Production of Strange and Charm Particles in ATLAS

Jessica Metcalfe, on behalf of the ATLAS Collaboration

University of New Mexico

Outline

- Introduction:
    - Tracking requirements
- Reconstruction:
    - Strange mesons
    - Charm mesons
    - Strange Baryons

Introduction

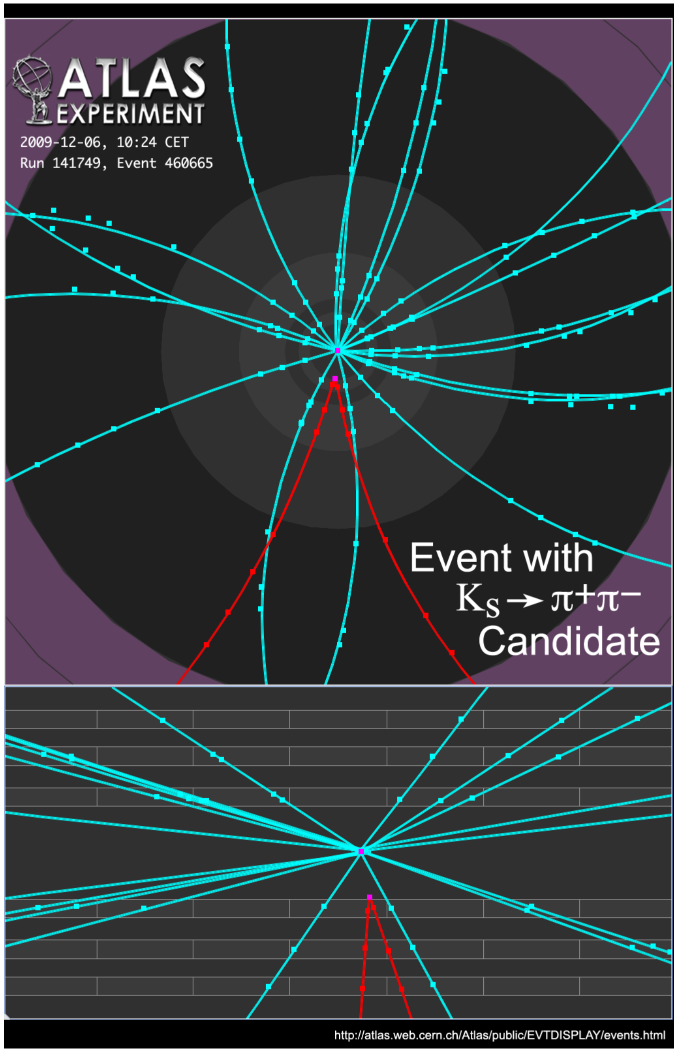
Rediscovering the Standard Model:

Identify particles in pp inelastic scattering

- tune modeling of backgrounds for high p_T processes
- evaluate and calibrate tracking performance
  - tracking reconstruction and efficiency, momentum scale, secondary vertexing, dE/dx

Present observations of low-p_T minimum bias events with 7 TeV collision data

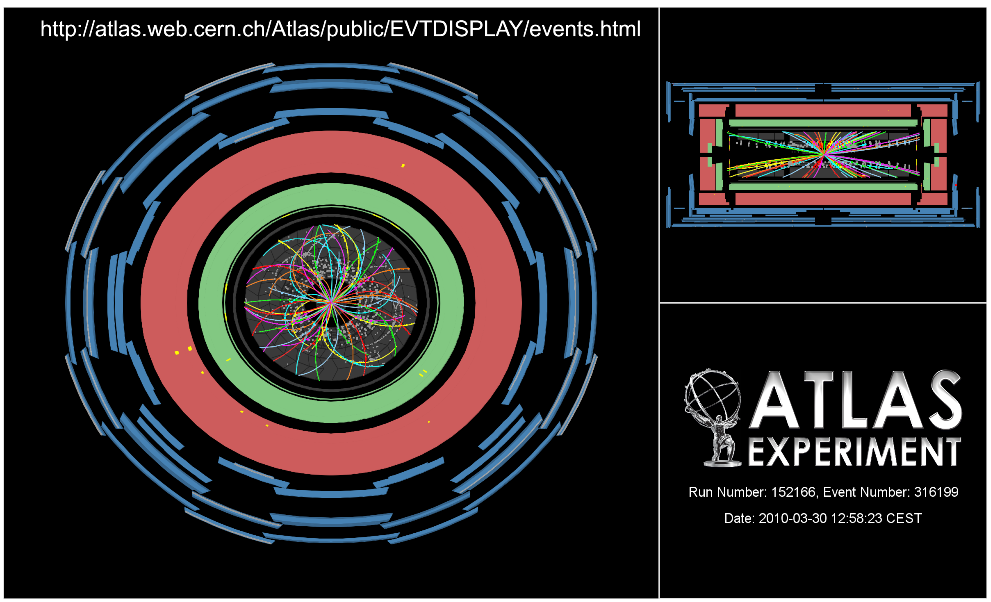
- $\phi \to K^+K^-$
- $K_S^0 \to \pi^+\pi^-$
- $D^{*+} \to D^0\pi_s^+ \to (K^-\pi^+)\pi_s^+$
- $D^+ \to K^-\pi^+\pi^+$
- $D_s^+ \to \phi\pi^+ \to (K^-K^+)\pi^+$
- K^{*+}, Ω^-, Ξ^-

