Measurement of Λ_c^+ production in Pb-Pb collisions with the ALICE experiment at the LHC

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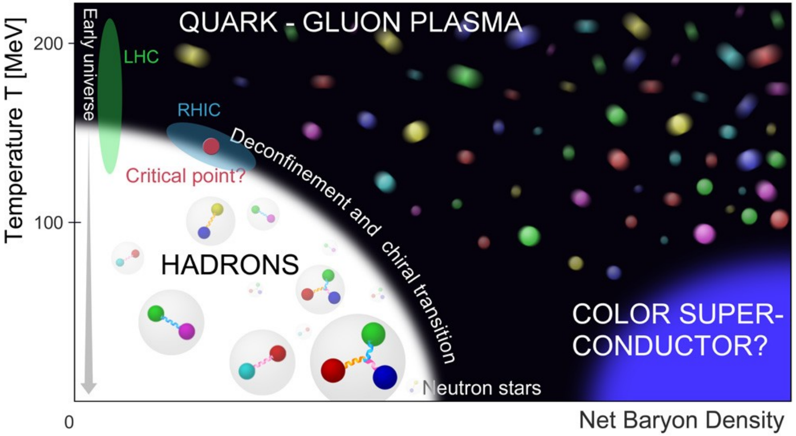
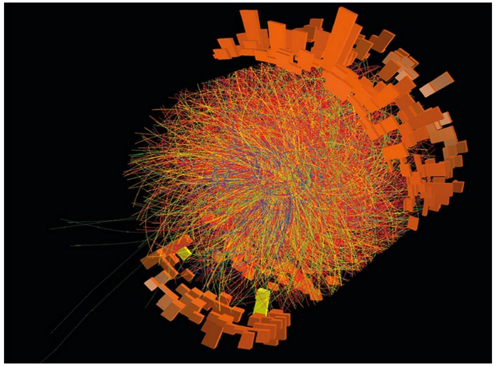
Annual Liverpool HEP meeting 2022

Heavy-ion collisions at ALICE

- Aim: study quark-gluon plasma (QGP)
  - Colour-deconfined state predicted by QCD
  - Created in ultra-relativistic heavy-ion collisions
- High-multiplicity environment:
  - Need excellent vertexing and particle identification (PID) capabilities

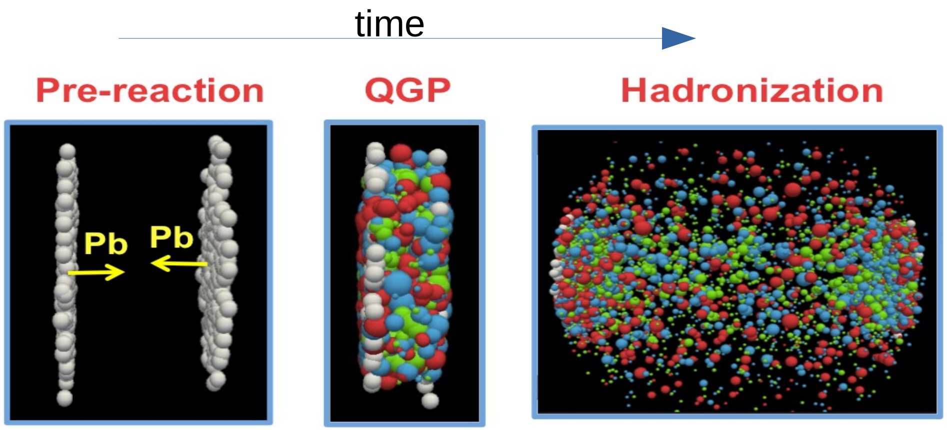




Λ_c^+ production in heavy-ion collisions

Quark gluon plasma:

- created during Pb-Pb collision
- Quickly cools down and hadronises



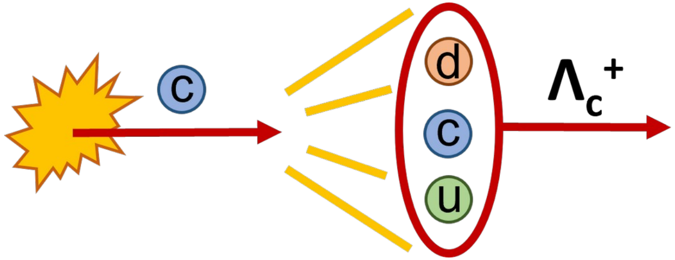
Heavy flavour quarks:

- Created at start of interaction
- Interact with medium during all stages of hadronisation
- Excellent probe of QGP evolution

Hadronisation mechanisms

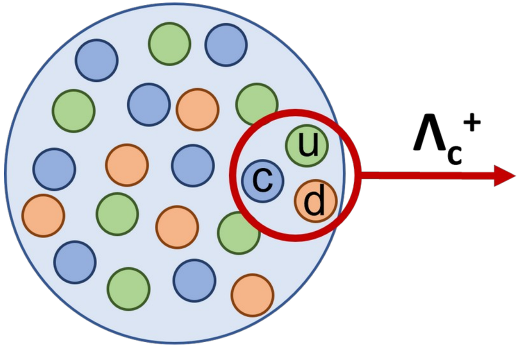
Fragmentation:

- Energetic quark or gluon excites the vacuum and creates a pool of quarks and antiquarks
- It combines with them into hadrons
- Predicted to be universal in collision systems

