



Simulation of Response of the BBC Detector to Heavy-Ion Collisions in SPD Phase0

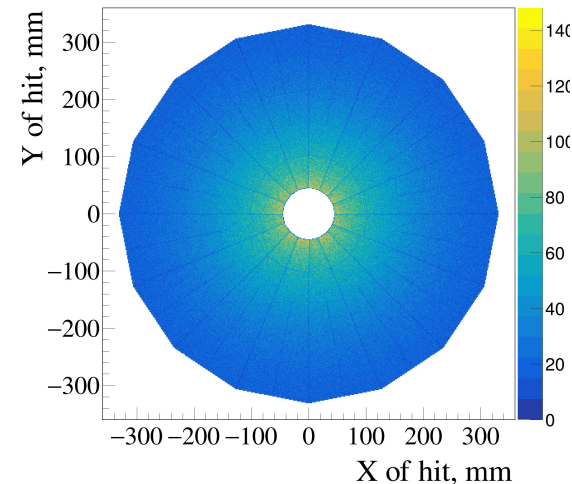
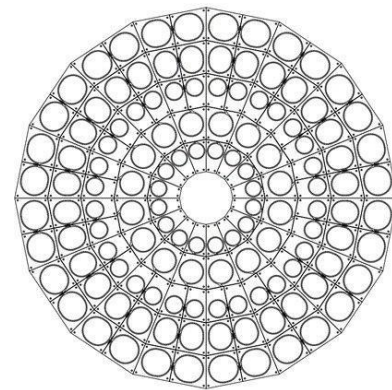
Ivan Volkov

October, 2025

Motivation

Phase 0 - first test runs at NICA

1. For **Phase 0**, which is planned to employ a ^{124}Xe beam scattering on a fixed target, the DCM-QGSM-SMM generator was chosen for its ability to simulate **clusterization** processes, critical for modeling nuclear fragmentation and secondary particle production in **heavy-ion** fixed-target collisions.
2. **Geant4** was preferred over **SPDRoot** because it fits better for **BBC Phase 0** conditions with its **simplified setup**.

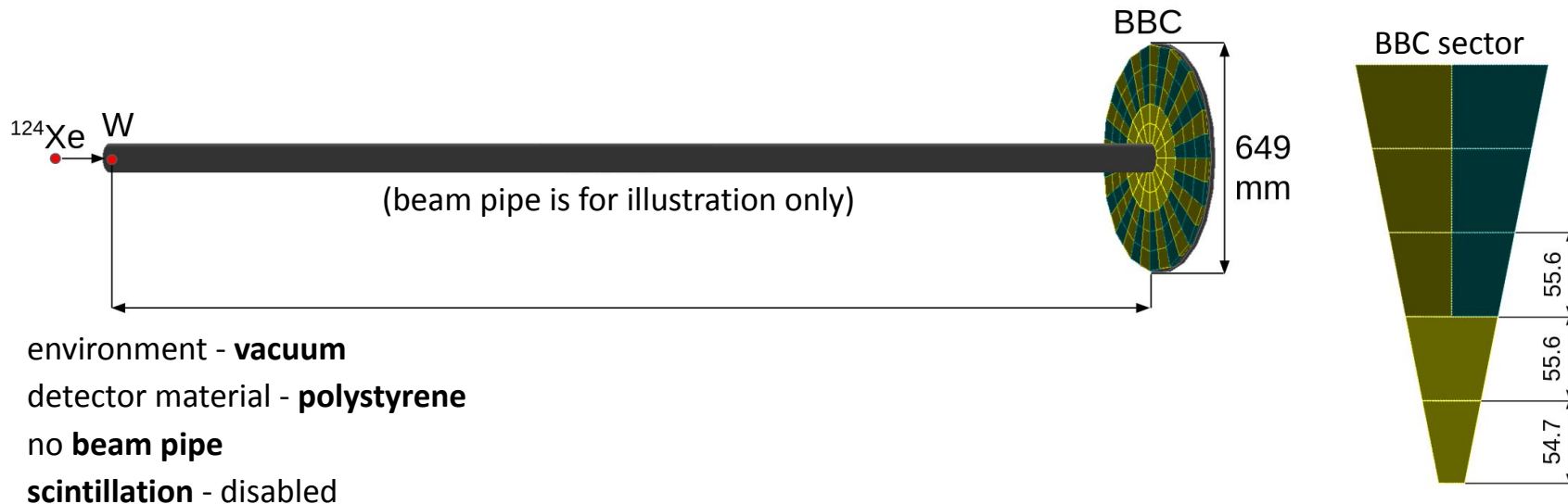


"Simplified" conditions of the simulation in Geant4

^{124}Xe (3 GeV/n) beam interacts with the various fixed targets (Al, Cu, Ag, Au).

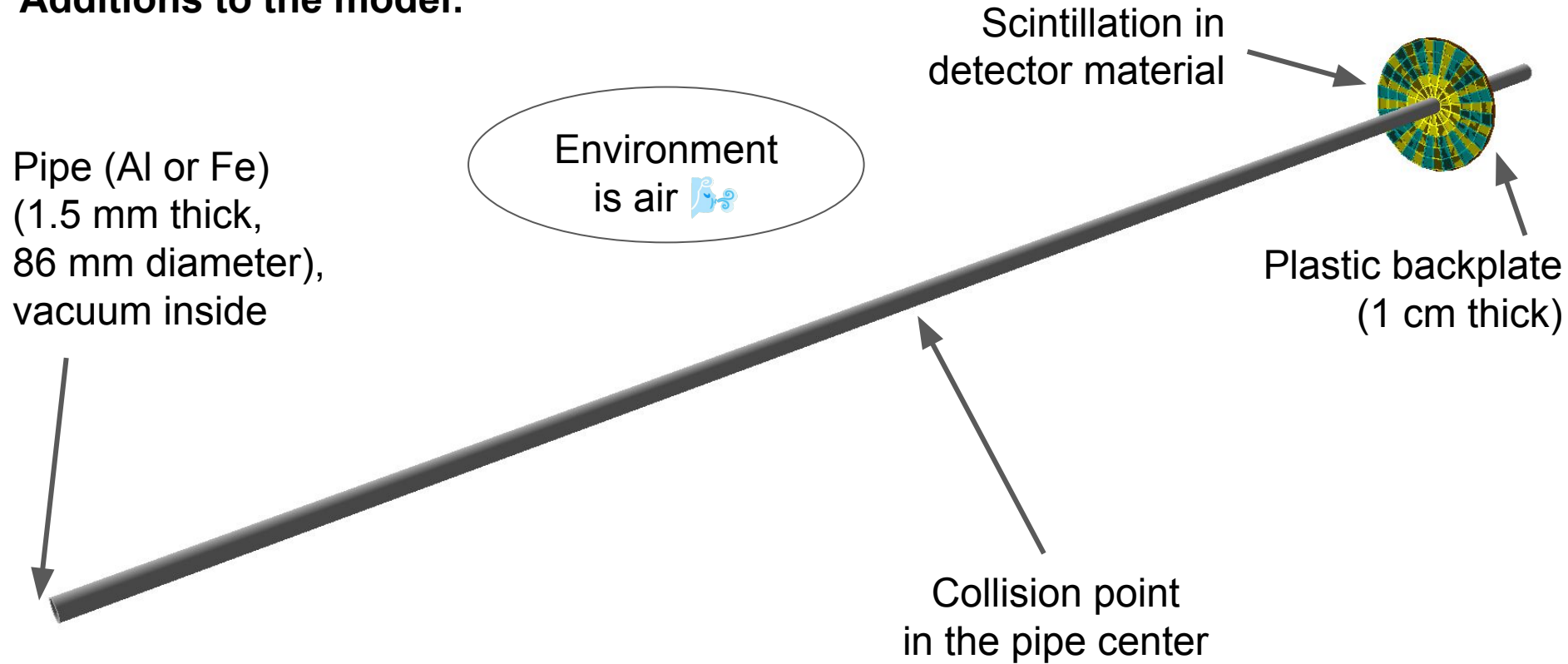
The detector is a wheel with an inner radius of **45 mm** and an outer radius of **324.5 mm**, which is divided into **16 sectors** and **5 rows**.

