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GAČR GRANTOVÁ AGENTURA ČESKÉ REPUBLIKY

Production of Jets at STAR

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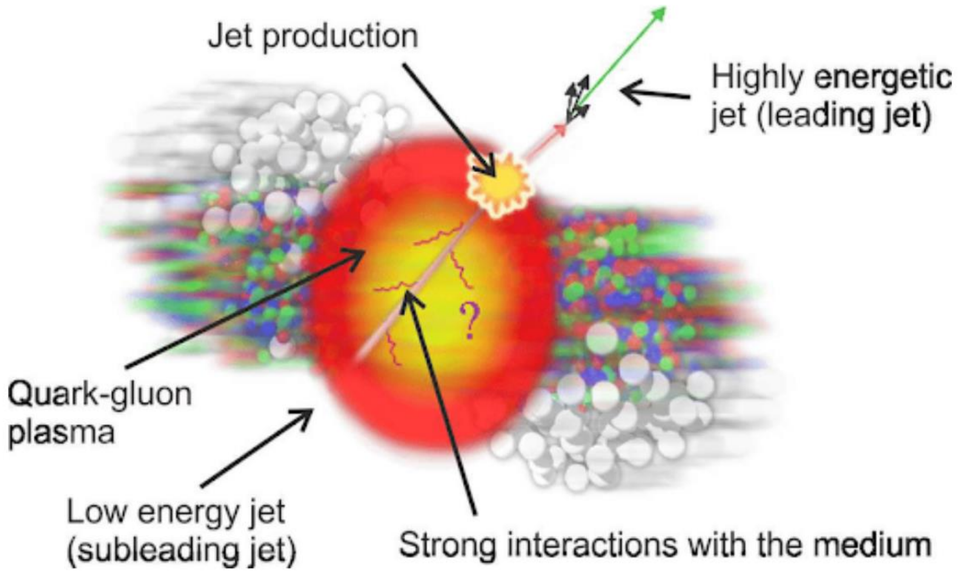
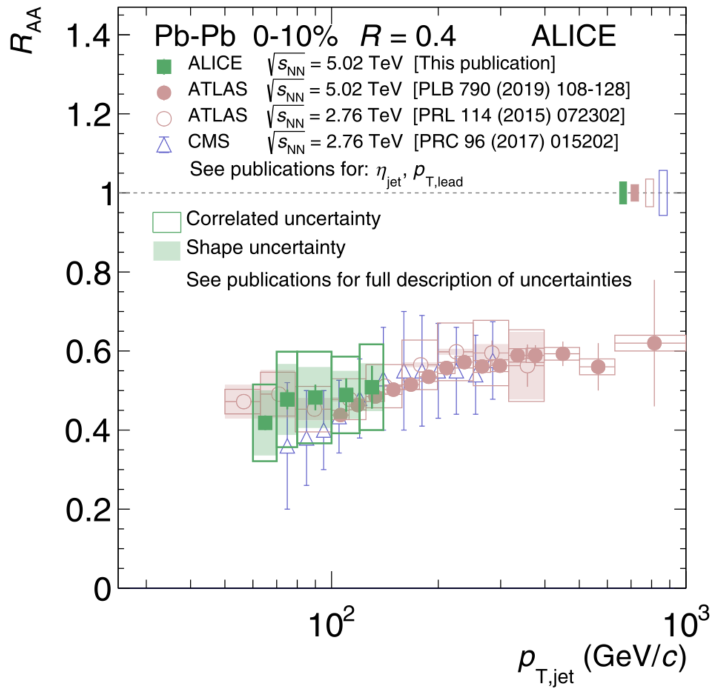
Motivation

- Jets are sprays of particles originating from highly energetic partons created during hard scattering
- Jet quenching measurements provide information about energy loss in the QGP
- Jets are reconstructed using clustering algorithms and connected to theoretical definition



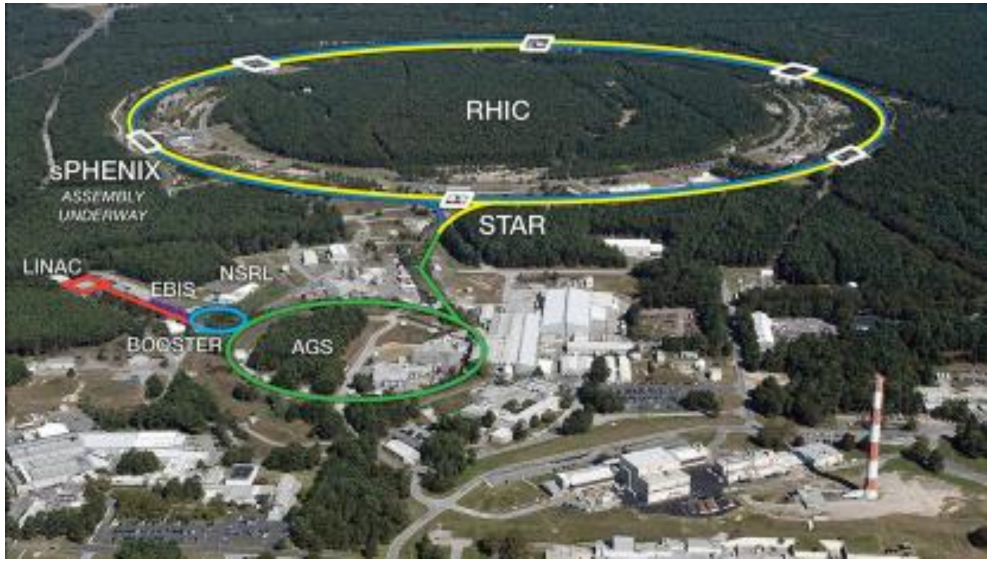
$$R_{\mathrm{AA}} = \frac{1}{\langle N_{\mathrm{coll}} \rangle} \cdot \frac{\frac{1}{N_{\mathrm{evt}}^{\mathrm{AA}}} \frac{\mathrm{d}^2 N_{\mathrm{AA}}^{\mathrm{jet}}}{\mathrm{d}p_{\mathrm{T,jet}}\mathrm{d}\eta}}{\frac{1}{N_{\mathrm{evt}}^{pp}} \frac{\mathrm{d}^2 N_{pp}^{\mathrm{jet}}}{\mathrm{d}p_{\mathrm{T,jet}}\mathrm{d}\eta}}$$

