Hadronic and semileptonic b-hadron decays at LHCb

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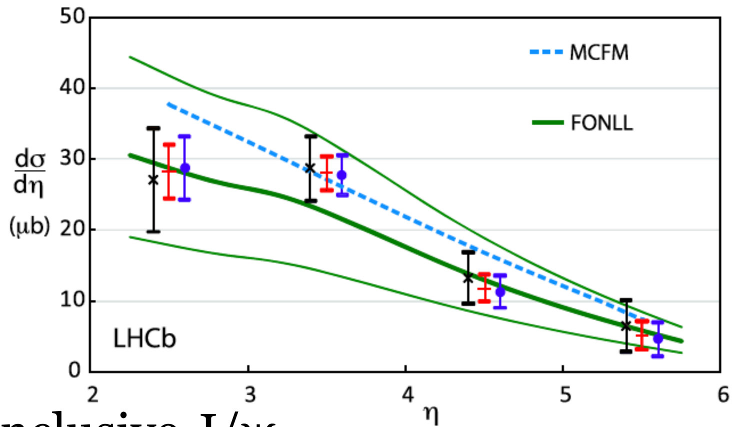
LHCb measurements of the b-hadron cross section

- LHCb measures b-hadron cross section in good agreement with state of the art perturbative QCD calculations (FONNL)

Phys.Lett.B694:209-216,2010

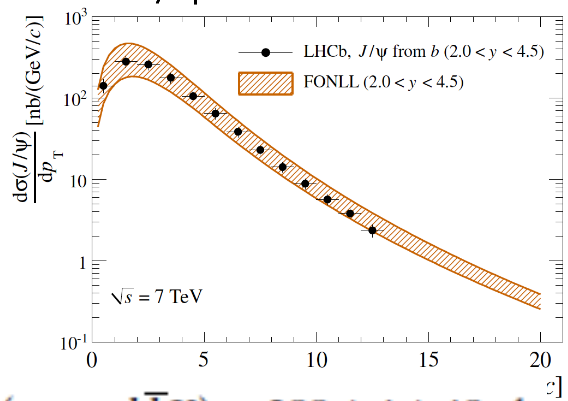
$\sigma(pp \to b\bar{b}X)$
From D°μνX

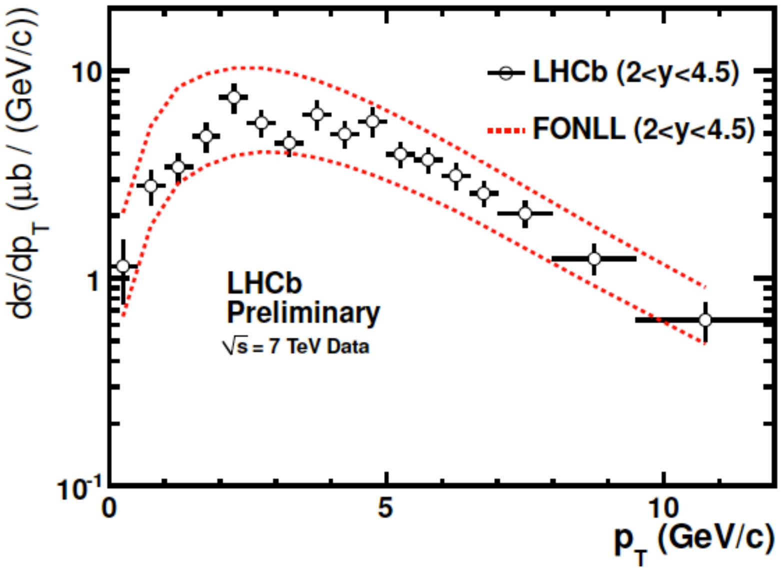


η	σ(μb)Theory I	σ(μb)Theory II	Measured σ(μb)
2,6	89.0	70.2	75.3 ± 5.4 ± 13.0
All	332	253	284 ± 20 ± 49

$\sigma(B^+, 2 < y < 4.5) = 37.1 \pm 1.9(\text{stat.}) \pm 5.3(\text{syst.})\,\mu\text{b}.$ from $B^\pm \to J/\psi K^\pm$

