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AMANDA

ANTARCTIC MUON AND NEUTRINO DETECTOR ARRAY

RECENT RESULTS

Andrea Silvestri

University of California, Irvine

UCIrvine

University of California, Irvine

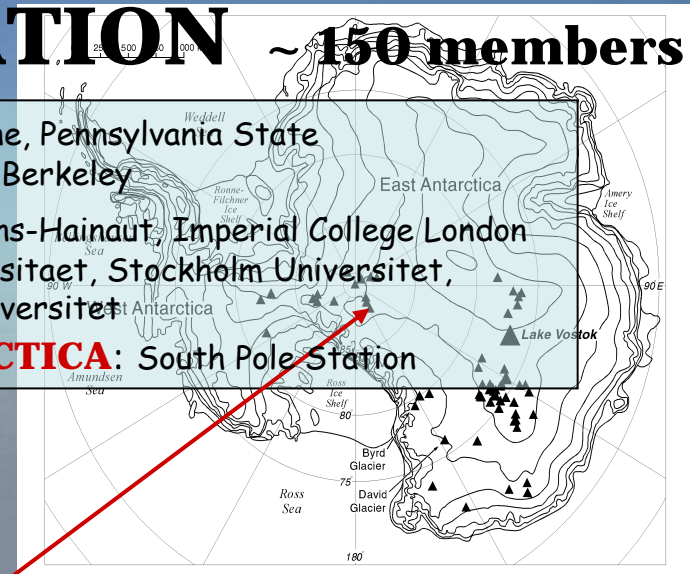
**The Division of Particles and Fields
of the American Physical Society
University of California, Riverside August 30, 2004**

THE AMANDA COLLABORATION ~ 150 members

UNITED STATES: Bartol Research Institute, UC Berkeley, UC Irvine, Pennsylvania State
UW Madison, UW River Falls, LBNL Berkeley

EUROPE: VUB-IIHE Brussel, ULB-IIHE Bruxelles, Universite' de Mons-Hainaut, Imperial College London
DESY Zeuthen, Mainz Universitaet, Wuppertal Universitaet, Stockholm Universitet,
Uppsala Universitet, Kalmar Universitet

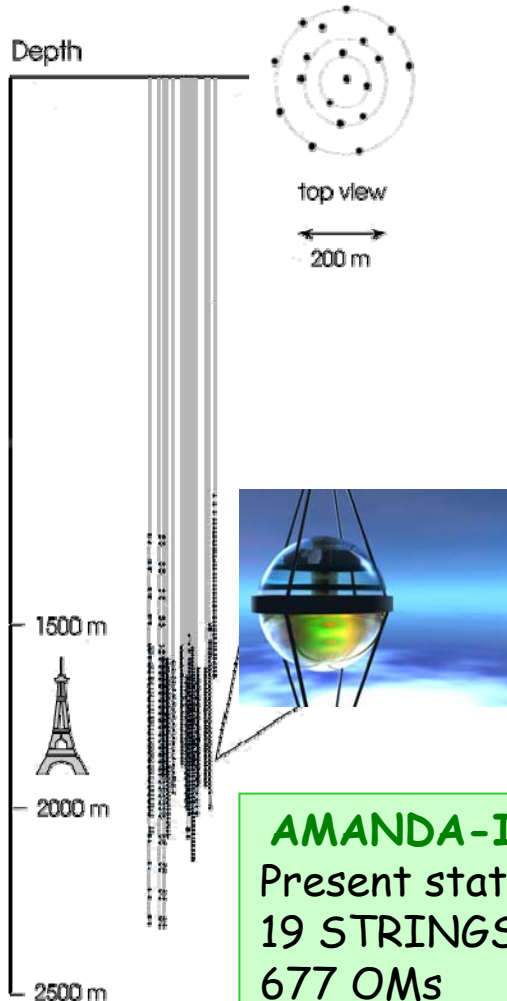
SOUTH AMERICA: Universidad Simon Bolivar Caracas **ANTARCTICA:** South Pole Station



