

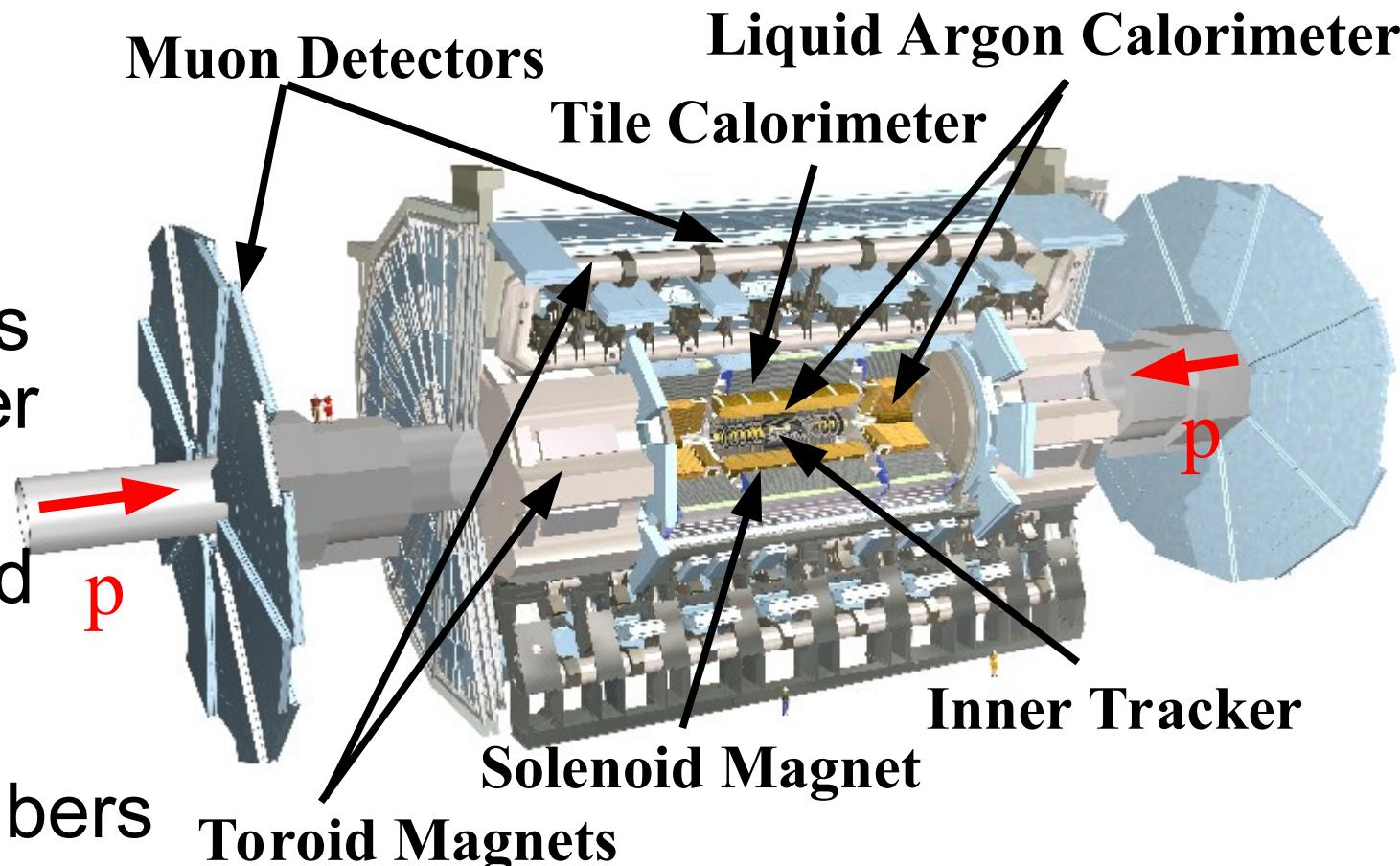
B_c^\pm production and decays in ATLAS

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On behalf of the ATLAS Collaboration

ATLAS: a particle detector at the LHC

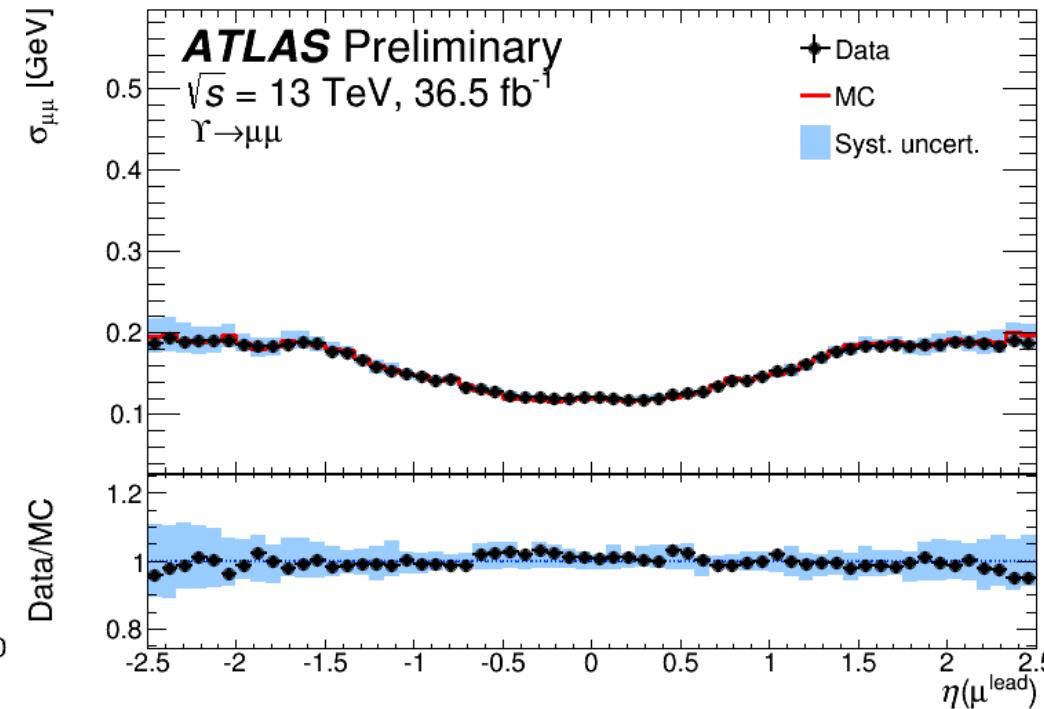
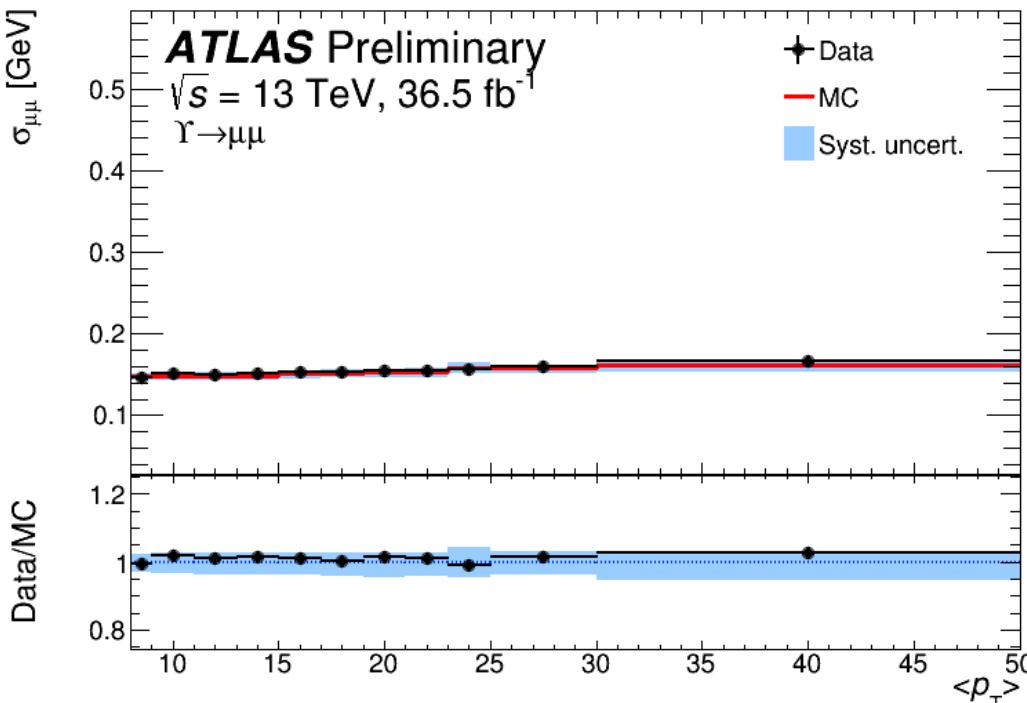
- Inner tracker
 - 2T solenoid
 - $|y| < 2.5$
 - Silicon pixel
 - Silicon strips
 - straw tracker
- Muon system
 - 0.5-2T toroid
 - $|y| < 2.7$
 - Precision & trigger chambers



