B_s decays and CPV in the B_s system

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for the LHCb collaboration, including results from CDF, D0, Belle, ATLAS + CMS

XXXII Physics in Collisions, 12-15 September 2012

Outline

Analysis discussed in this talk - apologies for those I had to skip:

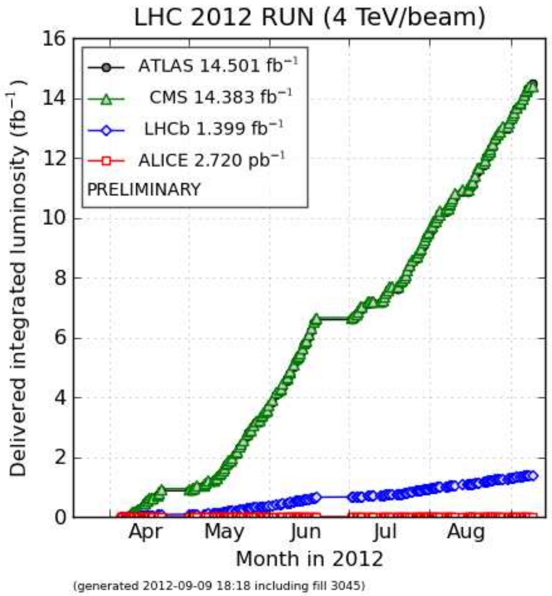
- Measurement of BR in $B_s \to \mu^+\mu^-$
- First evidence for direct CPV in B_s system in $B_s \to K\pi$
- Time dependent CPV in $B_s \to J/\psi\phi$ / $B_s \to J/\psi f_0$ $\longrightarrow \phi_s$
- Mixing induced CPV in B_s system using semileptonic decays $\longrightarrow a_{sl}$

Analysed B_s data sets:

- BELLE: 121 fb^{-1} e^+e^- collisions @ $Y(5S)$
- CDF + D0 @ Tevatron: $\sim$ 9 - 10.4 fb^{-1} $p\overline{p}$ collisions
- LHC: pp collisions @ $\sqrt{s}$ = 7 TeV

  LHCb $\sim$ 1 fb^{-1} in 2011

  ATLAS, CMS $\sim$ 5 fb^{-1} each in 2011



$B_{s/d} \to \mu^+\mu^-$

- B physics rare decay par excellence

  (FCNC and helicity suppressed)

- $\text{BR}_{SM}(B_s \to \mu^+\mu^-) = (3.6 \pm 0.2) \cdot 10^{-9}$

  $\text{BR}_{SM}(B_d \to \mu^+\mu^-) = (1.0 \pm 0.1) \cdot 10^{-10}$

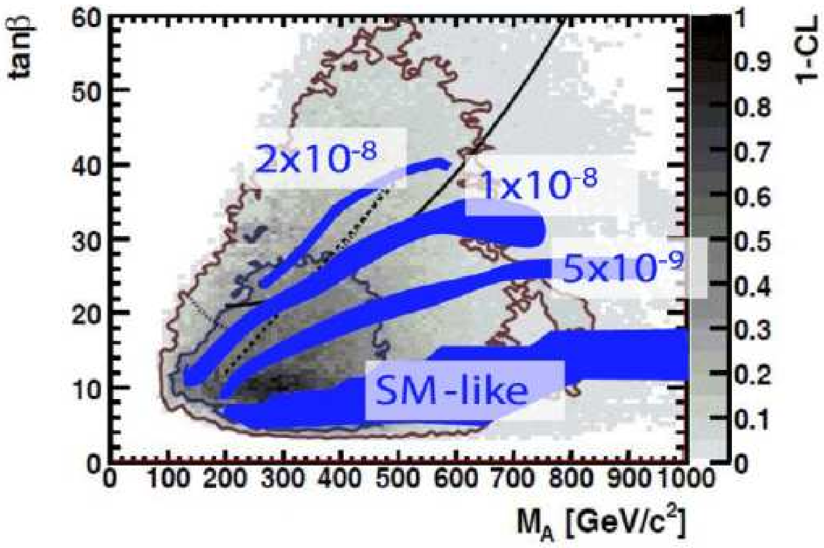
  [A. Buras, 2009]

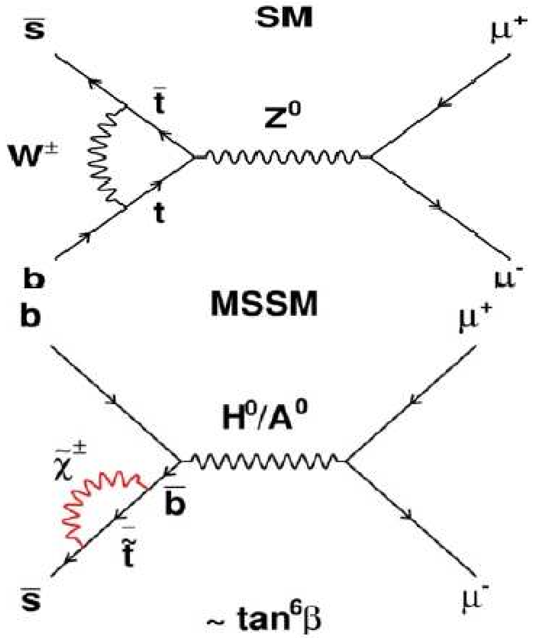
  Very precise prediction (which will improve)!

- Very high sensitivity to NP, e.g. MSSM

  One example (O. Buchmüller et al)

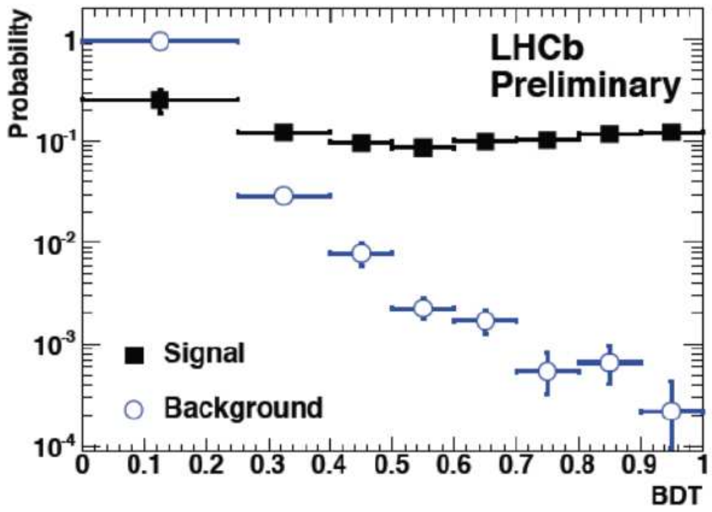
  NUHM (= generalized version of CMSSM)





Analysis Strategy LHCb

- Build Boosted Decision Tree (BDT) out of 9 kinematical and topologial variables. train BDT on MC, but calibrate on data:
  - signal response: use $B \to hh$ decays
  - background response: use sidebands



- Calibrate muon-ID using tag & probe method (J/ψ)
- Calibrate signal mass shape/width on dimuon resonances from data
- Look in 9×8 grid of $\mu^+\mu^-$ inv. mass vs. BDT output (diff. S/B in each bin)
- Three normalisation channels for BR: $B^+ \to J/\psi K^+$, $B_s \to J/\psi\phi$ and $B^0 \to K\pi$, give all consistent results

$$BR(B_s \to \mu^+\mu^-) = \frac{N(B_s \to \mu^+\mu^-)}{N(B^+ \to J/\Psi K^+)} \frac{\epsilon(B^+ \to J/\Psi K^+)}{\epsilon(B_s \to \mu^+\mu^-)} \frac{f_s}{f_d} BR(B^+ \to J/\Psi K^+)$$

Similar approaches by CMS and ATLAS!

$B_s \to \mu^+\mu^-$ Candidate

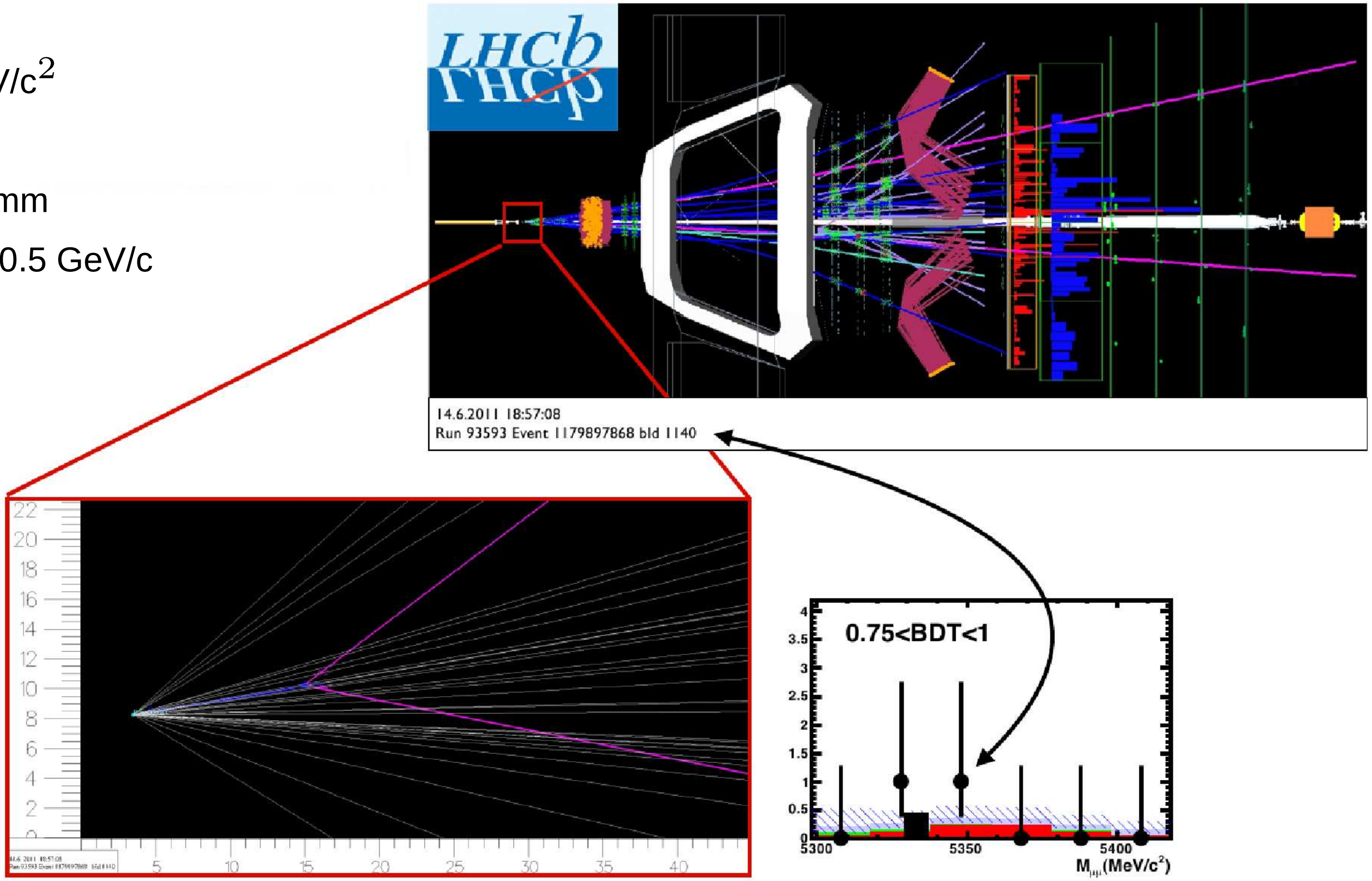
Even at the SM branching ratio, LHCb expects to accumulated $B_s \to \mu\mu$ decays in 2011 data ($\sim$ 12 after pre-selection). Indeed, plausible candidates are seen:

$m_{\mu\mu} = 5.347$ GeV/c^2

BDT = 0.9

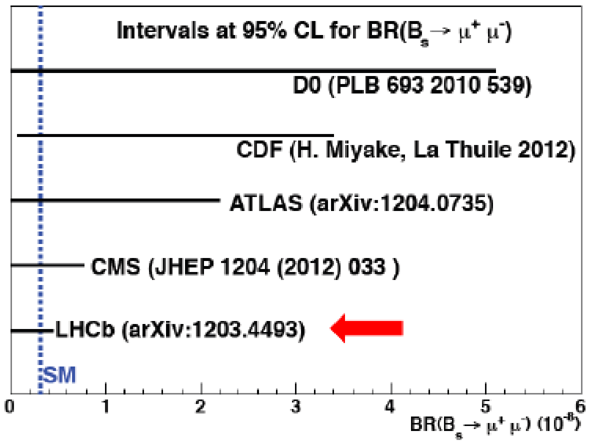
decay length = 11.5 mm

only tracks w. p_T >0.5 GeV/c



$B_{s/d} \to \mu\mu$ Results

LHCb - 2011: 1 fb^{-1} PRL 108, 231801 (2012)		CMS - 5.0 fb^{-1} JHEP 1204 (2012) 033		ATLAS - 2.4 fb^{-1} arXiv:1204.0735	
B_s limit	at 95% CL	B_s limit	at 95% CL	B_s limit	at 95% CL
Exp. bkg + SM	7.2×10^{-9}	Exp. bkg + SM	8.4×10^{-9}	Exp. bkg + SM	–
Exp. bkg	3.4×10^{-9}	Exp. bkg	–	Exp. bkg	2.3×10^{-8}
Observed	4.5×10^{-9}	Observed	7.7×10^{-9}	Observed	2.2×10^{-8}



Combined LHC result:

$BR(B_s) < 4.2 \times 10^{-9}$ @ 95%

$BR(B_d) < 8.1 \times 10^{-10}$ @ 95%

B_s limit about factor 1.5 lower than expected for bkg+SM hypothesis however consistent within 1 σ.

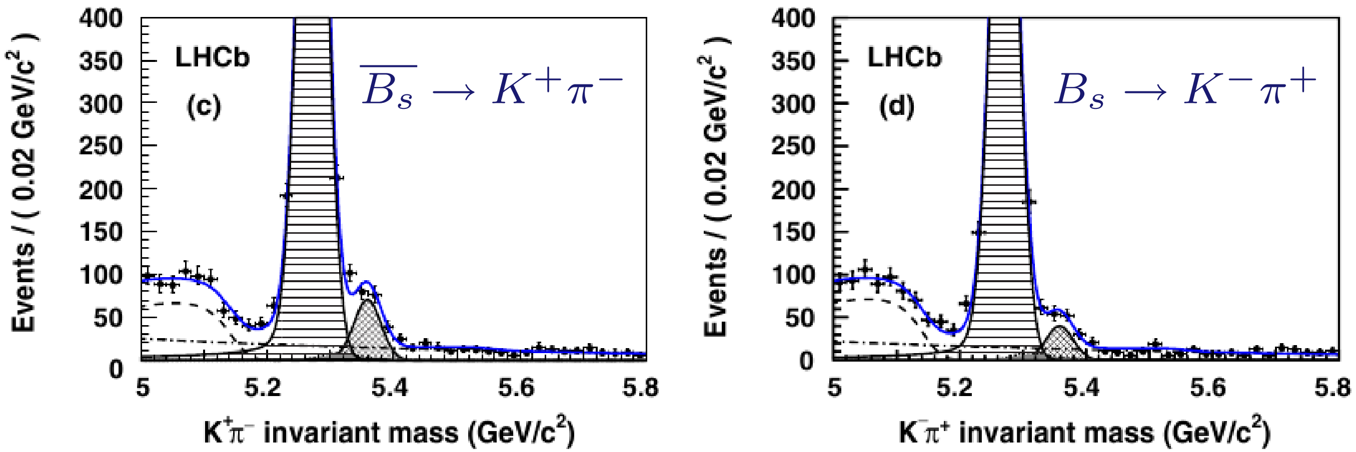
CMS PAS BPH-12-009, LHCb-CONF-2012-017, ATLAS-COM-CONF-2012-090

Very close to SM, no large NP enhancement!

Next step, perform a precision measurement to test if BR is *really* SM, data driven analyses equipped to controll all systematics.

Direct CPV in $B^0_{d/s} \longrightarrow K\pi$ @ LHCb

$$A_{raw} = \frac{N(B_s \to K^-\pi^+) - N(\overline{B_s} \to K^+\pi^-)}{N(B_s \to K^-\pi^+) + N(\overline{B_s} \to K^+\pi^-)}$$



LHCb - PRL 108, 201601 (2012) - 0.35 fb^{-1}

$$A_{raw} = A_{CP} + A_{IA} + \alpha\ A_D + \kappa\ A_{prod}$$

A_{IA} material interaction differences for $K^\pm/\pi^\mp$

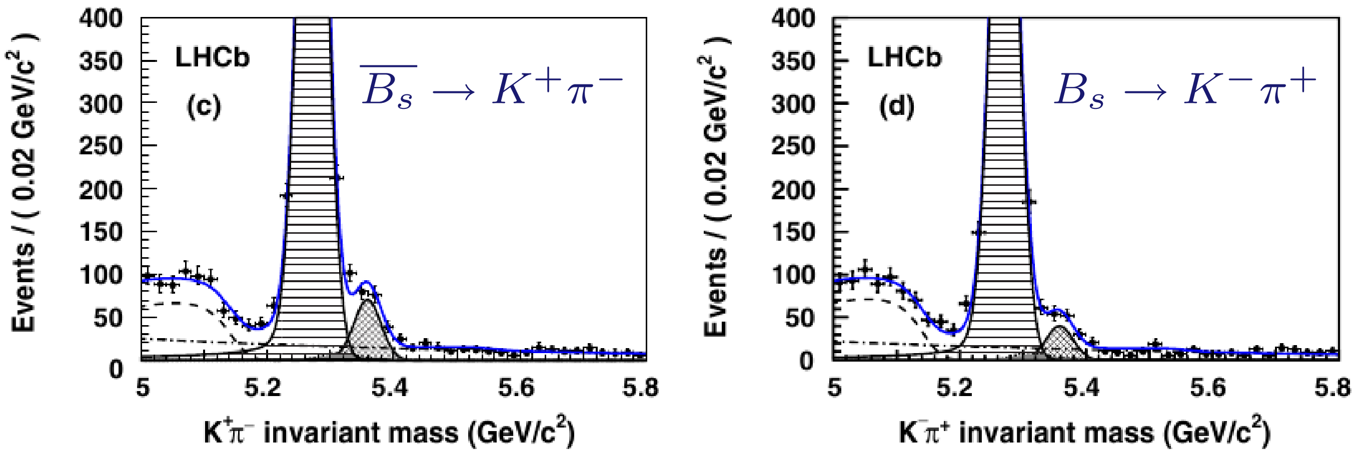
A_D detector asymmetries, cancel for swapped B field data

α correction factor to account for diff. lumi/trigger efficiency in magnet up and down sample; α = -0.202 $\pm$ 0.011

use $D^{*+} \to D^0(KK/K\pi)\pi^+$ and $D^0 \to K\pi$ decays to determine $A_{D,prod}$, A_{IA}, A_D.