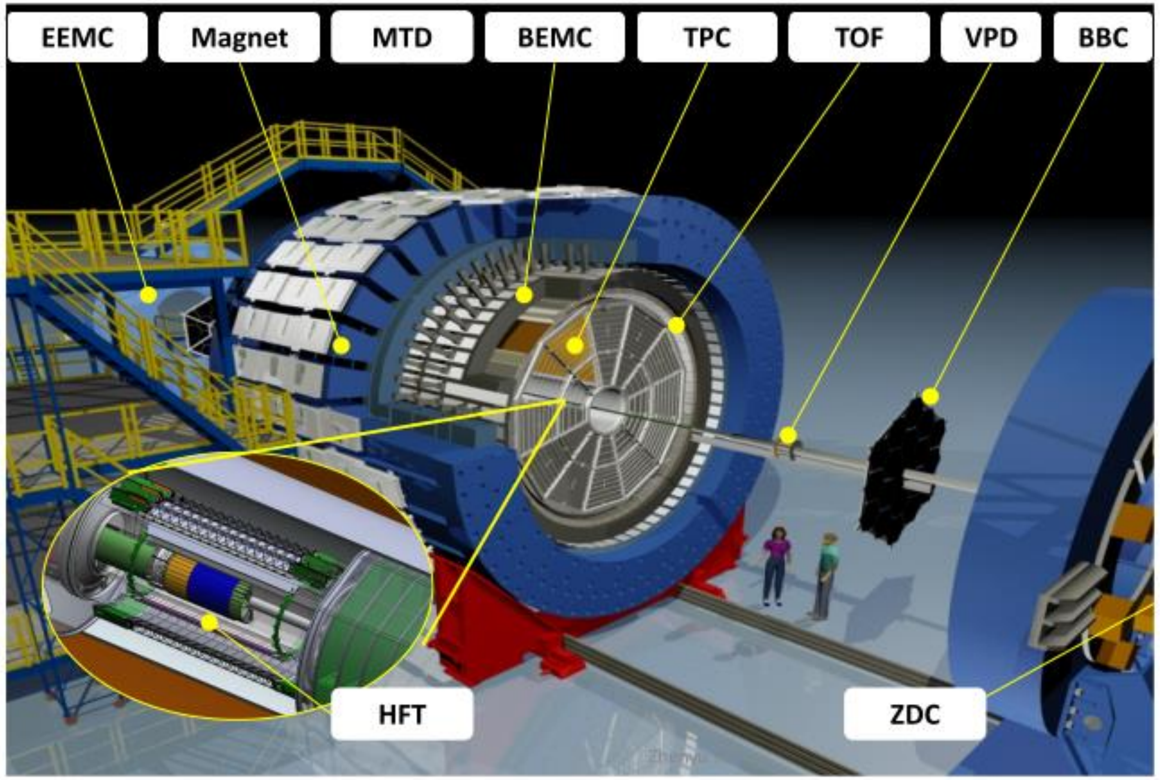


ALICE, PRC 101 (2020) 034911

Solenoidal Tracker at RHIC

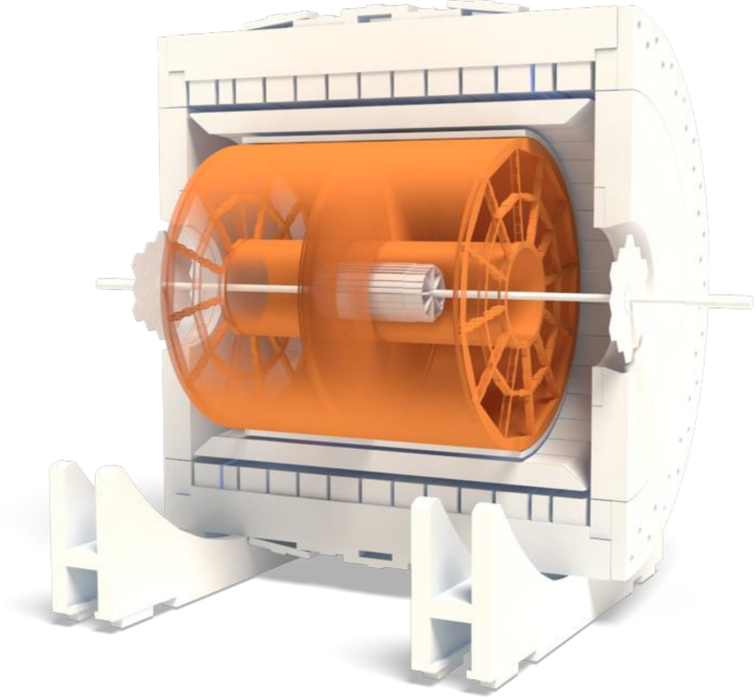
- Relativistic Heavy Ion Collider (RHIC) can collide
  - *p*+*p*, *p*+Au, O+O, Zr+Zr, Ru+Ru, Au+Au …
  - Au+Au beams at $\sqrt{s_{NN}}$ = 200 GeV





