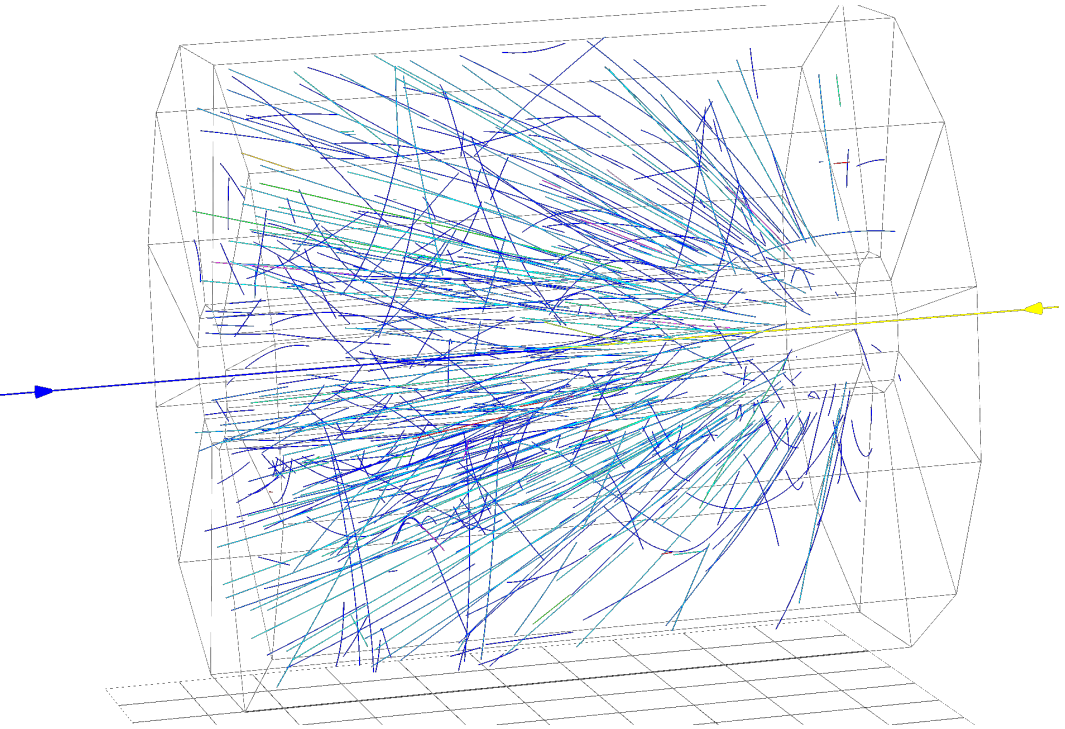

Centrality Determination in the Fixed-Target Program at STAR

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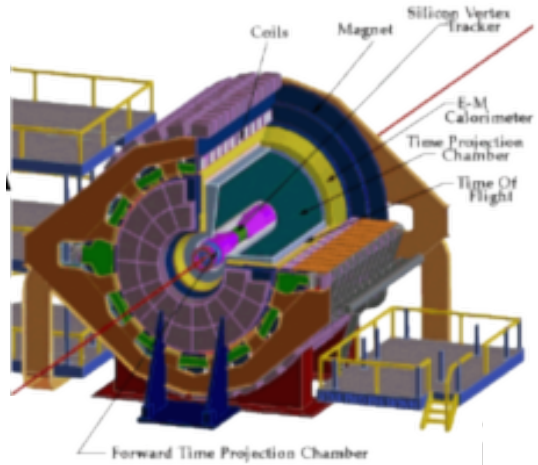
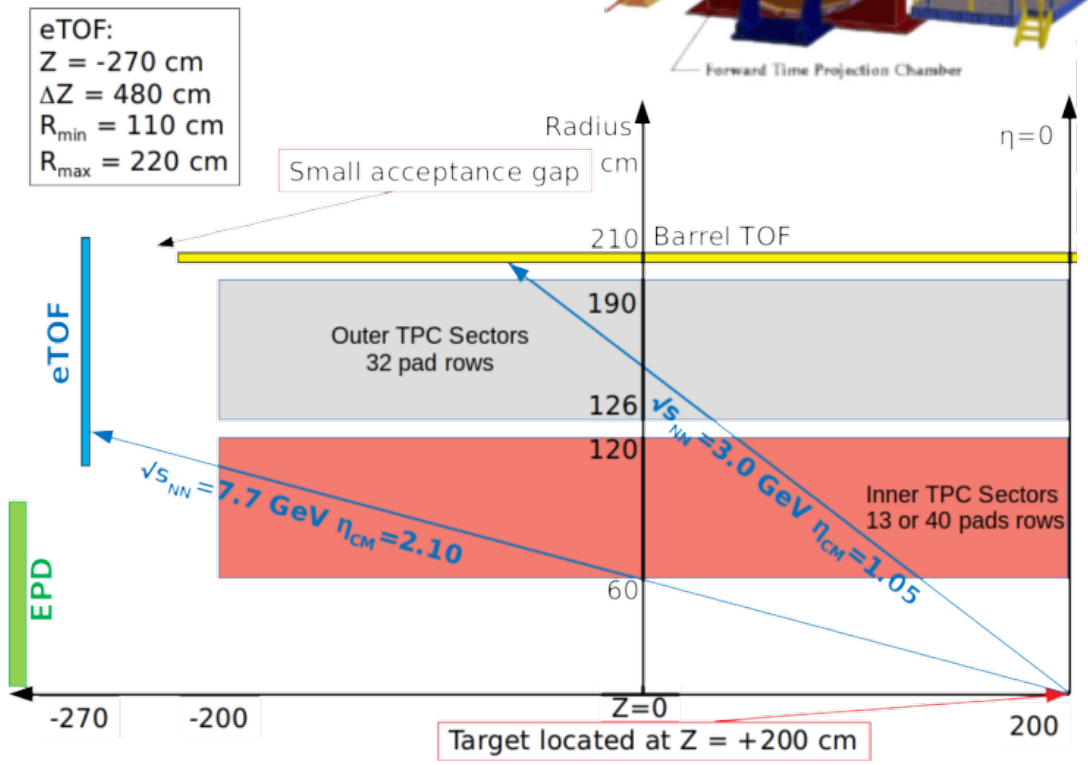
Fixed-Target (FXT) Program at STAR

- Test run with gold target performed in 2015
- First physics runs at $\sqrt{s_{NN}}$ = 3.0 GeV and 7.2 GeV in 2018
- Now have data at $\sqrt{s_{NN}}$ of 3.0, 3.2, 3.5, 3.9, 4.5, 5.2, 6.2, 7.2, and 7.7 GeV



Challenges for FXT Centrality

- Asymmetric acceptance at midrapidity, changing with beam energy
- As $\sqrt{s_{NN}}$ increases to 7.7 GeV midrapidity moves out of the Time Projection Chamber (TPC) acceptance
- Glauber model developed for higher energies
  - Assumes transparent nucleons
  - No account of energy loss in nucleons undergoing multiple collisions

