Study of B_c^+ physics at LHCb

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第29届 LHC Mini-Workshop
2024年12月13-16日 福州
福州大学

Outline

- **Introduction**

- **Recent results of B_c^+ study**
  - b quark decays
  - c quark decays

- **Summary and outlook**
  - Search for annihilation decays and CPV

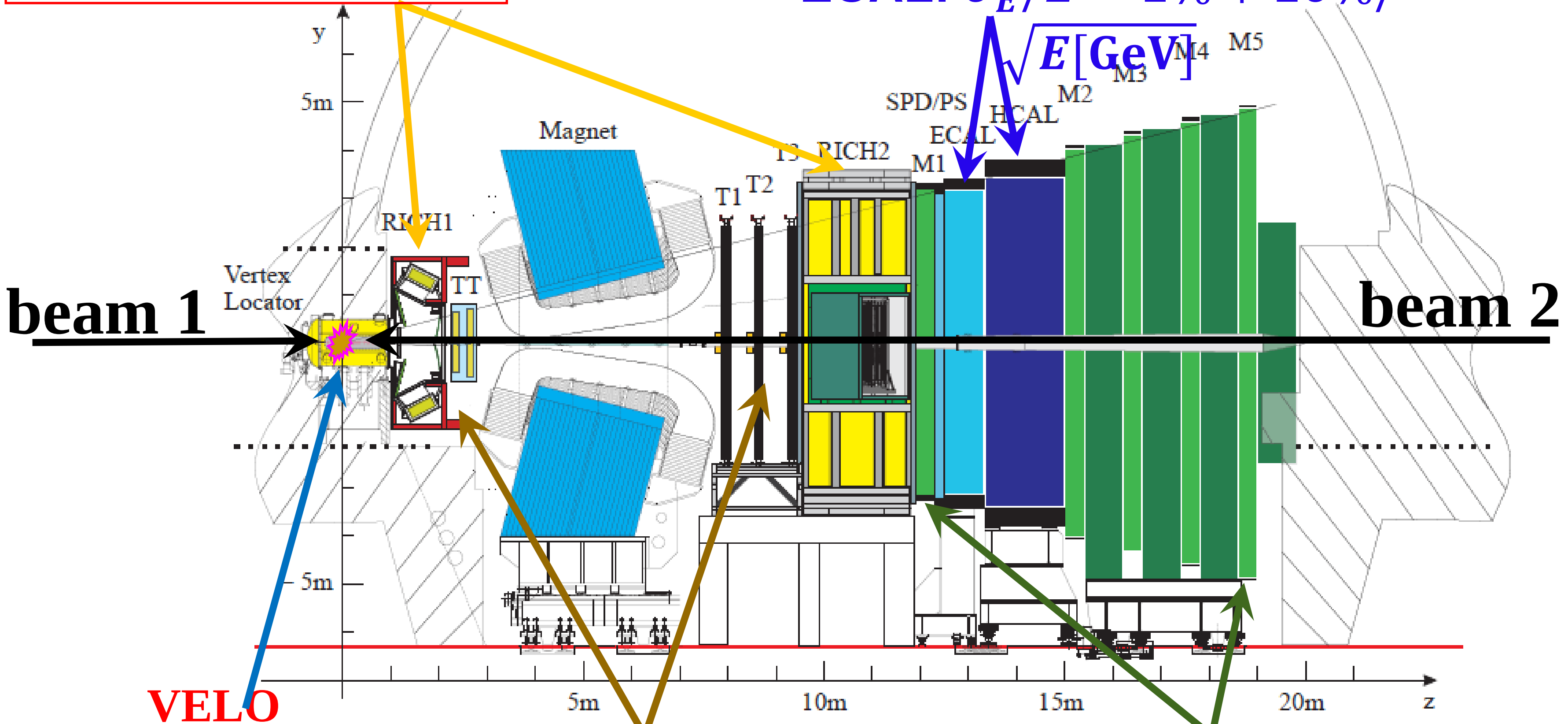
LHCb detector

JINST 3 (2008) S08005
IJMPA 30 (2015) 1530022

Pseudorapidity acceptance
$2 < \eta < 5$

RICH1 & RICH2
$\epsilon(K \to K) \sim 95\%$
$\pi \to K$ mis-id: $\sim 5\%$

Calorimeters
ECAL: $\sigma_E/E \sim 1\% + 10\%/\sqrt{E[\mathrm{GeV}]}$



VELO
$\sigma_{IP} \sim 20\ \mu m$
Decay time resolution:
45 fs (τ)~1.5 p

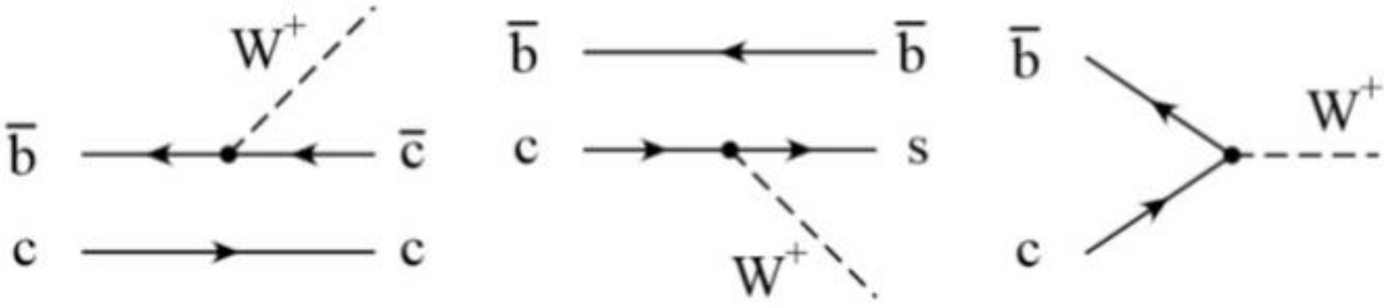
Tracking System
$\Delta p/p = 0.5\%@5\ \mathrm{GeV}/c$
to $1\%@200\ \mathrm{GeV}/c$

Muon System
$\epsilon(\mu \to \mu) \sim 97\%$
$\pi \to \mu$ mis-id: $1 \sim 3\%$

B_c^+ physics

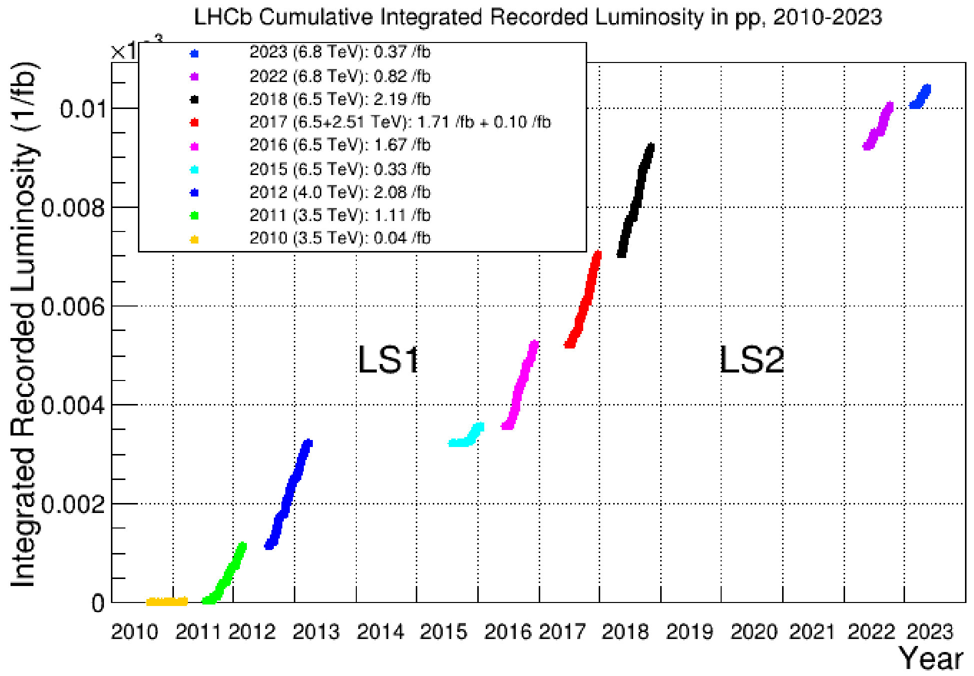
- **Unique state that contains two heavy quarks of different flavors**
  - Only decay through weak interaction

- **Rich decay modes**
  - b quark decay ~20%
  - c quark decay ~70%
  - Annihilation decay ~10%



- **Precise measurements of mass, lifetime, branching fractions can provide information to test theoretical models**

LHCb data samples



- **Luminosity levelling $L \sim 3 \times 10^{32}\ \mathrm{cm}^{-2}\mathrm{s}^{-1}$**
- **Run-I: 3 fb^{-1}, Run-II: 6 fb^{-1}, Run-III: 14 fb^{-1}**
- **All b hadrons: $B^0, B^{\pm}, B_s^0, B_c^{\pm}$ …**

LHCb: $\sigma(pp \to B_c^+)_{\mathrm{incl}} \approx 0.3\ \mu\mathrm{b}$

	B^0	B^+	B_s^0	b baryons (Λ_b …)	B_c^+
Fraction(%)	40	40	10	10	0.1
Component	$\bar{b}d$	$\bar{b}u$	$\bar{b}s$	bqq	$\bar{b}c$

