Study of charged spectators multiplicity distributions in nucleus-nucleus reactions at the HADES experiments

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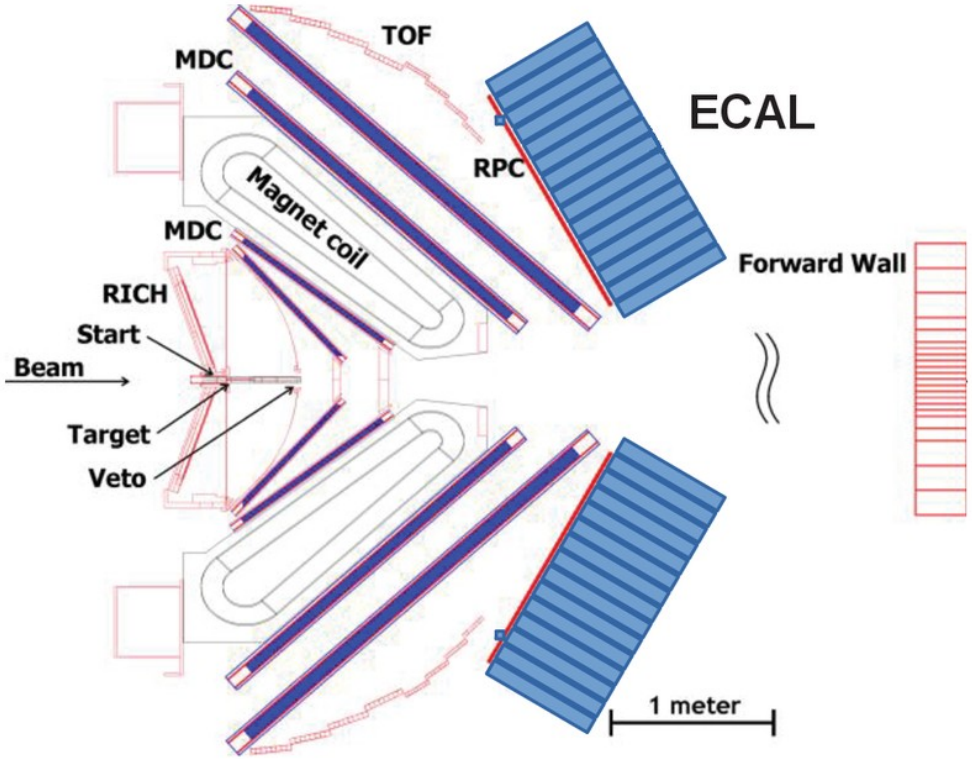
Moscow, 2022

Outline

- HADES experimental setup
- Motivation
- Data preparation
- FWall construction
- Fragmentation algorithms in generators
- Study of the multiplicity for different charge fragments in the Forward scintillation hodoscope
- Conclusions and outlook

HADES experimental setup



Tracking system:

- Multi-wire drift chambers (MDC)

Particle identification:

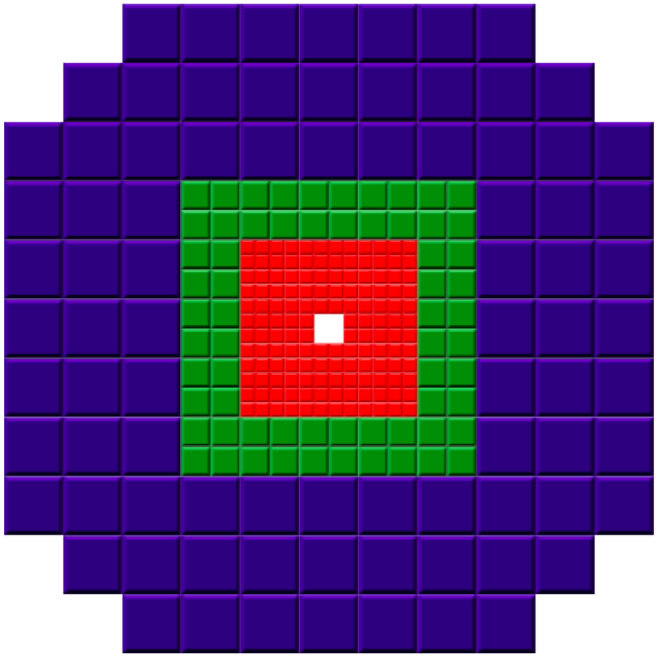
- Time Of Flight (TOF)
- Resistive Plate Chambers (RPC)
- ECAL

Event plane reconstruction:

- Forward Wall (FWall)

- The spectrometer has 85% azimuthal acceptance and covers polar angles between θ = 18 - 85.

