Spectroscopy and production of B_c mesons in ATLAS

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Outline

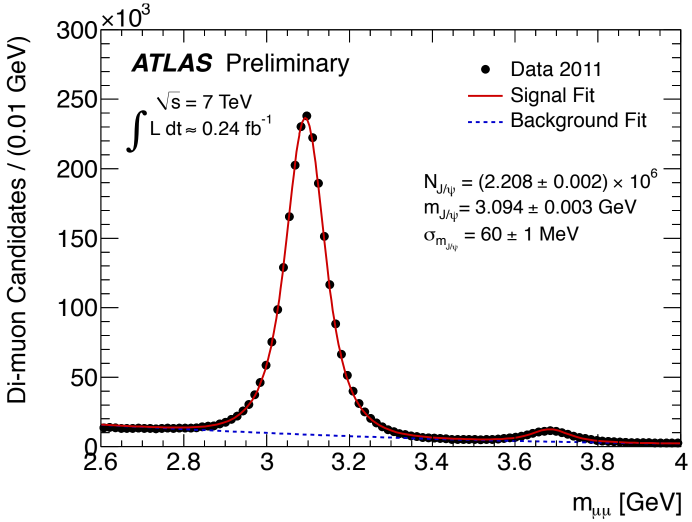
- The ATLAS detector @ LHC

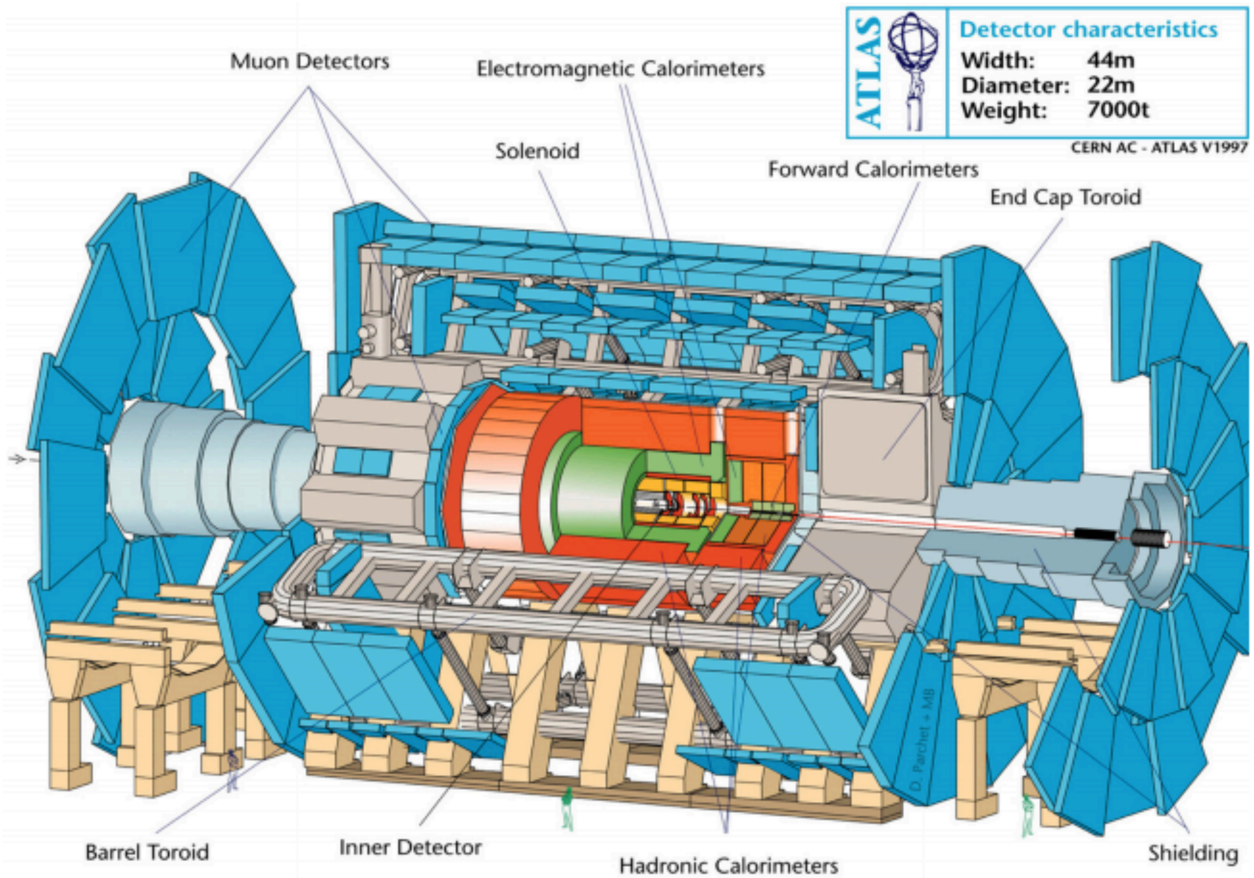
- Recent ATLAS result covered in this talk:
  - relative $B_c/B^{\pm}$ production cross section measurements @ 8 TeV

