IceCube 2009 status report

in light of the ICRR Inter-university program

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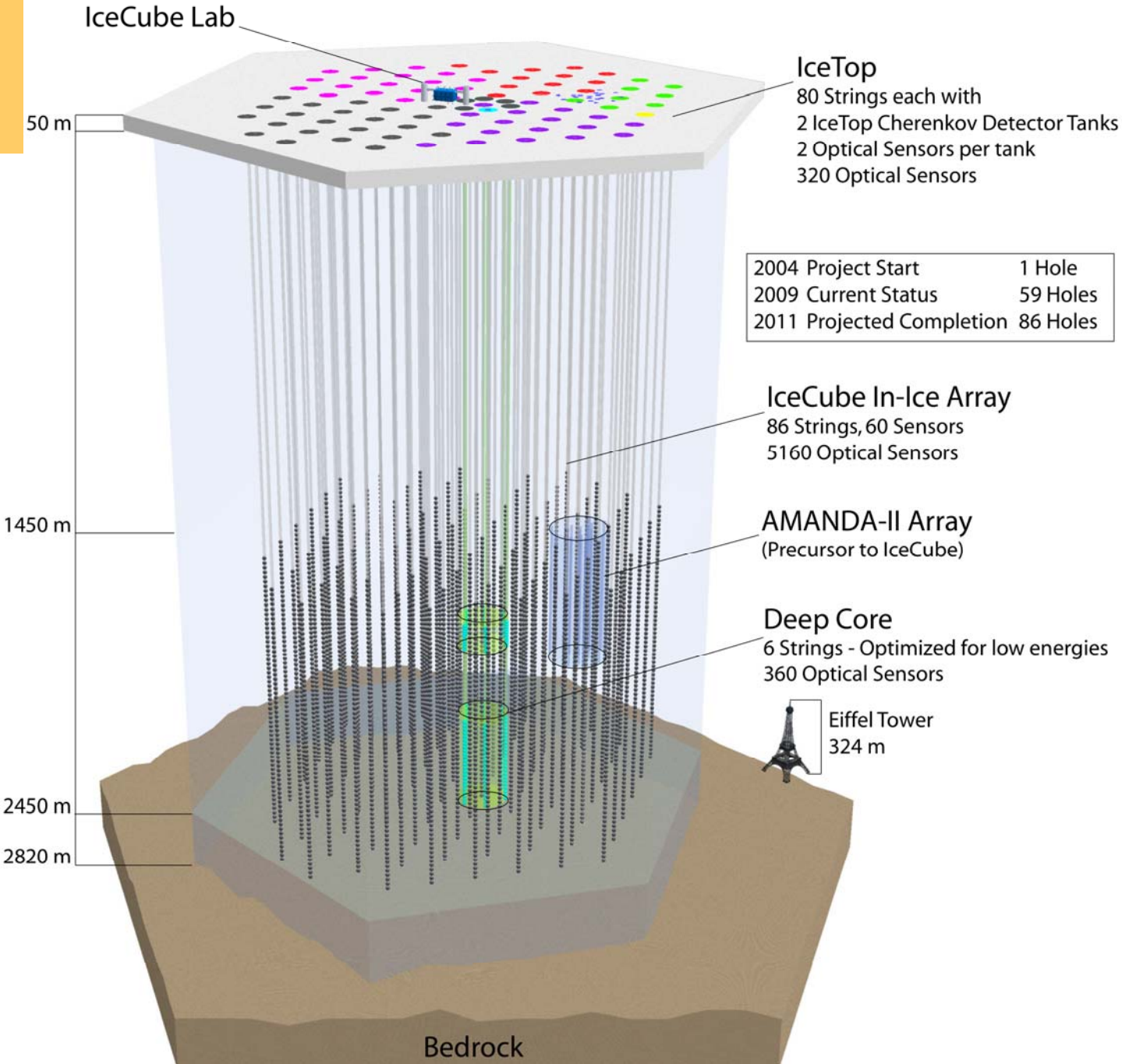
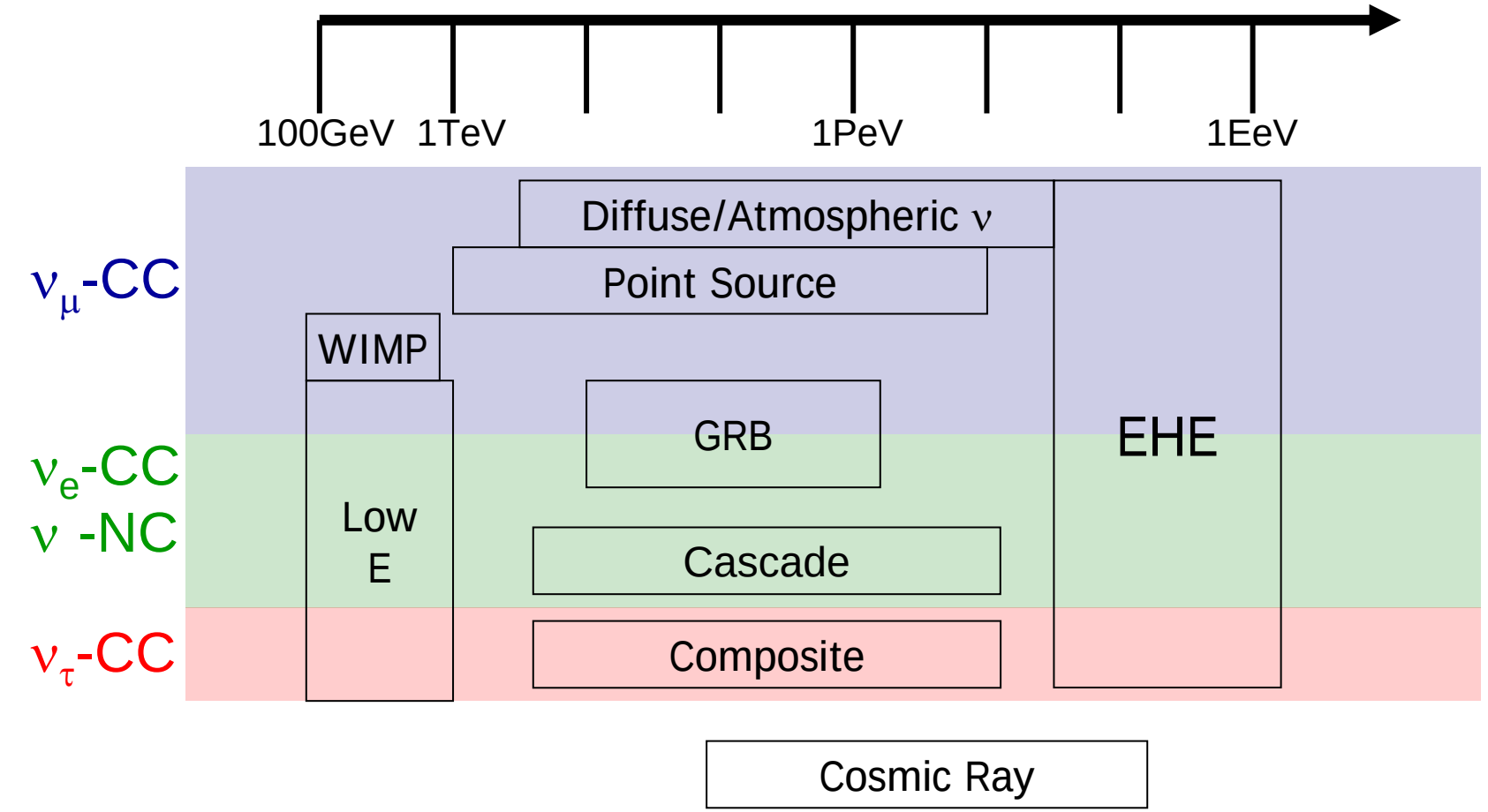
IceCube status

- Total of 59 strings and 118 IceTop tanks → over two thirds complete!
- Completion with 86 strings: January 2011
- Detector is taking data during construction phase.



IceCube working groups



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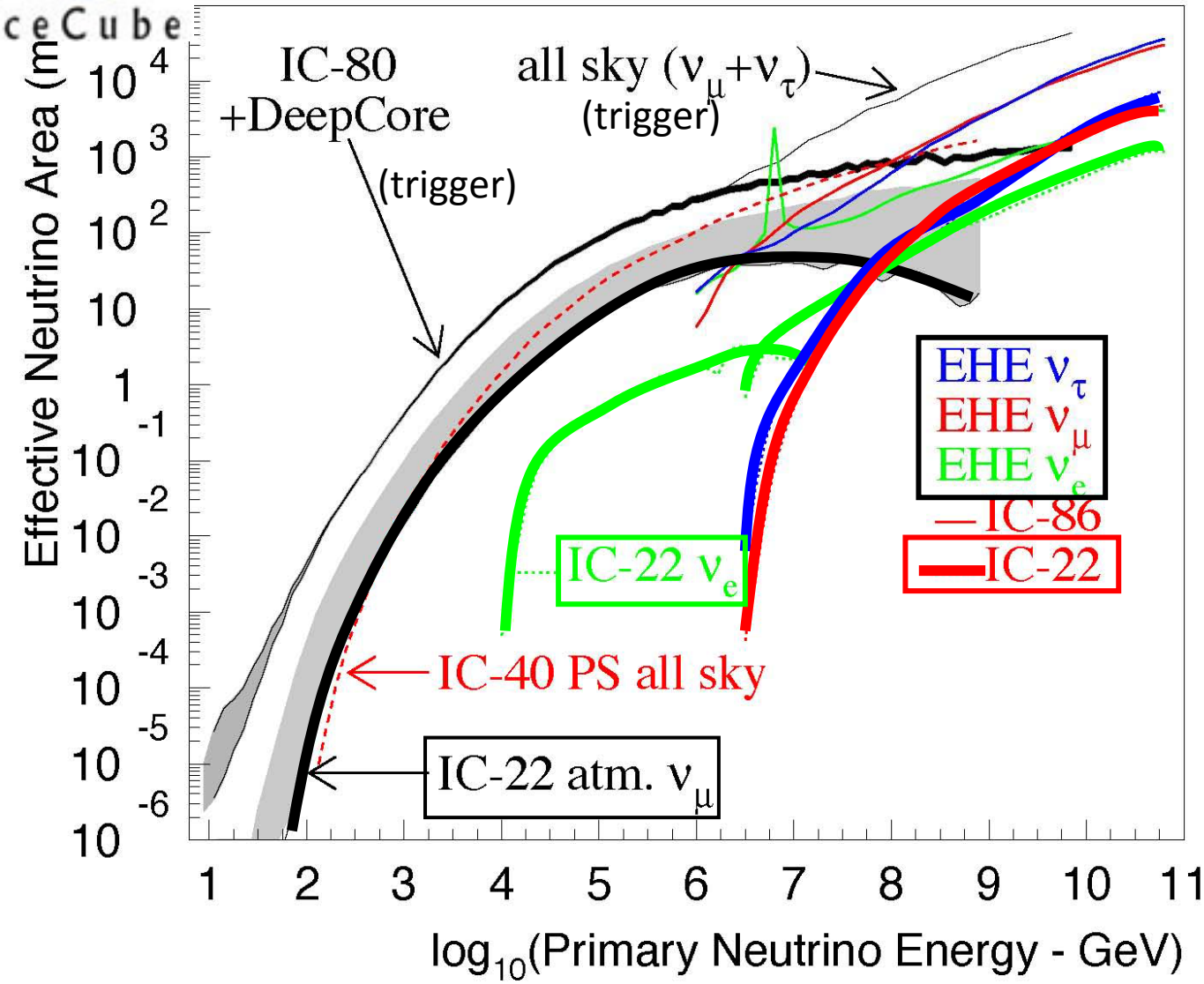
Effective Area

