Strangeness production with the ATLAS detector

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Outline

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- The ATLAS detector
- Analysis strategy
  - V^0 reconstruction
  - Selections
- Results
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  - Kinematic distributions
  - $\overline{\Lambda}/\Lambda$ ratio
  - Reconstruction efficiencies
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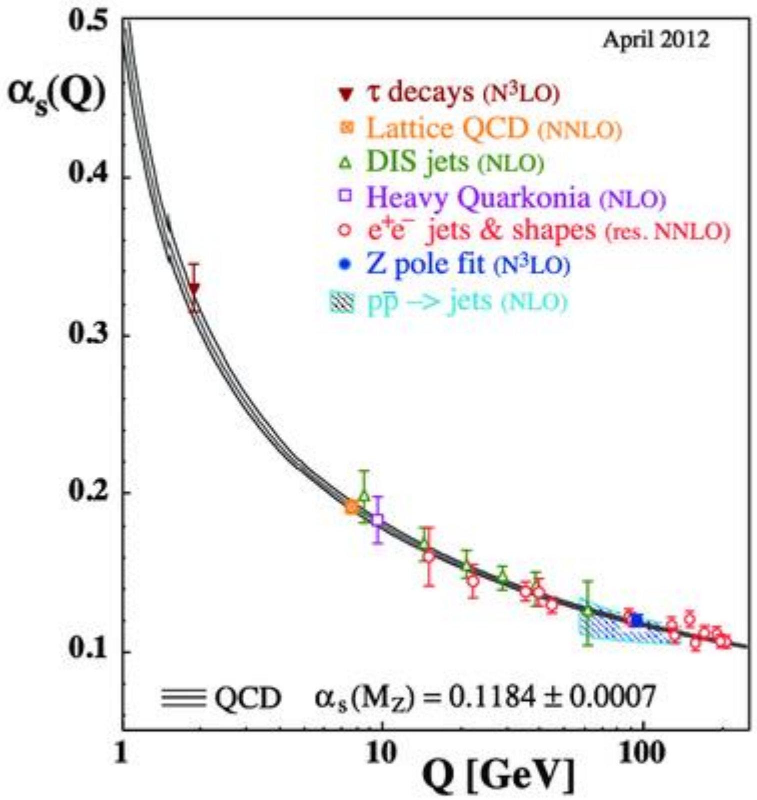
Motivation

- Production of strange hadrons is crucial to understanding QCD at low momentum transfer
- Mass of strange quark ~ Λ_{QCD}, hence strangeness production cannot be effectively modelled by perturbative techniques
  - Requires experiment data to help improve Monte Carlo (MC) parameters



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Motivation

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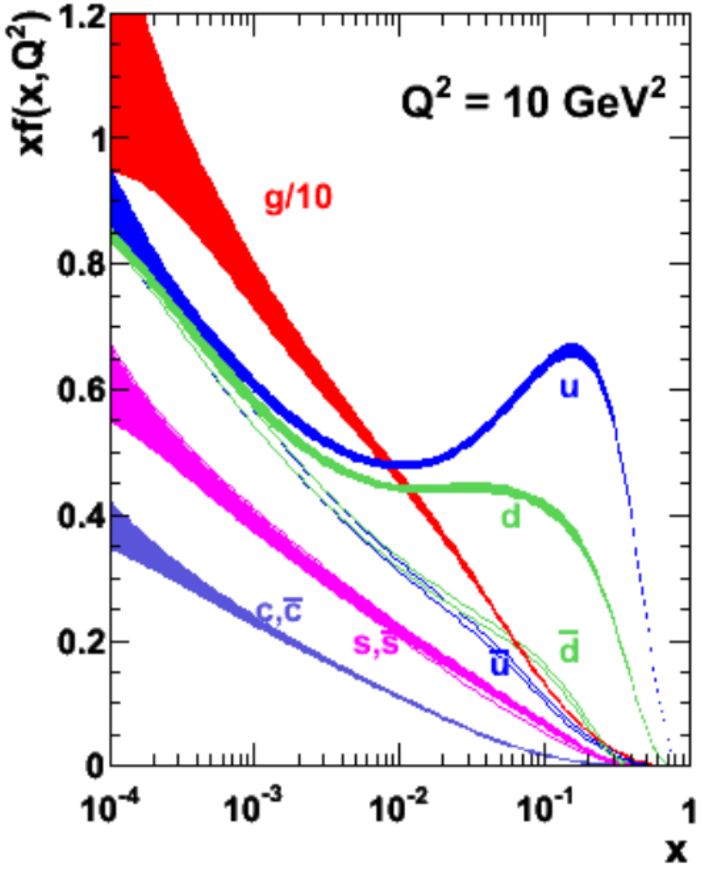
- Mass of strange quark ~ Λ_{QCD}, hence strangeness production cannot be effectively modelled by perturbative techniques
    - Requires experiment data to help improve Monte Carlo (MC) parameters
- Potential to constrain the strangeness content of proton parton distribution functions (PDFs) by comparing data and MC simulations
- Strangeness production also previously studied at LHC at lower energies and other experiments (Tevatron, HERA, …)



