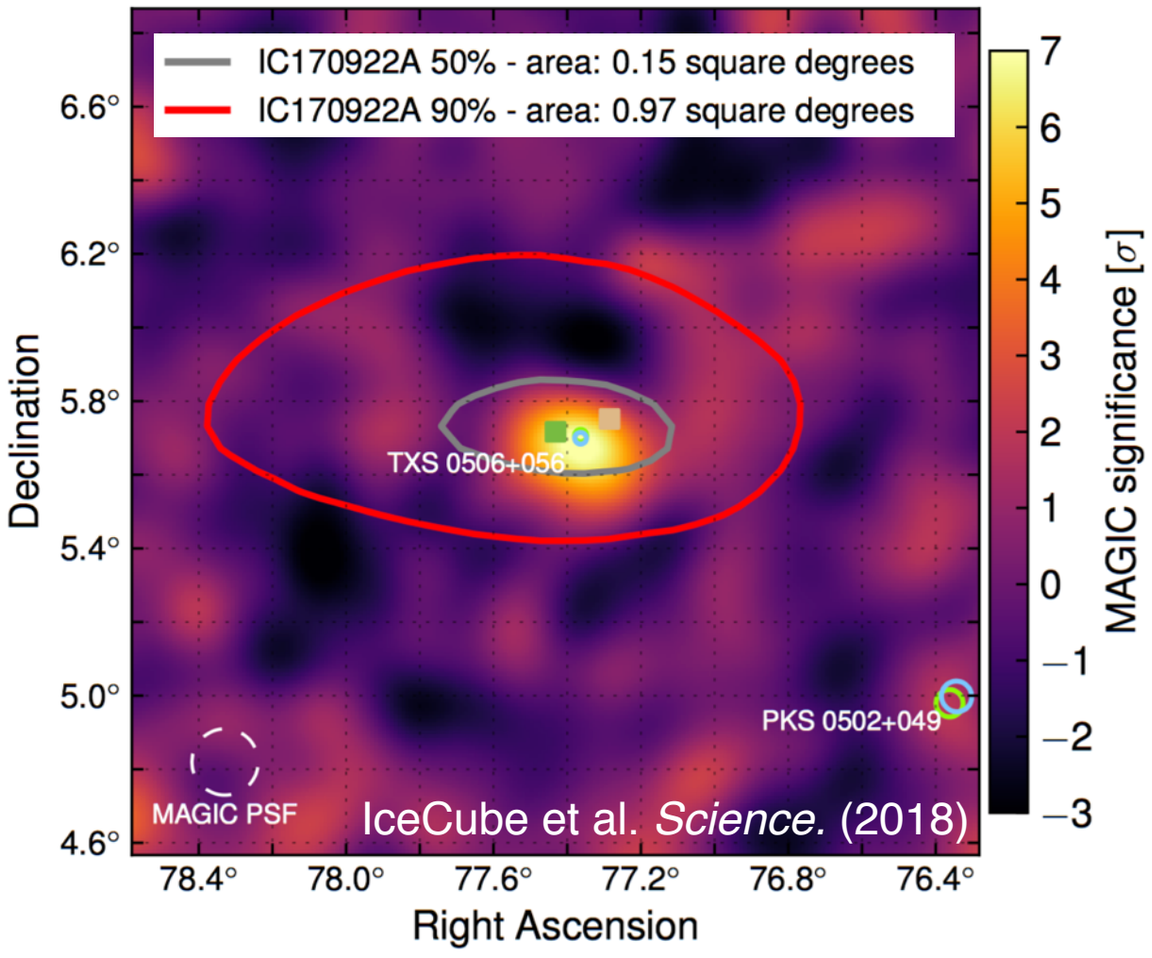
IceCube

WISCONSIN
UNIVERSITY OF WISCONSIN–MADISON

Photo: Martin Wolf

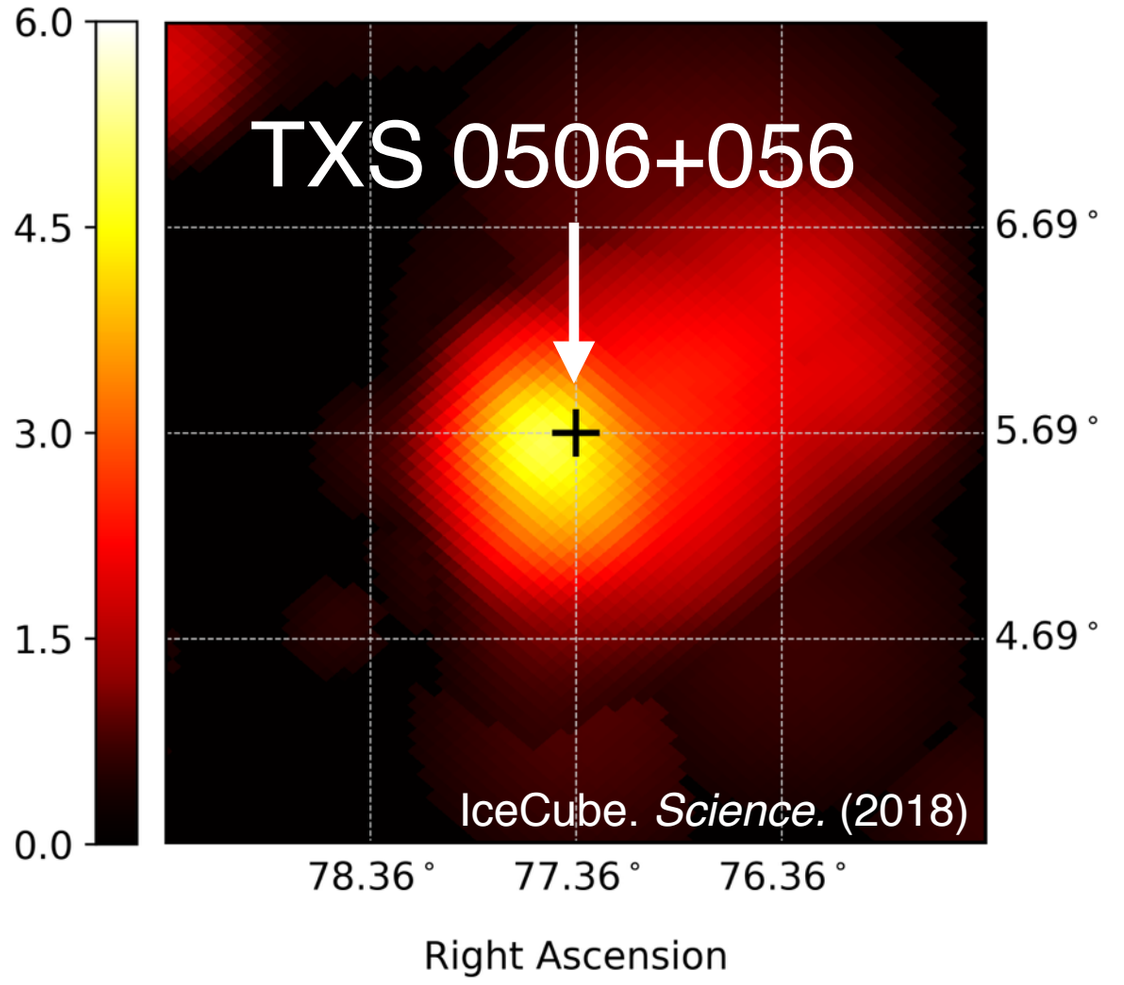
What to Remember: **TXS 0506+056**

First identified source of very high energy neutrinos!



~300 TeV neutrino coincident with gamma-ray flare up to 400 GeV

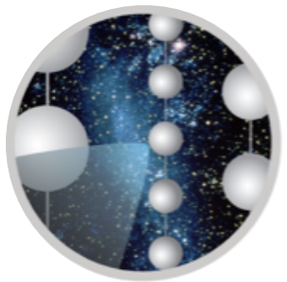
A.Franckowiak
(Nu.Astro. 2:20pm 8/27)



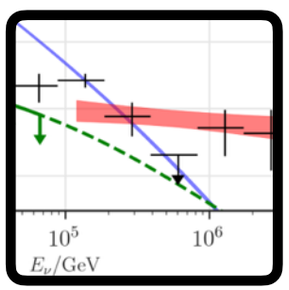
Independent neutrino flare identified during 2014-2015

I.Al Samarai
(Nu.Astro. 2:50pm 8/27)