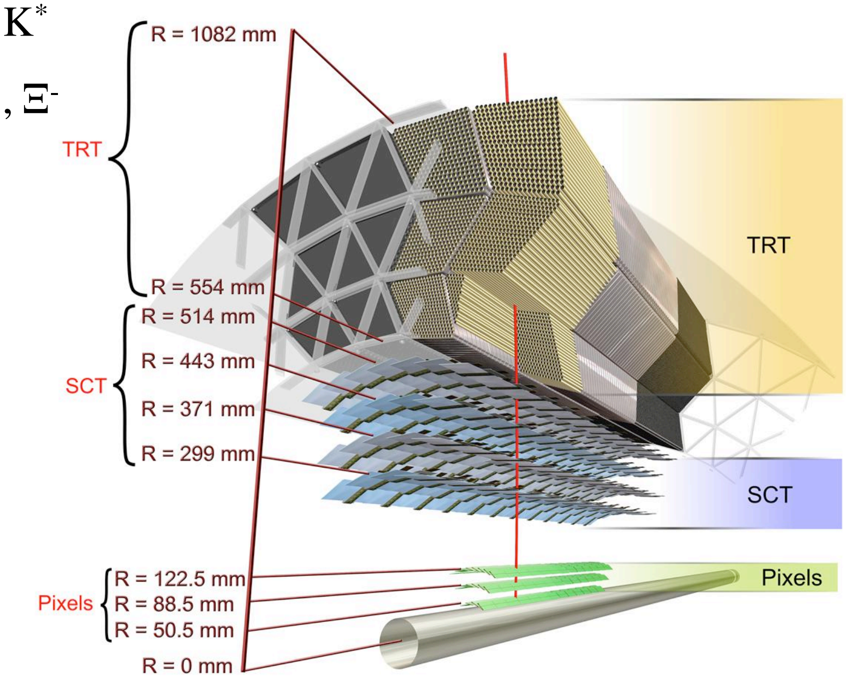


Introduction

Observations of mass peaks from ATLAS Inner Detector tracks:
(not corrected yet for efficiency or other detector defects)

- require at least one hit over threshold in the Minimum Bias Trigger Scintillators at both ends of the detector
- 2 silicon (SCT or Pixel) hits per track and track $p_T > 100$ MeV for K_S^0
- 1 Pixel + 4 SCT hits and track $p_T > 100$ MeV for D^*, D^+, D_s^+
- 1 B-layer + 1 other Pixel hit and track $p_T > 150$ MeV for K^*
- 2 silicon hits with $track_1/track_2$ $p_T > 150/500$ MeV for Ω^-, Ξ^-