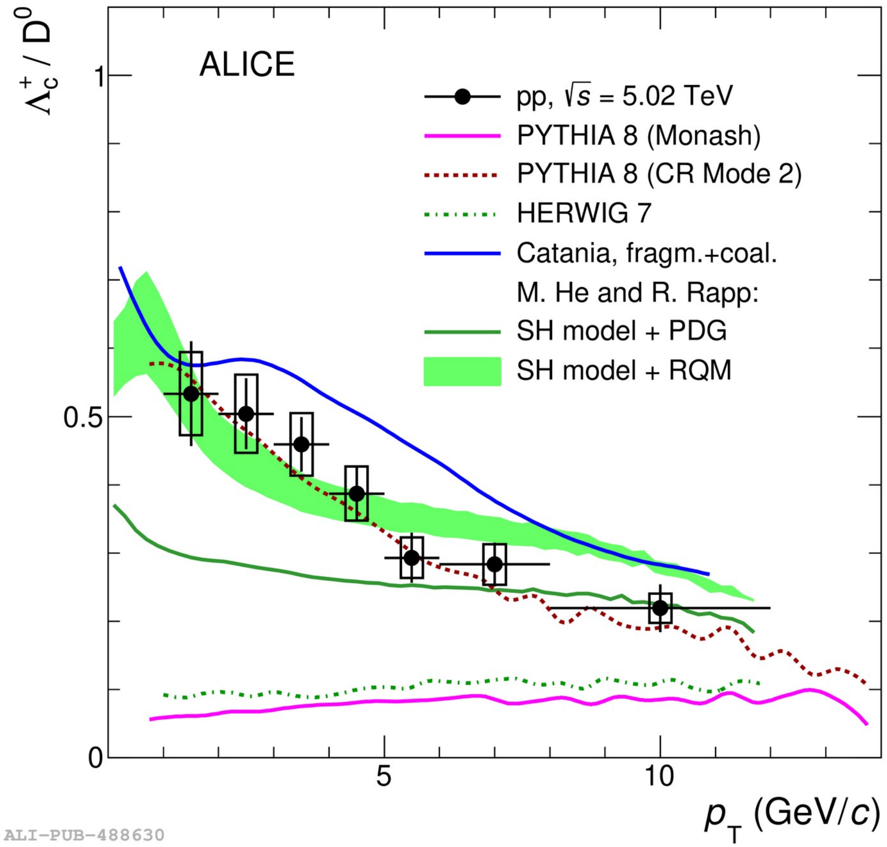


Coalescence:

- Quark and gluons get close enough to each other in the QGP to recombine into hadrons directly
- Predicted to occur in QGP



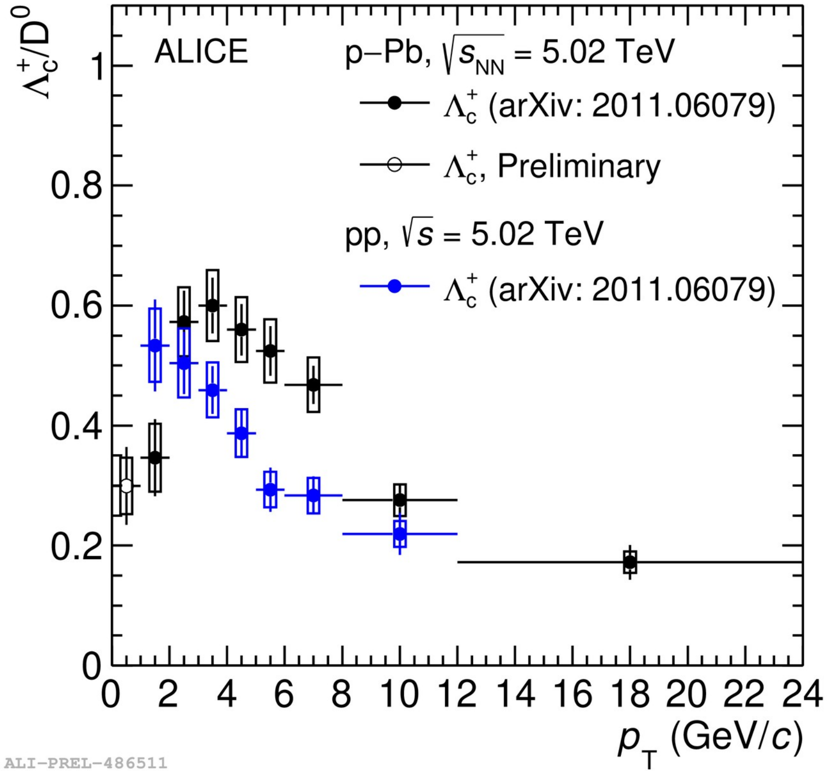
Measurements in pp and p-Pb



Λ_c^+/D^0 ratio in pp collisions:

- Underestimated by models using fragmentation function tuned on e^+e^- collisions
- Better described by model assuming coalescence in pp collisions also

Measurements in pp and p-Pb

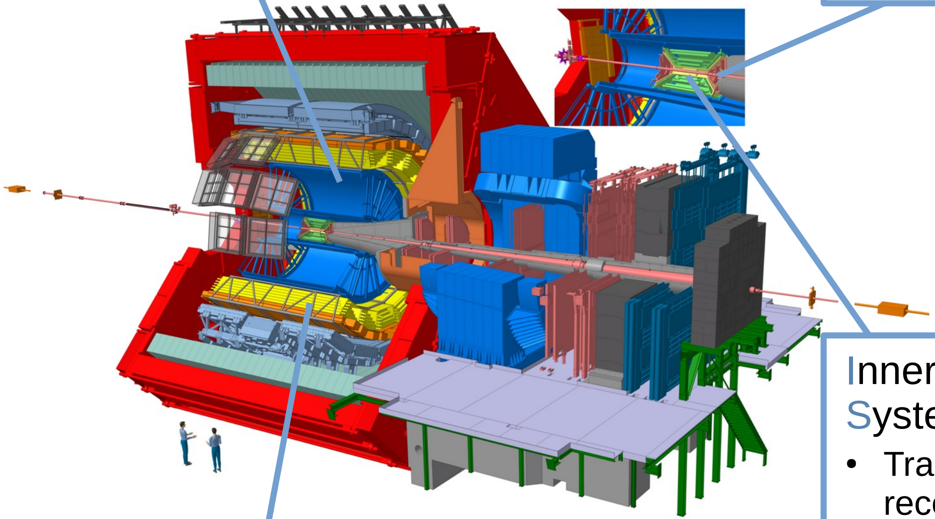


Λ_c^+/D^0 ratio in p-Pb collisions:

- Shift towards higher p_T compared to pp collisions
- p_T dependence not observed in measurements from e^+e^- and ep collisions

