Progress on the study of global hyperon polarization at MPD

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

01.12.2020

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

Outline

- Dataset for the global polarization study
- Centrality determination
- Event Plane determination
- Outlook

Dataset

- Data: MC simulation using PHSD generator[1]
  - Au-Au, $\sqrt{s_{NN}} = 7.7$ GeV, ~1.5M MB events
  - Global $\Lambda(\bar{\Lambda})$ polarization
    - Thermodynamical (Becattini) approach[2]
- Track selection criteria for reconstruction:
  - Number of TPC hits: $N_{hits} > 10$
  - $|\eta|<1.3$

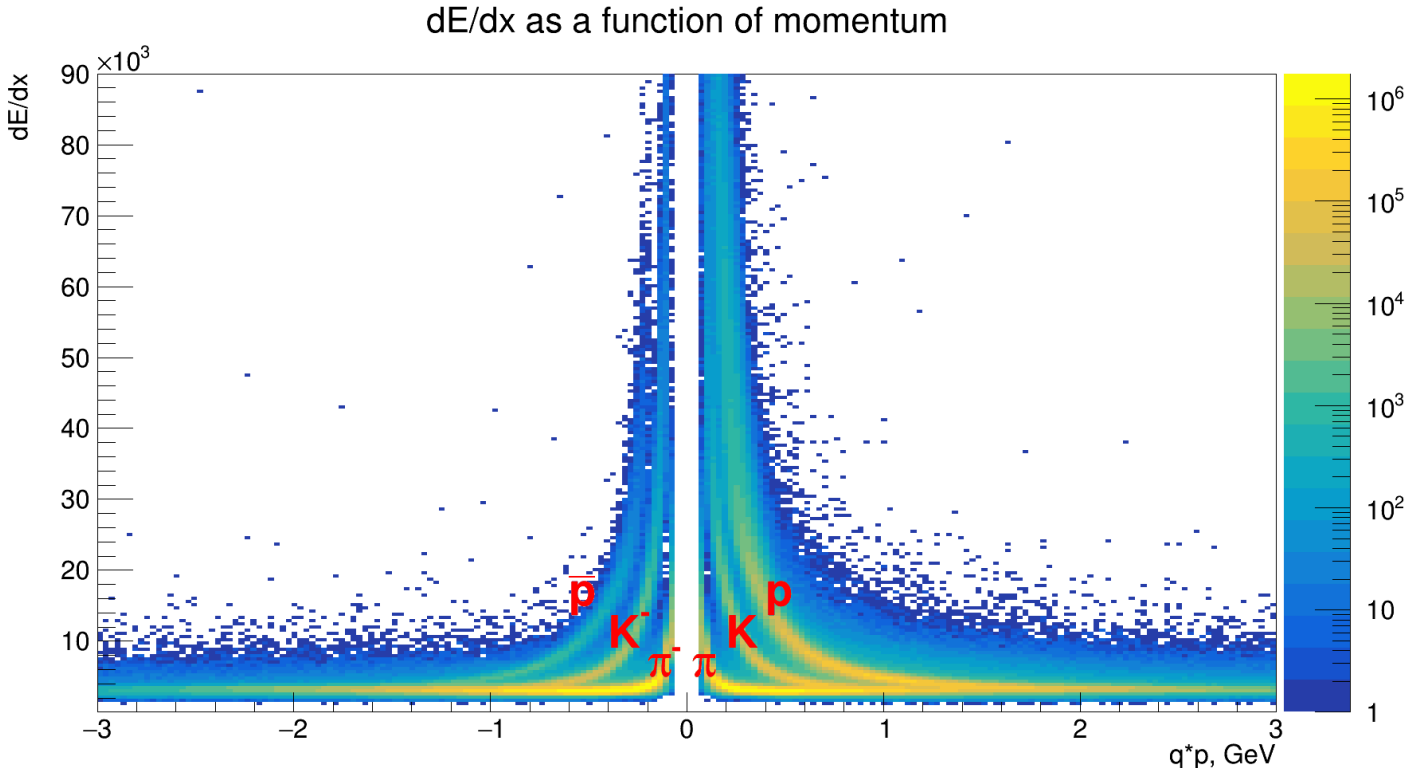
$$\overline{P}_{\Lambda/\bar{\Lambda}} = \frac{8}{\pi\alpha}\frac{1}{R^1_{\mathrm{EP}}}\left\langle \sin(\Psi^1_{\mathrm{EP}} - \phi^*_p)\right\rangle$$

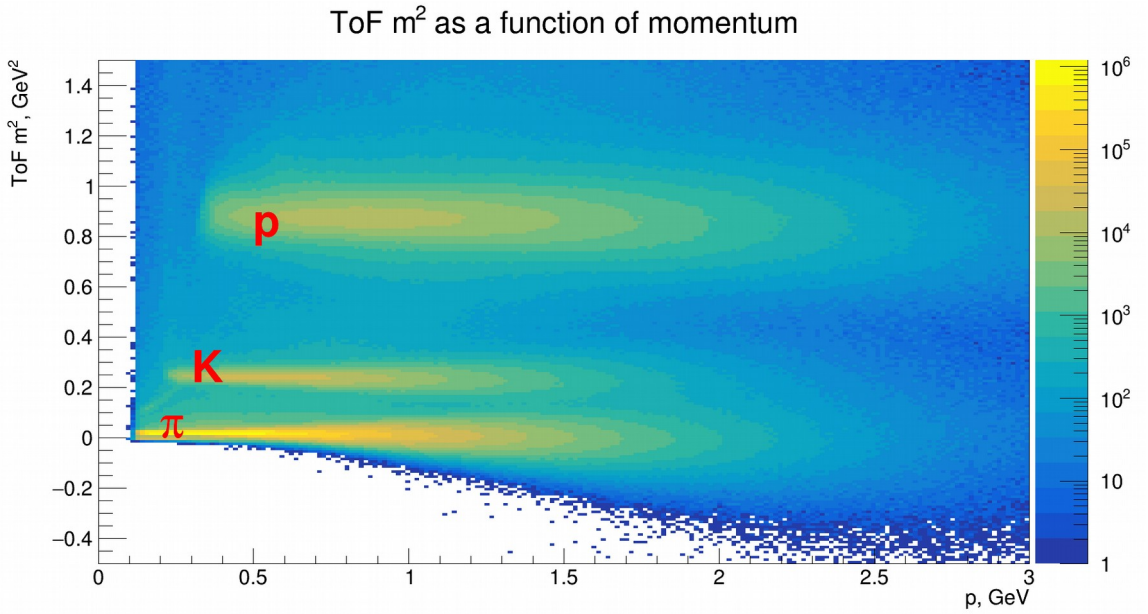
→ Need to calculate: Ψ^1_{EP} and R^1_{EP}

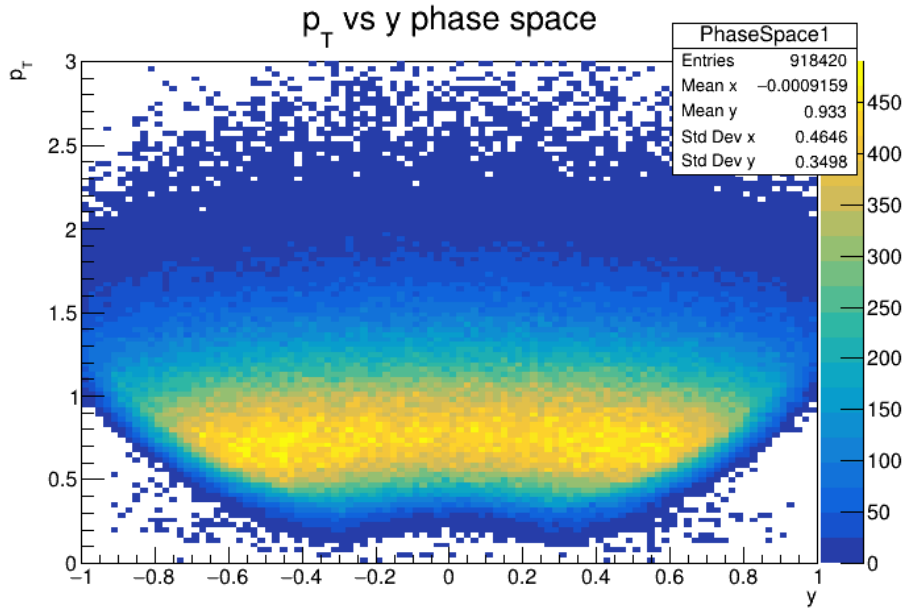
[1] W. Cassing, E. Bratkovskaya, PRC 78 (2008) 034919; NPA831 (2009) 215; W. Cassing, EPJ ST 168 (2009) 3

[2] F. Becattini, V. Chandra, L. Del Zanna, E. Grossi, Ann. Phys. 338 (2013) 32

PID performance for the dataset

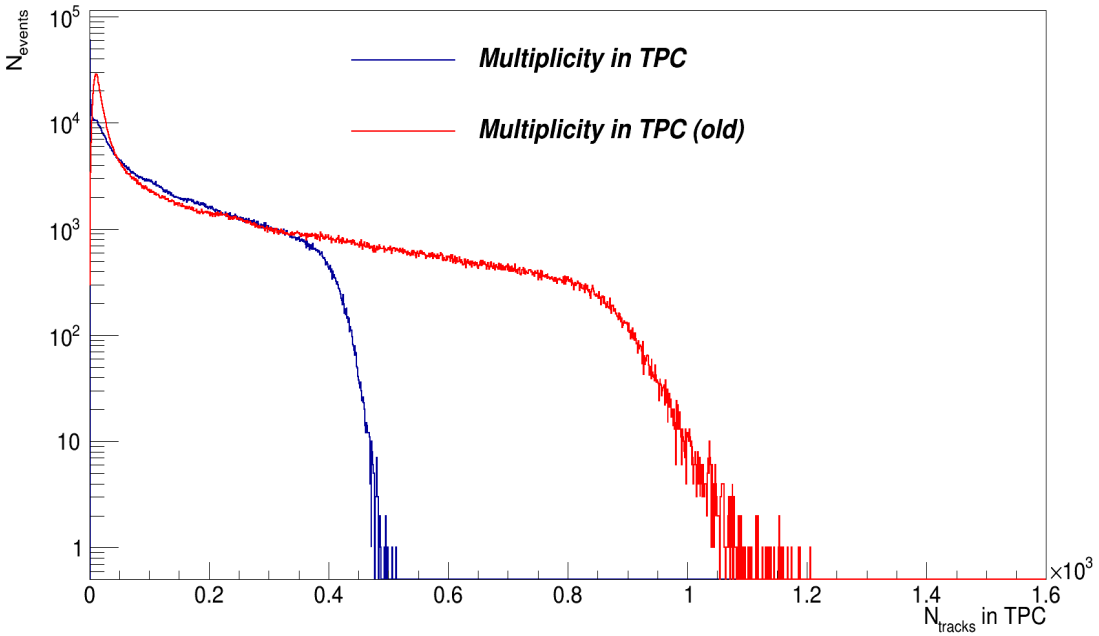






Centrality determination (TPC)

