

Characterization of ALICE SAMPA ASIC

Using Prototype GEM Detector for LHC Run3 and Beyond

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on behalf of ALICE Collaboration

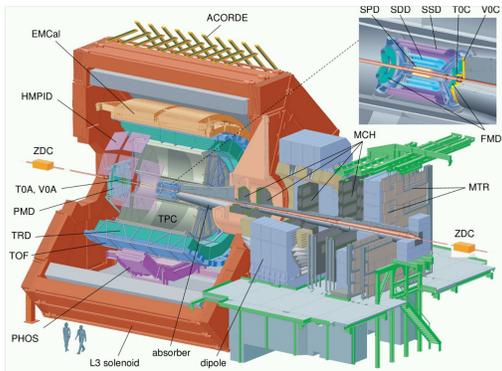
TWEPP 2016, Karlsruhe, Germany



ALICE

ALICE Experiment

- Studies the outcome of heavy ions (Pb-Pb), p-Pb and pp collisions at LHC
- Main goal is to characterize the strongly interacting matter at extreme energy densities where Quark-Gluon Plasma (QGP) is produced



Schematic view of ALICE Detector system.

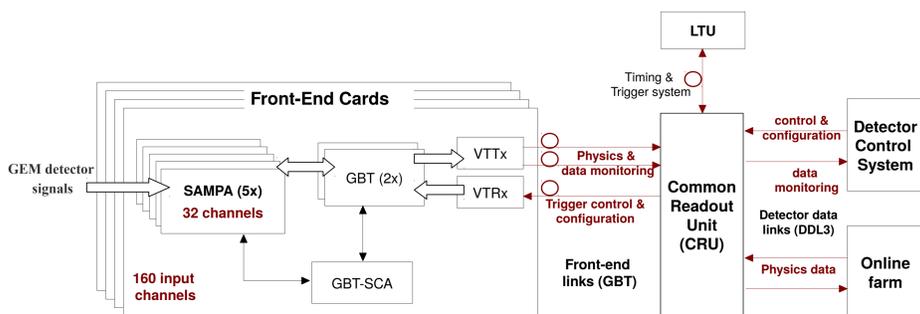
It consists of 18 different types of particle-detectors such as tracking system, time-of-flight, calorimeters, muon chambers.

- During RUN1 in 2010-2013:
 - Data collection for all collision systems (Pb-Pb, p-pb, pp) at center-of-mass energy 2.7 TeV (Pb-Pb), 5.02 TeV (p-Pb), 0.9 TeV/ 2.76 TeV/ 7 TeV/ 8 TeV (pp)
 - Valuable data sets were recorded and important results were published

ALICE-TPC Upgrade

- Data collection of the ALICE experiment is synchronized with the operation of the LHC
- Therefore, the ALICE experiment will progress in two (or more) phases namely RUN2 and RUN3 (and beyond) after the long shutdowns of the LHC in 2015 and 2018, respectively
- In RUN1, Pb-Pb collisions were performed at 2.76 TeV per nucleon pair and reached integrated luminosity (L_i) of 0.16 nb^{-1}
- The RUN2 is ongoing and data-collection for pp collisions at 13 TeV is in progress
- During RUN2 and RUN3, the Pb-Pb collisions will take place at 5.2 TeV center-of-mass energy, aiming to reach L_i of 1 nb^{-1} and 10 nb^{-1} , respectively
- In the RUN3, while achieving high luminosity, the collision rate of 50 kHz is expected
- To cope with the high collision rate, the present ALICE TPC and its readout system needs to be upgraded
 - The present Multi-Wire Proportional Chamber based TPC will be replaced with the Gas Electron Multiplier (GEM) based TPC
 - The Front-End Electronics (FEEs) and the readout system will also be replaced from the present triggered readout to continuous readout

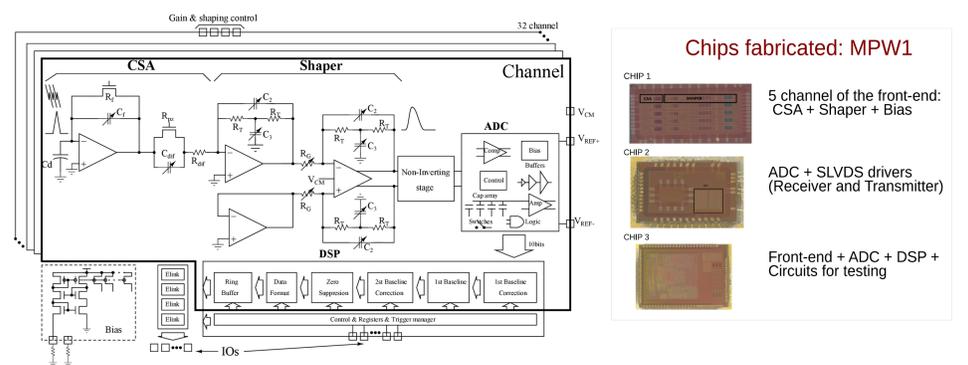
TPC Readout System upgrade



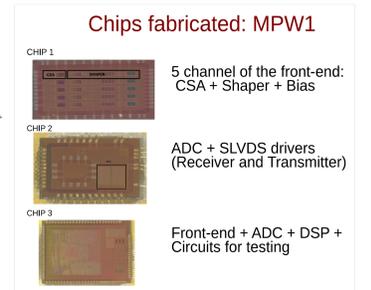
In the upgraded TPC readout,

- The GEM detector signals will be readout using the Front-End Cards (FECs)
- In the FECs, five custom-made ASICs, named SAMPA chips will process the data from its 160 readout channels (32 channels/each)
- The data from SAMPA will then be multiplexed and transmitted using GigaBit Transceiver (GBT) via optical links to a Common Readout Unit (CRU)
- The CRU is an interface to the on-line farm, trigger and detector control system