Inclusive J/ψ



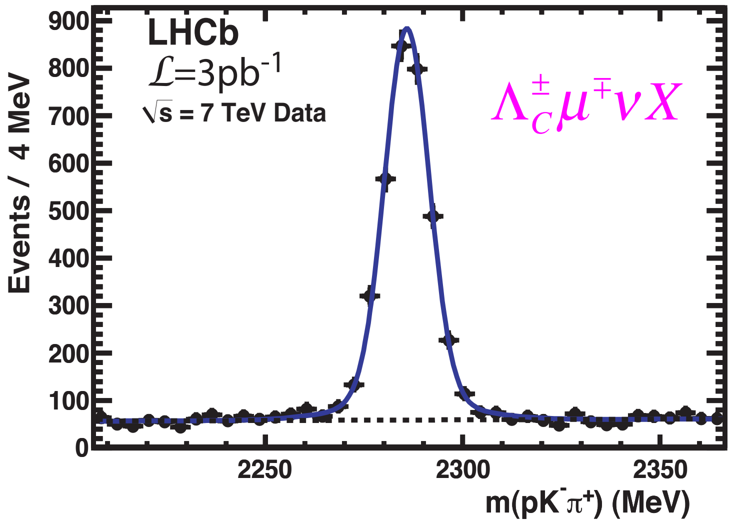


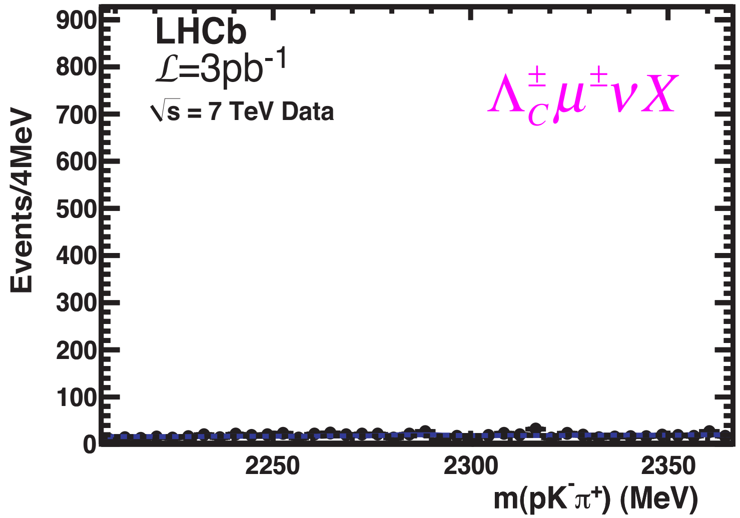
$\sigma(pp \to b\bar{b}X) = 288 \pm 4 \pm 48\,\mu\text{b}$

Eur.Phys.J.C71:1645,2011

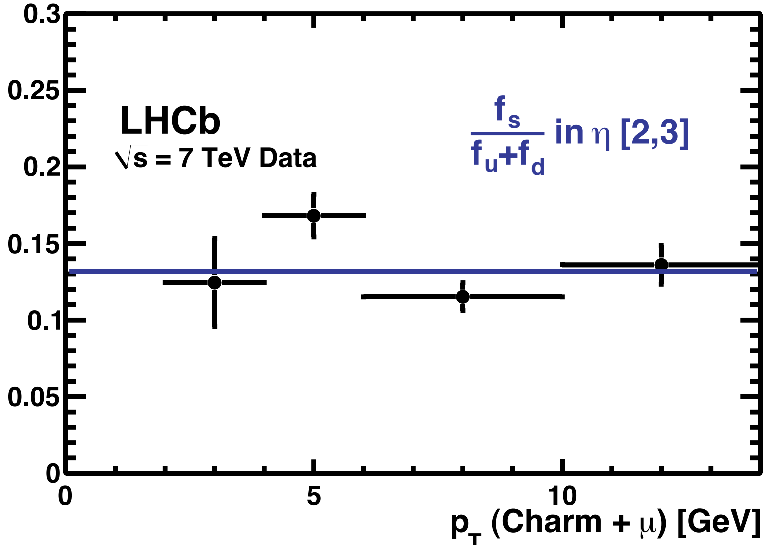
b-hadron production fractions

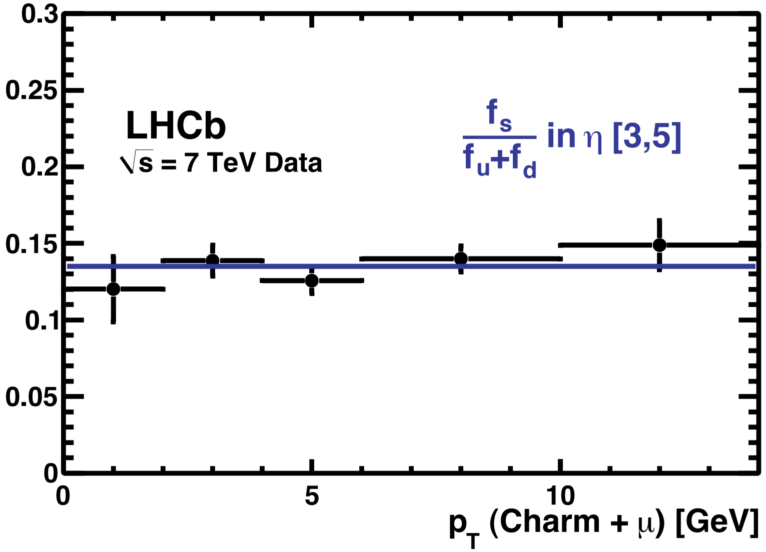
- b-fractions measured from charm-μ final states:
  - B^0+B^+ mostly $D^0\mu\nu+D^+\mu\nu$
  - B_s mostly $D_s\mu\nu$
  - Λ_b mostly $\Lambda_c\mu\nu$
- taking into account all the possible cross-feeds:
  - $D^{0,\pm}K\mu\nu$ (B^0,B^+,B_s)
  - D_sK (B^0,B^+, B_s)
  - $D^0p(n)$ (B^0,B^+, Λ_b)





