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Inclusive Jet Analysis in p+Au Collisions at $\sqrt{s_{NN}}$ = 200 GeV at STAR

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Introduction

Jets and Jet Quenching

- Collimated hadrons created by parton fragmentation at early stages of collision
- Jet modification through QGP → probe of the medium
- Modification factor $R_{\mathrm{p(d)A}} = \frac{Y_{\mathrm{p(d)A}}}{N_{\mathrm{coll}} * Y_{\mathrm{pp}}}$

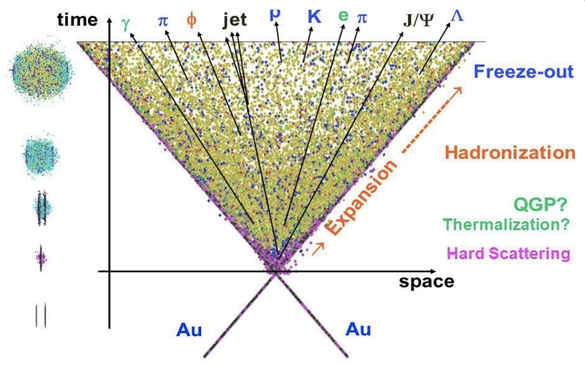

Fig. 1. Schematic time evolution of heavy ion collisions[1]

QGP in Small System

- Flow-like signals detected in small systems (p+Au, p+Pb, d+Au) at RHIC and the LHC
- Overall minimum bias $R_{\mathrm{p+Au}}$ for jet modification signals found to be consistent with unity [2][3][4]
- Event Activity (EA) binned ratios show suppression/enhancement in high/low EA

Inclusive Jet Analysis in p+Au

- Per-trigger analysis (D. Stewart's talk @QM2019[5]) provides relative comparison without Glauber calculation
- Although applicability to p+Au collisions being questionable, Glauber scaling and inclusive jet measurements provide **direct comparison to p+p collisions**

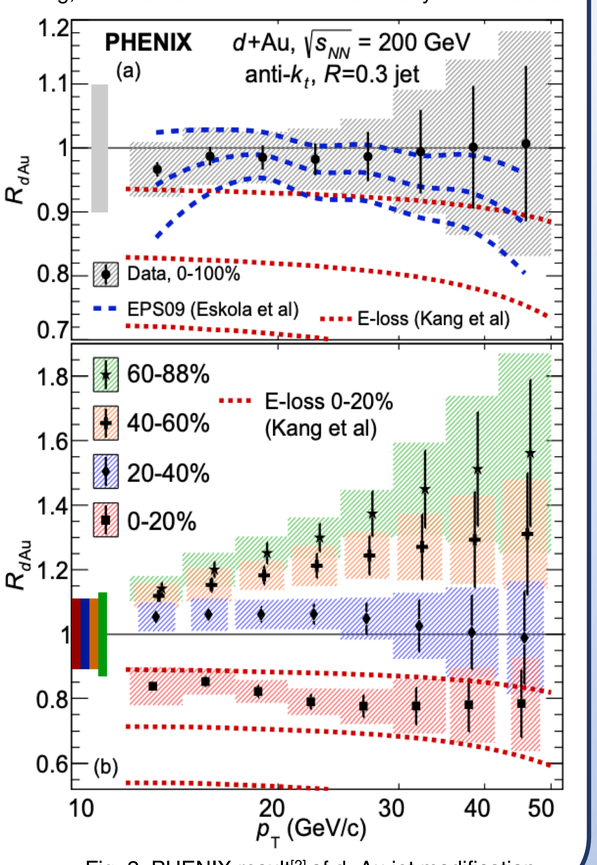

Fig. 2. PHENIX result[2] of d+Au jet modification

The Solenoid Tracker at RHIC (STAR)

Time Projection Chamber[7]

- Full ϕ coverage for |η|<1
- p_{T} resolution as good as 2% at ~1 GeV/c
- Primary detector for charged jet analysis

Barrel Electro-Magnetic Calorimeter[8]

