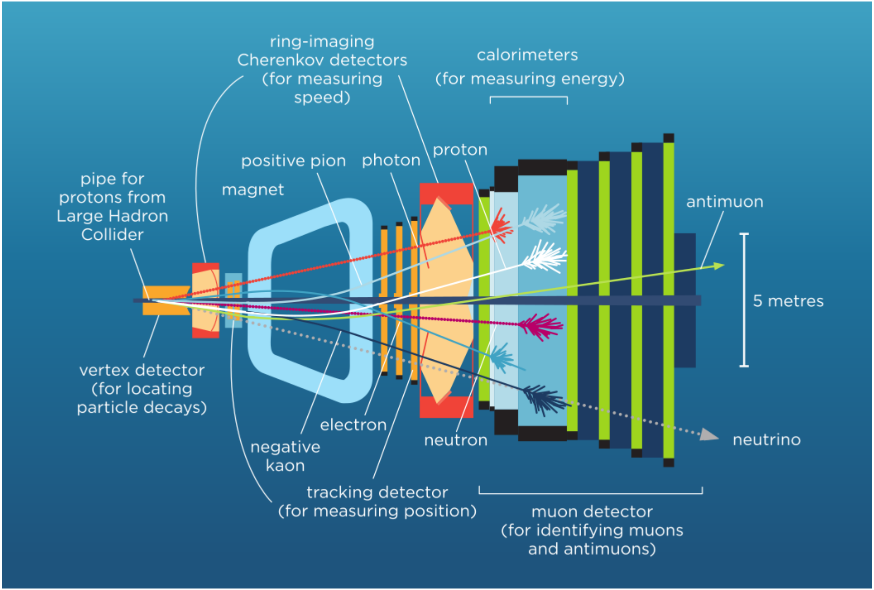
Scintillating Fiber Tracker for LHCb upgrade

Sevda Esen

17-18 December 2018
Utrecht

Nikhef jamboree

LHCb for beginners [from Antimatter-Matters]