Amundsen-Scott South Pole Station

THE AMANDA DETECTOR

AMANDA-II



AMANDA B-10

Inner core of AMANDA-II
10 STRINGS

302 OMs

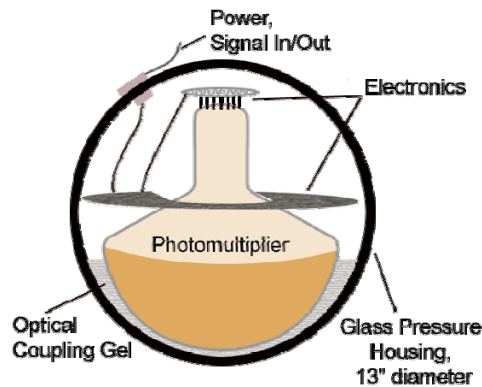
Data years: 1997-1999

OPTICAL MODULE

8-inch Hamamatsu R591202
 10^9 gain, 14 dynode stages
PMT noise (300-1000)Hz

Time resolution ~ 5 ns

AMANDA-II: astro-ph/0211269



AMANDA-II

Present status of the detector
19 STRINGS

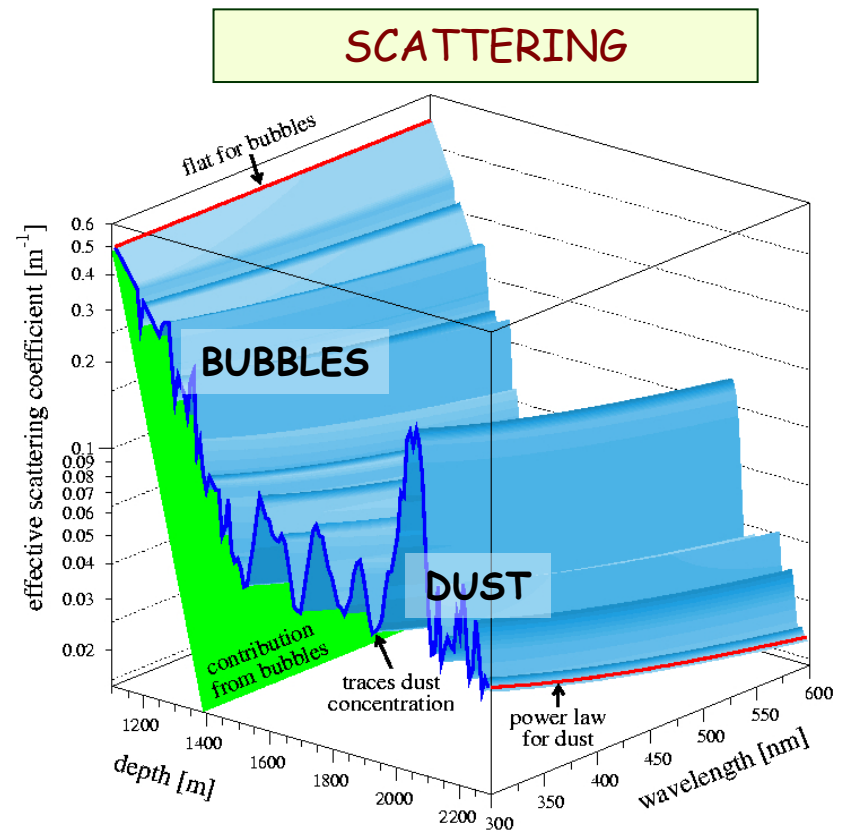
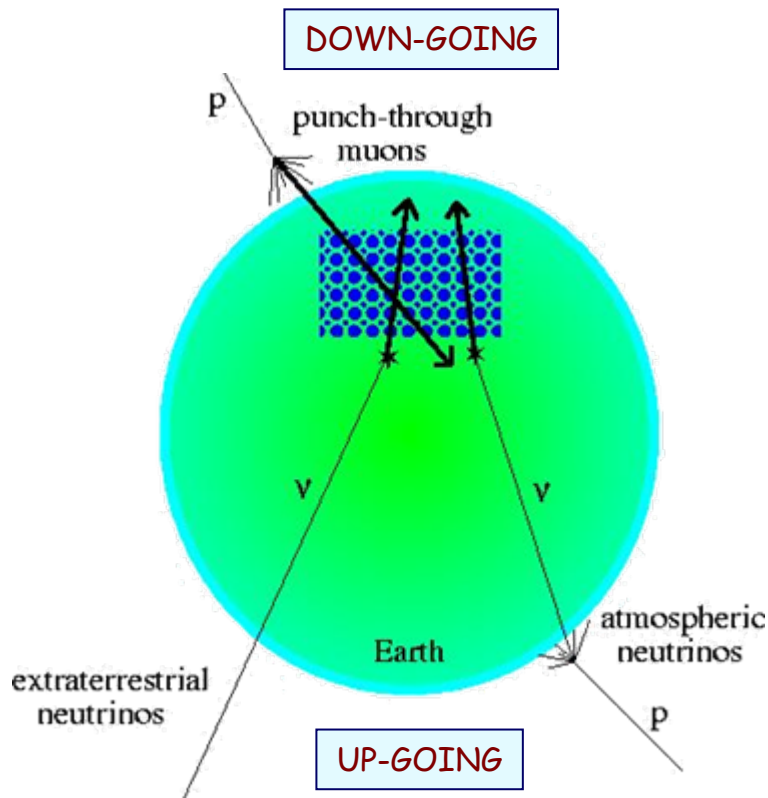
677 OMs

Data years: 2000-2004

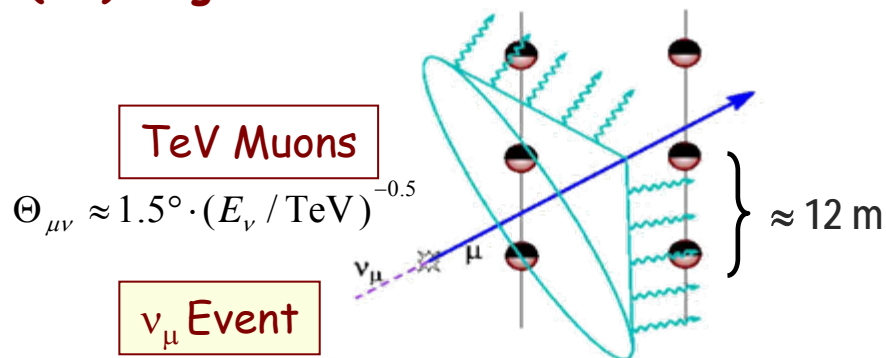
Trigger rate ~ 80 Hz

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PRINCIPLE OF NEUTRINO DETECTION