Motivation



- Forward Wall in the HADES experiment measures the multiplicity of spectators
- It is necessary to have reliable models for description of the experimental data
- There are several generators with different fragmentation procedures (DCM-QGSM-SMM, SHIELD, PHQMD)
- Multiplicity of fragments in the Forward Wall detector can be used to tune the model parameters as well as work of various event generators

Data preparation

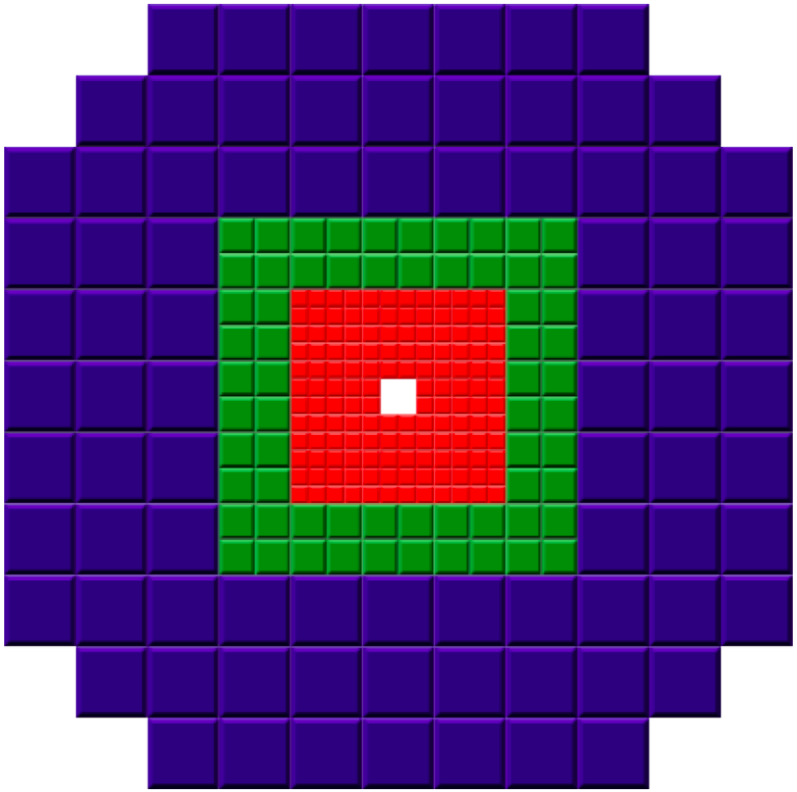
Collision systems	Au+Au at 1.23AGeV Ag+Ag at 1.58AGeV
Models	DCM-QGSM-SMM SHIELD PHQMD+SACA
Transport code	GEANT3
Framework	HYDRA
Event selection	Exp. data: PT3 trigger Simulation: centrality selection with TOF+RPC hits

FWall selection:

Amplitude of the signal in each FWall cell > 88 arb. units

Time of flight for each hit in the FWall [23.5, 27.5] ns

FWall construction



Forward Wall measures the charge and multiplicity of fragments.

It consists of the 288 individual scintillators:

- small cells 40x40 mm ^{2} (0.33 - 1.96°)
- medium cells 80x80 mm ^{2} (1.96 - 3.27)
- large cells 160x160 mm ^{2} (3.27 - 7.27°)

Fragments multiplicity is studied separately for cells of different sizes: small, medium and large, which corresponds to the different entering angle of particles.

Fragmentation algorithms in generators: PHQMD

Clusters recognition in **PHQMD** generator:

- **SACA** (Simulated Annealing Clusterization Algorithm)
- **MST** (Minimum Spanning Tree)

The MST algorithm searches for accumulations of particles in coordinate space:

1. Two particles are 'bound' if their distance in the cluster rest frame fulfills

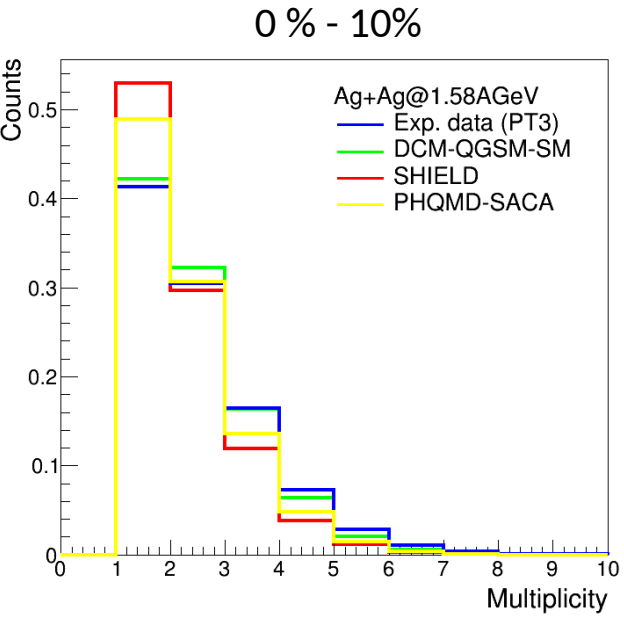
$$| r_i - r_j | \leq 4 \text{ fm}$$

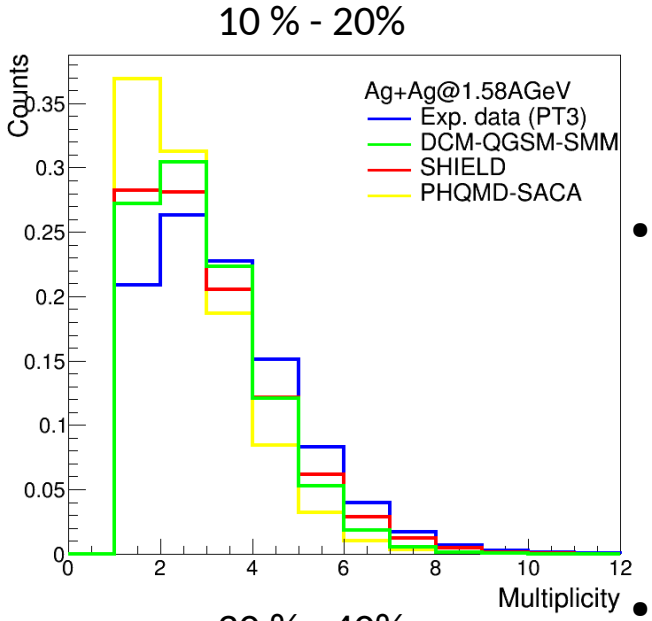
2. Particle is bound to a cluster if it bounds with at least one particle of the cluster.

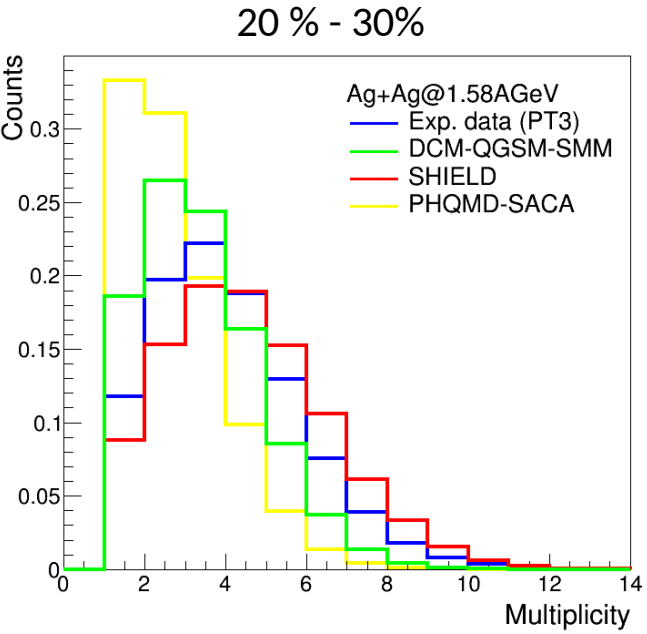
- SACA algorithm is based on the search for nucleon configurations with a minimal binding energy: SACA takes randomly one nucleon and adds it to another fragmet until the most bound configuration will be found. In SACA algorithm is it necessary to chose the time for its starting.

