Measurement of inclusive charged jet production in pp and Pb-Pb collisions at $\sqrt{S_{NN}} = 5.02 TeV$ with ALICE Run2 Data

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Outline

- **Motivation**
- **ALICE experiment**
- **Analysis flow**
- **Results**
  - Jet cross section in pp **at 5.02 TeV**
  - Underlying event subtraction in PbPb collisons **at 5.02 TeV**
  - Jet yield in Pb-Pb
  - Nuclear modification Factor RAA
- **Summary**

Jets in Heavy Ion Collisions (Hard Probes of the QGP)

What's a Jet

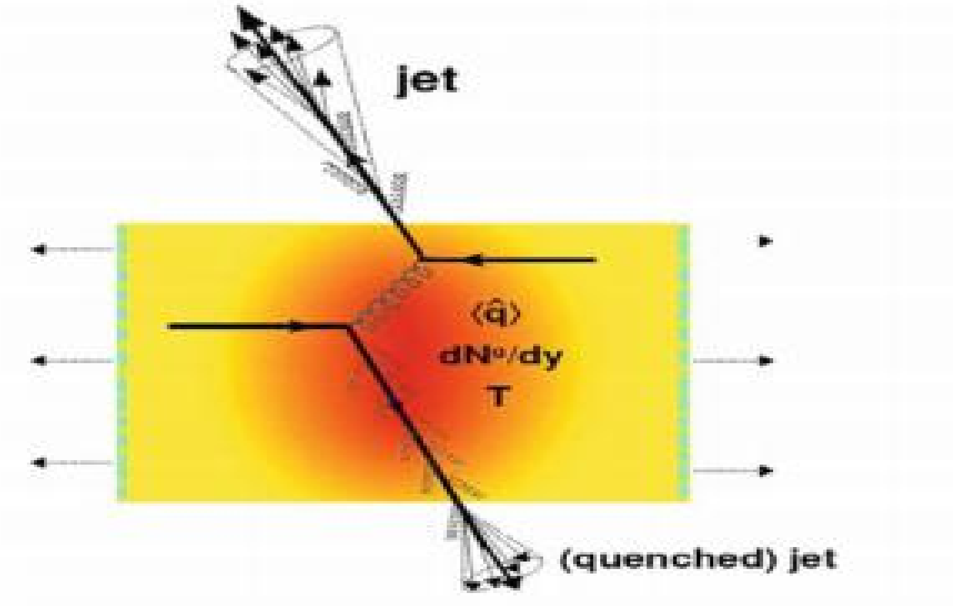
- ✓ Collimated spray of hadrons produced by the hard scattering of partons at the initial stage of the collision
- ✓ high Q^2 process

Why Jets

- ✓ The QGP lifetime is so short ($\approx 10^{-23} s$) that characterisation by external probes is ruled out
  - self-produced probes
- ✓ Occur at early stage : $\tau \sim 1/Q$
  - probe the entire medium evolution
- ✓ Production rate calculable within pQCD
  - well calibrated probes
- ✓ Large cross-section at the LHC
  - copious production
- ✓ Reconstructed jet enables to access
  - 4-momentum of original parton
  - jet structure (energy re-distribution)

Jet Quenching

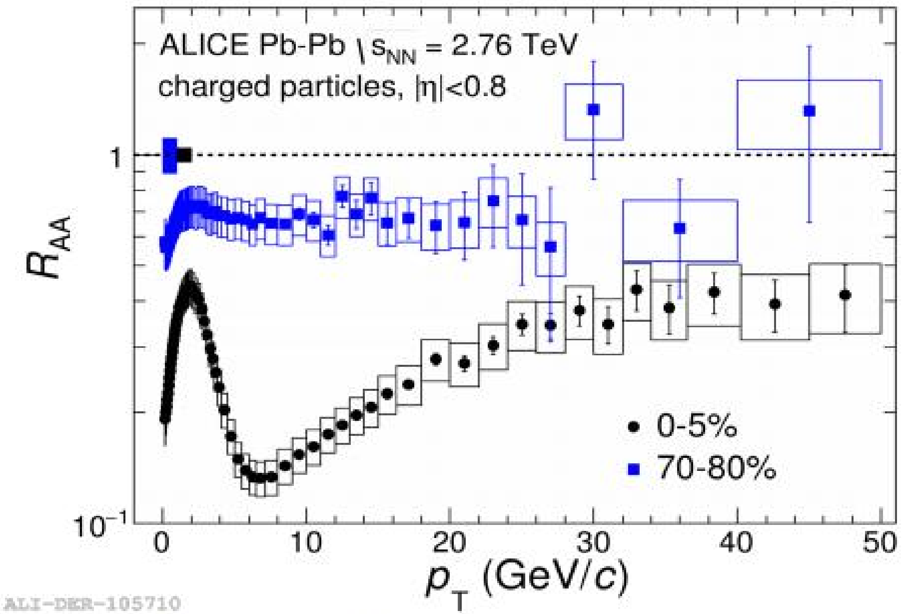
- ✓ Attenuation or disappearance of observed Jets in Pb-Pb
  - due to partons' energy loss in the QGP
  - jet shape broadening
- ✓ Evaluation of the degree of the attenuation allows to assess QGP properties



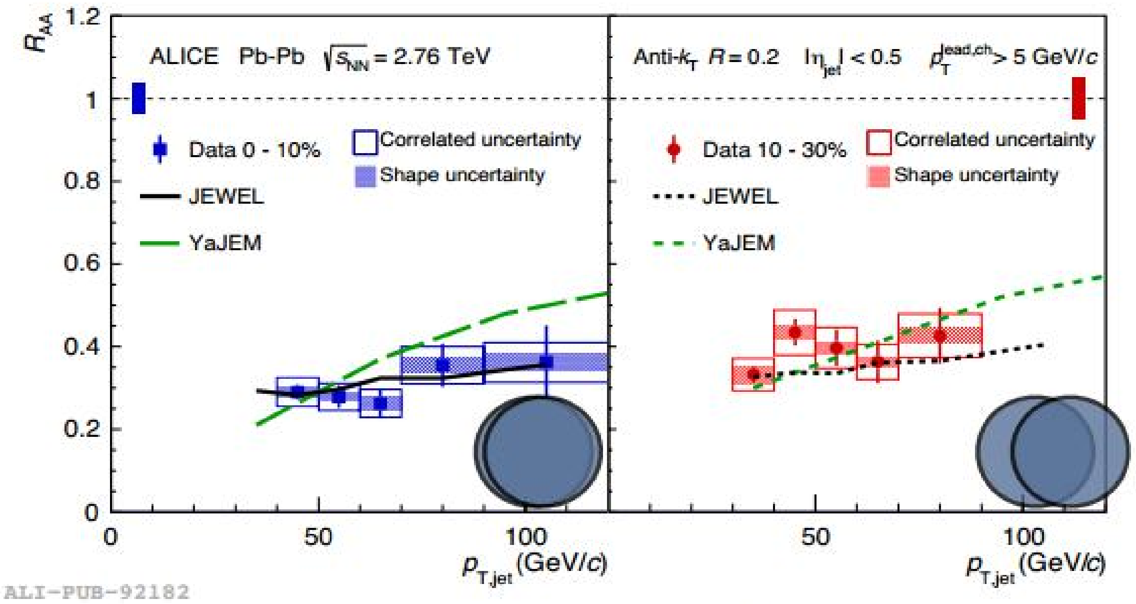
ALICE Jet Quenching Measurements in Pb-Pb

$$R_{AA} = \frac{\frac{1}{\langle T_{AA} \rangle} \frac{1}{N_{evt}} \frac{dN_{ch\ jet}}{dp_T d\eta}}{\frac{d\sigma_{pp}}{dp_T d\eta}}$$

