What does PYTHIA tell us about jets surrounded by extremely high underlying event ?

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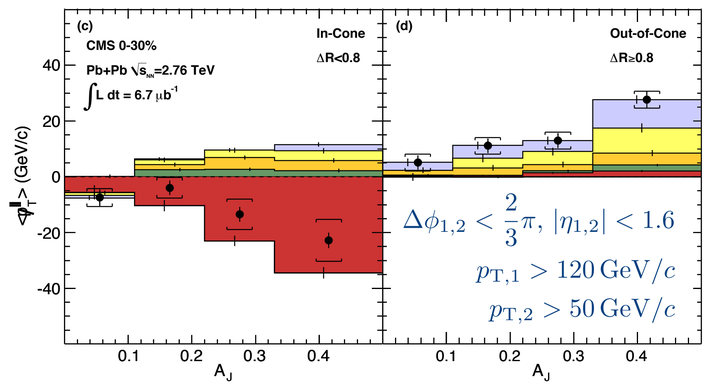
Motivation

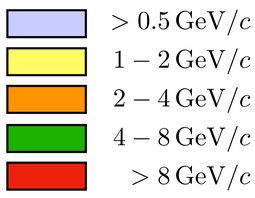
- In central heavy-ion collisions an imbalance in dijet transverse momentum (A_j) is observed, consistent with jet quenching
- Correlations of charged-particle tracks ($|\eta| < 2.4, p_{\mathrm{T}} > 0.5\,\mathrm{GeV}/c$) with jets indicate that the momentum imbalance is accompanied by a softening of the fragmentation. In-cone excess of high-p_{T} tracks is balanced by out-of-cone low-p_{T} tracks [1]



$$p_{\mathrm{T}}^{||} = \sum_i -p_{\mathrm{T}}^i cos(\phi_i - \phi_{\mathrm{LeadingJet}})$$

$$A_J = \frac{p_{\mathrm{T},1} - p_{\mathrm{T},2}}{p_{\mathrm{T},1} + p_{\mathrm{T},2}}$$

$$\Delta R = \sqrt{(\phi^{\mathrm{jet}} - \phi^{\mathrm{track}})^2 + (\eta^{\mathrm{jet}} - \eta^{\mathrm{track}})^2}$$

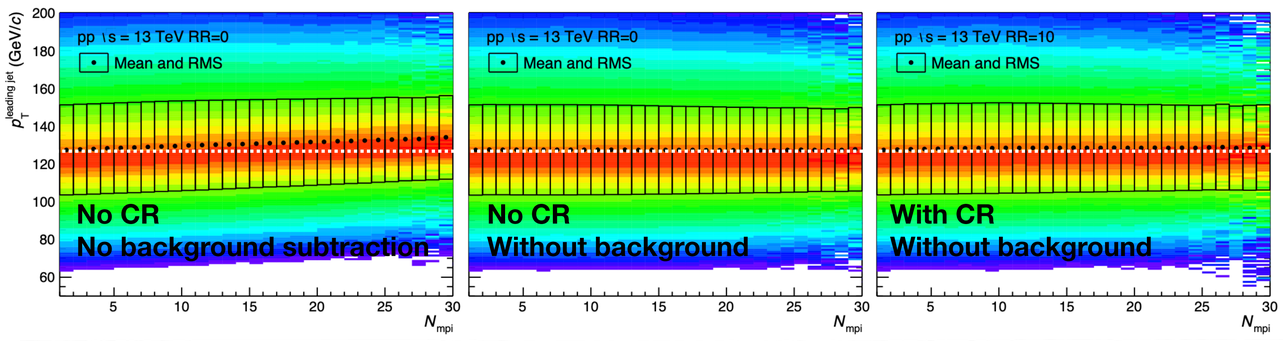


For small systems, the study of out-of-cone particle production could be interesting. This work: using PYTHIA 8.240 [2], jet-hadron correlations in pp collisions with large underlying event (UE), i.e. Multiple-Partonic Interactions (MPI), are studied

Jet-hadron correlations in PYTHIA

How the interaction of the leading jet ("a la Color Reconnection, CR") with surrounding partons could modify its transverse momentum ($p_{\mathrm{T}}^{\mathrm{leading\ jet}}$)?

