

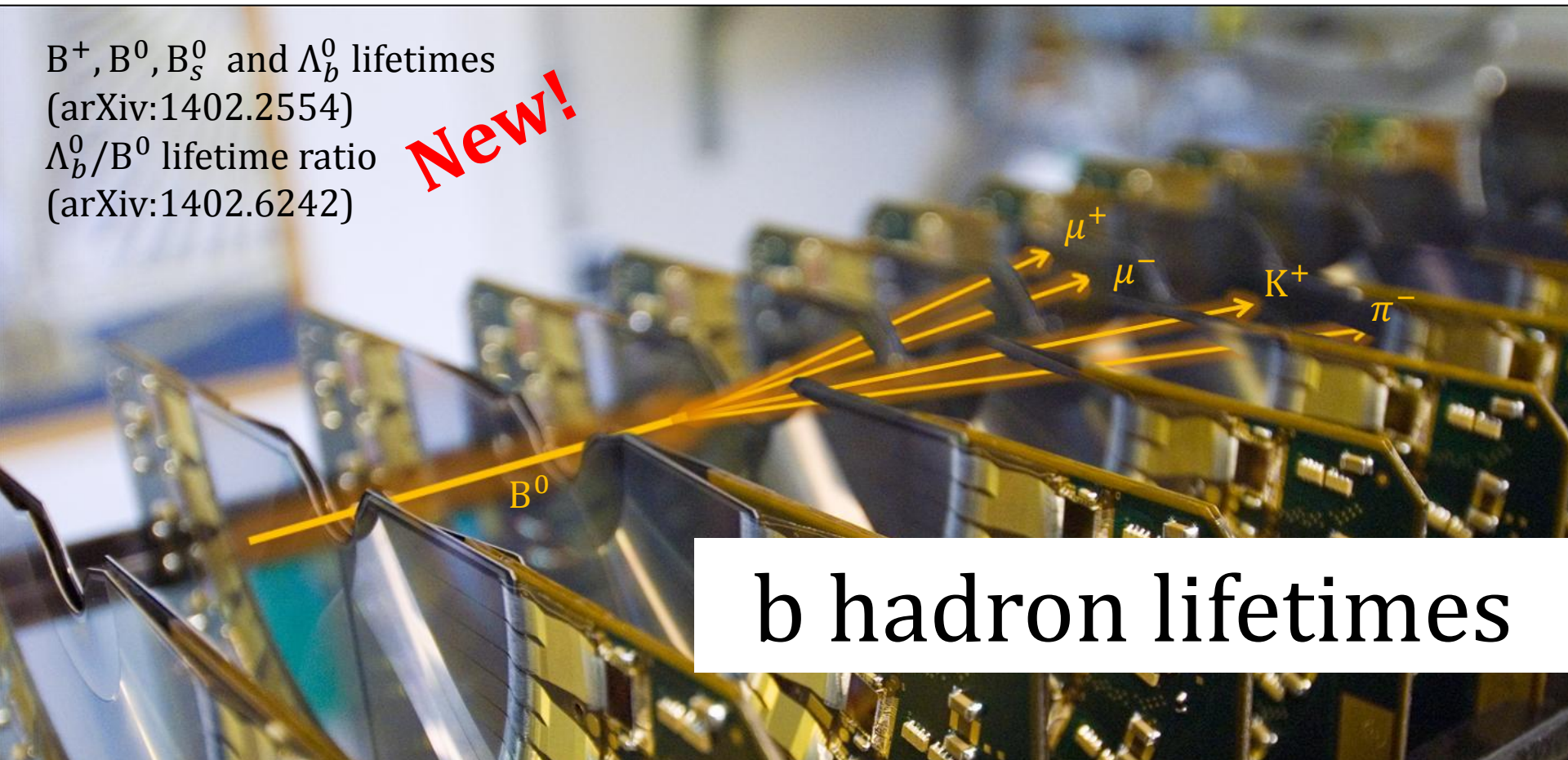
B^+ , B^0 , B_s^0 and Λ_b^0 lifetimes

(arXiv:1402.2554)