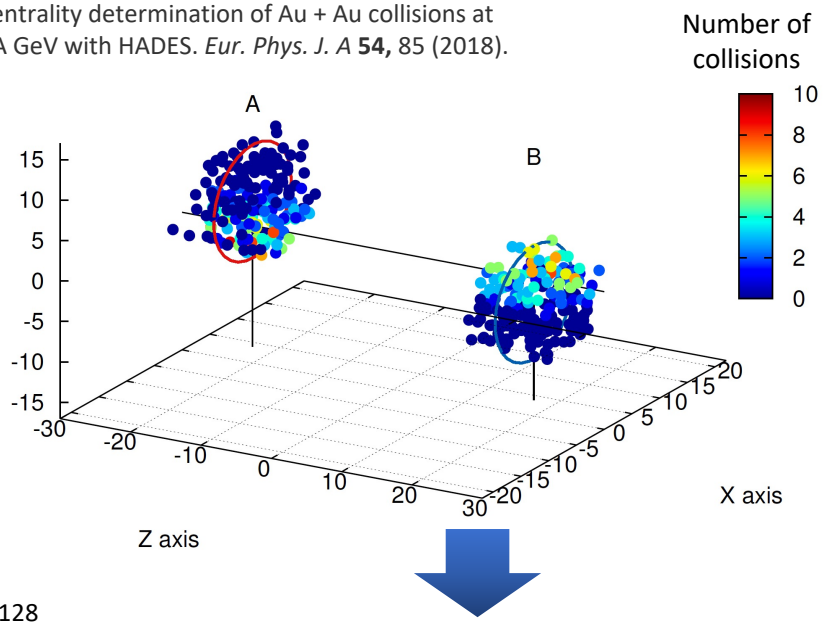


STAR Centrality Determination

Beam Energy Scan (BES)-I Centrality (2010-2014)

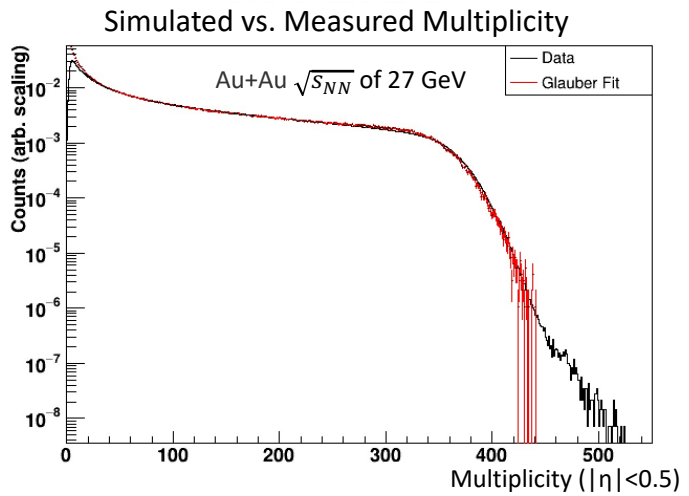
- Glauber model used from $\sqrt{s_{NN}}$ of 7.7 GeV to 62.4 GeV to simulate number of participant nucleons (N_{part}) and the number of nucleon collision (N_{coll}) distributions M.L. Miller *et al.*, Annual Rev. NPS. 57, 205-43 (2007)
- Particle production from collisions is modeled by sampling from a negative binomial probability distribution Ansorge RE, et al. Z. Phys. C 43:357 (1989)
- Two component multiplicity model paired with the Glauber scales particle production as: $\text{Multiplicity} \sim x N_{coll} + (1-x)\frac{N_{part}}{2}$ D. Kharzeev, M. Nardi, Phys.Lett. B507 (2001) 121-128

Adamczewski-Musch, J., Arnold, O., Behnke, C. *et al.* Centrality determination of Au + Au collisions at 1.23A GeV with HADES. *Eur. Phys. J. A* **54,** 85 (2018).



BES-II Centrality (2018-2021)

- Glauber model paired with two component multiplicity model for particle production once again used successfully from $\sqrt{s_{NN}}$ = 7.7 GeV to 200 GeV



FXT Centrality (2018-2021)

