B-meson Decays to Vector Mesons and Charmless Decays at LHCb

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On behalf of LHCb collaboration

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Outline

Several recent results from LHCb:

- **B-meson decays to vector mesons ($B \to VV$)**
  - NEW — First observation of CP violation and measurement of polarisation in $B^+ \to \rho(770)^0 K^*(892)^+$ decays [LHCb-PAPER-2025-026] (In preparation)
  - NEW — Updated measurement of CP violation and polarisation in $B_s^0 \to J/\psi \overline{K}^*(892)^0$ decays [arXiv: 2506.22090]
  - NEW — Search for the decay $B^0 \to \phi\phi$ [LHCb-PAPER-2025-018] (In preparation)
- **Searches for new charmless decay modes and BF measurements**
  - NEW — Observation of the decay $B_s^0 \to K^0 p\bar{p}$ and measurement of the $B_{(s)}^0 \to K^0 p\bar{p}$ branching fractions [arXiv: 2504.21269]
  - NEW — First observation of the charmless baryonic decay $B^+ \to \bar{\Lambda} p\bar{p}p$ [LHCb-PAPER-2025-032] (In preparation)
  - Study of light-meson resonances decaying to $K_S^0 K\pi$ in the $B \to (K_S^0 K\pi)K$ channels (will not be shown in this talk) [Phys. Rev. D111 (2025) 092009]

LHCb experiment

- A single-arm forward region spectrometer covering $2 < \eta < 5$
- Optimised for beauty and charm physics

High Vertex resolution

$\sigma_{\mathrm{IP}} \sim 20\ \mu\mathrm{m}$

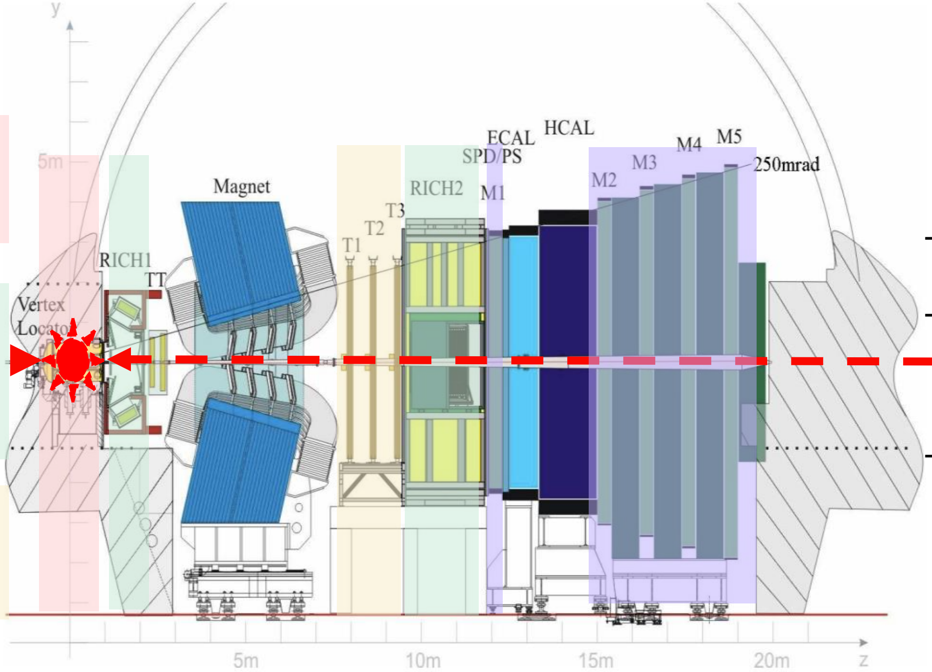
Crucial particle identification

$\epsilon(K \to K) \sim 95\%$

mis-ID $\epsilon(\pi \to K) \sim 5\%$

Good momentum resolution

$\sigma_p/p \sim 0.5\% - 1\%\ (5 - 200\ \mathrm{GeV})$



Analyses in this talk use data of

	Years	$\sqrt{s}$	Luminosity
Run1	2011/12	7/8TeV	$\sim 3\ \mathrm{fb}^{-1}$
Run2	2015/16/17/18	13TeV	$\sim 6\ \mathrm{fb}^{-1}$

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

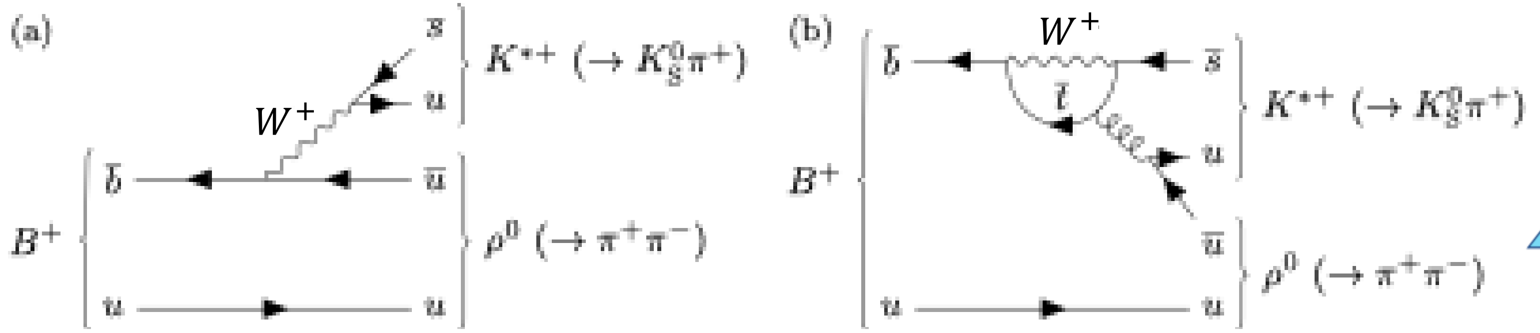
B-meson decays to vector mesons ($B \to VV$)

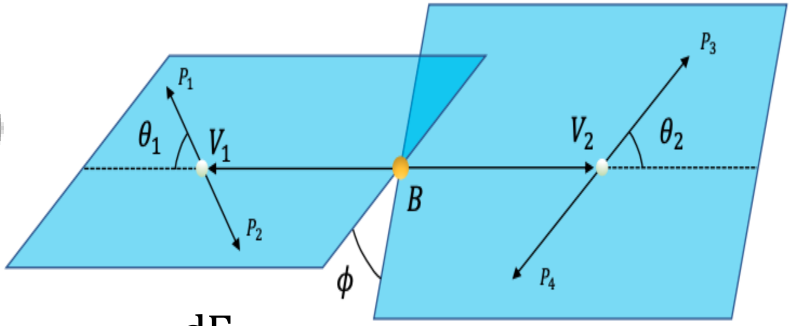
- First observation of CP violation and measurement of polarisation in $\boldsymbol{B^+ \to \rho(770)^0 K^*(892)^+}$ decays [LHCb-PAPER-2025-026] (In preparation)
- Updated measurement of CP violation and polarisation in $\boldsymbol{B_s^0 \to J/\psi \bar{K}^*(892)^0}$ decays [arXiv: 2506.22090]
- Search for the decay $\boldsymbol{B^0 \to \phi\phi}$ [LHCb-PAPER-2025-018] (In preparation)

