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 collisions 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 (≈ $10^{-23}$ 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

- Nuclear modification factor: \( R_{AA} \)
  - if \( R_{AA} = 1 \), No modification
  - \( R_{AA} > 1 \), enhancement
  - \( R_{AA} < 1 \), suppression

- High-pT hadrons strong suppression: \( R_{AA} \approx 0.2 \)
  - proxy for jet (parton): \( p_T > 10\text{GeV}/c \)
  - fragmentation of quenched partons

- Jets
  - Strong suppression: \( R_{AA} \approx 0.4 \)
  - Jet shape broadens?
  - where is the lost energy?
ALICE Jet Quenching Measurements in Pb-Pb

✔ Nuclear modification factor: $R_{AA}$
  if $R_{AA} = 1$, No modification

✔ High-pT hadrons strong suppression: $\sim 0.2$
  proxy for jet (parton):
  fragmentation of quenched partons

✔ $\sim 0.4$
  Jet shape broadens?
  where is the lost energy?

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
Jet Measurement in LHC-ALICE

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

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

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

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

- Dataset
  $\sqrt{s} = 5.02$ TeV, pp and Pb-Pb collisions
- MB triggered events
- Charged track selection
  $|\eta| < 0.9, \quad p_T^{\text{track}} \geq 0.15\text{GeV}/c$
- Jet reconstruction
  Anti-kt jet reconstruction algorithm
  $R = 0.2, 0.4$
  $|\eta| < 0.7, \quad p_T^{\text{lead}} > 5\text{GeV}/c$
- 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 reliable for correcting the jet spectrum
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: \( \rho \)

Median \( k_T \) excluding the highest two clusters

\[
\rho = \text{medina} \left\{ \frac{p_{T,i}}{A_i} \right\}
\]

Background subtraction

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

\[
p_{T,\text{jet}}^{\text{rec}} = p_{T,\text{jet}}^{\text{raw}} - \rho \cdot A_{\text{jet}}^{\text{rec}}
\]

Minimum leading constituent \( p_T > 5 \text{GeV}/c \) requirement suppresses combinatorial jets in low momentum
Underlying Event Fluctuation

**UE fluctuation : \( \delta p_T \)**

\( \delta p_T \) is used as a measurement for background fluctuations

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

**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 \( \eta - \phi \) randomised tracks
   to exclude flow effect

**\( \delta p_T \) 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

- pp Jet cross section (reference for $R_{AA}$)
  - pp reference run ($\sqrt{s_{NN}} = 5.02 \text{ TeV}$)
  - POWHEG simulation

- Pb-Pb Jet cross section
  - 4 centrality bins (0-10%, 10-30%, 40-50%, 50-90%)
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

\[
R_{AA} = \frac{\frac{1}{(T_{AA})} \frac{1}{N_{evt}} \frac{dN_{ch \, jet}}{dp_{T} d\eta}}{\frac{d\sigma_{pp}}{dp_{T} d\eta}}
\]
Summary

- First measurement of jet $R_{AA}$ at $\sqrt{S_{NN}} = 5.02 TeV$
  - Charged jet, $R=0.2$, $p_T^{\text{lead}} > 5 GeV/c$
  - pp cross section, $\sigma (R=0.2) / \sigma (R=0.4)$ 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