Systematic measurements of the gain and the energy resolution of single and double mask GEM detectors

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FRONTIER DETECTORS FOR FRONTIER PHYSICS, 13th Pisa Meeting on Advanced Detectors, 24-30 May 2015, La Biodola, Isola d'Elba, Italy

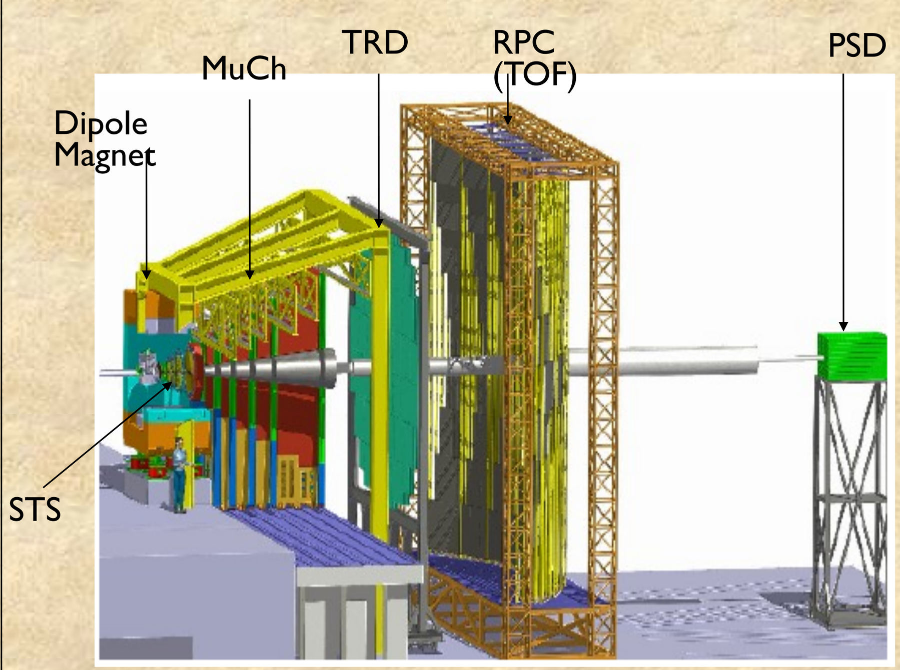
Introduction

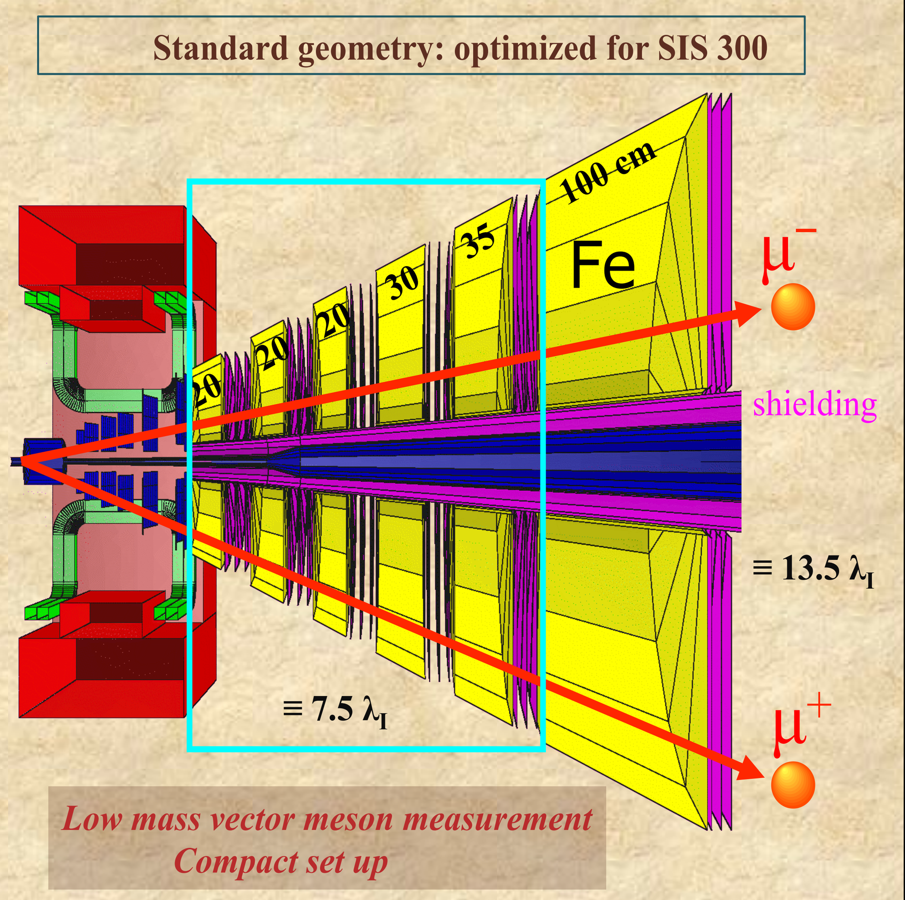
The Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR) will use proton and heavy ion beams to study matter at extreme compression. The CBM experiment is designed to explore the QCD phase diagram in the region of high baryon densities. Matter in the form of highly compressed nuclear matter exists in neutron stars and in the core of supernova explosions. In the laboratory, super-dense nuclear matter can be created in the reaction volume of relativistic heavy-ion collisions. The baryon density and the temperature of the fireball reached in such collisions depend on the beam energy. So, by varying the beam energy one may, within certain limits, produce different states and phases of strongly interacting matter. In the CBM experiment, particle multiplicities and phase-space distributions, the collision centrality and the reaction plane will be determined.

