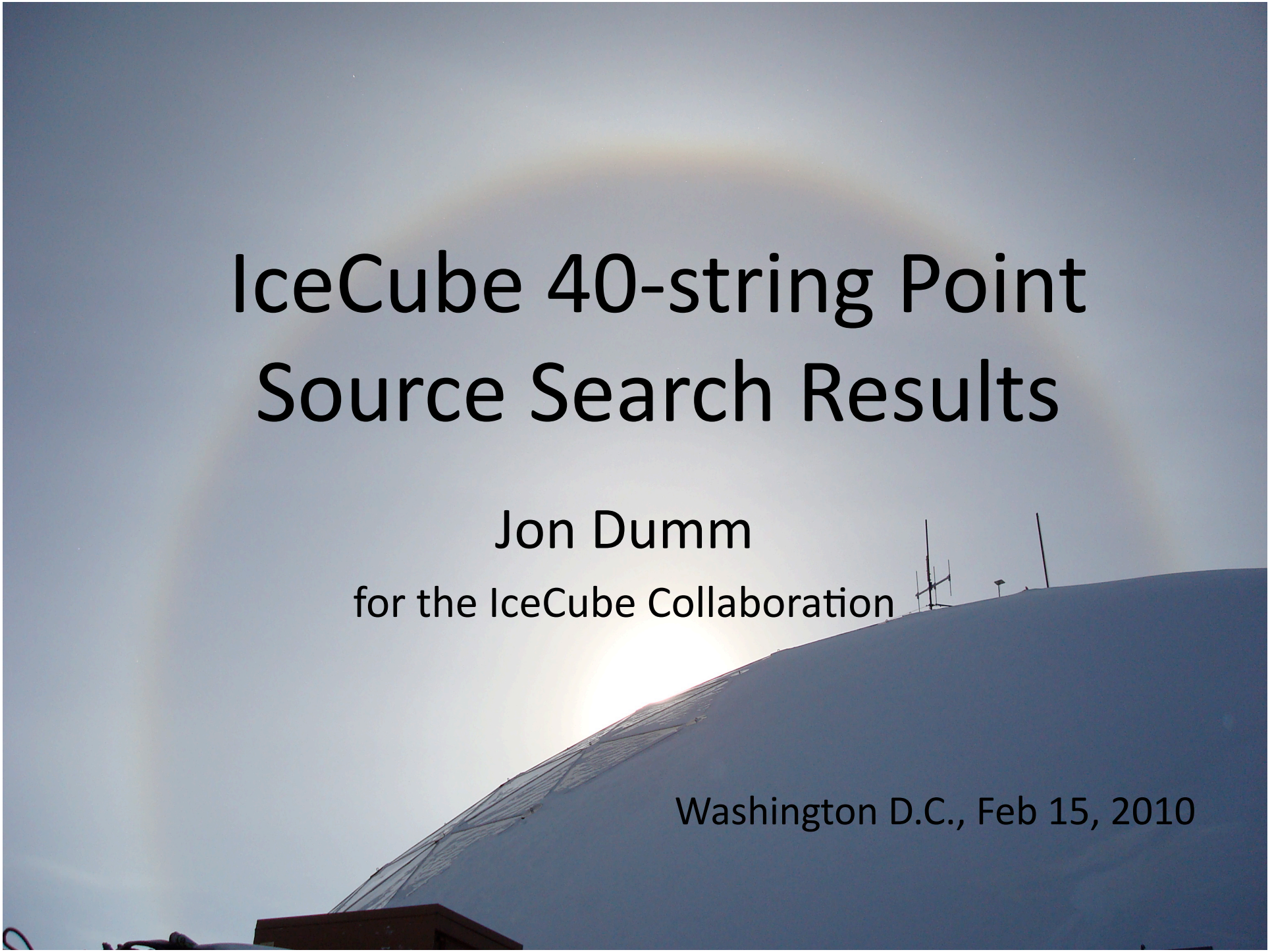
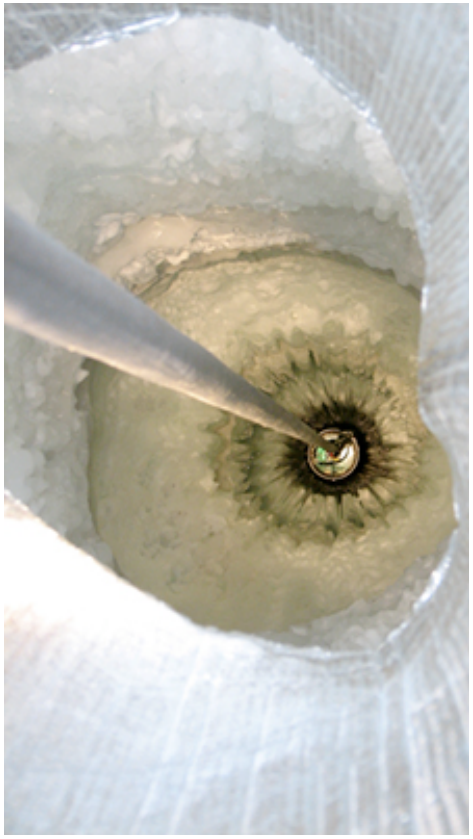