- Adapting the technique developed in the flow group
  - https://git.jinr.ru/nica/mpdroot/-/tree/dev/macro/physical_analysis/Flow
- Centrality determination through TPC:
  - $|\eta|<1.5$
  - $0 < p_T < 3$
  - DCA calibrations
  - Track multiplicity in TPC → centrality of the event



Division into 10-% centrality intervals

- 0 - 10 %
- 10 - 20 %
- 20 - 30 %
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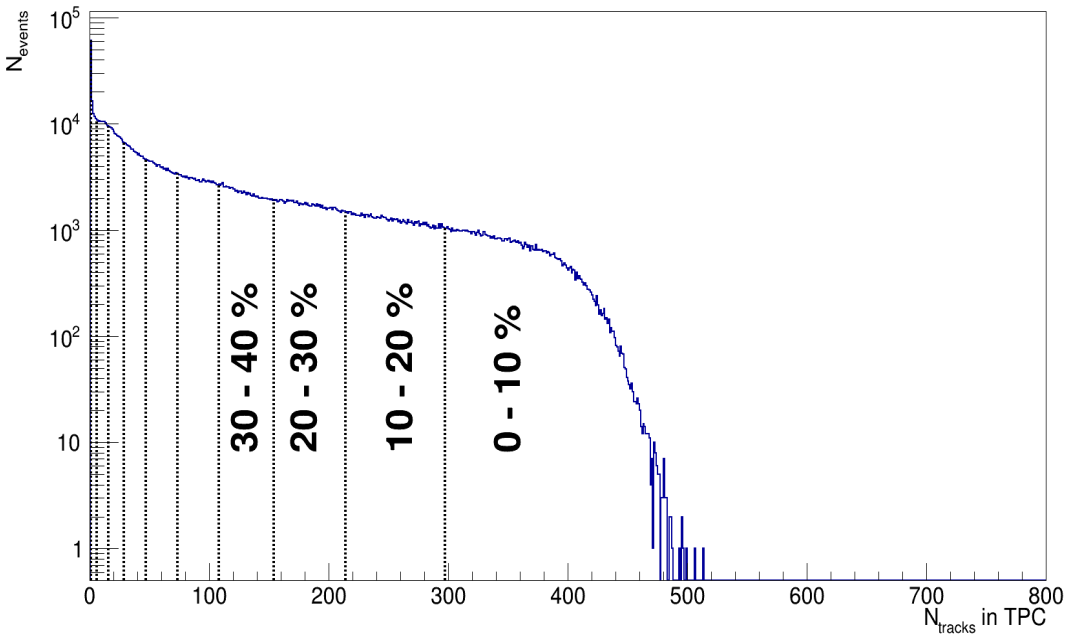
Event with multiplicity $N_{tr} \pm \sigma_N$ have impact parameter in range of $b \pm \sigma_b$



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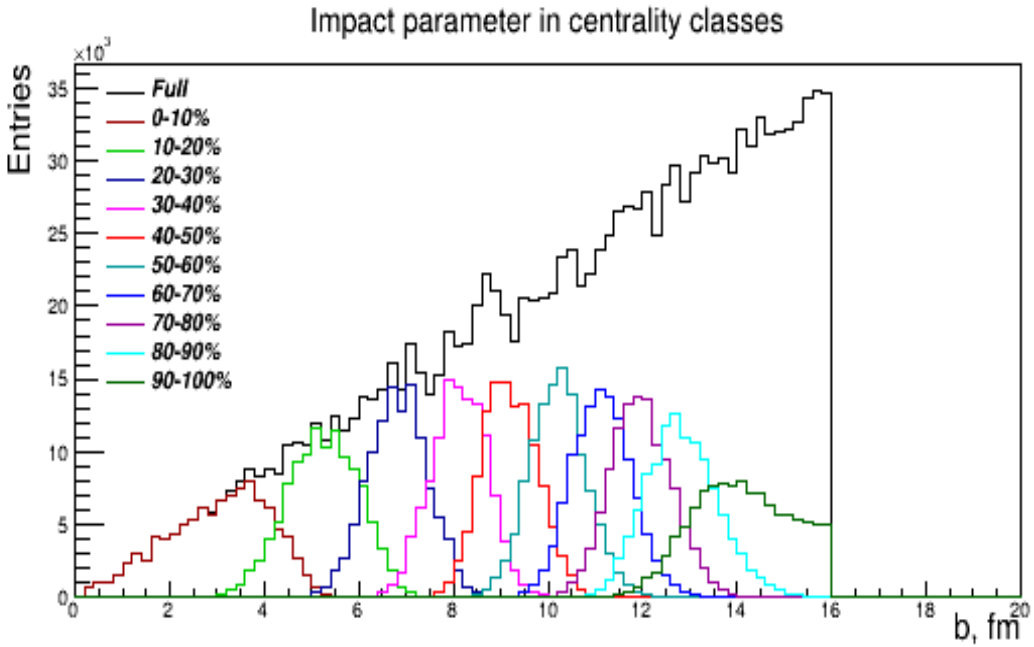

