LHCb Highlights

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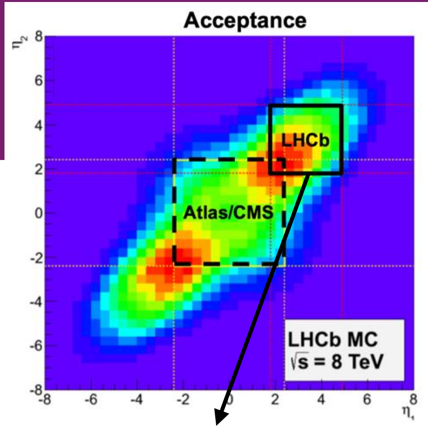
on behalf of the LHCb Collaboration

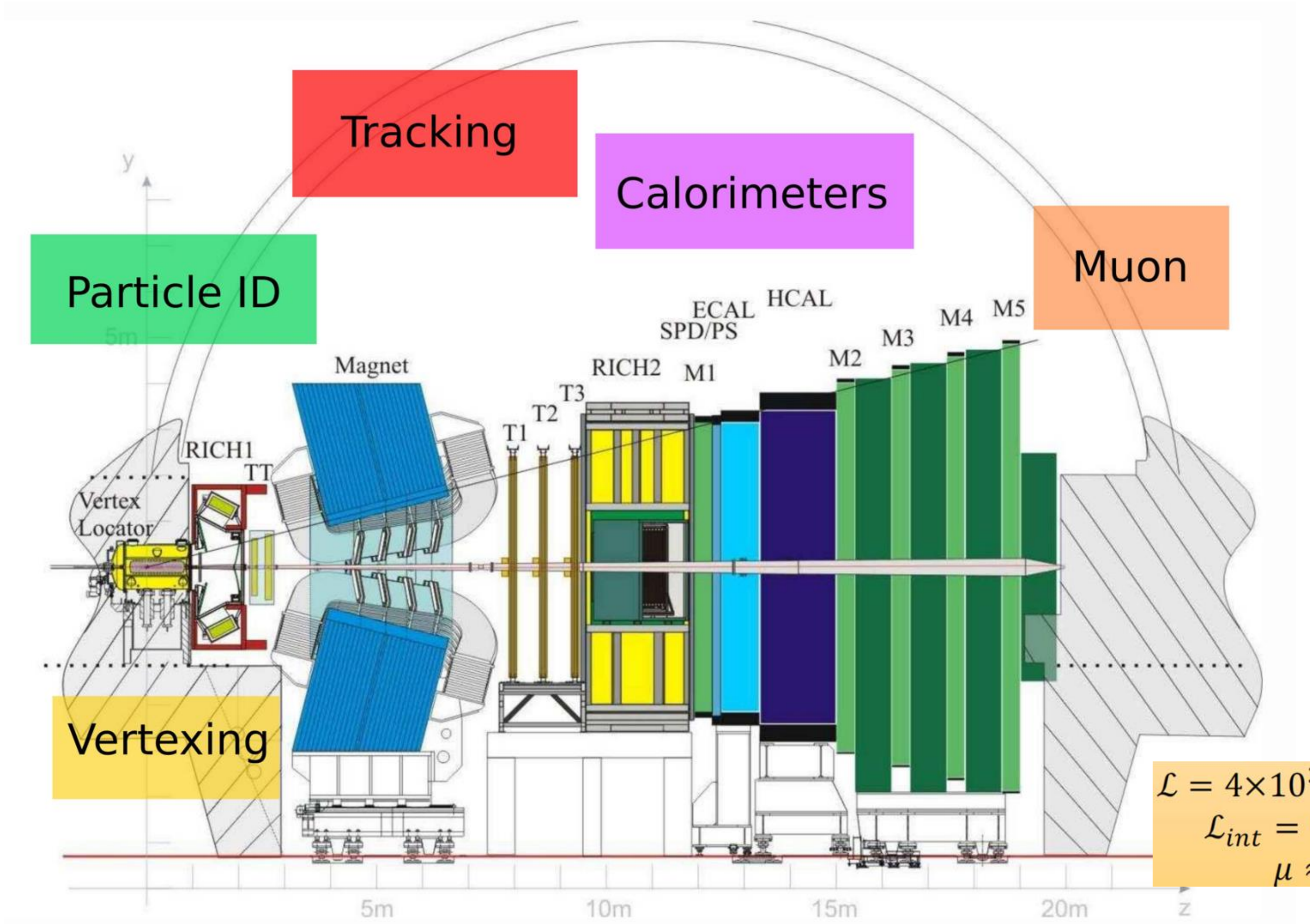
ICNFP 2024, Kolymbari
26 August – 4 September 2024

LHCb detector in a nutshell



25% of $b\bar{b}$

Forward arm spectrometer with unique coverage in pseudorapidity ($2 < \eta < 5$)



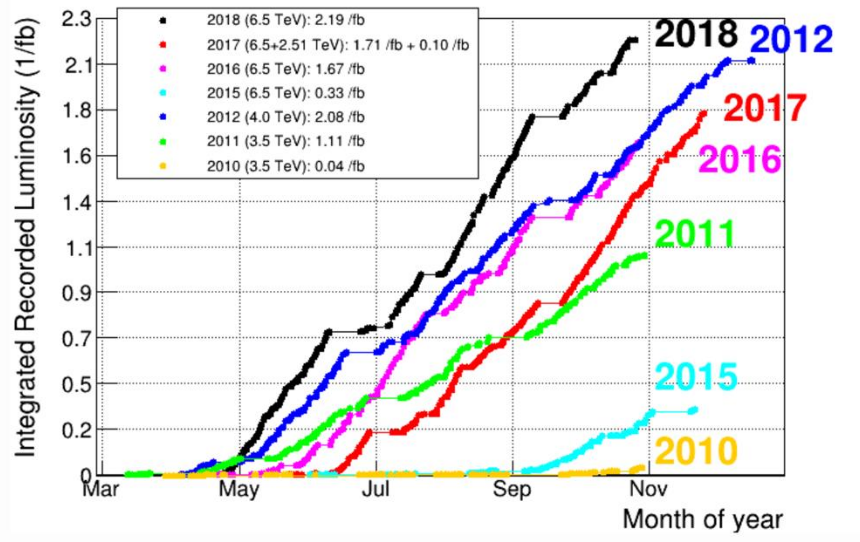
$\mathcal{L} = 4{\times}10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
$\mathcal{L}_{int} = 9\ \mathrm{fb}^{-1}$
$\mu \approx 1$

Schematic of the Run 1&2 LHCb detector

[Int. J. Mod. Phys. A30 1530022 (2015)]

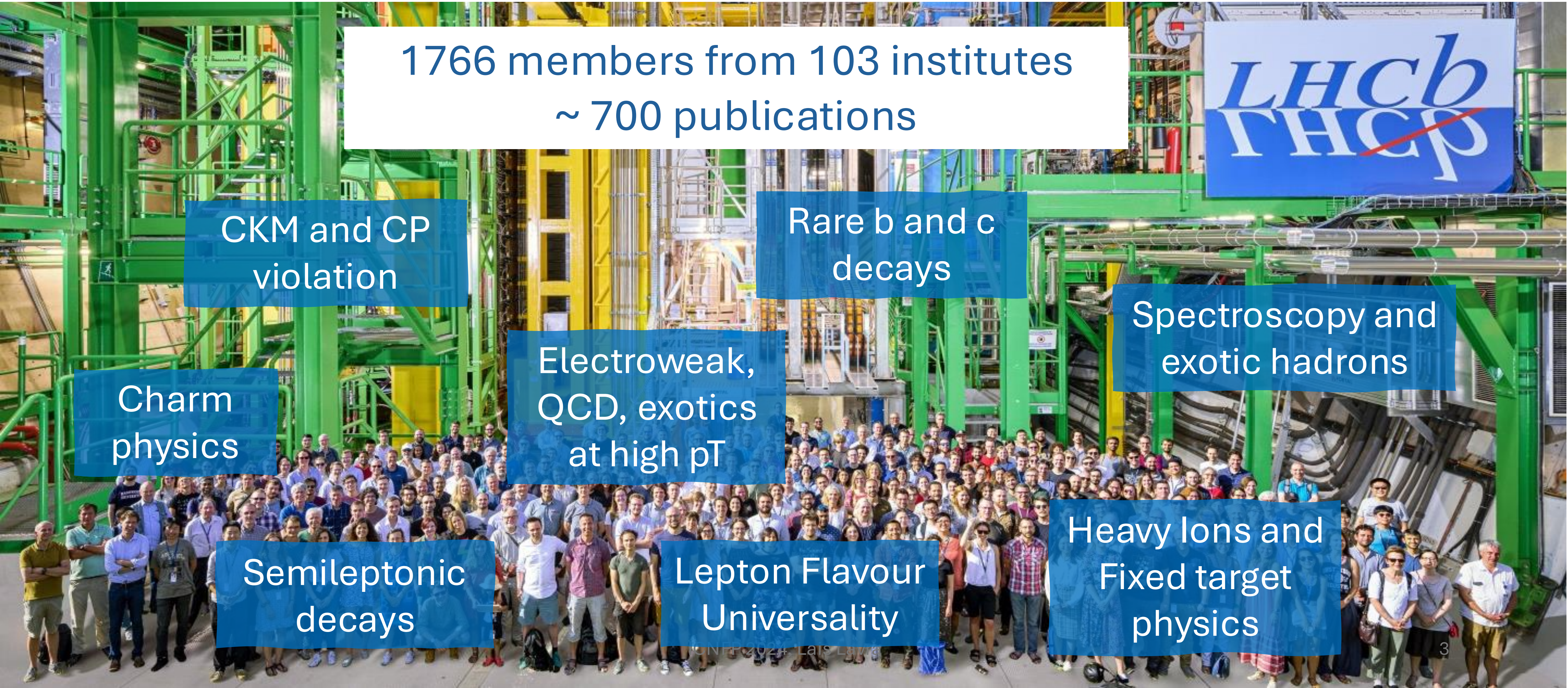
Designed for CPV and rare decays measurements in beauty and charm

