D^0-meson tagged jet axes difference in pp collisions at $\sqrt{s} = 5.02$ TeV

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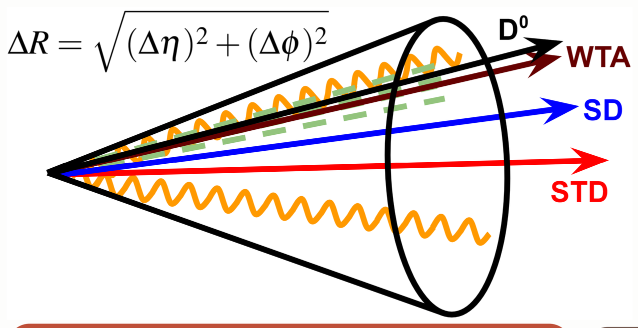
I. Introduction

Heavy quarks originate from hard scatterings in the early stages of hadronic collisions and develop parton-showers with unique features due to their mass.



different jet algorithm ⟷ different sensitivity to soft radiation

Angular differences between jet axis definitions, ΔR, reveal the radiation pattern inside D^0-jets.

Standard (STD)

D^0-tagged sample of jets clustered with anti-k_T algorithm with $R = 0.4$.

Most sensitive to soft radiation!

Winner-Takes-All (WTA)

STD jet with Cambridge Aachen (C/A) reclustering and WTA recombination.

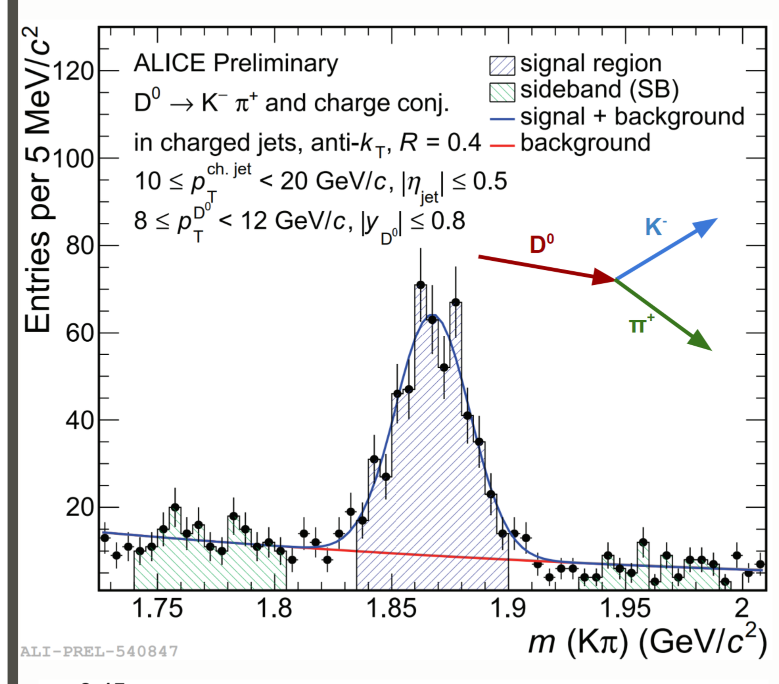
Insensitive to soft radiation!

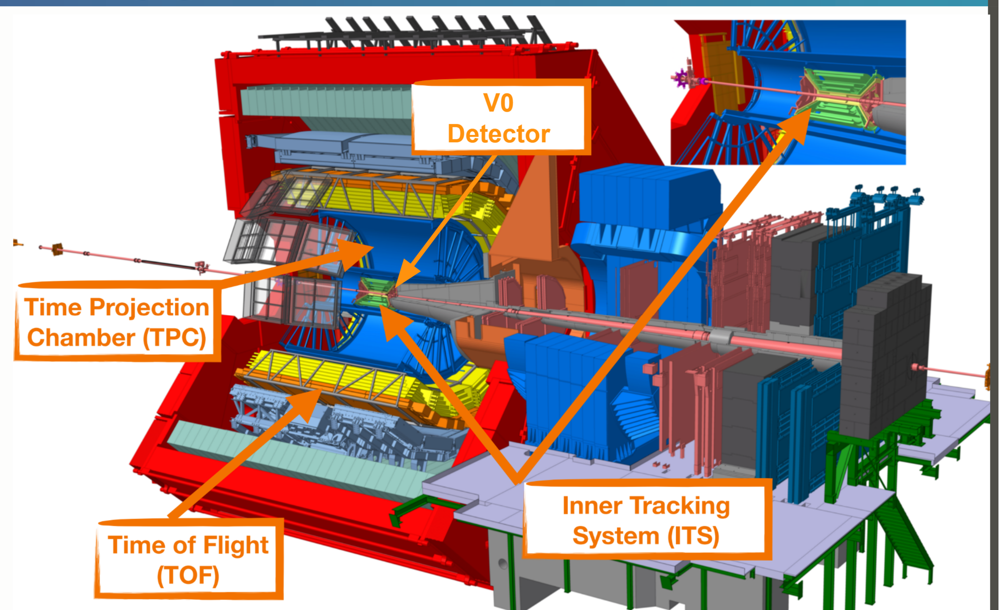
Soft-Drop Groomed (SD)