The ALICE detector

- One of the 4 main LHC experiments
- Optimised for heavy ion (Pb-Pb) collisions
  - Track and PID down to low p_T
  - Identification of short-lived particles
  - Low material budget
- Particle identification achieved with several different techniques and detectors



Time Projection Chamber
- Track reconstruction
- Particle identification

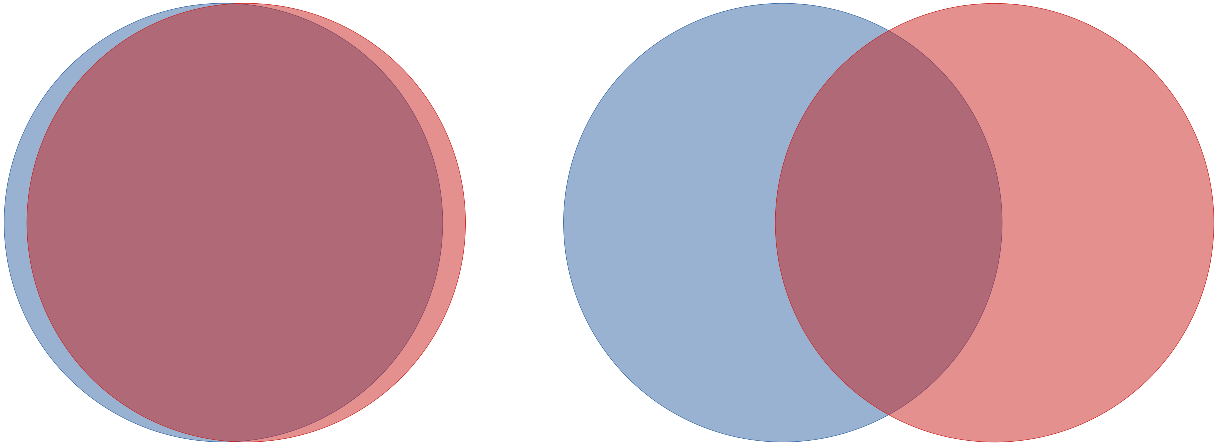
V0 detectors
- Trigger
- Event selection

Inner Tracking System
- Track reconstruction
- Primary and secondary decay vertices reconstruction

Time of Flight detector
- Particle identification

Reconstruction of the Λ_c^+ baryon

- two centrality classes:
  - 0-10% (central)
  - 30-50% (semicentral)
- Four p_T bins:
  - 4 GeV/c - 6 GeV/c
  - 6 GeV/c - 8 GeV/c
  - 8 GeV/c - 12 GeV/c
  - 12 GeV/c - 24 GeV/c



central collision

semi-central collision

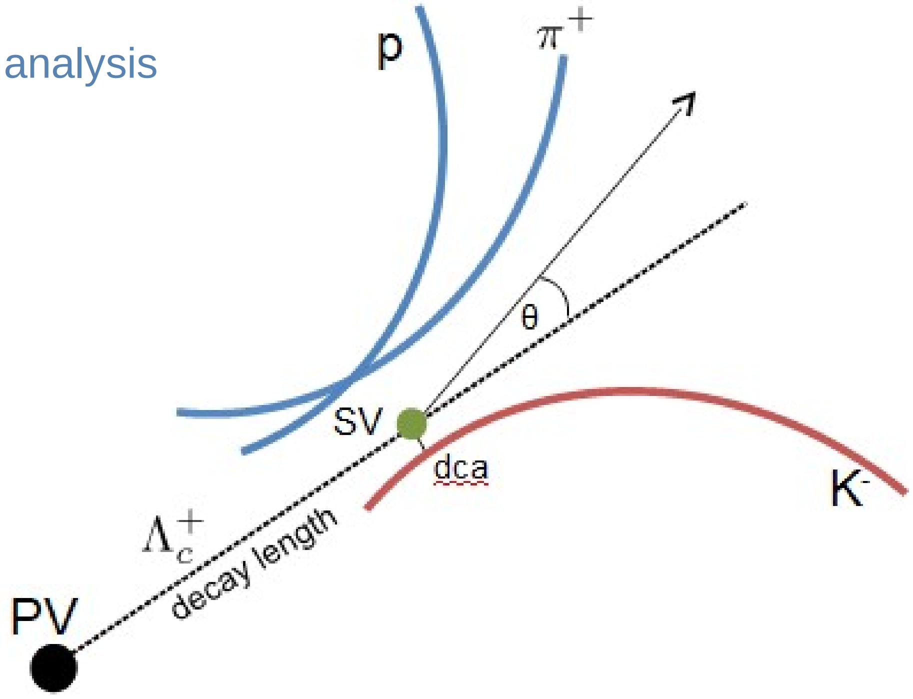
Reconstruction of the Λ_c^+ baryon

Λ_c^+ = udc, m = 2286.46 ± 0.14 MeV, cτ = 60μm

$\Lambda_c^+ \rightarrow pK^-\pi^+$ (BR = 6.28%) ← used in this analysis

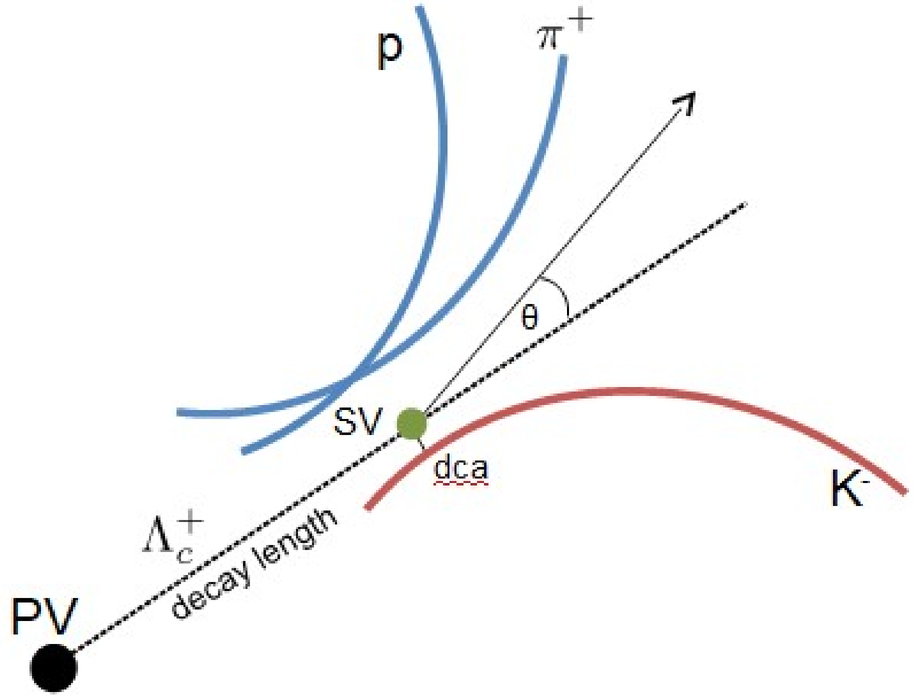
$\Lambda_c^+ \rightarrow pK_s^0$ (BR = 1.59%)

