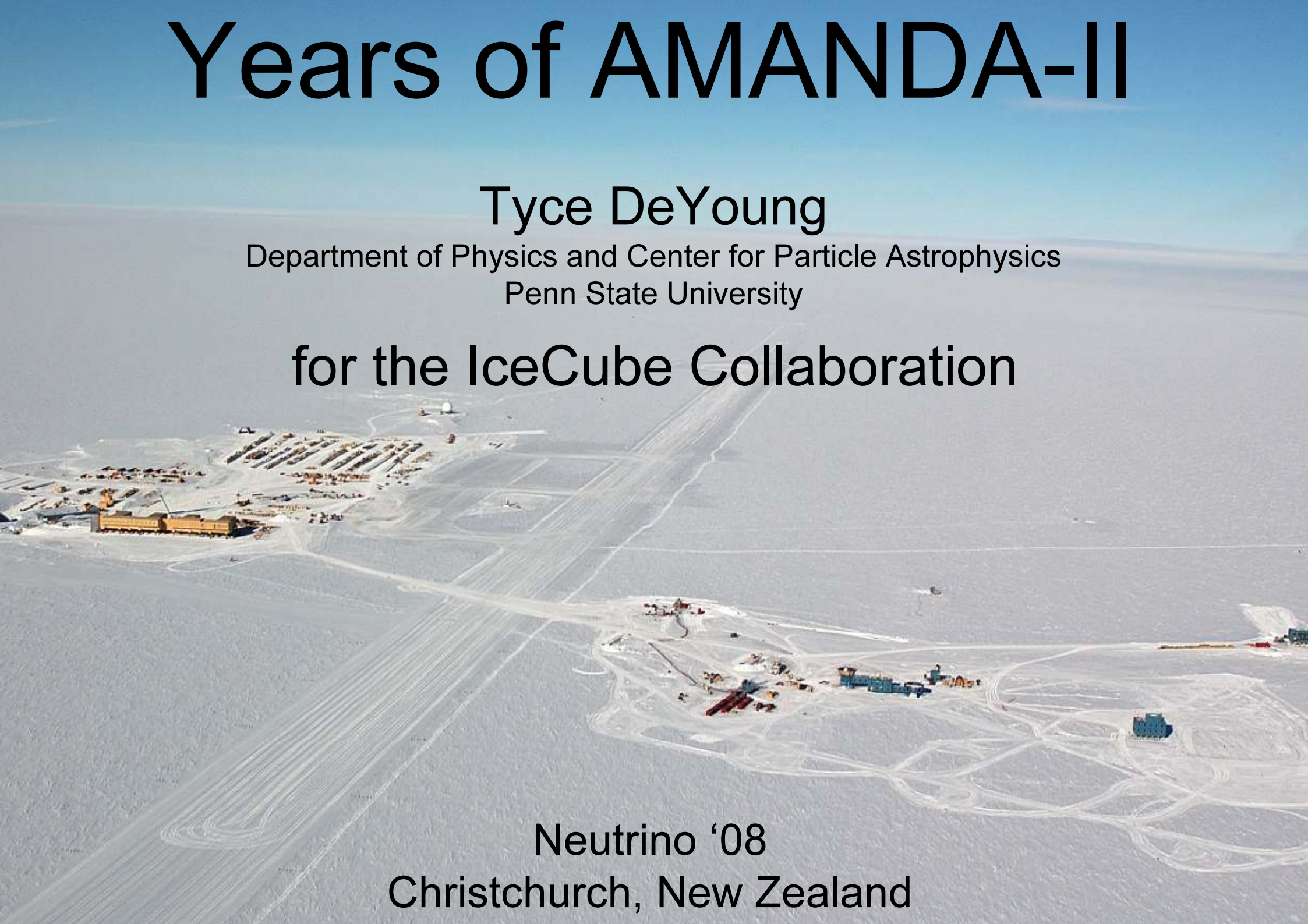
Years of AMANDA-II

Tyce DeYoung
Department of Physics and Center for Particle Astrophysics
Penn State University

for the IceCube Collaboration



Neutrino ‘08
Christchurch, New Zealand

The IceCube Collaboration

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

RWTH Aachen
DESY, Zeuthen
Universität Dortmund
MPIfK Heidelberg
Humboldt Universität zu Berlin
Universität Mainz

Stockholms Universitet
Uppsala Universitet

Vrije Universiteit Brusse
Université Libre de Brux
Universiteit Gent
Université de Mons-Hai

Chiba University

University of Canterbury Christchurch

Universiteit Utrecht

EPF Lausanne

Neutrino Sources

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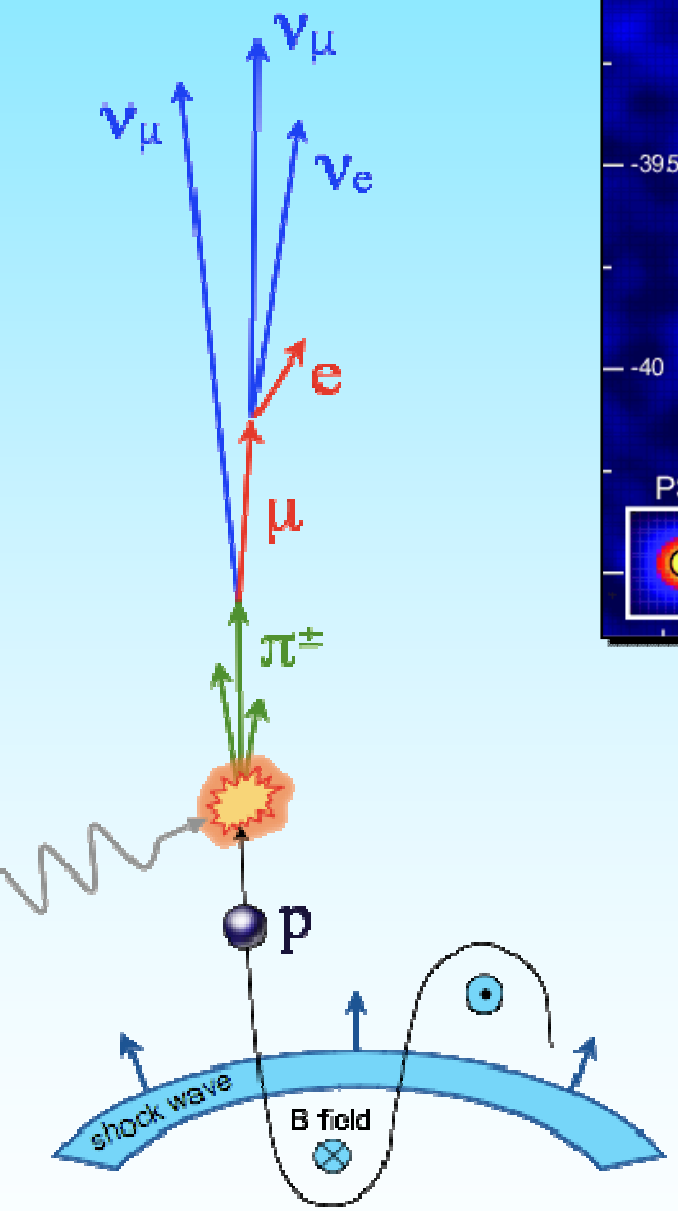
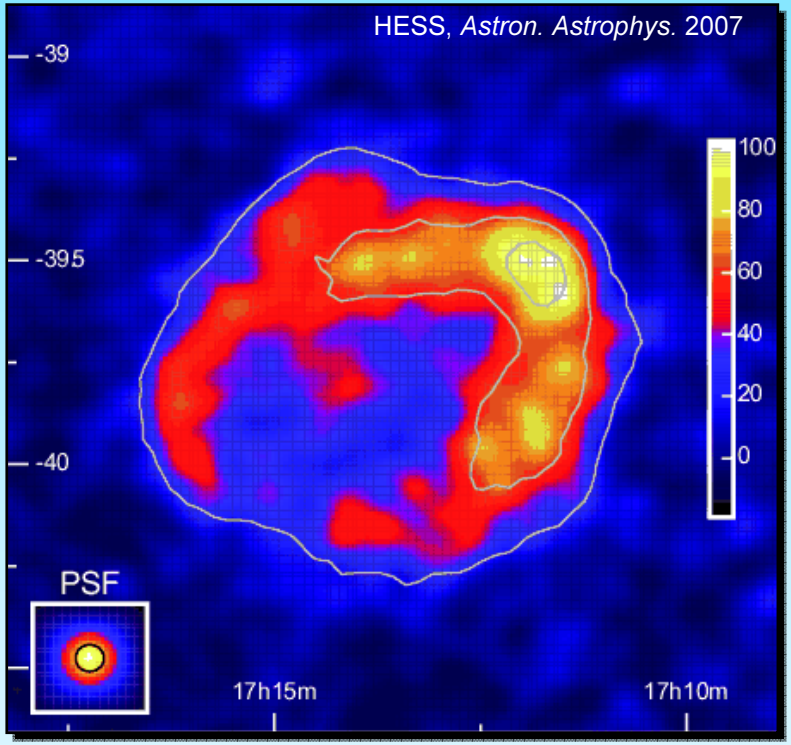
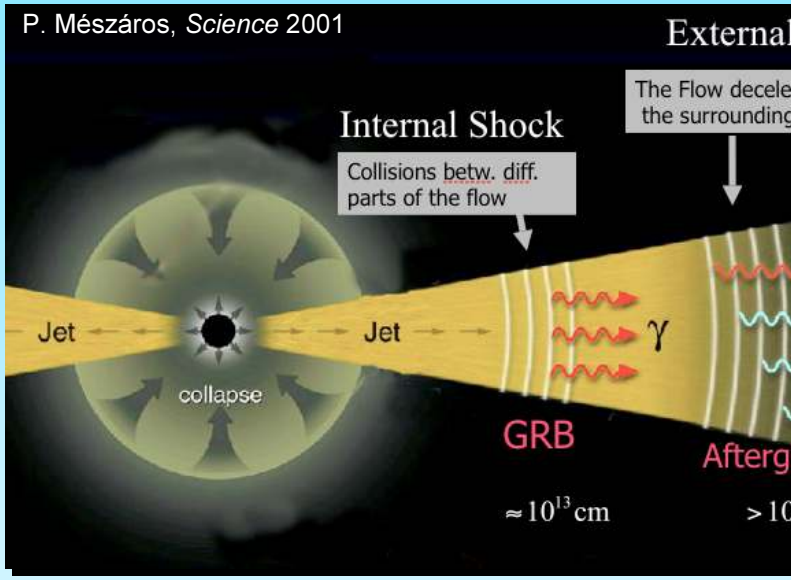
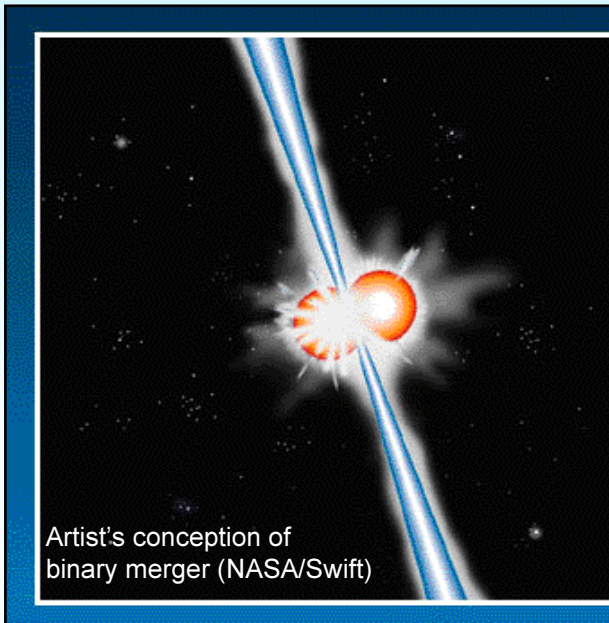




