Flow performance studies with CBM

Viktor Klochkov

(GSI, Frankfurt University)

Ilya Selyuzhenkov

(GSI, MEPhI)

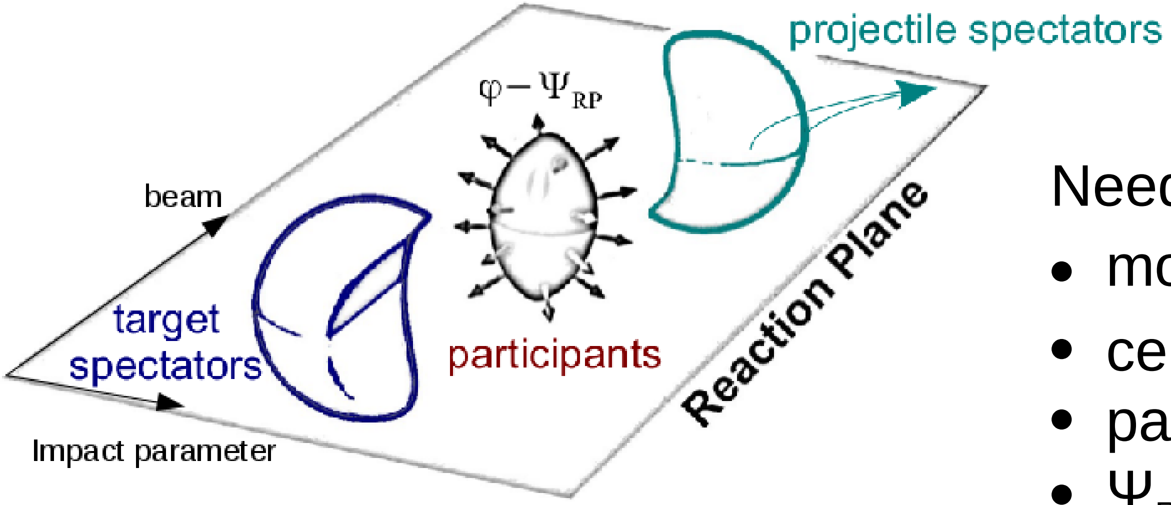
for the CBM Collaboration

Collision geometry and the transverse anisotropic flow

Asymmetry in coordinate space converts due to interaction into momentum asymmetry with respect to the symmetry plane (reaction plane - RP)

$$\rho(\varphi - \Psi_{RP}) = \frac{1}{2\pi}\left(1 + 2\sum_{n=1}^{\infty} v_n \cos\left(n(\varphi - \Psi_{RP})\right)\right)$$

$$v_n = \langle \cos[n(\varphi - \Psi_{RP})] \rangle$$

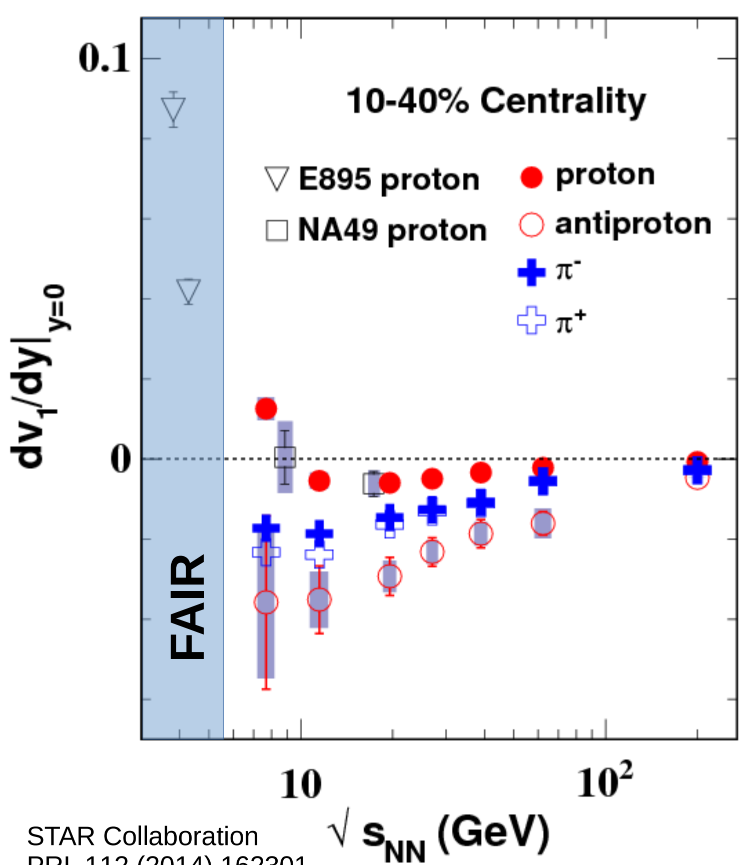


Needed components to calculate v_n:

- momentum (φ, Y, p_T)
- centrality estimation
- particle identification
- Ψ_{RP} estimation

