Production of Strange Particles at the LHC from the ALICE Experiment

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Outline of Seminar

- Introduction to project
- Relevant Physics
- Workflow of project
- Preliminary results and analysis
- Outlook for remainder of project

Project Introduction

- ALICE collaboration – aims to study properties of Quark-Gluon Plasma (QGP) by colliding heavy ions

AIM: Investigate the enhanced production of singly strange hadrons, K0 and Λ (V0's), in pp collisions.

- ➢ Make selection cuts to improve purity of data sample
- ➢ Use Monte Carlo simulations to calculate reconstruction efficiency
- ➢ Produce corrected momentum spectra for analysis

Data is taken from ALICE Run 3 - results may be compared to previous runs.

Relevant Physics

Quantum Chromodynamics (QCD):

- Governs strong force interactions between ‘coloured’ particles
- Quarks and gluons confined as hadrons

Formation of Quark Gluon Plasma (QGP):

- Asymptotic freedom of quarks at high energies

→ Deconfinement - liberation of quarks and gluons

Strangeness Enhancement:

- Increased production of strange quarks and hadrons
- Suggests QGP formation - enabling enhanced production processes

ALICE Detector

Inner Tracking System (ITS):

- Comprised of seven layers of silicon pixels arranged cylindrically around beam pipe
- Determines decay vertices

Time Projection Chamber (TPC):

- Large cylinder filled with gas – particles are ionized as they traverse the chamber
- Provides particle identification (PID) by measuring the specific energy loss of each particle

Additional terms:

pT - transverse momentum of particle

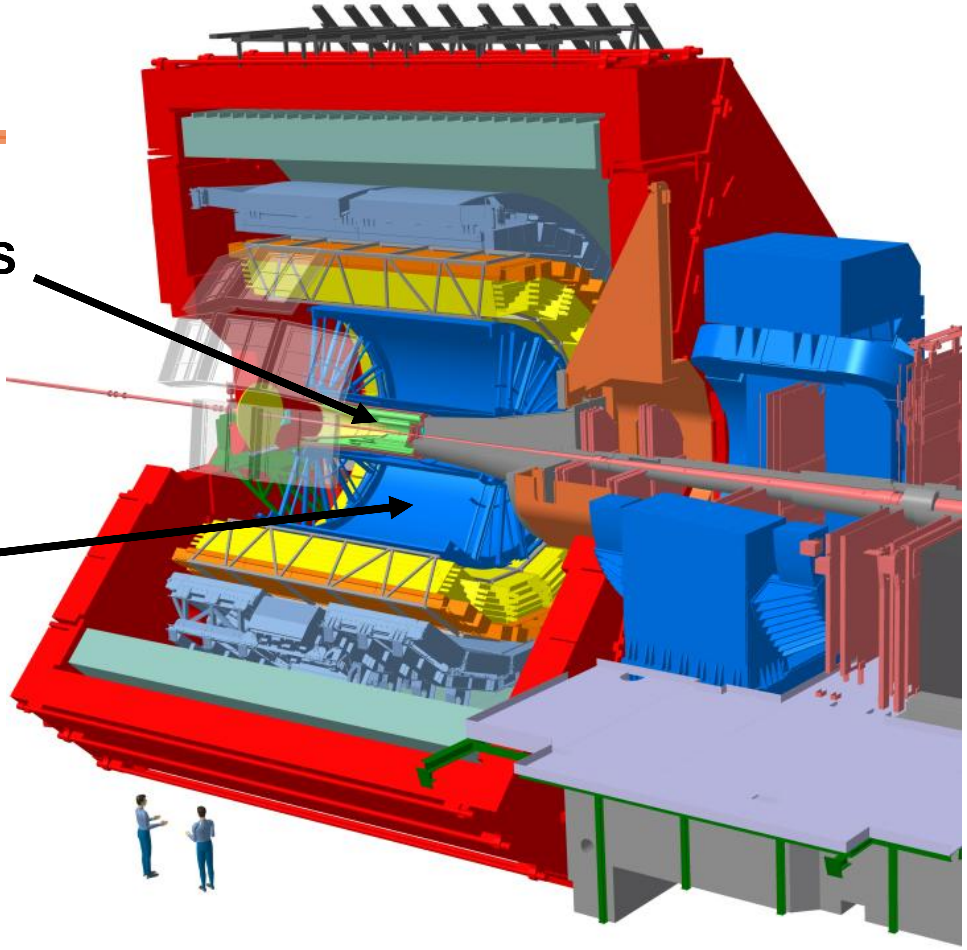


Figure 1. ALICE detector as in Run 3

Event Selection

- Make selection cuts to ensure detected particle originated from V0 decay:
  - Systematically adjust cut values
  - Extract signal and background levels from resulting mass plots

