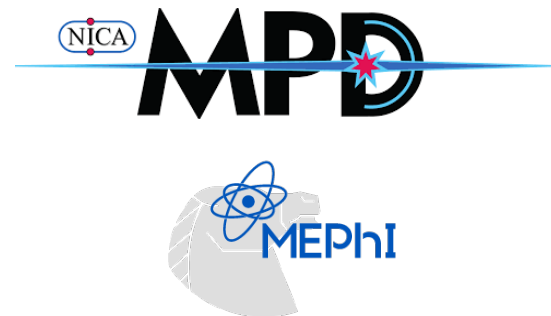


Performance for anisotropic flow measurement of inclusive photons and neutral pions in Bi+Bi@9.2 GeV with the MPD @ NICA



Oleg Golosov^{1,2}
Dmitry Peresunko¹
Dmitry Blau¹
for the MPD Collaboration



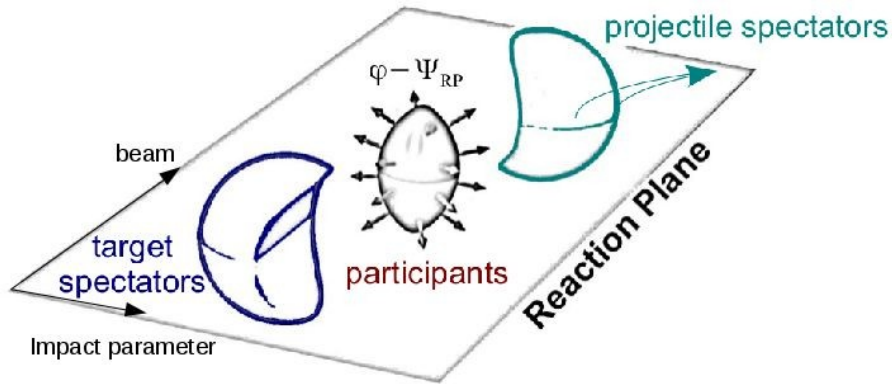
¹NRC "Kurchatov Institute"
²NRNU MEPhI

The work has been supported by the Ministry of Science and Higher Education of the Russian Federation,
Project "Fundamental and applied research at the NICA megascience experimental complex"
№ FSWU-2024-0024

ICPPA 2024

Anisotropic transverse flow

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

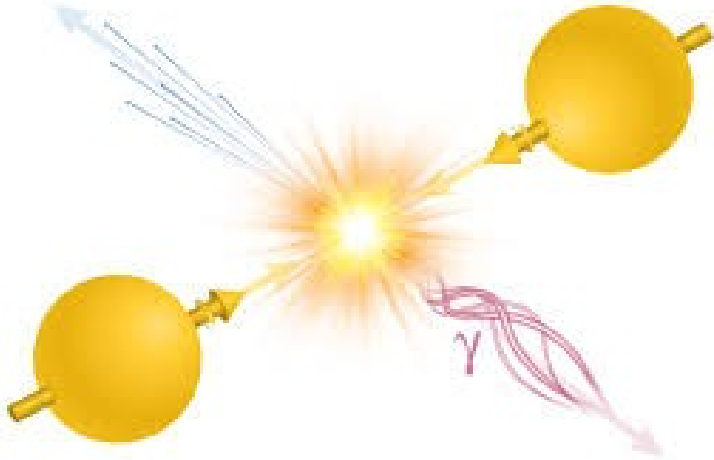


$$\rho(\phi) = \frac{1}{2\pi} \left[1 + 2 \sum_{n=1}^{\infty} v_n \cos(n(\phi - \Psi_s)) \right]$$