Direct CPV in $B^0_{d/s} \to K\pi$ @ LHCb

$$A_{raw} = \frac{N(B_s \to K^-\pi^+) - N(\overline{B_s} \to K^+\pi^-)}{N(B_s \to K^-\pi^+) + N(\overline{B_s} \to K^+\pi^-)}$$



LHCb - PRL 108, 201601 (2012) - 0.35 fb^{-1}

$$A_{raw} = A_{CP} + A_{IA} + \alpha\, A_D + \kappa\, A_{prod}$$

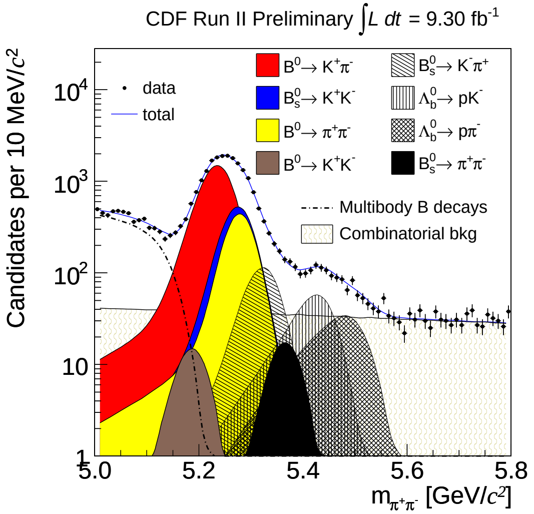
A_{prod} production asymmetry in pp collisions

$\kappa = \frac{\int_0^\infty e^{-\Gamma t}\cos(\Delta m t)\epsilon(B\to K\pi,t)dt}{\int_0^\infty e^{-\Gamma t}\cosh(\frac{\Delta\Gamma}{2}t)\epsilon(B\to K\pi,t)dt}$; ϵ: acceptance κ_d = 0.303 $\pm$ 0.005; κ_s = -0.033 $\pm$ 0.003;

exploit $B^0 \to J/\psi K^*(K\pi)$ decays (CPV $< 10^{-3}$ in SM) to determine B^0 production asymmetry; $A_{prod,d}$ = 0.010 $\pm$ 0.013;

B_s production asymmetry suppressed by κ_s

Direct CPV in $B^0_{d/s} \rightarrow K\pi$



CDF analysis

no need to worry about B and D

production asymmetries in $p\overline{p}$ collisions

reconstruction asymmetries from D decays

LHCb - PRL 108, 201601 (2012) - 0.35 fb^{-1}

$A_{CP}(B_s \rightarrow K\pi)$ = 0.27 $\pm$ 0.08 $\pm$ 0.02

$A_{CP}(B_d \rightarrow K\pi)$ = -0.088 $\pm$ 0.011 $\pm$ 0.008

CDF-note 10726 - 9.3 fb^{-1}

$A_{CP}(B_s \rightarrow K\pi)$ = 0.22 $\pm$ 0.07 $\pm$ 0.02

$A_{CP}(B_d \rightarrow K\pi)$ = -0.083 $\pm$ 0.013 $\pm$ 0.003

$A_{CP}(\Lambda_b^0 \rightarrow p\pi)$ = 0.07 $\pm$ 0.07 $\pm$ 0.03

First evidence for CPV in B_s system!

First observation of direct CPV in hadron colliders!

Neutral B_s^0 Meson Mixing

flavour eigenstates B_s^0 & $\overline{B_s^0} \neq$ mass eigenstates B_H & B_L

$$i\frac{d}{dt}\begin{pmatrix} B_s^0 \\ \overline{B_s^0} \end{pmatrix} = M - \frac{i}{2}\Gamma \begin{pmatrix} B_s^0 \\ \overline{B_s^0} \end{pmatrix}$$

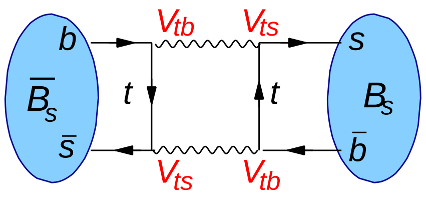
Diagonalizing of mass matrix, gives mass eigenstates:

$B_L = p|B^0 > +q|\overline{B^0} >$ $\quad$ $B_H = p|B^0 > -q|\overline{B^0} >$

In case of no CPV in mixing ($|\frac{q}{p}| = 1$): $B_H \equiv$ CP odd eigenstate $\quad$ $B_L \equiv$ CP even eigenstate

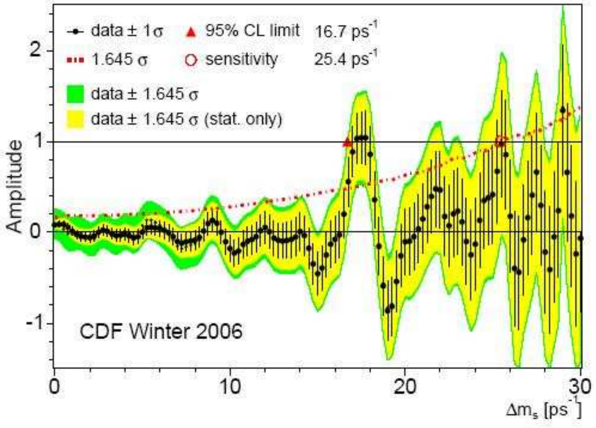
- $\Delta m_s = m_H - m_L = 2|M_{12}| \sim$ mixing frequency
- $\Delta\Gamma = \Gamma_L - \Gamma_H = 2|\Gamma_{12}| \cos\phi_s$
- phase: $\phi_s^{SM} = -arg(\frac{M_{12}}{\Gamma_{12}})$; $\quad -2\beta_s^{SM} = 2 * arg(\frac{V_{ts}V_{tb}^*}{V_{cs}V_{cb}^*})$

  for large new physics: $\phi_s = \phi_s^{SM} + \phi_s^{NP} \sim -2\beta_s^{SM} + \phi_s^{NP} = -2\beta_s$
- $\Gamma = \frac{\Gamma_H + \Gamma_L}{2}$, $m = \frac{m_H + m_L}{2}$



box dominated by top quark

$B_s - \overline{B}_s$ Oscillation

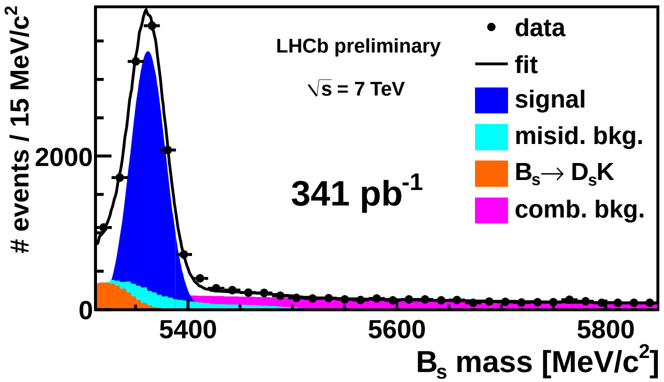


CDF: first measurement with 1 fb^{-1}

PRL 97, 24 2003 (2006)

Δm_s = 17.77 $\pm$ 0.10 $\pm$ 0.07 ps^{-1},

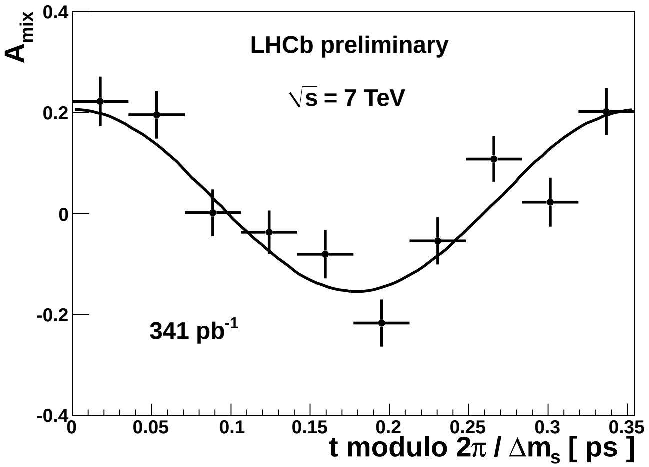
$\sigma_t \sim$ 100 fs, av. decay length 0.5-1.0 cm



LHCb: Δm_s = 17.725 $\pm$ 0.041 $\pm$ 0.026 ps^{-1}

Phy. Lett. B 709 (2012)

decay mode	signal yield
$B_s^0 \to D_s^-(\phi\pi^-)\pi^+$	4371 ± 91
$B_s^0 \to D_s^-(K^*K^-)\pi^+$	2910 ± 89
$B_s^0 \to D_s^-\pi^+$ non-resonant	1908 ± 74

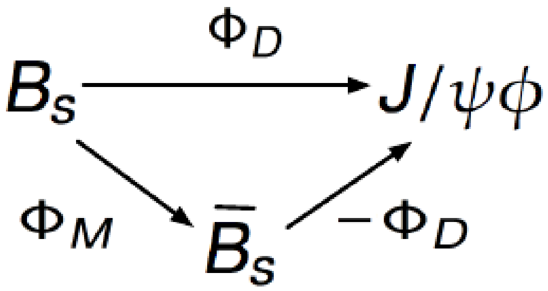


proper time resolution: σ_t = 45 fs

av. decay length 1-2 cm

How to access ϕ_s and $\Delta\Gamma_s$

- Measurement of CPV in interference between decay and mixing & decay



$$\phi_s = \phi_M - 2\phi_D$$

Two major players ($\phi_D \sim 0$ for both decays):

  - golden mode $B_s \to J/\psi\phi$

    clean mode, large statistics, angular analysis to separate CP even and CP odd contributions, access to Γ, $\Delta\Gamma$, ϕ_s

  - $B_s \to J/\psi f_0$ + non resonant $B_s \to J/\psi\pi\pi$ (CP odd - LHCb-CONF-2012-002)

    less statistics, no angular analysis, access to Γ_H and ϕ_s

- Lifetime measurements in decays in CP eigenstates

  ignoring small CPV: $B_H \equiv$ CP odd eigenstate $B_L \equiv$ CP even eigenstate

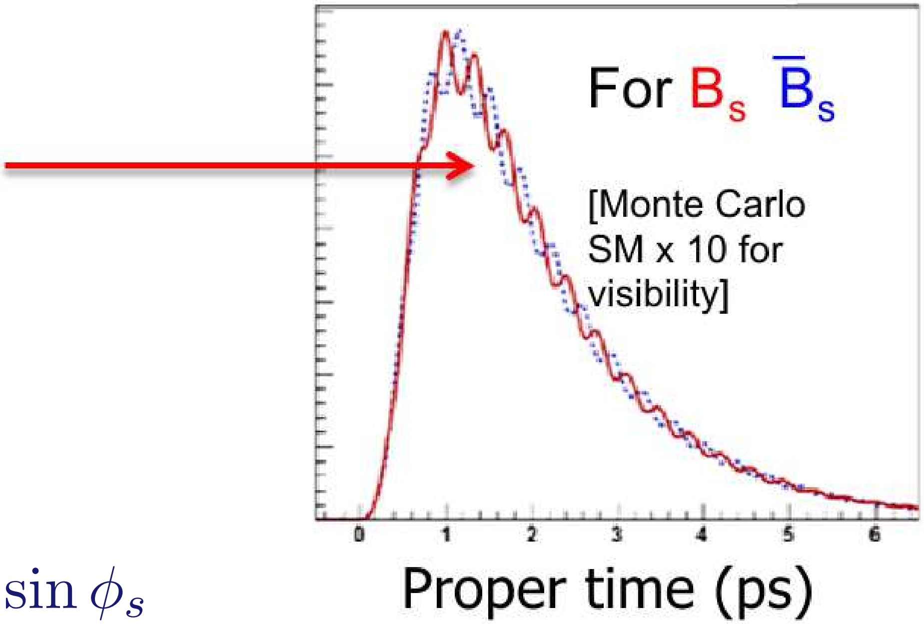
  e.g. $B_s \to J/\psi f_0$ (CP odd); $B_s \to KK$ (CP even)

