Measurement of leading charged-particle jet properties in p-Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV with ALICE

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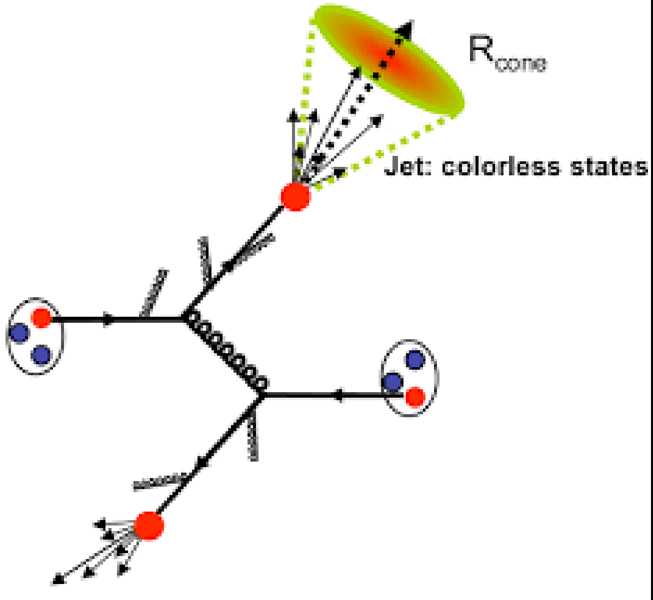
Outline

- Motivation
- Jet observables
- Analysis details
- Results and discussion
- Summary

Motivation

❖ Jets:

- Collimated showers of particles produced from the fragmentation and hadronization of hard-scattered partons
- Considered as the proxy to the initial hard-scattered partons and are expected to reflect the parton properties



❖ Jets in p-Pb collisions:

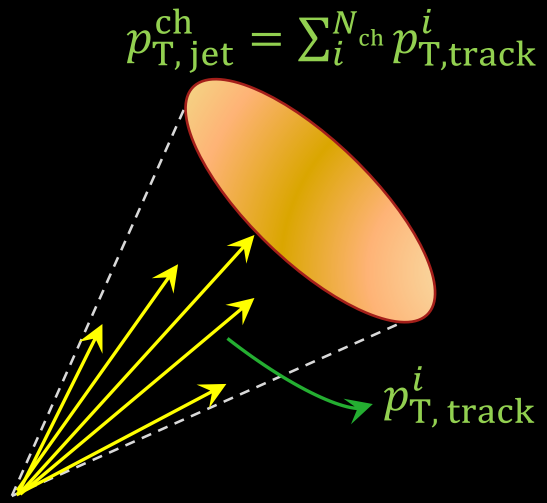
- Provide a baseline measurement for heavy-ion studies
- Test the impact of cold nuclear matter (CNM) effects[1]
- Offer possibility to address and understand the possible medium formation in small collision systems

[1] EPJ Web of Conferences 171, 11001 (2018)

Jet observables

- Mean charged-particle multiplicity within a leading charged-particle jet[1]:

$$< N_{\mathrm{ch}} > (p_{\mathrm{T,\,jet}}^{\mathrm{ch}}) = \frac{1}{N_{\mathrm{jets}}} \sum_{i=1}^{N_{\mathrm{jets}}} N_{\mathrm{ch}}^{i} \; (p_{\mathrm{T,\,jet}}^{\mathrm{ch}})$$



- Charged-particle jet fragmentation function[1]:

$$z^{\mathrm{ch}} = \frac{p_{\mathrm{T,\,track}}}{p_{\mathrm{T,\,jet}}^{\mathrm{ch}}}$$

where $p_{\mathrm{T,\,track}} = p_{\mathrm{T}}$ of jet constituent

- These intra-jet properties are sensitive to the details of parton showering processes

[1] Phys. Rev. D 91 (2015) 112012

Analysis details

Collision system: p-Pb

Center-of-mass energy ($\sqrt{s_{\mathrm{NN}}}$): 5.02 TeV

No. of events (minimum bias):

