Cocktail detection with CBM Experiment at 25 GeV

S. Ahmad[1], *S. Chattopadhyay*[2], *and M. Farooq*[1]
[1]University of Kashmir, Srinagar India; [2]Variable Energy Cyclotron Center, Kolkata India

Compressed Baryonic Matter (CBM) experiment is a future fixed target experiment scheduled to take data in 2019 at Facility for Anti-proton and Ion Research (FAIR), GSI Germany. High density matter is expected to be formed in heavy ion collisions at the energy range accessible at FAIR. CBM will look for signatures of the expected first order phase transition from partonic to hadronic matter, ending in a critical point, and on modifications of hadron properties, e.g. their masses, in the dense nuclear medium as a signal of chiral symmetry restoration. Detection of rare probes, like charmonium(J/ψ) and low mass vector mesons (ρ^0, ω, ϕ) decaying into dilepton channel, never accessible before on the energy range from 10-40 AGeV, will be the speciality of the experiment. This is possible only because reaction rates upto $\sim$10 MHz have been foreseen in CBM. The high interaction rates require unprecedented detector performances in terms of speed and radiation hardness, as well as a fast and efficient on-line event selection [1].

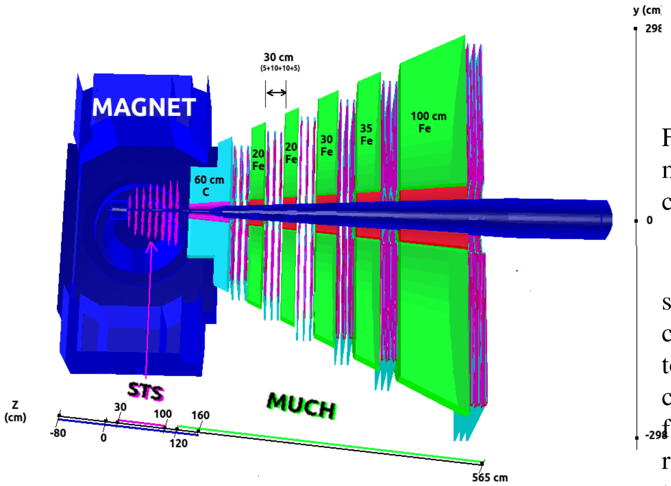

Figure 1: Muon Chamber set-up in CBM experiment for 25 AGeV collision energy

Muon Chamber(MUCH) in CBM-detector setup will look for the muonic channel of charmonium and LMVM (low mass vector mesons). MUCH detector is based on segmented hadron absorbers with detector chambers placed in between absorbers to facilitate momentum dependent track identification, in particular for soft muons from the decay of low-mass vector mesons. The MUCH system shown in Fig. refmuch for 25 AGeV comprises 6 absorbers, the first made of 60 cm Carbon, and the others made of (20 + 20 + 30 + 35 + 100) cm of Iron, in total equivalent to a nuclear interaction length of 13.5 λ_I. Between the absorber segments, 6 tracking stations each with three detector chambers are located. First few detector station will be made of GEM (Gas Electron Multiplier) as they are known to have stable gains and high resolution at high rates. Other advantage with GEM is that it is a large acceptance detector already employed or being implemented in many high energy physics experiments such as COMPASS, HBD, LHCb, CMS [2].

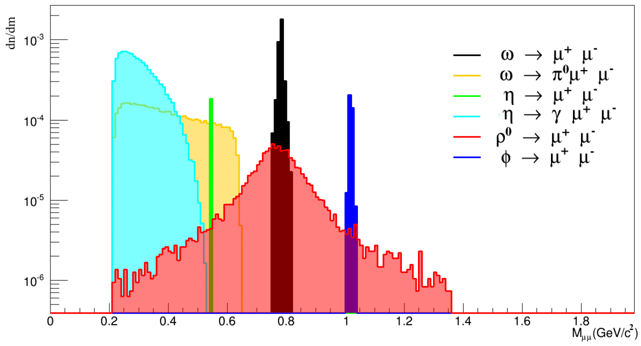

Figure 2: Invariant mass distributions of PLUTO input muon pairs from decaying low-mass vector mesons for central Au+Au collisions at 25 AGeV

The absorber properties like material, thickness, and position have been optimized in simulations of heavy-ion collision events generated by the UrQMD event generator [4], and transported through the setup with the GEANT code [3]. The same tools have been used to study the performance of the detector in the dimuon low invariant mass region. The multiplicities of the ω, η, ρ, and ϕ mesons are taken from the HSD event generator [7], and their branching ratios from the PDG [6]. Their phase-space distributions were calculated with the PLUTO event generator [5] for 25 A GeV Au+Au collisions. Fig. 2 shows the input coktail obtained from the PLUTO used in our simulation studies for central Au+Au collisions at 25 AGeV. The input for different signal sources of cocktail from PLUTO has been embedded with the UrQMD generated background events. GEANT3 particle transport code has been used to transport these particle through the set-up.

