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

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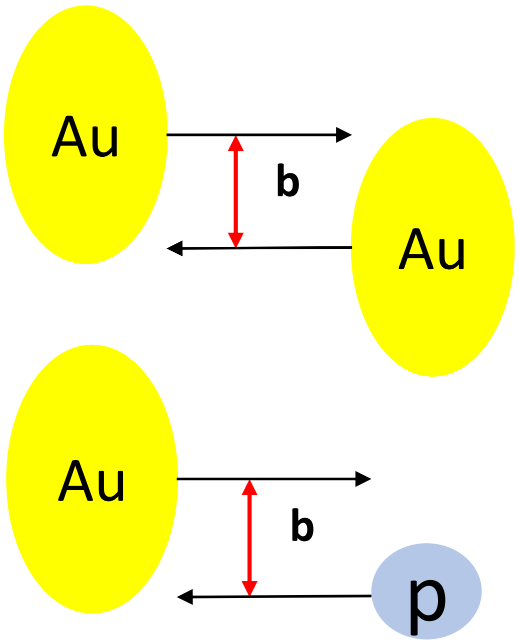
Motivation

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 do this, a good classification of centrality in p+Au collisions is needed to measure the physics quantities as a function of activity in the collision.



STAR Detector

TPC

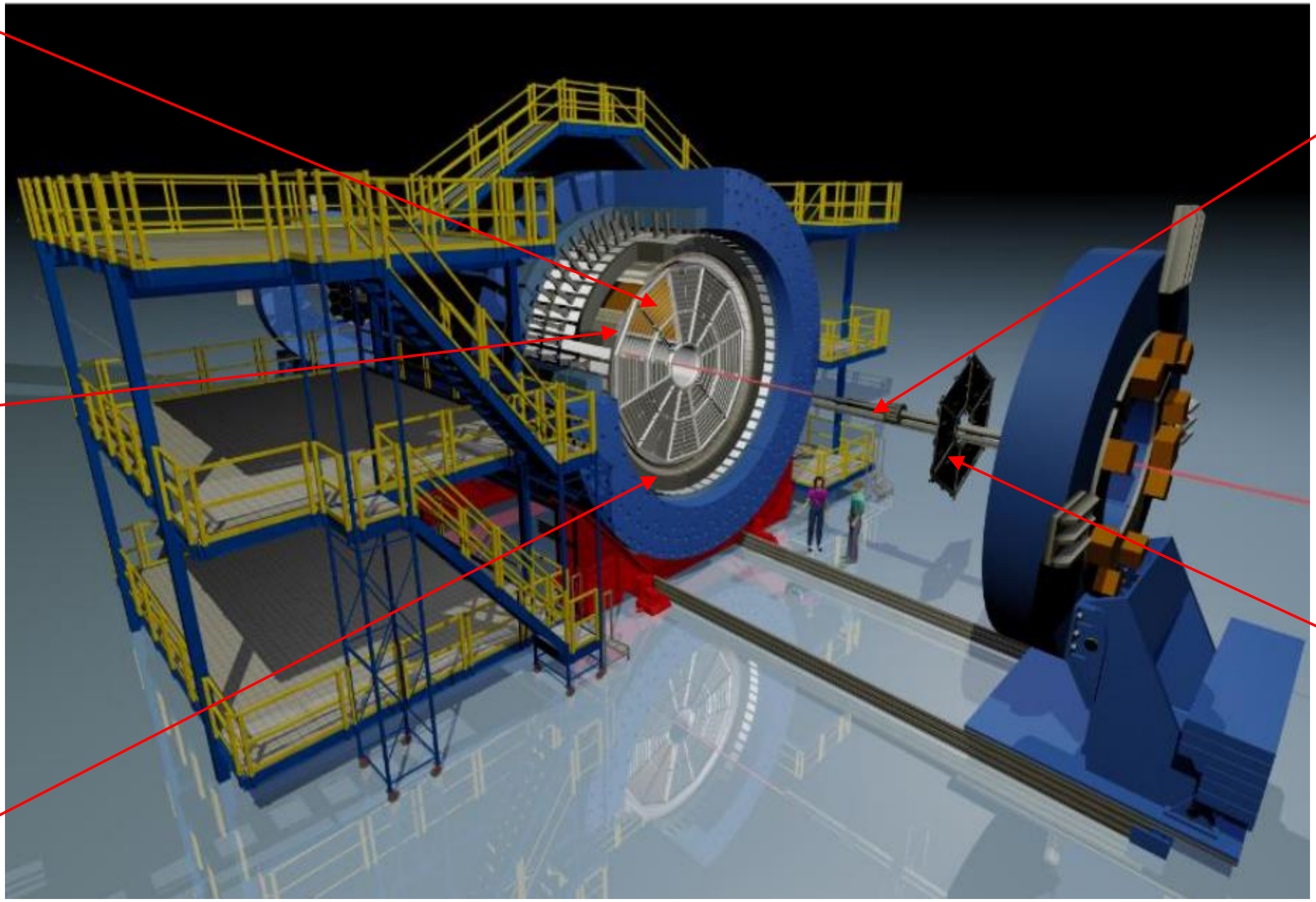
Time **P**rojection **C**hamber measures track trajectories to determine particle momenta. Covers |η|≤1.0

