Systematic studies of jet structure dependence on color reconnection schemes

Zimányi School'17

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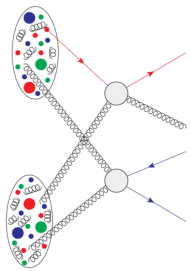
Our motivation

- Setting baseline for heavy ions.

- Recent findings: Heavy ion-like phenomena in high multiplicity p-p collisions (e.g., v_n).
- Phenomena in soft-hard transitions, like multiple parton interactions (MPI) become important at high multiplicity.
- This may cause modification in jet shapes.



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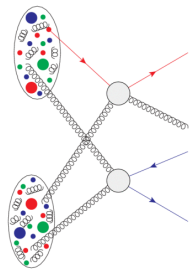
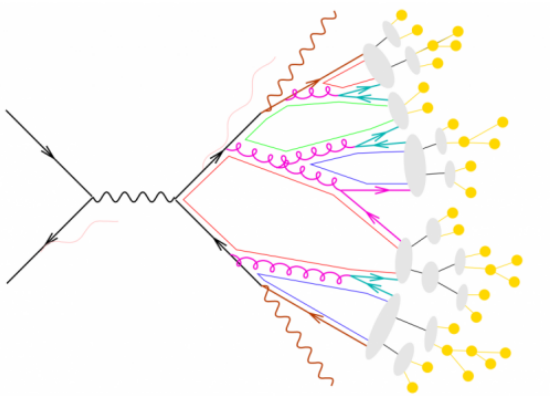
- Setting baseline for heavy ions.

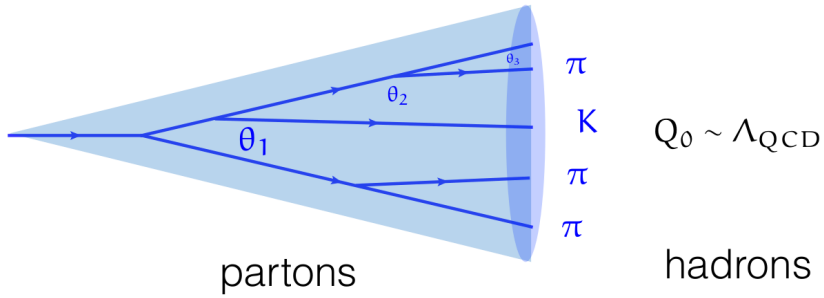
- Recent findings: Heavy ion-like phenomena in high multiplicity p-p collisions (e.g., v_n).
- Phenomena in soft-hard transitions, like multiple parton interactions (MPI) become important at high multiplicity.
- This may cause modification in jet shapes.
- **Is there any non-trivial jet shape dependence on event multiplicity?**



Introduction

- What are jets exactly? Why are they important?
- Monte Carlo event generator: PYTHIA 8.2 with default PDF sets.
- Jet reconstruction: Fastjet software package with anti-k_t algorithm.
- Full jet reconstruction with $R = 0.7$. $(R^2 = \Delta\phi^2 + \Delta\eta^2)$



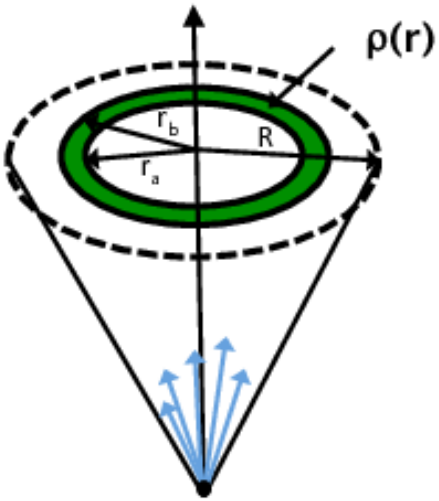


Different tunes and settings

- Tunes: Monash, Monash*, 4C.
- Settings: Multi parton interactions (MPI): on/off.
- Other settings: Colour reconnection (CR) models:
  - 0: MPI-based scheme,
  - 1: QCD-based string length minimisation scheme,
  - 2: gluon-move scheme.
  - off: we don't use it.

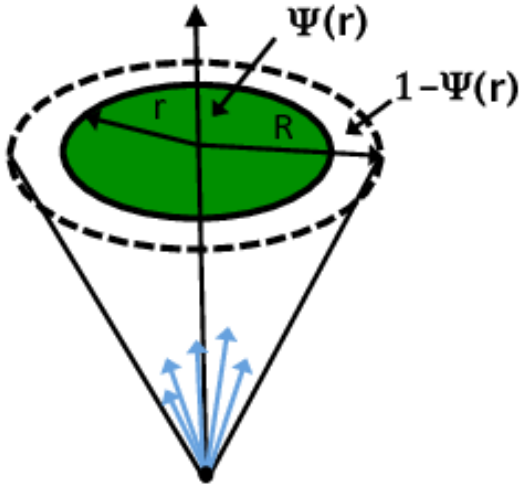
Differential and integral jet shapes

Differential jet shape:



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

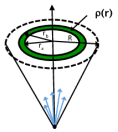
Integral jet shape:

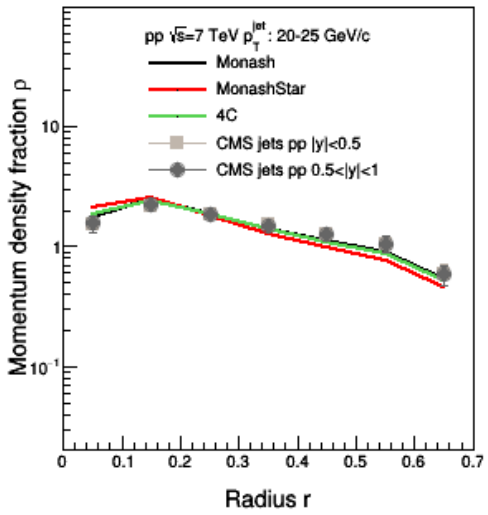


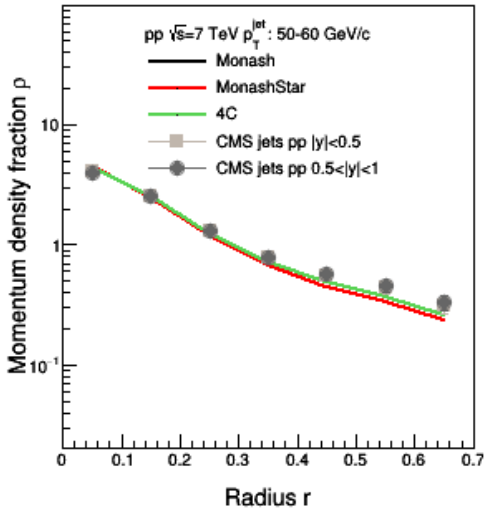
$$\psi(r) = \frac{\sum_{r_i < r} p_{t,i}}{\sum_{r_i < R} p_{t,i}}.$$

