Study of spectator distributions in the HADES experiment

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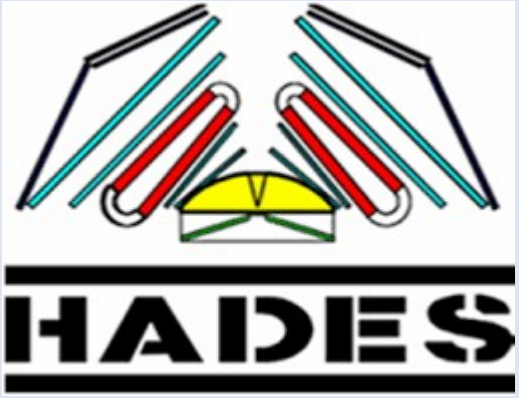


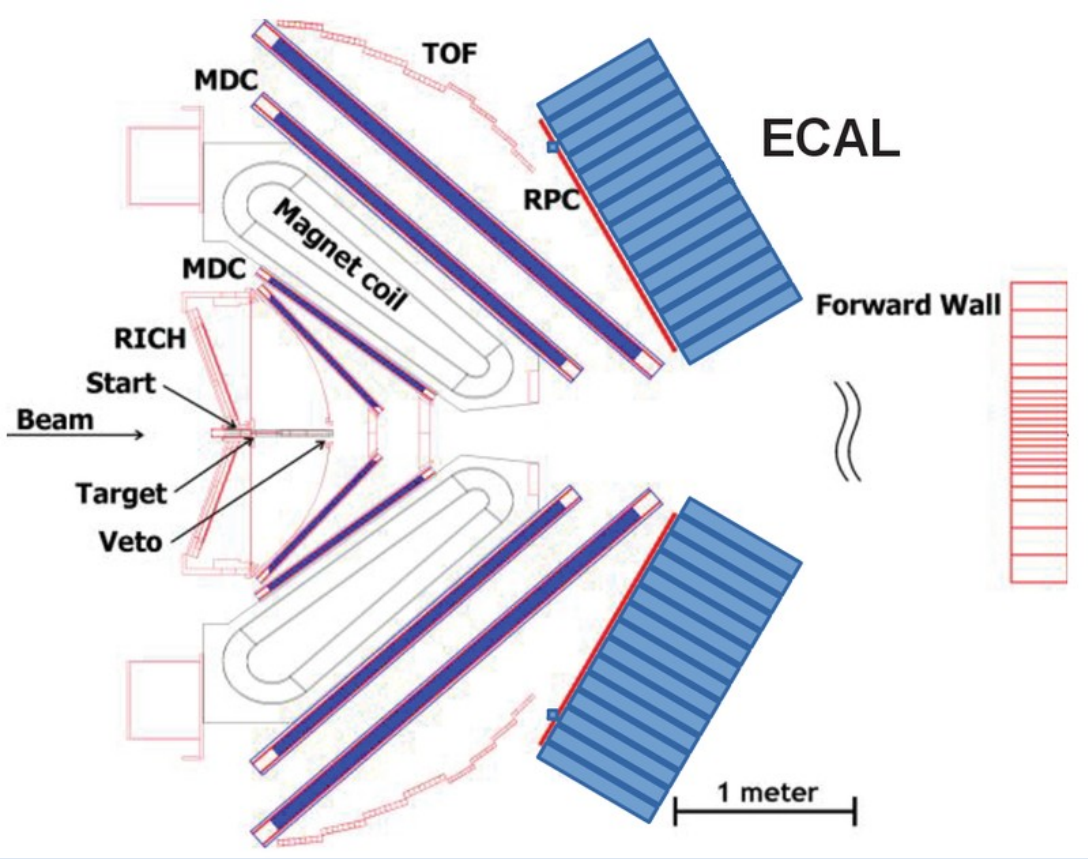
Outline

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

Aim of this research

- New results for comparing experimental data in the HADES experiment and various models at Au+Au@1.23AGeV and Ag+Ag@1.58AGeV for spectators detected in the forward detector.

HADES experimental setup



Tracking system:

- Multi-wire drift chambers (MDC)

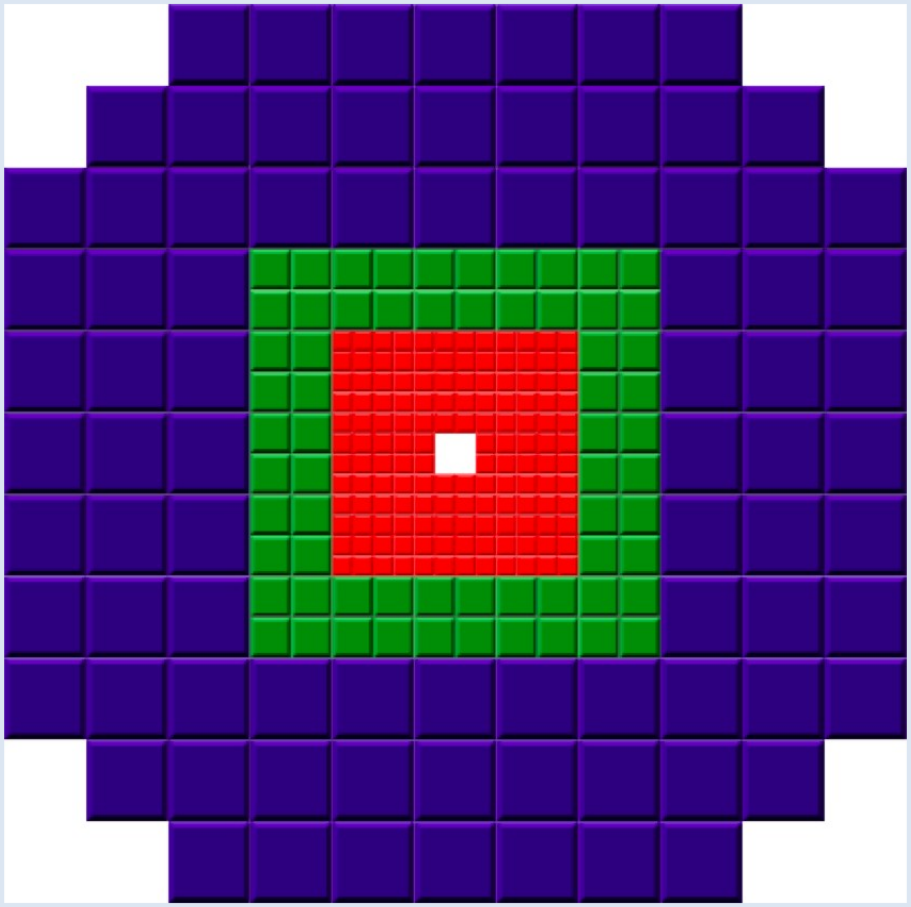
Particle identification:

