

$$I(J^P) = \frac{1}{2}(0^-)$$

## $D^\pm$ MASS

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

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1869.3 ± 0.4 OUR FIT</b>		Error includes scale factor of 1.1.		
<b>1869.4 ± 0.5 OUR AVERAGE</b>				
1870.0 ± 0.5 ± 1.0	317	BARLAG	90C ACCM	$\pi^-$ Cu 230 GeV
1863 ± 4		DERRICK	84 HRS	$e^+ e^-$ 29 GeV
1869.4 ± 0.6		<sup>1</sup> TRILLING	81 RVUE	$e^+ e^-$ 3.77 GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1875 ± 10	9	ADAMOVICH	87 EMUL	Photoproduction
1860 ± 16	6	ADAMOVICH	84 EMUL	Photoproduction
1868.4 ± 0.5		<sup>1</sup> SCHINDLER	81 MRK2	$e^+ e^-$ 3.77 GeV
1874 ± 5		GOLDHABER	77 MRK1	$D^0$ , $D^+$ recoil spectra
1868.3 ± 0.9		<sup>1</sup> PERUZZI	77 MRK1	$e^+ e^-$ 3.77 GeV
1874 ± 11		PICCOLO	77 MRK1	$e^+ e^-$ 4.03, 4.41 GeV
1876 ± 15	50	PERUZZI	76 MRK1	$K^\mp \pi^\pm \pi^\pm$

<sup>1</sup> PERUZZI 77 and SCHINDLER 81 errors do not include the 0.13% uncertainty in the absolute SPEAR energy calibration. TRILLING 81 uses the high precision  $J/\psi(1S)$  and  $\psi(2S)$  measurements of ZHOLENTZ 80 to determine this uncertainty and combines the PERUZZI 77 and SCHINDLER 81 results to obtain the value quoted.

## $D^\pm$ MEAN LIFE

Measurements with an error  $> 100 \times 10^{-15}$  s have been omitted from the Listings.

VALUE ( $10^{-15}$ s)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1040 ± 7 OUR AVERAGE</b>				
1039.4 ± 4.3 ± 7.0	110k	LINK	02F FOCS	$\gamma$ nucleus, $\approx$ 180 GeV
1033.6 ± 22.1 <sup>+9.9</sup> <sub>-12.7</sub>	3777	BONVICINI	99 CLE2	$e^+ e^- \approx \Upsilon(4S)$
1048 ± 15 ± 11	9k	FRABETTI	94D E687	$D^+ \rightarrow K^- \pi^+ \pi^+$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1075 ± 40 ± 18	2455	FRABETTI	91 E687	$\gamma$ Be, $D^+ \rightarrow K^- \pi^+ \pi^+$
1030 ± 80 ± 60	200	ALVAREZ	90 NA14	$\gamma$ , $D^+ \rightarrow K^- \pi^+ \pi^+$
1050 <sup>+77</sup> <sub>-72</sub>	317	<sup>2</sup> BARLAG	90C ACCM	$\pi^-$ Cu 230 GeV
1050 ± 80 ± 70	363	ALBRECHT	88i ARG	$e^+ e^-$ 10 GeV
1090 ± 30 ± 25	2992	RAAB	88 E691	Photoproduction

<sup>2</sup> BARLAG 90C estimates the systematic error to be negligible.

## $D^+$ DECAY MODES

Most decay modes (other than the semileptonic modes) that involve a neutral  $K$  meson are now given as  $K_S^0$  modes, not as  $\bar{K}^0$  modes. Nearly always it is a  $K_S^0$  that is measured, and interference between Cabibbo-allowed and doubly Cabibbo-suppressed modes can invalidate the assumption that  $2\Gamma(K_S^0) = \Gamma(\bar{K}^0)$ .

