Multiplicity-dependent inclusive and heavy-flavor jet structures in pp collisions at LHC energies [1,2]

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Role of multiplicity in pp collisions

Experimental indications: high-multiplicity pp collisions are non-trivial and similar to HI collisions

- Collectivity: flow coefficients are substantial [3]
- Relative enhancement of heavy flavor
  - Attributed to multiple-parton interactions (MPI) [4]

Jets in high-multiplicity pp collisions

- No soft, hot-matter effects such as jet quenching are expected
- QCD mechanisms in semi-hard regime may influence jet development (eg. MPI)
- Strong dependence on the exact mechanism,
  - Modeled by eg. MPI and Color Reconnection (CR)
- **Jet structure may be a sensitive tool to study the semi-hard regime** [5]
- Also provides baseline for analyses in heavy-ion collisions

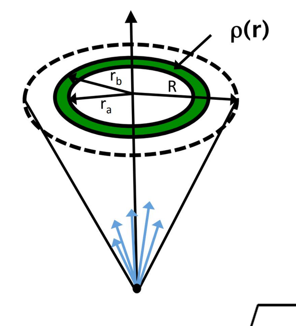
Multiplicity-dependent jet structures

Simulation of jet structure at LHC energies

- Anti-k_T jet finding in PYTHIA 8 [6] simulations
- Monash, Monash*, 4C tunes and several MPI/CR settings
- Multiplicity-integrated CMS data is reproduced well [7]
- Cross-check with HIJING++ [8] with different PDFs

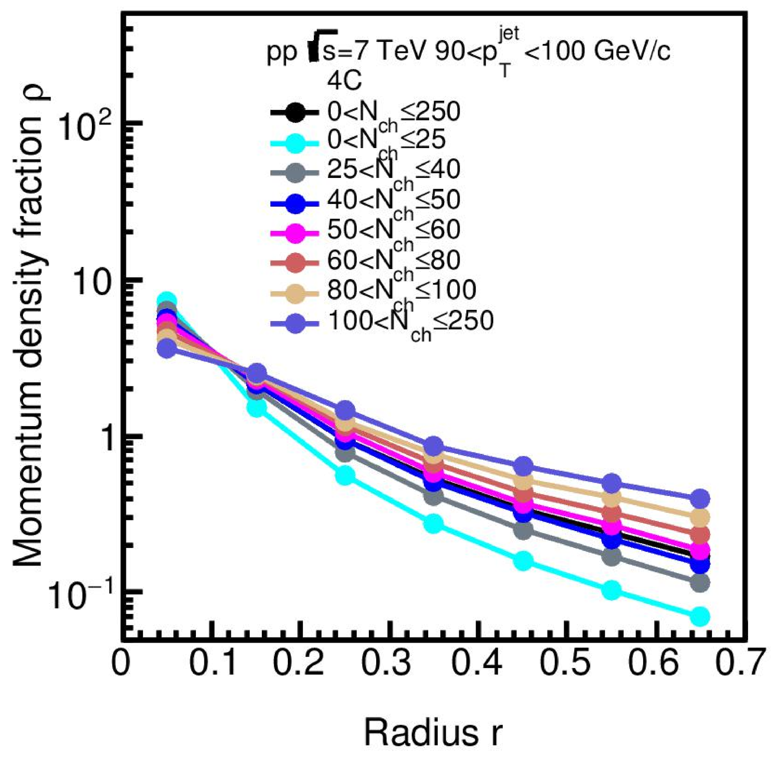
Differential jet structures...

