LHCb in 2010

First physics results

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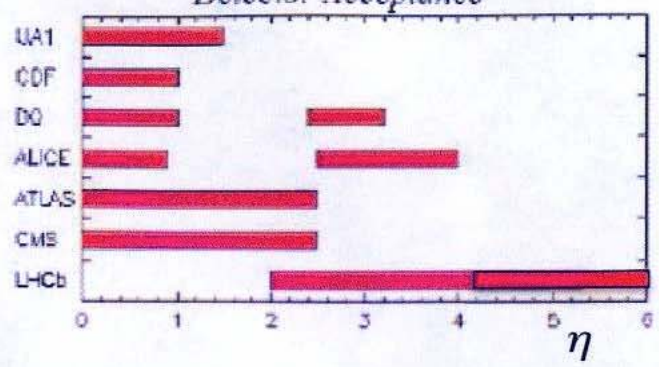
28 декабря 2010

The LHCb Detector (forward spectrometer)



RICH Detectors
specific feature of LHCb

Vertex Locator
VELO

Muon System

Movable device
35 mm from beam out of physics
7 mm from beam in physics

pp collision Point

~1 cm

B

20 m

10 m

0

Calorimeters

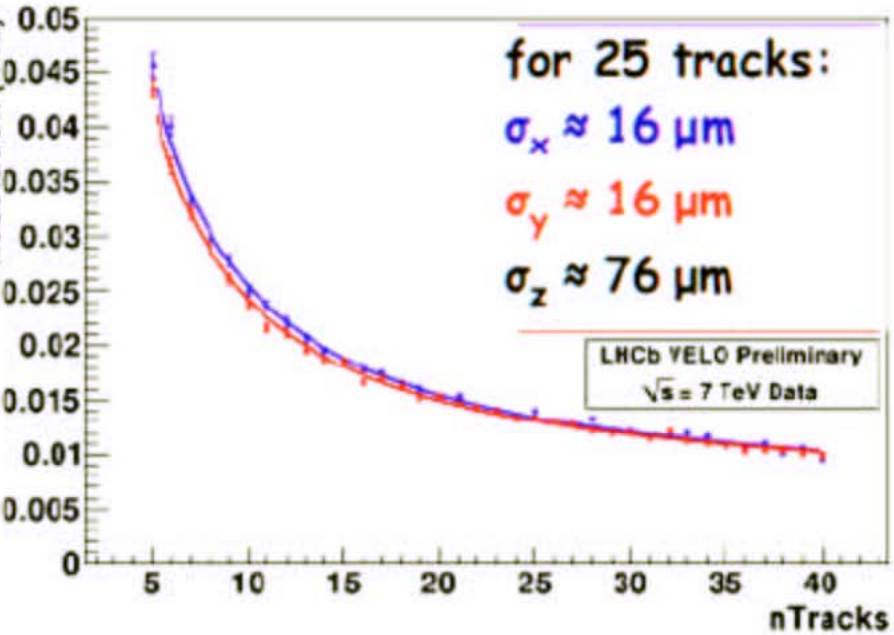
Tracking System

Отличительные особенности LHCb

- Прецизионный вертексный детектор
- Высокое разрешение по массе
- Идентификация K/π/p (RICH)
- Область малых углов
- 10 мрад <θ< 300 мрад
- 2 < η< 6

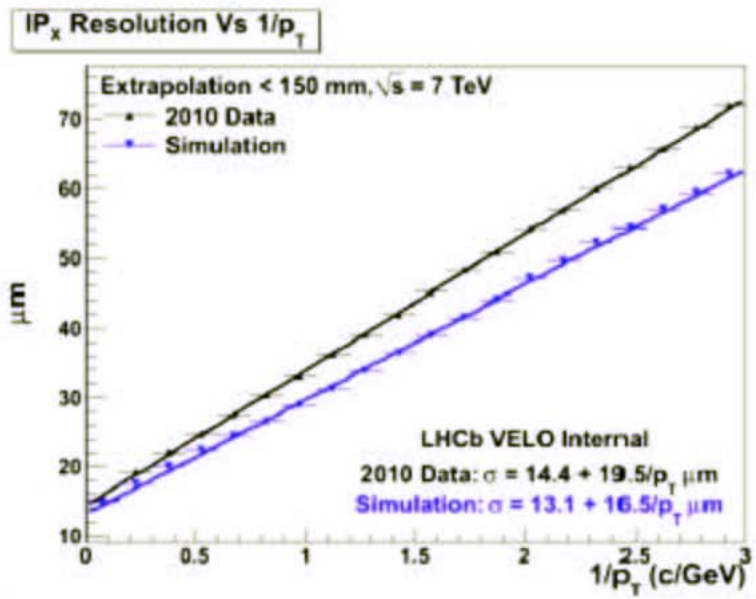
Primary Vertex (PV) & Impact Parameter (IP) resolution

PV resolution evaluated in data using random splitting of the tracks in two halves and comparing vertices of equal multiplicity



Resolution for PV with 25 tracks

*Data: 16 µm for **X** & **Y** and 76 µm for Z*
MC: 11 µm for X & Y and 60 µm for Z



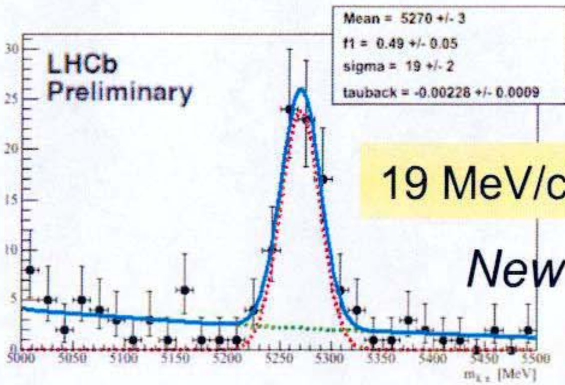
IP resolution ~15 µm for the highest p_t bins

- *slope determined by multiple scattering, not an alignment effect*
- *improvement of material description is ongoing*

Signal peaks & present mass resolution

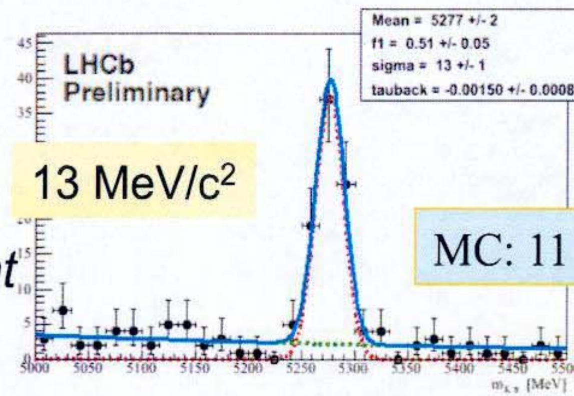
Mass resolutions approaching MC expectations

B⁺ → J/ψ K⁺



19 MeV/c²

New alignment →

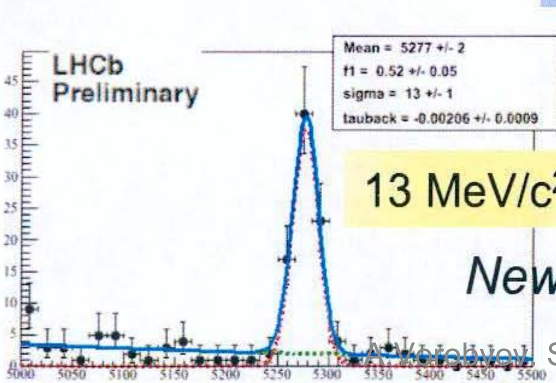


13 MeV/c²

MC: 11 MeV/c²

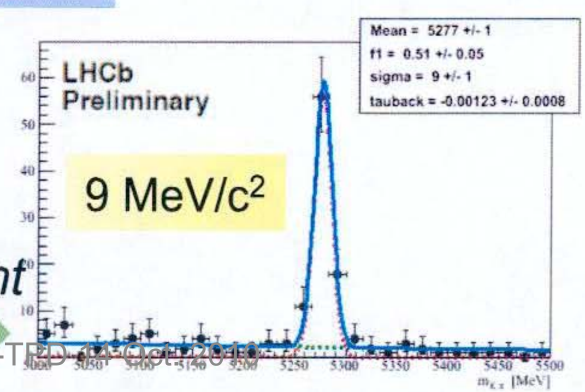
With J/ψ mass constraint

B⁺ → J/ψ K⁺



13 MeV/c²

New alignment →



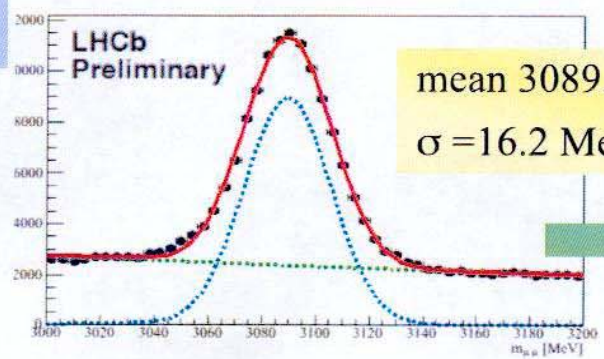
9 MeV/c²

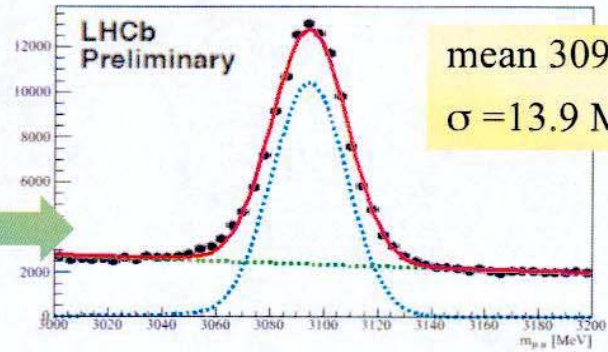
Signal peaks & present mass resolution

(Continuous improvement !!!)