PRD 85.032008

B_c^+ studies at LHCb

Mass	$M(B_c^+ \to J/\psi\pi^+)$	$M(B_c^+ \to J/\psi\pi^+\pi^-\pi^+)$
	$M(B_c^+ \to J/\psi D_s^+)$	$M(B_c^+ \to J/\psi D^{(*)} K^{(*)})$
	$M(B_c^+ \to J/\psi p\bar{p}\pi^+)$	$M(B_c^+ \to B_s^0\pi^+)$
Production	$\frac{\sigma(B_c^+)}{\sigma(B^+)}\frac{\mathcal{B}(B_c^+ \to J/\psi\pi^+)}{\mathcal{B}(B^+ \to J/\psi K^+)}$	$\frac{\sigma(B_c^+)}{\sigma(B_s^0)}\mathcal{B}(B_c^+ \to B_s^0\pi^+)$
Lifetime	$\tau(B_c^+ \to J/\psi\mu^+\nu_\mu X)$	$\tau(B_c^+ \to J/\psi\pi^+)$
Decays	$B_c^+ \to J/\psi\pi^+\pi^-\pi^+$	$B_c^+ \to \psi(2S)\pi^+\pi^-\pi^+$
	$\mathcal{B}(B_c^+ \to J/\psi K^+)$	$B_c^+ \to (\psi(2S) \to J/\psi\pi^+\pi^-)\pi^+$
	$\mathcal{B}(B_c^+ \to \psi(2S)\pi^+)$	$B_c^+ \to (\psi(2S) \to J/\psi\pi^+\pi^-)\pi^+\pi^-\pi^+$
	$B_c^+ \to J/\psi K^+K^-\pi^+$	$B_c^+ \to \psi(2S)K^+K^-\pi^+$(evidence)
	$B_c^+ \to J/\psi 3\pi^+ 2\pi^-$	$B_c^+ \to J/\psi K^+K^-\pi^+\pi^-\pi^+$
	$\mathcal{B}(B_c^+ \to J/\psi\pi^+)/\mathcal{B}(B_c^+ \to J/\psi\mu^+\nu_\mu)$	$B_c^+ \to J/\psi 4\pi^+ 3\pi^-$(evidence)
	$B_c^+ \to p\bar{p}\pi^+$(upper limit)	$B_c^+ \to B_s^0\pi^+$
	$B_c^+ \to K^+K^-\pi^+$	$B_c^+ \to \chi_{cj}\pi^+$
	$B_c^\pm \to D^0\pi^\pm$	$B_c^{(*)+}(2S) \to B_c^+\pi^+\pi^-$

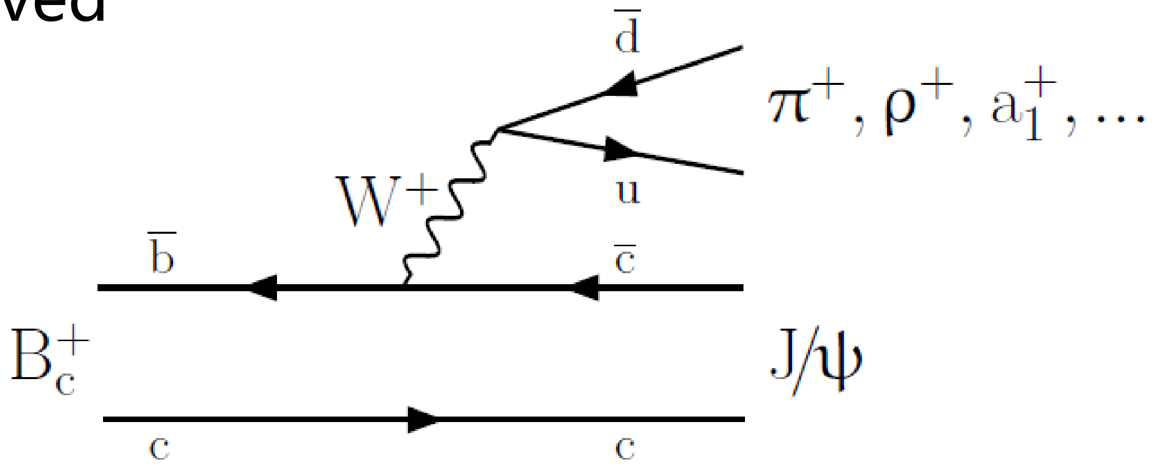
b quark decays

$$B_c^+ \to [c\bar{c}]X$$

$B_c^+ \to J/\psi\pi^+\pi^0$ with Run-I and Run-II data

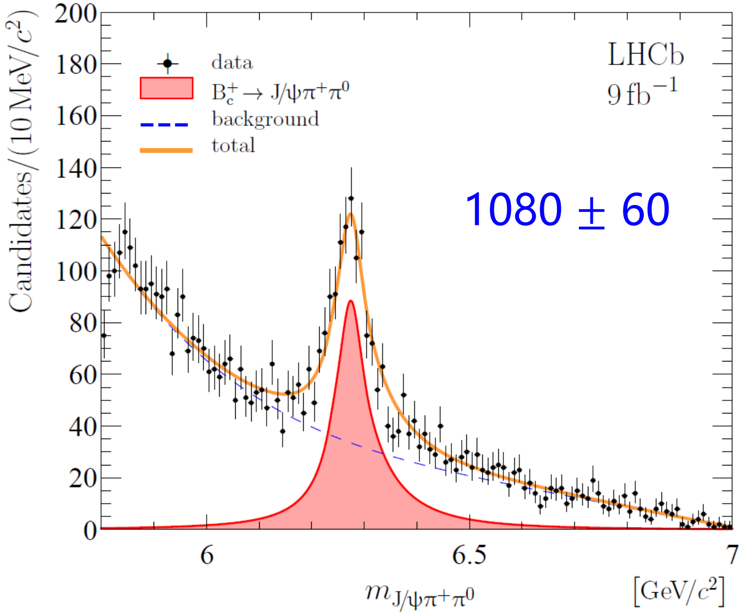
- $B_c^+ \to J/\psi\pi^+\pi^0$ has not yet been observed
- $B_c^+ \to J/\psi\pi^+$ as a normalization mode

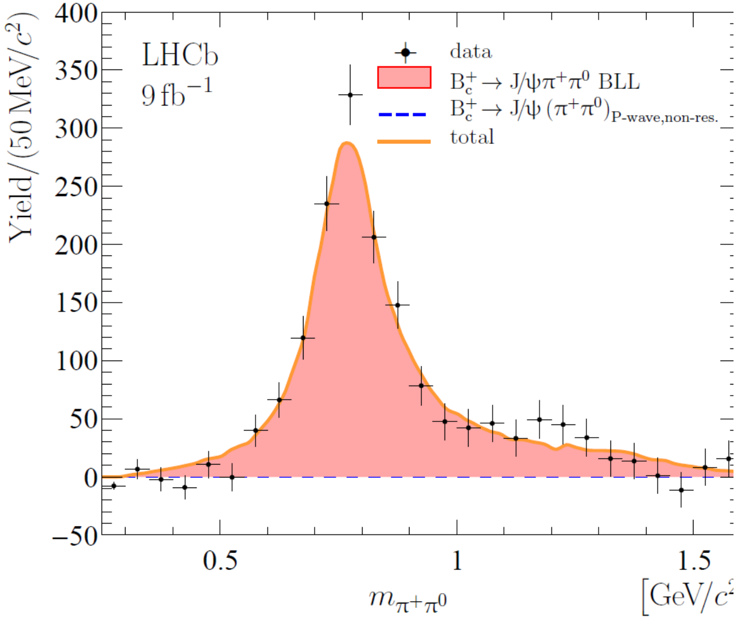
$$\mathcal{R} \equiv \frac{\mathcal{B}(B_c^+ \to J/\psi\pi^+\pi^0)}{\mathcal{B}(B_c^+ \to J/\psi\pi^+)}$$