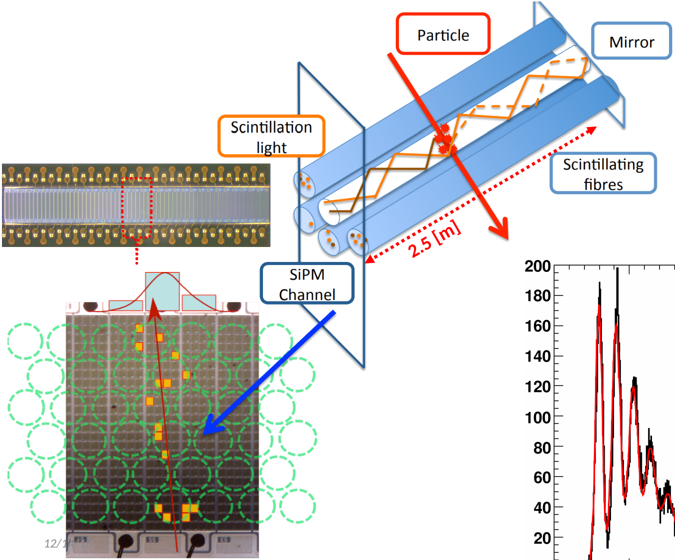


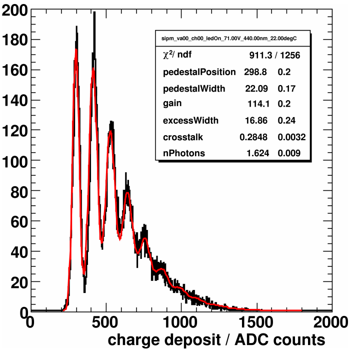
Fiber Tracker

Fiber Tracker

- High hit efficiency
- Good resolution
- Fast readout
- Radiation hard

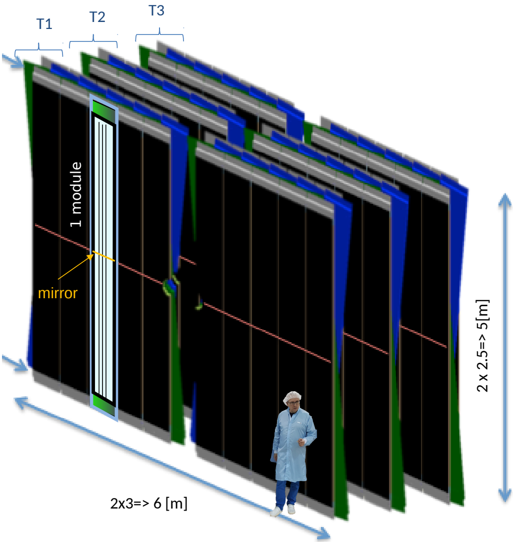
How it works


Particle
Mirror
Scintillation light
Scintillating fibres
2.5 [m]
SiPM Channel


sipm_va00_ch00_ledOn_71.00V_440.00nm_22.00degC
χ²/ ndf 911.3 / 1256
pedestalPosition 298.8 0.2
pedestalWidth 22.09 0.17
gain 114.1 0.2
excessWidth 16.86 0.24
crosstalk 0.2848 0.0032
nPhotons 1.624 0.009
0
20
40
60
80
100
120
140
160
180
200
0
500
1000
1500
2000
charge deposit / ADC counts

The [expected] Detector

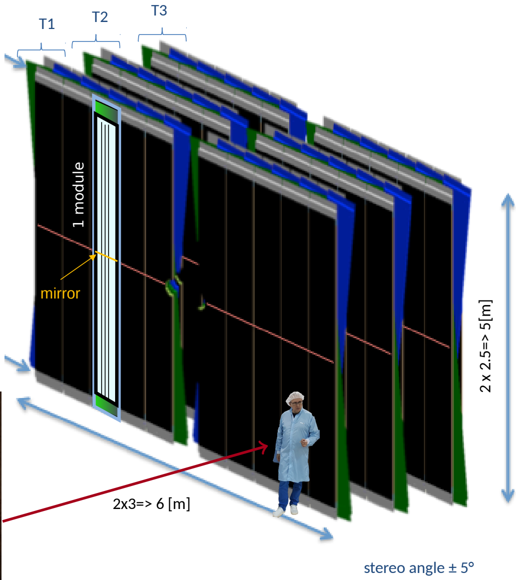
- 10000km fibers
  - ⇒ 1024 mats
  - ⇒ 128 modules
  - ⇒ 12 layers
  - ⇒ 3 stations
  - ⇒ **1 great tracker**
- $340m^2$ sensitive area
- Read out by 256x16 SiPms



stereo angle ± 5°

The [expected] Detector

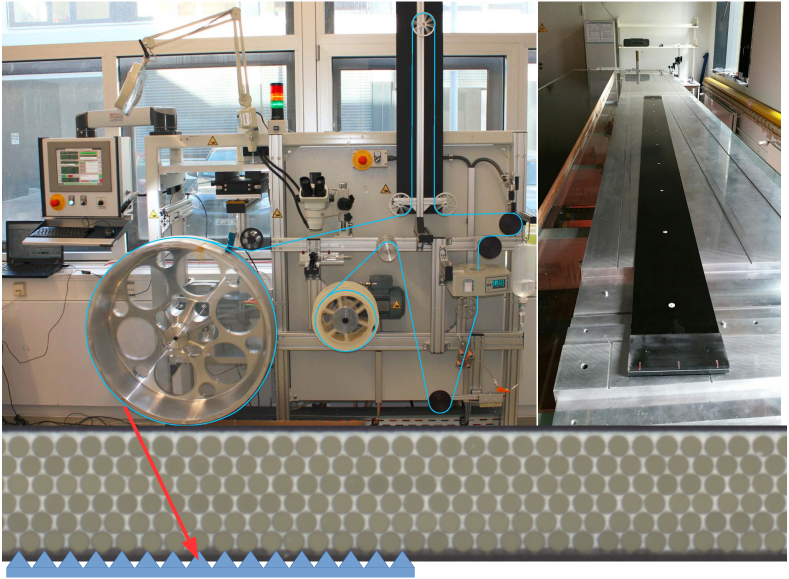
- 10000km fibers
  - ⇒ 1024 mats
  - ⇒ 128 modules
  - ⇒ 12 layers
  - ⇒ 3 stations
  - ⇒ **1 great tracker**
- 340m^2 sensitive area
- Read out by 256x16 SiPms



