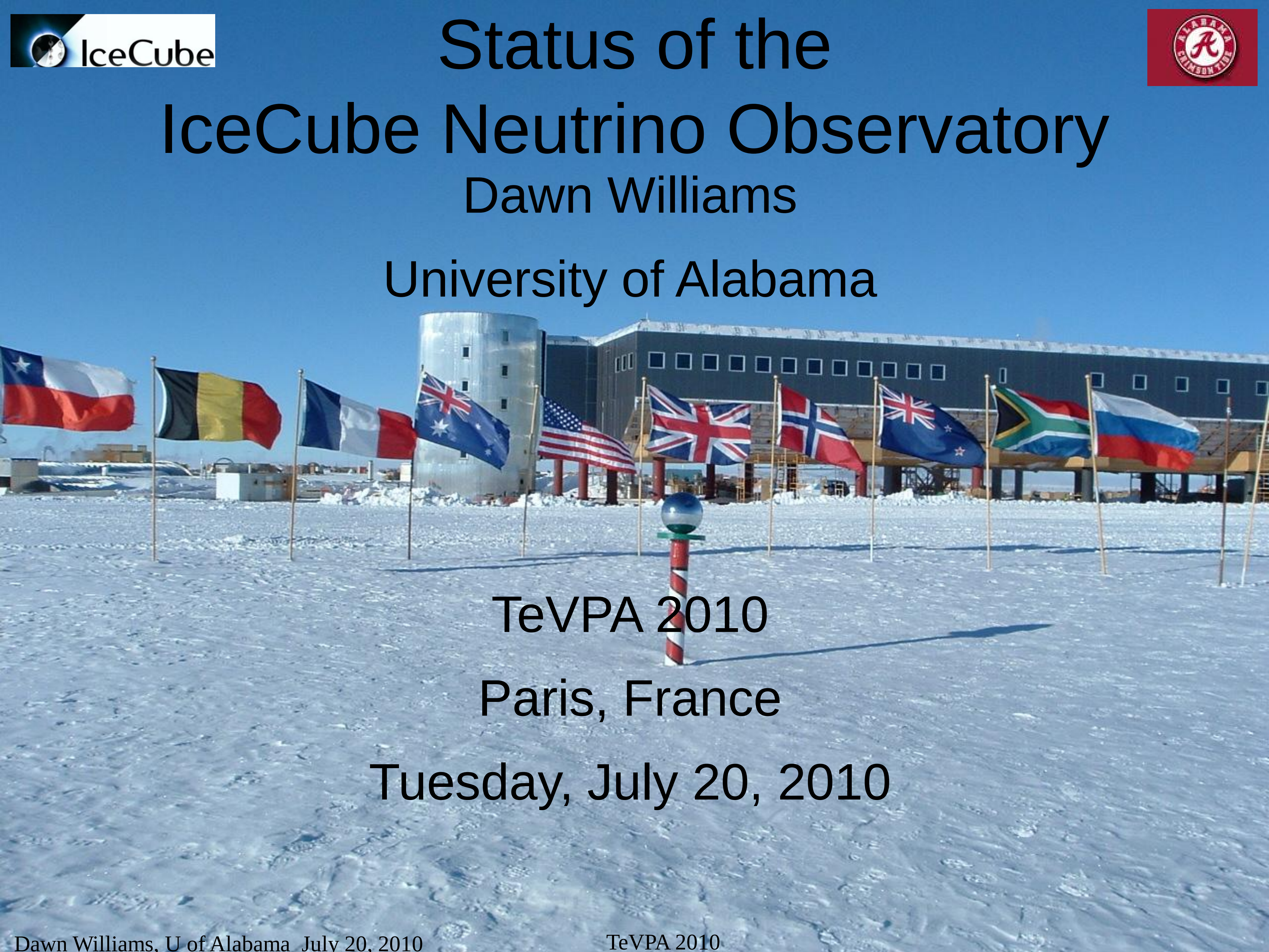


Status of the IceCube Neutrino Observatory

Dawn Williams

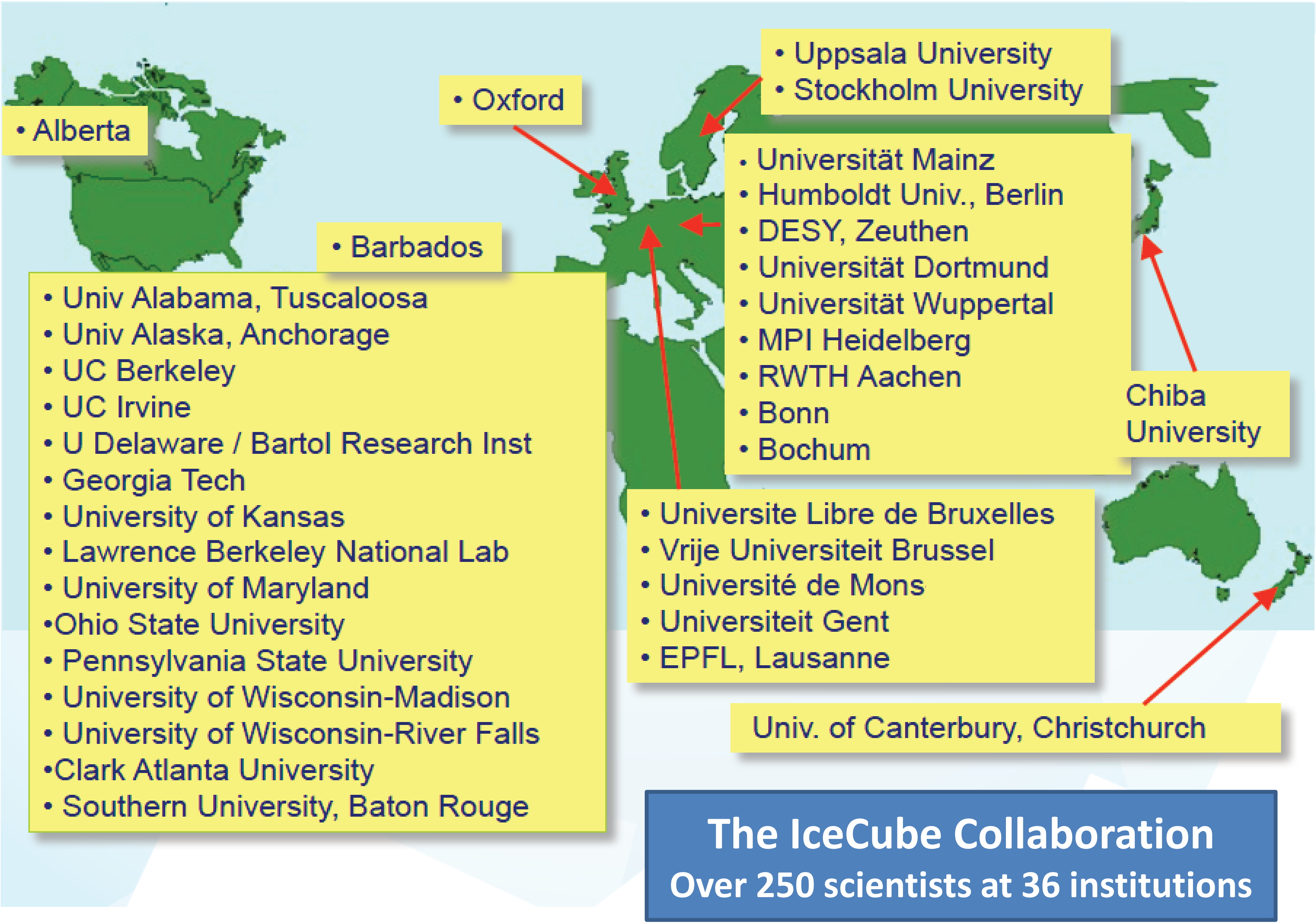
University of Alabama

TeVPA 2010

Paris, France

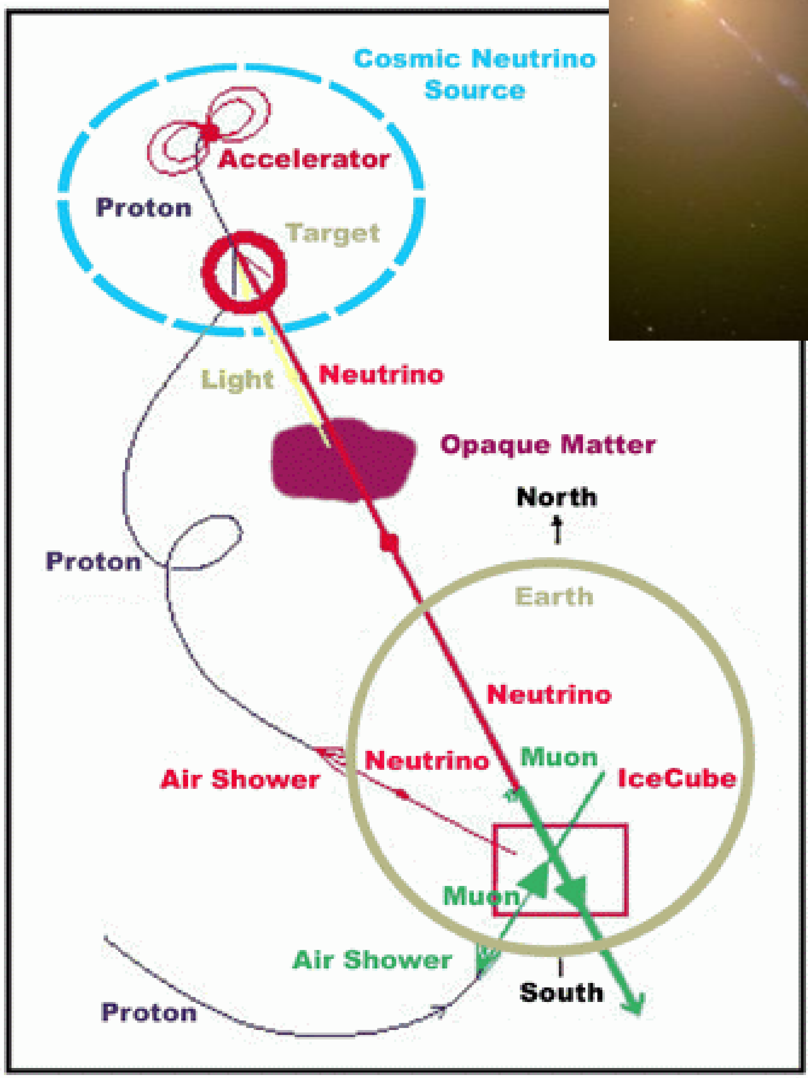
Tuesday, July 20, 2010

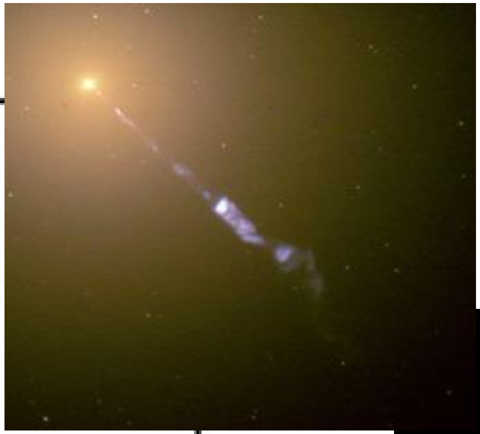
IceCube



• Alberta
• Oxford
• Uppsala University
• Stockholm University
• Universität Mainz
• Humboldt Univ., Berlin
• DESY, Zeuthen
• Universität Dortmund
• Universität Wuppertal
• MPI Heidelberg
• RWTH Aachen
• Bonn
• Bochum
Chiba University
• Barbados
• Univ Alabama, Tuscaloosa
• Univ Alaska, Anchorage
• UC Berkeley
• UC Irvine
• U Delaware / Bartol Research Inst
• Georgia Tech
• University of Kansas
• Lawrence Berkeley National Lab
• University of Maryland
•Ohio State University
• Pennsylvania State University
• University of Wisconsin-Madison
• University of Wisconsin-River Falls
•Clark Atlanta University
• Southern University, Baton Rouge
• Universite Libre de Bruxelles
• Vrije Universiteit Brussel
• Université de Mons
• Universiteit Gent
• EPFL, Lausanne
Univ. of Canterbury, Christchurch
The IceCube Collaboration
Over 250 scientists at 36 institutions

