Jet production in pp collisions using the ALICE detector

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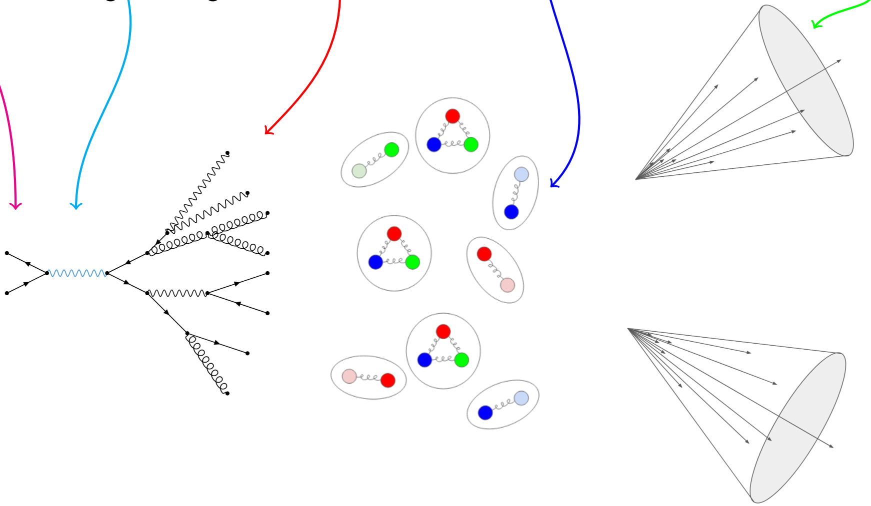
University of Tennessee Knoxville

May 21, 2023

Run:266438
Timestamp:2016-11-26 17:58:22(UTC)

Birth of a jet

Initial conditions → Hard scattering → Fragmentation → Hadronization → Reconstructed final state

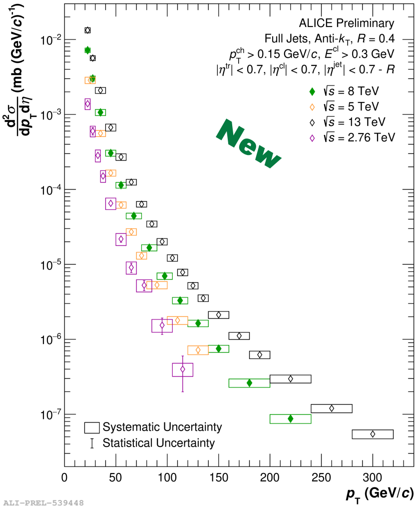


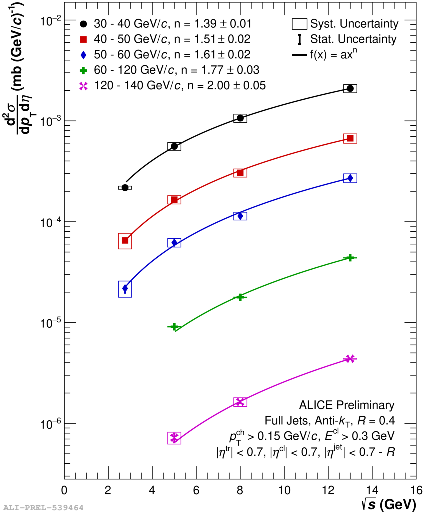
- To accurately predict the final state (jets) we need an understanding of all formation steps
- ALICE jet reconstruction
  - Charged jets: ITS+TPC tracks
  - Full jets: ITS+TPC tracks & EMCal clusters
  - Clustering: anti-$k_T$algorithm

Inclusive cross-section measurements

- pp measurements are **sensitive to all parts of jet formation** → Useful to constrain MC calculations
- Spectra get harder with increased collision energy
- Important reference for larger collision systems

[Public figures]



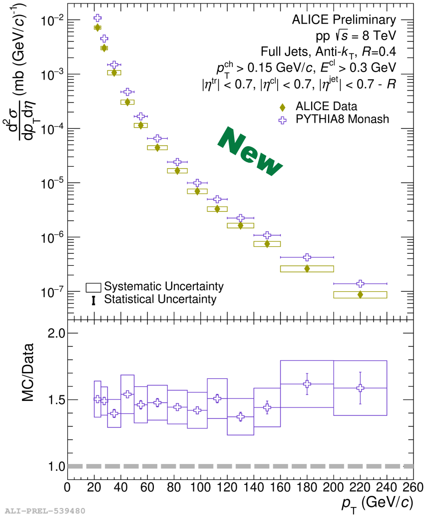


Comparison with MC Generators

- **PYTHIA alone over-predicts data** by ≈ 50%
- Similar behavior seen at other collision energies
- Predictions including POWHEG agree with data within uncertainties

