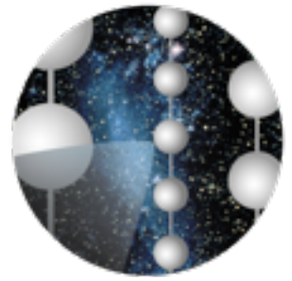
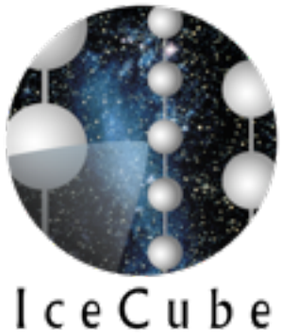
The IceCube Neutrino Observatory
Status and Initial Results



Tyce DeYoung
Department of Physics, Center for Particle Astrophysics
Pennsylvania State University
for the IceCube Collaboration

38th COSPAR Scientific Assembly
Bremen, Germany
July 22, 2010

The IceCube Collaboration



University of Alabama
University of Alaska, Anchorage
University of California, Berkeley
University of California, Irvine
Clark-Atlanta University
Bartol Research Institute, University of Delaware
Georgia Institute of Technology
University of Kansas
Lawrence Berkeley Natl. Laboratory
University of Maryland
Ohio State University
Pennsylvania State University
Southern University and A&M College
University of Wisconsin, Madison
University of Wisconsin, River Falls

RWTH Aachen
Ruhr-Universität Bochum
Universität Bonn
DESY, Zeuthen
Universität Dortmund
MPIfK Heidelberg
Humboldt Universität, Berlin
Universität Mainz
BUGH Wuppertal

Stockholms Universitet
Uppsala Universitet

Vrije Universiteit Brussel
Université Libre de Bruxelles
Universiteit Gent
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University of Alberta