Supernova Remnants

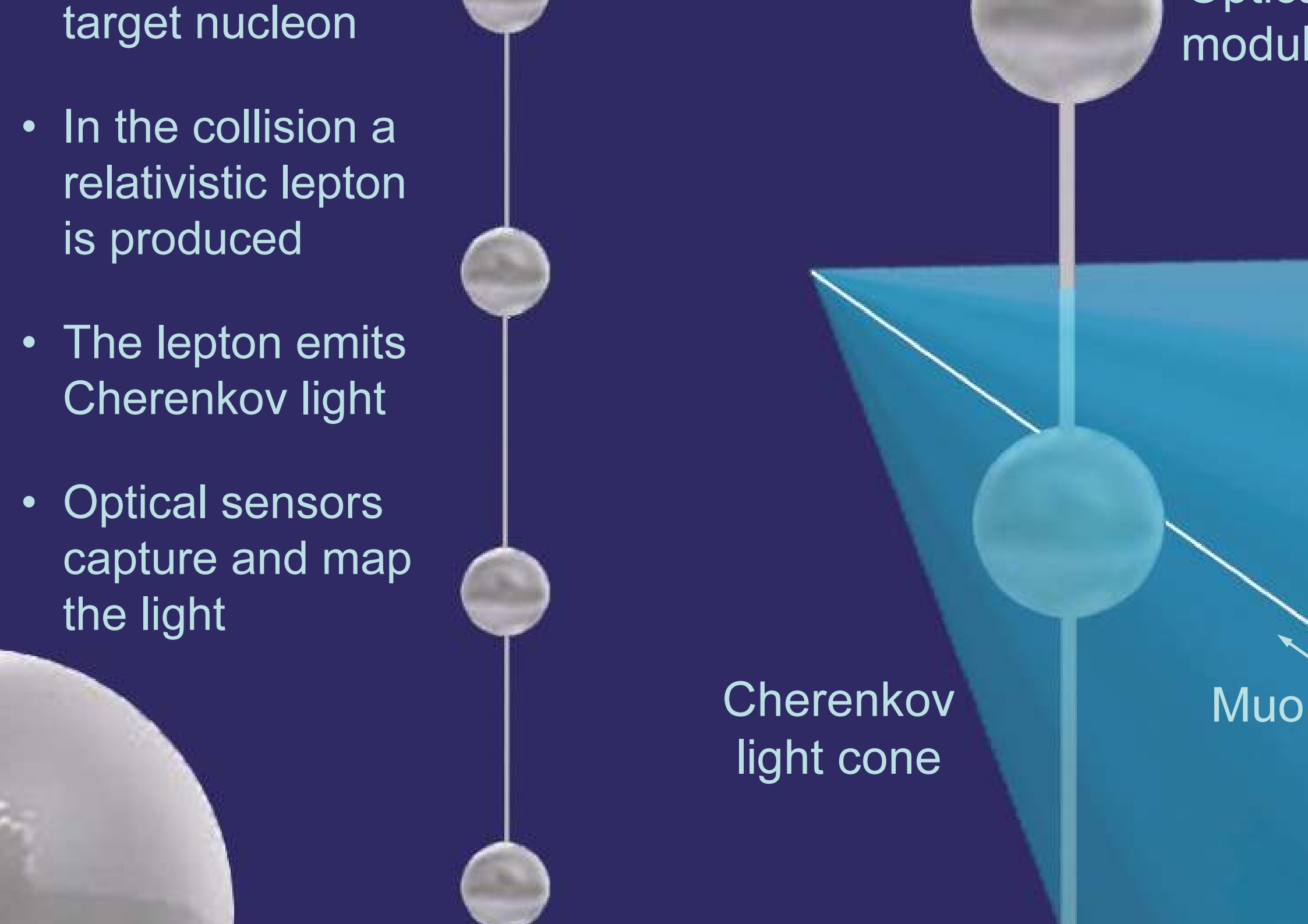


Gamma Ray Bursts



target nucleon

- In the collision a relativistic lepton is produced
- The lepton emits Cherenkov light
- Optical sensors capture and map the light



The AMANDA Detector

NDA

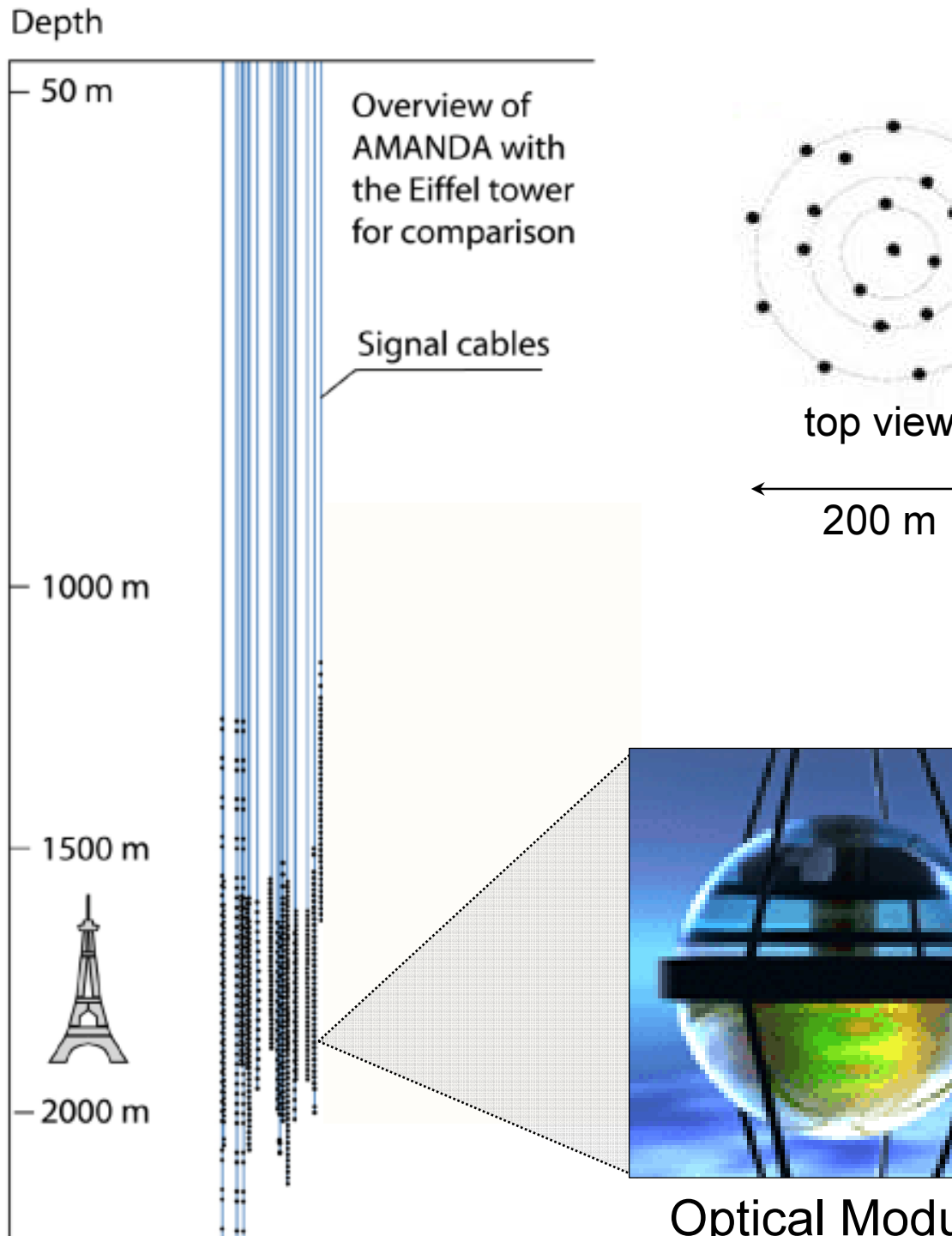
77 OMs on 19 strings

Hamamatsu 8” PMT in glass pressure vessel

Several readout systems (electrical, fiber-optic)

DAQ electronics on surface

Deployed in stages: AMANDA-II complete in 2000



AMANDA-II Data Set

1996

1997

1998

1999

AMANDA-B operations results from 4 string, 10 string and 13 string phases

AMANDA-II complete

2000

2001

2002

2003

2004

2005

2006

Phys.Rev.Lett.92:071102 **2004**

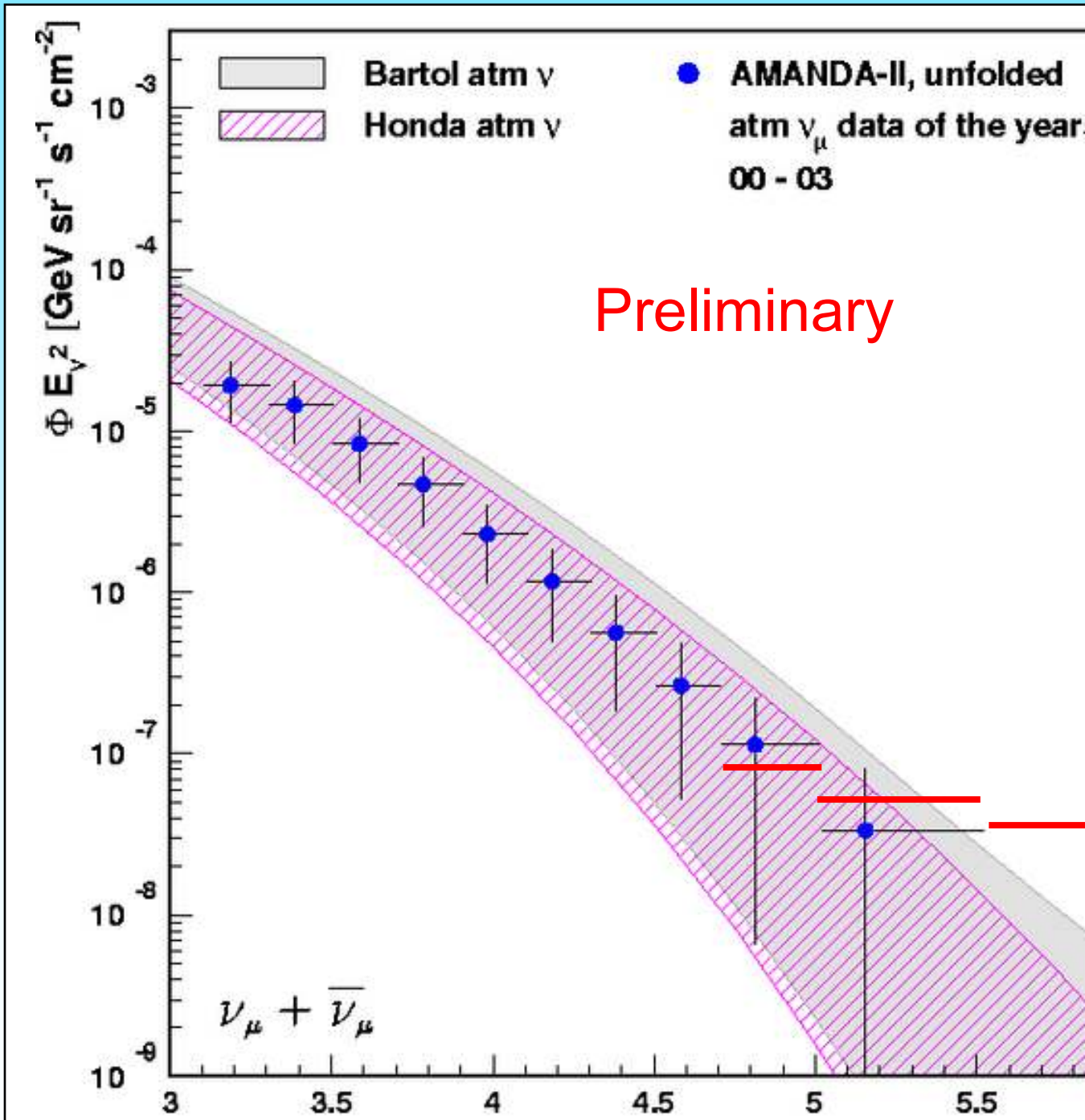
Phys.Rev.D71:077102 **2005**

Phys.Rev.D75:102001 **2007**

Year	Livetime
2000	197 d
2001	193 d
2002	204 d
2003	213 d
2004	194 d
2005	199.3 d
2006	187 d
Total	**3.8 yr**