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

$v_n = v_n(p_T, y, \text{centrality, particle type})$
 ψ_s – symmetry plane

Anisotropic flow of direct photons



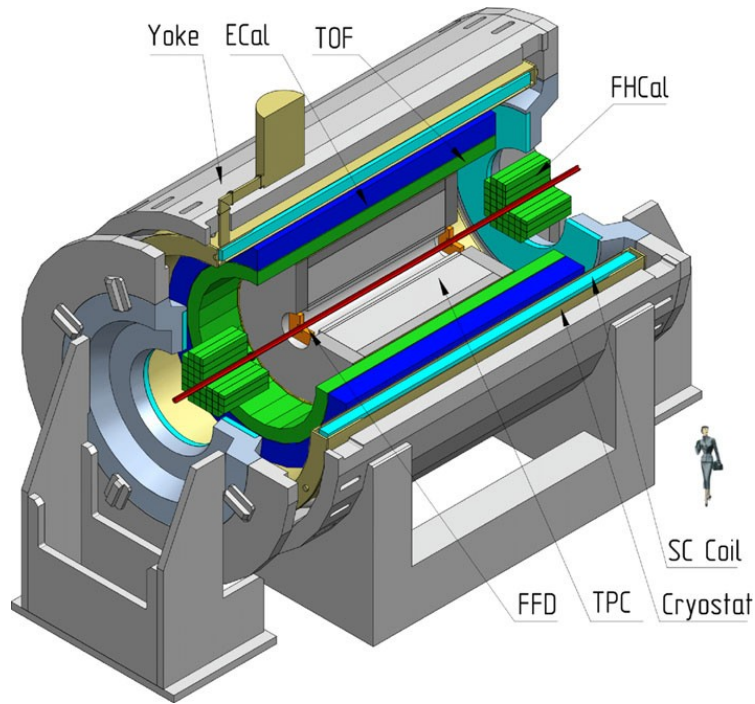
Direct photons

- produced in electromagnetic processes in heavy ion collisions
- do not interact with other particles in the interaction region

Anisotropic flow of direct photons

- may shed light on the mechanisms of formation of anisotropic flow, including the earliest stages of the collision
- to quantify one needs to measure anisotropic flow of inclusive and decay photons (main source are neutral pions)

MPD @ NICA



- **Aim** - study phase diagram of strongly interacting matter in the region of high baryon chemical potential
- Will detect particles produced in heavy ion collisions at $\sqrt{s_{NN}} = 4-11$ GeV.

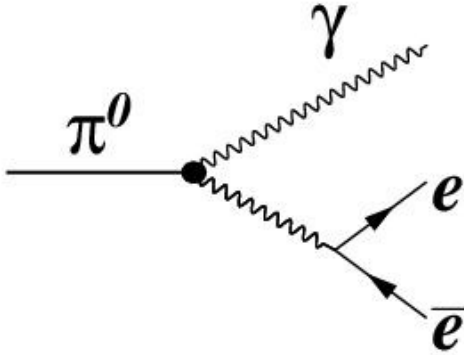
Main subsystems

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

Analysis description

- **Aim:** assess performance for measurement of anisotropic flow of inclusive photons and π^0 with the MPD @ NICA
- **Dataset:** 50M reconstructed UrQMD events for Bi+Bi @ 9.2 GeV.
- Event selection:
 - successfully reconstructed vertex within 50 cm from the center of the TPC barrel
 - ~25M events after selection.
- Symmetry plane from the assymetry of spectator energy deposition in the FHCaI
- Two subevent method to assess symmetry plane resolution

Methods to reconstruct γ 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)

