Performance for inclusive photon and neutral pion anisotropic flow measurements with the MPD experiment @ NICA

Oleg Golosov[1,2]
Dmitry Peresunko[1]
Dmitry Blau[1]
for the MPD Collaboration

[1]NRC “Kurchatov Institute”
[2]NRNU MEPhI

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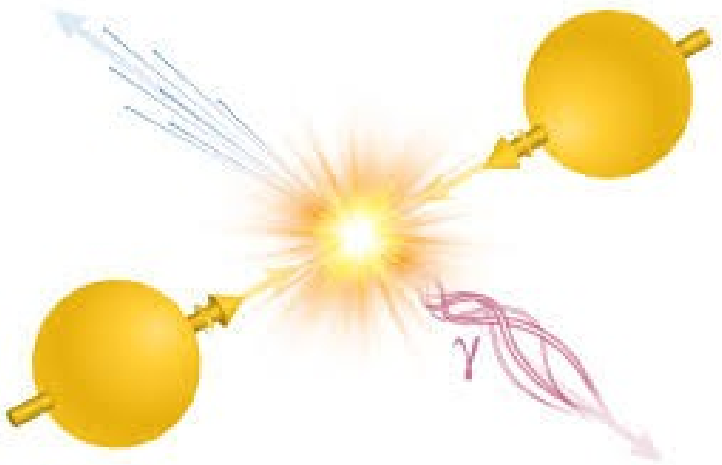
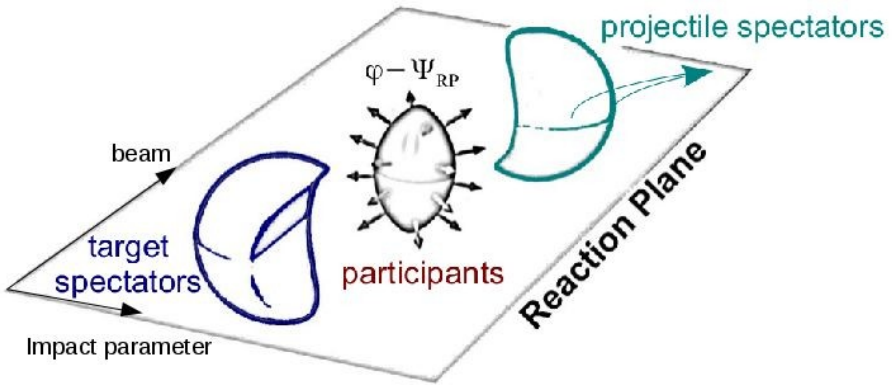
Direct photons



- produced in electromagnetic processes in heavy ion collisions
- escape the hot fireball and deliver information at all stages of the collision on:
  - temperature
  - development of the collective flow
  - space-time dimensions of the system
- scarce predictions on the yields and anisotropic flow at NICA energies (see the talk by V. Kuskov)
- Measurement is based on the subtraction of decay photon contribution from inclusive yields and spectra (the main source are neutral pions)

Anisotropic transverse flow



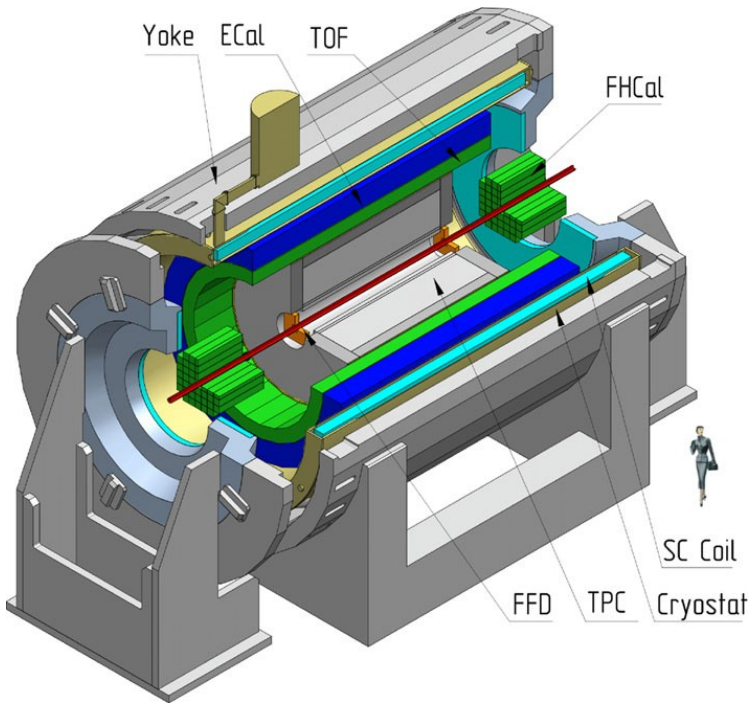
Asymmetry in coordinate space converts due to interaction into momentum asymmetry with respect to the collision symmetry plane:

$$\rho(\phi) = \frac{1}{2\pi}\left[1+2\sum_{n=1}^{\infty} v_n \cos\left(n\left(\phi-\Psi_s\right)\right)\right]$$

$$v_n = \langle \cos\left(n[\,\phi-\Psi_s\,]\right)\rangle$$

$v_n = v_n$ (p_T, y, centrality, particle type)
ψ_s – symmetry plane

MPD @ NICA



- **Aim** - study phase diagram of strongly interating matter in the region of high baryon chemical potential
- Will detect particles produced in heavy ion collisions at $\sqrt{s_{NN}}$ = 4-11 GeV.
- Start of operation in fixed-target regime with wire target at 87 cm from the barrel center.

Main subsystems

- Time-projection chamber (TPC)
- Time of flight system (TOF)
- Electromagnetic calorimeter (ECal)
- Forward hadron calorimeters (FHCal)

Analysis description

Aim: assess performance for measurement of spectra and anisotropic flow of inclusive photons and π^0 with the MPD @ NICA in collider and FXT modes

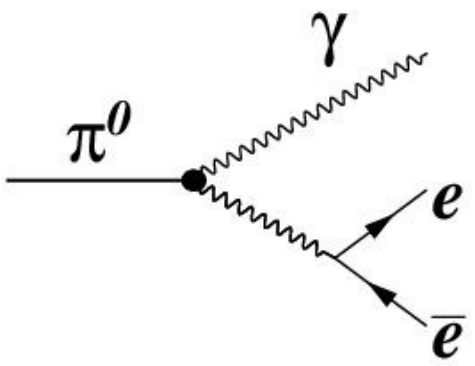
Datasets:

- 50M reconstructed UrQMD events for Bi+Bi @ 9.2 GeV (collider mode)
- 15M events UrQMD events for Xe-W @ 2.5 AGeV ($\sqrt{s_{NN}}$ = 2.9 FXT mode).
- Event selection:

  - successfully reconstructed vertex within 50 cm from the center of the TPC barrel (within 2 cm from nominal position for FXT)

  - ~25M events after selection (10M for FXT).
- Symmetry plane from the assymmetry of spectator energy deposition in the FHCal (true reaction plane for FXT)
- Two subevent method to assess symmetry plane resolution

Methods to reconstruct ɣ and π^0



Two possibilities for photon reconstruction:

- Signal in EMC
- e+e- pairs from TPC for converted photons

Three methods for π^0 reconstruction:

- Calorimeter (both photons reconstructed with EMC)
- Hybrid (EMC + converted photon)
- Conversion (two converted photons)

Conversion method gives significantly higher momentum resolution but much lower reconstruction efficiency.

Selection of clusters and e^+e^- pairs

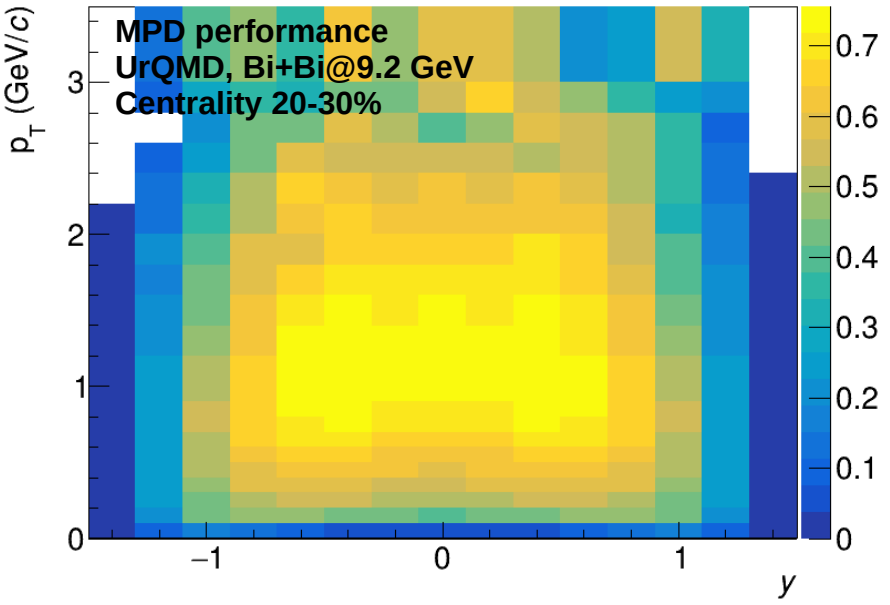
- Cluster selection in the Ecal:
  - $E_{core} > 50$ MeV
  - minimum 2 cells
  - maximum time of flight cut

