Current status of the global polarization analysis at MPD

Elizaveta Nazarova[1]

MPD Polarization Meeting
«Vorticity and Polarization in Heavy-Ion Collisions»

14.09.2021

[1] Joint Institute of Nuclear Research, Dubna, Russia

Outline

- Determination of EP angle & EP resolution
- Comparison of UrQMD, PHQMD & PHSD
- Global polarization measurement
- Outlook

Outline

- Main Dataset: MC simulation using PHSD generator
  - Au-Au @ 7.7GeV, 1.4M MB events, b [0,16]fm
  - Global $\Lambda(\bar{\Lambda})$ polarization
    - Thermodynamical (Becattini) approach
- Datasets for comparison:
  - UrQMD Au-Au @ 7.7GeV, 1.4M MB events (request 9), b [0,16]fm
  - PHQMD Au-Au @ 7.7GeV, ~400k MB events, b [0,12]fm

Event plane determination

- Event plane angle can be measured as:
  - $\Psi_{\mathrm{EP}}^{n} = \frac{1}{n} \arctan \frac{Q_y}{Q_x}$
  - $Q_y = \Sigma_i \mathrm{w}_i \sin(n\phi_i)$
  - $Q_x = \Sigma_i \mathrm{w}_i \cos(n\phi_i)$

$$\mathrm{w}_i = \begin{cases} -E_i,\ -p_{\mathrm{T}i} & \text{if } \eta < 0 \\ E_i,\ p_{\mathrm{T}i} & \text{if } \eta > 0 \end{cases}$$

«-» appears only for 1st-order EP!

- Respectively, within the flow group implementation:
  - $\mathrm{w}_i = E_i / E_{\mathrm{total}}$ (for the TPC Event plane)
  - $\mathrm{w}_i = p_{\mathrm{T}i} / p_{\mathrm{T}\mathrm{total}}$ (for the FHCal Event plane)

- Event plane resolution can be calculated as:
  - $R_{\mathrm{EP}}^{1} = \left\langle \cos(n(\Psi_{\mathrm{EP}}^{1} - \Psi_{\mathrm{RP}})) \right\rangle$ (w.r.t. reaction plane angle from the model)
  - $R_{\mathrm{EP}}^{1} = \left\langle \cos(n(\Psi_{\mathrm{EP,R}}^{1} - \Psi_{\mathrm{EP,L}}^{1})) \right\rangle$ (sub-event resolution method[1])

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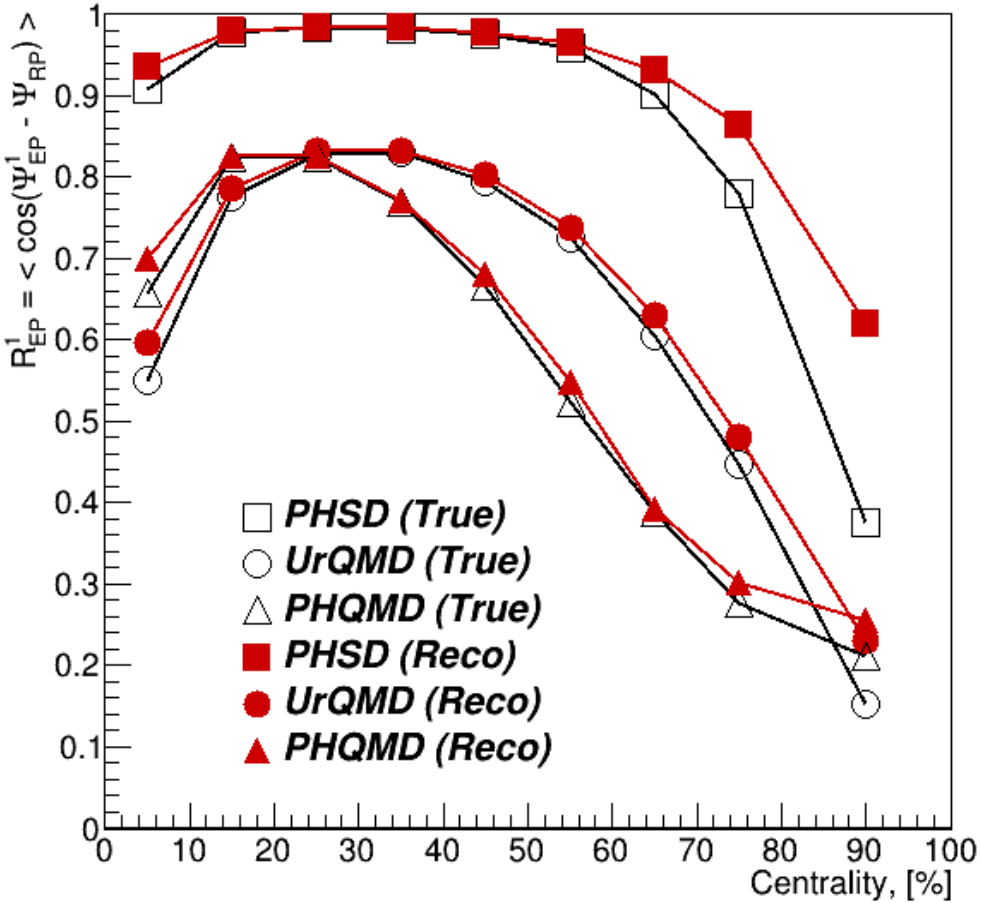
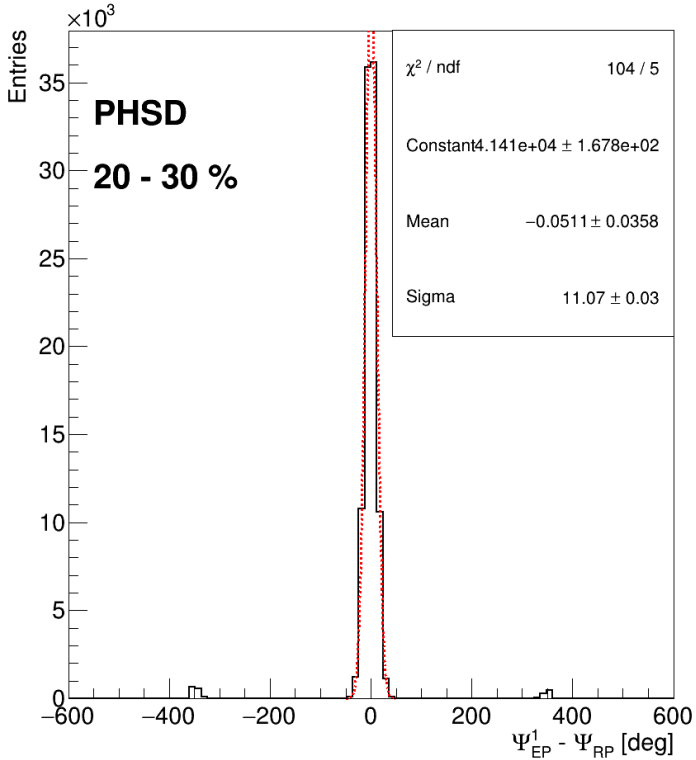
[1] A. M. Poskanzer , S. Voloshin Phys.Rev. C (1998) 58. pp. 1671–1678

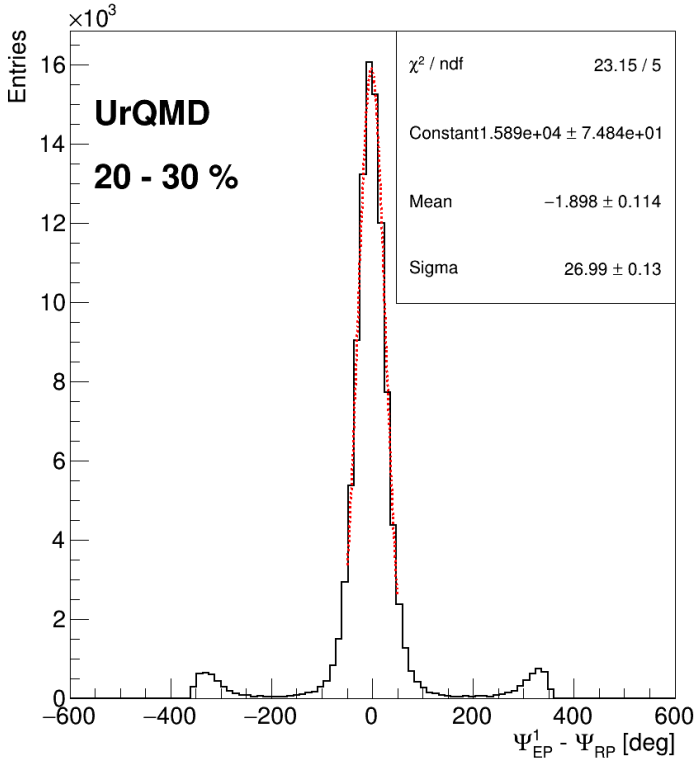
Event plane determination



- Comparison of the UrQMD, PHQMD & PHSD models
  - Much lower statistics in the PHQMD sample
  - 1-order EP resolution is similar for UrQMD and PHQMD
  - Feature of the PHQMD model: reaction plane is shifted by 180deg → need to account for the shift in the calculations