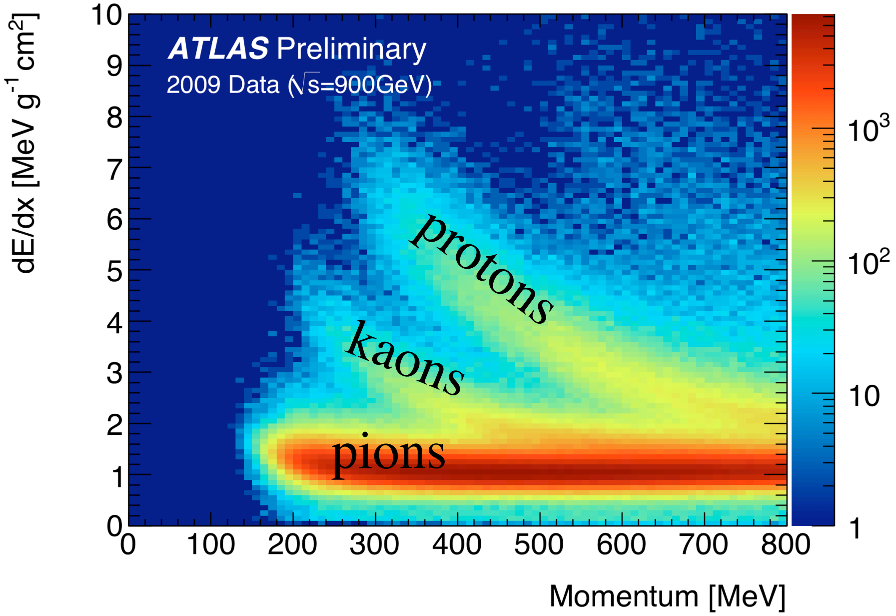


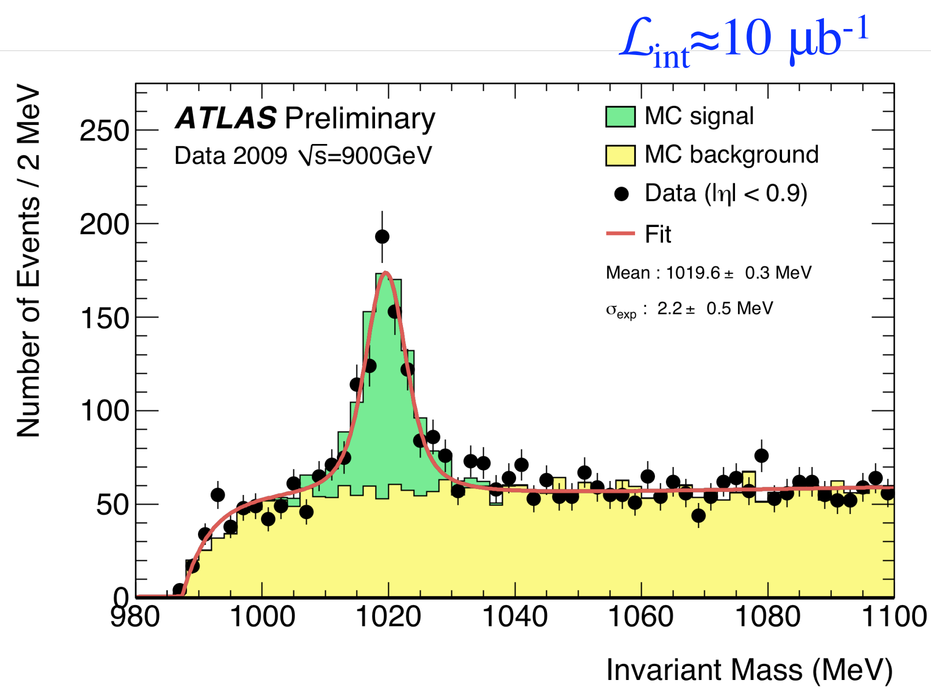


ϕ (1020) -> K^-K^+

ϕ -> K^-K^+ in 900 GeV data

- use time-over-threshold measurements from Pixel Detector
- p_T < 800 MeV for each track
- mass of signal peak consistent with MC simulation and PDG
  - Validates dE/dx identification





$K_S^0 \to \pi^+\pi^-$

$K_S^0 \to \pi^+\pi^-$ (BF≈69%, cτ=2.7 cm)

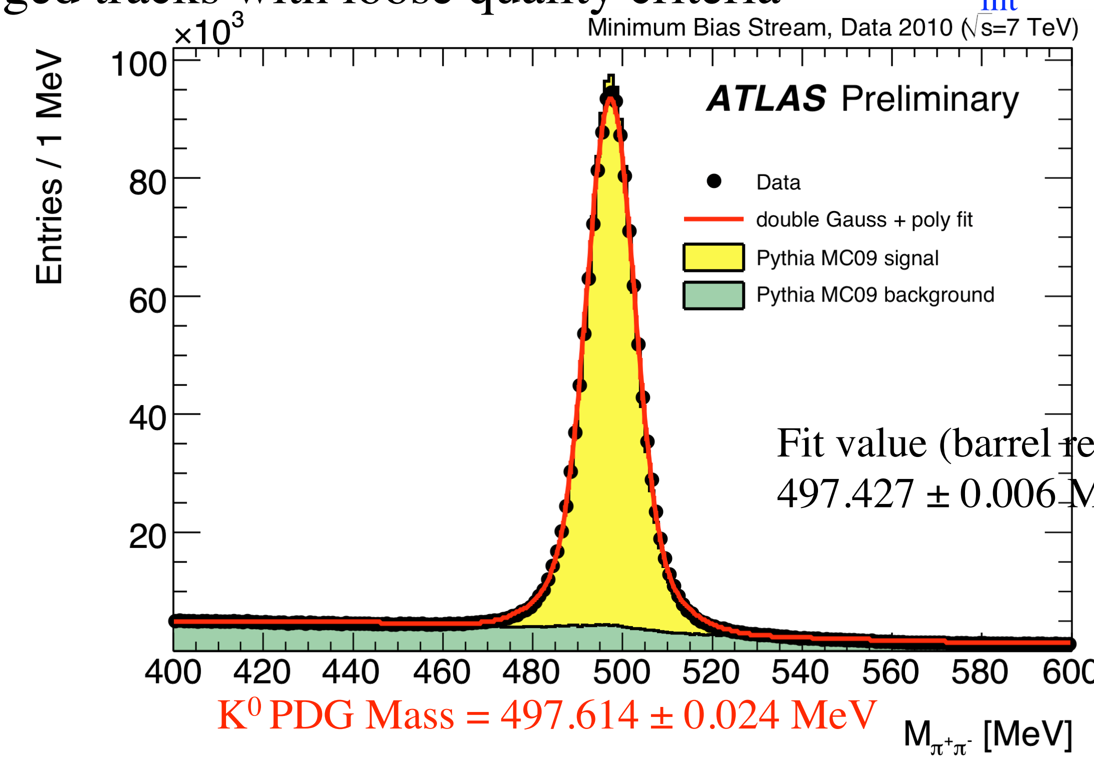
Simple strategy:

- require secondary vertex displaced from the primary vertex
- use pairs of oppositely charged tracks with loose quality criteria

$\mathcal{L}_{int} \approx 190\ \mu b^{-1}$

K_S^0 selection:

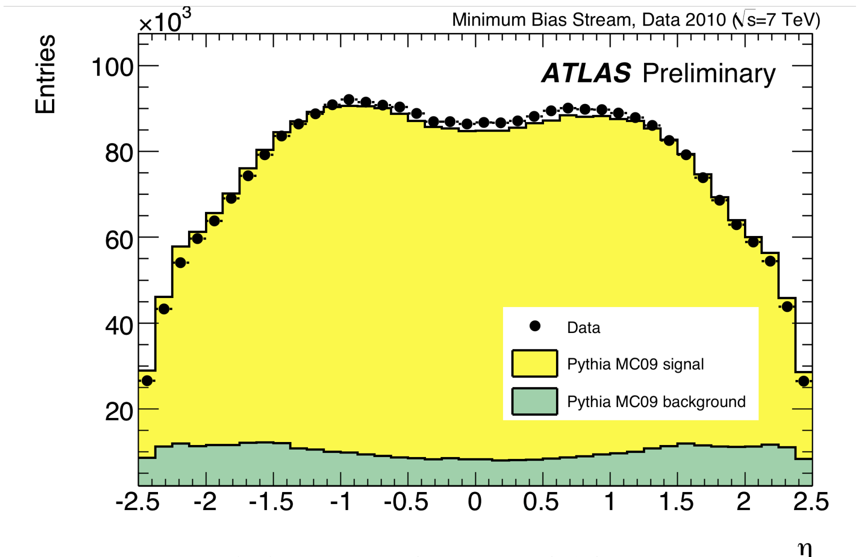
- $p_T(\pi) > 100$ MeV
- $L_{xy} > 0.4$ cm
- angle between flight and momentum direction: $\cos\theta > 0.999$



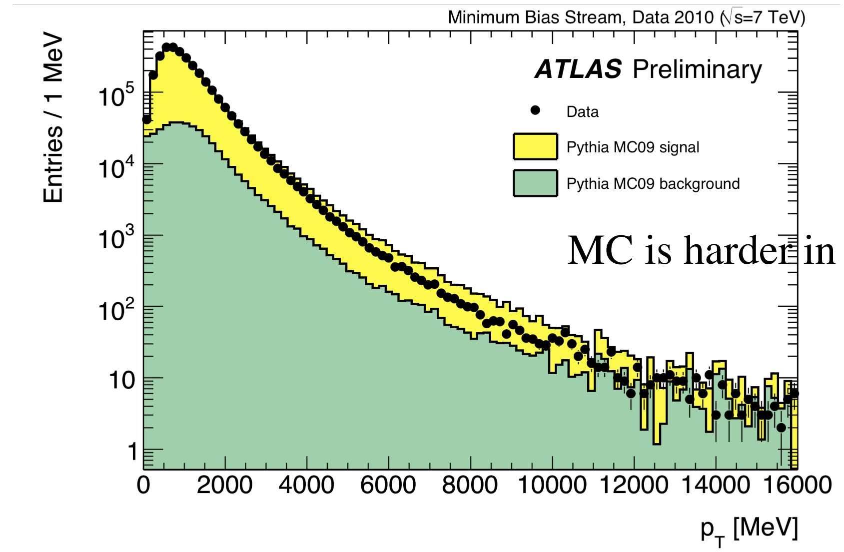
K^0 PDG Mass = 497.614 ± 0.024 MeV

$K_S^0 \to \pi^+\pi^-$

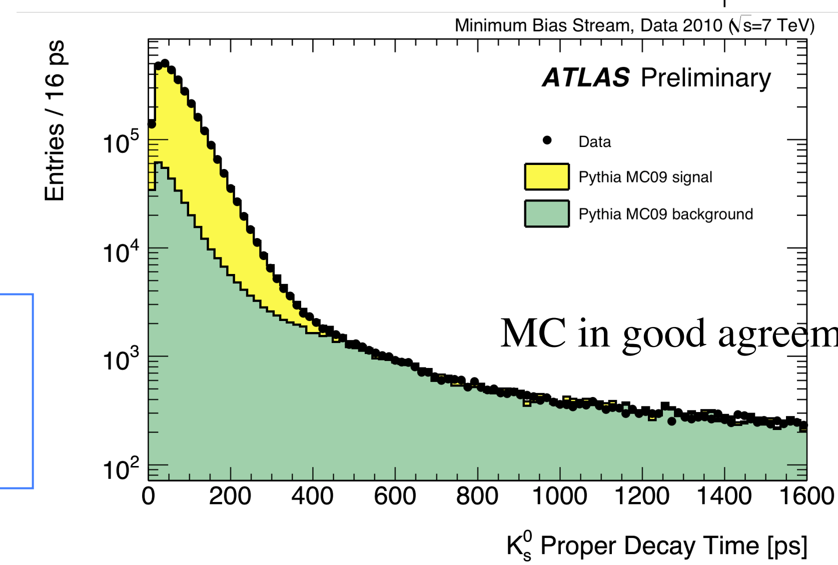
Kinematic Plots for $K_S^0 \to \pi^+\pi^-$



