$D_s^{\pm}$ was $F^{\pm}$

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

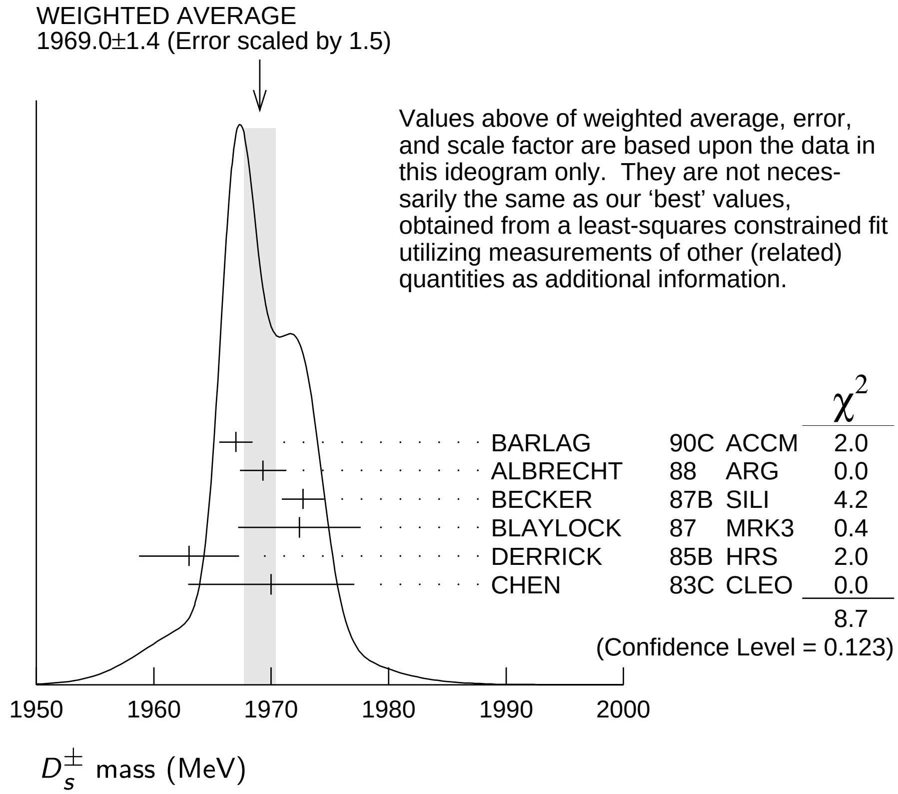
The angular distributions of the decays of the ϕ and $\overline{K}^*(892)^0$ in the $\phi\pi^+$ and $K^+\overline{K}^*(892)^0$ modes strongly indicate that the spin is zero. The parity given is that expected of a $c\overline{s}$ ground state.

$D_s^{\pm}$ 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 have been omitted altogether.

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
1968.3± 0.5 OUR FIT Error includes scale factor of 1.2.					
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).



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

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*
98.87±0.31 OUR FIT	Error includes scale factor of 1.4.				
98.85±0.25 OUR AVERAGE	Error includes scale factor of 1.1.				
99.41±0.38±0.21		ACOSTA	03D	CDF2	$\overline{p}p$, $\sqrt{s}$= 1.96 TeV
98.4 ±0.1 ±0.3	48k	AUBERT	02G	BABR	$e^+e^- \approx \Upsilon(4S)$
99.5 ±0.6 ±0.3		BROWN	94	CLE2	$e^+e^- \approx \Upsilon(4S)$
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 100×10^{-15} s or with fewer than 100 events have been omitted from the Listings.

VALUE (10^{-15} s)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
490 ± 9 OUR AVERAGE	Error includes scale factor of 1.1.				
472.5±17.2± 6.6	760	IORI	01	SELX	600 GeV Σ^-, π^-, p
518 ±14 ± 7	1662	AITALA	99	E791	π^- nucleus, 500 GeV
$486.3\pm15.0^{+4.9}_{-5.1}$	2167	[2] BONVICINI	99	CLE2	$e^+e^- \approx \Upsilon(4S)$

475	±20	± 7	900	FRABETTI	93F	E687	γBe, $\phi\pi^+$
500	±60	±30	104	FRABETTI	90	E687	γBe, $\phi\pi^+$
470	±40	±20	228	RAAB	88	E691	Photoproduction

[2] BONVICINI 99 obtains 1.19 ± 0.04 for the ratio of D_s^+ to D^0 lifetimes.

D_s^+ DECAY MODES

Unless otherwise noted, the branching fractions for modes 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.

	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 ±28) %	
Γ_3	K^+ anything		$(20\ {}^{+18}_{-14})$ %	
Γ_4	(non-$K\overline{K}$) anything		(64 ±17) %	
Γ_5	e^+ anything		$(8\ {}^{+6}_{-5})$ %	
Γ_6	ϕ anything		$(18\ {}^{+15}_{-10})$ %	
	Leptonic and semileptonic modes			
Γ_7	$\mu^+\nu_\mu$		$(5.0 \pm 1.9) \times 10^{-3}$	S=1.3
Γ_8	$\tau^+\nu_\tau$		(6.4 ± 1.5) %	
Γ_9	$\phi\ell^+\nu_\ell$	[a]	(2.0 ± 0.5) %	
Γ_{10}	$\eta\ell^+\nu_\ell$ + $\eta'(958)\ell^+\nu_\ell$	[a]	(3.4 ± 1.0) %	
Γ_{11}	$\eta\ell^+\nu_\ell$	[a]	(2.5 ± 0.7) %	
Γ_{12}	$\eta'(958)\ell^+\nu_\ell$	[a]	$(8.9 \pm 3.3) \times 10^{-3}$	
	Hadronic modes with a $K\overline{K}$ pair (including from a ϕ)			
Γ_{13}	$K^+\overline{K}^0$		(3.6 ± 1.1) %	
Γ_{14}	$K^+K^-\pi^+$	[b]	(4.4 ± 1.2) %	
Γ_{15}	$\phi\pi^+$	[c]	(3.6 ± 0.9) %	
Γ_{16}	$K^+\overline{K}^*(892)^0$	[c]	(3.3 ± 0.9) %	
Γ_{17}	$f_0(980)\pi^+$ $\times$ B($f_0 \to K^+K^-$)	[d]	$(4.9 \pm 2.3) \times 10^{-3}$	
Γ_{18}	$K^+\overline{K}_0^*(1430)^0$	[c]	$(7 \pm 4) \times 10^{-3}$	
Γ_{19}	$f_0(1710)\pi^+$ $\times$ B($f_0 \to K^+K^-$)			
Γ_{20}	$K^+K^-\pi^+$ nonresonant		$(9 \pm 4) \times 10^{-3}$	
Γ_{21}	$K^0\overline{K}^0\pi^+$		—	
Γ_{22}	$K^*(892)^+\overline{K}^0$	[c]	(4.3 ± 1.4) %	
Γ_{23}	$K^+K^-\pi^+\pi^0$		—	