- Track selection for reconstruction of conversion photons:
  - > 10 hits in the TPC
  - $p_T > 0.05$ GeV/c
  - dE/dx within 3σ from the nominal for electrons
  - TOF beta within 3σ from the nominal for electrons (if available)

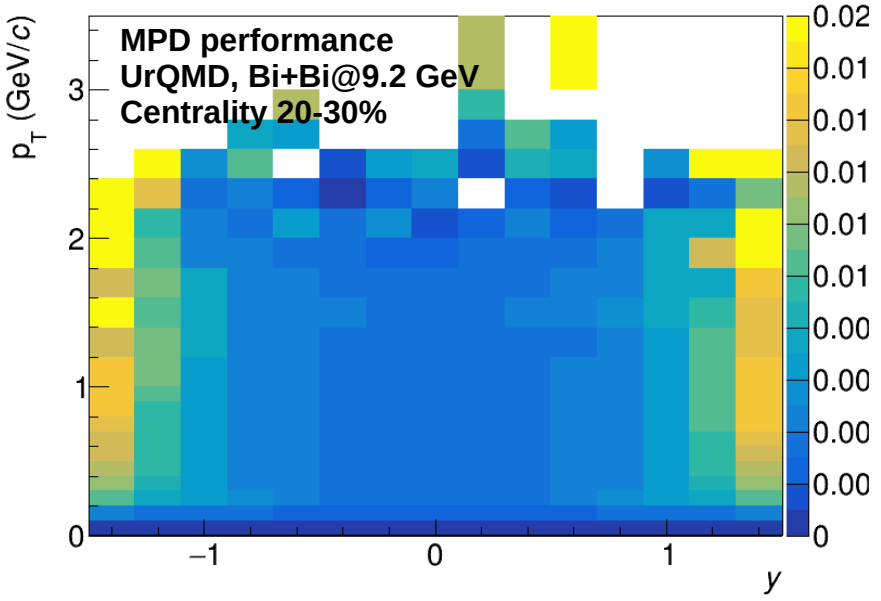
- Selection of e^+e^- pairs
  - tracks with opposite charge
  - $M_{inv} < 50$ MeV/c^2
  - track DCA < 1.2 cm
  - Armenteros-Podolyansky cut
  - quality of secondary vertex reconstruction

Photon reconstruction efficiency (collider mode)

