Update on photon and neutral pion spectra and flow in Xe+W @ 2.5A GeV

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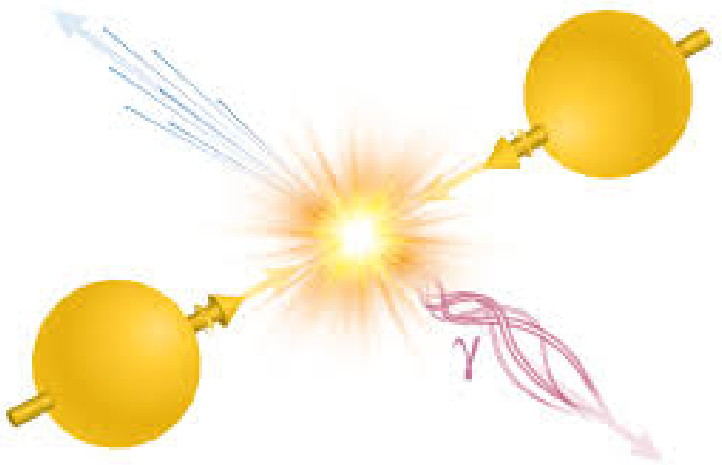
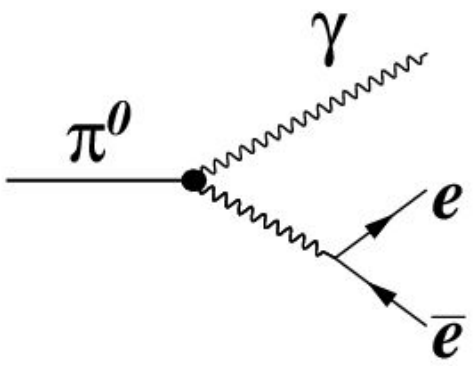
Direct photons



- 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
- Measurement is based on the subtraction of decay photon contribution from inclusive yields and spectra (the main source are neutral pions)

Methods to reconstruct ɣ and π^0



Two possibilities for photon reconstruction:

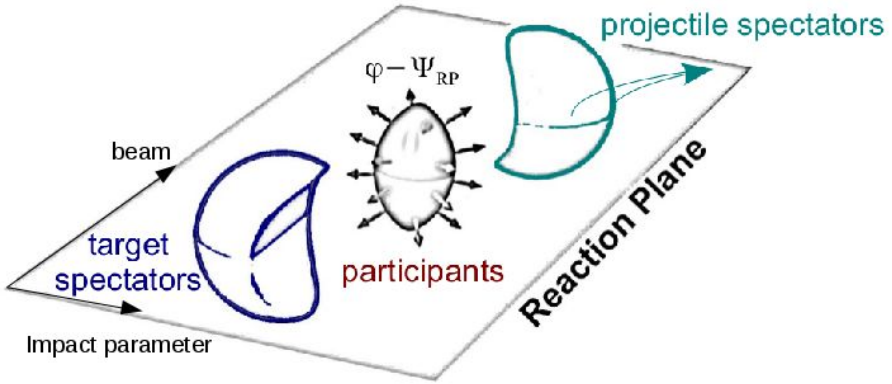
- Signal in EMC
- e+e- pairs from TPC for converted photons

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.

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

Analysis description

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

Dataset:

- 15M events UrQMD events for Xe+W @ 2.5 AGeV ($\sqrt{s_{NN}}$ = 2.9 GeV, production 36).
- Event selection:
  - successfully reconstructed vertex within 2 cm from nominal position
  - ~10M events after selection.
- Flow measurement relative to true symmetry plane

Selection of clusters and e^+e^- pairs

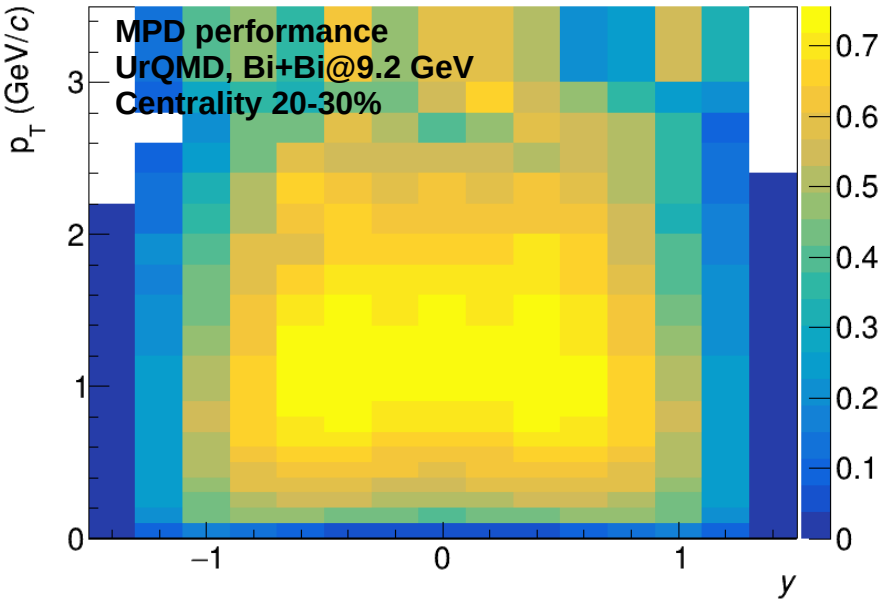
- Cluster selection in the Ecal:
  - E_{core} > 50 MeV
  - minimum 2 cells
  - time of flight cut