→now Forward General-Purpose Detector



LHCb Physics Program

Main focus on heavy flavour but plenty of other physics in the forward region



1766 members from 103 institutes
~ 700 publications

CKM and CP violation

Rare b and c decays

Spectroscopy and exotic hadrons

Charm physics

Electroweak, QCD, exotics at high pT

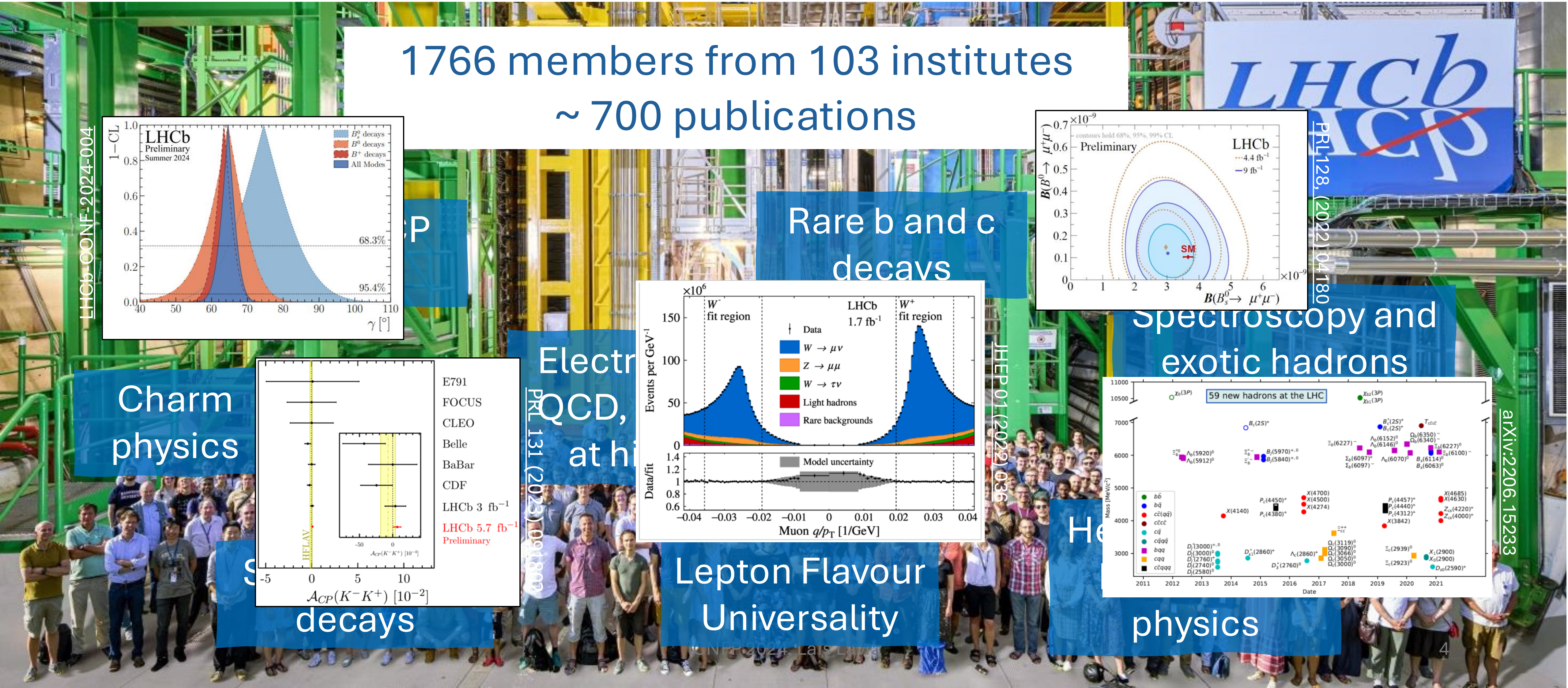
Semileptonic decays

Lepton Flavour Universality

Heavy Ions and Fixed target physics

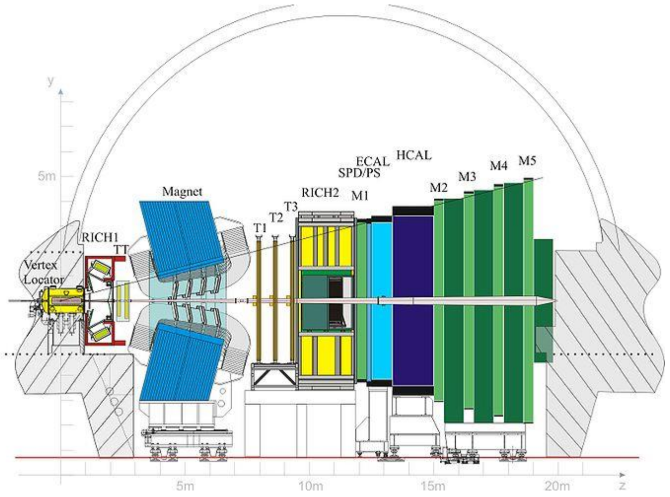
LHCb Physics Program

Main focus on heavy flavour but plenty of other physics in the forward region



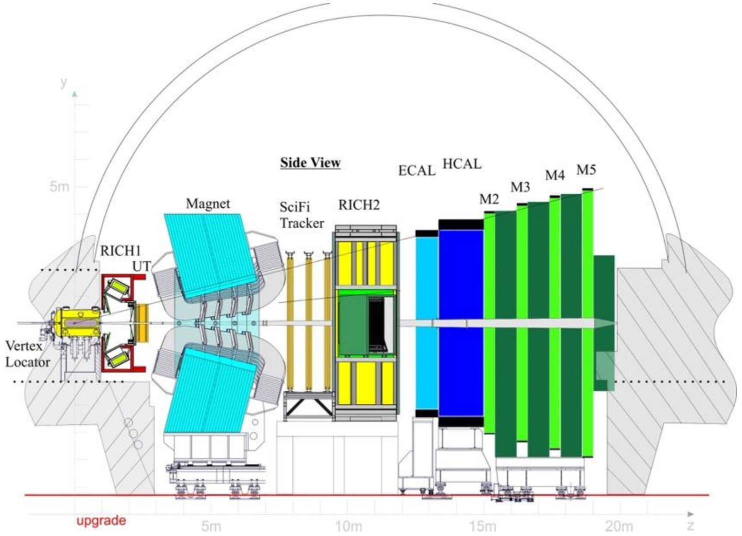
LHCb: Past - Present - Future

LHCb Original (Run 1&2)
2009-2018



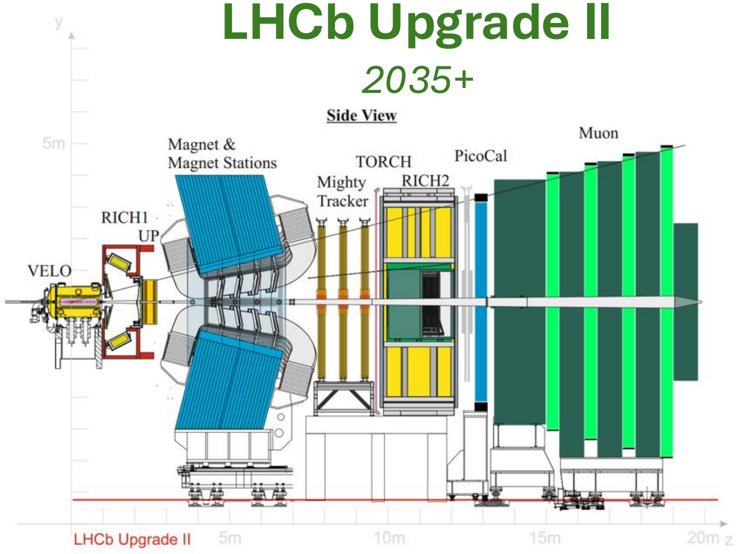
$\mathcal{L} = 4\times10^{32}\text{cm}^{-2}\text{s}^{-1}$
$\mathcal{L}_{int} = 9\ \text{fb}^{-1}$
$\mu \approx 1$

LHCb Upgrade I
2022-2032



$\mathcal{L} = 2\times10^{33}\text{cm}^{-2}\text{s}^{-1}$
$\mathcal{L}_{int} = 50\ \text{fb}^{-1}$
$\mu \approx 5$

LHCb Upgrade II
2035+



$\mathcal{L} = 1.5\times10^{34}\text{cm}^{-2}\text{s}^{-1}$
$\mathcal{L}_{int} = 300\ \text{fb}^{-1}$
$\mu \approx 40$

Luminosity

Outline

1. Very Selected LHCb Highligths from Run 1 & Run 2

    focus on rare b decays

2. LHCb Upgrade(s)

    Upgrade I: current status

    Upgrade II in few words

For more at LHCb see also :

- CP violation and mixing in charm (M. Kmiec)
- LFU tests in semileptonic decays (B. Kutsenko)
- Multi-quark states (S. Joshi)

LHCb Highlights from Run 1 & 2

(with focus on rare decays)

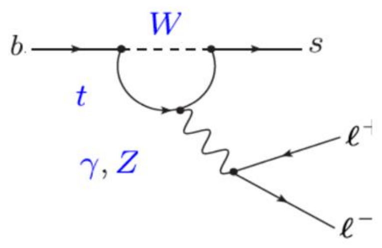
Rare decays as a probe of New Physics

Decays forbidden at the tree level in SM (BR of $10^{-6} - 10^{-10}$)

Flavour-Changing Neutral Currents(FCNC): $q \to q'\gamma$ and $q \to q' l^+ l^-$

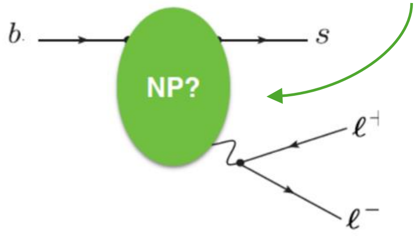
- Proceed at the loop level → very supressed in the SM
- Sensitive to virtual NP particles in the loop
- Benefit from precise SM predictions

$b \to s l^+ l^-$



Indirect search for NP

Observables can be altered by new (virtual) particles



$$\mathcal{H}_{eff} \propto V_{tb} V_{ts}^{*} \sum_i (C_i \mathcal{O}_i + C_i' \mathcal{O}_i')$$

Wilson Coefficients: NP enters here

$C_i = C_i^{SM} + C_i^{NP}$

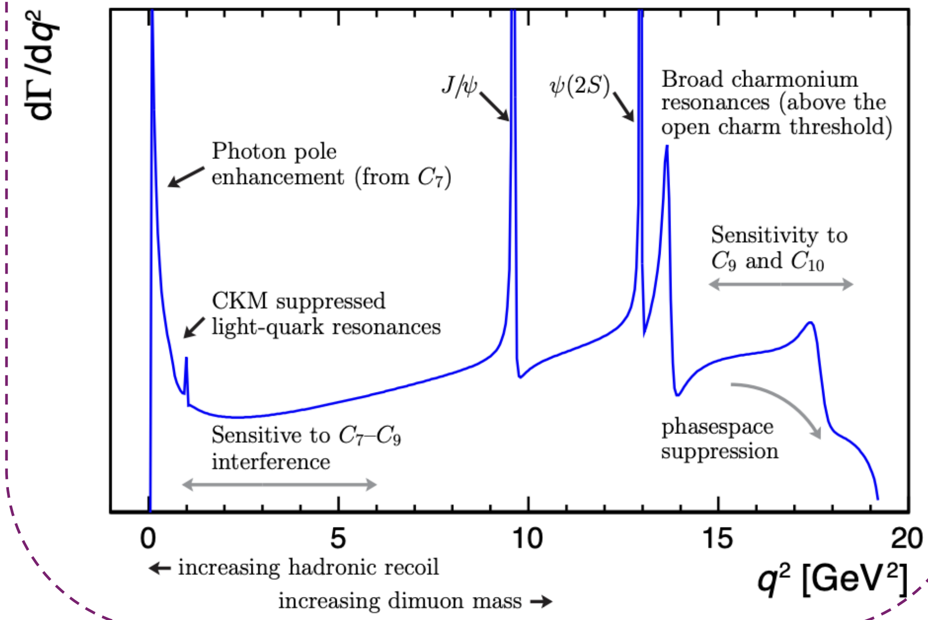
Local operators describe non-perturbative QCD

large theory uncertainties

What can we measure?

- New decay modes
- Branching fractions
- Angular observables
- Tests of LFU in μ/e

Measurements as a function of $q^2 = m^2(l^+ l^-)$



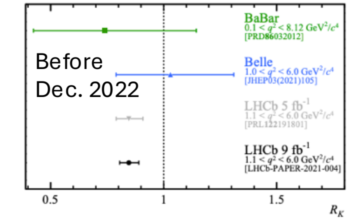
Anomalies in $b \to s l^+ l^-$ decays

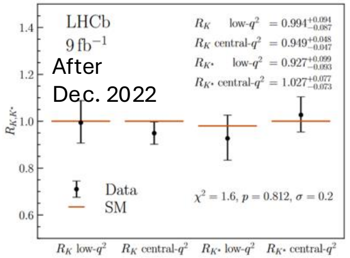
Increasing theoretical uncertainty

LFU tests in μ/e

$$\mathcal{R}_K = \frac{\mathcal{B}(b \to s\,\mu^+\,\mu^-)}{\mathcal{B}(b \to s\,e^+\,e^-)}$$

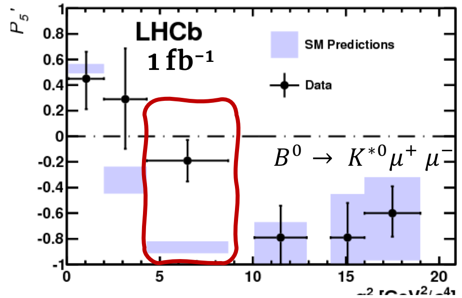
PRL 131 (2023) 051803 , PRD 108 (2023) 032002



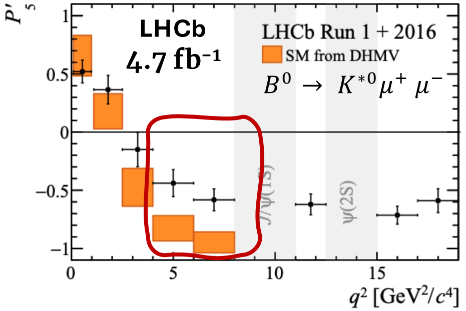


Most precise **LFU test compatible with SM**

Angular observables



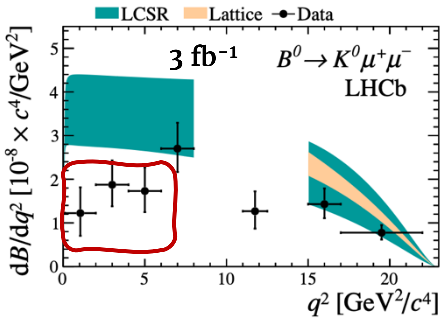
PRL 111 (2013) 191801



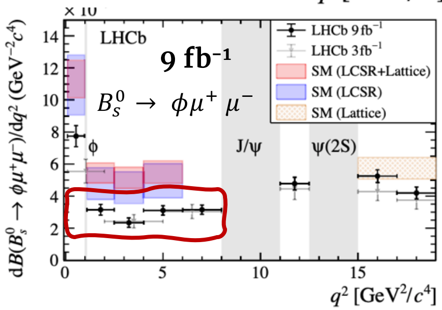
PRL 125 (2020) 011802

Local tension in the P_5'

Differential branching fraction



JHEP06(2014)133



PRL 127 (2021) 151801

lower than SM predictions

Tensions have remained for ~ 10 years

Complementary searches:

- Explore new final states of $b \to s l^+ l^-$ with **electrons and taus, new radiative** modes ...
- Search for **decays forbidden in the SM** or beyond experimental reach

Very selected results presented today

(from rare b decays)

