LHCb Status Report
105th LHCC meeting

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On behalf of the LHCb Collaboration

Outline

1. **Introduction:**
   - What happened since the last LHCC meeting?
   - LHCb performance.
   - The LHCb physics program.
2. **Production Studies:**
   - Weak bosons production
   - J/Ψ, double J/Ψ and Υ production
   - B_c production
   - b bbar production.
   - Ratio of fragmentation functions: f_d/f_s
3. **Observation of new B_s decays.**
4. **Search for new CP phases in B_d and B_s mixing.**
   - Towards a precise measurement of γ at tree level.
   - Observation of CP violation in $B \to hh'$: towards a measurement of γ from loops.
   - Status of the $B_s \to J/\psi\, \Phi$ analysis: Acceptance, angular analysis, flavour tagging, Δm_s,…
5. **Search for NP contributions in $B_{d,s}$ rare decays.**
   - Observation of $B_d \to K^*\mu^+\mu^-$.
   - Search for $B_{d,s} \to \mu^+\mu^-$
6. **Outlook and Conclusions.**

1. Introduction

What happened since the last LHCC?

Last LHCC meeting was on November 17th, few days after end of LHCb data taking in 2010.

Other than the **detector work** performed during the technical stop, since then, the whole 2010 data sample has been re-processed with the **latest alignment** database and **streamed** for Data Analysis.

Large MC samples consistent with the 2010 data taking conditions, have been produced to support the LHCb analyses shown at the Winter Conferences (**~20 Conference Notes**). Big effort from the LHCb computing group.

Today, in 30 minutes, you can only expect a superficial overview of some of the physics results. More information can be obtained from the Conference Notes quoted.

Technical Stop

Main Detector Activities:

Silicon Tracker: Exchange and repair of modules with broken bounds.
RICH: Replacement of ~7% HPDs.
OT: Repair FE, disconnect few broken channels.
CALO: Replace few PMTs.
MUON: Replace few non-fully operational chambers.

Overall very small changes to the detector. The biggest improvement is in the HLT farm:

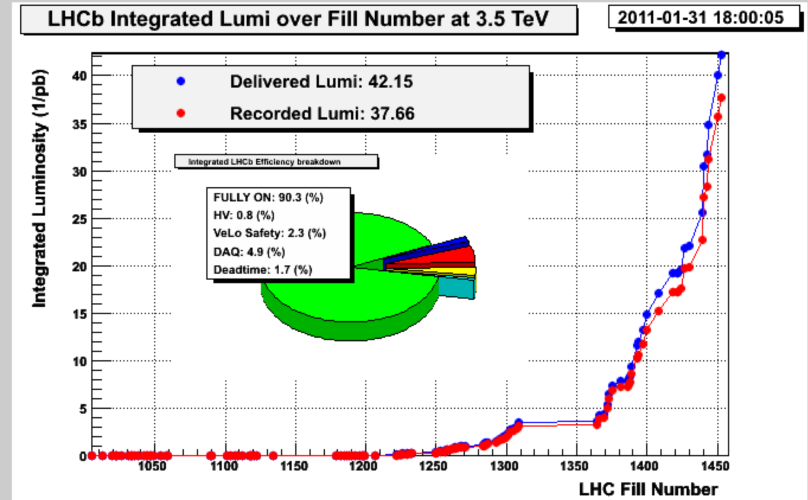
HLT: Addition of 100 boxes (400 nodes), for a total of 50 subfarms x 27 nodes x (8 to 20) HLT tasks running = 24600 HLT tasks!

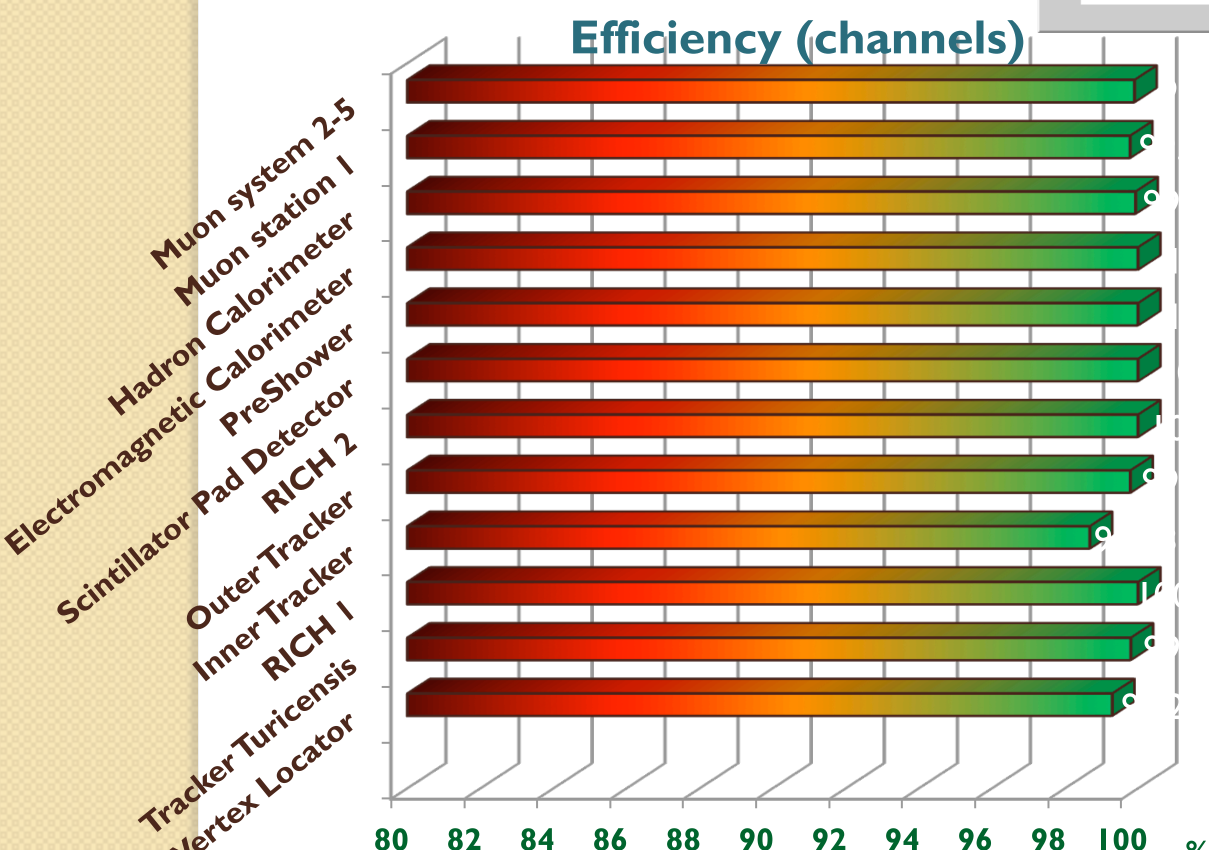
A lot of work also *on infrastructure maintenance and safety*

Data taking in 2010(11)

Recorded **~38 pb^{-1} in 2010** with **~90% efficiency**.

Most of it (~¾) was collected in a single month (October 2010).





All sub-detectors working at **> 99% efficiency**.

2011 data taking just started:

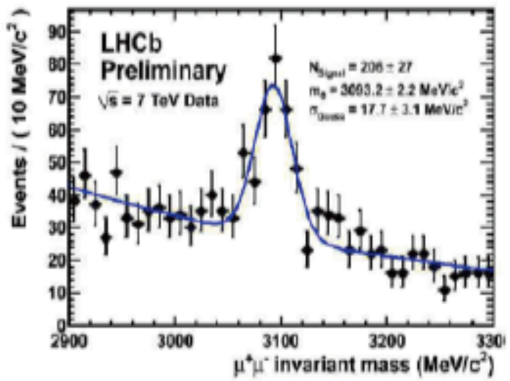
Initial 2011 fills (with 3 bunches) used to re-calibrate the detector. Some data taken with magnet off for alignment.

Fills with 32/64/136/200 bunches being taken as of today with >90% efficiency.

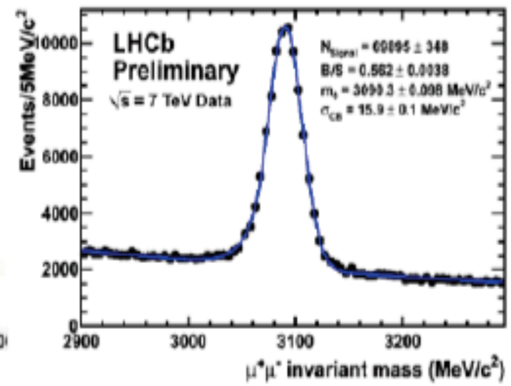
LHCb performance: momentum and vertex resolution

Evolution of $J/\psi \rightarrow \mu^+\mu^-$ mass resolution with time (MC ~ 12 MeV/c²)

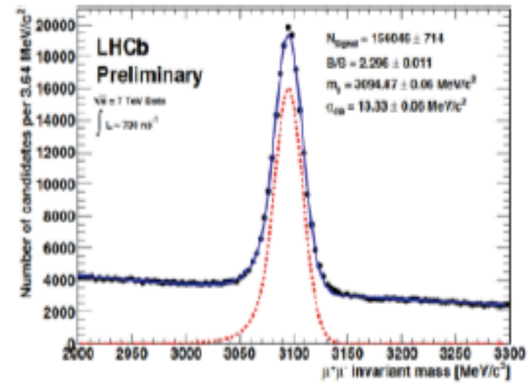
May: σ ~ 18 MeV/c²



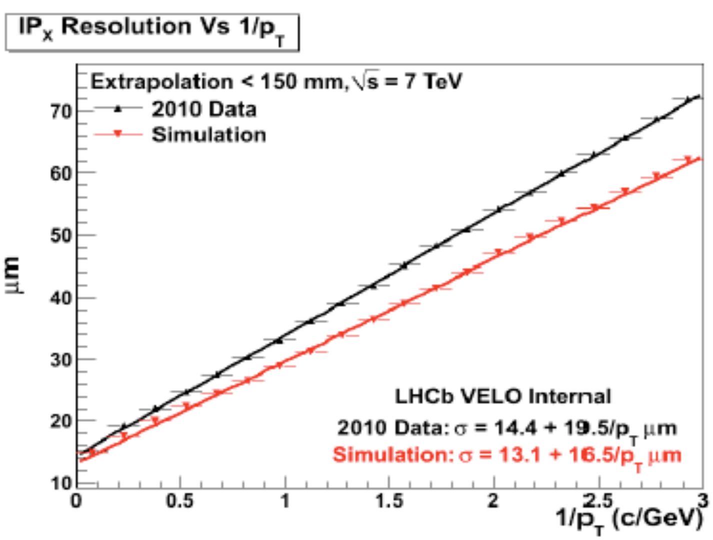
August: σ ~ 16 MeV/c²



November: σ ~ 13 MeV/c²



Fantastic job by a very hard-working group of people improving the alignment!

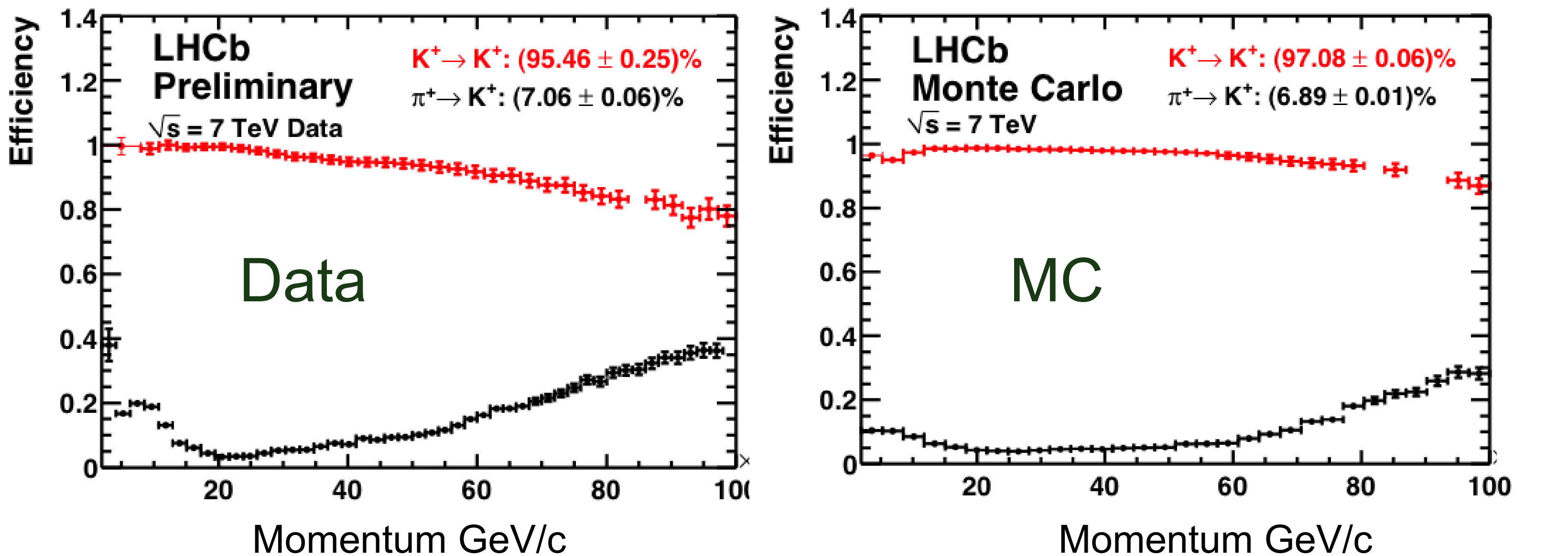


PV resolution: $\sigma_x \sim \sigma_y \sim 16$ μm (MC:11μm) , $\sigma_z \sim 76$ μm (MC:60 μm) as measured for events with 25 tracks/ event.

IP resolution: σ(IPx)~15-20 μm in the region of interest. Slope dominated by material interactions rather than misalignment.

LHCb performance: PID and Trigger

RICH PID working close to MC expectations.
Clean reconstruction of many hadronic decays.



Trigger efficiencies very close to expectations

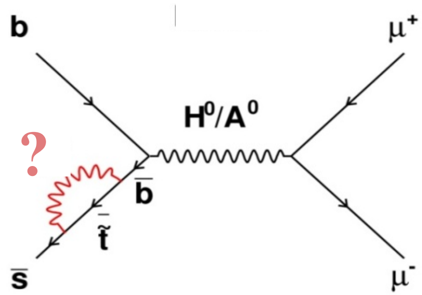
Trigger efficiencies L0xHLT1 determined on data using the tag-and-probe methods:

	Muon trigger (J/ψ)	Hadron trigger (D^0)
Data	94.9±0.2%	60±4%
MC	93.3±0.2%	66%

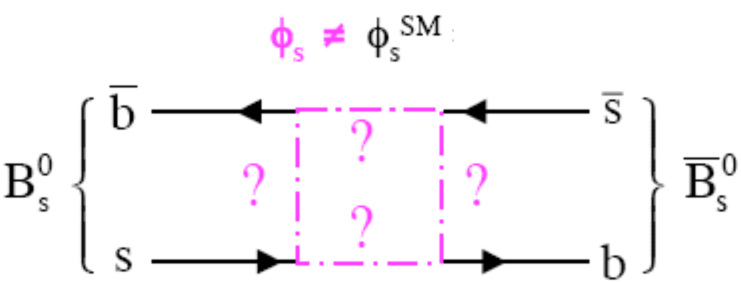
LHCb Physics Program

The main LHCb physics goal is to find **evidence for New Physics**, through the **indirect effect** that the new degrees of freedom may have on B and D decays.

This search is **complementary** to direct searches, and provides information on the **masses, couplings, spins and CP phases.**



$B_s \rightarrow \mu^+\mu^-$ Higgs "Penguin"



B_s–$\bar{B}_s$ oscillations: "Box" diagram

LHCb is therefore using LHC as an **"intensity frontier"** machine, rather than "energy frontier". But, if so, do we really expect to be **competitive with ~40 pb^{-1}** of data collected in 2010 compared with >6000 pb^{-1} at CDF/D0, when the b bbar xsection is only a factor three larger?

