Measurements of Jet Suppression with The ATLAS Detector

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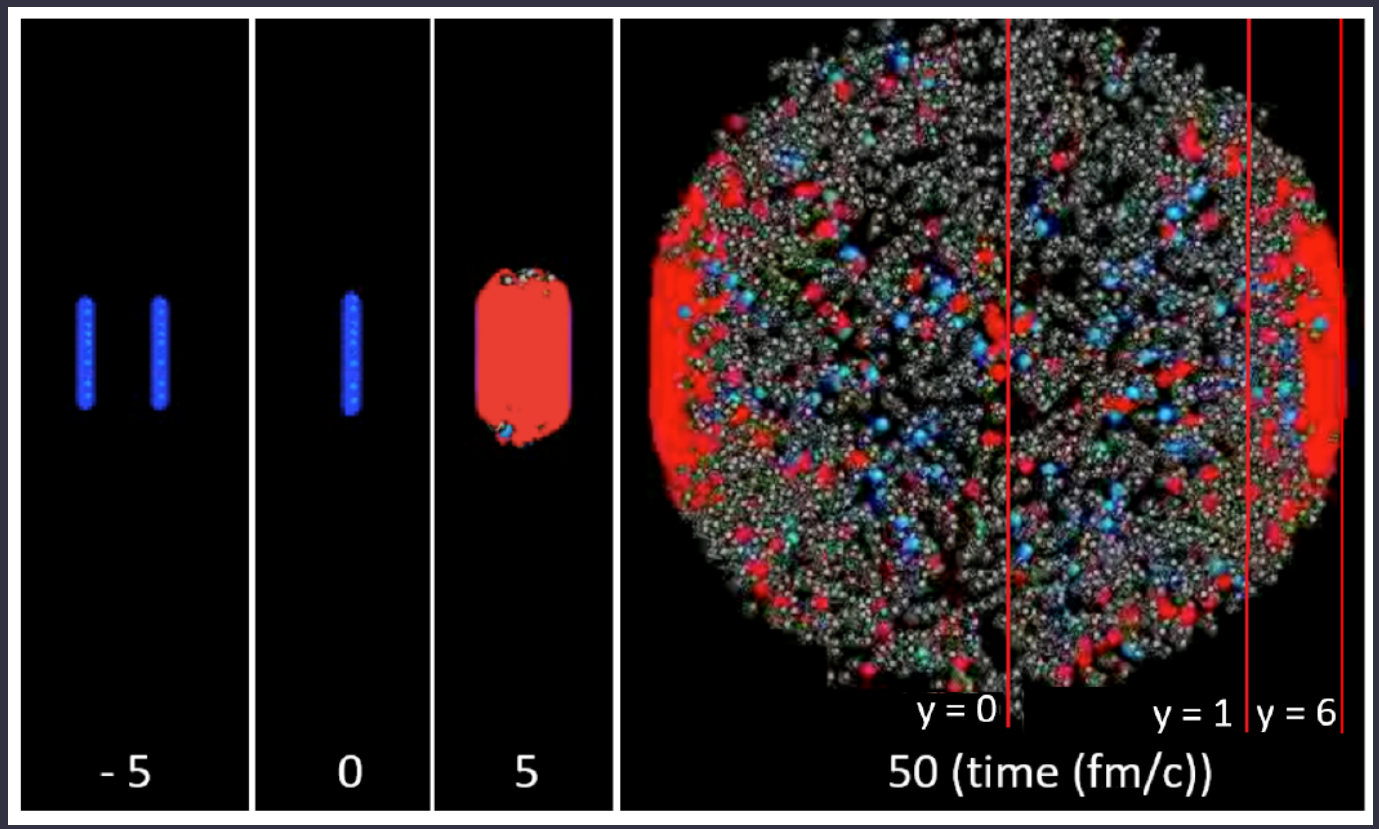
Producing Quark Gluon Plasma



1 2 3 4

1. Lorentz-contracted nuclei inbound
2. Initial collision; Hard-probes formed here
3. After some formation time, Quark Gluon Plasma (QGP)
4. After some longer time, freezeout and hadronization

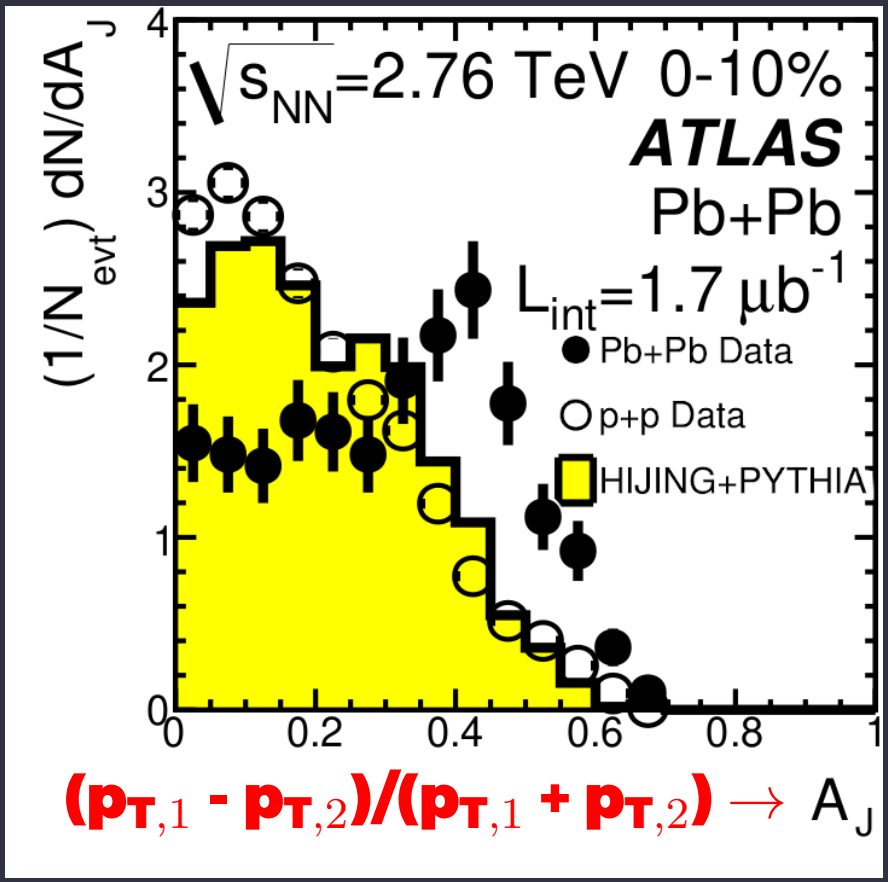
- What happens to jets in the QGP?

