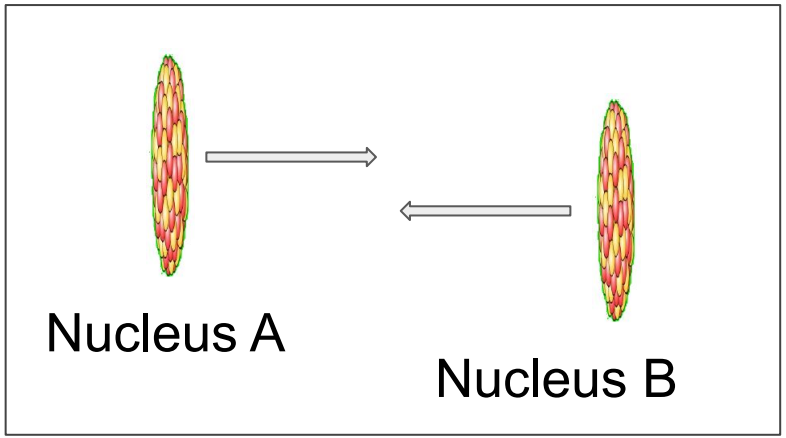
Study of production of jets and dijets in Xe+Xe and Pb+Pb collisions at the ATLAS experiment

Martin Krivoš

UNCE 15/12/2021

Heavy-Ion collisions - introduction



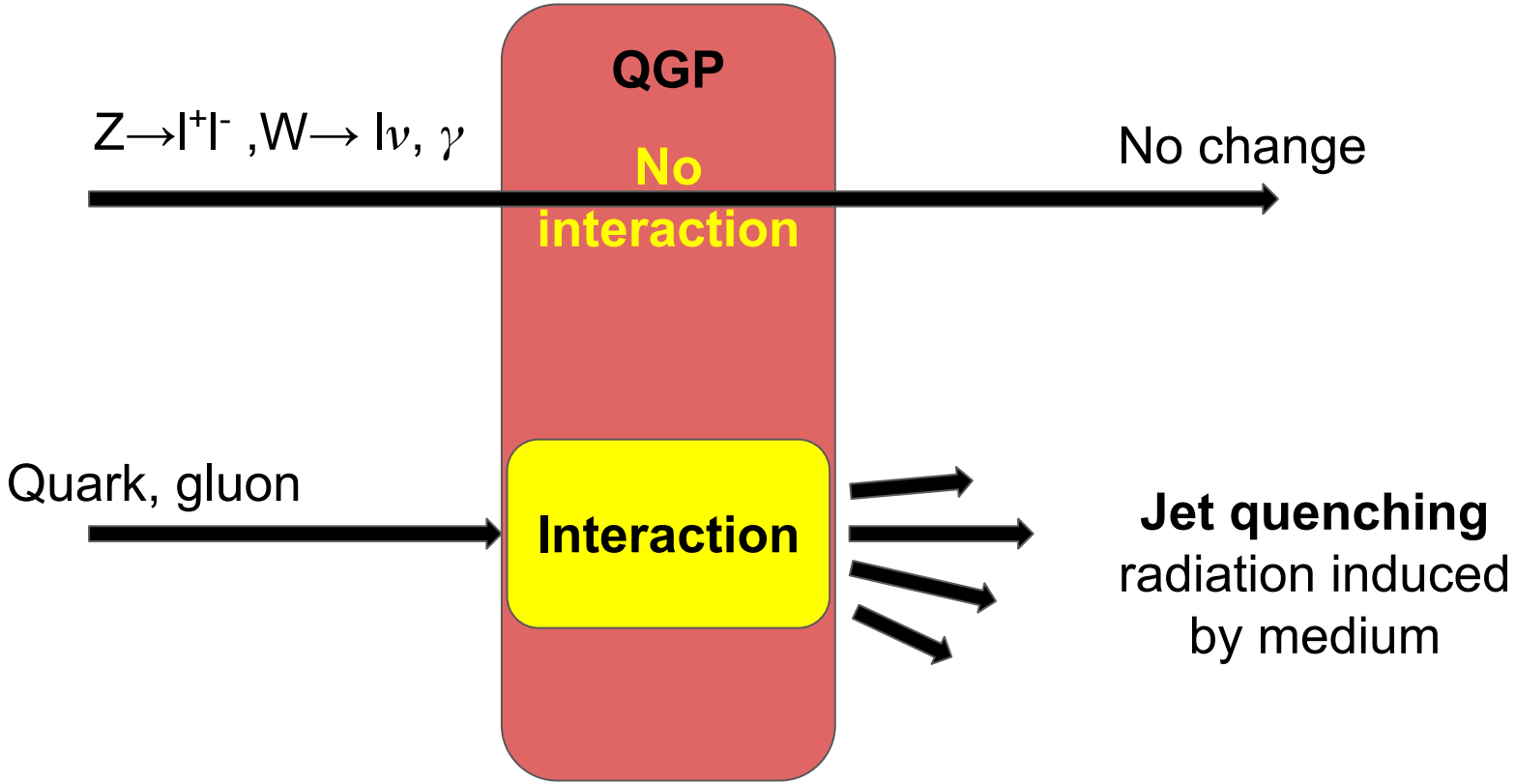
Is NOT a superposition of proton-proton collisions