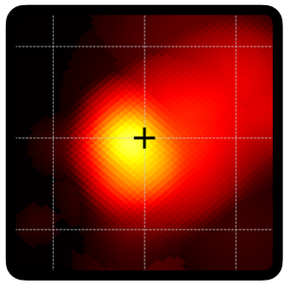
Overview



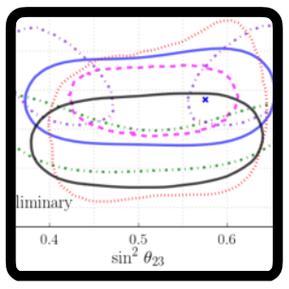
IceCube Neutrino Observatory



Astro. ν Flux Measurements



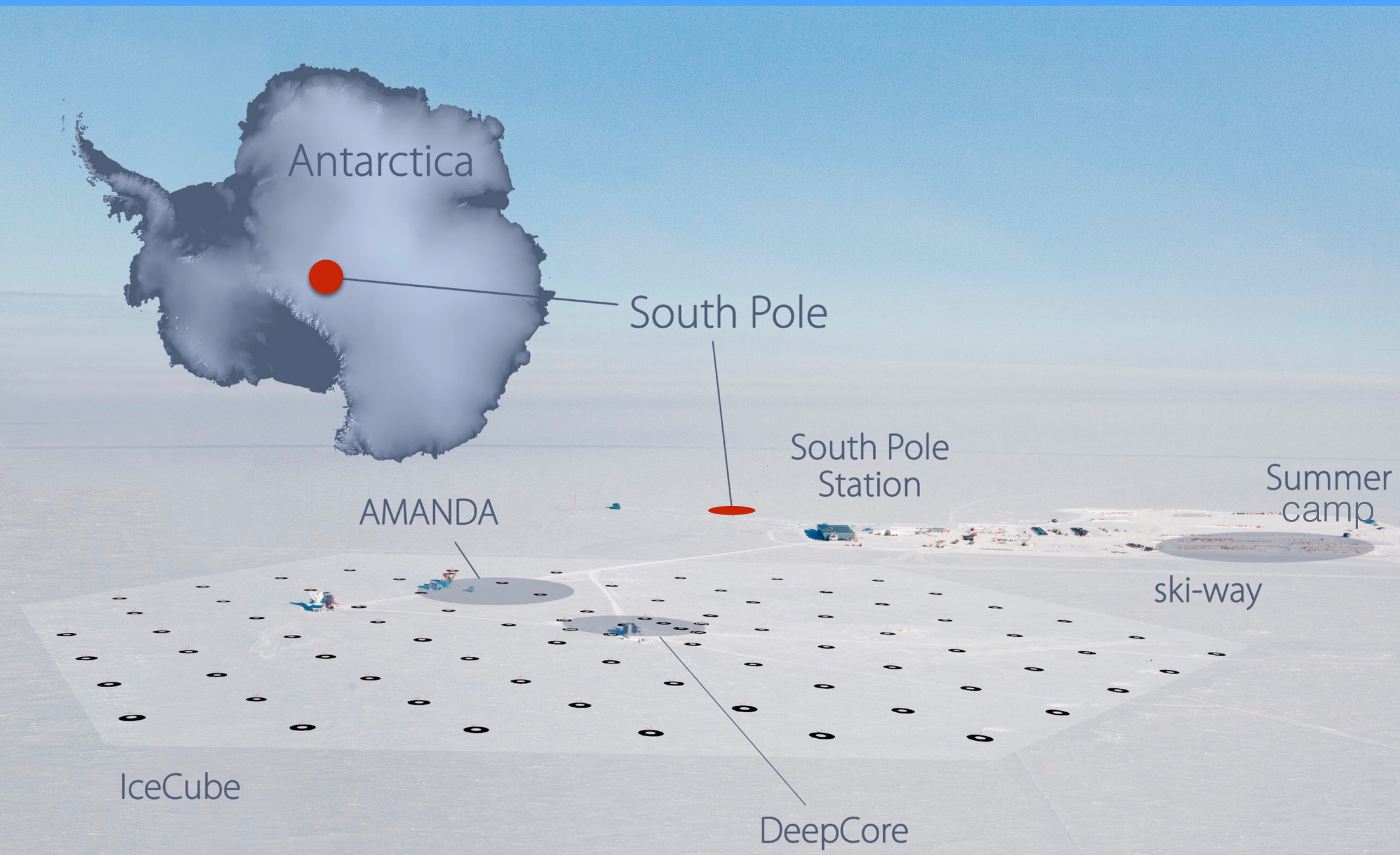
Searches for sources



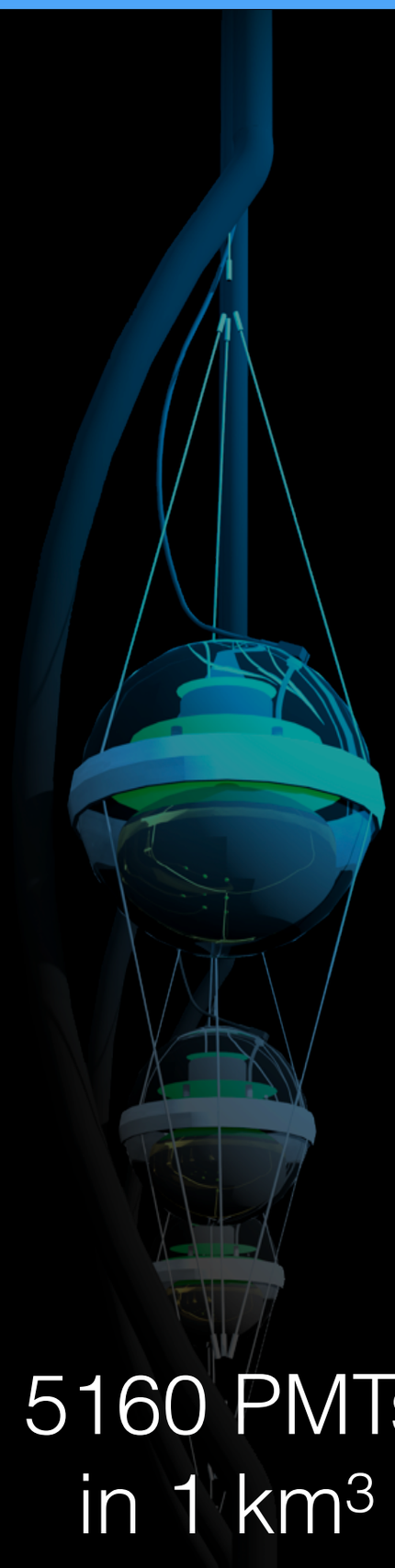
Additional Topics

Summary

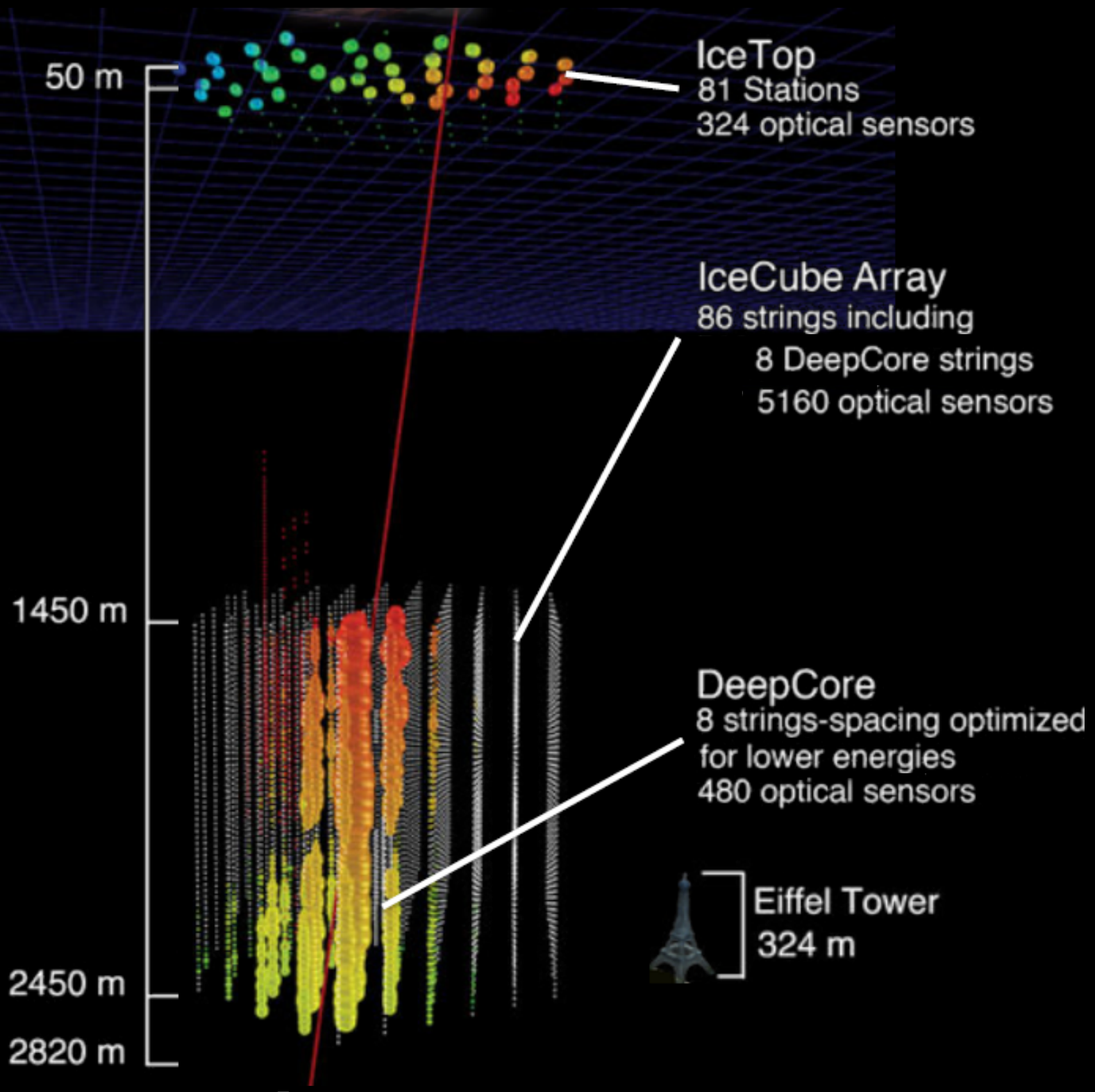
IceCube Neutrino Observatory



IceCube Neutrino Observatory

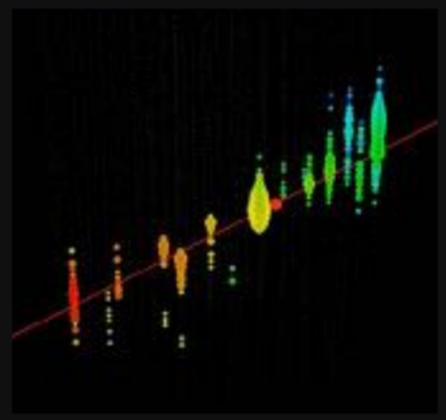


5160 PMTs
in 1 km^3



Event Topologies

Charged Current (CC) Muon Neutrino



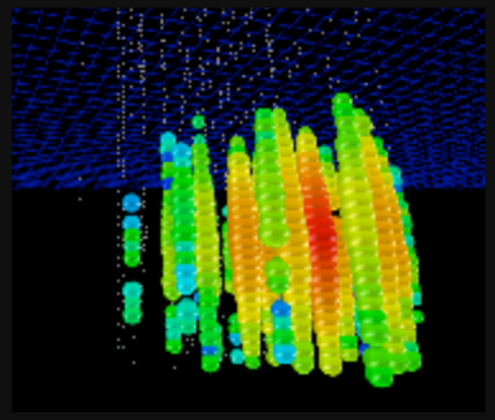
$$\nu_\mu + N \rightarrow \mu + X$$

track (data)

factor of ≈ 2 energy resolution
< 1° angular resolution

~70,000 $\nu\mu$ tracks/yr
above 0.2 TeV

Neutral Current / CC Electron Neutrino



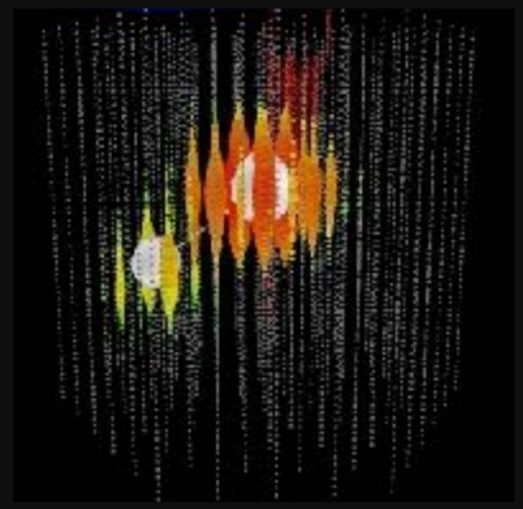
$$\nu_{\mathrm{e}} + N \rightarrow \mathrm{e} \ + X$$
$$\nu_{\mathrm{x}} + N \rightarrow \nu_{\mathrm{x}} + X$$

shower/cascade (data)

≈ ±15% deposited energy resolution
≈ 10° angular resolution
(at energies ≳ 100TeV)

~6 showers/yr above 60 TeV
in starting event analysis

CC Tau Neutrino



$$\nu_\tau + N \rightarrow \tau + X$$

“double-bang” and other signatures (simulation)