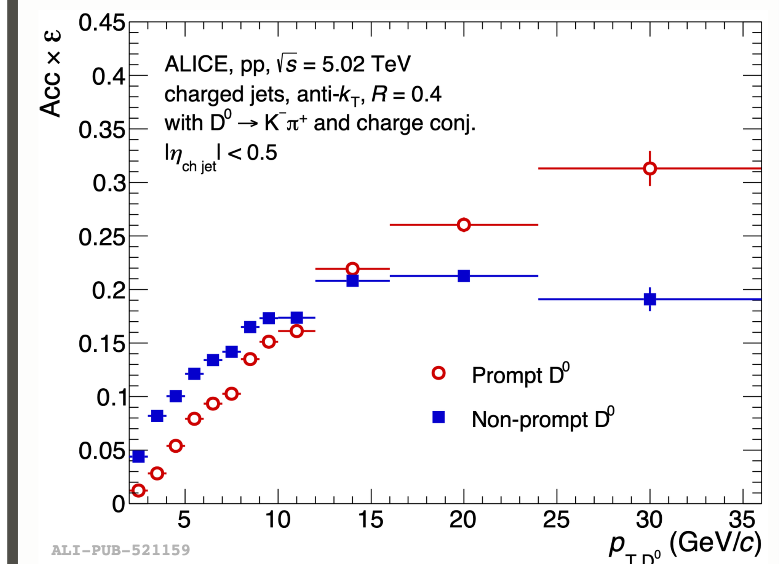
STD jet with C/A reclustering with the SD condition applied at each splitting:

$$\frac{\min(p_{T1}, p_{T2})}{p_{T1} + p_{T2}} > z_{cut}\left(\frac{\Delta R_{12}}{R_0}\right)^\beta$$

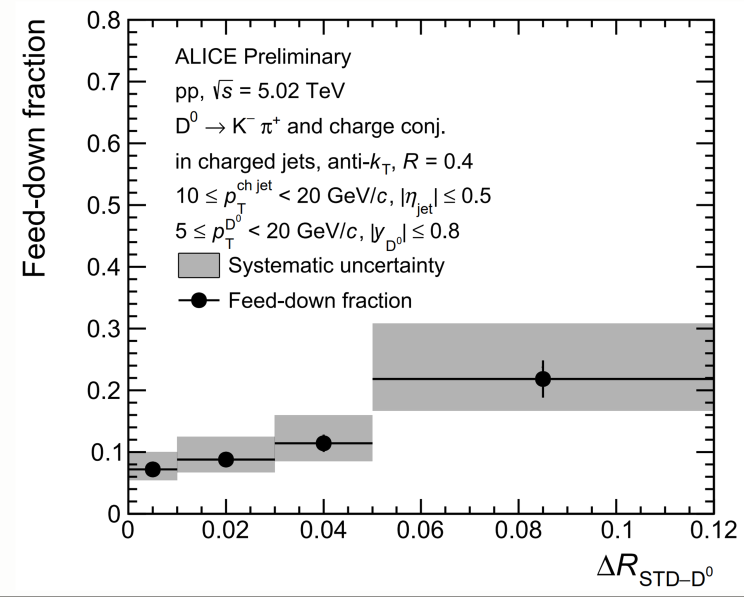
II. Analysis Steps: D^0-tagged jets in ALICE







