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STS Effects and MUCH Effeciency of CBM Experiment

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The Compressed Baryonic Matter (CBM) experiment will be one of the major scientific pillars of the future Facility for Antiproton and Ion Research (FAIR) in Darmstadt Germany. The goal of the CBM research program is to explore the QCD phase diagram in the region of high net-baryon densities using high-energy nucleus-nucleus collisions. The CBM research program includes the study of the equation-of-state of nuclear matter at neutron star core densities, the search for the chiral phase transition, and for new forms of strongly interacting matter. The CBM detector is designed to measure rare diagnostic probes such as multi-strange hyperons, charmed particles and vector mesons decaying into lepton pairs with unprecedented precision and statistics [1].

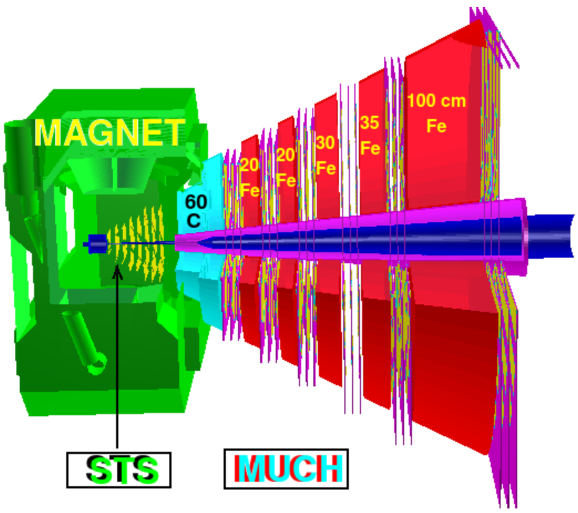

Figure 1: Muon Chamber set-up in CBM experiment for 25 AGeV collision energy

The CBM muon detection system is designed to measure muon pairs from the decay of vector mesons ($\rho, \omega, \phi, J/\psi$) produced in heavy-ion collisions. At FAIR energies the muon momenta can be rather low, therefore, a muon detection concept with a variable definition of absorber thickness according to the muon momentum has been developed. The full design of the muon detector system consists of 6 hadron absorber layers, first made of carbon of thickness 60 cm and rest five absorbers of iron of thickness 20, 20, 30, 35, 100 cm respectively as shown in Fig. 1. The 18 gaseous tracking chambers are located in triplets behind each hadron absorber. MUCH will be placed at a distance of 120 cm downstream the target. Upstream of MUCH is Silicon Tracking System(STS) which consists of 8 low-mass layers of silicon microstrip sensors located at distances between 30 cm and 100 cm downstream of the target inside the magnetic dipole. Signal particles are generated using PLUTO event generator [4], while background generation is done using the UrQMD event generator [3]. Events from PLUTO and UrQMD are then embedded and transported using the GEANT [2] through the CBM set-up. Primary track finding and reconstruction is carried at STS using cellular automaton method and MUCH detector propagates these tracks through the detector in which track and vertex fitting makes use of a Kalman filter [7, 8].

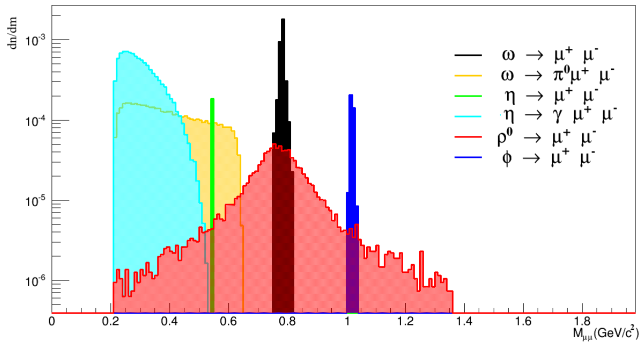

Figure 2: Invariant mass distributions of PLUTO input muon pairs from decaying low-mass vector mesons for central Au+Au collisions at 25 AGeV

In this work, we study the performance of MUCH taking STS as the reference. This way, MUCH performance would be judged independant of the performance of STS which effects overall performace of MUCH. Work has been done using GEANT3 simulation with heavy ion collision events given by the UrQMD event generator. We used input as cocktail at 25 AGeV Au+Au collisions taken from the PLUTO event generator as shown in Fig. 2 with multiplicities of different sources taken from HSD [6] and branching ratios from Particle Data Group(PDG) database [5].

