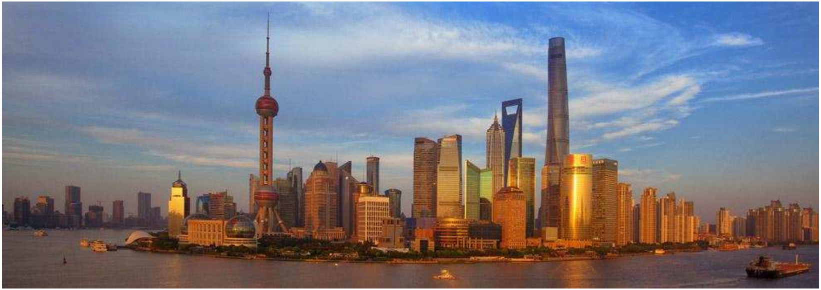


The LHCb upgrade

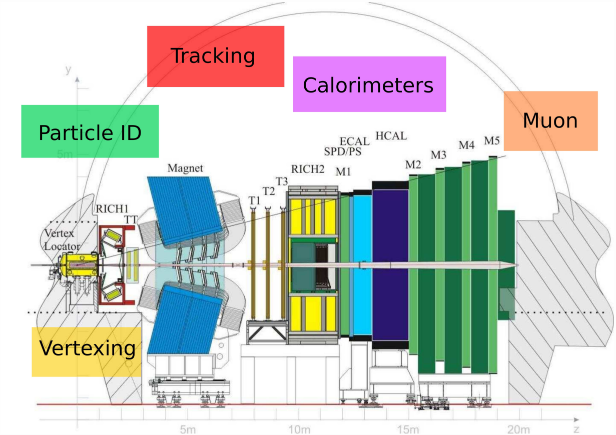
Silvia Gambetta,University of Edinburgh
on behalf of the LHCb collaboration

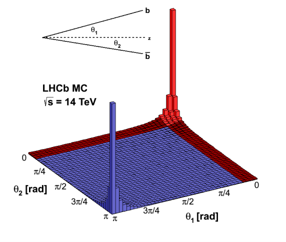
The Fitfh Annual Conference on Large Hadron Collider Physics

The LHCb experiment

General purpose single arm forward spectrometer
($2 < \eta < 5$, 4% of solid angle)

[J. Instrum. 3 (2008) S08005]





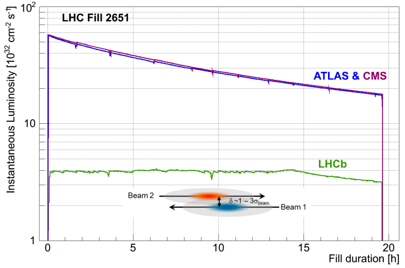
LHCb physics:

- rare b and c hadron decays
- CP-violation in b sector
- CKM parameters
- indirect search for NP
- spectroscopy
- electroweak physics

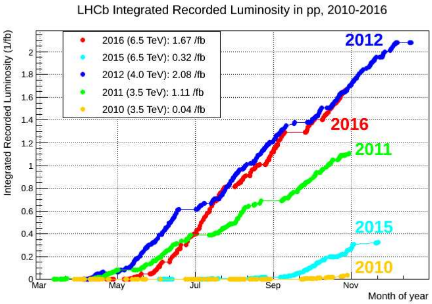
Unprecedented collection of bottom and charm hadrons
Very successful physics programme [See talk by Guy Wilkinson (Monday 15/5)]

The LHCb performance

- LHCb designed to to run at lower luminosity than ATLAS and CMS
- mean number of interactions per bunch crossing ~ 1
- pp beams displaced to reduce the instantaneous luminosity: $\mathscr{L} \sim 4 \times 10^{32}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- twice the design value



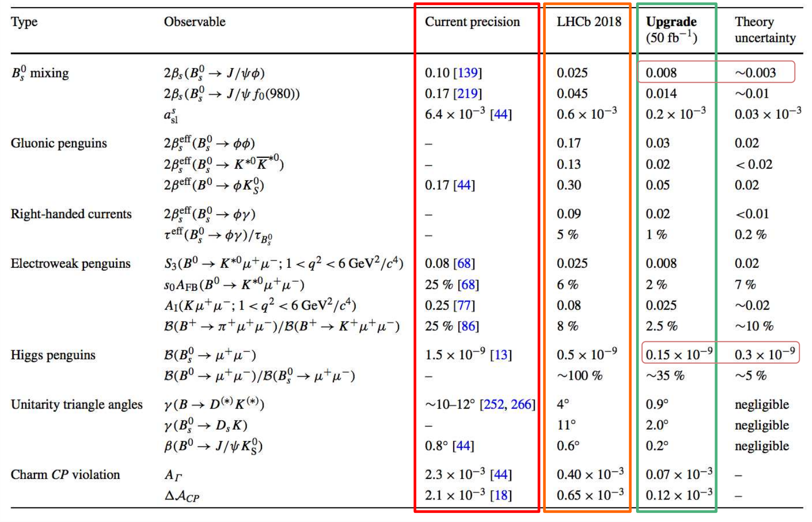
Excellent performance in 2016!



- $\sim$ 3 fb^{-1} of pp collisions at 7-8 TeV in Run 1
- $\sim$ 2 fb^{-1} of pp collisions at 13 TeV in Run 2

- expect to reach 8 fb^{-1} at the end of Run 2

Why upgrade?



