The AMANDA Neutrino Detector

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The first stage of the AMANDA High Energy Neutrino Detector at the South Pole, the 302 PMT array AMANDA-B with an expected effective area for TeV neutrinos of $\sim 10^4$ m^2, is taking data since 1997. Progress with calibration, investigation of ice properties, as well as muon and neutrino data analysis is described. The next stage 20-string detector AMANDA-II with ~800 PMTs will be completed in spring 2000.

1. Introduction

The first stage Neutrino Detector AMANDA-B was deployed in 1996-1997, at a depth of 1500-2000 m into the antarctic ice shield at the South Pole [1–3]. It consists of 302 Optical Modules (OMs) at 10 strings, see Fig. 1. Each Optical Module houses a 8"-Hamamatsu PMT, operated at 10^9 gain over an individual 2 km electrical cable to the surface.

During the 1997/98 campaign, 3 new strings with 123 OMs in total were deployed. They

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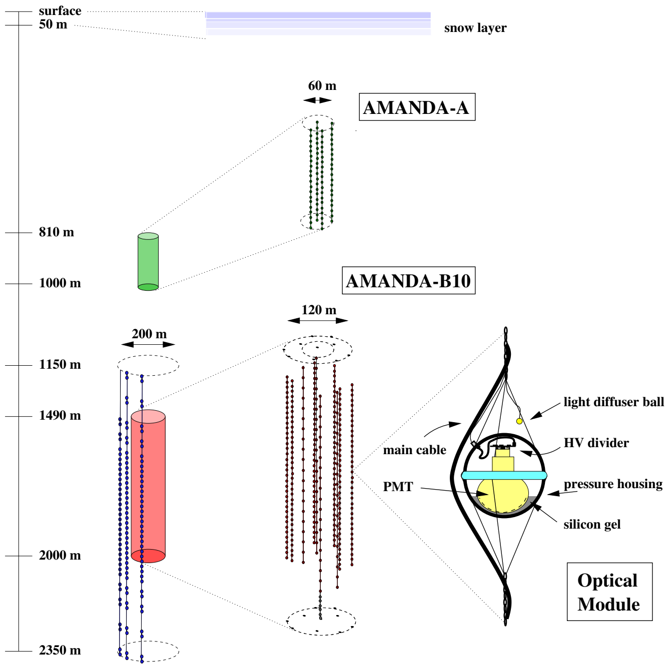

Figure 1. The AMANDA detector layout as for 1998. Indicated are Amanda-B at 1.5-2.0 km depth, three new technology strings (1.3-2.4 km) and Amanda-A at 0.8-1.0 km depth, and an Optical Module.

are successfully proving fiber-optic analog signal transmission (yielding nsec timing precision [3]), and also allow for ice studies from 1300-2400 m. The first full detector calibration (timing and geometry) could be completed, and a new Data Acquisition System was installed.

The AMANDA-A detector [4], deployed in 1994 at 800-1000 m in bubbly ice (see Fig. 1), and the airshower detectors SPASE and GASP at the ice surface, provide a unique external calibration source by tagging high energy muons.

The main physics goal of Deep Underwater/-Underice Detectors is High Energy Neutrino Astrophysics - the search for sources of highest energy cosmic rays [5]; they also cover a wide range of topics from particle physics to glaciology [4].

These novel technique detectors, sparsely instrumented compared to Underground Water Cerenkov Detectors (almost 10^3 less density of PMTs per effective detector area), put their initial experimental focus on (1) verification of high quality muon track reconstruction and (2) physics detector calibration by detection of atmospheric neutrinos to establish an atmospheric muon background rejection capability of $\geq 10^5$ [1,3].

2. Optical Ice Properties and Calibration

Optical ice properties in AMANDA are measured with a variety of in-situ pulsed and constant light sources, and cross checked with atmospheric muons. The effective scattering and absorption lengths are λ_{eff} ~24 m and λ_{abs} ~100 m. No negative effects of residual bubbles in the refrozen bore holes are seen, vertical ice properties are under study.

Timing calibration of all PMTs is done with laser pulses over 2 km fibers, yielding a precision of ~5 nsec.

Geometry calibration is using drill logging and interstring laser pulsing, with a typical distance precision of $\sim$1 m for Optical Modules.

3. Data Analysis and Summary

With above-mentioned calibrations now under control, data analysis of the full 1997 B-10 data (500 GB) is under way.

Spatial reconstruction of muon tracks is done by fitting the recorded hit times to a single muon track model, including light scattering [1]. Post-reconstruction track quality criteria require a minimum number of unscattered photon hits (typically $\geq$5), to achieve a $\geq 10^5$ background rejection rate. Simulations and data agree well. Energy reconstruction, muon bundle discrimination and shower classification algorithms are in progress.

Detailed tests were made with the 1996 AMANDA-B 4-string data. The reconstructed flux of downgoing atmospheric muons compares well with the standard depth-intensity curve [6]. A search [7] for strictly upward going neutrinos in 6 months data (upward muons with $\leq 20^o$ from the vertical) yields two upward muon candidates (Fig. 2), compatible with being due to atmospheric neutrinos or background.

An essential verification of muon track reconstruction is done with muons tagged by the SPASE and GASP detectors [1,7]. Angular resolution and absolute pointing will finally be deducible.

Detection of MeV neutrino bursts from stellar collapses, recorded by a special trigger system, is possible up to $\sim$8 kpc source distances [3].

The detector upgrade to the $\sim$800 PMT detector AMANDA-II with new technology OMs will be completed in spring 2000. ICECUBE, a km^2 detector with $\sim$5000 PMTs, is under discussion.

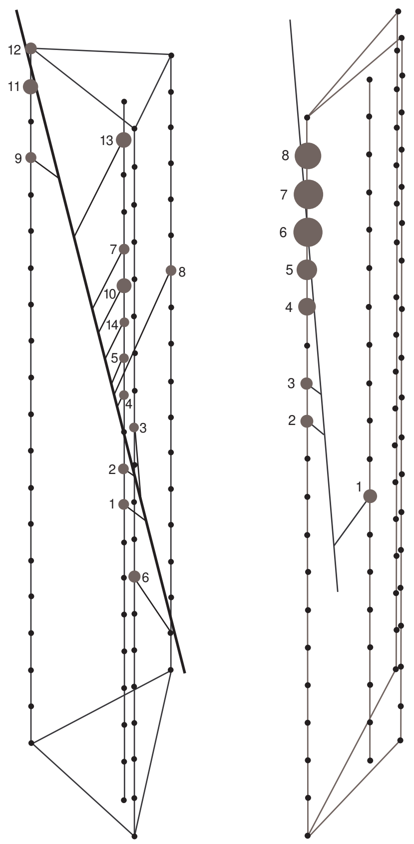

Figure 2. Two vertically upward muon event candidates detected with the AMANDA-B detector in 1996 (4 strings).

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