Feasibility study for a muon detector for the CBM Experiment

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Introduction

The Compressed Baryonic Matter (CBM) experiment [1] at the future FAIR accelerator facility at GSI, Darmstadt is being designed to investigate heavy ion collisions in fixed target mode at beam energies from 10 - 45AGeV. The major goal is to explore the QCD phase diagram in the region of high baryon densities and at moderate temperatures. One of the proposed key observables is the measurement of charmonium via the dilepton decay channel. As leptons leave the initially produced hot and dense fireball without further interactions, they are excellent probes to study in-medium properties of vector mesons. In this contribution we will present detailed feasibility studies for a di-muon measurement in CBM.

CBM experimental setup

The CBM experiment will measure hadronic and leptonic probes in a large acceptance and at very high interaction rates (up to 10MHz). The current detector concept for the muon measurement consists of a Silicon Tracking System (STS) located inside a magnetic dipole field as the primary tracking device. Upstream of the STS follows the Muon Chamber (MuCh) system consisting of several tracking stations sandwitched between iron absorber layers of varying thickness. The total thickness is 2.25m ($13.4\lambda_I$). In the present study, the MuCh system consists of 6 tracking stations; each tracking station having three detector layers made up of GEM detector modules which are arranged in rows on both sides of support structures as shown in Fig 1. However in future, for outer detector layers other solutions (straw tubes or MWPCs) are foreseen.

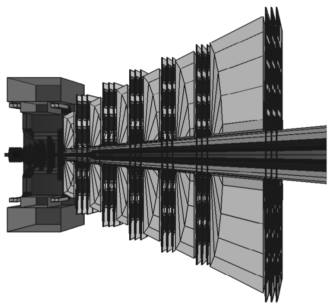

FIG. 1: Sketch of the CBM Muon detection system.

Simulation studies

Feasibility studies for the di-muon measurement are being performed within the CBM simulation framework CBMROOT which allows full event simulation and reconstruction. The vector meson decays are generated using the PLUTO generator [2] assuming an isotropic thermal source with a temperature of 130MeV. Multiplicities are taken from the HSD transport code [3] for central Au+Au collisions at 25AGeV. The UrQMD event generator [4] is being used for the generation of the hadronic background. Both, signal and background are transported through the detector setup using the transport code GEANT3 [5].

Segmentation scheme

A proper segmentation of the muon detector is essential for a realistic detector design

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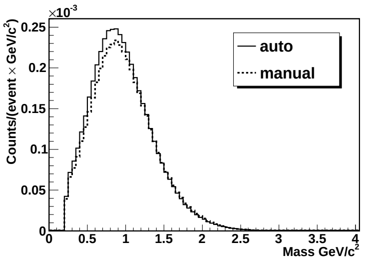

FIG. 2: Comparison of background distributions for different segmentation schemes.

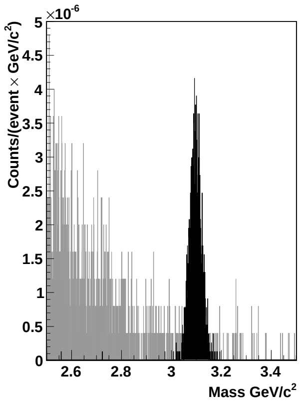

FIG. 3: Invariant mass spectrum of J/ψ in the muon decay channel for central Au+Au collisions at 25 AGeV beam energy.

and related optimization studies. In the default segmentation scheme ("auto segmentation"), the pad sizes are mostly governed by an occupancy restriction of 5%. The minimum pad dimension is 0.2cm×0.2cm and the total number of channels is 2.6M. A flexible segmentation scheme ("manual segmentation") was being implemented to optimize the detector layout with realistic pad dimensions without an occupancy restriction [6]. In Fig. 2, the background distribution from UrQMD central events is being compared for two segmentation schemes, "auto" and "manual". In this "manual" segmentation, detector layers are segmented into regions with increasing pad dimension from the inner to outer radial direction. An optimized arrangement is achieved in this "manual" segmentation where the minimum pad dimension is the same as above but the total number of channels is 1.3M (factor 2 less than "auto").

Results

Feasibility studies for the J/ψ detection are being performed with $10,000$ signal events and $50,000$ background events properly scaled according to a multiplicity of the J/ψ of 1.95×10^{-5} for central Au+Au collision at 25AGeV beam energy. The invariant mass spectrum of J/ψ after a full analysis with appropriate track quality cuts is shown in Fig. 3 for the "manual" segmentation. The efficiency and the signal to background ratio are estimated in a $\pm 2\sigma$ window around the signal peak and are presented in Table 1 for both "auto" and "manual" segmentation. The total efficiency for J/ψ detection including detector acceptance is found to be 14% with a good signal to background ratio (S/B) of 20. It should be noticed that, in "manual" segmentation, the same result is achieved as with the "auto" segmentation with a factor 2 less number of channels. The next step is a realistic description of the detector signals using routines for producing real charge distributions.

	auto	manual
Efficiency(%)	14.4	14.7
S/B	23.4	20.6

TABLE I: The efficiency and signal to background ratio for J/ψ meson feasibility studies in central Au+Au collisions at 25AGeV beam energy.

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