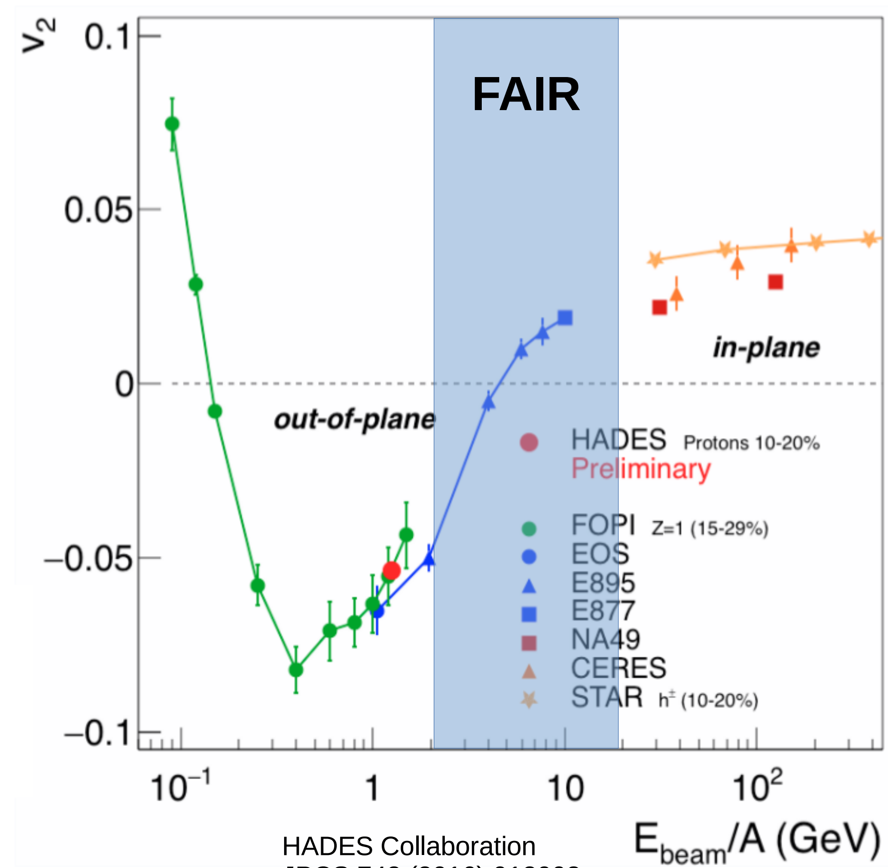
Collective flow at FAIR energies

Directed flow (slope)



STAR Collaboration
PRL 112 (2014) 162301

Elliptic flow



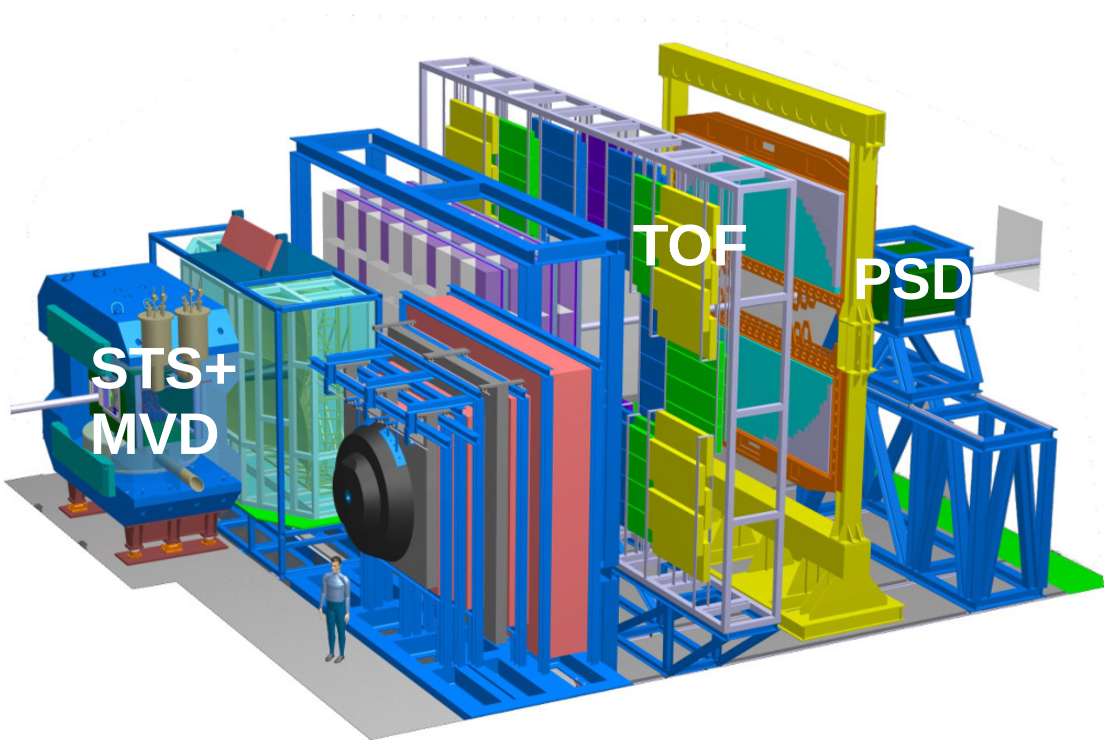
HADES Collaboration
JPCS 742 (2016) 012008

CBM will extend existing data and provide new measurements for identified particles including multistrange hyperons and di-lepton

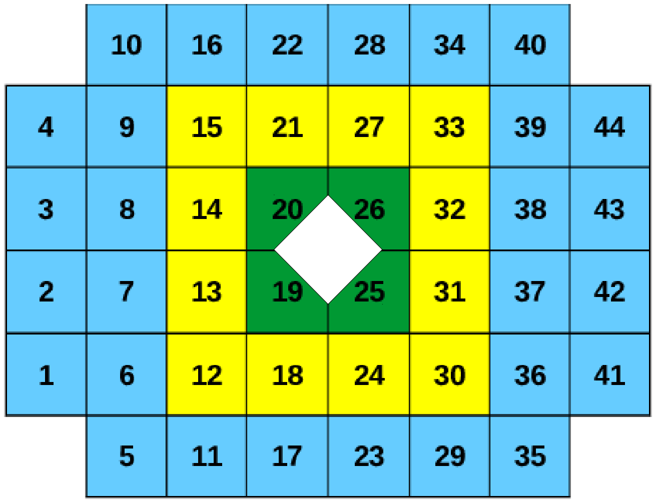
CBM detector setup

CBM subsystems needed for v_n measurements:

- Particle momentum (φ,Y, p_T): STS+MVD
- Centrality estimation: event classes defined with PSD energy (STS multiplicity)
- Particle identification: TOF
- Reaction plane (Ψ_{RP}): PSD transverse energy asymmetry (φ distribution in STS)

