New approach to measure centrality in the HADES heavy ion experiments

E. Zherebtsova, N. Karpushkin

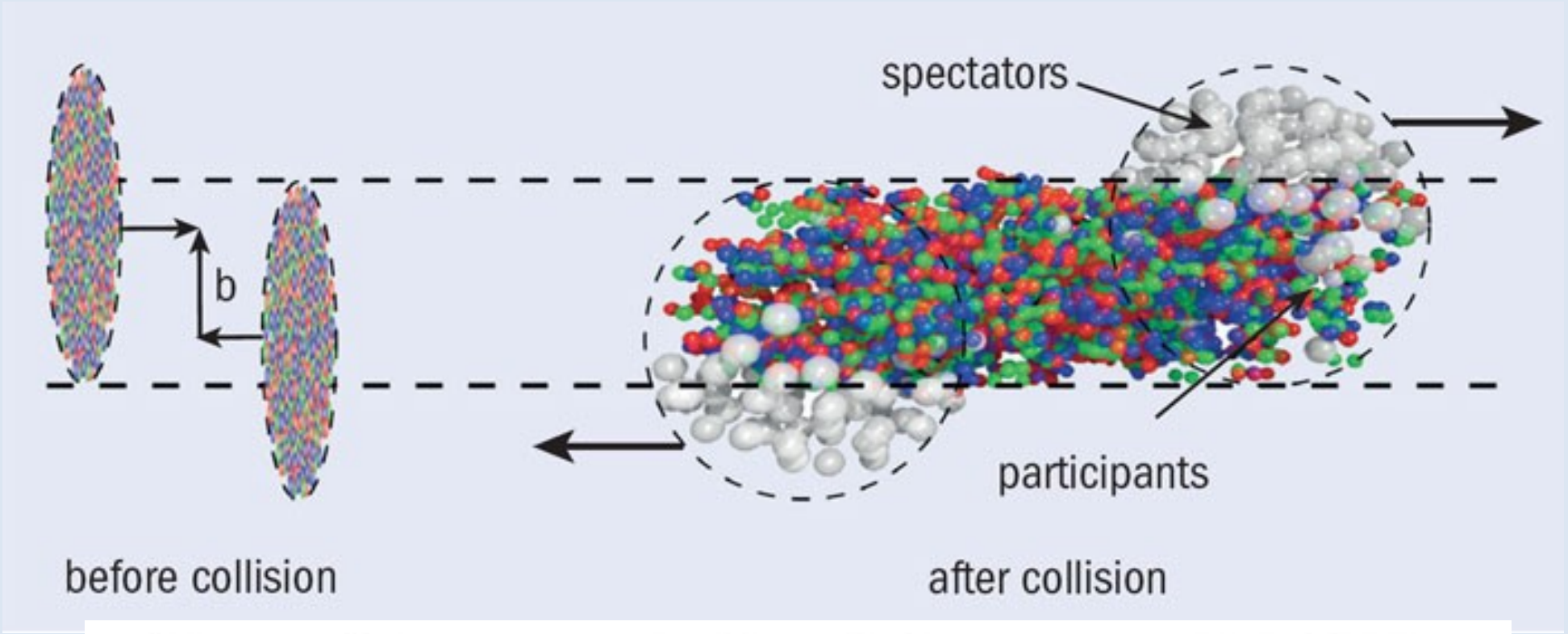
For the HADES Collaboration

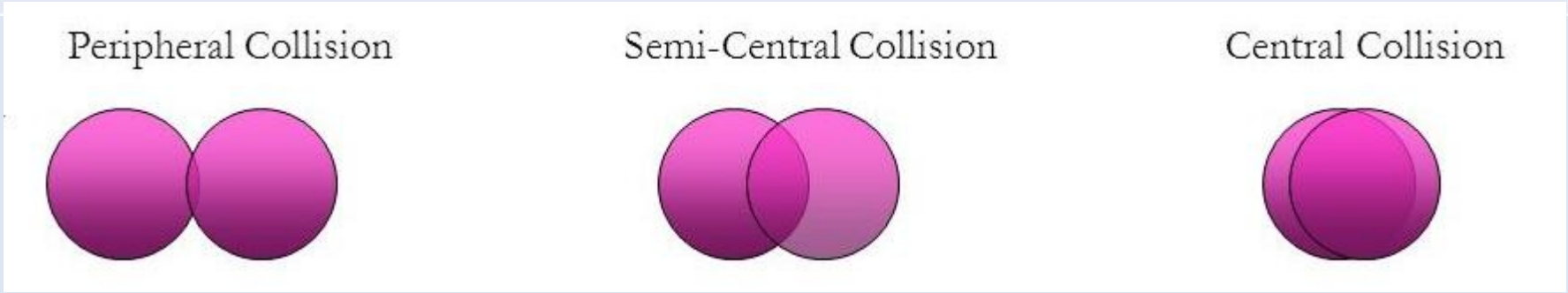
Institute for Nuclear Research RAS

Outline

- Collision geometry
- HADES experimental setup
- Forward Wall (FWall) detector
- Machine learning (ML) approach for centrality with FWall
- Centrality selection with ML in the HADES with FWall
- Conclusion and outlook

