Measurements of heavy-flavour correlations and jets with ALICE at the LHC

Salvatore Aiola,
on behalf of the ALICE Collaboration

Yale

Hard Probes 2018
Aix-Les-Bains, Savoie, France
October 1-5, 2018

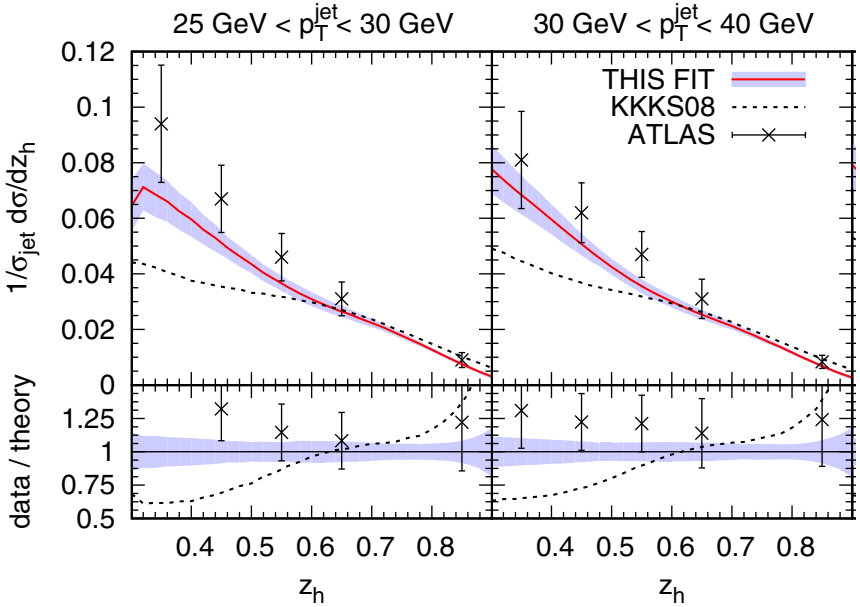
U.S. DEPARTMENT OF ENERGY | Office of Science

Introduction

Heavy-Flavor Jets and Correlations

pp collisions

- HF observables calculable in pQCD down to $p_{\mathrm{T}} \approx 0$
  FONLL, GM-VFNS, POWHEG,...
- HF fragmentation



D.P. Anderle et al., PRD 96 (2017) 034028

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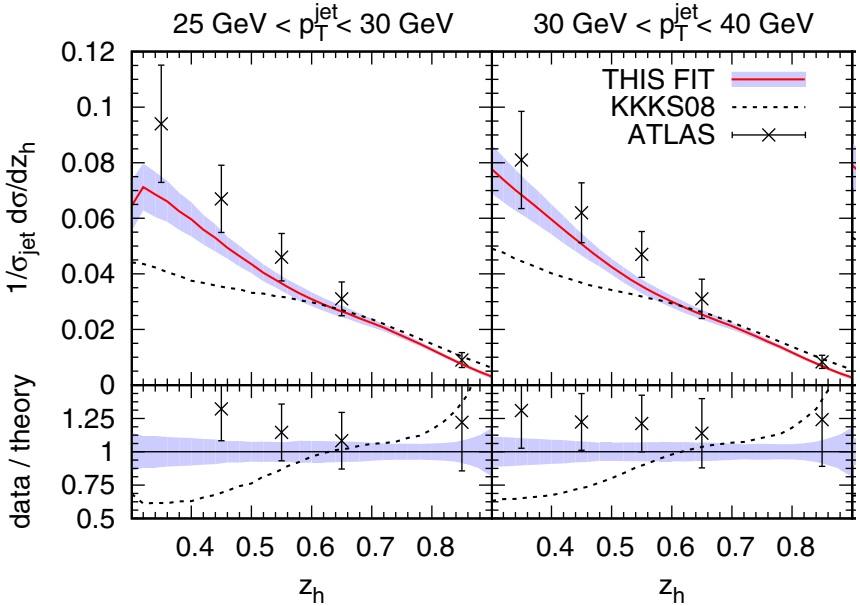

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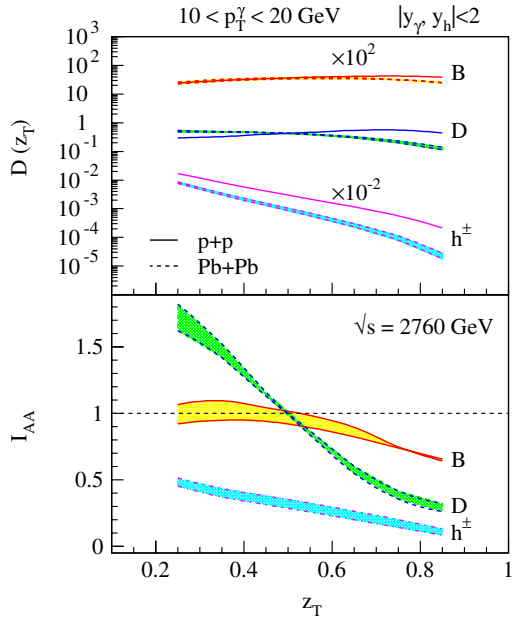
Pb–Pb collisions

- Color/mass dependence of in-medium energy loss
- Modification of internal jet sub-structure



I.Vitev

PRD 84 (2011) 014034

γ-tagged jets

$$z_{\mathrm{T}} = \frac{p_{\mathrm{T,h}}}{p_{\mathrm{T},\gamma}}$$

Heavy-Flavor Jets and Correlations

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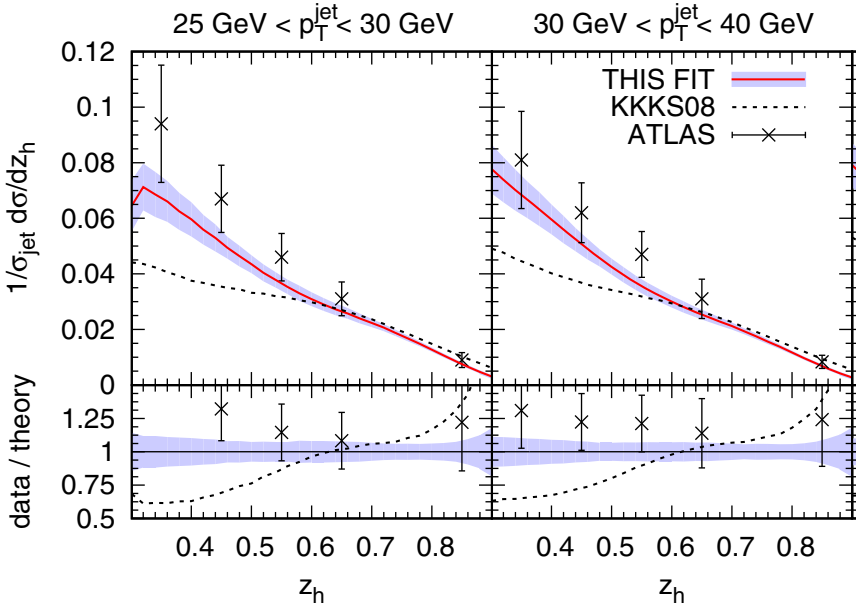

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Pb–Pb collisions

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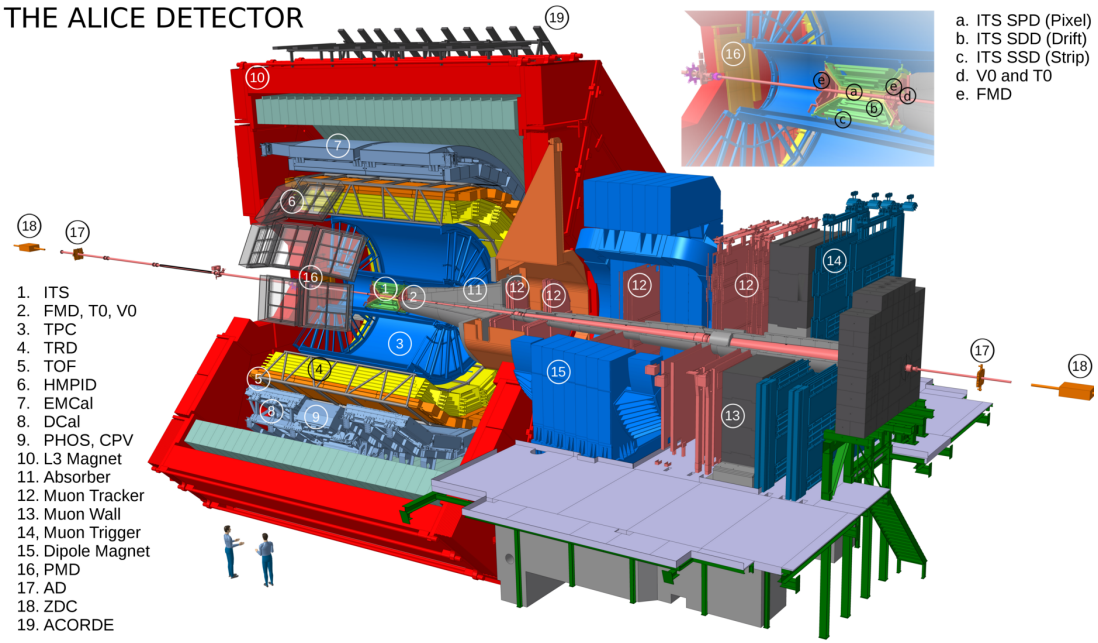
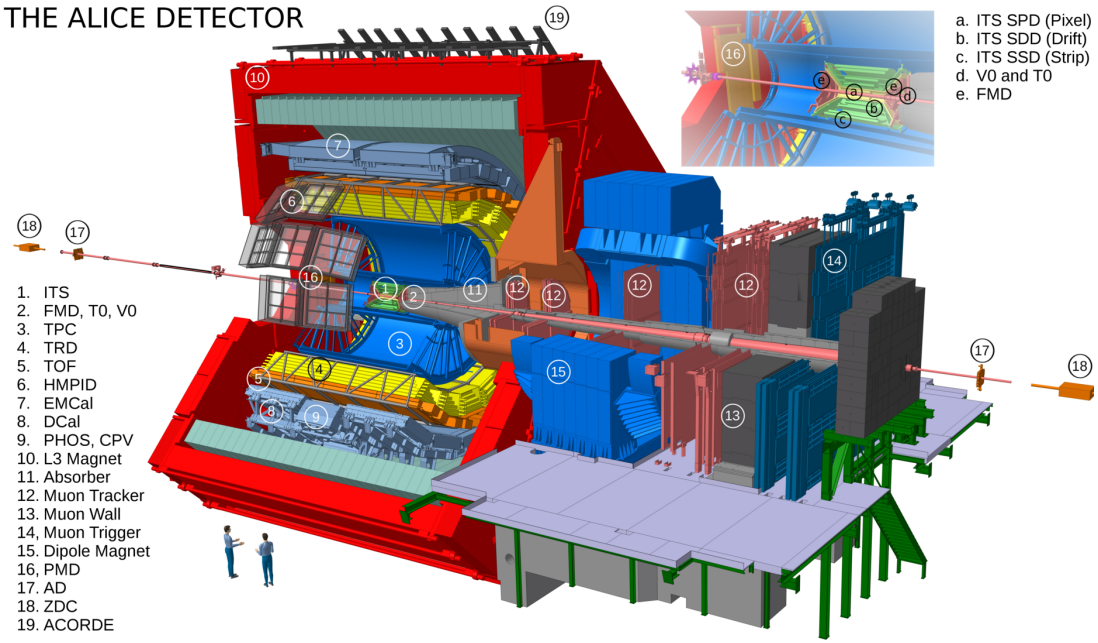
p–Pb collisions

- Cold nuclear matter effects?
- Collectivity?



- Low-p_{T} tracking
- Secondary vertex: ITS
- K/π/e$^{\pm}$ PID
  - TPC dE/dx
  - Time-of-Flight (TOF)
  - EMCal: E/p



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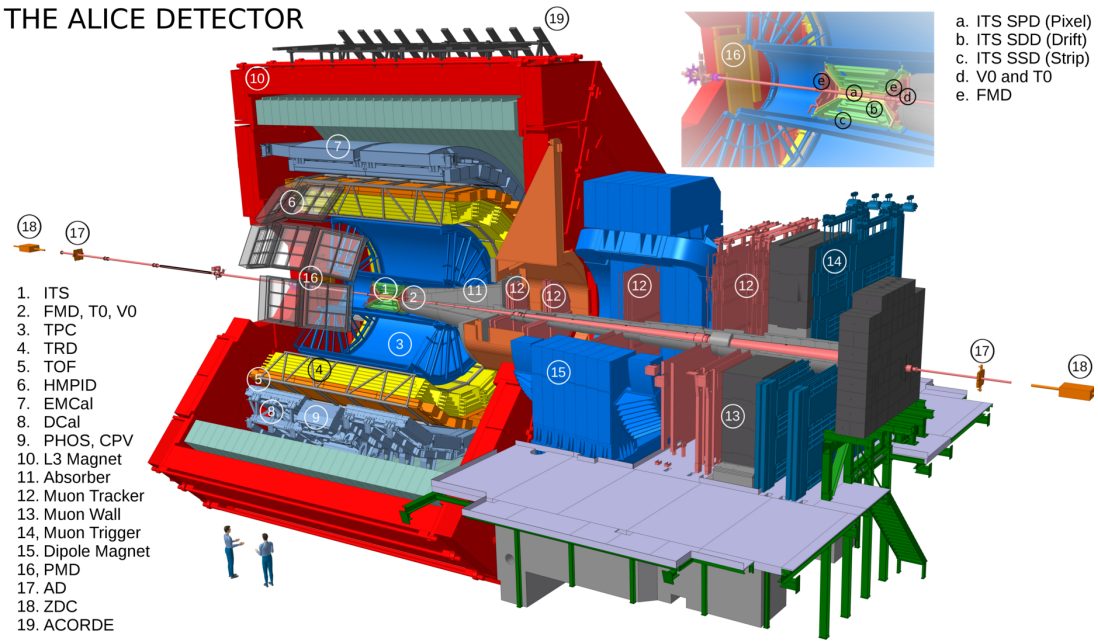

