D-tagged jet measurements in p-Pb collisions with ALICE

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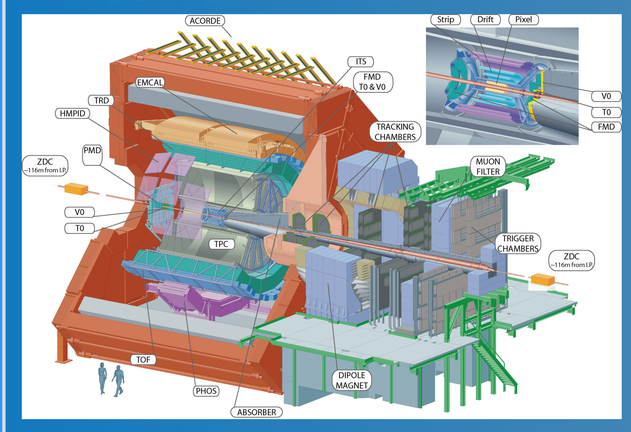
Physics motivation

- Charm quarks produced in hard scatterings at the initial stage of the collision → production cross section can be calculated within perturbative QCD, down to low transverse momentum.
- D-tagged jets → quark-jets enhanced sample;
  → measure jets from hard-scattering processes down to low transverse momentum.
- Pb-Pb collisions: provide new information about the heavy-quark energy loss mechanism, complementary to R_{AA} and v_2 studies.
- p-Pb and pp collisions: provide important reference for Pb-Pb measurements; test of theoretical models.

Tagging charm jets with D^{*+} mesons



p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV

98 M minimum-bias events

$D^{*\pm} \rightarrow D^0\pi^{\pm}$ (BR = 67.7 ± 0.5%)

$\rightarrow K^{\pm}\pi^{\mp}\pi^{\pm}$ (BR = 3.88 ± 0.05%)

$c\tau_{D^0} = 123\,\mu m$

- D^{*+}-meson identification:
  - topological cuts
  - PID information of the decay particles

  with ITS, TPC, TOF.

- D-meson daughter tracks are replaced with the D-meson track
- Charged jets reconstruction: FASTJET using the anti-k_T jet finding algorithm with R = 0.4, jet p_T corrected for the average background momentum density[1].
- $p_{T,D^*} > 3$ GeV/c; $|\eta_{jet}| < 0.9 - R$.

D^{*+}-jet reconstruction efficiency

- Reconstruction efficiency of D^{*+} mesons in a jet with $|\eta_{jet}| < 0.5$ *vs.* D^{*+}-meson p_T from PYTHIA6 + HIJING MC simulation.
  - Strong dependence of the efficiency on the D^{*+}-meson p_T due to the topological cuts.
  - Weak dependence on the jet p_T.

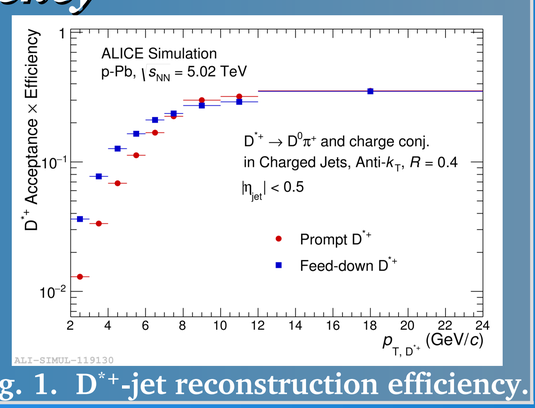


Fig. 1. D^{*+}-jet reconstruction efficiency.

B feed-down subtraction and unfolding

- Raw D^{*+}-jet p_T spectrum is corrected for the B feed-down (FD) contribution according to:

$$\frac{dN^{\mathrm{raw,Prompt}}}{dp_{T,\mathrm{jet}}} = \frac{dN^{\mathrm{raw}}}{dp_{T,\mathrm{jet}}} - \mathrm{RM}^{\mathrm{FD}} \otimes \sum_{p_{T,D^{*+}}} \frac{\varepsilon^{\mathrm{FD}}(p_{T,D^{*+}})}{\varepsilon(p_{T,D^{*+}})} \frac{dN^{\mathrm{sim,FD}}}{dp_{T,\mathrm{jet}}}(p_{T,D^{*+}})$$

$\frac{dN^{\mathrm{raw}}}{dp_{T,\mathrm{jet}}}$: efficiency-corrected raw D^{*+}-jet p_T spectrum

$\frac{dN^{\mathrm{sim,FD}}}{dp_{T,\mathrm{jet}}}$: expected yield from POWHEG+PYTHIA simulation for feed-down D^{*+}-jet

$\mathrm{RM}^{\mathrm{FD}}$: feed-down D^{*+}-jet response matrix

$\frac{\varepsilon^{\mathrm{FD}}(p_{T,D^{*+}})}{\varepsilon(p_{T,D^{*+}})}$: feed-down to prompt D^{*+}-jet efficiency ratio

- And then unfolded: $\frac{dN^{\mathrm{Prompt}}}{dp_{T,\mathrm{jet}}} = \mathrm{RM}^{-1,\mathrm{Prompt}} \otimes \frac{dN^{\mathrm{raw,Prompt}}}{dp_{T,\mathrm{jet}}}$

$\mathrm{RM}^{\mathrm{Prompt}}$: prompt D^{*+}-jet response matrix

- The detector response for prompt D^{*+}-jet from PYTHIA 6 simulations for pp collisions (Fig. 4).
- The background energy-density fluctuations evaluated from the p-Pb data using random cones with R = 0.4 (Fig. 5).
- A combined matrix of the detector response and background fluctuations is used at the unfolding step.

