Data analysis: heavy flavour

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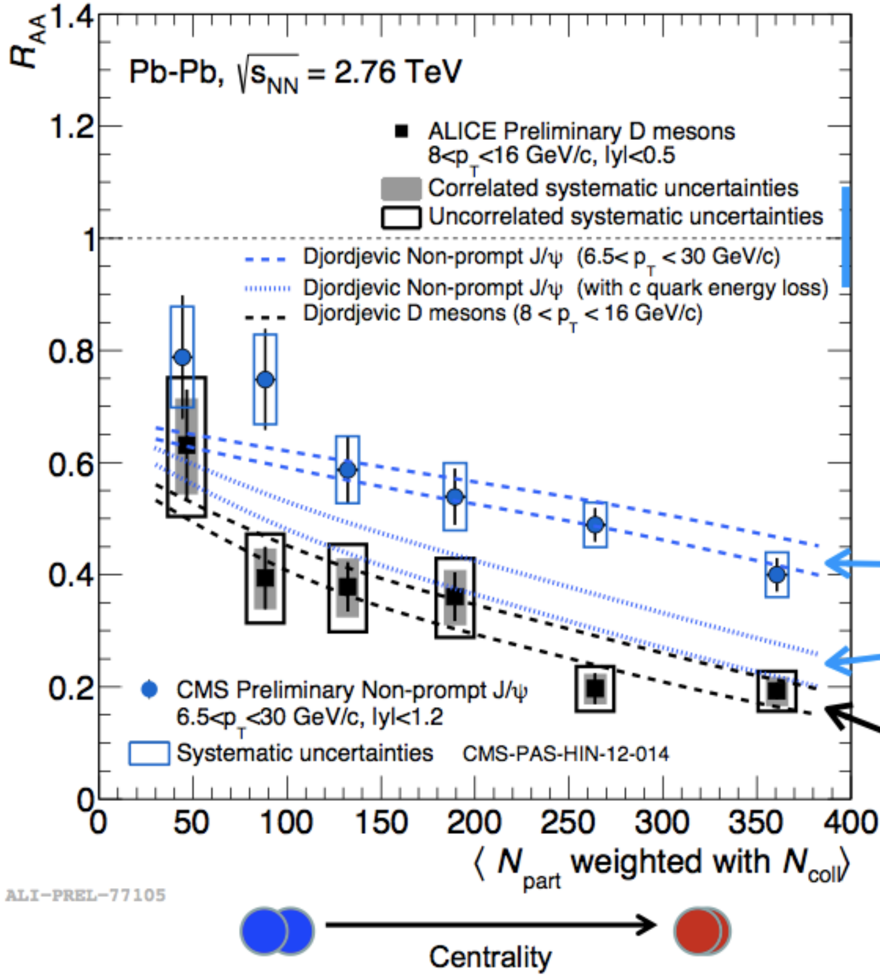
Charm in Pb-Pb: nuclear modif. factor and elliptic flow

- New preliminary results for HP13 (talk D.Caffarri) and QM14 (talk A. Festanti)
  - D^0 R_{AA} vs centrality in several p_T bins (in particular bin 8-16 GeV allows comparison with beauty measurements by CMS)
  - D^0 R_{AA} vs p_T in semi-peripheral collisions (30-50% centrality class)
- Final results (arXiv:1405.2001, → Phys. Rev. C)
  - D^0 v_2 in three centrality classes
  - D^0 R_{AA} in-plane and out-of-plane in 30-50% class
  - Extensive model comparison

D R_{AA} vs centrality: mass dependence of parton energy loss



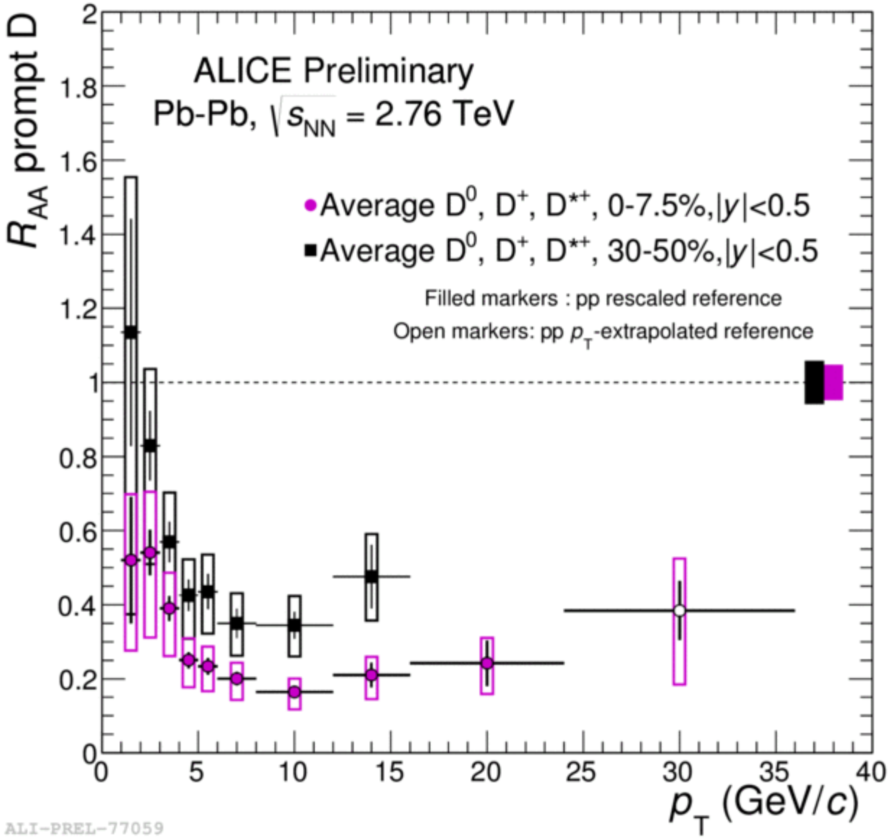
- ALICE prompt D mesons & CMS non-prompt J/ψ:
  - B and D mesons <p_T>~10 GeV/c
- **Clear indication of a dependence on quark mass : $R_{AA}^B > R_{AA}^D$**

