Study of $B_c \to J/\psi D_s^{(*)+}$ decays in pp collisions at $\sqrt{s} = 13$ TeV with the ATLAS detector

Leonid Gladilin[1,2], Tatiana Lyubushkina[2], Semen Turchikhin[2]

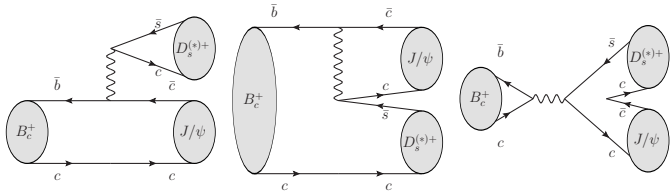
[1]Lomonosov Moscow State University
[2]Joint Institute for Nuclear Research

56th meeting of the PAC for Particle Physics,

24 January 2022

Introduction

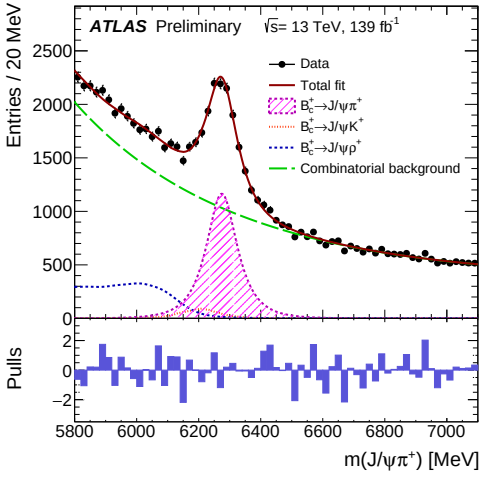
- Decays $B_c^+ \to J/\psi D_s^{(*)+}$ can occur through b decay with c as spectator, or through annihilation diagram



- Only $B_c^+ \to J/\psi D_s^{(*)+}$ decays observed earlier by LHCb (PRD 87 (2013) 112012) and ATLAS (EPJC 76 (2016) 4).
- This analysis aims at more precise measurement of $B_c^+ \to J/\psi D_s^{(*)+}$ branching fraction and polarization with full Run-2 data
  - Test various approaches predicting these (perturbative QCD calculation, relativistic potential models, sum rules calculations...)

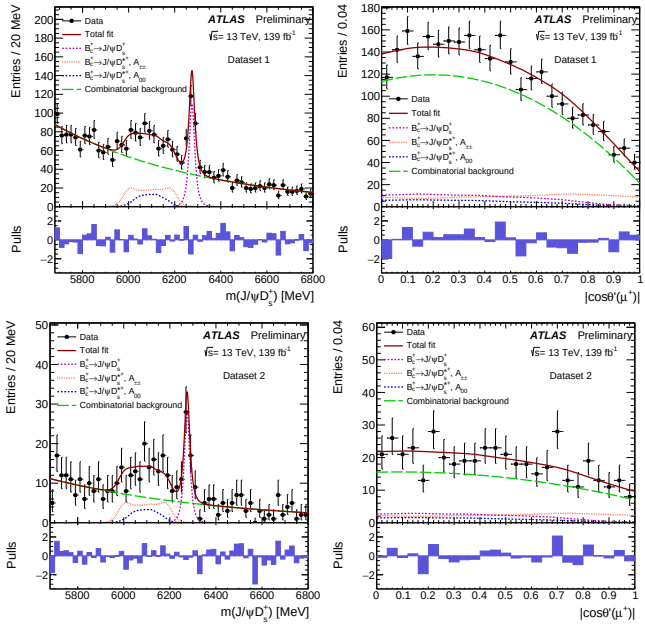
Study of the $B_c^+ \to J/\psi D_s^{(*)+}$ decays

- $B_c^+ \to J/\psi(\mu^+\mu^-)D_s^+(\to \phi(\to K^+K^-)\pi^+)$
- $B_c^+ \to J/\psi(\mu^+\mu^-)D_s^{*+}(\to D_s^+\gamma/\pi^0)$
  - Same reconstructed final state, soft neutral particle escapes detection
- **Reference channel:** $B_c^+ \to J/\psi\pi^+$
  - Use it for $\mathcal{B}$ measurement
- Define fiducial range of the measurement: $p_T(B_c^+) > 15\,\text{GeV}$, $|\eta(B_c^+)| < 2.0$
- Measured quantities:
  - Ratios b/w $\mathcal{B}$ of signal channels and $\mathcal{B}(B_c^+ \to J/\psi\pi^+)$: $R_{D_s^{(*)+}/\pi^+}$
  - Ratios b/w $\mathcal{B}$'s of signal channels (to cancel some of the uncertainties): $R_{D_s^{*+}/D_s^+}$
  - Transverse polarisation fraction $\Gamma_{\pm\pm}/\Gamma$ for $B_c^+ \to J/\psi D_s^{*+}$