0(km) long muon tracks



AVERAGE OPTICAL ICE PARAMETERS

$\lambda_{\text{abs}} \sim 110 \text{ m @ } 400 \text{ nm}$
 $\lambda_{\text{sca}} \sim 20 \text{ m @ } 400 \text{ nm}$

ATMOSPHERIC ν & DIFFUSE FLUX LIMITS [ν_μ]

AMANDA test beams: atmospheric ν and μ

Diffuse Flux analysis strategies:

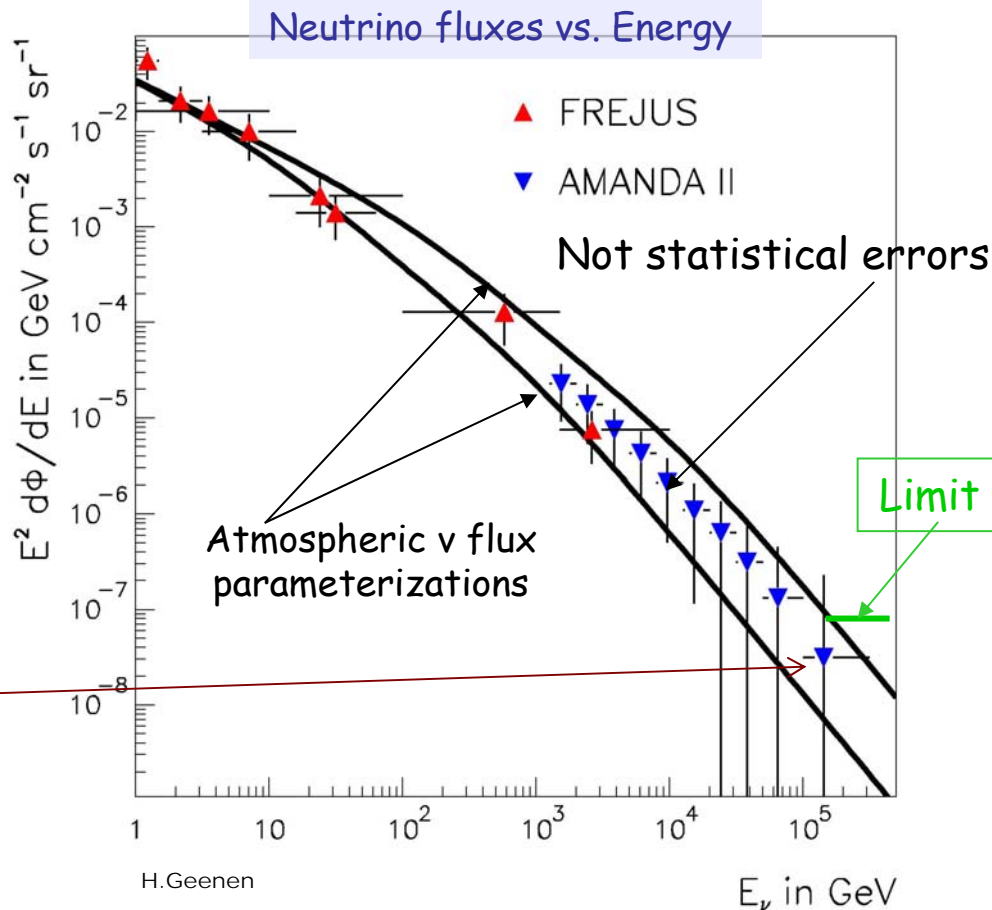
- Atmospheric ν excess
- Cascades
- UHE downgoing

First spectrum > 1 TeV (up to 100 TeV)

Last bin info to calculate the limit to Extraterrestrial E^2 neutrino flux

Observation compatible with atm. ν flux:

includes 33% systematic uncertainty



$$E^2 \Phi_{\nu_\mu}(E) < 2.58 \cdot 10^{-7} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

PRELIMINARY

DIFFUSE FLUX SEARCH & LIMITS [CASCADES]

4π coverage for cascades

Sensitive to all three flavors

2000 data sample (AMANDA-II)
197 days livetime
 $1.2 \cdot 10^9$ events @ trigger level

After optimized cuts:

$N_{\text{obs}} = 1 \text{ event}$

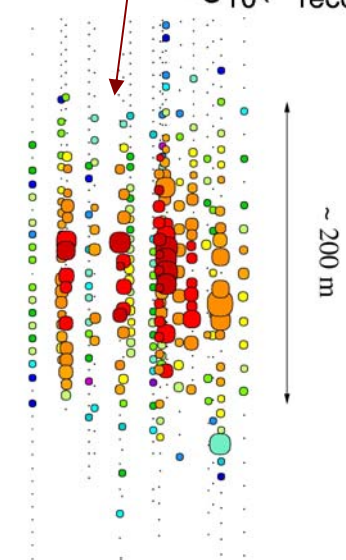
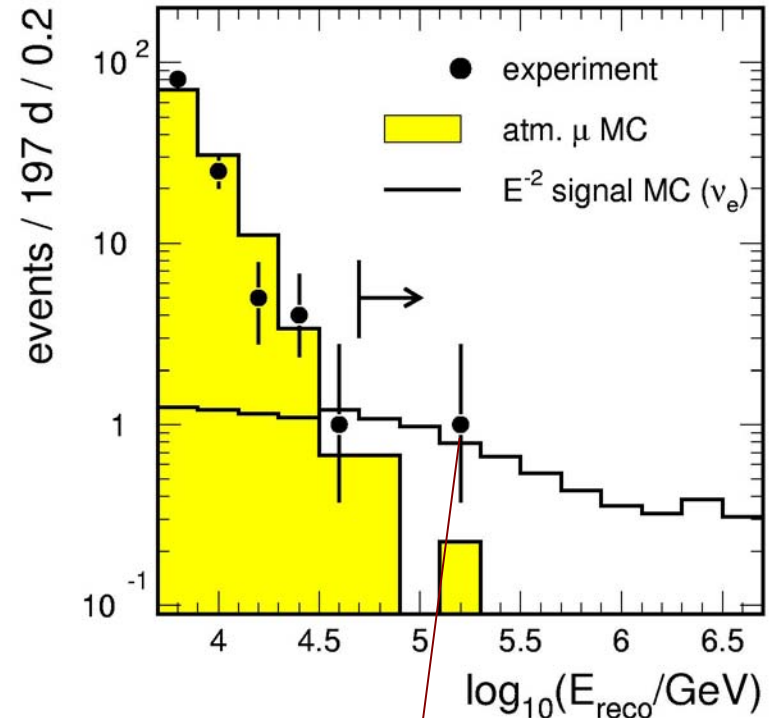
$N_{\text{atm } \mu} = 0.90^{+0.69}_{-0.43}$

$N_{\text{atm } \nu} = 0.06^{+0.09}_{-0.04} \pm 25\%_{\text{norm}}$

Assuming E^{-2} signal spectrum

$$E^2 \Phi_{\text{all } \nu}(E) < 8.6 \cdot 10^{-7} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

(flavor mixing $\nu_e : \nu_\mu : \nu_\tau = 1:1:1$)
 $50 \text{ TeV} < E_\nu < 5 \text{ PeV}$



'00 paper submitted to Astropart.Phys.

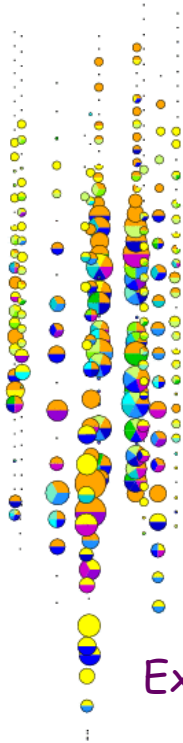
UHE NEUTRINO LIMITS $\Phi_{\text{all } \nu}$

1997 data (AMANDA-B10) 131 days livetime

$E_\nu > 10^{16}$ eV

Earth opaque

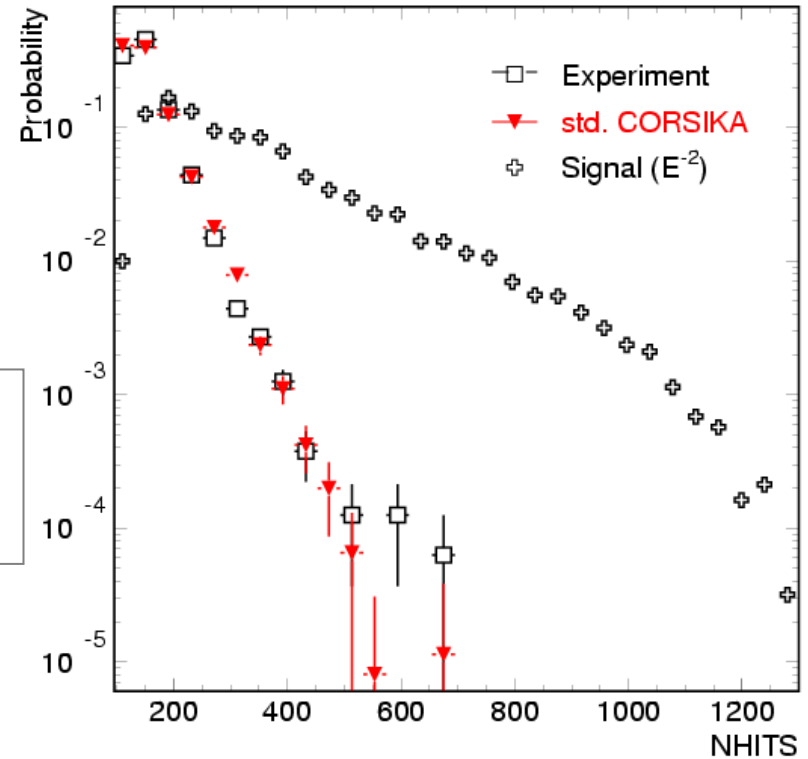
→ search in the upper hemisphere mostly close to horizon