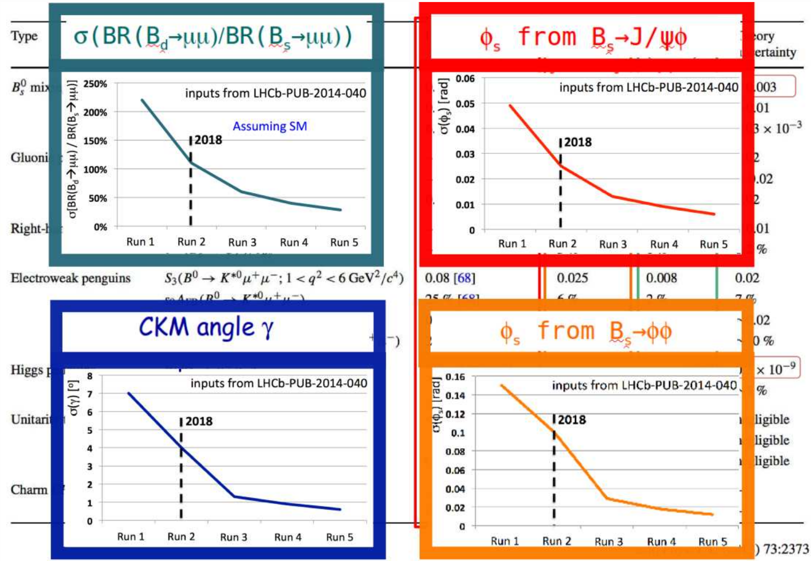
Type	Observable	Current precision	LHCb 2018	**Upgrade** (50 fb^{-1})	Theory uncertainty
B_s^0 mixing	$2\beta_s(B_s^0 \to J/\psi\phi)$	0.10 [139]	0.025	0.008	$\sim$0.003
	$2\beta_s(B_s^0 \to J/\psi f_0(980))$	0.17 [219]	0.045	0.014	$\sim$0.01
	a_{sl}^s	6.4×10^{-3} [44]	0.6×10^{-3}	0.2×10^{-3}	0.03×10^{-3}
Gluonic penguins	$2\beta_s^{\mathrm{eff}}(B_s^0 \to \phi\phi)$	–	0.17	0.03	0.02
	$2\beta_s^{\mathrm{eff}}(B_s^0 \to K^{*0}\overline{K}^{*0})$	–	0.13	0.02	< 0.02
	$2\beta^{\mathrm{eff}}(B^0 \to \phi K_S^0)$	0.17 [44]	0.30	0.05	0.02
Right-handed currents	$2\beta_s^{\mathrm{eff}}(B_s^0 \to \phi\gamma)$	–	0.09	0.02	<0.01
	$\tau^{\mathrm{eff}}(B_s^0 \to \phi\gamma)/\tau_{B_s^0}$	–	5 %	1 %	0.2 %
Electroweak penguins	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,\mathrm{GeV}^2/c^4)$	0.08 [68]	0.025	0.008	0.02
	$s_0 A_{\mathrm{FB}}(B^0 \to K^{*0}\mu^+\mu^-)$	25 % [68]	6 %	2 %	7 %
	$A_{\mathrm{I}}(K\mu^+\mu^-; 1 < q^2 < 6\,\mathrm{GeV}^2/c^4)$	0.25 [77]	0.08	0.025	$\sim$0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	25 % [86]	8 %	2.5 %	$\sim$10 %
Higgs penguins	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	1.5×10^{-9} [13]	0.5×10^{-9}	0.15×10^{-9}	0.3×10^{-9}
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	–	$\sim$100 %	$\sim$35 %	$\sim$5 %
Unitarity triangle angles	$\gamma(B \to D^{(*)}K^{(*)})$	$\sim$10–12° [252, 266]	4°	0.9°	negligible
	$\gamma(B_s^0 \to D_s K)$	–	11°	2.0°	negligible
	$\beta(B^0 \to J/\psi K_S^0)$	0.8° [44]	0.6°	0.2°	negligible
Charm *CP* violation	A_Γ	2.3×10^{-3} [44]	0.40×10^{-3}	0.07×10^{-3}	–
	$\Delta\mathcal{A}_{CP}$	2.1×10^{-3} [18]	0.65×10^{-3}	0.12×10^{-3}	–

Eur. Phys. J. C (2013) 73:2373

Need to increase the precision to reach theoretical uncertainty ⇒ search for NP

[LHCB-TDR-12]

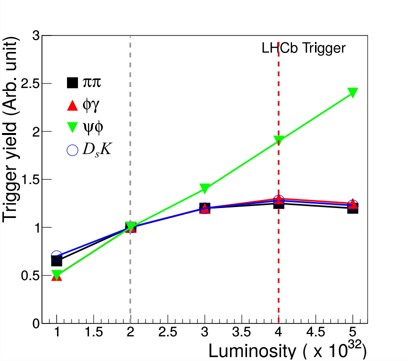
Why upgrade?



Need to increase the precision to reach theoretical uncertainty ⇒ search for NP

[LHCB-TDR-12]

Upgrade strategy

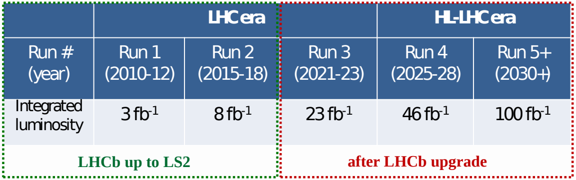


- LHC will increase luminosity
- Level-0 hardware trigger very efficient for dimuon events
- for hadronic channels trigger yield saturates with increasing luminosity
- detectors will start to degrade because of radiation
- physics programme limited by the detector

Strategy:

- remove 1MHz L0 bottleneck
- increase readout rate to 40MHz
- fully software trigger
- run at $\mathscr{L} \sim 2 \times 10^{33}\text{cm}^{-2}\text{s}^{-1}$

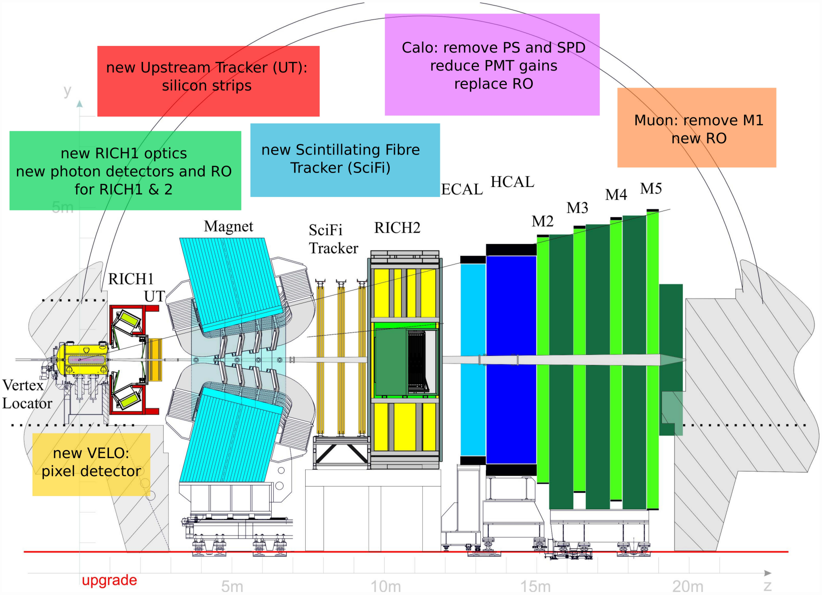
- need to cope with pile up
- need to cope with high occupancy and higher radiation
- new detector front-end electronics



	LHC era			HL-LHC era	
Run # (year)	Run 1 (2010-12)	Run 2 (2015-18)	Run 3 (2021-23)	Run 4 (2025-28)	Run 5+ (2030+)
Integrated luminosity	3 fb^{-1}	8 fb^{-1}	23 fb^{-1}	46 fb^{-1}	100 fb^{-1}
LHCb up to LS2			**after LHCb upgrade**		

