Reaction plane reconstruction in the CBM experiment at SIS100

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The determination of the azimuthal orientation of the reaction plane in nucleus-nucleus collisions is crucial for anisotropic flow measurements. In the CBM experiment, the reaction plane can be measured from the sidewards deflection of spectator particles using a forward hadronic calorimeter, referred to as the Projectile Spectator Detector (PSD). The Silicon Tracking System (STS) of the experiment, designed to cover a different region of particle rapidity, can provide another independent and complementary measurement. This work consisted in investigating the capabilities of each of these detectors for reconstructing the reaction plane at SIS100 energies. Also, to improve the collision rate capability of the experiment [1], an alternative solution involving a forward Time Of Flight (TOF) wall instead of a PSD has been studied.

The simulations were carried for Au+Au collisions in the CBMroot environment, using the event generator SHIELD and the transport code GEANT, the latter being complemented with the hadronic interaction package GEISHA. A realistic model of the CBM detector was considered, including a 250 μm thick Au target, a STS consisting of 8 silicon stations located between 30 cm and 1 m from the target and embedded in a dipole magnet, and a PSD constituted transversally of 44 modules of 20 $\times$ 20 cm^2, each composed, along the beam axis, of 60 layers with combined Lead absorber and scintillator material. The optimum position of the latter detector along the beam axis was one the objects of this study. As for the forward TOF wall, it is modeled by a silicon circular plane with approximately the same transverse dimensions as for the PSD.

The azimuthal orientation of the reaction plane has be determined with the help of the so-called event plane method [2]. The latter uses the anisotropic flow of emitted particles. This flow can be exploited directly by measuring the momentum of charged particles in the STS, while it is reflected in the distribution of the energy deposited by projectile spectators in PSD modules. In this study, Monte Carlo tracks with at least 4 hits in STS stations have been used. In the case of the forward TOF wall, the distribution of the position of impact of charged particles was used, assuming an ideal granularity. As the elliptic flow of charged particles is very weak at SIS100 energies, the results are given using the directed flow of emitted particles (a selection of forward rapidity particles in the STS is performed). The reaction plane resolution is then defined as the Gaussian width (σ) of the distribution of the measured reaction plane (Ψ_1) around the true one (Ψ_R).

It has been found that the reaction plane resolution is optimum when the PSD is located no further than 10 m from the target, over the range of SIS100 beam energies (see Figure 1). The degradation observed going to higher distances

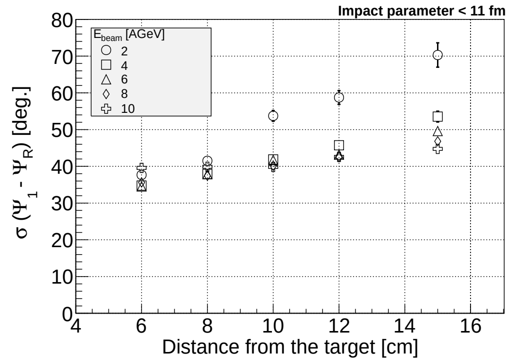

Figure 1: Reaction plane resolution achieved with the PSD as a function of the distance from the target.

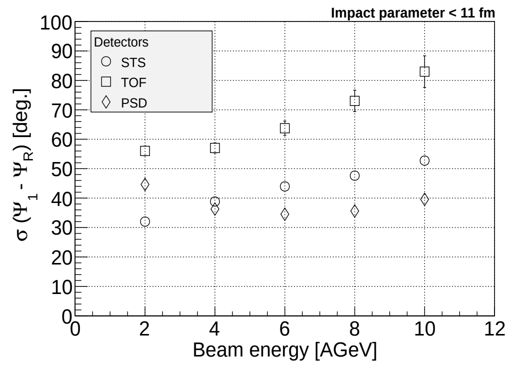

Figure 2: Reaction plane resolution as a function of beam energy. PSD and TOF are located at 6 m from the target.

is an acceptance effect. This effect is particularly strong at lower energies where the particle emission cone is wider due to a lower Lorentz boost. The resolutions obtained with the different detectors can be compared in Figure 2. The PSD shows significantly better resolutions with respect to the TOF ones, mostly as an effect of the loss of neutrons in the latter case. Both PSD and STS provides fairly good resolutions ($\sigma(\Psi_1$ - $\Psi_R) \in [30; 50]$ degrees). While the former gives better resolutions at higher energies due to the loss of forwardly emitted particles in the STS, the trend is opposite below 4 AGeV. These results show that STS and PSD can provide fairly precise, independent, and complementary reaction plane estimates in CBM at SIS100.

References

[1] A. Senger, this report

[2] A. M. Poskanzer et al., Phys. Rev. C 58, 1671-1678 (1998)