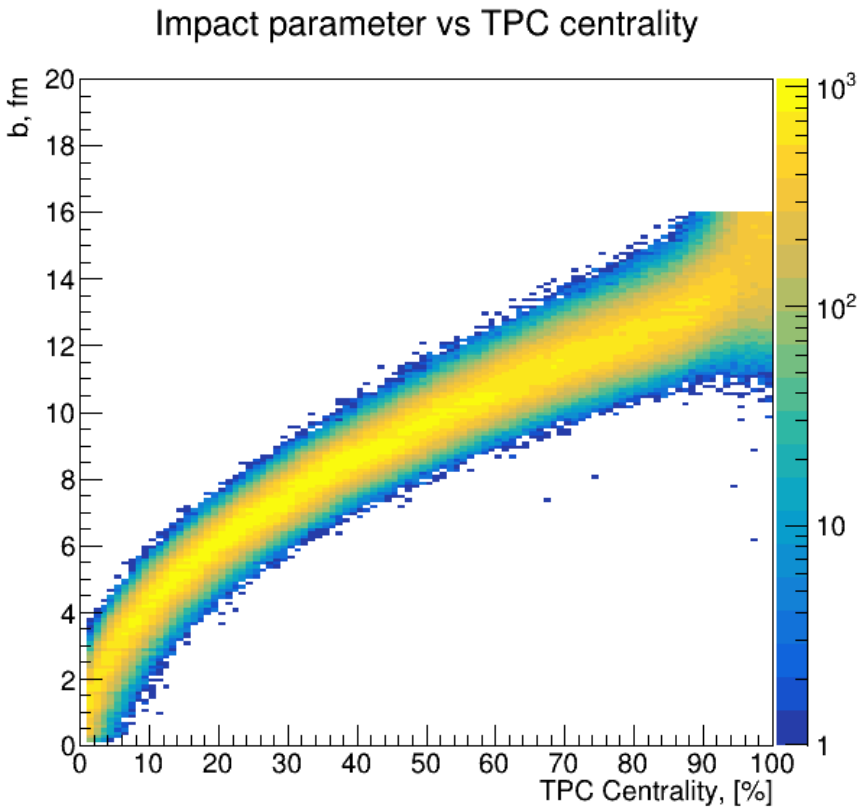

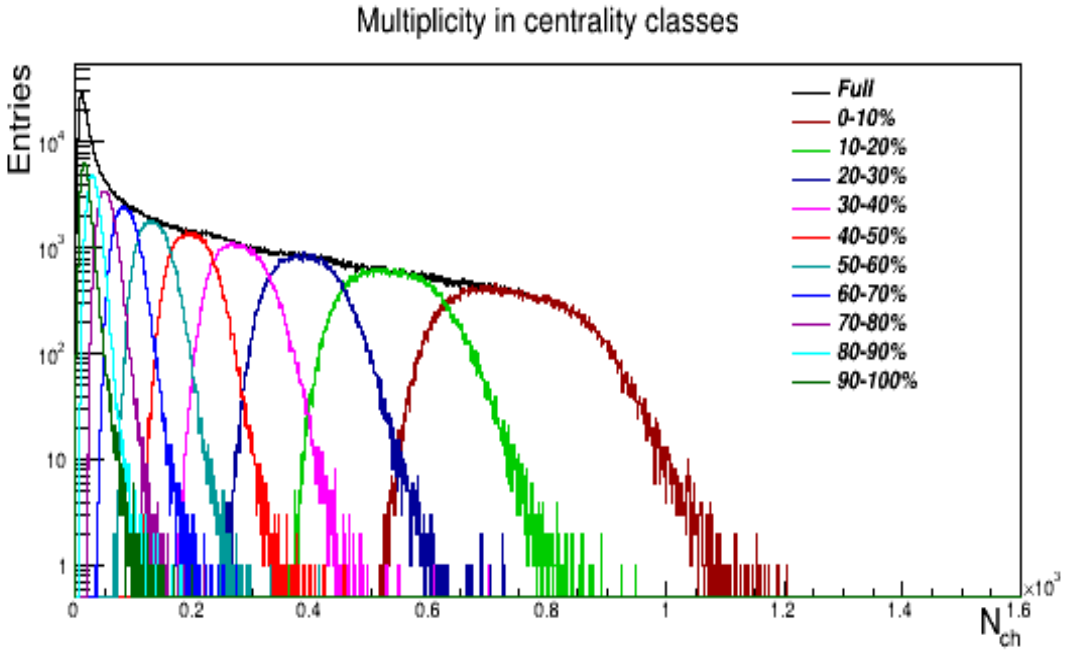

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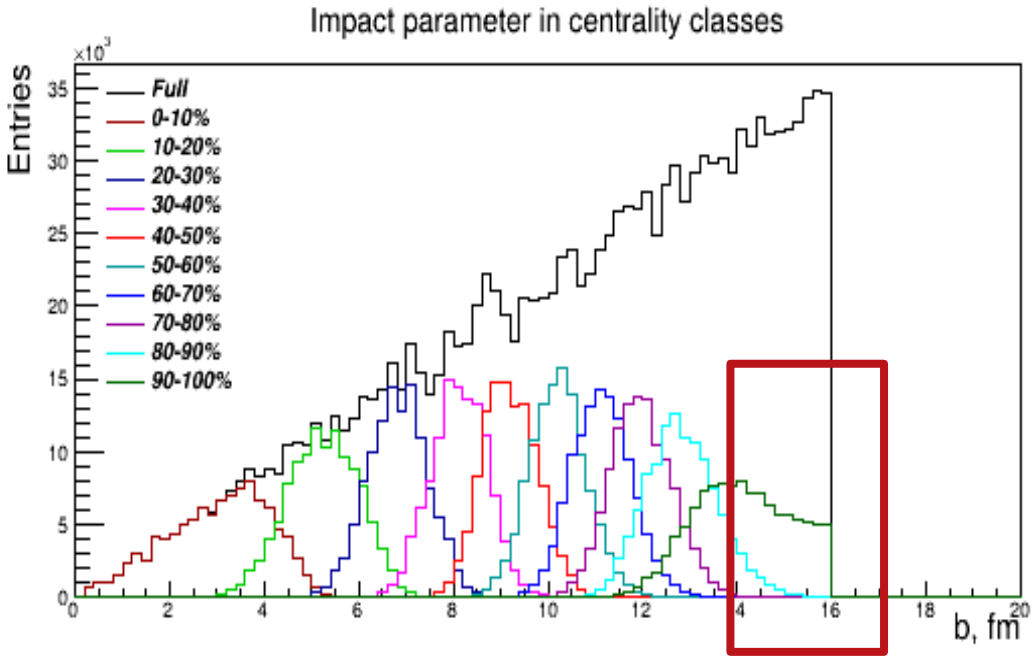

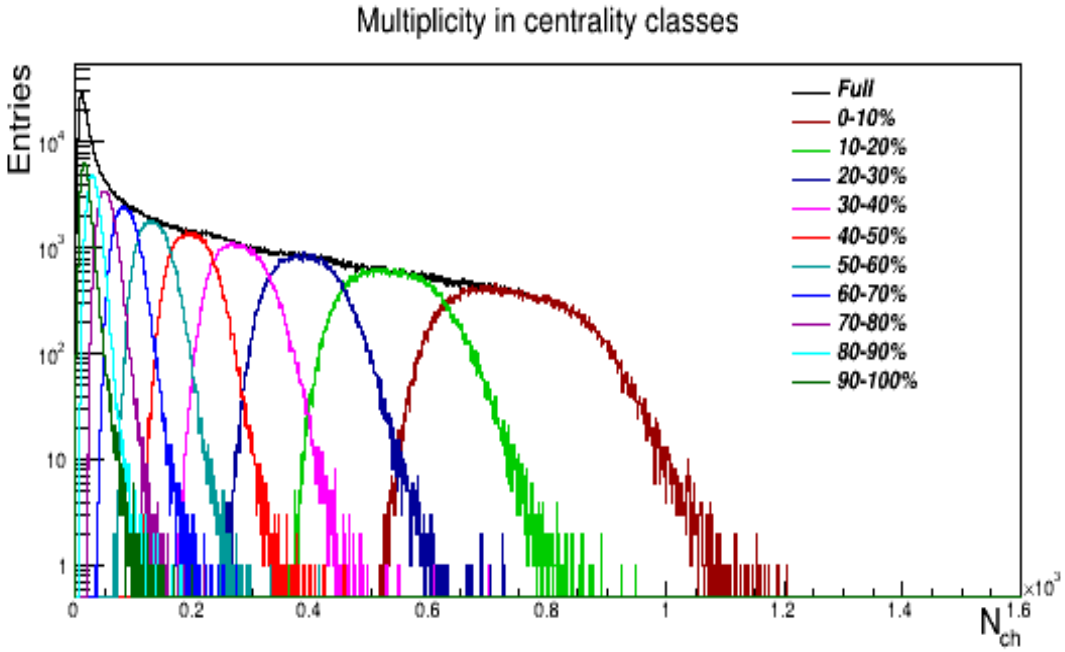

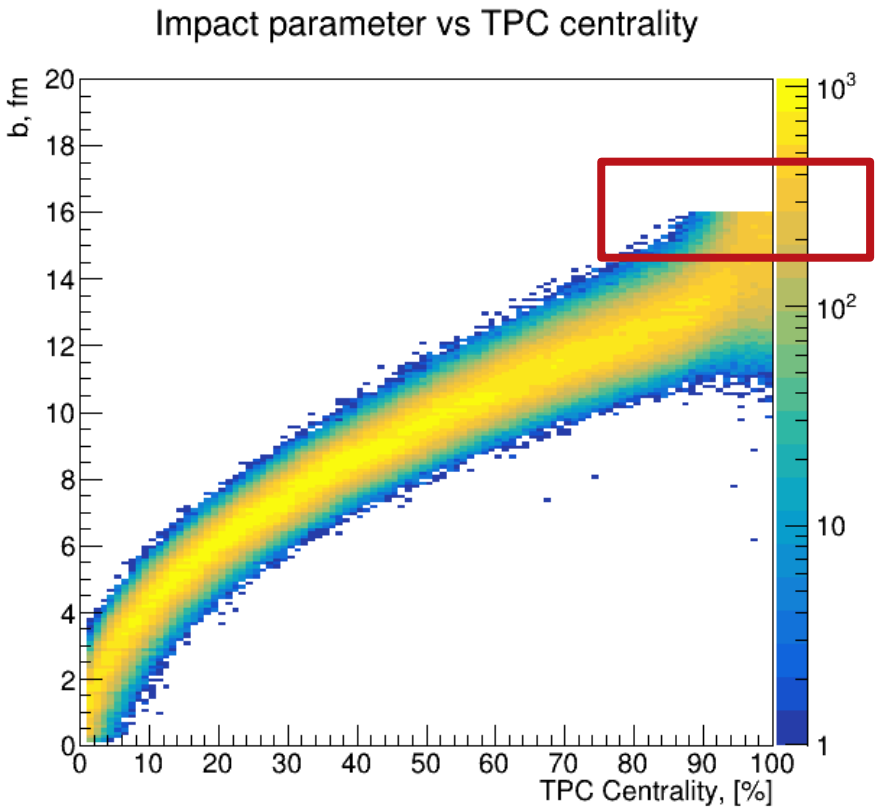

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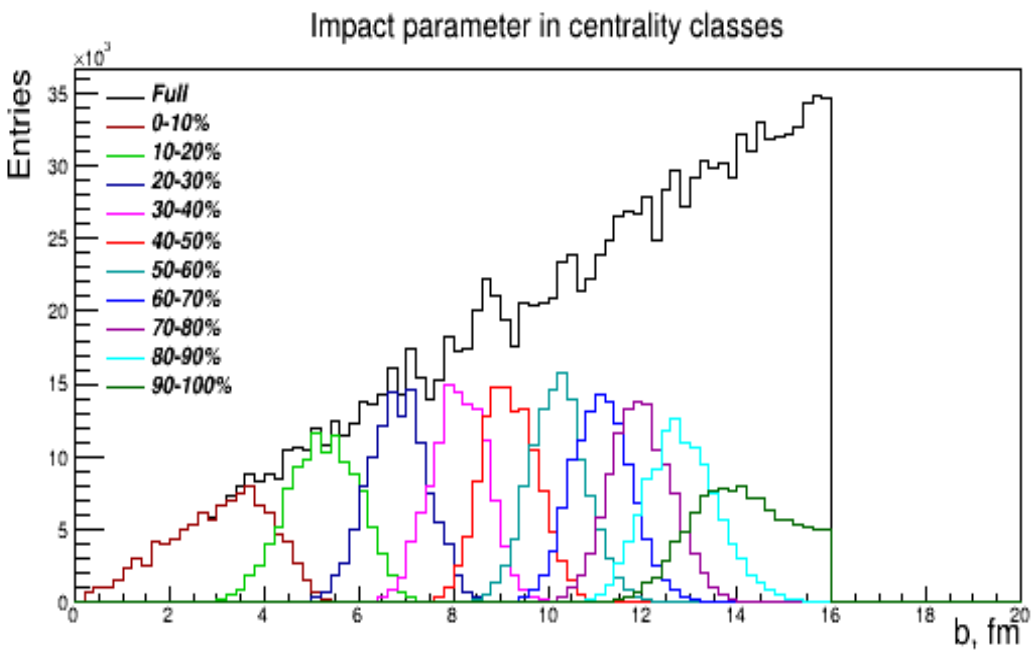