TOF

Time **O**f **F**light detector measures particles' flight time for particle identification. Covers |η|≤1.0

BEMC

Barrel **E**lectro-**M**agnetic **C**alorimeter is a fast detector that can be used to reject pile-up tracks. Covers |η|≤1.0



VPD

Vertex **P**osition **D**etectors provide main minimum-bias trigger, the event start time and the primary collision vertex location. Covers 4.24≤|η|≤5.1

BBC

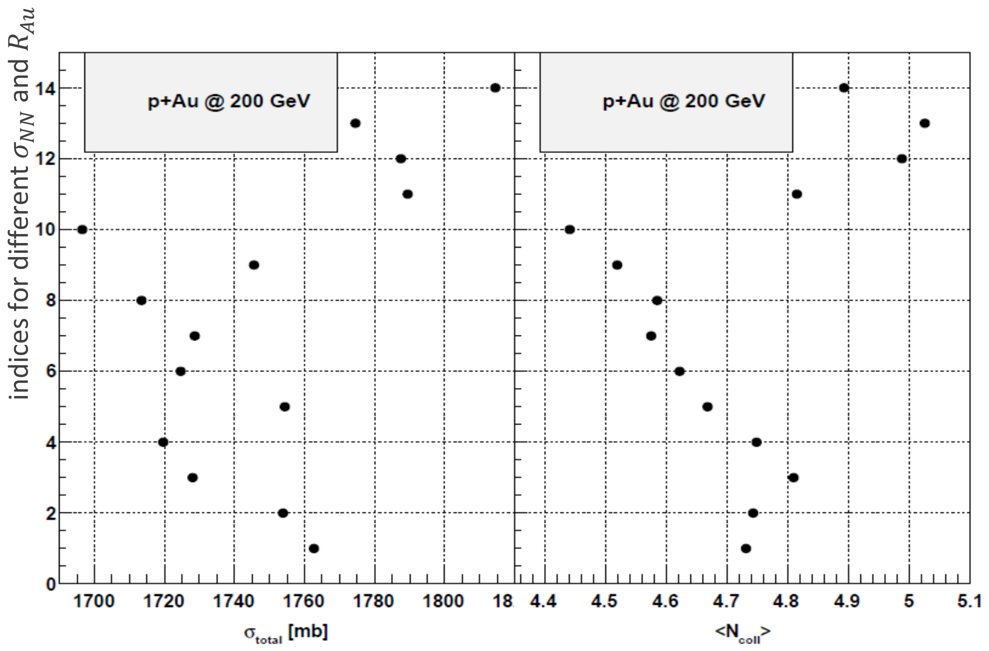
Beam **B**eam **C**ounters provide additional minimum-bias trigger and event activity measurement at forward rapidity. Covers 3.4≤|η|≤5.0

