$D_s^\pm$ was $F^\pm$

$I(J^P) = 0(0^-)$

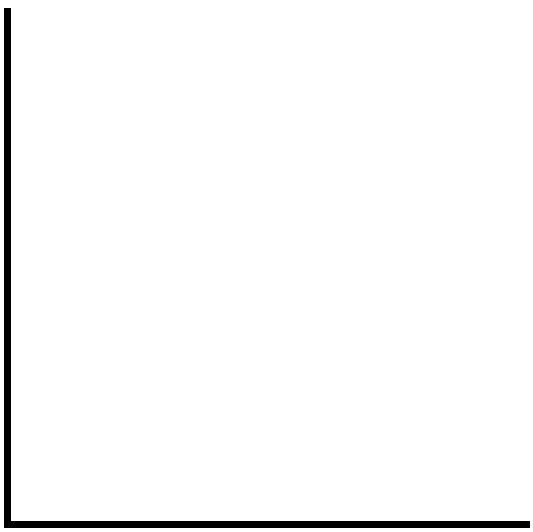
The angular distributions of the decays of the ϕ and $\overline{K}^*(892)^0$ in the $\phi\pi^+$ and $K^+\overline{K}^*(892)^0$ modes strongly indicate that the spin is zero. The parity given is that expected of a $c\overline{s}$ ground state.

$D_s^\pm$ MASS

The fit includes $D^\pm$, D^0, $D_s^\pm$, $D^{*\pm}$, D^{*0}, and $D_s^{*\pm}$ mass and mass difference measurements. Measurements of the $D_s^\pm$ mass with an error greater than 10 MeV are omitted from the fit and average. A number of early measurements giving $m > 2000$ MeV have been omitted altogether. They may be found in our 1990 edition (Phys. Lett. **B239**).

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1968.5± 0.6 OUR FIT Error includes scale factor of 1.1.					
1969.0± 1.4 OUR AVERAGE Error includes scale factor of 1.5. See the ideogram below.					
1967.0± 1.0± 1.0	54	BARLAG	90C	ACCM	π^- Cu 230 GeV
1969.3± 1.4± 1.4		ALBRECHT	88	ARG	e^+e^- 9.4–10.6 GeV
1972.7± 1.5± 1.0	21	BECKER	87B	SILI	200 GeV π, K, p
1972.4± 3.7± 3.7	27	BLAYLOCK	87	MRK3	e^+e^- 4.14 GeV
1963 ± 3 ± 3	30	DERRICK	85B	HRS	e^+e^- 29 GeV
1970 ± 5 ± 5	104	CHEN	83C	CLEO	e^+e^- 10.5 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1968.3± 0.7± 0.7	290	[1] ANJOS	88	E691	Photoproduction
1980 ±15	6	USHIDA	86	EMUL	ν wideband
1973.6± 2.6± 3.0	163	ALBRECHT	85D	ARG	e^+e^- 10 GeV
1948 ±28 ±10	65	AIHARA	84D	TPC	e^+e^- 29 GeV
1975 ± 9 ±10	49	ALTHOFF	84	TASS	e^+e^- 14–25 GeV
1975 ± 4	3	BAILEY	84	ACCM	hadron$^+$ Be $\rightarrow$ $\phi\pi^+$ X

[1] ANJOS 88 enters the fit via $m_{D_s^\pm} - m_{D^\pm}$ (see below).



$D_s^\pm$ mass (MeV)

$m_{D_s^\pm} - m_{D^\pm}$

The fit includes $D^\pm$, D^0, $D_s^\pm$, $D^{*\pm}$, D^{*0}, and $D_s^{*\pm}$ mass and mass difference measurements.

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
99.2±0.5 OUR FIT Error includes scale factor of 1.1.					
99.2±0.5 OUR AVERAGE					
99.5±0.6±0.3		BROWN	94	CLEO	$e^+e^-\approx \Upsilon(4S)$
98.5±1.5	555	CHEN	89	CLEO	e^+e^- 10.5 GeV
99.0±0.8	290	ANJOS	88	E691	Photoproduction

$D_s^\pm$ MEAN LIFE

Measurements with an error greater than 0.2×10^{-12} s are omitted from the average.

VALUE (10^{-12} s)	EVTS	DOCUMENT ID		TECN	COMMENT
0.467±0.017 OUR AVERAGE					
0.475±0.020±0.007	900	FRABETTI	93F	E687	γBe, $D_s^+ \to \phi\pi^+$
$0.33\ ^{+0.12}_{-0.08}\ \pm0.03$	15	ALVAREZ	90	NA14	γ, $D_s^+ \to \phi\pi^+$
$0.469^{+0.102}_{-0.086}$	54	[2] BARLAG	90C	ACCM	π^- Cu 230 GeV
$0.50\ \pm0.06\ \pm0.03$	104	FRABETTI	90	E687	γBe, $\phi\pi^+$
$0.56\ ^{+0.13}_{-0.12}\ \pm0.08$	144	ALBRECHT	88I	ARG	e^+e^- 10 GeV
$0.47\ \pm0.04\ \pm0.02$	228	RAAB	88	E691	Photoproduction
$0.33\ ^{+0.10}_{-0.06}$	21	[3] BECKER	87B	SILI	200 GeV π,K,p
$0.26\ ^{+0.16}_{-0.09}$	6	USHIDA	86	EMUL	ν wideband
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$0.31\ ^{+0.24}_{-0.20}\ \pm0.05$	18	AVERILL	89	HRS	e^+e^- 29 GeV
$0.48\ ^{+0.06}_{-0.05}\ \pm0.02$	99	ANJOS	87B	E691	See RAAB 88
$0.57\ ^{+0.36}_{-0.26}\ \pm0.09$	9	BRAUNSCH...	87	TASS	e^+e^- 35–44 GeV
$0.47\ \pm0.22\ \pm0.05$	141	CSORNA	87	CLEO	e^+e^- 10 GeV
$0.35\ ^{+0.24}_{-0.18}\ \pm0.09$	17	JUNG	86	HRS	See AVERILL 89
$0.32\ ^{+0.30}_{-0.13}$	3	BAILEY	84	ACCM	hadron$^+$ Be $\to \phi\pi^+$ X
$0.19\ ^{+0.13}_{-0.07}$	4	USHIDA	83	EMUL	See USHIDA 86