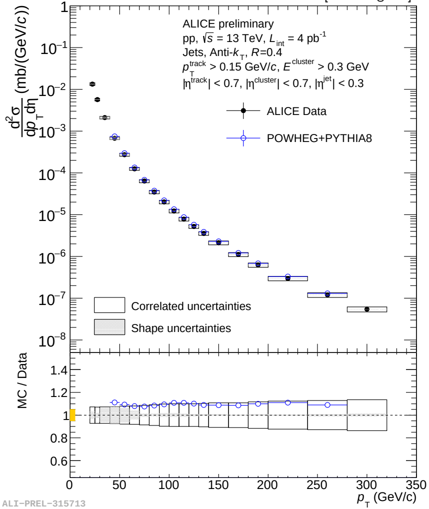
→ **Needs NLO correction**

8TeV



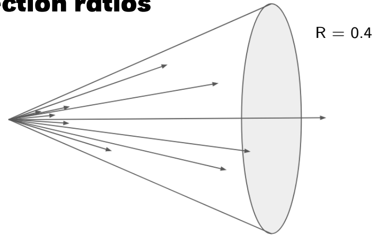
13 TeV

[Public figures]



Observable definitions

Cross-section ratios



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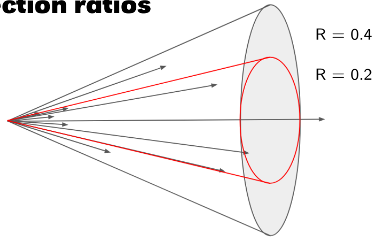

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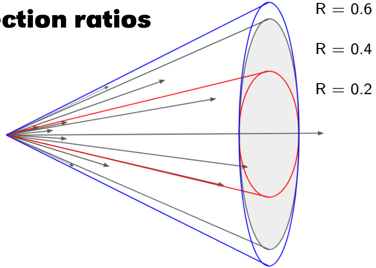

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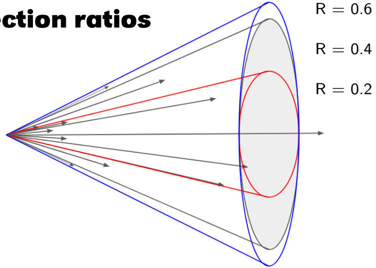
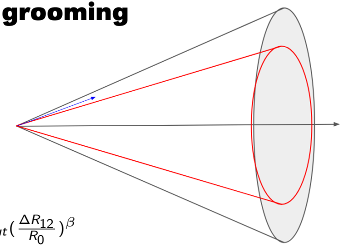


Soft drop grooming



$$z_g = \frac{p_T^{part}}{p_T^{jet}} > z_{cut}\left(\frac{\Delta R_{12}}{R_0}\right)^{\beta}$$

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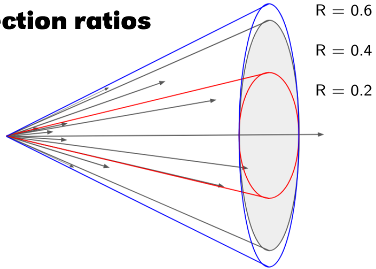

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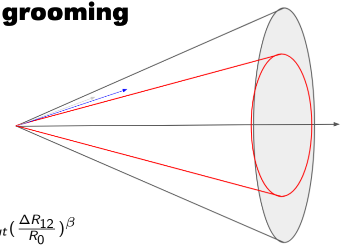

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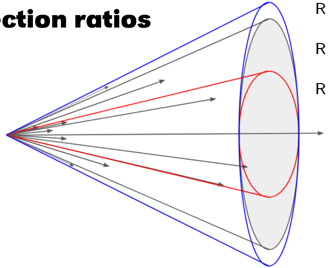