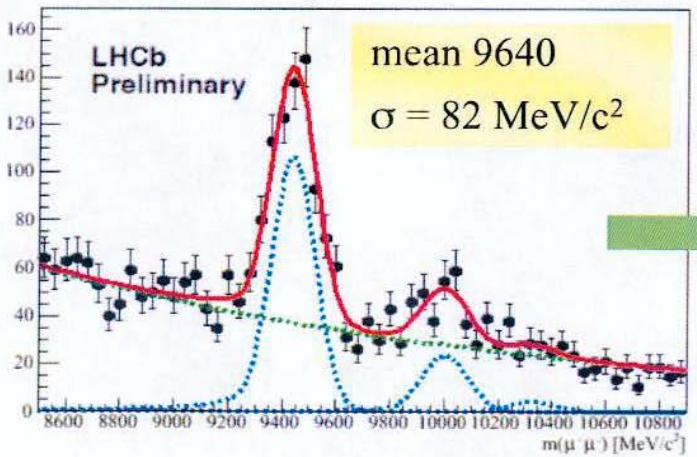
- *New alignment of all tracking system*
- *Good improvement in momentum resolution for high momentum tracks and mass resolution*

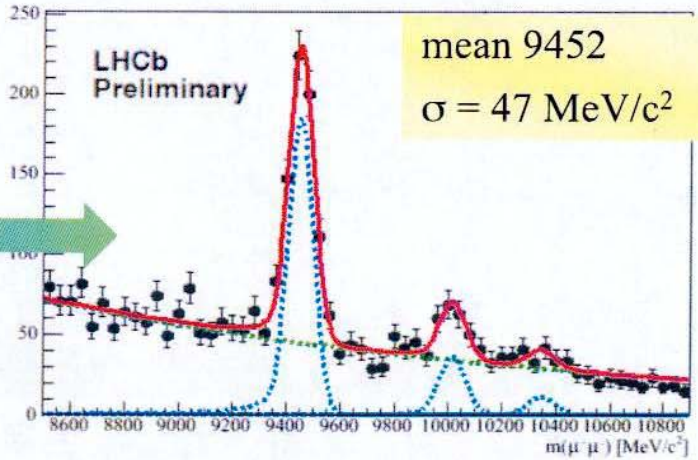
$J/\psi \rightarrow \mu^+\mu^-$





$\Upsilon \rightarrow \mu^+\mu^-$





Пучковые особенности в 2010

	Номинал	ноябрь 2010
Светимость	$2 \cdot 10^{32} см^{-2}/сек$	$1.6 \cdot 10^{32}$
Число банчей	2808	344
Число взаимодействий/банч	0.4	2.0
Расстояние между банчами	25 мксек	75 мксек

Интегральная светимость к концу 2010

30 pb^{-1}

LHCb publications

#1. Prompt K^0 production in pp collisions at $\sqrt{s}=0.9$ TeV

#2. Measurement of sigma (pp → b anti-b X) at $\sqrt{s}=7$ TeV in the forward region

B.Bochin, N.Bondar, A.Kashchuk, O.Maev, P.Neustroev, N.Sagidova, Yu.Shcheglov, E.Spiridenkov, A.Vorobyev, An.Vorobyev

Measurement of sigma (pp → b anti-b X) at √s =7 TeV in the forward region

- $pp \rightarrow bb \rightarrow D^o \mu^- X$
- $D^o \rightarrow K^- \pi^+$

$Br(b \rightarrow D^o X \mu^- \nu) = (6.82 \pm 0.35)\%$

Low background (main background - prompt Do)

Full Pt range

Pseudorapidity $2 < \eta < 6$ $\eta = - \ln(\tan(\theta/2))$

Sensitivity to $x \approx 10^{-5}$ $x \sim Mbb/\sqrt{s} \exp(- y)$

$\eta - y \approx 0.5 \pm 0.5$ (function on Pt)

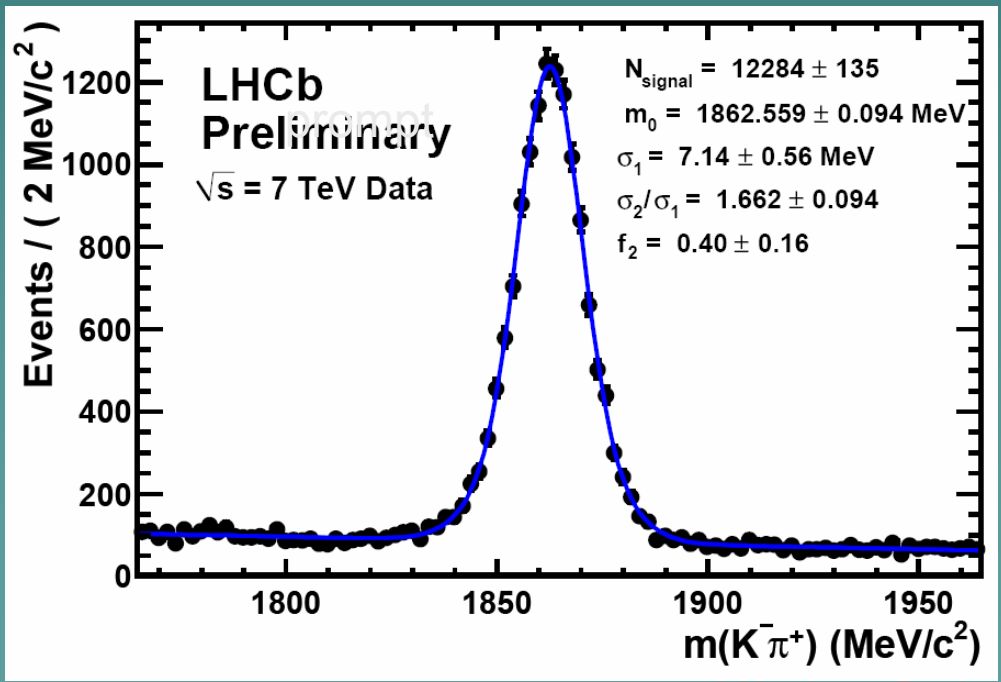
Measurement of sigma (pp → b anti-b X) at √s =7 TeV in the forward region