$f_s/(f_u+f_d) = 0.134 \pm 0.004(\text{stat.})\ ^{+0.012}_{-0.011}(\text{sys.})$





Systematic error breakdown

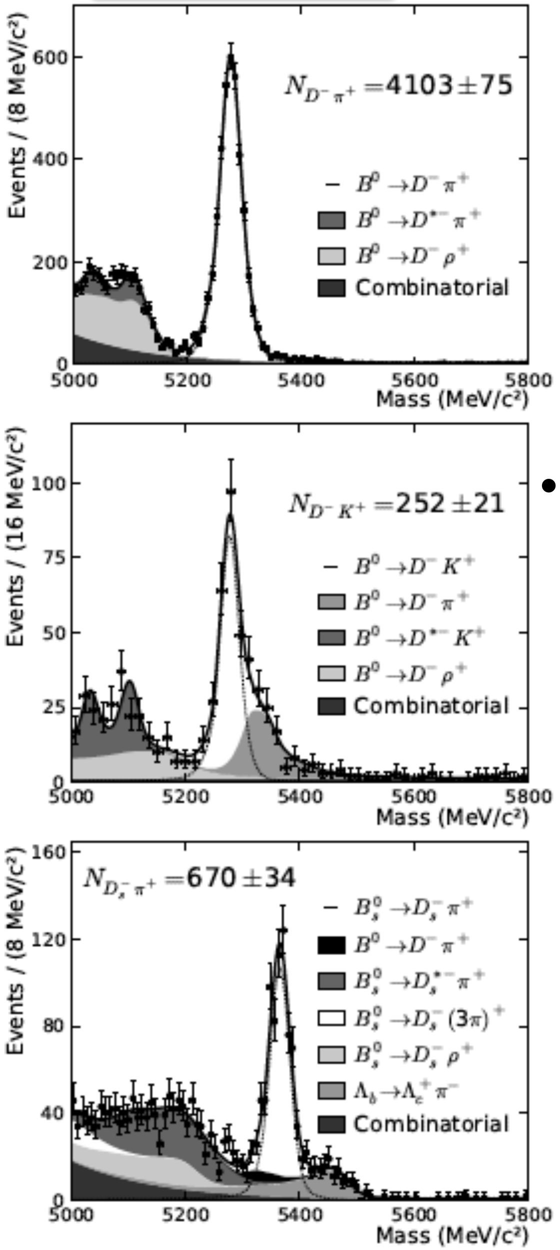
Source	Error (%)
Bin dependent errors	1.0
Charm hadron branching fractions	5.5
B_s semileptonic decay modeling	3.0
Backgrounds	2.0
Tracking efficiency	2.0
Lifetime ratio	1.8
PID efficiency	1.5
$\overline{B}^0_S \to D^0 K^+ X \mu^- \overline{\nu}$	$^{+4.1}_{-1.1}$
$(B^-, \overline{B}^0) \to D_s^+ K X \mu^- \overline{\nu}$	2.0
Total	$^{+8.6}_{-7.7}$

LEP: 0.128 ± 0.012
Tevatron: 0.156 ± 0.026 (HFAG)

$f_s/(f_u+f_d)$ doesn't depend on η or p_T (charm+μ)

LHCb determination of f_s/f_d

arXiv:1106.4435.



$$\frac{f_s}{f_d}(D_s\mu\nu X) = 0.268 \pm 0.008^{+0.024}_{-0.022}$$

LHCb has two other measurements:

$$\frac{BF(B_s^0 \to D_s^-\pi^+)}{BF(B^0 \to D^-K^+)} = 0.250 \pm 0.024(stat) \pm 0.017(syst) \pm 0.017(theor)$$

$$\frac{BF(B_s^0 \to D_s^-\pi^+)}{BF(B^0 \to D^-\pi^+)} = 0.256 \pm 0.014(stat) \pm 0.019(syst) \pm 0.026(theor)$$