- 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)

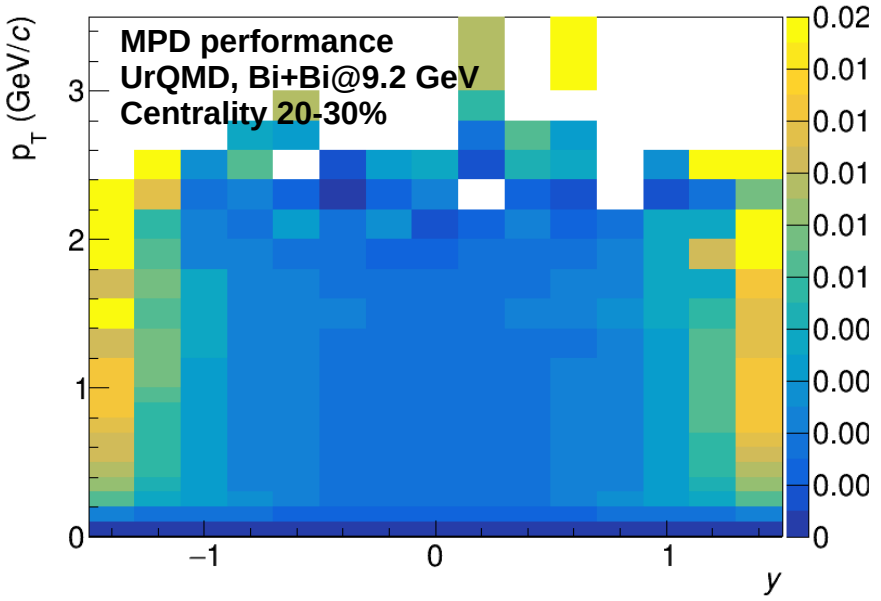
- Selection of e^+e^- pairs
  - tracks with opposite charge
  - M_{inv} < 50 MeV/c^2
  - track DCA < 1.2 cm
  - Armenteros-Podolyansky cut
  - quality of secondary vertex reconstruction

Photon reconstruction efficiency (**collider mode**)