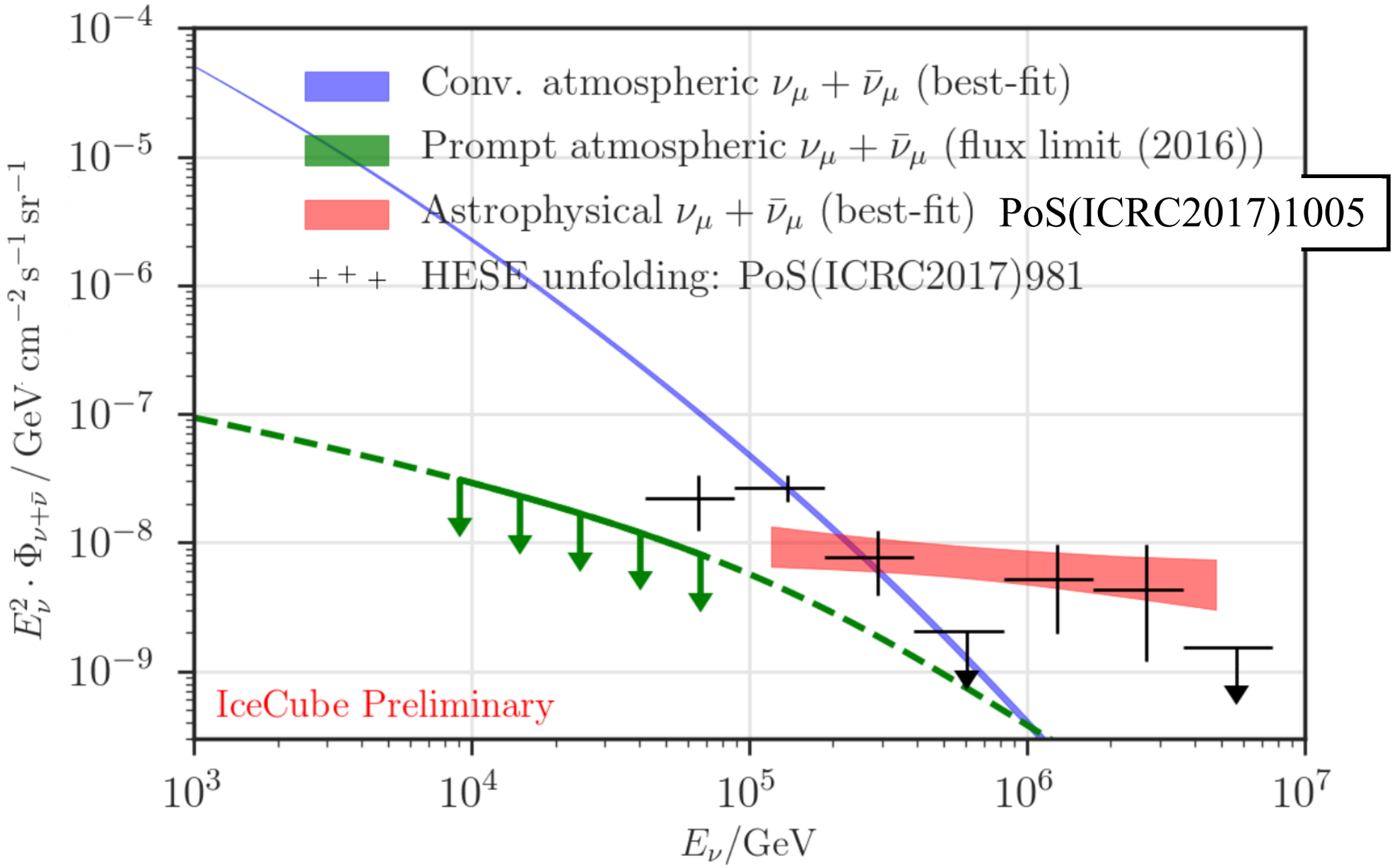
(not observed yet)

Astrophysical ν Flux Measurements

- Two independent observations

  8 years of $\nu\mu$ tracks through the Earth

  6 years of High Energy Starting Events (HESE)

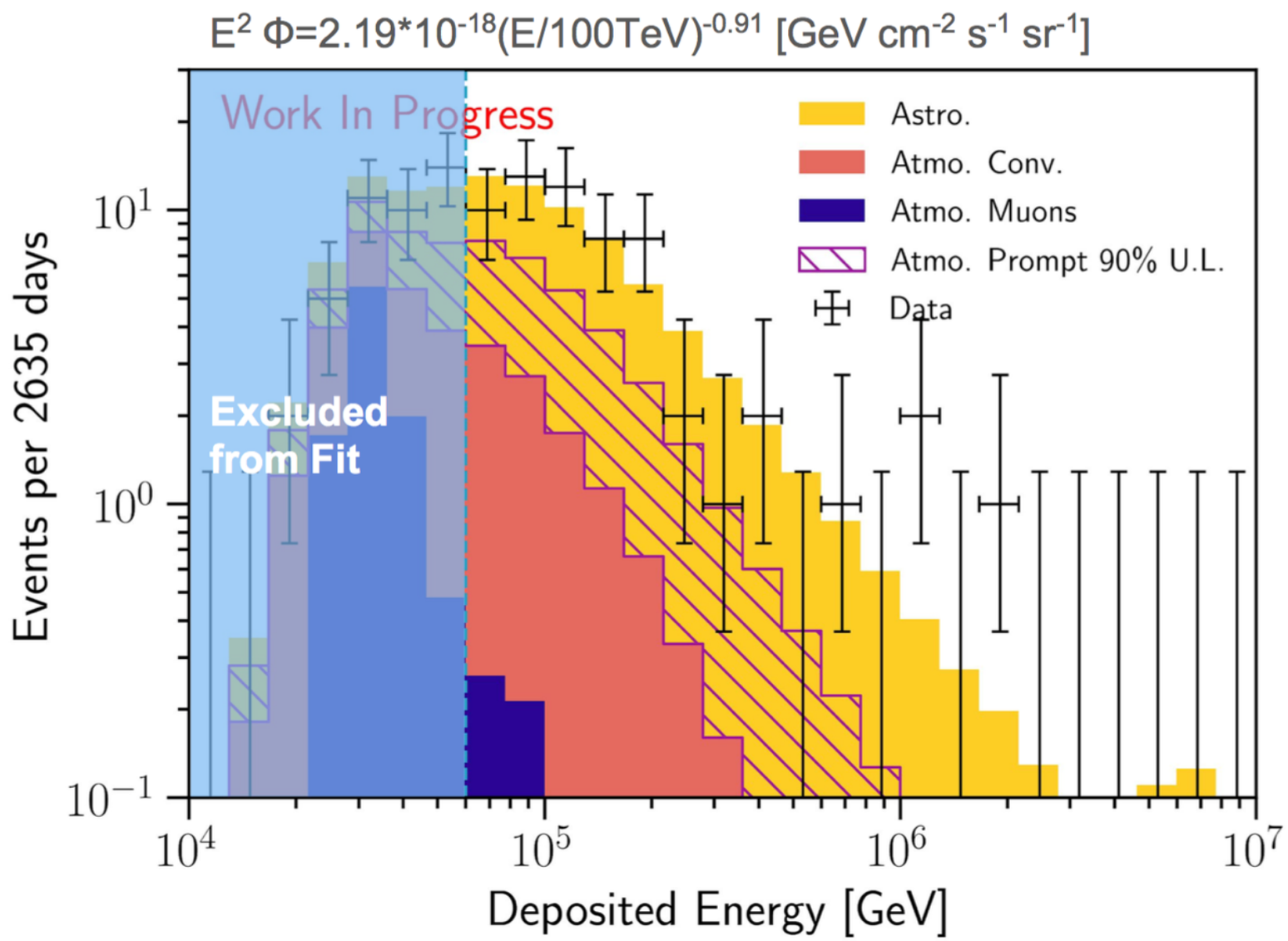


Astrophysical ν Flux Measurements

- Two independent observations

  8 years of $\nu\mu$ tracks through the Earth

Working to update HESE measurement with addition years



A.Schneider (Nu.Astro. 4:35pm 8/27)