This will only be possible with the application of advanced instrumentation, including highly segmented and fast gaseous detectors. The ambitious goal to measure rare probes in high multiplicity events at relatively low beam energy is, from the detector point of view, rather challenging: the low, sub-threshold cross sections have to be compensated by high interaction rates. This, in turn, puts rather stringent constraints onto the detector performance: stable performance in a high rate, high multiplicity environment, superior position and momentum resolution for precise tracking. Hence, detector development and characterization is one of the chief challenges of this experiment.

Here we will give a short description of the sub detector of the CBM experiment which is relevant to this work: the muon spectrometer (MUCH), which will be (partly) instrumented with GEM based tracking chambers. The aim of MUCH is to detect the dimuon signals arising from the decay of the low mass vector mesons and from the decay of charmonia produced in the heavy ion collisions at FAIR.

Muon detection system in CBM

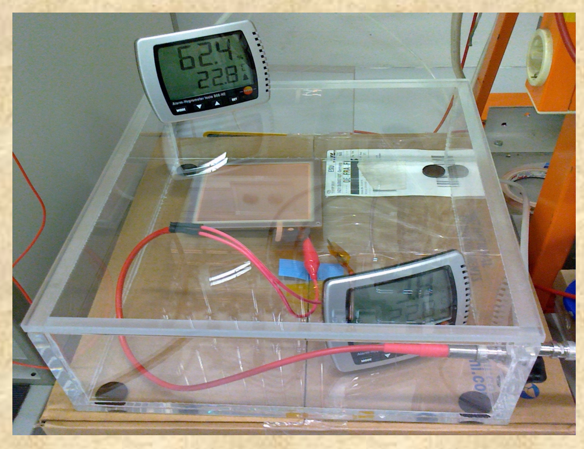




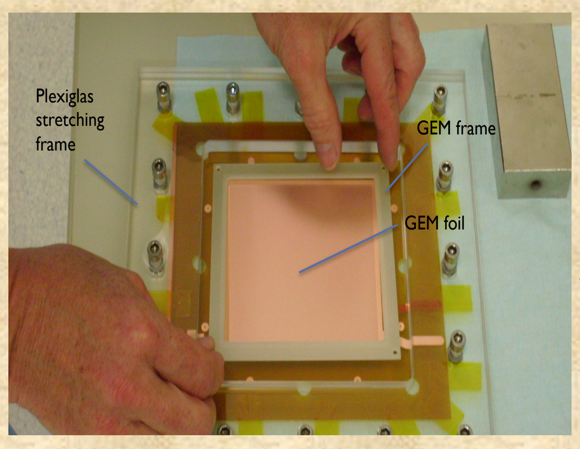
Schematic view of the CBM experiment: Muon set up (left). Implementation of the muon detection system in GEANT (right).