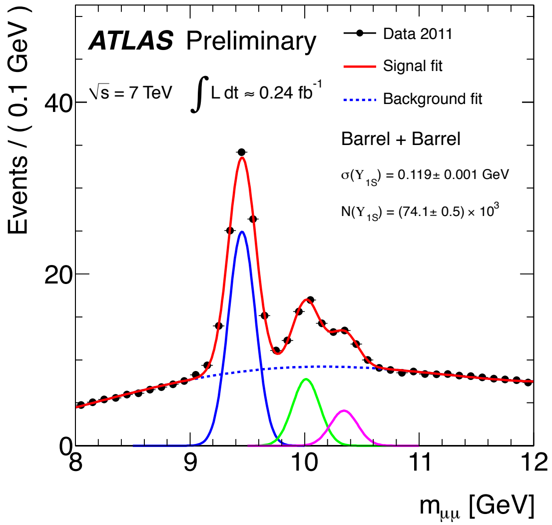
- Conclusions

The ATLAS detector @ LHC

- Subsystems essential for B-physics: Inner Detector and Muon Spectrometer.
- Inner detector: tracking, momentum and vertexing, |η|<2.5, d_0 resolution ~10μm.
- Muon spectrometer: trigger and muon identification, |η|<2.7.
- J/ψ mass resolution: 60±1 MeV, ϒ(1S): 119±1 MeV (resolutions depend on η).







Relative $B_c/B^{\pm}$ production cross section measurement

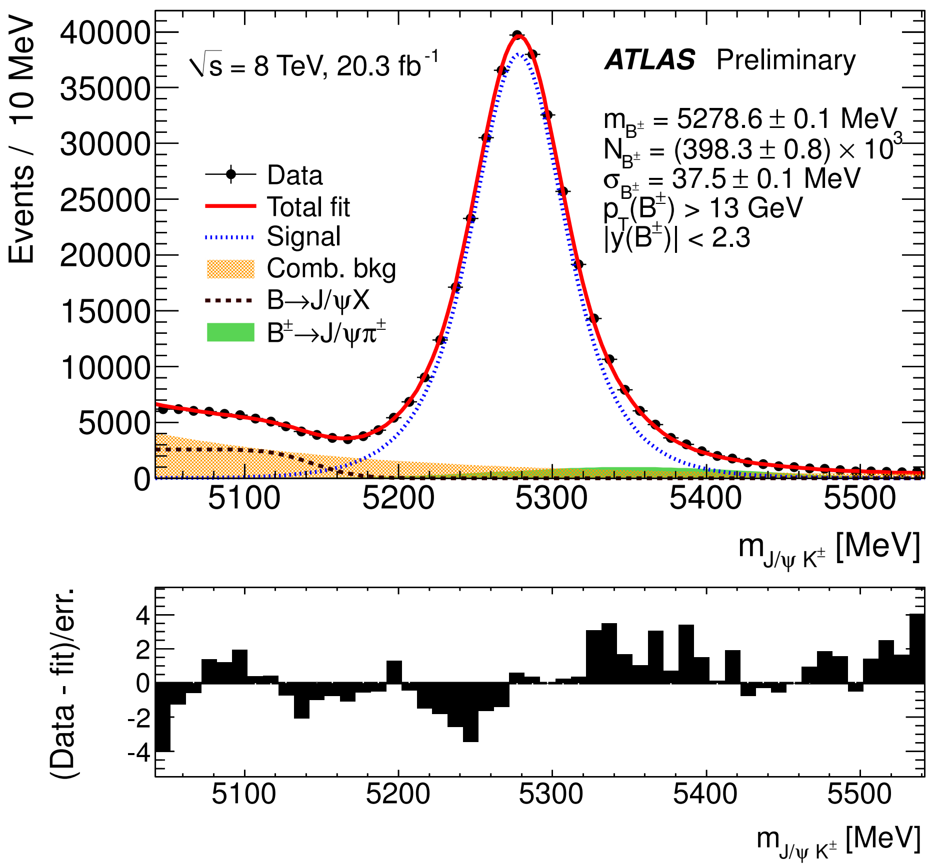
- About to be submitted to ArXiV.
- 20.3 fb^{-1} of 2012 pp collision data @ 8 TeV.
- Motivation:
  - test of QCD predictions;
  - important input for heavy quark production models;
  - first doubly-differential measurement in the central rapidity region;
  - complements CMS and LHCb measurements