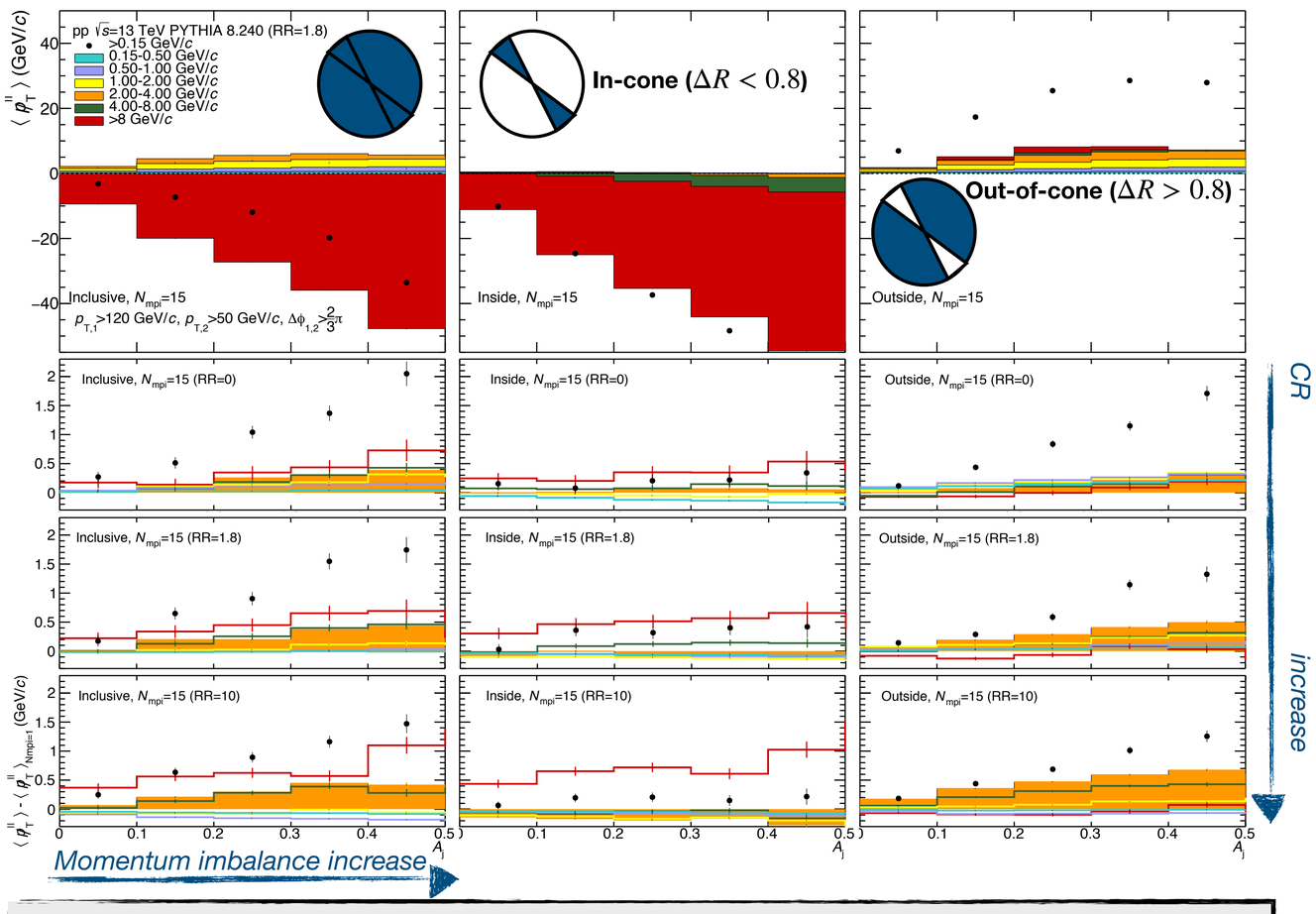
- pp collisions at 13 TeV were simulated with Pythia (Monash tune)
- Jets were reconstructed using the anti-k_{T} algorithm (R=0.5) implemented in FastJet. Background is estimated, on an event-by-event basis, using the median of the distribution $p_{\mathrm{T}}/\mathrm{A}$. The figures below show results for $\hat{p}_{\mathrm{T}} = 125\,\mathrm{GeV}/c$