Building of GEM detector at GSI

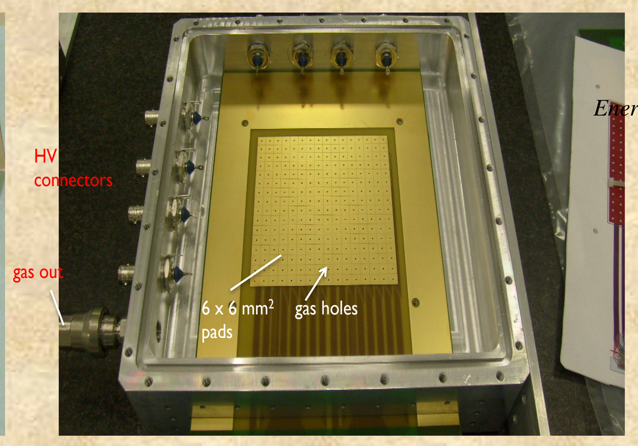
HV testing of GEM foil



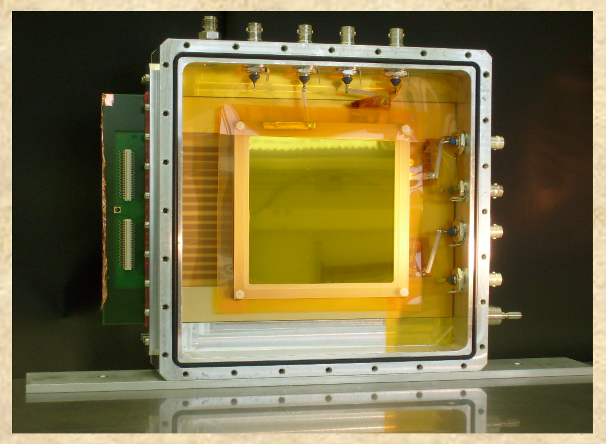
Stretching frame [1]



