Measurement of $(f_{\Lambda_b}/f_d)(BR(\Lambda_b \to \Lambda_c\pi)/BR(\bar{B}^0 \to D^+\pi^-))$

Text for the blessed web page – CDF note 6396

The CDF Collaboration

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Abstract

We present evidence for the decay mode $\Lambda_b \to \Lambda_c\pi$ using ~ 65 pb^{-1} of the Two Track Trigger (TTT) data stream. We observe $96 \pm 13(stat)$ events, making this the largest sample of fully reconstructed Λ_b's in existence, and the first such signature in CDF's TTT data. We furthermore use this signal to measure $(f_{\Lambda_b}/f_d)(BR(\Lambda_b \to \Lambda_c^+\pi^-)/BR(\bar{B}^0 \to D^+\pi^-)) = 0.66 \pm 0.11$ (stat) $\pm\, 0.09$ (syst) $\pm\, 0.18$ (BR).

1 Description

A combination of the increased luminosity of Run 2 and new triggers oriented towards B-physics creates new opportunities to study the heavy baryons and expand our knowledge of the structure of baryonic matter. The analysis begins with the observation of a $\sim 7\sigma$ $\Lambda_b \rightarrow \Lambda_c^+\pi^-$ signal. This leads to a branching ratio measurement. At CDF, measurements of ratios of branching ratios are more precise than absolute measurements, since most of the systematic errors cancel. It is then possible to rely on the B factories to provide precise measurements of higher-statistics branching ratios for use as denominators. Further, it is advantageous to package this branching ratio together with other poorly known quantities such as fragmentation fractions.

Therefore, the quantity reported in this analysis is

$$\frac{f_{\Lambda_b}}{f_d}\frac{BR(\Lambda_b \rightarrow \Lambda_c^+\pi^-)}{BR(\bar{B}^0 \rightarrow D^+\pi^-)} = \frac{BR(D^+ \rightarrow K\pi\pi)}{BR(\Lambda_c^+ \rightarrow pK\pi)}\frac{N_{\Lambda_b}}{N_{\bar{B}^0}}\frac{\epsilon_{\bar{B}^0}}{\epsilon_{\Lambda_b}} \tag{1}$$

First, the cuts are optimized for Λ_b signal and are used for reconstructing both $\bar{B}^0$ and Λ_b. The signals are observed.

- Pt(proton) $>$ 2.0Gev, Pt(π from Λ_b) $>$ 2.0Gev
- Pt(Λ_c)>4.5Gev , Pt(Λ_b) >7.5Gev
- Ct(Λ_b) $>$ 225 um , Ct(Λ_c from Λ_b) $>$ -65 um
- d0(Λ_b) $<$ 85 um
- Pt(proton) $>$ Pt(π from Λ_c)
- Λ_c mass window [2.269,2.302] GeV
- $\chi^2_{xy}(\Lambda_b) < 30$,$\chi^2_{xy}(\Lambda_c) < 20$

The decay $\Lambda_b \rightarrow \Lambda_c^+\pi^-$ is plagued by reflections from B meson decays, and satellite contributions from both B mesons and other baryons.All possible reflections are studied, following components are put into a one-dimensional binned extended likelihood fit. The systematic effects of the different fit models are investigated.

1. $\Lambda_b \rightarrow \Lambda_c\pi$ **signal**
2. **four-prong** B **meson reflections:**
3. **all other** B **meson decays**
4. **all other** Λ_b **decays**
5. $\Lambda_b \rightarrow \Lambda_c^+K$ **decays**
6. **true combinatorial bkg**

Next, the relative efficiencies for the two decay modes are calculated based on full monte carlo simulation

Finally, the sources of systematic error are enumerated.

2 Blessed Numbers

This section summarizes the numbers which have been blessed for this analysis.

