Sector layout of Muon Chambers (MUCH): First results

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Introduction

The Compressed Baryonic Matter (CBM) experiment at FAIR, the upcoming accelerator facility at Darmstadt, Germany offers us the unique possibilities to investigate QCD phase diagram in the region of high baryon densities. The proposed key observables include the measurement of lepton pairs originating from the decay of low mass vector mesons (lmvm) and charmonia. The CBM Indian group holds the responsibility of designing and building of a muon detector system to enable di-muon measurements [1]. An optimized version of the muon detection system has already been designed through simulations, as shown in Fig. 1. It includes 6 iron absorbers and 6 tracking stations. Each tracking station consists of three chambers located in the air gap between two successive absorbers. The total absorber length in the current design amounts to 2.25 m of iron. This geometry can be used for both charmonium and low mass vector mesons (lmvm). For the latter, hits before the last absorber are relevant. Thus the effective number of detector layers for lmvm measurement is thus 15 and hence requires the corresponding muons to pass only through 1.25 m of iron absorber. For inclusion of a realistic scenario, modular structure has been implemented in simulation. Each detector layer has been divided in several modules of size 30 cm. × 30 cm. (limited by the GEM foil production technology) and filled with an argon based gas mixture as the active medium. Up till now all the feasibility studies have been done with this modular design. However one practical disadvantage of this modular design is the non-availability of large size GEM modules which in turn results in complex detector design and large number of dead zones. One possible solution to this problem is to divide the detector planes into several sectors instead of modules. In case of sector design, large GEM foils limited by 60 cm size (width) in one direction and no limitation in length are available and prototypes are being made by CMS and other experiments. These GEMs are produced using single-mask technology which gives significantly larger yield of good foils compared to the conventional double-mask GEM. In this paper we report the first results of our feasibility study with sectored MUCH geometry.

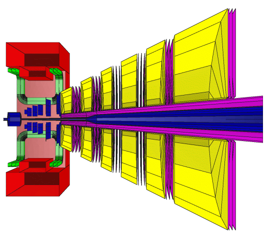

FIG. 1: A schematic view of the presently optimized version of the muon detection system, for di-muon measurements in the CBM experiment.

In Fig. 2 we have shown the sectored design of the muon detection system. Each detector layer has been divided into 6/10 uniform trapezoidal sectors (number of sectors is a tunable parameter). To accommodate detector electronics, cooling systems etc., half of the sectors are placed on the front side and rest are at the back. Segmentation of the detector planes are necessary for a realistic Doctor design in the high granularity environment. In order to take into account the variation of hit density with the distance from the beam pipe,

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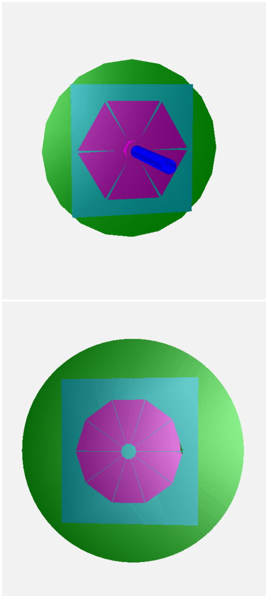

FIG. 2: A schematic view of the sector design layout of the muon detection system. A chamber plane is divided into six sectors (top) and ten sectors (bottom).

the muon chambers are segmented in different annular regions filled with square pad, with pad size (a tunable parameter) increasing with radius. Segmentation with radially increasing pads, and segmented in azimuth helps to keep occupancy close to constant. This helps in avoiding radial dependence response of the detectors. The total number of pads over all the six stations amounts to be 550,800, which is much less compared to the modular design ($\sim 18\times10^5$). This in turn helps to drastically reduce the cost.

Feasibility study

For the sake of feasibility study, we have simulated central Au+Au collisions for beam energies E_{Lab} = 8, 25 and 35 AGeV. As input particle we have considered ω meson from the lmvm sector. Omega mesons are generated through PLUTO [2] event generator, following a thermal p_T and Gaussian rapidity distribution. The background is simulated using UrQMD [3] event generator. Full event reconstruction has been done in the CBMROOT [4] framework. Basic digitization has been implemented, detailed digitization with the signal generation in gas is not implemented yet, but will be presented in the meeting. However comparisons have been done for two similar configurations in modular (M) and sector (S) geometries. The reconstruction efficiency and signal to background ratio (S/B) of ω mesons calculated in a (+/-) 2σ window around the signal peak and are presented in Table I. As it appears, even with significantly lower pad multiplicity, efficiency and S/B do not deteriorate for sector geometry compared to the modular geometry case.

TABLE I: Reconstruction Efficiency and Signal to Background ratio of ω meson in central Au-Au collision at 8, 25 and 35 AGeV (Input events: 10k UrQMD+PLUTO)

Energy (A GeV)	Efficiency(%)		S/B	
	M	S	M	S
8	1.21	1.42	1.41	2.57
25	2.9	2.48	0.49	0.36
35	3.31	2.79	0.34	0.35

Summary

In the CBM experiment,muons have been identified as one of the potential candidates for the measurement of penetrating probes like low-mass vector mesons and charmonia. Extensive simulation studies has already established the feasibility of di-muon measurements. The present paper gives the first results of muon measurements for the sectored structure of the muon chambers. From the practical point of view a sector layout is much easier to implement compared to the modular detector design. It also helps to significantly decrease the pad multiplicity and thus reduce the cost.

References

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