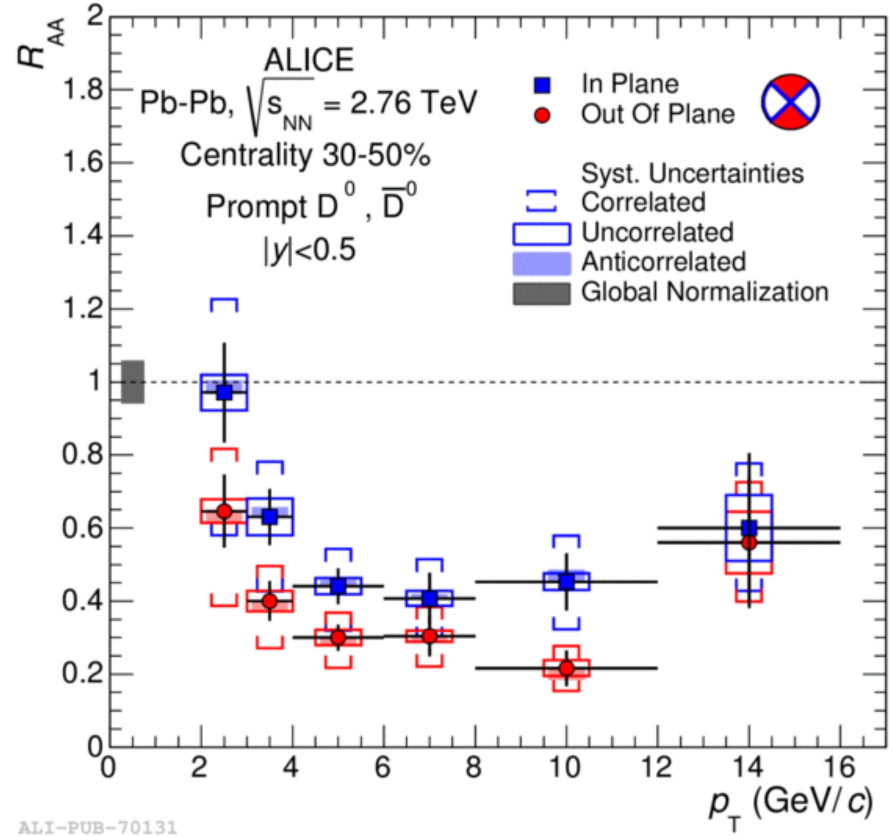
✓ Djordjevic: non-prompt J/ψ R_{AA} considering for energy loss
- b quark mass
- c quarkmass

✓ Djordjevic: D meson R_{AA}

Calculation by M. Djordjevic (including mass-dependent rad+coll energy loss) predict a difference

D R_{AA} vs p_T

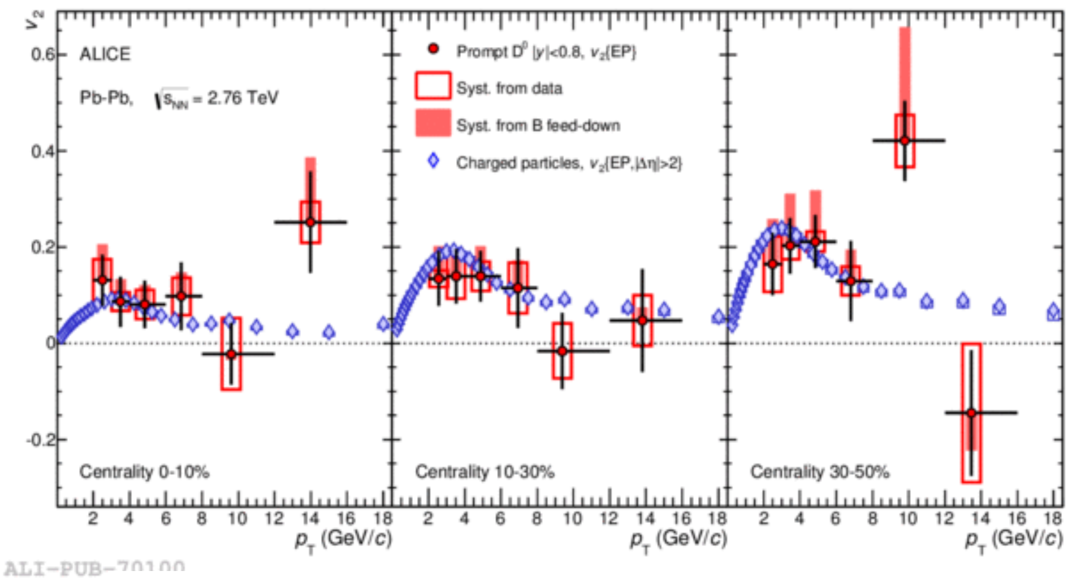




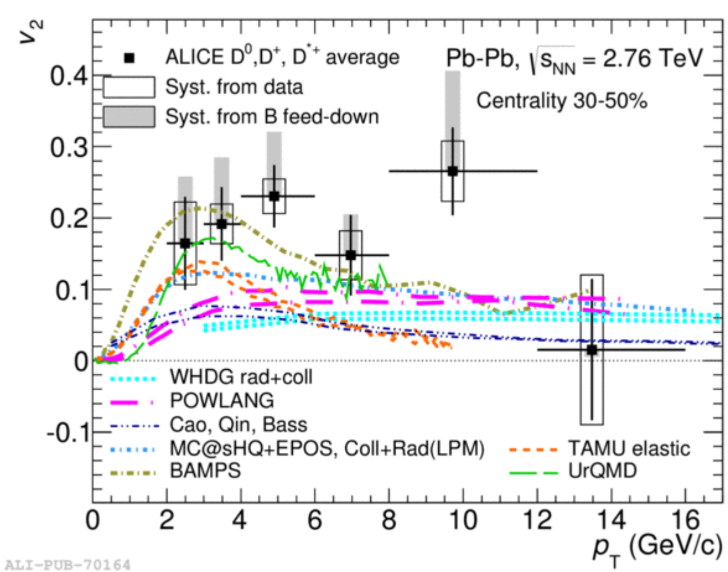
Less suppression in 30-50% than in 0-7.5%

More suppression out-of-plane than in-plane → reflects elliptic flow and path length dependence of energy loss

D elliptic flow v_2



- Indication for elliptic flow increasing from central to (semi)peripheral collisions



- Data are best described by models that include mechanisms that transfer the collective espansion to c quarks (e.g. collisional energy loss).
- Some of these models also include a component of hadronization of c quarks via quark recombination.

