“ϕ_s ’ world”

S.Vecchi- INFN Ferrara, Italy

on behalf of the LHCb collaboration

9th Franco-Italian meeting on B physics,
LAPP Annecy Annecy,
February, 18^{th}-19^{th} 2013

Outline

- Physics motivations
- ϕ_s measurement:
  - analysis of $B_s^0 \to J/\psi\pi^+\pi^-$
  - analysis of $B_s^0 \to J/\psi\phi$
- Solving the ambiguities on ϕ_s and $\Delta\Gamma_s$
- $B_s^0 \to \phi\phi$: initial steps toward ϕ_s
- Further constraints on ϕ_s and $\Delta\Gamma_s$: measurement of the effective lifetime
- Summary

I will present the latest public results by LHCb (2011 data sample, *pp* collisions at $\sqrt{s} = 7\text{TeV}$, $1\mathrm{fb}^{-1}$)

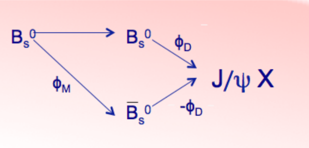
LHCb references are in yellow box

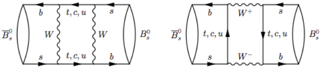
Physics motivations

ϕ_s arises from the interference of direct decay and decay via $B_s^0 - \bar{B}_s^0$ oscillations: $\phi_s = \phi_M - 2\phi_D$

$B_s^0 \to J/\psi X$ is a $b \to c\bar{c}s$ transition

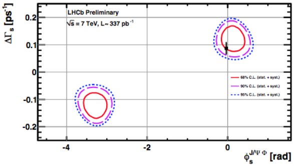
- In SM, assuming tree decays dominate and so neglecting sub-leading penguin contributions ($\phi_D \sim 0$), $\phi_s = -2\beta_s = arg(-V_{ts}V_{tb}^*/V_{cs}V_{cb}^*)$
- SM expectation: $\phi_s = -0.0364 \pm 0.0016$ rad http://cmkfitter.in2p3.fr
- if new particles contribute to the $B_s^0 - \bar{B}_s^0$ box-diagram ϕ_s can be enhanced: $\phi_s = \phi_s^{SM} + \phi_s^{NP}$ $\to$ precise measurement of ϕ_s can reveal presence of NP





Experimental status:

- DØ 8fb^{-1}, $\phi_s = -0.55^{+0.38}_{-0.36}$rad
- CDF 9.6fb^{-1}, $\phi_s : [-\pi, -2.52]\text{U}[0.60, 0.12]\text{U}[3.02, \pi]$ rad @68% CL
- Atlas $\phi_s = 0.22 \pm 0.41 \pm 0.10$ rad
- LHCb: $\phi_s = 0.15 \pm 0.18 \pm 0.06$ rad ($B_s^0 \to J/\psi\phi$, 0.377fb^{-1})



Analysis of $B_s^0 \to J/\psi\pi^+\pi^-$ decay

$B_s^0 \to J/\psi\pi^+\pi^-$ is a promising channel to measure ϕ_s : $\mathcal{B}$ is 19.79±0.47±0.52% of $B_s^0 \to J/\psi\phi$

- dominant $f_0(980) \to \pi^+\pi^-$ contribution: $\mathcal{R}_{f_0\to\pi^+\pi^-/\phi\to K^+K^-} = 0.252^{+0.053}_{-0.046}$ Phys. Lett. B 698 (2011) 115-122
- Dalitz analysis show that $\pi^+\pi^-$ is dominated by S-wave: >97.7% @95% C.L

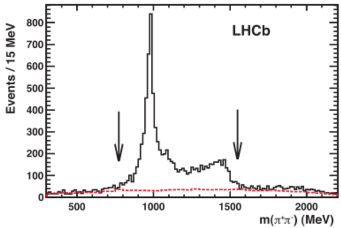
  Phys. Rev. D 86, 052006 (2012)
  - $PS \to VS$: $CP-$odd pure eigenstate

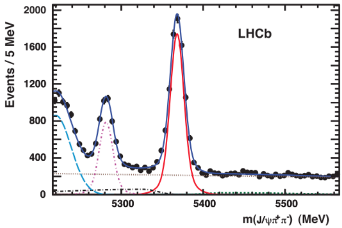
→ "only" a tagged time-dependent analysis is required to measure ϕ_s