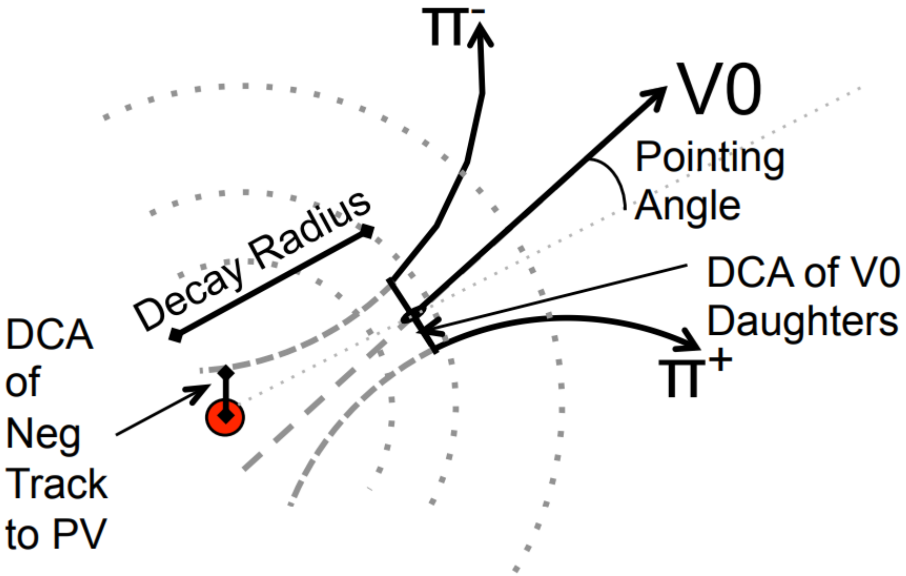


Figure 2. K0 decay topology with available cuts[1]

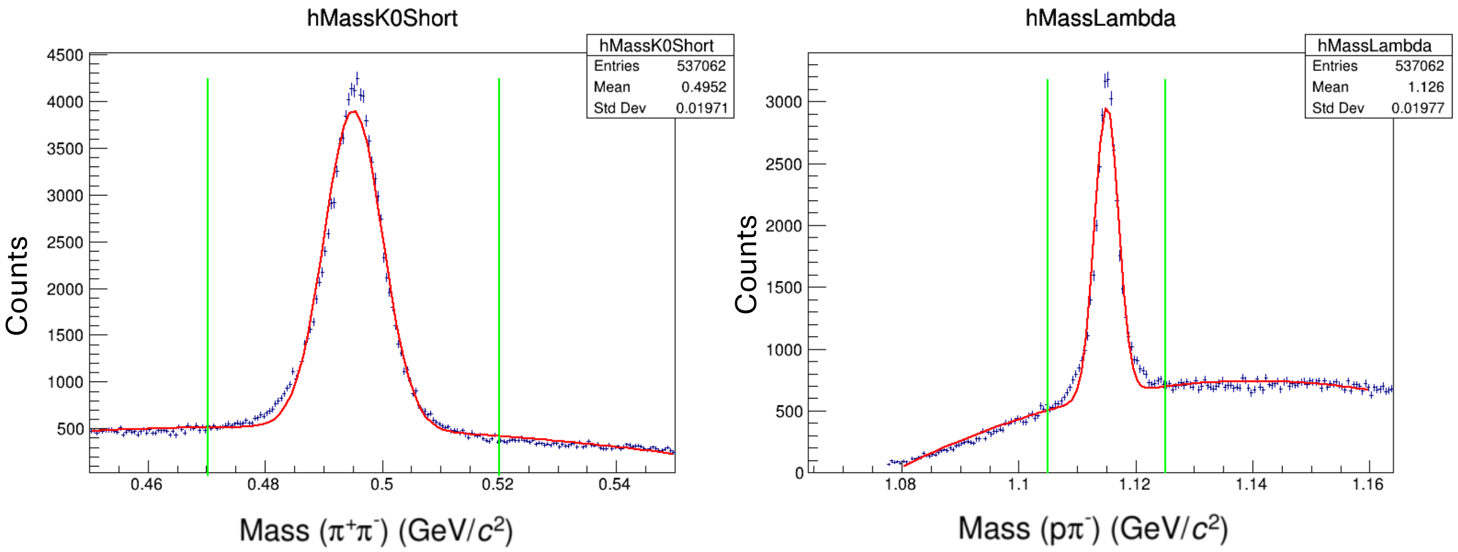


Figure 3: Invariant mass distribution of V0 candidates with fit. The green lines indicate the 5σ region where signal and background were extracted

- Plot significance against cut to determine optimal cut values

$$\text{Significance} = \frac{S}{\sqrt{S+B}},$$

S - signal
B - background

[1] Hanratty, L.D. (2014). "Λ and K0S production in Pb-Pb and pp collisions with ALICE at the LHC." Ph.D. thesis, University of Birmingham.

Significance plots

- Choose cuts that:
  - maximise significance
  - retain at least 90-95% signal
  - well described by Monte Carlo (MC) data

Cut Values	K0	Lambda
Dcanegtopv [cm]	> 0.101	> 0.181
Dcapostopv [cm]	> 0.106	> 0.050
Dcav0dau [σ]	< 0.205	< 0.250
Cosine of p.a.	> 0.993	> 0.990
V0radius [cm]	> 0.9	> 1.4

Table 1. Final cut values.

