Development of a trigger algorithm for the measurement of rare probes in the CBM Experiment at FAIR

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Introduction

The Compressed Baryonic Matter (CBM) experiment [1], at the upcoming FAIR center at GSI Darmstadt, aims at the exploration of baryonic matter at high density produced in relativistic heavy-ion collisions. The proposed key observables include the measurement of charmonia, which can be measured via their decay into the dimuon channel [2]. However the multiplicity of charmonium is extremely small at FAIR energy regime (E_L = 10 - 40 AGeV) which requires an extreme interaction rate (up to 10^7 events per second) to have good enough statistics. The foreseen Data Acquisition system (DAQ) can record the events at a rate of 25 KHz. In this report we describe the development of an algorithm for an on-line event selection to pick up the interesting physics events (events containing the rare particles) and reject the background events.

Algorithm

The aim is to select events on-line which contain muon pairs coming from charmonium decay. For faster selection, we have used hits only from the 3 layers of the last station which we call trigger station. Since our muon detection system is placed outside the magnetic field, high momentum muons coming from decay of J/ψ will go approximately straight up to the last station.

The present algorithm is based on following steps:

1. Take 3 hits from the trigger station with one from each of the 3 layers and fit with straight line, both in X-Z and Y-Z plane, passing through the origin (0,0) i.e. X = m_0*Z ; Y= m_1*Z

2. Find χ^2 and apply cut on both χ^2_x and χ^2_y. Hit combinations satisfying the cuts ($\chi^2_x, \chi^2_y \leq 0.2$) are called triplets. Hits once used for formation of a triplet is not used further.

3. Make all possible combinations.

4. Define a parameter $\alpha = \sqrt(m_0^2 + m_1^2)$ from m_0 and m_1 obtained from step1 and apply cut on α ($\alpha \geq 0.183$).

The cuts are applied sequentially from cut 1 to cut 4.

Figures and Tables

TABLE I: Background suppression factors for different trigger cuts (Input events: 80k mbias UrQMD)

Cut	Events survived	Statistical Error	B.S.F
1	2624	1.95	3
2	255	6.26	314
3	91	10.4	879
4	56	13.36	143

TABLE II: J/ψ reconstruction efficiency for different trigger cuts

Cut	Reconstruction efficiency
no cut	29.3
cut 1	29.2
cut 2	24.5
cut 3	24.2
cut 4	15.3

Results

For estimating the performance of the proposed algorithm, we have simulated 80K

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minimum bias UrQMD events for 25A GeV Au+Au collisions for simulating the background and 1K Pluto events for signals from J/ψ decayed into muons. The results for background suppression factors (BSF) and the efficiency for J/ψ are shown in tables I and II respectively. In these tables the specification of the cuts are as follows. Cut 1 demands that an event should have at least one triplet, whereas those events having two triplets satisfy cut 2. Cut 3 specifies that at least one of the two triplets satisfies the α cut, whereas cut 4 signifies that both the triplets satisfy the α cut. J/ψ reconstruction efficiency is obtained after full reconstruction of tracks and measurement of area under the invariant mass peak.

Summary

Muons are a potential candidate for the measurement of charmonia at FAIR. But due to their extremely low production rate at CBM energies, very high event rates are required for their measurement with a well defined statistics. An algorithm to filter out the rare events is under development to suppress the background events as much as possible without reducing the signal reconstruction efficiency. The algorithm has already been optimized to achieve the sought suppression rate (400). Work is ongoing to improve the signal reconstruction efficiency.

References

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