RECENT RESULTS FROM THE AMANDA EXPERIMENT

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We present recent results from searches for high energy extraterrestrial neutrinos using the Antarctic Muon and Neutrino Detector Array (AMANDA). Several analyses are briefly discussed, including searches for diffuse flux, point sources and gamma ray bursts.

1 The AMANDA detector

The AMANDA-II neutrino telescope[1] is composed of 677 optical modules arranged in 19 strings and has been operating since the year 2000. Prior to this, in the years 1997-1999, the detector was composed of what are now the inner 10 strings of AMANDA-II and was referred to as AMANDA B10. The detector is buried deep in the transparent ice near the geographic South Pole. When a neutrino interacts with an ice molecule through the weak force, AMANDA uses the Cherenkov light emitted by the products of this interaction to reconstruct the path of the original neutrino. The detector is sensitive to muon tracks from ν_μ interactions as well as cascade events. Cascades are hadronic or electromagnetic showers resulting from charged current interactions of ν_e or neutral current interactions of any flavor. Although its depth (1.5 to 2.2 km) protects it from a large percentage of cosmic-ray-induced atmospheric muons, these muons are still the primary background for the detector. For this reason, most analyses are limited to searching for neutrinos coming from the northern hemisphere or near the horizon, since the Earth itself acts as a shield against muons in these directions. Atmospheric neutrinos, also caused by cosmic rays interaction in the Earth's atmosphere, are the other main background in searches for an extraterrestrial neutrino signal.
The AMANDA detector addresses several issues in astrophysics. The analyses discussed in these proceedings search for high energy neutrinos (TeV and above) from astrophysical phenomena such as AGN and GRBs. These analyses address the origin of high energy cosmic rays, since the identification of high energy neutrinos from one of these phenomena would be indicative of hadronic interactions in them. AMANDA also studies the cosmic ray spectrum through analysis of the atmospheric neutrinos and muons, which are backgrounds for most analyses. Cosmic ray composition is studied by using AMANDA in coincidence with the SPASE-II air shower array. Additionally, searches for exotic particles such as WIMPs and magnetic monopoles are conducted. AMANDA is also used as a supernova monitor by looking for an overall noiserate increase resulting from a flux of neutrinos in the MeV range.

2 Diffuse Searches

2.1 Atmospheric Neutrino Spectrum

AMANDA has produced the first atmospheric neutrino spectrum for energies significantly above 1 TeV (see figure 1). This is in good agreement with the lower energy data from the Frejus experiment[2]. The lack of any excess compared to the predicted spectrum has allowed a limit of to be placed on any extraterrestrial neutrino flux contaminating the spectrum in the range of 100-300 TeV. This 90% confidence level upper limit is

$$E^2\Phi_{\nu_\mu} = 2.87 \times 10^{-7} GeV cm^{-2} s^{-1} sr^{-1} \tag{1}$$

This and all other limits presented here follow the ordering scheme of Feldman and Cousins[3] and include systematic uncertainties of around 25%. Modelling of muon propagation and optical ice properties are the main sources of this uncertainty[4].

2.2 Diffuse Flux Search using Cascades

A search for a diffuse flux using the cascade channel was conducted using data from the year 2000. Since cascade events appear distinctly more spherical than muon tracks, topology as well as energy can be used to distinguish cascades originating from extraterrestrial neutrinos from atmospheric backgrounds. The cascade search is therefore conducted in 4π steradians, rather than just the northern hemisphere. One event survived cuts, consistent with a background expectation of .96. The 90% C.L. flux upper limit set by this analysis was

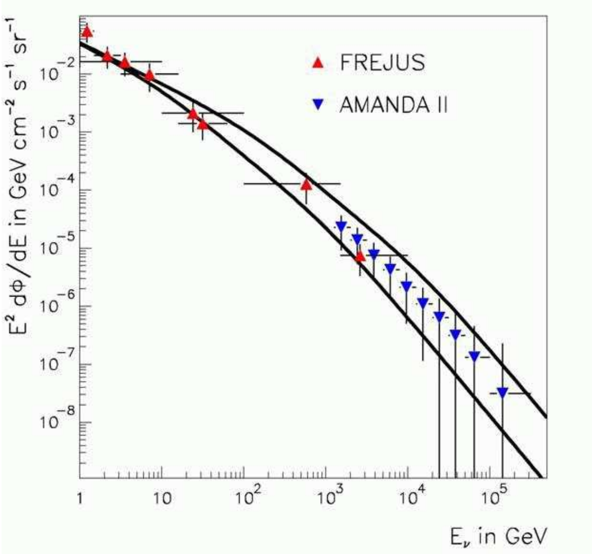

Figure 1: Preliminary atmospheric neutrino spectrum. AMANDA results are consistent with lower energy Frejus data[2] and are within the bounds of model predictions [5], with the upper solid black line showing predictions for horizontal flux and lower line showing the prediction for a vertical flux.