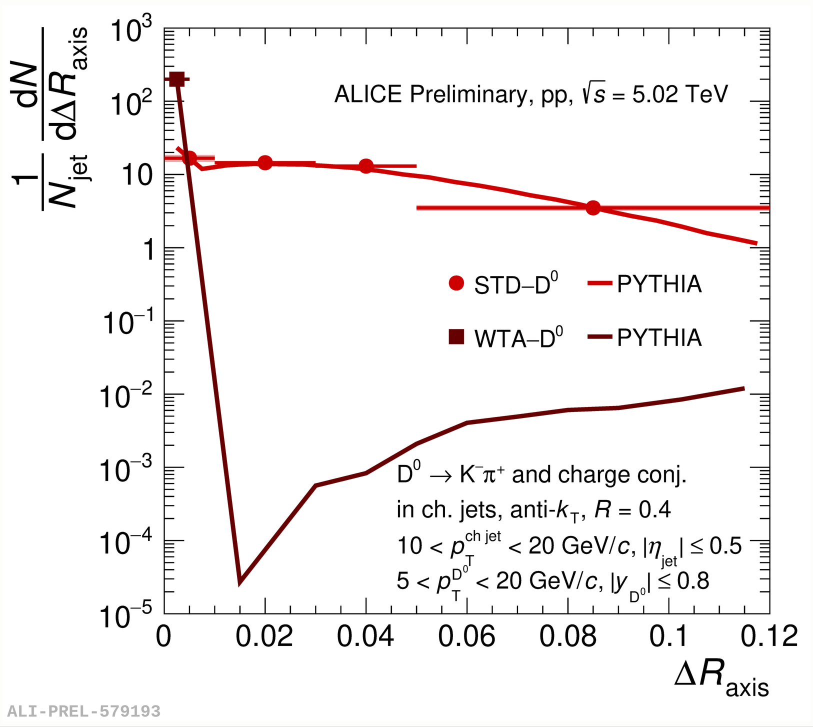
ALICE, "Measurement of the production of charm jets tagged with D0 mesons in pp collisions at $\sqrt{s} = 5.02$ and 13 TeV", *JHEP 2023*



Analysis Methods:

1. D^0 candidates were reconstructed from daughter tracks using topological and particle identification selections ($D^0 \to K^- + \pi^+$ and ch. conj.).
2. Jet finding performed for each D^0 candidate, using FastJet anti-k_T algorithm ($R = 0.4$).
3. D^0-jet yield evaluated via fit to invariant-mass distribution to remove combinatorial $K^\mp\pi^\pm$ pairs surviving the D^0 selections.
4. Yields corrected for D^0-tagged jet reconstruction efficiency and the non-prompt ($b \to c \to D^0$) contribution.
5. Jet axes differences corrected for detector effects with an iterative Bayesian unfolding approach.

III. WTA-D^0 Alignment

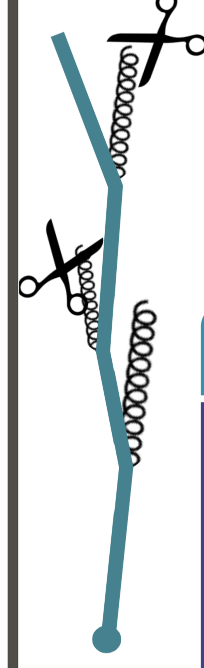


Measurement of ΔR_{STD-D^0} shows that the Standard jet axis may not always align with the D^0 meson.

Measurement of ΔR_{WTA-D^0} shows clear evidence that the WTA and D^0 axes are aligned.

- $99\% \pm 1\%$ in $10 \le p_{T,jet} \le 20$ GeV/c
- Results show that, in the measured kinematic ranges, the D^0 is almost always the leading particle

IV. Effects of Grooming on the Jet Direction



Grooming removes radiation softer than z_{cut} with $\beta = 0$.

