Charmed hadron properties and spectroscopy at LHCb

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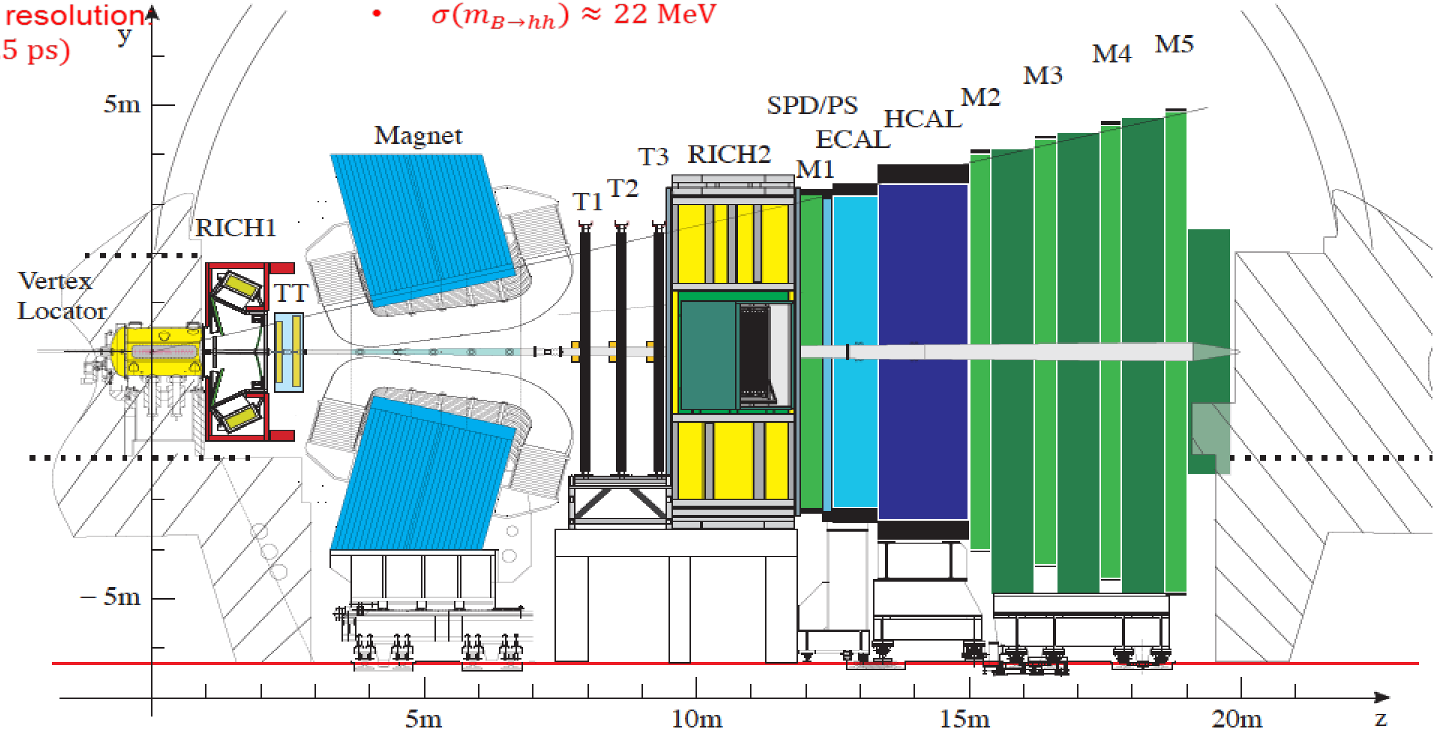
LHCb experiment in Run 1 + Run 2

LHCb detector Run 1 + 2

- General purpose detector in forward region with a special focus on heavy flavour physics
- Successful operation in Run 1 (2010-2012) and 2 (2015-2018), upgraded for Run 3 (2022-2025)

Vertex Locator(vertex reconstruction)
- Impact parameter resolution: 20 μm
- Decay time resolution 45 fs (τ_B~1.5 ps)

Tracking system(particle reconstruction)
- ϵ(Tracking) ~96%
- $\delta p/p$ ~0.5%-1%(5-200 GeV)
- $\sigma(m_{B\to hh}) \approx$ 22 MeV



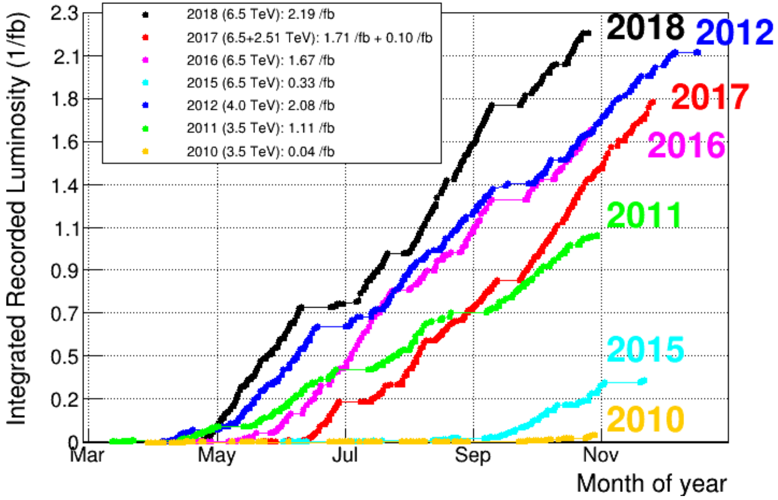
RICH: particle ID
- $\varepsilon(K \to K)$ ~95%
- Mis-ID: $\varepsilon(\pi \to K)$ ~5%

Magnet
- Bending power: 4 Tm

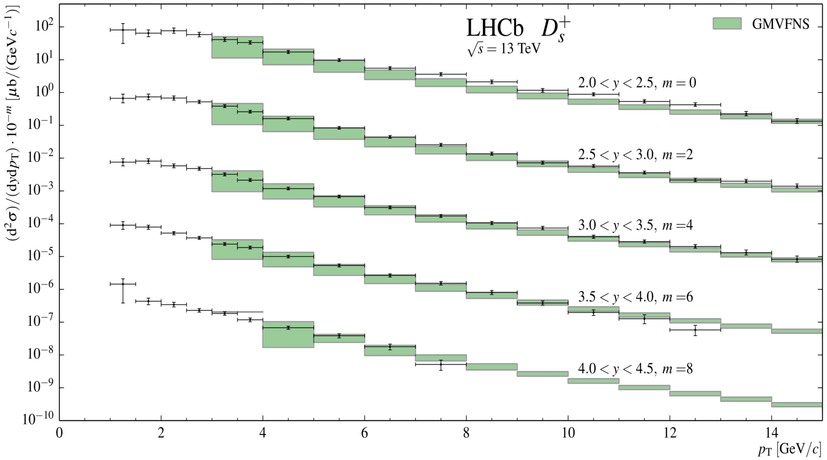
Muon system
- μ ID: $\varepsilon(\mu \to \mu)$ ~97%
- Mis-ID: $\varepsilon(\pi \to \mu)$ ~1-3%

Data collected by LHCb

- Successful operation in Run 1 and Run 2
- Annual data-taking efficiency above 90 %
- Various collision systems:
  - pp, p-Pb, Pb-Pb, SMOG (fixed target-like)
- Recorded substantial amount of data
  - Run 1: ~ 3 fb^{-1}
  - Run 2: ~ 6 fb^{-1}



- Largest recorded sample of heavy flavour hadrons
- LHCb historically focused mostly on decays with charged hadrons or muons in the final state
  - Increasing amount of studies involving neutral particles such as π^0 and ɣ
  - Progress on electron PID and bremsstrahlung corrections allowing wider usage of electron modes
  - Better understanding of relatively long-lived particles decaying outside of VELO (K^{0,} Λ^0, ...)



JHEP 05 074 (2017)

Precise measurements of Ω_c^0 baryon

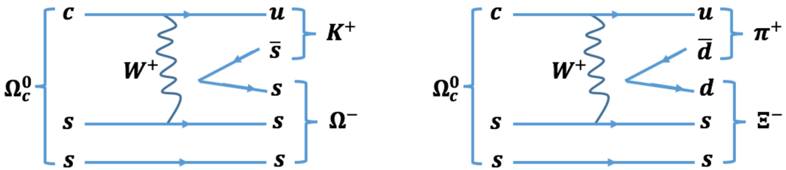
[PRL 132, 081802 (2024)]

Ω_c^0 measurement: analysis motivation

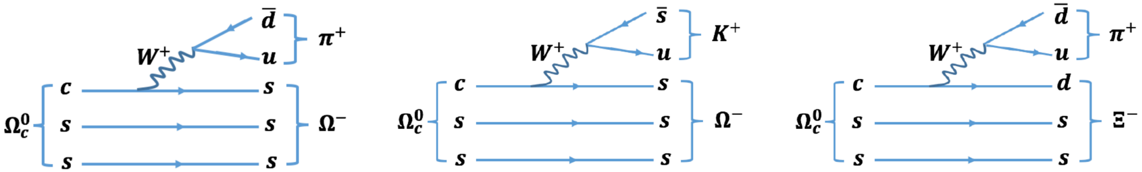
- Ω_c^0 is the least probed singly charmed baryon
  - Not accessible on various charm-factories such as BESIII

- No observation of singly Cabibbo-supressed (SCS) decays Ω_c^0 -> $\Xi^-\pi^+$ and Ω_c^0 -> Ω^-K^+
  - First evidence of $\Omega_c^0 \rightarrow \Xi^-\pi^+$ published by Belle [JHEP01(2023) 055]
  - Wide range of theoretical predictions for $\Xi^-\pi^+$ (1.96×10^{-3} ~1.04×10^{-1})
  - No prediction available for Ω^-K^+

- Aim of this analysis:
  - Measure BFs of Ω_c^0 -> $\Xi^-\pi^+$ and Ω_c^0 -> Ω^-K^+
  - Precise measurement of Ω_c^0 mass using Ω_c^0 -> $\Omega^-\pi^+$



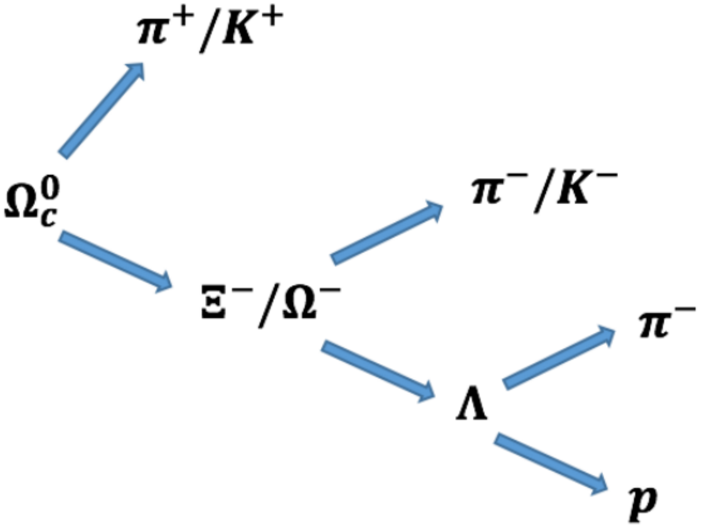
W-exchange: nonfactorizable contribution

