TMVA methods to reconstruct $\Lambda_c^+ \rightarrow pK^0_S$ in p–Pb collisions with ALICE at the LHC

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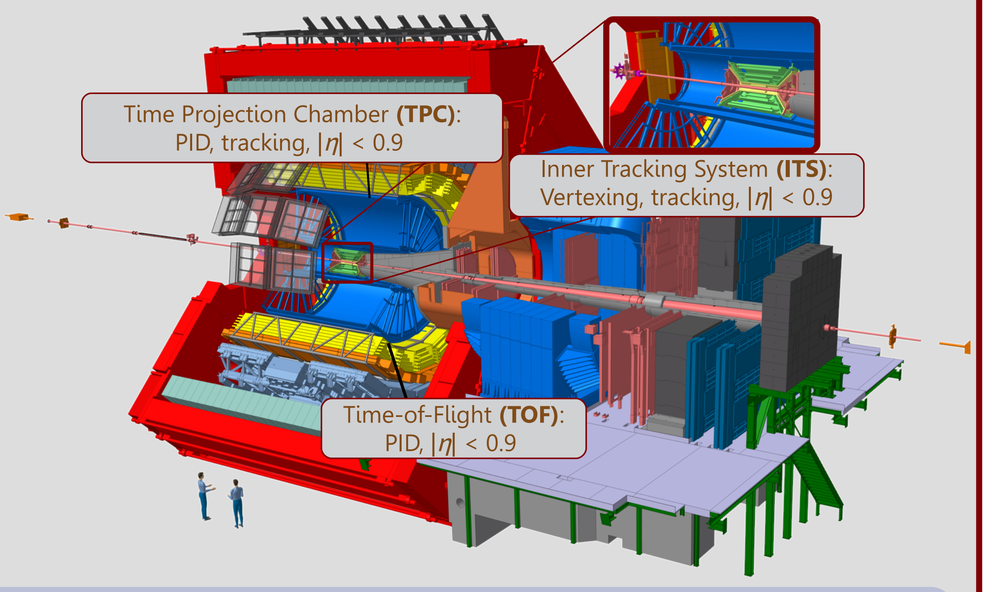
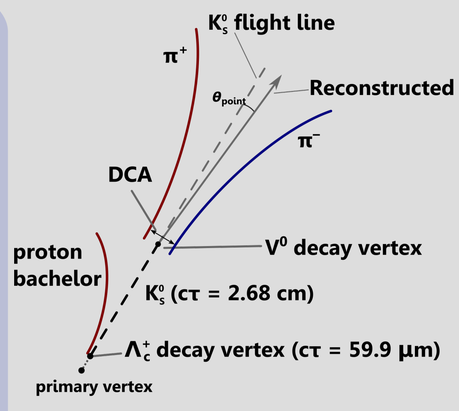
Physics motivation

- Heavy quarks (**charm** & **beauty**) are formed in early hard scattering processes in heavy-ion collisions → sensitive probe of strongly-interacting medium
- Λ_c^+ baryon: Lightest charmed baryon. Measuring production gives insight into charm-quark hadronisation
- Light-flavour sector: Enhancement of Λ/K^0 and p/π baryon-to-meson ratios in heavy-ion collisions
  - Mass-induced effect (← radial flow) and/or effect of quark coalescence on hadronisation mechanisms?
  - Do these effects extend to the charm sector?
- Measurements in p–Pb collisions: Search for evidence of initial-state nuclear effects



Λ_c^+ baryon reconstruction

- Λ_c^+ baryons reconstructed in fully hadronic decay channel: $\Lambda_c^+ \rightarrow K^0_S(\rightarrow\pi^+\pi^-)$ (total BR: 1.09%[1])
- K^0_S candidate from pair vertex of unlike-sign pions
- Paired with bachelor proton close to primary vertex to construct Λ_c^+ candidate
- Preselection of candidates using:
  - →distance of closest approach (DCA) of $K^0_S \rightarrow \pi^+\pi^-$ decay daughters
  - →cosine of pointing angle between K^0_S flight line & reconstructed momentum