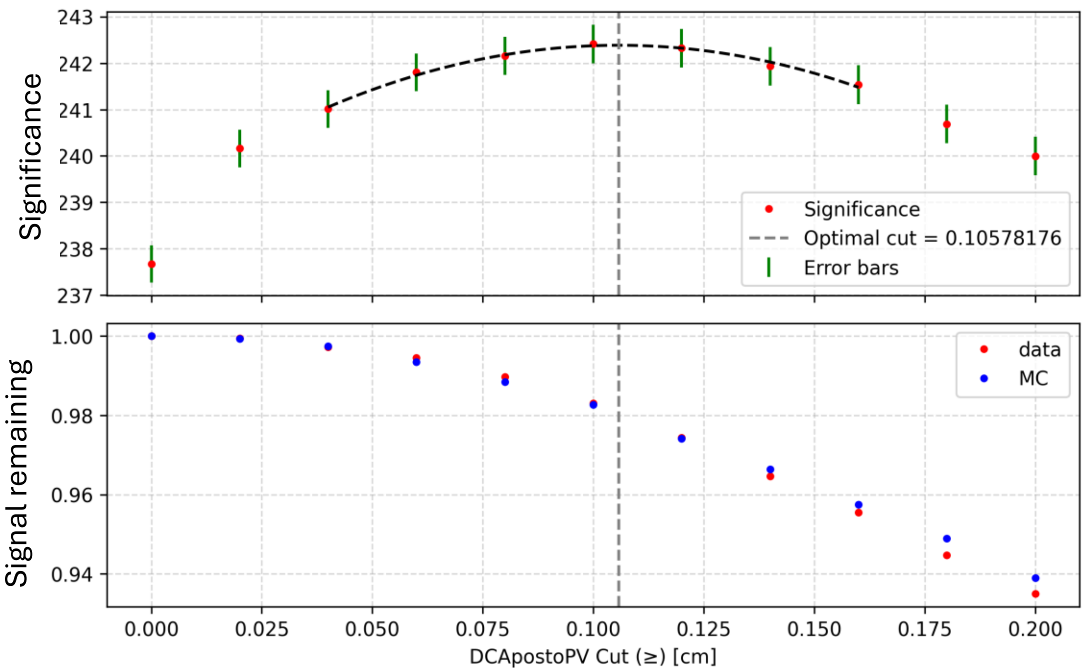


Figure 4. Significance of K0 mass plot and signal fraction remaining against DCAnegtoPV cut.

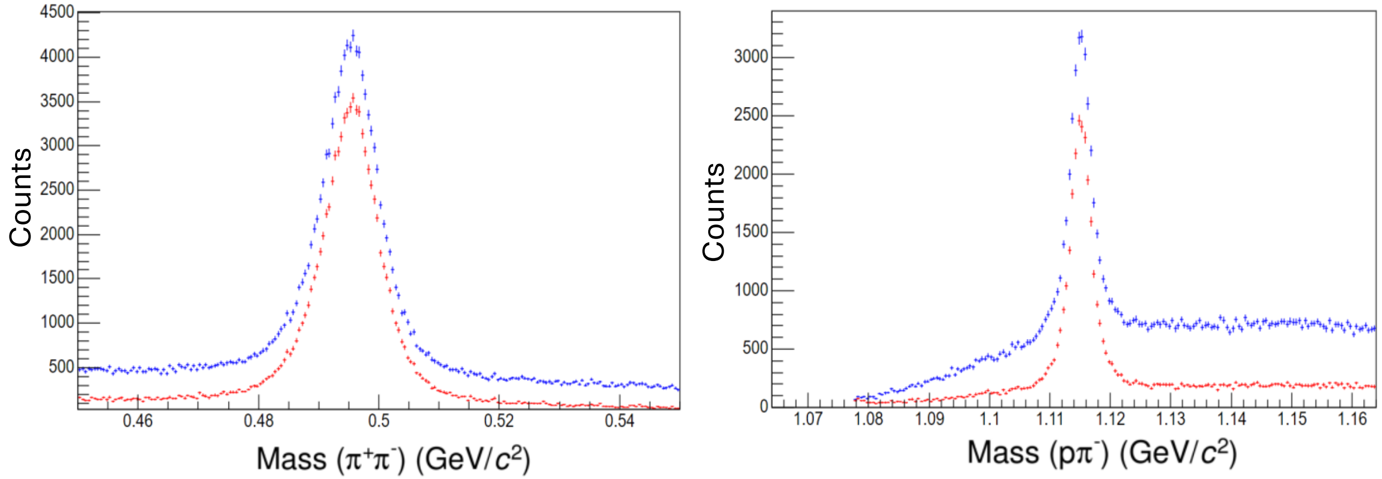


Figure 5. Invariant mass distribution for K0 (left) and Lambda (right). Blue indicates original loose cuts and red indicates the optimal cut values were used.

