

Measurement of the branching fraction ratio

$$\mathcal{B}(B_c^+ \rightarrow \psi(2S)\pi^+) / \mathcal{B}(B_c^+ \rightarrow J/\psi\pi^+)$$

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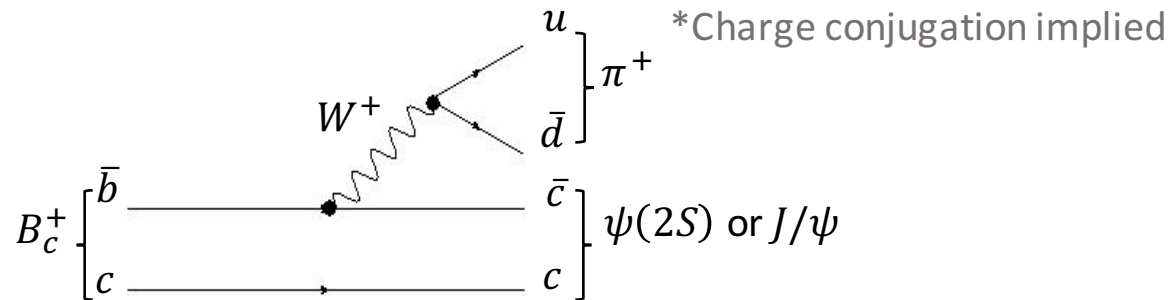
On behalf of the LHCb collaboration

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Introduction

- ✓ B_c : unique meson family consisting of **two different heavy** flavor quarks, charm and beauty.
 - ❖ Rich set of decay modes
 - ❖ Less explored limited by statistics
 - ❖ Improve understanding of QCD

✓ $B_c^+ \rightarrow \psi(2S)\pi^+$:



- ❖ First observed using 2011 LHCb data
 - Result dominated by **statistical uncertainty**

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- ❖ $R_B \equiv \mathcal{B}(B_c^+ \rightarrow \psi(2S)\pi^+)/\mathcal{B}(B_c^+ \rightarrow J/\psi\pi^+)$ measured using 3 fb^{-1} RUN-I data
 - Statistical uncertainty reduced
 - Analysis method improved

Analysis strategy

$$R_B \equiv \frac{\mathcal{B}(B_c^+ \rightarrow \psi(2S)\pi^+, \psi(2S) \rightarrow \mu^+\mu^-)}{\mathcal{B}(B_c^+ \rightarrow J/\psi\pi^+, J/\psi \rightarrow \mu^+\mu^-)} \times \frac{\mathcal{B}(J/\psi \rightarrow \mu^+\mu^-)}{\mathcal{B}(\psi(2S) \rightarrow \mu^+\mu^-)} \text{ Known!}$$

$$\frac{N(B_c^+ \rightarrow \psi(2S)\pi^+, \psi(2S) \rightarrow \mu^+\mu^-)}{N(B_c^+ \rightarrow J/\psi\pi^+, J/\psi \rightarrow \mu^+\mu^-)} \times \frac{\epsilon(B_c^+ \rightarrow J/\psi\pi^+, J/\psi \rightarrow \mu^+\mu^-)}{\epsilon(B_c^+ \rightarrow \psi(2S)\pi^+, \psi(2S) \rightarrow \mu^+\mu^-)}$$

$B_c^+ \rightarrow \psi(2S)\pi^+$ or $B_c^+ \rightarrow J/\psi\pi^+$ candidate selection:

✓ Trigger

- ❖ Muon track with high p_T and of good quality
- ❖ Invariant mass of muon pair $> 2.95 \text{ GeV}/c^2$

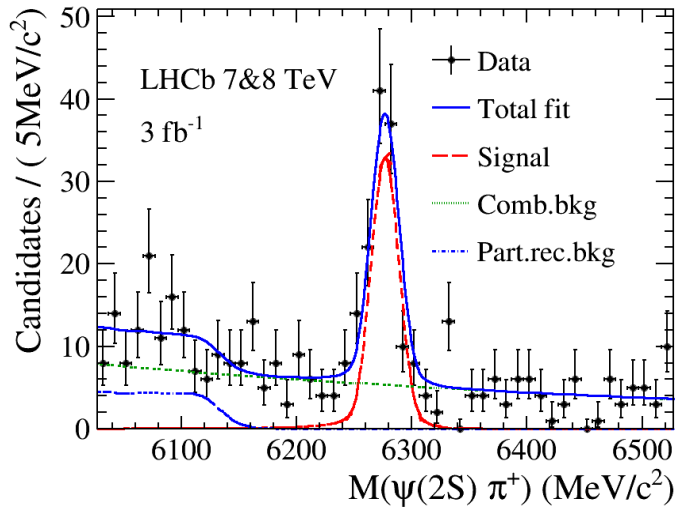
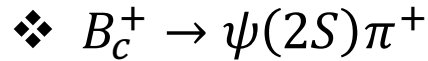
✓ Loose preselection