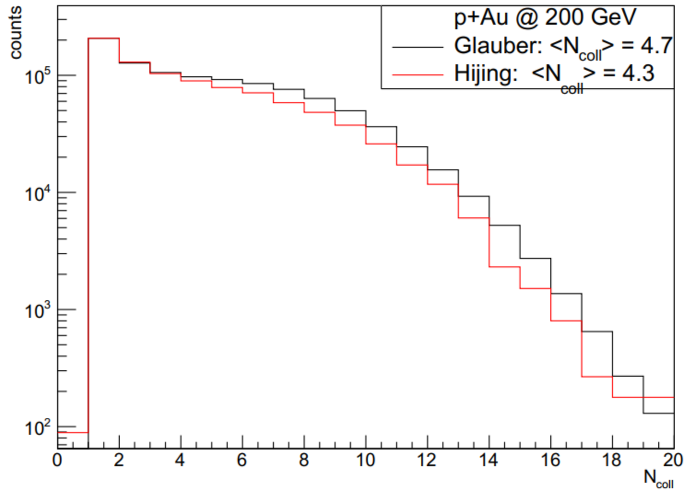
* η is the pseudo-rapidity

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 the number of nucleon-nucleon collisions (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 $\langle N_{coll} \rangle$.

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:

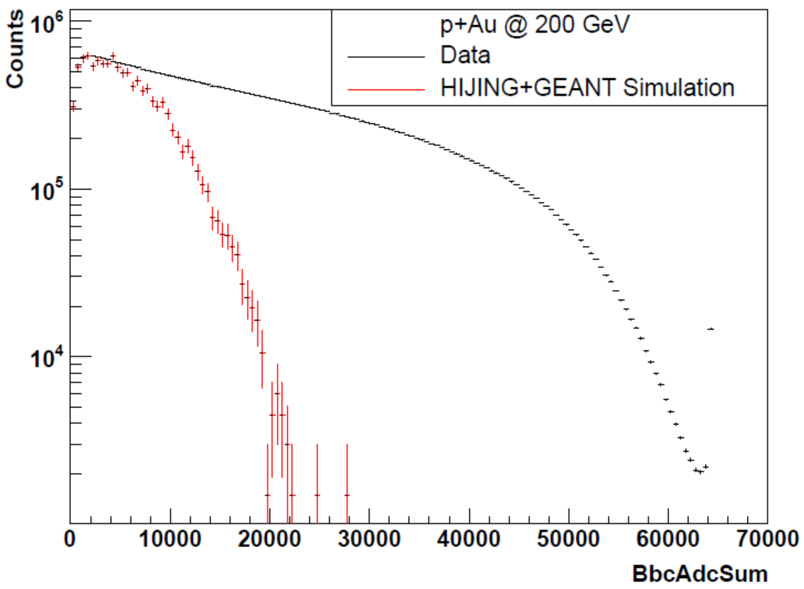
$$\sigma_{NN} = 42 \pm 2mb$$
$$R_{Au} = 6.38 \pm 0.12fm$$

and Gaussian smearing test.

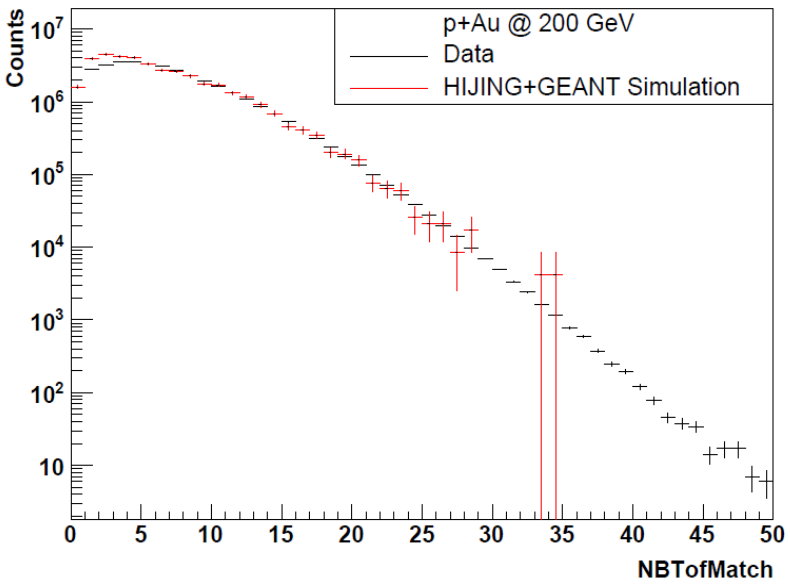
σ_{total}: total cross section; σ_{NN}: inelastic N-N cross section;
$\langle N_{coll}\rangle$: mean value of number of nucleon-nucleon collisions;
R_{Au}: radius of Au nucleus.