First if we try to see the detector acceptance compared with the input to see the losses. In Fig. 3 the phase-space coverage is shown for ω mesons and ρ mesons detected in the STS (blue) and in STS+MUCH (red) superimposed over the input from PLUTO (4π). Because of the absorption of soft muons in the hadron absorbers the MUCH only covers the region from mid-rapidity towards forward rapidity.

Invariant mass spectra has been calculated from the reconstructed signal muons after embedding them event

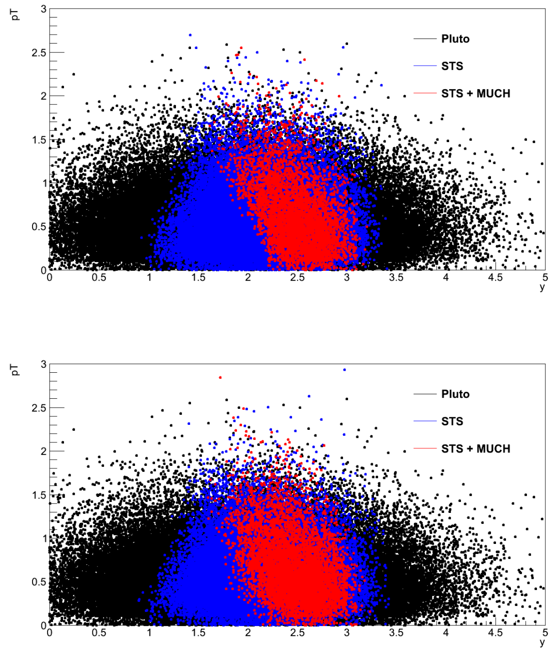

Figure 3: Acceptance of ω (upper panel) and ρ^0 (lower panel) mesons of the STS (blue) and STS+MUCH (red) in comparison to the input from PLUTO (black) for 25A GeV central Au+Au collisions

by event into the UrQMD events. Reconstructed different sources of cockatil from the MUCH after STS reconstructed track information have been used is shown in Fig. 4.

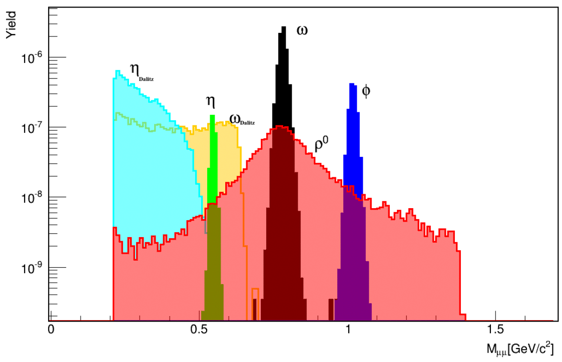

Figure 4: Invariant mass distributions of reconstructed muon pairs from decaying sources of cocktail for central Au+Au collisions at 25 A GeV

To calculate detector effeciencies for different sources of cocktail, STS reconstructed tracks and STS+MUCH reconstructed tracks have been used at STS and MUCH respectively. The detection efficiency of STS and MUCH detectors (including overall geometrical acceptance), at optimised cuts of MUCH for different cocktail sources are shown in Table.1. 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. The MUCH optimised cut values (sts hits $\geq$ 6, much hits $\geq$ 14, chi^2 vertex $\leq$ 2.0, chi^2 much $\leq$ 1.5) have been obtained from simulation after considering the best compromise between signal effeciency and background reduction.

Particle	Eff.(MUCH)	Eff.(STS)	MUCH/STS (%)
ω	0.83	17.1	4.9
ω_{Dalitz}	0.29	16.5	1.8
η	0.46	17.3	2.7
η_{Dalitz}	0.22	16.4	1.3
ρ	0.81	16.9	4.8
ϕ	1.47	17.0	8.7

Table 1: Reconstructed signal particle effeciencies of STS and MUCH for central Au+Au collisions at 25 A GeV

The efficiency for low-mass vector mesons in the STS is only of the order of 17 % for low mass vector mesons in the conditions discussed above are applied. These conditions are required to enhance the signal-to-background ratio for dimuons. If we correct for the STS efficiency, the efficiency for dimuon decays of ω, ρ, and ϕ is of th order of 5% in 25A GeV central Au+Au collisions. The signal-to-background ratio has been found to be very good in comparison to existing or planned muons detection systems in high energy heavy-ion collision experiments [9].

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