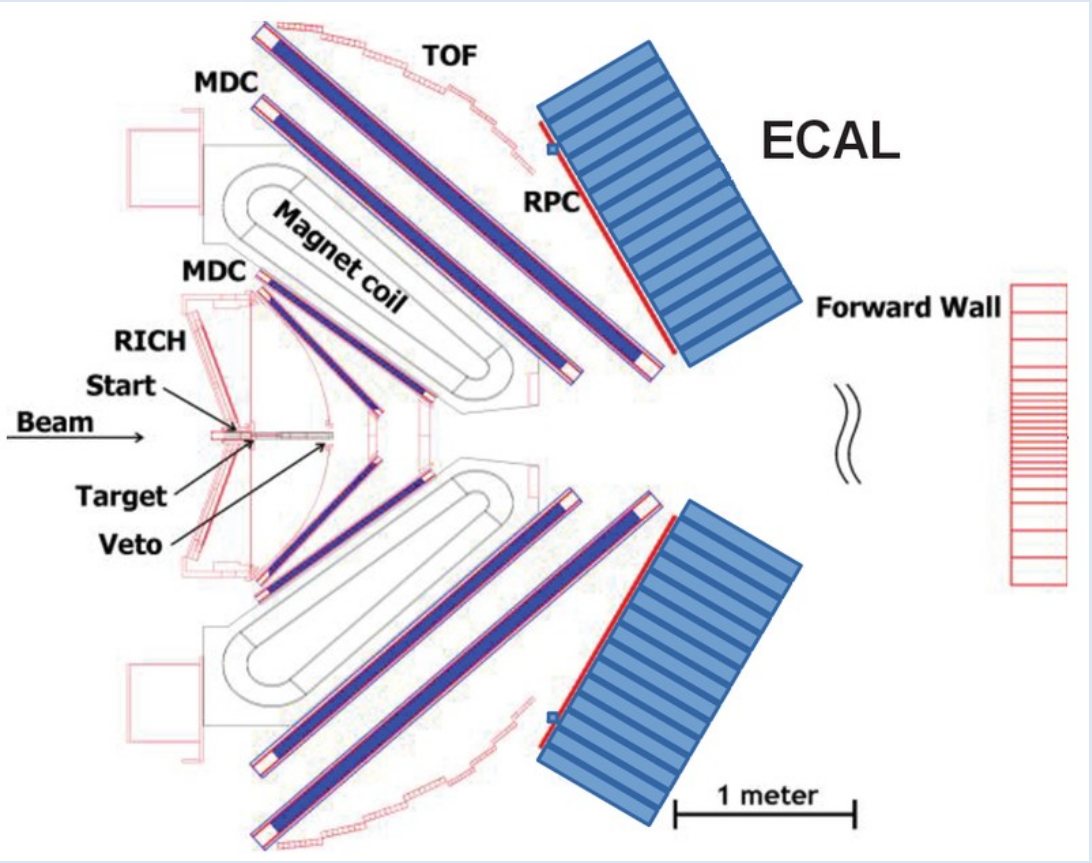
Collision geometry





- Spectators can be used for centrality selection and the reaction plane orientation.

HADES experimental setup



Tracking system:

- Multi-wire drift chambers (MDC)

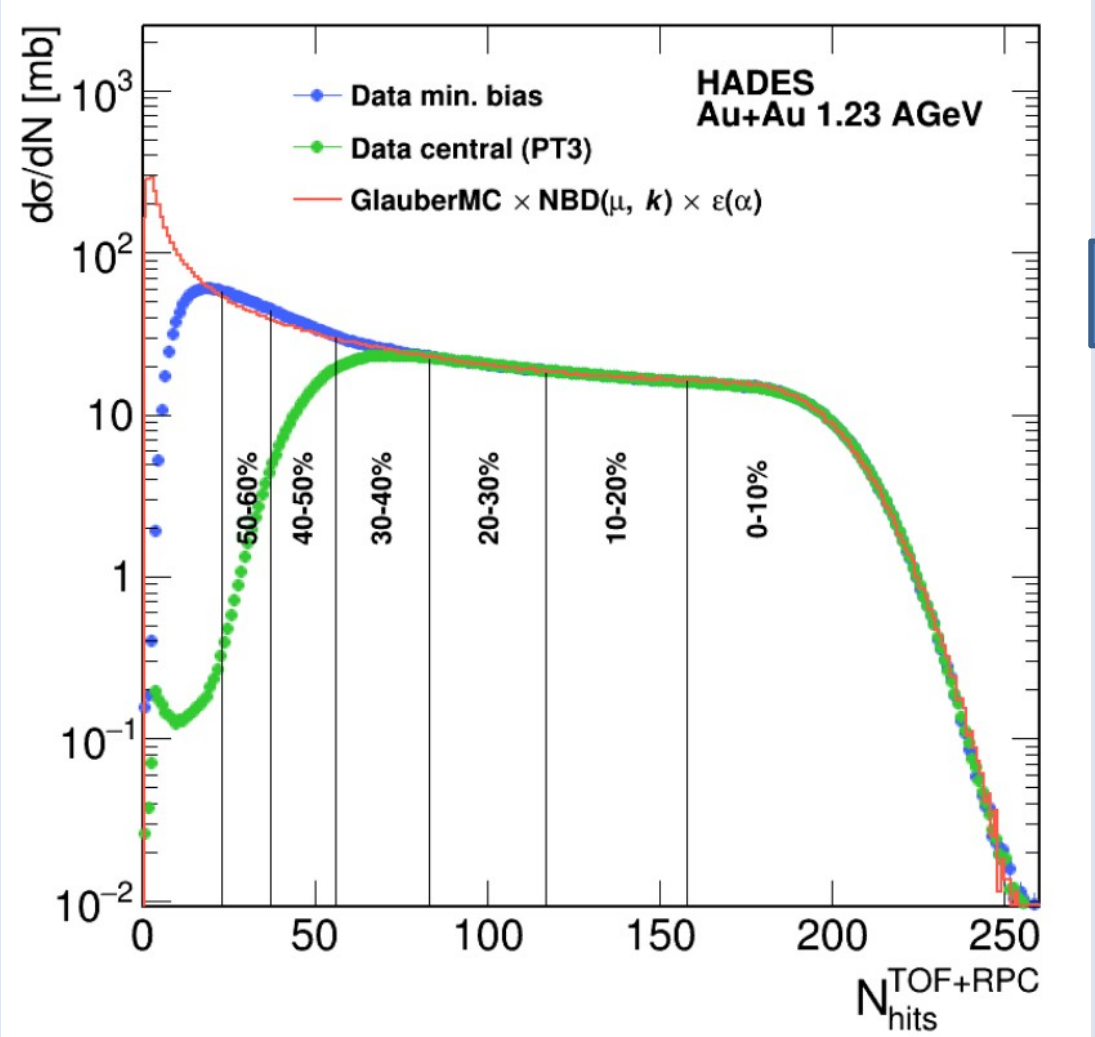
Particle identification:

- Time Of Flight (TOF)
- Resistive Plate Chambers (RPC)