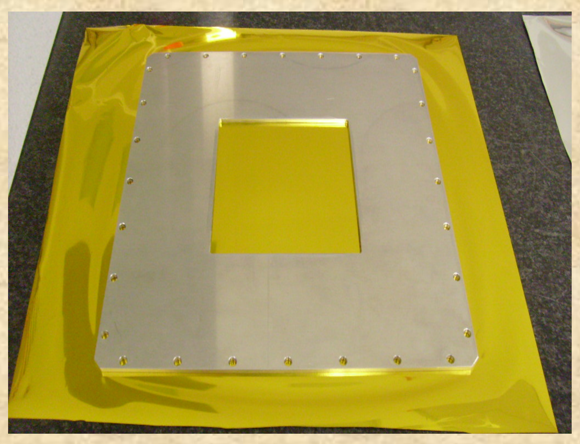
Pad plane, housing



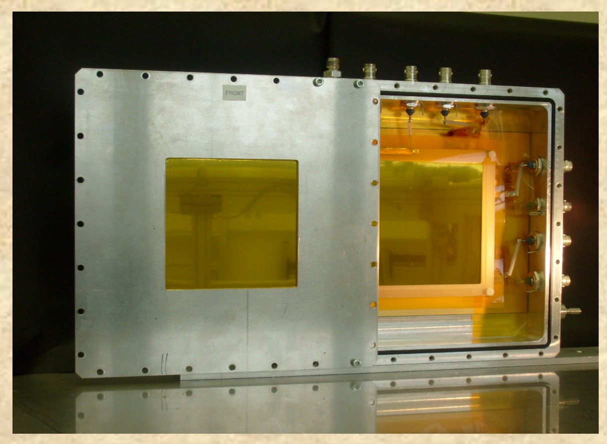
Assembled GEM



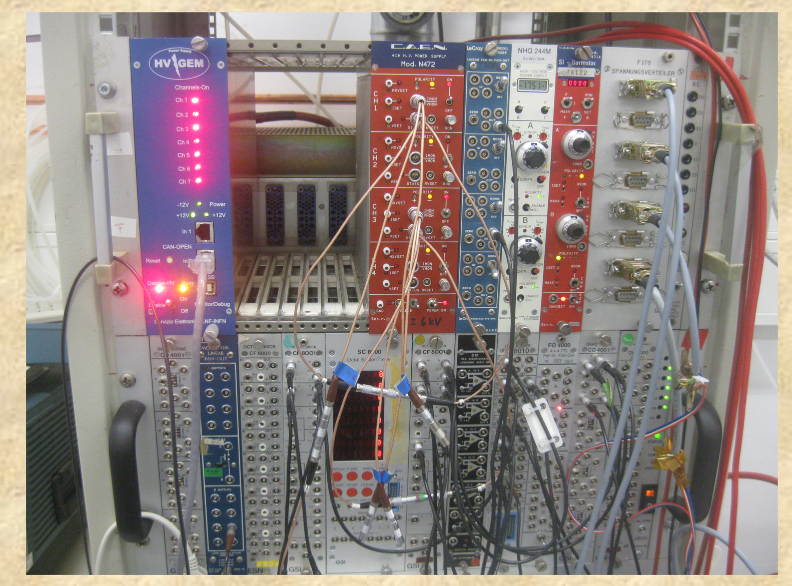
Cover plate

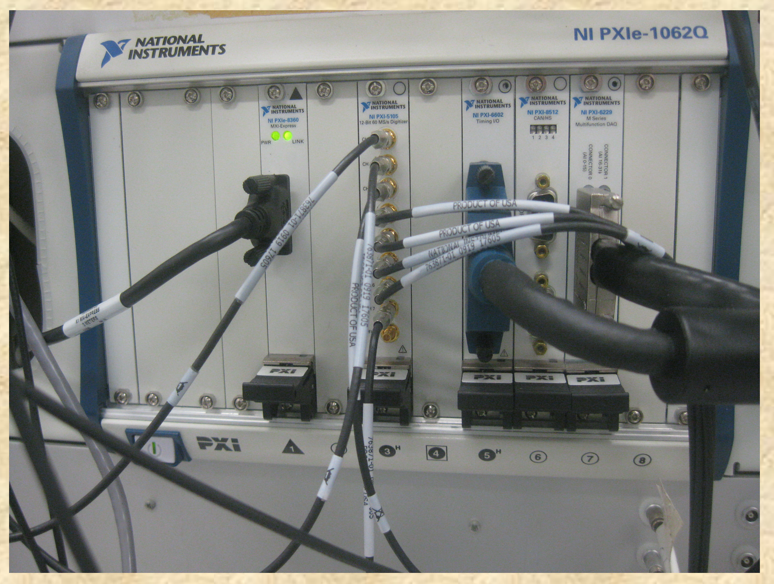


Complete GEM box



7-channel HV power supply (left) and PXI based DAQ (right)