Charm in Pb-Pb: Outlook

- Short paper in preparation on D R_{AA} vs centrality, with focus on comparison with pions (ALICE) and with Jpsi from B (CMS) – timescale ~end of summer
- Long paper with all D meson results on spectra and $R_{AA}(p_T)$ – timescale ~end of the year
- Look into very low p_T (with event-mixing) and high p_T (with EMCAL triggers, already started for pp 8 TeV)

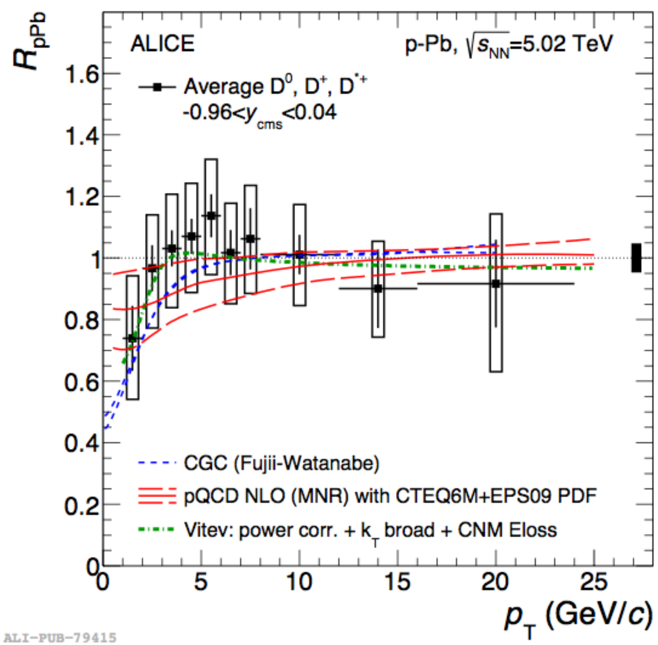
- Run-2 (Nov 2015): expect about 5x higher statistics (plus full SPD)

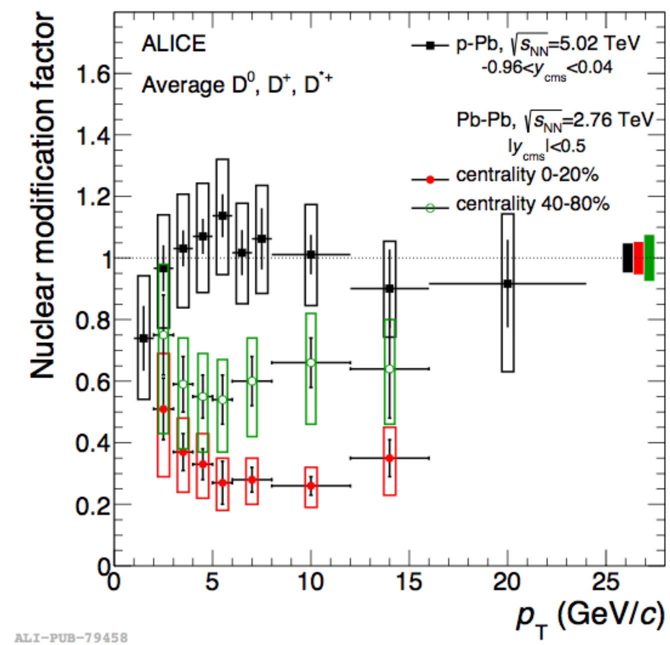
D meson production in min. bias p-Pb

- Paper on D meson production in min. bias p-Pb collision on the arXiv: 1405.3452 [submitted to Phys. Rev. Lett.]
- Measurement of the production cross section and R_{pPb}

$$\boxed{R_{\mathrm{pPb}} = \frac{(\mathrm{d}\sigma/\mathrm{d}p_{\mathrm{T}})_{\mathrm{pPb}}}{\mathrm{A}(\mathrm{d}\sigma/\mathrm{d}p_{\mathrm{T}})_{\mathrm{pp}}}}$$

- D^0, D^+, D^{*+} and D^+_s R_{pPb} compatible with unity within uncertainties





p-Pb min. bias
Pb-Pb 40-80%
Pb-Pb 0-20%

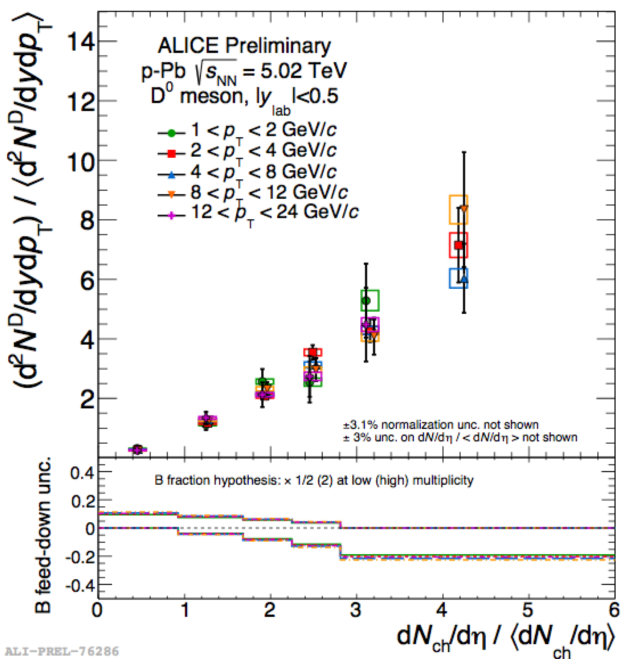
- Average D meson R_{pPb} described by theoretical calculations including cold nuclear matter effects.
- D meson suppression observed in most central Pb-Pb for $p_{\mathrm{T}} > 2$ GeV/c collision due to final state effects.

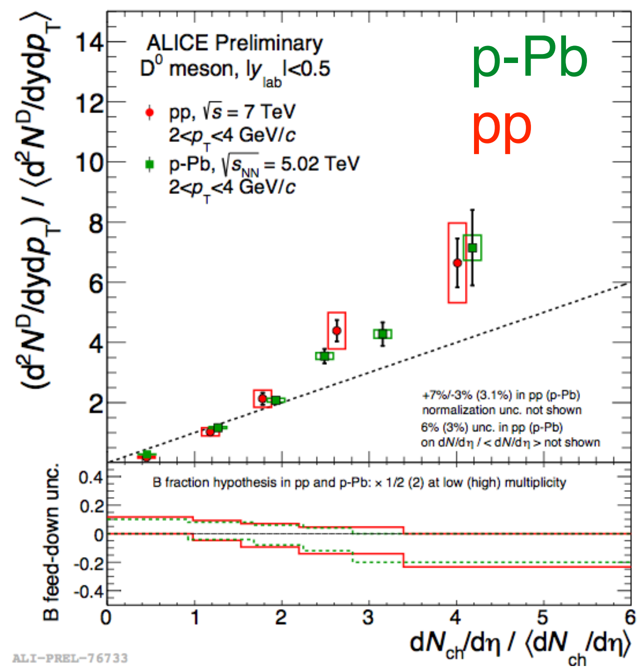
D^0 vs. charged particles multiplicity

- D^0 yields extracted in different bins of $N_{\mathrm{tracklets}}$ [|η|<1]
- Efficiency estimated in each [p_T, $N_{\mathrm{tracklets}}$] bin

$$Y^{\mathrm{corr}} = \frac{Y^{\mathrm{mult}}/(\epsilon^{\mathrm{mult}} \times N_{\mathrm{event}}^{\mathrm{mult}})}{Y^{\mathrm{tot}}/(\epsilon^{\mathrm{tot}} \times N_{\mathrm{event}}^{\mathrm{tot}}/\epsilon^{\mathrm{trigger}})}$$