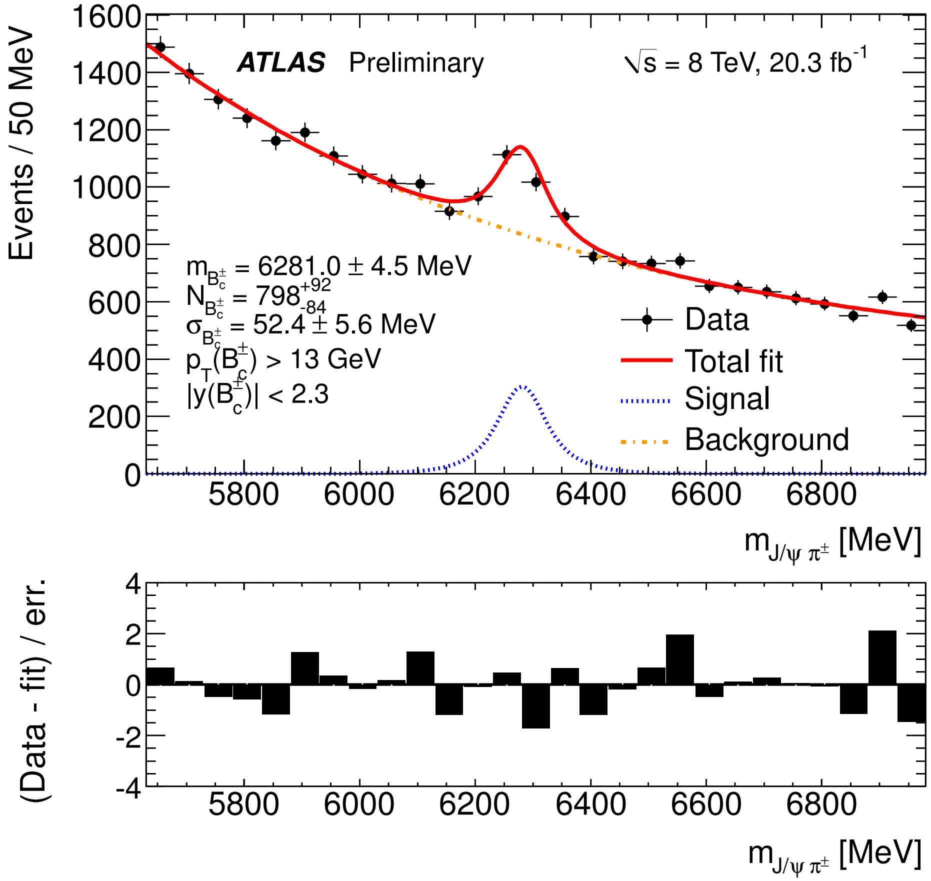
Analysis overview (1)