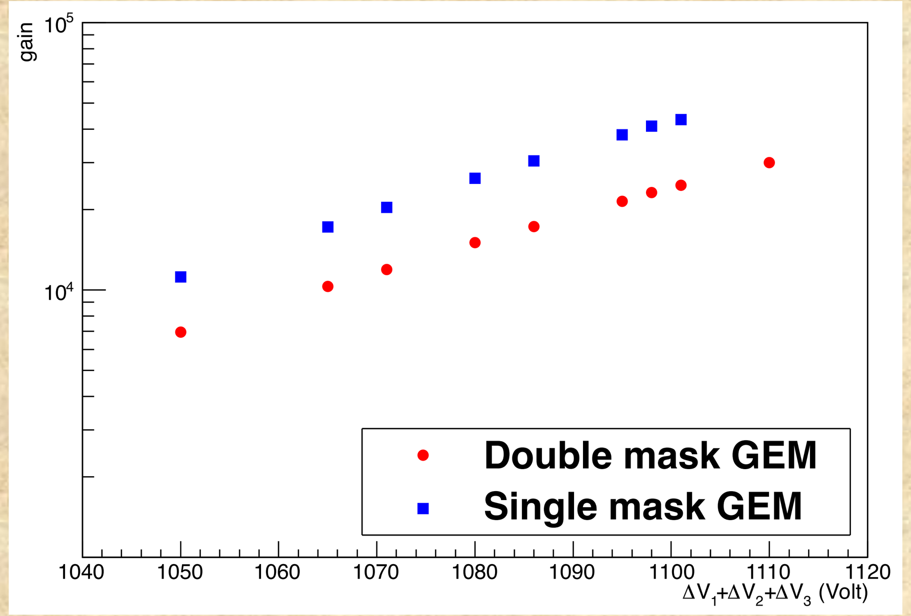




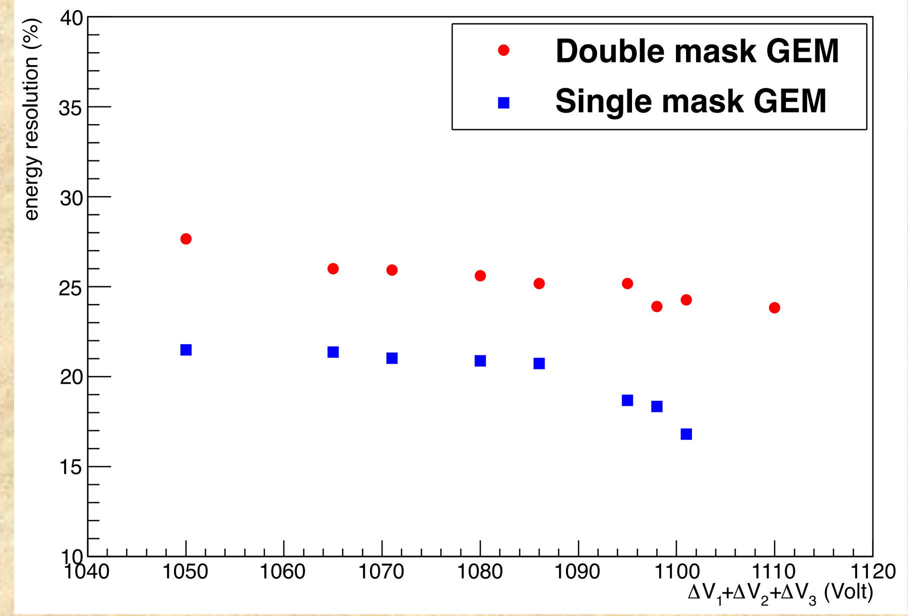
Experimental details

- Both single mask and double mask GEM detectors are used
- Dimension: 10 cm × 10 cm
- Drift gap: 3 mm, Transfer gap1: 2 mm, Transfer gap2: 2 mm, Induction gap: 2 mm
- Gas mixture: Ar/CO_2 70/30
- 7 channel HVG210 power supply is used
- 4 sum-up boards are used for signal (256 pads each of area 6×6 mm^2)
- PXI LabView based DAQ is used
- Gain and energy resolution are measured varying different voltages
- Gain is compared from Fe^{55} spectrum and from the anode current

Gain and energy resolution with global GEM Voltage [2]