Searching for Sources

Steady State

Galactic Point Sources + Diffuse

UHECR correlation

Blazars

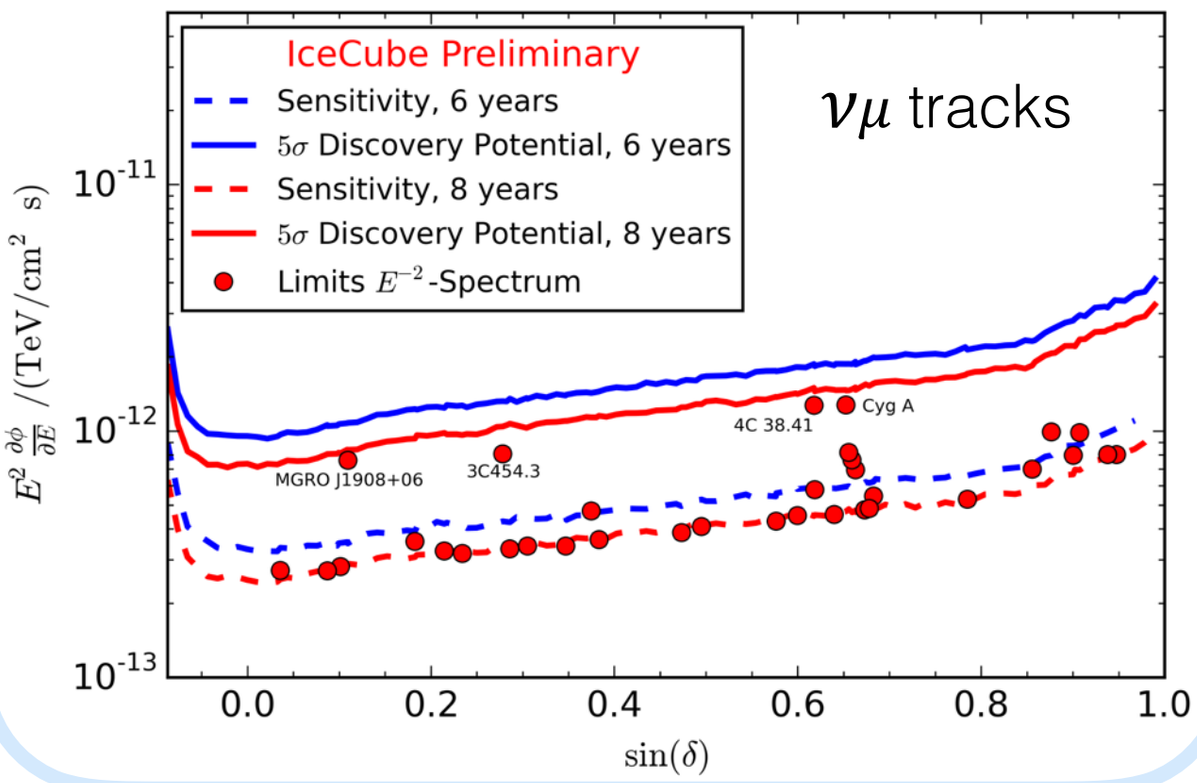
Transients

GRB, FRBs & GW

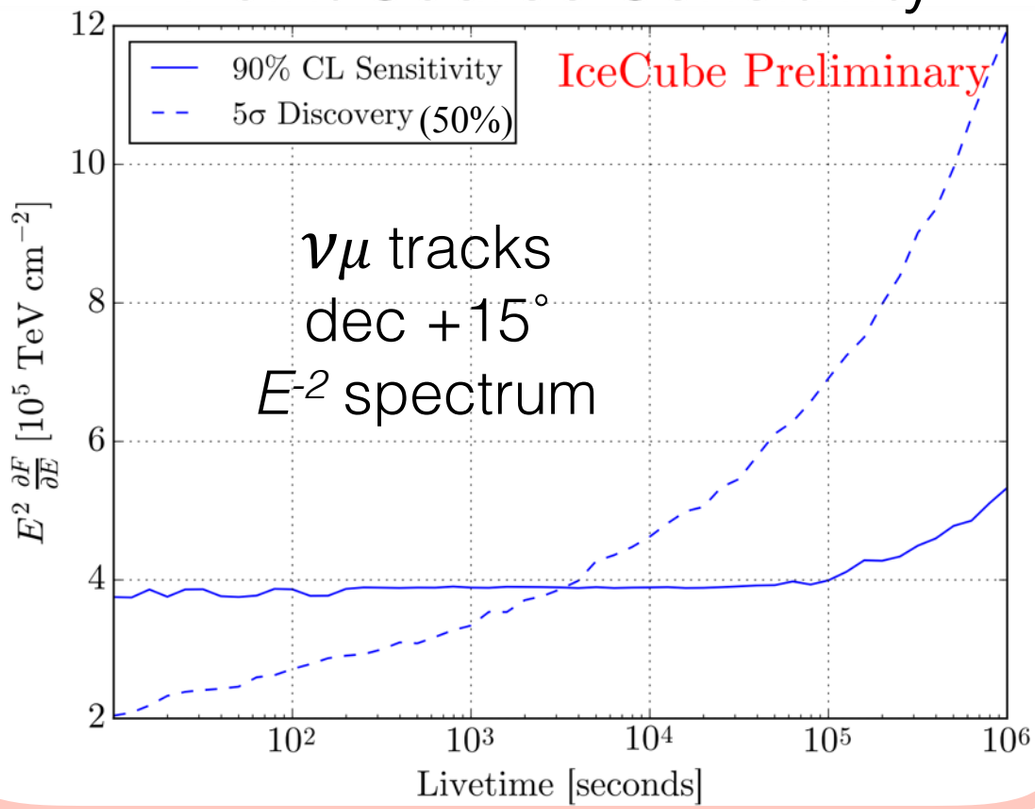
Supernova

Tidal Disruption Events

Point Source Sensitivity

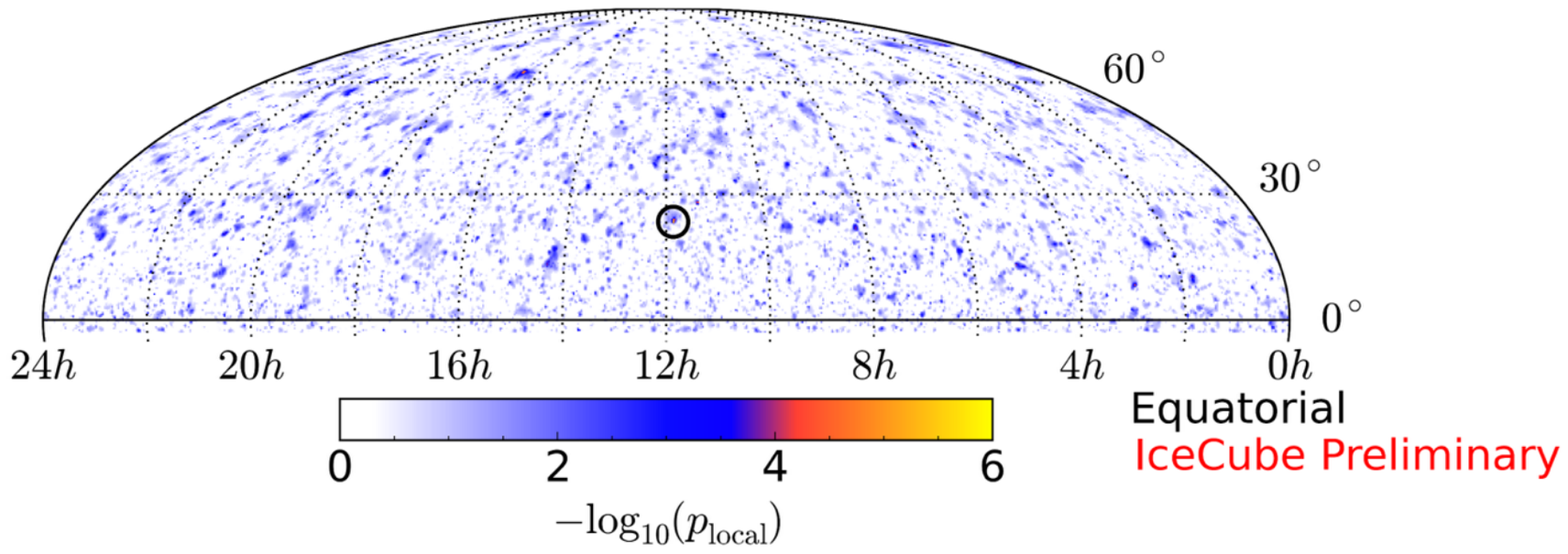


Point Source Sensitivity



Latest Sky Search

8 years of $\nu\mu$ tracks, Northern Sky Point Sources (steady state)



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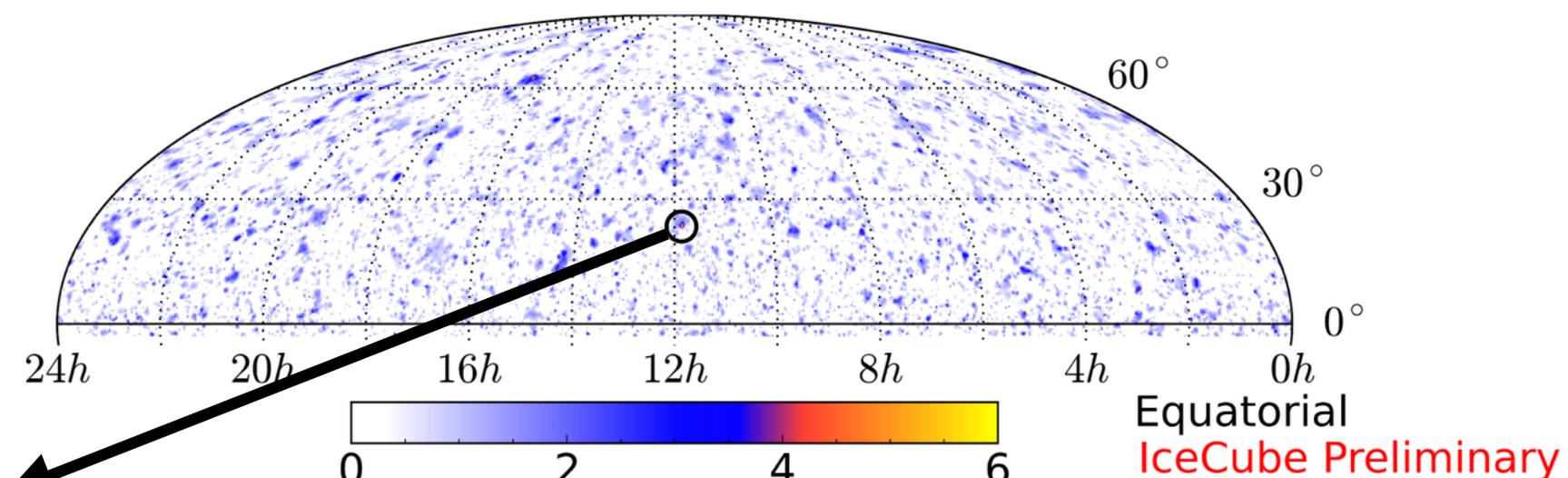
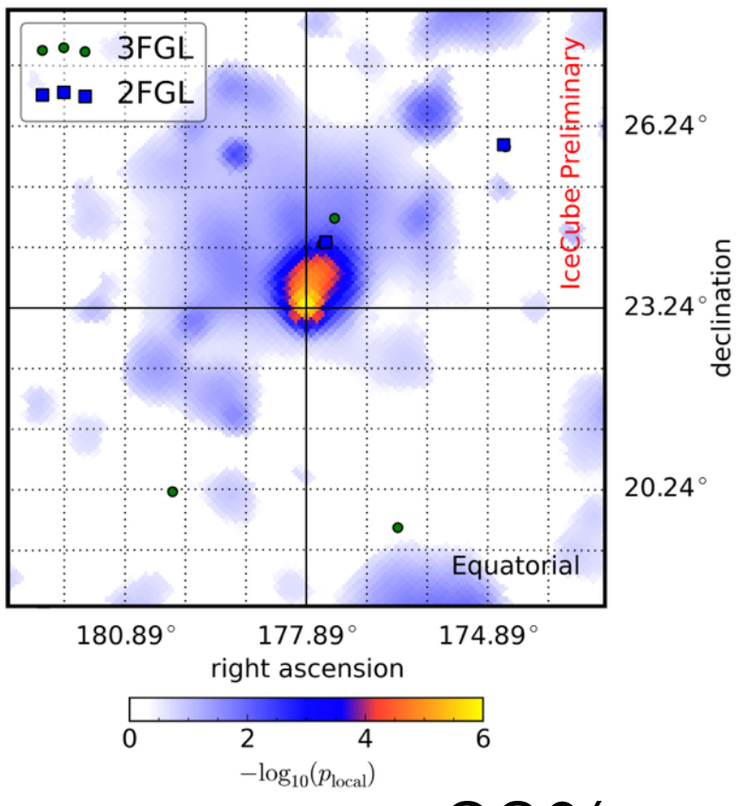


Hottest Spot



$p_{\text{post-trial}} = 26\%$

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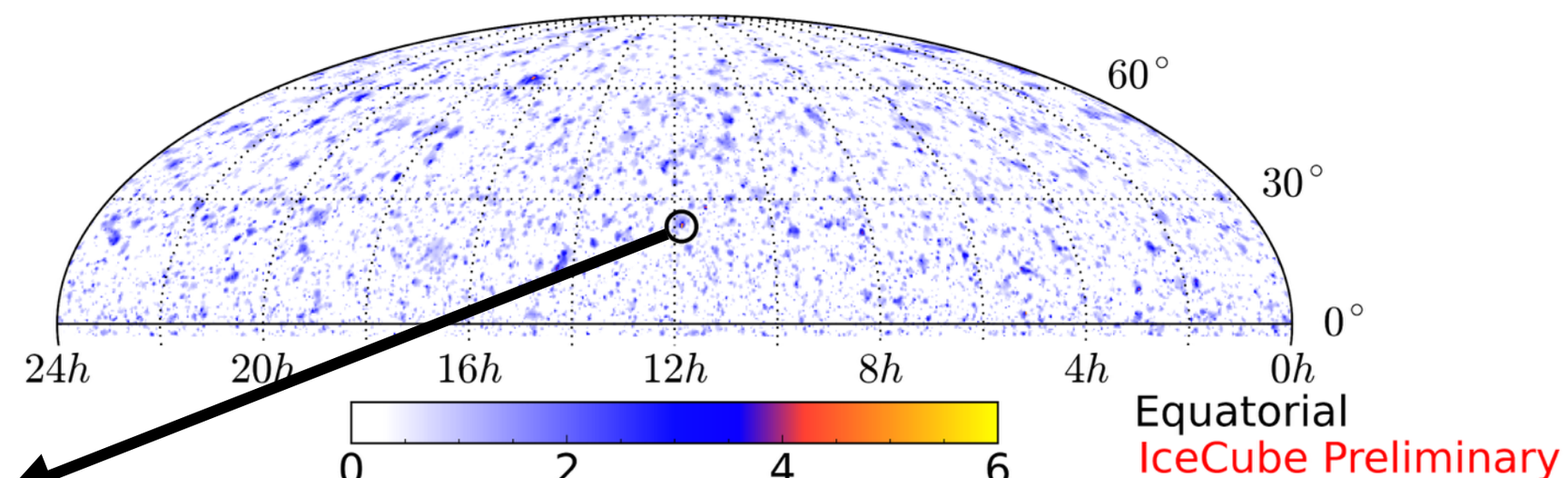