Λ_b^0/B^0 lifetime ratio

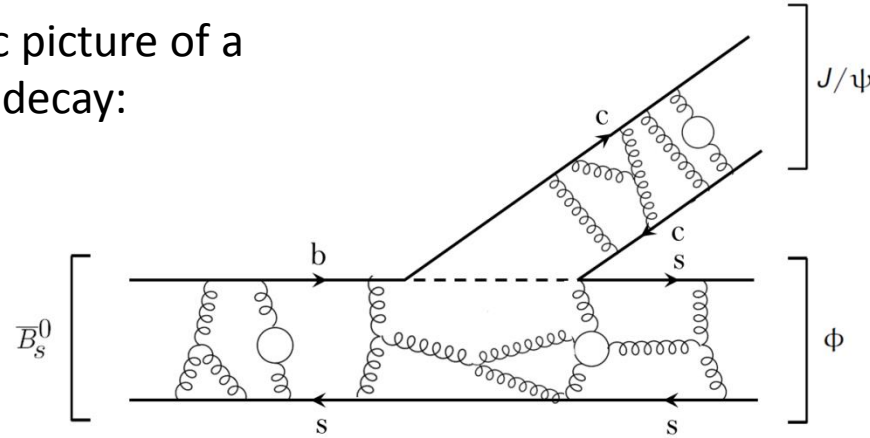
(arXiv:1402.6242)

New!



b hadron lifetimes

- More realistic picture of a non-leptonic decay:



- Heavy Quark Expansion:

$$\Gamma(H_b \rightarrow X_f) = \frac{G_F^2 m_b^5}{192\pi^3} \left\{ c_3^f \left(1 - \frac{\mu_\pi^2(H_b) - \mu_G^2(H_b)}{2m_b^2} \right) + 2c_5^f \frac{\mu_G^2(H_b)}{m_b^2} + \dots \right\}.$$

- What are nice observables?

$$\frac{\tau(B^-)}{\tau(B^0)} = 1 + O(1/m_b^3),$$

$$\frac{\tau(B_s)}{\tau(B_d)} = (1.00 \pm 0.01) + O(1/m_b^3),$$

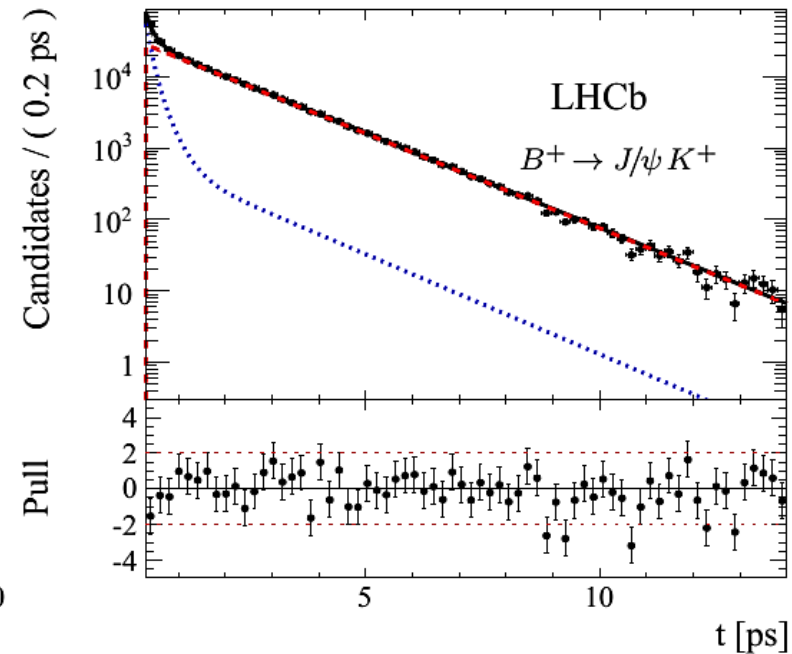
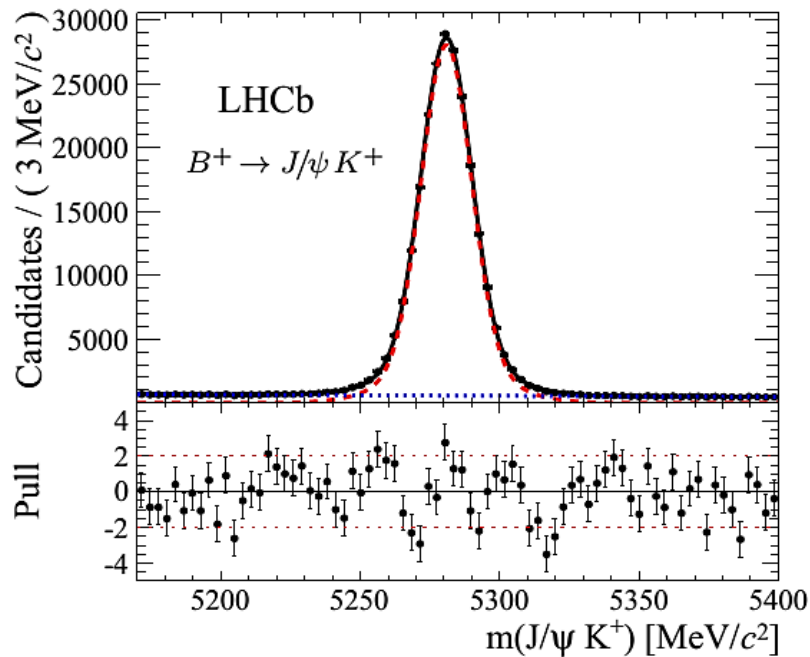
$$\frac{\tau(\Lambda_b)}{\tau(B^0)} = 1 + \frac{\mu_\pi^2(\Lambda_b) - \mu_\pi^2(B)}{2m_b^2} - c_G \frac{\mu_G^2(B)}{m_b^2} + O(1/m_b^3)$$