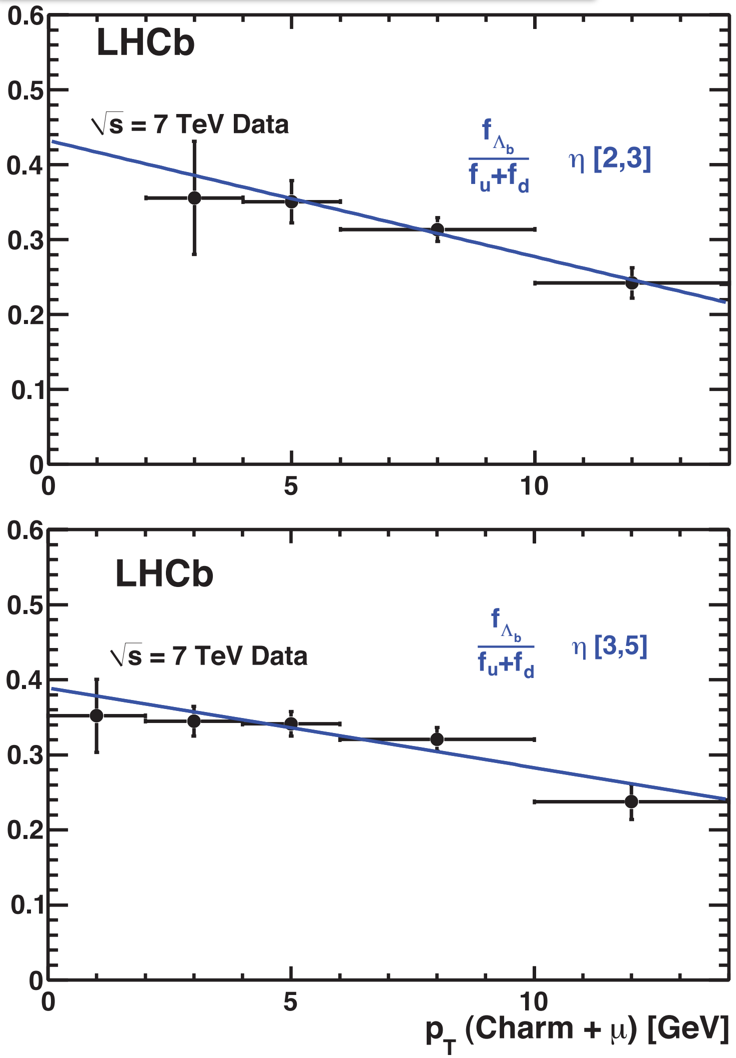
- We average the 3 LHCb measurements to get [LHCb-CONF-2011-34]

$$\left\langle \frac{f_s}{f_d} \right\rangle = 0.267^{+0.021}_{-0.020}$$

Source	Error(%)
Statistical	2.8
Experimental Sys (symme)	3.3
$B_s \to D_s K X \mu\nu$	+3.0 -0.8
$\mathcal{B}(D^+ \to K^-\pi^+\pi^-)$	2.2
$\mathcal{B}(D_s \to K^-K^+\pi^-)$	4.9
B lifetimes	1.5
$\mathcal{B}(B^o/B^+ \to D_s K^-)$	1.5
Theory	1.9

$f_{\Lambda b}/(f_u+f_d)$

LHCb-CONF-2011-028

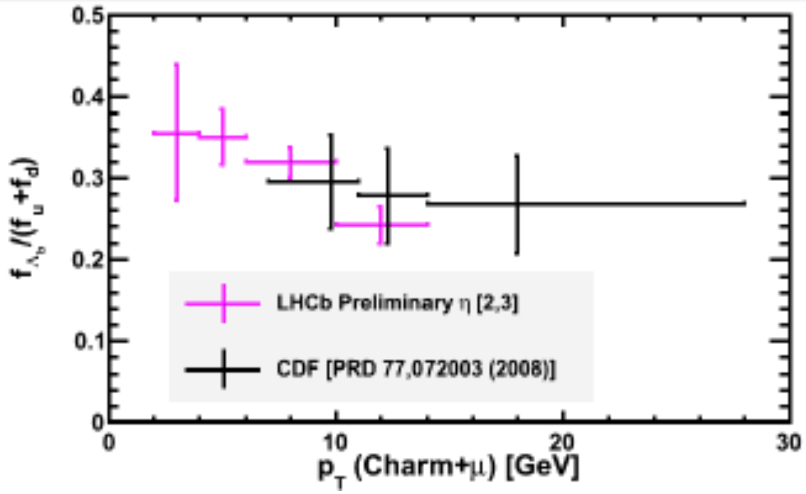


$f_{\Lambda b}/(f_u+f_d)$ not consistent with flat over p_T

If we fit with straight line, we get

$$\frac{f_{\Lambda_b}}{f_u+f_d} = (0.404 \pm 0.017 \pm 0.027 \pm 0.105) \times \left[1-(0.031 \pm 0.004 \pm 0.003) \times p_T / \text{GeV}\right]$$

Systematic error on the scale 26% from $\mathcal{B}(\Lambda_c \to pK\pi)$



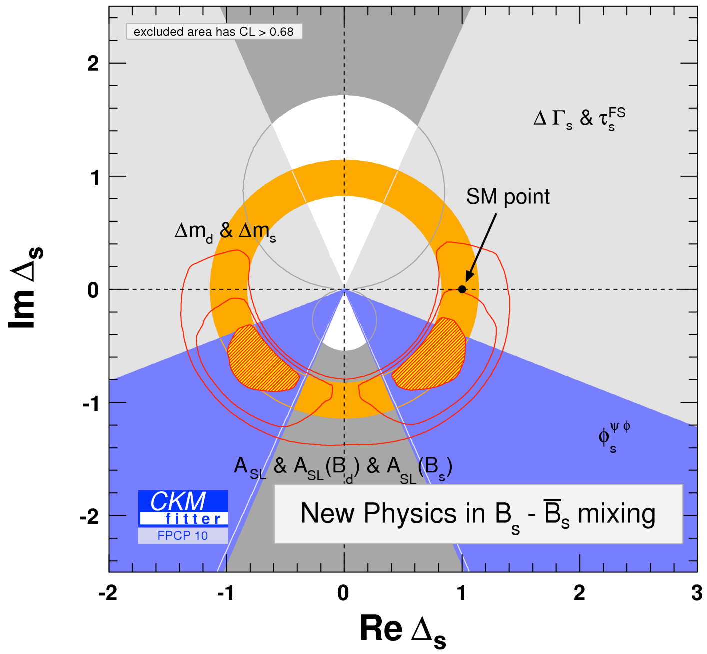
CDF value $(0.281 \pm 0.012^{+0.011}_{-0.056}{}^{+0.128}_{-0.086}) \; \langle p_T \rangle_{\text{CDF}} \approx 14.1\,\text{GeV}$