The answer is yes due to the LHCb acceptance, trigger and detector resolution. To be shown in the following slides…

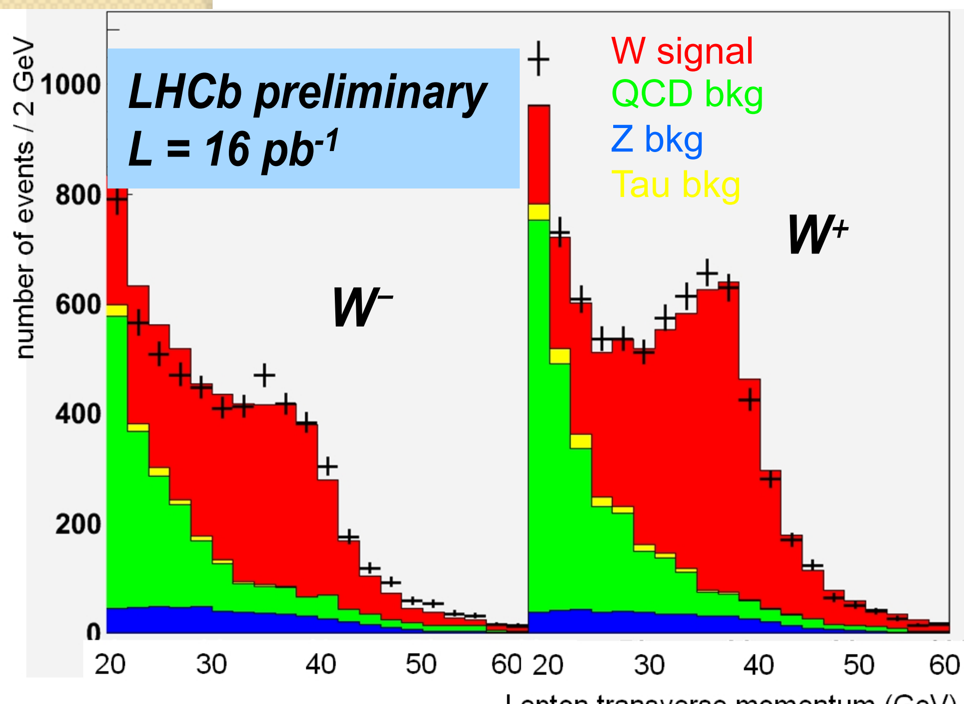
2. Production Studies

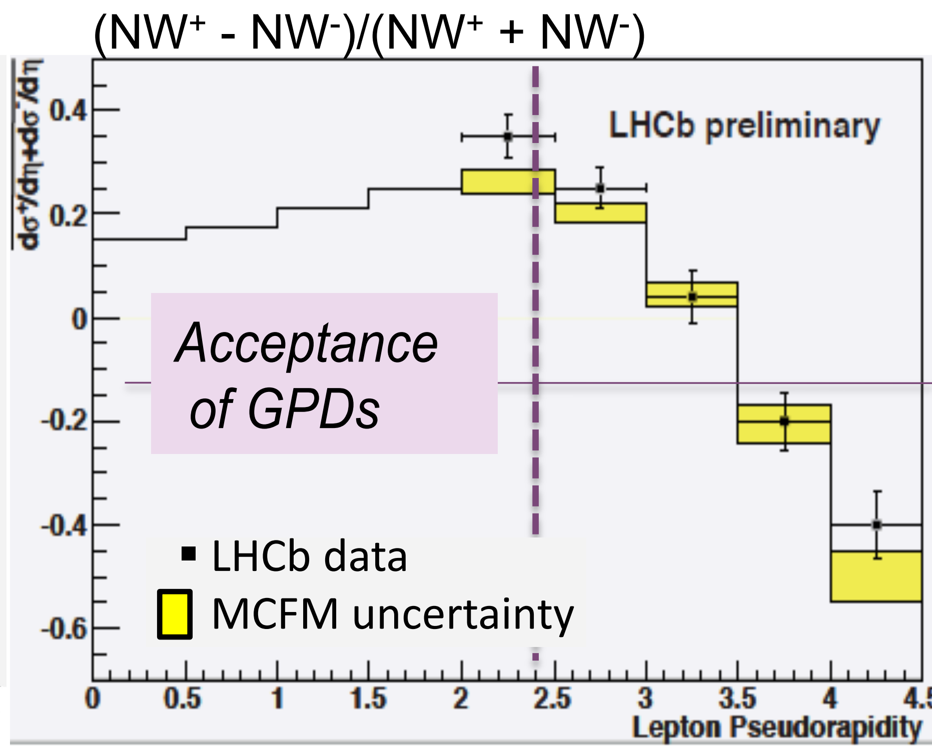
$W^{\pm}$ production in the forward region

LHCb-CONF-2011-012

The comparison of the $W^{\pm}$ asymmetries measured at LHCb with the different PDFs, provides constraints on the **low x** quark content of the protons at **high q^2.**

W selection: isolated μ with P_T>20 GeV/c and small recoil P_T.



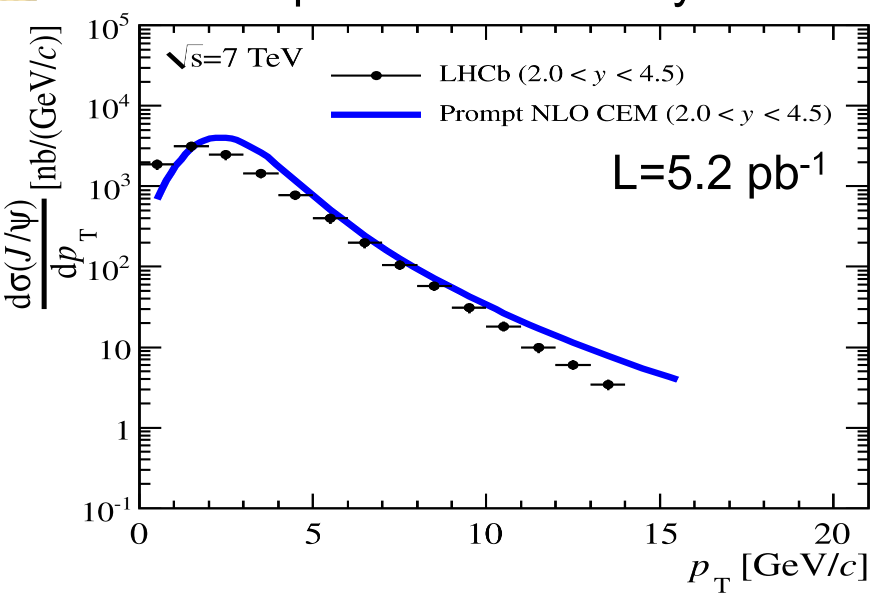


Prompt J/Ψ production

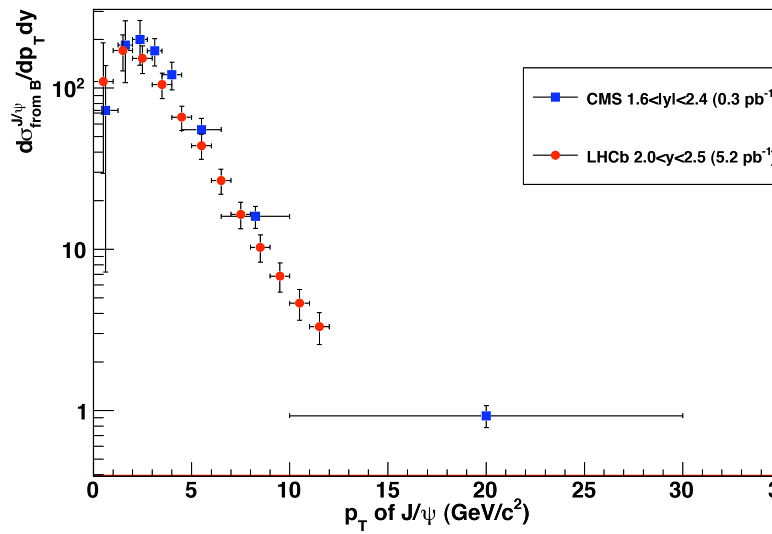
arXiv:1103.0423 (submitted to EPJ C)

σ(*prompt J/ψ, P_t<14 GeV/c, 2<y<4.5*) =
= (*10.52±0.04±1.40$^{+1.64}_{-2.20}$*) *μb*

Comparison with theory



Comparison with CMS



Double J/Ψ production observed in 35.2 pb^{-1} in agreement with expectations

LHCb-CONF-2011-009

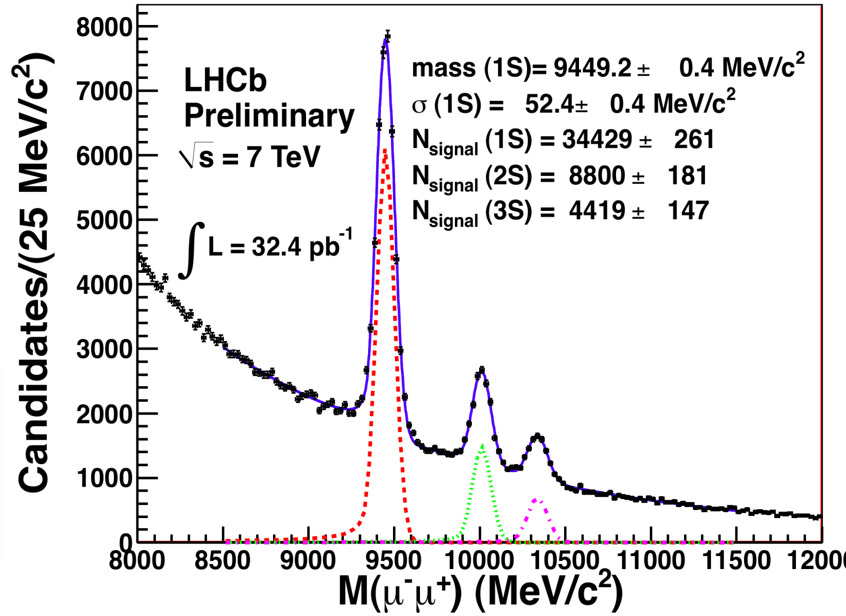
N(2J/ψ) = 136.7±17.5
σ(2J/ψ, P_t (J/ψ)<10 GeV, 2<y(J/ψ)<4.5) =
= 5.6 ± 1.1 ± 1.2 nb

Υ production

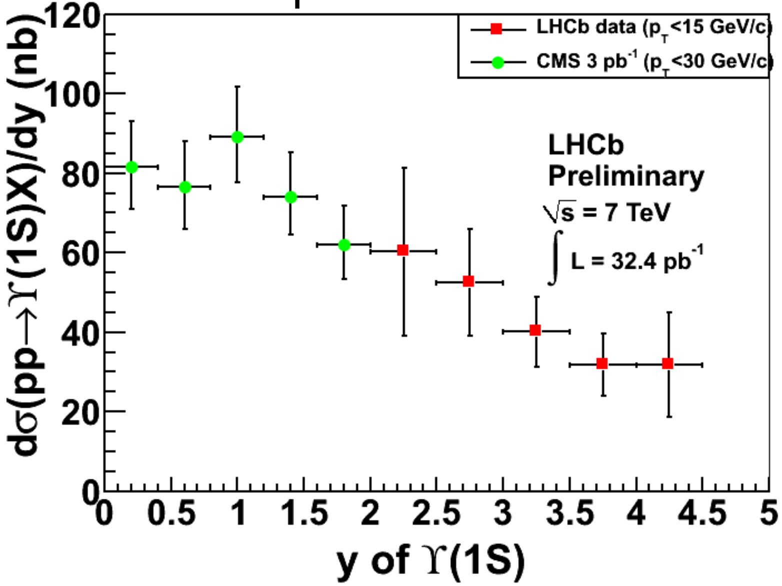
LHCb-CONF-2011-016

LHCb preliminary:

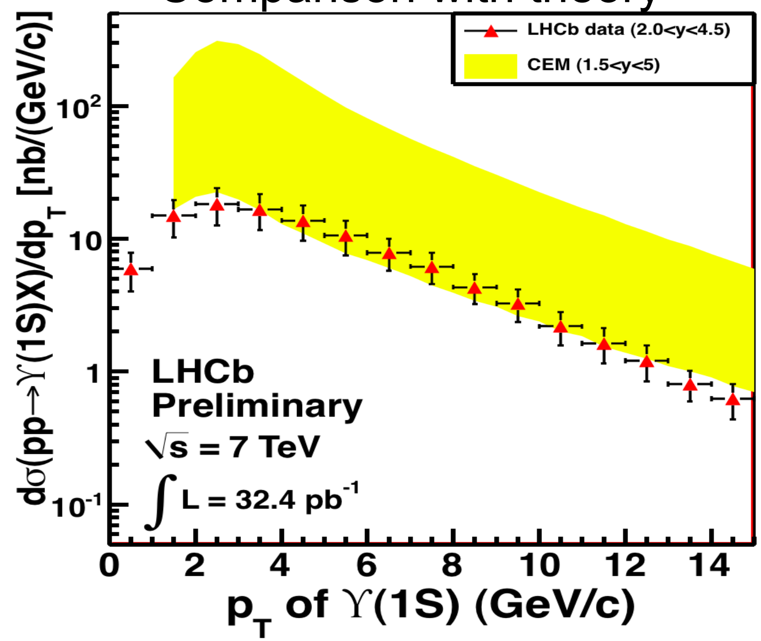
$\sigma(Y(1S),\ P_t < 15\ GeV,\ 2<y<4.5) = 108.3 \pm 0.7 \pm ^{30.9}_{25.8}\ nb$



Comparison with CMS



Comparison with theory



B_c^+ production

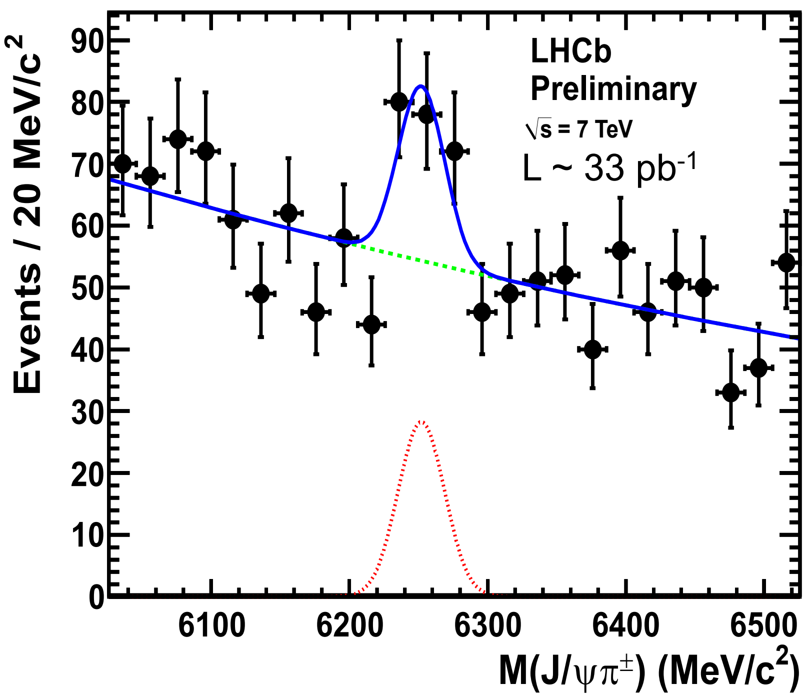
LHCb-CONF-2011-017

B_c^+ is an interesting object, (c bbar), to understand QCD.

First observation at CDF in 1998. Only seen in three decay modes:
$B_c^+ \rightarrow J/\Psi\ \pi^+$ (~100 candidates), $B_c^+ \rightarrow J/\Psi\ \mu^+ \nu$ and $B_c^+ \rightarrow J/\Psi\ e^+ \nu$ (~1k candidates each).

At LHCb we measure for $p_T(B_c^+)$>4 GeV/c:

$$R_{c+} = \frac{\sigma(B_c^+) \times \mathscr{B}(B_c^+ \to J/\psi\pi^+)}{\sigma(B^+) \times \mathscr{B}(B^+ \to J/\psi K^+)} = (2.2 \pm 0.8(\mathrm{stat}) \pm 0.2(\mathrm{syst}))\%$$



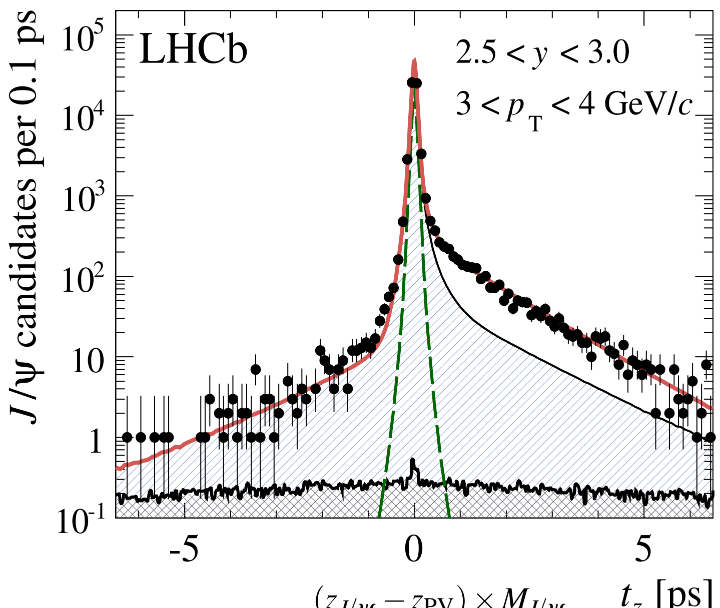
59±18 events observed,
4.1σ statistical significance.