- 4800 towers recording energy hits from charged and neutral particles

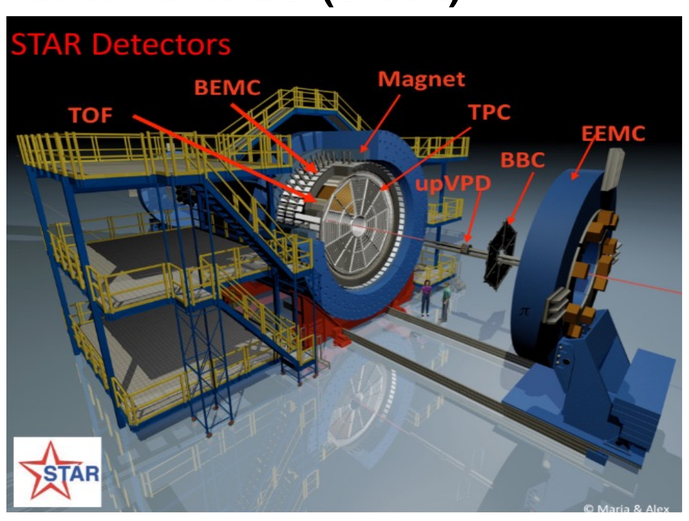

Fig. 3. The STAR experiment and detector components [6]

- Angular resolution $\Delta\eta$=$\Delta\phi$=0.05; full ϕ coverage at |η|<1
- Energy resolution $\sigma_E/E \sim 14\%/\sqrt{E(GeV)} + 1.5\%$
- Required for full (charge+neutral) jet analysis

Beam Beam Counter[9]

- Hexagon plastic scintillators arranged into inner & outer ring
- Full ϕ coverage at rapidity range 2.2< |η|<5.0
- Minimum bias trigger for p+Au analysis

Dataset

- p+Au $\sqrt{s_{NN}}$ =200 *GeV*: 2015
- $O(10^8)$ events after quality cuts
- Track level cuts:
  - $0.2\ \mathrm{GeV}/c < p_T < 30\ \mathrm{GeV}/c$
  - $|\eta| < 1$

Jet Clustering

- FastJet[10] (Anti-k_T R=0.4 jets)
- Charged tracks from TPC
- Full jets: EMC hits after performance study, hadronic correction applied
- Small uncorrelated background to be handled in the unfolding procedure

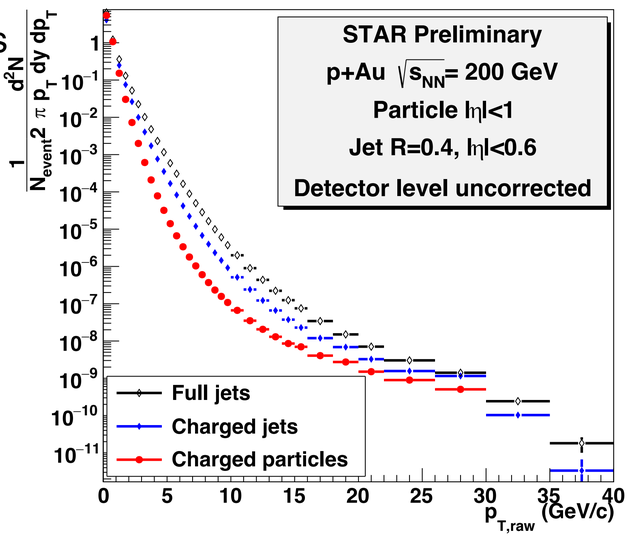

Fig 4. Charged particles and full & charged jet spectrum for STAR p+Au 200 GeV minbias collisions; Detector level uncorrected

Track-level correction

- $\pi^{\pm}/K^{\pm}/p(\bar{p})$ particle simulation embedded into p+Au minimum biased events
- Obtain tracking efficiency weighted by experimental prior[11] (Fig. 5)
- Track spectrum will be corrected by tracking efficiency, then will serve as new prior for weighting of mixed efficiency curve
- Iterate until matrix converges & compare with previous study[12]