Γ_{24}	$\phi\pi^+\pi^0$	[c]	(9 ± 5) %	
Γ_{25}	$\phi\rho^+$	[c]	(6.7 ± 2.3) %	
Γ_{26}	$\phi\pi^+\pi^0$ 3-body	[c]	< 2.6 %	CL=90%
Γ_{27}	$K^+K^-\pi^+\pi^0$ non-ϕ		< 9 %	CL=90%
Γ_{28}	$K^+\overline{K}^0\pi^+\pi^-$		(2.5 ± 0.9) %	
Γ_{29}	$K^0K^-\pi^+\pi^+$		(4.3 ± 1.5) %	
Γ_{30}	$K^*(892)^+\overline{K}^*(892)^0$	[c]	(5.8 ± 2.5) %	
Γ_{31}	$K^0K^-\pi^+\pi^+$ (non-$K^{*+}\overline{K}^{*0}$)		< 2.9 %	CL=90%
Γ_{32}	$K^+K^-\pi^+\pi^+\pi^-$		(7.1 ± 2.2) $\times 10^{-3}$	
Γ_{33}	$\phi\pi^+\pi^+\pi^-$	[c]	(9.7 ± 2.6) $\times 10^{-3}$	
Γ_{34}	$K^+K^-\rho^0\pi^+$ non-ϕ		< 2.1 $\times 10^{-4}$	CL=90%
Γ_{35}	$\phi\rho^0\pi^+$	[c]	(1.06 ± 0.35) %	
Γ_{36}	$\phi a_1(1260)^+$	[c]	(2.5 ± 0.8) %	
Γ_{37}	$K^+K^-\pi^+\pi^+\pi^-$ nonresonant		(7 ± 6) $\times 10^{-4}$	

Hadronic modes without *K*'s

Γ_{38}	$\pi^+\pi^+\pi^-$		(1.01 ± 0.28) %	S=1.1
Γ_{39}	$\rho^0\pi^+$		< 7 $\times 10^{-4}$	CL=90%
Γ_{40}	$f_0(980)\pi^+ \times$ B($f_0 \to \pi^+\pi^-$)	[e]	(5.7 ± 1.7) $\times 10^{-3}$	
Γ_{41}	$f_2(1270)\pi^+$	[c]	(3.5 ± 1.2) $\times 10^{-3}$	
Γ_{42}	$f_0(1370)\pi^+ \times$ B($f_0 \to \pi^+\pi^-$)	[e]	(3.3 ± 1.2) $\times 10^{-3}$	
Γ_{43}	$\rho(1450)^0\pi^+ \times$ B($\rho^0 \to \pi^+\pi^-$)	[e]	(4.4 ± 2.5) $\times 10^{-4}$	
Γ_{44}	$f_0(1500)\pi^+ \times$ B($f_0 \to \pi^+\pi^-$)			
Γ_{45}	$\pi^+\pi^+\pi^-$ nonresonant		(5 $^{+22}_{-\ 5}$) $\times 10^{-5}$	
Γ_{46}	$\pi^+\pi^+\pi^-\pi^0$		< 12 %	CL=90%
Γ_{47}	$\eta\pi^+$	[c]	(1.7 ± 0.5) %	
Γ_{48}	$\omega\pi^+$	[c]	(2.8 ± 1.1) $\times 10^{-3}$	
Γ_{49}	$3\pi^+2\pi^-$		(6.5 ± 1.8) $\times 10^{-3}$	
Γ_{50}	$\pi^+\pi^+\pi^-\pi^0\pi^0$		—	
Γ_{51}	$\eta\rho^+$	[c]	(10.8 ± 3.1) %	
Γ_{52}	$\eta\pi^+\pi^0$ 3-body	[c]	< 4 %	CL=90%
Γ_{53}	$3\pi^+2\pi^-\pi^0$		(4.9 ± 3.2) %	
Γ_{54}	$\eta'(958)\pi^+$	[c]	(3.9 ± 1.0) %	
Γ_{55}	$3\pi^+2\pi^-2\pi^0$		—	
Γ_{56}	$\eta'(958)\rho^+$	[c]	(10.1 ± 2.8) %	
Γ_{57}	$\eta'(958)\pi^+\pi^0$ 3-body	[c]	< 1.4 %	CL=90%

Modes with one or three K's

Γ_{58}	$K^0\pi^+$			$<$ 8	$\times 10^{-3}$	CL=90%
Γ_{59}	$K^+\pi^+\pi^-$			(1.0 $\pm$ 0.4) %		
Γ_{60}	$K^+\rho^0$			$<$ 2.9	$\times 10^{-3}$	CL=90%
Γ_{61}	$K^*(892)^0\pi^+$		[c]	(6.5 $\pm$ 2.8)	$\times 10^{-3}$	
Γ_{62}	$K^+K^+K^-$			(4.0 $\pm$ 1.7)	$\times 10^{-4}$	
Γ_{63}	ϕK^+		[c]	$<$ 5	$\times 10^{-4}$	CL=90%

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

Γ_{64}	$\pi^+e^+e^-$		[f]	$<$ 2.7	$\times 10^{-4}$	CL=90%
Γ_{65}	$\pi^+\mu^+\mu^-$		[f]	$<$ 2.6	$\times 10^{-5}$	CL=90%
Γ_{66}	$K^+e^+e^-$	*C1*		$<$ 1.6	$\times 10^{-3}$	CL=90%
Γ_{67}	$K^+\mu^+\mu^-$	*C1*		$<$ 3.6	$\times 10^{-5}$	CL=90%
Γ_{68}	$K^*(892)^+\mu^+\mu^-$	*C1*		$<$ 1.4	$\times 10^{-3}$	CL=90%
Γ_{69}	$\pi^+e^\pm\mu^\mp$	*LF*	[g]	$<$ 6.1	$\times 10^{-4}$	CL=90%
Γ_{70}	$K^+e^\pm\mu^\mp$	*LF*	[g]	$<$ 6.3	$\times 10^{-4}$	CL=90%
Γ_{71}	$\pi^-e^+e^+$	*L*		$<$ 6.9	$\times 10^{-4}$	CL=90%
Γ_{72}	$\pi^-\mu^+\mu^+$	*L*		$<$ 2.9	$\times 10^{-5}$	CL=90%
Γ_{73}	$\pi^-e^+\mu^+$	*L*		$<$ 7.3	$\times 10^{-4}$	CL=90%
Γ_{74}	$K^-e^+e^+$	*L*		$<$ 6.3	$\times 10^{-4}$	CL=90%
Γ_{75}	$K^-\mu^+\mu^+$	*L*		$<$ 1.3	$\times 10^{-5}$	CL=90%
Γ_{76}	$K^-e^+\mu^+$	*L*		$<$ 6.8	$\times 10^{-4}$	CL=90%
Γ_{77}	$K^*(892)^-\mu^+\mu^+$	*L*		$<$ 1.4	$\times 10^{-3}$	CL=90%

Γ_{78}	A dummy mode used by the fit.	(82 $\pm$ 5) %

[a] For now, we average together measurements of the $X e^+\nu_e$ and $X\mu^+\nu_\mu$ branching fractions. This is the *average*, not the *sum*.

[b] The branching fraction for this mode may differ from the sum of the submodes that contribute to it, due to interference effects. See the relevant papers.

[c] This branching fraction includes all the decay modes of the final-state resonance.

[d] This value includes only K^+K^- decays of the intermediate resonance, because branching fractions of this resonance are not known.