Quark gluon plasma - hot dense quark/gluon medium

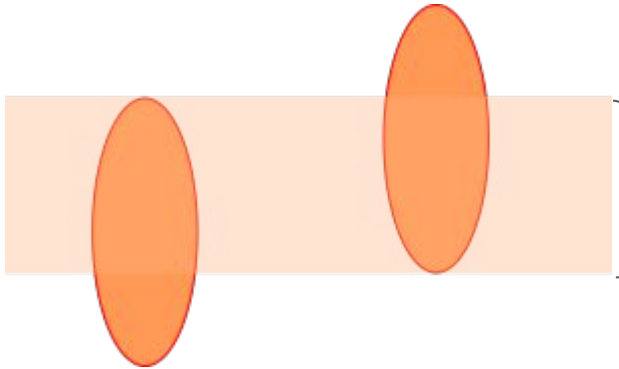
New phenomena:

- Jet (suppression) quenching
- Elliptic flow
- Photon collisions

Jet quenching in QGP

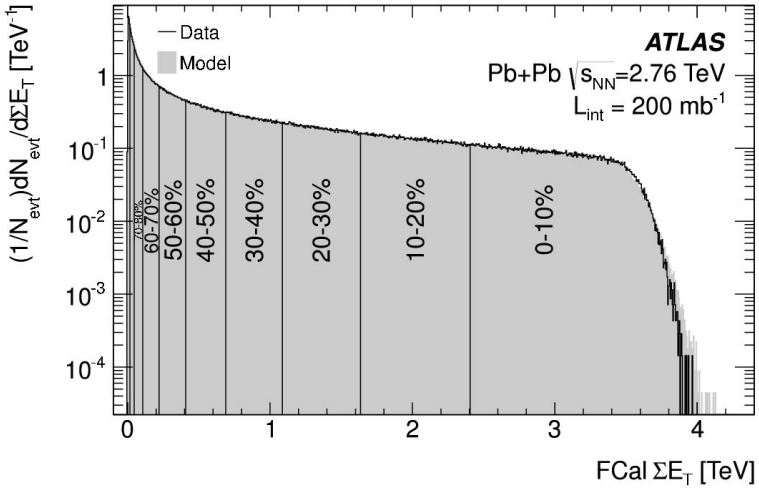


Centrality



Participants

- Unable to measure impact parameter directly -> measuring centrality



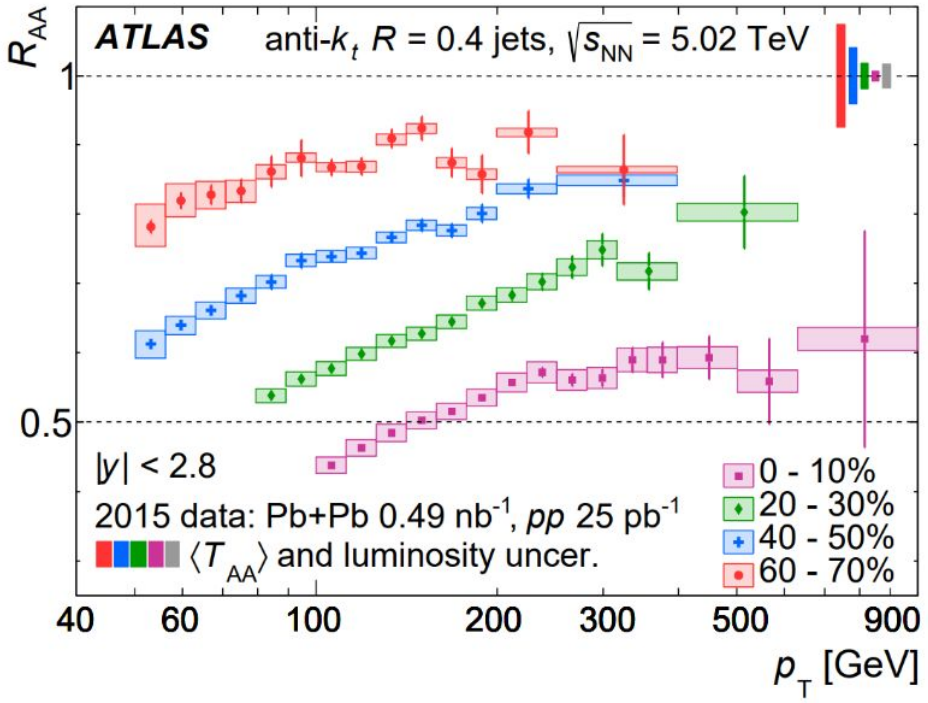
- Measuring energy in forward calorimeter
- 0-10% are the 10% most central collisions