Angular analysis	Angular analysis of $B^0 \to K^{*0} e^+ e^-$ decays [LHCb-PAPER-2024-022 in preparation]
Radiative decays	Search for the $B_s^0 \to \mu^+\mu^-\gamma$ decay [JHEP 07(2024) 101]
	Amplitude analysis of the radiative decay $B_s^0 \to K^+K^-\gamma$ [JHEP08(2024)093]
Very rare and forbidden decays	Search for $B^{*0}_{(s)} \to \mu^+\mu^-$ in $B_c^+ \to \pi^+\mu^+\mu^-$ decays [Submitted to EPJC, LHCb-CONF-2024-003]
	Search for lepton-flavour-violating decay $B_s^0 \to \phi\mu^\pm\tau^\mp$ [Submitted to PRD, arXiv:2405.13103]

Other recent results **not covered in this talk**

- Analysis of local and nonlocal amplitudes in the $B^0 \to K^{*0}\mu^+\mu^-$ [Submitted to JHEP, arXiv:2405.17347]
- Amplitude analysis of the decay $\Lambda_b^0 \to pK^-\gamma$ [JHEP 06 (2024) 098]

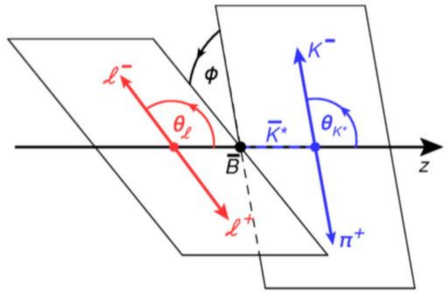
Still to come:

- Observation of the $\Sigma^+ \to p\mu^+\mu^-$ rare decay at LHCb [LHCb-CONF-2024-002, paper in preparation]
- Analysis of $\Lambda_b^0 \to pK^-\mu^-\mu^+$[Submitted to JHEP, paper in preparation]

Angular Analysis of $B^0 \to K^{*0} e^+ e^-$ decays

[LHCb-PAPER-2024-022 in preparation]

- First angular analysis at LHCb: central q^2 region $[1.1, 6.0]\ \mathrm{GeV}^2/c^4$
- Dataset: 9 fb^{-1} from LHCb (Run1 + Run2)
- Decay rate fully described by $\vec{\Omega} = (\theta_l, \theta_K, \phi)$, $q^2 = m^2(ee)$



$$\frac{d^4\Gamma[B^0 \to K^{*0} e^+ e^-]}{dq^2 d\vec{\Omega}} = \frac{9}{32\pi} \sum_i I_i(q^2) f_i(\vec{\Omega})$$

angular functions

angular coefficients

$\mathrm{I_i(q^2)}$:combination of different K^{*0} amplitudes (sensitive to WC $C_{9,10}^{(\prime)}$ and form factors)

angular observables

- F_L → Fraction of longitudinal K^{*0} polarization
- S_i → CP-averaged
- A_{FB} → forward-backward asymmetry of dieletron system

→ $P_i^{(\prime)}$ basis observables → LFU tests in angular distribution

$$P_5' = \frac{S_5}{\sqrt{F_L(1-F_L)}}$$

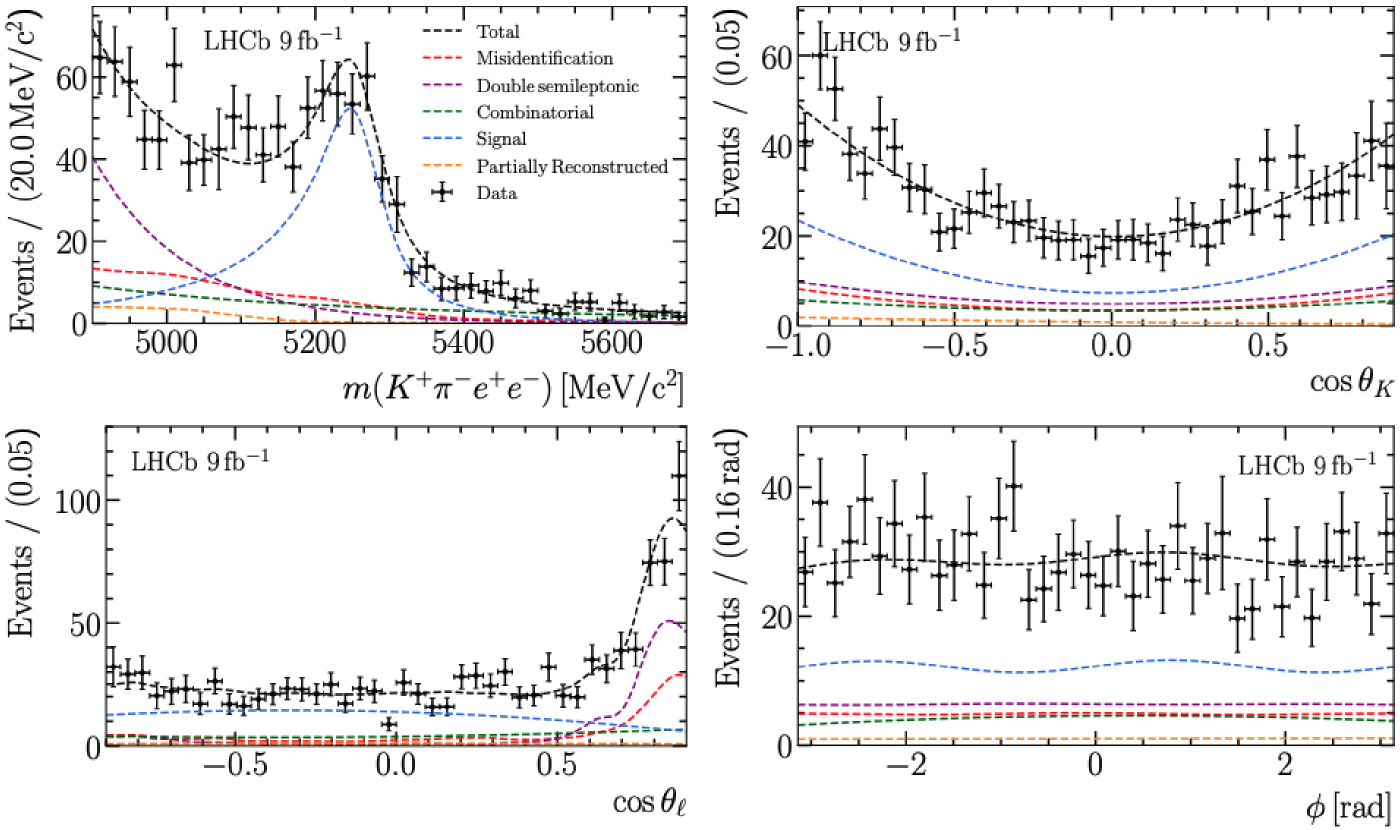
$$Q_i = P_i^{(\mu)} - P_i^{(e)}$$

Angular Analysis of $B^0 \to K^{*0} e^+ e^-$ decays

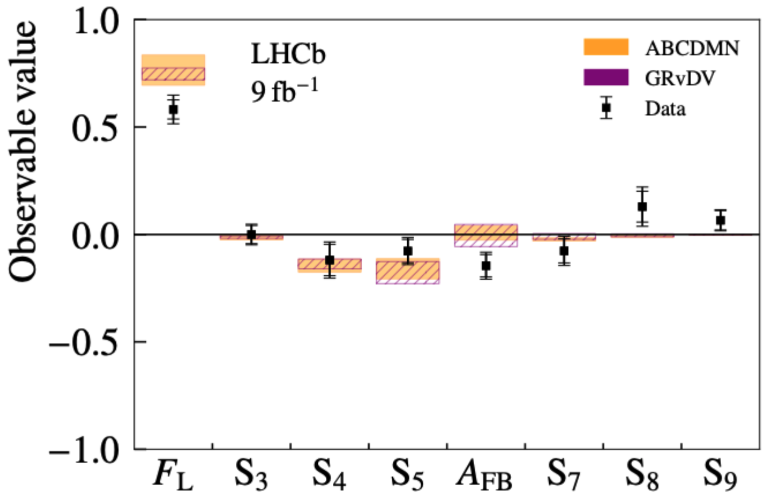
[LHCb-PAPER-2024-022 in preparation]

$q^2 = m^2(ee)$

Observables extracted from 4D unbinned weighted fit to the mass and angular distributions



Angular observables measured in the q^2 region [1.1,6.0] $\mathrm{GeV}^2/\mathrm{c}^4$

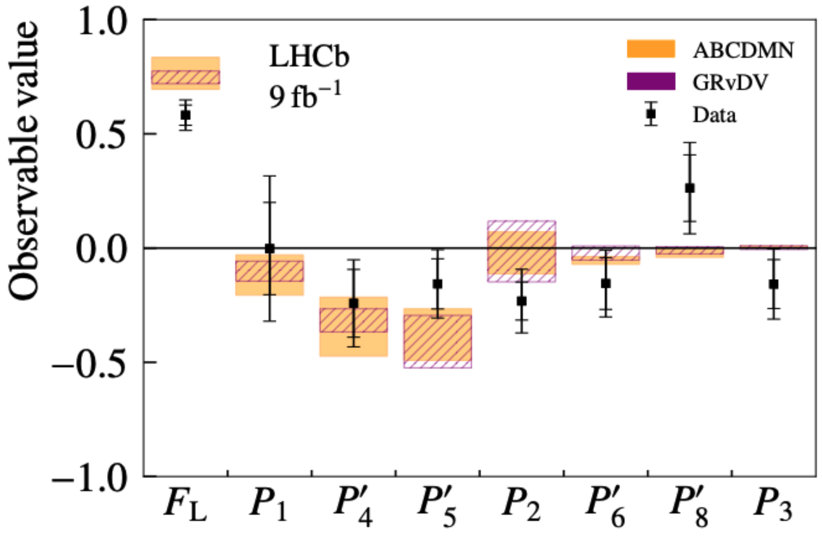


Overall good agreement with SM predictions

Angular Analysis of $B^0 \to K^{*0} e^+ e^-$ decays

[LHCb-PAPER-2024-022 in preparation]

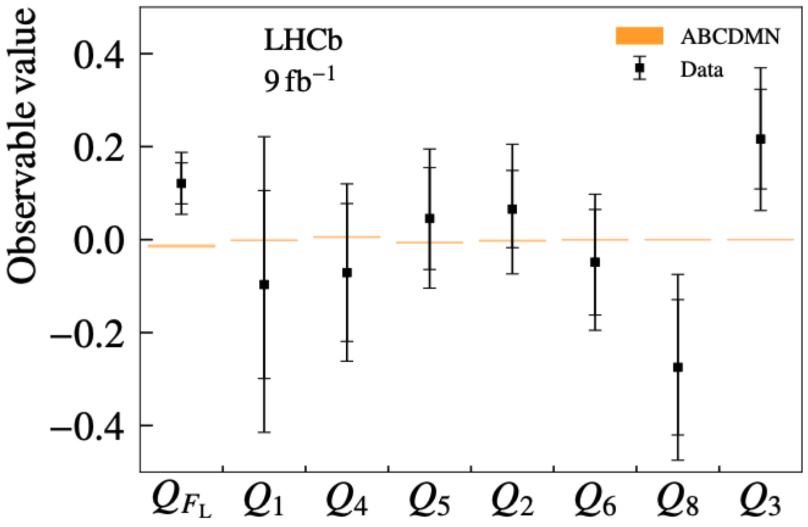
$P_i^{(\prime)}$ based on F_L , A_{FB} , S_i
→ reduced form factor uncertainties



Most precise determination of angular observables

LFU in angular observables

$Q_i = P_i^{(\mu)} - P_i^{(e)}$



No sign of lepton flavour universality violating effects are observed

Obtained by comparing with $B^0 \to K^{*0} \mu^+ \mu^-$ results [PRL 132 (2024) 131801]

This measurement paves the way for high-precision LFU/angular analyses at LHCb for Run 3 and beyond

Search for the $B_s^0 \to \mu^+\mu^-\gamma$ decay

JHEP 07(2024) 101

$B_s^0 \to \mu^+\mu^-\gamma$ vs $B_s^0 \to \mu^+\mu^-$

- Sensitive to a larger set of WCs ($C_{7,9,10}^{(\prime)}$) than $B_s^0 \to \mu^+\mu^-$ ($C_{10}^{(\prime)}$)
- $\mathcal{B}(B_s^0 \to \mu^+\mu^-\gamma) \sim \mathcal{B}(B_s^0 \to \mu^+\mu^-)$
- Large theoretical uncertainties
- Worse mass resolution due to the photon reconstruction

Theory Prediction [JHEP 11 (2017) 184]

$$\mathcal{B}(\bar{B}_s^0 \to \mu^+\mu^-\gamma)_{\text{low}\,q^2} = (8.4 \pm 1.3) \times 10^{-9}\,,$$