$B_s^0 \to J/\psi\pi^+\pi^-$ selection:

- based on a Boosted Decision Tree
- S∼7400 events 1fb^{-1} (2011)

Phys. Lett. B 713 (2012) 378386





Amplitudes for $B_s^0 \to J/\psi\pi^+\pi^-$

$B_s^0 \to J/\psi\pi^+\pi^-$ is a pure CP-odd final state ($\pi\pi$ in s-wave) $\to$ simple differential decay rates:

$$\Gamma(B_s^0 \to J/\psi(\pi\pi)_s) \propto e^{-\Gamma_s t}\{e^{\Delta\Gamma_s t/2}(1+\cos\phi_s) + e^{-\Delta\Gamma_s t/2}(1-\cos\phi_s) - \sin\phi_s \sin(\Delta m_s t)\}$$

$$\Gamma(\bar{B}_s^0 \to J/\psi(\pi\pi)_s) \propto e^{-\Gamma_s t}\{e^{\Delta\Gamma_s t/2}(1+\cos\phi_s) + e^{-\Delta\Gamma_s t/2}(1-\cos\phi_s) + \sin\phi_s \sin(\Delta m_s t)\}$$

Time dependent asymmetry $\mathcal{A}(t)$ is a sinusoidal function of the time:

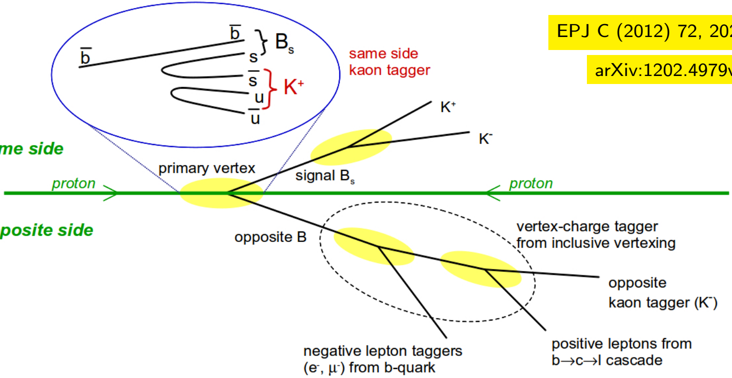
- amplitude $\propto \sin\phi_s$
- initial flavour tagging is required
- measured amplitude is diluted by the probability of mistag (ω) and by limited time resolution (σ_t)

$$\mathcal{A}(t) \simeq \sin\phi_s \times (1-2\omega) \times e^{-(\Delta m_s \sigma_t)^2/2} \times \sin(\Delta m_s t) = \sin\phi_s \times \mathcal{D}_{tag} \times \mathcal{D}_t \times \sin(\Delta m_s t)$$

If $\Delta\Gamma_s \neq 0$ also the untagged sample is sensitive to ϕ_s

$$\Gamma((B_s^0 + \bar{B}_s^0) \to J/\psi(\pi\pi)_s) \propto e^{-\Gamma_s t}\{e^{\Delta\Gamma_s t/2}(1+\cos\phi_s) + e^{-\Delta\Gamma_s t/2}(1-\cos\phi_s)\}$$

Tag the initial B flavour



EPJ C (2012) 72, 2022

arXiv:1202.4979v2

OS tagging: exploits the properties of the decays of the b-hadron opposite to the signal B

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

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

- SSπ (tag the B_d and B^+), SSK (tag the B_s) LHCb-CONF-2012-033

Tag the initial B flavour

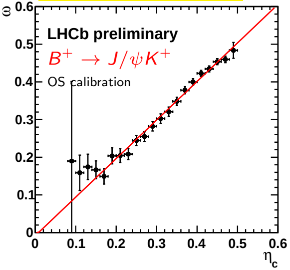
For each event the Flavour Tagging determine:

- **tag decision**: $q = \pm1, 0$ for the initial signal b-hadrons containing a $\bar{b}/b$ quark (based on the charge of the tagger)
- **mistag probability**: η based on a *Neural Network* trained on MC.
    - Calibrated using $B^+ \to J/\psi K^+$ data and validated using different control channels.
    - used ev-by-ev as an estimate of the mistag: $\omega = p_0 + p_1(\eta - \langle\eta\rangle)$

p_0	p_1	$\langle\eta\rangle$
0.392±0.002±0.009	1.035±0.021±0.012	0.391

2011 data sample $1fb^{-1}$

LHCb-CONF-2012-026



Tagging performance in $B_s^0 \to J/\psi\pi^+\pi^-$:

- $\varepsilon_{tag}(1-2\omega)^2 = 2.43 \pm 0.27\%$ **OS tagging only** ($\varepsilon_{tag} \sim 33\%$, $\mathcal{D}_{tag} \sim 0.72$)
- update with SSK tagging will be public soon ($\sim +30\%$) LHCb-CONF-2012-033

Time resolution

Time resolution depends on time $\rightarrow$ use ev-by-ev estimated resolution:

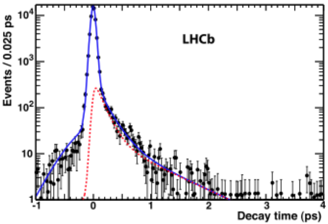
$$\mathcal{R}(t-\tau|\sigma_t) = \sum_{i=1}^{2} \frac{f_i}{\sqrt{2\pi}S_t^i\sigma_t} e^{-\frac{(t-\tau-\mu_t)^2}{2(S_t^i\sigma_t)^2}}$$

- tune S_t^i, μ_t and f_i parameters to match the distribution of "prompt-J/ψ"$+2\pi$ from a sample of trigger unbiased (no IP cuts)
- average time resolution $\langle\sigma_t\rangle$ ~40 fs ($\mathcal{D}_t$ ~0.78)

Time acceptance trigger and off-line selections introduce a bias to the decay time resolution:

- $A(t) = C\frac{[a(t-t_0)]^n}{1+[a(t-t_0)]^n}$
- parameters extracted fitting the time distribution of $B^0 \rightarrow J/\psi K^{*0}$ and cross-check on $B_s^0 \rightarrow J/\psi f_0$

$B_s^0 \rightarrow J/\psi\pi^+\pi^-$ trigger unbiased



Fit and results

Multidimensional fit to the observables $(m, t, \sigma_t, q, \eta)$

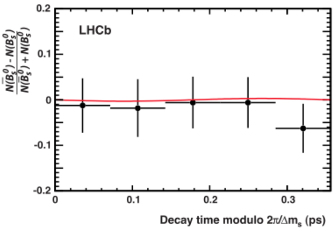
- signal: double gaussian mass, physical amplitudes ($\rightarrow$ slide 5)
- background mainly combinatorial: exponential mass distribution, double exponential time distribution
- small contribution of $B_s^0 \rightarrow J/\psi\eta'$

  time distribution convoluted with the signal resolution function and corrected for the time acceptance.

External (gaussian) constraints:

- $\Delta m_s = 17.63 \pm 0.11 \pm 0.02$ ps^{-1}
  Phys. Lett. B 709 (2012) 177
- $\Gamma_s = 0.657 \pm 0.009 \pm 0.008$ ps^{-1}
- $\Delta\Gamma_s > 0$ (slide 15)
- $\Delta\Gamma_s = 0.123 \pm 0.029 \pm 0.011$ ps^{-1}
  Phys. Rev. Lett. 108 (2012) 101803
- tagging calibration parameters (slide 7) stat. and systematic uncertainties.

possible effect of a direct CP violation considered (consistent with no CPV)



$$\phi_s = -0.019^{+0.173}_{-0.174}{}^{+0.004}_{-0.003} \text{ rad}$$

$B_s^0 \to J/\psi\phi$ channel: the "golden mode"

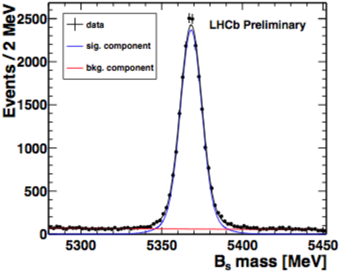
Golden mode for the ϕ_s measurement is $B_s^0 \to J/\psi\phi(\to K^+K^-)$ channel