128 scintillators total, the **gap** between scintillators is **0.6 mm**, **thickness** is **10 mm**.



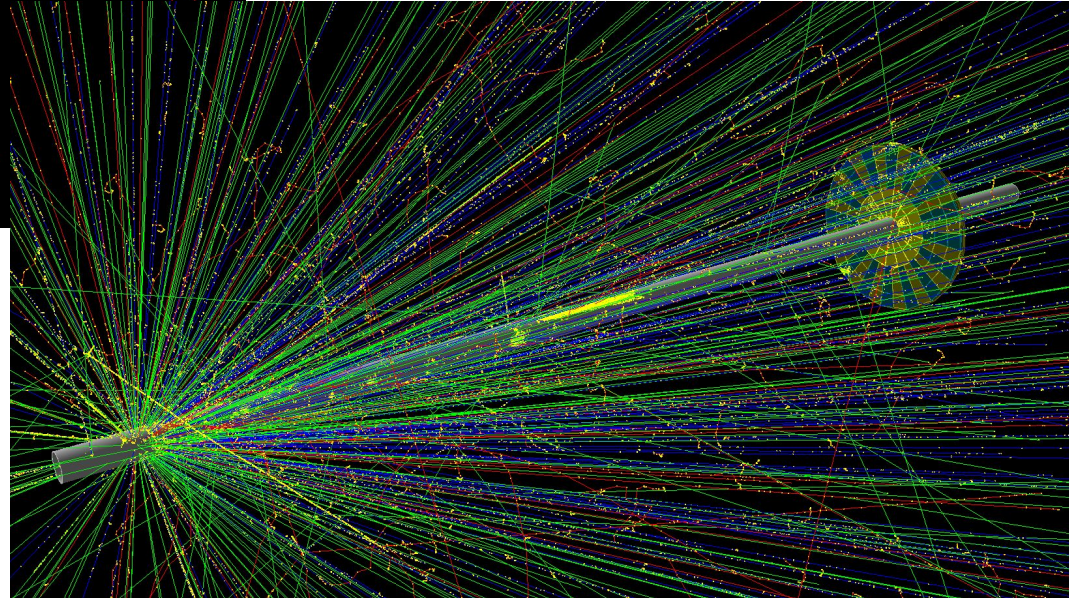
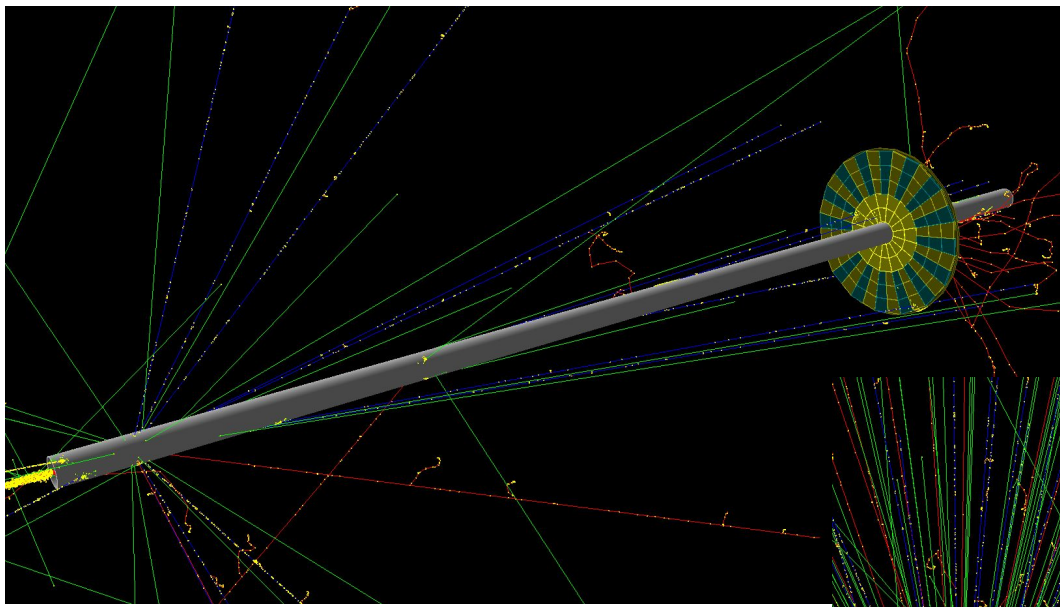
"Advanced" conditions of the simulation in Geant4

Additions to the model:



Large
impact factor

Geant4 simulation visualization (1 event)



Small
impact factor

Xe beam 3 GeV. Number of hitted tiles

Simplified model

BBC position 1 m

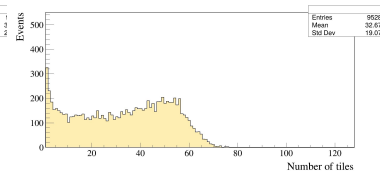
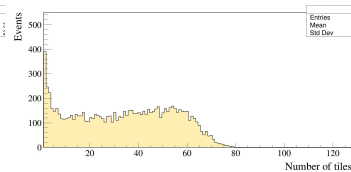
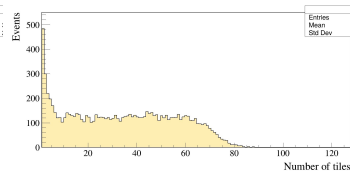
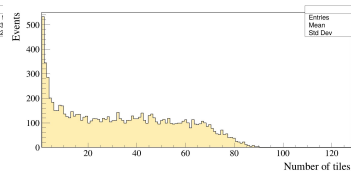
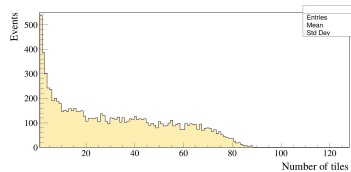
1.5 m