[2] BARLAG 90C estimates the systematic error to be negligible.
[3] BECKER 87B estimates the systematic error to be negligible.

D_s^+ DECAY MODES

Branching fractions for modes below with a resonance in the final state include all the decay modes of the resonance. D_s^- modes are charge conjugates of the modes below.

Nearly all other modes are measured relative to the $\phi\pi^+$ mode. However, none of the determinations of the $\phi\pi^+$ branching fraction are direct measurements: all rely on calculated relations between D^+ and D_s^+ decay widths, on estimates of D_s^+ cross sections, or on other model-dependent assumptions. Thus a better determination of the $\phi\pi^+$ branching fraction could cause the other branching fractions to slide up or down, all together.

Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level

Inclusive modes

Γ_1	K^- anything	$(13\ ^{+14}_{-12})$ %		
Γ_2	$\overline{K}^0$ anything + K^0 anything	$(39\ \pm 28)$ %		
Γ_3	K^+ anything	$(20\ ^{+18}_{-14})$ %		
Γ_4	non-$K\overline{K}$ anything	$(64\ \pm 17)$ %		
Γ_5	e^+ anything	< 20	%	CL=90%

Leptonic and semileptonic modes

Γ_6	$\mu^+\nu_\mu$		$(5.9 \pm 2.2) \times 10^{-3}$		S=1.1
Γ_7	$\phi\ell^+\nu_\ell$	[a]	(1.88 ± 0.29) %		
Γ_8	$\phi e^+\nu_e$				
Γ_9	$\phi\mu^+\nu_\mu$				
Γ_{10}	$\eta\mu^+\nu_\mu$ + $\eta'(958)\mu^+\nu_\mu$		(7.4 ± 3.2) %		
Γ_{11}	$\eta\mu^+\nu_\mu$				
Γ_{12}	$\eta'(958)\mu^+\nu_\mu$		< 3.0	%	CL=90%

Hadronic modes with two K's (including from ϕ's)

Γ_{13}	$K^+\overline{K}^0$	(3.5 ± 0.7) %		
Γ_{14}	$K^+K^-\pi^+$	(4.8 ± 0.7) %		
	In the fit as $\frac{1}{2}\Gamma_{15} + \frac{2}{3}\Gamma_{16} + \Gamma_{17}$.			
Γ_{15}	$\phi\pi^+$	(3.5 ± 0.4) %		
Γ_{16}	$K^+\overline{K}^*(892)^0$	(3.3 ± 0.5) %		
Γ_{17}	$K^+K^-\pi^+$ nonresonant	$(8.7 \pm 3.2) \times 10^{-3}$		
Γ_{18}	$K^0\overline{K}^0\pi^+$			
Γ_{19}	$K^*(892)^+\overline{K}^0$	(4.2 ± 1.0) %		
Γ_{20}	$K^+K^-\pi^+\pi^0$			
Γ_{21}	$\phi\pi^+\pi^0$	(8 ± 4) %		
Γ_{22}	$\phi\rho^+$	$(6.5\ ^{+1.6}_{-1.8})$ %		
Γ_{23}	$\phi\pi^+\pi^0$ 3-body	< 2.5	%	CL=90%
Γ_{24}	$K^+K^-\pi^+\pi^0$ non-ϕ	< 8	%	CL=90%
Γ_{25}	$K^+\overline{K}^0\pi^+\pi^-$	< 2.7	%	CL=90%
Γ_{26}	$K^0K^-\pi^+\pi^+$	(4.2 ± 1.1) %		
Γ_{27}	$K^*(892)^+\overline{K}^*(892)^0$	(5.6 ± 2.1) %		
Γ_{28}	$K^0K^-\pi^+\pi^+$ non-$K^{*+}\overline{K}^{*0}$	< 2.8	%	CL=90%
Γ_{29}	$K^+K^-\pi^+\pi^+\pi^-$			
Γ_{30}	$\phi\pi^+\pi^+\pi^-$	(1.8 ± 0.5) %		
Γ_{31}	$K^+K^-\pi^+\pi^+\pi^-$ non-ϕ	$(3.0\ ^{+3.0}_{-2.0}) \times 10^{-3}$		