- Density of charged particle multiplicity determined exploiting the proportionality between $N_{\mathrm{tracklets}}$ and N_{ch} in Monte Carlo



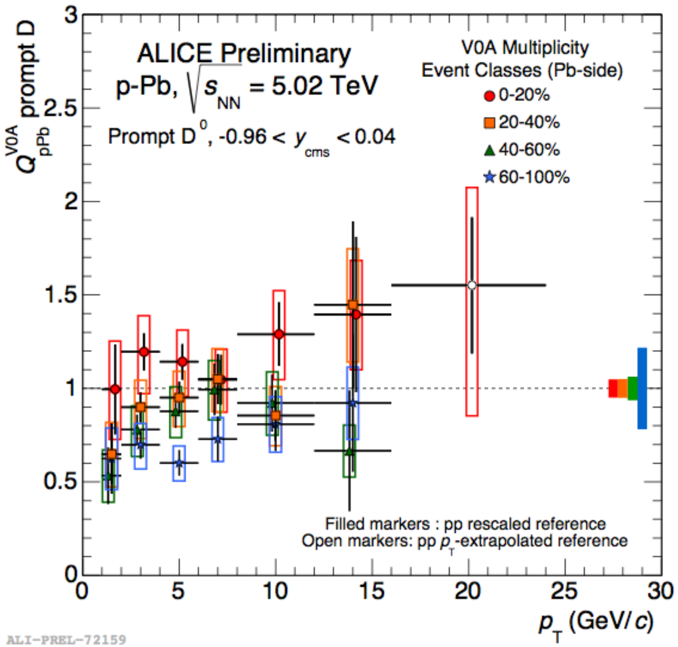


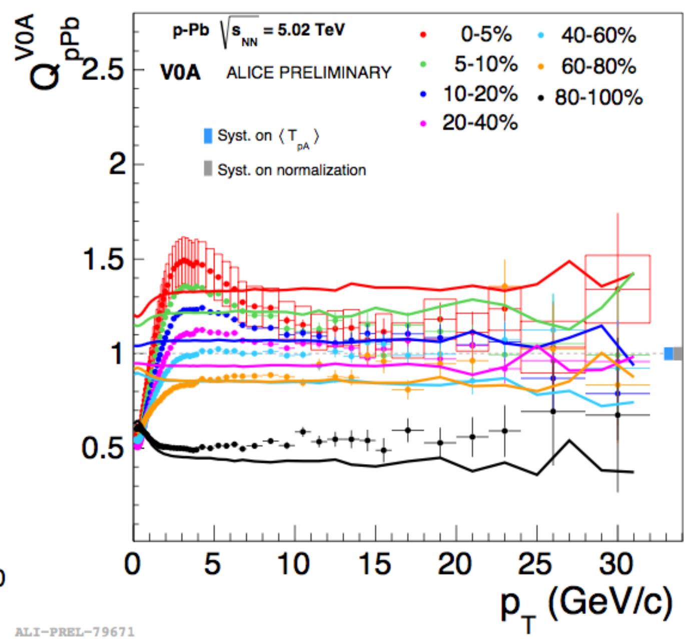
- Self-normalized yields increasing with charged particle multiplicity
- Same increasing trend in all p_T intervals

- Same behavior observed in pp collisions but:
  - high mult. events in pp → MPI
  - high mult. events in p-Pb → MPI + <N_{coll}>=6.9

D^0 Q_{pPb}

- D^0 nuclear modification factor measured in different event activity classes: 0-20%, 20-40%, 40-60% and 60-100%
- Classes obtained slicing the VZERO signal amplitude on the Pb-going side [V0A]
- $\langle N_{coll}^{Glauber} \rangle$ extracted from a Glauber fit to the V0A amplitude





$$Q_{\mathrm{pPb}}^{\mathrm{V0A}} = \frac{(\mathrm{d}N/\mathrm{d}p_{\mathrm{T}})_{\mathrm{pPb}}}{\langle T_{\mathrm{pPb}}^{\mathrm{Glauber}} \rangle (\mathrm{d}\sigma/\mathrm{d}p_{\mathrm{T}})_{\mathrm{pp}}}$$

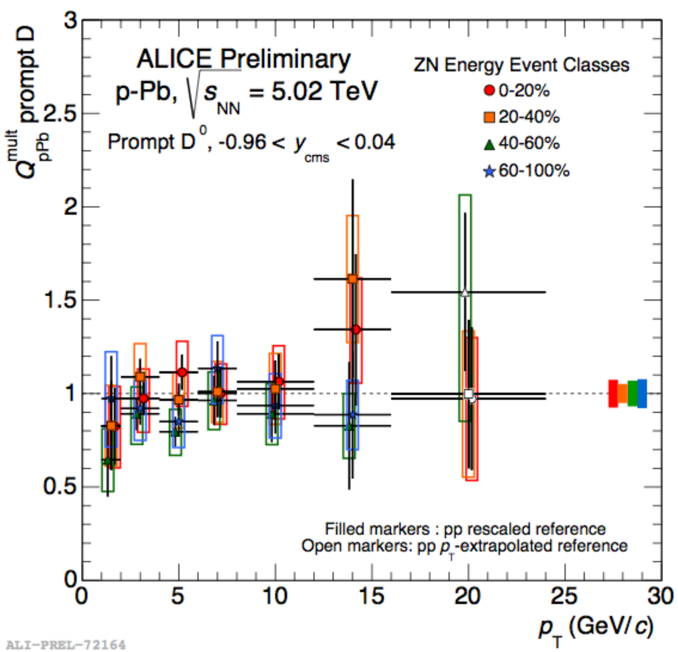
$$\langle T_{\mathrm{pPb}}^{\mathrm{Glauber}} \rangle = \langle N_{\mathrm{coll}}^{\mathrm{Glauber}} \rangle / \sigma_{\mathrm{NN}}^{\mathrm{inel}}$$