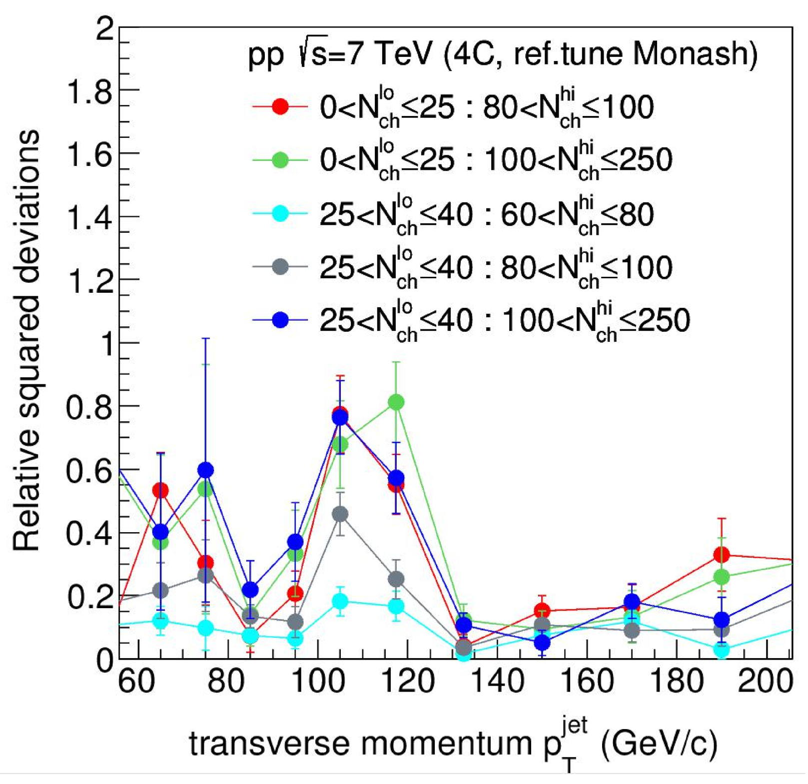
- Several charged-hadron multiplicity (N_{ch}) event classes



$$\rho(r) = \frac{1}{\delta r} \frac{\sum_{r_a < r_i < r_b} p_{T,i}}{\sum_{r_i < R} p_{T,i}}$$

$$r = \sqrt{(\varphi - \varphi_{jet})^2 + (\eta - \eta_{jet})^2}$$





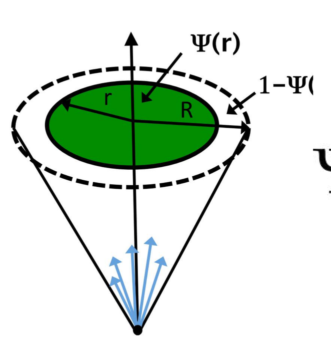
...help tell apart models

$$RSD = \sqrt{\sum_{r_i} \left(1 - \frac{\rho^{low}(r)/\rho^{hi}(r)}{\rho^{low}_{ref}(r)/\rho^{hi}_{ref}(r)}\right)^2}$$

- 4C tune compared to Monash
- Non-trivial structure in p_T
- Persistent through statistically independent N_{ch} classes
- **Great discrimination power for well-established models**

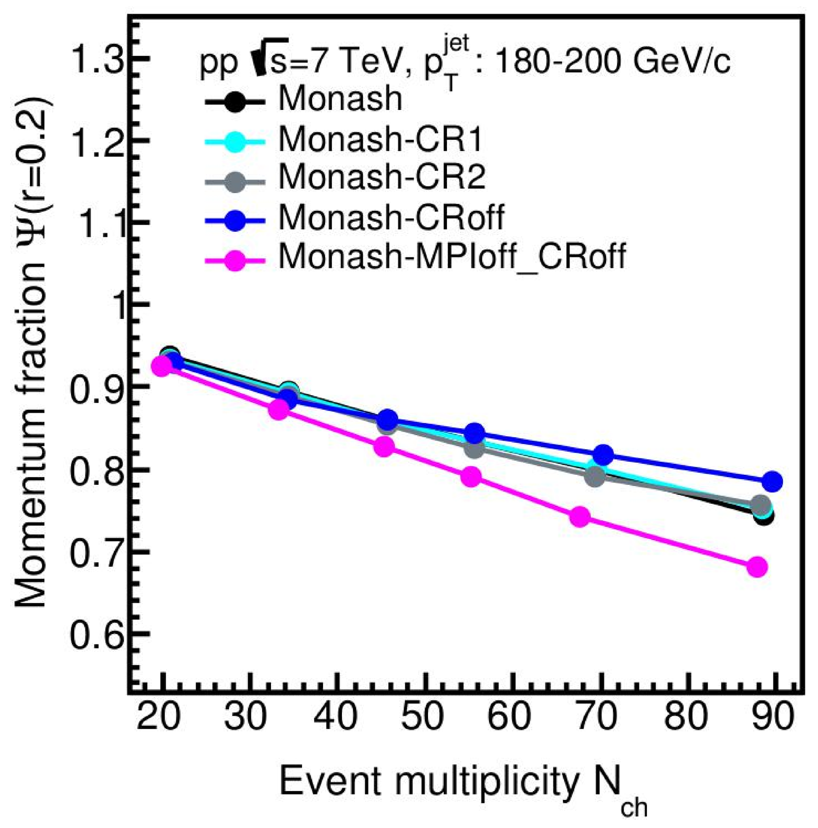
Integral jet structures: clear sign of modification by MPI

