First ATLAS results on charm production

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Introduction

Aim:

- measurement of charm (and beauty) production
- either full or partial D meson reconstruction
- b/c separation

Charm (and beauty) production at LHC, pp → QQX

- Flavour Creation (FC):
  - g+g →Q+Q
  - q+q →Q+Q
- Flavour Excitation (FE):
  - Q+g →Q+g
  - Q+q →Q+q
- Gluon Splitting (GS):
  - g →Q+Q

Production in pp collisions @ $\sqrt{s}$ = 7TeV:

- σ(cc) ~ 4.4mb
- σ(bb) ~ 0.24mb

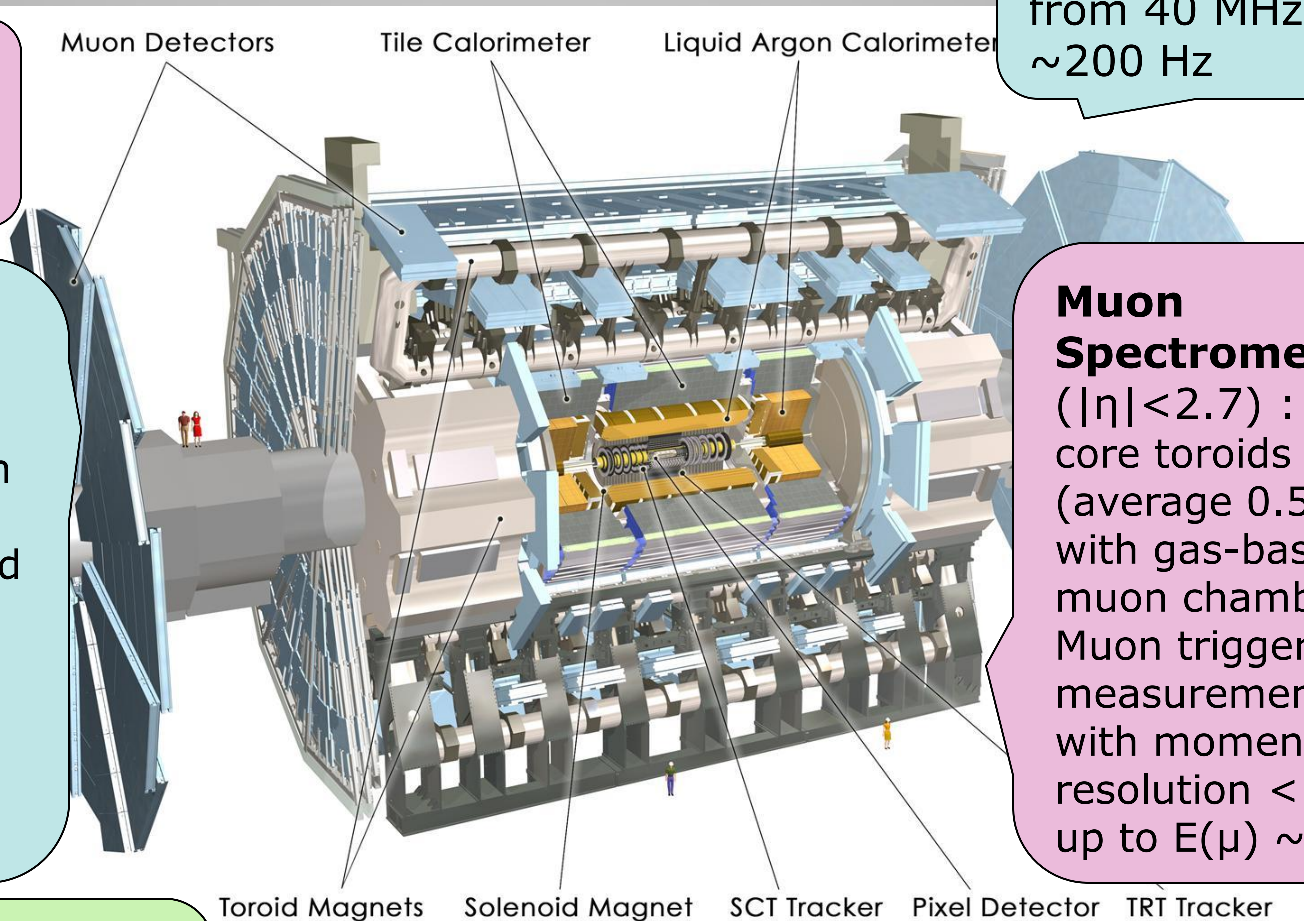
Reconstruction already feasible in ATLAS with the first LHC data due:

- large cross-section values
- clean D meson signatures
- very good ATLAS tracking

The ATLAS detector

Length: ~46 m
Radius: ~12 m
Weight: ~7 Ktons

3-level trigger reducing the rate from 40 MHz to ~200 Hz



Inner Detector ($|\eta|<2.5$, B=2T): Si Pixels, Si strips, Transition Radiation Tracker (straws). Precise tracking and vertexing, e/π separation.
p_t resolution:
$\varepsilon/p_t \sim 3.8\times10^{-4}\ p_t$ (GeV) $\pm$ 0.015

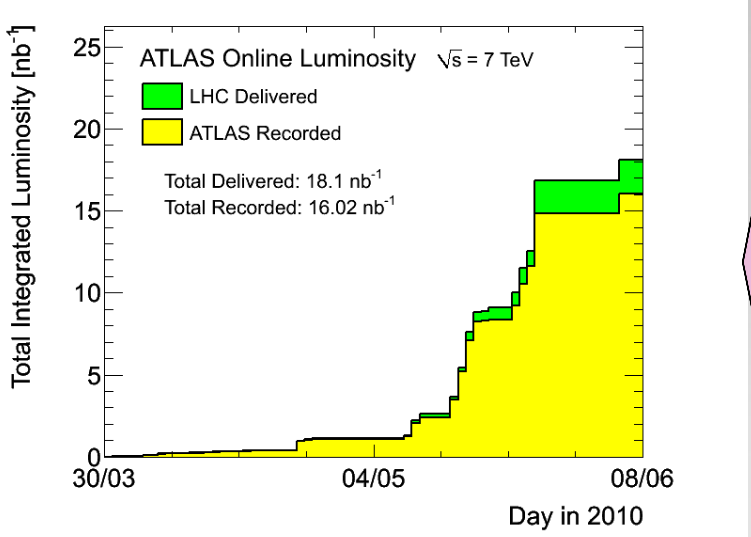
Muon Spectrometer ($|\eta|<2.7$) : air-core toroids (average 0.5T) with gas-based muon chambers. Muon trigger and measurement with momentum resolution < 10% up to E(μ) ~1 TeV

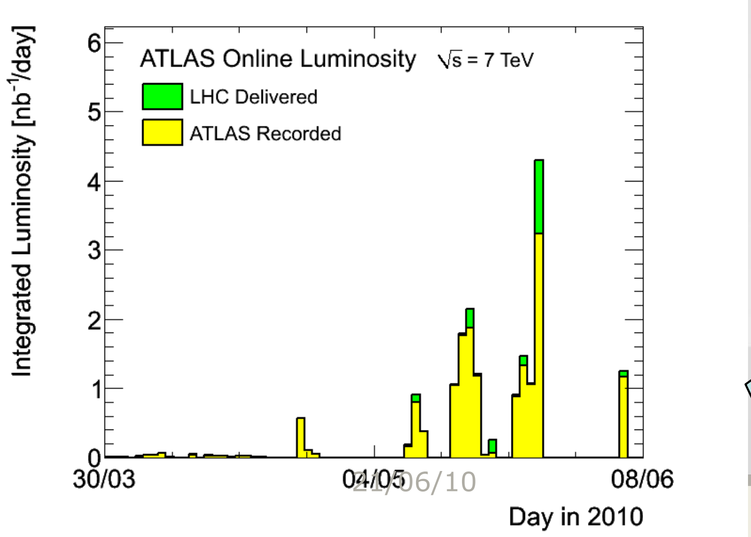
EM calorimeter: Pb-LAr Accordion. e/γ trigger, identification and measurement.
E-resolution: $\sigma/E \sim 10\%/\sqrt{E}$

HAD calorimetry ($|\eta|<5$): Fe/scintillator Tiles (central), Cu/W-LAr (fwd). Trigger and measurement of jets and missing ET.
E-resolution: $\sigma/E \sim 50\%/\sqrt{E} \pm 0.03$

