

Overview of LHCb results

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On behalf of the LHCb collaboration

DISCRETE

Bratislava, 16.11.2026



Run 1,2 and 3

A rich physics program:

- B-hadron properties
- CKM measurements
- Hadron spectroscopy
- Semileptonic decays
- Rare beauty, charm, strange decays
- Direct New Physics searches
- Electroweak measurements
- …



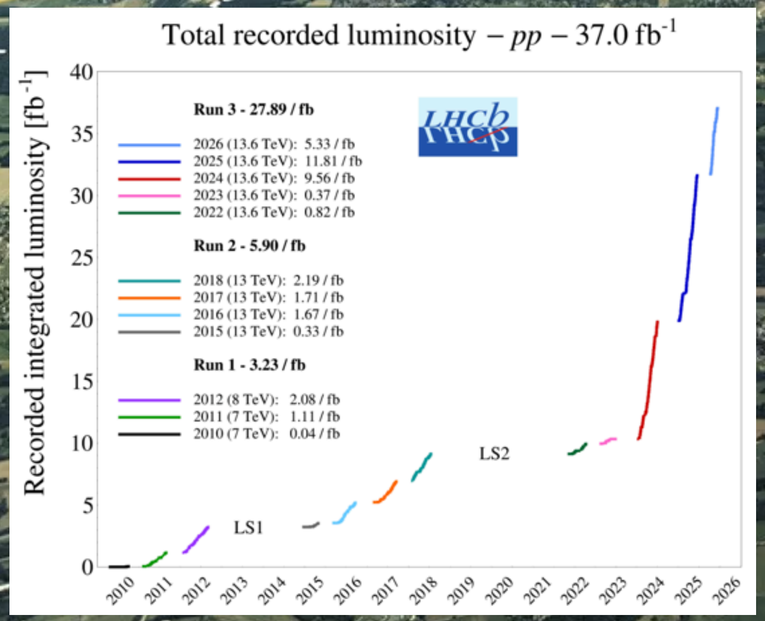
Upgrade II

The past and present

The future



The LHCb experiment at the LHC



pp collisions at 7,8,13 and 13.6 TeV

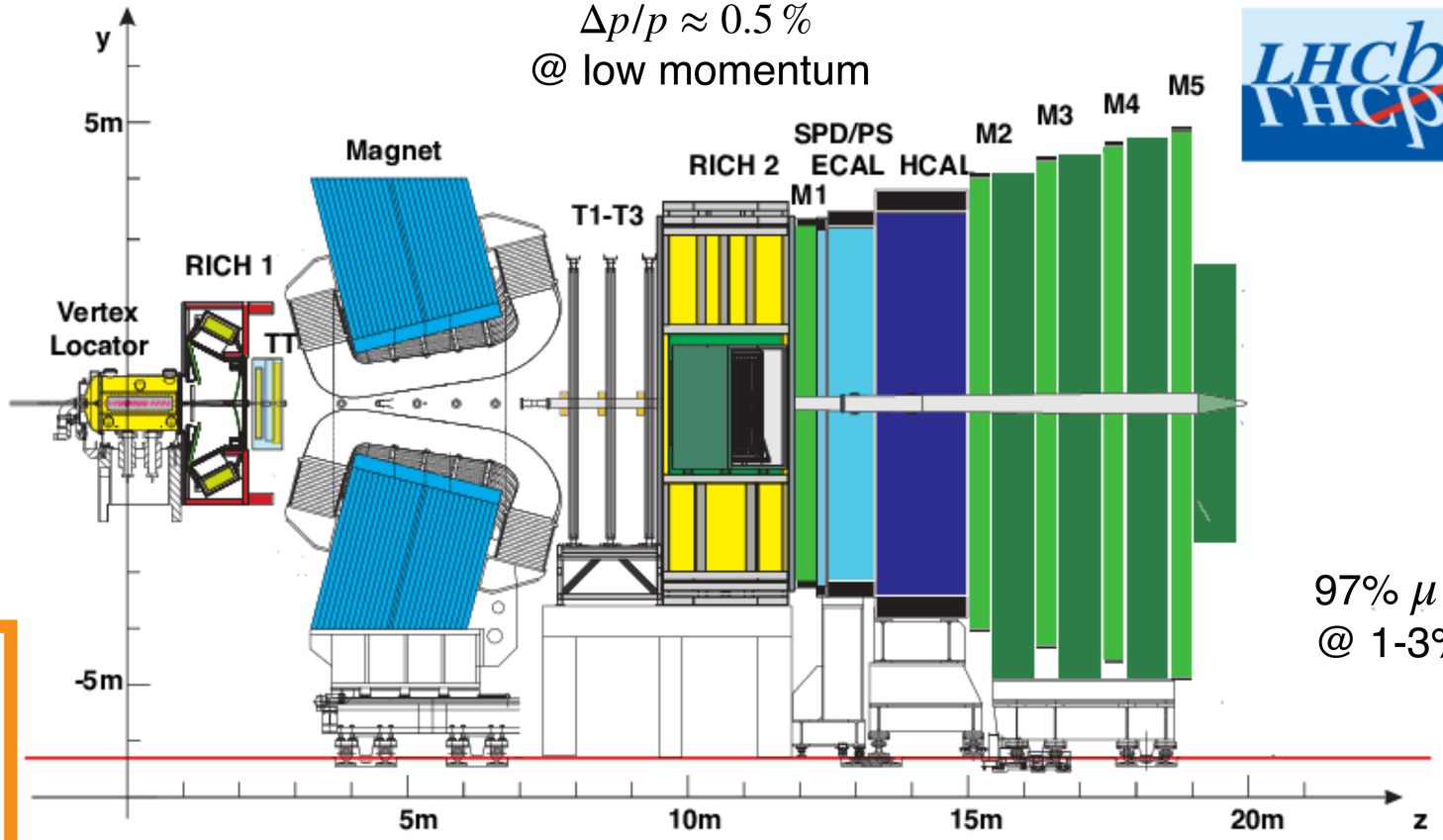
[IJMP A 30 (2015) 1530022]

LHCb in Run 1&2

Collected $9\,\text{fb}^{-1}$ in 2011-2018
@ 7,8,13 TeV

$\sigma_{IP} \approx 20\mu\text{m}$
@ high p_T

$\Delta p/p \approx 0.5\,\%$
@ low momentum



97% μ ID
@ 1-3% pion misID

Designed for CPV and rare decay measurements in beauty and charm

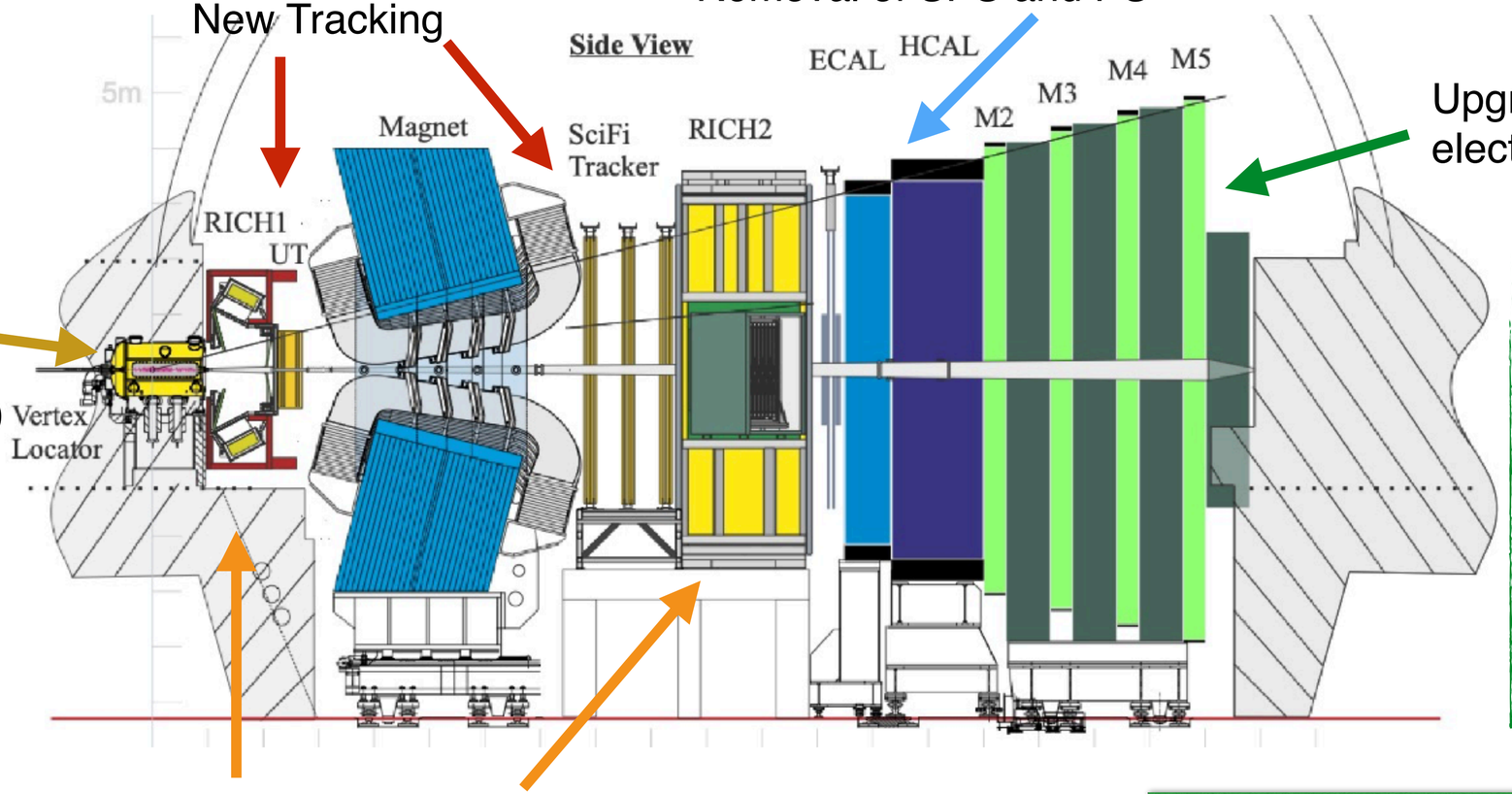
→ Now multipurpose flavour factory (and much more)

[LHCb Upgrade TDR]
[Muon Performance]
[UT Performance]
[PLUME Performance]

LHCb detector in Run 3

New front-end electronics,
Removal of SPS and PS

New Tracking



Upgrade Muon front-end electronics

New VELO:
Nominal sensor position
@ 5.1 mm (before: 7mm)
from collision region
→ improved vertexing!

Move to a software-only trigger:
- Exploit topology features
- $> \times 2$ efficiencies for hadronic, electronic final states and soft tracks

New RICH PMT's and electronics

Similar or better performance
@$5\times$ instantaneous Luminosity!

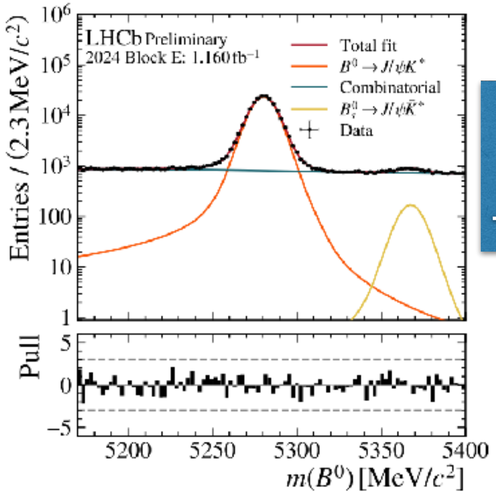
NEW!