  For new results on lifetimes, see talk from Stefano Argiro

Measurement of ϕ_s

measurement of modulation

in decay time distribution



- amplitude of modulation is $\sin \phi_s$
- opposite sign for B_s and $\overline{B_s}$ (and for CP eigenvalue)

essentially measure $\sin \phi_s \times \sin \Delta m_s$

$\longrightarrow$ important tools: flavour tagging & decay time resolution

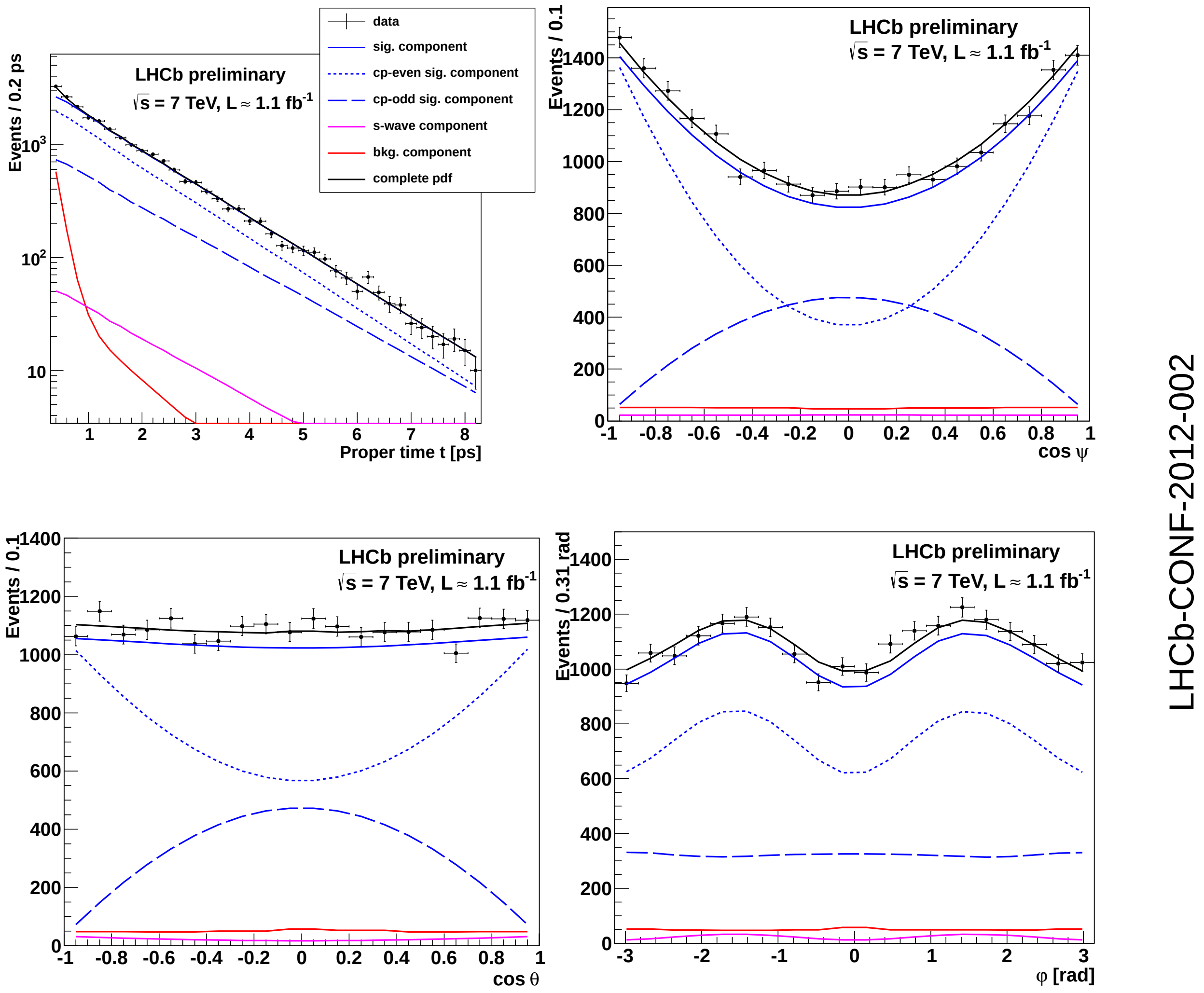
physics observables in $B_s \longrightarrow J/\psi\phi$ (L=0,1,2):

$A_\perp, A_{||}, A_0, \delta_{||}, \delta_\perp, \Gamma, \Delta\Gamma, \Delta m_s, m_B, \phi_s, \delta_S, F_S$

(analysis includes small fraction of non-resonant S-wave contribution - F_S, δ_S)

Angular Analysis

Simultaneous 4D fit for decay time and 3 decay angles.

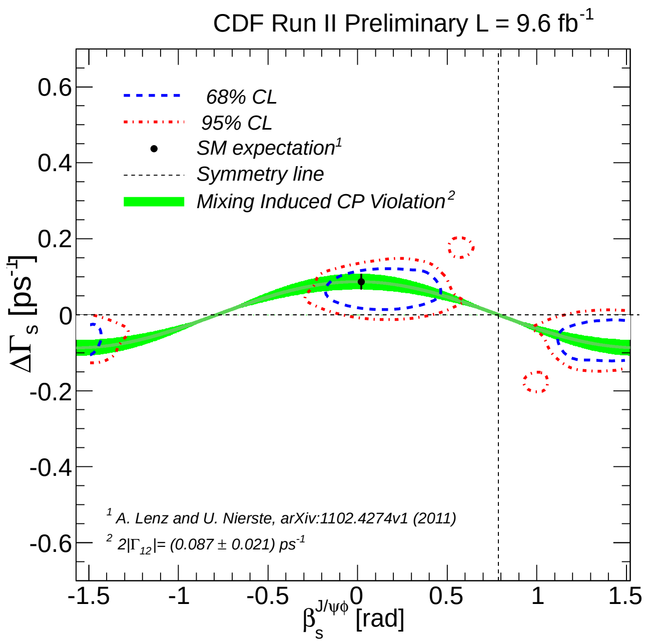


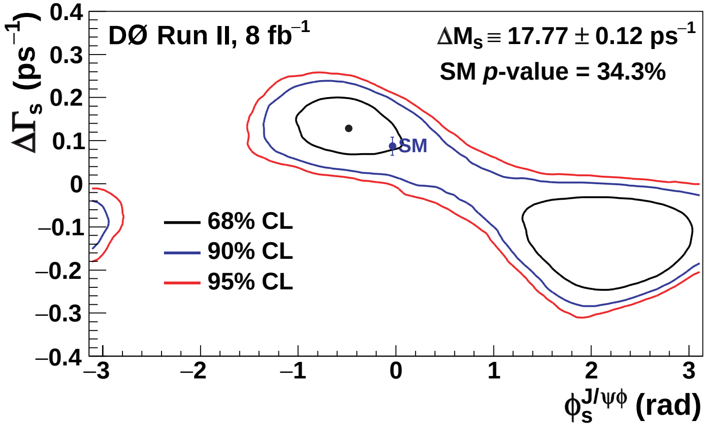
LHCb plots used for illustration, similar angular analysis for all experiments.

Tevatron Results: $B_s \to J/\psi\phi$

Tevatron experiments saw a combined deviation of up to $\sim 3\,\sigma$ in their early data, which went down in the final results ...

CDF result (9.1 fb^{-1}), CDF note 10778 D0 result (8 fb^{-1}), Phys. Rev. D 85, 032006 (2012)





11k events, $\sigma_{ct} \sim$ 100 fs

β_s in $[-\pi/s, -1.51]$ or $[1.26, \pi/2]$

τ_s = 1.528 $\pm$ 0.019 $\pm$ 0.009 ps

$\Delta\Gamma_s$ = 0.068 $\pm$ 0.026 $\pm$ 0.007 ps^{-1}

6.5k events, $\sigma_{ct} \sim$ 100 fs

ϕ_s = -0.55$^{+0.38}_{-0.36}$

τ_s = 1.443$^{+0.038}_{-0.035}$ ps

$\Delta\Gamma_s$ = 0.163$^{+0.065}_{-0.064}$ ps^{-1}

Due to limited statistics, a lot of work to determine proper contours.