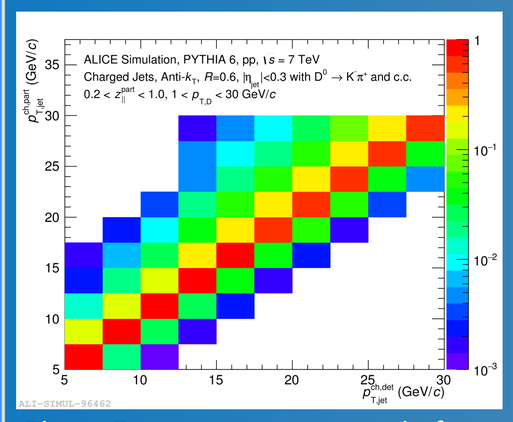


Fig. 4. Detector response matrix for D^0-jets from MC simulations for pp collisions at $\sqrt{s}$ = 7 TeV.

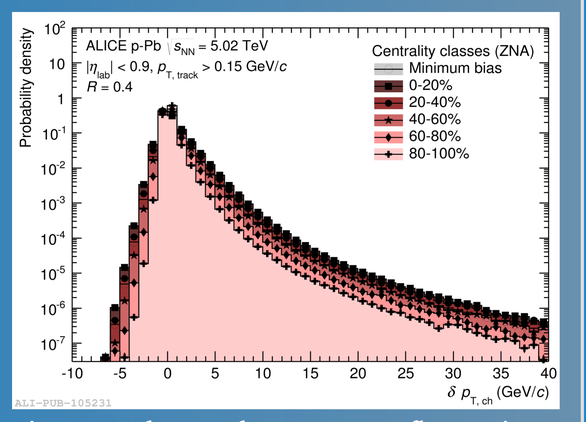


Fig. 5. Background momentum fluctuations of charged jets with random cones (R=0.4)[2].

D^{*+}-tagged jet yields

- D^{*+}-jet yields extracted using D^{*+}-meson invariant mass analysis; 3D distribution: $(p_{T,D}, p_{T,jet}, M)$, $M = M(\mathrm{K}\pi\pi) - M(\mathrm{K}\pi)$
- Two alternative methods:

I) <u>Signal in D^{*+}-meson p_T intervals</u>

- Fit invariant mass distributions in D^{*+}-meson p_T intervals (Fig. 2).
- Define, based on the fit:
  - Signal region: $|M - \mu_{fit}| < 3\,\sigma_{fit}$
  - Side Bands: $-8\,\sigma_{fit} < M - \mu_{fit} < -5\,\sigma_{fit}$ and $5\,\sigma_{fit} < M - \mu_{fit} < 13\,\sigma_{fit}$
- **Raw jet p_T distribution:**
  - Subtract the side-band jet p_T distribution $B\frac{dN^{SB}}{dp_{T,jet}}$ from the jet p_T distribution in the signal region $\frac{dN^{S}}{dp_{T,jet}}$ (B - normalization to the background in the signal region).
  - Correct for the prompt D^{*+}-jet reconstruction efficiency, $\varepsilon(p_{T,D^*})$ (Fig. 1) and sum up the D^{*+}-meson p_T intervals.

$$\frac{dN^{\mathrm{raw}}}{dp_{T,\mathrm{jet}}} = \sum_{p_{T,D^{*+}}} \frac{1}{\varepsilon(p_{T,D^{*+}})} \left[\frac{dN^{S}}{dp_{T,\mathrm{jet}}}(p_{T,D^{*+}}) - B\frac{dN^{SB}}{dp_{T,\mathrm{jet}}}(p_{T,D^{*+}})\right]$$

II) <u>Signal in jet p_T intervals</u>

- For every jet p_T interval, correct each D^{*+}-meson candidate by the corresponding prompt D^{*+}-jet efficiency, $\varepsilon(p_{T,D^*})$.
- Fit the efficiency-scaled invariant mass distributions in the jet p_T intervals (Fig. 3).
- **Raw jet p_T distribution:**
  - Extract the jet yield from the signal fit in the signal region.