⇒ upgrade detector during LS2

The LHCb Upgrade



new Upstream Tracker (UT):
silicon strips

Calo: remove PS and SPD
reduce PMT gains
replace RO

Muon: remove M1
new RO

new RICH1 optics
new photon detectors and RO
for RICH1 & 2

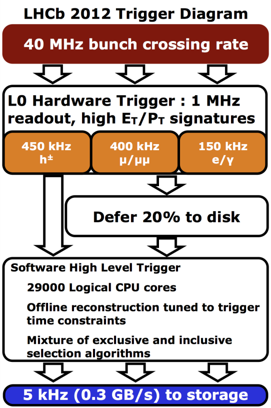
new Scintillating Fibre
Tracker (SciFi)

new VELO:
pixel detector

aim to reach 50 fb^{-1} [LHCB-TDR-12]

Trigger Upgrade

Run 1



LHCb 2012 Trigger Diagram

40 MHz bunch crossing rate

L0 Hardware Trigger : 1 MHz readout, high E_T/P_T signatures

450 kHz $h^{\pm}$ | **400 kHz $\mu/\mu\mu$** | **150 kHz e/γ**

Defer 20% to disk

Software High Level Trigger

29000 Logical CPU cores

Offline reconstruction tuned to trigger time constraints

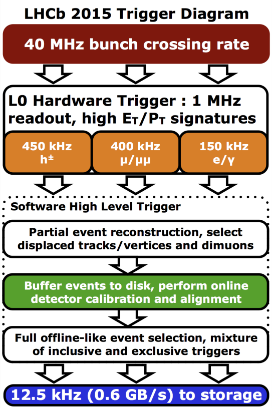
Mixture of exclusive and inclusive selection algorithms

5 kHz (0.3 GB/s) to storage

- first-level hardware trigger

[LHCB-TDR-016]

Run 2



LHCb 2015 Trigger Diagram

40 MHz bunch crossing rate

L0 Hardware Trigger : 1 MHz readout, high E_T/P_T signatures

450 kHz $h^{\pm}$ | **400 kHz $\mu/\mu\mu$** | **150 kHz e/γ**

Software High Level Trigger

Partial event reconstruction, select displaced tracks/vertices and dimuons

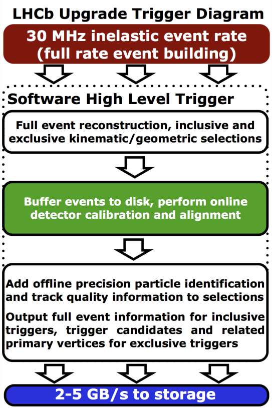
Buffer events to disk, perform online detector calibration and alignment

Full offline-like event selection, mixture of inclusive and exclusive triggers

12.5 kHz (0.6 GB/s) to storage

- first-level hardware trigger
- HLT and real time calibration

Run 3 & 4



LHCb Upgrade Trigger Diagram

30 MHz inelastic event rate (full rate event building)

Software High Level Trigger

Full event reconstruction, inclusive and exclusive kinematic/geometric selections

Buffer events to disk, perform online detector calibration and alignment

Add offline precision particle identification and track quality information to selections

Output full event information for inclusive triggers, trigger candidates and related primary vertices for exclusive triggers

2-5 GB/s to storage

- first-level trigger removed
- fully software flexible trigger

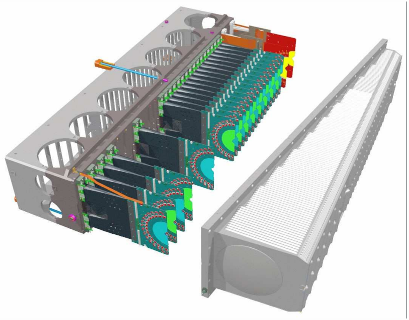
VELO Upgrade: requirements

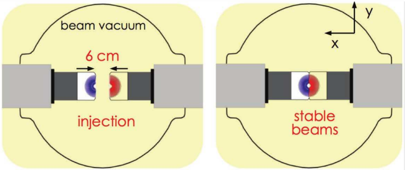
Current detector

- semi-circular modules, silicon strip sensors
- two retractable halves separated from the LHC vacuum by RF foil
- closest active strip at 8.2 mm from beam line
- one interaction per bunch crossing
- $\sigma_{IP} \sim 20\mu m$ for high p_T tracks

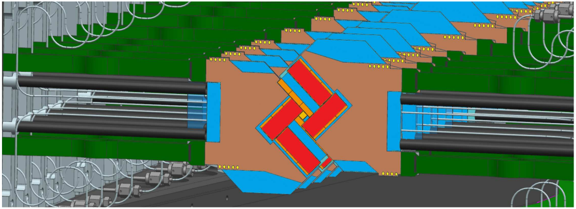
Requirements and challenges:

- ~ 5 interactions per bunch crossing
- measure impact parameter (IP) to high precision
- high tracking efficiency
- tolerance to high dose ($8 \times 10^{15} n_{eq} cm^{-2}$): 10 times the current VELO and highly non-uniform





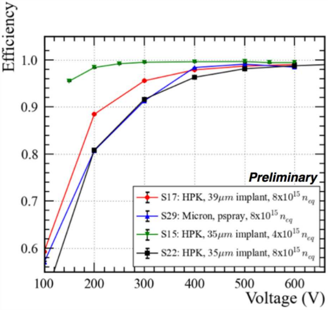
VELO Upgrade

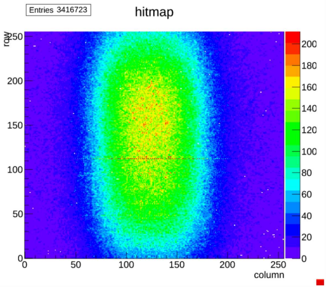


- hybrid pixel sensors, higher granularity (55μm pixel size)
- first sensor closer to the beam: 5.1mm
- reduced thickness for RF foil
- microchannel two-phase CO$_2$ cooling system (sensors at -20°C against radiation damage)
- improved IP resolution

intense testbeam campaign to validate sensors and radiation tolerance

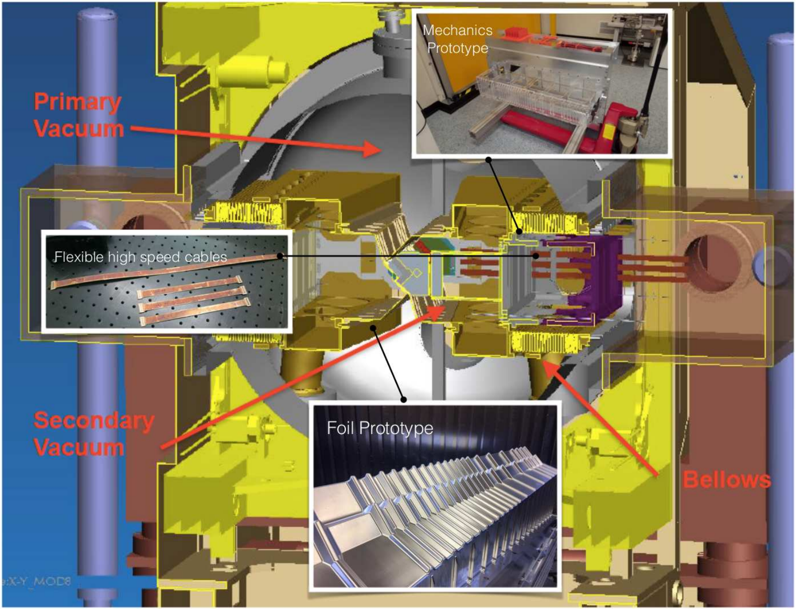
- charge collection
- charge collection efficiency
- spatial resolution





