

Jets and Hard Probes Workshop Summary

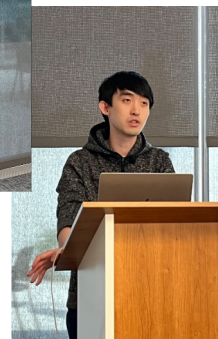
Virginia Bailey & Yeonju Go

*Workshop speakers: Hannah Bossi, João Barata, Hanpu Jiang,
Isaac Mooney, Chris McGinn, Felix Ringer*
2026 RHIC & AGS Annual Users' Meeting
May 12, 2026


Introduction


+30 in person + 10-20 online attendance

[Full presentations here](#)





Recent Measurements at the LHC 
Hannah Bossi
09:00 - 09:30


Jets in Heavy-Ion Collision (Theory) 
João Barata

Recent Measurements from the LHC 
Hanpu Jiang

Coffee Break
10:25 - 10:40

Recent Measurements from the LHC 
Isaac Mooney

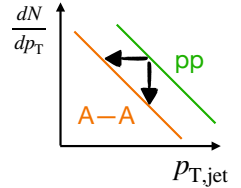
Recent Measurements in the LHC 
Christopher ...

Jets at the Electron-Ion Collider (Theory) 
Felix Ringer
11:35 - 12:00

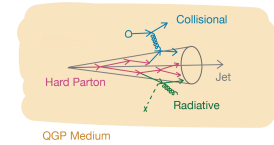
Recent measurements at the LHC - Hannah Bossi

EXPECTATIONS OF JET QUENCHING

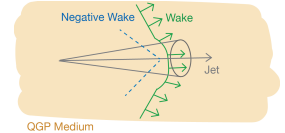
① **Parton energy loss** leading to a suppression of jet yields in heavy-ions (A—A) in comparison to vacuum (pp).



② **Internal structure modification**



③ **Medium should respond to the presence of the jet**

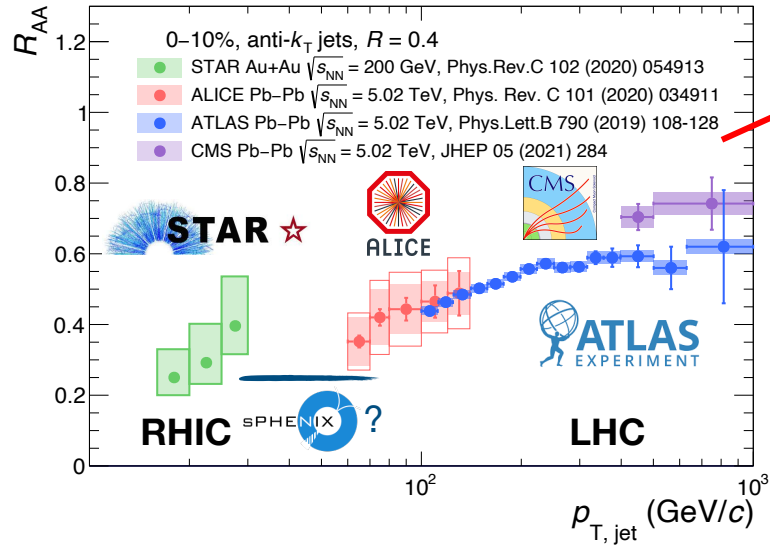


④ **Different jets lose energy differently** depending on different partonic structures, flavors, transverse momenta, path lengths through the medium, etc.

Differential measurements are key to understanding dynamical properties of QGP.

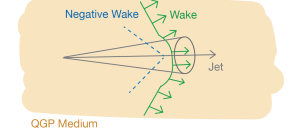
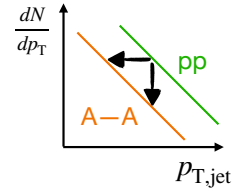
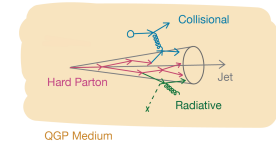
Recent measurements at the LHC - Hannah Bossi

[EPJC 84 (2024) 3, 247]



EXPECTATIONS OF JET QUENCHING

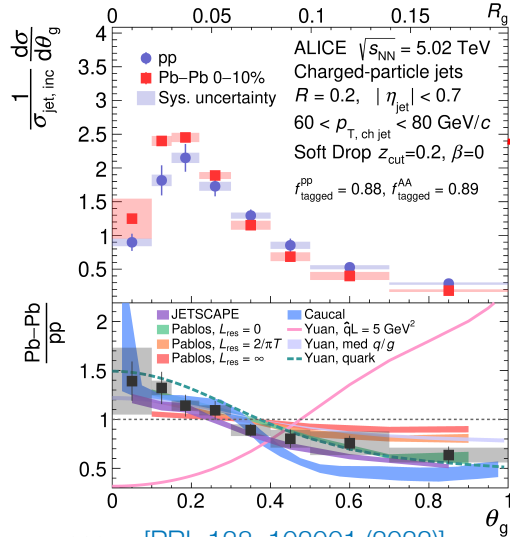
- 1 Parton energy loss leading to a suppression of jet yields in heavy-ions (A—A) in comparison to vacuum (pp).
- 2 Internal structure modification
- 3 Medium should respond to the presence of the jet
- 4 Different jets lose energy differently depending on different partonic structures, flavors, transverse momenta, path lengths through the medium, etc.



Differential measurements are key to understanding dynamical properties of QGP.

Recent measurements at the LHC - Hannah Bossi

Jets are narrowed

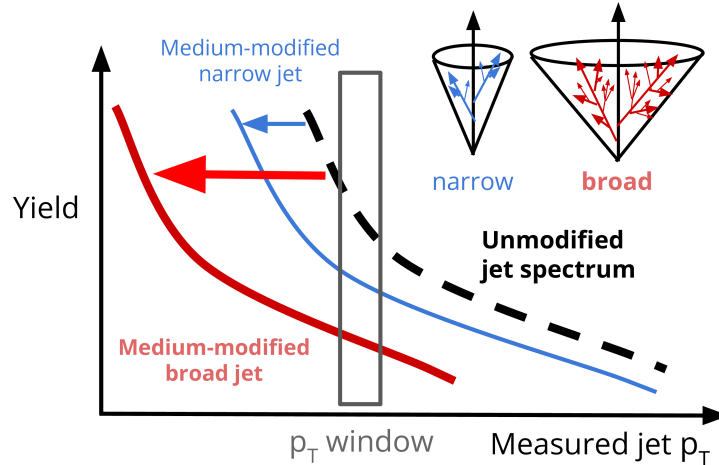
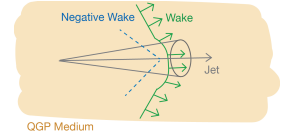
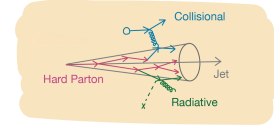
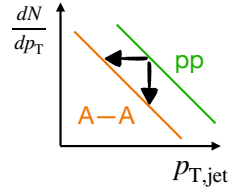


ALI-PUB-495863

Important to understand selection bias

EXPECTATIONS OF JET QUENCHING

- Parton energy loss leading to a suppression of jet yields in heavy-ions (A—A) in comparison to vacuum (pp).
- Internal structure modification