Overall statistics for 7TeV collisions

Period: 30 March – 8 June





Instantaneous luminosity L derived from:

- MBTS (trigger scintillators at ±3.5m from IP) double-side coincidence trigger rate
- LAr offline event selection (coincidence of in-time end-cap energy deposits)
- Measurement from dedicated LUCID forward detectors, at ±17m from IP
- Present overall L scale uncertainty ~20% from systematic uncertainties (MC cross-section)

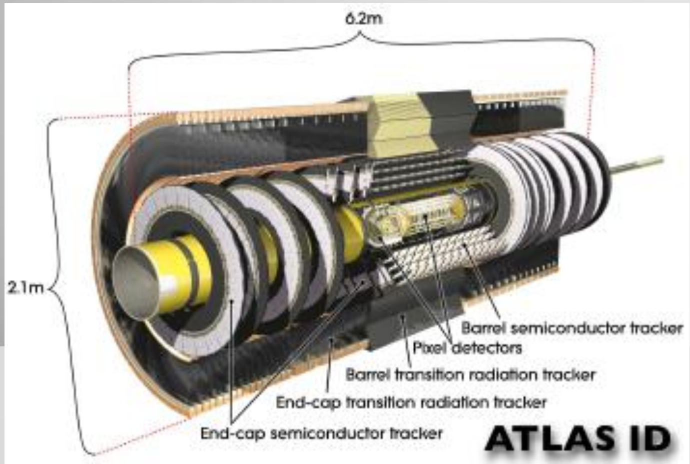
Total luminosity about 16 nb^{-1};

89 % of the luminosity delivered with Stable Beams was recorded by ATLAS

Introduction to the analysis

Ingredients of this analysis:

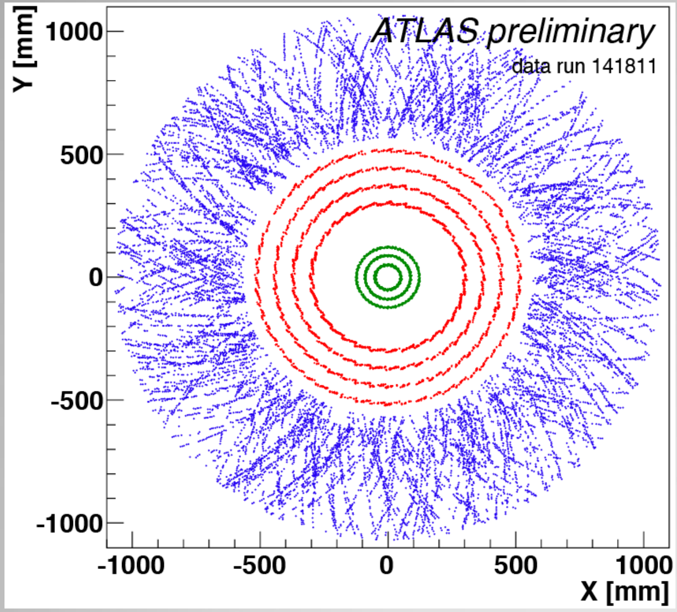
- Trigger
  - Using the ATLAS Minimum Bias Trigger Scintilators (MBTS): > 99.5% for any track multiplicity
  - With higher luminosity, lepton trigger will be used



- Tracking:

Inner Detector ($|\eta| < 2.5$)
  - Pixel Detector
  - Semiconductor Tracker (SCT)
  - Transition Radiation Tracker (TRT)

ATLAS Inner Detector



- Pixel Detector:
3 barrel layers, 2 x 3 end-cap discs
$\sigma_{r\phi} \sim 10\ \mu m$, $\sigma_z \sim 115\ \mu m$
- Silicon Strip Detector (SCT)
4 barrel layers, 2 x 9 end-cap discs
$\sigma_{r\phi} \sim 17\ \mu m$, $\sigma_z \sim 580\ \mu m$
- Transition Radiation Tracker(TRT)
73 barrel straw layers, 2x160 end-cap radial straw discs
$\sigma_{r\phi} \sim 130\ \mu m$