LEP value $0.110 \pm 0.035 \; \langle p_T \rangle_{\text{LEP}} \approx 40\,\text{GeV}$

Goals in hadronic *B* decays

- Perform precise measurements of 2 body B_d and B_s decays which, in combination with theoretical evaluations of QCD effects [QCD factorization…] and various flavor symmetries, will teach us more about the interplay of strong and electroweak interactions, and elucidate new physics contributions.
- Determine the mixing induce CP asymmetry in B_s decays and other CP violation observables such as the CKM angle γ

$B_s \rightarrow J/\psi(\pi^+\pi^-$ and $K^+K^-)$



- Measurements of mixing induced CP violation in B_s^0 decays are of prime importance in probing new physics, most studied channel is

$$B_s^0 \rightarrow J/\psi\phi$$

but other final state may play a major role such as

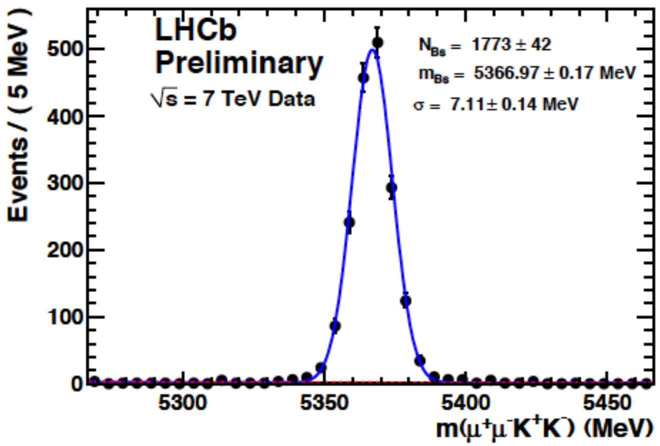
$$B_s^0 \rightarrow J/\psi f_0$$

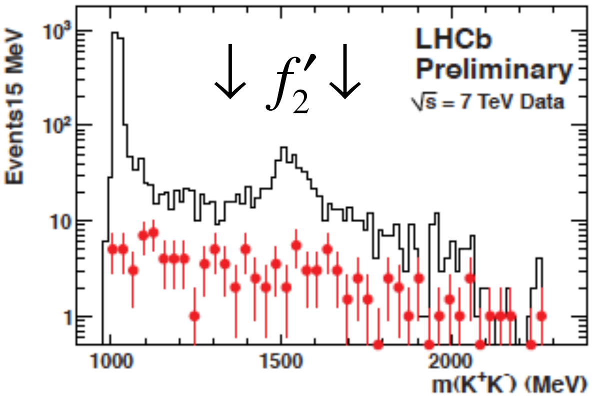
more in C.P.Linn's talk

Study of $B_s^0 \to J/\psi K^+K^-$ and first observation of $B_s^0 \to J/\psi f_2'(1525)$

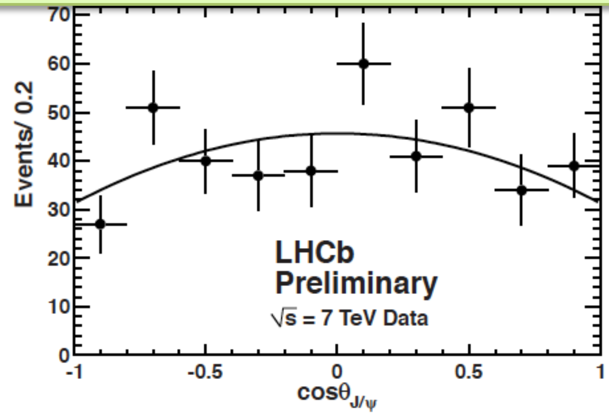
Selecting events with K^+K^- within ±20 MeV of the ϕ mass, we obtain the normalization $J/\psi\phi$ signal