$$\approx 0.98 + O(1/m_b^3),$$



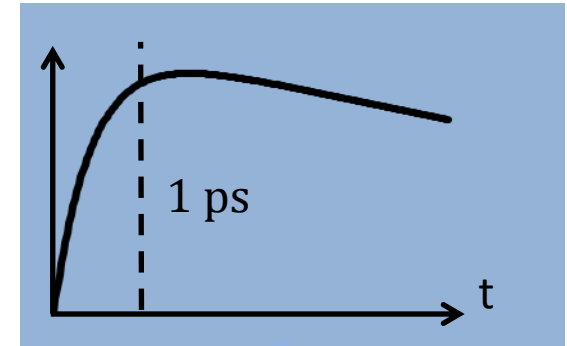
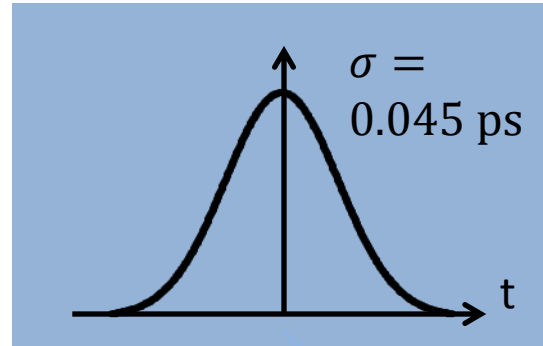
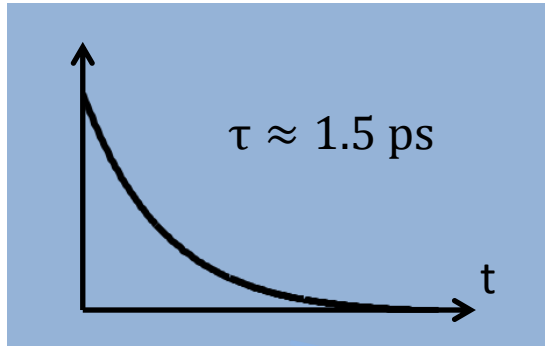
- Measured lifetime in 5 decay channels
- Performing a 2D Unbinned Maximum Likelihood Fit

decay channel	event yield
$B^+ \rightarrow J/\psi K^+$	229.000
$B^0 \rightarrow J/\psi K^*$	71.000
$B^0 \rightarrow J/\psi K_S$	17.000
$B_s^0 \rightarrow J/\psi \phi$	19.000
$\Lambda_b^0 \rightarrow J/\psi \Lambda$	4.000





- In principle easy to measure:

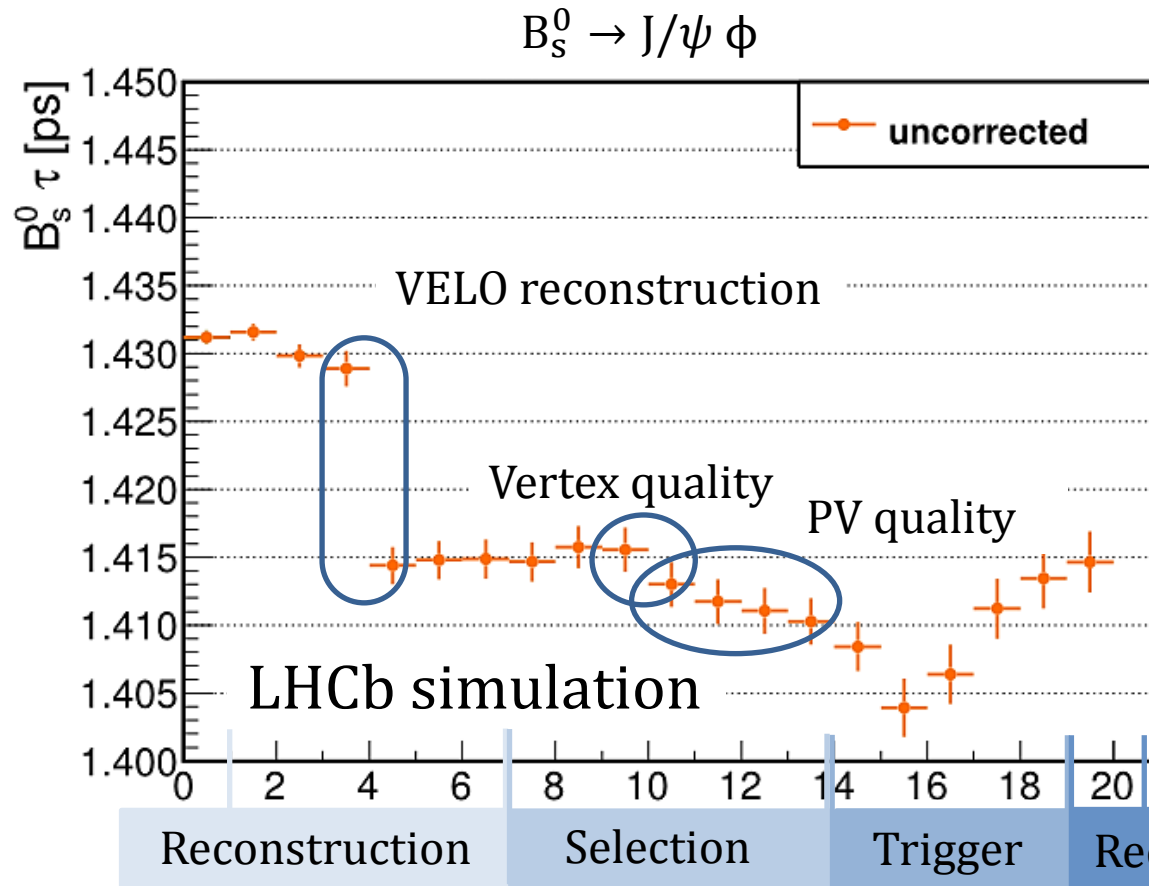


$$\text{measured distribution} = \exp(-t/\tau) \otimes \text{Res}(t, t') \cdot \text{Eff}(t')$$