After background subtraction, $p_{\mathrm{T}}^{\mathrm{leading\ jet}}$ vs Number of MPIs (N_{mpi}) is flat without CR. Contrarily, with CR $p_{\mathrm{T}}^{\mathrm{leading\ jet}}$ increases with increasing N_{mpi}

Same effect is observed w/o Initial-State and Final-State Radiation (ISR and FSR)

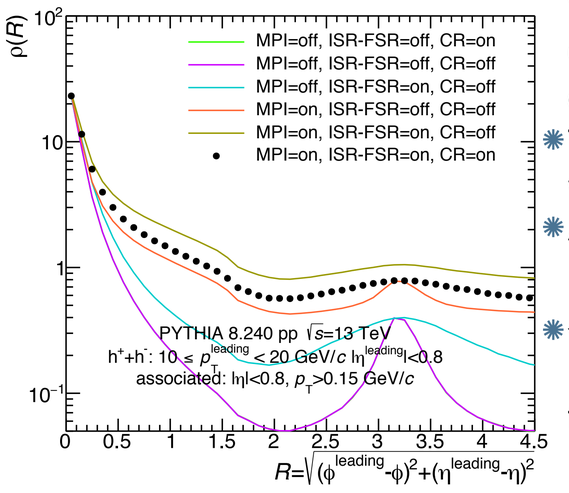
Momentum balance in dijet events within a high UE environment: albeit for pp, we understand the origin of the dijet asymmetry, it is still interesting to explore its behavior at high N_{mpi}. Strategy: (a) the missing p_{T} of charged particles is projected onto the leading jet axis. (b) The particle production both in-cone and out-of-cone regions in events with N_{mpi}=15 and N_{mpi}=1 is studied. (c) Reconnection Range (RR) is varied



Inclusive case: Compared with pure dijet systems (N_{mpi}=1), momentum imbalance at high A_j is reduced with increasing RR (30%)

- In-cone: The momentum excess is observed in the leading jet direction, it is nearly N_{mpi} and RR independent. The excess is carried by high p_{T} (>8 GeV/c) particles, which contribution increases with increasing RR
- The in-cone momentum excess gets more balanced by intermediate-p_{T} out-of-cone particles (2-4 GeV/c) when RR increases

Do we see something similar using leading particles?

