AMANDA

ANTARCTIC MUON AND NEUTRINO DETECTOR ARRAY

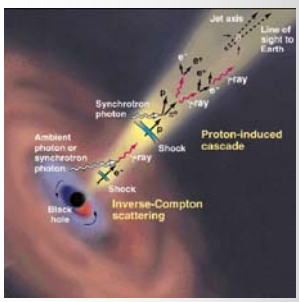
Steve Barwick and Andrea Silvestri
University of California, Irvine

JAFoS Symposium December 9-13 2004, Irvine

SCIENCE MOTIVATION

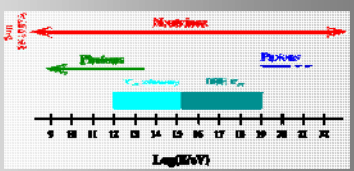
AMANDA is the first neutrino telescope constructed in transparent ice, and deployed between 1500m and 2000m. It is designed to search for neutrinos that originate in the most violent phenomena in the observable universe

Galactic and extragalactic objects like Supernova Remnants and Active Galactic Nuclei are expected to be the powerful engines accelerating protons and nuclei to the highest energies, eventually generating neutrinos.

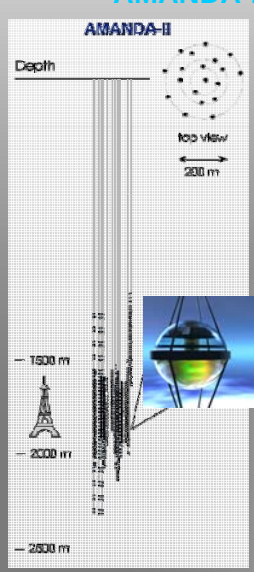


Extragalactic UHE gamma-ray astronomy falters for energies greater a few tens of TeV due to interactions with infrared and and Cosmic Microwave Background photons

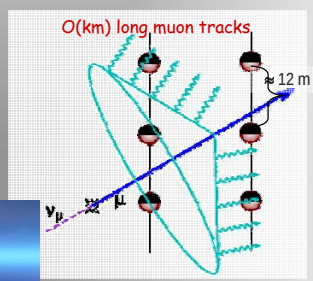
Neutrinos are the only particles able to propagate undeflected and unattenuated from the furthest reaches of the Universe



AMANDA-II PRINCIPLE OF DETECTION



The AMANDA-II neutrino telescope is an array of 677 Optical Modules (OM) arranged in 19 strings. An OM is a pressure sphere vessel enclosing the PMT and dedicated electronics



Down-going atmospheric muons are the major contribution to the background. The muon tracks are reconstructed with a maximum likelihood approach which models the arrival times and amplitudes of Cherenkov photons recorded by the PMTs, achieving an angular resolution of 1.5° - 2.5° Above a 10^6 GeV, the Earth becomes opaque to neutrinos, and only those moving down or horizontally can reach the detector.

$$\Theta_{\mu\nu} \approx 1.5° \cdot (E_\nu / \mathrm{TeV})^{-0.5}$$

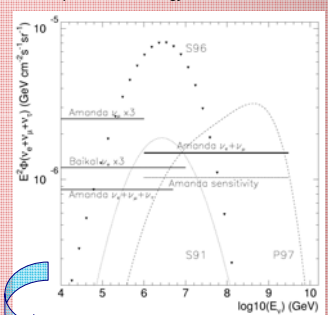
During the Austral summer season, Antarctica and the South Pole can be reached by cargo aircrafts

AMANDA scientists drill through the ice with hot water, in order to be able to bury the sensors more than 1 mile beneath the surface

SCIENCE RESULTS

SEARCH FOR DIFFUSE NEUTRINO FLUX

AMANDA has performed three different methods to search for diffuse flux of neutrinos. The figure shows the AMANDA-II limits for diffuse flux calculated for an E^{-2} spectrum. Here are shown the results of the two search methods sensitive to all neutrino flavors. The experimental limits assume 1:1:1 ratio of neutrino flavors at the Earth due to oscillation. The dotted and dashed lines represent a sample of model predictions which have been excluded by these analyses. The length of the lines correspond to the energy interval that contains 90% of the signal for a spectrum proportional to E^{-2}.