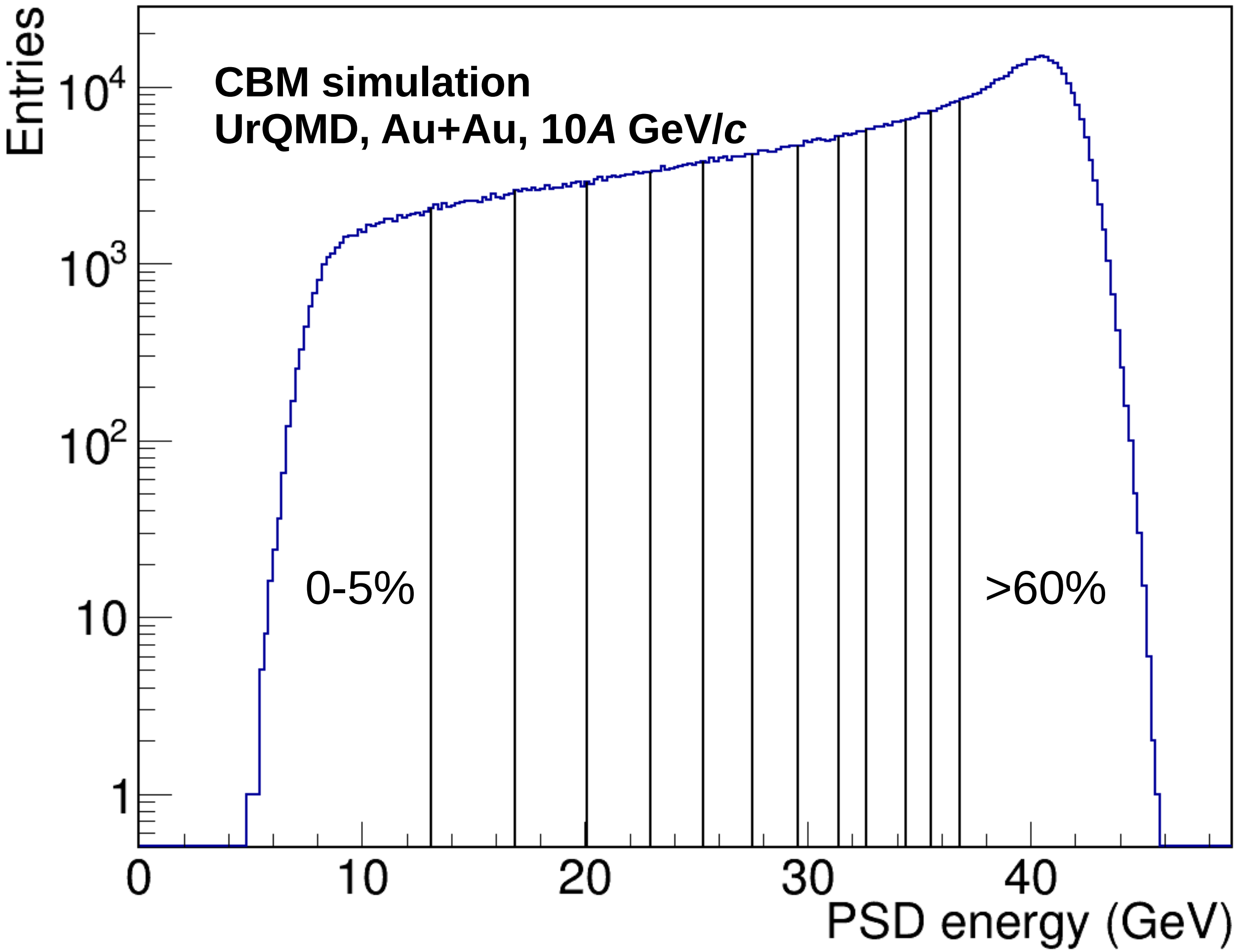


PSD transverse layout



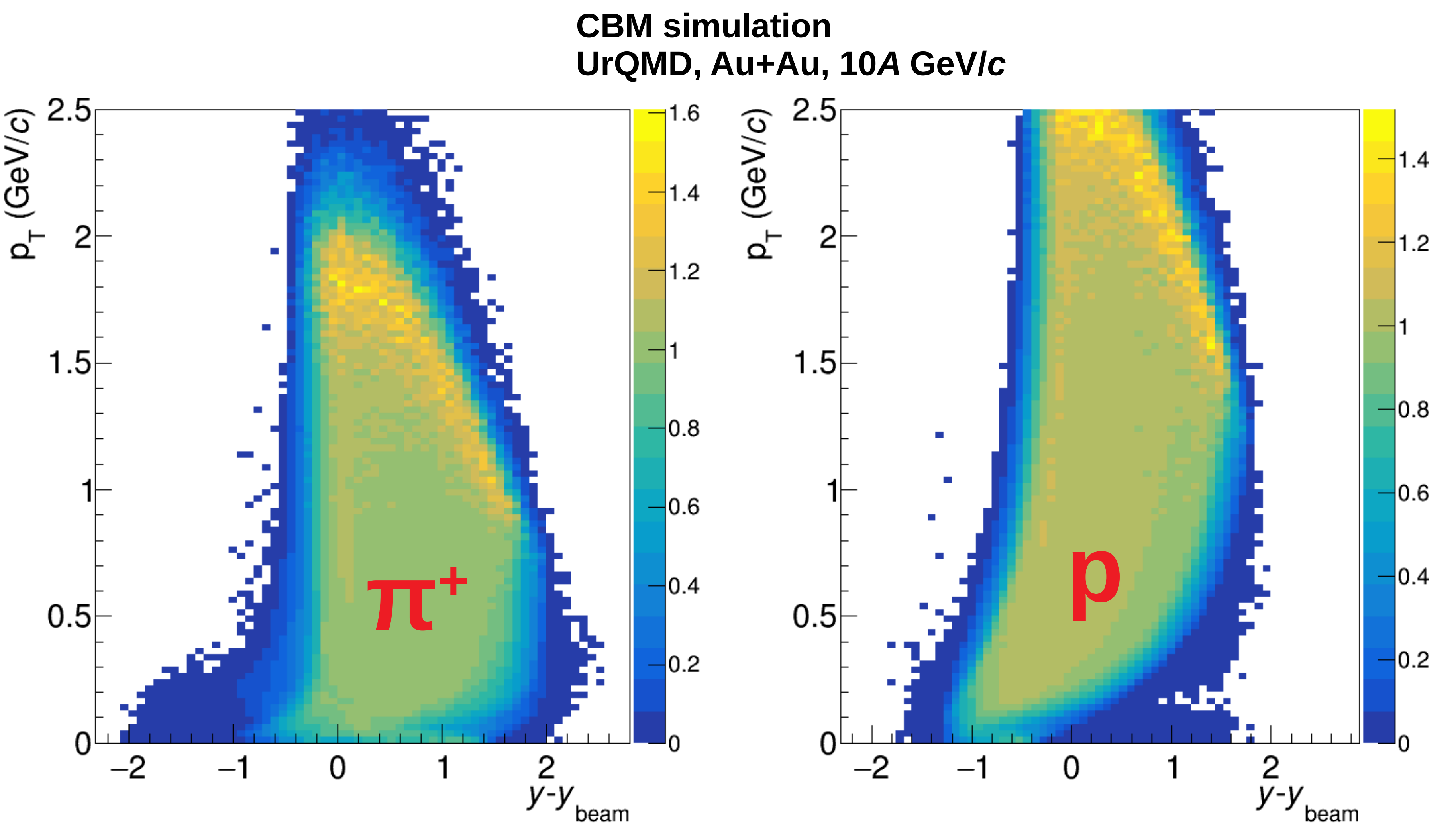
Hole size: 20 cm
(side of the square)