MC and data consistent within 10%



MC is harder in p_T



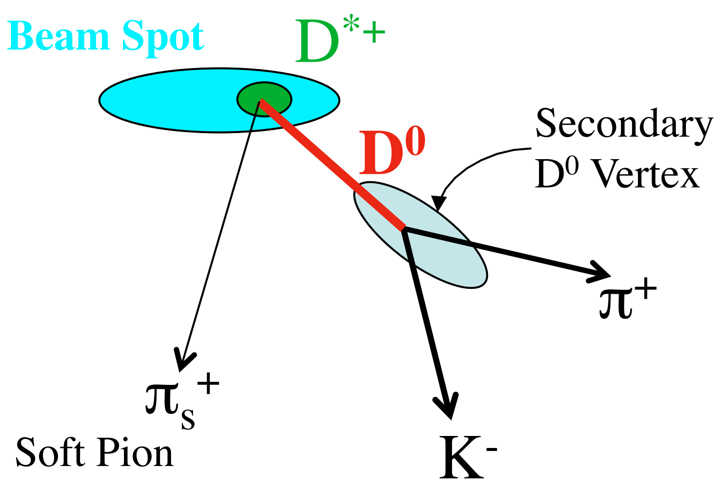
MC in good agreement

$|M(\pi^+\pi^-) - M(K_S^0)_{PDG}| < 20$ MeV

No corrections for detector effects

$D^{*+} \rightarrow D^0\pi_s^+ \rightarrow (K^-\pi^+)\pi_s^+$

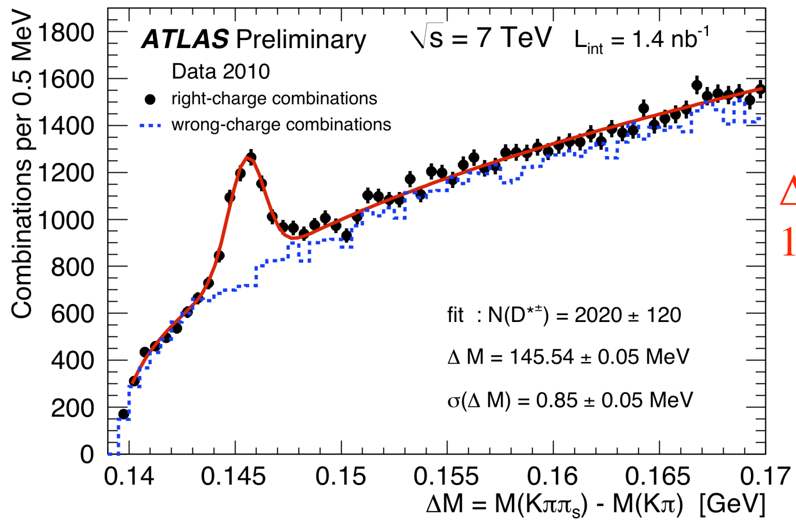
$D^{*+} \rightarrow D^0\pi_s^+$, where $D^0 \rightarrow K^-\pi^+$ (+ c.c.)

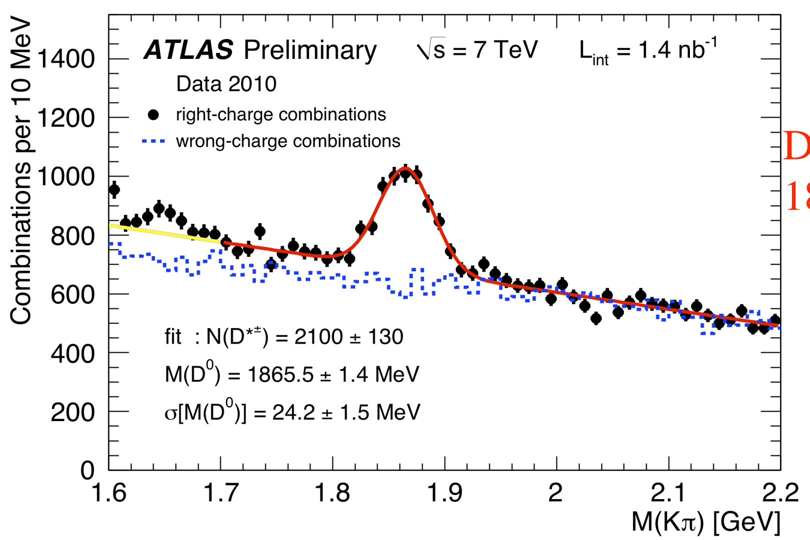


Reconstruction strategy:

- Exploit the displacement of the D^0 vertex: require positive transverse decay length, L_{xy}
- D^0 momentum points to primary vertex
- $p_T(D^*) > 3.5$ GeV $p_T(K,\pi) > 1.0$ GeV
- Exploit hard nature of charm fragmentation: $p_T(D^*) / \Sigma E_T > 0.02$
- Use $\Delta m = M(K\pi\pi) - M(K\pi)$ as discriminating variable
- $M(D^*) - M(D^0) - M(\pi) = 6$ MeV, so most tracking resolutions affect the D^0 decay and cancel out in the correlated difference => signal 40 times narrower than the D^* mass peak

$D^{*+} \to D^0\pi_s^+ \to (K^-\pi^+)\pi_s^+$





ΔM PDG Mass = 145.43 ± 0.24 MeV

D^0 PDG Mass = 1864.84 ± 0.17 MeV

D^{*+} Cuts:

- $p_T(D^{*+}) > 3.5$ GeV
- $|\eta(D^{*+})| < 2.1$
- $p_T(D^*) / \Sigma E_T > 0.02$
- $L_{xy}(D^0) > 0$ ($c\tau(D^0) = 123$ μm)
- $p_T(K,\pi) > 1$ GeV
- $p_T(\pi_s) > 0.25$ GeV

For ΔM:

- $1.83 < M(K\pi) < 1.90$ GeV

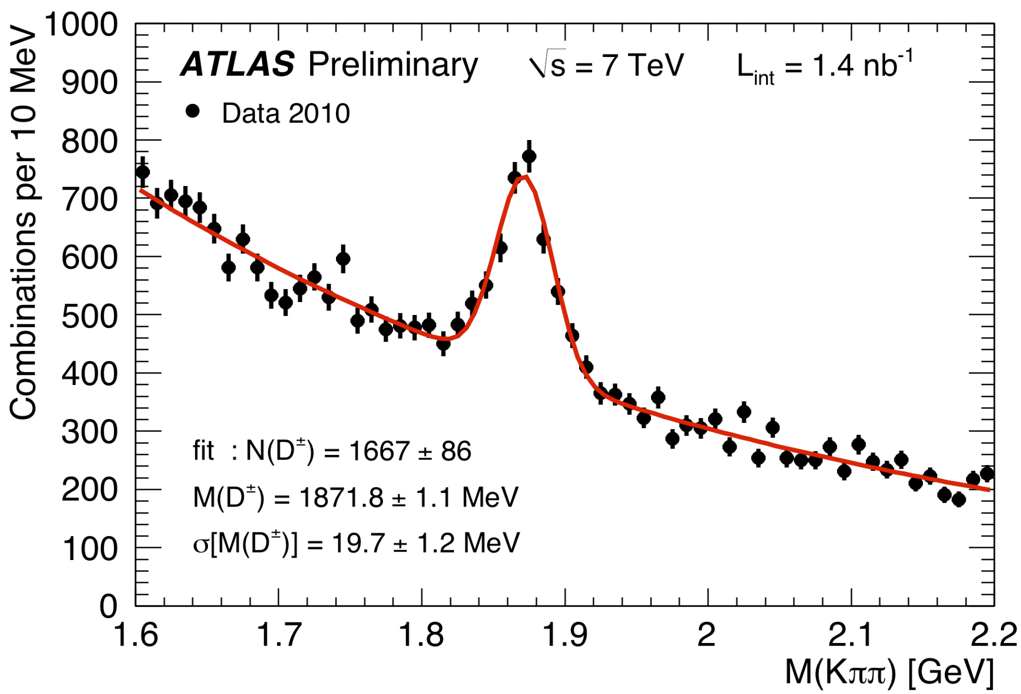
For $M(K\pi)$:

- $144 < M(K\pi\pi) < 147$ MeV

Wrong charge combinations: $K^-\pi^-\pi_s^+$ (+ c.c.)

$D^+ \rightarrow K^-\pi^+\pi^+$

$D^+ \rightarrow K^-\pi^+\pi^+$ (+ c.c.)