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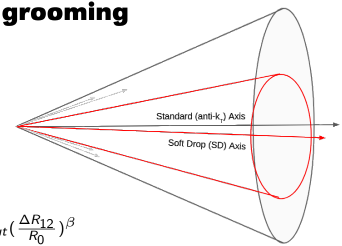

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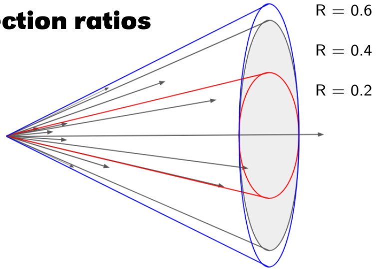

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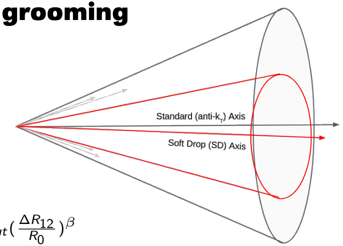

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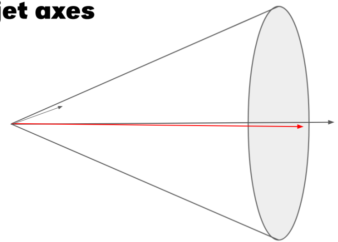
Angle b/t jet axes



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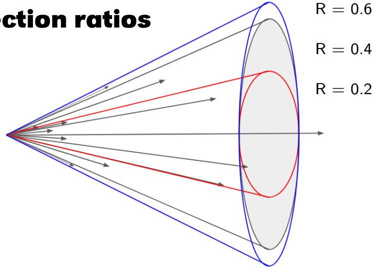

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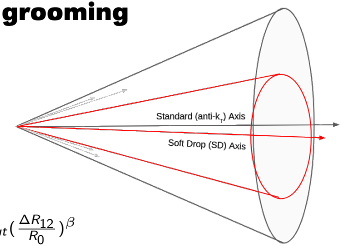

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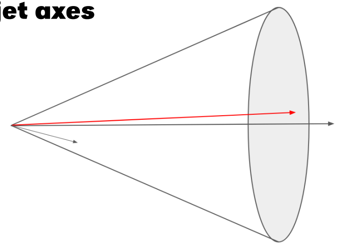

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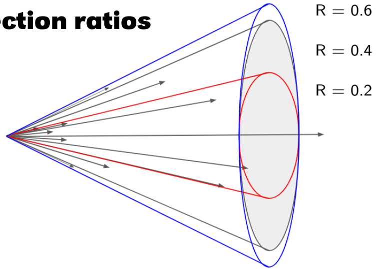

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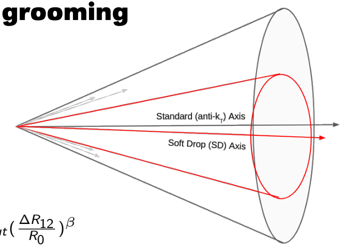

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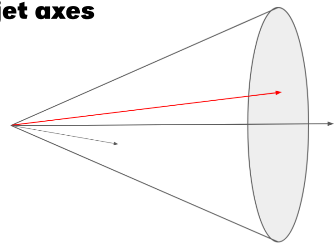

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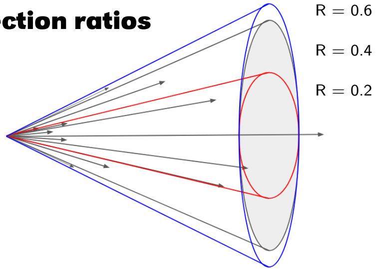

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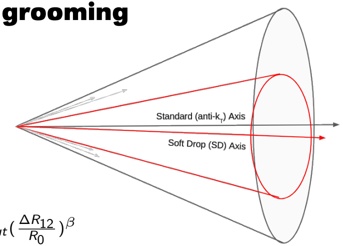

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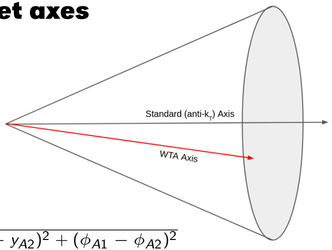

$$\Delta R_{axis} = \sqrt{(y_{A1} - y_{A2})^2 + (\phi_{A1} - \phi_{A2})^2}$$

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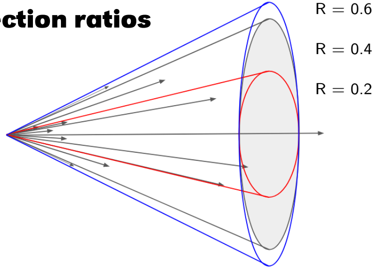