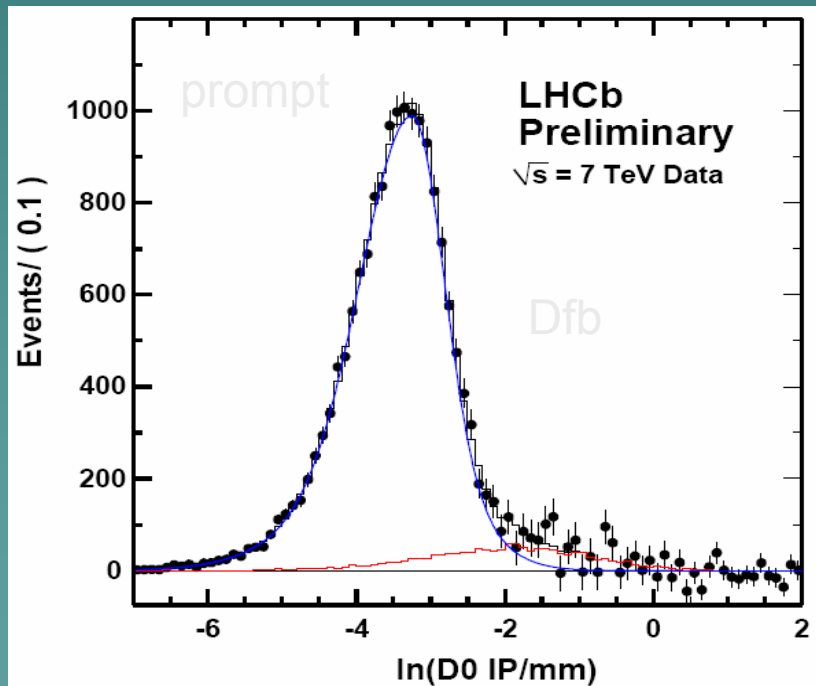
a) pp→ Do X

b) pp→ BX → Do X

Do→K^- π+

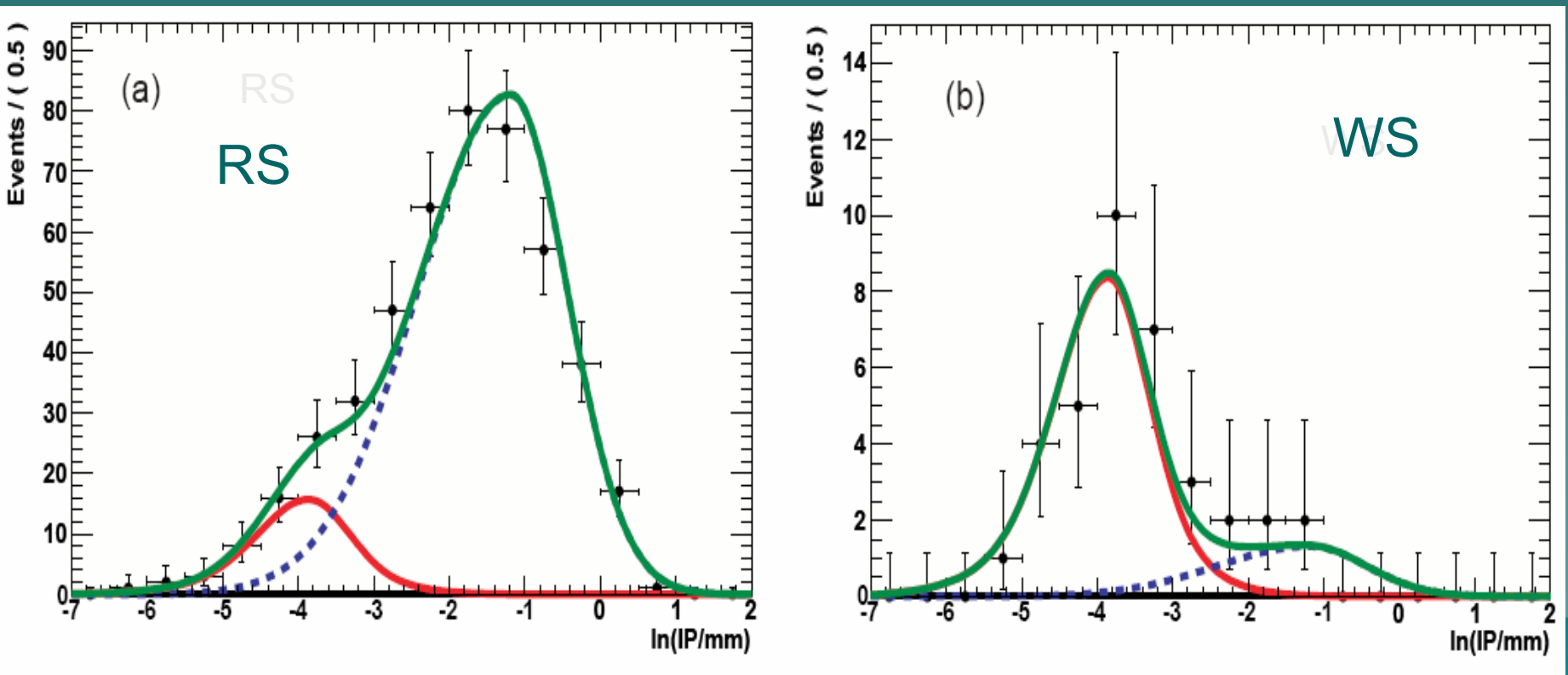
Analysis of 12 nb-1



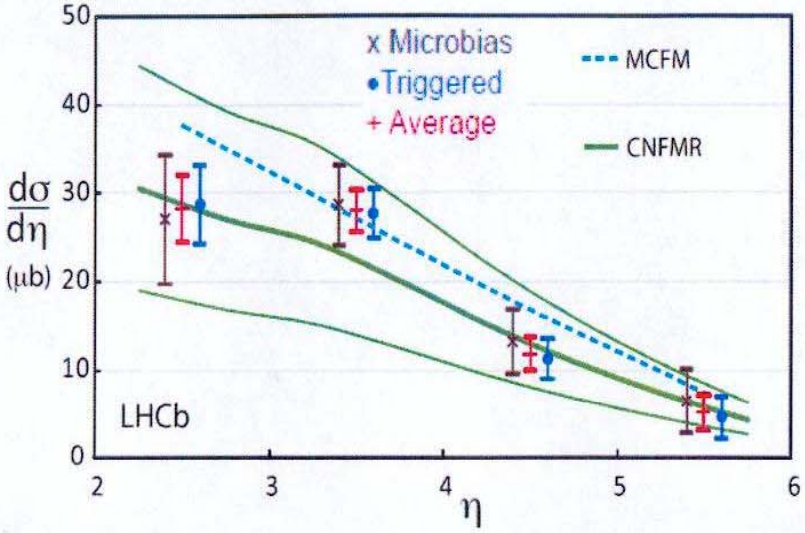


pp→ Doμ- X
Do→K- π+

Analysis of 12.2 nb-1 Pt(μ) >1.3 GeV



$b\bar{b}$ cross-section @ $\sqrt{s}$ = 7 TeV
(published in PLB)



Shapes and scales agree well with expectation. Validates QCD predictions at LHC energies

$\sigma(pp \to H_b X) = 75.3 \pm 5.4 \pm 13.0\ \mu b$ for $2<\eta<6$, any p_T, $\sqrt{s}$=7 TeV

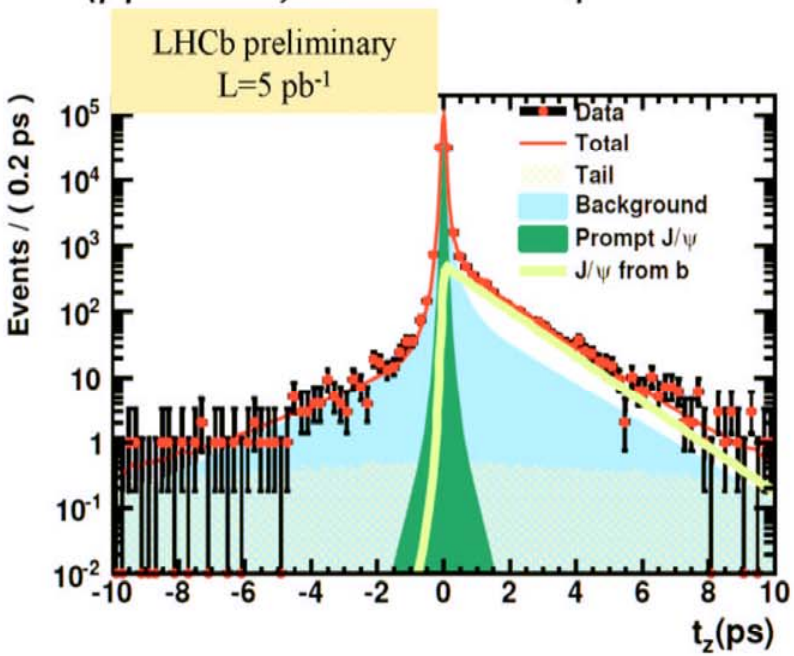
Extrapolating to 4π using PYTHIA 6.4: **$\sigma(pp \to b\bar{b}X) = 284 \pm 20 \pm 49\ \mu b$**

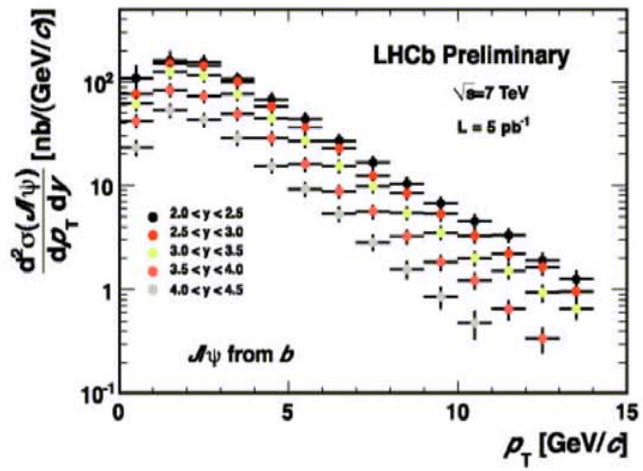
Theory: MCFM 332 μb, NFMR 254 μb

b cross section @ $\sqrt{s}$ = 7 TeV

Using J/ψ produced in B decays: $\sigma(J/\psi \text{ from } b,\ 2<y<4.5) = 1.16\pm0.01\pm0.17\ \mu b$

$\rightarrow \sigma(pp \rightarrow b\bar{b}X) = 295\pm4\pm48\ \mu b$

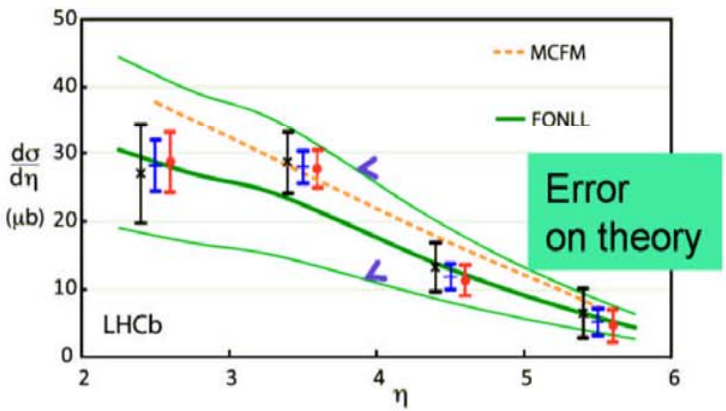




Using semileptonic B decays:

$\sigma(pp \rightarrow bbX \text{ in } 2<\eta<6) = 75.3\pm5.4\pm13.0\ \mu b$

$\rightarrow \sigma(pp \rightarrow bbX) = 282\pm20\pm48\ \mu b$



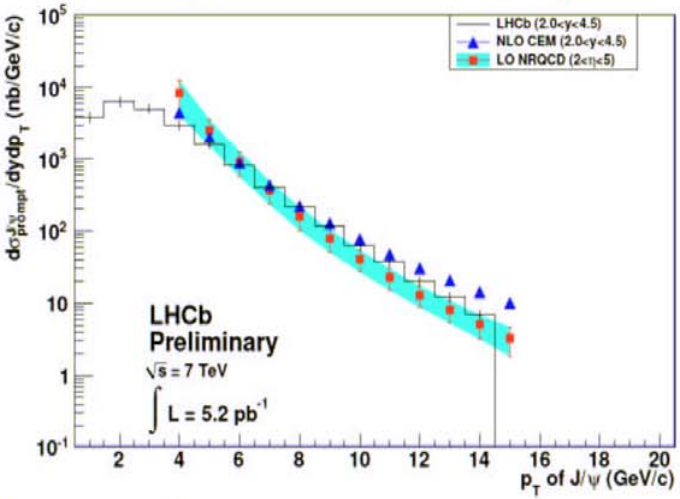
Prompt J/ψ and open charm cross-sections @ √s = 7 TeV

Prompt J/ψ production:

σ(prompt J/ψ, P_t<14 GeV/c, 2<y<4.5) =

= ($10.8 \pm 0.05 \pm 1.51^{+1.69}_{-2.25}$) μb

Comparison with theory

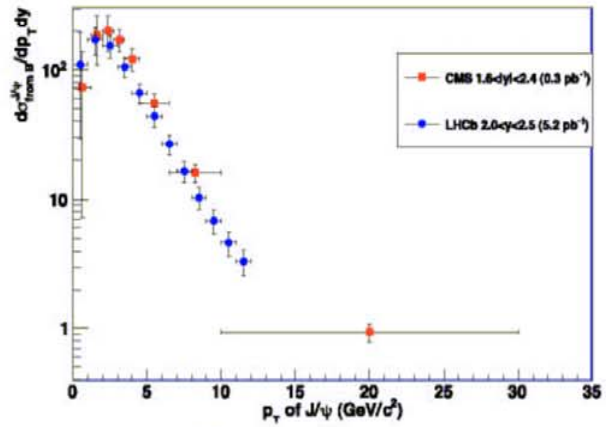


Open charm cross-sections

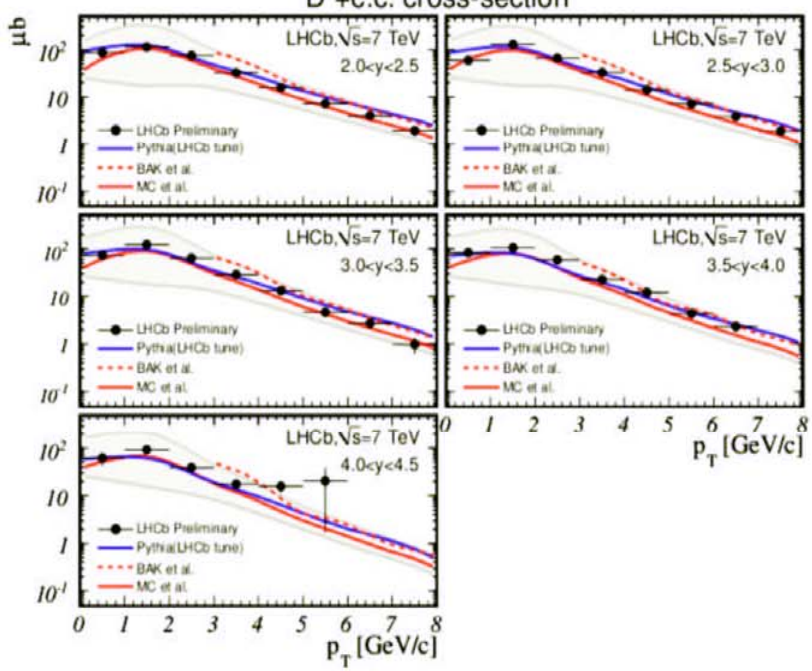
(D*, D^0, D^+, D_s and Λ_c) have been measured as well

As expected huge charm production in the forward direction: ~20 × b

Comparison with CMS in the overlapping region

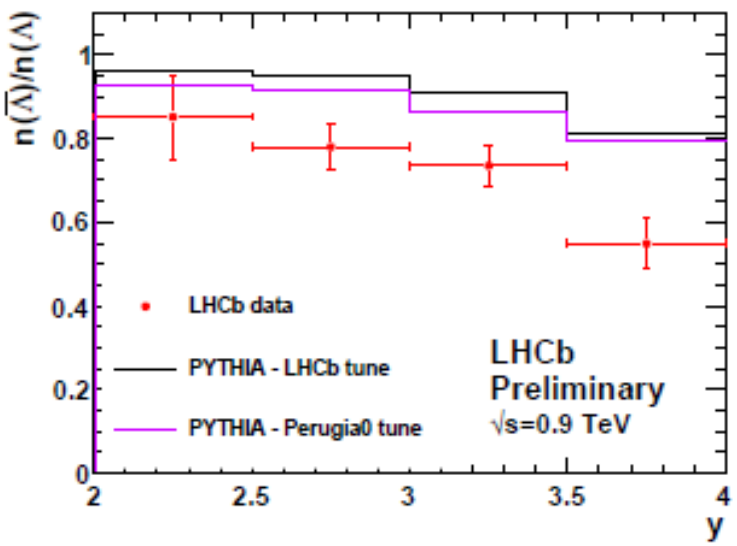


D^0+c.c. cross-section

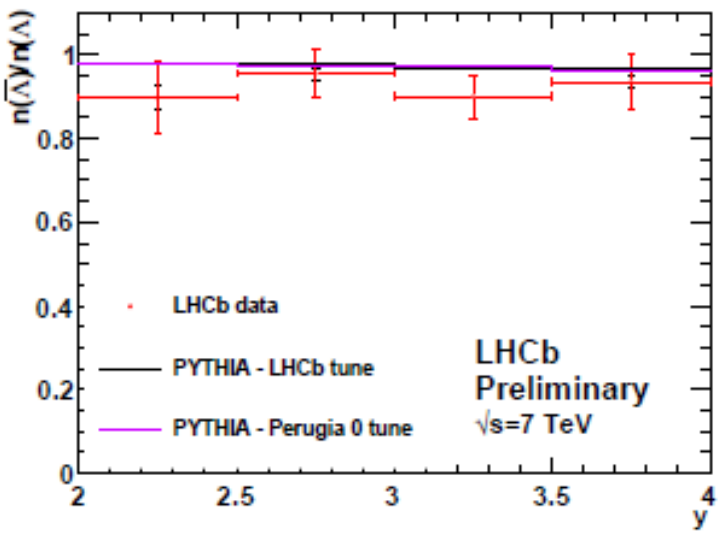


Measurement of prompt $\bar{\Lambda}/\Lambda$ and $\bar{\Lambda}/K^0_S$ production ratios in inelastic non-diffractive pp collisions at $\sqrt{s} = 0.9$ and 7 TeV

Lumi 0.3 nb^{-1}

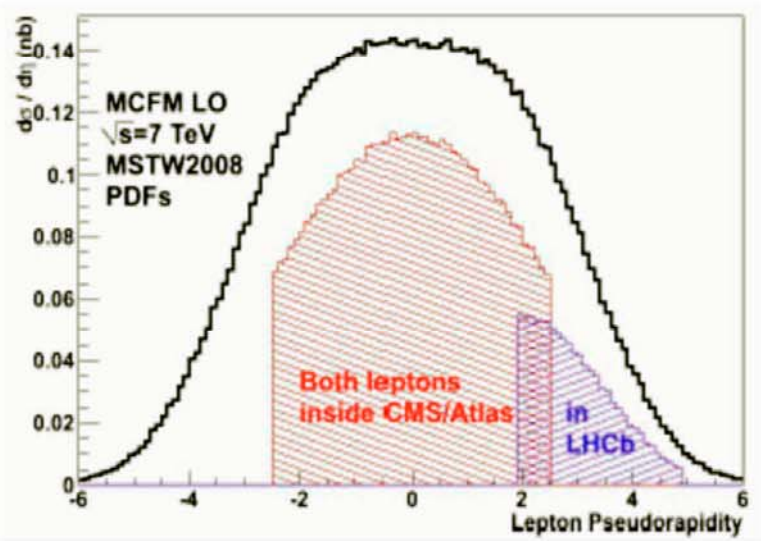


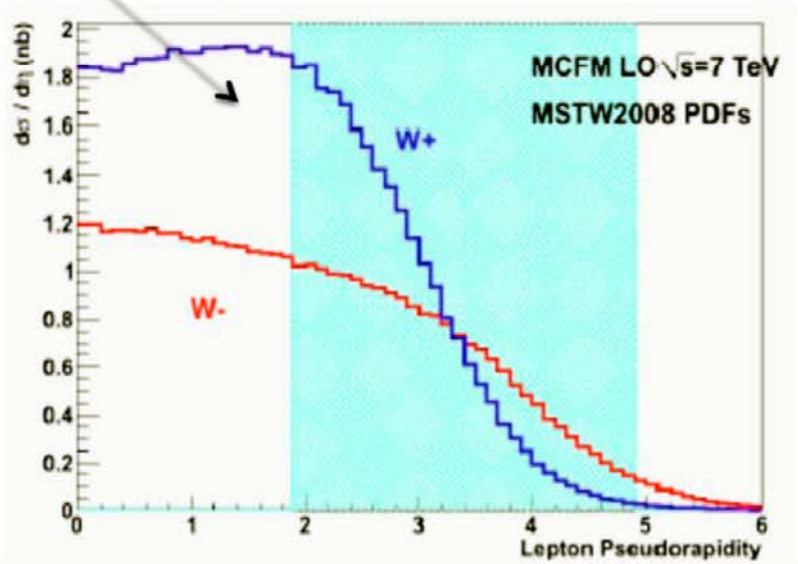
Lumi 0.2 nb^{-1}



Production of W and Z in the forward direction

Unique η coverage of LHCb allows for very interesting W,Z production studies such as switch-over in W^+ / W^- ratio in acceptance

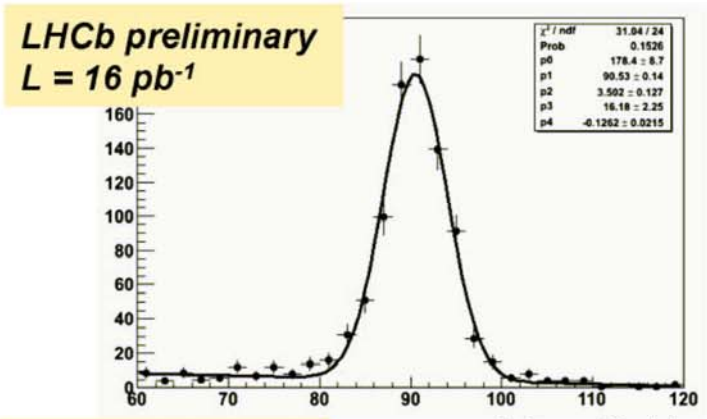


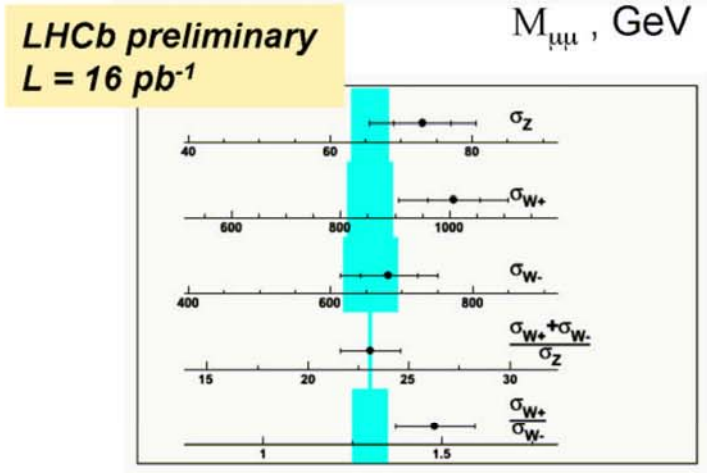


Very important to improve valence and sea quark distributions inside proton !!!