- dominant contribution is $B_s^0 \to J/\psi\phi$: $\mathcal{B} = (10.50 \pm 0.13 \pm 0.64 \pm 0.82) \times 10^{-4}$, arXiv:1302.1213
  - $PS \to VV$ decay: superimposition of $CP-$odd and $CP-$even eigenstates
- small contribution of K^+K^- in S-wave under the ϕ ($m_\phi \pm 12$MeV): $f_0(980)+$"non-resonant" $(1.1 \pm 0.1^{+0.2}_{-0.1})\%$ arXiv:1302.1213
  - $PS \to VS$ decay: $CP-$odd pure eigenstate

$\to$ angular analyses is required to disentangle the amplitudes

$B_s^0 \to J/\psi\phi$ is a very clean signal:

- S$\sim$21200 events in 1fb^{-1} (2011)
- B/S few percent $t > 0.3$ps suppress most of the prompt background



Amplitudes for $B_s^0 \to J/\psi\phi$

$B_s^0 \to J/\psi\phi$ is a coherent sum of CP-even and CP-odd final state $\to$ time&angular analysis[a] is needed:

$$\frac{d^4\Gamma(\overset{(-)}{B_s^0} \to J/\psi\phi)}{dt\, d\Omega} \propto \sum_{k=1}^{10} h_k(t) f_k(\Omega)$$

10 terms = 3 amplitudes for P-wave, 1 for S-wave + interferences

$$h_k(t) = N_k e^{-\Gamma_s t}[a_k \cosh(\Delta\Gamma_s t/2) + b_k \sinh(\Delta\Gamma_s t/2) \pm c_k \cos(\Delta m_s t) \pm d_k \sin(\Delta m_s t)]$$

coefficients a_k, b_k, c_k and d_k contain the dependency on relative strong phases and on ϕ_s.

k	$f_k(\theta,\psi,\varphi)$	N_k	a_k	b_k	c_k	d_k
1	$2\cos^2\psi\,(1-\sin^2\theta\cos^2\phi)$	$\lvert A_0(0)\rvert^2$	1	$-\cos\phi_s$	0	$\sin\phi_s$
2	$\sin^2\psi\,(1-\sin^2\theta\sin^2\phi)$	$\lvert A_\parallel(0)\rvert^2$	1	$-\cos\phi_s$	0	$\sin\phi_s$
3	$\sin^2\psi\sin^2\theta$	$\lvert A_\perp(0)\rvert^2$	1	$\cos\phi_s$	0	$-\sin\phi_s$
4	$-\sin^2\psi\sin 2\theta\sin\phi$	$\lvert A_\parallel(0)A_\perp(0)\rvert$	0	$-\cos(\delta_\perp-\delta_\parallel)\sin\phi_s$	$\sin(\delta_\perp-\delta_\parallel)$	$-\cos(\delta_\perp-\delta_\parallel)\cos\phi_s$
5	$\frac{1}{2}\sqrt{2}\sin 2\psi\sin^2\theta\sin 2\phi$	$\lvert A_0(0)A_\parallel(0)\rvert$	$\cos(\delta_\parallel-\delta_0)$	$-\cos(\delta_\parallel-\delta_0)\cos\phi_s$	0	$\cos(\delta_\parallel-\delta_0)\sin\phi_s$
6	$\frac{1}{2}\sqrt{2}\sin 2\psi\sin 2\theta\cos\phi$	$\lvert A_0(0)A_\perp(0)\rvert$	0	$-\cos(\delta_\perp-\delta_0)\sin\phi_s$	$\sin(\delta_\perp-\delta_0)$	$-\cos(\delta_\perp-\delta_0)\cos\phi_s$
7	$\frac{2}{3}(1-\sin^2\theta\cos^2\phi)$	$\lvert A_S(0)\rvert^2$	1	$\cos\phi_s$	0	$-\sin\phi_s$
8	$\frac{1}{3}\sqrt{6}\sin\psi\sin^2\theta\sin 2\phi$	$\lvert A_S(0)A_\parallel(0)\rvert$	0	$-\sin(\delta_\parallel-\delta_S)\sin\phi_s$	$\cos(\delta_\parallel-\delta_S)$	$-\sin(\delta_\parallel-\delta_S)\cos\phi_s$
9	$\frac{1}{3}\sqrt{6}\sin\psi\sin 2\theta\cos\phi$	$\lvert A_S(0)A_\perp(0)\rvert$	$\sin(\delta_\perp-\delta_S)$	$\sin(\delta_\perp-\delta_S)\cos\phi_s$	0	$-\sin(\delta_\perp-\delta_S)\sin\phi_s$
10	$\frac{4}{3}\sqrt{3}\cos\psi(1-\sin^2\theta\cos^2\phi)$	$\lvert A_S(0)A_0(0)\rvert$	0	$-\sin(\delta_0-\delta_S)\sin\phi_s$	$\cos(\delta_0-\delta_S)$	$-\sin(\delta_0-\delta_S)\cos\phi_s$

