Secondaries upstream and downstream the first absorber of muon detection system for CBM Experiment at FAIR

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Introduction

The Compressed Baryonic Matter (CBM) is a dedicated fixed target heavy ion-experiment being planned at the international research center FAIR, Darmstadt Germany. The research program comprises the exploration of the QCD phase diagram at high net baryon densities and moderate temperatures, the search for the de-confinement phase transition, and in-medium modifications of hadrons. Detector will record hadronic, leptonic and photonic observables both in proton-nucleus and nucleus-nucleus collisions at beam energies between 10 and 45AGeV. The interaction rates will reach 10 MHz to measure extremely rare probes like charm near threshold, never accessible before at FAIR energy range[1].

Muon Detection System

To explore the muonic decay channel of charmonium and low mass vector mesons, muon detection system has been proposed. The present design of standard muon detection system of CBM experiment, includes 6 iron absorbers and 18 detector layers (3 behind each absorber) as shown in figure 1.

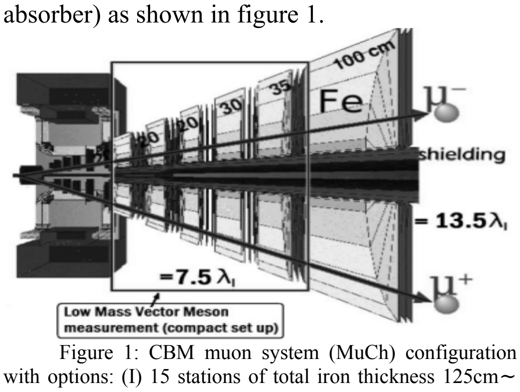

Figure 1: CBM muon system (MuCh) configuration with options: (I) 15 stations of total iron thickness 125cm∼ 7.5λI (interaction length of iron) for LMVM di-muon detection (II) 18 station of total iron thickness 225cm∼ 13.5λI for charmonium di-muon detection

The total absorber length in the current design amounts to 2.25 m of iron for charmonium and 1.25cm for low mass vector mesons. The idea is to continuously track all charged particles through the complete absorber, starting with the tracks measured by the Silicon tracker (which defines the momentum). This will ensure high tracking efficiency even for low momentum muons. Hadron punch-through contribution reduction and momentum measurement done by tracking before and after absorber (like NA60)

Analysis of secondaries

Secondaries lead to degradation of muon reconstruction efficiency as their radiation near the muon track may jeopardize the precision of the muon track measurement[2].

So we analysed the absorber layout of Much for secondaries in simulations using central Au+Au collisions at 25 AGeV for 1000 events generated by UrQMD event generator [3] then transported through the detector using GEANT[4] transport code, which creates the secondaries, utilising CbmRoot [5] framework. Reduced muon detection system, consisting of 3 absorber layers and 9 tracking chamber planes, grouped in triplets behind each absorber slab, have been used. The total absorber thickness is kept constant to 225 cm, whereas the thickness of the first layer is varied between 0 - 50 cm.

First we studied the particle multiplicity at last silicon tracking station (STS), which is behind MuCh, and particle multiplicity on first MuCh layer, which is infront of first iron absorber layer of much, as a function of the absorber thickness. The result is shown in Fig. 2. The particle multiplicity is dominated by the yield of secondary electrons which rises steeply up to an absorber thickness of about 5 cm, and then drops with increasing material thickness.

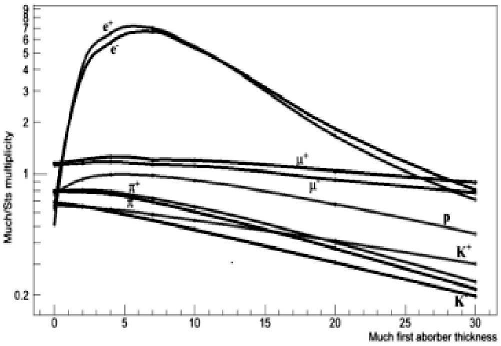

Figure 2 : Much/STS multiplicity ratio for different particles as a function of Fe absorber thickness

The particle multiplicity decreases also strongly with the increasing radial distance from the beam which is important for the segementation for Much tracking chambers.

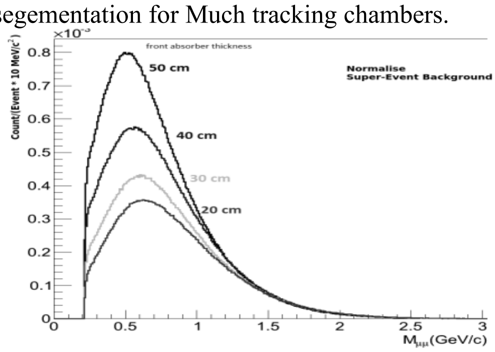

Figure 3: Invariant-mass spectra of reconstructed background tracks.

Influence of the thickness of the first iron absorber on the track reconstruction performance have also been analyzed. The results are shown in Fig. 3. Muons traversing iron absorber will undergo multiple coulomb scattering and it will deviate from its initial trajectory. These deviations will induce a contribution to the track curvature increasing mismatching and hence background.

Finally, we investigated the influence of the magnetic field, beam pipe, beam pipe shielding (tungsten) on secondaries especially electron-positron pairs and then neutrons. Removing Much from the set-up shows increase. Then after removing beam pipe, switching off magnetic field and finally removing the beam-pipe shielding. It is clear from the results shown in Fig. 4 that after removing the beam-pipe shielding (tungsten) completely,

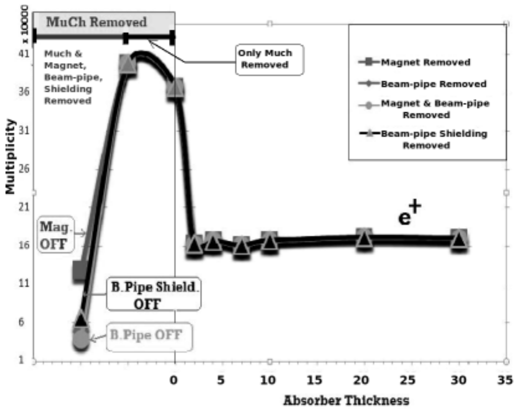

Figure 4 :Positron multiplicity at STS last station as a function of absorber thickness and when magnetic field, beam pipe and beam pipe shielding is removed completely.

while keeping magnetic field and beam pipe in the set-up, secondaries have mostly been reduced indicating that the tungsten shielding is the main source of the secondaries.

Conclusion

The particle multiplicity is dominated by the yield of secondary electrons, which rises steeply up to an absorber thickness of about 5 cm and then drops with increasing material thickness. In order to suppress this contribution, the muon detection system should be as close to the target and as compact as possible.

We also conclude that secondary electron positron pairs can be reduced if beam-pipe shielding material is re-optimized for different materials.

References

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