Chiba University

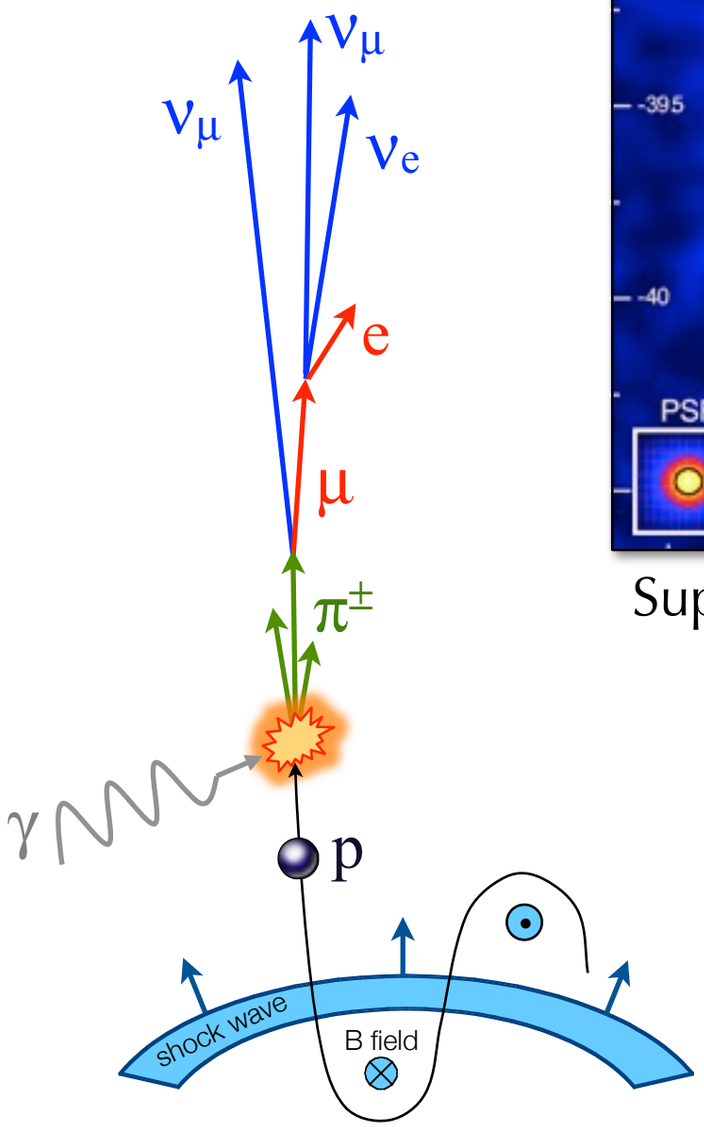
University of Canterbury

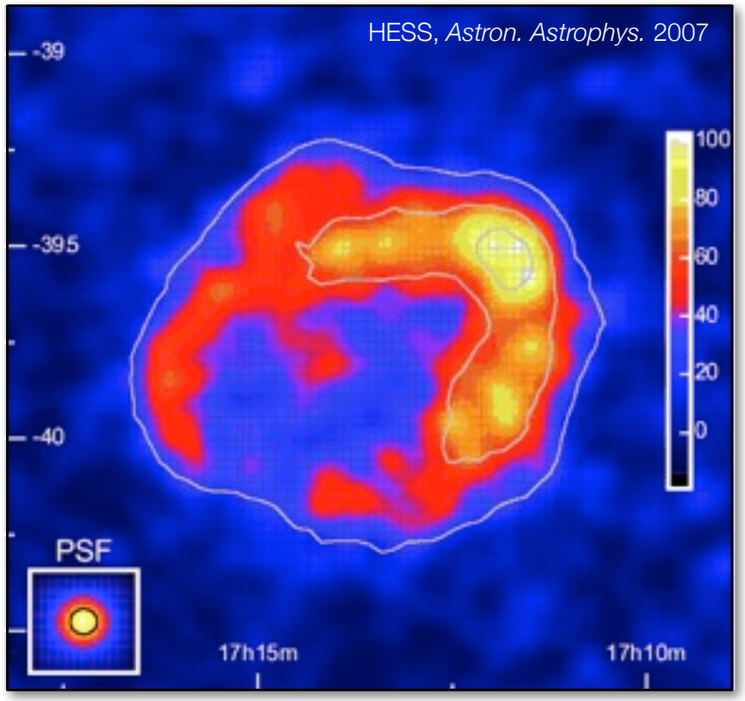
EPF Lausanne

Oxford University

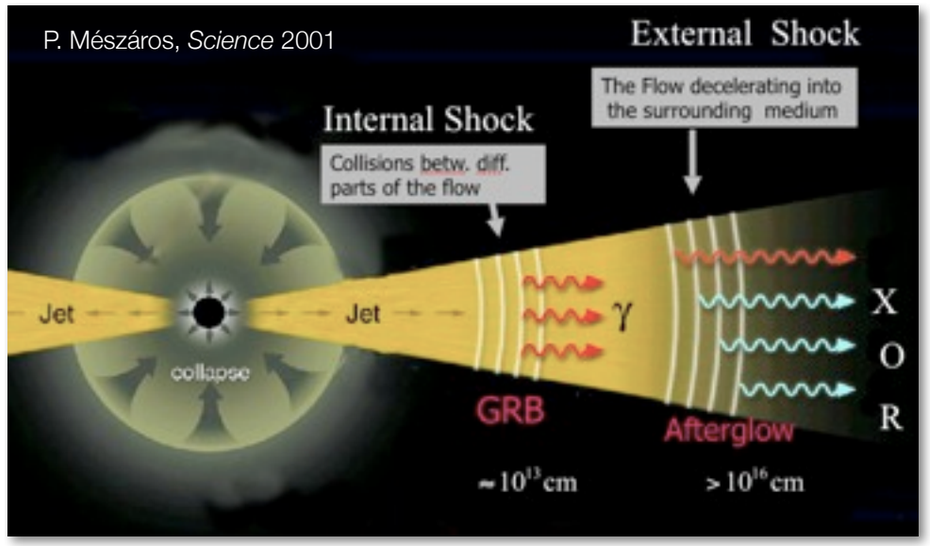
University of the West Indies

Neutrinos from Sources of Cosmic Rays



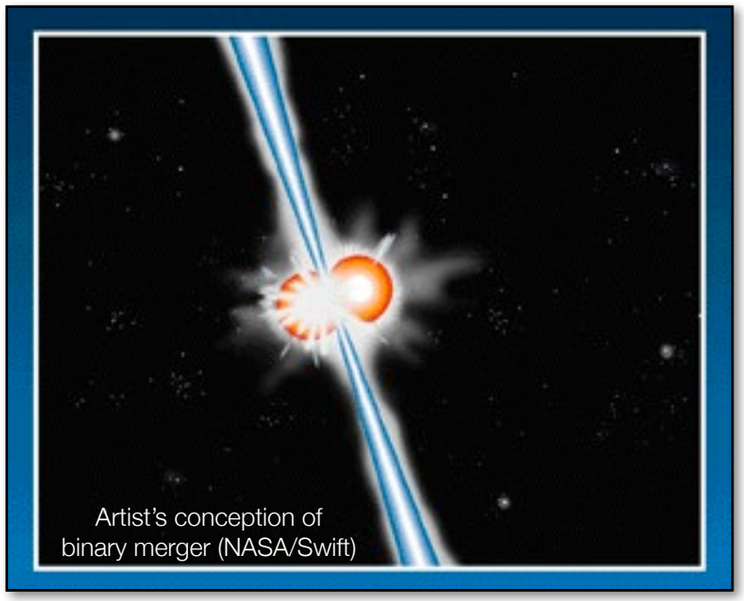


Supernova Remnants



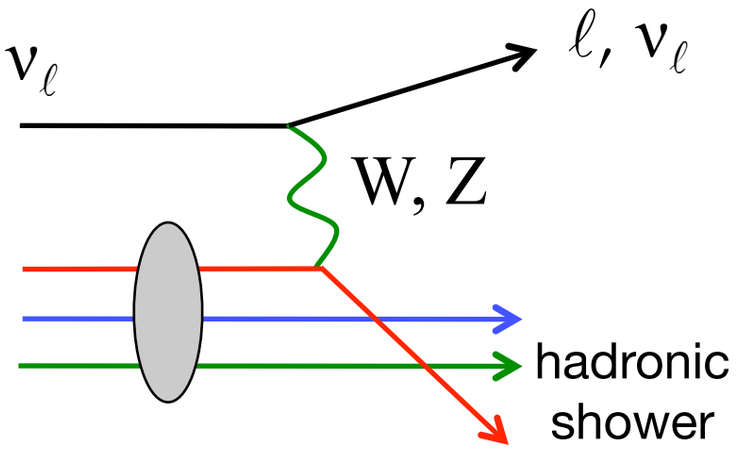
Gamma Ray Bursts

Active Galactic Nuclei

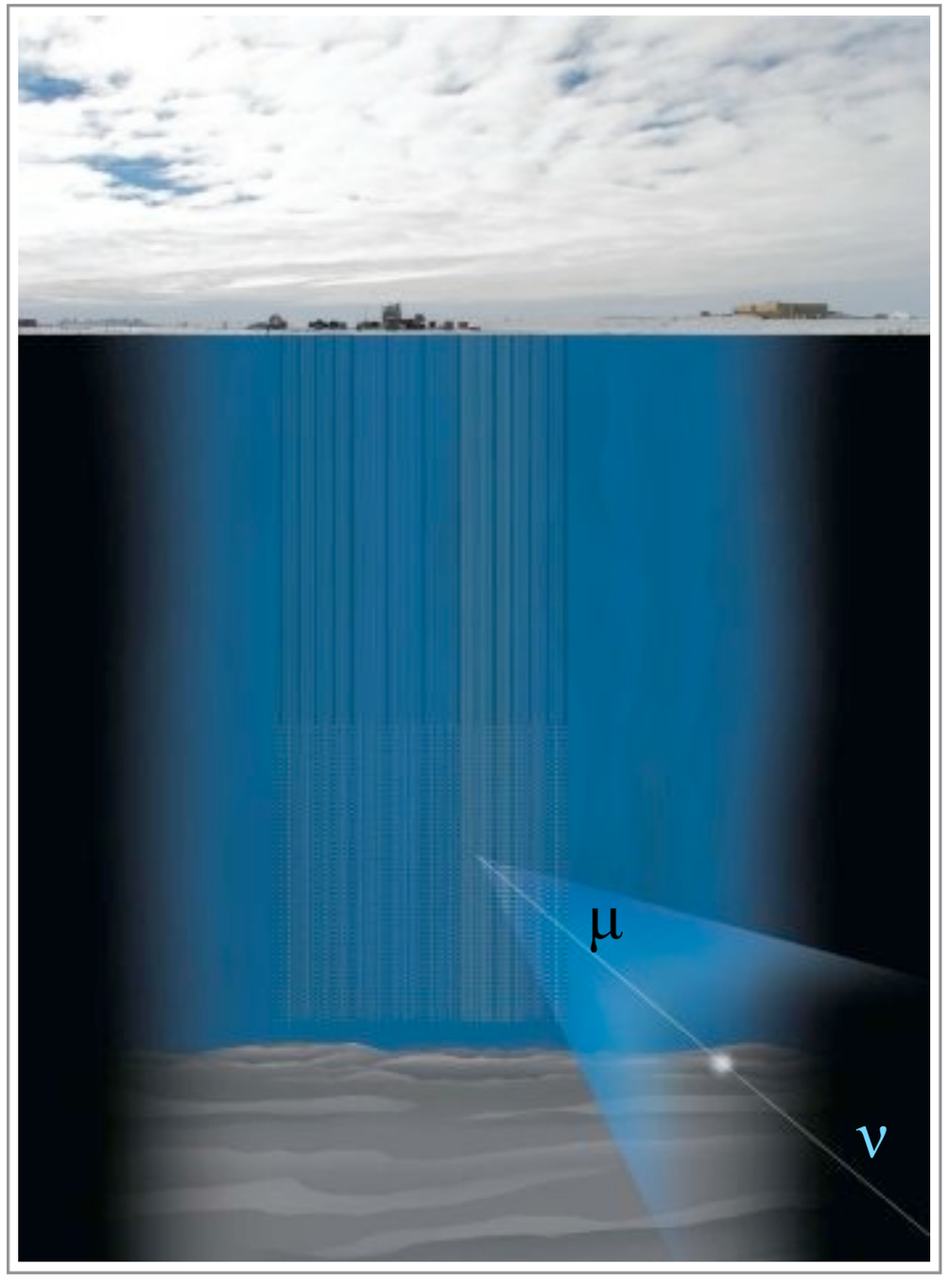


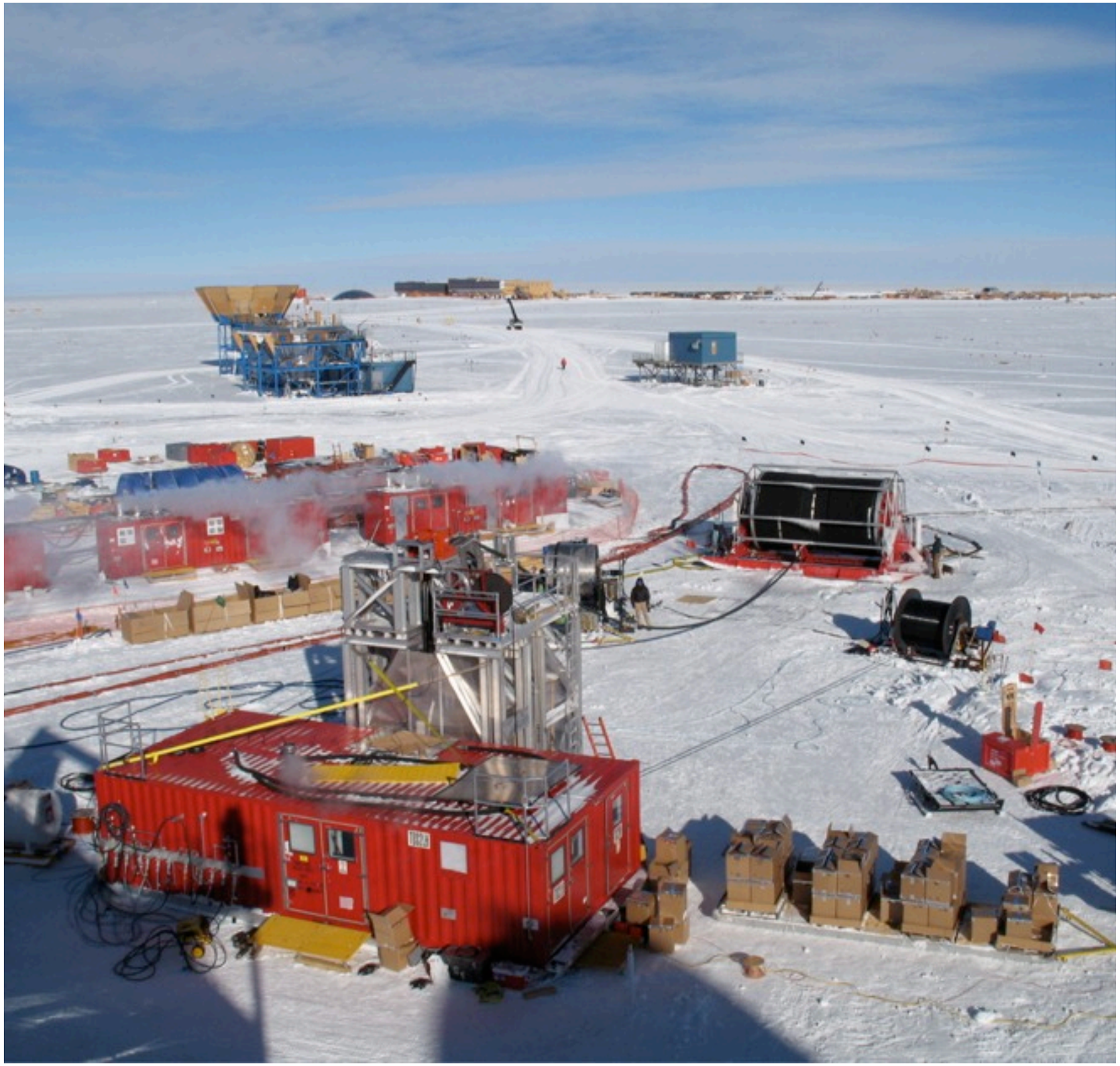
High Energy Neutrino Telescopes

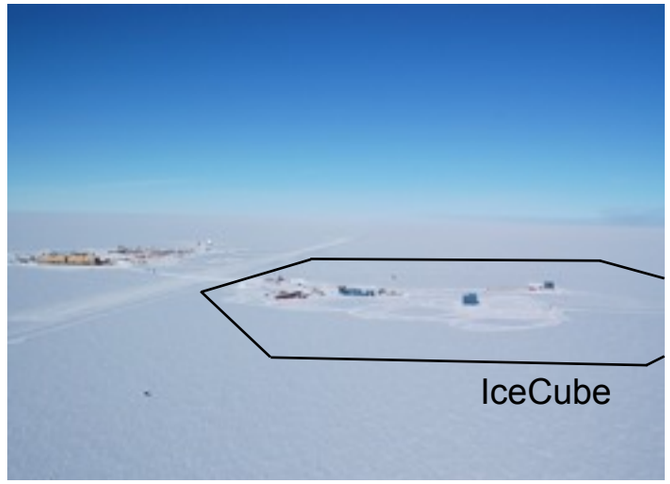
- Neutrinos interact in or near the detector