2 m

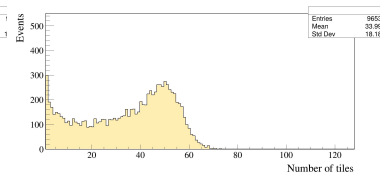
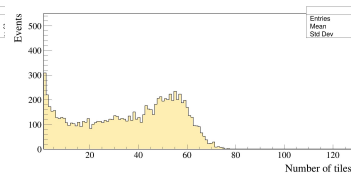
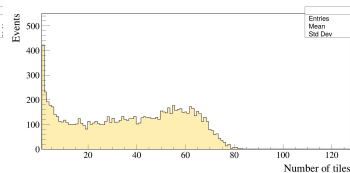
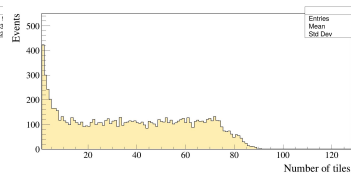
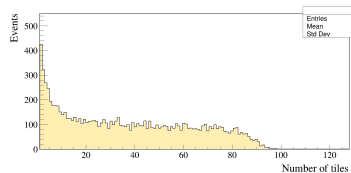
2.5 m

3 m

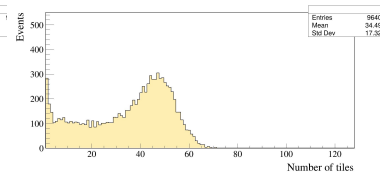
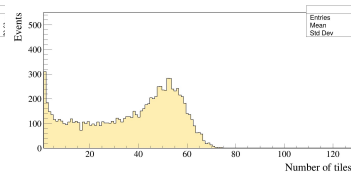
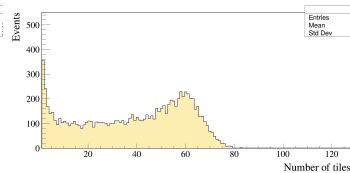
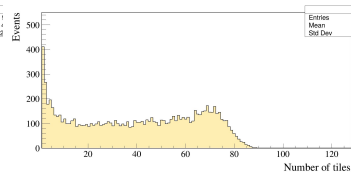
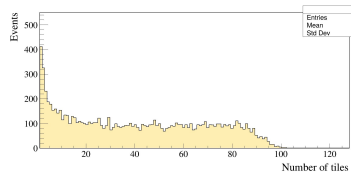
Al



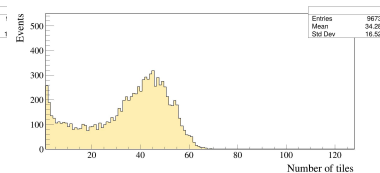
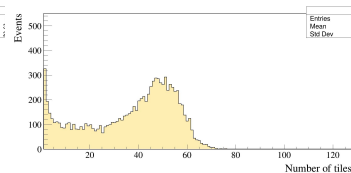
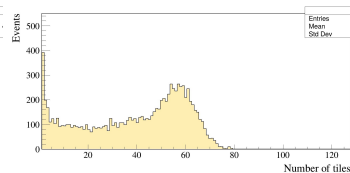
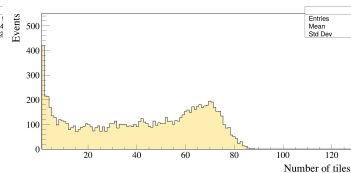
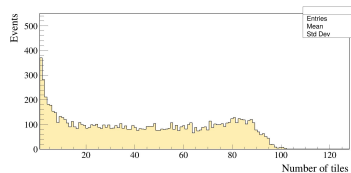
Cu



Ag



Au



Xe beam 3 GeV. Number of hitted tiles

Advanced model

BBC position 1 m

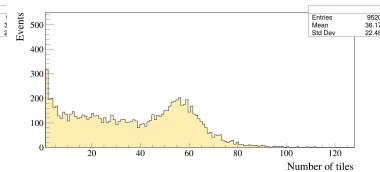
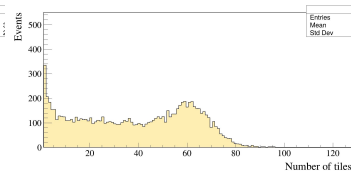
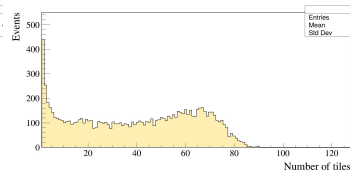
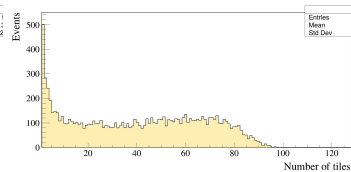
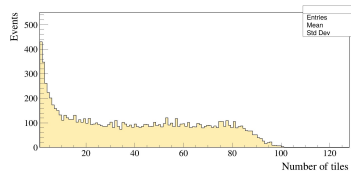
1.5 m

2 m

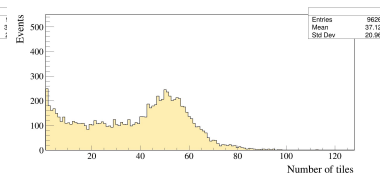
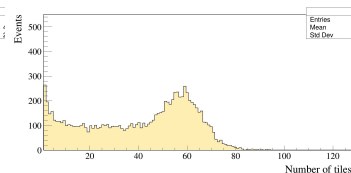
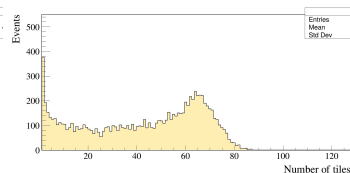
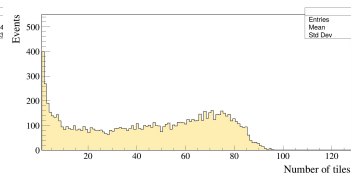
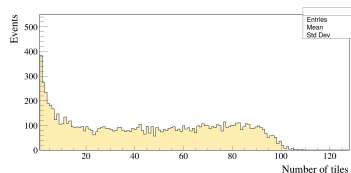
2.5 m