Centrality determination with PSD energy



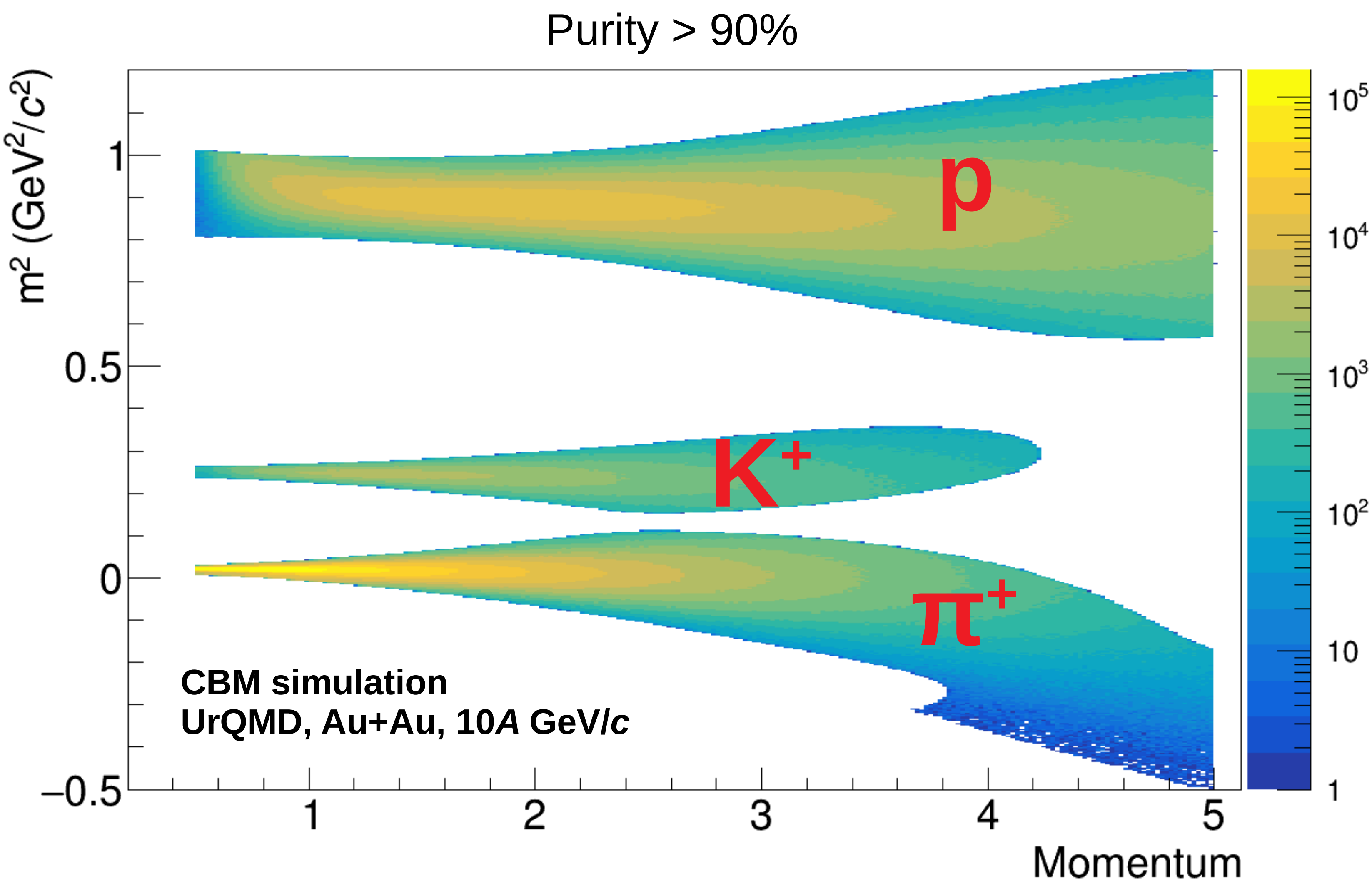
Centrality classes are defined using forward rapidity energy