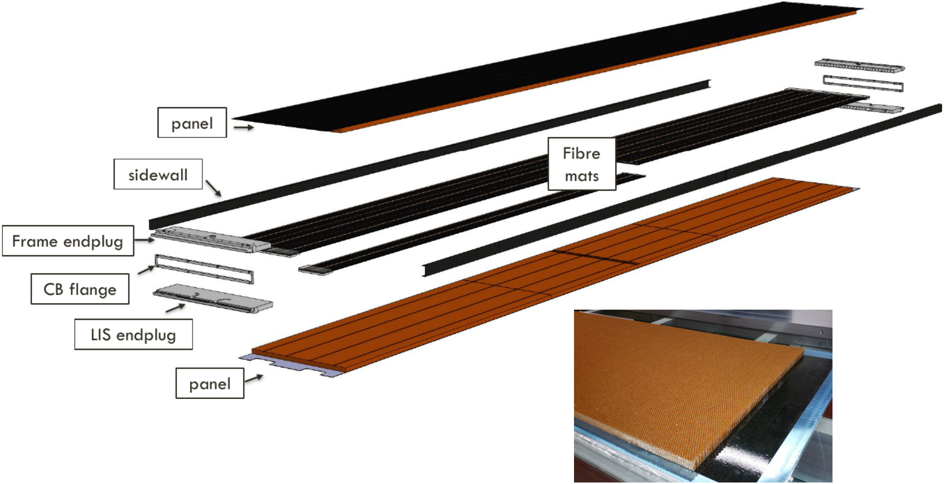
What we contribute at Nikhef

- Module production
- Cooling: development and production
- Quality assurance
- Test beam setup and analysis
- Simulation and reconstruction
- Commissioning and assembly

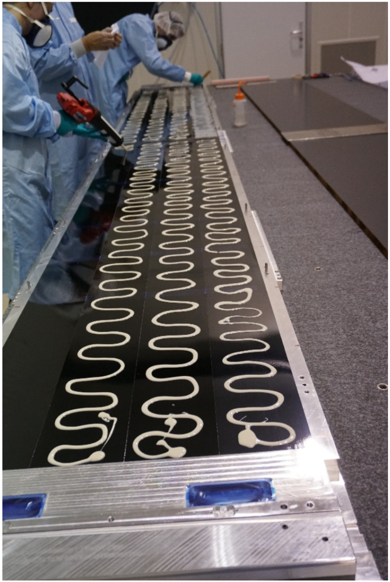
The Art of Fiber Winding



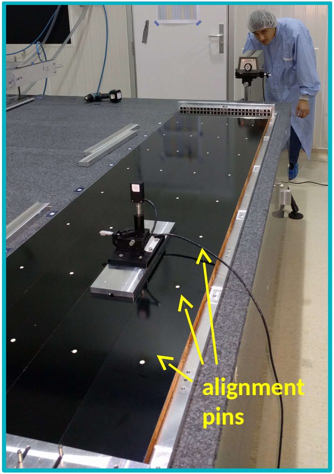
A Fiber Module



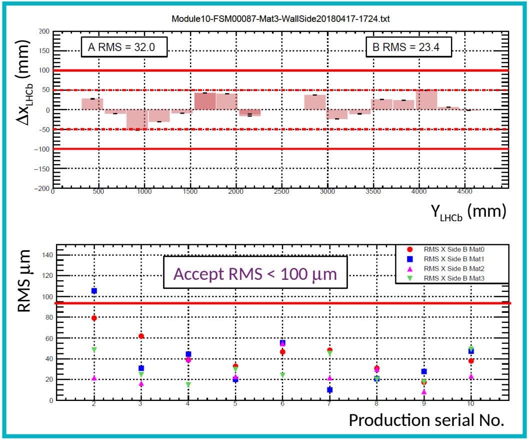
Module production



Module straightness

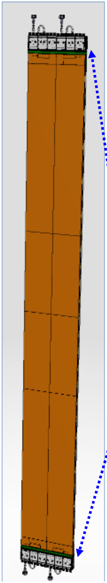


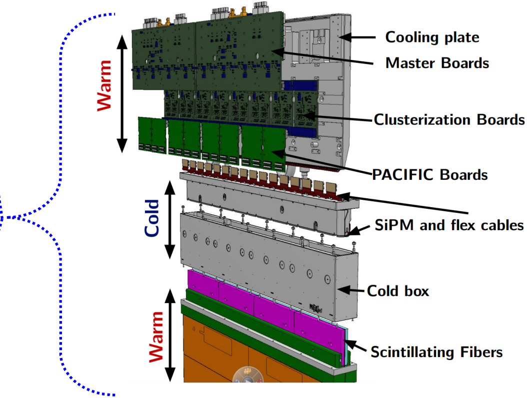
Measure the straightness of the 8 fiber mats glued in a module