Atmospheric Neutrinos

- Statistical unfolding of atmospheric muon neutrino spectrum
  - Based on observed muon energies at detector
- Consistent with theoretical models
- Limit placed on possible high energy component
  - Would appear as excess above expected atmospheric flux



Atmospheric Neutrinos

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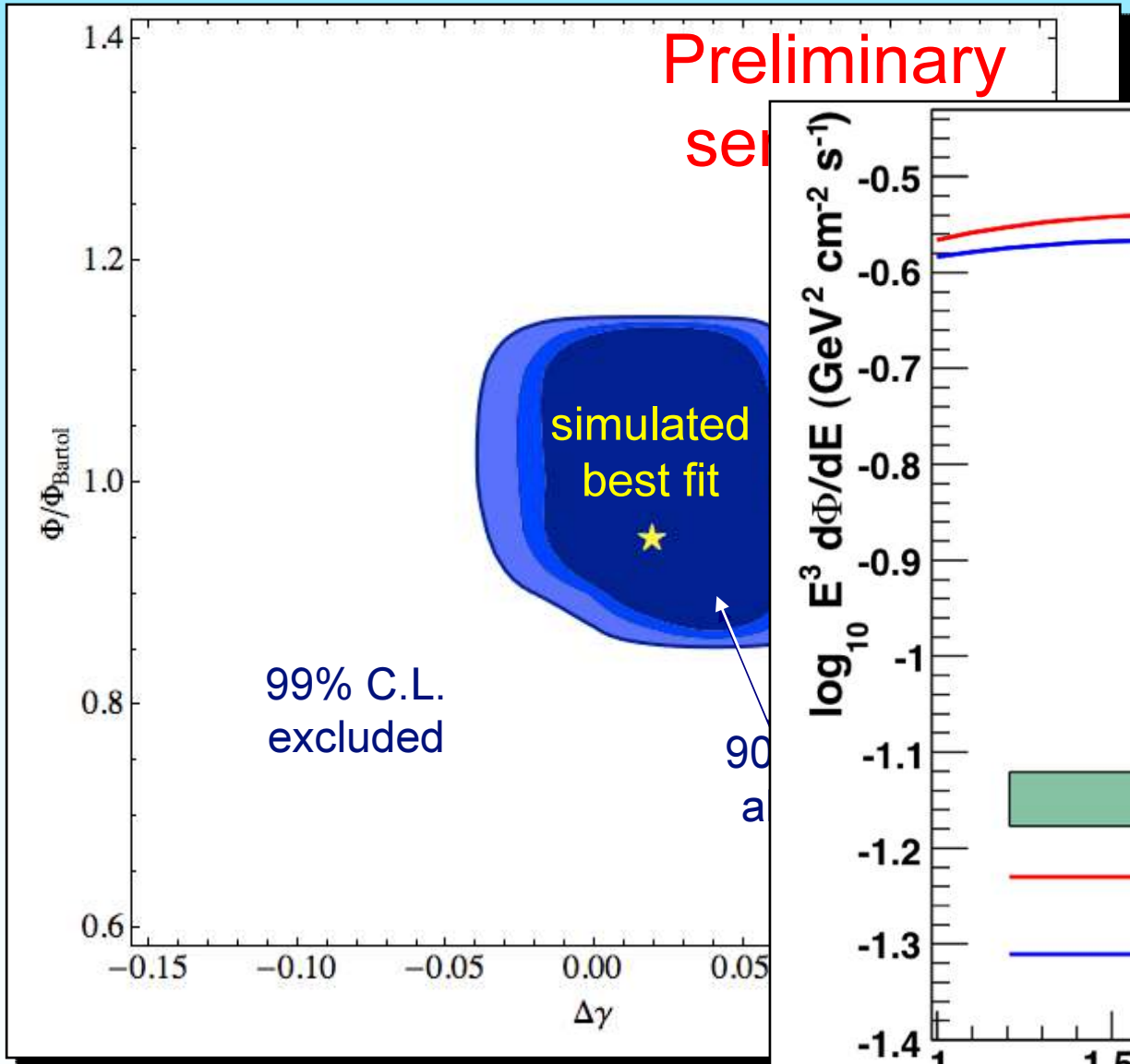
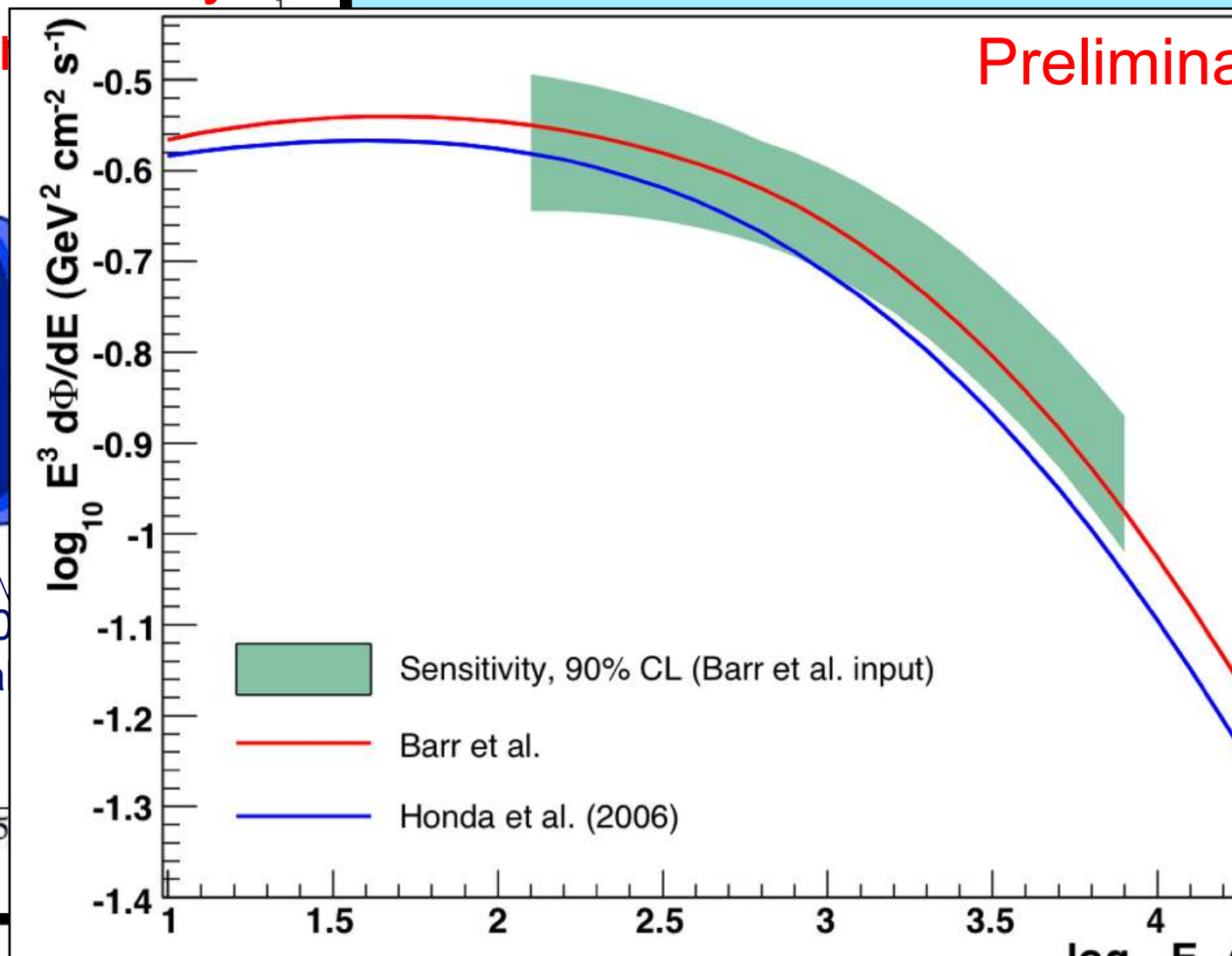
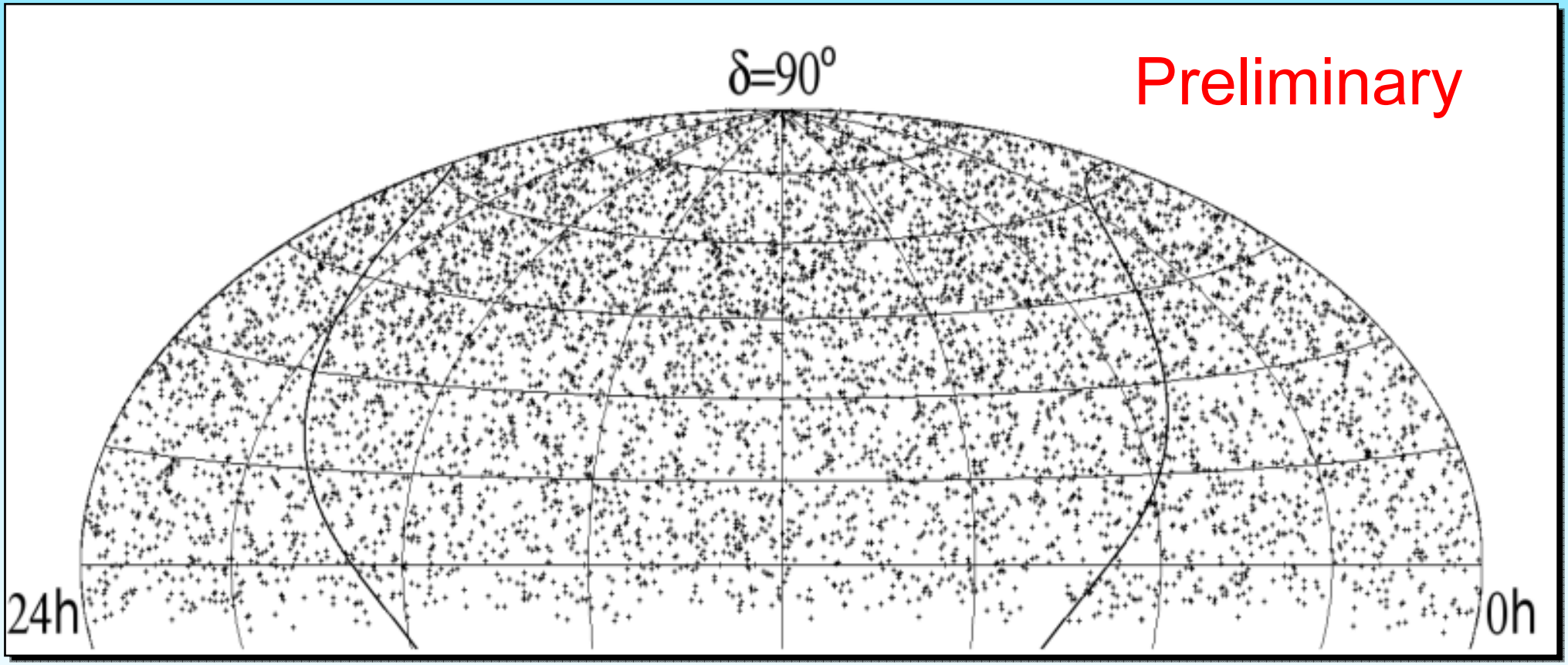
Analysis of full 7-year data set underway