Calorimeter method



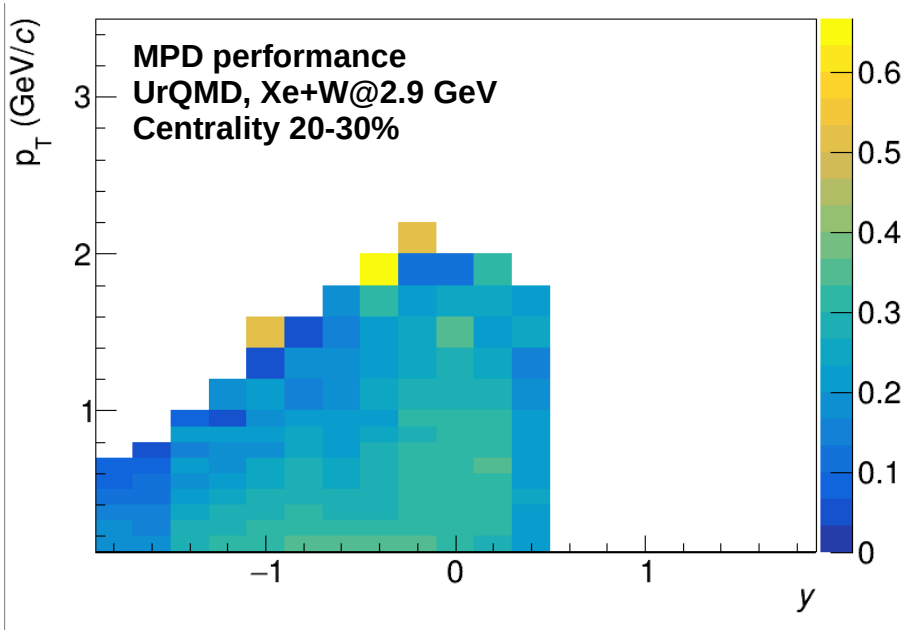
Conversion method



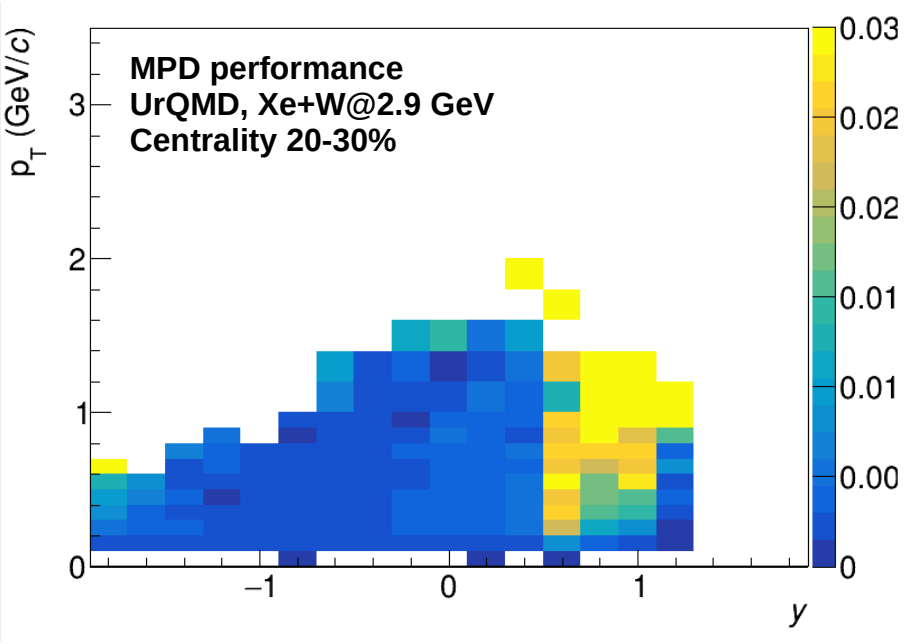
- Close to unity in wide p_T-y range with the calorimeter method
- Very low for conversion method
- p_T-y differential correction is applied in the analysis

Photon reconstruction efficiency (FXT)