$$E^2\Phi_\nu = 8.6 \times 10^{-7} GeV cm^{-2} s^{-1} sr^{-1} \tag{2}$$

between 50 TeV and 5 PeV, assuming neutrino flavor ratios of 1:1:1 at the Earth.

2.3 Ultrahigh Energy Search

The Earth is opaque to neutrinos above 10^{16} eV. However, events of energy this high produce long tracks, bright events and few single photoelectron peaks, which allows them to be distinguished from atmospheric muons. Therefore, it is possible to search the southern sky and the area near the horizon for ultrahigh energy neutrino events. Using year 2000 data for this analysis, 5 events were observed on a background of 4.6 events, with a 90% C.L. upper limit of

$$E^2\Phi_\nu = .99 \times 10^{-6} GeV cm^{-2} s^{-1} sr^{-1} \tag{3}$$

in the 1 PeV to 3 EeV range. This limit assumes an E^{-2} energy spectrum and a neutrino flavor ratio of 1:1:1.

3 Point Source Searches

Both binned and unbinned searches for extraterrestrial point sources have been conducted using the entire currently available AMANDA II data set (years 2000-2003). There were 3369 events after cuts in the sample used in these analyses, which is consistent with an expected background of 3438 events. In the binned analysis, a grid of 7 degree by 7 degree bins was applied to the sky, then the grid was shifted, so that any sources on the grid boundaries were not separated into multiple bins by both grid sets. The cuts were optimized independently in each declination band. Separate optimizations were done for both E^{-2} and E^{-3} energy spectra. No significant excess was found in any bin. An unbinned statistical analysis was also conducted, resulting in a maximum excess in any area of 3.4 sigma, which is again consistent with no signal (see figure 2).

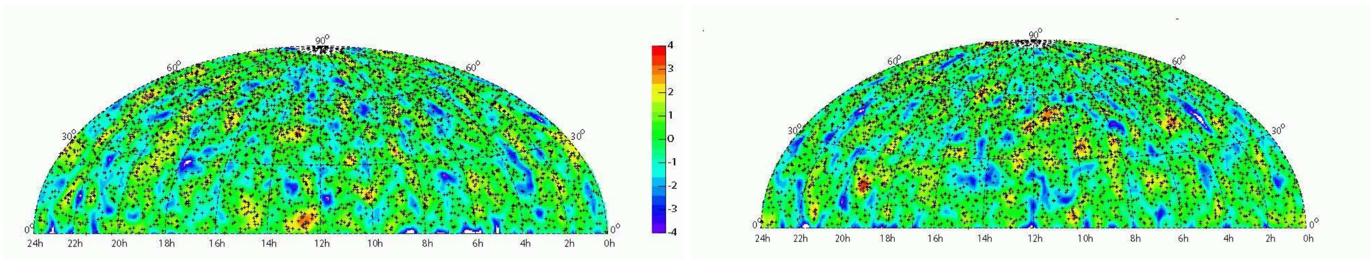

Figure 2: Unbinned 2000-2003 point source sample (left) with scrambled skymap for comparison (right) Maximum significance anywhere in the sky is 3.4σ, comparable to the results of the scrambled skymap.

4 Gamma Ray Burst Searches

Searches for a neutrino signal coincident with a gamma ray burst have been conducted for several years using GRB catalogs produced by the BATSE satellite and the IPN3 satellite network. The combination of burst-coincident searches from the years 1997-2000 has resulted in a 90% confidence level upper limit of

$$E^2\Phi_\nu = 4 \times 10^{-8} GeV cm^{-2} s^{-1} sr^{-1} \tag{4}$$

assuming a Waxman-Bahcall type broken power law spectrum [6] with $\Gamma_{bulk} = 300$ and $E_{break} =$ 100 TeV. Since there are also GRBs not caught by the satellite network, a rolling search, which looks for a signal from a Waxman Bahcall type spectrum througout the entire year rather than using satellite coincidences, is also in progress.

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