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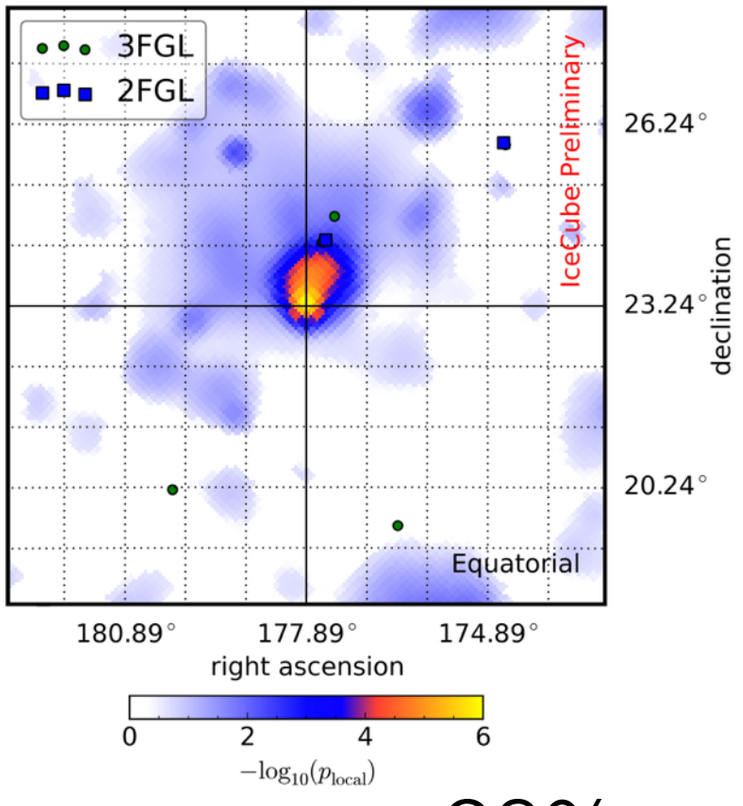
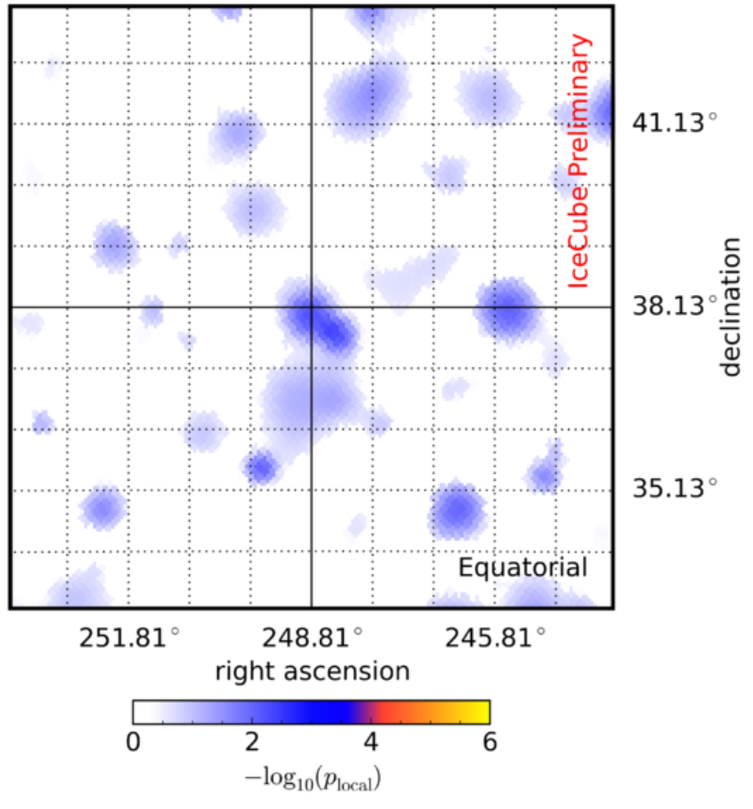


$p_{\text{post-trial}} = 26\%$

Best candidate from catalog search of 34 sources

4C 38.41



$p_{\text{post-trial}} = 20\%$

First Source: TXS 0506+056

- TXS 0506+056 is a blazar located at z = 0.33
- Two independent observations:

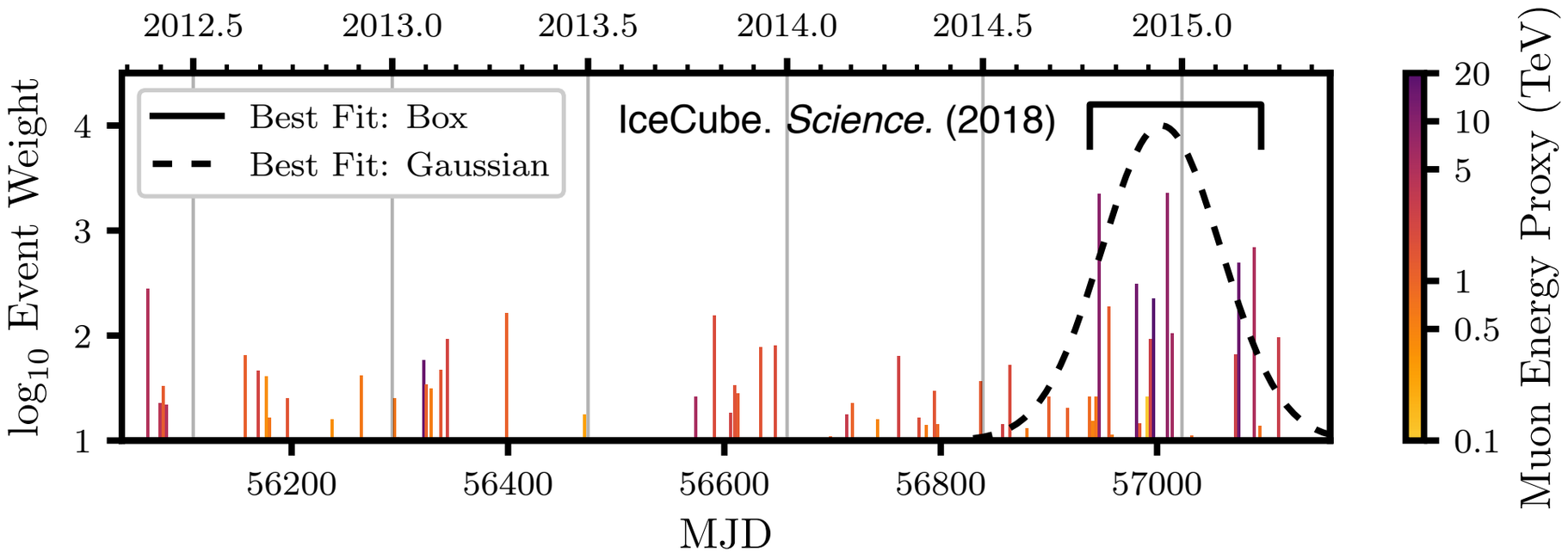
Sept 22, 2017: 3σ

High energy $\nu\mu$ track coincident gamma-ray flare

Oct 2014 - Feb 2015: 3.5σ

13 ± 5 $\nu\mu$ tracks on clustered in space and time, $E^{-2.1\pm0.2}$ spectrum*

*fit assumes simple power law



- Flux averaged over 9.5 yr is <1% of all-sky astro flux

First Source: TXS 0506+056

- TXS 0506+056 is a blazar located at z = 0.33
- Two independent observations:

time-dependence is crucial!

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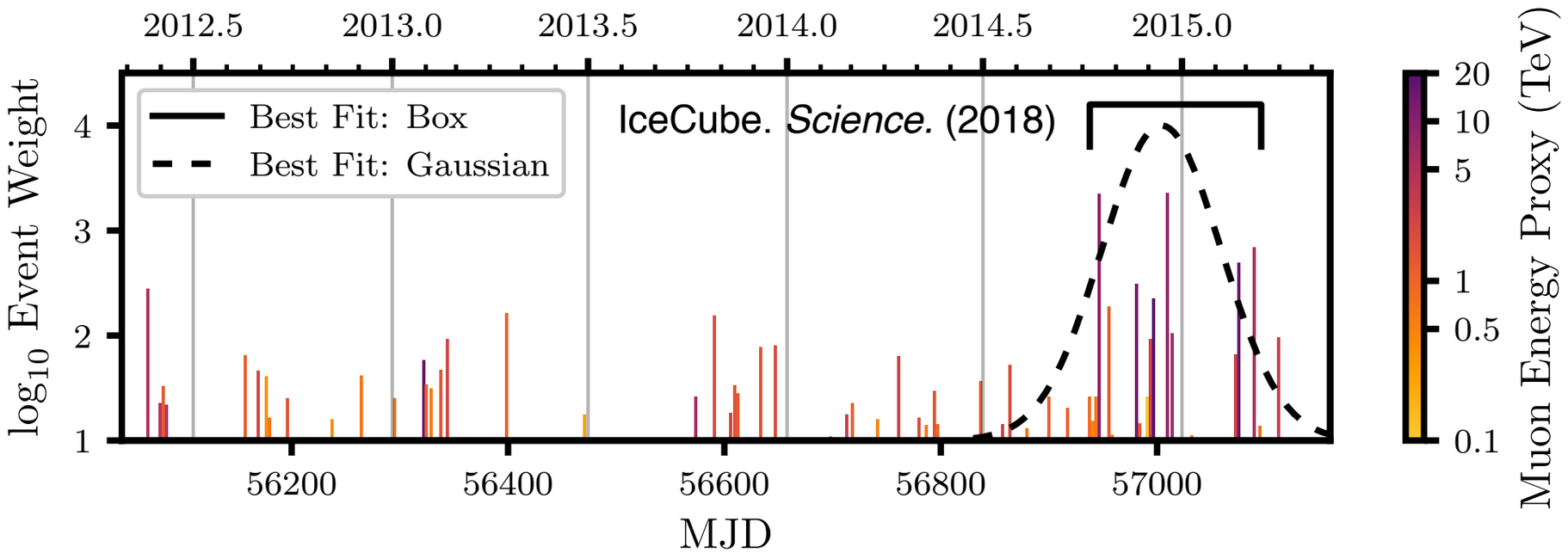