Event plane reconstruction:

- Forward Wall (FWall)

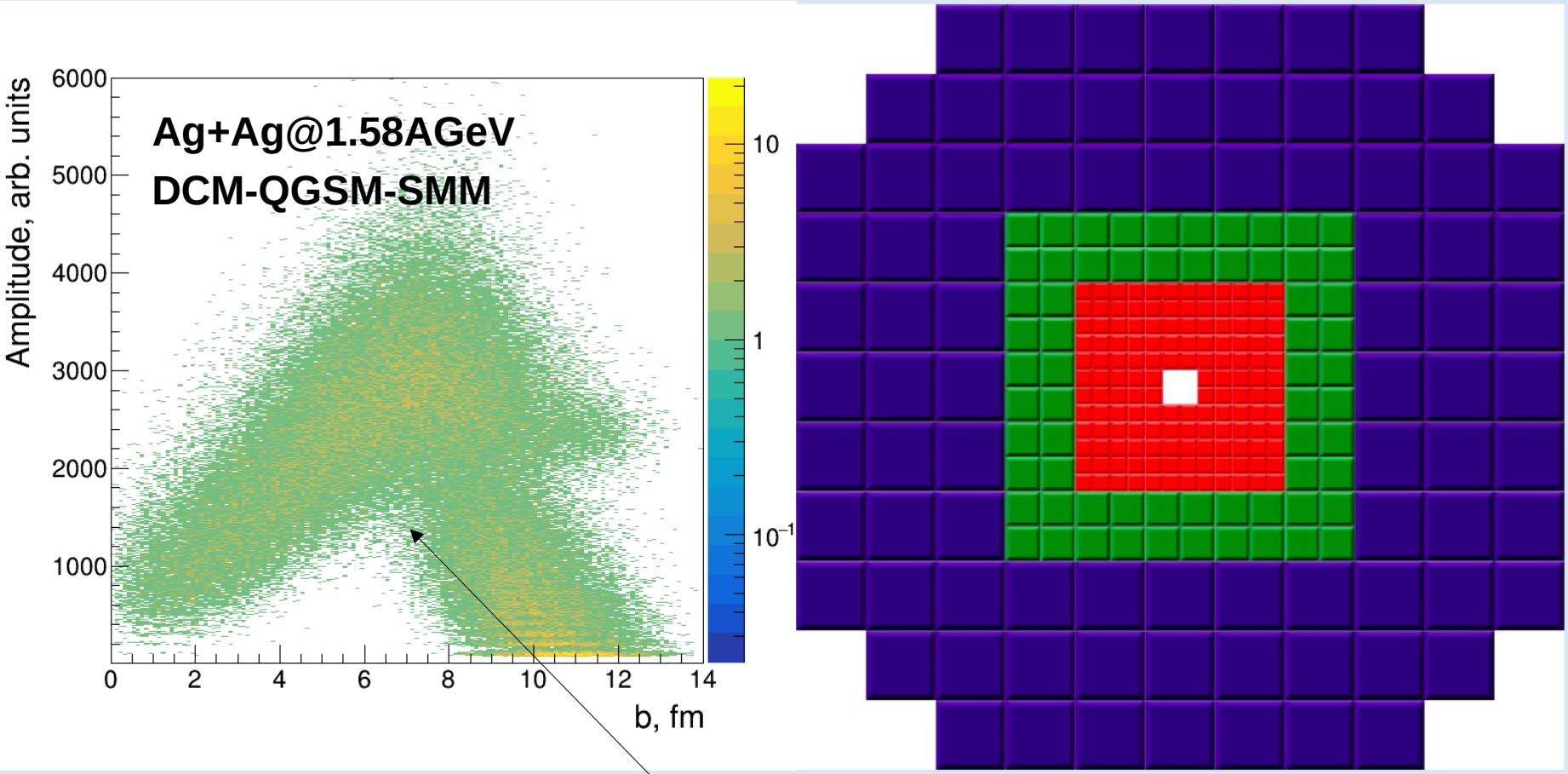
Centrality determination in the HADES



Glauber approach based on the multiplicity of produced particles

HADES Collaboration, Eur. Phys. J. A (2018) 54: 85

Forward Wall detector



288 individual scintillator detectors:

- small cells 40x40 mm^2
- medium cells 80x80 mm^2
- large cells 160x160 mm^2

Due to the beam hole, there is an ambiguity in FWall charge on impact parameter dependence.

Tools

System	Au+Au at 1.23AGeV Ag+Ag at 1.58AGeV
Models	DCM-QGSM (shield code) with fragments DCM-QGSM-SMM with fragments
Transport code	GEANT3
Framework	HYDRA
Trigger	PT3 (40% centrality)