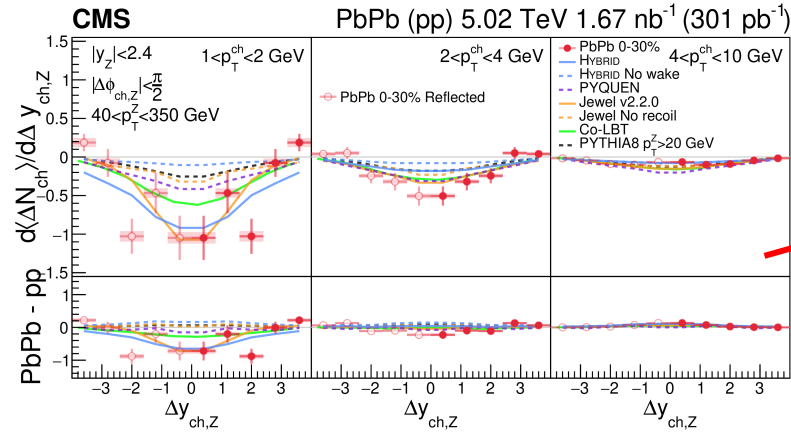


different partonic structures, ϵ medium, etc.

dynamical properties of QGP.

[PLB 861 (2025) 139088]

Recent measurements at the LHC - Hannah Bossi

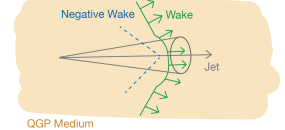
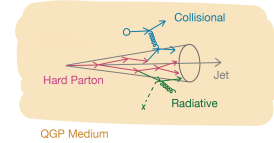
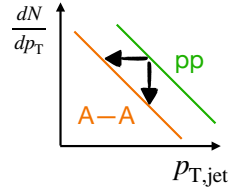


[PLB 874 (2026) 140120]

Negative wake measured in Z+hadron correlations

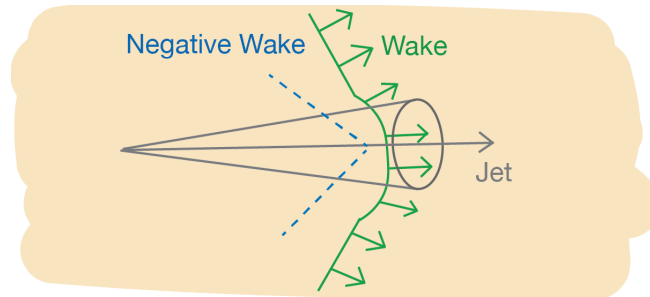
EXPECTATIONS OF JET QUENCHING

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- 3 Medium should respond to the presence of the jet



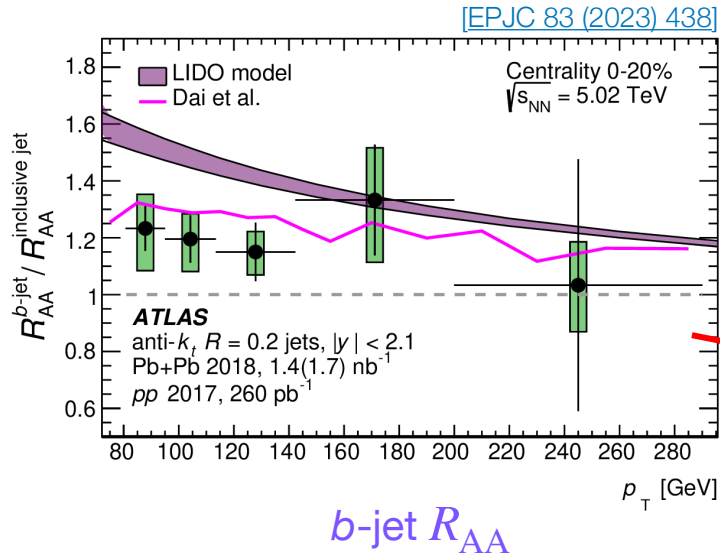
different partonic structures, medium, etc.

dynamical properties of QGP.



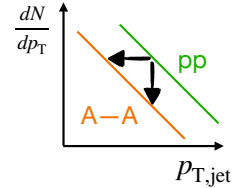
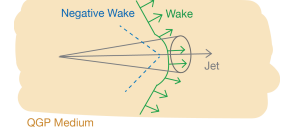
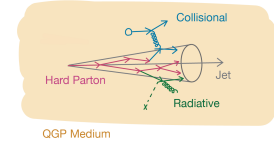
QGP Medium

Recent measurements at the LHC - Hannah Bossi



EXPECTATIONS OF JET QUENCHING

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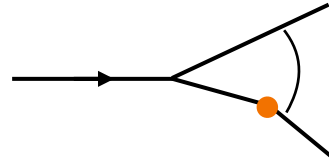


Differential measurements are key to understanding dynamical properties of QGP.

Recent measurements at the LHC - Hannah Bossi

WHAT DO WE STILL WANT TO LEARN?

- Overall, *we have successfully isolated* many fundamental aspects of jet quenching.
- **(Part 1)** Still many phenomena remaining that we have yet to fully isolate.
 - Medium induced emissions
 - Quasi-particle structure of QGP (Moliere Scattering)
 - Mass dependence of quenching
 - Full dynamics of pp jet physics
- **(Part 2)** Lacking a complete understanding of how these pieces fit together.
 - Transition between parton shower & hadronization in medium
 - How do different quenching effects balance one another? How does this depend on kinematic scales?
 - How do quenching effects scale with system size?



• Experimentally exploring synergies between RHIC and LHC very useful!

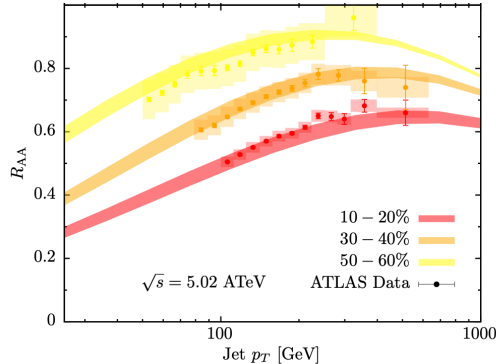
- Investigate impact of q/g fraction, balance of relative effects across kinematic scales. Having data with the same system (OO) makes this very timely.

Jets in heavy-ion collisions theory - João Barata

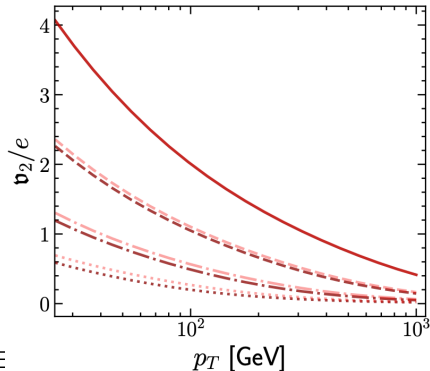


Medium induced modifications

[Mehtar-Tani, Pablos, Tywoniuk, 2101.01742]



[Adhya, Tywoniuk, 2409.04295]



[R. Baier, Y. Dokshitzer, A. H. Mueller, hep-ph/0106347]

$$\frac{d\sigma_q^{\text{med}}}{dp_t d\theta} \approx \frac{d\sigma_q^{\text{vac}}}{dp_t d\theta} \int_0^\infty d\varepsilon D_q(\varepsilon) e^{-\frac{n\varepsilon}{p_t}} \equiv Q_q(p_t) \frac{d\sigma_q^{\text{vac}}}{dp_t d\theta}$$

$$Q_{\text{rad}}^{(0)}(p_T) = \exp \left[- \int_{\omega_s}^\infty d\omega \frac{dI_{\geq}}{d\omega} (1 - e^{-\nu\omega}) - \int_T^{\omega_s} d\omega \frac{dI^{(0)}}{d\omega} \left(1 - e^{-\nu\omega(1 - (\frac{R}{R_{\text{rec}}})^2)} \right) \right]$$

$$v_2(p_T, R) \equiv \frac{\int_{-\pi}^{\pi} d\phi \cos(2\phi) (d\sigma^{\text{AA}}(p_T, R)/d\phi)}{\int_{-\pi}^{\pi} d\phi (d\sigma^{\text{AA}}(p_T, R)/d\phi)}$$

Several open questions when combining both observables:

Sensitivity to initial conditions ?