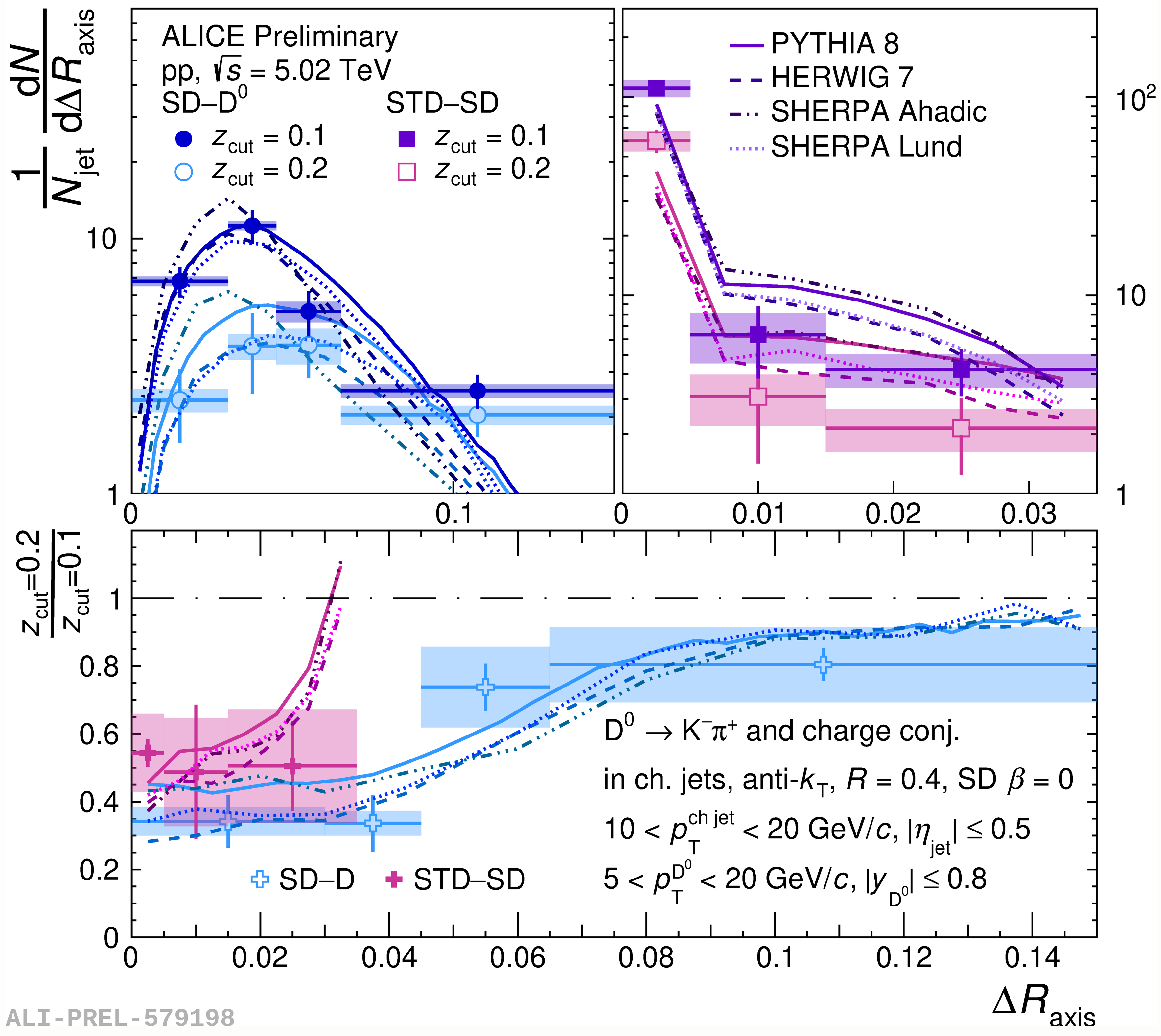
- ΔR_{SD-D^0} has some radiation (proportional to z_{cut}) removed compared to ΔR_{STD-D^0}

$$\frac{\min(p_{T1}, p_{T2})}{p_{T1} + p_{T2}} > z_{cut}\left(\frac{\Delta R_{12}}{R_0}\right)^\beta$$

- ΔR_{STD-SD} is non-zero due to the groomed-away radiation

Intensifying grooming from $z_{cut} = 0.1$ to $z_{cut} = 0.2$:

ΔR_{SD-D^0}	ΔR_{STD-SD}
...shows that SD jets are more likely to survive grooming if the SD axis is further from the D^0	...shows that radiation is removed uniformly with respect to the STD axis