some sensitivity to ϕ_s also from untagged sample.

[a] Choice: transversity frame, $\Omega = (\theta, \psi, \varphi)$

Resolution, acceptance and tagging in $B_s^0 \to J/\psi\phi$

- **angular acceptance:** from MC (re-weighting to match the momentum of K)
- **angular resolution:** negligible effects
- **time resolution:** ev-by-ev (like for $B_s^0 \to J/\psi\pi^+\pi^-$) scale factor calibrated using unbiased, "prompt" $J/\psi\phi$ events ($\langle\sigma_t\rangle = 45$ fs, $\mathcal{D}_t = 0.73$)
- **time acceptance:** non parametric function extracted from unbiased trigger sample + loss of efficiency at large time due to reconstruction inefficiencies for tracks displaced from the beam line ("a-posteriori" correction on the lifetime Γ_s)
- **tagging:** same strategy as in $B_s^0 \to J/\psi\pi^+\pi^-$ (slide 7)
    - **OS tagging only**: $\varepsilon_{tag}\mathcal{D}^2 = 2.29 \pm 0.07 \pm 0.26\%$ (ε_{tag} =33%, $\mathcal{D}_t \sim 0.74$)
    - update with SSK tagging will be public soon ($\sim +30\%$)

    LHCb-CONF-2012-033

Fit and results

Multidimensional fit to the observables $(m, t, \Omega, \sigma_t, q, \eta)$

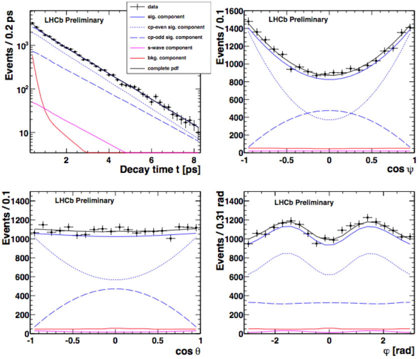
- signal: double gaussian mass, physical amplitudes ($\rightarrow$ slide 11)
- background mainly combinatorial: exponential mass distribution, double exponential time distribution (from B_s sidebands)
- negligible contribution from mis-identified channels (i.e. $B^0 \rightarrow J/\psi K^{*0}$)

  time distribution convoluted with the signal resolution function and corrected for the time acceptance.

External (gaussian) constraints:

- $\Delta m_s = 17.63 \pm 0.11 \pm 0.02$ ps^{-1}
  Phys. Lett. B 709 (2012) 177
- $\Delta\Gamma_s > 0$ (slide 15)
- tagging calibration parameters (slide 7) stat. and systematic uncertainties.

neglected possible direct CP violation (systematic uncertainty)



Fit and results

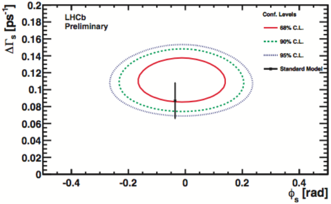
LHCb-CONF-2012-002

Source	Γ_s [ps^{-1}]	$\Delta\Gamma_s$ [ps^{-1}]	$A_\perp^2$	A_0^2	F_S	$\delta_\parallel$ [rad]	$\delta_\perp$ [rad]	δ_s [rad]	ϕ_s [rad]
Description of background	0.0010	0.004	-	0.002	0.005	0.04	0.04	0.06	0.011
Angular acceptances	0.0018	0.002	0.012	0.024	0.005	0.12	0.06	0.05	0.012
t acceptance model	0.0062	0.002	0.001	0.001	-	-	-	-	-
z and momentum scale	0.0009	-	-	-	-	-	-	-	-
Production asymmetry (± 10%)	0.0002	0.002	-	-	-	-	-	-	0.008
CPV mixing & decay (± 5%)	0.0003	0.002	-	-	-	-	-	-	0.020
Fit bias	-	0.001	0.003	-	0.001	0.02	0.02	0.01	0.005
Quadratic sum	0.0066	0.006	0.013	0.024	0.007	0.13	0.07	0.08	0.027