$\mathcal{L}^{int}$=162pb^{-1}





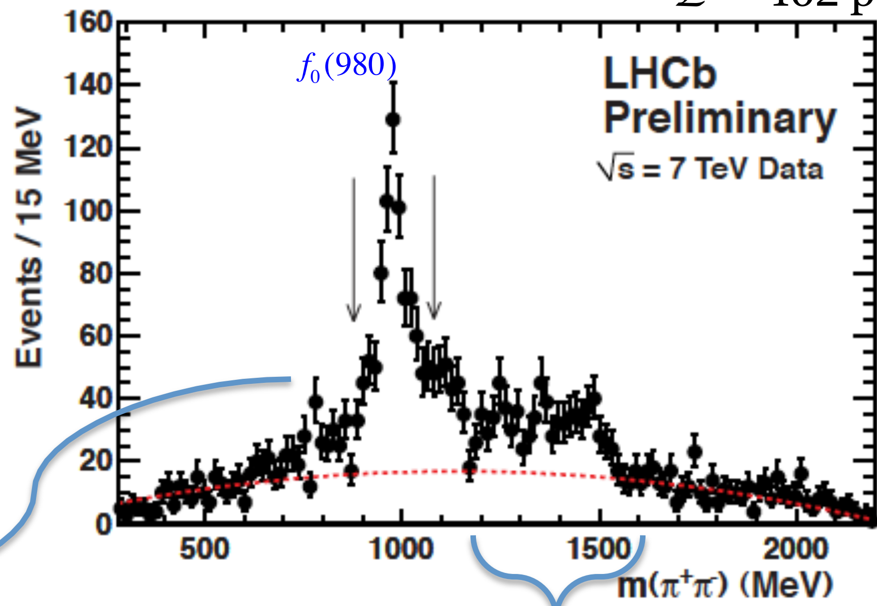
Angular analysis shows consistency with spin 2



$$R_{eff}^{f_2'} \equiv \frac{N_{corr}(B_s^0 \to J/\psi f_2')}{N_{corr}(B_s^0 \to J/\psi\phi)} = (19.4 \pm 1.8 \pm 1.1)\%$$

Study of m($\pi^+\pi^-$) from B_s decays

$\mathcal{L}^{int}$=162 pb^{-1}

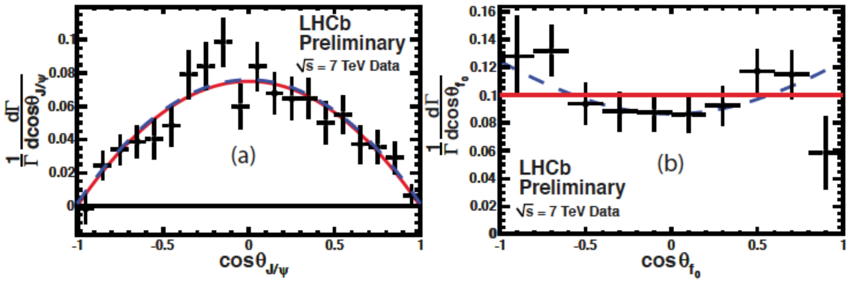


We require $J/\psi\pi^+\pi^-$ to be within ±25 MeV of the B_s mass, and we study the invariant mass of the $\pi^+\pi^-$ system.

$$R_{eff}^{f_0} \equiv \frac{N_{corr}(J/\psi f_0)}{N_{corr}(J/\psi\phi)} = (21.7 \pm 1.1 \pm 1.0)\%$$

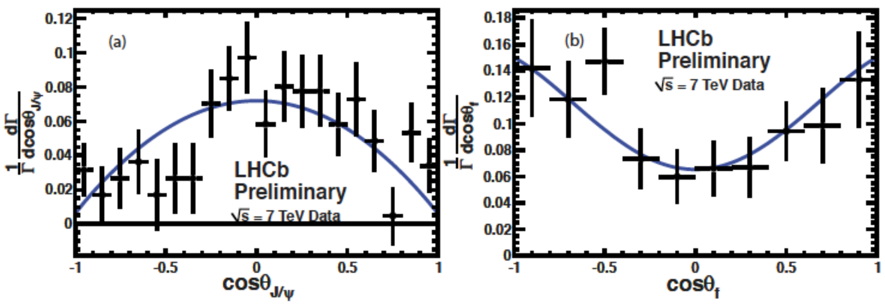
Prediction by Stone & Zhang $R_{th}^{f_0} \approx 20\%$

