

## $\Lambda_c^+$ BRANCHING FRACTIONS

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Most  $\Lambda_c^+$  branching fractions are measured relative to the decay mode  $\Lambda_c^+ \rightarrow pK^-\pi^+$ . However, there are no completely model-independent measurements of the absolute branching fraction for  $\Lambda_c^+ \rightarrow pK^-\pi^+$ . Here we describe the measurements that have been used to extract  $B(\Lambda_c^+ \rightarrow pK^-\pi^+)$ , the model-dependence of the results, and the method we have used to average the results.

ARGUS (ALBRECHT 88C) and CLEO (CRAWFORD 92) measure  $B(\overline{B} \rightarrow \Lambda_c^+ X) \cdot B(\Lambda_c^+ \rightarrow pK^-\pi^+)$  to be  $(0.30 \pm 0.12 \pm 0.06)\%$  and  $(0.273 \pm 0.051 \pm 0.039)\%$ . Under the assumptions that decays of  $\overline{B}$  mesons to baryons are dominated by  $\overline{B} \rightarrow \Lambda_c^+ X$  and that  $\Lambda_c^+ X$  final states other than  $\Lambda_c^+ \overline{N} X$  can be neglected, they also measure  $B(\overline{B} \rightarrow \Lambda_c^+ X)$  to be  $(6.8 \pm 0.5 \pm 0.3)\%$  (ALBRECHT 92O) and  $(6.4 \pm 0.8 \pm 0.8)\%$  (CRAWFORD 92). Combining these results, we get  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (4.14 \pm 0.91)\%$ . However, the assumption that  $\overline{B}$  decay modes to baryons other than  $\Lambda_c^+ \overline{N} X$  are negligible is not on solid ground experimentally or theoretically [2]. Therefore, the branching fraction for  $\Lambda_c^+ \rightarrow pK^-\pi^+$  given above may be low by some undetermined amount.

A second type of model-dependent determination of  $B(\Lambda_c^+ \rightarrow pK^-\pi^+)$  is based on measurements by ARGUS (ALBRECHT 91G) and CLEO (BERGFELD 94) of  $\sigma(e^+e^- \rightarrow \Lambda_c^+ X) \cdot B(\Lambda_c^+ \rightarrow \Lambda \ell^+ \nu_\ell) = (4.15 \pm 1.03 \pm 1.18)$  pb and  $(4.77 \pm 0.25 \pm 0.66)$  pb. ARGUS (ALBRECHT 96E) and CLEO (AVERY 91) have also measured  $\sigma(e^+e^- \rightarrow \Lambda_c^+ X) \cdot B(\Lambda_c^+ \rightarrow pK^-\pi^+)$ . The weighted average is  $(11.2 \pm 1.3)$  pb.

From these measurements, we extract  $R \equiv B(\Lambda_c^+ \rightarrow pK^-\pi^+)/B(\Lambda_c^+ \rightarrow \Lambda \ell^+ \nu_\ell) = 2.40 \pm 0.43$ . We estimate the  $\Lambda_c^+ \rightarrow pK^-\pi^+$  branching fraction from the equation

$$B(\Lambda_c^+ \rightarrow pK^-\pi^+) = R f F \frac{\Gamma(D \rightarrow X \ell^+ \nu_\ell)}{1 + |V_{cd}/V_{cs}|^2} \cdot \tau(\Lambda_c^+) , \quad (1)$$

where  $f = B(\Lambda_c^+ \rightarrow \Lambda \ell^+ \nu_\ell)/B(\Lambda_c^+ \rightarrow X_s \ell^+ \nu_\ell)$  and  $F = \Gamma(\Lambda_c^+ \rightarrow X_s \ell^+ \nu_\ell)/\Gamma(D^0 \rightarrow X_s \ell^+ \nu_\ell)$ . When we use  $1 + |V_{cd}/V_{cs}|^2 = 1.05$  and the world averages  $\Gamma(D \rightarrow X \ell^+ \nu_\ell) = (0.166 \pm$

$0.006) \times 10^{12} \text{ s}^{-1}$  and  $\tau(\Lambda_c^+) = (0.192 \pm 0.005) \times 10^{-12} \text{ s}$ , we calculate  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (7.3 \pm 1.4)\% \cdot fF$ . Theoretical estimates for  $f$  and  $F$  are near 1.0 with significant uncertainties.

So, we have two results with significant model-dependence:  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (4.14 \pm 0.91)\%$  from  $\overline{B}$  decays, and  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (7.3 \pm 1.4)\% \cdot fF$  from semileptonic  $\Lambda_c^+$  decays. If we set  $fF = 1.0$  in the second result, and assign an uncertainty of 30% to each result to account for the unknown model-dependence, we get the consistent results  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (4.14 \pm 0.91 \pm 1.24)\%$  and  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (7.3 \pm 1.4 \pm 2.2)\%$ . The weighted average of these two results is  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (5.0 \pm 1.3)\%$ , where the uncertainty contains both the experimental uncertainty and the 30% estimate of model dependence in each result. We assigned the value  $(5.0 \pm 1.3)\%$  to the  $\Lambda_c^+ \rightarrow pK^-\pi^+$  branching fraction in our 2000 *Review* [1].

A third type of measurement of  $B(\Lambda_c^+ \rightarrow pK^-\pi^+)$  has been published by CLEO (JAFFE 00). Under the assumption that a  $\overline{D}$  meson and an antiproton in opposite hemispheres is evidence for a  $\Lambda_c^+$  in the hemisphere of the  $\overline{p}$ , the fraction of such  $\overline{D}\overline{p}$  events with a  $\Lambda_c^+ \rightarrow pK^-\pi^+$  decay can be used to determine the  $\Lambda_c^+ \rightarrow pK^-\pi^+$  branching fraction. CLEO measures  $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (5.0 \pm 1.3)\%$ , which is coincidentally exactly the same value as our PDG 00 average given above. The quoted uncertainty includes significant contributions from model-dependent effects (*e.g.*, differences between the  $\overline{p}$  momentum spectrum in events with a  $\Lambda_c^+$  and  $\overline{p}$  in the same hemisphere, and with a  $\overline{D}$  and  $\overline{p}$  in opposite hemispheres; extrapolation of the  $\Lambda_c^+$  and  $\overline{D}$  momentum spectrum below the minimum value used for rejecting  $B$  decay products; and our limited understanding of backgrounds such as  $D\overline{D}N\overline{p}$  events).

We have chosen to continue to assign the value  $(5.0 \pm 1.3)\%$  to the  $\Lambda_c^+ \rightarrow pK^-\pi^+$  branching fraction (given as PDG 02 below). As was noted earlier, most of the other  $\Lambda_c^+$  decay modes are measured relative to this mode.

New methods for measuring the  $\Lambda_c^+$  absolute branching fractions have been proposed [2,3].

## References

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3. P. Migliozi *et al.*, Phys. Lett. **B462**, 217 (1999).