$$\phi_s = -0.001 \pm 0.101 \pm 0.027 \text{ rad}$$

$$\Gamma_s = 0.6540 \pm 0.0054 \pm 0.0066 \text{ ps}^{-1}$$

$$\Delta\Gamma_s = 0.116 \pm 0.018 \pm 0.006 \text{ ps}^{-1}$$



The fit is also able to find Δm_s :17.50±0.13ps^{-1}

Combined result of $B_s^0 \to J/\psi\phi$ and $B_s^0 \to J/\psi\pi^+\pi^-$: $\phi_s = -0.002 \pm 0.083 \pm 0.027$ rad

includes 5% of systematic uncertainty due to mistag calibration and Δm_s

Solving the ambiguities on ϕ_s and $\Delta\Gamma_s$

Phys. Rev. Lett. 108 (2012) 241801

The invariance of the decay rates under transformation $(\phi_s,\ \Delta\Gamma_s,\ \delta_{\|},\ \delta_{\perp}) \rightarrow (\pi - \phi_s,\ -\Delta\Gamma_s,\ -\delta_{\|},\ \pi - \delta_{\perp})$ lead to **ambiguities of the values of ϕ_s and $\Delta\Gamma_s$** parameters.

Solution: exploit the interference of S-wave and P-wave amplitudes using $B_s^0 \rightarrow J/\psi K^+ K^-$ channel

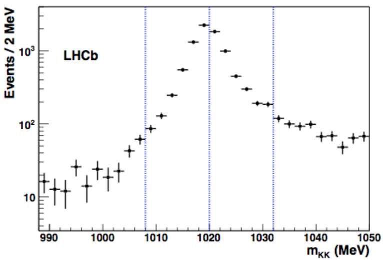
- The phase of P-wave amplitude raises rapidly around the ϕ mass
- The phase of S-wave amplitude has a smooth variation over the K^+K^- invariant mass (far from resonaces poles)

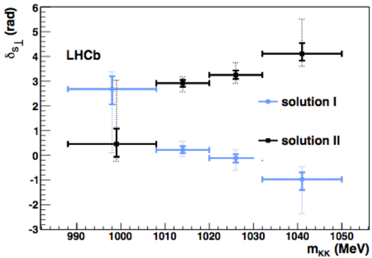
$\rightarrow$ the phase difference $S - P$ should fall rapidly for the "physical" solution, while should raise for "unphysical" solution[a].
Choose $\delta_s - \delta_{\perp}$ because it is the least correlated

[a] method introduced by BaBar while measuring the sign of $\cos(2\beta)$ in $B^0 \rightarrow J/\psi K_s \pi^-$

Solving the ambiguities on ϕ_s and $\Delta\Gamma_s$

Extend the m_{KK} mass range to 998-1050 MeV ($F_s = 7.2 \pm 1.6\%$ 4.5σ difference from zero)





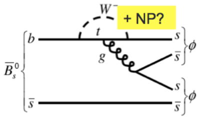
Solution I ($\Delta\Gamma_s$ >0 and $\phi_s \sim 0$) is the "physical" one (significance wrt flat is 4σ).

$\Delta\Gamma_s > 0$ Phys. Rev. Lett. 108 (2012) 241801

$\rightarrow$ the B_s^L mass eigenstate that is almost CP=+1 is lighter and decays faster than the mass eigenstate that is almost CP=–1

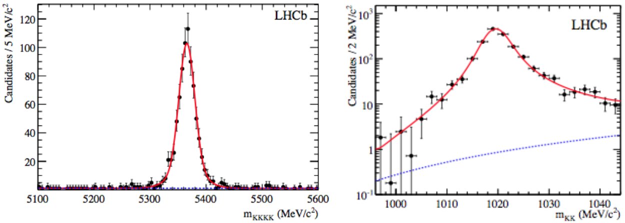
$B_s^0 \to \phi\phi$

- $B_s^0 \to \phi\phi$ promising channel. $b \to s\bar{s}s$ transition, proceeds via penguin decays
- SM prediction $\phi_s^{\phi\phi} < 0.02$ rad (cancellation)
- excellent channel to probe NP contribution to penguin loops



