Fermi National Accelerator Laboratory

FERMILAB-Conf-92/62

The 17 keV Neutrino and Neutrino Tagging

R. Bernstein

Fermi National Accelerator Laboratory
P.O. Box 500, Batavia, Illinois 60510

February 1992

Presented at the *Long-Baseline Neutrino Oscillation Workshop*, Batavia, Illinois, November 17-20, 1991.

Operated by Universities Research Association Inc. under Contract No. DE-AC02-76CHO3000 with the United States Department of Energy

Disclaimer

The 17 keV Neutrino and Neutrino Tagging

R. H. Bernstein

Fermi National Accelerator Laboratory, P.O. Box 500, Batavia, Illinois 60510 †

P–788 at FNAL proposed to search for neutrino oscillations in a tagged neutrino line.[1] A K_L beam and the decay modes $K_L \to \pi\mu\nu_\mu$ and $K_L \to \pi e\nu_e$ provides the neutrino flux. An upstream tagging spectrometer then identifies the hadron and lepton and reconstructs the K_L decay; the lepton identification will specifies the neutrino as ν_e or ν_μ and distinguishes ν from $\bar{\nu}$ at the decay vertex. A neutrino detector modeled after an existing deep-inelastic scattering spectrometer (rates have been worked out for the CCFR apparatus) can be used to associate the K_L with a neutrino interaction, measure the neutrino energy, and analyze outgoing muons. Monte Carlo studies show that 30K ν_e and 20K ν_μ could be obtained in two fixed target runs at the Tevatron.

The experiment will significantly improve existing oscillation limits, but it is especially sensitive to $\nu_e \to \nu_\tau$ oscillations. By searching for $\nu_\tau N \to \tau X, \tau \to \mu\nu\nu$ we may use the easy-to-identify muon as a signal for oscillations. In conventional accelerator-based experiments in ν_μ beams, we search for $\nu_\mu \to \nu_e$ and $\nu_\mu \to \nu_\tau$, and (1) the absence of a muon or (2) the presence of an electron, signals oscillations. Either conventional method poses formidable systematic barriers to a conclusive discovery. The tagging experiment could search to $\sin^2 2\theta \approx 2 \times 10^{-3}$ at 90% CL before backgrounds became significant, a factor of seventy better than existing limits. Constraining the pion and lepton to come from a K_L decay provides a prediction of the neutrino impact point and energy, which can be compared to the measured values in the neutrino detector. The backgrounds at the neutrino vertex are well understood after years of deep-inelastic scattering experiments at the Tevatron.

I show two Figures here, from P–788. The first is a crude schematic of the apparatus; the second shows the oscillation limits worked out in P–788. The rates discussed in the Proposal are approximately those expected by the Tevatron K_L program[2]; hence that detector could be used as a tagger. A first generation ($\approx$ 200 ton) detector mounted downstream could prove the tagging concept works and discover or rule out the 17 keV neutrino (assumed to be the ν_τ) at $\sin^2 2\theta > 1 \times 10^{-3}$.[3] By studying $\sigma(\nu_e)/\sigma(\nu_\mu)$ as a function of E_ν, we could check for oscillations of ν_e into sterile neutrinos.

It is worth pointing out that a tagged neutrino line would provide a unique handle on a variety of fundamental questions. The ratio of ν_e to ν_μ cross-sections would be measured to better than 1%, and a number of new electroweak tests could be performed.[4] In any case, a tagged neutrino beam would be the world's first copious, clean source of high-energy ν_e. This experiment, mounted at the 900 GeV Tevatron or at the 120 GeV Main Injector, would provide the first look at a new type of physics.

† Based on talk presented at Long-Baseline Neutrino Oscillation Workshop, Batavia IL 17–20 November 1991.