Other hadronic modes

Γ_{32}	$\pi^+\pi^+\pi^-$	(1.35 ± 0.31) %		
Γ_{33}	$\rho^0\pi^+$	< 2.8	$\times 10^{-3}$	CL=90%
Γ_{34}	$f_0(980)\pi^+$	$(10 \pm 4) \times 10^{-3}$		
Γ_{35}	$\pi^+\pi^+\pi^-$ nonresonant	(1.01 ± 0.35) %		
Γ_{36}	$\pi^+\pi^+\pi^-\pi^0$	< 12	%	CL=90%
Γ_{37}	$\eta\pi^+$	(1.9 ± 0.4) %		
Γ_{38}	$\omega\pi^+$	< 1.7	%	CL=90%
Γ_{39}	$\pi^+\pi^+\pi^+\pi^-\pi^-$	$(3.0\ ^{+4.0}_{-3.0}) \times 10^{-3}$		
Γ_{40}	$\pi^+\pi^+\pi^-\pi^0\pi^0$			
Γ_{41}	$\eta\rho^+$	(10.0 ± 2.2) %		
Γ_{42}	$\eta\pi^+\pi^0$ 3-body	< 2.9	%	CL=90%
Γ_{43}	$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0$	(4.9 ± 3.2) %		
Γ_{44}	$\eta'(958)\pi^+$	(4.7 ± 1.4) %		

Γ_{45}	$\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0\pi^0$					
Γ_{46}	$\eta'(958)\rho^+$			(12.0 ± 3.0) %		
Γ_{47}	$\eta'(958)\pi^+\pi^0$ 3-body		$<$	3.0	%	CL=90%
Γ_{48}	$K^0\pi^+$		$<$	7	$\times 10^{-3}$	CL=90%
Γ_{49}	$K^+\pi^+\pi^-$			$(3.0 \,^{+\,4.0}_{-\,3.0}) \times 10^{-3}$		
Γ_{50}	$K^+K^-K^+$					
Γ_{51}	ϕK^+		$<$	2.5	$\times 10^{-3}$	CL=90%

$\Delta C = 1$ weak neutral current ($C1$) modes, or Lepton number (L) violating modes

Γ_{52}	$\pi^+\mu^+\mu^-$		[b] $<$	4.3	$\times 10^{-4}$	CL=90%
Γ_{53}	$K^+\mu^+\mu^-$	$C1$	$<$	5.9	$\times 10^{-4}$	CL=90%
Γ_{54}	$K^*(892)^+\mu^+\mu^-$	$C1$	$<$	1.4	$\times 10^{-3}$	CL=90%
Γ_{55}	$\pi^-\mu^+\mu^+$	L	$<$	4.3	$\times 10^{-4}$	CL=90%
Γ_{56}	$K^-\mu^+\mu^+$	L	$<$	5.9	$\times 10^{-4}$	CL=90%
Γ_{57}	$K^*(892)^-\mu^+\mu^+$	L	$<$	1.4	$\times 10^{-3}$	CL=90%
Γ_{58}	A dummy mode used by the fit.			(91.7 ± 1.1) %		

[a] For now, we average together measurements of the $\phi e^+\nu_e$ and $\phi\mu^+\nu_\mu$ branching fractions.

[b] This mode is not a useful test for a ΔC=1 weak neutral current because both quarks must change flavor in this decay.

CONSTRAINED FIT INFORMATION

An overall fit to 5 branching ratios uses 16 measurements and one constraint to determine 5 parameters. The overall fit has a $\chi^2 = 9.4$ for 12 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients $\langle \delta x_i \delta x_j \rangle / (\delta x_i \cdot \delta x_j)$, in percent, from the fit to the branching fractions, $x_i \equiv \Gamma_i/\Gamma_{\text{total}}$. The fit constrains the x_i whose labels appear in this array to sum to one.

x_{15}	12			
x_{16}	9	73		
x_{17}	4	32	23	
x_{58}	−32	−87	−87	−55
	x_6	x_{15}	x_{16}	x_{17}

D_s^+ BRANCHING RATIOS

A few older, now obsolete results have been omitted. They may be found in our 1990 edition (Phys. Lett. **B239**).

Inclusive modes

$\Gamma(K^-\text{anything})/\Gamma_{\text{total}}$ Γ_1/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
$0.13^{+0.14}_{-0.12} \pm 0.02$	COFFMAN	91	MRK3	e^+e^- 4.14 GeV

$[\Gamma(\overline{K}^0\text{anything}) + \Gamma(K^0\text{anything})]/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
$0.39^{+0.28}_{-0.27} \pm 0.04$	COFFMAN	91	MRK3	e^+e^- 4.14 GeV

$\Gamma(K^+\text{anything})/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
$0.20^{+0.18}_{-0.13} \pm 0.04$	COFFMAN	91	MRK3	e^+e^- 4.14 GeV

$\Gamma(\text{non-}K\overline{K}\text{anything})/\Gamma_{\text{total}}$ Γ_4/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
0.64±0.17±0.03	[4] COFFMAN	91	MRK3	e^+e^- 4.14 GeV

[4] COFFMAN 91 uses the direct measurements of the kaon content to determine this non-$K\overline{K}$ fraction. This number implies that a large fraction of D_s^+ decays involve η, η', and/or non-spectator decays.

$\Gamma(e^+\text{anything})/\Gamma_{\text{total}}$ Γ_5/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.20	90	[5] BAI	90	MRK3	e^+e^- 4.14 GeV

[5] Expressed as a value, the BAI 90 result is $\Gamma(e^+\text{anything})/\Gamma_{\text{total}} = 0.05 \pm 0.05 \pm 0.02$.