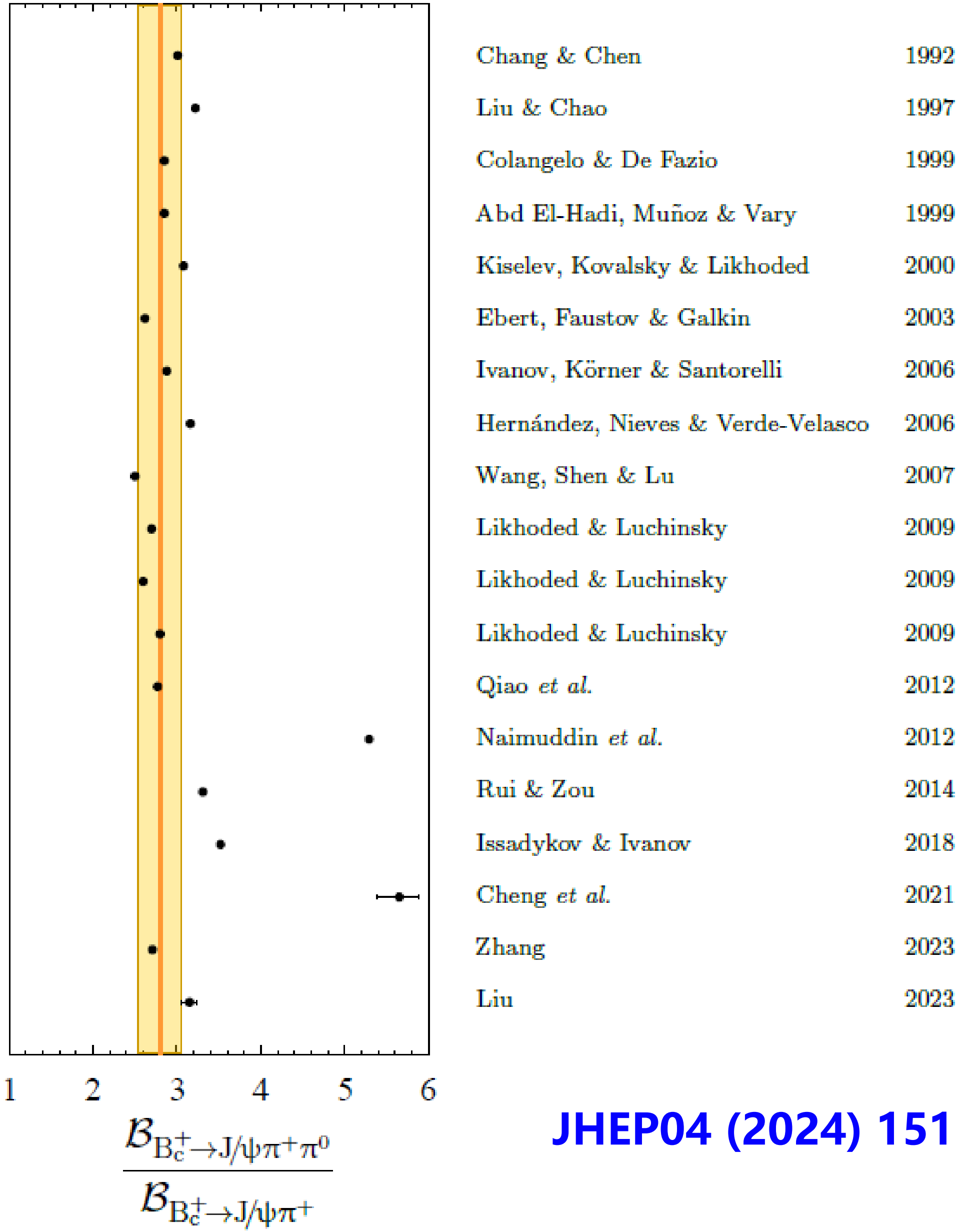


- In the SM, theoretical prediction $\mathcal{R}$:(2.5~5.7)
- $B^+ \to J/\psi K^{*+}(\to K^+\pi^0)$ as a control mode
  - detector resolution
  - mass bias

Results of $B_c^+ \to J/\psi\pi^+\pi^0$







- First observation
- Dominance ρ^+ and small $\rho^+(1450)$

$$\mathcal{R} \equiv \frac{\mathcal{B}(B_c^+ \to J/\psi\pi^+\pi^0)}{\mathcal{B}(B_c^+ \to J/\psi\pi^+)} = 2.80 \pm 0.15 \pm 0.11 \pm 0.16$$

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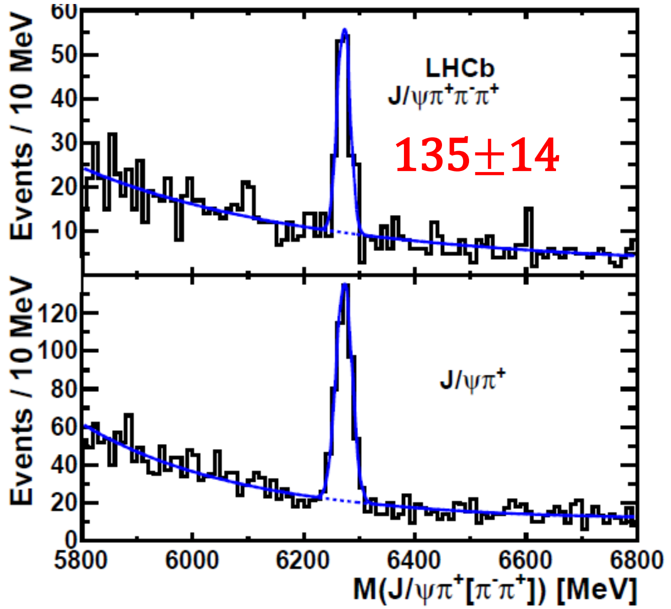
$B_c^+ \to J/\psi(\psi(2S))h^+h^-h^+$

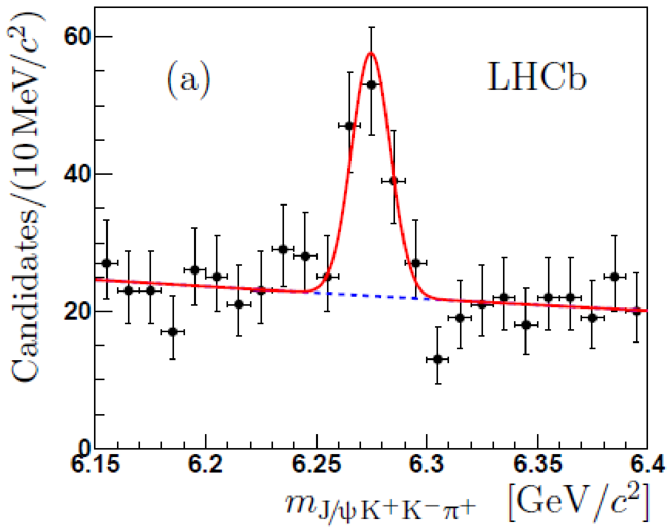
- Only two $B_c^+ \to \psi 3h$ decay mode were observed
- $B_c^+ \to J/\psi\pi^+$ as a normalization mode

$$\mathcal{R} \equiv \frac{\mathcal{B}(B_c^+ \to \psi 3h)}{\mathcal{B}(B_c^+ \to J/\psi\pi^+)}$$

- Theoretical prediction $\mathcal{R}(J/\psi\pi^+\pi^-\pi^+)$: (1.5~2.3)
- $\mathcal{R}(J/\psi\pi^+\pi^-\pi^+) = 2.41 \pm 0.30 \pm 0.33$
- Prefers the latter predictions
- Theoretical prediction $\mathcal{R}(J/\psi K^+K^-\pi^+)$: (0.49 and 0.47)
- $\mathcal{R}(J/\psi K^+K^-\pi^+) = 0.53 \pm 0.10 \pm 0.05$

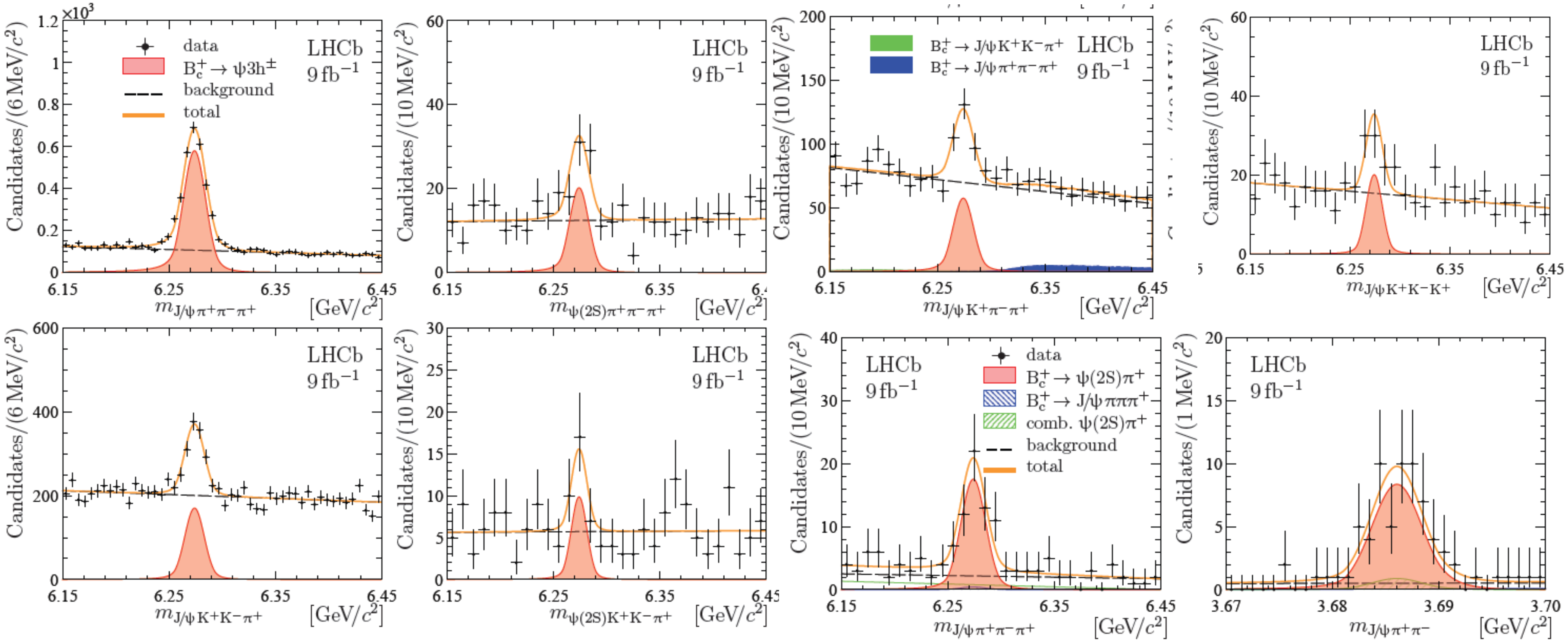


Phys. Rev. Lett. 108 (2012) 251802



JHEP 11 (2013) 094

$B_c^+ \to J/\psi(\psi(2S))h^+h^-h^+$ with Run-I and Run-II data



Decay	Yield	$\mathcal{S}$ [σ]
$B_c^+ \to J/\psi\pi^+\pi^-\pi^+$	2750 ± 69	
$B_c^+ \to J/\psi K^+K^-\pi^+$	686 ± 48	
$B_c^+ \to J/\psi K^+K^-K^+$	43 ± 10	5.2
$B_c^+ \to J/\psi K^+\pi^-\pi^+$	148 ± 22	7.8
$B_c^+ \to \psi(2S)\pi^+\pi^-\pi^+$	49 ± 11	5.8
$B_c^+ \to \psi(2S)K^+K^-\pi^+$	19 ± 6	3.7
$B_c^+ \to (\psi(2S) \to J/\psi\pi^+\pi^-)\pi^+$	54 ± 9	11.8