Calorimeter method



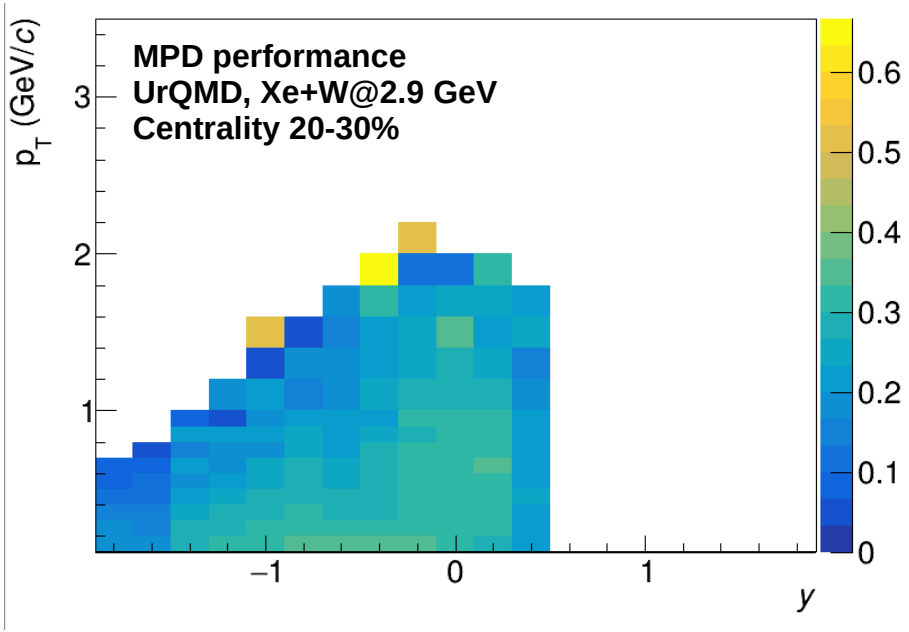
Conversion method



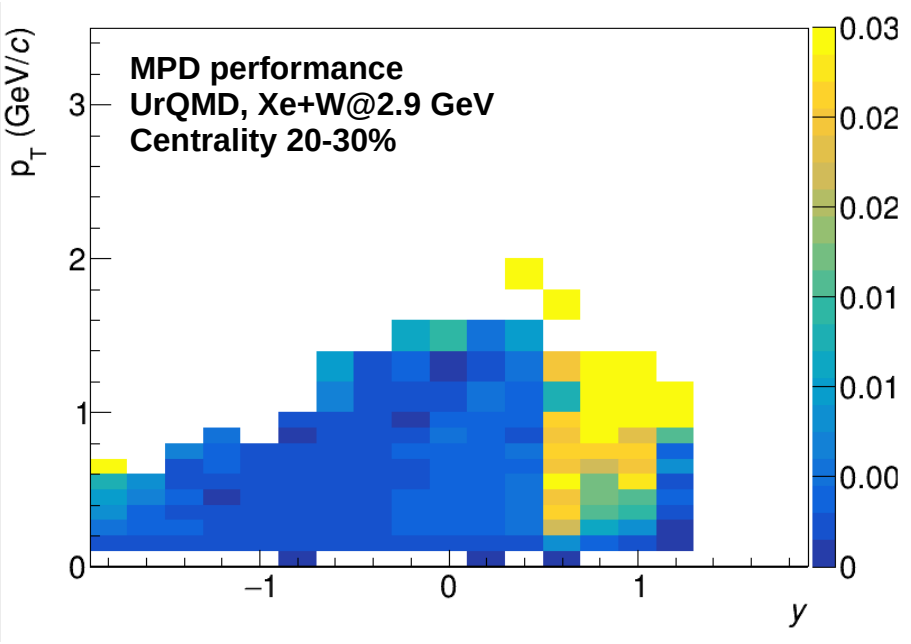
- Close to unity in wide p_T-y range with the calorimeter method
- Very low for conversion method
- p_T-y differential correction is applied in the flow analysis

Photon reconstruction efficiency (**FXT**)