Introduction to $B \to VV$ decays

$B \to VV$ decays (b-meson decays into two vector mesons) are highly interesting

- Generally mediated by both tree-level and loop processes





$$\frac{d\Gamma}{d\Omega} \propto |\Sigma_i A_i f_i(\Omega)|^2$$

  - Interference between them gives rise to direct ***CP* violation**

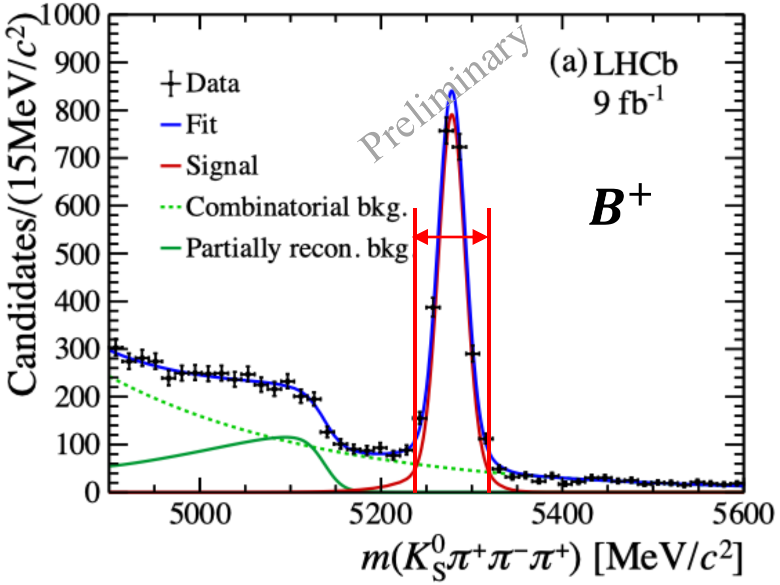
- Three contributing amplitudes: longitudinal (A_0), parallel ($A_\parallel$), and perpendicular ($A_\perp$)
  - Longitudinal polarisation $f_L = |A_0|^2/(|A_0|^2 + |A_\parallel|^2 + |A_\perp|^2)$
  - In the naive factorisation ansatz, $f_L \approx 1$ [Phys. Lett. B 89 (1979) 105.958]
  - Experimental results of f_L vary from 0.1 ~ 1 for general $B \to VV$ decays, which is the so-called "**polarisation** puzzle", motivating theoretical studies both in QCD effects and New Physics

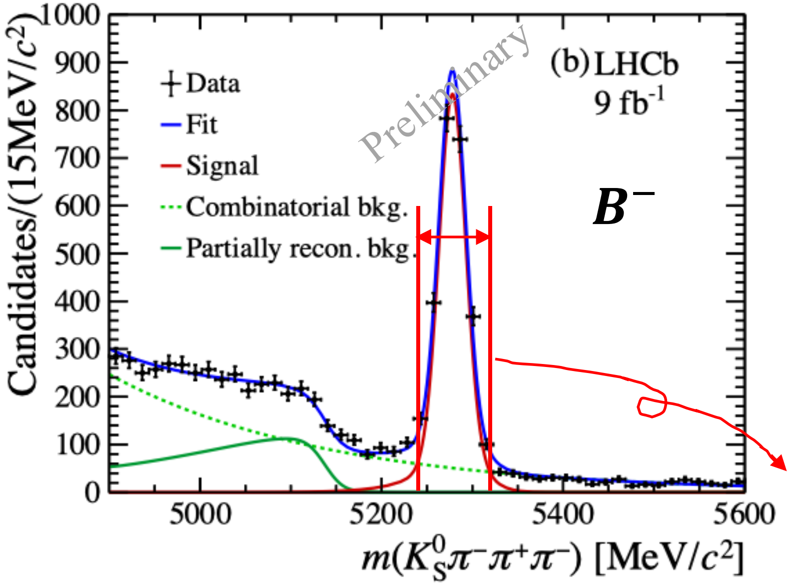
CPV and polarisation measurements in $B^+ \to \rho^0 K^{*+}$

[LHCb-PAPER-2025-026] (In preparation)

Preliminary!

- Charmless $B \to VV$ decay $B^+ \to \rho(770)^0 K^*(892)^+$
  $\hookrightarrow \pi^+\pi^-$ $\hookrightarrow K^0_S\pi^+$
  - Observed by BaBar, branching fraction, longitudinal polarization and CP asymmetry have also been measured [Phys.Rev.D83:051101,2011]
  - This is the first measurement by LHCb, larger statistics expected (Run 1 + Run 2)





- Simultaneous fit of B^+ and B^- decays
- Yields of $B^\pm$ signal candidates:

$$N(B^+) = 2208 \pm 53$$
$$N(B^-) = 2333 \pm 55$$

Candidates in signal region are retained for amplitude analysis

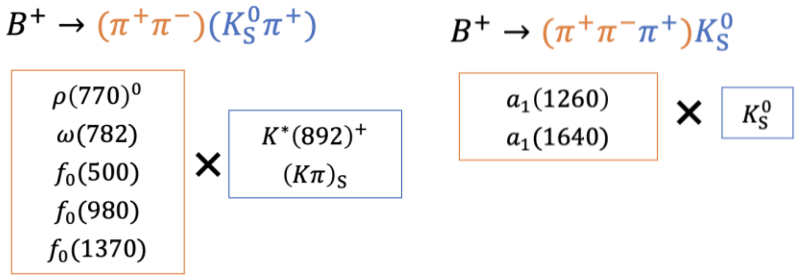
CPV and polarisation measurements in $B^+ \to \rho^0 K^{*+}$

[LHCb-PAPER-2025-026]
(In preparation)

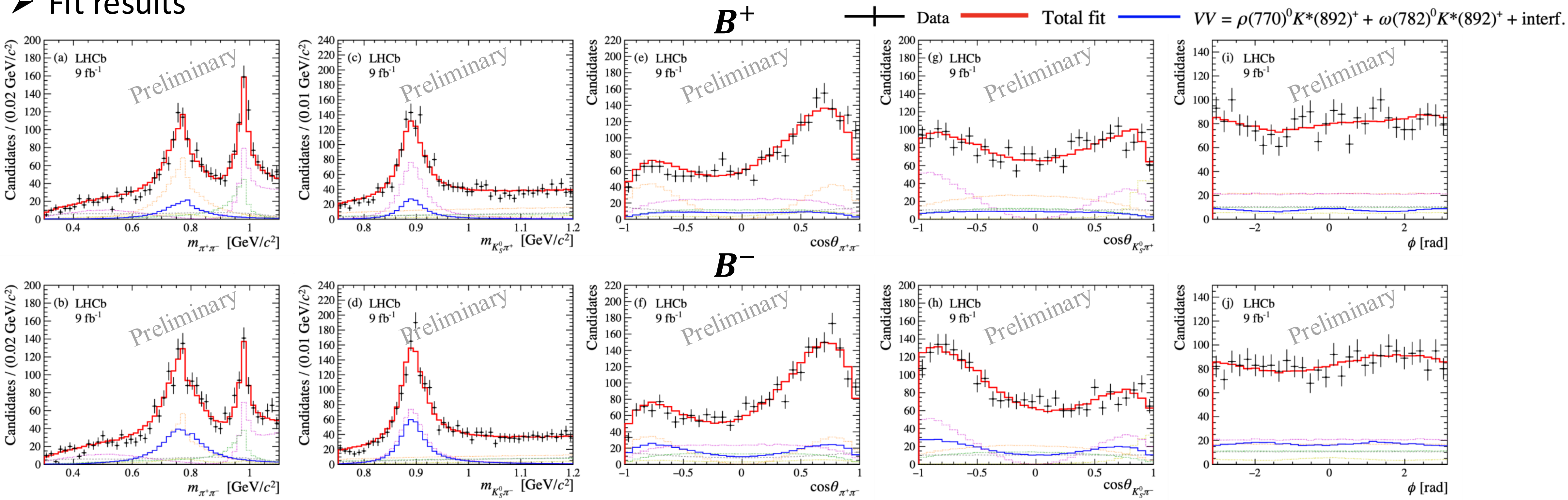
Preliminary!