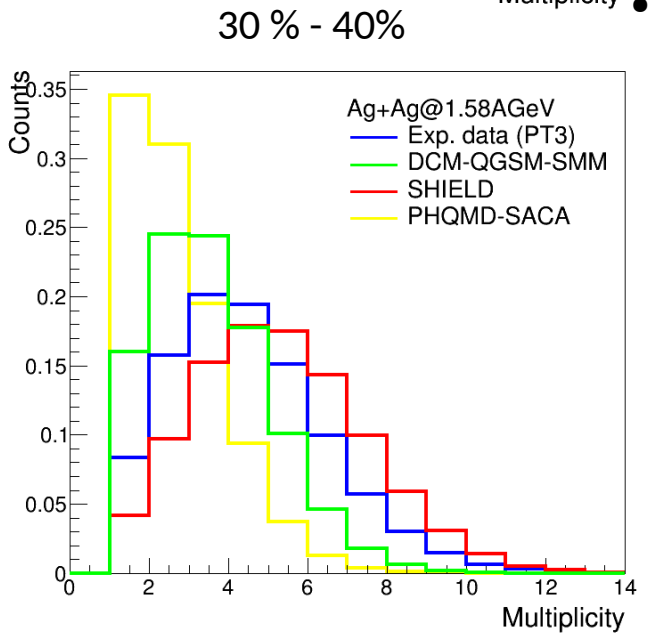
J. Aichelin et al., PRC 101 (2020) 044905