- This observable is not sensitive to multiplicity bias [1]
- Multiplicity distributions different when MPI is switched off



$$\Psi(r) = \frac{\sum_{r_i < r} p_{T,i}}{\sum_{r_i < R} p_{T,i}}$$

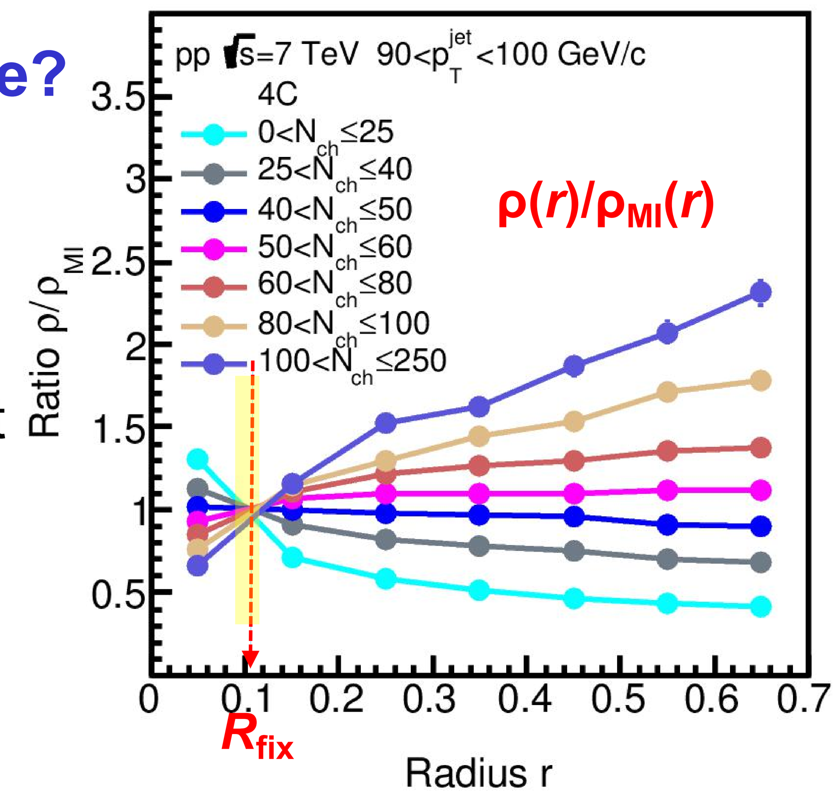
- **A significant difference present in $\psi(N_{ch})$**
- **Clear evidence: MPI influences jet structure at high N_{ch}**