Leptonic and semileptonic modes

$\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$ Γ_6/Γ

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the $\pi^\pm$.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.0059±0.0022 OUR FIT		Error includes scale factor of 1.1.			
0.004 $^{+0.0018}_{-0.0014}{}^{+0.0020}_{-0.0019}$	8	[6] AOKI	93	WA75	π^- emulsion 350 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.03	0	[7] AUBERT	83	SPEC	μ^+ Fe, 250 GeV

[6] AOKI 93 assumes the ratio of production cross sections of the D_s^+ and D^0 is 0.27. The value of $\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$ here gives a pseudoscalar decay constant $f_{D_s} = (232 \pm 45 \pm 52)$ MeV.

[7] AUBERT 83 assume that the $D_s^\pm$ production rate is 20% of total charm production rate.

$\Gamma(\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ Γ_6/Γ_{15}

See the "Note on Pseudoscalar-Meson Decay Constants" in the Listings for the $\pi^\pm$.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.17 ±0.06 OUR FIT		Error includes scale factor of 1.1.			
0.245±0.052±0.074	39	[8] ACOSTA	94	CLEO	$e^+e^- \approx \Upsilon(4S)$

[8] ACOSTA 94 obtains $f_{D_s} = (344 \pm 37 \pm 52 \pm 42)$ MeV from this measurement, using $\Gamma(D_s^+ \to \phi\pi^+)/\Gamma(\text{total}) = 0.037 \pm 0.009$.

$\Gamma(\phi\ell^+\nu_\ell)/\Gamma(\phi\pi^+)$ Γ_7/Γ_{15}

For now, we average together measurements of the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ and $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratios.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.54±0.05 OUR AVERAGE						
0.54±0.05±0.04		367	[9,10] BUTLER	94	CLEO	$e^+e^- \approx \Upsilon(4S)$
0.58±0.17±0.07		97	[11,12] FRABETTI	93G	E687	γBe $\overline{E}_\gamma$= 220 GeV
0.57±0.15±0.15		104	[13] ALBRECHT	91	ARG	$e^+e^- \approx$ 10.4 GeV
0.49±0.10 $^{+0.10}_{-0.14}$		54	[14] ALEXANDER	90B	CLEO	e^+e^- 10.5–11 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
seen		19	[15] KODAMA	93	E653	π^- emulsion 600 GeV
<0.45	90		[13] ANJOS	90B	E691	γBe, $\overline{E}_\gamma \approx 145$ GeV

[9] BUTLER 94 uses both $\phi e^+\nu_e$ and $\phi\mu^+\nu_\mu$ events, and makes a phase-space adjustment to the latter to use them as $\phi e^+\nu_e$ events.

[10] AVERY 94B finds $R_2 \equiv A_2/A_1 = 1.4 \pm 0.5 \pm 0.3$ and $R_V \equiv V/A_1 = 0.9 \pm 0.6 \pm 0.3$ for the ratios of the form factors evaluated at q^2=0 for $D_s^+ \to \phi e^+\nu_e$ decay.

[11] FRABETTI 93G measures the $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratio.

[12] FRABETTI 94F finds $R_2 \equiv A_2/A_1 = 1.1 \pm 0.8 \pm 0.1$ and $R_V \equiv V/A_1 = 1.8 \pm 0.9 \pm 0.2$ for the ratios of the form factors evaluated at q^2=0 for $D_s^+ \to \phi\mu^+\nu_\mu$ decay.

[13] ALBRECHT 91 and ANJOS 90B measure the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ ratio.

[14] ALEXANDER 90B measures an average of the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ and $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratios.

[15] KODAMA 93 measures form-factor ratios and the ratio of longitudinal to transverse partial widths.

$[\Gamma(\eta\mu^+\nu_\mu)+\Gamma(\eta'(958)\mu^+\nu_\mu)]/\Gamma(\phi\mu^+\nu_\mu)$ $(\Gamma_{11}+\Gamma_{12})/\Gamma_9$

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
3.9±1.6	13	KODAMA	93	E653	π^- emulsion 600 GeV

$\Gamma(\eta'(958)\mu^+\nu_\mu)/\Gamma(\phi\mu^+\nu_\mu)$ Γ_{12}/Γ_9

Unsearched for decay modes of the $\eta'(958)$ are included.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.6	90	KODAMA	93B	E653	π^- emulsion 600 GeV

Hadronic modes with two K's

$\Gamma(K^+\overline{K}^0)/\Gamma(\phi\pi^+)$ Γ_{13}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
1.01±0.16 OUR AVERAGE					
1.15±0.31±0.19	68	ANJOS	90C	E691	γ Be
0.92±0.32±0.20		ADLER	89B	MRK3	e^+e^- 4.14 GeV
0.99±0.17±0.10		CHEN	89	CLEO	e^+e^- 10 GeV

$\Gamma(K^+K^-\pi^+)/\Gamma_{\text{total}}$ $\Gamma_{14}/\Gamma \equiv (\frac{1}{2}\Gamma_{15}+\frac{2}{3}\Gamma_{16}+\Gamma_{17})/\Gamma$

