Large acceptance high rate GEM detectors for muon tracking in heavy ion collisions of CBM experiment at FAIR

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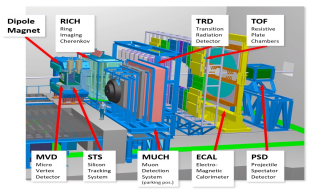
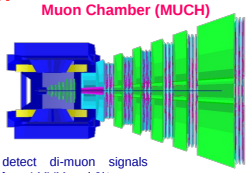
Compressed Baryonic Matter experiment at FAIR

Compressed Baryonic Matter (CBM)@FAIR



- A fixed target experiment in the energy range, 4-40 AGeV for heavy ions.
- Physics goal : To explore the QCD phase diagram in the region of high baryon densities, by study of Equation-of-state of nuclear matter at neurton star core densities, chiral symmetry restoration, etc.
- Main features: High interaction rates, up to ~10 MHz.
- Lot of new measurements in SIS 100 energy range. Requires very fast and radiation hard detectors, novel DAQ, free streaming electronics

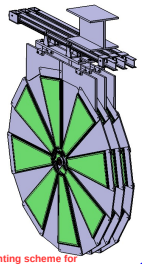
Muon Chamber (MUCH)



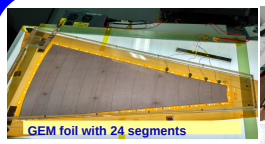
- Aim: to detect di-muon signals originating from LMVM and J/ψ
- The novel feature of MUCH: segemented absorbers and detector stations for detection of both LMVM and J/ψ.
- For the first two stations, triple GEM modules. A total of 120 trapezoidal chambers to be built. R/O plane: Progressively increasing pad size
- 3-17 mm. Ar/CO2-(70/30) as fill gas.
- Particle rates ~150 kHz/cm^2 for minimum bias collisions.

Radiation dose ~ 10^{13}neq./cm^2

- ~2000 readout pads/module, MUCH-xYTER, self trigerred ASIC, max. Data rate ~ max. 200 kHz/channel
- Cooling—1 kW/layer



Mounting scheme for the GEM-MUCH



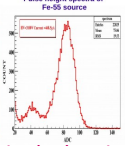
GEM foil with 24 segments

Placing spacers and stacking the GEM layers

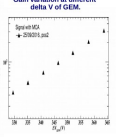
Stretching of foils

Complete chamber
15 FEBs, 2000

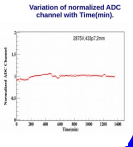
Fe-55



Pulse height spectra of Fe-55 source



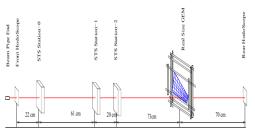
Gain variation at different delta V of GEM.



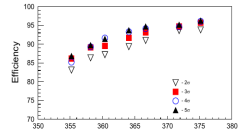
Variation of normalized ADC channel with Time(min).

Fabrication of large size chamber using "NS2" technique

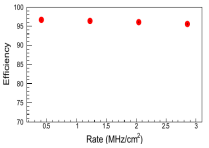
Testing with proton beams at COSY [2]



The test setup: Main-feature -- First large size module; Free streaming data



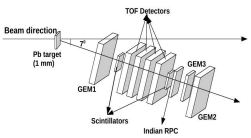
Efficiency with GEM voltage



Efficiency with particle rate

First tests with Pb+Pb collision using self triggered electronics @ CERN SPS

- Two large size (~1m x 0.5m) and one small (10 cm x 10 cm, GSI GEM) chambers were tested along with CBM-TOF detectors
- A 10 mm thick Al plate with water channels inside it was used for cooling n-XYTER chips as well as for mounting the GEM chambers.
- A diamond detector was used just before the target for beam monitoring



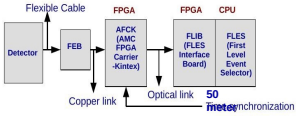
Schematic of experimental setup

FEBs with nXYTER electronics mounted on backside of 10 mm Al plate which does the

Picture of the detector setup at H4 beamline

DAQ (Self-Triggered readout)

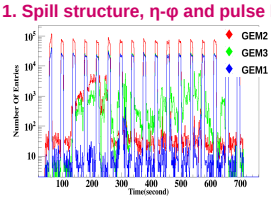
- Data were processed by FPGA based Data Processing Board (DPB).
- Time-synchronization for the two systems was carried out via two dedicated AFCK (master and slave)

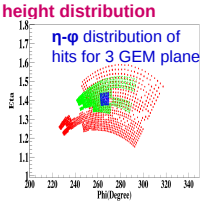


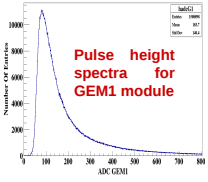
Block diagram of data acquisition system