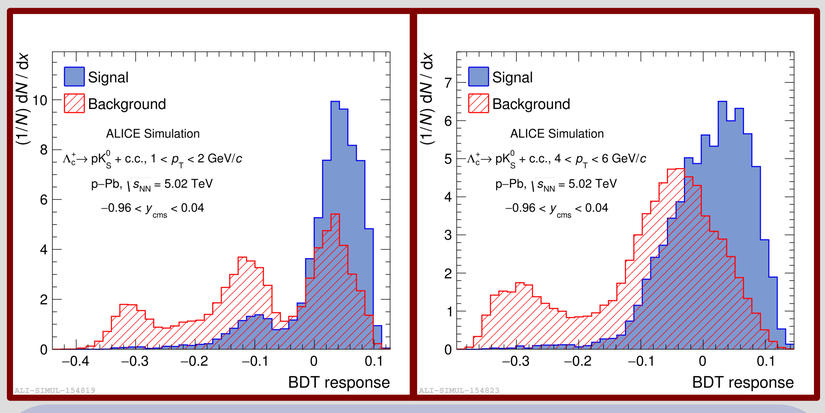


Experimental setup

- Vertex reconstruction with ITS
- Tracking with TPC & ITS
- Particle identification (PID) with TPC (via d*E*/d*x*) & TOF (via time-of-flight)

Data sample

- 6 x 10^8 minimum-bias p–Pb events at $\sqrt{s_{NN}}$ = 5.02 TeV (sixfold increase over Run 1)
- Monte Carlo (MC) samples based on HIJING + PYTHIA6 (Perugia 2011 tune) used for efficiency corrections and signal/background training



Toolkit for Multivariate Analysis (TMVA) [2]

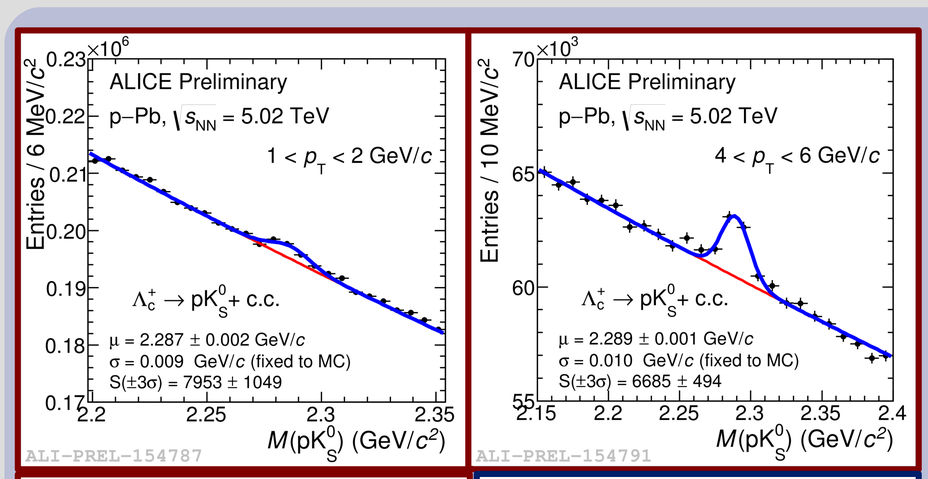
Further selection with **Boosted Decision Trees** to reduce combinatorial background.

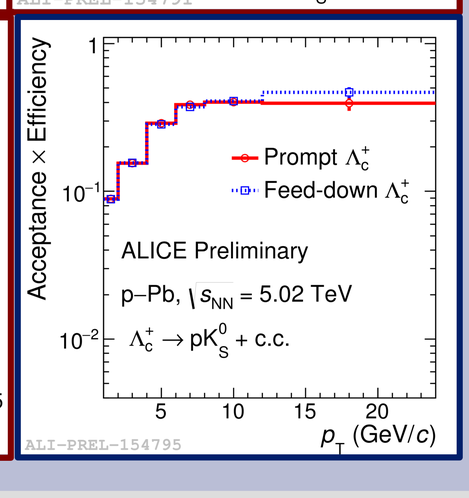
Machine learning approach that separates "signal-like" from "background-like" candidates based on MC training