- ✓ Nuclear modification factor : R_{AA}
  - if $R_{AA}= 1$, No modification
  - $R_{AA}>1$, enhancement
  - $R_{AA}<1$, suppression
- ✓ High-pT hadrons strong suppression : $R_{AA} \sim 0.2$
  - proxy for jet (parton) : $p_T > 10 GeV/c$
  - fragmentation of quenched partons
- ✓ Jets
  - Strong suppression : $R_{AA} \sim 0.4$
  - Jet shape broadens?
  - where is the lost energy?



Centrality Dependence of Charged Particle Production at Large Transverse Momentum in Pb-Pb Collisions at $\sqrt{s_{NN}}$ = 2.76 TeV , PLB 720 (2013) 52



Measurement of jet suppression in central Pb-Pb collisions at $\sqrt{s_{NN}}$ = 2.76 TeV , PLB 746 (2015) 1

ALICE Jet Quenching Measurements in Pb-Pb

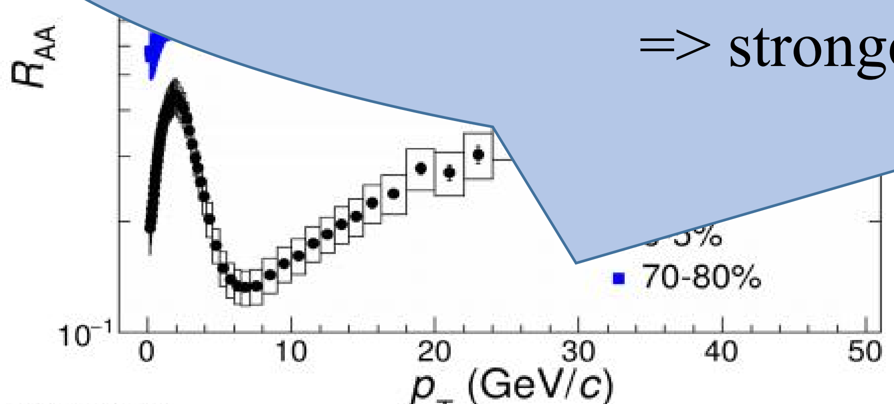
$$R_{AA} = \frac{\frac{1}{\langle T_{AA}\rangle}\frac{1}{N_{evt}}\frac{dN_{ch\ jet}}{dp_T d\eta}}{\frac{d\sigma_{pp}}{dp_T d\eta}}$$

- ✓ Nuclear modification factor : R_{AA}
  if R_{AA}= 1, No modification

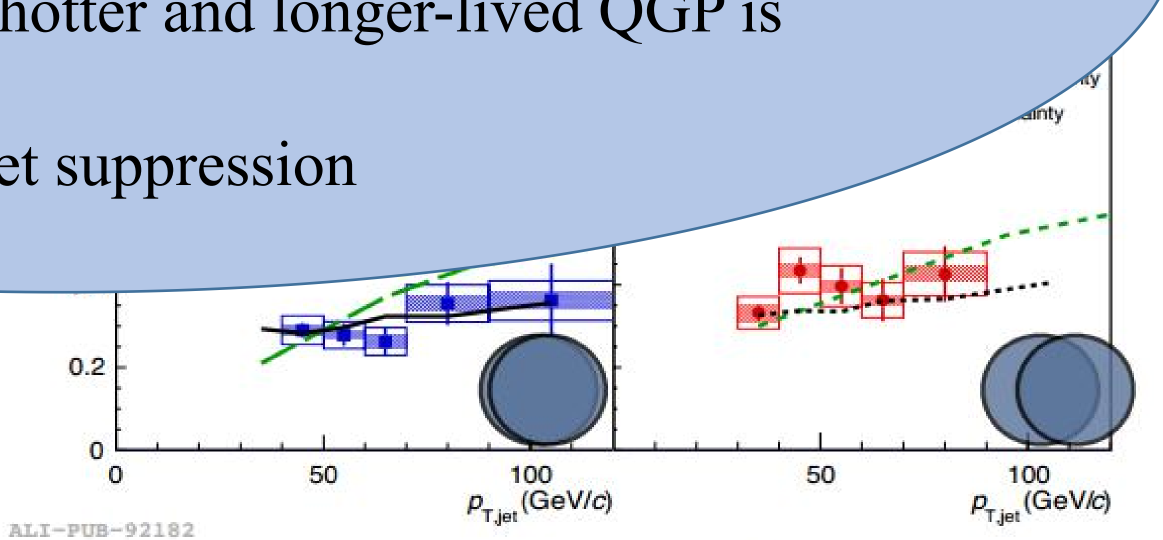
- ✓ High-pT h

- ✓ We are interested in quantifying the jet suppression (parton energy loss) as a function of Jet p_T , collision energy and centrality.

