Performance studies towards flow measurements in BM@N

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НИЯУ МИФИ

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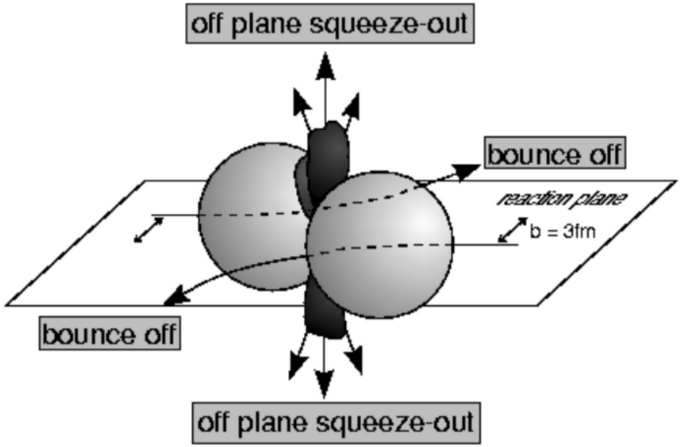
Anisotropic flow & spectators



The azimuthal angle distribution is decomposed in a Fourier series relative to reaction plane angle:

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

Anisotropic flow:

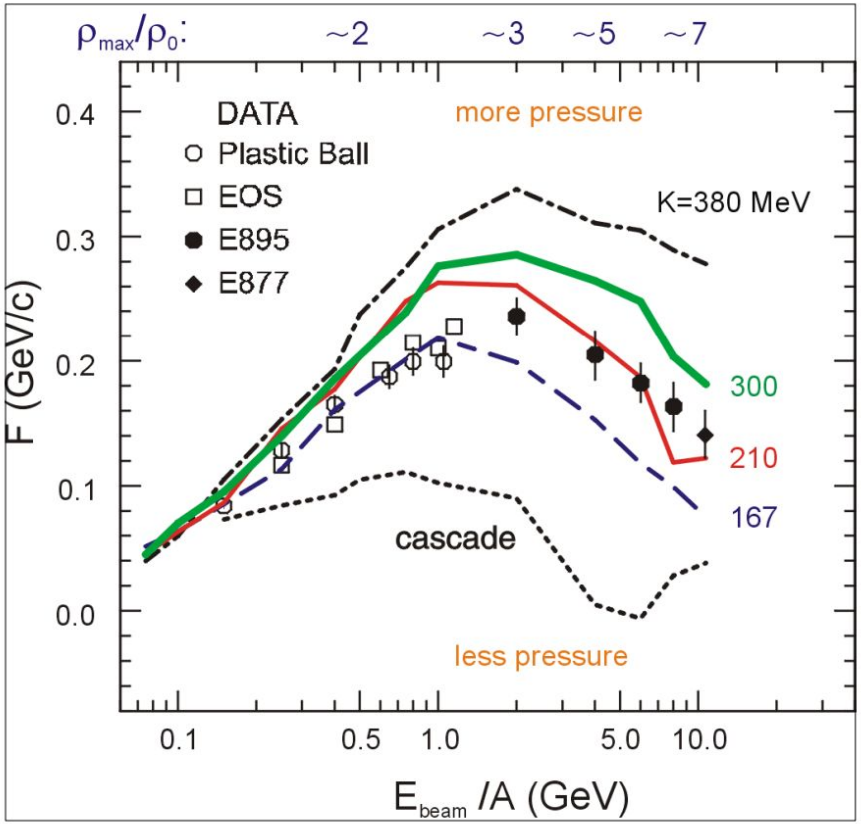
$$v_n = \langle \cos\left[n(\varphi - \Psi_{RP})\right] \rangle$$

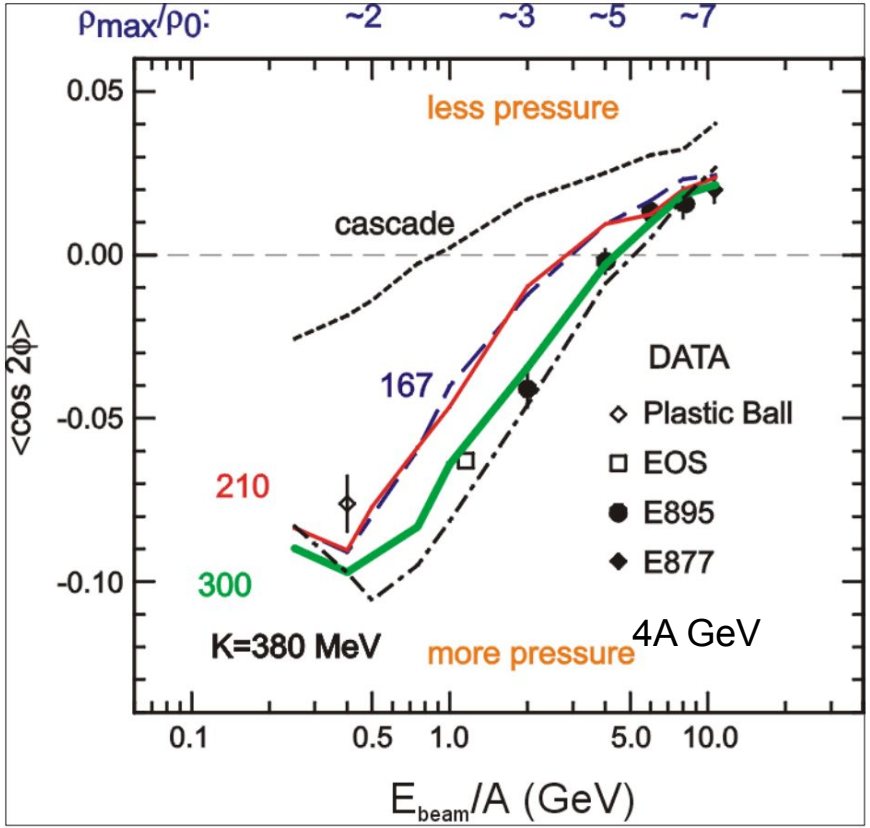
Anisotropic flow is sensitive to:

- Time of the interaction between overlap region and spectators
- Compressibility of the created matter

v_n as a function of collision energy

P. DANIELEWICZ, R. LACEY, W. LYNCH
10.1126/science.1078070



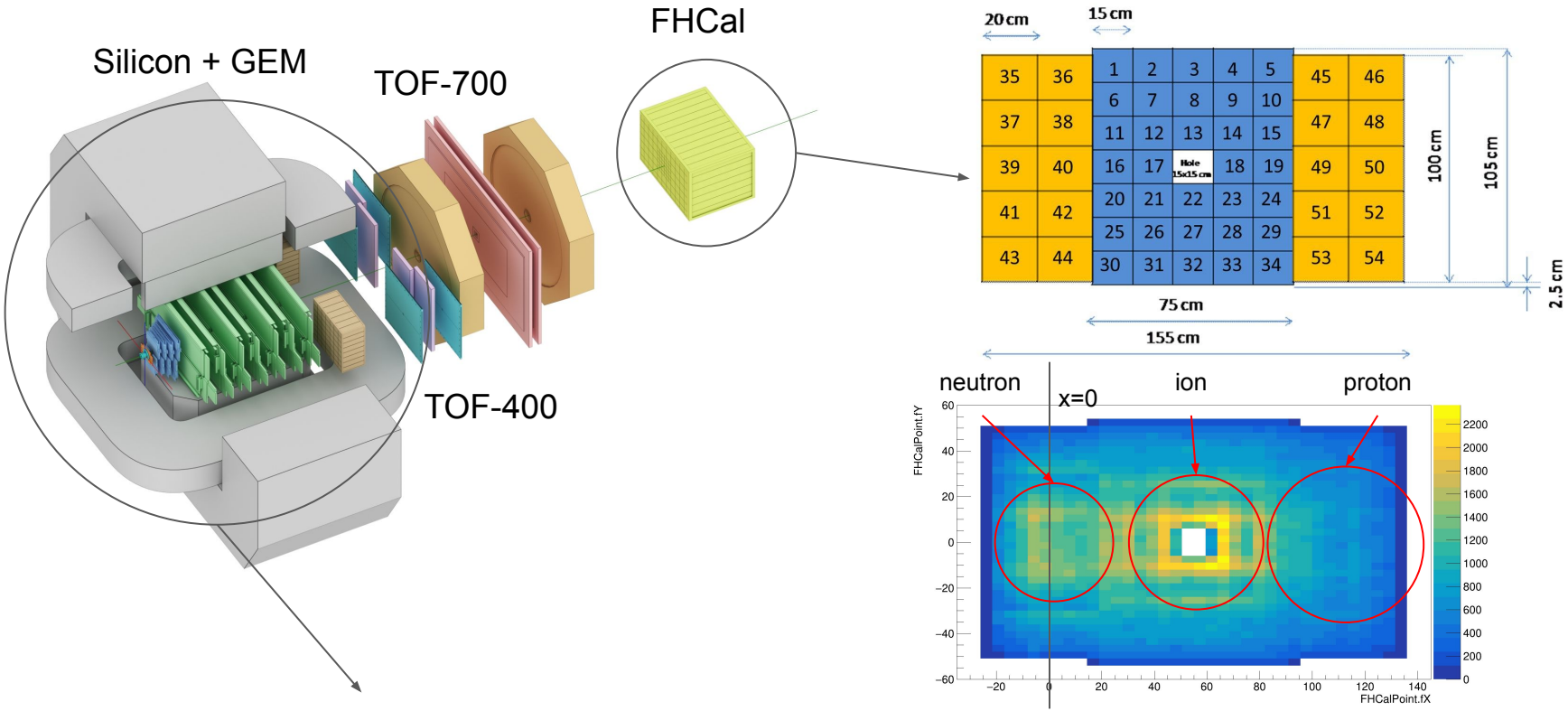


Simulation datasample

- Xe+Cs nuclei collisions
- DCMQGSM-SMM model (realistic yields of spectator fragments)
- JAM model (realistic flow signal)
- Geant4 transport code (important for simulation of hadronic showers in the forward calorimeter)

	1.5A GeV	3A GeV	4A GeV
DCMQGSM-SMM	6M	6M	2M
JAM MD3	3M	3M	-

The BM@N experiment (JINR, Dubna)