- Study with an amplitude analysis of $B^+ \to (\pi^+\pi^-)(K_S^0\pi^+)$
  - $0.3 < m(\pi^+\pi^-) < 1.1\ \mathrm{GeV}/c^2$, $0.75 < m(K_S^0\pi^+) < 1.2\ \mathrm{GeV}/c^2$

➢ Resonances considered



➢ Fit results



CPV and polarisation measurements in $B^+ \to \rho^0 K^{*+}$

[LHCb-PAPER-2025-026] (In preparation)

Preliminary!

- Results

- CP-averaged longitudinal polarization fractions

$$f_L^{\mathrm{avg}} \equiv \frac{|A_0|^2 + |\bar{A}_0|^2}{\Sigma_{\lambda\in\{0,\parallel,\perp\}}(|A_\lambda|^2 + |\bar{A}_\lambda|^2)} = 0.721 \pm 0.027(\mathrm{stat}) \pm 0.030(\mathrm{syst})$$

- Using likelihood-ratio test, significance of CP violation for $B^+ \to \rho K^{*+}$ decay is above 9σ taking systematics into account

First observation of CP violation in this decay

- Direct CP asymmetry

$$\mathcal{A}_{CP}^{\mathrm{dir}} \equiv \frac{\Sigma_{\lambda\in\{0,\parallel,\perp\}}(|\bar{A}_\lambda|^2 - |A_\lambda|^2)}{\Sigma_{\lambda\in\{0,\parallel,\perp\}}(|\bar{A}_\lambda|^2 + |A_\lambda|^2)} = 0.506 \pm 0.062(\mathrm{stat}) \pm 0.025(\mathrm{syst})$$

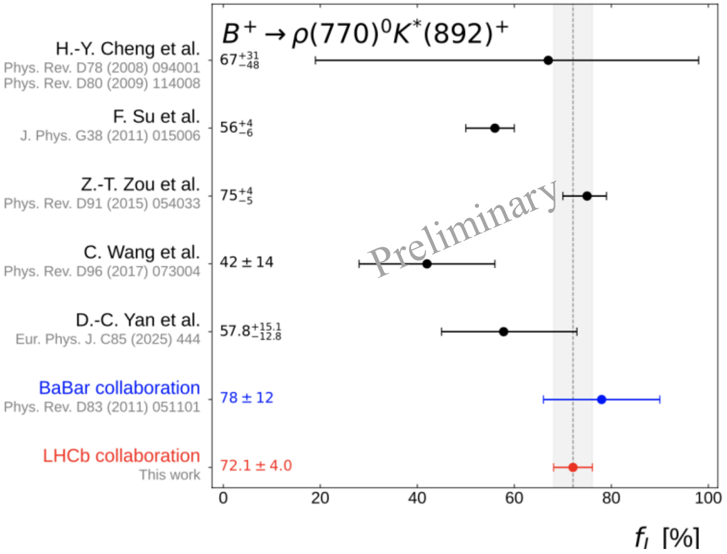
($\bar{A}_\lambda$ for B^-, A_λ for B^+)

- CP asymmetries for magnitude, phase and polarization

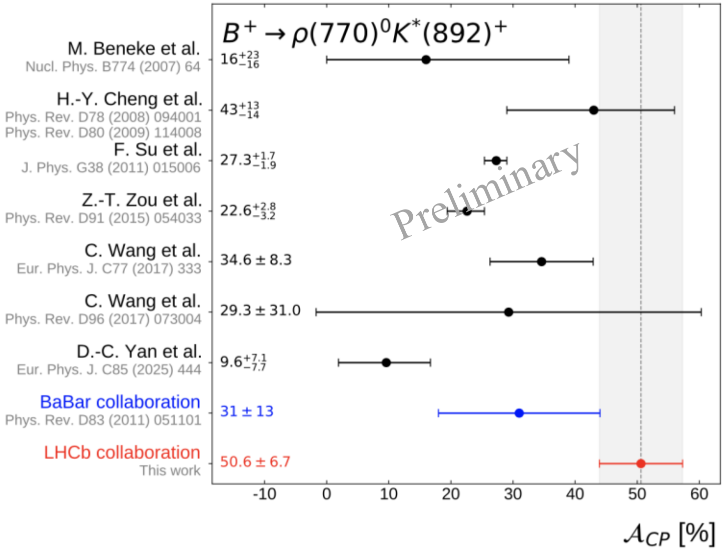
$$\mathcal{A}_{CP}(|A_0|^2) \equiv \frac{|\bar{A}_0|^2 - |A_0|^2}{|\bar{A}_0|^2 + |A_0|^2} = 0.666 \pm 0.081 \pm 0.048,$$

$$\Delta_{CP}(\delta_0) \equiv \bar{\delta}_0 - \delta_0 = 0.774 \pm 0.172 \pm 0.078$$

$$\mathcal{A}_{CP}(f_L) \equiv \frac{\bar{f}_L - f_L}{\bar{f}_L + f_L} = 0.241 \pm 0.083 \pm 0.050$$



- Theory
- BaBar
- This work

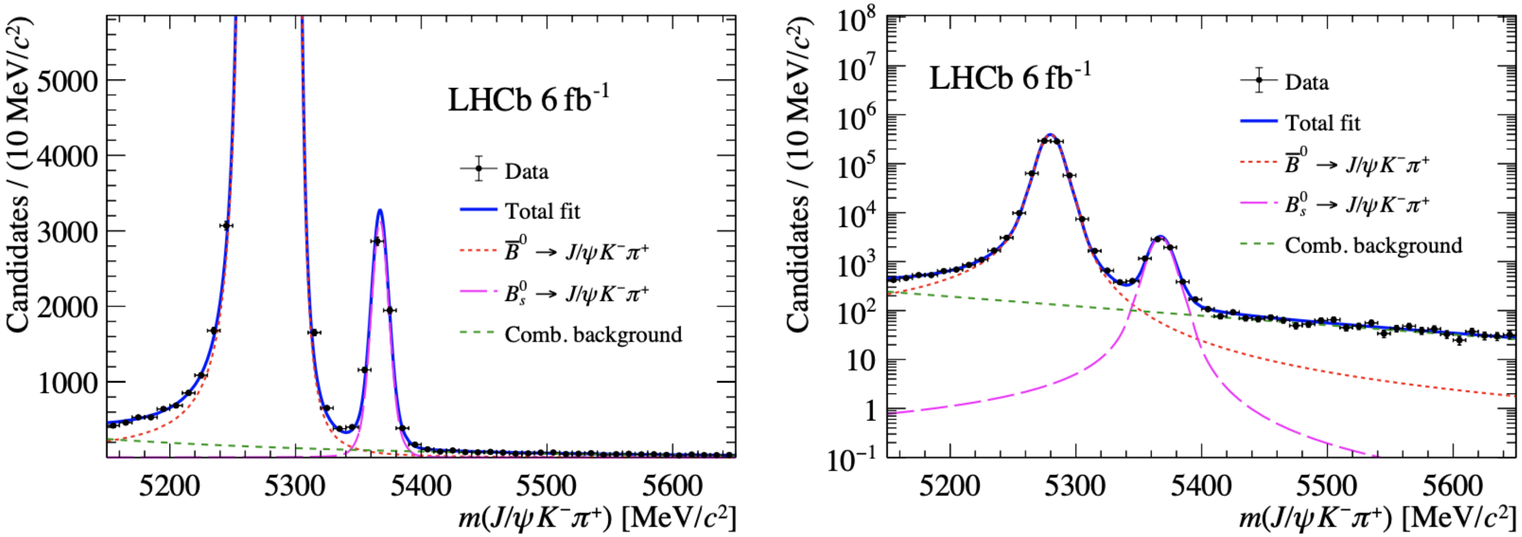


Consistent with and more precise than previous results

CPV and polarisation measurements in $B_s^0 \to J/\psi \overline{K}^{*0}$

[arXiv: 2506.22090]