Study of the $B_c^+ \to J/\psi D_s^{(*)+}$ decays

- *Dataset 1*: candidates in the events collected by the standard dimuon or three-muon triggers without requirements on additional ID track.
  - can be safely used to measure $R_{D_s^+/\pi^+}$, $R_{D_s^{*+}/\pi^+}$
- *Dataset 2*: candidates collected only by the dedicated $B_s^0 \to \mu^+\mu^-\phi$ triggers and not by other ones used in the analysis.
  - improve sensitivity to $R_{D_s^{*+}/D_s^+}$, $\Gamma_{\pm\pm}/\Gamma$



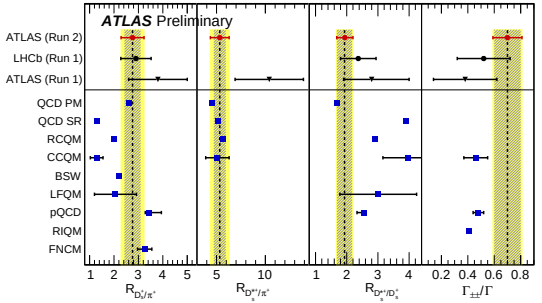
Study of the $B_c^+ \to J/\psi D_s^{(*)+}$ decays: results

$$R_{D_s^+/\pi^+} = 2.76 \pm 0.33(\text{stat.}) \pm 0.29(\text{syst.}) \pm 0.16(\text{br.f.})$$

$$R_{D_s^{*+}/\pi^+} = 5.33 \pm 0.61(\text{stat.}) \pm 0.67(\text{syst.}) \pm 0.32(\text{br.f.})$$

$$R_{D_s^{*+}/D_s^+} = 1.93 \pm 0.24(\text{stat.}) \pm 0.10(\text{syst.})$$

$$\Gamma_{\pm\pm}/\Gamma = 0.70 \pm 0.10(\text{stat.}) \pm 0.04(\text{syst.})$$



- All results are consistent with the earlier measurements of ATLAS and LHCb.
- The precision of the measurement exceeds that of all previous studies of these decays

$R_{D_s^+/\pi^+}$	$R_{D_s^{*+}/\pi^+}$	$R_{D_s^{*+}/D_s^+}$	$\Gamma_{\pm\pm}/\Gamma$	Ref.
2.76 ± 0.47	5.33 ± 0.96	1.93 ± 0.26	0.70 ± 0.11	ATLAS Run 2
2.90 ± 0.62	–	2.37 ± 0.57	0.52 ± 0.20	LHCb Run 1
3.8 ± 1.2	10.4 ± 3.5	$2.8^{+1.2}_{-0.9}$	0.38 ± 0.24	ATLAS Run 1
2.6	4.5	1.7	–	QCD potential model
1.3	5.2	3.9	–	QCD sum rules
2.0	5.7	2.9	–	RCQM
1.29 ± 0.26	5.09 ± 1.02	3.96 ± 0.80	0.46 ± 0.09	CCQM
2.2	–	–	–	BSW
2.06 ± 0.86	–	3.01 ± 1.23	–	LFQM
$3.45^{+0.49}_{-0.17}$	–	$2.54^{+0.07}_{-0.21}$	0.48 ± 0.04	pQCD
–	–	–	0.410	RIQM
3.257 ± 0.293	–	–	–	FNCM

Summary

- A study of $B_c^+ \to J/\psi D_s^+$ and $B_c^+ \to J/\psi D_s^{*+}$ decays has been performed by the ATLAS experiment at the LHC using *pp* collision data corresponding to an integrated luminosity of 139 fb^{-1} at 13 TeV centre-of-mass energy
- All results are consistent with the earlier measurements of ATLAS and LHCb.
- The precision of the measurement exceeds that of all previous studies of these decays
- CONF Note ATLAS-CONF-2021-046
- Results were presented at a number of international HEP conferences (EPS-HEP, HADRON, PANIC etc.)