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Electronics readout for the CGEM - Inner Tracker: TIGER ASIC and electronics chain

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An innovative CGEM (Cylindrical Gas Electron Multiplier) detector will upgrade the current inner tracker of the BESIII experiment.
A custom 64ch ASIC has been specifically designed for the analog readout.
The features of the engineering run version of TIGER will be presented alongside with the ASIC characterization and calibration.
The data are then collected via optical links by two different kind of FPGA-based modules, one in charge to interface the chip and the other deputed to event construction and DAQ communication.
The design of the electronics chain will be presented together with the first results of the integration tests.

Summary

BESIII is a high precision spectrometer in operation at Beijing Electron Positron Collider. Due to aging, it became mandatory to address the replacement of the inner drift chamber.
An innovative CGEM (Cylindrical triple Gas Electron Multiplier) tracker was proposed and built.
The detector is composed by three cylindrical layers, each one rolled, in turn, by three GEM multiplication foils. The signal is induced on a total of ˜10000 channels, read in analog mode.
TIGER (Torino Integrated Gem Electronics for Readout) is the read-out ASIC expressly designed for the CGEM tracker. This chip allows to perform a combination of two different reconstruction methods (charge centroid and micro-TPC), providing the analogue reading of the charge deposited on the CGEM strips.
Thanks to this kind of reconstruction, even with tilted tracks in a 1T magnetic field, the system can reach a spatial resolution of 130 µm, also in the z-direction, and a time resolution of 5 ns, with a strip pitch of 650 µm.
The chip specifications fully respect the design requests, providing a 60 kHz reading frequency for each of the 64 channels, 50 fC maximum input charge, less than 12 mW power dissipation per channel and 2000 e- rms noise for a sensor capacity up to 100 pF.
This ASIC integrates a charge sensitive amplifier (CSA) coupled with a two-branches shaper for each channel, optimized for charge and time measurement, followed by discriminators and ADC stages.
The time stamps are produced by time to digital converters based on an analogue interpolation technique with a quantization error better than 50 ps, while the charge measurement can be obtained with a Sample and Hold (SH) circuit or with a Time Over Threshold (TOT) system, selectable in configuration.
Four Time to Analog Converters (TAC) allow the SH to store more data hence lowering the pile-up probability.
The digital part of the chip also provides a full digital output for the event words and all the DACs and the logic needed for the voltage levels configuration. The configuration registers are protected against Single Event Upsets (SEU) caused by ionizing radiation.
The chip is manufactured in UMC 110nm technology, exportable to China.
The low voltage power supply, the configuration off each chip and the data collection will pass through the off-detector GEM Read-Out Cards (GEMROC), 20 FPGA-based modules controlled via UDP protocol.
The data will then be streamed to other FPGA-based modules, the GEM Data Concentrator (GEM-DC), which will collect the data and transmit them to the BESIII DAQ system.

The developed electronic system can, in principle, be used for the read-out of other Micro Pattern Gas Detectors.
The features of the engineering run version of TIGER will be presented alongside with the full data acquisition chain and the progresses in its integration.

Primary authors: BORTONE, Alberto (Universita e INFN Torino (IT)); BESIII ITALIAN COLLABORATION

Presenter: BORTONE, Alberto (Universita e INFN Torino (IT))

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