## NOTE ON $\Lambda_c^+$ BRANCHING FRACTIONS

Written 1998 by P.R. Burchat (Stanford University).

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

ARGUS (ALBRECHT 88C) and CLEO (CRAWFORD 92) measure $\mathrm{B}(\overline{B} \to \Lambda_c^+\mathrm{X}) \times \mathrm{B}(\Lambda_c^+ \to pK^-\pi^+)$ 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 $\overline{B} \to \Lambda_c^+\mathrm{X}$ and that $\Lambda_c^+\mathrm{X}$ final states other than $\Lambda_c^+\overline{N}\mathrm{X}$ can be neglected, they also measure $\mathrm{B}(\overline{B} \to \Lambda_c^+\mathrm{X})$ to be $(6.8 \pm 0.5 \pm 0.3)\%$ (ALBRECHT 92O) and $(6.4\pm0.8\pm0.8)\%$ (CRAWFORD 92). Combining these results, we get $\mathrm{B}(\Lambda_c^+ \to pK^-\pi^+) = (4.14 \pm 0.91)\%$. However, the assumption that $\overline{B}$ decay modes to baryons other than $\Lambda_c^+\overline{N}\mathrm{X}$ are negligible is not on solid ground experimentally or theoretically. Therefore, the branching fraction for $\Lambda_c^+ \to pK^-\pi^+$ given above may be low by some undetermined amount.

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

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

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

where $f = \mathrm{B}(\Lambda_c^+ \to \Lambda\ell^+\nu_\ell)/\mathrm{B}(\Lambda_c^+ \to X_s\ell^+\nu_\ell)$ and $F = \Gamma(\Lambda_c^+ \to X_s\ell^+\nu_\ell)/\Gamma(D^0 \to X_s\ell^+\nu_\ell)$. When we use $1+|V_{cd}/V_{cs}|^2$

$= 1.05$ and the world averages $\Gamma(D \rightarrow X\ell^+\nu_\ell) = (0.163 \pm 0.006) \times 10^{-12}$ s$^{-1}$ and $\tau(\Lambda_c^+) = (0.206 \pm 0.012) \times 10^{-12}$ s, we calculate $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (7.7 \pm 1.5)\% \cdot f\,F$. 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 $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (7.7 \pm 1.5)\% \cdot f\,F$ from semileptonic $\Lambda_c^+$ decays. If we set $f\,F = 1.0$ 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 $B(\Lambda_c^+ \rightarrow pK^-\pi^+) = (7.7 \pm 1.5 \pm 2.3)\%$. 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.

This procedure is clearly rather arbitrary, but so is any other procedure until good measurements of the absolute branching fraction are made. Therefore, we have assigned the value $(5.0 \pm 1.3)\%$ to the $\Lambda_c^+ \rightarrow pK^-\pi^+$ branching fraction (given as PDG 98 below). As was noted earlier, most of the other modes are measured relative to this mode.