Data: 515 M

Simulation: 312 M, DPMJET[1] (GRV94[2])

Track selection: $p_{\mathrm{T,track}} > 0.15$ GeV/c, $|\eta_{\mathrm{track}}| < 0.9$

Jet reconstruction: FastJet anti-k_{T} algorithm[3], jet radius $R = 0.4$, leading jet $p_{\mathrm{T,jet}}^{\mathrm{ch}} = 10\text{-}100$ GeV/c, $|\eta_{\mathrm{jet}}^{\mathrm{ch}}| < 0.5$

Underlying event (UE) estimation: Perpendicular cone method

UE subtraction: Performed on a statistical basis after unfolding

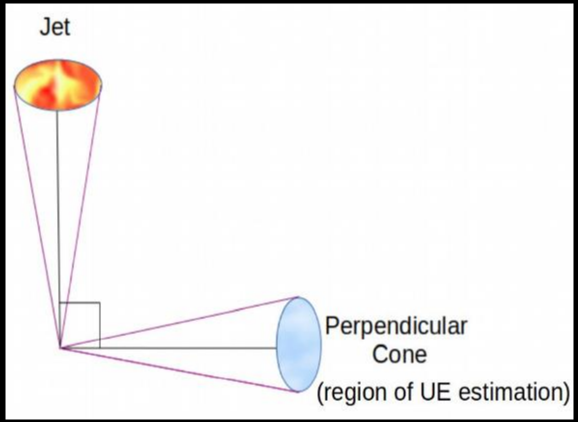
Correction for instrumental effects:

- Performed 2D unfolding
- 4D response matrix ($p_{\mathrm{T,jet}}^{\mathrm{detector}}$, $Observable^{\mathrm{detector}}$, $p_{\mathrm{T,jet}}^{\mathrm{truth}}$, $Observable^{\mathrm{truth}}$)
- Bayesian method[4] in RooUnfold[5]
- Unfolding parameter (no. of iterations)

  $< N_{\mathrm{ch}} >$: 4, z^{ch}: 2

Sources of systematic uncertainties:

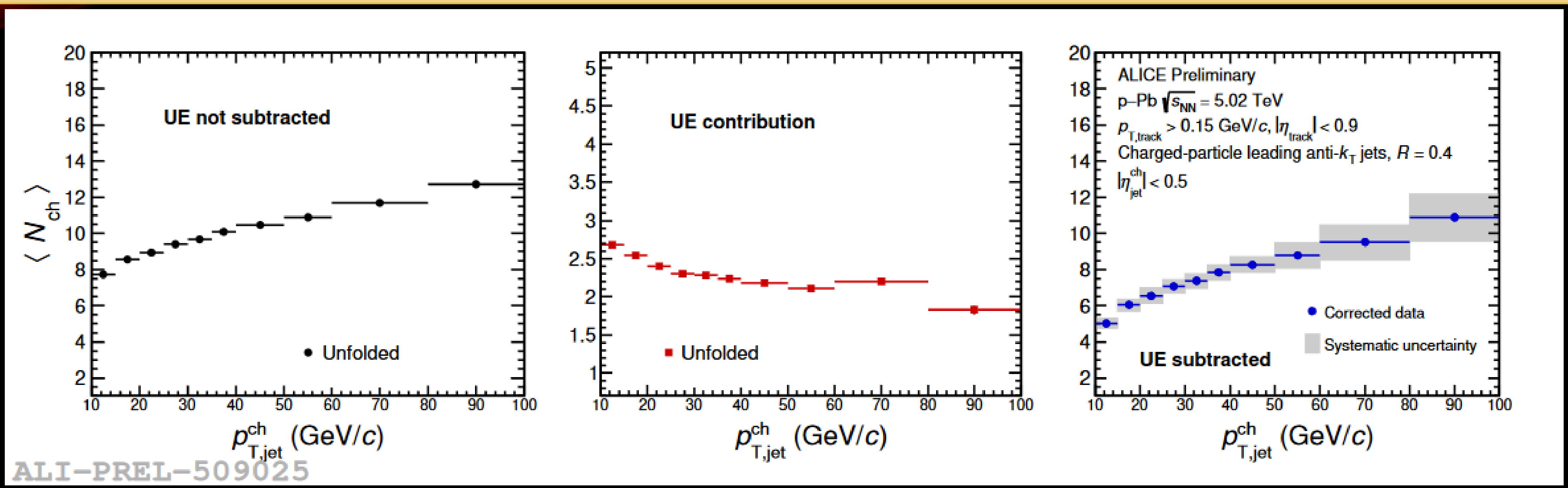
- Uncertainty in tracking efficiency
- MC dependence
- Change in prior
- Choice of number of iterations
- Uncertainty in estimation of UE