Calorimeter method

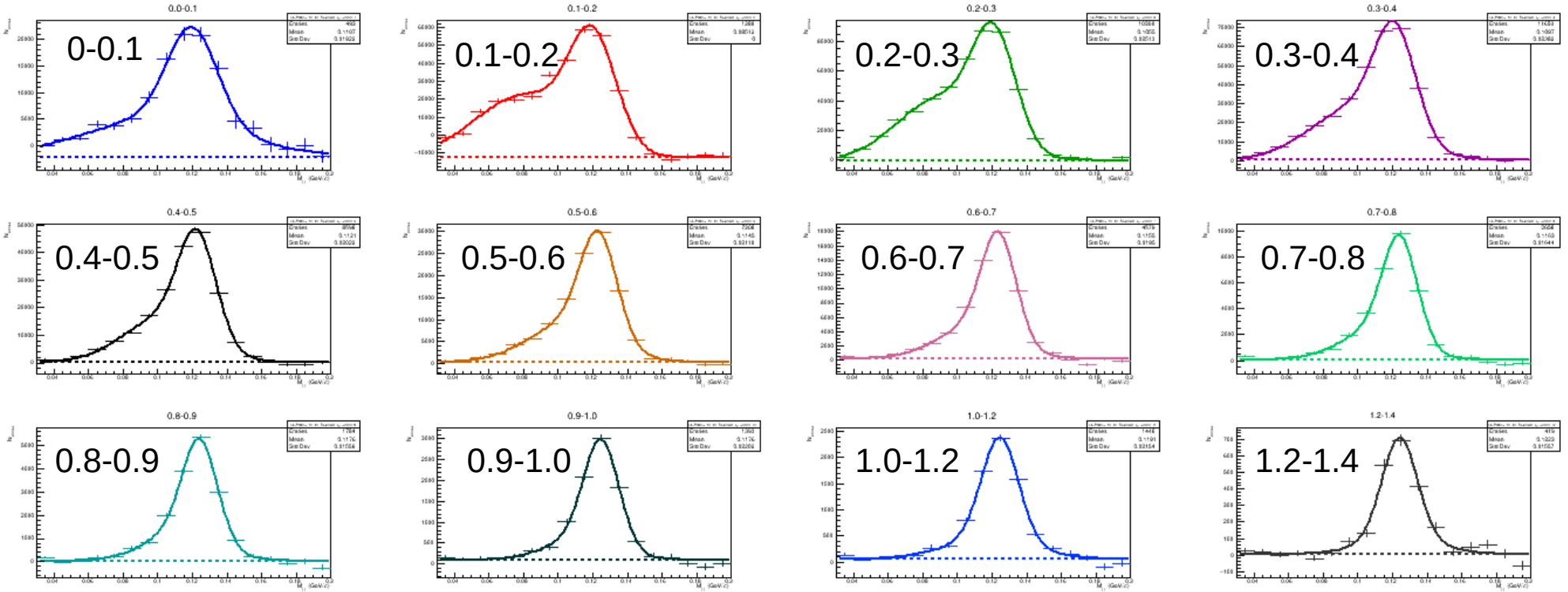


Conversion method



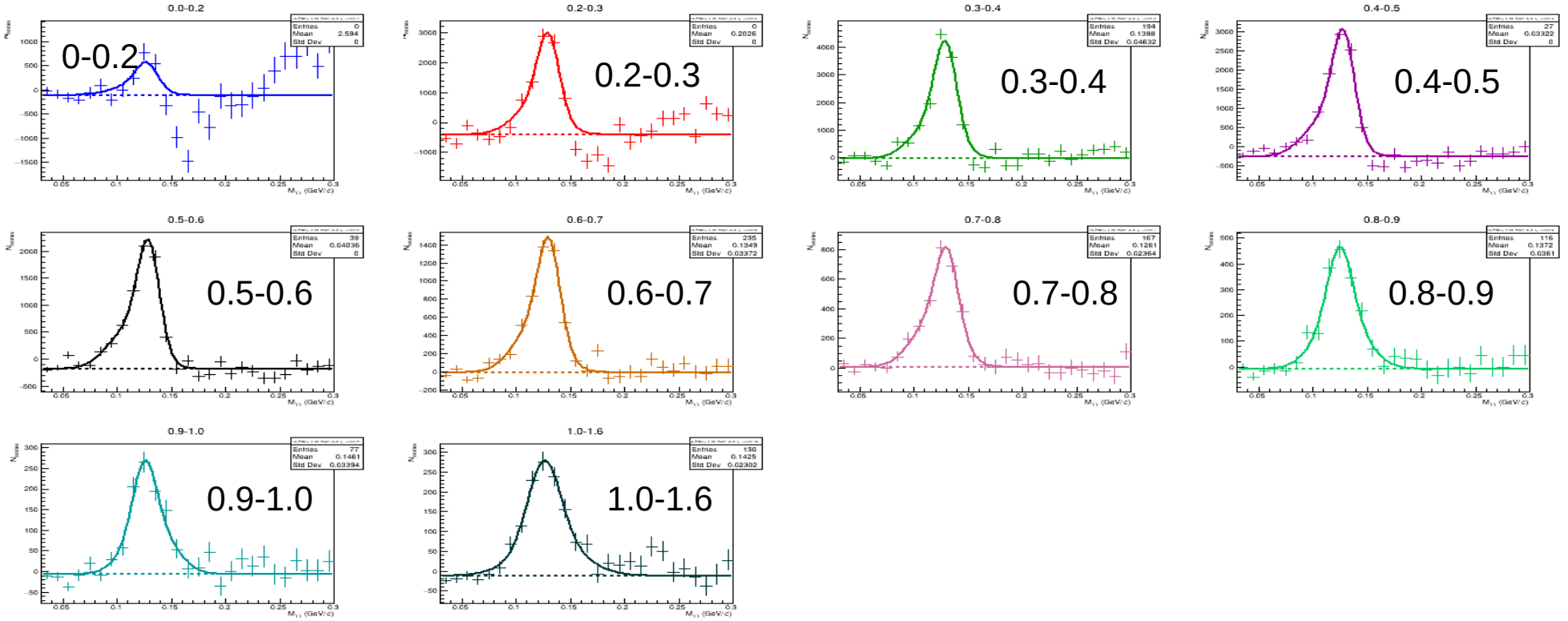
- Limited acceptance in FXT mode – have to switch to backward rapidity
- Significant rise in forward rapidity for conversion method (central TPC electrode)
- p_T-y differential correction is applied in the flow analysis

Invariant mass spectra after mixed event background subtraction (calorimeter method)



- Additional peak, more prominent at low p_T due to clusters from convertion electrons.
- Sum of two gaussians and polynomial makes a reasonable fit

Invariant mass spectra after mixed event background subtraction (hybrid method)