- Reconstructed via decay channel
- Candidates built as triplets with correct charge sign
- kinematic and topological cuts applied using Boosted Decision Trees (BDT)



Training the BDT model

- Training input:
  - MC production (signal)
  - Data sideband (background)
- Trained on kinematic and topological variables, e.g.
  - Decay length
  - Distance of closest approach (dca)
  - Pointing angle θ



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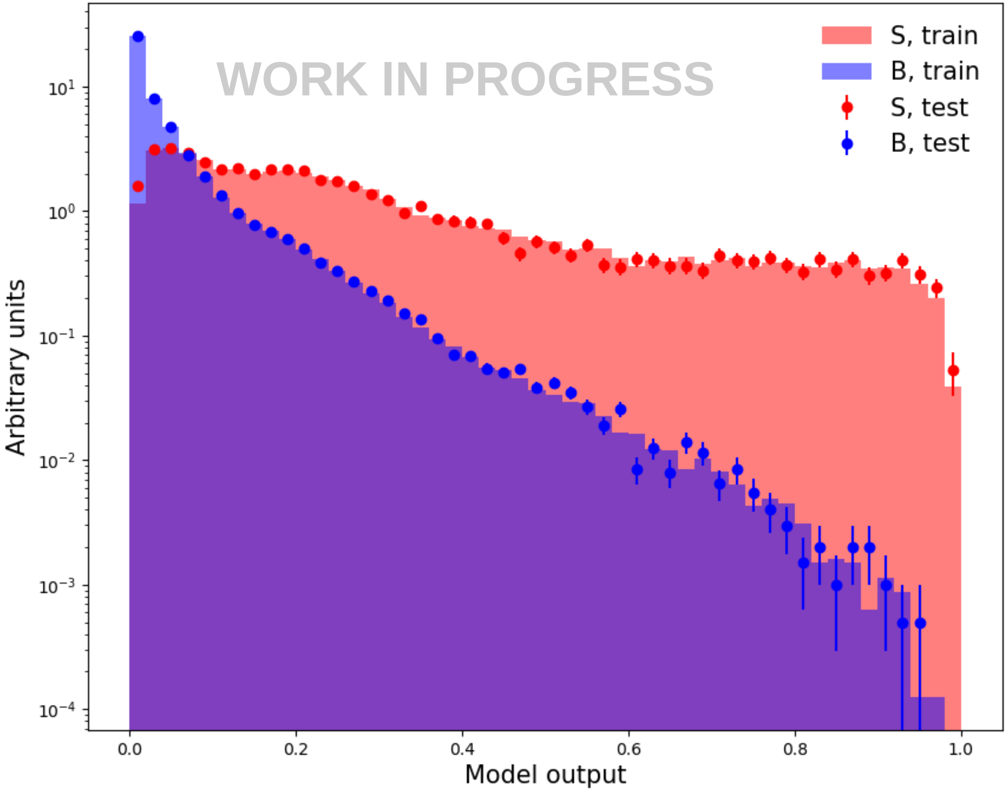