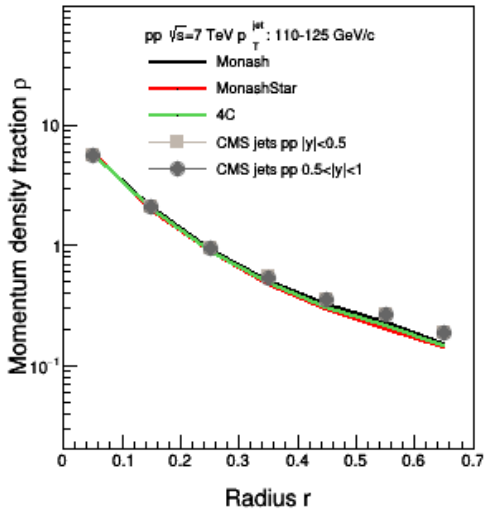
$$\psi(R) = \int_0^R \rho(r')dr' = 1.$$

A reality check: Comparison with CMS for $\rho(r)$



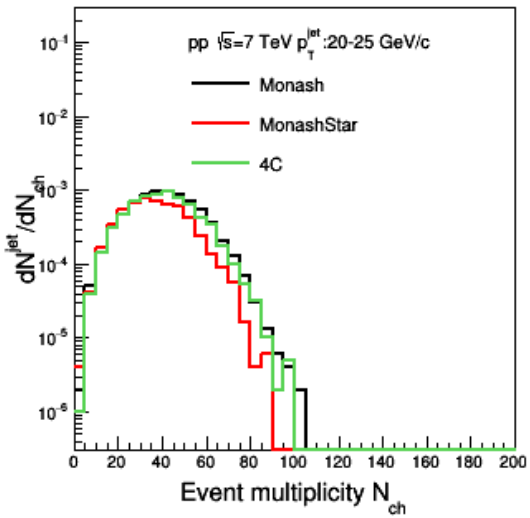


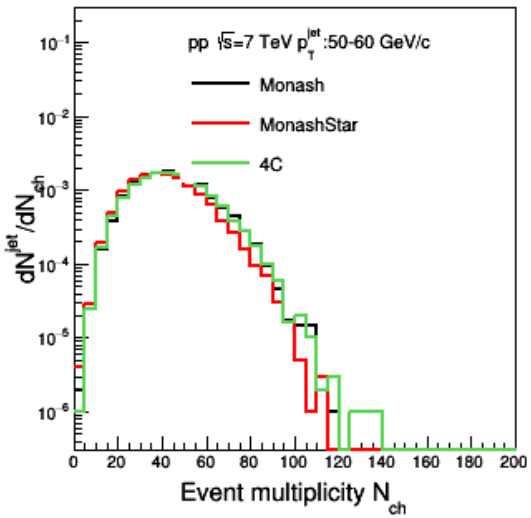


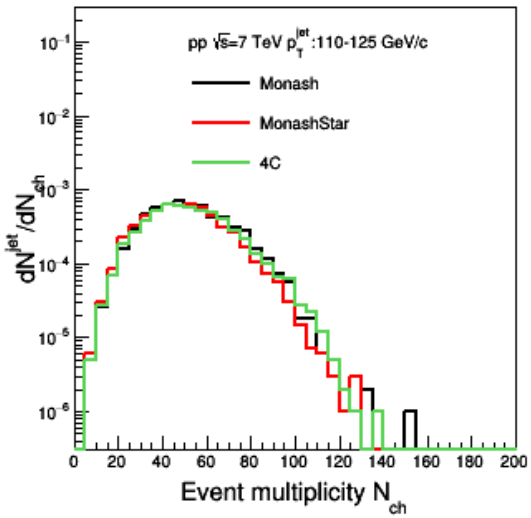


- Different tunes reproduce CMS data within uncertainty.
- We investigated different p_t^{jet} windows between $(20 - 200)$ GeV.

Event Nch multiplicity distribution for the tunes

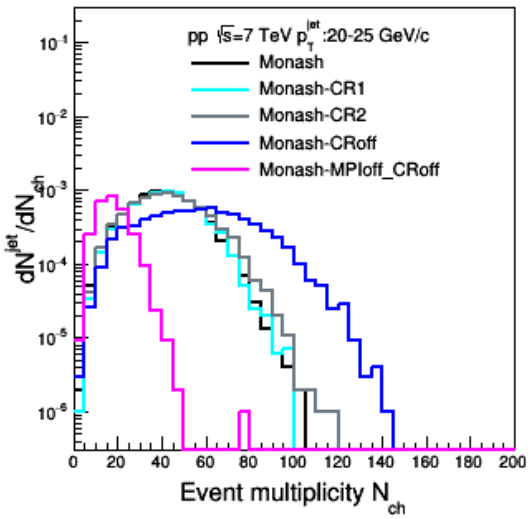


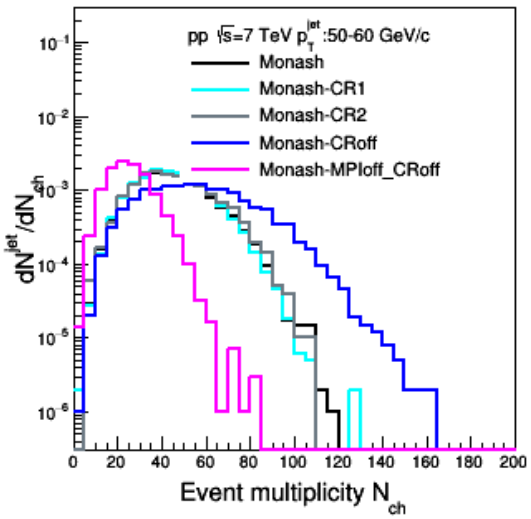


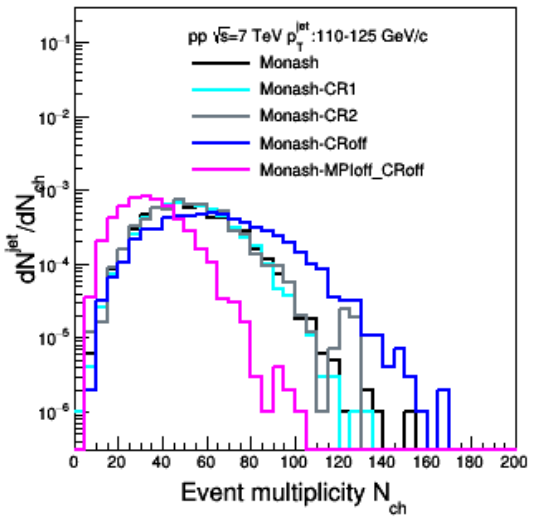


- All tunes show similar event Nch distributions.

Event Nch multiplicity distribution for the settings

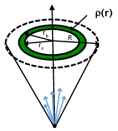


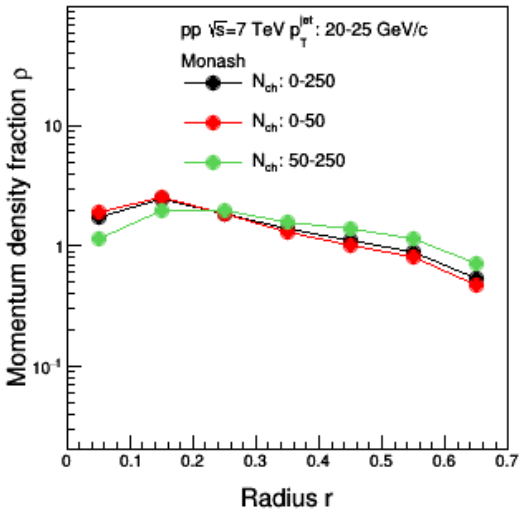


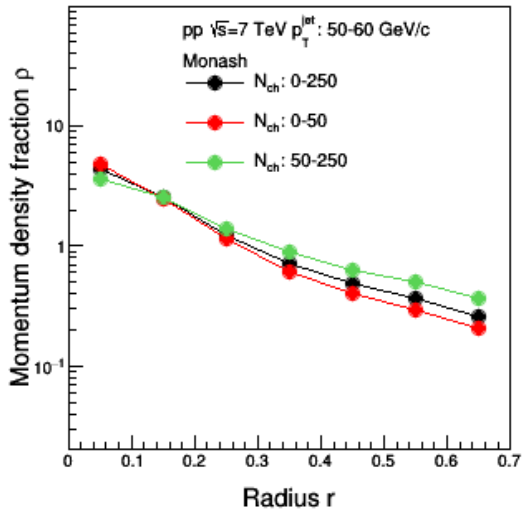


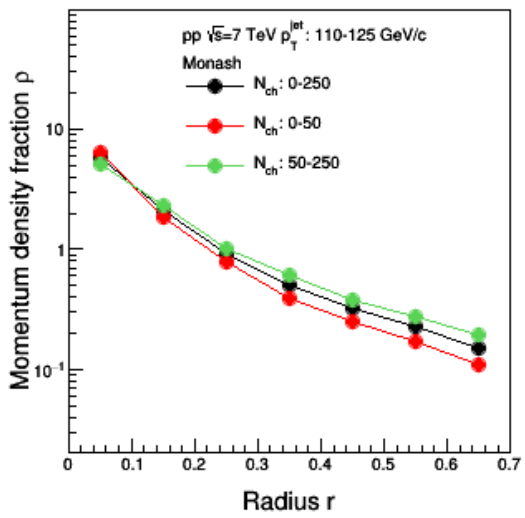
- All tunes show similar event Nch distributions.
- But huge differences between different settings!
- Colour reconnection schemes do not differ much.

