NAL Proposal No. 306

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A PROPOSAL TO SEARCH FOR ANOMALOUS OR "DIRECT" NEUTRINO PRODUCTION

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Some of the most intriguing possibilities at the new energies and intensities available at the NAL accelerator involve the possible discovery of totally new phenomena. Are there new heavy leptons, in addition to the neutrino, electron, and muon? Is there a W-boson which mediates the weak interaction? Are there some of the other new exotic possibilities such as "charmed" states? Are there totally unexpected new states produced?

Many of these possibilities have in common new states of very short lifetime with likely decay modes into leptons. Detection of "direct" production of muon or electrons in hadron collisions might be due to such states or they might result from other mechanisms (i.e. $\rho \rightarrow \ell^+ \ell^-$ decay or production by $q\bar{q}$ annihilation).

We suggest a simple and complimentary investigation by looking for "direct" production of neutrinos in hadron-hadron collisions. Conceptually, the experiment involves bombarding a totally absorbing target (i.e. a beam dump) with an intense high energy proton beam. The dump will absorb pions and kaons quickly, minimizing "background neutrinos" from π and K decay.

The "new" neutrino might be either muon or electron neutrinos; however the possibility exists that a totally new type of neutrino will be produced. We propose to investigate these possibilities using the Caltech neutrino detector and running two special short runs.

Search for Neutrinos Coupled to Muons

We propose a one-week run ($\sim 2\ 10^{17}$ protons) using 300 GeV protons and long spill. The primary proton beam untargeted will be transported directly down the decay pipe and targeted on the beam dump. We will then search for muon neutrino-like events in our detector, as determined by an observed outgoing muon. It should be noted that there is a possibility that these

neutrinos will have opposite helicity from ordinary muon neutrinos.

In the ordinary V-A interaction, the quark (q) component of negative helicity interacts with the neutrino (anti-neutrino). This gives a total angular momentum of zero for negative helicity neutrinos and of one for positive helicity neutrinos. The laboratory energy of the muon is related to the center of mass scatter angle between ν and outgoing muon by

$$1 - y \equiv \frac{E_\mu}{E_\nu} = \frac{1 + \cos\theta}{2}$$

For incident neutrinos of negative helicity (ordinary V-A neutrinos), we expect $\frac{dN}{dy} \sim$ const.; for incident neutrinos of positive helicity (ordinary V-A anti-neutrinos), we expect $\frac{dN}{dy} \sim (1-y)^2$. Figures 1 and 2 show observed distributions in y for neutrinos (outgoing μ^-) and anti-neutrino (outgoing μ^+) from π-decay and K-decay. They qualitatively verify the picture. Will neutrinos produced in a beam dump follow the same distributions? That is, do they have complete helicity?

It is difficult, to say the least, to estimate our sensitivity without a specific production mechanizm. However, for reference - due to the long lifetime and the production dynamics we are only sensitive to $\sim 10^{-3}$ of the decays of produced pions. In a comparable run to that proposed we detect $\sim 10^3$ events from pion decay. Therefore, the new states or neutrinos, depending on the production mechanizm, would need to be produced with 10^{-3} - 10^{-5} times the production cross section of pions for us to detect them. The background levels from the decay of produced pions before decay in an aluminum dump is estimated to be $\sim$ 5 - 10 events. A heavier dump would reduce this background.

Search for Neutral Current or Electron-type Neutrino Events

In order to search for other neutrino-like events, we propose to run short spill at a time when it is possible to deliver 200 GeV beam to the Neutrino Laboratory. Due to shielding limitations at our detector it is necessary to run at lower proton energy for this short spill experiment. Again, a one-week run of ($\sim 2\ 10^{17}$ protons) seems appropriate.

In this part of the experiment we will be able to look for neutral current or electron neutrino ν type events --- or any other anomalous interactions in our apparatus.

In summary, no special requirements or preparations are necessary from the laboratory. This experiment could be run, for example, while the horn is installed, just by removing the target and leaving the horn turned off. We propose then, two one-week runs to look for anomalous neutrinos coming directly from a beam dump. We promise nothing, but it will be fun to look!!