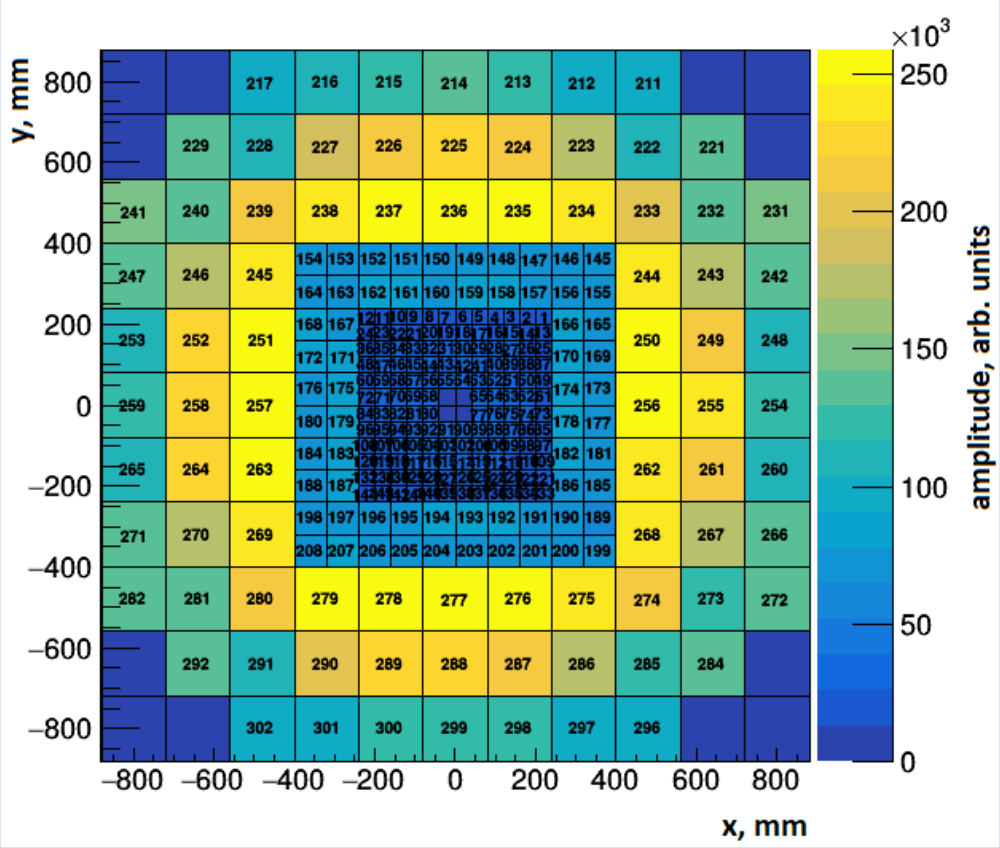
ML Framework: N. Karpushkin (INR RAS)

Machine learning technique

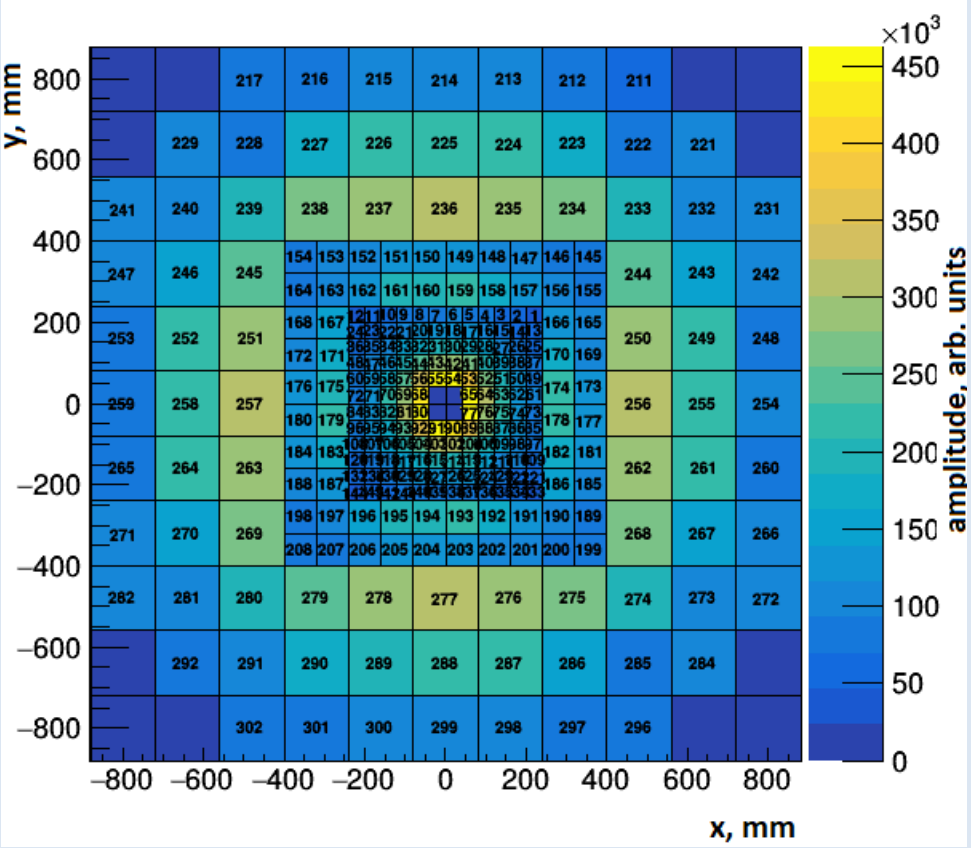
Input parameters – FWall cell positions and amplitudes in each cell
Target variable – number of TOF+RPC hits
Expected result: centrality selection

Space distribution of the FWall amplitudes

Events 0-5% centrality



Events 35-40% centrality



Machine learning techniques (ML)

Supervised approach

1. Train-test split
2. Train the model:

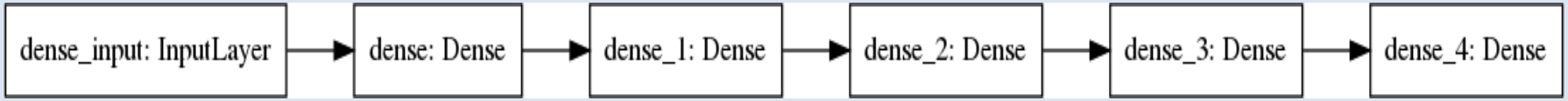
   Inputs:

   - 1D arrays of amplitudes in FWall cells

     (space distribution of FWall amplitudes)

   - Centrality class index

Model architecture:

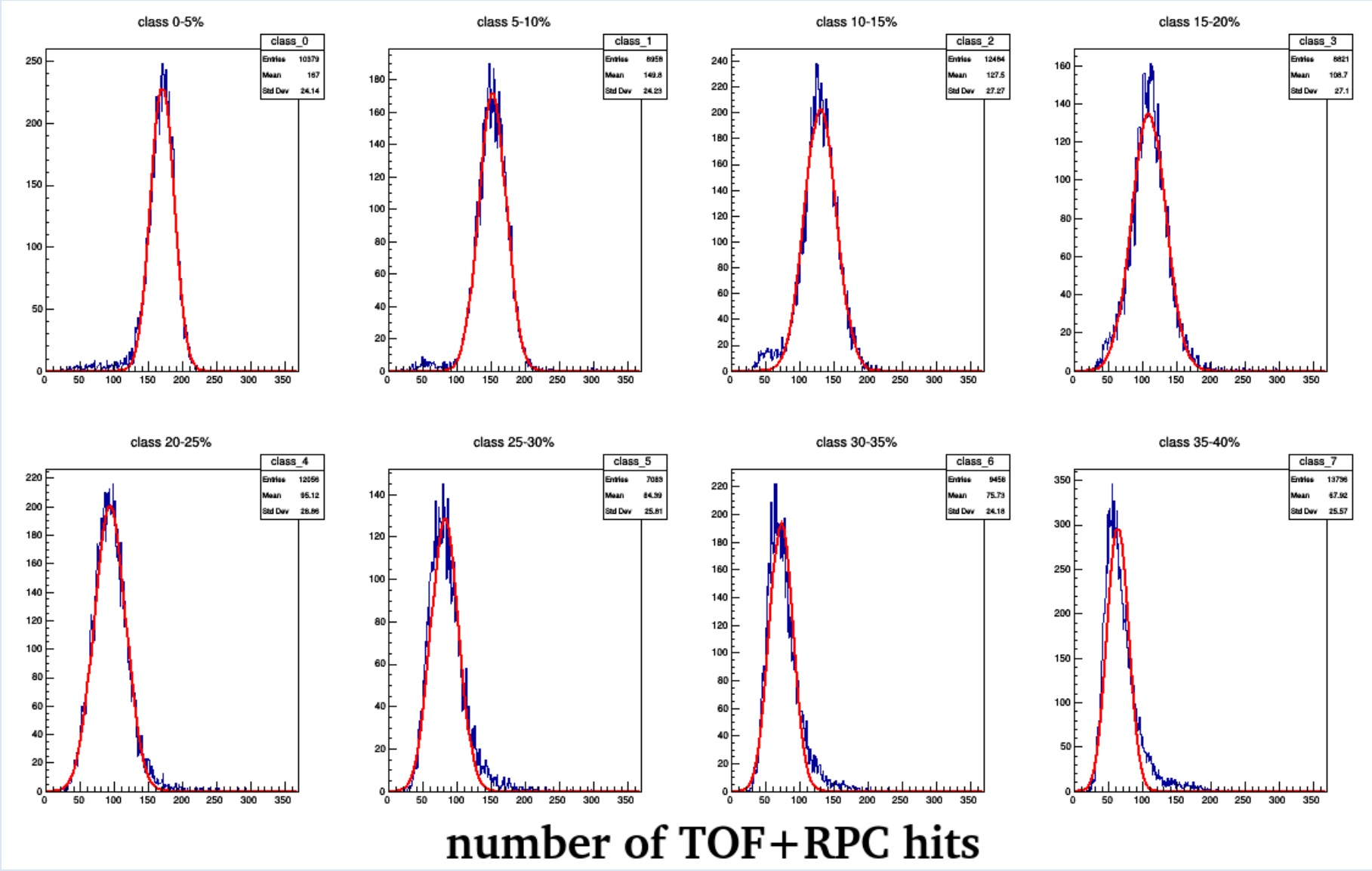


3. Test model accuracy

ML Framework: N. Karpushkin (INR RAS)