VALUE	DOCUMENT ID
0.048±0.007 OUR FIT	

$\Gamma(\phi\pi^+)/\Gamma_{\text{total}}$ Γ_{15}/Γ

Nearly all the other modes are measured relative to this mode, which, however, is an uncertain anchor; see the footnotes to the values below, and also the note at the beginning of the list of decay modes, above.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.035±0.004 OUR FIT						
0.036±0.004 OUR AVERAGE						
0.051±0.004±0.008			[16] BUTLER	94	CLEO	$e^+e^- \approx \Upsilon(4S)$
0.046±0.015			[17] MUHEIM	94		
0.031±0.009			[17] MUHEIM	94		
0.031±0.009±0.006			[16] FRABETTI	93G	E687	γBe $\overline{E}_\gamma$= 220 GeV
0.024±0.010			[16] ALBRECHT	91	ARG	$e^+e^- \approx$ 10.4 GeV
$0.031\pm0.006^{+0.011}_{-0.009}$			[16] ALEXANDER	90B	CLEO	e^+e^- 10.5–11 GeV
0.048±0.017±0.019			[18] ALVAREZ	90C	NA14	Photoproduction
0.033±0.016±0.010		9	[19] BRAUNSCH...	87	TASS	e^+e^- 35–44 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.048	90		MUHEIM	94		
<0.041	90	0	[20] ADLER	90B	MRK3	e^+e^- 4.14 GeV
>0.034	90		[16] ANJOS	90B	E691	γBe, $\overline{E}_\gamma \approx$ 145 GeV
0.02 ±0.01		405	[19] CHEN	89	CLEO	e^+e^- 10 GeV
0.033±0.011		30	[19] DERRICK	85B	HRS	e^+e^- 29 GeV

[16] BUTLER 94, FRABETTI 93G, ALBRECHT 91, ALEXANDER 90B, and ANJOS 90B measure the ratio $\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D_s^+ \to \phi\pi^+)$, where ℓ = e and/or μ, and then use a theoretical calculation of the ratio of widths $\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)/\Gamma(D^+ \to \overline{K}^{*0}\ell^+\nu)$. Not everyone uses the same value for this ratio.

[17] The two MUHEIM 94 values here are model-dependent calculations based on distinct data sets. The first uses measurements of the $D_2^*(2460)^0$ and $D_{s1}(2536)^+$, the second uses B-decay factorization and $\Gamma(D_s^+ \to \mu^+\nu_\mu)/\Gamma(D_s^+ \to \phi\ell^+\nu_\ell)$. A third calculation using the semileptonic width of $D_s^+ \to \phi\ell^+\nu_\ell$ is not independent of other results listed here. Note also the upper limit, based on the sum of established D_s^+ branching ratios.

[18] ALVAREZ 90C relies on the Lund model to estimate the ratio of D_s^+ to D^+ cross sections.

[19] Values based on crude estimates of the $D_s^\pm$ production level. DERRICK 85B errors are statistical only.

[20] ADLER 90 uses a technique based on full reconstruction of $D_s^+ D_s^-$ pairs (double tags) to obtain a branching ratio limit without assumptions about $\sigma(D_s^\pm)$.

$\Gamma(K^+\overline{K}^*(892)^0)/\Gamma(\phi\pi^+)$ Γ_{16}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.95±0.10 OUR FIT					
0.95±0.10 OUR AVERAGE					
0.85±0.34±0.20	9	ALVAREZ	90C	NA14	Photoproduction
0.84±0.30±0.22		ADLER	89B	MRK3	e^+e^- 4.14 GeV
1.05±0.17±0.12		CHEN	89	CLEO	e^+e^- 10 GeV
0.87±0.13±0.05	117	ANJOS	88	E691	Photoproduction
1.44±0.37	87	ALBRECHT	87F	ARG	e^+e^- 10 GeV

$\Gamma(K^+K^-\pi^+\text{nonresonant})/\Gamma(\phi\pi^+)$ Γ_{17}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.25±0.09 OUR FIT					
0.25±0.07±0.05	48	ANJOS	88	E691	Photoproduction

$\Gamma(K^*(892)^+\overline{K}^0)/\Gamma(\phi\pi^+)$ Γ_{19}/Γ_{15}

VALUE	DOCUMENT ID		TECN	COMMENT
1.20±0.21±0.13	CHEN	89	CLEO	e^+e^- 10 GeV

$\Gamma(K^*(892)^+\overline{K}^0)/\Gamma(K^+\overline{K}^0)$ Γ_{19}/Γ_{13}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.9	90	FRABETTI	95	E687	γBe $\overline{E}_\gamma \approx 200$ GeV

$\Gamma(\phi\pi^+\pi^0)/\Gamma(\phi\pi^+)$ Γ_{21}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
2.4±1.0±0.5		11	ANJOS	89E	E691	Photoproduction
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<2.6	90		ALVAREZ	90C	NA14	Photoproduction

$\Gamma(\phi\rho^+)/\Gamma(\phi\pi^+)$ Γ_{22}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{1.86\pm0.26^{+0.29}_{-0.40}}$	253	AVERY	92	CLEO	$e^+e^- \simeq 10.5$ GeV

$\Gamma(\phi\pi^+\pi^0\text{3-body})/\Gamma(\phi\pi^+)$ Γ_{23}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.71	90	DAOUDI	92	CLEO	$e^+e^- \approx 10.5$ GeV

$\Gamma(K^+K^-\pi^+\pi^0\text{non-}\phi)/\Gamma(\phi\pi^+)$ Γ_{24}/Γ_{15}

VALUE	CL%		DOCUMENT ID		TECN	COMMENT
<2.4	90	[21]	ANJOS	89E	E691	Photoproduction

[21] Total minus ϕ component.