Solenoidal Tracker at RHIC

- Time Projection Chamber (TPC) [$|\eta| < 1$]
  - Measures momentum of charged particles +identification
  - Centrality determination
- Barrel Electromagnetic Calorimeter (BEMC) [$|\eta| < 1$]
  - Energy deposits of neutral particles
  - Provides online trigger
- Beam-beam Counter (BBC) [$3.4 < |\eta| < 5.0$]
  - Proxy for centrality in *p*+Au collisions
  - Trigger for *p*+*p* collisions



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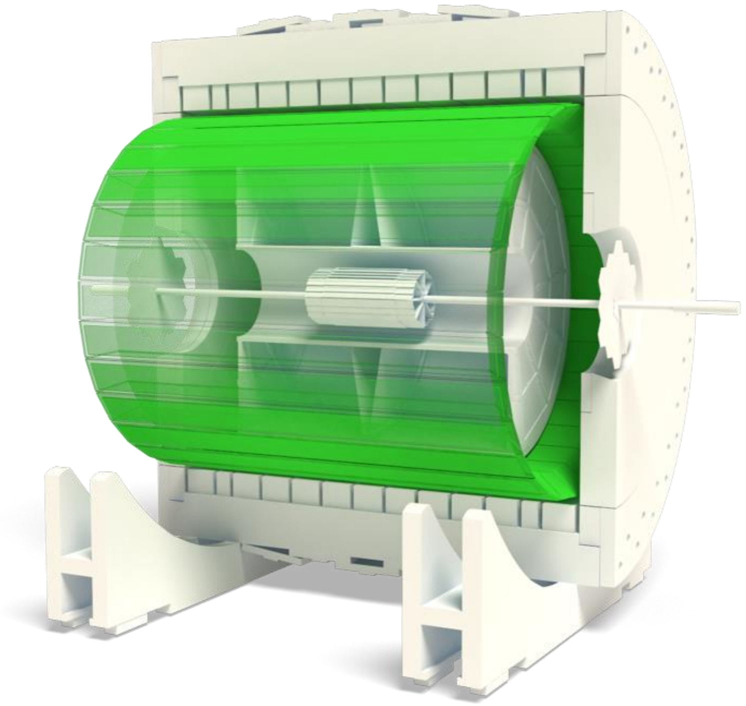

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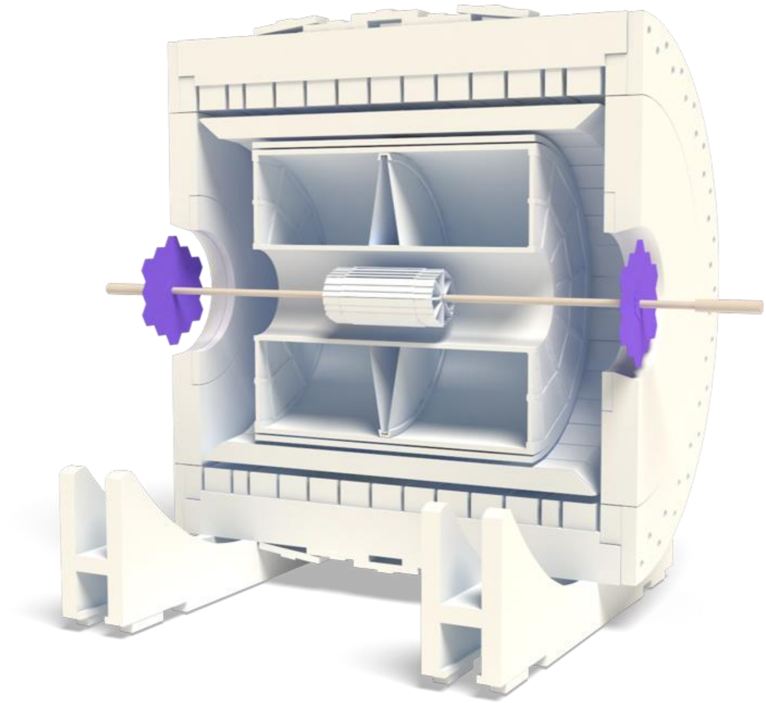
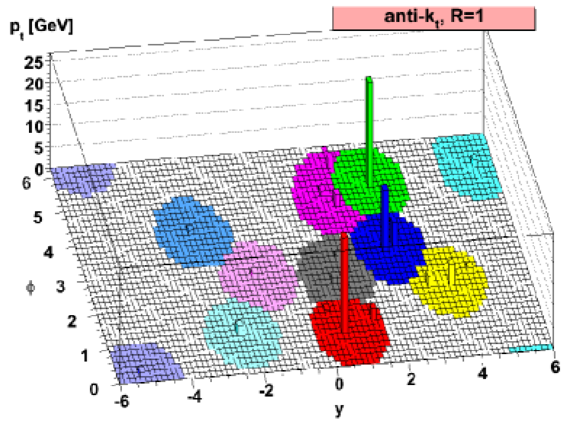