[LHCb-PAPER-2026-039]
[LHCb-PAPER-2026-040]

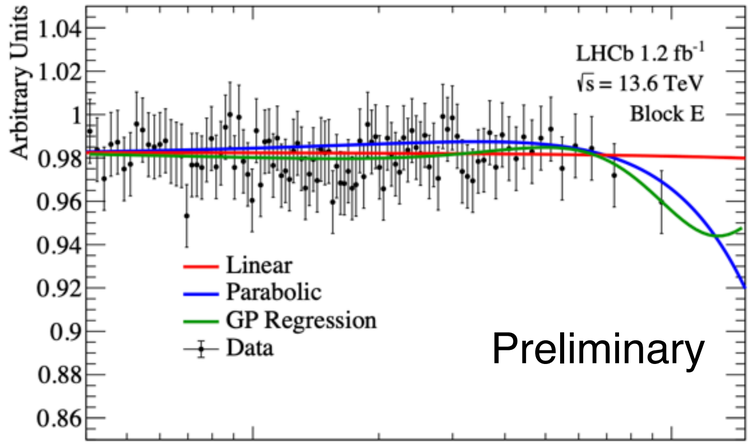
Precision measurements of the B^0 and B^+ lifetimes

- Experimentally well known, theory prediction $> \times 10$ less precise
  - Stringent tests of non-perturbative QCD effects
  - Calibrate other decay-time-dependent measurements
- Measure lifetimes with LHCb Upgrade I (2024 data)
- Most precise measurements of B^0 and $B^\pm$ lifetimes and their ratios!

$$\tau_{B^0\to J/\psi K^{*0}} = 1.5145 \pm 0.0020 \pm 0.0010\,\text{ps} \to 20\,\%\ \text{better than PDG}$$
$$\tau_{B^+} = 1.6370 \pm 0.0014 \pm 0.0014\,\text{ps} \to 2\times\ \text{better than PDG}$$
$$\tau_{B^+}/\tau_{B^0} = 1.0809 \pm 0.0017 \pm 0.0007$$
$$\tau_{B^+}/\tau_{B^-} = 1.0017 \pm 0.0017 \pm 0.0008$$



Extremely high yields
→ high precision



LHCb ready for decay-time-dependent precision measurements with Upgrade I!

Flat decay-time acceptance
→ excellent systematics control

Measurements of the CKM angle γ

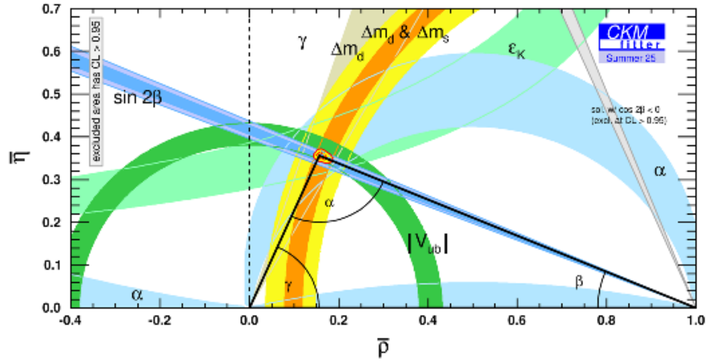
- NP search by testing the unitarity of the CKM matrix → see talk by Luiz

$$\gamma_{\text{dir}} = \left(65^{+2.7}_{-2.8}\right)^{\circ}$$

$$\gamma_{\text{ind}} = \left(66.16^{+0.78}_{-3.20}\right)^{\circ}$$

- Need combination of **many** $B \to DX$ and $D \to Y$ channels for good sensitivity on γ
- γ and charm observables depend on the same hadronic observables
- LHCb measures plethora of channels: NEW γ combination!

[CKMFitter '25]



D decay	Observable(s)	Ref.	Dataset	Status since Ref. [20]
$D^0 \to h^+h^-$	ΔA_{CP}	[31,98,99]	Runs 1 and 2	*As before*
$D^0 \to K^+K^-$	$A_{CP}(K^+K^-)$	[40,98,100]	Runs 1 and 2	Updated
$D^0 \to h^+h^-$	$y_{CP} - y_{CP}^{K^-\pi^+}$	[91,92]	Runs 1 and 2	Updated
$D^0 \to h^+h^-$	$\Delta Y_{K^+K^-}$, $\Delta Y_{\pi^+\pi^-}$	[93–96]	Runs 1 and 2	Updated
$D^0 \to K^+\pi^-$	$R_{K\pi}$, $A_{K\pi}^{(\prime)}$, $c_{K\pi}^{(\prime)}$, $\Delta c_{K\pi}^{(\prime)}$	[50,85]	Runs 1 and 2	Updated
$D^0 \to K^+\pi^-$	R^-, $(x'^-)^2$, y'^-	[84,86]	Runs 1 and 2	Updated
$D^0 \to K^+\pi^-\pi^+\pi^-$	r_+, $\kappa_+y'_+$, $(x^2+y^2)/4$	[118]	Run 1	*As before*
$D^0 \to K^+\pi^-\pi^+\pi^-$	$r_+^{\pm}$, $(\kappa_\pm c_\pm^{\pm})_+$, $x^{2\pm}+y^{2\pm}$	[51]	Run 2	New
$D^0 \to K_S^0\pi^+\pi^-$	x, y	[64]	2011	*As before*
$D^0 \to K_S^0\pi^+\pi^-$	x_{CP}, y_{CP}, Δx, Δy	[32,48,65]	Runs 1 and 2	Updated
$D^0 \to \pi^+\pi^-\pi^0$	$\Delta Y_{\pi^+\pi^-\pi^0}^{\text{diff}}$	[97]	Run 2	New

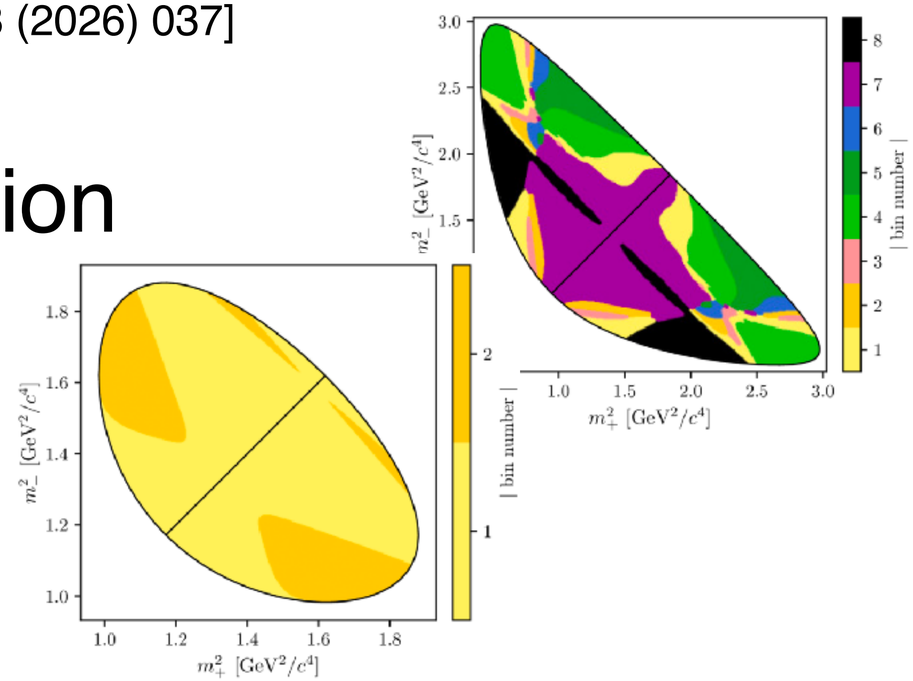
B decay	D decay	Ref.	Dataset	Status since Ref. [20]
$B^- \to Dh^-$	$D \to h^\pm h'^\mp$	[119]	Runs 1 and 2	*As before*
$B^- \to Dh^-$	$D \to h^+h^-\pi^+\pi^-$	[45,120]	Runs 1 and 2	New
$B^- \to Dh^-$	$D \to h^+h'^\mp\pi^0$	[121]	Runs 1 and 2	Updated
$B^- \to Dh^-$	$D \to K^\pm\pi^\mp\pi^+\pi^-$	[44]	Runs 1 and 2	Updated
$B^- \to Dh^-$	$D \to K_S^0h^+h^-$	[47,115]	Runs 1 and 2 & 2024	Updated
$B^- \to Dh^-$	$D \to K_S^0K^-\pi^+$	[122]	Runs 1 and 2	*As before*
$B^- \to D^*h^-$ (PR)	$D \to h^\pm h'^\mp$	[119]	Runs 1 and 2	*As before*
$B^- \to D^*h^-$ (PR)	$D \to K_S^0h^+h^-$	[40]	Runs 1 and 2	New
$B^- \to D^*h^-$ (FR)	$D \to K_S^0h^+h^-$	[39]	Runs 1 and 2	New
$B^- \to DK^{*-}$	$D \to h^\pm h'^+$	[41]	Runs 1 and 2	Updated
$B^- \to DK^{*-}$	$D \to h^+\pi^\mp\pi^-\pi^-$	[41]	Runs 1 and 2	Updated
$B^- \to DK^{*-}$	$D \to K_S^0h^+h^-$	[41]	Runs 1 and 2	New
$B^\pm \to Dh^\pm\pi^\pm$	$D \to h^\pm h'^+$	[123]	Run 1	*As before*
$B^0 \to DK^{*0}$	$D \to h^+h'^\mp$	[43]	Runs 1 and 2	Updated
$B^0 \to DK^{*0}$	$D \to h^\pm\pi^\mp\pi^-\pi^-$	[43]	Runs 1 and 2	Updated
$B^0 \to DK^{*0}$	$D \to K_S^0h^+h^-$	[42]	Runs 1 and 2	Updated
$B^0 \to D^\mp\pi^+$	$D^+ \to K^-\pi^+\pi^+$	[114]	Run 1	*As before*
$B_s^0 \to D_s^+K^-$	$D_s^+ \to h^+h^-\pi^-$	[46,124]	Runs 1 and 2	Updated
$B_s^0 \to D_s^\mp K^+\pi^+\pi^-$	$D_s^+ \to h^+h^-\pi^-$	[112]	Runs 1 and 2	*As before*

[LHCb-PAPER-2026-058]

NEW!