IceCube 40-string Point Source Search Results

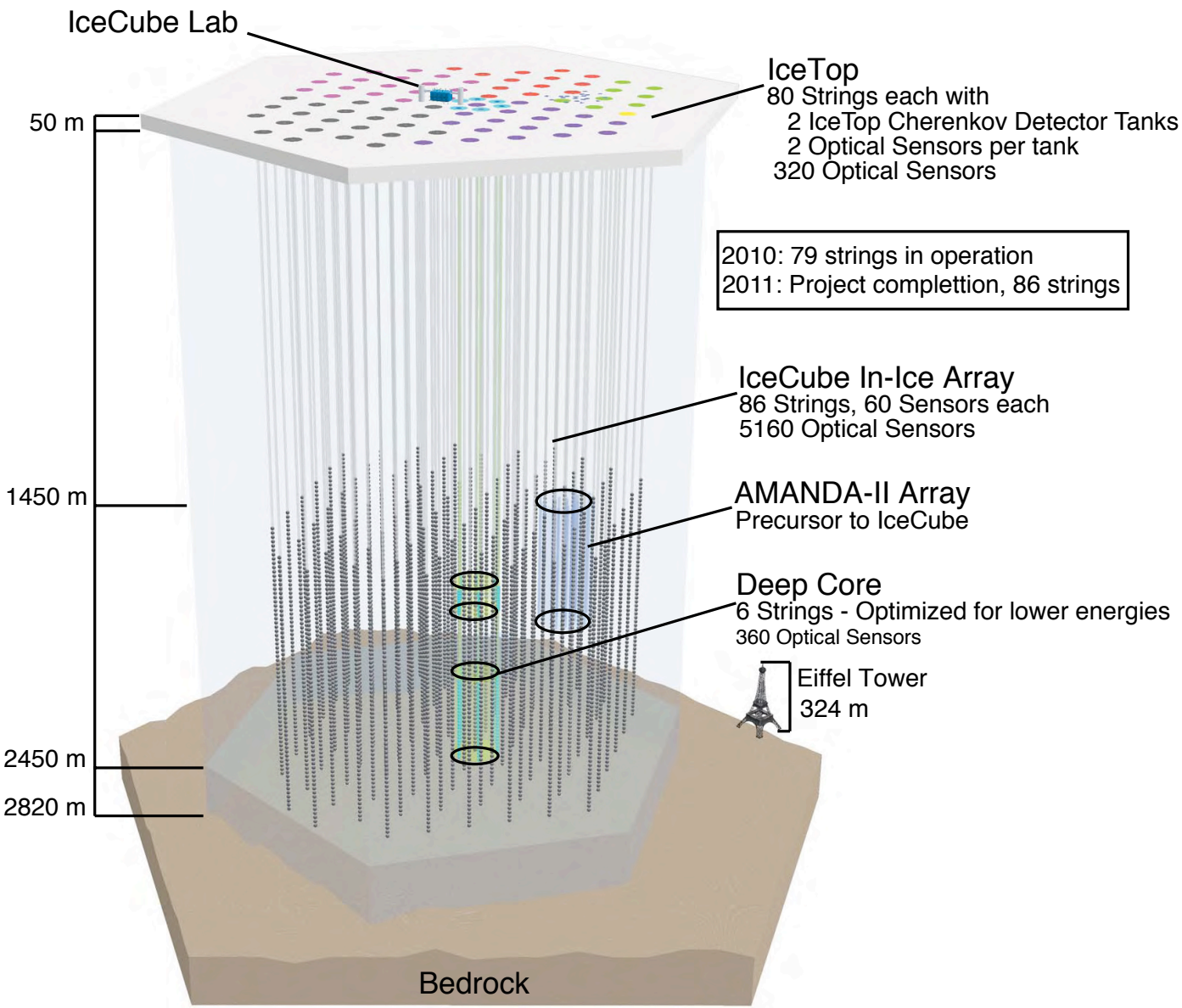
Jon Dumm

for the IceCube Collaboration

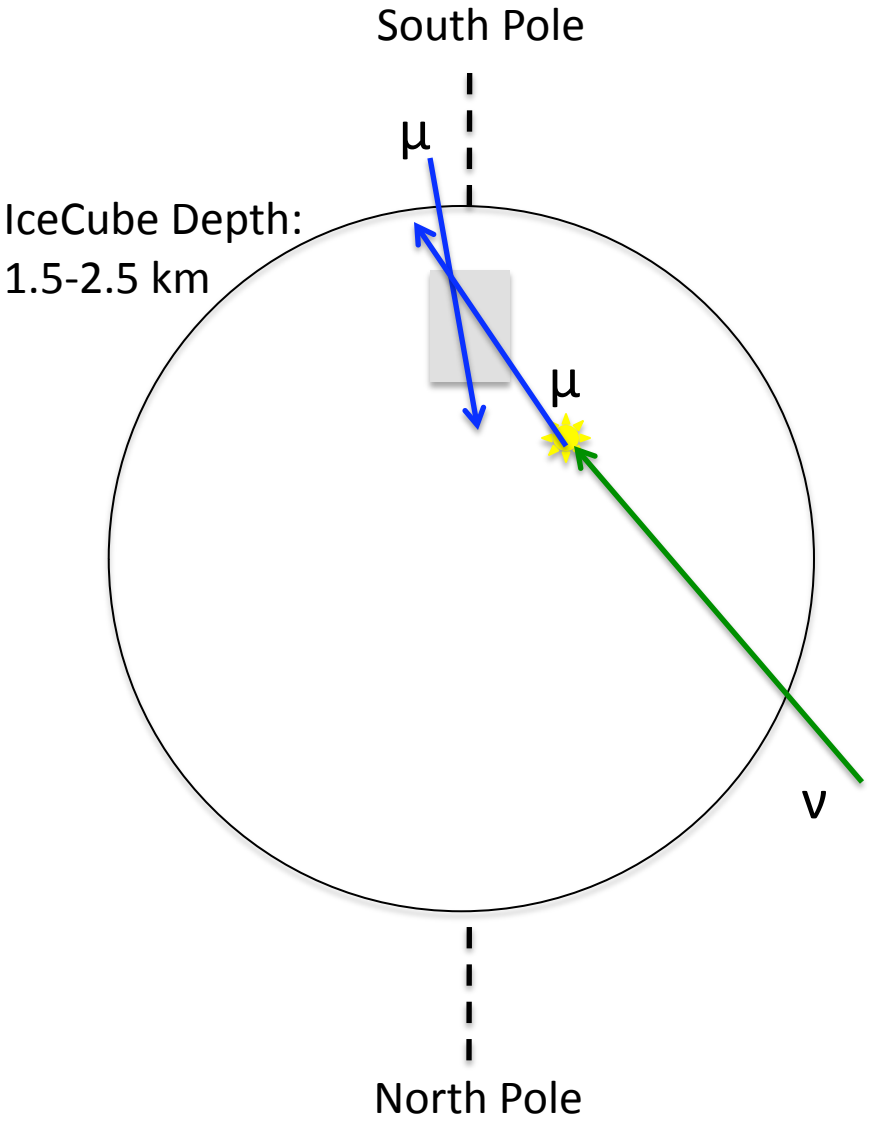
Washington D.C., Feb 15, 2010

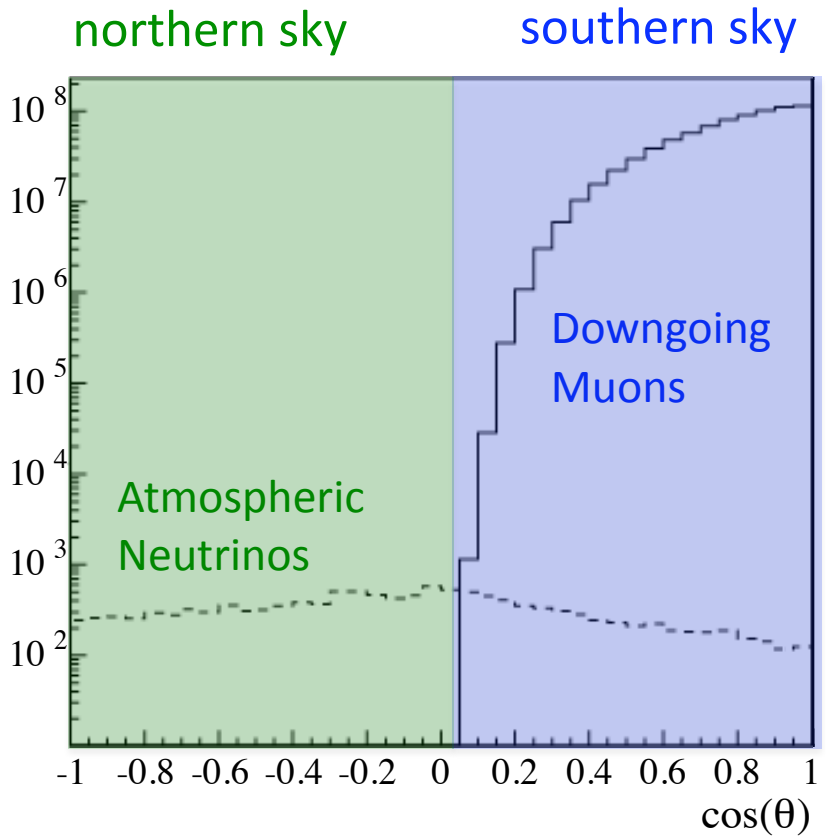





IceCube Lab
IceTop
80 Strings each with
2 IceTop Cherenkov Detector Tanks
2 Optical Sensors per tank
320 Optical Sensors
50 m
2010: 79 strings in operation
2011: Project complettion, 86 strings
IceCube In-Ice Array
86 Strings, 60 Sensors each
5160 Optical Sensors
1450 m
AMANDA-II Array
Precursor to IceCube
Deep Core
6 Strings - Optimized for lower energies
360 Optical Sensors
Eiffel Tower
324 m
2450 m
2820 m
Bedrock