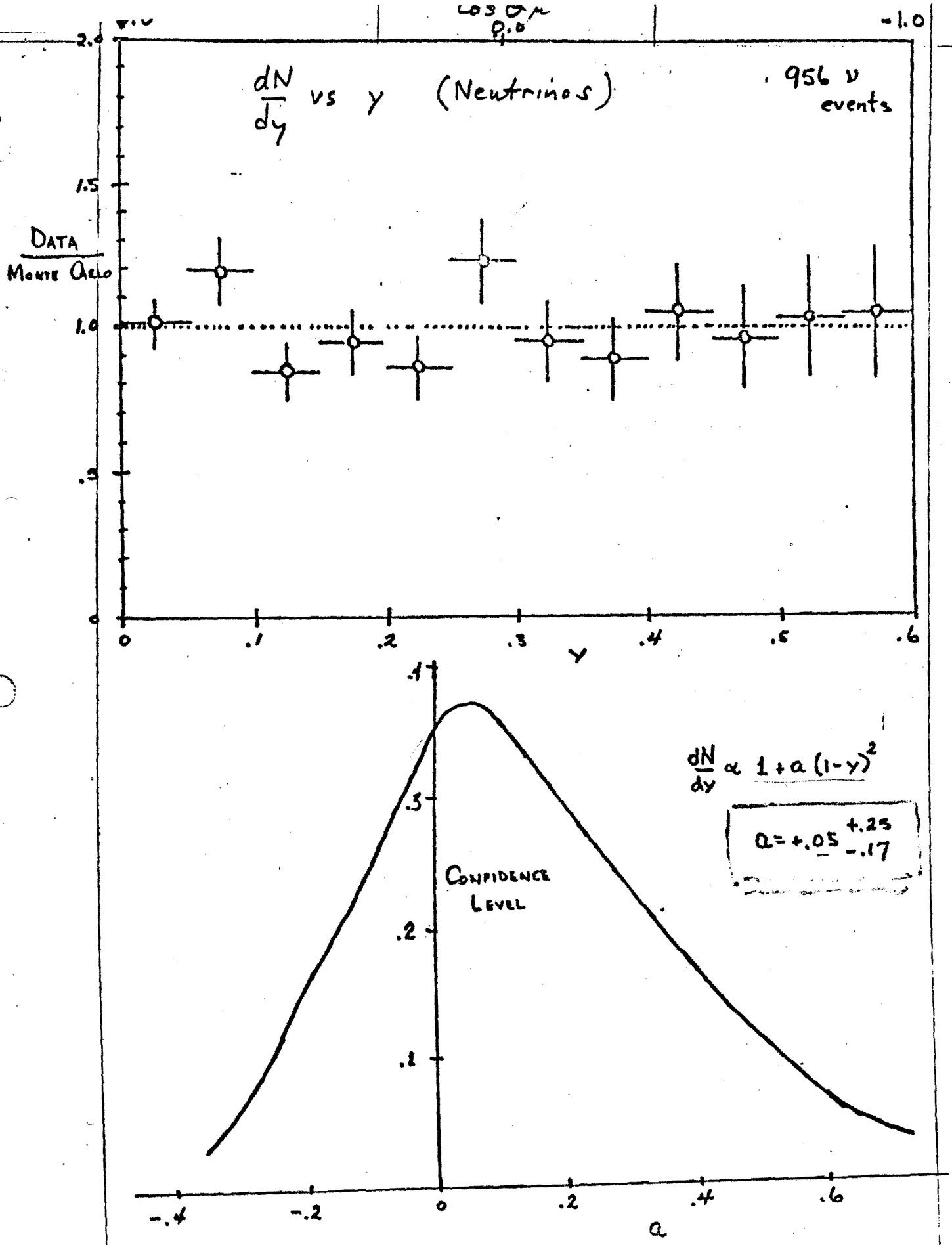
$\frac{dN}{dy}$ vs y (Neutrinos)
956 ν events
DATA / MONTE CARLO
y
$\frac{dN}{dy} \propto 1 + a(1-y)^2$
$a = +.05^{+.25}_{-.17}$
CONFIDENCE LEVEL
a