Reconstruction of Jets at STAR

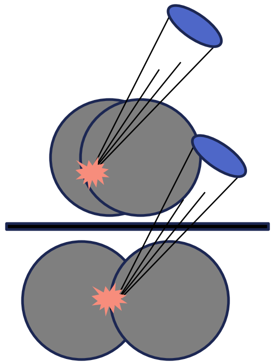
- Jets in the following shown analyses are reconstructed using anti-k_T algorithm
- Charged-particle jets: reconstructed from charged-particle tracks in TPC only
- Full jets: reconstructed from charged-particle tracks in TPC + energy in BEMC towers
- Jet measurements in various collision systems (*p*+*p*, ***p*+Au**, Zr+Zr, Ru+Ru, **Au+Au**...)
- Reconstruction with low constituent p_T cut-off (0.2 GeV/*c*)
- Kinematic reach up-to jet p_T of 50-60 GeV/*c* -> allows comparison with LHC experiments

$$d_{i,j} = \min\left(p_{\mathrm{T,i}}^{-2}, p_{\mathrm{T,j}}^{-2}\right) \frac{\Delta R_{ij}^2}{R^2}$$

$$\Delta R_{ij}^2 = (y_i - y_j)^2 + (\phi_i - \phi_j)^2$$



Charged-particle jet R_{CP}



$$R_{CP} = \frac{\langle N_{coll}^{per} \rangle}{\langle N_{coll}^{cent} \rangle} \cdot \frac{\frac{1}{N_{evt}^{AA,cent}} \frac{d^2 N_{AA,cent}^{jet}}{dp_{T,jet} d\eta}}{\frac{1}{N_{evt}^{AA,per}} \frac{d^2 N_{AA,per}^{jet}}{dp_{T,jet} d\eta}}$$

- Strong suppression of central data compared to peripheral in Au+Au collisions at 200 GeV
- At RHIC, similar suppression of jet production as at the LHC energies observed

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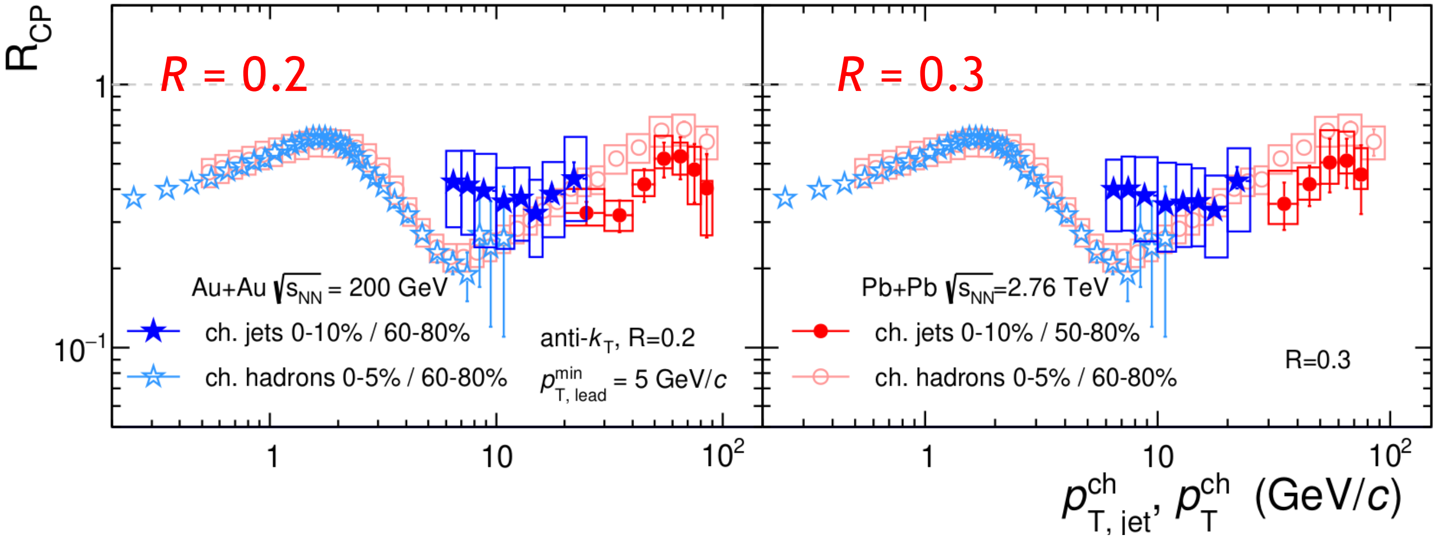
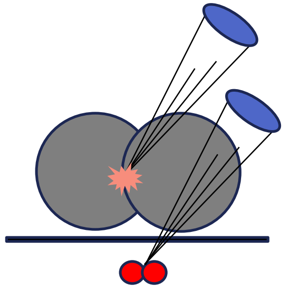


