Centrality Determination for p+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV by the STAR Experiment

Yanfang Liu, *for the STAR Collaboration*

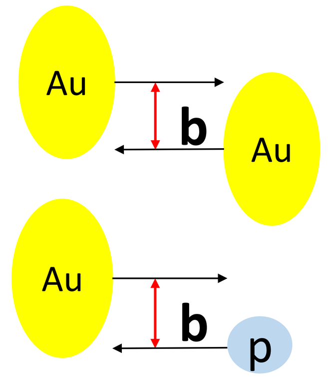
Texas A&M University

Abstract

In heavy-ion collisions, properties of the created QCD matter highly depend on the collision geometry or "centrality". In A+A collisions, centrality is related to the size of the overlap region determined by the impact parameter. In p+A collisions, the term "centrality" is still taken to be a classification of the amount of activity in the collision, which, however, is not strictly related to the impact parameter, but more closely to the number of nucleon-nucleon collisions (N_{coll}) in a Glauber-like picture. This study focuses on the determination of centrality classes in p+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV using data taken in 2015 by the STAR experiment. Comparisons between the data and simulations based on HIJING and GEANT modelling are presented.

Motivation

In heavy-ion collisions, cold nuclear-matter effects and hot-medium effects are largely entangled. We use p+Au collisions to help quantify cold nuclear-matter effects, so that we can get a better understanding of the hot-medium effects in heavy-ion collisions. In order to probe the properties of the QCD matter created in p+Au collisions, a good understanding of centrality is needed to measure the physics quantities as a function of activity in the collision.



Methods

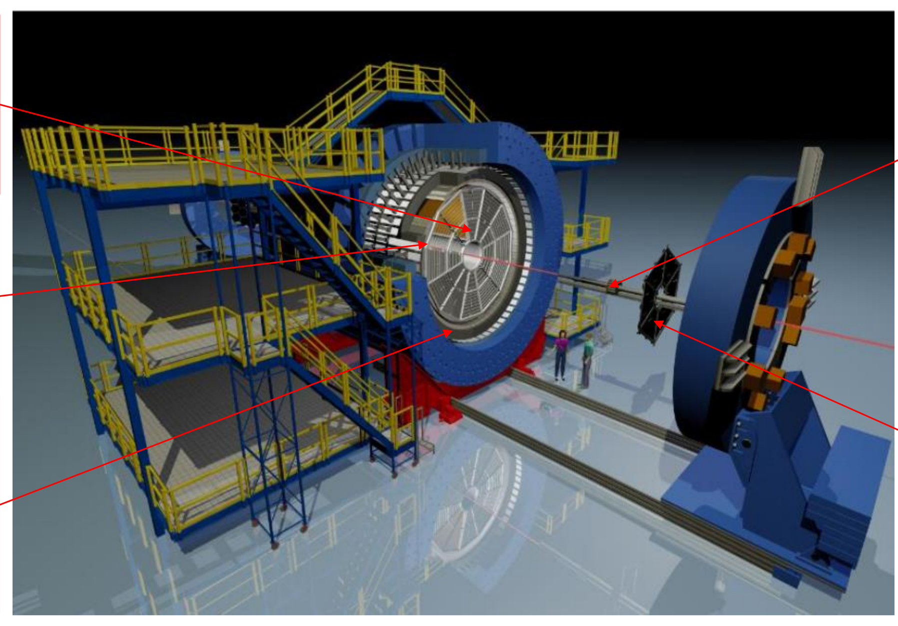
- Use minimum-bias p+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV taken by STAR in 2015. The minimum-bias trigger requires coincidence of signals present in both east- and west-side of VPD.
- Use HIJING + GEANT to study correlations between experimental observables and N_{coll}.
- Use Glauber simulation to estimate the total cross section and compare Glauber N_{coll} to HIJING.
- For intervals of the experimental observable, estimate the percentages of the sampled cross-section and calculate corresponding $\langle N_{coll} \rangle$.

STAR Detector

TPC
Time Projection Chamber measures track trajectories to determine particle momenta.

TOF
Time Of Flight detector measures particles' flight time for particle identification.

BEMC
Barrel Electro-Magnetic Calorimeter is a fast detector that can be used to reject pile-up tracks.