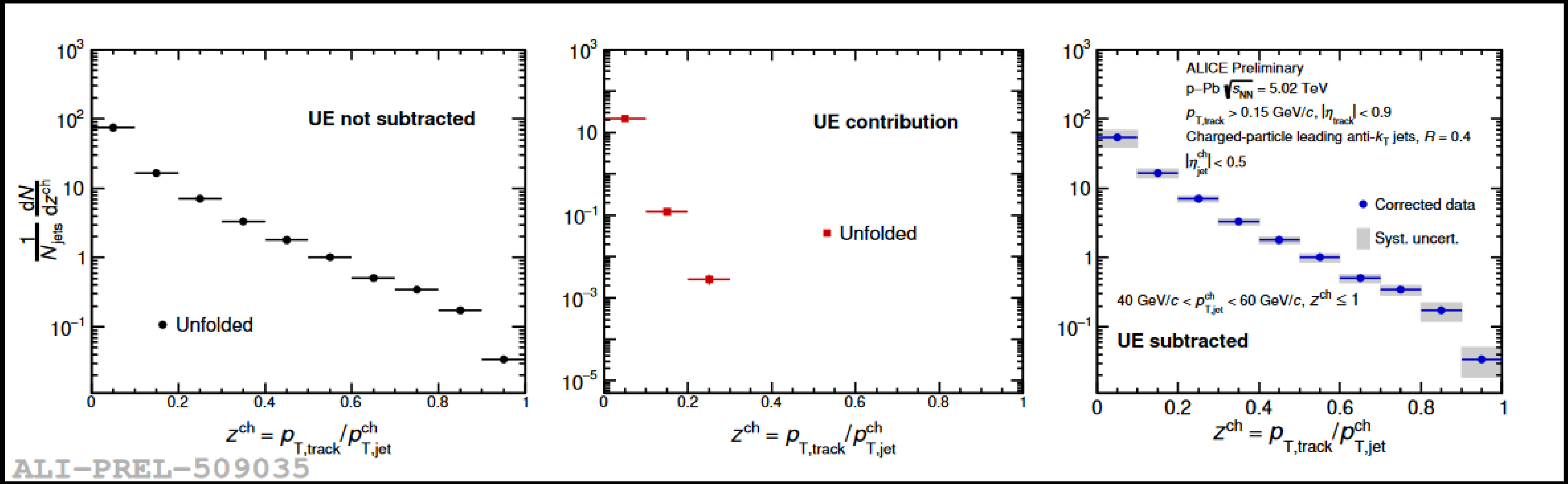
[1] Roesler et. al., https://doi.org/10.1007/978-3-642-18211-2_166
[2] A. Vogt, arXiv:hep-ph/9507241
[3] Matteo Cacciari et al JHEP04(2008)063
[4] G. D'Agostini, https://doi.org/10.1016/0168-9002(95)00274-X
[5] https://gitlab.cern.ch/RooUnfold/RooUnfold

