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Characterization of GEMINI, a 16-channels programmable readout interface for Triple-GEM detectors in 180 nm CMOS.

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Development of GEM detectors showed the need of a custom readout to fully exploit the advantages of this technology. GEM detectors can be realized with various shapes, also irregular, and high number of channels. GEMINI has been specifically designed to work with Triple-GEM detectors and it integrates 16 channels to perform readout with both analog and digital signal with Time over Threshold. GEMINI also allows to set a different threshold for every channel to compensate channel inhomogeneity. This work compares simulations with lab measurements and presents results of the imaging of an X-ray source performed with GEMINI.

Summary

The readout electronics for Triple-GEM must be able to measure charge in 30fC –500fC range with input capacitance up to 40 pF and maximum event rate of 5Mcps.
The GEMINI chip here presented is an evolution of the one presented in [1]. Its area is 6.74 mm2 and it includes 16 channels designed to comply with count rate, input range and input capacitance specifications. Each channel performs event detection comparing the signal read with a 9-bit user defined threshold. Every channel has analog and digital outputs and a power consumption of 2.7mW that becomes 6.7mW activating the LVDS output drivers.
This work describes the architecture of GEMINI and presents the results of lab measurements performed on the chip to verify the linearity of charge-voltage conversion and test Time over Threshold functionality. Furthermore, results of the characterization of the chip mounted on a Triple-GEM detector are shown. Images of an X-ray source acquired using GEMINI chips are also presented.
To guarantee constant performance independently from temperature and CMOS process variations, GEMINI integrates a calibration system that can be controlled manually or started in automatic mode. The user can also fine tune event detection thanks to a threshold system that allows independent setting for each channel. Information on input charge can be obtained both measuring the amplitude of signal generated at analog output or measuring the length of digital signal generated by the discriminator.
Lab measurements were performed using a voltage signal generator and a passive network to emulate the specific signal generated by a GEM detector. After a characterization that confirmed that channel can sustain counting rate up to 5Mcps and sensitivity of about 1 mV/fC in the whole range required by specifications with linear behavior, on-detector characterization started. GEMINI readout system was also used to acquire images of an X-ray source counting the number of events for every channel in a fixed period of time. The resulting images do not show artifacts and confirm results obtained with lab measurements. To fully characterize the readout system an estimate of noise introduced by readout system has been executed analyzing the variability of digital output with known input. Lab measurements also confirmed the expected Time over Threshold characteristic further enforced by the first ToT measurements on a test detector.
Results obtained give positive indications about the integration of GEMINI with Triple-GEM detectors, opening the possibility of using this readout system also in other applications where GEM detectors are employed or accurate charge measurement for imaging is required.

[1] Pezzotta, A., et al. "GEMINI, a CMOS 180 nm mixed-signal 16-channel ASIC for Triple-GEM detectors readout." SENSORS, 2015 IEEE. IEEE, 2015.

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