Nuclear modification factor

- Physical quantity for comparing proton-proton and nucleus-nucleus collisions

- R_{AA} = 1 … not suppressed
- R_{AA} = 0.5 … strong suppression

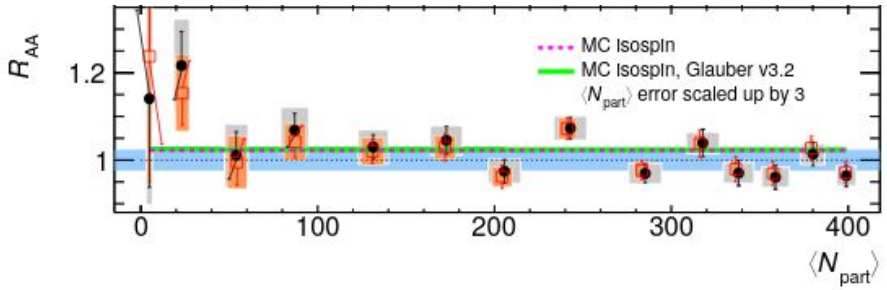
Strong suppression due to phenomenon called jet quenching.



Typical example of centrality dependence

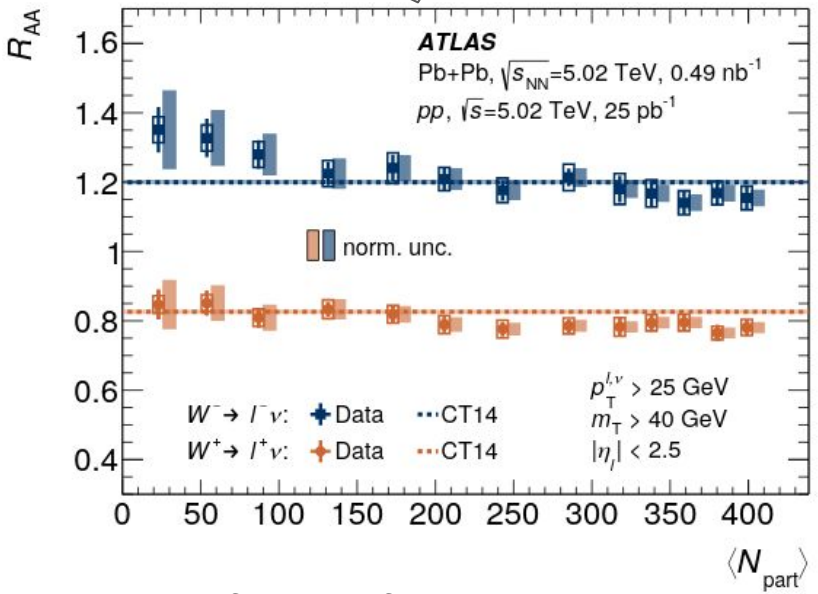
W and Z bosons

Z



- Z^0 (and leptons) consistent with unity

W



- larger fraction of d valence-quarks in Pb nuclei than in protons = isospin effect

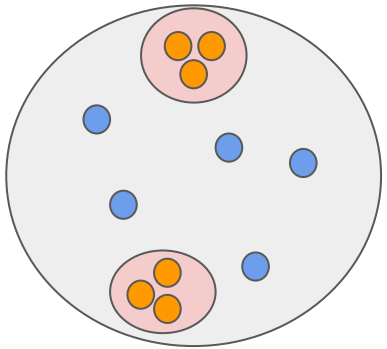
$$u\bar{d} \to W^+ \text{ and } d\bar{u} \to W^- \text{ processes}$$

- => Raa deviates from unity and consistent with CT14 PDFs

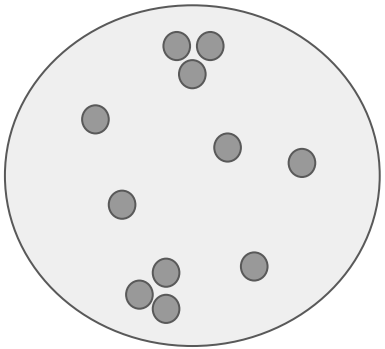
Back to jets: Large jets

- Jet quenching modifies also substructure of jets which we want to understand by measuring large-R jets
- Created by reclustering R=0.2 jets
- Quantitatively different from *simple* R=1.0 jets
- Soft contribution removed