Looks great for the LHCb B_c physics program

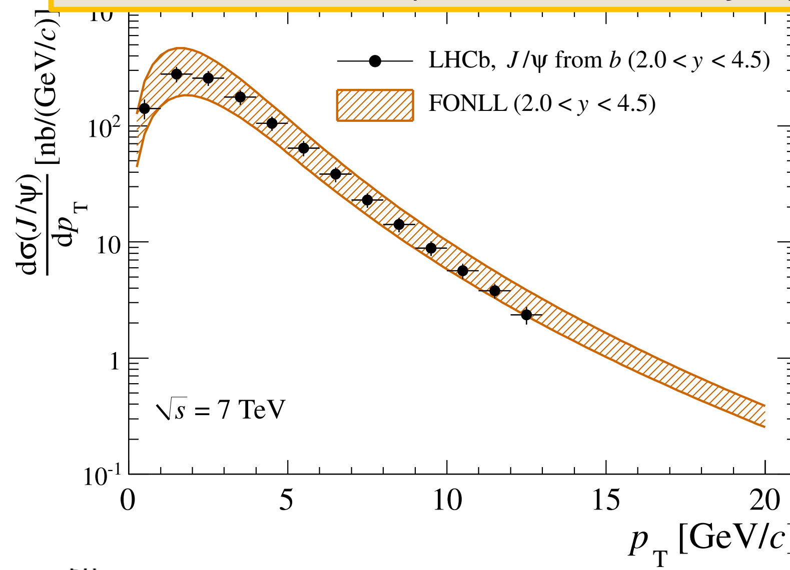
b bbar production

Using J/Ψ produced in B decays: σ(J/Ψ from b, 2<y<4.5)=1.14±0.01±0.16 μb, which would correspond to **σ(pp→b bbar X) = 288±4±48 μb**

arXiv:1103.0423 (submitted to EPJ C)

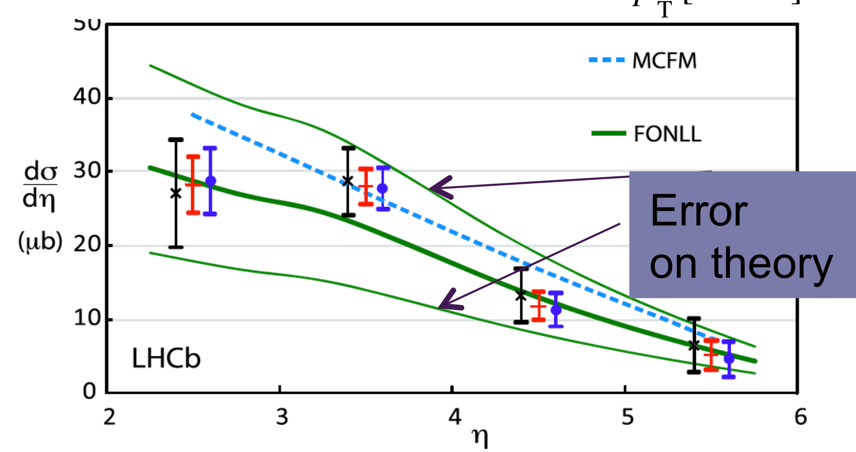


$$t_z = \frac{(z_{J/\psi} - z_{PV}) \times M_{J/\psi}}{p_z},$$



In excellent agreement with LHCb measurement using b → $D^0\mu\nu X$:
σ(pp→b bbar X) = 284±20±49 μb

PLB 694 (2010) 209.



Ratio of fragmentation functions

LHCb-CONF-2011-013

$B_d \to DK$ / $B_s \to D_s\pi$:

- Same 4 particles in the final state
- At present theoretical error of order 7%

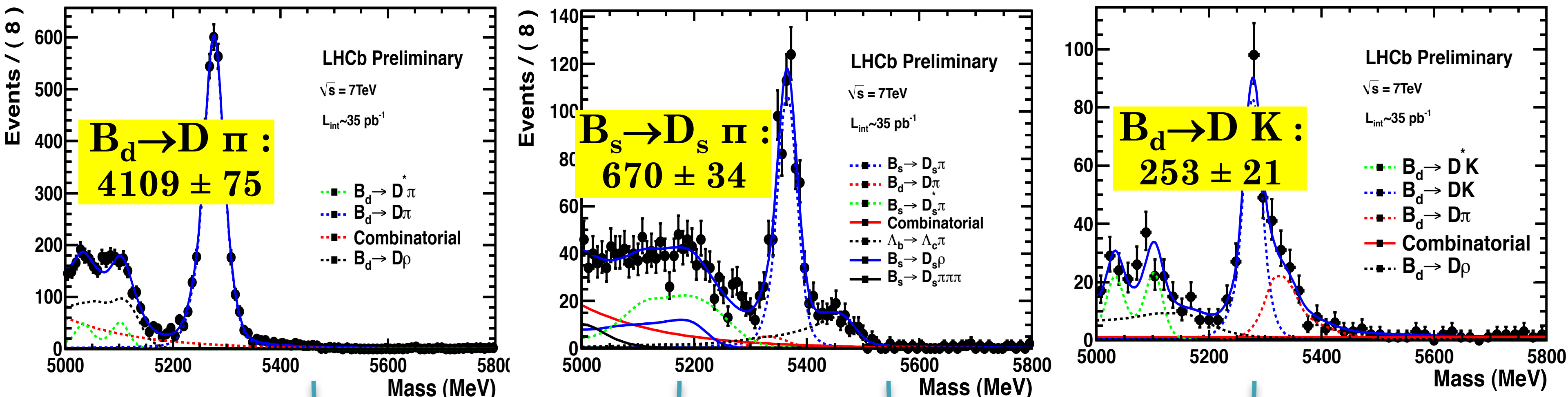
$$\frac{f_d}{f_s} = 13.45 \times \frac{\tau_{B_s}}{\tau_{B_d}} \times \left[\mathcal{N}_a \mathcal{N}_F \frac{\epsilon_{D_s\pi}}{\epsilon_{DK}} \frac{N_{DK}}{N_{D_s\pi}}\right]$$

$B_d \to D\pi$ / $B_s \to D_s\pi$:

- Similar final state
- Theoretical error of order 9% (extra contribution from *exchange diagram)*

$$\frac{f_d}{f_s} = 1.018 \times \frac{\tau_{B_s}}{\tau_{B_d}} \times \left[\tilde{\mathcal{N}}_a \mathcal{N}_F \mathcal{N}_E \frac{\epsilon_{D_s\pi}}{\epsilon_{D\pi}} \frac{N_{D\pi}}{N_{D_s\pi}}\right]$$

fd/fs using semileptonic $B_{(s)} \to D_{(s)}KX\mu\nu$ to be ready soon.



$$\frac{f_s}{f_d} = 0.249 \pm 0.013^{\mathrm{stat}} \pm 0.020^{\mathrm{syst}} \pm 0.025^{\mathrm{theor}}$$

$$\frac{f_s}{f_d} = 0.242 \pm 0.024^{\mathrm{stat}} \pm 0.018^{\mathrm{syst}} \pm 0.016^{\mathrm{theor}},$$

To be compared with HFAG average: $f_s/f_d = 0.270 \pm 0.034$

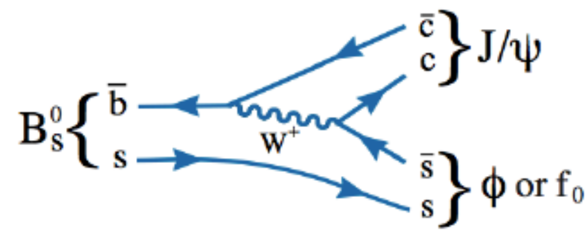
LEP: 0.256±0.026 CDF:0.327±0.039 new CDF(La Thuile): 0.269±0.03

3. Observation of new B_s Decays

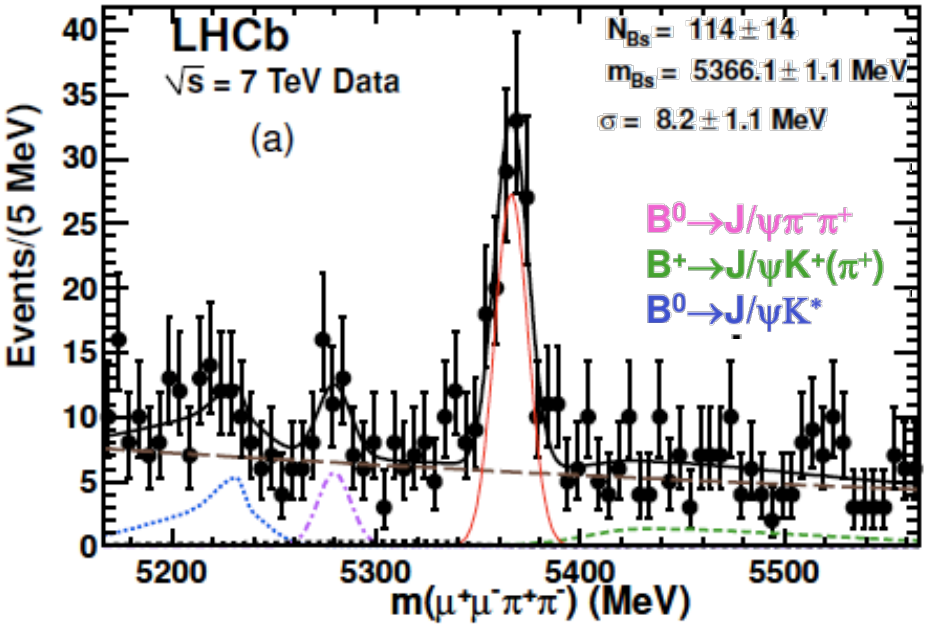
First observation of $B_s \rightarrow J/\Psi\, f_0(980)$ decays

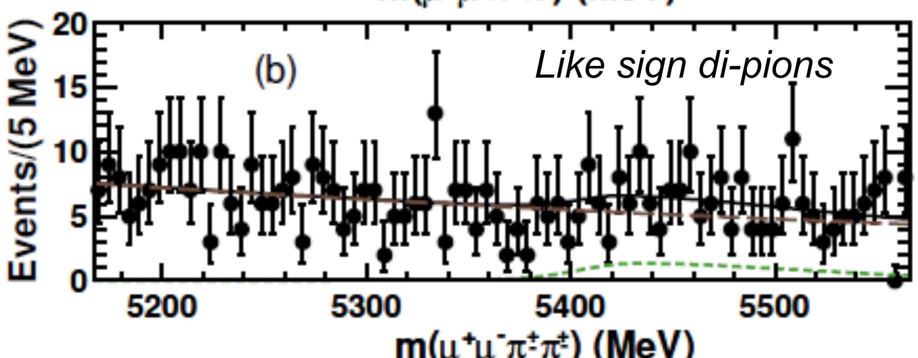
PLB 698 (2011) 115.

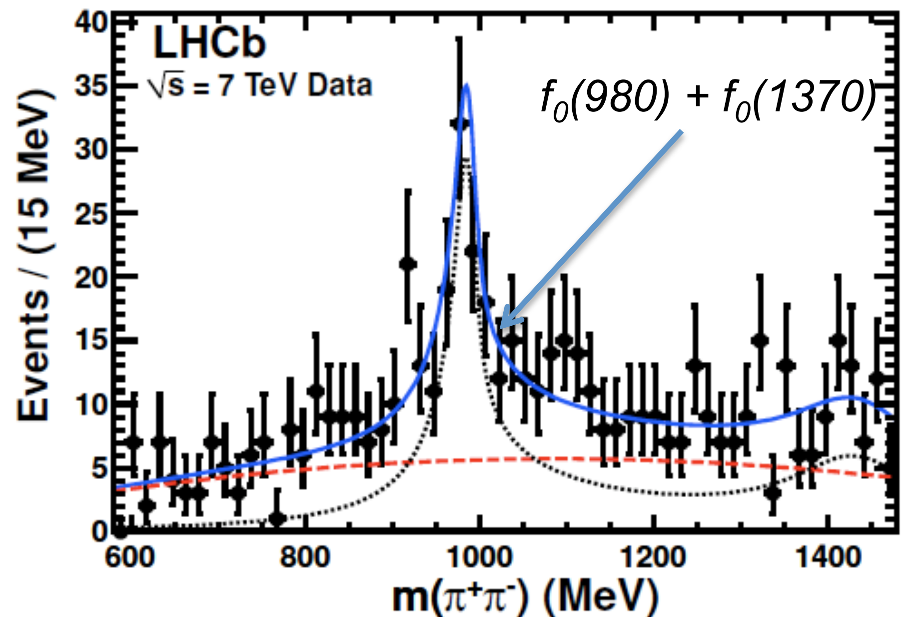
Final state is CP-eigenstate → *no need for angular analysis*
BR is ~¼ of B_s → $J/\Psi\phi$ → looks promising for β_s



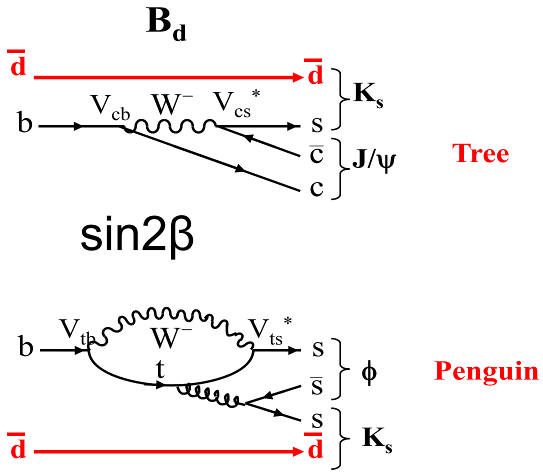
$$\frac{\Gamma(B_s \rightarrow J/\psi f_0,\ f_0 \rightarrow \pi^+\pi^-)}{\Gamma(B_s \rightarrow J/\psi \phi,\ \phi \rightarrow K^+K^-)} = 0.252^{+0.046+0.027}_{-0.032-0.033}$$

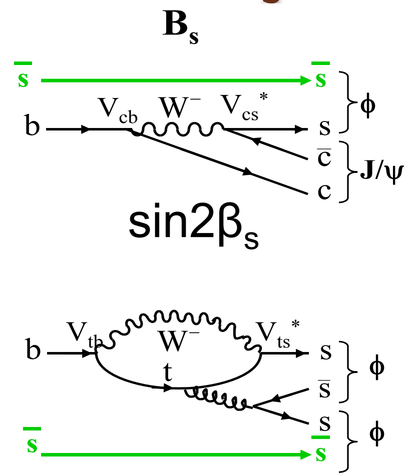






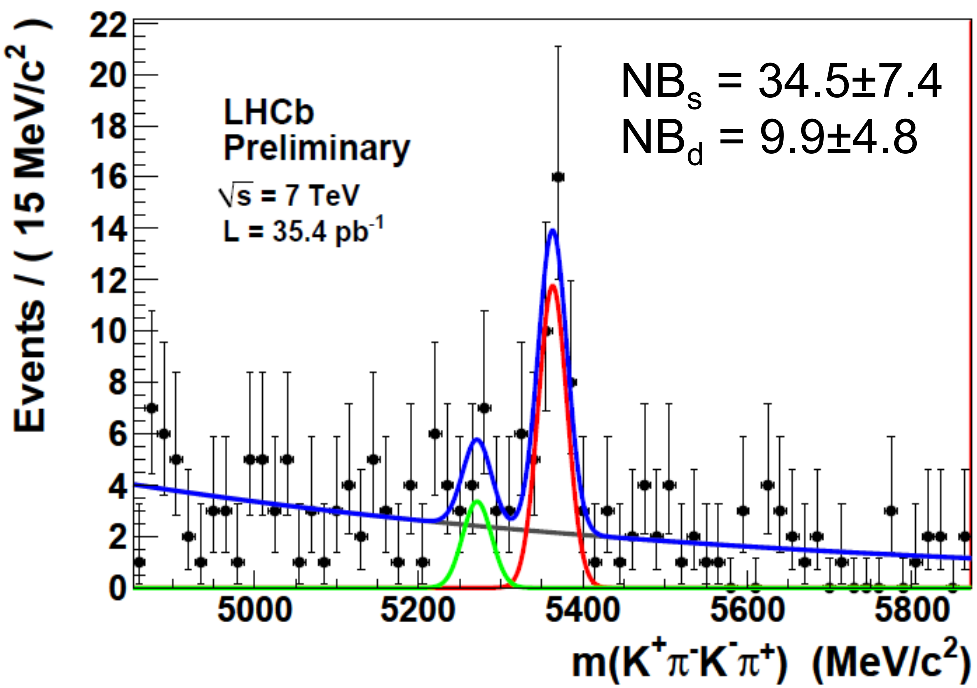
First observation of $B_s \rightarrow K^*K^*$ decay





LHCb-CONF-2011-019

The use of decays like $B_s \rightarrow \phi\phi$ and $B_s \rightarrow K^*K^*$ allows to disentangle NP contributions to the as yet unexplored **penguins in the B_s system.**



$B_d \rightarrow K^*K^*$ observed at BELLE with ~29 events.

