SLAM

Small Liquid Argon Module

Version 1.0

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Executive summary

We propose to construct a small liquid argon detector in a surface MINOS building. The detector will be a reuse of the 10 m^3 ICARUS prototype modifed to enable longer drift distance and placed in a newly constructed cryogenic vessel equipped with industrial purification system.

Such a setup placed in the large angle component of the NuMI neutrino beam offers a possibility of a wide range of physics, instrumentation and technological studies.

0.1 Motivation

ICARUS program has established the technology of liquid argon imaging detectors. Whereas its further exploitation for very large neutrino detectors will take full advantage of many od the technical solutions demonstrated by the ICARUS T600 module [1] there are several important new elements related to the scale of new applications.

Large detectors are utilizing commercial cryogenic storage tanks to house the detectors. Such a large scale introduces several potential problems with attaining the required argon purity. They may be related to the surface and surface treatments of the commercial storage tanks as well as to the fact that such tanks cannot be evacuated, as it is a standard procedure for ICARUS modules. While several plausible solutons exist, their practical demonstration would be an important factor.

Large storage vessels with the walls being a dominant heat source have thermal conitions very different from the ICARUS cryostats with active cooling of the vessels walls. This may lead to very different flow patterns, potentially affecting the stability of the detector. Large storage vessels may also present different stability problems related to a large volume of superheated liquid. Possible nucleation initiated on the walls of the vessel or on the detector elements can lead to major instabilities. Studies of these problems in medium size vessels may provide an insight and/or a verification of theoretical calculations.

Physics potential of the liquid argon imaging detector for the ν_e appearance oscillation experiment experiment is primarily due to the expected high efficiency of the identification of the ν_e CC interactions. This is expectations are motivated by the detailed simulation and rudimentary reconstruction studies, but they would be far more convincing if confirmed by the experimental results. An exposure to a test beam of ν_e's would be of particular interest.

Physics of low energy neutrino interactions is relatively poorly understood, primarily for lack of relevant data. This shortcoming is becoming an limiting factor in the studies of neutrino oscillations, especially in case of the atmospheric neutrinos. An exposure of an imaging detector to the low energy neutrino beam would lead to a significcant progress in verification of the neutrino interaction event generators.

Large liquid argon detectors operating on the surface will be exposed to an intense flux of cosmic rays. High granularity detectors, such a liquid argon TPC, will, therefore, generate a very large quantities of data. Various methods of data processing and reduction can be envisaged, but an experimental demonstration of the data acquistion and subsequent reduction would be very valuable.

Large liquid argon detector operating on the surface has a potential for studies of rare processes, like supernova explosions and/or proton decay. This potential may be reduced by cosmc ray induced backgrounds: muon induced production of long lived spallation products for the supernova search and neutral kaon induced production of single charged kaon for the proton decay search. While a modest size detector cannot demonstrate that the background rates are sufficiently low to enable such searches in a large surface detector, it can provide measurements of the relevant incoming fluxes, for example neutral kaons.

Large off-axis liquid argon detector will employ detectors similar, but different from the ICARUS modules. Wire spacing may be different, construction techniques will be different, high speed data acquisition may be desirable, progress in electronics may permit even better architecture or implementation of the front end electronics. A properly designed and constructed SLAM detector will provide a testing ground for an adiabatic transition from ICARUS to FLARE detector and for testing different detector components.

0.2 Overview

ICARUS collaboration has constructed an engineering prototype to demonstrate feasibility and expected performance of the T600 detector. This protype, T10 [2], consisted of the time projection chamber with an active area of $2.0 \times 3.26\ m^2$ and the drift space of 35 cm. After the succesful tests in Pavia and CNGS this prototype has not been in use, as it has been superseeded by the newly constructed T600 module. At present it is being upgraded by addition of field shaping electrodes to enlarge the drift space to 2 m hence yielding a detector with an active volume of 13 m^3.

NuMI neutrino beam is in operation since early spring of 2005. It is directed towards MINOS detectors, far and near. MINOS service building is located downstream of the decay pipe, some 100 meters above the beam line. Off-axis component of the NuMI beam offers a significant neutrino flux in the service building, as shown in Fig. 0.2: one expects almost 500 events a year per ton of the target mass. The ν_μ spectrum exhibts two peaks from kaon and pions decays, the former in the energy range very similar to the proposed NuMI off-axis experiments.

In addition to the ν_μ flux there is a significant ν_e component of the beam with energies between 1 and 2 GeV offering an opportunity to test the electron identification capability of the detector.

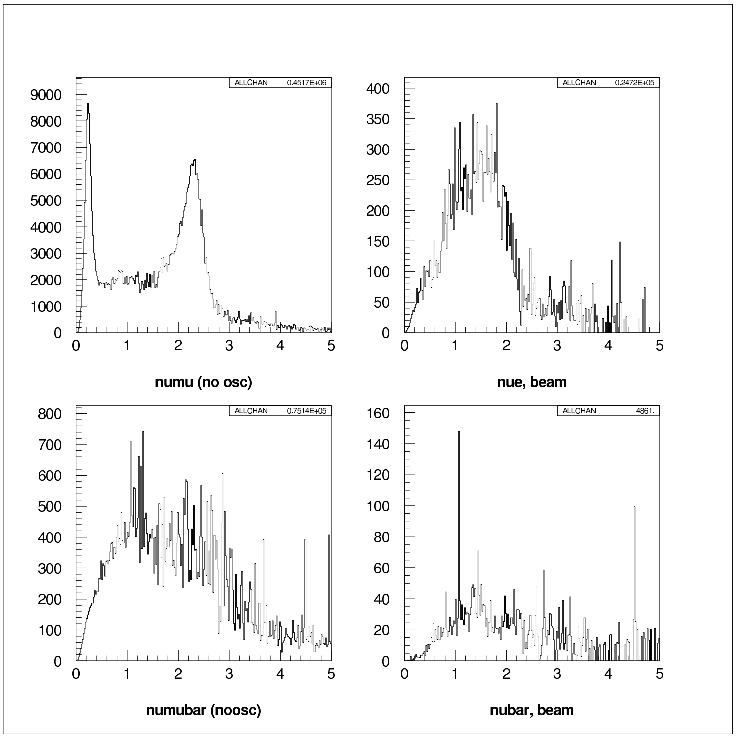

Figure 1: Expected event rates (per kton per year in a detector located in the MINOS service building) of different components of the NuMI beam, low energy version: top left - ν_μ, top right ν_e, bottom left $\bar{\nu}_\mu$, bottom right $\bar{\nu}_e$.

Bibliography

[1] S. Amerio *et al. Design, construction and tests of the ICARUS T600 detector, Nucl. Inst. Meth. A, 527 (2004), 329-410.*

[2] F. Arneodo et al, 'Performance of the 10 m^3 *ICARUS liquid argon prototype', NIM A 498 (2003) 292*