"Masurements of $\Delta m_{d,s}$ and $\Delta\Gamma_d$ at LHCb"

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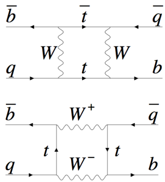
Outline

- Physics introduction on $B^0_{d/s} - \bar{B}^0_{d/s}$ mixing: why measuring Δm_d , Δm_s and $\Delta\Gamma_d$
- How to measure $\Delta m_{d/s}$
  - LHCb most precise measurement of Δm_d
  - LHCb most precise measurement of Δm_s
- How to measure $\Delta\Gamma_d$
  - LHCb measurement of $\Delta\Gamma_d$ ($\Delta\Gamma_s$ covered by G.Cowan's Talk)
- Implications of the measurements to the Standard Model and to possible New Physics scenarios
- Conclusions

In the Standard Model $B^0_{d/s} - \bar{B}^0_{d/s}$ mix through the box diagrams

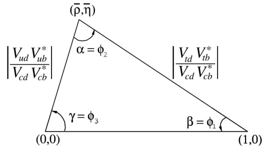


The two mass eigenstates B_H and B_L have:

- $\Delta m_q \propto m_W^2 m_{B_q} \hat{\mathcal{B}}_{B_q} f_{B_q}^2 (V_{tq}^* V_{tb})^2 \qquad q = d, s$
- $\Delta\Gamma_q \propto$
  $m_b^2 m_{B_q} \hat{\mathcal{B}}_{B_q} f_{B_q}^2 \left((V_{tq}^* V_{tb})^2 + V_{tq}^* V_{tb} V_{cq}^* V_{cb} \mathcal{O}(m_c^2/m_b^2) + (V_{cq}^* V_{cb})^2 \mathcal{O}(m_c^4/m_b^4)\right)$

Current WA: [HFAG Summer 2016]

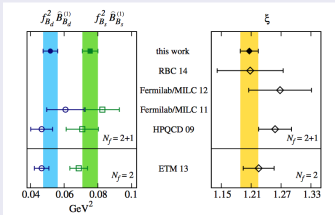
- $\Delta m_d = 0.5065 \pm 0.0016 \pm 0.0011 \ ps^{-1}$
- $\Delta m_s = 17.757 \pm 0.020 \pm 0.007 \ ps^{-1}$
- $\Delta\Gamma_d/\Gamma_d = (-0.2 \pm 1.0) \times 10^{-2}$



constrain the apex $(\bar{\rho}, \bar{\eta})$ of the CKM unitarity triangle

- $\hat{\mathcal{B}}_{B_q} f_{B_q}^2$ uncertainties limit the precision of V_{CKM}

[FNAL&MILC: arXiv:1602.03560]



Some of the theoretical uncertainties cancel in the ratio:

- $\frac{\Delta m_s}{\Delta m_d} = \frac{m_{B_s}}{m_{B_d}} \times \xi^2 \times \frac{|V_{ts}|^2}{|V_{td}|^2}$
- $\xi = 1.268 \pm 0.063$ Lattice QCD, PDG2016$\rightarrow$[FNAL&MILC: arXiv:1205.7013]
  $= 1.206 \pm 0.019$ new calculation [FNAL&MILC: arXiv:1602.03560]

$B^0_{d/s} - \bar{B}^0_{d/s}$ oscillations: measurement of $\Delta m_{d/s}$

Best precision is achieved by measuring the time-dependent mixing asymmetry in *flavour-specific* decays:

- $\mathcal{A}^{th}_{mix}(t) = \frac{\Gamma_{\bar{B}^0_q \to \bar{f}}(t) - \Gamma_{B^0_q \to f}(t)}{\Gamma_{\bar{B}^0_q \to \bar{f}}(t) + \Gamma_{B^0_q \to f}(t)} \sim cos(\Delta m_q\, t) \implies \mathcal{A}^{exp}_{mix}(t) \propto (1-2\omega)\, e^{-(\Delta m_q\, \sigma_t)^2/2}\, cos(\Delta m_q\, t)$
  assuming no CPV in mixing and $\Delta\Gamma_q = 0$

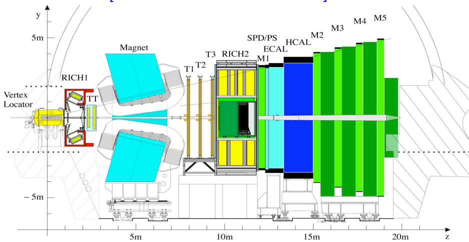
The average statistical significance is:

- $\mathcal{S} \sim \sqrt{N/2}\, f_{sig} \sqrt{\epsilon_{tag}(1-2\omega)^2}\, e^{-(\Delta m_q\, \sigma_t)^2/2}$

Experimental key-factors fully addressed by LHCb:

- Signal yield and background suppression: $\sqrt{N/2}\, f_{sig}$
  - large $\sigma_{\bar{b}b}$
  - $\mathcal{L}^{\rm int} = 3$ fb^{-1} in Run1 (2 fb^{-1} in Run2, so far)
  - efficient trigger and reconstruction
  - tracking: impact parameter, momentum, mass resolutions
  - particle identification: $(\mu/\pi/K/p)$
- Flavour tagging: $\sqrt{\epsilon_{tag}(1-2\omega)^2} = 3-6\%$
  - Opposite-side (OS e,μ, K, Vertex, Charm)
  - Same-side (SS: π, p and K)
- Decay time resolution: $e^{-(\Delta m_q\, \sigma_t)^2/2}$
  - excellent vertexing $\sigma_t \sim 45-55$ fs

[LHCb: 2008 JINST 3 S08005]



$B_d^0 - \bar{B}_d^0$ oscillations: Measurement of Δm_d at LHCb

Δm_d was first measured at DESY by ARGUS [Phys.Lett. B192 (1987) 245-252] then at Cornell, LEP then at B-Factories.

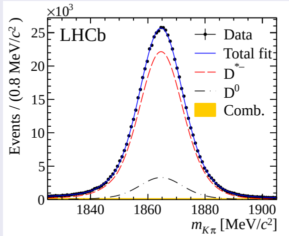
Previous LHCb measurements used data samples of increasing size of different *"flavour specific"* hadronic and semileptonic B_d decays [LHCb: Phys. Lett. B709 (2012) 177, Phys. Lett. B719 (2013) 318, Eur. Phys. J. C73 (2013) 2655]

Latest LHCb measurement exploits the full Run1 data sample (3 fb^{-1})
$\rightarrow$ most precise determination of Δm_d [LHCb: Eur. Phys. J. C76 (2016) 412]

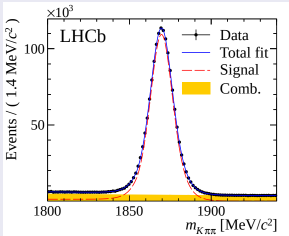
- Uses **semileptonic $\mathbf{B_d^0 \rightarrow D^{(*)-}\mu^+\nu_\mu X}$ decays**
  - large branching ratios ($\mathcal{B} \sim 2$–5%)
- Event reconstruction & selection:
  - reconstruct $\mathbf{D^{*-} \rightarrow \bar{D}^0(\rightarrow K^+\pi^-)\pi^-}$ and $\mathbf{D^- \rightarrow K^+\pi^-\pi^-}$ decays
  - $D^{(*)-}\mu^+$ from a common vertex (displaced from PV)
  - missing neutrino: cannot apply mass or kinematic cuts to the B_d , only to D^0, D^{*-} or D^-
  - vetoes on mis-ID J/ψ, Λ_c
- **Background:**
  - Combinatorial
  - D^0 from B decays
  - $B^+ \rightarrow D^{(*)-}\mu^+\pi^+\nu_\mu$

[LHCb: Eur. Phys. J. C76 (2016) 412]

$B_d^0 \rightarrow D^{*-}\mu^+\nu_\mu X$ 0.8 M events



$B_d^0 \rightarrow D^-\mu^+\nu_\mu X$ 1.6 M events



$B_d^0 - \bar{B}_d^0$ oscillations: Measurement of Δm_d at LHCb

$\mathbf{B^+ \to D^{(*)-} \mu^+ \pi^+ \nu_\mu}$ background:

- it is expected to be 10% and 13%, BUT its $\mathcal{B}$ is known with a precision of 10% [PDG2016]
- its fraction is correlated with the fit value of Δm_d