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  - MC production (signal)
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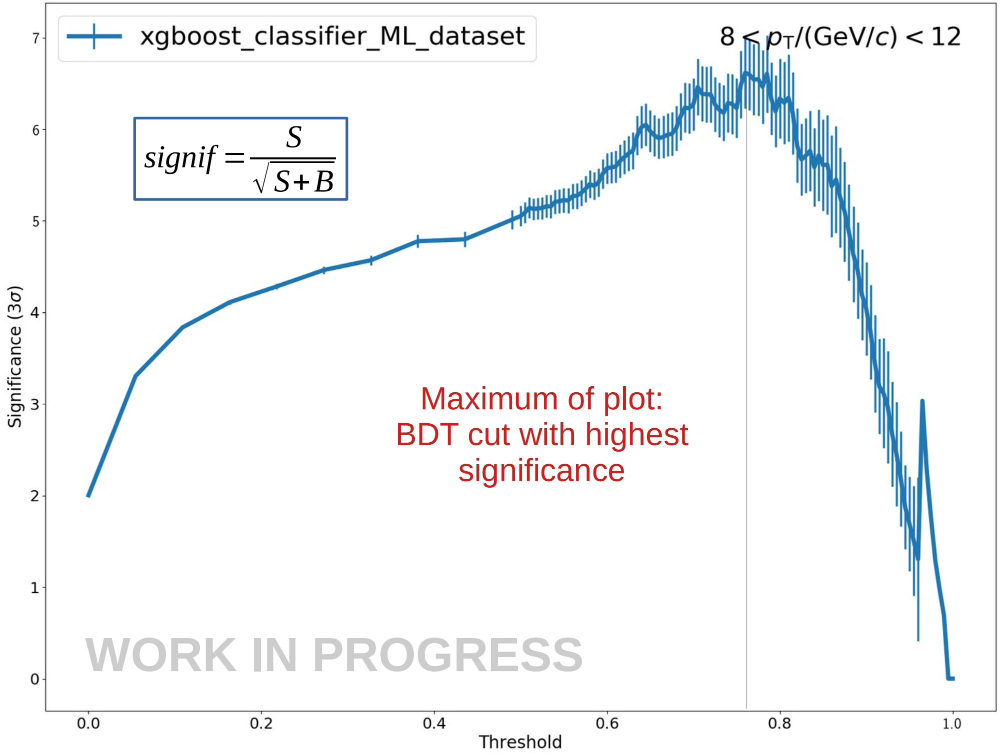
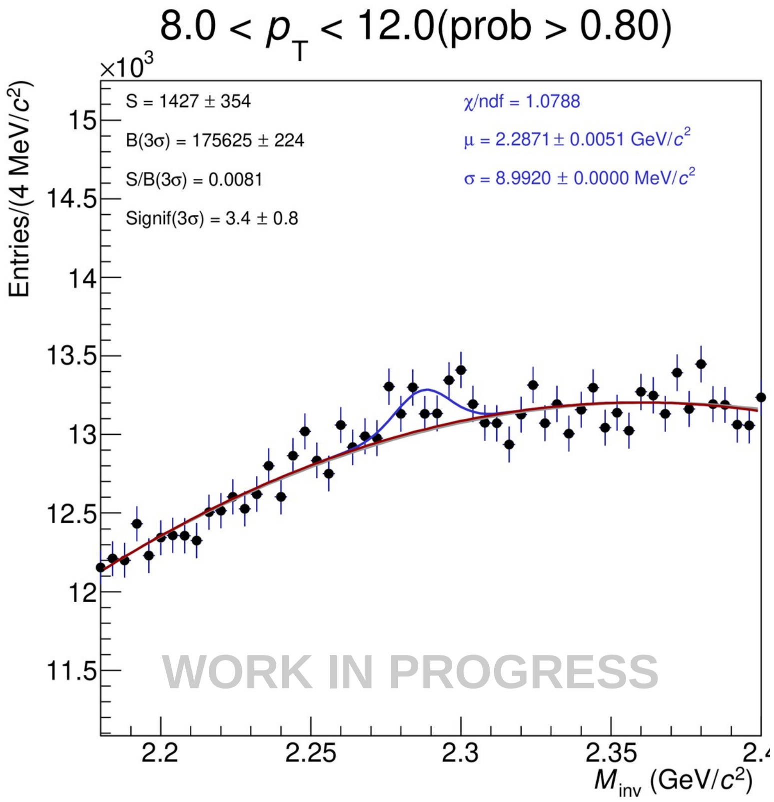
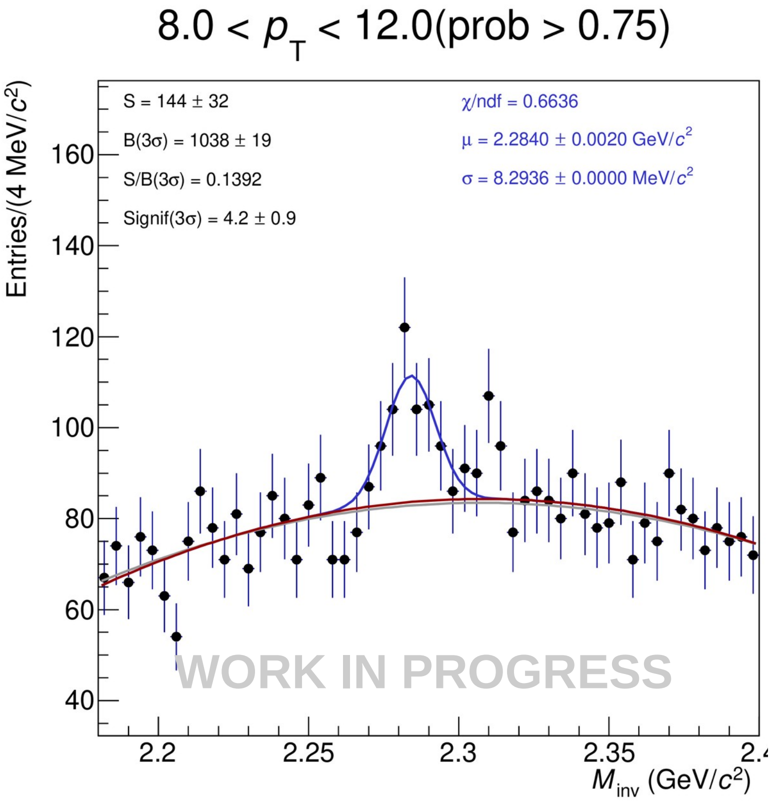
  - Distance of closest approach (dca)
  - Pointing angle θ
- BDT cut decided using significance optimisation