[e] This value includes only $\pi^+\pi^-$ decays of the intermediate resonance, because branching fractions of this resonance are not known.

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

[g] The value is for the sum of the charge states or particle/antiparticle states indicated.

CONSTRAINED FIT INFORMATION

An overall fit to 12 branching ratios uses 24 measurements and one constraint to determine 9 parameters. The overall fit has a $\chi^2 = 13.0$ for 16 degrees of freedom.

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

x_9	70							
x_{11}	60	85						
x_{12}	45	64	54					
x_{14}	66	88	75	56				
x_{15}	72	96	81	61	92			
x_{16}	67	89	76	57	93	93		
x_{38}	63	84	72	54	86	88	84	
x_{78}	−73	−96	−86	−66	−96	−98	−96	−89
	x_7	x_9	x_{11}	x_{12}	x_{14}	x_{15}	x_{16}	x_{38}

D_s^+ BRANCHING RATIOS

A few older, now obsolete results have been omitted. They may be found in earlier editions.

Inclusive modes

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

VALUE	DOCUMENT ID		TECN	COMMENT
$0.13^{+0.14}_{-0.12}\pm0.02$	COFFMAN	91	MRK3	e^+e^- 4.14 GeV

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

VALUE	DOCUMENT ID		TECN	COMMENT
$0.39^{+0.28}_{-0.27}\pm0.04$	COFFMAN	91	MRK3	e^+e^- 4.14 GeV

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

VALUE	DOCUMENT ID		TECN	COMMENT
$0.20^{+0.18}_{-0.13}\pm0.04$	COFFMAN	91	MRK3	e^+e^- 4.14 GeV

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.64±0.17±0.03	[3] COFFMAN	91	MRK3	e^+e^- 4.14 GeV

[3] 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
$0.077^{+0.057}_{-0.043}{}^{+0.024}_{-0.021}$		BAI	97	BES	$e^+e^- \rightarrow D_s^+ D_s^-$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.20	90	[4] BAI	90	MRK3	e^+e^- 4.14 GeV

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

$\Gamma(\phi \text{ anything})/\Gamma_{\text{total}}$ **Γ_6/Γ**

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$0.178^{+0.151}_{-0.072}{}^{+0.006}_{-0.063}$	3	BAI	98	BES	$e^+e^- \rightarrow D_s^+ D_s^-$

——— Leptonic and semileptonic modes ———

D_s^+ DECAY CONSTANT

Written October 2003 by A. Edwards and P. Burchat (Stanford University)

In the Standard Model, the D_s^+ leptonic branching fractions are related to the D_s^+ decay constant f_{D_s} by the equation [1]

$$\mathrm{B}(D_s^+ \rightarrow \ell^+\nu_\ell) = \frac{G_F^2}{8\pi}|V_{cs}|^2 f_{D_s}^2 \frac{\tau_{D_s}}{\hbar} m_{D_s} m_\ell^2 \left(1 - \frac{m_\ell^2}{m_{D_s}^2}\right)^2 . \quad (1)$$

Hence, measurements of $\mathrm{B}(D_s^+ \rightarrow \ell^+\nu_\ell)$ can be used to extract f_{D_s}. Eight experiments have published measurements of the branching fraction for D_s^+ decaying to $\mu^+\nu_\mu$ or $\tau^+\nu_\tau$: WA75 (AOKI 93), BES (BAI 95), E653 (KODAMA 96), L3 (ACCIARRI 97F), CLEO (CHADHA 98), BEATRICE (ALEXANDROV 00), OPAL (ABBIENDI 01L), and ALEPH (HEISTER 02I). All these experiments except BES either explicitly or implicitly measure the leptonic branching fraction relative to the branching fraction for $D_s^+ \rightarrow \phi\pi^+$, or for semileptonic D_s^+ or D^0 decays. The semileptonic D_s^+ branching fraction is in turn measured relative to $\mathrm{B}(D_s^+ \rightarrow \phi\pi^+)$. The fractional experimental uncertainty on $\mathrm{B}(D_s^+ \rightarrow \phi\pi^+)$ is currently 25%.

The LEP experiments (L3, OPAL, ALEPH) share a 23% correlated uncertainty in the normalization of the leptonic branching fraction. They use the partial decay rate for $Z \to c\overline{c}$ and the D_s^+ production rate in $Z \to c\overline{c}$ events, which in turn depends on the assumed value of $\mathrm{B}(D_s^+ \to \phi\pi^+)$. BES uses the relative number of events in which one or two D_s decays are fully reconstructed to determine the absolute $D_s^+ \to \mu^+\nu_\mu$ branching fraction; however, only three events are observed in which one D_s^+ decays to a hadronic final state and the other decays to $\mu^+\nu_\mu$ or $\tau^+\nu_\tau$.

We determine the world average value of f_{D_s} from the experimental measurements of the D_s^+ leptonic branching fractions, assuming lepton universality, taking into account correlated uncertainties, and using a consistent and up-to-date set of input parameters [2] for the μ, τ, and D_s^+ masses, the D_s^+ lifetime, V_{cs}, $\mathrm{B}(D_s^+ \to \phi\pi^+)$, and the relative D_s^+ branching fractions. Although the uncertainty on $\mathrm{B}(D_s^+ \to \phi\pi^+)$ is by far the largest correlated uncertainty, we also take into account correlated uncertainties in the input parameters. Weighting each measurement by its uncorrelated uncertainty, we determine the average leptonic branching fraction for all experiments except BES to be $\mathrm{B}(D_s^+ \to \mu^+\nu_\mu) = 0.00547 \pm 0.00067 \pm 0.00132$, where the second uncertainty in the average is the correlated uncertainty due to $\mathrm{B}(D_s^+ \to \phi\pi^+)$. Since the above average is less (by 1.5σ) than the BES result of $\mathrm{B}(D_s^+ \to \mu^+\nu_\mu) = 0.015^{+0.013+0.003}_{-0.006-0.002}$, the negative uncertainties on the BES measurement are used to calculate the weighted average for all experiments:

$$\mathrm{B}(D_s^+ \to \mu^+\nu_\mu) = 0.00596 \pm 0.00144\ . \qquad (2)$$

Using this value of the branching fraction and including the relatively minor uncertainties on the other parameters in Eq. (1), we extract the world average D_s^+ decay constant:

$$f_{D_s} = (267 \pm 33)\ \text{MeV}\ . \tag{3}$$

References

1. See the note on "Pseudoscalar-Meson Decay Constants" at the beginning of the Meson Particle Listings.
2. Review of Particle Properties 2004.

$\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$ — Γ_7/Γ

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$0.0068 \pm 0.0011 \pm 0.0018$	553	[5] HEISTER	02I	ALEP	Z decays
$0.015\ ^{+0.013}_{-0.006}\ ^{+0.003}_{-0.002}$	3	[6] BAI	95	BES	$e^+e^- \to D_s^+ D_s^-$
$0.004\ ^{+0.0018}_{-0.0014}\ ^{+0.0020}_{-0.0019}$	8	[7] AOKI	93	WA75	π^- emulsion 350 GeV
<0.03	0	[8] AUBERT	83	SPEC	μ^+ Fe, 250 GeV

[5] This HEISTER 02I result is not actually an independent measurement of the absolute $\mu^+\nu_\mu$ branching fraction, but is in fact based on our $\phi\pi^+$ branching fraction of $3.6 \pm 0.9\%$, so it cannot be included in our overall fit. HEISTER 02I combines its $D_s^+ \to \tau^+\nu_\tau$ and $\mu^+\nu_\mu$ branching fractions to get $f_{D_s} = (285 \pm 19 \pm 40)$ MeV.