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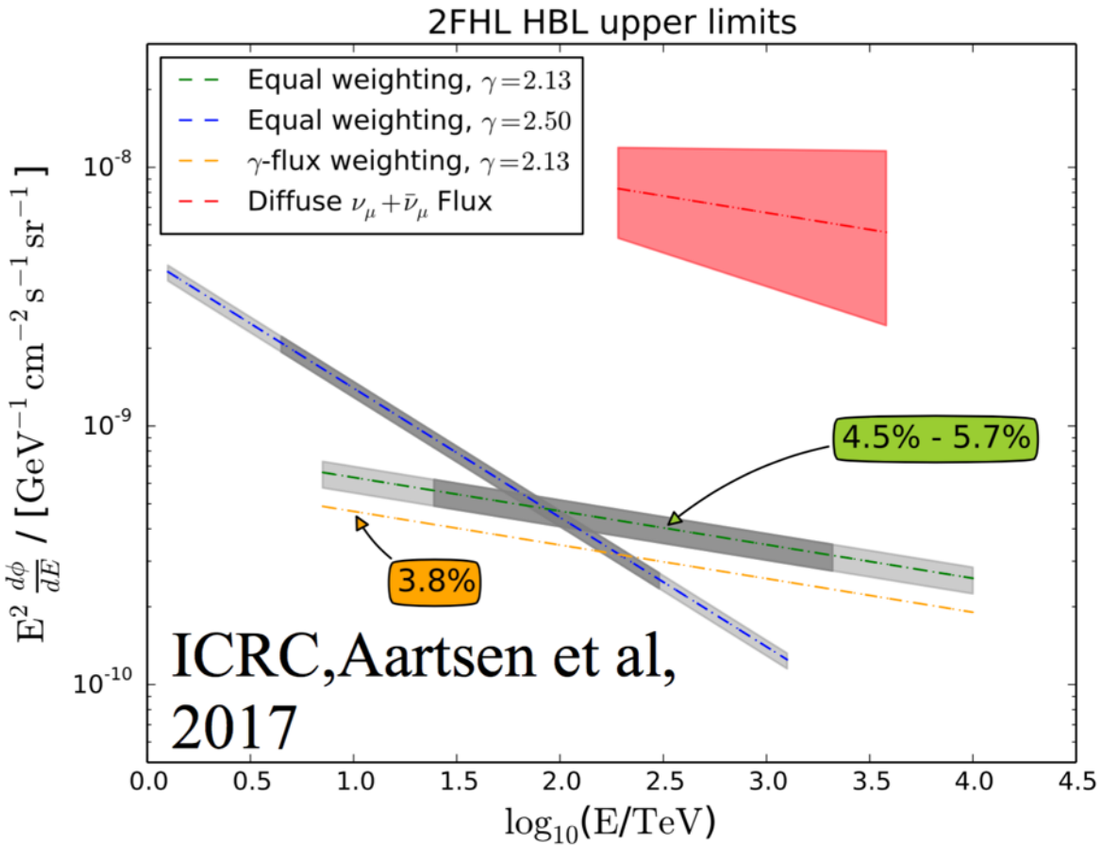
Blazar Population Studies

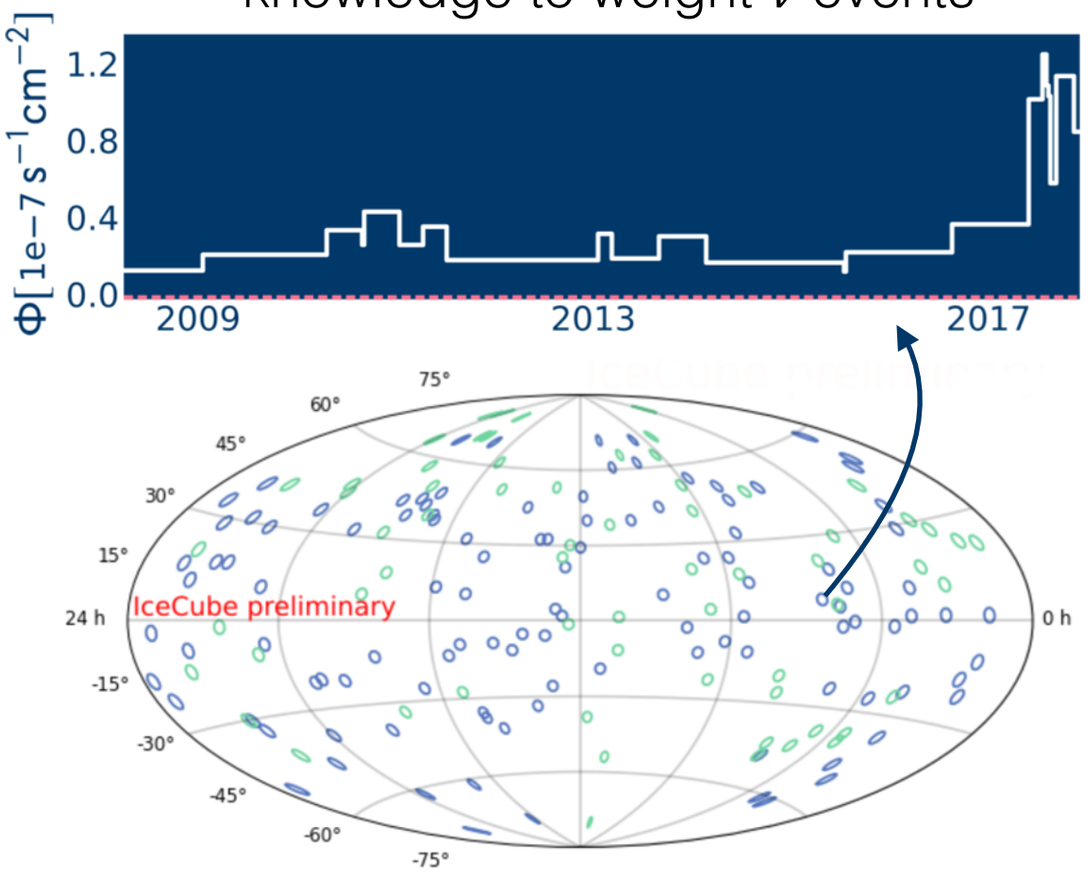
- Time-integrated search for ν emission from stacked 2FHL blazars



M.Huber (Nu.Astro. 4:05pm 8/28)

- Working on time-dependent blazar stacking search

Use gamma-ray light curve knowledge to weight ν events



C.Raab (Nu.Astro. 5:50pm 8/27)

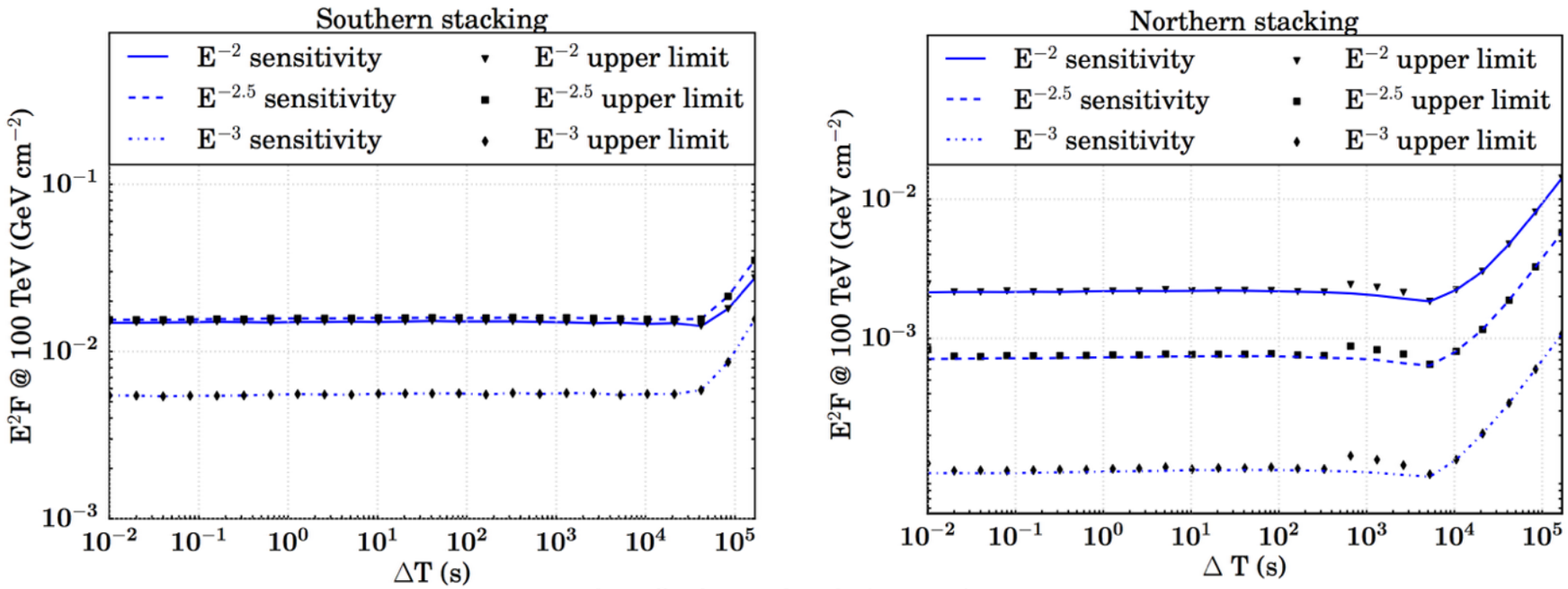
Important Caveat:

Answers depend strongly on *input hypothesis*

GRBs, FRBs & GW

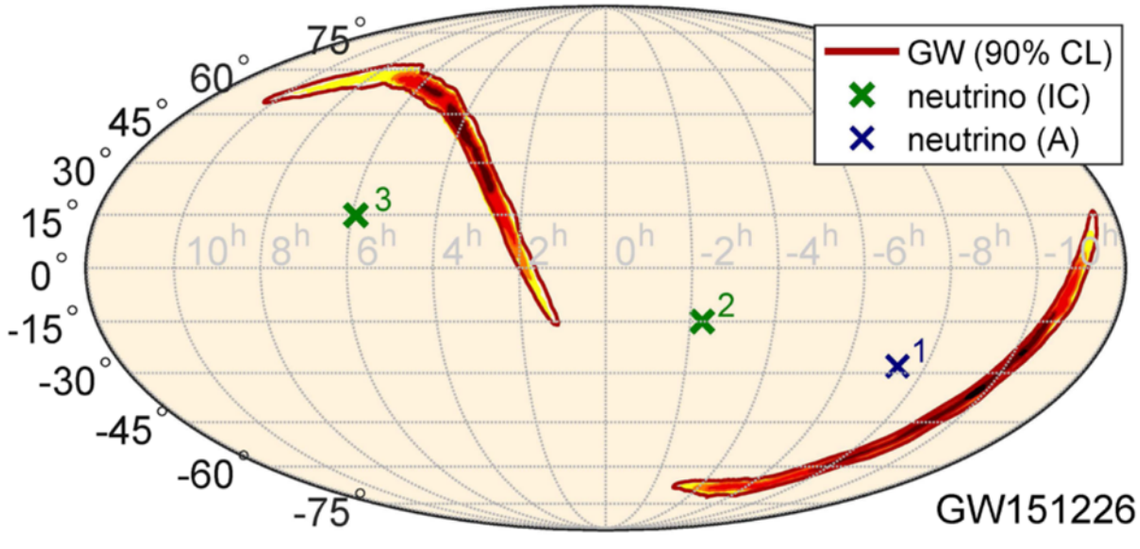
- GRBs excluded at <1% diffuse astrophysical flux

- FRB limits w/6 years of tracks:



IceCube. *ApJ.* (2018)

