Hadronic Cocktail Simulation with new CBM Muon Chamber at FAIR

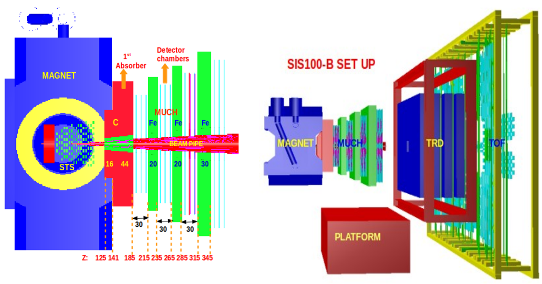
Ekata Nandy[1]*, Partha Pratim Bhaduri[1] and Subhasis Chattopadhyay[1]
[1] *Variable Energy Cyclotron Centre, HBNI ,Kolkata- 700064, INDIA*
* *email: ekata@vecc.gov.in*

Introduction

The Compressed Baryonic Matter (CBM) experiment is a future fixed target experiment , which will be commissioned at the Facility for Anti Proton and Ion Research (FAIR) in GSI, Darmstadt. The focus of this experiment is to investigate properties of nuclear matter, at very high net-baryon density (~5-10 $\rho_{Nuclear}$) and moderate temperature through collisions of heavy nuclei in 6-40 AGeV energy range [1]. Dilepton measurement is a central part of the CBM research program and constitutes a diagnostic probe of chiral symmetry restoration which is manifested as broadening of width and/or mass shift of low mass vector mesons (LMVMs). The Muon Chamber (MUCH) of CBM is specifically designed to measure low momentum muon pairs that originate from decay of LMVMs. This allows direct measurement of in-medium modification of spectral functions of these short-lived mesons. In this article we discuss about the feasibility of detecting LMVMs through newly designed CBM-MUCH.

Revised MUCH geometry and its implementation in CBMROOT

The MUCH system will be built in stages which are adapted to the beam energies available. Thus a modular MUCH system is presently under development which can be easily upgraded according to the beam energies under investigation. In all version of MUCH geometry the total absorber is segmented into several pieces, interlaced with tracking stations [2]. For the first two stations Gas Electron Multiplier (GEM) will be used and, in 3rd and 4th station Resistive Plate Chambers could be a potential detector. The standard MUCH setup has 4 stations + 4 absorber system (known as SIS100B) as shown in Fig.1. Absorber thicknesses are 60+20+20+30 cm consecutively down the beam line . In the standard setup, the first absorber is made of graphite, rest of the absorbers are made of iron and of parallelepiped in shape. The first absorber has a biconical geometry and segmented into two parts that has conical shape. One part is housed inside magnet and, the other part is placed out side magnet [3].



(a) (b)

Fig. 1 (a) CBM MUCH geometry (4 stations and 4 absorbers) with different specifications. (b) whole CBM setup with Magnet, MUCH,STS,TRD and TOF (revised version).

Recent simulations on radiation studies based on FLUKA have shown that the conical geometries lead to large neutron dose on the detector chambers of the first Much station. So it was proposed to make the 1st part of the 1st absorber as trapezoid shape and the 2nd part as a parallelepiped. Thus the absorber in revised design completely covers the downstream opening of the dipole magnet. The geometry of the modified absorber and its surroundings is shown in figure 1. There are total 4 stations so as a whole there are total 12 layers of GEM chambers. Absorbers are inter-spaced by 30 cm. There is a shielding inside the absorbers and it extends upto the beam pipe. Beam pipe is made of Aluminium. The full CBM setup is shown in Fig 2. consisting of Magnet, Silicon Tracking Stations (STS), MUCH, Transition Radiation

Detector (TRD) and Time of Flight detector (TOF).

Simulation Study and Results

First we studied the point density distribution of the stations w.r.t the standard setup because this tells us the rate of particles which are falling on detector per cm^2 per event. Figure 2 shows that point density distribution for all stations of the revised MUCH setup compared with the standard one at 8 AGeV central Au+Au collisions.