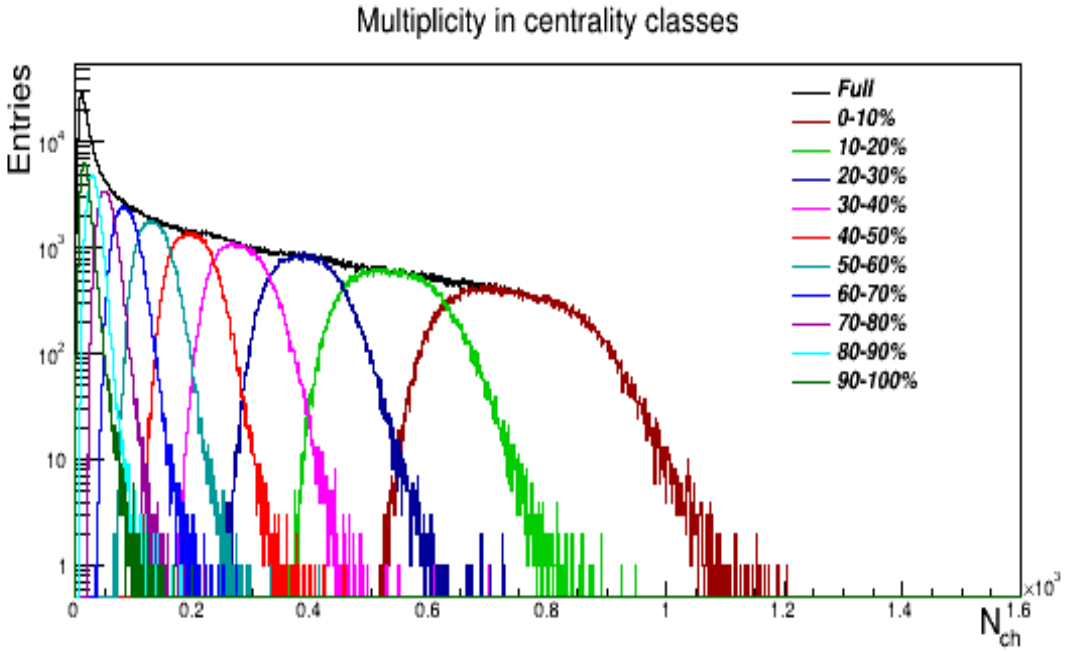

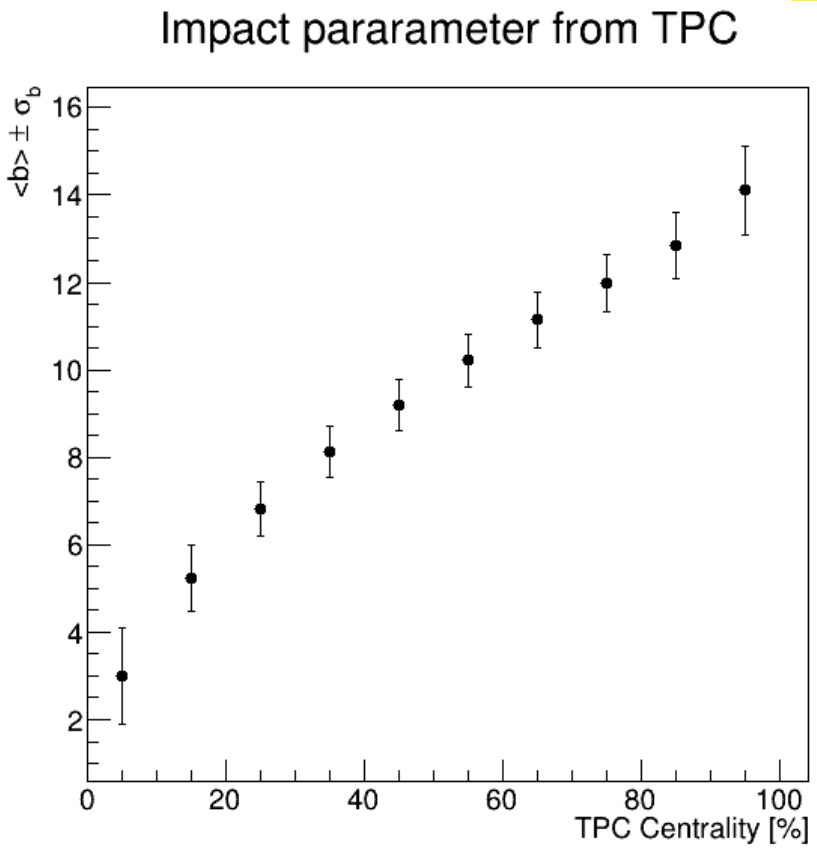

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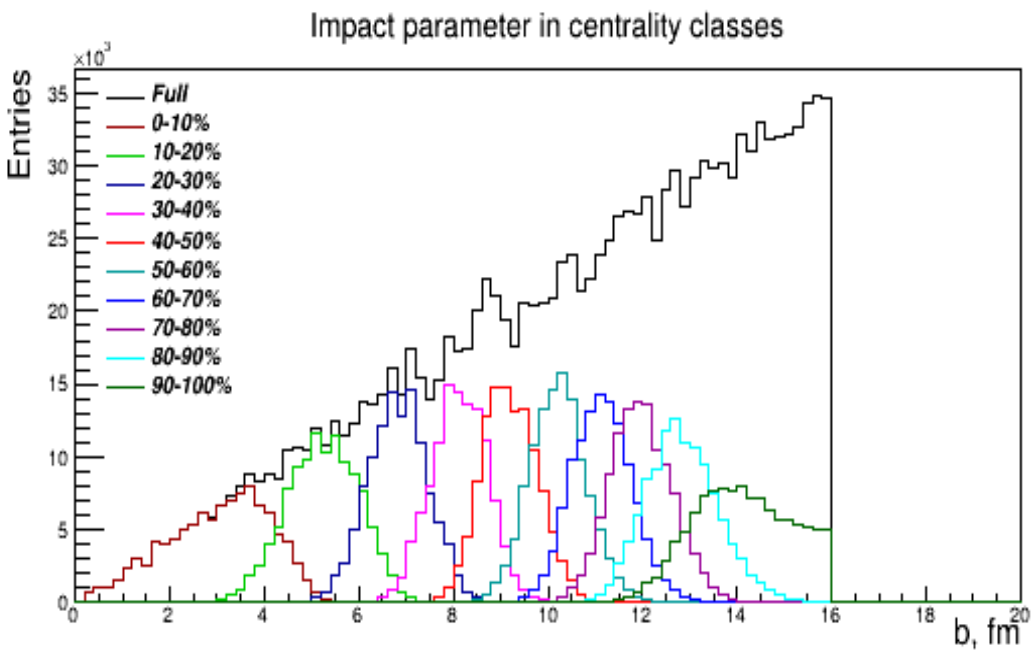

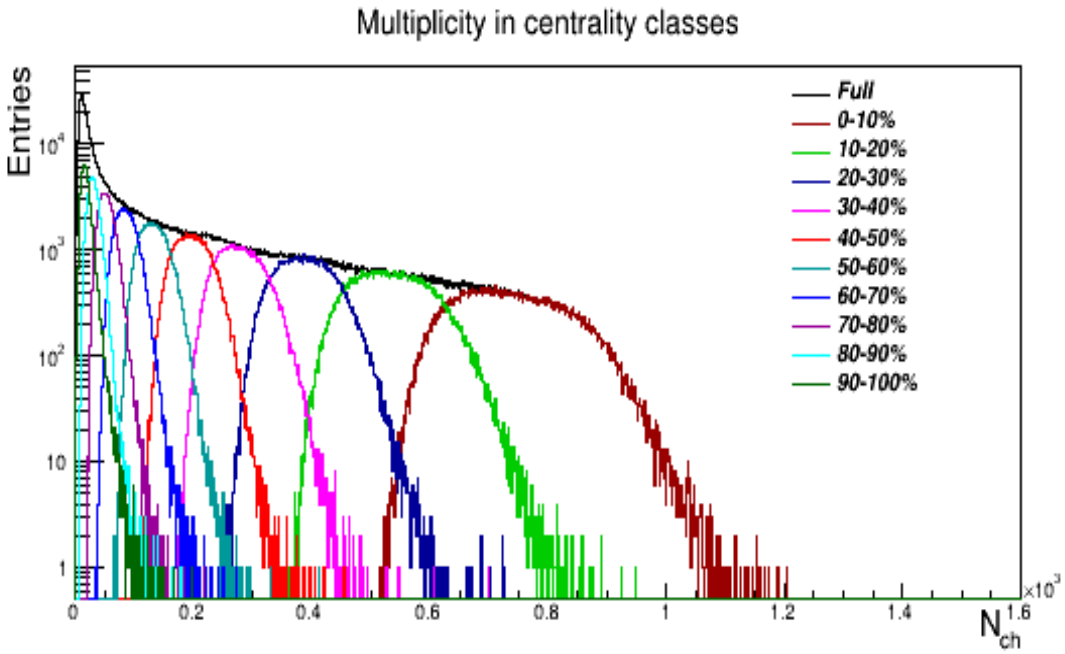

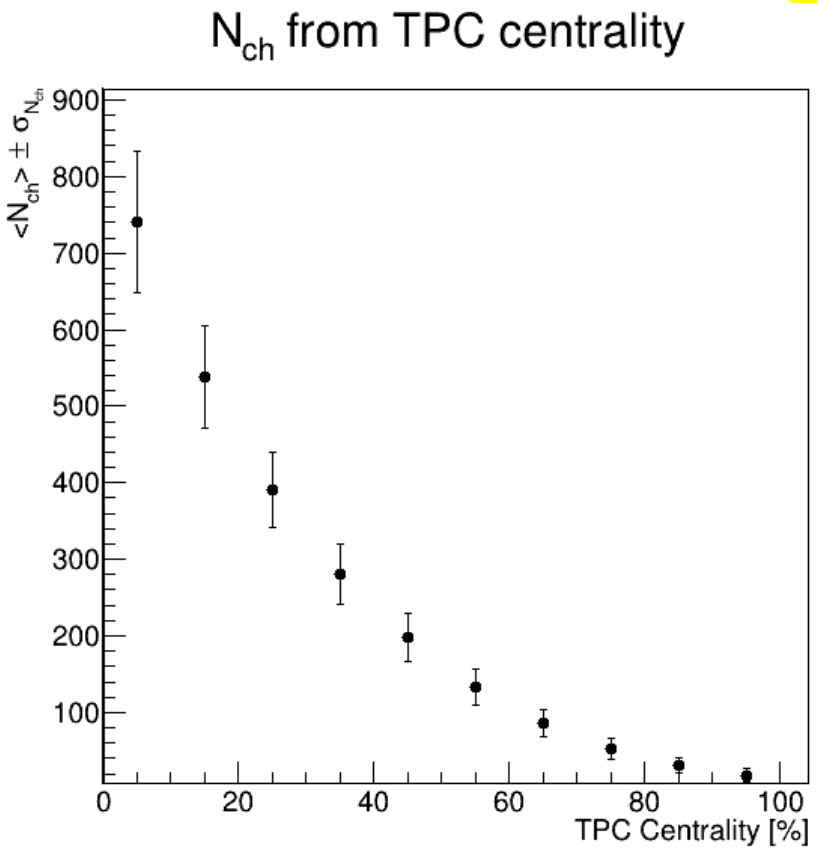

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Event plane determination

- 1-order event plane can be measured as:
  - $\Psi^1_{\mathrm{EP}} = \arctan \dfrac{Q_y}{Q_x}$
  - $Q_y = \Sigma_i \mathrm{w}_i \sin(\phi_i)$
  - $Q_x = \Sigma_i \mathrm{w}_i \cos(\phi_i)$