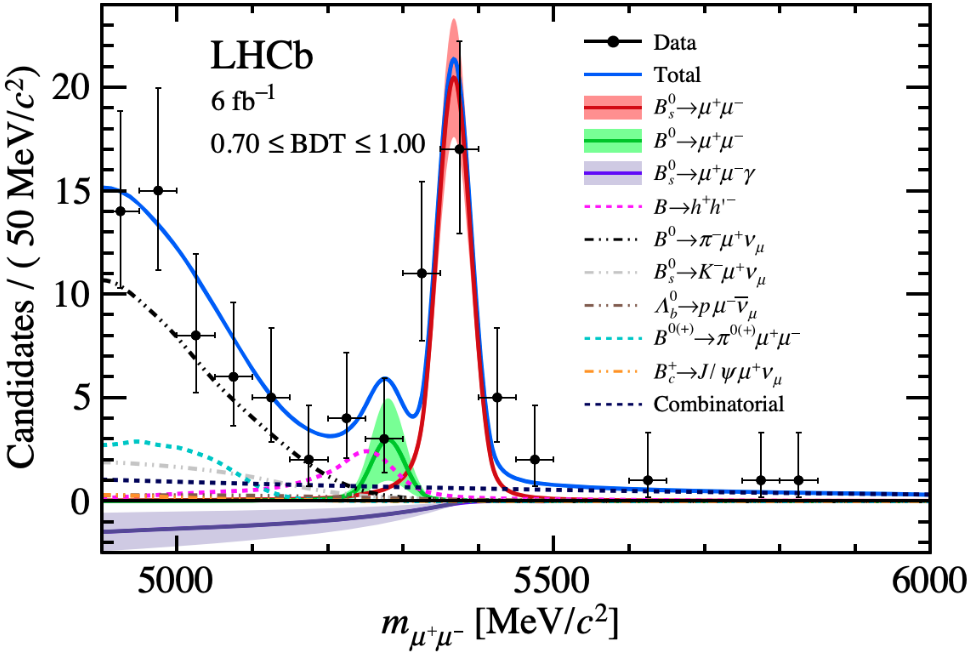
$$\mathcal{B}(\bar{B}_s^0 \to \mu^+\mu^-\gamma)_{\text{high}\,q^2} = (8.90 \pm 0.98) \times 10^{-10}\,,$$

low-q^2 $\to$ $q^2 < 8.64\ \mathrm{GeV}^2/\mathrm{c}^4$

high-q^2 $\to$ $q^2 > 15.84\ \mathrm{GeV}^2/\mathrm{c}^4$

$q^2 = m^2(\mu\mu)$

Indirect search from $B_s^0 \to \mu^+\mu^-$



$$\mathcal{B}(B_s^0 \to \mu^+\mu^-\gamma) < 1.5(2.0) \times 10^{-9}$$
$$\text{with} \quad m_{\mu\mu} > 4.9\ \mathrm{GeV}/c^2,$$

PRD 105(2022) 012010

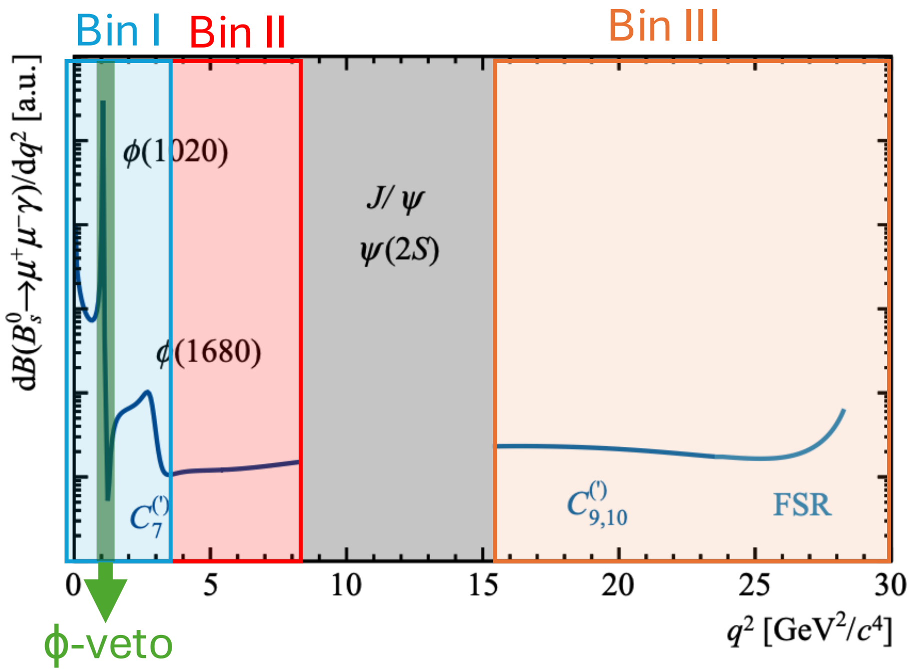
at 90% (95%) CL

Search for the $B_s^0 \to \mu^+\mu^-\gamma$ decay

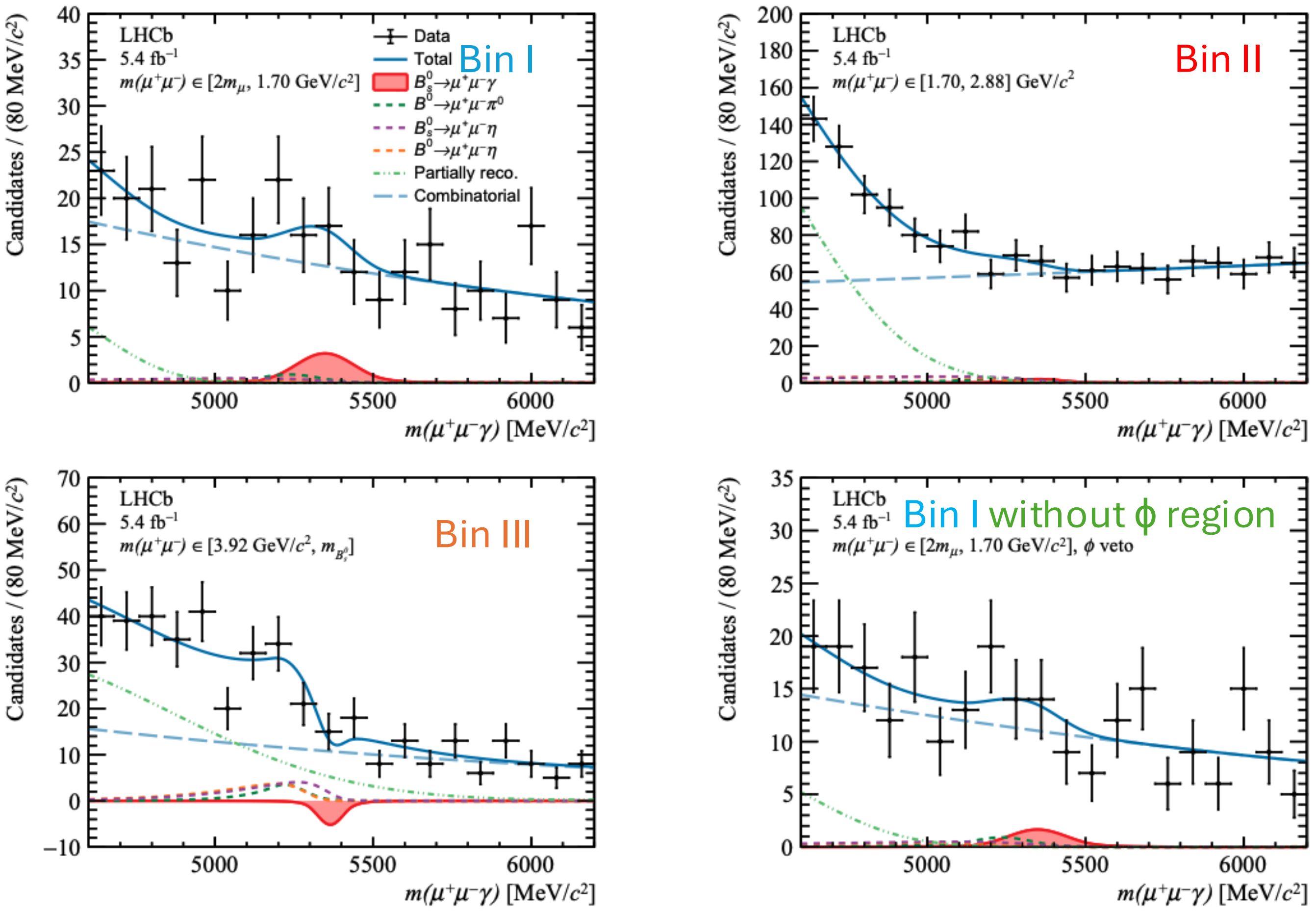
JHEP 07(2024) 101

- Dataset: 5.4 fb^{-1} from Run2 (2016-2018)
- Direct search in three q^2 regions

Bin I $\to$ low-q^2 (+ with ϕ-vetoed)
Bin II $\to$ middle-q^2
Bin III $\to$ high-q^2



Mass fit of $B_s^0 \to \mu^+\mu^-\gamma$ in all q^2regions



Search for the $B_s^0 \to \mu^+\mu^-\gamma$ decay

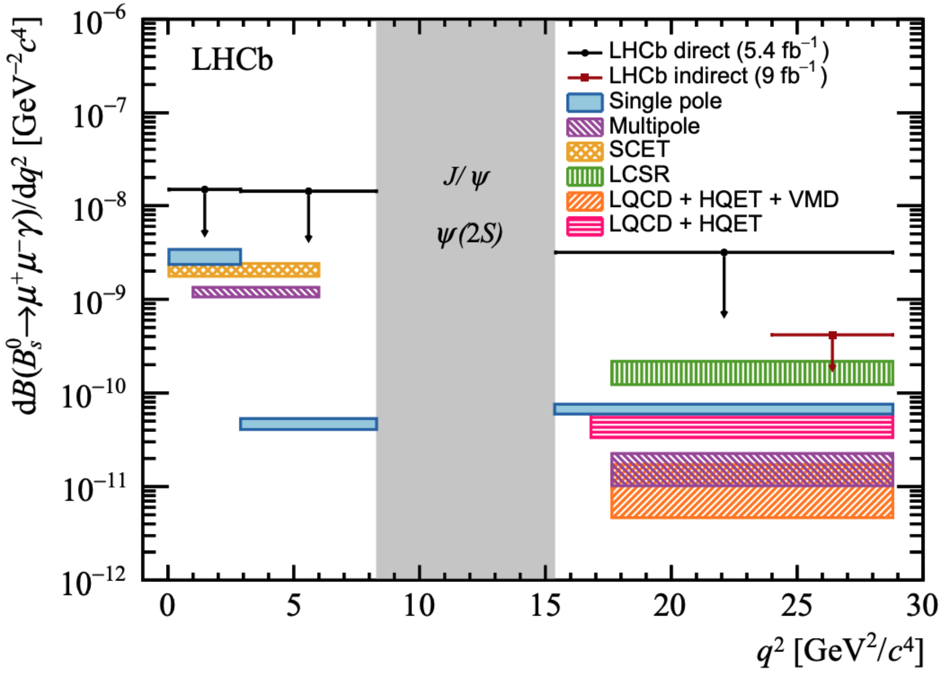
JHEP 07(2024) 101

Upper limits on the branching fraction

$$\mathcal{B}(B_s^0 \to \mu^+\mu^-\gamma)_{\mathrm{I}} < 3.6\,(4.2) \times 10^{-8},$$
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-\gamma)_{\mathrm{II}} < 6.5\,(7.7) \times 10^{-8},$$
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-\gamma)_{\mathrm{III}} < 3.4\,(4.2) \times 10^{-8},$$
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-\gamma)_{\mathrm{I,\ with\ }\phi\mathrm{\ veto}} < 2.9\,(3.4) \times 10^{-8},$$
$$\mathcal{B}(B_s^0 \to \mu^+\mu^-\gamma)_{\mathrm{comb.}} < 2.5\,(2.8) \times 10^{-8},$$

at 90% (95%) CL

Differential branching fraction $B_s^0 \to \mu^+\mu^-\gamma$



- First direct search for $B_s^0 \to \mu^+\mu^-\gamma$ at low q^2
- No significant excess is observed in all q^2 region

Run 3 data is expected to improve the sensitivity on the search

Amplitude Analysis of the $B_s^0 \to K^+K^-\gamma$ decay

[JHEP08(2024)09]

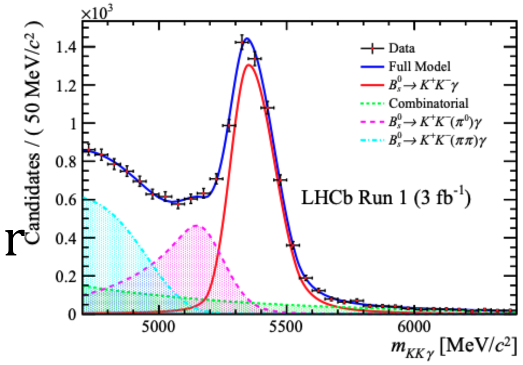
- $B_s^0 \to \phi(\to K^+K^-)\gamma$ giving access to photon polarization
- Both tagged and untagged analyses perfomed by LHCb [PRL 123 (2019) 8, 081802]
- $B_s^0 \to \phi\gamma$: only radiative transition observed in the B_s^0 sector

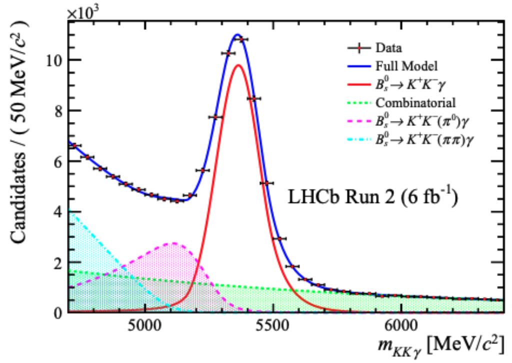
Other contributions to $B_s^0 \to K^+K^-\gamma$?