The AMANDA Diffuse Neutrino Flux Limits

Neutrino-Induced Cascade limit

$E^2\Phi_{all\ \nu}(E) < 8.6 \cdot 10^{-7}$ GeV cm^{-2} s^{-1} sr^{-1}
(flavor mixing $\nu_e:\nu_\mu:\nu_\tau$ =1:1:1) 50 TeV < E_ν < 5 PeV

The UHE Neutrino Flux limit

$E^2\Phi_{all\ \nu}(E) < 1.5 \cdot 10^{-6}$ GeV cm^{-2} s^{-1} sr^{-1}
($\nu_e:\nu_\mu:\nu_\tau$ = 1:1:1) (1 PeV < E_ν < 3 EeV)

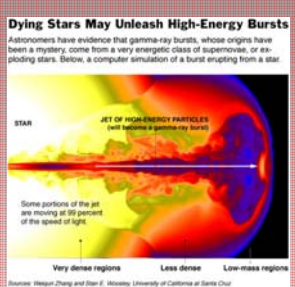
The Atmospheric Neutrino Spectrum results:

$E^2\Phi_{\nu_\mu}(E) < 2.58 \cdot 10^{-7}$ GeV cm^{-2} s^{-1} sr^{-1} 50
(100 TeV < E_ν < 300 TeV)

SEVERAL MODEL PREDICTIONS ARE NOW EXCLUDED

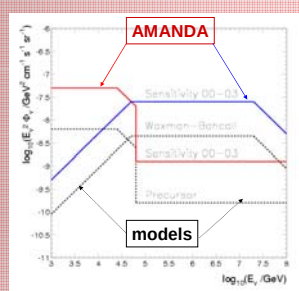
SEARCH FOR GRB NEUTRINOS

GETTING CLOSE



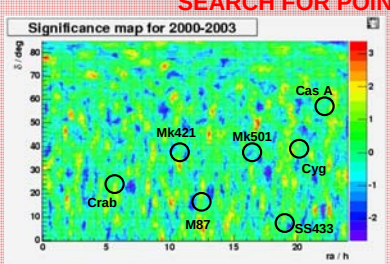
The AMANDA GRB search for correlated neutrino emission relies on temporal and angular information provided by BATSE and other satellites in the IPN network.

No excess was observed above the expected background from atm. neutrinos and poorly reconstructed atm. muons. The figure on right shows projected sensitivities using 149 bursts as a function of neutrino energy. Detector sensitivities are compared to Waxman-Bahcall and precursor model spectra.



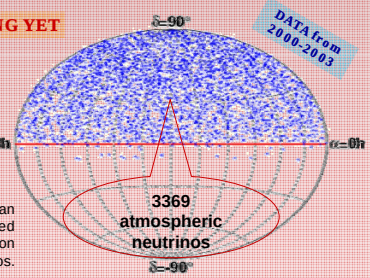
SEARCH FOR POINT SOURCES

NOTHING YET



AMANDA-II has surveyed the entire northern sky since 2000 for non-statistical excesses in small regions of the sky. None were found so far. The sky map on right, plotted in coordinates of right ascension and declination, show the 3369 observed events, which is in good agreement with the expected number of 3438 from atmospheric neutrinos.

The plot on left shows the statistical fluctuation for an unbinned sky search. No fluctuation exceeded 3.4sigma, which is compatible with random fluctuation in the spatial distribution of atmospheric neutrinos.



CONCLUSION

AMANDA has yet to observe an extraterrestrial neutrino source, but '**she**' has demonstrated the cost-effectiveness and robustness of the technique. Construction has started this year on **IceCube**, the next generation high energy neutrino telescope.