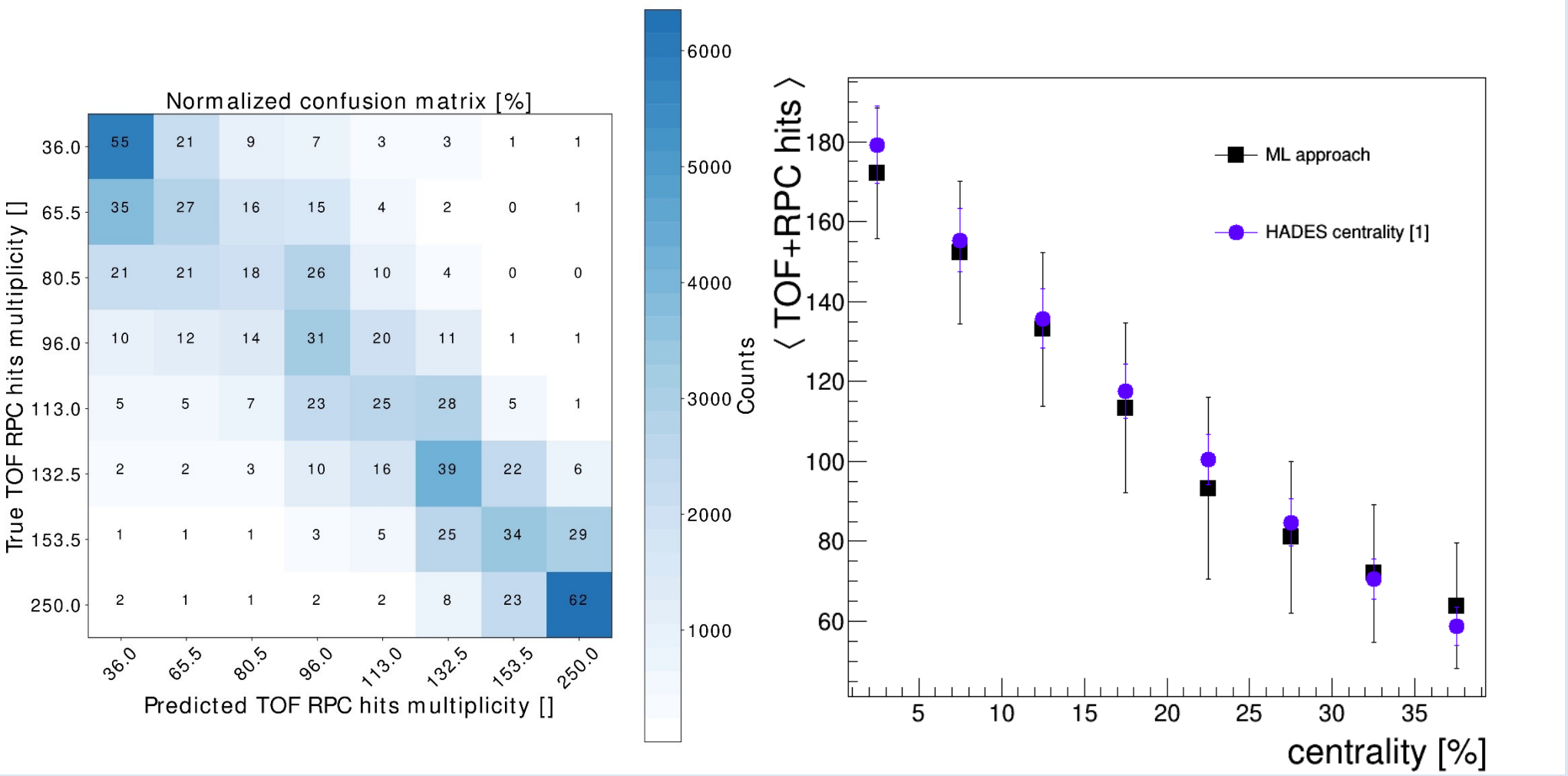
ML for the HADES exp. data

Au+Au at 1.23AGeV (PT3 trigger)
Number of TOF+RPC hits in centrality classes



ML for the HADES exp. data

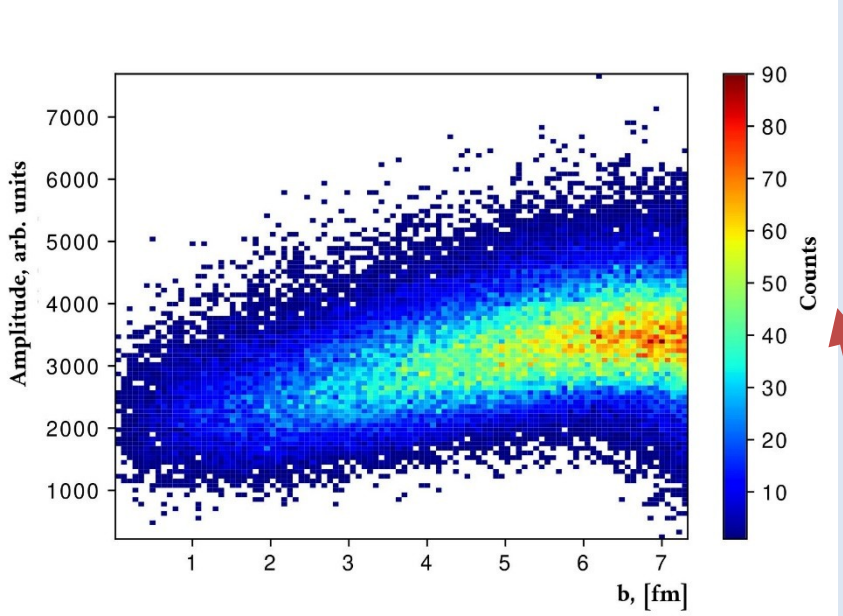
Au+Au at 1.23AGeV (PT3 trigger)
Number of TOF+RPC hits



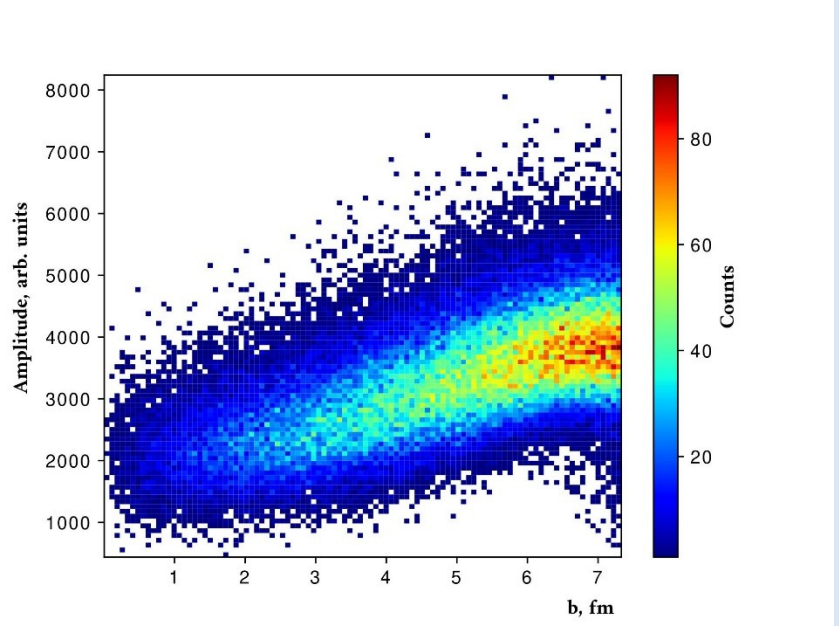
- Forward Wall can be used for centrality classes prediction.

ML for simulations (0-40% centrality)