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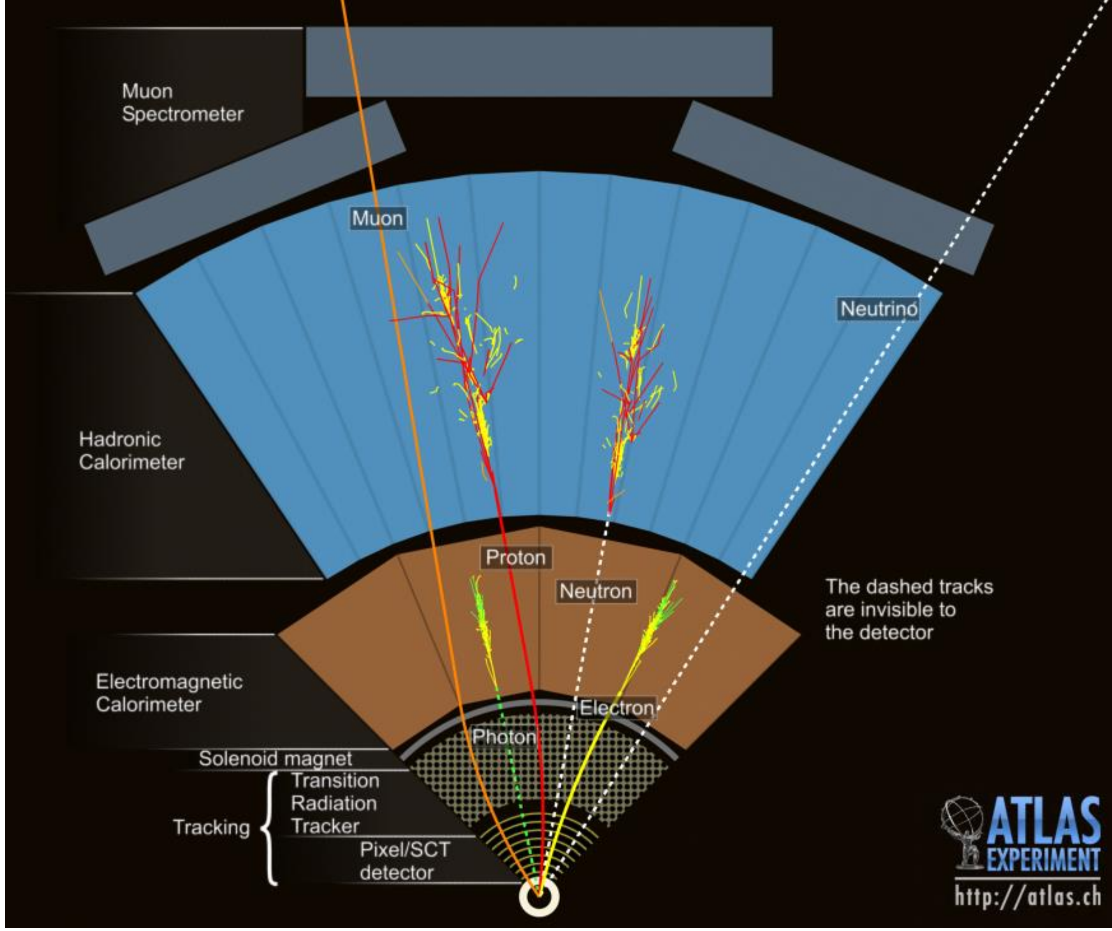
The ATLAS Detector

- A general-purpose detector at the LHC with almost full solid angle coverage
- Inner detector with charged particle tracking capabilities, with coverage $|\eta| < 2.5$
- Electromagnetic and hadronic calorimeters, and muon spectrometer
    - *Measurements by these components not used in this analysis*



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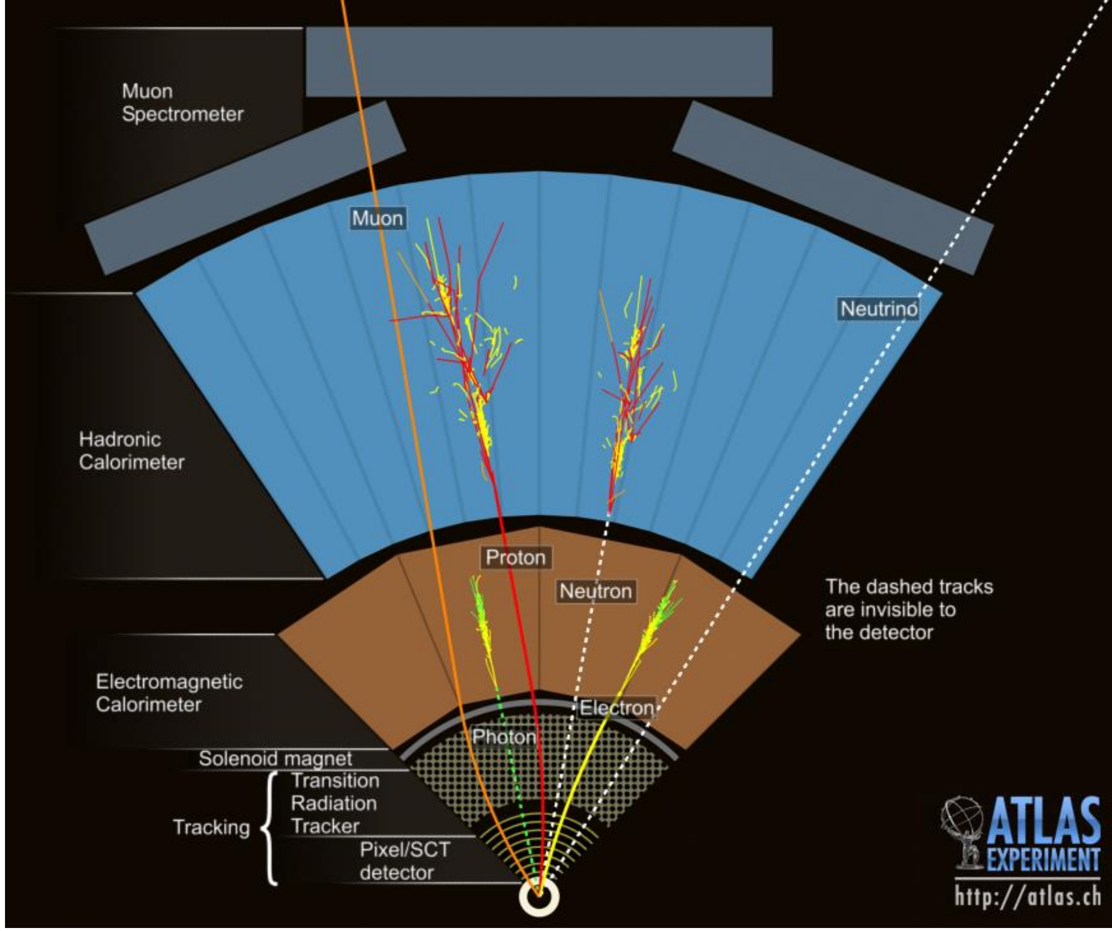
- Kinematic variables used:
  - p_T: momentum in the transverse plane
  - $\eta = -\ln\tan(\theta/2)$, where θ is the polar angle
  - ϕ: azimuthal angle around the beamline (z-axis)



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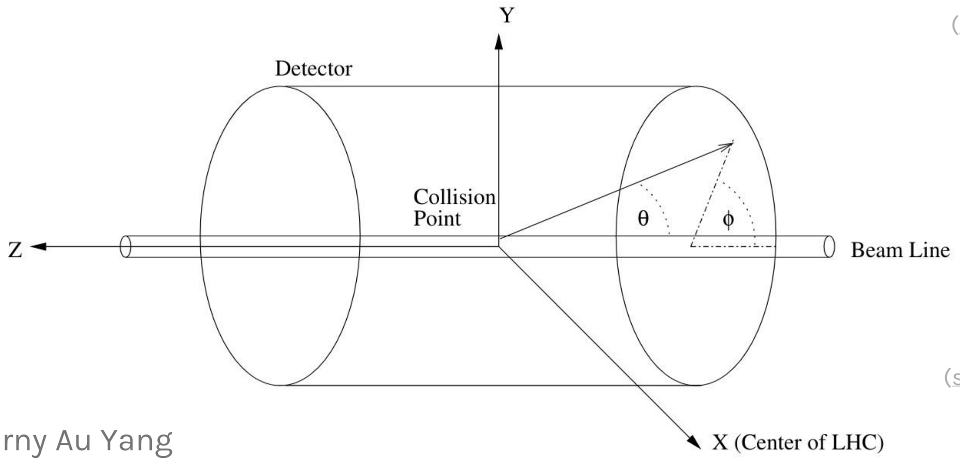

