As yet there are no direct measurements of D_s^+ branching fractions. One method for estimating the $D_s^+ \to \phi\pi^+$ branching fraction is based on the belief that $D_s^+ \to \phi\ell^+\nu_\ell$ and $D \to \overline{K}^*\ell^+\nu_\ell$ decays are quite similar. Quark-model-based estimates [40] for the ratio $\kappa = \Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D \to \overline{K}^*\ell^+\nu_\ell)$ are about 1.0. The branching fraction is then

$$\mathrm{B}(D_s^+ \to \phi\pi^+) = \frac{\tau_{D_s}\,\kappa\,\Gamma(D \to \overline{K}^*\ell^+\nu_\ell)}{R_\phi}\ . \tag{7}$$

The average over the two $\Gamma(D \to \overline{K}^* e^+\nu_e)$ charge states is $(4.6 \pm 0.4) \times 10^{10}\ \mathrm{s}^{-1}$. Using the PDG value for the D_s^+ lifetime, the value for R_ϕ in Table 11, and $\kappa = 1.0$ gives $\mathrm{B}(D_s^+ \to \phi\pi^+) = (4.0 \pm 0.5)\%$. This value also has a theoretical uncertainty, which we conservatively estimate to be about 25%. (The PDG value of this branching fraction, which combines several estimates, is (3.5±0.4)%.)

We will have more confidence in this method for determining the absolute D_s^+ branching fraction scale, and indeed more confidence in our understanding of charmed semileptonic decays in general, if the patterns for the D_s^+ semileptonic decays are seen to be the same as those for D^0 and D^+. It is important to measure the form factor ratios for $D_s^+ \to \phi\ell^+\nu_\ell$ decay, as has been done for $D \to \overline{K}^*\ell^+\nu_\ell$, to shed some light on the validity of the assumption of equal transition rates. With small numbers of events, Fermilab experiments E653 and E687 have made first measurements of these ratios (Table 12). These results, to be compared with the $D \to \overline{K}^* e\nu_e$ values of Table 3, are not yet precise enough to draw conclusions about the degree of similarity of the D_s^+ and D decays.

Perhaps even more important is the ratio of the rates of semileptonic decays of the D_s^+ to vector and pseudoscalar mesons, since this ratio is not as expected in D^+ and D^0 decays. The first observation of the pseudoscalar modes is from Fermilab E653 [24], who obtained $[\Gamma(D_s^+ \to \phi\mu^+\nu_\mu)]/[\Gamma(D_s^+ \to (\eta+\eta')\mu^+\nu_\mu)] = 0.26 \pm 0.11$. The result is certainly consistent with a low vector-to-pseudoscalar ratio. This experiment was unable to separate the η and η' modes.

Table 12: $D_s^+ \to \phi\ell^+\nu_\ell$ form factor ratios.

Experiment	Ref.	$R_2(0)$	$R_V(0)$	Γ_L/Γ_T
E653	[24]	$2.1^{+0.6}_{-0.5} \pm 0.2$	$2.3^{+1.1}_{-0.9} \pm 0.4$	$0.54 \pm 0.21 \pm 0.10$
E687	[29]	$1.1 \pm 0.8 \pm 0.1$	$1.8 \pm 0.9 \pm 0.2$	$1.0 \pm 0.5 \pm 0.1$
Ave.		1.8 ± 0.5	2.0 ± 0.7	0.6 ± 0.2

Conclusions on D-meson semileptonic decays

The study of semileptonic decays of D mesons has progressed enormously in the last few years. The q^2 dependence of the pseudoscalar form factor has been measured, and the intercepts of the three vector-decay form factors been determined by several experiments. New experiments confirm the old observation that the $D \to \overline{K}^*\ell^+\nu_\ell$ decay rate, and therefore the A_1 form factor, is low compared with model calculations. Presently, no model appears able to explain all of the form factors.

Problems remain in the precise quantitive comparisons between the transition rates of the different charge states in the $D \to \overline{K}\ell^+\nu_\ell$ exclusive decays. The difficulty may lie in the branching fractions of the normalizing modes for the D^+ decays. Strict upper limits are observed on rates of nonresonant decays. These limits are consistent with the observation that the transition rates for $D \to \overline{K}\ell^+\nu_\ell$ and $D \to \overline{K}^*\ell^+\nu_\ell$, plus a reasonable estimate of the Cabibbo-suppressed rate, nearly saturates the inclusive rate.

Measurements of Cabibbo-suppressed semileptonic decays have begun. Experiments are making good progress with D_s^+ semileptonic decays. First results have been obtained for the ratios of form-factor intercepts in $D_s^+ \to \phi\ell^+\nu_\ell$ and for observations of the pseudoscalar decays $D_s^+ \to \eta\ell^+\nu_\ell$ and $D_s^+ \to \eta'\ell^+\nu_\ell$.

In the near future, we can expect further significant advances. It will be very interesting to compare the form factors for Cabibbo-favored, Cabibbo-suppressed, and D_s^+ decays for the pseudoscalar- and vector-meson final states. Measurement of the q^2 dependences of the three vector-decay form factors may help in understanding the puzzle of the small semileptonic transition rate to vector-meson final states.

Continuation of this discussion can be found in the Listings for the $B^\pm$.