CBM performance for anisotropic flow measurements

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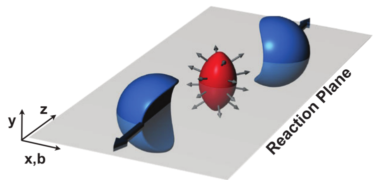
Abstract

CBM performance for anisotropic flow measurements is studied with Monte-Carlo simulations of gold ions at SIS-100 energies using UrQMD and DCM-QGSM heavy ion event generators.
Different combinations of the CBM detector subsystems are used to investigate the possible systematic biases in anisotropic flow measurement and to study effects of detector azimuthal non-uniformity.
Performance of the CBM is demonstrated for elliptic flow as a function of transverse momentum.

Anisotropic flow

Anisotropic transverse flow being connected to the collective behavior of the system plays an important role in understanding the properties of the dense matter created in a heavy-ion collision.
Anisotropic flow is quantified by v_n coefficients in the Fourier decomposition of the particle's azimuthal distribution wrt. the reaction plane:



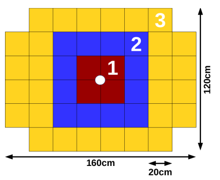
$$\frac{dN}{d\Delta\phi} \sim 1 + 2\sum_{n=1}^{\infty} v_n \cos n\Delta\phi$$

$\Delta\phi$ - particle's azimuthal angle relative to the reaction plane

CBM experiment

Compressed Baryonic Matter experiment (CBM) at FAIR has a potential of discoveries in the area of QCD phase diagram with high net baryon densities and moderate temperatures. CBM is a fixed target experiment. The following subsystems are used for flow performance studies:

- Silicon Tracking System (STS) – particles at midrapidity
- Projectile Spectator Detector (PSD) – forward rapidity region



Transverse layout of the PSD comprises 44 modules. The hole in the center of the PSD is needed because of expected high beam intensities at CBM. Modules are divided into 3 groups for the studies.

Simulation setup

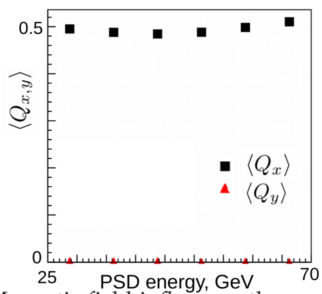
Simulation:

- Au+Au events generated with UrQMD and DCM-QGSM models
- GEANT4 for detector response simulation
- Simulated CBM components: target, STS, PSD, beam pipe and magnetic field

Track and event selection:

- STS – charged particles tracking
- PSD – spectator energy

Q-vector and recentering



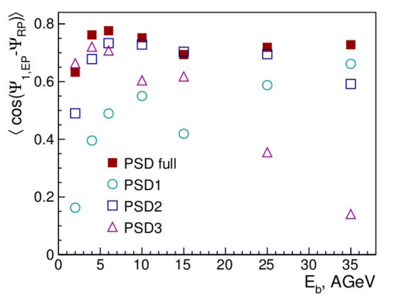
The Q-vectors for PSD_1, PSD_2, PSD_3 subevents are defined as

$$\vec{Q_A} = \sum_{k\in A} E_k \vec{r}_k / E_A |r_k|$$

with $\vec{r}_k$ and E_k – module position and its energy deposition; E_A – total energy for a subevent.

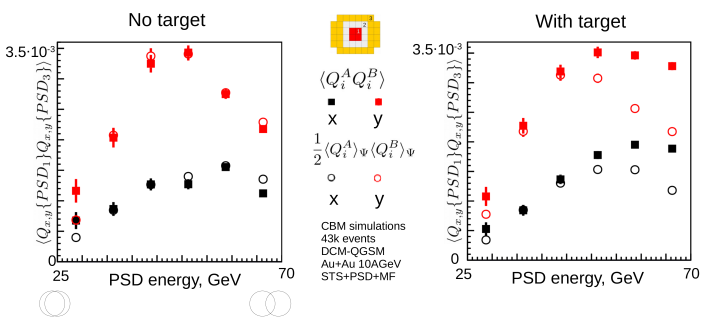
Magnetic field influences the angular distribution of charged particles in PSD. This leads to non-zero value of average Q-vector. The recentering correction is applied: $\vec{Q} \rightarrowtail \vec{Q} - \langle\vec{Q}\rangle$.

Reaction plane resolution correction



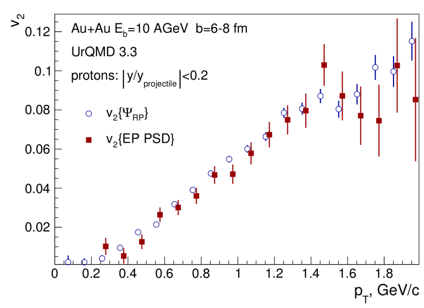
First order reaction plane resolution correction factor vs. the kinetic beam energy E_b for semi-central (20-50%) Au+Au collisions for different PSD subevents.
The PSD is located at 8 m from the target for energies up to 10 A GeV, and at 15 m for higher energies.

Systematic biases



Target material biases correlations for peripheral collisions [high PSD energy] because of rescattering of heavy fragments on target material.

Elliptic flow of protons



Comparison of proton v_2 vs. p_T for 1M Au+Au collisions generated with the UrQMD. Simulated v_2 is reproduced using the PSD event plane.

Conclusion and outlook

Performance of CBM for elliptic flow measurement is presented. Reaction plane estimates are corrected for detector azimuthal non-uniformity with QnCorrections Framework. Different detector configurations are studied to test the systematical biases in flow extraction. Further investigations of systematic bias in v_n estimates with PSD event plane are ongoing.

Bibliography

- F. Guber, I. Selyuzhenkov [CBM Collaboration], Technical Design Report for CBM PSD [http://repository.gsi.de/record/109059]
- J. Onderwaater, I. Selyuzhenkov, QnCorrections Framework [https://github.com/FlowCorrections/FlowVectorCorrections]