- $B_s^0 \to J/\psi \overline{K}^*(892)^0$ decay is mediated by $b \to c\bar{c}d$ transition
  - Measuring its CP asymmetry can help to constrain penguin effects, improving the prediction and interpretation of the CP-violating phase $\phi_s^{c\bar{c}s}$ [Phys. Rev. D60 (1999) 073008]
- $B_s^0 \to J/\psi(\to \mu^+\mu^-)\overline{K}^{*0}(\to K^-\pi^+)$ has been measured by LHCb using Run1 data [JHEP 11 (2015) 082]
- This is an updated analysis using Run2 data

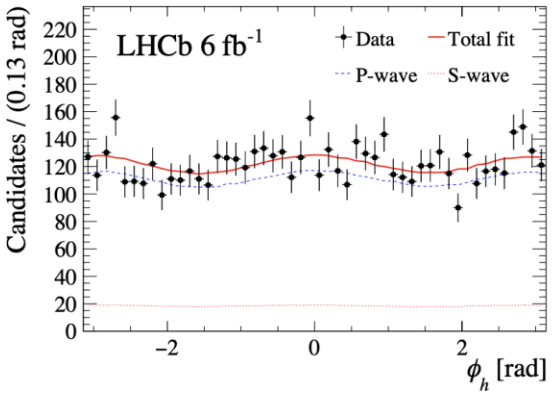


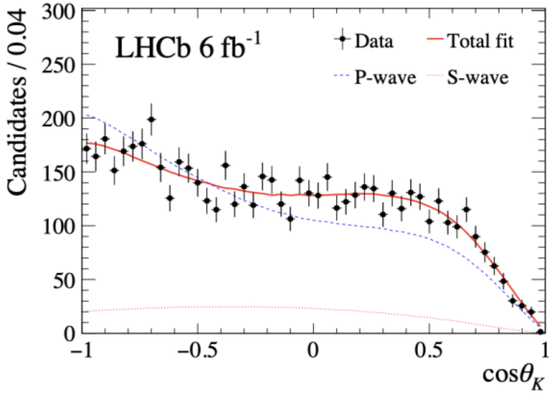
Invariant mass fit of $m(J/\psi K^-\pi^+)$ give:
$N_{B_s^0} = \quad 6\,098 \pm 84$ (stat)

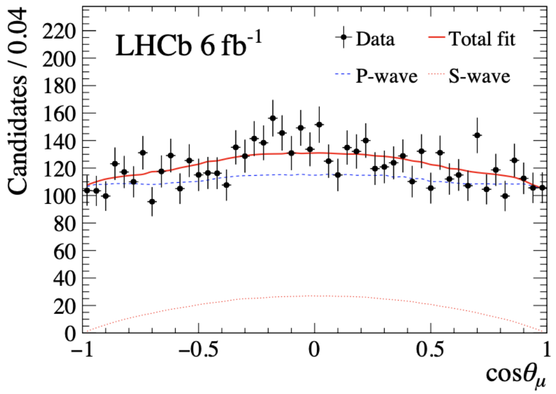
CPV and polarisation measurements in $B_s^0 \to J/\psi \bar{K}^{*0}$

[arXiv: 2506.22090]

- Contributions in angular analysis
  - P-wave $J/\psi\bar{K}^{*0}$: $A_0, A_\parallel, A_\perp$
  - S-wave $J/\psi(K\pi)$: A_S
- Angular fit results







- Results after combining Run 1 and Run 2

➢ CPV and polarization measurements

$$A_k^{CP} = \frac{\bar{\Gamma}_k - \Gamma_K}{\bar{\Gamma}_k + \Gamma_K},\ f_k = \frac{\Gamma_k^{\rm avg}}{\Gamma_0^{\rm avg} + \Gamma_\parallel^{\rm avg} + \Gamma_\perp^{\rm avg}},\ \text{where } \Gamma_k^{\rm avg} = (\bar{\Gamma}_k + \Gamma_K)/2$$

$$\begin{aligned}
f_0 &= 0.528 \pm 0.011\,(\text{stat}) \pm 0.009\,(\text{syst}),\\
f_\parallel &= 0.205 \pm 0.012\,(\text{stat}) \pm 0.005\,(\text{syst}),\\
A_0^{CP} &= 0.021 \pm 0.026\,(\text{stat}) \pm 0.007\,(\text{syst}),\\
A_\parallel^{CP} &= -0.073 \pm 0.060\,(\text{stat}) \pm 0.007\,(\text{syst}),\\
A_\perp^{CP} &= 0.057 \pm 0.049\,(\text{stat}) \pm 0.014\,(\text{syst}).
\end{aligned}$$

- The most precise determinations to date of the angular parameters
- CP asymmetries are consistent with zero within uncertainties

➢ Branching fraction measurement

- Normalization channel: $B^0 \to J/\psi K^{*0}$
- $\mathcal{B}(B_s^0 \to J/\psi \bar{K}^{*0}) = (4.13 \pm 0.12 \pm 0.07 \pm 0.14 \pm 0.45) \times 10^{-5}$

Stat. | Syst. | Hadronization fraction | Norm. channel

Search for the decay $B^0 \to \phi\phi$

[LHCb-PAPER-2025-018]
(In preparation)

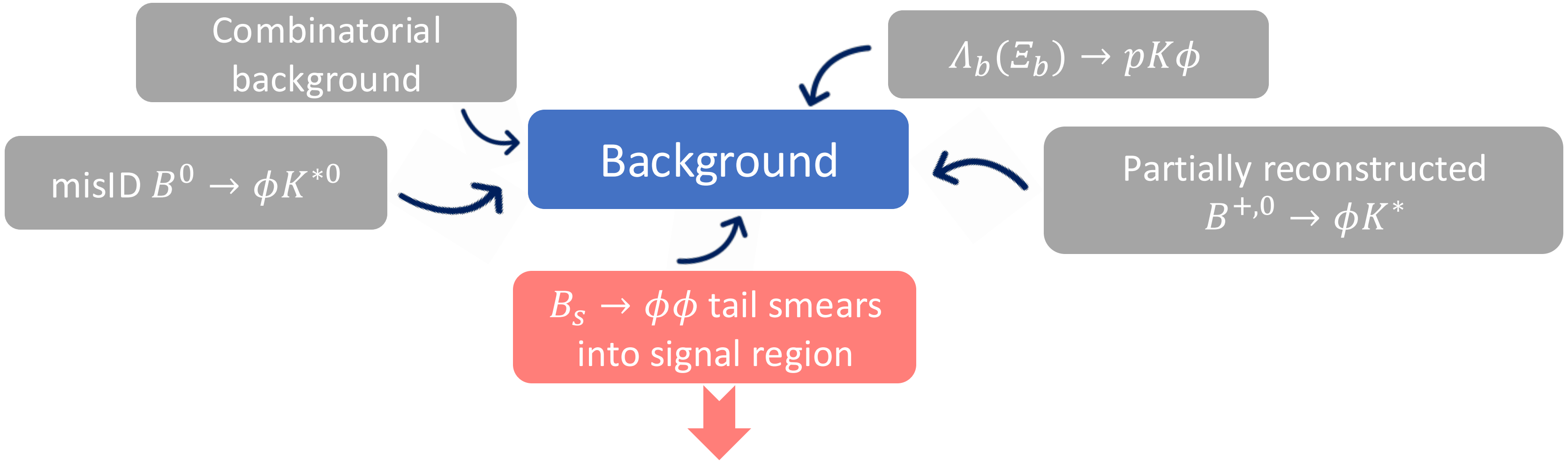
Preliminary!