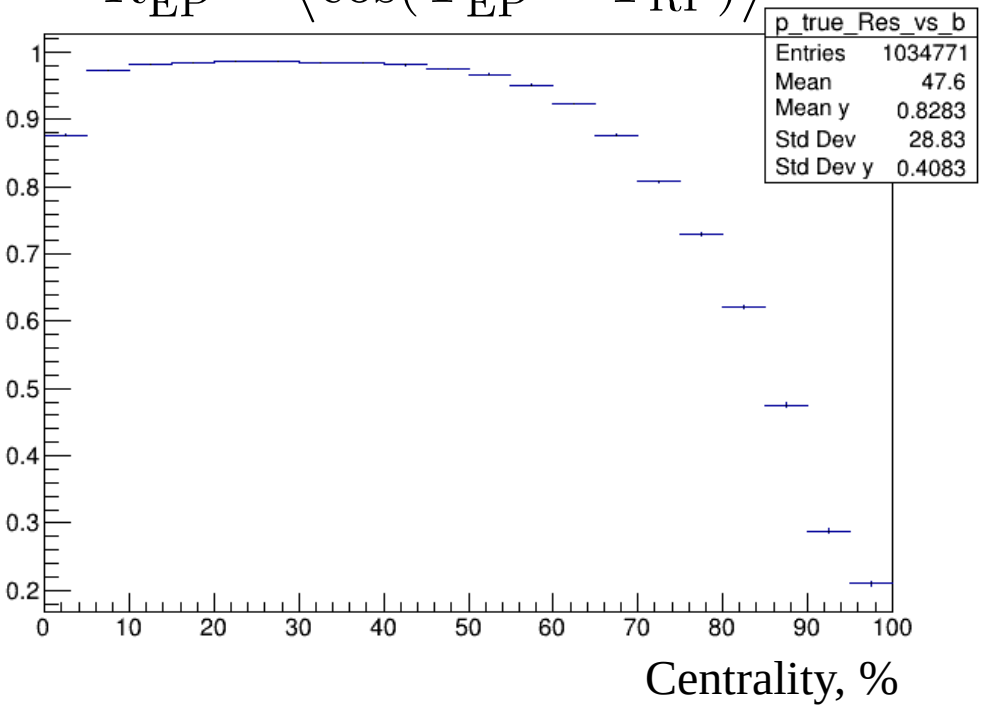
$$\mathrm{w}_i = \begin{cases} -E_i,\ -p_{\mathrm{T}i} & \text{if } \eta < 0 \\ E_i,\ p_{\mathrm{T}i} & \text{if } \eta > 0 \end{cases}$$

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

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

Event plane determination (ZDC)

$$R^1_{\mathrm{EP}} = \left\langle \cos\left(\Psi^1_{\mathrm{EP}} - \Psi_{\mathrm{RP}}\right)\right\rangle$$



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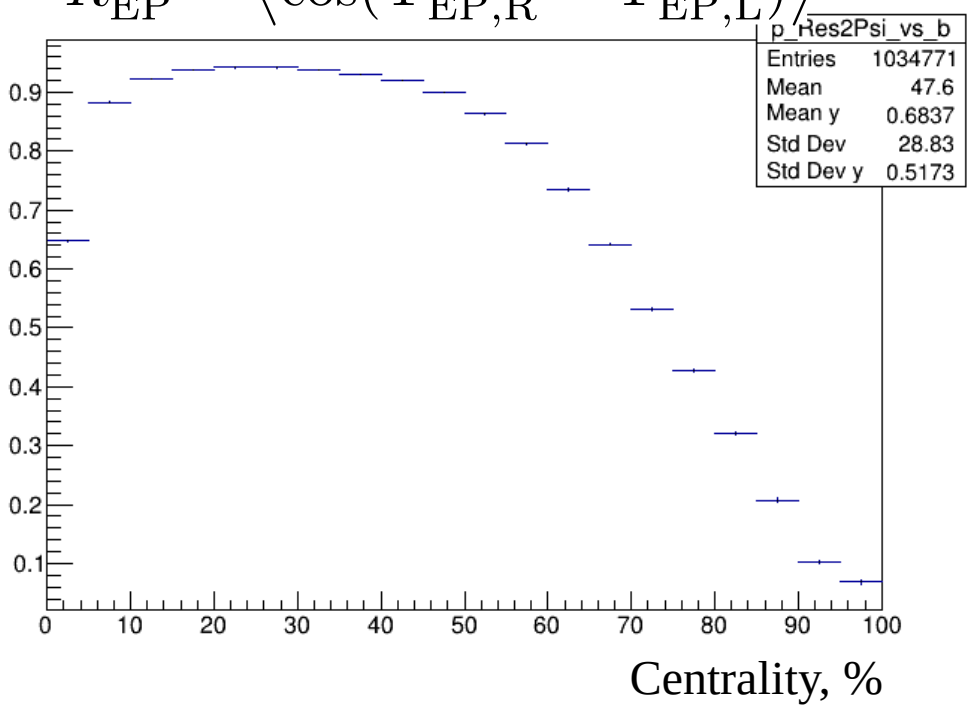
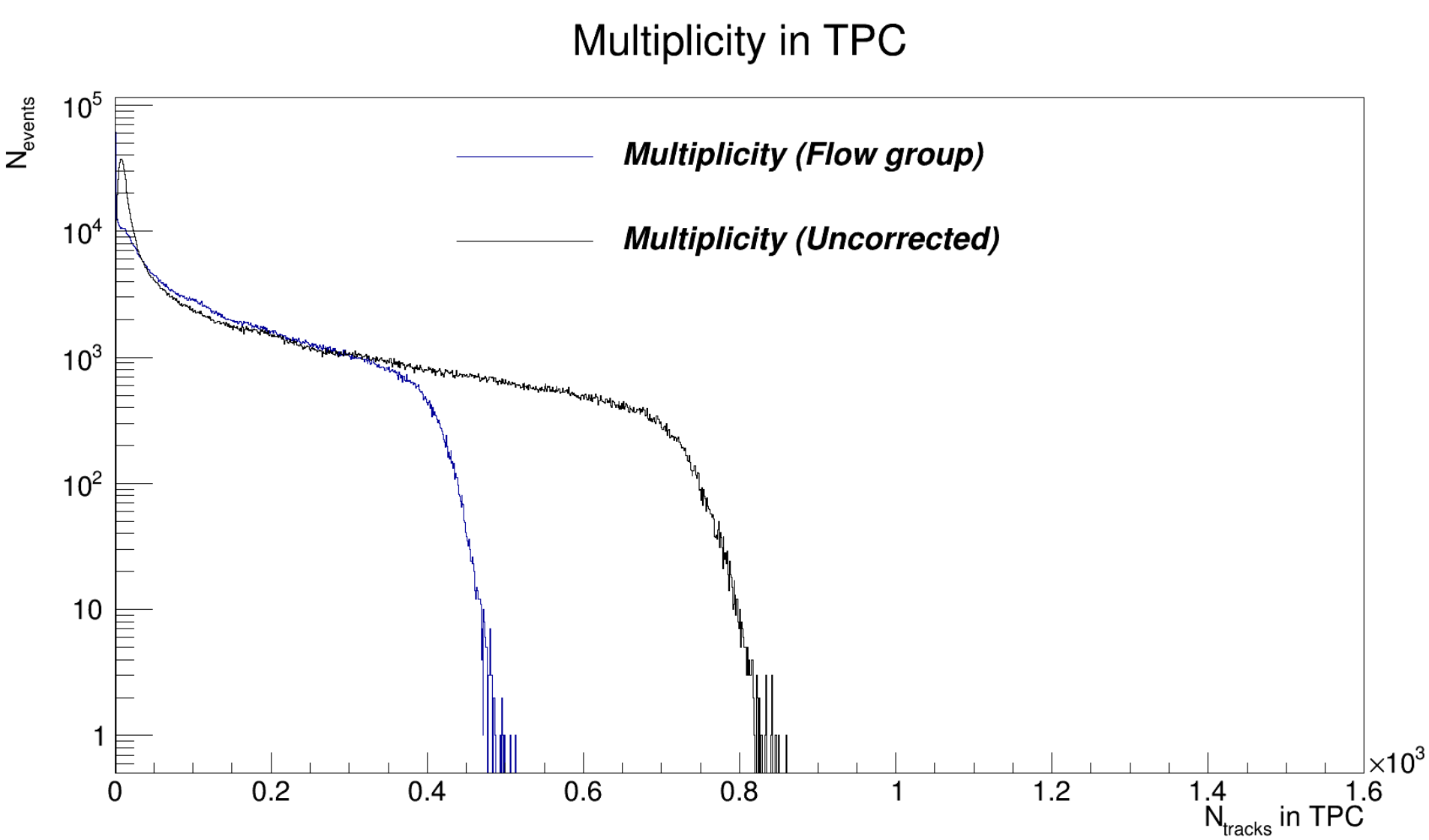