Z & W

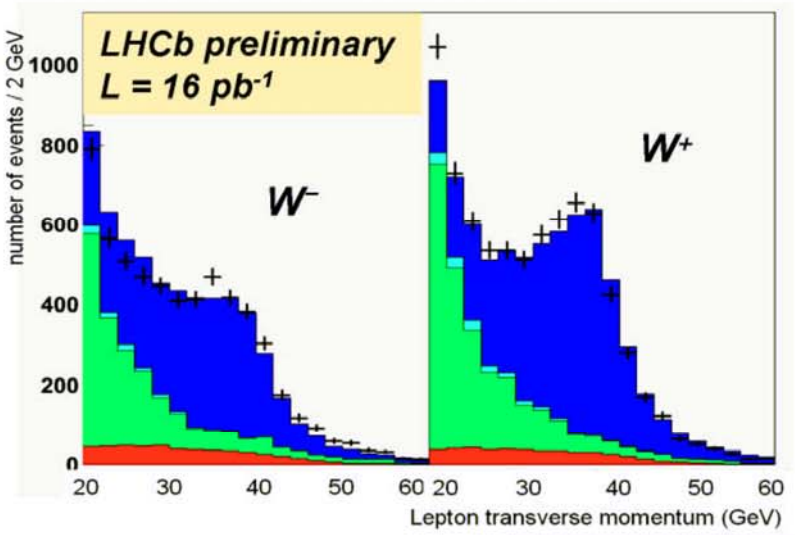
Z: 2 μ, each with P_t > 20 GeV/c

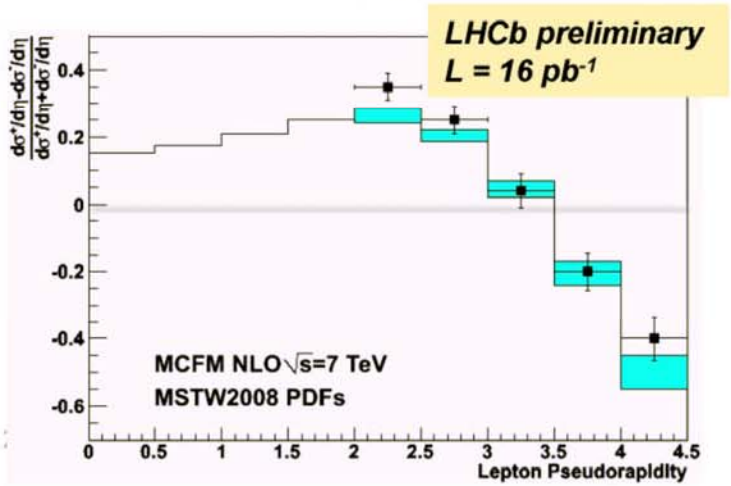




W/Z ratios test SM at 6%

W: single isolated μ with P_t > 20 GeV/c & small P_t opposite

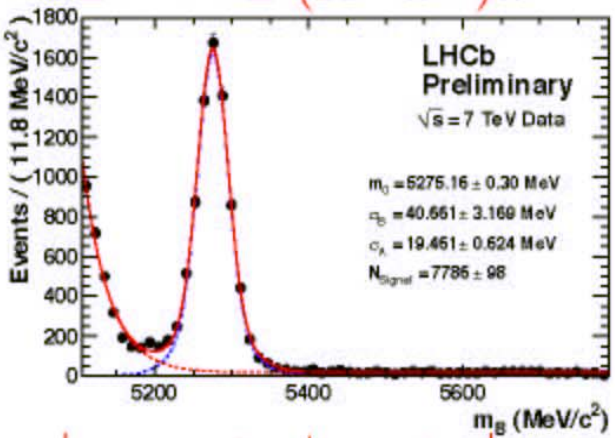




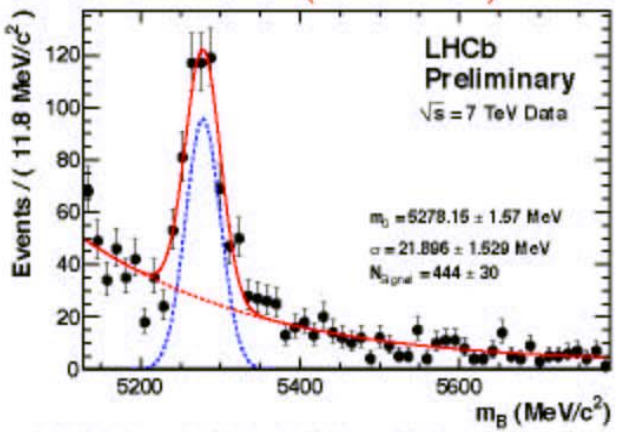
LHCb yields in $B^+ \to D\pi^+$ & $B^+ \to DK^+$

(LHCb takes shape !)

$B^{\pm} \to D(K^{\pm}\pi^{\mp})\pi^{\pm}$



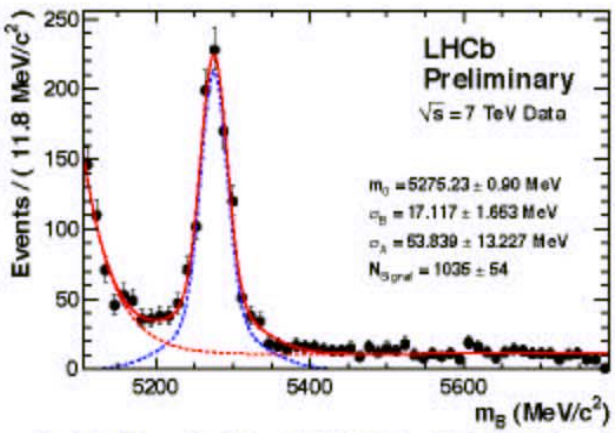
$B^{\pm} \to D(K^{\pm}\pi^{\mp})K^{\pm}$



LHCb yield: 444 ± 30 / 34 pb^{-1}

CDF yield: 516 ± 37 / fb^{-1}

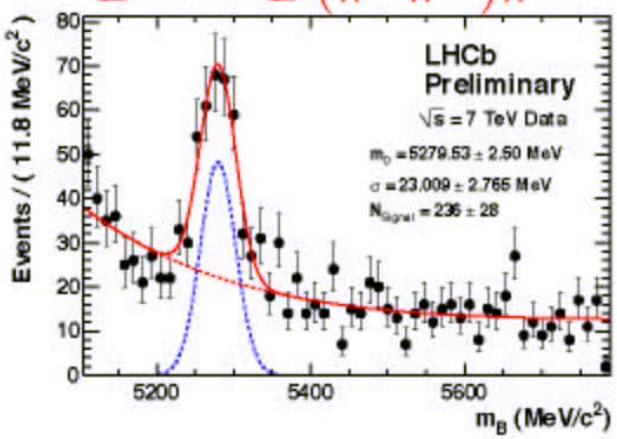
$B^{\pm} \to D(K^{+}K^{-})\pi^{\pm}$



LHCb yield: 1035 ± 54 / 34 pb^{-1}

CDF yield: 718 ± 36 / fb^{-1}

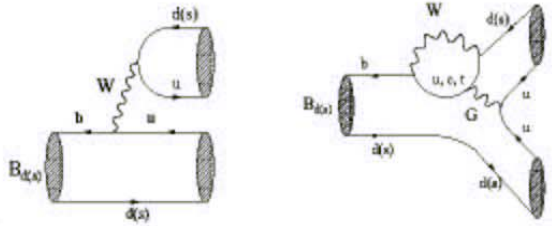
$B^{\pm} \to D(\pi^{+}\pi^{-})\pi^{\pm}$

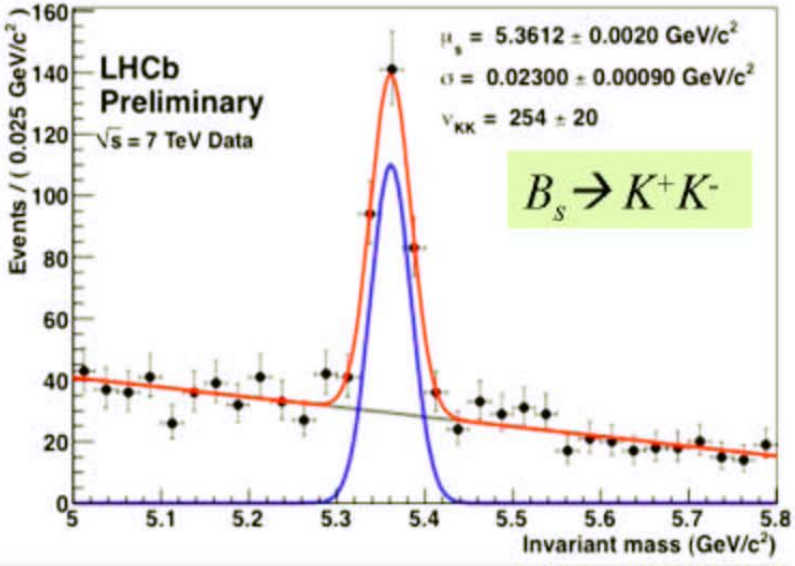


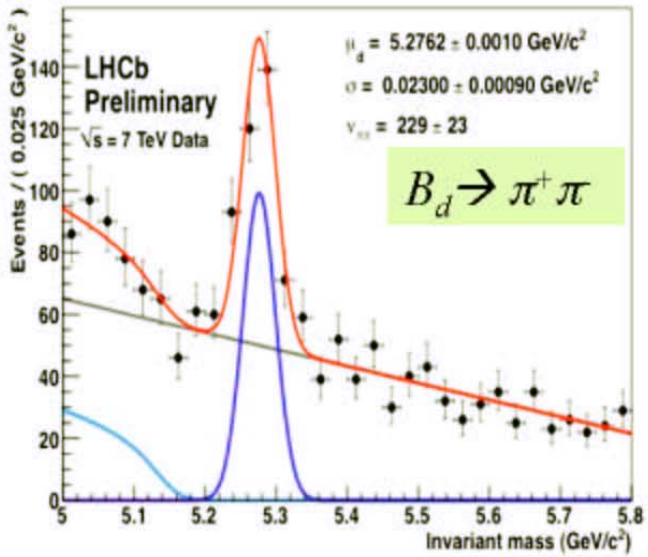
Prospects for γ measurement in $B_s \to K^+K^-$ & $B_d \to \pi^+\pi^-$