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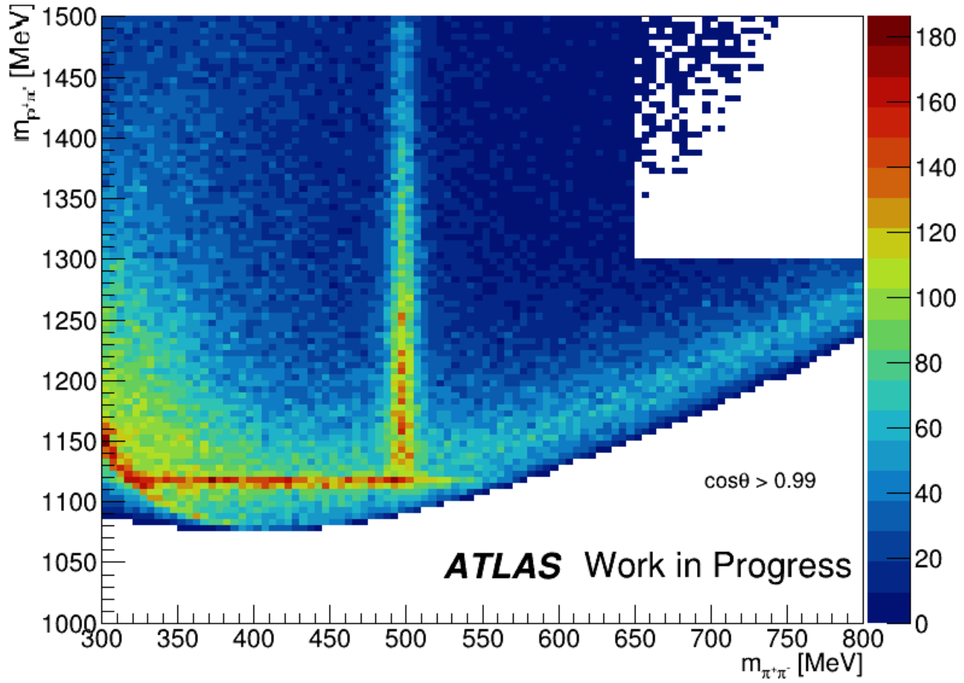
V^0 reconstruction

$K_s^0: \quad \frac{d\bar{s}+s\bar{d}}{\sqrt{2}}, \quad m = 497.611 \pm 0.013 \text{ MeV}$

$\Lambda: \quad uds, \quad m = 1115.683 \pm 0.006 \text{ MeV}$

- In this analysis, reconstructing K_s^0 and Λ ($\bar{\Lambda}$) via their dominant decay channels:
  - $K_s^0 \rightarrow \pi^+\pi^-$ $(\approx 69\%)$
  - $\Lambda \rightarrow p\pi^-$, $\bar{\Lambda} \rightarrow \bar{p}\pi^+$ $(\approx 64\%)$
- The V^0 finder tool combines all possible pairs of oppositely charged tracks in the inner detector and forms V^0 candidates
- Each V^0 candidate is assigned K_s^0, Λ & $\bar{\Lambda}$ reconstructed mass values by assuming the identity of the charged track particles to calculate the invariant mass

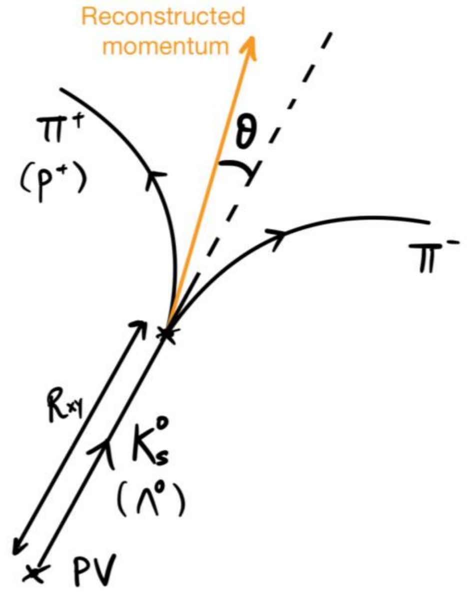
$\Lambda(\bar{\Lambda})$ invariant mass



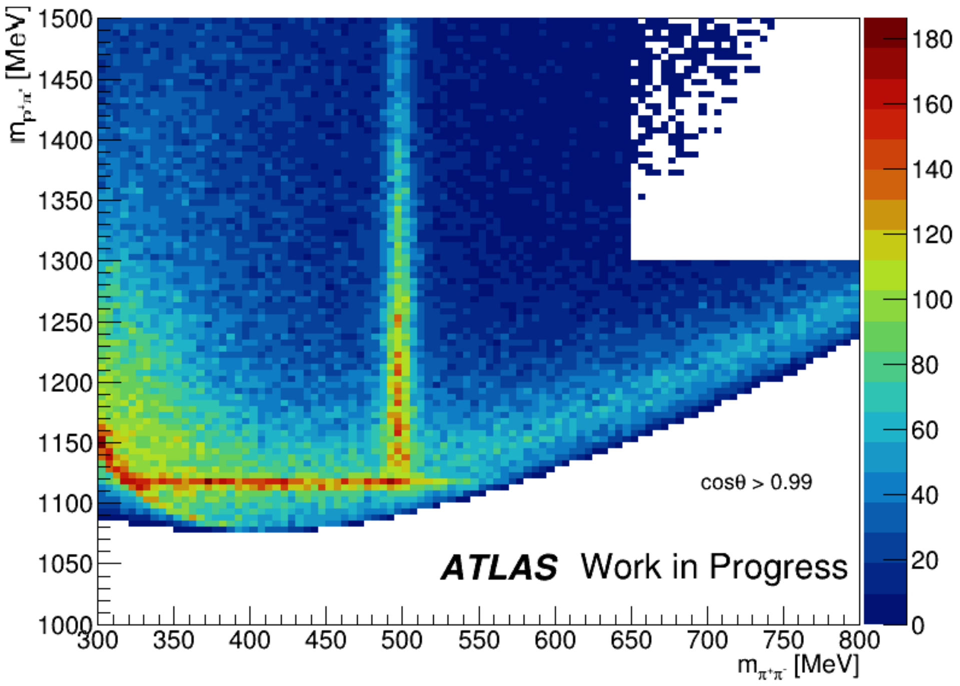
K_s^0 invariant mass

Selections

- Using ATLAS data at $\sqrt{s} = 13$ TeV
- V^0 candidate must be fitted with 2 tracks with $p_T > 100$ MeV
- Further selections on kinematic variables:
  - θ: angle between reconstructed momentum and line connecting the V^0 vertex and PV
  - R_{xy}: flight distance in the transverse plane, ~ lifetime
  - p_T
  - Reconstructed K_s^0 /Λ masses