- $\frac{\sigma}{Pt} / Pt \sim 0.05\% Pt[\text{GeV}] \oplus 1.5\%$
 - $\sim 10 \mu\text{m}$ impact parameter resolution

ATLAS: a particle detector at the LHC

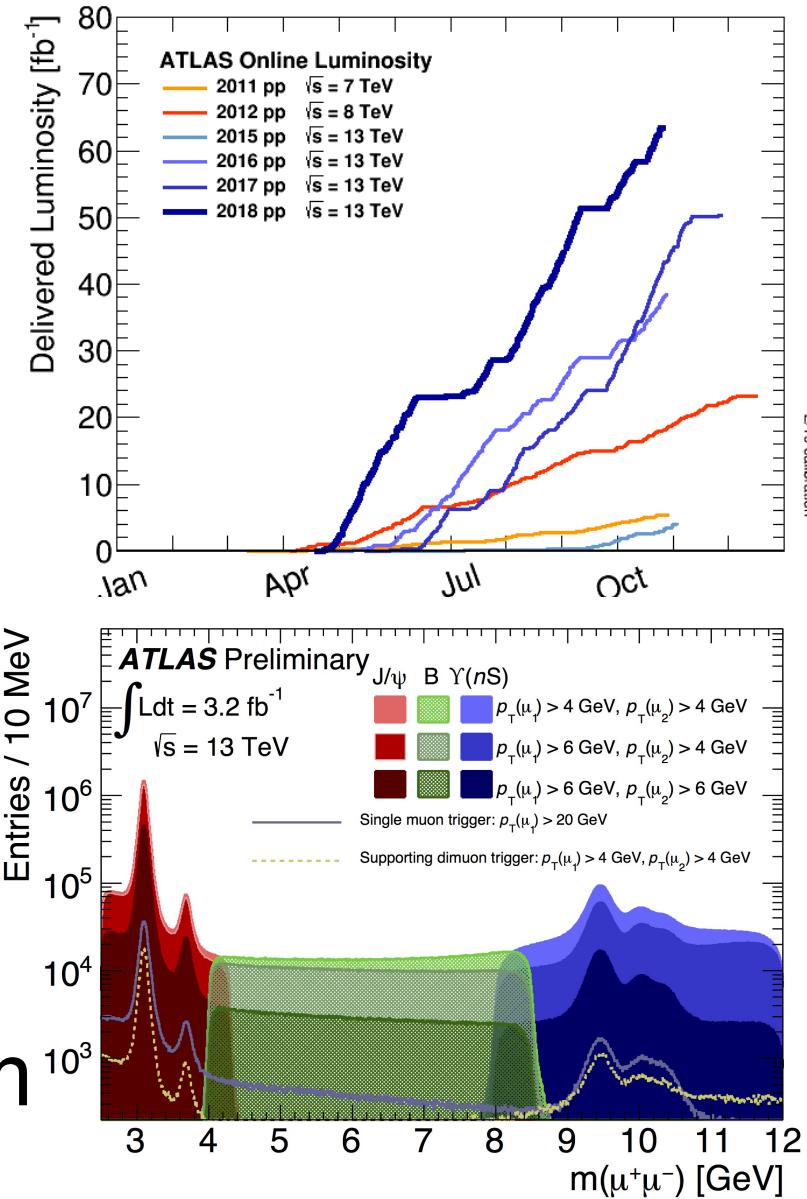
Muon momentum resolution



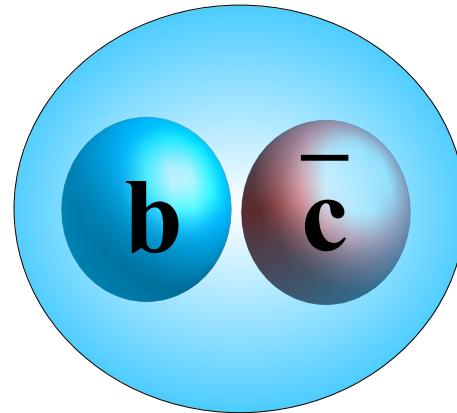
- $\frac{\sigma}{p_T} / \text{Pt} \sim 0.05\% \text{ Pt}[\text{GeV}] \oplus 1.5\%$
- $\sim 10 \mu\text{m}$ impact parameter resolution

LHC performance

- Excellent LHC performance
- Collected
 - 5.02 TeV : 25 pb^{-1}
 - 7 TeV : 4.9 fb^{-1}
 - 8 TeV : 20.3 fb^{-1}
 - 13 TeV : 139 fb^{-1}
- B-physics relies largely on (di-) muon triggers
- Bc analysis: 8 TeV: 20.3 fb^{-1}
- Broad ATLAS flavour program



