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Status of the Data Acquisition System and Slow Control for the JRA2 TPC test beam infrastructure

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Abstract

A large Time Projection Chamber (TPC) is proposed as part of the tracking system for a detector at the future electron positron linear collider. The Linear Collider TPC (LCTPC) Collaboration is currently building a large TPC prototype (60 cm long, with an outer radius of 77 cm), offering some modularity to investigate various gas amplification systems (GEM or Micromegas), pad sizes and geometries as well as different read-out systems. Detector technologies based on silicium will also be investigated. In this memo, we present the read-out systems that will be used with gas detectors for this large prototype, the connection to the EUDET central data acquisition system as well as the slowcontrol.

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1 Introduction

The detector at the future linear electron-positron collider ILC (International Linear Collider) will include a high precision tracking device with a track momentum resolution of $\delta p_t/p_t^2 \sim 5.0\ 10^{-5}$ GeV^{-1}c^{-1}. A large Time Projection Chamber (TPC) is a candidate for the central tracker system. Within the EUDET framework, a field-cage for a large prototype TPC (LP-TPC), 60 cm long, with an outer radius of 77 cm has been built [1] and installed in the 6 GeV electron test beam area of DESY in October 2008. This research infrastructure offers modularity to investigate various TPC endplate amplification systems, pad sizes and geometries as well as different readout systems.
Among other possibilities, a readout system based on the ALTRO (“ALICE TPC Read Out) electronic used in the ALICE experiment at LHC [2], as well as a readout system based on the AFTER (“ASIC For TPC Electronic Readout) electronic of the T2K experiment electronic [3] have been developed. They both need to be interfaced to the EUDET Trigger Logic Unit (TLU) [4], which provides a common trigger source and an event synchronization mechanism to all subdetectors under test beams, as well as to the EUDET central data acquisition system.

2 ALTRO readout electronic

Several modifications with respect to the original ALICE TPC readout which are described in this note have been necessary to adapt it to the expected output signals from the gas amplification systems. These modifications include a new programmable charge amplifier. The schematic layout of the system is shown in Fig. 1. One complication

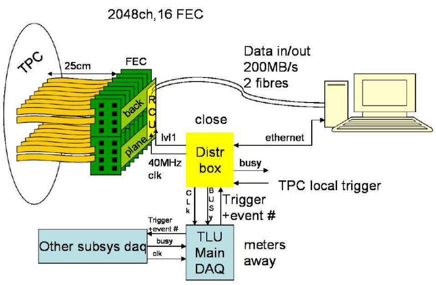

Figure 1: Schematic Layout of the ALTRO based LCTPC DAQ.

is given by the fact that the effective area occupied by the front-end card (FEC) per channel is significantly larger than the smallest pad size to be investigated, which is 1×4 mm^2. Therefore the FECs cannot be attached directly to the pad plane, but have to be connected via 25 cm long kapton cables. The FECs contain the programmable charge amplifier ASIC PCA16 as well as a modified version of the ALTRO chip [2], based on the 130 nm technology, to digitize with a sampling rate of up to 40 MHz the preamplifier output signal.

The FECs are placed on a backplane together with a Readout Control Unit (RCU) used to control the readout. The data are sent through an 200MB/s optical link to a 64-bit PCI card, called Detector Read Out Card (DRORC) and located in a PC. The readout software is based on the ALICE system but it has been modified and extended, while the control software is entirely new for this TPC application.

2.1 The charge sensitive preamplifier

The specifications of the newly developed PCA16 programmable charge preamplifier are the following:

- 1.5 V supply; low power consumption, < 8 mW/channel
- 16 channels charge amplifier + anti-aliasing filter
- single ended preamplifier
- fully differential output amplifier
- operated with both signal polarities
- power down mode with a wake-up time of 1 ms
- programmable peaking time between 30 and 120 ns
- programmable gain in four steps between 12 to 27 mV/fC
- tunable decay time constant

The final PCA16 chip was delivered at the end of 2007. It has a silicon area of 6 mm^2 with 94 pins in total. Out of these, there are 16 input pins and 32 output pins for the differential pulses. The remaining pins are for grounding and voltage supply, and 9 pins are used to set the programmable parameters of the chip. To control the PCA16, the Board Controller FPGA on the FEC is used to set an octal Digital to Analog Converter (DAC), which defines the decay time of the preamplifier output. An 8-bit shift register provides the digital input to the PCA16 in order to set the rise time, the gain, the polarity and to bypass the shaping function. To include these new functions (with respect to the ALICE version) the FPGA had to be reprogrammed.

2.2 The Front End Card

The ALTRO chip has been designed for the ALICE TPC to be operated at 10 MHz, with a 10 bit resolution. The ALTRO chip offers a large flexibility and can be used as a general purpose AD-Converter for a multi-channel system. A modified version with 40 MHz sampling rate has been developed, providing a resolution corresponding to an effective number of bits equal to 9.5. These are intended to be used by the LCTPC.