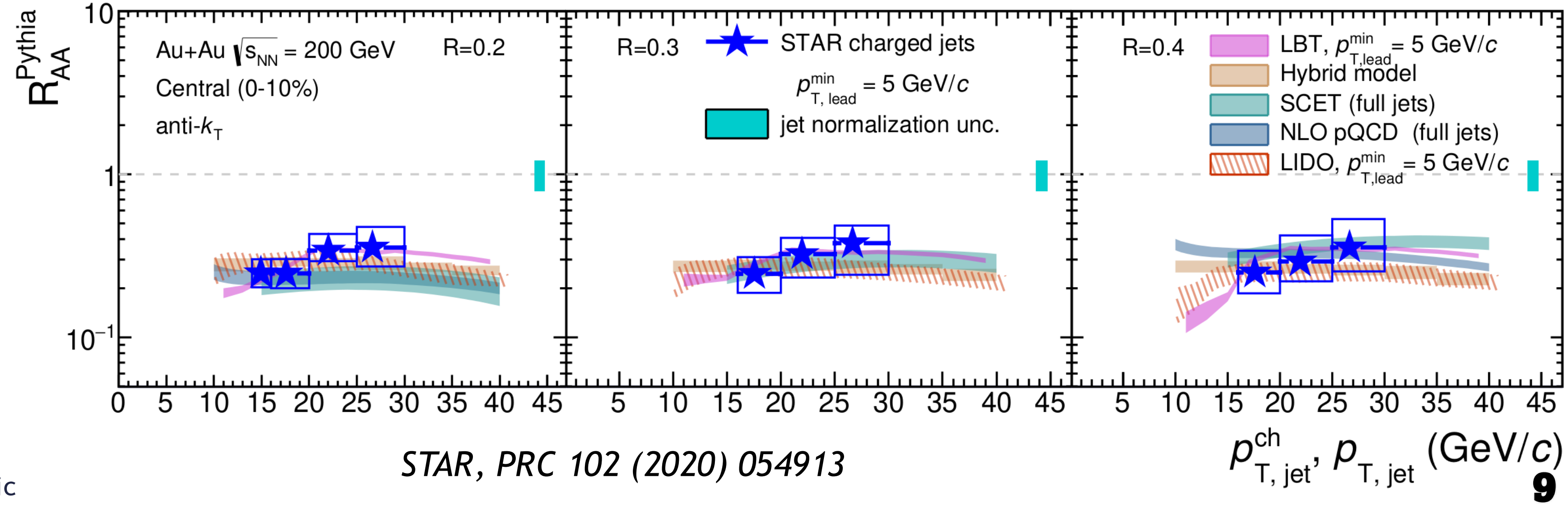
Charged-particle jet R_{AA}



- Significant jet-yield suppression in central Au+Au collisions at 200 GeV
- Weak p_T and R dependence
- LIDO, LBT and SCET calculated for charged-particle jets
- All models are consistent within uncertainties

NLO: Vitev, Zhang, PRL 104, 132001 (2010)
SCET: Chien, Vitev, JHEP 05, 023 (2016)
Hybrid: Casalderrey-Solana, Gulhan, Milhano, Pablos, Rajagopal, JHEP 03, 135 (2017)
LBT: He, Luo, Wang, Zhu, PRC 91, 054908 (2015)
LIDO: Ke, Xu, Bass, PRC 100, 064911 (2019)

$$R_{AA} = \frac{\frac{1}{N_{evt}^{AA}} \frac{d^2 N_{AA}^{jet}}{dp_{T,jet} d\eta}}{T_{AA} \cdot \frac{d^2 \sigma_{pp}^{jet}}{dp_{T,jet} d\eta}}$$



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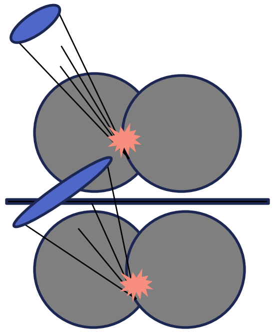
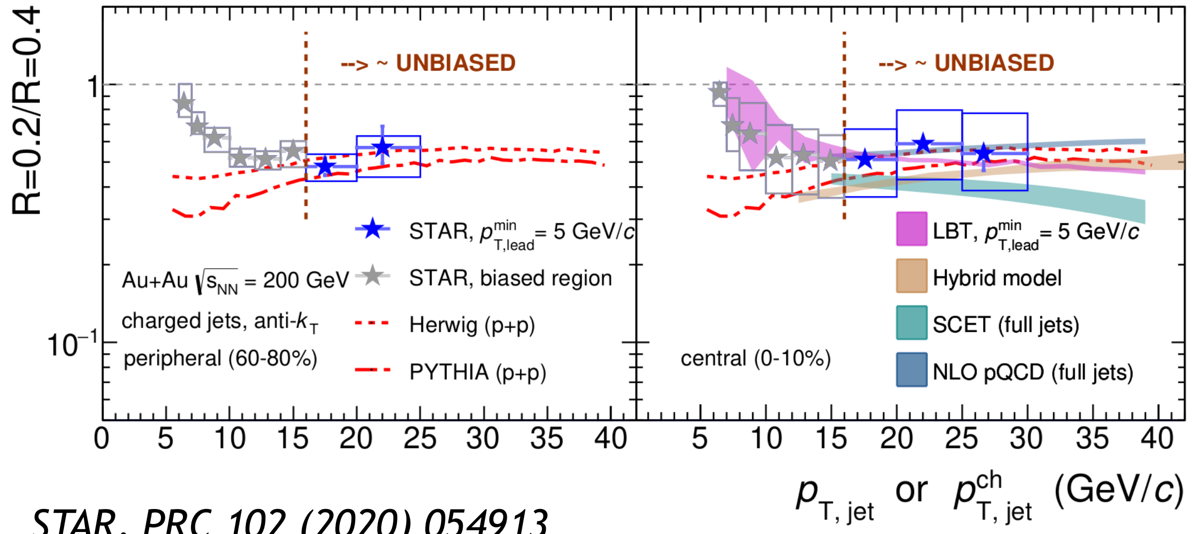
Jet transverse energy distribution