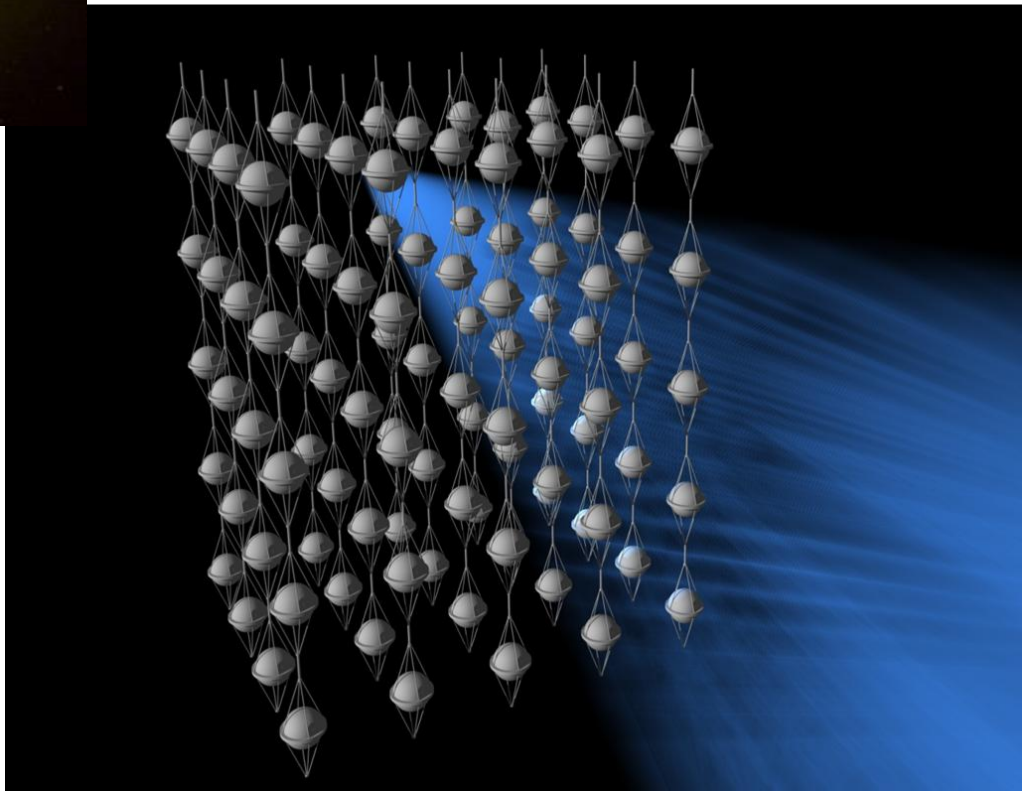
Neutrino Astronomy





Sources of the highest energy cosmic rays are also potential neutrino sources

Neutrinos will open up a new window in astronomy

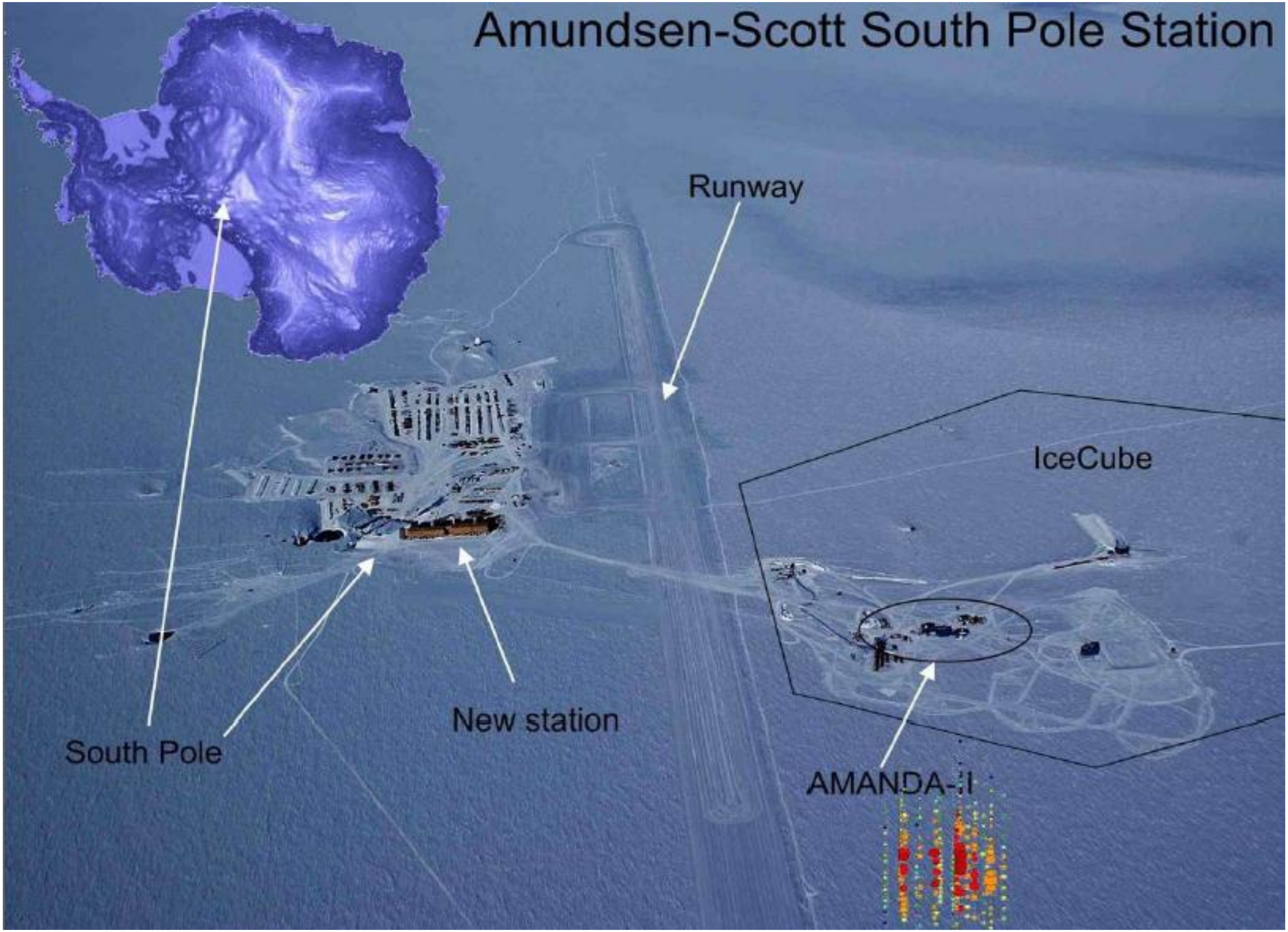


Large detector required for neutrino astronomy… many possibilities for science!

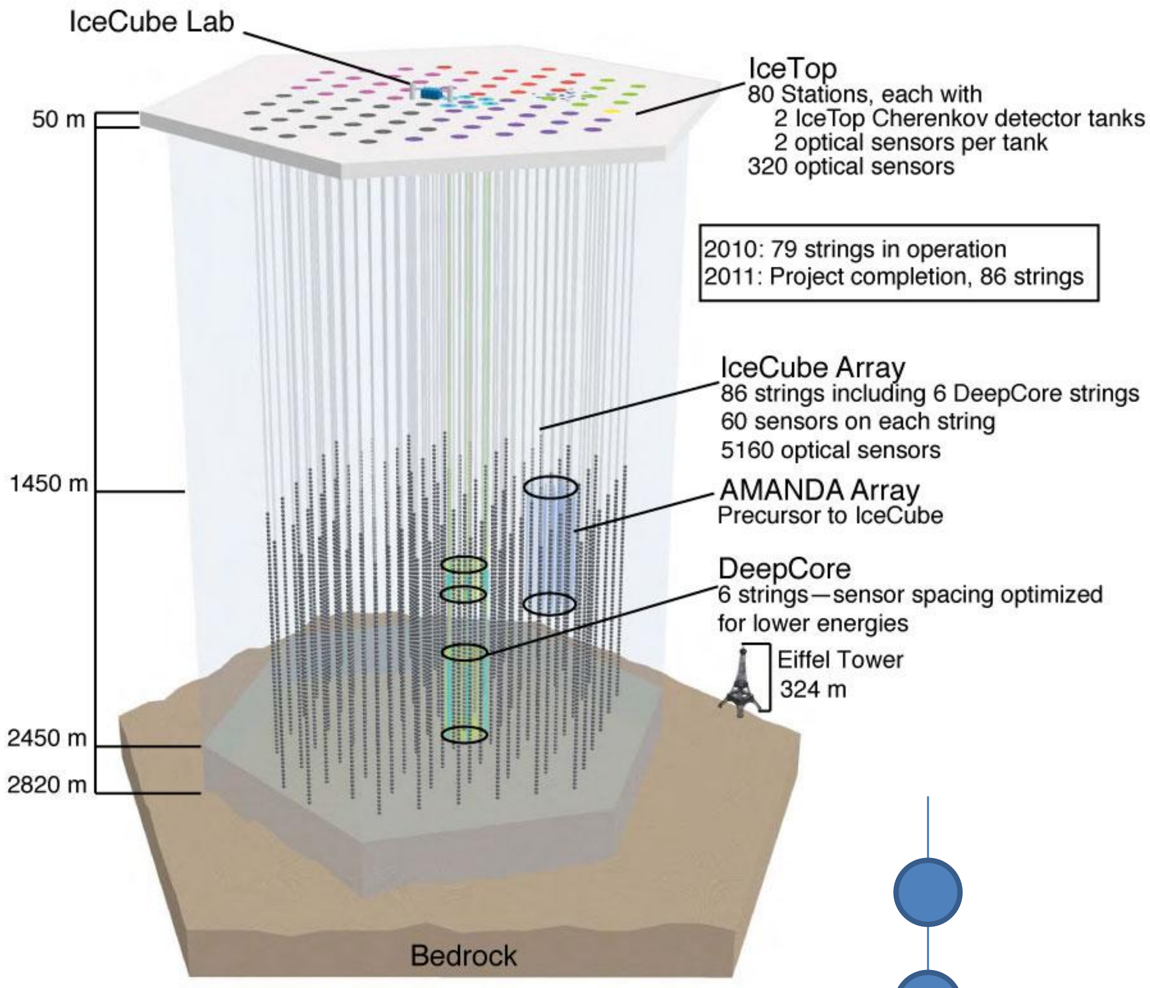
Km^3 Neutrino Telescopes: North and South

Mediterranean Sea

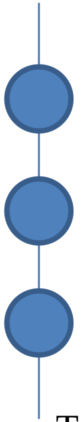
Amundsen-Scott South Pole Station, Antarctica


Amundsen-Scott South Pole Station
Runway
IceCube
South Pole
New station
AMANDA-II

IceCube



- 79 strings
  - 60 Digital Optical Modules (DOMs) per string
  - 91% of strings deployed
  - 98% of DOMs functioning
- Completed detector will have 86 strings, instrument 1 km^3
- Scheduled for completion in 2010/11



<u>IceCube data taken during construction</u>

2006-7 data set – IC9

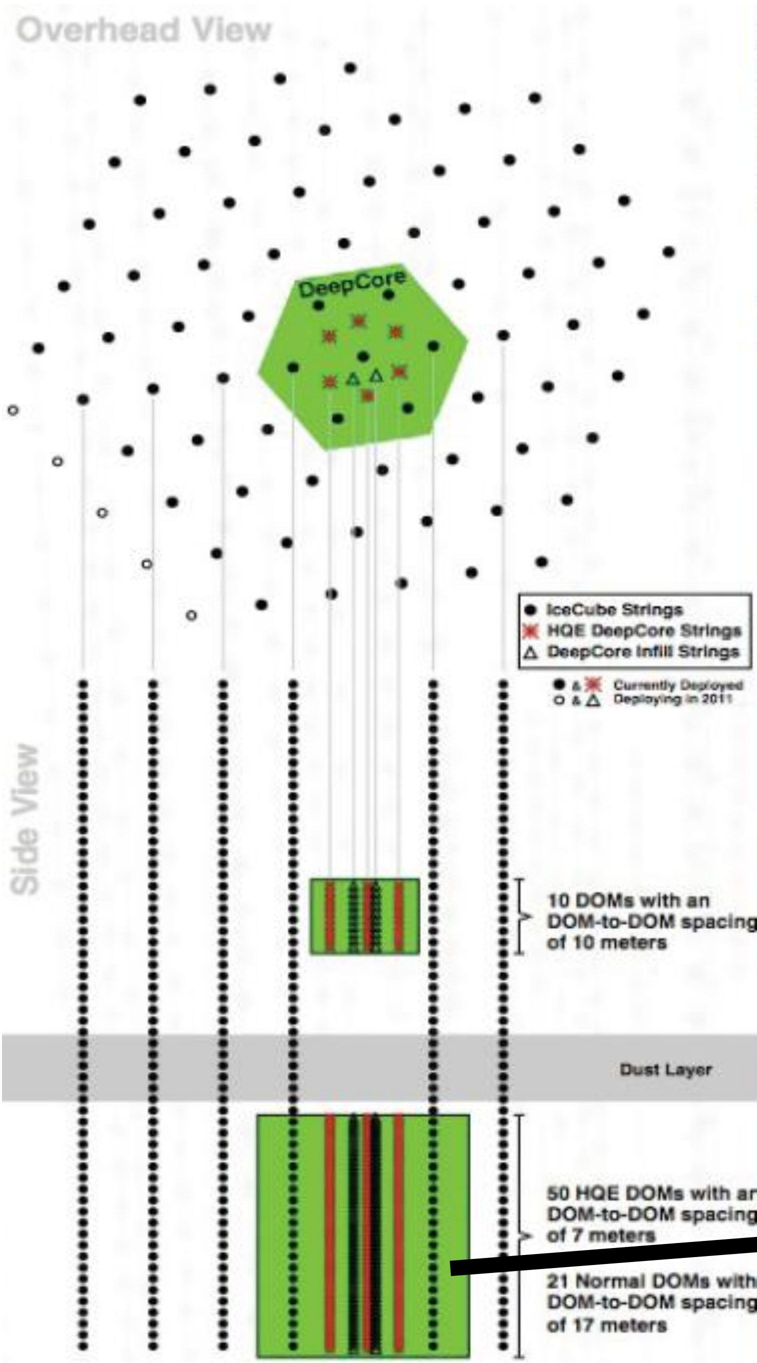
2007-8 data set – IC22

2008-9 data set – IC40

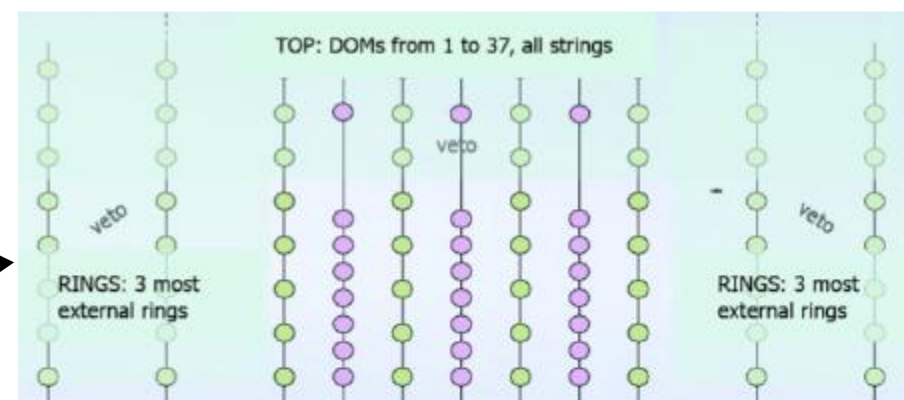
2009-10 data set– IC59

Current configuration– IC79

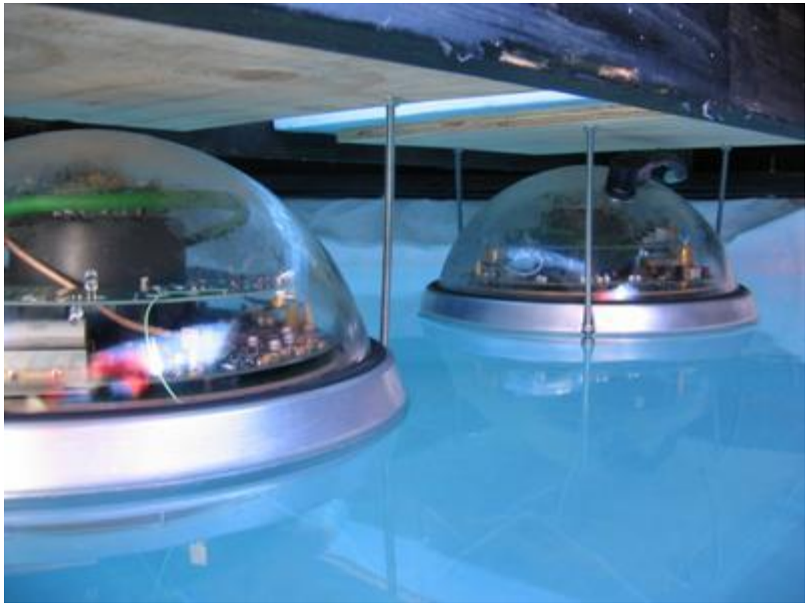
IceCube "Deep Core"



- 6 strings + 2 infill strings
  - densely spaced DOMs
  - higher quantum efficiency
  - Center of IceCube, deepest and clearest ice
- IceCube is active veto for DeepCore
- 6 DeepCore strings deployed, infill strings to be deployed in 2010/11
- Will improve science capability at low energies compared to decommissioned AMANDA detector

