Production Status of the JLAB Hall-A GEM and Si μstrip Tracker

Frontier Detectors for Frontier Physics

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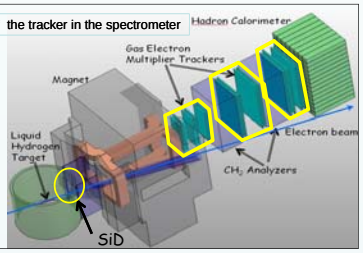
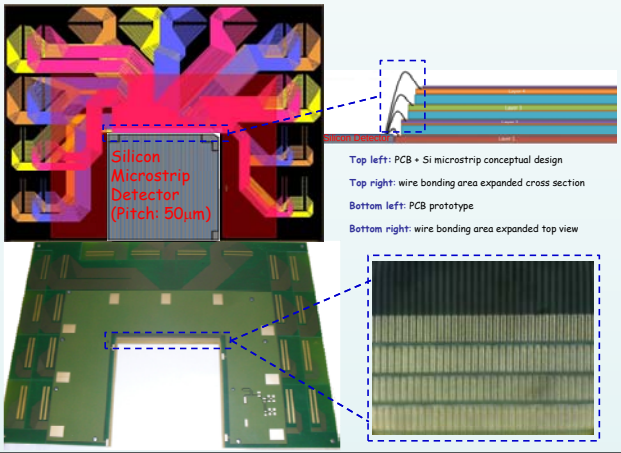
Abstract

We developed and tested a new charged particle tracking system, able to operate in high luminosity experiments, which will be installed at Jefferson Laboratory Hall-A (VA, USA) for optimally exploit the new 11 GeV energy electron beam available at the end of 2013.
The tracker is made of 6 GEM (Gas Electron Multiplier) large chambers and two 10x20 cm² planes of SIlicon microstrip Detectors (SID).
Each GEM chamber is composed by three 40x50 cm² GEM modules, with 2 dimensional strip readout, with expected spatial resolution of about 70 μm.
The same dedicated acquisition system will be used for both detectors (GEM & SID) for a grand total of more than 50000 channels.
The readout electronics is divided in two parts: the front-end cards (based on existing APV25 chip), hosted on the detectors periphery and the digitizer, a multi purpose VME-64x/VXS board located far from the high radiation environment.
The very same electronics has been adopted by the Olympus experiment (DESY, Hamburg, D) to read out the 6 GEM chambers of its lumi monitor.
The developed detectors and electronics are now ready for the production.

Sketch of the tracker in the spectrometer



SBS Silicon Microstrip Detector



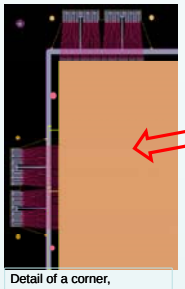
Top left: PCB + Si microstrip conceptual design

Top right: wire bonding area expanded cross section

Bottom left: PCB prototype

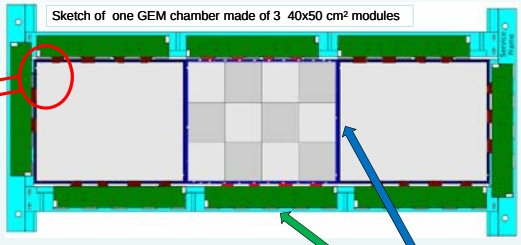
Bottom right: wire bonding area expanded top view

GEM detectors

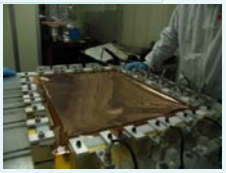


Detail of a corner, with ZIF connnector fingers

Sketch of one GEM chamber made of 3 40x50 cm² modules

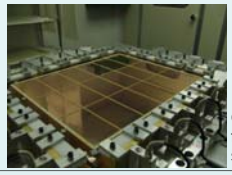


Horizontal and vertical backplanes holding the front-end cards



Stretching

Clean room assembly of a 40x50 cm² module



Gluing the next frame with spacers

Front End Electronics

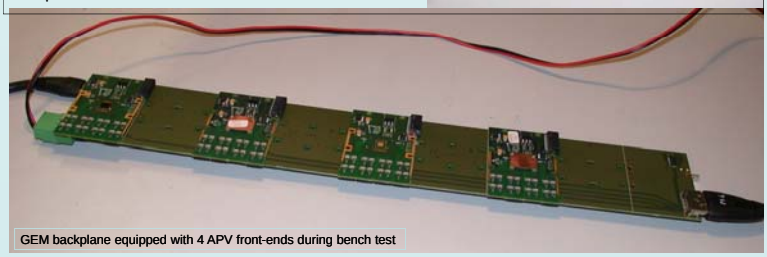
Both detectors (GEM and SID) share the same electronic system for a grand total of about 50k channels.
The front end is based on radiation tolerant devices originally developed for silicon detectors of the CMS experiment: the APV25 chip, a 128 channel analog device. Low voltage levels will be supplied by the radiation tolerant LHC4913 regulators; availability is currently an issue.
Up to 16 APV front end cards can be connected to a single Multi Purpose Digitizer (MPD) board in different ways (depending on experiment requirement):

- Using high density ribbon cable (for small systems)
- By means of dedicated backplanes (for high density)

Olympus adopted the simple ribbon cable connection, while the present tracker use custom backplanes, due to very different geometry.

We adopted standard HDMI cables for transferring signals between the Backplane and the MPD: they have very good signal quality, wide availability and low prices.

Latest release of the APV25 front-end card



GEM backplane equipped with 4 APV front-ends during bench test

Readout Electronics

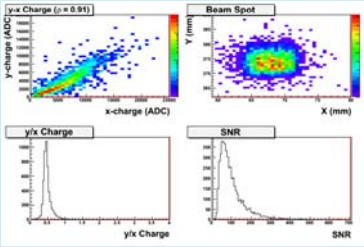
The readout is based on a custom designed VME board:
the Multi Purpose Digitizer (MPD) which hosts 16 free running ADC (12 bit@40 MHz).
The synchronous samples will be crunched by a digital network (inside a powerful FPGA), to identify the APV frames, extract the analog data, correct them for common mode noise, select the signals (zero suppression) and provide the reduced data for readout.
On the other side it handles the configuration of the connected APVs and provide them the required control signals.
The board is standard 6U x 160 mm VME format, with VME64x and VXS extensions, but it can be used also in standard VME32 environments.
DAQ control signals are compliant with JLAB DAQ system, using VXS extension.
The MPD is equipped with several additional devices:

- 10/100 Ethernet phy interface
- Optical SPF transceiver (high speed)
- 128 MB DDR-SDRAM
- Flash eprom
- Front panel coaxial NIM/LVTTL (selectable) I/O

These functionalities make the board rather flexible and applicable to different scenarios, i.e. setting up a SOC system a networked DAQ can be implemented.

MPD card

First beam tests and Olympus online data



DESY test beam: charge correlation, beam spot and SNR. The suppression of the y signal has not completely undestood yet.

Olympus commissioning: 2 typical events with opposite magnet field direction, showing opposite bending on X projection