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

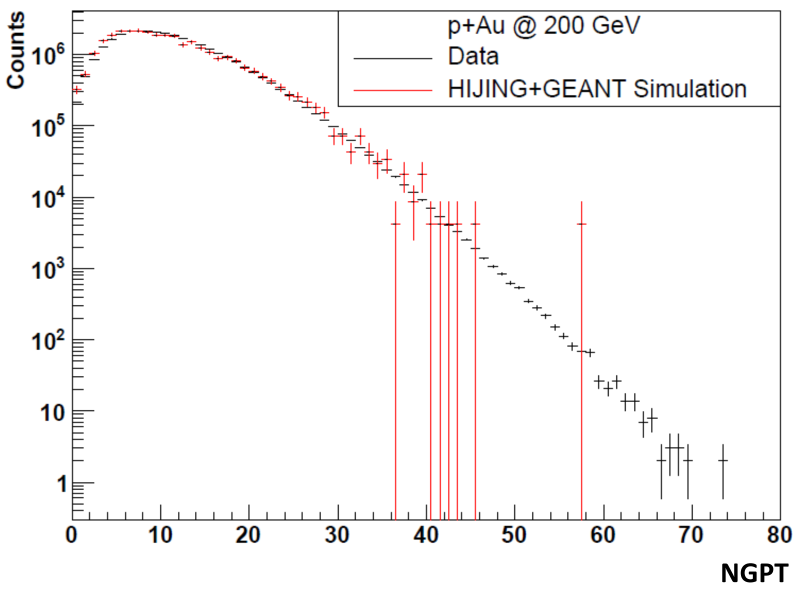
Data vs. HIJING



BbcAdcSum: Charge sum measured in the BBC



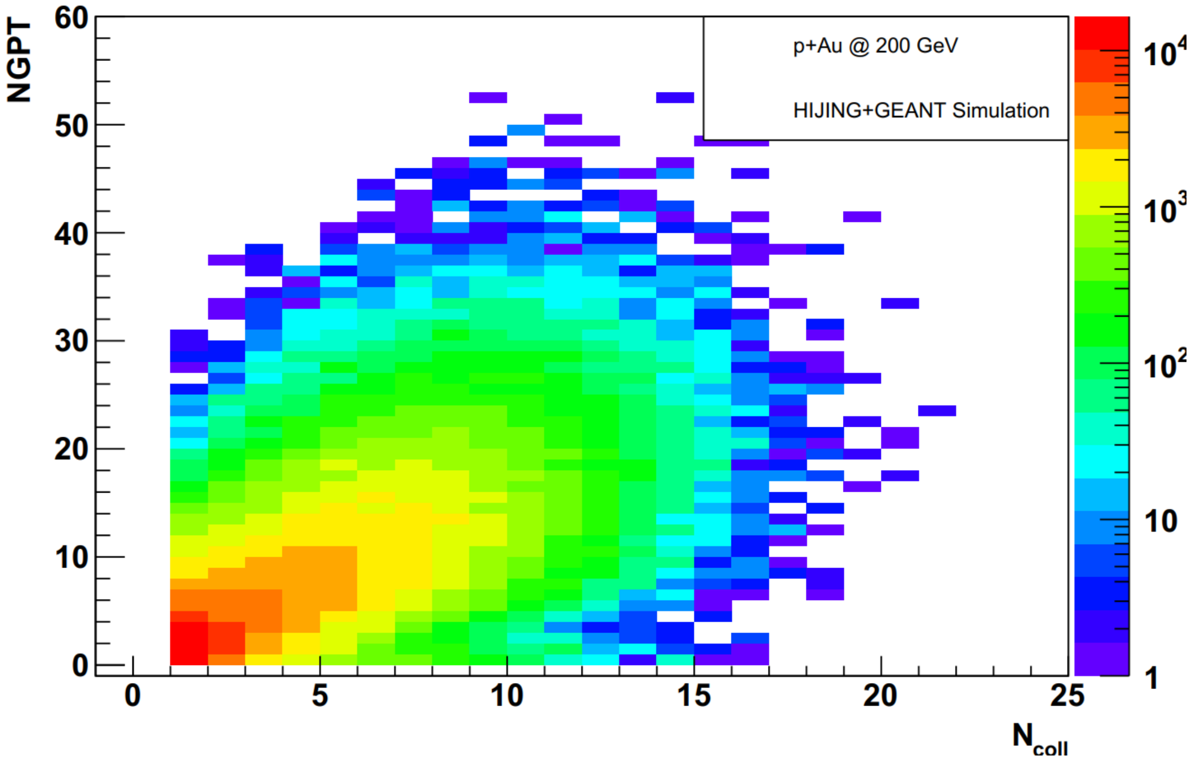
NBTofMatch: Number of tracks matched to TOF