LHCb Result: $B_s \to J/\psi\phi$

LHCb-CONF-2012-002

21k very clean signal events in 1.0 fb^{-1}

$\sigma_t \sim$ 50 fs

parabolic likelihood distributions

$\longrightarrow$ point estimates

ϕ_s = -0.001 $\pm$ 0.101 $\pm$ 0.027

Γ_s = 0.6580 $\pm$ 0.0054 $\pm$ 0.0066* ps

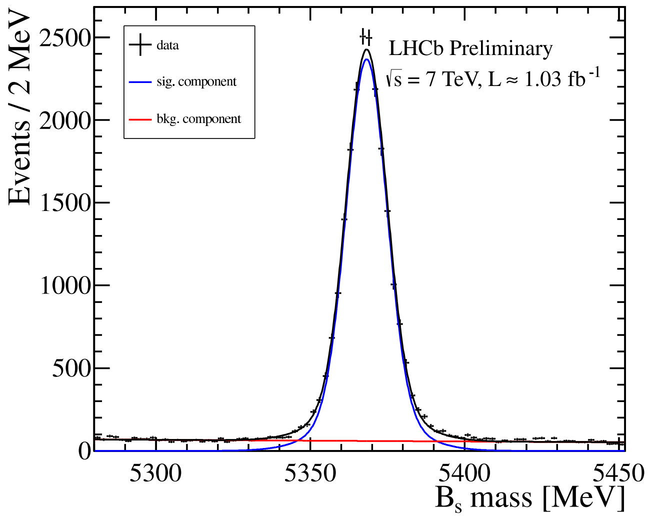
$\Delta\Gamma_s$ = 0.116 $\pm$ 0.018 $\pm$ 0.006 ps^{-1}

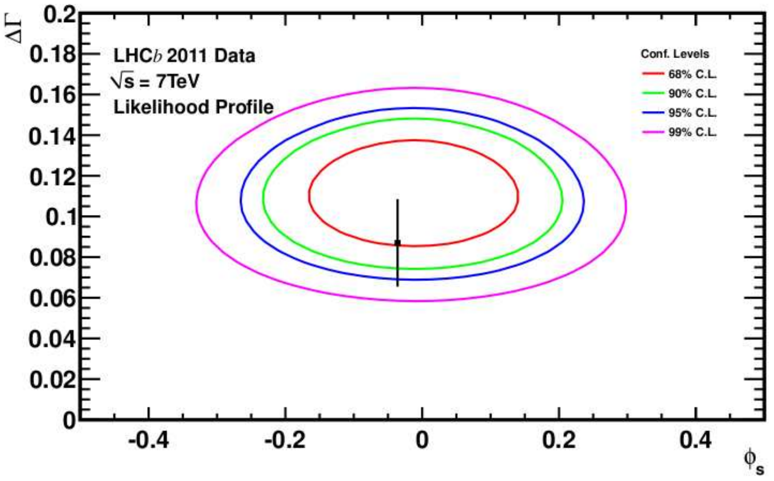
* syst. limited by lifetime acceptance introduced by pattern reco

Observation of non-zero $\Delta\Gamma_s$

fraction of non-resonant contribution:

F_s = 0.022 $\pm$ 0.012 $\pm$ 0.007





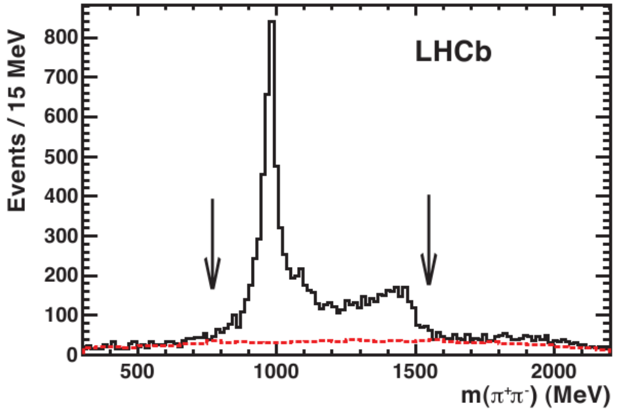
2-fold ambiguity resolved

PRL **108**, 241801 (2012)

Combined LHCb result

Observation of $B_s \to J/\psi f_0$ decay by LHCb,

followed by CDF, D0 & BELLE



7.500 $J/\phi\pi\pi$ candidates

Dalitz-like analysis: pure CP odd eigenstate

($>$ 97.7 % 95% CL); LHCb-PAPER-2011-005

$\frac{BR(B_s \to J/\psi f_0, f_0 \to \pi\pi)}{BR(B_s \to J/\psi\phi, \phi \to KK)}$ = 0.257 $\pm$ 0.020 $\pm$ 0.014

CDF - arXiv:1106.3682v2

fit for ϕ_s in $B_s \to J/\psi\pi\pi$:

ϕ_s = -0.02 $\pm$ 0.17 $\pm$ 0.02 rad

LHCb-PAPER-2012-006

+ $B_s \to J/\psi KK$:

ϕ_s = -0.002 $\pm$ 0.083 $\pm$ 0.027 rad

LHCb-CONF-2012-002

Further improvements ahead:

additional triggers, use of SSKT,

fit for direct CPV, enlarged $m(KK)$

mass window, more data ...

ATLAS result

world largest sample of $B_s \to J/\psi\phi$ decays:

25k signal candidates in 4.9 fb^{-1}

very hard conditions: $\sim$ 6 pile up vertices per event

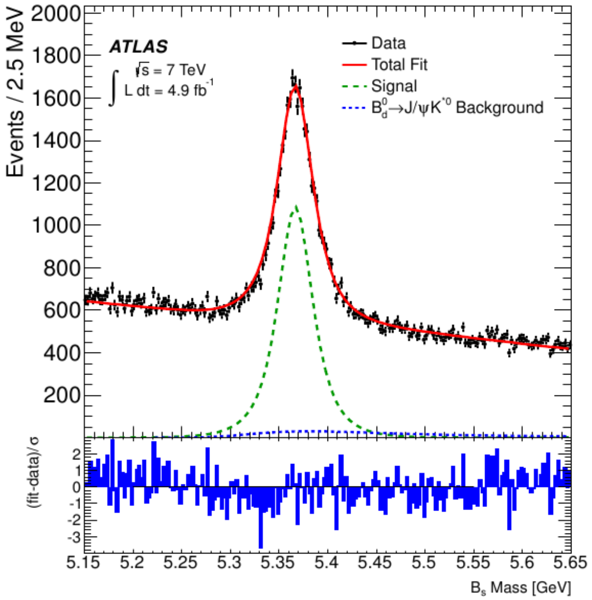
untagged analysis $\longrightarrow$ no need to resolve fast mixing

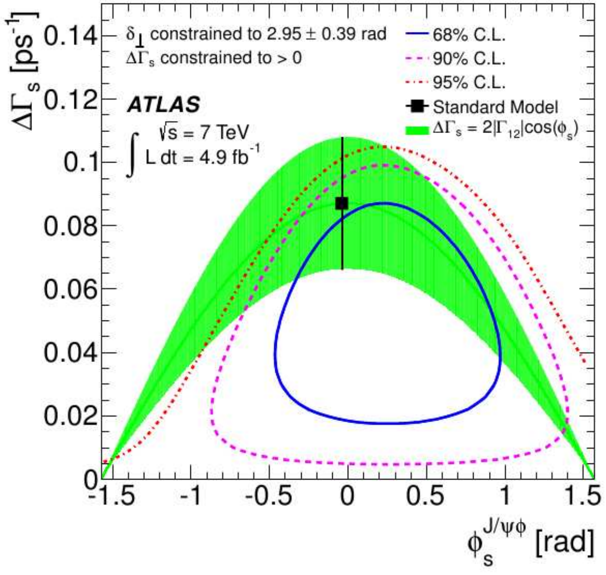
($\sigma_t \sim$ 100 fs)

$\longrightarrow$ significant loss in precision for ϕ_s

competitive result on $\Delta\Gamma$

external input on $\delta_\perp$ from LHCb





$$\phi_s = 0.22 \pm 0.41 \pm 0.10 \text{ rad}$$

$$\Delta\Gamma_s = 0.053 \pm 0.021 \pm 0.008 \text{ ps}^{-1}$$

$$\Gamma_s = 0.677 \pm 0.007 \pm 0.004 \text{ ps}^{-1}$$

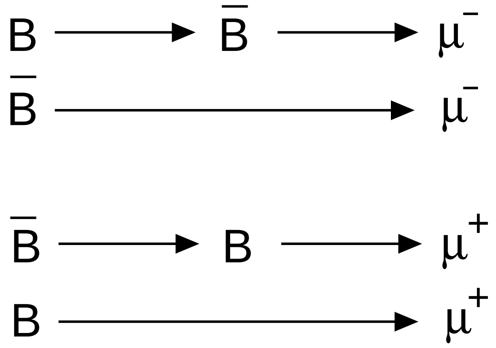
arXiv:1208.0572v1

NP in B_s-Mixing? - Status 2011

- $P(B \to \bar{B}) \neq P(\bar{B} \to B)$

semileptonic asymmetry

$(B^0 + B_s)$

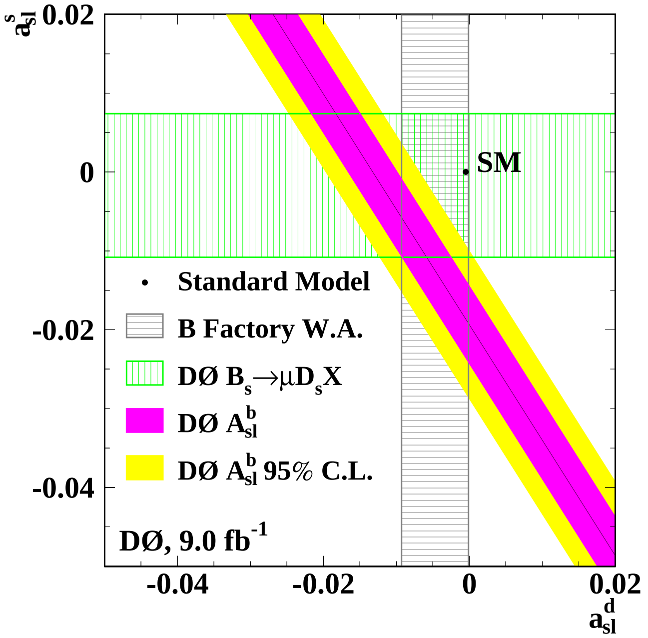


$$A = \frac{N(\mu^+\mu^+) - N(\mu^-\mu^-)}{N(\mu^+\mu^+) + N(\mu^-\mu^-)}$$

$$a = \frac{N(\mu^+) - N(\mu^-)}{N(\mu^+) + N(\mu^-)}$$

SM: A^b_{sl} = (-0.20 $\pm$ 0.03) $\times$ 10^{-3}

A. Lenz, U. Nierste, (2006/2011)



$A^b_{sl,IP<120\mu m}$ =-1.14 $\pm$ 0.37 (stat) $\pm$ 0.32 (syst) %

$A^b_{sl,IP>120\mu m}$ = -0.579 $\pm$ 0.210 (stat) $\pm$ 0.094 (syst) %

(Phys. Rev. D84, 052007 (2011))

$\rightarrow$ 3.9σ deviation from SM

A_{sl}^s in $B_s \rightarrow D_s \mu X$

$$A_{sl}^s = \frac{N(B_s \rightarrow D_s^- \mu^+ \nu_\mu) - N(\overline{B_s} \rightarrow D_s^+ \mu^- \overline{\nu_\mu})}{N(B_s \rightarrow D_s^- \mu^+ \nu_\mu) + N(\overline{B_s} \rightarrow D_s^+ \mu^- \overline{\nu_\mu})}$$

This measurement requires tagging to determine production flavour

very challenging at hadron colliders: $\epsilon D^2 \sim$ 2-5%

Alternative approach:

$$A_{meas} = \frac{N(D_s^- \mu^+ \nu_\mu) - N(D_s^+ \mu^- \overline{\nu_\mu})}{N(D_s^- \mu^+ \nu_\mu) + N(D_s^+ \mu^- \overline{\nu_\mu})} = \frac{A_{sl}^s}{2} + [A_{prod} - \frac{A_{sl}^s}{2}]\kappa_s \sim \frac{A_{sl}^s}{2}$$

fast B_s mixing dilutes second term below precision of this measurement.

detection asymmetries:

D0 & LHCb analysis uses $D_s \rightarrow \phi(K^+ K^-)\pi$ decays, thus need to worry only about π and μ detection/reconstruction asymmetries. Due to opposite sign of π and μ in the decay, effects almost cancel; on top exploit swap of B field

all corrections/systematics data driven!

