Status of the ICARUS Project

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Abstract

The ICARUS detector is based on the Liquid Argon Time Projection Chamber (LAr TPC) technology, that combines the detection features of a bubble chamber with the advantage of the electronic read-out. The feasibility of large mass LAr TPC has been demonstrated by a full scale 600 ton module (T600), tested in 2001 at surface conditions. The ongoing data analysis confirms that the excellent detector performance observed in small scale prototypes are fully preserved in the 600 ton detector.

The way to the ICARUS design goal, 3000 tons of liquid Argon in the Gran Sasso underground Laboratory, is open.

The ICARUS unique imaging and calorimetric capabilities will allow for a rich physics program, covering atmospheric, solar and supernova neutrinos, nucleon decay and LBL neutrino oscillations.

1. Introduction

The final phase of the ICARUS project requires a sensitive mass of liquid Argon of 3000 tons or more, to be placed in the Gran Sasso underground laboratory. It will allow for low-background, low systematics studies in atmospheric, solar and long baseline (CNGS) neutrino physics, Supernova detection, and nucleon decay searches. This goal will be reached in a modular way, and the first step in this direction is the T600 detector.

The realization of the T600 followed ten years of an extensive R&D programme and five years of studies with several prototypes of increasing mass. A full test has been carried out in Pavia during 2001. The detector is now ready to be transported at Gran Sasso.

The ICARUS T600 detector, has its own physics program, as detailed in [1].It will provide an observation of atmospheric neutrinos of very high quality. The detection threshold, as low as the kinematic one, will allow to explore the low energy part of the ν flux (about 50 % of the expected 100 ev/year). The detection of all reaction products will improve the reconstruction of the ν direction, and the identification of NC events will allow for an "indirect" ν_τ search. A supernova

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Fig. 1. Picture of the inner T600 detector.

collapse at 10 kpc would be detected as a burst of about 40 events in 10 seconds, with no background. The verification of predicted background levels and detector efficiences for nucleon decay searches will also be of utmost importance.

2. Detector description

The operational principle of the LAr TPC [5]is based on the fact that in highly purified LAr (less than 0.1 part per billion O_2 equivalent) ionization tracks can be transported practically undistorted by a uniform electric field over distances of meters. Imaging is then provided by an appropriate set of electrodes (wires) continuously sensing and recording the signals.

ICARUS T600 (Fig. 1) is a large cryostat split in two identical, adjacent half-modules, each one with internal dimensions 3.6 m width $\times$ 3.9 m height $\times$ 19.9 length. The internal structure of each half-module consists of two TPCs separated by a common cathode. Each TPC is made of three parallel planes of wires, 3 mm apart, oriented at 60 degrees with respect to each other, with a pitch of 3 mm between adjacent wires. At the nominal electric field of 500 V/cm, the maximum drift time is about 1 ms.

The total number of wires in the T600 detector is about 55,000. The read-out of the signals induced by ionizing particles in LAr on the TPC wires allows a full 3D-image reconstruction of the event topology.