- ✓ For higher $\sqrt{s_{NN}}$, denser, hotter and longer-lived QGP is created.
  => stronger jet suppression



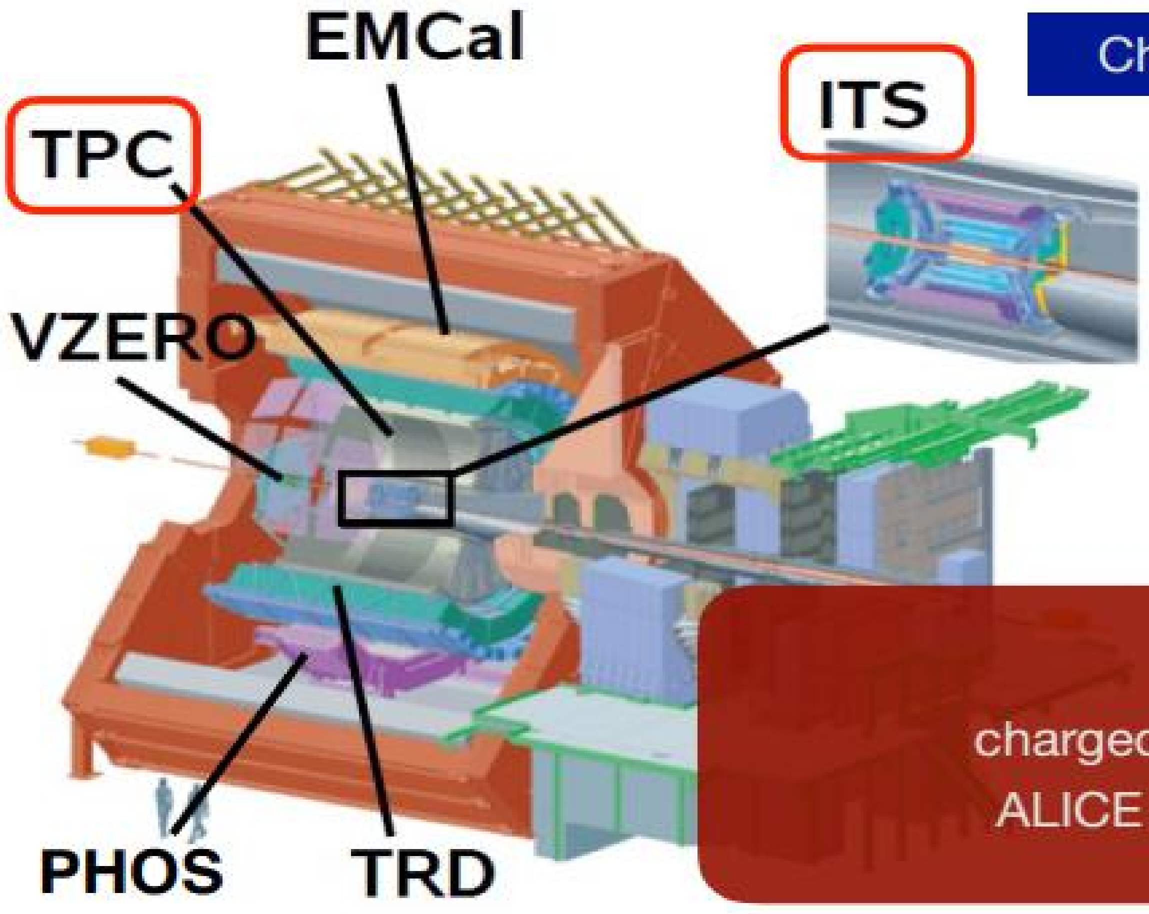
Centrality Dependence of Charged Particle Production at Large Transverse Momentum in Pb-Pb Collisions at $\sqrt{s_{NN}}$ *= 2.76 TeV , PLB 720 (2013) 52*



Measurement of jet suppression in central Pb-Pb collisions at $\sqrt{s_{NN}}$ *= 2.76 TeV , PLB 746 (2015) 1*

Jet Measurement in LHC-ALICE

- ALICE detector : focus on Heavy-Ion Collisions
  - LHC Run2 period started from 2015
    - $\sqrt{s}$ = 13 TeV pp , $\sqrt{s_{NN}}$ = 5.02 TeV Pb-Pb, pp



Charged Particles : $|\eta| < 0.9$, $0<\phi<2\pi$

- ITS : silicon tracking detector
- TPC : Time Projection Chamber

Charged Jet

In this analysis,
charged jets are measured using
ALICE central barrel detectors.

Analysis Flow

- ✓ Dataset

  √s = 5.02 TeV, pp and Pb-Pb collisions
- ✓ MB triggered events
- ✓ Charged track selection