2.1 $\bar{B}^0 \to D^+\pi^-$ yield

$$N_{\bar{B}^0} = 321 \pm 22(stat.) \pm 20(syst.) \tag{2}$$

2.2 $\Lambda_b \to \Lambda_c^+\pi^-$ yield

Parameter	Fit Output	Global Corr
Nos Signal Events	96 ± 13	0.316655
Λ_bMass(MeV/c^2)	5.623 ± 0.004	0.150600
Nos 4-prong Reflections	91 ± 19	0.621319
Nos Other B decays	1484 ± 180	0.951576
Nos Other Λ_b	1072 ± 184	0.950523
Nos Comb Background	1098 ± 159	0.950848
Comb Bkg exp slope	-0.88 ± 0.16	0.929133
χ^2/NDF	1.43	

Table 1: Parameter central values, uncertainties and global correlation coefficients from the fit.

Type of check	error
No $N_{\Lambda_b}/N_{\mathrm{otherB}}$ constraint	± 0.197
N_{ref} constraint only	± 0.654
$N_{\mathrm{ref}}/N_{\mathrm{otherB}}$ constraint only	± 0.709
No constraints	± 1.874
Tails of "other B" and "other Λ_b"	± 5.778
Width of Λ_b (± 3 MeV)	± 5.477
No $\Lambda_b \to \Lambda_c K$	± 0.43
total	± 8

Table 2: A summary of the effects (in number of events) of various changes to the fit conditions.

$$N_{\Lambda_b} = 96 \pm 13(stat.) \pm 8(syst.) \tag{3}$$

2.3 Efficiency ratio $\epsilon_{\bar{B}^0}/\epsilon_{\Lambda_b}$ from MC

	$\bar{B}^0/\Lambda_b$
$\epsilon_{Trigger}$	1.30 ± 0.01
ϵ_{Reco}	0.96 ± 0.01
ϵ_{Ana}	0.96 ± 0.01
ϵ_{tot}	1.20 ± 0.02

Table 3: Summary of efficiencies.

2.4 Systematic errors

	central value	variation range	(%) change
$\bar{B}^0$ lifetime (μm)	462	457-467	$\pm$ 0
Λ_b lifetime (μm)	369	345-393	+4-5
Λ_c Dalitz structure	nonresenant		+1
Pt spectrum			+1
Λ_b polarization	0	± 1	± 7
XFT	2 miss	1 miss	+3
ϕ efficiency			+3
subtotal			± 9
Fit model($\bar{B}^0$)			± 6
Fit model(Λ_b)			± 8
$BR(\Lambda_c \to pk\pi)/BR(D^+ \to K\pi\pi)$	0	$\pm 27\%$	$\pm$ 27
Total			± 30

Table 4: A summary of the sources of the systematic uncertainty.

2.5 Final result

$$\frac{N_{\Lambda_b}}{N_{\bar{B}^0}} == 0.30 \pm 0.05(stat.) \pm 0.03(syst.) \tag{4}$$

$$\frac{\epsilon_{\bar{B}^0}}{\epsilon_{\Lambda_b}} = 1.20 \pm 0.02(stat.) \pm 0.11(syst.) \tag{5}$$

$$\frac{f_{\Lambda_b}}{f_d}\frac{BR(\Lambda_b \to \Lambda_c^+\pi^-)}{BR(\bar{B}^0 \to D^+\pi^-)} = 0.66 \pm 0.11 \text{ (stat)} \pm 0.09 \text{ (syst)} \pm 0.18 \text{ (BR)} \tag{6}$$

For comparison, 2002 PDG fragmentation ratio $f_{baryon}/f_d = 0.304 \pm 0.053$ is used to extract relative braching ratio

$$\frac{BR(\Lambda_b \to \Lambda_c^+\pi^-)}{BR(\bar{B}^0 \to D^+\pi^-)} = 2.2 \pm 0.4 \text{ (stat)} \pm 0.3 \text{ (syst)} \pm 0.7 \text{ (BR+FR)} \tag{7}$$

3 Blessed Figures

The following figures have been blessed for the braching ratio measurement. More text can be found in CDF note 6396.