[LHCb-PAPER-2026-058] [JHEP 08 (2026) 037]

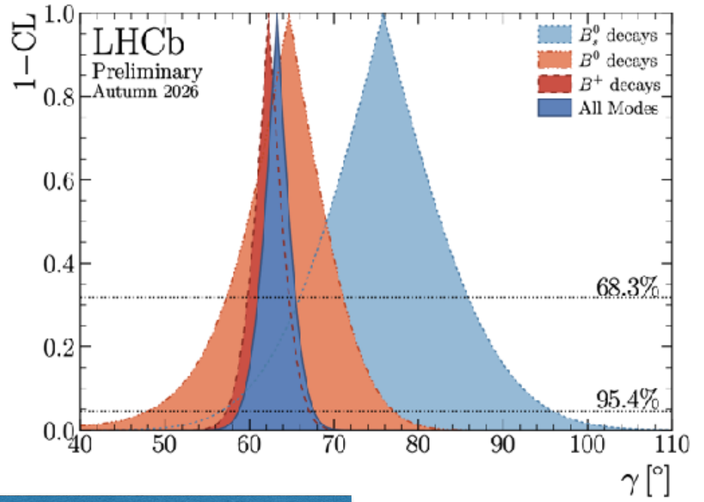
New developments in the γ determination



- Measure γ in $B^\pm \to D(\to K^0_S h^+ h^-) h'^\pm$ decays with 2024
  - Similar sensitivity from 1 year Run 3 like full Run 1&2 together!
  - Upgrade I provides improved hadron trigger efficiencies and PID
  - Binned phase space: local strong-phases from BESIII and CLEO-c
- New ideas for improvement: joint BESIII-LHCb analysis [arXiv:2604.05712] encoding strong-phase variation in per-event weights! [arXiv:2604.05701]

NEW combination $\gamma = \left(63.2^{+2.3}_{-2.2}\right)^\circ$

- Many updated measurements
- Reduced model dependence in charm hadronic inputs
- $< 1^\circ$ with full Run 3 in reach! (target: 1.5°)



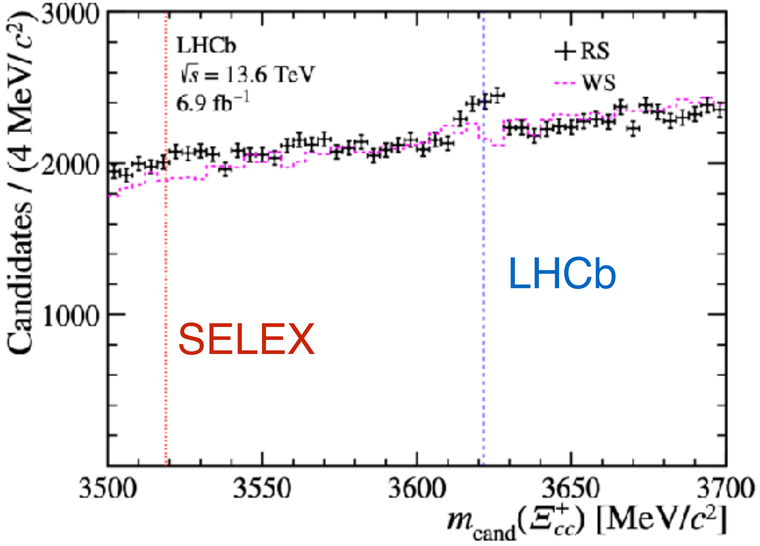
Talk by Michael

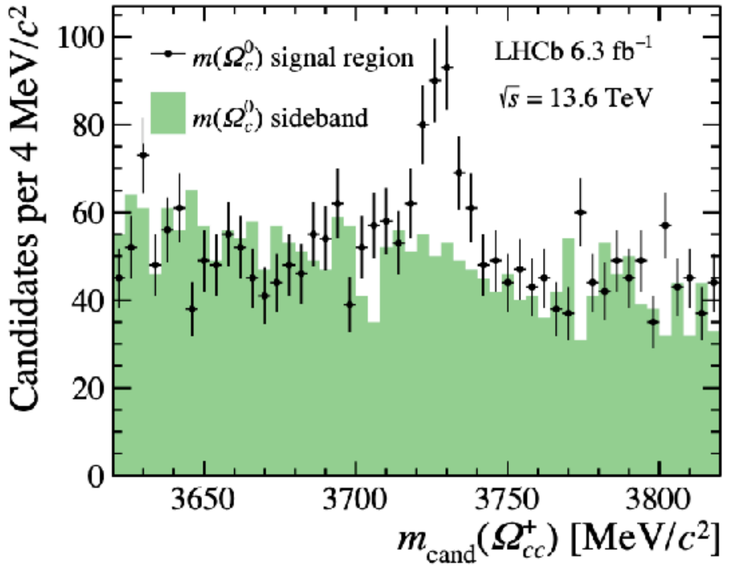
NEW!

[PRL 137 (2026) 021902] [arXiv:2609.21921]

Charm baryon spectroscopy

- Huge charm production at LHC → LHCb design ideal to exploit!
- Observation of the Ξ_{cc}^{+} (dcc) and Ω_{cc}^{+} (scc) with 2024 data
- Turbo enabled: efficiency $2.5\times$ (Ξ_{cc}^{+}) and $8\times$ (Ω_{cc}^{+}) higher than Run 2
- $\Xi_{cc}^{+} \to (\Lambda_c^{+} \to pK^{+}\pi^{-})K^{-}\pi^{+}$
  - Refuting SELEX claim of $\mathcal{B}(\Xi_{cc}^{+} \to \Lambda_c^{+}X) \approx 20\,\%$ not confirmed by earlier FOCUS, BaBar, Belle and LHCb searches
- $\Omega_{cc}^{+} \to (\Omega_c^{0} \to pK^{-}K^{-}\pi^{+})\pi^{+}$
  - Discriminate from combinatorics thanks to established large lifetime of Ω_c^{0}
- Studies of lifetimes and further decay modes will follow



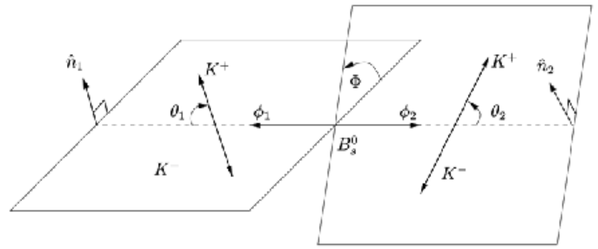


Complete experimental observation of ALL SU(4) ground state baryons predicted by quark model!

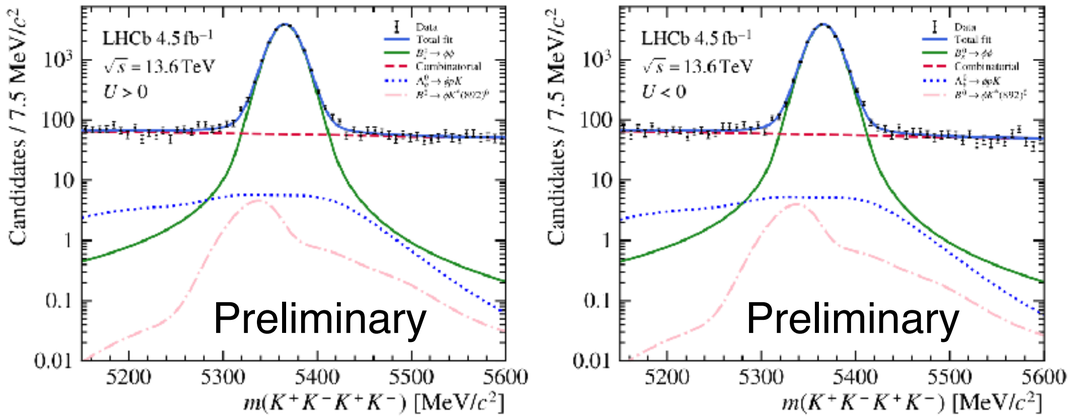
NEW!

[LHCb-PAPER-2026-055]

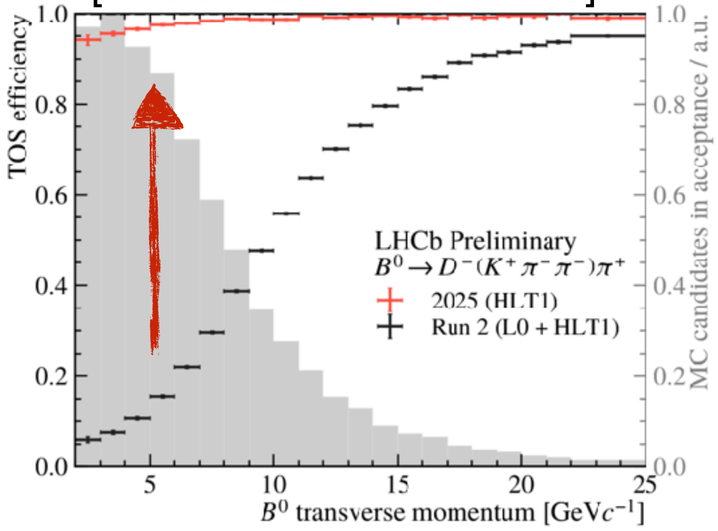
CP studies in suppressed charmless decays



- Study CP-violation in $b \to ds\bar{s}$ with $B_s^0 \to \phi\phi$ in 2024 data
  - Golden channel: negligible CP-violation in the SM
  - Time-integrated method: measure triple-product asymmetries
    $A_U = (5.6 \pm 5.4 \pm 2.4) \times 10^{-3}$
    $A_V = (3.8 \pm 5.4 \pm 2.4) \times 10^{-3}$
  - Statistics dominated → strong improvement with full Run 3 data expected



[LHCb-FIGURE-2025-015]



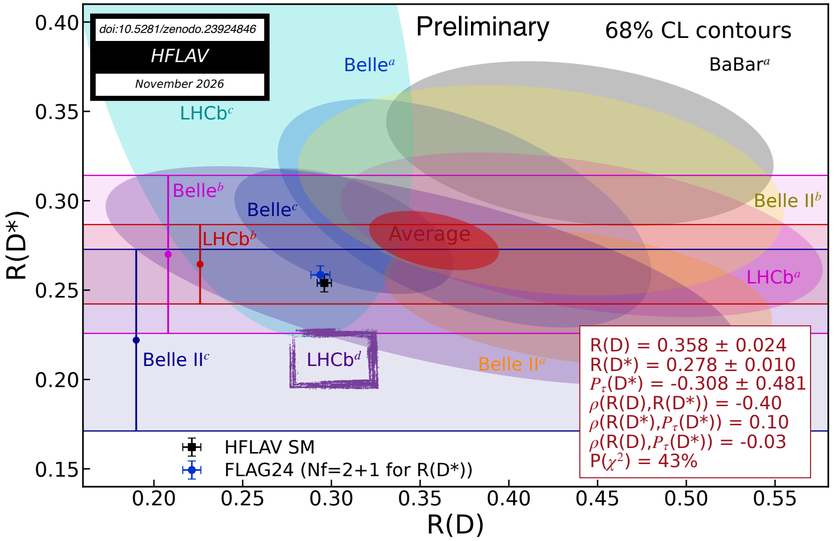
× 2 better sensitivities in $4.5\ \text{fb}^{-1}$ of 2024 data wrt full Run 1+2 ($9\ \text{fb}^{-1}$) due to software-only trigger!