Large penguin contribution in both $B_s \to KK$ & $B_d \to \pi\pi$

→ *Sensitive to NP effects in time-dependent CP asymmetries (exploit U-spin symmetry)*





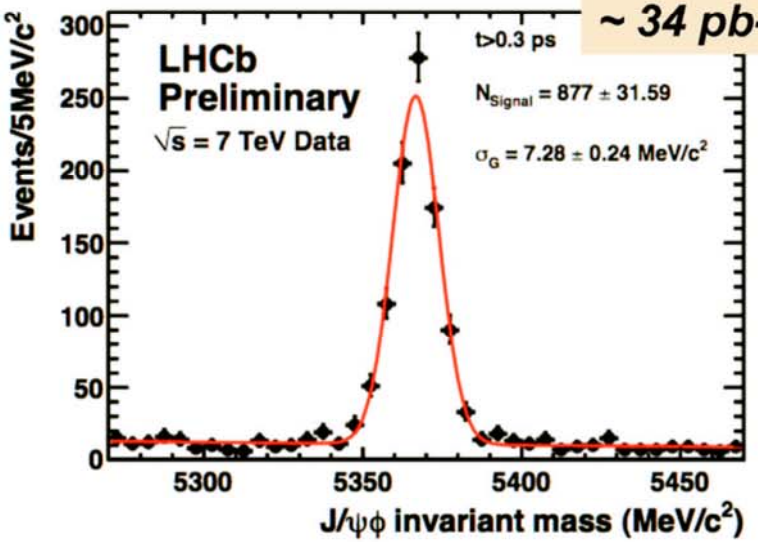


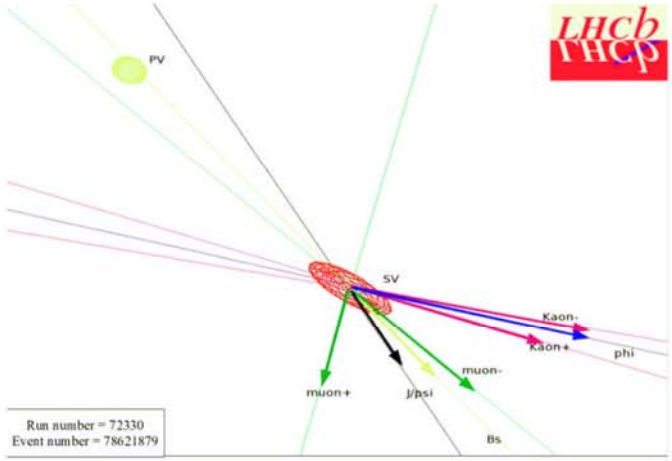
- *LHCb yiels in ~35 pb^{-1}: 254±20 $B_s \to K^+K^-$ & 229±23 $\pi^+\pi^-$*
  c.f. CDF in 1 fb^{-1} 1307±64 $B_s \to K^+K^-$ & 1121±63 $B_d \to \pi^+\pi^-$

- *Expect first time-dependent measurements in 2011/2012 (including measurement of B_s lifetime in CP-even K^+K^- final state*

Very clean $B_s \rightarrow J/\psi\phi$ signal

~ 34 pb-1



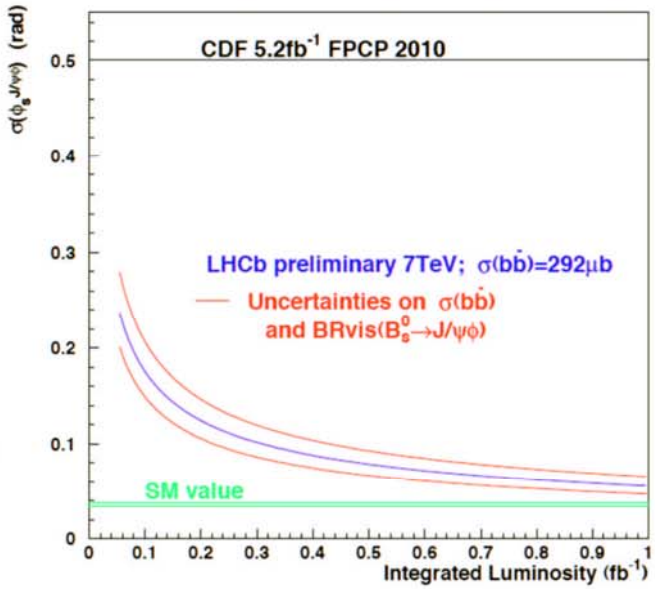


Expected sensitivity for $2\beta_s$

50k events / fb^{-1} consistent with number of $B_s \rightarrow J/\psi\phi$ candidates seen in data

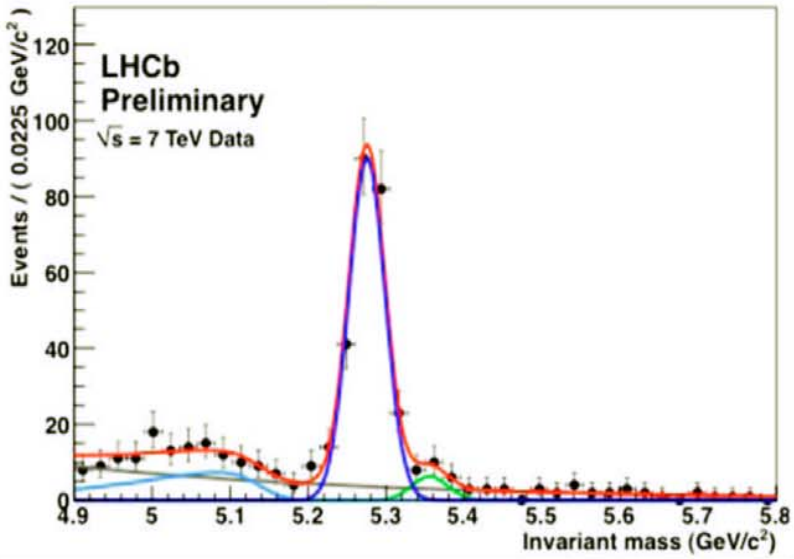
$\langle\sigma_t\rangle$ = 0.040 ps. Present time resolution worse in data but sufficient for Δm_s ~ 17.7/ps