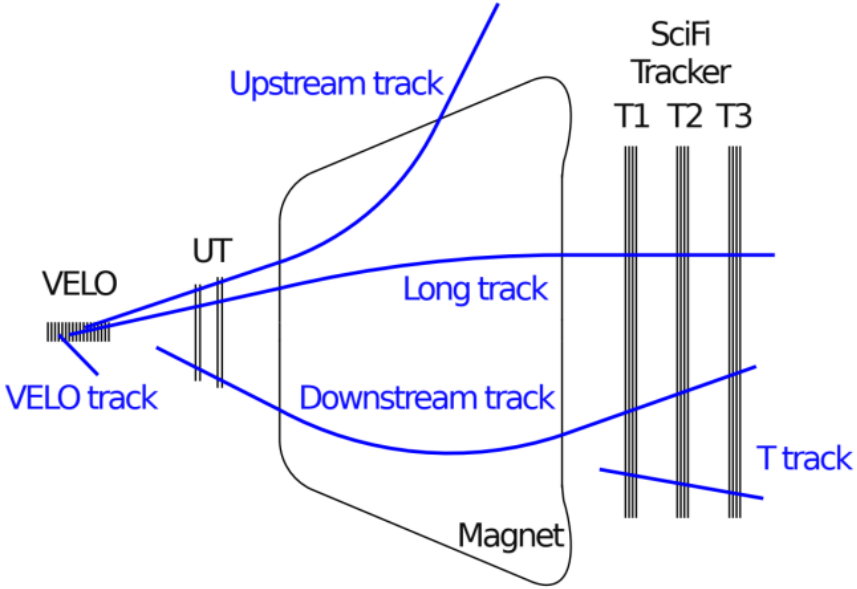


W-emission: factorizable contribution

Ω_c^0 measurement: dataset and unique challenges

- Analysis based on 2016-2018 LHCb data (5.5 fb^{-1})
  - Full online reconstruction and selection of signal candidates
  - LHCb Turbo model [Comput. Phys. Commun. 208 (2016) 35]
- Challenging analysis due to presence of two long-lived particles
  - Most of the signal events decaying outside of VELO
  - Various possible combinations of Long and Downstream tracks
- Analysis based on Ξ^- / Ω^- → $\Lambda\pi^-/K^-$ in Down-Down-Long configuration





Ω_c^0 measurement: analysis strategy

- Relative branching fraction measurement using a proper normalization decay channel

- $\Omega_c^0 \to \Omega^- \pi^+$ used as the normalization channel due to its relatively high yield and same topology

- Relative branching fractions then can be calculated as:

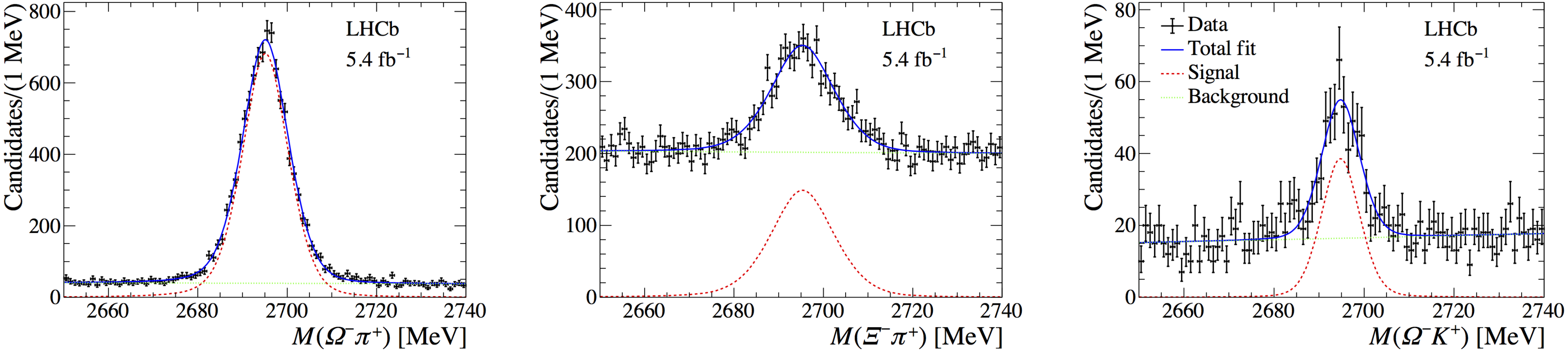
$$R(\Omega_c^0 \to \Xi^- \pi^+) \equiv \frac{\mathcal{B}(\Xi^- \pi^+)}{\mathcal{B}(\Omega^- \pi^+)} = \frac{N(\Xi^- \pi^+)}{N(\Omega^- \pi^+)} \cdot \frac{\mathcal{B}(\Omega^- \to \Lambda K^-)}{\mathcal{B}(\Xi^- \to \Lambda \pi^-)} \cdot \frac{\varepsilon(\Omega^- \pi^+)}{\varepsilon(\Xi^- \pi^+)}$$

$$R(\Omega_c^0 \to \Omega^- K^+) \equiv \frac{\mathcal{B}(\Omega^- K^+)}{\mathcal{B}(\Omega^- \pi^+)} = \frac{N(\Omega^- K^+)}{N(\Omega^- \pi^+)} \cdot \frac{\varepsilon(\Omega^- \pi^+)}{\varepsilon(\Omega^- K^+)}$$

- Where:
  - *B:* branching fraction
  - N: Yield of the specific decay mode
  - ϵ: related total experimental efficiency

Ω_c^0 measurement: invariant mass fit

- Extended unbinned maximum likelihood fits are performed to full dataset
- Signal is based on Johnson SU + Gaussian distribution, the tail and fraction of Johnson are fixed from simulation
- Background is modeled by an Exponential



Decay modes	$\Omega_c^0 \to \Omega^-\pi^+$	$\Omega_c^0 \to \Xi^-\pi^+$	$\Omega_c^0 \to \Omega^-K^+$
Mass (MeV/c^2)	2695.28 ± 0.07	2695.62 ± 0.34	2694.77 ± 0.35
Resolution (MeV/c^2)	5.40 ± 0.07	7.39 ± 0.41	4.31 ± 0.45
N_{signal}	9326.4 ± 111.4	2779.1 ± 146.3	425.0 ± 35.1

Ω_c^0 measurement: results

- The first observation of singly Cabbibo-suppressed decays of $\Omega_c^0 \to \Xi^-\pi^+$ and $\Omega_c^0 \to \Omega^- K^+$
- Ratio of Branching fraction obtained:

$$\frac{\mathcal{B}(\Omega_c^0 \to \Omega^- K^+)}{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)} = [6.08 \pm 0.51\,(\text{stat}) \pm 0.40\,(\text{syst})]\%,$$

$$\frac{\mathcal{B}(\Omega_c^0 \to \Xi^- \pi^+)}{\mathcal{B}(\Omega_c^0 \to \Omega^- \pi^+)} = [15.81 \pm 0.87\,(\text{stat}) \pm 0.44\,(\text{syst}) \pm 0.16\,(\text{ext})]\%$$

- Results showing some tension with the theory predictions:
  - $\Omega_c^0 \to \Omega^- K^+ / \Omega_c^0 \to \Xi^-\pi^+$ is larger than 10.38 % predicted by algebra with factorizable and nonfactorizable amplitudes [Phys. Rev. D 101, 094033 (2020)]
  - Light-front quark model using only the external W-emission then predicts value of 3.45 % [Eur. Phys. J. C 80, 1066 (2020), Chin. Phys. C 42, 093101 (2018)]

- Ω_c^0 mass is consistent with the PDG value and while the precision is improved by a factor 4:

$$M(\Omega_c^0) = 2695.28 \pm 0.07\,(\text{stat}) \pm 0.27\,(\text{syst}) \pm 0.30\,(\text{ext})\ \text{MeV}$$

- Mass difference between Ω_c^0 and Ω^- obtained as:

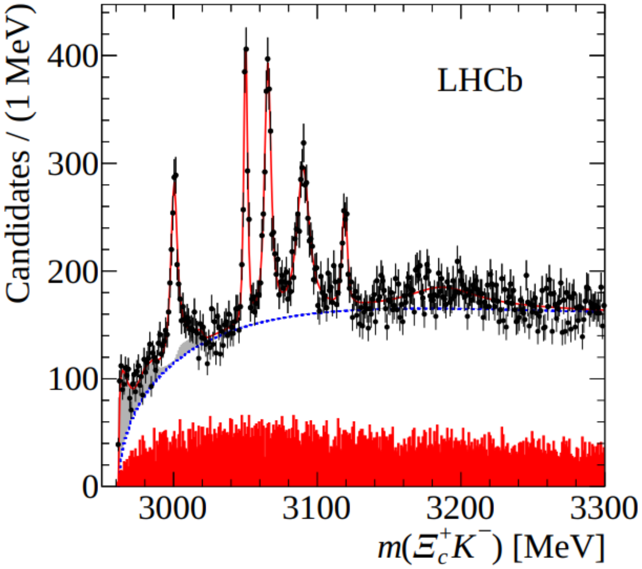
$$m(\Omega_c^0) - m(\Omega^-) = 1022.83 \pm 0.07\,(\text{stat}) \pm 0.27\,(\text{syst})\ \text{MeV}/c^2$$

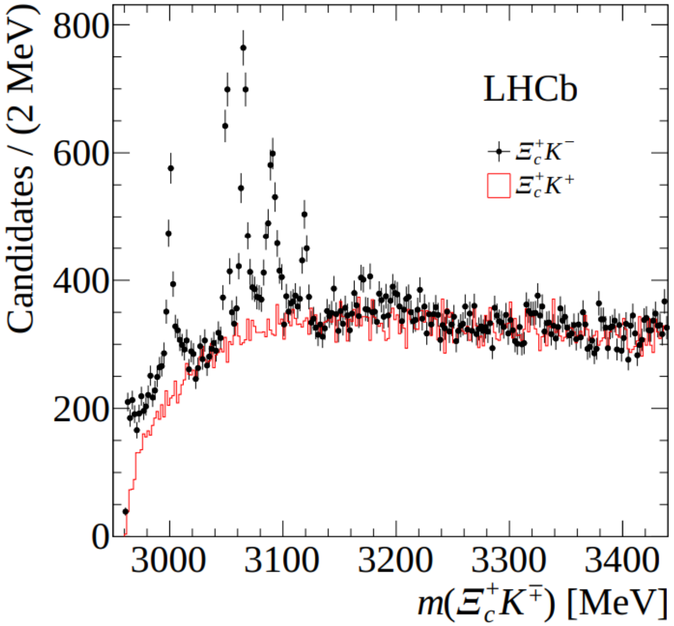
Observation of new Ω_c^0 states decaying to the $\Xi_c^+K^-$ final state