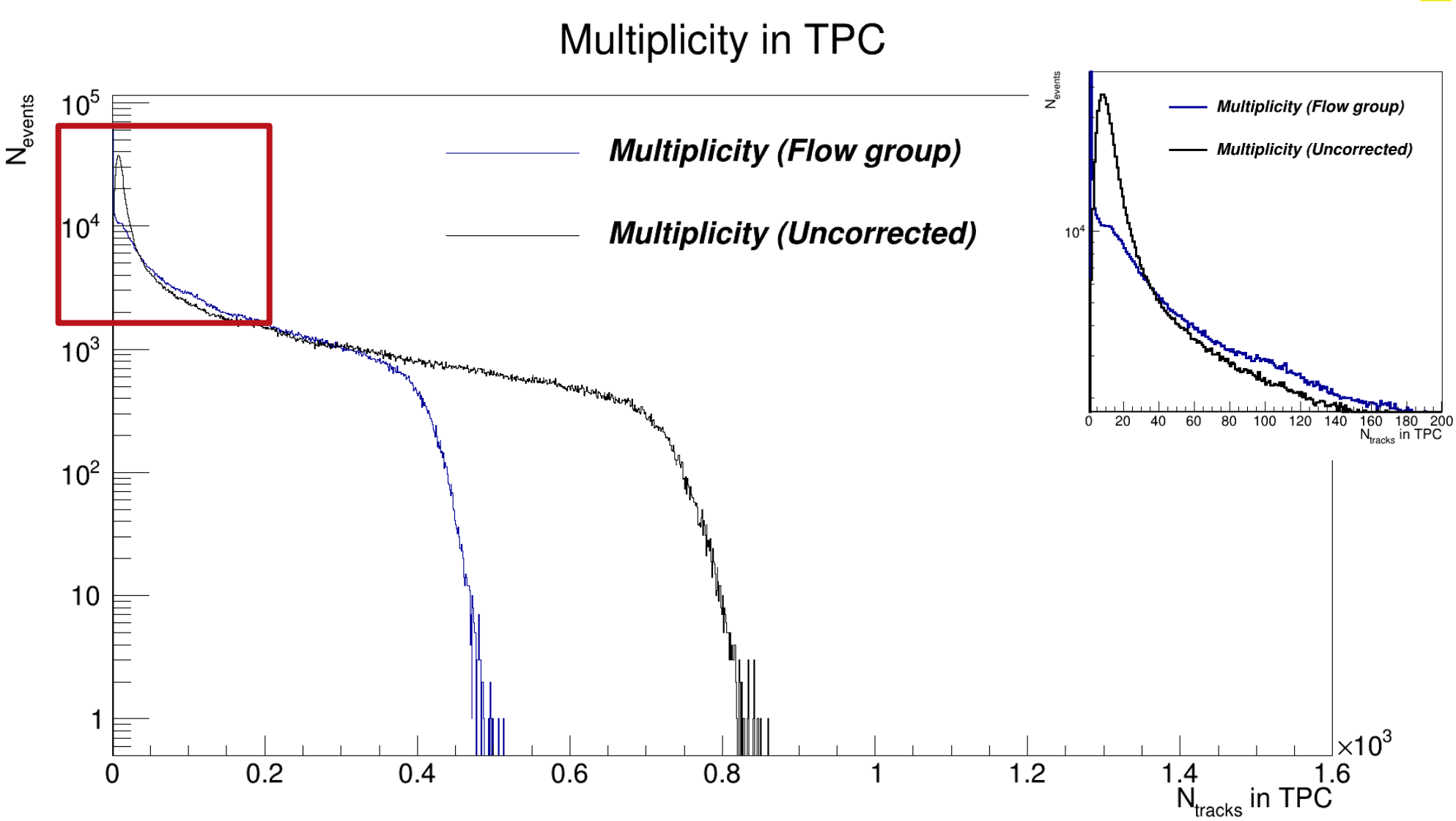
- Centrality is calculated via TPC multiplicity
- Event Plane angle through ZDC
- Dependence of R^1 on TPC centrality is shown as TProfile

Results with uncorrected multiplicity



- When using uncorrected multiplicity, biggest problems should arise in peripheral regions

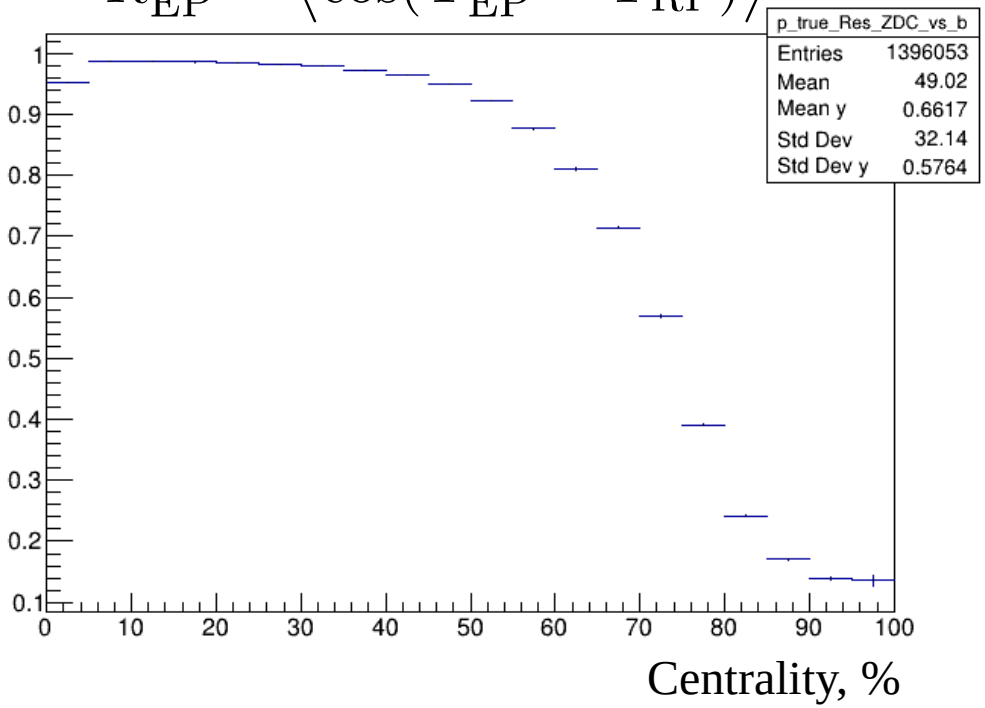
Results with uncorrected multiplicity



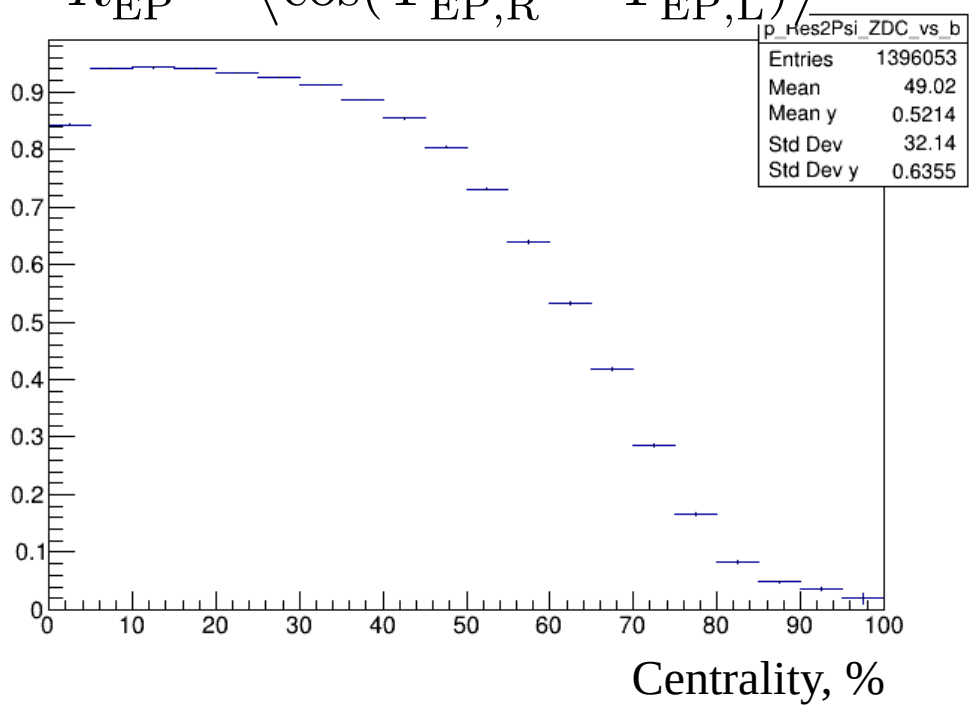
- When using uncorrected multiplicity, most noticeable problems should arise in peripheral regions

Event plane determination (ZDC)

$$R^1_{\mathrm{EP}} = \left\langle \cos\left(\Psi^1_{\mathrm{EP}} - \Psi_{\mathrm{RP}}\right)\right\rangle$$



$$R^1_{\mathrm{EP}} = \left\langle \cos\left(\Psi^1_{\mathrm{EP,R}} - \Psi^1_{\mathrm{EP,L}}\right)\right\rangle$$



- Centrality is calculated via uncorrected TPC multiplicity
- Dependence of R^1 on TPC centrality is shown as Tprofile
- Resolution in peripheral regions drops significantly