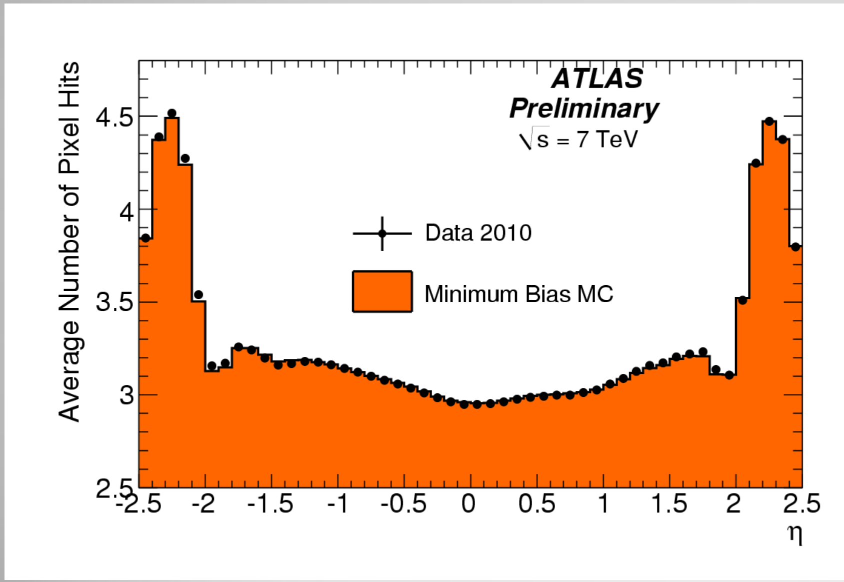
Subdetector	Number of Channels	Approximate Operational Fraction
Pixels	80 M	97.5%
SCT Silicon Strips	6.3 M	99.3%
TRT Transition Radiation Tracker	350 k	98.0%

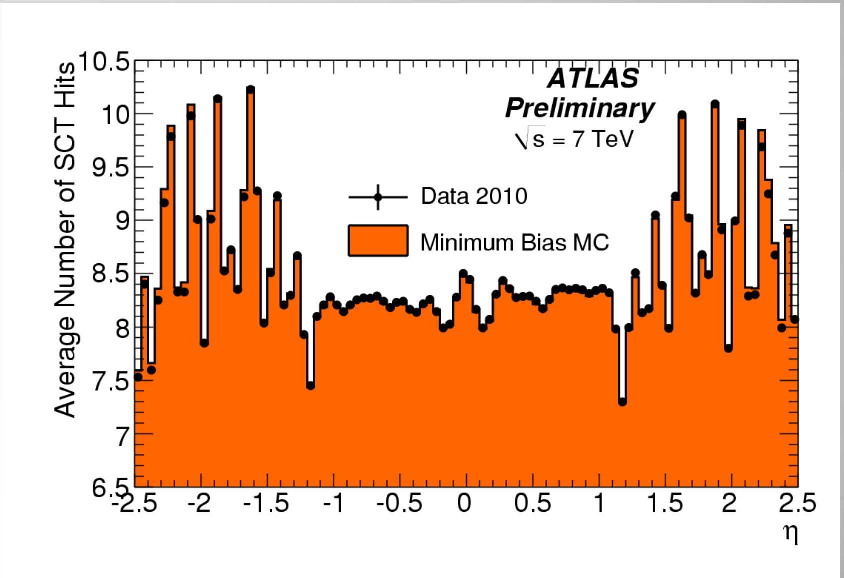
All components operational > 97.5%!

Tracking: data/MC agreement

Detailed studies comparing data/MC

- Dedicated care that Monte Carlo samples reflect conditions during data taking (beam spot position, inactive modules, noisy channels)



