Measurement of non–prompt Λ_c^+ production in pp collisions at $\sqrt{s} = 13$ TeV with ALICE

Daniel Battistini, on behalf of the ALICE collaboration
Technische Universität München

Quark Matter 2022 – Kraków, Poland
April 4–10, 2022

Heavy Flavour hadrons and the factorisation approach

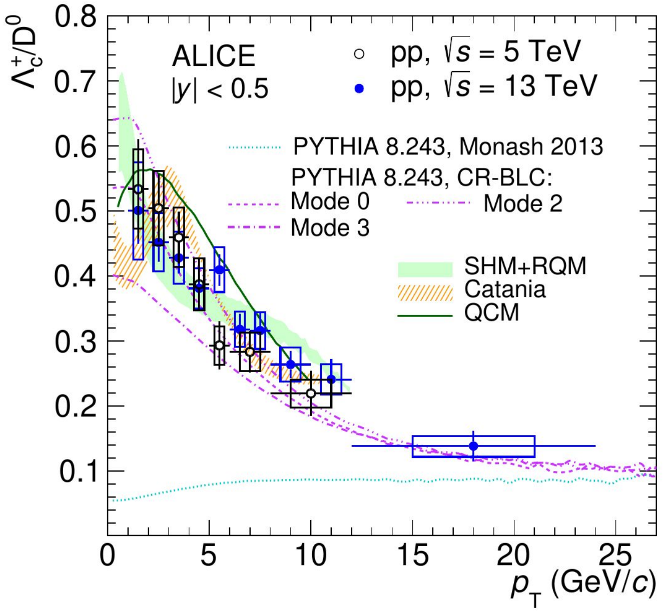
The production of heavy–flavour (HF) hadrons (i.e. containing charm or beauty) is typically described using the ***factorisation approach***:

Parton distribution functions — Fragmentation Functions

$$\sigma_{H_Q} = \sum_{\mathrm{i,j=q,\bar{q},g}} f(x_\mathrm{i}, Q^2) \otimes f(x_\mathrm{j}, Q^2) \otimes \sigma_{\mathrm{ij}\to Q\bar{Q}} \otimes D(z_\mathrm{Q}, Q^2)$$

Partonic cross section

Recent measurements[1,2]: the hadronisation of heavy–quarks depends on the collision system.



In this work: production of non–prompt Λ_c^+ (i.e. coming from beauty–hadron decay):

- test for perturbative QCD calculations,
- access the fragmentation of the b quark.

[1] Phys. Rev. Lett. 128, 012001
[2] Phys. Rev. D 100, 031102(R)

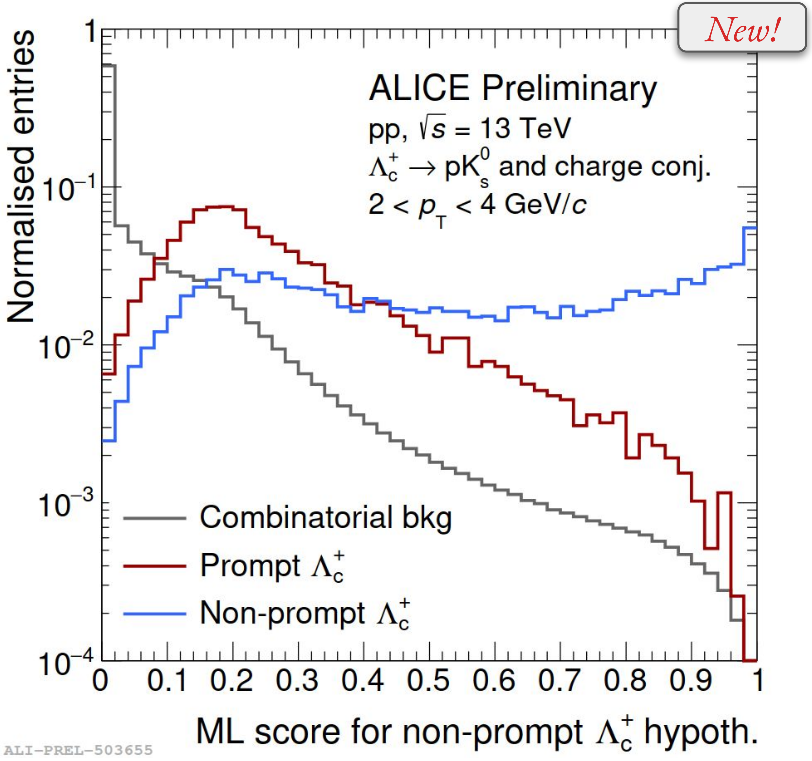
Analysis strategy

The Λ_c^+ candidate sample is made of three classes:
- combinatorial background,
- prompt Λ_c^+,
- non–prompt Λ_c^+.