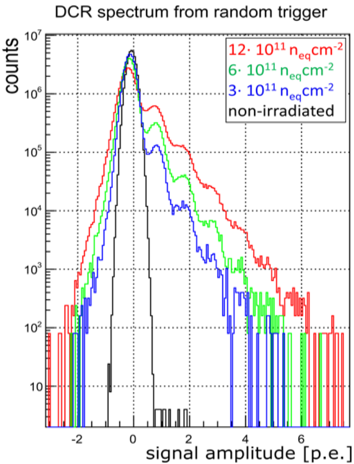
Modules ready to go

Readout box

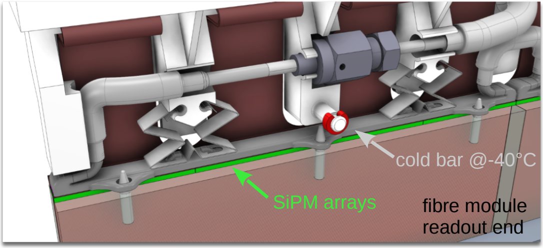



Warm
Cold
Warm
Cooling plate
Master Boards
Clusterization Boards
PACIFIC Boards
SiPM and flex cables
Cold box
Scintillating Fibers

Cooling

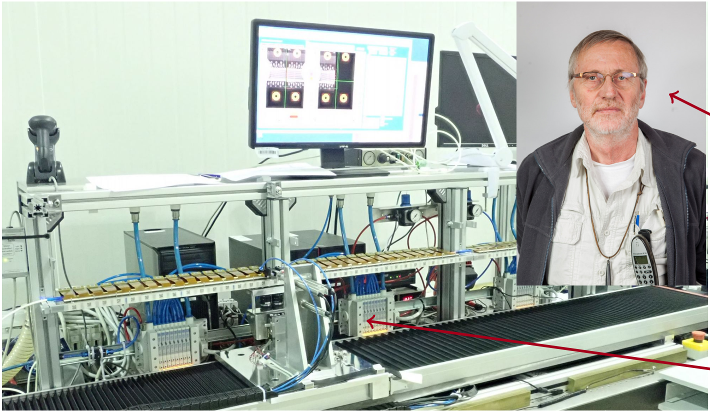


DCR spectrum from random trigger
counts
signal amplitude [p.e.]
12· 10^11 n_eq cm^-2
6· 10^11 n_eq cm^-2
3· 10^11 n_eq cm^-2
non-irradiated



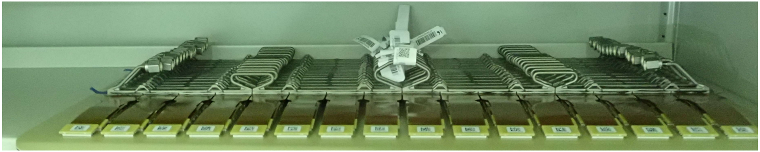
cold bar @-40°C
SiPM arrays
fibre module readout end