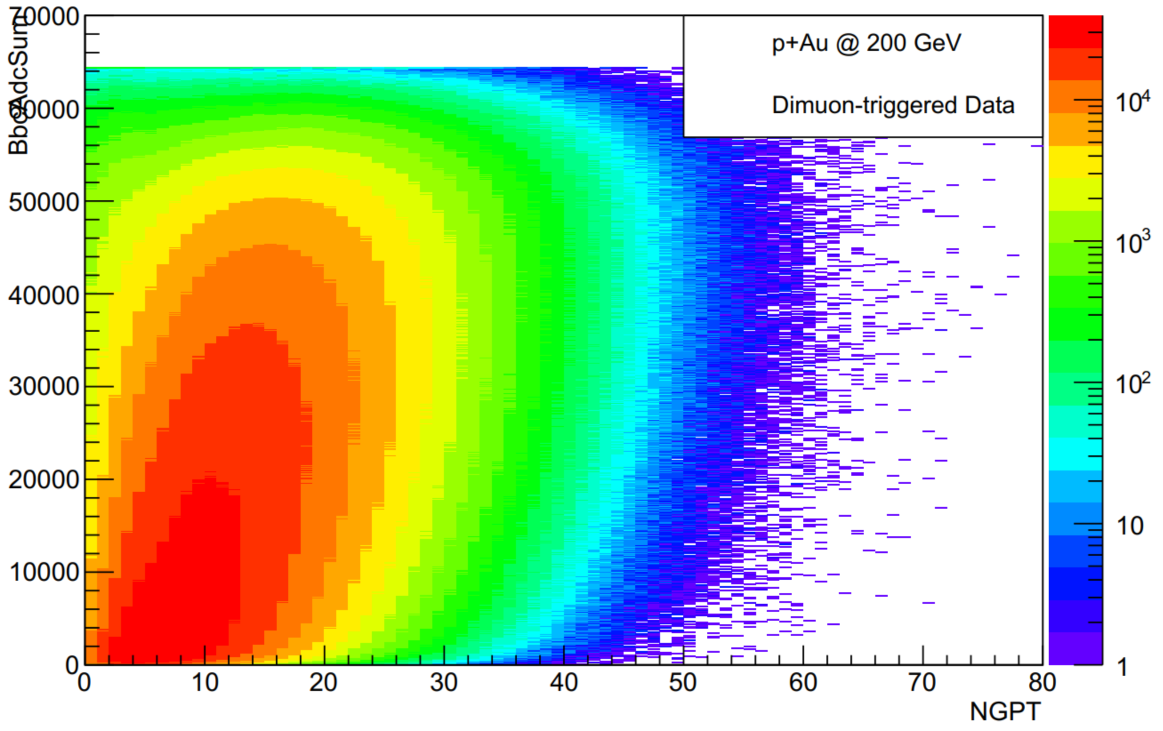


NGPT: Number of “good” primary tracks

- BbcAdcSum would be preferred because it is not auto-correlated to physics measurements at mid-rapidity. However, HIJING+GEANT simulation does not describe the BbcAdcSum distribution.
- For NBTofMatch, simulation and data match well.
- Also, at mid-rapidity the NGPT shows agreement between simulation and data. The conditions for selecting “good” primary tracks are DCA<1cm, $|\eta| < 1$, and NHitsFit≥10.