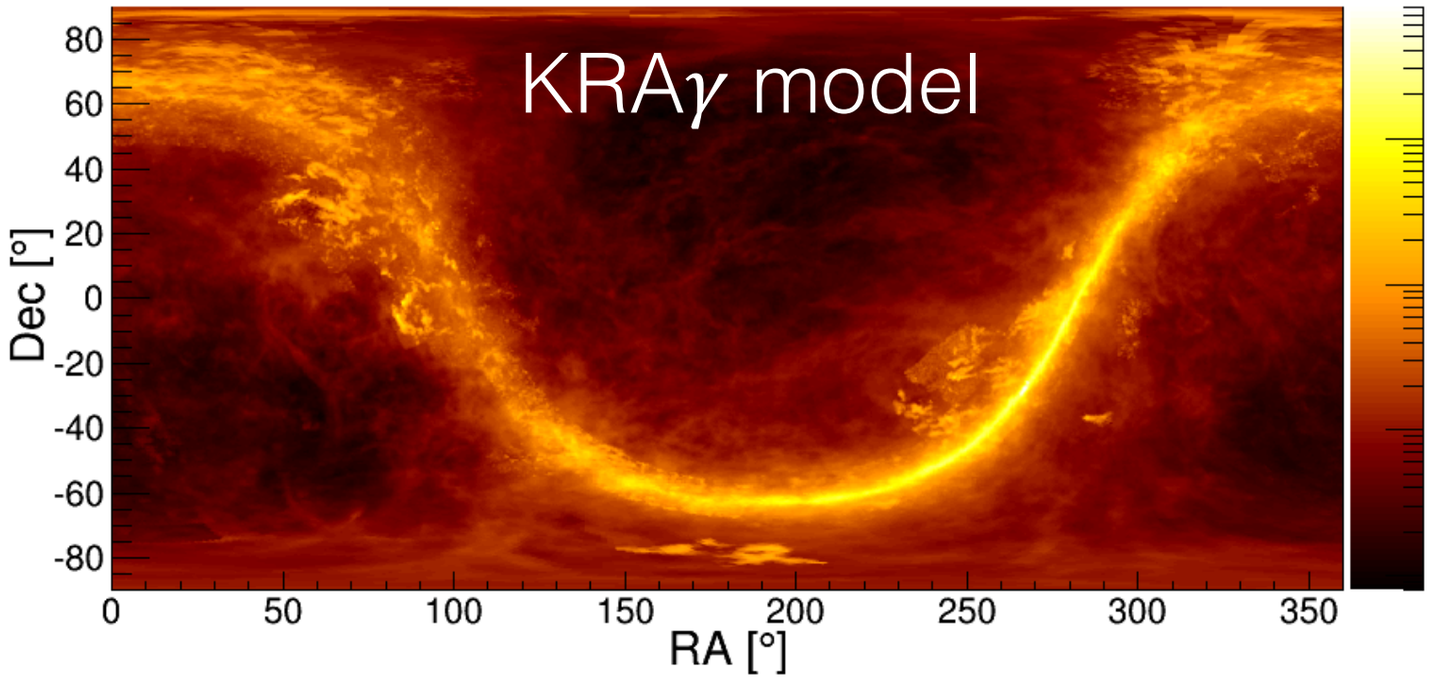
- Search for neutrino emission coincident with LIGO GW events

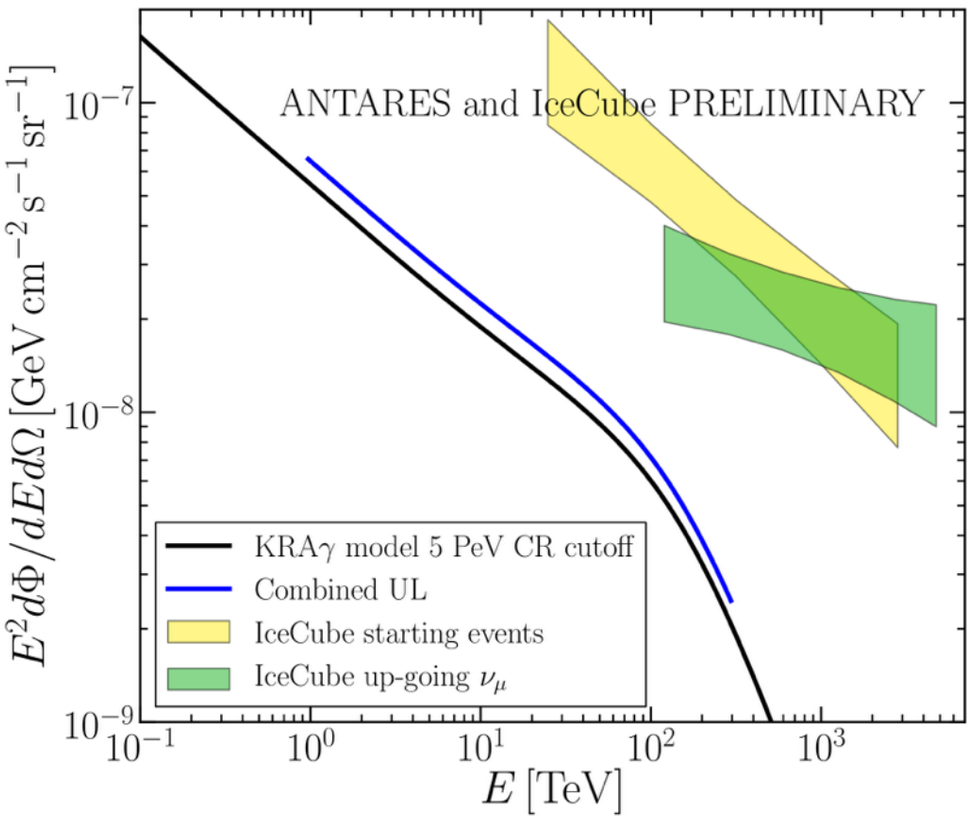


ANTARES et al. *Phys.Rev.D.* (2017)

Galactic Searches

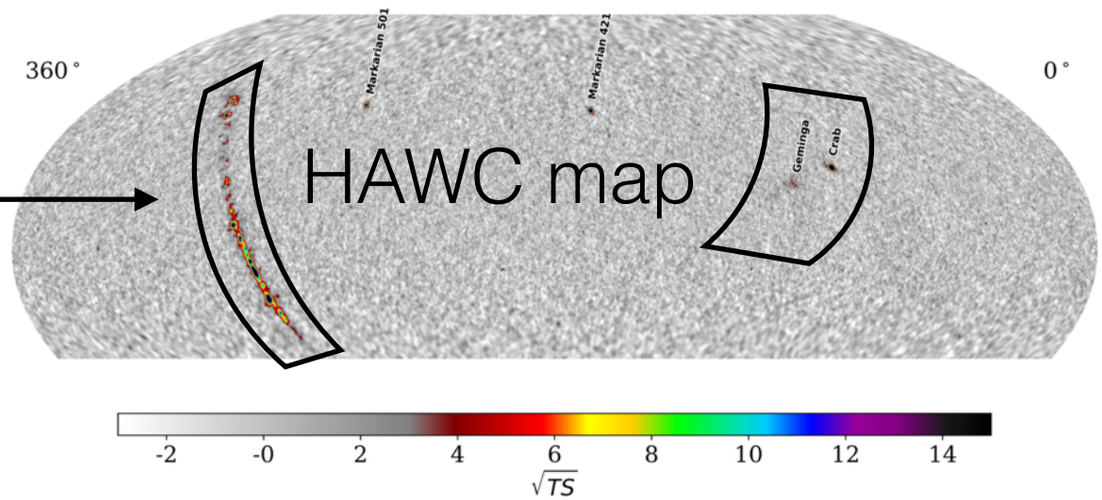
- Combined ANTARES and IceCube search for diffuse ν emission from Galactic plane





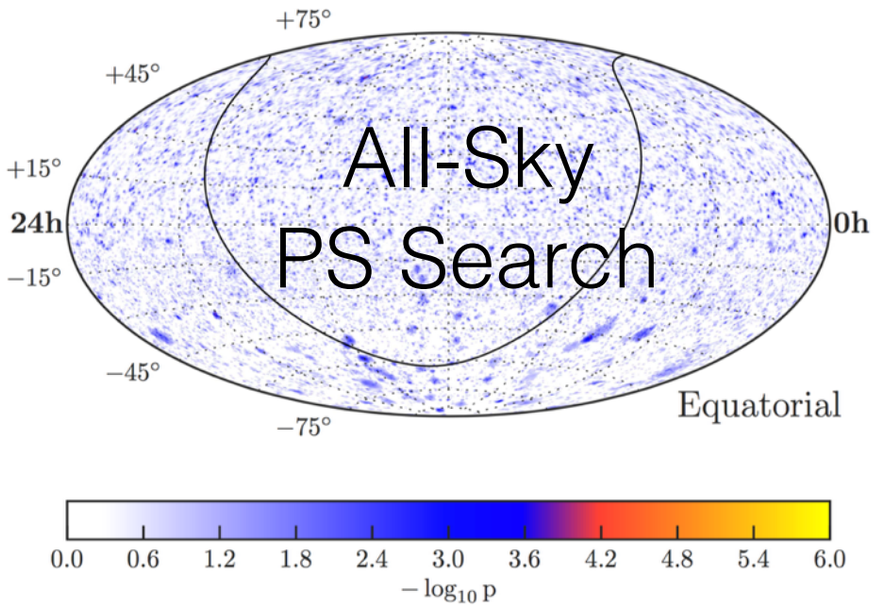
- Working on search for ν from from Galactic HAWC sources

J.Wood (Nu.Astro. 4:55pm 8/30)

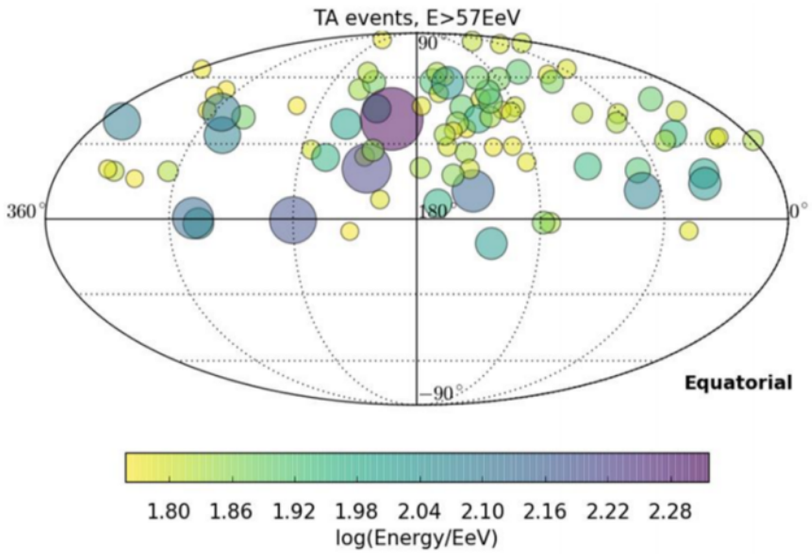


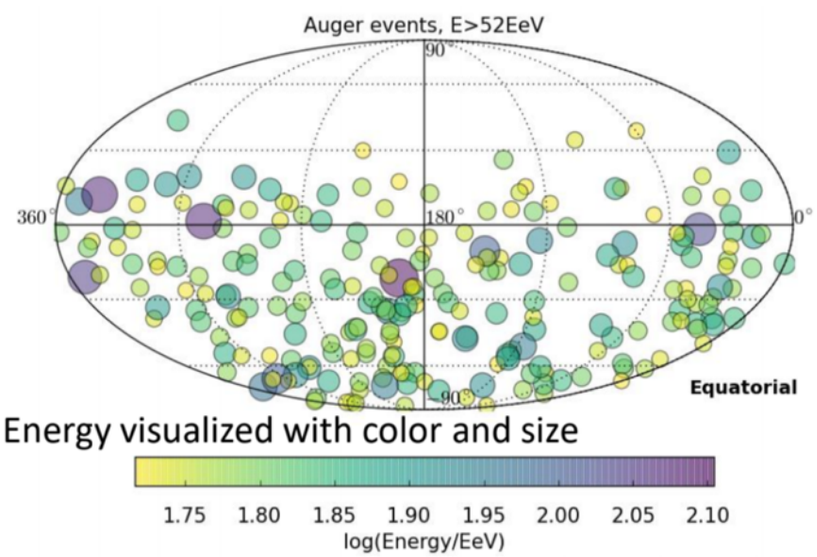
UHECR Correlation Study

- Look for neutrino hotspots consistent with ultra high energy cosmic rays (UHECR) and vice-versa jointly with ANTARES, TA, AUGER