JHEP01(2022)065

$B_c^+ \to J/\psi(\psi(2S))h^+h^-h^+$ with Run-I and Run-II data

$\mathcal{R}^{\psi(2S)K^+K^-\pi^+}_{\psi(2S)\pi^+\pi^-\pi^+}$	$0.37 \pm 0.15 \pm 0.01$	0.16	BLL [27, 28]
$\mathcal{R}^{J/\psi K^+\pi^-\pi^+}_{J/\psi K^+K^-\pi^+}$	$0.35 \pm 0.06 \pm 0.01$	0.37	BLL [27]
$\mathcal{R}^{J/\psi K^+\pi^-\pi^+}_{J/\psi \pi^+\pi^-\pi^+}$	$(6.4 \pm 1.0 \pm 0.2) \times 10^{-2}$	7.7×10^{-2}	BLL [27]
$\mathcal{R}^{J/\psi K^+K^-\pi^+}_{J/\psi \pi^+\pi^-\pi^+}$	$0.185 \pm 0.013 \pm 0.006$	0.21	BLL [27, 28]
$\mathcal{R}^{\psi(2S)\pi^+}_{J/\psi K^+K^-\pi^+}$	$0.19 \pm 0.03 \pm 0.01$	0.18 ± 0.04	LHCb [6, 11]
$\mathcal{R}^{\psi(2S)\pi^+}_{J/\psi \pi^+\pi^-\pi^+}$	$(3.5 \pm 0.6 \pm 0.2) \times 10^{-2}$	$(3.9 \pm 0.9) \times 10^{-2}$	LHCb [1, 11]
$\mathcal{R}^{J/\psi K^+K^-\pi^+}_{J/\psi \pi^+\pi^-\pi^+}$	$0.185 \pm 0.013 \pm 0.006$	0.22 ± 0.06	LHCb [1, 6]

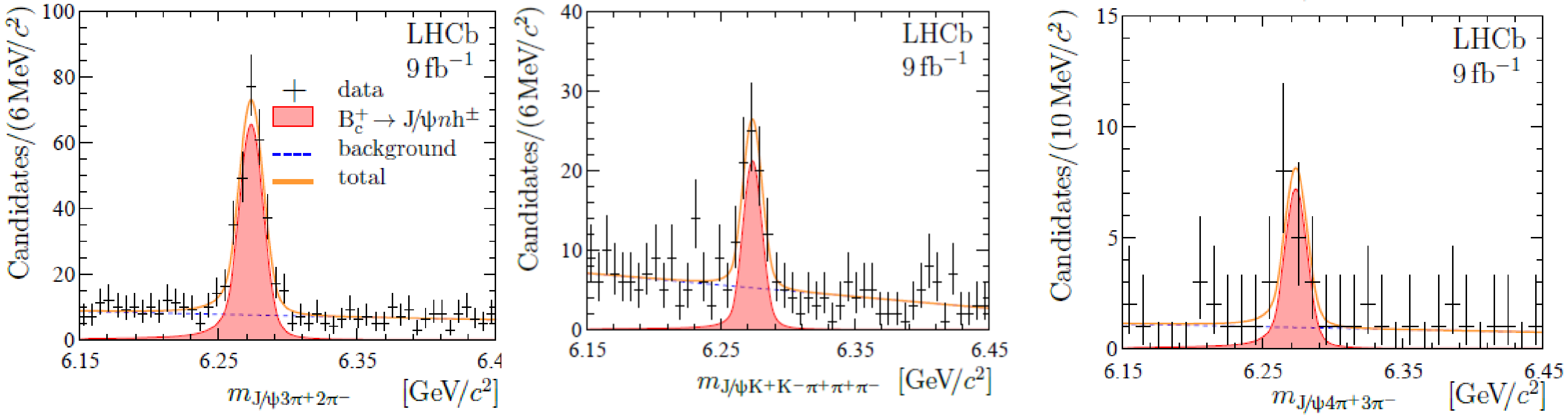
JHEP01(2022)065

- Agree with BLL model based on QCD factorisation
- Consistent with Run I result

	Value $[10^{-2}]$	Reference
$\mathcal{R}^{J/\psi K^+K^-K^+}_{J/\psi K^+K^-\pi^+}$	$7.0 \pm 1.8 \pm 0.2$	This paper
$\mathcal{R}^{J/\psi K^+\pi^-\pi^+}_{J/\psi \pi^+\pi^-\pi^+}$	$6.4 \pm 1.0 \pm 0.2$	This paper
$\frac{\mathcal{B}(B_c^+ \to J/\psi K^+)}{\mathcal{B}(B_c^+ \to J/\psi \pi^+)}$	7.9 ± 0.8	[14]
$\frac{\mathcal{B}(B^+ \to \overline{D}^0 K^+\pi^-\pi^+)}{\mathcal{B}(B^+ \to \overline{D}^0 \pi^+\pi^-\pi^+)}$	9.3 ± 5.1	[51, 69]
$\frac{\mathcal{B}(B^0 \to D^- K^+\pi^-\pi^+)}{\mathcal{B}(B^0 \to D^- \pi^+\pi^-\pi^+)}$	5.8 ± 1.5	[51, 69]
$\frac{\mathcal{B}(B^0 \to D^{*-} K^+\pi^-\pi^+)}{\mathcal{B}(B^0 \to D^{*-} \pi^+\pi^-\pi^+)}$	6.5 ± 0.6	[51, 70]
$\frac{\mathcal{B}(B_s^0 \to D_s^- K^+\pi^-\pi^+)}{\mathcal{B}(B_s^0 \to D_s^- \pi^+\pi^-\pi^+)}$	5.2 ± 1.3	[51, 71]

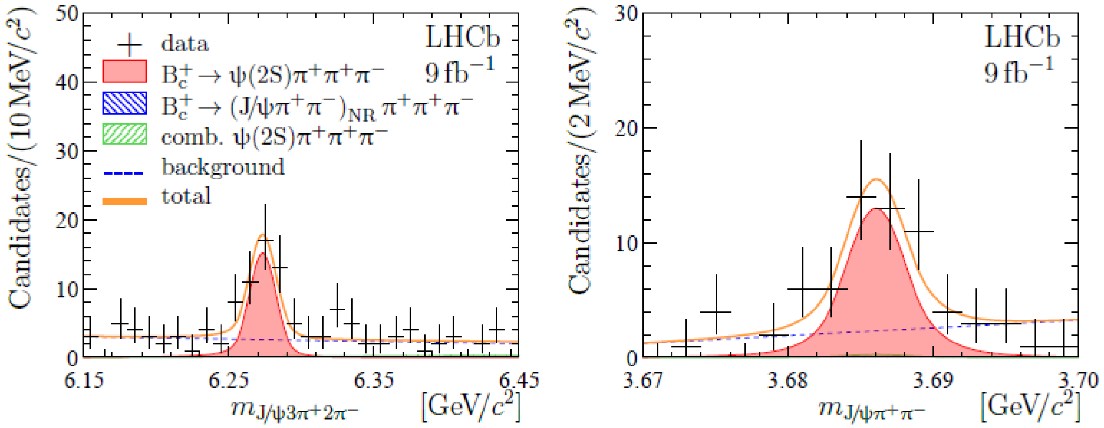
- Agree with the ratios of branching fraction for the multibody decays of B^+, B^0 and B_s^0

$B_c^+ \to J/\psi(\psi(2S))nh$ with Run-I and Run-II data



JHEP 07 (2023) 198

Decay	Yield	$\mathcal{S}$ [σ]
$B_c^+ \to J/\psi 3\pi^+ 2\pi^-$	268 ± 20	21.0
$B_c^+ \to J/\psi K^+K^-\pi^+\pi^+\pi^-$	69 ± 11	9.1
$B_c^+ \to J/\psi 4\pi^+ 3\pi^-$	16 ± 5	4.9
$B_c^+ \to (\psi(2S) \to J/\psi\pi^+\pi^-)\pi^+\pi^+\pi^-$	40 ± 8	6.4