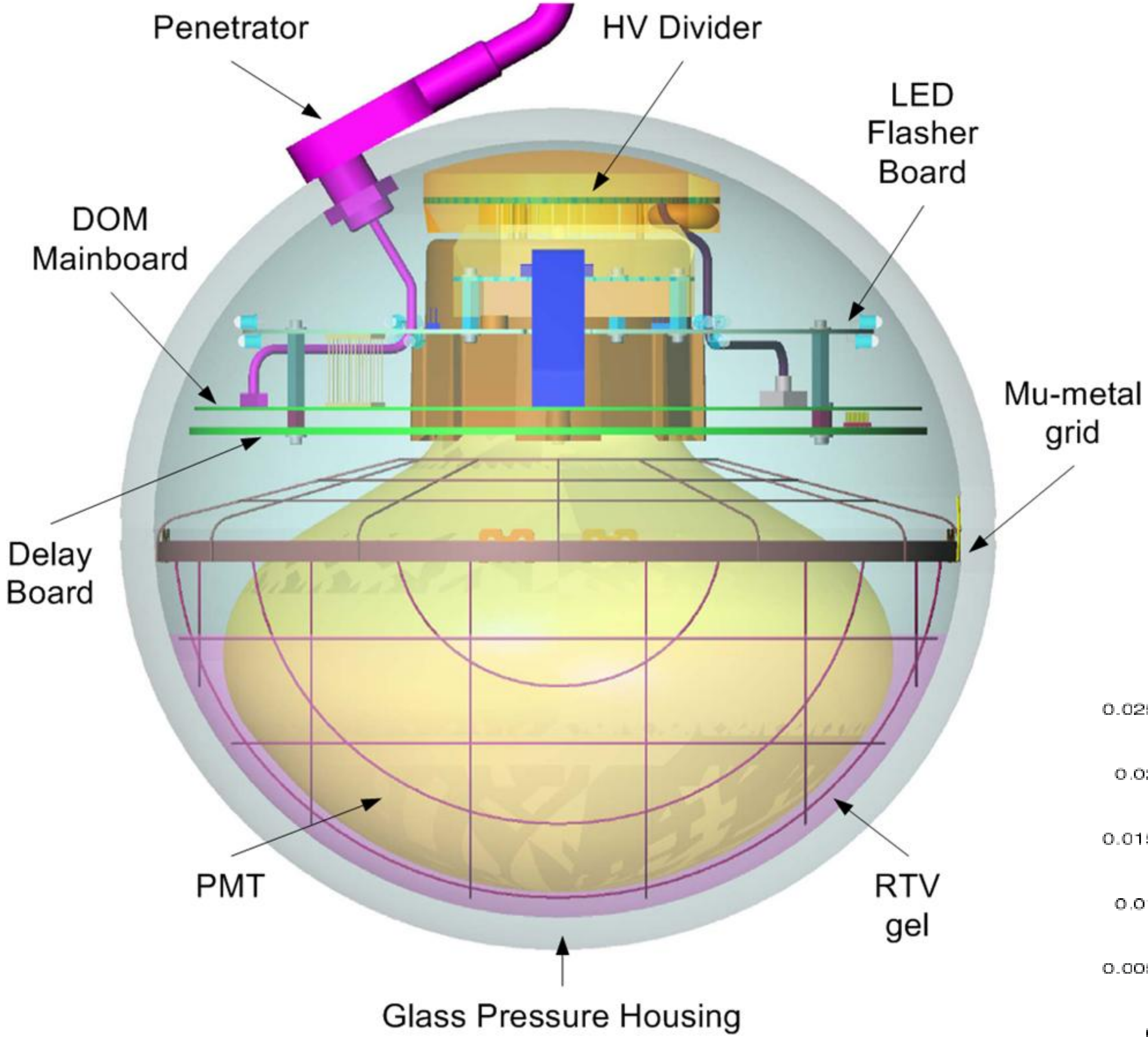


IceTop

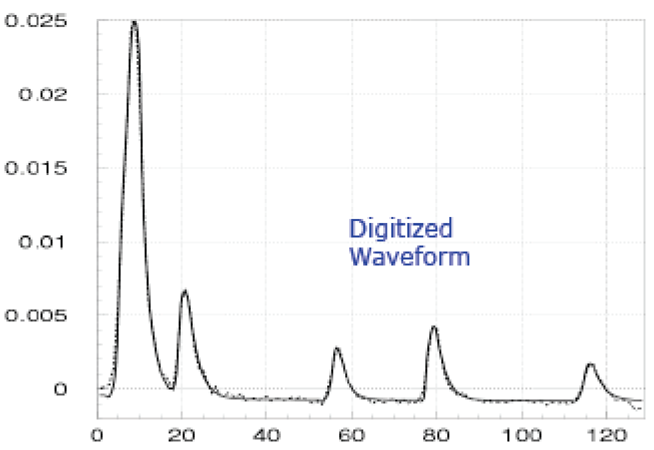


- 2 DOMs per tank
- 80 stations with 2 tanks per station
- Cosmic ray studies, veto for IceCube

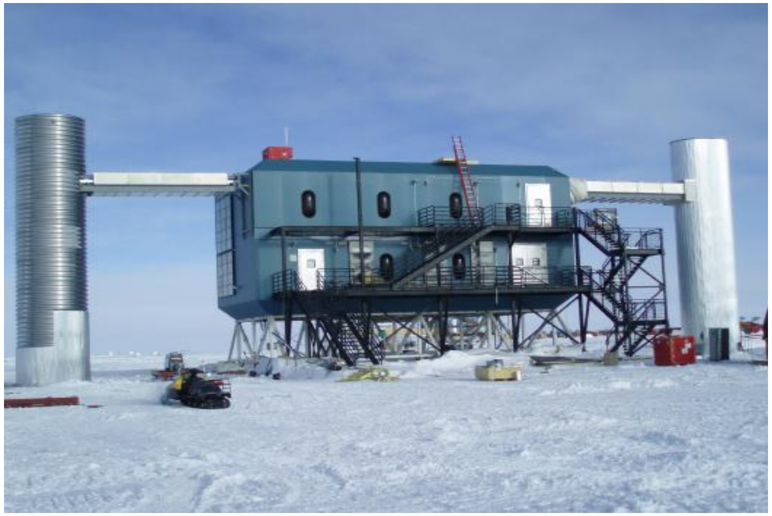
The IceCube DOM

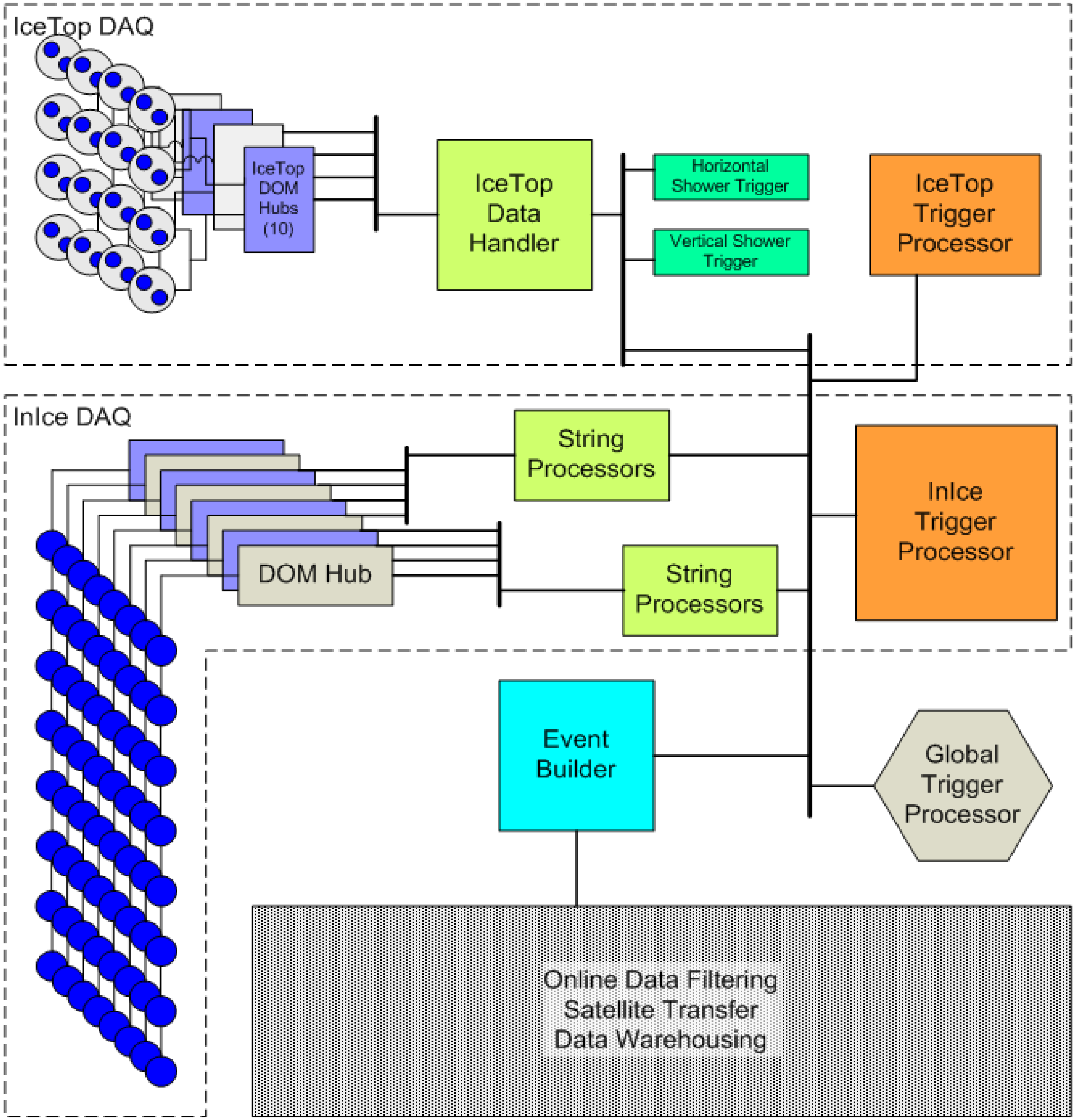


- PMT waveform digitization in-ice
- On-board flasher LEDS for calibration
- Time calibration from surface GPS



IceCube Triggering and Filtering





Local coincidence communication between DOMs in ice

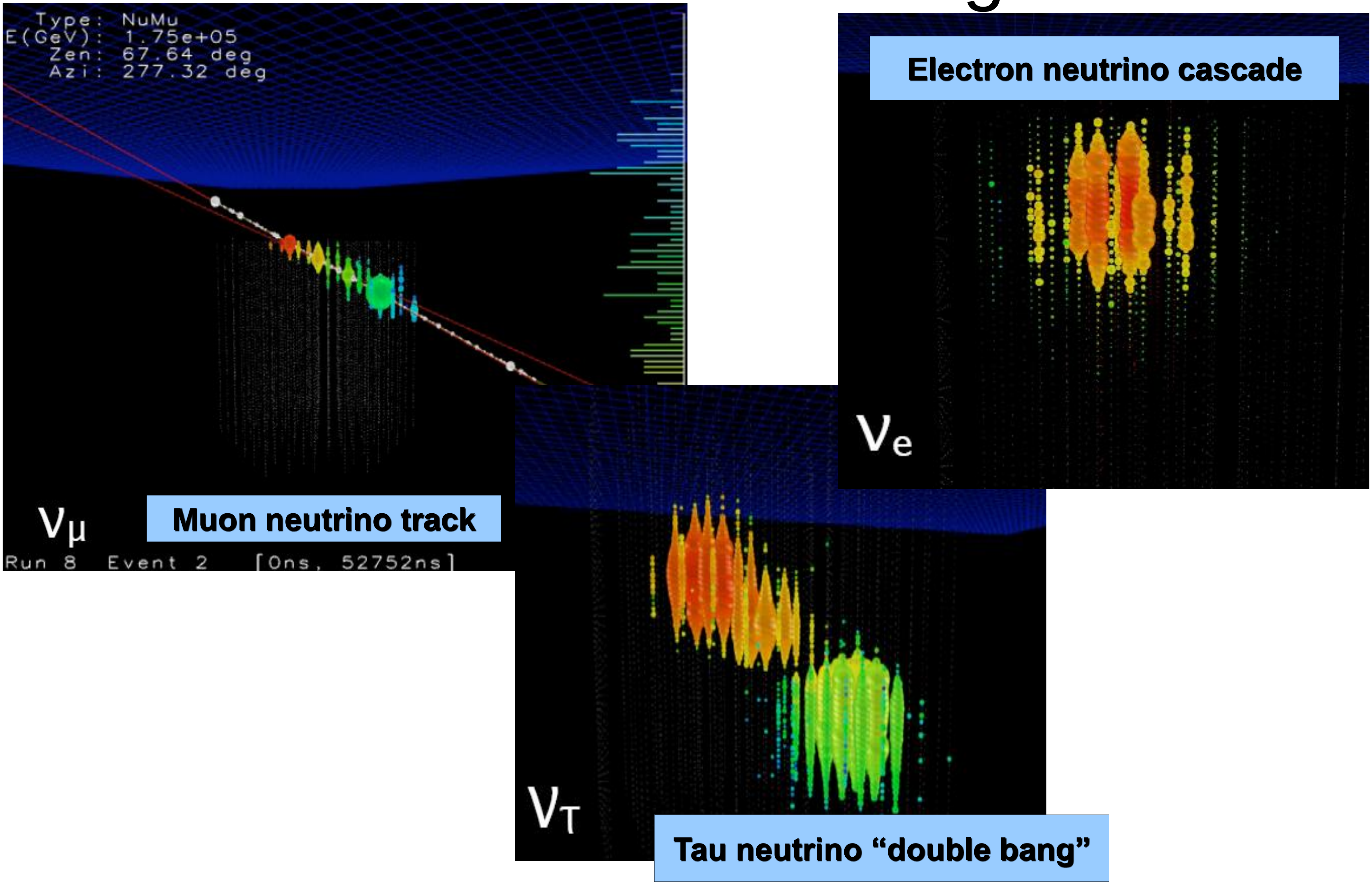
↓

Triggering on surface (simple majority, etc.)

↓

Physics filtering on data sent to the North via sattelite

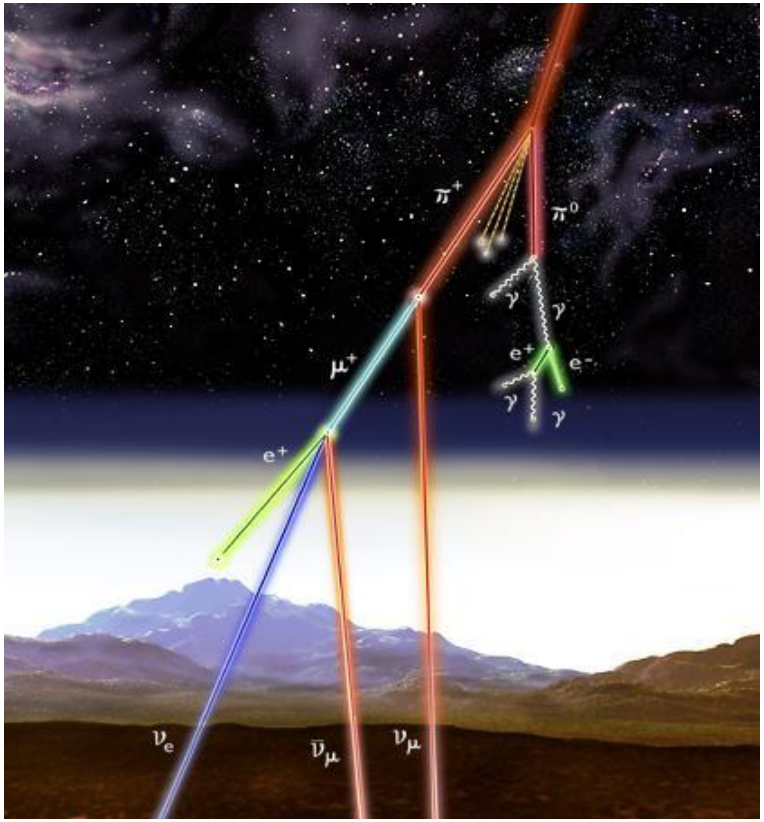
Simulated IceCube Signals

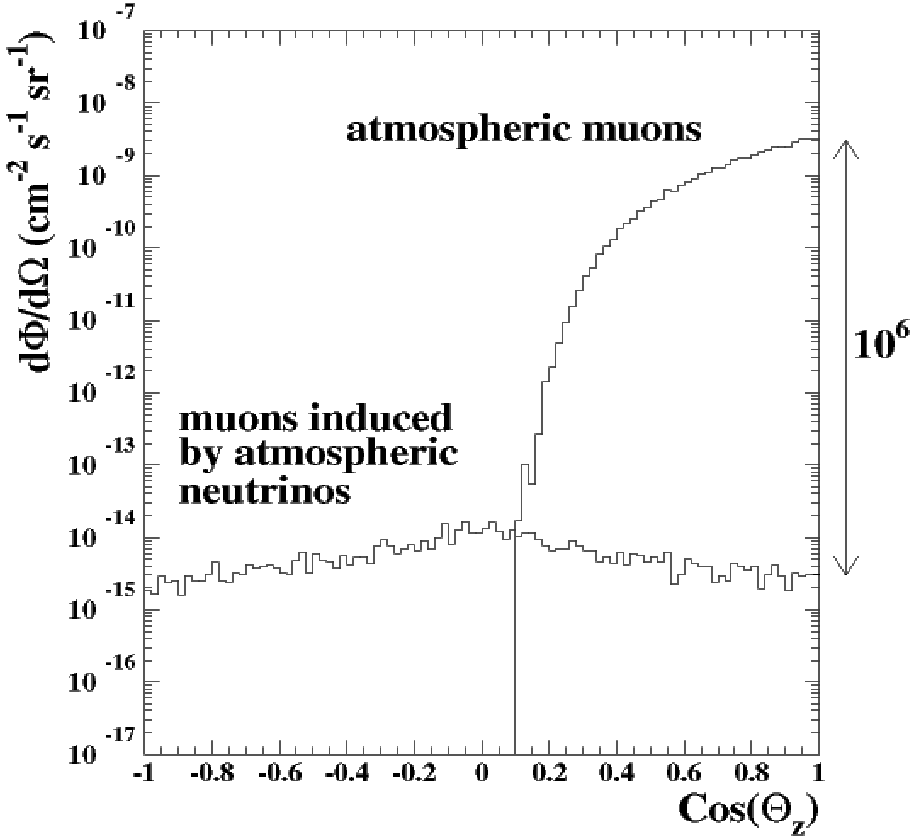


IceCube Science

- Backgrounds and Effective Area
- Diffuse analysis
- Point source analysis
  - see talks by Sirin Odrowski and Claudine Colnard
- Gamma Ray Bursts
  - see poster by Nathan Whitehorn
- Indirect dark matter search
  - see talks by Jan-Patrick Huelss and Matthias Danninger
- Supernovae
- Cosmic rays
  - See talks by Patrick Berghaus and Segev BenZvi