Multiplicity of fragments with Z=1 in small cells



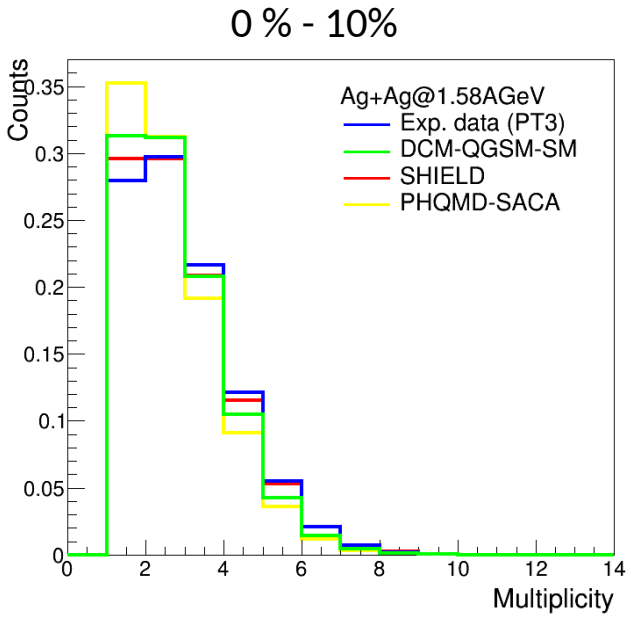


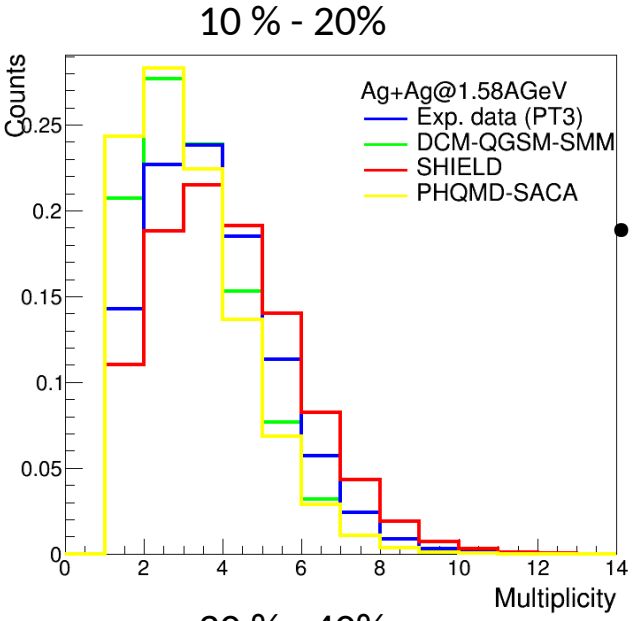


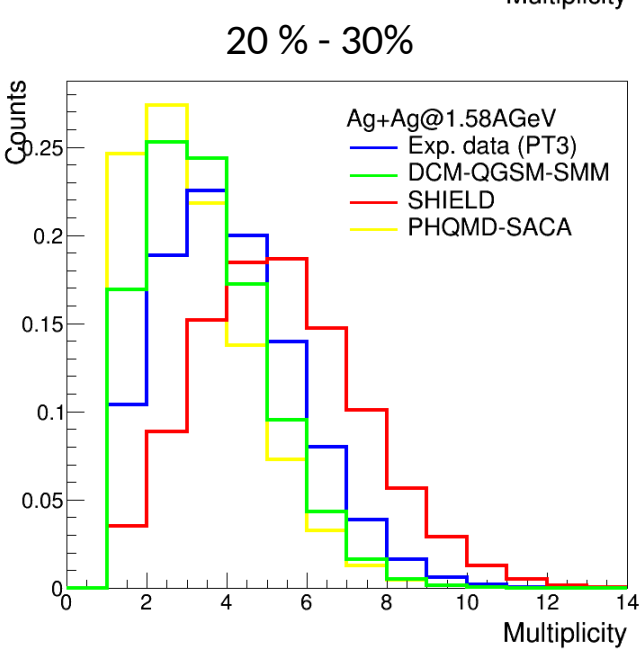


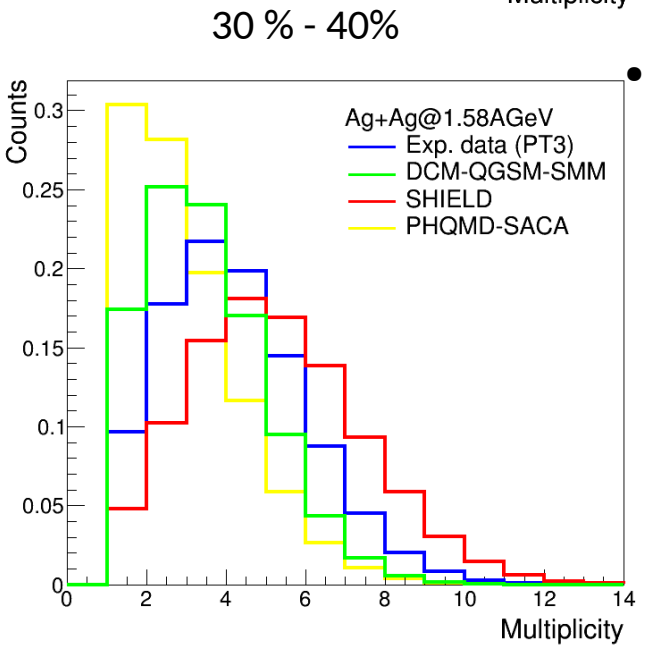
- The most central collisions are in a better agreement with experimental data in small cells of the FWall
- SHIELD generator provides better description of the more peripheral collisions than other models

Multiplicity of fragments with Z=1 in medium cells





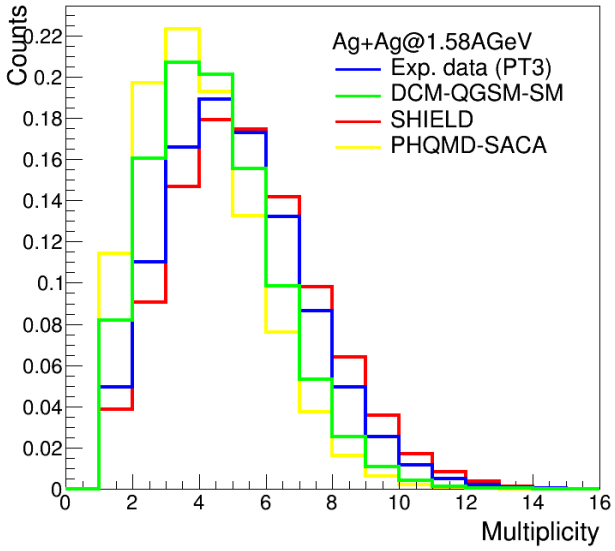




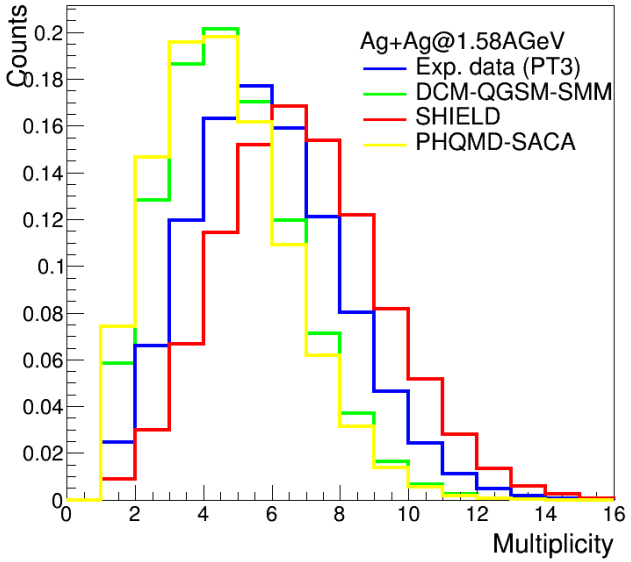
- The most central collisions are in a good agreement with experimental data in medium cells of the FWall
- In more peripheral collisions there is a shift of all model spectra relatively to the experimental data