SiPM Array Positioning

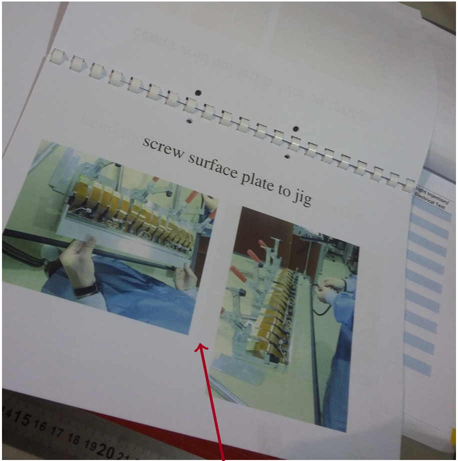


Fred

Fred's machine

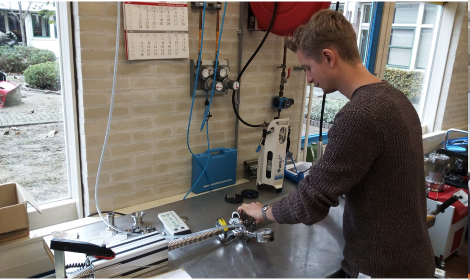


Top cover assembly

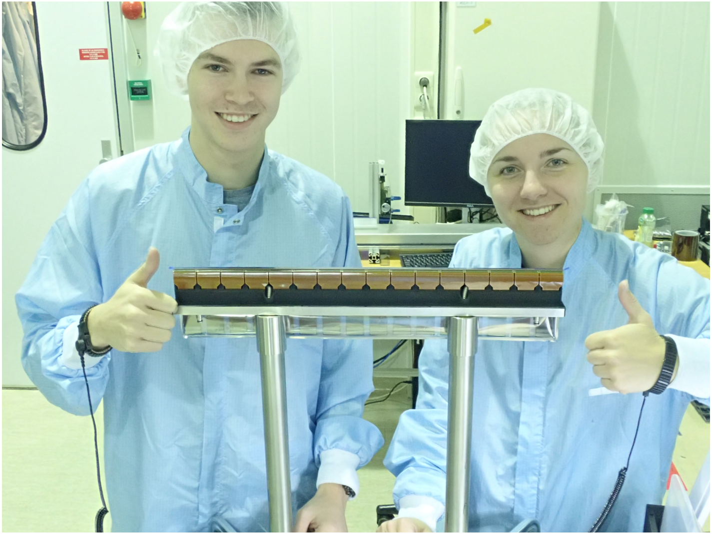


The Manual

Quality assurance at every step



One ready, 300 to go!



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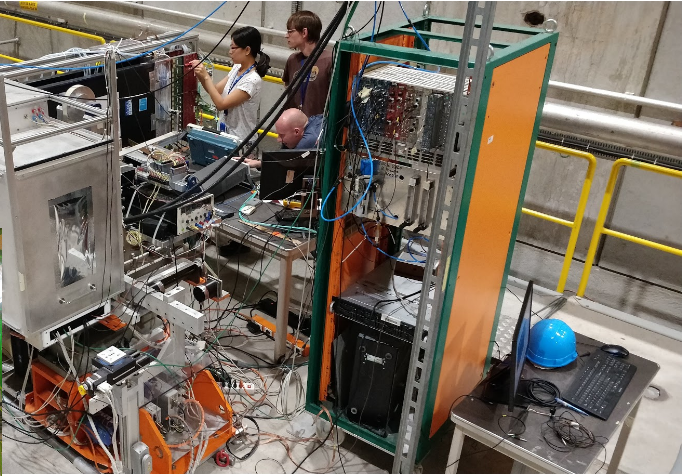
Box and ship them to CERN!

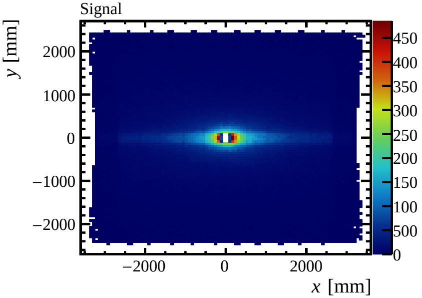
First shipment of 24 cold-boxes arrived at CERN

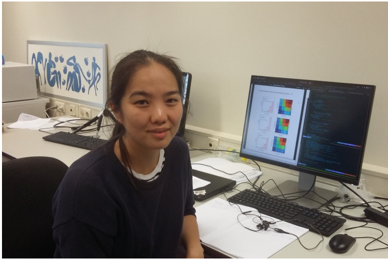
Testbeam

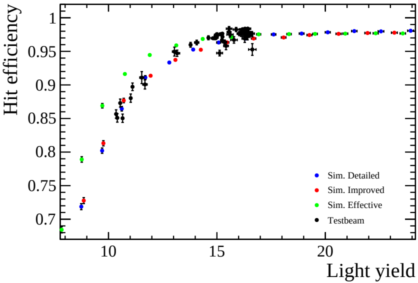


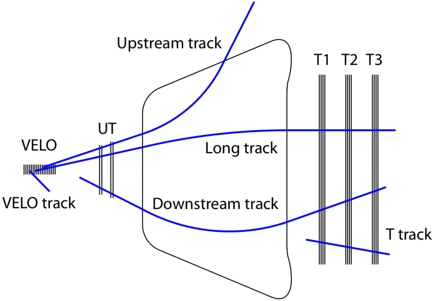
Putting things together

Computing, Simulation and reconstruction









What we expect [not up to date]