with $\text{Res}(t, t')$: Time resolution
 $\text{Eff}(t)$: Efficiency

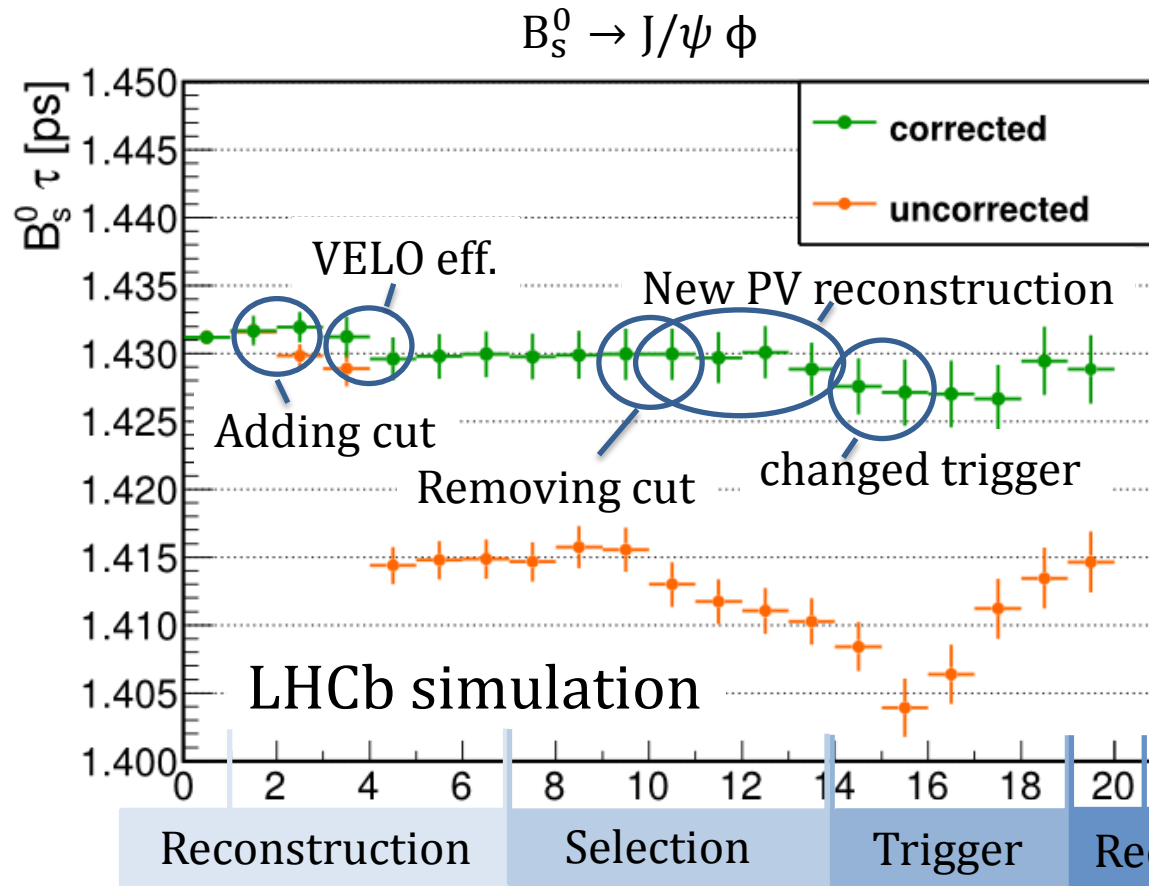
- However, challenging to do within the per mille level:
 - Time dependent acceptance must be understood as good as possible.
 - To reach a systematic uncertainty of a few fs, use data driven methods.

Measured lifetime after different Selection and Reconstruction steps



- Several effects bias the measured lifetime already in the simulation!
- Remove bias in simulation and use same methods on data.

Measured lifetime after different Selection and Reconstruction steps



- Completely data driven corrections:
 - Optimized selection
 - Efficiency: Tag and Probe technique ($B^+ \rightarrow J/\psi K^+$)
 - Dedicated full decay time unbiased trigger
- Remaining Bias statistically not significant

New!

B^+, B^0, B_s^0 and Λ_b^0 lifetimes, $\mathcal{L} = 1 \text{ fb}^{-1}$
(arXiv:1402.2554)

Lifetime	Value [ps]
τ_{B^+}	$1.637 \pm 0.004 \pm 0.003$
$\tau_{B^0 \rightarrow J/\psi K^{*0}}$	$1.524 \pm 0.006 \pm 0.004$
$\tau_{B^0 \rightarrow J/\psi K_S}$	$1.499 \pm 0.013 \pm 0.005$
$\tau_{B_s^0 \rightarrow J/\psi \phi}$	$1.480 \pm 0.011 \pm 0.005$
$\tau_{\Lambda_b^0}$	$1.415 \pm 0.027 \pm 0.006$

Ratio	Value
$\tau_{B^+} / \tau_{B^0 \rightarrow J/\psi K^{*0}}$	$1.074 \pm 0.005 \pm 0.003$
$\tau_{B_s^0 \rightarrow J/\psi \phi} / \tau_{B^0 \rightarrow J/\psi K^{*0}}$	$0.971 \pm 0.009 \pm 0.004$
$\tau_{\Lambda_b^0} / \tau_{B^0 \rightarrow J/\psi K^{*0}}$	$0.929 \pm 0.018 \pm 0.004$