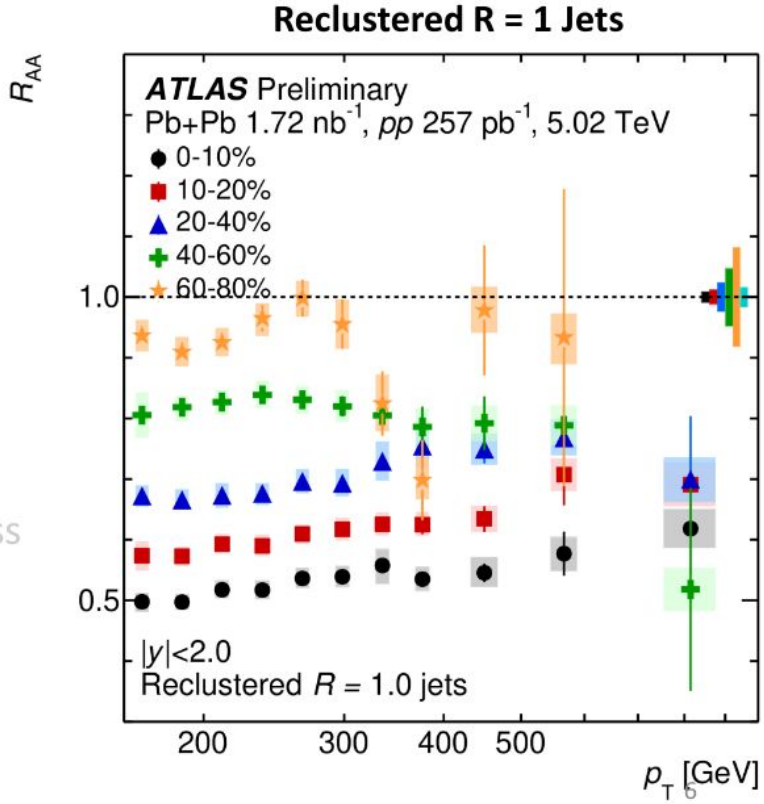
Reclustered R=0.2 jets into R=1.0 jet



Simple R=1.0 jets using anti-kt algorithm

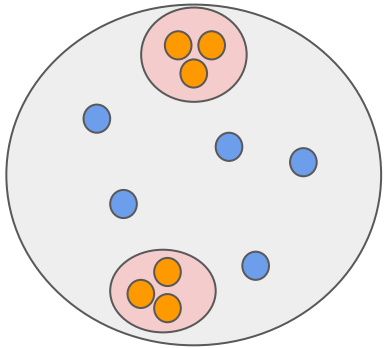


Large jets



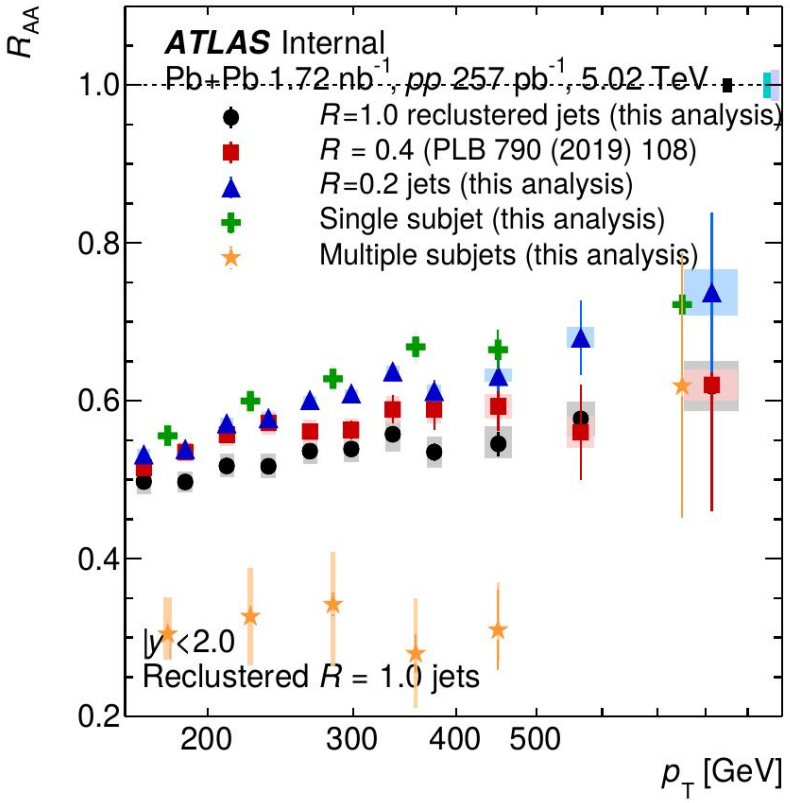
- Similar suppression to R=0.4 jets

Reclustered R=0.2 jets
into R=1.0 jet



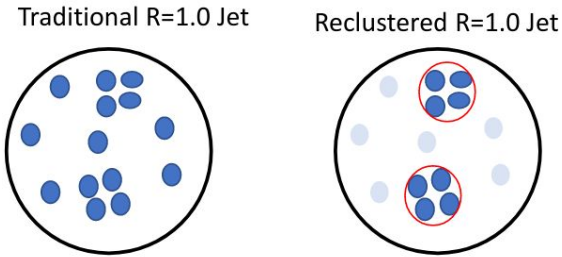
Suppression dependence on jet structure

ATLAS-CONF-2019-056



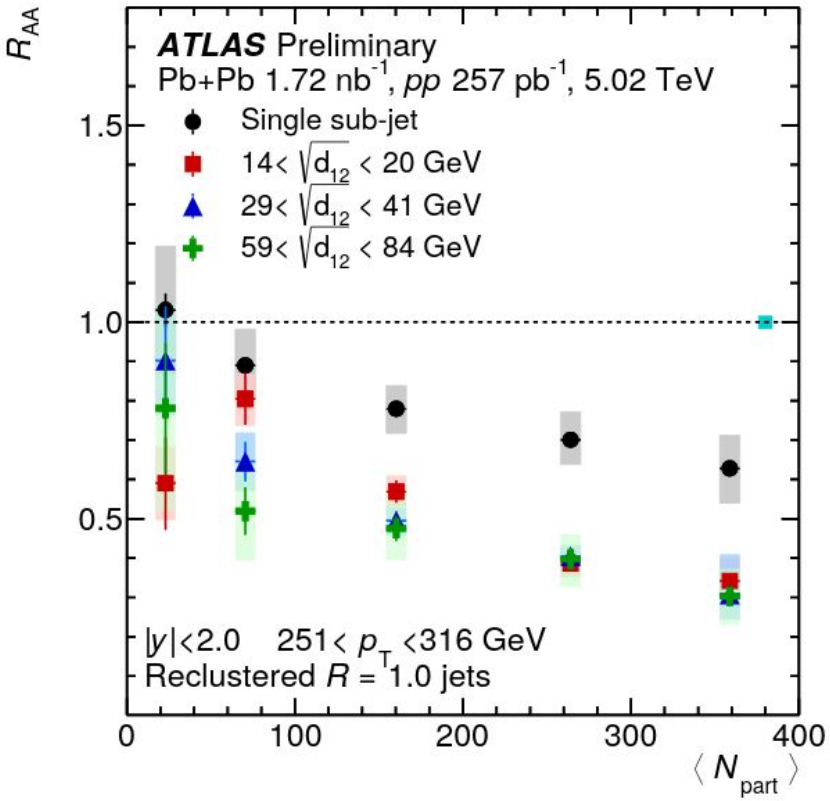
- Jets with single sub jet are less suppressed
- Opposite effect than what could be expected for “simple” R=1.0 jets (comparing to R=0.4)

$$\sqrt{d_{12}} = \min(p_{T,1}, p_{T,2}) \cdot \Delta R_{12}$$



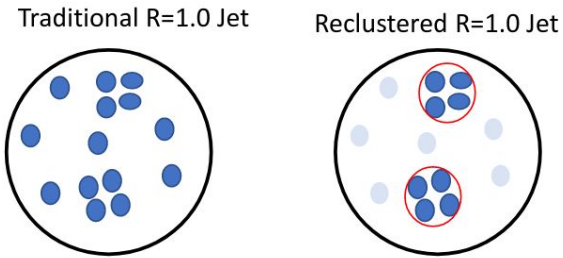