Table 3: Statistical sensitivities of the LHCb upgrade to key observables. For each observable the expected sensitivity is given for the integrated luminosity accumulated by the end of LHC Run 1, by 2018 (assuming 5 fb^{-1} recorded during Run 2) and for the LHCb Upgrade (50 fb^{-1}). An estimate of the theoretical uncertainty is also given – this and the potential sources of systematic uncertainty are discussed in the text.

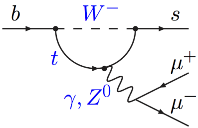
Type	Observable	LHC Run 1	LHCb 2018	**LHCb upgrade**	Theory
B_s^0 mixing	$\phi_s(B_s^0 \to J/\psi\,\phi)$ (rad)	0.05	0.025	**0.009**	~ 0.003
	$\phi_s(B_s^0 \to J/\psi\, f_0(980))$ (rad)	0.09	0.05	**0.016**	~ 0.01
	$A_{\text{sl}}(B_s^0)$ (10^{-3})	2.8	1.4	**0.5**	0.03
Gluonic penguin	$\phi_s^{\text{eff}}(B_s^0 \to \phi\phi)$ (rad)	0.18	0.12	**0.026**	0.02
	$\phi_s^{\text{eff}}(B_s^0 \to K^{*0}\bar{K}^{*0})$ (rad)	0.19	0.13	**0.029**	< 0.02
	$2\beta^{\text{eff}}(B^0 \to \phi K_S^0)$ (rad)	0.30	0.20	**0.04**	0.02
Right-handed currents	$\phi_s^{\text{eff}}(B_s^0 \to \phi\gamma)$	0.20	0.13	**0.030**	< 0.01
	$\tau^{\text{eff}}(B_s^0 \to \phi\gamma)/\tau_{B_s^0}$	5%	3.2%	**0.8%**	0.2 %
Electroweak penguin	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1 < q^2 < 6\,\text{GeV}^2/c^4)$	0.04	0.020	**0.007**	0.02
	$q_0^2\, A_{\text{FB}}(B^0 \to K^{*0}\mu^+\mu^-)$	10%	5%	**1.9%**	$\sim 7\%$
	$A_{\text{I}}(K\mu^+\mu^-; 1 < q^2 < 6\,\text{GeV}^2/c^4)$	0.14	0.07	**0.024**	~ 0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+ \to K^+\mu^+\mu^-)$	14%	7%	**2.4%**	$\sim 10\%$
Higgs penguin	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$ (10^{-9})	1.0	0.5	**0.19**	0.3
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	220%	110%	**40%**	$\sim 5\,\%$
Unitarity triangle angles	$\gamma(B \to D^{(*)}K^{(*)})$	7°	4°	**1.1°**	negligible
	$\gamma(B_s^0 \to D_s^{\mp}K^{\pm})$	17°	11°	**2.4°**	negligible
	$\beta(B^0 \to J/\psi\, K_S^0)$	1.7°	0.8°	**0.31°**	negligible
Charm *CP* violation	$A_\Gamma(D^0 \to K^+K^-)$ (10^{-4})	3.4	2.2	**0.5**	–
	ΔA_{CP} (10^{-3})	0.8	0.5	**0.12**	–

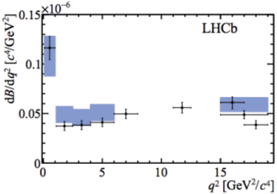
What we expect [not up to date]

Table 3: Statistical sensitivities of the LHCb upgrade to key observables. For each observable the expected sensitivity is given for the integrated luminosity accumulated by the end of LHC Run 1, by 2018 (assuming 5 fb^{-1} recorded during Run 2) and for the LHCb Upgrade (50 fb^{-1}). An estimate of the theoret… rtainty is also given – this and the potential sources of systematic uncertainty are discussed in the text.