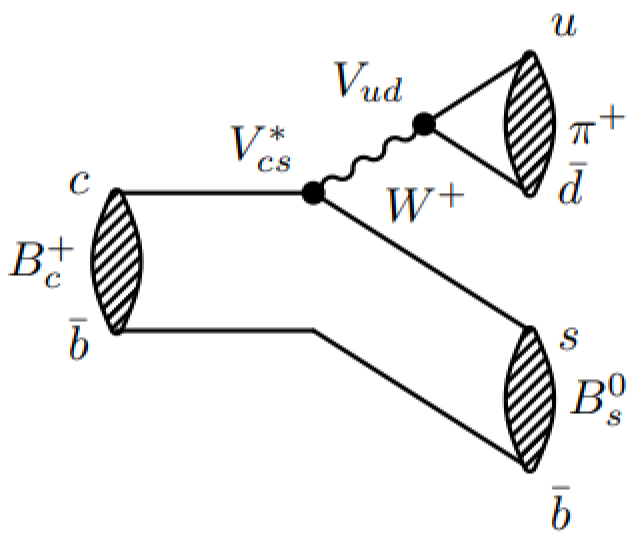
$$\mathcal{R}^{J/\psi K^+K^-\pi^+\pi^+\pi^-}_{J/\psi 3\pi^+ 2\pi^-} = (33.7 \pm 5.7 \pm 1.6) \times 10^{-2},$$

$$\mathcal{R}^{J/\psi 4\pi^+ 3\pi^-}_{J/\psi 3\pi^+ 2\pi^-} = (28.5 \pm 8.7 \pm 2.0) \times 10^{-2},$$

$$\mathcal{R}^{\psi(2S)\pi^+\pi^+\pi^-}_{J/\psi 3\pi^+ 2\pi^-} = (17.6 \pm 3.6 \pm 0.8) \times 10^{-2},$$

- Agree with BLL model based on QCD factorization (backup)
- $\mathcal{R}^{J/\psi K^+K^-\pi^+}_{J/\psi\pi^+\pi^-\pi^+} = (18.5 \pm 1.3 \pm 0.6) \times 10^{-2} < \mathcal{R}^{J/\psi K^+K^-\pi^+\pi^-\pi^+}_{J/\psi 3\pi^+ 2\pi^-}$

c quark decays



$B_c^+ \to B_s^0 \pi^+$

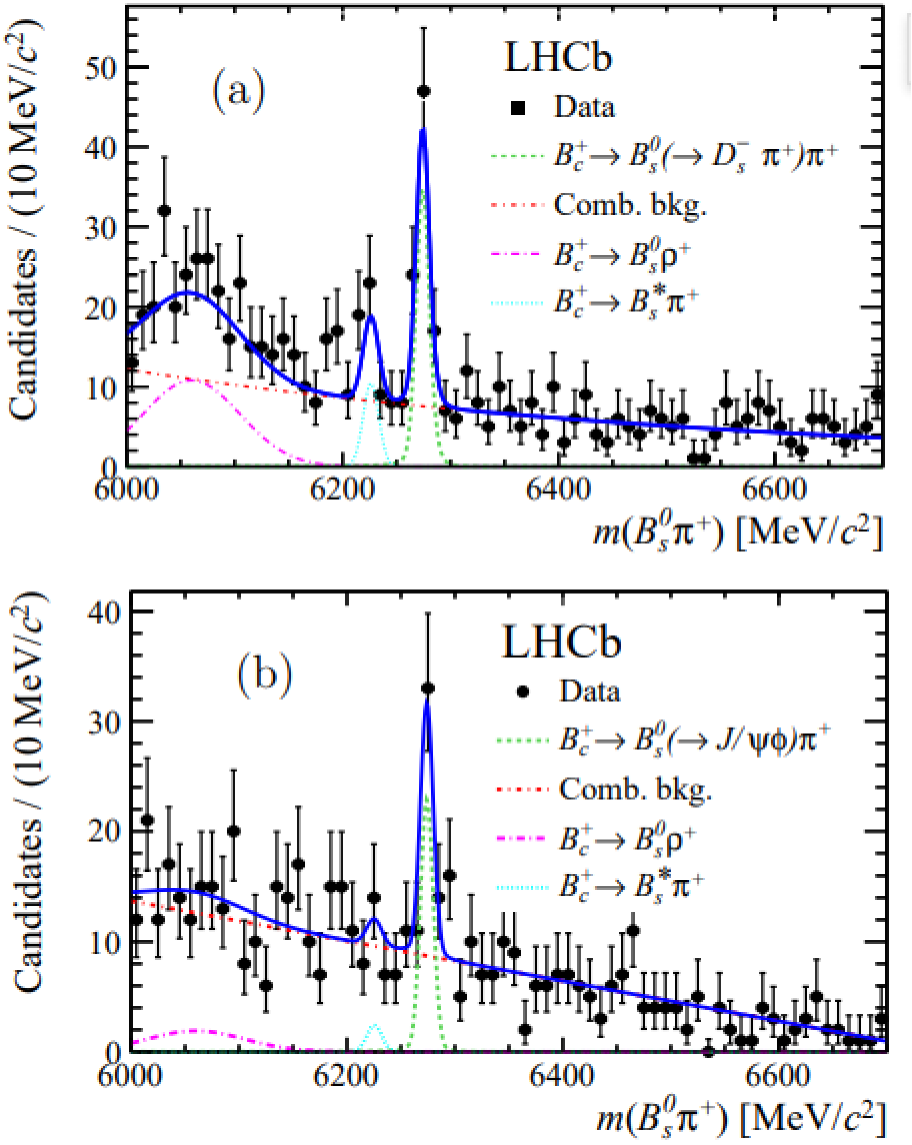
- $B_c^+ \to B_s^0 \pi^+$ was first observed by LHCb with Run I data

- A wide range of predictions $\mathcal{B}(B_c^+ \to B_s^0 \pi^+)$: (16.4% ~2.5%)

- $B_s^0 \to D_s^+ \pi^+$ and $B_s^0 \to J/\psi \phi$ as normalization mode

- $R \equiv \frac{\sigma(B_c^+)}{\sigma(B_s^0)} \times \mathcal{B}(B_c^+ \to B_s^0 \pi^+) = (2.37 \pm 0.31 \pm 0.11^{+0.17}_{-0.13}) \times 10^{-3}$

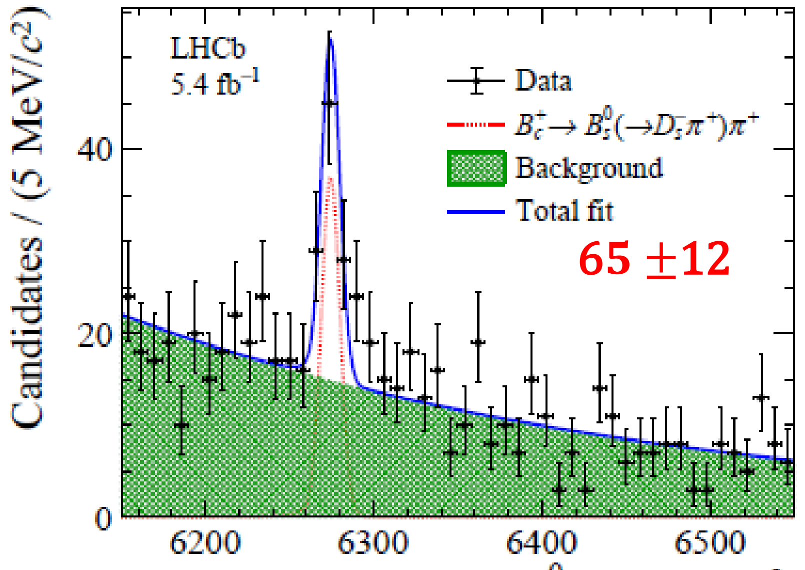
- $\mathcal{B}(B_c^+ \to B_s^0 \pi^+) \approx 10\%$



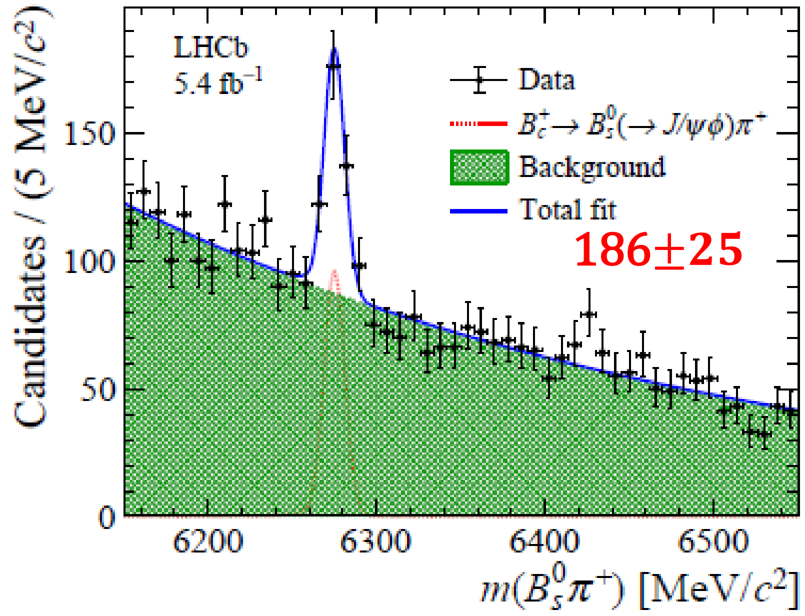
Phys. Rev. Lett. 111 (2013) 181801

Study of $B_c^+ \to B_s^0\pi^+$ with Run II data

- $B_c^+ \to J/\psi\pi^+$ as a normalization mode
- $\mathcal{R} \equiv \frac{\mathcal{B}(B_c^+\to B_s^0\pi^+)}{\mathcal{B}(B_c^+\to J/\psi\pi^+)} = 91 \pm 10(\text{stat}) \pm 8(\text{syst}) \pm 3(\mathcal{B})$
- $\mathcal{B}(B_c^+ \to B_s^0\pi^+) = (8.3 \pm 0.7(\text{stat}) \pm 0.3(\text{syst}) \pm 2.2(\mathcal{B}))\%$
- Consistent with Run I result
- The largest branching fraction of B_c^+