$\rho(r)$ distribution for different tunes



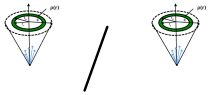






- We see a multiplicity dependence in the jet shapes,
- but it is the trivial multiplicity dependence we expected.

An intersection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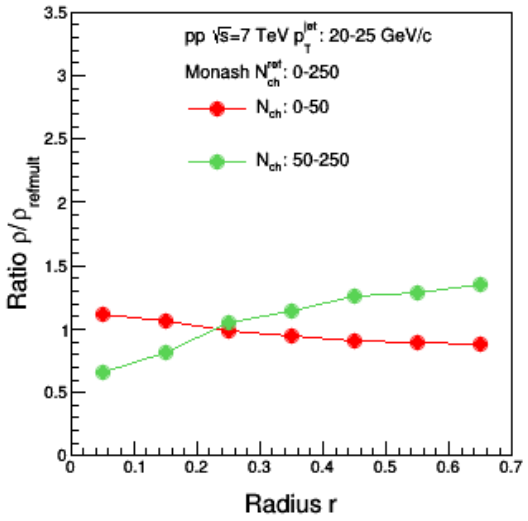
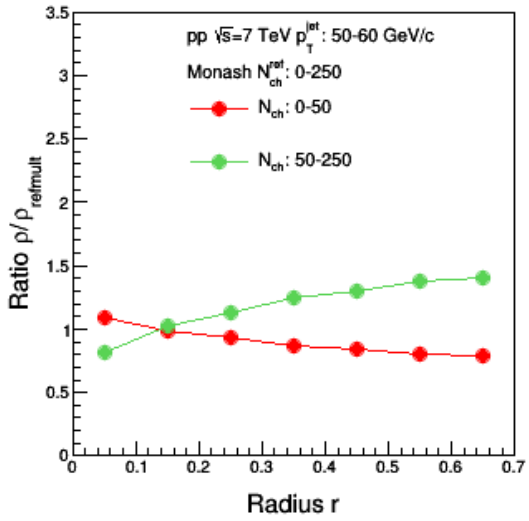
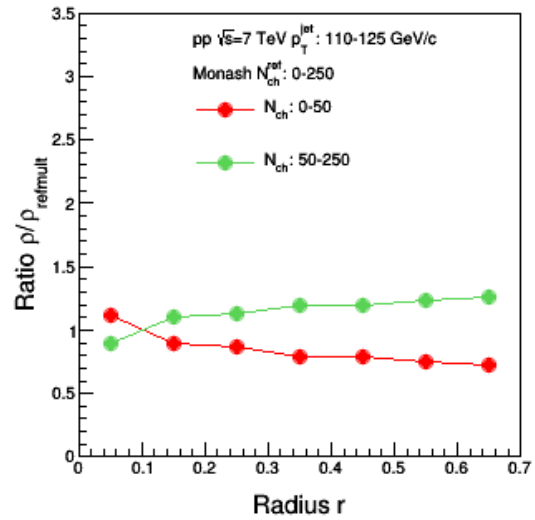
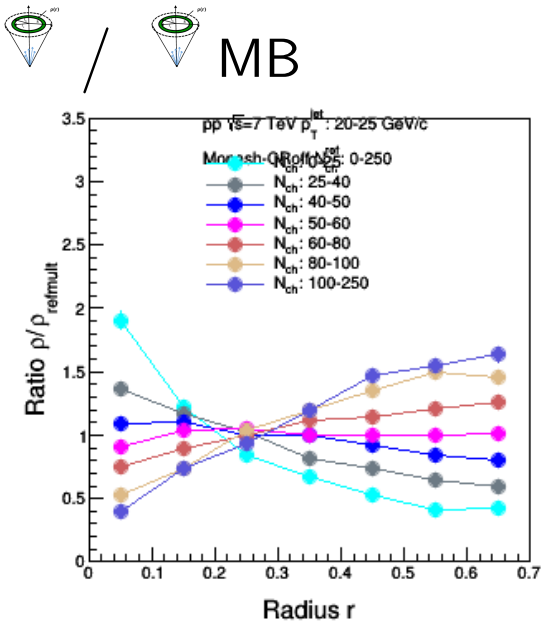


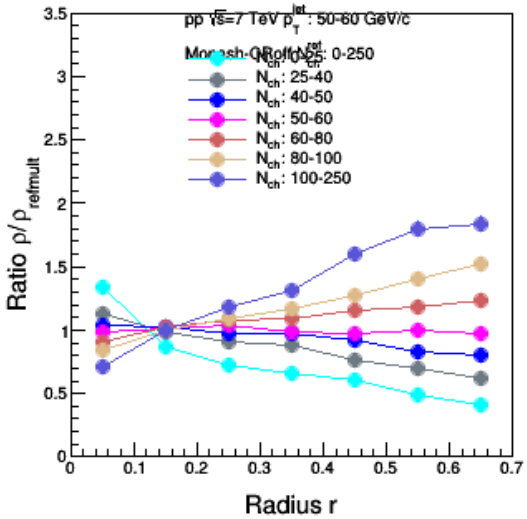


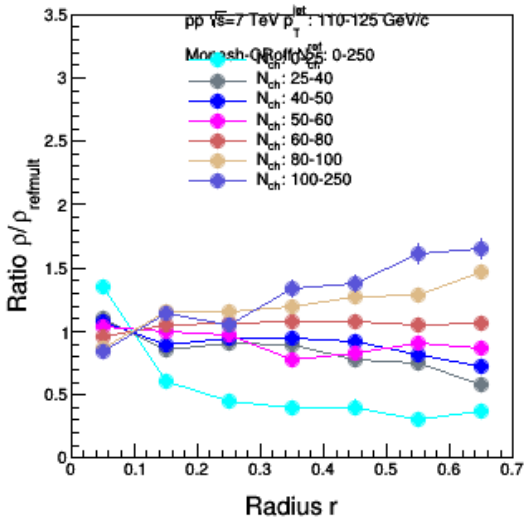


- The two low- and high-multiplicity curves intersect each other at unity.
- The interception point depends on the p_t^{jet}.
- What happens for different multiplicities?

A characteristic jet size measure?