Correction procedure

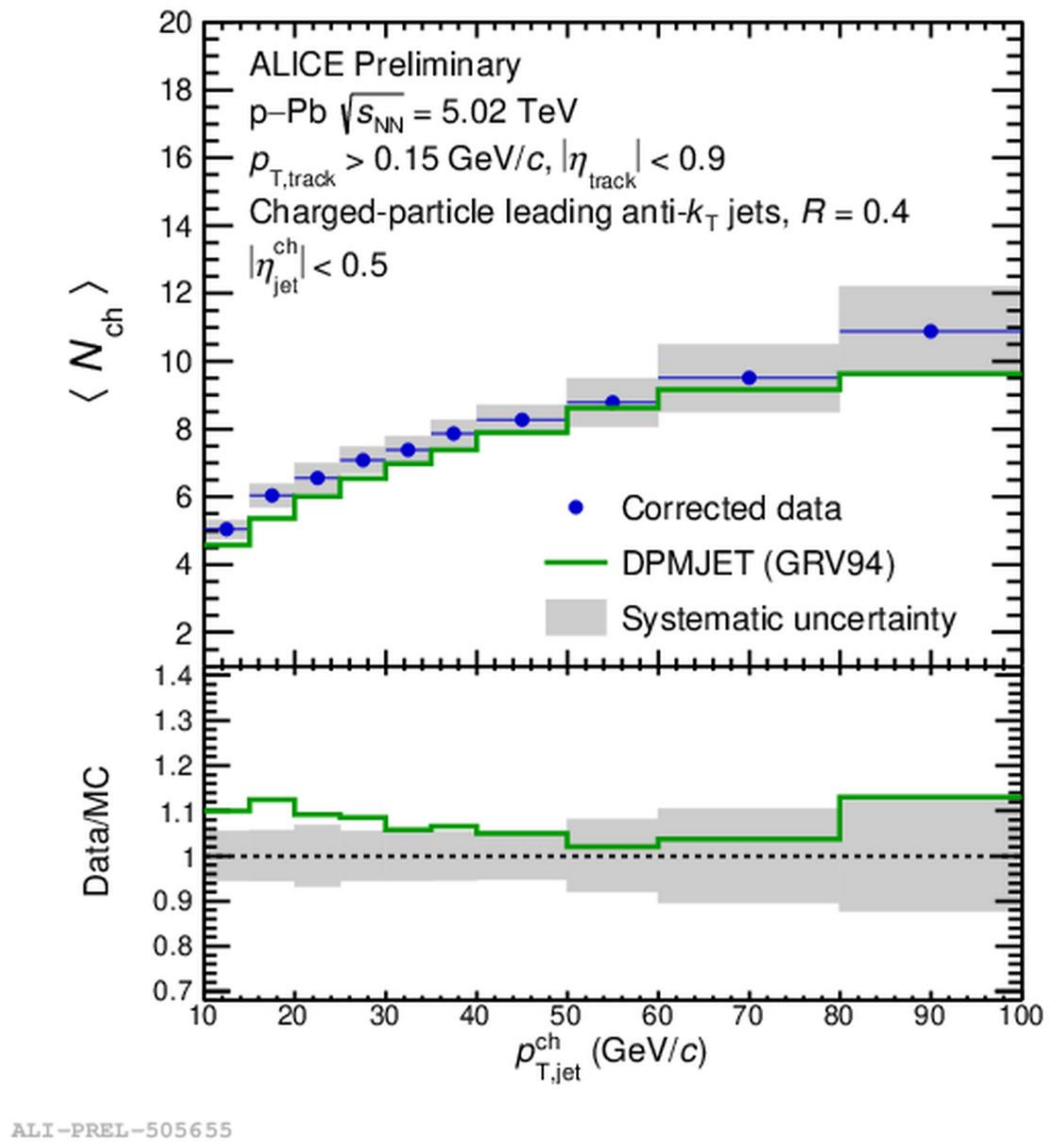
$< N_{\mathrm{ch}} >$ as a function of leading $p_{\mathrm{T,\,jet}}^{\mathrm{ch}}$



z^{ch} distribution (leading $p_{\mathrm{T,\,jet}}^{\mathrm{ch}}$ = 40-60 GeV/c)