[LHCB-TDR-013]

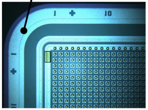
Few highlights



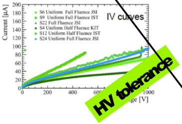
Few highlights

Pixel sensors

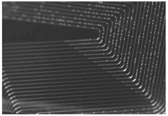
prototyped to withstand 1000V



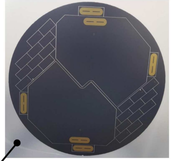
rounded corners



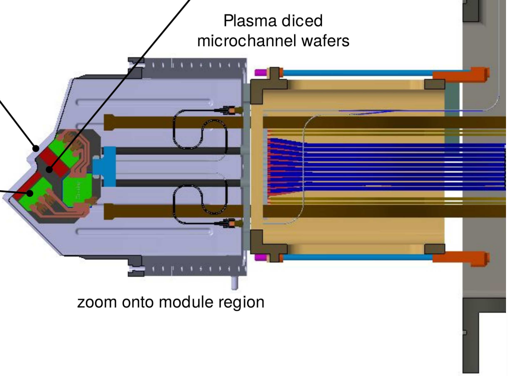
Module Cooling



CO_2 circulating
in microchannels

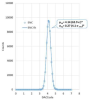


Plasma diced
microchannel wafers

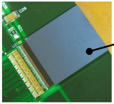


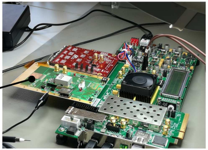
zoom onto module region

VeloPix ASIC



excellent performance;
final submission in ~ 1 month





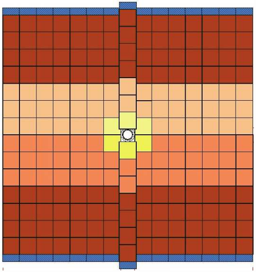
Tracking system

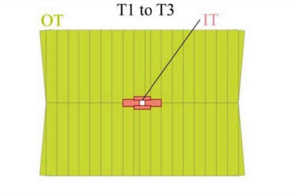
TT

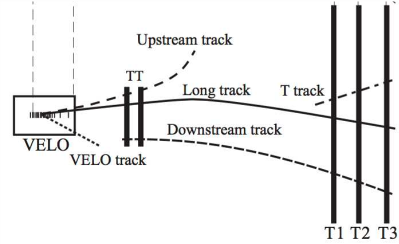
- 4 planes of silicon strips, crucial to detect tracks originated outside the VELO
- Insufficient radiation hardness for upgrade
- Readout of consecutive strips incompatible with high occupancy
- Front-end electronics non easily replaceable

IT and OT

- inner tracker: 4 planes of silicon strips in high η region
- outer tracker: 4 planes of straw tubes in the low η region
- incompatible with high occupancy

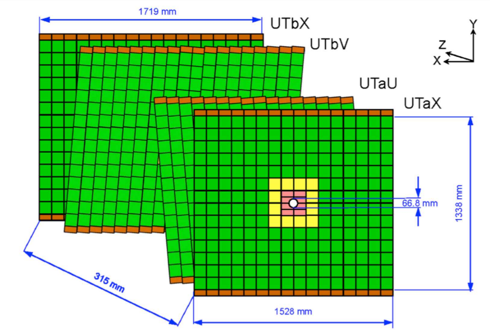


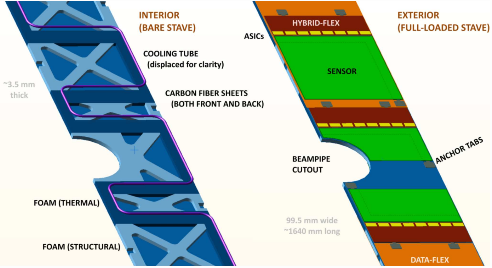




- reconstruct long tracks combining signal from VELO
- downstream tracks for the reconstruction of long lived particles

Tracking Upgrade: Upstream Tracker (UT)



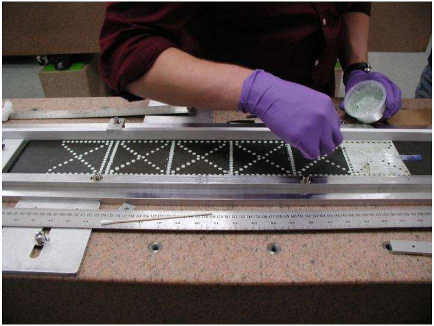


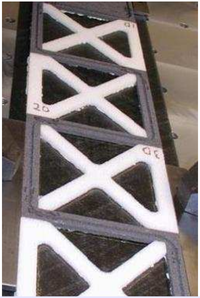
[LHCB-TDR-015]

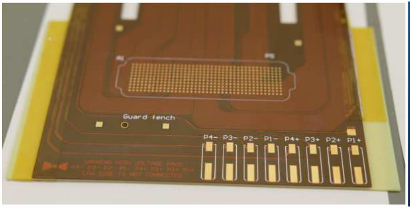
- Reconstruct particles decaying after the VELO
- Reconstruct low-momentum tracks deflected out of the T-acceptance
- 4 planes of silicon strip as for TT
- Finer segmentation: from 183μm×10cm to 95μm×4.9cm, 95μm×9.7cm, 190μm×9.7cm
- Better coverage, no gaps
- Lower material budget
- Higher radiation hardness
- Front-end in the active area, close to sensors: better signal to noise ratio

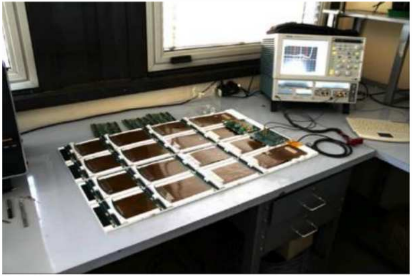
- intense campaign of testbeam
- stave design well advanced