A meson of charm & beauty



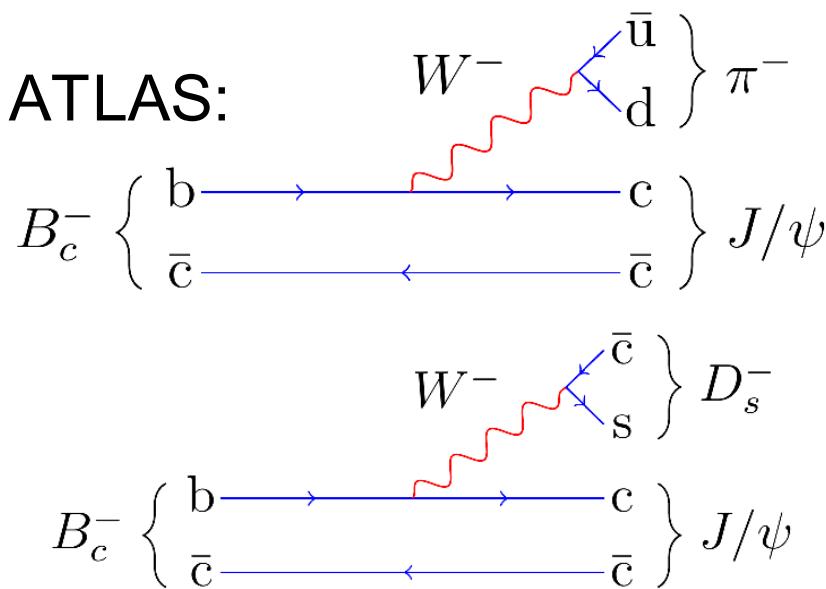
Double Heavy meson

Decay modes investigated by ATLAS:

$$B_c^\pm \rightarrow J/\psi \pi^\pm$$

$$B_c^\pm \rightarrow J/\psi D_s^{\pm (*)}$$

Eur. Phys. J. C. 76 (2016) 1





Relative B_c^\pm/B^\pm production

- Measured in 20 fb^{-1} of 8 TeV pp collision data
- Utilize similar decay mode for B_c^\pm and B^\pm :

$$B_c^\pm \rightarrow J/\psi \pi^\pm \rightarrow (\mu^+ \mu^-) \pi^\pm, \quad B^\pm \rightarrow J/\psi K^\pm \rightarrow (\mu^+ \mu^-) K^\pm$$

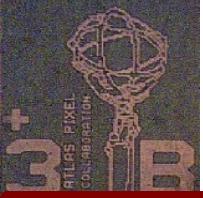
$$\frac{\sigma(B_c^\pm) \cdot \mathcal{B}(B_c^\pm \rightarrow J/\psi \pi^\pm) \cdot \mathcal{B}(J/\psi \rightarrow \mu^+ \mu^-)}{\sigma(B^\pm) \cdot \mathcal{B}(B^\pm \rightarrow J/\psi K^\pm) \cdot \mathcal{B}(J/\psi \rightarrow \mu^+ \mu^-)} = \frac{N^{\text{reco}}(B_c^\pm)}{N^{\text{reco}}(B^\pm)} \cdot \frac{\epsilon(B^\pm)}{\epsilon(B_c^\pm)}.$$

- Correct for efficiency differences:

$$\epsilon = \epsilon^{\text{trigger}} \cdot \epsilon^{\text{MS}}(\mu^+) \cdot \epsilon^{\text{MS}}(\mu^-) \cdot \left(\epsilon^{\text{ID}}(\mu^\pm) \right)^2 \cdot \epsilon^{\text{ID}}(X_h) \cdot \epsilon^{\text{vertex}}(B) \cdot \epsilon^{\text{selection}}(B),$$

- Extract yield, via unbinned log likelihood fit

$$\mathcal{L} = \frac{e^{-N_{\text{sig}} - N_{\text{bkg}}}}{N!} \prod_{i=1}^N \left[N_{\text{sig}} \mathcal{F}_{\text{signal}}(m_{J/\psi X_h}^i, \delta m_{J/\psi X_h}^i) + N_{\text{bkg}} \mathcal{F}_{\text{bkg}}(m_{J/\psi X_h}^i) \right]$$



Event selection

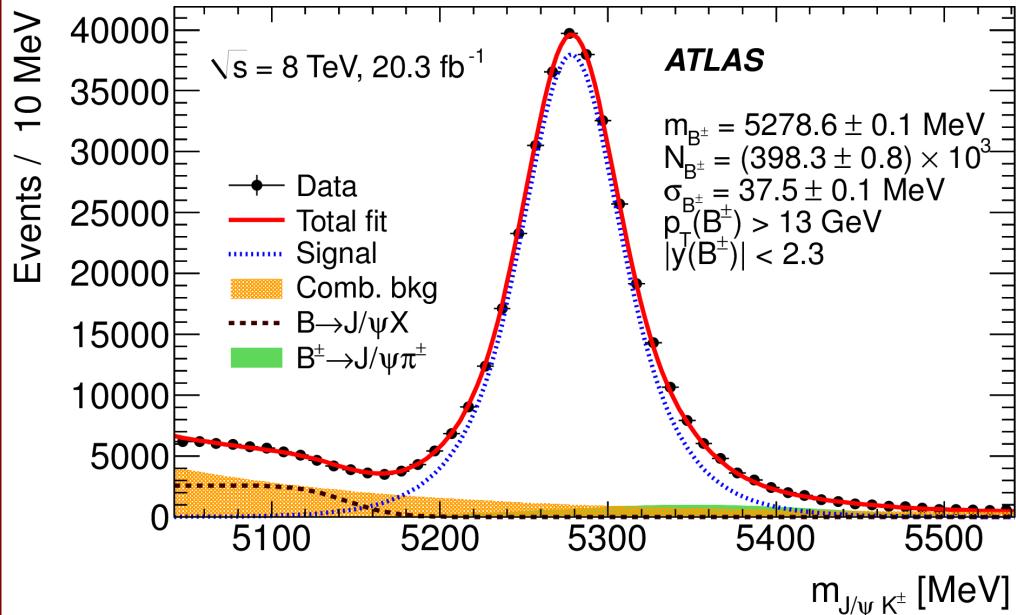
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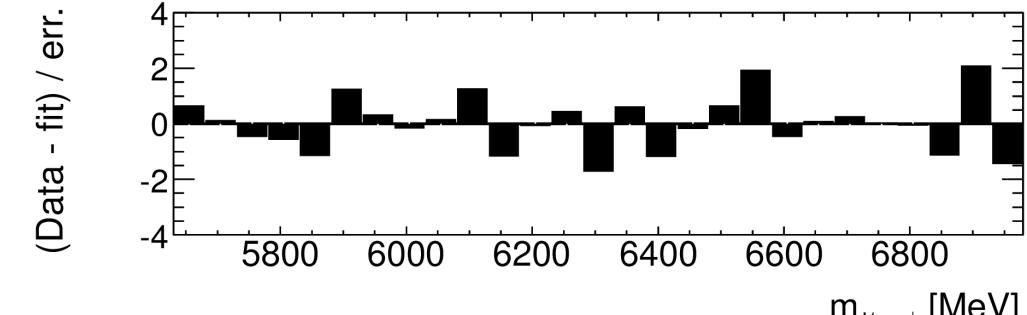
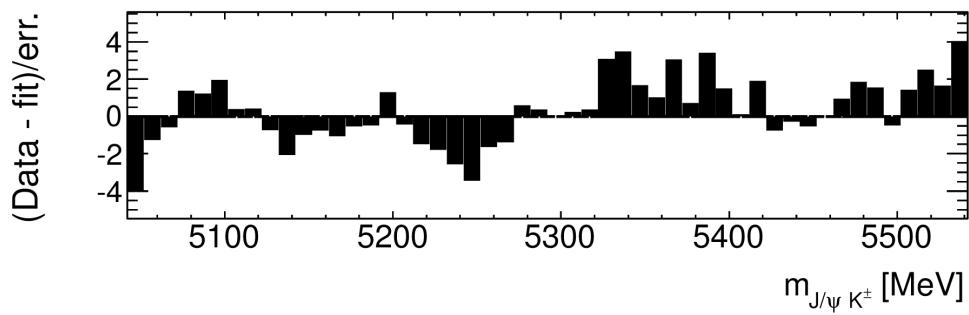
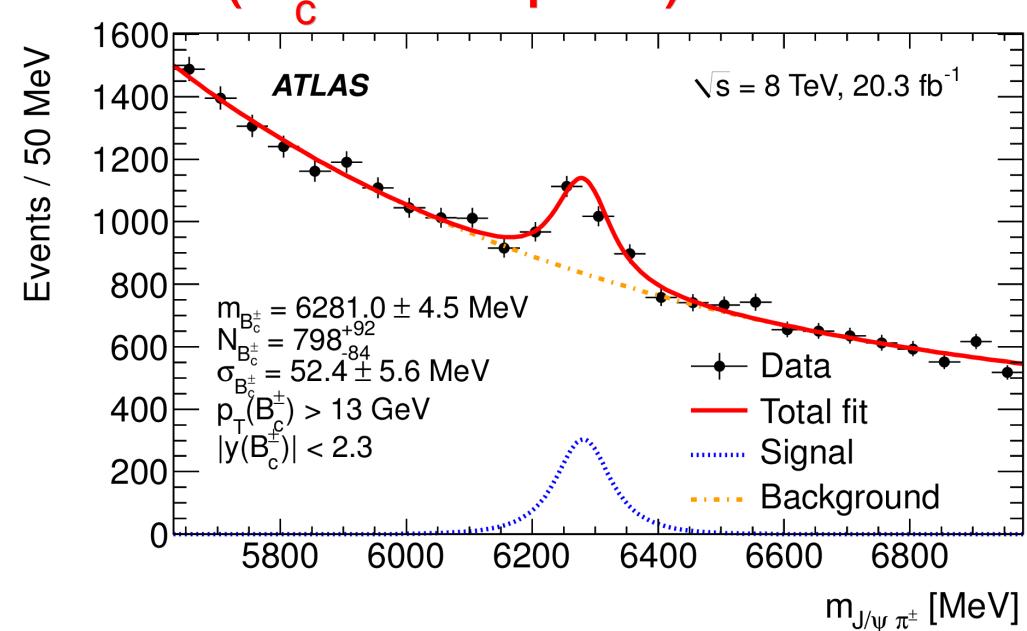
- Candidates formed from 3 tracks
- Rely on dimuon trigger:
 $p_T(\mu 1, \mu 2) > 4 \text{ GeV}$ and $2.5 < m(\mu\mu) < 4.3 \text{ GeV}$
- Select offline muons with opposite charge:
 $| \eta | < 2.3$ and $2.6 < m(J/\psi) < 3.5 \text{ GeV}$
- Hadronic (π , K) track:
 - Track momentum: $p_T > 2 \text{ GeV}$
 - Transverse impact parameter significance : $d0/\sigma(d0) > 1.2$
- Cut on three track vertex $\chi^2/\text{NDoF} < 1.8$
- Momentum of B meson candidate: $p_T > 13 \text{ GeV}$

