Abstract

We present evidence for the decay mode $\Lambda_b^0 \to \Lambda_c^+ \pi^-$ using ~ 106 pb^{-1} of the Two Track Trigger (TTT) data stream. We observe $214 \pm 19(stat)$ events. We furthermore use this signal to measure $\left(\sigma_{\Lambda_b^0}(p_T > 6)/\sigma_{\overline{B^0}}(p_T > 6)\right) \times \mathcal{B}\left(\Lambda_b^0 \to \Lambda_c^+ \pi^-\right)/\mathcal{B}\left(\overline{B^0} \to D^+ \pi^-\right) = 0.82 \pm 0.08$ (stat) $\pm$ 0.11 (syst) $\pm$ 0.22 (Λ_c $\mathcal{B}$).

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 $\sim 11\sigma$ $\Lambda_b^0 \to \Lambda_c^+ \pi^-$ 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 production cross-sections.

Therefore, the quantity reported in this analysis is

$$\frac{\sigma_{\Lambda_b^0}(p_T > 6)}{\sigma_{\overline{B^0}}(p_T > 6)} \times \frac{BR(\Lambda_b^0 \to \Lambda_c^+ \pi^-)}{BR(\bar{B}^0 \to D^+ \pi^-)} = \frac{BR(D^+ \to K\pi\pi)}{BR(\Lambda_c^+ \to pK\pi)} \times \frac{N_{\Lambda_b^0}}{N_{\bar{B}^0}} \times \frac{\epsilon_{\bar{B}^0}}{\epsilon_{\Lambda_b^0}} \quad (1)$$

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

- Pt(proton) > 2.0Gev, Pt(π from Λ_b^0) > 2.0Gev
- Pt(Λ_c^+)>4.5Gev , Pt(Λ_b^0) >7.5Gev
- Ct(Λ_b^0) > 225 um , Ct(Λ_c^+ from Λ_b^0) > -65 um
- d0(Λ_b^0) < 85 um
- Pt(proton) > Pt(π from Λ_c^+)
- Λ_c^+ mass window [2.269,2.301] GeV
- $\chi^2_{xy}(\Lambda_b^0) < 30$,$\chi^2_{xy}(\Lambda_c^+) < 20$

The decay $\Lambda_b^0 \to \Lambda_c^+ \pi^-$ 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.

- $\Lambda_b^0 \to \Lambda_c^+\pi^-$ signal
- four-prong B meson reflections:
- all other B meson decays
- all other Λ_b^0 decays
- $\Lambda_b^0 \to \Lambda_c^+\pi^-$ decays
- 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.

$\overline{B^0} \to D^+\pi^-$ yield:

$$N(\overline{B^0}) = 790 \pm 32 \tag{2}$$

$\Lambda_b^0 \to \Lambda_c^+\pi^-$ yield:

$$N(\Lambda_b^0) = 214 \pm 19 \tag{3}$$

Parameter	Fit Output	Global Corr. Coef.
Nos Signal Events	214 ± 19	0.32
Λ_b^0 mass (MeV/c^2)	5615 ± 3 MeV	0.17
Nos 4-prong Reflections	162 ± 24	0.66
Nos Other B decays	2482 ± 225	0.95
Nos Other Λ_b	1921 ± 234	0.95
Nos Comb. Background	1674 ± 184	0.94
Comb. Bkg. exp. slope	-0.84 ± 0.12	0.92

Table 1: Parameter central values, uncertainties and global correlation coefficients from the fit. Compare the PDG 2004 Λ_b^0 mass measurement 5624 ± 9 MeV

2.1 Efficiency ratio $\frac{\epsilon_{\bar{B}^0}}{\epsilon_{\Lambda_b}}$

$$\frac{\epsilon_{\bar{B}^0}}{\epsilon_{\Lambda_b}} = 1.65 \pm 0.03 \tag{4}$$

Source	Uncertainty (%)
Initial Λ_b^0 p_T spectrum	7.6
Λ_b^0 polarisation	7.0
Λ_b^0 lifetime	-4.0 +5.0
Initial $\overline{B^0}$ p_T spectrum	4.0
Simulation statistics	1.9
Λ_c^+ resonance structure	1.0
proton vs π trigger efficiency	0.6
Λ_b^0 background shapes	4.3
$\overline{B^0}$ background shapes	0.9
Λ_b^0 width	2.8
$\overline{B^0}$ width	1.8
$\Lambda_b^0 \to \Lambda_c^+ K^-$	1.6
Total	+13.6 -13.3

Table 2: A summary of the sources of systematic uncertainty (not including Λ_c^+ branching ratio uncertainty).

2.2 Systematic errors:

See table 2 for a list of systematic errors.

2.3 Goodness of fit:

The total χ^2 and number of degrees of freedom is used for Λ_b^0 and $\overline{B^0}$ to determine goodness of fit:

- Λ_b^0 : $Nd.o.f = 88$, $\chi^2_{tot} = 80.6$, so 70% of fits have a worse χ^2.
- $\overline{B^0}$: $Nd.o.f = 94$, $\chi^2_{tot} = 70.9$, so 96% of fits have a worse χ^2.

2.4 Final result:

$$\frac{BR(D^+ \to K\pi\pi)}{BR(\Lambda_c^+ \to pK\pi)} = 1.84 \pm 0.493 \tag{5}$$

$$N_{\Lambda_b} = 214 \pm 19(stat.) \tag{6}$$

$$N_{\bar{B}^0} = 790 \pm 32(stat.) \tag{7}$$

$$\frac{N_{\Lambda_b}}{N_{\bar{B}^0}} = 0.27 \pm 0.03(stat.) \tag{8}$$

$$\frac{\epsilon_{\bar{B}^0}}{\epsilon_{\Lambda_b}} = 1.65 \tag{9}$$

The CDF systematic errors (including the statistical error on the ratio of reconstruction efficiencies) combine to give: $+13.6\%$, -13.3%.

Putting together Eqs. (5), (8) and (9), one obtains

$$\frac{\sigma_{\Lambda_b^0}(p_T > 6)}{\sigma_{\overline{B^0}}(p_T > 6)} \times \frac{BR(\Lambda_b \to \Lambda_c^+ \pi^-)}{BR(\bar{B}^0 \to D^+ \pi^-)} = 0.82 \pm 0.08\ (\mathrm{stat}) \pm 0.11\ (\mathrm{syst}) \pm 0.22\ (\mathrm{BR}) \tag{10}$$

where the final source of error is due to the uncertainty on the $\Lambda_c^+ \to pK\pi$ branching ratio.

For comparison, making the assumption that:

$$\frac{f_{\Lambda_b}}{f_d} \sim \frac{\sigma_{\Lambda_b^0}(p_T > 6)}{\sigma_{\overline{B^0}}(p_T > 6)} \tag{11}$$

and using the 2004 PDG fragmentation ratio $f_{baryon}/f_d = 0.249 \pm 0.043$ is used to extract relative braching ratio

$$\frac{BR(\Lambda_b \to \Lambda_c^+ \pi^-)}{BR(\bar{B}^0 \to D^+ \pi^-)} = 3.3 \pm 0.3\ (\mathrm{stat}) \pm 0.4\ (\mathrm{syst}) \pm 1.1\ (\mathrm{BR{+}FR}) \tag{12}$$