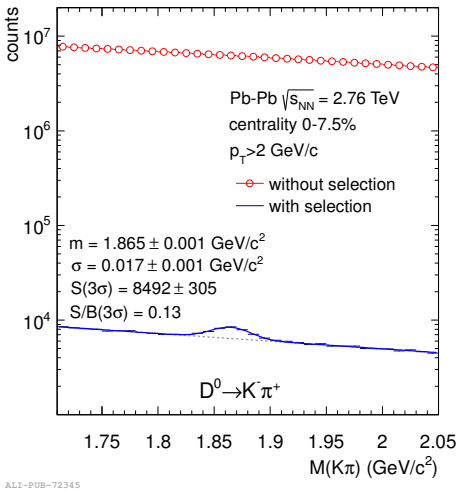

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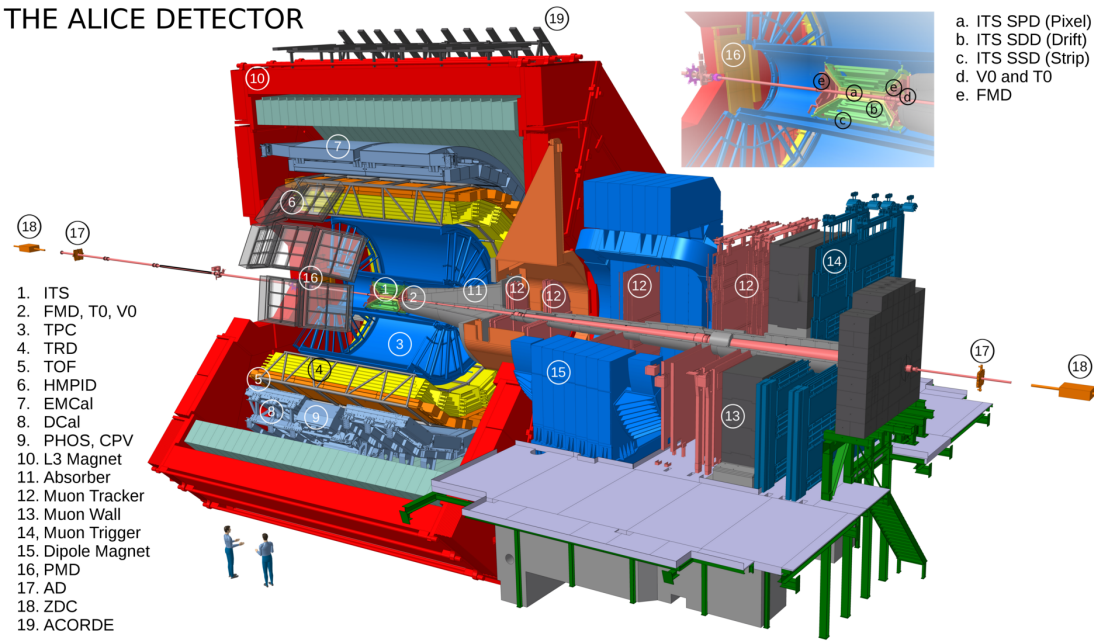
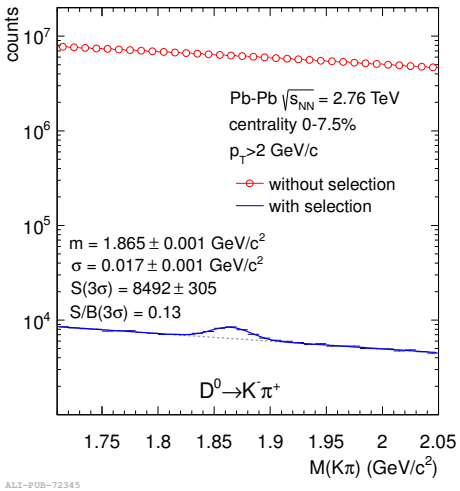
ALICE, International Journal of Modern Physics A 29 (2014) 1430044





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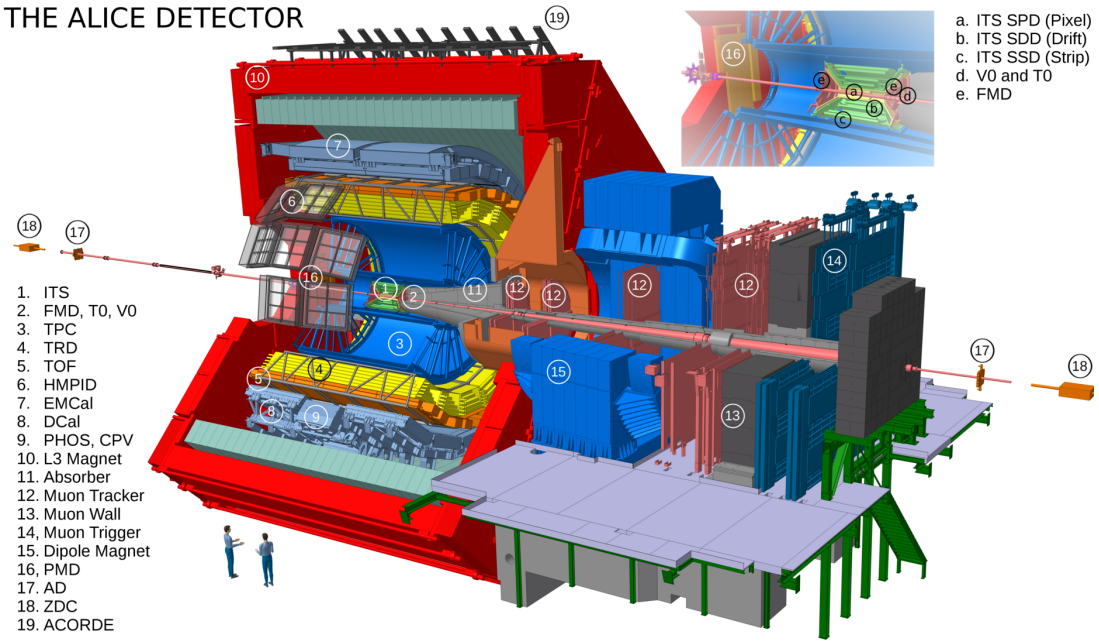

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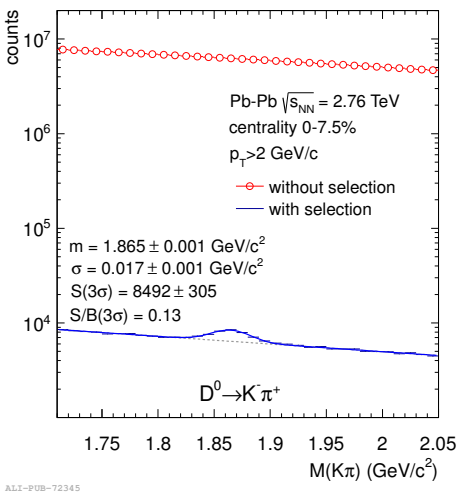

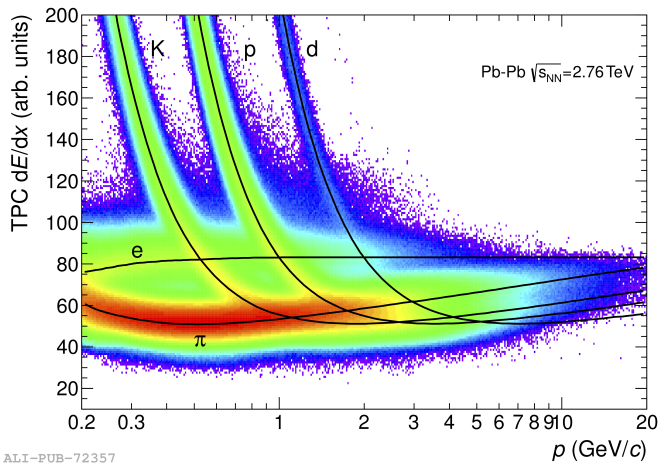

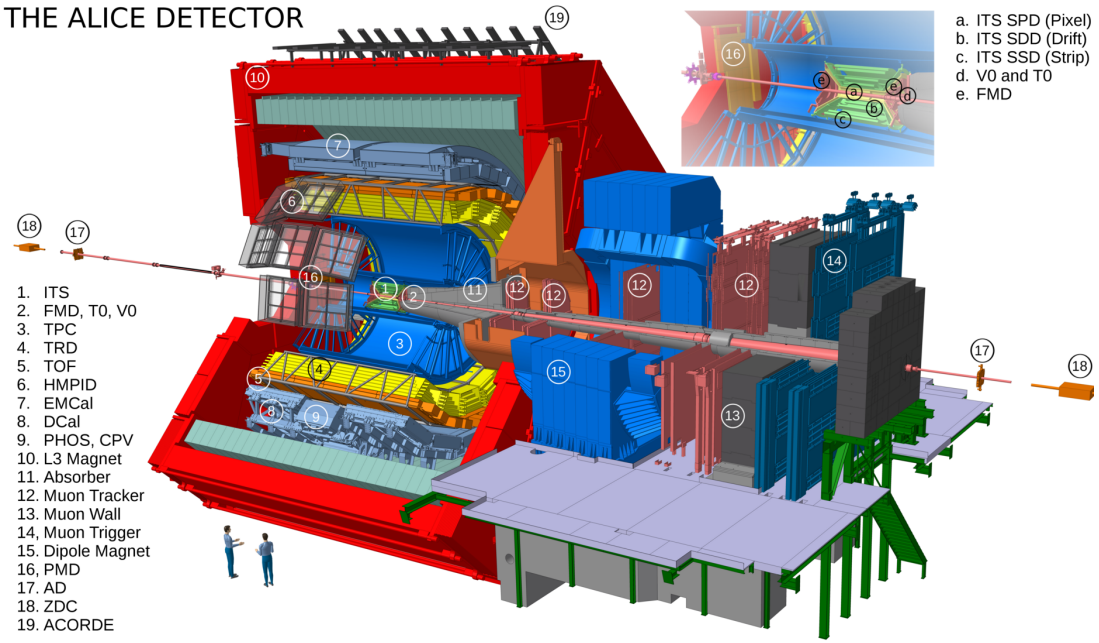

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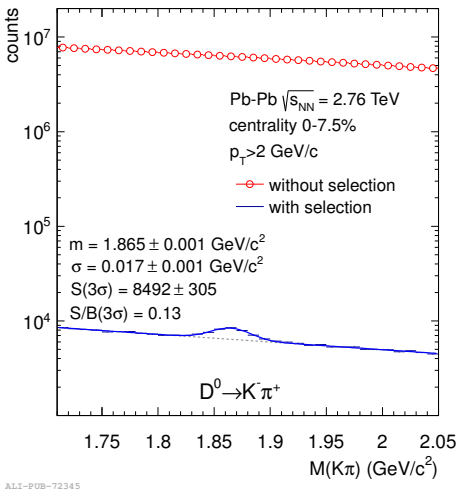

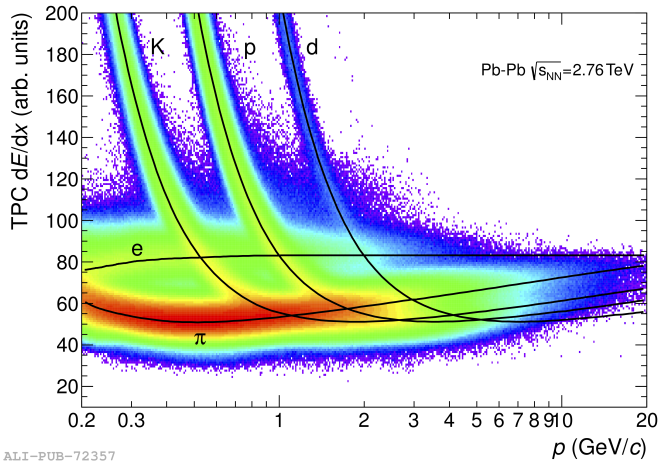

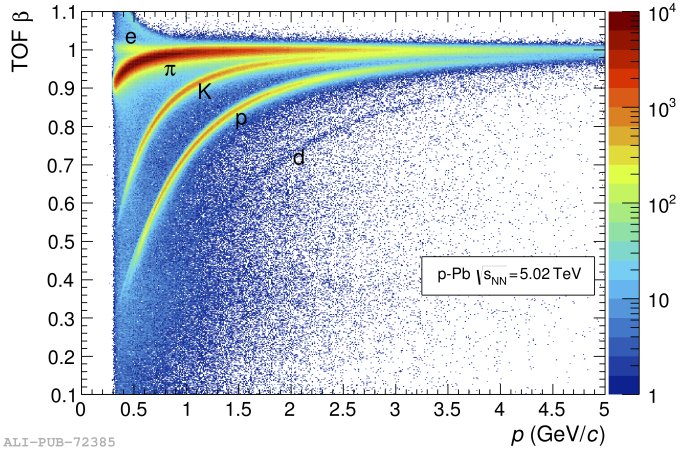

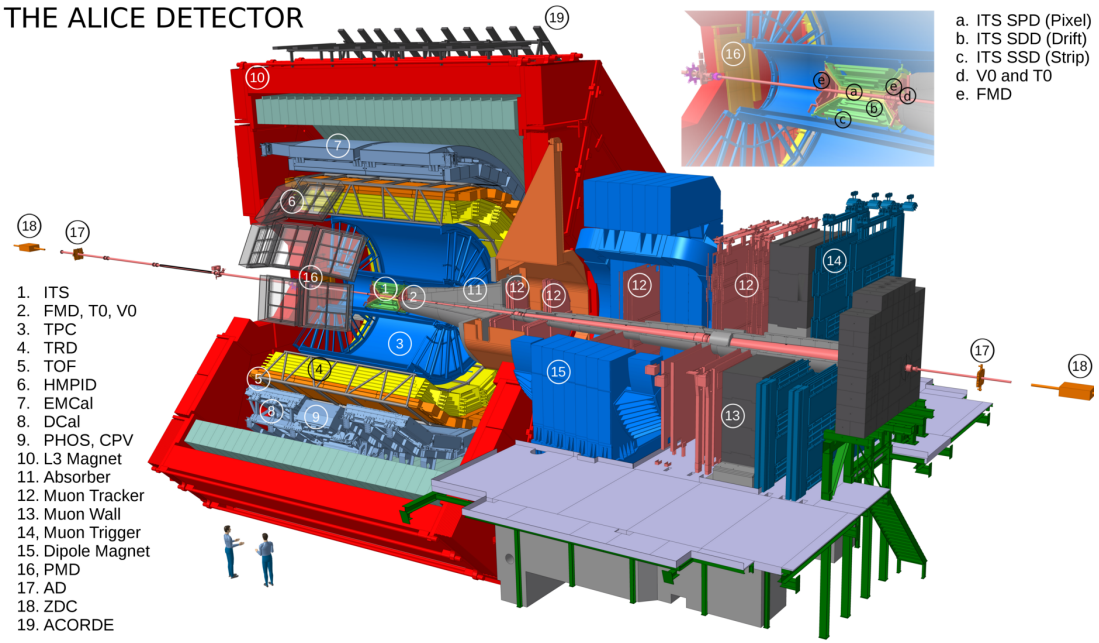

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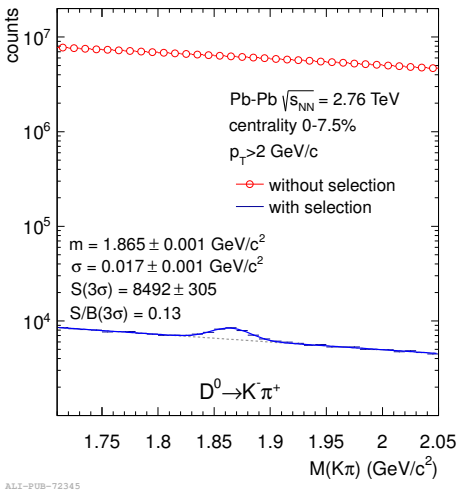