$\Gamma(K^+\overline{K}^0\pi^+\pi^-)/\Gamma(\phi\pi^+)$ Γ_{25}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.77	90	ALBRECHT	92B	ARG	$e^+e^- \simeq 10.4$ GeV

$\Gamma(K^0K^-\pi^+\pi^+)/\Gamma(\phi\pi^+)$ Γ_{26}/Γ_{15}

VALUE	DOCUMENT ID		TECN	COMMENT
1.2 ±0.2 ±0.2	ALBRECHT	92B	ARG	$e^+e^- \simeq 10.4$ GeV

$\Gamma(K^*(892)^+\overline{K}^*(892)^0)/\Gamma(\phi\pi^+)$ Γ_{27}/Γ_{15}

VALUE	DOCUMENT ID		TECN	COMMENT
1.6±0.4±0.4	ALBRECHT	92B	ARG	$e^+e^- \simeq 10.4$ GeV

$\Gamma(K^0K^-\pi^+\pi^+\text{non-}K^{*+}\overline{K}^{*0})/\Gamma(\phi\pi^+)$ Γ_{28}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.80	90	ALBRECHT	92B	ARG	$e^+e^- \simeq 10.4$ GeV

$\Gamma(\phi\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ Γ_{30}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.51±0.12 OUR AVERAGE						
0.58±0.21±0.10		21	FRABETTI	92	E687	γBe
0.42±0.13±0.07		19	ANJOS	88	E691	Photoproduction
1.11±0.37±0.28		62	ALBRECHT	85D	ARG	e^+e^- 10 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.24	90		ALVAREZ	90C	NA14	Photoproduction

$\Gamma(K^+K^-\pi^+\pi^+\pi^-\ \text{non-}\phi)/\Gamma_{\text{total}}$ Γ_{31}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
$0.003\ ^{+0.003}_{=0.002}$	BARLAG	92C	ACCM	π^- 230 GeV

$\Gamma(K^+K^-\pi^+\pi^+\pi^-\ \text{non-}\phi)/\Gamma(\phi\pi^+)$ Γ_{31}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<0.32	90	10	ANJOS	88	E691	Photoproduction

Other hadronic modes

$\Gamma(\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ Γ_{32}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.39±0.08 OUR AVERAGE					
0.33±0.10±0.04	29	ADAMOVICH	93	WA82	π^- 340 GeV
0.44±0.10±0.04		ANJOS	89	E691	Photoproduction

$\Gamma(\rho^0\pi^+)/\Gamma(\phi\pi^+)$ Γ_{33}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.08	90	ANJOS	89	E691	Photoproduction
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.22	90	ALBRECHT	87G	ARG	e^+e^- 10 GeV

$\Gamma(f_0(980)\pi^+)/\Gamma(\phi\pi^+)$ Γ_{34}/Γ_{15}

VALUE	DOCUMENT ID		TECN	COMMENT
0.28±0.10±0.03	ANJOS	89	E691	Photoproduction

$\Gamma(\pi^+\pi^+\pi^-\ \text{nonresonant})/\Gamma(\phi\pi^+)$ Γ_{35}/Γ_{15}

VALUE	DOCUMENT ID		TECN	COMMENT
0.29±0.09±0.03	ANJOS	89	E691	Photoproduction

$\Gamma(\pi^+\pi^+\pi^-\pi^0)/\Gamma(\phi\pi^+)$ Γ_{36}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<3.3	90	ANJOS	89E	E691	Photoproduction

$\Gamma(\eta\pi^+)/\Gamma(\phi\pi^+)$ Γ_{37}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.54±0.09±0.06		165	ALEXANDER	92	CLEO	$\eta \to \gamma\gamma$, $\pi^+\pi^-\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.5	90		ANJOS	89E	E691	Photoproduction

$\Gamma(\omega\pi^+)/\Gamma(\phi\pi^+)$ Γ_{38}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.5	90	ANJOS	89E	E691	Photoproduction

$\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-)/\Gamma_{\text{total}}$ Γ_{39}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
$0.003\ ^{+0.004}_{=0.003}$	BARLAG	92C	ACCM	π^- 230 GeV

$\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-)/\Gamma(\phi\pi^+)$ Γ_{39}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.29	90	ANJOS	89	E691	Photoproduction

$\Gamma(\eta\rho^+)/\Gamma(\phi\pi^+)$ Γ_{41}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$2.86\pm0.38^{+0.36}_{-0.38}$	217	AVERY	92	CLEO	$\eta \to \gamma\gamma$, $\pi^+\pi^-\pi^0$

$\Gamma(\eta\pi^+\pi^0\ \text{3-body})/\Gamma(\phi\pi^+)$ Γ_{42}/Γ_{15}

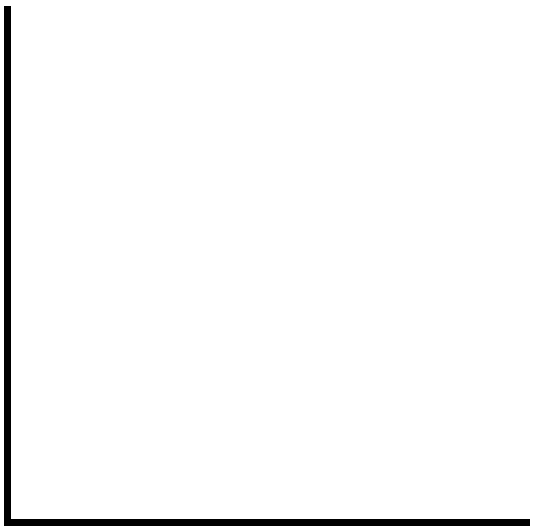
VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.82	90	DAOUDI	92	CLEO	$e^+e^- \approx$ 10.5 GeV