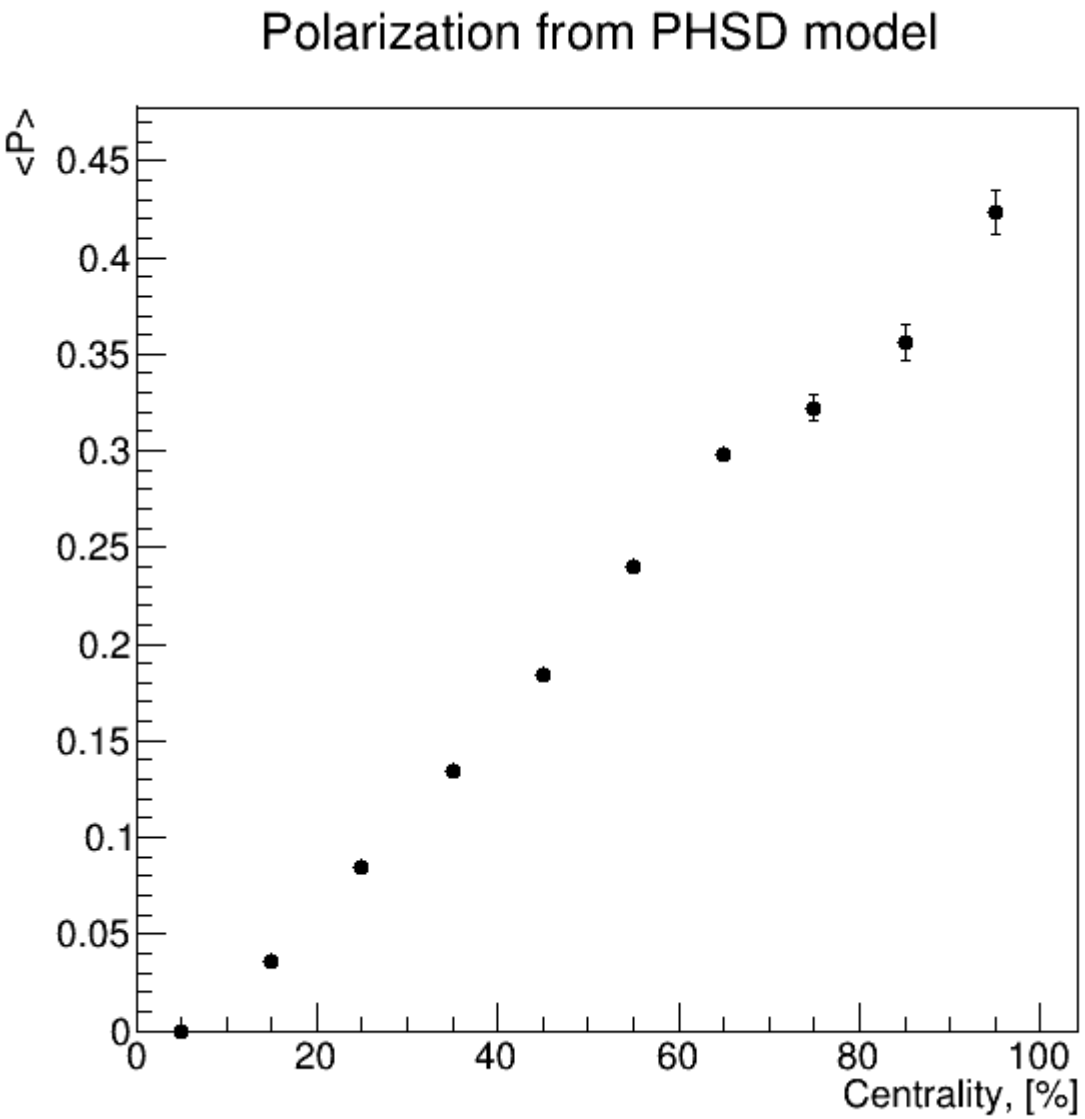
Conclusions

- Available technique from the flow group
  - Centrality estimated via track multiplicity in TPC
  - Event plane via FHCal w.r.t. centrality from TPC
  - Event plane via TPC w.r.t. centrality from TPC
- Outlook
  - Optimize centrality estimation
  - Add centrality calculation through FHCal (possibly combined FHCal + TPC multiplicity)
  - Choose the best method to avoid possible correlations with the analysis

The End

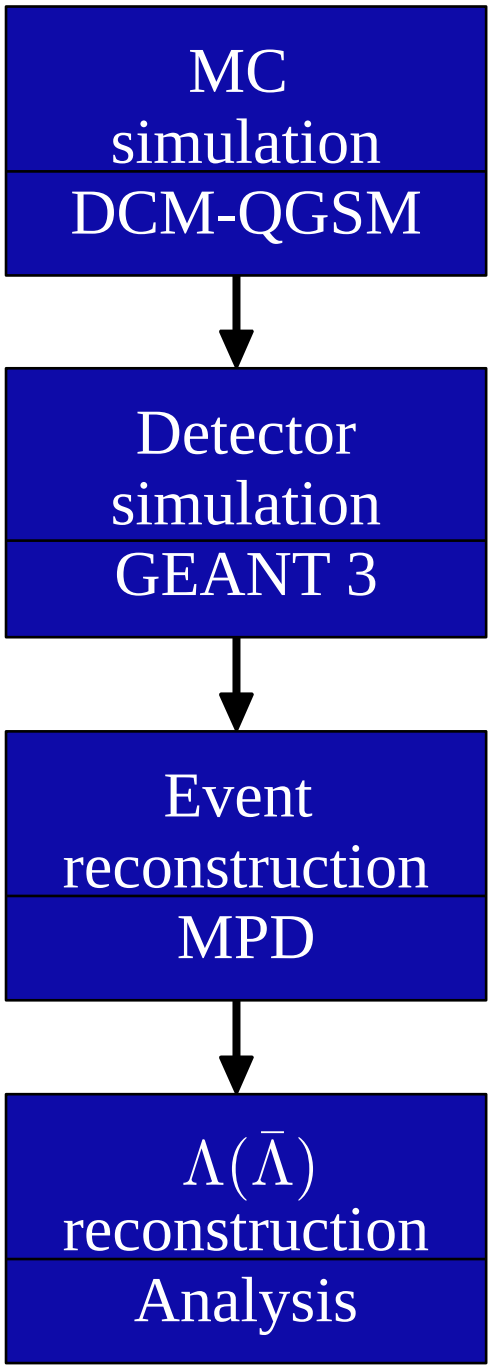
Thank you for your attention!

Back Up



- Mean value of the P_y component of the polarization vector from the PHSD model (MpdMCTrack)
- Should correspond to P_J ($P_J = -P_y$)
- Uncorrrected TPC centrality was used
- Seems to have correct dependence
- Need to finish the full-scale analysis for the final conclusion

Analysis method



- Realistic Monte-Carlo simulation using DCM-QGSM generator (inclusive Λ polarization)

This is currently done via P_x component of the polar. vector!

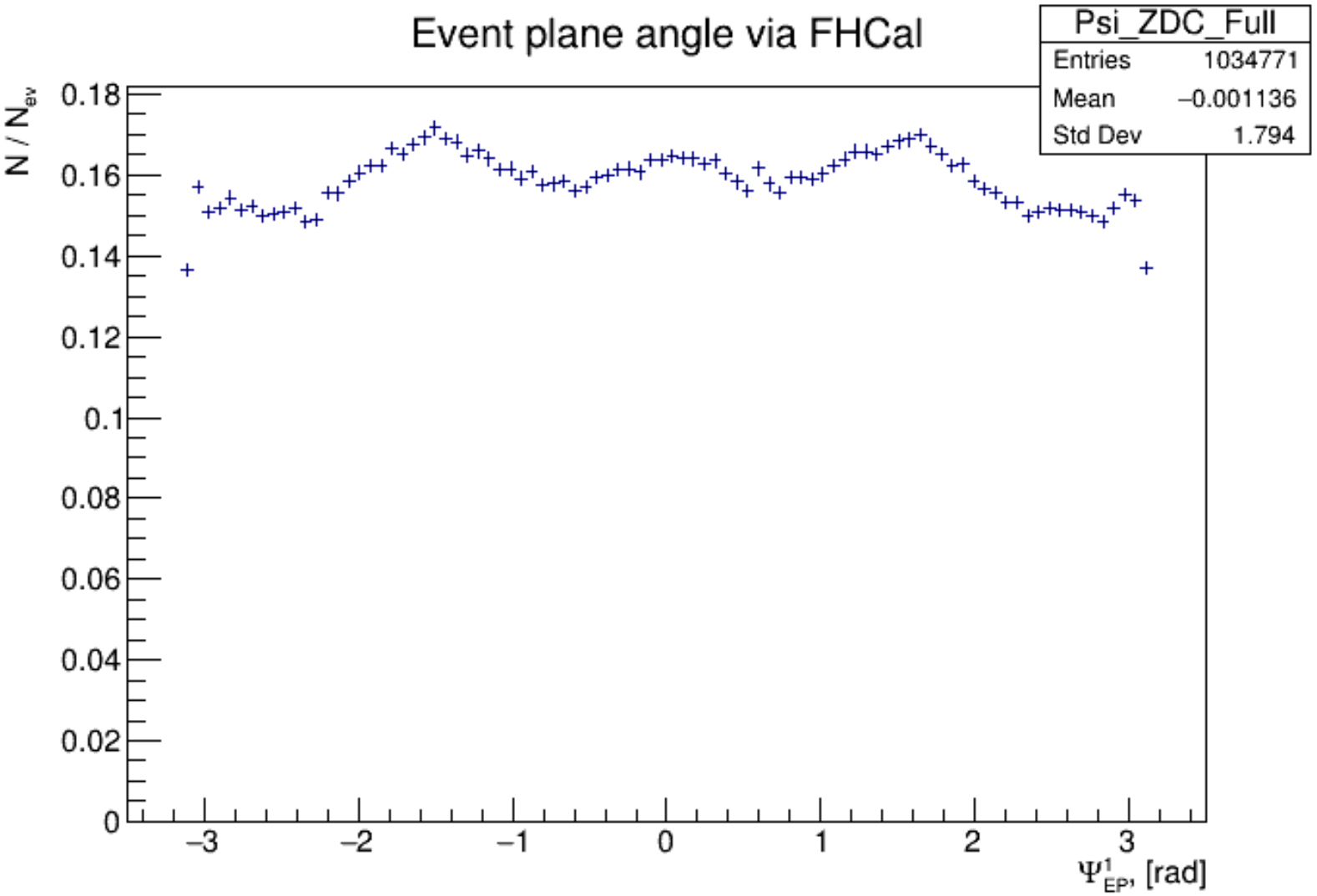
- Simulation of polarization effects in the detector via GEANT 3 (anisotropic decay of Λ hyperons) — can be switched on/off to study the effect

$$\frac{\mathrm{d}N}{\mathrm{d}\cos\theta^*} = 1 + \alpha_\Lambda P_\Lambda \cos\theta^*$$