  - For a complete study of CPV full angular, tagged time-dependent analysis is required:
    - superposition of CP-even and CP-odd, + (KK) in s-wave like $B_s^0 \to J/\psi\phi$ (small, compatible with zero)
    - coefficients of angular functions depend on $\phi_s^{\phi\phi}$
  - Asymmetry of triple products can reveal CPV

- Clean signal of $\sim$ 8k evts. in 1fb^{-1} (2011) Phys. Lett. B 713 (2012) 369-377



$B_s^0 \to \phi\phi$: results

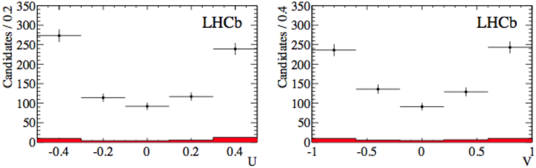
- triple products asymmetry probe CPV:

$$A_U = \frac{N^{U>0} - N^{U<0}}{N^{U>0} + N^{U<0}} \qquad U = \sin(2\Phi)/2$$

$$A_V = \frac{N^{V>0} - N^{V<0}}{N^{V>0} + N^{V<0}} \qquad V = \pm \sin\Phi \text{ (depending on the sign of } \cos\theta_1 \cos\theta_2 \text{ [a])}$$

- previous measurement by CDF: Phys. Rev. Lett. 107 (2011) 261802
  - $A_U = -0.007 \pm 0.064 \pm 0.018 \qquad A_V = -0.120 \pm 0.064 \pm 0.016$

Phys. Lett. B 713 (2012) 369-377



$A_U = -0.055 \pm 0.036 \pm 0.018$ $\qquad$ $A_V = 0.010 \pm 0.036 \pm 0.018$

consistent with the hypothesis of CP conservation
Full angular-tagged time dependent analysis is being finalised (expected for Moriond 2013)

[a] angles defined in the helicity frame

Further constraints on ϕ_s and $\Delta\Gamma_s$: measurement of the effective lifetime

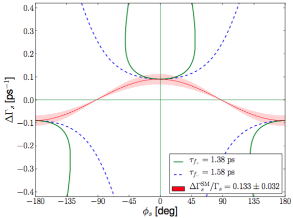
From an idea of Fleischer and Knegjens arXiv:1109.511:

- the information provided by the lifetimes of a pair of B_s^0 decays into pure CP-even and CP-odd final states is sufficient to determine ϕ_s and $\Delta\Gamma_s$ [a]:

$$\langle \Gamma(B_s(t) \to f) \rangle \propto e^{-\Gamma_s t} \left[\cosh(\frac{\Delta\Gamma_s t}{2}) + A^f_{\Delta\Gamma_s} \sinh(\frac{\Delta\Gamma_s t}{2}) \right]$$

$$\frac{\tau_f}{\tau_{B_s}} = 1 + A^f_{\Delta\Gamma_s} \left(\frac{\Delta\Gamma_s}{2\Gamma_s} \right) + [2 - (A^f_{\Delta\Gamma_s})^2] \cdot \left(\frac{\Delta\Gamma_s}{2\Gamma_s} \right)^2 + \mathcal{O}\left(\frac{\Delta\Gamma_s}{2\Gamma_s} \right)^3$$

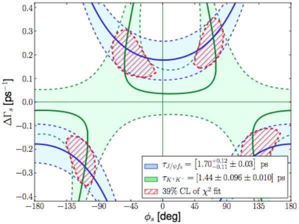
SM and no CPV



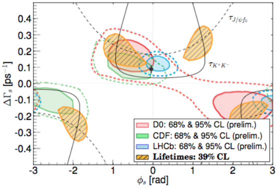
[a] $\Gamma_s = (\Gamma_s^L + \Gamma_s^H)/2 = \tau_{B_s}^{-1}$ and $\Delta\Gamma_s = \Gamma_s^L - \Gamma_s^H$, $A^f_{\Delta\Gamma_s} = -\frac{2\eta_f \cos(\phi_s + \Delta\phi_f)}{1+|\lambda|^2}$