Exploring with an amplitude analysis

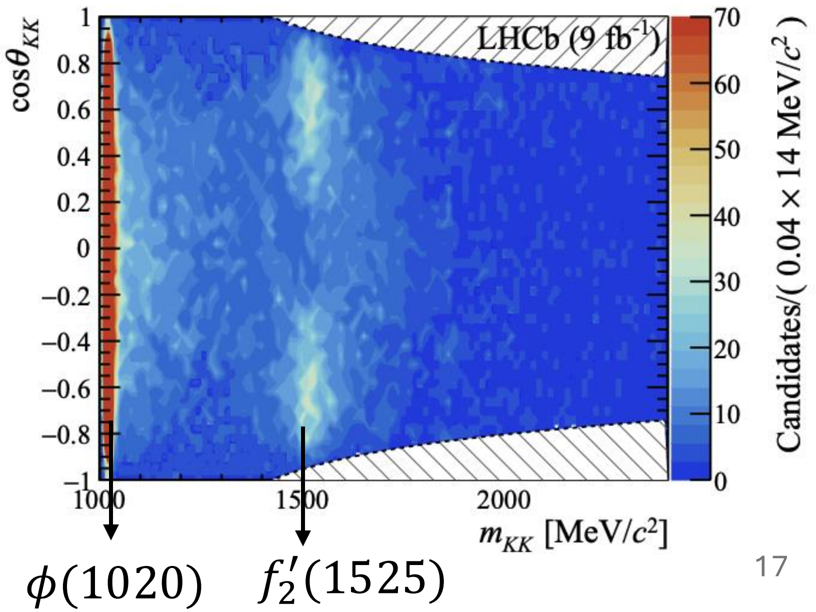
- Full LHCb Run1 + Run2 (2011-2018) dataset
- Performed in the $m(KK)$ range: $[2m_K, 2400\ MeV]_{Run2}$, $[2m_K, 1950\ MeV]_{Run1}$
- Isobar model in folded helicity plane $(m_{KK}, |\cos\theta_{KK}|)$

$B_s^0 \to K^+K^-\gamma$ mass fit





Background subtracted projection of $B_s^0 \to K^+K^-\gamma$

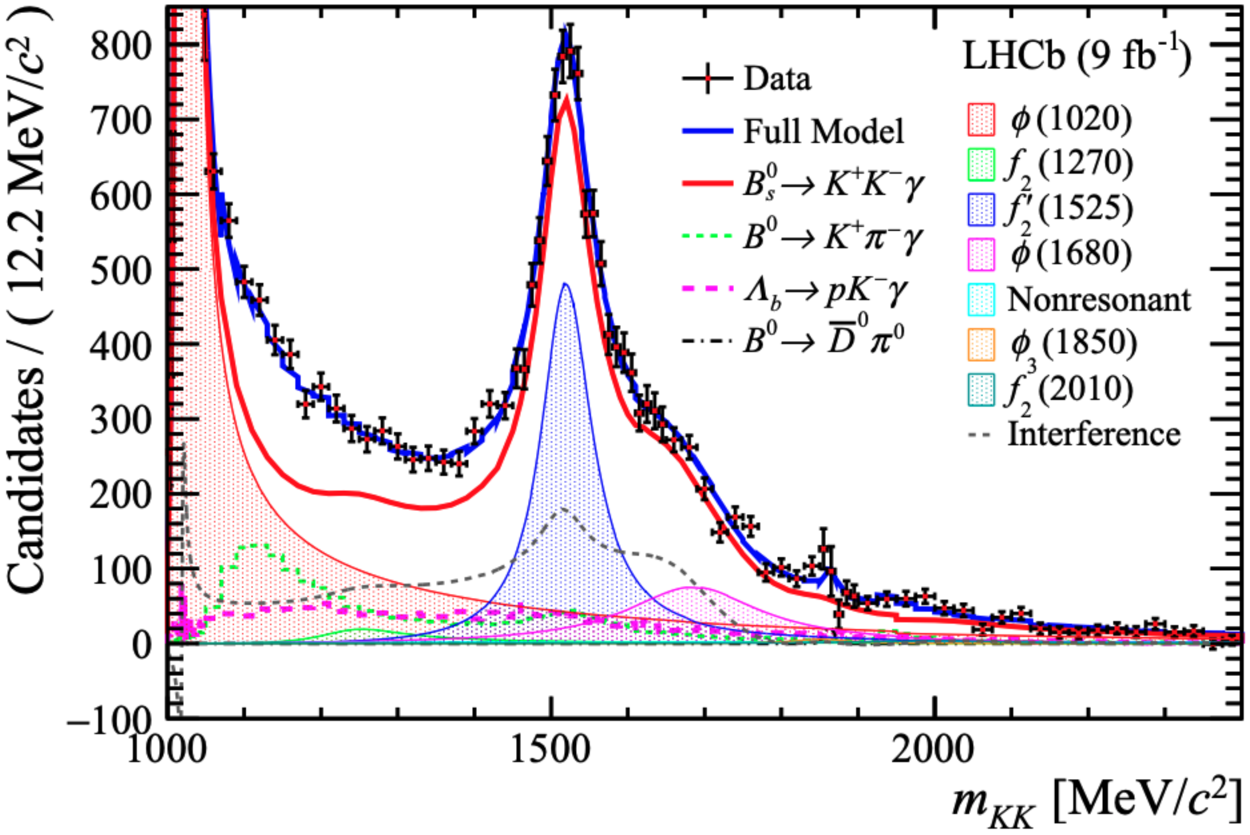


Amplitude Analysis of the $B_s^0 \to K^+K^-\gamma$ decay

[JHEP08(2024)09]

Best fit projection

$\mathrm{N}(B_s^0) = (44.4 \pm 0.5) \times 10^3$, about 2% have $m_{KK} > 1.8$ GeV



- Overall tensor states (f_2) fit-fraction is

$$\mathcal{F}_{\{f_2\}} = 16.8 \pm 0.5\,(\mathrm{stat}) \pm 0.7\,(\mathrm{syst})\%,$$

- The decay $B_s^0 \to f_2'(1525)\gamma$ is observed for the first time

$$\frac{\mathcal{B}(B_s^0 \to f_2'(1525)\gamma)}{\mathcal{B}(B_s^0 \to \phi(1020)\gamma)} = 0.194^{+0.009}_{-0.008}\ (\mathrm{stat.})^{+0.014}_{-0.005}\ (\mathrm{syst.}) \pm 0.005\ (\mathcal{B})$$

- Mass and width for the $f_2'(1525)$ are in good agreement with the current world average and LHCb measurements

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

Submitted to Eur. Phys. J. C, LHCb-CONF-2024-003

- $B^{*0}_{(s)} \to \mu^+\mu^-$ can provide constraints on WCs complementary to $B^0_{(s)} \to \mu^+\mu^-$ decays
- SM prediction $\mathcal{B}(B^{*0}_s \to \mu^+\mu^-) \sim 10^{-11}$ [PRL 116 (2016) 141801]

First search for $B^{*0} \to \mu^+\mu^-$ and $B^{*0}_s \to \mu^+\mu^-$ decays

- 9 fb^{-1} from Run1 +Run2 dataset (2011-2018)
- Search within $B_c^+ \to B^{*0}_{(s)}\pi^+ \to \mu^+\mu^-\pi^+$ decay chain
- Exploit displaced B_c^+ vertex to suppress background

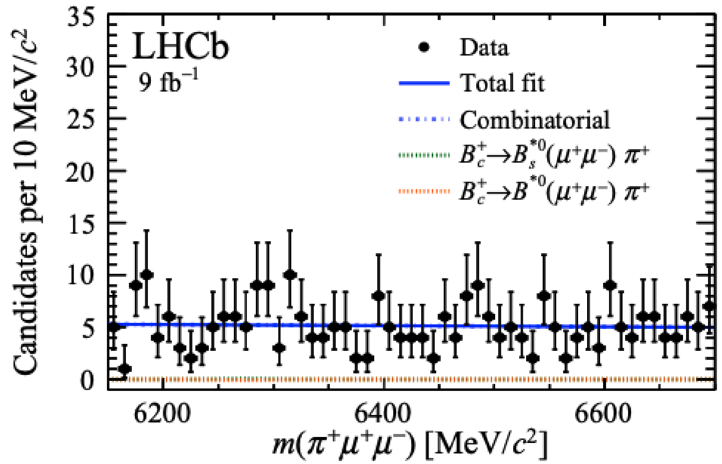
↳ Similar approach as $D^{*0} \to \mu^+\mu^-$ search [EPJ C83 (2023) 666]

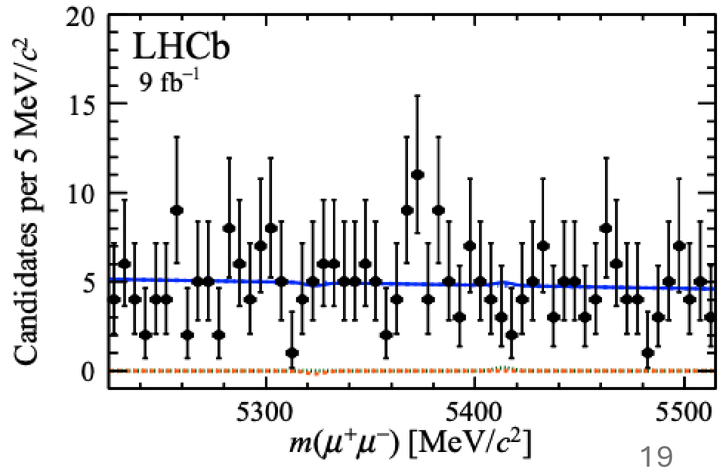
No signal observed for both decay modes

$$\mathcal{R}_{B^{*0}(\mu^+\mu^-)\pi^+/J/\psi\pi^+} < 3.8\,(5.2) \times 10^{-5} \text{ at } 90\ (95)\%\,\text{CL},$$
$$\mathcal{R}_{B^{*0}_s(\mu^+\mu^-)\pi^+/J/\psi\pi^+} < 5.0\,(6.3) \times 10^{-5} \text{ at } 90\ (95)\%\,\text{CL}.$$

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

Simultaneous 2D ML fit to $m(\pi^+\mu^+\mu^-)$ and $m(\mu^+\mu^-)$





Search for cLFV decay $B_s^0 \to \phi(\to K^+K^-)\mu^\pm\tau^\mp$

Submitted to Phys. Rev. D, arXiv:2405.13103

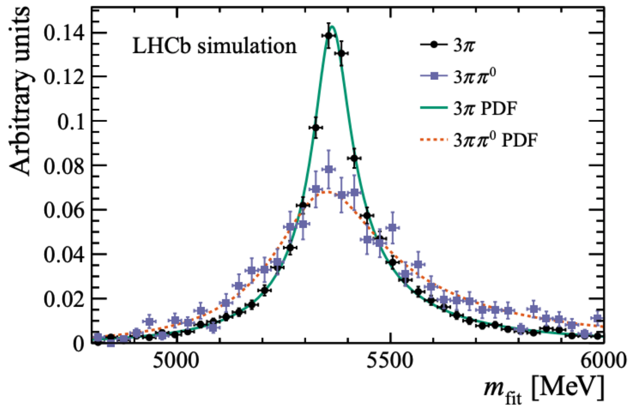
- Possible in SM with neutrino oscillation ($\mathcal{B} < 10^{-50}$) , NP scenarios $\mathcal{B} < 10^{-11}$
- NP models predict deviations especially involving the 3rd family

First search for the $B_s^0 \to \phi\mu^\pm\tau^\mp$ decay

- Data from full Run1 + Run2 (9 fb^{-1})