- Event reconstruction using realistic PID within mpdroot framework

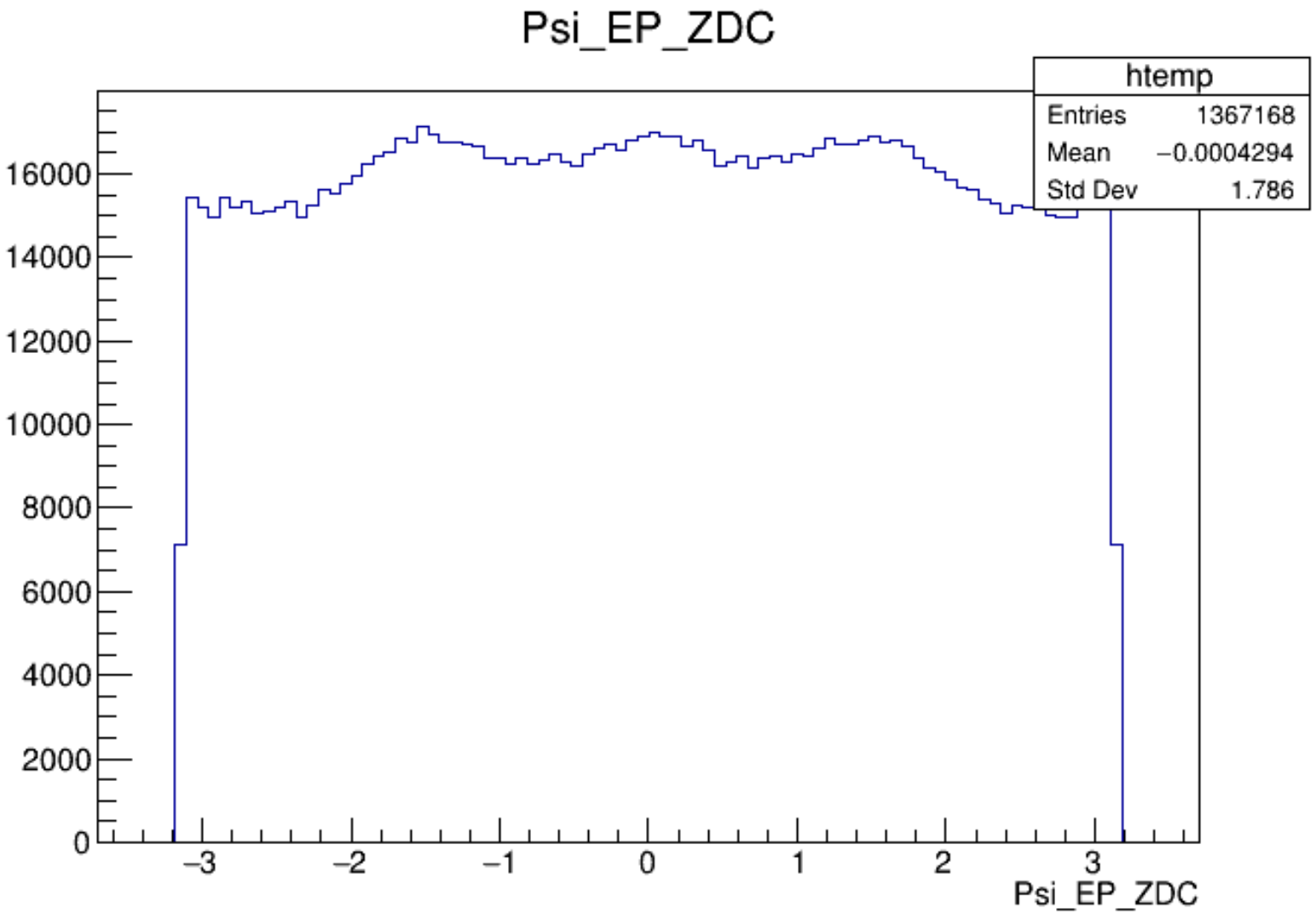
- $\Lambda(\bar{\Lambda})$ reconstruction through the weak decay channel $\Lambda \to p + \pi^-$

Back Up



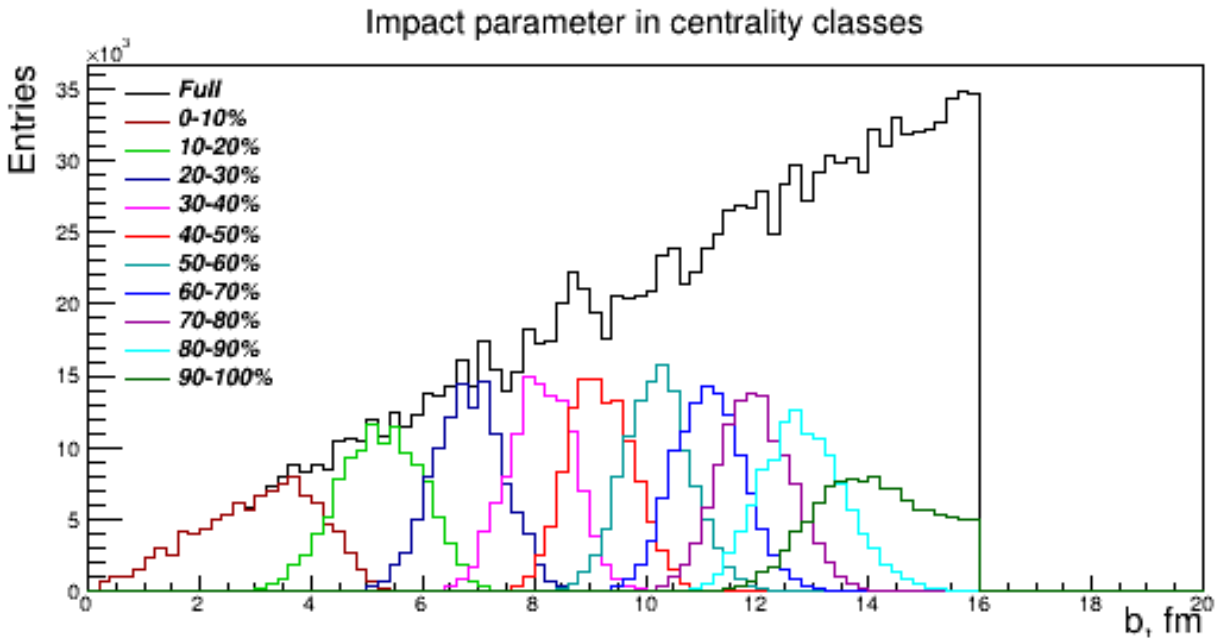
- Flow group technique

Back Up



- Using uncorrected multiplicity

Back Up


Impact parameter in centrality classes
Entries
×10³
Full
0-10%
10-20%
20-30%
30-40%
40-50%
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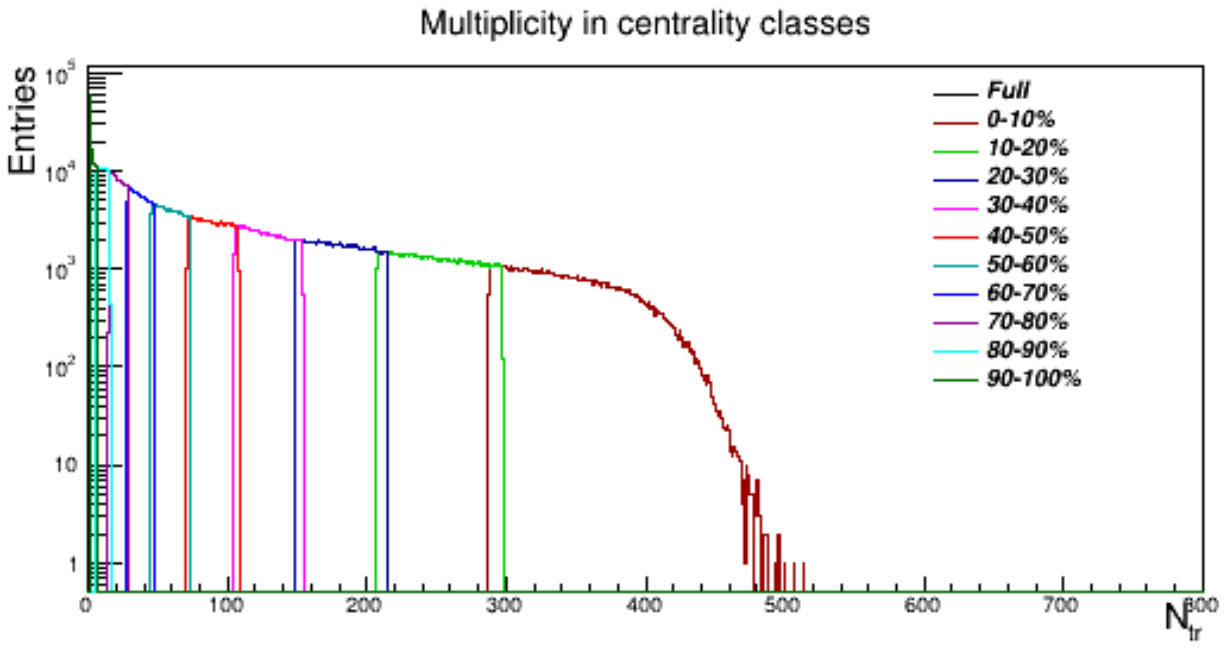
b, fm


Multiplicity in centrality classes
Entries
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