Test beam results and discussion

1. Spill structure, η-φ and pulse height distribution



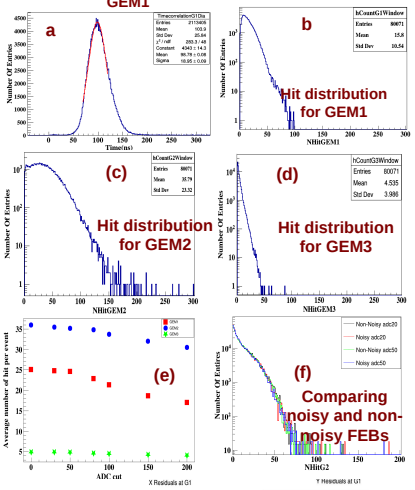




2. Event Reconstruction:

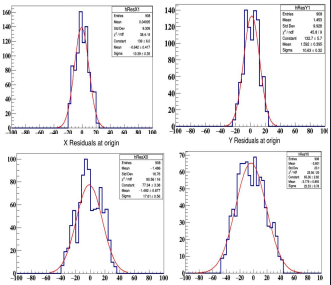
- Events reconstructed using hit-time stamp of diamond detector. All the GEM hits which lie between two consecutive diamond hits in time were grouped together to form an event.
- Typical and hit distribution per (b,c,d) event for three GEMs plane are shown.
- Variation of average hit per event with ADC threshold for three planes are shown in the figure (e). Variation remains unchanged up to adc ~80 and decrease afterwards.
- Reconstructed hits for noisy and non noisy FEBs. The two spectra fall on top of each other (f).

Time correlation spectra for GEM1



3. Tracking:

- A straight line track fitting algorithm used for calculating the residuals.
- Performed using three GEM planes within η-φ window. Tracking in another zone of η-φ has been also performed and the residuals in both the case are found to be consistent.

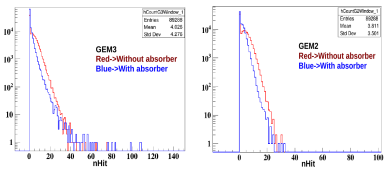


Effect of ADC cut:
GEM1 : 50 adc channel
GEM2 : 100 adc channel
GEM3 : 100 adc channel

η-φ selection
η-φ cut for all planes
1.37<η<1.40
264<φ<266

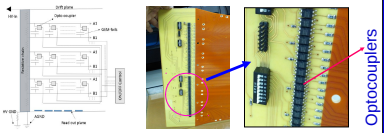
4. Effect of 20 cm thick Fe absorber on detector multiplicity

- Variation of number of hit per event with and without 20 cm Fe (placed before GEM2 and GEM3) absorber for 1.37<η<1.44 and 262<φ<272 is shown here.
- Similar trend observed in the simulation (not shown here) as in the data.

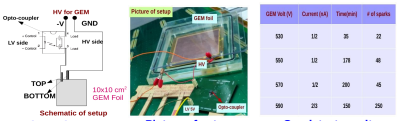


Optocoupler based high voltage scheme

- A optocoupler based high voltage design will be used for powering the GEM foils.
- Radiation tests of optocouplers: withstood 70k rad and 10^{12} neq/cm^2.
- Two real size triple GEM chambers using this high voltage scheme were fabricated and successfully tested locally with ^{55}Fe.
- These optocouplers were also tested for the sparks in GEM foil and shown in the table.



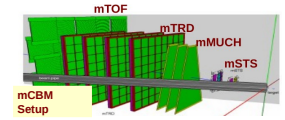
Optocoupler based HV distribution for GEM detectors

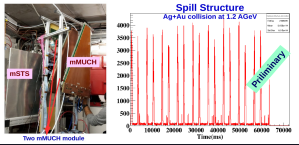


Schematic setup | Picture of setup | Spark test result

Outlook: Testing large size GEM detector in mCBM experiment

- ✔Two large size (~80 cm x ~ 40 cm) trapezoidal shaped triple GEM has been commissioned recently and being tested in mCBM experiment
- ✔Readout consists of pad with progressively sizes (~3 mm to ~17 mm)
- ✔Preliminary result showing the spill structure as seen by one FEB is shown here.
- ✔Dedicated tests with heavy ions Ag+Ag beam in March 2019.





Acknowledgment

RD51 lab, CERN

Reference

1. http://www.sympnp.org/proceedings/61/G73.pdf
2. https://www.sciencedirect.com/science/article/pii/S0168900216312530
3. http://www.sympnp.org/proceedings/62/G8.pdf

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