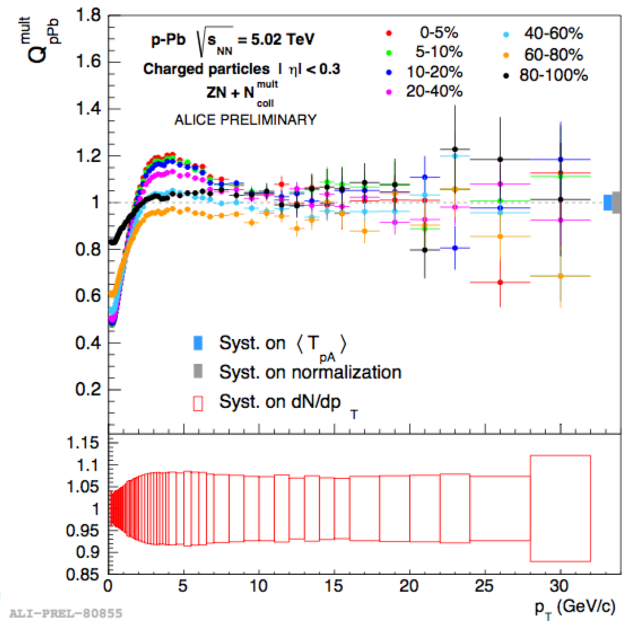
In collaboration with C. Terrevoli

- Bias observed for charged particles seems to be present also for D meson
- Bias induced by the correlation between hard scattering yields and event-activity in the VZERO acceptance

D^0 Q_{pPb}

- Classes obtained slicing the energy deposited in the neutron calorimeter on the Pb-going side [ZNA]
- Collision geometry information extracted with an hybrid method
- $\langle N_{coll}^{mult} \rangle$ obtained by rescaling the min. bias value with the ratio of multiplicity at mid-rapidity in a given class to the min. bias one





$$Q_{pPb}^{mult} = \frac{(dN/dp_T)_{pPb}}{\langle T_{pPb}^{mult} \rangle (d\sigma/dp_T)_{pp}}$$

$$\langle T_{pPb}^{mult} \rangle = \langle N_{coll}^{mult} \rangle / \sigma_{NN}^{inel}$$

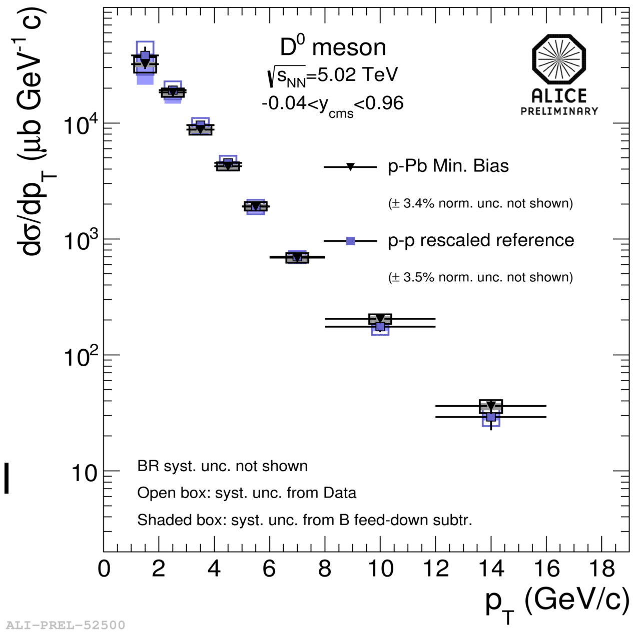
- Bias reduced
- We do not observe an event-activity/centrality dependent modification of the p-Pb p_T spectra w.r.t. pp collisions

Outlook

- Prepare a paper with the D meson multiplicity differential measurements in p-Pb
  - cut optimization in order to have better statistical significance and extract the signal in $1<p_T<2$ and $12<p_T<24$ GeV/c in the highest $N_{\mathrm{tracklets}}$ class [100, 200]
- Data driven B feed-down estimate in p-Pb: technique based on a fit to the impact parameter distribution (developed by Andrea Rossi)
- PhD thesis

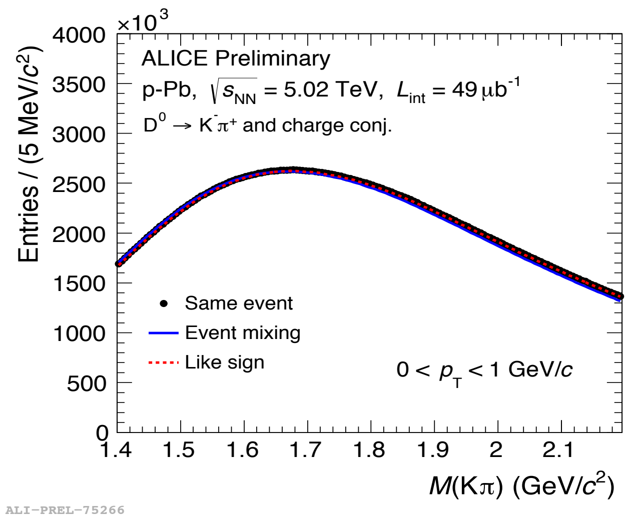
D^0 signal at low-p_T in pp and p-Pb collisions

- In ALICE, inclusive p_T-differential production cross section of D^0 meson has been measured in the p_T range 1 to 16 GeV/*c* in pp collisions and 1 to 24 GeV/*c* in p-Pb collisions.
- Standard procedure for the reconstruction of D^0 mesons is based on the selection of displaced secondary vertices.
- At low p_T, the topological selection on the decay vertex is less effective for the background rejection and gives low efficiency for the signal.
- This analysis aims at extending the measurement of D^0 production cross section down to $p_T = 0$ using the combinatorial background subtraction techniques.



Event mixing method:

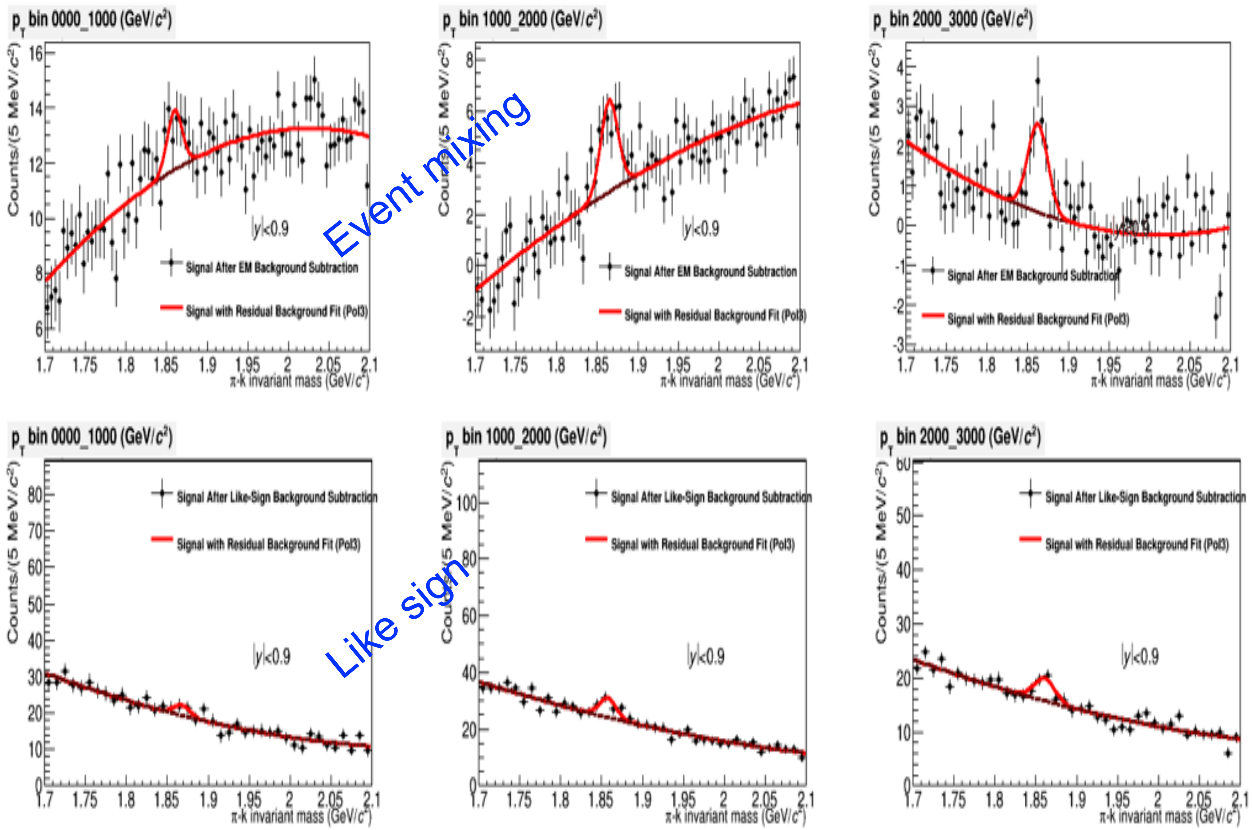
- Mix tracks from different events to break track to track correlation and increase the statistics.
- Mix events with similar characteristics.
- Normalize outside the D^0 mass peak region.

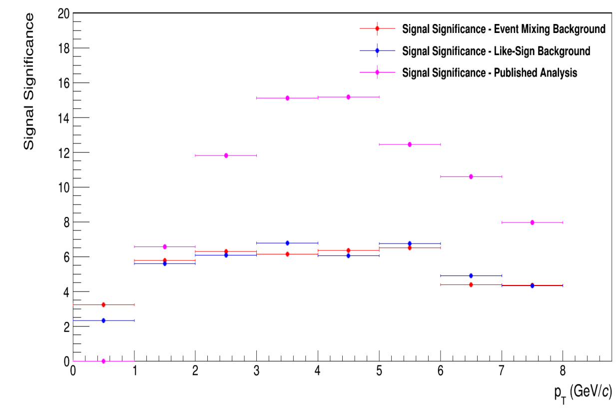


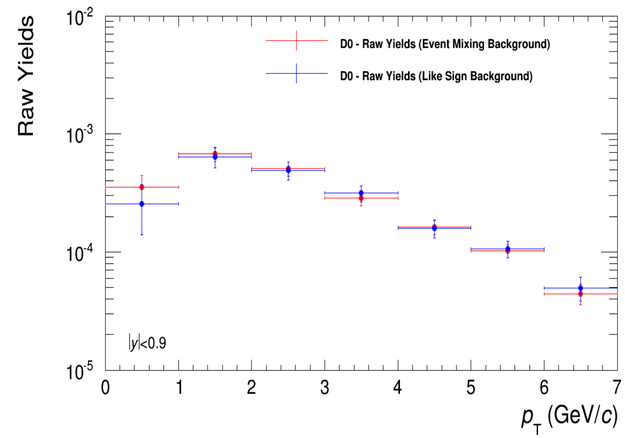
Like sign method:

- Combine two positive or two negative tracks (like-sign pairs) instead of a negative and positive track in the same event.
- Normalization: $2\sqrt{(N^{++})\times(N^{--})}$