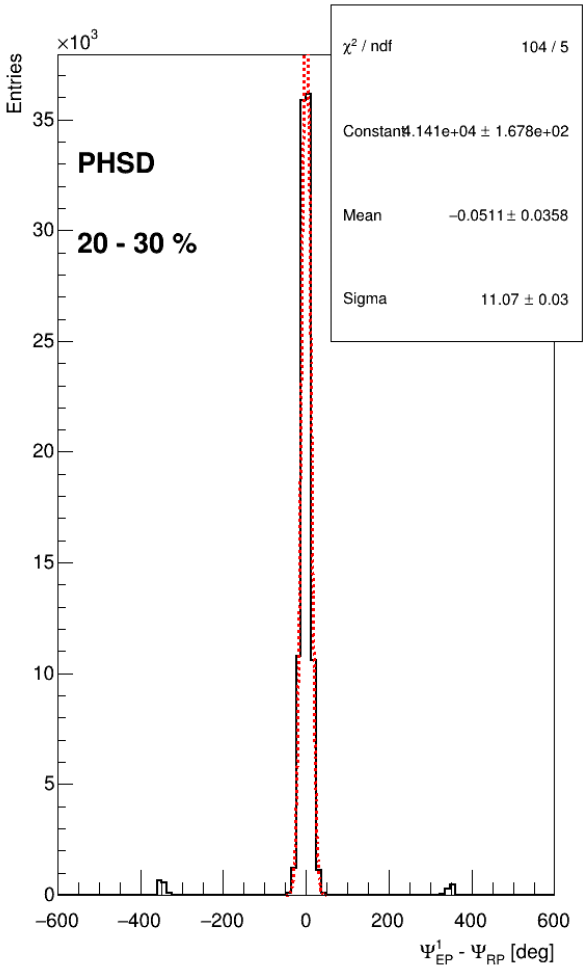
Event plane determination

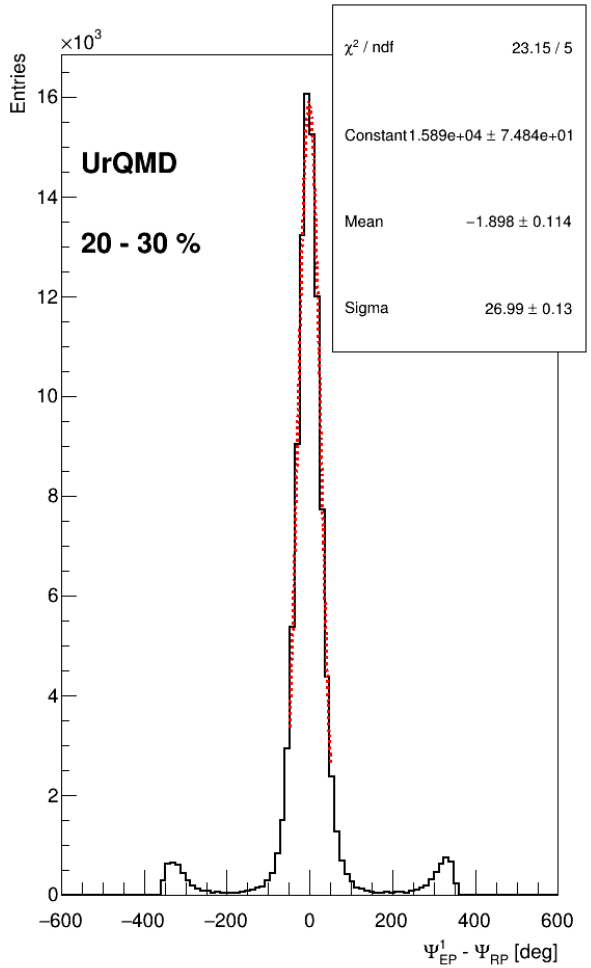


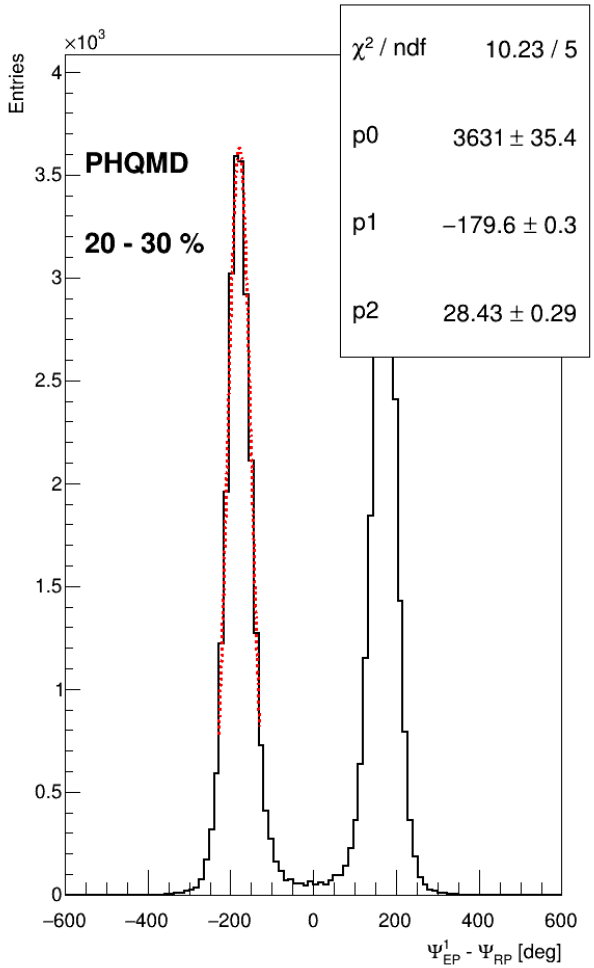


- Difference between EP and RP angles
  - Gaussian fit
  - Resolution of ~ 27 deg. for UrQMD and ~ 11 deg. for PHSD
  - Centered at 0