Produced particles trajectories are reconstructed using the tracking system inside the dipole magnet

Symmetry plane estimation with the azimuthal asymmetry of projectile spector energy

Flow vectors

From momentum of each measured particle define a u_n-vector in transverse plane:

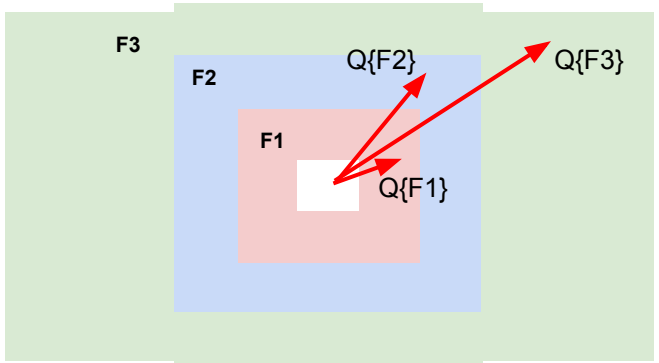
$$u_n = e^{in\phi}$$

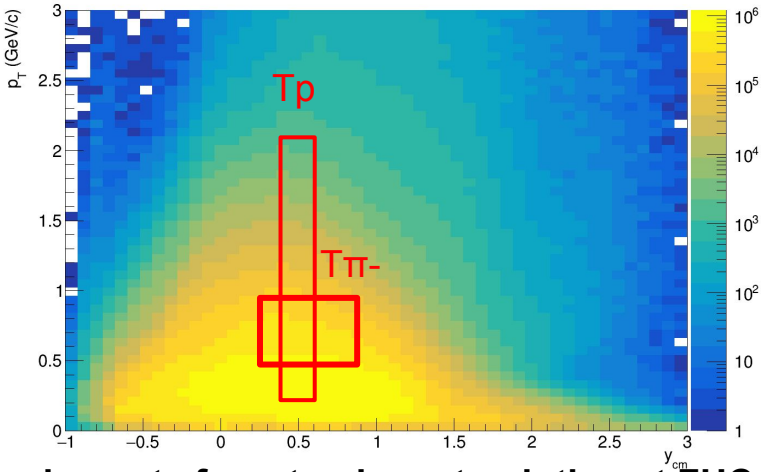
where φ is the azimuthal angle

Sum over a group of u_n-vectors in one event forms Q_n-vector:

$$Q_n = \frac{\sum_{k=1}^{N} w_n^k u_n^k}{\sum_{k=1}^{N} w_n^k} = |Q_n| e^{in\Psi_n^{EP}}$$

Ψ_n^{EP} is the event plane angle





Additional subevents from tracks not pointing at FHCal:
Tp: p; 0.4<y<0.6; 0.2 < p_T < 2 GeV/c; w=1/eff
Tπ: π-; 0.2<y<0.8; 0.1 < p_T < 0.5 GeV/c; w=1/eff
T-: all negative; 1.0<η<2.0; 0.1 < p_T < 0.5 GeV/c; w=1/eff

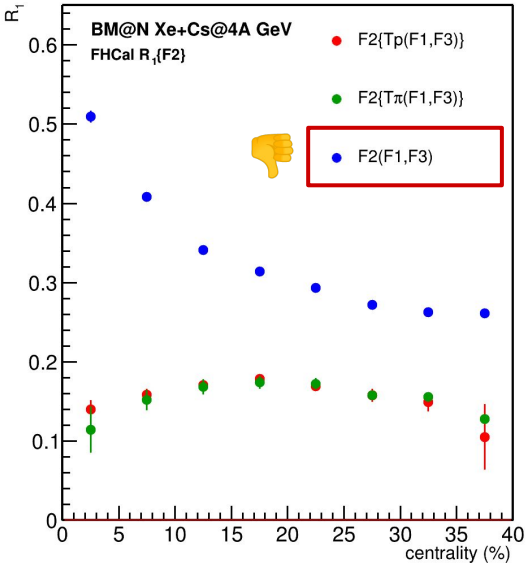
Flow methods for v_n calculation

Scalar product (SP) method:

$$v_1 = \frac{\langle u_1 Q_1^{F1} \rangle}{R_1^{F1}} \qquad v_2 = \frac{\langle u_2 Q_1^{F1} Q_1^{F3} \rangle}{R_1^{F1} R_1^{F3}}$$

Where R_1 is the resolution correction factor

$$R_1^{F1} = \langle \cos(\Psi_1^{F1} - \Psi_1^{RP}) \rangle$$



Symbol “F2(F1,F3)” means R_1 calculated via (3S resolution):

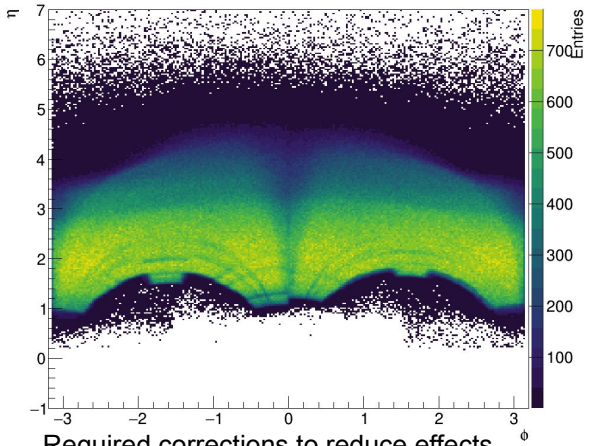
$$R_1^{F2(F1,F3)} = \frac{\sqrt{\langle Q_1^{F2} Q_1^{F1} \rangle \langle Q_1^{F2} Q_1^{F3} \rangle}}{\sqrt{\langle Q_1^{F1} Q_1^{F3} \rangle}}$$