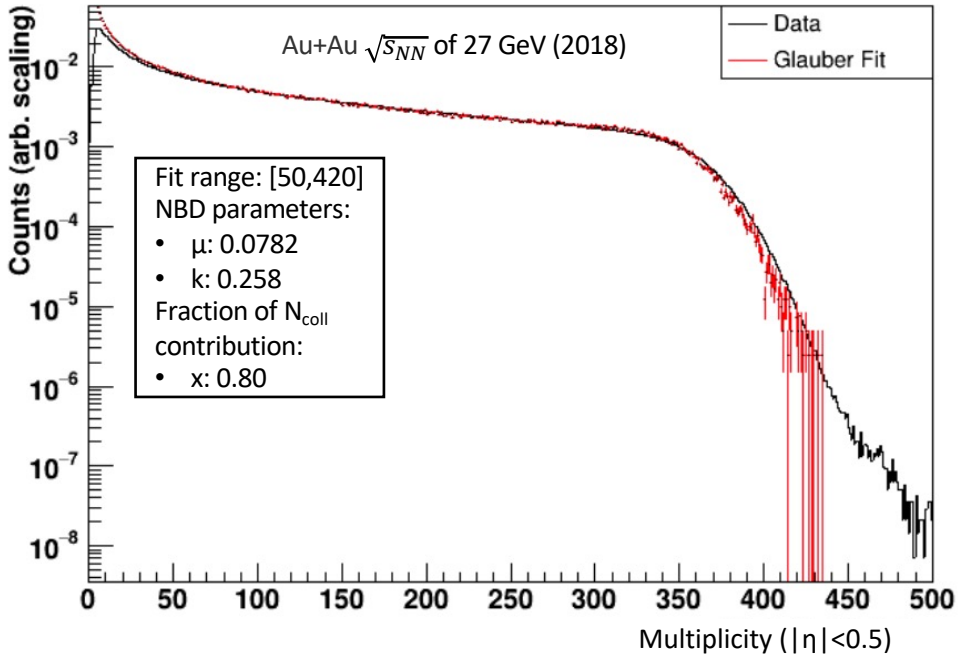
- Does the Glauber model work at these energies?
- Can the model represent multiplicities skewed by limited acceptance at mid-rapidity?

Glauber Methodology Works for Data Taken in Collider Mode

Centrality Definition in Collider Mode

- The Glauber model fits collider data very well
- Deviates only for most peripheral collisions where trigger bias becomes significant