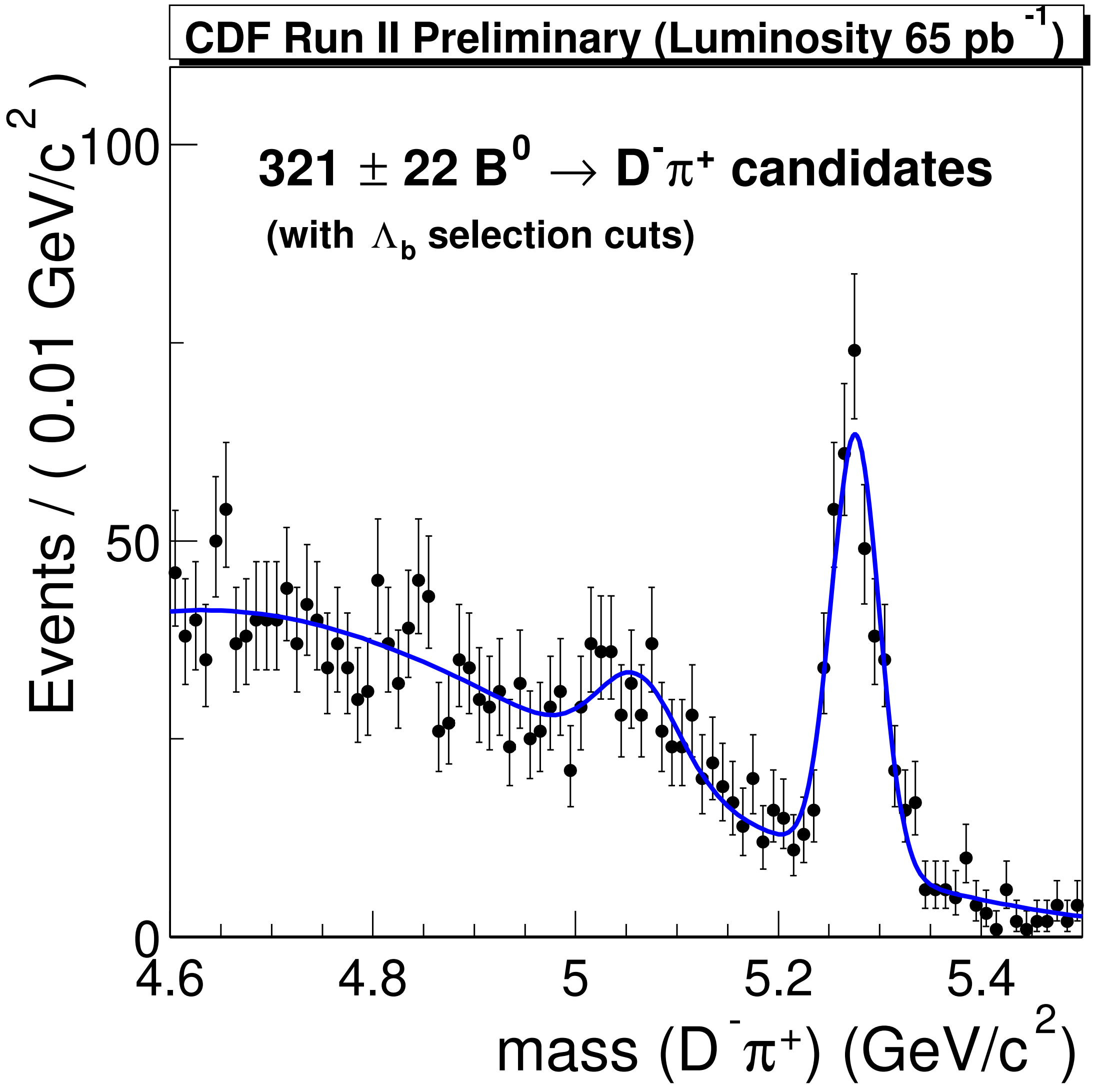

Figure 1: Invariant mass distribution of $\bar{B}^0 \to D^+\pi^-$ candidates. The histogram is fit with two Gaussians on top of a broad Gaussian background.