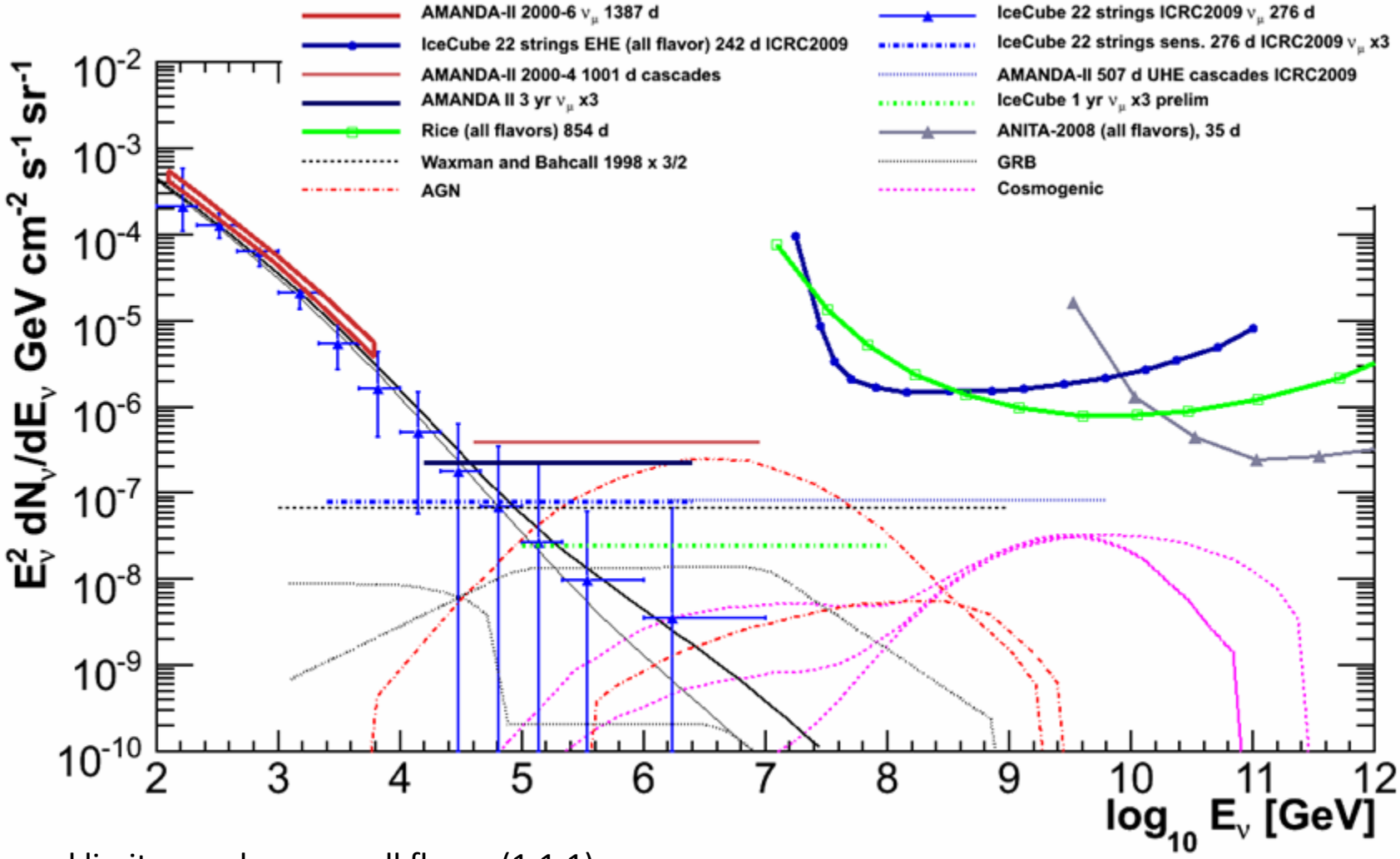


Effective area for ν_μ

Strong rise with energy:

- $\sigma \propto E_\nu$
- Increase of muon range with energy up to PeV

And ν flux limits

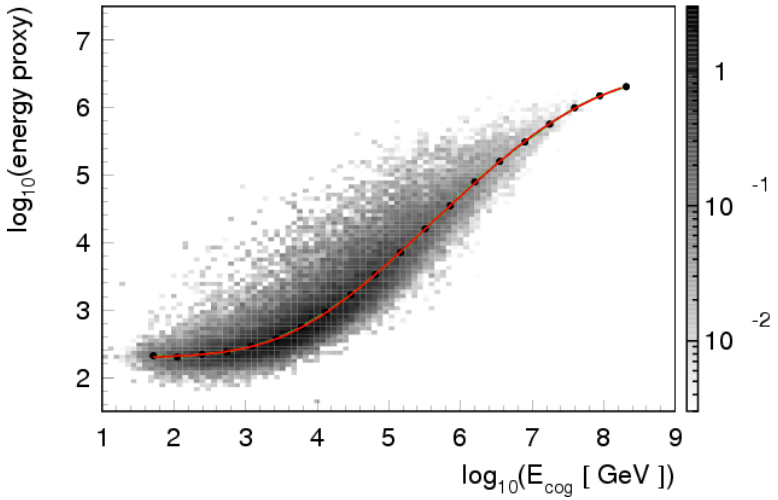


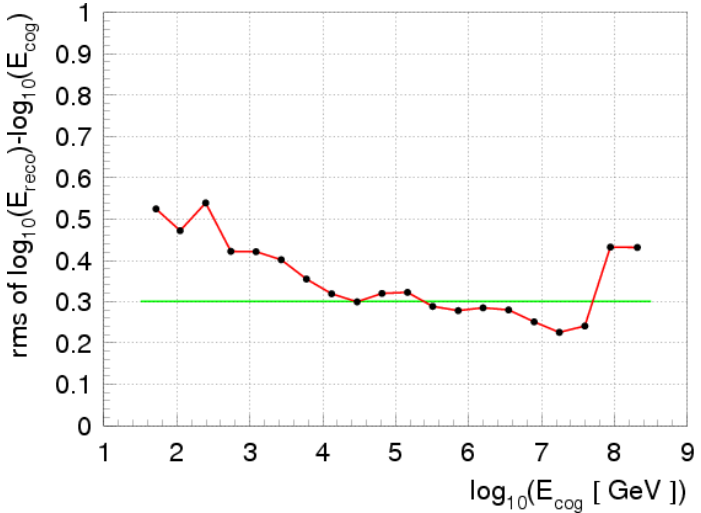
Models and limits are shown as all flavor (1:1:1).

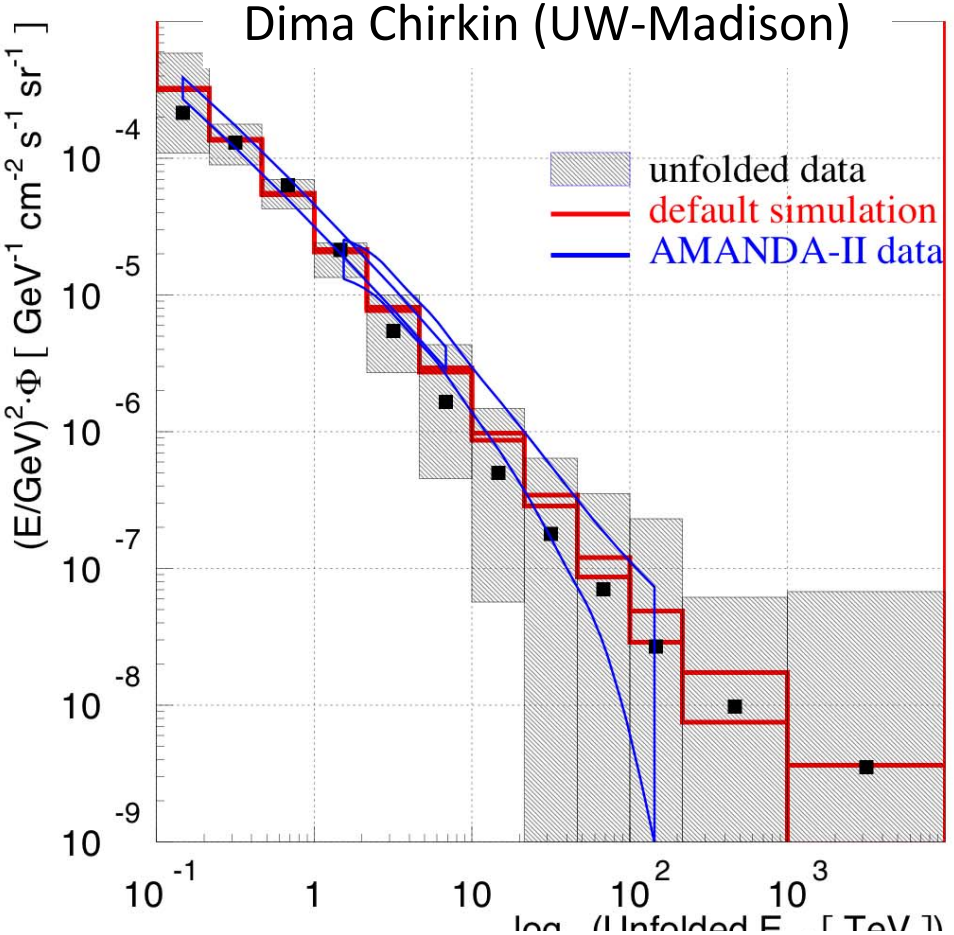
Atmospheric ν : muon

Dima Chirkin (UW-Madison)

Muon energy resolution: ~0.3 in log(E)