[PRL. 131 (2023) 131902]

New excited Ω_c^0 states: status in 2017

- In 2017 LHCb studied $\Xi_c^+K^-$ spectrum up to 3450 MeV using 3.3 fb^{-1} of data [PRL 118 (2017) 182001]





- Five new Ω_c^0 states observed:
  - $\Omega_c(3000)^0$, $\Omega_c(3050)^0$, $\Omega_c(3066)^0$, $\Omega_c(3090)^0$, $\Omega_c(3119)^0$
  - Hint on another broad structure around 3200 and 3300 MeV

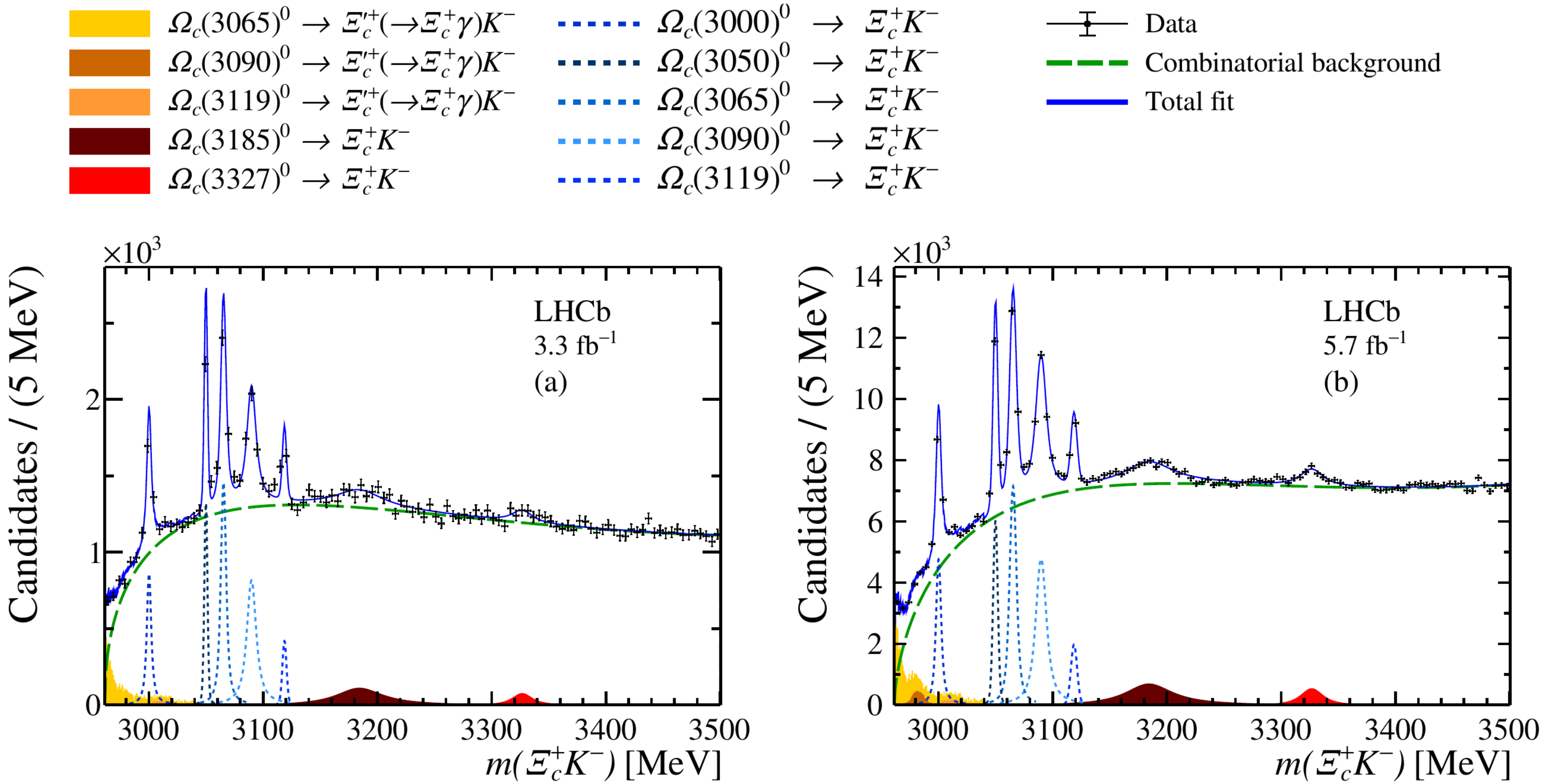
New excited Ω_c^0 states: motivation and data

- New states can be described by heavy quark effective theory
- However large difference in predictions for masses and quantum numbers diverges in different models
  - Lattice quantum chromodynamics predicts invariant-mass spectrum with D or F–wave excited states [PRL 119 042001]
  - Baryon-meson molecular (quasi-bound) states interpretation for $\Omega_c(3050)^0$ and $\Omega_c(3090)^0$ [PRD 97 (2018) 094035 , EPJ. A54 (2018) 64, Few Body Syst. 61 (2020) 34]
  - Interpretation as pentaquark states [PRD96 (2017) 034012, CTP 73 (2021) 035201]

- New study is based on a full LHCb data-set of 9 fb^{-1}
- Data are split into two samples
  - Previously analysed data from Run 1 and 2015 (3.3 fb^{-1})
  - Newly added 2016-2018 data (5.7 fb^{-1})
  - Higher instantaneous luminosity and improved trigger result into five times large data-set
  - Dedicated selection and BDT training per sample
- BDT trained with a special focus not to favour any particular excited state
- $\Omega_c(X)^0$ candidates are described by S-wave relativistic Breit–Wigner functions convolved with a Gaussian resolution function

New excited Ω_c^0 states: results

- In total 7 states are reported, including two new states $\Omega_c(3185)^0$ and $\Omega_c(3327)^0$
- Several checks performed to confirm the existence of new states:
  - Splitting data into subsamples based on data-taking conditions, charge combination ($\Xi_c^+K^-$ or $\Xi_c^-K^+$) and different kinematic regions of pT(K^-) and pT(Ξ_c^+)



First determination of the spin-parities of the $\Xi_c(3055)^{+(0)}$ baryons

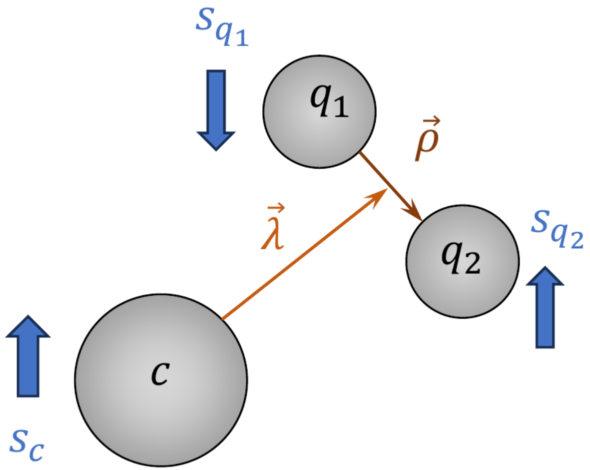
[LHCb-PAPER-2024-018; to be submitted to PRL]

New results

$\Xi_c(3055)^{+(0)}$ measurement: analysis motivation

- $\Xi_c(3055)^{+(0)}$ observed for the first time by Babar (Belle)

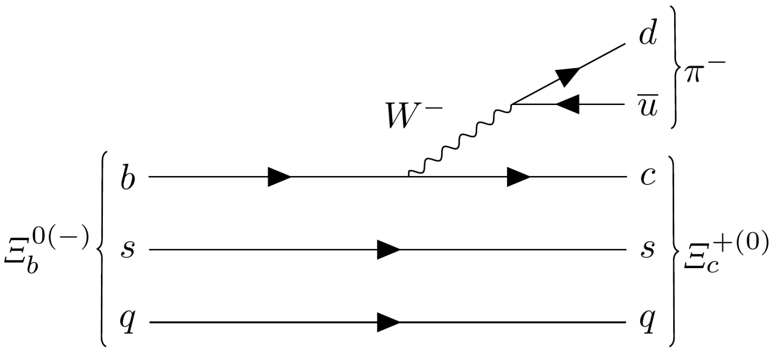
- Excitation modes of $\Xi_c(3055)^{+(0)}$ extensively studied in literature
  - Excitation can happen between heavy quark and diquark (ƛ-mode) or between two light quarks (ρ-mode)
- Many proposed interpretations, including:
  - D-wave excitation with the spin-parity (J^P) assignments of $3/2^+$, $5/2^+$ or $7/2^+$ [PRD 78 (2008) 056005]
  - Possible compatibility with the 2S excitation of the $\Xi_c(3F)$ or $\Xi_c(6F)$ states, with a possible J^P assignment of $1/2^+$ or $3/2^+$ [PRD 96 (2017) 114003]
  - Hadron molecular states are also proposed, favouring a J^P assignment of $1/2^-$ or $3/2^-$ [EPJC 79 (2019) 167]