B^\pm and B_c^\pm total dataset

$N(B^\pm \rightarrow J/\psi K^\pm) : \sim 398000$



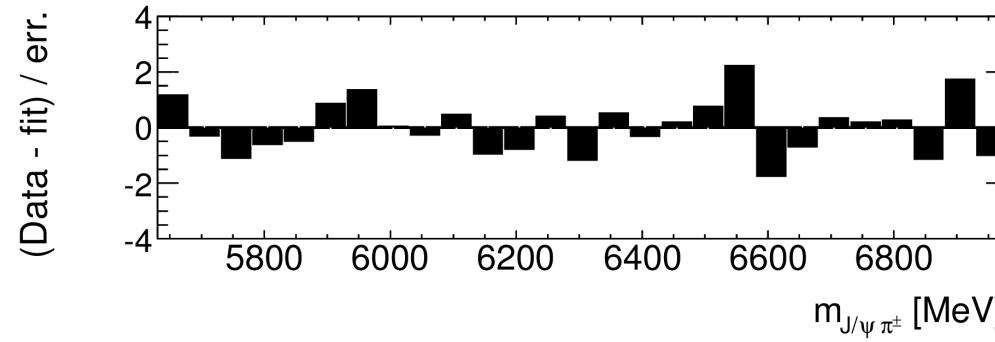
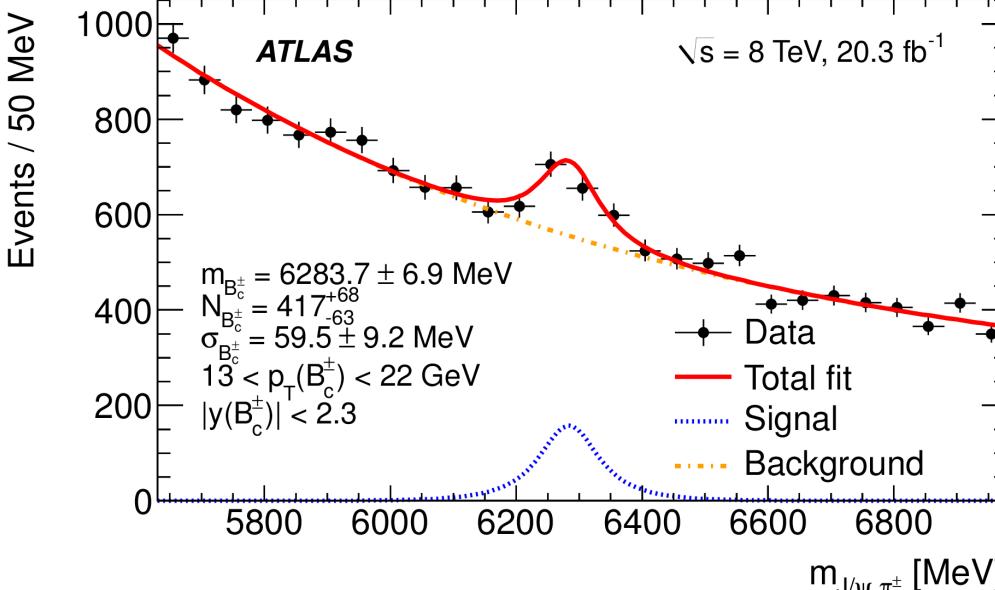
$N(B_c^\pm \rightarrow J/\psi \pi^\pm) : \sim 800$