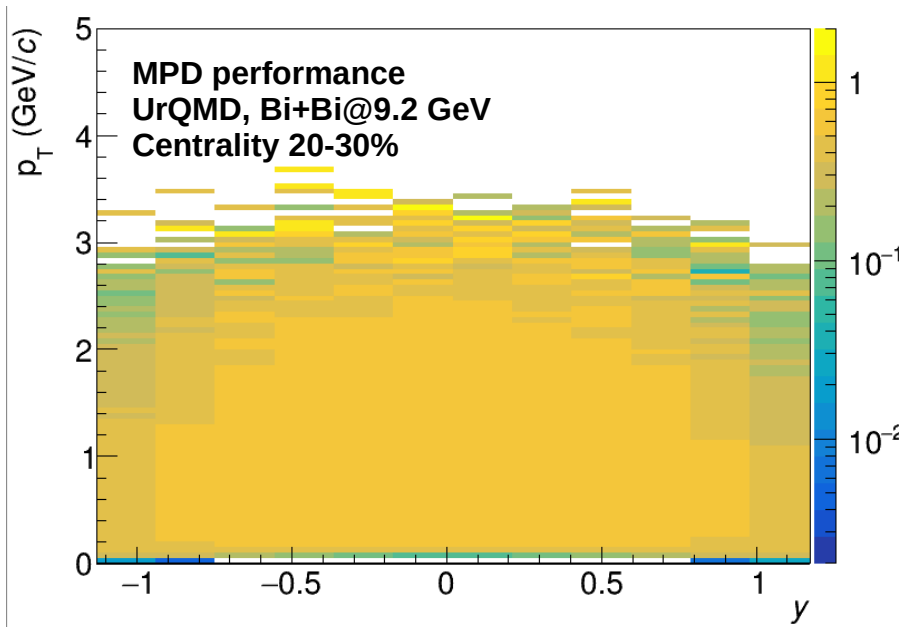
Conversion method gives significantly higher momentum resolution but much lower reconstruction efficiency.

Selection of clusters and e^+e^- pairs

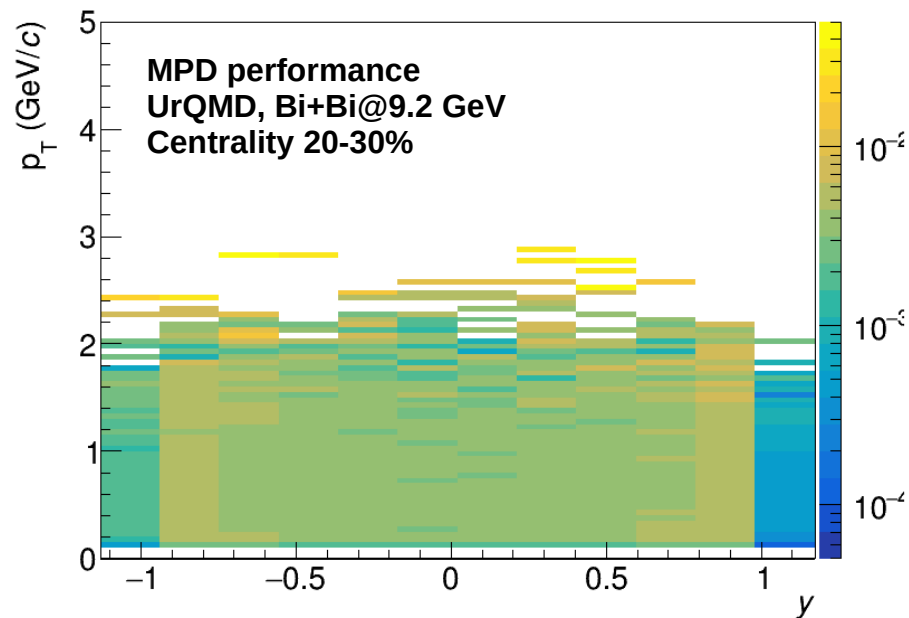
- Cluster selection in the Ecal:
 - $E_{\text{core}} > 50 \text{ MeV}$
 - minimum 2 cells
 - more than 1 cm from the nearest extrapolated track
 - maximum time of flight cut
- Track selection for reconstruction of conversion photons:
 - > 10 hits in TPC
 - $|\eta| > 1$
 - $p_{\text{T}} > 0.05 \text{ GeV}/c$
 - dE/dx within 5σ from the nominal for electrons
- Selection of e^+e^- pairs
 - tracks with opposite charge
 - $M_{\text{inv}} < 50 \text{ MeV}/c^2$
 - track DCA $< 1.2 \text{ cm}$
 - Armenteros-Podolyansky cut
 - quality of secondary vertex reconstruction