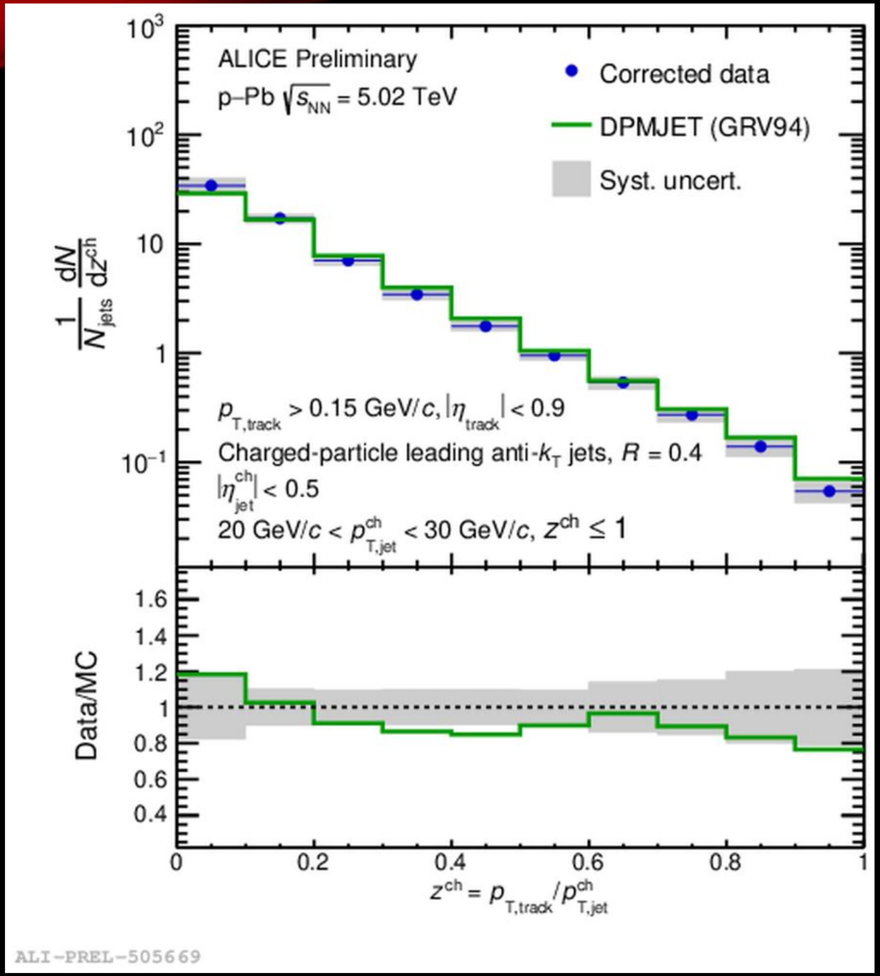
Results and discussion: $<N_{ch}>$

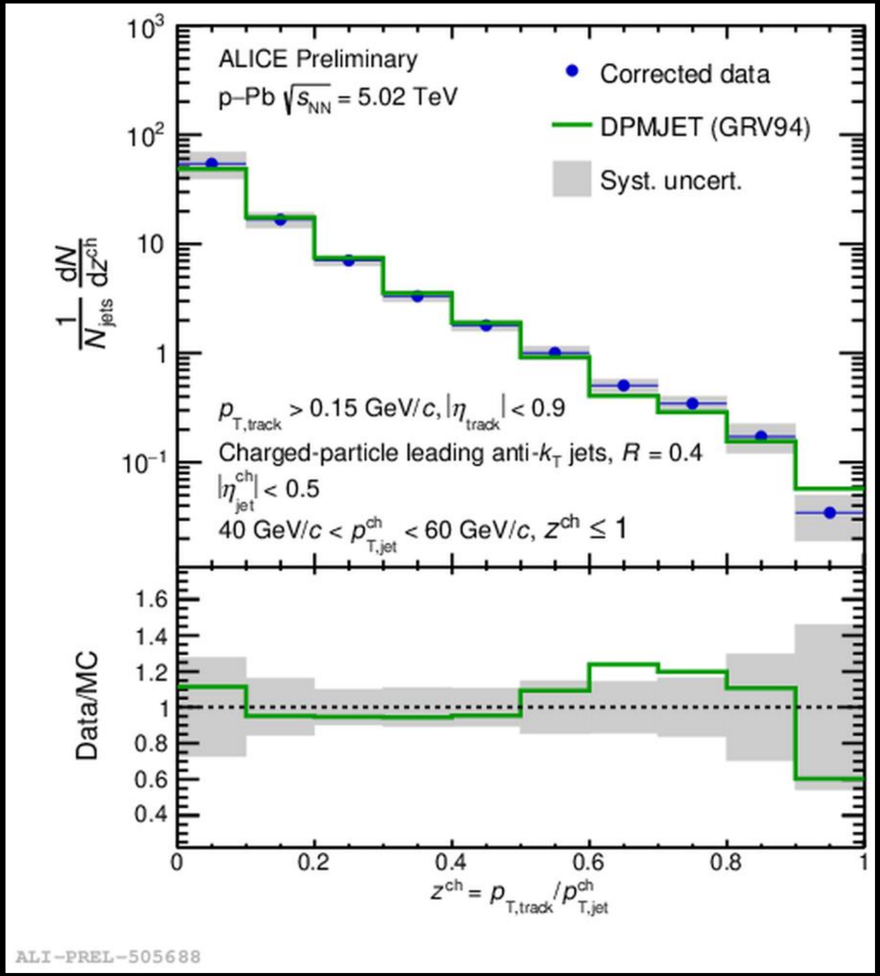


- ❑ $< N_{ch} >$ increases monotonically with leading $p^{ch}_{T,jet}$
- ❑ DPMJET (GRV94) explains the data within systematic uncertainties except at low $p^{ch}_{T,jet}$ ($<$ 30 GeV/c)

Prottoy Das for the ALICE Collaboration, arXiv:2208.01389 [nucl-ex]