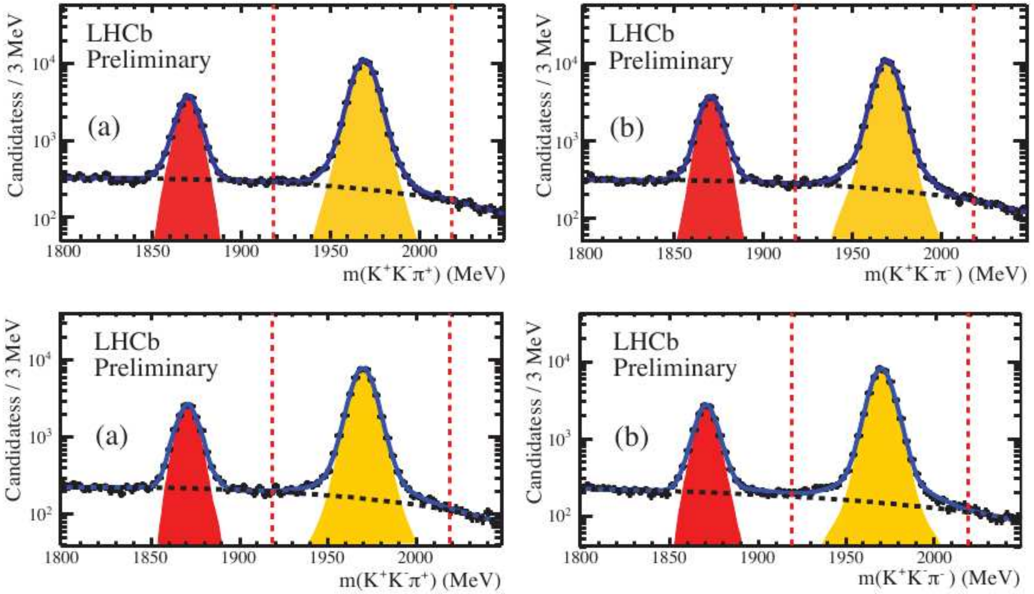
aim for permille precision, cannot trust MC at this level

A_{sl} in $B_s \to D_s \mu X$ @ LHCb

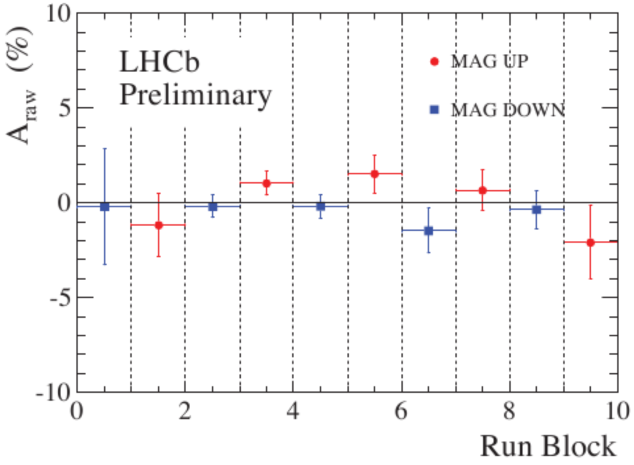
stability checks w. raw asymmetry

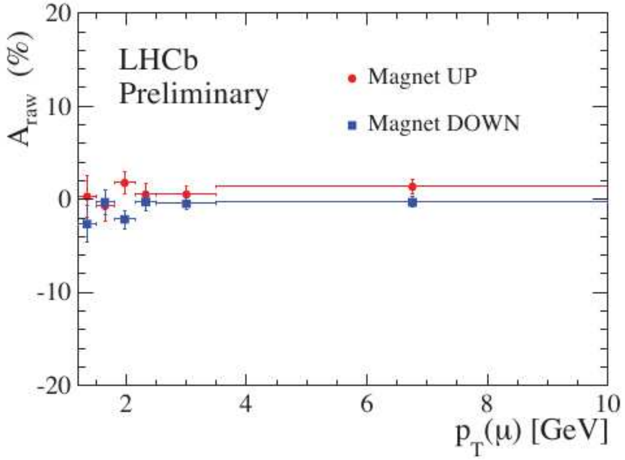
190k B_s signal candidates in magnet up+down

magnet up – magnet down



plot: $D^-_{(s)} \to \phi\pi^-$ mass

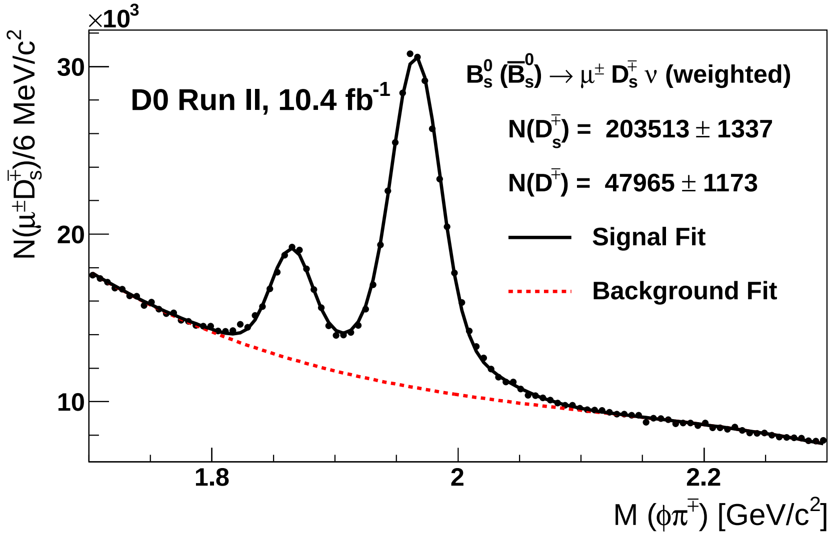




LHCb-CONF-2012-022

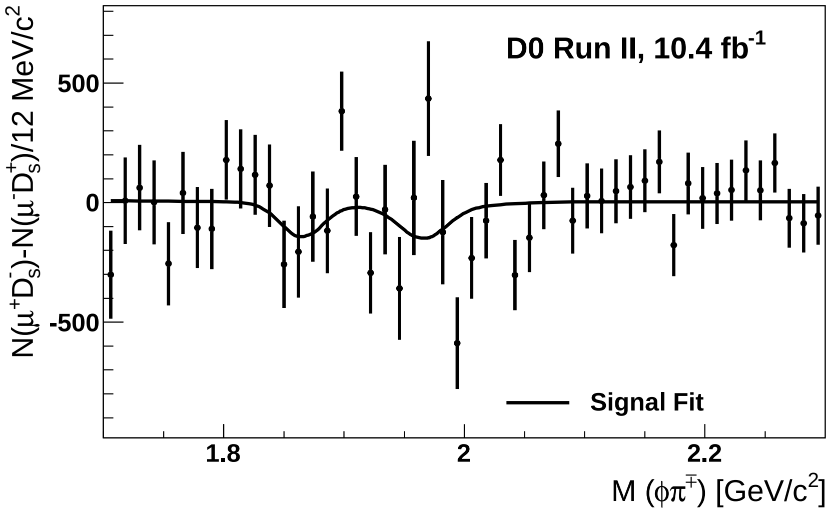
A_{sl} in $B_s \longrightarrow D_s \mu X$ @ D0

200k B_s signal candidates



plot: $D \longrightarrow \phi\pi$ mass

Fit for $N(D_s^+\mu^-) - N(D_s^-\mu^+)$



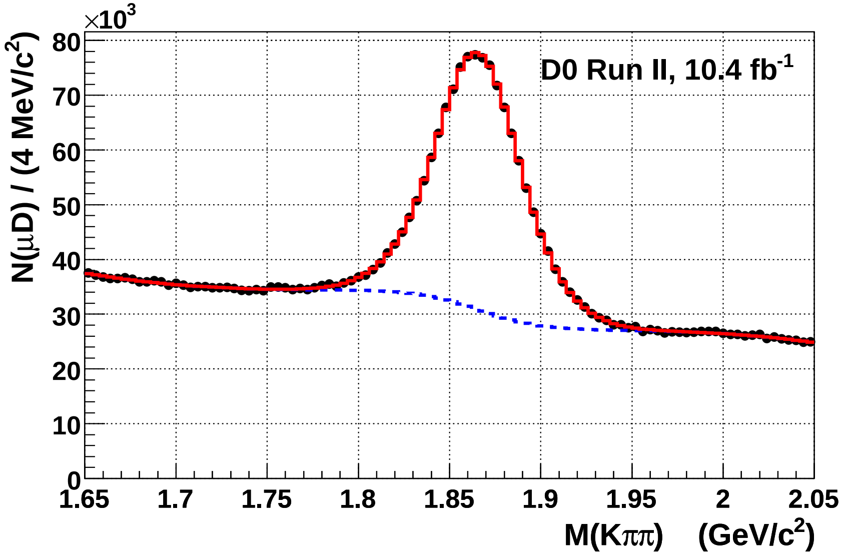
small bkg from $B^0 \longrightarrow D^-\pi^+$