- Significant jet-yield suppression in central collisions
- Ratio of different jet radii allows better model comparison
- Shown models predict different values for the ratio – however all of them are consistent within uncertainties -> better precision needed

- On-going analysis of full jets will allow extension of kinematic reach

Peripheral 60-80 % Central 0-10 %



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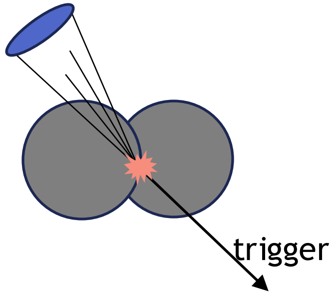
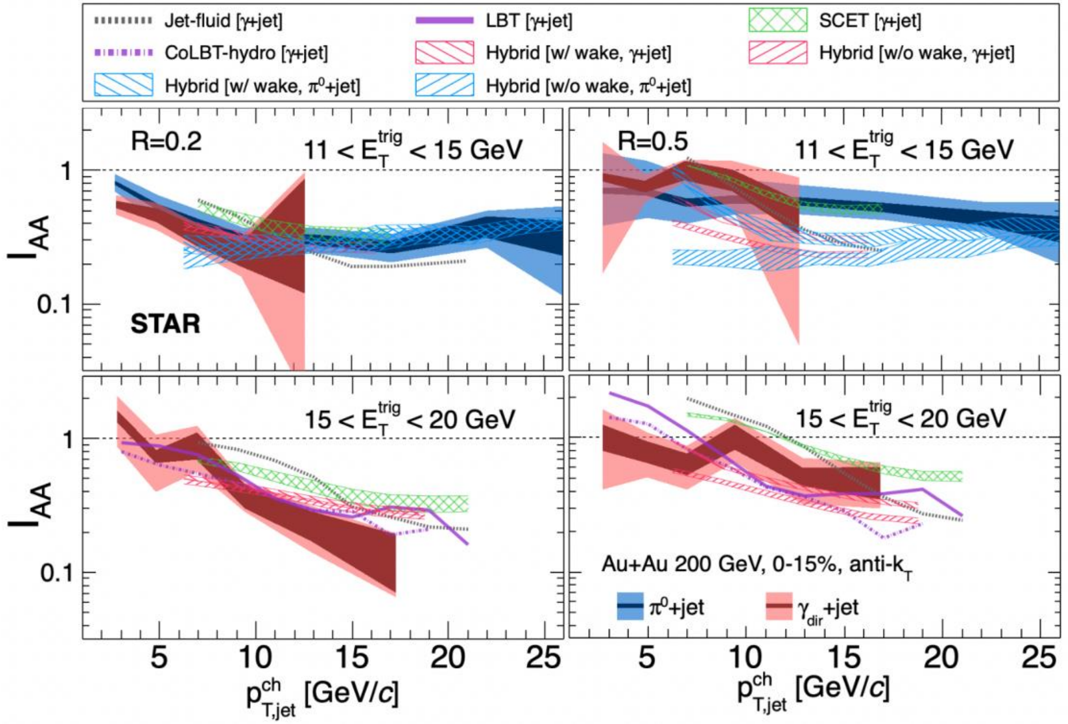


Semi-inclusive recoil jet yield modification

$$I_{AA} = \frac{Y^{Au+Au}(p_{T,jet}^{ch}, R)}{Y^{p+p}(p_{T,jet}^{ch}, R)}$$

- Correlation between direct photon and recoil jet (γ_{dir}+jet) can provide unmodified reference for mesurement of jet quenching
- Simultaneous measurement of γ_{dir} and h+jet correlations enables studies of jet populations with different q/g contributions and path-length distributions
- I_{AA} is consistent within uncertainties for γ_{dir} and π^0 triggered jets