Still via Ann.Rev.Nucl.68 (2018)

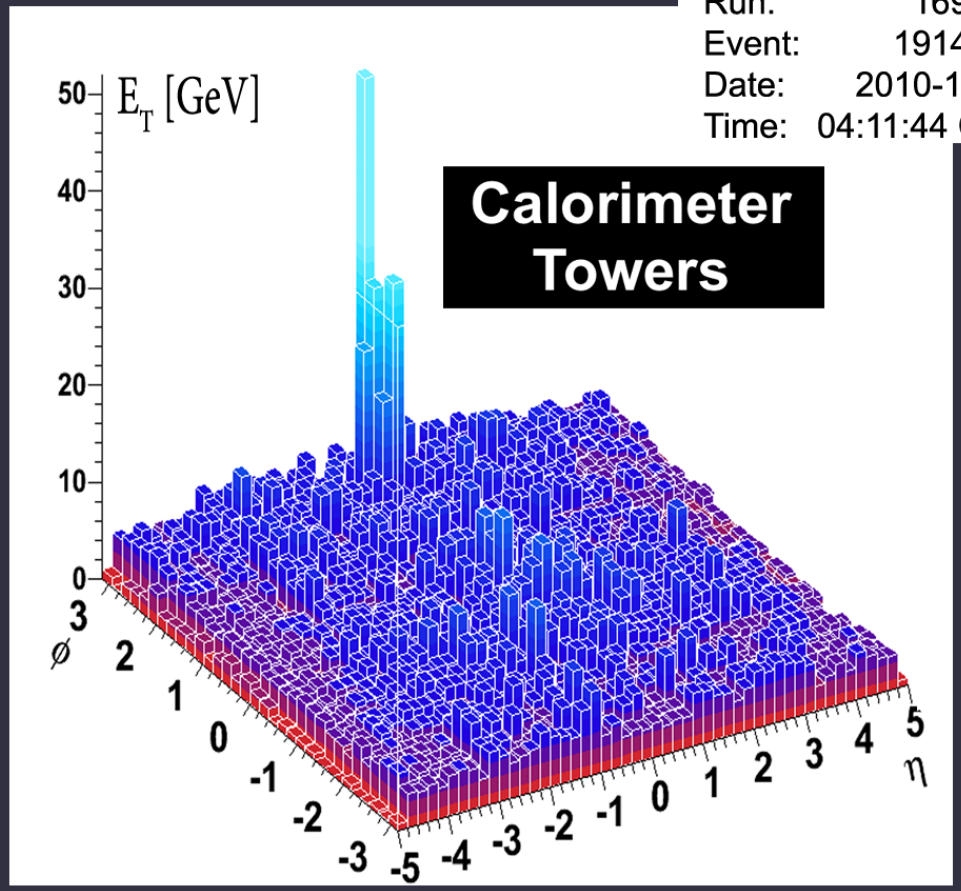
Full video via Yen-jie Lee, Wit Busza, and Andre Yoon

Jets in QGP

PRL 105 (2010) 252303



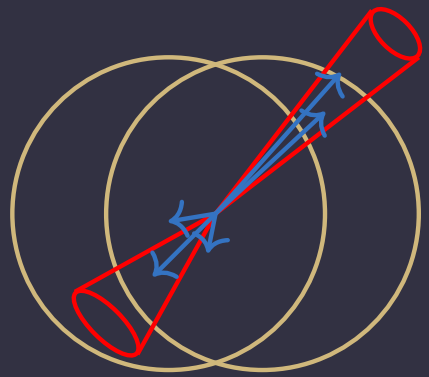
$(p_{T,1} - p_{T,2})/(p_{T,1} + p_{T,2}) \rightarrow A_J$

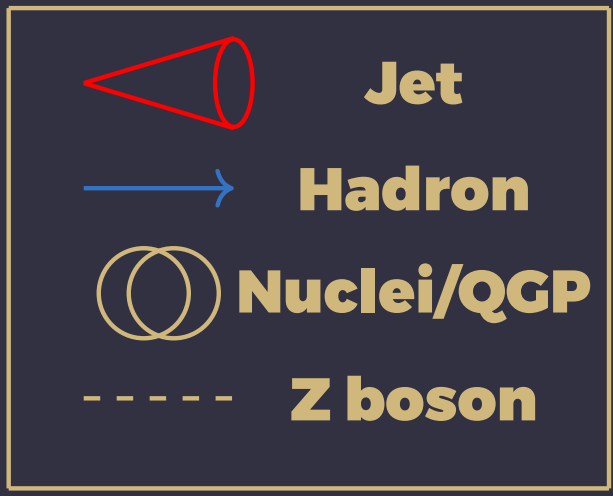


- **Observe significant modification to dijet asymmetry (A_J)!**
- **Interpret as jet energy 'lost' to medium interactions**

Three Ways of Study (I)

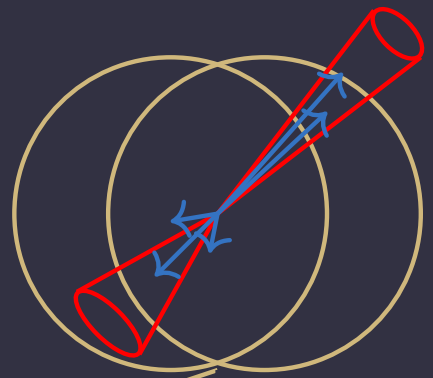
Full system
Jet in QGP





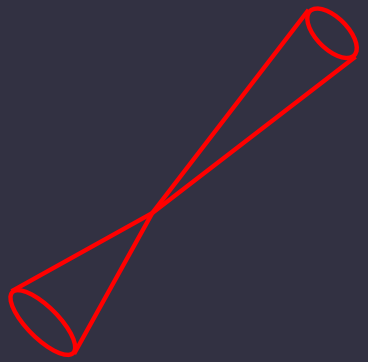
Three Ways of Study (II)