Glauber Comparison to Collider Data

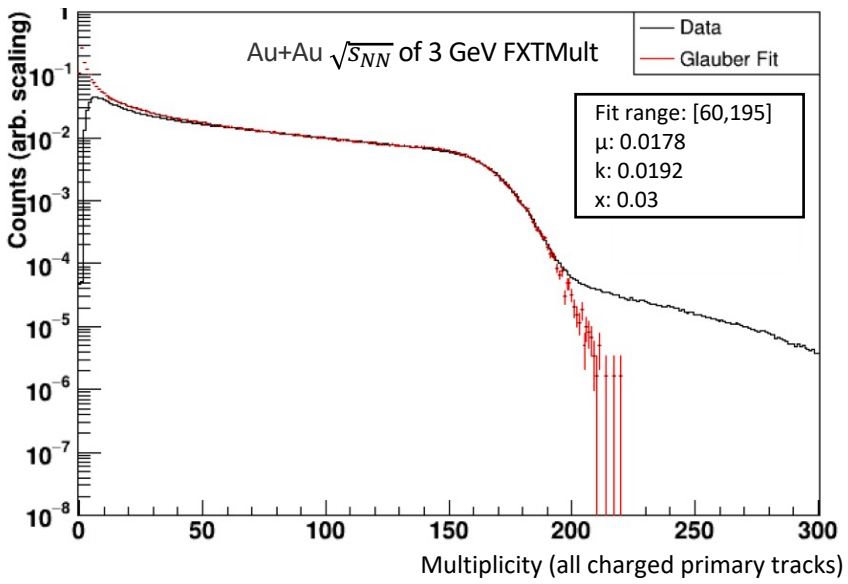


$\sqrt{s_{NN}}$ of 3 GeV and 7.2 GeV

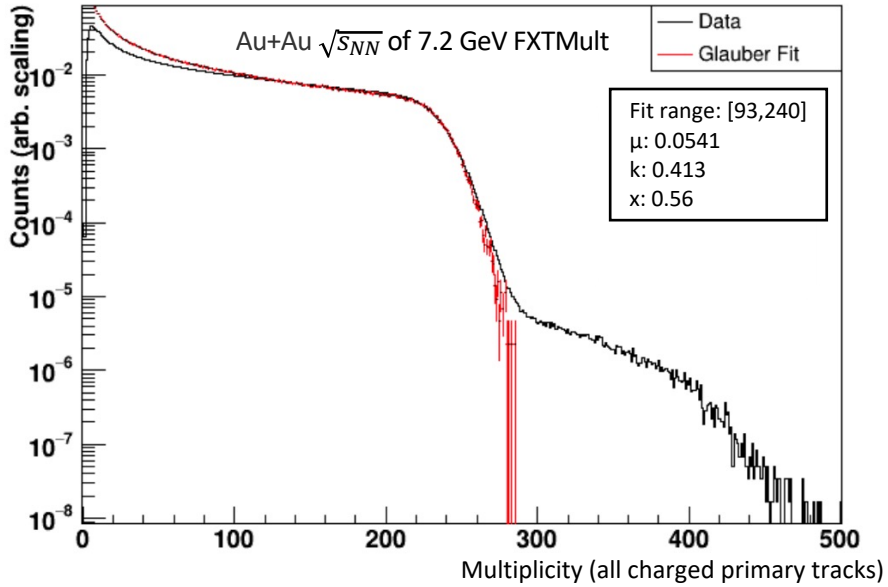
Centrality Definition in the Fixed-Target Program

- Pile-up becomes visible for most central events
- Glauber model works well at 3.0 GeV
- Glauber significantly overestimates low multiplicity region at 7.2 GeV
  - Trigger bias?
  - Incomplete acceptance?