Photon reconstruction efficiency

Calorimeter method

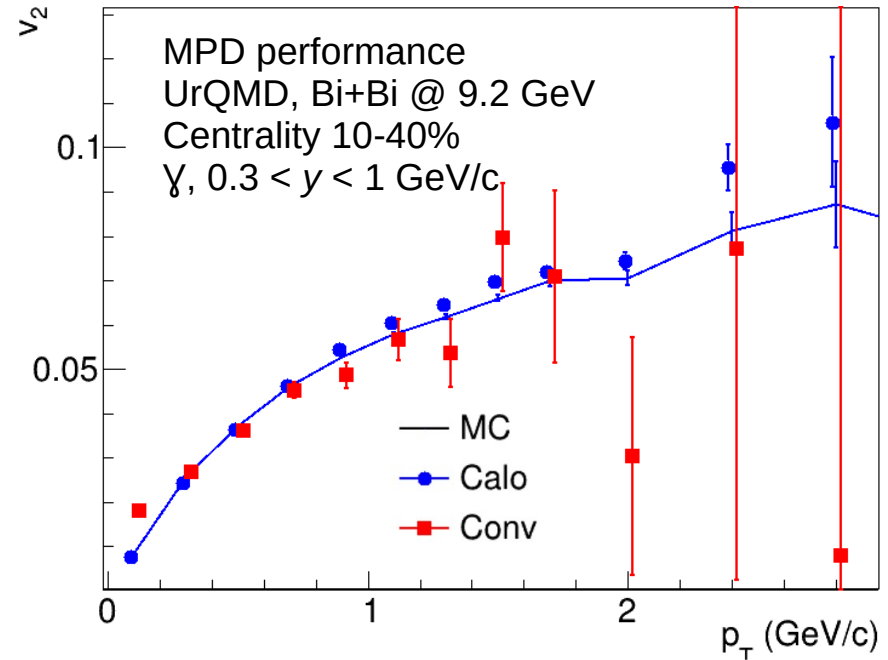
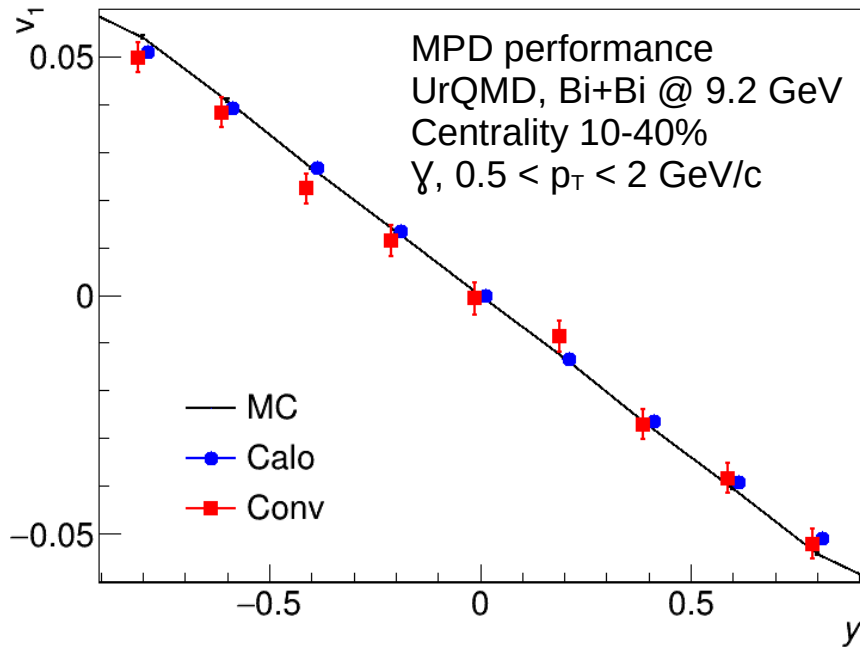