Type	Observable		b 2018	**LHCb upgrade**	Theory
B_s^0 mixing	$\phi_s(B_s^0 \to J/$		025	**0.009**	~ 0.003
	$\phi_s(B_s^0 \to$		5	**0.016**	~ 0.01
	$A_{sl}($			**0.5**	0.03
Gluonic penguin	$\phi_s^{eff}(B_s^0$			**0.026**	0.02
	$\phi_s^{eff}(B_s^0 \to$			**0.029**	< 0.02
	$2\beta^{eff}(B^0 \to$			**0.04**	0.02
Right-handed currents	$\phi_s^{eff}(B_s^0$			**0.030**	< 0.01
	$\tau^{eff}(B_s^0 \to$			**0.8%**	0.2 %
Electroweak penguin	$S_3(B^0 \to K^{*0}\mu^+\mu^-; 1$			**0.007**	0.02
	$q_0^2\, A_{FB}(B^0 \to K$			**1.9%**	$\sim 7\%$
	$A_I(K\mu^+\mu^-; 1 < q^2 <$			**0.024**	~ 0.02
	$\mathcal{B}(B^+ \to \pi^+\mu^+\mu^-)/\mathcal{B}(B^+$			**2.4%**	$\sim 10\%$
Higgs penguin	$\mathcal{B}(B_s^0 \to \mu^+\mu^-)$ (1		[illegible]	**0.19**	0.3
	$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0$ –		110%	**40%**	$\sim 5\%$
Unitarity triangle angles	$\gamma(B \to D^{(*)}K^{(*)})$	[illegible]	4°	**1.1°**	negligible
	$\gamma(B_s^0 \to D_s^{\mp}K^{\pm})$	17°	11°	**2.4°**	negligible
	$\beta(B^0 \to J/\psi K_S^0)$	1.7°	0.8°	**0.31°**	negligible
Charm CP violation	$A_\Gamma(D^0 \to K^+K^-)$ (10^{-4})	3.4	2.2	**0.5**	–
	ΔA_{CP} (10^{-3})	0.8	0.5	**0.12**	–

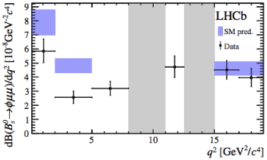
Anomalies: real or not?





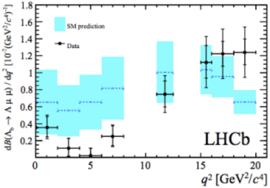
$B^0 \rightarrow K^{*0}\mu^+\mu^-$

[JHEP 11 (2016) 047]



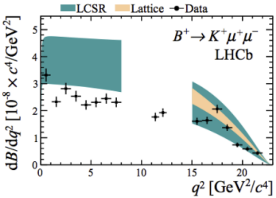
$B_s^0 \rightarrow \phi\mu^+\mu^-$

[JHEP 09 (2015) 179]



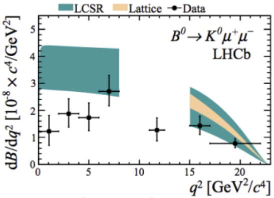
$\Lambda_b^0 \rightarrow \Lambda\mu^+\mu^-$

[JHEP 06 (2015) 115]



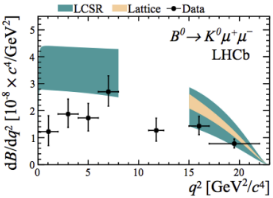
$B^+ \rightarrow K^+\mu^+\mu^-$

[JHEP 06 (2014) 133]



$B^0 \rightarrow K^0\mu^+\mu^-$

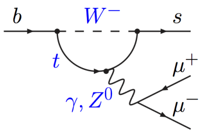
[JHEP 06 (2014) 133]