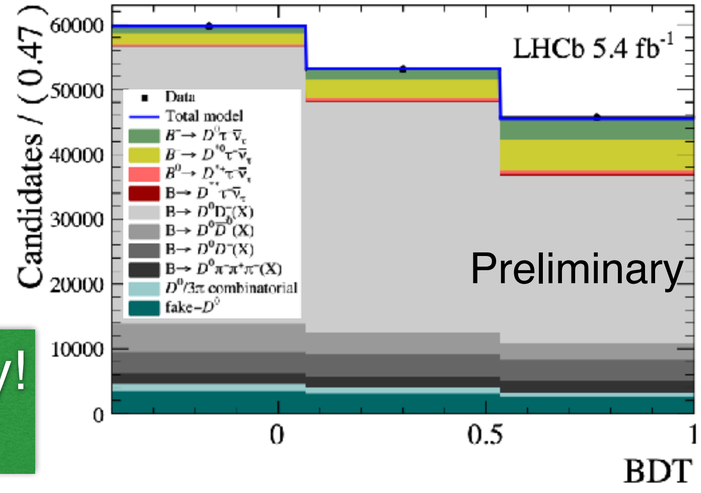
NEW!

[LHCb-PAPER-2026-059]

New measurement of $R(D^{(*)0}) \equiv \mathcal{B}(\overline{B} \to D^{(*)0}\tau^-\bar{\nu})/\mathcal{B}(\overline{B} \to D^{(*)0}\mu^-\bar{\nu})$

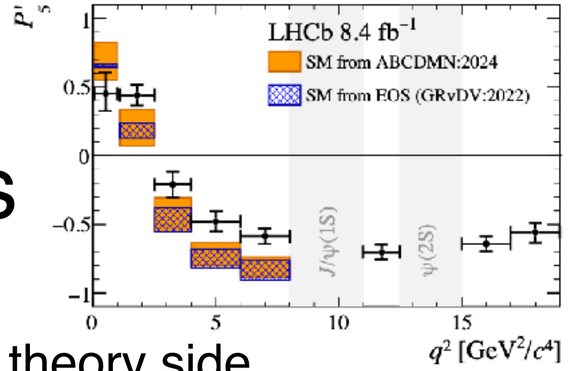
- Long-standing tension between SM and experiment in $b \to c\ell\nu$
  - Theoretically clean: ~1%
  - Experimentally very challenging: large $B \to DX$ backgrounds and $D \sim \tau$
- First simultaneous R(D) and R(D*) with $\tau^- \to \pi^+\pi^-\pi^-(\pi^0)\bar{\nu}$
  - Full Run 2 data set
  - Measure relative to $B^+ \to (\overline{D}^0 \to K^+\pi^-)(D_s^+ \to \pi^+\pi^-\pi^+)$
  - 3D fit in τ decay time, q^2 and BDT rejecting $B \to D^0 D_s X$ decays
- Systematic uncertainties at similar level as statistical uncertainties:
  - Background simulation statistics
  - External branching fractions
- Tension moves from 3.7σ to 3.4σ (or 1.8σ: Marcello's news)





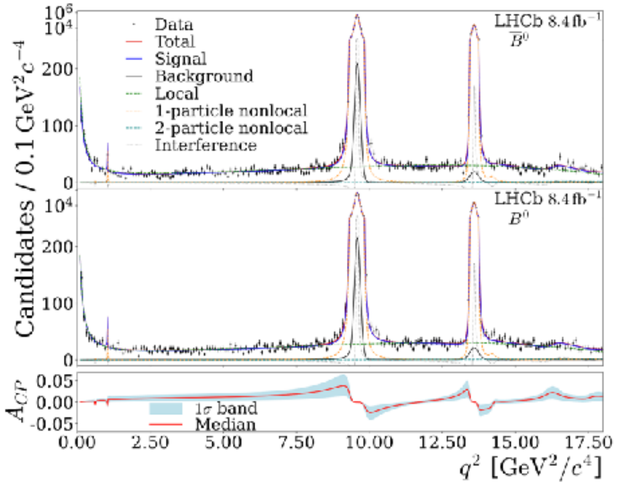
Improvements on fast simulations and external measurements on the way!
Significant improvements with Run 3 measurements expected!

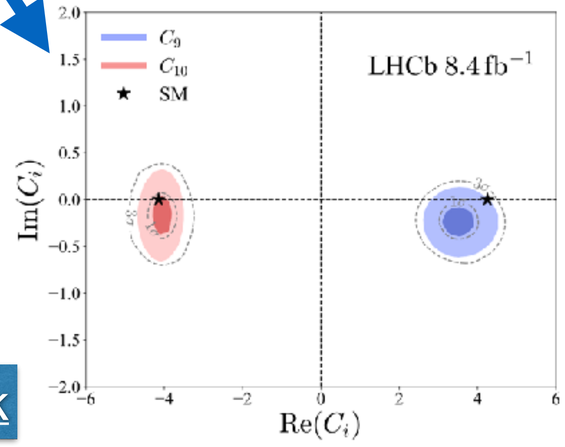
Studies of $b \to s(d)\ell^+\ell^-$ decays



[PRL 137 (2026) 021802]

- Large community interest: → Bernat's and Tobias' talks on theory side
  $B \to K^{(*)}(\pi)\ell\ell, \Lambda_b^0 \to \Lambda/\Lambda(1520)\ell\ell, \ldots$
  - Tensions wrt SM in $\partial\mathcal{B}/\partial q^2$ and angular observables
  - Lepton-flavour universality measurements consistent with SM
- NEW studies of the $B^0 \to K^{*0}\mu^+\mu^-$ angular structure with full Run 1&2:
  - binned in q^2 [PRL 137 (2026) 021802]
  - Unbinned fit to Wilson Coefficients of WET using dispersion relation [PRL 137 (2026) 061801]
  - Unbinned "model-independent": model q^2 distribution with Legendre polynomials [arXiv:2608.12215]
  - …
  - Many additional ideas using sPlot, method of moments, allow to extract unbinned quantities in function of q^2 also for low-stats modes! [JINST 20 (2026) P07042, arXiv:2609.39998], [PRD 112 (2025) 016007]





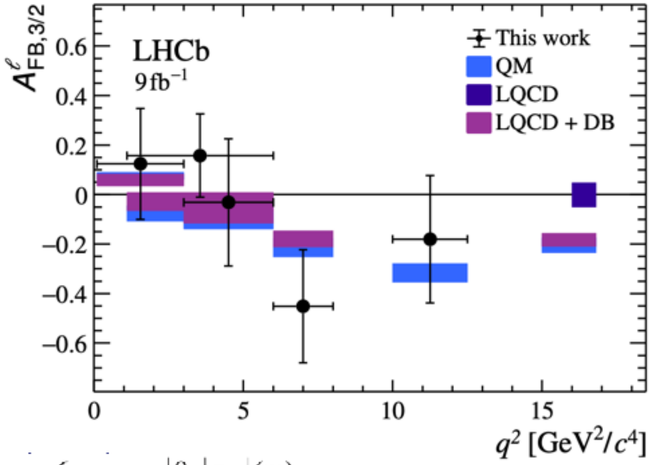
Moving towards LFU measurements: Lorenzo's talk

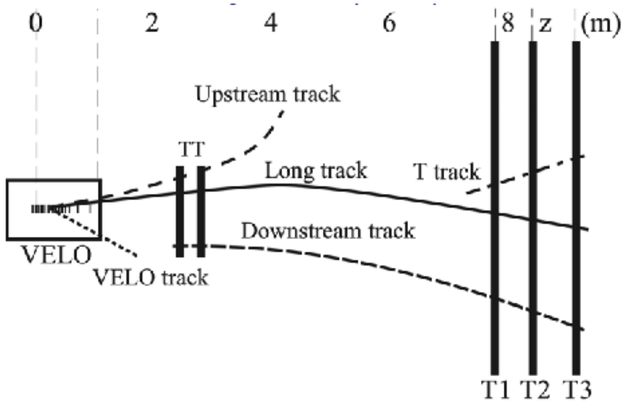
NEW!

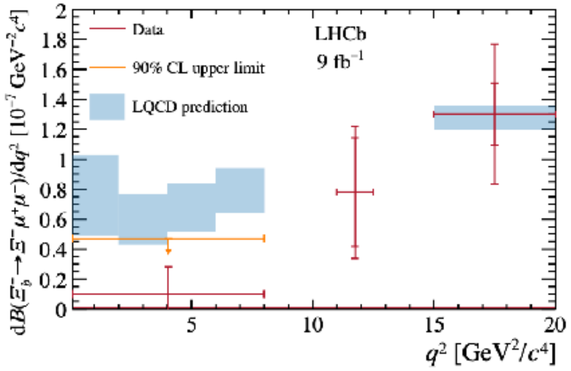
[arXiv:2608.21082]
[arXiv:2610.22452]

New studies of baryonic $b \to s\ell\ell$ decays with Run 1/2

- Angular analysis of $\Lambda_b^0 \to \Lambda(1520)\mu^+\mu^-$
  - Baryonic counterpart to $B^0 \to K^{*0}\mu^+\mu^-$ but much more rare
  - Good agreement with the SM
- First differential measurement of $\Xi_b^- \to \Xi^-\mu^+\mu^-$
  - Use cascade $\Xi^- \to (\Lambda \to p\pi^-)\pi^-$
  - Exploit different track types: $\sim 90\,\%$ decays have at least one track not registered in VELO







Large Run 3 data set offers much better precision and plethora of new channels, e.g. $\Xi_b^0 \to \Xi^0\ell^+\ell^-$ [arXiv:2609.15251]

Same pattern as $\Lambda_b^0 \to \Lambda\mu^+\mu^-$

BBC

Scientists detect signals at the smallest scale ever explored

3 November 2026

Pallab Ghosh, Science correspon
Science

Cern breakthrough offers firs glimpse into the zeptoverse

British-led researchers using the Large Hadron Collider detected a r
gives clues to a minuscule world where exotic new particles may be



NATIONAL GEOGRAPHIC ESPAÑA

CIENCIA ANIMALES MEDIO AMBIENTE HISTORIA VIAJES

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Bienvenidos al Zeptoverso: el mundo más pequeño jamás detectado que el CERN ha descubierto

Bild STARTSEITE

Durchbruch am Cern

Haben Forscher das Tor zum Zeptoversum geöffnet?

CNN BRASIL CURIOSIDADES Ao vivo Política Money WW Agro Infra IA

O que os cientistas estão descobrindo sobre o zeptoverso, a menor escala do universo que se conhece até agora

GEO

Le CERN découvre l' "zeptoverse", un mor pourrait contenir les

I fisici del Cern alle porte dello zeptoverso

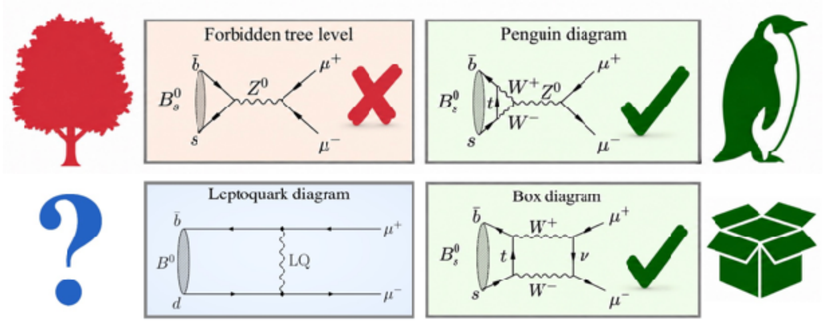
E' un mondo infintamente piccolo in cui potrebbero nascondersi nuove particelle

NEW!