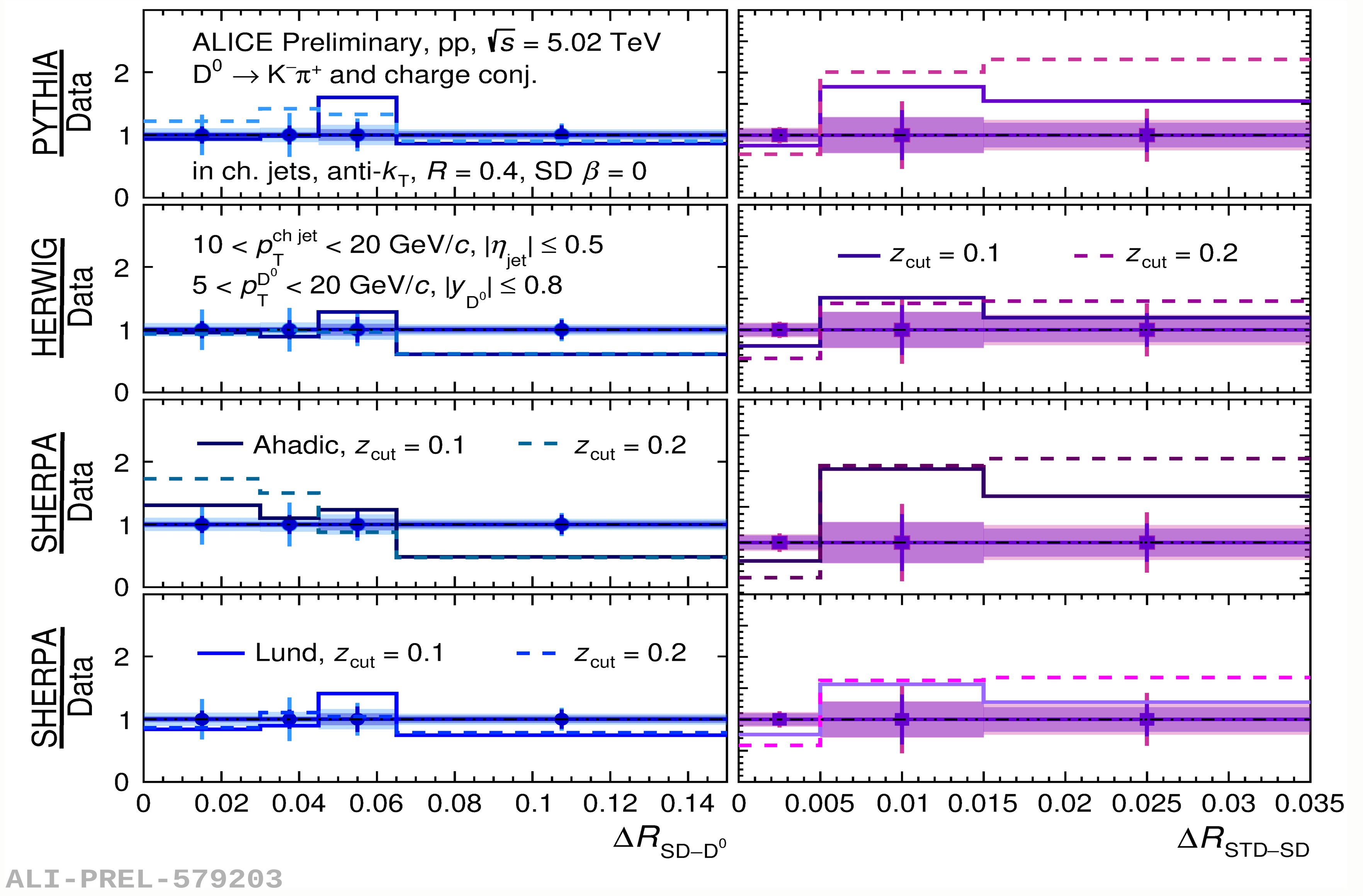


V. Comparison to Generators

String-Based Generators: *PYTHIA 8* and *SHERPA Lund*
Based on lattice simulations of gluonic interactions from QCD

Cluster-Based Generators: *HERWIG 7* and *SHERPA Ahadic*
Based on evolution of proto-hadron clusters

ΔR_{SD-D^0}	ΔR_{STD-SD}
• String-based models match data, overall better predictions • HERWIG predicts the least dependence on z_{cut}	• String-based models describe the data better for $z_{cut} = 0.1$ • HERWIG predicts less dependence on z_{cut} for large ΔR



VI. Summary

1. The D^0 is aligned with the WTA axis (leading particle)
2. If SD axis and D^0 are further apart → jet more likely to survive grooming
   - Inclusive jets: grooming did not substantially change jet direction [1]
   - D^0-jets: addition of D^0 axis → stronger sensitivity to the SD condition.
3. *HERWIG* and *SHERPA Lund* provide the best description of the data

[1] ALICE, "Measurements of jet-axis differences in pp collisions at $\sqrt{s} = 5.02$ TeV", *JHEP 2022, no.242, p.37*