Tagging performance is being tuned using data

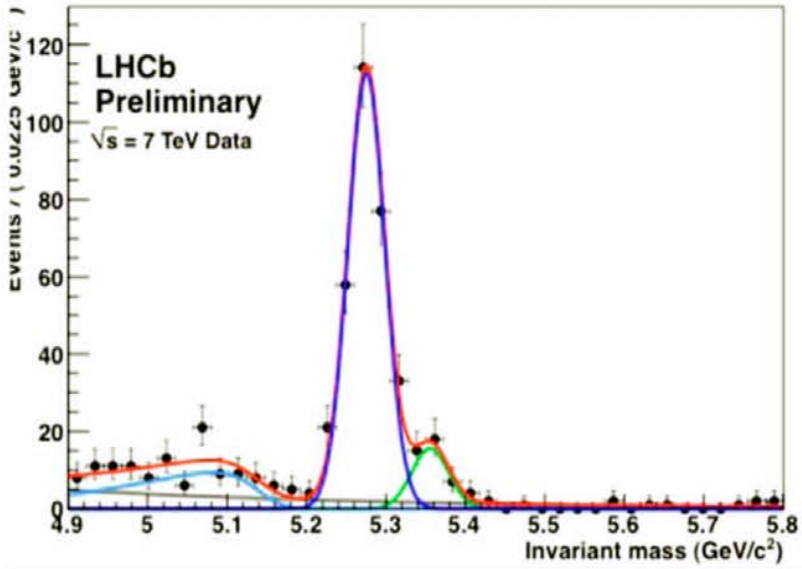


Prospects for direct CP violation in $B_{d/s} \to K\pi$

$\bar{B}_{d/s} \to K^-\pi^+$

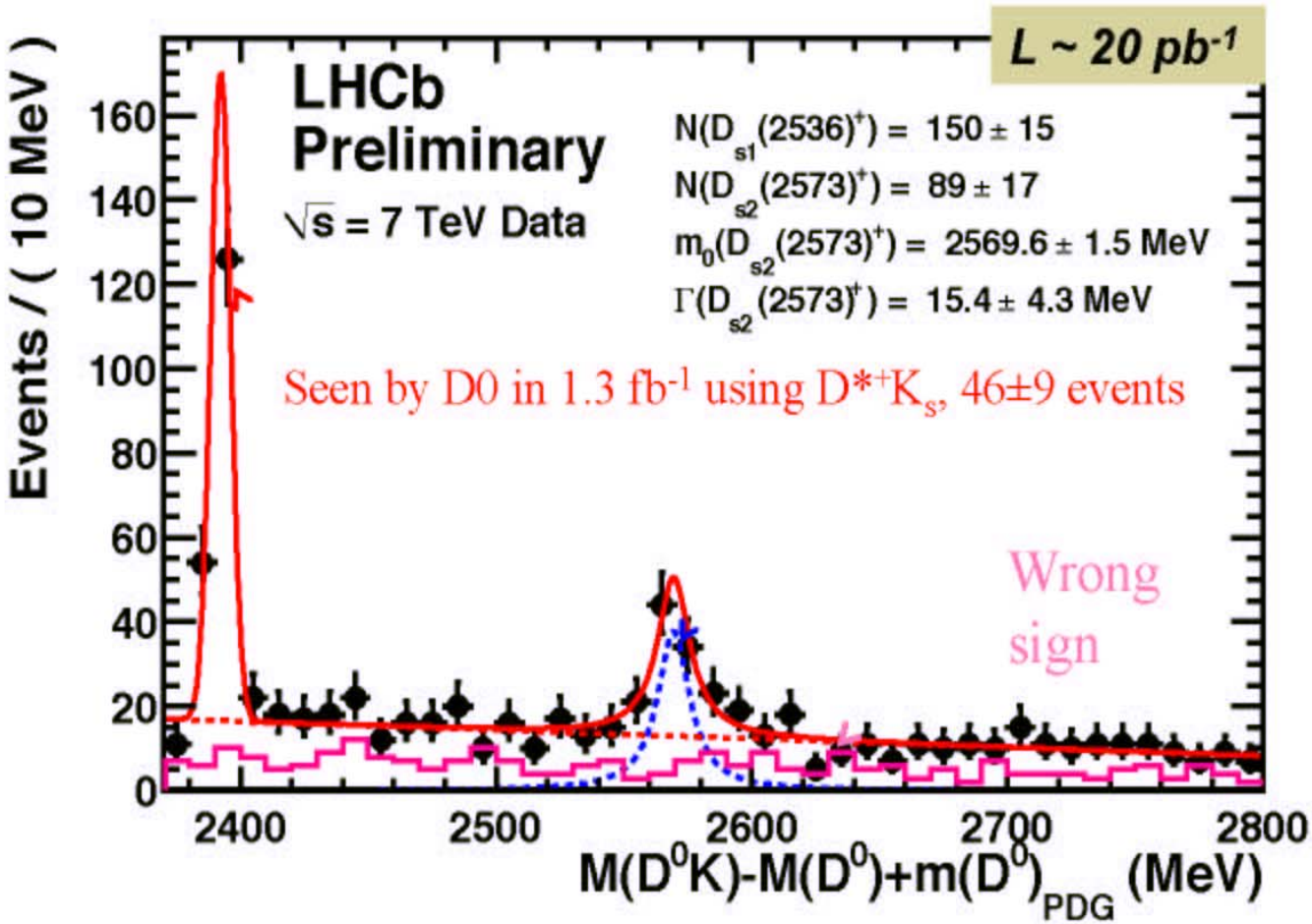


$B_{d/s} \to K^+\pi^-$

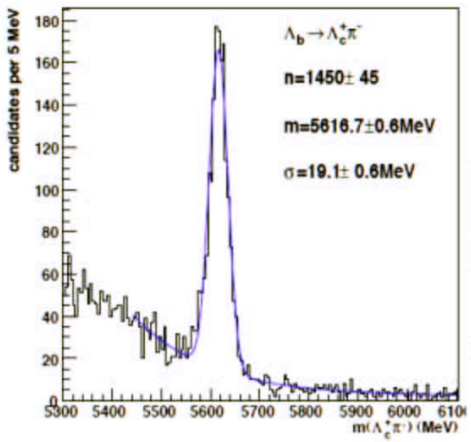


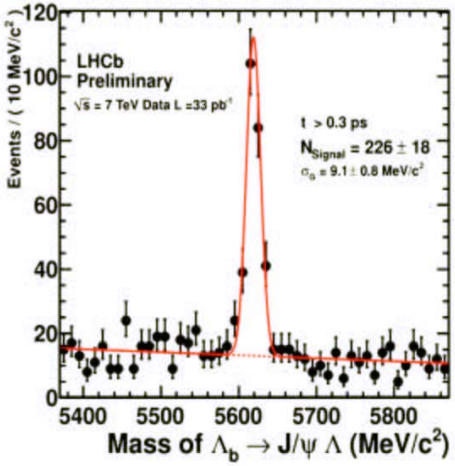
- **Raw asymmetries clearly visible in data: direct CPV > 3σ**
- *Central values consistent with expectations and previous measurements*
- *Evaluation of systematic uncertainties is ongoing*

First observation of new semileptonic B_s decay: $B_s \to D_{s2} X \mu \nu$, $D_{s2} \to D^0 K^+$

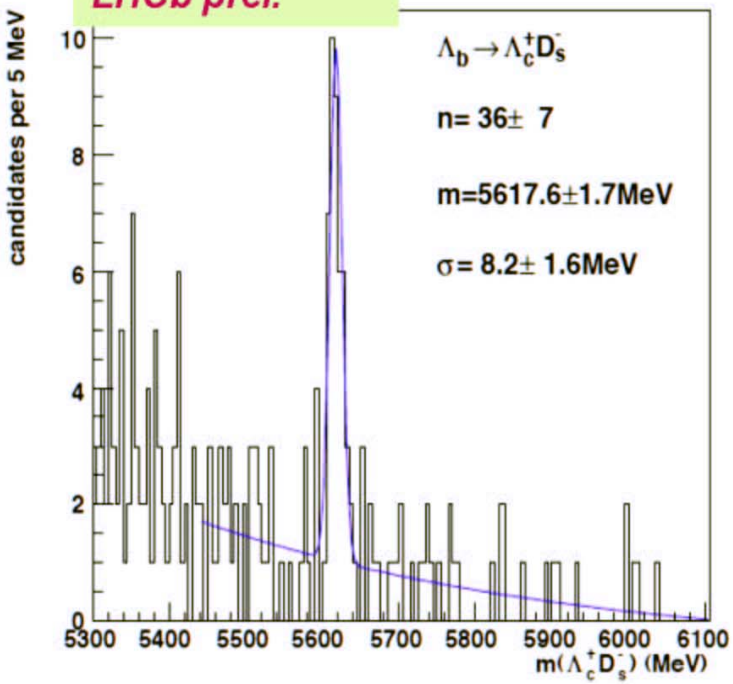


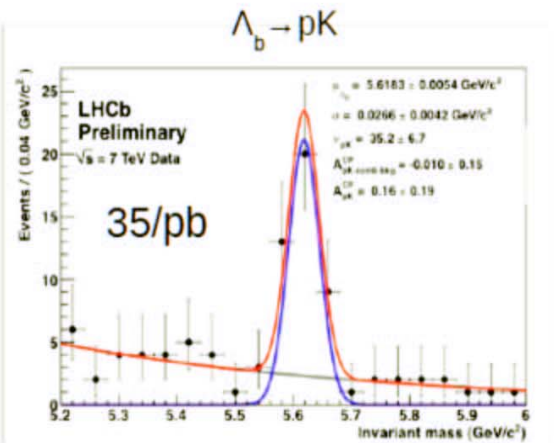
First observation of new Λ_b decay mode: $\Lambda_b \rightarrow \Lambda_c D_s$

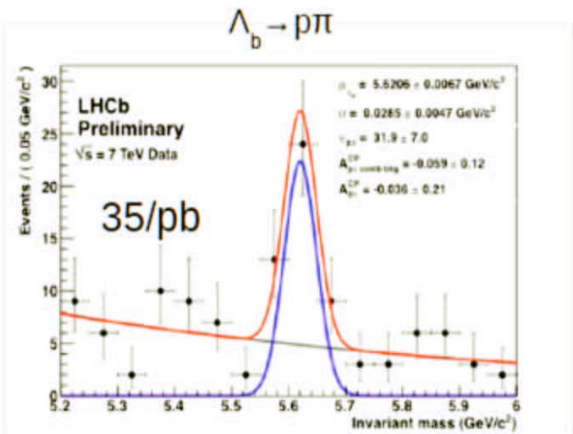




New: L~30 pb-1
LHCb prel.





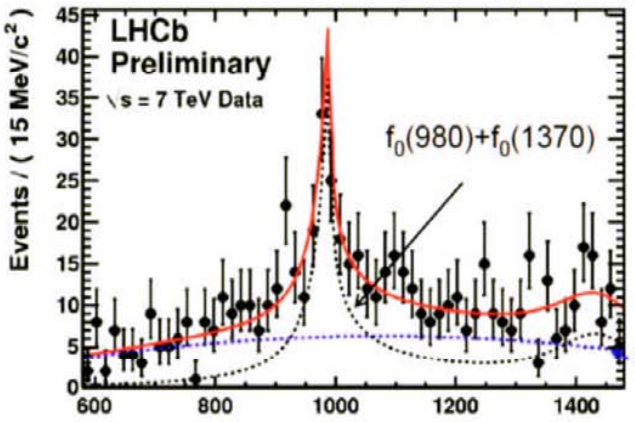


Excellent prospects for A_{CP} observation with $L \sim 1\ fb^{-1}$

First observation of $B_s \rightarrow J/\psi f_0$ (CP eigenstate)

Very useful decay mode for β_s measurement !