Tracking efficiency correction



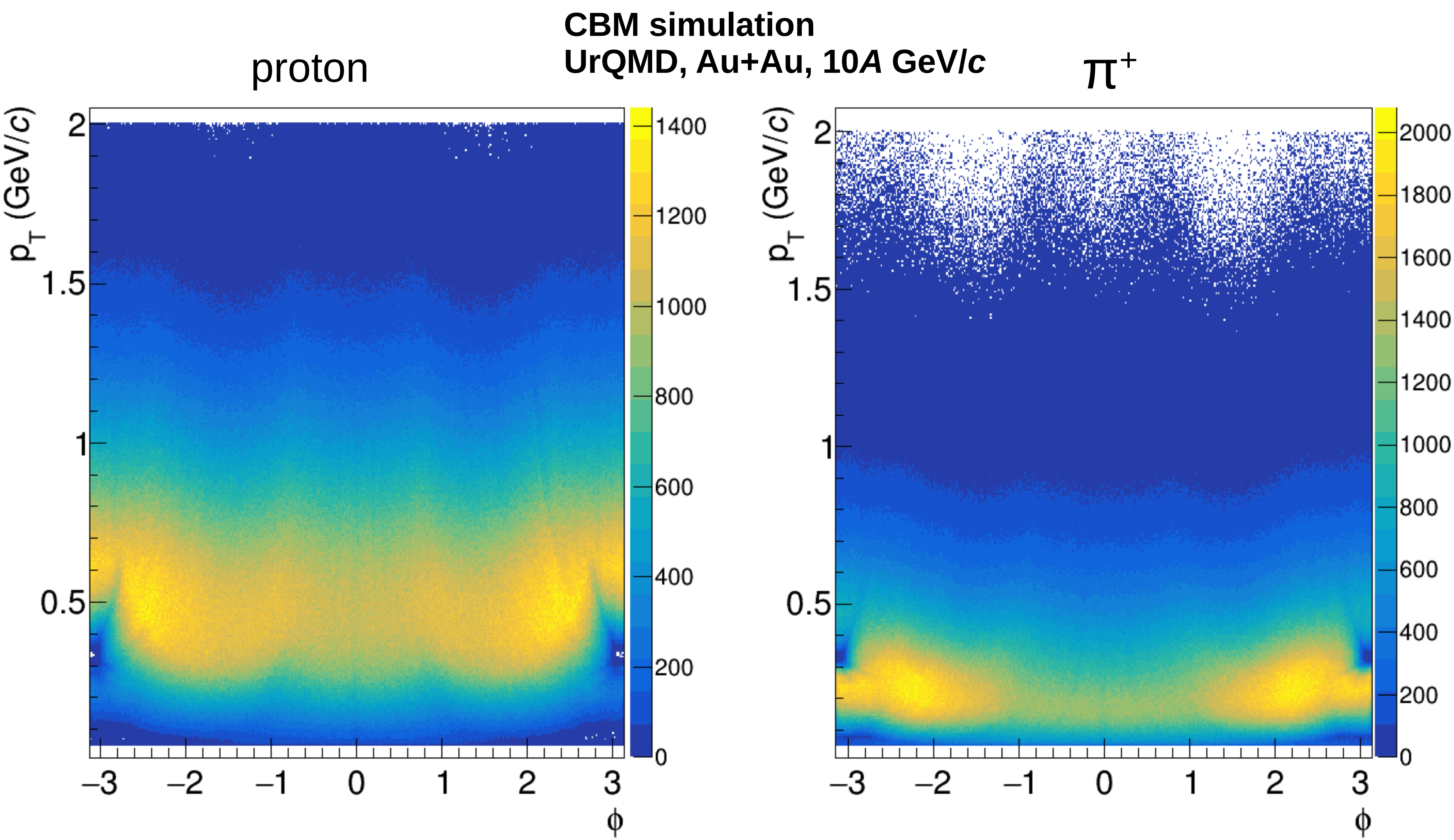
Correction for tracking efficiency was applied

Particle identification with Bayesian approach



Time-of-Flight technique provides clear separation between charged hadrons

Azimuthal angle acceptance



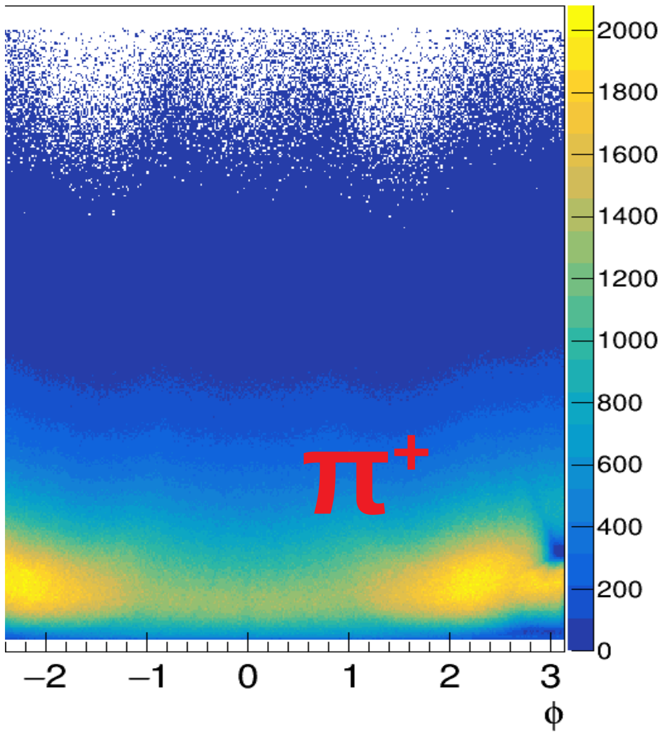
Non-uniformity of azimuthal acceptance – corrections are needed!