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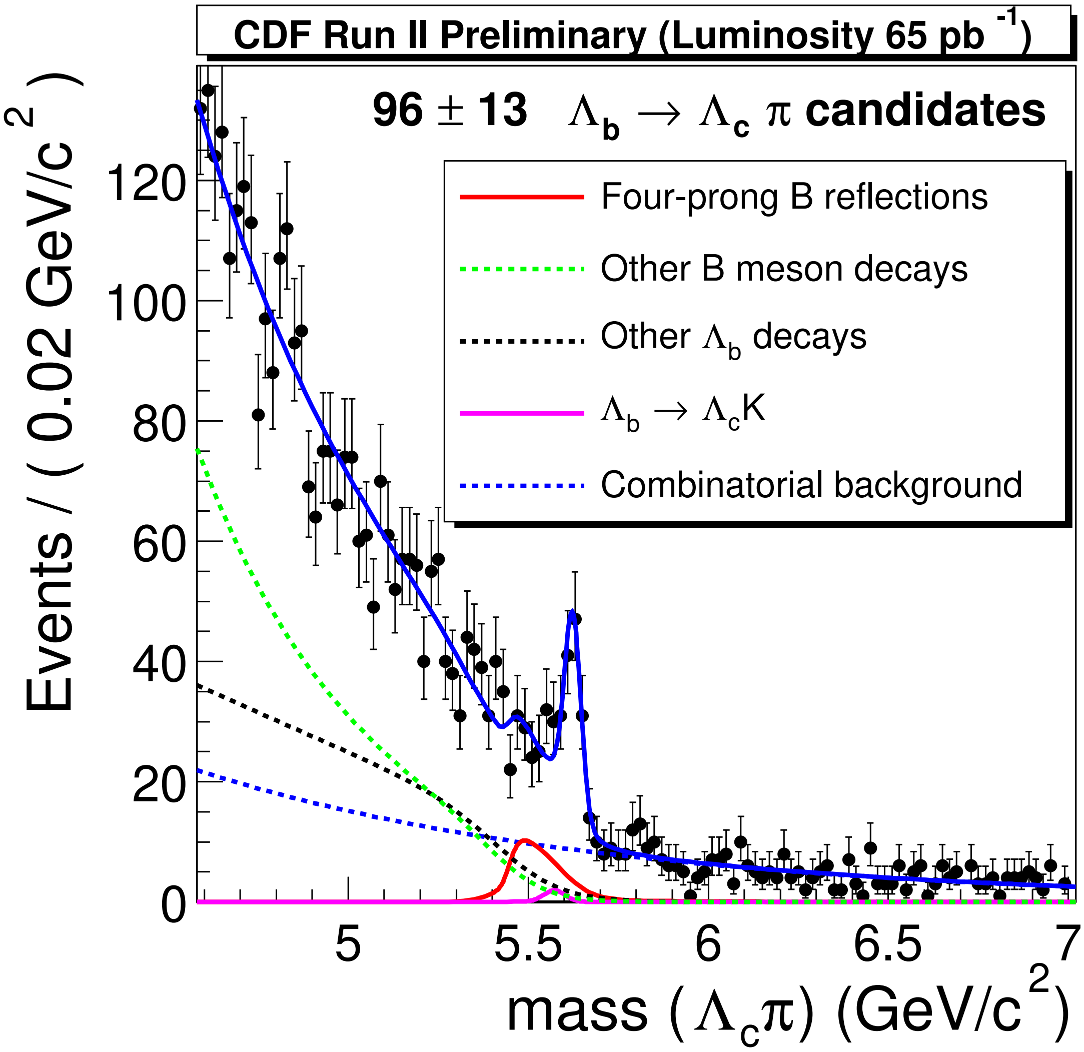

Figure 2: The "baseline" Λ_b mass fit.