JHEP 07 (2023) 066

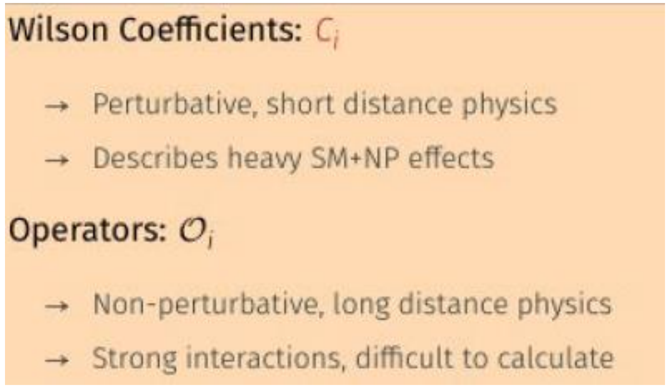


$b \to sl^+l^-$ decays

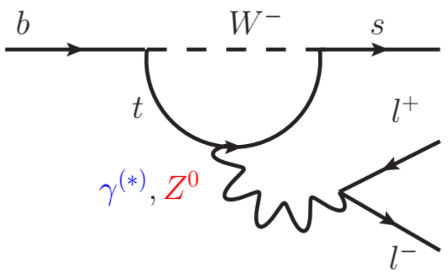
- **$b \to sl^+l^-$ decays described by effective Hamiltonian**

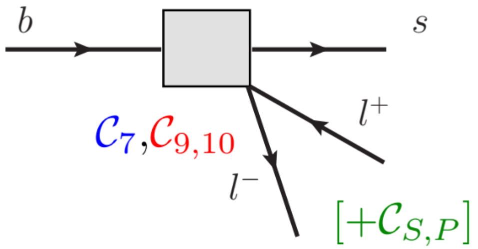
$$H = -\frac{4G_F}{\sqrt{2}} V_{tb} V_{ts}^* \sum_i C_i O_i + \frac{K}{\Lambda_{NP}^2} O_j^{(6)}$$

New physics can affect Wilson coefficients C_i or add new operators O_j



- **Sensitivity to Wilson coefficients**

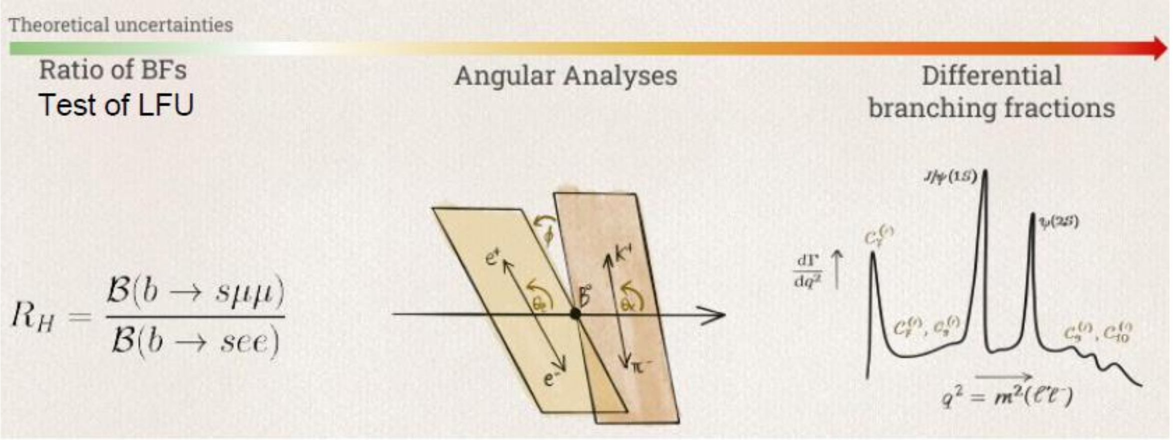




- $B^0_{(s)} \to l^+l^-$ $[\mathcal{C}_{10}, \mathcal{C}_S, \mathcal{C}_P]$
- $b \to sl^+l^-$ $[\mathcal{C}_7, \mathcal{C}_9, \mathcal{C}_{10}]$

7: photon penguin; 9,10: EW penguin; S,P: (pseudo-) scalar penguin

- **Theoretically clean probes of NP**
  - Pure leptonic decays
  - Ratio between $e/\mu/\tau$
  - Special angular observables
  - Differential BF



Search for $B_{(s)}^{*0} \to \mu^+\mu^-$ in $B_c^+ \to \pi^+\mu^+\mu^-$

- $B_{(s)}^{*0} \to \mu^+\mu^-$ are highly suppressed in SM due to EM, BF is $\sim 10^{-11}$