LHCb measures BR($B_s \rightarrow K^*K^*$) to be:

$$\frac{\mathcal{B}(\overline{B}^0_s \rightarrow K^{*0}\overline{K}^{*0})}{\mathcal{B}(\overline{B}^0 \rightarrow J/\psi\, \overline{K}^{*0})} = 0.37 \pm 0.09 \pm 0.14$$

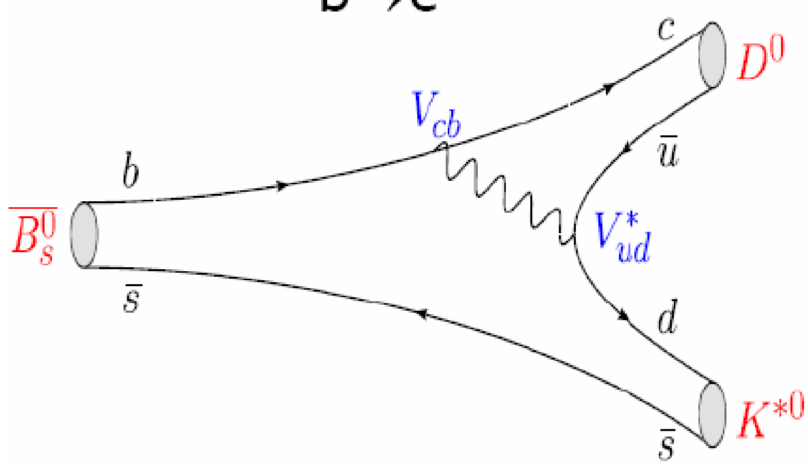
$$\mathcal{B}(\overline{B}^0_s \rightarrow K^{*0}\overline{K}^{*0}) = (1.95 \pm 0.47 \pm 0.72) \times 10^{-5}$$

on the upper side of expectations.

First observation of $\overline{B}_s \rightarrow D^0 K^*$ decay

LHCb-CONF-2011-08

b→c



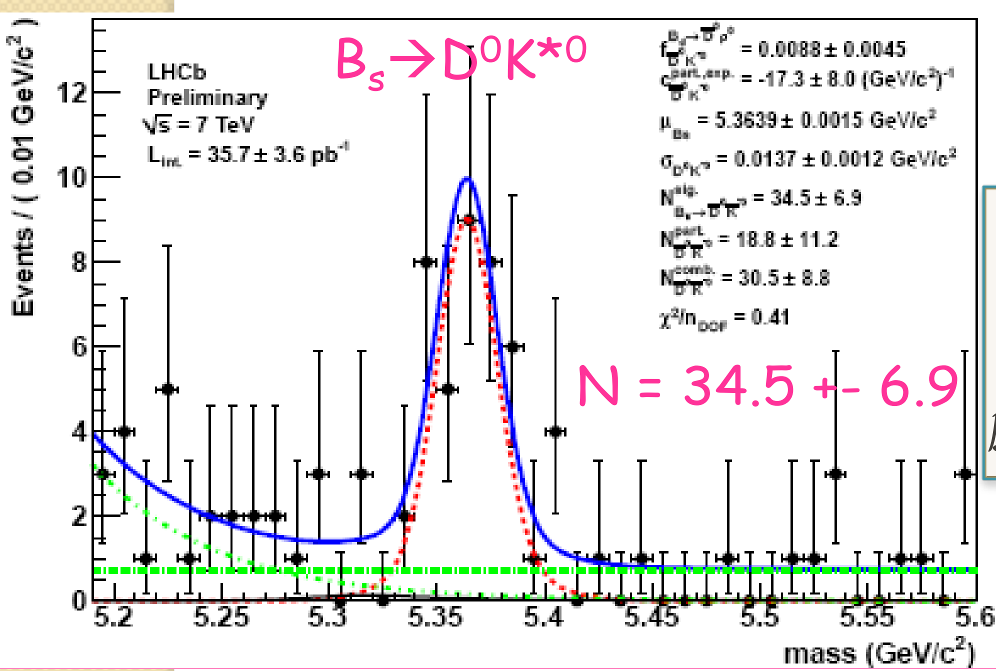
This decay may be a potentially **dangerous background** for the measurement of γ using the ADS method in $B_d \rightarrow D^0K^*$ decays.

With ~36 pb^{-1} the expected yield of $B_d \rightarrow D^0K^*$ is negligible.

LHCb measures BR($B_s \rightarrow D^0K^*$) to be:

$$\frac{\mathcal{B}\left(\overline{B}_s^0 \rightarrow D^0 K^{*0}\right)}{\mathcal{B}\left(\overline{B}^0 \rightarrow D^0 \rho^0\right)} = 1.39 \pm 0.31 \pm 0.25$$

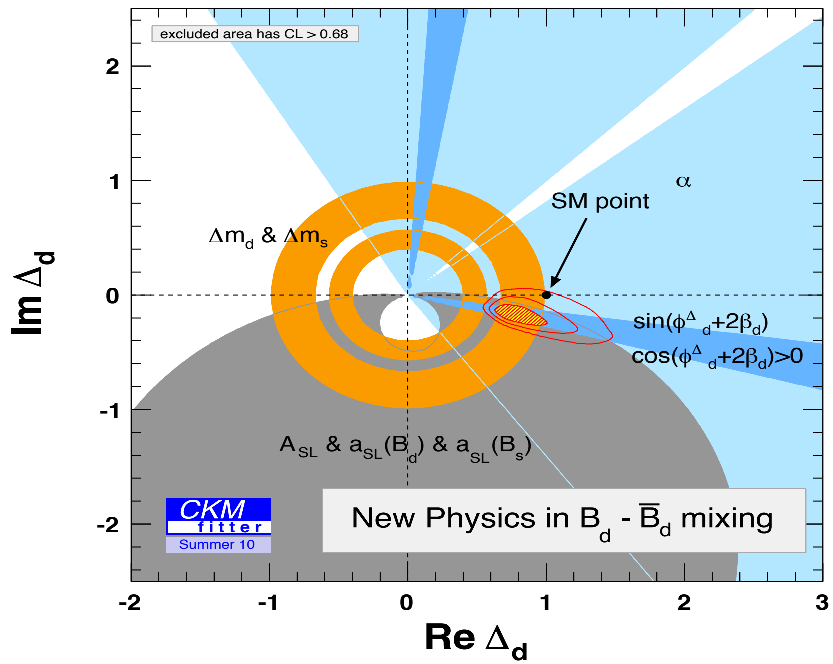
$$\mathcal{B}\left(\overline{B}_s^0 \rightarrow D^0 K^{*0}\right) = (4.44 \pm 1.00 \pm 0.79) \times 10^{-4}$$

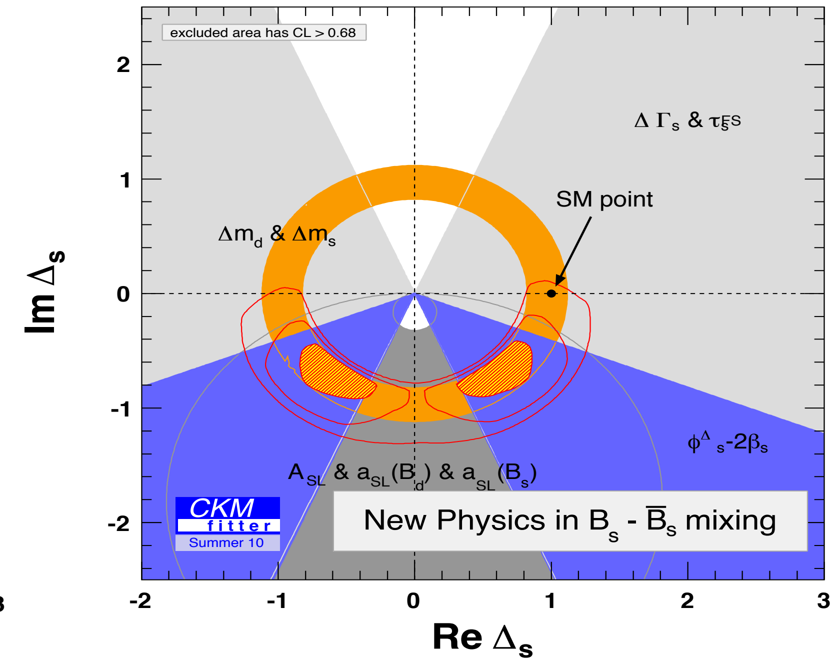


4. Search for new CP phases in B_d and B_s mixing

Is there room for NP in $B_{d,s}$ mixing?

$$\Delta_q \equiv \frac{M_{12}^q}{M_{12}^{q,\mathrm{SM}}}, \qquad \Delta_q \equiv |\Delta_q| e^{i\phi_q^\Delta}.$$





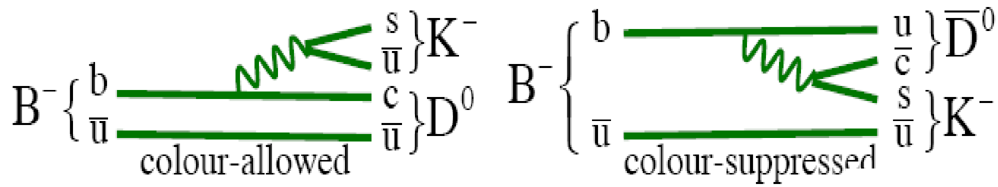
Both, B_d (due to the measurement of $B^+ \rightarrow \tau\nu$) and B_s (due to the measurement of β_s) disfavor the SM at 2.7σ.

Yes, indeed, there is **plenty of room for NP** and it does not look like CMSSM.
LHCb main goals:

1. precise determination of **γ at tree level** (disentangle NP contribution to sin2β)
2. precise determination of $\boldsymbol{\beta_s}$

Prospects for a measurement of γ using $B^+ \to D^0K^+$, $B^0 \to D^0K^*$ and $B_s \to D_sK$

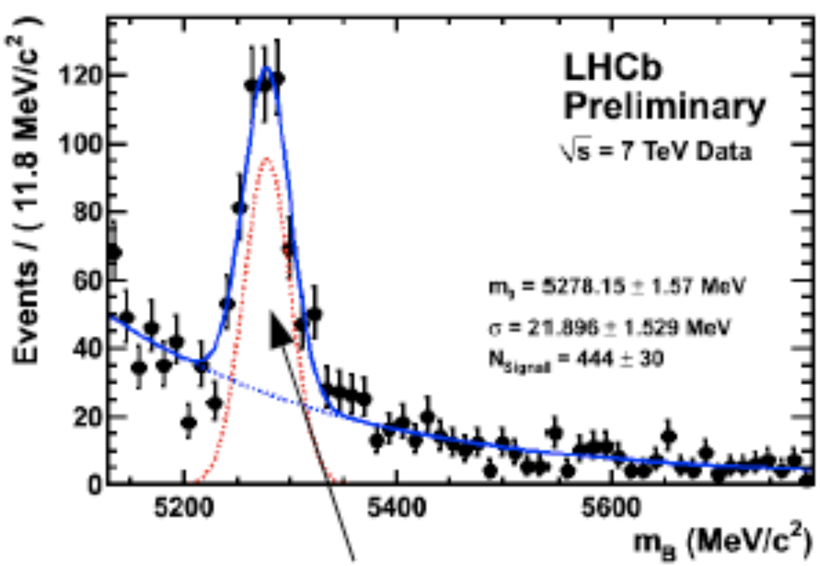
Similar diagrams for B^0. No penguin pollution, only affected by possible NP in D^0 mixing.



B^0 and D^0 decays self tagging.

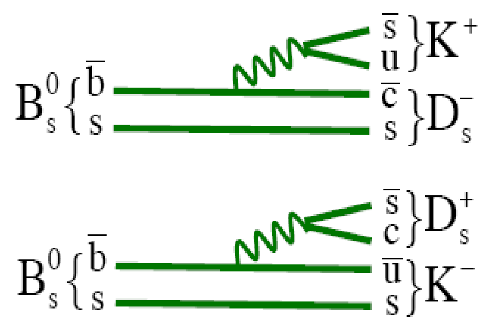
No need to do a time dependent analysis. Only the ratio of the different decay modes is needed → Challenge is to extract the suppressed modes.

$B^\pm \to DK^\pm$ with $D \to \pi K$



LHCb yield: 444 ± 30 / 34 pb^{-1}
CDF yield: 516 ± 37 / fb^{-1}

Alternatively, use **time dependent CP asymmetry from $B_s \to D_sK$.**



Expect to measure γ with a combined precision of ~5° from 2011/2012 data

Prospects for a measurement of γ using multi-body B_d decays.

LHCb-CONF-2011-07

In analogy to the decay $B^{\pm}\rightarrow D^0K^{\pm}$, the decay $B^{\pm}\rightarrow D^0K^{\pm}\pi^+\pi^-$ can be used to determine γ if the intermediate resonances can be properly modelled.

As proof of principle LHCb has measured:

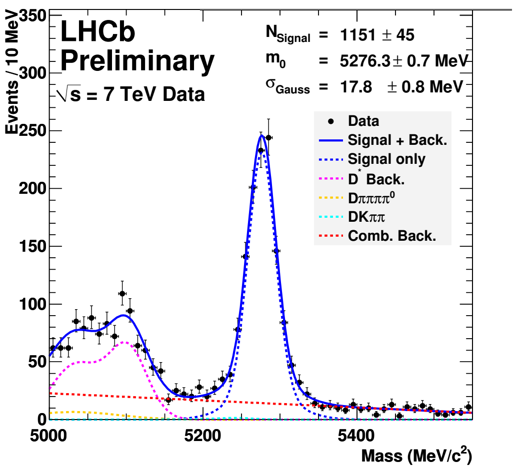
$$\frac{\mathcal{B}(\bar{B}^0 \to D^+\pi^-\pi^+\pi^-)}{\mathcal{B}(\bar{B}^0 \to D^+\pi^-)} = 2.35 \pm 0.11(\text{stat}) \pm 0.24(\text{syst})$$

$$\frac{\mathcal{B}(B^- \to D^0\pi^-\pi^+\pi^-)}{\mathcal{B}(B^- \to D^0\pi^-)} = 1.26 \pm 0.07(\text{stat}) \pm 0.12(\text{syst})$$

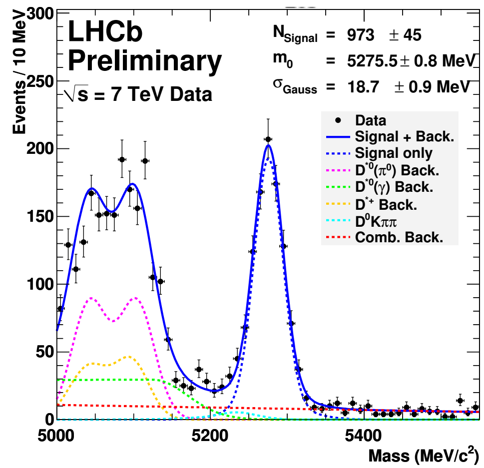
$$\frac{\mathcal{B}(\bar{B}^0_s \to D^+_s\pi^-\pi^+\pi^-)}{\mathcal{B}(\bar{B}^0_s \to D^+_s\pi^-)} = 2.22 \pm 0.41(\text{stat}) \pm 0.25(\text{syst})$$

$$\frac{\mathcal{B}(\Lambda^0_b \to \Lambda^+_c\pi^-\pi^+\pi^-)}{\mathcal{B}(\Lambda^0_b \to \Lambda^+_c\pi^-)} = 1.32 \pm 0.15(\text{stat}) \pm 0.14(\text{syst})$$

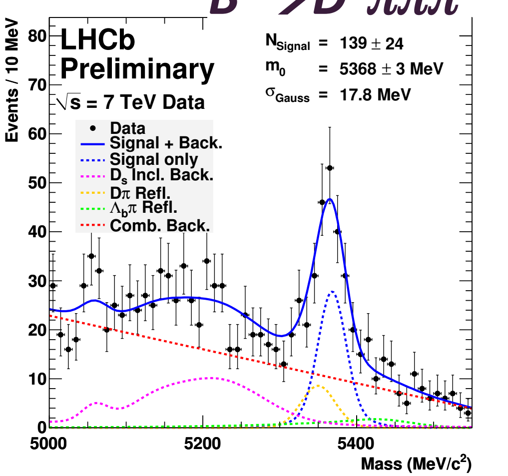
$B^0 \rightarrow D^-\pi^+\pi^-\pi^+$



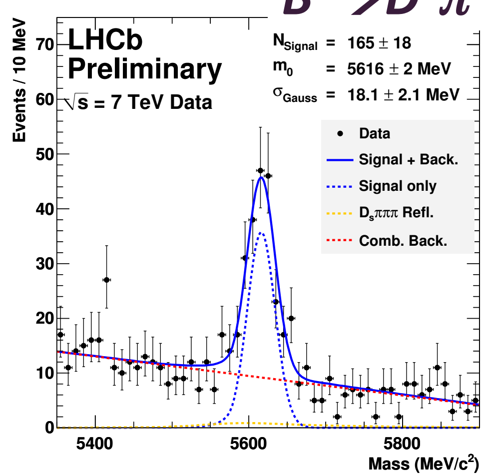
$B^0 \rightarrow D^-\pi^+$



$B^+ \rightarrow D^0\pi\pi\pi$



$B^+ \rightarrow D^0\pi$



Up to six tracks in the final state!