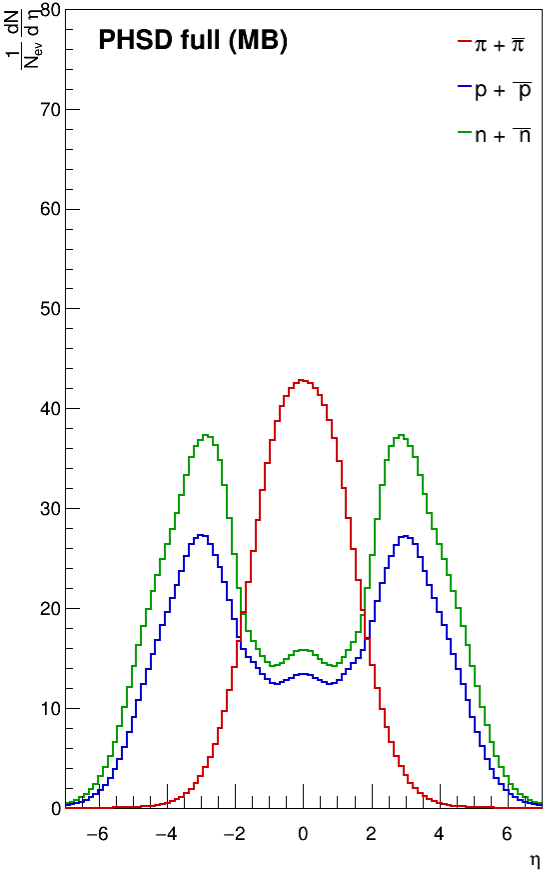
Event plane determination

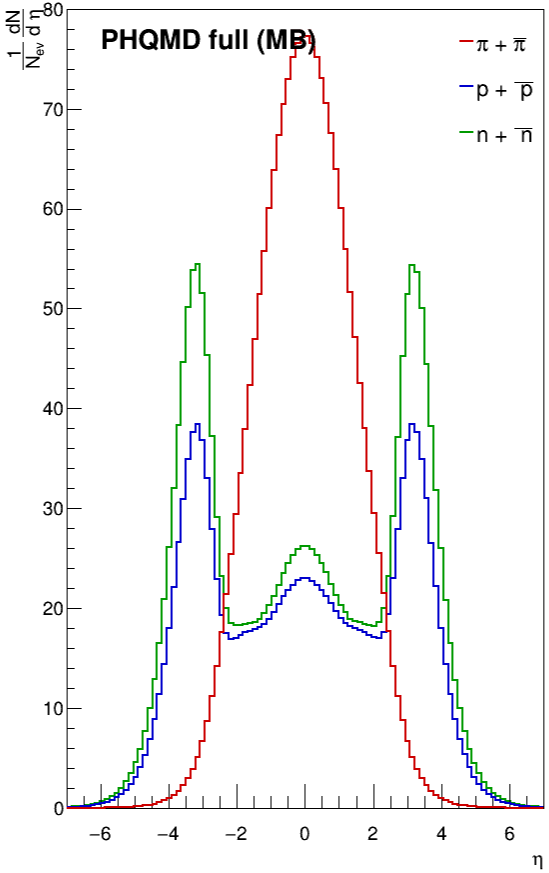


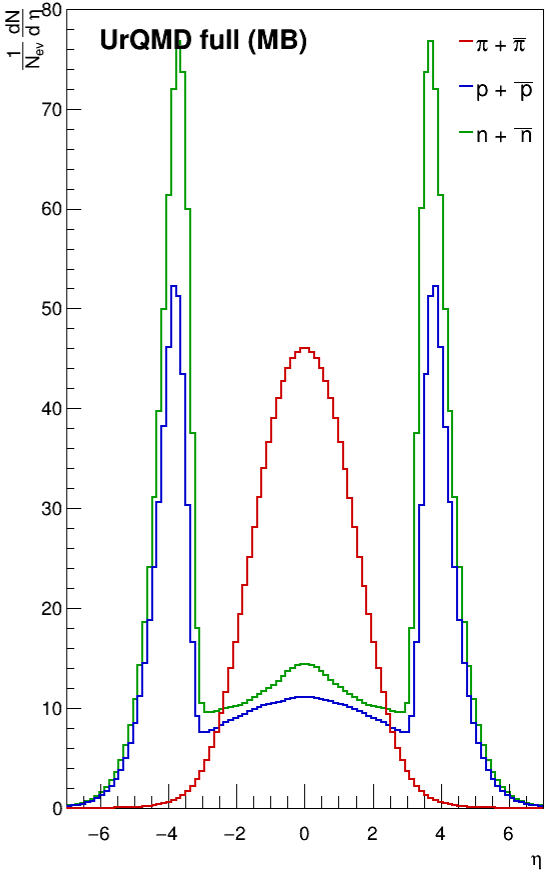




Pseudorapidity distributions



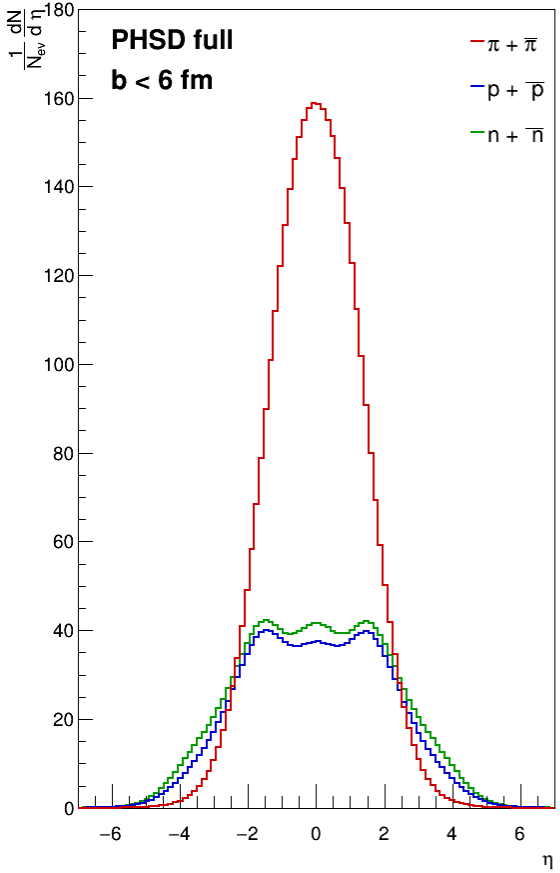


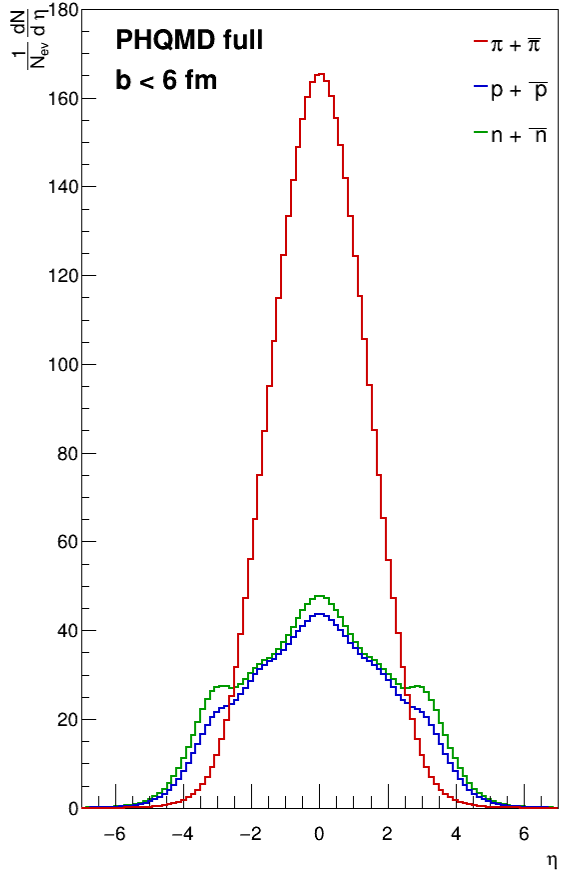


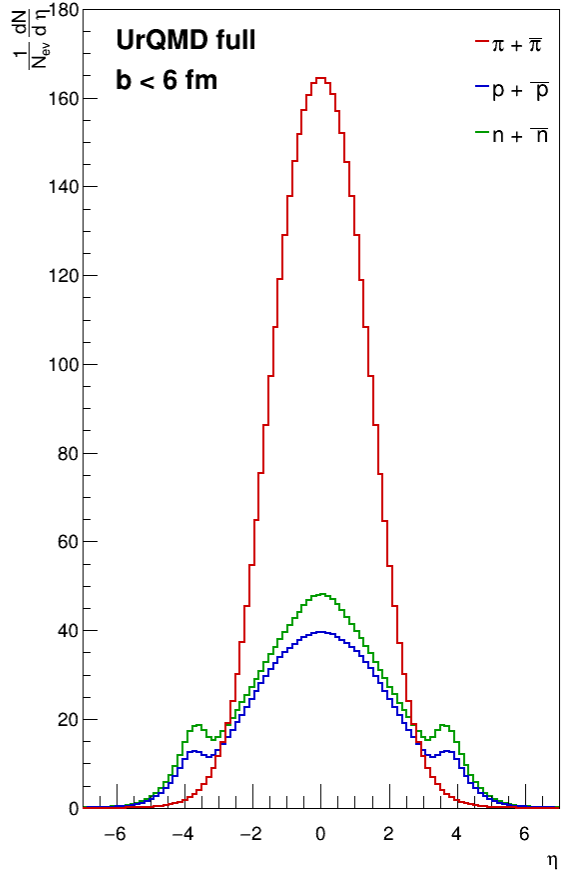
$2 < |\eta| < 5$ region corresponds to FHCal