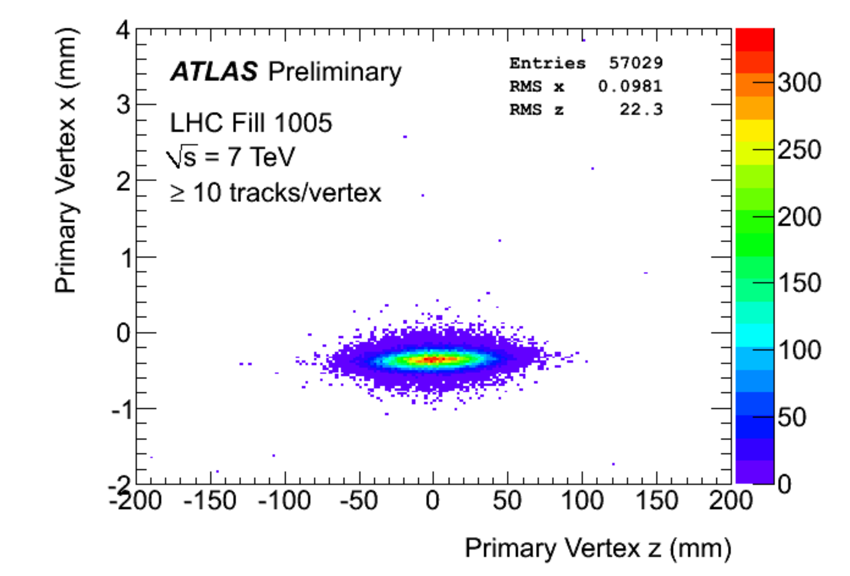


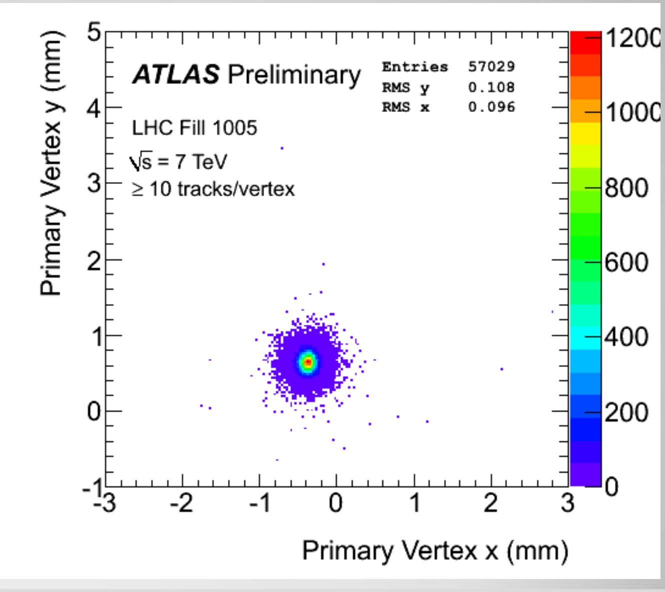
In general, there is an excellent agreement between data and MC

ATLAS vertex reconstruction

Longitudinal Plane distribution for events with at least 10 tracks

Transverse Plane distribution for events with at least 10 tracks





Excellent primary vertex reconstruction

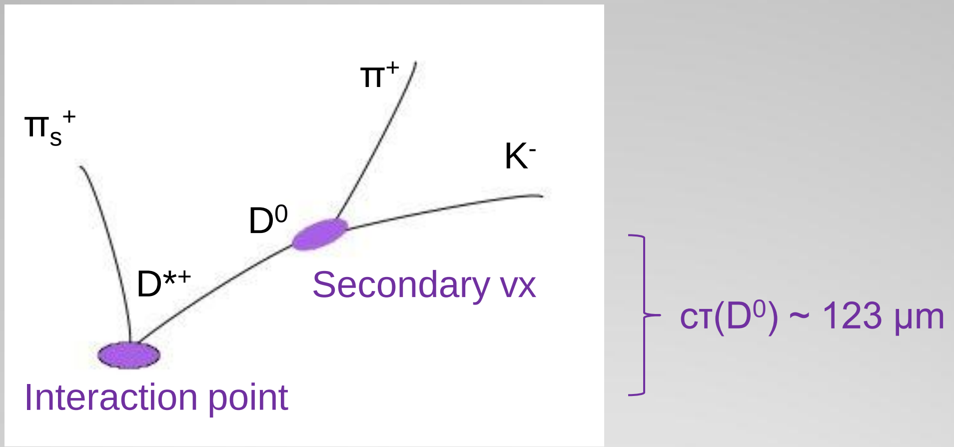
Analysis strategy

- D-meson selection:
  - hard nature of charm production ($p_t(D)$, p_t (K, π))
  - hard nature of charm fragmentation ($p_t(D)/E_t$)
  - relatively large D-mesons' life-time (decay length L_{xy})
  - "spin" angular behaviour of D-mesons' decays (cosθ*, cosθ'[1])