  | η | < 0.9, $p_T^{track} \geq 0.15 GeV/c$
- ✓ Jet reconstruction

  Anti-kt jet reconstruction algorithm

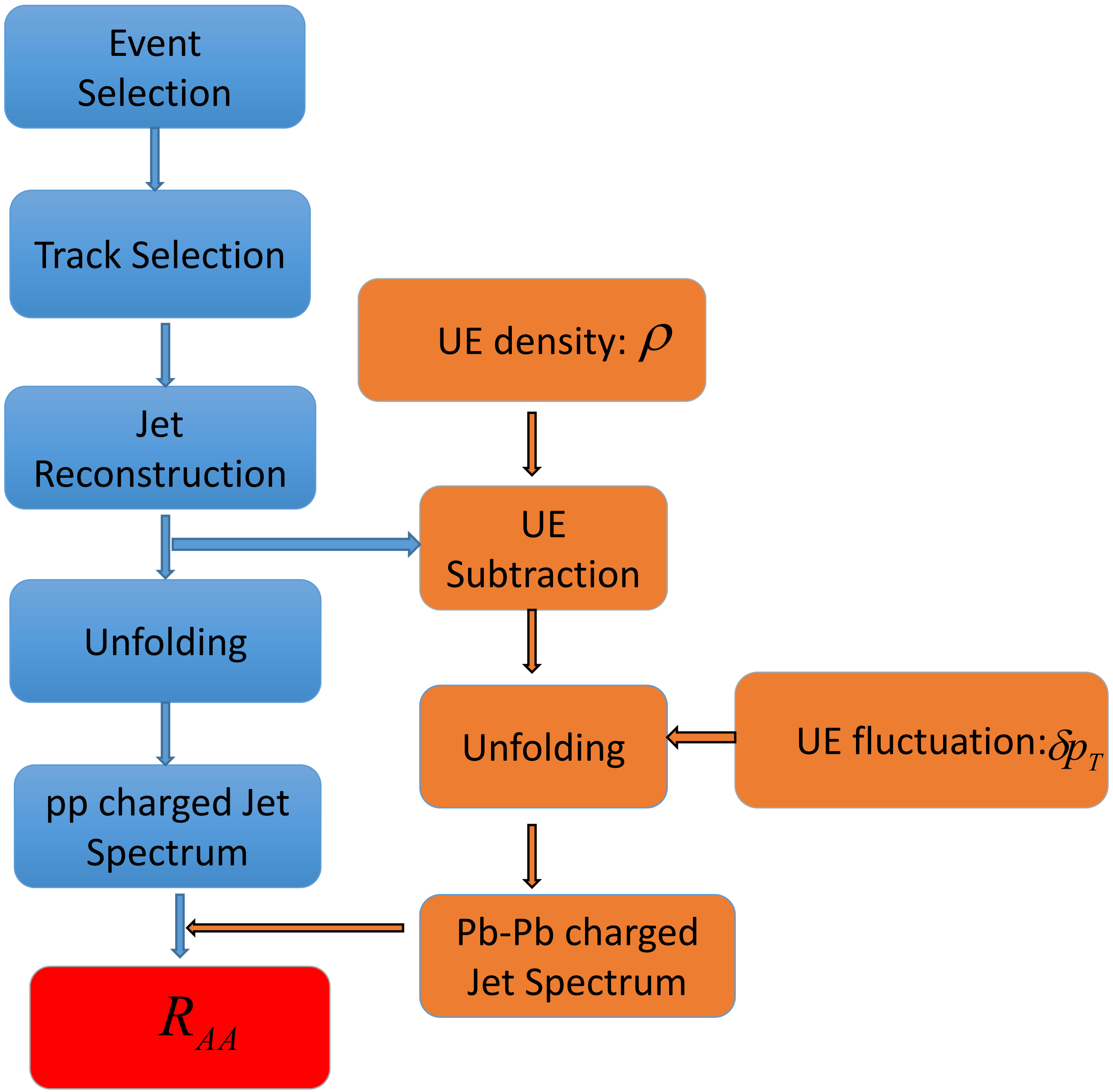
  R = 0.2, 0.4

  | η | < 0.7, $p_T^{lead} > 5 GeV/c$
- ✓ Unfolding

  To correct for detector effects
- ✓ Inclusive jet spectrum

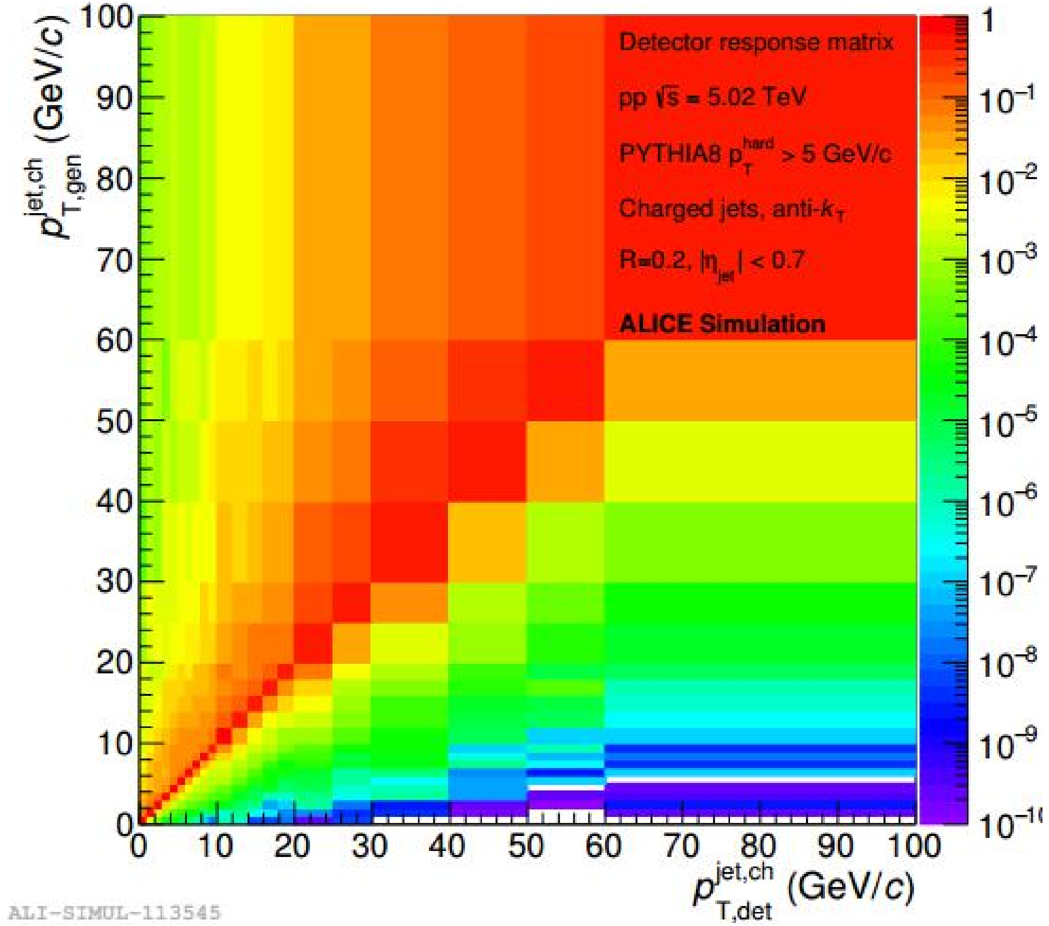
  Fully corrected to charged particle level

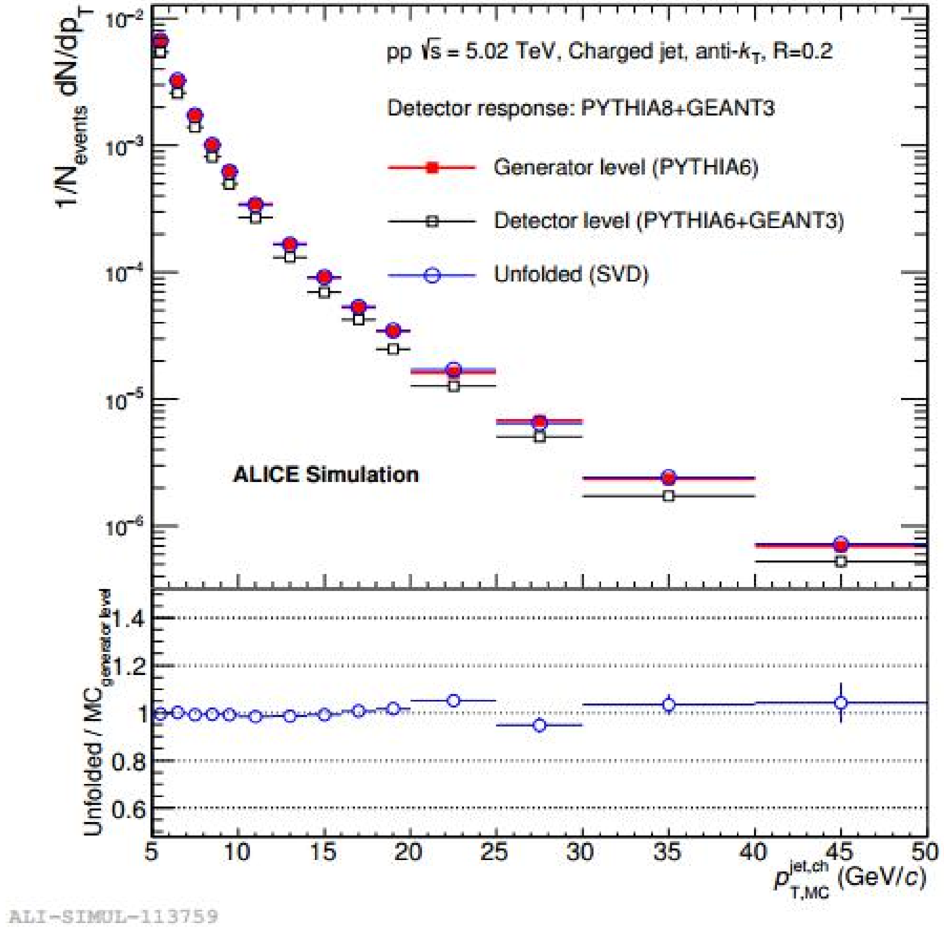
  Assess nuclear modification for Pb-Pb collision