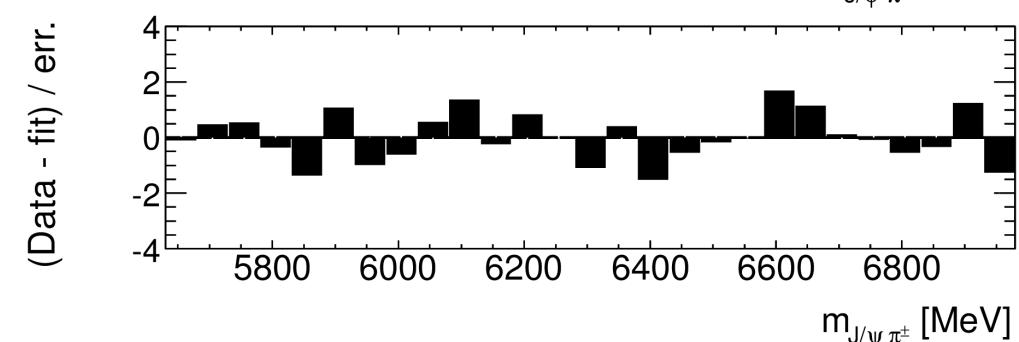
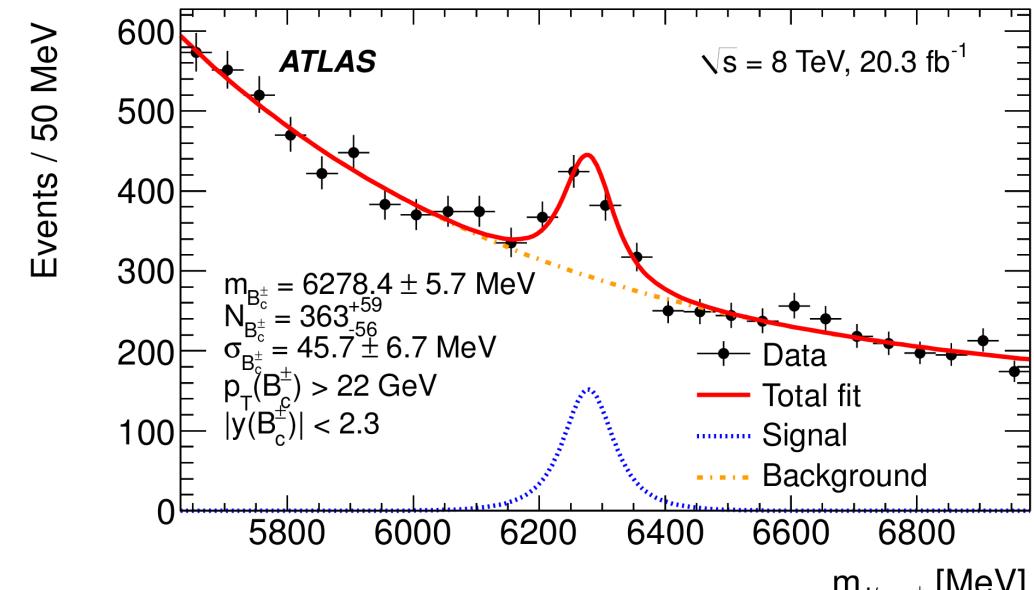
arXiv:1912.02672, Submitted to PRD