3 m

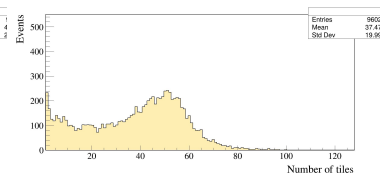
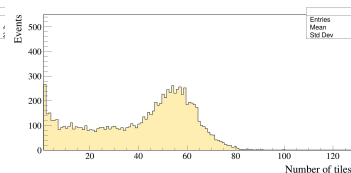
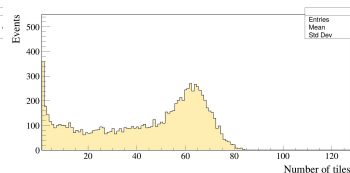
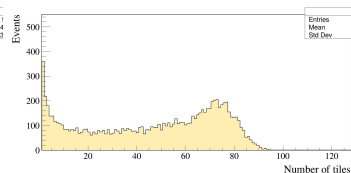
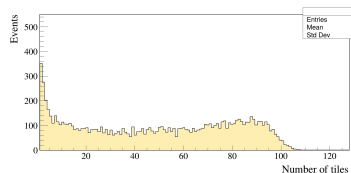
Al



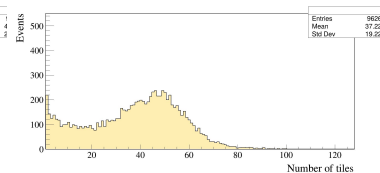
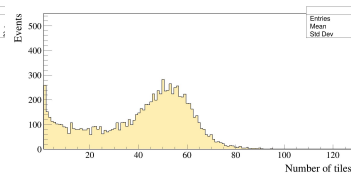
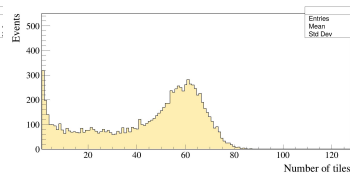
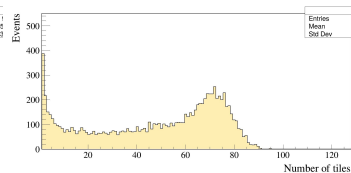
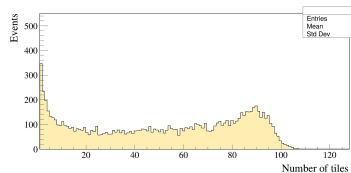
Cu