Calorimeter method

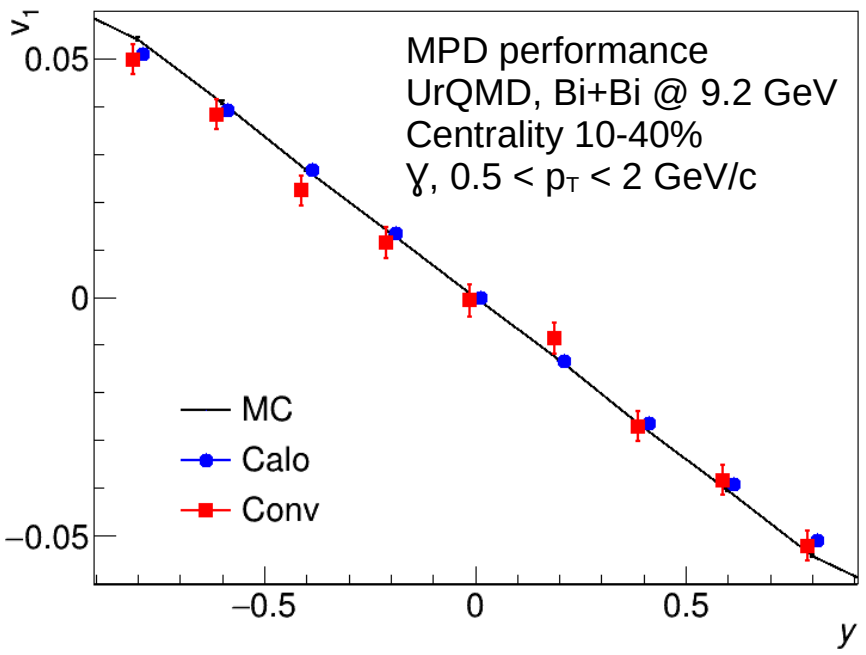


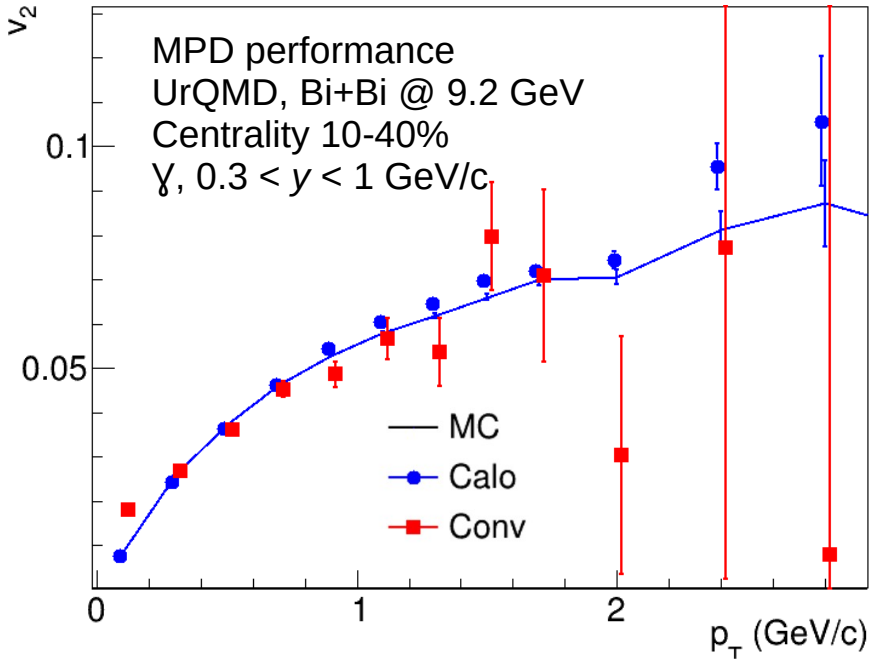
Conversion method



- Limited acceptance in FXT mode – have to switch to backward rapidity
- Significant rise in forward rapidity for conversion method
- p_T-y differential correction is applied in the analysis

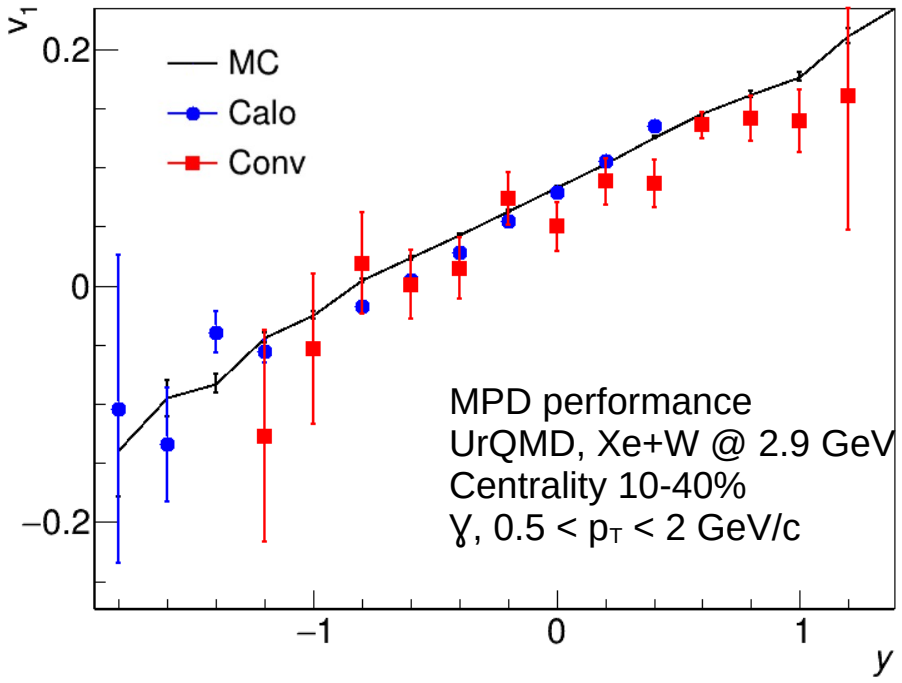
Flow of inclusive photons (collider mode)