Vertex cut of 50cm

Pseudorapidity distributions







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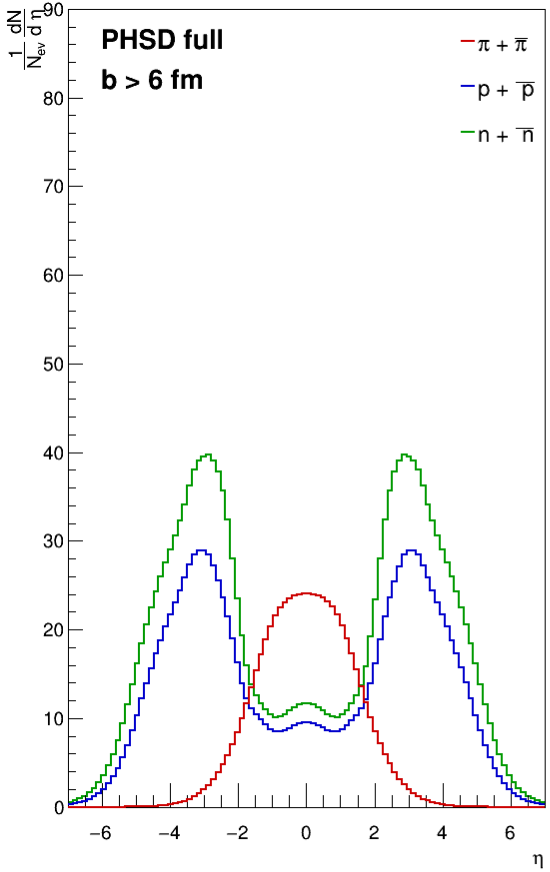
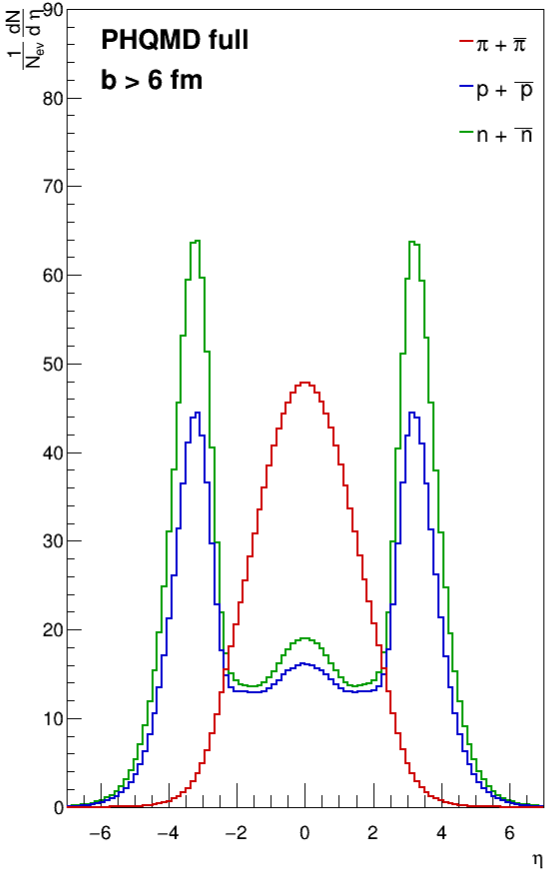
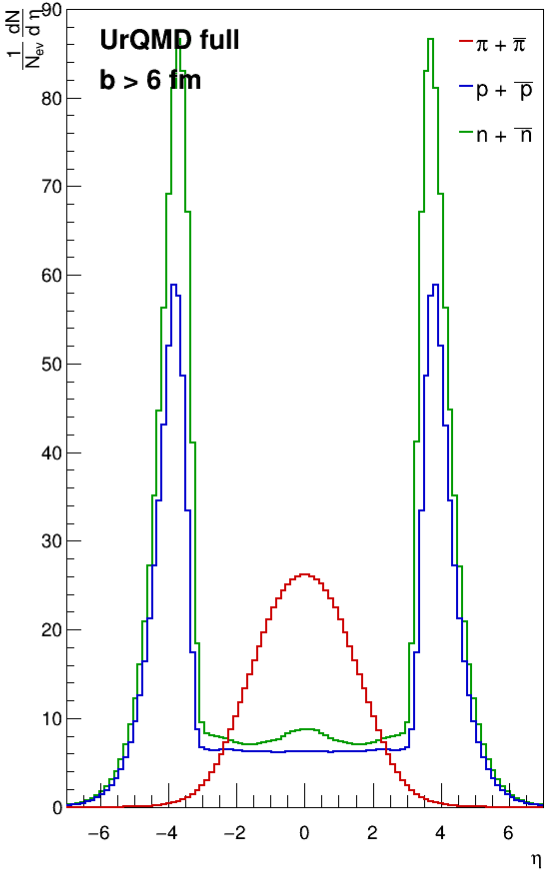
Pseudorapidity distributions



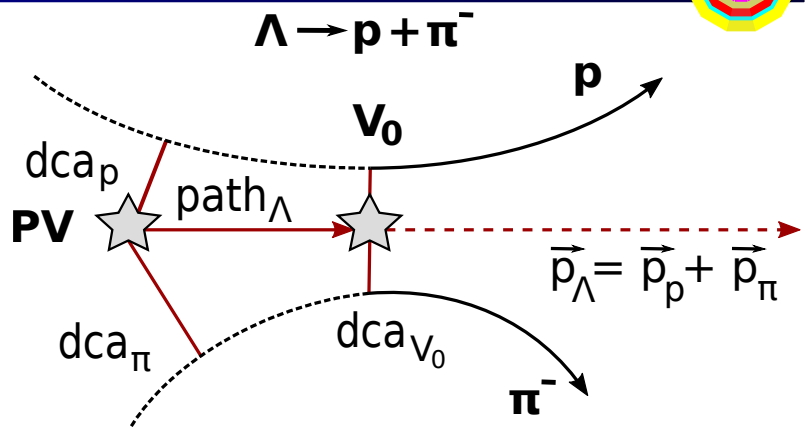




$2 < |\eta| < 5$ region corresponds to FHCal

Global polarization reconstruction

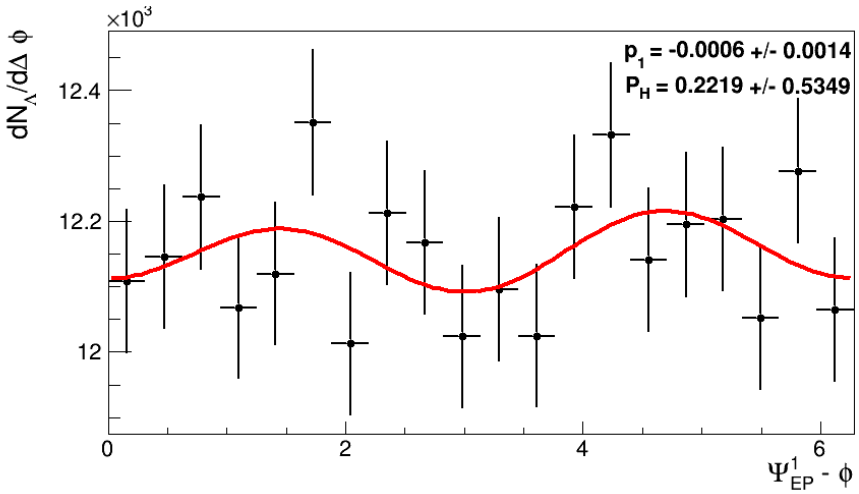
- Lambda reconstructed through the weak decay channel
  - Cut based on maximum significance in MB
  - Fit of background in sidebands
- Centrality estimated via the MC-Glauber technique
  - ~ 20% empty events
  - Analyzed 4 centrality intervals: 0-10%, 10-20%, 20-50%, 50-100%
- EP angle & its resolution determined through FHCal
- Event plane technique for global polarization measurement
  - Invariant mass distribution in bins of $\Delta\phi_p^* = \Psi_{\rm EP}^1 - \phi_p^*$
  - Net amount of Lambda in each bin
  - Distribution of $N_\Lambda(\Delta\phi_p^*)$
  - Fit of the distribution[1] to get $\langle \sin(\Delta\phi_p^*)\rangle$ → P_Λ

