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A local trigger system for the large LAr-TPC detector

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Summary. — A special dedicated double-rebinning algorithm has been successfully developed in order to extract the physical hit signal from the TPC wires. This solution has been implemented on digital boards, allowing to realize a local trigger able to identify even localized low-energy small events.

PACS 07.05.Hd – Data acquisition: hardware and software.
PACS 07.50.Qx – Signal processing electronics.

1. – LAr-TPC: a technology for imaging detectors

A suitable technology for the detection of rare events, especially concerning neutrino oscillations and p-decay search, is that of the LAr-TPC (Liquid Argon TPC), thanks to its high energy resolution and completely uniform and redundant 3D imaging.

The ICARUS-T600 detector at LNGS, in final commissioning after more than 20 years of R&D, is the first underground large mass LAr-TPC, whose start-up represents an important test of the Liquid-Argon technology towards the realization of any much larger LAr-TPC detectors.

2. – DR-slw algorithm. Implementation on FPGA

A key feature of the trigger system for a LAr-TPC detector, especially in case of huge mass, is the capability of localizing the Region of Interest (R.o.I.) of the event, in order to reduce the amount of data to be stored. The PMT signal is not suitable for this purpose, since the LAr is transparent to scintillation light; on the other side, the TPC wire signal is optimal, since it allows for a good segmentation of the detector.

A special dedicated double-rebinning algorithm (DR-slw) has been successfully developed in order to extract the physical hit signal on the single wire, even in case of critical noise patterns consisting of a high-frequency component overlapped to a low-frequency one. A short and a long rebinning are performed on the single wire averaging over 8 and

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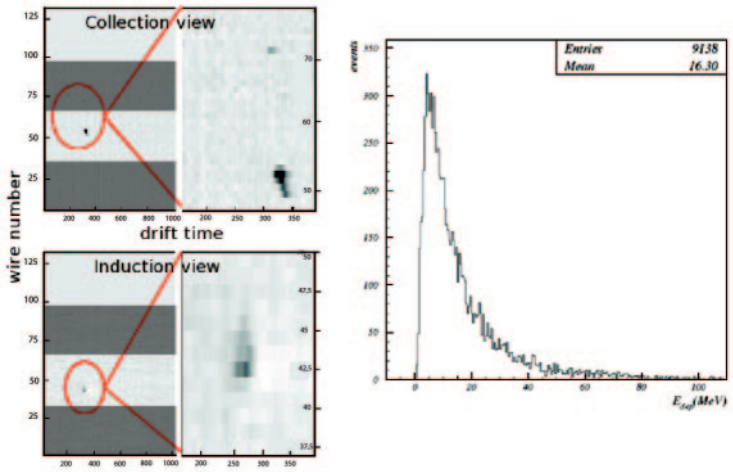

Fig. 1. – Example (left) and distribution of the energy deposition (right) of low-energy localized events collected with internal trigger configuration based on the GTO signal from the central board.

128 t-samples, respectively (1 t-sample = 400 ns). The signal is then calculated as a difference, and a hit is identified if it stays over a given threshold Q_{thr} for at least 3 t-samples.

The DR-slw solution has been implemented on FPGA (chip Super-Daedalus) installed on digital boards. Each board handles 32 channels, treating each one of them with the DR-slw algorithm, and gives as an output a GTO (Global Trigger Out) signal obtained imposing a majority level M.

3. – Test and results

The performance of this solution has been investigated exposing the test-facility Icarino at LNL to cosmic rays. It consists of a 120 l LAr dewar containing a $29.4 \times 29.4 \times 31.8\,\mathrm{cm}^3$ TPC working with a $\sim 0.5\,\mathrm{kV/cm}$ uniform electric field. The DAQ setup is *à la* ICARUS. $50\,\mathrm{cm}^2$ plastic scintillation counters are properly positioned in order to collect, with an external trigger system, through-going muon tracks parallel to the wire planes or with a 45° inclination. Data have been collected in a 15 days long test-run in December 2009, with over 52000 recorded events.

Tests have been performed with the external trigger system, in order to study the Super-Daedalus chip performance, both on the single wire and on the whole board, using different signal discrimination threshold Q_{thr} and majority M values. The collected data showed an overall full detection efficiency ($\epsilon \sim 100\%$) associated to a negligible fake frequency ($\leq 0.1\%$) both for parallel and inclined tracks.

Furthermore a dedicated internal trigger configuration, based on the GTO signals only from one board (the central one), was set up in order to collect low-energy localized events (fig. 1, left). The system was able to recognize isolated events (γ-rays and neutrons) down to a fraction of MeV energy deposition (fig. 1, right).

The results are extremely positive for both the algorithm and its hardware implementation. The employment of this kind of internal trigger system in ICARUS-T600 and in forthcoming experiments using huge LAr-TPC detectors is thus envisaged.