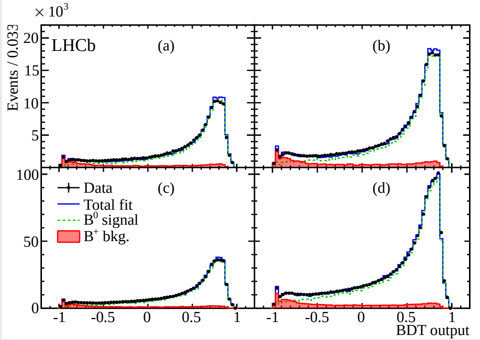
$\rightarrow$ need to suppress it to reduce the systematic uncertainty

MVA classifier was developed to discriminate such background from the signal:

- inputs:
  - geometrical and kinematical info on the B candidate $(D^{(*)-}\mu^+)$
  - isolation info on additional tracks reconstructed in a cone around the B candidate direction
- training:
  - on MC samples of signal $B^0 \to D^{*-}\mu^+\nu_\mu$ and $B^+ \to D^{*-}\mu^+\pi^+\nu_\mu$
- **output** (BDT):
  - used both as selection cut (suppression of 70%) and to evaluate on data the remaining fraction ($\rightarrow$3% and 6%)

[LHCb: Eur. Phys. J. C76 (2016) 412]

$B_d^0 \to D^-\mu^+\nu_\mu X$ in 4 tagging categories



$B_d^0 - \bar{B}_d^0$ oscillations: Measurement of Δm_d at LHCb

Event reconstruction suffers from the missing neutrino:

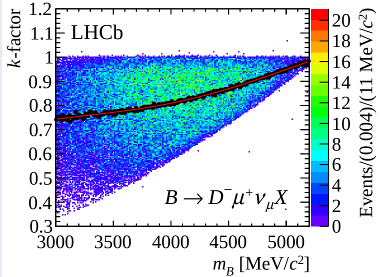
- B_d **momenta** & **decay time** are corrected by a k-factor determined on MC:

$$t = \frac{M_{B^0} \cdot L}{p_{D^{(*)}\mu} \cdot c / k(m_B)} \quad \text{with} \quad k(m_B) = \langle p_{\mathrm{D}^{(*)}\mu} / p_{B^0}^{\mathrm{true}} \rangle$$

→ limited time resolution

[LHCb: Eur. Phys. J. C76 (2016) 412]

$B_d^0 \to D^- \mu^+ \nu_\mu X$



Flavour Tagging:

- determine q_{mix} from the tagging decision&the charge of the μ ($q_{\mathrm{mix}} = \pm 1$)
- Split in four categories of increasing mistag ω to gain sensitivity
- Tagging power: $\varepsilon \mathcal{D}^2 \sim$ 2.3-2.6%

Fit stratergy:

- fit the m_{D^-} / m_{D^0} & $\delta m = m_{D^{*-}}$ - m_{D^0} distributions: disentangle **$\mathcal{S}$ignal**+$\mathcal{B}^+$ (*sWeights*) from other backgrounds (combinatorial + D^0 from B)
- perform an *sFit* to the weighted distribution of the decay time:

$$\mathcal{P}(t, q_{\rm mix}) = (1 - f_{B+})\mathcal{S}(t, q_{\rm mix}) + f_{B+}\mathcal{B}^+(t, q_{\rm mix})$$

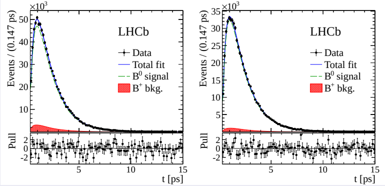
$$\mathcal{S}(t, q_{\rm mix}) \propto a(t)\left[e^{-t/\tau}(1 + q_{\rm mix}(1 - 2\omega)\cos(\Delta m_d\, t)\otimes R(L)\otimes F(k)\right.$$

- time acceptance $a(t)$, f_{B+} and ω extracted from fit to data
- convolution with resolution functions from MC $R(L)$,$F(k)$

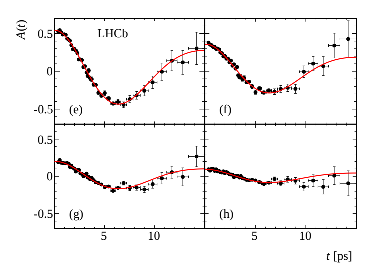
Assuptions: $\Delta\Gamma_d = 0$, $|q/p| = 1$

[LHCb: Eur. Phys. J. C76 (2016) 412]