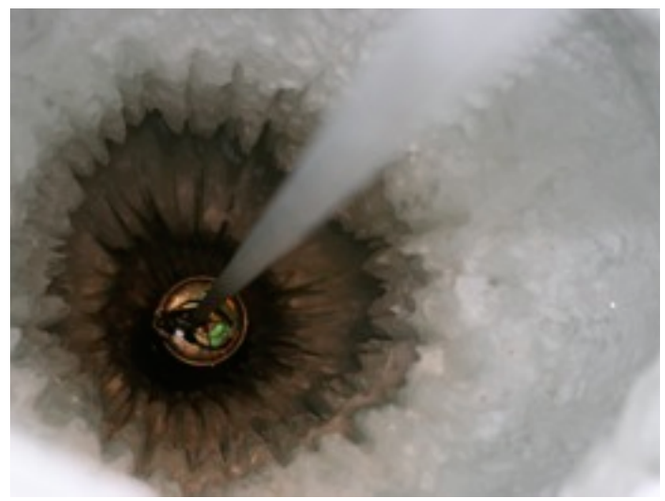


- $\mathcal{O}$(km) muon tracks from ν_μ CC
- $\mathcal{O}$(10 m) cascades from ν_e CC, low energy ν_τ CC, and ν_x NC
- Cherenkov radiation detected by 3D array of optical sensors (OMs)









Amundsen-Scott South Pole Station, Antarctica

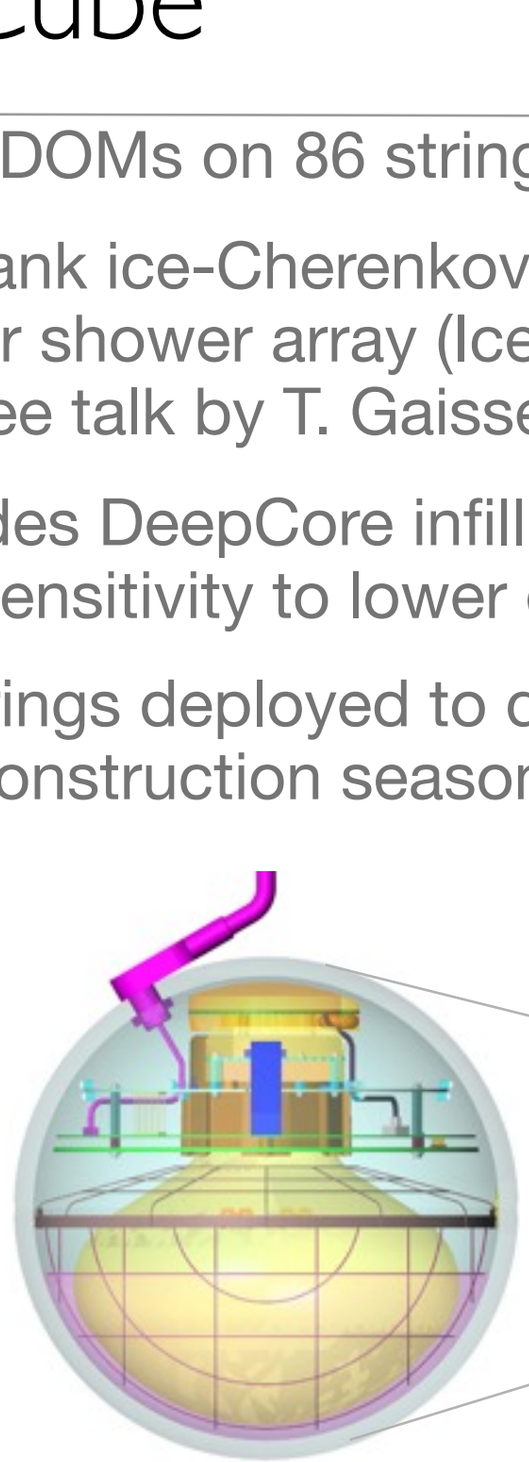
IceCube

5160 DOMs on 86 strings

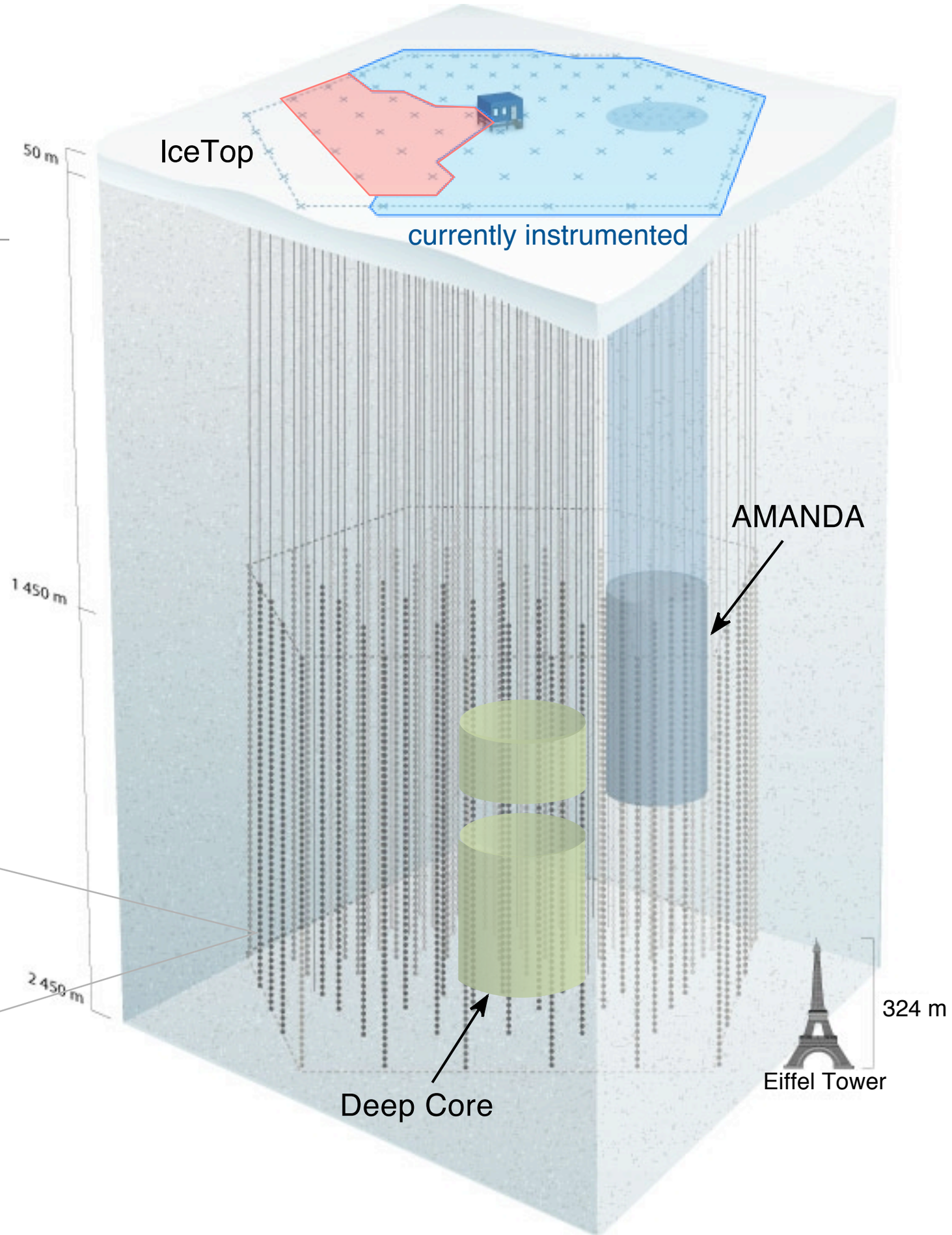
160 tank ice-Cherenkov surface air shower array (IceTop) – see talk by T. Gaisser

Includes DeepCore infill array (sensitivity to lower energies)