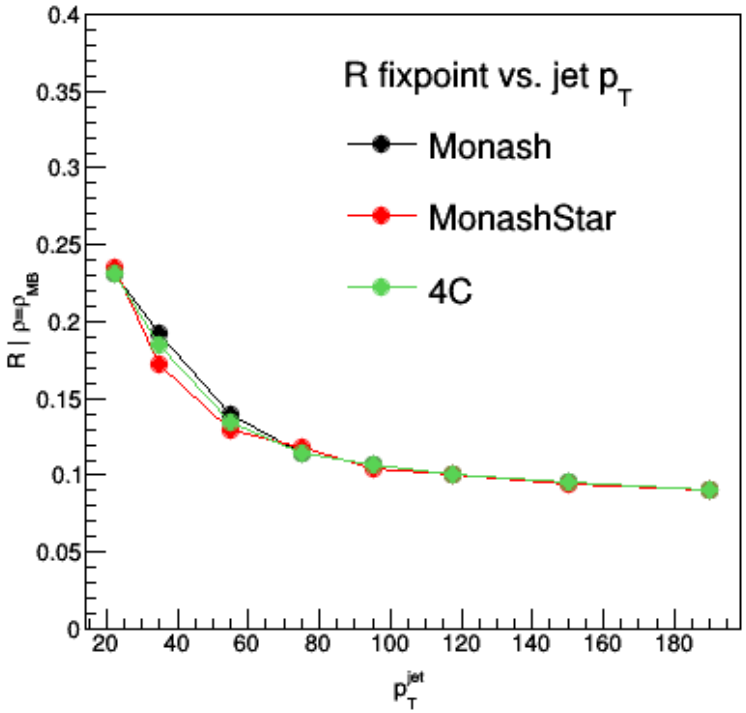


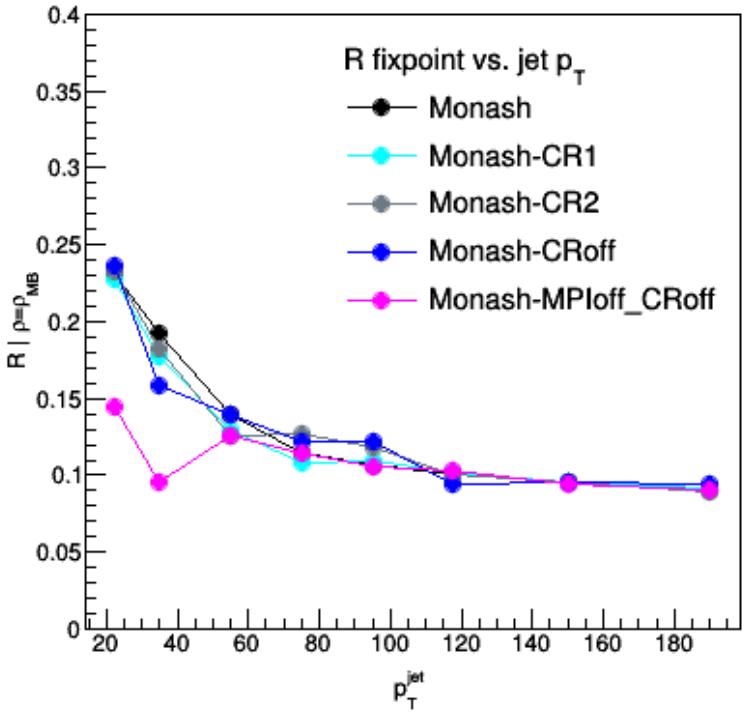




- The intersection does not depend on our bin choice.
- Our finding: it is also independent from tunes and settings!
- Could this r be a characteristic jet size?

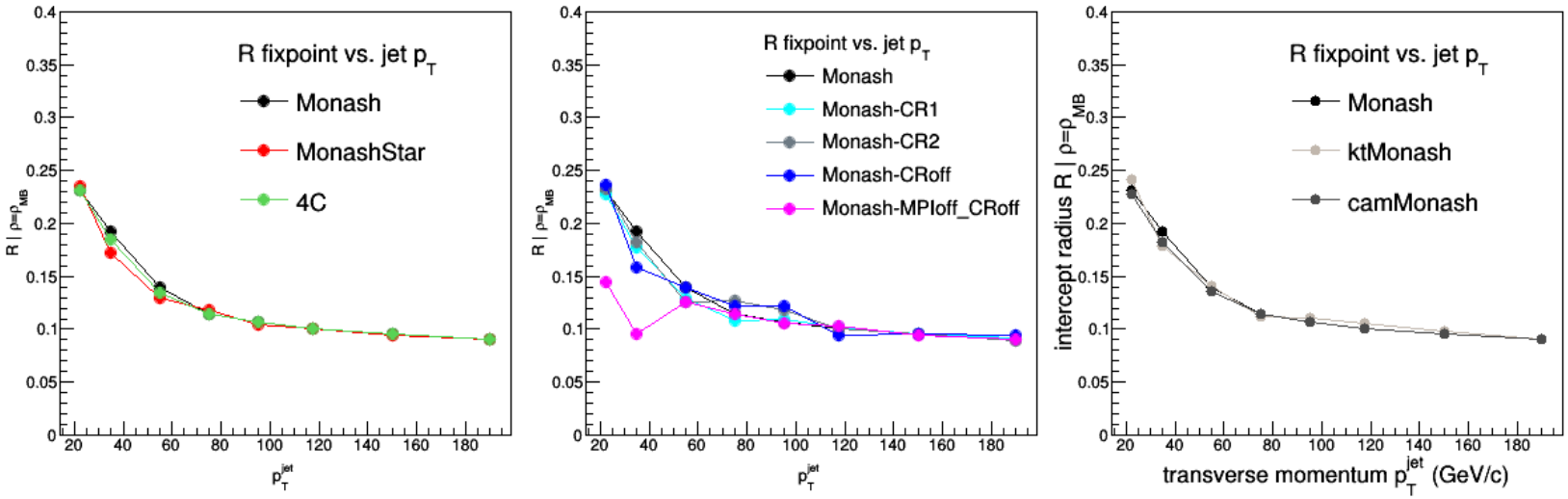
The p_t^{jet} dependence of the r "fix point"





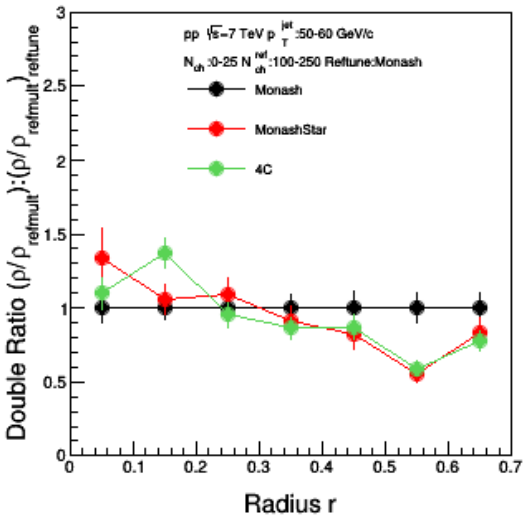
- Good agreement between tunes and settings.
- It is a characteristic jet size at a given p_t^{jet}. Or is it some trivial effect?
- Is it an artefact of our jet reconstruction algorithm?

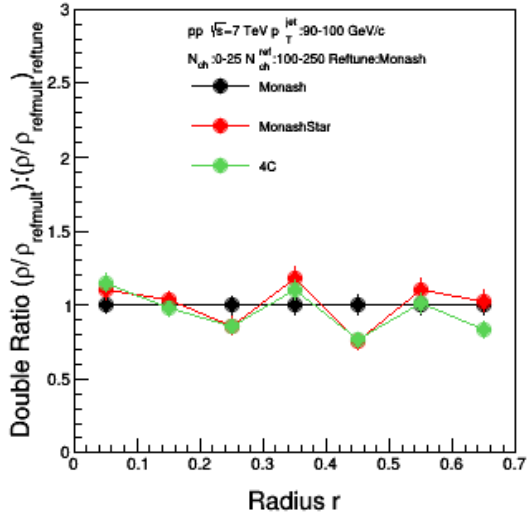
The p_t^{jet} dependence of the r "fix point"

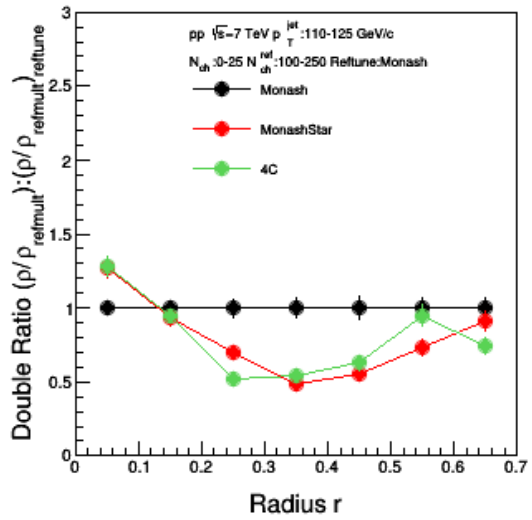


- Good agreement between tunes and settings.
- This "characteristic jet size" is independent of the three jet reconstruction algorithms.

