A Study on Heavily Ionizing Particles using Simulation

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Introduction

CBM experiment at FAIR, Germany aims to study various aspects of a new form of matter known as the Quark Gluon Plasma or QGP. Inside QGP, hadronic degrees of freedom are converted to partonic degrees of freedom. In other words, the partons inside the hadrons become deconfined and their interaction range increases from nucleonic to nuclear volume. The CBM experiment will try to produce QGP by collision of a heavy nuclei at a fixed target. The energy of collision is kept low (2-11 AGeV) thus producing a fireball of density many times higher than normal nuclei in hope that the partons inside the nuclei get deconfined.
CBM wishes to study various rare probes (like double hyper-nuclei and multi strange anti-hyperons) produced from the fireball that have never been studied before at appreciable statistics. No wonder that unprecedented interaction rates (upto 10 MHz) are required for this study. Along with this ambitious goal comes a great challenge of making radiation hard detectors and developing novel data acquisition techniques.
As part of one such attempt, we at VECC are trying to study the robustness of our Muon detection chamber or MuCh (a detector subsytem made by VECC, India for the CBM) in the environment of heavily ionizing particles. This study is done using simulation and is composed of two parts. First part invloves isolating the potential heavily ionizing particles amongst the zoo of particles produced in the collision. Second part involves calculation of their rates and energy depositions thus calculating the risk posed to our system at different stations (discussed in more detail later).

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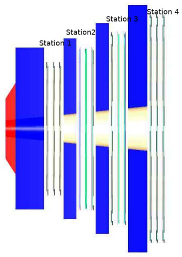

FIG. 1: One of the proposed Geometries of MuCh for the CBM experiment

MuCh Geometry

The MuCh Setup consists of four GEM module stations (Ref. FIG 1). Each station consists of three layers each and each layer consists further of two sides. The particular geometry shown in the above figure consists of all four GEM stations. Apart from the detector stations there are absorbers which are depected in dark blue and red. The absorber material used by us for the simulation is Carbon before the first station and rest of the absorbers being made of Iron. Apart from the geometry shown above, multiple combinations of absorber materials and modules (apart from GEM) have been considered, but they are beyond the scope of this particular study.

Simulation and Results

Firstly a list of all the particles detected in all the subsytems was simulated using UrQMD transport model and GEANT4 simulation software. In this particular study, we have taken the collisions for Gold nuclei on a Gold Target at a beam energy of 10 AGeV with only central events (greater than 90%) taken into account.
In FIG. 2 is the list of all the particles that were detected at the Muon Chambers with their multiplicities. Please note that this histogram is only for hadrons and do not contain any leptons.

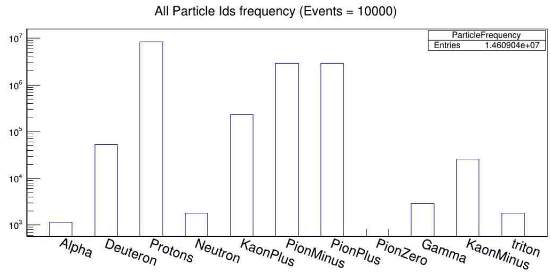

FIG. 2: All particles detected at the Muon Chambers.

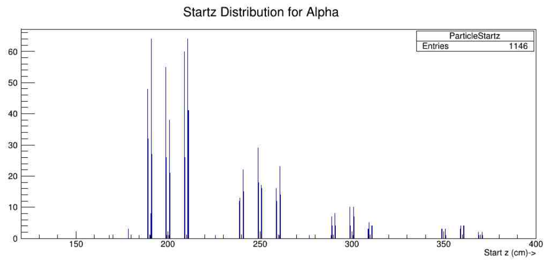

FIG. 3: Z-coordinate for the origin of alphas vs. number of alphas detected

Out of these particles only the particles of interest are those which deposit high energies in the gaseous media of the detector. After some studies the particles od interest were narrowed down to three:

1. Alphas
2. Deuterons
3. Tritons

For the sake of convenience we only present the study for alpha particles.

From FIG. 3 It is clearly visible that the energy deposited is restricted purely to the absorbers of the MuCh and that too very close to the detector volume. A more detailed study shall be presented later.

Further Studies

From FIG. 4 we get a quanitative understating of how the alphas are getting produced and how they are detected within the gaseous medium.

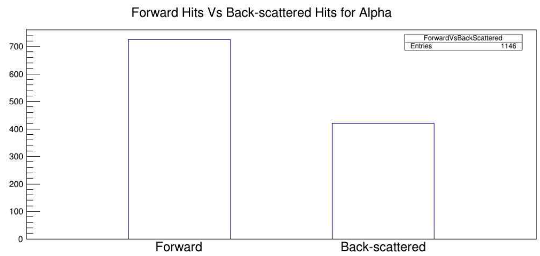

FIG. 4: A study of alphas that are coming from the beam direction vs. those that get backscattered

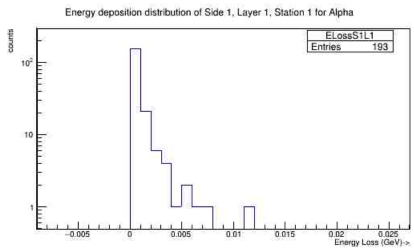

FIG. 5: A study of alphas and how much energy each deposit

Acknowledgments

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References

[1] Technical design report for CBM-MuCh.