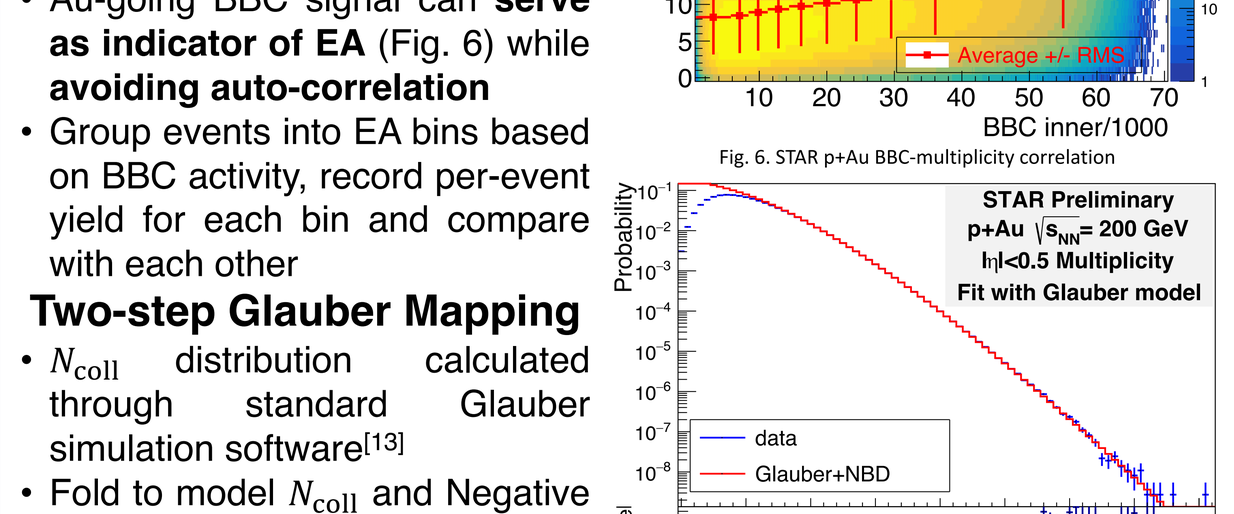

Fig. 5. STAR tracking efficiency from embedding data

Event Activity Category

- Standard STAR analyses use the mid-rapidity charged-particle multiplicity for Event Activity definition, but has auto-correlation with jet yield
- Au-going BBC signal can **serve as indicator of EA** (Fig. 6) while **avoiding auto-correlation**
- Group events into EA bins based on BBC activity, record per-event yield for each bin and compare with each other

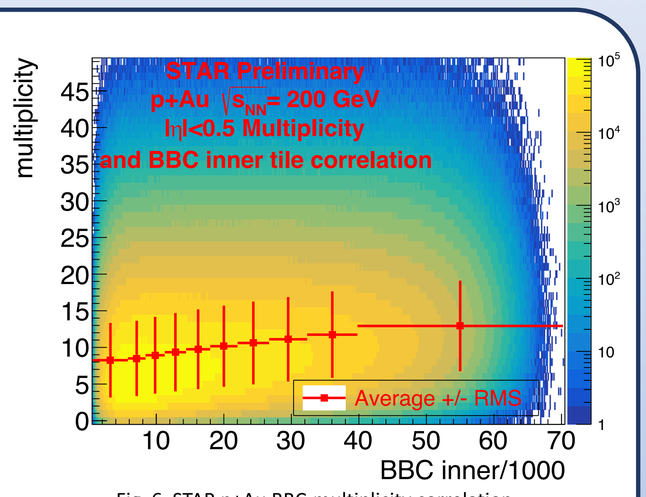

Fig. 6. STAR p+Au BBC-multiplicity correlation

Two-step Glauber Mapping

- N_{coll} distribution calculated through standard Glauber simulation software[13]
- Fold to model N_{coll} and Negative Binomial Distribution (NBD) to fit with data multiplicity, obtain $\langle N_{coll} \rangle$ **for each multiplicity value** (Fig. 7)
- Calculate average $\langle N_{coll} \rangle$ **for each EA bin** (as in Fig. 6) according to **multiplicity distribution in the category**
- Divide EA-categorized jet yield by $\langle N_{\mathrm{coll}} \rangle$ in each bin and obtain Glauber-scaled R_{CP} and nuclear modification factor R_{pAu}