Symbol “F2{Tp}(F1,F3)” means R_1 calculated via (4S resolution):

$$R_1^{F2\{Tp\}(F1,F3)} = \langle Q_1^{F2} Q_1^{Tp} \rangle \frac{\sqrt{\langle Q_1^{F1} Q_1^{F3} \rangle}}{\sqrt{\langle Q_1^{Tp} Q_1^{F1} \rangle \langle Q_1^{Tp} Q_1^{F3} \rangle}}$$

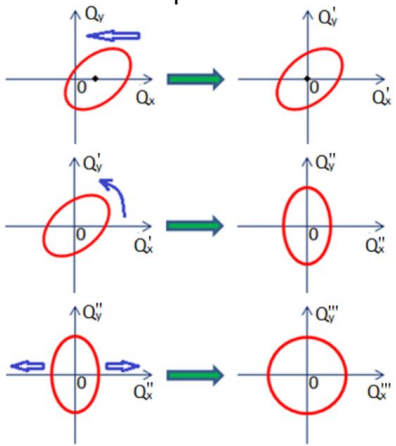
Azimuthal asymmetry of the BM@N acceptance

φ-η yield of protons

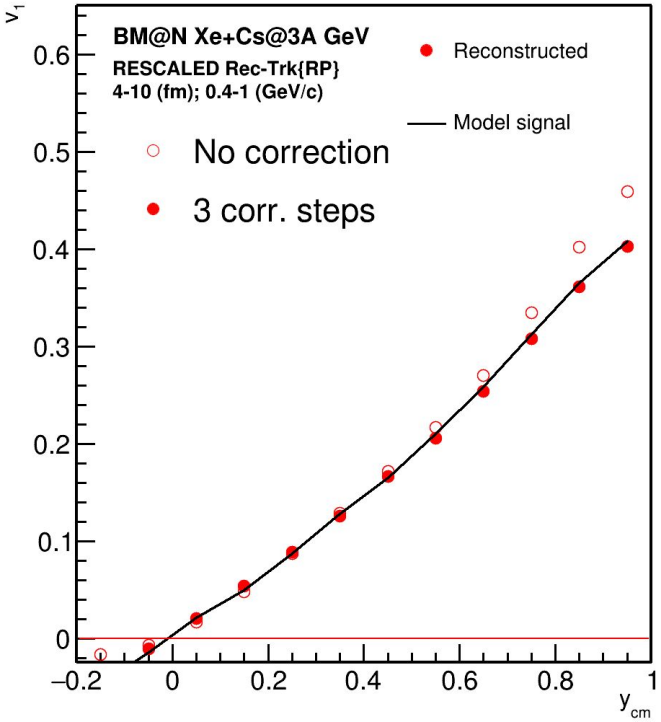


Required corrections to reduce effects of non-uniform azimuthal acceptance

