**AMANDA – Search for UHE Neutrinos**

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**Introduction**

Cosmic Rays have been measured beyond $10^{17}$ eV, implying the existence of UHE ($>10^{17}$ eV) neutrinos. Candidate sites or particles for the production of UHE neutrinos are:

- Active galactic nuclei (AGN)
- Gamma-ray burster (GRB)
- Topological defects (TD)

AMANDA is an open muon detector and allows to make use of the tons of kilometers range of UHE muons, thus monitoring huge volumes for charged current neutrino interactions. Most theoretical models require a km$^2$ detector to detect UHE neutrinos. Here it is shown that almost the first stage AMANDA detector reaches areas of this order.

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**Downgoing Muon Bundle Event**

The background for this analysis consists of downgoing atmospheric muon bundles created by interactions of cosmic ray primaries with the atmosphere. The energy of the primary is transferred to the air shower and part of it to the resulting muons. Muons passing through the ice lose energy stochastically. This is seen in the figure to the right as small “showers” along the tracks. The light emitted by the muon and the showers is seen by the detector. For sufficient energetic showers large numbers of hit Optical Modules are seen, but multiple resolved hits within one Optical Module are only seen in close encounters.

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**Method and Analysis**

The main idea that drives this analysis is that UHE muon events passing through or close by the detector leave a different signature than downgoing muon bundles caused by a primary of the same or higher energy. This can be seen in the event displays above. Using simple global event variables downgoing muon bundle events can be separated from UHE neutrino induced events. The variables used separately and combined in two neural nets are:

- Number of hit channels
- Number of all hits (each channel can register multiple hits)
- Fraction of hit channels with only one hit
- Mean amplitude
- Reconstructed zenith angle
- Reconstruction quality

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**Downgoing Muon Event**

There is a high energy muon deposits large amounts of energy via catastrophic processes, seen as colored “showers” along the track. The light emitted by these showers reaches the detector as a cloud of photons, causing a large number of Optical Modules to see several resolved hits throughout the detector. Afterpulsing of the photomultiplier dramatically enhances this effect.

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**UHE Neutrino induced Muon Event**

A high energy muon deposits large amounts of energy via catastrophic processes, seen as colored “showers” along the track. The light emitted by these showers reaches the detector as a cloud of photons, causing a large number of Optical Modules to see several resolved hits throughout the detector. Afterpulsing of the photomultiplier dramatically enhances this effect.

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**Conclusion**

Performing a search for UHE neutrinos, the AMANDA-B10 array reaches effective areas of 0.4 km$^2$ at the highest energies. There is good agreement between background simulation and the experimental data. Using 75 days livetime a preliminary limit without taking into account systematic uncertainties is set. It is shown that the AMANDA detector can set limits that will exclude models for UHE neutrino generation in the near future. AMANDA is currently the largest operating detector for UHE muons. In total data from more than 5 years of operation partly with the larger AMANDA II detector is available and will be analysed. A writeup, including references, can be found at.

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**References**

- F. Halzen, astro-ph/0103195

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