Applying a double ratio for $\rho(r)$

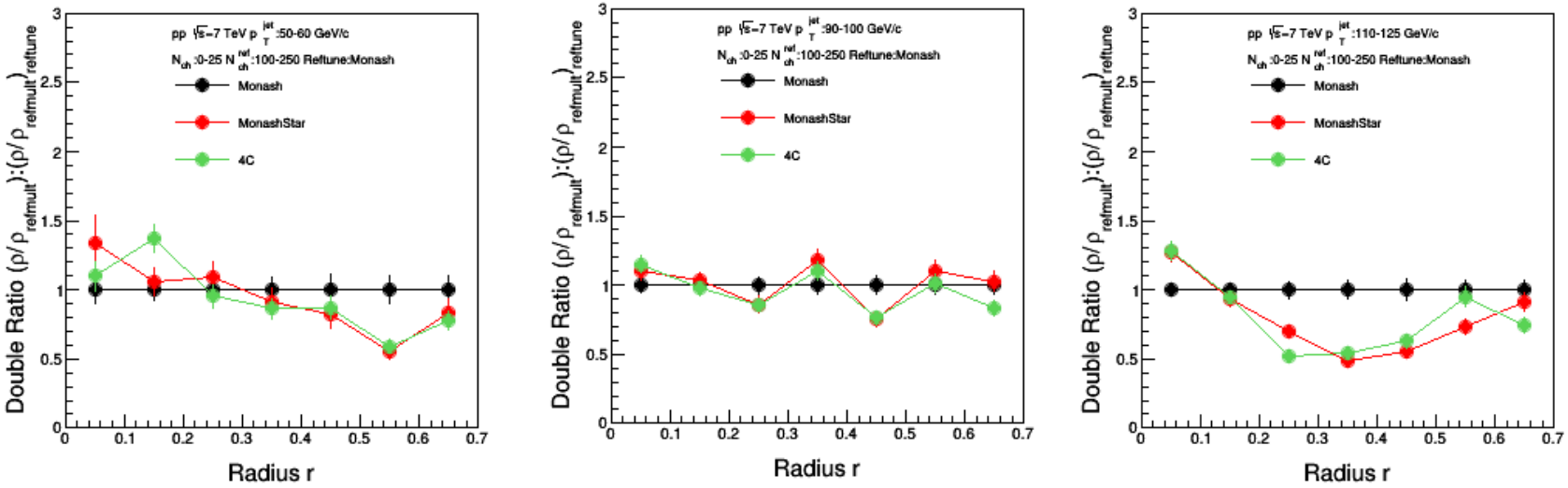






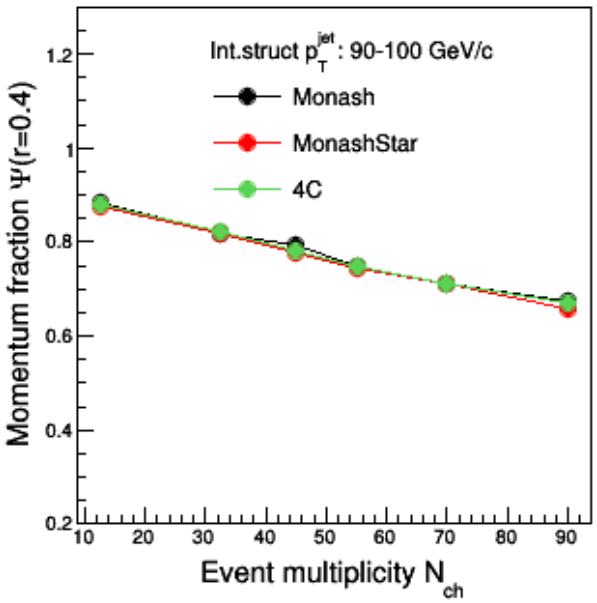
A double ratio for $\rho(r)$: $\dfrac{(\rho_{low}/\rho_{high})}{(\rho_{low}/\rho_{high})_{default}}$.

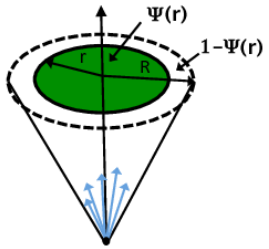
Applying a double ratio for $\rho(r)$

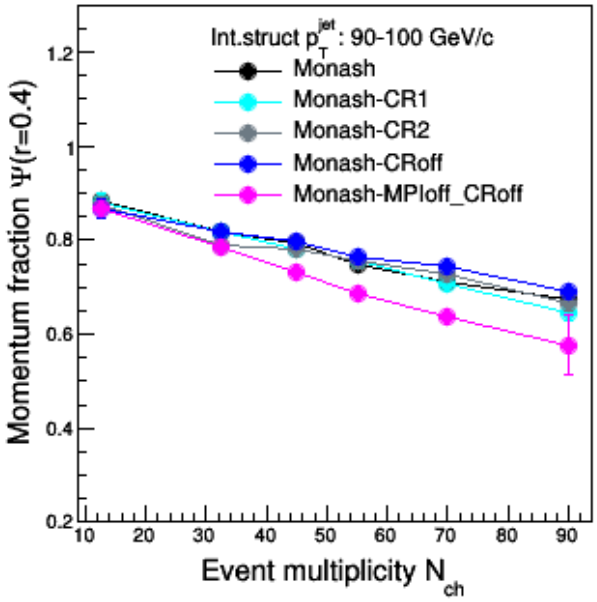


- Trivial multiplicity bias cancelled out.
- We find a significant effect at a given p_t^{jet} windows.
- Non-trivial dependence on p_t^{jet}, origin of the effect needs further investigation.

$\psi(r = 0.2)$ dependence on multiplicity







- No observable effect in integral structure between different tunes.
- Turning off MPI causes significant differences within the same multiplicity class,
- which suggests MPI has an influence on jet structure.