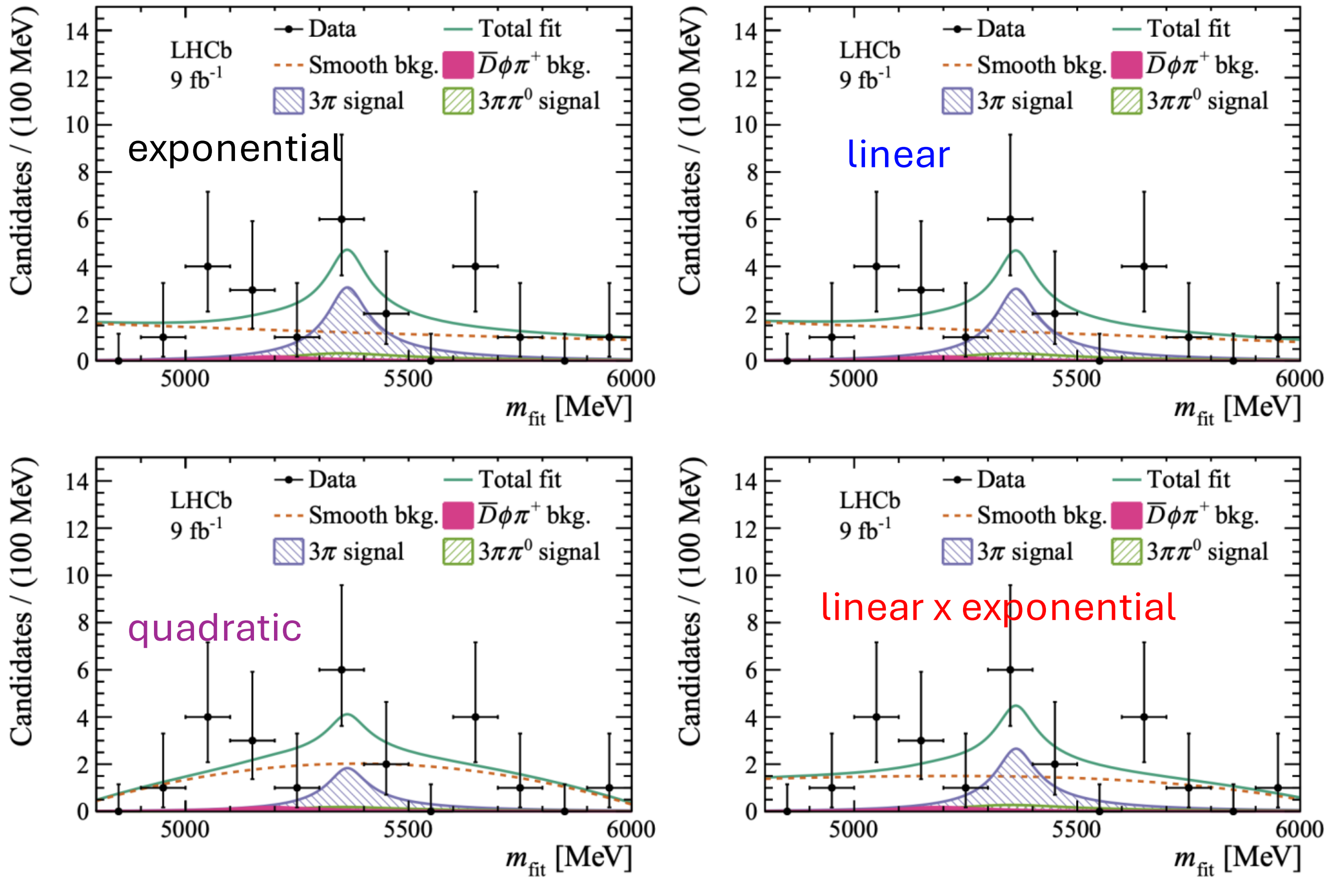
○ Signal reconstruction with $\phi \to K^+K^-$ and $\tau \to 3\pi$ (including $\tau \to 3\pi\pi^0$)

○ Neutrino missing : reconstruct B_s^0 mass using vertex and kinematic constraints



Fit and distributions of the constrained mass

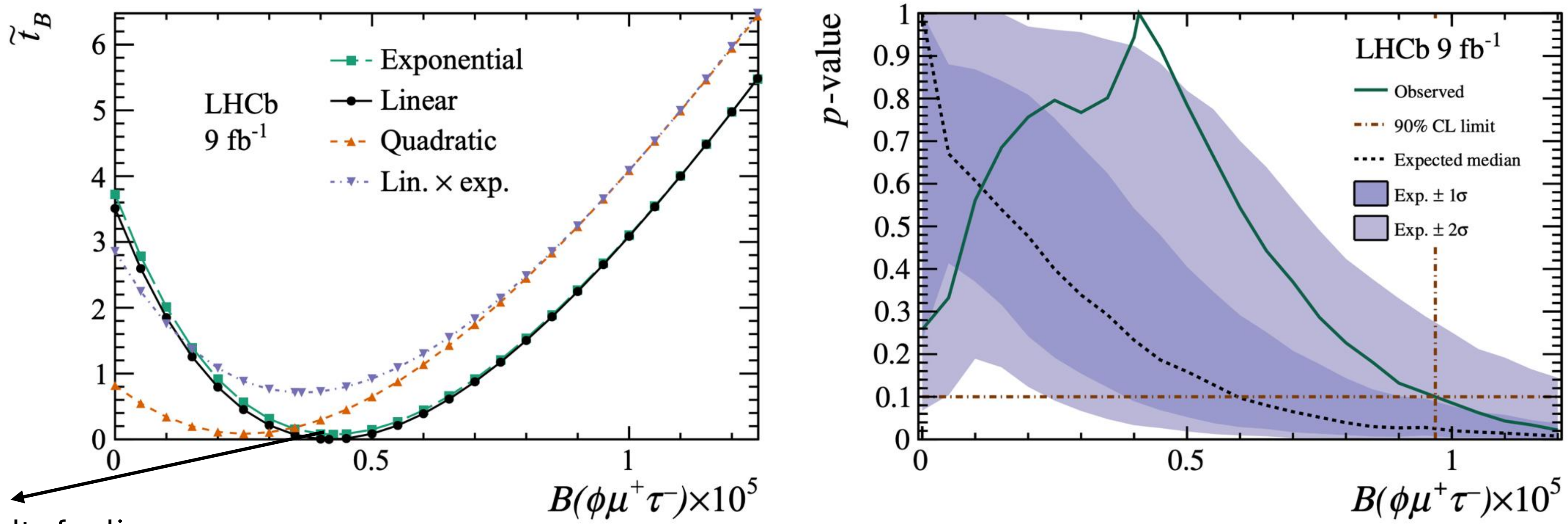
Mass fit: 4 different background shapes considered



Search for cLFV decay $B_s^0 \to \phi(\to K^+K^-)\mu^\pm\tau^\mp$

Submitted to Phys. Rev. D, arXiv:2405.13103

- No excess observed over background-only hypothesis
- First upper limit on this decay mode → comparable sensitivity with other $b \to s\tau\mu$ searches [JHEP 06 (2020) 129, JHEP 06 (2023) 143]

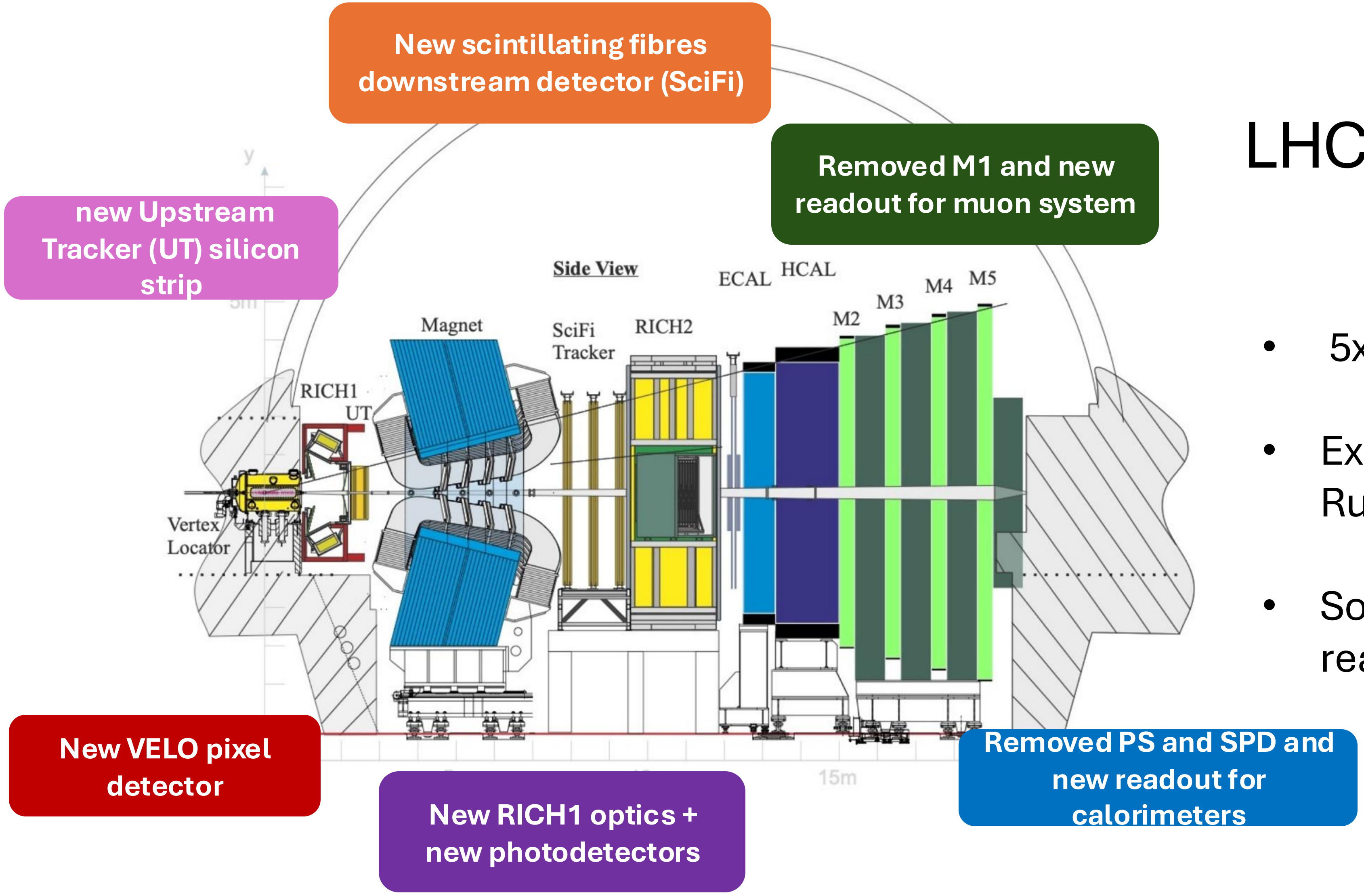


Best fit results for linear model at 4.1×10^{-6} with a local significance below 1.5σ

$$\mathcal{B}(B_s^0 \to \phi\mu^+\tau^-) < 1.0 \times 10^{-5} \text{ at } 90\% \text{ CL},$$
$$\mathcal{B}(B_s^0 \to \phi\mu^+\tau^-) < 1.1 \times 10^{-5} \text{ at } 95\% \text{ CL}.$$

LHCb Upgrade(s)

LHCb Upgrade I (2022+)



WE ARE HERE NOW

LHCb in Run 3 (& Run4): a new detector!

- 5x higher instantaneous luminosity
- Expected to collect $\sim 23\ \mathrm{fb}^{-1}$ end of Run 3, and 50 fb^{-1} end of Run 4
- Software only trigger: full detector readout at 30 MHz

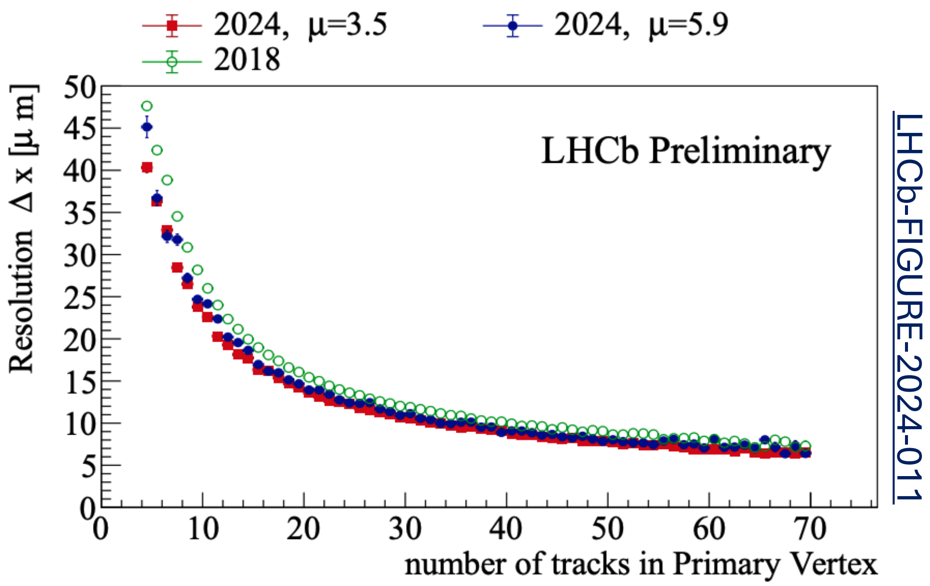
$\mathcal{L} = 2\times10^{33}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
$\mathcal{L}_{int} = 50\ \mathrm{fb}^{-1}$
$\mu \approx 5$

JINST 19 (2024) 05, P05065

LHCb Run 3 performance

Current status: detectors stably operating and collecting pp data!