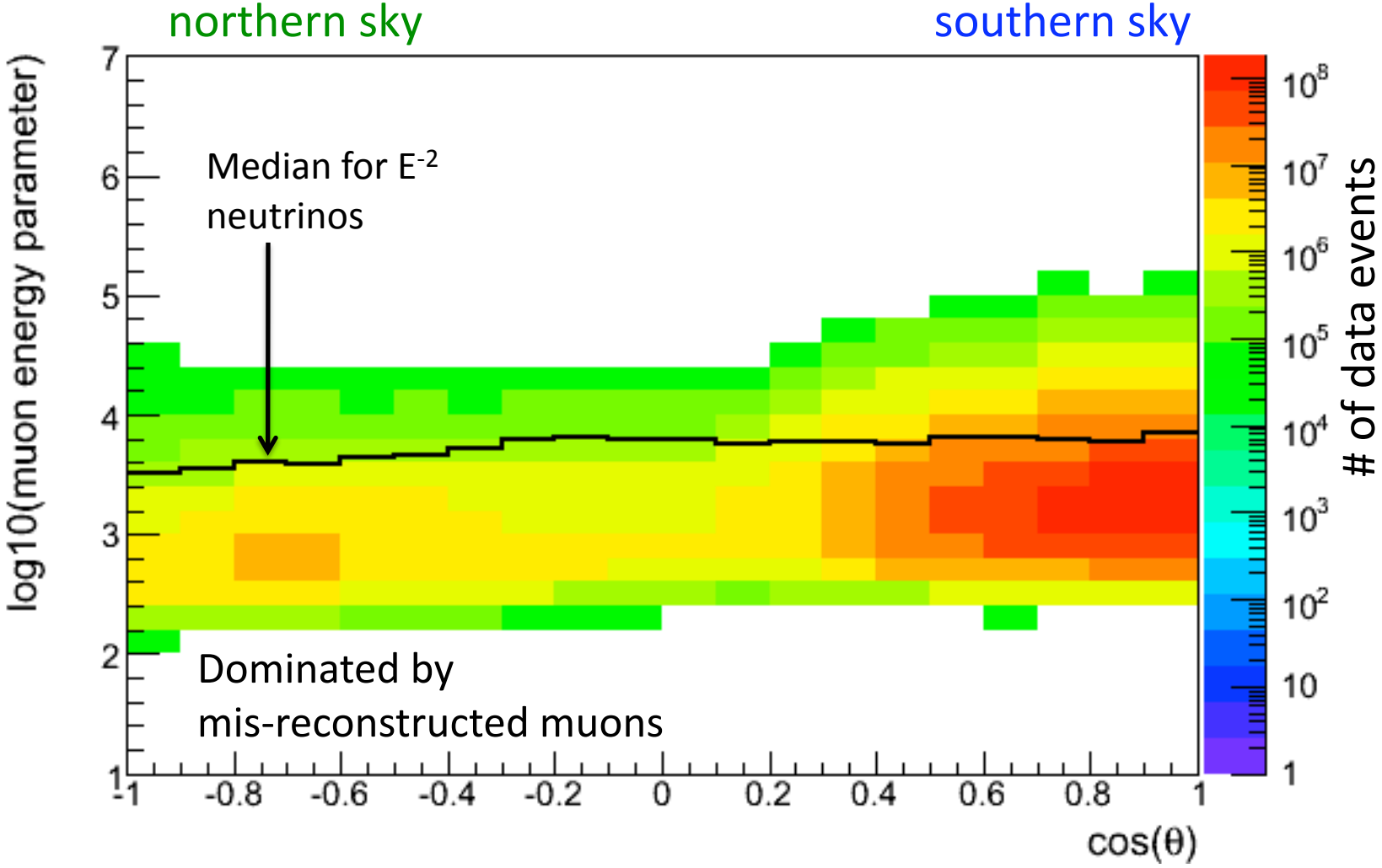
Backgrounds



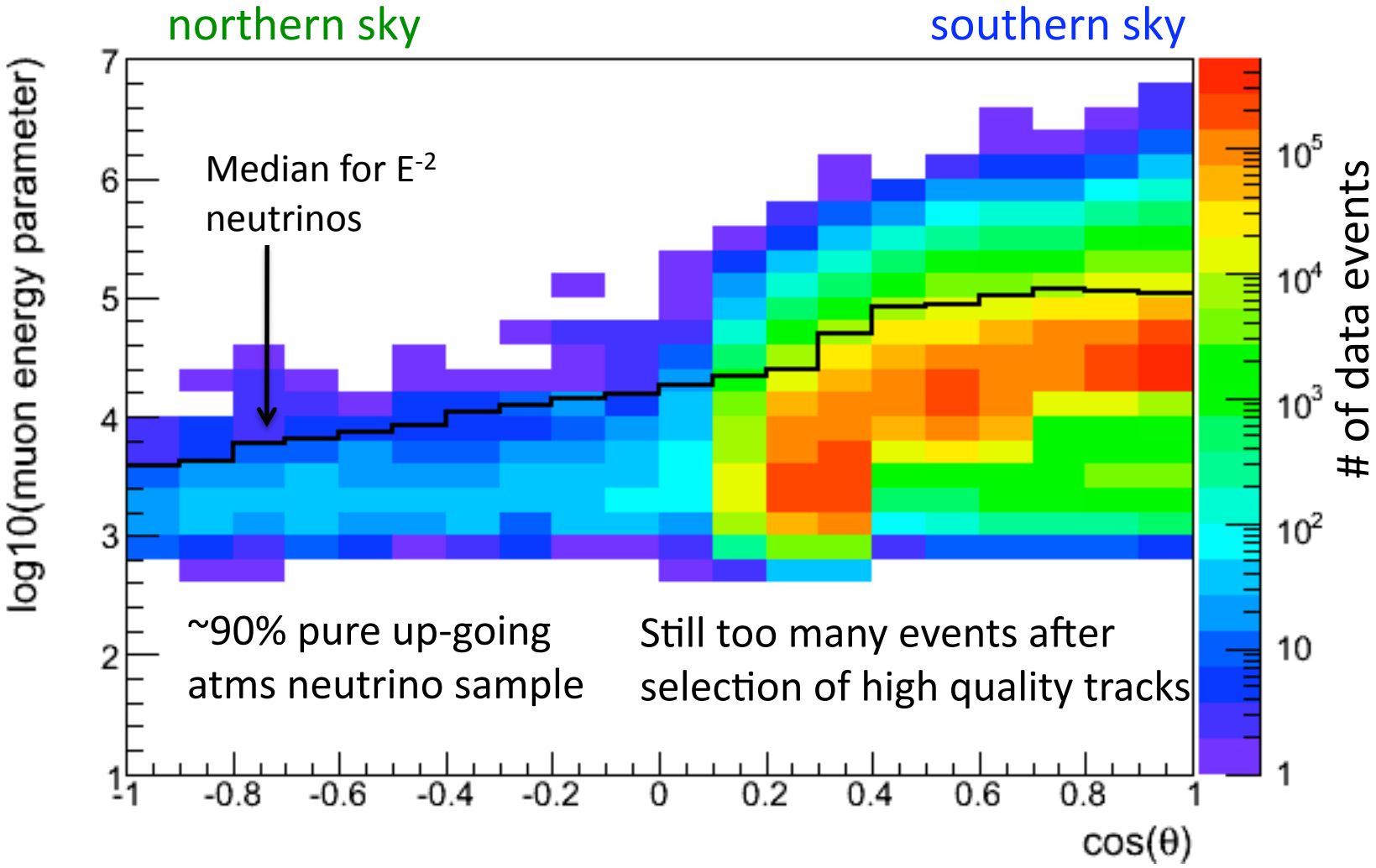


Atmospheric backgrounds for extra-terrestrial neutrino searches at the depth of IceCube