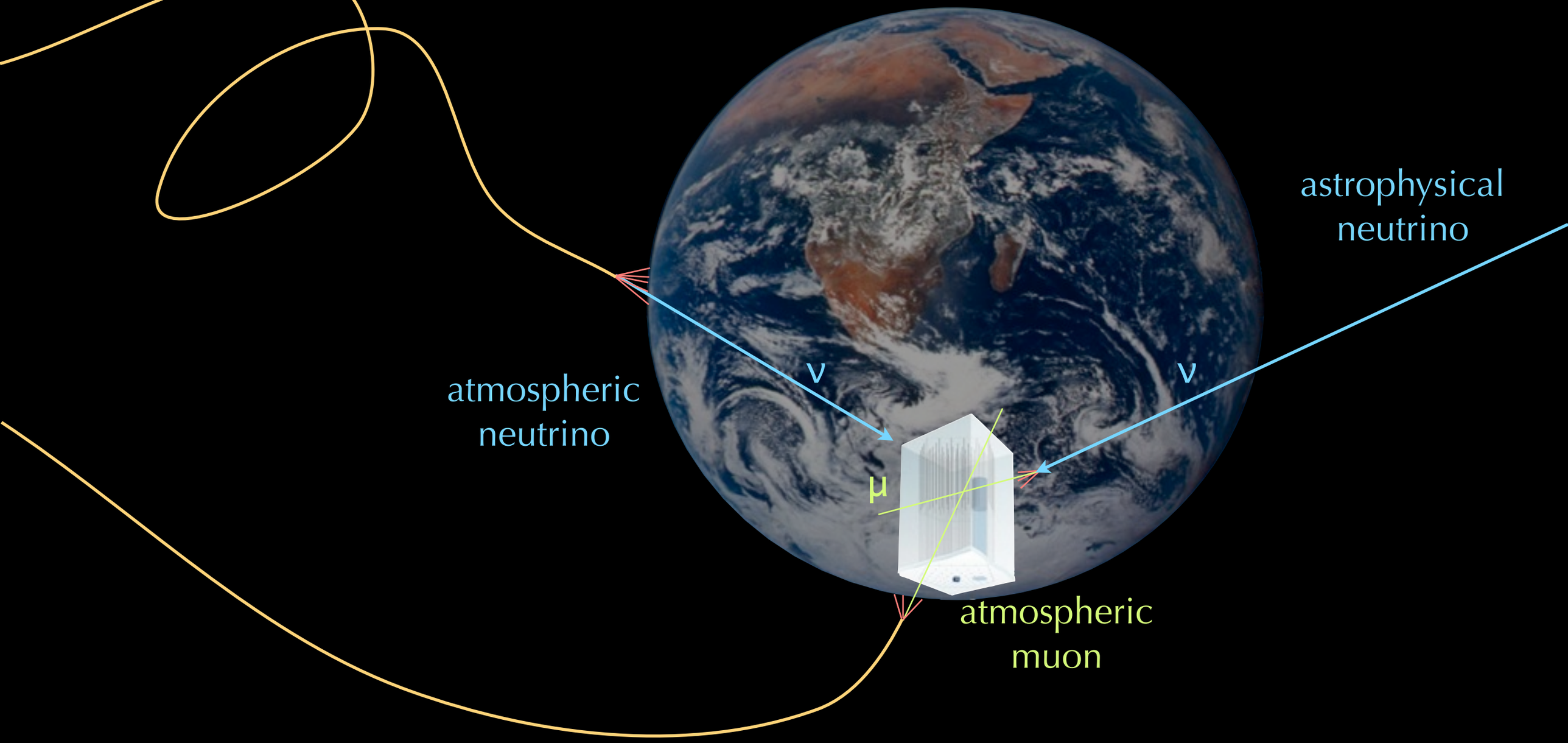
79 strings deployed to date in 6 construction seasons



Digital Optical Module (DOM)

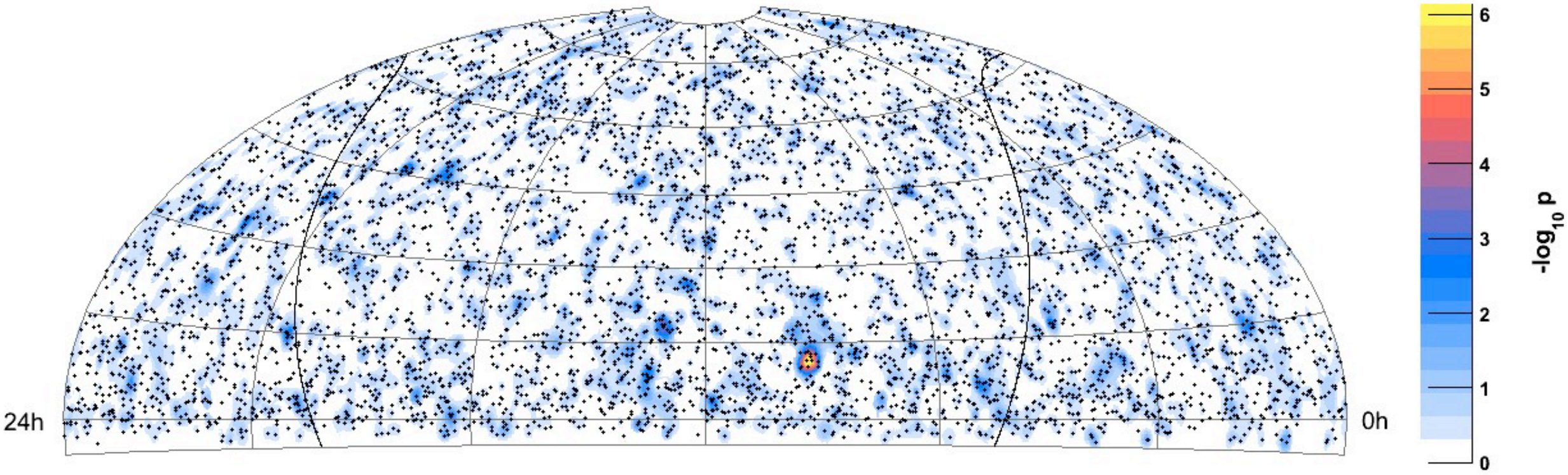


Signals and Backgrounds



IceCube 2007 (22 String) Northern Sky Search

Astrophys. J. **701**, L47 (2009)



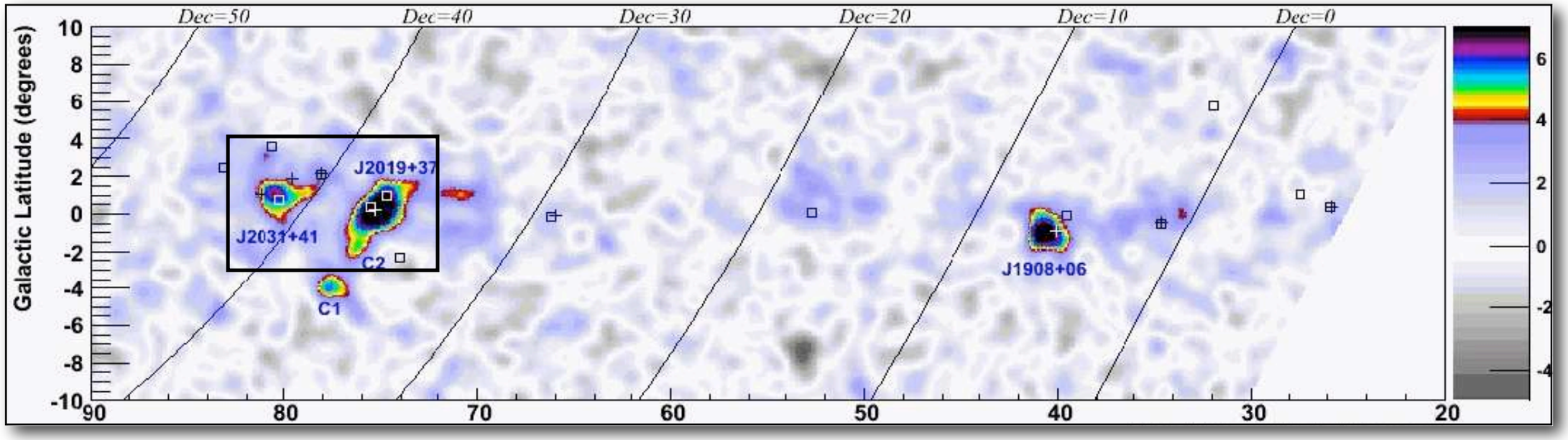
5,114 events from 276 days exposure, May 2007 to April 2008

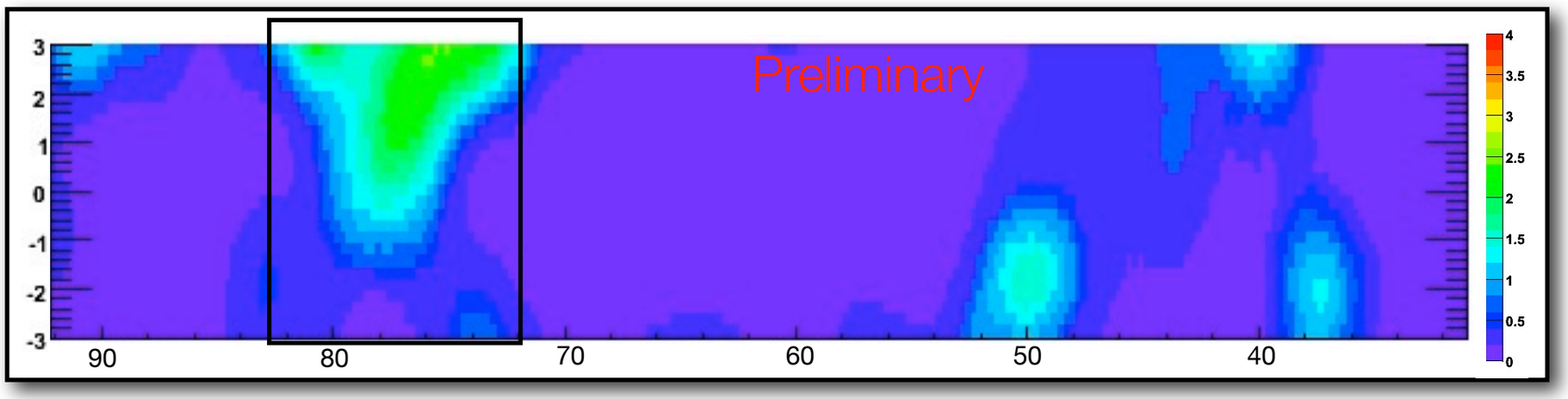
22 IceCube strings operational (¼ of full array)