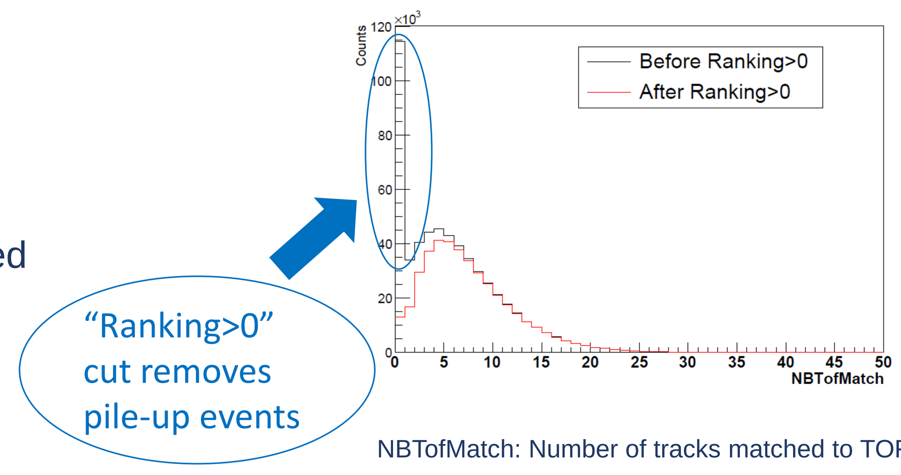


VPD
Vertex Position Detectors provide main minimum-bias trigger.

BBC
Beam Beam Counters provide additional minimum-bias trigger and event activity measurement at forward rapidity.

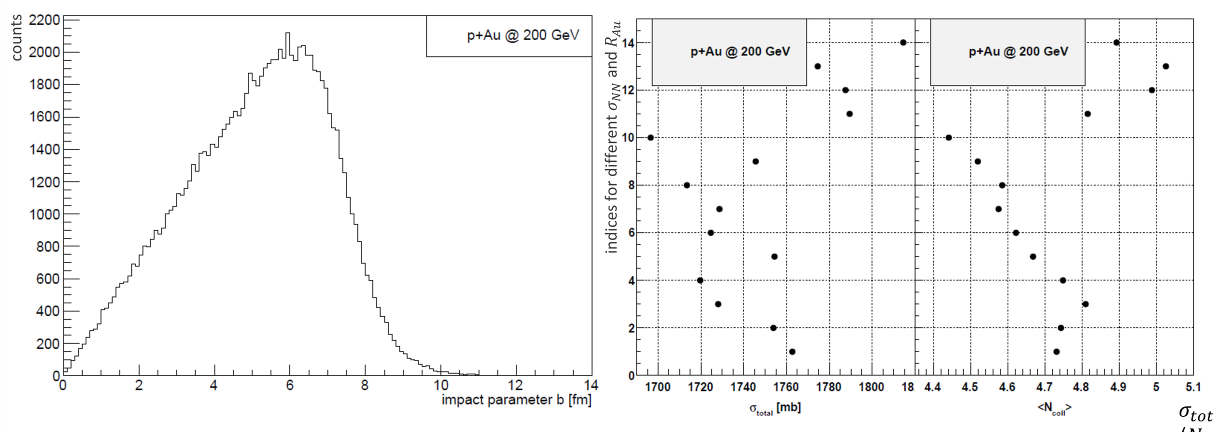
Vertex Selection in Data

- Select the vertex, reconstructed using TPC tracks, that correlates along the beam direction with the vertex reconstructed using VPD information.
- To further remove pile-up events, the selected vertex is required to be associated with at least two tracks that are either matched to BEMC or crossing the TPC central membrane, i.e. the "Ranking>0" cut.