✓ Boosted decision tree selection

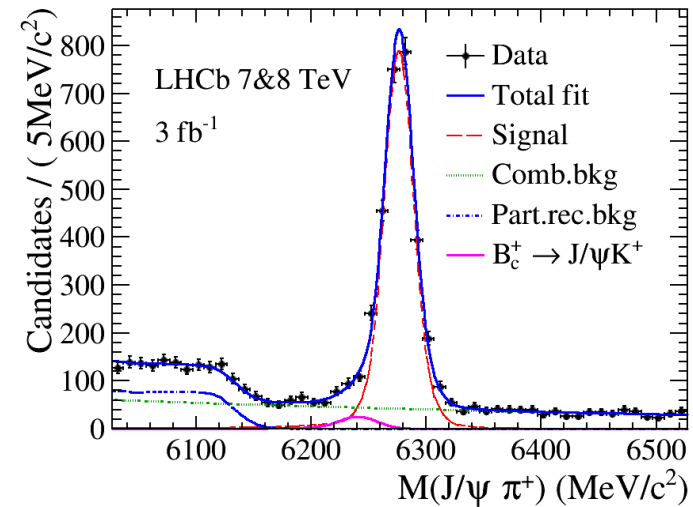
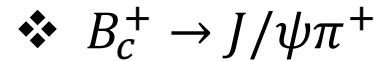
- ❖ Input variables: B_c^+ and π^+ kinematic properties; B_c^+ decay length; B_c^+ vertex quality; B_c^+ and π^+ impact parameters.
- ❖ Input variables and BDT output distributions similar for $B_c^+ \rightarrow \psi(2S)\pi^+$ and $B_c^+ \rightarrow J/\psi\pi^+$
- ❖ Threshold cut chosen to maximize $B_c^+ \rightarrow \psi(2S)\pi^+$ significance
> 99% background rejected

Signal yields and efficiencies

- ✓ Signal yields extracted from unbinned maximum likelihood fits to the invariant mass distributions of $\psi(2S)\pi^+$ or $J/\psi\pi^+$



Yield: 105 ± 12



Yield: 2745 ± 61

- ✓ π^\pm PID efficiency calibrated using pions from $D^{*+} \rightarrow D^0(\rightarrow K^-\pi^+)\pi^+$ decays
- ✓ Other efficiencies determined using simulated samples
- ✓ Most of the efficiencies cancelled due to the same final states

Systematic uncertainties

Component	Uncertainty
Signal shape	0.6%
Background shape	2.4%
BDT classifier	0.2%
Monte-Carlo statistics	0.3%
Trigger efficiency	1.1%
B_c^+ lifetime	0.1%
Total	2.7%

- ✓ Background shape: **reducing fit range** to exclude contribution from partially reconstructed background; vary the parameters of background model
- ✓ Trigger efficiency: determined using **data driven** methods

LHCb-PUB-2011-016; Eur. Phys. J. C72 (2012) 2118

Results

➤ $R_B = 0.268 \pm 0.032(\text{stat}) \pm 0.007(\text{syst}) \pm 0.006(\text{BF})$

BF: uncertainty on $\mathcal{B}(J/\psi \rightarrow \mu^+ \mu^-) / \mathcal{B}(\psi(2S) \rightarrow \mu^+ \mu^-)$

- ✓ Consistent with previous measurement and uncertainty significantly reduced owing to increased sample size and improved analysis method
 - ❖ 2011 result:
 - $R_B = 0.250 \pm 0.068(\text{stat}) \pm 0.014(\text{syst}) \pm 0.006(\text{BF})$

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- ✓ Consistent with theoretical predictions (0.07 – 0.29), especially
 - ❖ Non-relativistic QCD at next-to-leading order: $0.26^{+0.05}_{-0.06}$
 - ❖ Perturbative QCD based on k_T factorization: $0.29^{+0.17}_{-0.11}$

Phys. Rev. D89 (2014) 034008

Eur. Phys. J. C (2015) 75:293

Thank you!