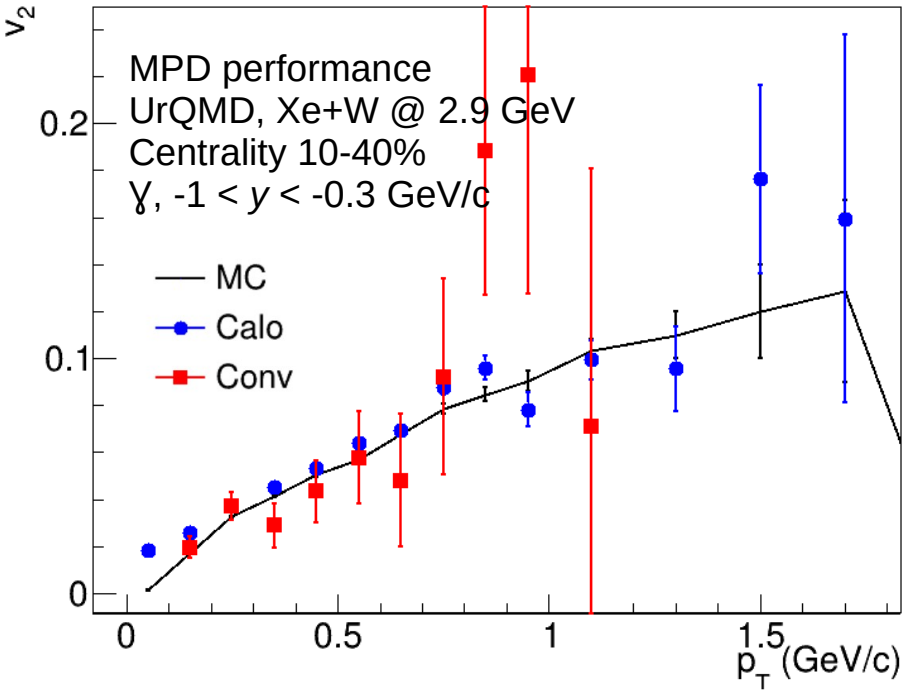




- Good agreement with the generator values for both methods
- Conversion method requres larger statistics

Flow of inclusive photons (FXT mode)

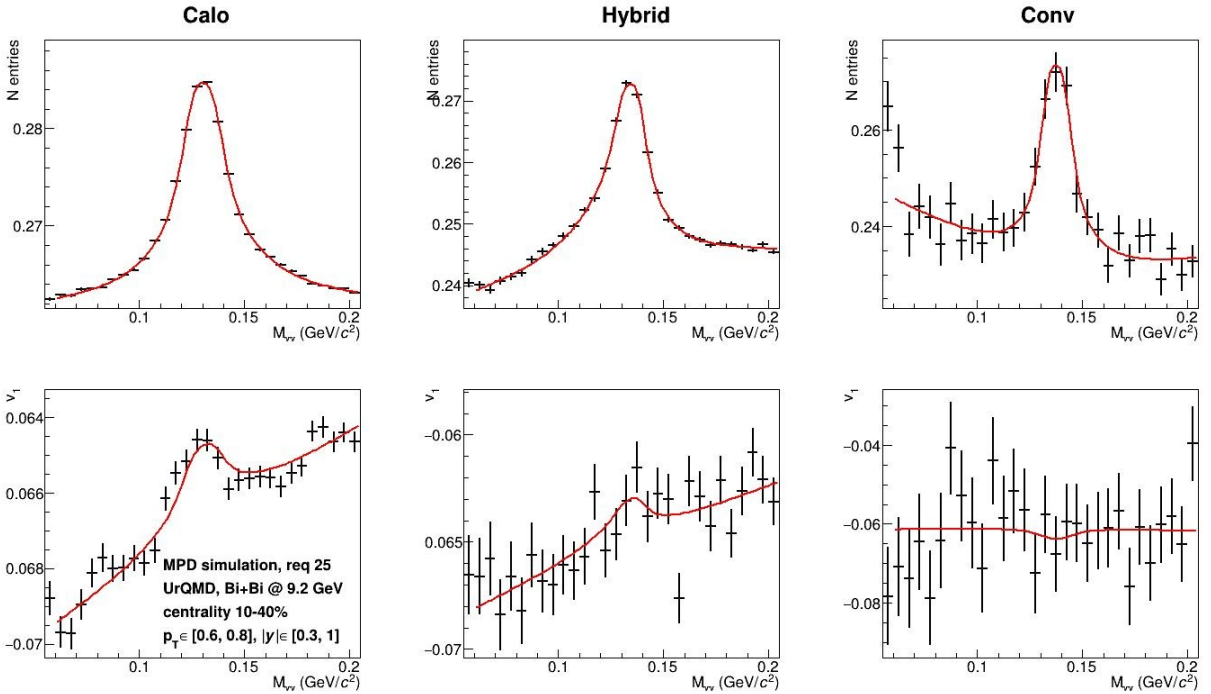




- Good agreement with the generator values for both methods
- Methods complement one another in rapidity coverage