Raw asymmetry: A_{raw} = [-0.40 ± 0.33 ± 0.05] %

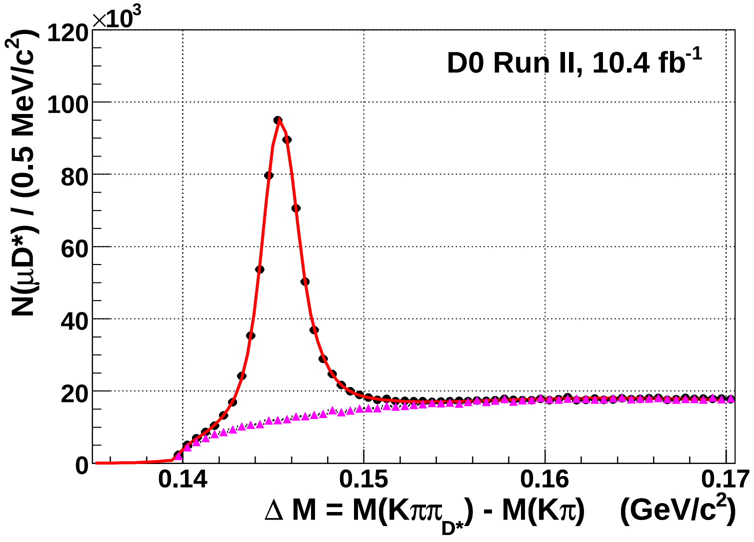
FERMILAB-PUB-12-338-E

A_{sl} in $B_d \to D^{(*)-}\mu^+ X$ @ D0

740 k $D\mu$ candidates



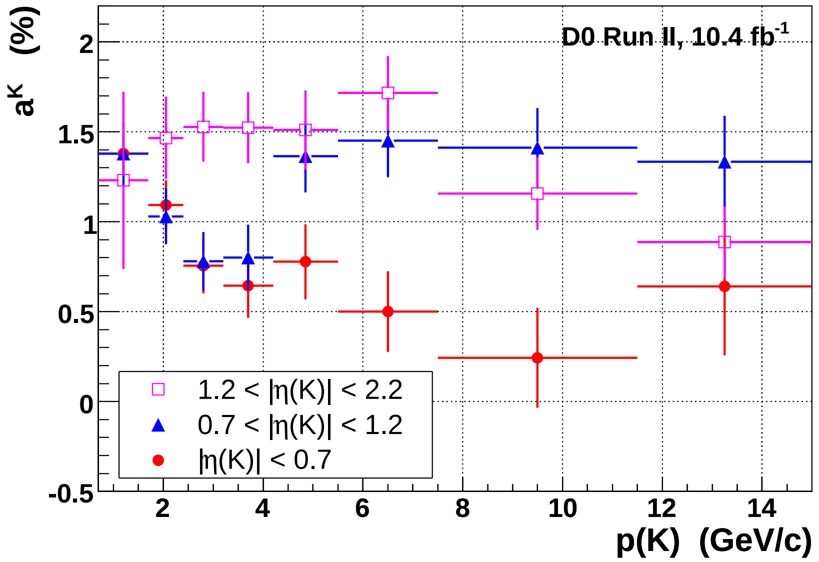
454 k $D^*\mu$ candidates



main challenge to determine asymmetry

in kaon material IA (a_K)

$\longrightarrow$ exploit $K^{*0} \to K^+\pi^-$ decays

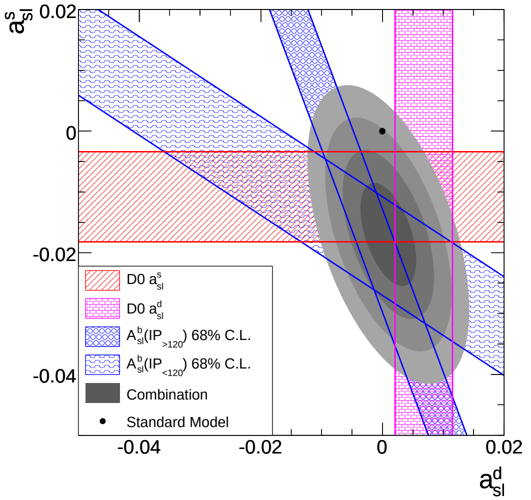


FERMILAB-PUB-12-488-E

A_{sl} Results

D0

FERMILAB-PUB-12-338-E/FERMILAB-PUB-12-488-E



a^s_{sl} = [-1.08 $\pm$ 0.72 $\pm$ 0.17] %

a^d_{sl} = [0.68 $\pm$ 0.45 $\pm$ 0.14] %

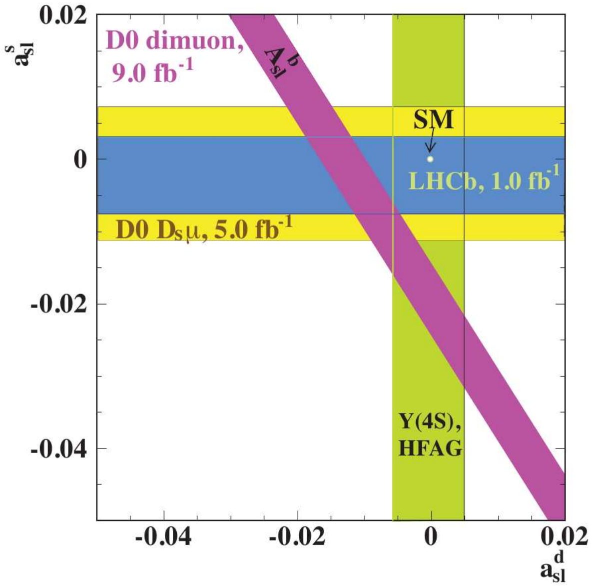
combination with previous result:

a^s_{sl}(comb) = [-1.70 $\pm$ 0.56] %

a^d_{sl}(comb) = [0.10 $\pm$ 0.30] %

LHCb

LHCb-CONF-2012-022



a^s_{sl} = [-0.24 $\pm$ 0.4 $\pm$ 0.33] %

(limiting systematic, statistics of control samples)

next step:

more data, more modes + B_d

$\sim 3\sigma$ tension with SM in D0 result, neither confirmed nor excluded by LHCb ...

Summary

Many new world best results in B_s system:

- combined LHC result: $BR(B_s \rightarrow \mu^+\mu^-) < 4.2 \cdot 10^{-9})$

  large new physics contributions ruled out

- First evidence for direct CPV in B_s system

  $A_{CP}(B_s \rightarrow K\pi)$ = 0.27 $\pm$ 0.08 $\pm$ 0.02 (LHCb)

  $A_{CP}(B_s \rightarrow K\pi)$ = 0.22 $\pm$ 0.07 $\pm$ 0.02 (CDF)

- Mixing phase ϕ_s in good agreement with SM, still room for NP

  ϕ_s = -0.002 $\pm$ 0.083 $\pm$ 0.027 rad (LHCb)

- D0 confirms tension in a_{sl} in analysis of $B_s \rightarrow D_s \mu X$

  a^s_{sl} = [-1.70 $\pm$ 0.56]%, a^d_{sl} = [0.10 $\pm$ 0.30]%

  LHCb result consitent with SM and with D0 result.

  a^s_{sl} = [-0.24 $\pm$ 0.4 $\pm$ 0.33]%

B_s systems stays interesting to look for NP - many more LHC data available!

Backup

BR $(B_s \to J/\psi K^+ K^-)$

$N = \mathcal{L} \times \sigma_{b\bar{b}} \times f_s \times \sigma \times \epsilon$

signal yield = luminosity × prod. X-section × fragmentation func. × BR × efficiency

Belle Y(5S) - 121 fb^{-1} (ICHEP 2012)

BR($B_s \to J/\psi\phi$) = $(1.25 \pm 0.07 \pm 0.20) \times 10^{-3}$ limiting systematic f_s

CDF (9.6 fb^{-1})

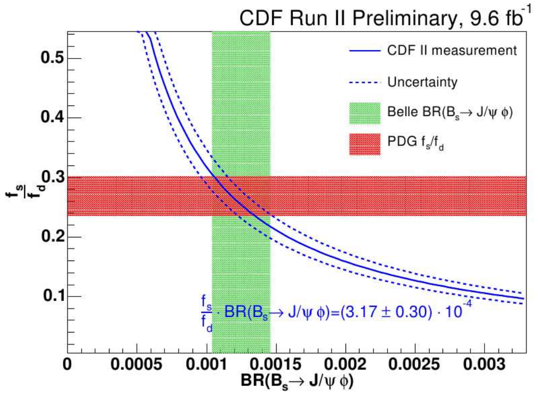
CDF Note 10795

$$\frac{f_s}{f_d}\frac{BR(B_s \to J/\psi\phi)}{BR(B_d \to J/\psi K^*)} = 0.239 \pm 0.003 \pm 0.019$$

BR $(B_s \to J/\psi\phi)$ = $(1.18 \pm 0.02 \pm 0.09 \pm 0.14 \text{ (frag.)} \pm 0.05 \text{ (PDG)}) \times 10^{-3}$

with Belle result as input:

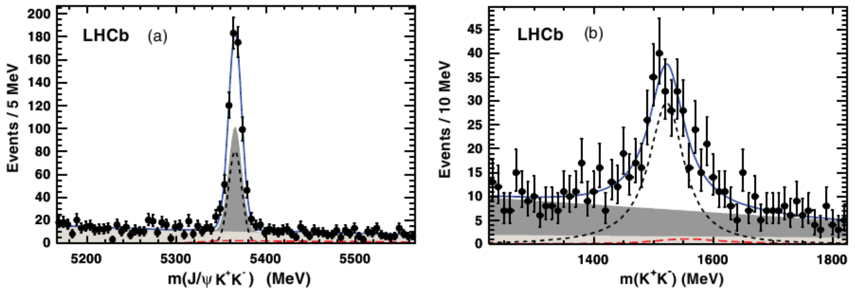
$$\frac{f_s}{f_d}(\text{all } p_T \text{ range}) = 0.254 \pm 0.003 \pm 0.020 \pm 0.044 \text{ (BR)}$$