Unfolding correction for jets

- ✓ Detector response matrix for detector effects
- ✓ The result of MC closure test for unfolding is reilable for correcting the jet spectrum





pp Inclusive Jet Cross Section

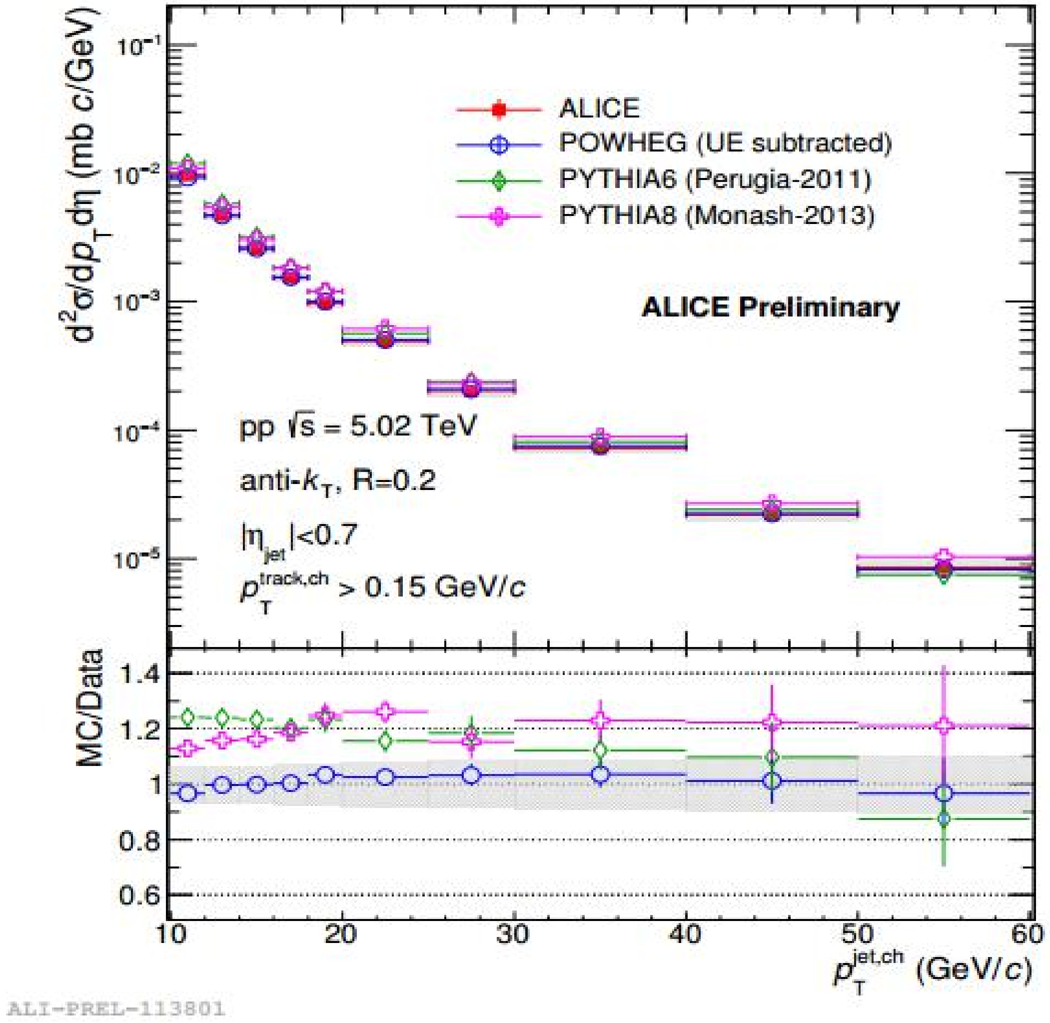
✓ Jet cross section

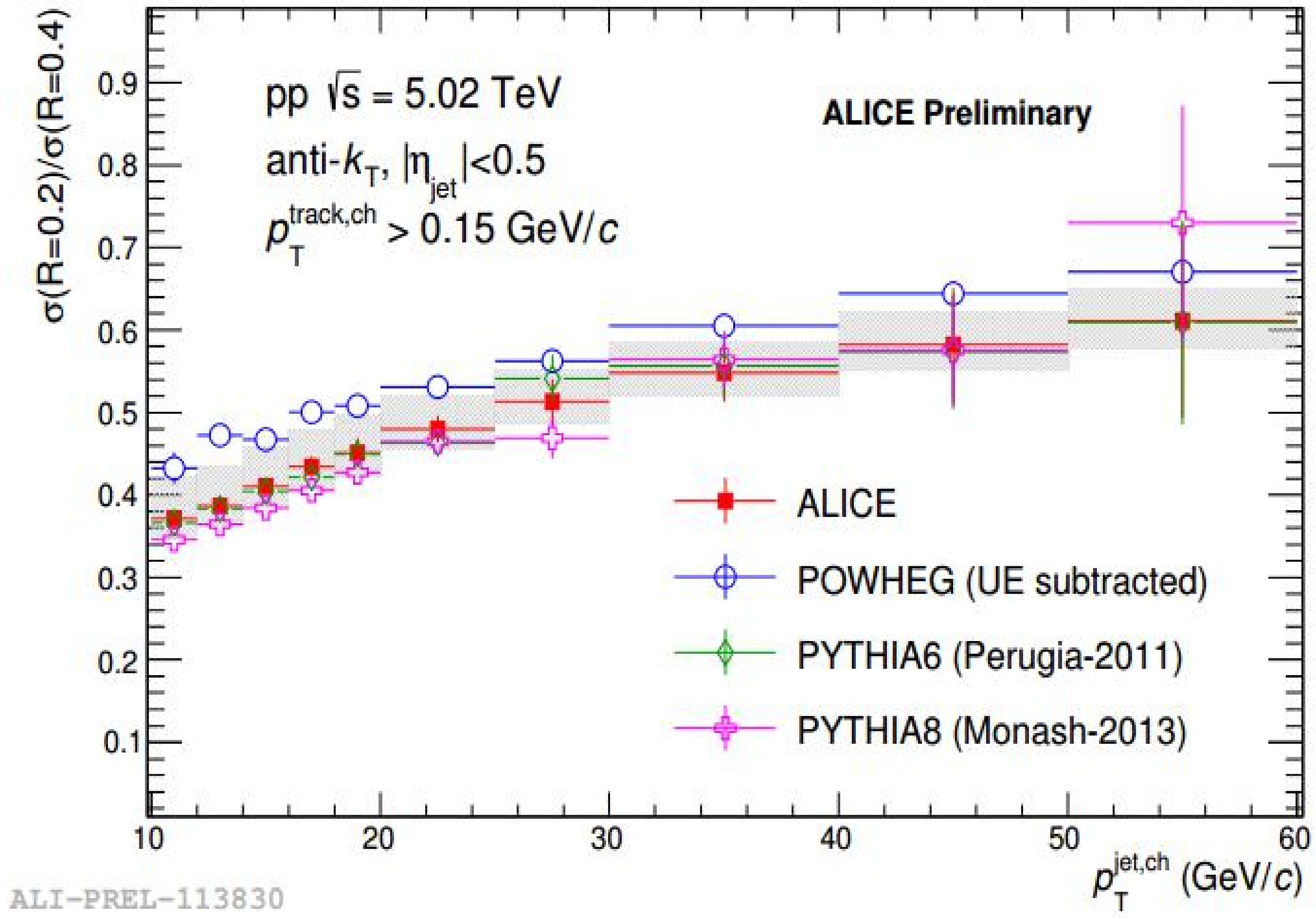
Well described by POWHEG NLO calculations within systematic uncertainties.