Backgrounds

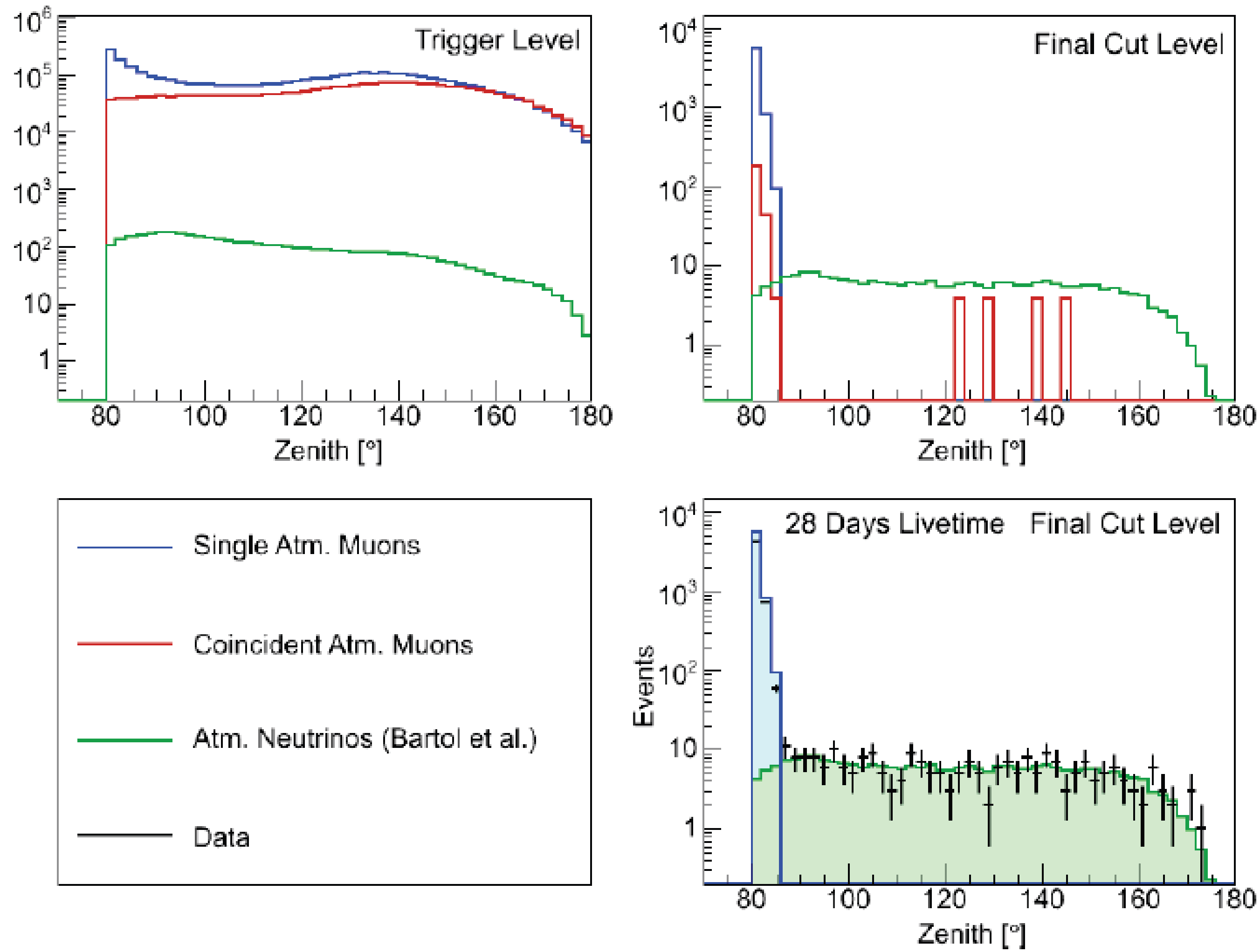




IceCube

Background Cuts: Zenith Angle

Reconstructed Zenith Angle



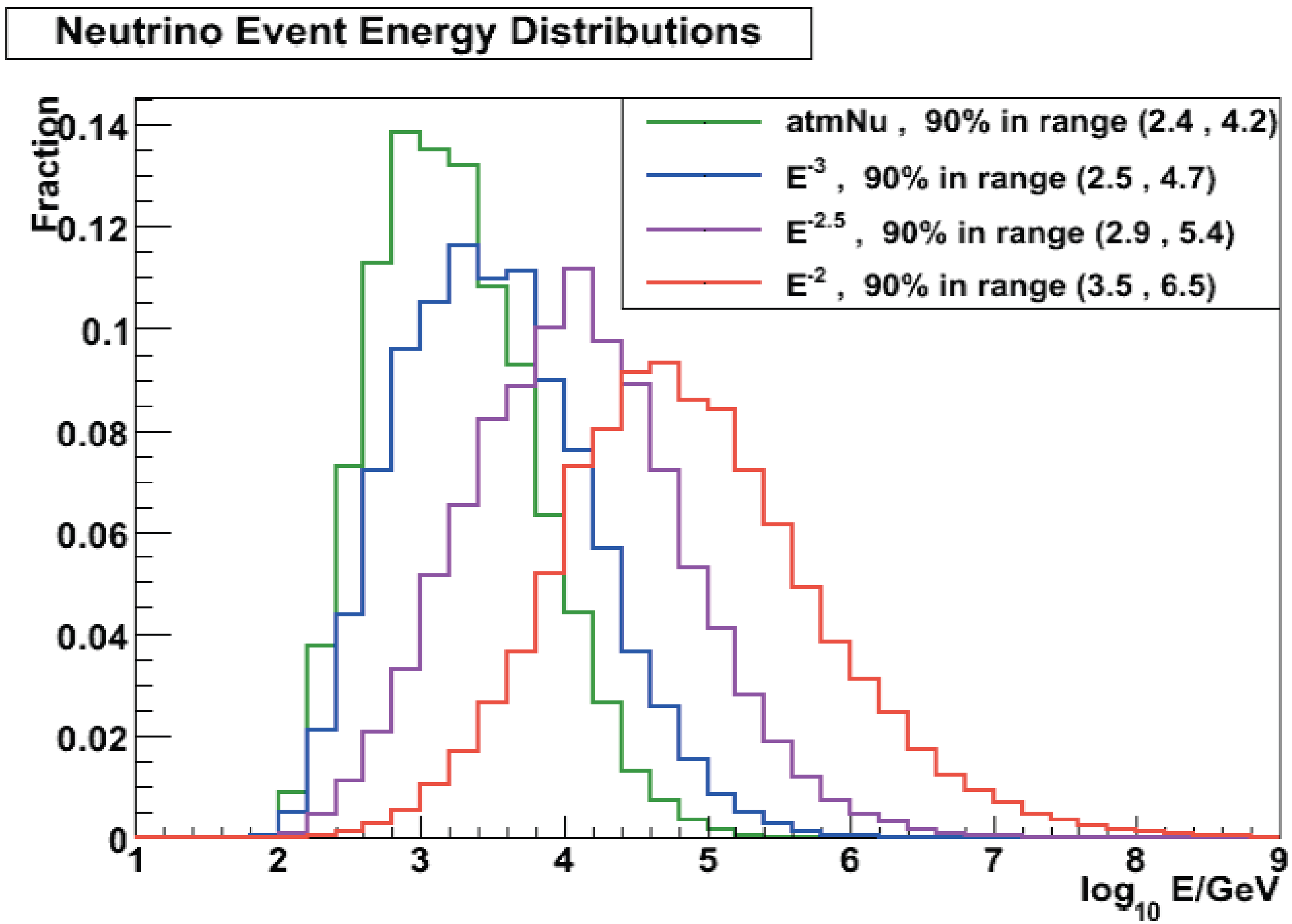
Backgrounds:

- Downgoing μ
- Coincident μ
- Atmospheric ν

Downgoing :
zenith angle < 90

Upgoing :
zenith angle > 90

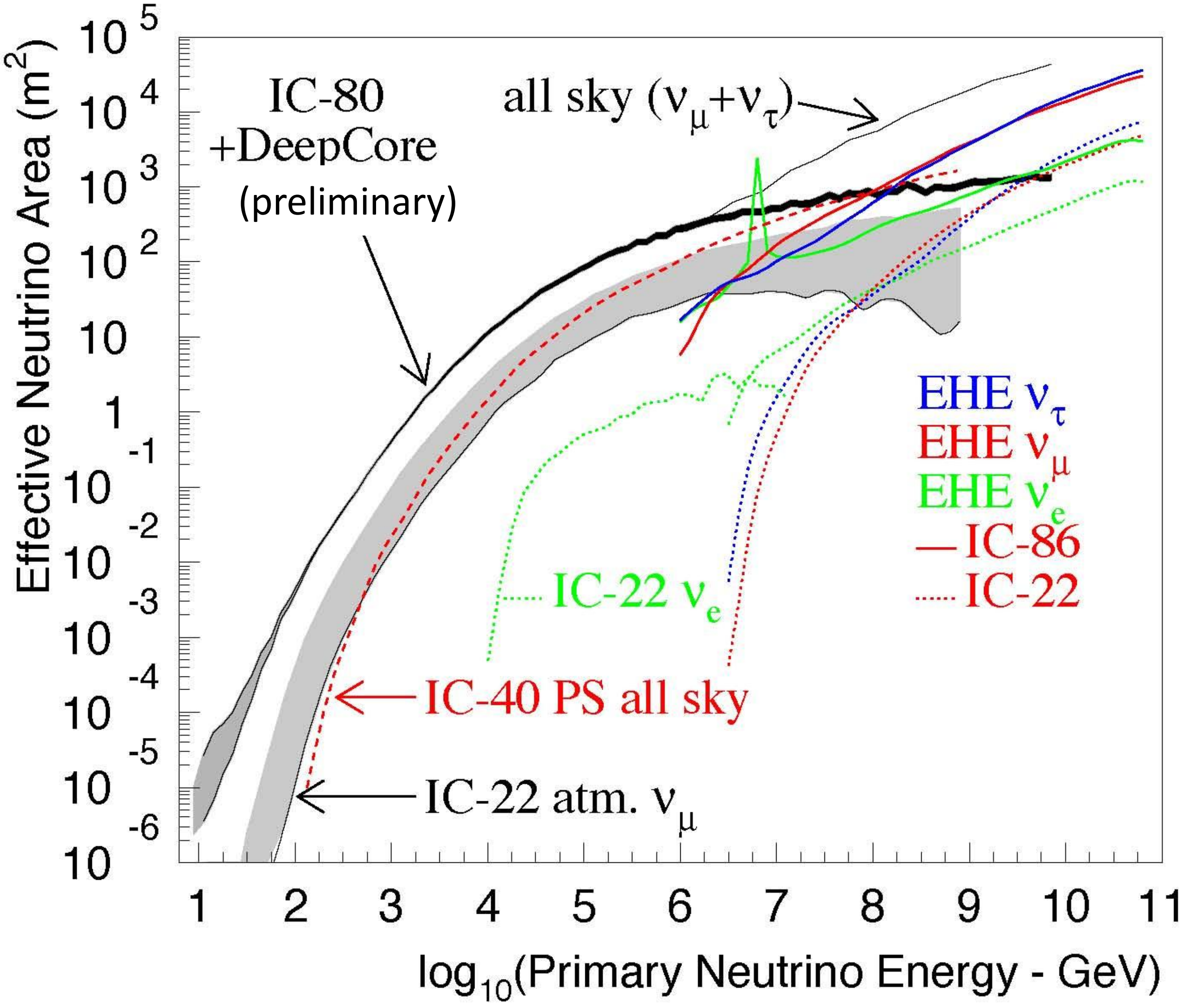
Background Cuts: Energy



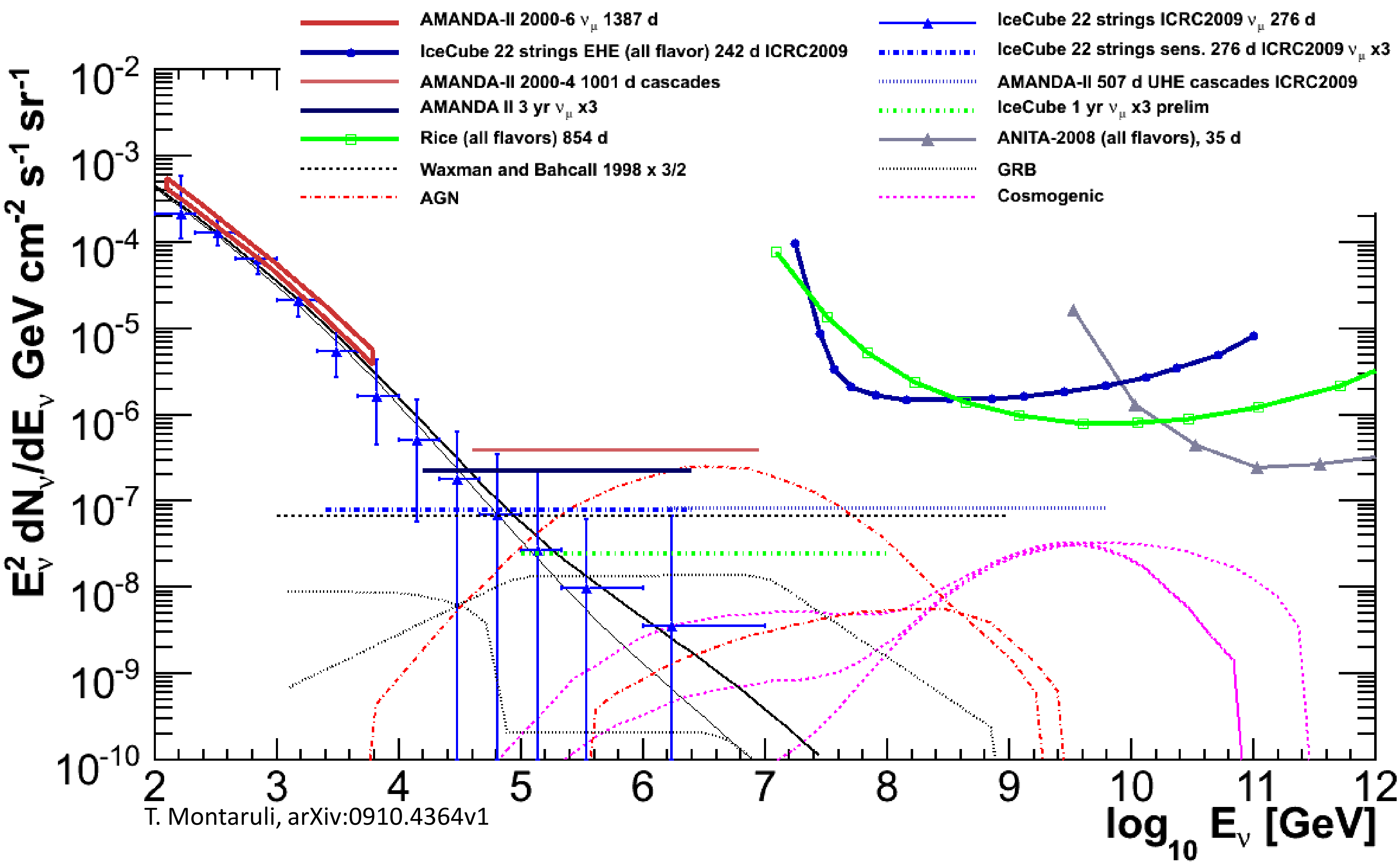
Astrophysical neutrino energy spectra are expected to be harder than the atmospheric neutrino spectrum