  Phys. Rev. Lett. 116 (2016) JHEP 11 (2015) 142

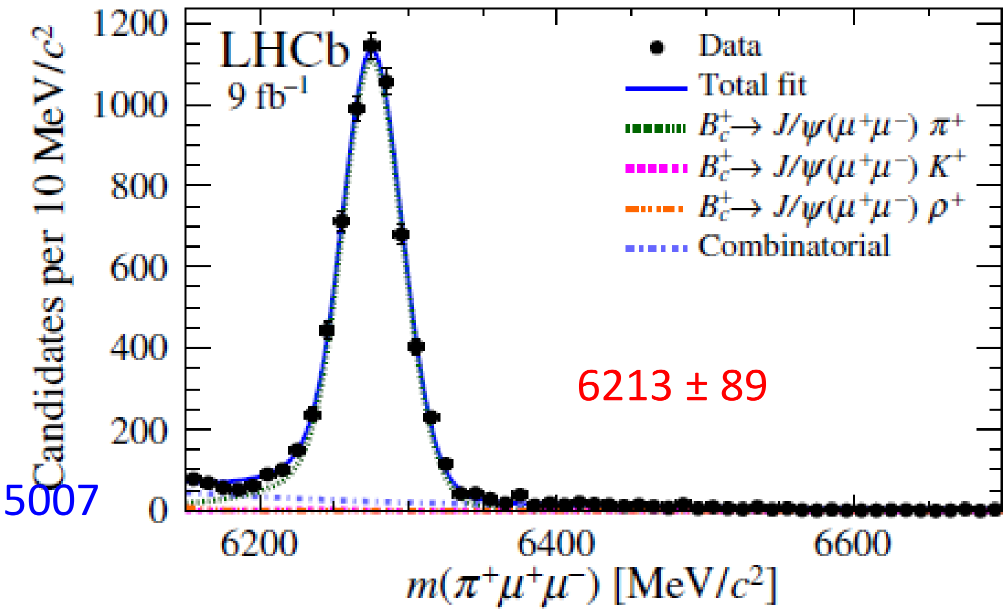
- Could be enhanced by New Physics

  Eur. Phys. J. C76 (2016) 583 J. Phys. G44 (2017) 035001

  Int. J. Mod. Phys. A32 (2017) 1750075 Phys. Rev. D97 (2018) 035007

- Prompt $B_{(s)}^{*0}$ have large background from pp interactions

- $B_c^+ \to J/\psi(\to \mu^+\mu^-)\pi^+$ as normalization channel

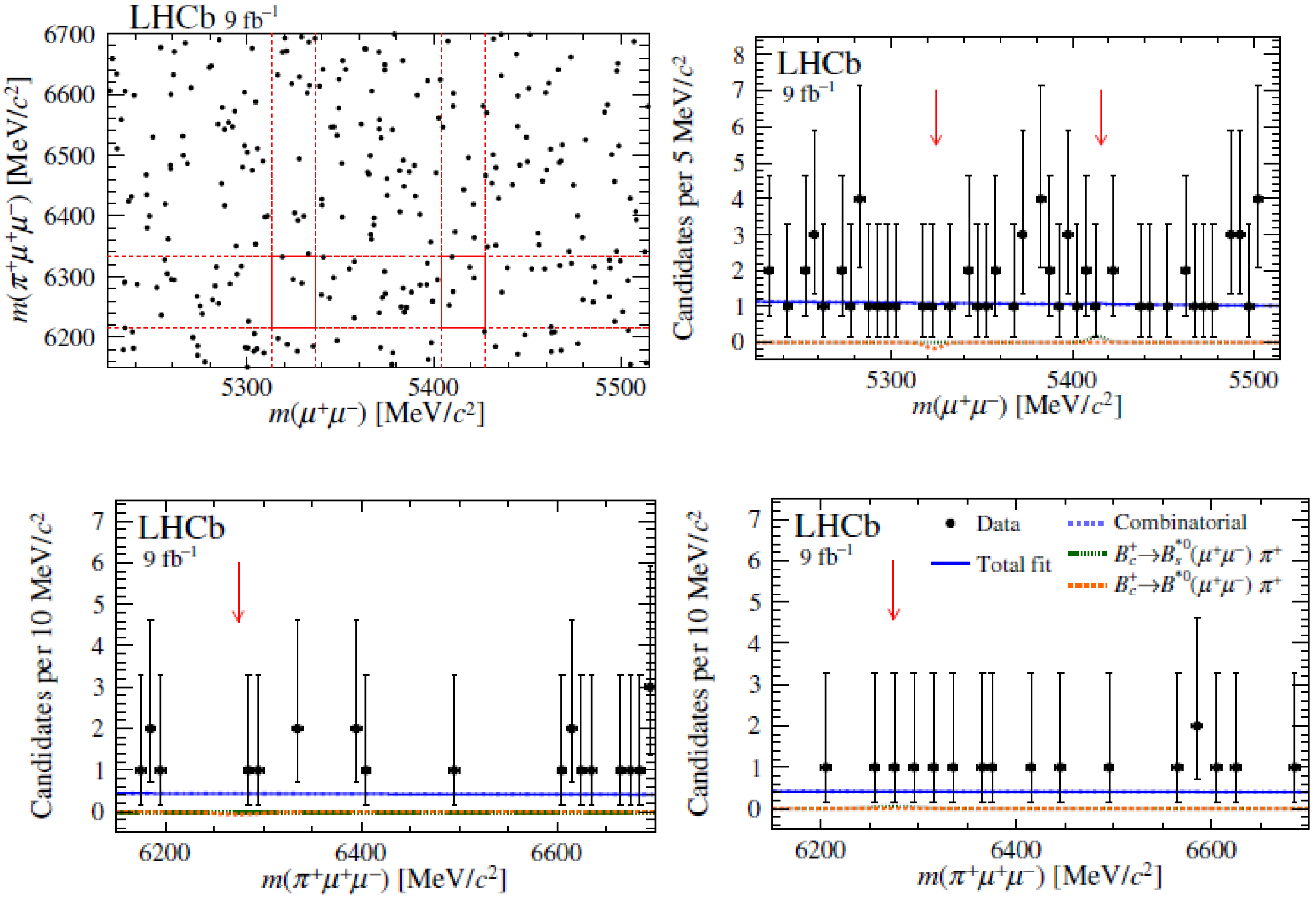


$$\mathcal{R}_{B_{(s)}^{*0}(\mu^+\mu^-)\pi^+/J/\psi\pi^+} \equiv \frac{\mathcal{B}(B_c^+ \to B_{(s)}^{*0}(\mu^+\mu^-)\pi^+)}{\mathcal{B}(B_c^+ \to J/\psi\pi^+)}$$
$$= \frac{N_{B_{(s)}^{*0}\pi^+}}{N_{J/\psi\pi^+}} \cdot \frac{\varepsilon_{J/\psi\pi^+}}{\varepsilon_{B_{(s)}^{*0}\pi^+}} \cdot \mathcal{B}(J/\psi \to \mu^+\mu^-)$$
$$= \alpha^{\mathrm{SES}}_{B_{(s)}^{*0}\pi^+} \cdot N_{B_{(s)}^{*0}\pi^+},$$

Search for $B^{*0}_{(s)} \to \mu^+\mu^-$ in $B_c^+ \to \pi^+\mu^+\mu^-$

- First measurement, no significant signal and upper limits on the branching ratio

$$\mathcal{R}_{B^{*0}(\mu^+\mu^-)\pi^+/J/\psi\pi^+} < 3.8 \times 10^{-5}\,,$$
$$\mathcal{R}_{B_s^{*0}(\mu^+\mu^-)\pi^+/J/\psi\pi^+} < 5.0 \times 10^{-5}\,,$$



Arxiv:2409.17209v1

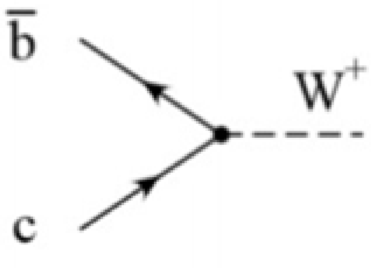
Summary and Outlook

- **Many results on B_c^+ mesons physics by LHCb**
  - b quark decays: $B_c^+ \to [c\bar{c}]X$
  - c quark decays: $\mathcal{B}(B_c^+ \to B_s^0\pi^+) \sim 10\%$
  - Mass: $6274.47 \pm 0.27 \pm 0.17\ MeV/c^2$

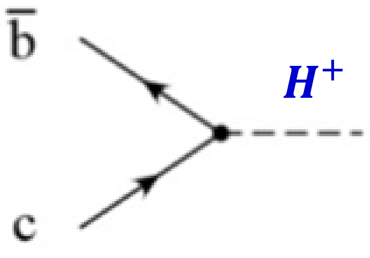
- **Opportunities with Run-III (14 $\mathbf{fb^{-1}}$)**
  - Search for annihilation decay: $B_c^+ \to 3h$
  - CPV?
  - Search for more c quark decays: $B_c^+ \to B^+X, B^0X$?
  - Form factor never be measured
  - Lepton universality

Outlook of $B_c^+ \to h^+h^-h^+$

- In the SM, theoretical prediction B_c^+ annihilation decays :$10^{-8}\sim10^{-6}$)

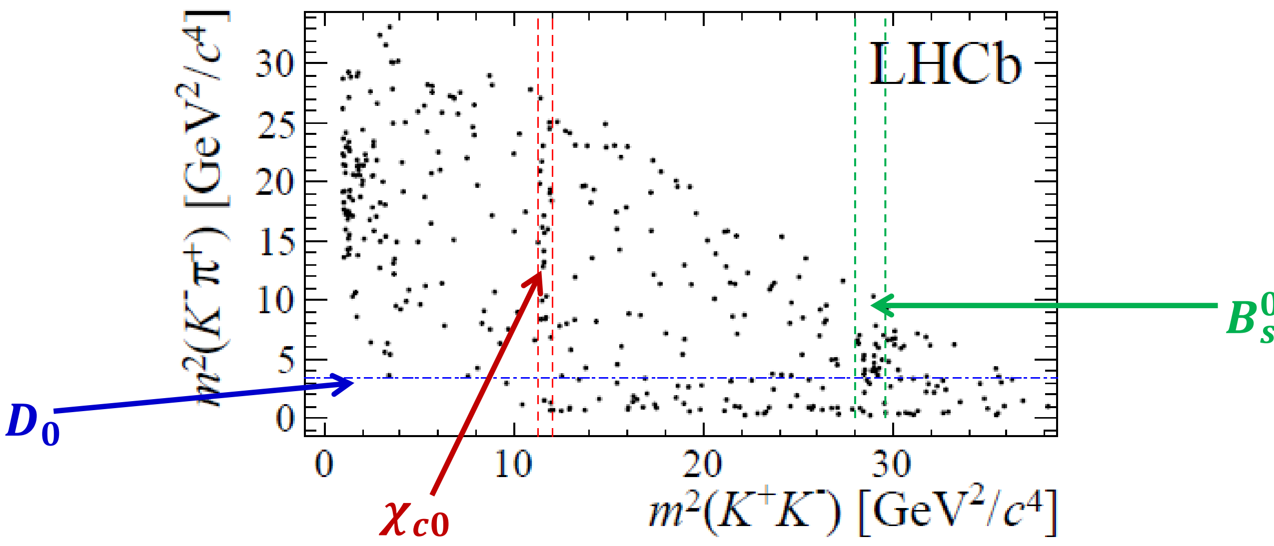


- Any significant enhancement could indicate the particles beyond the SM (like H^+)



- Decay modes for $B_c^+ \to K^+K^-\pi^+$
  1. $\bar{b} \to \bar{q}$: $B_c^+ \to K^+D^0(\to K^-\pi^+)$
  2. $\bar{c} \to \bar{q}$: $B_c^+ \to \pi^+B_q^0(\to K^-K^+)$
  3. $\bar{b} \to \bar{c}$: $B_c^+ \to \pi^+[c\bar{c}](\to K^-K^+)$
  4. **$\bar{b}c$ annihilation: NR**