Full system
Jet in QGP

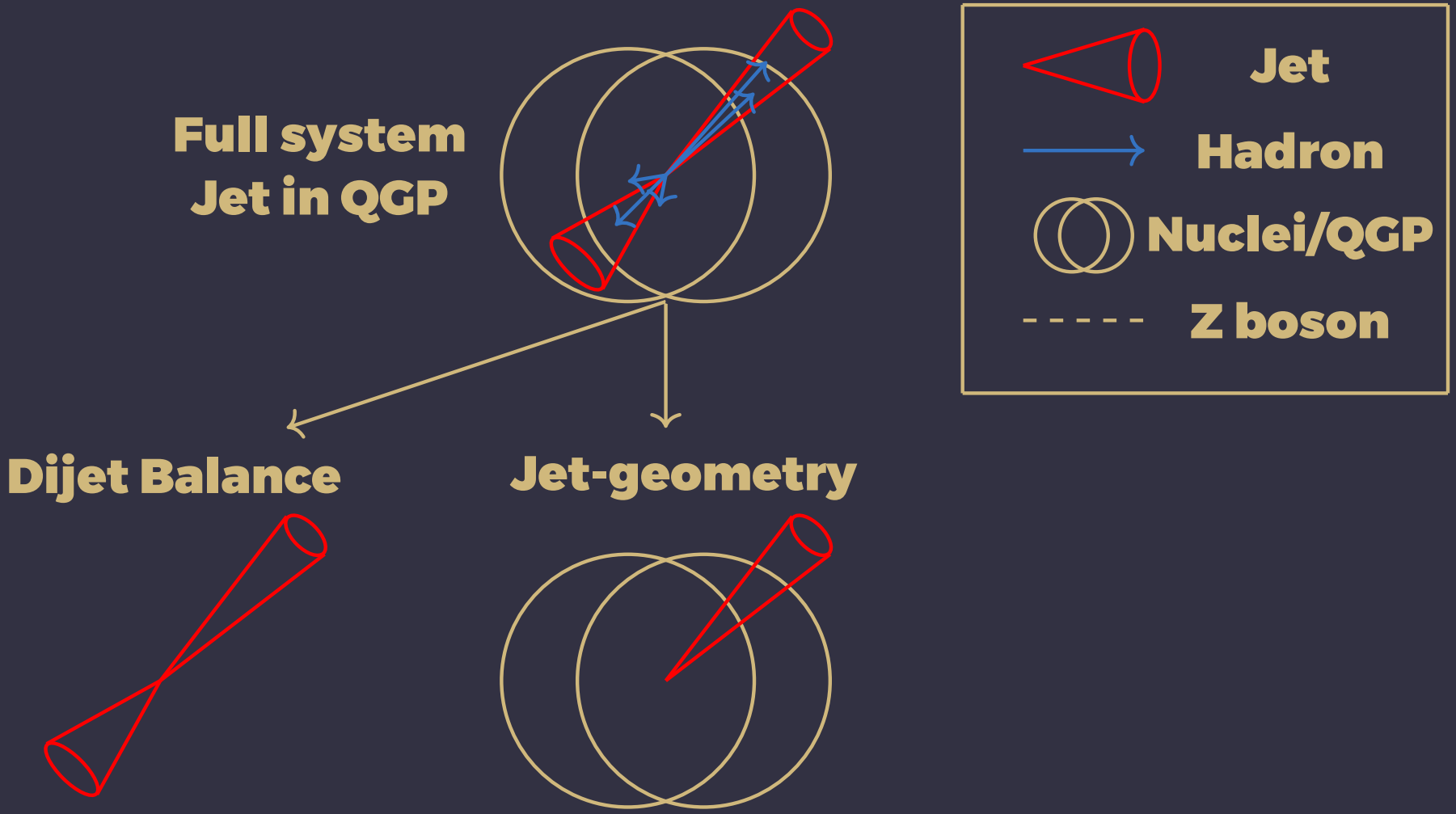


Jet
Hadron
Nuclei/QGP
Z boson

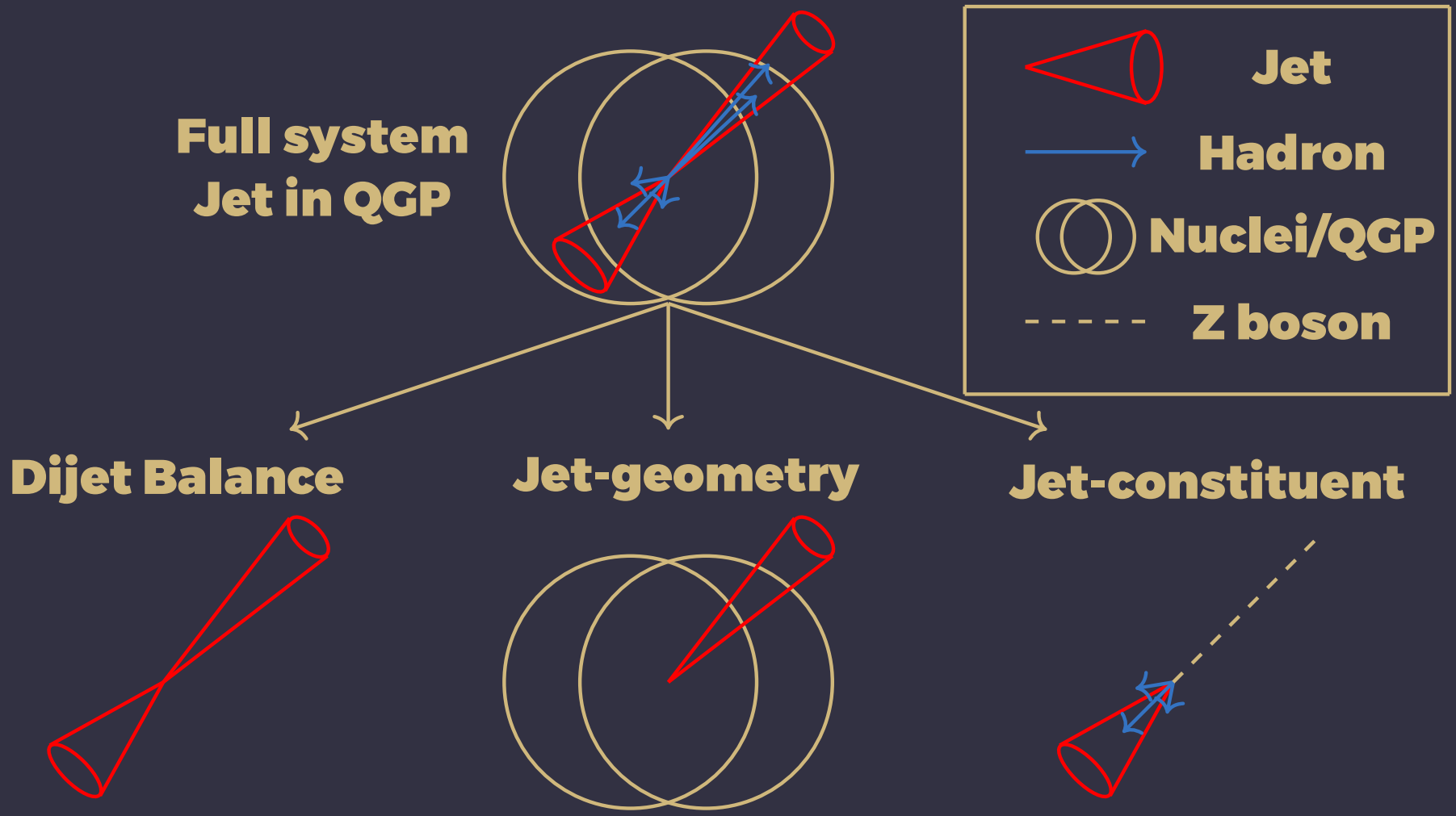
Dijet Balance



Three Ways of Study (III)



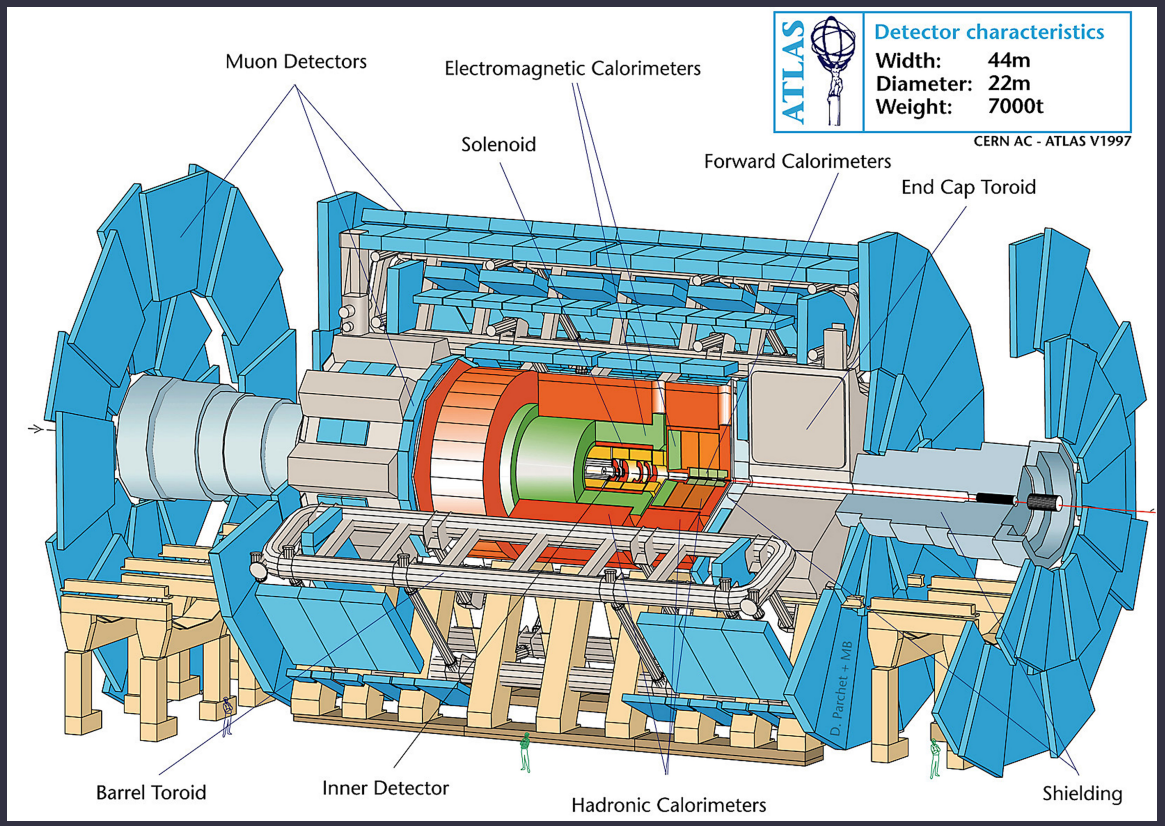
Three Ways of Study (IV)