Maximum deviation from background $p = 7 \times 10^{-7}$, 1.34% probability as determined with randomized sky maps → consistent with background

IceCube + AMANDA Study of Cygnus Region

Y. Sestayo for the Collaboration, VLVnT 2009





2-point correlation analysis of 11° x 7° region (defined a priori)

122 pairs within 2° observed, 66.5 expected → prelim. *p*-value 1.2% ~ 2.3σ

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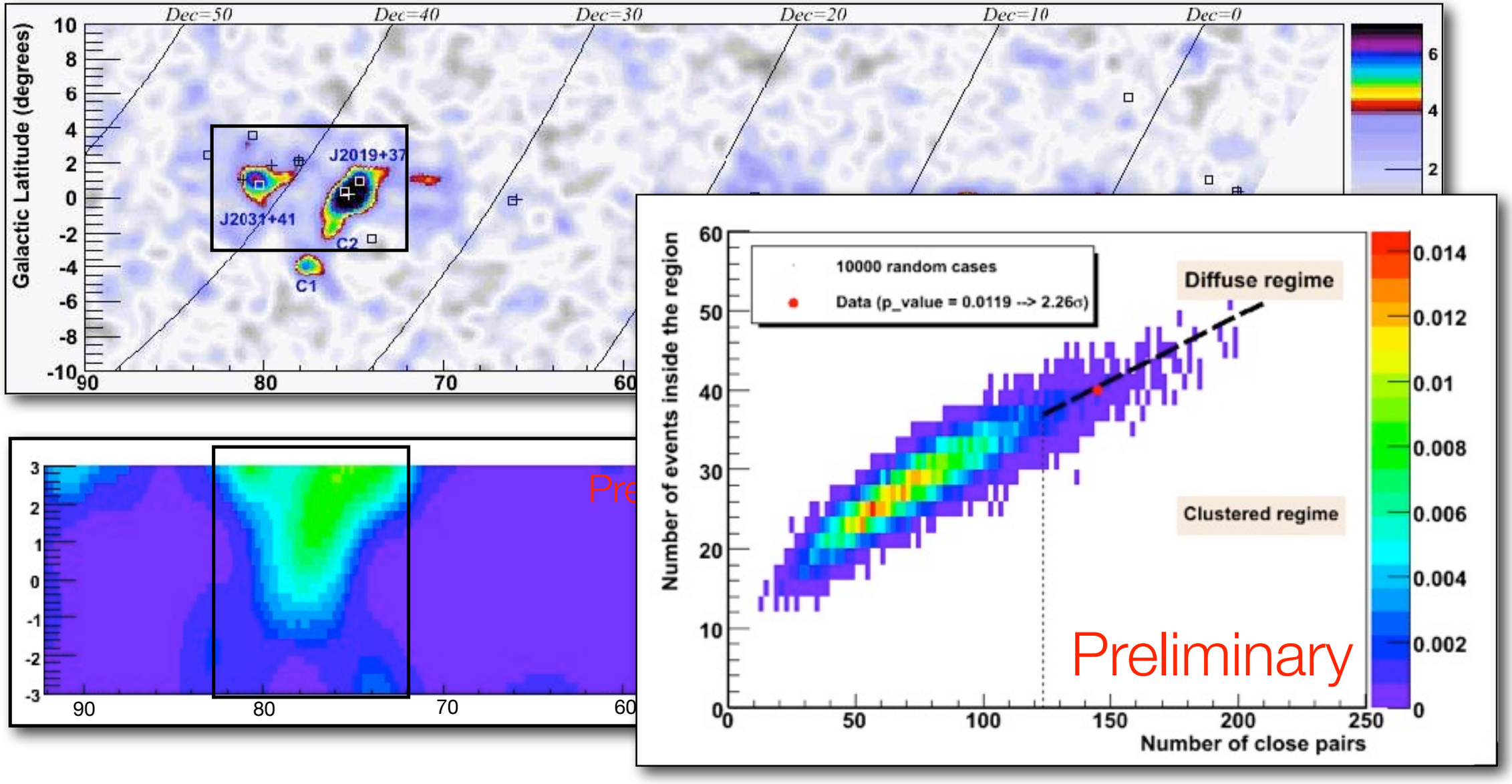

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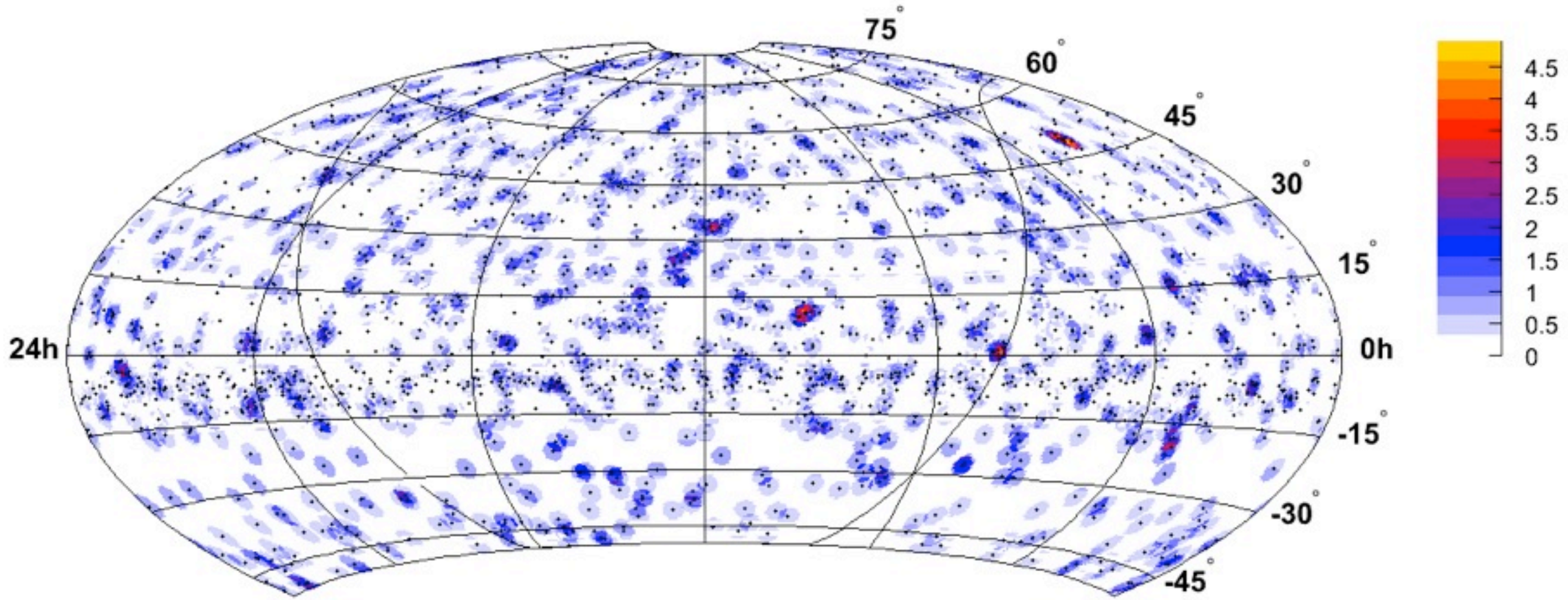
IceCube 22-String Ultrahigh Energy Search

Phys. *Rev. Lett*. **103**, 221102 (2009)



Look for neutrinos from entire sky by demanding high energies (~PeV)