[6] BAI 95 uses one actual $D_s^+ \to \mu^+\nu_\mu$ event together with two $D_s^+ \to \tau^+\nu_\tau$ events and assumes μ-τ universality. This value of $\Gamma(\mu^+\nu_\mu)/\Gamma_{\text{total}}$ gives a pseudoscalar decay constant of $(430^{+150}_{-130} \pm 40)$ MeV.

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

[8] 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_7/Γ_{15}

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.14 ±0.04 OUR FIT Error includes scale factor of 1.4.					
0.19 ±0.04 OUR AVERAGE					
$0.23 \pm 0.06 \pm 0.04$	18	[9] ALEXANDROV	00	BEAT	π^- nucleus, 350 GeV
$0.173 \pm 0.023 \pm 0.035$	182	[10] CHADHA	98	CLE2	$e^+e^- \approx \Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$0.245 \pm 0.052 \pm 0.074$	39	[11] ACOSTA	94	CLE2	See CHADHA 98

[9] ALEXANDROV 00 uses $f_D^2/f_{D_s}^2 = 0.82 \pm 0.09$ from a lattice-gauge-theory calculation to get the relative numbers of $D^+ \to \mu^+\nu_\mu$ and $D_s^+ \to \mu^+\nu_\mu$ events. The present result leads to $f_{D_s} = (323 \pm 44 \pm 36)$ MeV.

[10] CHADHA 98 obtains $f_{D_s} = (280 \pm 19 \pm 28 \pm 34)$ MeV from this measurement, using $\Gamma(D_s^+ \to \phi\pi^+)/\Gamma(\text{total}) = 0.036 \pm 0.009$.

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

$\Gamma(\mu^+\nu_\mu)/\Gamma(\phi\ell^+\nu_\ell)$ — Γ_7/Γ_9

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.25±0.07 OUR FIT Error includes scale factor of 1.5.					
0.16±0.06±0.03	23	[12] KODAMA	96	E653	π^- emulsion, 600 GeV

[12] KODAMA 96 obtains $f_{D_s} = (194 \pm 35 \pm 20 \pm 14)$ MeV from this measurement, using $\Gamma(D_s^+ \to \phi\ell^+\nu)/\Gamma_{\text{total}} = 0.0188 \pm 0.0029$. The third error is from the uncertainty on $\phi\ell^+\nu_\ell$ branching fraction.

$\Gamma(\tau^+\nu_\tau)/\Gamma_{\text{total}}$ — Γ_8/Γ

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.064 ±0.015 OUR AVERAGE					
0.0579±0.0077±0.0184	881	[13] HEISTER	02I	ALEP	Z decays
0.070 ±0.021 ±0.020	22	[14] ABBIENDI	01L	OPAL	$D_s^{*+} \to \gamma D_s^+$ from Z's
0.074 ±0.028 ±0.024	16	[15] ACCIARRI	97F	L3	$D_s^{*+} \to \gamma D_s^+$ from Z's

[13] HEISTER 02I combines its $D_s^+ \to \tau^+\nu_\tau$ and $\mu^+\nu_\mu$ branching fractions to get $f_{D_s} = (285 \pm 19 \pm 40)$ MeV.

[14] This ABBIENDI 01L value gives a decay constant f_{D_s} of $(286 \pm 44 \pm 41)$ MeV.

[15] The second ACCIARRI 97F error here combines in quadrature systematic (0.016) and normalization (0.018) errors. The branching fraction gives $f_{D_s} = (309 \pm 58 \pm 33 \pm 38)$ MeV.

$\Gamma(\phi\ell^+\nu_\ell)/\Gamma(\phi\pi^+)$ — Γ_9/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. See the end of the D_s^+ Listings for measurements of $D_s^+ \to \phi\ell^+\nu_\ell$ form-factor ratios.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.55 ±0.04 OUR FIT					
0.54 ±0.04 OUR AVERAGE					
0.540±0.033±0.048	793	[16] LINK	02J	FOCS	γ nucleus, ≈ 180 GeV
0.54 ±0.05 ±0.04	367	[17] BUTLER	94	CLE2	$e^+e^- \approx \Upsilon(4S)$
0.58 ±0.17 ±0.07	97	[18] FRABETTI	93G	E687	γBe $\overline{E}_\gamma = 220$ GeV
0.57 ±0.15 ±0.15	104	[19] ALBRECHT	91	ARG	$e^+e^- \approx 10.4$ GeV
0.49 ±0.10 $^{+0.10}_{-0.14}$	54	[20] ALEXANDER	90B	CLEO	e^+e^- 10.5–11 GeV

[16] LINK 02J measures the $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratio.
[17] 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.
[18] FRABETTI 93G measures the $\Gamma(\phi\mu^+\nu_\mu)/\Gamma(\phi\pi^+)$ ratio.
[19] ALBRECHT 91 measures the $\Gamma(\phi e^+\nu_e)/\Gamma(\phi\pi^+)$ ratio.
[20] 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.

$\Gamma(\eta\ell^+\nu_\ell)/\Gamma(\phi\ell^+\nu_\ell)$ — Γ_{11}/Γ_9

Unseen decay modes of the η and the ϕ are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.27±0.19 OUR FIT				
1.24±0.12±0.15	440	[21] BRANDENB... 95	CLE2	$e^+e^- \approx \Upsilon(4S)$

[21] BRANDENBURG 95 uses both e^+ and μ^+ events and makes a phase-space adjustment to use the μ^+ events as e^+ events.

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

Unseen decay modes of the resonances are included.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.44±0.13 OUR FIT					
0.43±0.11±0.07		29	[22] BRANDENB... 95	CLE2	$e^+e^- \approx \Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.6	90		[23] KODAMA 93B	E653	π^- emulsion 600 GeV

[22] BRANDENBURG 95 uses both e^+ and μ^+ events and makes a phase-space adjustment to use the μ^+ events as e^+ events.
[23] KODAMA 93B uses μ^+ events.

$\left[\Gamma(\eta\ell^+\nu_\ell)+\Gamma(\eta'(958)\ell^+\nu_\ell)\right]/\Gamma(\phi\ell^+\nu_\ell)$ — $\Gamma_{10}/\Gamma_9 = (\Gamma_{11}+\Gamma_{12})/\Gamma_9$

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
1.72±0.23 OUR FIT				
3.9 ±1.6	13	[24] KODAMA 93	E653	π^- emulsion 600 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.67±0.17±0.17		[25] BRANDENB... 95	CLE2	$e^+e^- \approx \Upsilon(4S)$

[24] KODAMA 93 uses μ^+ events.
[25] This BRANDENBURG 95 data is redundant with data in previous blocks.

Hadronic modes with a $K\overline{K}$ pair.