Glauber Comparison to Fixed Target Data

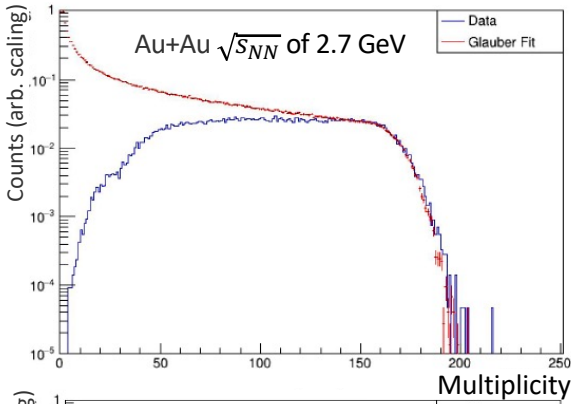


Glauber Comparison to Fixed Target Data

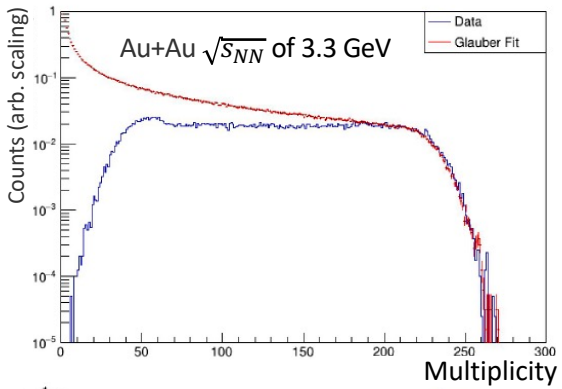


Application of Glauber to AGS Data

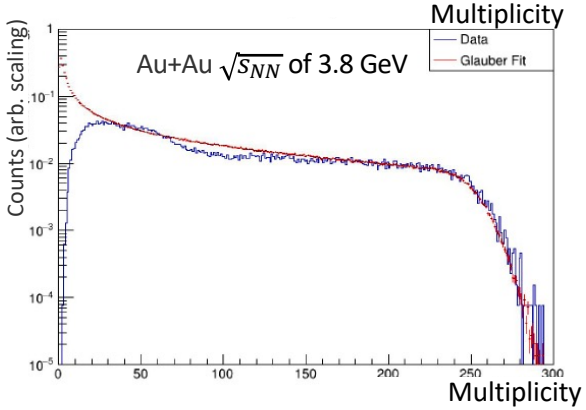
- E895 experiment at the AGS at BNL collided gold nuclei at $\sqrt{s_{NN}}$ values of 2.7, 3.3, 3.8, 4.3 GeV
- Triggering ion chamber allowed for direct measurement of every incident gold ion, making Glauber approach unnecessary
- We tested out Glauber approach on these data



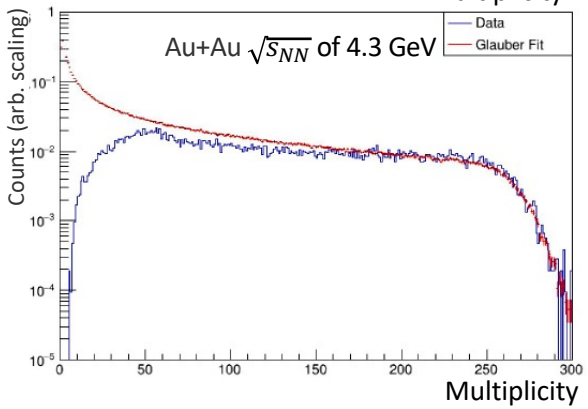
Efficiency predicted by Glauber: 24%
E895 determination of efficiency: 23%



Efficiency predicted by Glauber: 25%
E895 determination of efficiency: 27%



Efficiency predicted by Glauber: 60%
E895 determination of efficiency: 68%



Efficiency predicted by Glauber: 40%
E895 determination of efficiency: 42%

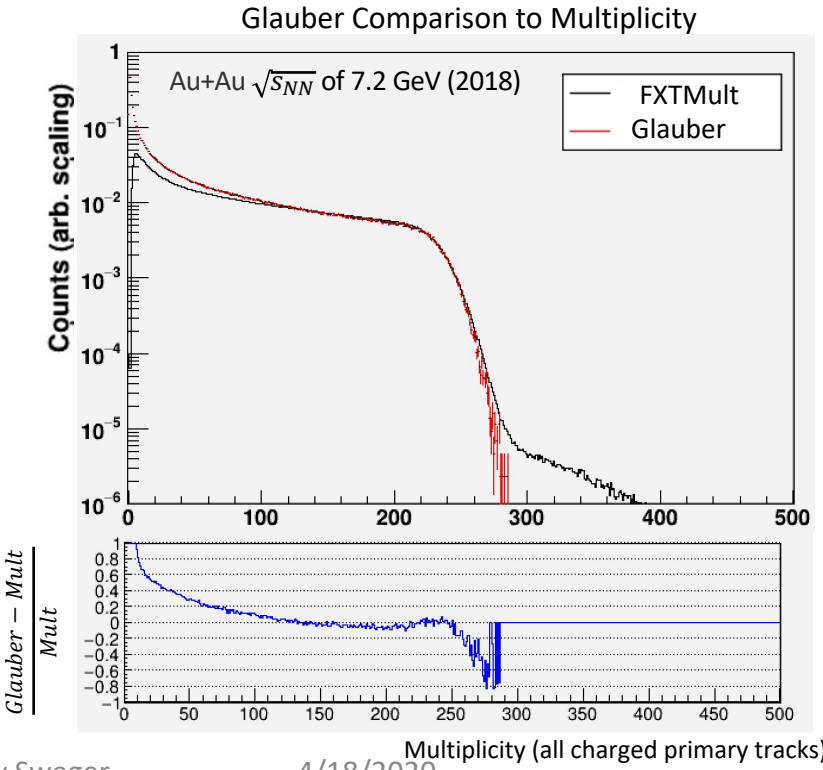
- HADES Experiment applied Glauber to Au+Au at $\sqrt{s_{NN}}$ = 2.4 GeV