$B_c^\pm : 2 p_T$ bins

$13 \text{ GeV} < p_T(B_c^\pm) < 22 \text{ GeV}$

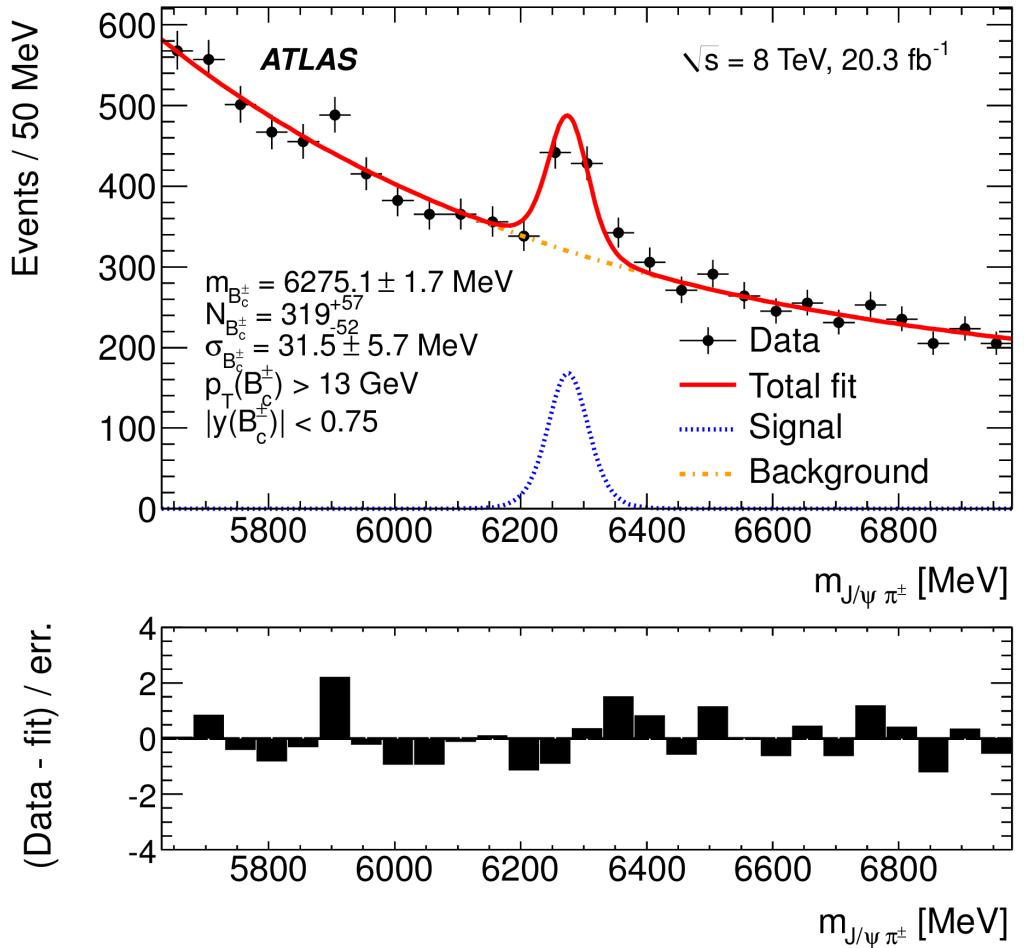


$p_T(B_c^\pm) > 22 \text{ GeV}$

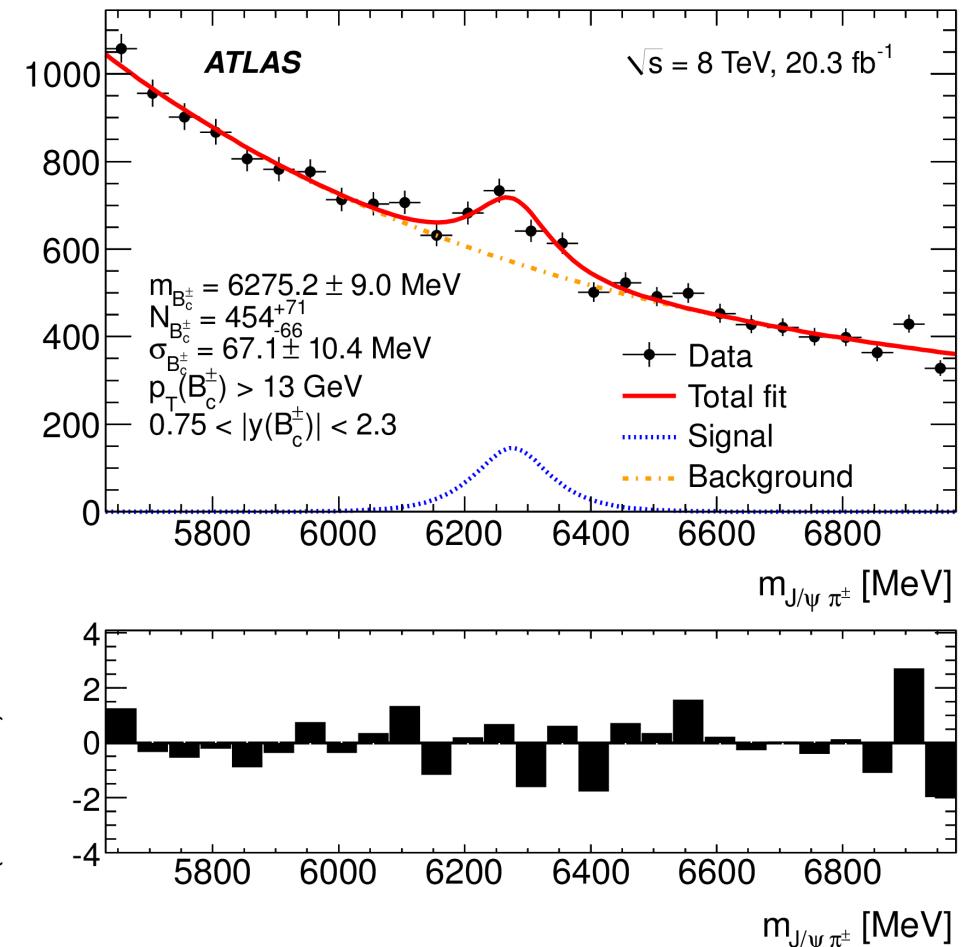


B_c^\pm : 2 rapidity bins

$|y(B_c^\pm)| < 0.75$

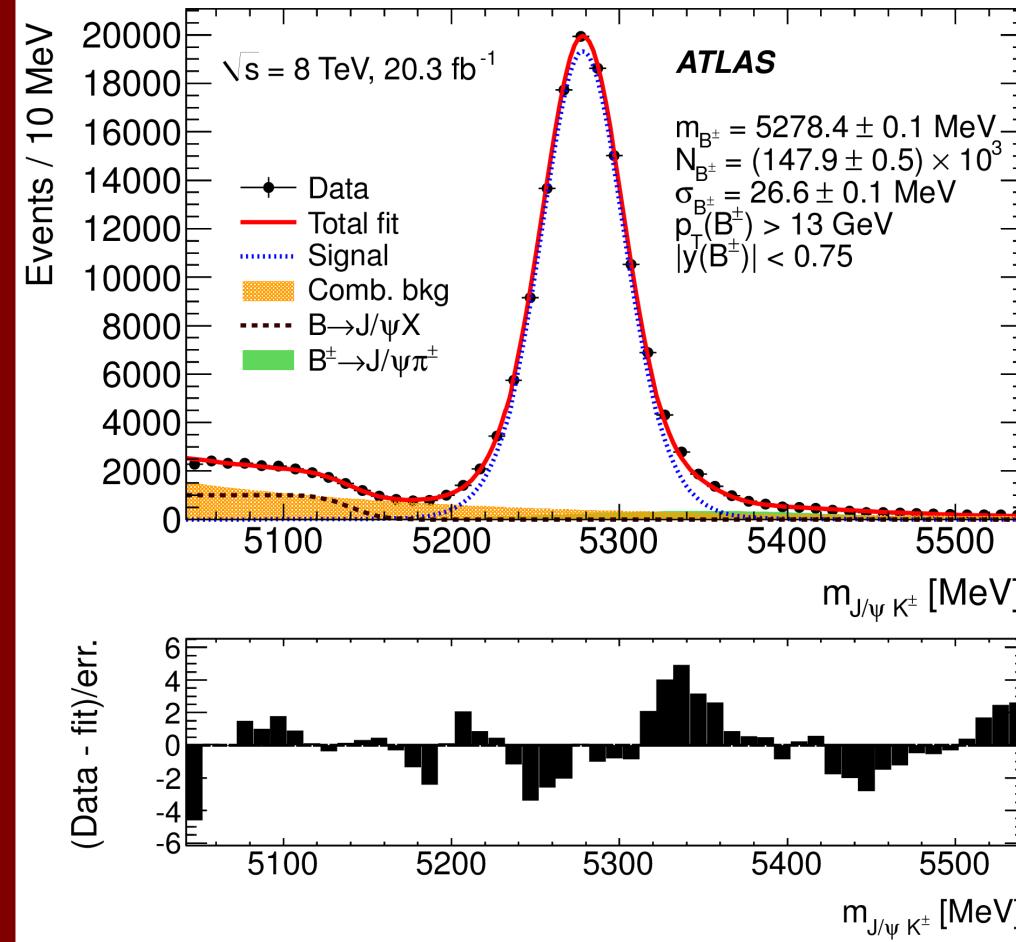