Front End Electronics - SAMPA



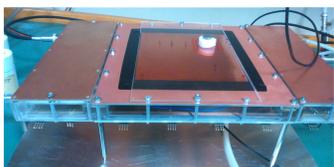
- The SAMPA contains
 - Charge-Sensitive preAmplifier (CSA), Shaper, 10 bit/10 MHz digitizer (ADC) and Digital Signal Processing (DSP) part
- The acquired data from the SAMPA is transferred at 1.2 Gbps over four 320 Mbps serial links
- 32 channels continuous as well as external triggered readout is possible
- The first version of the SAMPA chip (MPW1) is produced in 2014



SAMPA (chip1) Test with GEM Detector Prototype

GEM prototype detector and its gain

GEM chamber



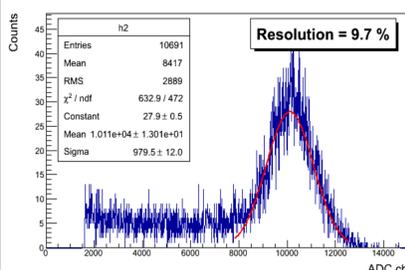
Detector Schematic

| Cathode | |
|-------------------|------------------------------------|
| 7 mm drift | $E_d = 400 \text{ V/cm}$ |
| gem1 | 2.1 mm $E_{d1} = 3 \text{ KV/cm}$ |
| gem2 | 2.1 mm $E_{d2} = 400 \text{ V/cm}$ |
| gem3 | 2.25 mm $E_{d3} = 3 \text{ KV/cm}$ |
| Pad plane (Anode) | |

Operational parameters

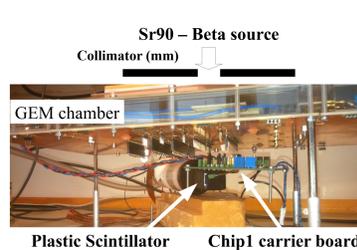
- GEM detector (3 GEM foils - $10 \times 10 \text{ cm}^2$):
 - HV = -2.97 KV (-297 V @ Foil)
 - Fe55 source (R) = 1.1 kHz
 - Anode current (I_a) ~ 60 pA
 - Gain = $R / (I_a * N_{pri} * e^-) \sim 2000$
 - N_{pri} is 165 for Ne mix
 - Ne+CO₂+N₂ (90%+10%+5%)
 - Sr90 for MIPs
- MPW1 - chip1:
 - Diff. channel #2, Gain 20 mV/FC @ 160 ns
- VME DAQ:
 - CAEN ADC: 1 GHz, 14 bit, LSB = 0.125 mV

Fe55 spectrum for 6 x 15 mm² pad size

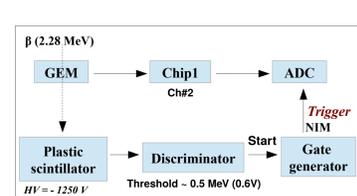


Signal-to-Noise ratio for MIP's in 7 mm drift

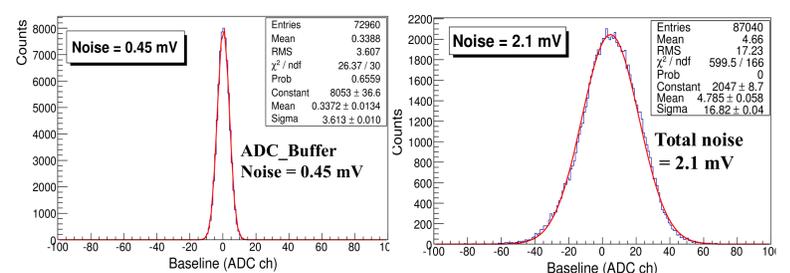
Test setup



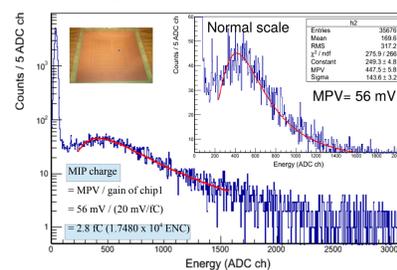
Schematic of Data acquisition



$$\text{Chip1 noise} = [(\text{ADC_Buffer noise})^2 - (\text{Total noise})^2]^{1/2} \sim 2 \text{ mV} \sim 641 \text{ ENC}$$



MIP charge distribution using Sr90 source



- SNR = MIP charge / chip1 noise = (17480 / 641) = 27
- Close to the requirement of upgraded ALICE TPC



ALICE

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