High energy events also used to look at the Southern Hemisphere sky

IceCube Effective Areas, Trigger and Analysis Level

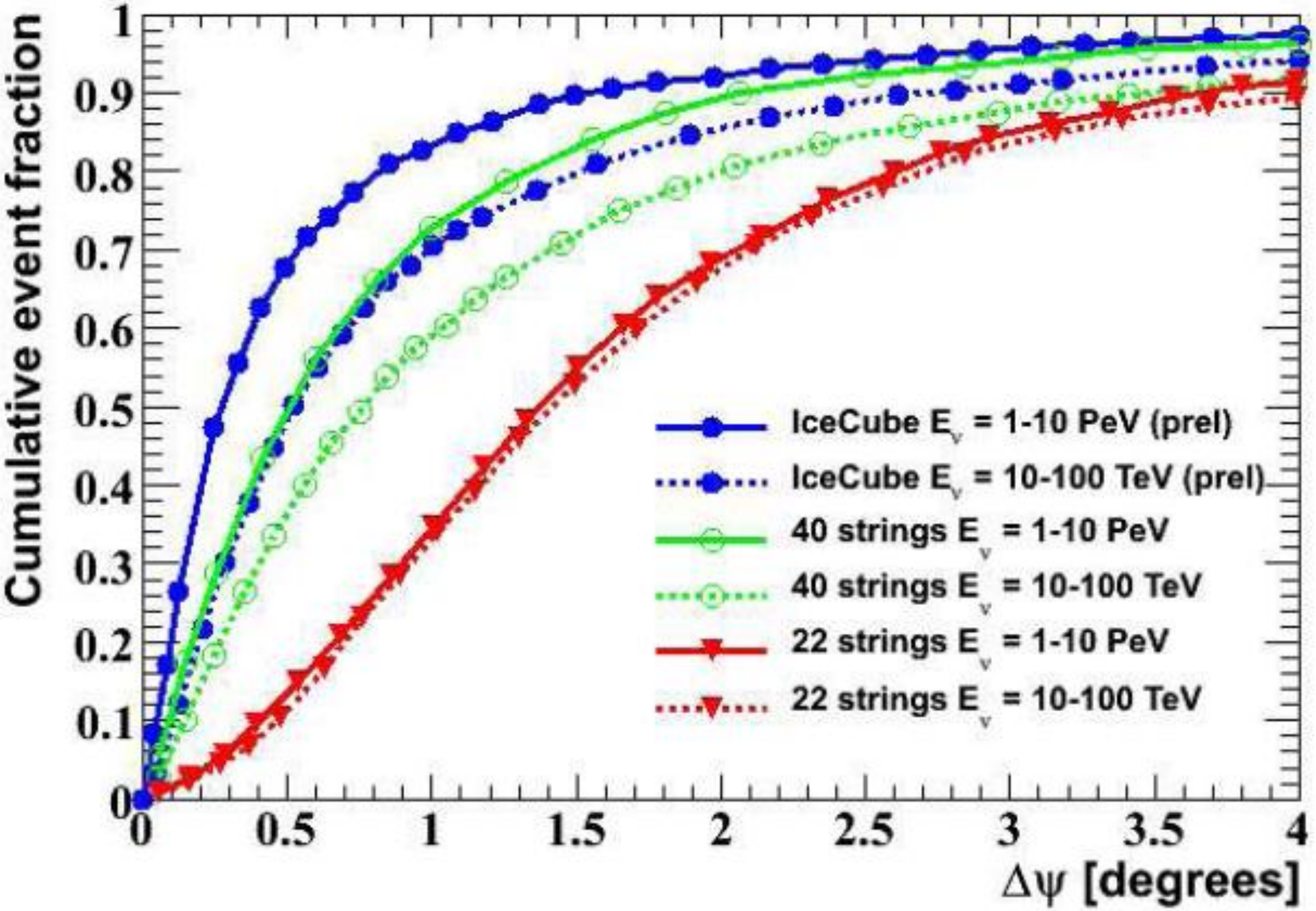


Atmospheric Neutrinos and Diffuse Flux Limits (IC22)

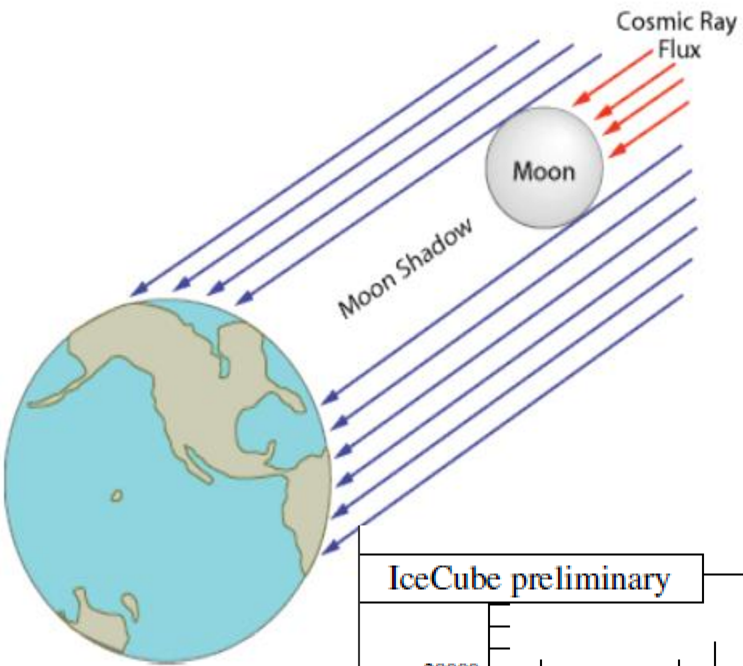


T. Montaruli, arXiv:0910.4364v1

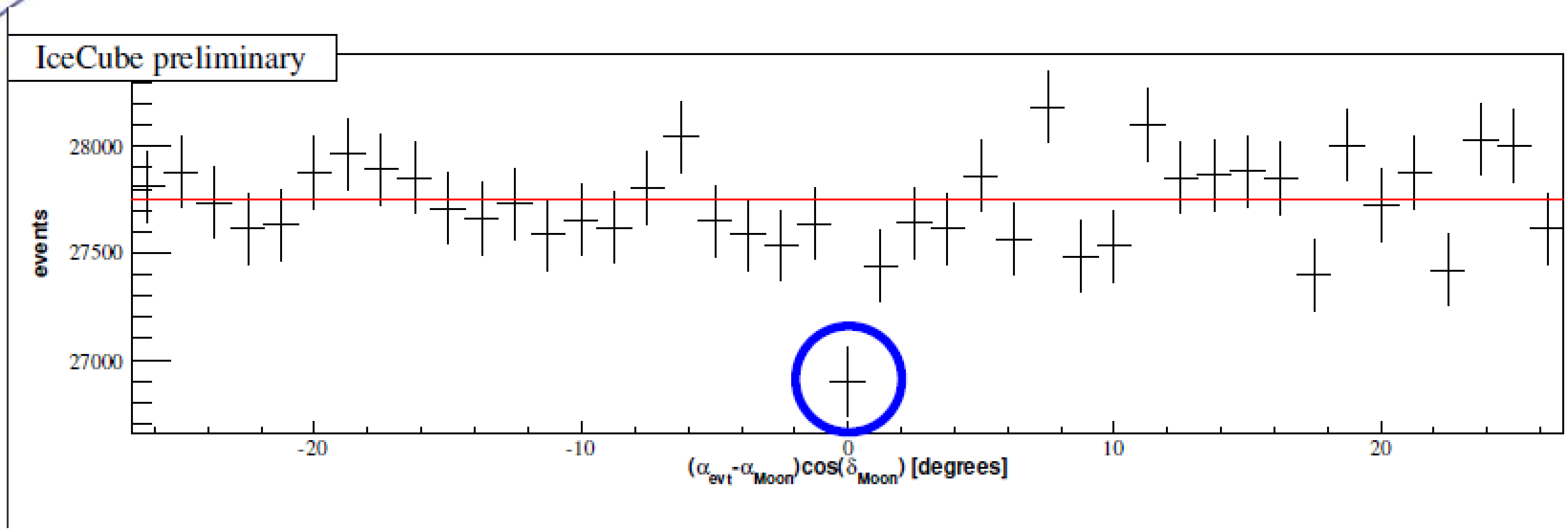
IceCube Angular Resolution



IceCube Pointing: the Moon Shadow

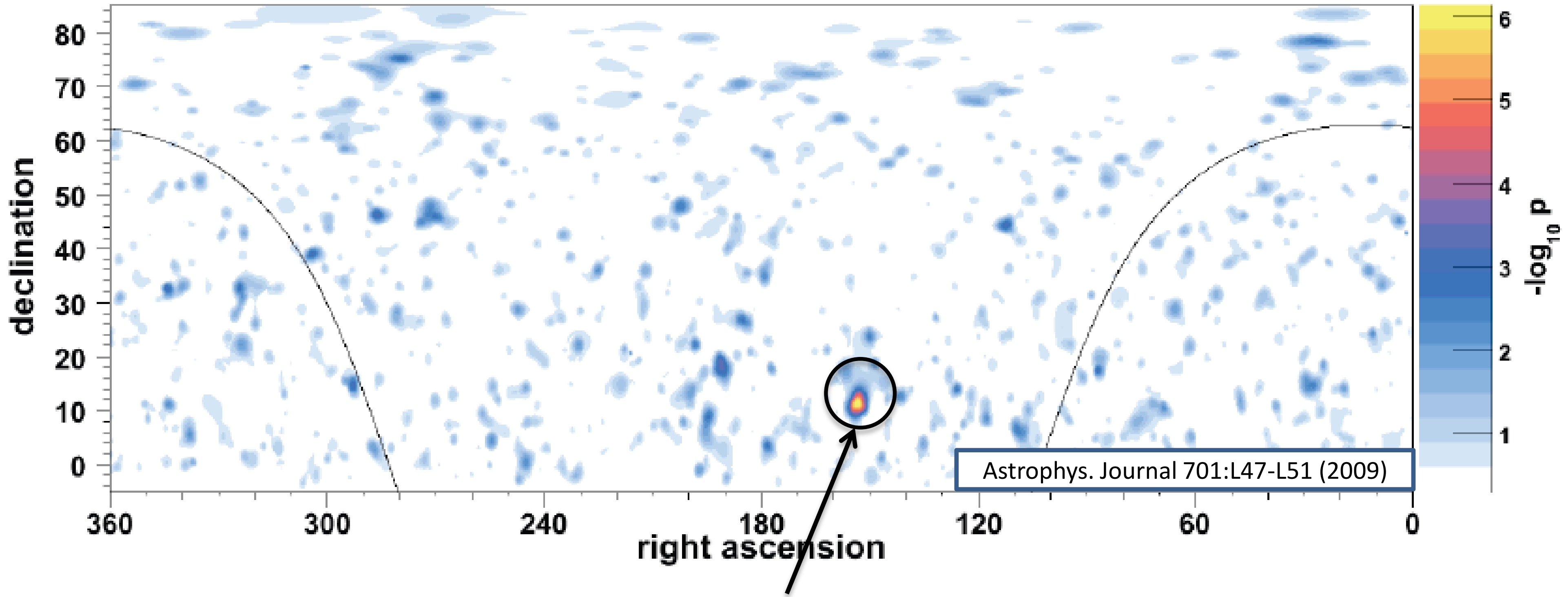


- **Deficit observed in atmospheric neutrinos from the direction of the moon in IC40 data**
- **Will be used to further investigate pointing resolution of IceCube**



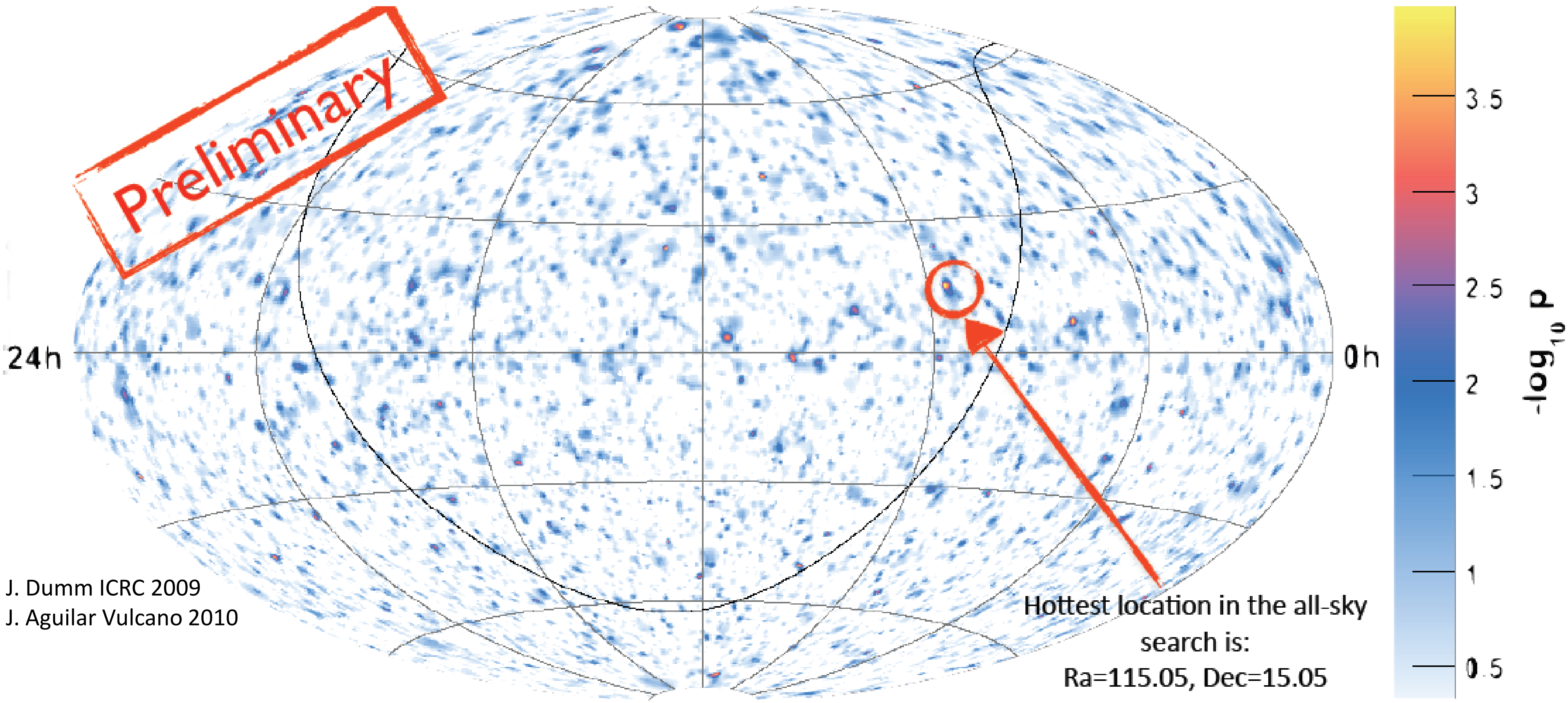
Event count vs. angular separation from Moon position