	K_s^0	Λ ($\bar{\Lambda}$)
$cos\theta$	> 0.9990	> 0.9998
R_{xy} (mm)	$4 - 450$	$17 - 450$
p_T (MeV)	> 300	> 500
K_s^0 mass (MeV)		$340 - 480$ *or* > 520
Λ mass (MeV)	< 1105 *or* > 1125	



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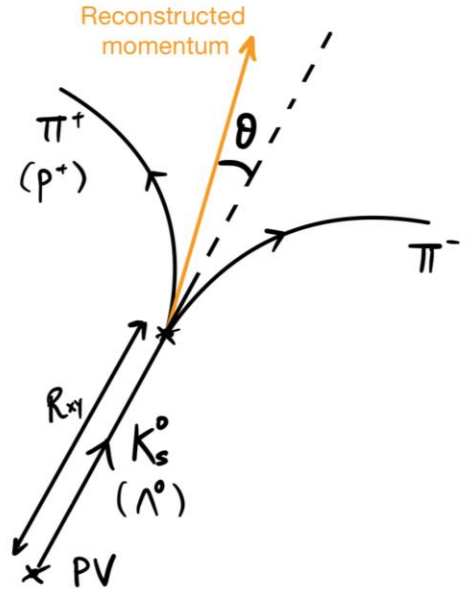

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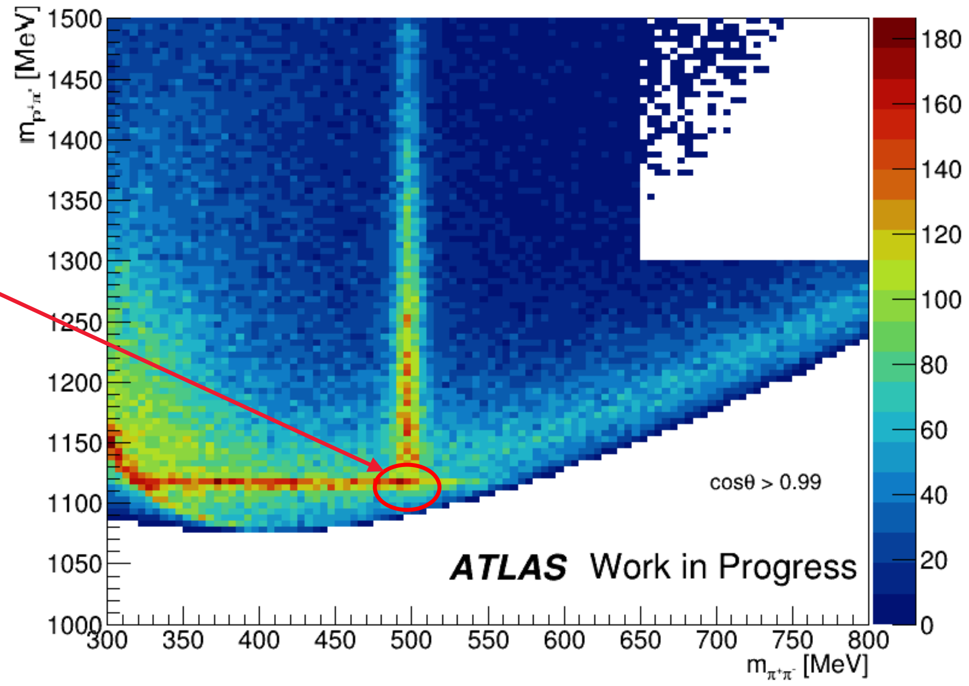
K_s^0 /Λ ambiguity



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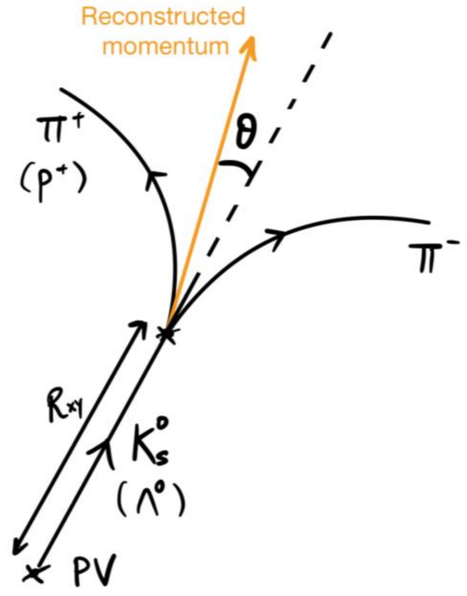