QnVector Corrections Framework

- Developed for ALICE by
  J. Onderwaater, V. Gonzalez, I. Selyuzhenkov
  https://github.com/jonderwaater/FlowVectorCorrections

- Applies corrections for azimuthal acceptance non-uniformity
  → corrections calculated from reconstructed azimuthal distributions

- Recentering, twist, rescaling, and rotation corrections are applied separately in different event classes



*PRC77 034904 (2008)

Event plane and scalar product methods

$$v_n = \langle \cos[n(\varphi - \Psi_{RP})] \rangle$$

- v_n with respect to symmetry plane estimated using group of particles (subevent) A:

$$v_n(A;i) = \frac{\langle 2 u_i Q_i^n(A) \rangle}{R_i^n(A)} \qquad i = (x, y)$$

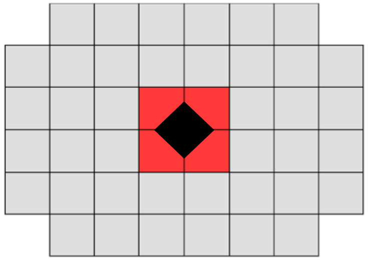
$$\vec{u}_n = (\cos(n\varphi), \sin(n\varphi)) \qquad \vec{Q}_n = \frac{1}{N} \sum \omega_j \vec{u}_{n,j}$$

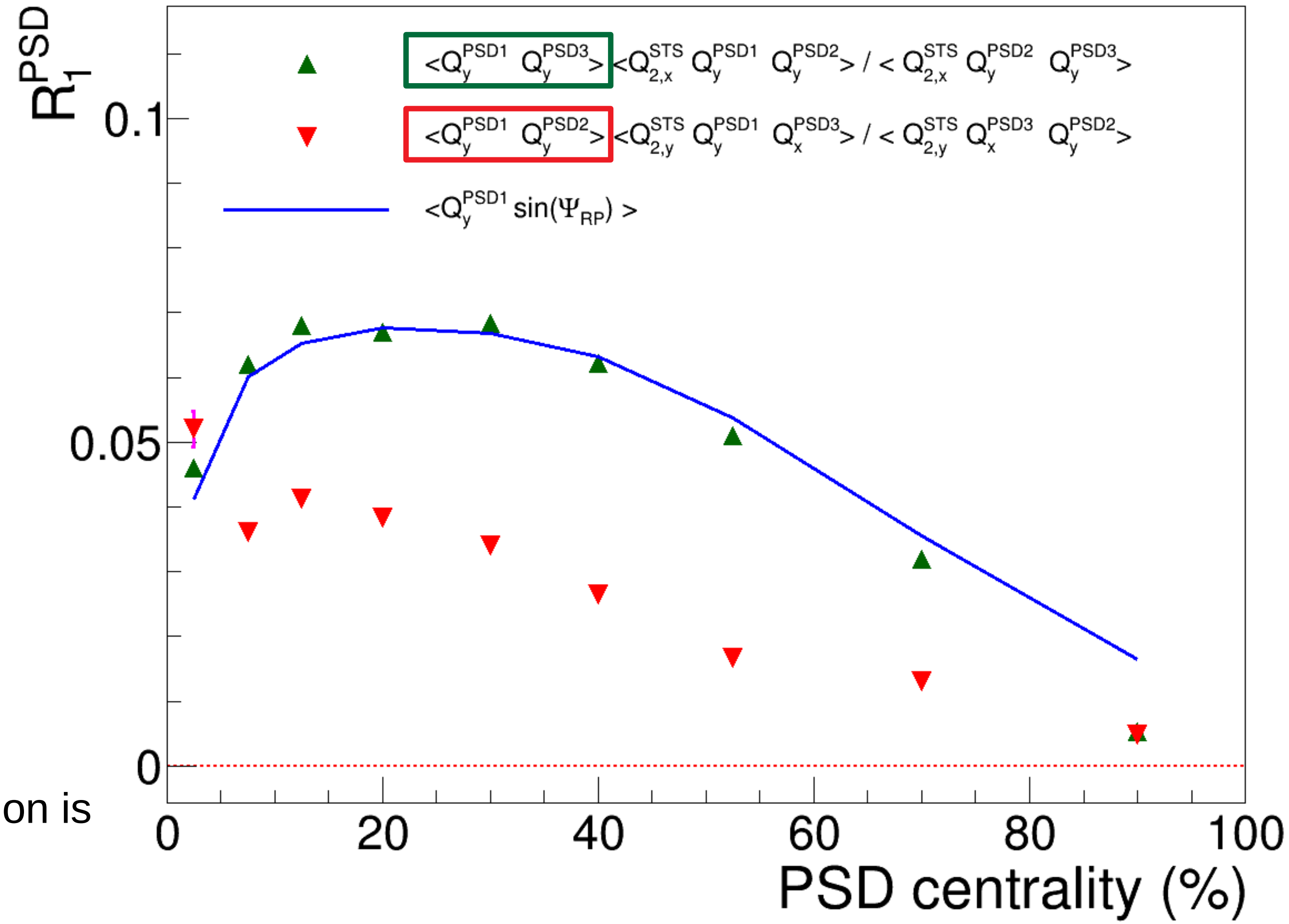
- mixed harmonic method:

$$R_i^n(A;B,C,D) \propto \sqrt{\frac{\langle Q_i^1(A) Q_i^1(B) \rangle \langle Q_i^1(A) Q_i^1(C) Q_i^2(D) \rangle}{\langle Q_i^1(B) Q_i^1(C) Q_i^2(D) \rangle}}$$