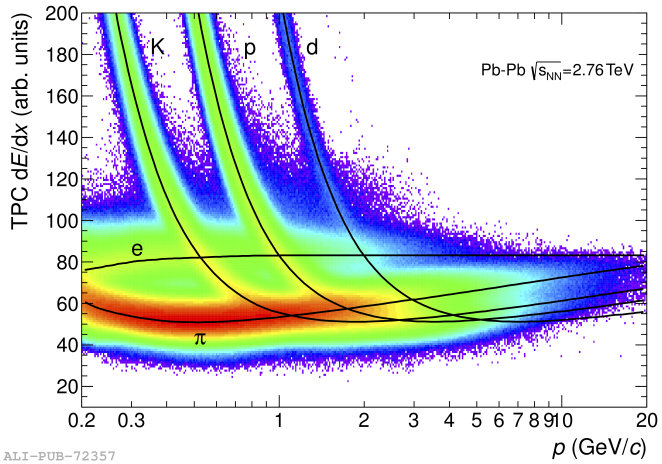

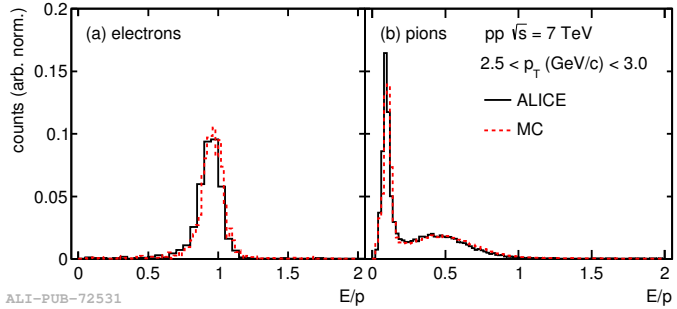

Heavy-Flavor Jets

Heavy-flavor electron (HFe) Jet Reconstruction

- HF electrons: c,b$\rightarrow$D,B$\rightarrow e^{\pm}$
  - TPC dE/dx + EMCal E/p
  - $p_{\mathrm{T,e}} > 4$ GeV/c
- Jets
  - Track-based
  - anti-k_{T}, $R = 0.3$
  - $p_{\mathrm{T,ch\,jet}} > 10$ GeV/c
- Jets containing identified electrons among their constituents
- Subtract jets containing non-HF (photonic) electrons (inv. mass)
- Corrections
  - Residual contamination from photonic electrons
  - Reconstruction efficiency
  - Detector $p_{\mathrm{T,ch\,jet}}$ resolution $\approx 17 - 20\%$ (SVD unfolding)

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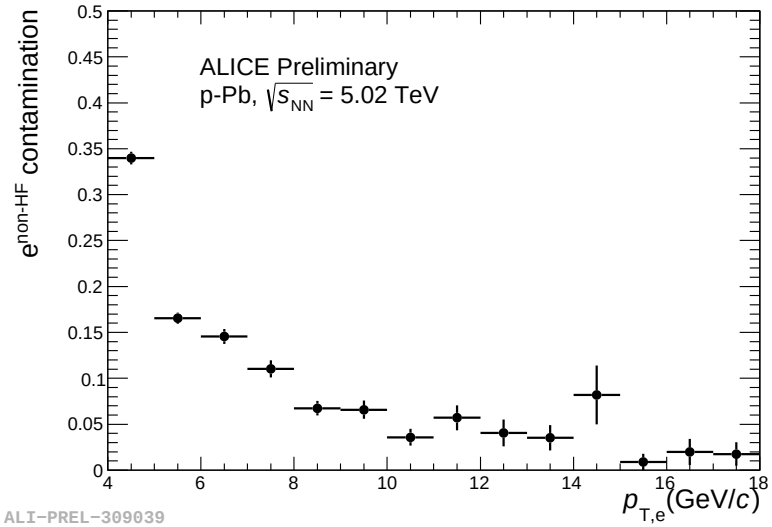

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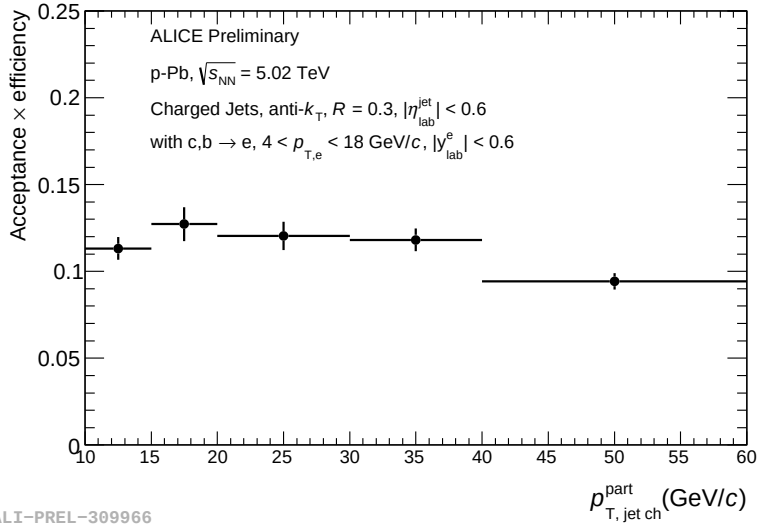

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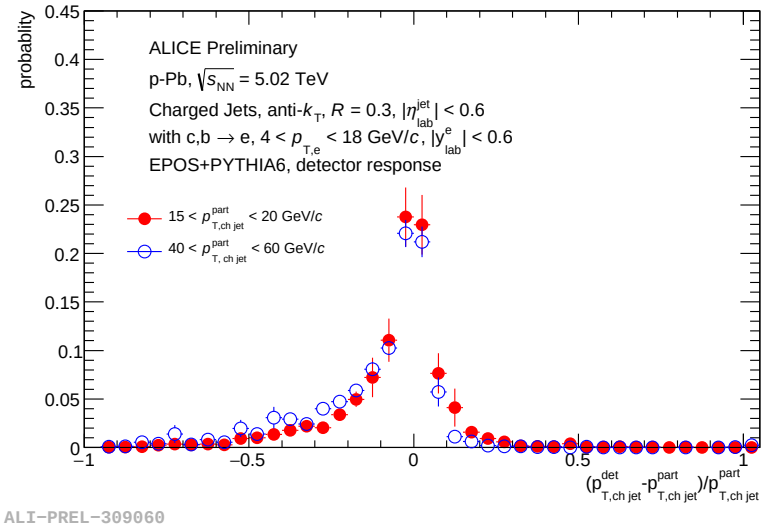

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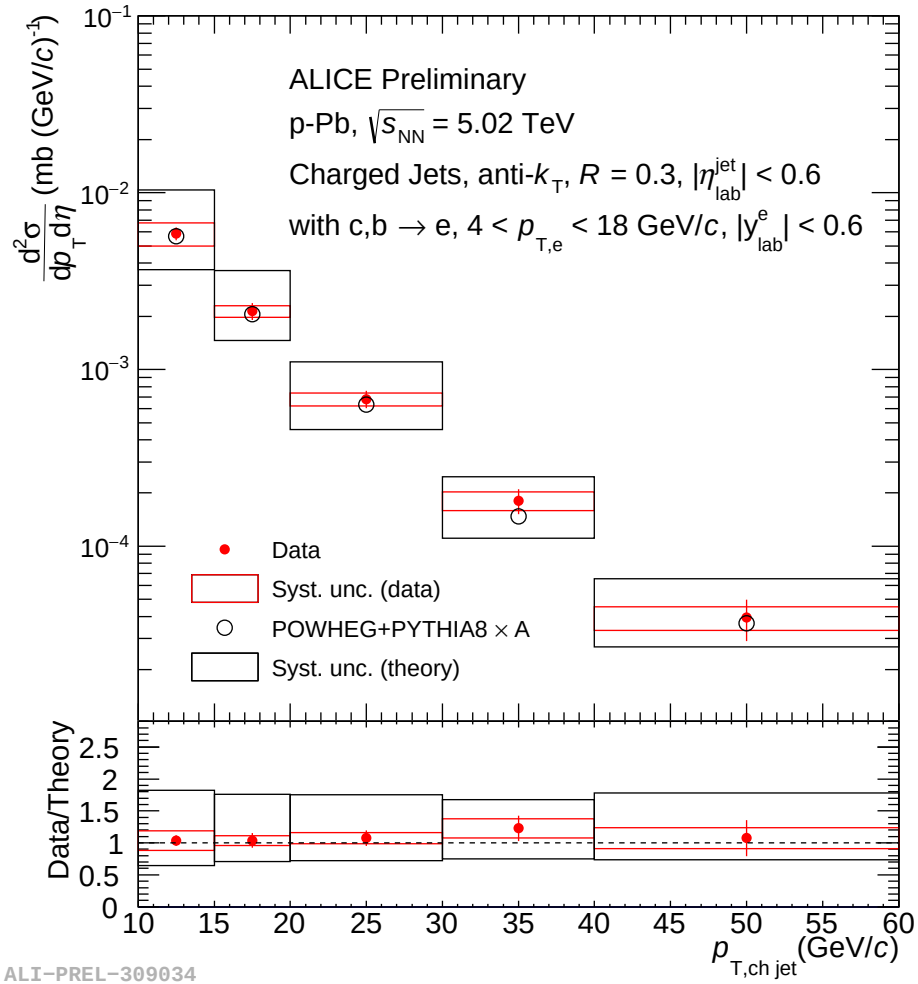
HFe Jets in p–Pb at $\sqrt{s_{NN}} = 5.02$ TeV (NEW)



Includes HFe from beauty and charm

Agreement with NLO pQCD **POWHEG+PYTHIA8** simulation

No evidence of CNM effects

D^0 Jet Reconstruction

- D^0 Meson
  - Decay channel: $\mathrm{D}^0 \to \mathrm{K}^-\pi^+$, $\mathrm{BR} = 3.89\%$ [PDG PRD 98 (2018) 030001]
  - TPC dE/dx + TOF PID for K/π discrimination
  - Topological selections (secondary vertex)
  - $p_{\mathrm{T,D}} > 3$ GeV/c
- Jet finding
  - D^0-meson candidates replace the decay products in the jet finding
  - Track-based
  - anti-k_{T}, $R = 0.3, 0.4$
  - $p_{\mathrm{T,ch\,jet}} > 5$ GeV/c

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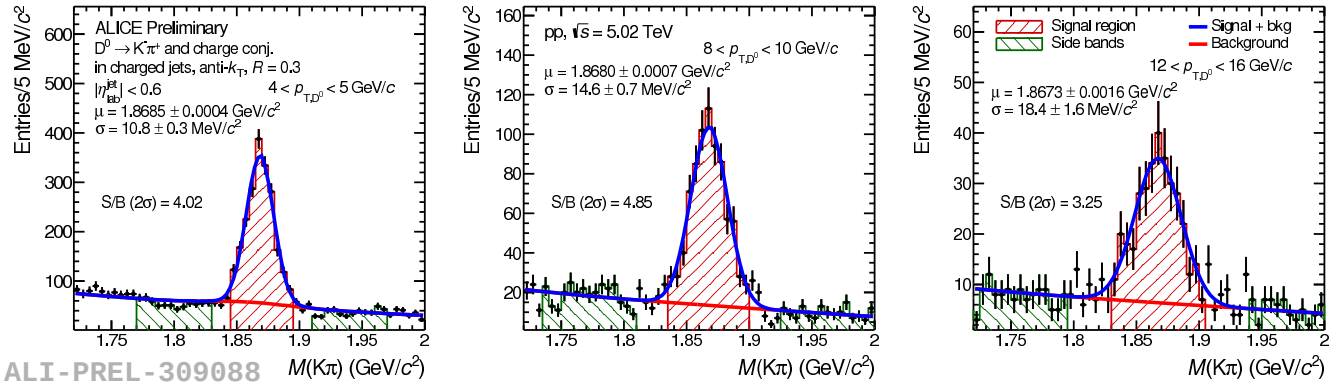
D^0 Jet Reconstruction

$4 < p_{T,D} < 5$ GeV/c $8 < p_{T,D} < 10$ GeV/c $12 < p_{T,D} < 16$ GeV/c



- Invariant mass analysis to extract signal in bins of $p_{T,D}$
- Identify signal-region and side-bands