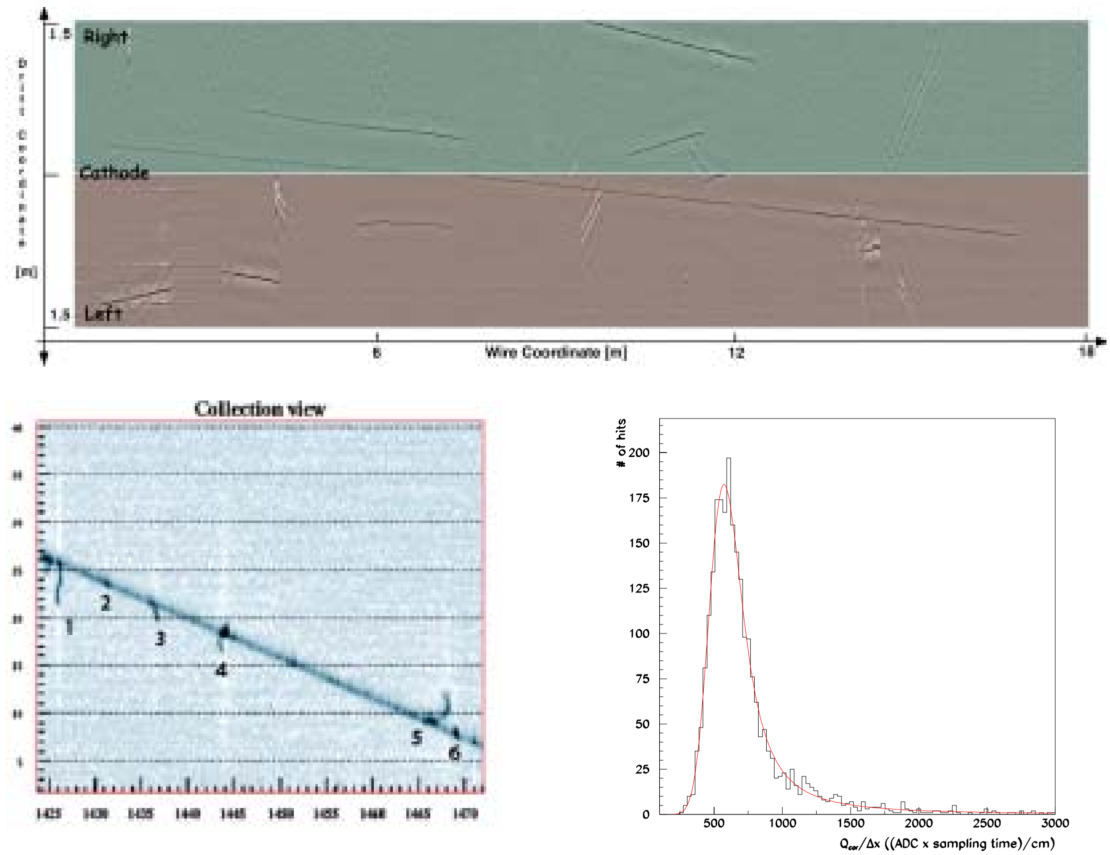

Fig. 2. Top: Event display of a long muon track; Bottom left: zoom with δ rays, Bottom right: reconstructed dE/dx (from [3])

Ionization in LAr is accompanied by scintillation light emission. This light is detected by large-surface (8") PMT's immersed in the LAr and can provide an absolute time measurement of the event and an internal trigger signal.

ICARUS T3000 will be composed of the T600, of two T1200 modules, and of a muon spectrometer [2].The full project has been recently approved by INFN and CERN, and the T3000 is planned to be commissioned for the first CNGS ν beam events, in mid 2006.

3. Test run data

One half of the T600 has been fully equipped and tested in non-underground conditions, in Pavia. All technical aspects of the system, cryogenics, LAr purification, read-out chambers, detection of LAr scintillation light, electronics and DAQ have been tested and performed as expected. During the data-taking period about 30'000 events were collected, both with external and internal triggers.

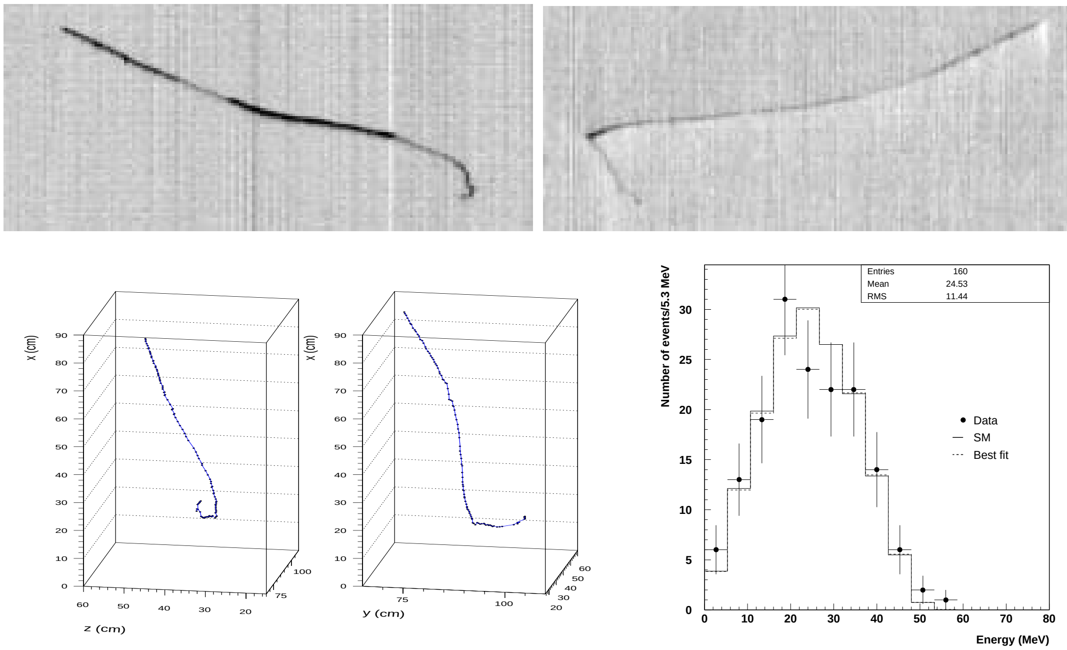

Fig. 3. Top: 2-D views of a stopping muon event, bottom left:result of the 3–D software reconstruction, bottom right: **preliminary** spectrum of Michel electrons.

The data confirmed the feasibility of high quality imaging on large scale. For instance, dE/dx, multiple scattering and δ rays can be studied on μ tracks as long as 20 m (see Fig. 2), and the Michel electron spectrum is well reproduced from the stopping muon events sample [4](Fig. 3).

4. Conclusions

The successful test of the ICARUS T600 detector confirms the maturity of the LAr TPC technique and its superior performance for astro-particle and rare events physics.

5. References

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