Performance Study of MUCH Beam Pipe and Shielding for CBM Experiment

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Compressed baryonic matter (CBM) experiment is considered as one of the major scientific project at the future accelerator facility for antiproton and ion research(FAIR) in Darmstadt Germany. CBM is a future fixed target experiment to explore the QCD phase diagram in the region of very high baryon density in heavy ion collisions, with very high interaction rate (10 MHz) in the energy range 2 - 45 AGeV. The high luminosity CBM experiment makes detection of rare probes like charmonium (J/ψ) and low mass vector mesons (ρ, ω, ϕ) possible via dileptonic decay channel. The novel feature of the muon detection system, the Muon Chamber for the CBM experiment, as compared to the muon detectors in other HEP experiments is that the total absorber is sliced and chambers are placed in between absorbers to facilitate momentum dependent track identification. This is to improve the capturing of low momentum muons, which would have been otherwise stopped by a single thick absorber [1].

Detailed simulations have been performed to optimize the detector system with respect to efficiency, signal-to-background ratio, and phase-space coverage. Optimization has been done based on the location and composition of the shielding materials along the beampipe length. Results from two configurations (called "old" and "new") are shown as a part of the study. The "new" configuration has been taken as the final configuration in CBM.Detector response to the low mass vector mesons(LMVM) has been studied for both the beampipe configurations in the SIS100-B setup (shown in Fig. 1) for Au+Au collisions at 8 AGeV.In new configuration, lead is used as a part of beam pipe in the region of 1st absorber from 120 cm to 180 cm along the beam direction which was not present in the

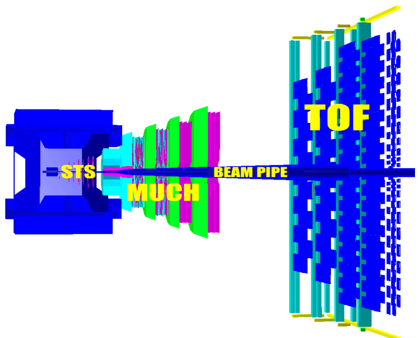
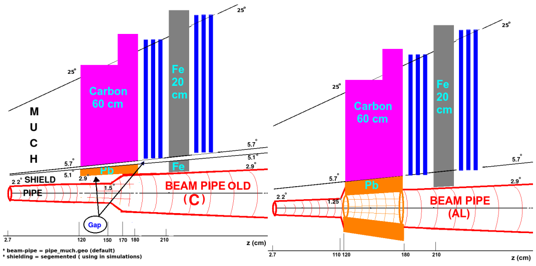


FIG. 1: Schematic view of the SIS100-B configuration with different sub detectors: Silicon Tracking System (STS),Muon Chamber(MUCH) and Time of Flight(TOF)

previous configuration. Gaps are present in between old beam-pipe and MUCH which has been filled with shielding material in new geometry as shown in Fig. 2 as sketch.



(a) (b)

FIG. 2: MUCH set-up with beam-pipe and shielding of: (a) Old configuration (b) New configuration

To study the performance of the new configuration we used PLUTO[2] event generator for signal particle (ρ, ω, ϕ, η, η_D, ω_D etc.) di-muonic decay events and UrQMD[3] for background events. GEANT3 transport code has been used to transport all these particles through the CBM set up. PLUTO generates signal dimuon pairs per event. For proper normalization multiplicities have been taken from the HSD, and branching ratios from PDG. Track reconstruction is first done in STS using cellular automata techinique and then the tracks are propagated through MUCH detector using kalman filter. Finally selection cuts are used to distinguish between the background and signal muon candidates for the improvement of signal to background (S/B) ratio. Cuts applied on hits are: STS hits $\geq$ 7, MUCH hits $\geq$ 11 and on tracks are: $\chi^2_{Vertex} \leq 2.0$, $\chi^2_{MUCH} \leq 1.3$. Moreover, background was further reduced by using TOF information in the simulation.

We use reconstructed $\mu^+ \mu^-$ pairs to obtain invariant mass spectra for signal as well as background. The combinatorial background has been calculated using super event (SE) technique to increase the statistics.

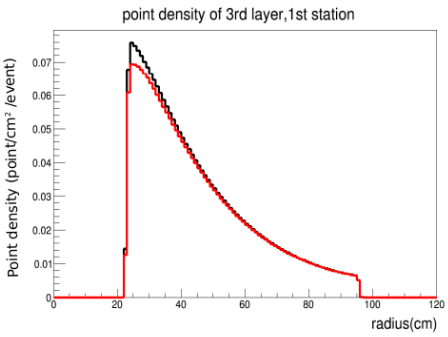
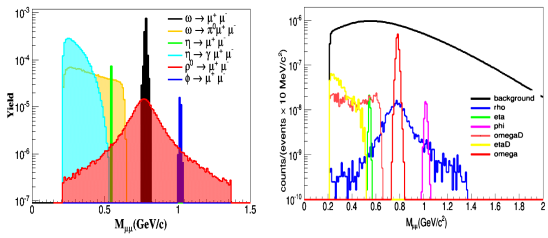


FIG. 3: Point Density distribution of the 1st station of MUCH

Fig. 3 shows the density of the points of the 1st station of MUCH as obtained from Geant (called MC- points) and the new configuration shows reduction in point density thereby reducing the occupancy of the detector layers which is expected due to filling up the empty gaps of old geometry.

Fig. 4a shows the input cocktail obtained from the PLUTO used in our simulation studies for central Au+Au collisions at 8 AGeV. Whereas, Fig. 4b shows the invariant mass distribution of the reconstructed muon pairs from low-mass vector mesons together with the combinatorial background.



(a) (b)

FIG. 4: (a) Input Cocktail from PLUTO at 8 AGeV (b) Reconstructed cocktail sources superimposed over background

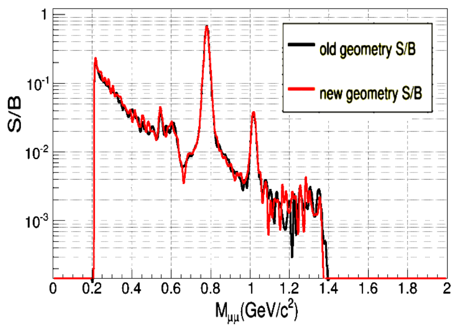


FIG. 5: Signal to background ratio

It can be seen from Fig 4b that all cocktail sources have been reconstructed well at 8 AGeV using new configuration. Fig 5 shows S/B ratio which is better than the existing detectors at this energy. No significant change in detection efficiencies of signals and the background has been observed in two configurations (old and new). It can therefore be concluded that the new beam pipe and shielding configuration looks suitable for detection of LMVMs with CBM-MUCH.

References

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