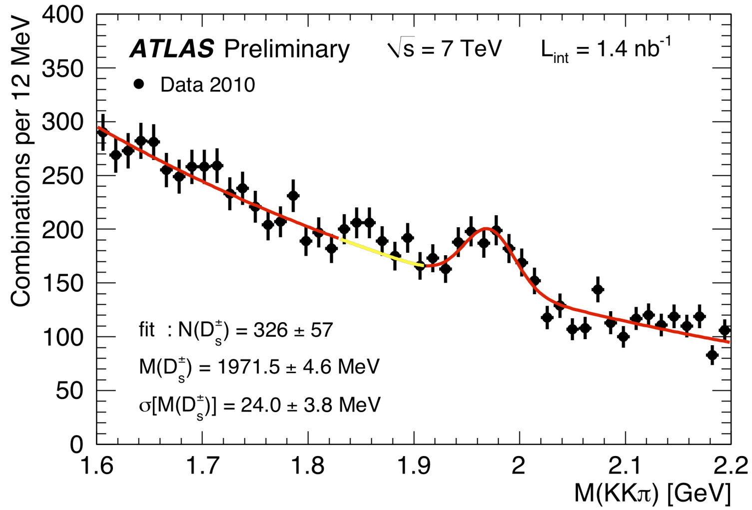


D+ PDG Mass = 1869.62 ± 0.20 MeV

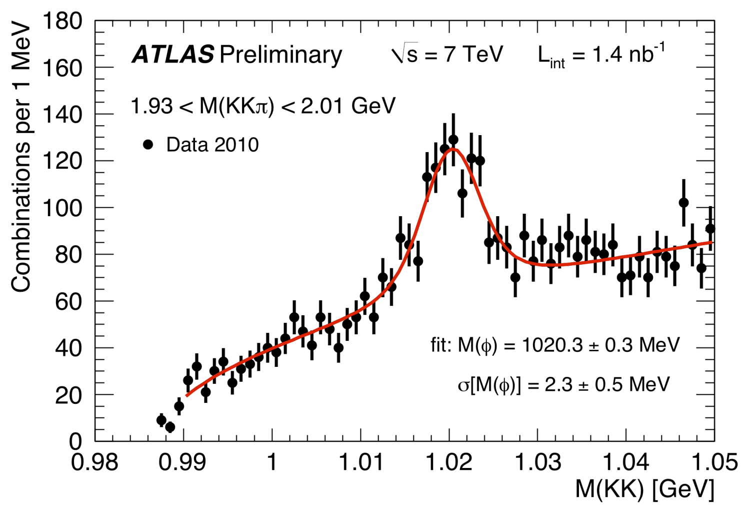
<u>D^+ Cuts:</u>

- $p_T(D^+) > 3.5$ GeV
- $|\eta(D^+)| < 2.1$
- $p_T(D^+) / \Sigma E_T > 0.02$
- $L_{xy}(D^+) > 1.3$ cm ($c\tau(D^+) = 312$ μm)
- $p_T(K) > 1$ GeV
- $p_T(\pi_{1,2}) > 0.8$ GeV, $p_T(\pi_{1,2}^{max}) > 1$ GeV

$D_s^+ \to \phi\pi^+ \to (K^-K^+)\pi^+$



D_S^+ PDG Mass = 1968.49 ± 0.34 MeV



ϕ PDG Mass = 1019.455 ± 0.020 MeV

<u>D^+ Cuts:</u>

- $p_T(D_S^+) > 3.5$ GeV
- $|\eta(D_S^+)| < 2.1$
- $p_T(D_S^+) / \Sigma E_T > 0.04$
- $L_{xy}(D_S^+) > 0.4$ cm ($c\tau(D_S^+) = 150$ μm)
- $p_T(K_{1,2}) > 0.7$ GeV
- $p_T(\pi) > 0.8$ GeV

For M(KKπ):

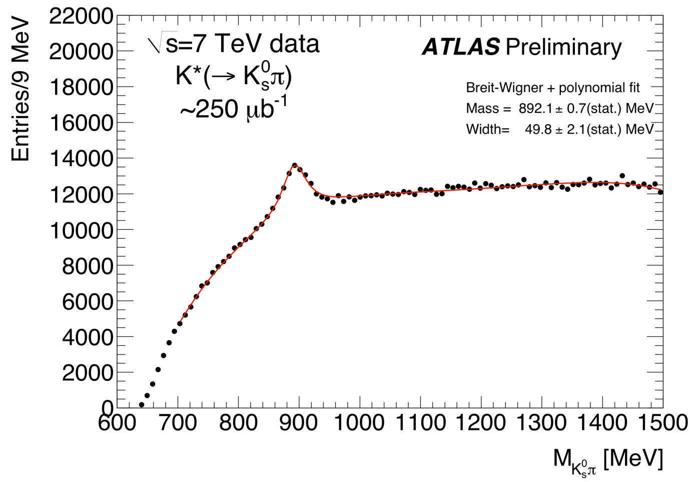
- $| M(KK) - M(\phi)_{PDG} | < 6$ MeV

For M(KK):

