

Capabilities of the DUMAND II Phase I 3-String Array

Victor J. Stenger
University of Hawaii
for the DUMAND Collaboration*

ABSTRACT

The expected properties of the DUMAND II Phase I 3-string array, called the Triad, are summarized. The effective area will exceed that of previous detectors for muon energies above 3 TeV. The Triad may be able to detect the diffuse flux of VHE neutrinos from active galaxies that is predicted by several models.

1. INTRODUCTION

The first phase of DUMAND II, scheduled for deployment this Fall, will comprise three of the planned nine strings of 24 optical modules each. This array, which we will call the Triad, will have the full 230 m height of DUMAND II, with the string bases forming a triangle with sides 53, 53, and 40 m. The optical modules will be spaced 10 m apart along the string.

While the complete 9-string array is necessary to exploit the full capacities of DUMAND II, in particular the search for point sources with a pointing accuracy of about 1° , the Triad will possess some capability to search for events having energy spectra flatter than the neutrinos produced by cosmic rays hitting the atmosphere.

2. MONTE CARLO SIMULATIONS OF THE TRIAD

Monte Carlo simulations of the response of the Triad array to through-going muons indicate that the Triad will have an effective detection area for muons above 3 TeV that exceeds previous and existing underground detectors. The median pointing accuracy at this energy will be about 3° . Thus the Triad will be able to search for astronomical sources of very high energy neutrinos at a greater level of sensitivity than has so far been achieved in other experiments.

In order to keep the backgrounds of fake neutrino events low and guarantee a good muon track fit, multiple coincidences are demanded among adjacent optical modules on all three strings. For example, consider the following coincidence patterns: (1) at least a 3-fold coincidence on each of two strings, and at least a 2-fold on the other string; (2) a 5-fold and two 2-folds. The resulting backgrounds after these coincidence requirements are applied are sufficiently small that a point source producing ten events per year in a 3° pixel will be detectable.

The tight coincidence requirement results in a strong energy dependence of the effective area of fully reconstructed muons, as seen in Fig. 1.

3. POSSIBLE SIGNALS

The strong energy dependence of the sensitivity of the Triad offers an advantage in the search for neutrinos from active galactic nuclei (AGNs) and other astronomical sources that are expected to have flat energy spectra. The primary background to this signal, atmospheric neutrinos, has a steep spectrum. In a year, the Triad will register only about 40 atmospheric neutrinos that meet the tight coincidence requirements described above.

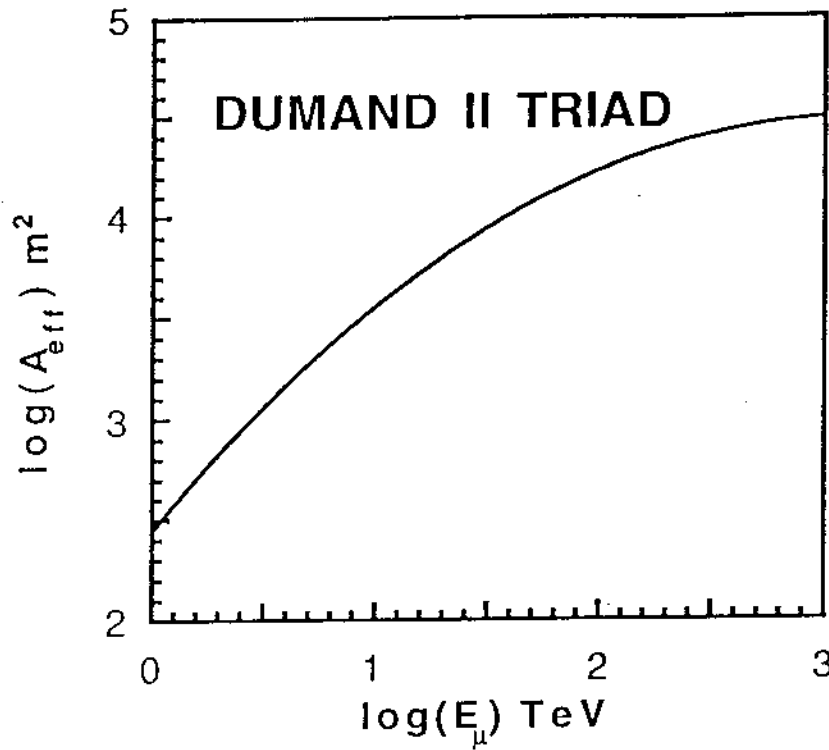


Fig. 1: Effective area for fully-reconstructed muons in the Triad, as a function of muon energy, with the 3-string coincidence requirement explained in the text.

