Studying effect of detector digitization parameters on ω reconstruction in CBM

A. Kumar[1,2*] and A. K. Dubey[1,2]
[1] *Variable Energy Cyclotron Centre, Kolkata - 700064, INDIA and*
[2] *Homi Bhabha National Institute, Anushaktinagar, Mumbai, Maharashtra 400094, INDIA*

Compressed Baryonic Matter (CBM) is a fixed target heavy-ion experiment at the FAIR facility of GSI Darmstadt Germany. This experiment aims to study the Quantum Chromodynamics (QCD) matter at high net-baryon densities and moderate temperature by colliding heavy-ion beams in the energy range of 2-14 AGeV at the SIS100 setup [1]. The di-lepton physics is the central part of the CBM experiment as they are sensitive diagnostic probes for the condition inside the fireball. Measurements of di-leptons (decaying from J/ψ, ρ, ω, ϕ) will provide information on the temperature and lifetime of the fireball, chiral symmetry restoration, and in-medium properties of the vector mesons. The di-muon measurements at CBM will be carried out using a Muon Chamber (MuCh) system [2], which consists of alternating layers of segmented absorbers and detector stations. This novel scheme of using segmented absorbers allows the detection of muon tracks in a broad momentum range. A Gas Electron Multiplier (GEM) detector will be used for the first two stations due to high particle rates. The simulation chain consists of the following steps:

- Particle generation using event generators like URQMD for background events and PLUTO for signal events.
- Transport of particles through the detector setup using GEANT3 transport engine.
- Digitization of Monte Carlo (MC) points (generated by incident particles on the detector) to form digitized signal.
- Clustering and local hit reconstruction.
- Di-muon reconstruction.

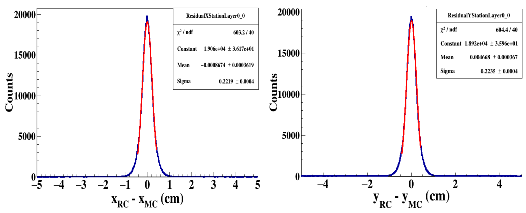

FIG. 1: Distribution of residual in x (cm) and y (cm)

In the third step, we provide the detector digitization parameters, such as spot size, gas gain and noise threshold etc., for studying realistic performance. In this report, we have studied the systemtic effect of these parameters on ω reconstruction for central Au+Au collision at 8 AGeV beam energy.

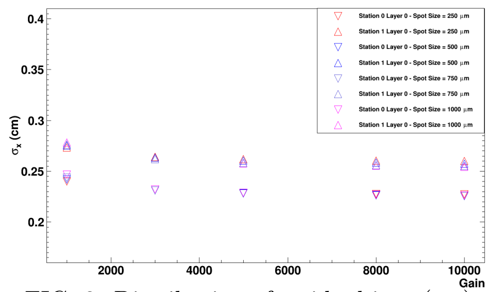

FIG. 2: Distribution of residual in x (cm)

The residual distribution or the difference between reconstructed hit coordinates and Monte Carlo hit coordinates in x & y is shown in Fig. 1. The sigma of this distribution is related to the track resolution, which can vary by changing the digitization parameters. The variation of σ_x with detector gain for different spot size is shown in Fig. 2. The resolution improves slightly by increasing gain and is observed to saturates after 3.0 k. At any par-

*Electronic address: `akmaurya@vecc.gov.in`

ticular gain, the effect of spot size is observed to be insignificant on track resolution. It can also be seen from the same figure that the 1^{st} station has a smaller value compared to 2^{nd} station. The relative increase at the second station is attributed to the multiple scattering of charged particles inside the second absorber. The same observation was seen for σ_y.

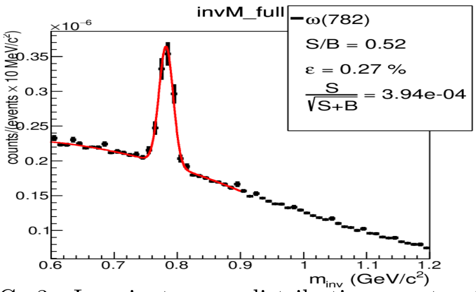

FIG. 3: Invariant mass distribution spectra for omega meson

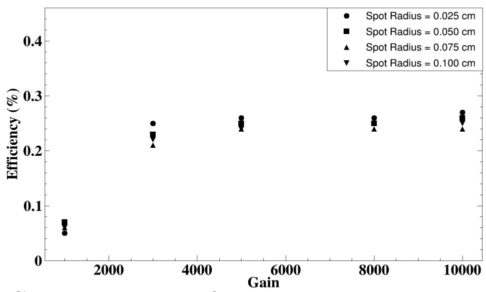

FIG. 4: Variation of omega reconstruction efficiency with gain for various spot size settings

The invariant mass spectra is obtained for all the digitization parameter settings after a full simulation and reconstruction. A set of single track quality cuts are applied to the reconstructed global tracks to identify the muon track candidates. Reconstructed global tracks satisfying the condition of STS hits $\geq$ 7, MUCH hits $\geq$ 11, TRD hits $\geq$ 1, $\chi^2{}_{Vertex}$ $\leq$ 2.0, $\chi^2{}_{STS}$ $\leq$ 2.0 and $\chi^2{}_{MUCH}$ $\leq$ 2.0 are selected as valid muon track candidates. The contribution of non-muonic tracks can be further reduced by applying a 2σ cut on the reconstructed TOF mass. The signal is extracted from the embedded set of events by selecting oppositely charged muon candidate tracks on an event by event basis. The background is calculated using the super event (SE) technique, where one muon candidate track is combined with all the other oppositely charged muon candidate tracks. The invariant mass distribution for omega meson at the default setting of digitization parameter is shown in Fig. 3.

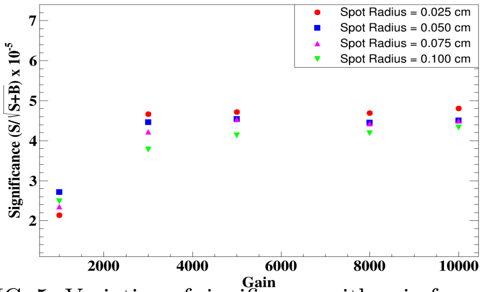

FIG. 5: Variation of significance with gain for various spot size settings

The variation of reconstructed efficiency with gain at various spot-size setting is shown in Fig. 4. It is low at a lower gain and jumps up to saturation value at mean gas gain >3000. At any particular gain, the effect of spot size on the efficiency is observed to be insignificant and remains constant. The detector gain is expected to directly influence the reconstruction efficiency. But at a gain >3.5 k, it is observed that it becomes independent of gain. The variation of significance (S/$\sqrt{S+B}$) with a gain is shown in Fig. 5. The trend is entirely similar to what we saw in the efficiency plot.

In summary, we conclude that the efficiency of finally detecting ω meson does not vary with spot radius. It however increases with gain and saturates after a gain of about 3.0k. From this study, the optimized value of mean gas is about 3.5 k or greater, and the spot radius can be between 250 μm-1000 μm.

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References

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