D^0 Jet Reconstruction

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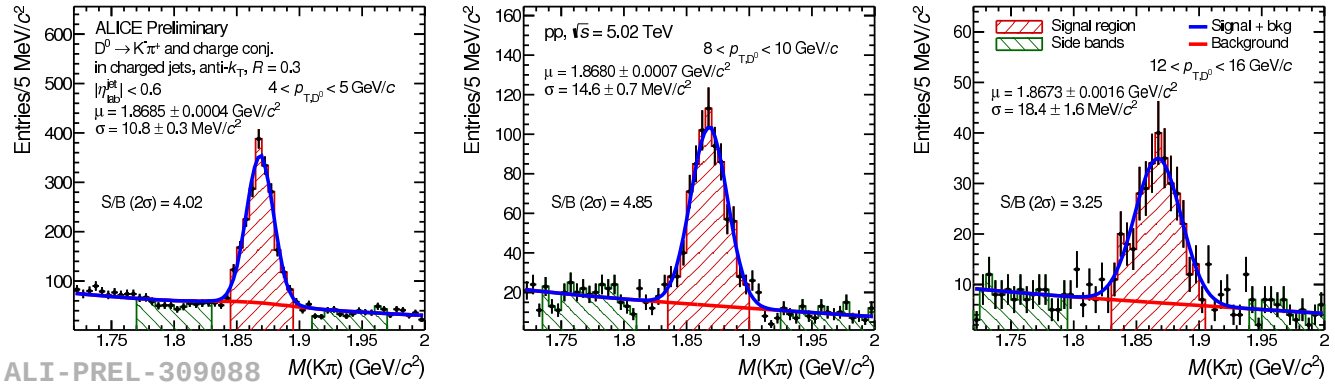
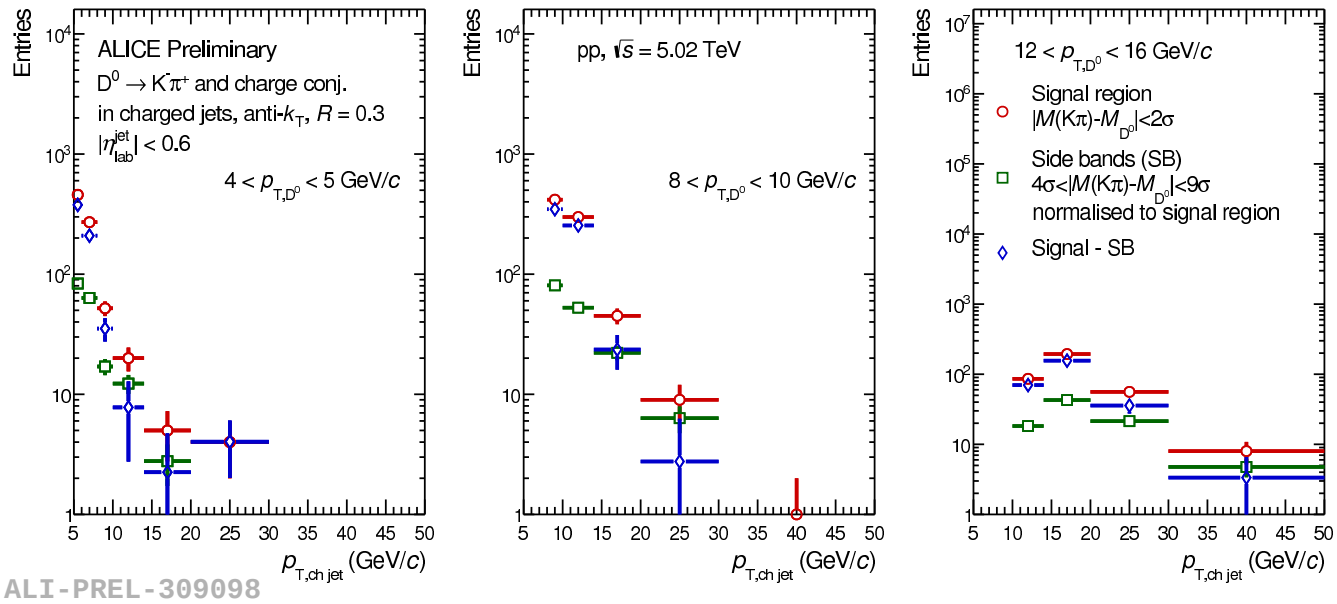
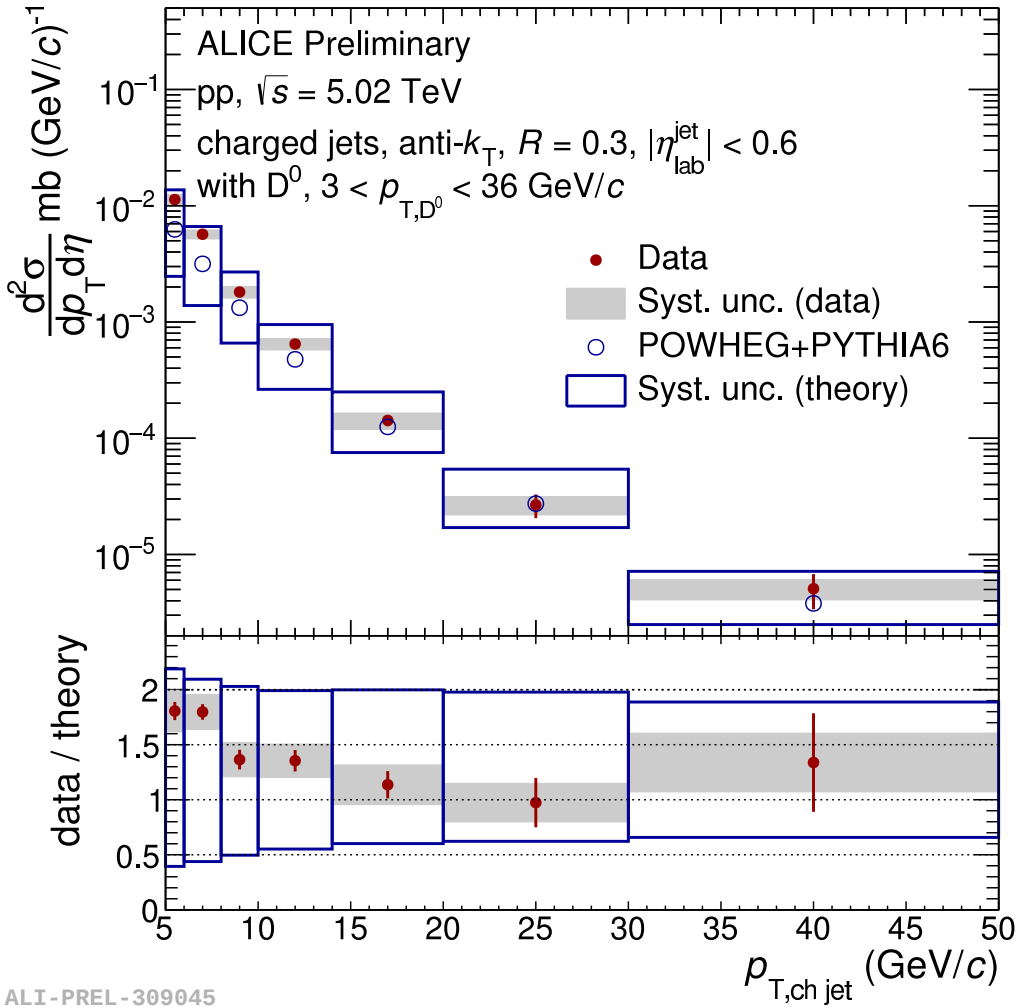




Subtract **side-band** from **signal-region** distributions to obtain the **raw yield**

D^0 Jets in pp at $\sqrt{s} = 5.02$ TeV (NEW)

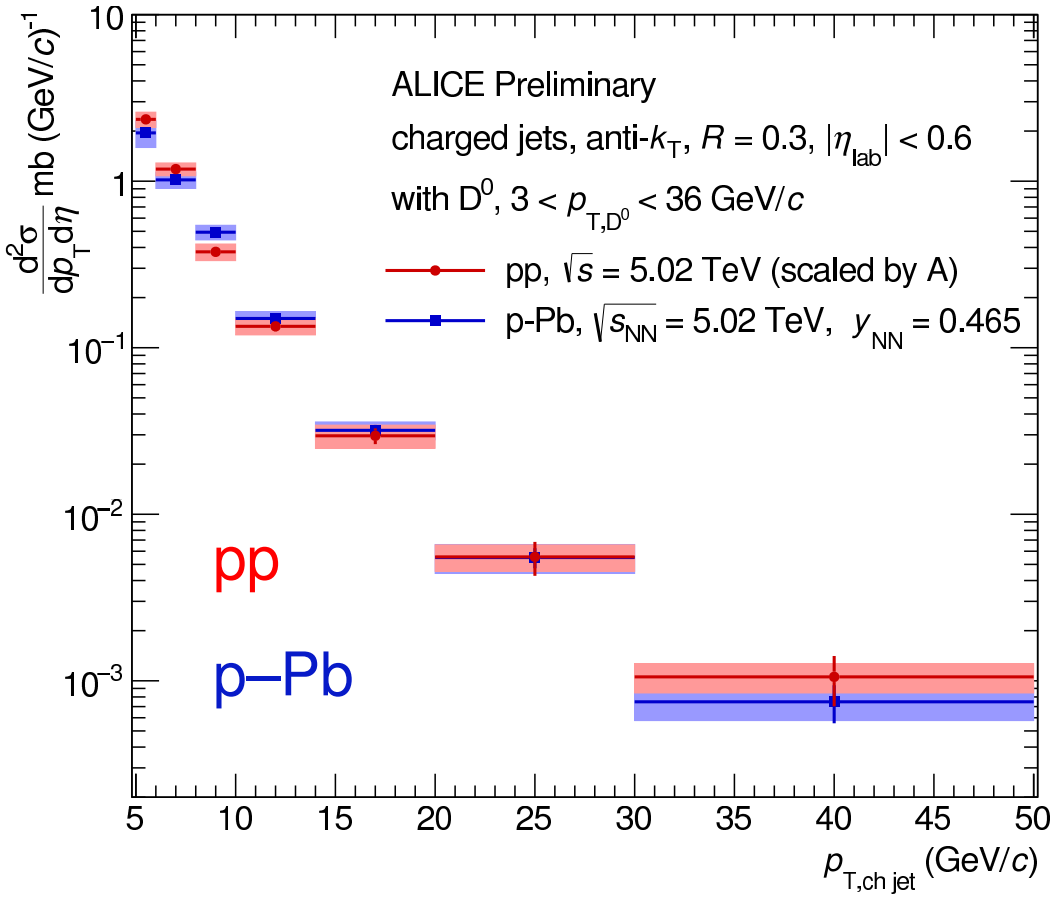


Corrections

- Reconstruction efficiency
- B Feed-Down
  POWHEG-based
- Detector resolution
  Bayesian unfolding

Agreement
with NLO pQCD
POWHEG+PYTHIA6
simulation

D^0 Jets in pp and p–Pb at $\sqrt{s_{NN}} = 5.02$ TeV (NEW)



ALI-PREL-309078

- Subtraction of the **average background density** from the reconstructed $p_{T,ch\ jet}$

$$p_{T,ch\ jet}^{raw} = p_{T,ch\ jet}^{reco} - A_{jet} \times \rho$$

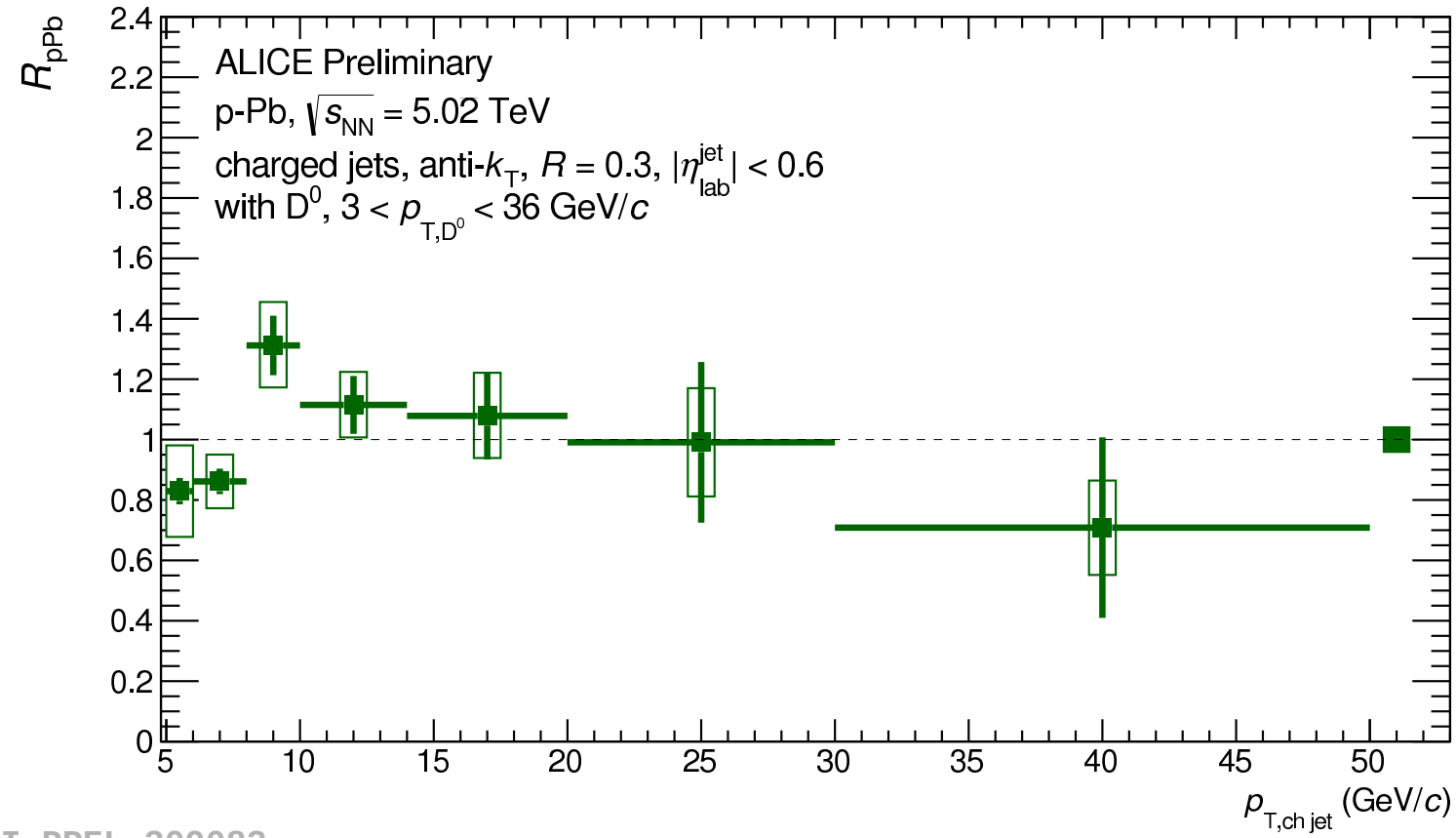
PLB 659 (2008) 119, JHEP 08 (2012) 130

- Reconstruction efficiency
- B Feed-Down subtraction

  POWHEG-based
- Detector resolution + **background fluctuations**

  Bayesian unfolding

R_{pPb} of D^0 Jets, $\sqrt{s_{NN}} = 5.02$ TeV (NEW)