Figure 1

— PRELIMINARY — 8/10/73

Ratio of $\bar{\nu}$ to ν events vs Y

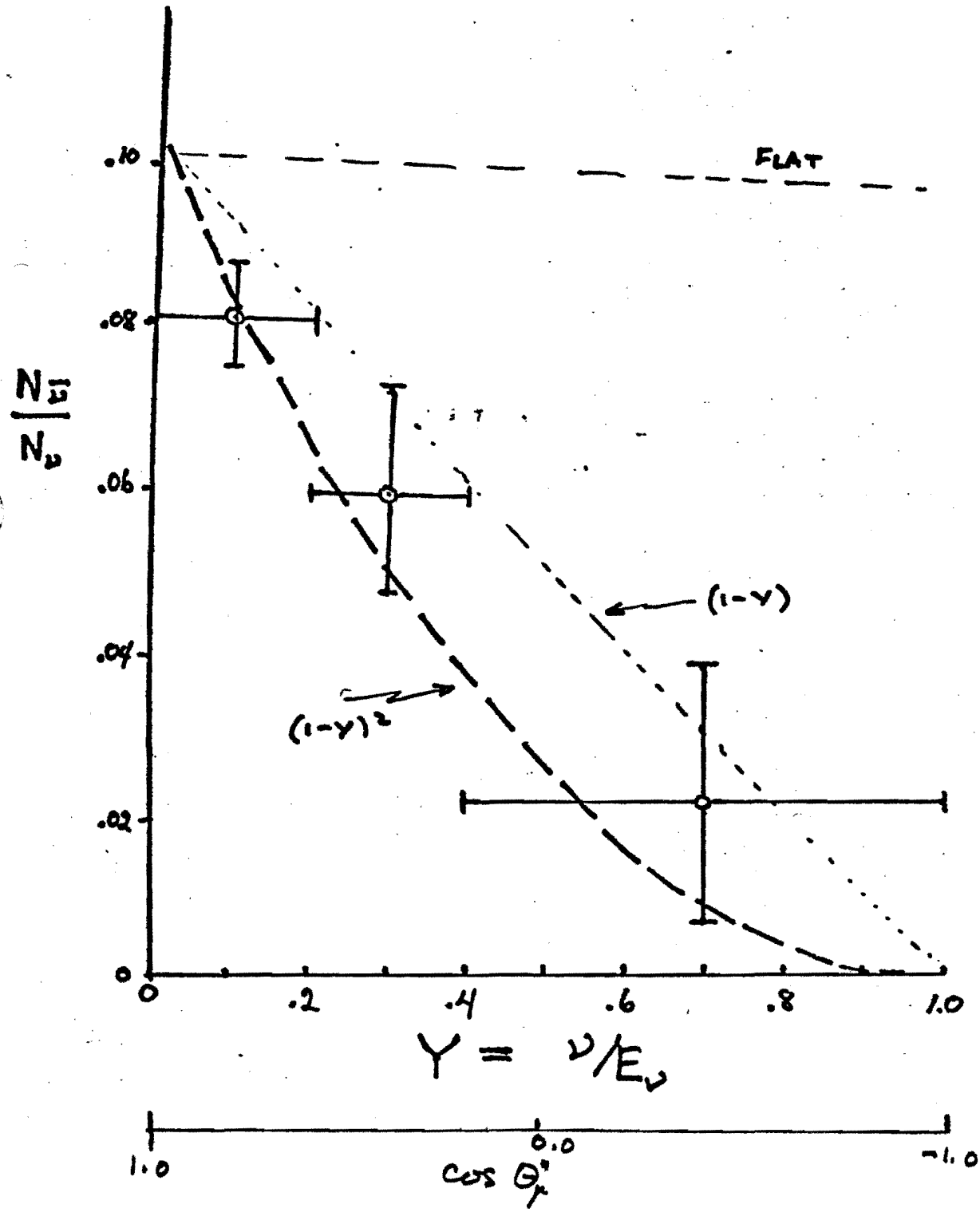

Figure 2