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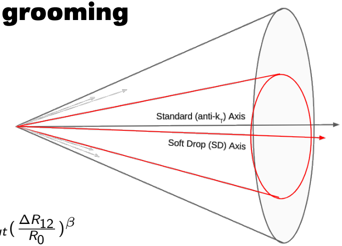

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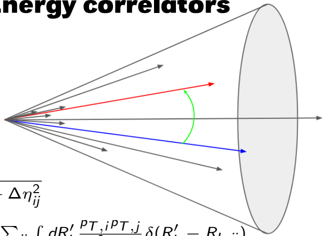
Energy-Energy correlators



$$R_L = \sqrt{\Delta\phi_{ij}^2 + \Delta\eta_{ij}^2}$$

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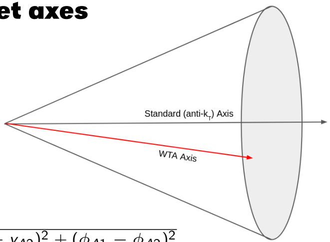

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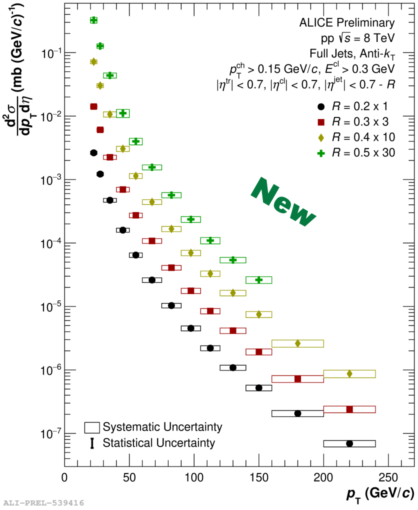
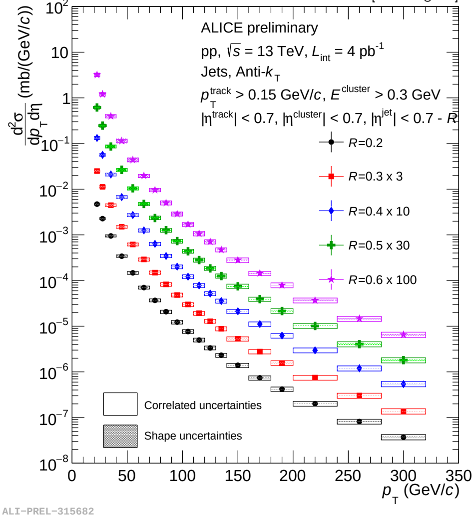
- How does the spectral shape change with changing R?
- Similar cross section evolution independent of collision energy

8TeV



13 TeV

[Public figures]



Cross-section ratios

8TeV

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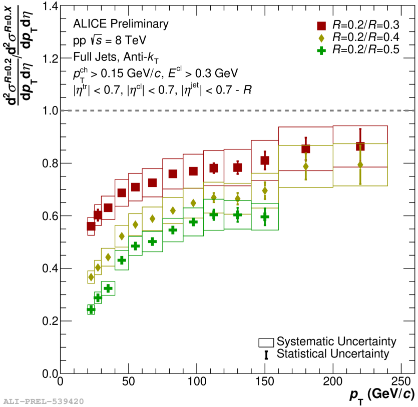
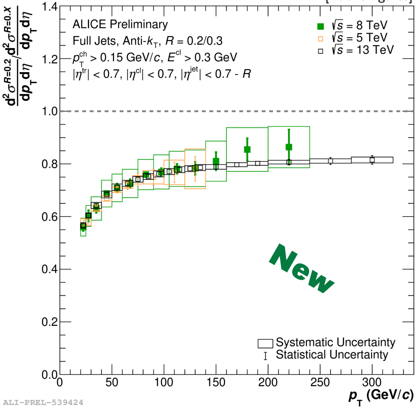




- Ratios allow for error cancellation
- Fragmentation patterns constant across collision energies