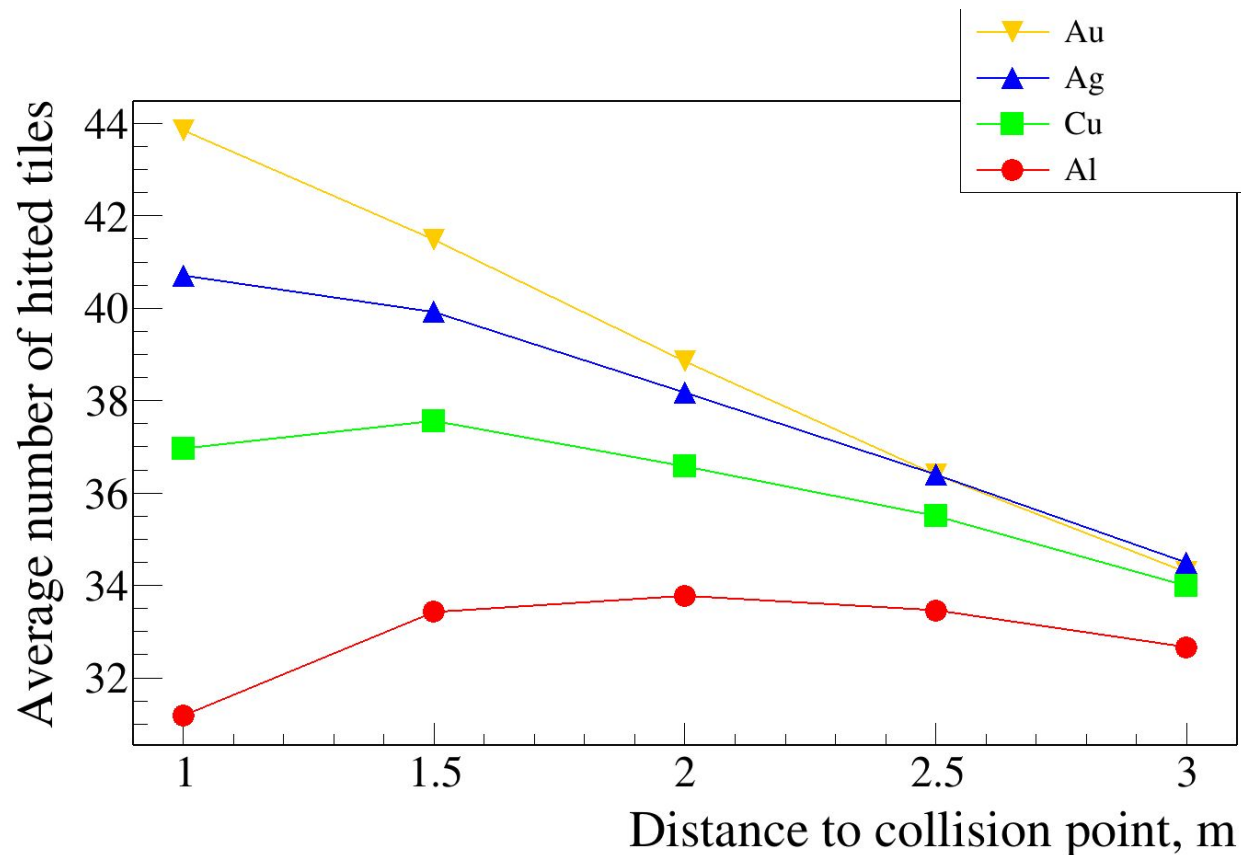
Ag



Au



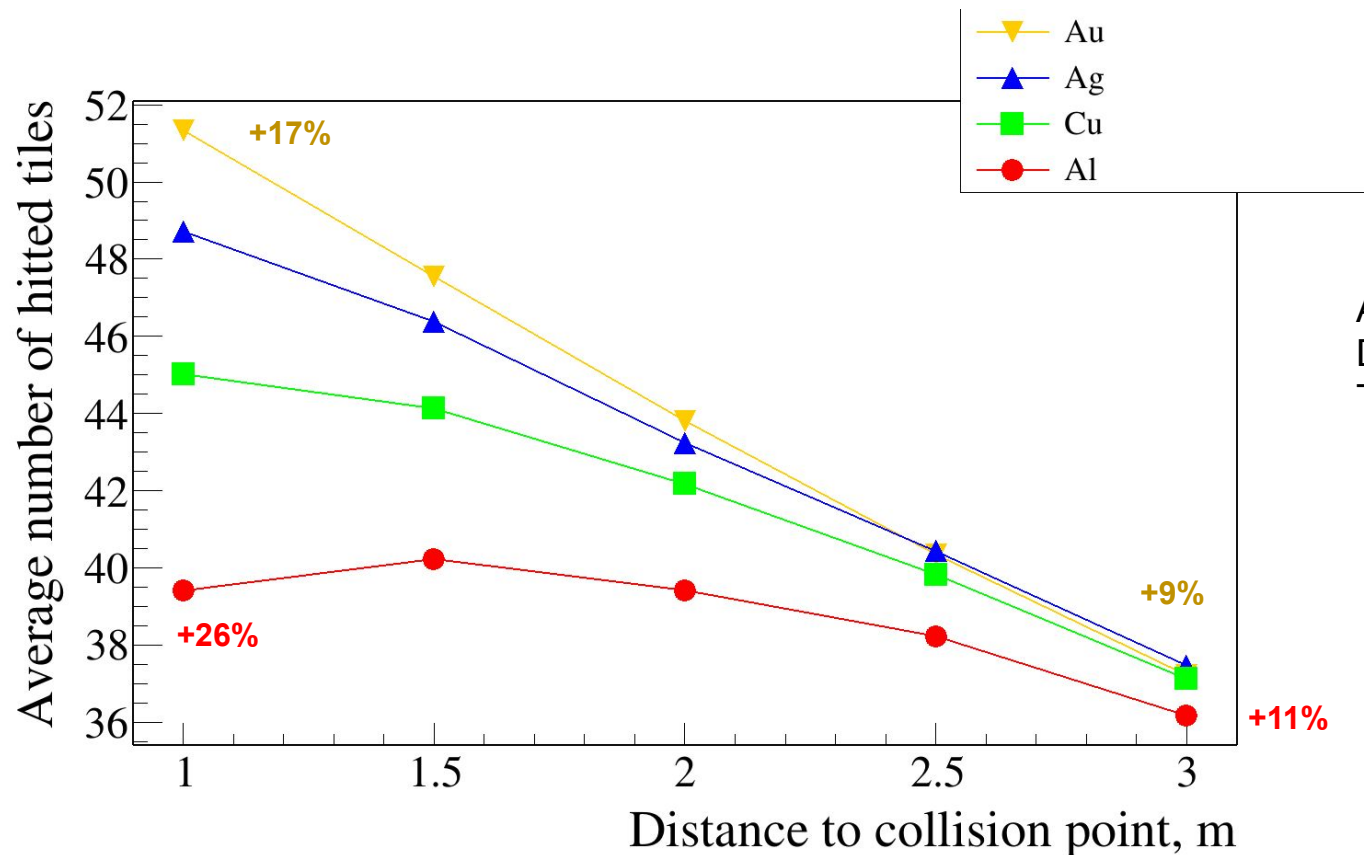
Xe beam 3 GeV. Average number of hitted tiles with different targets



Simplified model

More heavy target means
that more tiles be hitted.

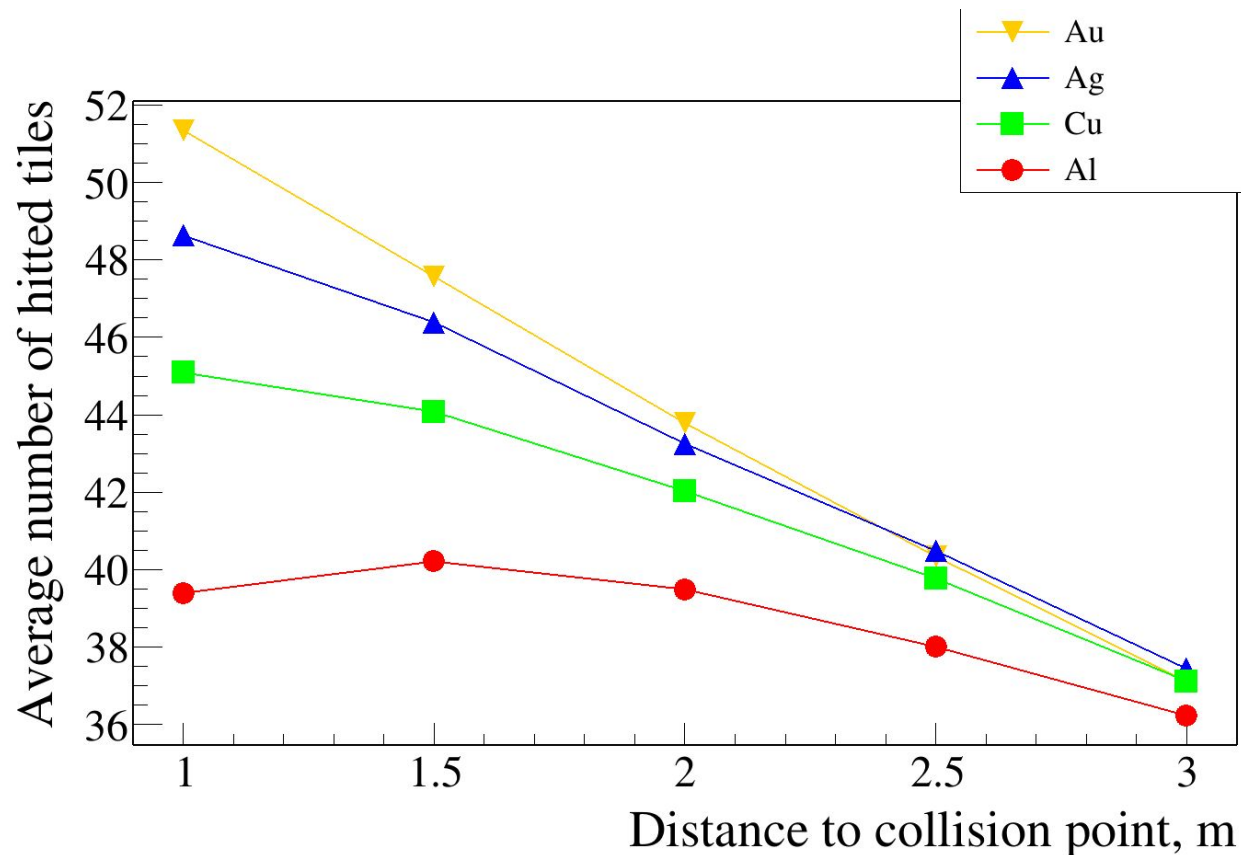
Xe beam 3 GeV. Average number of hitted tiles with different targets



Advanced model

Al pipe.
D = 86 mm.
Thickness = 1.5 mm.