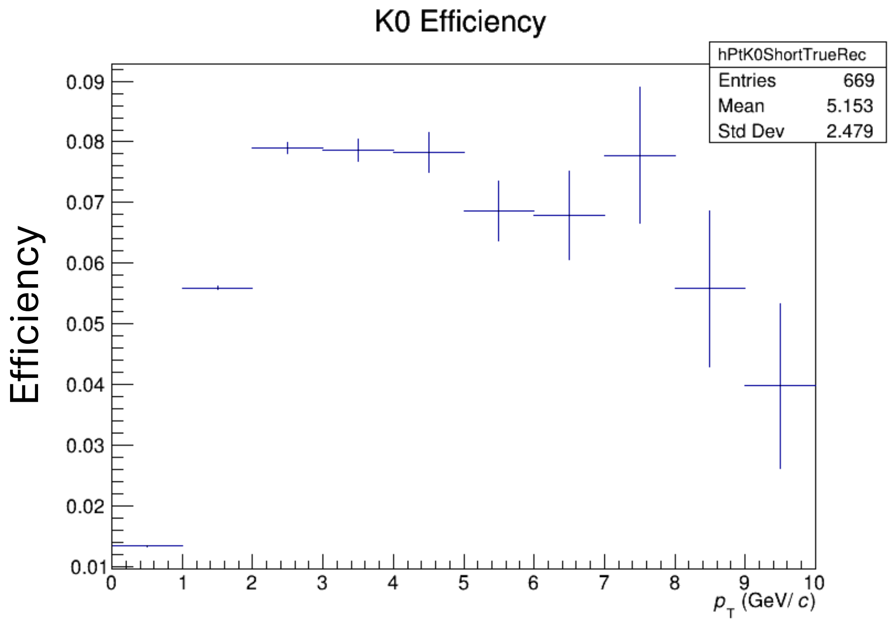
V0 Efficiencies

- Monte Carlo data used to account for the acceptance of the detectors

$$eff = \frac{MC\ count\ after\ simulated\ detector}{no.MC\ particles\ initially\ generated}$$

- Must ensure MC is subject to same selection cuts as data

- Dividing the raw spectra by efficiency gives corrected Pt distribution, assuming MC is accurate.