- Additional peak, more prominent at low p_T due to clusters from convertion electrons.
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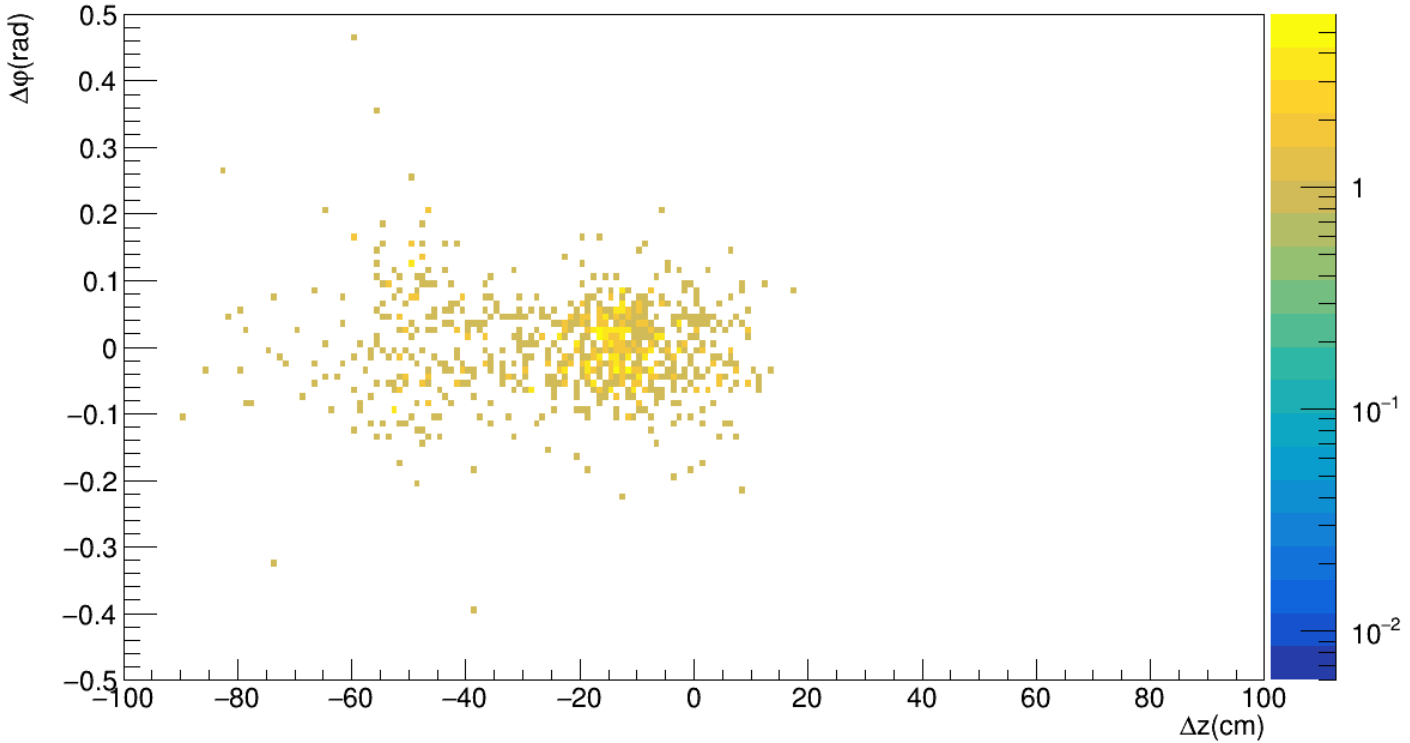
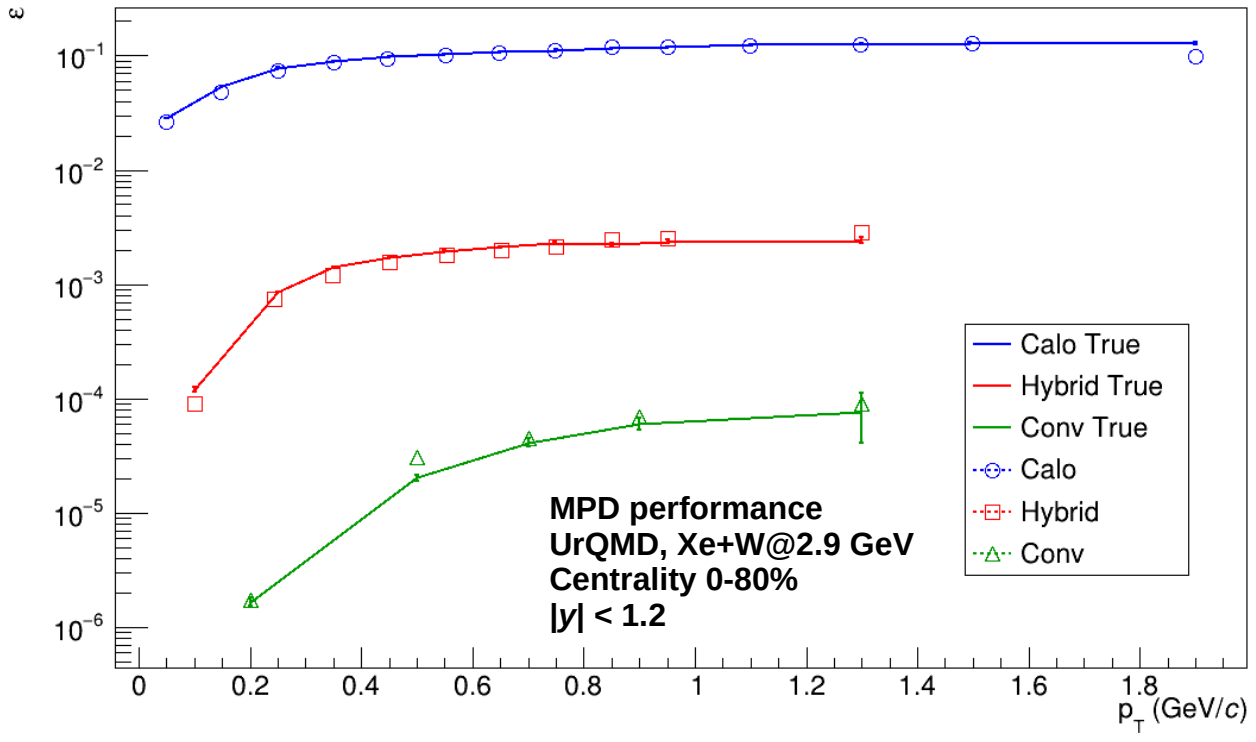
Possible solution: TOF veto



