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PROPOSAL FOR AN EXTENSION OF E151/227 TO STUDY NEUTRINO INTERACTIONS IN DEUTERIUM IN THE 15-FOOT BUBBLE CHAMBER WITH PLATES

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I. INTRODUCTION

As the study of neutrino and antineutrino physics at Fermilab and other laboratories has progressed, new and interesting features of these interactions have been discovered. In particular, we take note of the observations of neutral current interactions, of di-lepton and even tri-lepton events, and evidence for charm production. It becomes evident that in order to understand these interactions detailed analysis of large numbers of complete neutrino (antineutrino) events on protons and neutrons is going to be required. We request additional running with the broad band, horn focussed neutrino beam. We propose an exposure of 300,000 pictures in the 15-foot bubble chamber with a deuterium fill, and a four plate configuration,[1] and the external muon identifier (EMI) in order to study νp and νn interactions.

Our group - IIT, Maryland, Stony Brook, Tufts - are presently approved for ν-deuterium running in the near future (E-151 and E-227). We consider this ν-deuterium proposal with plates a natural extension that will allow more detailed study of di-lepton events and of neutral current events on neutrons and protons individually.

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[1] This is a downstream series of four tantalum plates, each 0.5 conversion length thick and 9" apart, as proposed by M. Derrick et al, ANL, Carnegie-Melon, Purdue Proposal for $(\bar{\nu},d)$, March, 1977.

II. PHYSICS

We have estimated the number of events of various types expected and they are listed in Table I.

The downstream plates are particularly useful for the following physics studies:

A. μ^-, e^+ Events

The excellent e^+ identification possible with the plates, when combined with the EMI, will allow a large fraction of the ∿375 expected events to be detected. The clean target should yield considerable information about the sources of these events and in particular can allow a determination of the ratio of neutron to proton production cross sections.

B. Charmed Baryon Detection in Non Leptonic Decay Modes

A large number of charmed baryons are expected to be produced in the quasi elastic channel, e.g. $\nu_\mu + n \rightarrow C_o^+ + \mu^-$, by neutrinos in the 10 to 30 GeV energy region.

Isolating these events from all others will be enhanced considerably by using the plates as a γ-ray veto.

C. Neutral Currents

One of the important comparisons not yet carried out is the relation between neutral current interactions with neutrons compared to protons. The plates can improve the determination of the physical parameters of neutral currents (x, y, E_ν).

D. Flux Normalization

The reaction $\nu_\mu + n \rightarrow p\mu^-$ can be used for neutron flux normalization. The plates, when used as a veto for γ-rays, can

TABLE I. Neutrino + Deuterium Event Rates

Reaction	Events* in 300K Pictures at 400 GeV/c
$\nu_\mu p \to \mu^- X$	12,000
$\nu_\mu n \to \mu^- X$	23,000
$\nu_\mu p \to \nu_\mu X$	2,800
$\nu_\mu n \to \nu_\mu X$	2,800
$\nu_\mu \begin{pmatrix} p \\ n \end{pmatrix} \to \Lambda^o$(Visible)X	1,500
$\nu_\mu \begin{pmatrix} p \\ n \end{pmatrix} \to K_s^o$(Visible)X	1,500
$\nu_\mu \begin{pmatrix} n \\ p \end{pmatrix} \to \mu^-$ + charm	1,700
$\nu_\mu p \to \mu^- e^+ X$	130
$\nu_\mu n \to \mu^- e^+ X$	260
$\nu_\mu n \to \mu^- p$	750
$\nu_\mu p \to \mu^- p\pi^+$	900
$\nu_\mu n \to \mu^- p\pi^o$, $\mu^- n\pi^+$	750
Total ν_μ + D	48,350

*We assume 1.3×10^{13} p/pulse assuming the upstream 2/3 of a chamber as fiducial volume, and $(\Sigma p_x) \geq 9$ GeV (5 GeV) for charged (neutral) current events.

help separate this channel from background channels such as $\nu_\mu + n \rightarrow p\mu^- \pi^o$.

E. Search for New Flavors, and for Production of Old Flavors by Neutral Currents.

III. COMMENTS ON PLATE ARRANGEMENT

The plates described in this proposal have the advantages described above in a large fraction of the events, but not in all (e.g. the efficiency for gamma ray conversion is approximately 65%). It would clearly be possible to increase the efficiency for this analysis by adding more plates, as has been proposed by others. We rejected this possibility since we feel it would compromise the ability to analyse the events. Cascading of electron and hadron interactions will obscure the tracks of charged particles and the origin of neutral decays. It will reduce the precision and reliability of measurement of charged particles and thus the mass resolution. It would have a major reduction in effective volume since it is necessary to remove from the fiducial volume a region large enough to allow the charged tracks to be resolved and to be sure that the neutrals do not trace back to the vertex.