Experimental UHE event

$N_{\text{obs}} = 5$ events
 $N_{\text{bgr}} = 4.6 \pm 36\%$ events

NO EXCESS OBSERVED



assuming E^{-2} flux ($1 \text{ PeV} < E_n < 3 \text{ EeV}$):

$$E^2 \Phi_{\text{all } \nu}(E) < 1.5 \cdot 10^{-6} \text{ GeV cm}^{-2} \text{ s}^{-1} \text{ sr}^{-1}$$

($\nu_e : \nu_\mu : \nu_\tau = 1:1:1$)

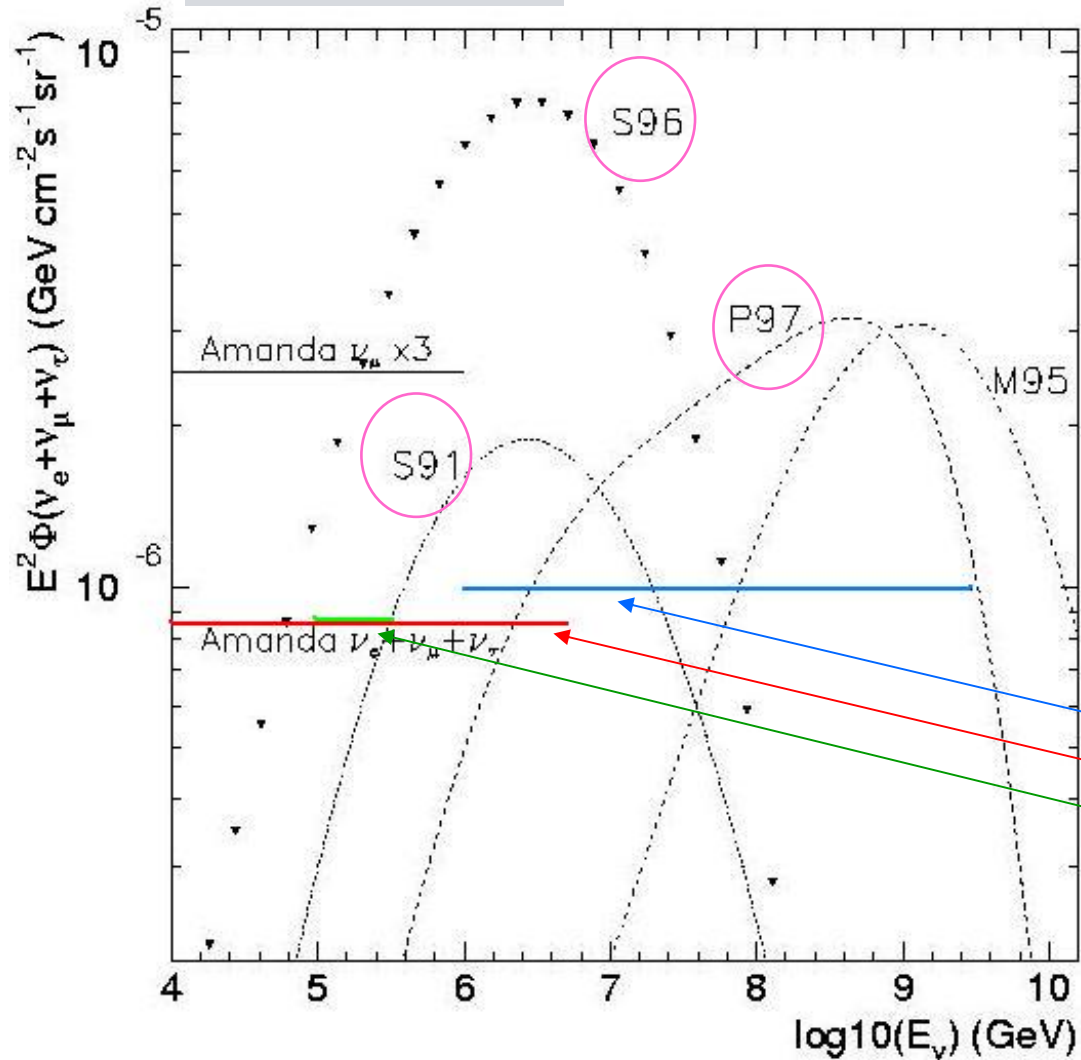
Paper submitted to Astropart.Phys.