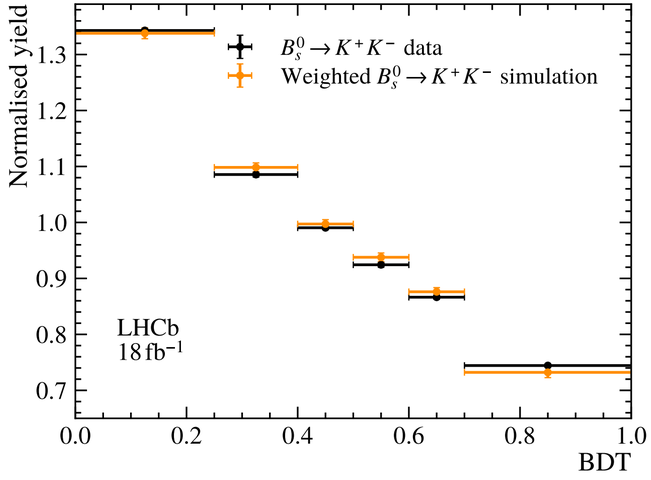
[arXiv:2611.00230]

New measurements of the $B^0_{(s)} \to \mu^+\mu^-$ properties

- Golden channels search for New Physics:
  - Theoretically very clean in the SM
    - Only allowed at loop level and helicity suppressed
    - Known to <10% precision
  - Experimentally very clean: 2 energetic muons from displaced vertex
  - Many NP models imply rate enhancements
- New measurement based on data from Run 1&2 ($9\,\mathrm{fb}^{-1}$) and part of Run 3 ($18\,\mathrm{fb}^{-1}$)
  - Similar combinatorial rejection despite 5x higher pile-up
  - Better suppression of $B \to hh^{(\prime)}$ wrt Run 1/2



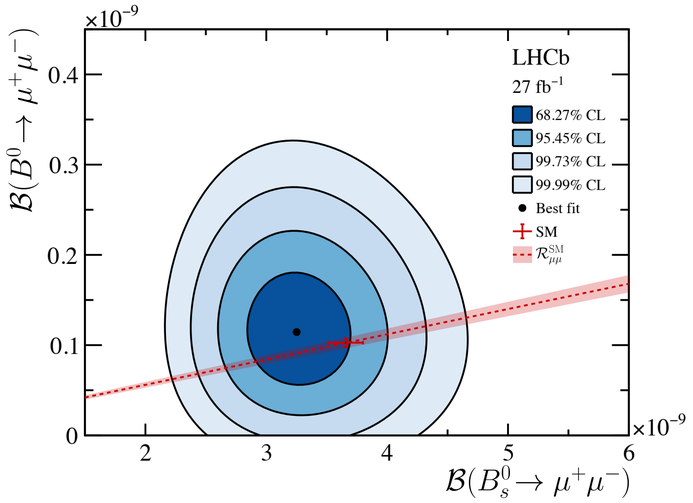
Precise calibration of BDT slices thanks to simplified trigger

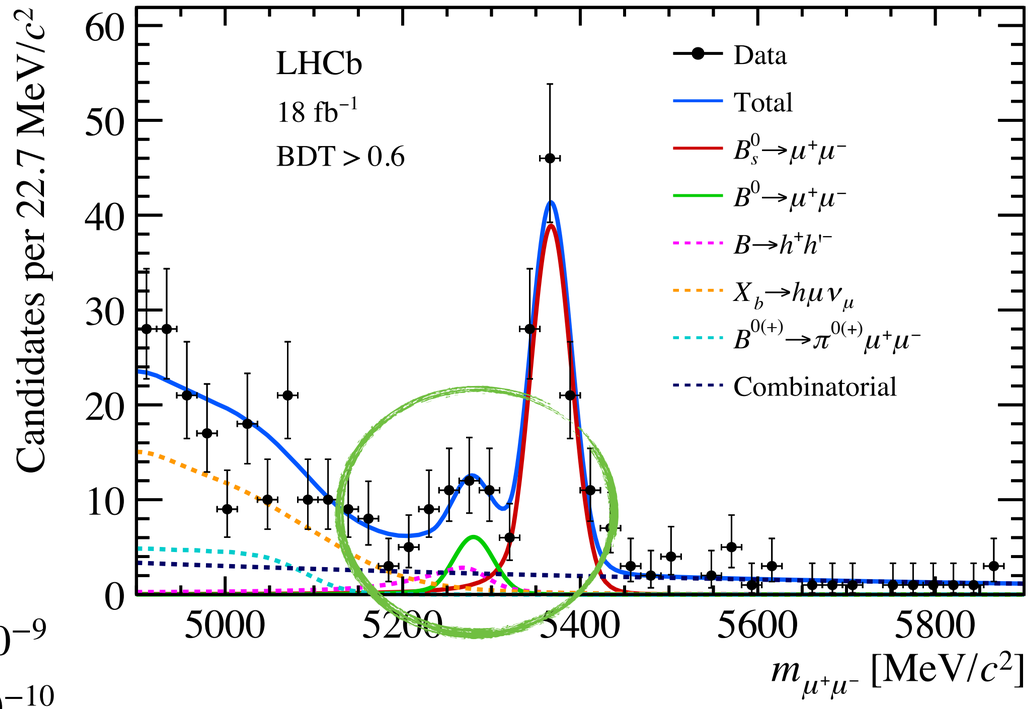


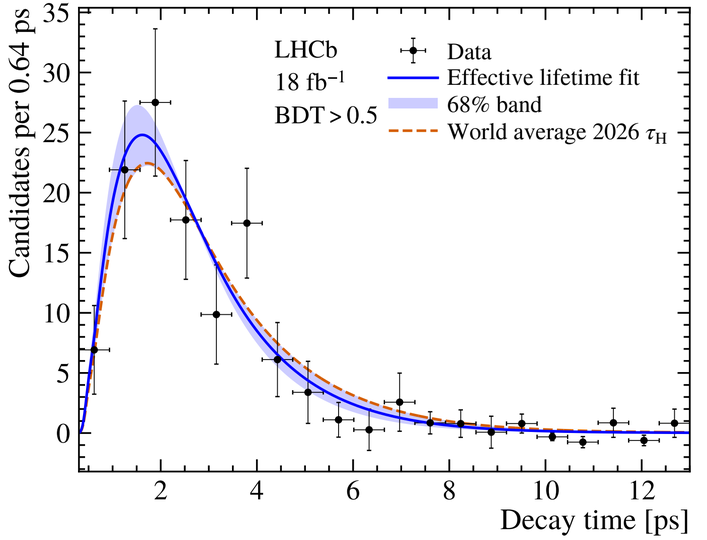
NEW!

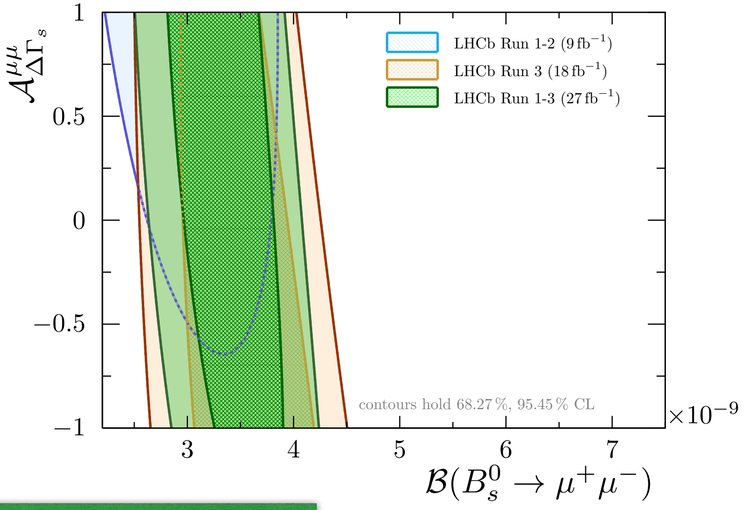
[arXiv:2611.00230]

Evidence for $B^0 \to \mu^+\mu^-$ decays!









$$\mathcal{B}(B_s^0 \to \mu^+\mu^-) = \left(3.25^{+0.26+0.13}_{-0.25-0.12}\right) \times 10^{-9}$$

$$\mathcal{B}(B^0 \to \mu^+\mu^-) = \left(1.14^{+0.42+0.06}_{-0.39-0.05}\right) \times 10^{-10}$$

$$R_{\mu\mu} = 0.035^{+0.014+0.002}_{-0.012-0.001}$$

$$\tau_{\mu\mu} = 1.60 \pm 0.16 \pm 0.01 \text{ ps}$$

$$\mathcal{A}^{\mu\mu}_{\Delta\Gamma_s} = 0.91 \pm 1.92 \pm 0.18 \pm 0.10$$

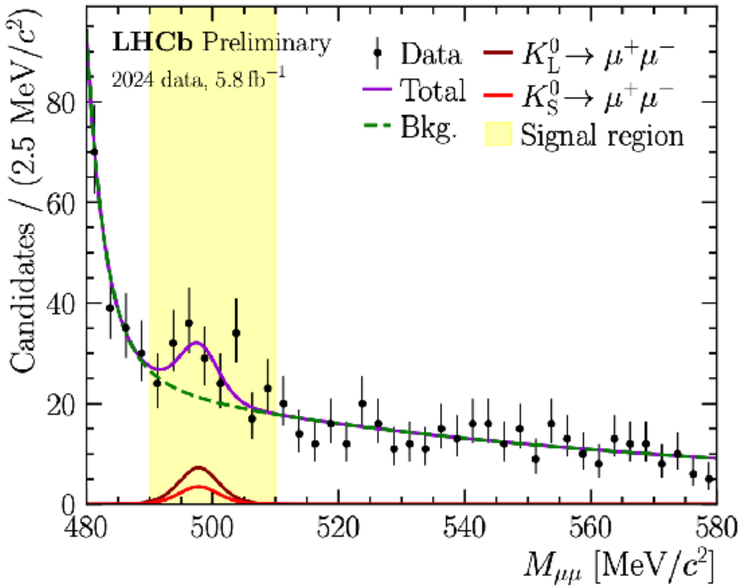
Next step: full Run 3 analysis and time dependent CP analysis of $B_s^0 \to \mu^+\mu^-$!

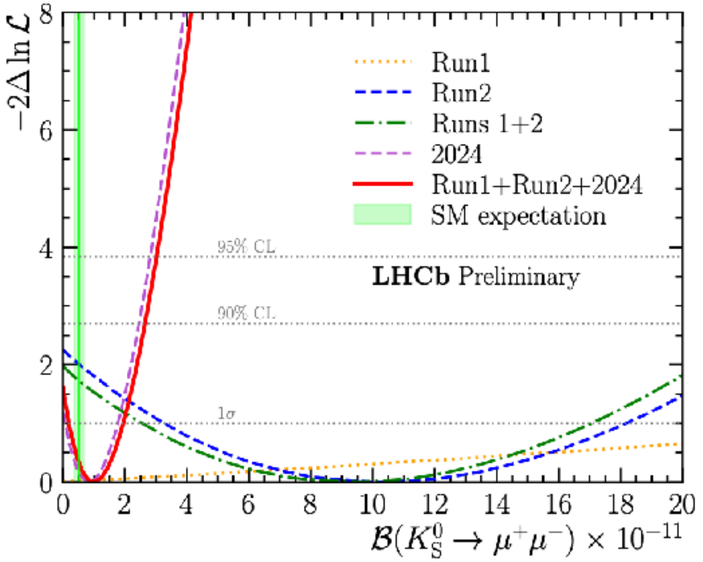
NEW!