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

Event plane reconstruction:

- Forward Wall (FWall)

Forward Wall detector

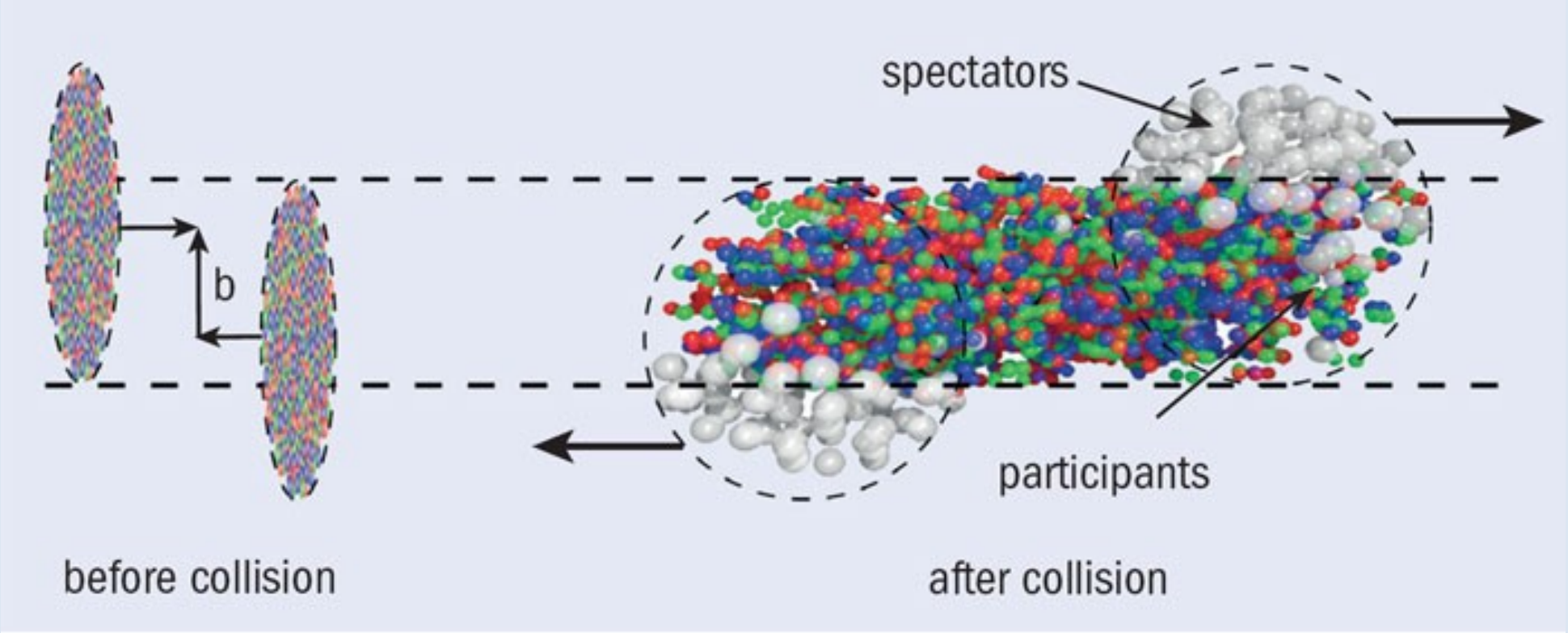


288 individual scintillator detectors:

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

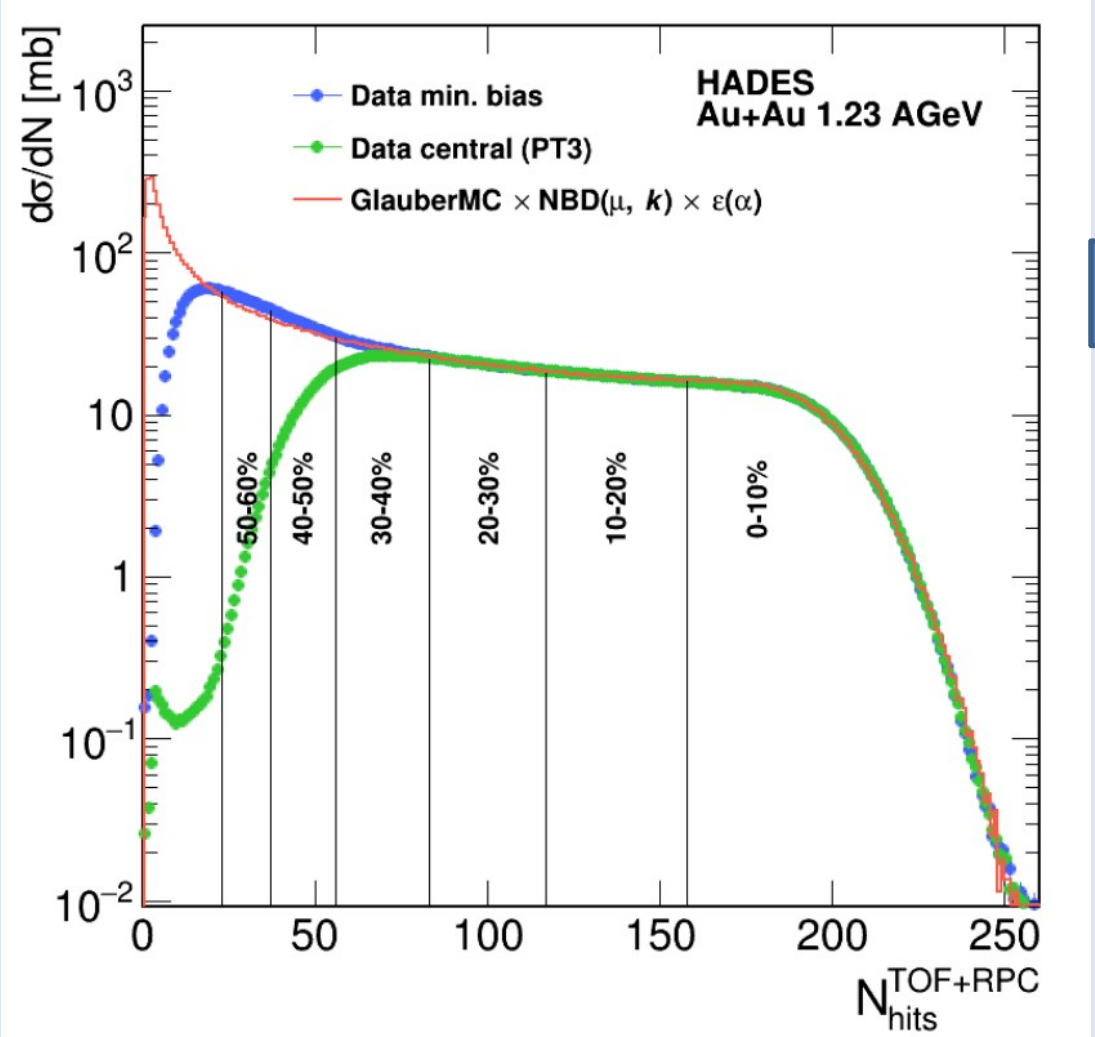
In this work spectators charge distributions are studied separately for cells of different sizes: small, medium and big.