- Goals:
  - use widest kinematic range where signals can be measured [$p_t(D) > 3.5$ GeV, $|\eta(D)| < 2.1$]
  - make signals as clean (significant) as possible in the kinematic range

[1] In the example of $D_s^+ \to \varphi \pi^+ \to (K^- K^+) \pi^+$
θ*(π): angle between the π in the KKπ rest frame and the KKπ line of flight in the laboratory frame
θ'(K): angle between the K and the π in the KK rest frame

D* reconstruction



- Tracks used satisfying the selection criteria
- Vertexing has been used to combine the 2 oppositely charged tracks to a single vertex (secondary vertex) and combination of 3rd track
- Apply D-meson selection criteria (in previous slide)
- For D* the $\Delta m = M(K\pi\pi) - M(K\pi)$ variable is mostly discriminant

D* reconstruction in 7TeV data

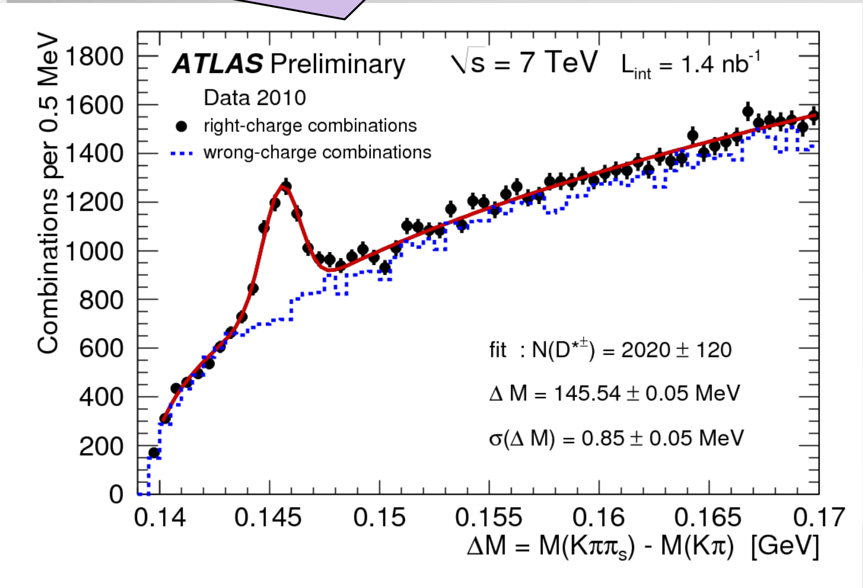
$D^{*+} \to D^0 \pi_s^+ \to (K^- \pi^+) \pi_s^+$

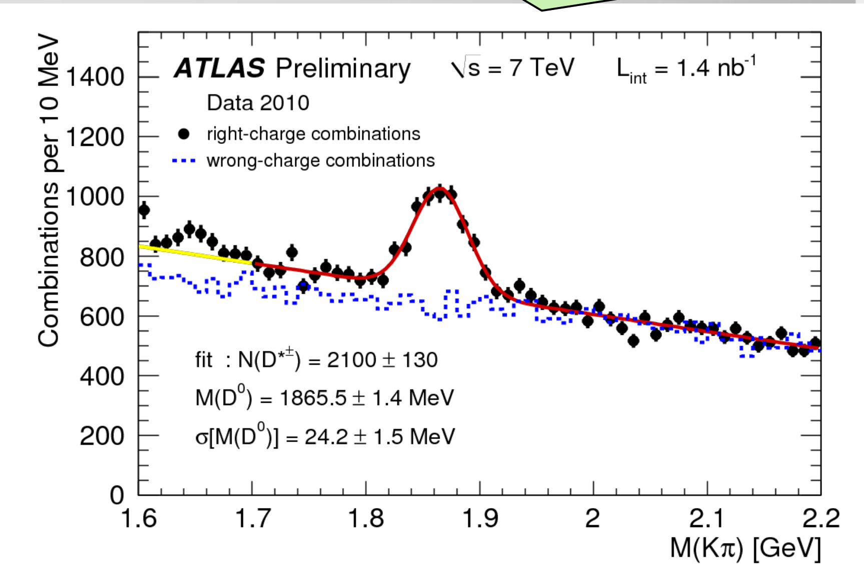
Positive decay length
$p_t(D^*)/E_t > 0.02$