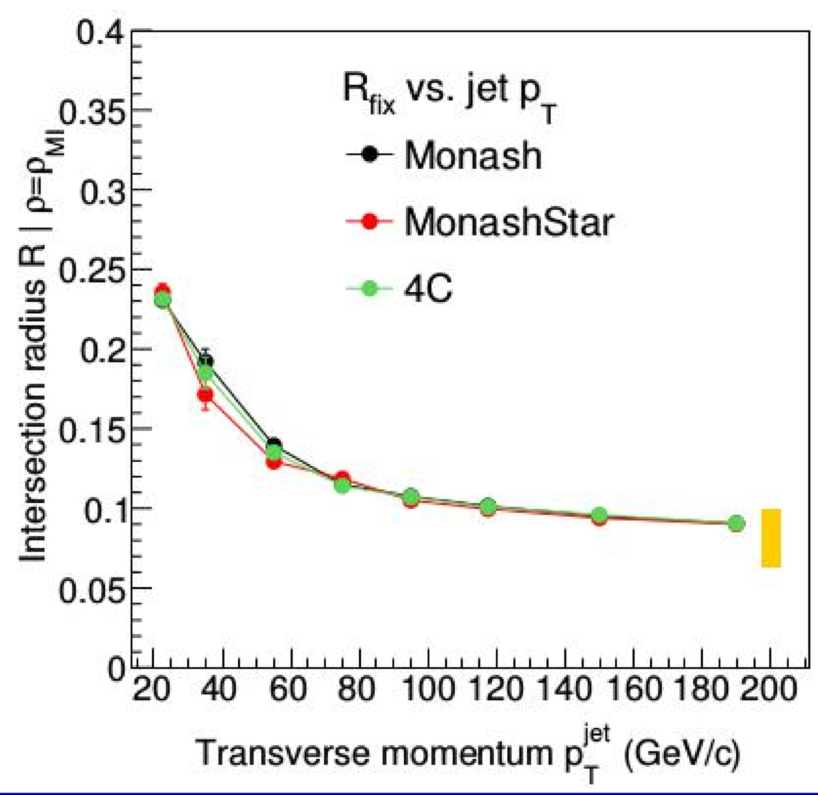


The characteristic size of a jet

Is there a characteristic jet size?

- Jets are generally narrower in low-N_{ch} events: expected bias (jets tend to be more compact in events with less particles)
- However, all ρ(r) curves intersect at a given $r = R_{fix}$