1. Recentering
2. Twist
3. Rescaling

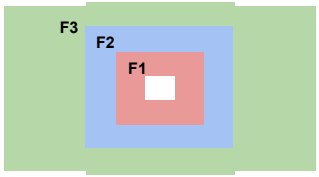


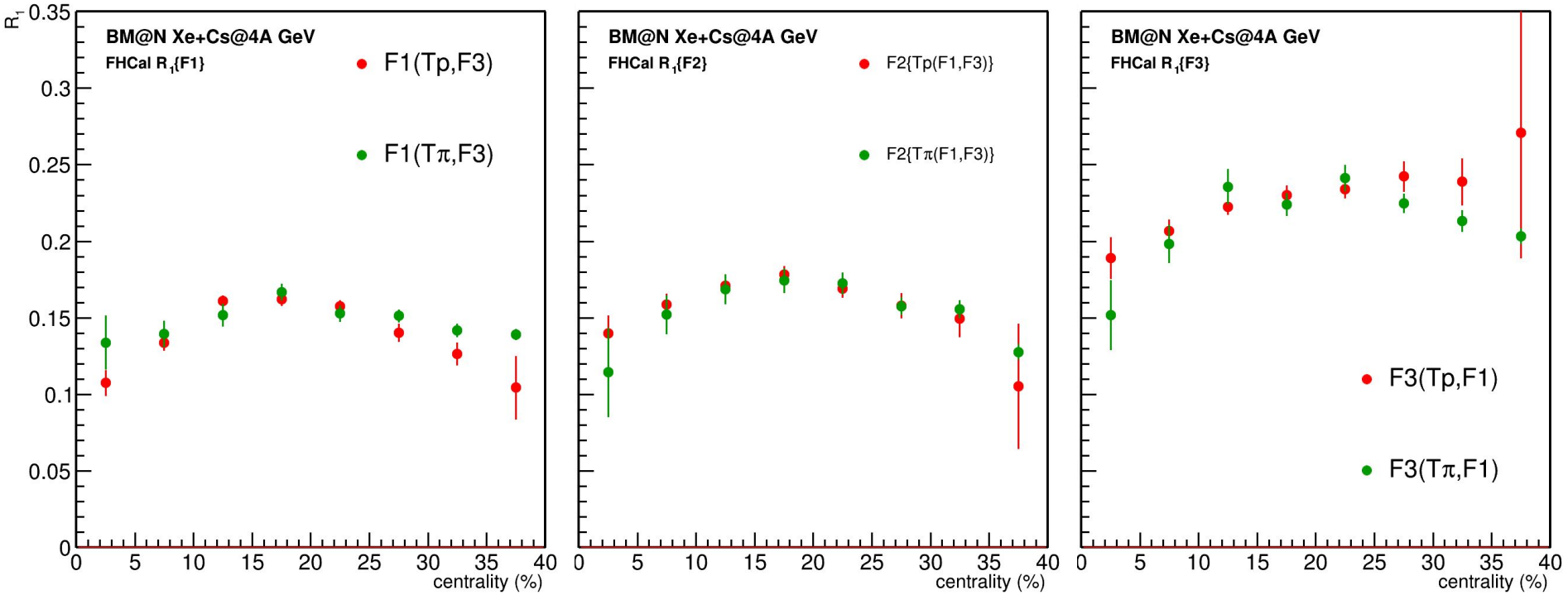
Corrections are based on method in:
I. Selyuzhenkov and S. Voloshin PRC77, 034904 (2008)



Better agreement after rescaling

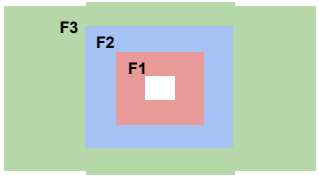
Rec R1: DCMQGCM-SMM Xe+Cs@4A GeV

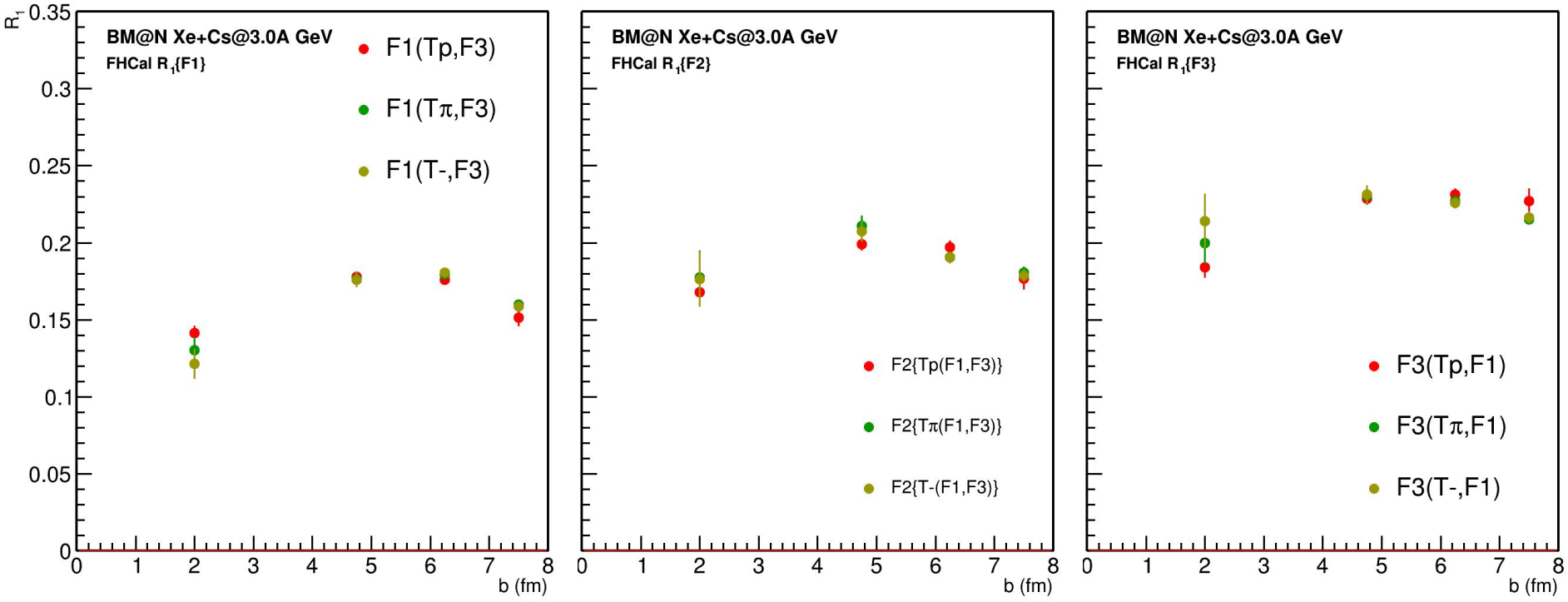




Using the additional sub-events from tracking provides a robust combination to calculate resolution