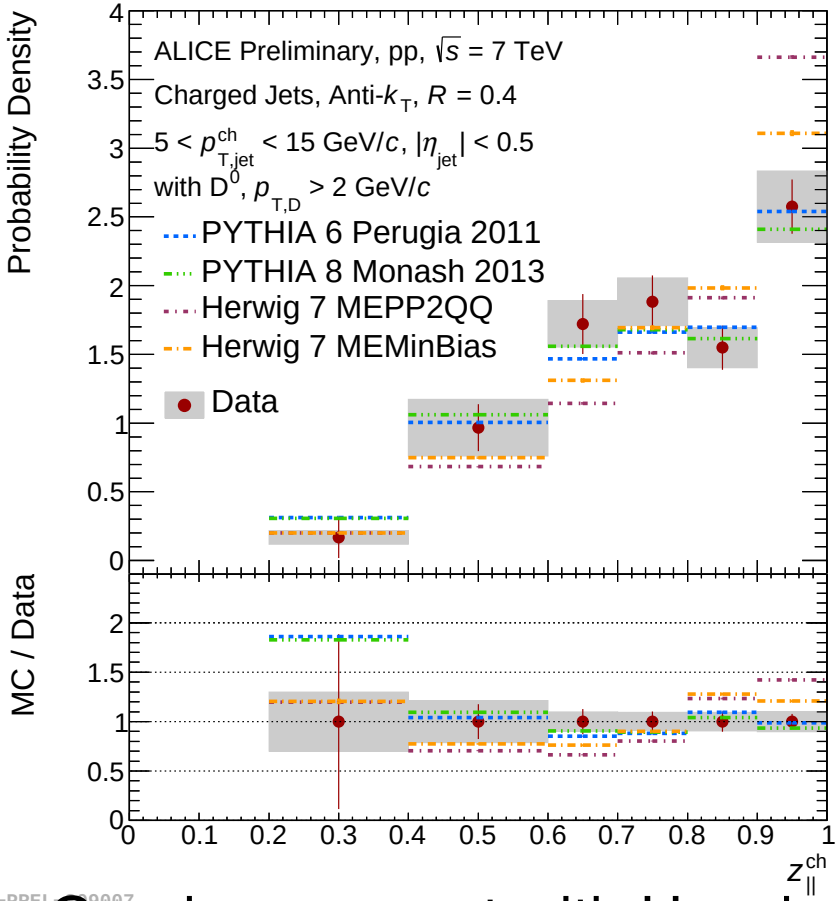


ALI-PREL-309083

$R_{pPb} \approx 1$ within uncertainties

Fragmentation of D^0-Meson Jets in pp at $\sqrt{s} = 7$ TeV

$5 < p_{T,\mathrm{ch\,jet}} < 15$ GeV/c



Momentum fraction carried by the D^0 meson in the direction of the jet axis

$$z_{||}^{\mathrm{ch}} = \frac{\vec{p}_{\mathrm{jet}}^{\,\mathrm{ch}} \cdot \vec{p}_{\mathrm{D}}}{\vec{p}_{\mathrm{jet}}^{\,\mathrm{ch}} \cdot \vec{p}_{\mathrm{jet}}^{\,\mathrm{ch}}}$$

Good agreement with Herwig++ 7 and PYTHIA6/8 generators

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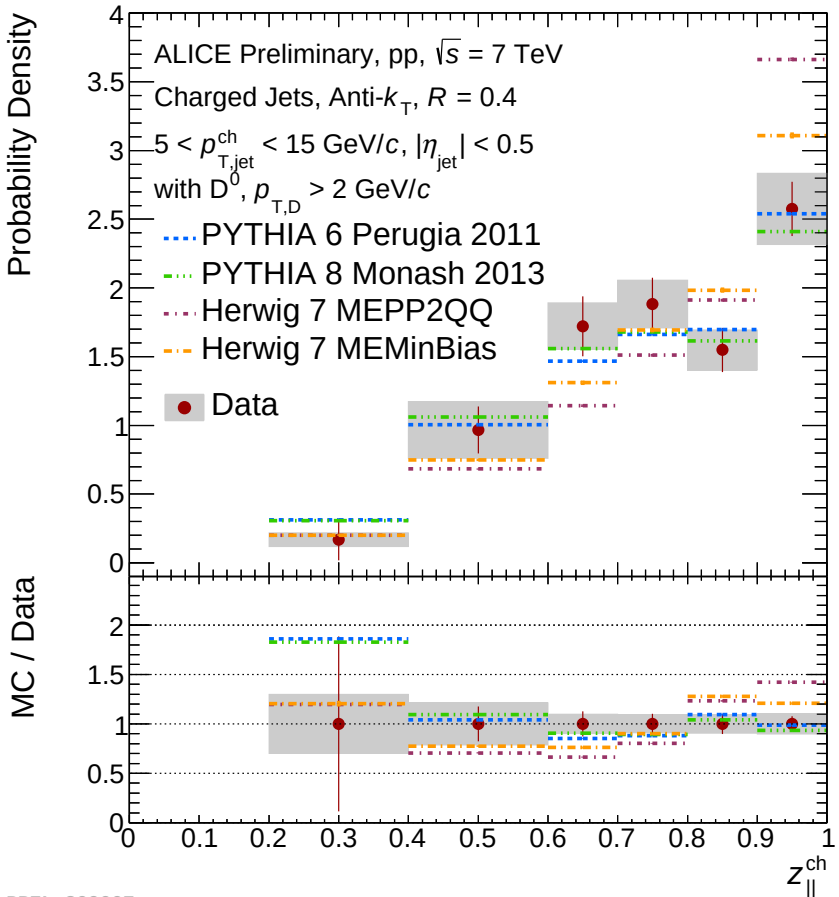
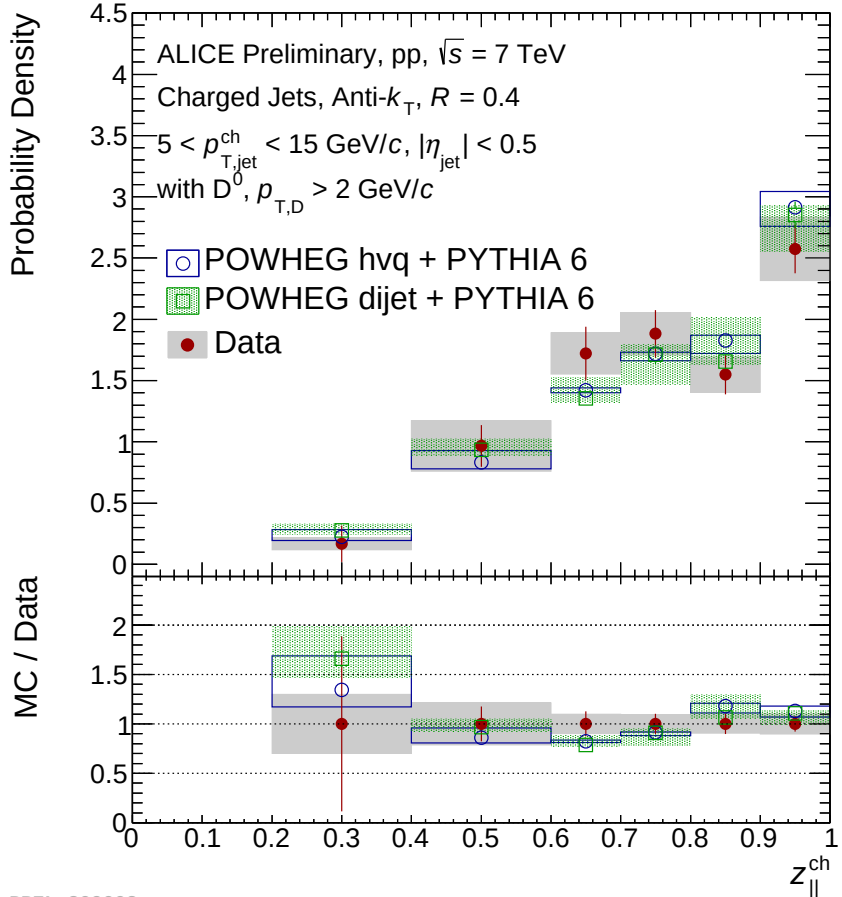
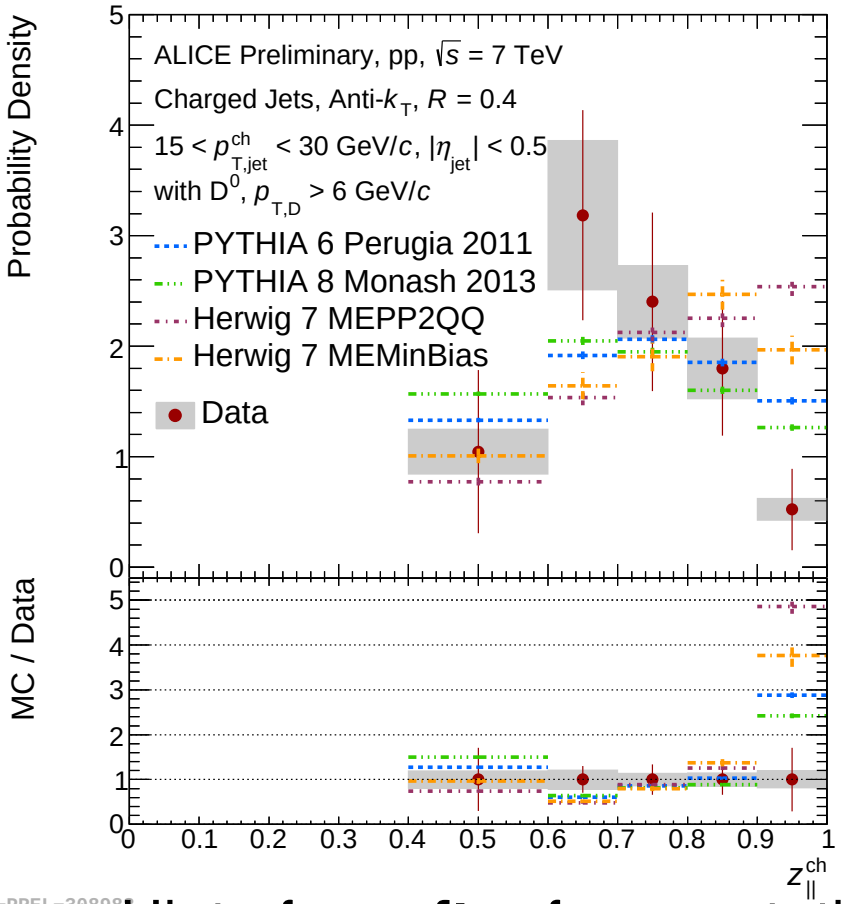