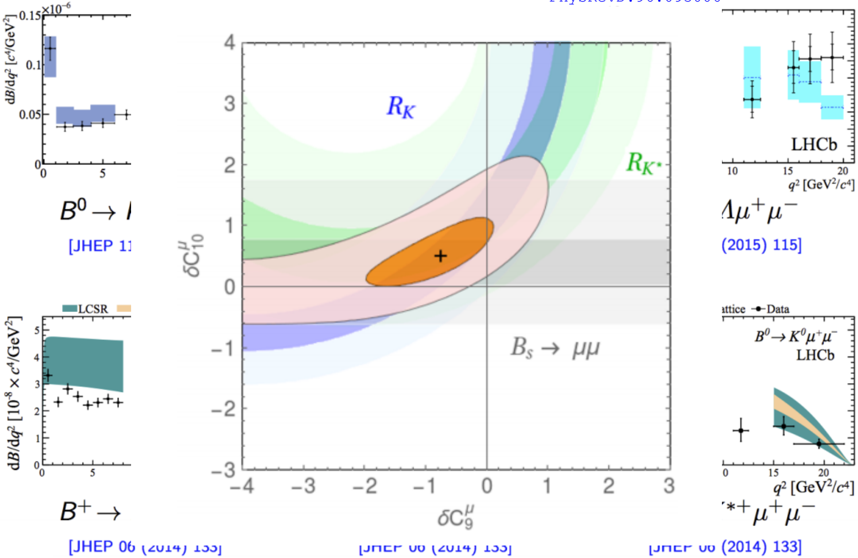
$B^+ \rightarrow K^{*+}\mu^+\mu^-$

[JHEP 06 (2014) 133]

Anomalies: real or not?

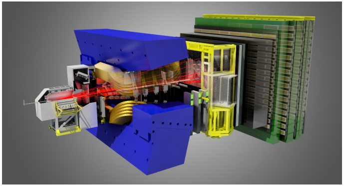


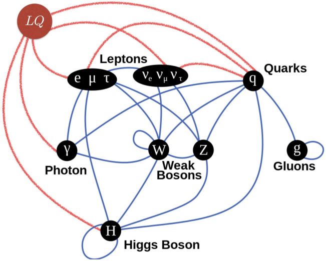
PhysRevD.96.093006



Let's find out together..

Observable	Current LHCb	LHCb 2025
EW Penguins		
R_K $(1 < q^2 < 6\,\mathrm{GeV}^2c^4)$	0.1 [274]	0.025
R_{K^*} $(1 < q^2 < 6\,\mathrm{GeV}^2c^4)$	0.1 [275]	0.031
R_ϕ, R_{pK}, R_π	–	0.08, 0.06, 0.18
CKM tests		
γ, with $B_s^0 \to D_s^+ K^-$	$(^{+17}_{-22})^\circ$ [136]	4°
γ, all modes	$(^{+5.0}_{-5.8})^\circ$ [167]	1.5°
$\sin 2\beta$, with $B^0 \to J/\psi K_S^0$	0.04 [609]	0.011
ϕ_s, with $B_s^0 \to J/\psi\phi$	49 mrad [44]	14 mrad
ϕ_s, with $B_s^0 \to D_s^+ D_s^-$	170 mrad [49]	35 mrad
$\phi_s^{s\bar{s}s}$, with $B_s^0 \to \phi\phi$	154 mrad [94]	39 mrad
a_{sl}^s	33×10^{-4} [211]	10×10^{-4}
$\lvert V_{ub}\rvert/\lvert V_{cb}\rvert$	6% [201]	3%
$\boldsymbol{B_s^0, B^0 \to \mu^+\mu^-}$		
$\mathcal{B}(B^0 \to \mu^+\mu^-)/\mathcal{B}(B_s^0 \to \mu^+\mu^-)$	90% [264]	34%
$\tau_{B_s^0 \to \mu^+\mu^-}$	22% [264]	8%
$S_{\mu\mu}$	–	–
$\boldsymbol{b \to c\ell^-\bar{\nu}_l}$ **LUV studies**		
$R(D^*)$	0.026 [215, 217]	0.0072
$R(J/\psi)$	0.24 [220]	0.071
Charm		
$\Delta A_{CP}(KK - \pi\pi)$	8.5×10^{-4} [613]	1.7×10^{-4}
A_Γ $(\approx x \sin\phi)$	2.8×10^{-4} [240]	4.3×10^{-5}
$x \sin\phi$ from $D^0 \to K^+\pi^-$	13×10^{-4} [228]	3.2×10^{-4}
$x \sin\phi$ from multibody decays	–	$(K3\pi)$ 4.0×10^{-5}





THE END


NO BACKUPS, NO FAILOVER, NO CLUE
LET'S HIT IT
memegenerator.net