Reaction plane reconstruction in the CBM experiment*

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The determination of the reaction plane in nucleus-nucleus collisions is crucial for several measurements, including anisotropic collective flow. In CBM, the reaction plane can be measured by the forward hadronic calorimeter, referred to as the Projectile Spectator Detector (PSD). The Silicon Tracking System (STS) of the experiment, designed to cover a large fraction of the particle phase space, can also provide a complementary measurement. In this work, we investigated the capabilities of these two detectors for reconstructing the reaction plane at FAIR energies.

The simulations were carried for Au+Au collisions in the CBMROOT framework, using the event generator SHIELD, the simulation package GEANT4 and the physics list FTFP BERT. The detector model includes a 250 μm thick Au target, a STS consisting of 8 stations (located between 30 cm and 1 m from the target) embedded inside a dipole magnet and a PSD constituted transversally of 45 modules of 20 $\times$ 20 cm^2. Each module is composed longitudinally of 60 layers with combined Lead absorber and scintillator material. The central one features a cylindrical beam hole (to let beam ions pass) with a diameter of 6 cm.

The azimuthal orientation of the reaction plane has been determined using the event plane method [1]. The flow of emitted particles (used in the method) is exploited directly by measuring the momentum of charged particles in the STS, while the flow of projectile spectators is reflected in the azimuthal distribution of the energy measured in PSD modules. In this study, Monte Carlo tracks with at least 4 hits in STS stations have been used. As the elliptic flow of charged particles is relatively weak at FAIR energies, the results are given using the directed flow of emitted particles (a selection of forward rapidity particles measured by the STS is performed). The reaction plane resolution is defined as the Gaussian width ($\sigma(\Psi_1 - \Psi_{MC})$) of the distribution of the measured 1^{st} harmonic event plane angle (Ψ_1) around the true reaction plane angle (Ψ_{MC}).

At SIS100 energies, the PSD reaction plane resolution is optimal ($\sigma(\Psi_1 - \Psi_{MC}) \leq 40°$ for collision impact parameters below 11 fm) when the detector is located at 8 m from the target (see Fig.1), accordingly at 15 m at SIS300 due to higher Lorentz boosts of spectators.

The integrated magnetic dipole field is of about 1 Tm in the target region at $E_{beam} \geq 10$ AGeV, while it is scaled down with beam momentum at lower energies to reduce the induced bias in the PSD event plane calculation. However, a minimal field is required (of about 0.6 Tm) to keep the tracking performance on an acceptable level. A significant degradation of the PSD resolution was only seen for

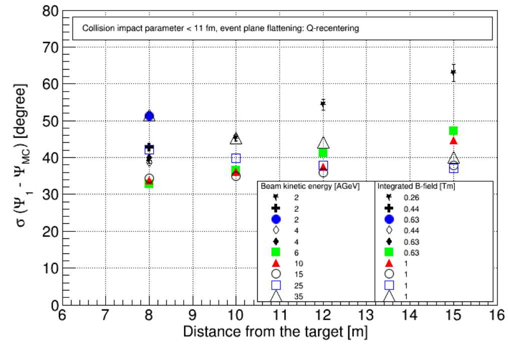

Figure 1: PSD reaction plane resolution (1^{st} harmonic event plane) at several distances from the target in Au+Au collisions (impact parameters below 11 fm) at FAIR energies. The Gaussian fits were performed in the range [-80, 80] degrees. The effect of the magnetic dipole field is also shown for $E_{beam} \leq 4$ AGeV and a PSD distance of 8 m.

$E_{beam} < 4$ AGeV e.g. at $E_{beam} = 2$ AGeV, $\sigma(\Psi_1 - \Psi_{MC})$ increases from 39° to 51° while enhancing the field from 0.26 Tm to 0.63 Tm.

The resolutions obtained with the PSD and the STS can be compared in Fig.2. At FAIR energies, both detectors provide good and complementary performance: $\sigma(\Psi_1 - \Psi_{MC})$ between 30° and 40°.

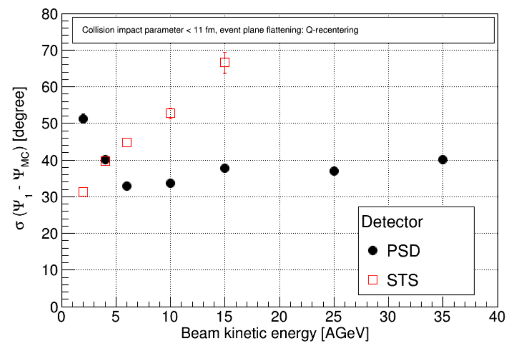

Figure 2: Reaction plane resolution (1^{st} harmonic event plane) as a function of beam energy. The PSD is located at 8 (15) m from the target at SIS100 (SIS300) energies. The integrated magnetic dipole field is of 0.63 Tm at E_{beam} = 2, 4 and 6 AGeV and 1 Tm at higher energies.

References

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

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