Invariant mass distribution

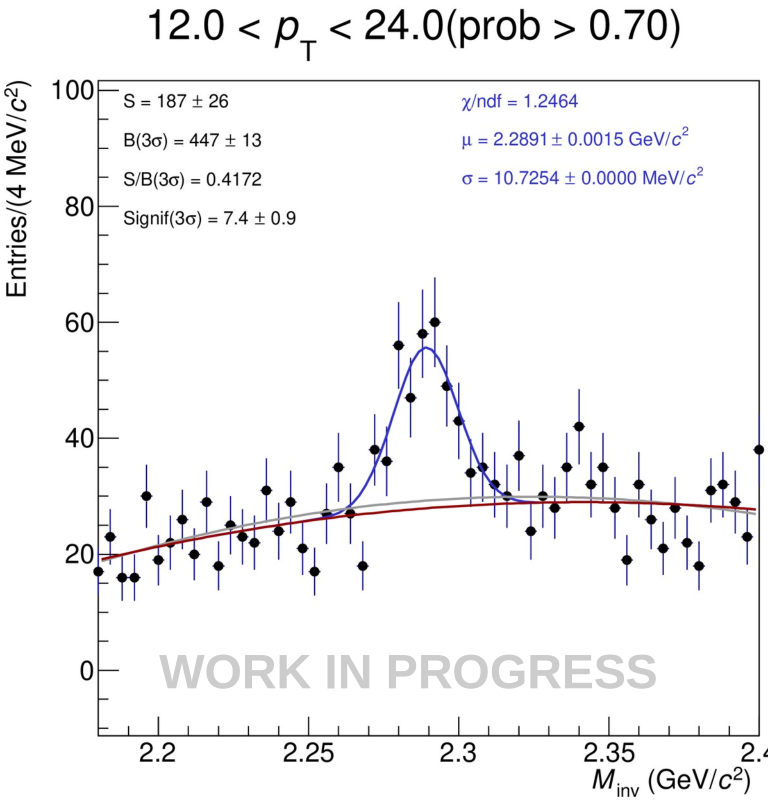


central collisions



semi-central collisions

Invariant mass distribution



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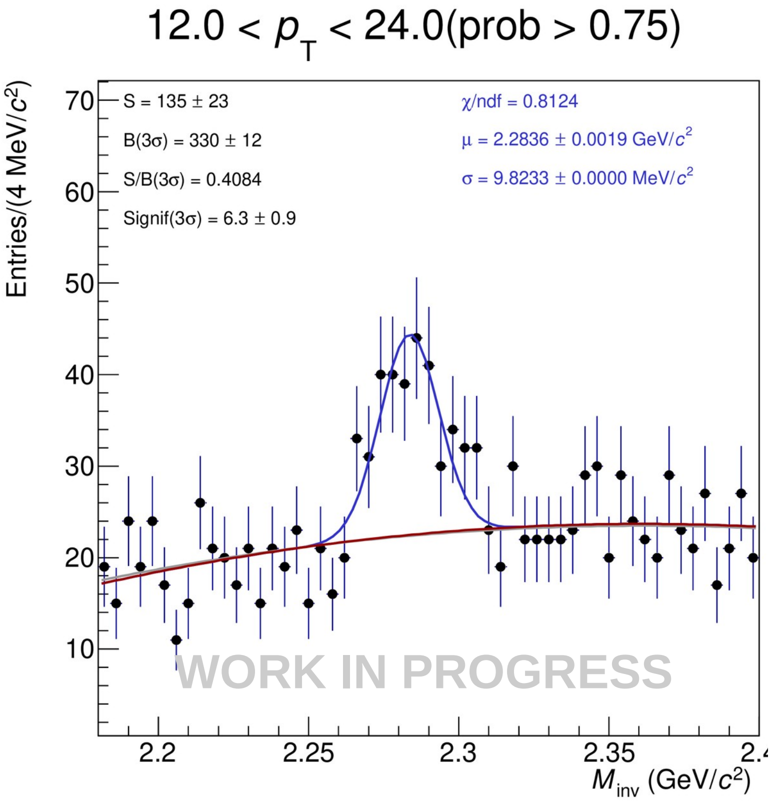

semi-central collisions

Calculating the corrected yield

$$\text{Corrected yield} = \frac{f_{\text{prompt}} \times N^{\Lambda_c}_{|y|<y_{\text{fid}}}}{(A \times \epsilon)_{\text{prompt}}}$$

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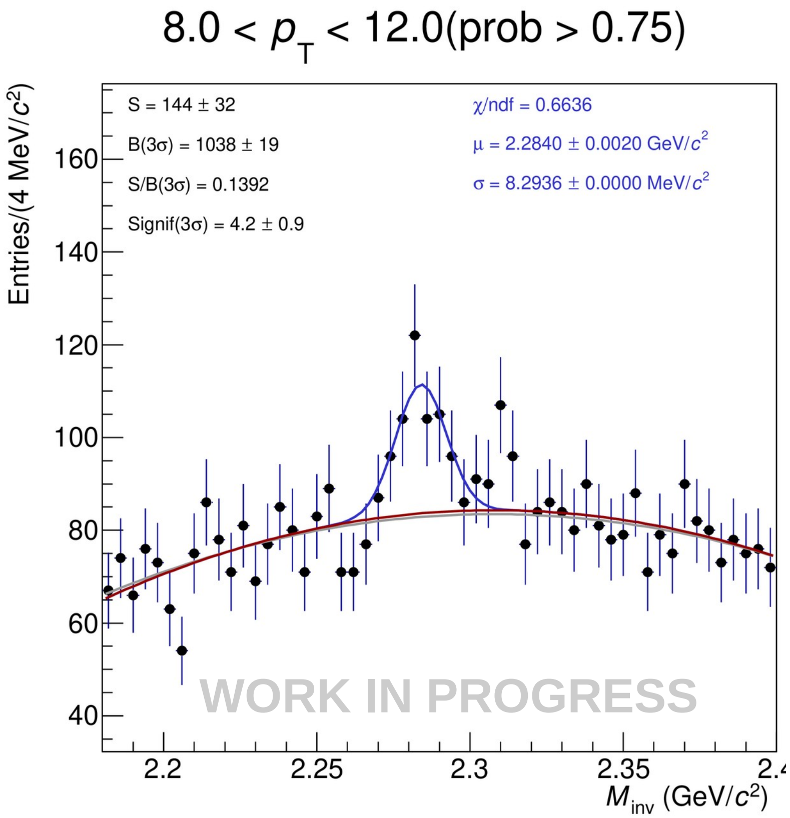
- Raw yield