Point Source Search

Raw skymap, 6595 events



Final results based on unbinned max likelihood method

- Reconstruction uncertainty from eventwise shape of likelihood

Event Parameters

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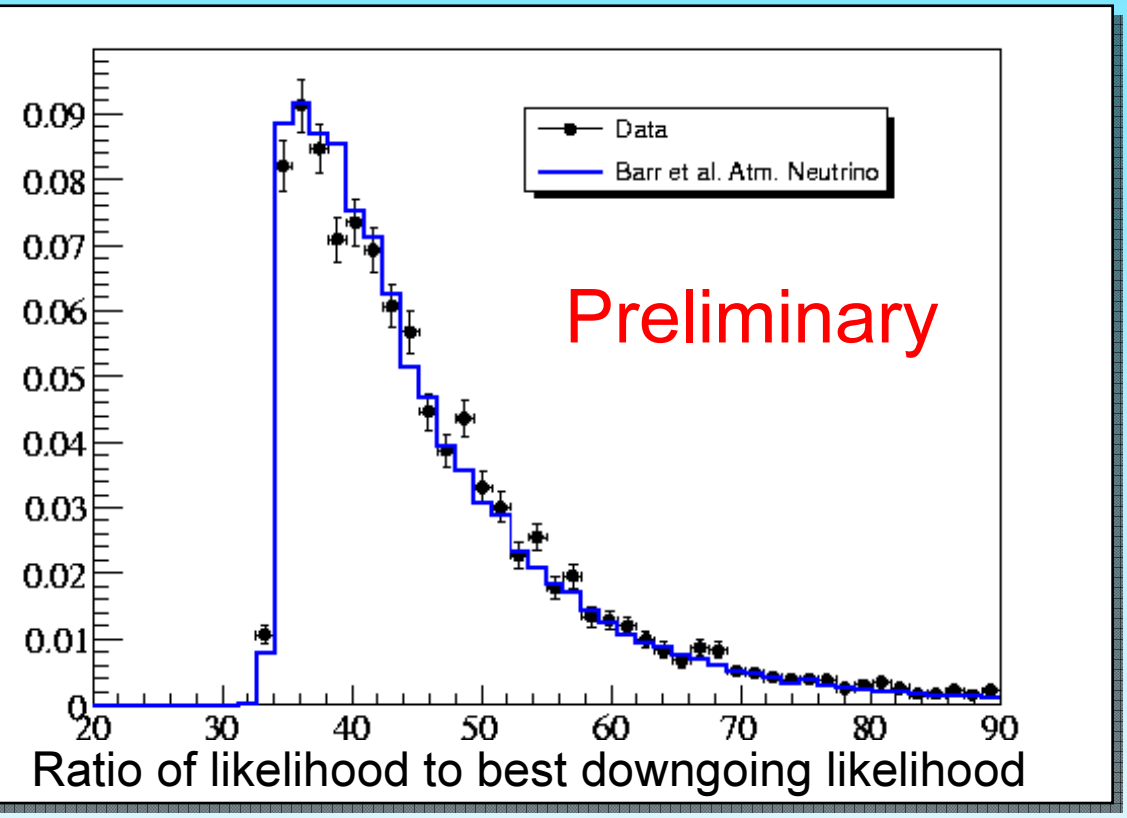
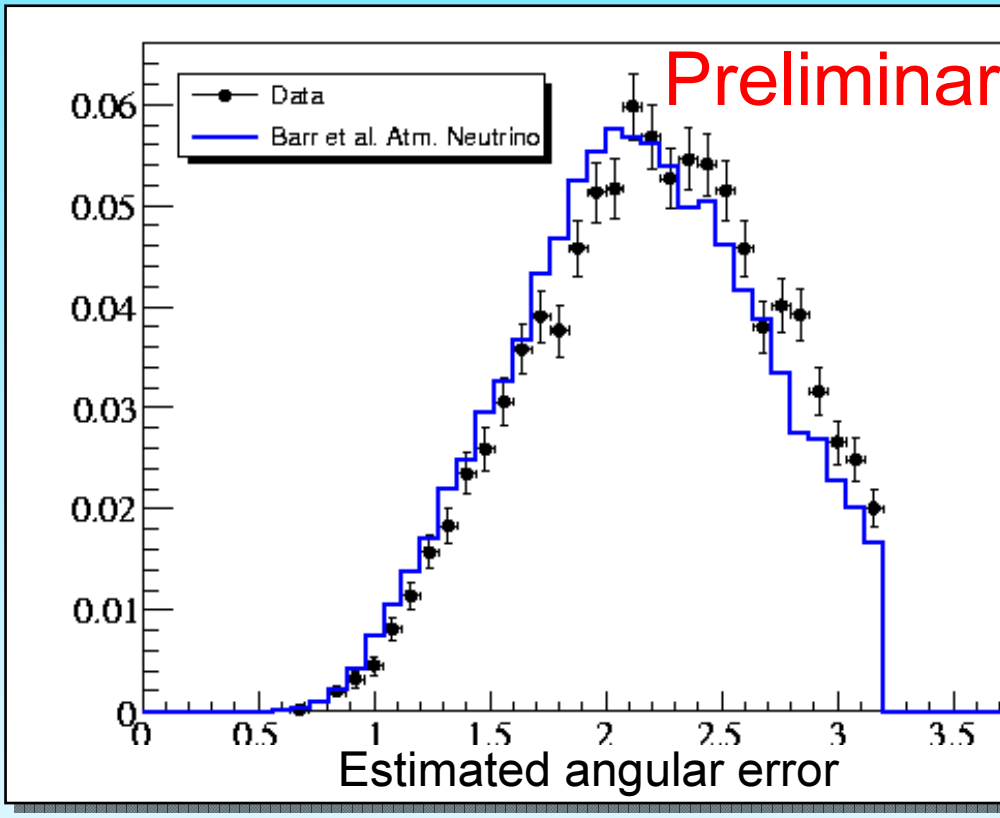
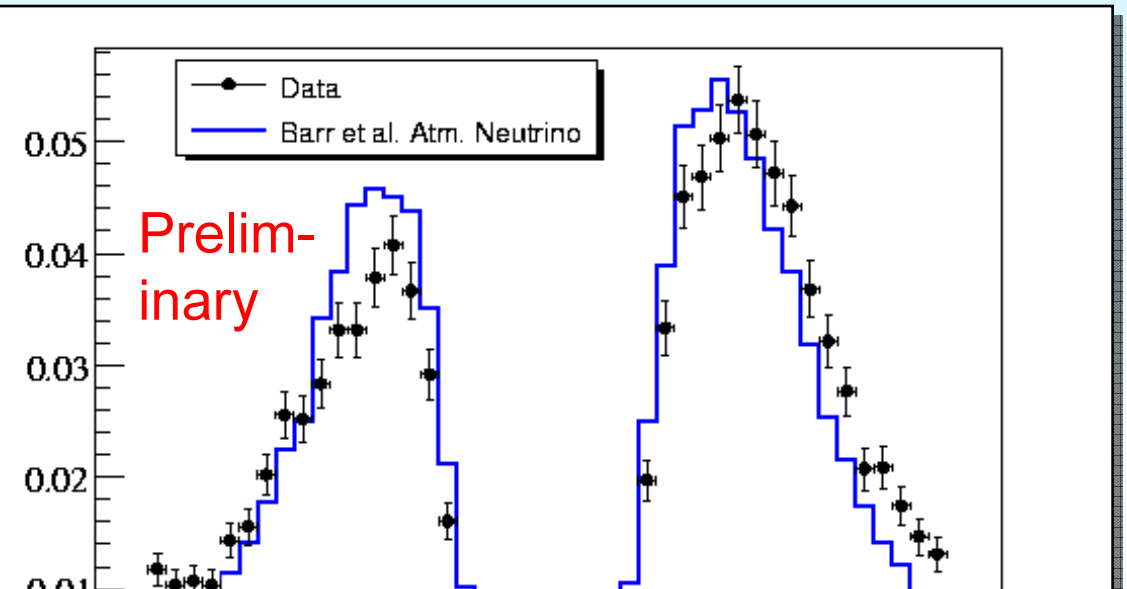
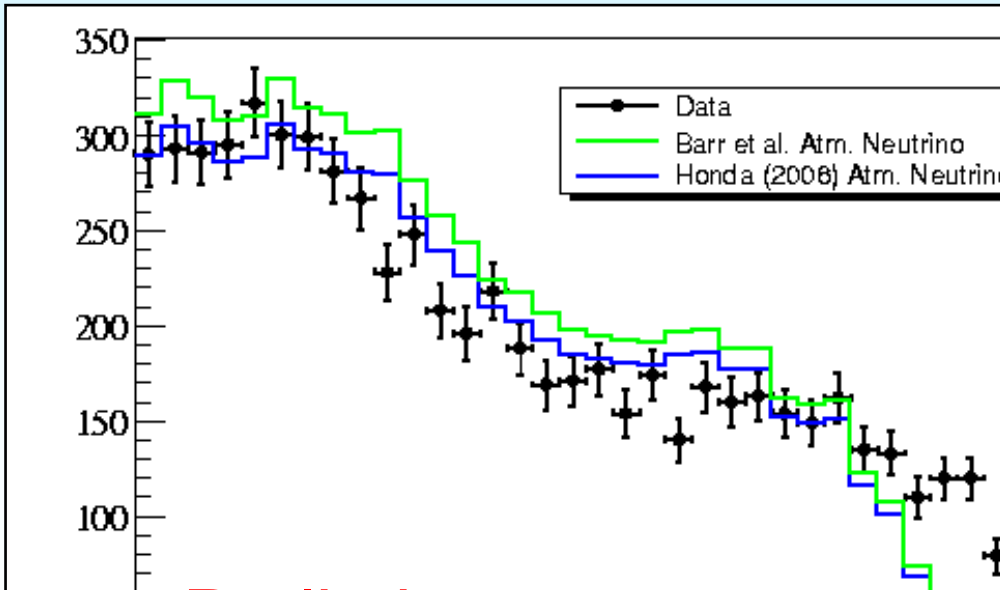
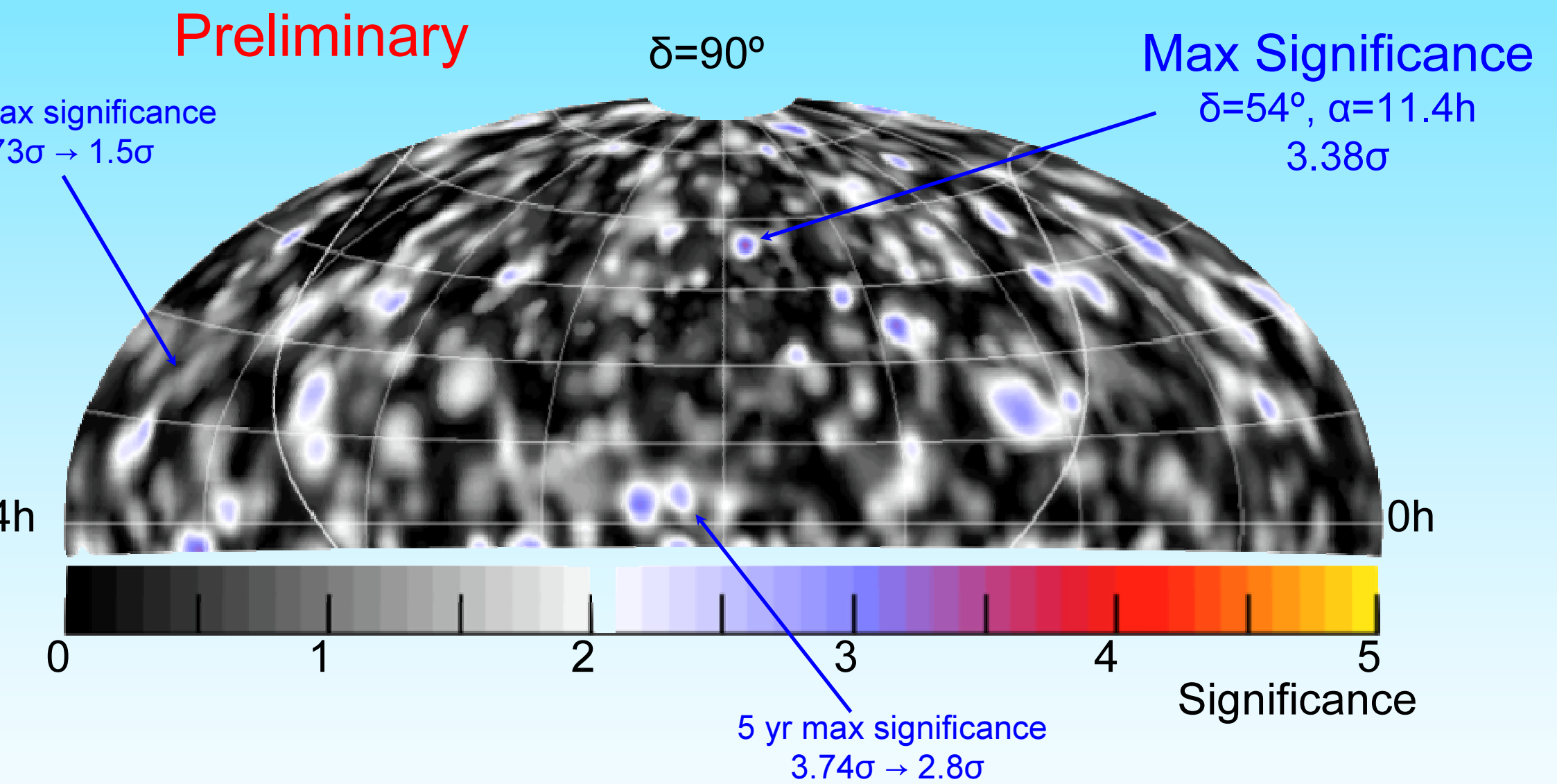