Correlation with Geometry



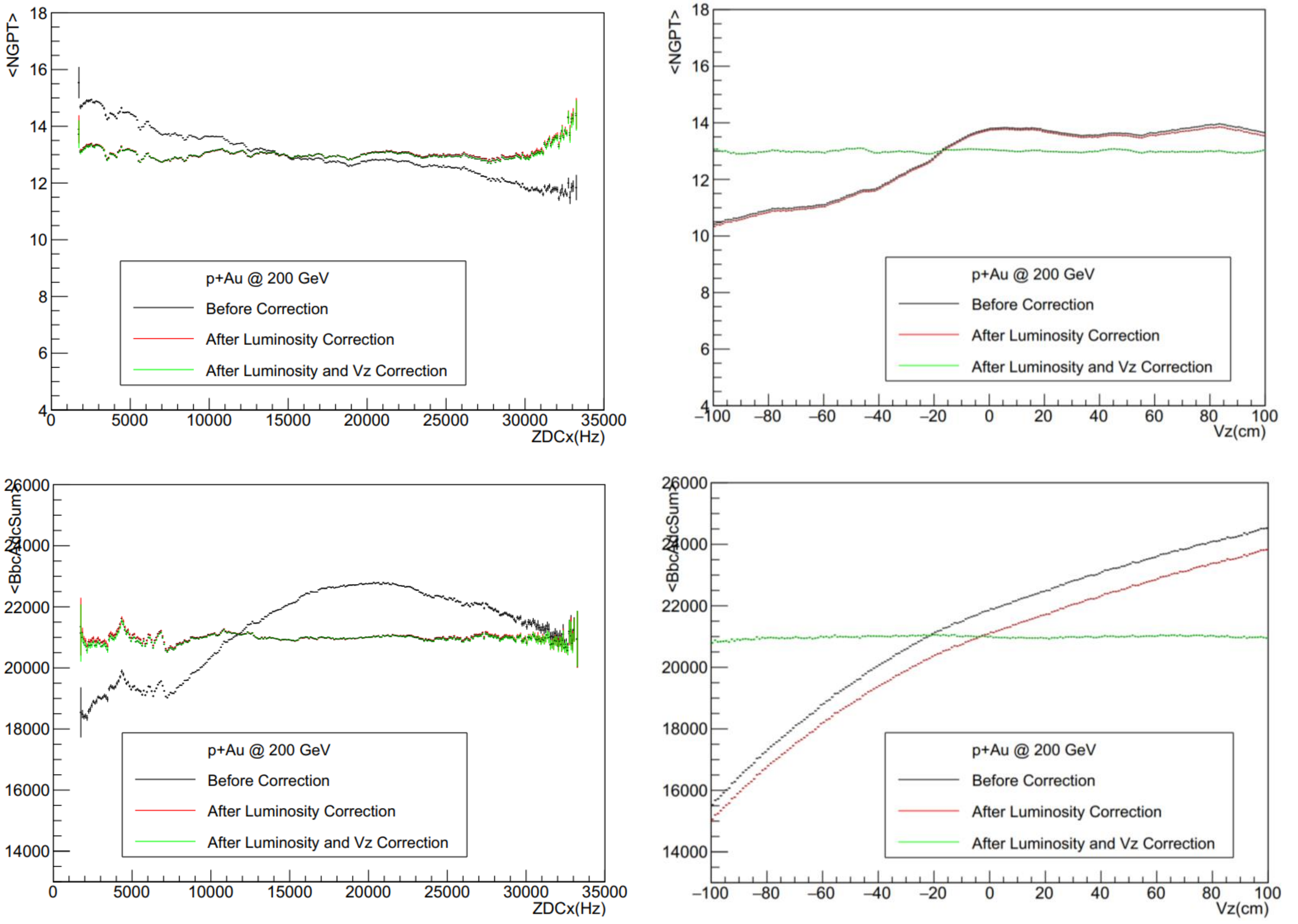


- Number of good primary tracks (NGPT) shows positive correlation with N_{coll} according to HIJING+GEANT simulation.
- BbcAdcSum shows weaker correlation with NGPT. Although, we cannot know the N_{coll} directly from HIJING+GEANT simulation, we may infer it by using this correlation between BbcAdcSum and NGPT.