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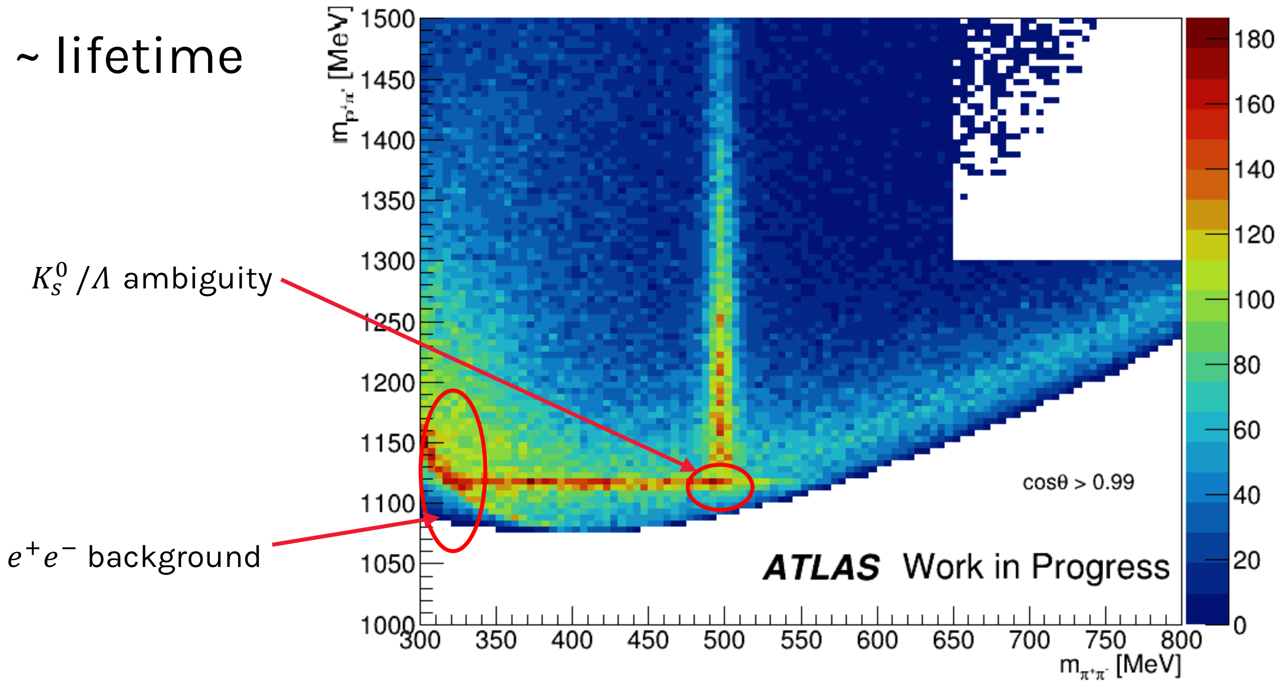
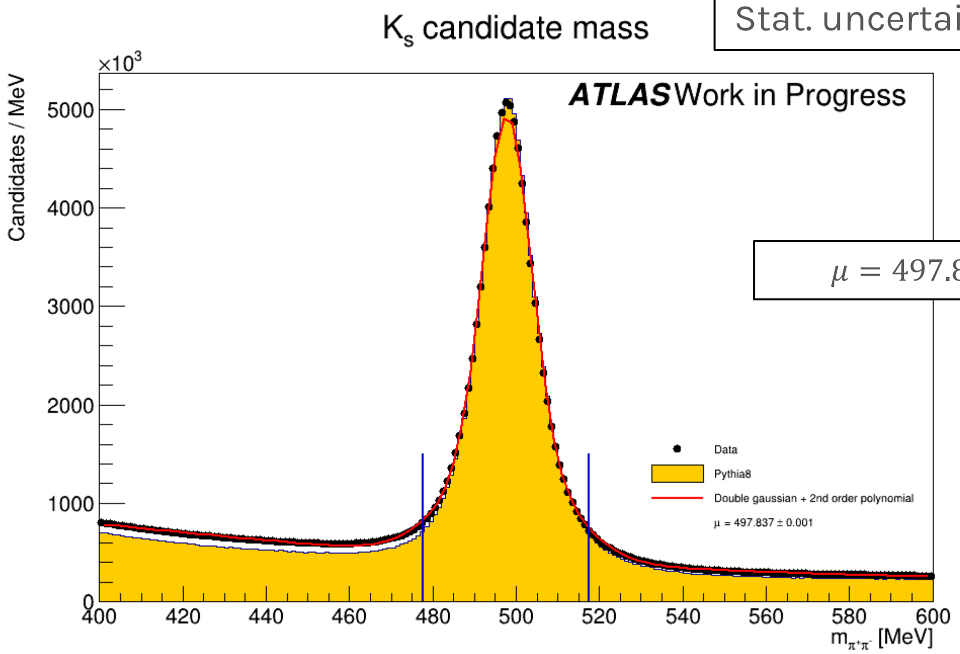


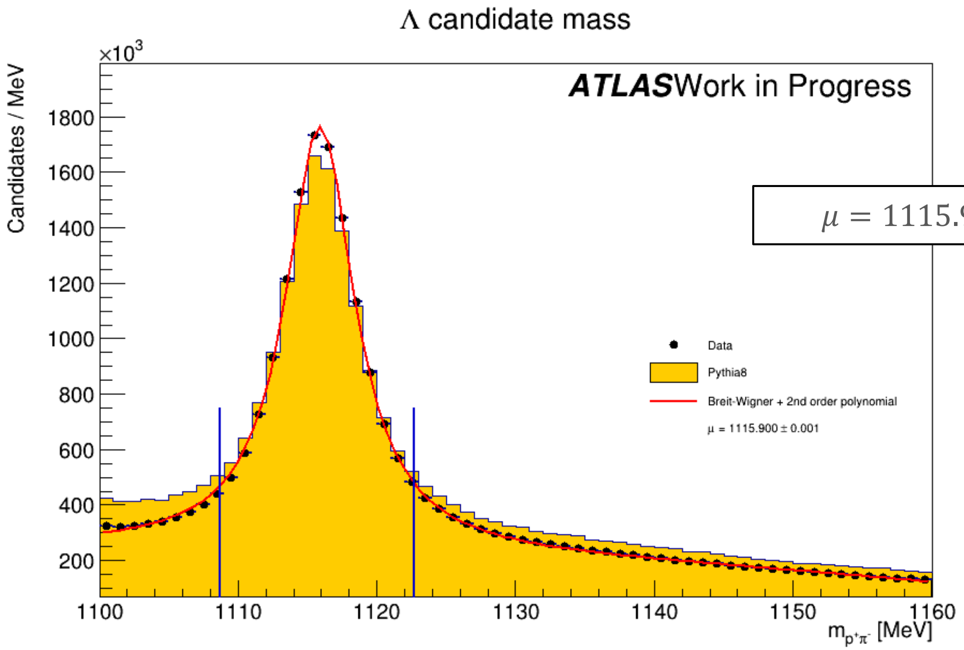
Mass distributions

- Same selections applied to both data and MC
- MC normalized to data within the signal region:
  - K_S^0 : $\left|m_{K_S^0,V^0} - m_{K_S^0,\mathrm{PDG}}\right| < 20\ \mathrm{MeV}$
  - $\Lambda(\bar{\Lambda})$: $\left|m_{\Lambda,V^0} - m_{\Lambda,\mathrm{PDG}}\right| < 7\ \mathrm{MeV}$