✓ Ratio of cross sections

$\sigma(R = 0.2) / \sigma(R = 0.4)$

Stronger collimation at high pT





Underlying Event Density

Challenge in Heavy-Ion Collisions

- ✓ large background contribution to jet energy
- ✓ $dN_{ch}/d\eta \sim 1300$ (0-10% centrality)

Jet Background Subtraction

Background density : ρ

median k_T excluding the highest two clusters

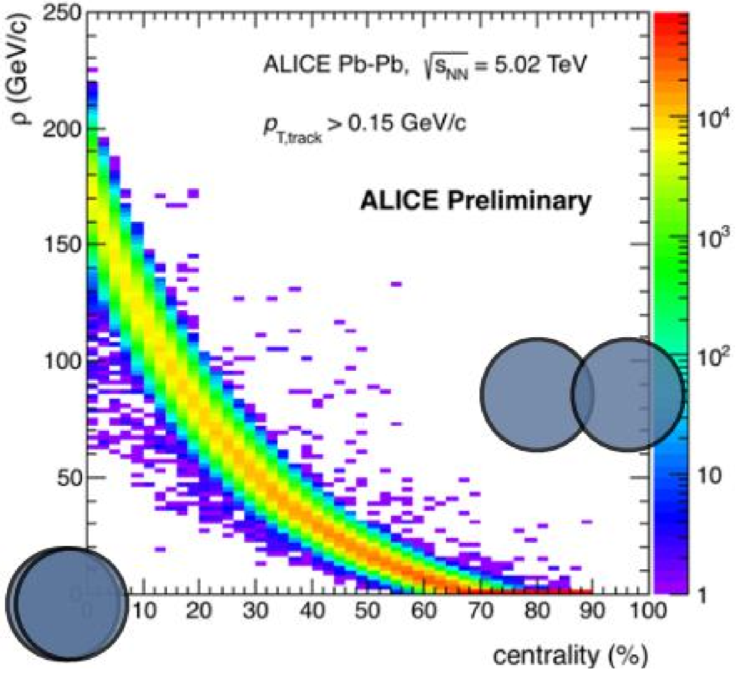
$$\rho = medina\{\frac{p_{T,i}}{A_i}\}$$

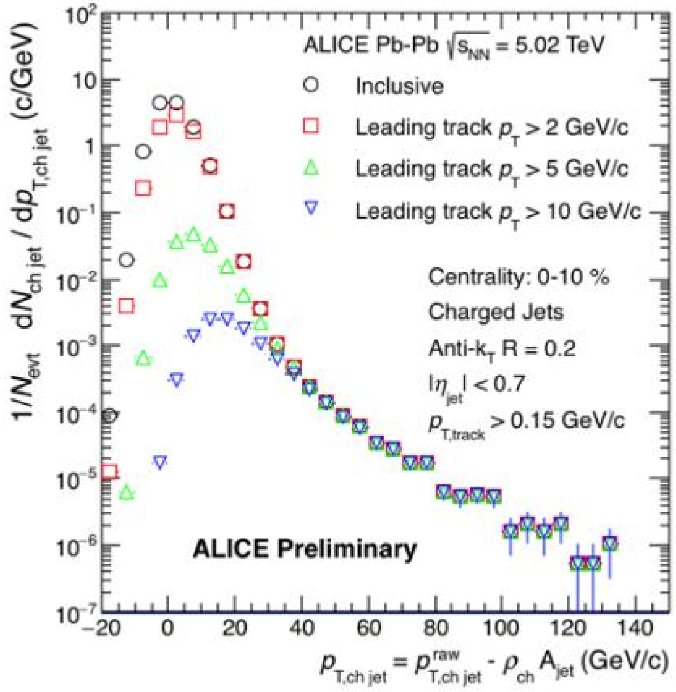
Background subtraction

background is estimated event-by-event and subtracted from each jet

$$p_{T,jet}^{rec} = p_{T,jet}^{raw} - \rho \cdot A_{jet}^{rec}$$

Minimum leading constituent $p_T > 5GeV/c$ requirement suppresses combinatorial jets in low momentum





Underlying Event Fluctuation

UE fluctuation : δp_T

δp_T is used as a measurement for background fluctuations

$$\delta p_T = \sum_{i}^{RC} p_{T,i}^{track} - A \cdot \rho$$

Random Cone Method

1) random selection

2) RC apart from leading jet ($\Delta r > 1.0$)

to reduce jet component.