Signal in pp collisions at $\sqrt{s}$ = 7 TeV

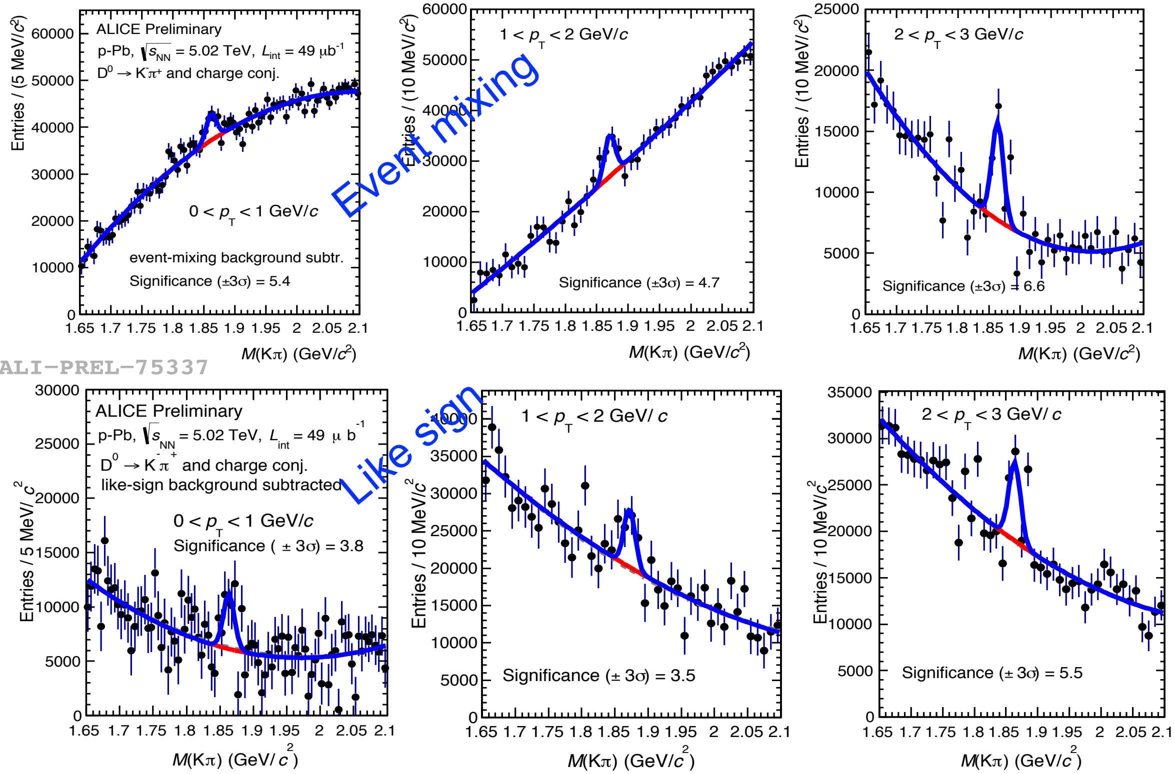


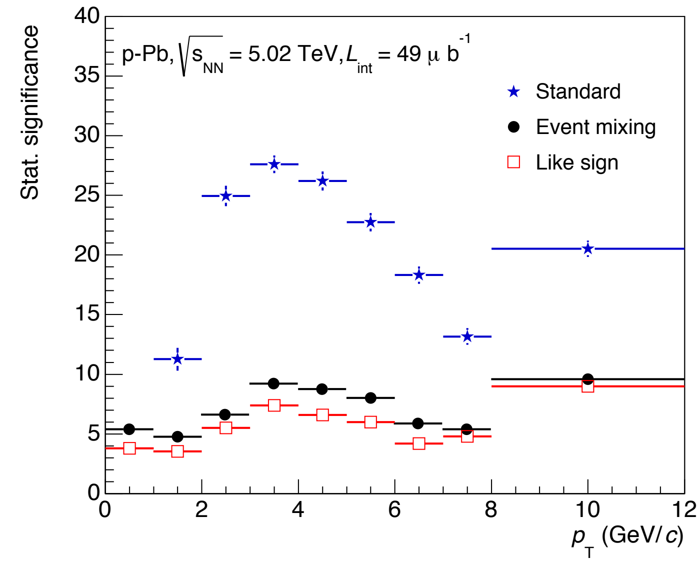


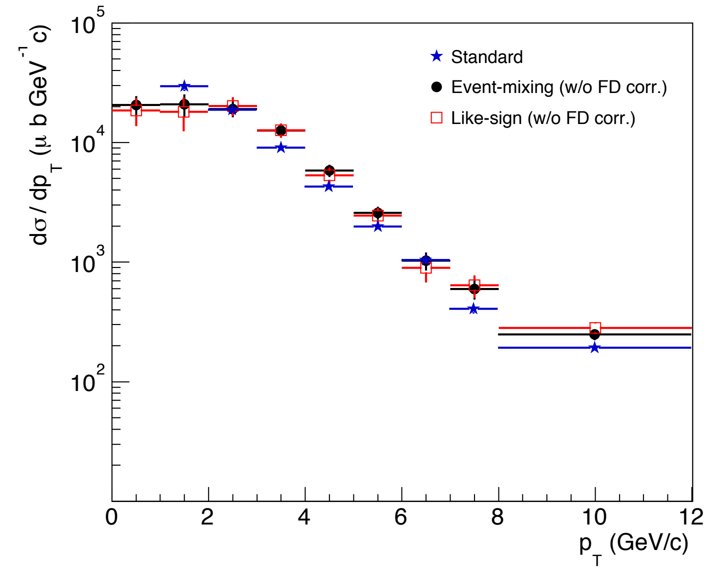


- Invariant mass spectra after event mixing and like sign background subtraction fitted with a Gaussian term for signal and a pol3 term for residual background.
- D^0 signal extracted at low p_T using event mixing and like sign techniques with reasonably good significance.
- D^0 signal extracted using event mixing and like sign techniques compares well for all measured p_T bins.

Signal in p-Pb collisions at √s = 5.02 TeV







$$\left.\frac{d\sigma^D}{dp_T}\right|_{|y|<0.8} = \frac{1}{2}\frac{1}{\Delta y \Delta p_T}\cdot\frac{N^{D\ raw}}{(Acc\times\varepsilon)\cdot BR}\cdot\frac{\sigma^{pPb}}{N_{evt}}$$

- No feed-down correction have been done for event mixing and like sign techniques.
- D^0 cross section from event mixing and like sign techniques compares well with the standard analysis.

Summary

- For the first time in ALICE, D^0 signal has been extracted for $0 < p_T < 1$ GeV/c using event mixing and like sign techniques in both pp and p-Pb collisions.
- D^0 cross section have been calculated in p-Pb using event mixing and like sign techniques.
- Comparison of D^0 cross section with the standard analysis looks reasonably good in p-Pb collisions.
- Study on the systematic uncertainties are ongoing.

Outlook:

In pp collisions:

- Finalize D^0 signal extraction at low p_T using both event mixing and like sign techniques.
- Study the systematic uncertainties.
- Calculate cross section.
- Do the feed-down correction.

In p-Pb collisions:

- Try to split p_T: 0-1 GeV/c bin into two bins.
- Finalize systematic uncertainties study.
- Do the feed-down correction.

In Pb-Pb collisions:

- Efforts are ongoing to extract the D^0 signal at low p_T using both event mixing and like sign techniques.

Motivation

- Jets: unique link between lagrangian (partons) and data (detected particles)
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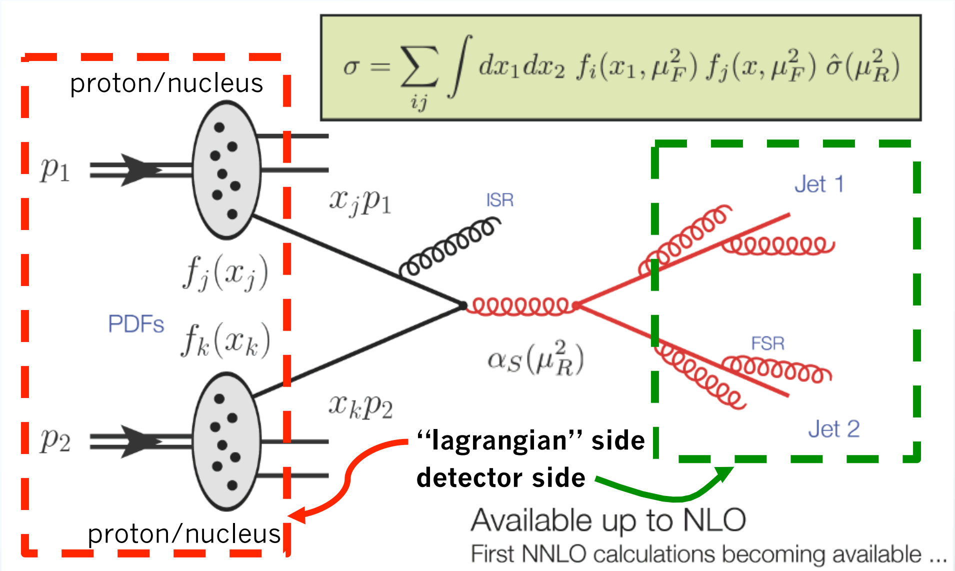
- Key tool to study QCD properties
  - e.g. underlying event, fragmentation
- Specific to HI and HF jets:
  - study of energy loss → in-medium modification of fragmentation functions
  - hf production mechanisms, quark vs. gluon jets
  - low-p_T (of the parton) accessible via γ-jet correlations