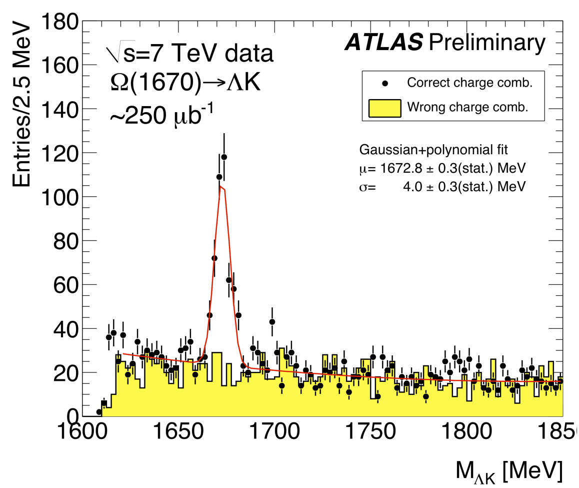
- $1.83 < M(KK\pi) < 1.91$ GeV

K^{*+}, Ω^-, Ξ^-

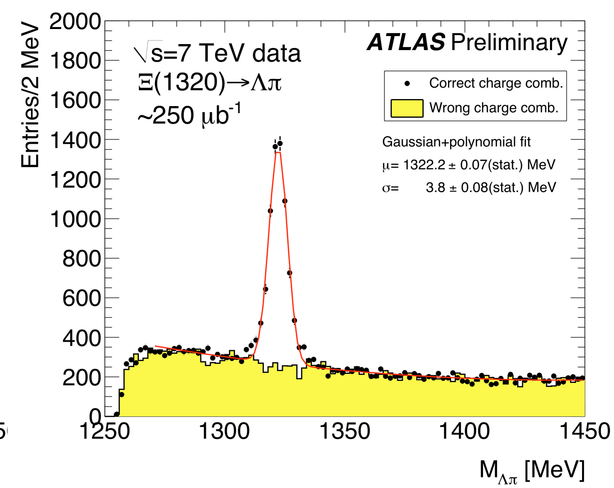
$K^{*+} \to K_S^0\pi^+$



$\Omega^- \to \Lambda_0 K^-$



$\Xi^- \to \Lambda_0\pi^-$



$L_{xy}(K^{*+}) > 0.8$ cm
$p_T(K^{*+}) > 1.5$ GeV

$L_{xy}(\Omega^-) > 0.6$ cm
$p_T(\Omega^-) > 1.5$ GeV

$L_{xy}(\Xi^-) > 0.4$ cm

K^{*+} PDG Mass = 891.66 MeV

Ω^- PDG Mass = 1672.4MeV

Ξ^- PDG Mass = 1321.7 MeV

Charged cascade decays with more complicated secondary and tertiary vertexing

- Masses close to PDG values => validates complex vertexing algorithms

Summary

- Successful identification of ϕ resonance
  - validates dE/dx identification
- Mass, width and kinematic variable reconstruction of K_S^0 is in good agreement with simulation
  - demonstrates good low p_T track momentum scale
  - excellent modeling of Inner Detector's solenoid magnetic field
- Successful reconstruction of charm mesons and strange baryons
  - masses are in agreement with simulation and PDG values
  - validates vertexing algorithms
  - confirms the excellent performance for ATLAS high precision track measurements

References

The following references were used:

ATLAS-CONF-2010-023

ATLAS-CONF-2010-024

ATLAS-CONF-2010-032

ATLAS-CONF-2010-033

ATLAS-CONF-2010-034

ATLAS-CONF-2010-035

Extra

Extra

Ξ, Ω, K* Decays – more complicated vertexing

Charged cascade decays:

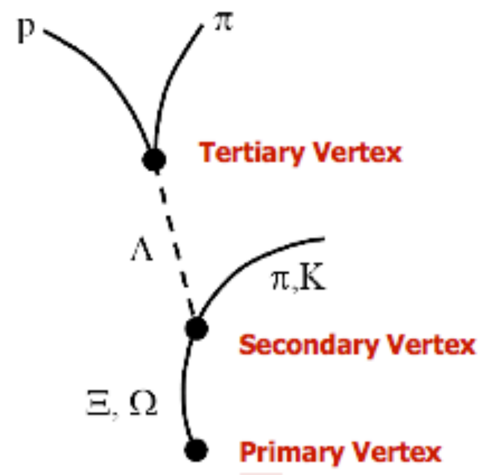
$\Xi^- \rightarrow \Lambda(p\pi^-)\pi^-$ $c\tau$=4.91cm (+ charged conjugate)

$\Omega^- \rightarrow \Lambda(p\pi^-)K^-$ $c\tau$=2.46cm (+ charged conjugate)

Use simultaneous vertexing of entire decay chain with pointing constraints

Λ is mass-constrained in the vertex fit

$|M_{p\pi} - M_\Lambda| < 8$ MeV pre-selection



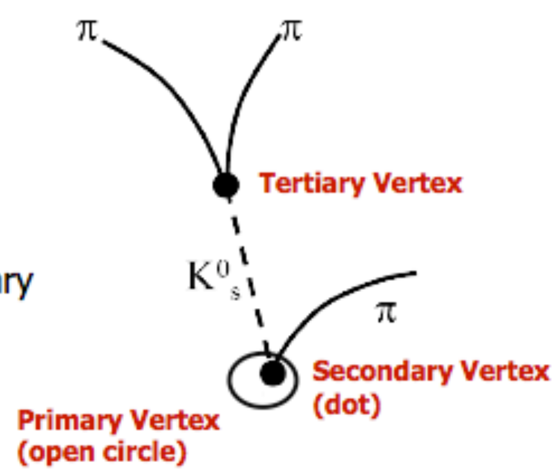
Prompt hadronic decay:

$K^{*+/-} \rightarrow K^0(\pi^+\pi^-)\pi^{+/-}$

Same vertexing but enforcing small distance between secondary and primary vertices to enhance the signal

K_S is mass-constrained in fit

$|M_{\pi\pi} - M_{Ks}| < 25$ MeV pre-selection



$\Lambda^0 \rightarrow p\pi^-$ (+ c.c.)