[LHCb-PAPER-2026-052]

Zeroing in on $K^0_S \to \mu^+\mu^-$

- Flavour-changing neutral current, not observed to date
  - $\mathcal{B}(K^0_S \to \mu^+\mu^-)_{SM} = (5.18 \pm 1.50_{LD} \pm 0.02_{SD}) \times 10^{-12}$
  - NP: large enhancements, e.g. SUSY or LQ scenarios
- Huge K^0_S production at LHC: sensitivity jumps at LHCb and recently CMS
  - NEW LHCb search with 2024 data: upgrade trigger leads to **5 × better efficiency**
  - Additional improvements with dedicated muonID network
  - First evidence for $K^0 \to \mu^+\mu^-$ at the LHC, $K^0_S \to \mu^+\mu^-$ at 1.1σ





Evidence for $K^0_S \to \mu^+\mu^-$ with full Run 3 in reach
→ next step: study $K^0_S - K^0_L$ interference!

[arXiv:2611.00135]

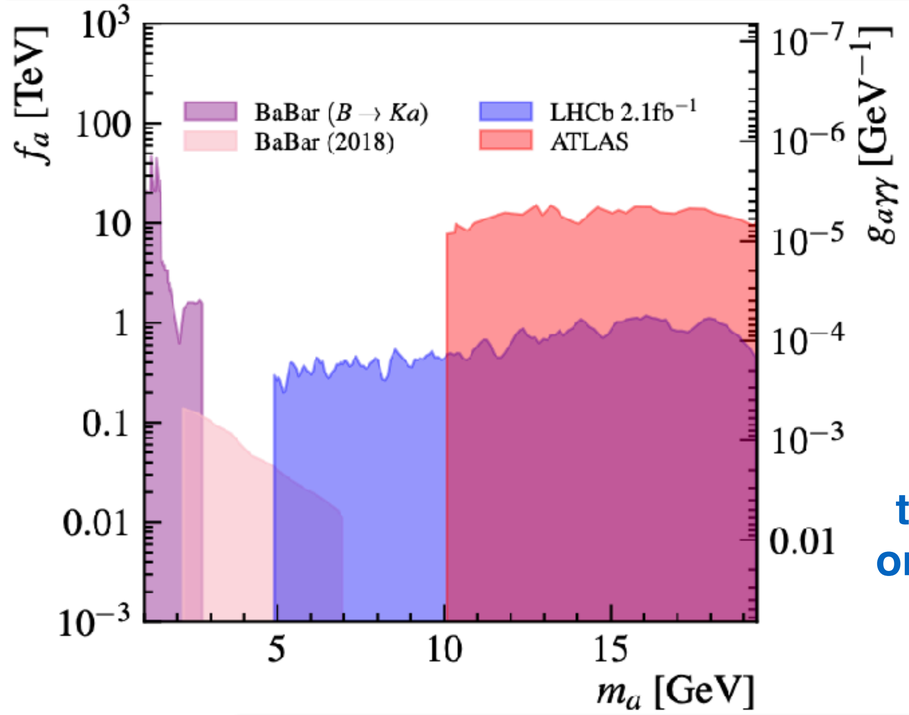
NEW!

Axion-like particles with 2018-only LHCb data

$$\mathscr{L} \supset \frac{a}{4\pi f_a}\left[\alpha_3 c_3 G\tilde{G} + \alpha_2 c_2 W\tilde{W} + \alpha_1 c_1 B\tilde{B}\right] + \frac{1}{2} m_a a^2$$

$$pp \to \mathrm{ALP} \to \gamma\gamma$$

Highly challenging:
2D calorimeter clusters in busy pp environment

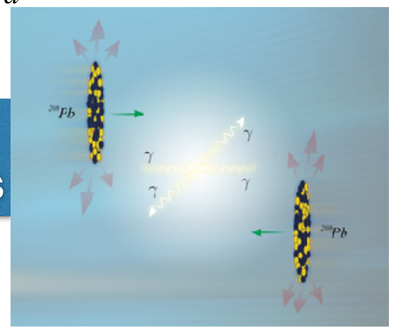


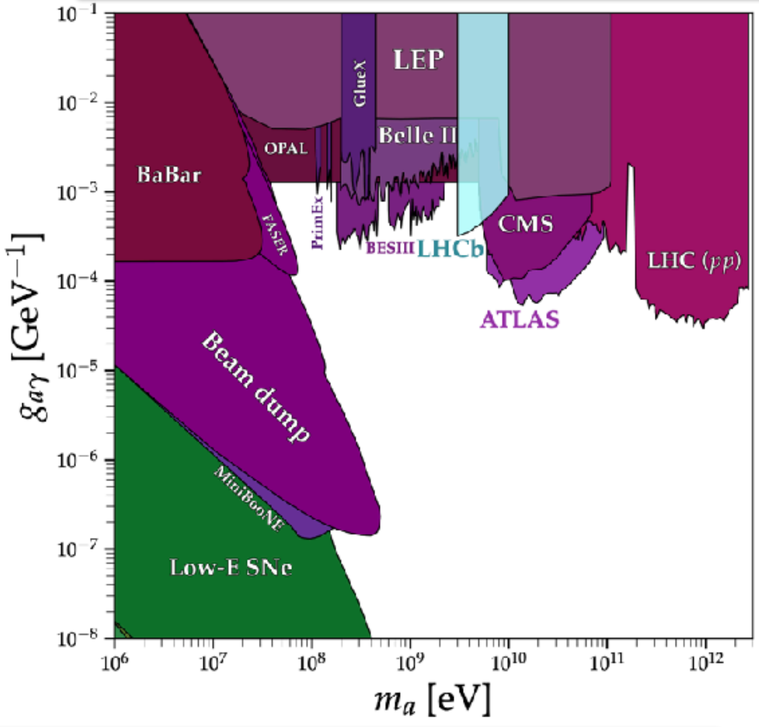
[arXiv: 2507.14390]

$$\mathscr{L} \supset \frac{a}{4\pi f_a}\left[\alpha_3 c_3 G\tilde{G} + \alpha_2 c_2 W\tilde{W} + \alpha_1 c_1 B\tilde{B}\right] + \frac{1}{2} m_a a^2$$

$$\mathrm{UPC}: \mathrm{PbPb} \to \mathrm{ALP} \to \gamma\gamma$$

Extremely clean:
zero background vetoing any tracks





New Belle II search
slightly more stringent
[arXiv:2607.07800]

Compare talk by André on ATLAS/CMS searches

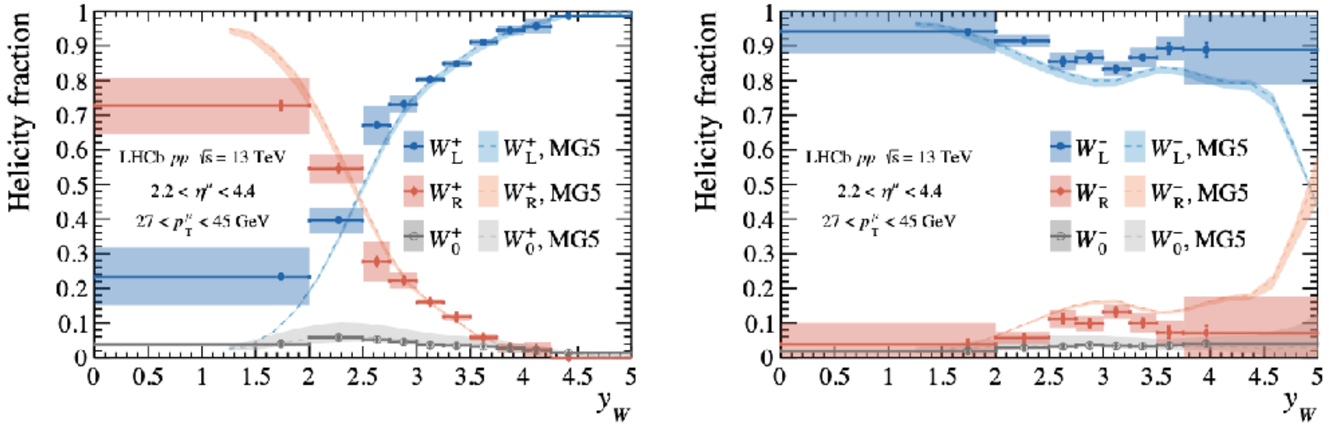
Pathfinder analyses: significant improvements with full Run 3 expected

NEW!

[arXiv:2609.22555]

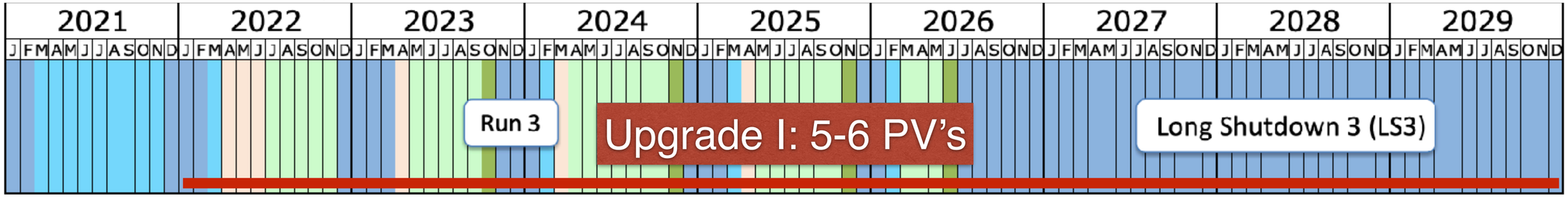
Forward rapidity dependence of W boson transverse helicity fractions

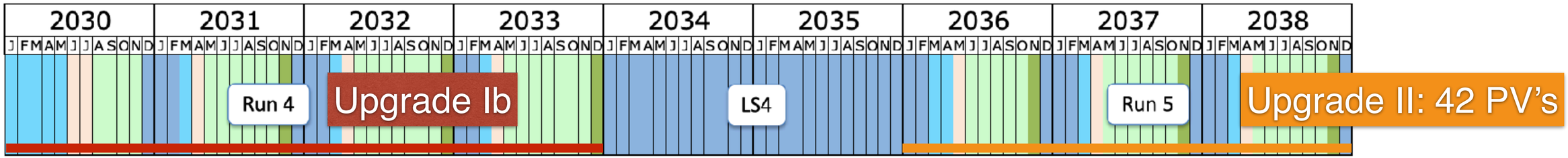
- Rapidity-dependent helicity fractions test interplay between parton-distribution-functions (PDFs), higher-order QCD effects and weak interaction
  - Forward acceptance provides access to unexplored high rapidity region
  - Important for future precision electroweak measurements @LHC
- New measurement with Run 2 data:
  - Strong rapidity dependence
  - Confirming NLL predictions from the SM

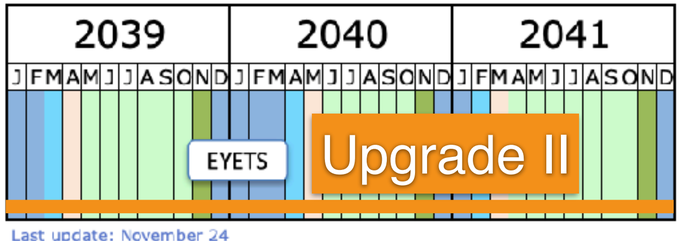


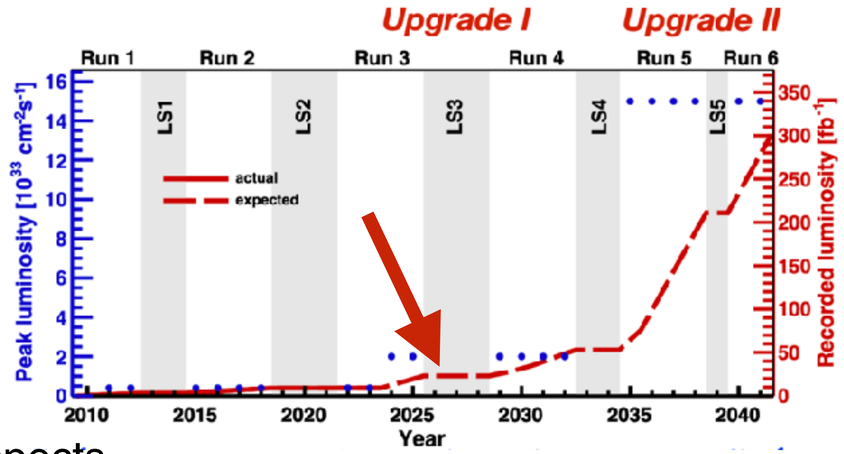
Quo vadis, LHCb?

