D MESON BRANCHING FRACTIONS

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This edition strongly reflects the impact that CLEO-II has had on charm meson physics in the last two years. The CESR-II luminosity for data taken at the $\Upsilon(4S)$ resonance and in the nearby e^+e^- continuum since startup in 1991 has climbed to $\sim 15\text{pb}^{-1}/\text{day}$ and has totaled more than 2 fb^{-1}. In addition, this edition includes the first high-statistics results of the next (post-E691) generation of fixed-target experiments at FNAL (E653, E687). We anticipate that the CLEO-II and the FNAL fixed-target programs will continue to dominate the field through the end of the decade. The BES program for charmed physics is now also underway, and its first results should appear within the next year.

In this edition, we have restructured the Full Listings to further clarify and reduce the uncertainty in the normalization of the charmed D^+, D^0, and D_s^+ branching fractions. We continue to enter only experimentally measured quantities and not derived quantities, except where noted. All experiments measuring ratios of branching fractions are included in our calculations. (We shall call $\text{B}_1 = \Gamma_1/\Gamma_{\text{total}}$ a branching *fraction*, and Γ_1/Γ_2 a branching *ratio*.) These are usually measurements of branching fractions relative to the most accessible channels, such as $K^-\pi^+\pi^+$ for the D^+, $K^-\pi^+$ and $K^-\pi^+\pi^+\pi^-$ for the D^0, and $\phi\pi^+$ for the D_s^+. The problem is to set the absolute scales for the branching fractions.

In our 1992 edition, we combined results from several experimental methods to set the scale of branching fractions of D^+ and D^0 mesons. One source was the direct measurements of the D^+ and D^0 branching fractions as reported in BALTRUSAITUS 86 and subsequently updated in ADLER 88C, using data at the $\psi(3770)$ resonance. In the latter paper, the rates of observed production of single charm and pairs of charm particles were compared to establish the absolute branching fraction scale. A second source was the results from topologically normalized experiments (*e.g.*, AGUILAR-BENITEZ 84) and other so-called "double tagging" techniques (*e.g.*, BARLAG 90D). A third source was measurements from ALEPH of the D^0 absolute branching fraction (DECAMP 91) using the technique pioneered by HRS (ABACHI 88) applied to D^* from Z decays. This technique compares the total rate for $Z \to D^{*+}$X followed by $D^{*+} \to D^0\pi^+$, measured by observing only the soft low Q-value π^+, with the total rate for $Z \to D^{*+}$X followed by $D^{*+} \to D^0\pi^+$ and then $D^0 \to K^-\pi^+$.

In this edition, we have revisited the question, in the light of new measurements of the D^+ and D^0 branching fractions from CLEO-II. In AKERIB 93, CLEO-II measures the $D^0 \to K^-\pi^+$ branching fraction as $(3.91 \pm 0.08 \pm 0.17)\%$, in excellent agreement with the previous e^+e^- results at the $\psi(3770)$ and the Z but with better precision. In BALEST 94, CLEO-II uses a similar technique applied to the D^{*0} to measure the branching fraction $D^+ \to K^-\pi^+\pi^+$ to be $(9.3 \pm 0.6 \pm 0.8)\%$, with a precision comparable to the previous e^+e^- results at the $\psi(3770)$. In this edition, we use the direct measurements of branching fractions at the $\psi(3770)$ and the recent measurements using D^* decays, but remove the topological results from the averages and fits because of the uncertainty in the topological normalization and the inherent correlations with other measurements in the fitting procedure used to obtain them. The result is that the important $D^0 \to K^-\pi^+$ branching fraction is $(4.01 \pm 0.14)\%$ and the important $D^+ \to K^-\pi^+\pi^+$ branching fraction is $(9.1 \pm 0.6)\%$.

It may help to say a word about our averages and fits. An average is of (good) measurements of a single quantity, say of $\Gamma(D^0 \to K^-\pi^+)/\Gamma_{\rm total}$. A fit involves two or more different quantities, say several different D^0 branching ratios. Our fits only include quantities that "push" against one another. For example, if there are measurements of $\Gamma_1/\Gamma_{\rm total}$, $\Gamma_2/\Gamma_{\rm total}$, and Γ_1/Γ_2, then these three quantities are included in the fit. But if Γ_3 only occurs in Γ_3/Γ_1, then $\Gamma_3/\Gamma_{\rm total}$ is simply calculated from the fit value of $\Gamma_1/\Gamma_{\rm total}$. Thus for the D^0, say, we determine all the different measured branching ratios that push against one another and include them in one big fit. (The correlation-coefficient matrix for this fit is right in front of the measurements of the branching ratios.) Since the sum of branching fractions included in the fit is less than unity, a "dummy" mode is added to account for modes absent. Once the overall fit is done, remaining branching fractions (of the sort $\Gamma_3/\Gamma_{\rm total}$ mentioned above) are calculated from branching fractions obtained in the fit.

The absolute branching fraction scale for the D_s^+ is still quite uncertain. We anticipate in the near future a measurement at BES of the absolute branching fraction for $D_s^+ \to \phi\pi^+$, using the direct technique exploited first by MARK-III (*e.g.*, ADLER 90B). At present, we are constrained to rely on a set of experiments (ARGUS, CLEO, CLEO-II, and E687) that determine the ratio $\Gamma(D_s^+ \to \phi e^+\nu_e)/\Gamma(D_s^+ \to \phi\pi^+)$. The ratio $\Gamma(D_s^+ \to \phi e^+\nu_e)/\Gamma(D^+ \to \overline{K}^{*0} e^+\nu_e)$ is reliably calculated theoretically, and the experiments measure $\mathrm{B}(D^+ \to \overline{K}^{*0} e^+\nu_e)$ and use the well-measured relative lifetimes (or total widths) of the D_s^+ and D^+ to then obtain $\mathrm{B}(D_s^+ \to \phi\pi^+)$. We thus get $\mathrm{B}(D_s^+ \to \phi\pi^\pm) = 3.5 \pm 0.4\%$ for normalizing the other decays.

A result of much theoretical interest is the measurement of the pseudoscalar weak decay constants (f_D) of the D_s^+ and the D^+. The decay constant measures the overlap of the heavy and light quark wave functions in the meson and is measured directly through the observation of pure leptonic decays of the D^+ or D_s^+ to $\mu^+\nu_\mu$ or $\tau^+\nu_\tau$. The precise value provides an unambiguous test of lattice QCD. The best limit on the D^+ decay constant was set by MARK-III ($<$ 290 MeV at 90% CL). Two experiments, WA75 (AOKI 93) and CLEO-II (ACOSTA 94) have published evidence for pure leptonic decays of the D_s^+. BES has also presented evidence in the form of a few events recoiling from tagged D_s^+ mesons in the 4-GeV region in e^+e^-. AOKI 93 claims 8 events in an emulsion experiment and finds a decay constant value of 232 MeV. CLEO-II finds about 39 events above background, corresponding to a decay constant of about 344 MeV. Both experiments have errors of about 75 MeV. The CLEO value is surprisingly large, but the error from the background subtraction and statistics still remains large. For further discussion, see also the note on "Pseudoscalar-Meson Decay Constants" in the $\pi^\pm$ Full Listings.

See also the note on "Semileptonic Decays of D and B Mesons" that follows for a review of the many new results in that area.