- Not comprehensive! Many more ways to probe QGP
- All ATLAS HI results (including jets) can be found here

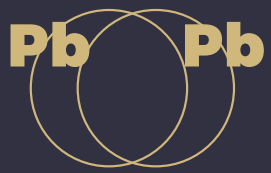
ATLAS Detector and Data

Via CDS



p p

p+p collected in 2017
260 pb^{-1} lumi.



Pb+Pb collected in 2018
1.72 nb^{-1} lumi.

- **Jets are reconstructed w/ EMCal and HCal**
- **Charged particles via inner tracking detectors**
- **Centrality (nuclear overlap) is determined by FCal**
- **Z boson reconstructed w/ muon detectors and EMCal+track**

Dijet Balance (I)

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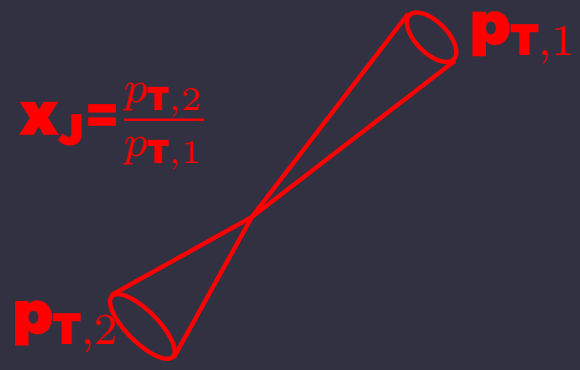

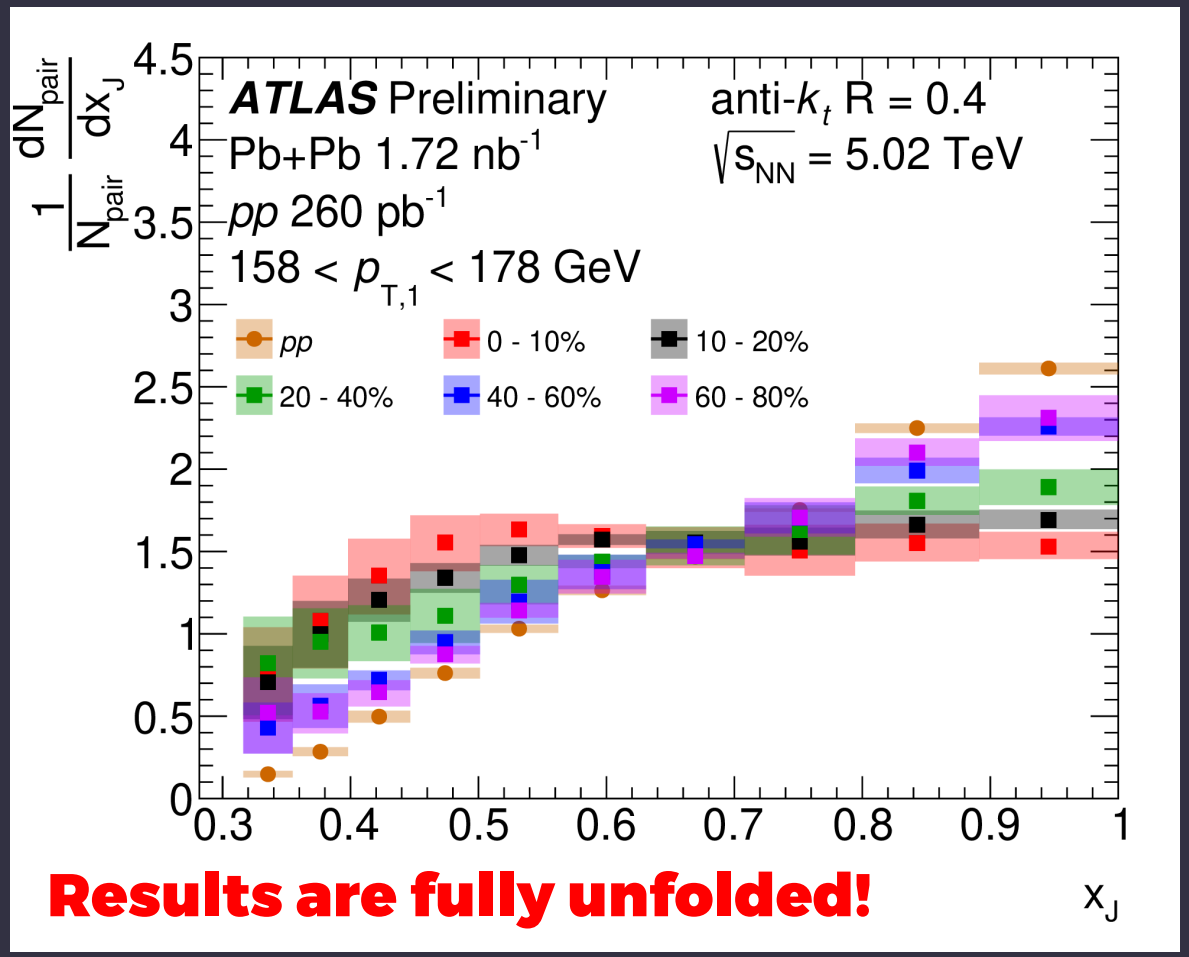

- Observe an enhanced imbalance in Pb+Pb compared to p+p
- Increases monotonically w/ nuclear overlap (100%→0%)
  - More medium produced → greater energy loss!

Dijet Balance (II)