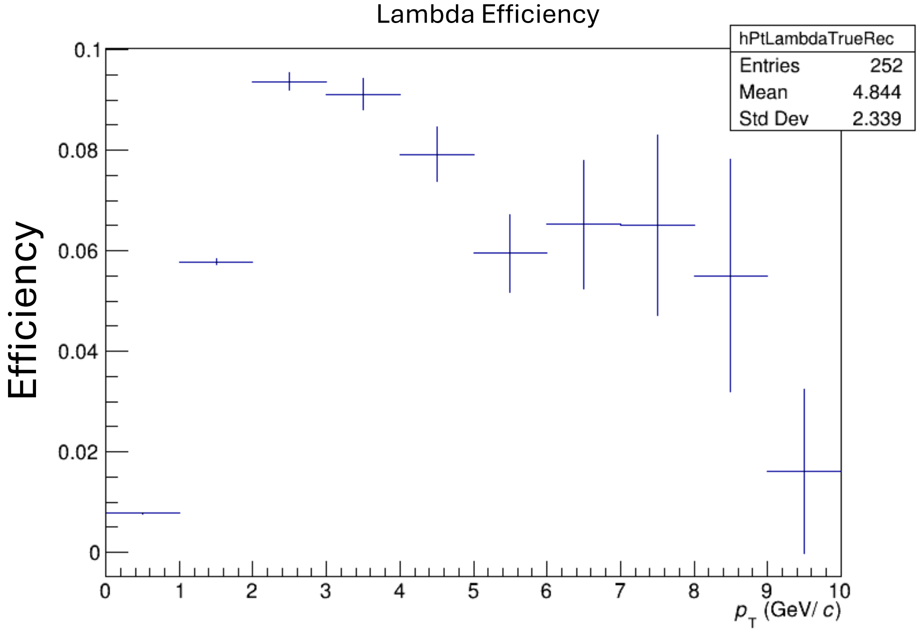


Figure 6. Efficiency for K0 (top) and Lambda (bottom) as a function of Pt

Results: Uncorrected and Corrected pT distributions for K0 and Lambda

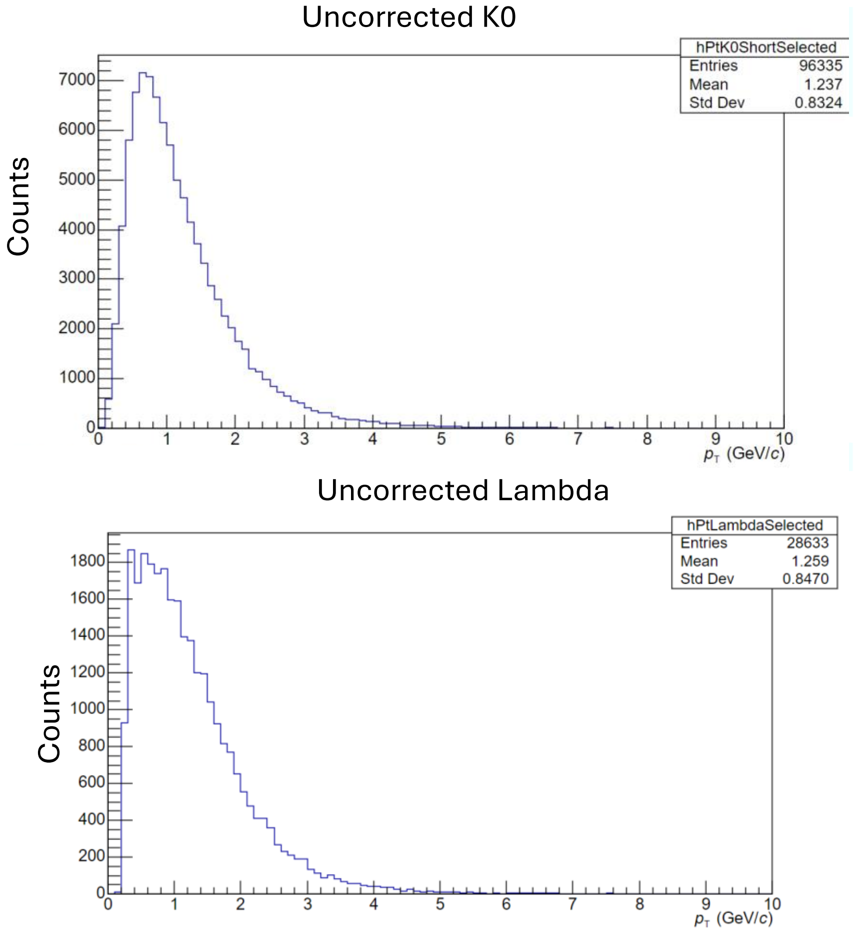


Figure 7. Uncorrected pT distributions for K0 (top) and Lambdas (bottom)

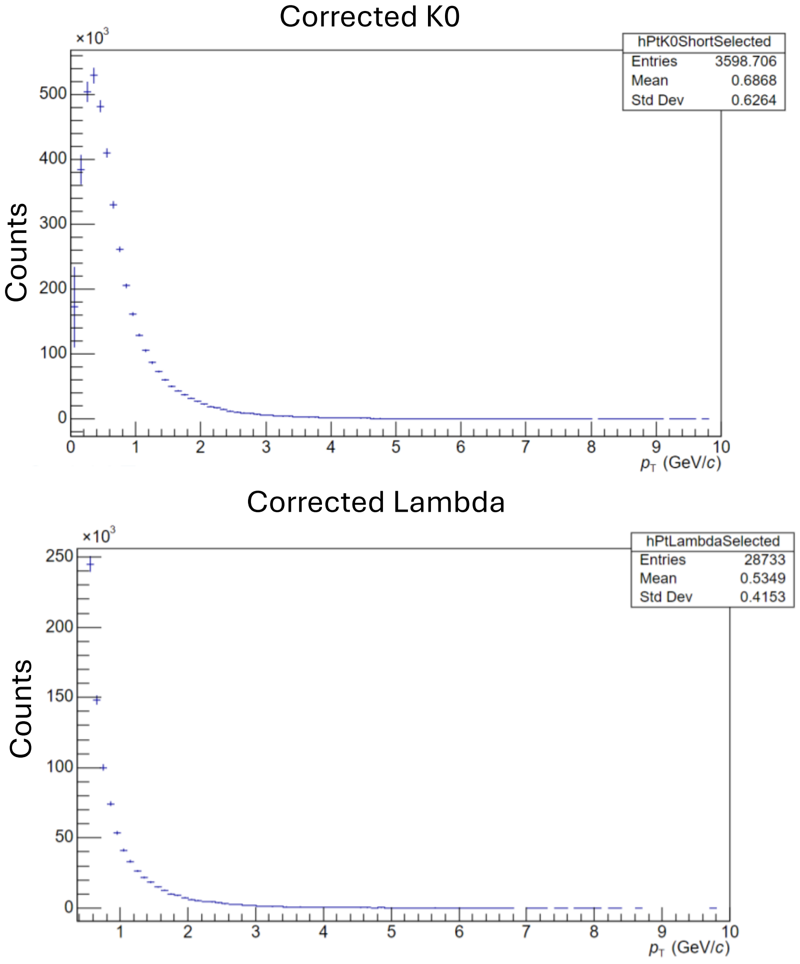


Figure 8. Corrected pT distributions for K0 (top) and Lambdas (bottom)