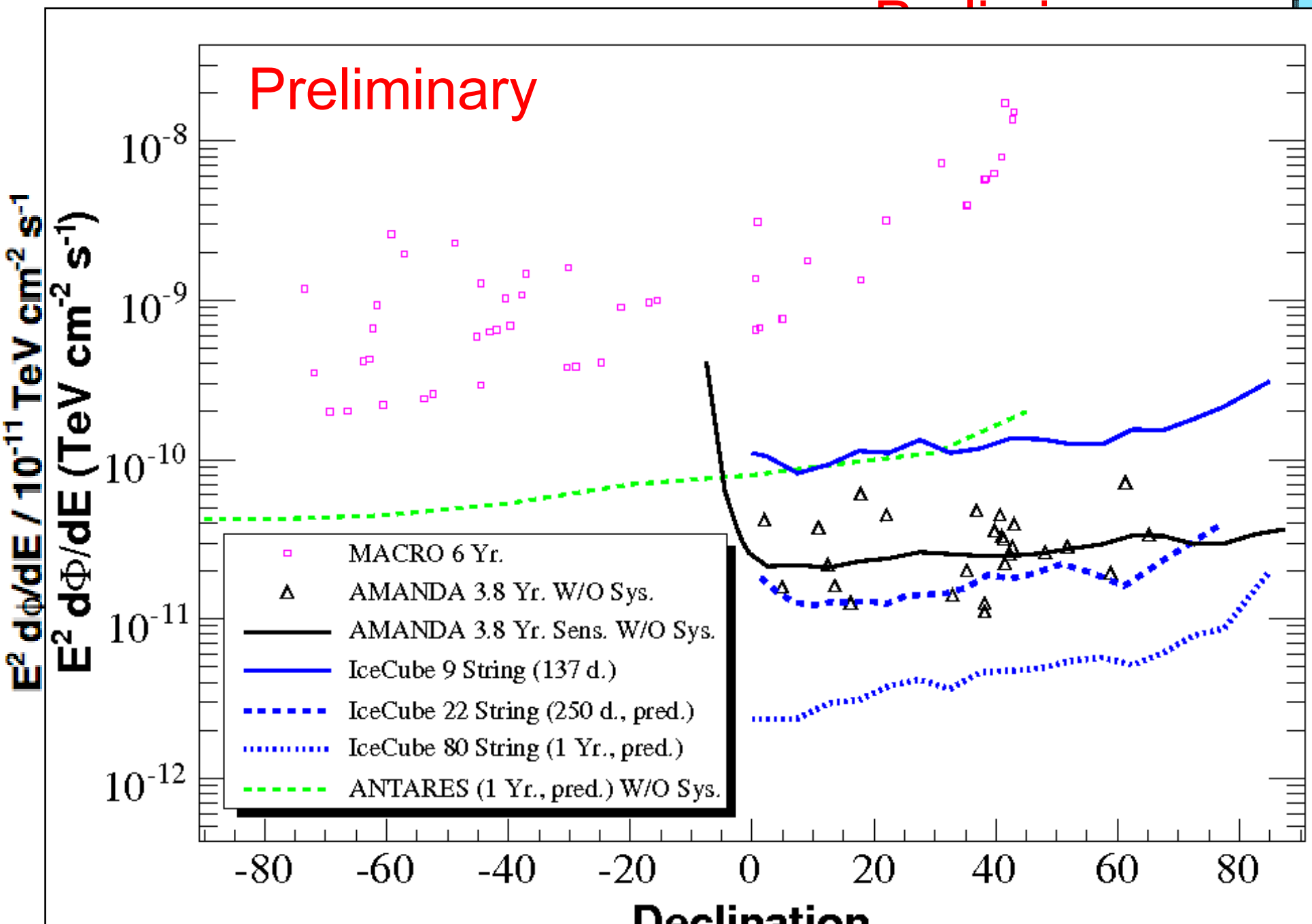


Full Sky Source Search



- All significances pre-trials
- 95 of 100 background maps (data randomized in RA) have a point with significance > 3.38σ

Sensitivity



Source Catalog Search

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List of 26 sources selected *a priori*

Preliminary

Source	μ_{90}	P-value
Crab Nebula	4.47	0.10
MGRO J2019+37	4.75	0.077
Mrk 421	1.26	0.82
Mrk 501	3.56	0.22
LS I +61 303	7.21	0.033
Geminga	6.07	0.0086
1ES 1959+650	3.38	0.44
M87	2.18	0.43
Cyg X-1	2.00	0.57

90% C.L. limits of
$E^2\Phi < \mu_{90} \times 10^{-11}$ TeV cm^{-2} s^{-1}

Upward fluctuations:
LS I +61 303
Geminga
MGRO J2019+37

Downward fluctuations:
Mrk 421

probability of $p \leq 0.0086$ for
at least one of 26 sources is 20%

GRB Search

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search:
ver 400 Northern
emisphere GRBs

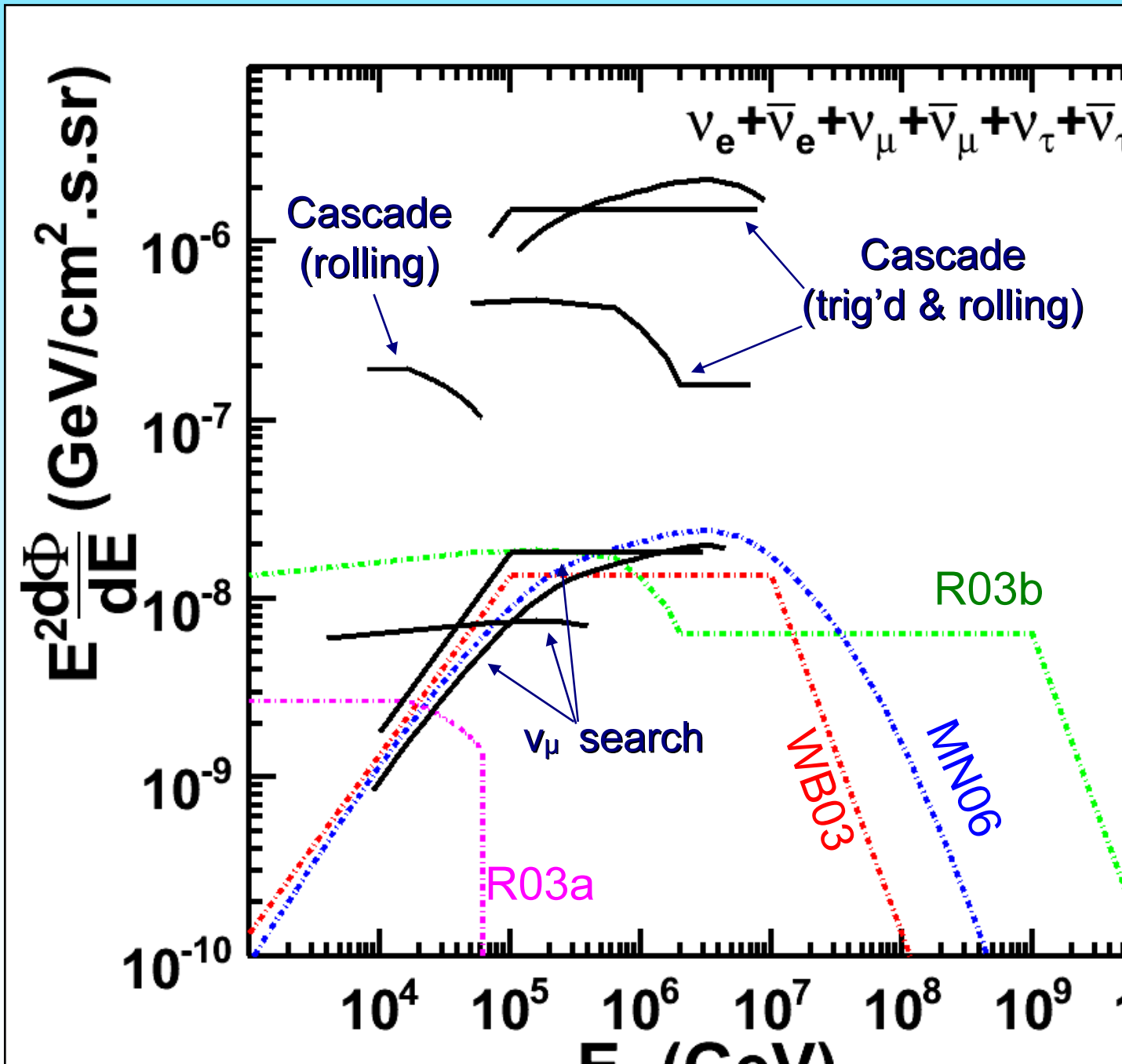
scade search
iggered search with 73 GRBs
olling search for 2001-2003

