Contribution ID: **33** Type: **Poster**

Characterization of ALICE SAMPA ASIC Using Prototype GEM Detector for LHC Run3 and Beyond

Tuesday 27 September 2016 16:33 (1 minute)

The ALICE experiment at the LHC plans upgrade of its TPC, due to expected high Pb-Pb collision-rate after the shutdown of LHC in 2018. In the upgraded TPC, Gas Electron Multiplier (GEM) chambers and continuous readout system will replace MWPC chambers and conventional triggered readout. In the continuous readout, GEM signals will be processed using 32 channels of SAMPA ASIC (preamplifier and ADC). The first version of the SAMPA was delivered in 2014 and the production of final version is in progress. During the presentation, test results of the SAMPA coupled with GEM detector prototype will be reported.

Summary

The heavy-ion beam of CERN's LHC is expected to be colliding at 50 kHz (present rate few kHz) during Run3 onwards of the ALICE experiment planned to start in 2020. Due to these new high collision rates, the Multi-Wire Proportional Chambers of the present ALICE TPC will be replaced by readout chambers featuring Gas Electron Multiplier (GEM) foils. A continuous readout system will replace the existing triggered readout.

In the upgraded TPC readout, the current signals from the GEM detector pads will be readout by Front-End Cards (FECs) via custom-made SAMPA ASICs. The SAMPA contains a charge-sensitive preamplifier, a shaper, a 10 bit 10 MHz digitizer and a digital filter, processing and data compression chain. In the FECs, the output of the SAMPA will be multiplexed and transmitted using GigaBit Transceivers (GBTx) via optical links to a Common Readout Unit (CRU). The CRU is an interface to the on-line computer farm, trigger and detector control system. The upgraded readout system will utilize 3400 FECs, each containing 5 SAMPA ASICs (32 channels each), and in total of about 500k channels. The data rate from SAMPA to CRU via GBTx will be 1 TBytes/s.

This presentation will be focused on the characterization of SAMPA ASICs done using waveform generator and GEM detector prototype. The tests performed using waveform generator showed an excellent pulse shape stability and gain linearity at various input charges (5 fC to 110 fC). The noise performance of SAMPA is also quite good (540 ENC @ 12 pF). The average cross-talk between the readout channels varied from 0.3 to 0.8% and the average power consumption is about 8 mW.

The GEM detector prototype consists of a stack of three 10 x10 mm^2 GEM foils with standard pitch. To initiate the processes of excitation and ionization inside the detector, Am-241, Sr-90, and Fe-55 radioactive sources were used. The Am-241 alpha spectrum was recorded by operating GEM chamber at gain less than 1000 for different readout pad sizes of the detector in ArCO2 (90%+10%) and NeCO2N2 (90%+10%+5%) gas mixture. Similarly, a Sr-90 electron (2.28 MeV) or Minimum-Ionizing-Particle (MIP) and a soft-photon energy (5.9 keV) spectrum is recorded at the detector gain of 2000. The measured energy resolution for the Fe55 photon is 9.7%. The results obtained from these tests are close to the ALICE TPC requirement and it helped to improve the design of second/final SAMPA ASIC.

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Session Classification: POSTER

Track Classification: ASIC