$B_d^0 \to D^- \mu^+ \nu_\mu X$ $B_d^0 \to D^{*-} \mu^+ \nu_\mu X$



$B_d^0 \to D^{*-} \mu^+ \nu_\mu X$ in 4 tagging categories



similar plots for $B_d^0 \to D^- \mu^+ \nu_\mu X$

$B_d^0 - \bar{B}_d^0$ oscillations: Measurement of Δm_d at LHCb

Results: [LHCb: Eur. Phys. J. C76 (2016) 412]

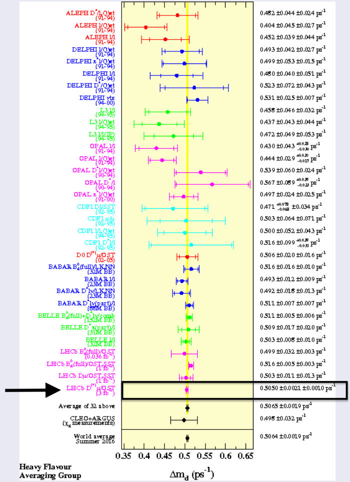
Mode	2011 sample Δm_d [ns^{-1}]	2012 sample Δm_d [ns^{-1}]	Total sample Δm_d [ns^{-1}]
$B_d^0 \to D^- \mu^+ \nu_\mu X$	506.2 ± 5.1	505.2 ± 3.1	$505.5 \pm 2.7 \pm 1.1$
$B_d^0 \to D^{*-} \mu^+ \nu_\mu X$	497.5 ± 6.1	508.3 ± 4.0	$504.4 \pm 3.4 \pm 1.0$
combination			**$505.0 \pm 2.1 \pm 1.0$**

Systematic uncertainties:

Source of uncertainty	$D^- \mu^+ \nu_\mu$ [ns^{-1}] Uncorrelated	Correlated	$D^{*-} \mu^+ \nu_\mu$ [ns^{-1}] Uncorrelated	Correlated
B^+ background	0.4	0.1	0.4	–
Other backgrounds	–	0.5	–	–
k-factor distribution	0.4	0.5	0.3	0.6
Other fit-related	0.5	0.4	0.3	0.5
Total	0.8	0.8	0.6	0.8

Most precise measurement, dominates the average.

[HFAG Summer 2016]



WA : $\Delta m_d = 506.4 \pm 1.9$ ns^{-1}

$B_s^0 - \bar{B}_s^0$ oscillations: Measurement of Δm_s at LHCb

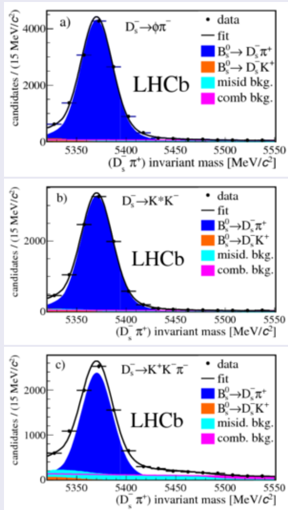
Δm_s was first measured by CDF in 2006: $\Delta m_s = 17.77 \pm 0.10 \pm 0.07$ ps^{-1} [CDF: Phys.Rev.Lett. 97 (2006) 242003]

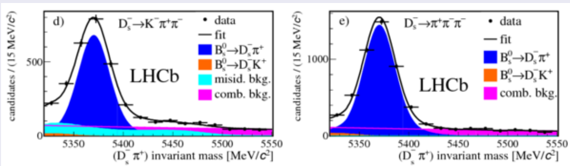
Previous LHCb measurements used partial Run1 data samples of *"flavour specific"* $B_s^0 \to D_s^-(3)\pi^+$ decays [LHCb: Phys. Lett. B709 (2012) 177], and semileptonic B_s^0 decays [LHCb: Eur. Phys. J. C73 (2013) 2655]

The most precise LHCb measurement exploits 1 fb^{-1} of Run1 data sample [LHCb: New J. Phys. 15 (2013) 053021]

- Uses $\mathbf{B_s^0 \to D_s^- \pi^+}$ decays $\sim$ **34000 signal events**
  - hadronic *flavour specific* decay with the largest $\mathcal{B}$ ($\sim$0.3%)
- **Event selection**: reconstruct $\mathbf{D_s^-}$ in **5 fully reconstructed decay modes**: $\phi\pi$, K^*K, $(KK\pi)_{\mathrm{nonres}}$, $K\pi\pi$ and 3π
  - MVA selection for an optimal discrimination of signal from background