To separate the three classes → Machine Learning (ML) approach:
- exploit the different decay–vertex topologies,
- multi–class classification algorithm based on Boosted Decision Trees,
- training with examples obtained from:
  data (background),
  Monte Carlo (prompt and non–prompt).

Output: 3 ML scores → probabilities that the candidate belongs to each class.

Good separation!
Select the candidates with:
- large non–prompt score,
- small bkg score.



Measurement of the non–prompt fraction

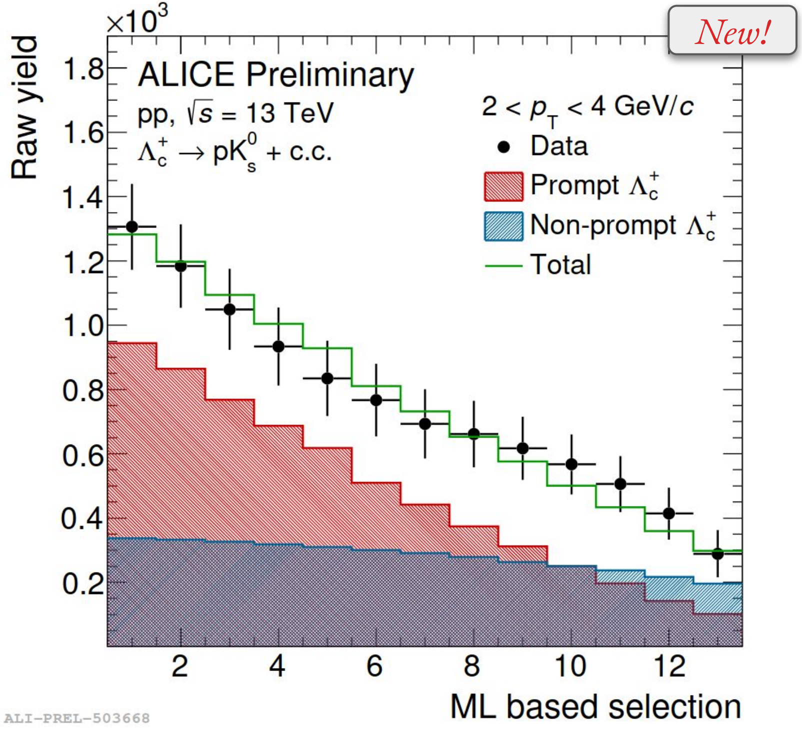
Different selections → different proportions between prompt and non–prompt contributions.

To measure the non–prompt fraction[1]:

- define many selections, for each:

$$Y_i = \varepsilon_i{}^{\mathrm{p}} N^{\mathrm{p}} + \varepsilon_i{}^{\mathrm{np}} N^{\mathrm{np}}$$

  Raw yields (from data),
  Efficiencies × acceptance (from MC),
  True yields (Unknown parameters).
- An overdetermined system of equation is defined.
- Solve numerically for N^{p} and N^{np}.
- Measure the non–prompt fraction.



[1] JHEP 05 (2021) 220

The non–prompt Λ_c^+ and non–prompt D^0 cross section

The non–prompt Λ_c^+ cross section is measured in:

- $\Lambda_c^+ \rightarrow pK_S^0$,
- $\Lambda_c^+ \rightarrow pK^-\pi^+$

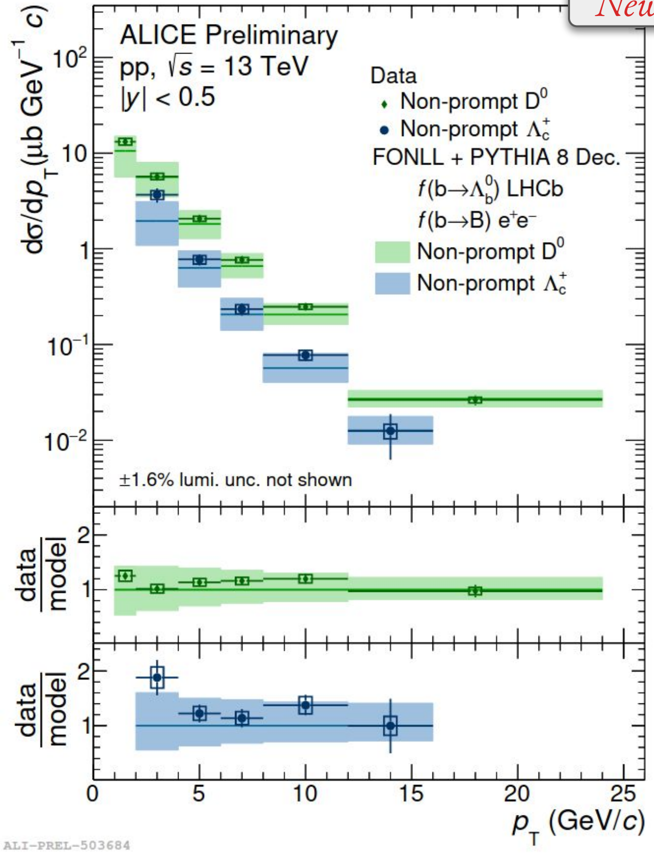
decay channels.

Theoretical model: FONLL[1] using:

- Λ_b^0 fragmentation fractions measured by LHCb[2],
- folding with $H_b \rightarrow \Lambda_c^+ + X$ decay from PYTHIA8.

For both non–prompt D^0 mesons and Λ_c^+ baryons the data is compatible with the model!

New!



[1] JHEP 03 (2001) 006
[2] Phys. Rev. D 100, 031102(R)

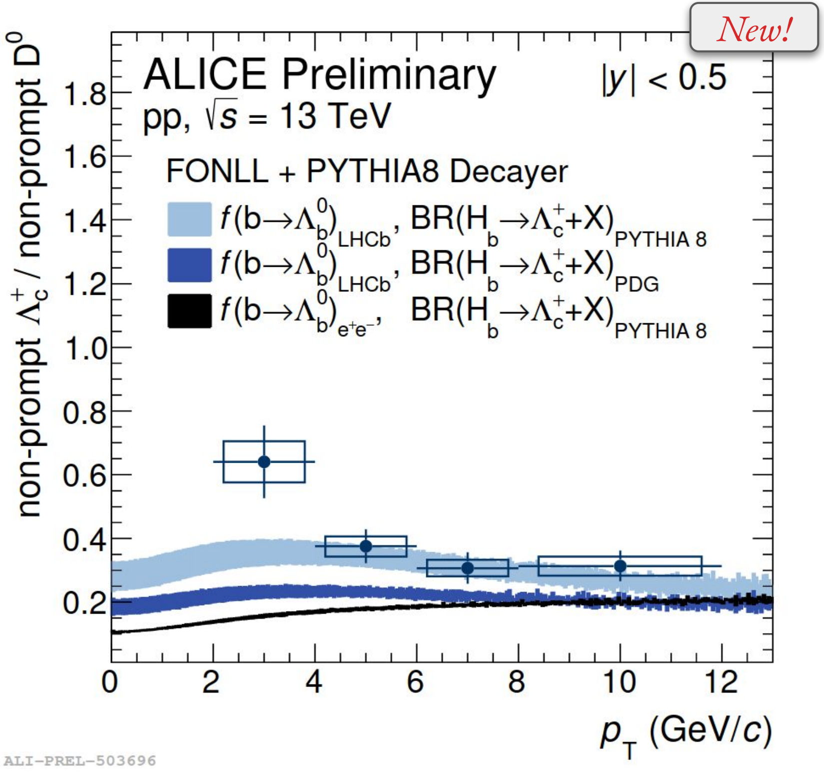
The fragmentation of the beauty quark

The fragmentation of beauty is accessible via:
non–prompt Λ_c^+/ non–prompt D^0 ratio

FONLL tested using fragmentation fractions from
- **LHCb**[1] (pp collisions),
- **e^+e^- collisions**,

and folded with the $H_b \rightarrow \Lambda_c^+ + X$ decay, using:
- PDG decay table (only measured decays),
- PYTHIA8 decay table (also unmeasured decays).

Enhanced beauty–baryon production w.r.t e^+e^- collisions.



[1] Phys. Rev. D 100, 031102(R)