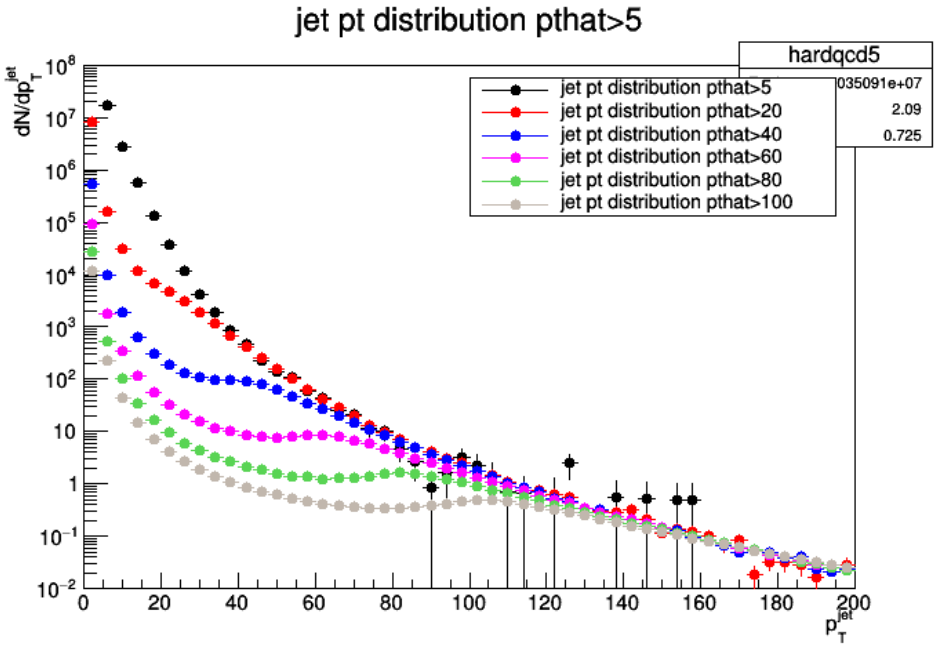
Summary

- We analysed jet structure versus multiplicity using PYTHIA simulations.
- Integral jet structure vs. multiplicity is different when MPI is off. Suggests jet modification by MPI.
- Differences depending on tunes. Needs understanding, validation by data would be useful.
- Jets have a multiplicity independent characteristic jet radius. Will this be true for heavy ions?
- Studies concerning heavy-flavour-tagged jets are under way.

Thank you for your attention!

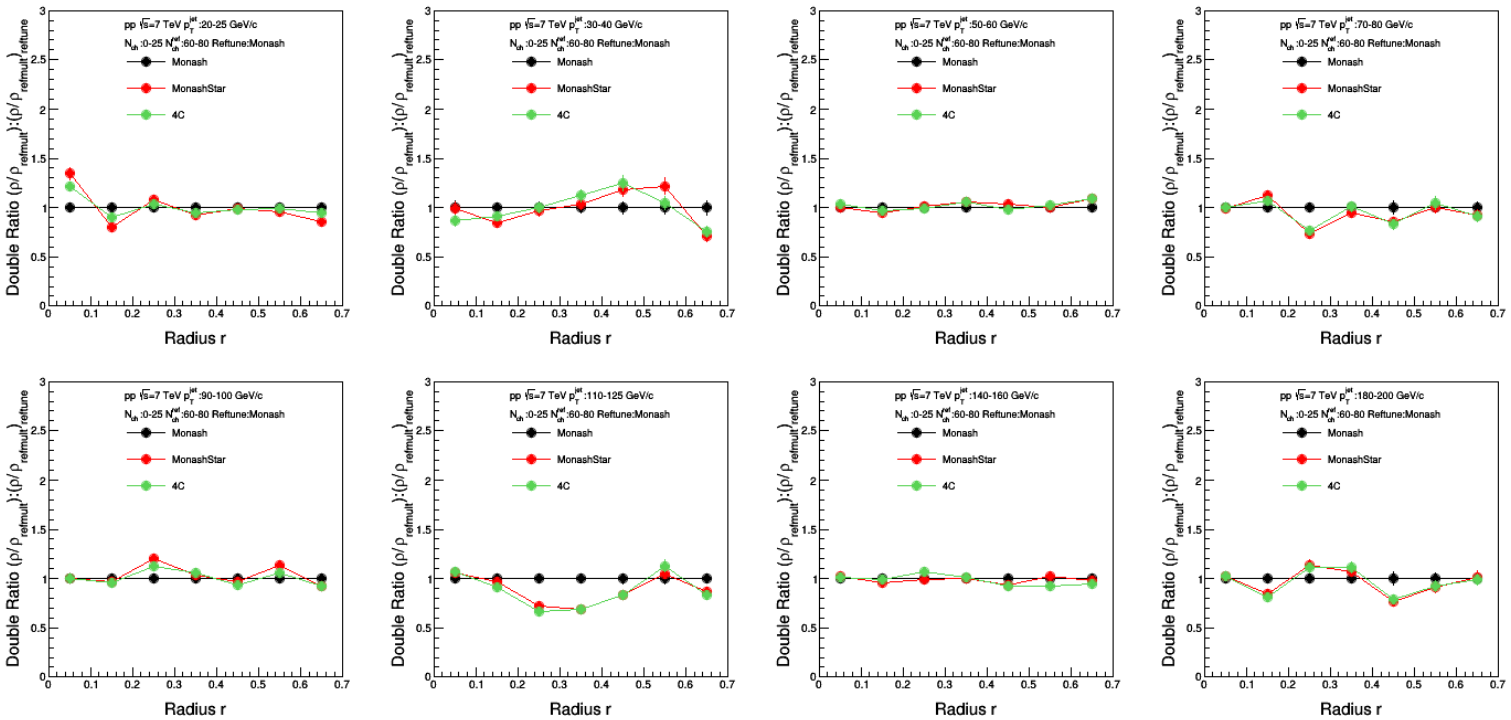
Backup

p_t^{jet} distributions for different $\hat{p}_t$

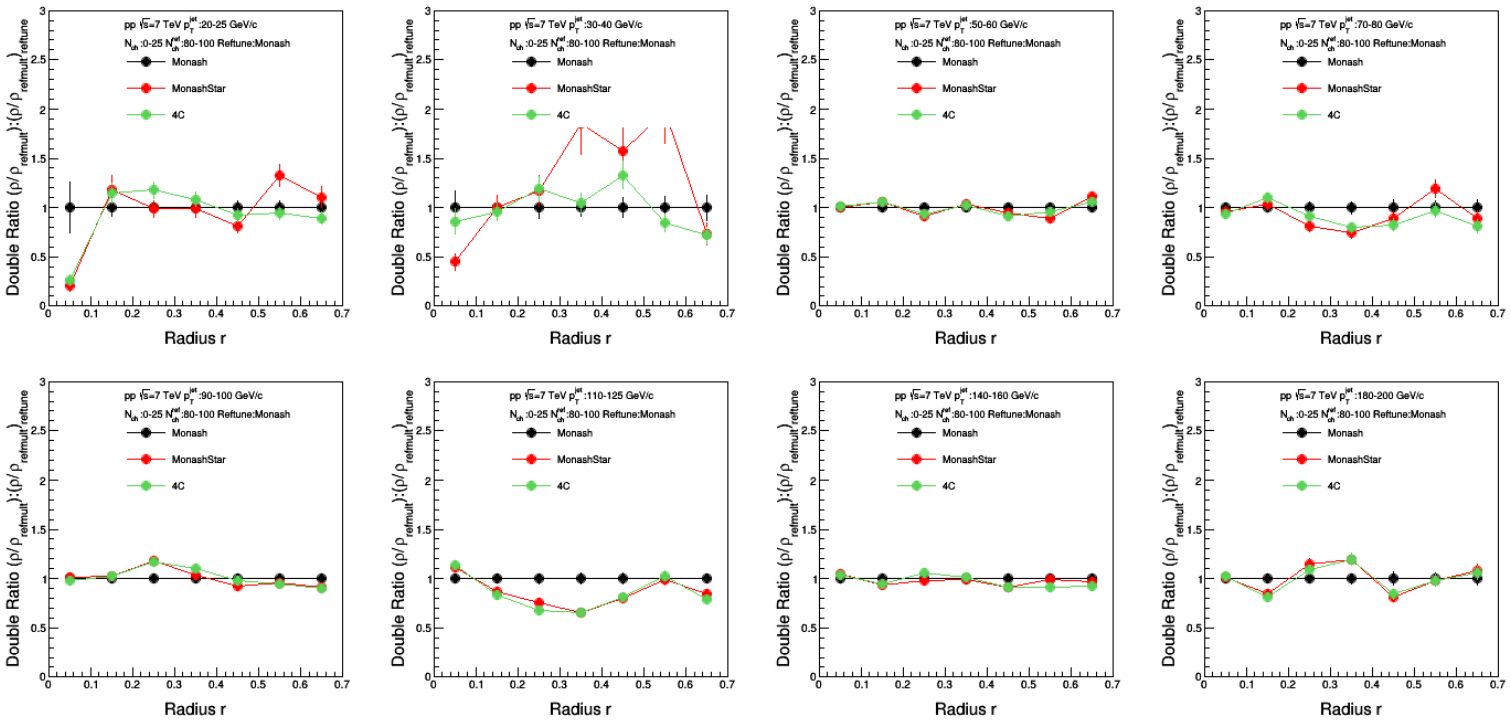


p_t^{jet}	$\hat{p}_t$
20 - 25	5 $\leq$
30 - 40	5 $\leq$
50 - 60	20 $\leq$
70 - 80	20 $\leq$
90 - 100	40 $\leq$
110 - 125	40 $\leq$
140 - 160	80 $\leq$
180 - 200	80 $\leq$
225 - 250	80 $\leq$