Using the neutrino fluxes calculated for the sum total of all AGNs by several authors, the projected event rates shown in Table 1 are obtained.†

Table 1. Projected event rates from AGNs in the Triad, according to several models.

Model	Events per year in Triad
Biermann	33
Stecker et al	27
Sikora and Begelman	65
Protheroe and Szabo	10

In only Sikora and Begelman's model does the AGN rate exceed that for atmospheric neutrinos. However the range of predictions illustrate that no strong statement can be made at this time and at least some possibility exists that the Triad will see AGN neutrinos.

As seen in Fig. 2, the zenith angular distribution of the AGN events is predicted to be significantly different from atmospheric neutrinos. This is a consequence of the greater attenuation of the higher energy AGN neutrinos in the earth and affords a possible test for an AGN signal.

4. CONCLUSION

The 3-string Triad array for Phase I of DUMAND II to be deployed this year will have sufficient effective area and pointing accuracy at energies above a few TeV to extend current searches for astronomical sources of very high energy neutrinos. While calculations indicate that the Triad has at best a marginal chance of seeing a neutrino signal, the uncertainties in these calculations, as indicated by the differences between models, leave open the possibility that the Triad may be able to detect neutrinos from active galaxies or other sources.

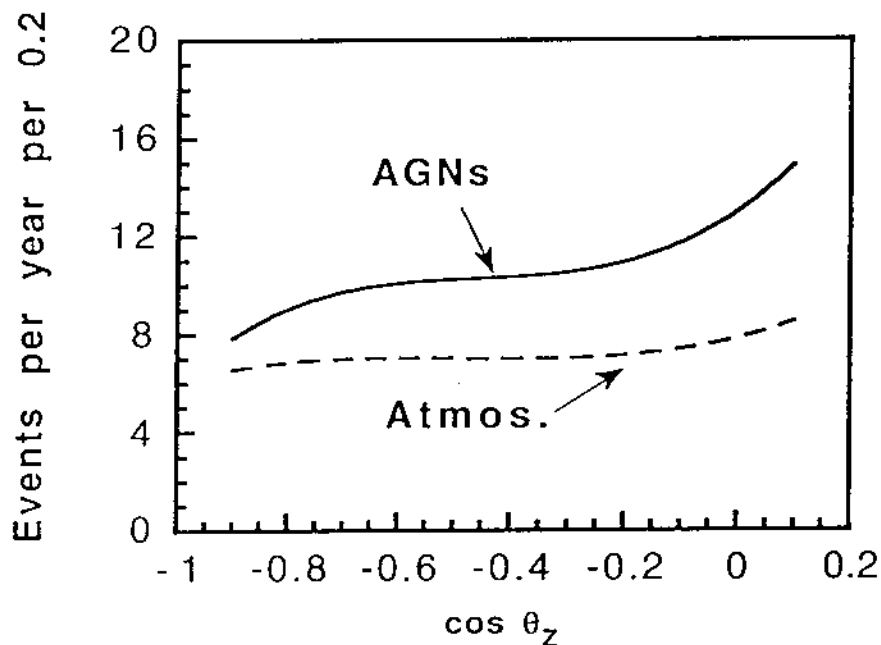


Fig. 2: Number of events per year per 0.2 bin in $\cos \theta_z$, where θ_z is the zenith angle, for atmospheric neutrinos and AGNs. The AGN neutrino flux calculated by Sikora and Begelman is used.

REFERENCES

* See "Update on the Status of DUMAND," these proceedings.

† The neutrino fluxes used are taken from the papers by the authors listed in Table I found in the Proceedings of the Workshop on High Energy Neutrino Astrophysics, edited by V.J. Stenger, J.G. Learned, S. Pakvasa, and X. Tata, 23-26 March, 1992 (World Scientific).