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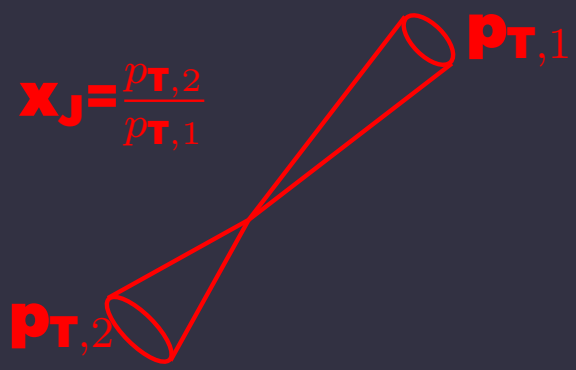
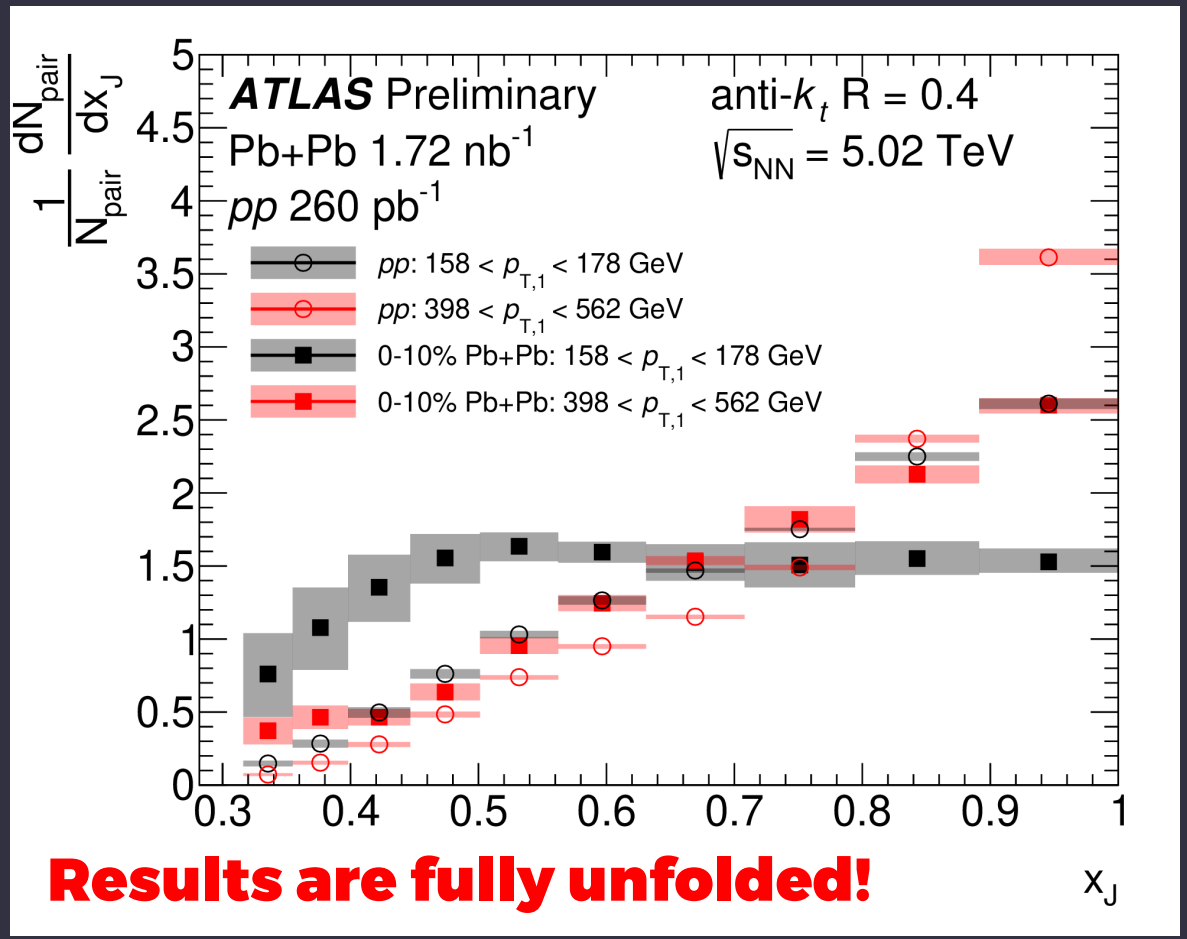


Central Only!

0%



Results are fully unfolded!

- As $p_{T,1}$ increases, return to a more balanced system
- However, even at highest p_T, 0-10% still distinct from p+p

Jet-Geometry Correlations (I)

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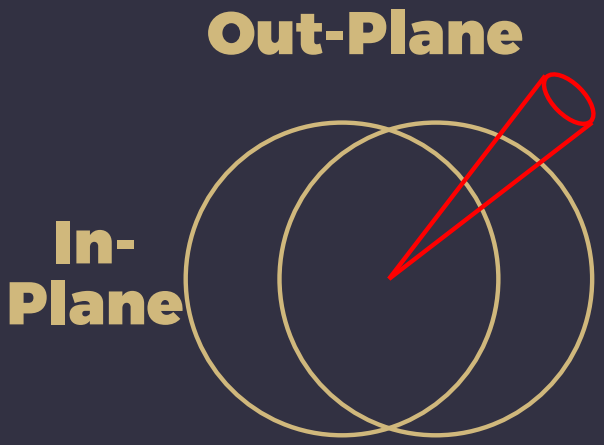
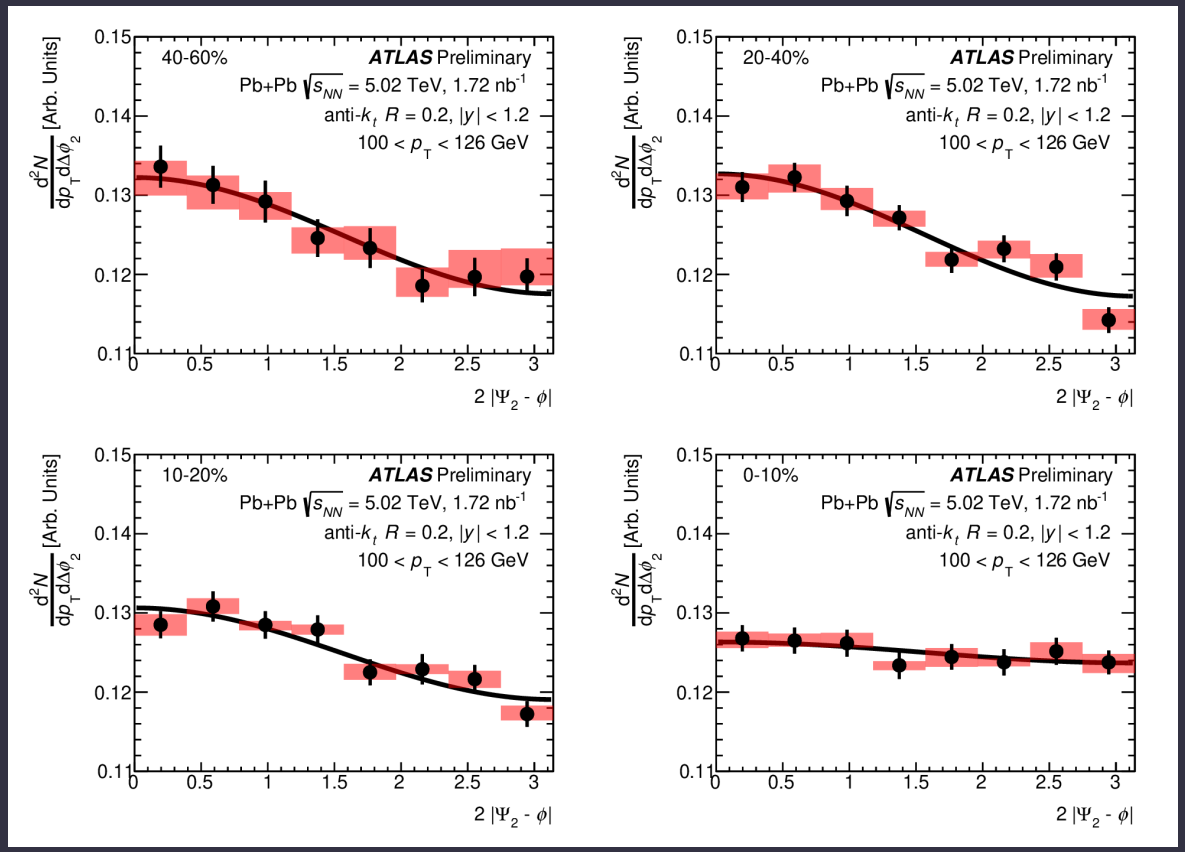


$$0 \xrightarrow{\qquad} \pi \quad \text{for} \quad 2|\Psi_2 - \phi|$$

In-Plane → **Out-Plane**



- **Simple counting of jets in-and-out-of-plane**
  - **We observe more jets in the final state in-plane!**