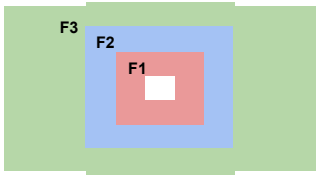
Rec R1: DCMQGCM-SMM Xe+Cs@3A GeV

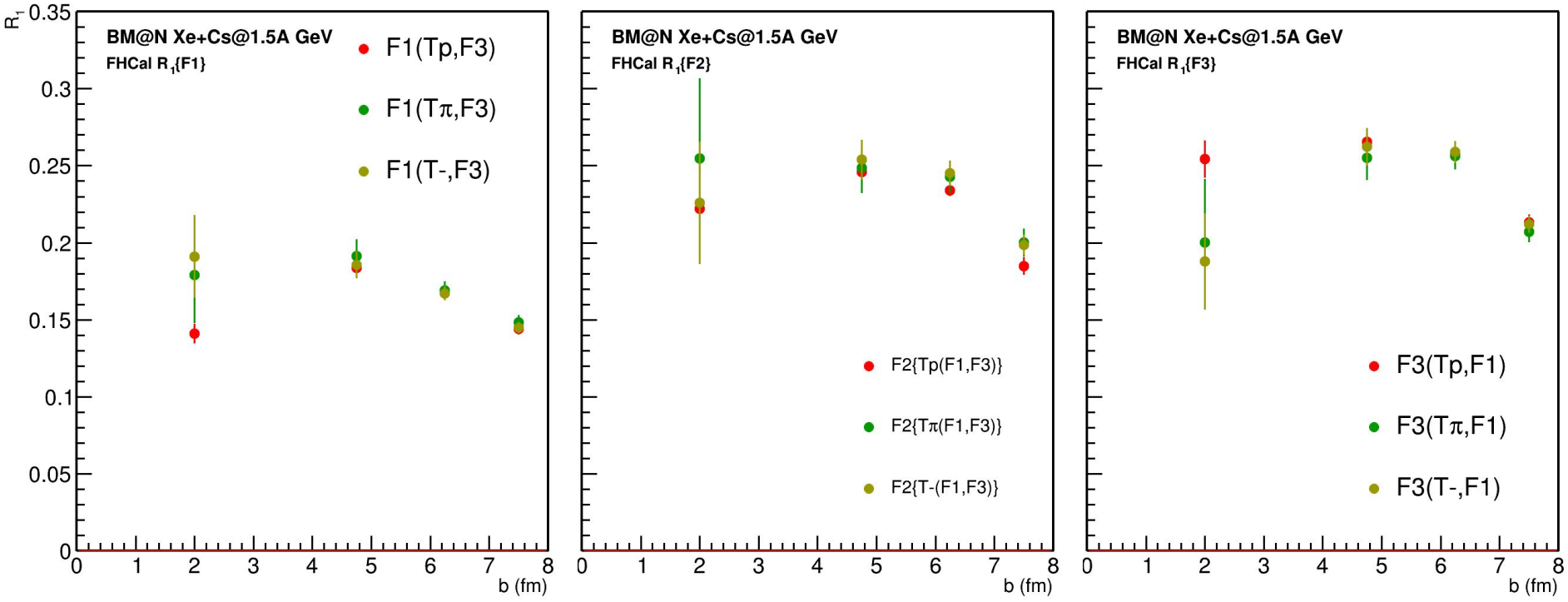




We can use unidentified negatively charged tracks as well for resolution calculation