- $B^0 \to \phi\phi$ decay proceeds via a $\bar{b}d \to s\bar{s}$ annihilation – heavily suppressed and not observed yet
  - At least one loop, Cabibbo suppressed, and Okubo–Zweig–Iizuka (OZI) suppressed
- Theoretical predictions for the branching fraction lie in the range $(0.5\text{–}5) \times 10^{-8}$
  - Branching fraction may be enhanced by long-range contributions or new physics models
- The most stringent limit to date is set by LHCb [JHEP 12 (2019) 155]
  - $\mathcal{B}(B^0 \to \phi\phi) < 2.7 \times 10^{-8}$ at 90% confidence level
- This work uses full Run1 and Run2 data
  - Double the statistics from the previous LHCb study
  - More detailed understanding of background sources allows to reduce the background significantly

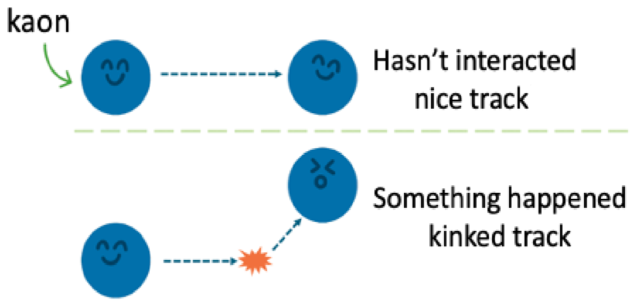
Search for the decay $B^0 \to \phi\phi$

- Backgrounds to control in $B^0 \to \phi(\to K^+K^-)\phi(\to K^+K^-)$ candidates

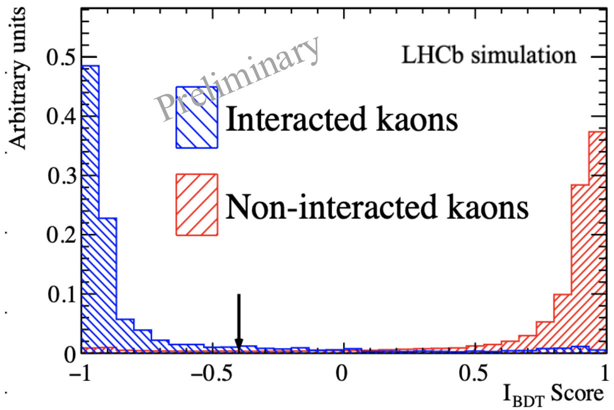
Preliminary!



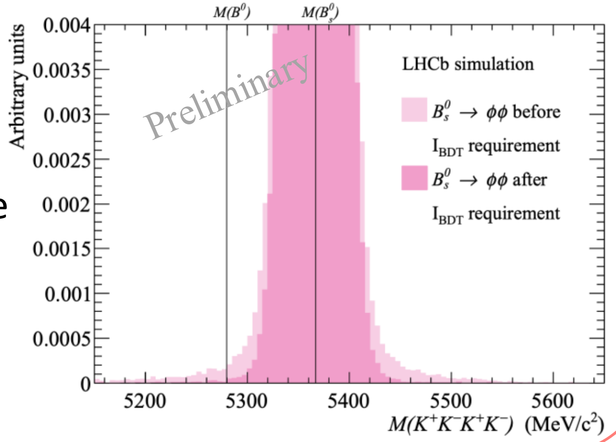
Kaon interactions: decay in flight or interact hadronically within the tracking system



Train a gradient boosted decision tree classifier to discriminate



Requirement on I_{BDT} score



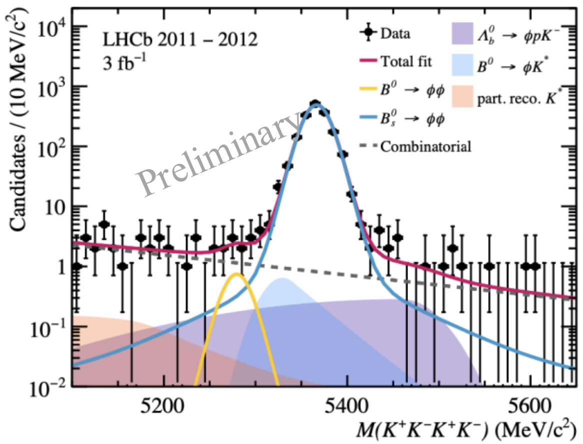
Search for the decay $B^0 \to \phi\phi$

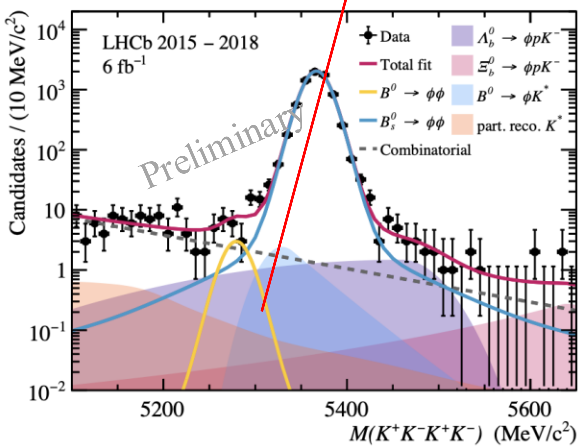
[LHCb-PAPER-2025-018]
(In preparation)

Preliminary!

- Mass fit results

Consistent with the background-only hypothesis at the level of 1.9σ

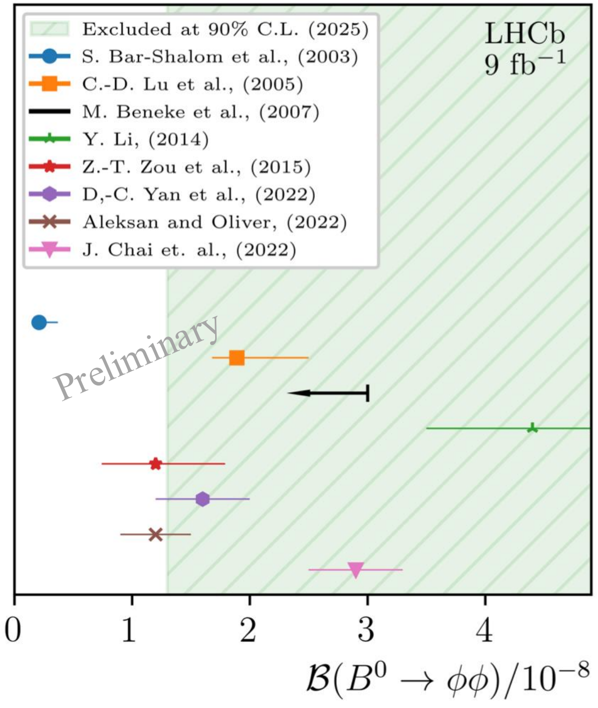




Signal yields:

- Run1: 2.6 ± 1.5
- Run2: 10.5 ± 6.3

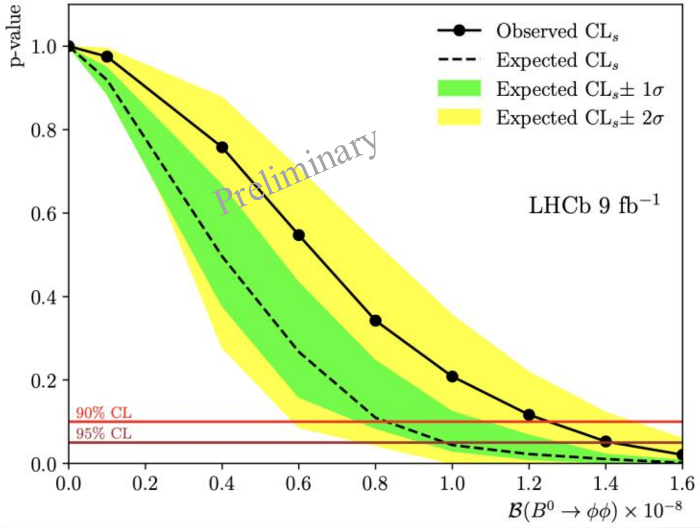
Compare with theoretical predictions



- $\mathrm{CL_S}$ method for setting an upper limit

$\mathcal{B}(B^0 \to \phi\phi) < 1.3\ (1.4) \times 10^{-8}$
at 90% (95%) confidence level

supersedes the previous LHCb limit, improving by a factor of two.



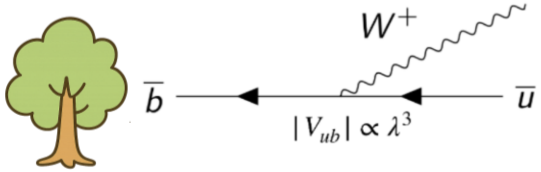
Searches for new decay modes and branching fraction measurements in charmless decays

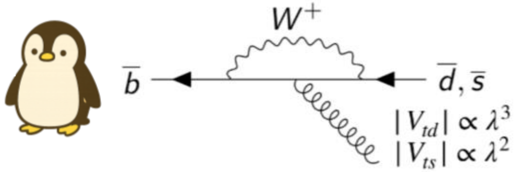
- Observation of the decay $B_s^0 \to K^0 p\bar{p}$ and measurement of the $B_{(s)}^0 \to K^0 p\bar{p}$ branching fractions [arXiv: 2504.21269]
- First observation of the charmless baryonic decay $B^+ \to \bar{\Lambda} p \bar{p} p$
  [LHCb-PAPER-2025-032] (In preparation)

Introduction to charmless decays

* B-hadron decays without charm or charmonium contributions in final states

- Suppressed in the Standard Model (SM)
- Proceed through $b \to u$ tree and $b \to s, d$ penguin transitions
  - have comparable magnitudes and a relative weak phase
  - Interference can give rise to CP violation in decay





- Multi-body decays also have rich resonance structures

➢ Provide inputs and tests for theoretical models

➢ Search for New Physics (NP)
  - Branching fractions and CP violations can differ from SM predictions
  - NP particles can contribute to penguin loops and additional sources of CP violation

Observation of $B_s^0 \to K^0 p\bar{p}$ and BF measurements of $B_{(s)}^0 \to K^0 p\bar{p}$

[arXiv: 2506.22090]

- $B_{(s)}^0 \to K^0 p\bar{p}$ decays proceed via both penguin and tree-level diagrams
  - Penguin: $b \to q\bar{q}s$ and $b \to q\bar{q}d$, spectator quarks are d and s (where $q = u, d$)
  - Tree-level: $b \to u$
- Threshold enhancement in $p\bar{p}$ mass distribution
  - Indicating the involvement of nontrivial intermediate states that influence the decay dynamics
- Branching fraction measurements are essential for testing and refining theoretical model
  - Relative branching fractions of $B^0 \to K^0 p\bar{p}$ and $B_s^0 \to K^0 p\bar{p}$ decays provide precise tests of flavour symmetries
  - $\mathcal{B}(B^0 \to K^0 p\bar{p})$ has been measured by Belle and BaBar, $B_s^0 \to K^0 p\bar{p}$ is yet to be observed
- Search for $B_s^0 \to K^0 p\bar{p}$ and measure branching fractions of $B_{(s)}^0 \to K^0 p\bar{p}$ decays using full Run 1 and Run 2 data collected by LHCb

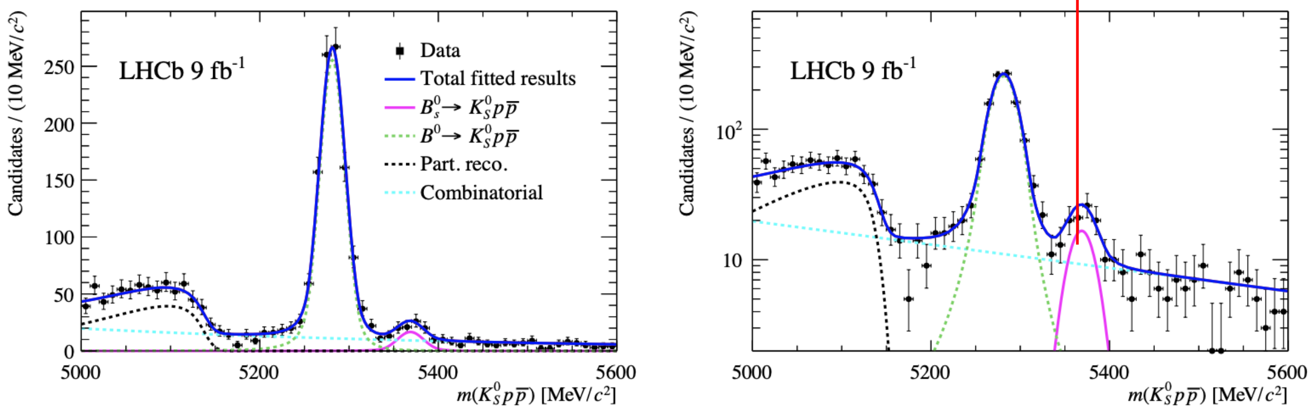
Observation of $B_s^0 \to K^0 p\bar{p}$ and BF measurements of $B_{(s)}^0 \to K^0 p\bar{p}$

[arXiv: 2506.22090]

- Results

$B_s^0 \to K_S^0 p\bar{p}$

Significance of 5.6σ



$B^0 \to K_S^0 \pi^+\pi^-$

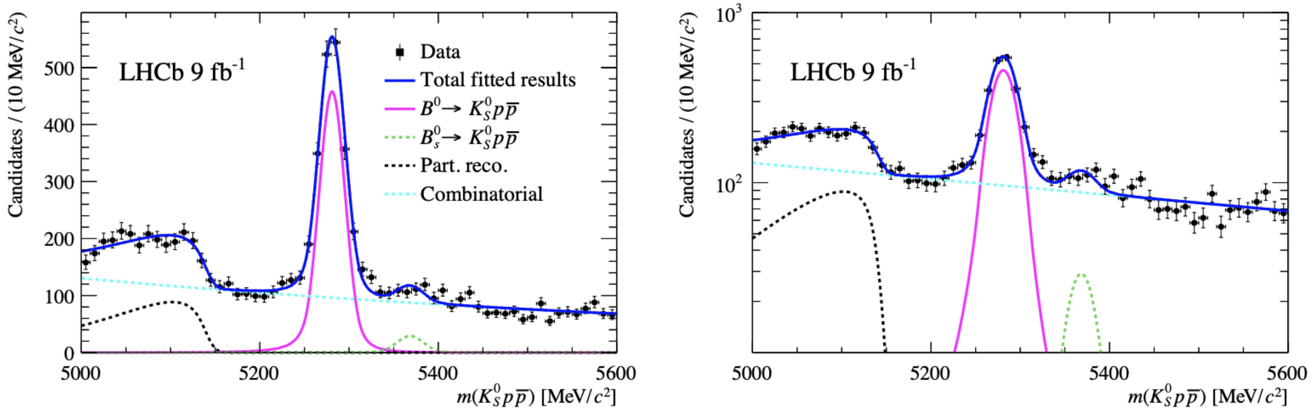
$N(B_s^0 \to K_S^0 p\bar{p}) = 66 \pm 12$