Jet-Geometry Correlations (II)

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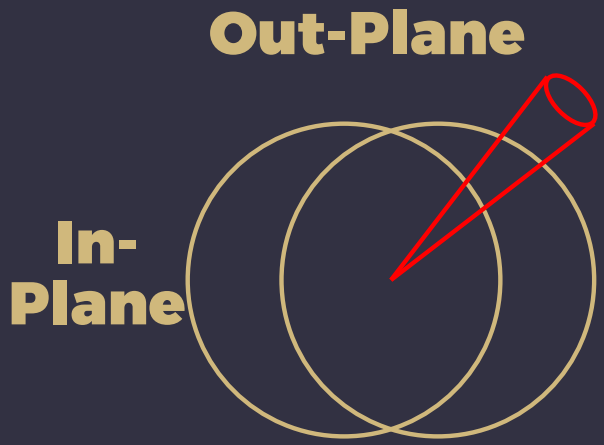
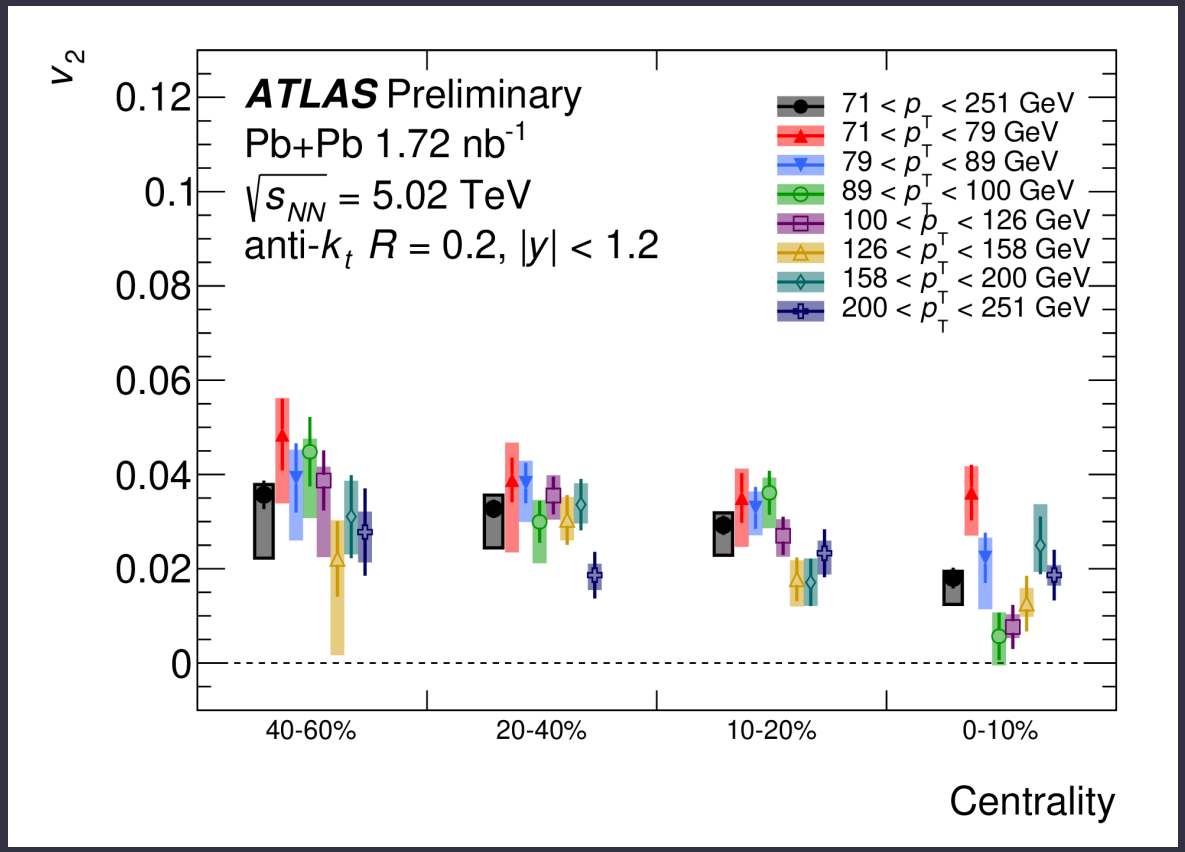


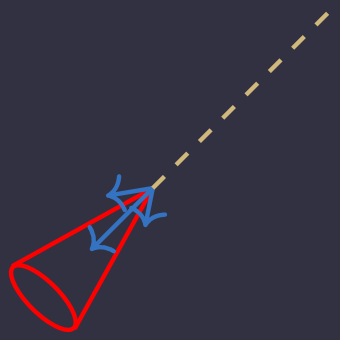
v_2: 2nd Fourier Coef.
$A(1 + 2v_n\cos(n(\Psi_n - \phi)))$



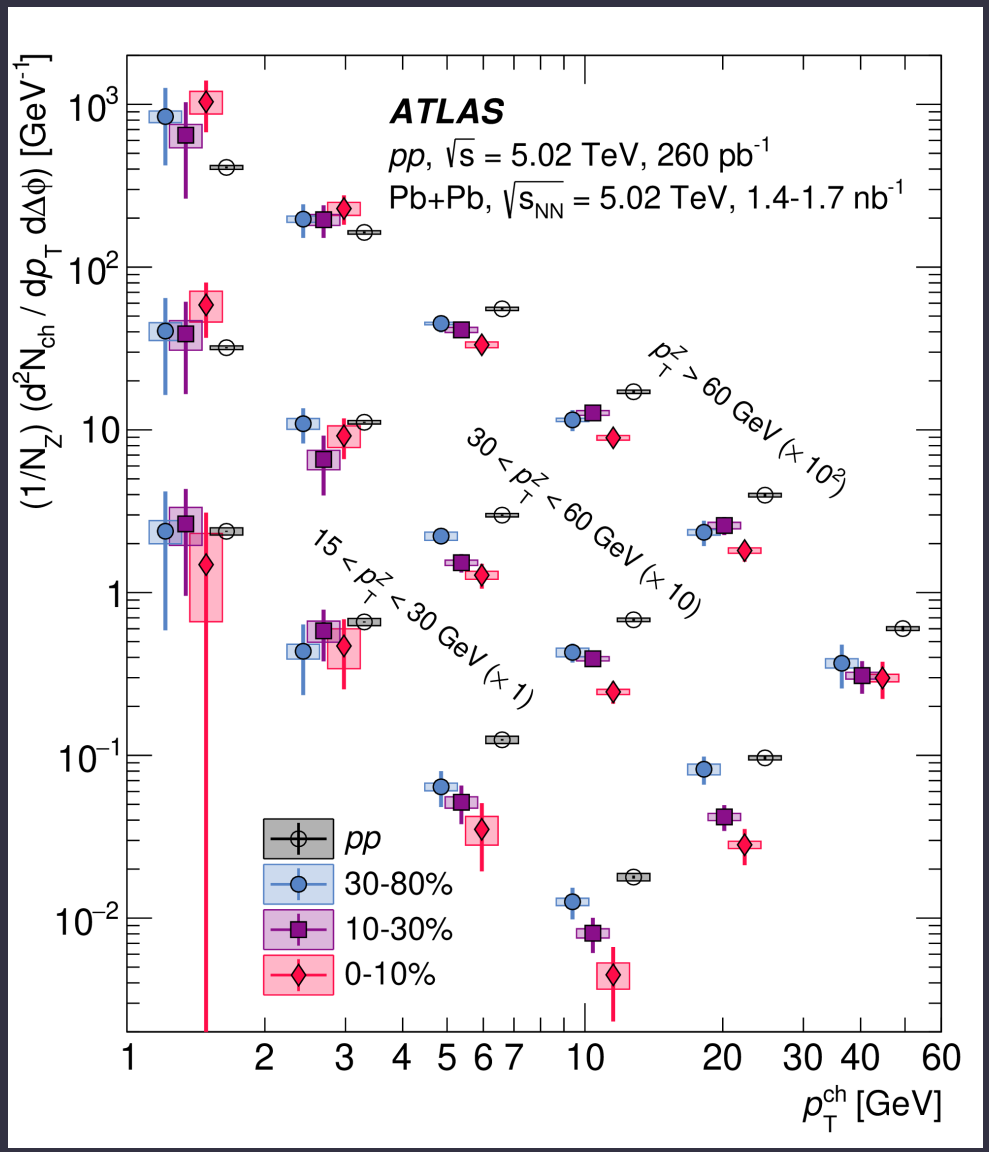
- Significance ranges from $\sim 2\sigma$ (40-60%) to $\sim 4\sigma$ (10-20%)
  - Implies a path-length dependence in energy loss!