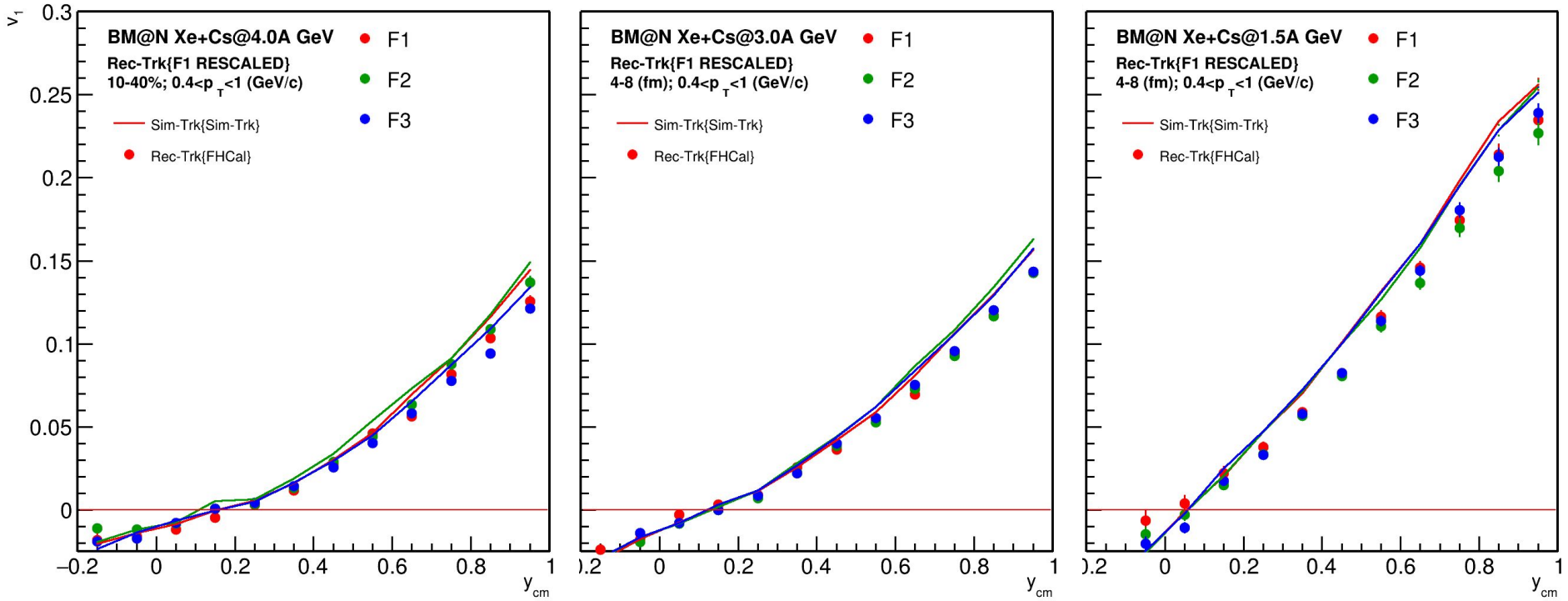
Rec R1: DCMQGCM-SMM Xe+Cs@1.5A GeV





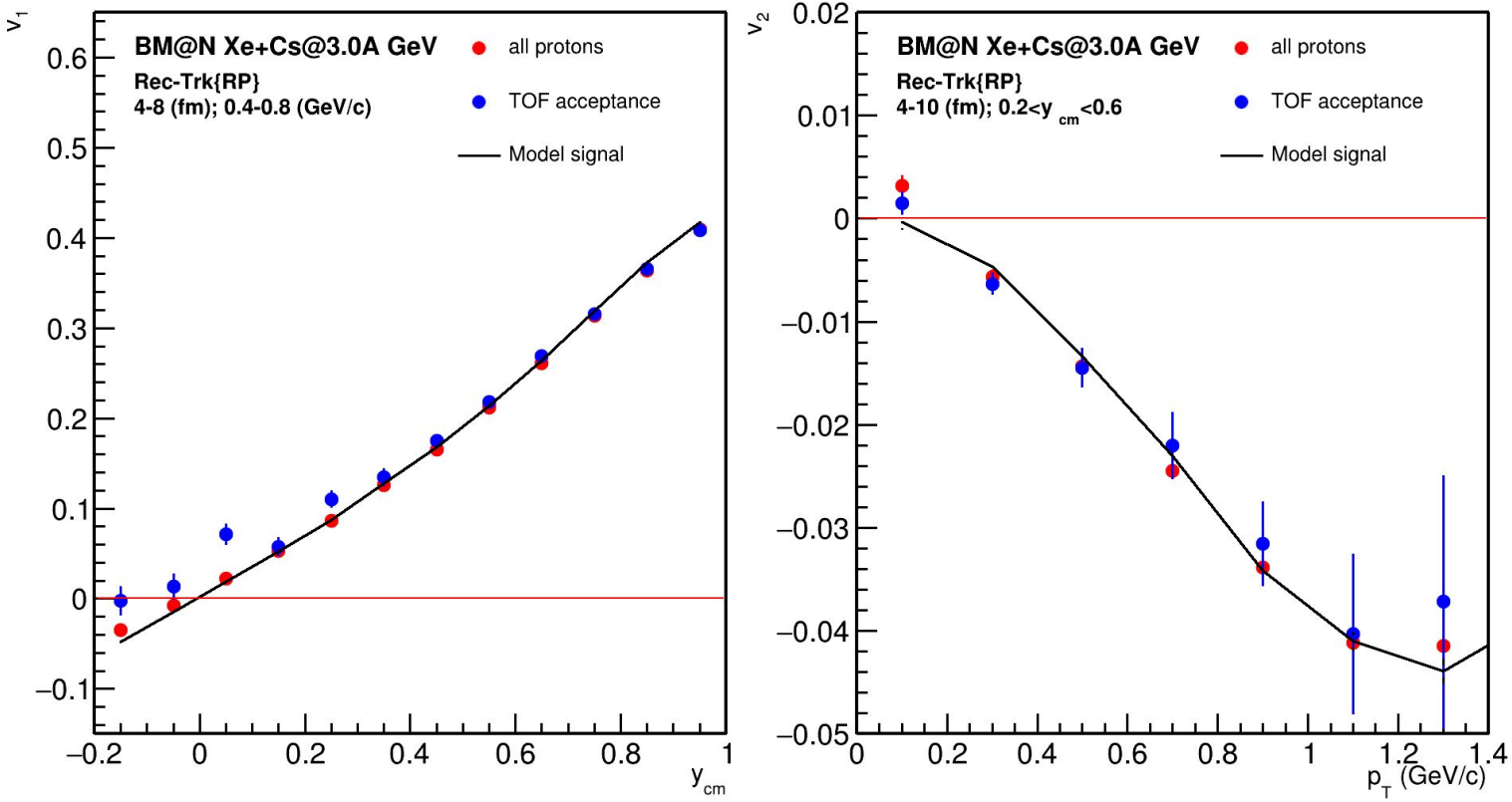
We can use unidentified negatively charged tracks as well for resolution calculation

v_1: DCMQGCM-SMM Xe+Cs (true momenta)



