Charm jet production and properties in pp, p-Pb, and Pb-Pb collisions measured with ALICE at the LHC

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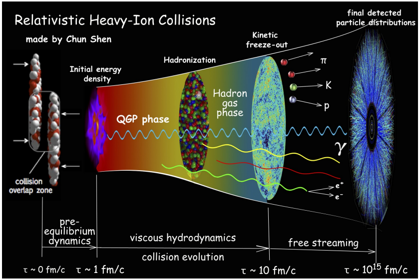
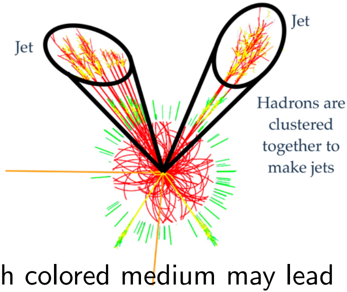
Introduction

- During Pb-Pb collisions at the LHC a hot and dense medium of deconfined quarks and gluons is created (QGP).
- In Cosmology, QGP is expected to have been the state of matter up to few microseconds after the Big Bang.
- Jet suppression in Pb-Pb collisions is expected if QGP is formed.



Introduction

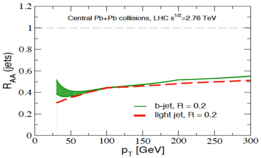
- A jet is a narrow cone of particles.
- Practically, a jet is what a specified jet-finder algorithm finds.
- Ideally with jets we would like to identify particles from the fragmentation and hadronization of a quark or a gluon.



- Interactions of hard-scattered partons with colored medium may lead to in-medium partonic energy loss, resulting in a suppression of jet production at high p_T.
- The investigation of jet suppression and parton energy loss provides information on QGP properties (transport coefficient, $\hat{q}$, medium density, etc..)

Why Heavy-Flavor jets ??

- Heavy-quarks are excellent probes for the study of the QGP.
  - They are produced before the QGP formation.
  - Mainly produced in hard scattering processes.
  - Their production cross section is calculable with pQCD ⇒well calibrated probe.
  - Heavy-flavor hadrons like D mesons can be used to tag jets originating from heavy quarks.
- Tagging the HF-jets allows for the study of the mass and the color charge dependence of parton energy loss.



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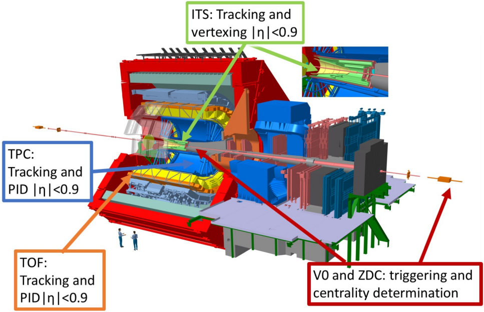
- Comparison of HF-jet measurements in pp, p-Pb, and Pb-Pb is mandatory to disentangle final-state effects due to the presence of a QGP from cold nuclear matter effects (like nuclear PDF (shadowing)). Open Charm in pA by A. Grelli, 23/5/2018 and also Charmed mesons and baryons in pp and p-Pb by S. Jaelani, 25/5/2018 .

A Large Ion Collider Experiment (ALICE) at the LHC

ALICE is the dedicated heavy-ion detector at the LHC.

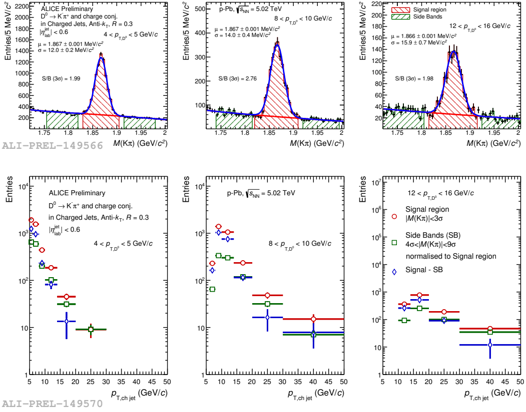
- D mesons are reconstructed through hadronic decays exploiting PID with TPC and TOF and applying topological selections to identify displaced secondary vertices:
  - $D^0 \Rightarrow K^-\pi^+$ with $BR \approx 3.93\%$.
  - $D^{*+} \Rightarrow D^0\pi^+$ with $BR \approx 67.7\%$
- Charged jets are reconstructed with the anti-kt algorithm from the charged tracks using the ITS and TPC.