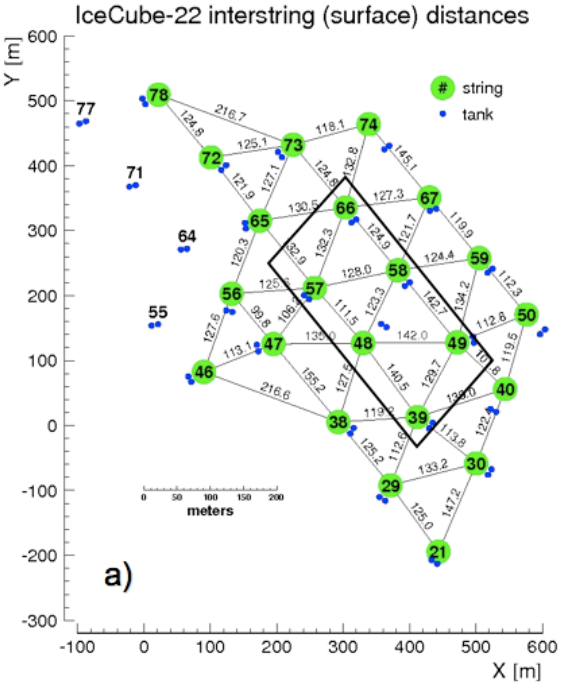




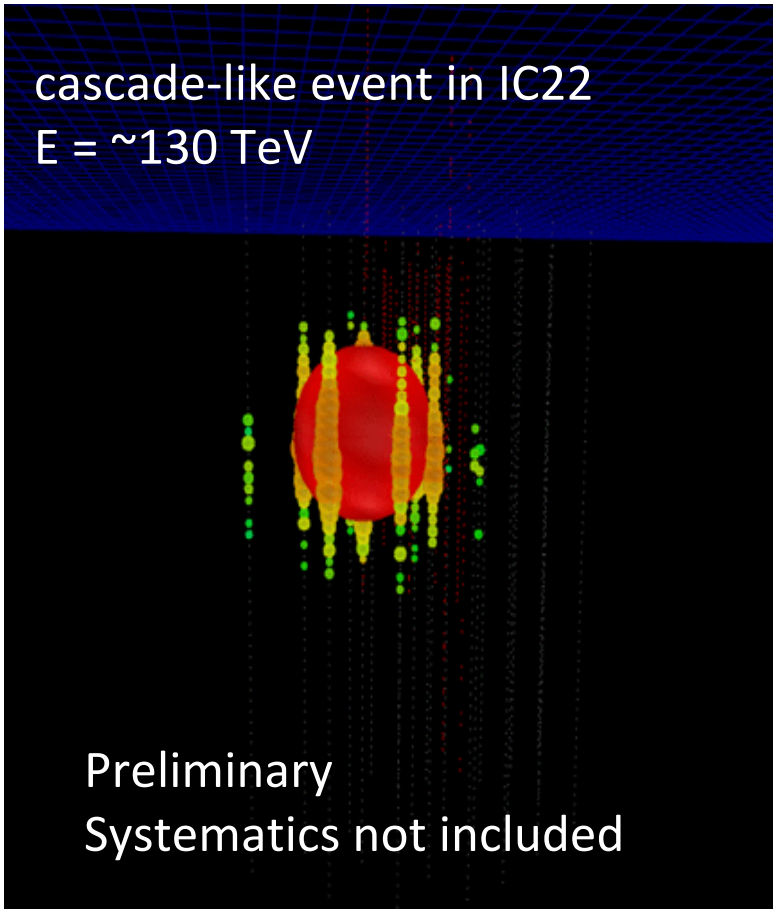
- IceCube 22 string analysis
- 4492 neutrino events at high purity (>95%)

Atmospheric ν ? : cascade

- Cascade searches look for electron-, tau-neutrinos and neutral current interactions.
- Challenge: bremstrahlung events from cosmic ray muons
- Apply veto techniques (first hits must all be inside defined volume) and test cascade fit quality parameters.
- Approaching the level where atmospheric cascade events are expected.

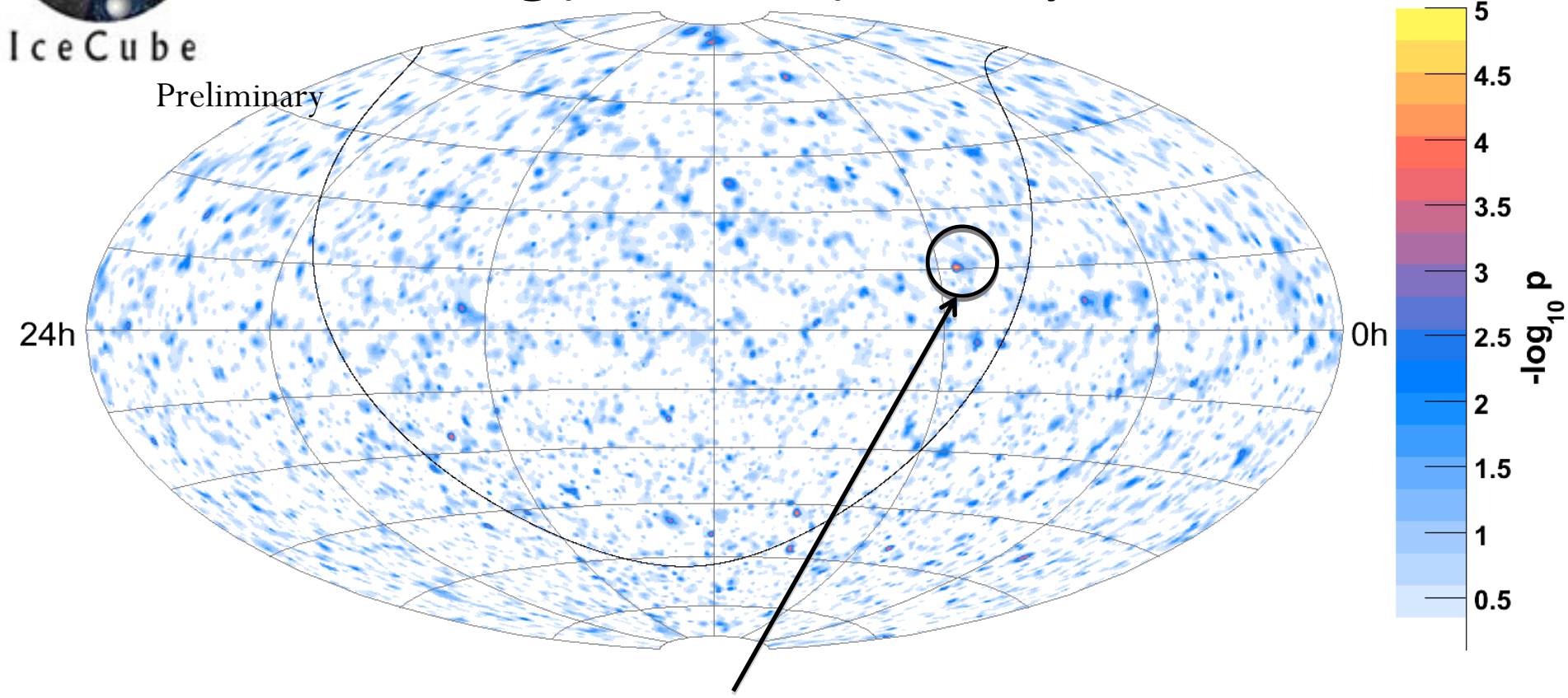


IC22



Michalangelo d'Agostino (UC-Berkley)
Joanna Kiryluk (LBNL)

Search for point sources - 40-string(6month) all-sky results



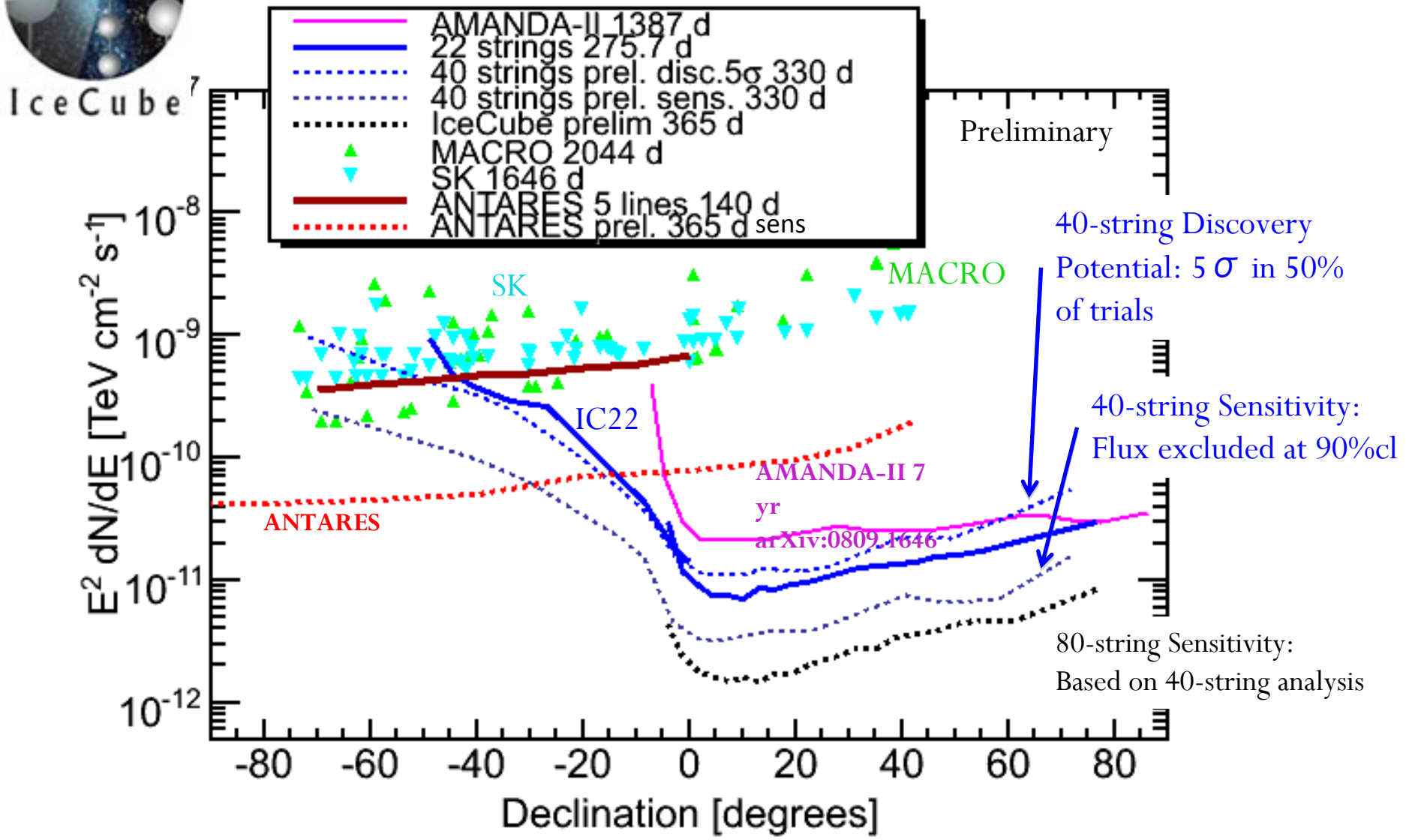
Hottest location in the all-sky search is:
r.a.=114.95˚ , dec.=15.35˚

Pre-trial $-\log_{10}$(p-value) = 4.43
Best-fit # of source events = 7.1
Best-fit spectral index = 2.1