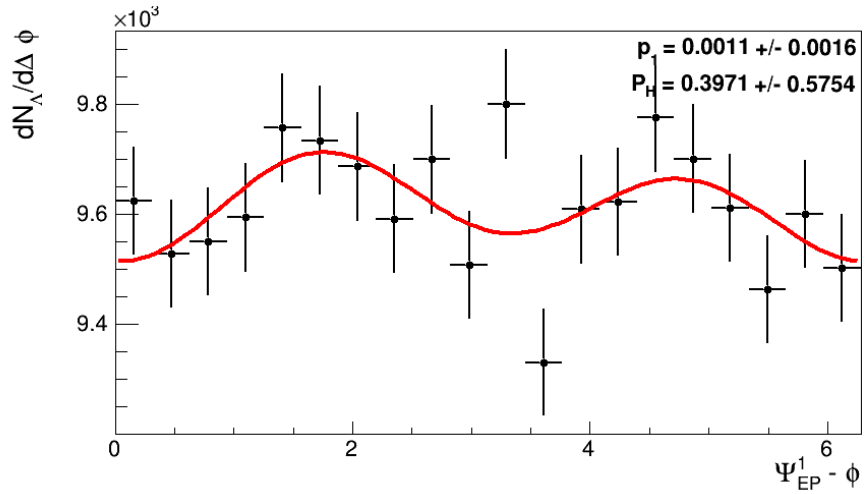


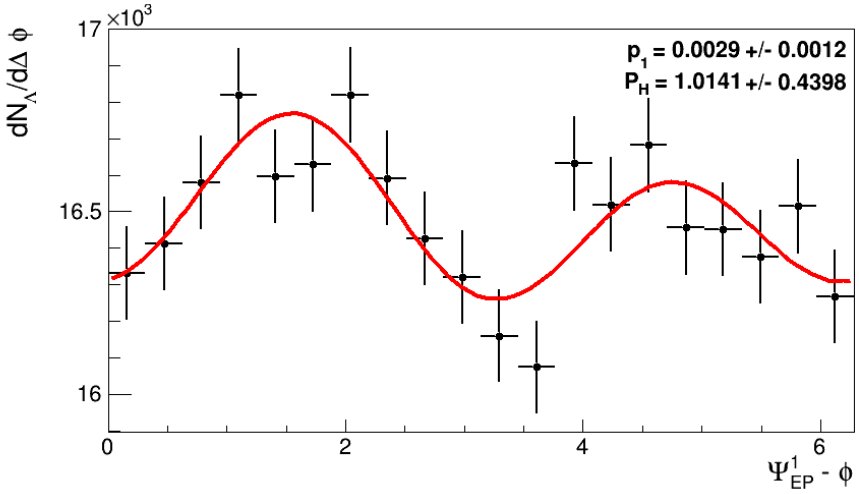
$$\overline{P}_{\Lambda/\bar{\Lambda}} = \frac{8}{\pi\alpha}\frac{1}{R_{\rm EP}^1}\left\langle \sin(\Psi_{\rm EP}^1 - \phi_p^*)\right\rangle$$

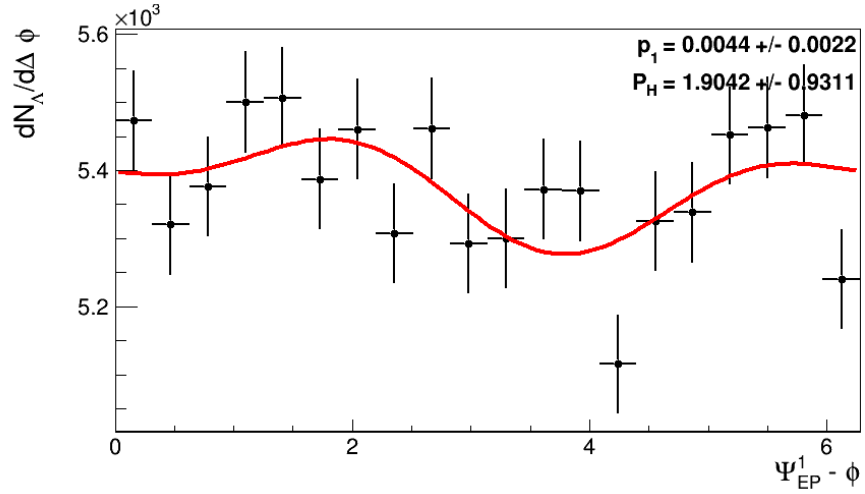
[1] $$\frac{{\rm d}N}{{\rm d}\Delta\phi_p^*} = [0](1 + 2[1]\sin(\Delta\phi_p^*) + 2[2]\cos(\Delta\phi_p^*) + 2[3]\sin(2\Delta\phi_p^*) + 2[4]\cos(2\Delta\phi_p^*) + ...)$$