[LHC schedule]









Increase inst. luminosity
@ **similar or better performance!**

~25 fb-1 in Run 3
~50 fb-1 by end of Run 4
~300 fb-1 by end of Run 5/6

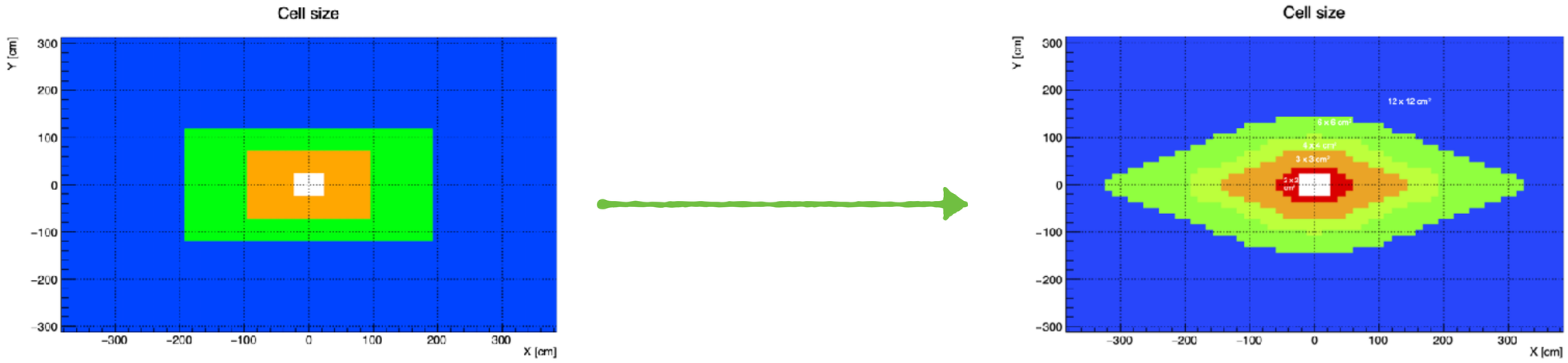
LHCb Upgrade II prospects

[LHCb-TDR-024]

[LHCb-TDR-025]

Enhancements for Run 4 (>2030)

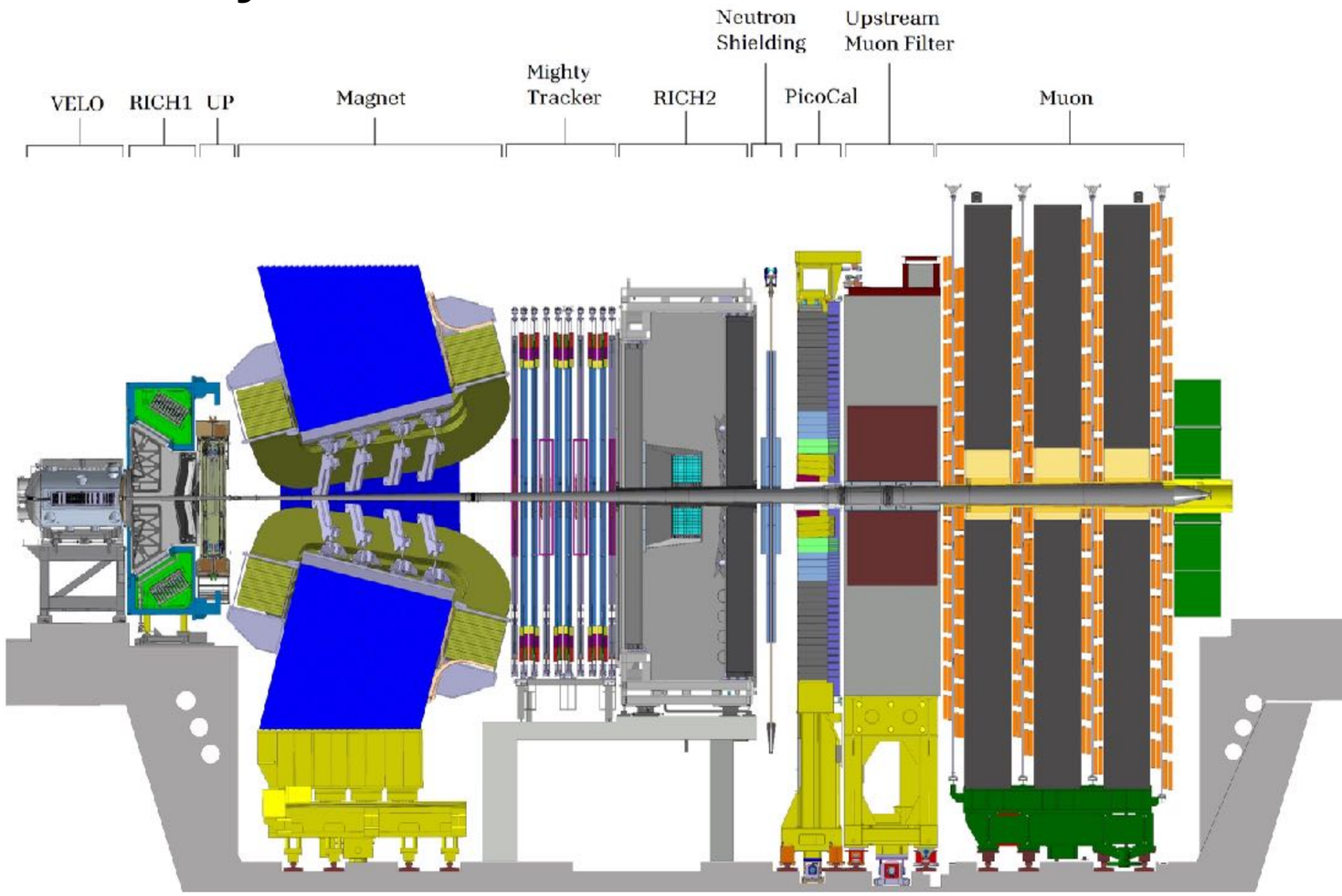
- Improved Charged PID (RICH): new electronics that allows photon time-of-arrival measurement → better photon-track matching
  - Relevant for suppressing backgrounds with misidentified particles
  - Also important for flavour tagging
- Improved neutral PID (ECAL): replace inner section (radiation damage) with higher granularity and different basic geometry that better matches occupancy
- Enable FPGA-based SciFi tracks to accelerate reconstruction



LHCb in Run 5&6 - another fully new detector

- Expect to cope with Pile-Up of ~42 PV's
  →High timing resolution to resolve PV's
- Replace almost all sub detectors
  - Biggest challenge: occupancy
  - Main tracker out of silicon and fibres
  - More fine-grained calorimeter
    - Lateral segmentation
    - Neutron shield to enhance performance
  - New Muon system
- Reoptimisation ongoing to match budget

TDR writing in full swing



[LHCb Upgrade II prospects]

Conclusions and outlook

- LHCb shaped the field of flavour physics
  → and broad program beyond!
- Upgrade I overwhelming success
  - Evidence for $B^0 \to \mu^+\mu^-$, $K^0 \to \mu^+\mu^-$
  - Sensitivity jumps in γ measurements
  - Discoveries of exotic baryons
  - CP-violation studies in suppressed decays
  - … and much much more to come!
- Upgrade Ib and II preparing in full swing



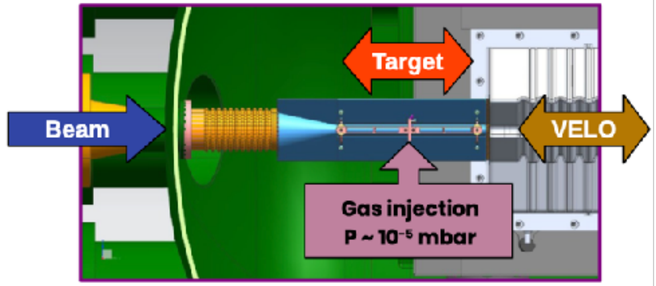
Many new flavourful results to come!



Backup

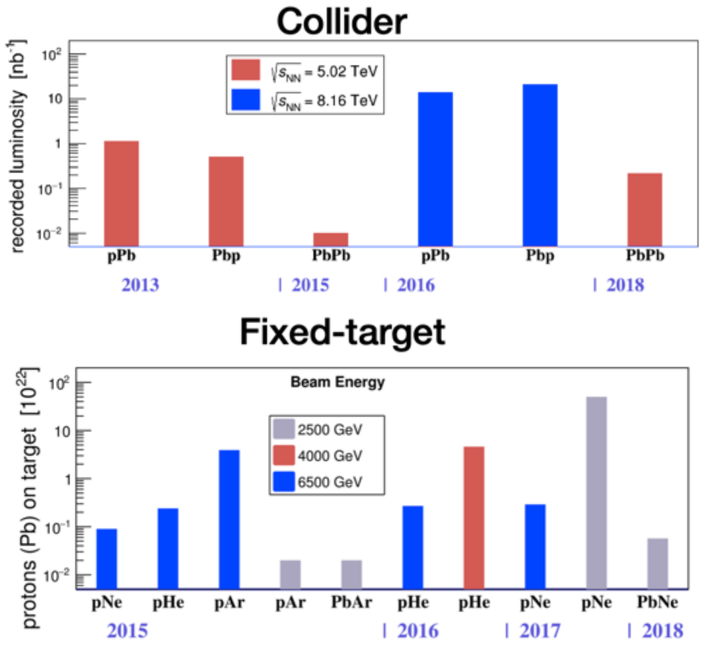
Heavy Ions and Fixed Target @LHCb

- Not only pp, study rich set of collision systems at LHCb
  - In Upgrade I explore HeavyIon collisions down to 30% centrality
- SMOG: Fixed target program in parallel to collider!
  - SMOG2 in Upgrade I: more localised gas → luminosity increase by orders of magnitude