R03a: Razzaque et al.
choked burst model

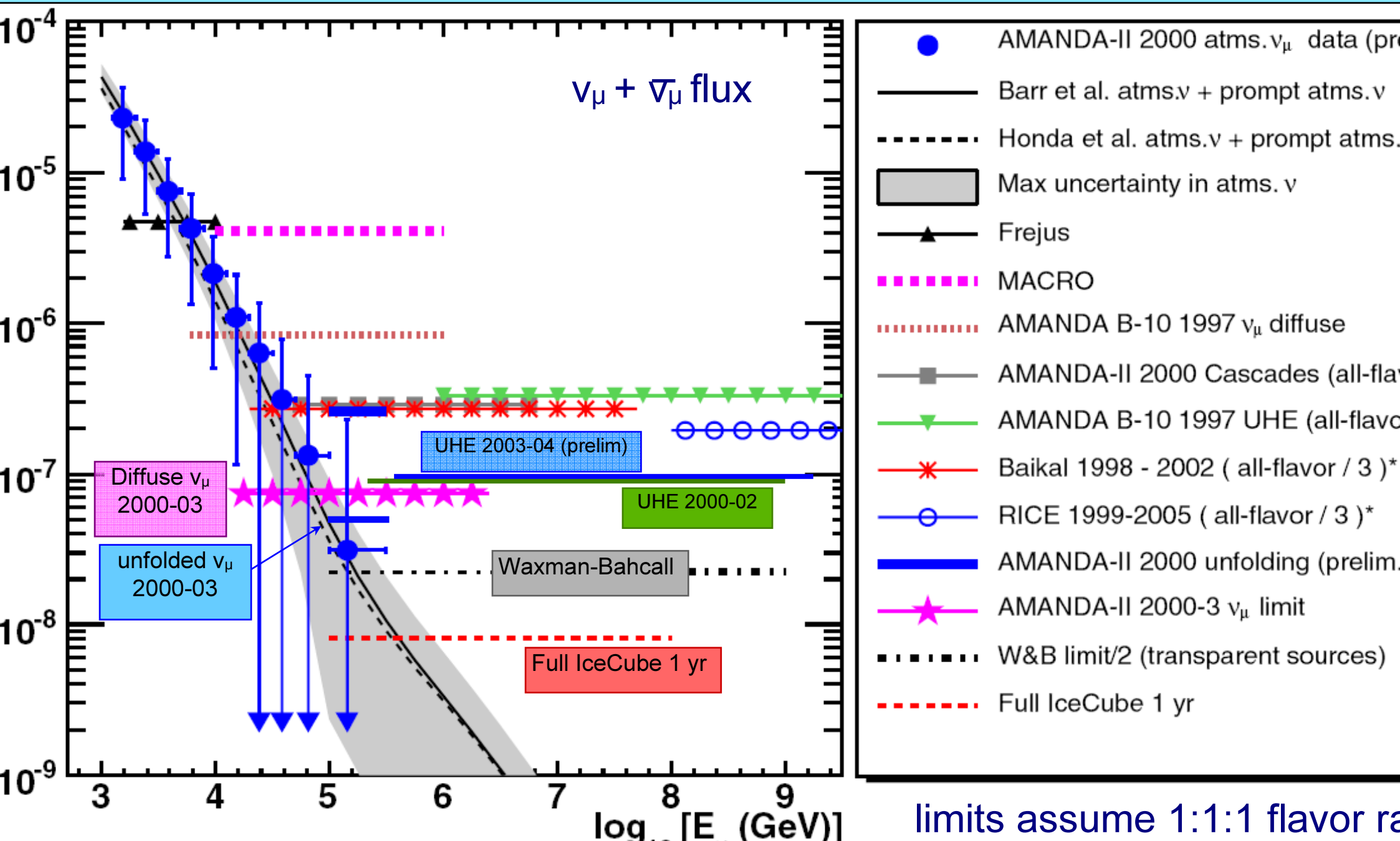
R03b: Razzaque et al.
supranova model

WB03:
Waxman-Bahcall model

MN06: Murase-Nagataki
internal shock model



Diffuse Neutrino Limits



limits assume 1:1:1 flavor ra

SM

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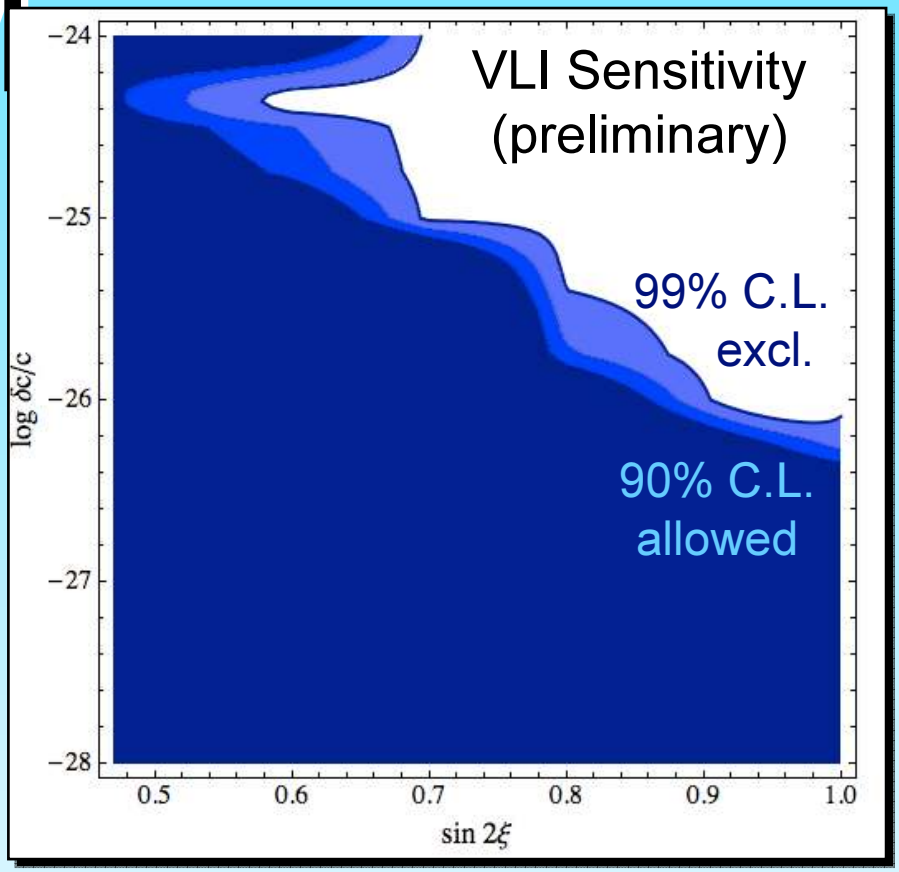
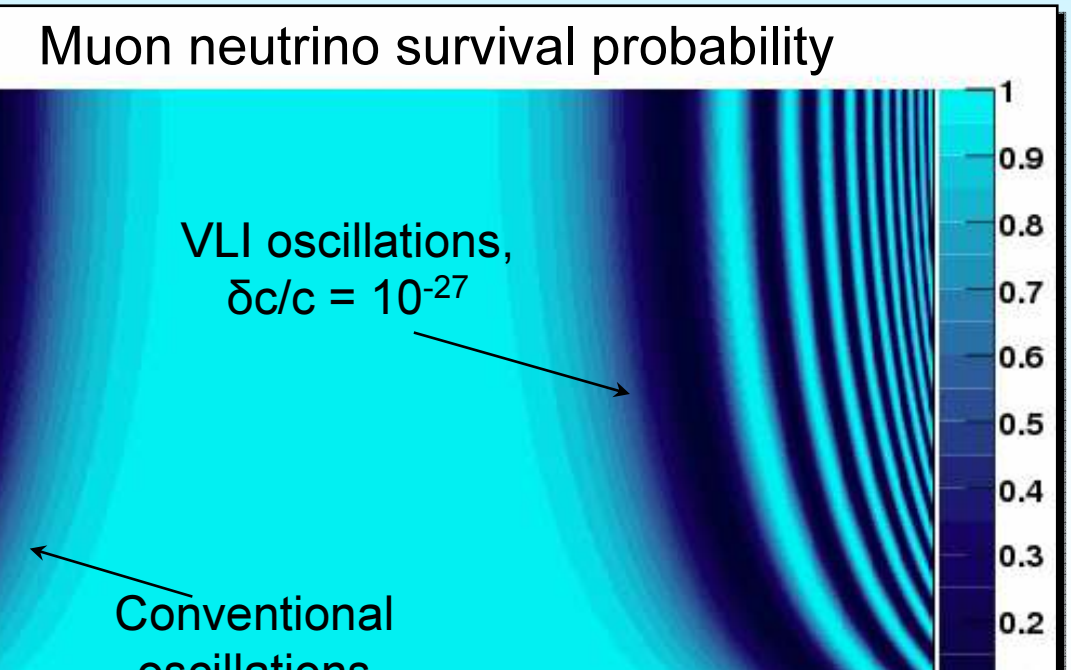
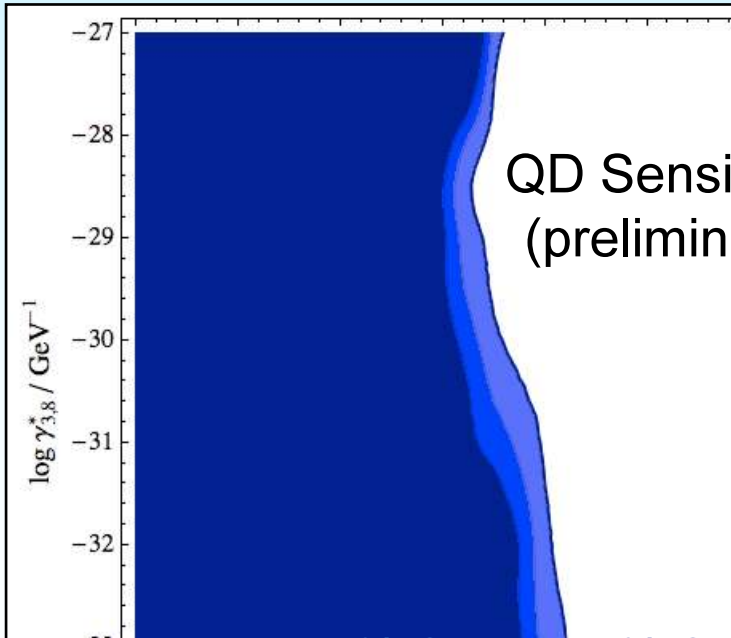
Use large atmospheric neutrino sample, look for ν_μ disappearance