NBTofMatch: Number of tracks matched to TOF

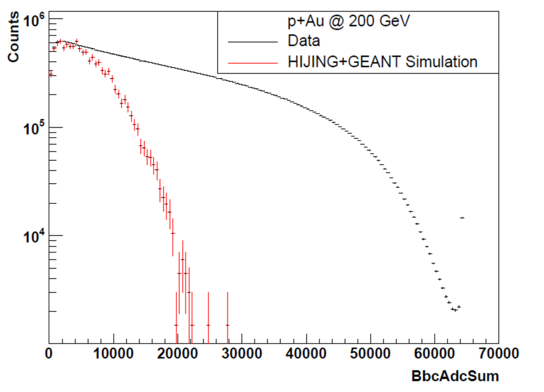
Glauber Model



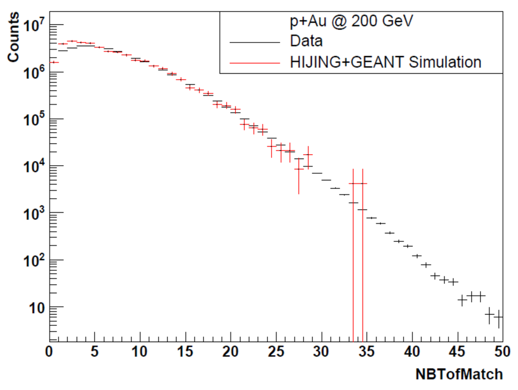
Conclusion :
$\sigma_{total} = 1760 \pm 60\ mb$
$\langle N_{coll} \rangle^{0-100\%} = 4.7 \pm 0.3$
Glauber simulation default parameters:
$\sigma_{NN} = 42mb$
$R_{Au} = 6.38fm$
which are varied as:
$\sigma_{NN} = 42 \pm 2mb$
$R_{Au} = 6.38 \pm 0.12fm$
and Gaussian smearing test.

σ_{total}: total cross section; σ_{NN}: inelastic N-N cross section; $\langle N_{coll} \rangle$: mean value of number of nucleon-nucleon collisions; R_{Au}: radius of Au nucleus.

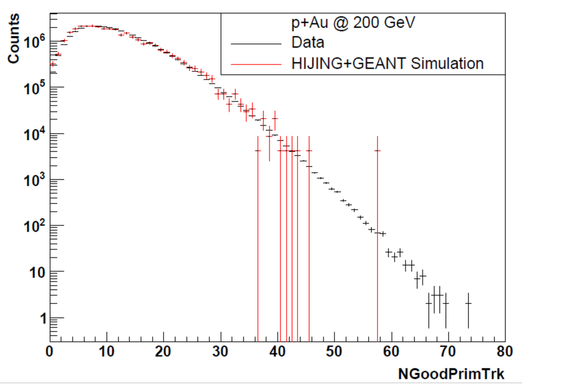
Data vs. HIJING



BbcAdcSum: Charge sum measured in the BBC



NBTofMatch: Number of tracks matched to TOF

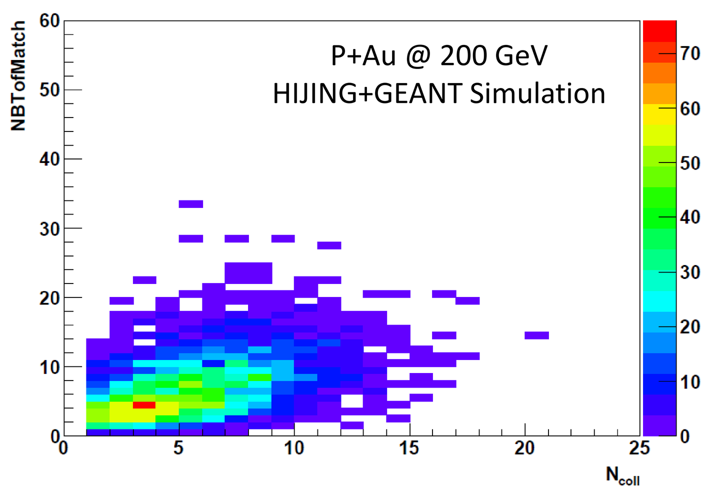


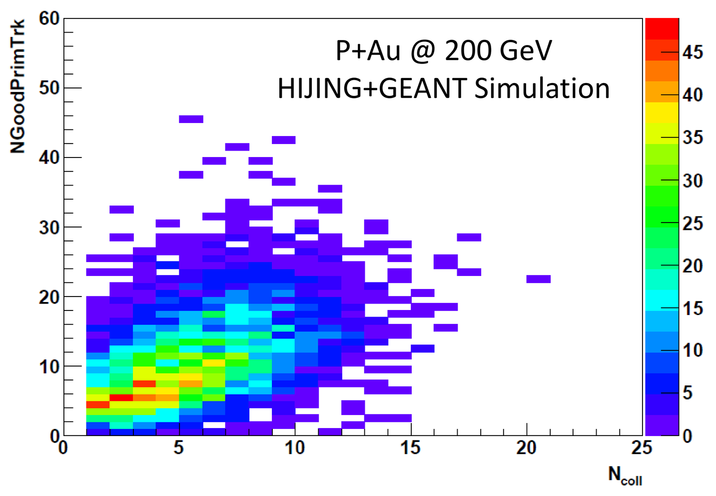
NGoodPrimTrk: Number of "good" primary tracks