Primary Vertex resolution

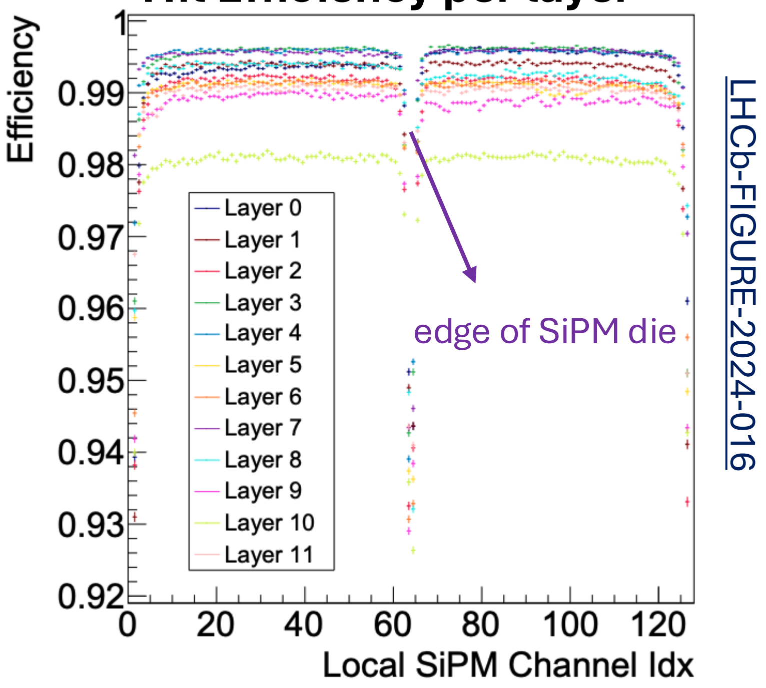


Better performance than Run 2 at higher luminosity

early data → further improvements expected

SciFi

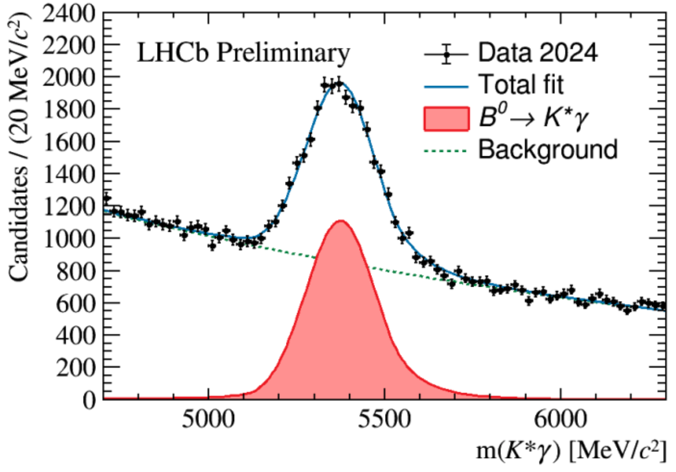
Hit Efficiency per layer



Hit Efficiency approaching design specification (better than 99%)

Calibration

ECAL calibration with π^0

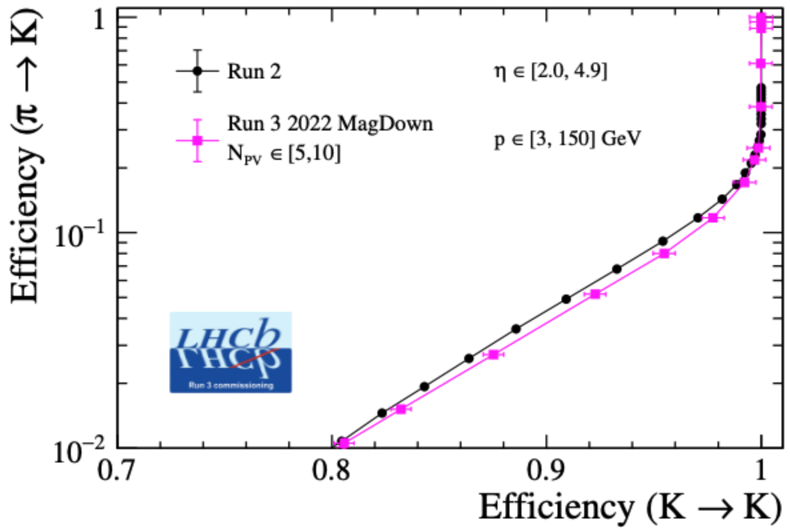


Neutral ID performance maintained at higher pileup

LHCb Run 3 performance

Current status: detectors stably operating and collecting pp data!

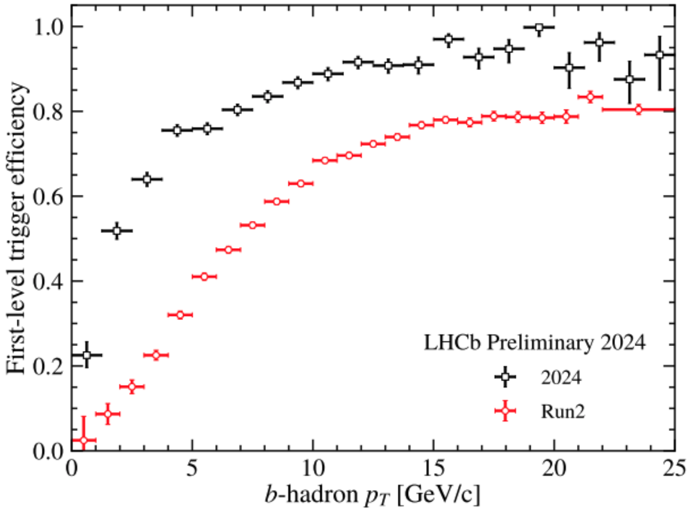
Particle Identification Hadrons



LHCb-FIGURE-2023-019

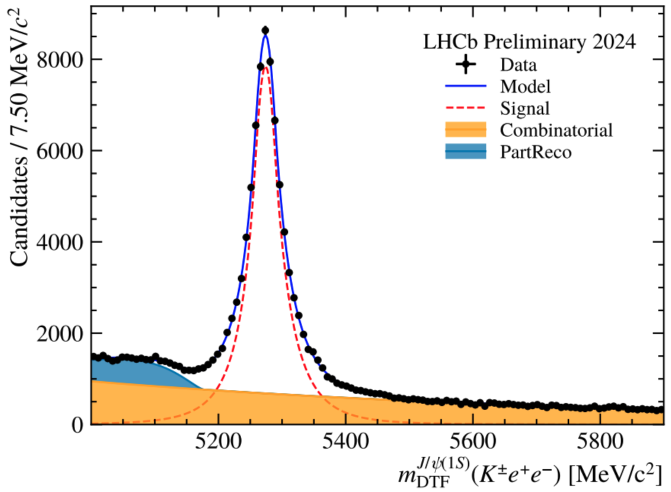
PID as good as Run2 but operating at 5x instantaneous luminosity

Trigger efficiency
$B^{\pm} \to K^{\pm} e^{+} e^{-}$



LHCb-FIGURE-2024-007

Data mass peak
$B^{\pm} \to K^{\pm} J/\psi(\to e^{+} e^{-})$



LHCb-FIGURE-2024-007

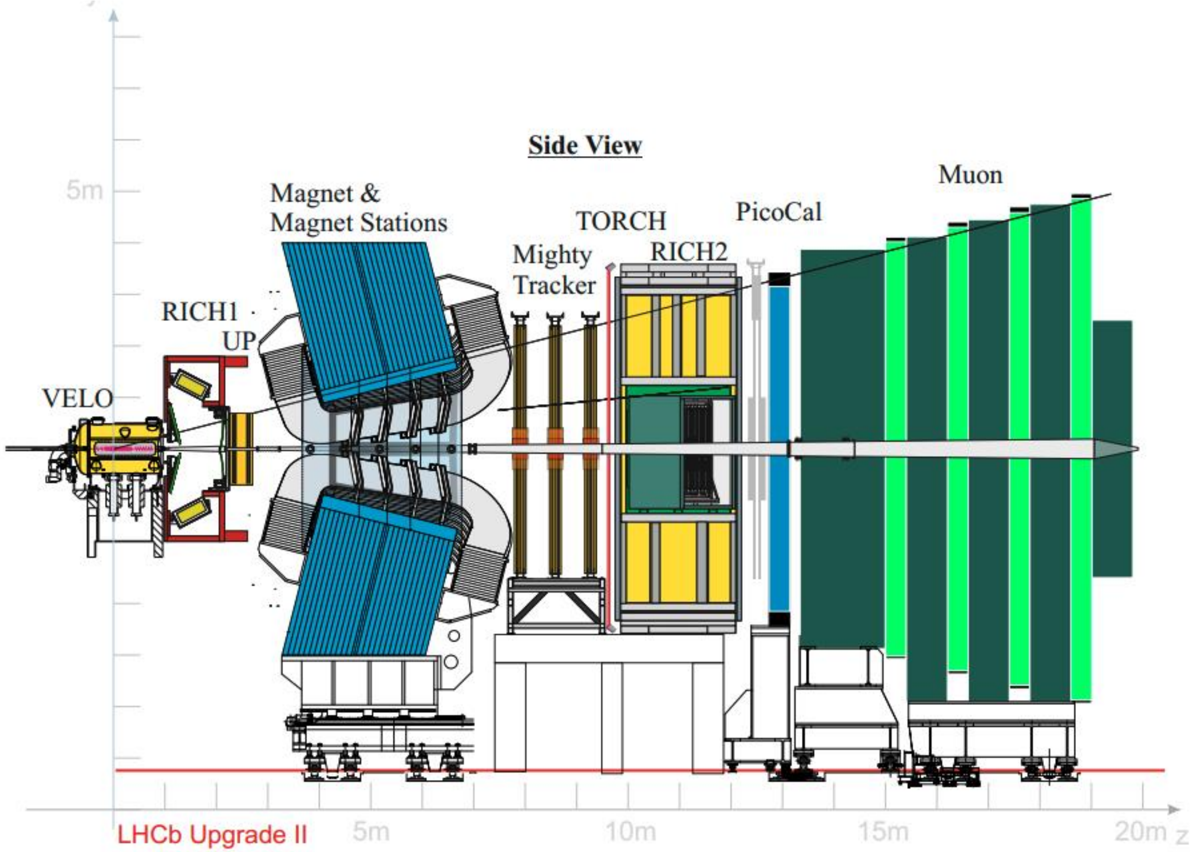
Significant trigger improvement in selecting hadronic B decays with electrons in the final state

Very promising performance anticipates exciting results from LHCb Physics programme in Run3

LHCb Upgrade II

$\mathcal{L} = 1.5\times10^{34}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
$\mathcal{L}_{int} = 300\ \mathrm{fb}^{-1}$
$\mu \approx 40$

LHCb in Run5 & 6:
Another fully new detector to exploit the flavour physics potential of the HL-LHC

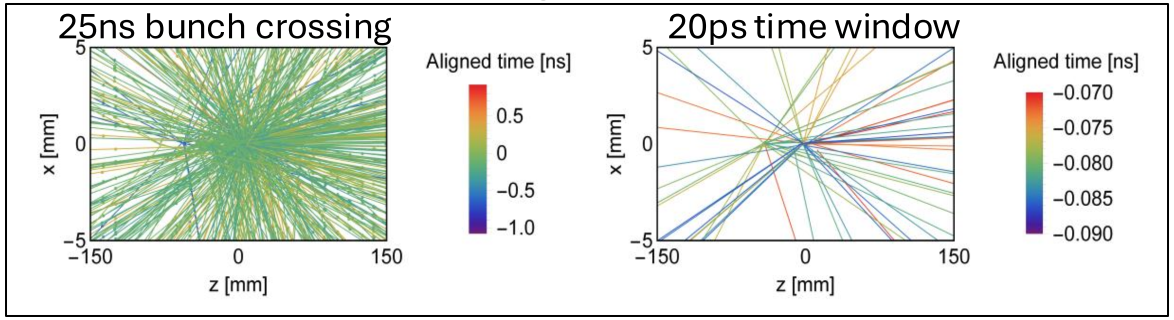


LHCB-TDR-023

Target: 300 fb^{-1} by the end of Run6 (~2040)

Goal: same performance as in Run 3, but with ~7 times the pileup of Run 3

Tracks in an Upgrade II collision



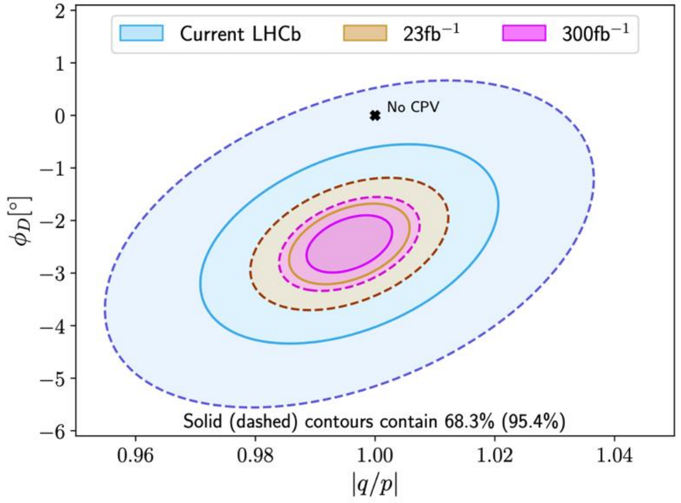
- Addition of precise timing information
- Replace almost all subdectors + new detectors to improve performance