No excess found!
⇒all-sky p-value is 61%, not significant

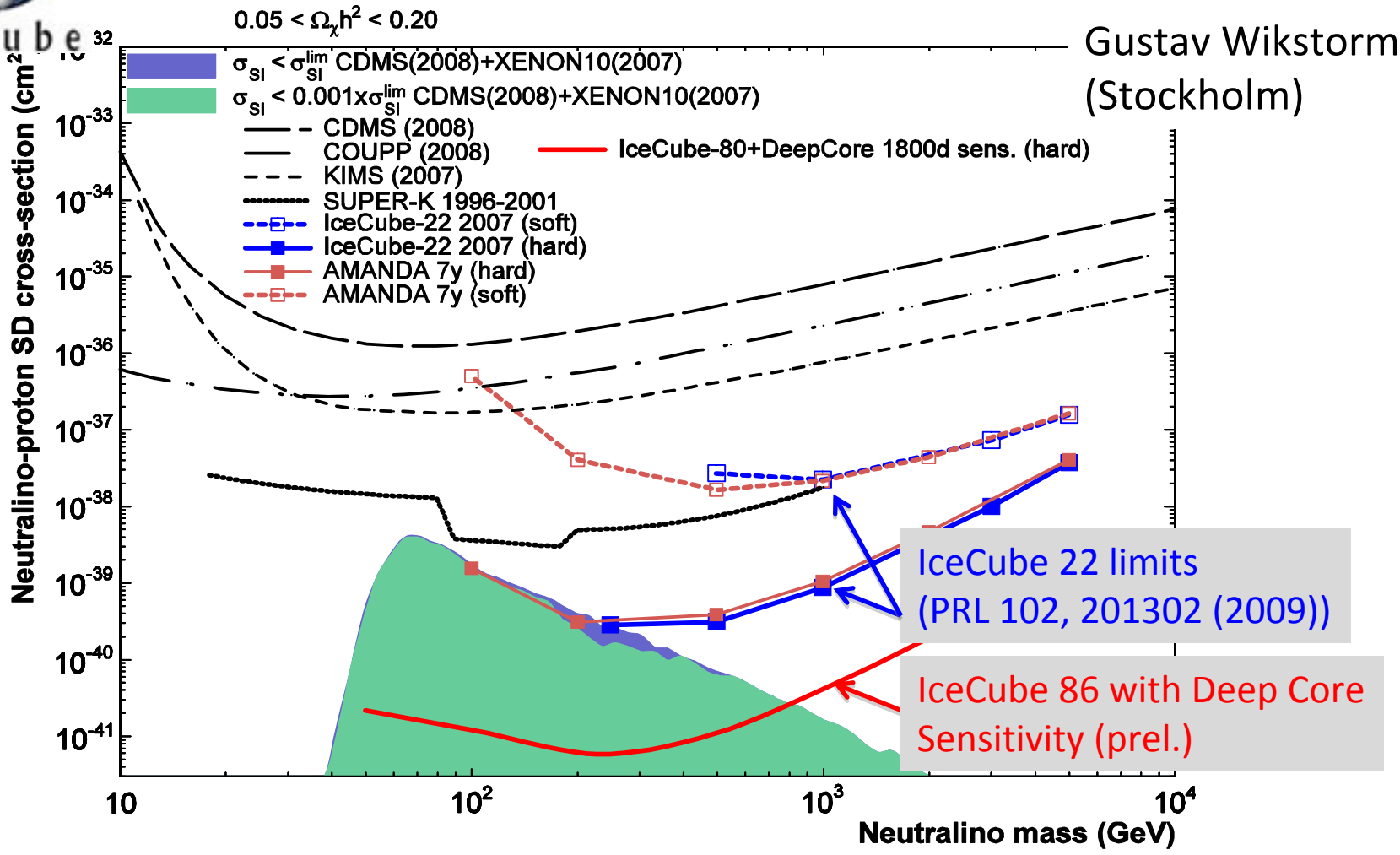
Jon Dumm (UW-Madison)

E^{-2} Sensitivities, limits vs zenith angle



Dark Matter search: neutrinos from WIMP annihilation in the sun

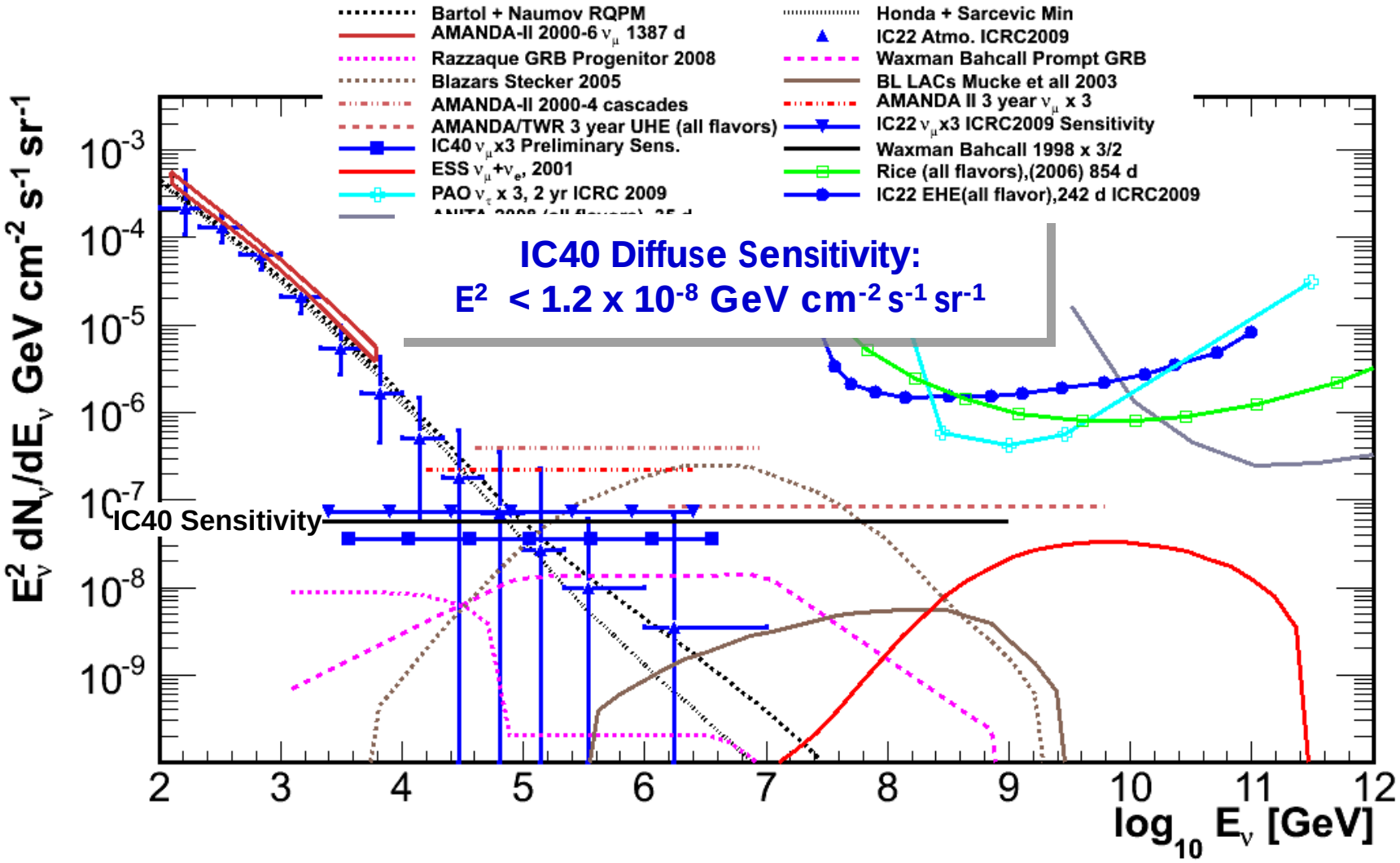
Gustav Wikstorm (Stockholm)



→ Deep core enhancement under construction will greatly enhance sensitivity.

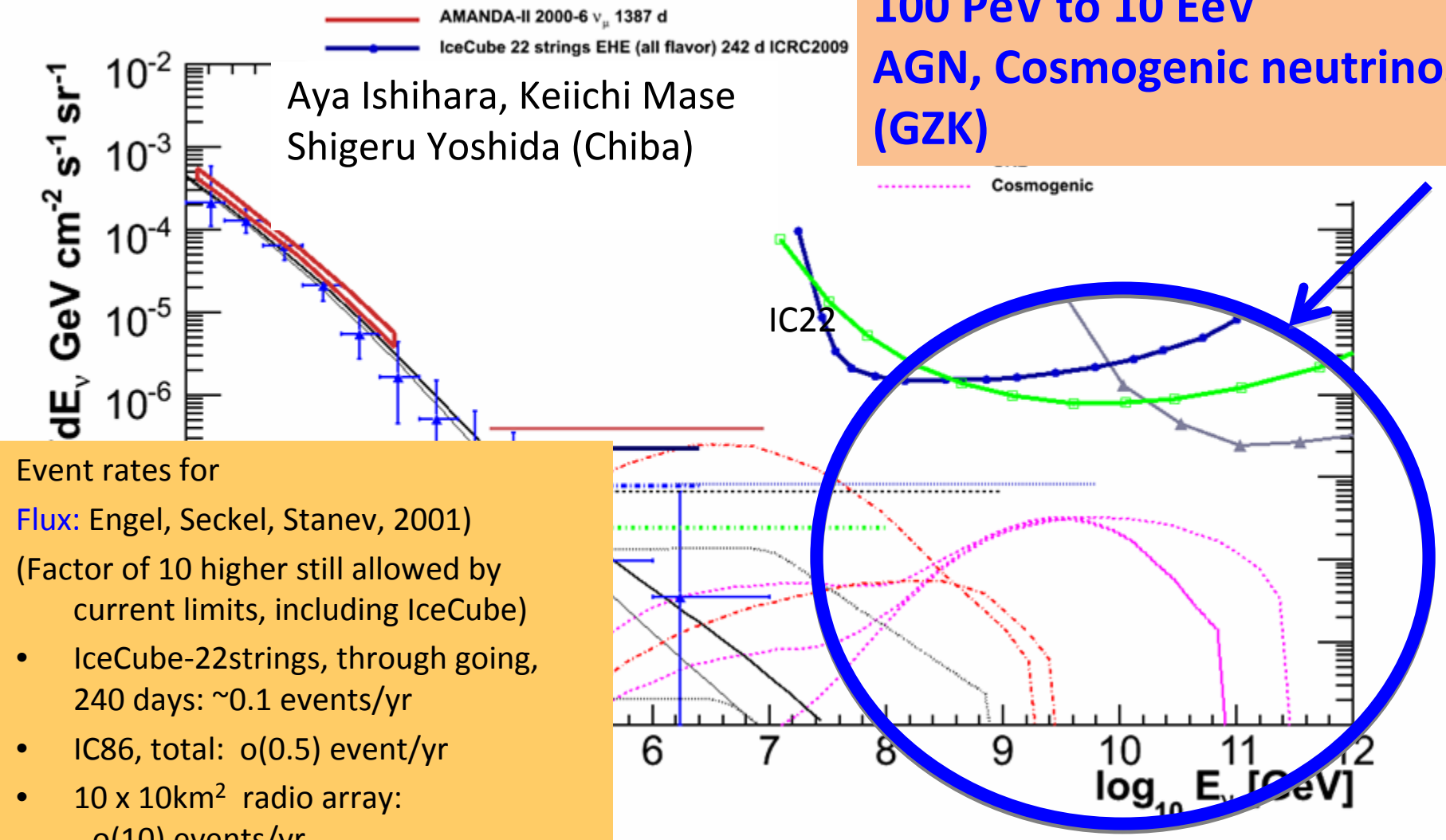
Diffuse ν flux

Kotoyo Hoshina/Sean Grullon
(UW-Madison)



EHE (EeV and higher)