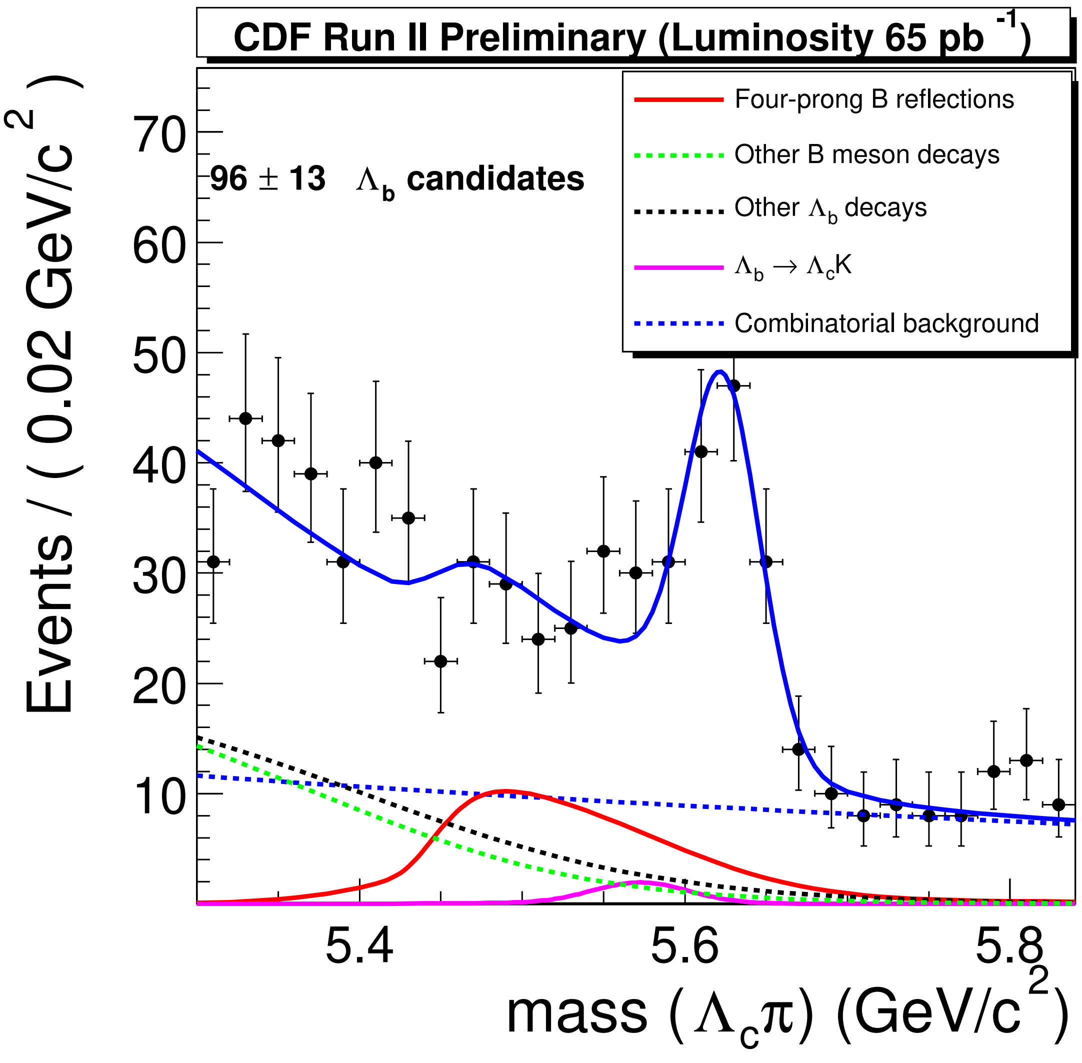

Figure 3: The "baseline" Λ_b mass fit, but zoomed into the region just around the Λ_b peak, demonstrating a fairly good agreement between the data points and the fit result.