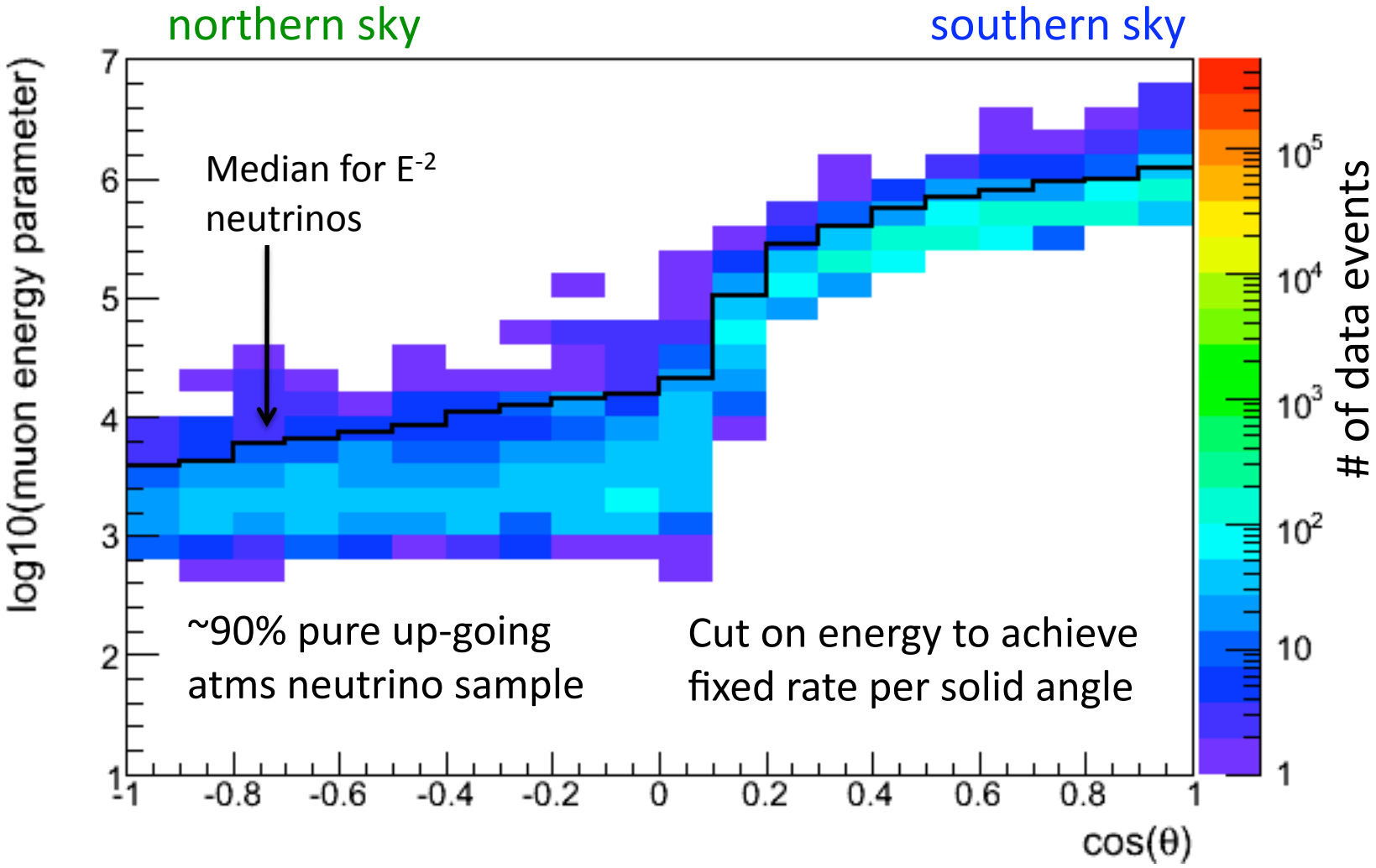
Energy vs Zenith – Trigger Level



Energy vs Zenith – Quality Cuts

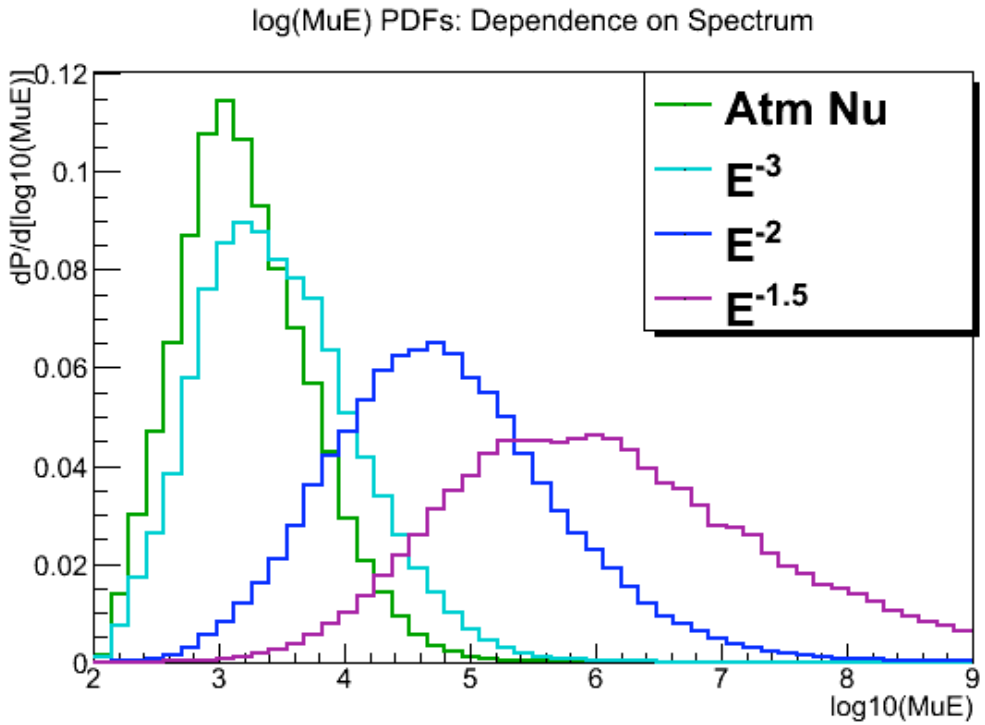


Energy vs Zenith – Quality + Energy Cuts



Search Method

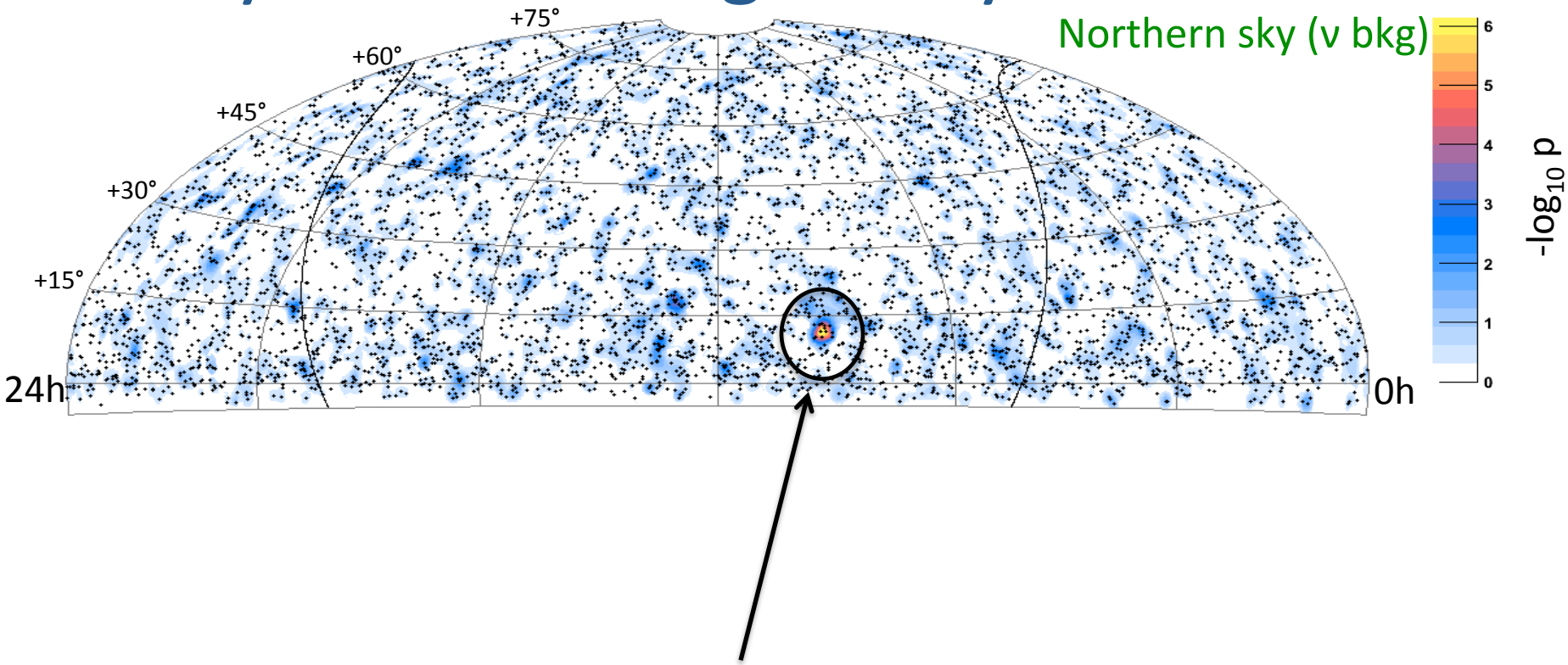
- Unbinned maximum likelihood search
  - Directional clustering → Median PSF for E^{-2} neutrino spectrum:
    0.7° in northern sky
    0.5° in southern sky
  - Energy



Robust results:

- Blind analysis
- Background pdfs drawn from data
- Final significance comes from scrambling data in r.a.

Last year: 22-string all-sky results

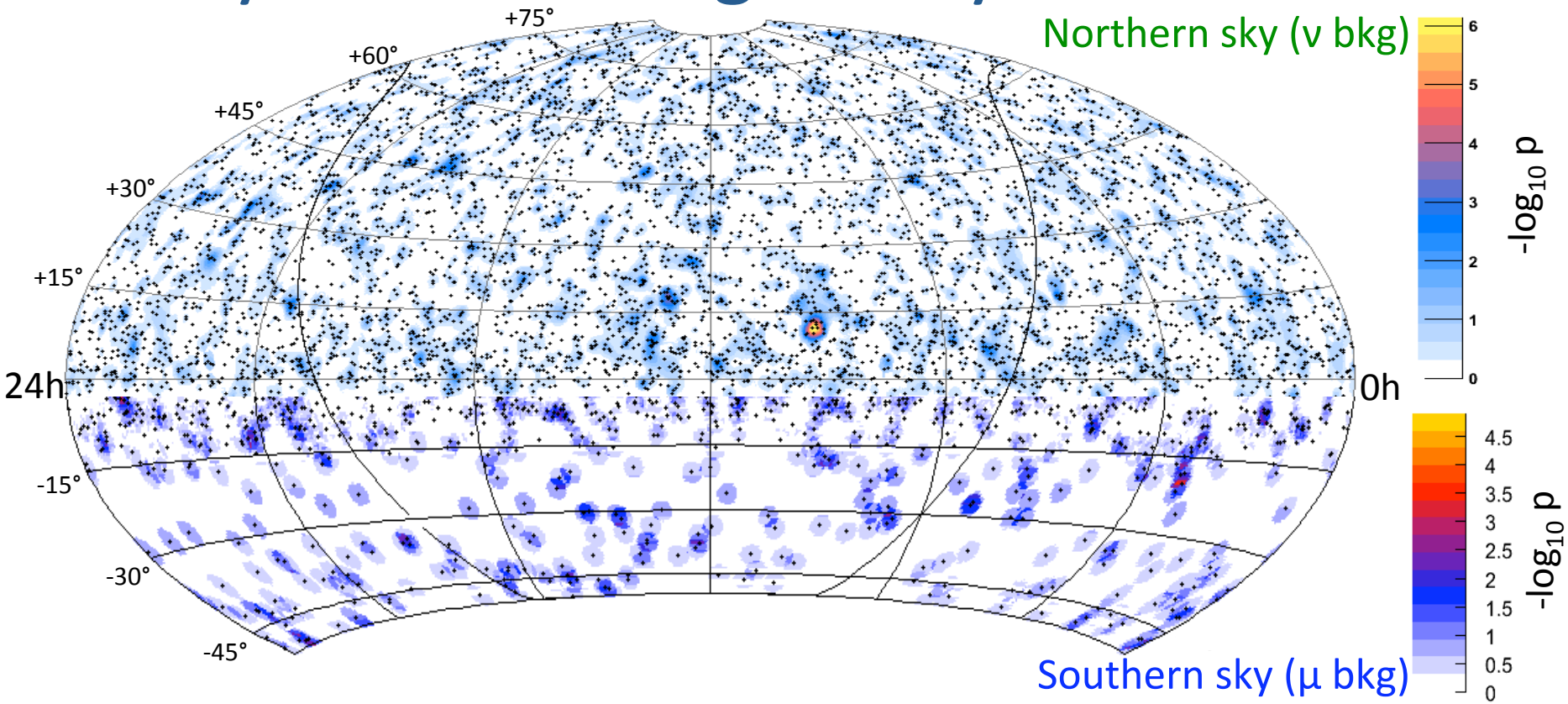


Hottest spot found at r.a. 153.4° , dec. 11.4°

Post-trials p-value of analysis is ~ 1.34% (2.2 sigma) ...