Point Source Map: IC22



- **Significance of largest excess is 2.2σ**
- **Consistent with background fluctuation**

Point Source Map: IC40 (375 days of data)



- **All-sky search: post-trial p-value of 18%**
- **Largest excess is in a different location from IC22 largest excess**

Point Source List

40-string 6-month source list results

Northern Sky Sources:

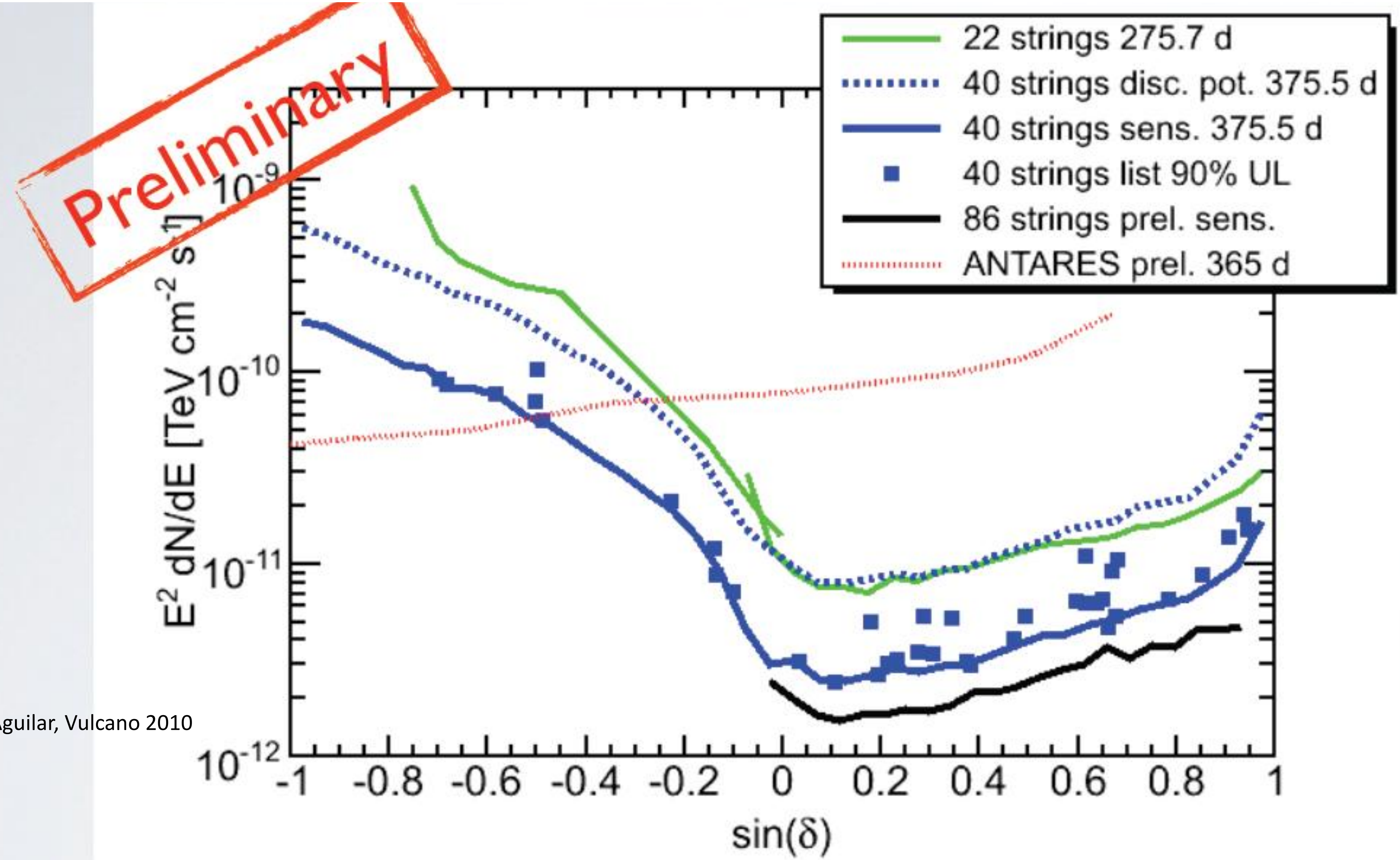
Source Name	Ra , Dec (deg)		p-value
Cyg_OB2	(308.083, 41.510)	:	0.47834
MGRO_J2019+37	(305.220, 36.830)	:	---
MGRO_J1908+06	(286.976, 6.269)	:	---
Cas_A	(350.850, 58.815)	:	---
IC443	(94.179, 22.529)	:	---
Geminga	(98.476, 17.770)	:	---
Crab_Nebula	(83.633, 22.014)	:	---
1ES_1959+650	(299.999, 65.149)	:	---
1ES_2344+514	(356.770, 51.705)	:	---
3C66A	(35.673, 43.043)	:	0.36423
H_1426+428	(217.136, 42.672)	:	---
BL_Lac	(330.680, 42.278)	:	---
Mrk_501	(253.468, 39.760)	:	0.42203
Mrk_421	(166.114, 38.209)	:	0.32724
W_Comae	(185.382, 28.233)	:	---
1ES_0229+200	(38.202, 20.287)	:	0.34695
M87	(187.706, 12.391)	:	---
S5_0716+71	(110.473, 71.343)	:	---
M82	(148.967, 69.680)	:	---
3C_123.0	(69.268, 29.671)	:	---
3C_454.3	(343.491, 16.148)	:	---
4C_38.41	(248.815, 38.135)	:	0.47002
PKS_0235+164	(39.660, 16.620)	:	---
PKS_0528+134	(82.735, 13.532)	:	---
PKS_1502+106	(226.104, 10.494)	:	0.27947
3C_273	(187.278, 2.052)	:	---
NGC_1275	(49.951, 41.512)	:	---
Cyg_A	(299.868, 40.734)	:	---
IC-22_maximum	(153.375, 11.375)	:	--- ←

P-values >=0.5 (downward fluctuations) are given as "---"

(aside: chance of obtaining 27 or more downward fluctuations out of 39 sources is 10%)

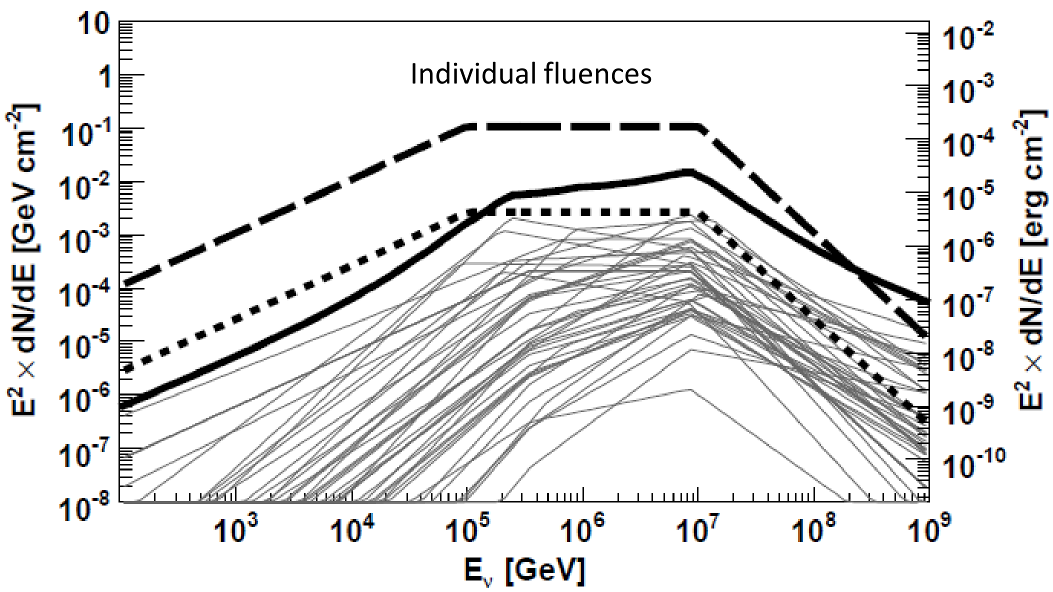
22-string hottest spot is now a downward fluctuation →

Point Source Sensitivity



J. Aguilar, Vulcano 2010

GRB results from IC22

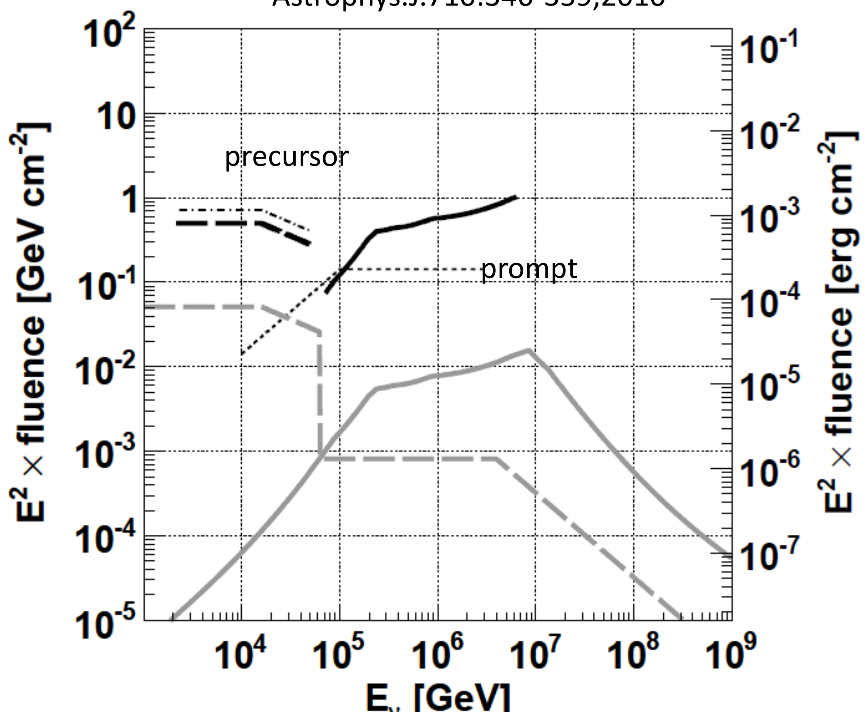


- 41 GCN bursts, mostly SWIFT
- Individual neutrino flux calculated for each based on gamma ray fluence, instead of using WB average
- Search for neutrino fluxes in a -1 +3 hour time window around the GRB times
- Direction window ~2° around burst

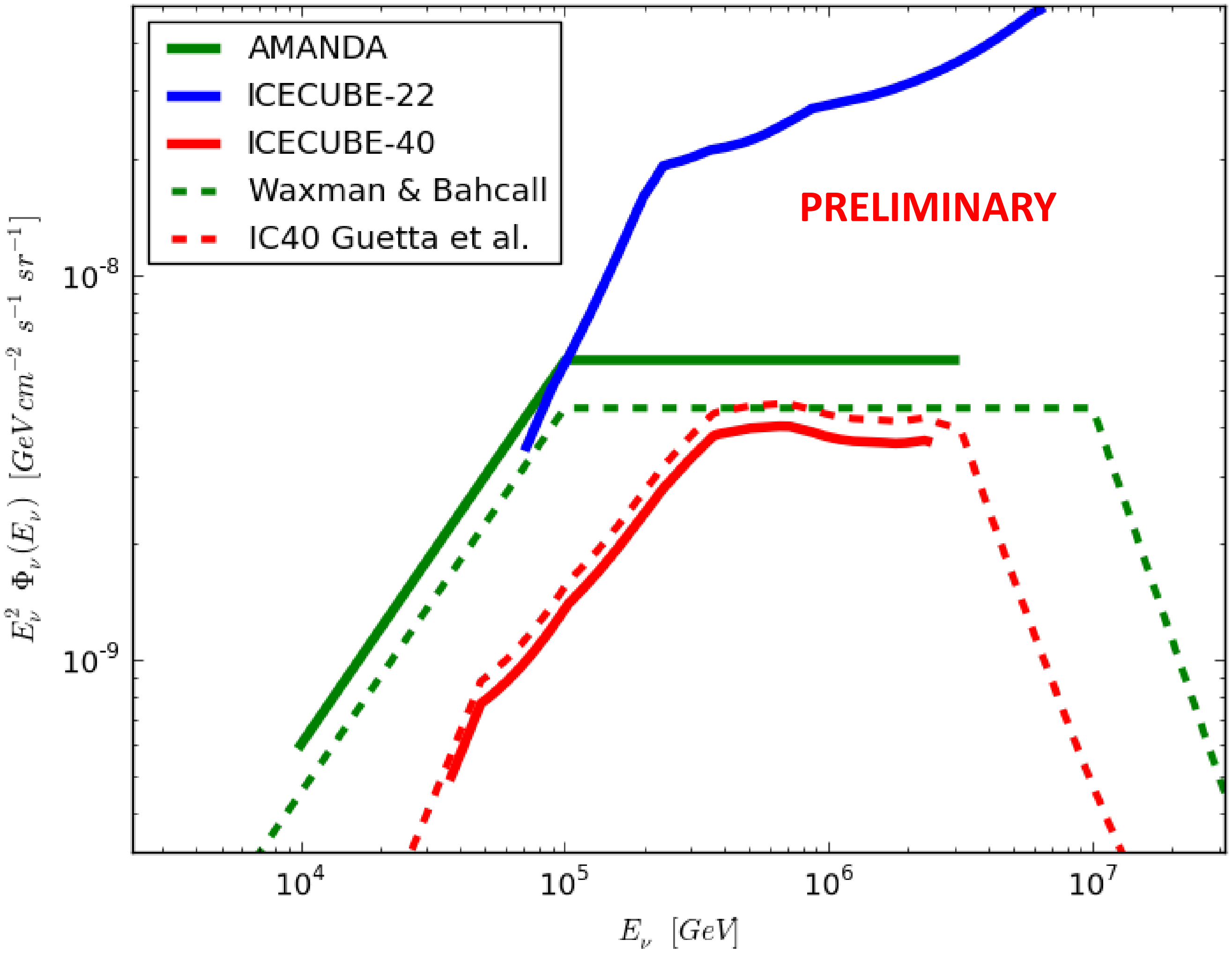
Search on the IC22 data sample is consistent with background only

IC80 sensitivity studies indicate that we will be sensitive to GRB neutrino flux at the Waxman-Bahcall level within the first few years of operation