$\mathcal{B}(B_s^0 \to K^0 p\bar{p}) = (9.14 \pm 1.69 \pm 0.90 \pm 0.20 \pm 0.33) \times 10^{-7}$

Stat. Syst. Hadronization fraction Norm. channel

$$\frac{\mathcal{B}(B_s^0 \to K_S^0 p\bar{p})}{\mathcal{B}(B^0 \to K_S^0 p\bar{p})} = (3.25 \pm 0.61 \pm 0.36 \pm 0.07) \times 10^{-1}$$

$B^0 \to K_S^0 p\bar{p}$



$N(B^0 \to K_S^0 p\bar{p}) = 1791 \pm 52$

$\mathcal{B}(B^0 \to K^0 p\bar{p}) = (2.82 \pm 0.08 \pm 0.12 \pm 0.10) \times 10^{-6}$

consistent with and more precise than the world average value $(2.66 \pm 0.32) \times 10^{-6}$

Observation of charmless baryonic decay $B^+ \to \bar{\Lambda} p \bar{p} p$ [LHCb-PAPER-2025-032] (In preparation)

Preliminary!

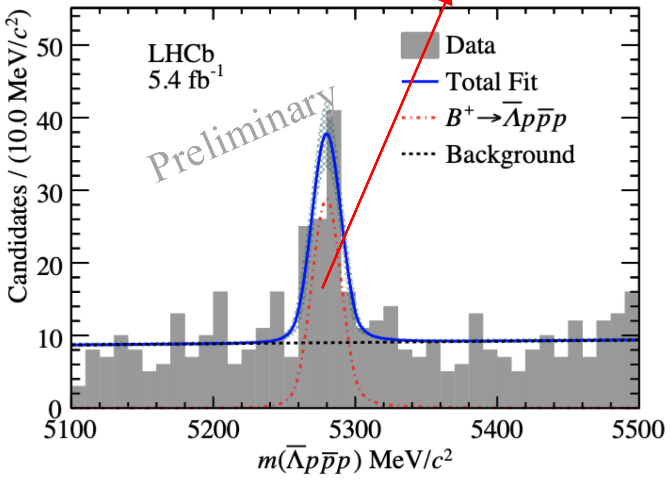
- Search for $B^+ \to \bar{\Lambda} p \bar{p} p$ decay
  - A purely baryonic 4-body decay
  - Theoretical prediction: $\mathcal{B}(B^+ \to \bar{\Lambda} p \bar{p} p) = (7.4^{+0.6}_{-0.2} \pm 0.03^{+3.6}_{-2.6}) \times 10^{-7}$ [Phys. Lett. B 845 (2023)138158]
- Explore the mass spectra
  - Double threshold enhancement of two baryon–antibaryon pairs $(\bar{\Lambda} p)$ and $(\bar{p} p)$
  - Benefit the study of baryonium-like bound states such as the $X(1835)$ and $X(2085)$
- This analysis uses 2016-2018 LHCb data

➢ CP asymmetry

$$\mathcal{A}_{CP} = (5.4 \pm 15.6(\text{stat}) \pm 2.4(\text{syst}))\%$$

➢ Mass fit

statistical significance of 9.2σ



$$N(B^+ \to \bar{\Lambda} p \bar{p} p) = 77.8 \pm 12.4$$

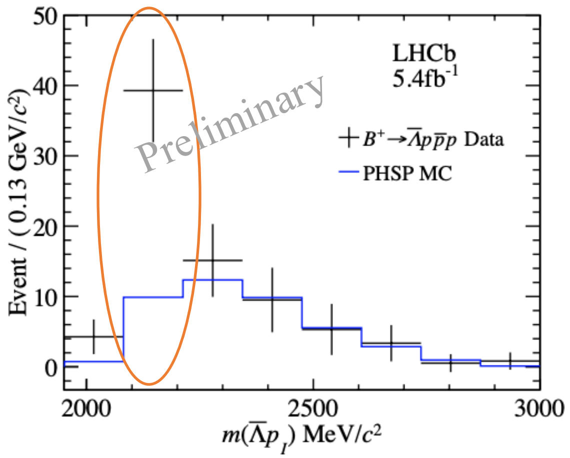
$$\mathcal{B}(B^+ \to \bar{\Lambda} p \bar{p} p) = (2.08 \pm 0.34 \pm 0.10 \pm 0.26) \times 10^{-7}$$

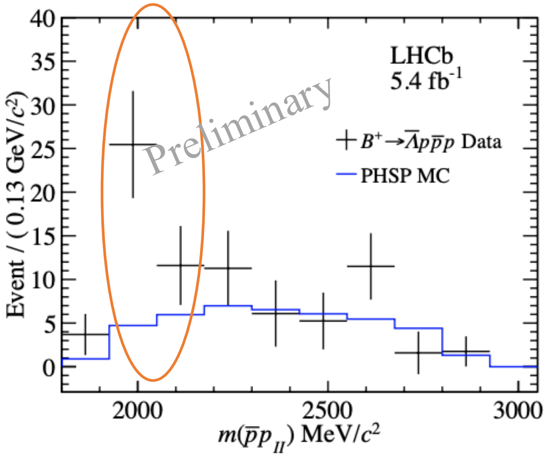
Stat. Syst. Norm. channel

$B^+ \to J/\psi(\to \bar{\Lambda} p K^-) K^+$

➢ Mass spectra

A clear double threshold enhancement is observed





Summary

- LHCb provides a rich environment to study the dynamics of B decays
- Recent results on $B \to VV$ and charmless decays (shown in this talk)
  - $B^+ \to \rho^0 K^{*+}$: first observation of CPV in this decay, precise measurement of polarisation
  - $B_s^0 \to J/\psi \bar{K}^{*0}$: updated precise measurements of BF, CPV and polarisation
  - $B^0 \to \phi\phi$: improve upper limit of BF by a factor of two
  - $B_{(s)}^0 \to K^0 p\bar{p}$: observation of $B_s^0 \to K^0 p\bar{p}$ and precise measurement of BF of $B_{(s)}^0 \to K^0 p\bar{p}$
  - $B^+ \to \bar{\Lambda} p\bar{p}p$: observation of this purely baryonic decay, measure BF and CPV
- Many new results **with high precision from LHCb** using Run 1 and Run 2 data
  - Provide crucial inputs for testing and refining theoretical models
  - More analyses using Run 3 data are on the way, with largely increased statistics and higher efficiency

Thanks!

BackUp

CPV and polarisation measurements in $B^+ \to \rho^0 K^{*+}$ [LHCb-PAPER-2025-026]

Preliminary!