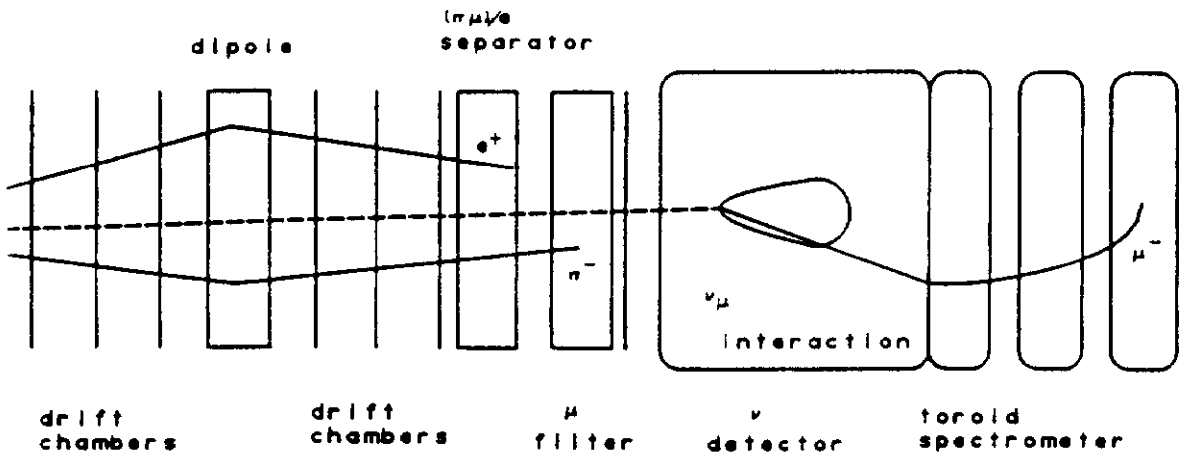

Figure 1: A schematic of a neutrino tagger (not to scale). The beam direction is from the left. A $Ke3$ decay is pictured in the tagger, with the π and e identified and momentum analyzed. The ν_e oscillated into a ν_μ or ν_τ, which produced a muon at the primary vertex.

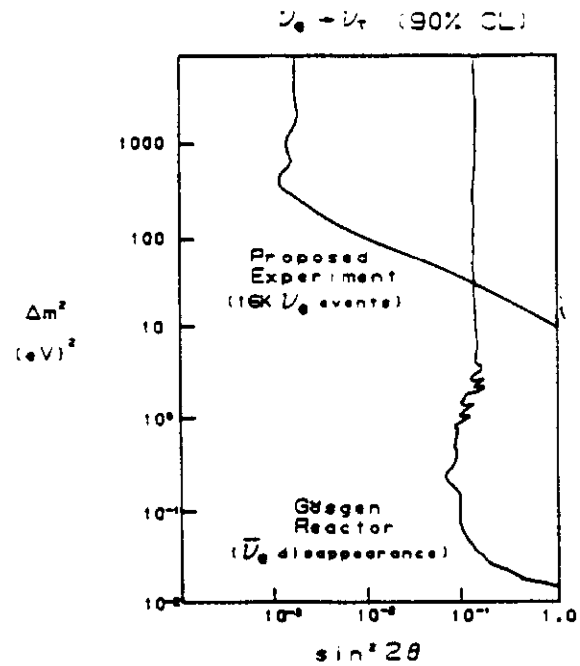

Figure 2: $\nu_e \rightarrow \nu_\tau$ limits compared to existing limits. All cuts have been applied in determining the statistics and spectrum.

References

[1] A Proposal for a Neutrino Oscillation Experiment in a Tagged Neutrino Line, P–788, September 1988 and references therein.

[2] FNAL P–832; also see Conceptual Design Report: Kaons at the Main Injector, FNAL (unpublished), 1991.

[3] See both F. Calabrese and A. Hime, these Proceedings.

[4] R. Bernstein, "A New Method of Determining $\sin^2\theta_W$ in Deep-Inelastic $\nu_\mu N$ Scattering," Proceedings of the Workshop on Weak Interactions and Neutrinos, Ginosar, Israel (1989). Published in Nucl.Phys. **B13** (1990) 335.