With better precision than current PDG, and yields larger than the single bachelor equivalent. The decays $X_b\rightarrow X_c\pi\pi\pi\pi$ are dominated by a single resonance $a_1(1260)^+$.

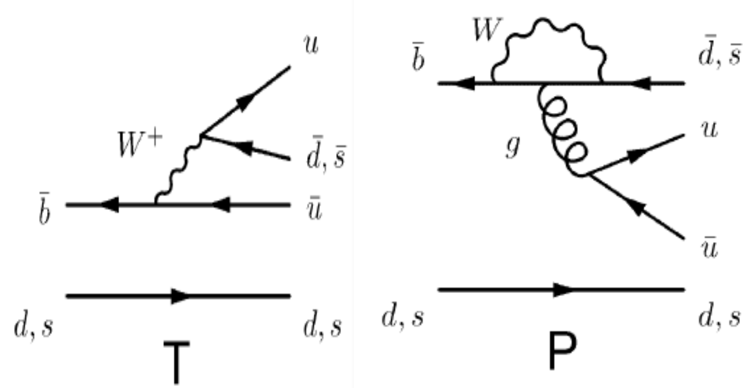
Looks interesting for an improved measurement of γ

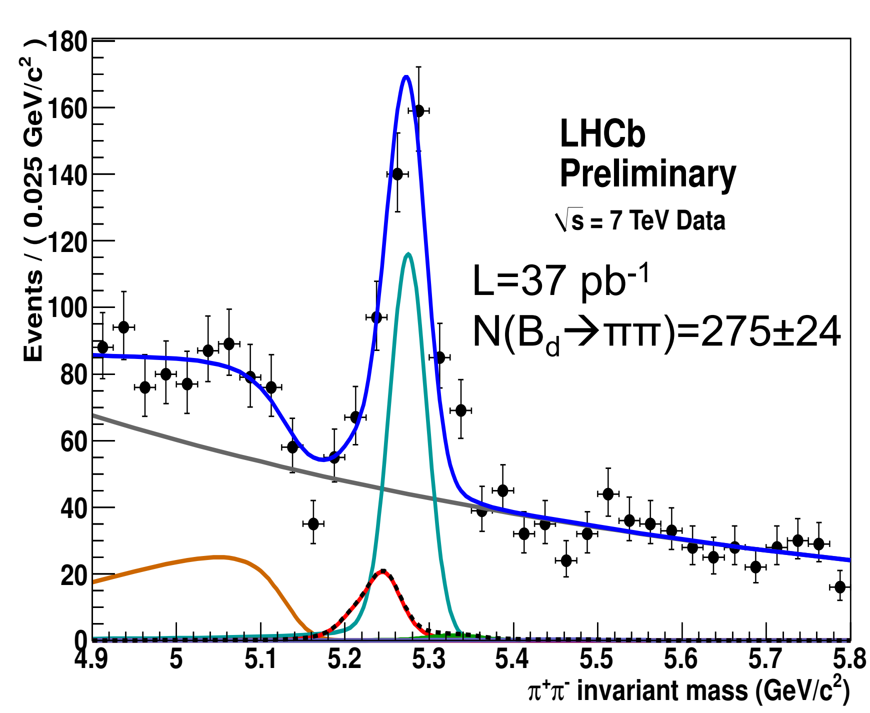
Prospects for a measurement of γ from loops using $B_s \to K^+K^-$ and $B_d \to \pi^+\pi^-$

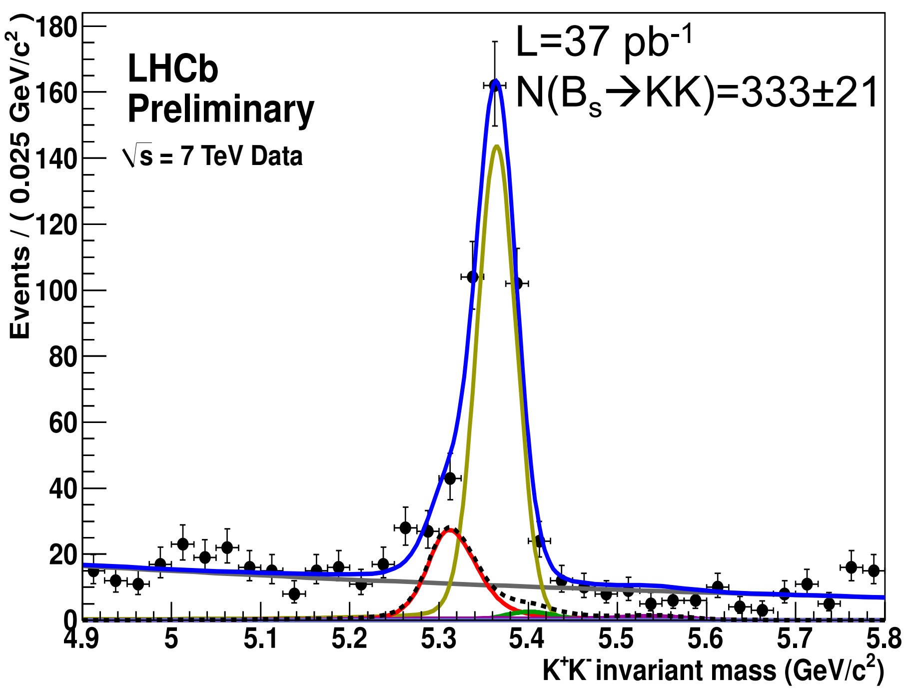
LHCb-CONF-2011-11

Large Penguin contributions are expected for **$B_s \to K^+K^-$ and $B_d \to \pi^+\pi^-$**.

Assuming U-spin and the measured β (B_d mixing phase), the **time dependent CP asymmetry of these decays allows for a measurement of γ and β_s.**







Observation of direct CP violation in $B_{d,s} \to K\pi$

LHCb-CONF-2011-11

Direct CP asymmetry in $B_d \to K\pi$ is well established (~9σ) but not yet convincing in $B_s \to \pi K$.

$$A_{CP}(B_s^0 \to \pi^+ K^-) \approx \mathcal{A}^{dir}_{\pi^+\pi^-}$$
$$A_{CP}(B^0 \to K^+ \pi^-) \approx \mathcal{A}^{dir}_{K^+K^-}$$

Detector asymmetries controlled using D* and $D^0 \to K\pi$ decays taken with both magnet polarities (A_D=-0.004±0.004).

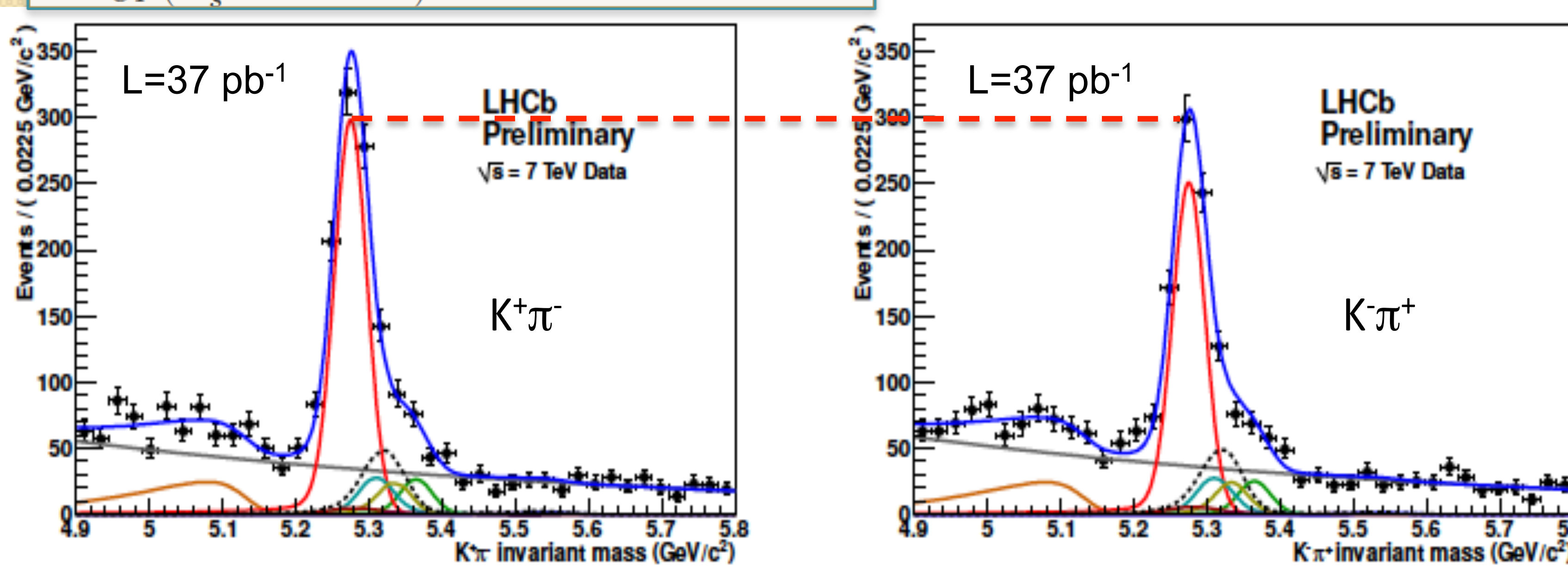
Production asymmetry constrained using $B^\pm \to J/\Psi K^\pm$ (A_P=-0.024±0.016).

LHCb preliminary:

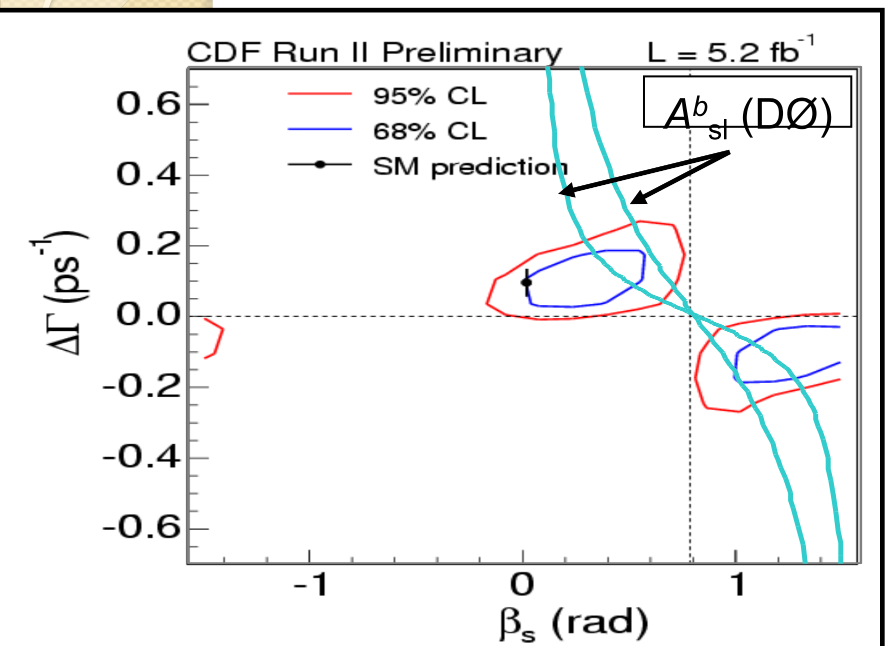
$$A_{CP}(B^0 \to K^+\pi^-) = -0.077 \pm 0.033 \pm 0.007$$
$$A_{CP}(B_s^0 \to \pi^+ K^-) = 0.15 \pm 0.19 \pm 0.02$$

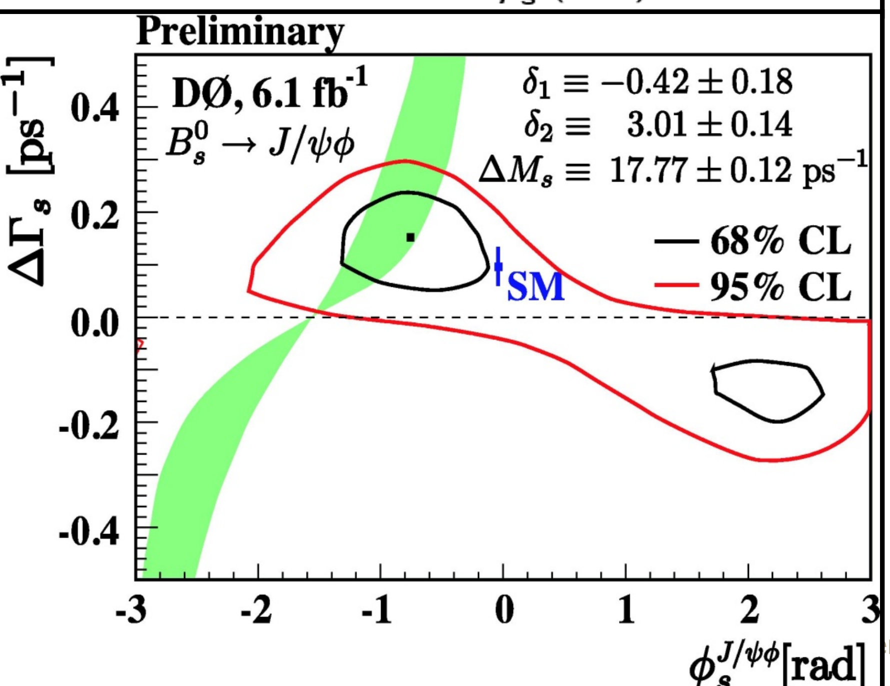
HFAG average:

$$A_{CP}(B^0 \to K^+\pi^-) = -0.098^{+0.012}_{-0.011}$$
$$A_{CP}(B_s^0 \to \pi^+ K^-) = 0.39 \pm 0.17$$



Towards a measurement of the B_s mixing phase: Strategy





1. Trigger & select $B^0_s \to J/\psi\phi$ events
   - Together with control channels, $B^+ \to J/\psi K^+$, $B^0 \to J/\psi K^{*0}$, ...
2. Measure proper time
   - *Proof of principle:* measure $B \to J/\psi X$ lifetimes
3. Measure decay angles
   - P→VV decay: $J/\psi\phi$ is a mixture of CP odd and CP even states → angular analysis to disentangle statistically the 3 amplitudes
   - *Proof of principle:* measure transversity amplitudes in $B^0 \to J/\psi K^{*0}$ and $B^0_s \to J/\psi\phi$ and $\Delta\Gamma_s$
4. Tag initial flavour
   - Calibration using control channels: $B^0 \to J/\psi K^{*0}$, $B^+ \to J/\psi K^+$, $B^0 \to D^{*-}\mu^+\nu_\mu$, $B^0_s \to D^-_s \pi^+$, ...
   - *Proof of principle:* measure Δm_d and Δm_s
5. Fit differential decay rates (for B^0_s and $\overline{B}^0_s$)

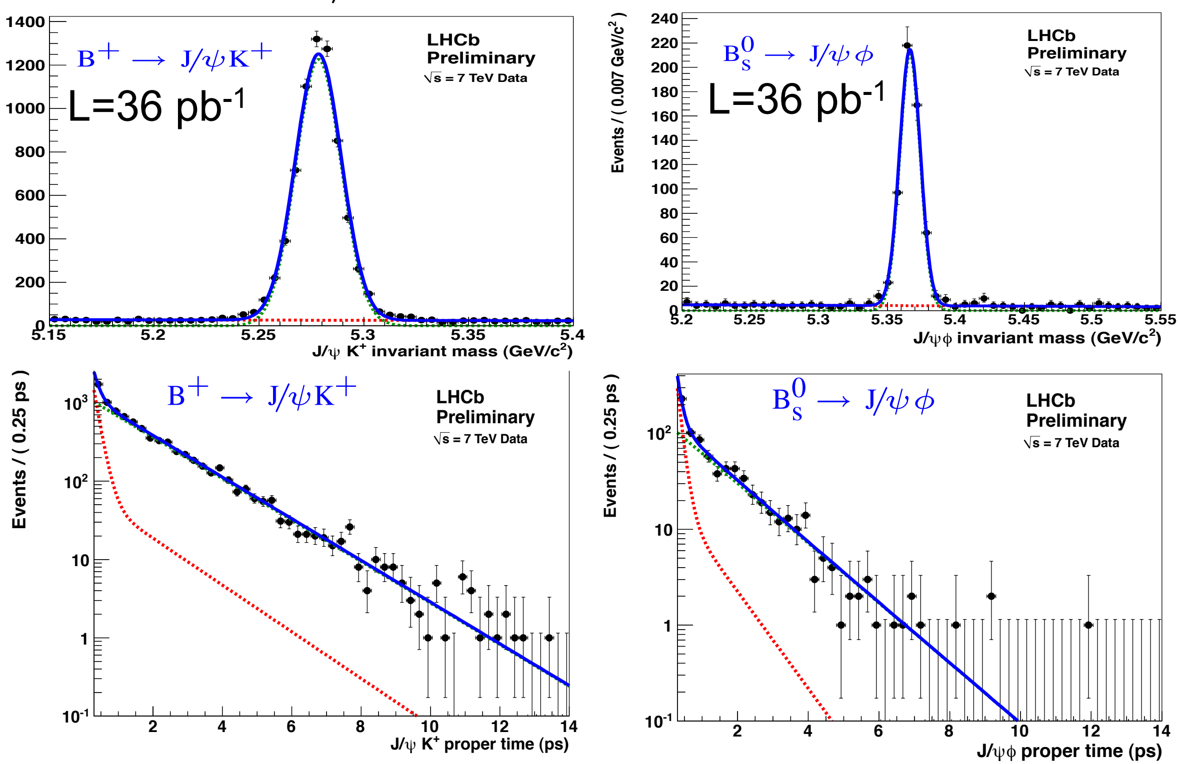
$$\frac{d^4\Gamma(B^0_s \to J/\psi\phi)}{dt\, d\cos\theta\, d\phi\, d\cos\psi} = f(\phi_s, \Delta\Gamma_s, \Gamma_s, \Delta m_s, M_{B^0_s}, |A_\perp|, |A_\parallel|, \delta_\perp, \delta_\parallel)$$

depends on 9 physics parameters and > 15 detector parameters

Towards a measurement of the B_s mixing phase: Acceptance

LHCb-CONF-2011-01

$\sigma_m = 10.7\,\mathrm{MeV}/c^2$ $\sigma_m = 7\,\mathrm{MeV}/c^2$



Clean signals, **very low bkg**!

