SEARCH FOR NEUTRINO OSCILLATIONS AND TEST OF THE STANDARD MODEL OF ELECTRO-WEAK INTERACTIONS USING THE PROPOSED ORLaND NEUTRINO DETECTOR

T. Awes, V. Cianciolo, Y. Efremenko, Yu. Kamyshkov,* A. Mezzacappa, F. Plasil*

The study of neutrino properties is one of the most important probes of possible physics beyond the Standard Model. Searching for the effects of neutrino mass and flavor mixing, the determination of the Dirac or Majorana character of neutrinos, searching for the neutrino magnetic moment, and accurate measurement of neutrino-nuclear cross sections all have a potentially significant impact on particle physics, astrophysics, and cosmology.

The recent excitement over the potential discovery of $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ flavor oscillations by the Liquid Scintillator Neutrino Detector (LSND) at Los Alamos [1], and the recent report of evidence for $\nu_\mu \rightarrow \nu_\tau$ oscillations by the Super Kamiokande Collaboration [2] provide strong motivation for new, next-generation experiments.

The ORLaND Collaboration [3, 4] proposes to build a neutrino facility in an underground experimental hall next to the first Spallation Neutron Source (SNS) [5] target station at the Oak Ridge National Laboratory (ORNL). The new neutrino facility will provide space for several neutrino detectors (one large and one or two small detectors are envisaged) which can be built and run by independent groups and which can address a broad range of neutrino physics from neutrino oscillations and tests of the Standard Model, to neutrino processes relevant for nuclear physics and astrophysics.

As a first task we propose to search for $\bar{\nu}_\mu \rightarrow \bar{\nu}_e$ neutrino oscillations with neutrinos from pion and muon decays at rest (DAR) in the large 2-kton liquid scintillator ORLaND detector. This will provide a check of the LSND effect and either precisely determine the oscillation parameters (using two neutrino sources from two spallation targets with the same detector) or to extend the mixing angle sensitivity to the ultimate level achievable in accelerator experiments.

Figure 1 shows the discovery potential limits of the proposed SNS-based neutrino detector in oscillation-parameter space Δm^2 vs $sin^2 2\theta$. We calculated the limits assuming the signal to background excess of 3σ. We also assumed three years of data-taking with an efficiency of 40%. The two lines represent two distances between the detector and the first and second target stations. We assume that the first target will run with intensity corresponding to 2 MW power on the target and the second one with 1 MW. Also shown in the same figure is the oscillation-parameter region allowed by LSND results [6] and 90% CL exclusion regions from Bugey and BNL E776 experiments [7, 8]. The ORLaND detector will not only completely cover the entire region where LSND indicates an oscillation effect but will probe a significantly larger area of possible mixing parameter space.

Furthermore, the ORLaND detector will also be capable of making a precise measurement of $\sin^2\theta_W$ with neutrino-electron scattering at intermediate energies, of searching for the effects of a nonzero magnetic moment of the muon neutrino, of searching for CP violation, and of investigating the evidence for an anomalous

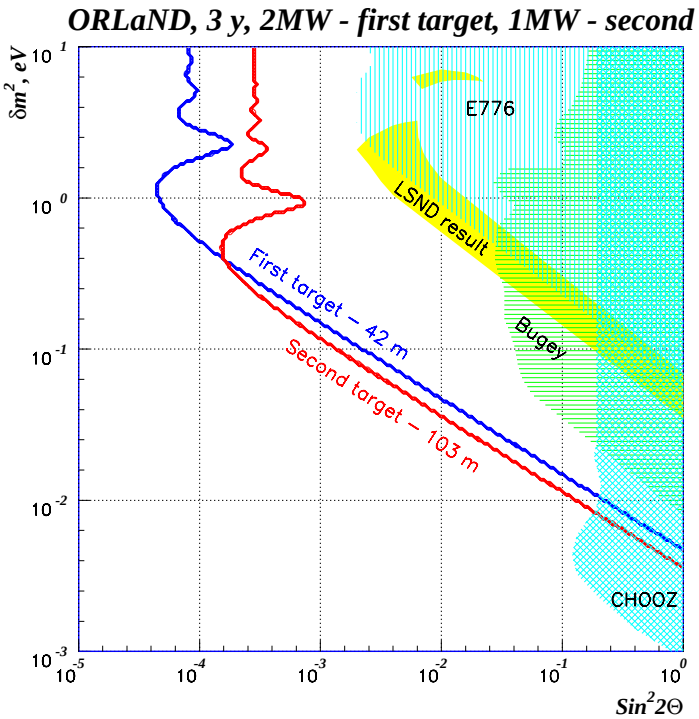

Figure 1: ORLaND discovery potential for three years of data-taking.

particle with a long mean lifetime and a mass of 33.9 MeV, [9, 10] presumably from a new, rare decay mode $\pi^+ \to \mu^+ x$ as indicated by the KARMEN Collaboration .

Small neutrino detectors can be built in a segmented way which allows the insertion of different target materials into the detector for accurate measurements of νA cross sections (relevant for astrophysics), as well as for measurements of the neutrino interactions leading to specific final states of the nuclei.

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* Guest assignee, University of Tennessee, Knoxville.

[1] C. Athanassopoulos et al., *Phys. Rev. Lett.* **81**, 1774 (1998).

[2] Y. Fukuda et al., *Phys. Lett. B* **433**, 9 (1998).

[3] W. Bugg et al., *Prospects for a Neutrino Oscillation Experiment at the National Spallation Neutron Source*, in Proceedings of the 6th Conference on the Intersections of Particle and Nuclear Physics, Big Sky, Montana (1997).

[4] B. D. Anderson, F. Avignone et al., *A Large Neutrino Detector Facility at the Spallation Neutron Source in Oak Ridge National Laboratory*, Proposal to U.S. Department of Energy (in preparation).

[5] The NSNS Collaboration, May 1997, National Spallation Neutron Source *Conceptual Design Report*, Vol. 1 and 2, ORNL, Oak Ridge, Tennessee.

[6] C. Athanassopoulos et al., *Phys. Rev. Lett.* **77**, 3082 (1996).

[7] B. Achkar et al., *Nucl. Phys. B* **434**, 503 (1995).

[8] L. Borodovsky et al., *Phys. Rev. Lett.* **68**, 274 (1992).

[9] B. Armbruster et al., *Phys. Lett. B* **348**, 19 (1995).

[10] V. Barger, R.J.N. Phillips, and S. Sarkar, *Phys. Lett. B* **352**, 365 (1995).