Accurate description of radiation rate ?

Novel physical mechanisms?

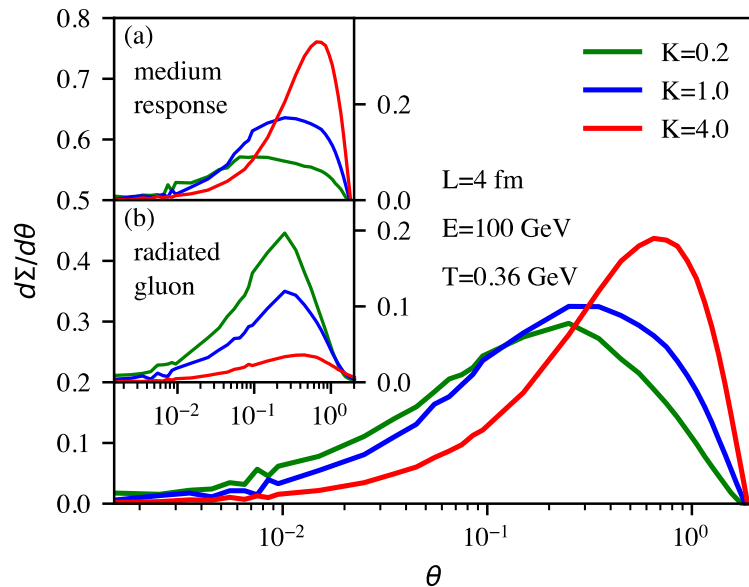
Valuable test-bed for basic picture of jets in heavy ions !

Jets in heavy-ion collisions theory - João Barata



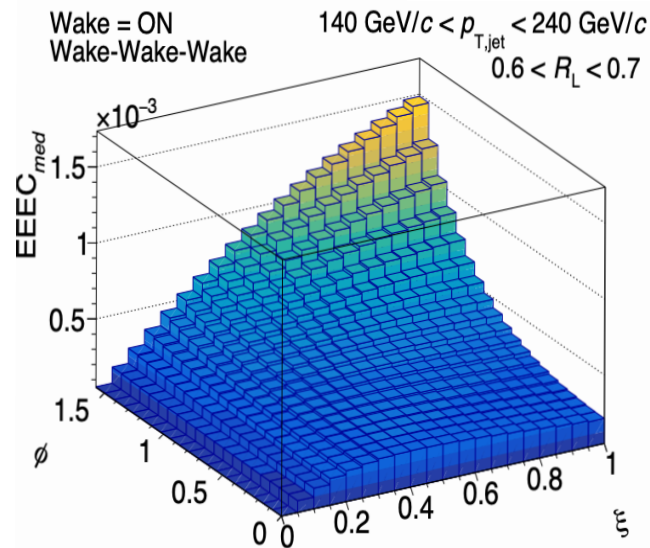
Jet substructure in heavy ion collisions

[Z. Yang, et al, 2310.01500]



Scales controlling *shape of distributions* still poorly understood on theory side

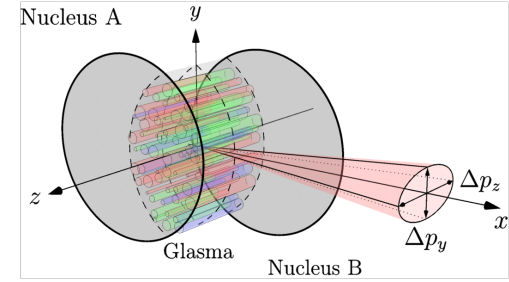
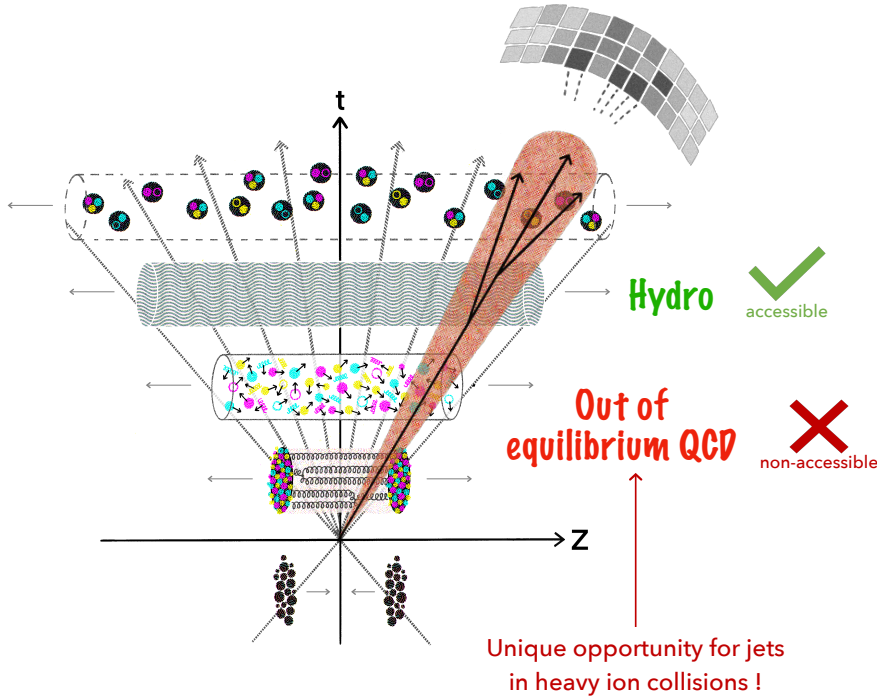
[Bossi et al., JHEP, 2024]



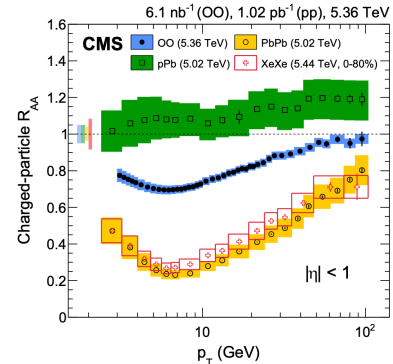
Exciting opportunity to *realize tomographic jet imaging* with these observables !