STAR, arXiv:2309.00145, STAR, arXiv:2309.00156

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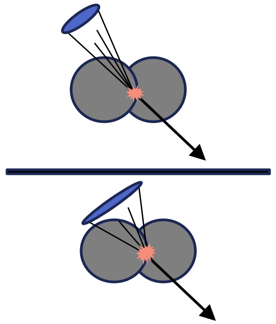
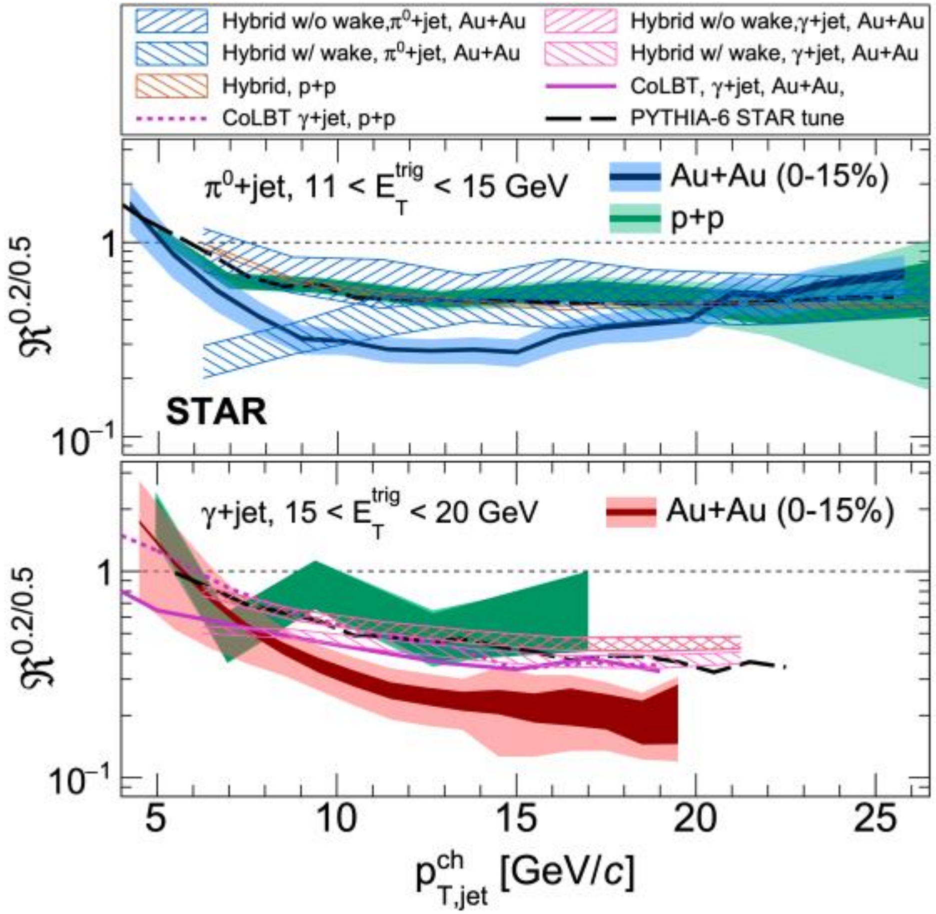


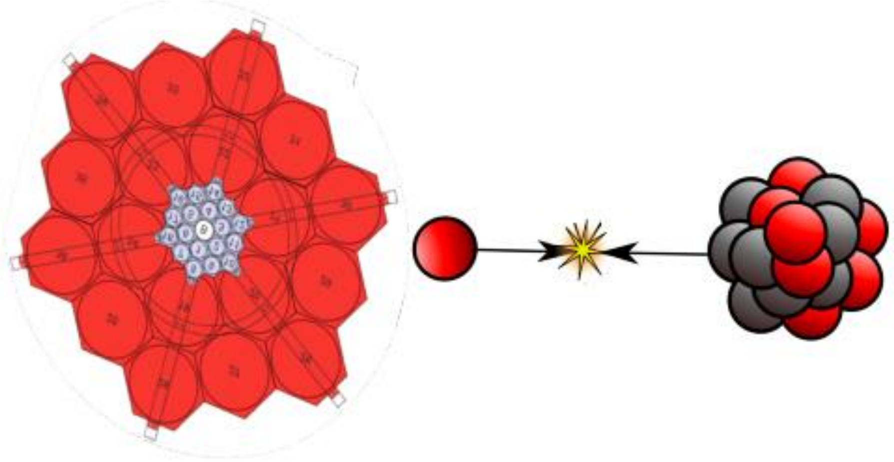
- Recoil jet yield suppression in Au+Au at 200 GeV, stronger in small R jets -> larger fraction of the initial jet energy is captured in larger jets
- Clear observation of intra-jet broadening
- Models unable to quantitatively describe the effect



STAR, arXiv:2309.00145, STAR, arXiv:2309.00156

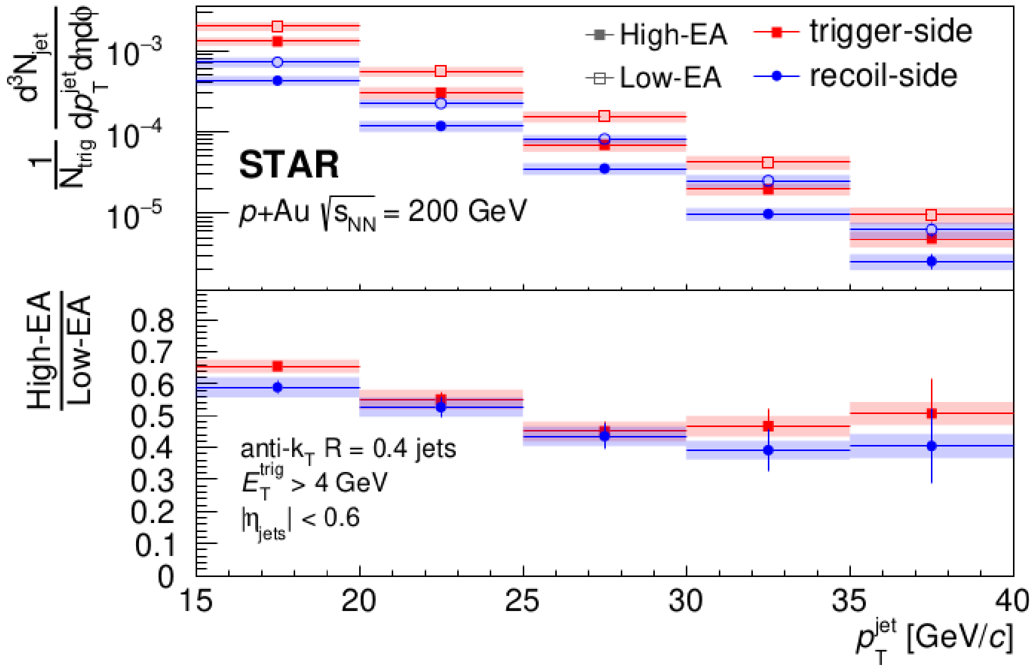
Searching for jet quenching in small systems