ApJL 70, 47 (2009)

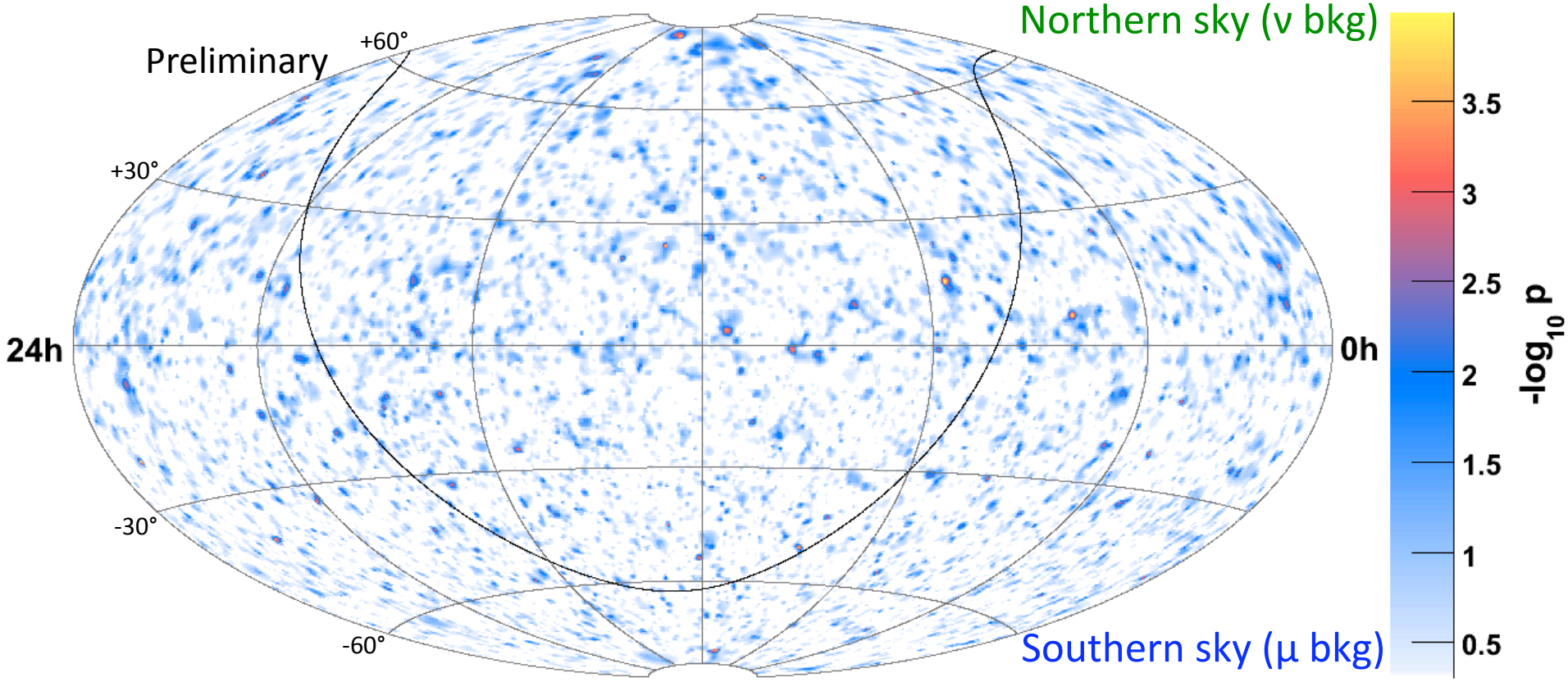
Last year: 22-string all-sky results



First IceCube analysis extended to -50° dec

PRL 103, 221102 (2009)

40-string all-sky results

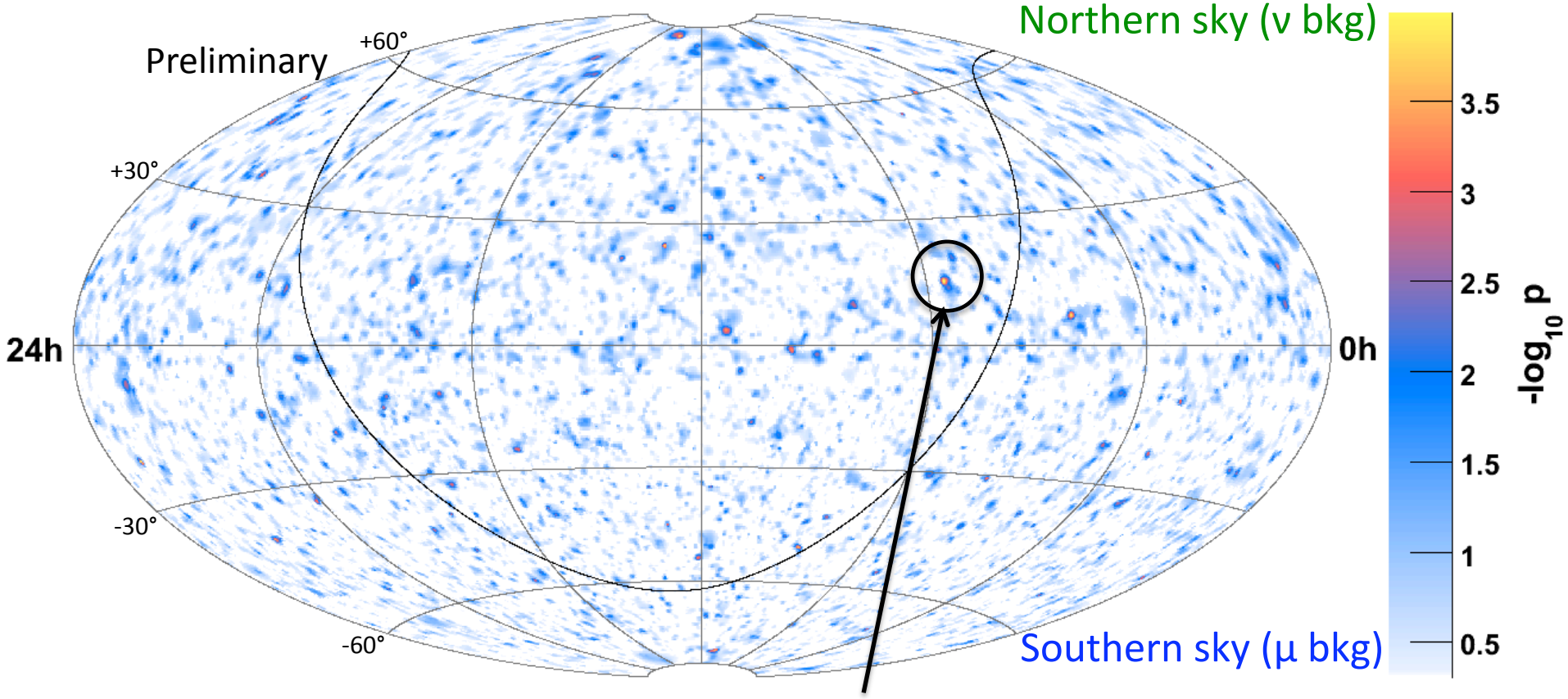


Hottest location in the all-sky search is:
Ra=115.05, Dec=15.05

Livetime = 375.5 days

Events = 37290
(14139 up-going,
23151 down-going)

40-string all-sky results



Hottest location in the all-sky search is:
Ra=115.05, Dec=15.05

Livetime = 375.5 days

Events = 37290
(14139 up-going,
23151 down-going)

In background simulated trials (scrambling data in r.a.), an equal or greater excess occurs by chance 9588/10000 times.
=> **all-sky final p-value is 96%, not significant**

40-string Source List Results

Northern Sky **Sources:**

Highest significance comes from southern sky (see next slide)

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

Source Name	Ra , Dec (deg)	p-value
Cyg_OB2	(308.083, 41.510) :	---
MGRO_J2019+37	(305.220, 36.830) :	0.42759
MGRO_J1908+06	(286.976, 6.269) :	---
Cas_A	(350.850, 58.815) :	---
IC443	(94.179, 22.529) :	---
Geminga	(98.476, 17.770) :	0.47413
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) :	0.23808
H_1426+428	(217.136, 42.672) :	---
BL_Lac	(330.680, 42.278) :	0.22601
Mrk_501	(253.468, 39.760) :	0.42262
Mrk_421	(166.114, 38.209) :	0.14000
W_Comae	(185.382, 28.233) :	---
1ES_0229+200	(38.202, 20.287) :	0.15528
M87	(187.706, 12.391) :	---
S5_0716+71	(110.473, 71.343) :	---
M82	(148.967, 69.680) :	0.39095
3C_123.0	(69.268, 29.671) :	0.43538
3C_454.3	(343.491, 16.148) :	0.45811
4C_38.41	(248.815, 38.135) :	0.47329
PKS_0235+164	(39.660, 16.620) :	0.13602
PKS_0528+134	(82.735, 13.532) :	0.48542
PKS_1502+106	(226.104, 10.494) :	0.10331
3C_273	(187.278, 2.052) :	---
NGC_1275	(49.951, 41.512) :	---
Cyg_A	(299.868, 40.734) :	0.44191
IC-22_maximum	(153.375, 11.375) :	---