Jets in heavy-ion collisions theory - João Barata

The unknown in heavy ion collisions



Jet structure in complex matter

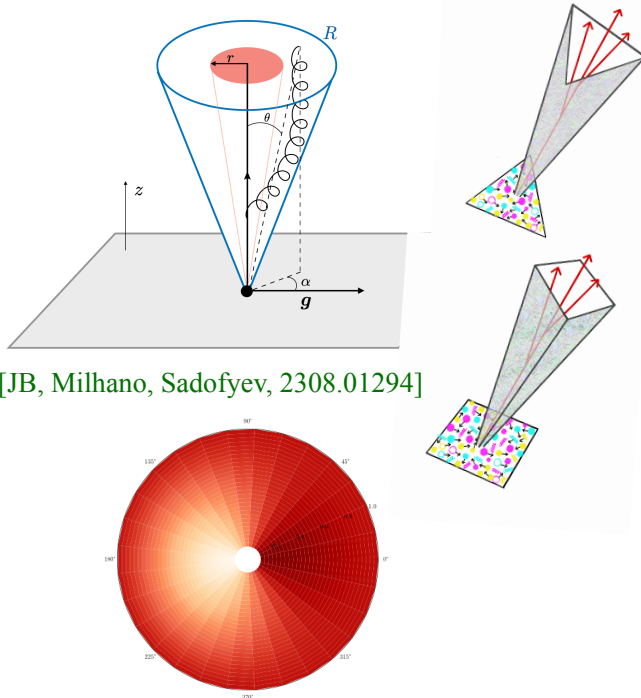


Jet evolution in small systems

Jets in heavy-ion collisions theory - João Barata

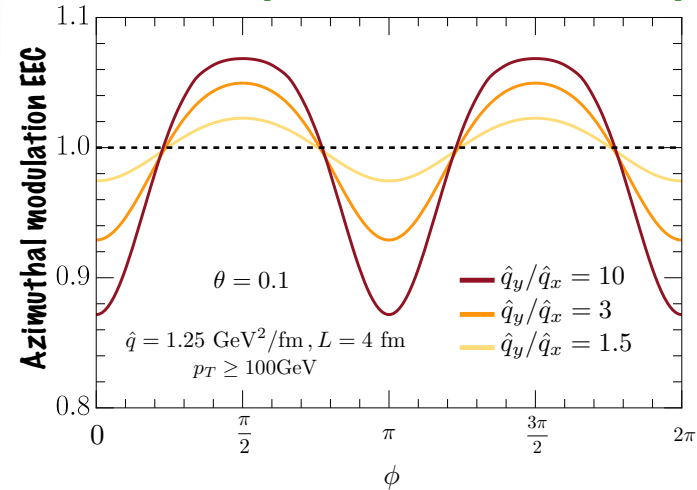


Jet quenching in the early stages



[JB, Milhano, Sadofyev, 2308.01294]

[JB, Brewer, Lee, Silva, 2508.19404]

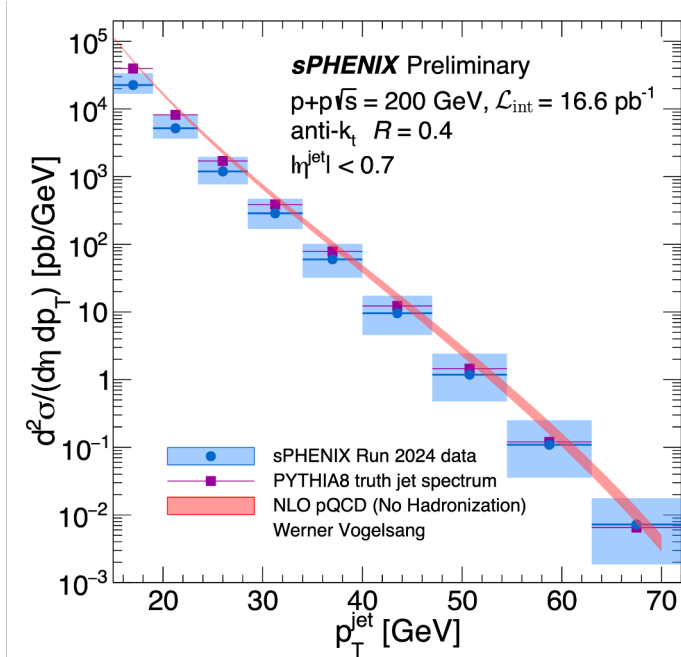


see also [Ke, Terry, Vitev, 2412.12250]

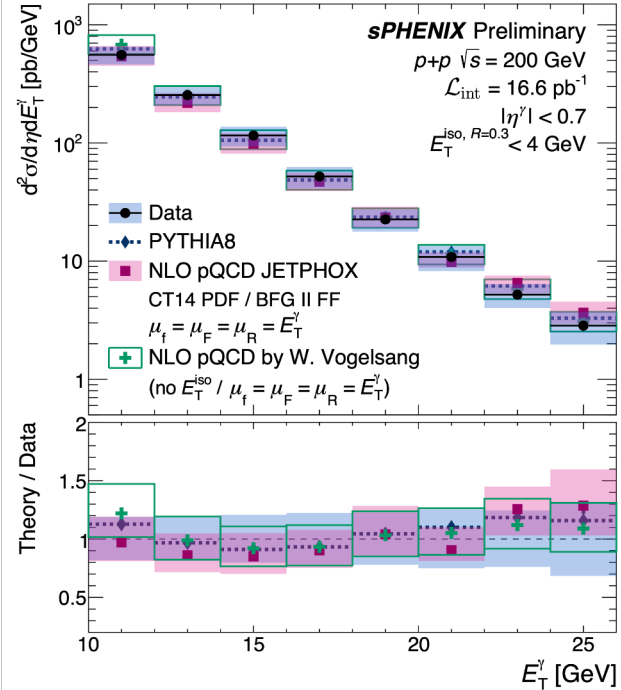
Observing a *vn-like deformation inside jets* would be extremely useful !