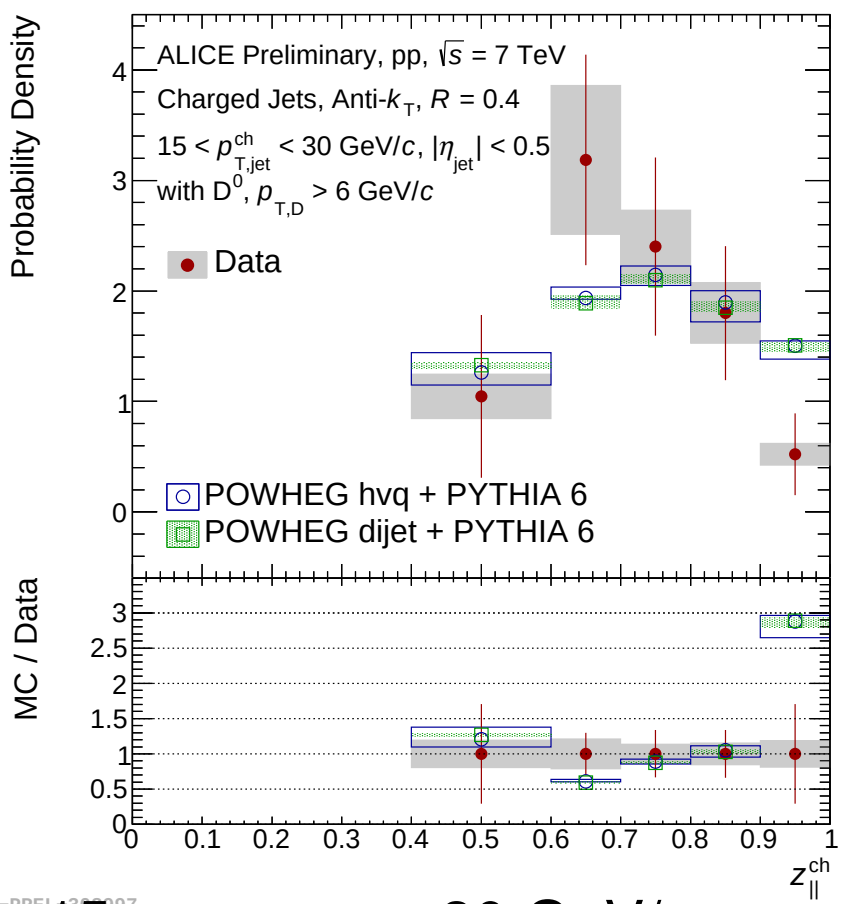


Also with pQCD NLO POWHEG+PYTHIA6 simulation

Fragmentation of D^0-Meson Jets in pp at $\sqrt{s} = 7$ TeV

$15 < p_{T,\mathrm{ch\,jet}} < 30$ GeV/c





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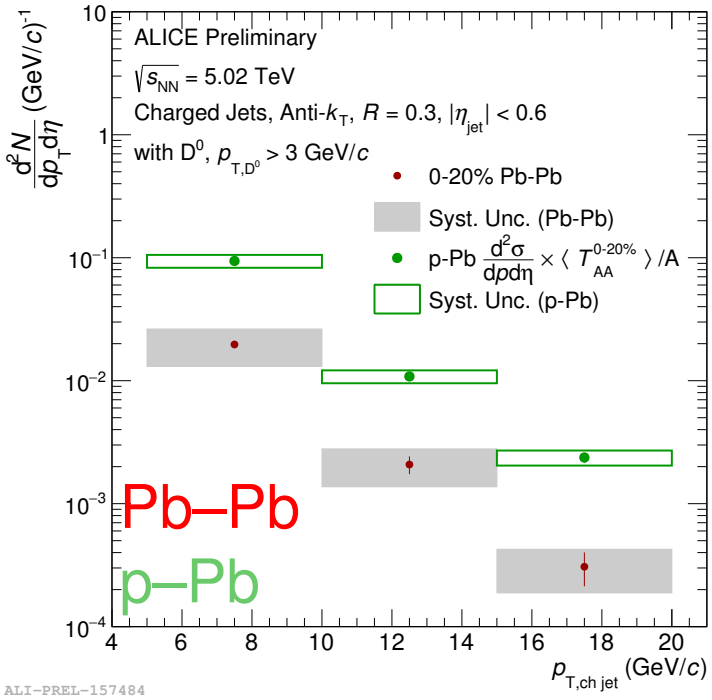
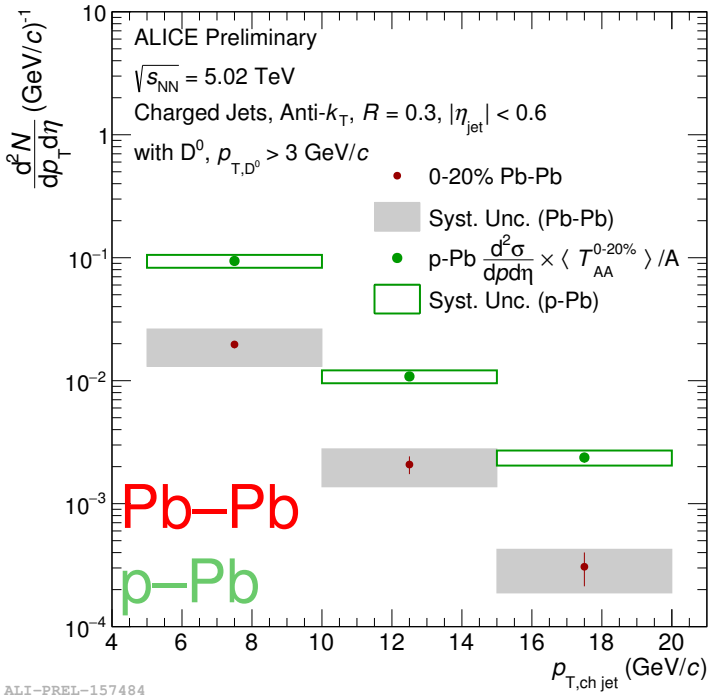
Hint of a **softer** fragmentation for $15 < p_{T,\mathrm{ch\,jet}} < 30$ GeV/c

R_{AA} of D^0-Meson Jets, Pb–Pb at $\sqrt{s_{NN}} = 5.02$ TeV

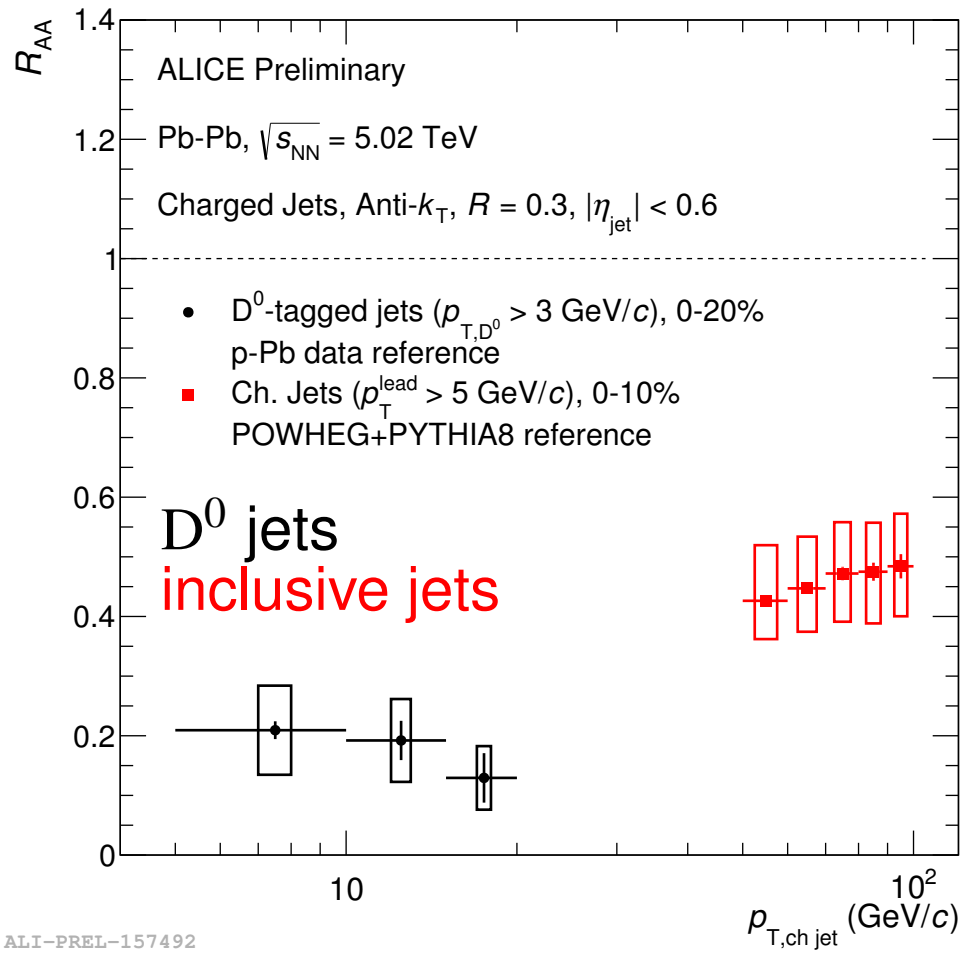


Fully corrected, including
UE background fluctuations
as in JHEP 30 (2014) 013

R_{AA} of D^0-Meson Jets, Pb–Pb at $\sqrt{s_{NN}} = 5.02$ TeV



$R_{AA} \sim 0.2$
for $5 < p_{T,ch\,jet} < 20$ GeV/c
Similar trend of
inclusive jets



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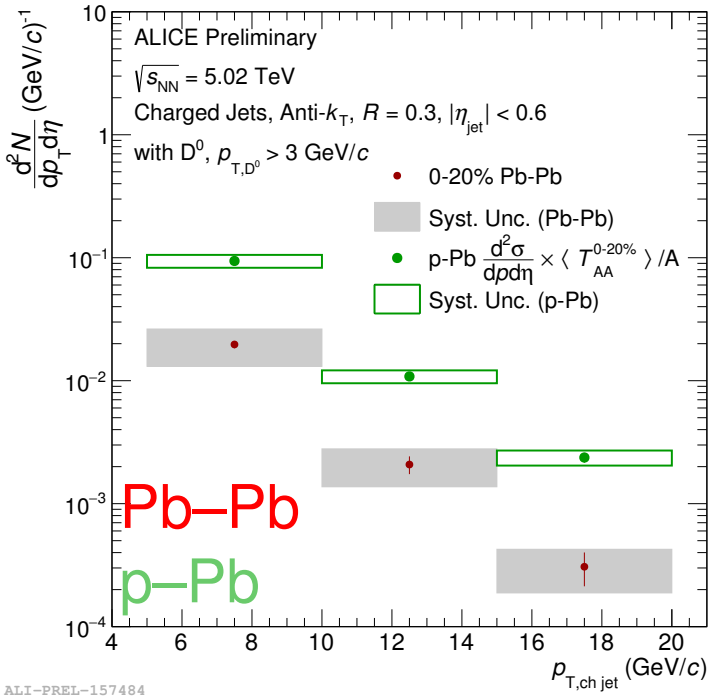

$R_{AA} \sim 0.2$
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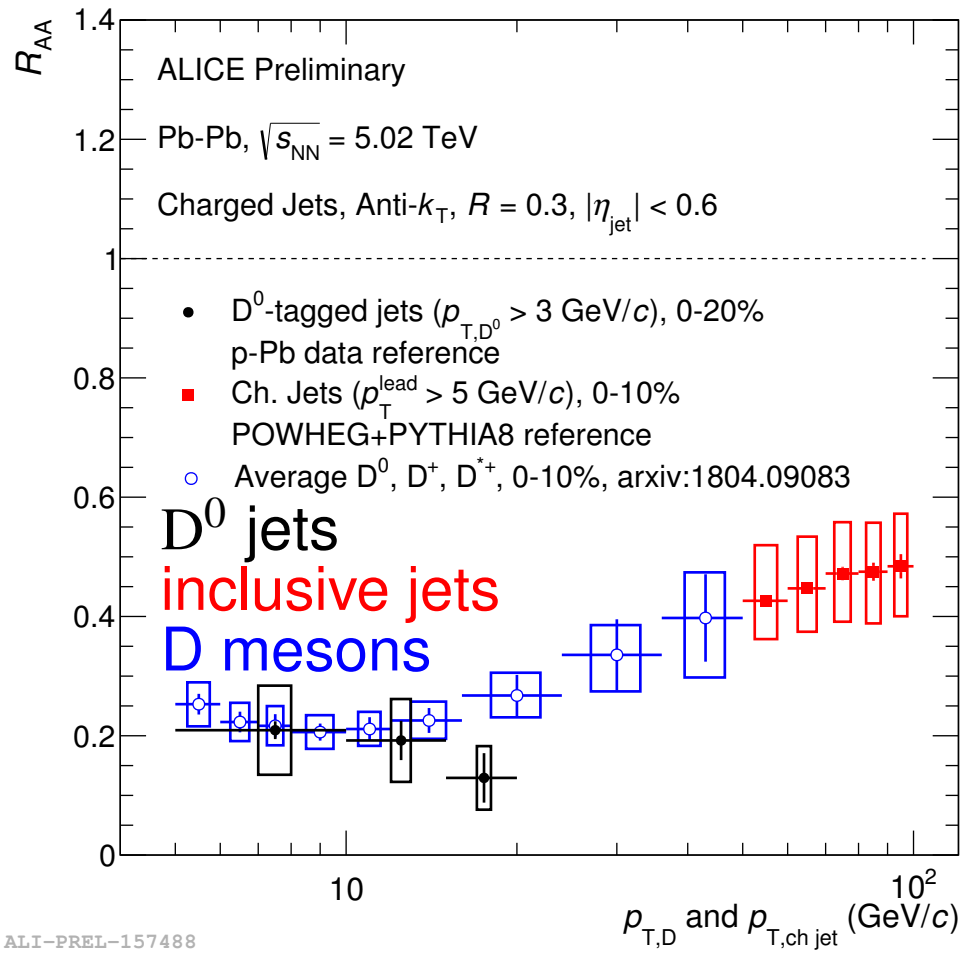
SImilar suppression of
D mesons



D-Meson – Hadron Correlations

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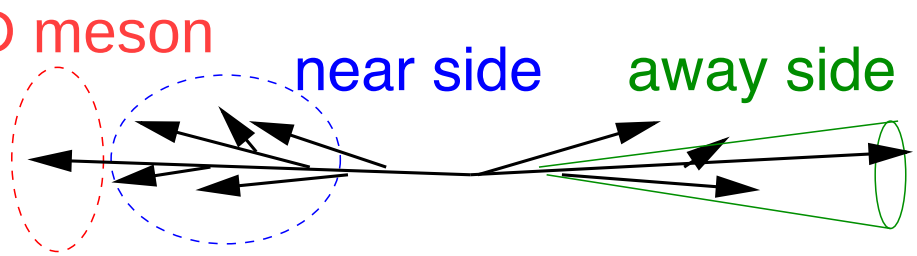
- Trigger particle: D meson
- Associated particles: charged tracks
- Finite acceptance correction with event mixing
- B feed-down subtracted
  Based on FONLL beauty cross section and correlation templates from PYTHIA
- Fit performed with a double Gaussian and a constant for the baseline



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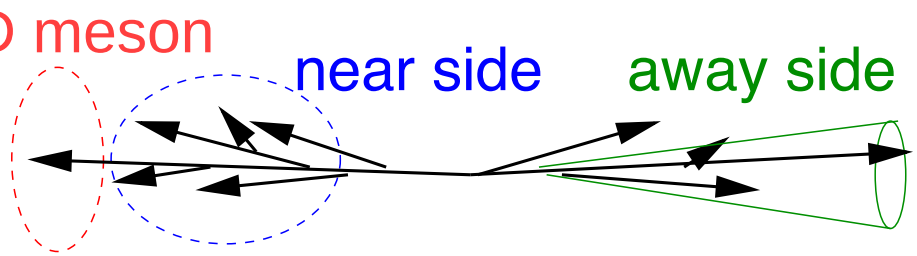

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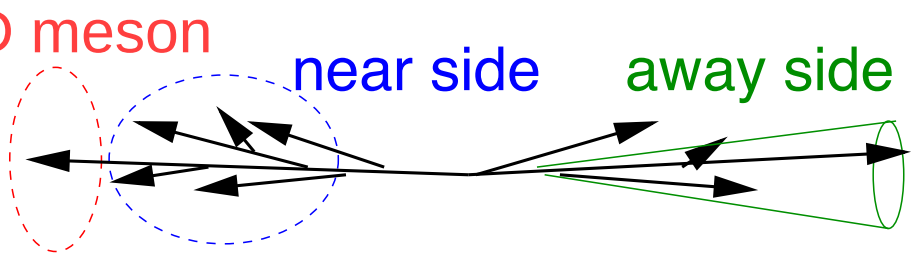