- Dimuon trigger, $p_T(\mu_1,\mu_2)$>4 GeV, 2.5<m(μμ)<4.3 GeV.
- $B_c \to J/\psi(\mu^+\mu^-)\ \pi^\pm$, $B^\pm \to J/\psi(\mu^+\mu^-)\ K^\pm$.
- J/ψ candidates are formed from oppositely charged muons, $p_T(\mu)$>4 GeV, |η|<2.3, 2.6<m(J/ψ)<3.5. Three invariant mass windows, defined by the ATLAS detector resolution.
- Hadronic tracks: p_T > 2 GeV.
- A cut on the impact parameter significance of the hadronic track (wrt primary vertex) is introduced: $d^0_{xy}/\sigma(d^0_{xy}) > 1.2$.
- B candidates are formed from the 3 tracks: two muonic and one hadronic.
- The χ^2(B vertex)/NDoF < 1.8.

Analysis overview (2)

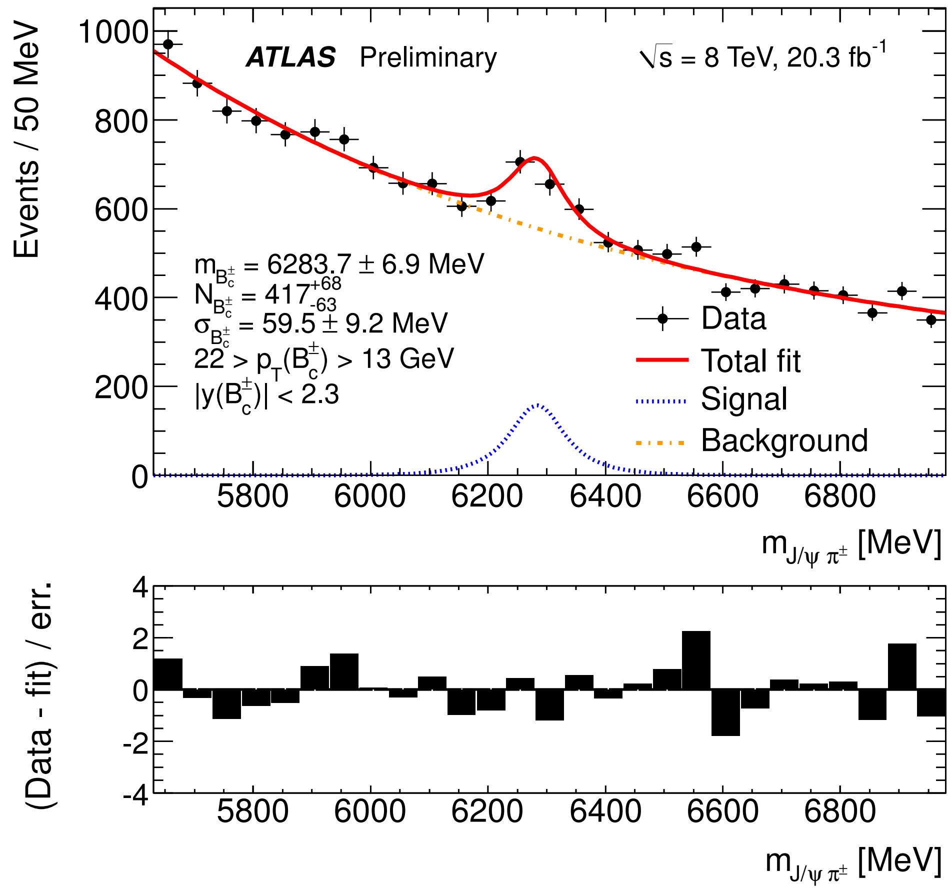
- Extended unbinned maximum likelihood fits to the B invariant mass distributions yield ~400k events for the $B^{\pm}$ and ~800 events for the B_c; $p_T(B)>13$ GeV, $|y|<2.3$.