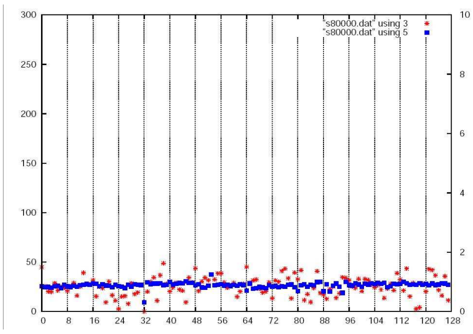

Figure 2: RMS noise (in blue) as a function of the pad number of the small TPC prototype.

2.3 The data acquisition system

Since the FECs are designed to receive the LHC clock, an additional card, called distribution box [5], has been developed in order to send the trigger signals and the clock to the FECs. The trigger signals can be received from local triggers when the TPC is operated in a stand-alone mode, or from the central Trigger Logic Unit (TLU)[4] when the TPC is tested with other subdetectors in a common test beam setup. The ALICE drivers and libraries for communicating with the readout hardware are used unmodified. The software which has been developed for this DAQ system consists of the code that provides the configuration of the hardware, the readout and the local data storage. A stand alone monitoring and histogram presenter system has been implemented. The run control is done from a graphical user interface.

2.4 First tests

During the summer 2008, part of the DAQ system (not including the TLU nor the distribution box) has been successfully tested with cosmics using a small TPC equipped with a GEM as preamplification structure in Lund (Sweden). One FEC has been connected to two rows of pads of $1 \times 4\text{mm}^2$ (128 channels). The first results look very promising. As shown in Fig 2. the RMS noise (in blue) is of the order of 1.0 ADC count, and degrades to 1.5 with the worst pre-amplifier settings (highest gain, shortest shaping time) and with the detector connected through the 25 cm long kapton cables. The signal to noise ratio is higher than 10, and the first cosmic muon tracks are observed as shown in Fig 3.

2.5 Coming test beams and plans

At the begin of 2009, a complete system of 2048 channels read-out by 128 PCA16 preamplfiers and by 16 FECs including the Trigger Logic Unit as well as the distribution box will be exposed to a 6 GeV electron beam in the EUDET facility in Desy, Hamburg, Germany. This will allow to tests different type detectors, including GEM. An upgrade

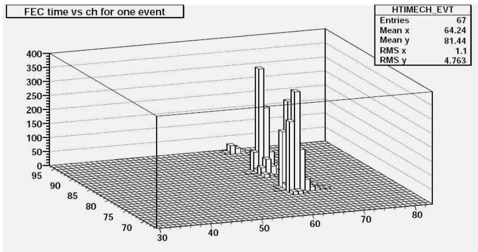

Figure 3: A cosmic muon "track" recorded by the small TPC prototype. The time (100ns) is shown on the X axis and the raw pad number on the Y axis.

to a 10000 channel system is foreseen in 2009 as well to allow the readout of more than one detector.

3 AFTER readout electronic

The AFTER readout electronics [3], which was developed for the TPC of the T2K near detector, is composed of frontend cards on which 4 AFTER asics, based on the 0.35 micron technology, are mounted. The AFTER chip contains 72 preamplifiers with programmable settings as well as analog pipelines. They are followed by a commercial analog to digital converter. Up to 6 FECs are driven by a Front-End Mezzanine (FEM) card which also concentrate the data. Each FEM card is linked to an off-detector Data Concentrator Card (DCC) via a duplex optical fiber which finally sends the data to the central DAQ computer via a fast Ethernet link. One AFTER kit corresponding to 1728 channels, i.e. 6 FECs, 1 FEM and a DCC, is used to readout data of the first Micromegas detector to be put under test in November and December 2008 at the 6 GeV electron test beam DESY. Due to the size of this electronic, it is not possible to read all seven detectors and a redesign of different cards would hence be needed.

4 Common central DAQ

The data from the different TPC readout electronic systems as well as from the the silicium detector envelope and the TLU will be collected and assembled together on basis of the central DAQ software developed within the JRA1 [6]. This software require that a data collector is written for each detector and/or readout system. The data transfer between the local detector DAQ and its data collector is ensured by an Ethernet connection and the data can be converted to the common ILC data format (LCIO) by the central DAQ which will also ensure the event building. The implementation of the first TPC data collector is foreseen by the end of 2008 and other local DAQ will be implemented later on.

5 Slowcontrol

In order to record condition data, like the high voltage status, the TPC gas properties, the PCMAG magnet parameters and potentially several others, the DOOCS system (Distributed Object Oriented Control System) will be used. The DOOCS system developed by DESY for accelerator controls[7] provides an infrastructure and a broad set of tools for data monitoring that can be adapted to the needs of the TPC test beams.

6 Conclusion

This work presents the DAQ system of a large prototype of TPC for the future International Linear Collider. This system is based on the DAQ of the ALICE experiment at LHC, with several modifications (new pre-amplifier, new trigger and clock distribution, etc.). A first prototype of this DAQ system has been built and tested with cosmics. The first results are promising and while its performance are still under study, a larger system made of 2048 channels is being prepared for a test beam in Desy at the begin of 2009; and a 10,000 channels system is already planned.
A small 1728 channels DAQ based on the AFTER electronic from the near T2K experiment will be used for test beam of Micromegas detector at the end of 2008.

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