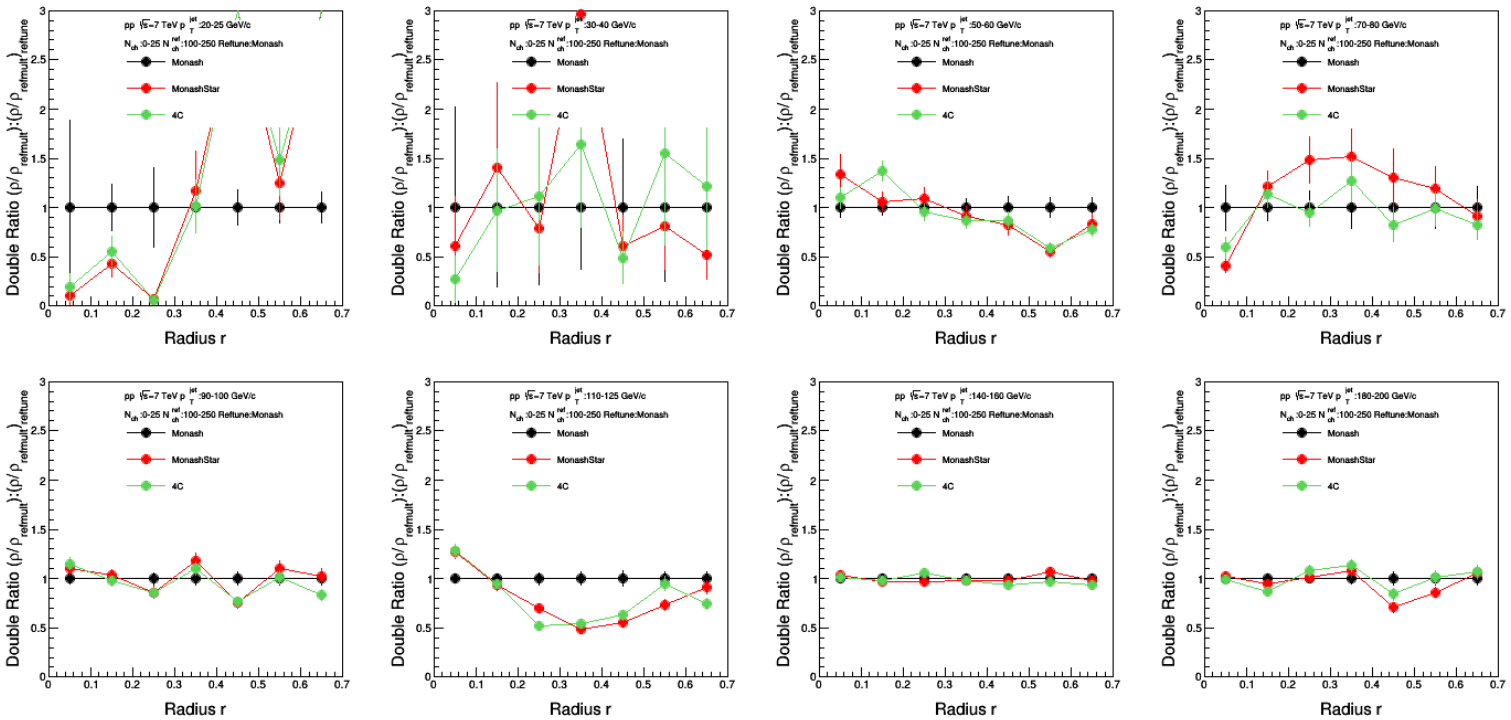
$\rho(r)$ double ratio figure: 1/6



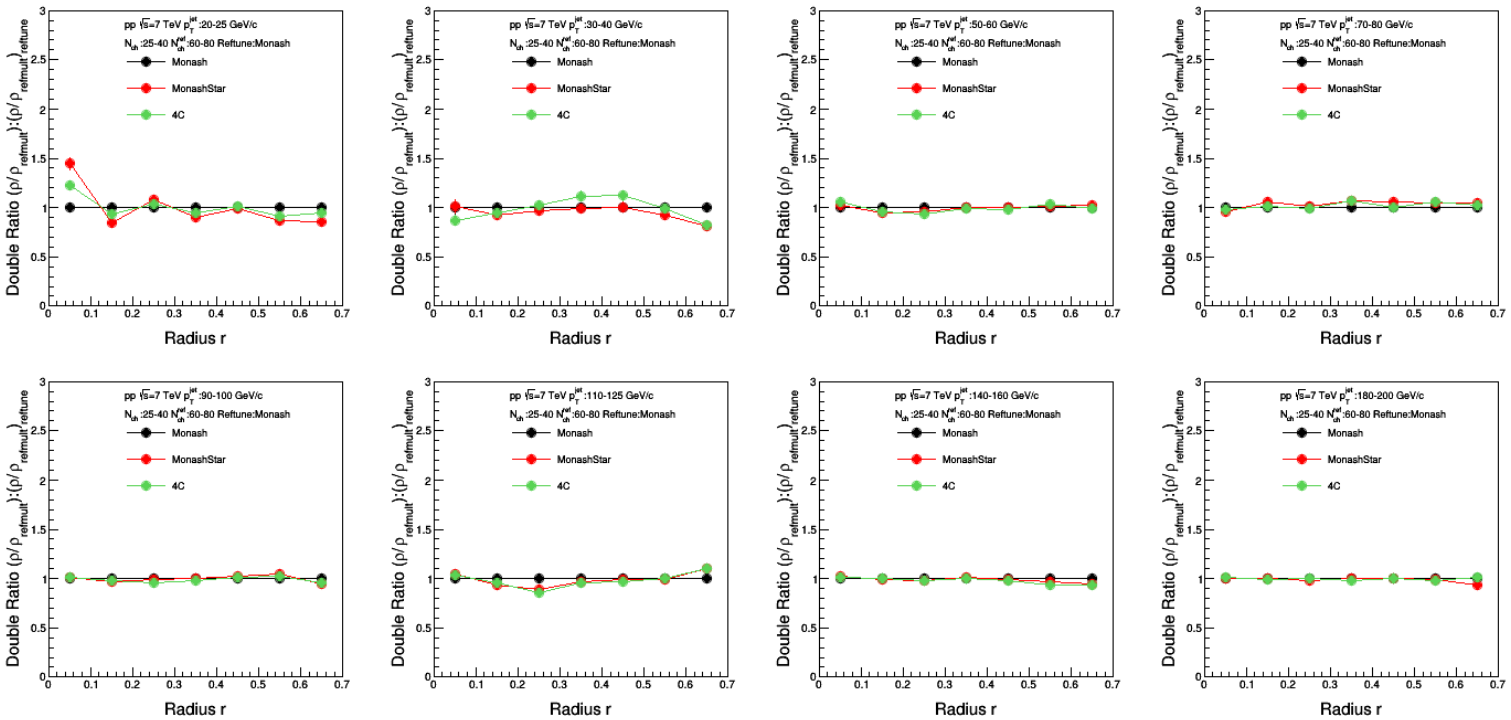
$\rho(r)$ double ratio figure: 2/6



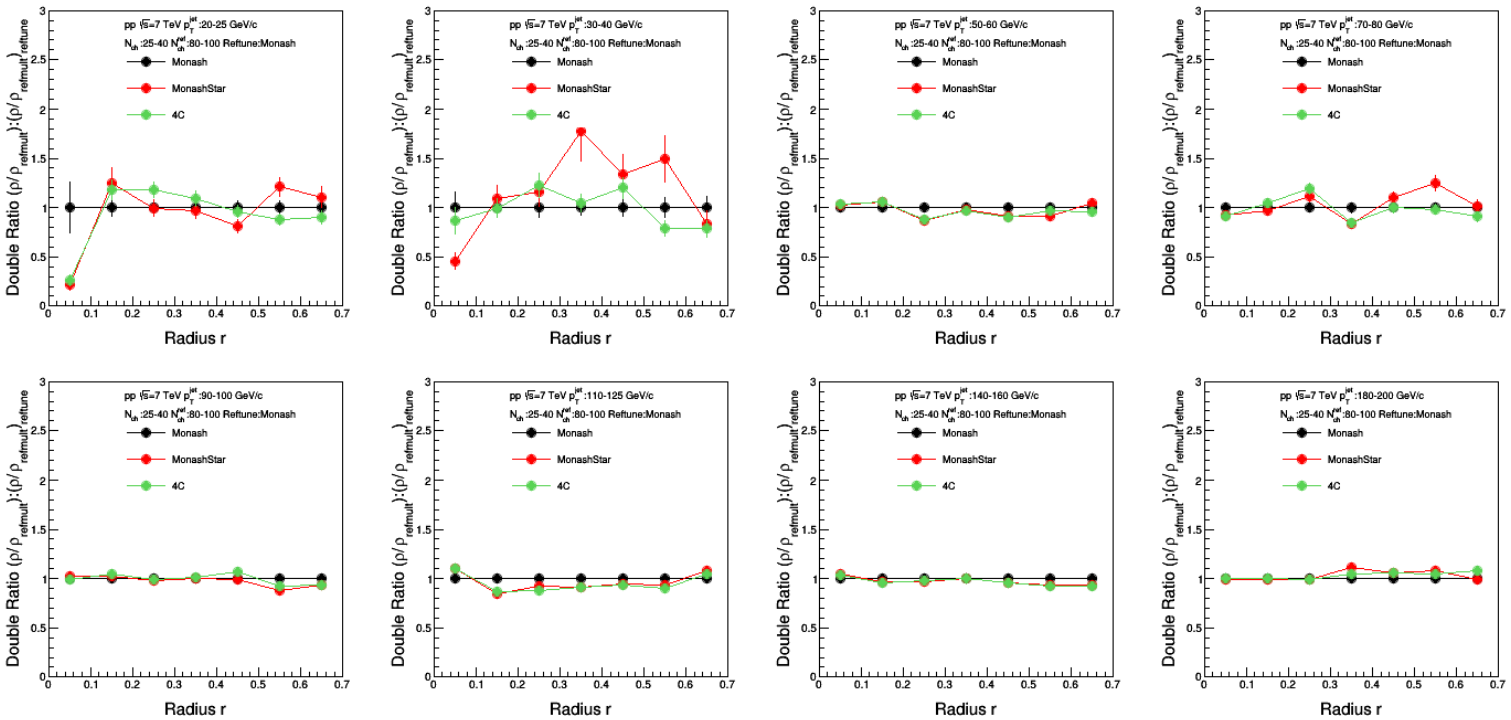
$\rho(r)$ double ratio figure: 3/6