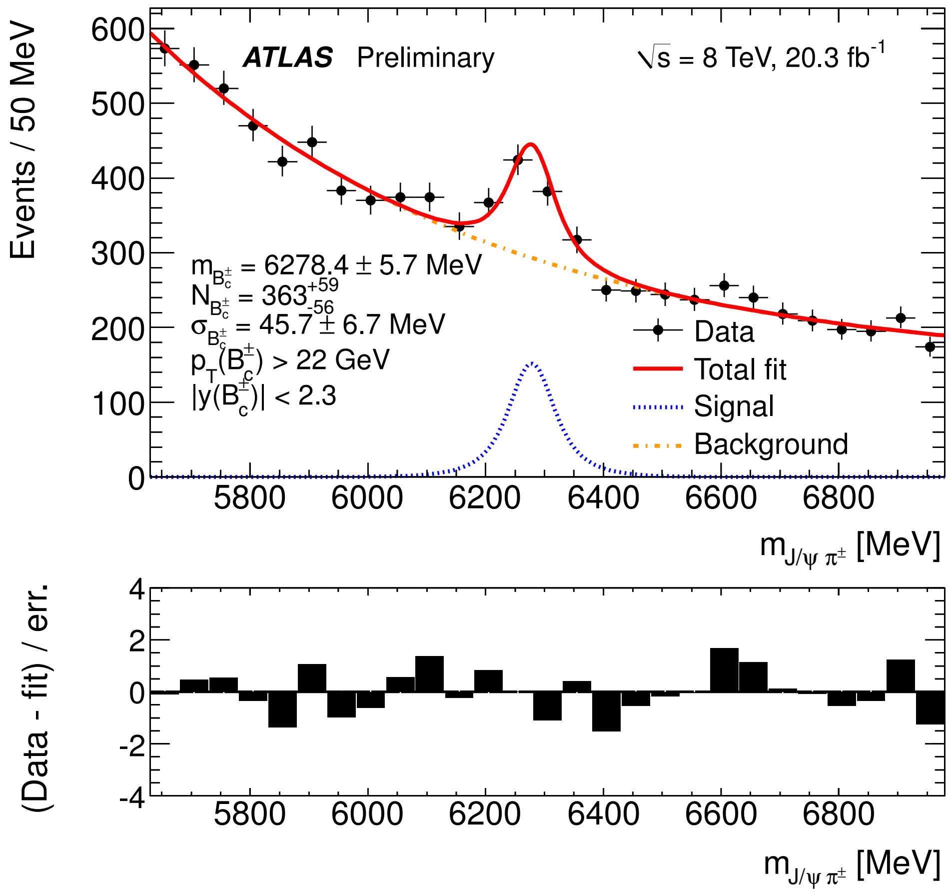




Analysis overview (3)

- In addition to the full bin we define two bins in p_T ([13—22 GeV] and [>22 GeV]) and two bins in rapidity (|y|<0.75 and 0.75<|y|<2.3).
- Bin sizes are selected to equalize the B_c yields.
- Example: fits for two bins in p_T for the $B_{c.}$





Analysis overview (4)

- The relative cross section times branching fraction is given by:

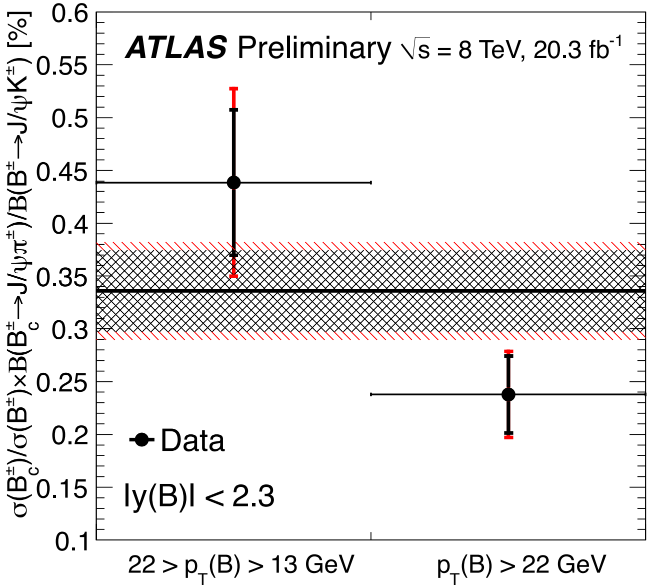
$$\frac{\sigma(B_c^\pm)\cdot BR(B_c^\pm \to J/\psi\pi^\pm)\cdot BR(J/\psi \to \mu^+\mu^-)}{\sigma(B^\pm)\cdot BR(B^\pm \to J/\psi K^\pm)\cdot BR(J/\psi \to \mu^+\mu^-)} = \frac{N^{\mathrm{reco}}(B_c^\pm)}{N^{\mathrm{reco}}(B^\pm)}\cdot\frac{\epsilon(B^\pm)}{\epsilon(B_c^\pm)}$$