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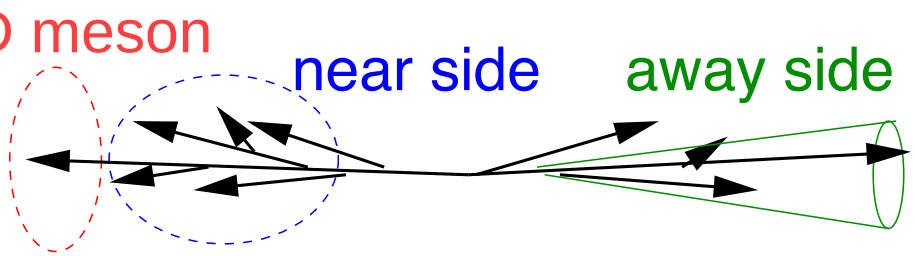
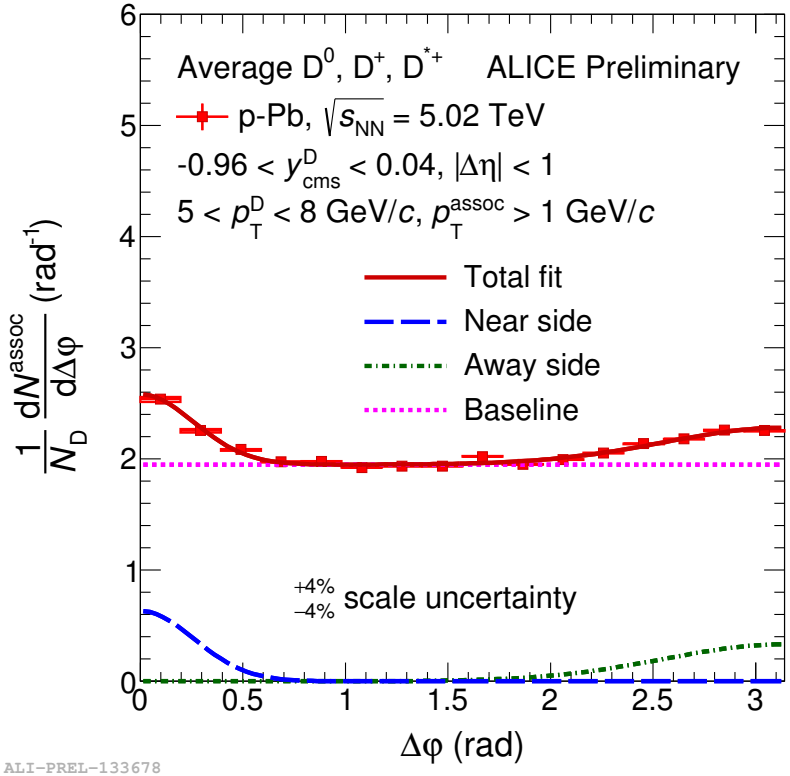
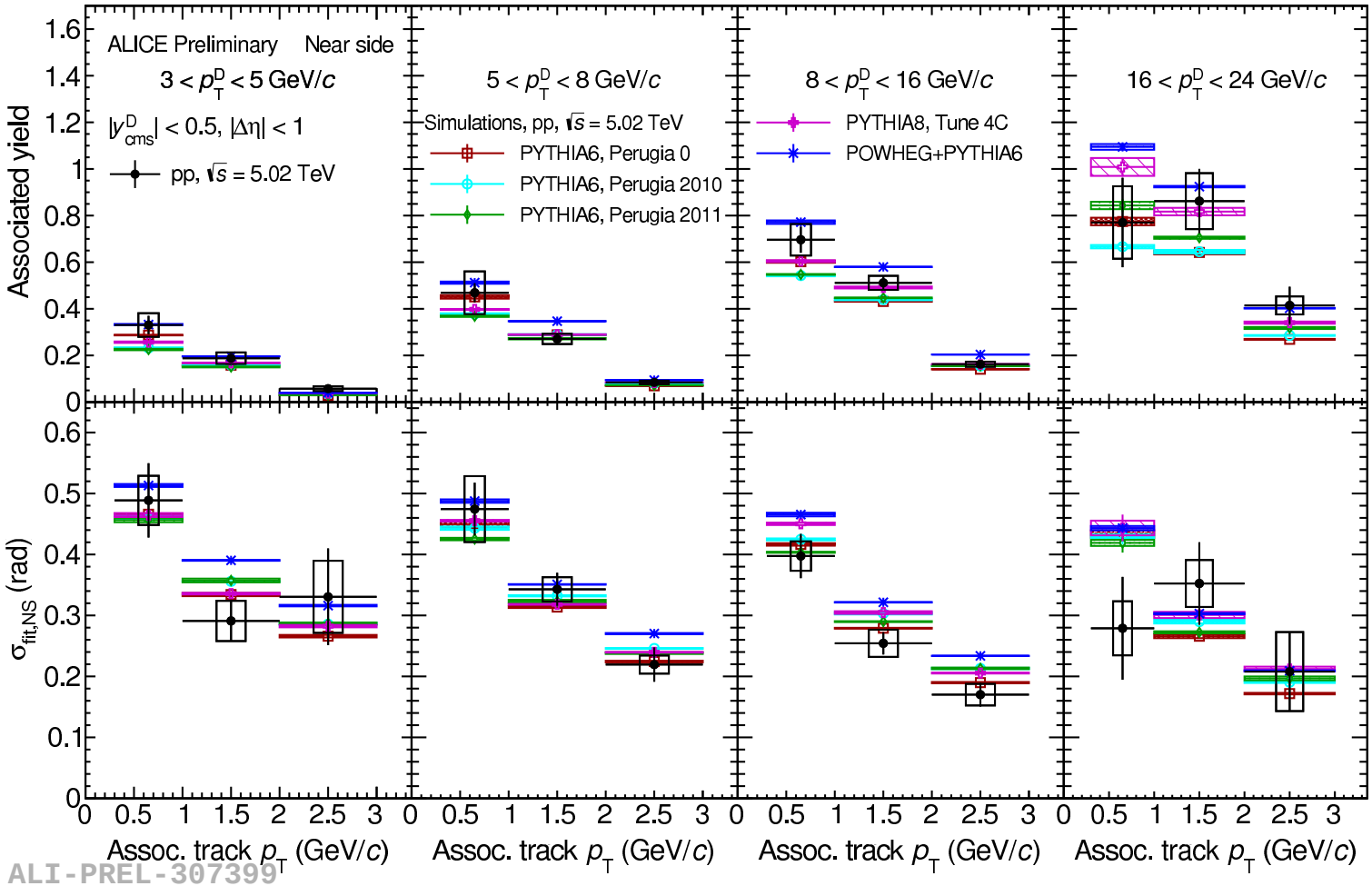


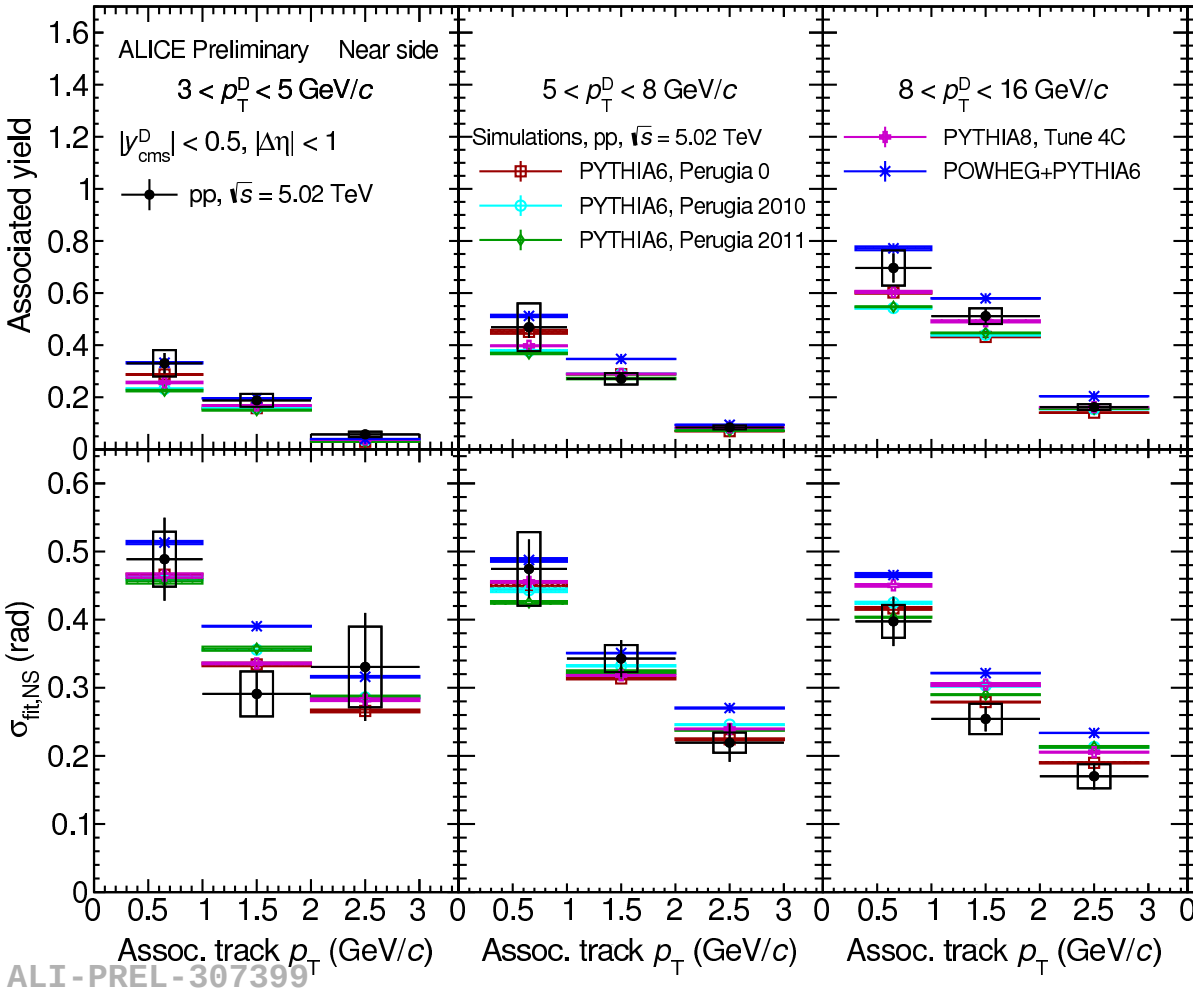


D-h Correlations: pp at $\sqrt{s} = 5.02$ vs. models (NEW)



ALI-PREL-307399

D-h Correlations: pp at $\sqrt{s} = 5.02$ vs. models (NEW)

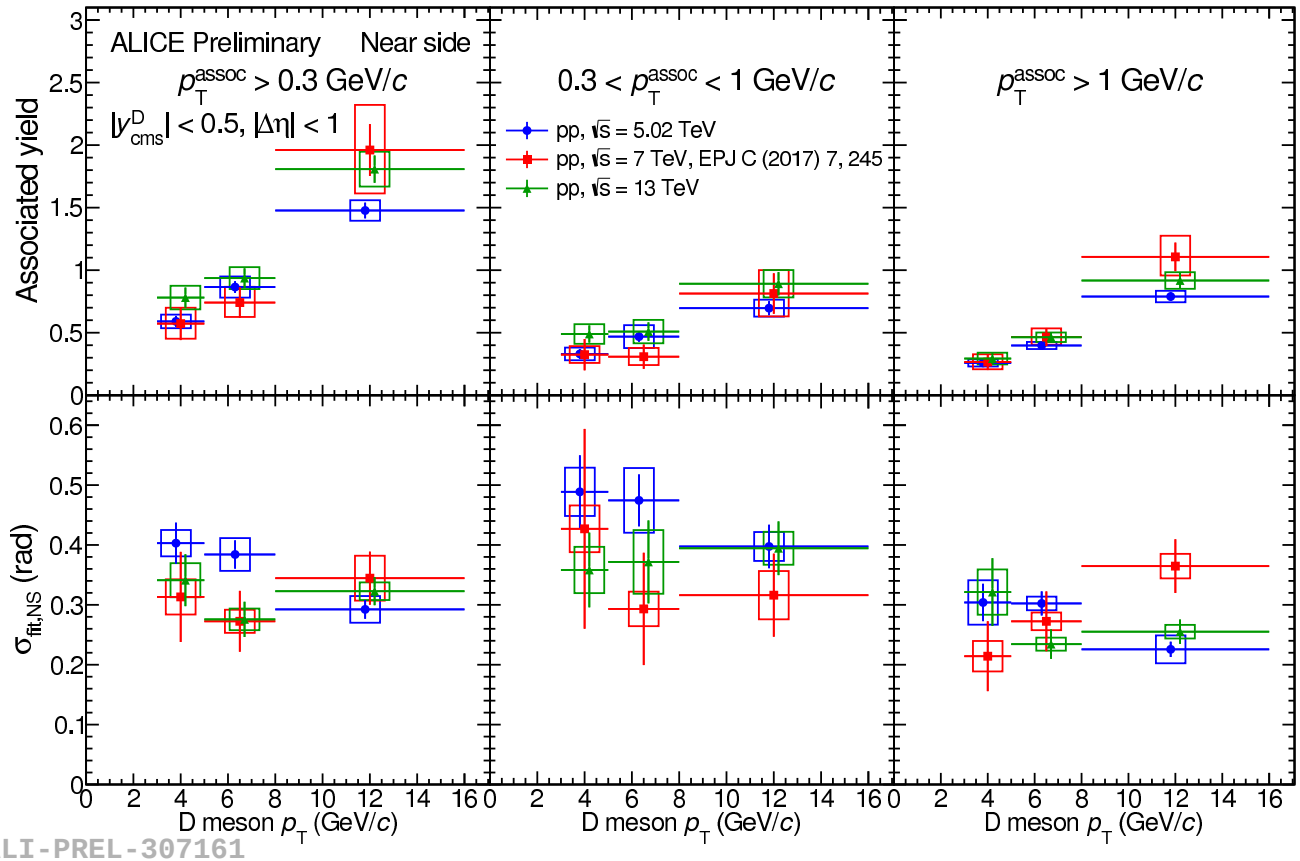


ALI-PREL-307399

- Yield and width vs. assoc. track $p_T \rightarrow$ direct investigation of charm jet fragmentation
- Agreement with PYTHIA6/8 and POWHEG+PYTHIA6
- Well under control $\rightarrow$ use it to investigate cold/hot nuclear effects