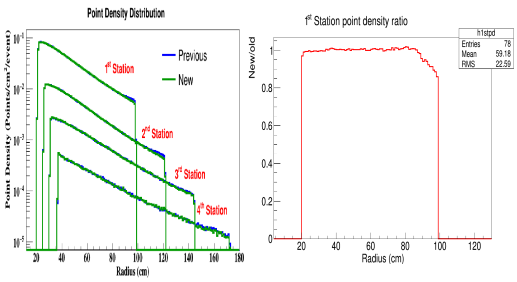
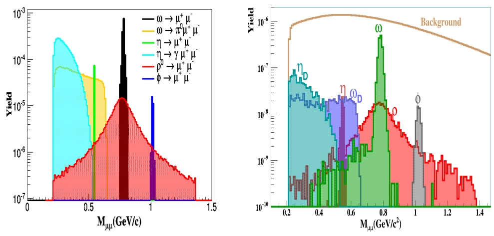


Fig. 2 Comparison of point density distribution of different stations of revised MUCH with previous one. (b) Ratio of point density (revised/standard geometry) of 1st station.

We can see from Fig 2. that for revised MUCH geometry particle density distribution is nearly same and at the outer radius the particle density for the modified MUCH geometry reduces somewhat. This is expected as in new MUCH the 1st absorber coverage in transverse direction is more hence more particles are absorbed.

Now, to study the feasibility of LMVM detection of modified MUCH setup, we have transported the produced particles from Au+Au reactions through CBM set up for 8 AGeV central collisions. Particles generated from UrQMD constitute the background particles and PLUTO is used to generate LMVMs which decay to dimuons. Here we have considered ρ, η, φ, ω, ω_D, η_D hadronic cocktails through their dimuon decay channel. Kalman filter and Cellular Automaton technique is used for particle tracking. After reconstruction dimuons are filtered through some selection cuts. For 12 layer tracking chambers selection cuts are – STS hits ≥ 7, MUCH hits ≥ 11 , $\chi^2_{vertex} \leq 2.0$, $\chi^2_{MUCH} \leq 1.3$. After selecting dimuons , they are combined by super event technique to get invariant mass distribution of background particles. Fig (a) shows the invariant mass distribution of hadronic cocktails from raw PLUTO. Fig (b) shows invariant mass distribution of reconstructed dimuons. We can see that the yield of reconstructed dimuons reduces significantly compared to input PLUTO which is basically loss of muon pairs due to finite reconstruction efficiency. In table 1. efficiency of hadronic cocktails have been listed. Fig shows the S/B of hadronic cocktails with invariant mass. We can see clear peaks in S/B plot around η, φ and ω. S/B of all cocktails have been listed in table. So it indicates the feasibility of the measurement of vector mesons through CBM- MUCH.



(a) (b)

Fig : Invariant mass distribution of (a) cocktails from PLUTO, (b) reconstructed cocktails

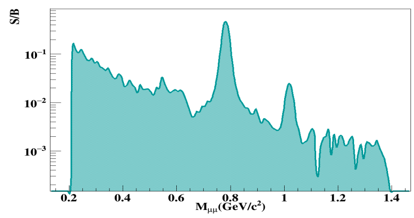


Fig : Invariant mass distribution of S/B of hadronic cocktails.

	ω	ρ	η	φ	ω_D	η_D
Eff (%)	0.92	0.92	0.49	1.35	0.33	0.2
S/B	0.25	0.006	0.005	0.007	0.004	0.006

Table 1 : Efficiency and S/B of hadronic cocktails.

References

[1] "Challenges in QCD Matter Physics",Eur. Phys. J. A(2017)53:60.
[2] MUCH Technical Design Report.
[3] DAE Symp. On Nucl.Phys. 61,p-808, (2016)