$\Gamma(K^+\overline{K}^0)/\Gamma(\phi\pi^+)$ — 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

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

We now have model-independent measurements of this branching fraction, and so we no longer use the earlier, model-dependent results.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.036 ±0.009 OUR FIT						
0.036 ±0.009 OUR AVERAGE						
0.0359±0.0077±0.0048			[26] ARTUSO	96	CLE2	e^+e^- at $\Upsilon(4S)$
0.039 $^{+0.051}_{-0.019}$ $^{+0.018}_{-0.011}$			[27] BAI	95C	BES	e^+e^- 4.03 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.051 ±0.004 ±0.008			[28] BUTLER	94	CLE2	$e^+e^- \approx \Upsilon(4S)$
<0.048	90		MUHEIM	94		
0.046 ±0.015			[29] MUHEIM	94		
0.031 ±0.009			[29] MUHEIM	94		
0.031 ±0.009 ±0.006			[28] FRABETTI	93G	E687	γ Be $\overline{E}_\gamma$= 220 GeV
0.024 ±0.010			[28] ALBRECHT	91	ARG	$e^+e^- \approx$ 10.4 GeV
<0.041	90	0	[27] ADLER	90B	MRK3	e^+e^- 4.14 GeV
0.031 ±0.006 $^{+0.011}_{-0.009}$			[28] ALEXANDER	90B	CLEO	e^+e^- 10.5–11 GeV
0.048 ±0.017 ±0.019			[30] ALVAREZ	90C	NA14	Photoproduction
>0.034	90		[28] ANJOS	90B	E691	γ Be, $\overline{E}_\gamma \approx$ 145 GeV
0.02 ±0.01		405	[31] CHEN	89	CLEO	e^+e^- 10 GeV
0.033 ±0.016 ±0.010		9	[31] BRAUNSCH...	87	TASS	e^+e^- 35–44 GeV
0.033 ±0.011		30	[31] DERRICK	85B	HRS	e^+e^- 29 GeV

[26] ARTUSO 96 uses partially reconstructed $\overline{B}^0 \rightarrow D^{*+}D_s^{*-}$ decays to get a model-independent value for $\Gamma(D_s^- \rightarrow \phi\pi^-)/\Gamma(D^0 \rightarrow K^-\pi^+)$ of 0.92 ± 0.20 ± 0.11.

[27] BAI 95C uses $e^+e^- \rightarrow D_s^+D_s^-$ events in which one or both of the $D_s^\pm$ are observed to obtain the first model-independent measurement of the $D_s^+ \rightarrow \phi\pi^+$ branching fraction, without assumptions about $\sigma(D_s^\pm)$. However, with only two "doubly-tagged" events, the statistical error is very large. ADLER 90B used the same method to set a limit.

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

[29] 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 $\Gamma(D_s^+ \rightarrow \mu^+\nu_\mu)/\Gamma(D_s^+ \rightarrow \phi\ell^+\nu_\ell)$. A third calculation using the semileptonic width of $D_s^+ \rightarrow \phi\ell^+\nu_\ell$ is not independent of other results listed here. Note also the upper limit, based on the sum of established D_s^+ branching ratios.

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

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

$\Gamma(\phi\pi^+)/\Gamma(K^+K^-\pi^+)$ — Γ_{15}/Γ_{14}

Unseen decay modes of the ϕ are included.

VALUE	DOCUMENT ID		TECN	COMMENT
0.81 ±0.08 OUR FIT				
0.807±0.067±0.096	FRABETTI	95B	E687	Dalitz plot analysis

$\Gamma(K^+\overline{K}^*(892)^0)/\Gamma(K^+K^-\pi^+)$ — Γ_{16}/Γ_{14}

Unseen decay modes of the $\overline{K}^*(892)^0$ are included.

VALUE	DOCUMENT ID		TECN	COMMENT
0.75 ±0.07 OUR FIT				
0.717±0.069±0.060	FRABETTI	95B	E687	Dalitz plot analysis

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

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.92±0.09 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

$\Gamma(f_0(980)\pi^+ \times B(f_0 \to K^+K^-))/\Gamma(K^+K^-\pi^+)$ — Γ_{17}/Γ_{14}

This includes only the K^+K^- decays of the $f_0(980)$, because branching fractions of this resonance are not known.

VALUE	DOCUMENT ID		TECN	COMMENT
0.11±0.035±0.026	FRABETTI	95B	E687	Dalitz plot analysis

$\Gamma(f_0(1710)\pi^+ \times B(f_0 \to K^+K^-))/\Gamma(K^+K^-\pi^+)$ — Γ_{19}/Γ_{14}

This includes only K^+K^- decays of the $f_0(1710)$, because branching fractions of this resonance are not known.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.034±0.023±0.035	[32] FRABETTI	95B	E687	Dalitz plot analysis

[32] In other words, FRABETTI 95B doesn't see this resonance.

$\Gamma(K^+\overline{K}^*_0(1430)^0)/\Gamma(K^+K^-\pi^+)$ — Γ_{18}/Γ_{14}

Unseen decay modes of the $\overline{K}^*_0(1430)^0$ are included.

VALUE	DOCUMENT ID		TECN	COMMENT
0.150±0.052±0.052	FRABETTI	95B	E687	Dalitz plot analysis

$\Gamma(K^+K^-\pi^+\text{nonresonant})/\Gamma(\phi\pi^+)$ — Γ_{20}/Γ_{15}

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

$\Gamma(K^*(892)^+\overline{K}^0)/\Gamma(\phi\pi^+)$ — Γ_{22}/Γ_{15}

Unseen decay modes of the resonances are included.

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_{22}/Γ_{13}

Unseen decay modes of the $K^*(892)^+$ are included.

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

$\Gamma(\phi\pi^+\pi^0)/\Gamma(\phi\pi^+)$ — Γ_{24}/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_{25}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{1.86\pm0.26^{+0.29}_{-0.40}}$	253	AVERY	92	CLE2	$e^+e^- \simeq$ 10.5 GeV

$\Gamma(\phi\pi^+\pi^0$ 3-body$)/\Gamma(\phi\pi^+)$ — Γ_{26}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.71	90	DAOUDI	92	CLE2	$e^+e^- \approx$ 10.5 GeV

$\Gamma(K^+K^-\pi^+\pi^0$ non-$\phi)/\Gamma(\phi\pi^+)$ — Γ_{27}/Γ_{15}

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

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.77	90	ALBRECHT	92B	ARG	$e^+e^- \simeq$ 10.4 GeV

$\Gamma(K^+\overline{K}^0\pi^+\pi^-)/\Gamma(K^0K^-\pi^+\pi^+)$ — Γ_{28}/Γ_{29}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.586±0.052±0.043	476	LINK	01C	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV

$\Gamma(K^0K^-\pi^+\pi^+)/\Gamma(\phi\pi^+)$ — Γ_{29}/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_{30}/Γ_{15}

Unseen decay modes of the resonances are included.