Astrophysical sources:
100 PeV to 10 EeV
AGN, Cosmogenic neutrinos (GZK)



Aya Ishihara, Keiichi Mase
Shigeru Yoshida (Chiba)

Event rates for

Flux: Engel, Seckel, Stanev, 2001)

(Factor of 10 higher still allowed by current limits, including IceCube)

- IceCube-22strings, through going, 240 days: ~0.1 events/yr
- IC86, total: o(0.5) event/yr
- 10 x 10km^2 radio array: o(10) events/yr

2007 Extremely High E ν search Data Chain

Level1 : NDOM >=80 with excluding bad runs

"EHE" filter data ~1.5 Hz 242 days

Level2 : NPE >= 10^4

6516 events

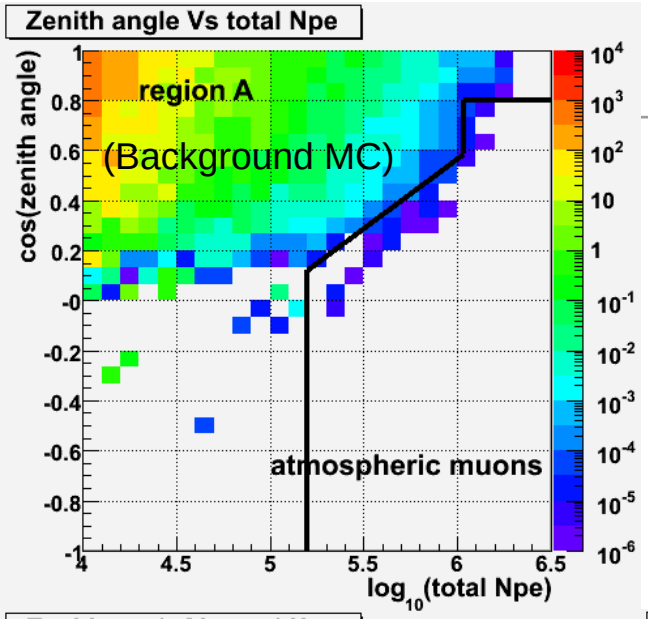
Level3 : cos(Zenith) < 0.8

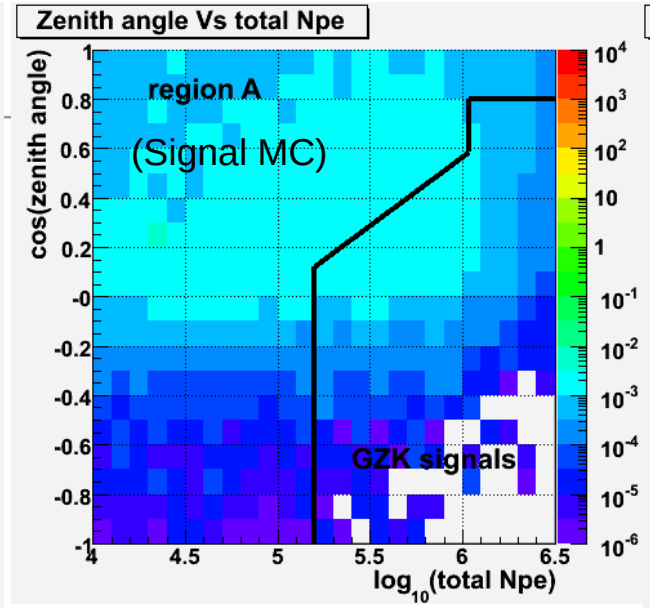
2011 events

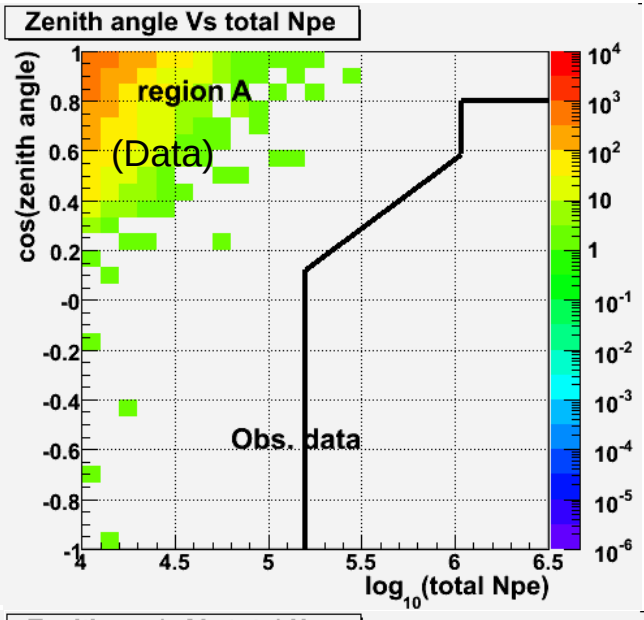
Level4 : cuts on NPE and Zenith

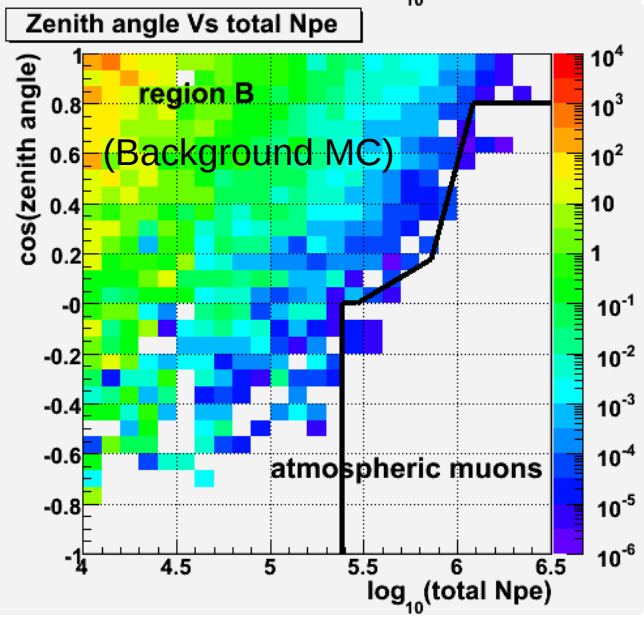
0 events

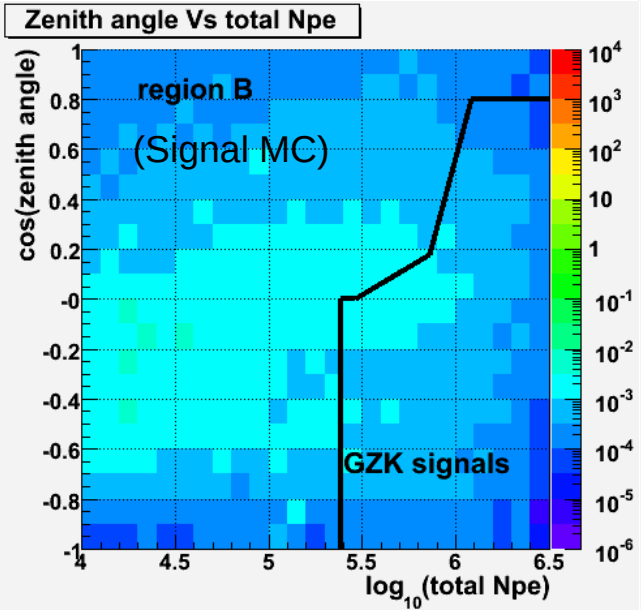
region A: -250 < CoGZ < -50 m and CoGZ > 50 m
region B: CoGZ < -250 m and -50 < CoGZ < 50m