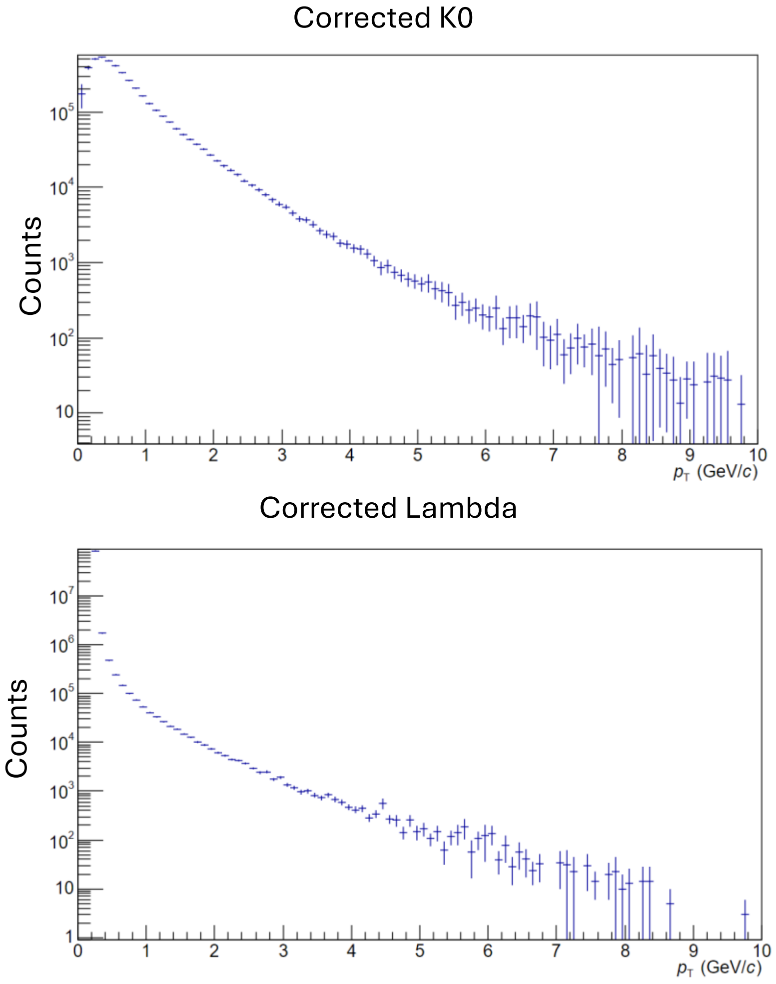


Figure 9. Corrected pT distributions for K0 (top) and Lambdas (bottom) with a log scale

Baryon to meson ratio

- Ratio spikes at low pT, before settling at ~0.3
- Previous analysis showed ratio peaking at ~0.6 at approximately 2GeV/c
- Uncorrected ratio shows a more consistent shape