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

$\Gamma(K^0K^-\pi^+\pi^+($non-$K^{*+}\overline{K}^{*0}))/\Gamma(\phi\pi^+)$ — Γ_{31}/Γ_{15}

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

$\Gamma(K^+K^-\pi^+\pi^+\pi^-)/\Gamma(K^+K^-\pi^+)$ — Γ_{32}/Γ_{14}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.160±0.027 OUR AVERAGE					
0.150±0.019±0.025	240	LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
0.188±0.036±0.040	75	FRABETTI	97C	E687	γBe, $\overline{E}_\gamma \approx$ 200 GeV

$\Gamma(\phi\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ — Γ_{33}/Γ_{15}

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.269±0.027 OUR AVERAGE						
0.249±0.024±0.021		136	LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
0.28 ±0.06 ±0.01		40	FRABETTI	97C	E687	γBe, $\overline{E}_\gamma \approx$ 200 GeV
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

$\Gamma(\phi\pi^+\pi^+\pi^-)/\Gamma(K^+K^-\pi^+\pi^+\pi^-)$ — Γ_{33}/Γ_{32}

Unseen decay modes of the ϕ are included.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.42±0.10±0.12	136	[33] LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV

[33] This LINK 03D result is redundant with its $\Gamma(\phi\pi^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ result above.

$\Gamma(K^+K^-\rho^0\pi^+\text{ non-}\phi)/\Gamma(K^+K^-\pi^+\pi^+\pi^-)$ — Γ_{34}/Γ_{32}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.03	90	LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV

$\Gamma(\phi\rho^0\pi^+)/\Gamma(K^+K^-\pi^+\pi^+\pi^-)$ — Γ_{35}/Γ_{32}

Unseen decay modes of the ϕ are included.

VALUE	DOCUMENT ID		TECN	COMMENT
1.50±0.12±0.08	LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV

$\Gamma(\phi a_1(1260)^+)/\Gamma(K^+K^-\pi^+)$ — Γ_{36}/Γ_{14}

Unseen decay modes of the ϕ and $a_1(1260)^+$ are included.

VALUE	DOCUMENT ID		TECN	COMMENT
0.559±0.078±0.044	LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV

$\Gamma(K^+K^-\pi^+\pi^+\pi^-\text{ nonresonant})/\Gamma(K^+K^-\pi^+\pi^+\pi^-)$ — Γ_{37}/Γ_{32}

VALUE	DOCUMENT ID		TECN	COMMENT
0.10±0.06±0.05	LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV

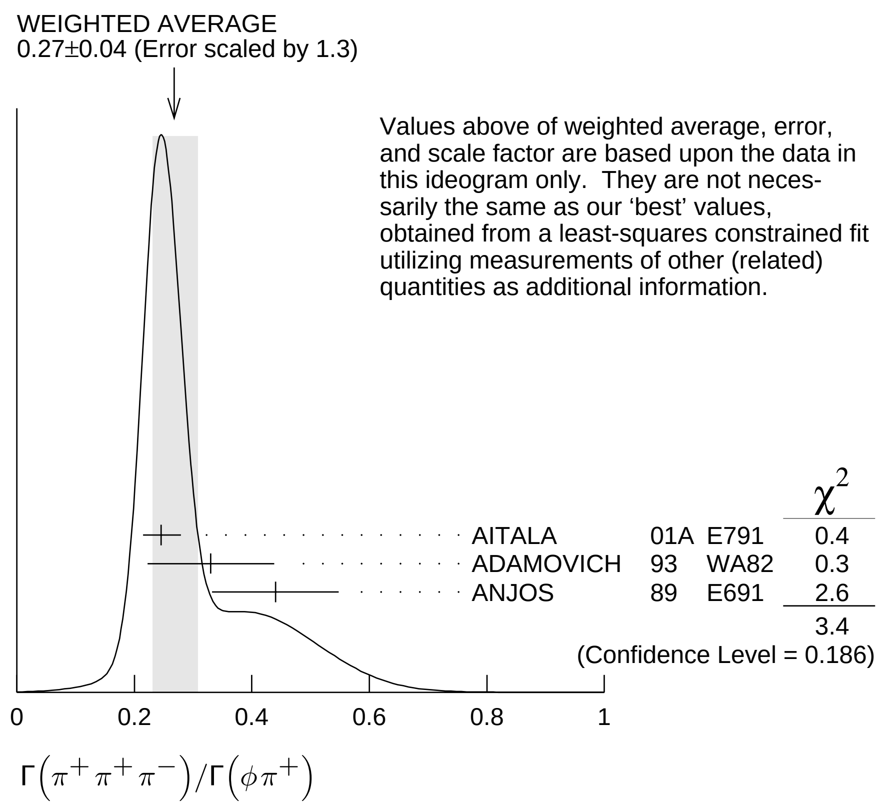
Pionic modes

$\Gamma(\pi^+\pi^+\pi^-)/\Gamma(K^+K^-\pi^+)$ — Γ_{38}/Γ_{14}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.227±0.033 OUR FIT Error includes scale factor of 1.1.					
0.265±0.041±0.031	98	FRABETTI	97D	E687	γ Be ≈ 200 GeV

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.28 ±0.04 OUR FIT Error includes scale factor of 1.3.					
0.27 ±0.04 OUR AVERAGE Error includes scale factor of 1.3. See the ideogram below.					
$0.245\pm0.028^{+0.019}_{-0.012}$	848	AITALA	01A	E791	π^- nucleus, 500 GeV
0.33 ±0.10 ±0.04	29	ADAMOVICH	93	WA82	π^- 340 GeV
0.44 ±0.10 ±0.04	68	ANJOS	89	E691	Photoproduction



$\Gamma(\rho^0\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$ — Γ_{39}/Γ_{38}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.073	90	FRABETTI	97D	E687	γ Be ≈ 200 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.058±0.023±0.037		[34] AITALA	01A	E791	π^- nucleus, 500 GeV

[34] This AITALA 01A result does not have enough statistical significance to prefer it to the FRABETTI 97D limit.

$\Gamma(\rho^0\pi^+)/\Gamma(\phi\pi^+)$ Γ_{39}/Γ_{15}

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

$\Gamma(f_0(980)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ Γ_{40}/Γ_{38}

This includes only the $\pi^+\pi^-$ decays of the $f_0(980)$, because branching fractions of this resonance are not known. In general, we favor the results of AITALA 01A over those of FRABETTI 97D (848 ± 44 events versus 98 ± 12). It makes no sense to average them.

VALUE	DOCUMENT ID		TECN	COMMENT
0.565±0.043±0.047	AITALA	01A	E791	π^- nucleus, 500 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.074±0.140±0.043	FRABETTI	97D	E687	γ Be ≈ 200 GeV

$\Gamma(f_0(980)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\phi\pi^+)$ Γ_{40}/Γ_{15}

This includes only the $\pi^+\pi^-$ decays of the $f_0(980)$, because branching fractions of this resonance are not known.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.28±0.10±0.03	ANJOS	89	E691	Photoproduction

$\Gamma(f_2(1270)\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$ Γ_{41}/Γ_{38}

Unseen decay modes of the $f_2(1270)$ are included. In general, we favor the results of AITALA 01A over those of FRABETTI 97D (848 ± 44 events versus 98 ± 12). It makes no sense to average them.

VALUE	DOCUMENT ID		TECN	COMMENT
0.349±0.059±0.011	[35] AITALA	01A	E791	π^- nucleus, 500 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.22 ±0.10 ±0.03	FRABETTI	97D	E687	γ Be ≈ 200 GeV

[35] See AITALA 01A for the magnitude and phase of this amplitude relative to the $f_0(980)\pi^+$ amplitude.

