

LArIAT Liquid Argon In A Testbeam

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For the LArIAT collaboration

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Liquid Argon Time Projection Chambers (LArTPCs) are now being developed as the detector technology of choice for high precision neutrino physics at short and long baselines. The ICARUS collaboration pioneered LArTPC technology in Europe. Interest in LArTPCs in the US has grown recently, starting with the Argoneut LArTPC experiment, which ran in the NuMI beamline at Fermilab in 2009 and is now producing physics results, and followed by MicroBooNE, which is currently under construction and scheduled to begin running in 2014. LBNE has also made a technology choice to use an LArTPC for the far detector design.

Detailed study and calibration of these detectors is a critical step to understanding the output response of LArTPCs; it is required for a range of energies ($\mathcal{O}(0.2 - 2)$ GeV) relevant to upcoming experiments like MicroBooNE, and future experiments such as LAr1 and long-baseline LAr experiments at the Intensity Frontier. The Fermilab Test Beam Facility (FTBF) is the ideal place to do these studies, providing beams of not only a range of known energies, but also a selection of different particle types. A test beam also provides a controlled environment in which to tune simulations and to develop tools for particle identification (PID), calorimetry, and event reconstruction without relying solely on simulation.

We are proposing a two phased program to fully characterize the response of LArTPCs. Phase-I will use a modified Argoneut detector and will focus on the determination of the charge recombination factors and the impact of charge recombination on particle identification through dE/dx measurements for a variety of different particles, including protons, kaons, pions, and muons. Additionally, the direct experimental measurement of electron/photon separation will be crucial input to MicroBooNE in addressing its primary physics goal of understanding the MiniBooNE low energy excess. Phase-I has been approved by the DOE. The cryostat is now being modified to have a window to admit the incoming beam with minimal scattering and to add a PMT based light detection system. Upgrades to the argon filtration system, the DAQ system, and readout electronics are also under study or underway.

In Phase-II, a larger LArTPC will be used to expand on the Phase-I program by containing particle showers in both the transverse and longitudinal directions. Reconstruction of collective topologies (as opposed to single tracks) will permit the precise calibration of detected energy to incident energy as well as the characterization of the size and features of electromagnetic and hadronic showers. This will include studies of $e \rightarrow$ EM showers and the contribution of soft gammas down to low energy thresholds, $\pi \rightarrow$ hadronic showers and the “invisible” components which would bias a calorimetric energy reconstruction, and determination of the e/π ratio in LAr. The possibility of developing “TPC/imaging-aided calorimetric measurements” may provide a new method for investigating energy deposition mechanisms at an unprecedented level of detail. We plan that the project tasks will be divided to play to the strengths of the national labs (beam and cryogenics) and university groups (detector systems).

The entire program is based on the availability and semi-permanent use of a pure low momentum tertiary beam of muons, pions, kaons, and protons (both signs) at the FTBF in the M-Center beamline. This tertiary beam is now being designed. An experimental area with cryogenic infrastructure is also needed and is under design and procurement. This area will have the flexibility and versatility to provide a long term testing ground for LAr detector subsystems for future experiments. Possible R&D topics include: cold readout electronics for signal-to-noise optimization, new designs of wire plane assemblies, electron charge drift over longer distance, scintillation light detection and signal extraction techniques, and cryostat insulation schemes.