Recent measurements from sPHENIX - Hanpu Jiang

Jet cross-section

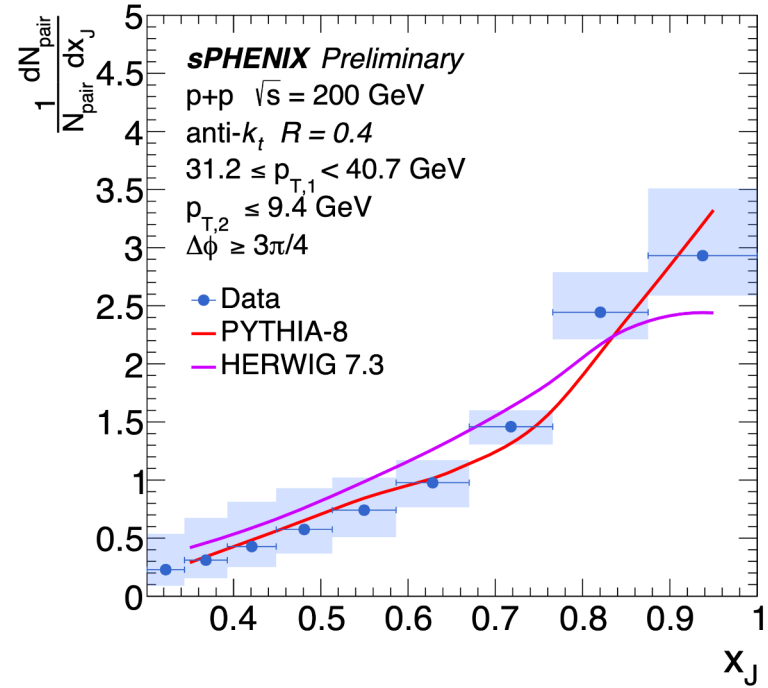
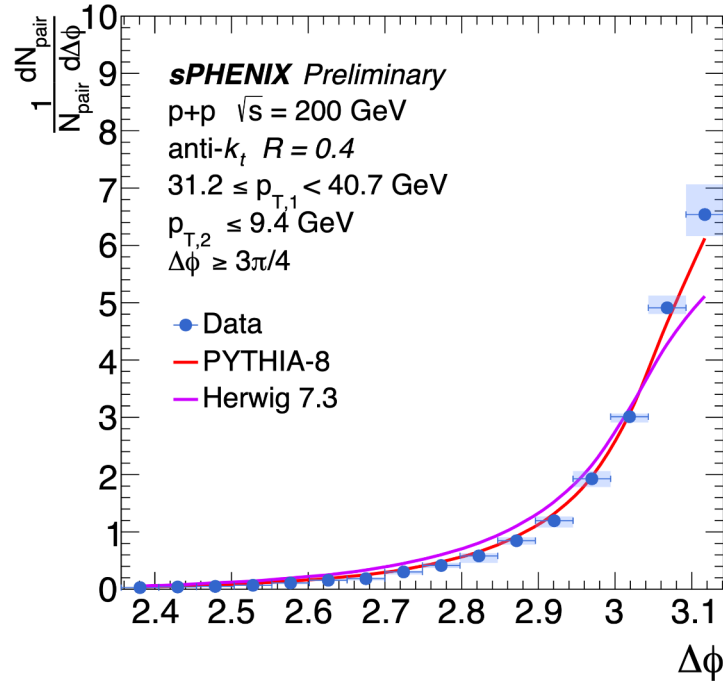


Isolated photon cross-section



Expectations for improvements in statistics & uncertainties in final results

Recent measurements from sPHENIX - Hanpu Jiang



Detailed comparisons of dijet systems in p+p to MC generators

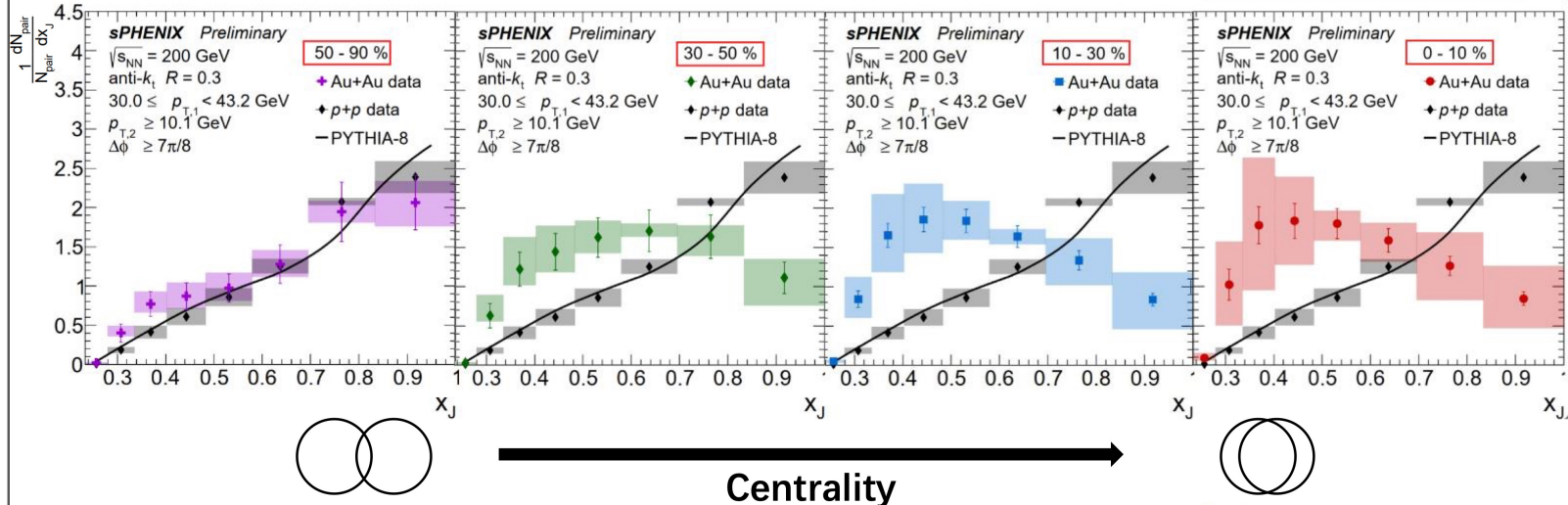
Recent measurements from sPHENIX - Hanpu Jiang

Au+Au Dijet x_J



- First sPHENIX measurement of jet energy loss in QGP with full-jet x_J and observe large suppression. Only $\sim 0.1 \text{ nb}^{-1}$ of Au+Au data ($\sim 1.5\%$ of Au+Au data we have).
- Unfolded x_J with $\Delta\phi > 7\pi/8$, $R=0.3$ and leading jet $p_{T,1} = 30.0 - 43.2 \text{ GeV}$.

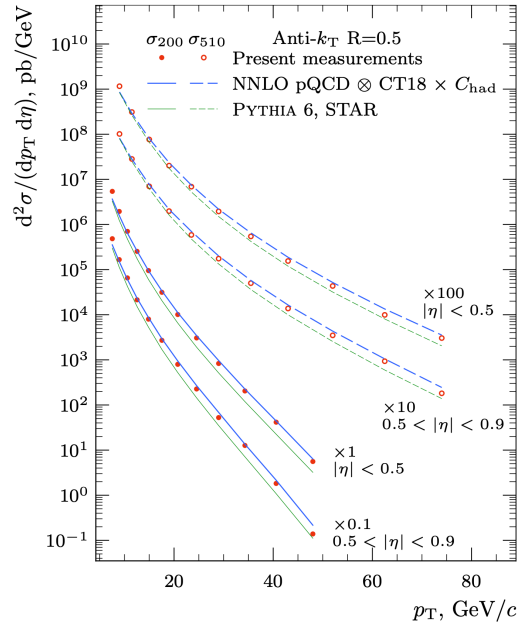
sPH-CONF-JET-2025-05



Recent measurements from STAR - Isaac Mooney

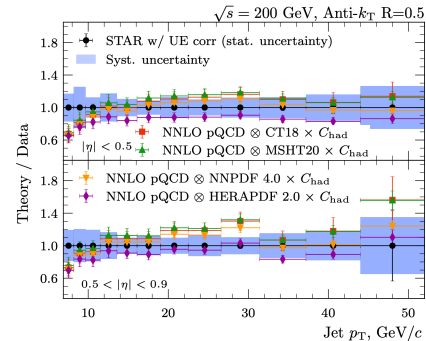


Inclusive jet cross sections



STAR, arXiv:[2603.28695](https://arxiv.org/abs/2603.28695) (Recently submitted to PRD!)