- Reduces data to 1,877 events; max *p*-value 37.4% – not significant

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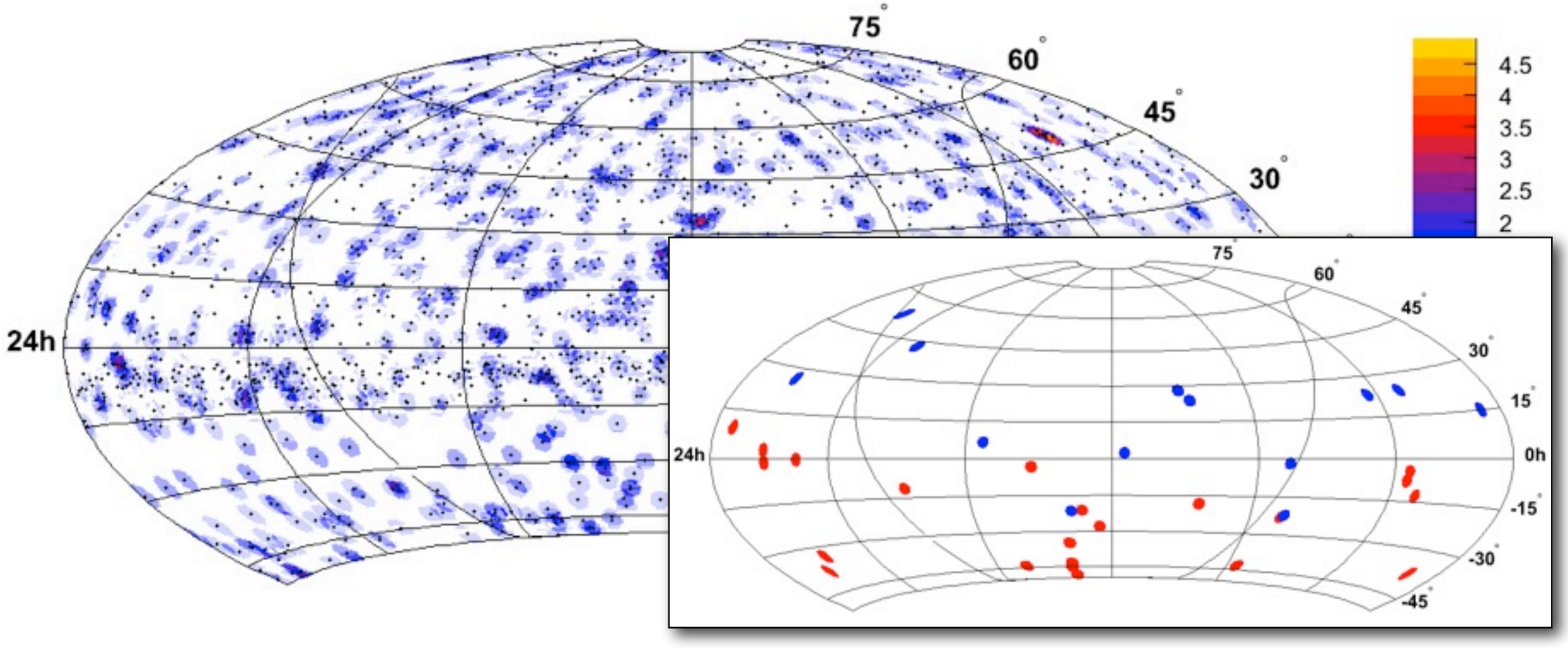
Phys. *Rev. Lett*. **103**, 221102 (2009)



Look for neutrinos from entire sky by demanding high energies (~PeV)

- Reduces data to 1,877 events; max *p*-value 37.4% – not significant

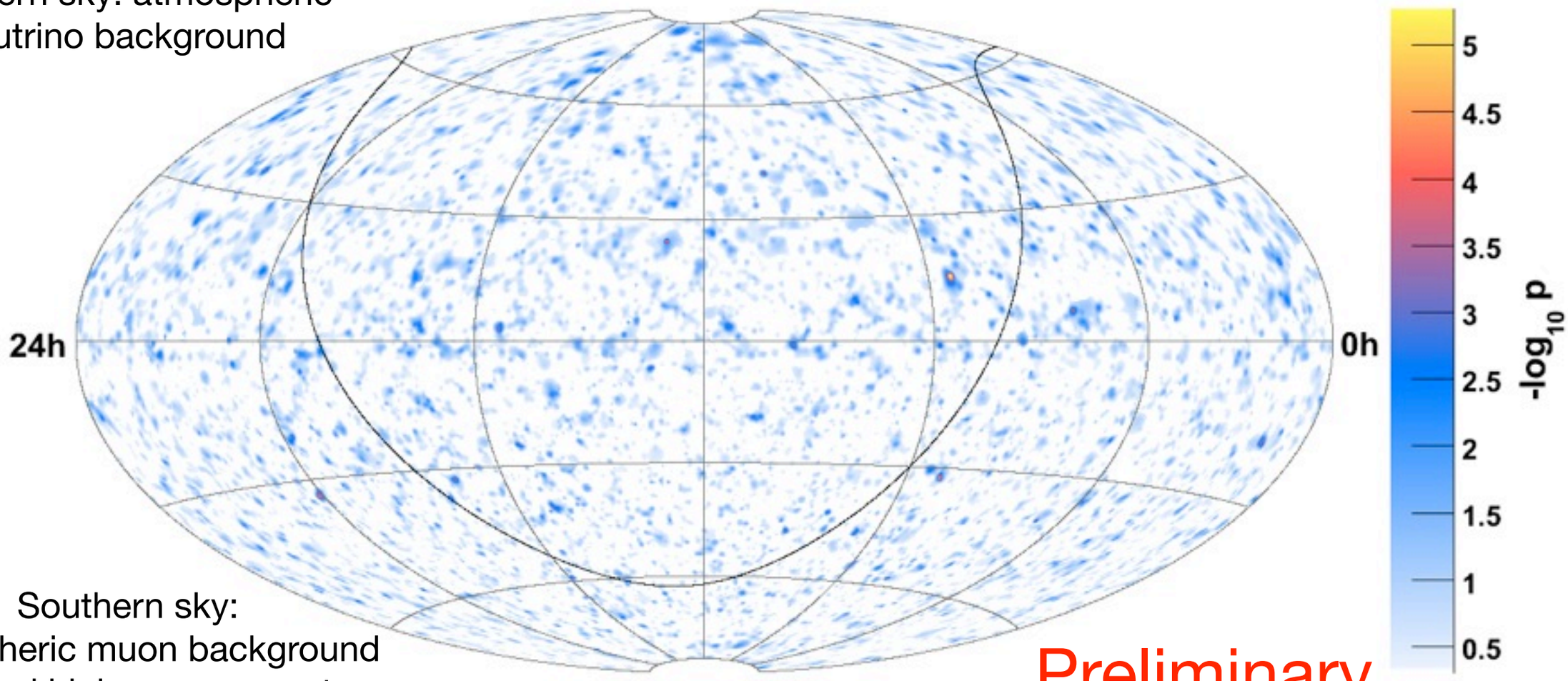
Also search for correlations with Auger, HiRes UHE events within 3° radius

- Observe 60 events, 43.7 expected → *p*-value 0.98%, 2.33σ (preliminary)

IceCube 2008 (40 String) Full Sky Source Search

J. Dumm for the Collaboration, 31st ICRC, Łódź

Northern sky: atmospheric neutrino background



Southern sky: atmospheric muon background demand high energy events

Preliminary

Preliminary results from 375.5 days exposure

36,900 events: 14,121 upgoing and 22,779 downgoing

Maximum *p*-value 5.2 x 10^{-6}, seen in 18% of randomized sky maps

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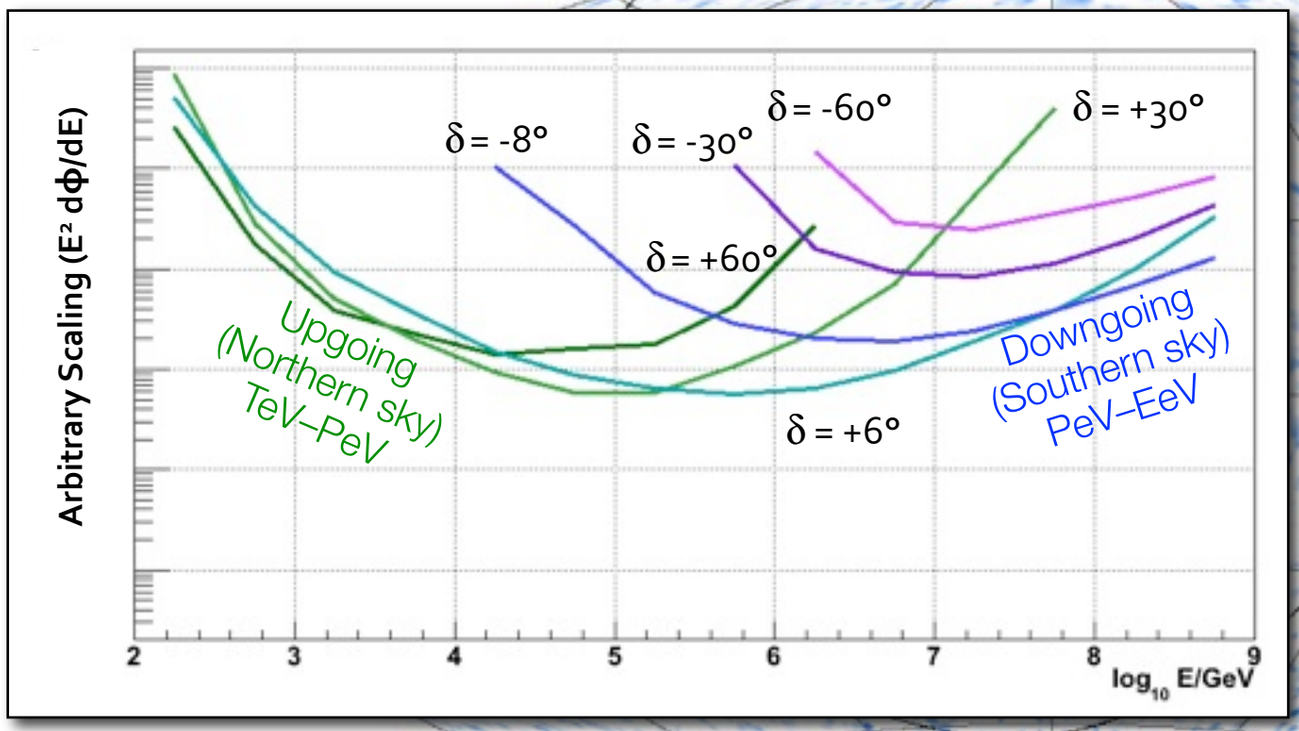