Further constraints on ϕ_s and $\Delta\Gamma_s$: measurement of the effective lifetime

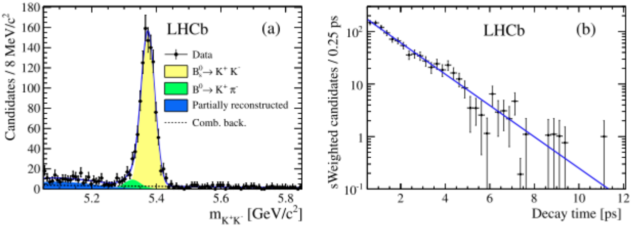
$B_s^0 \to J/\psi f_0(980)$ (CDF)
$B_s^0 \to K^+K^-$ (LHCb 2011)



including constraints from analyses of
$B_s^0 \to J/\psi\phi$

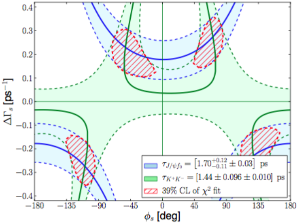


new measurement of τ_{KK} by LHCb using a dedicated unbiased trigger and a selection based on neural network: $\tau_{KK} = 1.455 \pm 0.046 \pm 0.006$ ps Phys. Lett. B716 (2012) 393-400

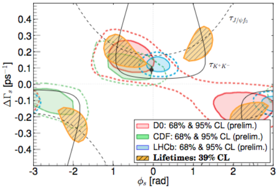


Further constraints on ϕ_s and $\Delta\Gamma_s$: measurement of the effective lifetime

$B_s^0 \to J/\psi f_0(980)$ (CDF)
$B_s^0 \to K^+K^-$ (LHCb 2011)



including constraints from analyses of
$B_s^0 \to J/\psi\phi$

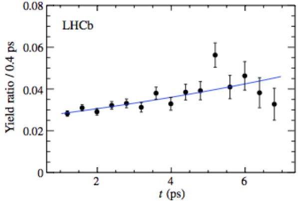


new measurement of τ_{KK} by LHCb using a dedicated unbiased trigger and a selection based on neural network: $\tau_{KK} = 1.455 \pm 0.046 \pm 0.006$ ps Phys. Lett. B716 (2012) 393-400

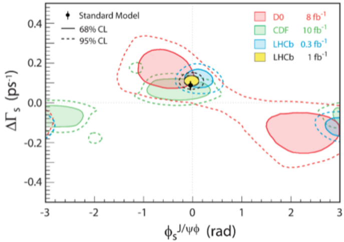
new measurement of $\tau_{J/\psi f_0(980)}$ by LHCb relative to B_d^0 lifetime in $B_d^0 \to J/\psi \bar{K}^{*0}$:

$\tau_{J/\psi f_0(980)} = 1.700 \pm 0.014 \pm 0.001$ ps

Phys. Rev. Lett. 109 (2012) 152002



Summary



- LHCb measurement of ϕ_s and $\Delta\Gamma_s$ in the analysis of $B_s^0 \to J/\psi\pi^+\pi^-$ & $B_s^0 \to J/\psi\phi$ are the world's best
- Solved the ambiguity on $\Delta\Gamma_s$ and ϕ_s
  - Update of the $B_s^0 \to J/\psi\phi$ and $B_s^0 \to J/\psi\pi^+\pi^-$ results with 2011 1fb^{-1} data sample is expected soon (improved signal yield and tagging)
- Analysis of $B_s^0 \to \phi\phi$: triple products $\to$ no CP violation
  - results of the full analysis are expected soon (Moriond 2013)
- Further constraints on ϕ_s and $\Delta\Gamma_s$ come from the measurement of B_s^0 effective lifetime in CP eigenstates

$\to$ everything so far is consistent with Standard Model

- Next: precision measurements ...
  - 2.0fb^{-1} taken in 2012 at $\sqrt{s} = 8$TeV
  - Run2 at $\sqrt{s} = 14$TeV
  - Upgrade (50fb^{-1})

$\to$ for sure ... this is not the end ....