Astrophys.J.710:346-359,2010

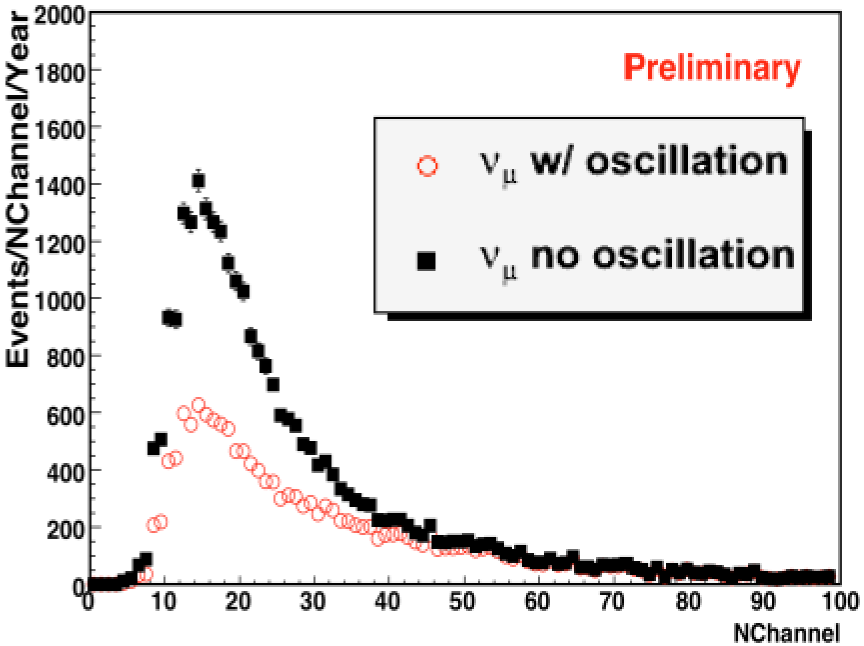


GRB results from IC40



Deep Core Physics

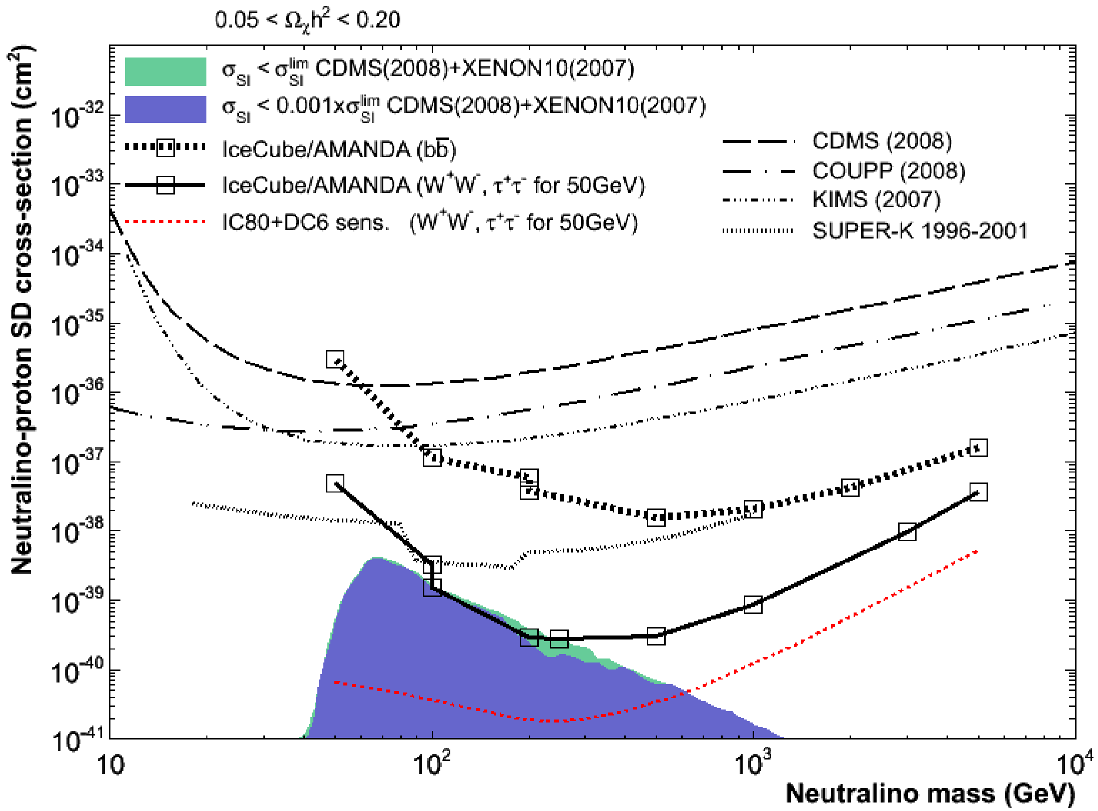
- Increase sensitivity down to energies ~ 20 GeV
- Increase sensitivity to dark matter (following slides)
- Southern hemisphere sky with IceCube as active veto
- Fundamental neutrino measurements complementary to long-baseline accelerator measurements



Muon neutrino signals at trigger level, with and without oscillation

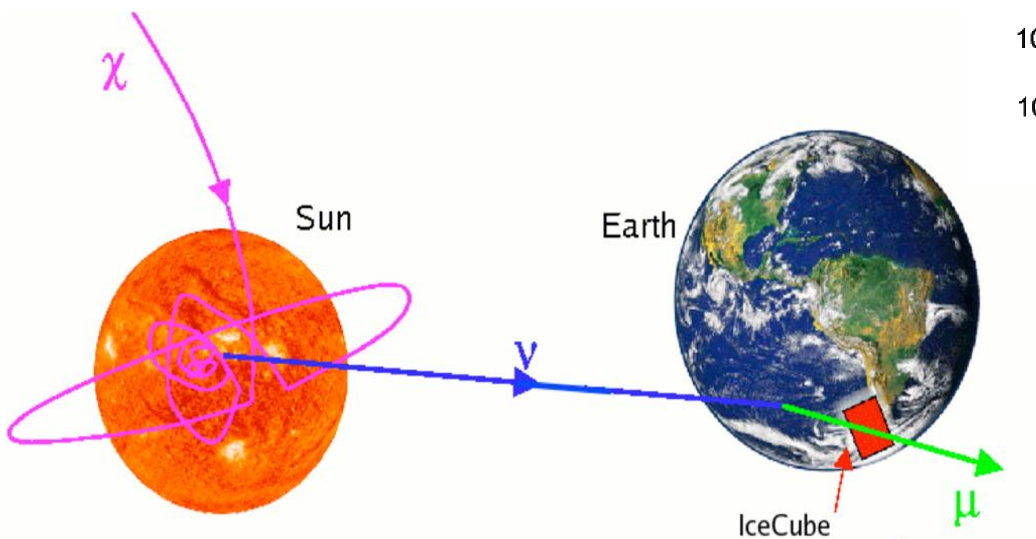
Indirect Dark Matter Search: solar

- **Search for neutralinos annihilating in the core of the Sun**
- **No observed excess in IC22**



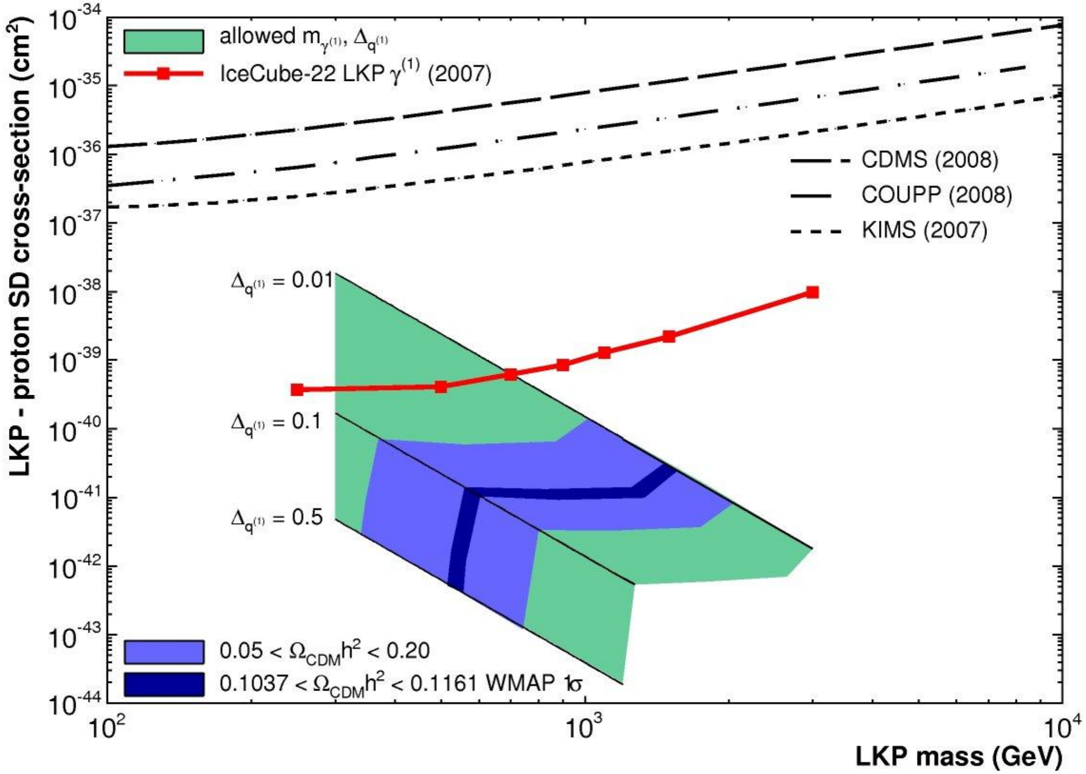
Competitive spin-dependent limit

Abbasi et al., *Phys. Rev. Lett. 102, 201302 (2009) (IC22 result)*

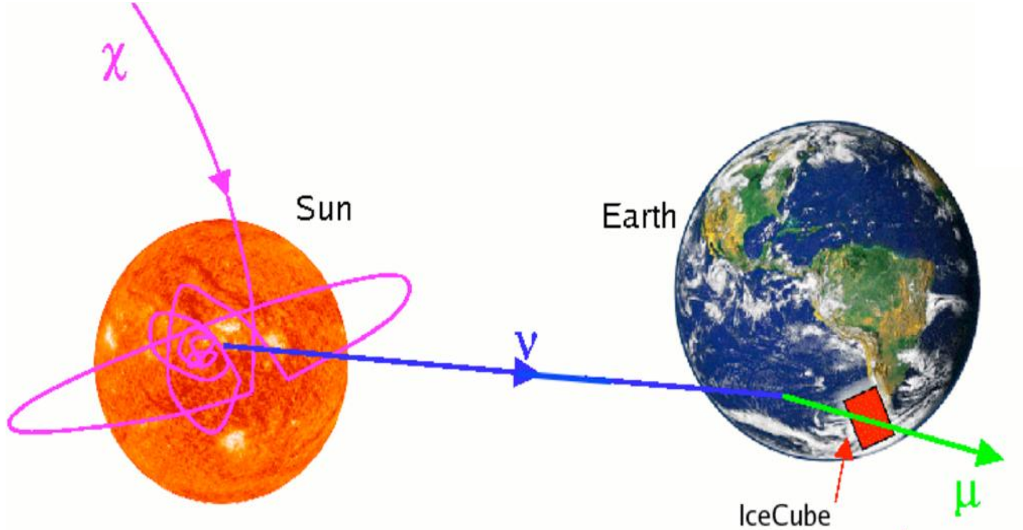


Indirect Dark Matter Search: solar

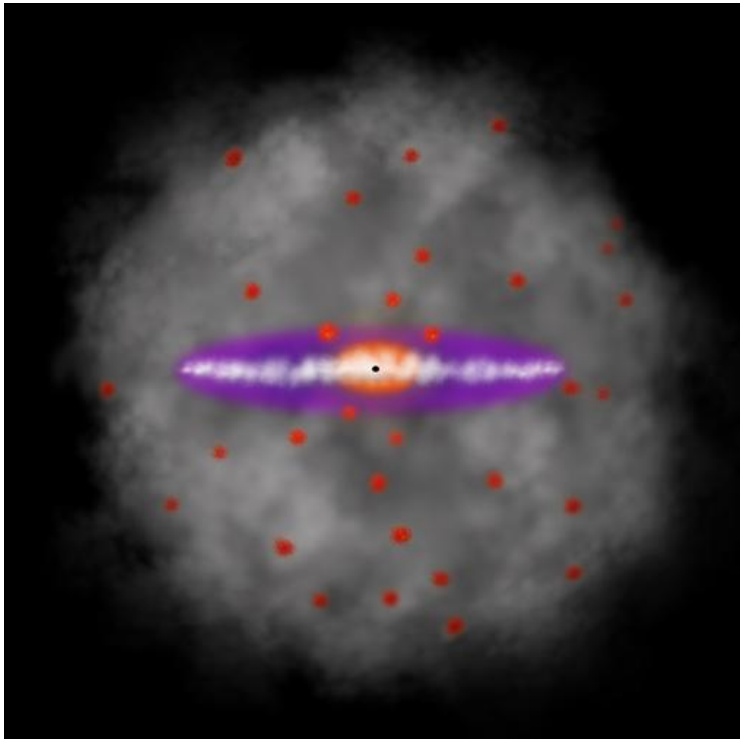
- **Search for Kaluza-Klein dark matter**
- **No observed excess in IC22**

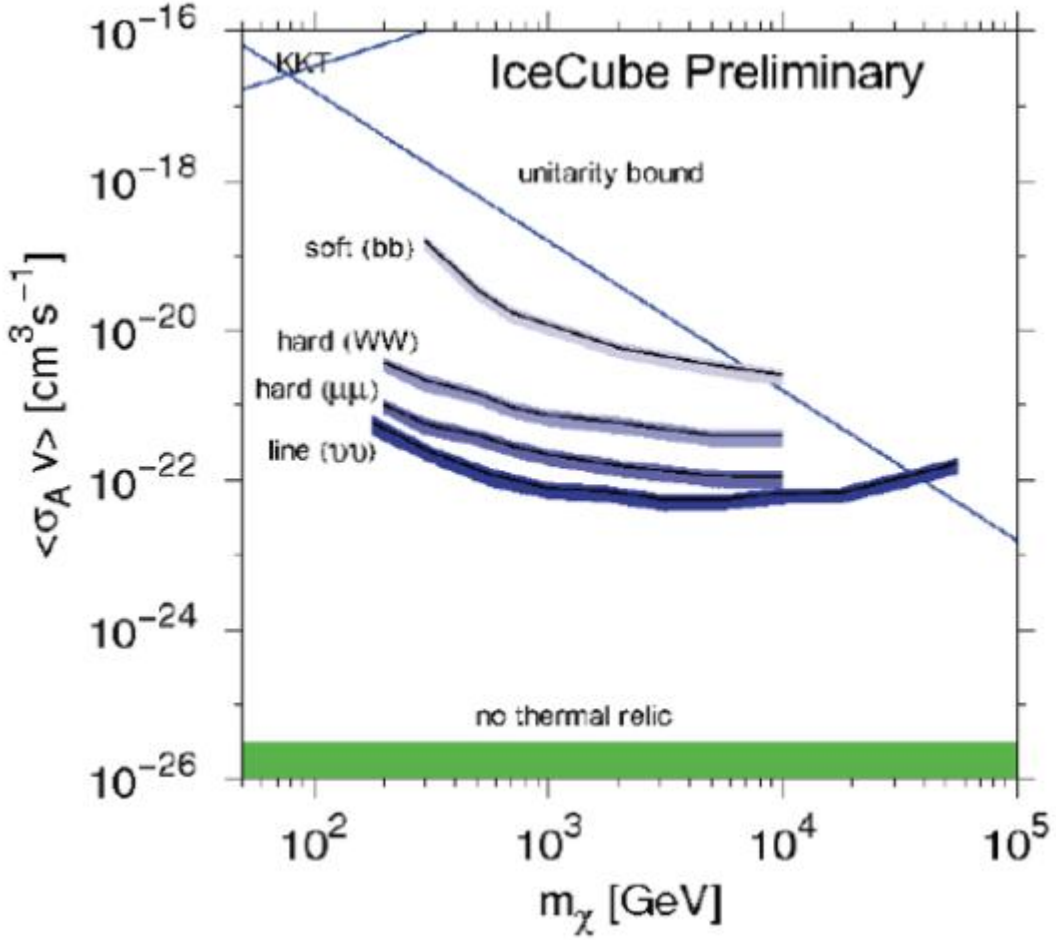


Abbasi et al., *Physical Review D*, 81(5) 057101.