Measurements of lifetimes in agreement with PDG, confirms **understanding of the proper time distributions.** Systematic uncertainties probably conservative at this very preliminary stage.

Proper time resolution ~ 50 fs!

Channel	LHCb yield	LHCb "lifetime"(*) stat. and sys. (ps)	PDG (ps)
$B^+ \to J/\psi K^+$	$6\,741 \pm 85$	$1.689 \pm 0.022 \pm 0.047$	1.638 ± 0.011
$B^0 \to J/\psi K^{*0}$	$2\,668 \pm 58$	$1.512 \pm 0.032 \pm 0.042$	1.525 ± 0.009
$B^0 \to J/\psi K^0_S$	838 ± 31	$1.558 \pm 0.056 \pm 0.022$	1.525 ± 0.009
$B^0_s \to J/\psi\phi$	570 ± 24	$1.447 \pm 0.064 \pm 0.056$	1.477 ± 0.046
$\Lambda_b \to J/\psi\Lambda$	187 ± 16	$1.353 \pm 0.108 \pm 0.035$	$1.391^{+0.038}_{-0.037}$

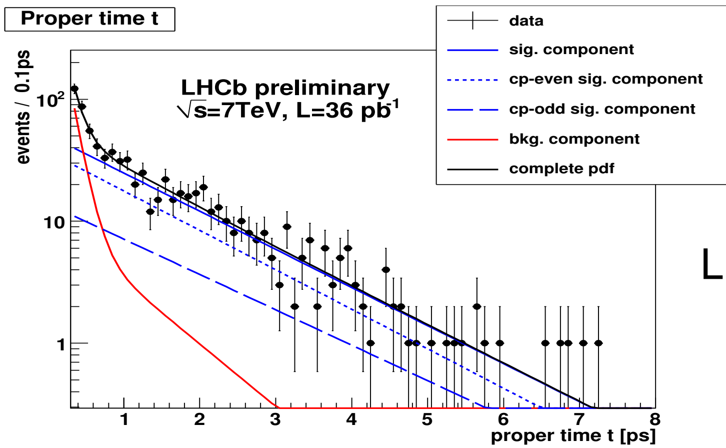
using only lifetime unbiased trigger and $t \in [0.3,\ 14]$ ps

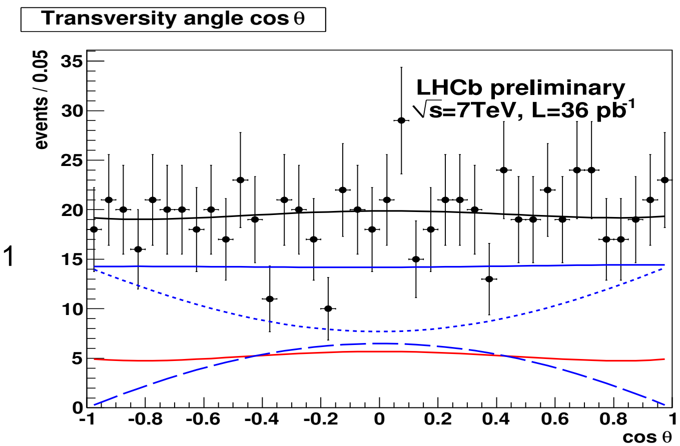
(*) $B^0_s \to J/\psi\phi$ proper time fitted by a single exponential!

Towards a measurement of the B_s mixing phase: Angular analysis.

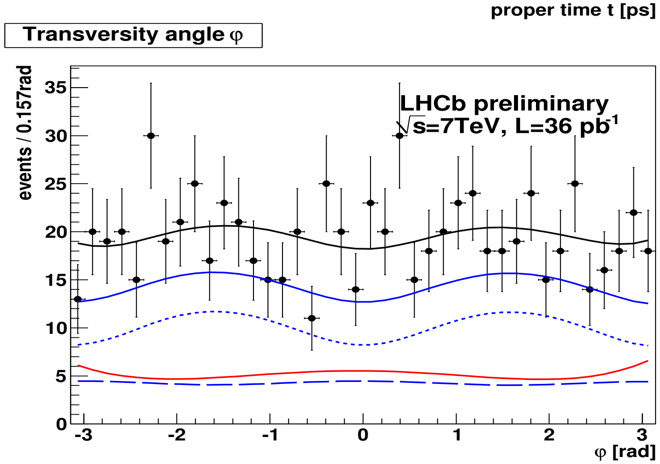
LHCb-CONF-2011-02

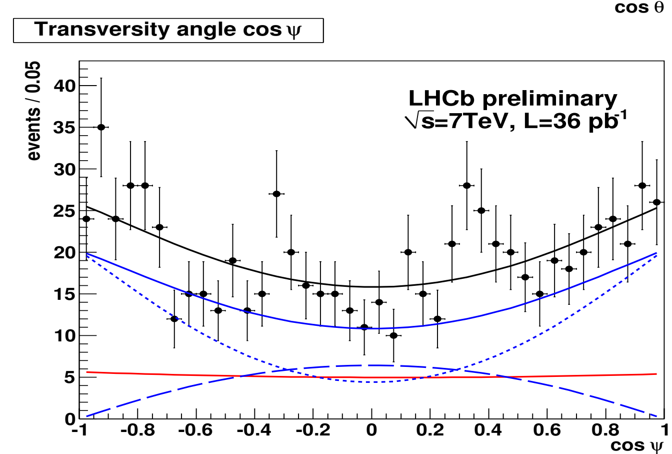
Untagged $B_s \rightarrow J/\Psi\phi$ analysis (Φ_s fixed to zero)





L=36 pb^{-1}





$$
\begin{aligned}
\Gamma_s\,(\mathrm{ps}^{-1}) &= 0.679 \pm 0.036(\mathrm{stat}) \pm 0.027(\mathrm{sys}) \\
\Delta\Gamma_s\,(\mathrm{ps}^{-1}) &= 0.077 \pm 0.119(\mathrm{stat}) \pm 0.021(\mathrm{sys}) \\
|A_0|^2 &= 0.528 \pm 0.040(\mathrm{stat}) \pm 0.028(\mathrm{sys}) \\
|A_\perp|^2 &= 0.263 \pm 0.056(\mathrm{stat}) \pm 0.014(\mathrm{sys}) \\
\delta_\parallel\,(\mathrm{rad}) &= 3.14 \pm 0.52(\mathrm{stat}) \pm 0.13(\mathrm{sys})
\end{aligned}
$$

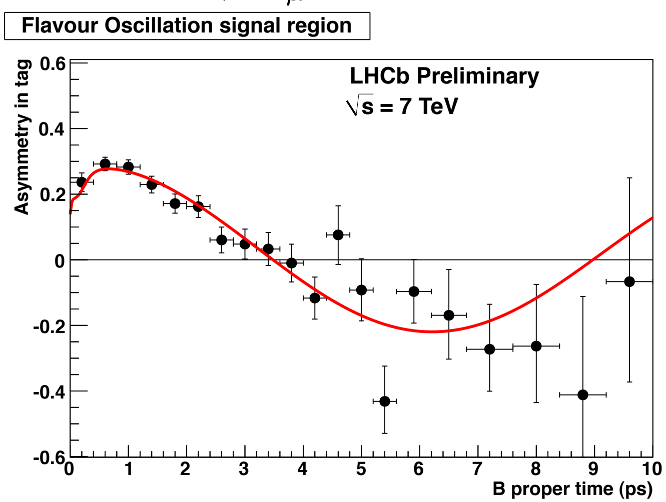
The measurements of **the transversity amplitudes** in both untagged **$B_d \rightarrow J/\Psi K^*$ and $B_s \rightarrow J/\Psi\phi$** are compatible with world average → **fitting model validated**

Towards a measurement of the B_s mixing phase: Flavour tagging

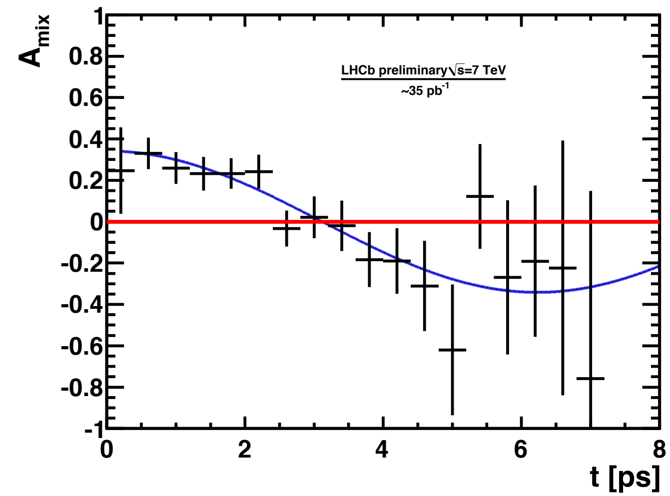
- Tagging algorithm optimized and calibrated on real data with $B^0 \to D^{*-}\mu^+\nu_\mu$, $B^+ \to J/\psi K^+$ and $B^0 \to J/\psi K^{*0}$

LHCb-CONF-2011-03
LHCb-CONF-2011-10

48 k $B^0 \to D^{*-}\mu^+\nu_\mu$



6 k $B^0 \to D^-\pi^+$



- Proof of principle that flavour tagging is working: measure Δm_d in $B^0 \to D^-(K^+\pi^-\pi^-)\pi^+$:

$$\Delta m_d = 0.499 \pm 0.032(\text{stat}) \pm 0.003(\text{sys})\ \text{ps}^{-1}$$

(World average: $\Delta m_d = 0.507 \pm 0.005\ \text{ps}^{-1}$)

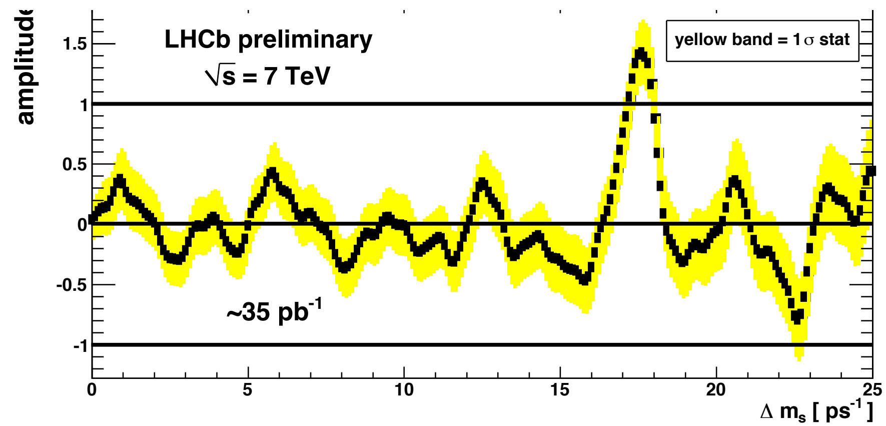
Towards a measurement of the B_s mixing phase: Δm_s

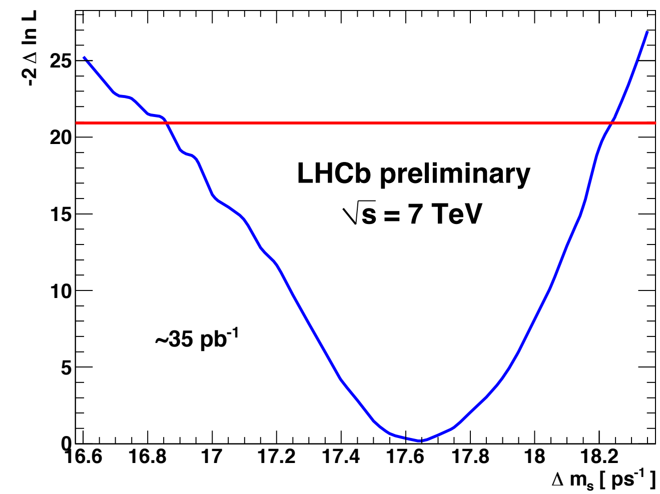
Decay mode	# signal candidates
$B_s \to D_s(\phi\pi)\pi$	515 ± 25
$B_s \to D_s(K^*K)\pi$	338 ± 27
$B_s \to D_s\pi$ non-resonant	283 ± 27
$B_s \to D_s 3\pi$	245 ± 46

LHCb-CONF-2011-05

Use:

- per event proper time uncertainties, $\langle\sigma_t\rangle = 36 - 44\,\mathrm{fs}$
- per event mistag rate, $\varepsilon_{\mathrm{eff}} = 3.8 \pm 2.1\%$ (OS only)





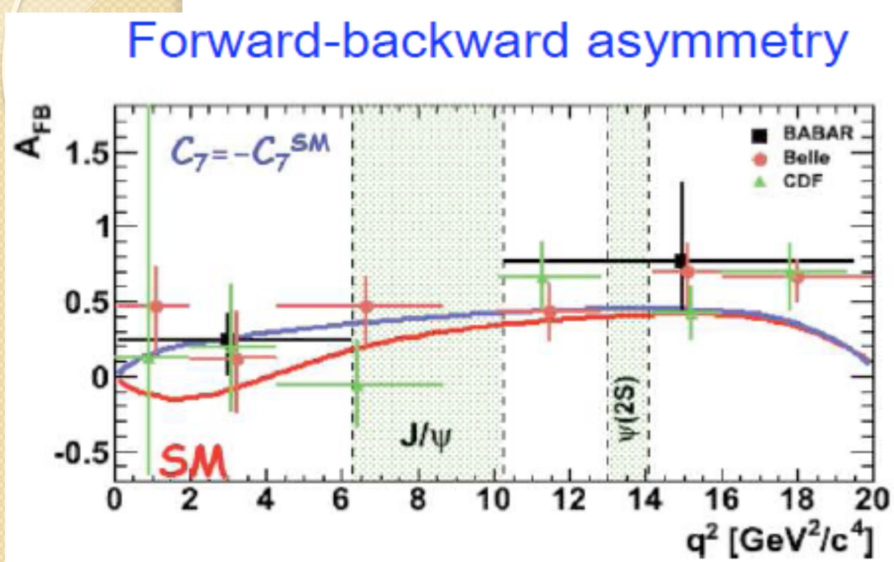
- $\Delta m_s = 17.63 \pm 0.11(\mathrm{stat}) \pm 0.04(\mathrm{sys})\,\mathrm{ps}^{-1}$ (4.6σ stat. significance)
- CDF: $\Delta m_s = 17.77 \pm 0.10$ (stat) $\pm$ 0.07 (sys) ps^{-1}

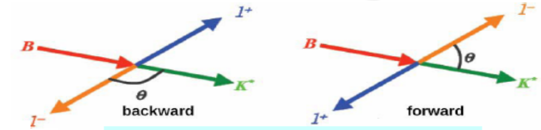
	LHCb 36 pb^{-1}	CDF 5.2 fb^{-1}
$B_s^0 \to J/\psi\phi$	960	6500
Proper time resolution	50 fs	100 fs
OS tagging power	$2.5 \pm 0.8\%$	$1.2 \pm 0.2\%$
SS tagging power	work ongoing	$3.5 \pm 1.4\%$

Expect world best sensitivity on the B_s mixing phase very soon (Beauty 2011?)