Reconstruction of the tracks is performed in two steps: (I) first all tracks are reconstructed at STS, which is a primary detector, using the cellular automata technique (II) then STS tracks are propagated through the MUCH us-

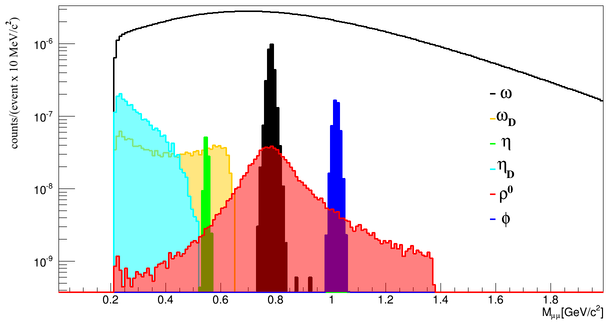

Figure 3: Invariant mass distributions of reconstructed muon pairs from decaying low-mass vector mesons together with the combinatorial background simulated for central Au+Au collisions at 25 A GeV

ing the kalman filter technique reconstruction is performed. The combinatorial background is calculated from UrQMD events using the superevent technique to increase the statistics. In order to reduce the background, conditions on the quality of the number of hits in STS and MUCH, on the quality of the primary vertex, and on the quality of the tracks in the MUCH were required in the analysis (sts hits $\geq$ 6, much hits $\geq$ 14, chi^2 vertex $\leq$ 2.0, chi^2 much $\leq$ 1.5). In Fig.3, the invariant mass distribution of the reconstructed muon pairs from low-mass vector mesons is shown together with the combinatorial background. It can be seen that MUCH has reconstructed all cocktail sources very well.

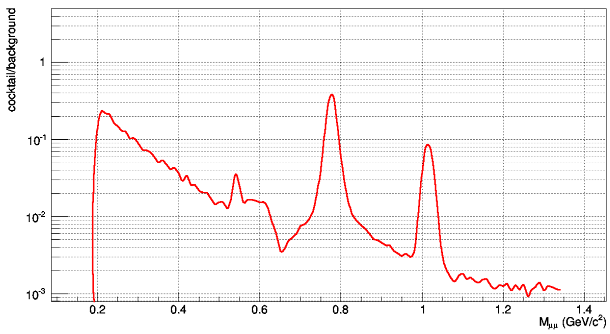

Figure 4: Signal to background ratio of the low mass dimuon invariant mass spectra for central Au+Au collisions at 25 A GeV

Figure 4 depicts the signal-to-background ratio(S/B) as extracted from Fig.3. It has been found that the S/B can be improved by a time-of-flight (TOF) measurement using the standard CBM TOF-RPC wall downstream the MUCH. The TOF measurement helps in the reduction of the background with minimal signal losses. The efficiency for the identification of ω, ρ, and ϕ mesons with the STS+MUCH detectors including overall geometrical acceptance is of the order of 1 %.

Figure 5 shows the phase-space coverage of ω mesons detected in MUCH superimposed over the input from PLUTO (4π). It can be seen that detector only covers region from mid-rapidity towards forward rapidity due to absorption of soft muons in the hadron absorbers of the detector.

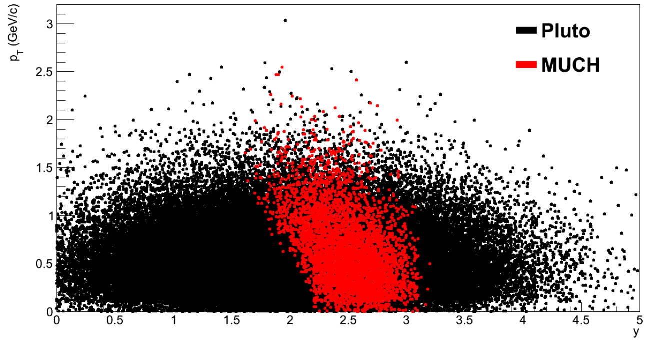

Figure 5: Acceptance of ω mesons of the MUCH (red) in comparison to the input from PLUTO (balck) for central Au+Au collisions at 25 A GeV

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