Xe beam 3 GeV. Average number of hitted tiles with different targets



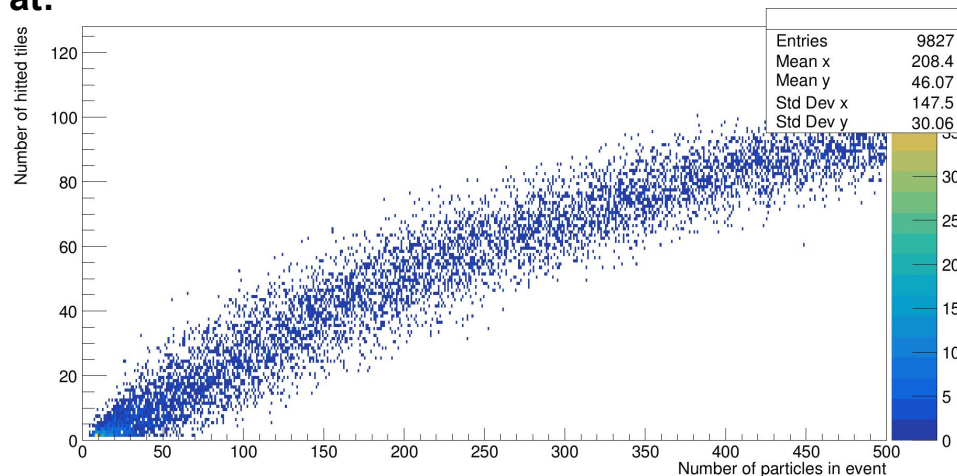
Advanced model

Fe pipe.
D = 86 mm.
Thickness = 1.5 mm.

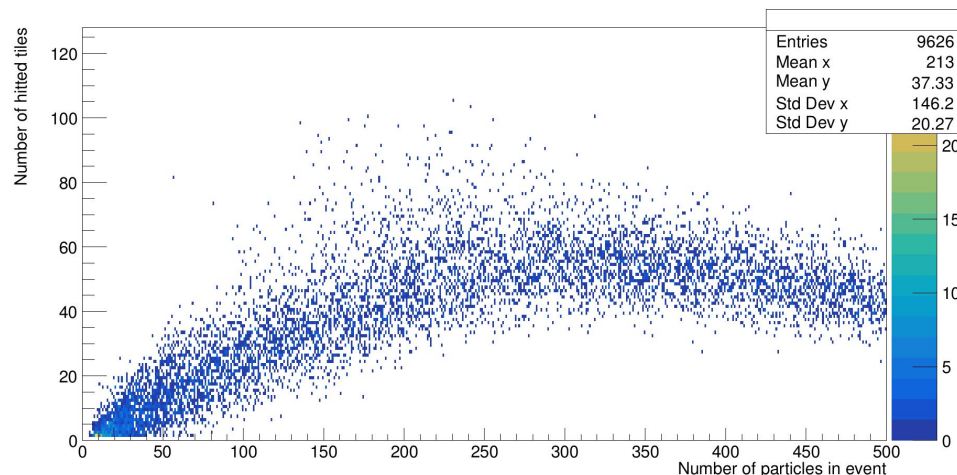
The difference depending on
the pipe material (Al or Fe) is
in the statistical error level.

Target at:

1 m



3 m



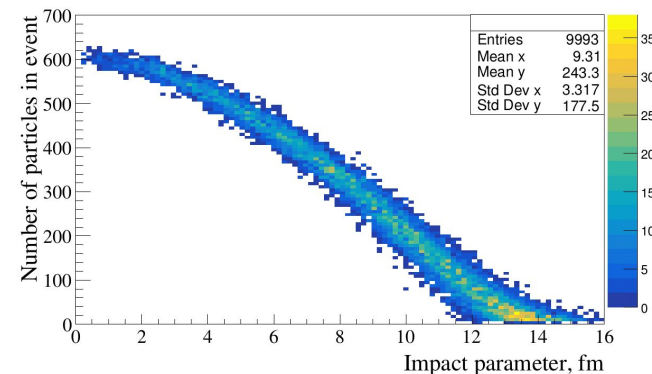
XeAu collision, 3 GeV. Multiplicity correlation

Advanced model

If we can estimate multiplicity

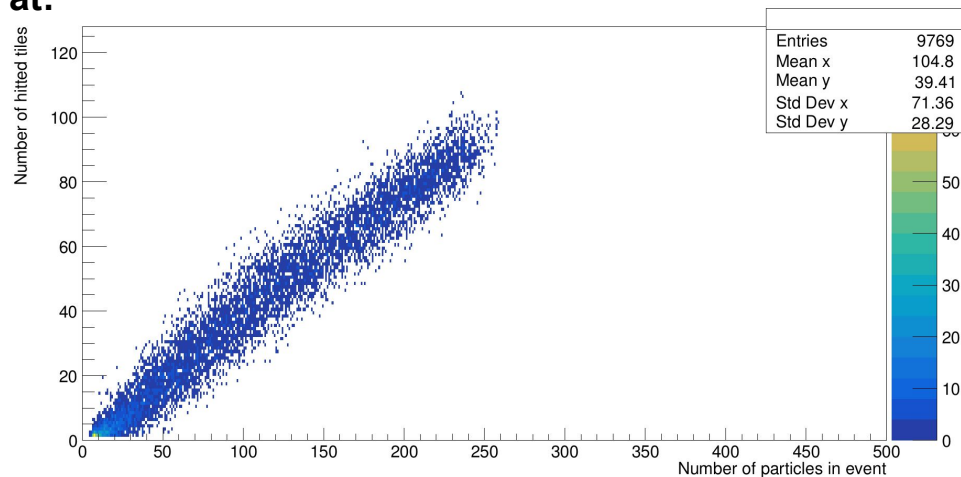
->

we can estimate impact parameter

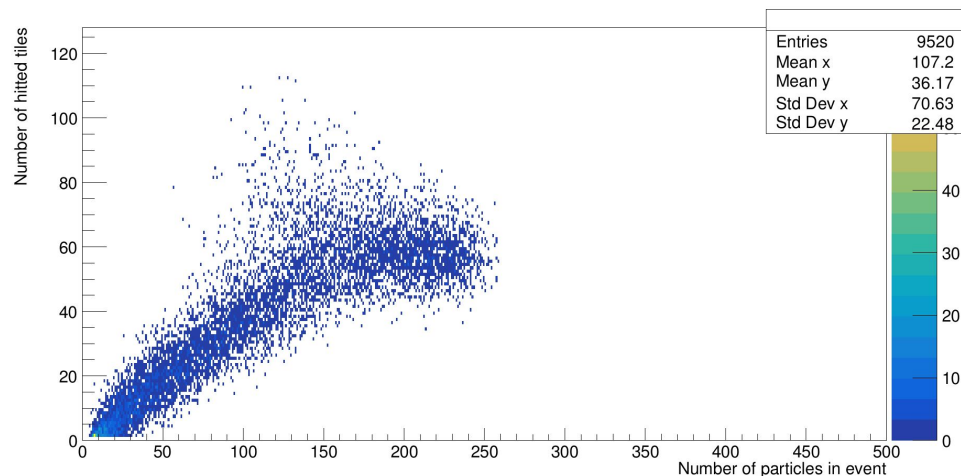


Target at:

1 m



3 m



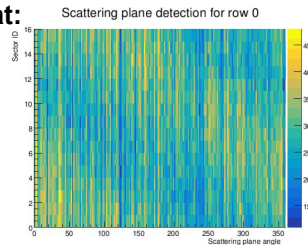
XeAl collision, 3 GeV. Multiplicity correlation

Advanced model

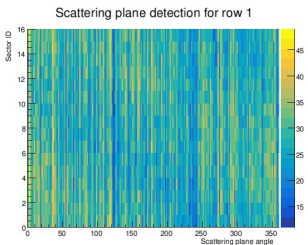
Almost the same way as for Au target

Target at:

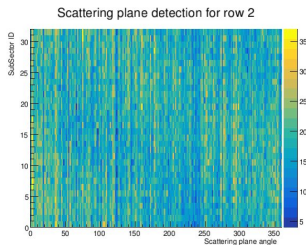
Scattering plane detection for row 2



Scattering plane detection for row 1



Scattering plane detection for row 2

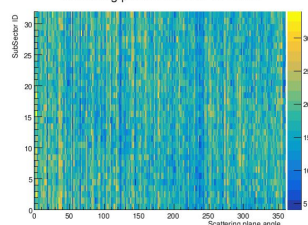


XeAu collision, 3 GeV. Scattering plane correlation

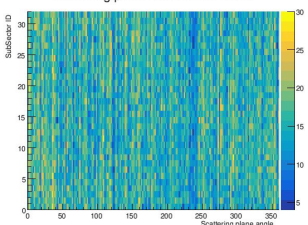
Advanced model

1 m

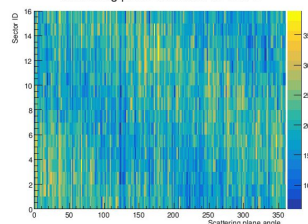
Scattering plane detection for row 3



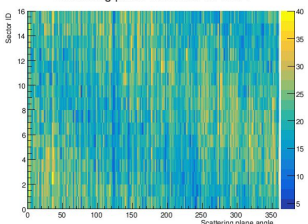
Scattering plane detection for row 4



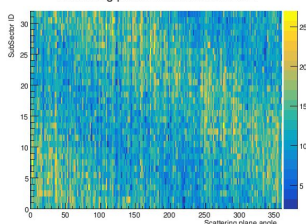
Scattering plane detection for row 0



Scattering plane detection for row 1

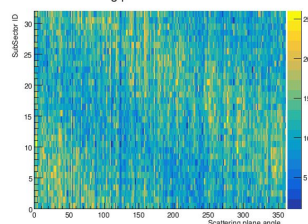


Scattering plane detection for row 2

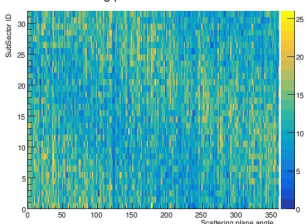


3 m

Scattering plane detection for row 3

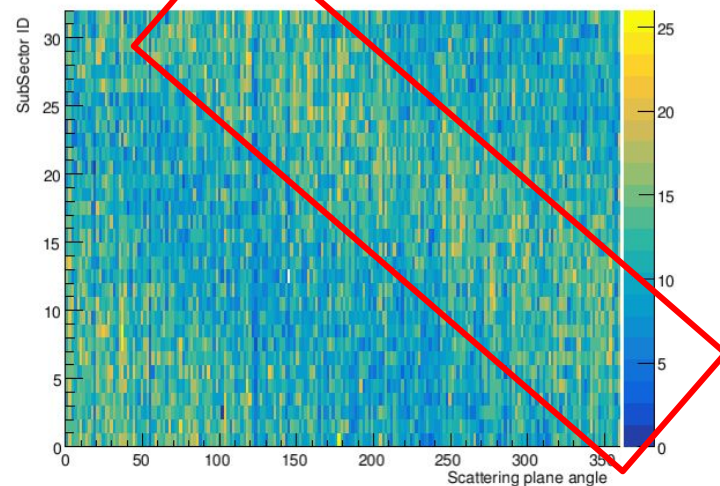


Scattering plane detection for row 4



There is some dependence!

Scattering plane detection for row 4



Conclusions

- Simulations of ^{124}Xe collisions with various targets (**Al, Cu, Ag, Au**) using DCM-QGSM-SMM generator under different conditions for BBC Phase 0 were performed.
- The "advanced" model shows an increase in the number of hitted tiles in comparison to the "simplified" model.
- The pipe material has no significant effect on the number of hitted tiles.
- The impact parameter of a collision can be evaluated if the detector placed at ~ 1 m from collision point.

Future plans:

- Develop methods to **estimate background** in the model
- Incorporate **time** and **energy resolution** parameters of the detector into simulations
- Investigate **spatial** and **temporal correlations** between detector **tiles** for potential detection of angular multiparticle **correlations**
- Perform dedicated studies of **Xe+Xe** collisions in **collider mode** using **2 BBC wheels** to explore wheel-to-wheel correlations

**Thank you
for your attention!**

d beam 6 GeV. UrQMD4. Number of hitted tiles

Advanced model

BBC position 1 m

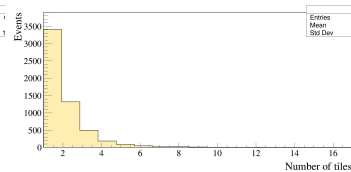
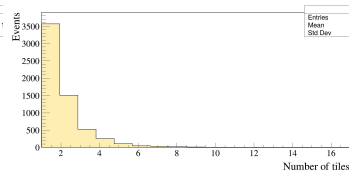
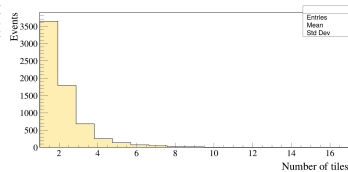
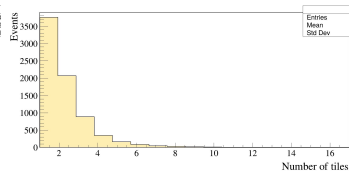
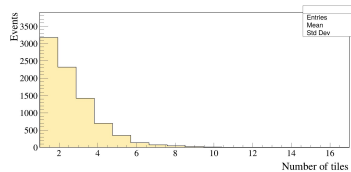
1.5 m