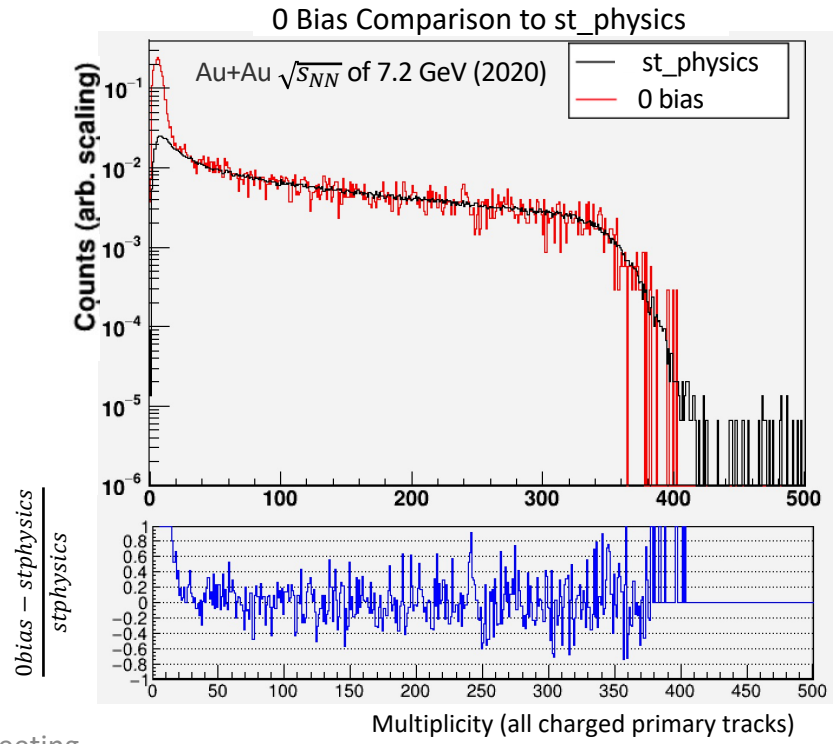
Adamczewski-Musch, J., Arnold, O., Behnke, C. *et al.* Centrality determination of Au + Au collisions at 1.23A GeV with HADES. *Eur. Phys. J. A* **54,** 85 (2018).

Exploring Trigger Bias at 7.2 GeV

Trigger Bias Study

- Zero bias data at 7.2 GeV taken parasitically during beam test runs
- Do we see the dramatic trigger bias for mid-peripheral events predicted by the Glauber model?
- No, trigger bias is not nearly as large as predicted
  - ➢ Discrepancy due to incomplete acceptance: we need to retool particle production model





Success with Inclusion of Efficiency

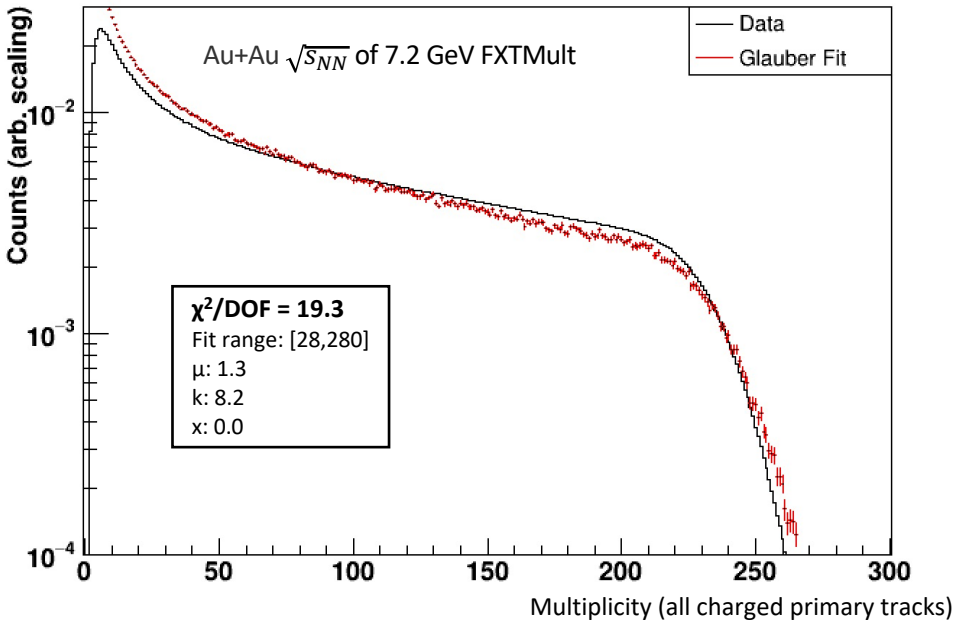
- Preliminary study demonstrates large improvement when Glauber model is paired with a multiplicity-dependent efficiency