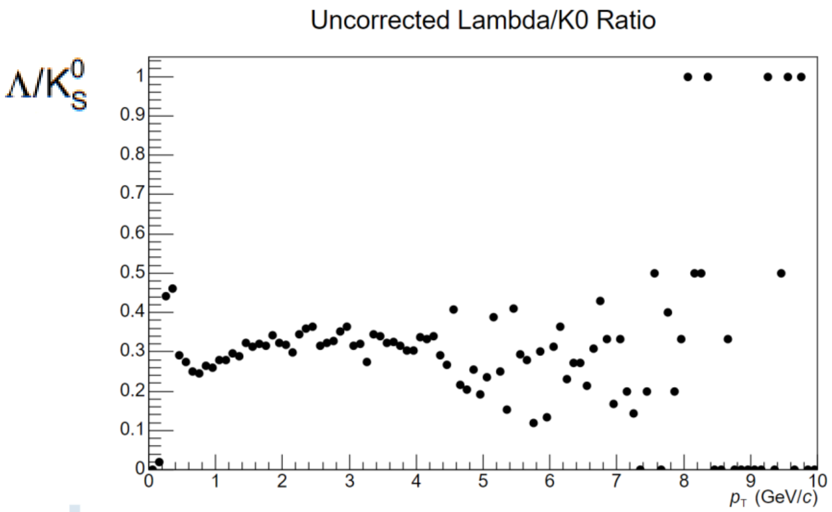


Figure 11. Uncorrected Lambda/K0 ratio. Error bars have been omitted for clarity

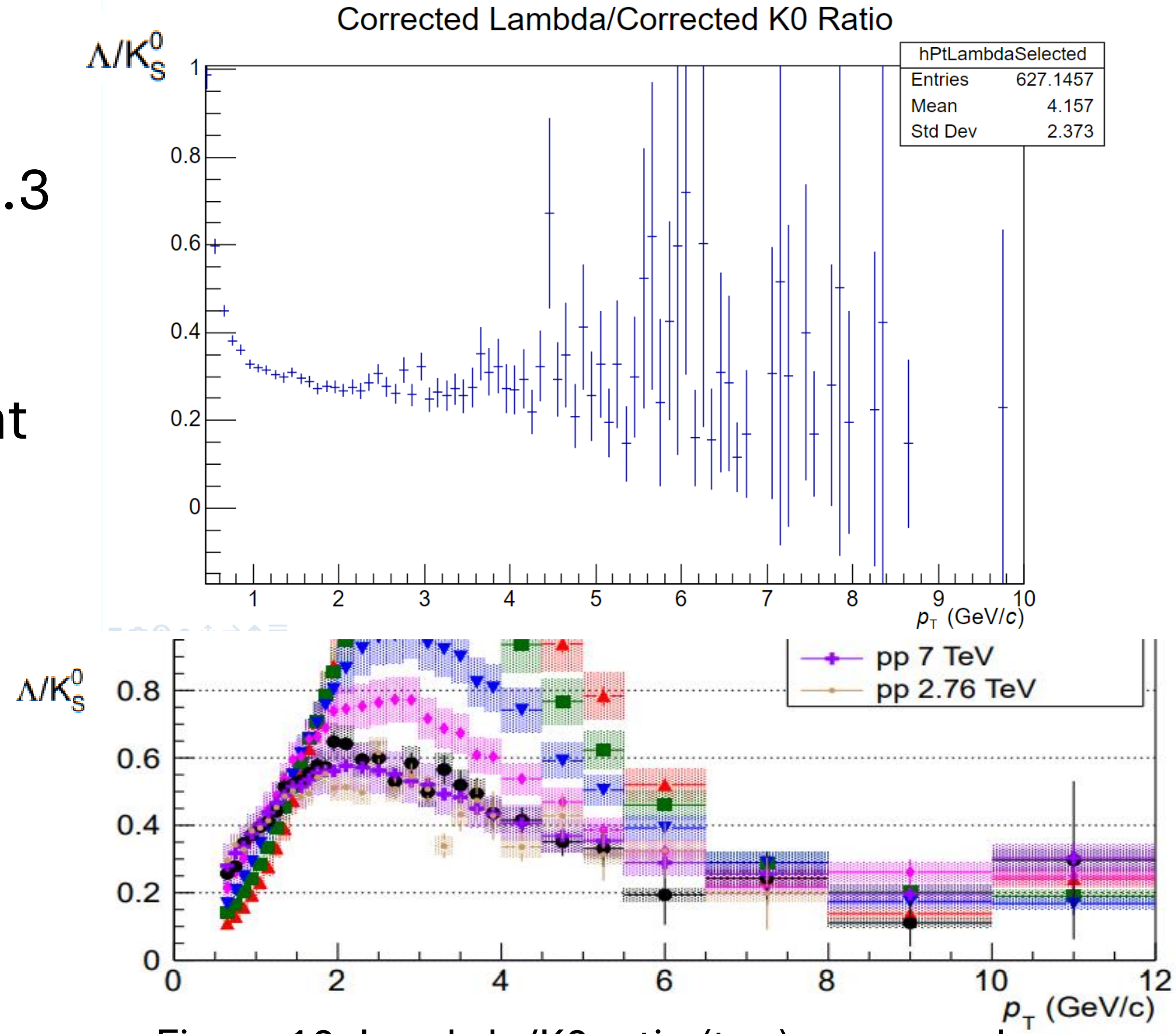


Figure 10. Lambda/K0 ratio (top) compared with similar analysis of data from 2010[1]

[1] Hanratty, L.D. (2014). "Λ and K0S production in Pb-Pb and pp collisions with ALICE at the LHC." Ph.D. thesis, University of Birmingham.