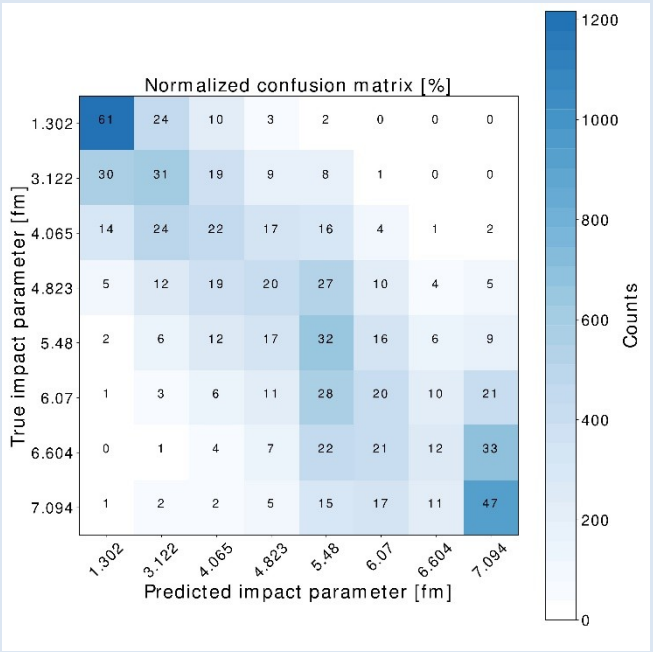
Ag+Ag@1.58 DCM-QGSM-SMM

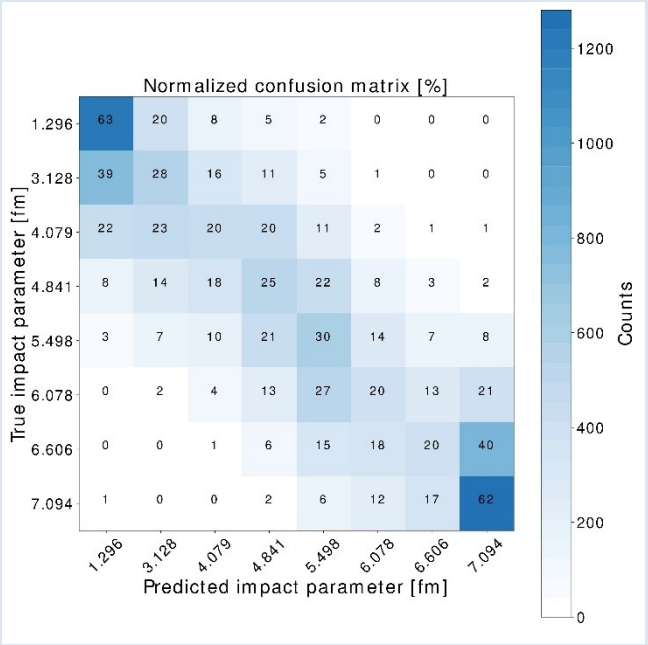


Ag+Ag@1.58 DCM-QGSM



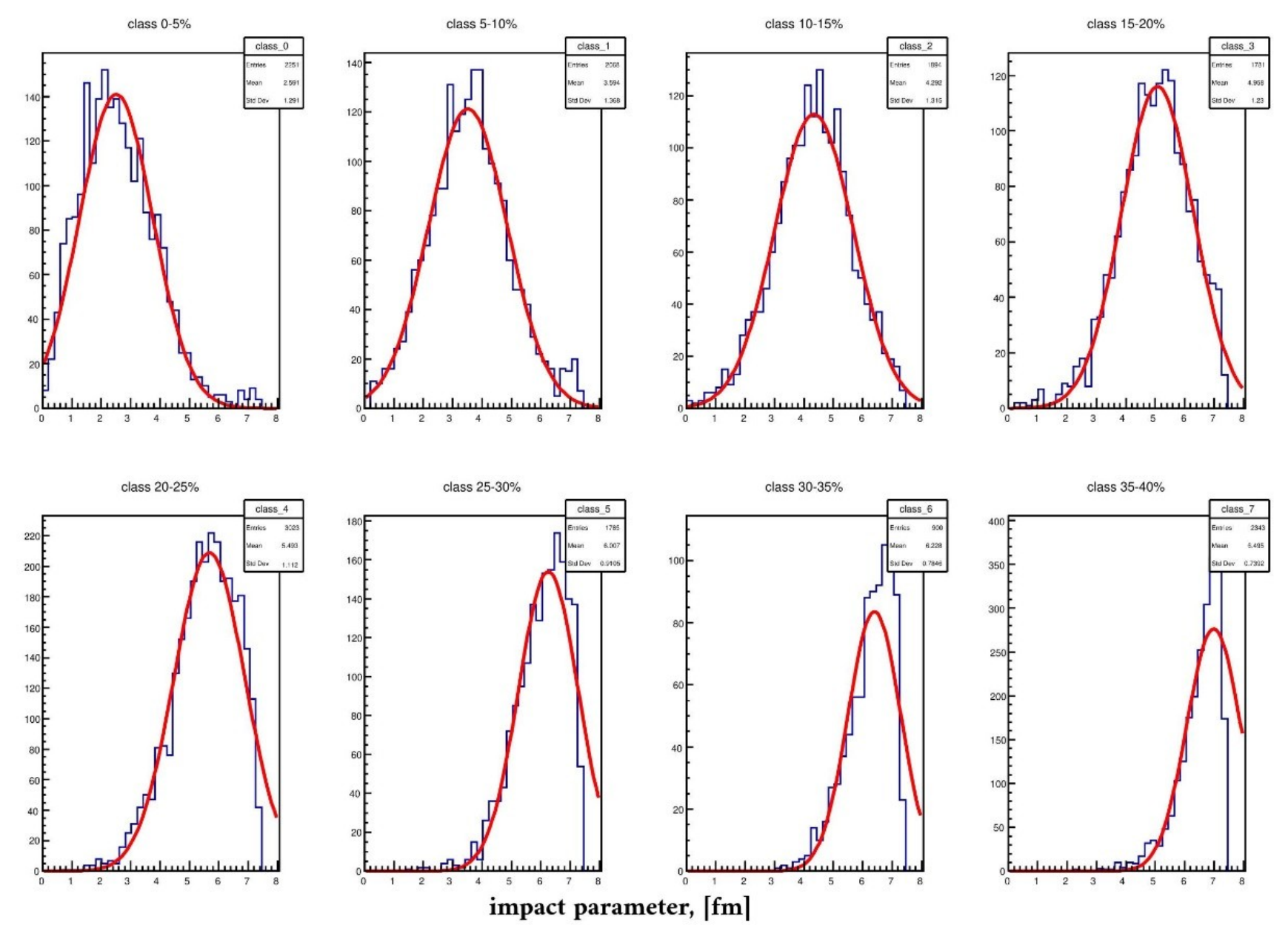
Charge distributions for Forward Wall depend on a model