$$\Delta r = \sqrt{(\eta_{RC} - \eta_{jet})^2 - (\phi_{RC} - \phi_{jet})^2}$$

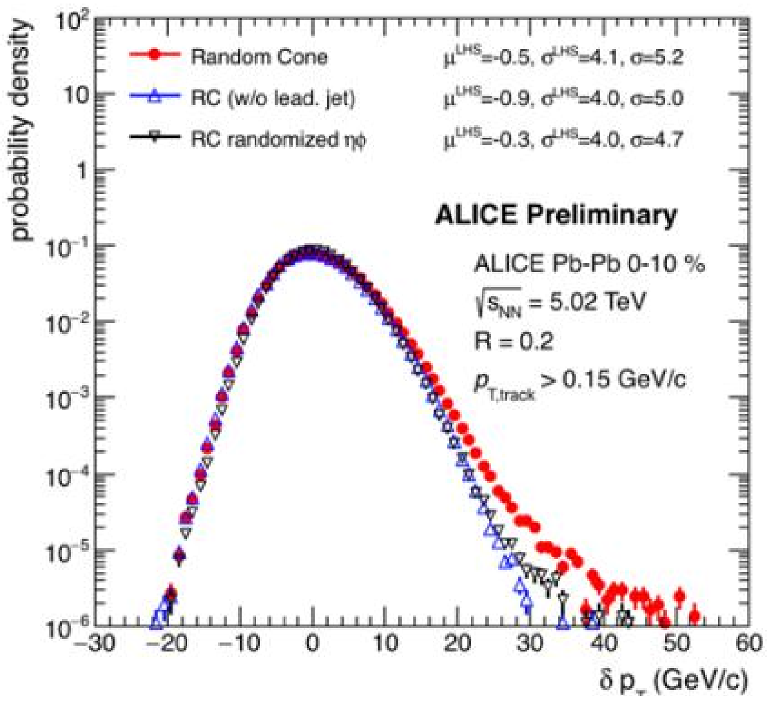
3) use η - ϕ randomised tracks

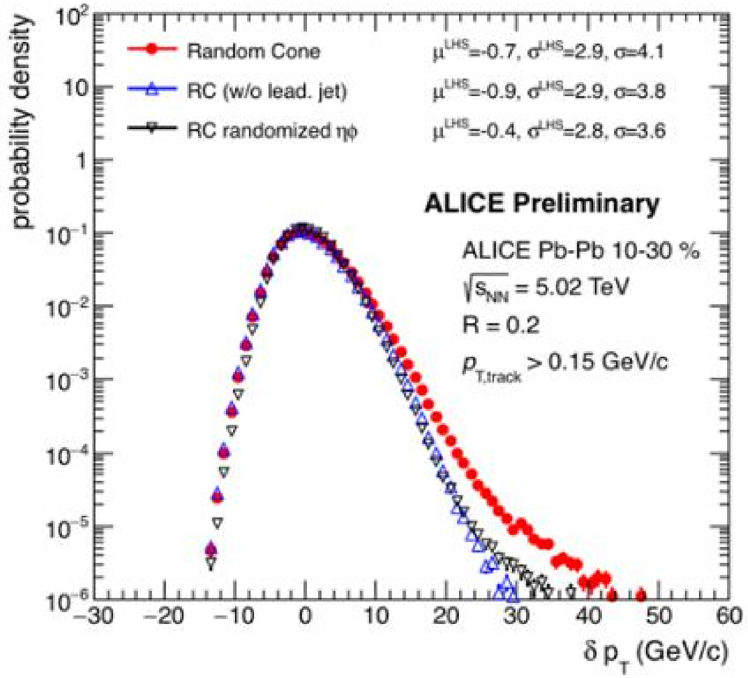
to exclude flow effect

δp_T width (magnitude of UE fluctuation)

fluctuations larger in central than in peripheral collisions

~5 GeV/c for R=0.2, 0-10% centrality





Inclusive Jet Cross Section

$$\frac{d^2\sigma}{dp_T d\eta} = \frac{\langle N_{coll}\rangle}{\langle T_{AA}\rangle}\frac{1}{N_{evt}}\frac{dN^2_{ch\ jet}}{dp_T d\eta}$$

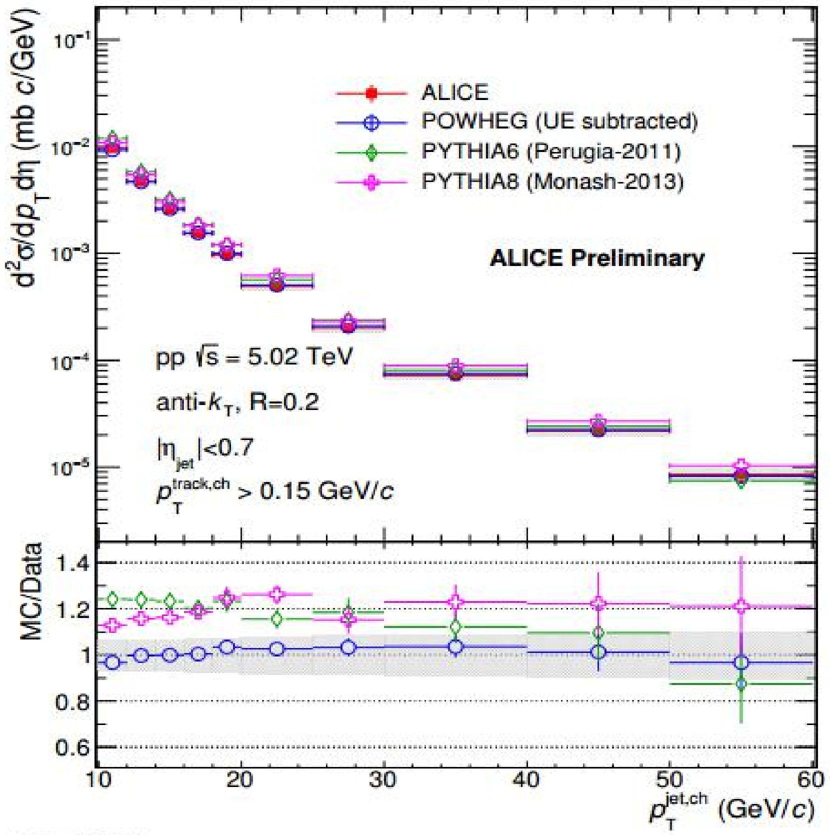
✓ pp Jet cross section (reference for R_{AA})

pp reference run ($\sqrt{S_{NN}} = 5.02\ TeV$)

POWHEG simulation

✓ Pb-Pb Jet cross section

4 centrality bins (0-10%, 10-30%, 40-50%, 50-90%)