Few highlights



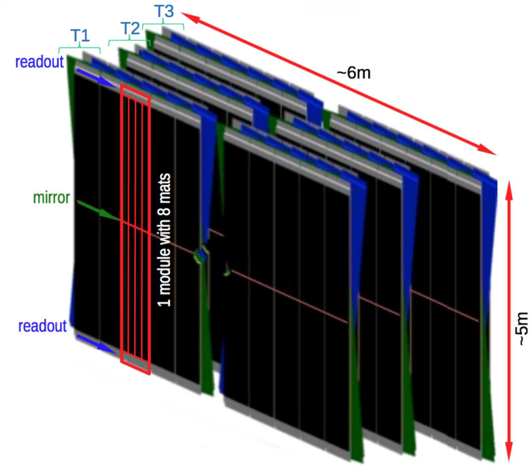


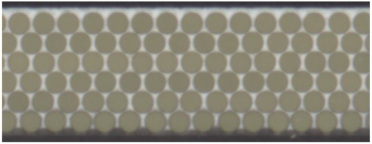




- assembly of staves
- pre-production of flex cables
- QA of flex cables

Tracking Upgrade: Scintillating Fibre Tracking



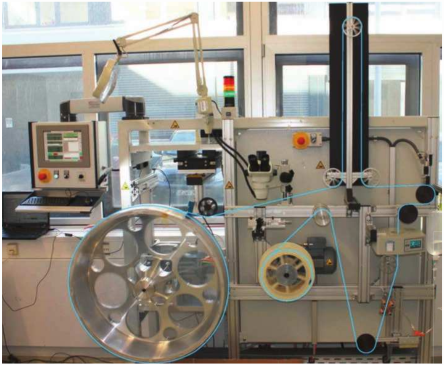


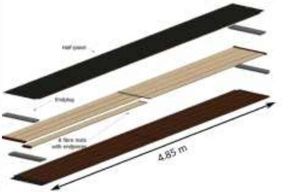
- Scintillating fibres mats transport signal outside the the acceptance volume
- 2.5m long fibres with diameter of $250\mu m$
- Each mat composed by 6 layers of fibres
- Signal readout by SiPMs at -40°C
- Homogeneous coverage with high granularity
- Spatial efficiency better than $70\mu m$
- Single hit efficiency $> 99\%$

See dedicated talk by P. Hopchev (Friday 19/5)

[LHCB-TDR-015]

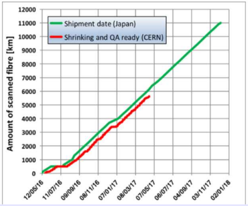
Few highlights





- QA of the fibre
- winding of fibre mats

∼ 11000km of fibre
QA half way there!!!

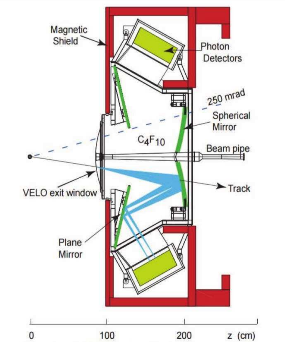


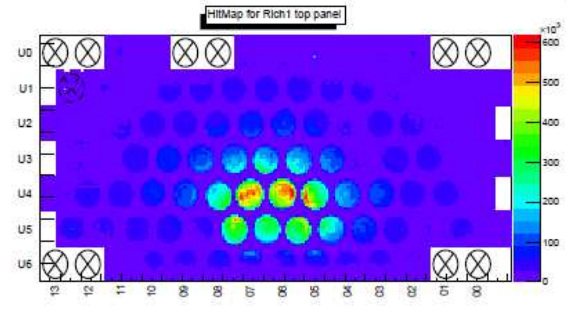
RICH

Two RICH detectors

- RICH1: upstream, 2GeV/c - 40GeV/c over 25mrad - 300mrad
- RICH2: downstream, 30GeV/c - 100GeV/c over 15mrad - 120mrad

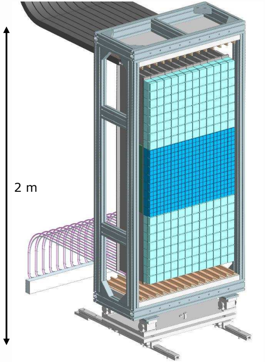
Excellent PID performance See talk by F. Ferrari (Monday 15/5)



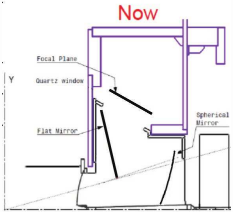


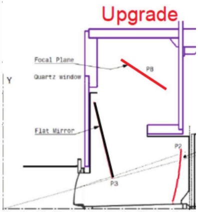
- Charged particles produce Cherenkov radiation focused on Hybrid Photon Detectors (HPD) plane
- HPDs equipped with embedded FE electronics, 1MHz readout
- need to change photon detectors in order to move to 40 MHz readout
- need to modify RICH1 optics in order to cope with high peak occupancy

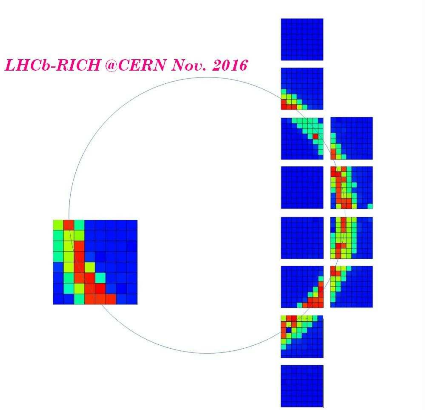
RICH Upgrade



- Replace HPDs with Multi-anode Photomultipliers (∼3000 units), finer granularity
- New external readout
- RICH1 focal plane and optics modified to increase size of Cherenkov rings
- intense testbeam campaign to validate new photon detectors and readout

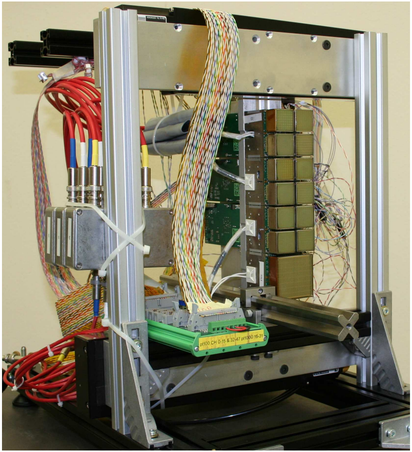


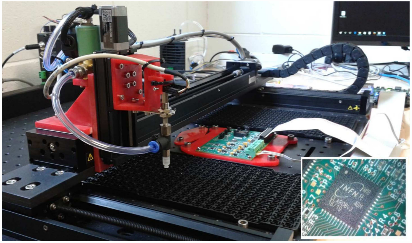


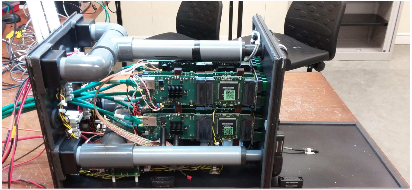


[LHCB-TDR-014]