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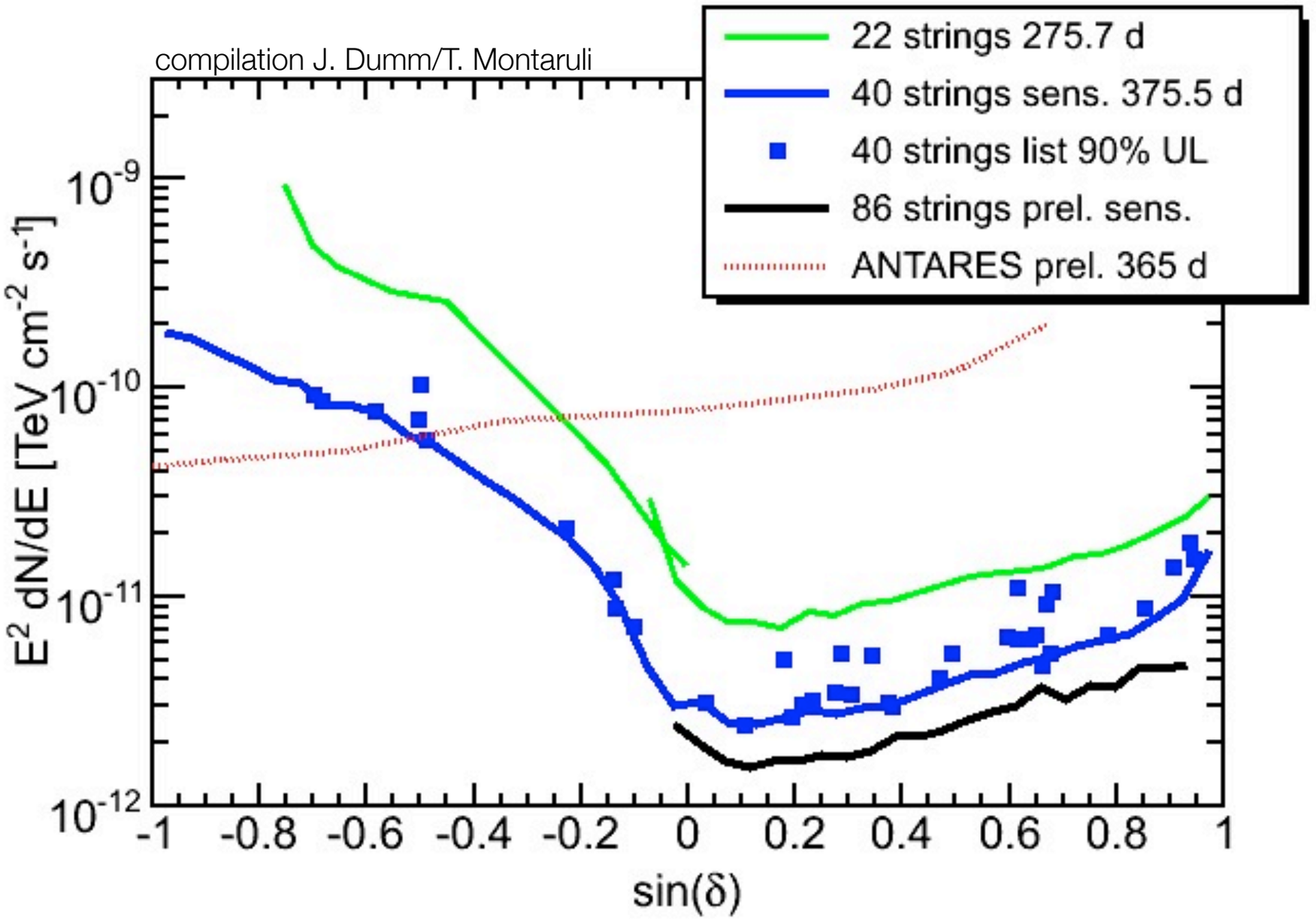
Sensitivities to Neutrino Point Sources

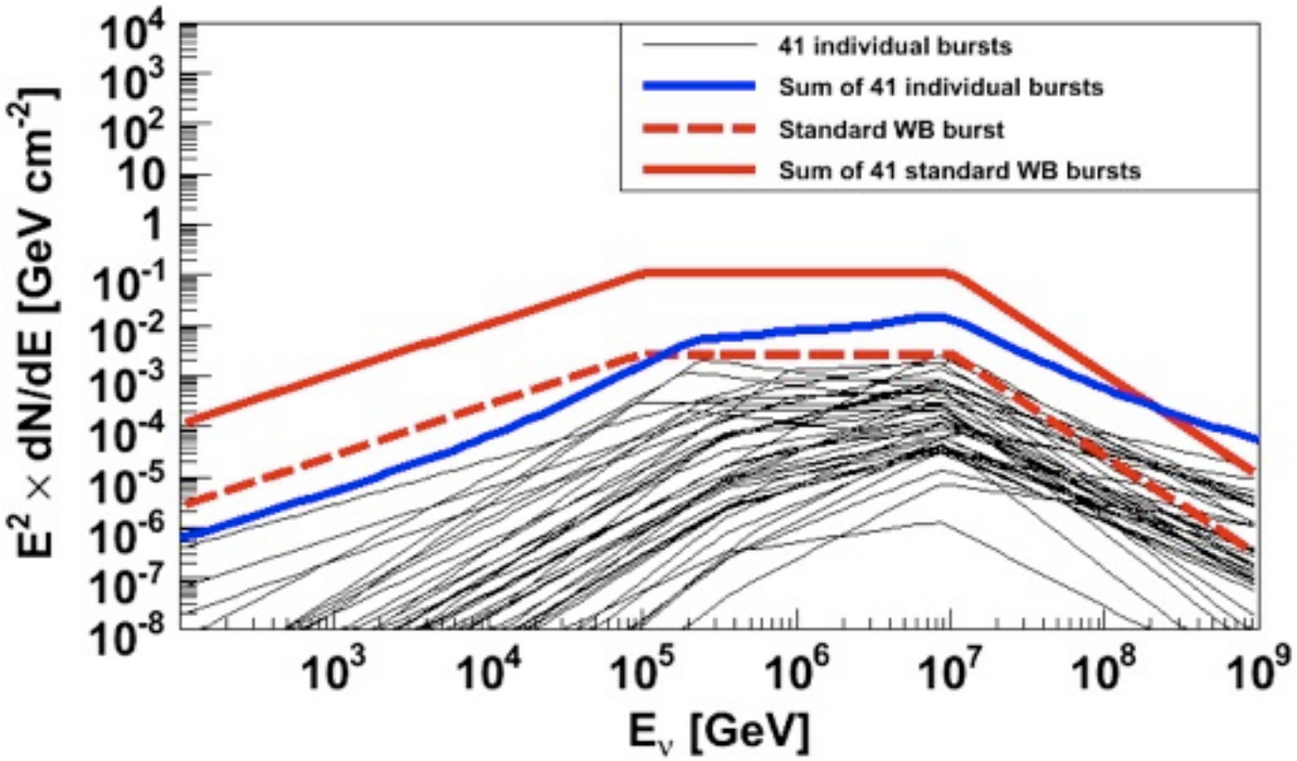


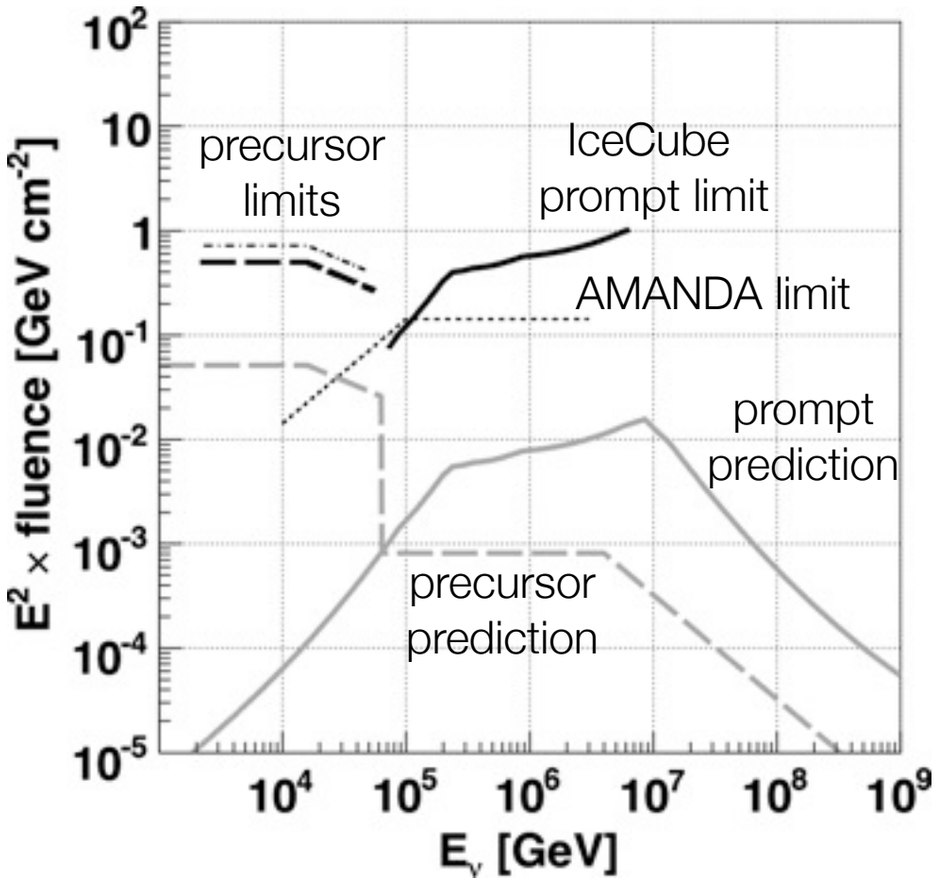
Includes preliminary limits on 39 pre-selected point sources, largest *p*-value 62%