Collision geometry



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

Centrality determination in the HADES



Glauber approach based on the multiplicity of produced particles

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

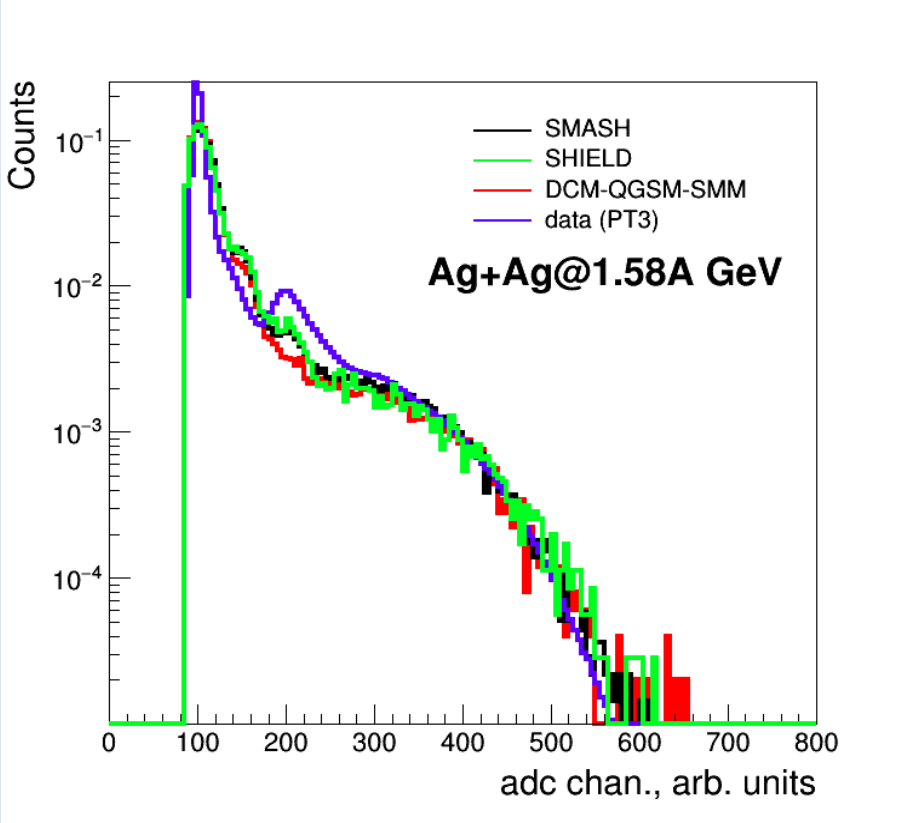
Tools

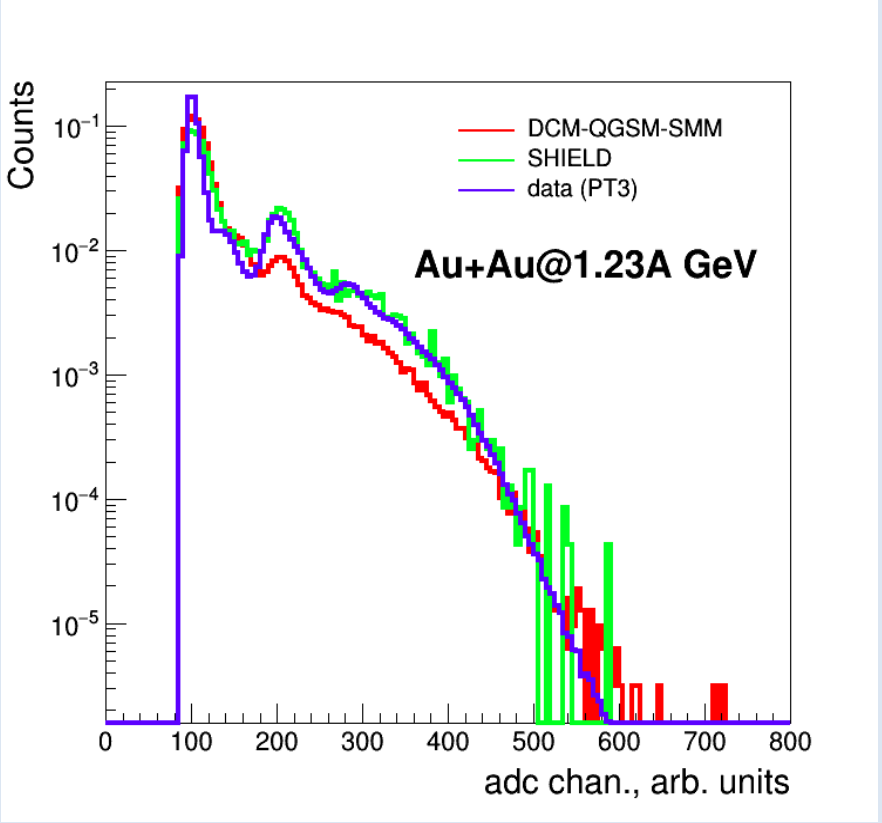
Models	DCM-QGSM-SMM SHIELD SMASH+naive clusterization
System	Au+Au at 1.23AGeV Ag+Ag at 1.58AGeV
Transport code	GEANT3
Detector response	HYDRA
Trigger	PT3 (0-40% centrality)