Stat. uncertainties only



$\mu = 497.8$ MeV



$\mu = 1115.9$ MeV

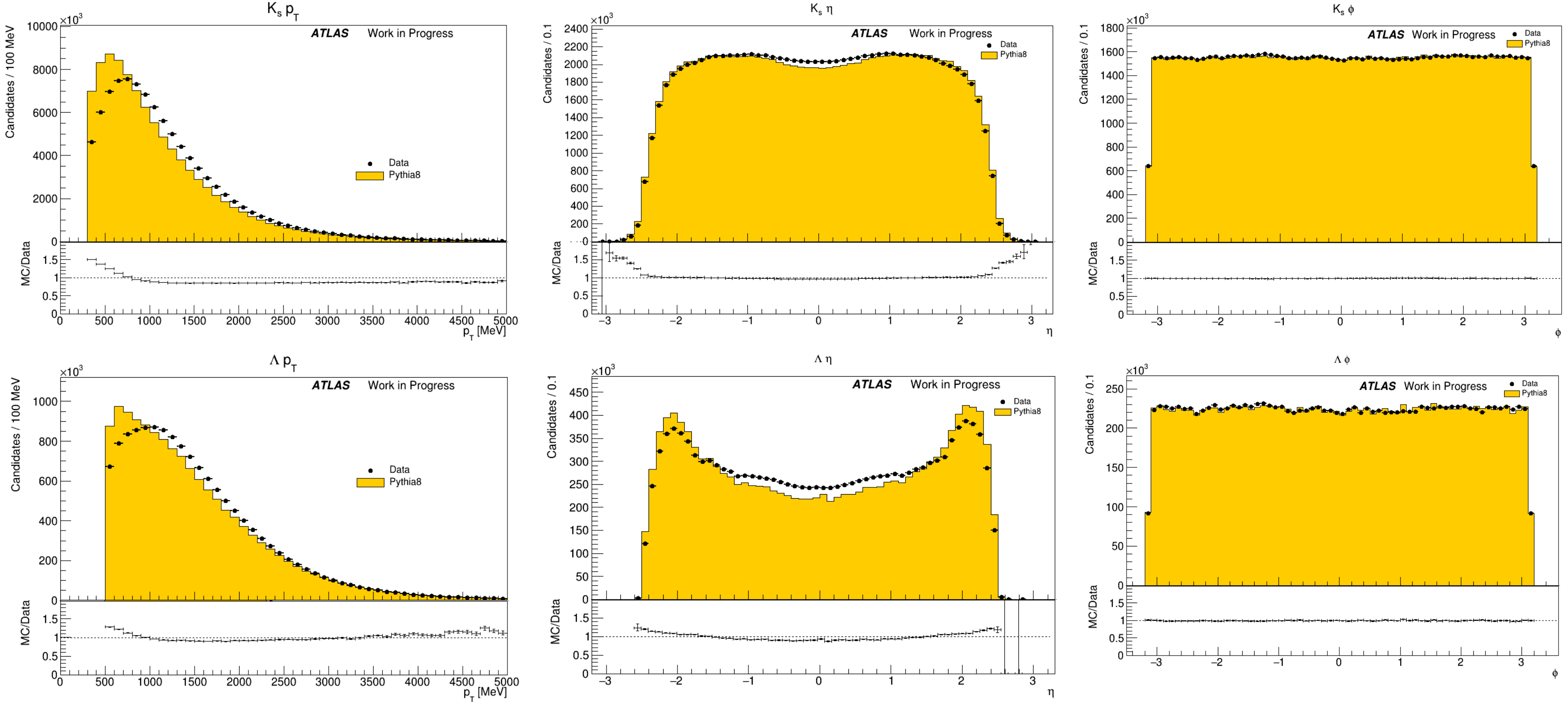
Kinematic distributions

Stat. uncertainties only

- p_T, η and ϕ distributions of K_S^0 /Λ candidates passing selections and in signal regions (MC normalized to data)

K_S^0 :

Λ:

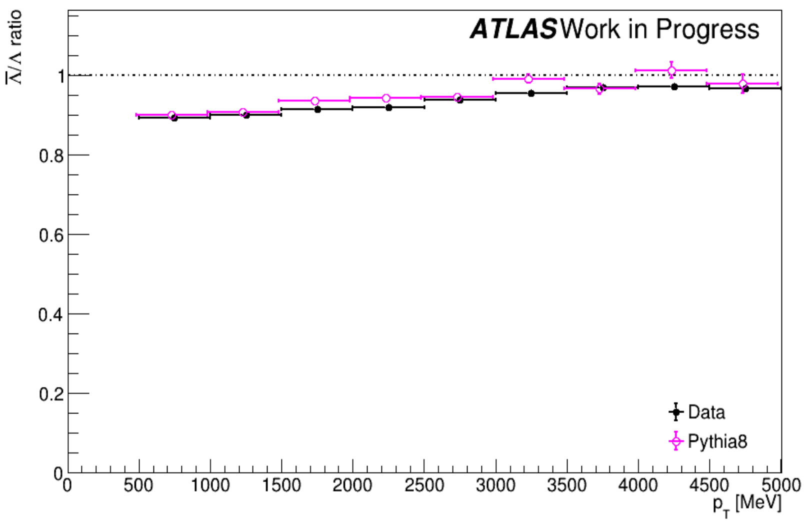


$\bar{\Lambda}/\Lambda$ ratio

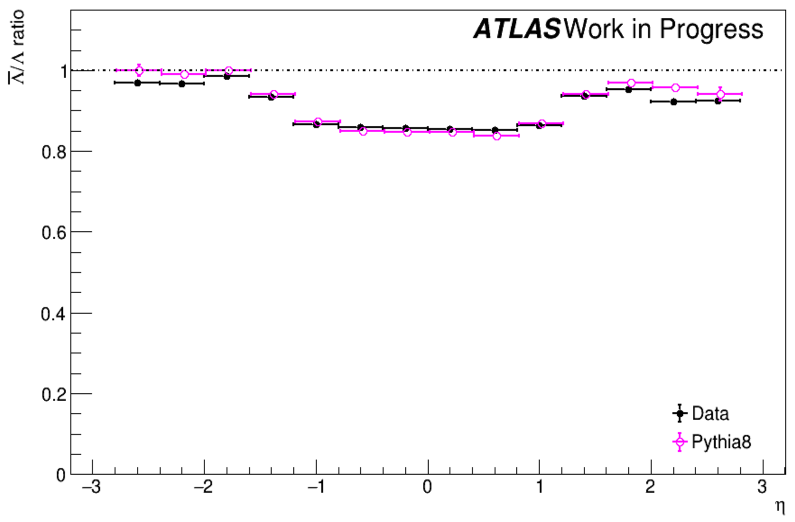
Stat. uncertainties only

- Production ratio between $\bar{\Lambda}$ and Λ versus p_T, η and ϕ
- Both data and MC agree in general $\bar{\Lambda}/\Lambda < 1$