Few highlights

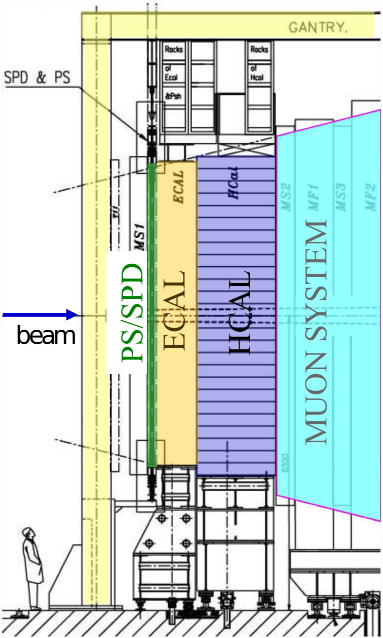






- QA MaPMTs started (1/3 tested)
- CLARO pre-production qualified
- full readout chain to be tested at testbeam

CALO & Muon



Calorimeter (four systems):

- Scintillating Pad Detector (SPD): identifies charge particles for e/γ separation
- PreShower (PS): identifies electromagnetic particles
- ECAL: 2mm lead sheets and 4mm scintillator planes
- HCAL: 16mm iron and 4mm scintillator tiles

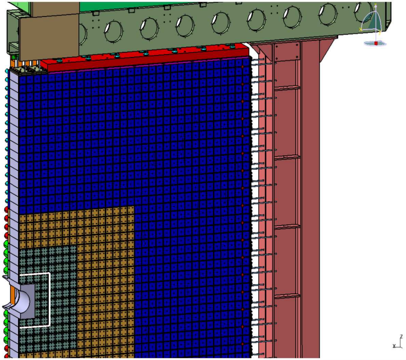
Muon:

- 5 stations: M1→M5
- Multi-Wire Proportional Chambers
- Triple-GEM detector
- Concentric geometry with decreasing granularity

Calo & Muon Upgrade

CALO

- Remove PS and SPD used for L0 trigger
- HCAL modules ok up to $\sim 50\text{fb}^{-1}$
- Inner ECAL modules need to be replaced after $\sim 20\text{fb}^{-1}$
- Reduce PMT gains
- Modify FE electronics



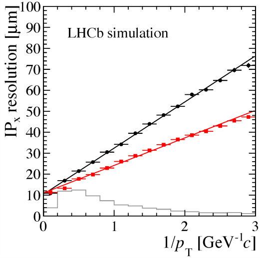
Muon

- Remove first station (M1) used for L0 trigger
- Replace readout electronics
- Additional shielding in front of M2, around the beam pipe to reduce the rate in the central region

[LHCB-TDR-014]

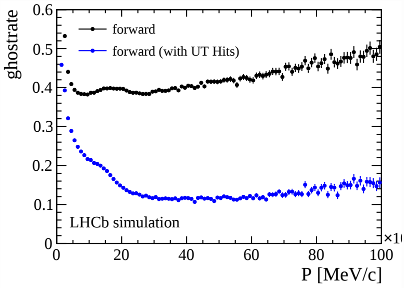
Performance of the upgraded LHCb

IP resolution for upgraded and current VELO

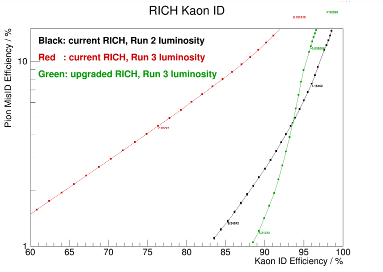


[LHCB-TDR-013]

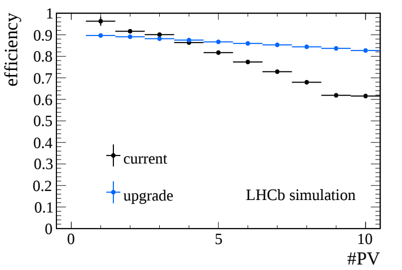
Tracking performance after upgrade



PID performance of the upgraded RICH



[S. Easo, talk at RICH2016]



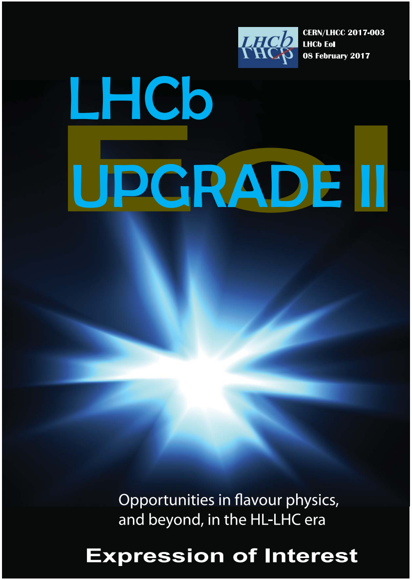
[LHCB-TDR-015]

LHCb upgrade: status

- Very challenging program
- Project on schedule
- Many Engineering Design Reviews have already been conducted
- Production Readiness Reviews are already ongoing

What's next?

LHCb Phase-II upgrade



CERN/LHCC 2017-003
LHCb EoI
08 February 2017

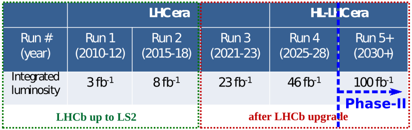
LHCb
UPGRADE II
EoI

Opportunities in flavour physics,
and beyond, in the HL-LHC era

Expression of Interest

Recently submitted the Expression of Intent to install a second upgrade of the LHCb detector [CERN-LHCC-2017-003]

- install new detector for the beginning of Run 5
- operate at $\mathscr{L} \sim 2 \times 10^{34}\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- mean number of interactions per bunch crossing: $\mu \sim 50$
- collect more than $300\mathrm{fb}^{-1}$
- improve even more Phase-I LHCb precision (even after first upgrade many measurements still limited by statistics)
- fully exploit HL-LHC



	LHC era			HL-LHC era	
Run # (year)	Run 1 (2010-12)	Run 2 (2015-18)	Run 3 (2021-23)	Run 4 (2025-28)	Run 5+ (2030+)
Integrated luminosity	3 fb^{-1}	8 fb^{-1}	23 fb^{-1}	46 fb^{-1}	100 fb^{-1}