22-string hottest spot is now a downward fluctuation →

←

…Southern Sky sources continue on next slide…

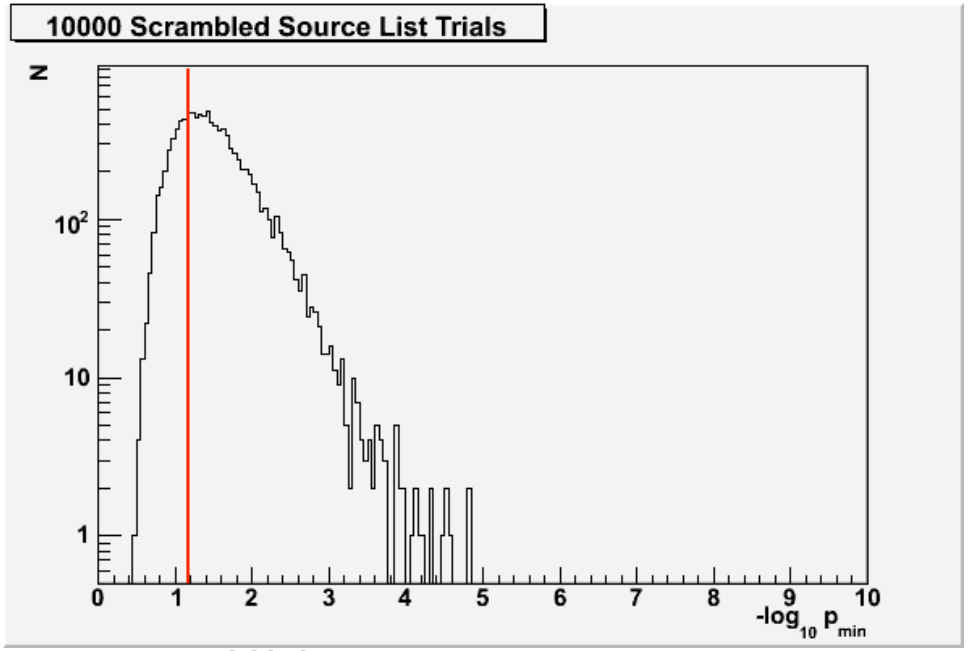
40-string Source List Results (cont.)

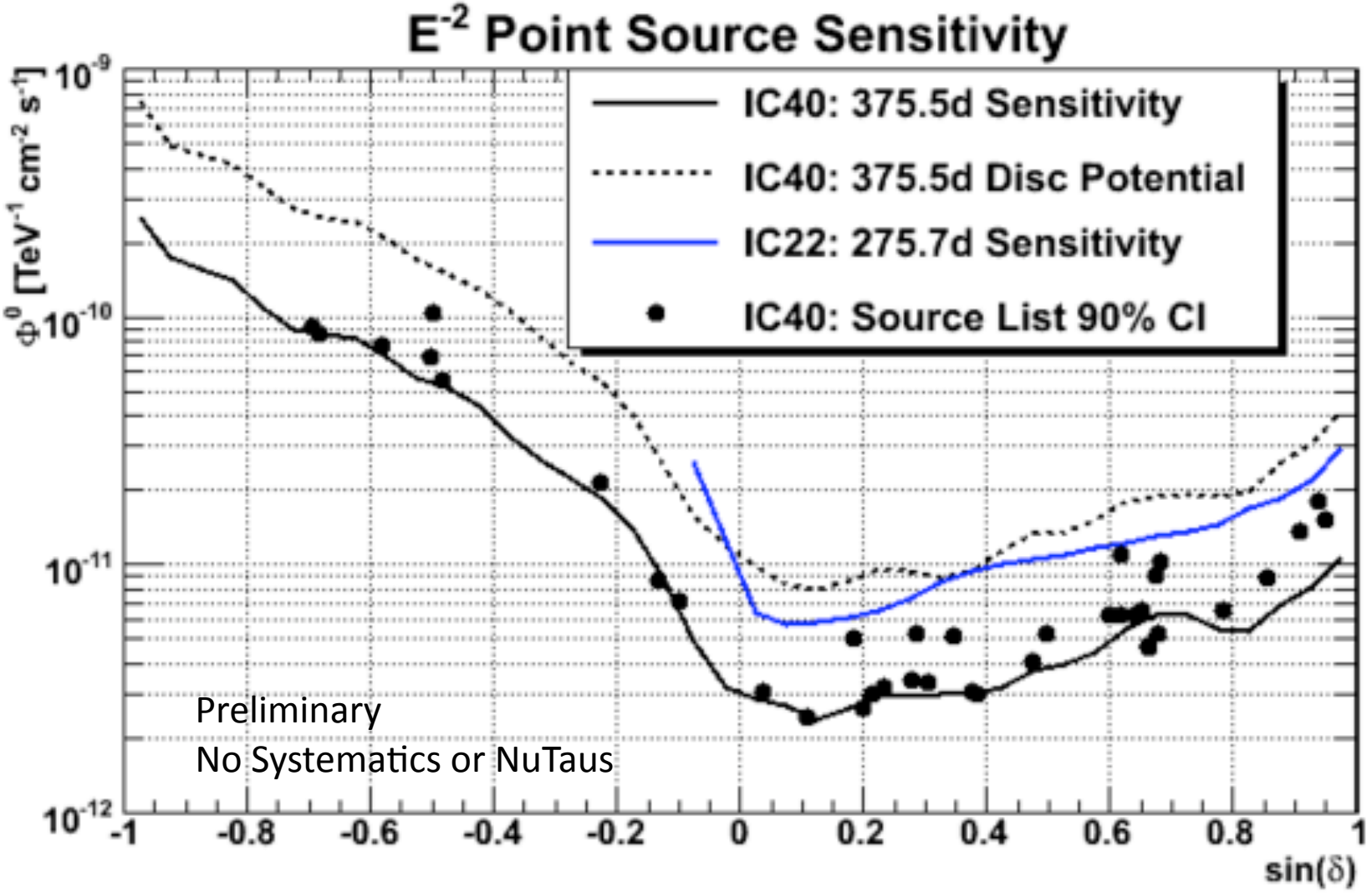
Southern Sky **Sources:**

Highest significance from list of 39 sources comes from PKS 1622-297

Source Name	Ra , Dec (deg)	p-value
Sgr_A*	(266.417, -29.008) :	---
PKS_0537-441	(84.710, -44.086) :	---
Cen_A	(201.365, -43.019) :	---
PKS_1454-354	(224.361, -35.653) :	---
PKS_2155-304	(329.717, -30.225) :	0.31679
PKS_1622-297	(246.525, -29.857) :	0.06622
QSO_1730-130	(263.261, -13.08) :	0.44807
PKS_1406-076	(212.235, -7.874) :	0.36176
QSO_2022-077	(306.420, -7.640) :	---
3C279	(194.050, -5.790) :	0.48659

Pretrial p-value of 6.6% or less for any of the 39 sources happens in 75% of scrambled skymaps
=> **source list final p-value = 75%**





Median Neyman 90% sensitivity and upper limits for source list as well as 5-σ 50% Discovery Potential

Conclusions

- The 40-string configuration of IceCube recently finished taking 375.5 days of data
  - A search for point sources of neutrinos over the entire sky was performed in a blind fashion
  - No evidence for a signal was found
- The 40-string dataset provides the best HE astrophysical neutrino limits to date over most of the sky
  - 1 year of 80-string data will provide a factor of ~2 improvement in sensitivity
- IceCube now has 79 of the planned 86 strings deployed
  - 59-string data analysis starting
  - An exciting time for IceCube

Backup slides

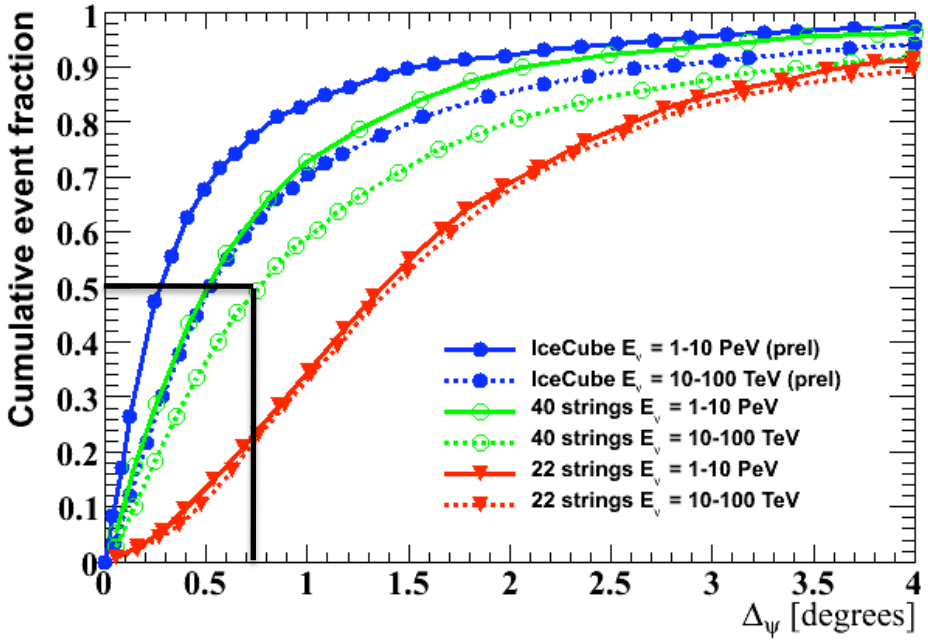
Median of the PSF for
E^{-2} neutrino spectrum:

0.7° in northern sky

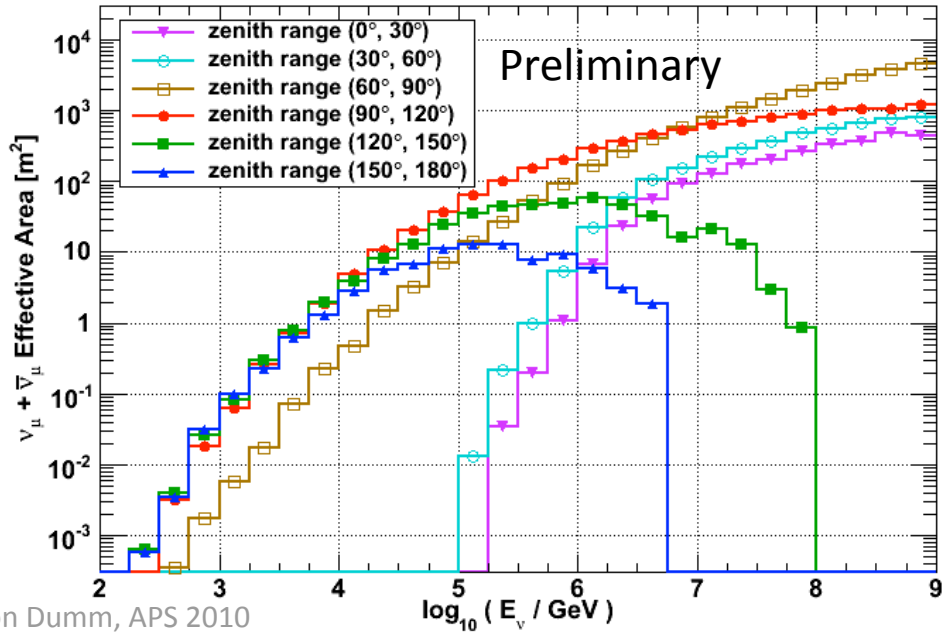
0.5° in southern sky

(difference due to energy of events in final sample)

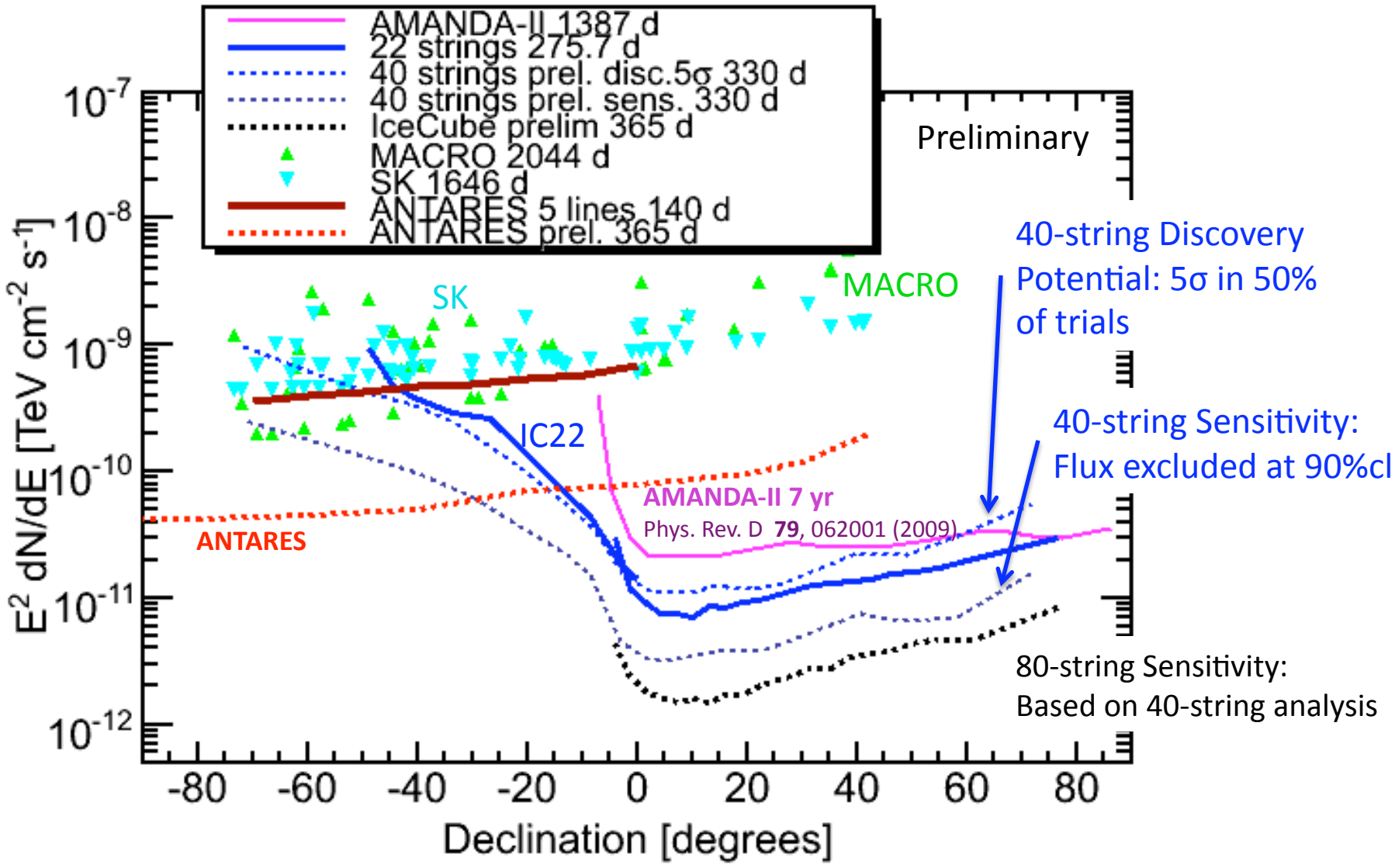
Preliminary



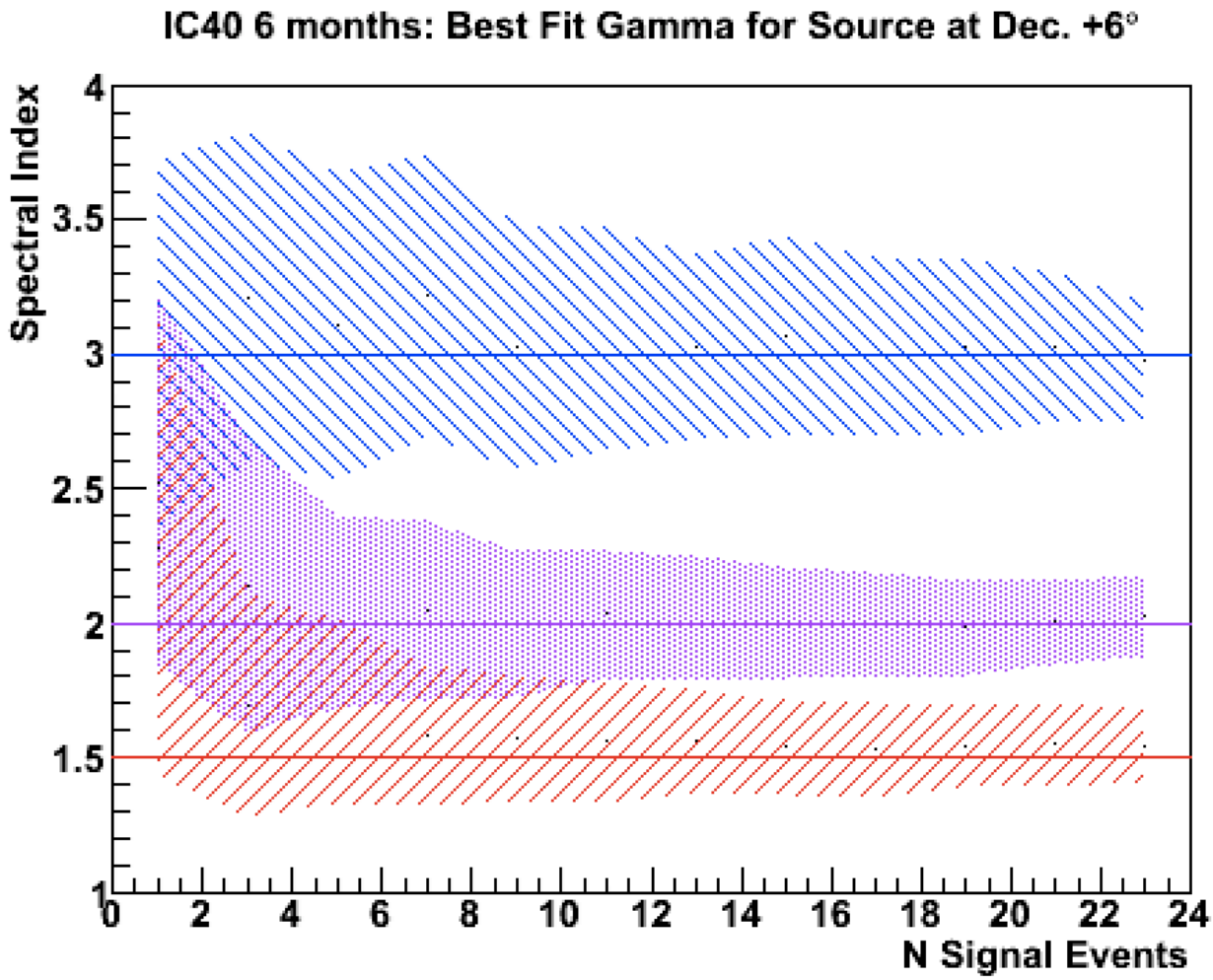
Solid-angle averaged effective area to an equal flux of $\nu_\mu + \bar{\nu}_\mu$, reconstructed within 2° of truth for 6 declination bands



