System and event activity dependent
inclusive jet production with ALICE

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Why the study of jets at the LHC?

- Jet cross section provides constraints to pQCD calculations
- Investigate the splitting function of parton in vacuum: close to original collimation information.
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- Jet cross section provides constraints to pQCD calculations
- Investigate the splitting function of parton in vacuum: close to original collimation information.
- Study jet quenching effect in nucleus-nucleus collision.

\[ R_{\text{CP}} \]

\begin{tabular}{c|c}
Ch. particles & Jets \\
\hline
| ALICE & ALICE Ch. Jets $R=0.3$ \\
| (0-10%)/(50-80%) & (0-10%)/(50-80%) \\
| CMS & ATLAS Calo Jets $R=0.3$ \\
| (0-5%)/(50-90%) & (0-10%)/(60-80%) \\
\end{tabular}

\[ R \]

\[ p_T^{\text{track}}, p_T^{\text{jet}} (\text{GeV} / c) \]

\[ \text{Pb-Pb} \ \backslash s_{\text{NN}}=2.76 \text{ TeV} \]

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Small $R$  

Larger $R$
Why the study of jets at the LHC?

- Charged particle density increases with $\sqrt{s}$ for different collision systems.
- High particle multiplicity pp events can have similar particle multiplicity as in pA/AA collisions.
- What happens for jet production in high particle multiplicity environment: quenching? enhancement?

\(\text{pp: Minimum bias} \quad \text{pp: high particle multiplicity} \quad \text{Pb-Pb}\)

\[\langle dN_{\text{ch}}/d\eta\rangle^{2}\]

\[
\begin{align*}
\text{pp(\text{pp}), NSD} & \quad \text{pA(dA), NSD} \\
\text{ALICE} & \quad \text{ALICE} \\
\text{CMS} & \quad \text{CMS} \\
\text{UA5} & \quad \text{UA5} \\
\text{UA1} & \quad \text{UA1} \\
\text{STAR} & \quad \text{STAR} \\
\text{ALICE Xe-Xe} & \quad \text{ALICE Pb-Pb} \\
\text{CMS} & \quad \text{CMS} \\
\text{ATLAS} & \quad \text{ATLAS} \\
\text{PHENIX} & \quad \text{PHENIX} \\
\text{PHOBOS} & \quad \text{PHOBOS} \\
\text{BRAHMS} & \quad \text{BRAHMS} \\
\text{STAR} & \quad \text{STAR} \\
\text{NA50} & \quad \text{NA50} \\
\end{align*}
\]

\[1 < l|\eta| < 0.5 \quad \sqrt{s_{NN}} (\text{GeV}) \]

arXiv:1805.04432v2
Jet measurements in ALICE

- Event selection and multiplicity categorization: SPD, V0
- Track and jet reconstruction: ITS, TPC, EMCal

**V0**

\[-3.7 < \eta < -1.7\]
\[2.8 < \eta < 5.1\]

**EM calorimeter**

\[|\eta| < 0.7, \ 80^\circ < \varphi < 187^\circ\]

Remove charged particle contributions

**Neutral constituents**

\[E_{\text{cluster}} > 0.3 \text{ GeV}\]

**Charged constituents**

\[p_T^{\text{track}} > 0.15 \text{ GeV/c}\]

**full jet**

**Charged jet**

**ITS (Inner Tracking System)**

\[|\eta| < 0.9, \ 0 < \varphi < 2\pi\]

**TPC (Time Projection Chamber)**

\[|\eta| < 0.9, \ 0 < \varphi < 2\pi\]
Measurement of charged jets in pp and Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02$ TeV
• Charged jets are reconstructed using different resolution parameters and down to very low $p_T$ ($p_{T,\text{jet}} > 5 \text{ GeV/c}$)

• Jet cross section is well described by POWHEG+PYTHIA8 predictions (NLO pQCD+parton shower+hadronization) within systematic uncertainties
• Charged jet spectra in different centrality intervals are measured in Pb-Pb collisions with different cone radii
• Centrality ordered jet production found in Pb-Pb collisions after $T_{AA}$ scaling
Jet nuclear modification factor $R_{AA}$

- Strong suppression is observed in central Pb-Pb collisions
- Less suppression for peripheral events
- $R_{AA}$ of different radius jets agree with each other within uncertainties

\[ R_{AA} = \frac{dN_{jets}^{AA}/dp_T d\eta}{<T_{AA}^{}> d\sigma_{jets}^{pp}/dp_T d\eta} \]
Jet $R_{AA}$ comparison

- Full jets and charged jets $R_{AA}$ are consistent
- $R_{AA}$ in different collision energies are similar
  - Compensating effect of flattening of the spectrum and stronger jet suppression in higher collision energy

\[
R_{AA} = \frac{dN_{jets}^{AA}/dp_T d\eta}{<T_{AA}> d\sigma_{jets}^{pp}/dp_T d\eta}
\]
Charged jets measurements in pp collisions at

$$\sqrt{s} = 13 \text{ TeV}$$
Charged jet cross section in pp collisions

- Charged jet cross sections measured for $R=0.2$ and $R=0.4$
- Cross sections are compared with different MC calculations, POWHEG + PYTHIA8 (NLO pQCD+parton shower+hadronization) agrees with data
Multiplicity dependent jet production

- Charged jet cross sections in different multiplicity bins for $R = 0.2$ and $R = 0.4$ in pp collisions
- More jets are produced in high multiplicity events compared to low multiplicity bins
Ratio of charged jet cross sections in different multiplicity intervals with respect to Min. bias one in pp collision
Cross section ratio has weak $p_T$ and resolution parameter $R$ dependence in different multiplicity bins
Jet cross section ratio: $R = 0.2/R = (0.4 \text{ or } 0.6)$

- Jet cross section ratio measurements reflect jet collimation information.
- Different jet cross section ratio is slightly increasing with jet $p_T$, and consistent with Monte Carlo simulation.
- Similar jet cross section ratios for different $\sqrt{s}$ and collision mode.

arXiv:1905.02536
• Jet cross section ratio between $R=0.2$ and $R=0.4$ in different multiplicity intervals

• No strong multiplicity dependence in ratio of the jet spectra
Cross section ratio from data and simulation

- Jet cross section ratio from data shows no centrality dependence while simulation indicates centrality ordering
  - Inclusive jet cross section can be reproduced by POWHEG calculation but not the centrality dependent cross section ratio in pp collisions

  Multiplicity differences or UE subtraction effect?
Summary and outlook

• **Charged jet production** studied in pp and Pb-Pb collisions

• **Inclusive** jet cross sections in pp collisions can be reproduced by **POWHEG+PYTHIA8**

• **Nuclear modification factor** \( R_{AA} \) has been measured
  • Centrality dependent jet suppression is observed in Pb-Pb collisions
  • Full jets and charged jets \( R_{AA} \) are consistent

• **Multiplicity dependent jet cross section** is studied
  • Higher(lower) jet yield in high(low) multiplicity events compared to inclusive one
  • Jet production ratios have no significant jet \( p_T \) and resolution parameter dependence

• **Jet cross section ratio between** \( R = 0.2/R = 0.4 \) (or 0.6) have been measured
  • No strong dependence for different collision systems or collision energies
  • Weak dependence on multiplicities from data, while multiplicity ordering in simulation

Thanks for your attention!
Backup
Multiplicity estimator in pp collisions

- Selecting different multiplicity events using forward detector (V0) to avoid auto correlations between event activities and jet measurements

Event activity categorization (V0M): V0A+V0C

Jet measurements: ITS+TPC

- Multiplicity percentile is determined using V0M amplitude distribution