PRD 94(2016) 091102



Outlook of CPV

No.	Final state	$\Gamma(B_c^+ \to f)$ (GeV)	$\overline{\Gamma(B_c^- \to \bar{f})}$ (GeV)	$\mathcal{A}_{CP}$
1	ψD^{*+}	6.65×10^{-16}	6.53×10^{-16}	0.00954
2	$\eta_c D^{*+}$	9.42×10^{-17}	9.09×10^{-17}	0.0179
3	ψD^{+}	2.91×10^{-17}	2.89×10^{-17}	0.00383
4	$\eta_c D^{+}$	4.07×10^{-16}	3.89×10^{-16}	0.0226
5	ψD_s^{*+}	1.76×10^{-14}	1.76×10^{-14}	−0.000480
6	$\eta_c D_s^{*+}$	2.20×10^{-15}	2.21×10^{-15}	−0.000902
7	ψD_s^{+}	8.54×10^{-16}	8.55×10^{-16}	−0.000186
8	$\eta_c D_s^{+}$	9.58×10^{-15}	9.60×10^{-15}	−0.00118
9	$D^{*0}\rho^+$	8.34×10^{-18}	8.99×10^{-18}	−0.0379
10	$D^{0}\rho^+$	8.38×10^{-18}	9.04×10^{-18}	−0.0379
11	$D^{*0}\pi^+$	2.80×10^{-18}	2.88×10^{-18}	−0.0154
12	$D^{0}\pi^+$	3.11×10^{-18}	3.54×10^{-18}	−0.0645
13	$D^{*0}K^{*+}$	5.81×10^{-18}	5.13×10^{-18}	0.0622
14	$D^{0}K^{*+}$	5.35×10^{-18}	4.72×10^{-18}	0.0622
15	$D^{*0}K^{+}$	7.71×10^{-19}	6.46×10^{-19}	0.0879
16	$D^{0}K^{+}$	6.76×10^{-18}	6.16×10^{-18}	0.0463
17	$D^{*+}\rho^0$	1.94×10^{-18}	1.83×10^{-18}	0.0302
18	$D^{*+}\pi^0$	9.83×10^{-20}	9.46×10^{-20}	0.0210
19	$D^{+}\rho^0$	5.90×10^{-19}	5.56×10^{-19}	0.0302
20	$D^{+}\pi^0$	3.12×10^{-19}	3.01×10^{-19}	0.0185
21	$D^{*+}K^{*0}$	4.48×10^{-18}	4.41×10^{-18}	0.00822
22	$D^{+}K^{*0}$	4.22×10^{-18}	4.15×10^{-18}	0.00822
23	$D^{*+}K^{0}$	4.10×10^{-19}	4.03×10^{-19}	0.00822
24	DK^{0}	7.22×10^{-18}	7.11×10^{-18}	0.00822
25	$D_s^{*+}\phi$	5.68×10^{-18}	5.58×10^{-18}	0.00822
26	$D_s^{+}\phi$	2.30×10^{-18}	2.26×10^{-18}	0.00822
27	$D_s^{*+}\overline{K}^{*0}$	2.88×10^{-19}	3.76×10^{-19}	−0.133
28	$D_s^{*+}\overline{K^0}$	2.69×10^{-20}	3.52×10^{-20}	−0.133
29	$D_s^{+}\overline{K}^{*0}$	1.32×10^{-19}	1.72×10^{-19}	−0.133
30	$D_s^{+}\overline{K^0}$	2.40×10^{-19}	3.14×10^{-19}	−0.133

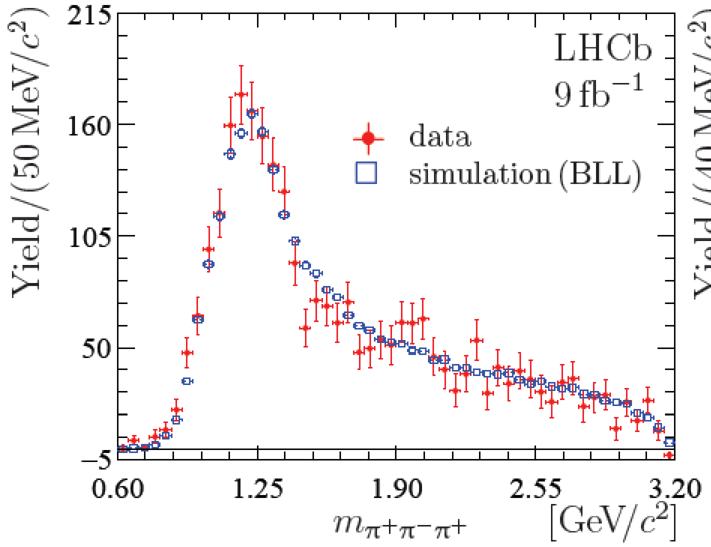
PhysRevD.56.4133

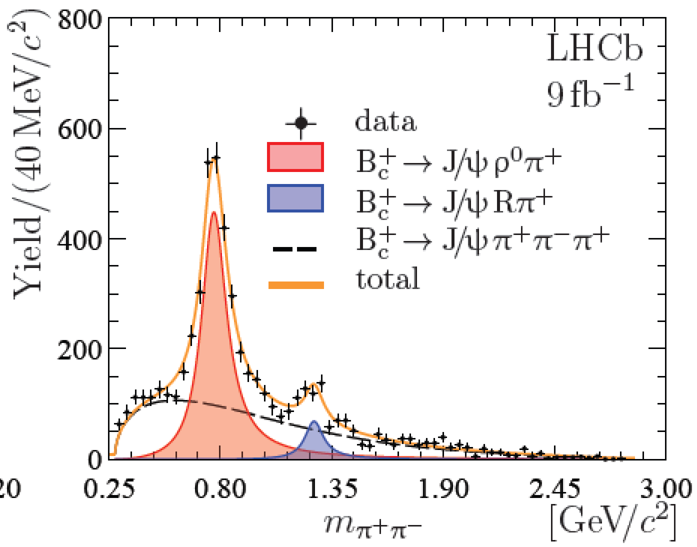
Mode Prediction: A_{cp}	Lum (fb^{-1})	N Precision of A_{cp}	Lum (fb^{-1})	N Precision of A_{cp}
$B_c^+ \to J/\psi D^+$ $A_{cp} = 0.4\%$	9.0	x	14.0	x
$B_c^+ \to J/\psi D_s^+$ $A_{cp} = 0.02\%$	9.0	1135 ± 49 ~5%	14.0	~2000 ~3%
$B_c^+ \to D^0 K^+$ $A_{cp} = 4.6\%$	3.0	20 ± 5 x	9.0 14.0	~100 15~20% 200~300 10%
$B_c^+ \to D_s^+ K^{*0}$ $A_{cp} = 13.3\%$	9.0	x	14.0	x

Thank you

Backup

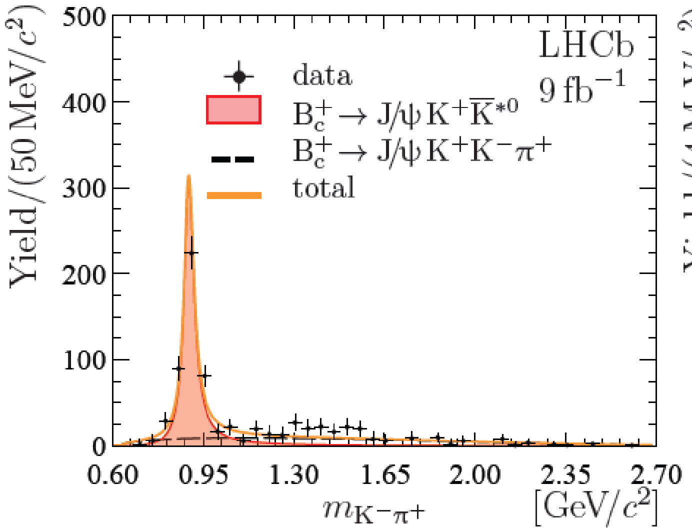
Resonance structure of $B_c^+ \to J/\psi(\psi(2S))h^+h^-h^+$

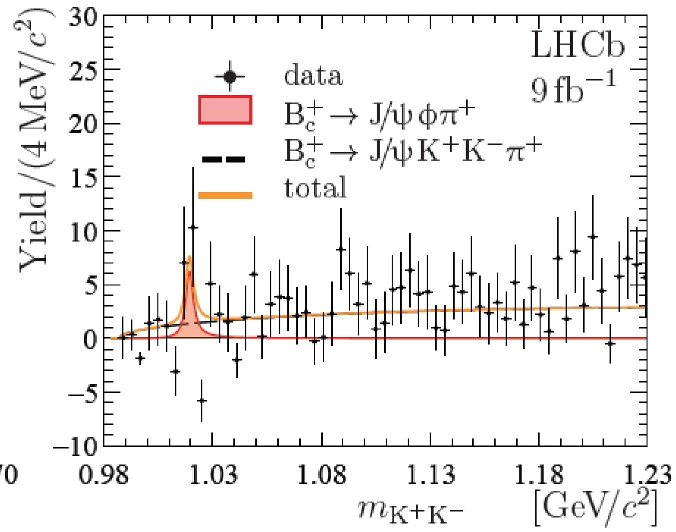




Parameter		Value
$f_{\rho^0}^{B_c^+\to J/\psi\pi^+\pi^-\pi^+}$	[%]	88.1 ± 3.0
$f_{R}^{B_c^+\to J/\psi\pi^+\pi^-\pi^+}$	[%]	10.4 ± 1.4
m_R	[MeV/c^2]	1265 ± 10
Γ_R	[MeV]	110 ± 21
$\mathcal{S}_R$	[σ]	8

- BLL model: $B_c^+ \to J/\psi a_1(1260)(\to 3\pi)$





$$f_{\overline{K}^{*0}}^{B_c^+\to J/\psi K^+K^-\pi^+} = (64.5 \pm 4.7)\ \%\,,$$

$$f_{\phi}^{B_c^+\to J/\psi K^+K^-\pi^+} = \left(1.6\ {}^{+0.7}_{-0.6}\right)\ \%\,,$$

Resonance structure of $B_c^+ \to J/\psi(\psi(2S))nh$