DIR-10-90

MC RESULTS ON LOW ENERGY NEUTRINOS IN DUMAND

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[Note: this supersedes the preliminary version of DIR-10-90 previously distributed under a somewhat different title. It also supersedes DIR-8-90]

I have used the Hawaii DUMAND Monte Carlo DUMC to study the capabilities of the Octagon array to detect low energy electron and muon neutrinos. This was done with an array of half Hamamatsu and half Philips tubes having a time resolution of 2.5 ns (standard deviation) and least count of 2 ns (see V. Stenger, DIR-9-90). All optical modules were assumed to be set at a threshold of 1/3 pe. Background noise at the 1 pe (true) level of 60 Hz in each tube was assumed, with a time gate of 1137 ns.

Generation of Events

Neutrino events are generated at random positions within a vertical cylinder centered on the array with each outer string on the face of the cylinder. That is, the fiducial volume is essentially the contained volume. Two different methods of generating the neutrino direction were used:

(a) Fixed cos(zenith) = -.492 (corresponding to direction of Fermilab) and phi = pi/4 (arbitrary). (See J. Learned and V. Peterson, HDC-5-89, for details on Fermilab beam proposal).

(b) Random cos(zenith) between -1 and .2, corresponding the signal region for cosmic neutrino events.

Only charged current events have been considered. In the case of electron neutrinos, all the neutrino energy Enu is assumed to go into a cascade at the point of interaction. For muon neutrinos, Emu = (1-y)Enu, Ehad = yEnu, where Bjorken y is random (anti muon neutrinos not studied), with Ehad going into the cascade and Emu into the muon track. In order to determine the energy dependence, fixed neutrino energies of 1, 3, 10, 30, and 100 GeV were used for a succession of MC runs of 1000 events each. Then runs of 1000 events were made with the expected Fermilab spectrum (from HDC-5-89).

Trigger

Two triggers were OR'd:

1. Standard muon trigger. Any string with three adjacent OM hits with the absolute difference of absolute time differences less than 15 ns.

2. Total pe trigger. Sum of the simulated charge outputs of all PMTs in the array greater than 25.

(See J. Learned, DIR-12-90, for background rates and other considerations).

Fitting

The standard space-time pre-fit was used, except that, for case (a) above, the direction of the neutrino was forced to be that which was generated (see above). The standard background rejection algorithms were then used (points with bad pulls tossed out and up to three pre-fit attempts made). Using the pre-fit results as initial values, and freeing the direction, the standard chisq search was them performed. (See V. Stenger, HDC-1-90, for details on track fitting in DUMC).

Results

Table 1 presents the efficiencies for triggering and fitting as a function of neutrino energy. Since the events were generated within a volume of 2x10^6 m^3, multiply by this to get the effective volume as a function of energy. Note the that "fit efficiency" refers to the fraction of all events generated within the fiducial volume which fit, not just the fraction of triggers which fit. The trigger efficiencies are essentially the same for cases (a) and (b). Also shown are the median pointing errors for the fits. These are only listed for the case (a) where the neutrino direction is fixed, since the case (b) fits with the current algorithm should not be taken too seriously. However, note that the fit efficiency is not much different than in case (a).

Conclusions

The DUMAND II Octagon has capabilities for low energy events not previously appreciated, with our emphasis on >100 GeV throughgoing muons. Although the efficiency at a few GeV is low, the large volume of the array still results in an effective volume, almost 10^6 m^3 for triggers from events from Fermilab. This is 100 x IMB! Even at 1 GeV, DUMAND is almost 20 times bigger than IMB.

About half the triggers pass the fitting algorithm that is used for normal muon reconstruction and is not optimized for neutrino events.

Thus it appears that we can go lower in E/L than previously assumed, making our limits on delta-m^2 even better. With the longest baseline L of any of the proposals, we may have eliminated some of the advantage claimed by our competitors on the basis of lower threshold energy.

We have not yet explored the physics significance of this result to other physics and astrophysics.

Acknowledgment

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Table 1. Efficiency for triggering and fitting low energy neutrino events as a function of energy. Fit efficiency refers to the fraction of original events which fit, not the fraction of triggers. The row labelled FNAL corresponds to the runs with the Fermilab spectrum. Fits (a) were forced to point in a fixed direction, fits (b) were allowed to search (see text). Median pointing errors are also shown for fits (a).

	Electron neutrinos				Muon neutrinos			
Enu	Trig. eff.	Fit eff. (a)	Fit eff. (b)	Med. pt. err. (a)	Trig. eff.	Fit Eff. (a)	Fit Eff. (b)	Med. pt. err. (a)
1 GeV	.075	.039	.032	28 deg.	.146	.080	.060	25 deg.
3	.139	.065	.053	28	.206	.112	.072	24
10	.384	.158	.138	21	.493	.218	.167	20
30	.739	.283	.265	20	.873	.329	.290	14
100	.981	.303	.317	14	.977	.413	.344	5.3
FNAL	.410	.166		23	.507	.214		21