Correction factor for mixed harmonic

PSD1





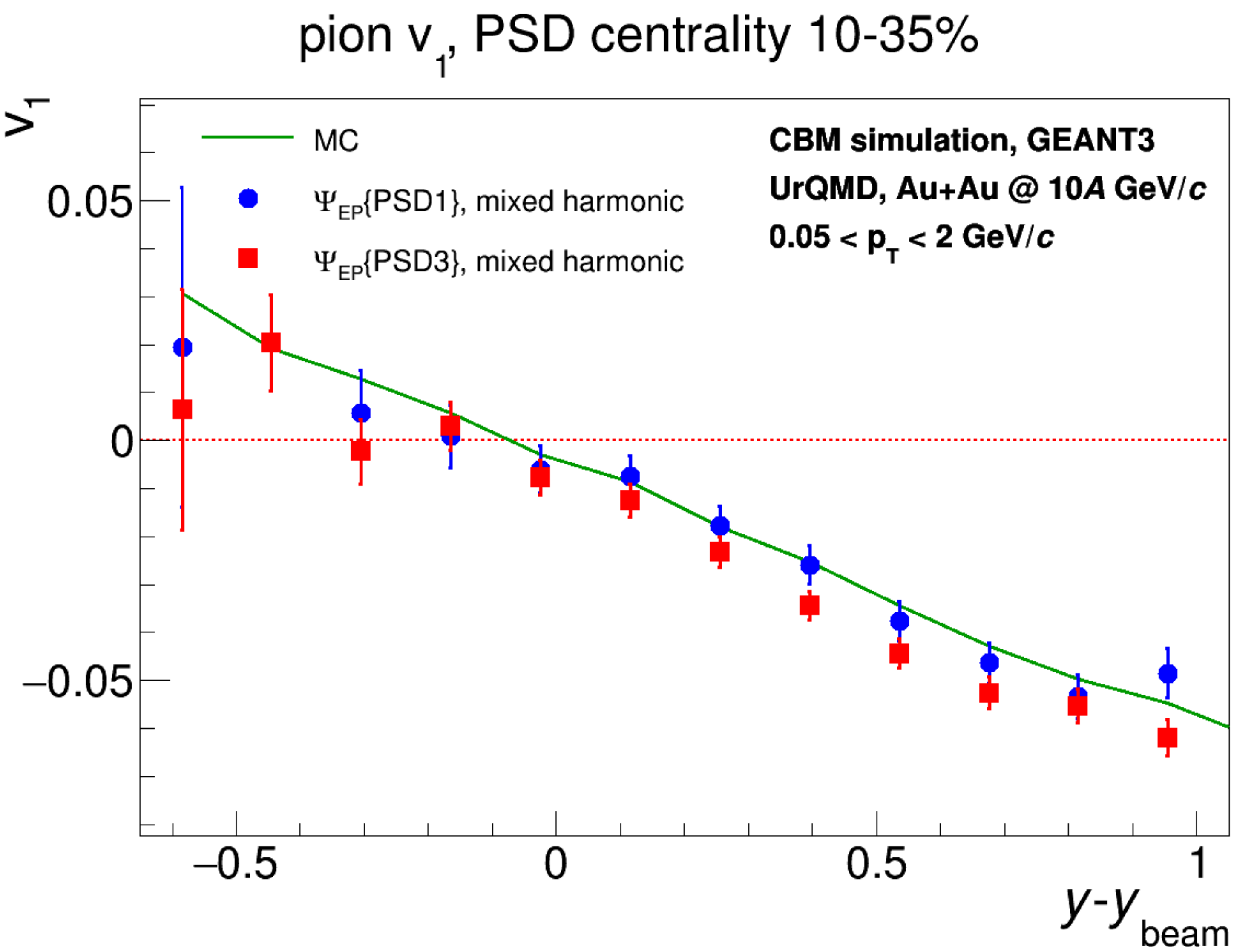
Neighboring PSD subevents correlation is distorted due to autocorrelations

Results

Results are presented for correlations between
positively charged identified hadrons (pions and kaons)
and all hadrons at forward rapidity (in the PSD acceptance).

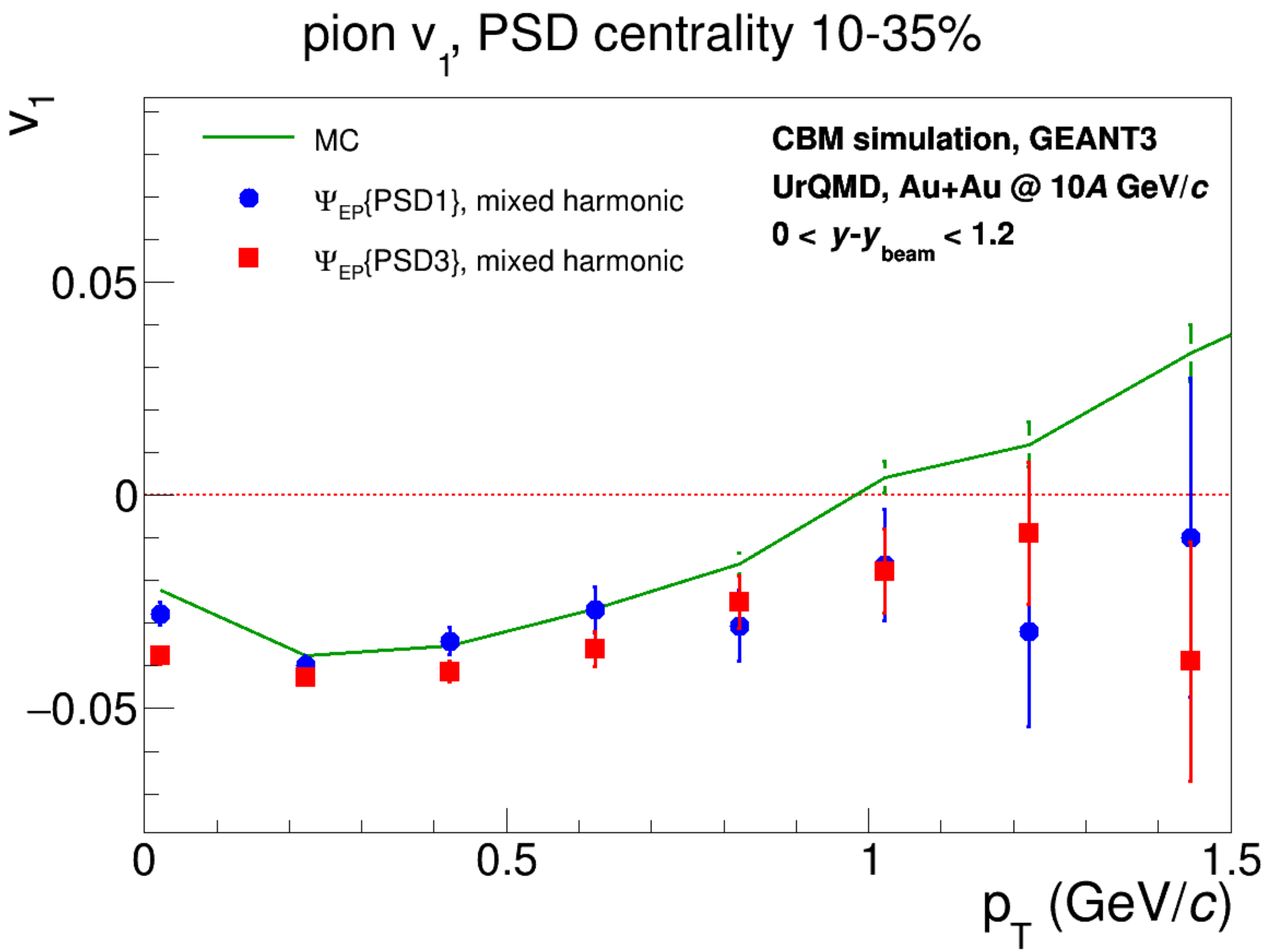
The results are corrected for detector non-uniformity.
Correction for PID efficiency is not done yet.
Only statistical uncertainties are shown.

