LANNDD – Liquid Argon Neutrino and Nucleon Decay Detector

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A large (≈ 100 kton) liquid argon detector is proposed to study neutrino mixing in long baseline neutrino beams (Question 2 of the NRC CPU [1]), and to search for nucleon decay with excellent sensitivity to the mode $p \to K^+\bar{\nu}$ (Question 5 [1]). The detector would also have good sensitivity to supernovae neutrinos (Question 11 [1]).

The concept of the LANNDD has been sketched in [2, 3], and is featured in a recent Letter of Intent to Brookhaven National Laboratory [4].

A liquid argon detector is the best choice for the next generation of neutrino mixing physics, in which the oscillation $\nu_\mu \to \nu_e$ provides an "appearance" that depends on $\sin^2 2\theta_{13}$ of the MNS mixing matrix, because of the ability of the detector to reject backgrounds from neutral current interactions. A recent study [5] indicates that a liquid argon detector is 10 times as sensitive, per unit mass, as a water Čerenkov detector for background-limited measurements. Also, a liquid argon detector has full sensitivity to the proton decay $p \to K^+\bar{\nu}$ [6], which produces no Čerenkov light to first order.

The LANNDD would perform well with accelerator neutrino beams even if it were located at the surface of the Earth. For proton decay and neutrino astrophysics it should be sited at least $1500'$ deep. Good accelerator physics could be done with LANNDD if it were sited at an underground laboratory at the proposed NSF NUSL, or at the DOE WIPP, but a more

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productive program is possible if the detector is closer to the accelerator [4], *i.e.*, if it is sited closer to BNL or FNAL.

A 300-ton liquid argon detector is now operational [7]. The highest performance of LANNDD would be obtained if it were immersed in a magnetic field, for which R&D has been proposed [8]. Safe operation of a large liquid argon detector in an underground laboratory also requires further study [9].

A nonmagnetic LANNDD would cost roughly $1.5-2M per kton for masses over 10 kton. The cost of an underground site is dependent on local geology and the amount of existing infrastructure, but could easily be half again the cost of the detector. High performance accelerator-based neutrino beams require proton driver upgrades, target stations and decay tunnels at costs of $100-200M for 1-4 MW proton sources.

The quickest path to competitive neutrino physics with a LANNDD would be to build a 10-20 kton device in Wisconsin, in an off-axis NUMI beam. Later phases would emphasize a larger detector for proton decay, as well as upgraded neutrinos beams from BNL and/or FNAL.

References

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