$0.75 < |y(B_c^\pm)| < 2.3$

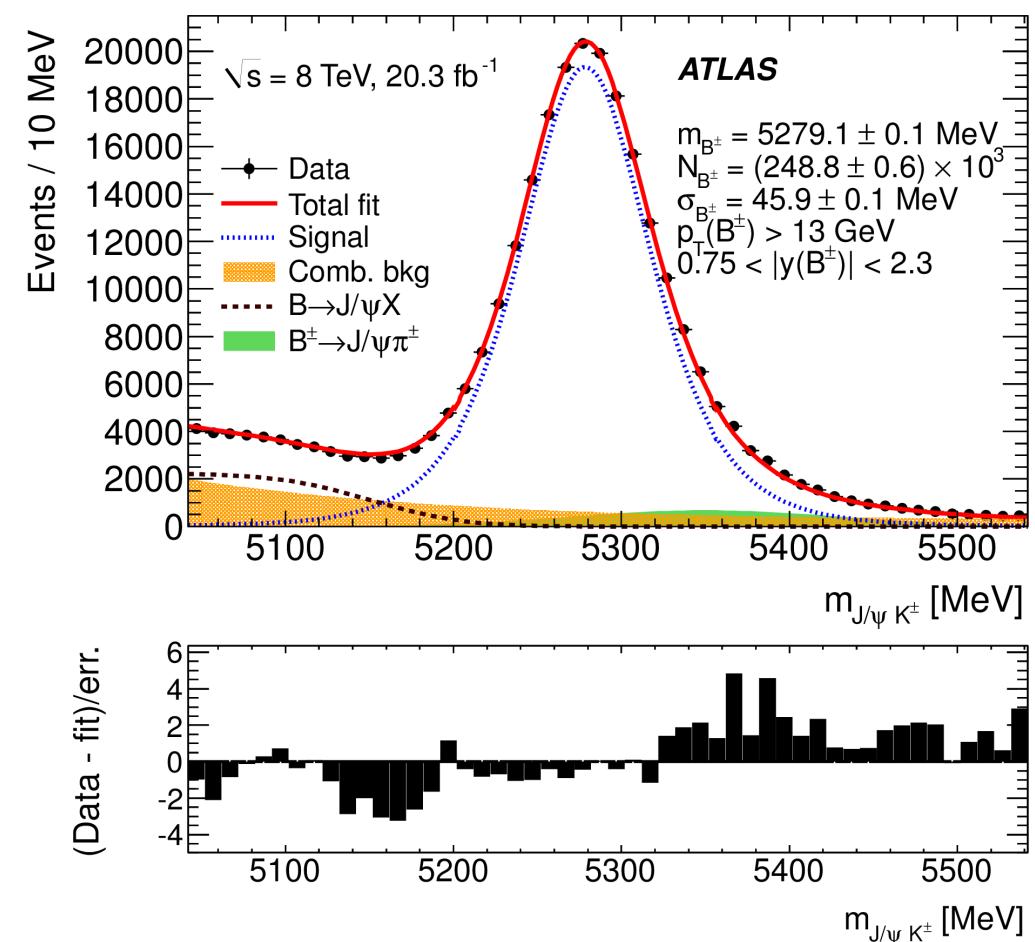


B^\pm : 2 rapidity bins

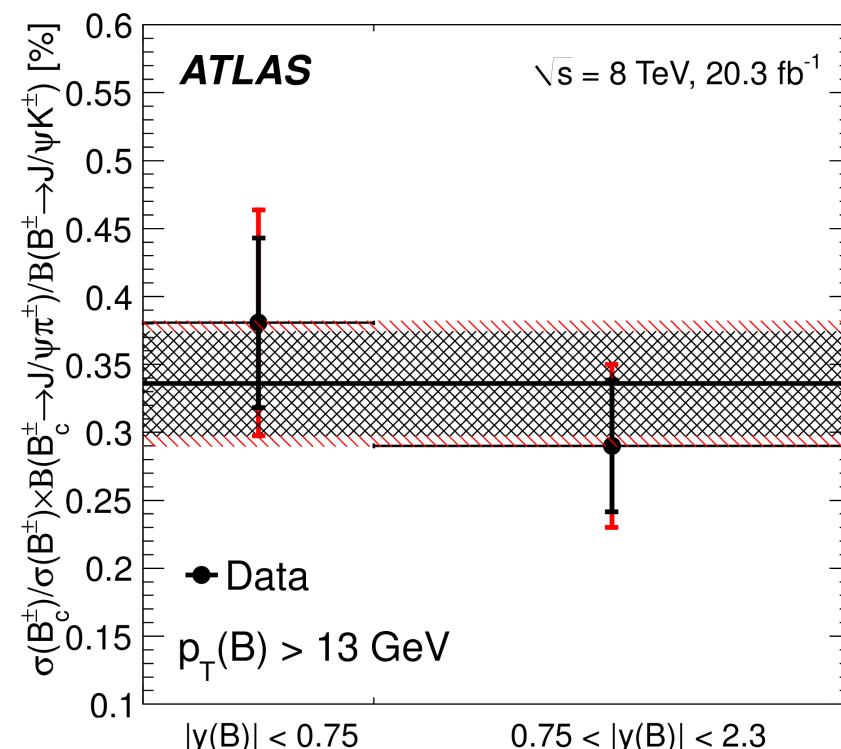
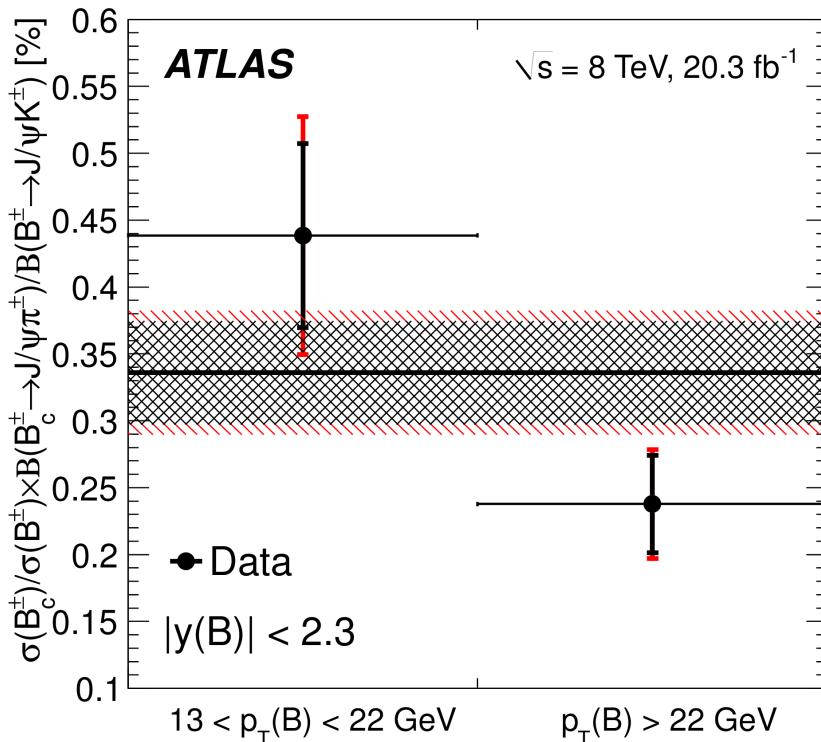
$|y(B^\pm)| < 0.75$



$0.75 < |y(B^\pm)| < 2.3$

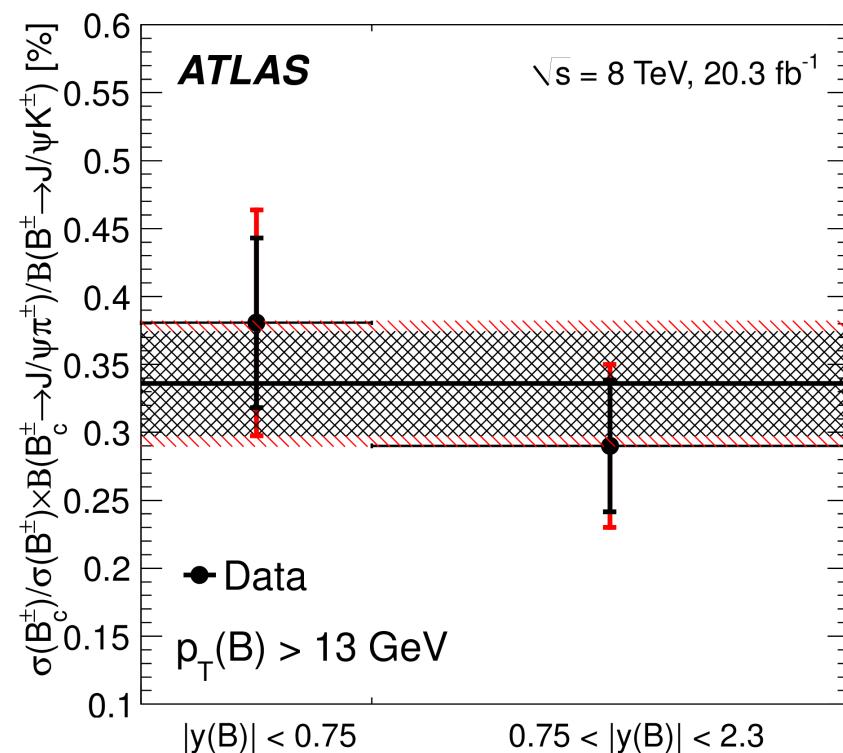
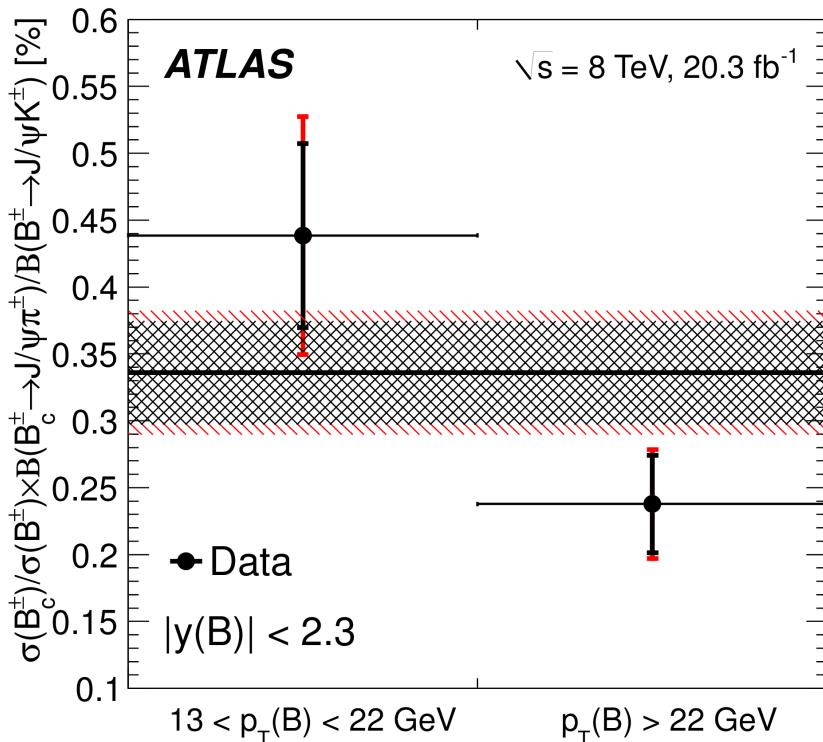