PRELIMINARY

AMANDA-II (TWR 2003): expected further improvement using waveforms

SUMMARY: DIFFUSE NEUTRINO FLUXES $\Phi_{\text{all } \nu}$

PRELIMINARY



Specific predicted model spectra excluded by AMANDA:

- ✓ Szabo, Protheroe (1992)
- ✓ Protheroe (1997)
- ✓ Stecker, Salamon (1996)
- ✓ Nellen et al. (1993)
- ✓ Stecker (1991)

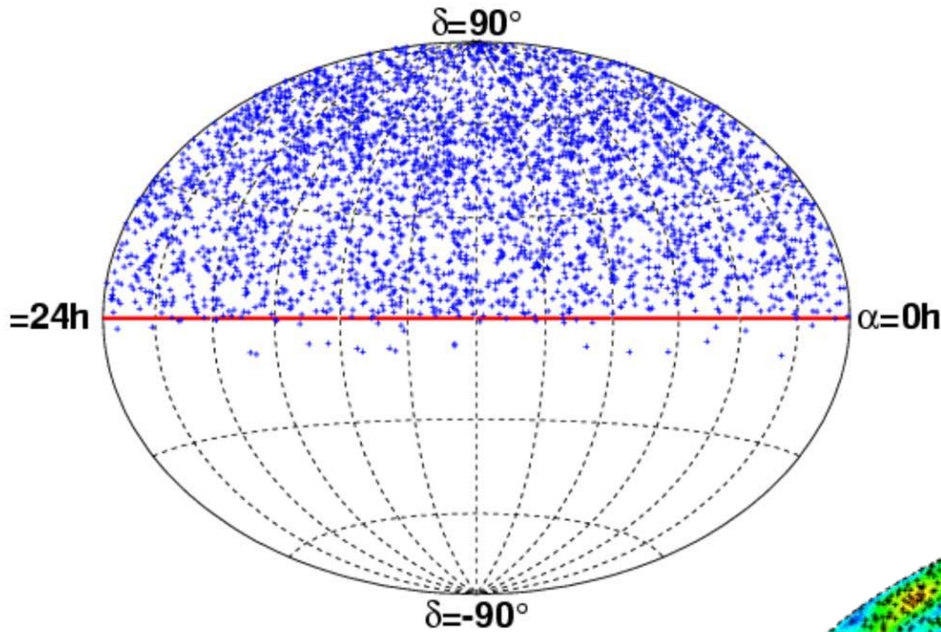
AMANDA 90% CL upper limits to a diffuse $E^{-2} \Phi_{\text{all } \nu}$ obtained from:

- ❖ search for UHE events
- ❖ search for cascade events
- ❖ High energy tail of atm. neutrino spectrum

POINT SOURCE

4 YEAR AMANDA-II (00-03) SEARCH

Cuts optimized in declination bands for $E^{-2..-3}$ signal spectra (grid of 300 bins)



3369 observed below the horizon
[+ declination]

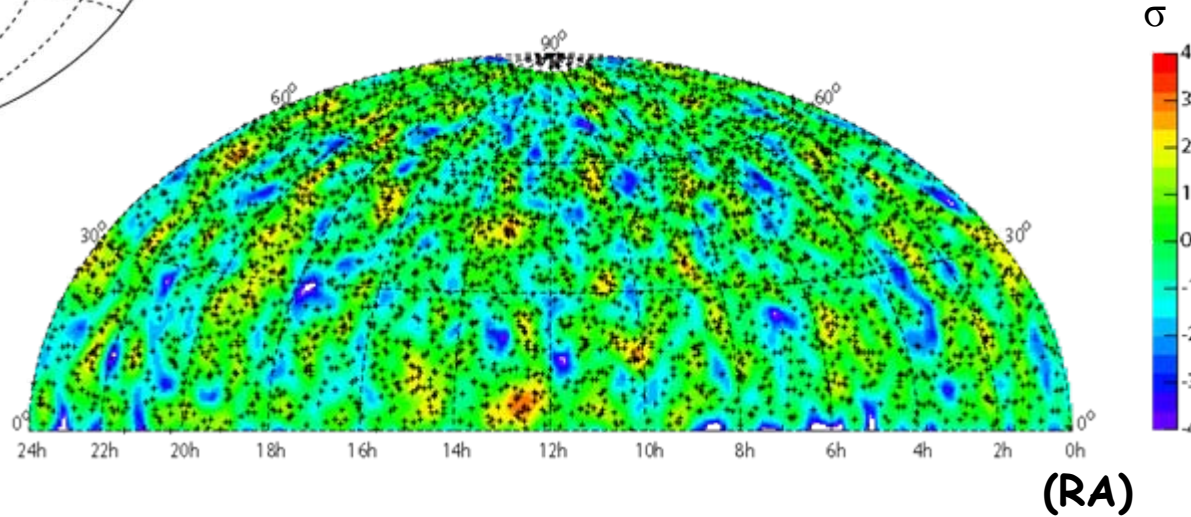
3438 expected from atm-V simulation

Livetime = 807 Days

Phys. Rev. Lett. 92 071102 (2004)