Global polarization reconstruction

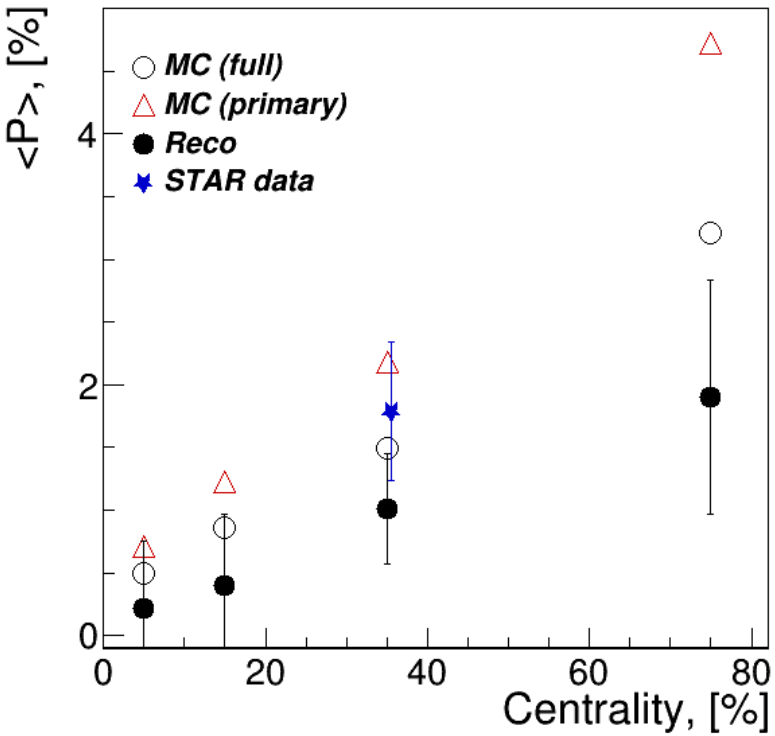


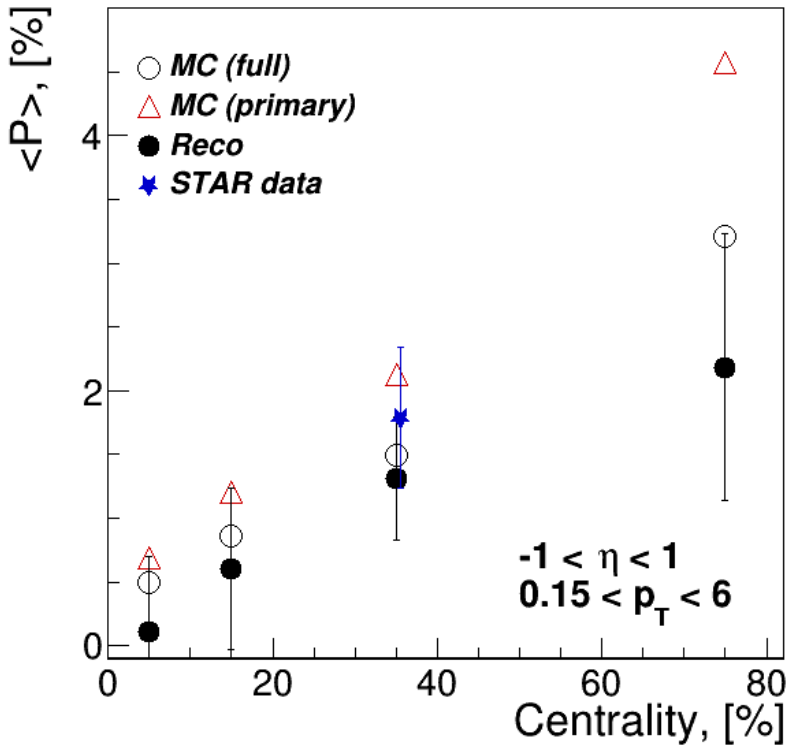






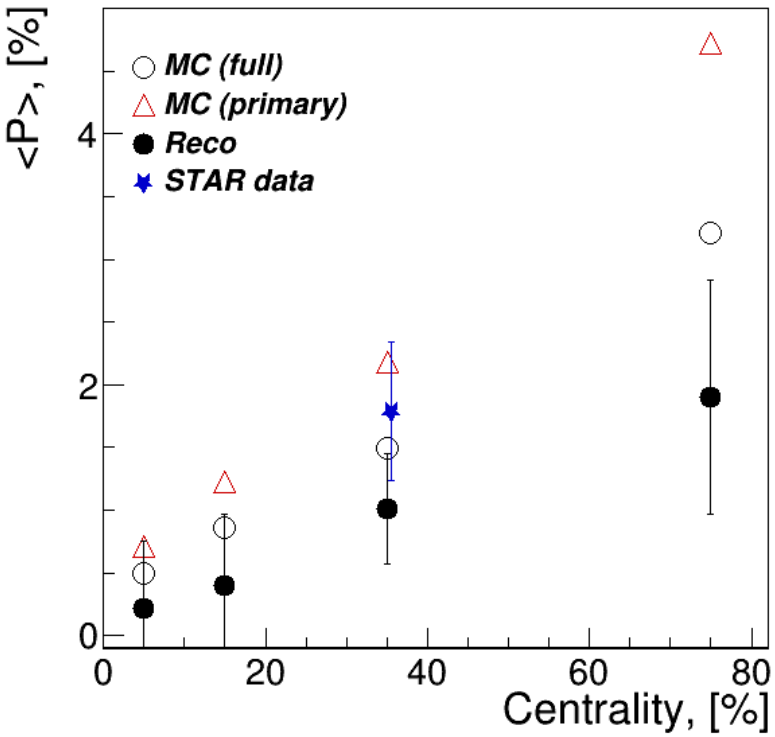
Global polarization reconstruction



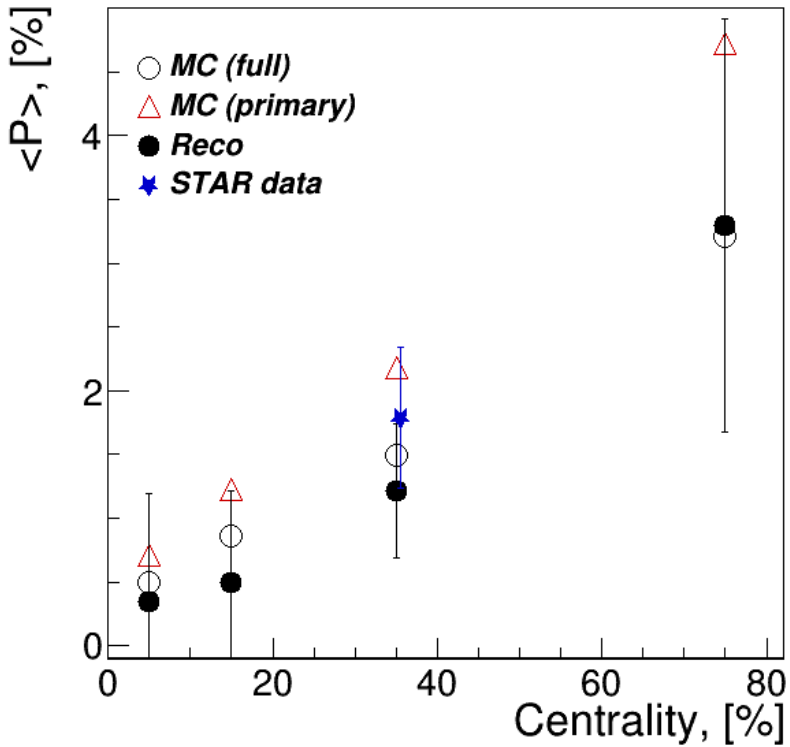


Accounted only for the statistical errors (of the fit)
For comparison STAR measurement is shown (corrected for the new value of decay asymmetry)

Global polarization reconstruction

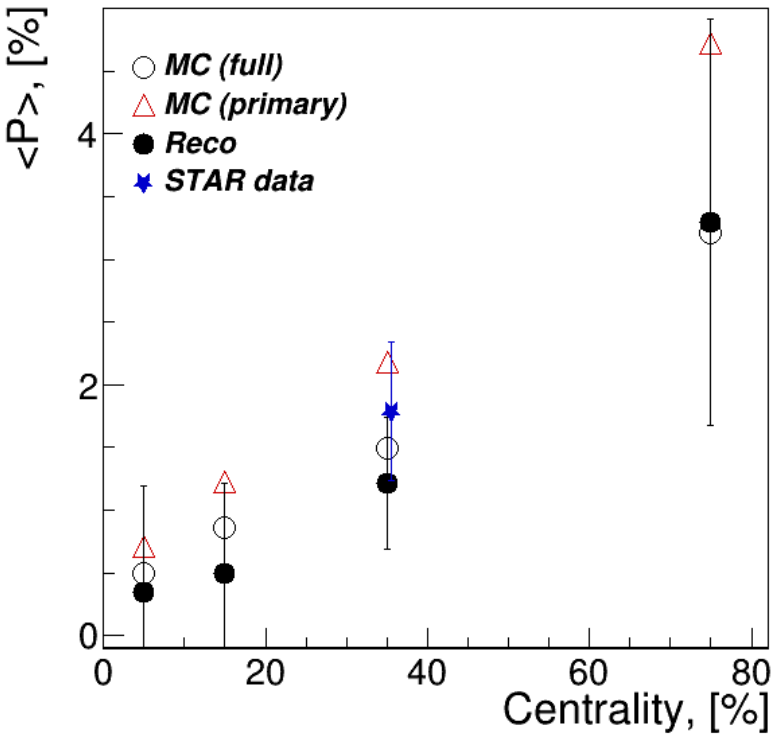


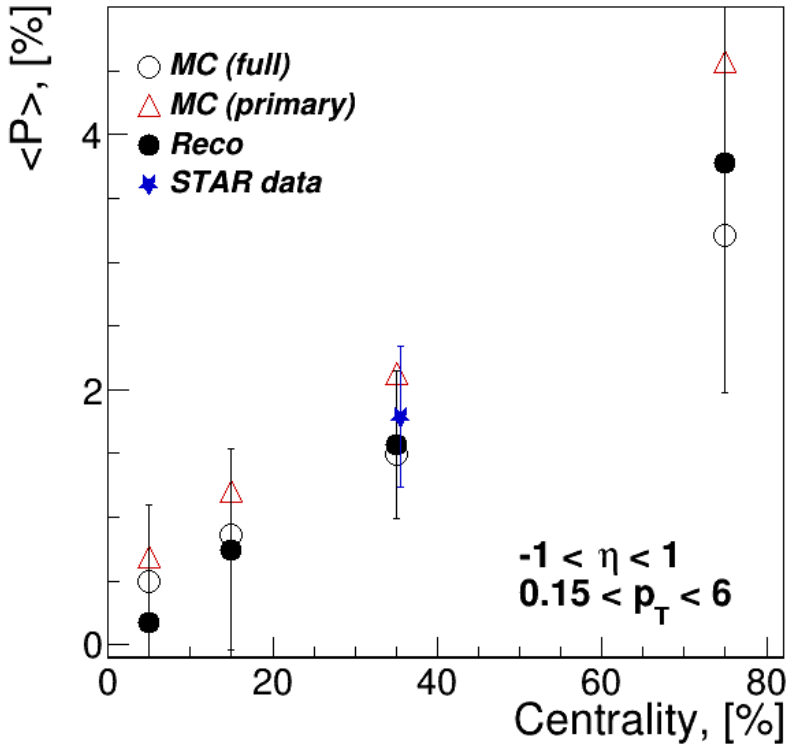
Using PHSD EP resolution values



Using UrQMD EP resolution values

Global polarization reconstruction





Using UrQMD EP resolution values

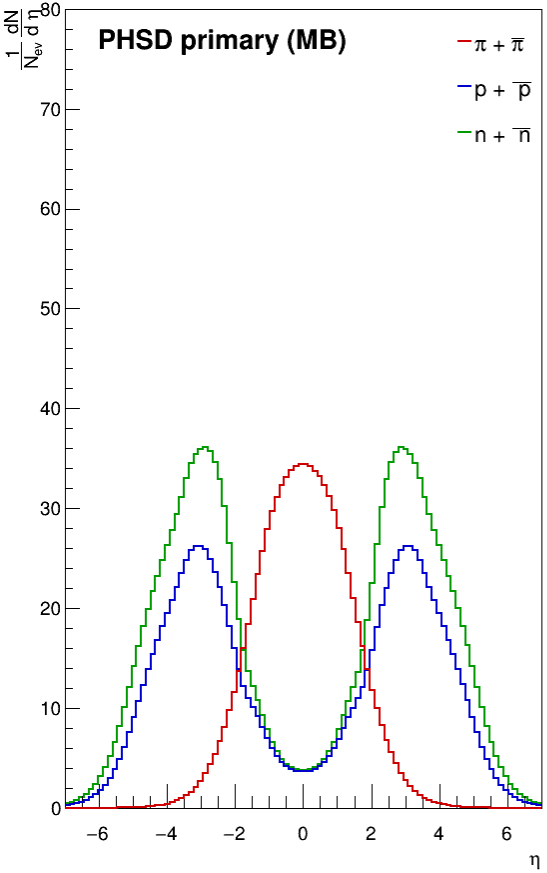
Summary

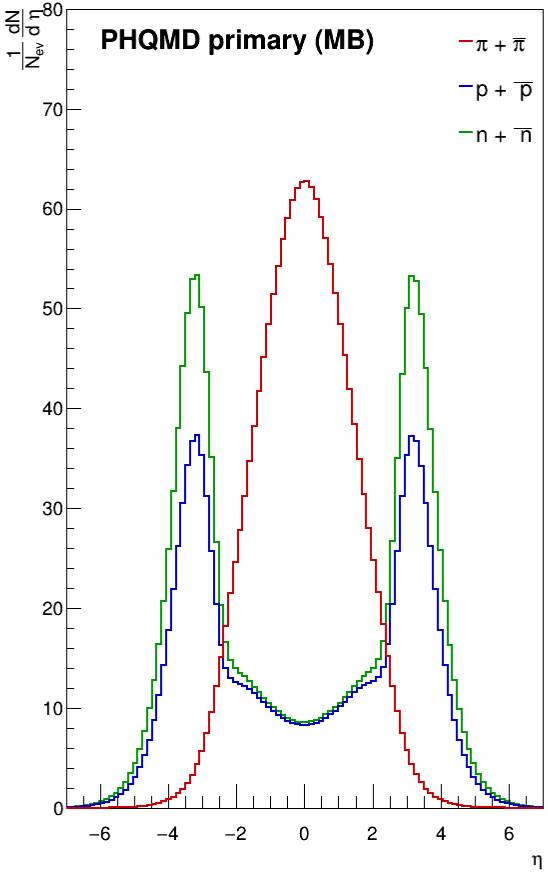
- Implemented transfer of polarization to secondary Lambda
- Realized event plane method for global polarization measurements
  - Need to resolve the question about EP resolution
- Event plane resolution comparison (PHSD vs UrQMD vs PHQMD)
  - Similar pseudorapidity distributions in the FHCal region for UrQMD and PHQMD
  - PHSD has large differences
- Outlook
  - Need to resolve the issue with spectators and EP in PHSD
  - Alternative method of global polarization measurements