Intense and attractive R&D program is ongoing

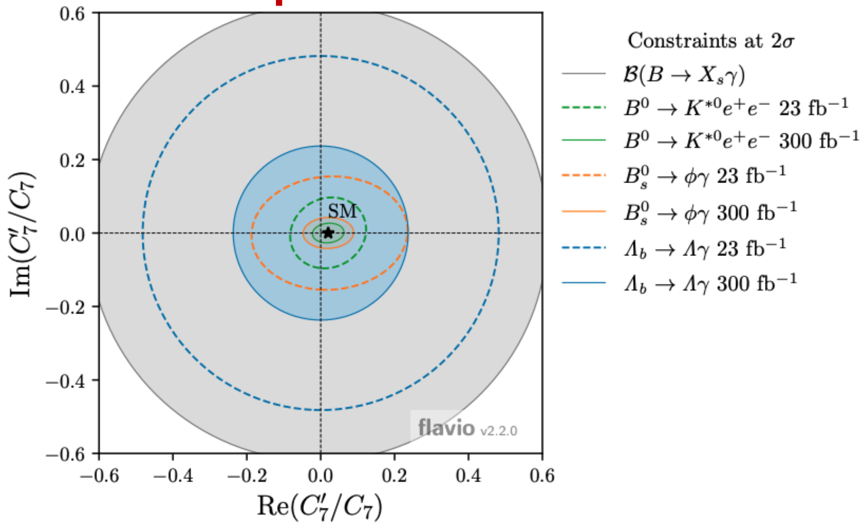
LHCb Upgrade I & II projections

LHCB-TDR-023

CPV and mixing in charm

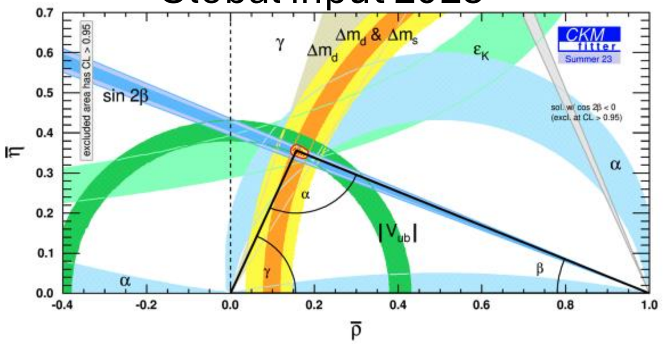


Photon polarisation

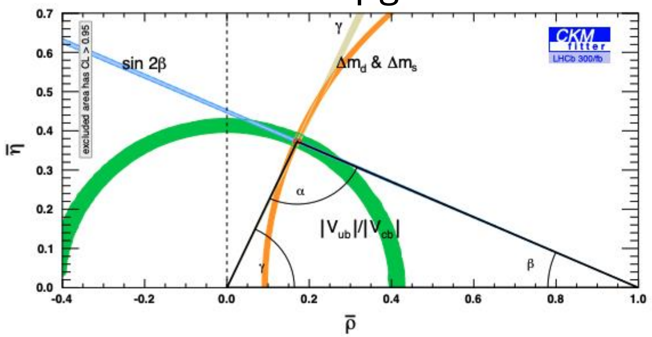


CKM precision

Global input 2023



LHCb Upgrade II

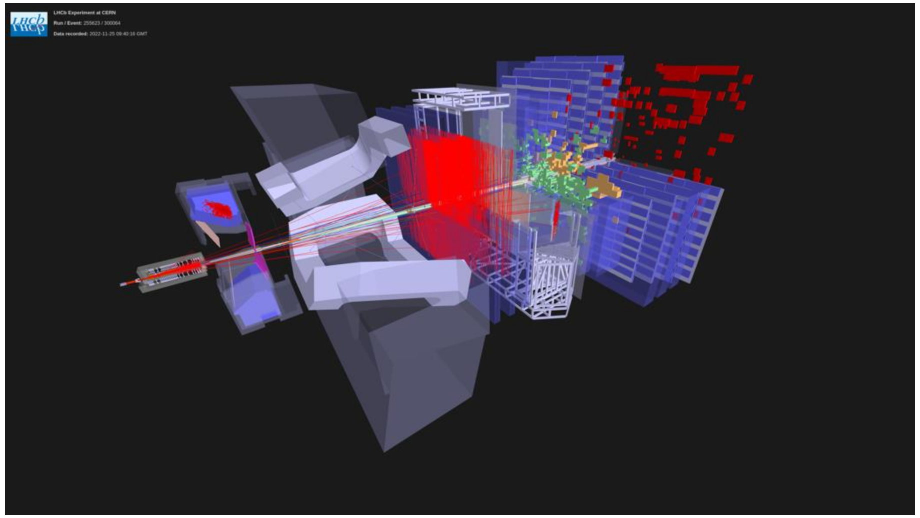


	Run1&Run2	Run3			
Observable	Current LHCb	LHCb 2025	Belle II	Upgrade II	ATLAS & CMS
EW Penguins					
R_K $(1 < q^2 < 6\,\mathrm{GeV}^2c^4)$	0.1 [274]	0.025	0.036	0.007	–
R_{K^*} $(1 < q^2 < 6\,\mathrm{GeV}^2c^4)$	0.1 [275]	0.031	0.032	0.008	–
R_ϕ, R_{pK}, R_π	–	0.08, 0.06, 0.18	–	0.02, 0.02, 0.05	–
CKM tests					
γ, with $B^0_s \to D^+_s K^-$	$(^{+17}_{-22})°$ [136]	4°	–	1°	–
γ, all modes	$\boxed{3°}$ $\cancel{(^{+5.0}_{-5.8})°}$ [167]	1.5°	1.5°	0.35°	–
$\sin 2\beta$, with $B^0 \to J/\psi K^0_S$	$\boxed{0.013}$ $\cancel{0.04}$ [609]	0.011	0.005	0.003	–
ϕ_s, with $B^0_s \to J/\psi\phi$	$\boxed{20\,\mathrm{mrad}}$ $\cancel{49\,\mathrm{mrad}}$ [44]	14 mrad	–	4 mrad	22 mrad [610]
ϕ_s, with $B^0_s \to D^+_s D^-_s$	170 mrad [49]	35 mrad	–	9 mrad	–
$\phi^{s\bar{s}s}_s$, with $B^0_s \to \phi\phi$	154 mrad [94]	39 mrad	–	11 mrad	Under study [611]
a^s_{sl}	33×10^{-4} [211]	10×10^{-4}	–	3×10^{-4}	–
$\lvert V_{ub}\rvert/\lvert V_{cb}\rvert$	6% [201]	3%	1%	1%	–
$B^0_s, B^0 \to \mu^+\mu^-$					
$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B^0_s \to \mu^+\mu^-)$	90% [264]	34%	–	10%	21% [612]
$\tau_{B^0_s \to \mu^+\mu^-}$	22% [264]	8%	–	2%	–
$S_{\mu\mu}$	–	–	–	0.2	–
$b \to c\ell^-\bar{\nu}_l$ LUV studies					
$R(D^*)$	0.026 [215, 217]	0.0072	0.005	0.002	–
$R(J/\psi)$	0.24 [220]	0.071	–	0.02	–
Charm					
$\Delta A_{CP}(KK - \pi\pi)$	8.5×10^{-4} [613]	1.7×10^{-4}	5.4×10^{-4}	3.0×10^{-5}	–
A_Γ $(\approx x \sin\phi)$	$\boxed{2.9 \times 10^{-4}}$ $\cancel{2.8 \times 10^{-4}}$ [240]	4.3×10^{-5}	3.5×10^{-4}	1.0×10^{-5}	–
$x \sin\phi$ from $D^0 \to K^+\pi^-$	13×10^{-4} [228]	3.2×10^{-4}	4.6×10^{-4}	8.0×10^{-5}	–
$x \sin\phi$ from multibody decays	–	$(K3\pi)$ 4.0×10^{-5}	$(K^0_S\pi\pi)$ 1.2×10^{-4}	$(K3\pi)$ 8.0×10^{-6}	–

CERN-LHCC-2018-027

With some edits for current LHCb

Summary



LHCb Highlights on rare decays

- LHCb collected 9 fb^{-1} of high-quality data from 2011 to 2018
- Provides an excellent laboratory for studying rare decays
- Extensive physics program for testing SM, searching for NP, and exploring new decay modes
- Many analyses are currently ongoing at LHCb

LHCb Upgrade I

- Calibration and operations are progressing
- Early Run3 data show excellent performance

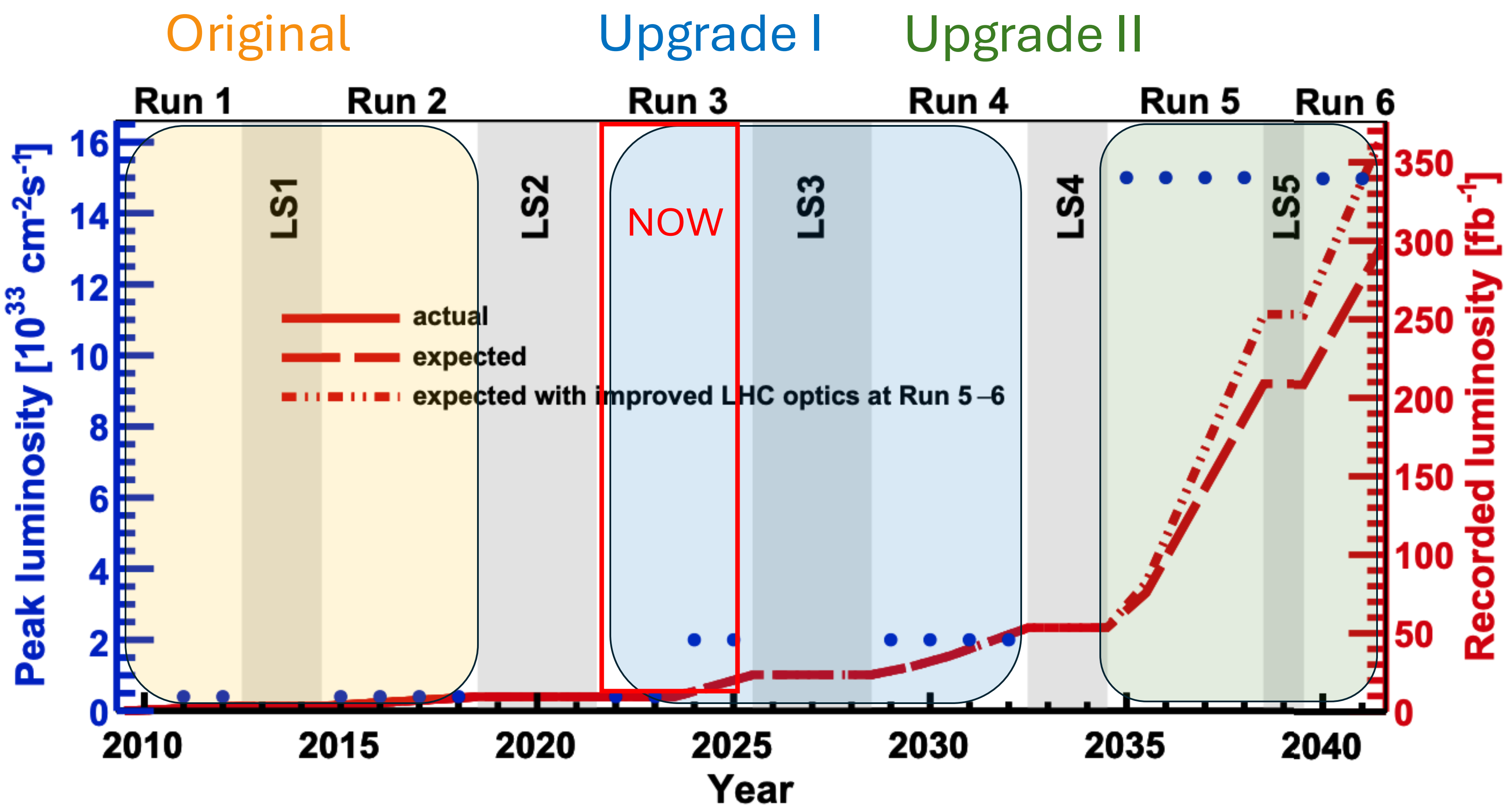
Plans underway for LHCb Upgrade II

- R&D in new detectors is ongoing

Thank you
for your attention!!

BACKUP SLIDES

LHCb Upgrade(s)



$\mathcal{L} = 4\times10^{32}\text{cm}^{-2}\text{s}^{-1}$
$\mathcal{L}_{int} = 9\ \text{fb}^{-1}$
$\mu \approx 1$

$\mathcal{L} = 2\times10^{33}\text{cm}^{-2}\text{s}^{-1}$
$\mathcal{L}_{int} = 50\ \text{fb}^{-1}$
$\mu \approx 5$

$\mathcal{L} = 1.5\times10^{34}\text{cm}^{-2}\text{s}^{-1}$
$\mathcal{L}_{int} = 300\ \text{fb}^{-1}$
$\mu \approx 40$