π^+ v_1 vs rapidity



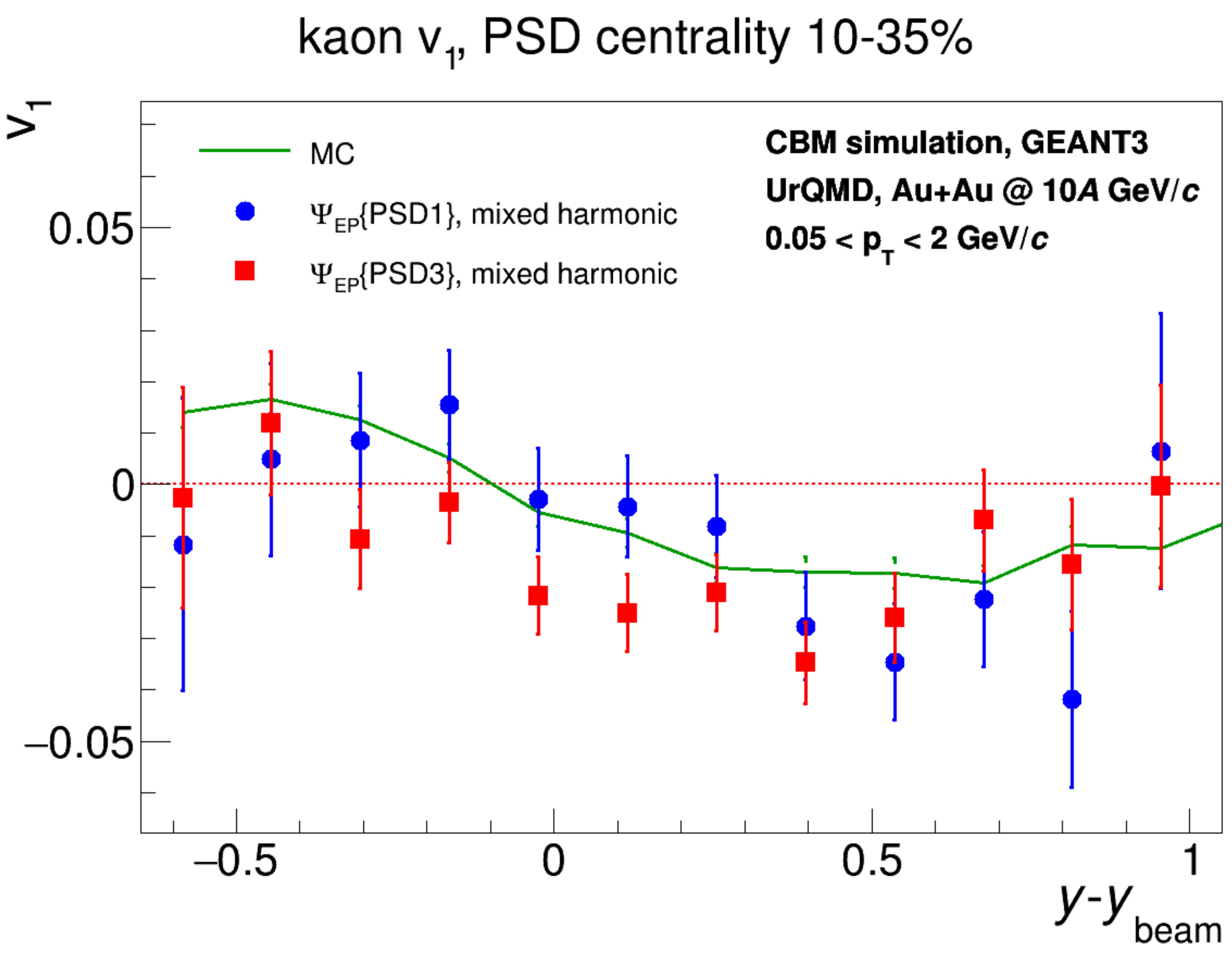
Good agreement between simulated and reconstructed values

π^+ v_1 vs transverse momentum



Good agreement between simulated and reconstructed values

K^+ v_1 vs rapidity



Large statistics simulation is needed!

Summary

- CBM detector system is well-suited for flow measurements
- Performance for π^+ and K^+ directed flow measurements

  for Au+Au collisions at 10*A* GeV/*c* are presented differentially

  vs rapidity and transverse momentum:
  - Centrality using PSD
  - PID using TOF

Next steps:

- PID efficiency correction
- Performance for other particle species