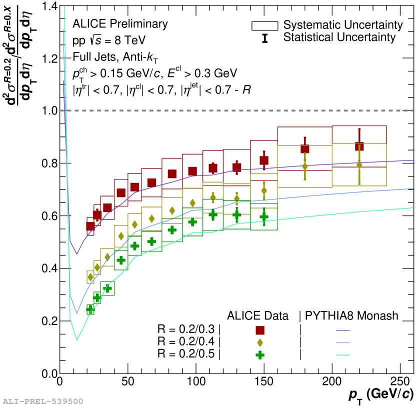
- Interesting at low momentum where non-perturbative effects play a larger role
- Jets become more collimated with increasing momentum

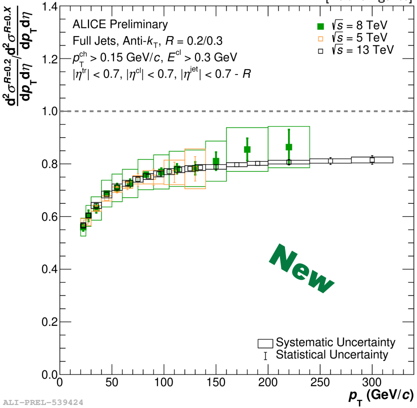
$\rightarrow$ Sensitive to fragmentation & hadronization, reproduced by MC models

Cross-section ratios

8TeV

[Public figures]





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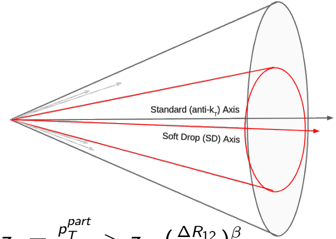
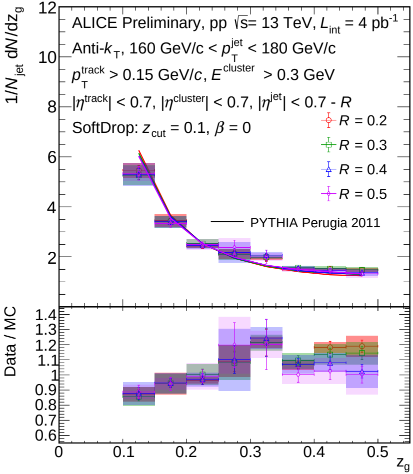
Soft drop (SD) grooming



$$z_g = \frac{p_T^{part}}{p_T^{jet}} > z_{cut}\left(\frac{\Delta R_{12}}{R_0}\right)^{\beta}$$

- High p_T: Distributions overlap
- Low p_T: Significant R-dependence
- Despite grooming, low p_T jets still less collimated

High p_T: Perturbative regime



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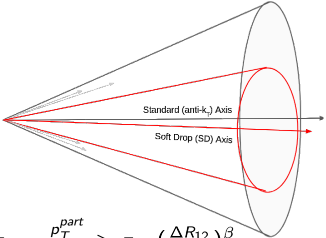

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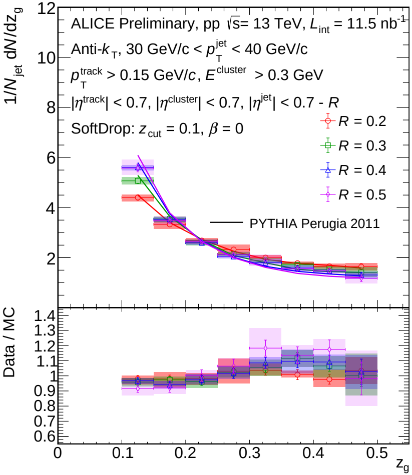
Low p_T: Non-Perturbative regime



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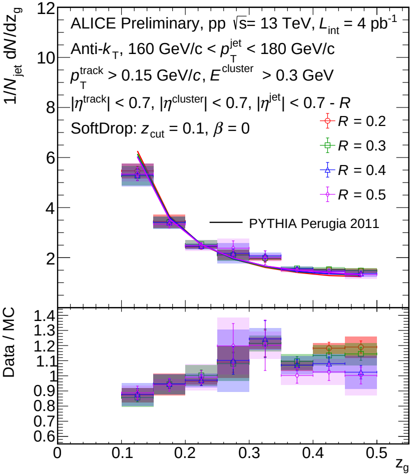
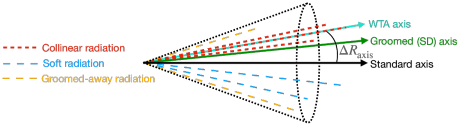