+

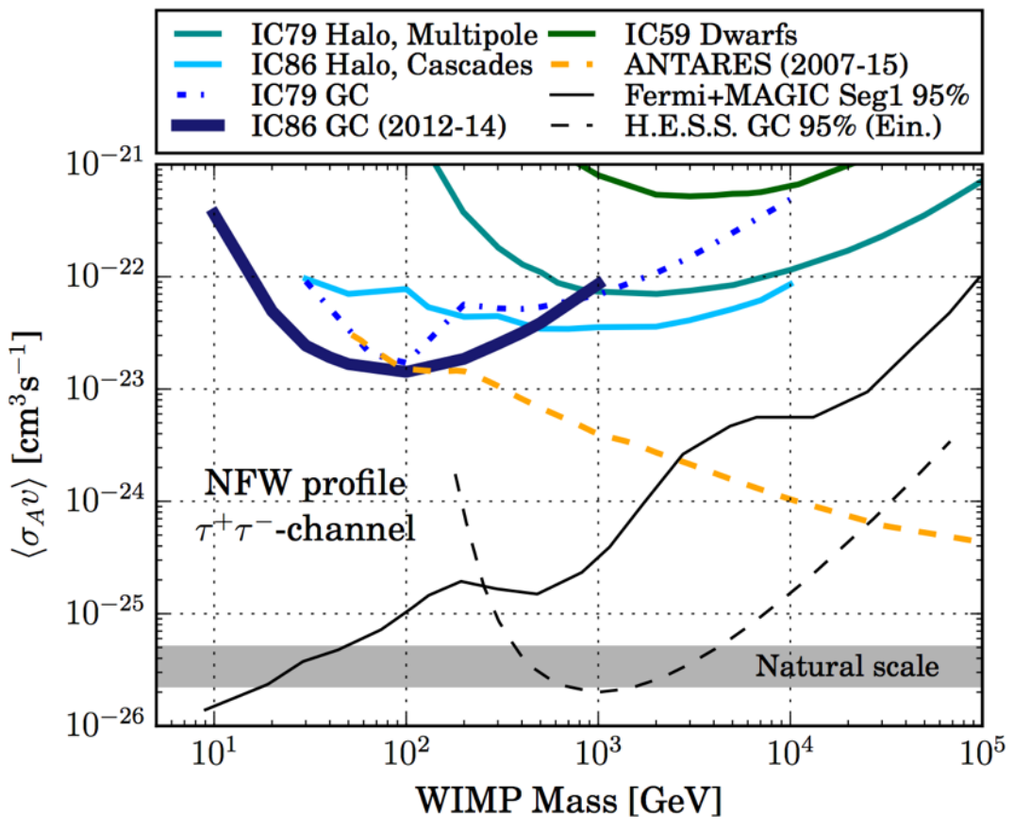




See L.Schumacher
(Nu.Astro. 2:15pm 8/31)

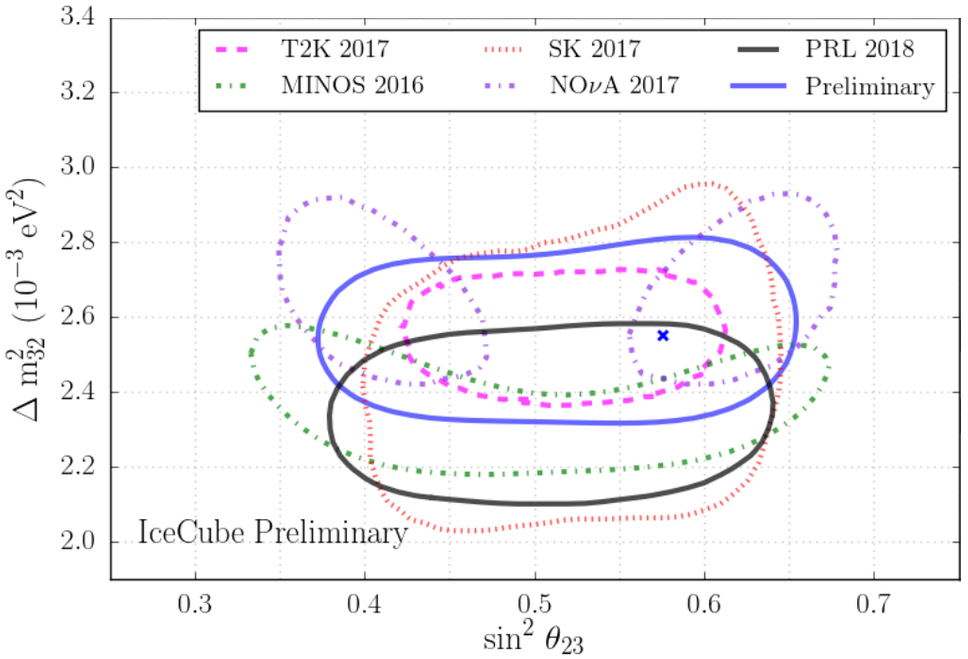
Additional Topics

Dark Matter



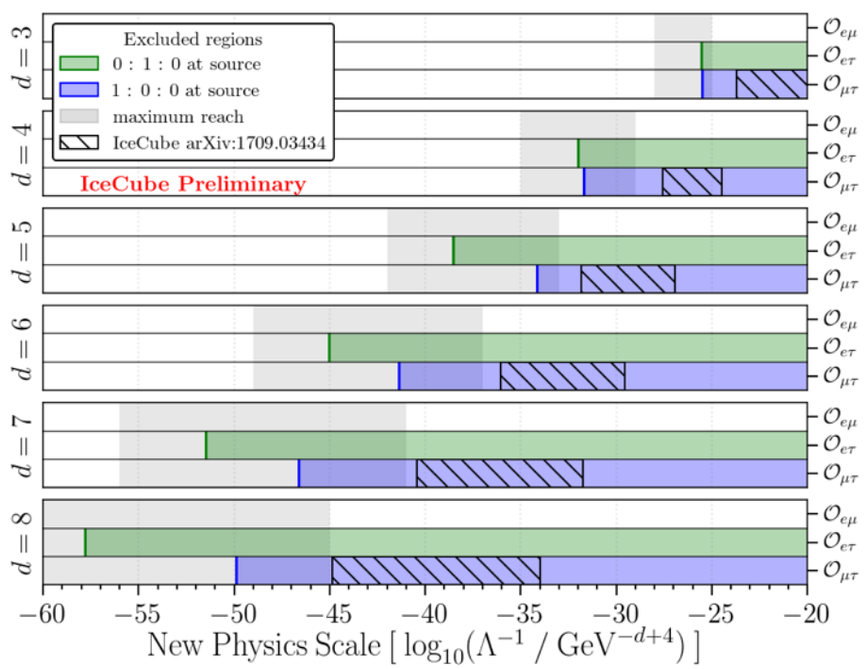
C. de los Heros
(DM 2:00pm 8/30)

Oscillations



T. DeYoung
(Nu.Astro. 5:40pm 8/30)

BSM



C. Agüelles
(PLEN 11:00am 8/31)

Summary

- Identified the first source of the very high energy astrophysical neutrino flux —> blazar TXS 0506+056
- Time dependence + multi-messenger information was essential to its identification
- Continue to search for additional sources, both transient and steady state
- Hopefully this is the start of many detections to come, especially with the IceCube upgrade on the way!

see S.Blot (Nu.Astro 4:15pm 8/27)

Thanks!


THE ICECUBE COLLABORATION
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Universiteit Gent
Vrije Universiteit Brussel
CANADA
SNOLAB
University of Alberta–Edmonton
DENMARK
University of Copenhagen
GERMANY
Deutsches Elektronen-Synchrotron
ECAP, Universität Erlangen-Nürnberg
Humboldt–Universität zu Berlin
Ruhr-Universität Bochum
RWTH Aachen University
Technische Universität Dortmund
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Sungkyunkwan University
SWEDEN
Stockholms universitet
Uppsala universitet
SWITZERLAND
Université de Genève
UNITED KINGDOM
University of Oxford
UNITED STATES
Clark Atlanta University
Drexel University
Georgia Institute of Technology
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Marquette University
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Michigan State University
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The Swedish Research Council (VR)
University of Wisconsin Alumni Research Foundation (WARF)
US National Science Foundation (NSF)
IceCube
South Pole Neutrino Observatory
icecube.wisc.edu

IceCube @ TeVPA 2018

Talks

Anna Franckowiak - TXS coincidence (Nu 2:20pm 8/27)
Imen Al Samarai - TXS archival flare (Nu 2:35pm 8/27)
Summer Blot - IceCube upgrade and Gen2 (Nu 4:15pm 8/27)
Austin Schneider - Updated HESE diffuse flux measurement (Nu 4:35pm 8/27)
Juliana Stachurska - Updated HESE flavor measurement (Nu 4:50pm 8/27)
Chris Raab - Blazar correlation with gamma-ray light curves (Nu 5:50pm 8/27)
Matthias Huber - 3FHL Blazars (Nu 6:05pm 8/28)
Ludwig Rauch - Optical counterparts to HE neutrinos (Nu 2:55pm 8/29)
Josh Wood - Joint HAWC/IceCube Galactic analysis (Nu 4:55pm 8:30)
Ty DeYoung - Neutrino Oscillations (Nu 5:40pm 8/30)
Lisa Schumacher - UHECR correlation with neutrinos (Nu+CR 2:15pm 8/31)
Matthias Plum - Cosmic ray composition (CR 2:45pm 8/28)
Carlos de los Heros - Dark Matter (DM 2:00pm 8/30)
Carlos Agüelles - New physics with > 1 TeV neutrinos (PLEN 11:15am 8/31)

Posters

Thomas Huber - Scintillator upgrade to IceTop (CR04)
Christian Haack - Improved cascade reconstruction (N04)
Sarah Mancina - Enhanced Starting Tracks (N05)
Thomas Kintscher - Real-time transient search (N08)