- Previous study: by BaBar
  - Branching fraction $\mathcal{B}(B^+ \to \rho^0 K^{*+}) = (4.6 \pm 1.0 \pm 0.4) \times 10^{-6}$
  - Longitudinal polarization $f_L = 0.78 \pm 0.12 \pm 0.03$
  - Direct CP asymmetry $\mathcal{A}_{CP} = 0.31 \pm 0.13 \pm 0.03$
- Definition of f_L
  - B^+: $f_L = |A_0|^2/\Sigma_{\lambda\in\{0,\parallel,\perp\}}(|A_\lambda|^2)$, B^-: $\bar{f}_L = |\bar{A}_0|^2/\Sigma_{\lambda\in\{0,\parallel,\perp\}}(|\bar{A}_\lambda|^2)$
  - CP-average: $f_L^{\text{avg}} \equiv \frac{|A_0|^2+|\bar{A}_0|^2}{\Sigma_{\lambda\in\{0,\parallel,\perp\}}(|A_\lambda|^2+|\bar{A}_\lambda|^2)}$, CP-asymmetry: $\mathcal{A}_{CP}(f_L) \equiv \frac{\bar{f}_L - f_L}{\bar{f}_L + f_L}$
- Triple Product Asymmetries (TPA)
  - To study the CP violation between interferences of two amplitudes
  - A nonzero TPA can either be due to a CP-violating phase ($true$) or a CP-conserving phase induced by final-state interactions ($fake$) [Eur. Phys. J. C 81 (2021) 806, Phys. Rev. D 84 (2011) 096013]

$$\mathcal{A}^{(1)}_{\substack{true\\fake}} \equiv -\frac{2\sqrt{2}}{\pi}\frac{\Im(A_\perp A_0^* \mp \bar{A}_\perp \bar{A}_0^*)}{\sum_{\lambda\in\{0,\parallel,\perp\}}(|A_\lambda|^2 + |\bar{A}_\lambda|^2)},$$

$$\mathcal{A}^{(2)}_{\substack{true\\fake}} \equiv -\frac{4}{\pi}\frac{\Im(A_\perp A_\parallel^* \mp \bar{A}_\perp \bar{A}_\parallel^*)}{\sum_{\lambda\in\{0,\parallel,\perp\}}(|A_\lambda|^2 + |\bar{A}_\lambda|^2)},$$

Measured to be →

$$\begin{aligned}\mathcal{A}^{(1)}_{true} &= -0.110 \pm 0.024 \pm 0.009, \quad 4.3\sigma\\ \mathcal{A}^{(2)}_{true} &= 0.005 \pm 0.019 \pm 0.005,\\ \mathcal{A}^{(1)}_{fake} &= -0.155 \pm 0.024 \pm 0.009,\\ \mathcal{A}^{(2)}_{fake} &= 0.012 \pm 0.018 \pm 0.006.\end{aligned}$$

CPV and polarisation measurements in $B_s^0 \to J/\psi \bar{K}^{*0}$

[arXiv: 2506.22090]

- Angular basis functions $G_k(\Omega)$ and the corresponding amplitude products a_k

Index k	Amplitude product a_k	Angular function $G_k(\Omega_{\text{hel}})$
1 (0)	$\|A_0\|^2$	$\frac{9}{16\pi}\cos^2\theta_K(1-\cos^2_{\theta_\mu})$
2 ($\parallel$)	$\|A_\parallel\|^2$	$\frac{9}{32\pi}(1-\cos^2\theta_K)(1-(1-\cos^2_{\theta_\mu})\cos^2\phi_h)$
3 ($\perp$)	$\|A_\perp\|^2$	$\frac{9}{32\pi}(1-\cos^2\theta_K)((1-\cos^2_{\theta_\mu})\cos^2\phi_h+\cos^2_{\theta_\mu})$
4	$\mathcal{Im}(A_\parallel^* A_\perp)$	$\frac{9}{16\pi}(1-\cos^2\theta_K)(1-\cos^2_{\theta_\mu})\sin(2\phi_h)$
5	$\mathcal{Re}(A_0^* A_\parallel)$	$\frac{9\sqrt{2}}{16\pi}\cos\theta_K\cos_{\theta_\mu}\sqrt{(1-\cos^2\theta_K)(1-\cos^2_{\theta_\mu})}\cos\phi_h$
6	$\mathcal{Im}(A_0^* A_\perp)$	$\frac{9\sqrt{2}}{16\pi}\cos\theta_K\cos_{\theta_\mu}\sqrt{(1-\cos^2\theta_K)(1-\cos^2_{\theta_\mu})}\sin\phi_h$
7 (S)	$\|A_S\|^2$	$\frac{3}{16\pi}(1-\cos^2_{\theta_\mu})$
8	$\mathcal{Re}(A_S^* A_\parallel)$	$\frac{3\sqrt{6}}{16\pi}\cos_{\theta_\mu}\sqrt{(1-\cos^2\theta_K)(1-\cos^2_{\theta_\mu})}\cos\phi_h$
9	$\mathcal{Im}(A_S^* A_\perp)$	$\frac{3\sqrt{6}}{16\pi}\cos_{\theta_\mu}\sqrt{(1-\cos^2\theta_K)(1-\cos^2_{\theta_\mu})}\sin\phi_h$
10	$\mathcal{Re}(A_S^* A_0)$	$\frac{3\sqrt{3}}{8\pi}\cos\theta_K(1-\cos^2_{\theta_\mu})$

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- Run2 results

$$\mathcal{B}(B_s^0 \to J/\psi \overline{K}^{*0}) = (4.07 \pm 0.15\,(\text{stat}) \pm 0.07\,(\text{syst}) \pm 0.13\,(\frac{f_d}{f_s}) \pm 0.45\,(\mathcal{B}_{B^0})) \times 10^{-5}.$$

$$\begin{aligned} f_0 &= 0.534 \pm 0.012\,(\text{stat}) \pm 0.009\,(\text{syst}), \\ f_{\parallel} &= 0.211 \pm 0.014\,(\text{stat}) \pm 0.005\,(\text{syst}). \end{aligned}$$

$$\begin{aligned} A_0^{CP} &= 0.014 \pm 0.029\,(\text{stat}) \pm 0.007\,(\text{syst}), \\ A_{\parallel}^{CP} &= -0.055 \pm 0.065\,(\text{stat}) \pm 0.007\,(\text{syst}), \\ A_{\perp}^{CP} &= 0.060 \pm 0.057\,(\text{stat}) \pm 0.016\,(\text{syst}). \end{aligned}$$

- Run1 results

$$\mathcal{B}(B_s^0 \to J/\psi\, \overline{K}^{*0}) = (4.14 \pm 0.18(\text{stat}) \pm 0.26(\text{syst}) \pm 0.24(f_d/f_s)) \times 10^{-5}$$

$$\begin{aligned} f_0 &= 0.497 \pm 0.025\ (\text{stat}) \pm 0.025\ (\text{syst}) \\ f_{\parallel} &= 0.179 \pm 0.027\ (\text{stat}) \pm 0.013\ (\text{syst}) \\ A_0^{CP}(B_s^0 \to J/\psi\, \overline{K}^{*0}) &= -0.048 \pm 0.057\ (\text{stat}) \pm 0.020\ (\text{syst}) \\ A_{\parallel}^{CP}(B_s^0 \to J/\psi\, \overline{K}^{*0}) &= 0.171 \pm 0.152\ (\text{stat}) \pm 0.028\ (\text{syst}) \\ A_{\perp}^{CP}(B_s^0 \to J/\psi\, \overline{K}^{*0}) &= -0.049 \pm 0.096\ (\text{stat}) \pm 0.025\ (\text{syst})\,, \end{aligned}$$