Multiplicity of fragments with Z=1 in large cells

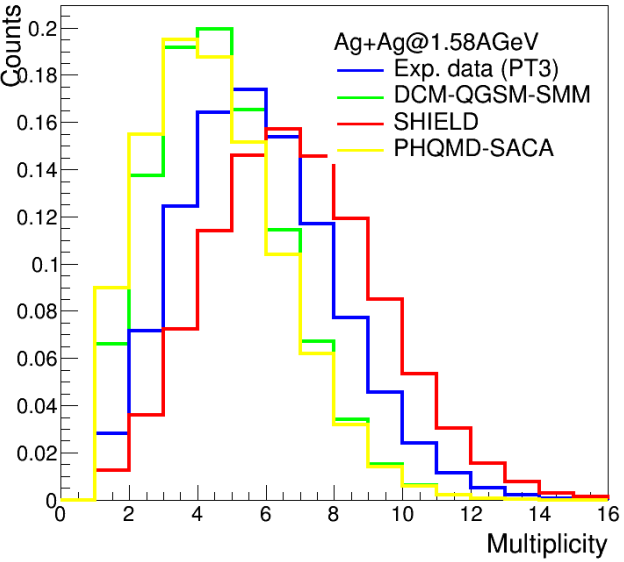
0 % - 10%



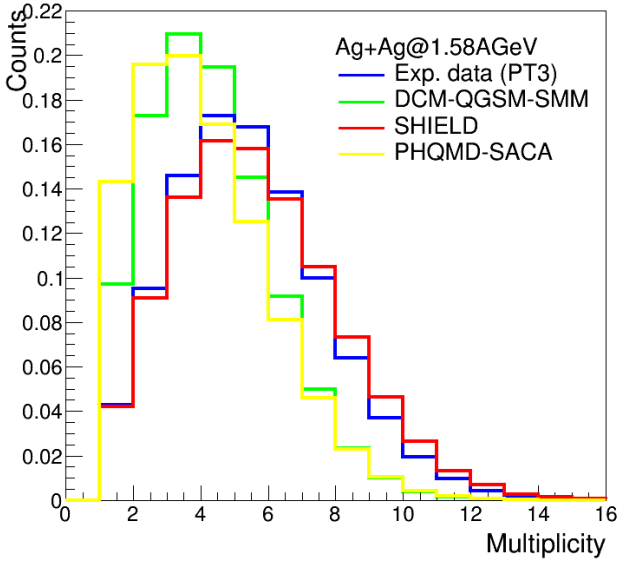
10 % - 20%



20 % - 30%



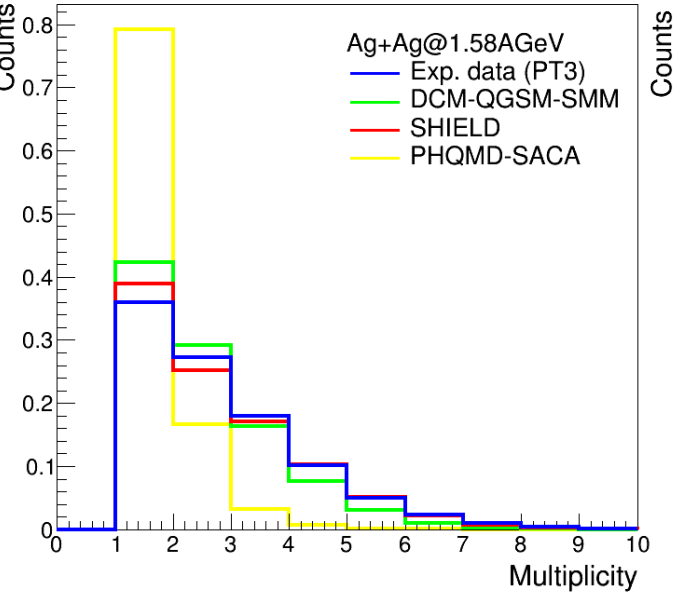
30 % - 40%



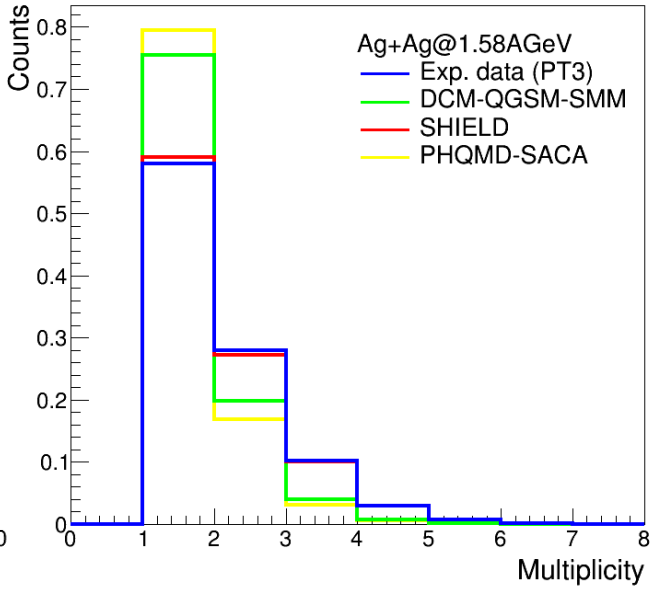
- The most central and most peripheral collisions in the SHIELD generator are