Z-Tag w/ Jet Fragments (I)

PRL 126 (2021) 072301



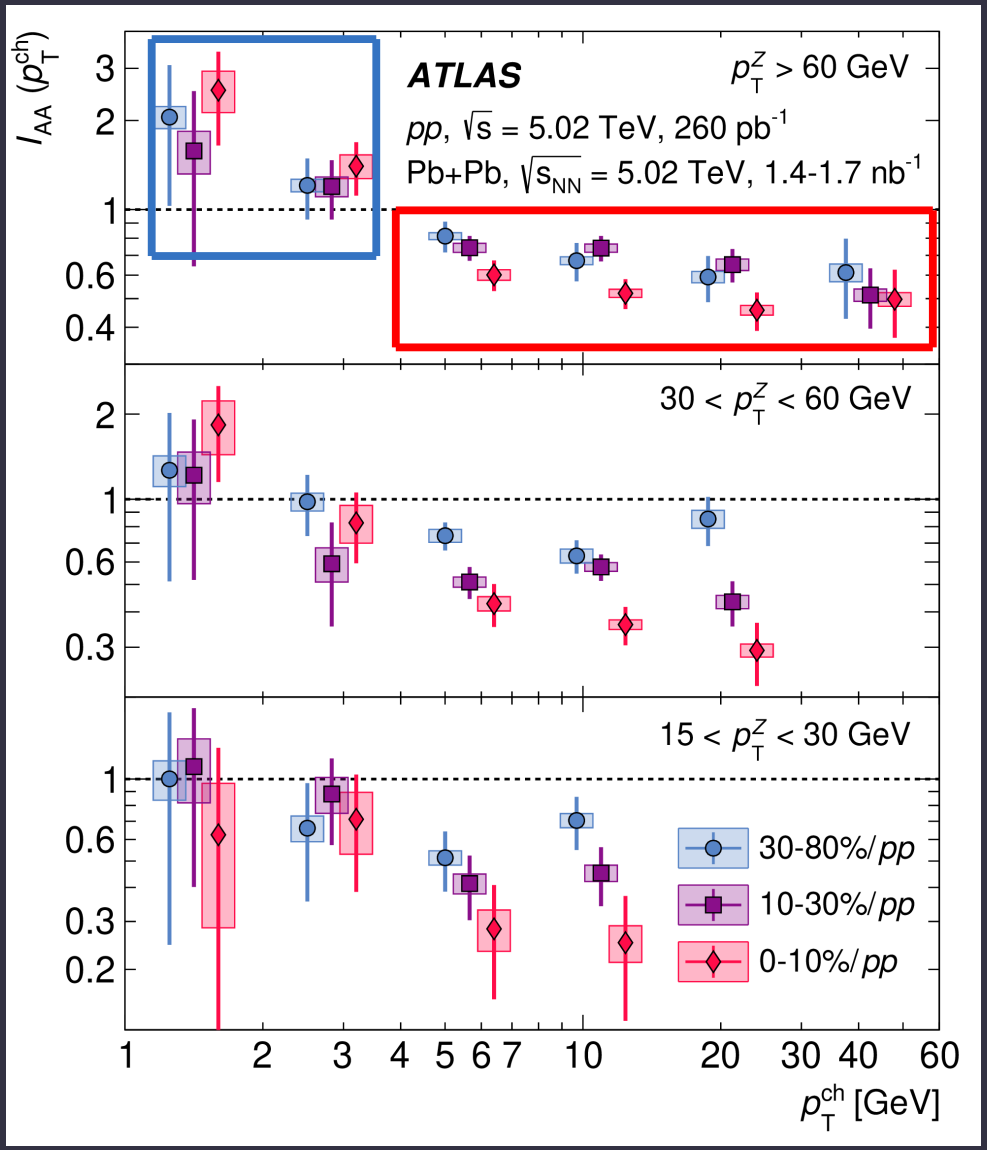
- Colorless tag (Z) unmodified by medium
  - Initial scattering proxy
- Study charged particles opposite the jet
- Right: Charged particles produced in hemisphere opposite Z in Pb+Pb, p+p



Z-Tag w/ Jet Fragments (II)

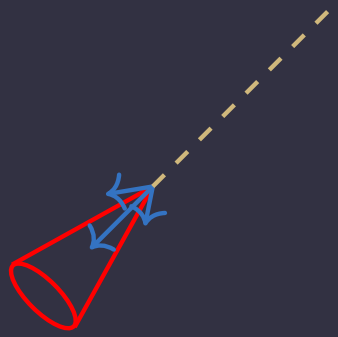
PRL 126 (2021) 072301

- How does energy loss modify jet constituents?
- Observe suppression of high-p_T particles
- Excess of low p_T particles
- Medium interactions attenuate+redistribute