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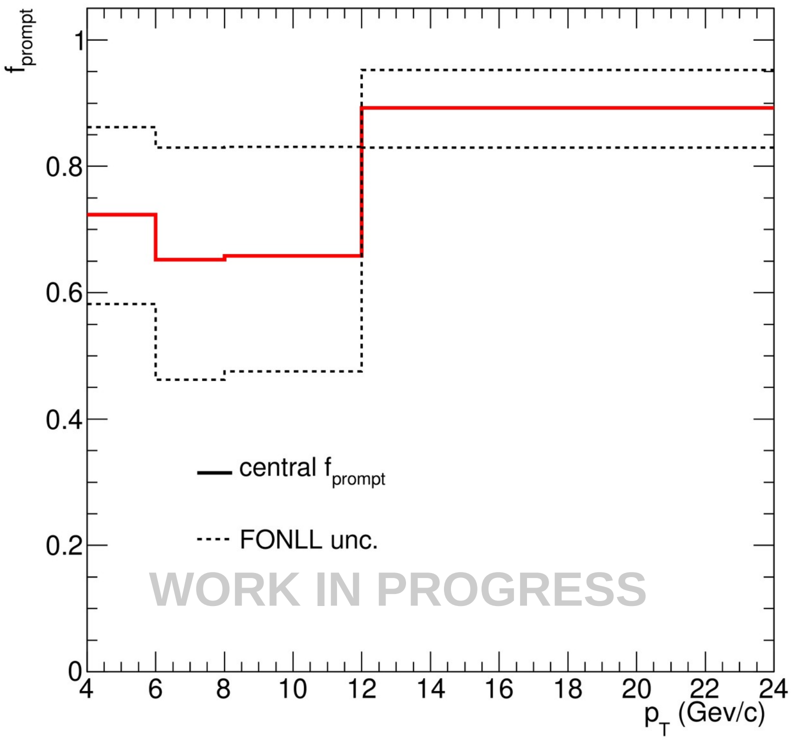
- Raw yield
- Feed-down correction

Non-prompt Λ_c^+ production:

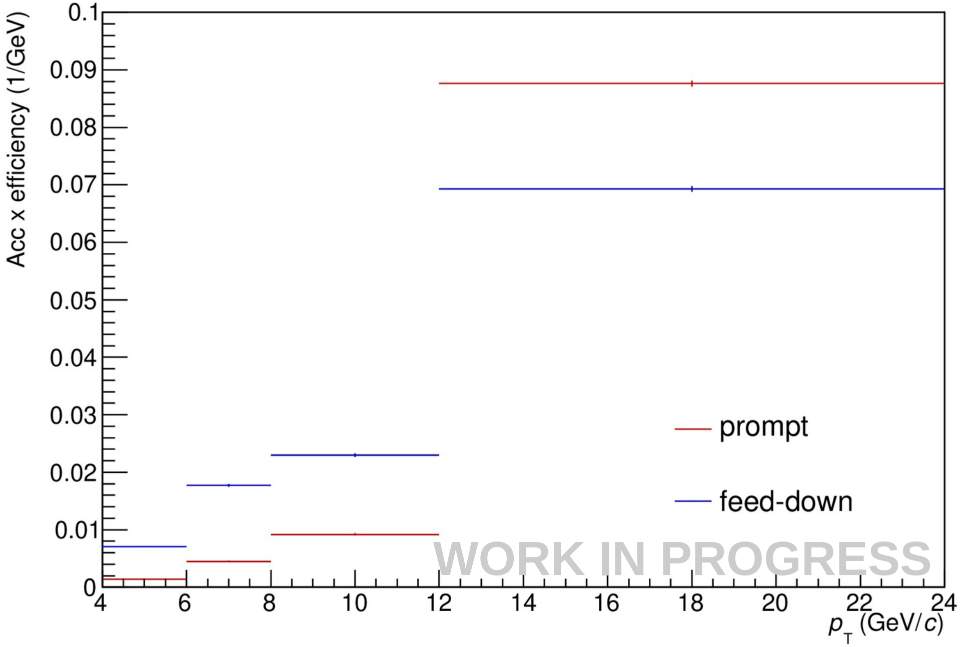
$$\Lambda_b^0 \rightarrow \Lambda_c^+ + X$$



Calculating the corrected yield

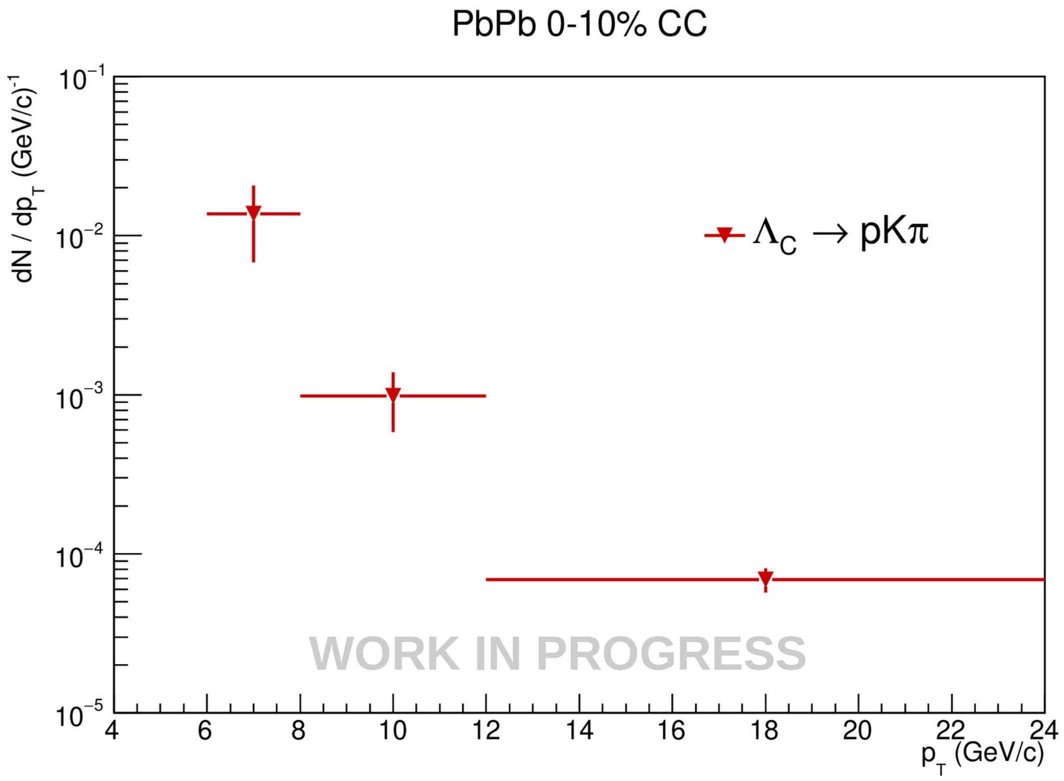
$$\text{Corrected yield} = \frac{f_{\text{prompt}} \times N^{\Lambda_c}_{|y|<y_{\text{fid}}}}{(A \times \epsilon)_{\text{prompt}}}$$