5. Search for NP contributions in $B_{d,s}$ decays

Search for new Lorentz structure: Observation of $B_d \rightarrow K^* \mu^+ \mu^-$ decay

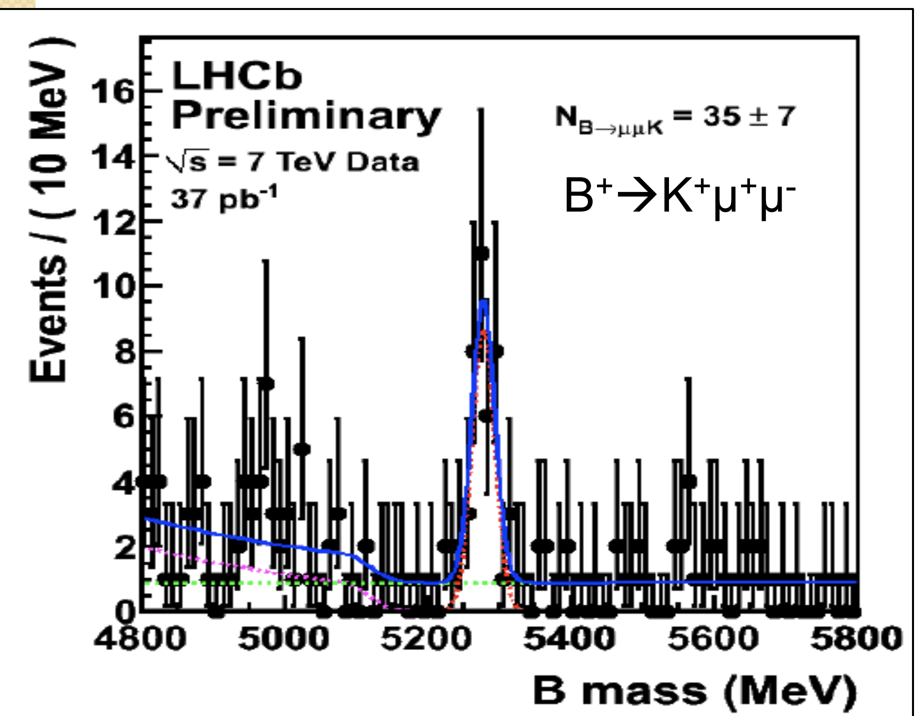


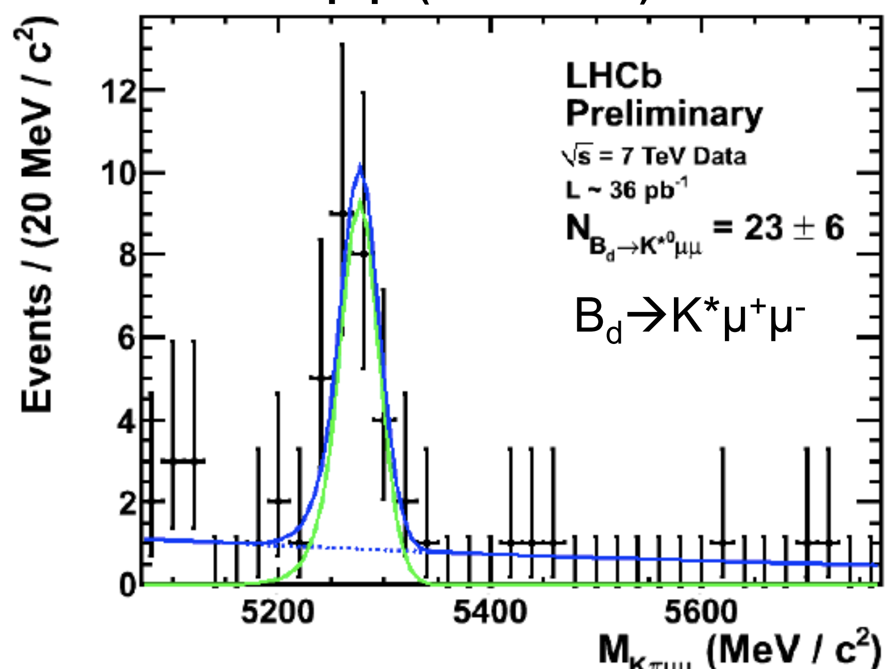


$$A_{FB}\left(s = m^2_{\mu^+\mu^-}\right) = \frac{N_F - N_B}{N_F + N_B}$$

Measurements at BaBar, BELLE and CDF (O(100) events) are consistent, with a slight preference for non-SM contributions to C_7.

Clean **observation at LHCb of $B_d \rightarrow K^* \mu^+ \mu^-$ (23±6)** events close to expectations.
Also **observation of the rarest B decay at LHCb** so far: **$B^+ \rightarrow K^+ \mu^+ \mu^-$ (BR~5×10^{-7}).**



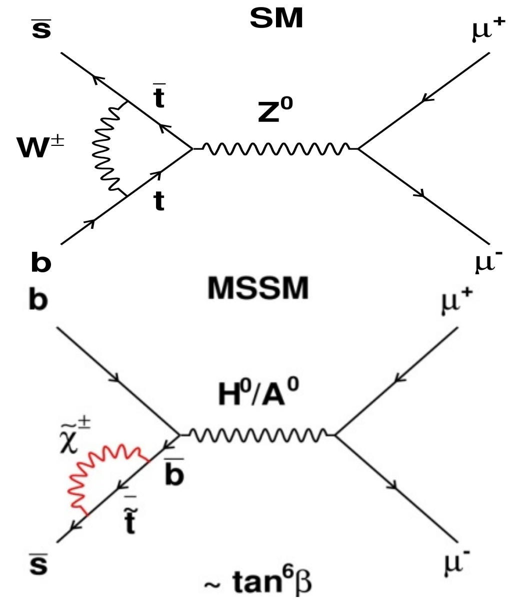


Search for non SM Higgs contributions: $B_{d,s} \rightarrow \mu^+ \mu^-$ decays

arXiv:1103.2465 (submitted to PLB)

$$BR(B_q \to l^+ l^-) \approx \frac{G_F^2 \alpha^2 M_{B_q}^3 f_{B_q}^2 \tau_{B_q}}{64\pi^3 \sin^4\theta_W} |V_{tb} V_{tq}^*|^2 \sqrt{1 - \frac{4m_l^2}{M_{B_q}^2}}$$

$$\left\{ M_{B_q}^2 \left(1 - \frac{4m_l^2}{M_{B_q}^2}\right) c_S^2 + \left[M_{B_q} c_P + \frac{2m_l}{M_{B_q}} (c_A - c_A') \right]^2 \right\}.$$



This decay is very sensitive to **new scalar and/or pseudoscalar** interactions. In the MSSM the BR is proportional to $\tan^6\beta/M_A^4$.

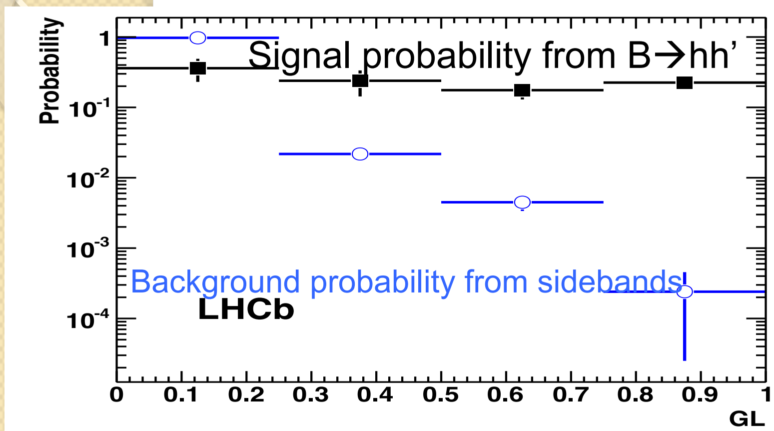
Mode	SM
$B_s \to \mu^+\mu^-$	$3.2 \pm 0.2\ 10^{-9}$
$B^0 \to \mu^+\mu^-$	$0.10 \pm 0.01\ 10^{-9}$

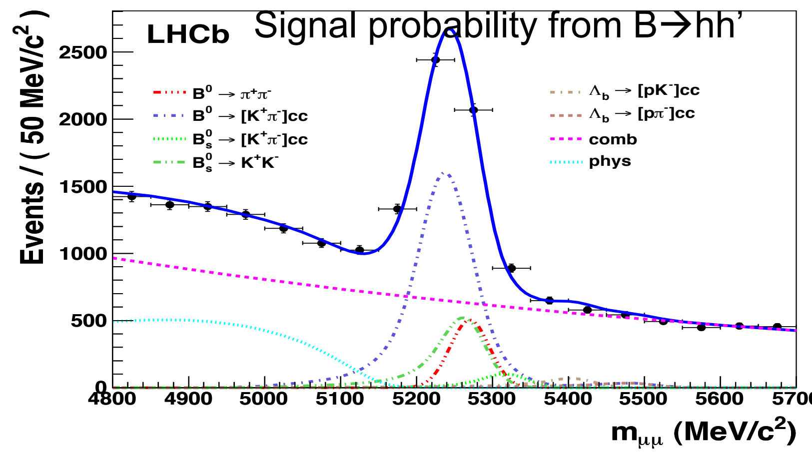
A.J.Buras: arXiv:1012.1447
E. Gamiz et al: Phys.Rev.D 80 (2009) 014503

Search for the rare decays $B_{d,s} \to \mu^+ \mu^-$.

arXiv:1103.2465 (submitted to PLB)

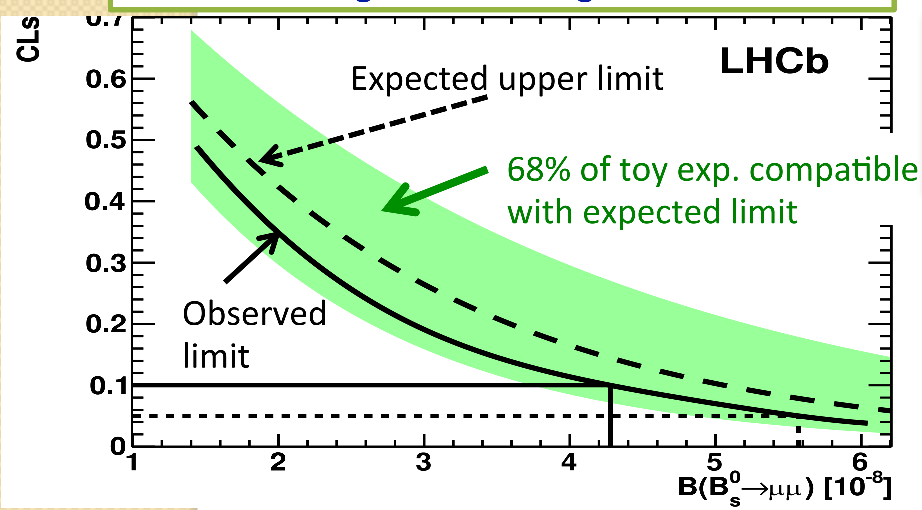
Signal and background candidates are discriminated by a 2D likelihood: **multivariate discriminant variable (GL) and invariant mass**, both obtained **from data.**





Three complementary normalization channels: $B^+ \to J/\psi K^+$, $B_s \to J\Psi\Phi$ and $B_d \to K^+\pi^-$.

CL_S vs $BR(B_S \to \mu\mu)$



LHCb results with 37 pb^{-1}:

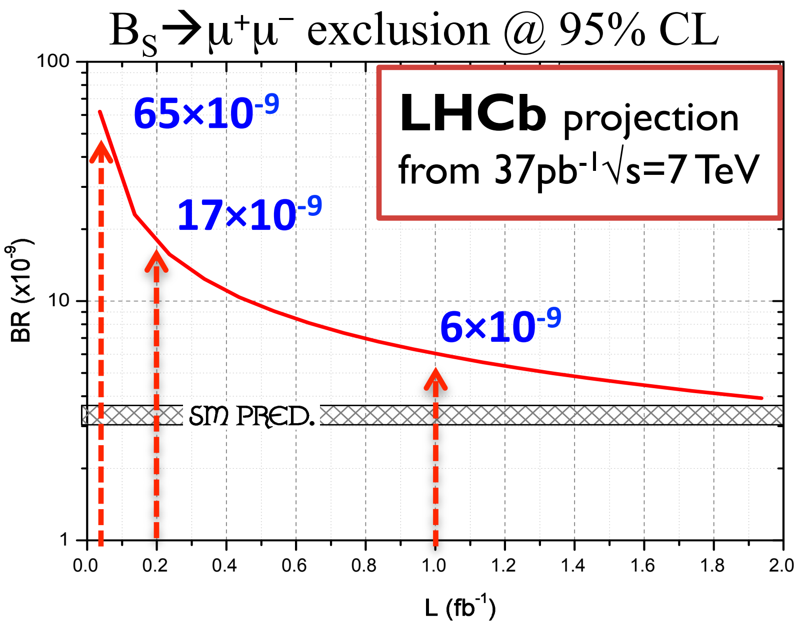
$BR(B_s \to \mu^+\mu^-) < 5.6\times10^{-8}$ @ 95% CL *(expected 6.5×10^{-8})*

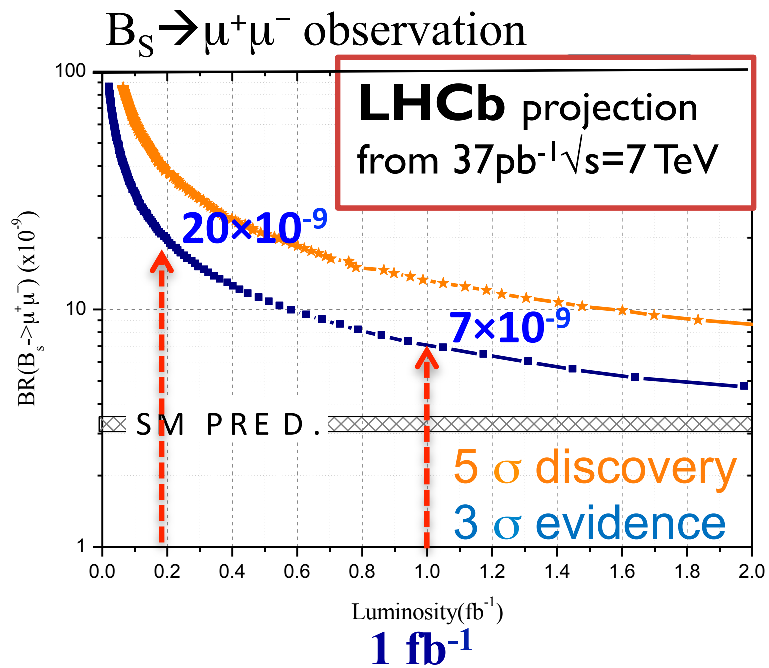
$BR(B^0 \to \mu^+\mu^-) < 1.5\times10^{-8}$ @ 95% CL *(expected 1.8×10^{-8})*

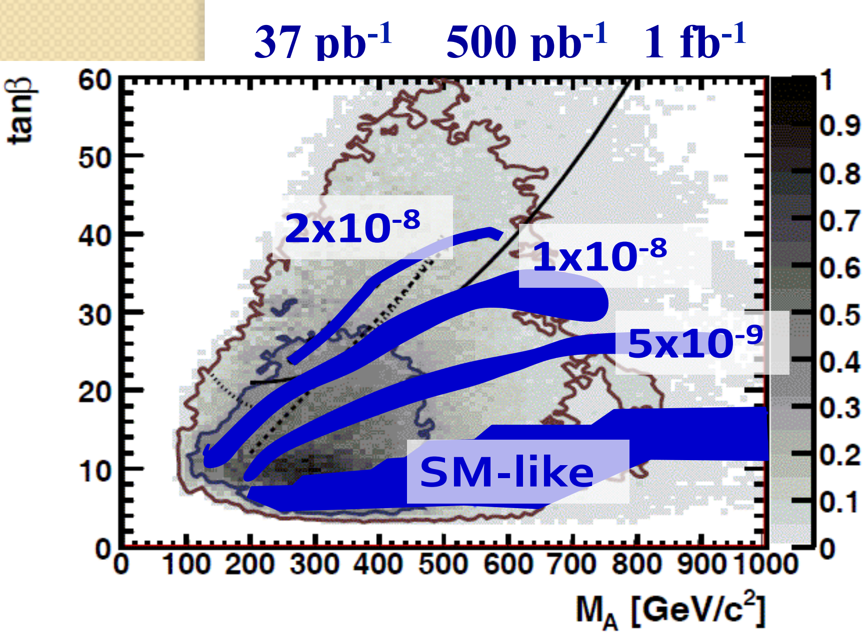
Already very close to best limits from CDF using 3.7 fb^{-1}:

$BR(B_s \to \mu^+\mu^-) < 4.3\times10^{-8}$ @ 95% CL
$BR(B^0 \to \mu^+\mu^-) < 0.76\times10^{-8}$ @ 95% CL

Search for $B_{d,s} \rightarrow \mu^+ \mu^-$ decays: 2010/2011 prospects







LHCb will either **find signs of NP** or **exclude most of the tanβ vs M_A** plane with the 2010/2011 data.

Strong impact on viable SUSY scenarios

Very exciting indeed!