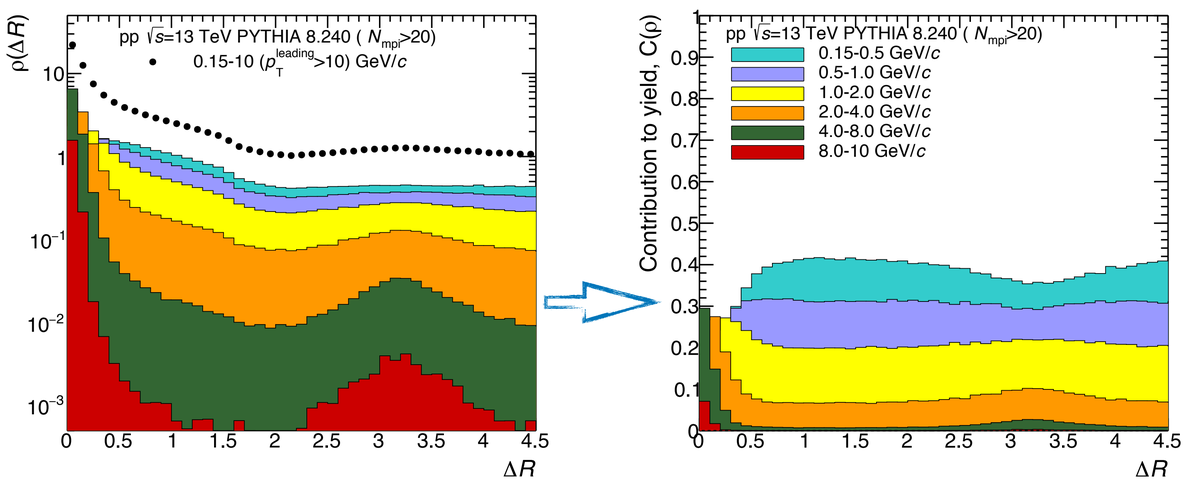


YES: To answer the question, leading-hadron correlations are studied in inelastic pp collisions at $\sqrt{s} = 13\,\mathrm{TeV}$

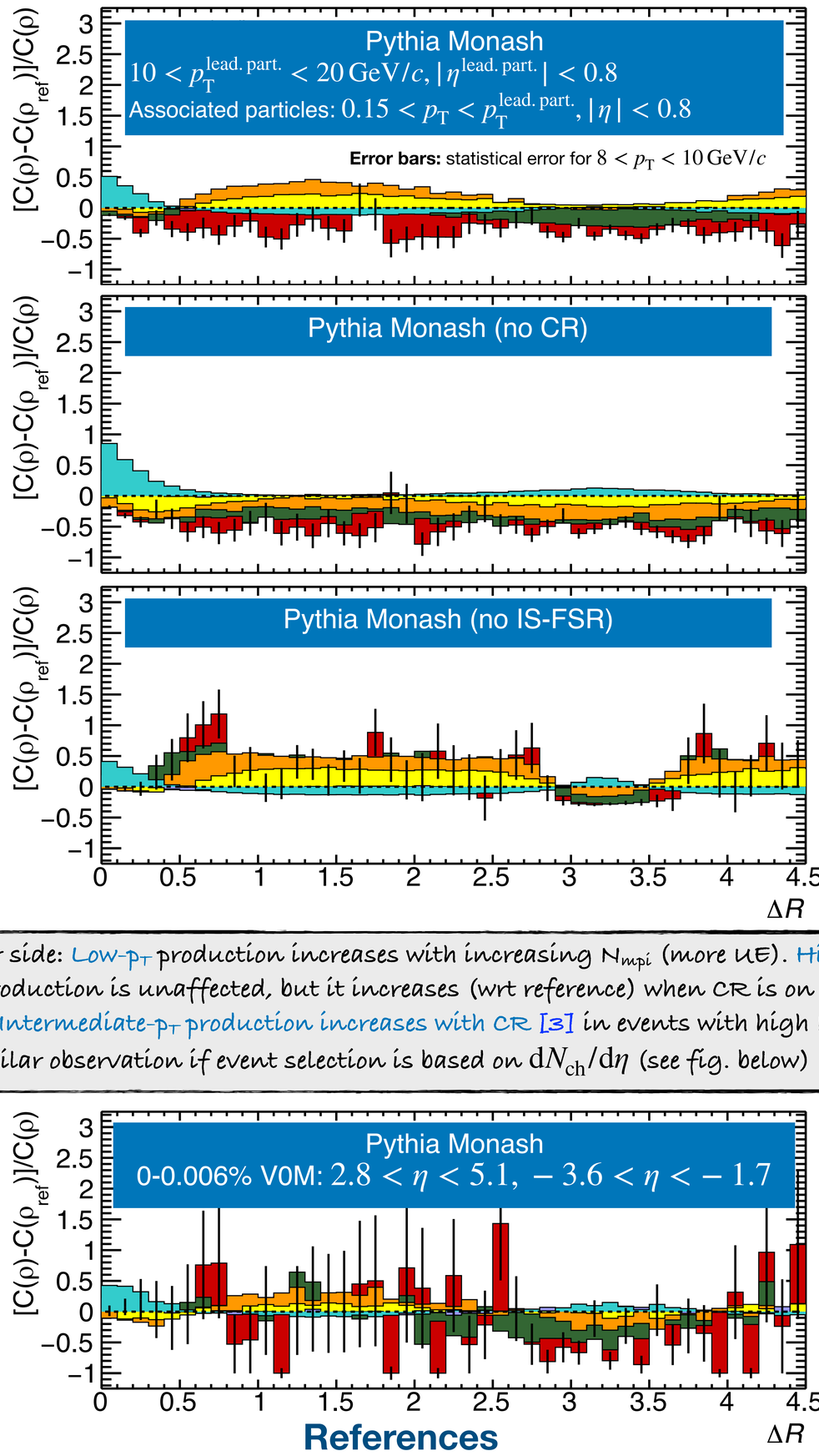
- The leading charged particle is determined within $|\eta| < 0.8$ and $10 < p_{\mathrm{T}} < 20\,\mathrm{GeV}/c$
- Associated particles are selected within $|\eta| < 0.8$ and $0.15 < p_{\mathrm{T}} < 10\,\mathrm{GeV}/c$
- Yields $\left(\rho = \frac{N_{\mathrm{ch}}}{\Delta\eta\Delta\phi}\right)$ are studied as a function of ΔR