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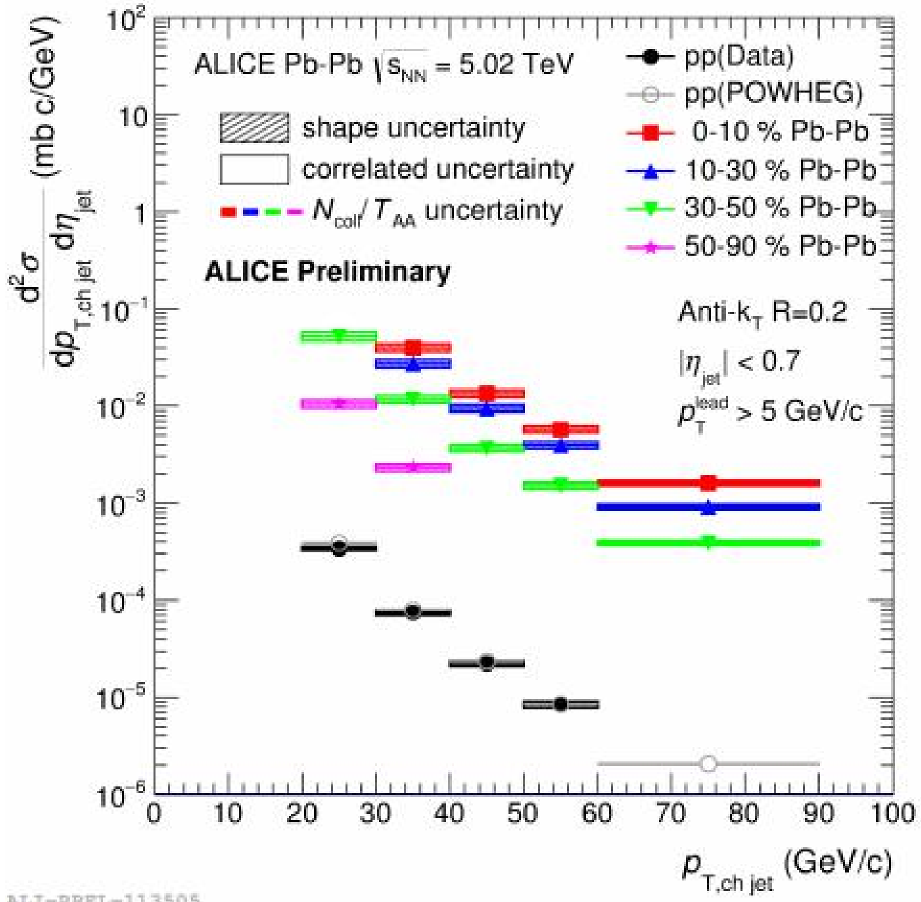

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Nuclear Modification Factor : R_{AA}

✓ R_{AA} in each centrality bin

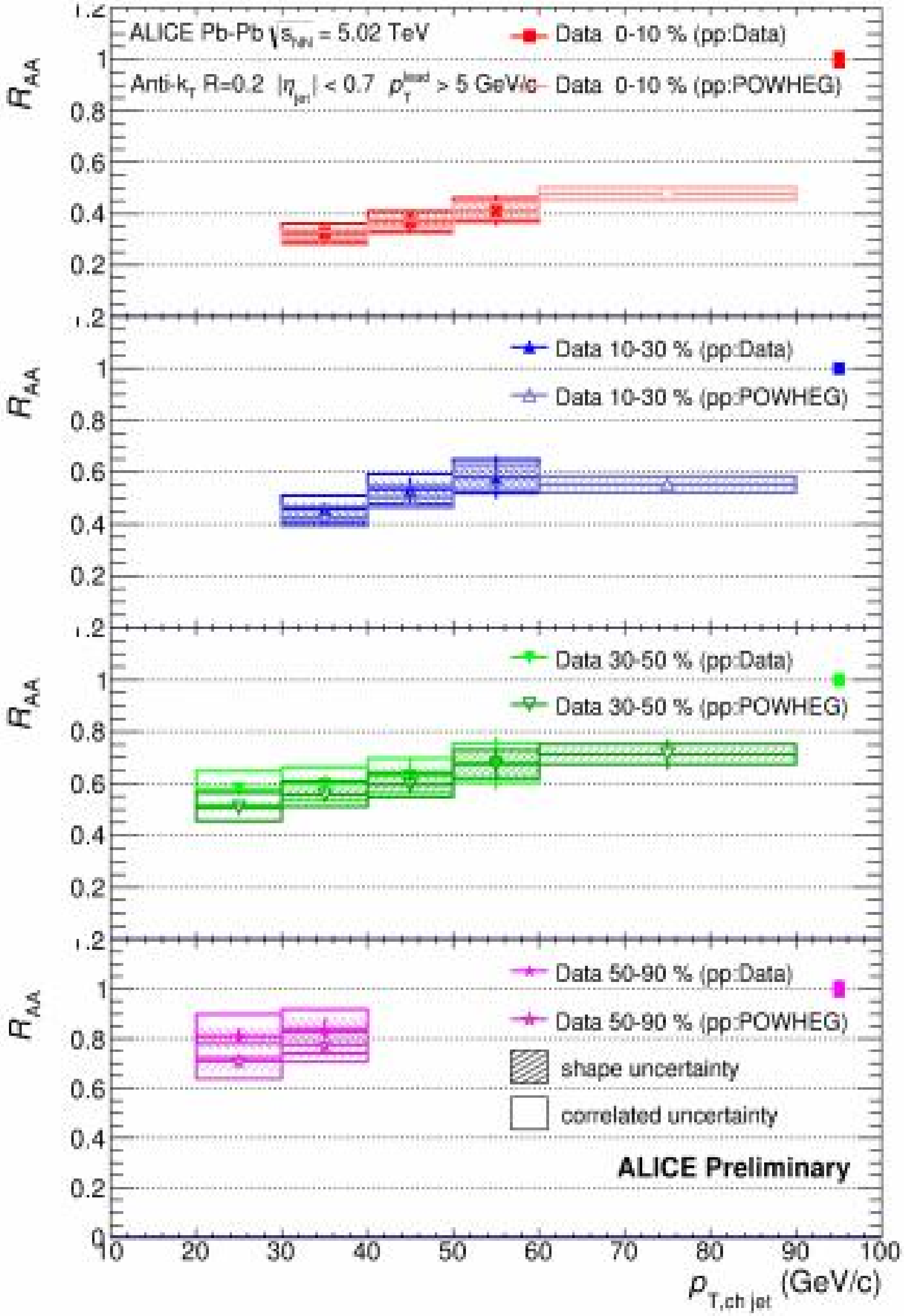
Increased suppression from peripheral ~0.8 to central ~0.4

✓ Difference of pp reference

pp data / POWHEG simulation

Consistent within uncertainties

$$R_{AA} = \frac{\frac{1}{\langle T_{AA} \rangle} \frac{1}{N_{evt}} \frac{dN_{ch\ jet}}{dp_T d\eta}}{\frac{d\sigma_{pp}}{dp_T d\eta}}$$



Summary

- ✓ First measurement of jet R_{AA} at $\sqrt{S_{NN}} = 5.02 TeV$

  Charged jet, R=0.2, $p_T^{lead} > 5 Gev/c$

  pp cross section , σ (R=0.2) / σ (R=0.4)

  well described by POWHEG NLO simulation

  Evaluation of Underlying Event density / fluctuation

  large fluctuating underlying event in most central collisions

  Nuclear Modification Factor : R_{AA}

  strong suppression in most central collisions

  Effect of flattening of the spectrum compensated by stronger jet suppression