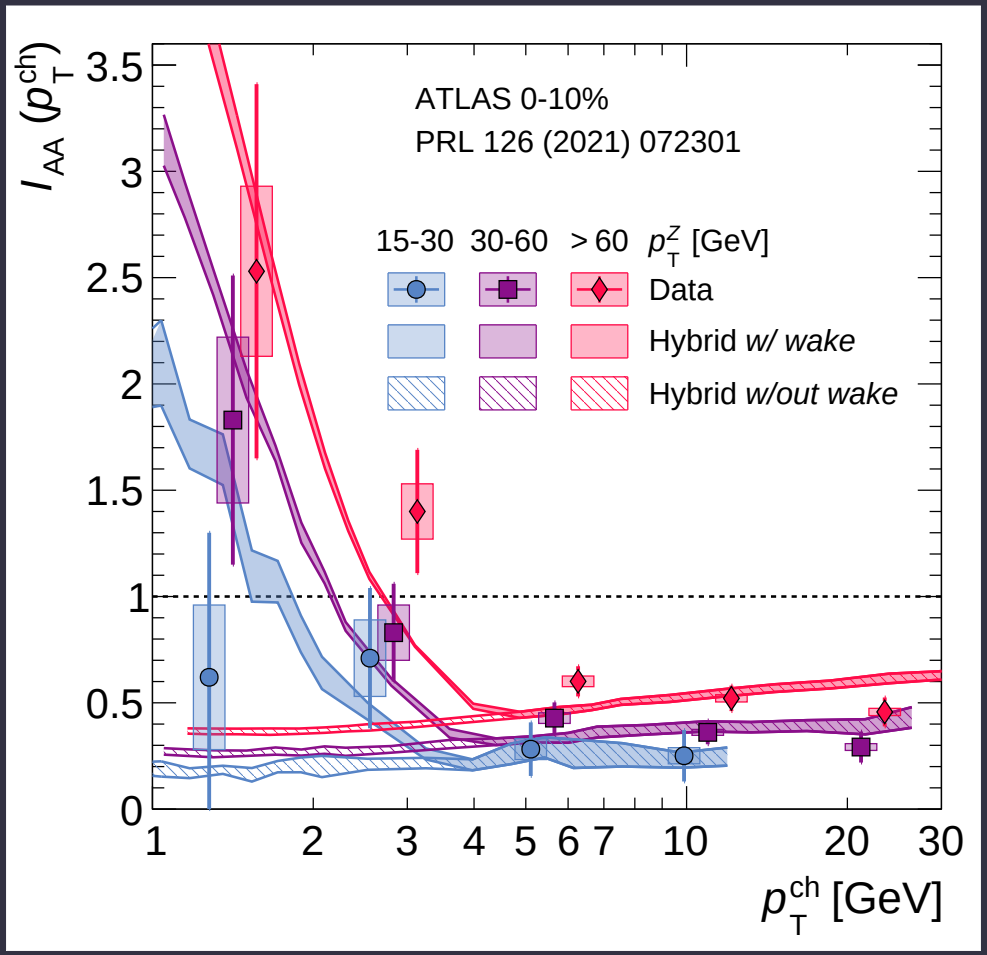


Z+hadrons Theory Comparison

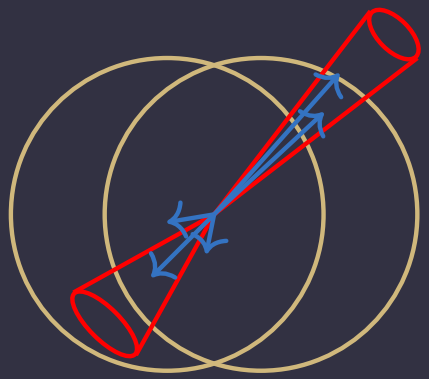
PRL 126 (2021) 072301



- **Does a jet in medium leave a wake?**
- **Hybrid model does not describe low-p_T excess in data w/o such a backreaction**



Conclusion



- Jets are an excellent probe for learning the properties of QCD matter
- Relative to vacuum, medium increases dijet imbalance
- The path length of jet thru medium impacts suppression
- Energy of the jet is redistributed from high-to-low-p_T particles

Backup

Jet-Geometry Correlations v_3

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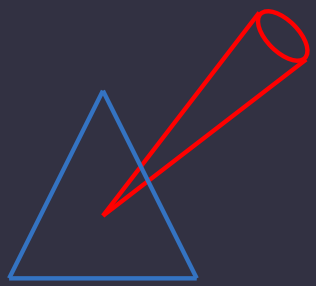
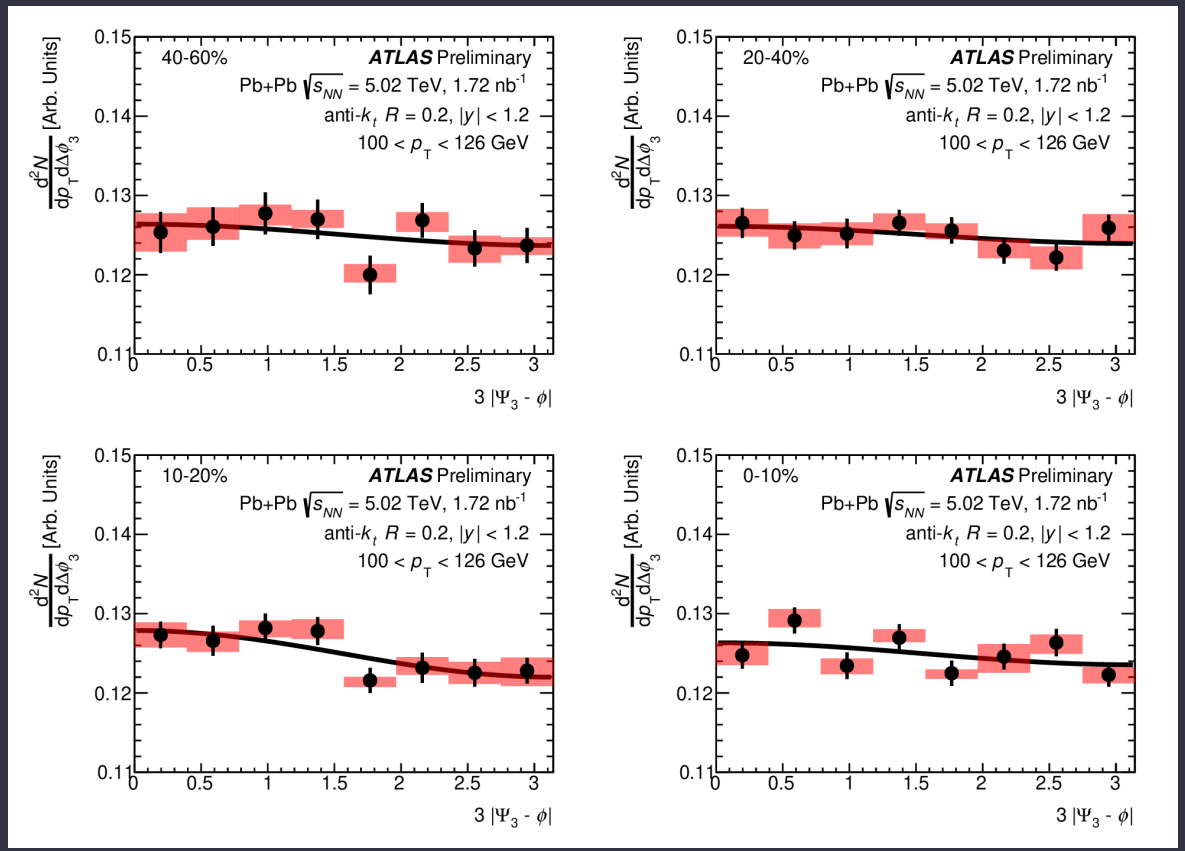


$$0 \longrightarrow \pi$$
$$3|\Psi_3 - \phi|$$

v_3 In-Plane — **v_3 Out-Plane**



- **Spatial fluctuations of nucleons → higher order geometries**
- **Observe null result w.r.t. triangular geometry**

Cross-experiment Comparison

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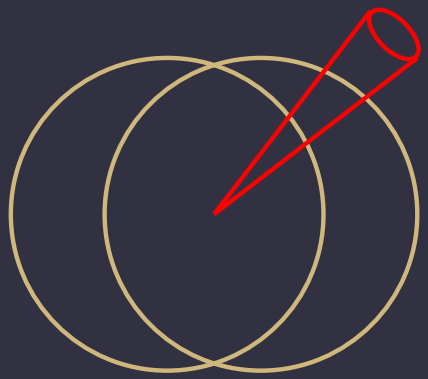
Out-Plane

In-Plane



v_2: 2nd Fourier Coef.
$A(1 + 2v_n\cos(n(\Psi_n - \phi)))$

- **Nice agreement in semi-central**
- **Modest tension in 0-10%**