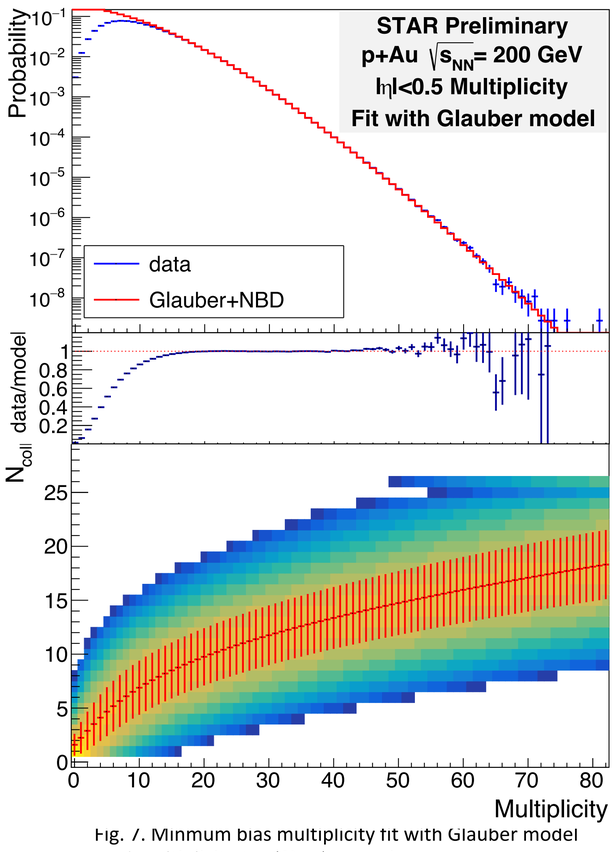

Fig. 7. Minimum bias multiplicity fit with Glauber model and multiplicity-to-$\langle N_{\mathrm{coll}} \rangle$ mapping

Summary

- Utilized backward (Au-going) BBC signal as an event activity indicator
- Measured inclusive particle & jet spectrum
- Developed a method to obtain $< N_{coll} >$ for each centrality class

Outlook

- Further validate the BBC-$< N_{coll} >$ mapping method
- Measure jet R_{pAu} and compare with previous results
- Study EA dependence of fully corrected p+Au jet spectra and modification via R_{pAu}

References

[1] D. Anderson, 2018 RHIC-AGS user meeting; Adapted from Tatsuya Chujo, JPS RHIC Symposium 2001. https://www.bnl.gov/aum2018/content/workshops/ws2a.php
[2] PHENIX collaboration, Phys. Rev. Lett. 116, 122301 (2016). https://arxiv.org/abs/1509.04657
[3] CMS collaboration, Eur. Phys. J. C 76, 372 (2016), https://arxiv.org/abs/1601.02001
[4] ATLAS collaboration, Phys. Lett. B 748, 392-413 (2015), https://arxiv.org/abs/1412.4092
[5] D. Stewart for the STAR collaboration, QM 2019, https://indico.cern.ch/event/792436/contributions/3535637/
[6] A. Sarkar, Higher Moments Measurement of Net-Kaon Multiplicity Distribution in the Search for the QCD Critical Point, PhD thesis, Indian Institute of Technology, India, 2015.
[7] M. Anderson et al., Nucl. Instrum. Meth. A 499, 659 (2003). https://arxiv.org/abs/nucl-ex/0301015
[8] M. Beddo, et al., The STAR barrell electromagnetic calorimeter, Nucl. Instr. and Meth. A 499 (2003) 721.
[9] L.C. Bland, for the S. collaboration, STAR Results from Polarized Proton Collisions at RHIC, arXiv:Hep-Ex/0403012. (2004). http://arxiv.org/abs/hep-ex/0403012.
[10] Cacciari, Salam & Soyez, EPJC72 (2012) 1896, https://arxiv.org/abs/1111.6097
[11] STAR collaboration, Phys.Lett.B637:161-169,2006, https://arxiv.org/abs/nucl-ex/0601033v2
[12] PHOBOS collaboration, Phys. Rev. C 92, 034915, https://arxiv.org/abs/1505.06766
[13] C. Loizides, Phys. Rev. C 94 (2016) 024914, https://arxiv.org/abs/1603.07375

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