ML Framework: N. Karpushkin (INR RAS)

Comparison of the FWall charge distributions in various models

Big cells (Angle: 3.27 - 7.27°)

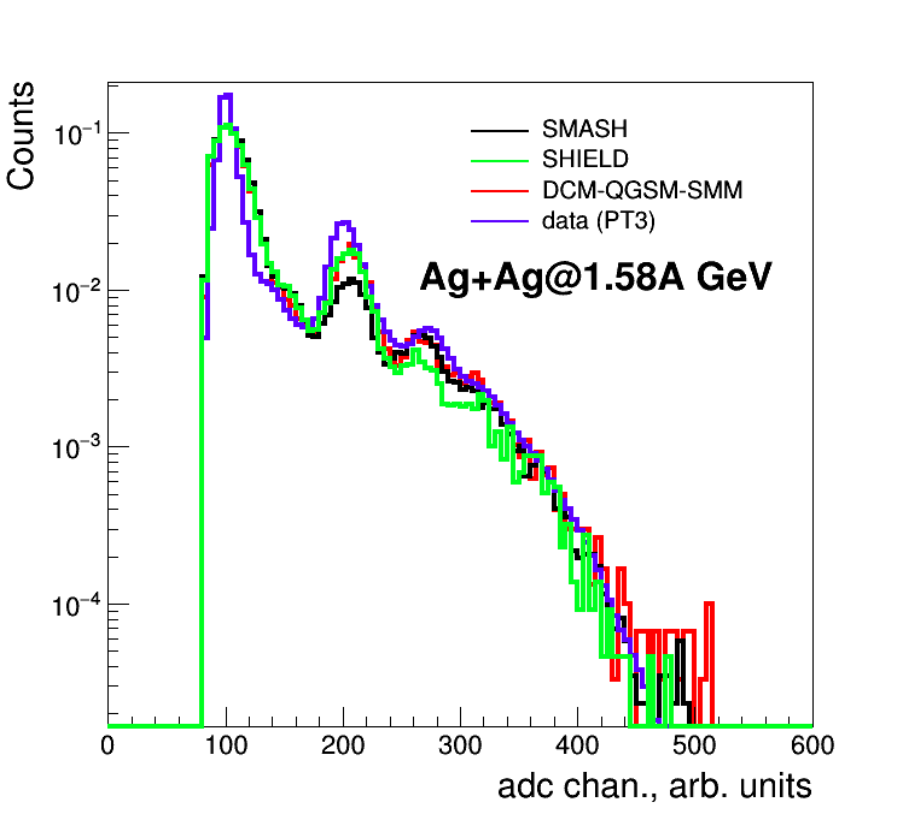


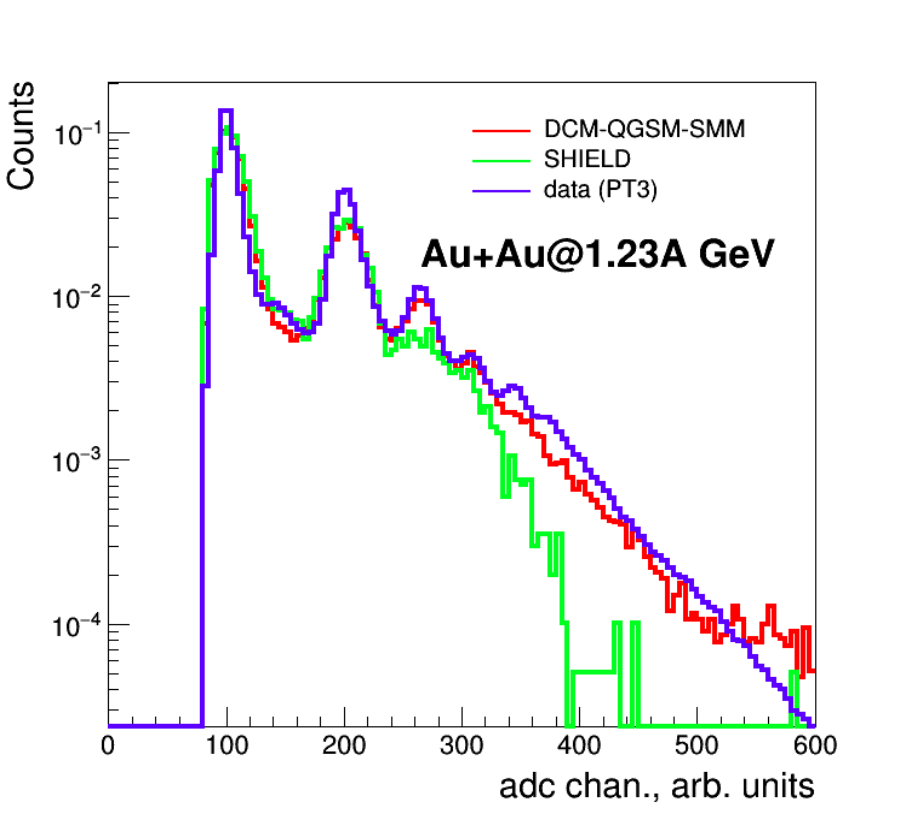


- In all models there is a discrepancy for particles with Z = 2.
- In DCM-QGSM-SMM there is a discrepancy for particles with Z = 2. SHIELD is in a good agreement with data.