Discovery with IC86 possible if highest significances (1%) are hints of real sources

Search for Neutrinos from Gamma Ray Bursts

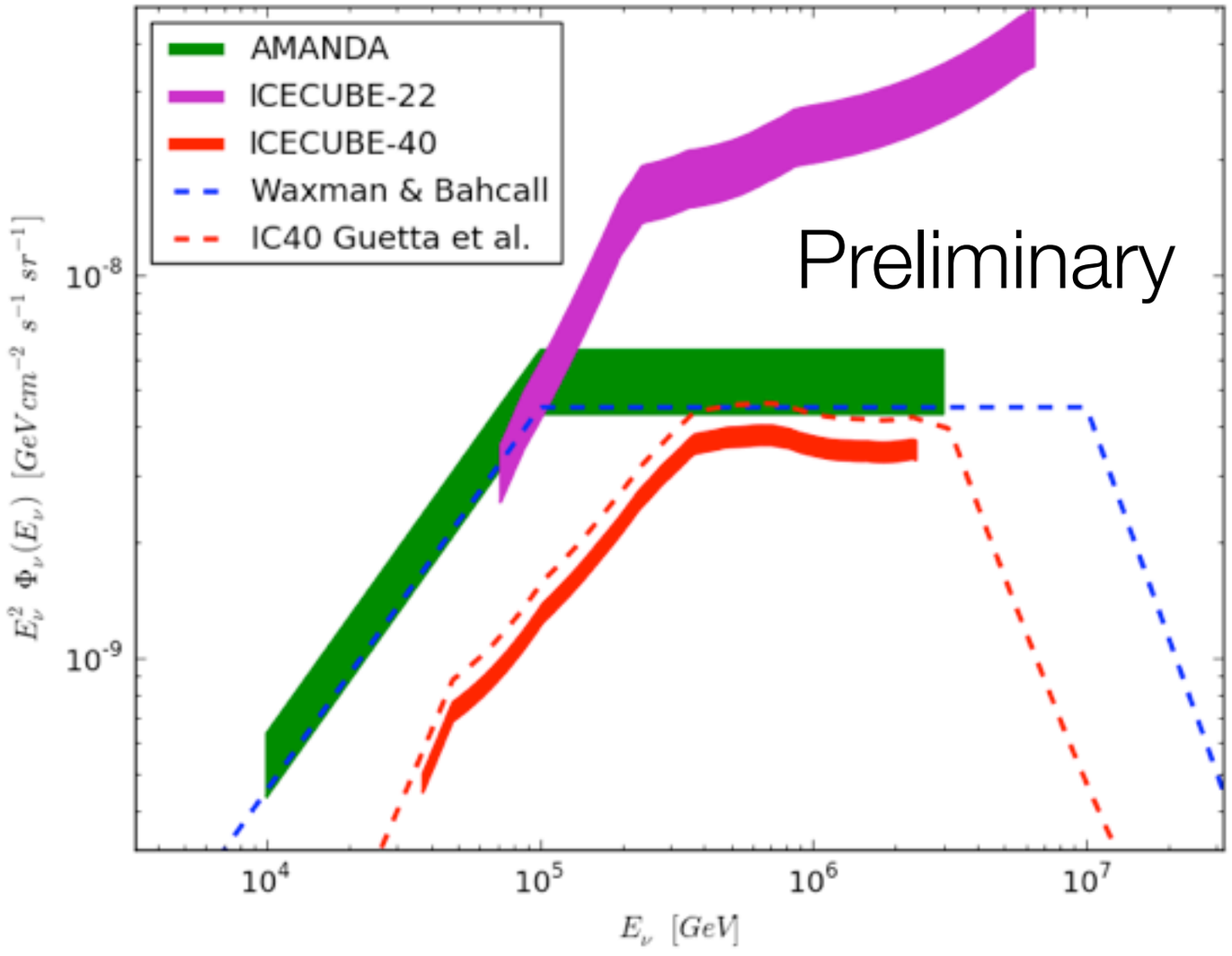
Astrophys. J. **674**, 357 (2008),
Astrophys. J. **710**, 346 (2010)





- 41 GCN bursts, mostly from Swift, neutrino fluence calculated based on observed burst parameters
  - Unbinned search method incorporating angular resolution, reconstructed energy, and observed T100 of burst
- Data from 2007 (22 strings) consistent with background

GRB Search with IceCube 40-String Data



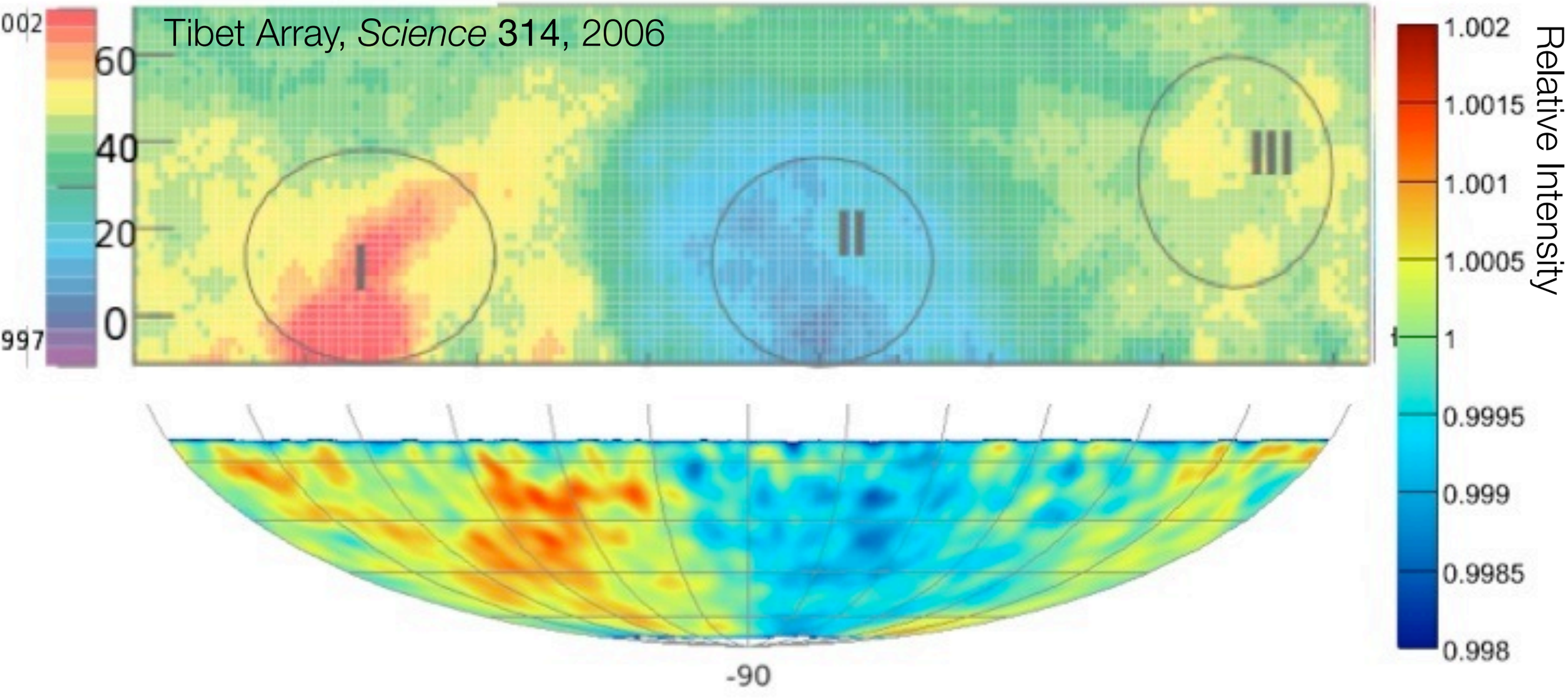
117 Northern hemisphere GRBs from 2008 (40-string) data run

Preliminary 90% CL upper limit is 81% of predicted Guetta-like neutrino flux

- One year with 40 strings provides better sensitivity than the full seven year AMANDA-II data set

Anisotropy in TeV-Scale Cosmic Rays

arXiv:1005.2960, accepted *Astrophys. J. Lett.*



Appears consistent with an extension of Northern anisotropy previously reported by Tibet and Milagro

Summary

- IceCube construction is nearly complete
  - 79 of a planned 86 strings now operating
- Results from 22-string and 40-string configurations consistent with background, but several interestingly low *p*-values
  - Rapidly increasing sensitivity to astrophysical neutrino sources
  - Full detector will detect sources quickly, if these are hints of real sources
  - Already becoming sensitive to ‘standard’ models of cosmic ray-producing gamma ray bursts
- Anisotropy of cosmic rays presents an interesting puzzle
  - Confirmed by several experiments, still needs explanation