$|m(\pi\pi\mu\mu - m(B_s)| < 30$ MeV

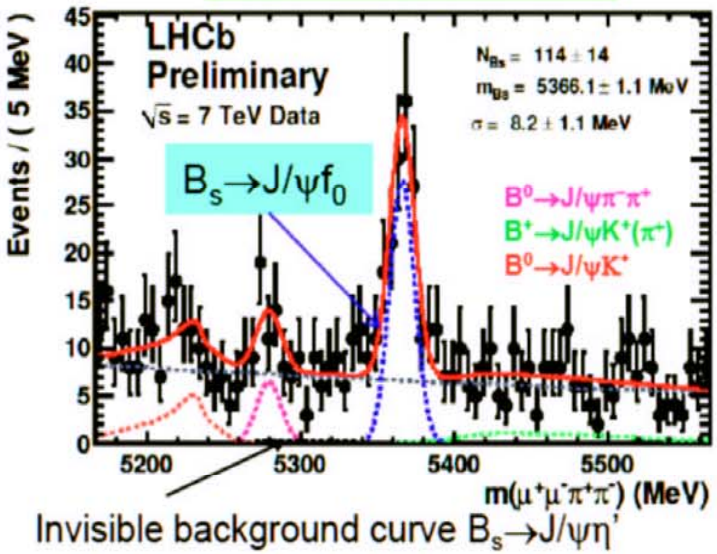


$N(f_0(980)) = 175^{+32}_{-23}$

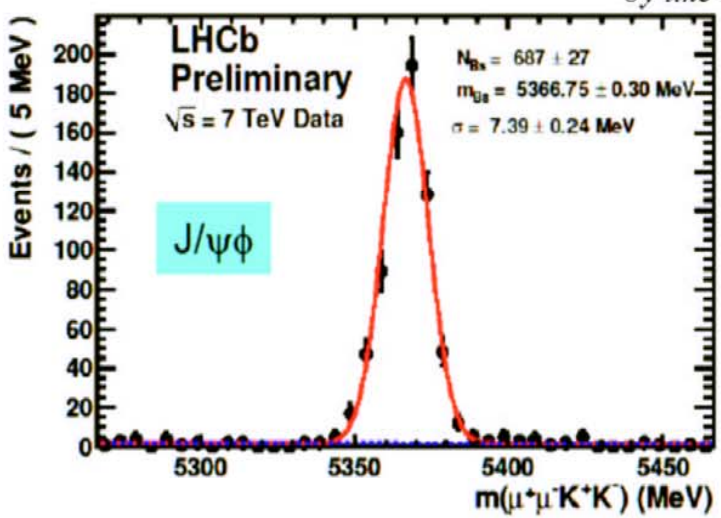
Bg constrained by like-sign dipions

Helicity distributions are as expected: flat for f_0 and $\sin^2\theta$ for J/ψ

$|m_{\pi\pi} - m_{f_0(980)}| < 90\,\text{MeV}$

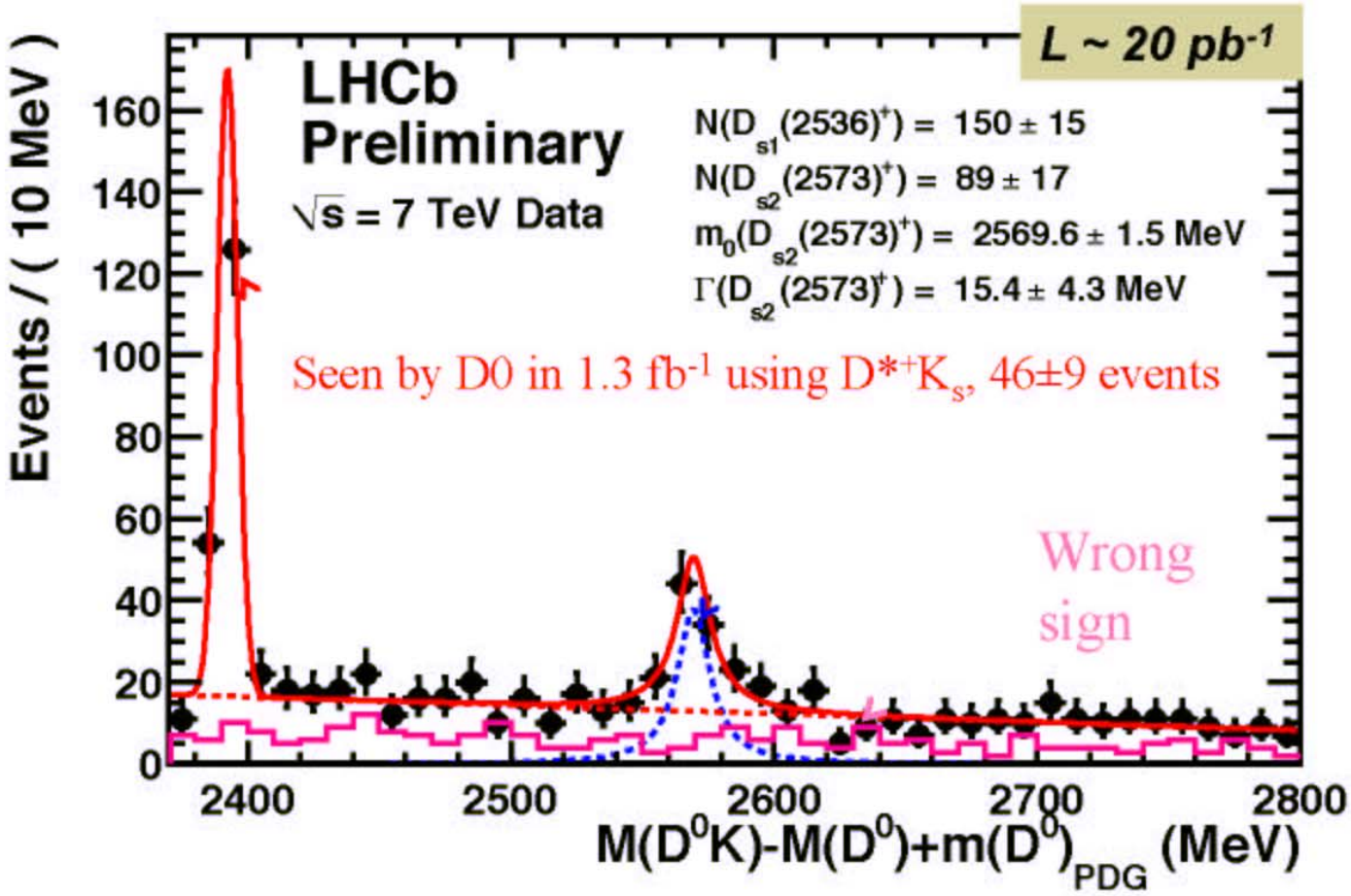


Invisible background curve $B_s \rightarrow J/\psi\eta'$



$R_{f0/\phi} = BR(B_s \rightarrow J/\psi f_0, f_0 \rightarrow \pi^+\pi^-) / BR(B_s \rightarrow J/\psi\phi, \phi \rightarrow K^+K^-) = (25.9^{+4.7}_{-3.4})\%$

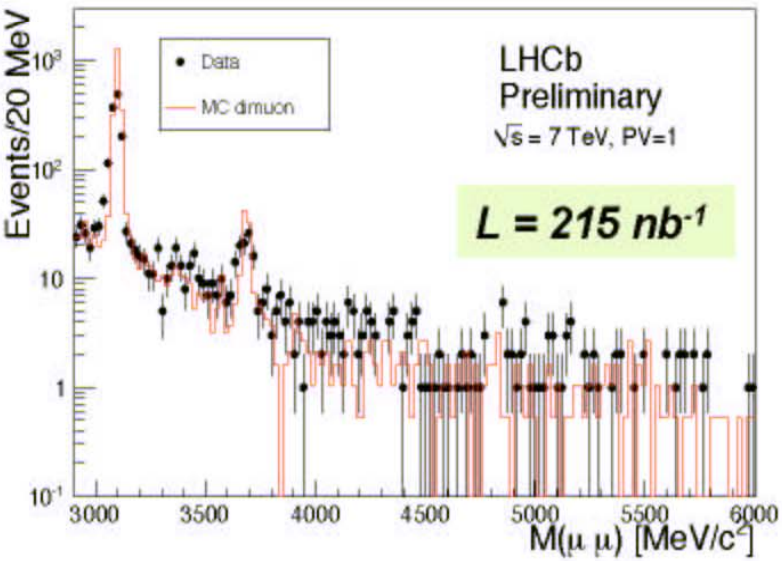
First observation of new semileptonic B_s decay: $B_s \to D_{s2} X \mu \nu$, $D_{s2} \to D^0 K^+$

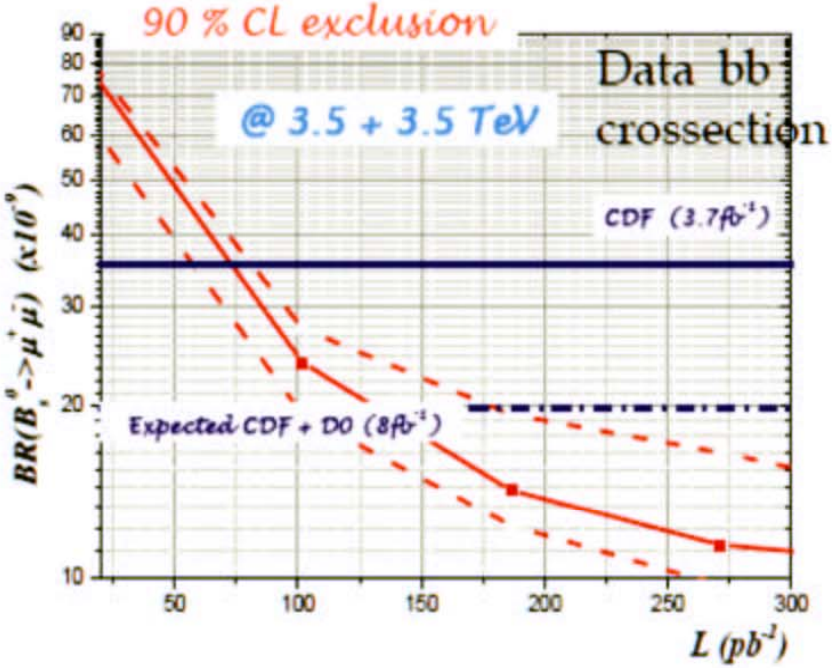


Prospects for $B_s \rightarrow \mu\mu$

For the SM prediction LHCb expects 10 signal events in 1 fb^{-1}

Background expected from MC is in good agreement with data





Very interesting sensitivity possible even with 40 pb^{-1} !!!

With L ~ 1 fb^{-1} exclusion of SM enhancement up to BR($B_s \rightarrow \mu\mu$) ~ 7×10^{-9}

The End