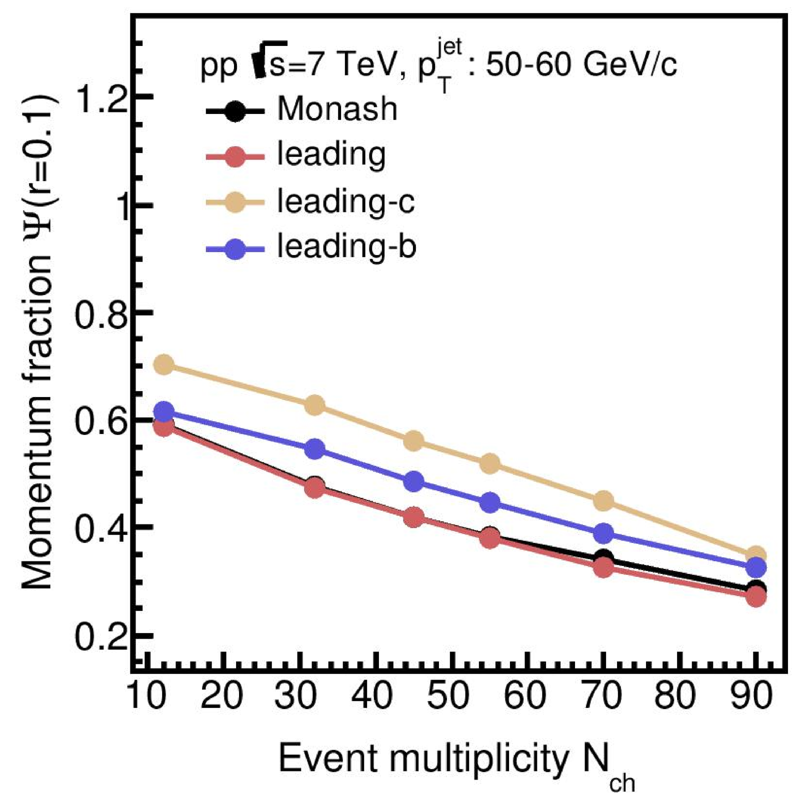


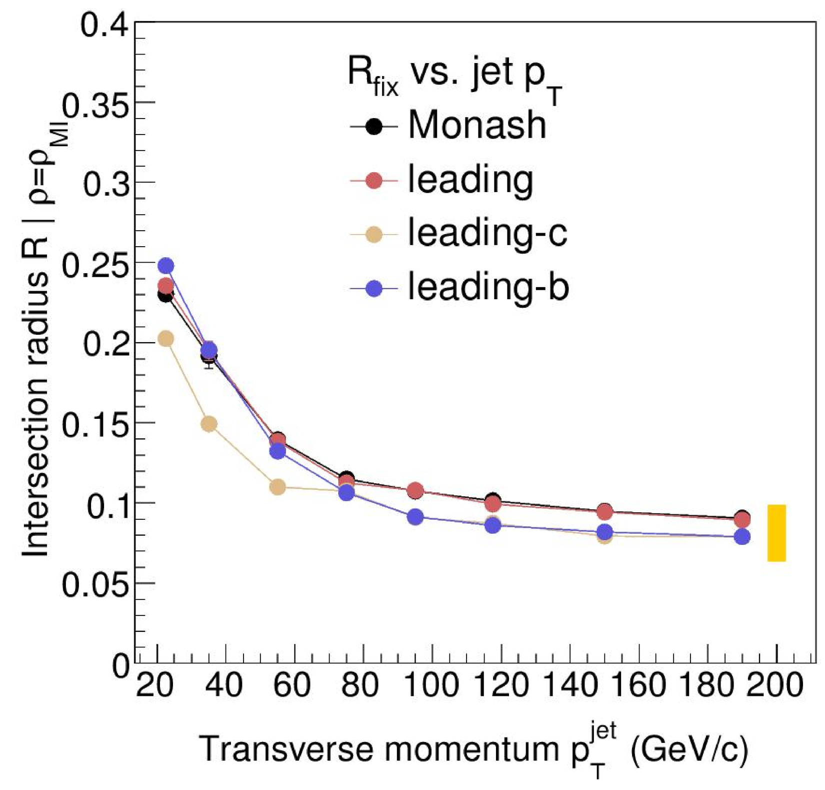
- **We find a well-defined $R_{fix}(p_T)$**
- No significant dependence on...
  - choice of simulation tunes [1,2]
  - simulation parameters [1]
  - PDF settings [2]
  - jet reconstruction algorithms [1]
- $R_{fix}(p_T)$ is qualitatively similar to a Lorentz-boost curve [1]

Heavy flavor: fragmentation sensitivity

HF integral jet structures

- Leading+subleading beauty, charm and inclusive jets
- Clear flavor sensitivity of integral jet structure vs. N_{ch}
- No mass ordering, however
- Charm jets are the narrowest, followed by beauty jets, inclusive jets are the widest





Evolution of heavy-flavor R_{fix}

- Low-p_T
  - Charm differs from inclusive
  - Beauty is similar to inclusive
- High-p_T
  - Charm and beauty jets differ equally from inclusive jets

- **Multiplicity-differential jet structures provide a sensitive probe of flavor-dependent fragmentation**

Conclusion

- We give predictions on multiplicity-differential jet structures in $\sqrt{s}$=7 TeV pp collisions, using PYTHIA8. We show that multiplicity-differential jet-structure studies have strong discriminative power among well-established tunes.
- We demonstrate the influence of Multiple-Parton Interactions (MPI) on jet structure in high-multiplicity events.
- We define a characteristic jet-size measure R_{fix} that is found to be independent of the chosen simulation settings or jet reconstruction method.
- We show that multiplicity-differential jet structures are a sensitive probe of flavor-dependent fragmentation.

[1] arXiv:1805.03101
[2] arXiv:1809.10102

[3] L. Yan, J. Y. Ollitrault, PRL 112, 082301 (2014)
[4] ALICE Collaboration, JHEP 1608, 078 (2016)
[5] CMS Collaboration, EPJ. C73, 2674 (2013)
[6] T. Sjöstrand *et al.*, JHEP 05, 026 (2006)
[7] CMS Collaboration, JHEP 06, 160 (2012)
[8] G. G. Barnaföldi *et al.*, NPPP 289, 373 (2017)

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