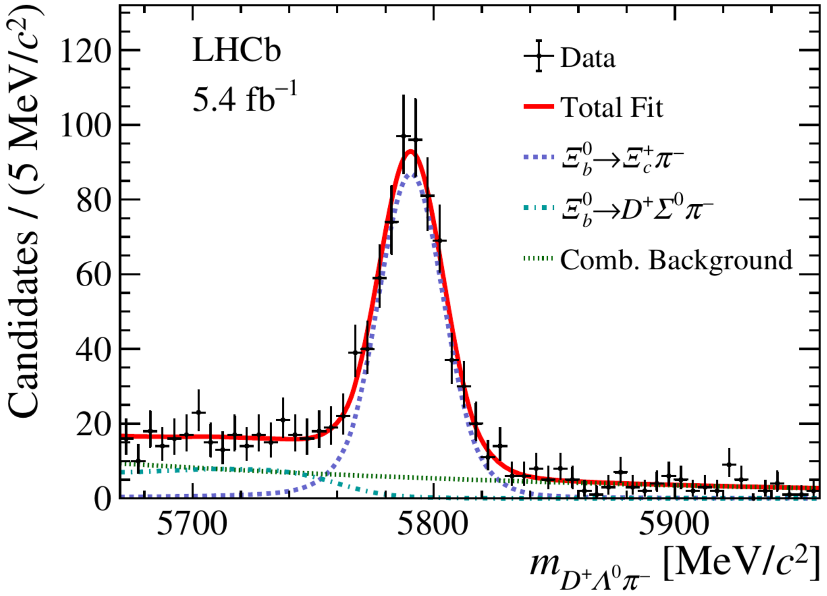


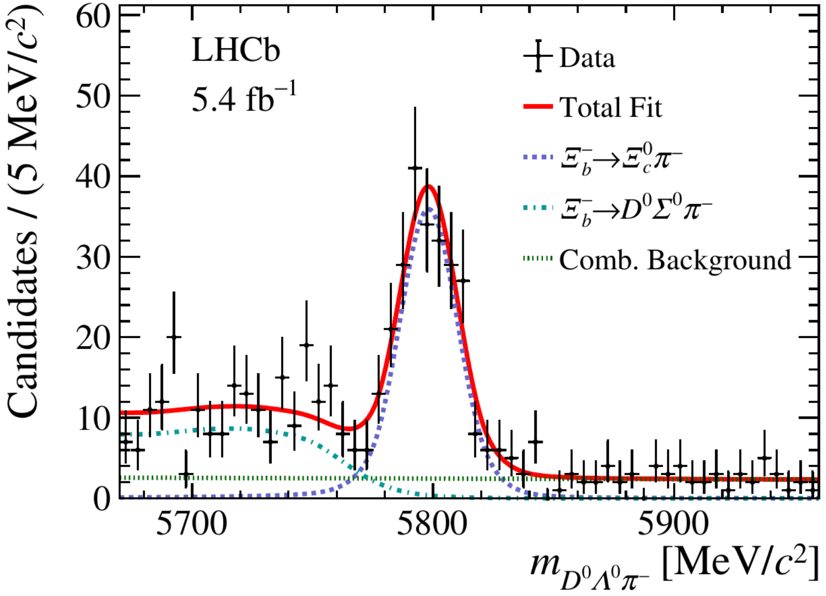
- Experimental determination of $\Xi_c(3055)^{+(0)}$ J^P is an important information for charm baryon spectroscopy

$\Xi_c(3055)^{+(0)}$ measurement: data

- Study of $\Xi_c(3055)^{+(0)}$ based on 2016-2018 data (5.4 fb^{-1})
- $\Xi_c(3055)^{+(0)}$ studied in decay of $\Xi_b^{0(-)}$
  - $\Xi_b^{0(-)} \rightarrow \Xi_c^{**+(0)}\pi^-$
  - $\Xi_c^{**+(0)} \rightarrow D^{+(0)}\Lambda^0$, $D^{+(0)} \rightarrow K\pi\pi(K\pi)$, $\Lambda^0 \rightarrow p\pi^-$
  - Λ^0 can be both Long-Long or Down-Down
- The total $\Xi_b^{0(-)}$ yields are 637 ± 31 (232 ± 19)

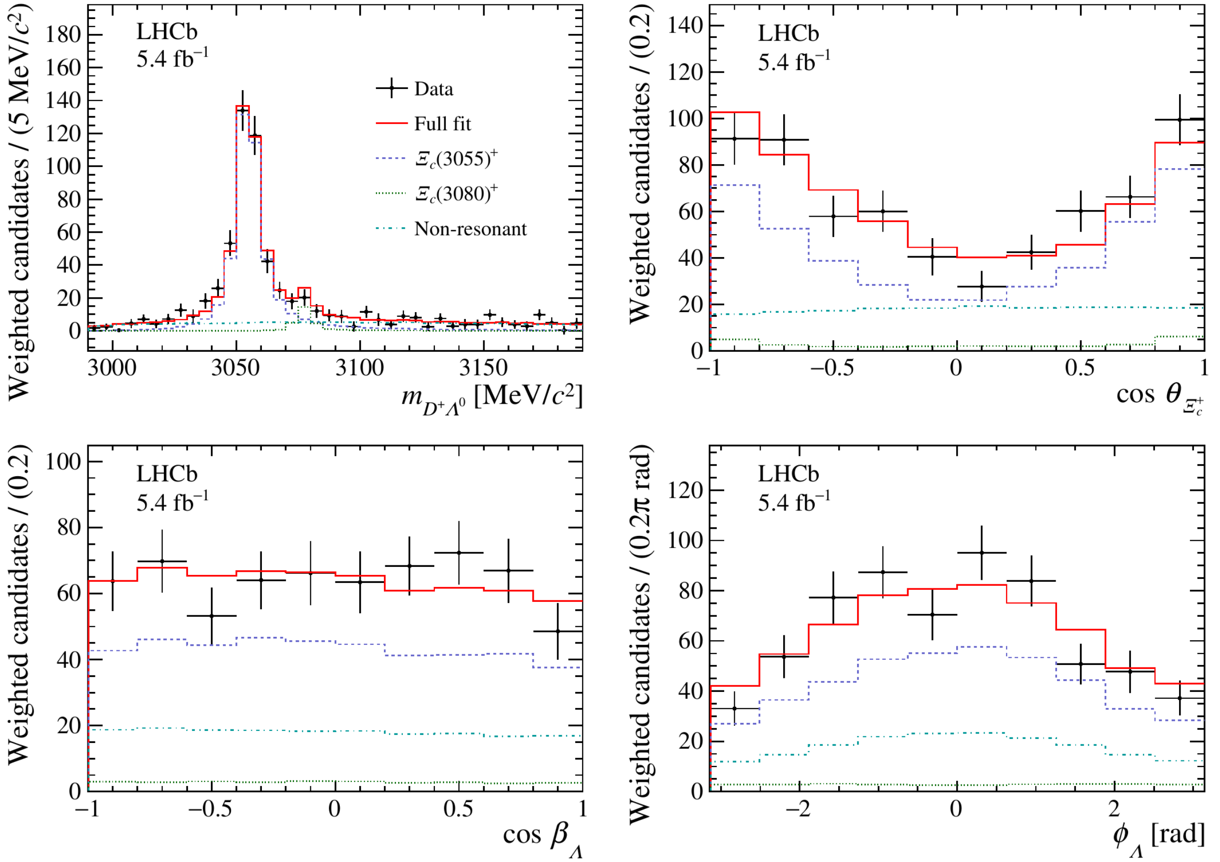






$\Xi_c(3055)^{+(0)}$ measurement: amplitude analysis

- Amplitude analysis using helicity formalism
- Resonances described by relativistic Breit-Wigner convoluted by Gaussian resolution fucntions
- Non-resonant component described by exponential functions
- Free parameters:
  - $\Xi_c^{**+(0)}$ mass
  - $\Xi_c^{**+(0)}$width
  - $\Xi_c^{**+(0)}$ helicity couplings
- Best fit corresponds to $J^P = 3/2^+$



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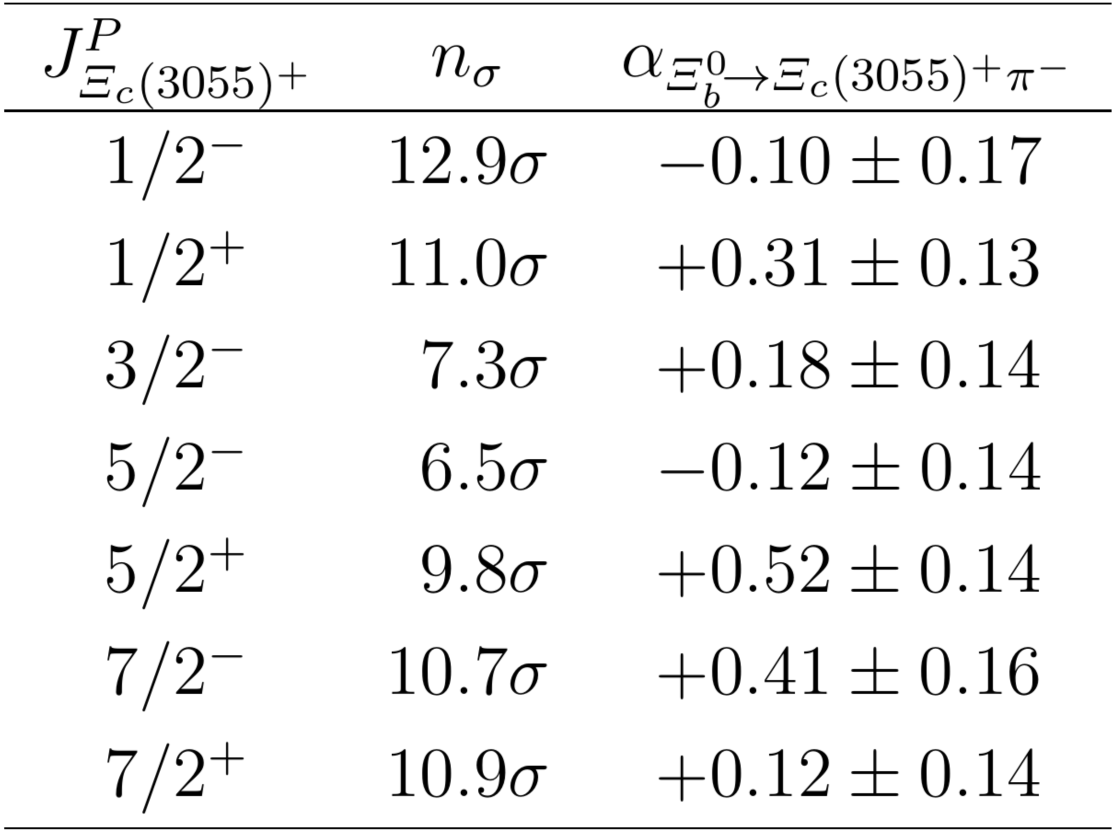
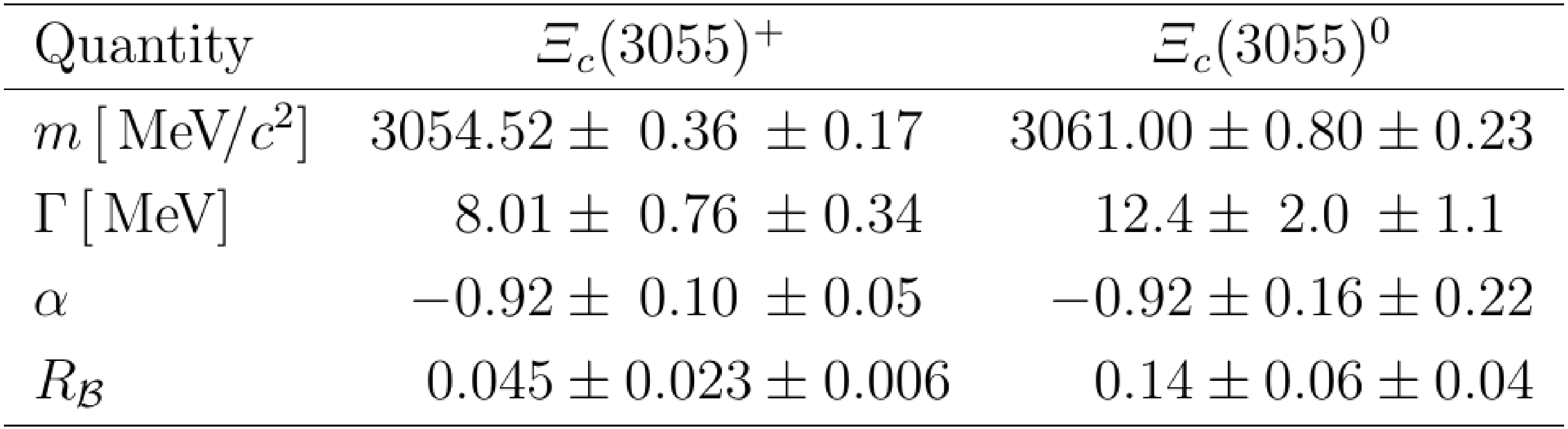
  - $\Xi_c^{**+(0)}$ helicity couplings
- Best fit corresponds to J^P = 3/2$^+$
- Other hypotheses rejected at level above 6σ