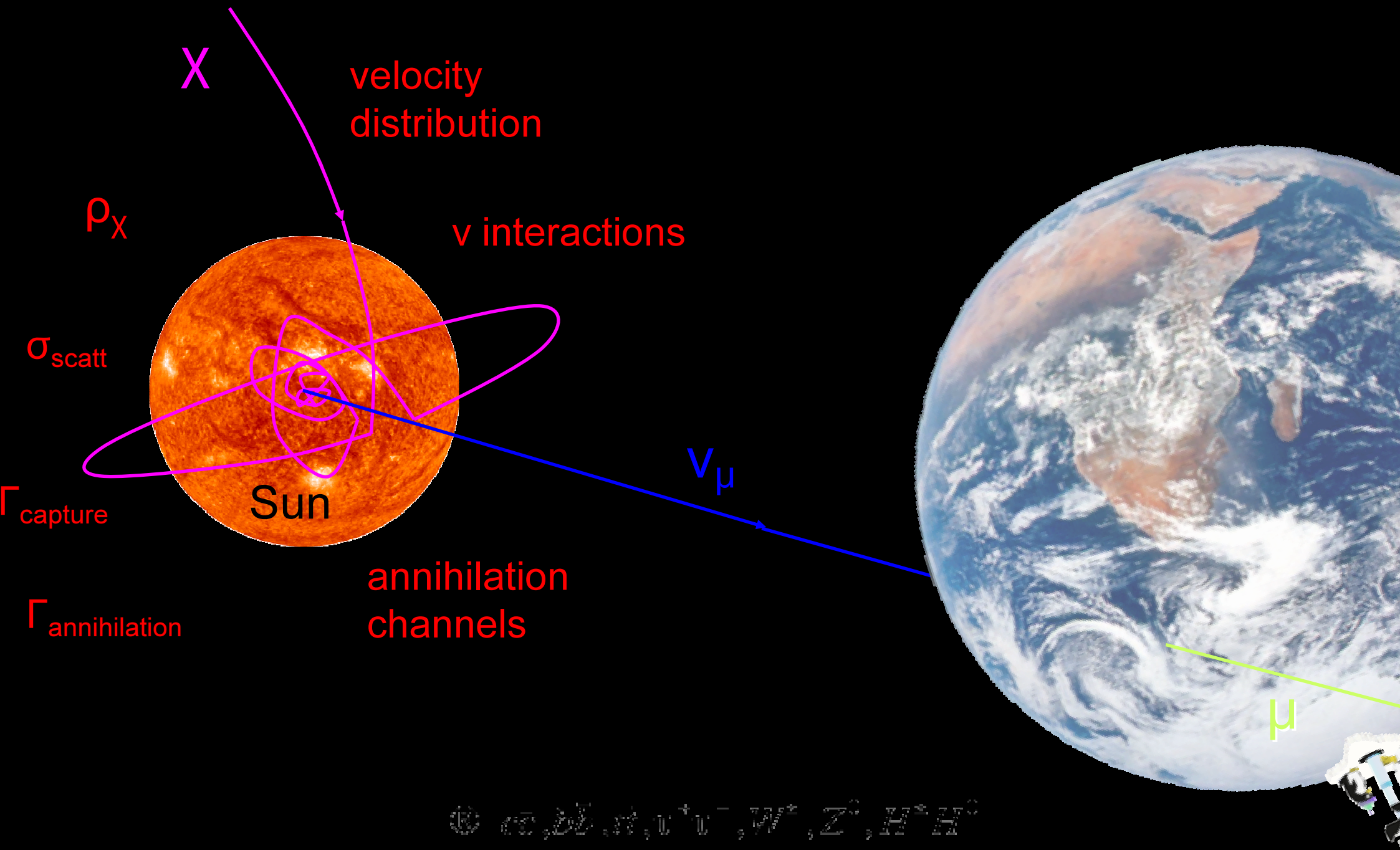
- Violation of Lorentz invariance
- Quantum decoherence







Solar WIMP Search



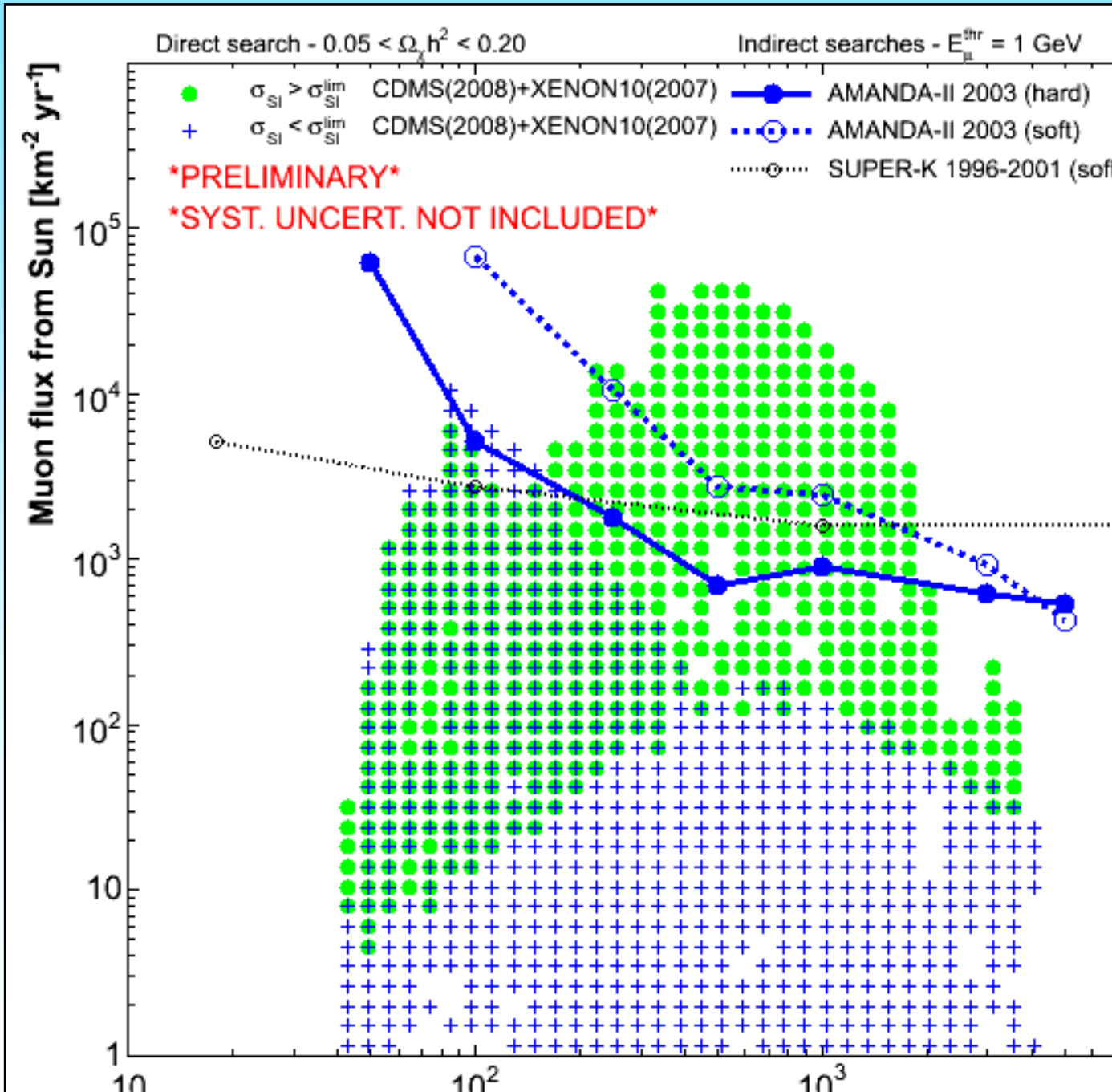
ve and Srednicki, '85

Solar WIMP Search

Based on 2003 data set

- WIMP decay mode affects expected muon spectrum
- Hard: $\chi\chi \rightarrow b\bar{b}$
- Soft: $\chi\chi \rightarrow W^+ W^-$ (or $\chi\chi \rightarrow \tau^+ \tau^-$)

Also searching for WIMP annihilation in center of Earth



IceCube + AMANDA

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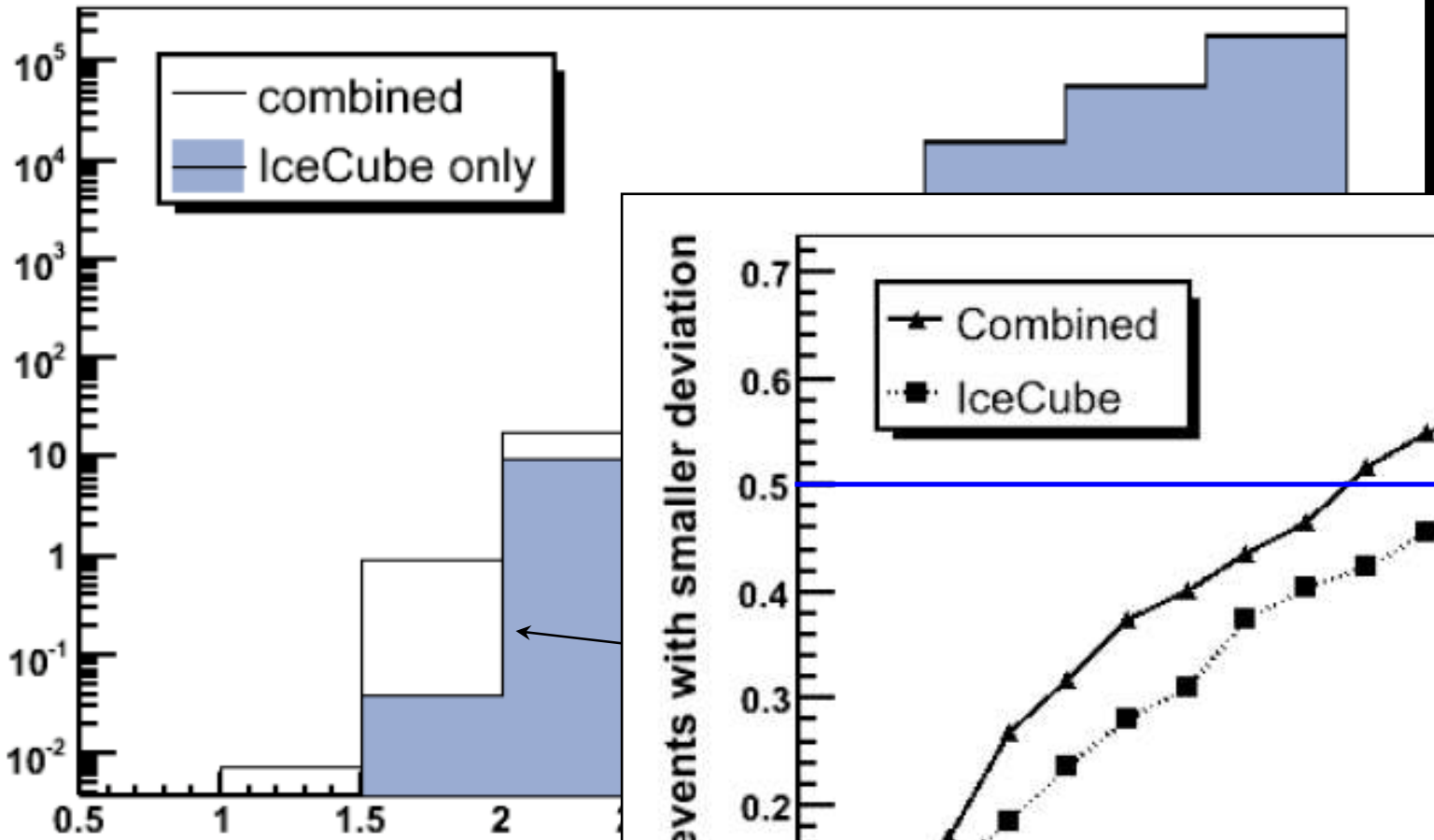
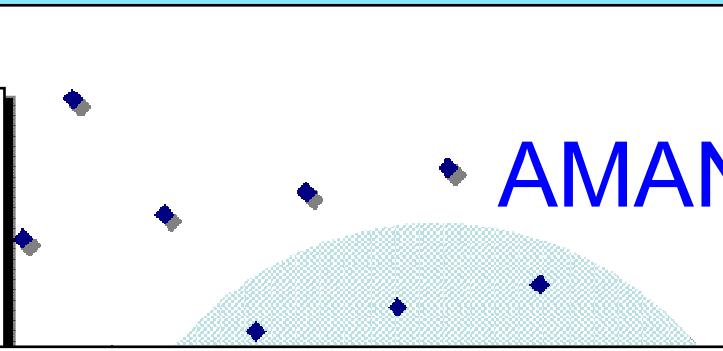
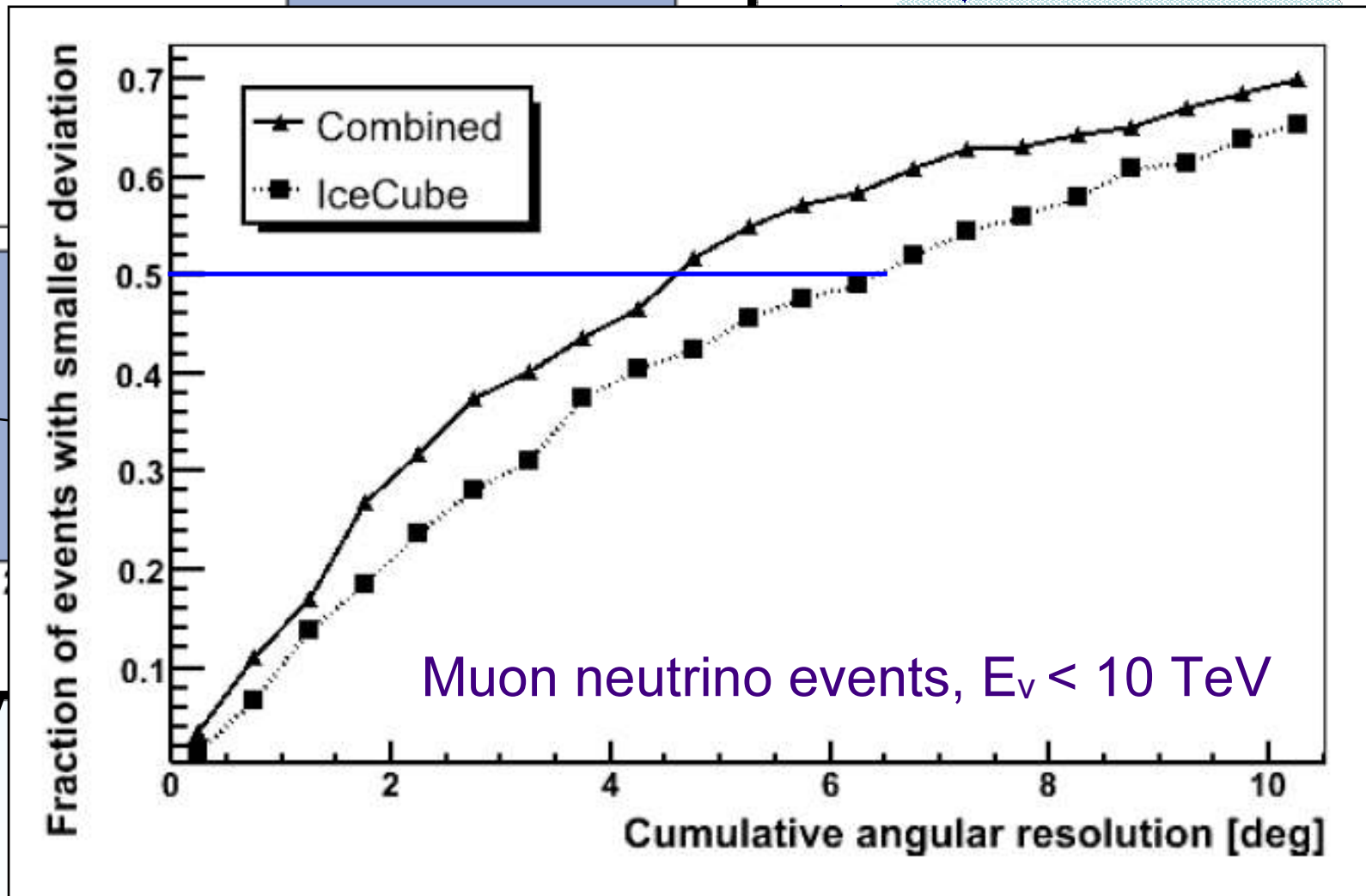
Region with dense