- Raw yield
- Feed-down correction
- Correction for detector efficiency and acceptance



Corrected Yield

- Corrections are applied to the yield:
  - Fragmentation function
  - Efficiency
  - Detector acceptance
- Find corrected yield



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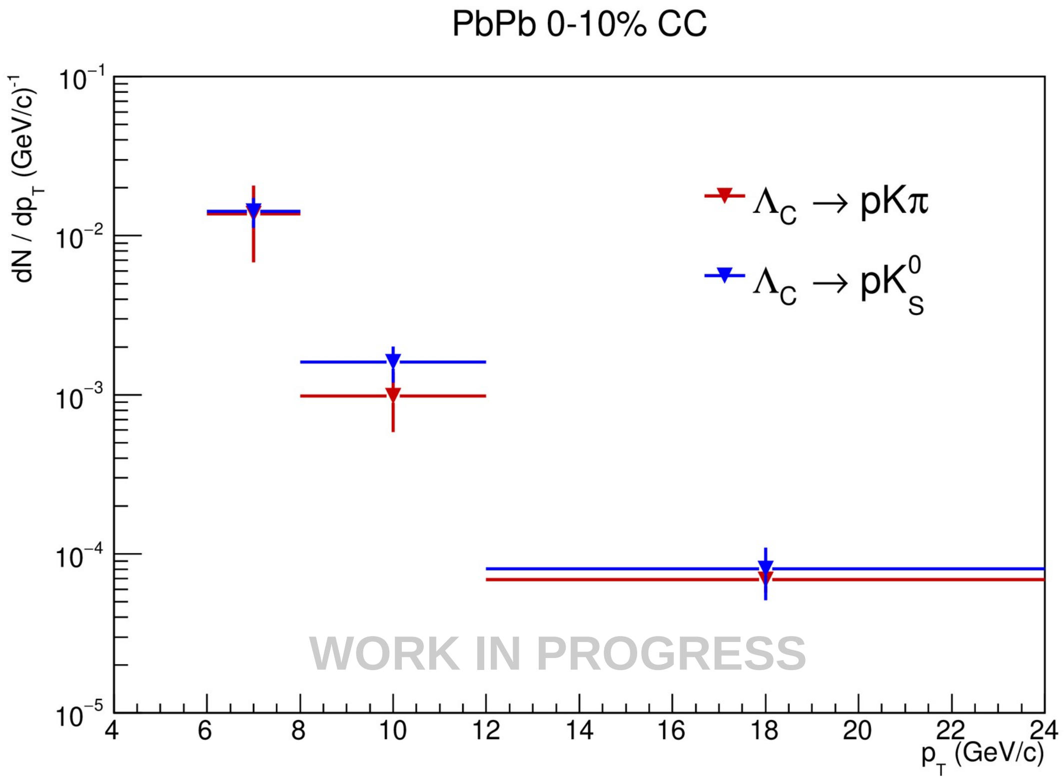
- Comparison to measurement in other decay channel



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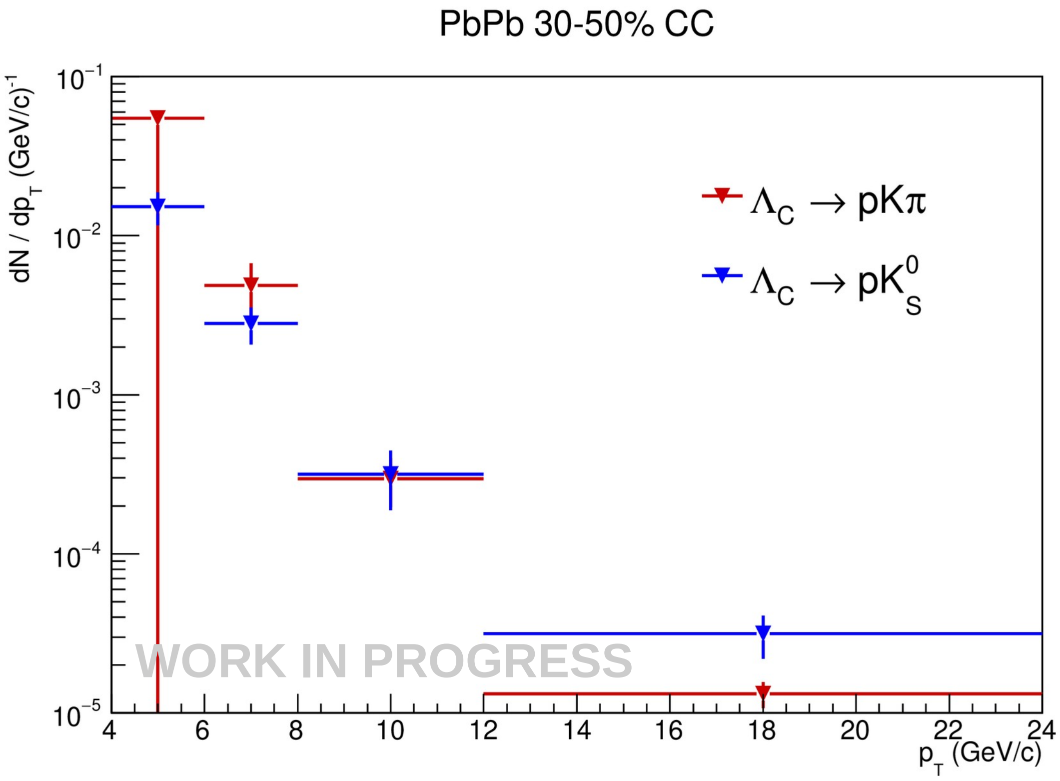

Summary

- A quark gluon plasma can be created in heavy-ion collisions
- Heavy flavour hadrons are a useful probe into hadronisation mechanisms
- Lc production measured via corrected yield in two centrality classes
- Compatible with measurements from different decay channel
- Next steps:
  - Evaluate systematic uncertainties
  - Merge with pK_s^0 channel