- Stringent test of vacuum pQCD
- Constrain PDFs, with x_T coverage 0.07 - 0.5 and 0.03 - 0.31 at 200 and 510 GeV

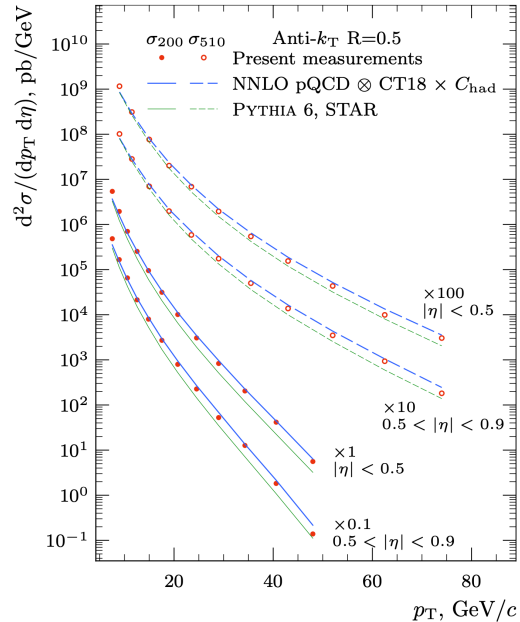


- Baseline for future studies with forward jets (varying x)

Recent measurements from STAR - Isaac Mooney



Inclusive jet cross sections



- Discussion about UE (MPI) subtraction – important to understand differences in procedure for comparisons to other experiments
- Interest in seeing this used as reference in heavy ion measurements

STAR, arXiv:[2603.28695](https://arxiv.org/abs/2603.28695) (Recently submitted to PRD!)

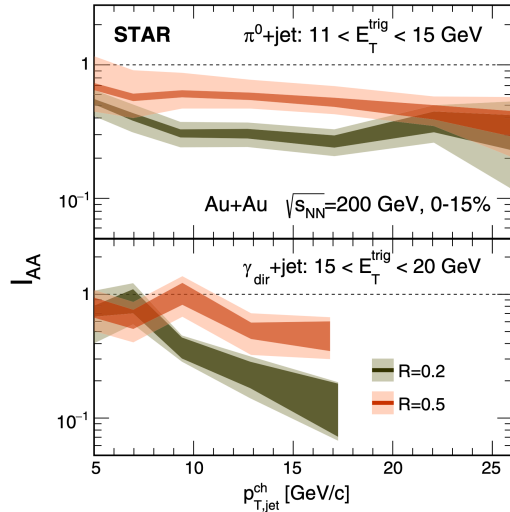
Recent measurements from STAR - Isaac Mooney



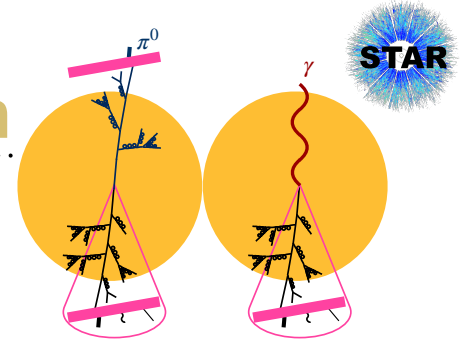
Semi-inclusive yield modification

$$I_{AA} = \frac{Y_{AA}(p_{T,jet}^{ch}, R)}{Y_{pp}(p_{T,jet}^{ch}, R)}, Y(p_{T,jet}^{ch}, R) = \frac{1}{N_{trig}} \int_{3\pi/4}^{5\pi/4} d\Delta\phi \left[\frac{d^2 N_{jet}(R)}{dp_{T,jet}^{ch} d\Delta\phi} \right]_{E_T^{trig} \in [E_T^{min}, E_T^{max}]}$$

Recently published! STAR, [PRC 111 \(2025\) 6, 064907](#),
 STAR, [PRL 134 \(2025\) 23, 232301](#)

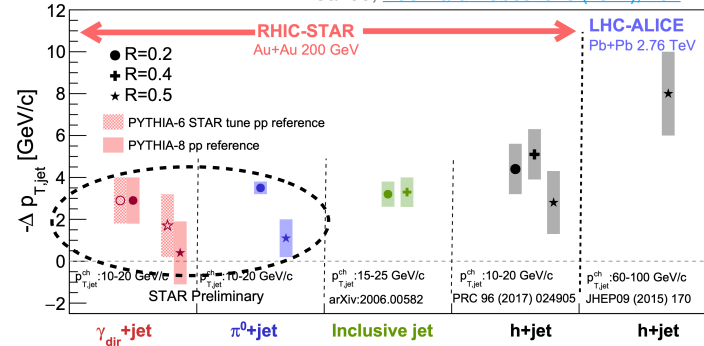


RHIC/AGS AUM Jet Workshop, 5/11/2026



Recoil jet yield suppression in Au+Au, reduced for larger-R jets

Sahoo, [PoS HardProbes2020 \(2021\), 132](#)



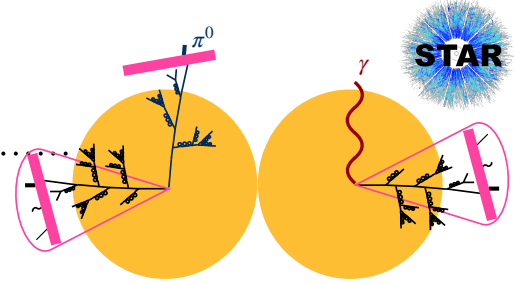
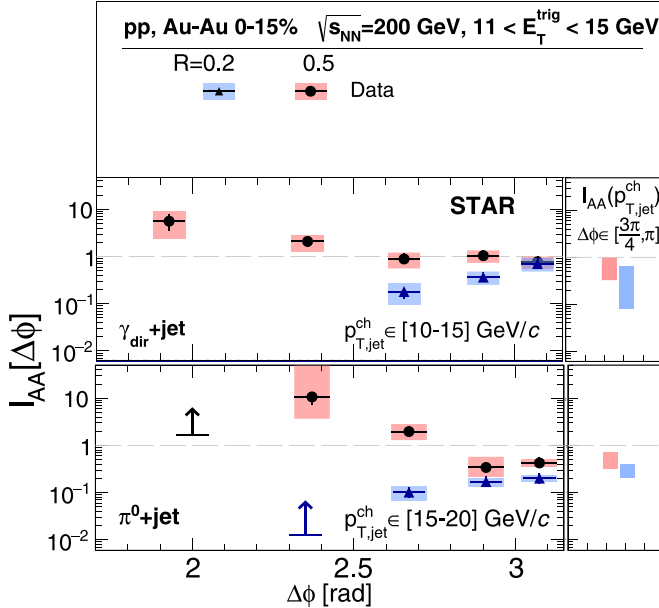
Isaac Mooney (Yale / CFNS)

Recent measurements from STAR - Isaac Mooney



Medium-induced acoplanarity

Recently published! STAR, [PRC 113 \(2026\) 1.014902](#)



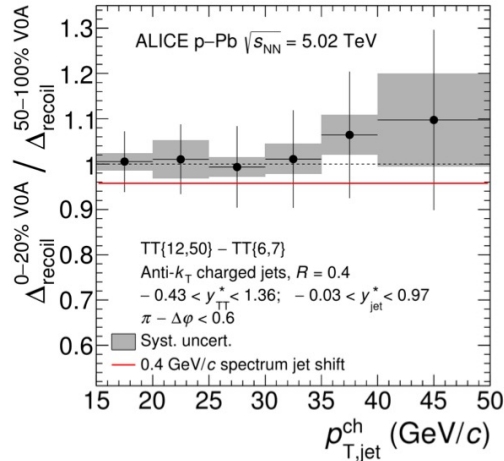
Substantial R -dependence of acoplanar yield:
small- R suppression, large- R enhancement