Away-side parameters in backup

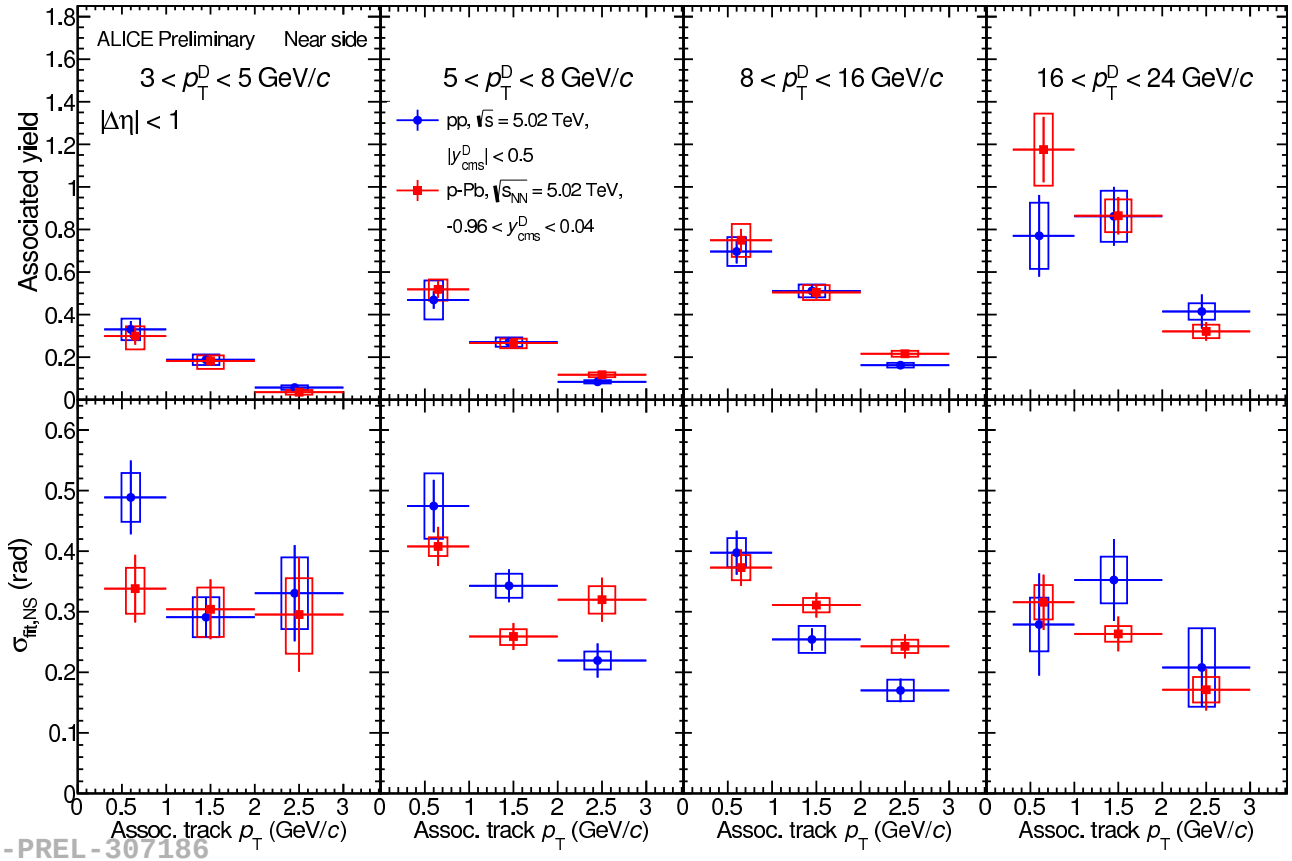
D-h Correlations: pp at $\sqrt{s} = 5.02, 7, 13$ TeV (NEW)



ALI-PREL-307161

No $\sqrt{s}$ dependence within uncertainties

D-h Correlations: pp vs. p–Pb at $\sqrt{s_{NN}} = 5.02$ (NEW)



No evidence of CNM effects

Away-side parameters in backup

Conclusions

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- Summary of ALICE HF jet and correlation measurements:
  1. p_{T} spectra of **HF jets** with $\mathrm{e}^{\pm}$ (p–Pb) and D^0 (pp, p–Pb, Pb–Pb)
  2. **fragmentation** of D^0 mesons in jets in pp at $\sqrt{s} = 7$ TeV (analysis in progress for other systems/energies)
  3. D-h correlations in pp (5.02, 7, 13 TeV) and p–Pb (5.02 TeV)
- pp in **agreement** with various MC generators and NLO pQCD
- No $\sqrt{s}$ dependence of D-h correlation in pp at 5.02, 7, 13 TeV
- **No evidence of cold nuclear matter effects in p–Pb**
- First measurement of charm jets in Pb–Pb tagged with fully reconstructed D^0-meson:
  - $R_{\mathrm{AA}} \approx 0.2$ for $5 < p_{\mathrm{T,ch\,jet}} < 20$ GeV/c
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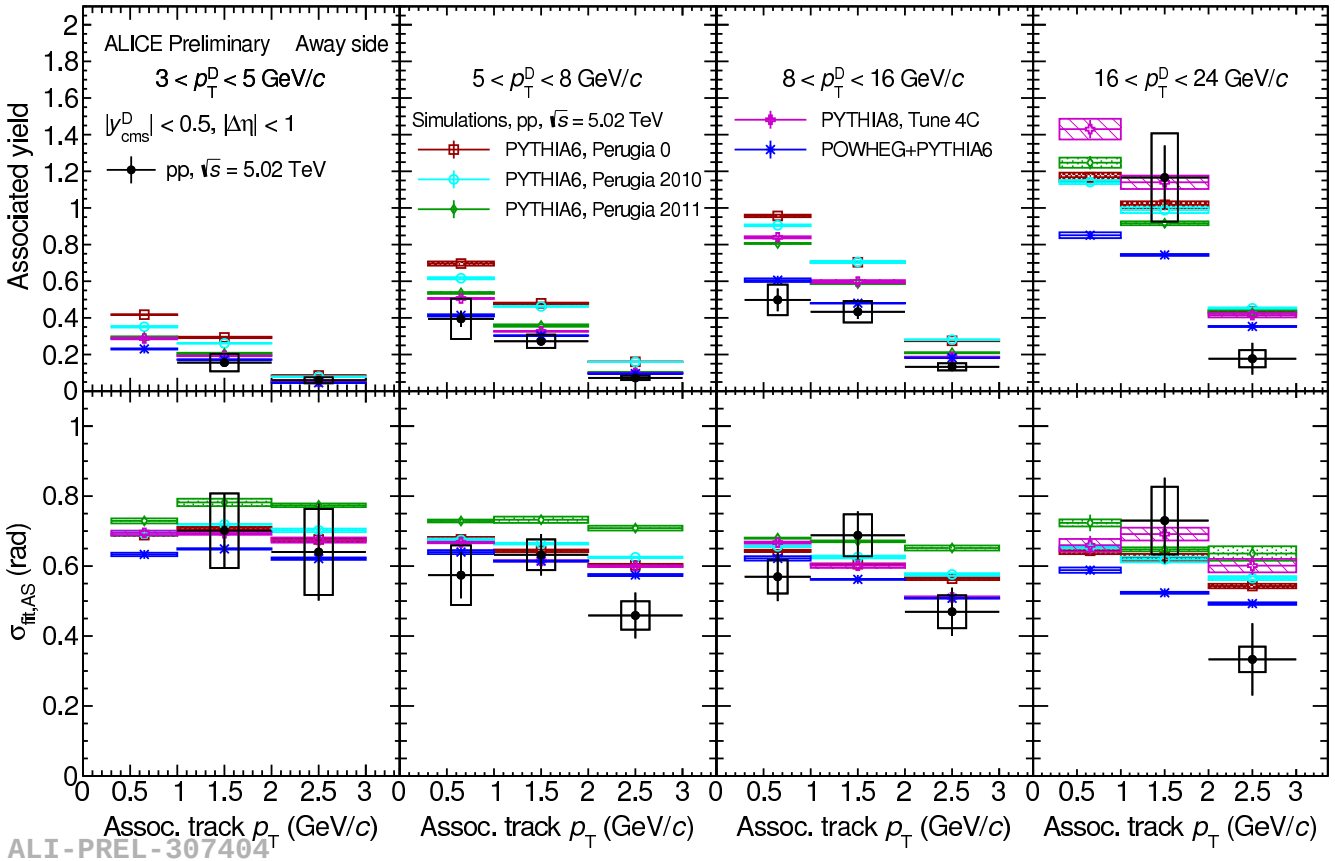
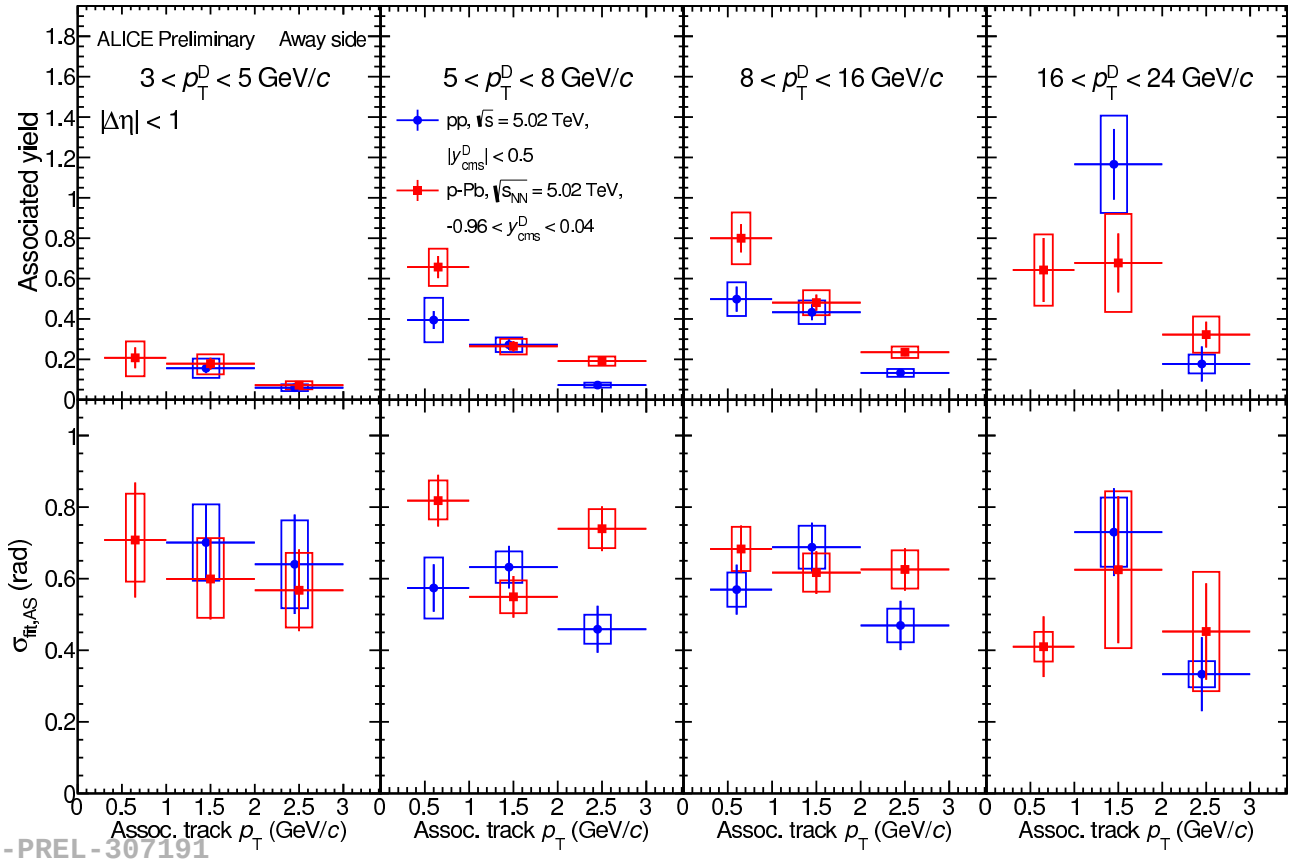
D-h Correlations (away side)



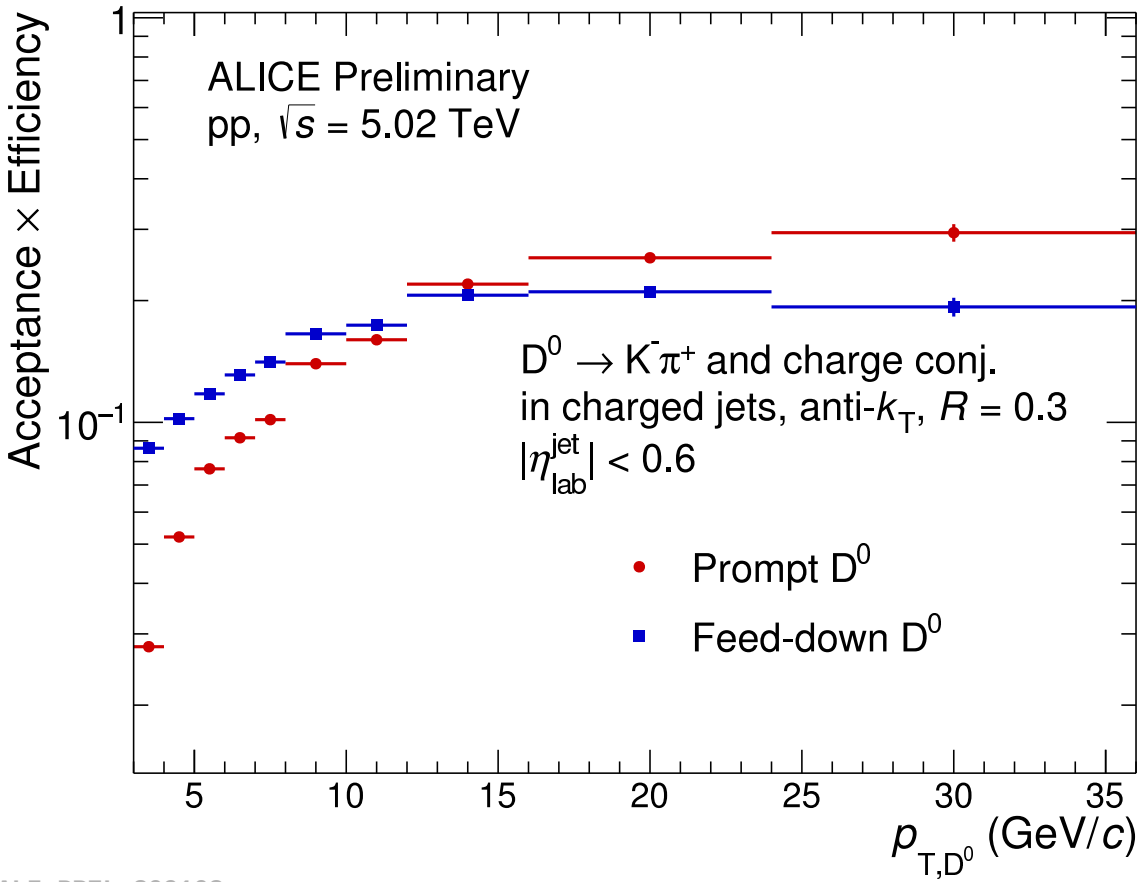
D-h Correlations: pp vs. p–Pb (away side)



ALI-PREL-307191

No evidence of CNM effects

Reconstruction Efficiency of D^0 Jets



ALI-PREL-309103

R_{AA} and R_{pPb} of D^0 Jets