Indirect Dark Matter Search: Galactic Halo

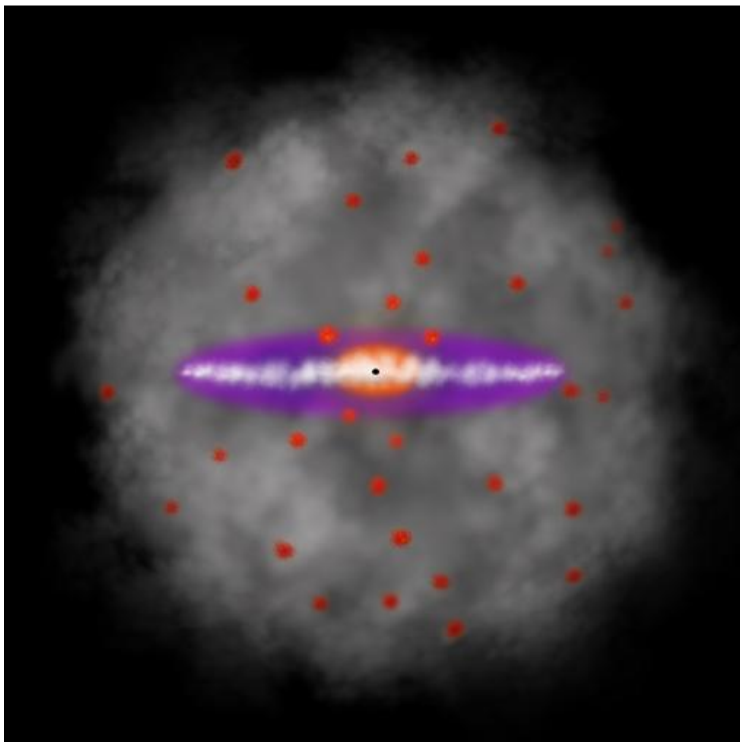




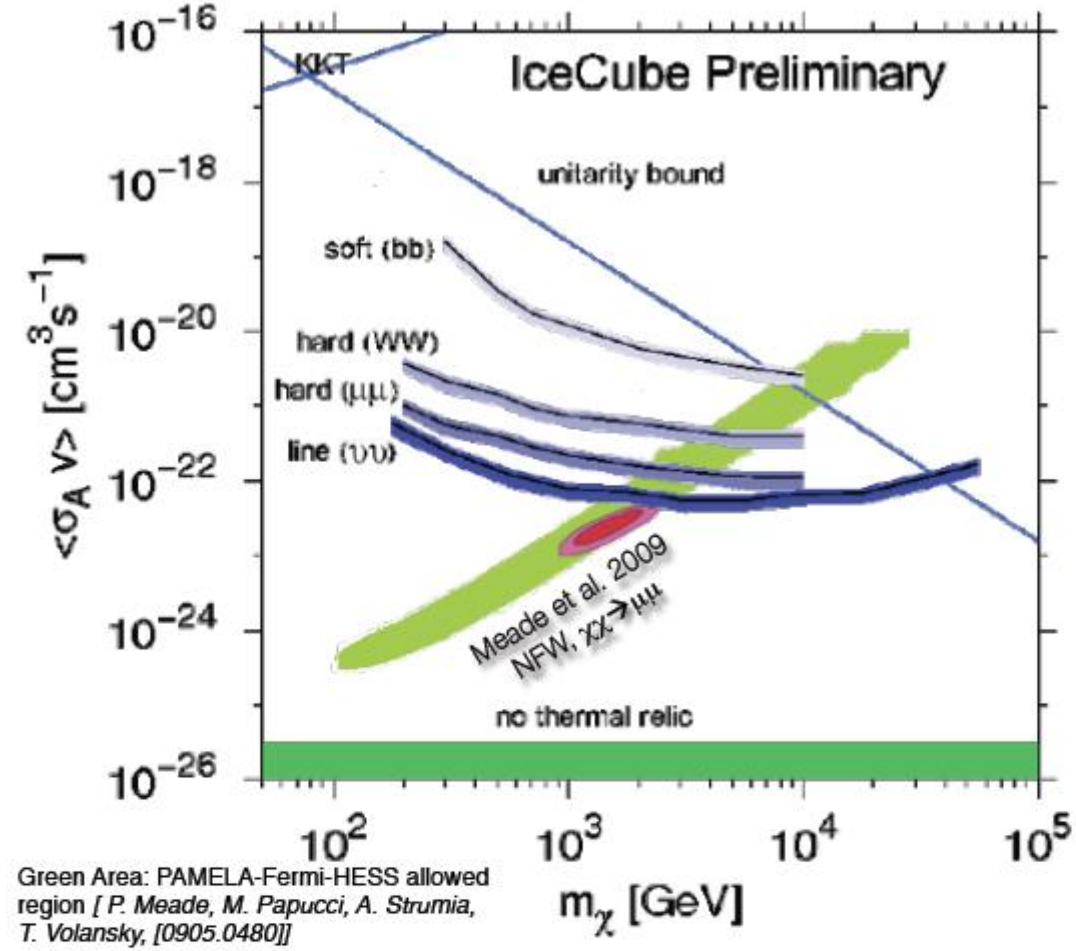
arXiv0912.5183

- **Search for neutralinos annihilating in galactic halo**
- **No observed excess in IC22 (275 days of data)**

Indirect Dark Matter Search: Galactic Halo



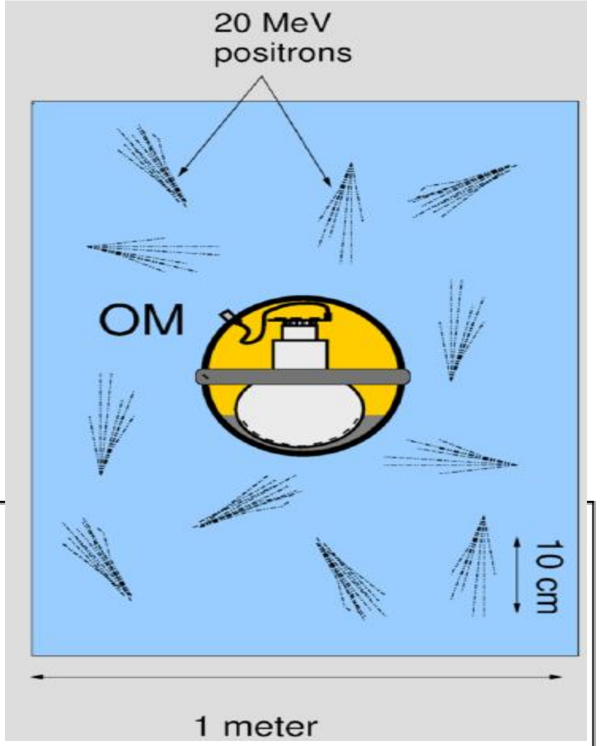
- **Search for neutralinos annihilating in galactic halo**
- **No observed excess in IC22 (275 days of data)**



arXiv0912.5183

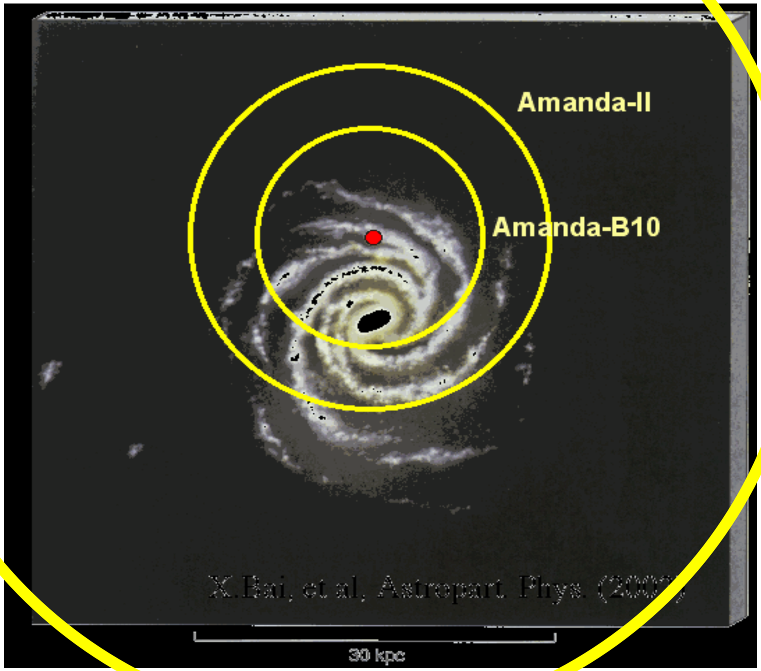
Supernovae

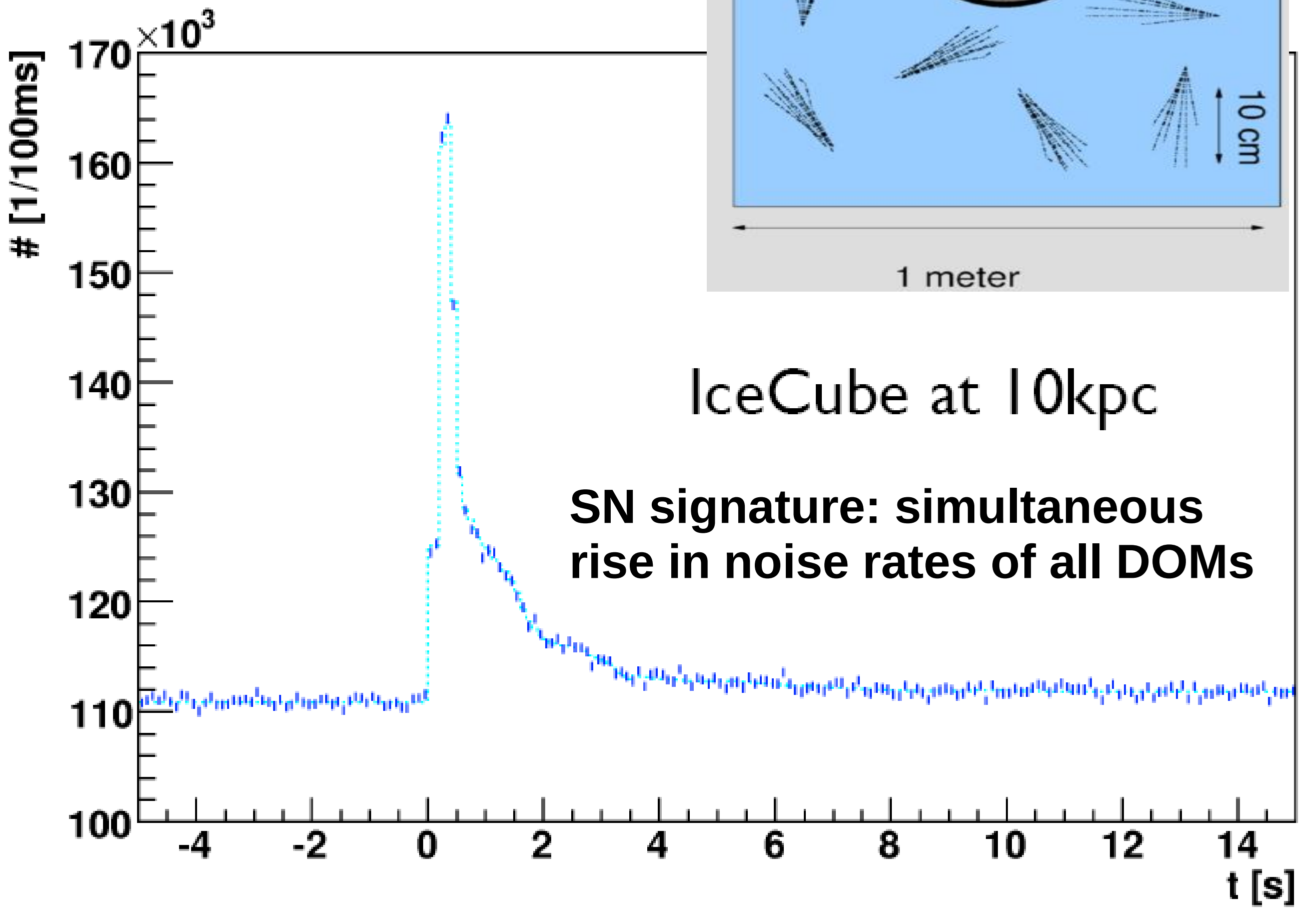
A supernova in the Milky Way will fill the detector with low-energy events



IceCube participates in SNEWS

IceCube can see out to the Large Magellanic Cloud



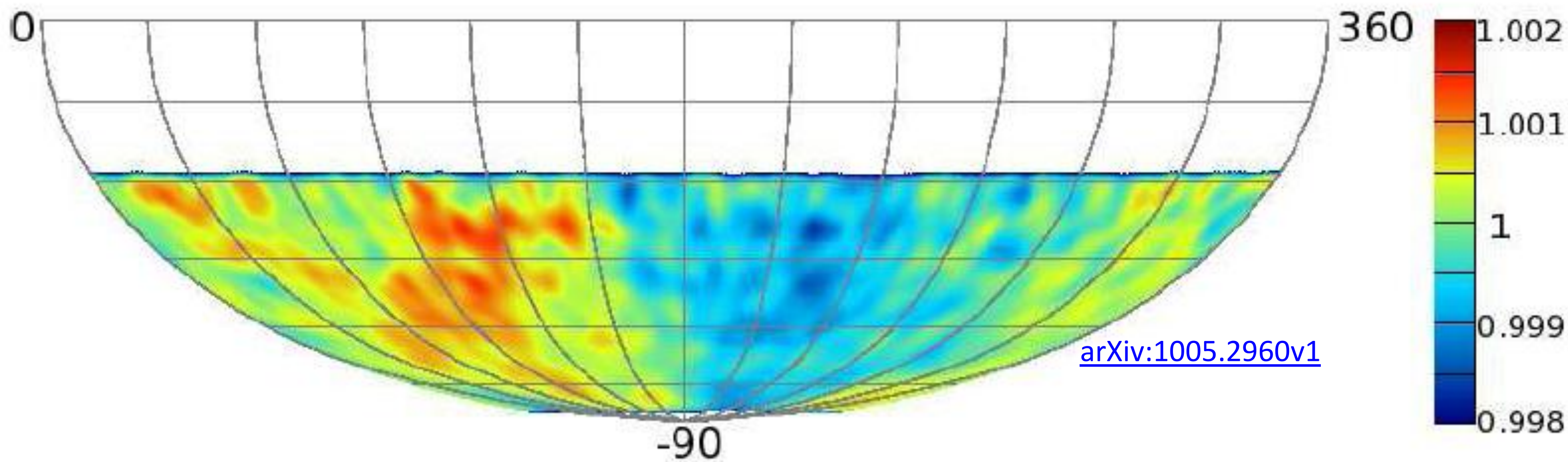


IceCube at 10kpc

SN signature: simultaneous rise in noise rates of all DOMs

Cosmic Rays with IceCube

- First measurement of anisotropy at TeV energies in the Southern Hemisphere Sky
  - Compatible with results from Tibet and Milagro in the Northern hemisphere
- Correlation between CR muon flux and stratospheric temperature



Cosmic ray anisotropy observed with IC22

Additional Physics

- Electron and tau neutrino searches
- Exotic particle searches
- Radio and acoustic prototypes for a multi-km^3 GZK neutrino detector

Conclusions

- IceCube is 91% complete and already taking physics data, with results available from the 22- and 40-string detector
- IceCube now probing theoretically interesting regions
- The DeepCore component will increase IceCube's sensitivity at low energies