Efficiency Comparison to Previous Analysis

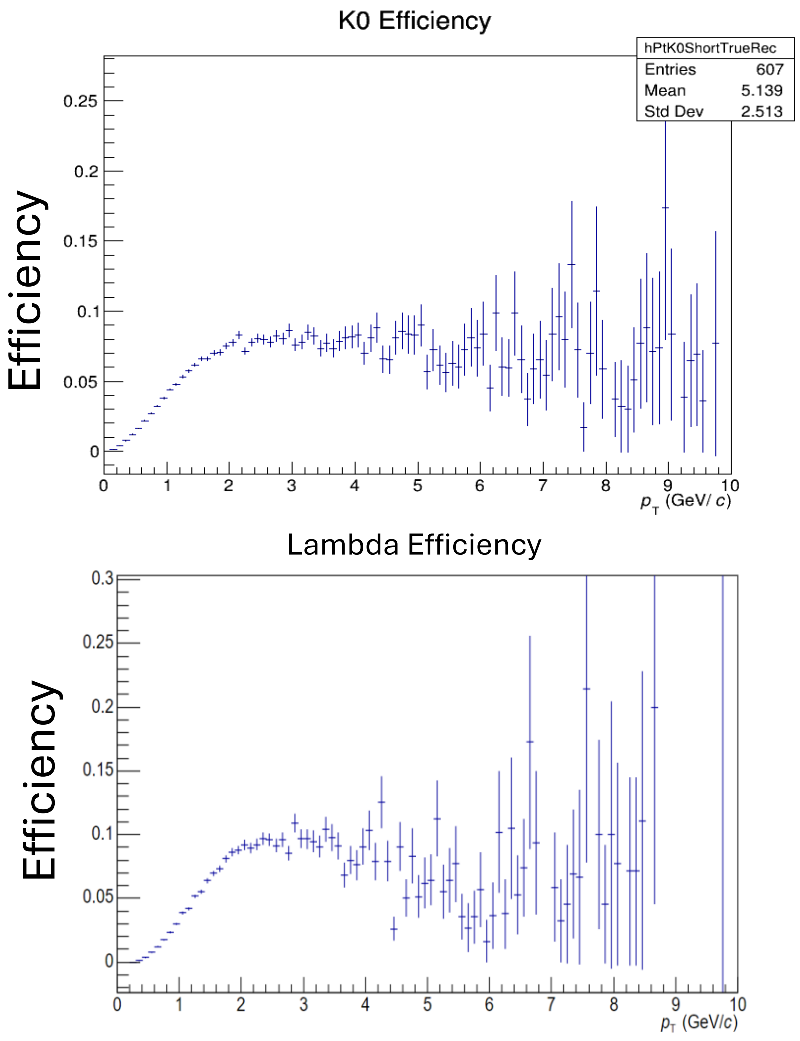


Figure 12. K0 (top) and Lambda (bottom) efficiencies with more bins

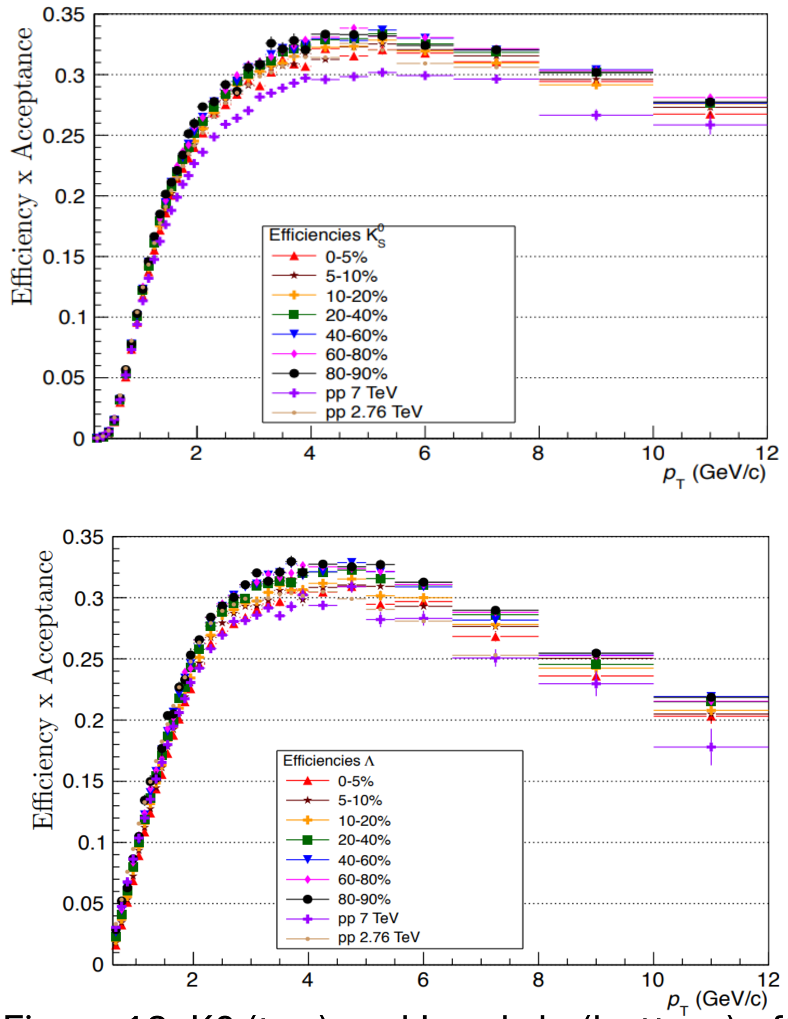


Figure 13. K0 (top) and Lambda (bottom) efficiencies calculated using data from previous runs[1]

- General shape is consistent
- However, peak is lower and to the left compared to previous calculations
- Efficiencies are a factor of three lower than expected

[1] Hanratty, L.D. (2014). "Λ and K0S production in Pb-Pb and pp collisions with ALICE at the LHC." Ph.D. thesis, University of Birmingham.

Remainder of Project

Plan:

- Compare pT distributions with previous analysis

- Plot anti-lambda/lambda ($\bar{\Lambda}/\Lambda$) ratio:

  - at high temperatures, production rates are nearly equal
  - any deviation from 1 may indicate changes in production mechanisms
  - deduce relative abundances of strange and anti-strange quarks

Summary

Project Progress:

- Optimised selection cuts for K0 and Lambdas
- Obtained efficiencies and corrected pT distributions

Results

- Efficiencies are lower than expected
- Corrected Lambda/K0 distribution also differs from that obtained in previous analysis

Remainder of Project:

- Further comparisons between corrected pT spectra may be useful
- Anti-Lambda/Lambda plot