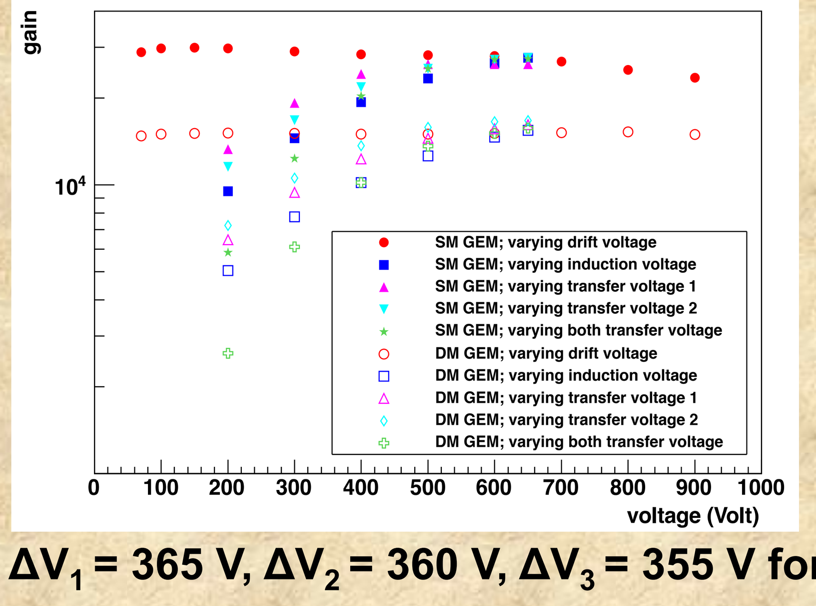
Gain as a function of global GEM voltage

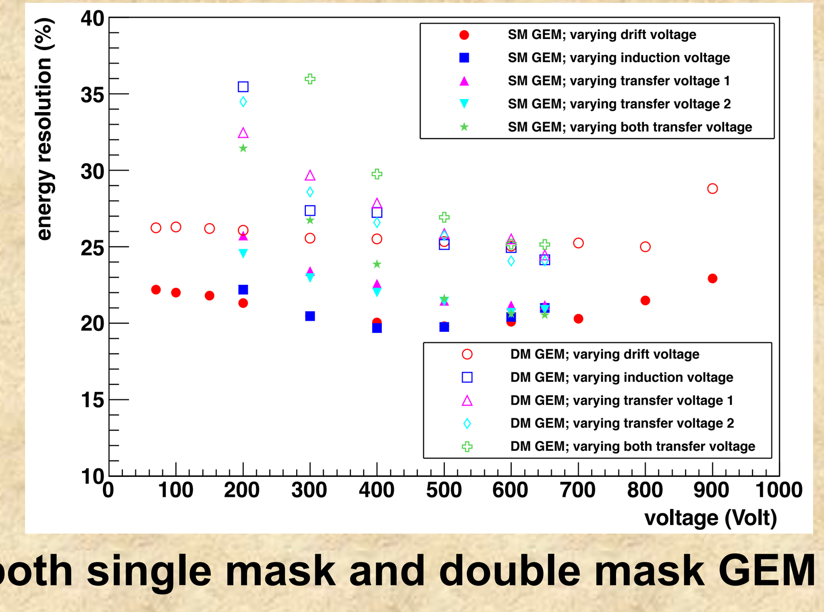


Energy resolution as a function of global GEM voltage

- Drift field: 2.33 kV/cm, Transfer field: 3.25 kV/cm, Induction field: 3.25 kV/cm for both single mask and double mask GEM detector
- Gain increases exponentially with global GEM voltage for both single mask and double mask GEM detectors
- Temperature and pressure correction are not made
- Energy resolution value decreases as gain increases

Variation of gain and energy resolution with different voltages





ΔV_1 = 365 V, ΔV_2 = 360 V, ΔV_3 = 355 V for both single mask and double mask GEM

Summary

Triple GEM's will be used to instrument the CBM muon detector MUCH (MUon CHamber). In the GSI detector laboratory an R&D effort has been performed to study the characteristics of both single and double mask GEM detectors. In this study, the gain and the energy resolution have been measured systematically employing an ^{55}Fe source as a function of the voltages applied to the GEM foils. It has been observed that for very low and very high drift voltage the gain is somewhat reduced, while it is nearly constant at the intermediate values. In case of other voltage variations such as the induction and transfer voltages, it has been observed that the gain increases with the voltage and saturates at some point.

References

[1] GDD Group - CERN, http://gdd.web.cern.ch/GDD/ .
[2] S. Biswas et al., Nucl. Instr. and Meth. A 718 (2013) 403.