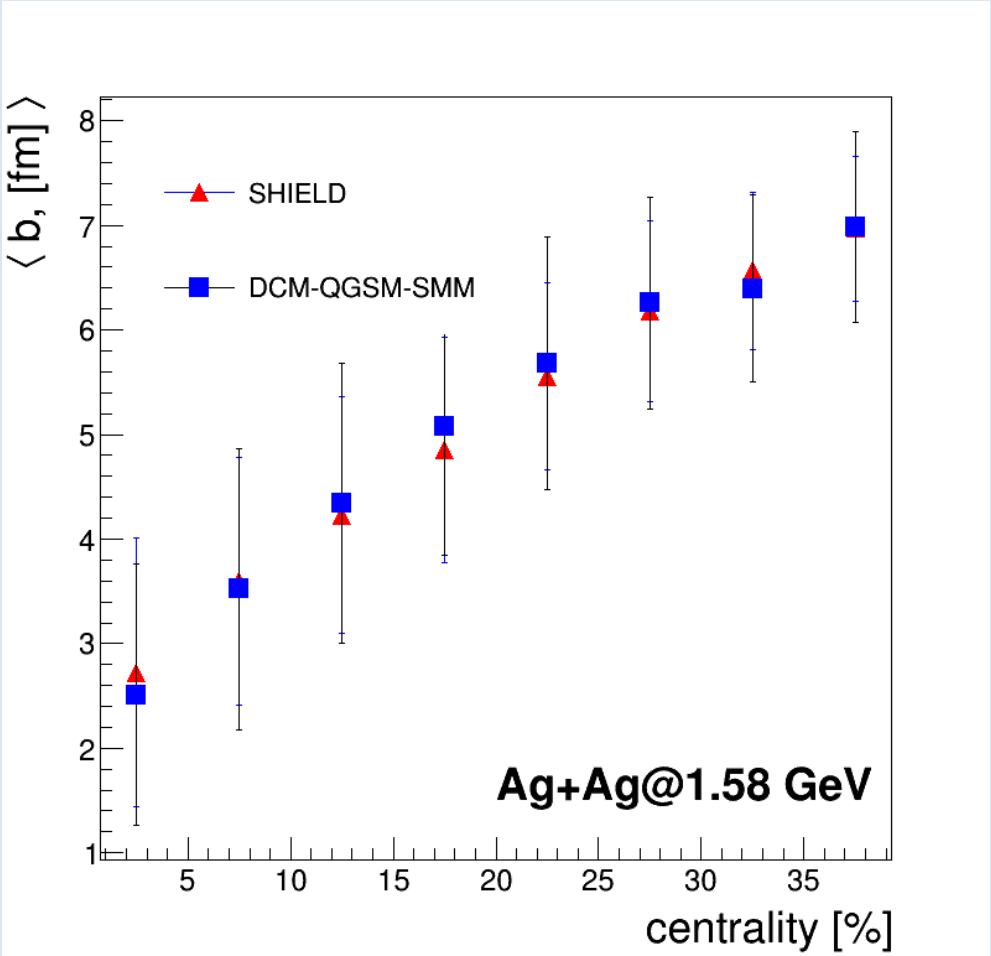
ML for simulations (0-40% centrality)

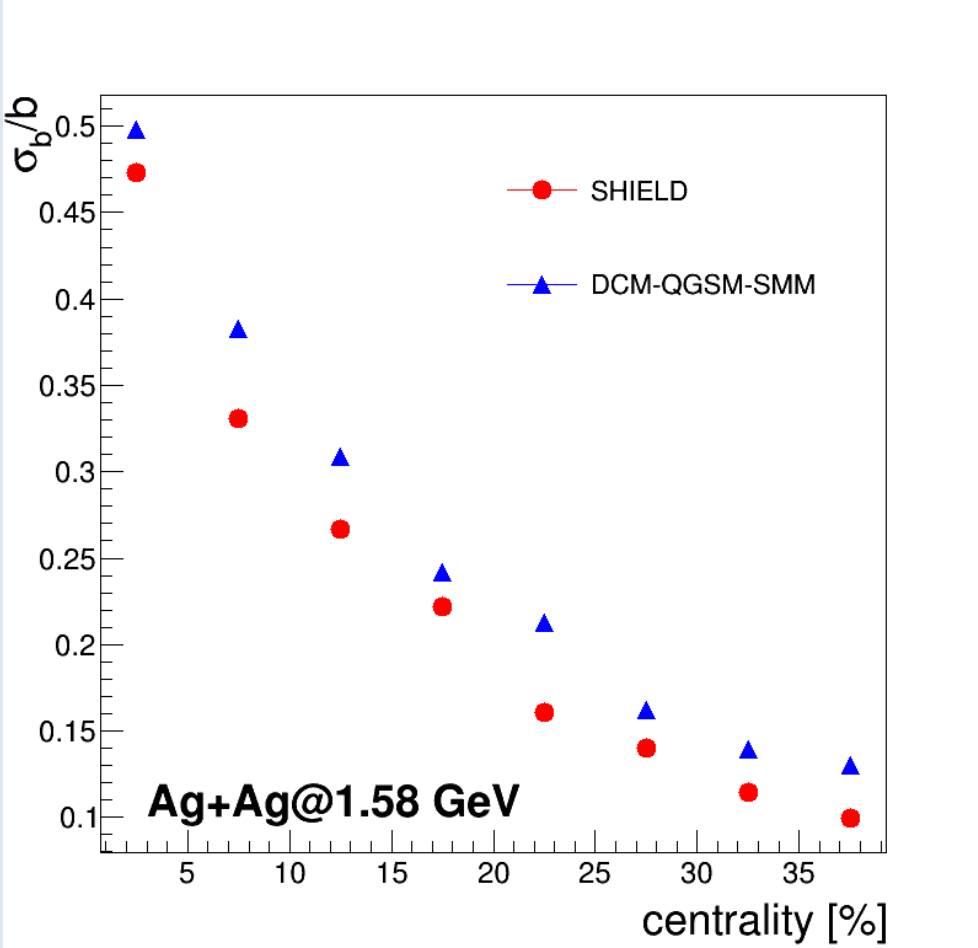
Ag+Ag@1.58 DCM-QGSM-SMM



ML for simulations (0-40% centrality)

Comparing centrality determination with ML for DCM-QGSM-SMM vs DCM-QGSM (SHIELD code)





- SHIELD provides slightly better resolution than DCM-QGSM-SMM.

Summary

- Supervised ML approach was applied for centrality classes determination in HADES with Forward Wall detector.
- The results of applying the approach to the HADES data and simulations with different collision energies and systems were shown.

Outlook

- Further improvement of method will be carried out.