LHCb up to LS2

after LHCb upgrade

Phase-II

Phase-II Upgrade goals

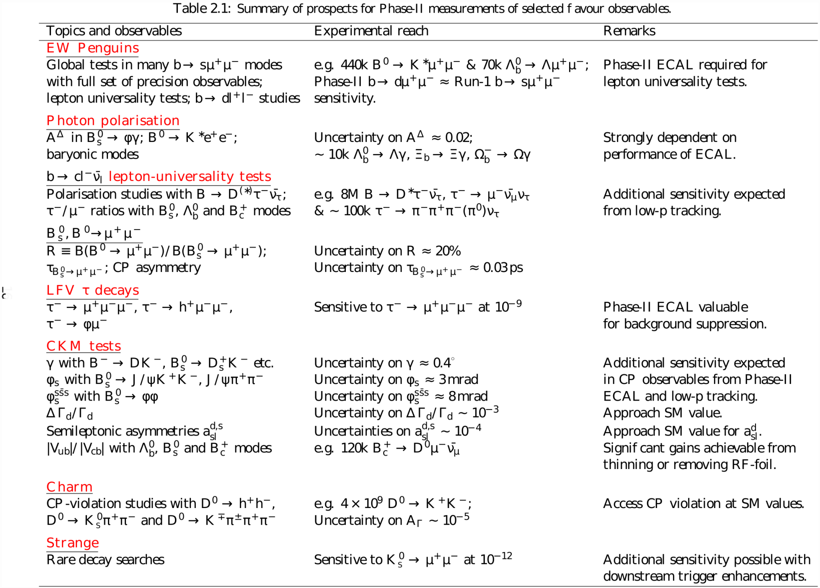
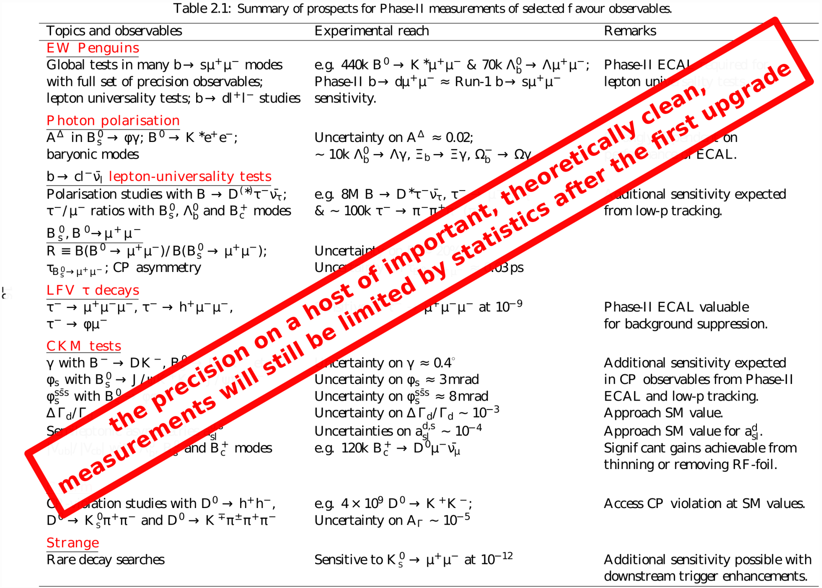


Table 2.1: Summary of prospects for Phase-II measurements of selected flavour observables.

Topics and observables	Experimental reach	Remarks
EW Penguins		
Global tests in many $b \to s\mu^+\mu^-$ modes with full set of precision observables; lepton universality tests; $b \to dl^+l^-$ studies	e.g. 440k $B^0 \to K^*\mu^+\mu^-$ & 70k $\Lambda_b^0 \to \Lambda\mu^+\mu^-$; Phase-II $b \to d\mu^+\mu^- \approx$ Run-1 $b \to s\mu^+\mu^-$ sensitivity.	Phase-II ECAL required for lepton universality tests.
Photon polarisation		
A^Δ in $B_s^0 \to \phi\gamma$; $B^0 \to K^*e^+e^-$; baryonic modes	Uncertainty on $A^\Delta \approx 0.02$; $\sim$ 10k $\Lambda_b^0 \to \Lambda\gamma$, $\Xi_b \to \Xi\gamma$, $\Omega_b^- \to \Omega\gamma$	Strongly dependent on performance of ECAL.
$b \to cl^-\bar{\nu}_l$ lepton-universality tests		
Polarisation studies with $B \to D^{(*)}\tau^-\bar{\nu}_\tau$; τ^-/μ^- ratios with B_s^0, Λ_b^0 and B_c^+ modes	e.g. 8M $B \to D^*\tau^-\bar{\nu}_\tau$, $\tau^- \to \mu^-\bar{\nu}_\mu\nu_\tau$ & $\sim$ 100k $\tau^- \to \pi^-\pi^+\pi^-(\pi^0)\nu_\tau$	Additional sensitivity expected from low-p tracking.
$B_s^0, B^0 \to \mu^+\mu^-$		
$R \equiv \mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$;	Uncertainty on $R \approx 20\%$	
$\tau_{B_s^0 \to \mu^+\mu^-}$; CP asymmetry	Uncertainty on $\tau_{B_s^0 \to \mu^+\mu^-} \approx 0.03\,\mathrm{ps}$	
LFV τ decays		
$\tau^- \to \mu^+\mu^-\mu^-$, $\tau^- \to h^+\mu^-\mu^-$, $\tau^- \to \phi\mu^-$	Sensitive to $\tau^- \to \mu^+\mu^-\mu^-$ at 10^{-9}	Phase-II ECAL valuable for background suppression.
CKM tests		
γ with $B^- \to DK^-$, $B_s^0 \to D_s^+K^-$ etc.	Uncertainty on $\gamma \approx 0.4^\circ$	Additional sensitivity expected in CP observables from Phase-II ECAL and low-p tracking.
ϕ_s with $B_s^0 \to J/\psi K^+K^-$, $J/\psi\pi^+\pi^-$	Uncertainty on $\phi_s \approx 3\,\mathrm{mrad}$	
$\phi_s^{s\bar{s}s}$ with $B_s^0 \to \phi\phi$	Uncertainty on $\phi_s^{s\bar{s}s} \approx 8\,\mathrm{mrad}$	
$\Delta\Gamma_d/\Gamma_d$	Uncertainty on $\Delta\Gamma_d/\Gamma_d \sim 10^{-3}$	Approach SM value.
Semileptonic asymmetries $a_{sl}^{d,s}$	Uncertainties on $a_{sl}^{d,s} \sim 10^{-4}$	Approach SM value for a_{sl}^d.
$\lvert V_{ub}\rvert/\lvert V_{cb}\rvert$ with Λ_b^0, B_s^0 and B_c^+ modes	e.g. 120k $B_c^+ \to D^0\mu^-\bar{\nu}_\mu$	Significant gains achievable from thinning or removing RF-foil.
Charm		
CP-violation studies with $D^0 \to h^+h^-$, $D^0 \to K_S^0\pi^+\pi^-$ and $D^0 \to K^\mp\pi^\pm\pi^+\pi^-$	e.g. 4×10^9 $D^0 \to K^+K^-$; Uncertainty on $A_\Gamma \sim 10^{-5}$	Access CP violation at SM values.
Strange		
Rare decay searches	Sensitive to $K_S^0 \to \mu^+\mu^-$ at 10^{-12}	Additional sensitivity possible with downstream trigger enhancements.