Conversion method



- 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

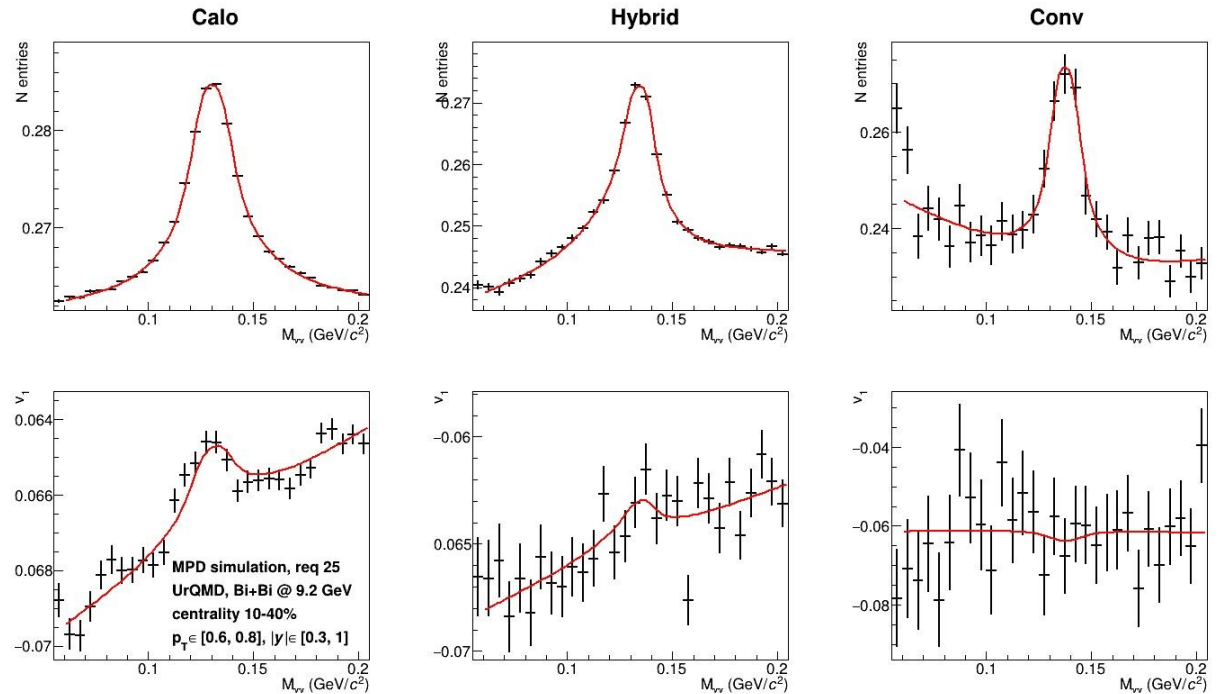
Flow of inclusive photons



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

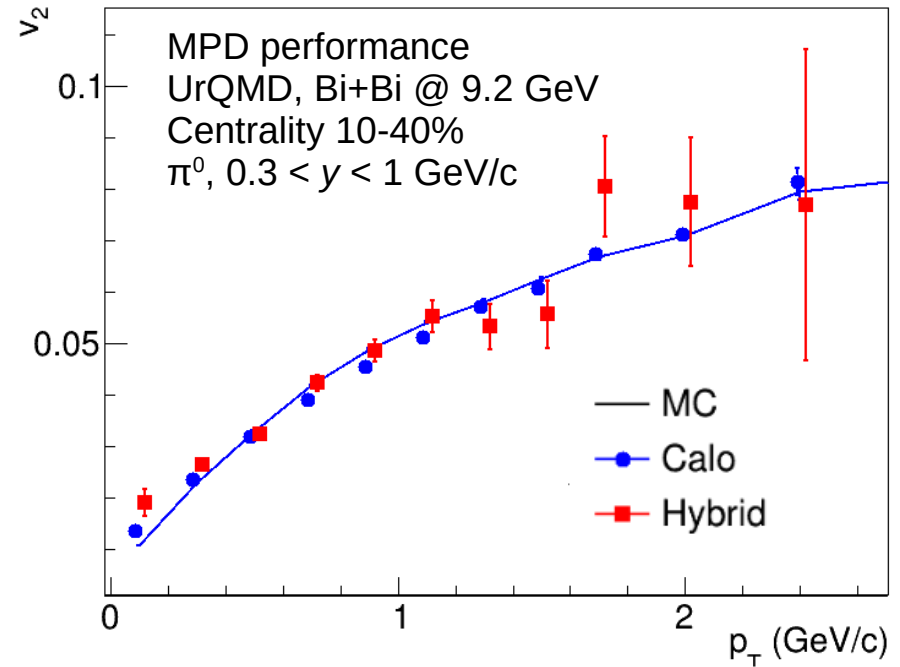
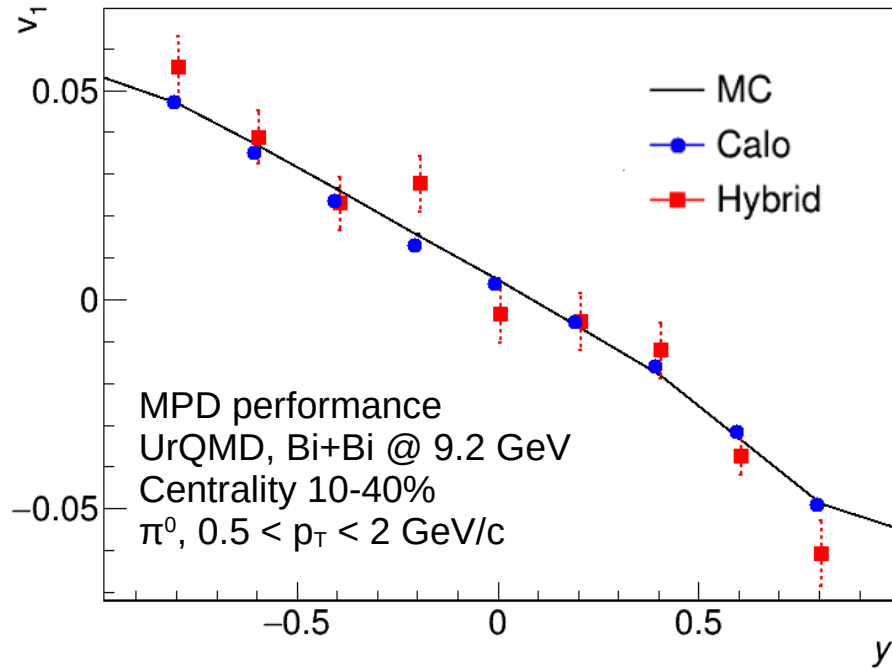
Measurement of neutral pion flow

- 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



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

Conclusion

- Differential measurement of directed and elliptic flow of inclusive photons and neutral pions in Bi+Bi @ 9.2 GeV should be feasible with the MPD @ NICA
- Cross check of the measurements with hybrid and calorimeter methods will be possible with reasonable statistics
- For more precise assessment of the performance the analysis should be performed using the input generator with realistic flow values of photons and neutral pions.
- Study of systematics is to be performed

The work has been supported by the Ministry of Science and Higher Education of the Russian Federation, Project "Fundamental and applied research at the NICA megascience experimental complex" № FSWU-2024-0024