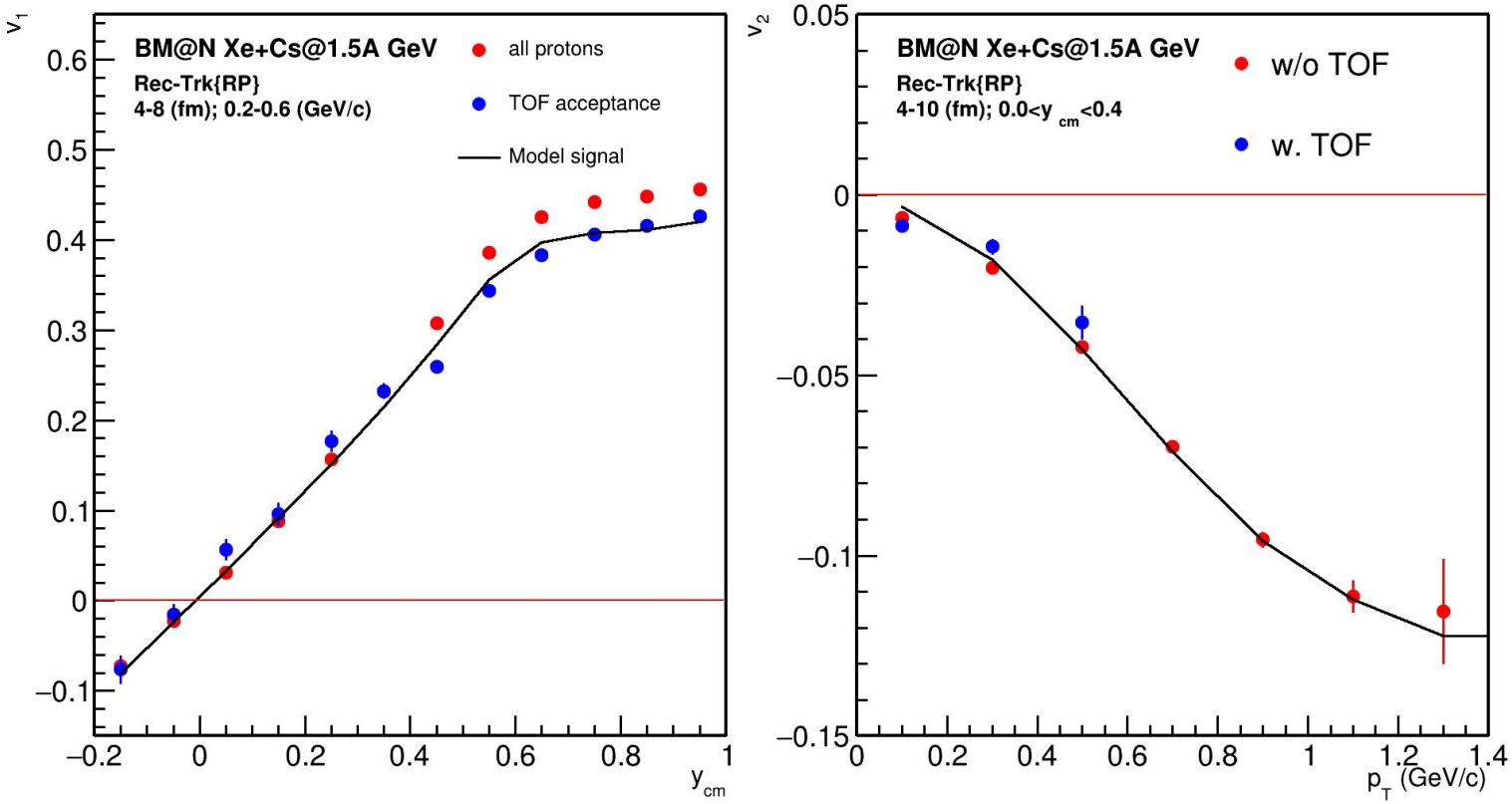
Reasonable agreement between model and reconstructed data

Directed and elliptic flow in Xe+Cs@3A GeV (JAM)



- Good agreement between reconstructed and model data
- Approximately 250-300M events are required to perform multidifferential measurements of v_n

Directed and elliptic flow in Xe+Cs@1.5A GeV (JAM)



- Larger amount of statistics is required to measure v_n at higher p_T
- Approximately 350-500M events are required to perform multidifferential measurements of v_n

Summary

- Resolution correction factor is calculated for DCMQGSM-SMM Xe+Cs collisions at beam energies of 4A, 3A and 1.5A GeV:
  - Using only FHCal sub-events for resolution calculation gives biased estimation due to transverse hadronic showers propagation
  - Using additional sub-events from tracking provides with a robust estimation
- Good agreement between model and reconstructed data is observed for v_1 and v_2 at 3AGeV
- Approximately 250-300M events are required to perform multidifferential flow analysis for Xe+Cs@3AGeV
- Approximately 350-500M events are required to perform multidifferential flow analysis for Xe+Cs@1.5AGeV

BACKUP