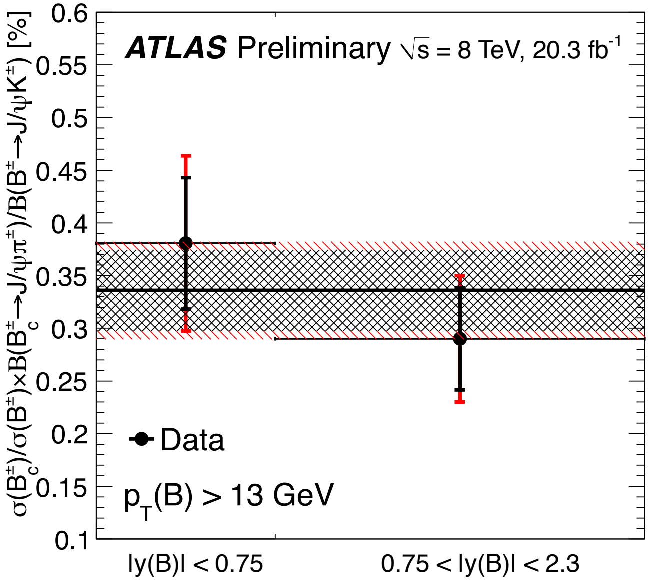
- $N^{reco}(B)$ are obtained from the fits. Overall analysis efficiencies $\varepsilon(B_c)$ and $\varepsilon(B^\pm)$ are obtained from the MC.
- MC is corrected in several ways:
  - sPlot reweighting of the $p_T(B)$ and $y(B)$ distributions;
  - trigger acceptance;
  - distributions of variables used for minimal selections.

Results (1)

- The measurement of the relative cross section times branching fraction is performed in 5 bins:

Analysis bin	$\sigma(B_c^\pm)/\sigma(B^\pm) \times \mathcal{B}(B_c^\pm \to J/\psi\pi^\pm)/\mathcal{B}(B^\pm \to J/\psi K^\pm)$
$p_T(B) > 13$ GeV, $\lvert y(B)\rvert < 2.3$	$(0.34 \pm 0.04_{\text{stat}} \pm 0.02_{\text{syst}} \pm 0.01_{\text{lifetime}})\%$
$22 > p_T(B) > 13$ GeV, $\lvert y(B)\rvert < 2.3$	$(0.44 \pm 0.07_{\text{stat}} \pm 0.04_{\text{syst}} \pm 0.01_{\text{lifetime}})\%$
$p_T(B) > 22$ GeV, $\lvert y(B)\rvert < 2.3$	$(0.24 \pm 0.04_{\text{stat}} \pm 0.01_{\text{syst}} \pm 0.01_{\text{lifetime}})\%$
$p_T(B) > 13$ GeV, $\lvert y(B)\rvert < 0.75$	$(0.38 \pm 0.06_{\text{stat}} \pm 0.04_{\text{syst}} \pm 0.01_{\text{lifetime}})\%$
$p_T(B) > 13$ GeV, $2.3 > \lvert y(B)\rvert > 0.75$	$(0.29 \pm 0.05_{\text{stat}} \pm 0.02_{\text{syst}} \pm 0.01_{\text{lifetime}})\%$





Results (2)

- The measurement precision is limited by the statistical uncertainty on the number of B_c candidates.
- The following systematic uncertainties are considered:
  - fitting procedure (including Cabibbo-suppressed decays contribution);
  - trigger, reconstruction and tracking effects;
  - B_c lifetime uncertainty;
  - MC-related uncertainties (sample size, minimal selection criteria).
- The measurement suggest a dependence on the p_T: the production cross section of the B_c meson decreases faster with p_T than the production cross section of the $B^{\pm}$ meson. No significant dependence on rapidity has been observed.