$J^P_{\Xi_c(3055)^+}$	n_σ	$\alpha_{\Xi_b^0\to\Xi_c(3055)^+\pi^-}$
$1/2^-$	12.9σ	-0.10 ± 0.17
$1/2^+$	11.0σ	$+0.31\pm0.13$
$3/2^-$	7.3σ	$+0.18\pm0.14$
$5/2^-$	6.5σ	-0.12 ± 0.14
$5/2^+$	9.8σ	$+0.52\pm0.14$
$7/2^-$	10.7σ	$+0.41\pm0.16$
$7/2^+$	10.9σ	$+0.12\pm0.14$

$\Xi_c(3055)^{+(0)}$ measurement: results

- The spin-parity of the $\Xi_c(3055)^{+(0)}$ determined to be $3/2^+$
- The masses and widths updated with a precision comparable to previous determinations
- Up-down asymmetries of $\Xi_b^{0(-)} \to \Xi_c(3055)^{+(0)}\pi^-$ decays measured
  - Consistent with a complete parity violation
  - The first measurement for the transition of the Ξ_b to Ξ_c baryon with a pseudoscalar meson
- The first determination of the relative branching fraction $\frac{\mathcal{B}_{\Xi_c(3080)^+}}{\mathcal{B}_{\Xi_c(3055)^+}}$

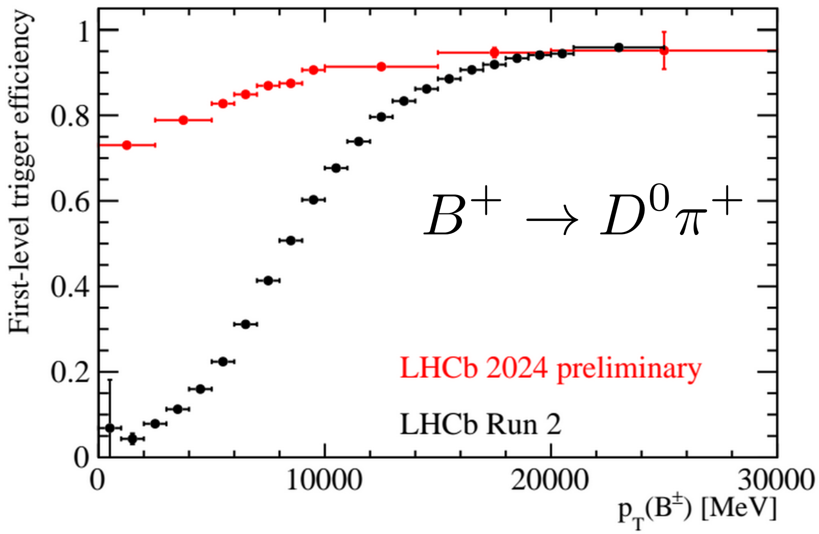


Quantity	$\Xi_c(3055)^+$	$\Xi_c(3055)^0$
$m\,[\mathrm{MeV}/c^2]$	$3054.52 \pm 0.36 \pm 0.17$	$3061.00 \pm 0.80 \pm 0.23$
$\Gamma\,[\mathrm{MeV}]$	$8.01 \pm 0.76 \pm 0.34$	$12.4 \pm 2.0 \pm 1.1$
α	$-0.92 \pm 0.10 \pm 0.05$	$-0.92 \pm 0.16 \pm 0.22$
$R_{\mathcal{B}}$	$0.045 \pm 0.023 \pm 0.006$	$0.14 \pm 0.06 \pm 0.04$

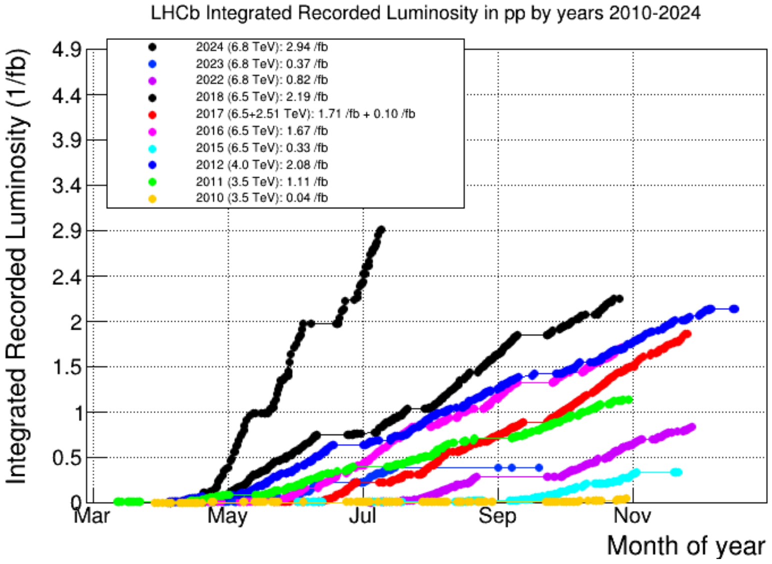
Conclusion

Conclusion and outlook

- LHCb is highly active in Charm sector and leading many studies of charm baryons
  - One of the largest recorded charm samples with high purity and excellent PID information
  - Many still ongoing analyses using Run 1 and Run 2 data
- LHCb Upgrade I successfully taking Run 3 data with
  - Around 3 fb^{-1} of pp data recorded in 2024 (½ of full Run 2 statistics)
  - Run 3 performance talk by G. Tuci on 18/07/2024 (Operation and Performance, 09:24)
- Upgraded hardware and fully software trigger significantly improving LHCb reach in charm sector

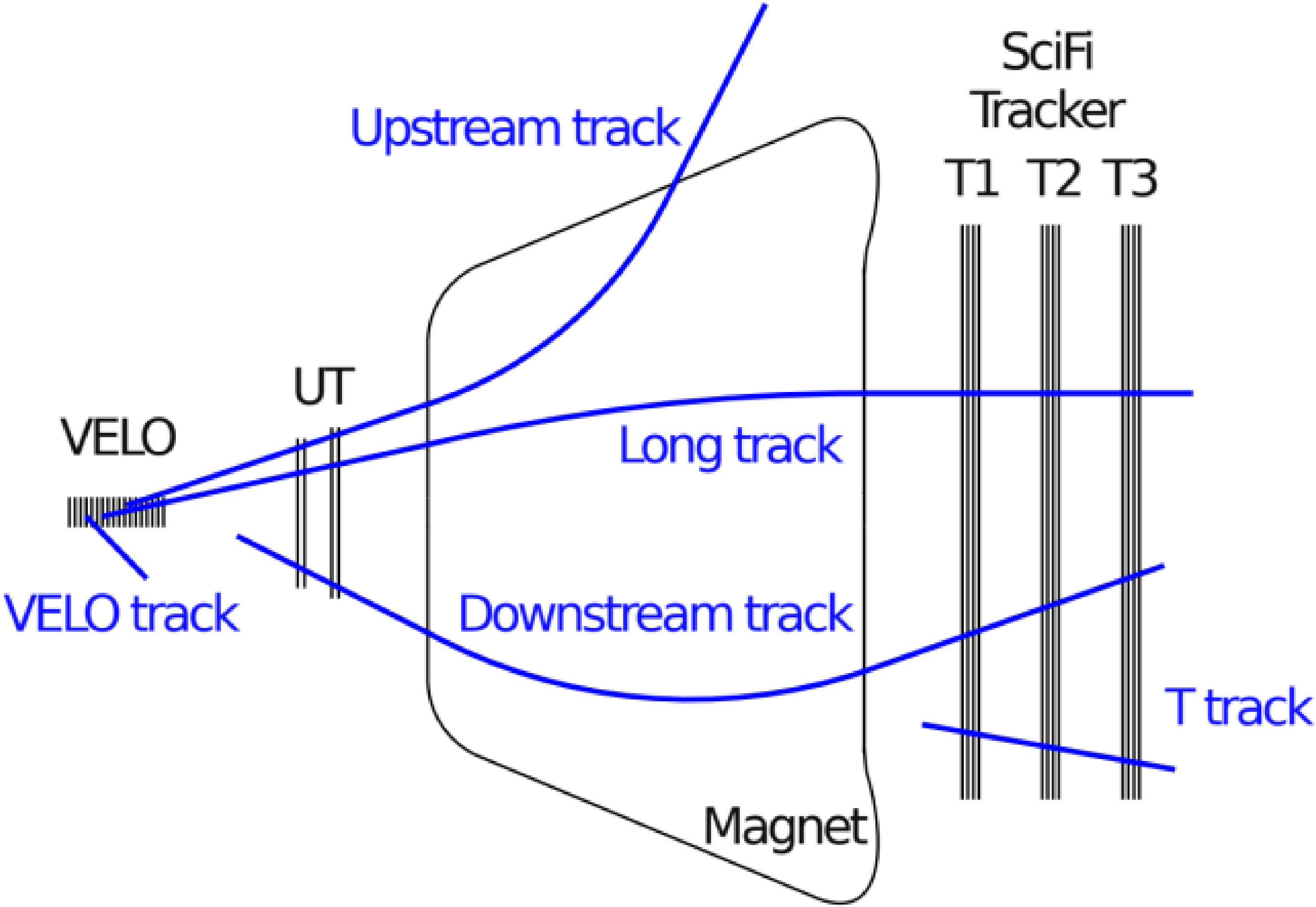


LHCb-FIGURE-2024-014



Thank you for the attention

Spare slides


Upstream track
SciFi
Tracker
T1 T2 T3
UT
VELO
Long track
VELO track
Downstream track
T track
Magnet