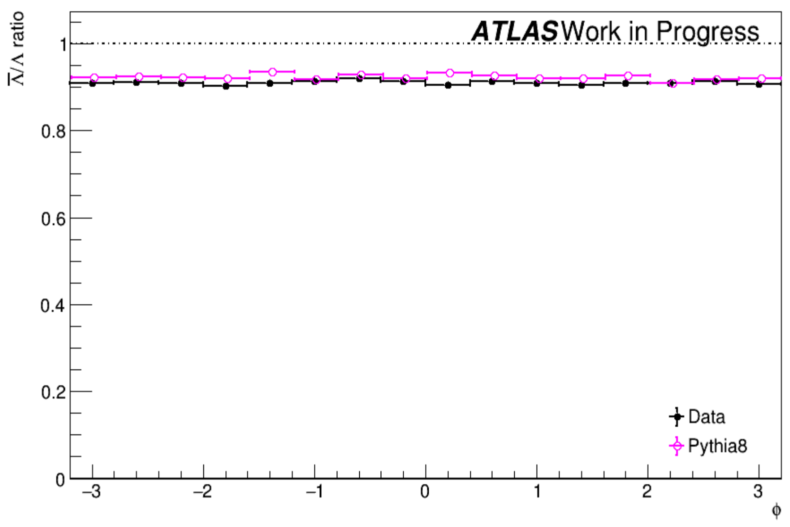
p_T



η



ϕ



Reconstruction efficiencies

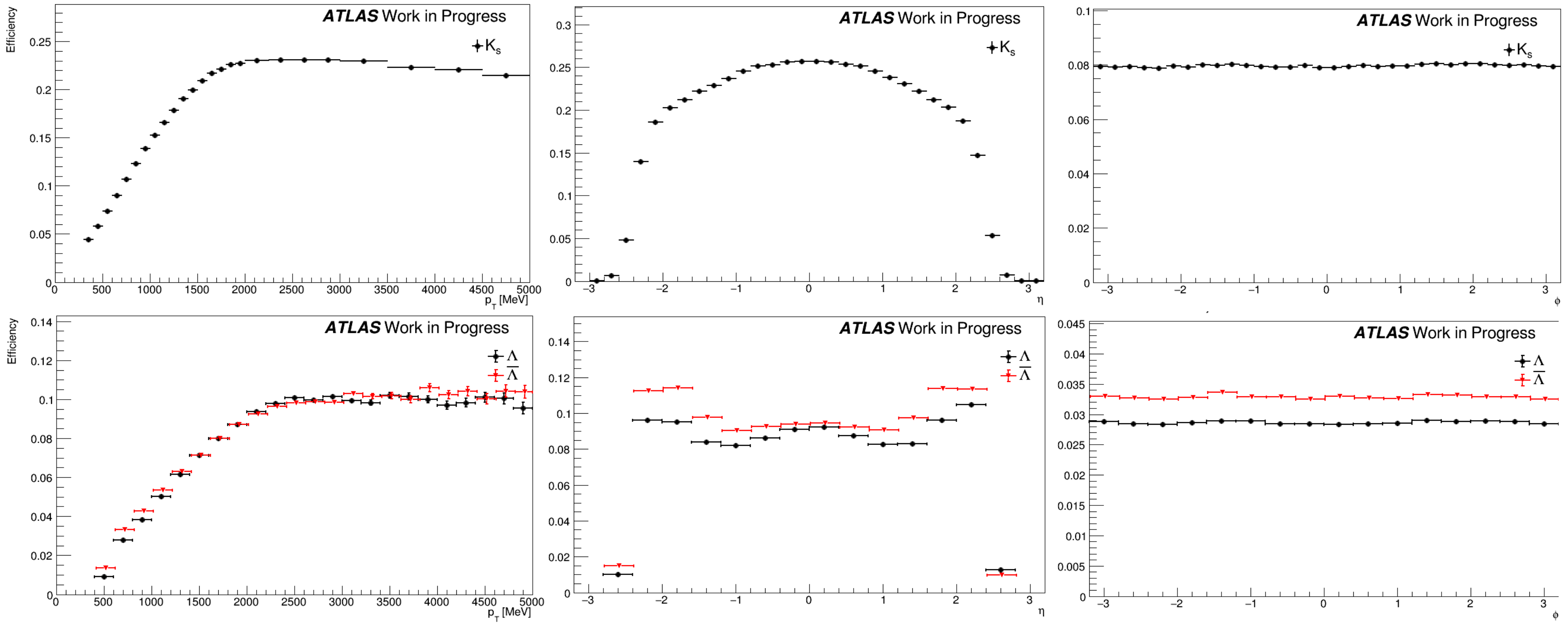
Stat. uncertainties only

- MC efficiency obtained by comparing number of reconstructed candidates passing all selections and number of truth-level generated particles

p_T η ϕ

K_S^0 :

$\Lambda, \overline{\Lambda}$:



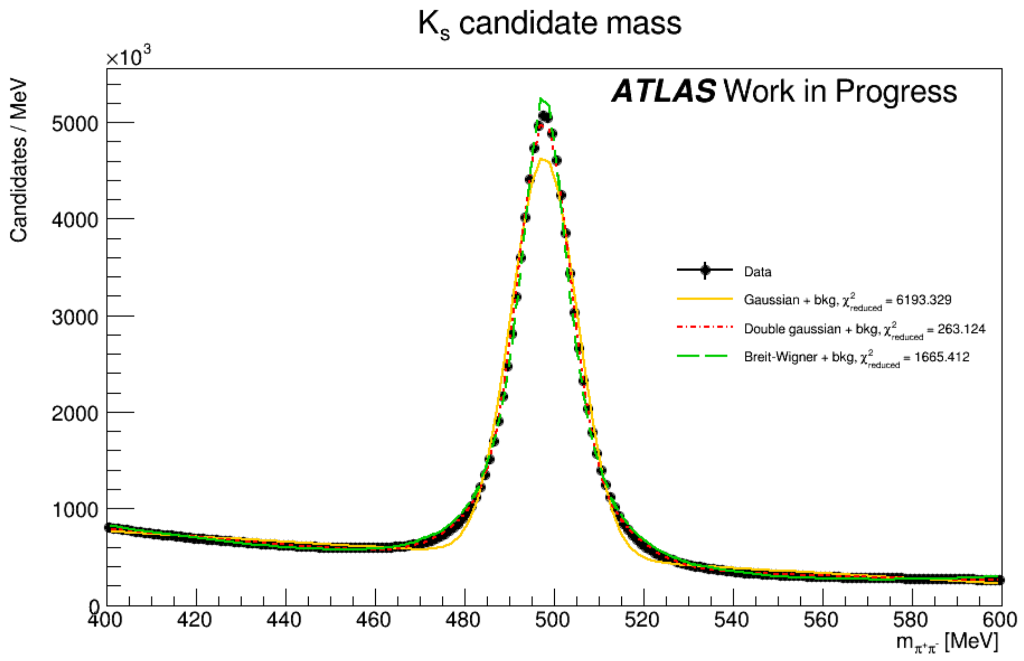
Outlook

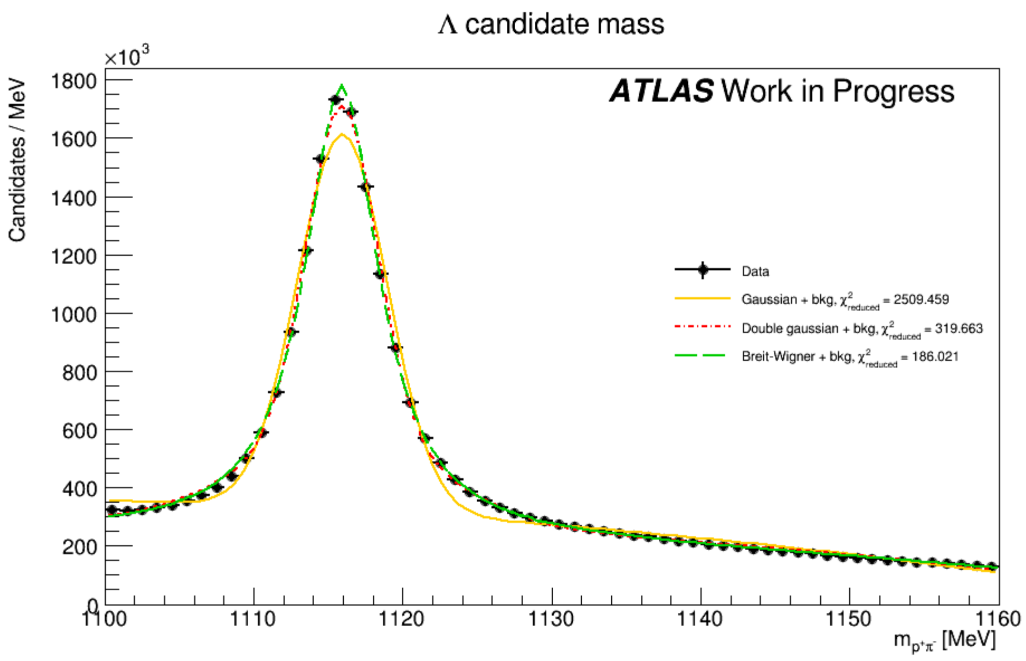
- Production cross-sections are being calculated using reconstruction efficiencies
- Looking into multiplicity distributions per event as another test of MC models
- Comparisons with results from previous experiments
- Comparisons with different MC models may help constrain proton PDFs and parameters
- Expanding analysis to other strange particles, e.g. Ξ^- (dss), may give better sensitivity to proton strangeness content despite a lower yield

Thank you!

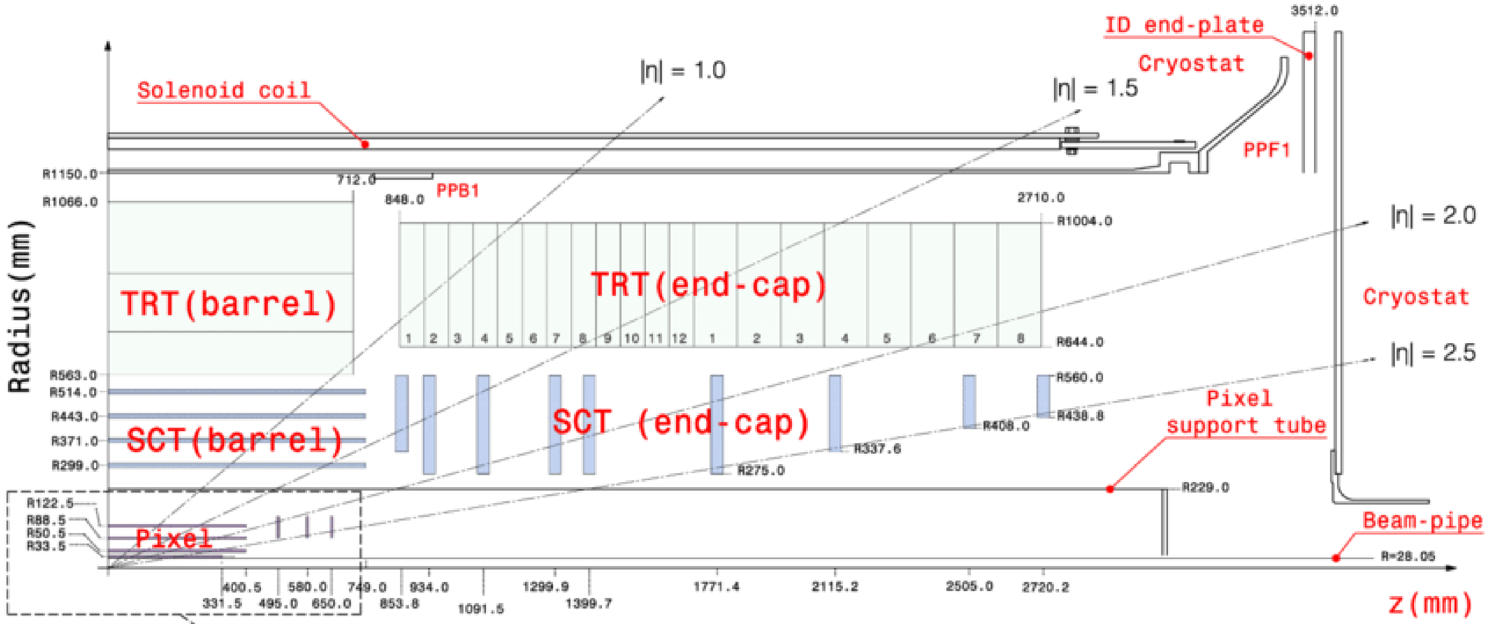
Backup

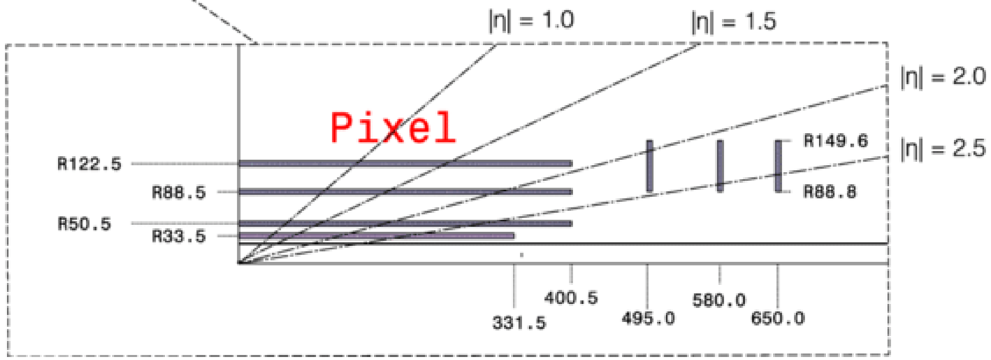
Fit functions to mass distributions





Inner Detector





Envelopes

Pixel	31<R<242 (mm)
SCT barrel	255<R<549 (mm)
SCT end-cap	251<R<610 (mm)
TRT barrel	554<R<1082 (mm)
TRT end-cap	617<R<1106 (mm)

(source)