PRELIMINARY

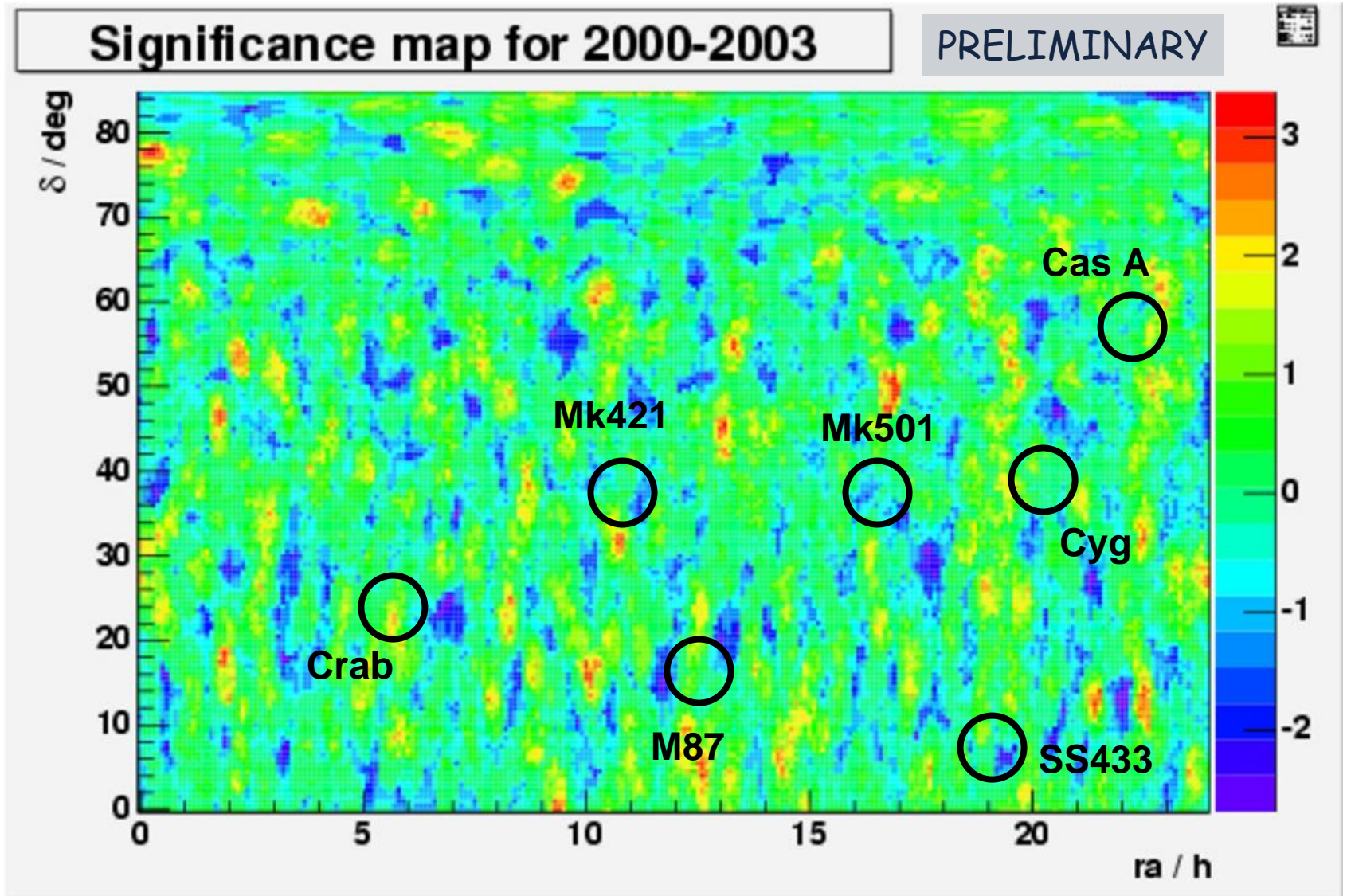
**NO EXCESS
beyond randomly expected**



compatible →

Atmospheric Neutrinos!