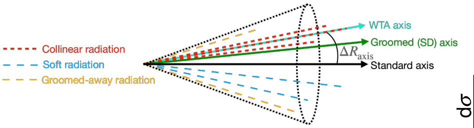
Probing soft radiation with the jet axis



$$\Delta R_{axis} = \sqrt{(y_{A1} - y_{A2})^2 + (\phi_{A1} - \phi_{A2})^2}$$

- Standard axis → all anti-k_{T}jet constituents
- SD axis → removes soft, wide-angle radiation
- Winner takes all (WTA) axis
  → Only sees energetic collinear radiation

Probing soft radiation with the jet axis



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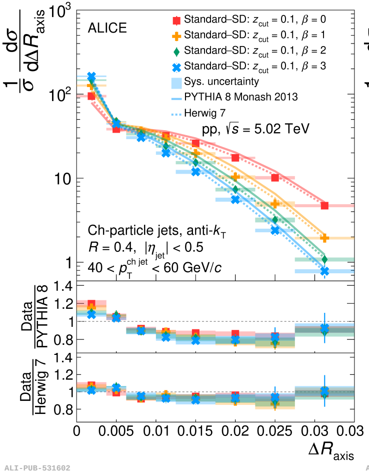
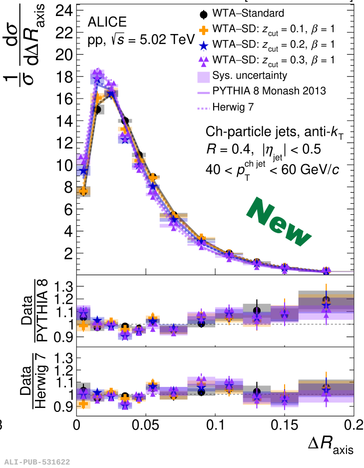
- Standard - SD
  - Sensitive to groomed away radiation
  - **Constrain hadronization models**
- Standard/SD - WTA
  - Low sensitivity to SD parameters
  - **Provides handle on soft radiation in jets in a large background**

[arXiv:2211.08928]





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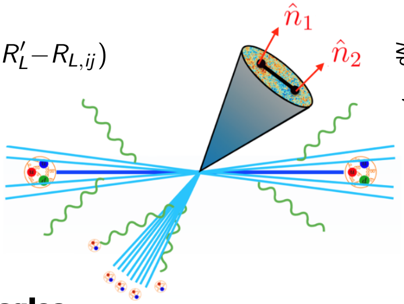
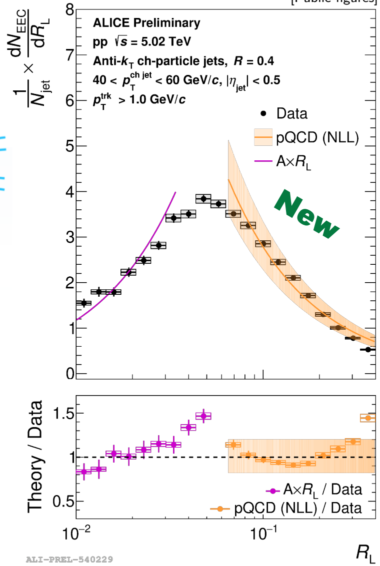


[Public figures]



- **Direct sensitivity to QCD scales**
  - Perturbative (large angular distance)
  - Non-perturbative (small angular distance)
- Perturbative regime $\rightarrow$ good agreement with pQCD
- Non-perturbative regime $\rightarrow$ good agreement with AxR$_L$
- Both models break down at the extremes
- Good overall agreement with MC generators

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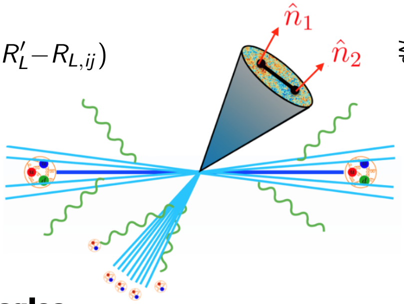