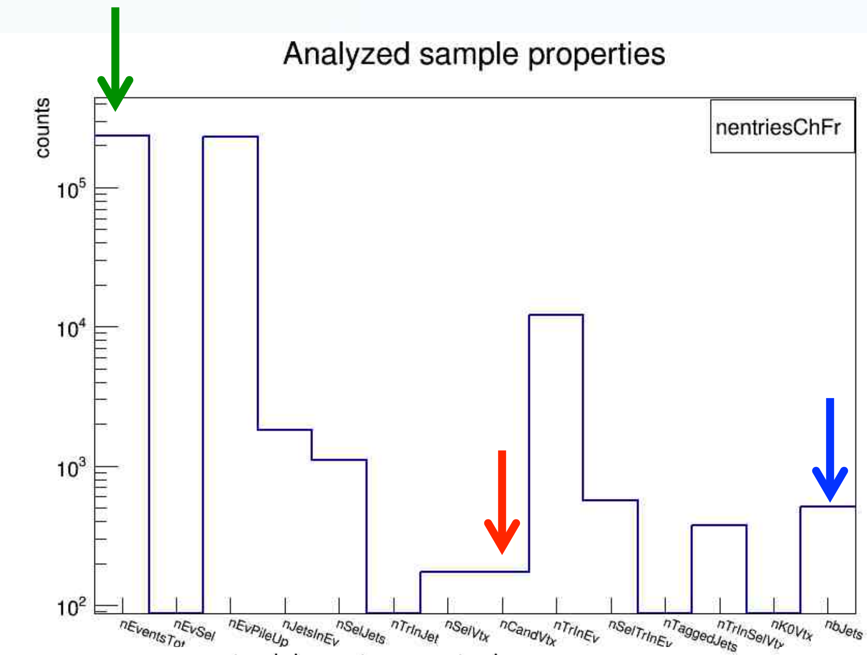


Our implementation of the method

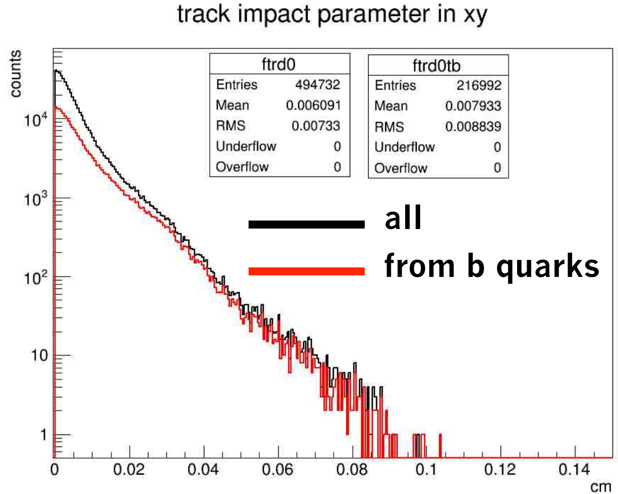
- Analysis strategy (in brief, marked * main differences with CMS):
  - select seeder according to d_0 (ordered list)* (CMS uses S_{d3D})
  - cluster other tracks with the seeder according to:
    - D_{3D} (distance in 3D)
    - $S(D_{3D})$ significance of the above
    - θ_{rel} relative angle
    - tracks excluded from further analysis if selected * (CMS does vtx merging and ''single track vertex'' treatment)
  - fit the vertex
  - save it for future tagging (no merge) *
  - call this a vertex if:
    - $\geq$ 3-prong, flight distance in xy $\leq$2.5 cm, significance of this last >3, M_{INV}<6.5 GeV
  - call this a b-vertex if:
    - S of 3D flight distance >5, η<2, p_T>8, M_{INV}>1.4 GeV

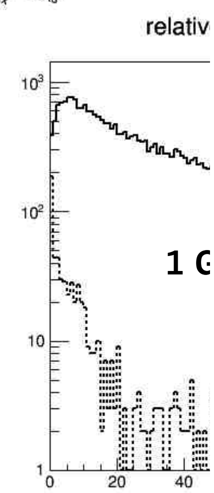
these numbers still to be tuned...

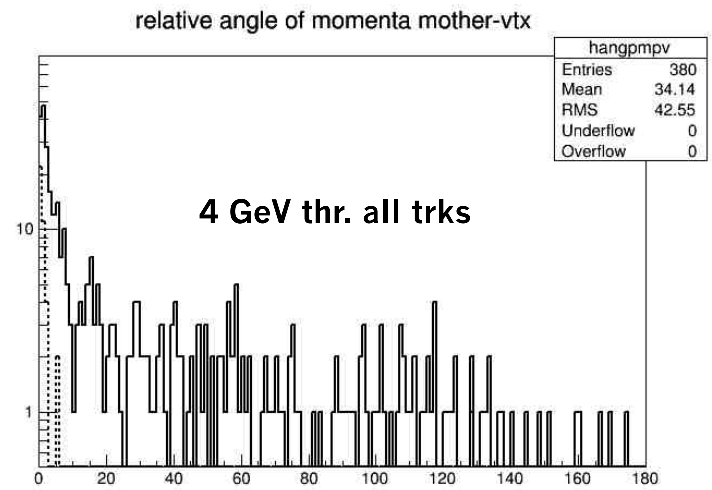
Snapshots from *work in progress*



Legenda
1. total number of events
2. selected events (not used)
3. don’t look at
4. n of candidate jets
5. n of selected jets = passed “standard” jet cuts
6. don’y look at
7. number of vertices “non-K0”
8. number of candidate vtx’s
9. number of tracks in the event with no d0 cut, but quality “standard” cuts and pt>1
10. n of tracks in the event with d0 cut
11. not (yet) used
12. n of tracks in selected vertices
13. n of K0’s
14. n of “real” b jets (jet which have a particle with a b-ancestor)







Outlook

- This analysis is hard to be performed on the current data samples, because of stats
- A study of the achievable performance is mandatory for our future physics plan
- next goals:
  - **determination of the efficiency**
  - **fine tuning of the method to ALICE specs** (yet a bit on the "try and fail" side)
- Limits on the measurement of tagged jets can (will) be put on RUN I data and, who knows...