$\Gamma(f_0(1370)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ Γ_{42}/Γ_{38}

This includes only the $\pi^+\pi^-$ decays of the $f_0(1370)$, because branching fractions of this resonance are not known.

VALUE	DOCUMENT ID		TECN	COMMENT
0.324±0.077±0.017	[36] AITALA	01A	E791	π^- nucleus, 500 GeV

[36] See AITALA 01A for the magnitude and phase of this amplitude relative to the $f_0(980)\pi^+$ amplitude.

$\Gamma(\rho(1450)^0\pi^+ \times B(\rho^0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ Γ_{43}/Γ_{38}

This includes only the $\pi^+\pi^-$ decays of the $\rho(1450)^0$, because branching fractions of this resonance are not known.

VALUE	DOCUMENT ID		TECN	COMMENT
0.044±0.021±0.002	[37] AITALA	01A	E791	π^- nucleus, 500 GeV

[37] See AITALA 01A for the magnitude and phase of this amplitude relative to the $f_0(980)\pi^+$ amplitude.

$\Gamma(f_0(1500)\pi^+ \times B(f_0 \to \pi^+\pi^-))/\Gamma(\pi^+\pi^+\pi^-)$ — Γ_{44}/Γ_{38}

This includes only $\pi^+\pi^-$ decays of the $f_0(1500)$, because branching fractions of this resonance are not known. In general, we favor the results of AITALA 01A over those of FRABETTI 97D (848 ± 44 events versus 98 ± 12).

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.274±0.114±0.019	[38] FRABETTI	97D	E687	γ Be ≈ 200 GeV

[38] FRABETTI 97D calls this mode $S(1475)\pi^+$, but finds the mass and width of this $S(1475)$ to be in excellent agreement with those of the $f_0(1500)$.

$\Gamma(\pi^+\pi^+\pi^-$ nonresonant$)/\Gamma(\pi^+\pi^+\pi^-)$ — Γ_{45}/Γ_{38}

In general, we favor the results of AITALA 01A over those of FRABETTI 97D (848 ± 44 events versus 98 ± 12).

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
0.005±0.014±0.017		AITALA	01A	E791	π^- nucleus, 500 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.269	90	[39] FRABETTI	97D	E687	γ Be ≈ 200 GeV

[39] See FRABETTI 97D on the difficulty of disentangling the $f_0(1500)\pi^+$ and nonresonant modes.

$\Gamma(\pi^+\pi^+\pi^-$ nonresonant$)/\Gamma(\phi\pi^+)$ — Γ_{45}/Γ_{15}

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.29±0.09±0.03	ANJOS	89	E691	Photoproduction

$\Gamma(\pi^+\pi^+\pi^-\pi^0)/\Gamma(\phi\pi^+)$ — Γ_{46}/Γ_{15}

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

$\Gamma(\eta\pi^+)/\Gamma(\phi\pi^+)$ — Γ_{47}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
0.48±0.03±0.04		920	JESSOP	98	CLE2	$e^+e^- \approx \Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
0.54±0.09±0.06		165	ALEXANDER	92	CLE2	See JESSOP 98
<1.5	90		ANJOS	89E	E691	Photoproduction

$\Gamma(\omega\pi^+)/\Gamma(\phi\pi^+)$ — Γ_{48}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.5	90	ANJOS	89E	E691	Photoproduction

$\Gamma(\omega\pi^+)/\Gamma(\eta\pi^+)$ — Γ_{48}/Γ_{47}

VALUE	DOCUMENT ID		TECN	COMMENT
0.16±0.04±0.03	BALEST	97	CLE2	$e^+e^- \approx \Upsilon(4S)$

$\Gamma(3\pi^+2\pi^-)/\Gamma(K^+K^-\pi^+)$ — Γ_{49}/Γ_{14}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.146±0.014 OUR AVERAGE					
0.145±0.011±0.010	671	LINK	03D	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
0.158±0.042±0.031	37	FRABETTI	97C	E687	γBe, $\overline{E}_\gamma \approx$ 200 GeV

$\Gamma(3\pi^+2\pi^-)/\Gamma(\phi\pi^+)$ — Γ_{49}/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_{51}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
2.98±0.20±0.39	447	JESSOP	98	CLE2	$e^+e^- \approx \Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$2.86\pm0.38^{+0.36}_{-0.38}$	217	AVERY	92	CLE2	See JESSOP 98

$\Gamma(\eta\pi^+\pi^0\text{ 3-body})/\Gamma(\phi\pi^+)$ — Γ_{52}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.1	90	JESSOP	98	CLE2	$e^+e^- \approx \Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.82	90	[40] DAOUDI	92	CLE2	See JESSOP 98

[40] We use the JESSOP 98 limit, even though the DAOUDI 92 limit, from the same experiment but with a much smaller data sample, is more restrictive.

$\Gamma(3\pi^+2\pi^-\pi^0)/\Gamma_{total}$ — Γ_{53}/Γ

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

$\Gamma(\eta'(958)\pi^+)/\Gamma(\phi\pi^+)$ — Γ_{54}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
1.08±0.09 OUR AVERAGE						
1.03±0.06±0.07		537	JESSOP	98	CLE2	$e^+e^- \approx \Upsilon(4S)$
$2.5\pm1.0^{+1.5}_{-0.4}$		22	ALVAREZ	91	NA14	Photoproduction
2.5 ±0.5 ±0.3		215	ALBRECHT	90D	ARG	$e^+e^- \approx$ 10.4 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
1.20±0.15±0.11		281	ALEXANDER	92	CLE2	See JESSOP 98
<1.3	90		ANJOS	91B	E691	γBe, $\overline{E}_\gamma \approx$ 145 GeV

$\Gamma(\eta'(958)\rho^+)/\Gamma(\phi\pi^+)$ — Γ_{56}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
2.78±0.28±0.30	137	JESSOP	98	CLE2	$e^+e^- \approx \Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$3.44\pm0.62^{+0.44}_{-0.46}$	68	AVERY	92	CLE2	See JESSOP 98

$\Gamma(\eta'(958)\pi^+\pi^0\,\text{3-body})/\Gamma(\phi\pi^+)$ — Γ_{57}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.4	90	JESSOP	98	CLE2	$e^+e^- \approx \Upsilon(4S)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.85	90	DAOUDI	92	CLE2	See JESSOP 98

Modes with one or three K's

$\Gamma(K^0\pi^+)/\Gamma(\phi\pi^+)$ — Γ_{58}/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_{58}/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	γ Be $\overline{E}_\gamma \approx$ 200 GeV

$\Gamma(K^+\pi^+\pi^-)/\Gamma(\phi\pi^+)$ — Γ_{59}/Γ_{15}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.28±0.06±0.05	85	FRABETTI	95E	E687	γ Be, $\overline{E}_\gamma$= 220 GeV

$\Gamma(K^+\rho^0)/\Gamma(\phi\pi^+)$ — Γ_{60}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.08	90	FRABETTI	95E	E687	γ Be, $\overline{E}_\gamma$= 220 GeV