Comparison of the FWall charge distributions in various models

Medium cells (Angle: 1.96 - 3.27°)

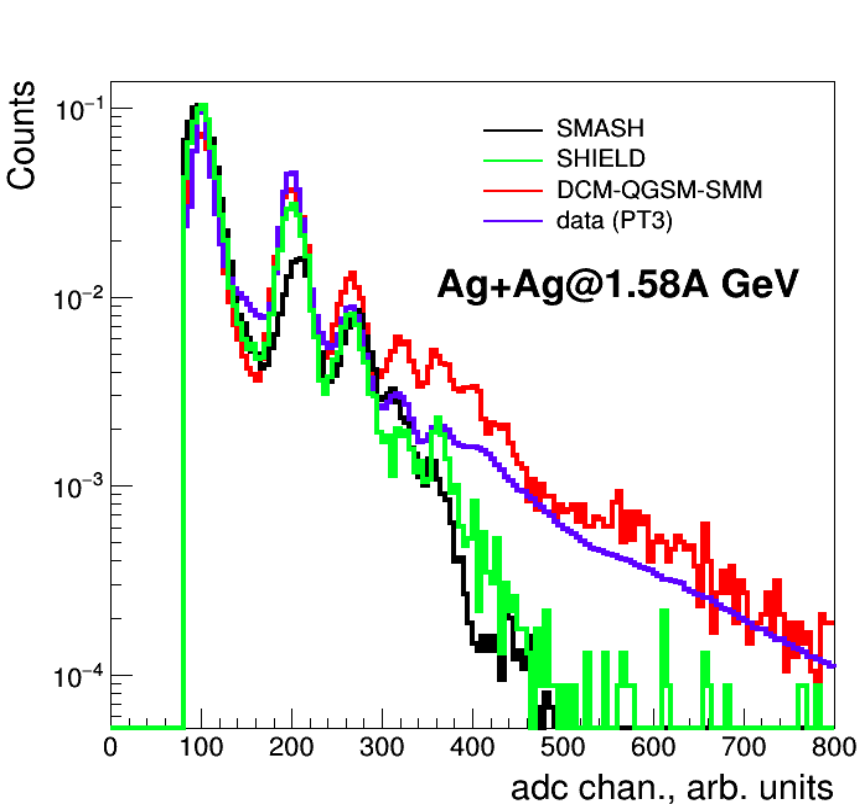


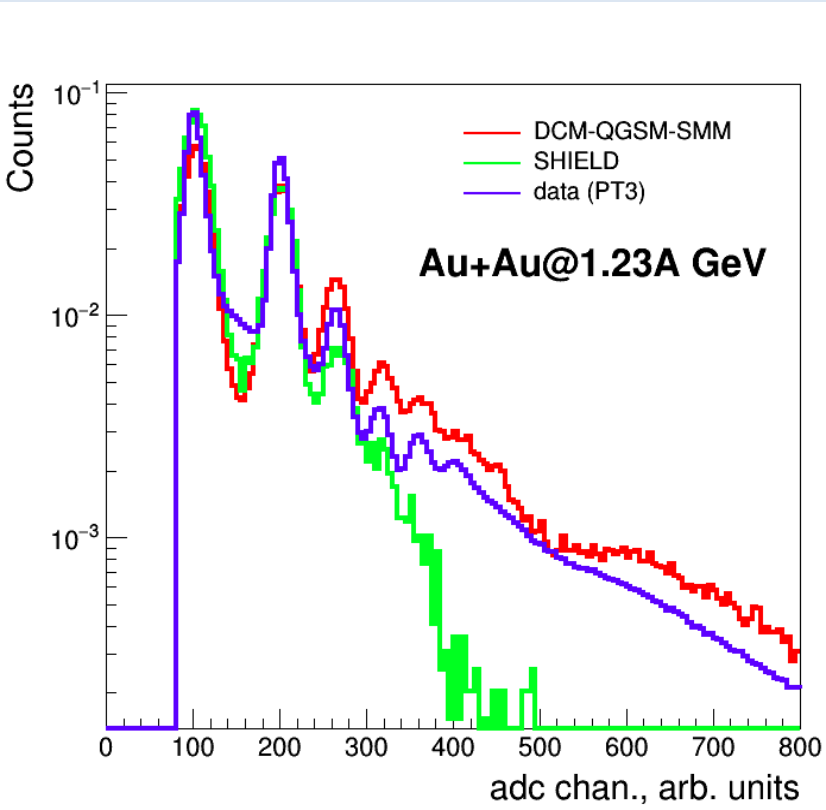


- SMASH and DCM-QGSM-SMM models have a good agreement with data except particles with Z=2.
- DCM-QGSM-SMM model has a good agreement with data. SHIELD has less particle yields for particles with Z>3.

Comparison of the FWall charge distributions in various models

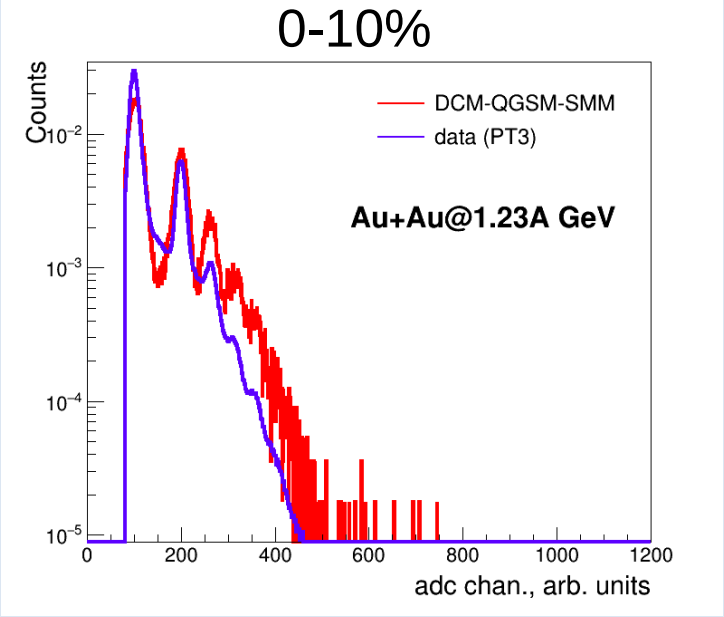
Small cells (Angle: 0.33 - 1.96°)