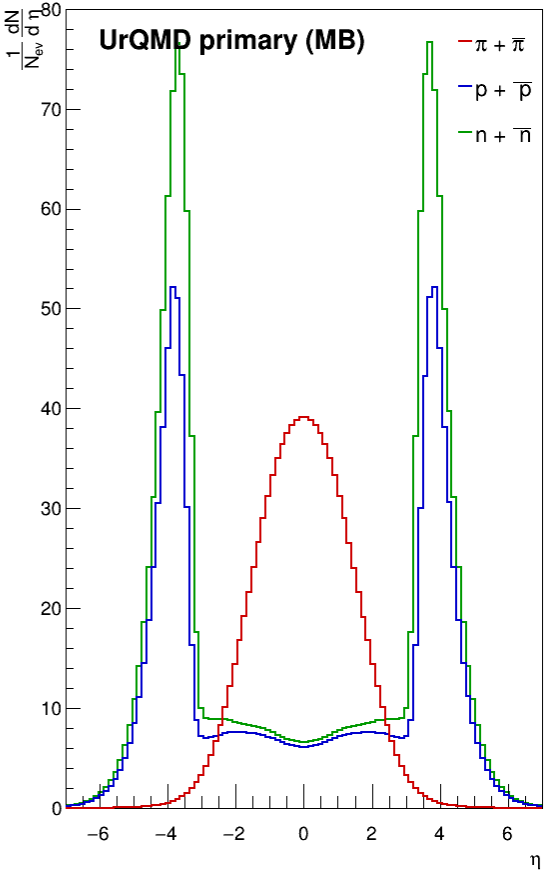
The End

Thank you for your attention!

Pseudorapidity distributions







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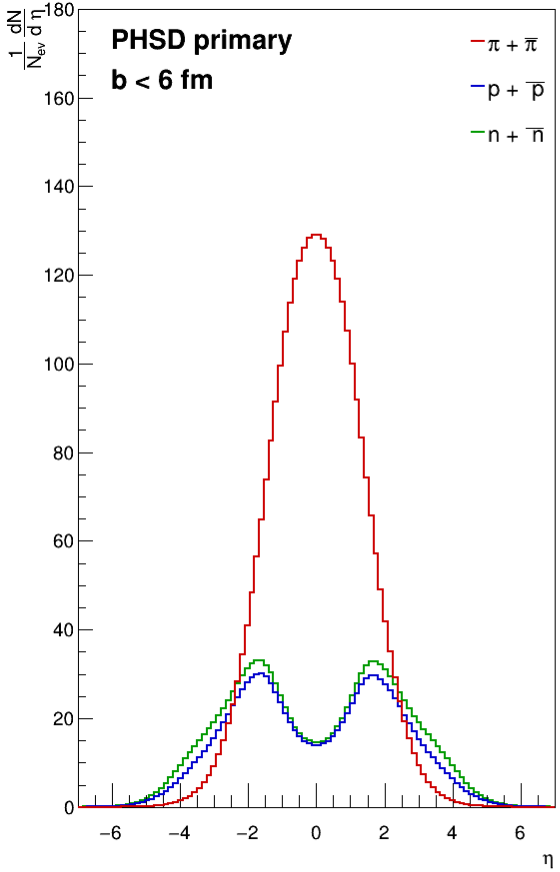
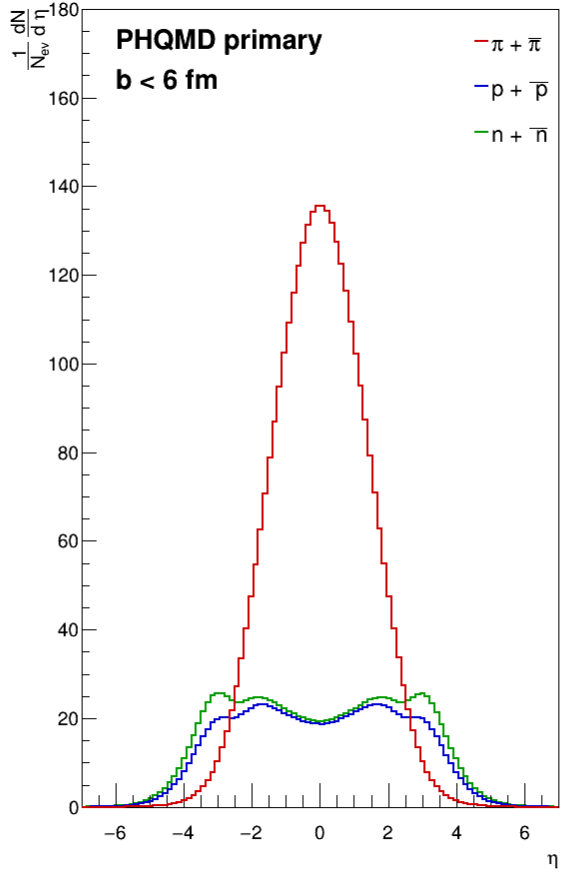
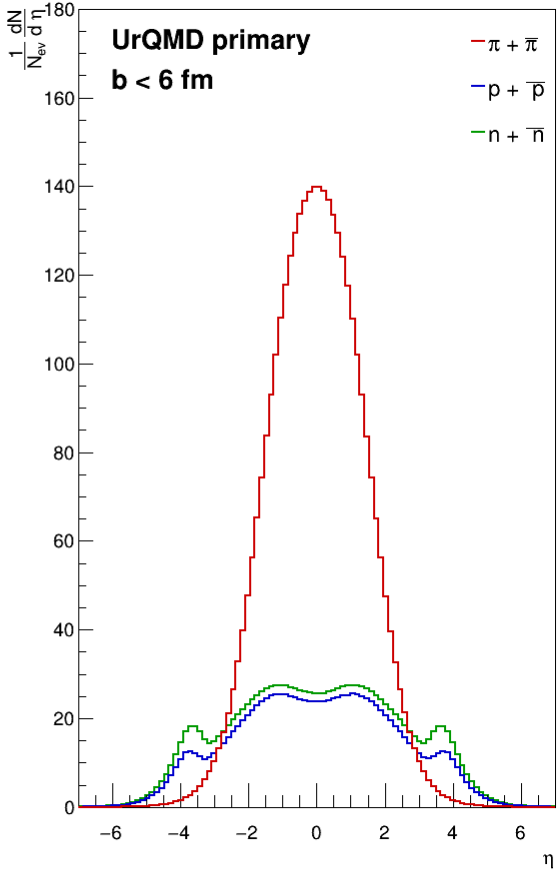
Pseudorapidity distributions