$p_t(\pi_s) > 0.25$ GeV, $p_t(K,\pi) > 1.0$ GeV
$|\eta(K,\pi,\pi_s)| < 2.5$, $N^{pix} \geq 1$, $N^{SCT} \geq 4$
$d_0^{PV}(\pi_s) < 0.8$mm, $z_0^{PV}(\pi_s)\sin\theta < 1.5$mm
$d_0^{PV}(D^0) < 0.2$mm, $z_0^{PV}(D^0)\sin\theta < 0.5$mm
$\chi^2(D^0) < 5$

$|M(K\pi) - M^{PDG}(D^0)| < 35$MeV

144MeV $< \Delta m <$ 147MeV





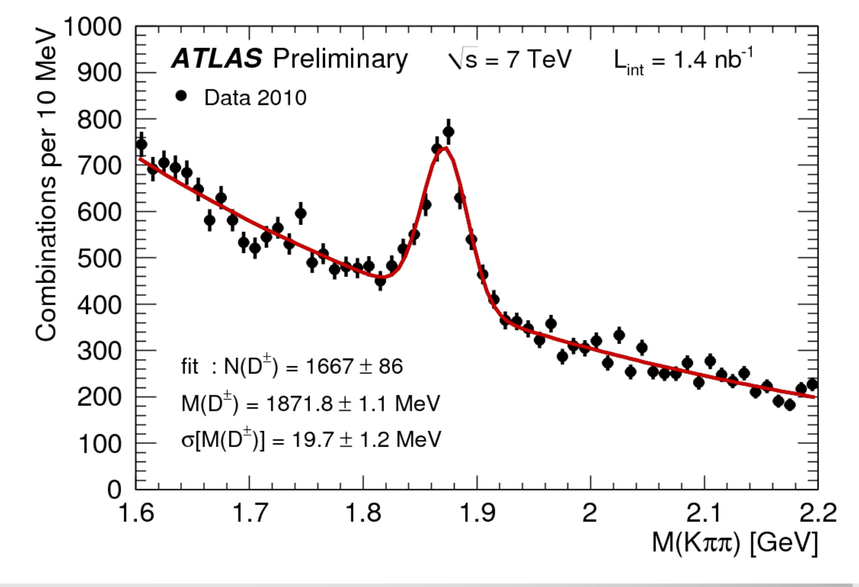
- ~2000 $D^{*\pm}$ in the signal

D^+ reconstruction in 7TeV data

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

$p_t(\pi_{1,2}) > 0.8$ GeV, $p_t(K) > 1.0$ GeV
$\max(p_t(\pi_{1,2})) > 1.0$GeV
$|\eta(K, \pi_{1,2})| < 2.5$, $N^{pix} \geq 1$, $N^{SCT} \geq 4$
$d_0^{PV}(D) < 0.15$mm, $z_0^{PV}(D)\sin\theta < 0.3$mm
$\chi^2(D) < 6$

$L_{xy} > 1.3$ mm
$p_t(D)/E_t > 0.02$
$\cos\theta^*(K) > -0.8$



Suppressing D* and Ds:
$D^* \to D^0 \pi \to (K \pi) \pi$ vetoing $\Delta m < 150$ MeV
$D_s^+ \to \varphi \pi \to (K K) \pi$ vetoing $|M(K\text{"}K\text{"}) - M^{PDG}(\varphi)| < 8$MeV