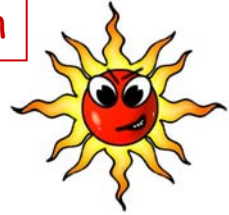
Neutrinos from known Sources



DARK MATTER INDIRECT SEARCH

Look for vertically upgoing tracks

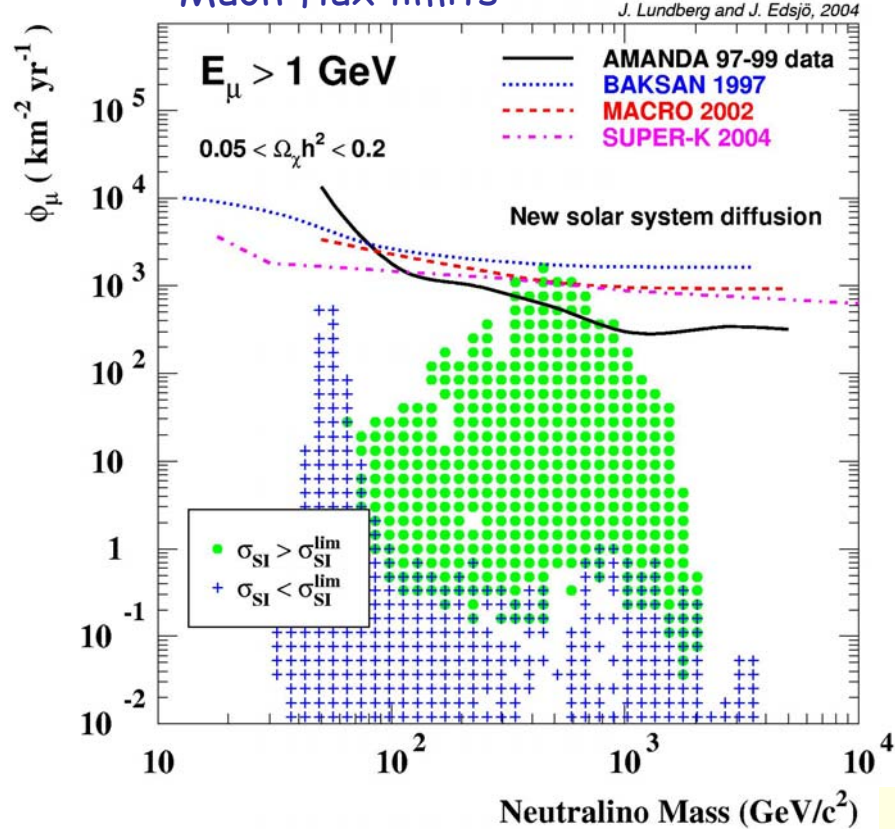
Sun is maximally 23° below horizon



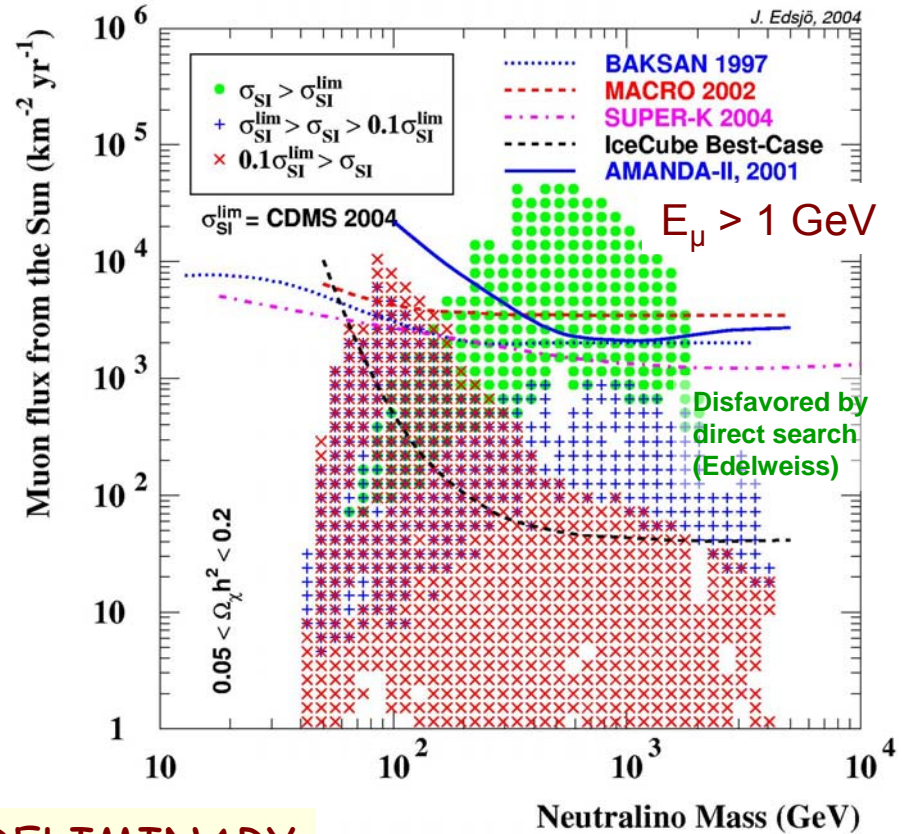
Combine 3 years: 1997-99
Total livetime (80%): 422 days

2001 data 0.39 years livetime

Muon flux limits



Muon flux limits



Limit for "hardest" channel:

PRELIMINARY

$$xx \rightarrow \tau^+ \tau^- \rightarrow \nu_\mu \quad M_x = 50 \text{ GeV}$$

$$xx \rightarrow W^+ W^- \rightarrow \nu_\mu \quad M_x = 100-5000 \text{ GeV}$$

SUMMARY & OUTLOOK

AMANDA hasn't seen ν sources yet,
But "she" has produced a lot of Physics!!

- Ice description mature
- Limits on diffuse neutrino fluxes (TeV-EeV)
- Papers on 1997-2003 data in progress
- Search for GRB neutrinos: Kyler Kuehn tomorrow VHE astrophysics session
- Results from AMANDA-II:
 - Four year Point source search (data set 00+01+02+03)
 - Improved Diffuse limits: over wide energy interval
 - Several predictions excluded
- For update: <http://amanda.uci.edu>