- 60% of electrons associated with clusters produce a hit in TOF
- TOF hit position and time is correlated with corresponding cluster characteristics
- Method for TOF-based rejection is currently being studied

Invariant mass spectra after mixed event background subtraction (hybrid method)



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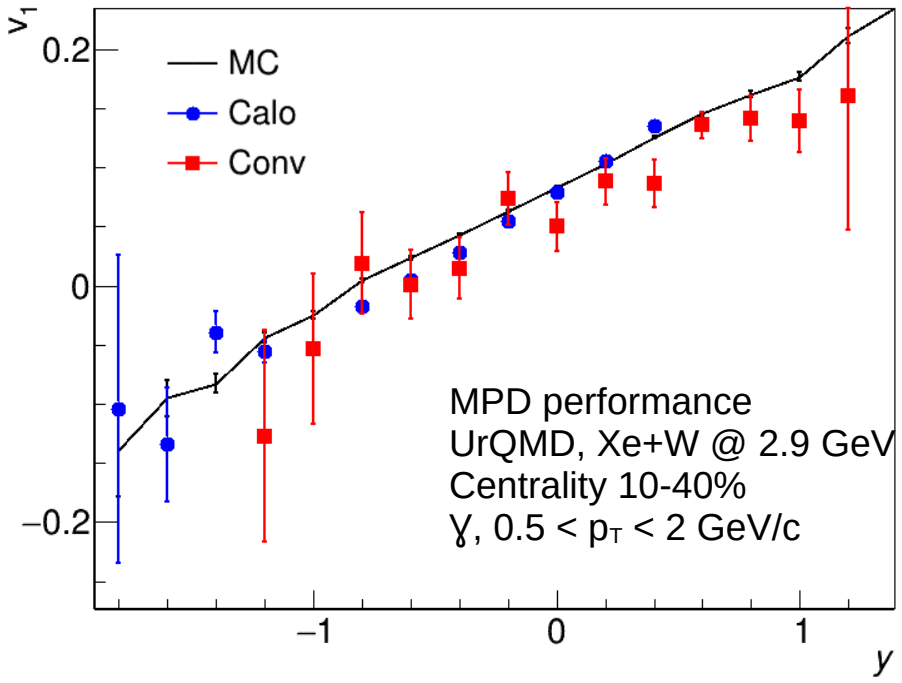
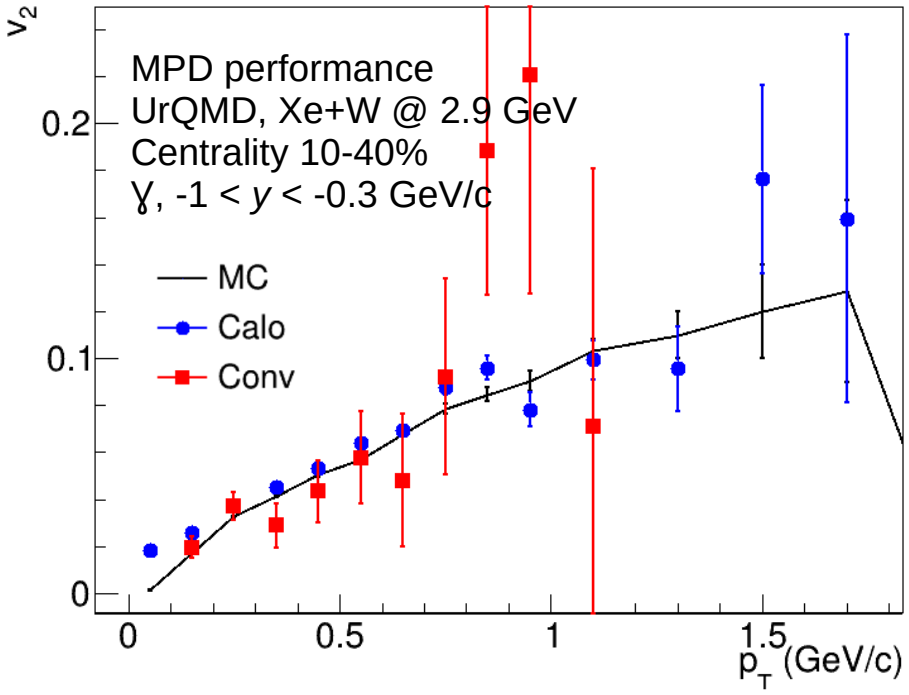
Flow of inclusive photons