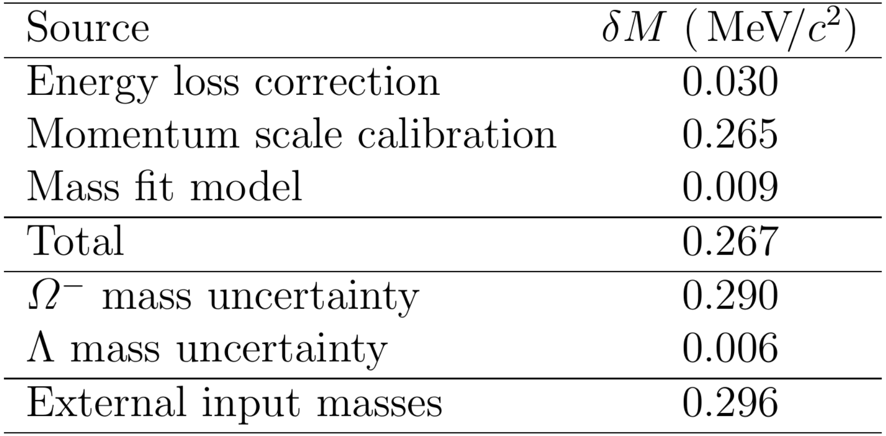
Systematic uncertainties: branching fraction

- Tracking efficiency:
  - Evaluated centrally, assigned 0.8 % per track not-canceling in the ratio
- Decay model:
  - The decay asymmetry of three processes could be non-trivial but not properly modeled in MC
  - Simultaneously reweighted the MC according to the sWeighted data in different angular distributions
- PID efficiency:
  - Using central calibration samples, limited by the size and selection of calibration samples
- Reweight strategy:
  - Correction between MC and data based on the normalization channel instead of per-channel

Source	$\mathcal{B}(\Xi^-\pi^+)/\mathcal{B}(\Omega^-\pi^+)$	$\mathcal{B}(\Omega^-K^+)/\mathcal{B}(\Omega^-\pi^+)$
Tracking efficiency	1.78	1.78
PID efficiency	0.62	3.37
L0 trigger efficiency	0.69	1.26
Fit model	0.54	0.16
Decay model	1.32	3.59
Lifetimes of Ω^- and Ξ^-	0.59	
Simulation statistics	0.08	0.07
Reweight strategy	0.52	2.82
Signal resolution	0.97	2.35
Total	2.76	6.51
External input	1.04	

Systematic uncertainties: mass

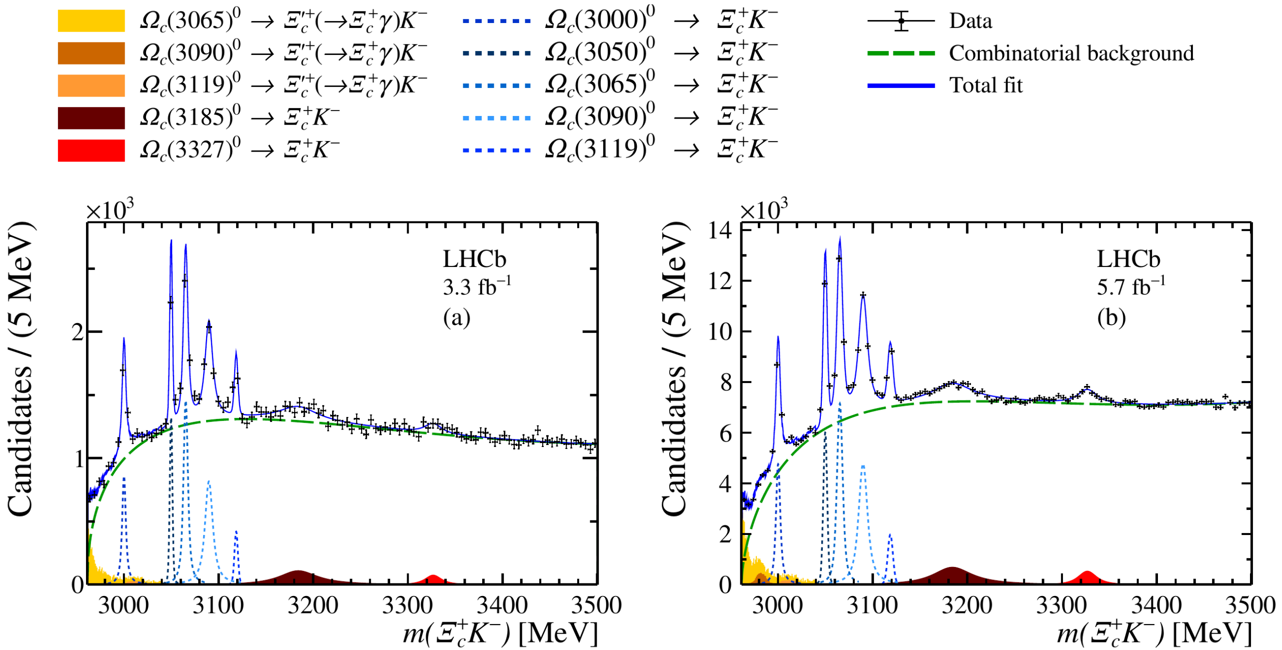
- Momentum scale calibration
  - Momenta of charged tracks require calibration due to non-perfect alignment, uncertainty on B, …
  - Empirically, momentum of final-state particles can vary up to 0.03%
  - Largest possible deviation takes as a systematic uncertainty
- Energy loss correction
  - Particles energy loss due to the interaction with detector materials
  - Scaling by a number of final-state particles (4 final-state particles)
- Mass fit model:
  - Alternative model for signal (Johnson SU + CB) and background (Chebyshev polynomial)



Source	δM (MeV/c^2)
Energy loss correction	0.030
Momentum scale calibration	0.265
Mass fit model	0.009
Total	0.267
Ω^- mass uncertainty	0.290
Λ mass uncertainty	0.006
External input masses	0.296

New observations

- In total 7 states are reported, including two new states $\Omega_c(3185)^0$ and $\Omega_c(3327)^0$



Resonance	m (MeV)	Γ (MeV)
$\Omega_c(3000)^0$	$3000.44 \pm 0.07\ ^{+0.07}_{-0.13} \pm 0.23$	$3.83 \pm 0.23\ ^{+1.59}_{-0.29}$
$\Omega_c(3050)^0$	$3050.18 \pm 0.04\ ^{+0.06}_{-0.07} \pm 0.23$	$0.67 \pm 0.17\ ^{+0.64}_{-0.72}$
		$< 1.8\,\text{MeV}, 95\%$ C.L.
$\Omega_c(3065)^0$	$3065.63 \pm 0.06\ ^{+0.06}_{-0.06} \pm 0.23$	$3.79 \pm 0.20\ ^{+0.38}_{-0.47}$
$\Omega_c(3090)^0$	$3090.16 \pm 0.11\ ^{+0.06}_{-0.10} \pm 0.23$	$8.48 \pm 0.44\ ^{+0.61}_{-1.62}$
$\Omega_c(3119)^0$	$3118.98 \pm 0.12\ ^{+0.09}_{-0.23} \pm 0.23$	$0.60 \pm 0.63\ ^{+0.90}_{-1.05}$
		$< 2.5\,\text{MeV}, 95\%$ C.L.
$\Omega_c(3185)^0$	$3185.1 \pm 1.7\ ^{+7.4}_{-0.9} \pm 0.2$	$50 \pm 7\ ^{+10}_{-20}$
$\Omega_c(3327)^0$	$3327.1 \pm 1.2\ ^{+0.1}_{-1.3} \pm 0.2$	$20 \pm 5\ ^{+13}_{-1}$

$\Xi_c(3055)^{+(0)}$ measurement: helicity angles

- $\Xi_b \to \Xi_c^{**}\pi^-$ $$A^{\Xi_b\to\Xi_c\pi^-}_{\lambda_{\Xi_b},\lambda_{\Xi_c},\lambda_\pi} = H^{\Xi_b\to\Xi_c\pi^-}_{\lambda_{\Xi_c}}\,\delta_{\lambda_{\Xi_b},\lambda_{\Xi_c}}$$
- $\Xi_c^{**} \to D\Lambda$ $$A^{\Xi_c\to D\Lambda}_{\lambda_{\Xi_c},\lambda_D,\lambda_\Lambda} = H^{\Xi_c\to D\Lambda}_{\lambda_\Lambda}\,d^{J_{\Xi_c}}_{\lambda_{\Xi_c},\lambda_\Lambda}(\theta)$$
- $\Lambda \to p\pi^-$ $$A^{\Lambda\to p\pi^-}_{\lambda_\Lambda,\lambda_p,\lambda_\pi} = H^{\Lambda\to p\pi^-}_{\lambda_p}\,D^{j_\Lambda}_{\lambda_\Lambda,\lambda_p}(\phi,\beta,0)$$

Floated for each resonance

Strong decay, only phase term:

$\eta^{P_{\Xi_c}}(-1)^{J_{\Xi_c}+1/2}$

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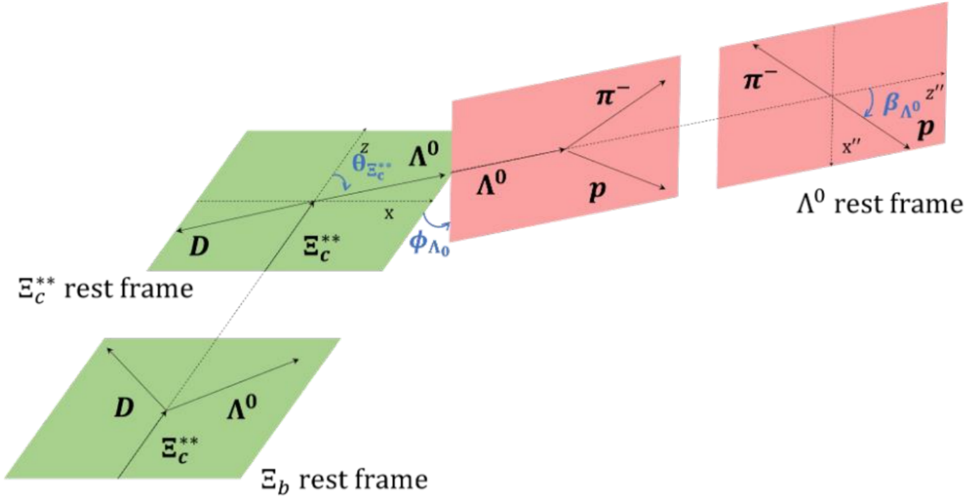
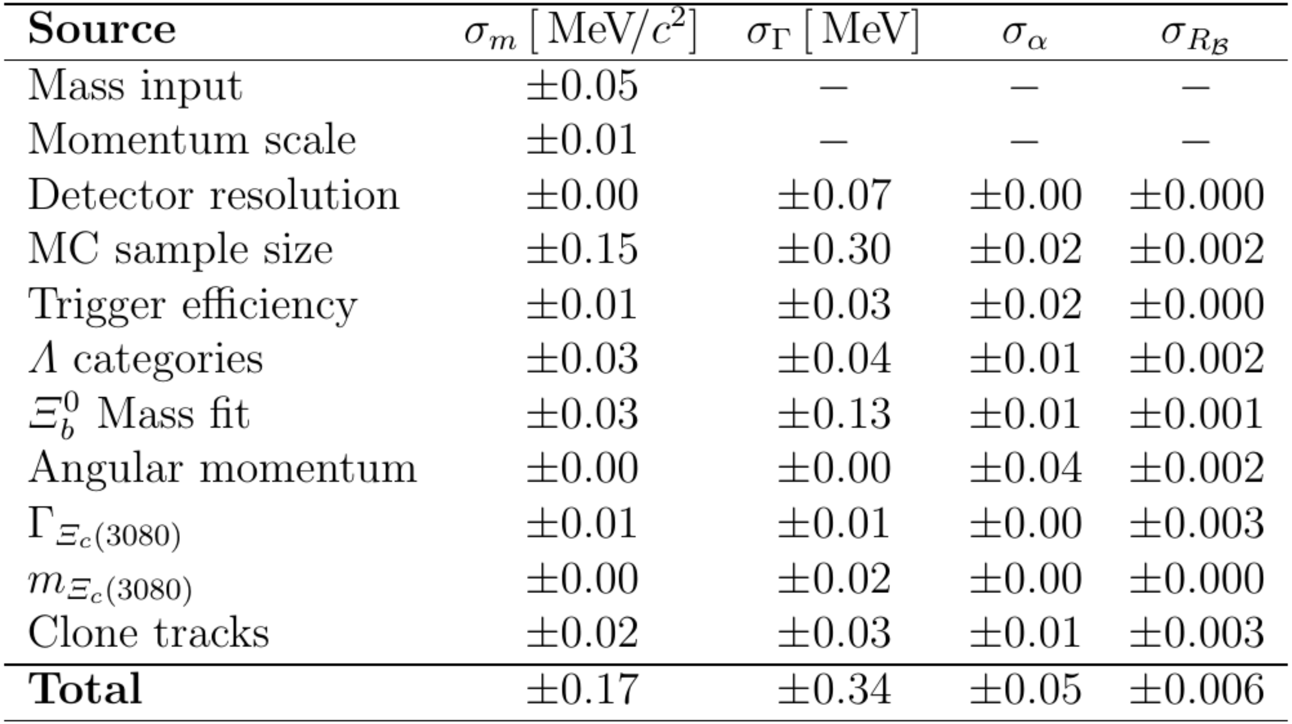


$\Xi_c(3055)^{+(0)}$ measurement: systematic unc.



Source	σ_m [MeV/c^2]	σ_Γ [MeV]	σ_α	$\sigma_{R_{\mathcal{B}}}$
Mass input	±0.05	–	–	–
Momentum scale	±0.01	–	–	–
Detector resolution	±0.00	±0.07	±0.00	±0.000
MC sample size	±0.15	±0.30	±0.02	±0.002
Trigger efficiency	±0.01	±0.03	±0.02	±0.000
Λ categories	±0.03	±0.04	±0.01	±0.002
Ξ_b^0 Mass fit	±0.03	±0.13	±0.01	±0.001
Angular momentum	±0.00	±0.00	±0.04	±0.002
$\Gamma_{\Xi_c(3080)}$	±0.01	±0.01	±0.00	±0.003
$m_{\Xi_c(3080)}$	±0.00	±0.02	±0.00	±0.000
Clone tracks	±0.02	±0.03	±0.01	±0.003
Total	±0.17	±0.34	±0.05	±0.006

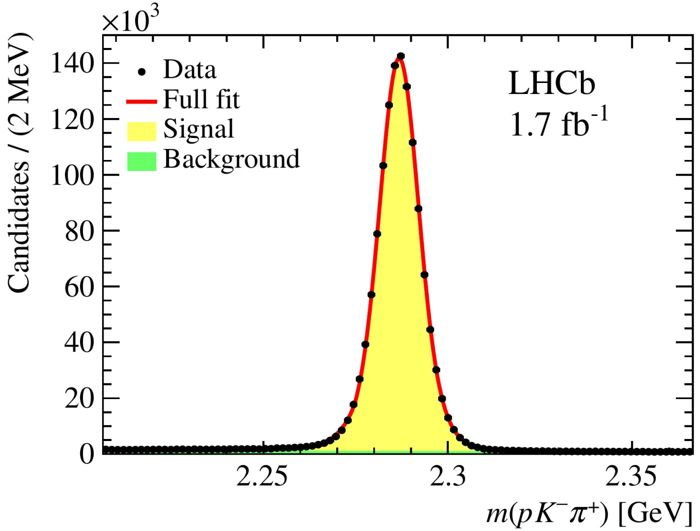
Amplitude analysis of the $\Lambda_c^+ \to pK^-\pi^+$ decay and Λ_c^+ baryon polarization measurement in semileptonic beauty hadron decays

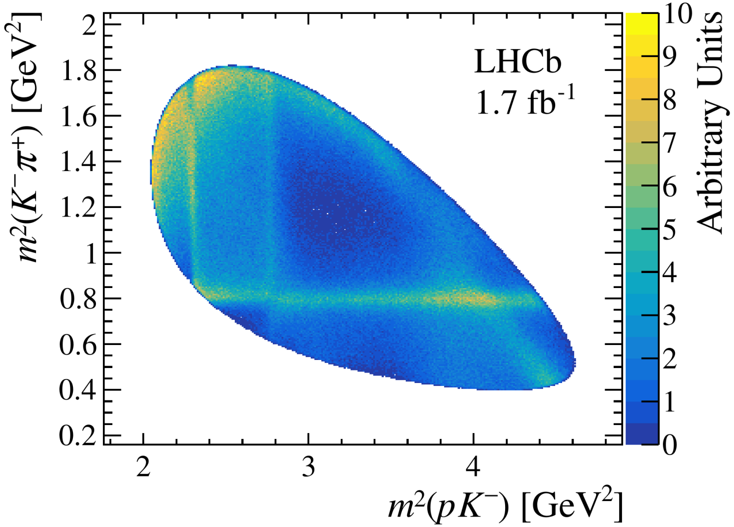
[PRD 108 (2023) 012023]

Amplitude analysis of $\Lambda_c^+ \rightarrow pK^-\pi^+$: data

- Semileptonic (SL) decay can be studied to determine amplitude models for polarisation measurements
  - Large polarisation from parity-violating weak decay gives full sensitivity on decay amplitude
  - Cleaner samples with more regular detector efficiency
  - Preferable for amplitude fit with many free parameters

- Study of Λc+ → $pK^-\pi^+$ polarisation in SL decays of b-hadrons
  - Based on 2016 data (~ 1.7 fb^{-1})
  - Significant available statistics ~ 1.27 M signal event
  - Minimal combinatorial background,
  - Negligible physical contributions
  - Fit performed on subsample of 400 000 signal candidates
  - Already dominated by systematics uncertainties

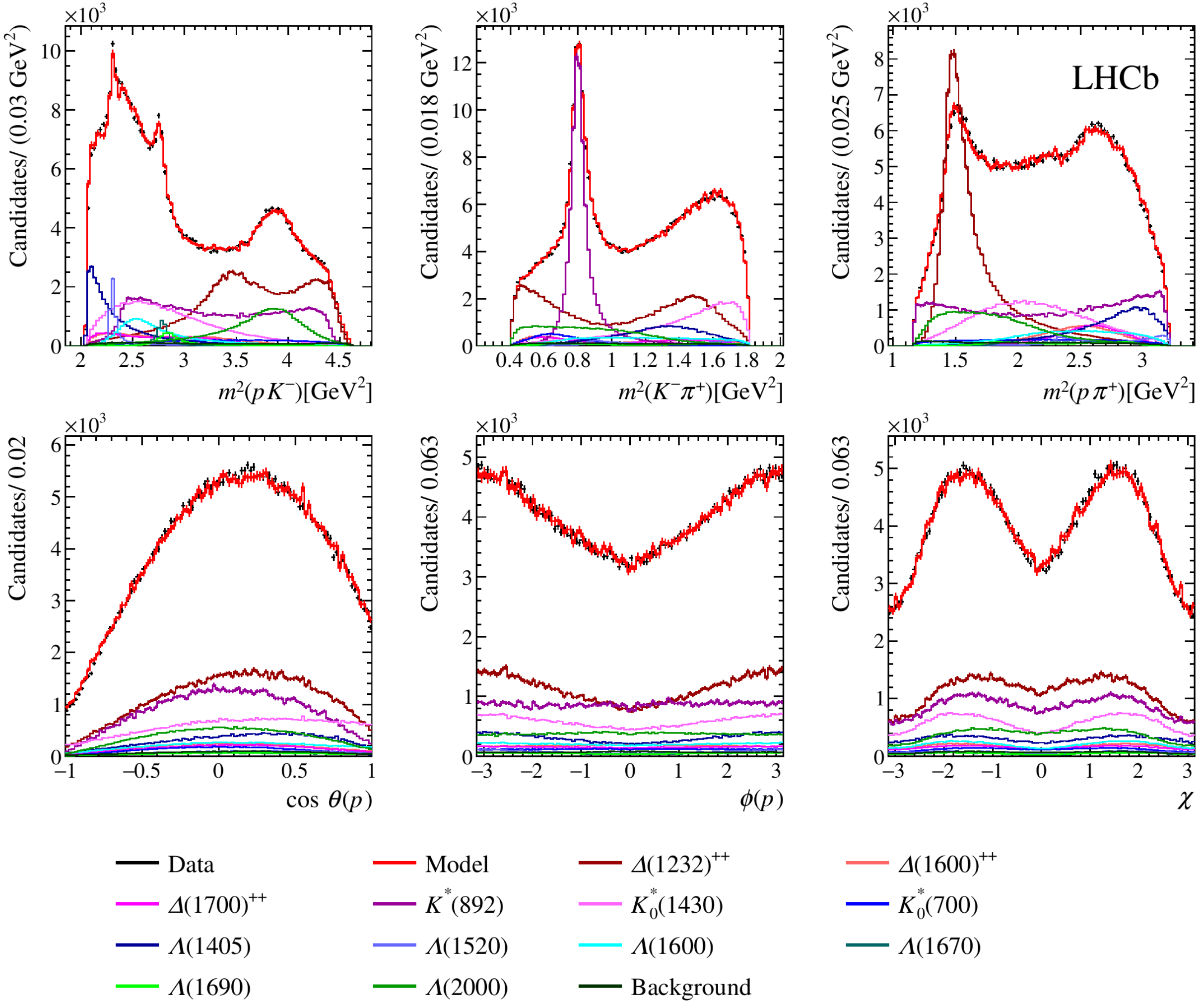




Amplitude analysis of $\Lambda_c^+ \to pK^-\pi^+$: fit

- Amplitude model built from contributions visible in the Dalitz plot and PDG resonances
- Contributions improving the fit quality are retained
- Alternative models with similar quality considered for systematic uncertainties
- Polarisation weakly dependent on specific amplitude model
- Main contributions:
  - Δ++(1232), K*(892), K_0^*(1430)