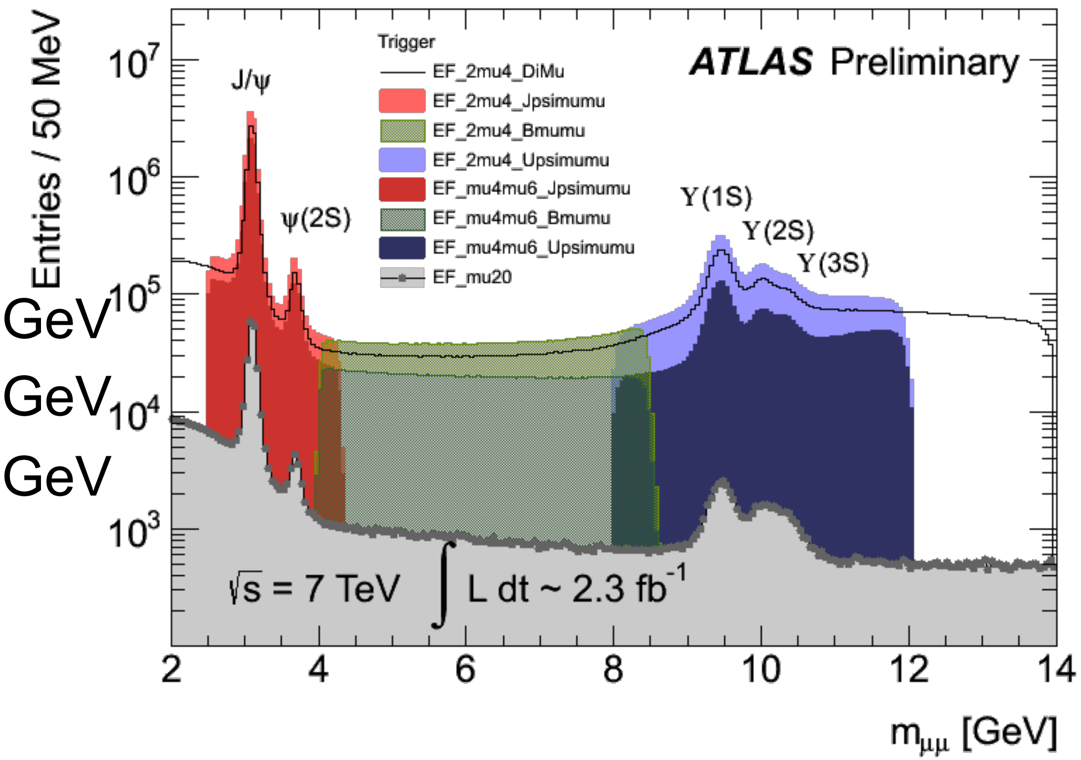
Conclusions

- ATLAS has studied the $B_c/B^{\pm}$ production cross section at 8 TeV.
- First doubly-differential study in the central rapidity region.
- The measurement suggests some p_T dependence.

BACKUP

Trigger and datasets

- B-physics starts with single or di-muon triggers with various thresholds:
  - $p_T(\mu) > 6$ GeV
  - $p_T(\mu) > 18$ GeV
  - $p_T(\mu_1) > 4$ GeV & $p_T(\mu_2) > 4$ GeV
  - $p_T(\mu_1) > 6$ GeV & $p_T(\mu_2) > 4$ GeV
  - $p_T(\mu_1) > 6$ GeV & $p_T(\mu_2) > 6$ GeV



- Di-muon mass range: m(μμ)∈[2.5; 4.3] GeV (final states containing J/ψ) and m(μμ)∈[4.0; 8.5] GeV (B to μ transitions).