- ~1700 $D^{\pm}$ in the signal

D_s^+ reconstruction in 7TeV data

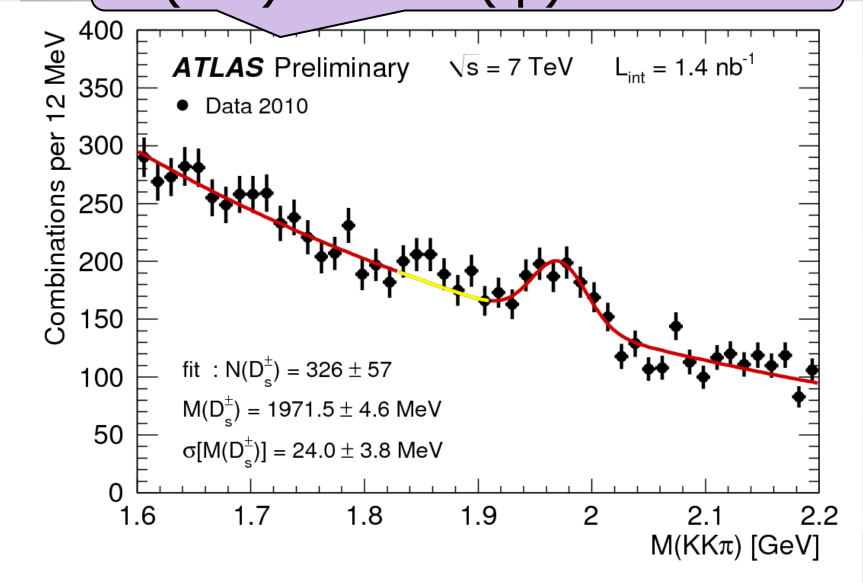
$D_s^+ \rightarrow \varphi\, \pi^+ \rightarrow (K^- K^+)\, \pi^+$

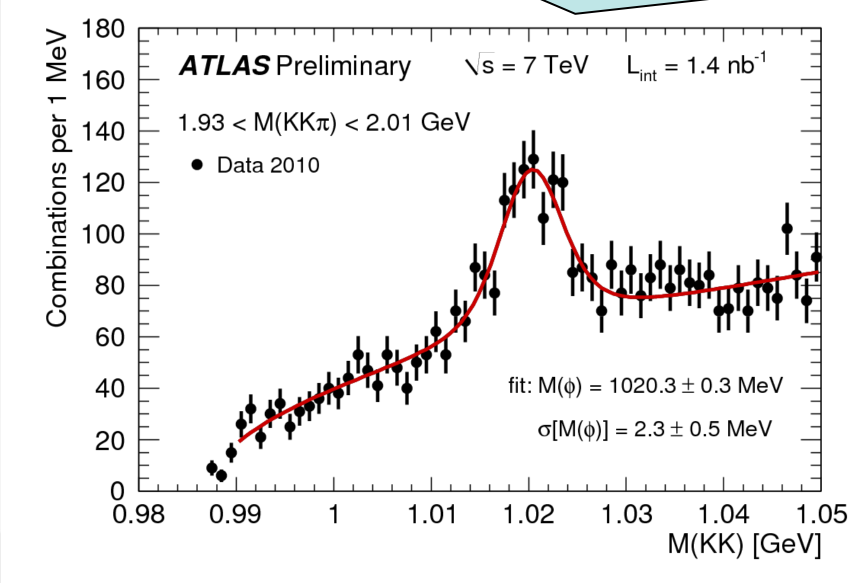
$p_t(K_{1,2}) > 0.7$ GeV, $p_t(\pi) > 0.8$ GeV
$|\eta(\pi, K_{1,2})| < 2.5$, $N^{pix} \geq 1$, $N^{SCT} \geq 4$
$d_0^{PV}(D_s) < 0.15$mm, $z_0^{PV}(D_s)\sin\theta < 0.3$mm
$\chi^2(D_s) < 6$

$L_{xy} > 0.4$ mm
$p_t(D_s^+)/E_t > 0.04$
$\cos\theta^*(\pi) < 0.4$
$|\cos\theta'(K)|^3 > 0.2$

$M(KK) - M^{PDG}(\varphi) < 6$ MeV

$1.93\text{GeV} < M(KK\pi) < 2.01\text{GeV}$





- ~330 $D_s^{\pm}$ in the signal

Conclusions

- Clear $D^{*\pm}$, $D^{\pm}$ and $D_s^{\pm}$ signals reconstructed with the ATLAS detector in pp collisions @ 7TeV using $\int\mathcal{L}$ of $1.4 nb^{-1}$:
  - $D^{*\pm}$: 2020 ± 120
  - $D^{\pm}$: 1667 ± 86
  - $Ds^{\pm}$: 326 ± 57
- Confirm high performance of ATLAS detector for precision tracking measurements
- Validate vertexing algorithms in ATLAS