[LHCb: New J. Phys. 15 (2013) 053021]



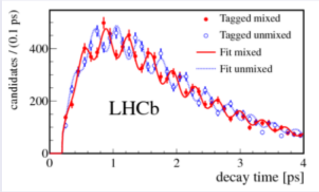


$B_s^0 - \bar{B}_s^0$ oscillations: Measurement of Δm_s at LHCb

Fit strategy:

- perform a simultaneous fit of the 5 data samples of all contributions
  $\mathcal{P}(m, t, \sigma_t, q, \eta) = \mathcal{P}_m(m)\mathcal{P}_{t,q}(t, q|\sigma_t, \eta)\mathcal{P}_{\sigma_t}(\sigma_t)\mathcal{P}_\eta(\eta)$
  $\mathcal{P} = f_{\rm sig}\mathcal{S} + \sum_i f^i_{\rm bkg}\mathcal{B}_i$
- $\mathcal{P}_m(m)$ mainly discriminate signal from background contributions
- $\mathcal{P}_{t,q}(t, q|\sigma_t, \eta)$:
  - Use per-event decay time resolution model $\langle\sigma_t\rangle \sim 44$ fs ($\mathcal{P}_{\sigma_t}(\sigma_t)$), calibrated on data using prompt $D_s\&\pi$
  - Use per-event OS and SSK combined tagging decision and mistag: $\varepsilon\mathcal{D}^2 = 3.5\pm0.5\%$ ($\mathcal{P}_\eta(\eta)$)

[LHCb: New J. Phys. 15 (2013) 053021]



Result: $\Delta m_s = 17.768 \pm 0.023 \pm 0.006$ ps^{-1}

Most precise measurement to date.

Systematic uncertainties

Source	Uncertainty [ps^{-1}]
z-scale	0.004
Momentum scale	0.004
Decay time bias	0.001
Total	0.006

More recently LHCb determined Δm_s also in the analysis of $B_s^0 \to J/\psi K^+K^-$ for ϕ_s and $\Delta\Gamma_s$ measurements: $\Delta m_s = 17.711^{+0.055}_{-0.057} \pm 0.011$ ps^{-1} [LHCb: Phys. Rev. Lett. 114 (2015) 041801]
(see also G.Cowan's Talk)

$B_q^0 - \bar{B}_q^0$ oscillations: Measurement of $\Delta\Gamma_q$

The decay rates of B_L and B_H to a given final state f can be different, therefore:

$$\Gamma(B_q^0(t) \to f) \propto e^{-\Gamma_q t}\left[\cosh(\Delta\Gamma_q t/2) + A^f_{\Delta\Gamma}\sinh(\Delta\Gamma_q t/2) + A^{dir,f}_{CP}\cos(\Delta m_q t) + A^{mix}_{CP}\sin(\Delta m_q t)\right]$$

$$\Gamma(\bar{B}_q^0(t) \to f) \propto e^{-\Gamma_q t}\left[\cosh(\Delta\Gamma_q t/2) + A^f_{\Delta\Gamma}\sinh(\Delta\Gamma_q t/2) - A^{dir,f}_{CP}\cos(\Delta m_q t) - A^{mix}_{CP}\sin(\Delta m_q t)\right]$$

assuming $|q/p| = 1$

The untagged rate: $\Gamma(B_q^0(t) \to f) \propto e^{-\Gamma_q t}\left[\cosh(\Delta\Gamma_q t/2) + A^f_{\Delta\Gamma}\sinh(\Delta\Gamma_q t/2)\right]$

assuming production asymmetry $A_P = 0$

The effective lifetime $\tau^{\mathrm{eff}}_{B_q^0 \to f}$ depends on $y_q = 2\Delta\Gamma_q \cdot \Gamma_q$:

$$\tau^{\mathrm{eff}}_{B_q^0 \to f} = \frac{1}{\Gamma_q}\frac{1}{1-y_q^2}\left[\frac{1 + 2A^f_{\Delta\Gamma}y_q + y_q^2}{1 + A^f_{\Delta\Gamma}y_q}\right]$$

$\Delta\Gamma_q$ can be measured by comparing $\tau^{\mathrm{eff}}_{B_q^0 \to f}$ in different decay channels (different $A^f_{\Delta\Gamma}$)