E^{-2} Sensitivity: Past, Present, Future



Reconstructing Energy Spectrum



Shaded regions indicate 1-sigma errors for nu spectrum of:

E^{-3}

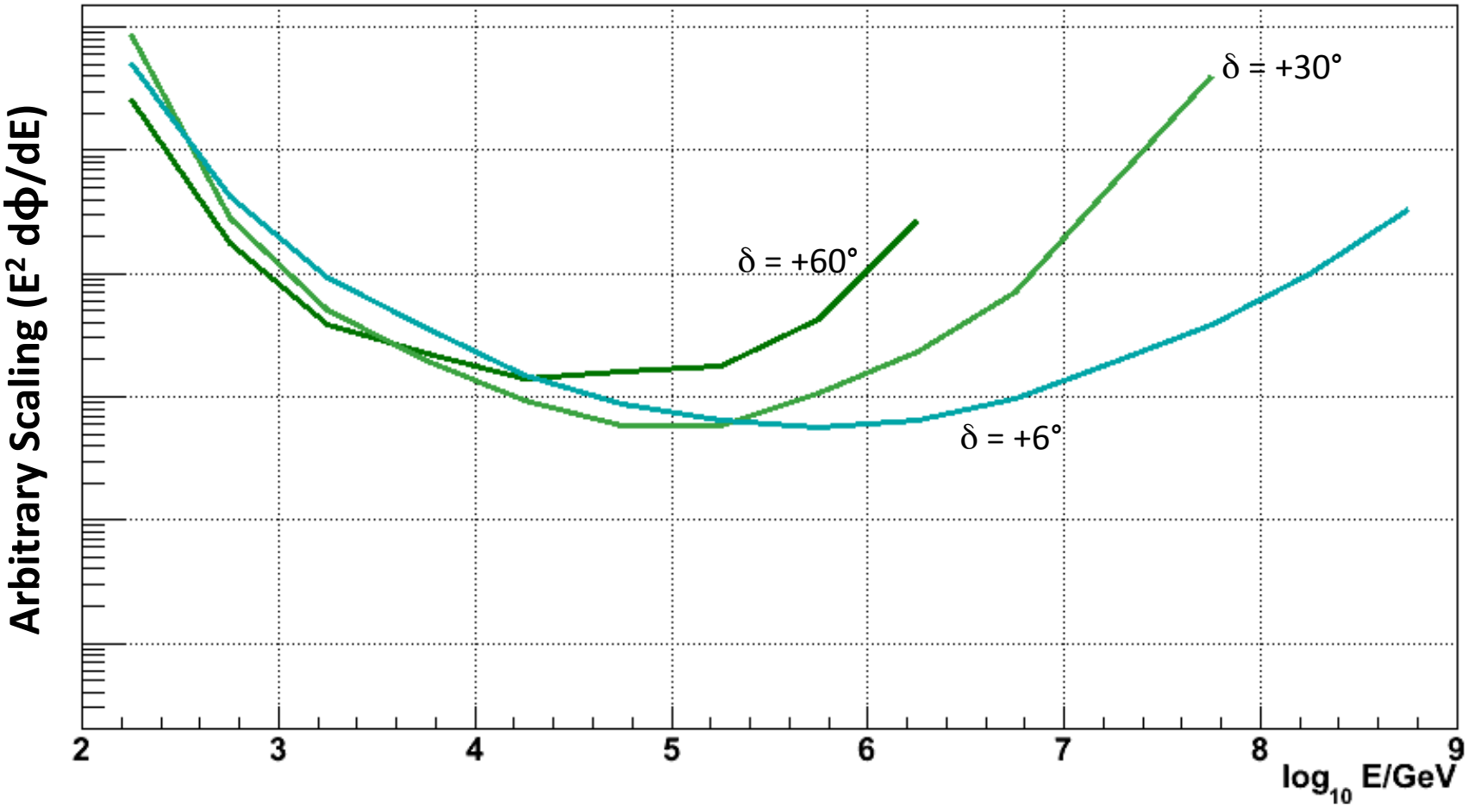
E^{-2}

$E^{-1.5}$

(assumes power law, no systematics)

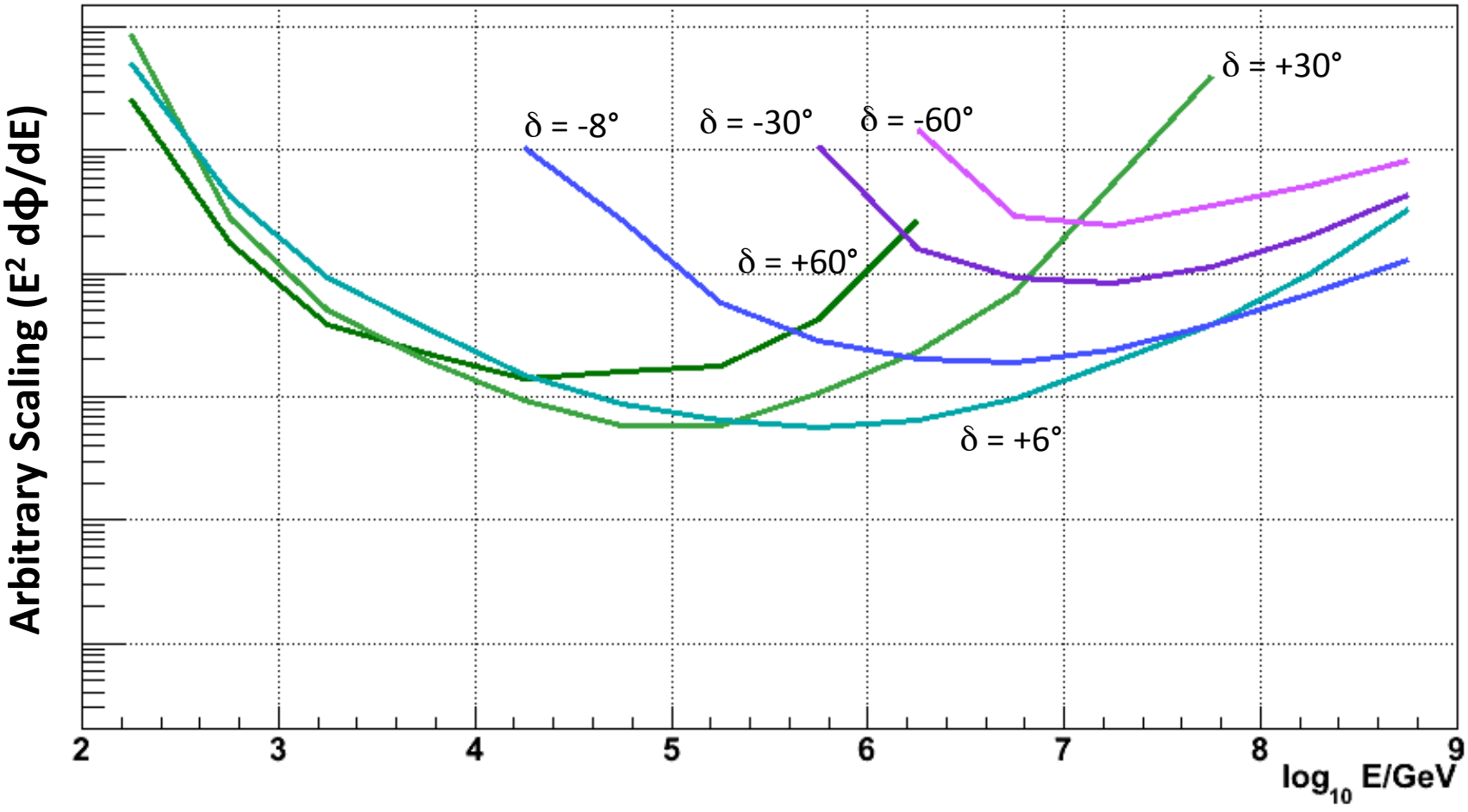
An example of how well we can reconstruct the neutrino energy spectrum vs number of source events

Differential Discovery Potential



40-string Differential 5σ Discovery Potentials
Northern Sky

Differential Discovery Potential



40-string Differential 5σ Discovery Potentials
Northern and Southern Sky