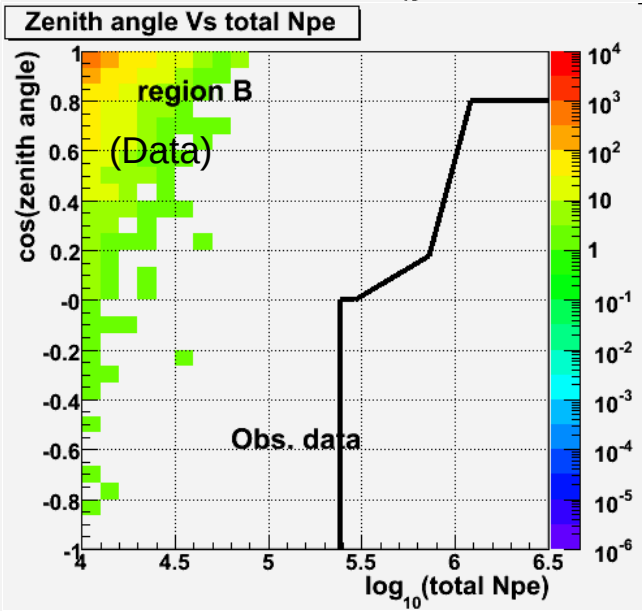


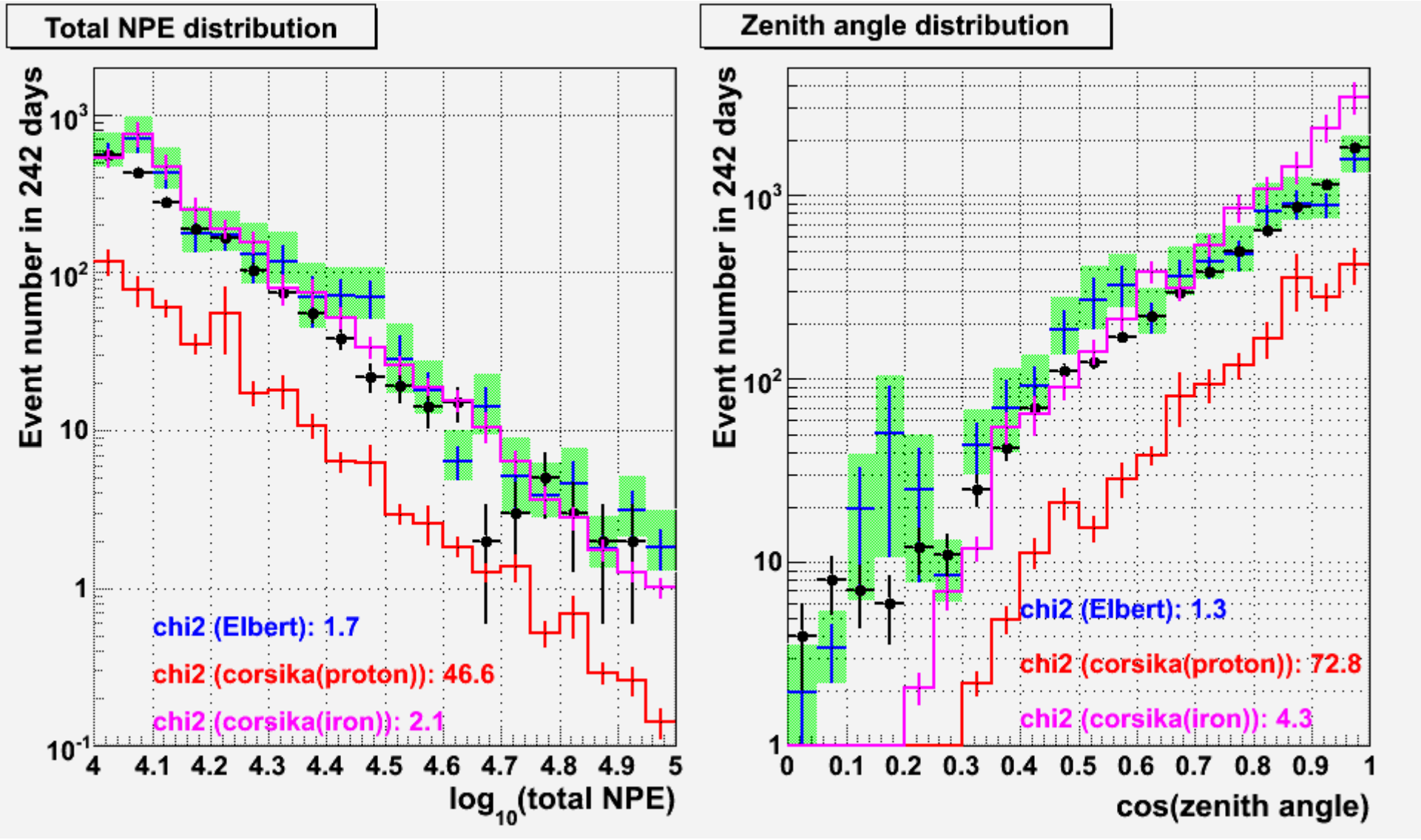






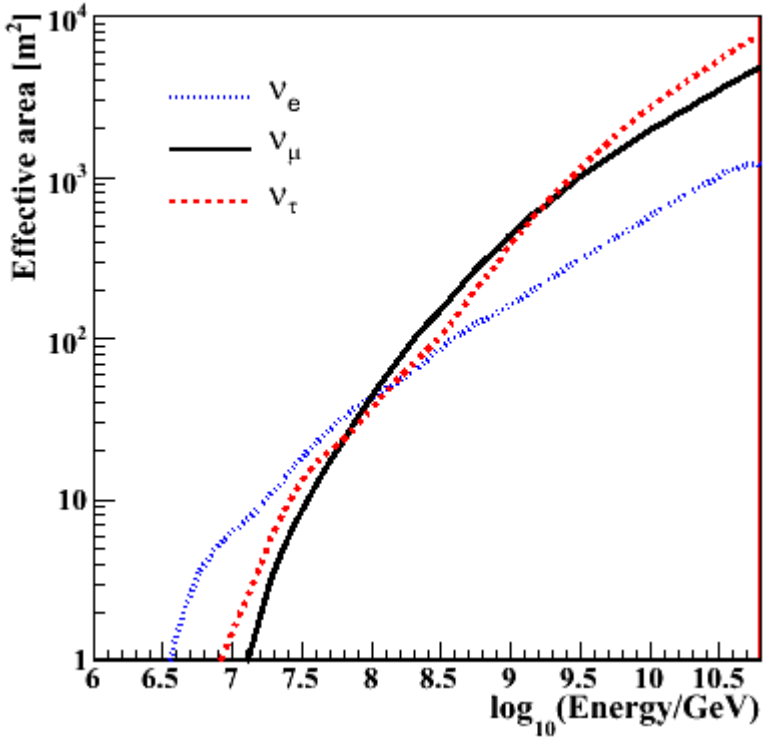


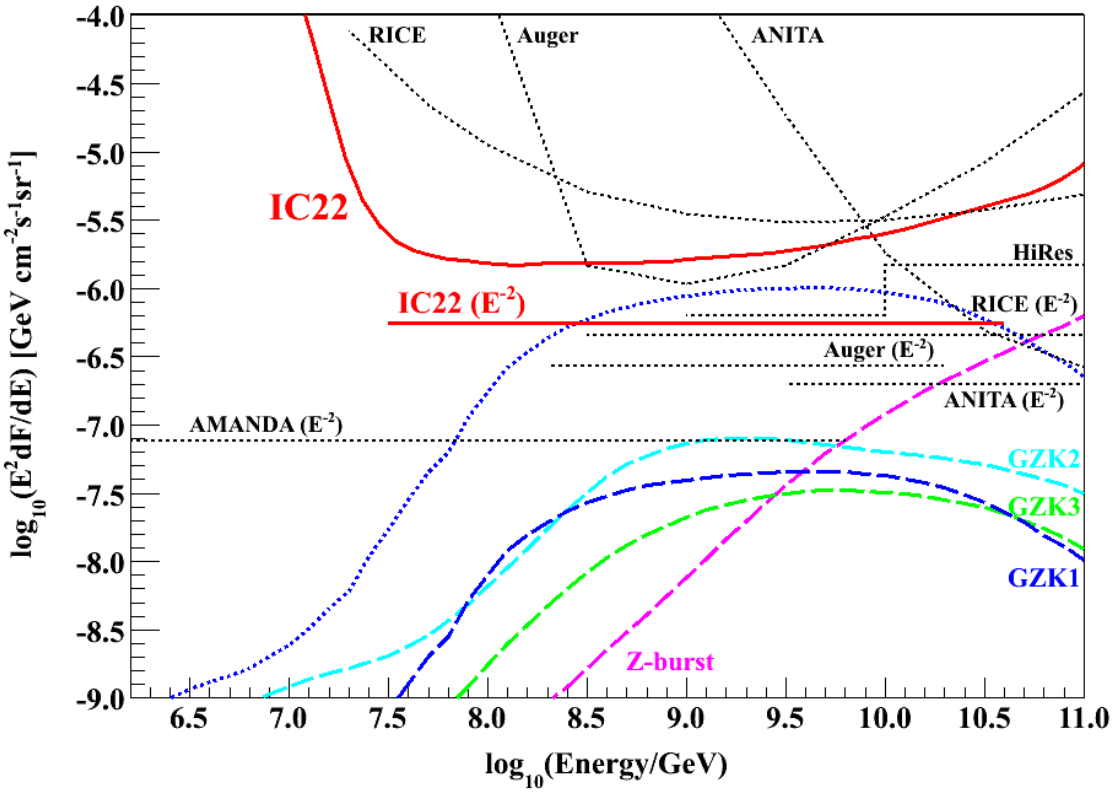



Total NPE distribution
Event number in 242 days
10^3
10^2
10
1
10^{-1}
4
4.1
4.2
4.3
4.4
4.5
4.6
4.7
4.8
4.9
5
$\log_{10}$(total NPE)
chi2 (Elbert): 1.7
chi2 (corsika(proton)): 46.6
chi2 (corsika(iron)): 2.1
Zenith angle distribution
Event number in 242 days
10^3
10^2
10
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
cos(zenith angle)
chi2 (Elbert): 1.3
chi2 (corsika(proton)): 72.8
chi2 (corsika(iron)): 4.3

Extremely-High Energy ν limits

with 241 days observation in 2007



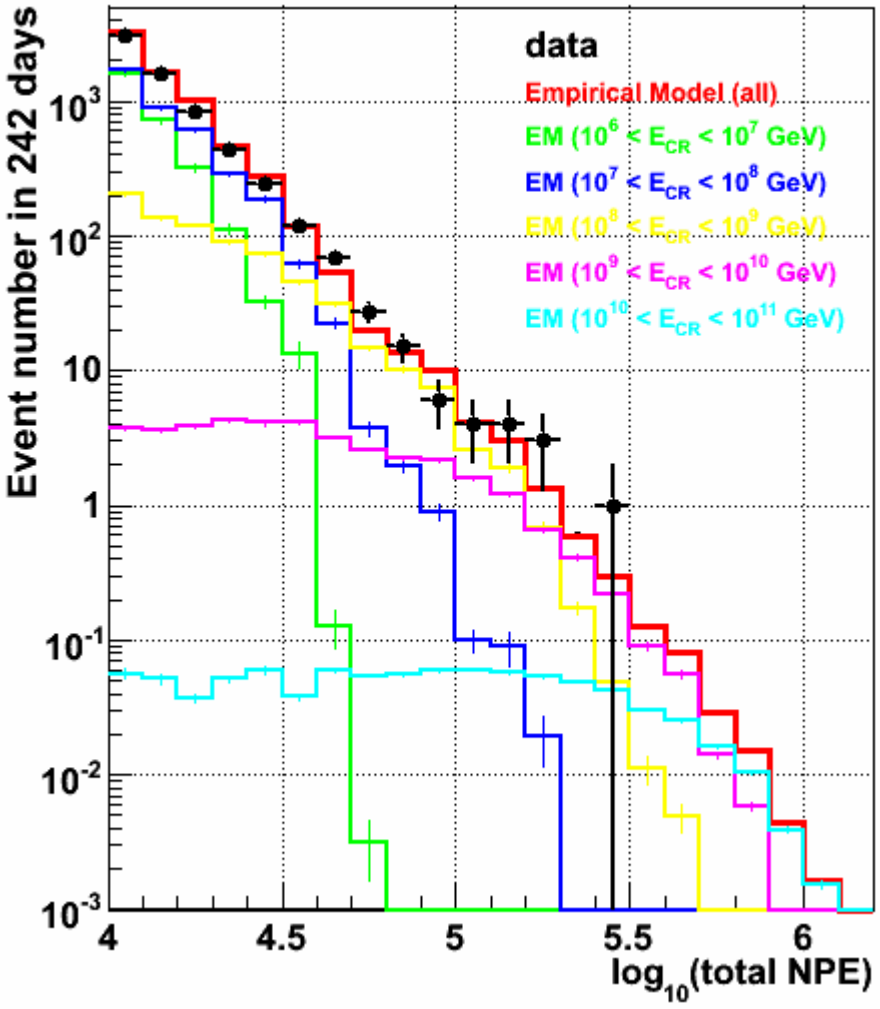


Aya Ishihara, Keiichi Mase
Shigeru Yoshida (Chiba)

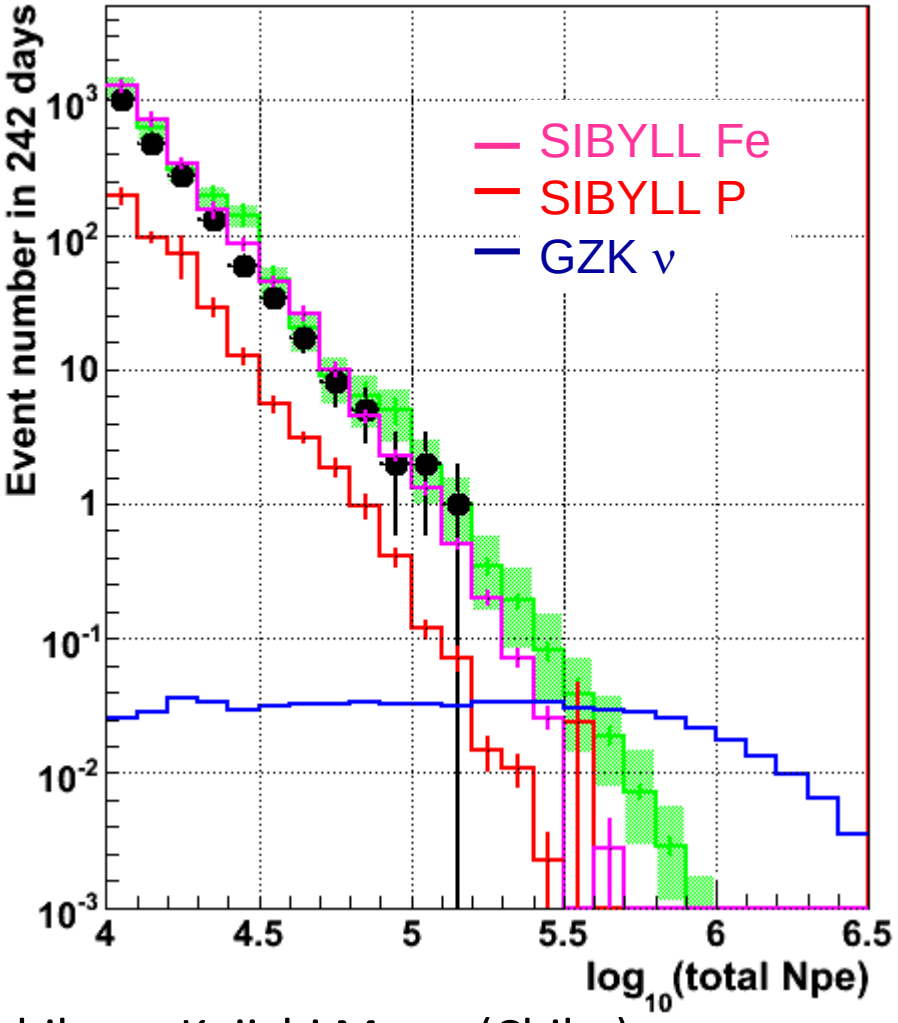
By products – UHECR composition?