Analysis method

A D-meson jet is a jet that contains a D-meson among its constituent.

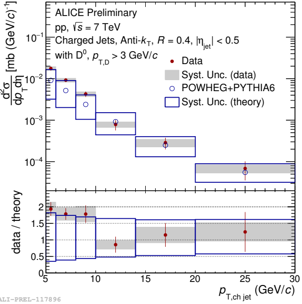
- The raw yield of D-tagged jets is obtained from the 2D distribution (D-meson invariant mass, jet p_T):
  - The jet background p_T spectrum is obtained from the sidebands and subtracted to the signal+background obtained from the D-meson mass peak region.
- Correction for the D-meson efficiency and subtraction of feed-down from beauty (using POWHEG+PYTHIA).

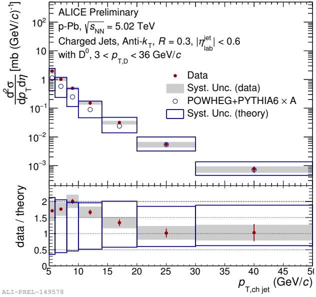


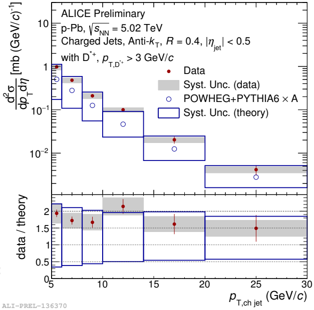
- Correction for the jet p_T resolution: unfolding for detector effects and (only p-Pb and Pb-Pb) background fluctuations .

D-tagged jets in pp and p-Pb

The p_T-differential cross section was measured for D^0-jet in pp and p-Pb collisions and D^{*+}-jet in p-Pb collisions.



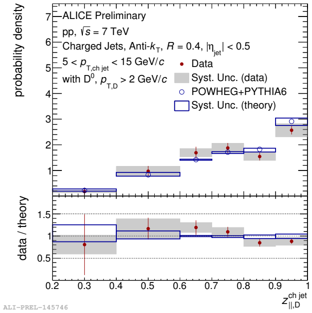


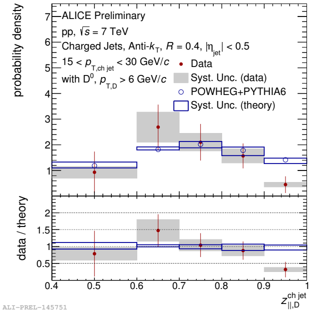


Good agreement with NLO prediction (POWHEG+PYTHIA6) within uncertainties.

D^0-meson jet momentum fraction

- The momentum fraction carried by D^0 meson inside the jet ($z_{\parallel} = \frac{\vec{p}_{jet} \cdot \vec{p}_D}{\vec{p}_{jet} \cdot \vec{p}_{jet}}$) was measured in pp collisions at $\sqrt{s} = 7\,TeV$.

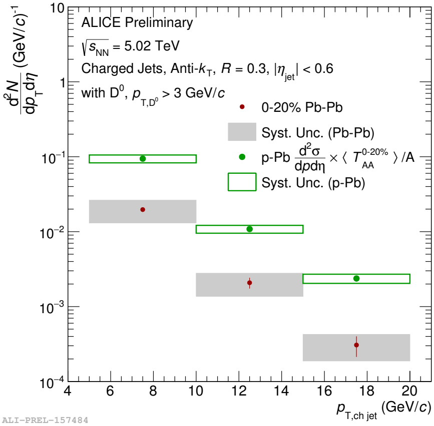




- The D^0 meson carries most of the jet momentum in the measured jet p_T intervals, but a change of shape with jet p_T is visible.
- Good agreement with NLO predictions (POWHEG+PYTHIA6) within uncertainties.