Phys.Rev. D79 (2009) 074024



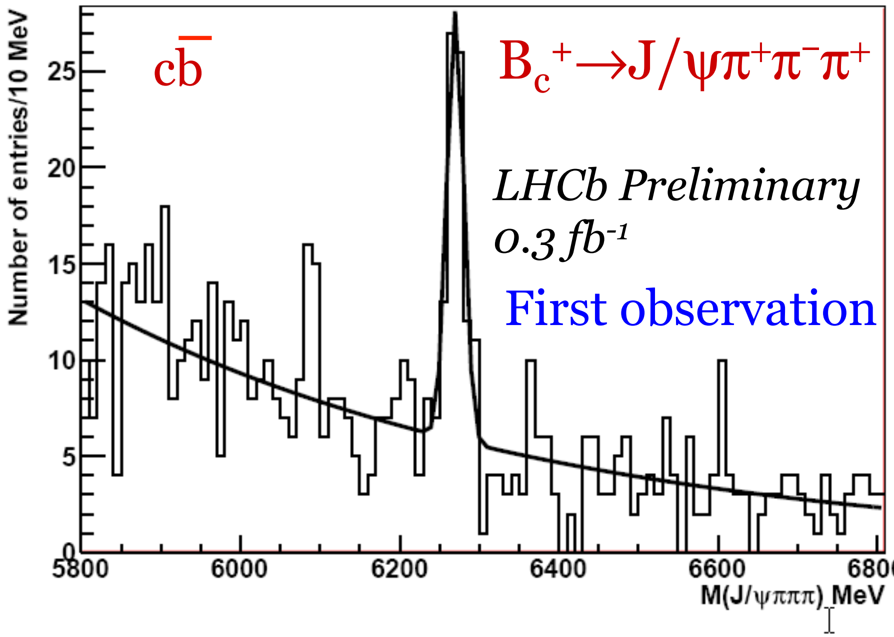
f$_0$ mass region ≈ s-wave

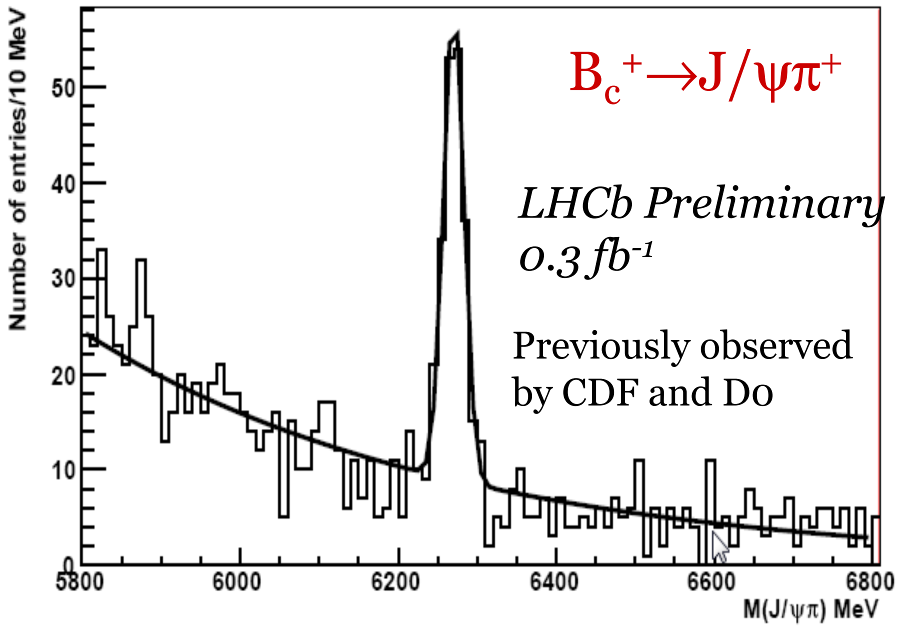
Cutting on m($\pi^+\pi^-$)= (1200,1600) significant D-wave component



First observation of $B_c^+ \to J/\psi\pi^+\pi^-\pi^+$

Only 3rd B_c^+ decay mode ever observed





58.2±9.6 events
6268.4±1.7 MeV (uncalibrated)
σ=9.7±1.6 MeV
6.8σ

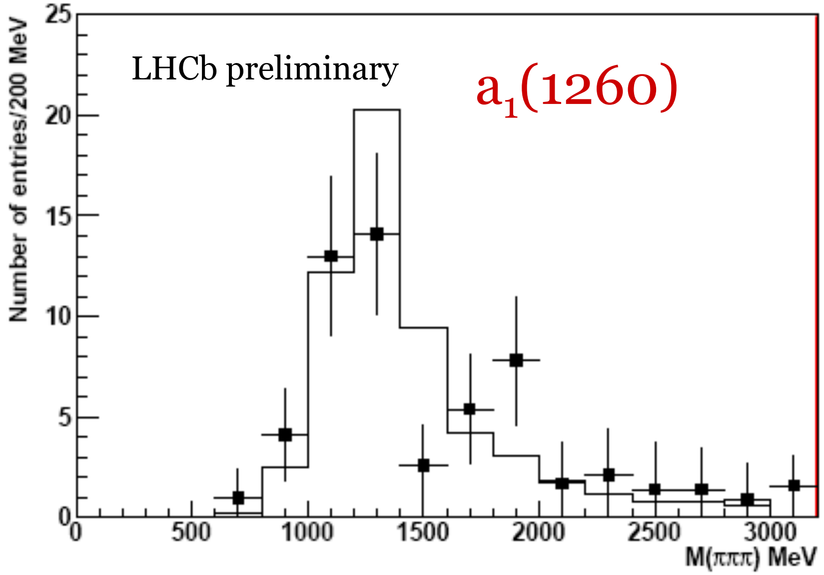
163.1±15.7 events
6270.3±1.4 MeV (uncalibrated)
σ=12.7±1.6 MeV
11σ