Disfavors Molière scattering picture (naively
radius-independent)

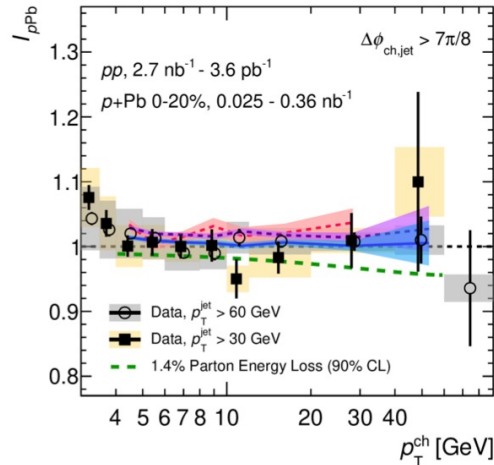
Potential **medium response effect?**

Recent measurements in small systems - Chris McGinn

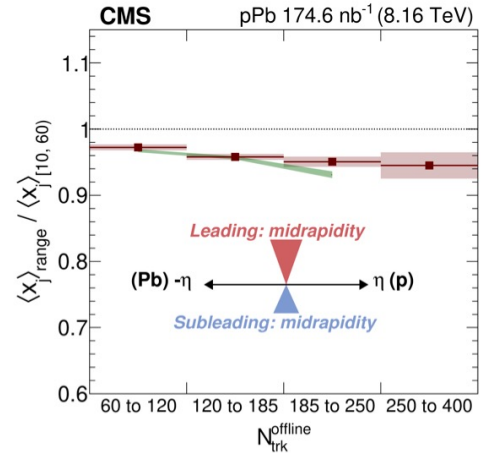
Where Is Quenching in Small Systems?



PLB 783 (2018) 95



PRL 131 (2023) 072301

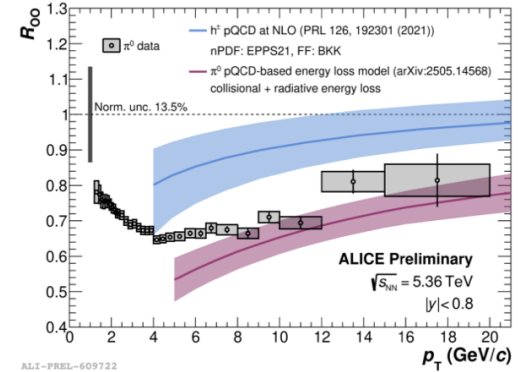
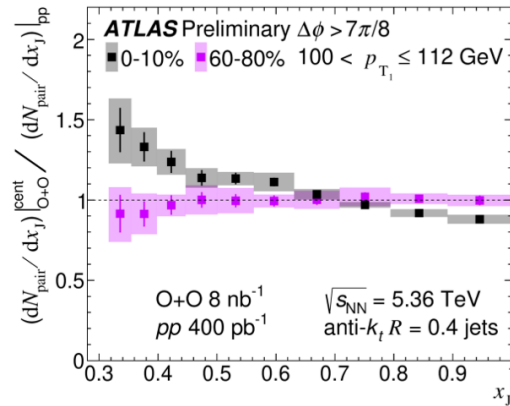
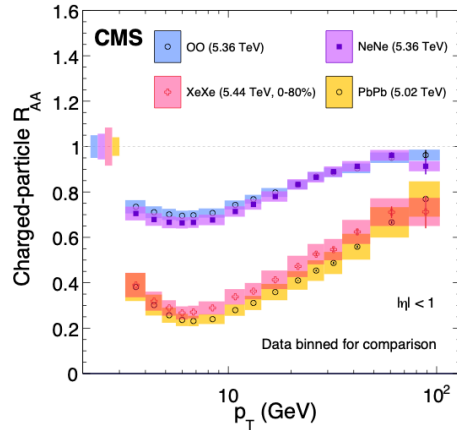


JHEP 07 (2025) 118

- Many independent searches for quenching in pPb have returned no indications
- ALICE, ATLAS, and CMS have all set stringent limits w/ dijet x_J , jet-hadron correlations

Recent measurements in small systems - Chris McGinn

Big Picture: Quenching Models Preferred



- Each experiment's results come with caveats regarding significance of quenching
- Considered together, a strong case for the formation of a QGP

Recent measurements in small systems - Chris McGinn

New STAR Evidence of Quenching

Submitted PRL

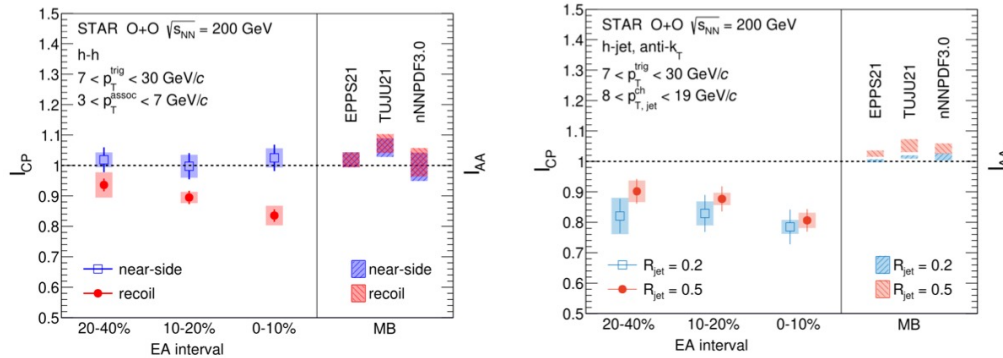


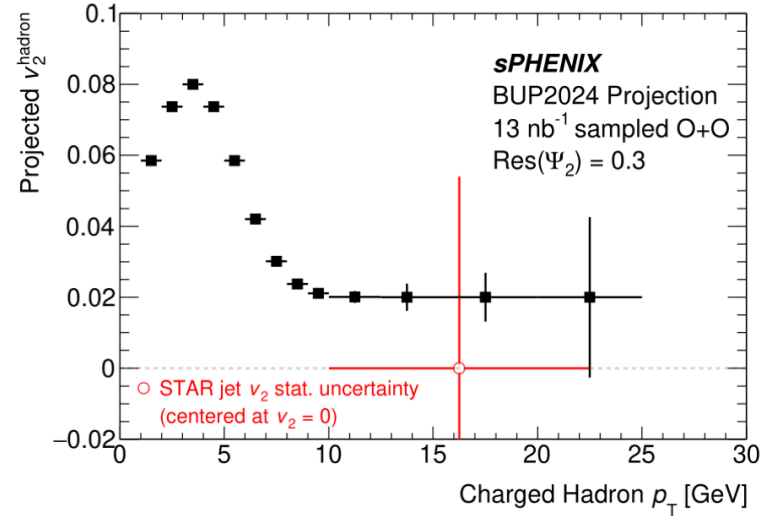
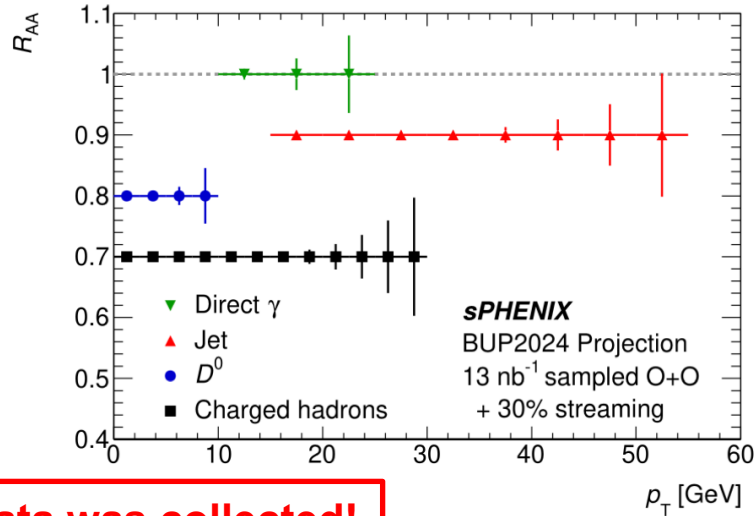
TABLE I. Significance of recoil yield suppression in h-h and h-jet correlations in the 0-10% EA population, compared to several different choices of no-quenching baseline. See text for details.