- An observable at large rapidity in the Au-going side, such as the charge sum measured in the BBC (BbcAdcSum), would be preferred because it is not auto-correlated to physics measurements at mid-rapidity. However, HJING+GEANT simulation does not match the BbcAdcSum distribution measured in data.
- For distribution of the number of tracks matched to TOF (NBTofMatch), simulation and data match well.
- Also, the number of "good" primary tracks (NGoodPrimTrk) shows agreement between simulation and data. The conditions for selecting "good" primary tracks are DCA<1cm, $|\eta| < 1$, and NHitsFit≥10, where the DCA is the closest distance between the track and the primary vertex; η is the pseudo-rapidity; and NHitsFit is the number of TPC space points used for track reconstruction. The DCA<1cm cut is crucial for removing pile-up tracks.

Correlation of Observables to N_{coll}

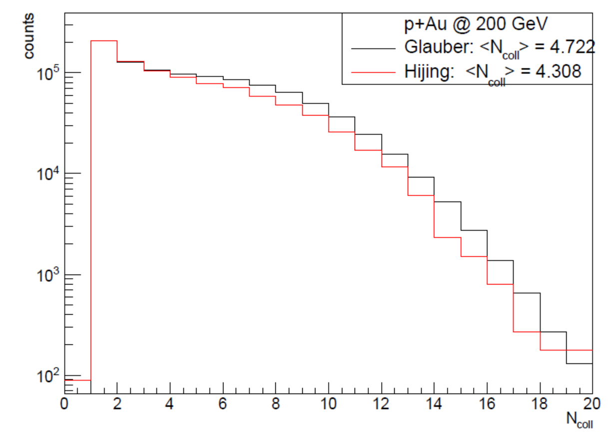
- The following quantities show correlation between observed signal and N_{coll} according to HIJING +GEANT.



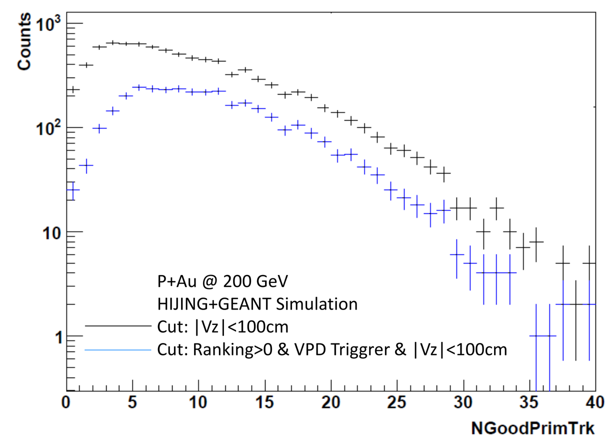


- Both NBTofMatch and NGoodPrimTrk, measured at mid-rapidity, show positive correlations with N_{coll}. NGoodPrimTrk is preferred as it spans a larger range, which is important for specifying multiple centrality bins.