τ_{B^+} / τ_{B^-}	$1.002 \pm 0.004 \pm 0.002$
$\tau_{\Lambda_b^0} / \tau_{\Lambda_b^0}$	$0.940 \pm 0.035 \pm 0.006$
$\tau_{B^0 \rightarrow J/\psi K^{*0}} / \tau_{\bar{B}^0 \rightarrow J/\psi \bar{K}^{*0}}$	$1.000 \pm 0.008 \pm 0.009$

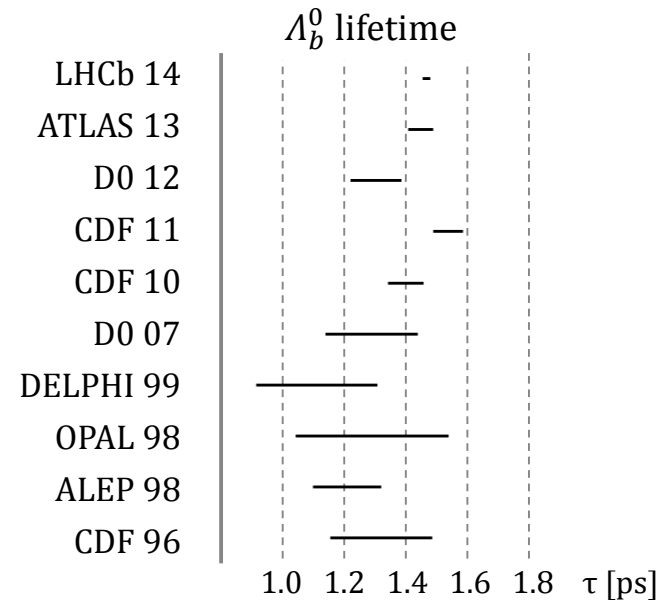
New!

Λ_b^0 / B^0 lifetime ratio, $\mathcal{L} = 3 \text{ fb}^{-1}$
(arXiv:1402.6242)

$$\frac{\tau_{\Lambda_b^0 \rightarrow J/\psi p K^-}}{\tau_{B^0 \rightarrow J/\psi \pi^+ K^-}} = 0.974 \pm 0.006 \pm 0.004$$

Combining both papers:

$$\tau_{\Lambda_b^0} = 1.468 \pm 0.009 \pm 0.008 \text{ ps}$$



Lifetimes world best (single) measurements consistent with world average and theory!

Backup

Uncertainty	Comment	Value				
		$B_s^0 \rightarrow J/\psi \phi$	$B^0 \rightarrow J/\psi K^*$	$B^+ \rightarrow J/\psi K^+$	$B_s^0 \rightarrow J/\psi K_S$	$\Lambda_b^0 \rightarrow J/\psi \Lambda$
VELO Reconstruction	Precision of efficiency measurement	2.3 fs	2.3 fs	2.0 fs	0.9 fs	0.5 fs
MC Statistic	Simulation sample size	2.4 fs	2.3 fs	1.7 fs	2.9 fs	3.7 fs
Trigger efficiency	Control sample size	2.5 fs	1.2 fs	1.1 fs	2.0 fs	2.0 fs
Mass-time correlation	Fit mass in different decay time bins	0.7 fs	1.8 fs	1.4 fs	2.1 fs	3.0 fs
Background modeling	Different fit models	0.4 fs	0.2 fs	0.1 fs	2.2 fs	2.1 fs
Mass modeling	Different fit models	0.5 fs	0.2 fs	0.1 fs	0.4 fs	0.2 fs
Peaking background	Misreconstructed decays	0.4 fs	-	-	0.3 fs	1.1 fs
Effective lifetime bias	Angular acceptance	1.6 fs	-	-	-	-
Prod. asymmetry	Proton collider	-	-	-	1.1 fs	-
LHCb length scale	VELO alignment	0.3 fs	0.3 fs	0.4 fs	0.3 fs	0.3 fs
Total systematic		4.6 fs	3.9 fs	3.2 fs	4.9 fs	5.7 fs
Statistical		11.4 fs	6.1 fs	3.5 fs	12.8 fs	26.5 fs