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# TIGER/GEMROC: a versatile and modular readout system for micro-pattern gaseous detectors

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A special readout chain was developed for the data acquisition of an innovative cylindrical gas-electron multiplier (CGEM) [1], which is being built to replace the inner drift chamber of the BESIII [2] experiment.

The whole system [3] was designed with modularity, versatility and scalability in mind and can be used to test other innovative micro-pattern gaseous detectors.

Signals from the detector strips are processed by TIGER, a custom 64-channel ASIC that provides an analog charge readout via a fully digital output. TIGER continuously transmits data over thresholds in triggerless mode, has a linear charge readout up to about 50 fC, less than 3ns jitter, and a power dissipation of less than 12 mW per channel.
The ASICs can operate in Sample-and-Hold (SH) and Time-Over-Threshold (TOT) modes. In SH mode, the output of the discriminator connected to the fast shaper provides a trigger to the control logic, which generates a sampling pulse with a delay suitable to capture the slow shaper output around its maximum. The delay between the trigger and the sampling pulse can be fine-tuned. In TOT mode, the leading and trailing edges of the discriminator are sensed by the TDCs. Thus, the charge is derived from the measured pulse duration. The ToT readout allows the charge sensitivity to be extended beyond the saturation point of the front-end amplifier. In principle, either discriminator can be chosen, although the one following the fast shaper provides more accurate timing information and is therefore the default choice.

An FPGA-based off-detector module (GEMROC) was developed specifically to interface with TIGER. The module configures the ASICs and organizes the incoming data by assembling the event packets when the trigger arrives. The GEMROC can be operated in the mode without trigger or with trigger. In the first mode, the data received from the activated TIGERs is merged and transmitted through the Ethernet output port using the UDP protocol. In the second mode, incoming data from each TIGER pair is stored in a latency buffer circular buffer organized in pages until a signal trigger is received.

Control software was developed to characterize, debug, and test the system prior to installation. This software (Graphical User Frontend Interface, GUFI), written in Python, controls the electronic operations and acquisitions in real time. The software is coded with an object-oriented approach and structured in classes to be easily scalable and extensible. Data, along with environmental and detector metrics, are continuously collected in a database and queried via a GRAFANA [4] dashboard to ensure operational reliability and verify data quality.
Fast analysis software was also developed to provide rapid, real-time feedback on data collection. CIVETTA (Complete Interactive VErsatile Test Tool Analysis), written in Python, is fully parallelized at the subrun level to use all CPUs on the machine and integrates all steps to obtain complete metrics on detector performance.

The entire readout system was tested during a test beam at CERN in July 2021.

This presentation will introduce the TIGER /GEMROC system, with particular attention to the test beam results and an outlook on its use for other innovative micro-pattern detectors.

[1] M. Alexeev et al, Triple GEM performance in magnetic field, JINST 14, P08018, DOI:10.1088/1748-0221/14/08/P08018 (2019).
[2] [1] M. Ablikim et al., Design and construction of the BESIII detector, NIM A 614, 345 (2010).
[3] A. Amoroso et al., The CGEM-IT readout chain, JINST 16, P08065, DOI:10.1088/1748-0221/16/08/P08065 (2021).
[4] Grafana Labs, Grafana, https://grafana.com/

## In-person participation

Yes

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