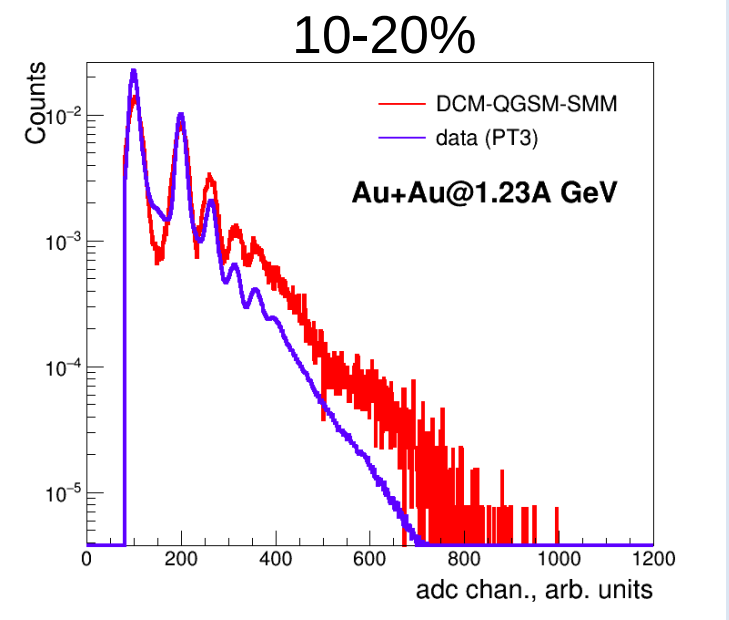


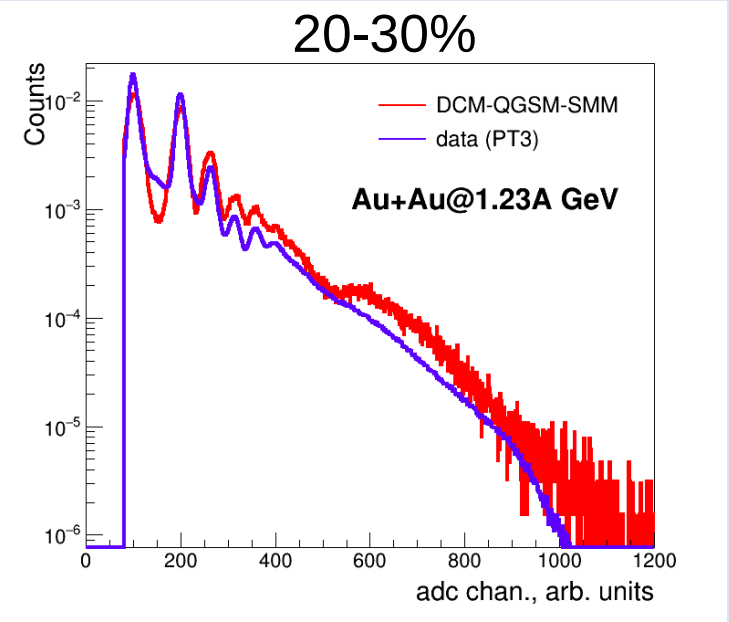


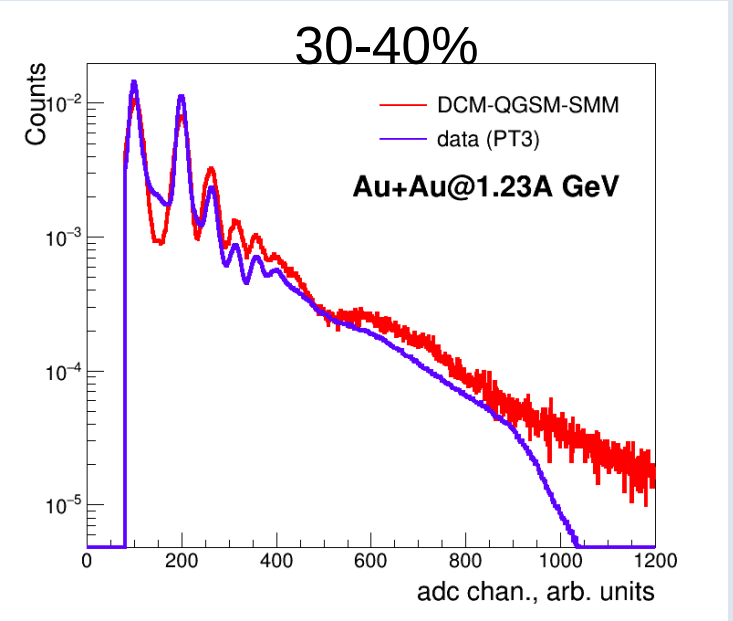
- SMASH and SHIELD couldn't decribe particles charges with Z>3, while DCM-QGSM-SMM provides larger yields for it.
- DCM-QGSM-SMM provides larger yields for particles with Z>3.

Centrality dependence of charge distributions for cells of different size









Conclusion for charge distributions in different models

- Comparison of the FWall charge distributions was carried out for cells of different sizes between experimental data and various models
- The presented models deviate from the data for nuclei with charge Z>3

Future plans

- Further investigation of discrepancies between data and models is required.
- Selection C+Au and C+Ag events from experimental data.
- Configure parameters of other fragmentation models to describe data from the Forward Wall (PHQMD model).