$\Gamma(K^*(892)^0\pi^+)/\Gamma(\phi\pi^+)$ — Γ_{61}/Γ_{15}

Unseen decay modes of the resonances are included.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.18±0.05±0.04	25	FRABETTI	95E	E687	γ Be, $\overline{E}_\gamma$= 220 GeV

$\Gamma(K^+K^+K^-)/\Gamma(K^+K^-\pi^+)$ — Γ_{62}/Γ_{14}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{0.00895\pm0.00212^{+0.00224}_{-0.00231}}$	31	LINK	02I	FOCS	γ nucleus, $\approx$ 180 GeV

$\Gamma(K^+K^+K^-)/\Gamma(\phi\pi^+)$ — Γ_{62}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.016	90	FRABETTI	95F	E687	γ Be, $\overline{E}_\gamma \approx$ 220 GeV

$\Gamma(\phi K^+)/\Gamma(\phi \pi^+)$ — Γ_{63}/Γ_{15}

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<0.013	90	FRABETTI	95F	E687	γ Be, $\overline{E}_\gamma \approx$ 220 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.071	90	ANJOS	92D	E691	γ Be, $\overline{E}_\gamma$ = 145 GeV

Rare or forbidden modes

$\Gamma(\pi^+ e^+ e^-)/\Gamma_{total}$ — Γ_{64}/Γ

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<2.7 × 10^{-4}	90	AITALA	99G	E791	π^- N 500 GeV

$\Gamma(\pi^+ \mu^+ \mu^-)/\Gamma_{total}$ — Γ_{65}/Γ

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

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<2.6 × 10^{-5}	90		LINK	03F	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.4 × 10^{-4}	90		AITALA	99G	E791	π^- N 500 GeV
<4.3 × 10^{-4}	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(K^+ e^+ e^-)/\Gamma_{total}$ — Γ_{66}/Γ

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.6 × 10^{-3}	90	AITALA	99G	E791	π^- N 500 GeV

$\Gamma(K^+ \mu^+ \mu^-)/\Gamma_{total}$ — Γ_{67}/Γ

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

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<3.6 × 10^{-5}	90		LINK	03F	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<1.4 × 10^{-4}	90		AITALA	99G	E791	π^- N 500 GeV
<5.9 × 10^{-4}	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(K^*(892)^+ \mu^+ \mu^-)/\Gamma_{total}$ — Γ_{68}/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 × 10^{-3}	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(\pi^+ e^\pm \mu^\mp)/\Gamma_{total}$ — Γ_{69}/Γ

A test of lepton-family-number conservation.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<6.1 × 10^{-4}	90	AITALA	99G	E791	π^- N 500 GeV

$\Gamma(K^+ e^\pm \mu^\mp)/\Gamma_{total}$ **Γ_{70}/Γ**

A test of lepton-family-number conservation.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6.3 \times 10^{-4}$	90	AITALA	99G	E791	$\pi^- N$ 500 GeV

$\Gamma(\pi^- e^+ e^+)/\Gamma_{total}$ **Γ_{71}/Γ**

A test of lepton-number conservation.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6.9 \times 10^{-4}$	90	AITALA	99G	E791	$\pi^- N$ 500 GeV

$\Gamma(\pi^- \mu^+ \mu^+)/\Gamma_{total}$ **Γ_{72}/Γ**

A test of lepton-number conservation.

VALUE	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<2.9 \times 10^{-5}$	90		LINK	03F	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<8.2 \times 10^{-5}$	90		AITALA	99G	E791	$\pi^- N$ 500 GeV
$<4.3 \times 10^{-4}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(\pi^- e^+ \mu^+)/\Gamma_{total}$ **Γ_{73}/Γ**

A test of lepton-number conservation.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<7.3 \times 10^{-4}$	90	AITALA	99G	E791	$\pi^- N$ 500 GeV

$\Gamma(K^- e^+ e^+)/\Gamma_{total}$ **Γ_{74}/Γ**

A test of lepton-number conservation.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6.3 \times 10^{-4}$	90	AITALA	99G	E791	$\pi^- N$ 500 GeV

$\Gamma(K^- \mu^+ \mu^+)/\Gamma_{total}$ **Γ_{75}/Γ**

A test of lepton-number conservation.

VALUE	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<1.3 \times 10^{-5}$	90		LINK	03F	FOCS	γ nucleus, $\overline{E}_\gamma \approx$ 180 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$<1.8 \times 10^{-4}$	90		AITALA	99G	E791	$\pi^- N$ 500 GeV
$<5.9 \times 10^{-4}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$\Gamma(K^- e^+ \mu^+)/\Gamma_{total}$ **Γ_{76}/Γ**

A test of lepton-number conservation.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6.8 \times 10^{-4}$	90	AITALA	99G	E791	$\pi^- N$ 500 GeV

$\Gamma(K^*(892)^- \mu^+ \mu^+)/\Gamma_{total}$ **Γ_{77}/Γ**

A test of lepton-number conservation.

VALUE	*CL%*	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<1.4 \times 10^{-3}$	90	0	KODAMA	95	E653	π^- emulsion 600 GeV

$D_s^+ \rightarrow \phi \ell^+ \nu_\ell$ FORM FACTORS

$r_2 \equiv A_2(0)/A_1(0)$ in $D_s^+ \rightarrow \phi \ell^+ \nu_\ell$

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
1.60±0.24 OUR AVERAGE					
1.57±0.25±0.19	271	AITALA	99D	E791	$\phi e^+ \nu_e$, $\phi \mu^+ \nu_\mu$
1.4 ±0.5 ±0.3	308	AVERY	94B	CLE2	$\phi e^+ \nu_e$
1.1 ±0.8 ±0.1	90	FRABETTI	94F	E687	$\phi \mu^+ \nu_\mu$
2.1 $^{+0.6}_{-0.5}$ ±0.2	19	KODAMA	93	E653	$\phi \mu^+ \nu_\mu$

$r_v \equiv V(0)/A_1(0)$ in $D_s^+ \rightarrow \phi \ell^+ \nu_\ell$

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
1.92±0.32 OUR AVERAGE					
2.27±0.35±0.22	271	AITALA	99D	E791	$\phi e^+ \nu_e$, $\phi \mu^+ \nu_\mu$
0.9 ±0.6 ±0.3	308	AVERY	94B	CLE2	$\phi e^+ \nu_e$
1.8 ±0.9 ±0.2	90	FRABETTI	94F	E687	$\phi \mu^+ \nu_\mu$
2.3 $^{+1.1}_{-0.9}$ ±0.4	19	KODAMA	93	E653	$\phi \mu^+ \nu_\mu$

Γ_L/Γ_T in $D_s^+ \rightarrow \phi \ell^+ \nu_\ell$

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.72±0.18 OUR AVERAGE					
1.0 ±0.3 ±0.2	308	AVERY	94B	CLE2	$\phi e^+ \nu_e$
1.0 ±0.5 ±0.1	90	[41] FRABETTI	94F	E687	$\phi \mu^+ \nu_\mu$
0.54±0.21±0.10	19	[41] KODAMA	93	E653	$\phi \mu^+ \nu_\mu$

[41] FRABETTI 94F and KODAMA 93 evaluate Γ_L/Γ_T for a lepton mass of zero.

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