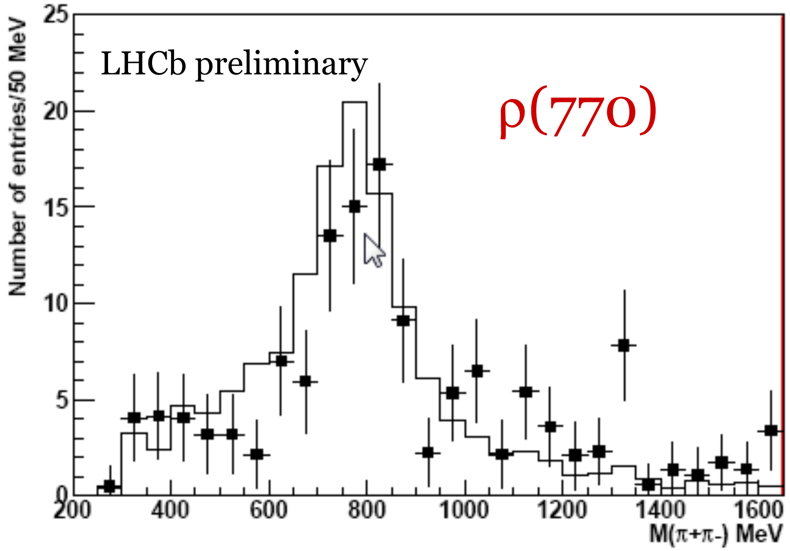
$BR(B_c^+ \to J/\psi\pi^+\pi^+\pi^-)/BR(B_c^+ \to J/\psi\pi^+)$= **3.0±0.6±0.4**

Consistent with the theoretical prediction 2.1±0.3 (ff uncertainty)

A.K.Likhoded,A.V.Luchinsky PRD81, 014015(2010)

$B_c \to J/\psi\pi\pi\pi$ resonant substructure

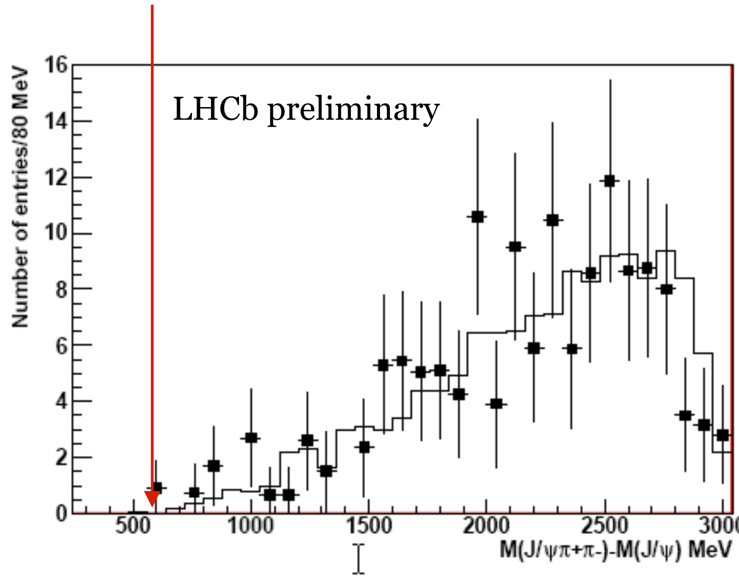




Sideband subtracted signal in the real data

MC $B_c \to J/\psi\, a_1(1260)$, $a_1(1260) \to \rho(770)\pi$

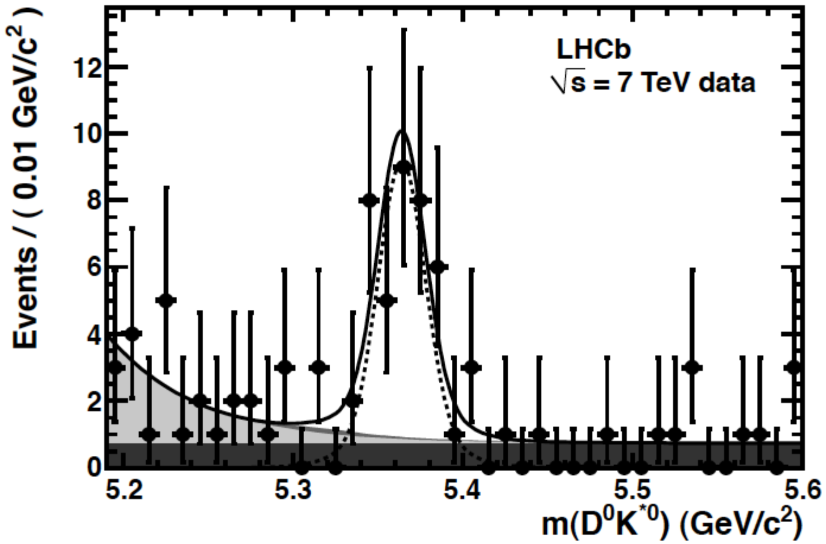
No $B_c \to \psi(2S)\pi$



same studies have also led to another **non-observation** of interest, see Yanxi Zhang's presentation tomorrow

First observation of $B_s^0 \to D^0 K^{*0}$

2010 data 36 pb^{-1}



BR($B \to D^0 \rho^0$) =(3.2 ± 0.5) 10^{-4} (PDG)

BR($B_s \to D^0 K^{*0}$) = (5.14 ±1.17 ±0 .52 ± 0.64±0 .80) 10^{-4}

Conclusions

- LHCb is probing a vast array of b-hadron decays, in search of a better understanding of the Standard Model and new physics signatures:
  - Observed b-production fraction dependence upon event environment
  - New modes to probe ϕ_s in B_s decays
  - New B_s, B_c, Λ_b decay modes discovered and many more on the way!
- New theoretical ideas to exploit these data are welcome!