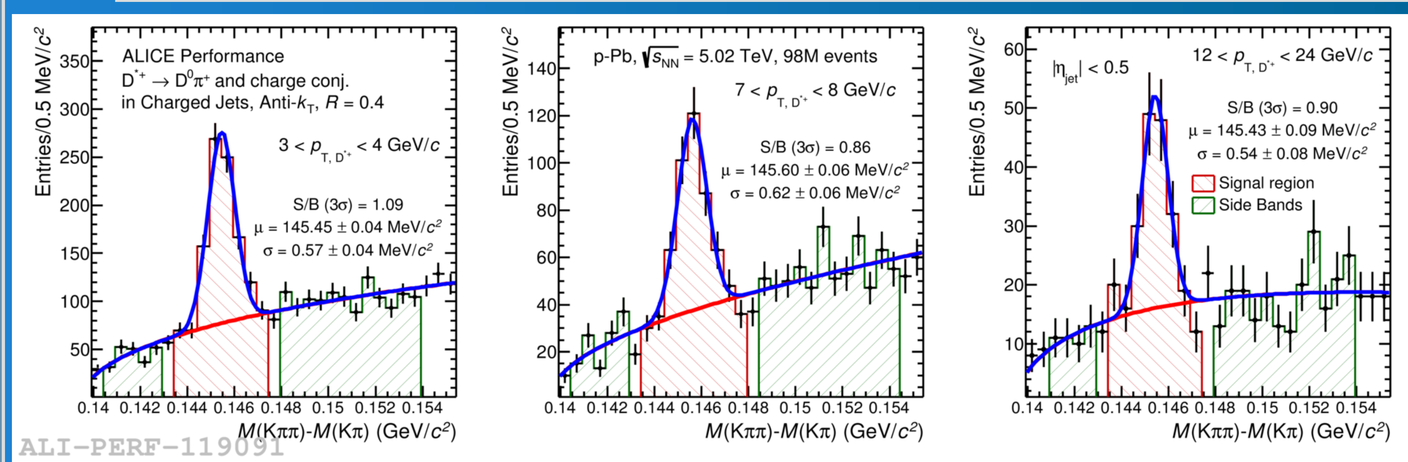


Fig. 2. Invariant mass distributions in D^{*+}-meson p_T intervals, with the signal region and side bands.

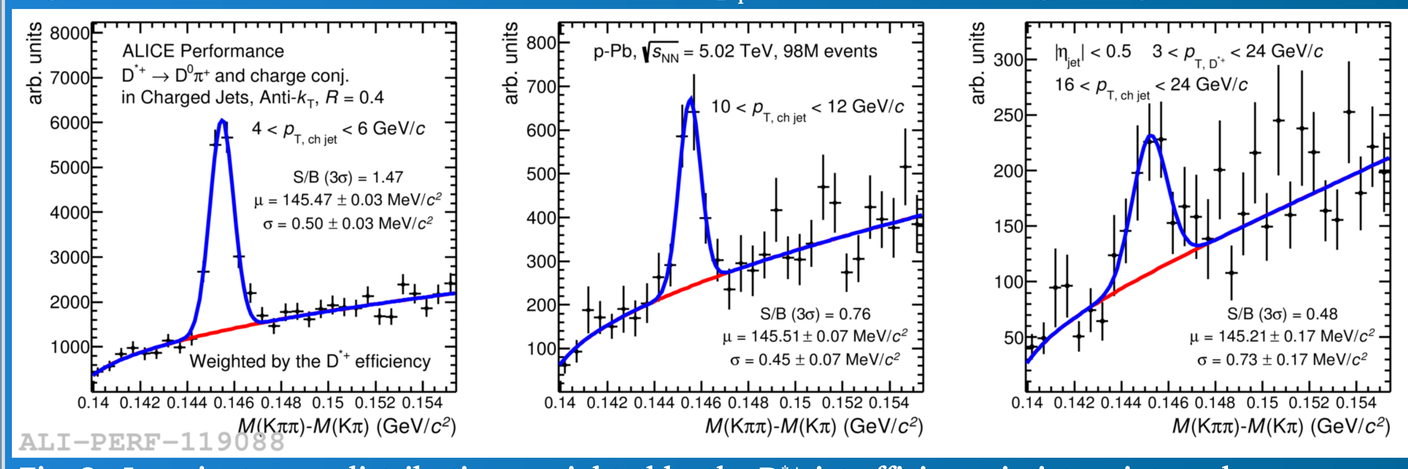


Fig. 3. Invariant mass distributions weighted by the D^{*+}-jet efficiency in jet p_T intervals.

Outlook

- The D^{*+}-tagged charged jets in Run 1 p-Pb collisions at $\sqrt{s_{NN}}$ = 5.02 TeV can be measured in the range of 4 < p_T < 24 GeV/c, with the ALICE detector.
- The final D^{*+}-tagged jet p_T spectrum will provide a reference for D-tagged jet analysis in Pb-Pb collisions.
- The studies will be extended to analysis of the D-meson momentum fraction with respect to the jet, using also the Run 2 p-Pb dataset at $\sqrt{s_{NN}}$ = 5.02 TeV.

[1] S. Chatrchyan et al. (CMS Collaboration), JHEP 1208 (2012) 130
[2] J. Adam et al. (ALICE Collaboration), Eur. Phys. J. C76 (2016) no.5, 271

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