Results



Source of uncertainty	Uncertainty value	
	B_c^\pm	B^\pm
Signal model of the fit	2.4%	0.1%
Cabibbo-suppressed decay modeling	2.4%	0.5%
Background model of the fit	2.9%	0.1%
Trigger effects and reconstruction effects	0.9%	0.9%
B -meson lifetime uncertainty	0.7%	< 0.1%

Results



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

Summary and Conclusion

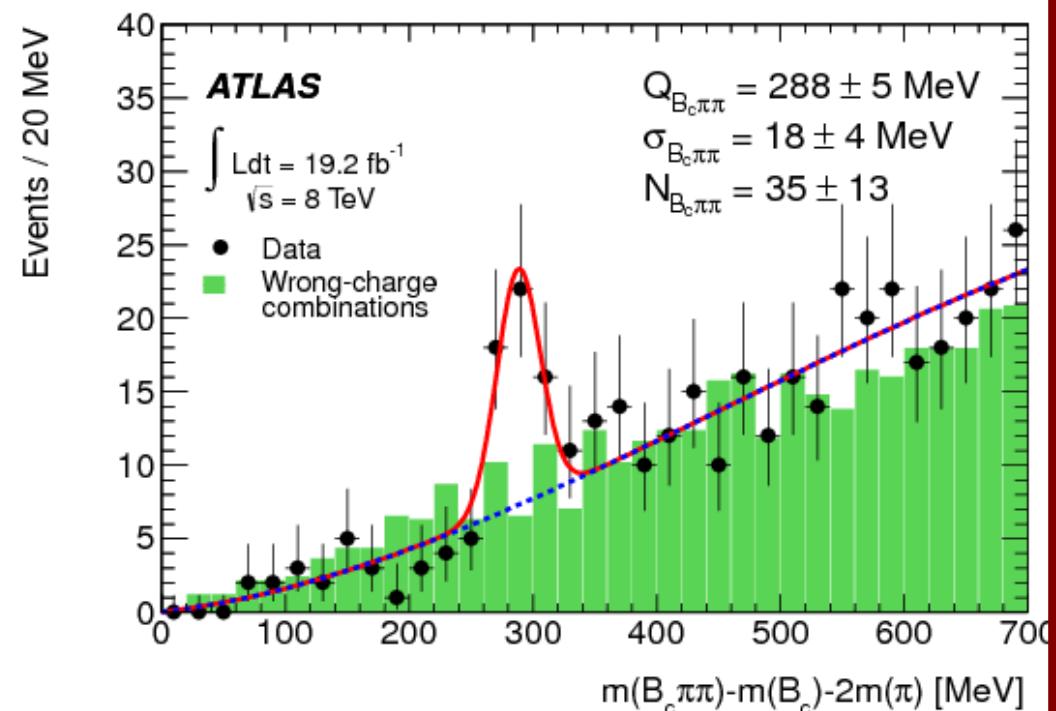
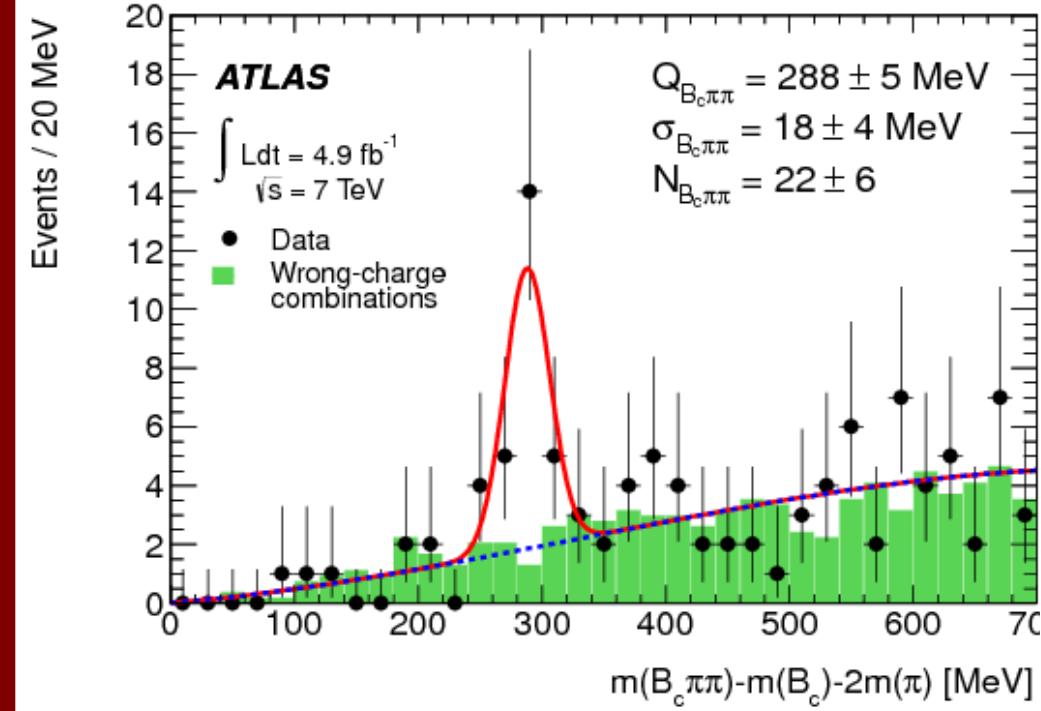
- Measured relative production of B_c^\pm/B^\pm
 - ATLAS 8 TeV: $(0.34 \pm 0.04_{\text{stat}} \pm 0.02_{\text{sys}} \pm 0.01_{\text{lifetime}}) \%$
 $(|y| < 2.3, 13 \text{ GeV} < p_T(B_c^\pm))$
 - LHCb 8 TeV: $(0.683 \pm 0.018_{\text{stat}} \pm 0.009_{\text{syst}}) \%$
 $(2.0 < y < 4.5, 0 < p_T(B_c^\pm) < 20 \text{ GeV})$
 - CMS 7 TeV: $(0.48 \pm 0.05_{\text{stat}} \pm 0.03_{\text{sys}} \pm 0.05_{\text{lifetime}}) \%$
 $(|y| < 1.6, 15 \text{ GeV} < p_T(B_c^\pm))$

Summary and Conclusion

- ATLAS has an active B-physics program
 - Measured relative production of B_c^\pm/B^\pm
 - In differential bins of p_T and rapidity
 - No rapidity dependence
 - Limited p_T dependence, decrease with p_T
 - Excited B_c^\pm States under further investigation
 - Watch this space!

Bonus Slides

Excited Bc



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