Good isolation of the leading jet peak

- The contributions ($C(\Delta R)$) of low- and high-p_{T} particles to $\rho(\Delta R)$ are quantified



- $C(\Delta R)$ of reference data (no explicit selection on event activity) is subtracted from that of N_{mpi}-enhanced sample (N_{mpi}>20)



Near side: Low-p_{T} production increases with increasing N_{mpi} (more UE). High-p_{T} production is unaffected, but it increases (wrt reference) when CR is on

UE: Intermediate-p_{T} production increases with CR [3] in events with high N_{mpi}

Similar observation if event selection is based on $\mathrm{d}N_{\mathrm{ch}}/\mathrm{d}\eta$ (see fig. below)

References

[1] The CMS Collaboration, Phys. Rev. C84 (2011) 024906
[2] T. Sjöstrand, S. Mrenna and P. Skands, Comput. Phys. Comm. 178 (2008) 852
[3] A. Ortiz and L. Valencia, Phys. Rev. D99 (2019) no.3, 034027
[4] E. Cuautle. A. Ortiz and G. Paic. Nucl.Phvs. A956 (2016) 749-752

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SUMMARY

Missing p_{T} vs A_j ($p_{\mathrm{T}}^{\mathrm{lead.jet}} > 120\,\mathrm{GeV}/c, |\eta^{\mathrm{lead.jet}}| < 1.6$): CR contributes to increase the $p_{\mathrm{T}}^{\mathrm{jet}}$ (more in-cone high-p_{T} particles). Out-of-cone particles (UE) at intermediate p_{T} increases with increasing CR

ρ vs ΔR($|\eta^{\mathrm{lead.part.}}| < 0.8, 10 < p_{\mathrm{T}}^{\mathrm{lead.part.}} < 20\,\mathrm{GeV}/c$): According with PYTHIA, $\langle p_{\mathrm{T}}^{\mathrm{led.\ part.}} \rangle$ increases with $\langle dN_{\mathrm{ch}}/d\eta \rangle$. Therefore, intermediate-p_{T} production (in UE) is higher in high-multiplicity events than in MB. Given the way CR is constructed, the effect should be η-dependent [4]. (What do we expect if we compare pp, p-A and A-A similar $\langle dN_{\mathrm{ch}}/\mathrm{d}\eta \rangle$ and same $\sqrt{s_{\mathrm{NN}}}$?)