Results and discussion: z^{ch}

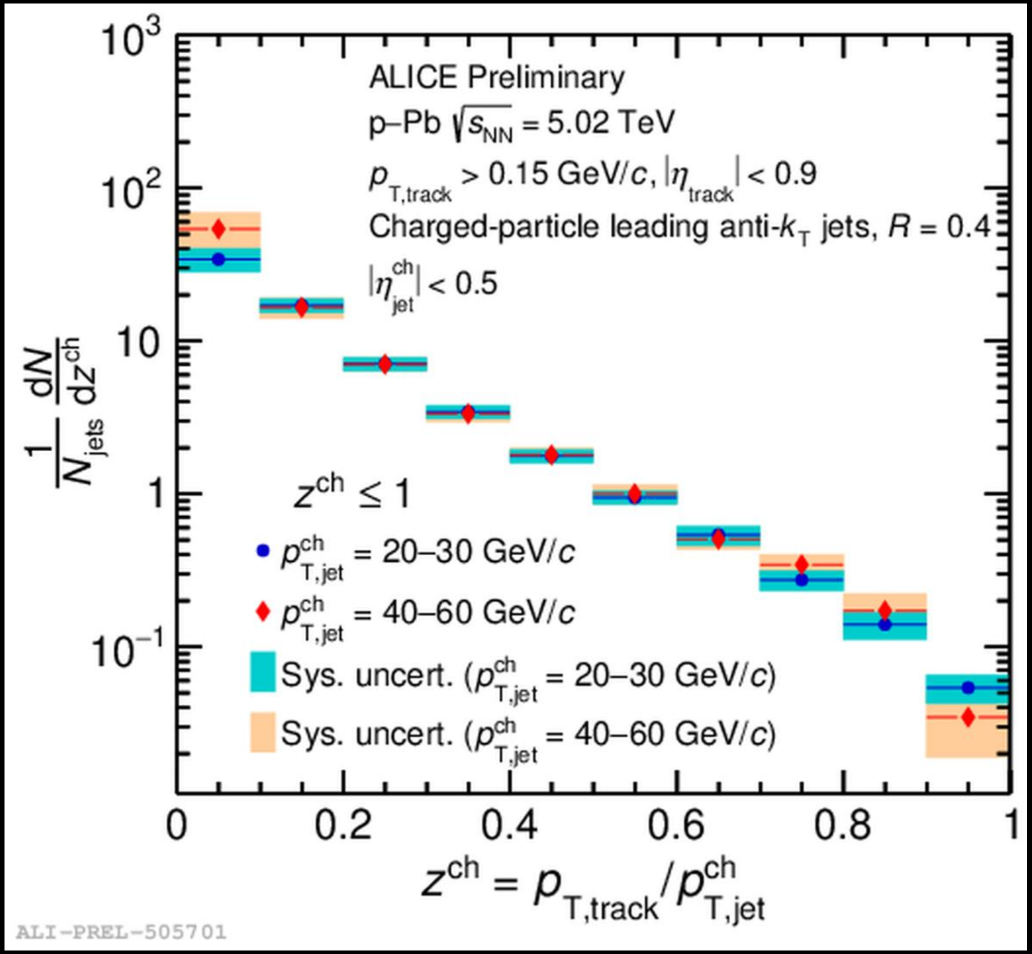




- DPMJET (GRV94) explains z^{ch} distributions in the intervals $20 < p^{ch}_{T,jet} < 30$ GeV/c and $40 < p^{ch}_{T,jet} < 60$ GeV/c within systematic uncertainties

Prottoy Das for the ALICE Collaboration, arXiv:2208.01389 [nucl-ex]

Results and discussion: z^{ch} scaling



- Scaling of jet fragmentation with leading $p^{ch}_{T,jet}$ is observed
  - The probability of jet constituents having a given fraction of jet p_T is independent of total jet p_T in this kinematic range

Prottoy Das for the ALICE Collaboration, arXiv:2208.01389 [nucl-ex]

Summary

- ✓ First measurement of charged-particle jet properties ($< N_{\mathrm{ch}} >$, z^{ch}) for leading $p_{\mathrm{T,jet}}^{\mathrm{ch}}$ = 10-100 GeV/c in minimum bias p-Pb collisions at $\sqrt{s_{\mathrm{NN}}}$ = 5.02 TeV with ALICE
- ✓ DPMJET (GRV94) explains the data within systematic uncertainties
- ✓ Scaling of charged-particle jet fragmentation with leading $p_{\mathrm{T,jet}}^{\mathrm{ch}}$ observed

Outlook

- ✓ Comparison to minimum bias pp results → cold nuclear matter effects
- ✓ Multiplicity dependent study in p-Pb collisions → possible medium formation

See Debjani's poster on "Multiplicity dependence of intra-jet properties in pp collisions at 13 TeV with ALICE", PoS ICHEP2022 (2022) 927

Thank you

Backup

DPMJET model

- ✓ Based on Dual Parton Model (DPM) for the description of soft and multi-particle interactions in high-energy collisions
- ✓ Can be used to simulate a wide range of hh, γh, γγ, AB and γA collisions for energies ranging from few GeV to cosmic-ray interactions of the highest energy scale
- ✓ Soft processes → pomeron exchange under the Regge theory scheme
- ✓ Hard processes → perturbative parton scattering approach
- ✓ Hadronic interaction model for pp collisions → derived from PHOJET
- ✓ Fragmentation configurations → acceded from PYTHIA Lund model
- ✓ The physics models and flexibility of DPMJET allows for the calculations of total, (quasi) elastic as well as production cross-sections for various colliding systems at high energies

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