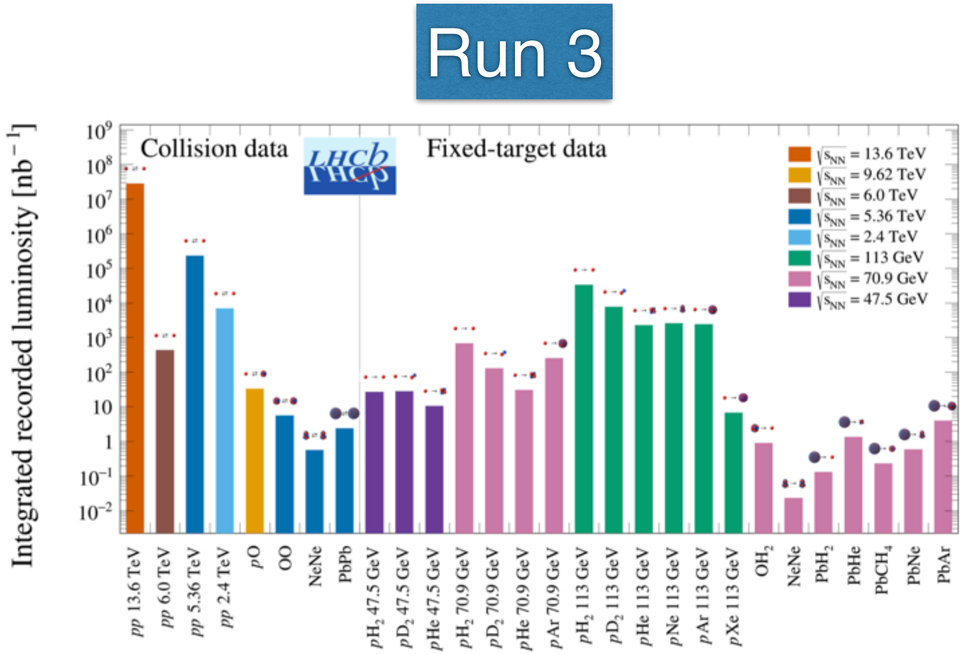


[SMOG2]

Run 1/2



Run 3



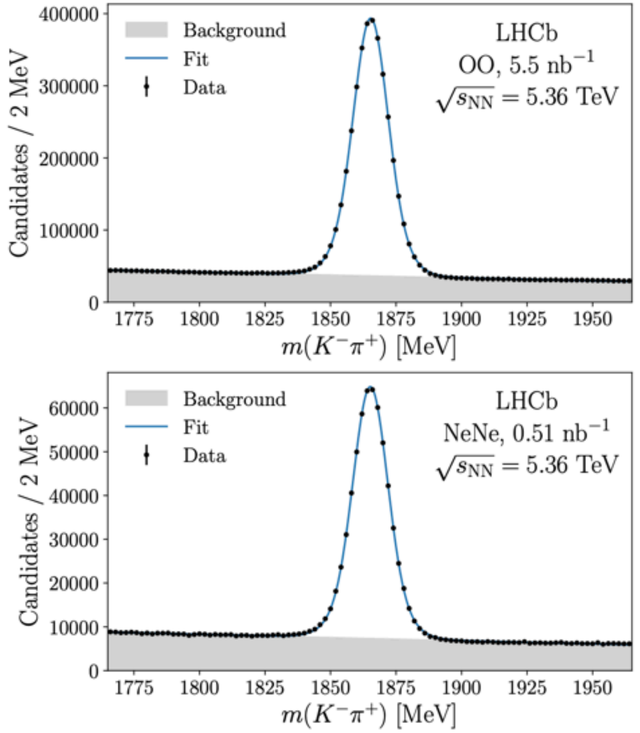
[LHCb Operations plots]

NEW!

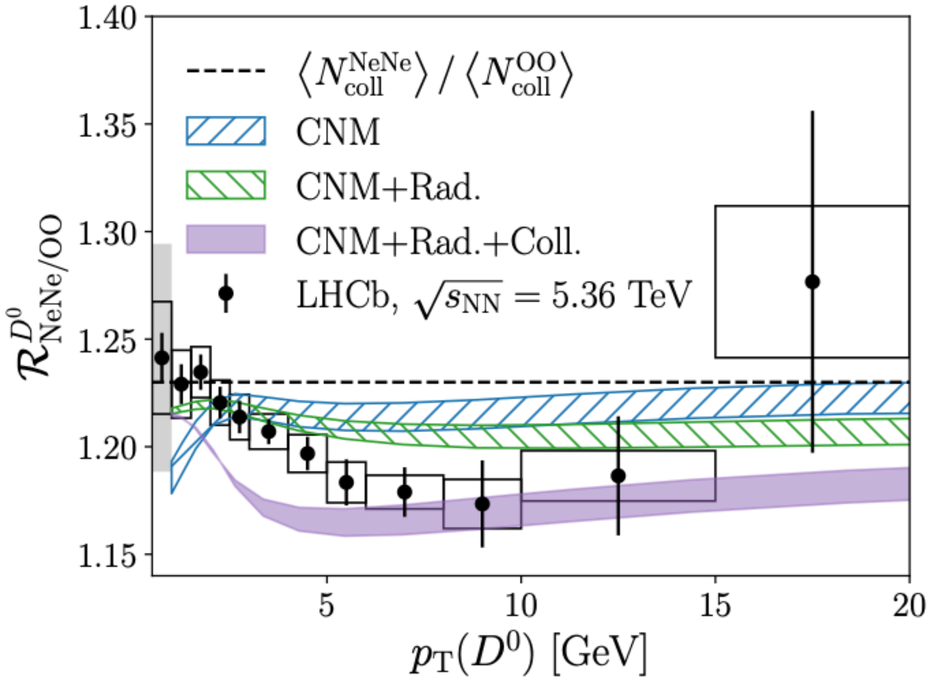
[arXiv:2605.27273]

D^0 production in OO and $NeNe$ collisions

Extremely clean samples



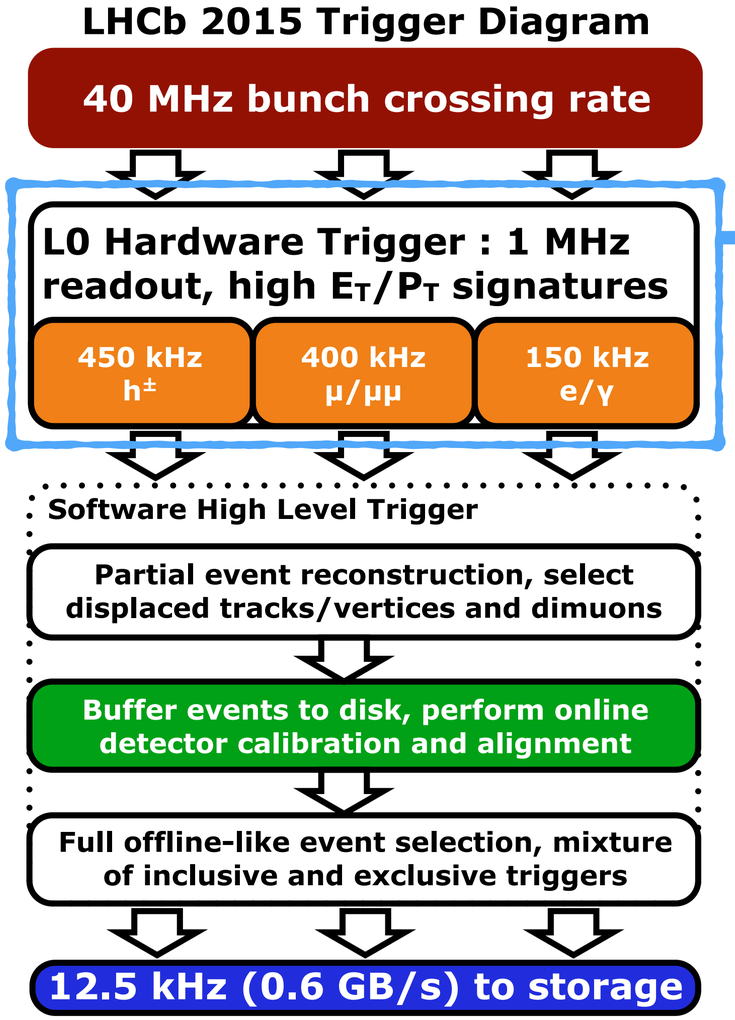
Clear difference between OO and $NeNe$



Shape indicates effects like Quark-Gluon-Plasma
→ study onset of QGP production with increasing nucleus sizes!

Stay tuned for rich program studying initial state, medium properties and hadronisation through many collision systems!

LHCb trigger in Run 3

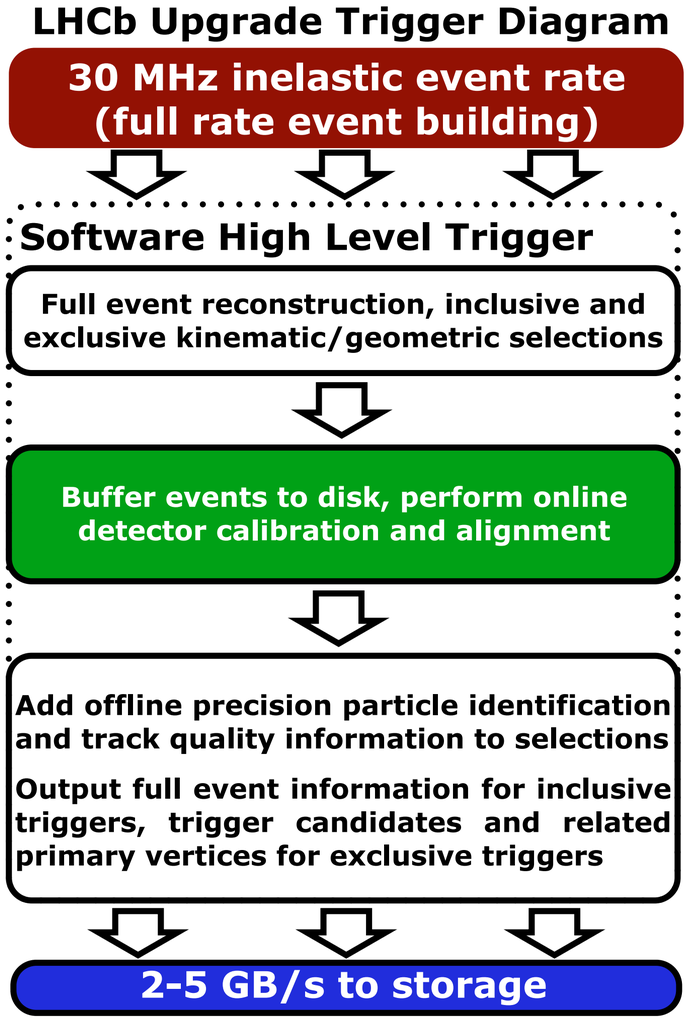


Removal of L0 hardware trigger

Two-staged high-level trigger: HLT 1 (GPU) and HLT2 (CPU)

Full software trigger allows

- Topology-based selection with softer p_T requirements
  → benefit to soft daughters from charm, tau, strange
  → benefit with electrons in final state
- Offline quality HLT2 trigger allows sophisticated selections → gain of up to $\times 2$ in fully hadronic final states



[Trigger schemes]