in a good agreement with experimental data in large cells of the FWall
- In centrality range from 10-30% there is a shift of all model spectra relatively to the experimental data

Multiplicity of fragments with Z=2

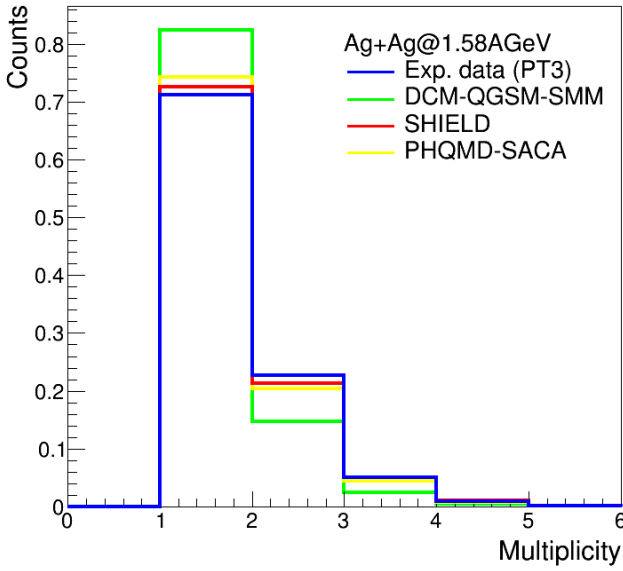
Small cells:



Medium cells:



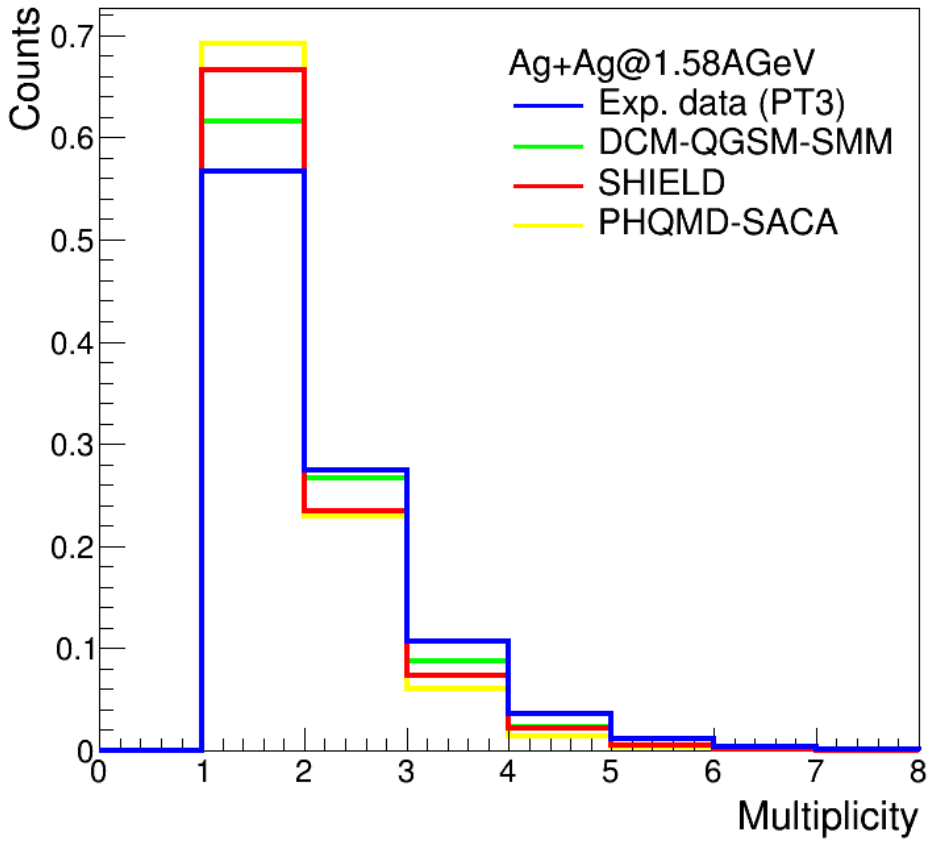
Large cells:



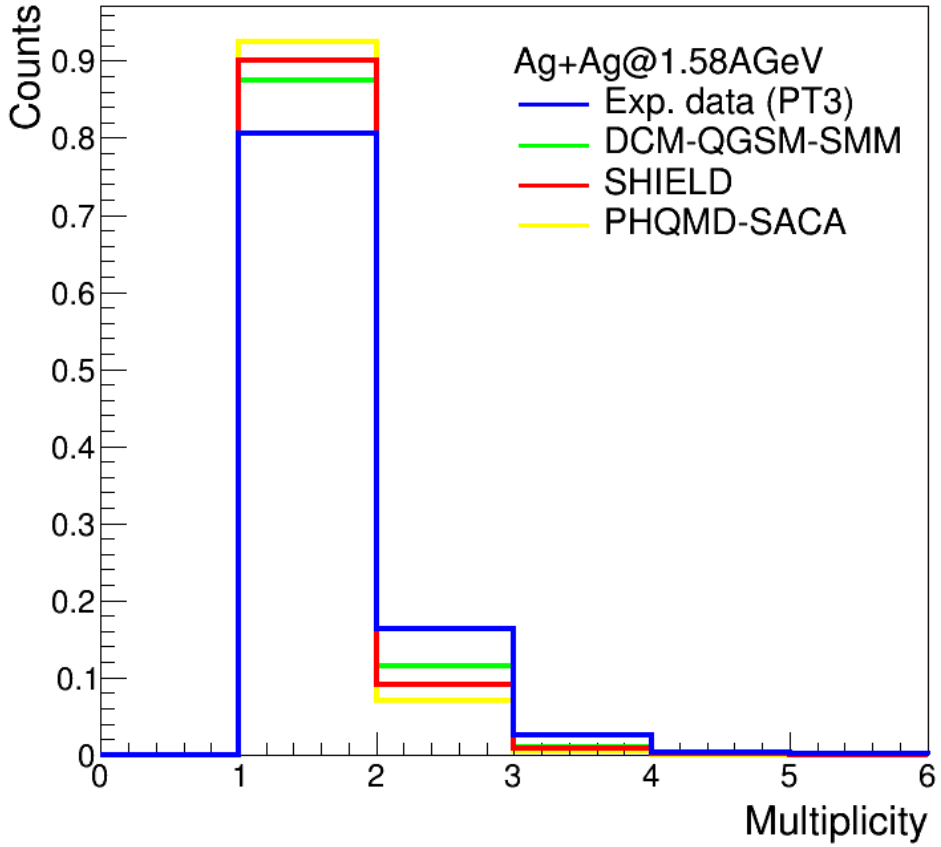
- SHIELD generator provides better description of particles with Z=2 in forward hodoscope

Multiplicity of fragments with Z=3 and Z=4

Z=3



Z=4



- For each event, on average, there is one triggered cell for particles with charges of 3 and 4 for experimental data and simulations.

Conclusion

- Multiplicity distributions were studied for particles with Z=[1-4] in FWall for different centrality classes in experimental data and different models (DCM-QGSM-SMM, SHIELD and PHQMD)
- In Ag+Ag@1.58 AGeV experimental data multiplicity distributions from Forward scintillation hodoscope are better described by the SHIELD model
- There is no model which is in a good consistency for all centrality classes with experimental data
- The obtained results can be used futher to tune the models

Fragmentation algorithms in generators: DCM-QGSM-SMM

Clusters recognition in **DCM-QGSM-SMM** generator.

In DCM-QGSM fragment production is subdivided into three stages:

- A dynamical stage leading to formation of equilibrated nuclear system, which is described by DCM,
- Disassembly of the system into individual primary fragments described by SMM,
- De-excitation of hot primary fragments according to evaporation/fission models. If on the stage 2 we obtain the compound nucleus, then its disintegration takes place at the stage 3 as in the case of other hot fragments.