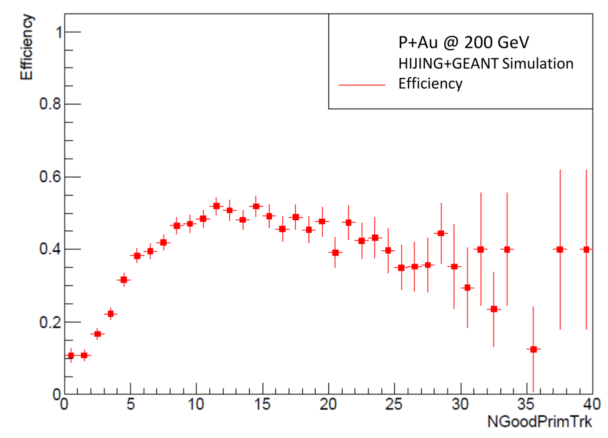
Results



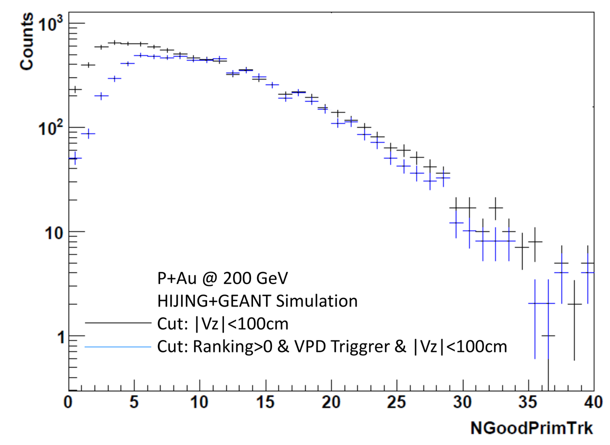
$\langle N_{coll} \rangle$ agrees within 10% between Glauber and HIJING



Scaled to match in flat efficiency region

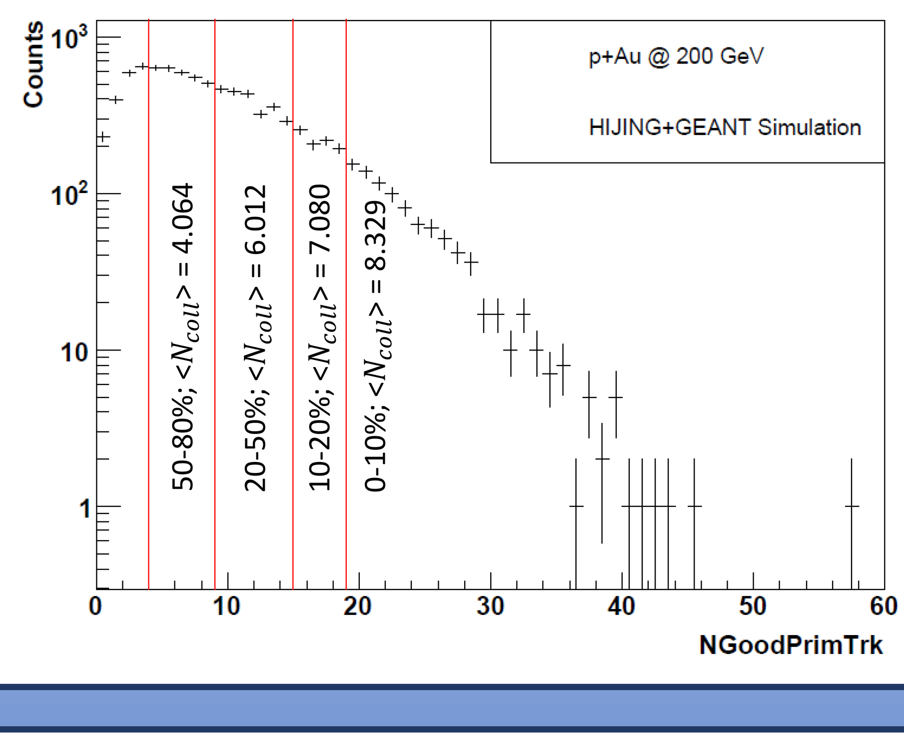


VPD trigger and ranking cut efficiency nearly flat for NGoodPrimTrk > 10



23% of events are lost by requiring VPD trigger condition and applying ranking cut

Centrality Cuts



Centrality cuts made on NGoodPrimTrk in HIJING+GEANT simulation for p+Au collisions at $\sqrt{s_{NN}}$ = 200 GeV.

References

[1] J. Adam *et al.* (ALICE), Phys. Rev. **C91** 064905 (2015)
[2] M. L. Miller *et al.* , Annu. Rev. Nucl. Part. Sci. 57. 205 (2007)

Office of Science, U.S. DEPARTMENT OF ENERGY

The STAR Collaboration
drupal.star.bnl.gov/STAR/presentations

TEXAS A&M UNIVERSITY