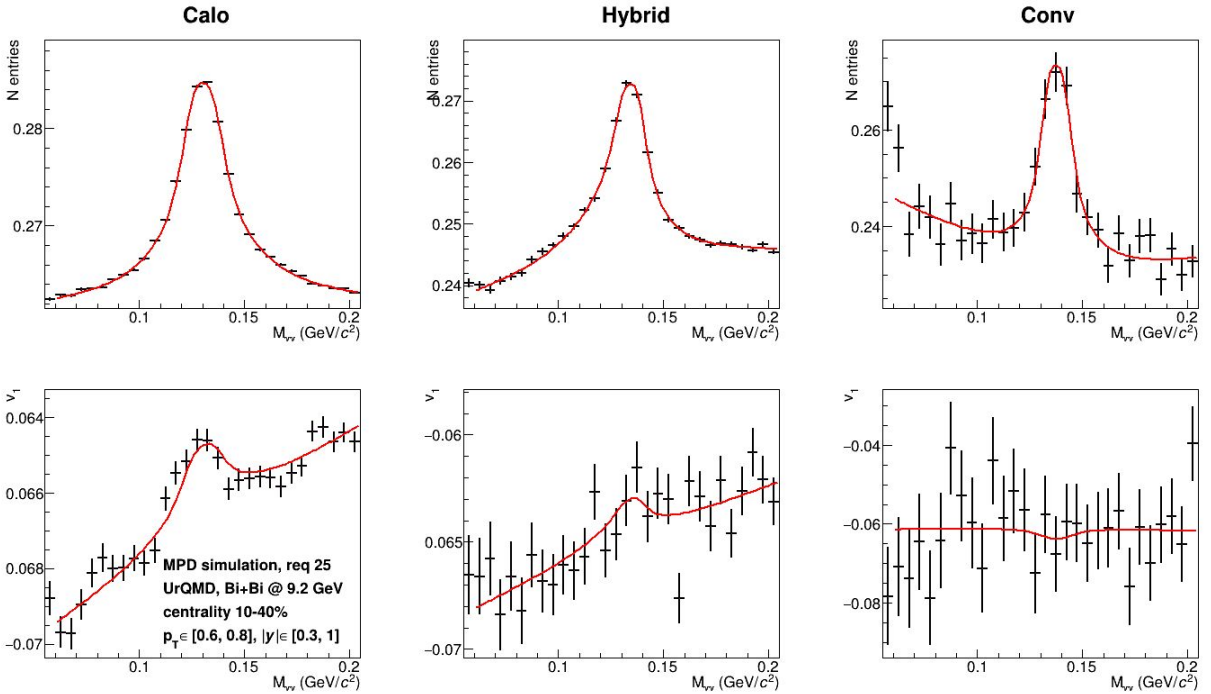




- Good agreement with the generator values for both methods
- Methods complement one another in rapidity coverage