Resonance	J^P	Mass (MeV)	Width (MeV)
$\Lambda(1405)$	$1/2^-$	1405.1	50.5
$\Lambda(1520)$	$3/2^-$	1515 – 1523	10 – 20
$\Lambda(1600)$	$1/2^+$	1630	250
$\Lambda(1670)$	$1/2^-$	1670	30
$\Lambda(1690)$	$3/2^-$	1690	70
$\Lambda(2000)$	$1/2^-$	1900 – 2100	20 – 400
$\Delta(1232)^{++}$	$3/2^+$	1232	117
$\Delta(1600)^{++}$	$3/2^+$	1640	300
$\Delta(1700)^{++}$	$3/2^-$	1690	380
$K_0^*(700)$	0^+	824	478
$K^*(892)$	1^-	895.5	47.3
$K_0^*(1430)$	0^+	1375	190



Amplitude analysis of $\Lambda_c^+ \to pK^-\pi^+$: polarisation

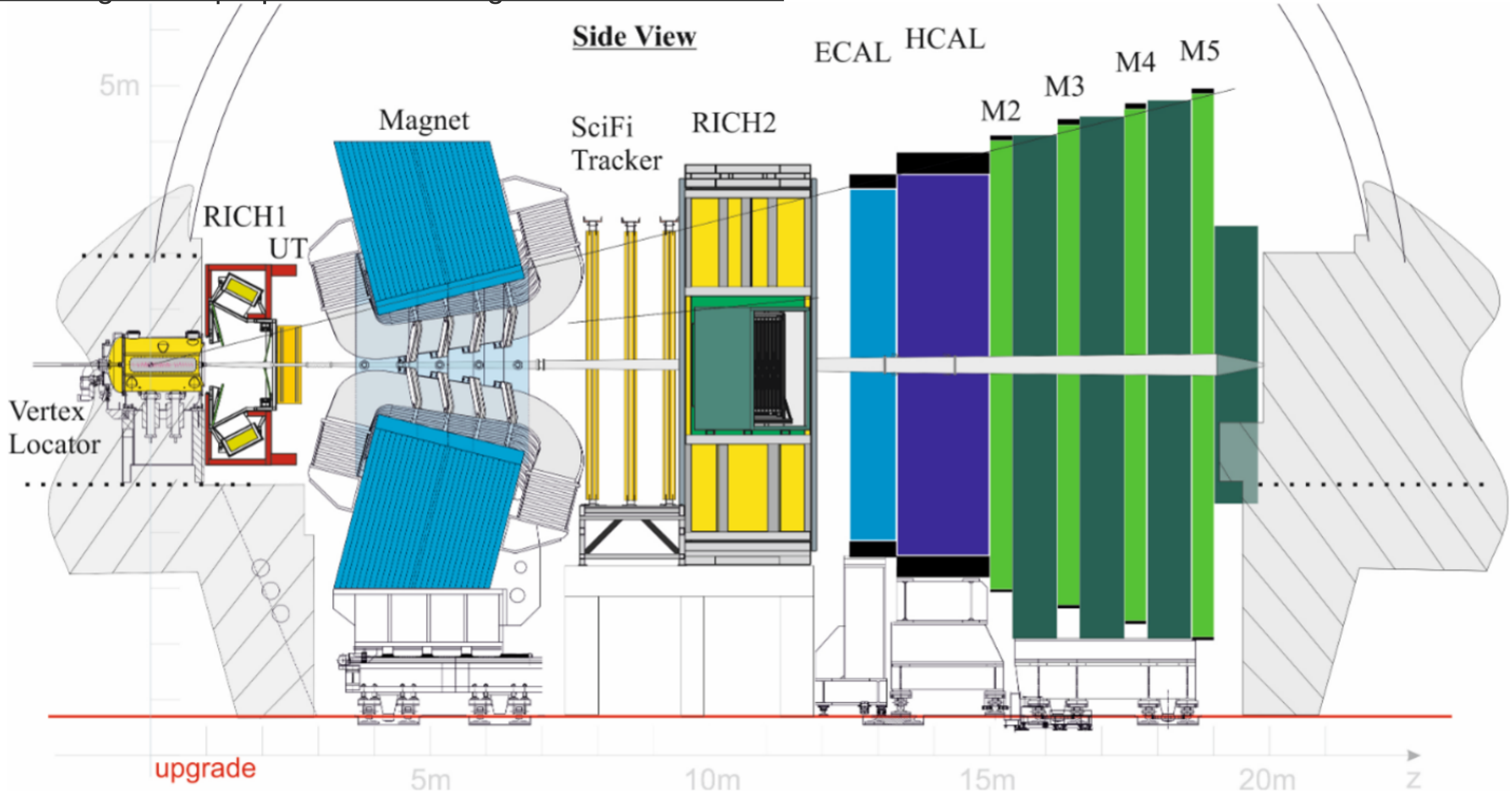
- Precision measurement of the Λ_c^+ polarisation vector
  - Uncertainties in sub-% level
- Large polarisation measured in both helicity frames (HF)
  - Λ_c^+ laboratory HF: more transverse (Px) than longitudinal (Pz)
  - Λ_c^+ HF from approximate rest frame of b-hadron: more longitudinal than transverse
- Normal polarisation (Py) compatible with zero in both systems
  - Sensitive to time-reversal violation effects and final-state interactions

Component	Value (%)
P_x (lab)	$60.32 \pm 0.68 \pm 0.98 \pm 0.21$
P_y (lab)	$-0.41 \pm 0.61 \pm 0.16 \pm 0.07$
P_z (lab)	$-24.7 \pm 0.6 \pm 0.3 \pm 1.1$
P_x $(\tilde{B})$	$21.65 \pm 0.68 \pm 0.36 \pm 0.15$
P_y $(\tilde{B})$	$1.08 \pm 0.61 \pm 0.09 \pm 0.08$
P_z $(\tilde{B})$	$-66.5 \pm 0.6 \pm 1.1 \pm 0.1$

LHCb Upgrade 1
+
Modern trigger at LHCb

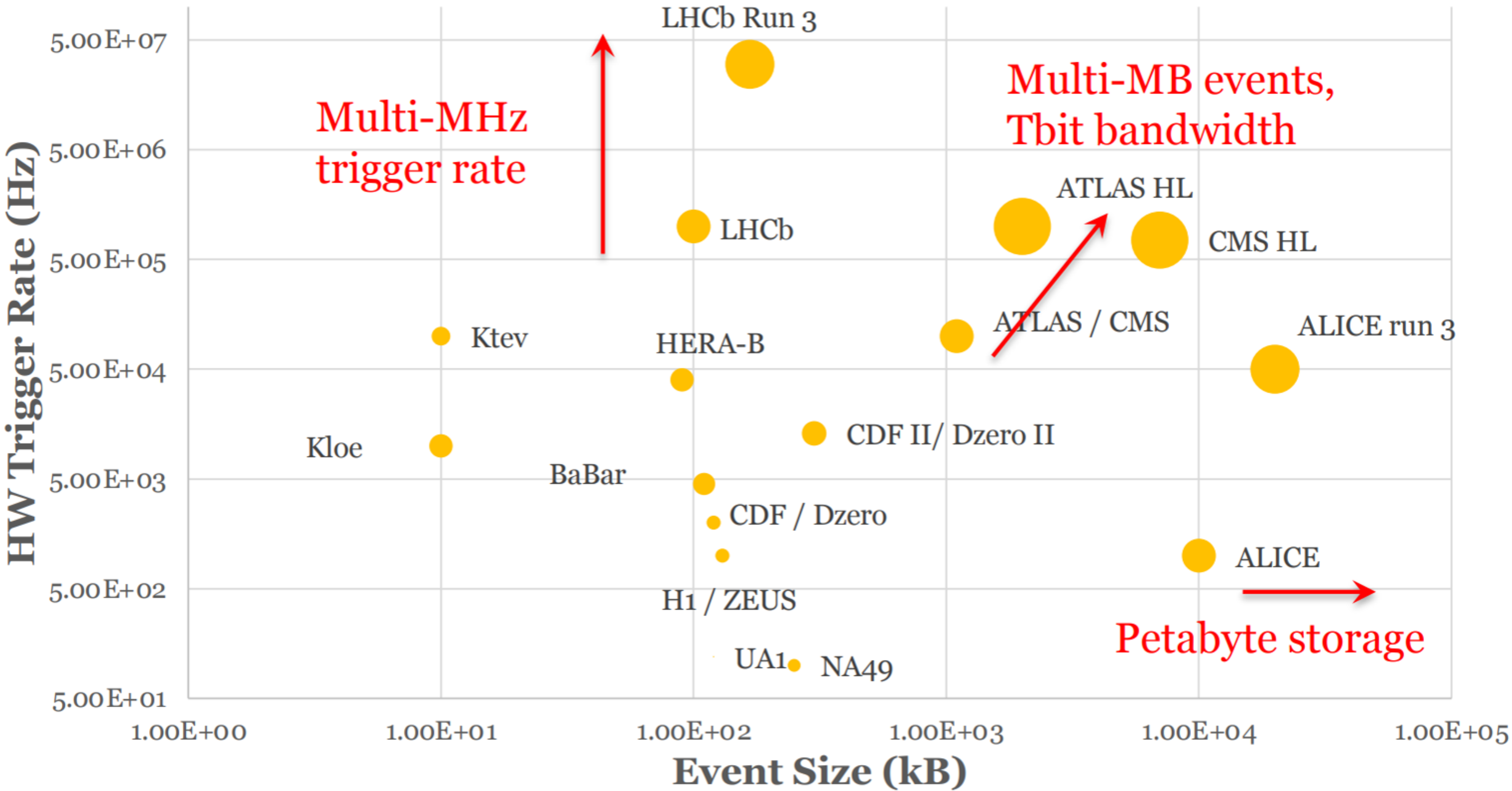
LHCb experiment in Run 3

- LHCb conditions in Run 3: luminosity of $2\text{x}10^{33}$ $\text{cm}^{-2}\text{s}^{-1}$, $\sqrt{s}$ = 13.6 TeV, visible collisions per bunch $\mu \sim 5$
- New tracker detectors, upgraded electronics, fully software trigger, ...
- A new general-purpose forward-region detector at LHC



Trigger strategies

- Almost every pp collision is interesting for LHCb as is contains a heavy quark (*b*, *c*)



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