For example: [T.Gershon, J. Phys. G 38:015007, 2011]

- $A^f_{\Delta\Gamma} = 0$ for *flavour specific* decays
- $A^f_{\Delta\Gamma} = \cos 2\beta$ for $B_d \to J/\psi K^0_S$

$B_d^0 - \bar{B}_d^0$ oscillations: Measurement of $\Delta\Gamma_d$ at LHCb

Strategy: measure effective lifetime $\tau^{\text{eff}}_{B_d^0}$ using

- $\mathbf{B_d^0 \to J/\psi K^{*0}}$ (flavour specific)
- $\mathbf{B_d^0 \to J/\psi K_s^0}$ (CP eigenstate)

Selection:

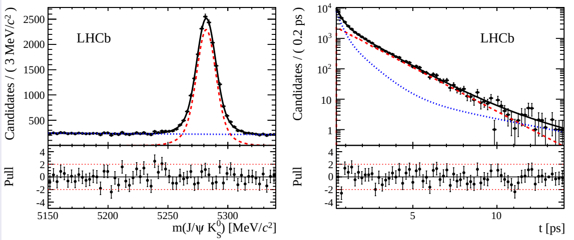
- Run1 data sample (1 fb^{-1})
- **minimize any decay time biasing selection cuts**

Fit strategy:

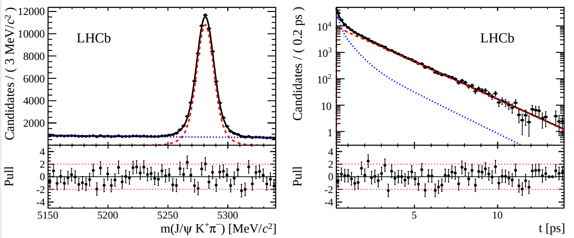
- **fit** the distributions of **time** and invariant **mass**:
  $\mathcal{P}(m,t) = f_{\text{sig}}\mathcal{S}(m,t) + \sum_i f^i_{\text{bkg}}\mathcal{B}_i(m,t)$
- time resolution $\sigma_t \sim 45$, 65 fs

[LHCb: JHEP 04 (2014) 114]

$B_d^0 \to J/\psi K_s^0$ 17k events



$B_d^0 \to J/\psi K^{*0}$ 70.5k events



$B_d^0 - \bar{B}_d^0$ oscillations: Measurement of $\Delta\Gamma_d$ at LHCb

Effective lifetime results:

$\tau^{\text{eff}}_{B_d^0 \to J/\psi K^{*0}} = 1.524 \pm 0.006 \pm 0.004$ ps

$\tau^{\text{eff}}_{B_d^0 \to J/\psi K_s^0} = 1.499 \pm 0.013 \pm 0.005$ ps

[LHCb: JHEP 04 (2014) 114]

Systematic uncertainties	$\tau^{\text{eff}}_{B_d^0 \to J/\psi K^{*0}}$ [fs]	$\tau^{\text{eff}}_{B_d^0 \to J/\psi K_s^0}$ [fs]	$\Delta\Gamma_d/\Gamma_d$ $\times 10^{-3}$
VELO reconstruction	**2.3**	0.9	4.1
Simulation sample size	**2.3**	**2.9**	**6.3**
Mass-time correlation	1.8	2.1	**4.7**
Trigger and selection eff.	1.2	2.0	4.0
Background modelling	0.2	2.2	3.8
Mass modelling	0.2	0.4	0.8
Peaking background	–	0.3	0.5
Effective lifetime bias	–	–	–
B_d production asym.	–	1.1	1.9
LHCb length scale	0.3	0.3	–
Total	3.9	4.9	10.7

$$\tau^{\text{eff}}_{B_q^0 \to f} = \frac{1}{\Gamma_q} \frac{1}{1 - y_q^2} \left[\frac{1 + 2A^f_{\Delta\Gamma} y_q + y_q^2}{1 + A^f_{\Delta\Gamma} y_q} \right]$$

- $A^f_{\Delta\Gamma} = 0$ for *flavour specific* decays
- $A^f_{\Delta\Gamma} = \cos 2\beta$ for $B_d \to J/\psi K_S^0$

we measure:

$\Gamma_d = 0.656 \pm 0.003 \pm 0.002 \text{ ps}^{-1}$

$\Delta\Gamma_d = -0.029 \pm 0.016 \pm 0.007 \text{ ps}^{-1}$

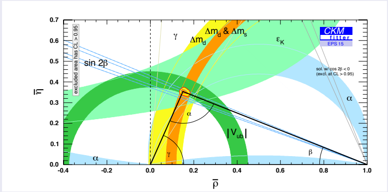
$$\Delta\Gamma_d/\Gamma_d = (-4.4 \pm 2.5 \pm 1.1) \times 10^{-2}$$

From the measurements to the SM-CKM picture

Measurement	Value	reference
Δm_d [ps^{-1}]	$0.5050 \pm 0.0021 \pm 0.0010$	[LHCb: Eur. Phys. J. C76 (2016) 412]
	0.5064 ± 0.0019	[HFAG Summer 2016]
Δm_s [ps^{-1}]	$17.768 \pm 0.023 \pm 0.000$	[LHCb: New J. Phys. 15 (2013) 053021]
	17.757 ± 0.021	[HFAG Summer 2016]
$\Delta\Gamma_d/\Gamma_d$	$(-4.4 \pm 2.5 \pm 1.1) \times 10^{-2}$	[LHCb: JHEP 04 (2014) 114]
	$(-0.1 \pm 1.1 \pm 0.9) \times 10^{-2}$	[ATLAS:JHEP06 (2016) 081]
	$(-0.2 \pm 1.0) \times 10^{-2}$	[HFAG Summer 2016]

Within SM, such measurements constrain
$\frac{|V_{ts}|^2}{|V_{td}|^2} = 0.2159 \pm 0.0004(\mathrm{exp}) \pm 0.0107(\mathrm{lattice})$ [PDG2016]

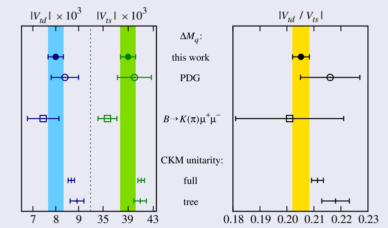
[CKMfitter Summer2015]



With the latest, improved LatticeQCD calculations
$\frac{|V_{ts}|^2}{|V_{td}|^2} = 0.2052 \pm 0.0032$ [FNAL&MILC: arXiv:1602.03560]:

a tension ($\mathcal{O}(2\sigma)$) arises when comparing $|V_{ts}|, |V_{td}|$ results from mixing measurement with results from tree-processes

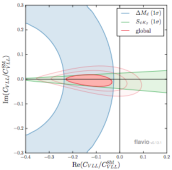
[see previous talk by E. Gamiz]



From the measurements to possible hints of NP ?

[D.Straub, Talk @ LHCb Implication Workshop 2016]

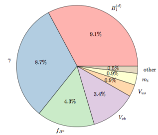
Status: new physics in B^0 mixing



- Using CKM from tree and matrix element from FNAL/MILC
- best fit **1.5σ** from SM
- Currently probing SM at 10% level in CP conserving, few-% level in CP violating observable

ΔM_d error budget

$$\Delta M_s \propto f_{B_d}^2 \hat{B}_{B_d} |V_{tb} V_{td}^*|^2 \approx f_{B_d}^2 \hat{B}_{B_d} \left(V_{ub}^2 + V_{cb}^2 V_{us}^2 - 2 V_{ub} V_{cb} V_{us} \cos\gamma \right)$$

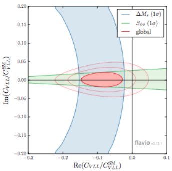


Relative uncertainty:

- Theory: **15%**
- Experiment: **0.4%**

(Using FNAL/MILC bag parameters and neglecting the correlation between f_{B^0} and $B_1^{(d)}$)

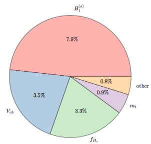
Status: new physics in B_s mixing



- Using CKM from tree and matrix element from FNAL/MILC
- best fit again **1.5σ** from SM

ΔM_s error budget

$$\Delta M_s \propto f_{B_s}^2 \hat{B}_{B_s} |V_{tb} V_{ts}^*|^2 = f_{B_s}^2 \hat{B}_{B_s} \left[V_{cb}^2 (1 + O(\lambda^2)) \right]$$



Relative uncertainty:

- Theory: **9%**
- Experiment: **0.1%**

Clearly, need lattice & CKM from tree to make progress!