$$\epsilon = 0.98 * (1.0 - \text{multiplicity} * d/280.0)$$

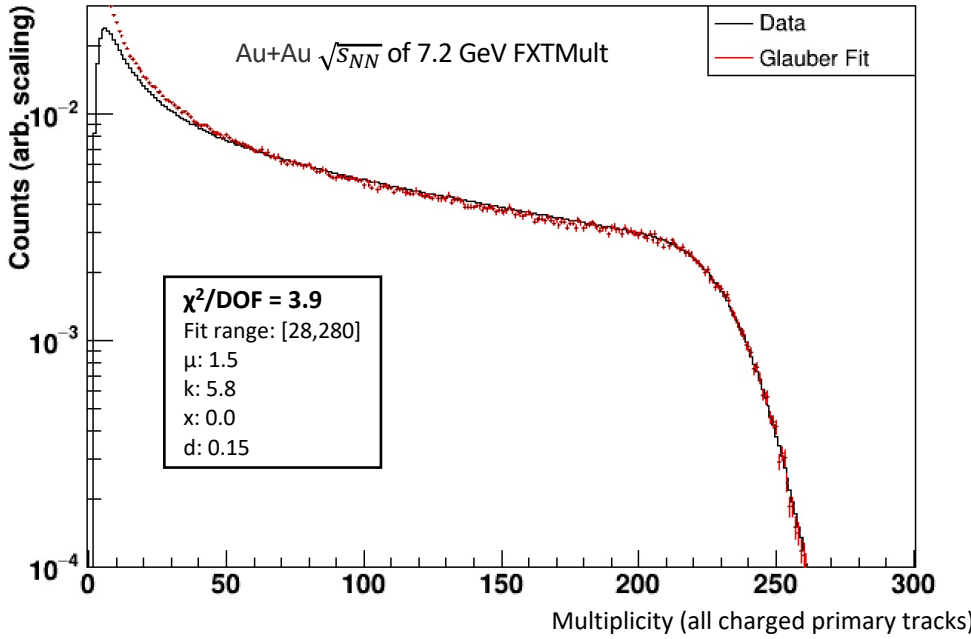
d: free parameter
280: highest multiplicity

- Correction models decreasing efficiency with increasing tracks caused by large occupancy in TPC
  - Linear efficiency correction has been used by STAR in the past
  - Magnitude of correction should be investigated using simulations

Glauber Fit without Efficiency Correction



Glauber Fit with Efficiency Correction



Conclusions and Outlook

What we know

- Glauber with two-component particle production model approach has been shown to work at energies at and below current FXT energies
  - Glauber application to E895 data roughly matches distributions and predicts experimental efficiencies
  - HADES successfully used Glauber below these energies

What to investigate

- We are working to understand the effect of multiplicity-dependent efficiency in FXT data
- Simulate charged particle tracks
- Analyze expected charged particle efficiency
  - Possible modification of efficiency function for fixed-target analysis