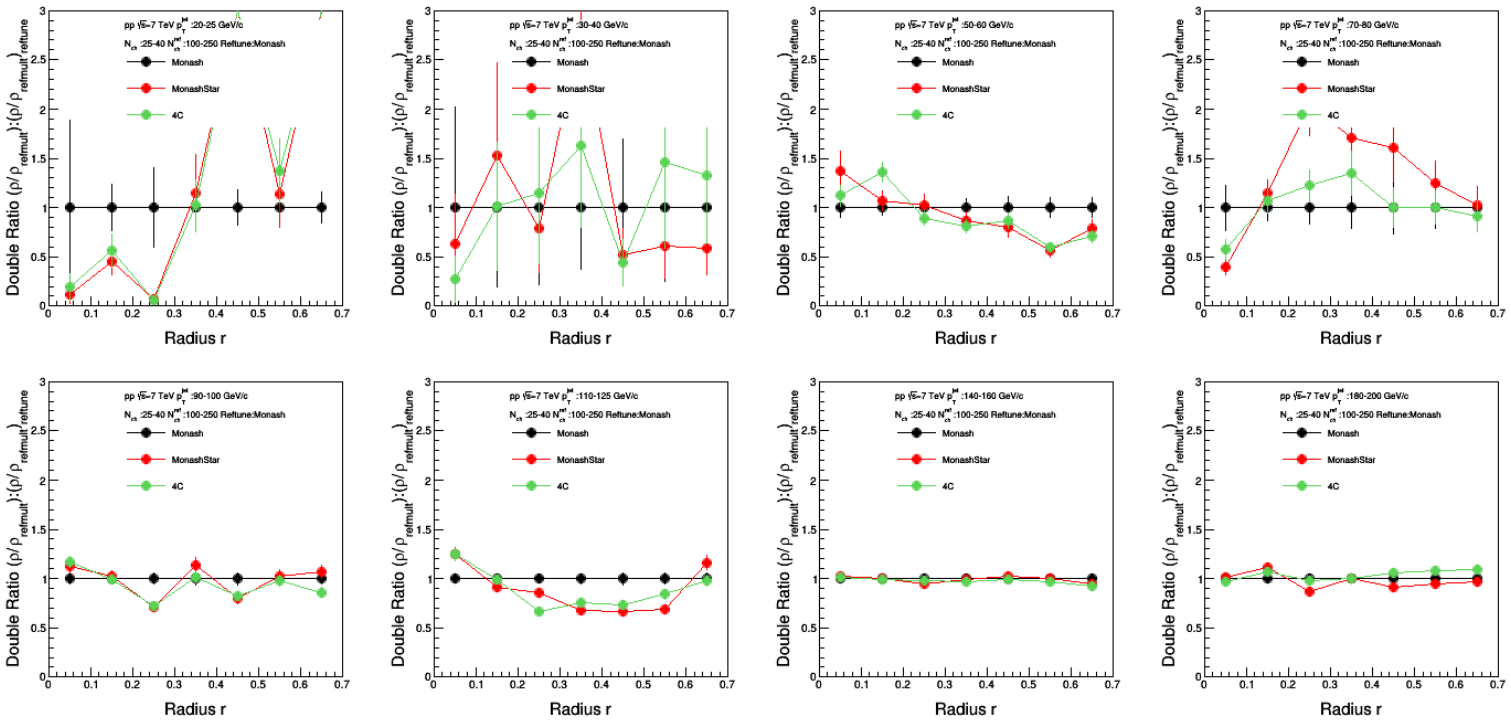
$\rho(r)$ double ratio figure: 4/6



$\rho(r)$ double ratio figure: 5/6



$\rho(r)$ double ratio figure: 6/6



Significant difference between MPIoff-CRoff and CRoff