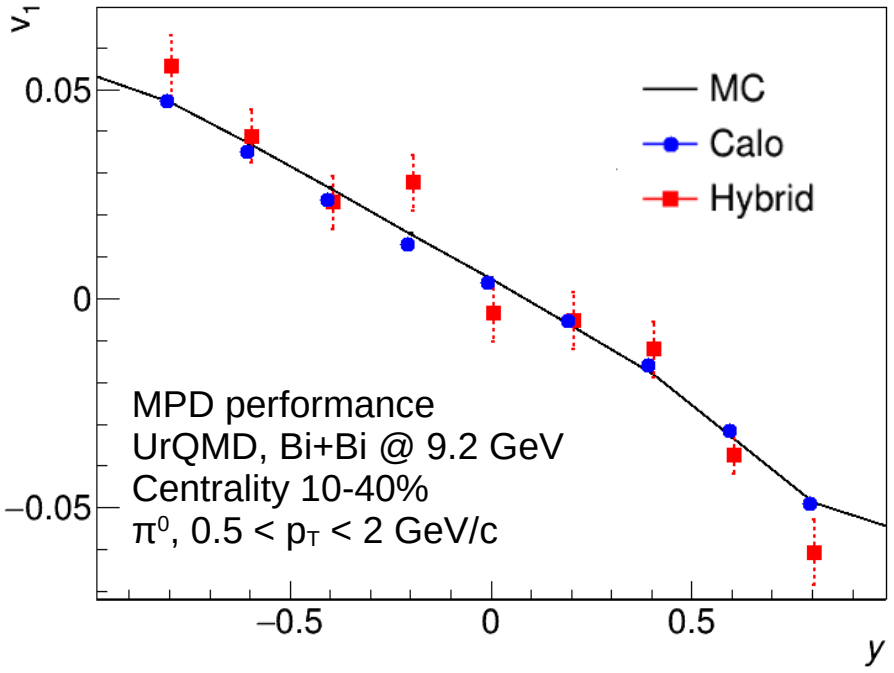
Measurement of neutral pion flow

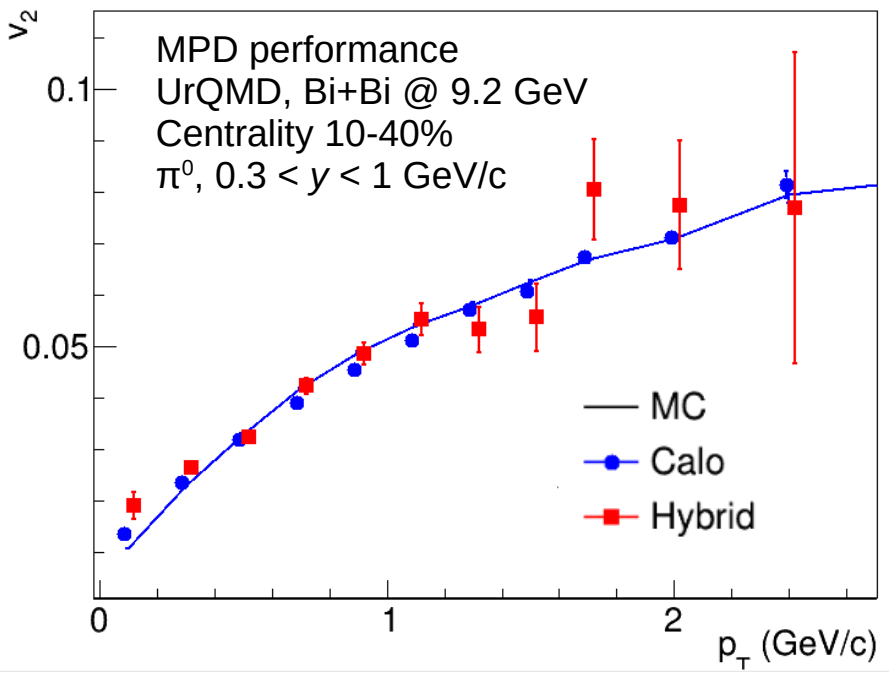
- Fit of v_n dependence on photon pair invariant mass with the function below
- v_{sig} and v_{bg} are free parameters, n_{sig} and n_{bg} are defined by fitting photon pair invariant mass distribution with double-sided Crystall Ball function + second order polynomial
- Conversion method is not accessible with the available statistics



$$v_{all}(M_{inv}) = \frac{n_{sig}(M_{inv})v_{sig} + n_{bg}(M_{inv})(v_{bg}^{const} + v_{bg}^{lin} * M_{inv})}{n_{sig}(M_{inv}) + n_{bg}(M_{inv})}$$