IceCube

Total NPE distribution



Total Npe distribution



Aya Ishihara, Keiichi Mase (Chiba)

2008-2009 Data Status

Aya Ishihara (Chiba)

2008/4/17~2009/5/20: 40String operation

- **livetime ~370days (>93%)**

month	June08	July08	Aug08	Sept08	Oct08	Nov08	Dec08	Jan09	Feb09
live-time[day]	**28.59 (95.3%)**	**28.86 (93.1%)**	**29.85 (96.3%)**	**26.92 (89. 7%)**	**28.11 (90.1%)**	**28.95 (96.5%)**	**28.59 (92.2%)**	**26.83 (86.5%)**	**25.01 (89%)**

- Trigger Rate (8 Optical Module)
- High Energy Trigger Rate
  - Bright Event Condition: NPE>630 → 1.23Hz
  - High Energy Condition: NPE>10000 → 45evts/day

Strings	Year	Livetime	μ rate	ν rate	HE rate
IC9	2006	137days	80Hz	1.7/day	4.3/day
IC22	2007	250days	550Hz	28/day	27/day
IC40	2008	370days	1000Hz	110/days	45/days
IC59	2009	~365days	1500Hz	150/days	??/days

2009/5/20 ~ : 59String operation

- Trigger Rate (8 Optical Module)
- High Energy Trigger Rate
  - Bright Event Condition: NPE>630 → 2.29Hz

We'll have *one full IceCube year of data by* the end of 59 string operation !

2009/Nov-2010/Feb:（59+18=77strings）2010/Nov-2011/Feb: Complete（86 Strings）

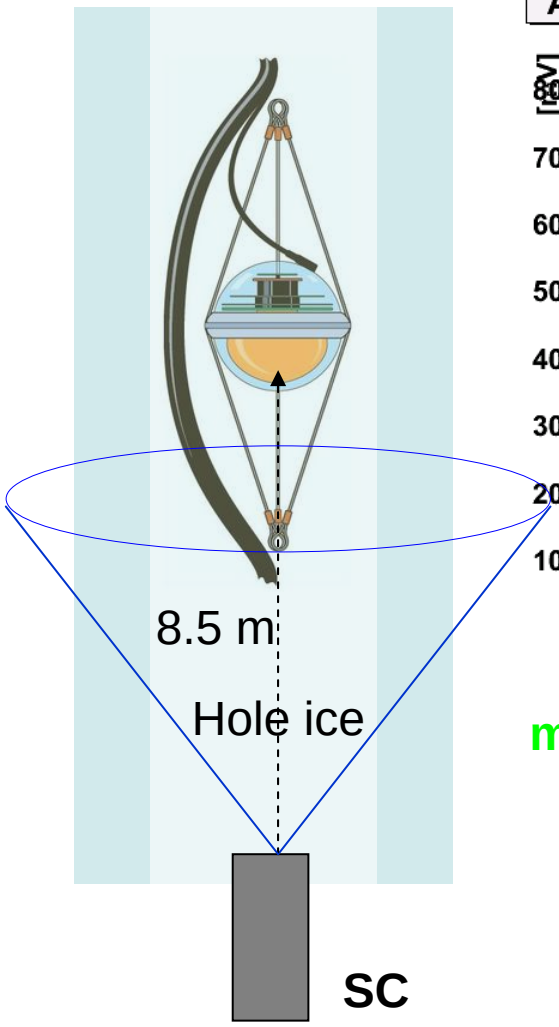
Systematic Error Budget (EHE analysis)

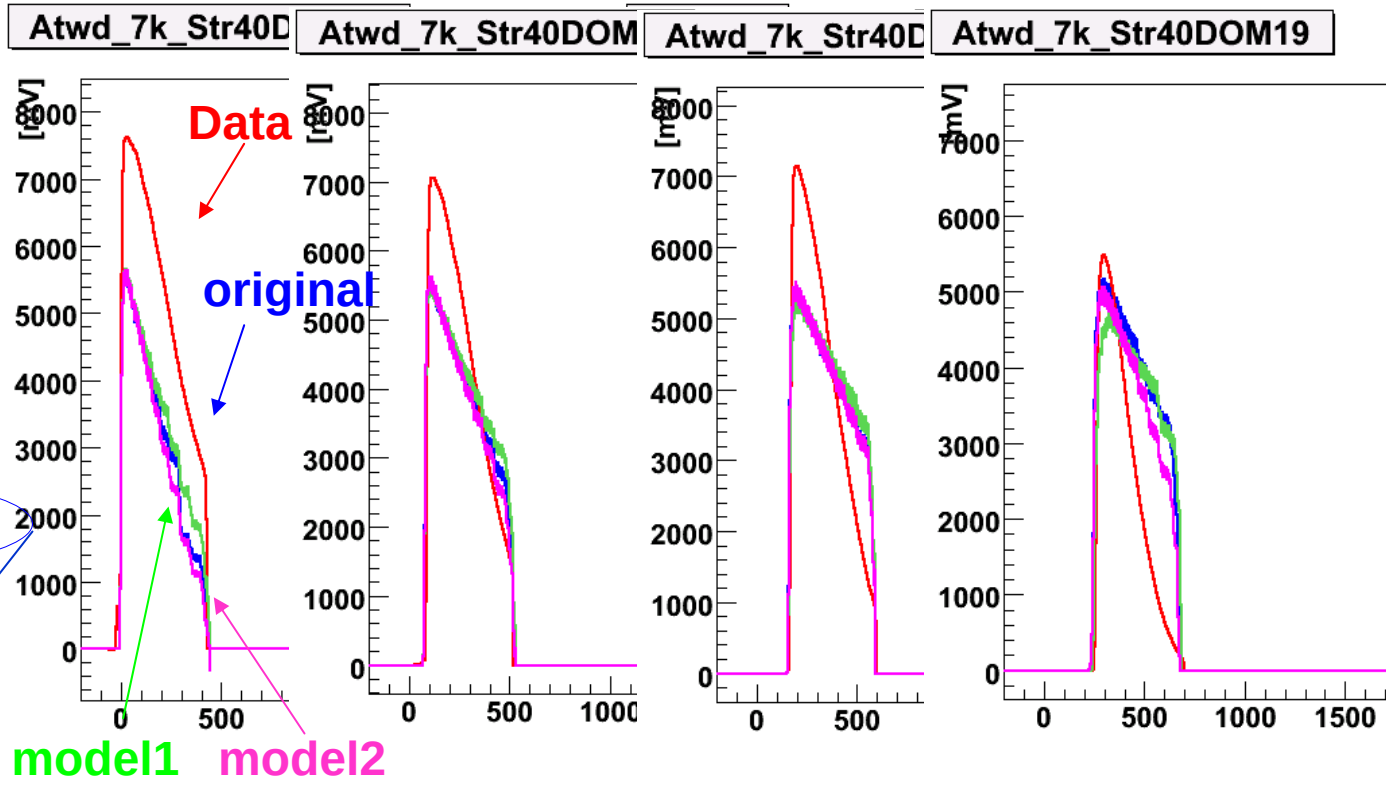
TABLE III: List of the statistical and systematic errors. The signal rate is estimated by assuming the high evolution flux $(m, Z_{max}) = (4, 4)$ in Ref [6].

Error source	backgrounds rate	signals (GZK) rate
Statistical error	±22%	±0.6%
Detector sensitivity	-	±8%
Yearly variation	±17%	-
Empirical model	+99 -59%	-
Hadronic int. model	±4 %	-
NPE yield	-	-32%
Neutrino cross-section	-	±9%
Photo-nuclear interaction	-	+10%
LPM effect	-	±1%
Total	±22% (stat.) +101 -62% (sys.)	±0.6% (stat.) +16 -34% (sys.)