6. Outlook and conclusions

Outlook and conclusions

Thanks to the superb work at the CERN **accelerator departments**, LHCb was able to collect ~38 pb^{-1} of pp collisions. This was good enough to provide **world class measurements at this winter conferences**:

Δm_s = 17.63± 0.11(stat) ±0.04(syst) ps^{-1}
$BR(B_s \to \mu^+\mu^-) < 5.6\times10^{-8}$ @ 95% CL
$BR(B^0 \to \mu^+\mu^-) < 1.5\times10^{-8}$ @ 95% CL

and open **new paths** to look for NP in the barely explored **B_s system** with several new decay modes observed.

Many new results are in the pipeline still with 2010 data: **β_s, D^0 mixing**…

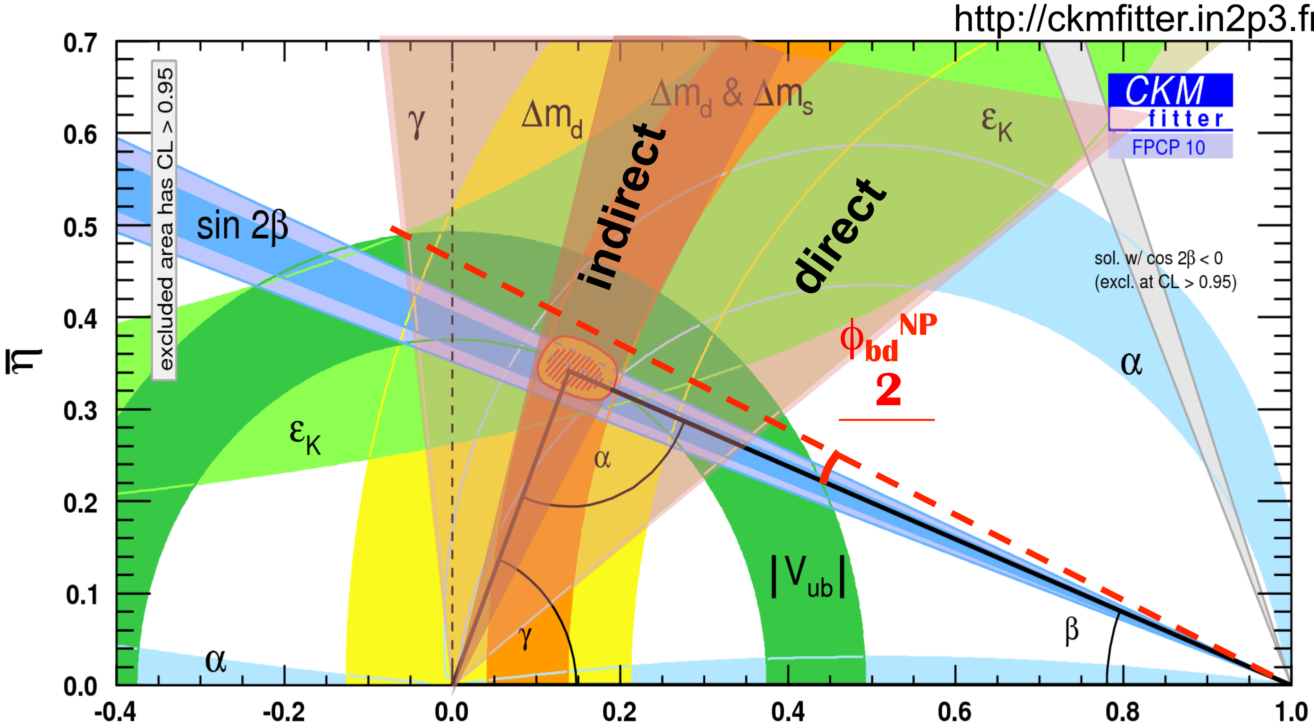
LHCb is performing very well and the results obtained already guarantee we will start exploring **"terra incognita" in 2011** provided we get **enough luminosity.**

LHCb would like to run in 2011 with a visible pp-collisions/bunch crossing **up to μ=2 (2.5 at start-up).** Prefer to **maximize the number of bunches** to minimize μ. **Luminosity leveling** will be crucial and we will run with almost **flat luminosity (3×10^{32} cm^{-2} s^{-1})** throughout the year.

We would like to get ≥200 pb^{-1} by end of June and ~1 fb^{-1} by the end of 2011.

Backup

γ measurement



- All measurements together determine (indirectly) the CKM angle $\gamma = (68 \pm 4)^o$
- However, as processes involve loops, may be affected by new physics:

$$\sin(2\beta + \phi_{bd}^{NP})$$

→ should be compared with measurement of γ from tree process:
B → DK, unaffected by new physics
Currently only poorly constrained: $\gamma = (70\ ^{+14}_{-21})^o$ (direct measurement)

A precise measurement of γ from tree processes and improved precision in V_{ub} will show if there are new phases involved in B_d mixing processes.

What about the flavour specific asymmetry measured at D0?

$$a^q_{fs} \propto A^q_{fs}(t) = \frac{\Gamma\left(B^0_q \text{ or } \overline{B}^0_q \to \overline{f}\right) - \Gamma\left(B^0_q \text{ or } \overline{B}^0_q \to f\right)}{\Gamma\left(B^0_q \text{ or } \overline{B}^0_q \to \overline{f}\right) + \Gamma\left(B^0_q \text{ or } \overline{B}^0_q \to f\right)}$$

$$a^q_{fs} = \mathrm{Im}\left\{\frac{\Gamma^q_{12}}{M^q_{12}}\right\}$$

$$\left(a^d_{fs}\right)^{SM} = -(5.0 \pm 1.1)\times 10^{-4}$$

$$\left(a^s_{fs}\right)^{SM} = (2.1 \pm 0.4)\times 10^{-5}$$

D0 measurement using bb→μμX events:

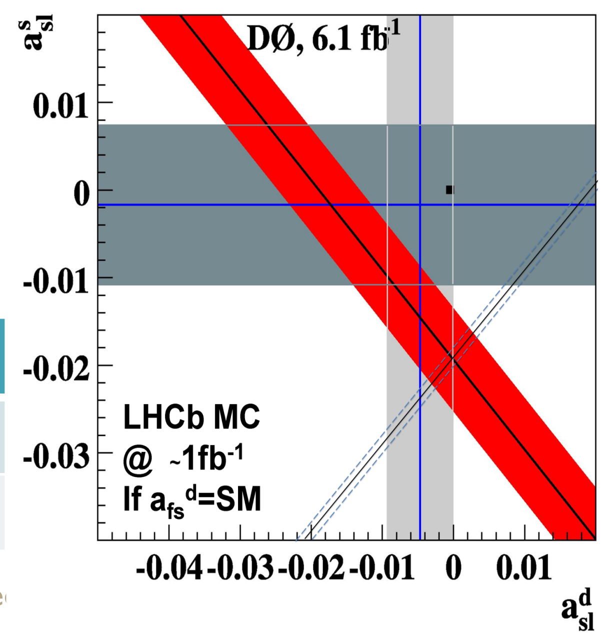
$$A^b = \frac{N^{++} - N^{--}}{N^{++} + N^{--}} = (0.494)a^s_{fs} + (0.506)a^d_{fs}$$

$$\left(a^s_{fs}\right)^{\text{using b-fact}} = -(1.46 \pm 0.75)\times 10^{-2}$$

~2σ

Inclusive method using bb→μμX is difficult at LHCb due to the ~10^{-2} production (pp collider) and detector asymmetry.

More promising looks fitting simultaneously the production asymmetry using the exclusive method either with $B_s \to D_s\pi$ decays, or using the B_s and B_d semileptonic decays and subtracting them, such that the detector asymmetry cancels and we are left with:

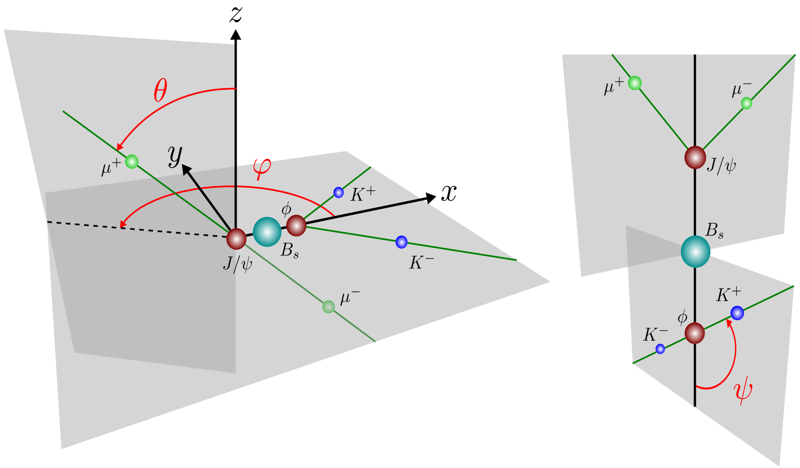


$$\Delta A^{s,d}_{fs} \approx \frac{a^s_{fs} - a^d_{fs}}{2}$$

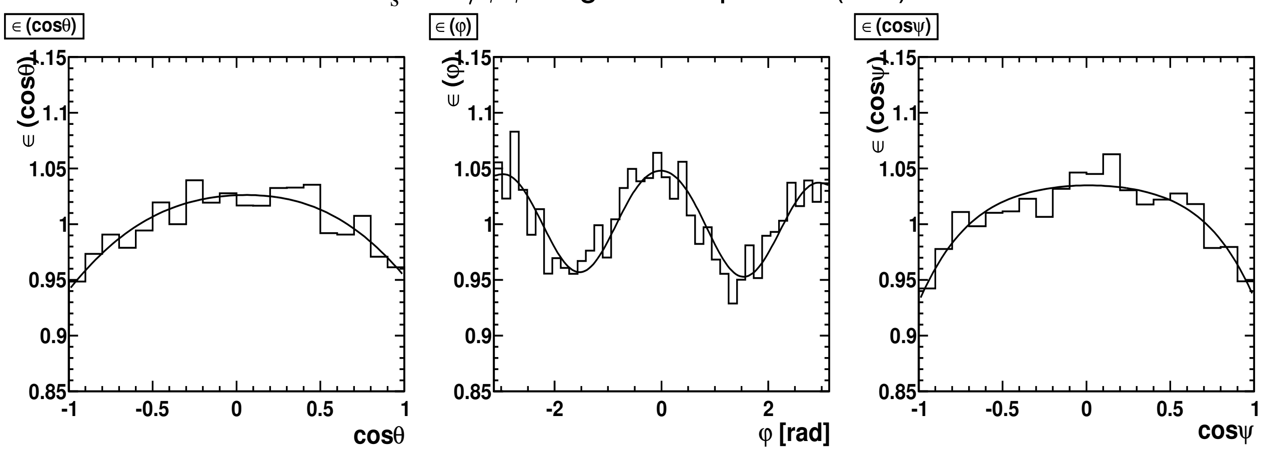
Stat. Error	100 pb^{-1}	1fb^{-1}
a_{fs}^s (D_s π)	2 x10^{-2}	6.8x10^{-3}
ΔA_{fs} (D_q μν)	2 x10^{-3}	6.3 x10^{-4}

Towards a measurement of the B_s mixing phase: Angular analysis.

- LHCb forward geometry $\rightarrow$ small distortions of angular acceptance $\rightarrow$ corrected with MC



$B_s^0 \rightarrow J/\psi\phi$ angular accptance (MC)



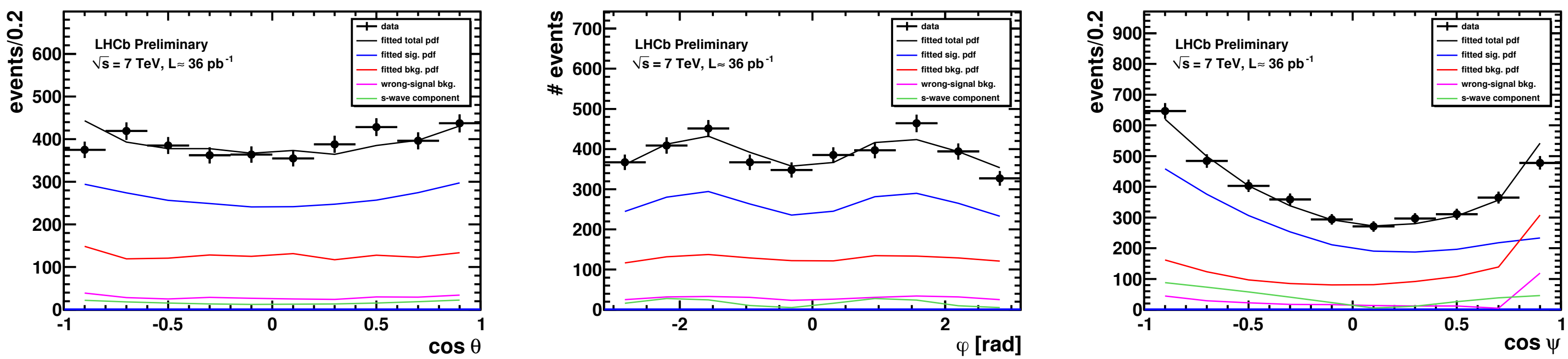
- Validity of MC-angular acceptance corrections tested measuring known values of polarization amplitude in $B^0 \rightarrow J/\psi K^{*0}$

Towards a measurement of the B_s mixing phase: Angular analysis.

Untagged angular analysis of $B^0 \to J/\psi K^{*0}$ [LHCb-CONF-2011-002]

5D unbinned likelihood fit ($m, t, \cos\theta, \varphi, \cos\psi$)

Projection on transversity angles:



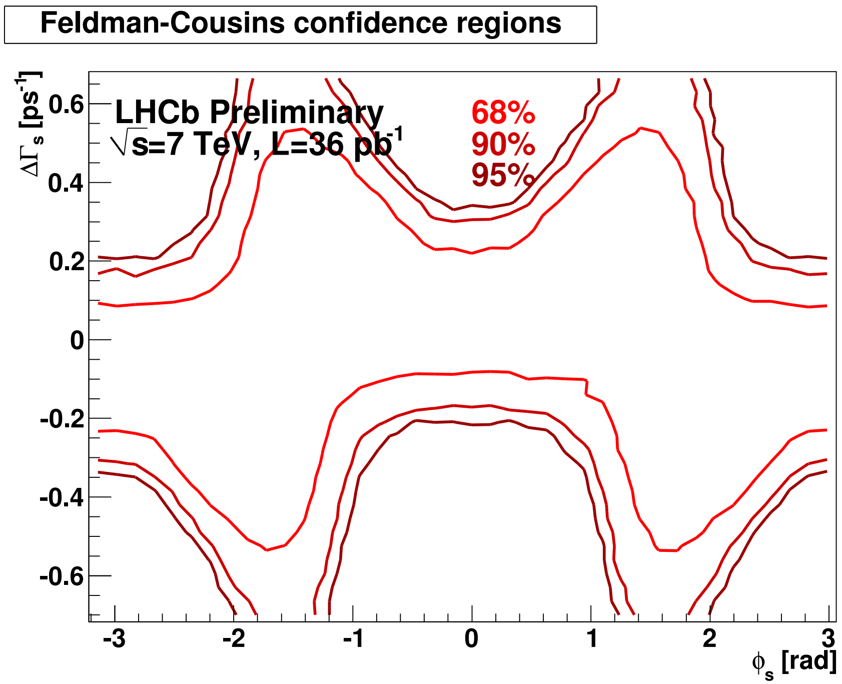
$$
\begin{aligned}
|A_{\parallel}|^2 &= 0.252 \pm 0.020(\text{stat}) \pm 0.016(\text{sys}) \\
|A_{\perp}|^2 &= 0.178 \pm 0.022(\text{stat}) \pm 0.017(\text{sys}) \\
\delta_{\parallel}\ (\text{rad}) &= -2.87 \pm 0.11(\text{stat}) \pm 0.10(\text{sys}) \\
\delta_{\perp}\ (\text{rad}) &= 3.02 \pm 0.10(\text{stat}) \pm 0.07(\text{sys})
\end{aligned}
$$

BaBar, Phys. Rev. D76, 031102 (2007),

$$
\begin{aligned}
|A_{\parallel}|^2 &= 0.211 \pm 0.010 \pm 0.006 \\
|A_{\perp}|^2 &= 0.233 \pm 0.010 \pm 0.005 \\
\delta_{\parallel}\ (\text{rad}) &= -2.93 \pm 0.08 \pm 0.04 \\
\delta_{\perp}\ (\text{rad}) &= 2.91 \pm 0.05 \pm 0.03
\end{aligned}
$$

- Compatible with world best measurements
- Will be competitive in 2011

Towards a measurement of the B_s mixing phase: Angular analysis.



Coverage-adjusted two-dimensional profile likelihood of $\Delta\Gamma_s - \phi_s$

- As expected, $\sim$no constraint on ϕ_s. However, can still limit $\Delta\Gamma_s$
- 4-fold ambiguity
  $\rightarrow$ use flavour tagging to discard two solutions