second upgrade to realise the flavour potential of HL-LHC

Phase-II Upgrade goals



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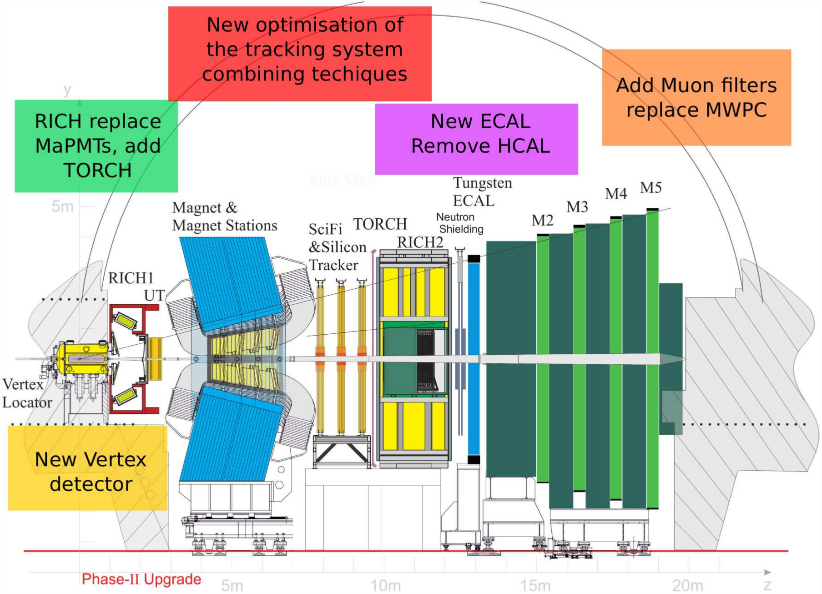
A^{Δ} in $B_s^0 \to \phi\gamma$; $B^0 \to K^{*}e^+e^-$; baryonic modes	Uncertainty on $A^{\Delta} \approx 0.02$; $\sim$ 10k $\Lambda_b^0 \to \Lambda\gamma$, $\Xi_b \to \Xi\gamma$, $\Omega_b^- \to \Omega\gamma$	Strongly dependent on performance of ECAL.
$b \to c l^- \bar{\nu}_l$ lepton-universality tests		
Polarisation studies with $B \to D^{(*)}\tau^-\bar{\nu}_\tau$; τ^-/μ^- ratios with B_s^0, Λ_b^0 and B_c^+ modes	e.g. 8M $B \to D^{*}\tau^-\bar{\nu}_\tau$, $\tau^- \to \mu^-\bar{\nu}_\mu\nu_\tau$ & $\sim$ 100k $\tau^- \to \pi^-\pi^+\pi^-(\pi^0)\nu_\tau$	Additional sensitivity expected from low-p tracking.
$B_s^0, B^0 \to \mu^+\mu^-$		
$R \equiv \mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$; $\tau_{B_s^0 \to \mu^+\mu^-}$; CP asymmetry	Uncertainty on $R \sim 20\%$ Uncertainty on $\tau_{B_s^0 \to \mu^+\mu^-} \approx 0.03$ ps	
LFV τ decays		
$\tau^- \to \mu^+\mu^-\mu^-$, $\tau^- \to h^+\mu^-\mu^-$, $\tau^- \to \phi\mu^-$	Sensitive to $\tau^- \to \mu^+\mu^-\mu^-$ at 10^{-9}	Phase-II ECAL valuable for background suppression.
CKM tests		
γ with $B^- \to DK^-$, $B^0 \to D^-\pi^+$ etc. ϕ_s with $B_s^0 \to J/\psi K^+K^-$, $J/\psi\pi^+\pi^-$ $\phi_s^{s\bar{s}s}$ with $B_s^0 \to \phi\phi$ $\Delta\Gamma_d/\Gamma_d$ Semileptonic asymmetries $a_{sl}^{d,s}$ $\lvert V_{ub}\rvert/\lvert V_{cb}\rvert$ with Λ_b^0, B_s^0 and B_c^+ modes	Uncertainty on $\gamma \approx 0.4^\circ$ Uncertainty on $\phi_s \approx 3$ mrad Uncertainty on $\phi_s^{s\bar{s}s} \approx 8$ mrad Uncertainty on $\Delta\Gamma_d/\Gamma_d \sim 10^{-3}$ Uncertainties on $a_{sl}^{d,s} \sim 10^{-4}$ e.g. 120k $B_c^+ \to D^0\mu^-\bar{\nu}_\mu$	Additional sensitivity expected in CP observables from Phase-II ECAL and low-p tracking. Approach SM value. Approach SM value for a_{sl}^d. Significant gains achievable from thinning or removing RF-foil.
Charm		
CP-violation studies with $D^0 \to h^+h^-$, $D^0 \to K_S^0\pi^+\pi^-$ and $D^0 \to K^{\mp}\pi^{\pm}\pi^+\pi^-$	e.g. 4×10^9 $D^0 \to K^+K^-$; Uncertainty on $A_\Gamma \sim 10^{-5}$	Access CP violation at SM values.
Strange		
Rare decay searches	Sensitive to $K_S^0 \to \mu^+\mu^-$ at 10^{-12}	Additional sensitivity possible with downstream trigger enhancements.

the precision on a host of important, theoretically clean, measurements will still be limited by statistics after the first upgrade

second upgrade to realise the flavour potential of HL-LHC

The LHCb Upgrade Phase-II



New optimisation of the tracking system combining techiques

RICH replace MaPMTs, add TORCH

New ECAL Remove HCAL

Add Muon filters replace MWPC

New Vertex detector

Timing is the key!!!

Conclusions

LHCb is currently taking high quality data above the design parameters

The LHCb Phase-I upgrade is foreseen to collect 50 fb^{-1}

- very challenging project
- all subdetectors are progressing towards the production of the components
- installation foreseen during LS2
- operations foreseen in Run 3 and 4
- upgrade is mandatory to reach experimental precision of the order of theoretical uncertainties

The EoI for the LHCb Phase-II upgrade has been submitted

- project very technologically challenging
- aim to collect 300 fb^{-1} $\Rightarrow$ upgrade would allow to collect 100× more data and reach higher precision!

Thank you for your attention!