Suppression dependence on jet structure

ATLAS-CONF-2019-056



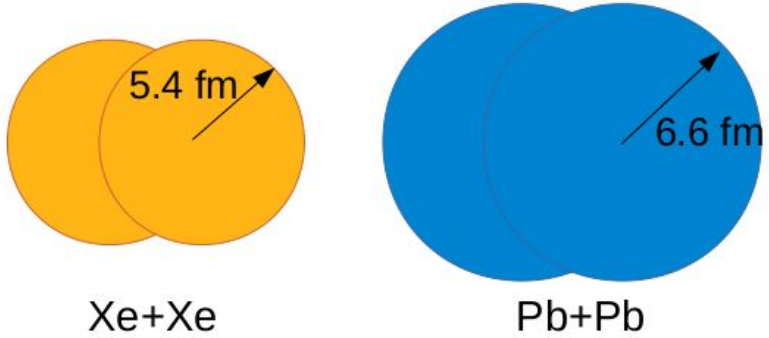
- Jets with single sub jet are less suppressed

$$\sqrt{d_{12}} = \min(p_{T,1}, p_{T,2}) \cdot \Delta R_{12}$$



Xe+Xe collisions

- Comparing Pb+Pb and Xe+Xe collisions
- Different system size:
  - different path-length of partons in the medium
  - possibly smaller suppression
- Run 3 at the LHC will likely be doing Oxygen+Oxygen -> New system (better performance) – need to explore jet quenching in smaller systems

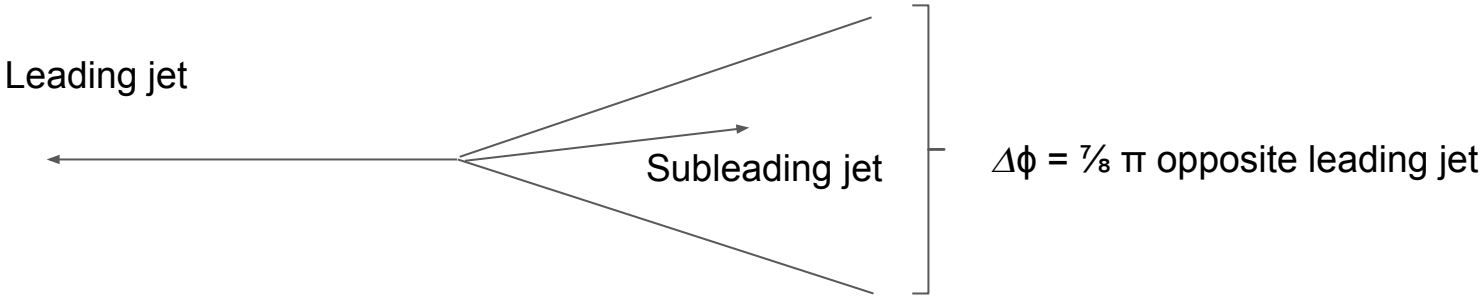


Advantages
Smaller underlying event

Disadvantages:
Smaller statistics => impossible to perform inclusive jet measurements