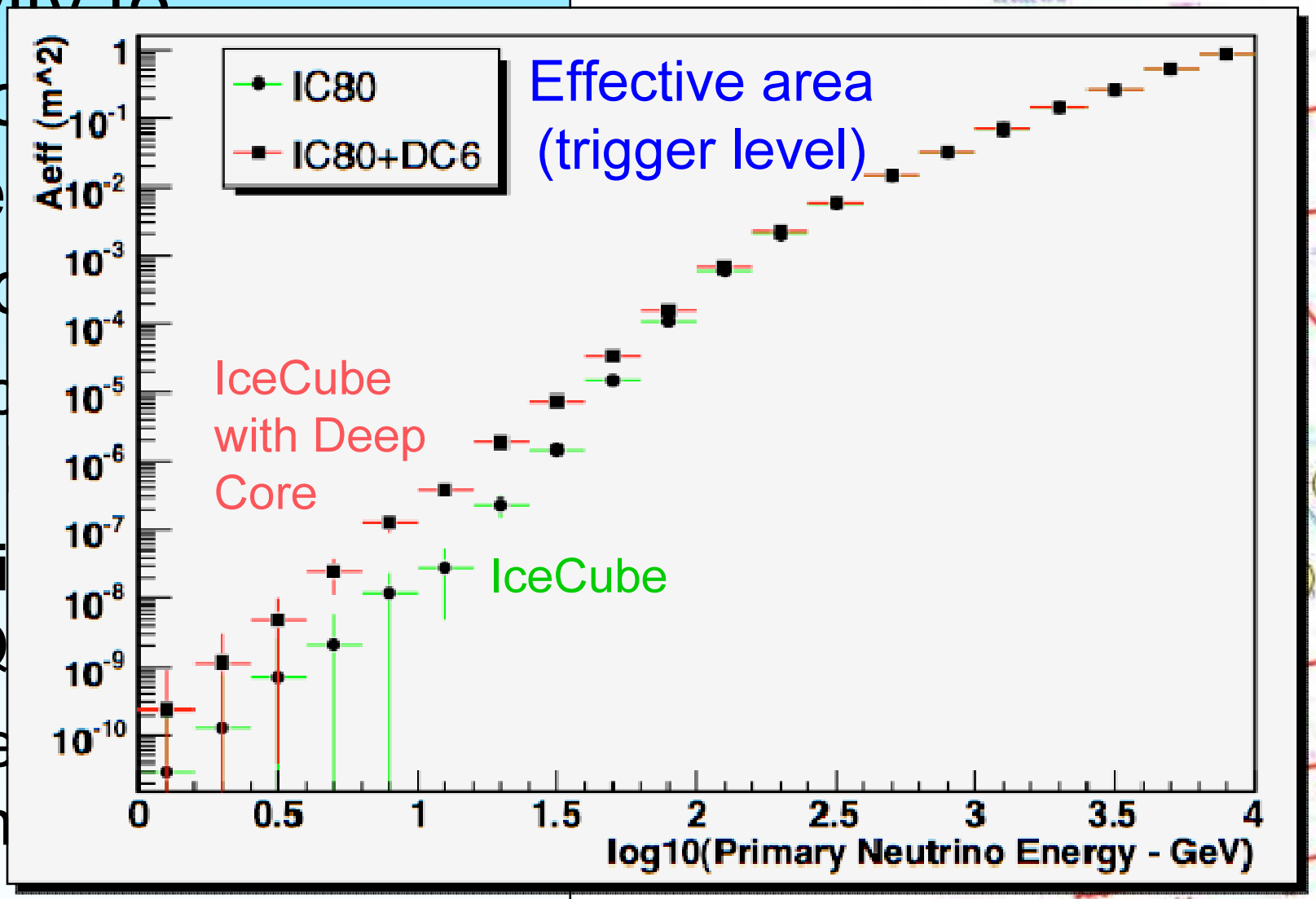
Analysis underway
(2007 data
to present)

IceCube Deep Core

Extend IceCube sensitivity to neutrino energie hundred

- Replac AMAN
- Six stri high-Q
- Use ve bottom

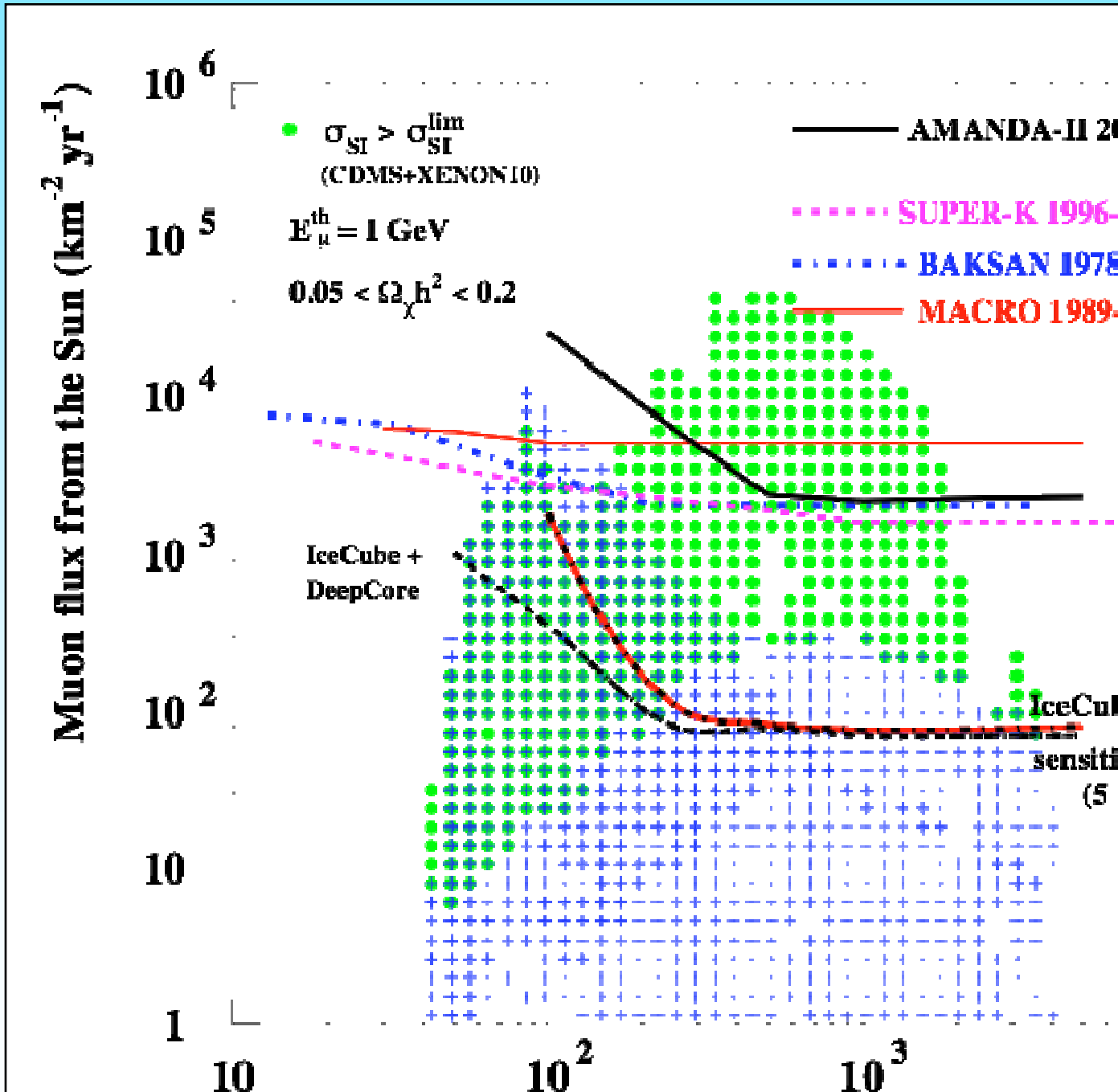
See poster by D.



Deep Core WIMPs

Example: solar WIMPs with Deep Core

- 5 year sensitivity
- Significantly increased sensitivity to WIMPs with masses below 200 GeV
- Probe SUSY models inaccessible to current direct searches (e.g.



Summary

- Final seven year AMANDA-II analysis nearly complet
- Point source search results to be published soon
  - 3.8 yr total exposure
- Results for other analyses available, final results coming
  - Diffuse fluxes, GRBs, WIMPs, physics beyond Std Model
- AMANDA now operating as a component of IceCube
  - Extended low energy sensitivity
- Deep Core will be deployed in two coming seasons
  - Significant improvement on AMANDA+IceCube
  - AMANDA will be decommissioned