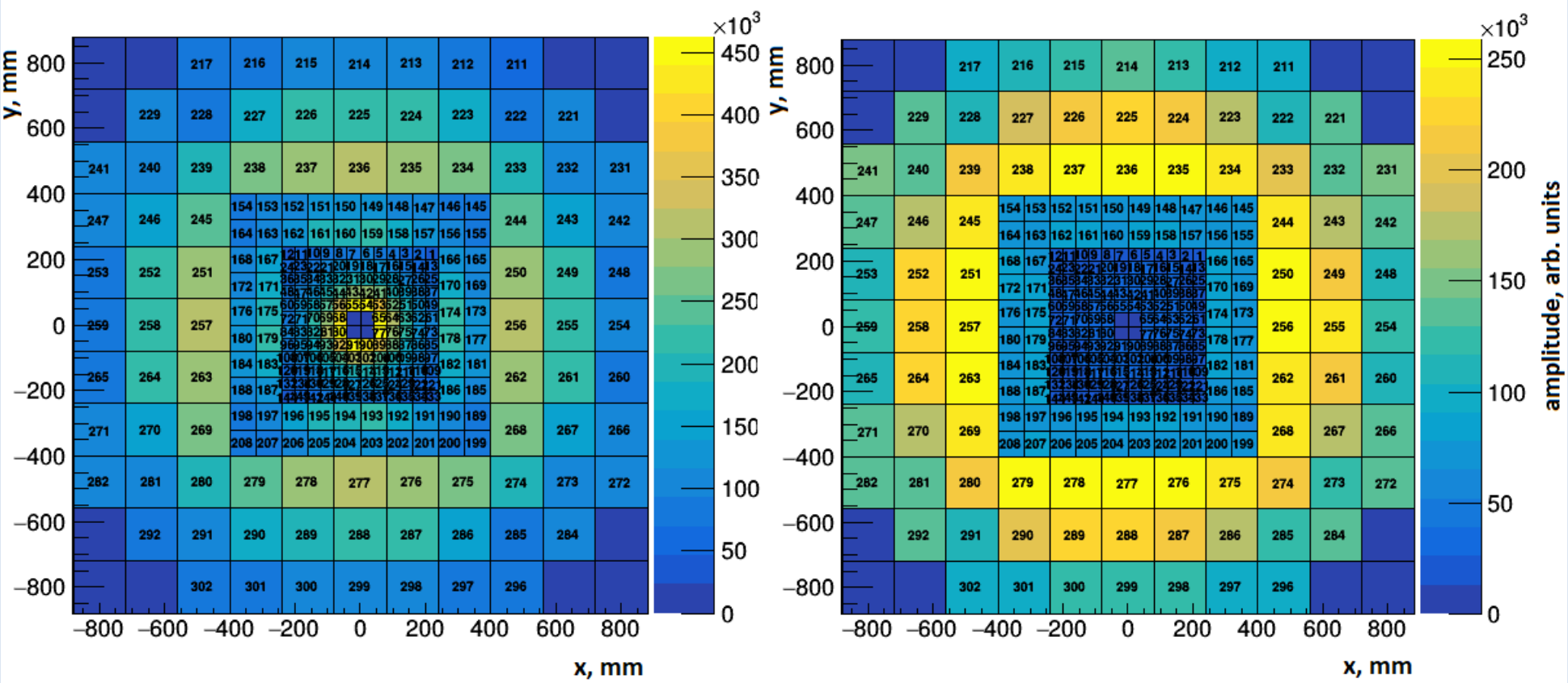
Machine learning technique

Input parameters – FWall cells positions and amplitude 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

Supervised approach

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

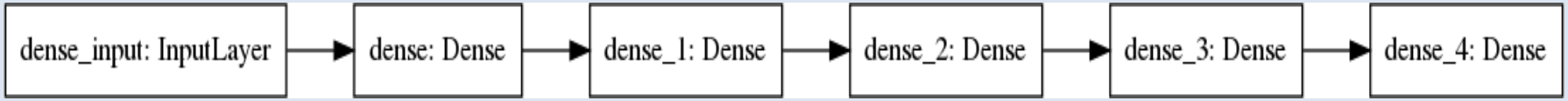
   Inputs:

   - 1D arrays of amplitudes in FWall cells

     (space distribution of Fwall amplitudes)

   - Centrality class index

Model architecture:

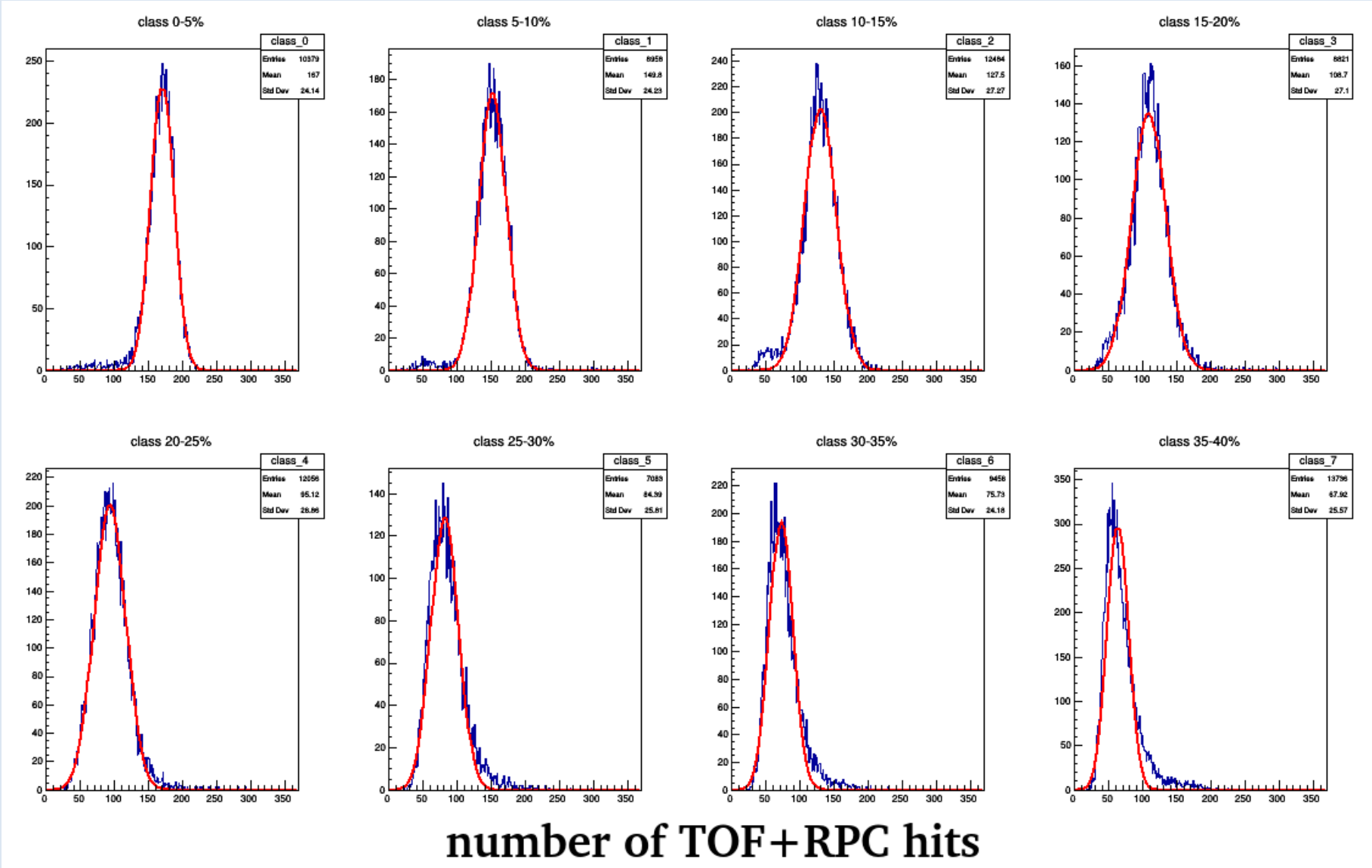


3. Test model accuracy

ML Framework: N. Karpushkin (INR RAS)

ML for the HADES exp. data

Au+Au at 1.23AGeV
Number of TOF+RPC hits



ML for the HADES exp. data

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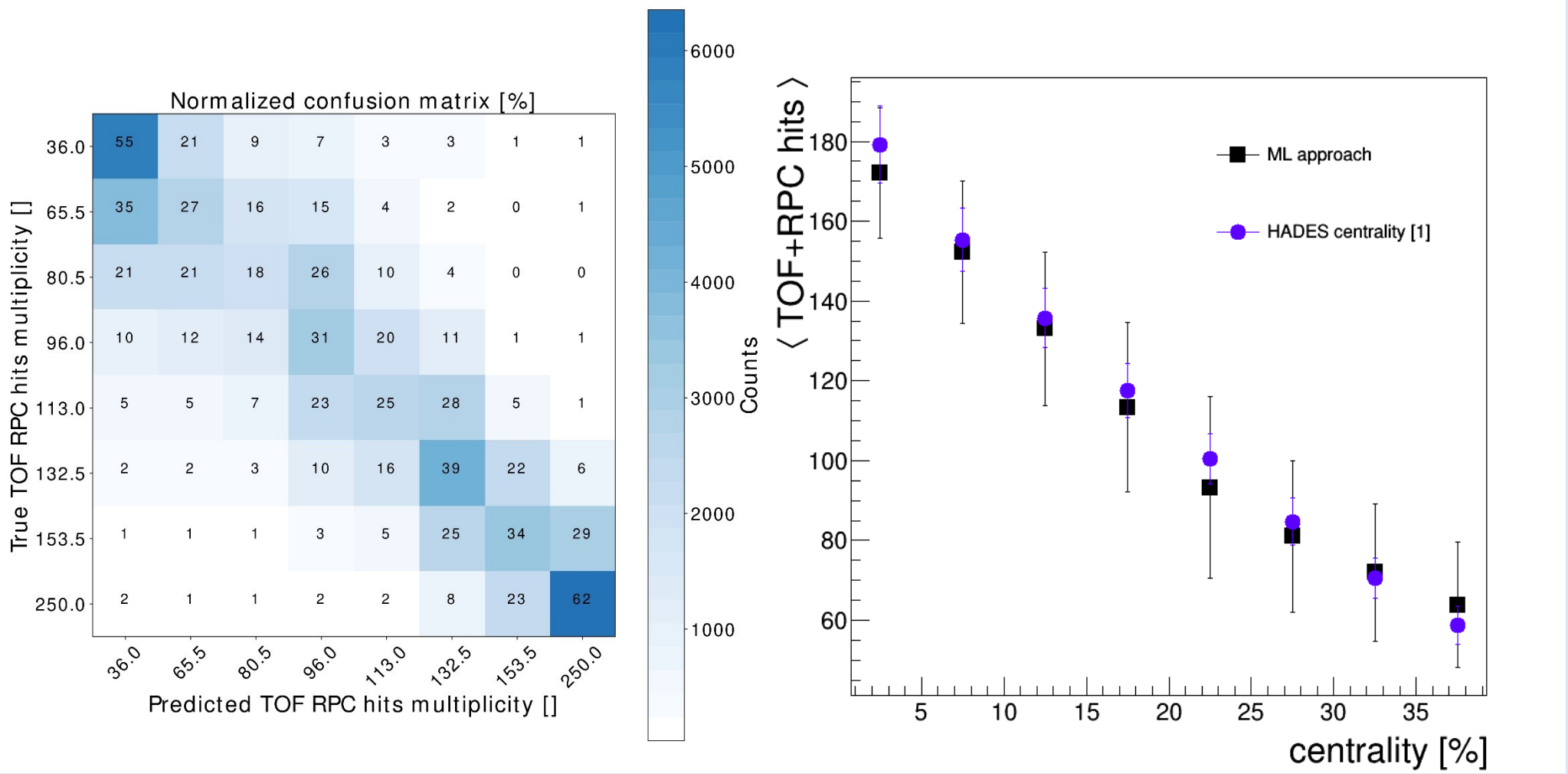

Summary

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

Outlook

- Further improvement of method will be carried out.