The biggest disagreement

Waveforms of the detector just above the SC, **Data > MC**

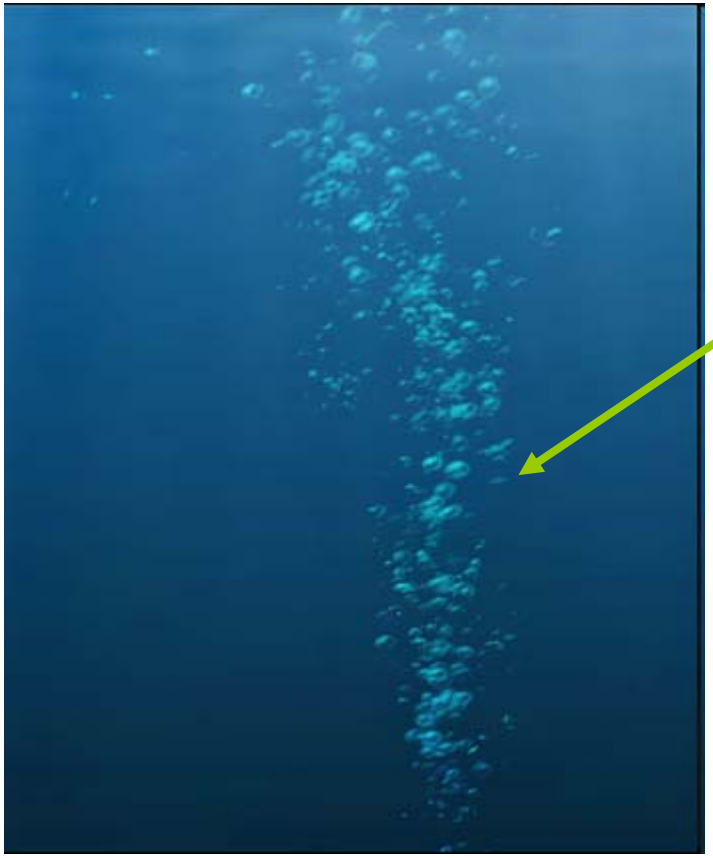


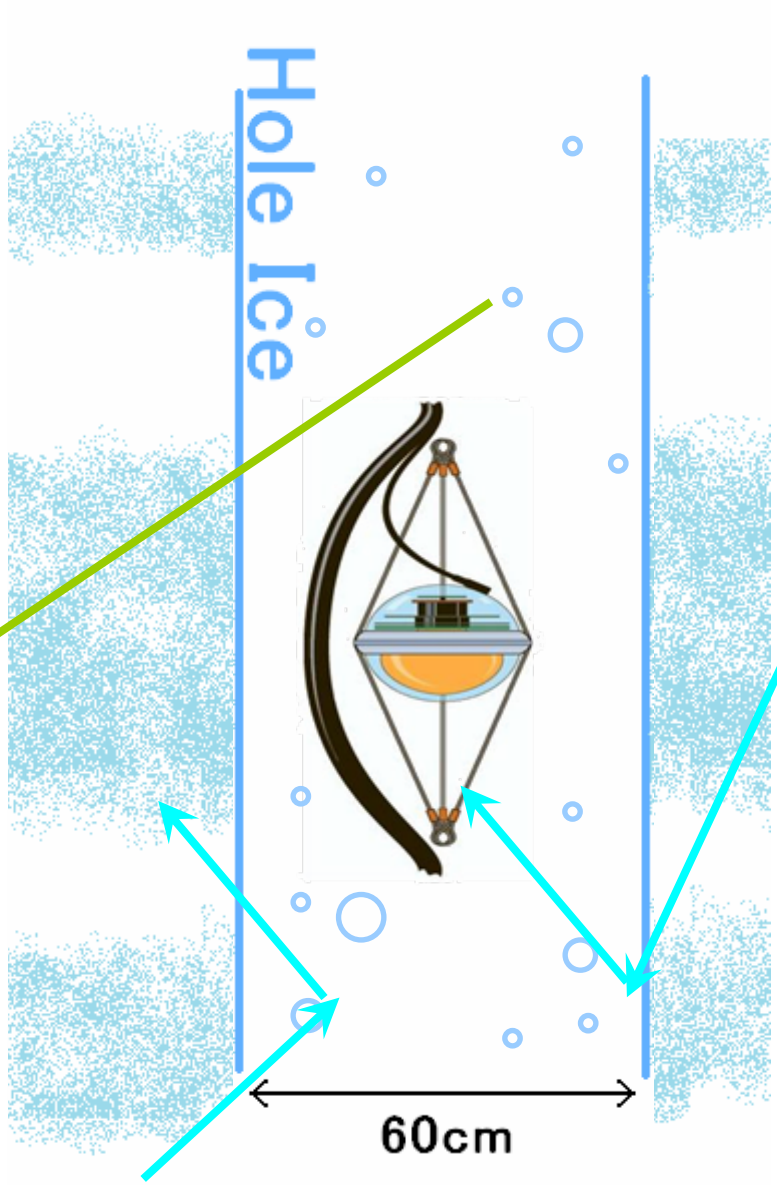


The disagreement of the peak suggests that there are photons coming directly from the SC in the real.

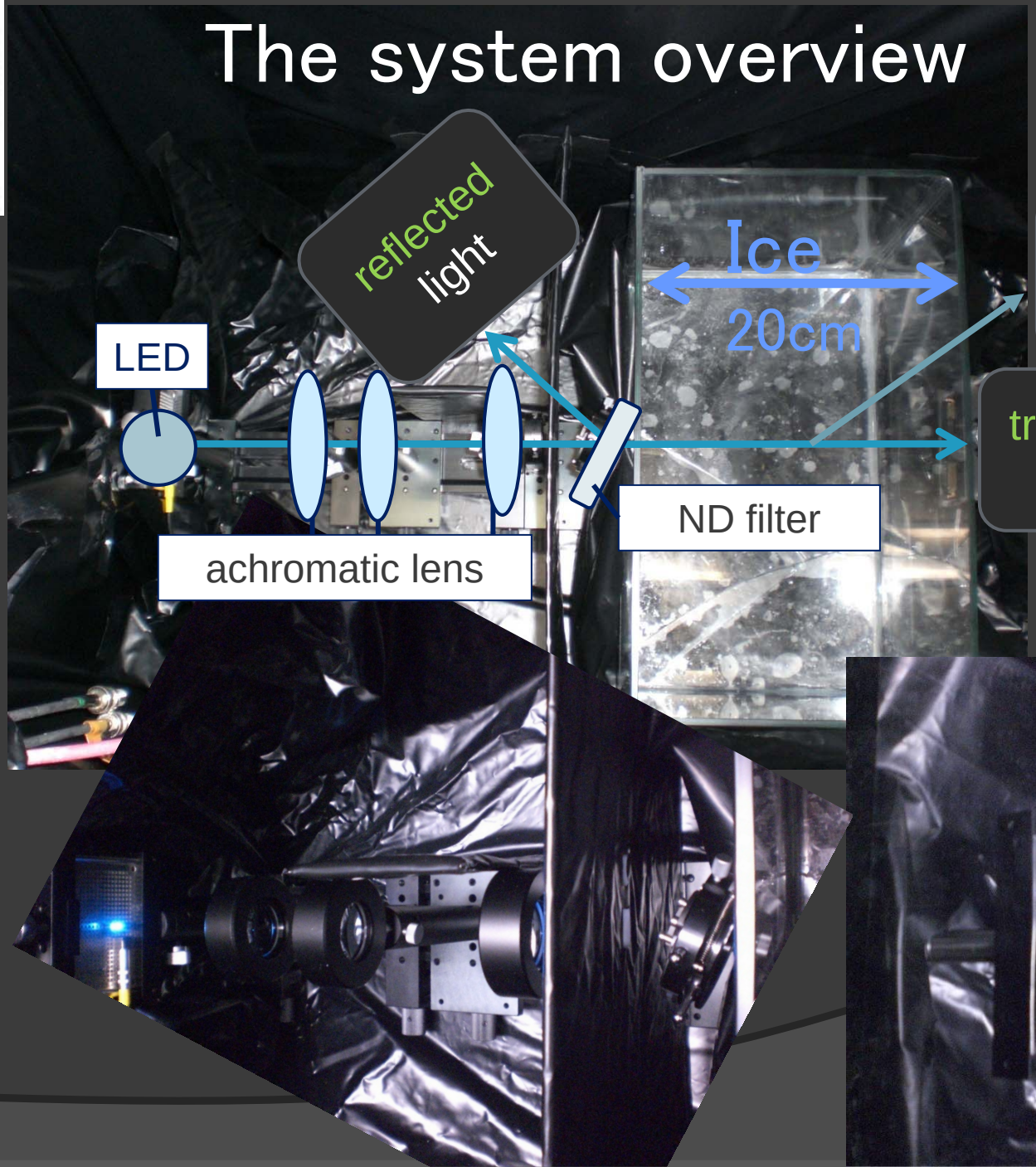
Mission

Count the number of
“Bubbles”
in a path in hole-ice

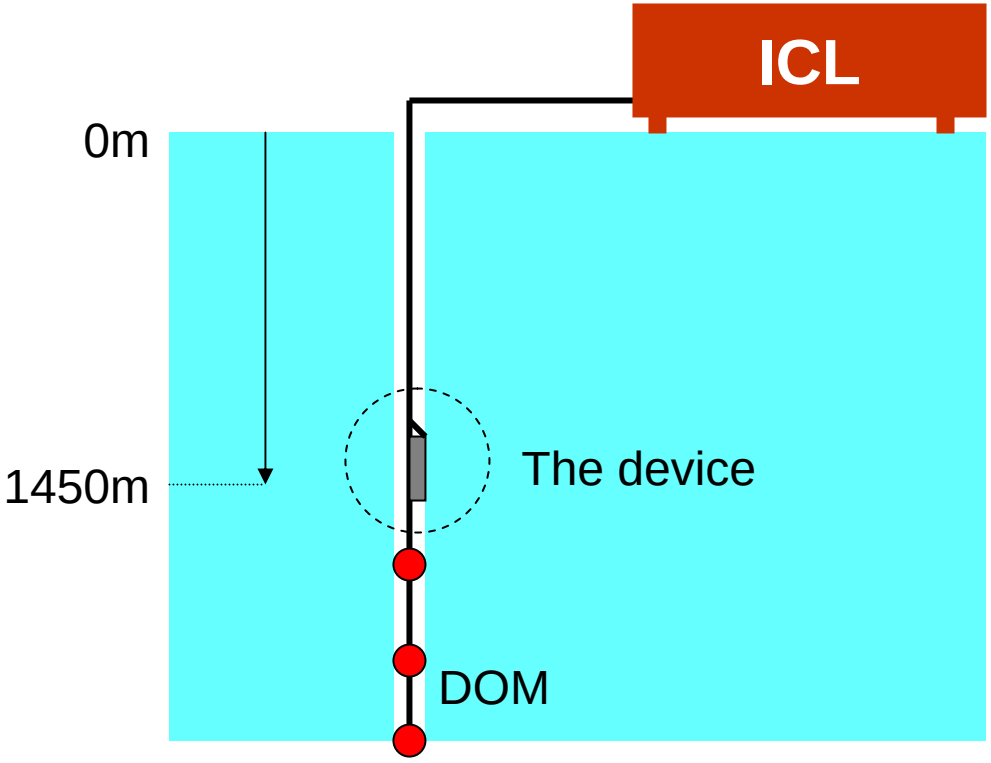


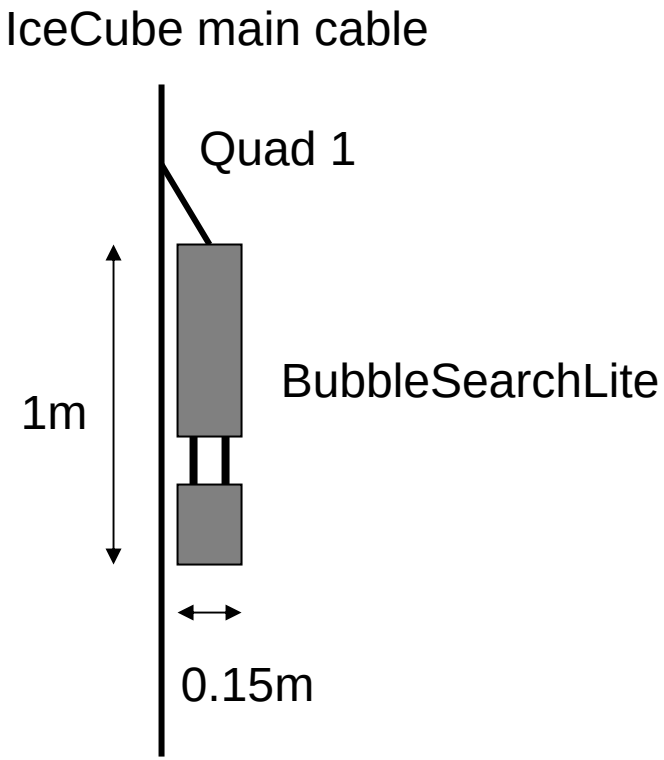


The system overview



BubbleSearchLite Deployment Configuration





IceCube

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The BubbleSearchLite