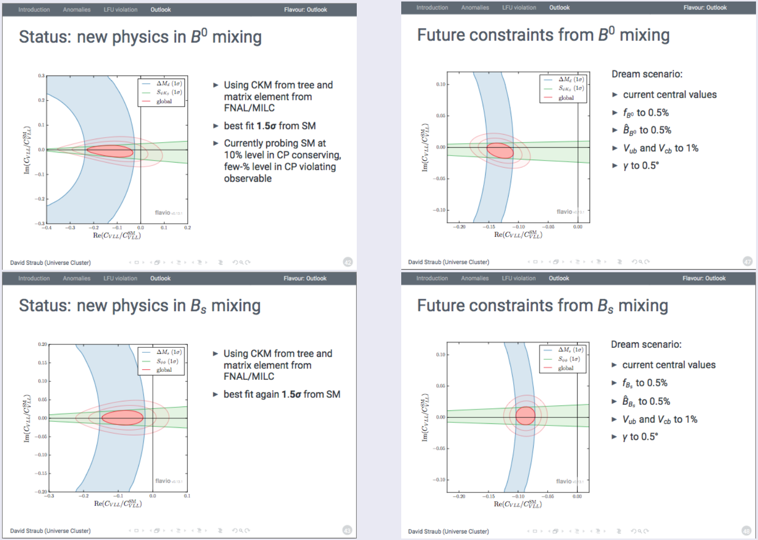
(Using FNAL/MILC bag parameters and neglecting the correlation between f_{B_s} and $B_1^{(s)}$)

plots can be reproduced from this link to the open source code flavio

Current measurements are compatible with SM in 1.5σ

From the measurements to possible hints of NP ?

[D.Straub, Talk @ LHCb Implication Workshop 2016]



plots can be reproduced from this link to the open source code flavio

Future improvements can reveal NP

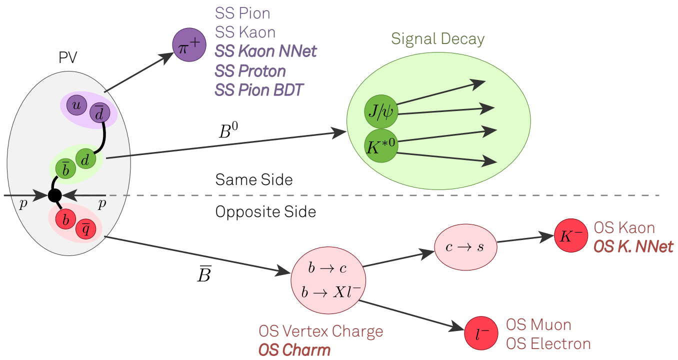
Conclusions

- LHCb measurements of Δm_d and Δm_s have reached a precision of ‰, and dominate the current World Averages.
- Together with the measurement of $\Delta\Gamma_d$ and $\Delta\Gamma_s$, they provide useful constraints to the CKM parameters $|V_{ts}|$ and $|V_{td}|$ and important tests of the SM.
- The precision of $|V_{ts}|$ and $|V_{td}|$ is currently limited by theoretical uncertainties.
- Latest Lattice QCD calculations allowed a factor $\sim$3 of improvement in $|V_{ts}|^2/|V_{td}|^2$ with respect to previous calculations that renewed the interest on $B_q^0 - \bar{B}_q^0$ mixing parameters.

Looking forward for further improvements on theoretical computations and on experimental measurements (for prospects at LHCb see talk by V. Chobanova)

BACKUP

Flavour Tagging: identifying the initial B flavour



OS tagging: exploits the properties of the decays of the b-hadron opposite to the signal B [LHCb: Eur. Phys. J. C72 (2012) 2022]

- μ, e ($b \to cl^- \bar{\nu}_l$), K ($b \to c \to s$), Q_{vtx} (inclusive secondary vertex reconstruction)

SS tagging: exploits the hadronization process of the signal B, or in the decays of excited states B^{**}

- SSπ, SSp [LHCb: LHCb-PAPER-2016-039, arXiv:1610.06019] (tag the B_d) (see also M.Calvi's Talk) ,
- SSK [LHCb: JINST 11 (2016) P05010] (tag the B_s)

tagging power: $\varepsilon(1-2\omega)^2 \sim 3-6\%$ depending on the B decay channel