Dijet asymmetry

- Asymmetry of back-to-back jets
- xJ quantifies how large is the di-jet asymmetry



$$x_{\mathrm{J}} = \frac{p_{\mathrm{T}_2}}{p_{\mathrm{T}_1}}$$

2D vs 1D xJ calculation

1D method:

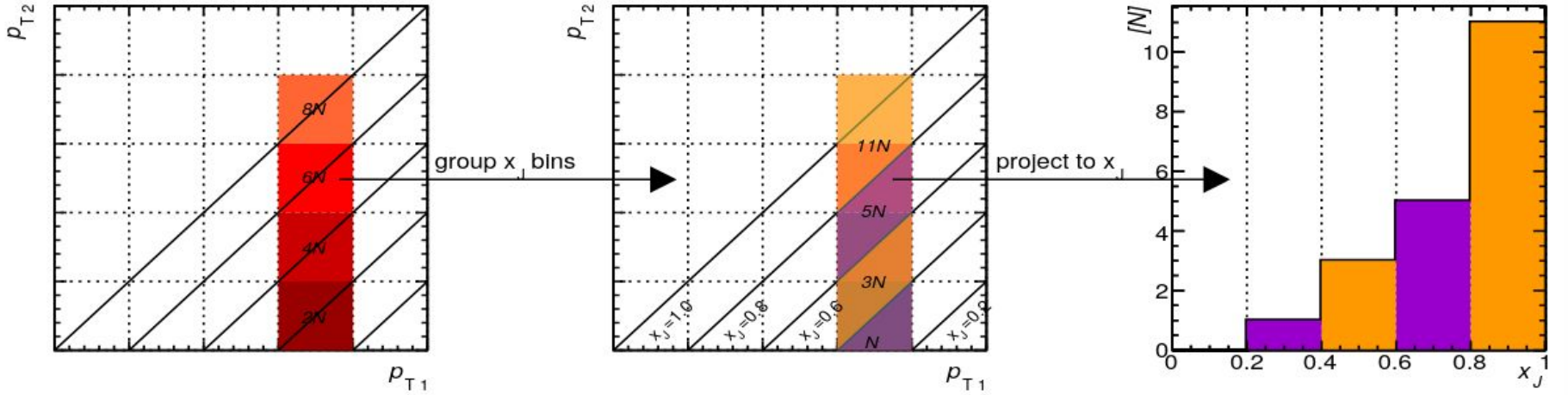
$$x_J = \frac{p_{T2}}{p_{T1}}$$

p_T and x_J binning:

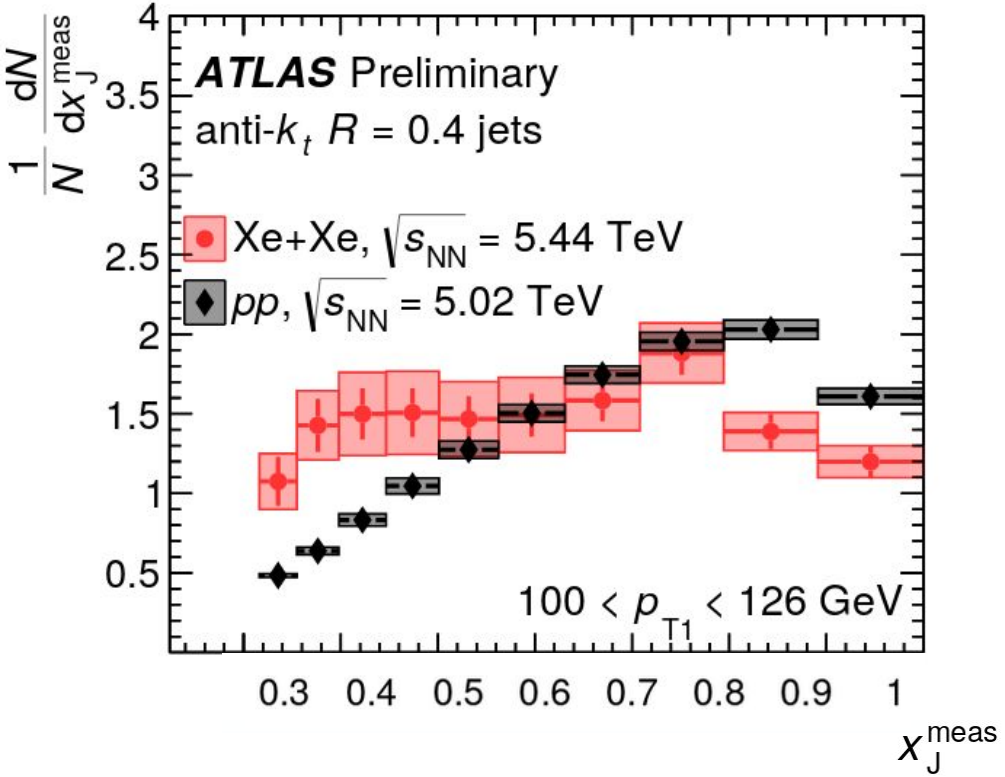
$$p_{Ti} = p_{T0}\,\alpha^i, \quad \alpha = \left(\frac{p_{TN}}{p_{T0}}\right)^{1/N}$$