D^0 jet in Pb-Pb

- First measurement of D-tagged jets in nucleus-nucleus collisions.
- The measurement goes down to 5 GeV/c ⇒ careful checks of unfolding robustness against background fluctuations performed.
- Clear suppression of D-jet yield in Pb-Pb collisions w.r.t. p-Pb collisions.

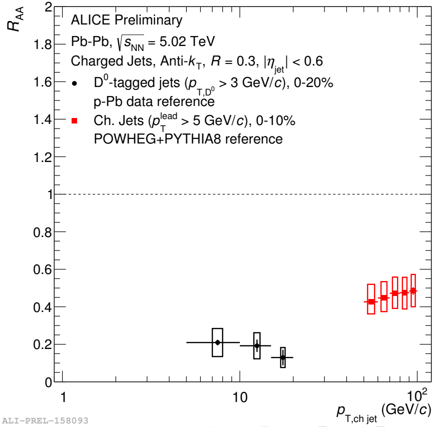


D^0 jet R_{AA}

The nuclear modification factor R_{AA} is determined as $R_{AA} = \frac{\frac{dN^2_{AA}}{dp_T d\eta}}{\frac{\langle T_{AA} \rangle}{A} \frac{d\sigma_{pPb}}{dp_T d\eta}}$,

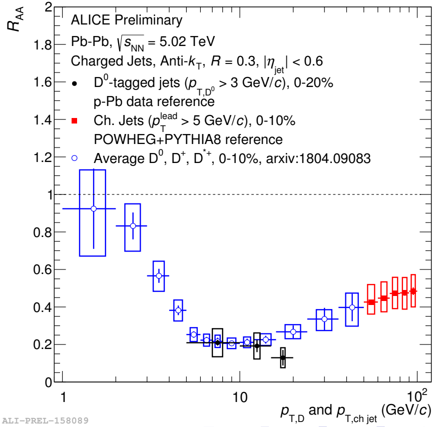
where T_{AA} is the nuclear overlap function.

- The R_{AA} reveals the effect due to the interaction with QGP:
  - $R_{AA} = 1 \Rightarrow$ no nuclear effects.
  - $R_{AA} < 1 \Rightarrow$ energy loss.
- Strong D^0-tagged jet suppression is observed in central Pb-Pb collisions.
  - Hint that D-tagged jets in $5 < p_T < 30 GeV/c$ are more suppressed than inclusive jets with $p_T > 40$ GeV/c.



D^0 jet R_{AA}

- Similar R_{AA} of D-tagged jets and D mesons.



Summary and Outlook

- The D^0-tagged jet production cross section and the D^0-meson jet momentum fraction were measured in pp collisions and they are in a good agreement with NLO predictions.
- The D^{*+}-tagged jet and the D^0-tagged jet production cross section was measured in p-Pb collisions and it is in a good agreement with NLO predictions.
- Strong suppression for the D^0-tagged jet production in central Pb-Pb collisions.

- Precise measurement will be made with the Pb-Pb data that will be collected by the end of this year.
- The measurement of the b-jet cross section is being finalized in pp and p-Pb collisions.

Thank you for listening.

Backup.

- The fraction of the non-prompt *D*-jet is subtracted using the following equation:

$$N^{c\to D^{*\pm}}(p^{det}_{T,ch\,jet}) = N^{c,b\to D^{*\pm}}(p^{det}_{T,ch\,jet}) - R^{b\to D^{*\pm}}_{det}(p^{det}_{T,ch\,jet}, p^{part}_{T,ch\,jet}) \otimes \sum_{p_{T,D}} \frac{\varepsilon^{b\to D^{*\pm}}(p_{T,D})}{\varepsilon^{c\to D^{*\pm}}(p_{T,D})} N^{b\to D^{*\pm}}_{POWHEG}(p_{T,D}, p^{part}_{T,ch\,jet})$$

- The non-prompt *D*-jet spectrum was extracted from POWHEG+PYTHIA simulation.