Trained on multiple variables (impact parameter & p_T of bachelor track, Bayesian PID probability assigned to bachelor proton, mass and $c\tau$ of K^0_S)

Simplifies all variables to a single axis ("BDT weight")

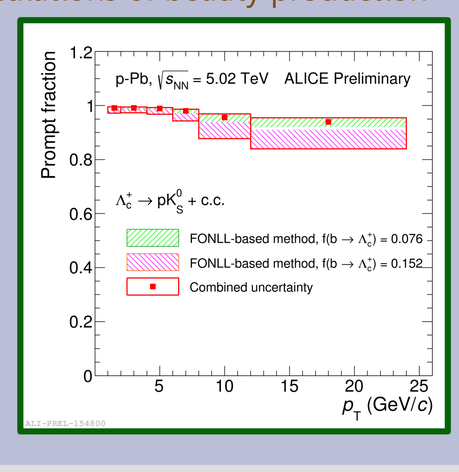
Trained separately in each p_T interval; efficiency computed as the fraction of generated Λ_c selected





Signal extraction

- Λ_c^+ baryon signal extracted via fit to **invariant mass distribution** after selections
- Modelled with Gaussian function for signal, exponential for background.
- Width of Gaussian function determined from MC; mean left as free fit parameter
- Raw signal **corrected for selection efficiency** using MC: preselection efficiency, BDT efficiency, geometrical acceptance
- **Feed-down subtraction** using FONLL pQCD calculations of beauty production



Results & Conclusions

Λ_c^+ baryon cross section:

In good agreement with analyses using other decay channels and analysis techniques - see posters by **C. Hills** ($\Lambda_c^+ \rightarrow pK\pi$, poster 269), **E. Meninno** ($\Lambda_c^+ \rightarrow pK^0_S$ with standard cuts, poster 44), **Y. Watanabe** (Pb–Pb collisions, poster 132)

Results consistent with run-1 measurement[3], factor of 2 improvement in statistical precision; wider p_T range measured (1–2 & 12–24 GeV/c)

Λ_c^+ / D^0 production ratio:

Results consistent in pp[3] and p–Pb collisions within uncertainties

Baryon-to-meson ratio generally higher than predicted by models (PYTHIA8 with enhanced colour reconnection)[3]

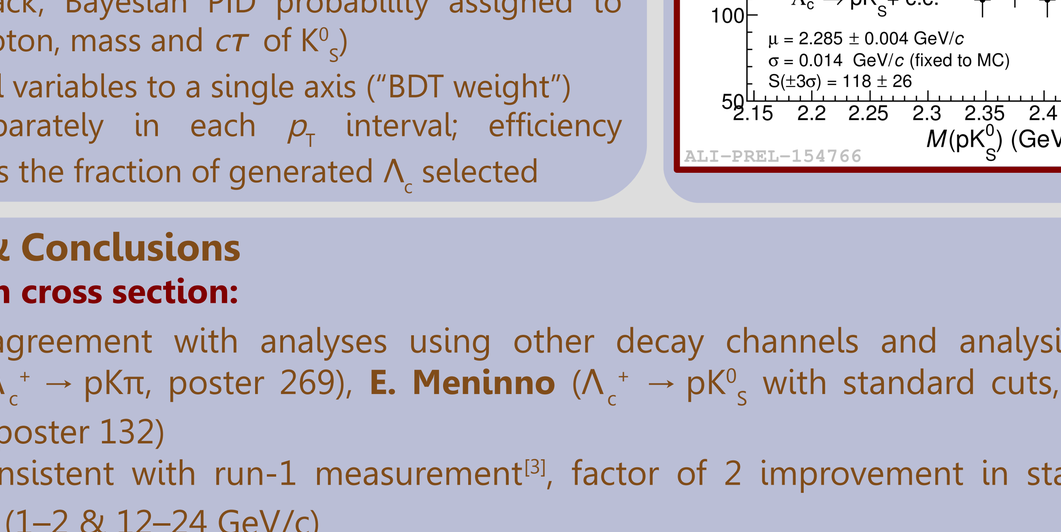
Similar pattern to Λ/K^0_S and p/π ratios; similar values to Λ/K^0_S ratio in both systems within uncertainties