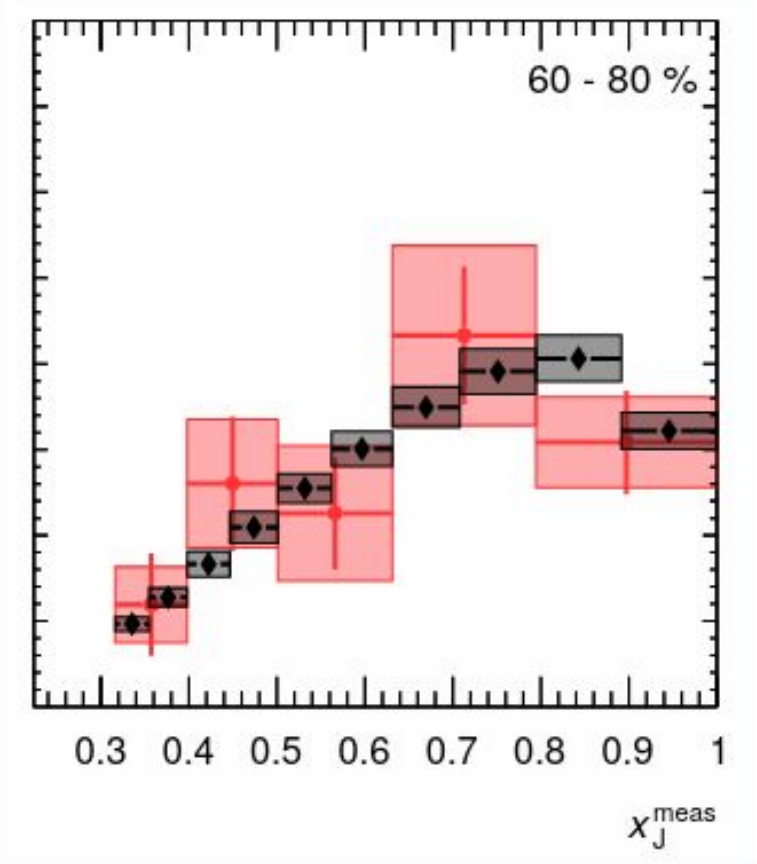
$$x_{Ji} = \alpha^{i-N}$$

2D method:



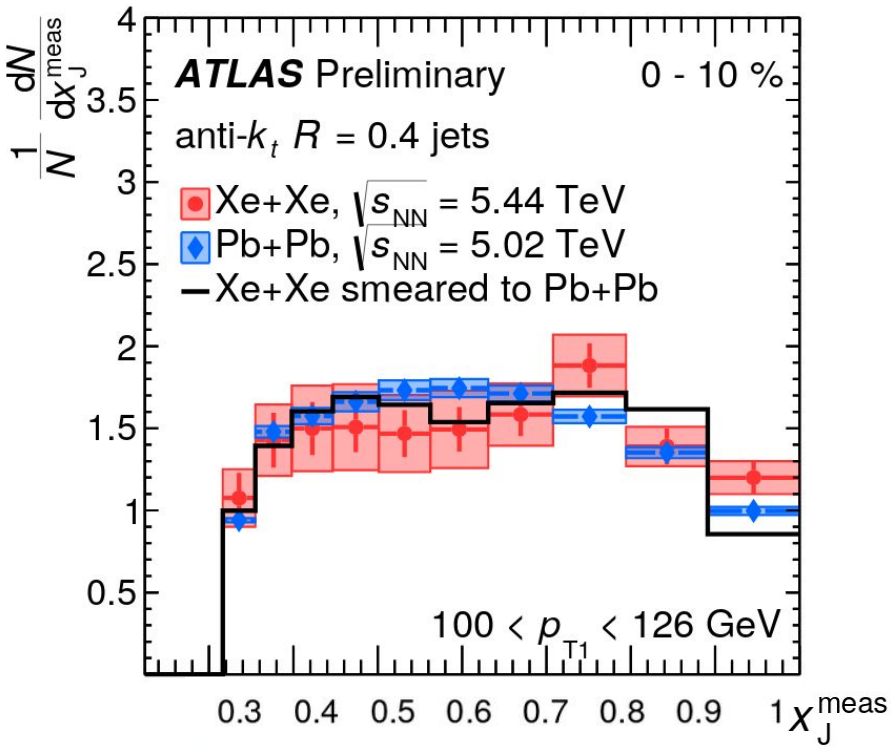
Raw dijet asymmetry

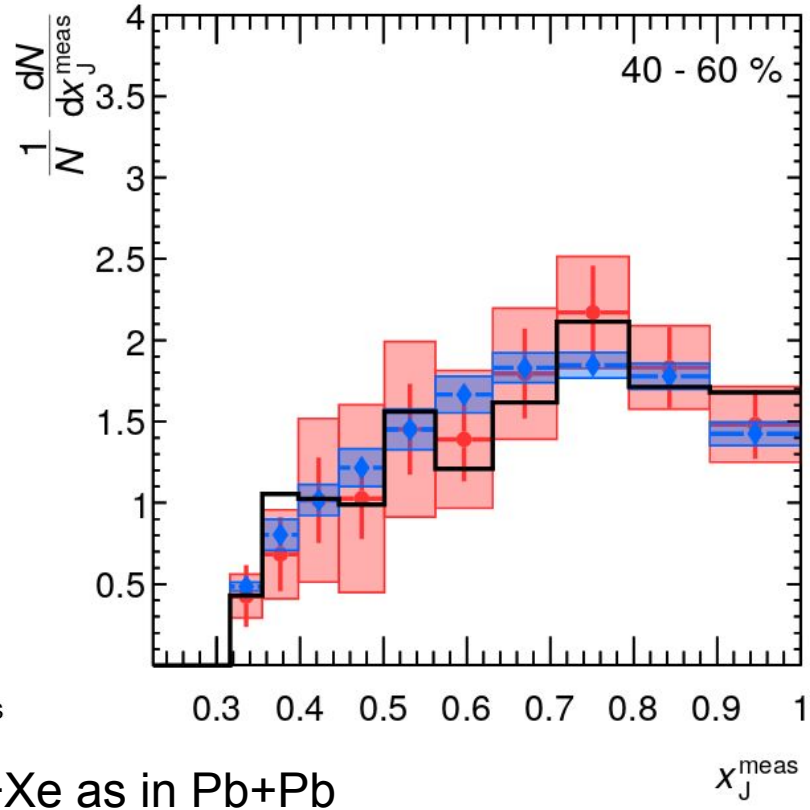




Comparison between proton-proton and Xe+Xe collisions

Similar behaviour as in Pb+Pb

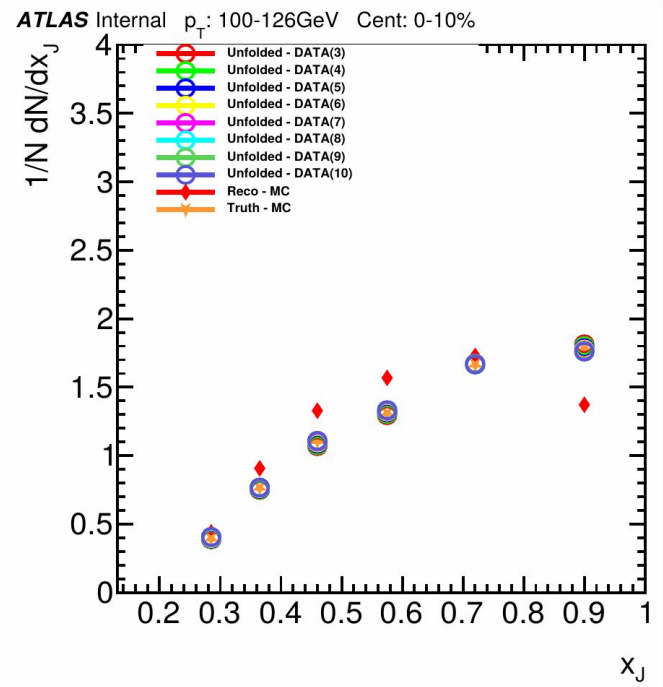


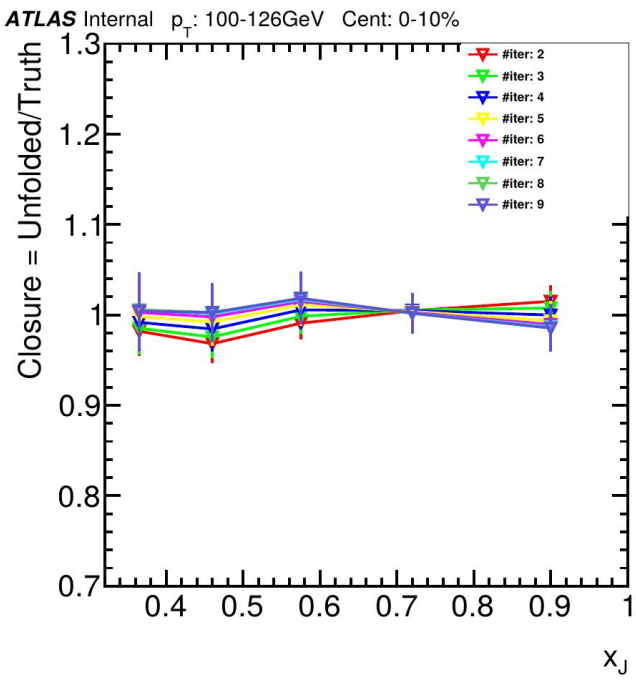


- Similar level of dijet suppression in Xe+Xe as in Pb+Pb

Ongoing studies

- Perform unfolding of x_J in Xe+Xe
- Improve on the precision of the measurement
- Include other observables (leading, subleading R_{AA})
- Compare with fully corrected Pb+Pb data





Thank you for your attention

Backup