Monte carlo simulation of collective flow analysis for SπRIT-TPC

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The SAMURAI Pion-Reconstruction and Ion-Tracker-Time-Projection Chamber (SπRIT-TPC)[1] project aims to constrain the nuclear equation of state (EoS) at supra-saturation density using heavy ion collisions.

In heavy ion collision, the corrective flow, which is one of sensitive probes to the nuclear EoS, characterized by asymmetric azimuthal emission amplitude, v1 and v2 with respect to a reaction plane orientation, Ψ,

$$\frac{2\pi}{N}\frac{dN}{d(\phi-\Psi)} = 1+2v_1\cos(\phi-\Psi)+2v_2\cos(2(\phi-\Psi)). \quad (1)$$

The Ψ is determined from an azimuthal angle distribution of charged particles event by event. In SπRIT-TPC experiment, the Ψ is calculated summing up unit vectors of transverse momentum for $Z = 1$ and 2 particles.[2] The detector bias on the Ψ caused by its rectangular shape and a limited acceptance was corrected using shifting and flattening methods.[3] The coefficients, v1 and v2, were obtained after correcting with a reaction plane resolution[4] which depends on the laboratory azimuthal angle.

A Monte Carlo simulation was performed to validate our analysis method. Configurations of the generated events were chosen to reproduce distributions of real data as listed in Table 1. Two acceptance setting for the SπRIT-TPC and 4π (full) coverage were compared by analyzing through the same code developed for real data.

Table 1. Configurations in the Mote Carlo simulation. The center of mass rapidity normalized with the beam rapidity was defined as $y_{nrm} \equiv y_{cm}/y_{beam}$. The transverse momentum $u_t(=\beta_t\gamma_t)$ was utilized.

Particle	proton
Multiplicity	40
dN/dy_{nrm}	$\exp(-0.5*(y_{nrm}/0.78)^2)$
dN/du_t	$\exp(-0.1u_t)$
$v1$	$0.52y_{nrm} - 0.18y_{nrm}^3$, const. in u_t
$v2$	$-0.08 + 0.1y_{nrm}^2 - 0.02y_{nrm}^4$, const. in u_t
Acceptance	(A) SπRIT-TPC/(B) Full

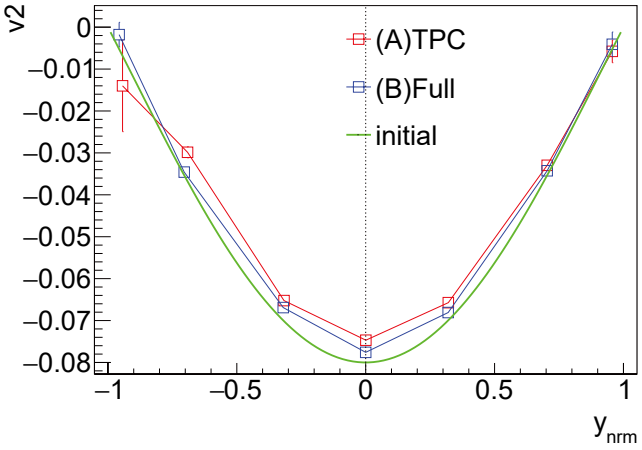

Fig. 1. The v2 simulated with (A) SπRIT-TPC and (B) Full acceptance. A green line shows the initial function.

In Fig. 1, v2 as a function of the center of mass rapidity were shown for (A)SπRIT-TPC and (B)full acceptance.The rapidity was normalized by the beam rapidity, $y_{nrm}(\equiv y_{cm}/y_{beam})$. As a result, both of them almost reproduce the initial function (green line). It indicates that the correction for the detector bias was done properly. However, the absolute v2 are ∼6% smaller at $y_{nrm} = 0$, whereas v1 reproduces the initial value. This discrepancy should be taken into account as a systematic error.

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