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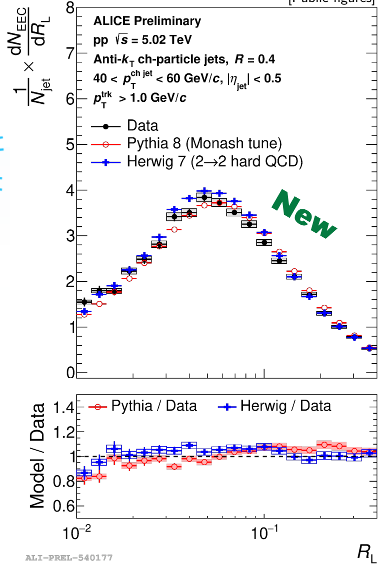

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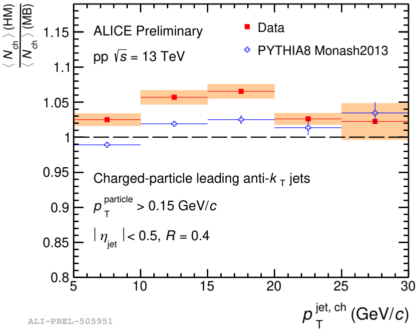
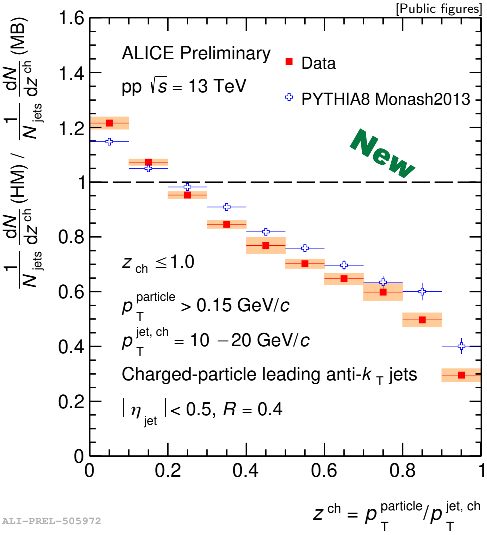
Jet properties and event activity

How does high multiplicity affect the shape of jet observables?

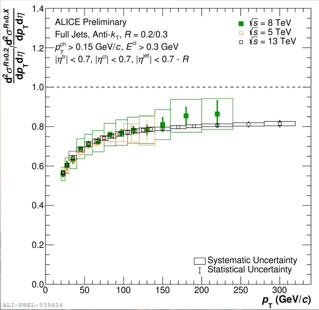
- Softer jet fragmentation in HM vs. MB events
- More event activity = more soft particles created
- Higher probability of rare jet events

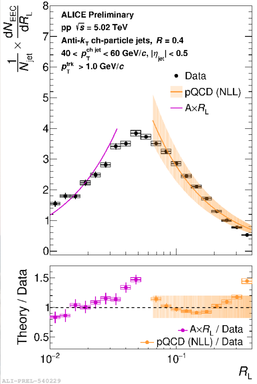




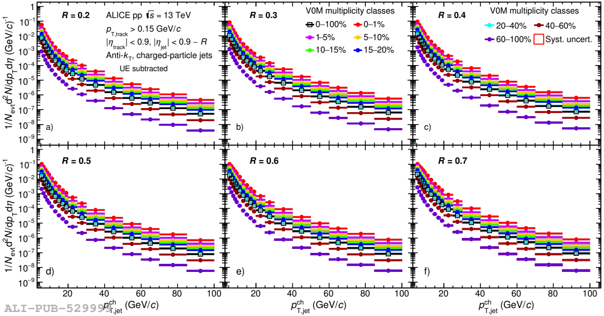
Summary

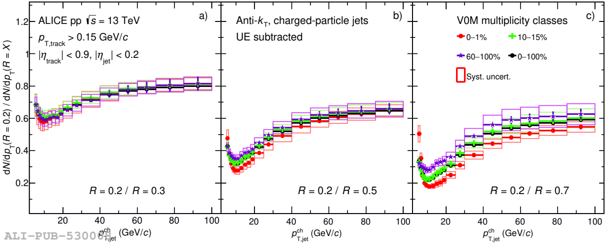
- **Inclusive jet measurements** can help us **understand jet formation** as a whole and constrain important values
- **Jet substructure** allows us to **separate and individually study different QCD processes**
- High multiplicity studies allow us to look for behavior typically seen in heavy-ion events
- There is a **rough agreement with models, but room for improvement**





High Multiplicity Jet Production





arXiv:2202.01548