Observation of $f_2(1525)$ (S=2):

$R_{f_2'(1525)/\phi}$ = $0.264 \pm 0.027 \pm 0.024$

LHCb - Phys. Rev. Lett 108 151801 - 2012



$R_{f_2'(1525)/\phi}$ = $0.22 \pm 0.05 \pm 0.04$ D0 - FERMILAB-PUB-12-104-E

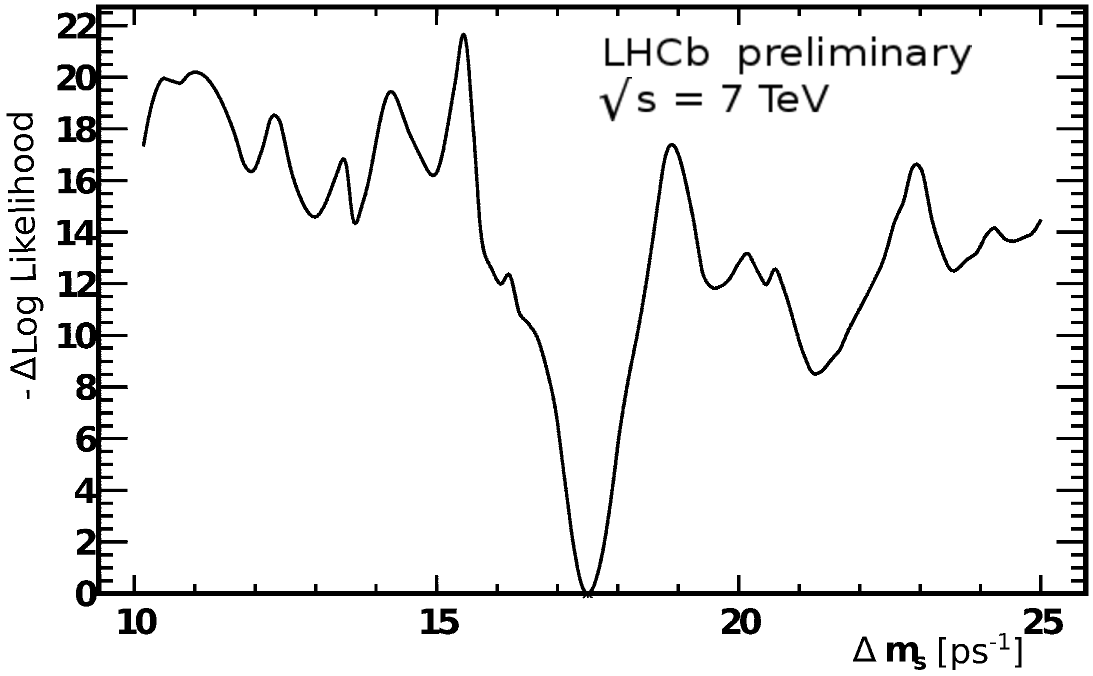
Δm_s in $B_s \to J/\psi\phi$

Extract ϕ_s from terms like $\sin\phi_s \times \sin\Delta m_s$

$\longrightarrow$ are we able to resolve the fast mixing frequency?

For cross-check, fit without constraint on Δm_s

(PDF has terms of $\sin\Delta m_s$ independently of ϕ_s):



We observe a central value Δm_s = 17.50 $\pm$ 0.15 ps^{-1}

(compare to LHCb published measurement: 17.725 $\pm$ 0.041 $\pm$ 0.026 ps $^{-1}$)

Lifetimes

lifetime in flavour specific final states (e.g. $B_s \to D_s\pi$): $\Gamma_s = \frac{\Gamma_H + \Gamma_L}{2}$

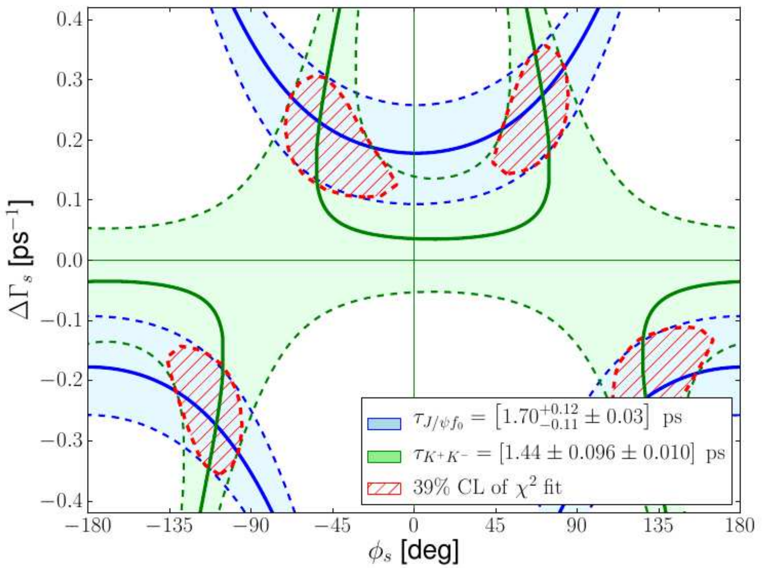
in case of no CPV: CP odd: $B_s \to J/\psi f_0$: Γ_H CP even: $B_s \to KK$: Γ_L

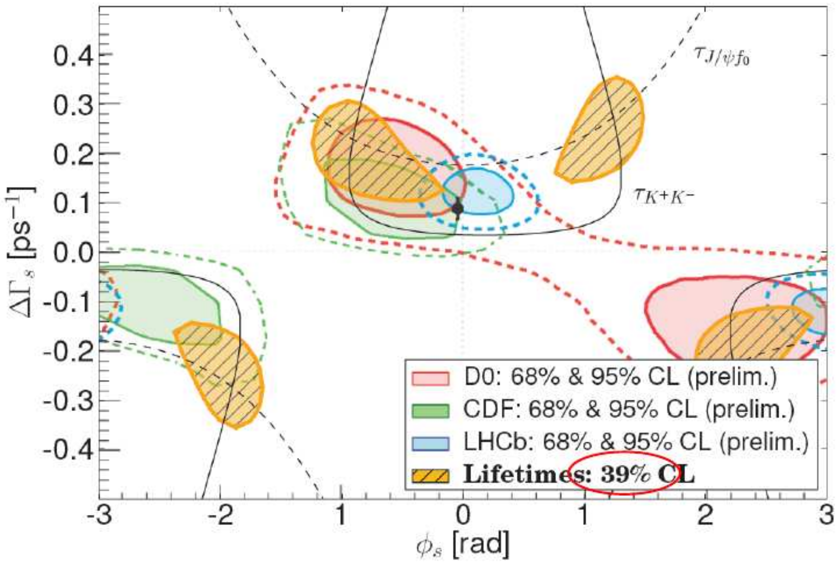
Lifetimes provide independent constraints in $\Delta\Gamma$ vs. ϕ_s plane!

with $B_s \to J/\psi\phi$ status end of 2011

$\tau_{K^+K^-}$ = 1.440 $\pm$ 0.096 (stat) $\pm$ 0.010 (sys) ps LHCb, [PLB 707 (2012)], superceded

$\tau_{J/\psi f^0}$ = 1.70 $^{+0.096}_{-0.11}$ (stat) $\pm$ 0.03 (sys) ps CDF, [PRD84:052012,2011]





Fleischer, Knegjens [arXiv:1109.5115]

For new results on lifetimes, see talk from Stefano Argiro

New Lifetime Results

Several approach to deal with potential acceptance bias

1) "swimming" (determine event-by-event acceptance, first used by CDF PRD 83, 032008 (2011)

2) measure relative lifetime

$$\tau_{J/\psi f^0} = 1.700 \pm 0.040(stat) \pm 0.026(sys) \text{ ps}$$

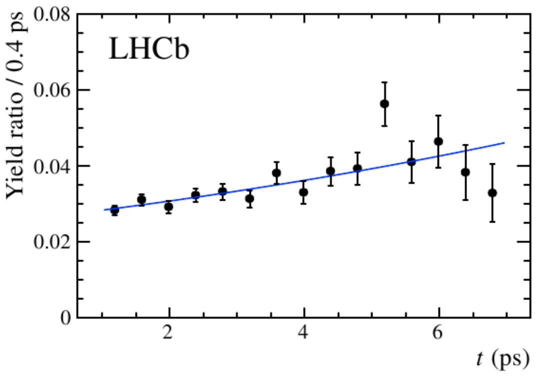
LHCb: arXiv:1207.087v2

3) develop dedicated trigger/reconstruction lines avoiding any biasing cuts

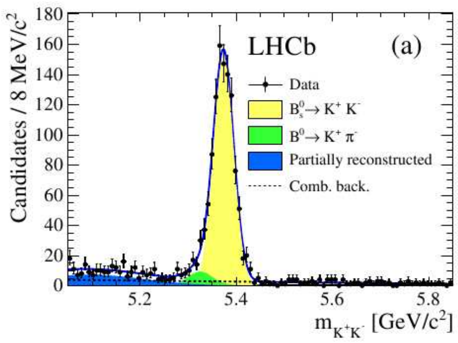
(very challenging for fully hadronic modes)

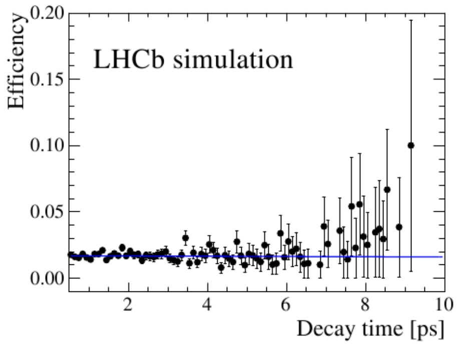
$$\tau_{K^+K^-} = 1.455 \pm 0.046(stat) \pm 0.006(sys) \text{ ps}$$

arXiv:1207.5993v1 (supercedes pervious result)



$\tau(B_s \to J/\psi f_0)/\tau(B_d \to J/\psi K^*)$





$B_s \to KK$