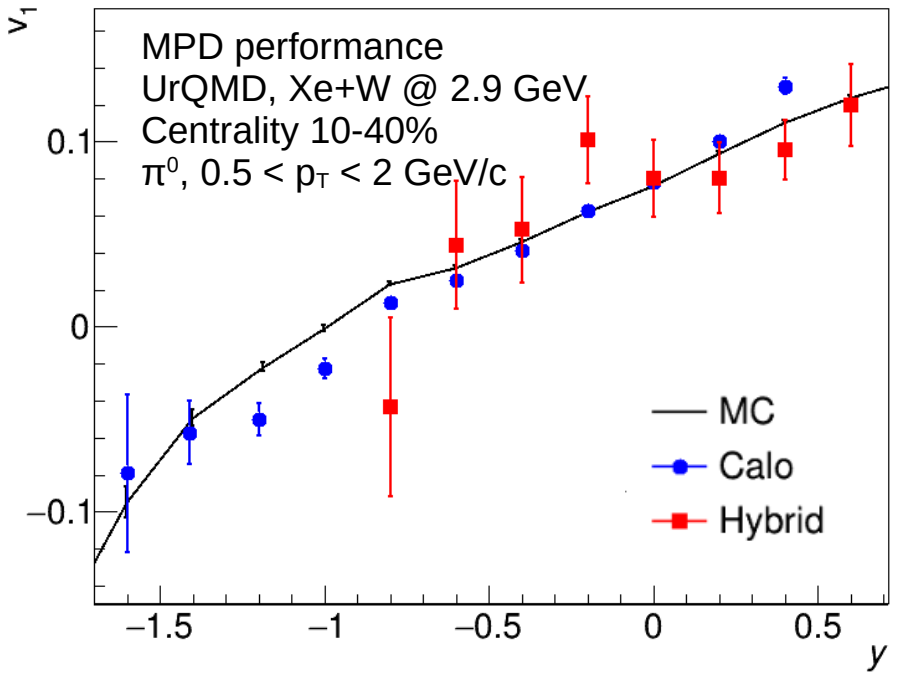
Measurement of neutral pion flow

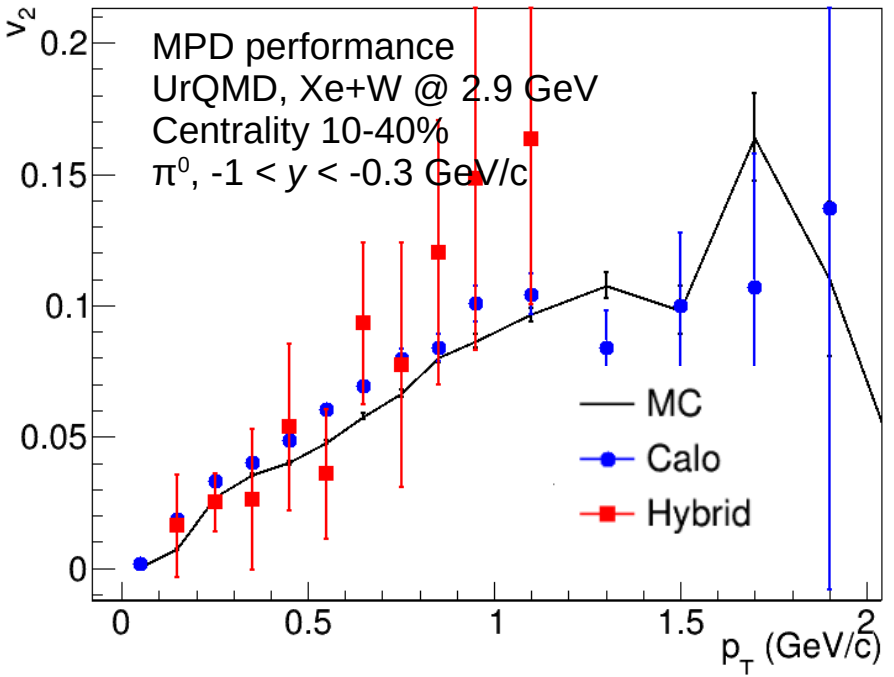
- Fit of v_n dependence on photon pair invariant mass with the function below
- v_{sig} and v_{bg} are free parameters, n_{sig} and n_{bg} are defined by fitting photon pair invariant mass distribution with double-sided Crystall Ball function + second order polynomial
- Conversion method is not accessible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





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

Conclusion

- Differential measurement of spectra, directed and elliptic flow of inclusive photons and neutral pions should be feasible with the MPD @ NICA in fixed-target mode

- Cross check of the measurements with hybrid and calorimeter methods will be possible with reasonable statistics. Methods complement one another in rapidity coverage.

- 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.

Nearest plans:

- Optimize cluster and e^+e^- pair selection for FXT mode
- Try TOF veto to remove additional invariant mass peak at lower p_T
- Optimize invariant mass spectra fits
- Use reconstructed symmetry plane in flow analysis