Corrections for Luminosity and Vertex Dependence

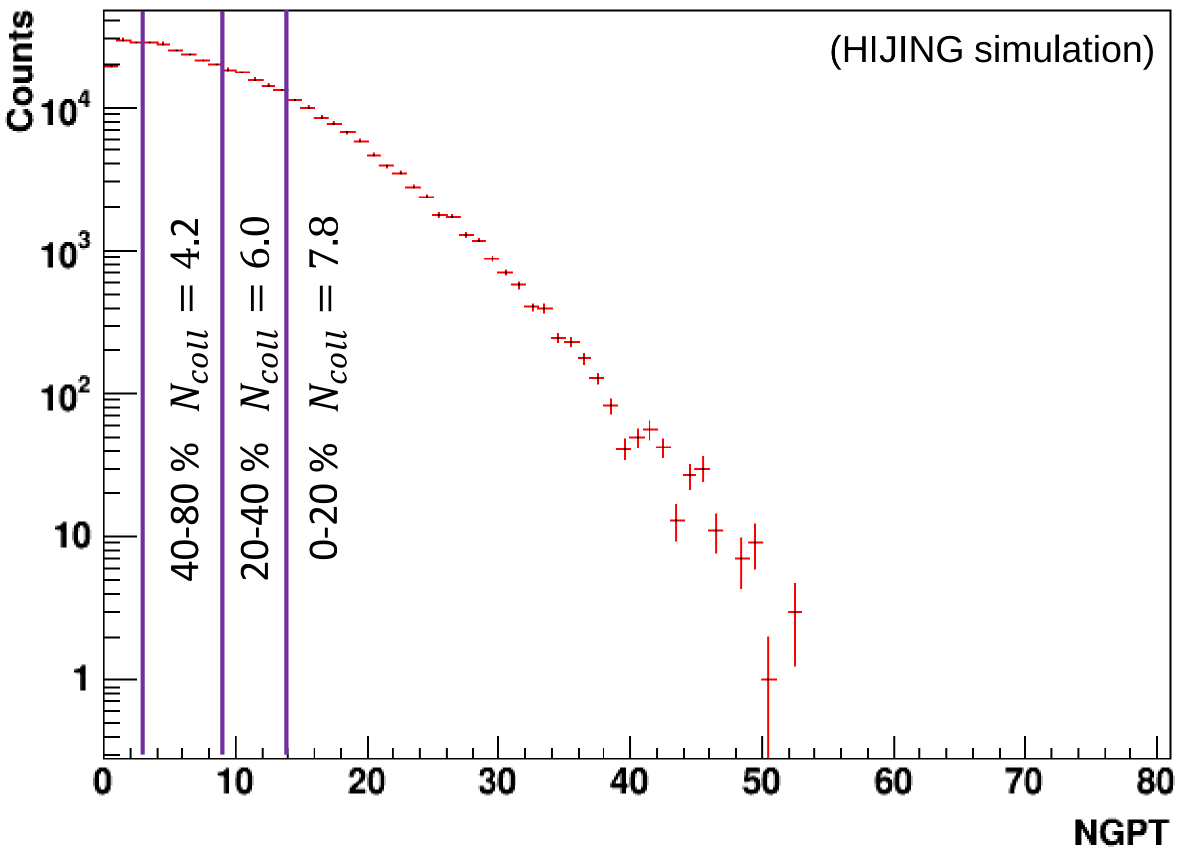
Correction on the NGPT for luminosity (upper left) and vertex (upper right) dependence

