Performance study of the MPD fixed-target setup for anisotropic flow measurements at NICA

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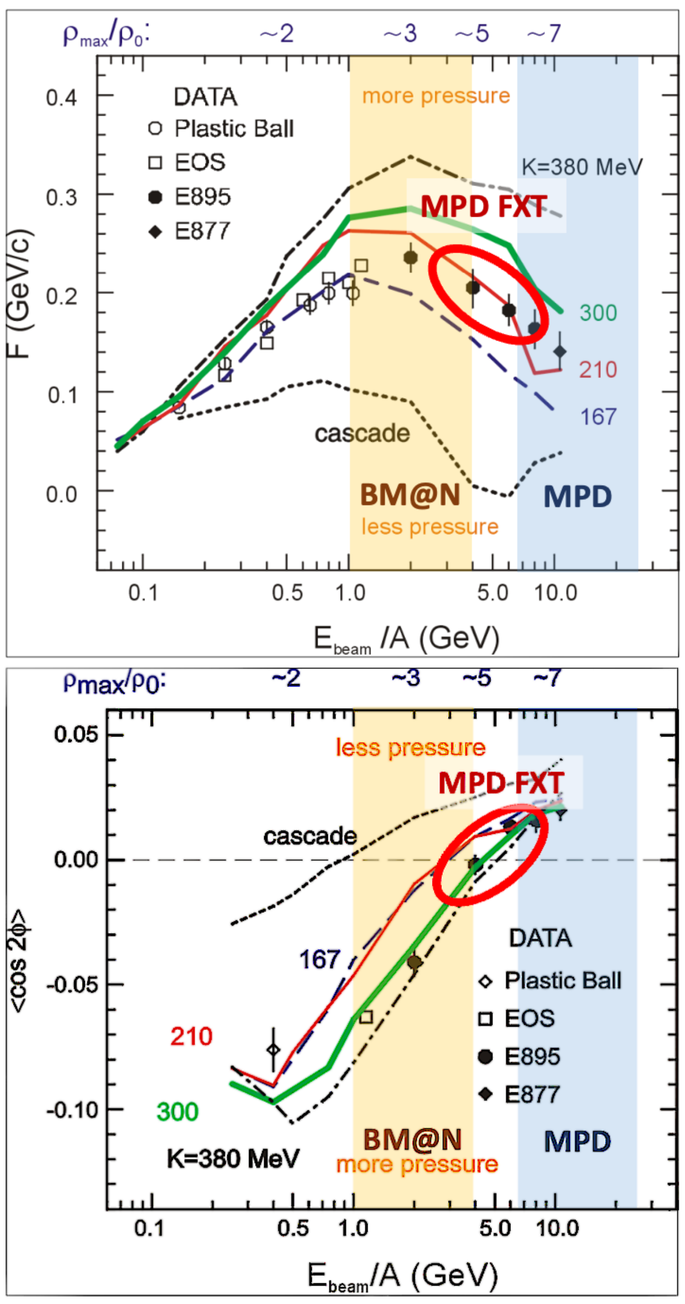
v_n at Nuclotron-NICA energies

The Multi-Purpose Detector (MPD) is designed to explore the phase diagram of strongly interacting matter, with a focus on the high baryon-density and intermediate-temperature regime. This investigation utilizes relativistic heavy-ion collisions at center-of-mass energies of $\sqrt{s_{NN}}$ = 4–11 GeV. Key observables sensitive to the equation of state (EOS) and transport properties of dense matter will be measured as critical diagnostic tools for these studies.

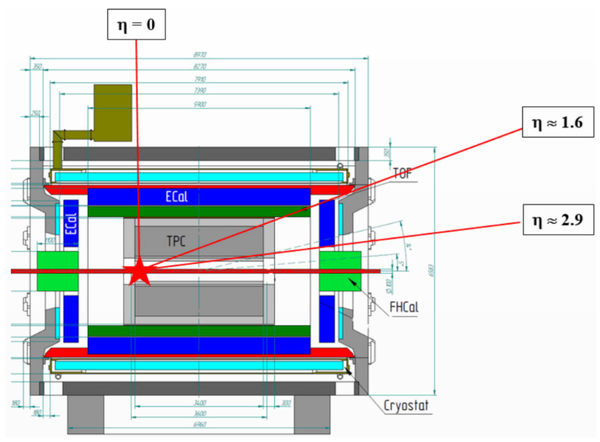


$$\frac{dN}{d\varphi} \approx 1 + 2\sum_{n=1} \boldsymbol{v_n} \cos\left[n\left(\varphi - \Psi_{\mathrm{RP}}\right)\right]$$

The MPD fixed-target configuration (MPD-FXT) extends the experiment's energy coverage down to $\sqrt{s_{NN}}$=2.8-3.5 GeV, enabling investigations in the energy range where current experimental results show discrepancies:

- **v_1 data suggests softer EOS ($K_0 \simeq 200$ MeV)**
- **v_2 data suggests stiffer EOS ($K_0 \simeq 300$ MeV)**

MPD in fixed target mode (MPD-FXT)



Analysis setup:

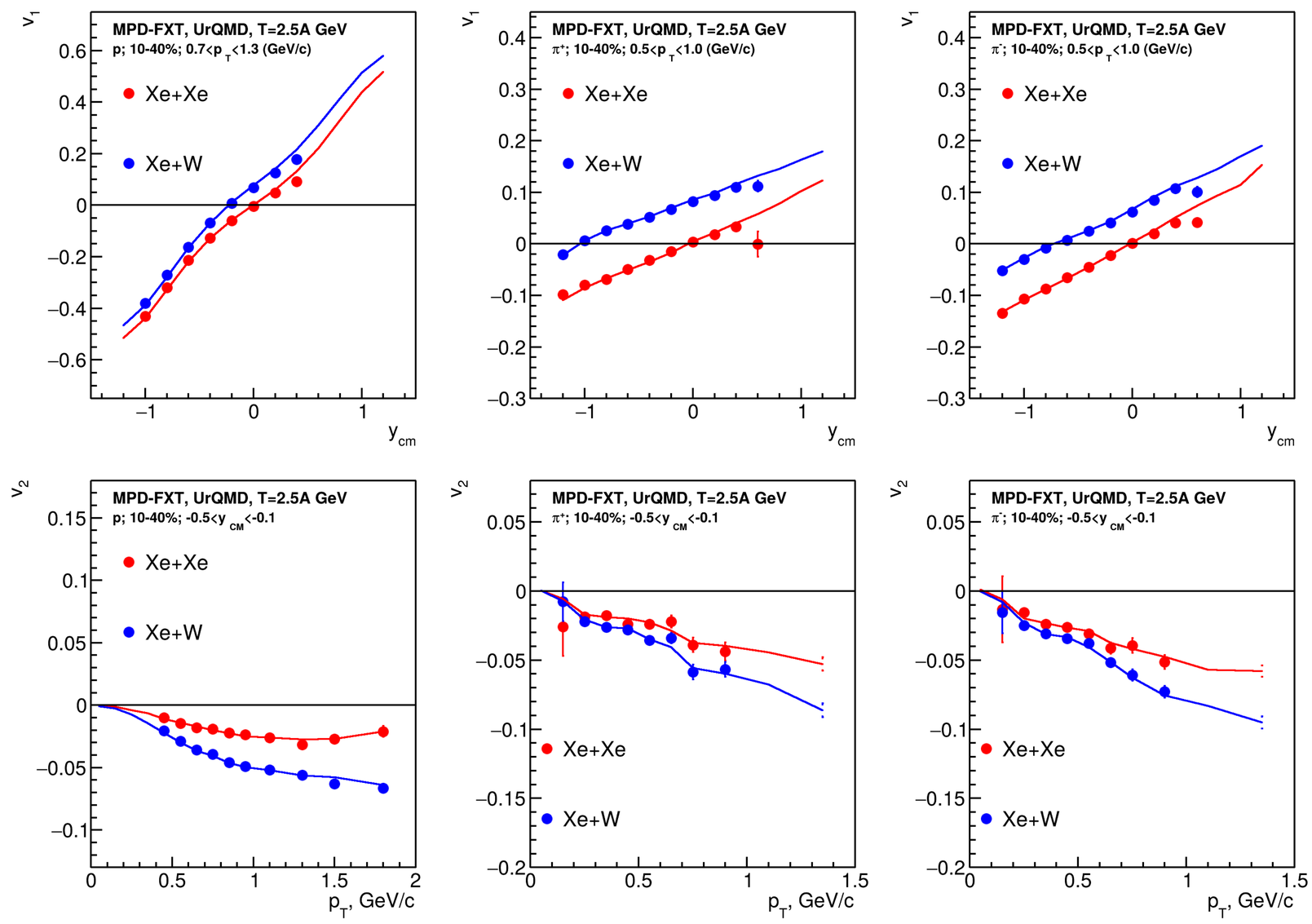
- Model: UrQMD mean-field (ver. 3.4)
  - 15M, Xe+W, T=2.5A GeV
  - 15M, Xe+Xe, T=2.5A GeV
- Point-like target at (0,-2,-85) cm
- Realistic detector response and reconstruction using GEANT4 and MPDROOT
- Multiplicity-based centrality and realistic particle identification using dE/dx (TPC) and m^2 (TPC+TOF)
- Track selection: DCA<1 cm (protons), DCA<0.2 cm (pions), quality track cut N_{hits}>27

Results

The scalar product method was employed to extract flow coefficients for protons and pions. In this approach, the flow harmonics are expressed through flow vectors Q_n and unit vectors u_n:

$$v_1 = \frac{\langle u_1 Q_1^{F2} \rangle}{R_1\{F2\{Tp\}(F1,F3)\}}, \; v_2 = \frac{\langle u_2 Q_1^{F1} Q_1^{F3} \rangle}{R_1\{F1(TpF3)\}R_1\{F3(TpF1)\}}.$$

Resolution correction factors R_1 were defined through pairwise Q-vector correlations from different subevents.



The measured flow coefficients from reconstructed data (full markers) demonstrate good agreement with UrQMD model predictions (lines) within the TPC acceptance region ($|y_{cm}| < 0.5$). A distinct shift in $v_1(y_{cm})$ is observed for the asymmetric Xe+W system compared to symmetric Xe+Xe collisions, consistent with expectations of participant deflection in asymmetric collision systems. These flow patterns remain qualitatively similar for both protons and pions, while displaying expected differences in magnitude.

Conclusions

We present the experimental setup of the MPD fixed-target configuration (MPD-FXT) and evaluate its performance for differential anisotropic flow measurements of identified hadrons in Xe+W and Xe+Xe collisions at T = 2.5A GeV ($\sqrt{s_{NN}}$ = 2.87 GeV).

The analysis methodology, validated using fully reconstructed events from the UrQMD model, demonstrates detector's capabilities for precise measurements of directed (v_1) and elliptic (v_2) flow up to midrapidity ($y_{cm} < 0.5$), with observed forward-rapidity discrepancies attributable to TPC acceptance effects.

The asymmetric Xe+W system exhibits a clear shift in $v_1(y_{cm})$ compared to symmetric Xe+Xe collisions, consistent with expected participant deflection patterns. These features remain qualitatively similar for both protons and pions, though with magnitude differences.

Acknowledgements

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