$\Gamma(\pi^+\pi^+\pi^+\pi^-\pi^-\pi^0)/\Gamma_{total}$ Γ_{43}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
$0.049^{+0.033}_{-0.030}$	BARLAG	92C	ACCM	π^- 230 GeV

$\Gamma(\eta'(958)\pi^+)/\Gamma(\phi\pi^+)$ Γ_{44}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
1.4 ±0.4 OUR AVERAGE			Error includes scale factor of 2.1. See the ideogram below.			
1.20±0.15±0.11		281	ALEXANDER	92	CLEO	$\eta' \to \eta\pi^+\pi^-$, $\rho^0\gamma$
2.5 ±1.0 $^{+1.5}_{-0.4}$		22	ALVAREZ	91	NA14	Photoproduction
2.5 ±0.5 ±0.3		215	ALBRECHT	90D	ARG	e^+e^- ≈ 10.4 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.3	90		ANJOS	91B	E691	γBe, $\overline{E}_\gamma$ ≈ 145 GeV



$\Gamma(\eta'(958)\pi^+)/\Gamma(\phi\pi^+)$

$\Gamma(\eta'(958)\rho^+)/\Gamma(\phi\pi^+)$ Γ_{46}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$3.44\pm0.62^{+0.44}_{-0.46}$	68	AVERY	92	CLEO	$\eta' \to \eta\pi^+\pi^-$

$\Gamma(\eta'(958)\pi^+\pi^0$ 3-body$)/\Gamma(\phi\pi^+)$ Γ_{47}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.85	90	DAOUDI	92	CLEO	e^+e^- ≈ 10.5 GeV

$\Gamma(K^0\pi^+)/\Gamma(\phi\pi^+)$ Γ_{48}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.21	90	ADLER	89B	MRK3	e^+e^- 4.14 GeV

$\Gamma(K^0\pi^+)/\Gamma(K^+\overline{K}^0)$ Γ_{48}/Γ_{13}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.53	90	FRABETTI	95	E687	γBe $\overline{E}_\gamma \approx 200$ GeV

$\Gamma(K^+\pi^+\pi^-)/\Gamma_{total}$ Γ_{49}/Γ

VALUE	DOCUMENT ID		TECN	COMMENT
$0.003\ ^{+0.004}_{-0.003}$	BARLAG	92C	ACCM	π^- 230 GeV

$\Gamma(\phi K^+)/\Gamma(\phi\pi^+)$ Γ_{51}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.071	90	ANJOS	92D	E691	γBe $\overline{E}_\gamma$ = 145 GeV

Rare or forbidden modes

$\Gamma(\pi^+\mu^+\mu^-)/\Gamma_{\text{total}}$ Γ_{52}/Γ

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<4.3\times10^{-4}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(K^+\mu^+\mu^-)/\Gamma_{\text{total}}$ Γ_{53}/Γ

A test for the ΔC=1 weak neutral current. Allowed by higher-order electroweak interactions.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<5.9\times10^{-4}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(K^*(892)^+\mu^+\mu^-)/\Gamma_{\text{total}}$ Γ_{54}/Γ

A test for the ΔC=1 weak neutral current. Allowed by higher-order electroweak interactions.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<1.4\times10^{-3}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(\pi^-\mu^+\mu^+)/\Gamma_{\text{total}}$ Γ_{55}/Γ

A test of lepton-number conservation.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<4.3\times10^{-4}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(K^-\mu^+\mu^+)/\Gamma_{\text{total}}$ Γ_{56}/Γ

A test of lepton-number conservation.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<5.9\times10^{-4}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(K^*(892)^-\mu^+\mu^+)/\Gamma_{\text{total}}$ Γ_{57}/Γ

A test of lepton-number conservation.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<1.4\times10^{-3}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$D_s^\pm$ REFERENCES