2 m

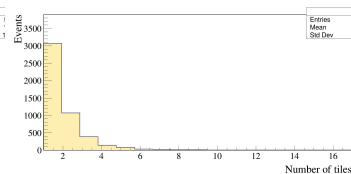
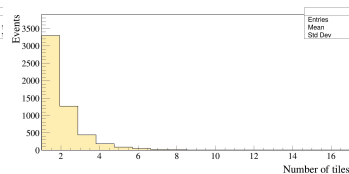
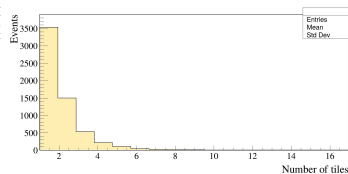
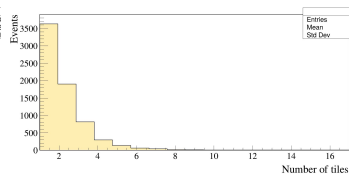
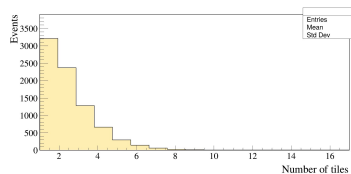
2.5 m

3 m

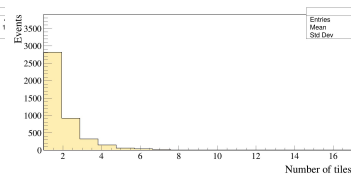
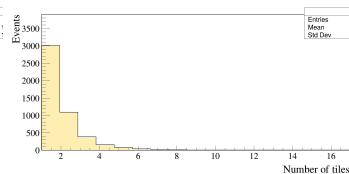
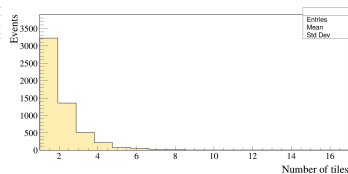
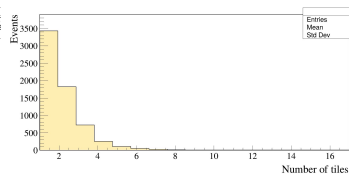
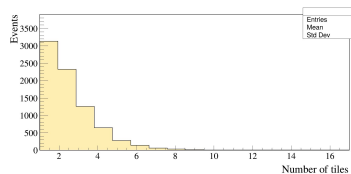
Al



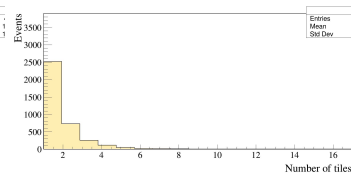
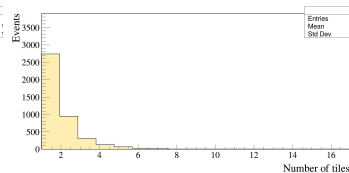
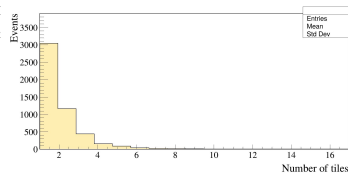
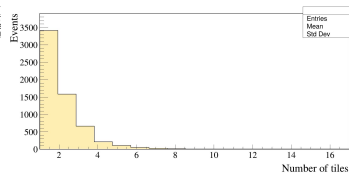
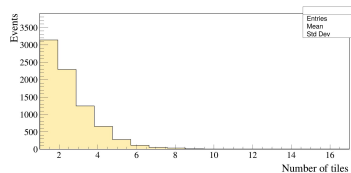
Cu



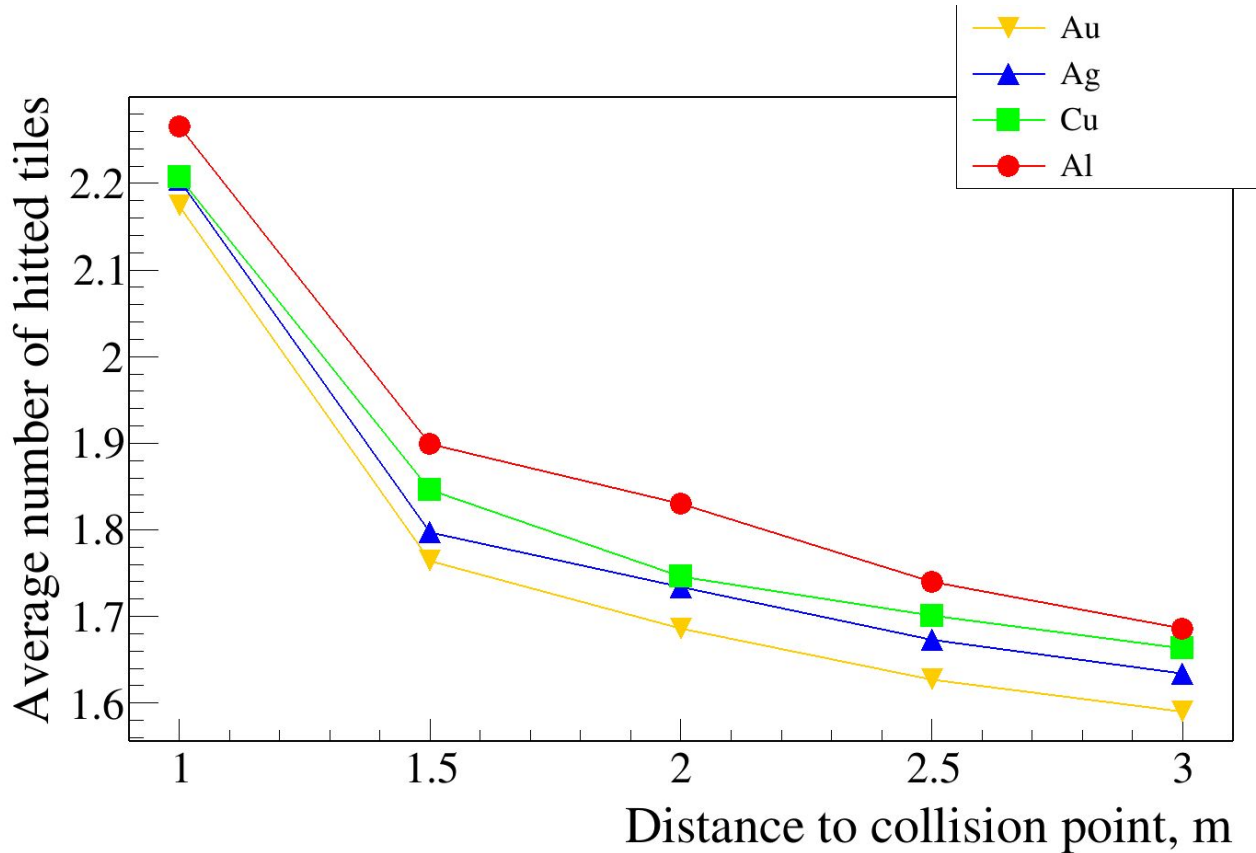
Ag



Au



d beam 6 GeV. Average number of hitted tiles with different targets



Advanced model