Baseline	h-h recoil	h-jet, $R = 0.5$	h-jet, $R = 0.2$
Unity	4.3σ	4.3σ	3.5σ
h-h near side	3.3σ	N/A	N/A
EPPS21	4.0σ	4.8σ	3.5σ
TUJU21	5.2σ	4.9σ	3.7σ
nNNPDF3.0	2.7σ	5.0σ	3.7σ

- **Left: Hadron-hadron I_{CP} , integrated over p_T . Right: hadron-jet I_{CP} , integrated over p_T**
- **nPDF effects accounted for w/ I_{AA} on right-hand side of figures**
- **Global significance greatest for $R=0.5$ hadron-jet correlations**
- **Emergent light-ions quenching picture shared between RHIC and the LHC!**

Recent measurements in small systems - Chris McGinn

Projections for 00 with sPHENIX



4x data was collected!

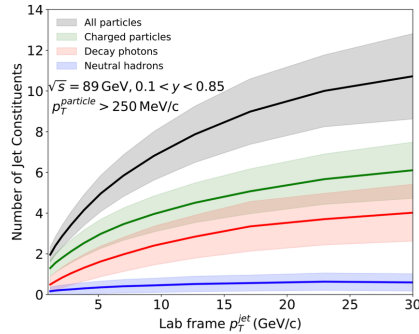
- Projections for sPHENIX measurements in 00 should be sensitive to quenching
 - Sensitivity to high- p_T $v_2 \rightarrow$ understanding signal in pA (see next slides)

Jets at the electron-ion collider - Felix Ringer

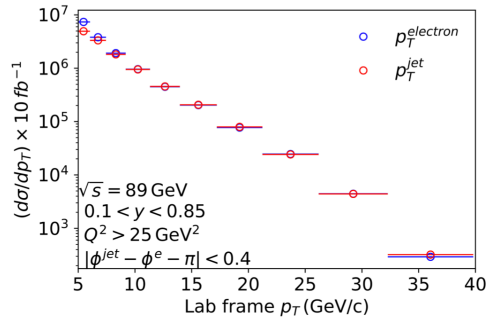
Nature of jets at the EIC

Particle #

Quark-like

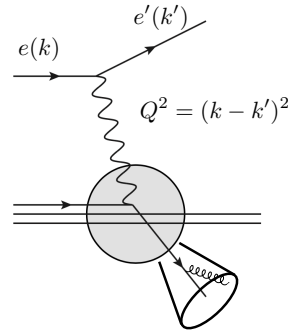


Transverse momentum



Two “natural” hard scales

- Jet transverse momentum p_T
- Photon virtuality Q^2

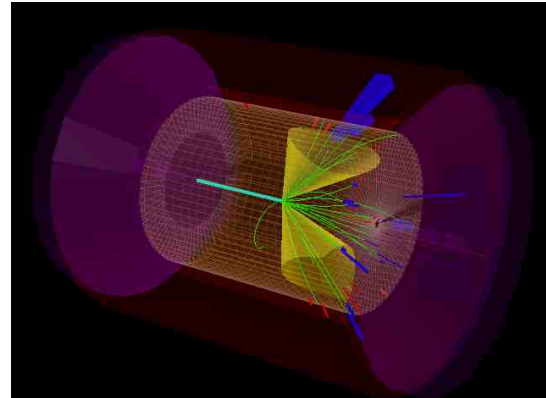
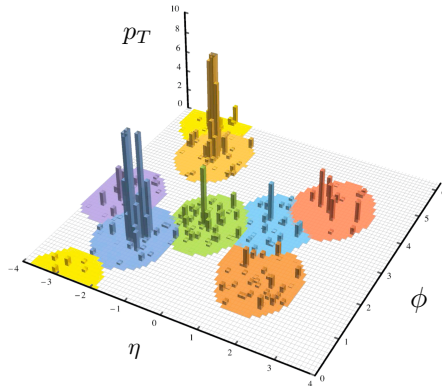


Arratia, Jacak, FR, Song '19
 see also Aschenauer et al.

Jets at the electron-ion collider - Felix Ringer

EIC jet physics

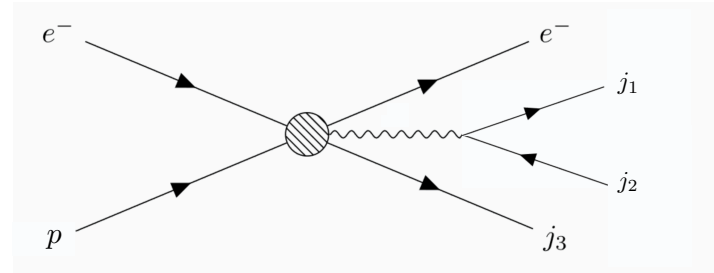
- Relevant for hadron structure, cold nuclear matter effects, etc.
- Clean EIC environment
- Jet substructure & correlations
- Versatile jet reconstruction algorithms & frame dependence
- New physics searches



Jets at the electron-ion collider - Felix Ringer

New physics searches with jets

- Consider an exemplary BSM signal
- B-L model, Z'_{B-L} from gauged $U(1)_{B-L}$
- Constraints in the low-mass region within reach of the EIC
- Electron + 3 jet signal (hadronic decay)



$$\mathcal{L}_{\text{int}} = g_{B-L} Z'_{\mu} J_{B-L}^{\mu} \quad \text{with} \quad J_{B-L}^{\mu} = \sum_f Q_{B-L}^f \bar{f} \gamma^{\mu} f$$

Athanasakos, Grienering, Liu,
Mangan, FR, Szafron - in preparation

Summary

Lots of interest in jet measurements at RHIC from the community

Differential measurements from recent high statistics datasets at sPHENIX and STAR will help to complete the picture of the QGP

O+O collisions provide a unique testing ground for QGP production in small systems both at RHIC and the LHC

Jet measurements will provide a key role in the physics of the EIC

Thanks to all workshop speakers and attendees for interesting discussions!