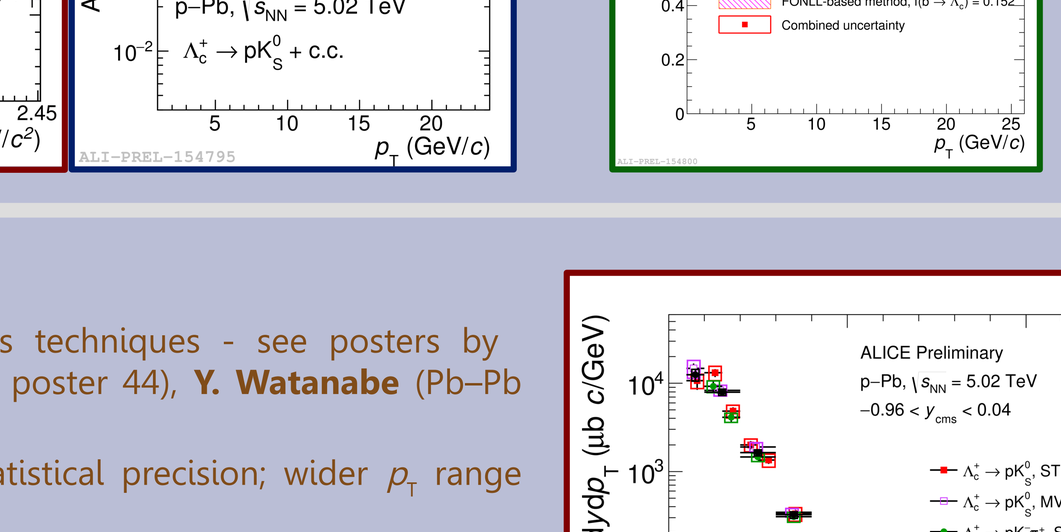
Measurement ongoing in pp collisions at $\sqrt{s}$ = 5 TeV (3x more statistics than pp at $\sqrt{s}$ = 7 TeV[3]) and 13 TeV

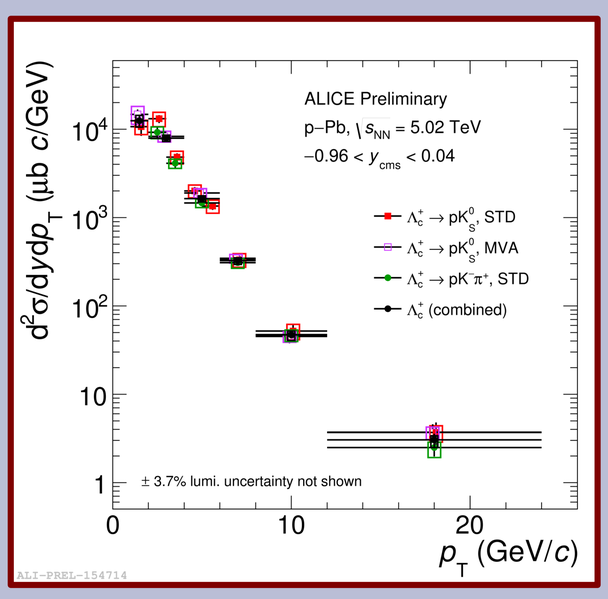
Λ_c^+ baryon nuclear modification factor (R_{pPb}):

Consistent with D-meson R_{pPb} in the common measured p_T interval

Consistent with unity within uncertainties; no evidence of cold nuclear matter effects







[1] C. Patrignani *et al.* (Particle Data Group), Chin. Phys. C40, 100001 (2017)
[2] A. Hoecker *et al.*, PoS ACAT 040 (2007)
[3] ALICE Collaboration, arXiv:1712.09581 (accepted by JHEP)

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