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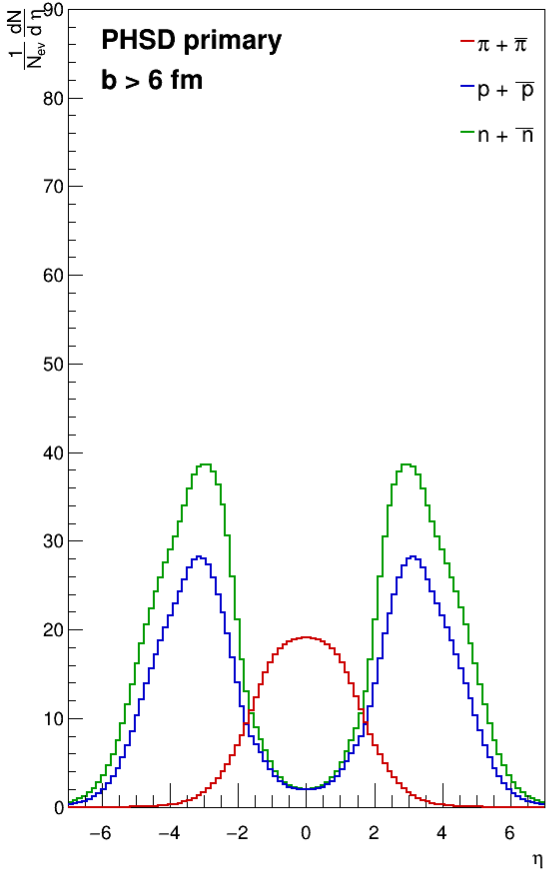
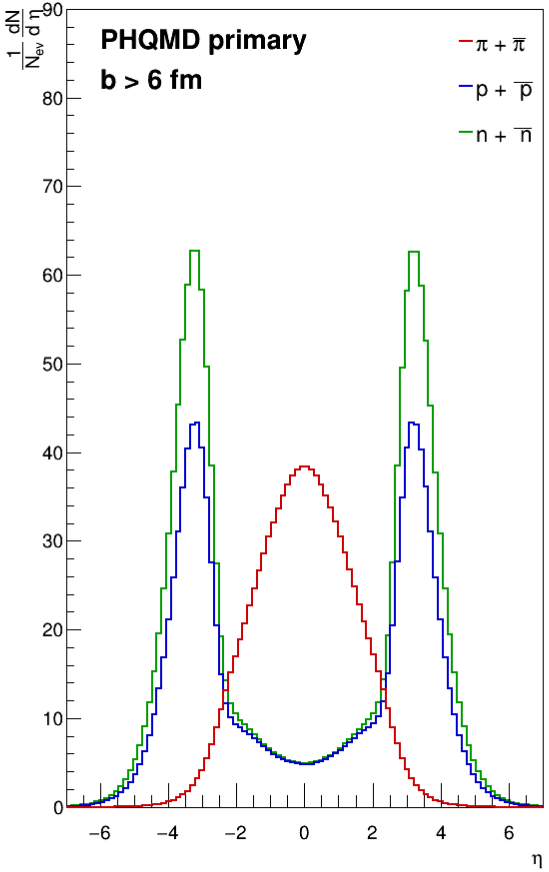
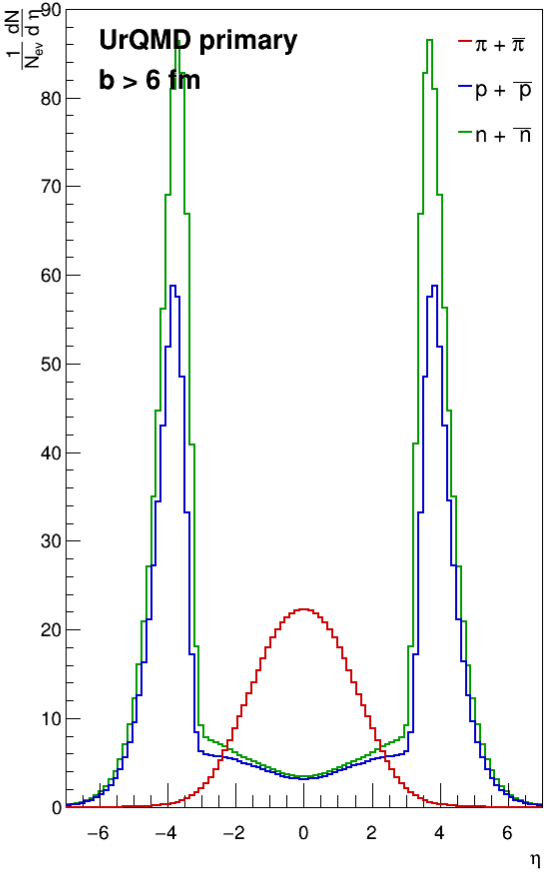
Pseudorapidity distributions







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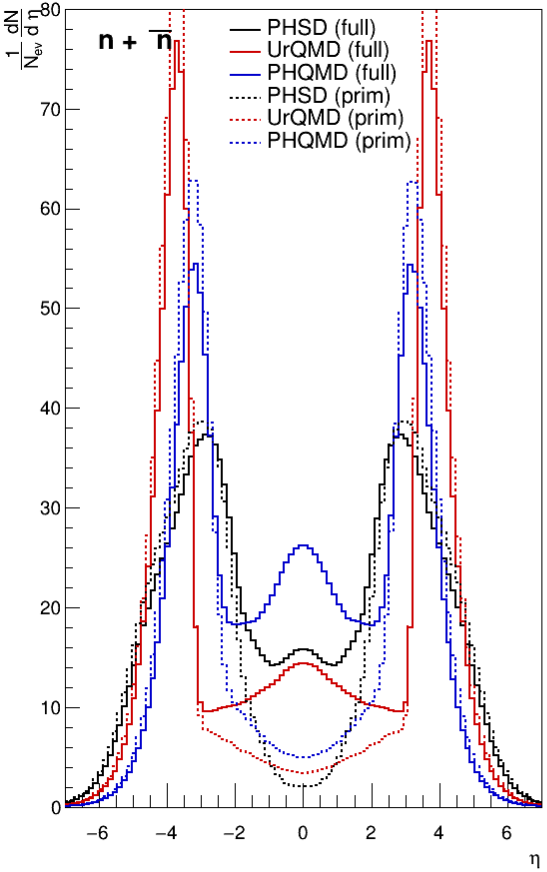
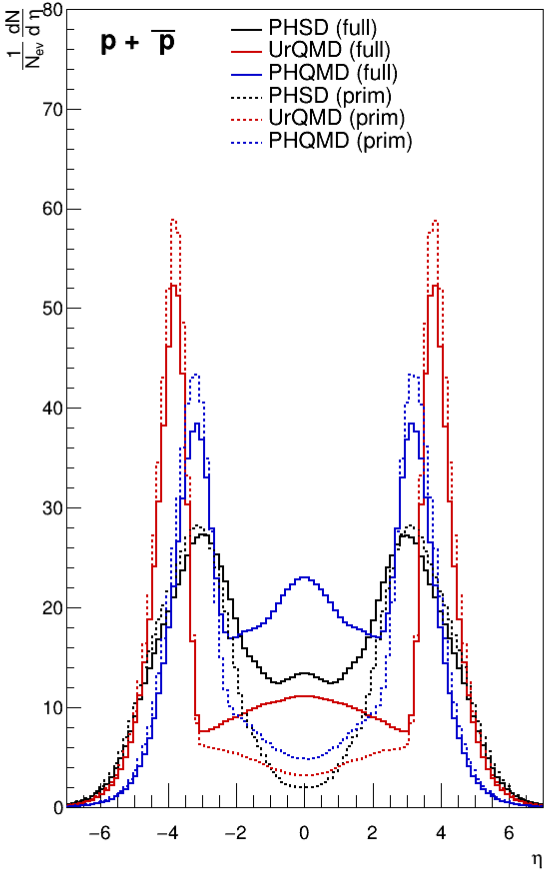
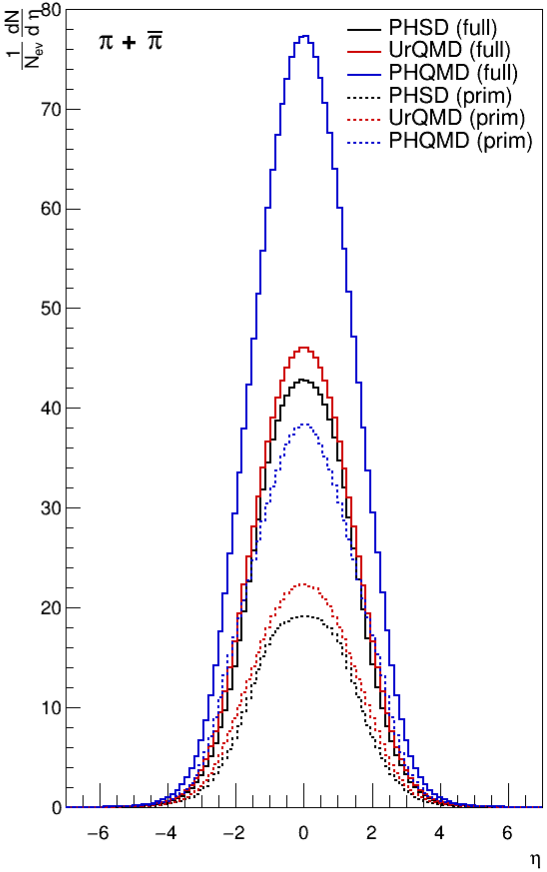
Pseudorapidity distributions







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Global polarization reconstruction