- Centrality is not easily defined in *p*+Au collisions
- Event Activity (EA) is the sum of signal (iBBCEsum) from BBC in the Au-going direction
- Backward event activity used as a proxy of centrality in *p*+Au
- EA percentiles are estimated from iBBCEsum from minimum bias events



Semi-inclusive yield modification in *p*+Au

- Hot nuclear matter effects in *p*+Au collisions?
- Semi-inclusive jet spectra distinctly suppressed in high-EA events relative to low-EA events
- Suppression similar for both trigger and recoil side



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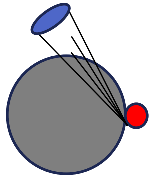
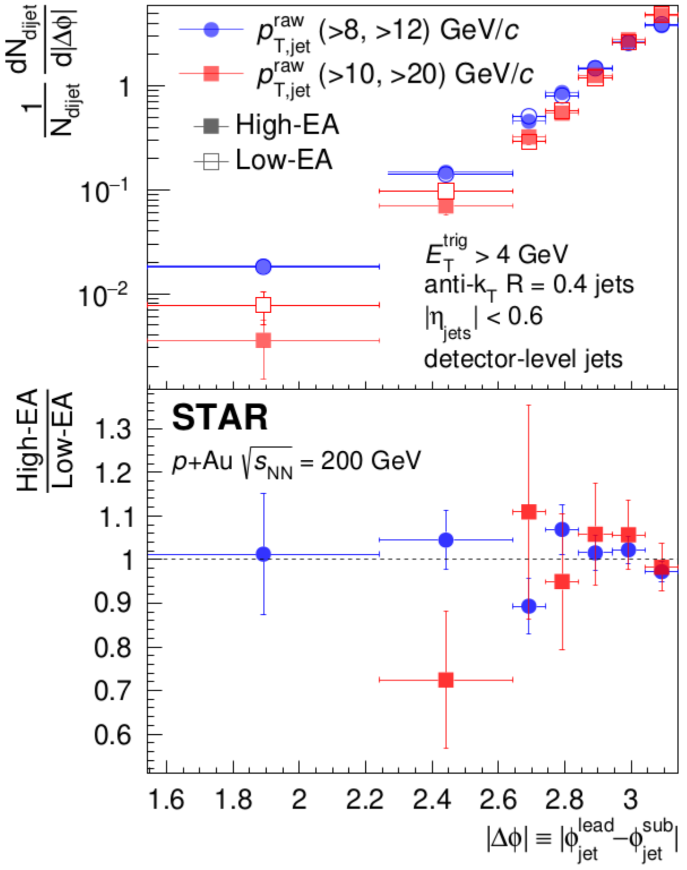


Semi-inclusive yield modification in p+Au

- No significant broadening of Δφ for high-EA events relative to low-EA events
- Leading and subleading jets retain their initial back-to-back configuration
- No jet quenching observed in small systems at STAR

$$|\Delta\phi| \equiv |\phi_{\rm jet}^{\rm lead} - \phi_{\rm jet}^{\rm sub}|$$



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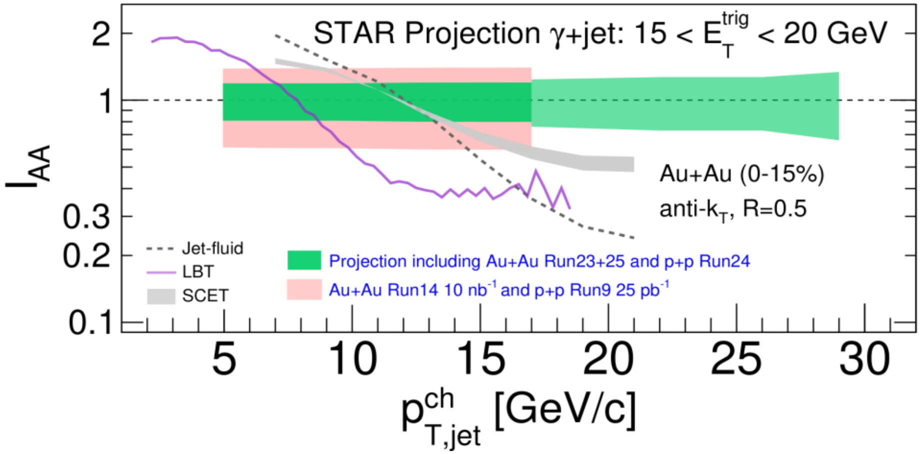
Conclusions and Outlook

- In A+A collisions, jets are a useful probe to study in-medium energy loss
- STAR observes a strong jet suppression in Au+Au collisions
- No significant suppression observed for *p*+Au collisions
- New datasets with larger statistics will allow more precise measurements with larger kinematic reach and/or full jets



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