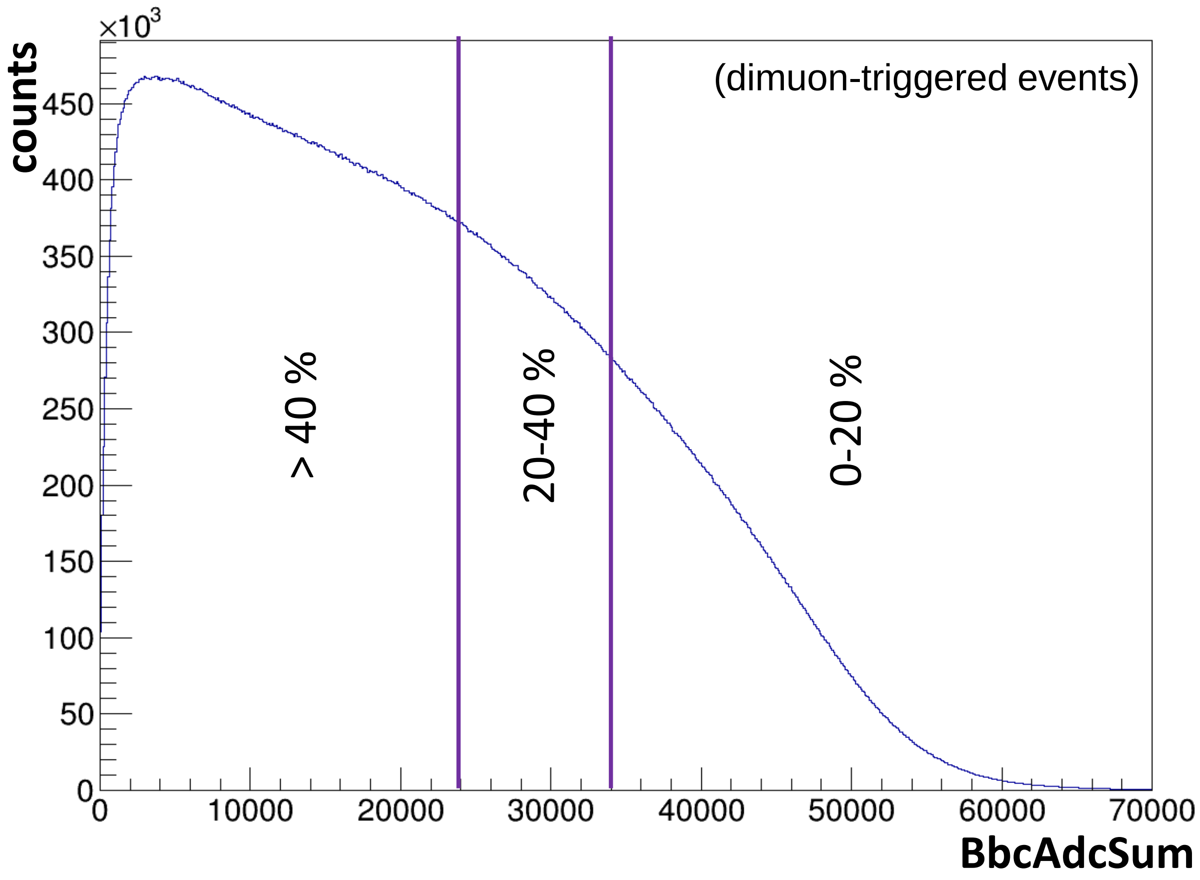
Correction on the BbcAdcSum for luminosity (lower left) and vertex (lower right) dependence



(*Shown for dimuon-triggered events).

Centrality Classes





Centrality Bins in NGPT:

- 0-20%: Number of Good Primary Tracks from 14 to 80
- 20-40%: Number of Good Primary Tracks from 9 to 13
- 40-80%: Number of Good Primary Tracks from 3 to 8

Centrality Bins in BbcAdcSum:

- 0-20%: BbcAdcSum larger than 34000
- 20-40%: BbcAdcSum from 24000 to 34000
- >40%: BbcAdcSum less than 24000

Discussions and Future Work

- NGPT (Number of Good Primary Tracks)
  - Centrality percent determined with respect to full cross section using comparisons to HIJING
  - The advantage of NGPT is that HIJING describes data well, allowing for the determination of the centrality percent of the full cross section
  - The disadvantage is that it is at mid rapidity which can cause bias in the measurement
- BbcAdcSum
  - Centrality percent is not yet relative to a full cross section
  - The advantage is it is not at mid rapidity, so it does not bias the measurement
  - The disadvantage is that HIJING does not reproduce the BBC response
- Future Work
  - Further study of BbcAdcSum as a centrality measure and calculate $<N_{coll}>$ for selections in this variable.

Back up

- Future Work

The procedures are:

1. Use BbcAdcSum alone to determine centrality classes.
2. For each centrality class in BbcAdcSum, there is a distribution of NGPT.
3. Determine <N_{coll}> by using map of N_{coll} vs NGPT.
4. Using this technique to calculate < N_{coll} > for each centrality class in BbcAdcSum and see whether values per centrality class differ significantly.