FRABETTI	95	PL B346 199	+Cheung, Cumalat+	(FNAL E687 Collab.)
KODAMA	95	PL B345 85	+Ushida, Mokhtarani+	(FNAL E653 Collab.)
ACOSTA	94	PR D49 5690	+Athanas, Masek, Paar+	(CLEO Collab.)
AVERY	94B	PL B337 405	+Freyberger, Rodriguez+	(CLEO Collab.)
BROWN	94	PR D50 1884	+Fast, McIlwain, Miao+	(CLEO Collab.)
BUTLER	94	PL B324 255	+Fu, Kalbfleisch, Ross+	(CLEO Collab.)
FRABETTI	94F	PL B328 187	+Cheung, Cumalat+	(FNAL E687 Collab.)
MUHEIM	94	PR D49 3767	+Stone	(SYRA)
ADAMOVICH	93	PL B305 177	+Alexandrov, Antinori+	(CERN WA82 Collab.)
AOKI	93	PTP 89 131	+Baroni, Bisi, Breslin+	(CERN WA75 Collab.)
FRABETTI	93F	PRL 71 827	+Cheung, Cumalat, Dallapiccola+	(FNAL E687 Collab.)
FRABETTI	93G	PL B313 253	+Cheung, Cumalat+	(FNAL E687 Collab.)
KODAMA	93	PL B309 483	+Ushida, Mokhtarani+	(FNAL E653 Collab.)
KODAMA	93B	PL B313 260	+Ushida, Mokhtarani+	(FNAL E653 Collab.)
ALBRECHT	92B	ZPHY C53 361	+Ehrlichmann, Hamacher, Krueger+	(ARGUS Collab.)
ALEXANDER	92	PRL 68 1275	+Bebek, Berkelman, Besson+	(CLEO Collab.)
ANJOS	92D	PRL 69 2892	+Appel, Bean, Bediaga+	(FNAL E691 Collab.)
AVERY	92	PRL 68 1279	+Freyberger, Rodriguez, Yelton+	(CLEO Collab.)
BARLAG	92C	ZPHY C55 383	+Becker, Bozek, Boehringer+	(ACCMOR Collab.)
Also	90D	ZPHY C48 29	Barlag, Becker, Boehringer, Bosman+	(ACCMOR Collab.)
DAOUDI	92	PR D45 3965	+Ford, Johnson, Lingel+	(CLEO Collab.)
FRABETTI	92	PL B281 167	+Bogart, Cheung, Culy+	(FNAL E687 Collab.)
ALBRECHT	91	PL B255 634	+Ehrlichmann, Hamacher, Krueger+	(ARGUS Collab.)
ALVAREZ	91	PL B255 639	+Barate, Bloch, Bonamy+	(CERN NA14/2 Collab.)
ANJOS	91B	PR D43 R2063	+Appel, Bean, Bracker+	(FNAL E691 Collab.)
COFFMAN	91	PL B263 135	+DeJongh, Dubois, Eigen, Hitlin+	(Mark III Collab.)
ADLER	90	PRL 64 2615	+Blaylock, Bolton+	(Mark III Collab.)
ADLER	90B	PRL 64 169	+Bai, Blaylock, Bolton+	(Mark III Collab.)
ALBRECHT	90D	PL B245 315	+Ehrlichmann, Glaeser, Harder+	(ARGUS Collab.)
ALEXANDER	90B	PRL 65 1531	+Artuso, Bebek, Berkelman+	(CLEO Collab.)
ALVAREZ	90	ZPHY C47 539	+Barate, Bloch, Bonamy+	(CERN NA14/2 Collab.)
ALVAREZ	90C	PL B246 261	+Barate, Bloch, Bonamy+	(CERN NA14/2 Collab.)
ANJOS	90B	PRL 64 2885	+Appel, Bean, Bracker+	(FNAL E691 Collab.)

ANJOS	90C	PR D41 2705	+Appel, Bean+	(FNAL E691 Collab.)
BAI	90	PRL 65 686	+Blaylock, Bolton, Brient+	(Mark III Collab.)
BARLAG	90C	ZPHY C46 563	+Becker, Boehringer, Bosman+	(ACCMOR Collab.)
FRABETTI	90	PL B251 639	+Bogart, Cheung, Coteus+	(FNAL E687 Collab.)
ADLER	89B	PRL 63 1211	+Bai, Becker, Blaylock, Bolton+	(Mark III Collab.)
Also	89D	PRL 63 2858 erratum		
ANJOS	89	PRL 62 125	+Appel, Bean, Bracker+	(FNAL E691 Collab.)
ANJOS	89E	PL B223 267	+Appel, Bean, Bracker+	(FNAL E691 Collab.)
AVERILL	89	PR D39 123	+Blockus, Brabson+	(HRS Collab.)
CHEN	89	PL B226 192	+McIlwain, Miller, Ng, Shibata+	(CLEO Collab.)
ALBRECHT	88	PL B207 349	+Binder, Boeckmann+	(ARGUS Collab.)
ALBRECHT	88I	PL B210 267	+Boeckmann, Glaeser+	(ARGUS Collab.)
ANJOS	88	PRL 60 897	+Appel+	(FNAL E691 Collab.)
RAAB	88	PR D37 2391	+Anjos, Appel, Bracker+	(FNAL E691 Collab.)
ALBRECHT	87F	PL B179 398	+Binder, Boeckmann, Glaeser+	(ARGUS Collab.)
ALBRECHT	87G	PL B195 102	+Andam, Binder, Boeckmann+	(ARGUS Collab.)
ANJOS	87B	PRL 58 1818	+Appel, Bracker, Browder+	(FNAL E691 Collab.)
BECKER	87B	PL B184 277	+Boehringer, Bosman+	(NA11 and NA32 Collab.)
BLAYLOCK	87	PRL 58 2171	+Bolton, Brown, Bunnell+	(Mark III Collab.)
BRAUNSCH...	87	ZPHY C35 317	Braunschweig, Gerhards+	(TASSO Collab.)
CSORNA	87	PL B191 318	+Mestayer, Panvini, Word+	(CLEO Collab.)
JUNG	86	PRL 56 1775	+Abachi+	(HRS Collab.)
USHIDA	86	PRL 56 1767	+Kondo, Tasaka, Park+	(FNAL E653 Collab.)
ALBRECHT	85D	PL 153B 343	+Drescher, Binder, Drews+	(ARGUS Collab.)
DERRICK	85B	PRL 54 2568	+Fernandez, Fries, Hyman+	(HRS Collab.)
AIHARA	84D	PRL 53 2465	+Alston-Garnjost, Badtke, Bakken+	(TPC Collab.)
ALTHOFF	84	PL 136B 130	+Braunschweig, Kirschfink+	(TASSO Collab.)
BAILEY	84	PL 139B 320	+Belau, Bohringer, Bosman+	(ACCMOR Collab.)
AUBERT	83	NP B213 31	+Bassompierre, Becks, Best+	(EMC Collab.)
CHEN	83C	PRL 51 634	+Alam, Giles, Kagan+	(CLEO Collab.)
USHIDA	83	PRL 51 2362	+Kondo, Fujioka, Fukushima+	(FNAL E653 Collab.)