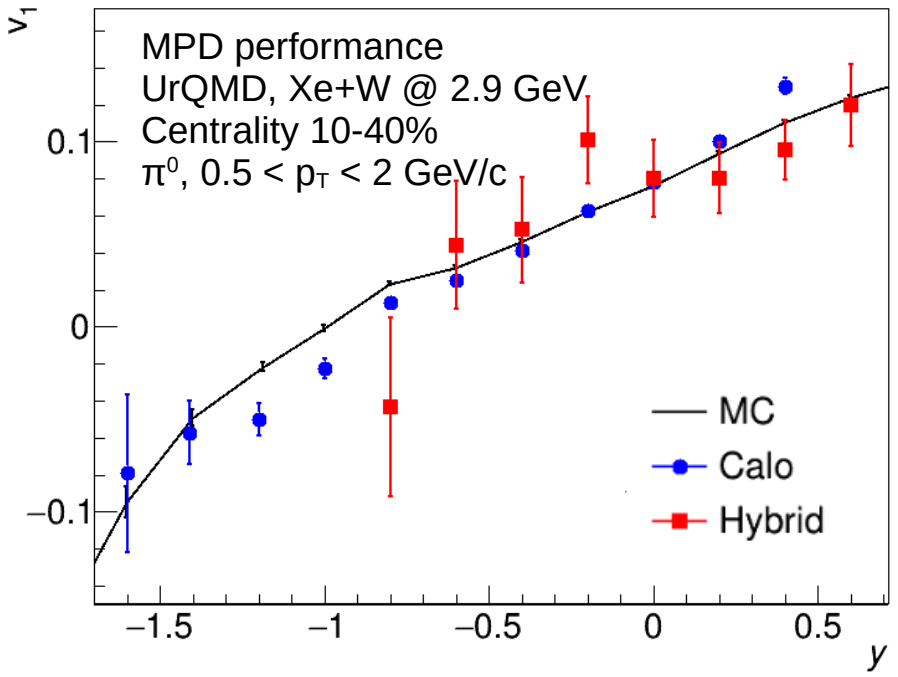
Neutral pion flow (collider mode)

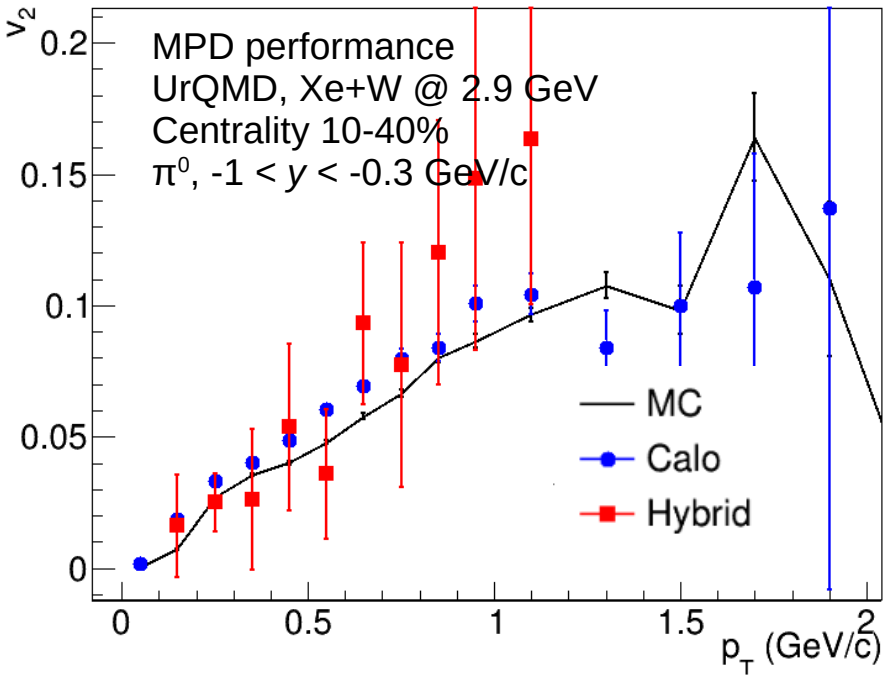




- Reasonable agreement with the generator values for both methods
- Hybrid method requres larger statistics

Neutral pion flow (FXT mode)





- Reasonable agreement with the generator values for both methods
- Hybrid method requres larger statistics, esp. at backward rapidity

Conclusion

- Differential measurement of directed and elliptic flow of inclusive photons and neutral pions should be feasible with the MPD @ NICA in both collider and fixed-target modes
- Cross check of the measurements with hybrid and calorimeter methods will be possible with reasonable statistics. Methods complement one another in rapidity coverage in FXT setup.
- For more precise assessment of the performance the analysis should be done using the input generator with realistic flow values of photons and neutral pions.
- Study of sytematics is to be performed

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