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level
<b>Inclusive modes</b>		
$\Gamma_1$ $e^+$ anything	$(17.2 \pm 1.9) \%$	
$\Gamma_2$ $K^-$ anything	$(27.5 \pm 2.4) \%$	
$\Gamma_3$ $\bar{K}^0$ anything + $K^0$ anything	$(61 \pm 8) \%$	
$\Gamma_4$ $K^+$ anything	$(5.5 \pm 1.6) \%$	
$\Gamma_5$ $\bar{K}^*(892)^0$ anything	$(23 \pm 5) \%$	
$\Gamma_6$ $K^*(892)^0$ anything	$< 6.6$	% CL=90%
$\Gamma_7$ $\eta$ anything	[a] $< 13$	% CL=90%
$\Gamma_8$ $\phi$ anything	$< 1.8$	% CL=90%
$\Gamma_9$ $\phi e^+$ anything	$< 1.6$	% CL=90%
$\Gamma_{10}$ $\mu^+$ anything		
<b>Leptonic and semileptonic modes</b>		
$\Gamma_{11}$ $e^+ \nu_e$	$< 2.4 \times 10^{-5}$	CL=90%
$\Gamma_{12}$ $\mu^+ \nu_\mu$	$(4.4 \pm 0.7) \times 10^{-4}$	
$\Gamma_{13}$ $\bar{K}^0 \ell^+ \nu_\ell$	[b]	
$\Gamma_{14}$ $\bar{K}^0 e^+ \nu_e$	$(8.6 \pm 0.5) \%$	
$\Gamma_{15}$ $\bar{K}^0 \mu^+ \nu_\mu$	$(9.5 \pm 0.8) \%$	
$\Gamma_{16}$ $K^- \pi^+ e^+ \nu_e$	$(4.5 \pm_{-0.8}^{+1.0}) \%$	S=1.1
$\Gamma_{17}$ $\bar{K}^*(892)^0 e^+ \nu_e$ , $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$(3.74 \pm 0.21) \%$	
$\Gamma_{18}$ $K^- \pi^+ e^+ \nu_e$ nonresonant	$< 7 \times 10^{-3}$	CL=90%
$\Gamma_{19}$ $K^- \pi^+ \mu^+ \nu_\mu$	$(4.0 \pm 0.5) \%$	
$\Gamma_{20}$ $\bar{K}^*(892)^0 \mu^+ \nu_\mu$ , $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$(3.7 \pm 0.3) \%$	
$\Gamma_{21}$ $K^- \pi^+ \mu^+ \nu_\mu$ nonresonant	$(2.1 \pm 0.6) \times 10^{-3}$	
$\Gamma_{22}$ $(\bar{K}^*(892)\pi)^0 e^+ \nu_e$	$< 1.2$	% CL=90%
$\Gamma_{23}$ $(\bar{K}\pi\pi)^0 e^+ \nu_e$ non- $\bar{K}^*(892)$	$< 9 \times 10^{-3}$	CL=90%
$\Gamma_{24}$ $K^- \pi^+ \pi^0 \mu^+ \nu_\mu$	$< 1.7 \times 10^{-3}$	CL=90%
$\Gamma_{25}$ $\pi^0 e^+ \nu_e$	$(4.4 \pm 0.7) \times 10^{-3}$	
$\Gamma_{26}$ $\pi^0 \ell^+ \nu_\ell$	[b]	

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\Gamma_{27}$	$\bar{K}^*(892)^0 e^+ \nu_e$	( 5.61 ± 0.31 ) %	S=1.1
$\Gamma_{28}$	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$	( 5.5 ± 0.5 ) %	S=1.1
$\Gamma_{29}$	$\bar{K}_1(1270)^0 \mu^+ \nu_\mu$	< 4 %	CL=95%
$\Gamma_{30}$	$\bar{K}^*(1410)^0 \mu^+ \nu_\mu$		
$\Gamma_{31}$	$\bar{K}_0^*(1430)^0 \mu^+ \nu_\mu$	< 2.5 × 10 <sup>-4</sup>	
$\Gamma_{32}$	$\bar{K}_2^*(1430)^0 \mu^+ \nu_\mu$	< 1.1 %	CL=95%
$\Gamma_{33}$	$\bar{K}^*(1680)^0 \mu^+ \nu_\mu$	< 1.6 × 10 <sup>-3</sup>	
$\Gamma_{34}$	$\rho^0 e^+ \nu_e$	( 2.2 ± 0.4 ) × 10 <sup>-3</sup>	
$\Gamma_{35}$	$\rho^0 \mu^+ \nu_\mu$	( 3.4 ± 0.8 ) × 10 <sup>-3</sup>	
$\Gamma_{36}$	$\omega e^+ \nu_e$	( 1.6 <sup>+0.7</sup> <sub>-0.6</sub> ) × 10 <sup>-3</sup>	
$\Gamma_{37}$	$\phi e^+ \nu_e$	< 2.09 %	CL=90%
$\Gamma_{38}$	$\phi \mu^+ \nu_\mu$	< 3.72 %	CL=90%
$\Gamma_{39}$	$\eta \ell^+ \nu_\ell$	< 7 × 10 <sup>-3</sup>	CL=90%
$\Gamma_{40}$	$\eta'(958) \mu^+ \nu_\mu$	< 1.1 %	CL=90%

### Hadronic modes with a $\bar{K}$ or $\bar{K}K\bar{K}$

$\Gamma_{41}$	$K_S^0 \pi^+$	( 1.47 ± 0.06 ) %	S=1.1
$\Gamma_{42}$	$K^- \pi^+ \pi^+$	[c] ( 9.51 ± 0.34 ) %	S=1.1
$\Gamma_{43}$	$\bar{K}_0^*(800)^0 \pi^+, \bar{K}_0^*(800) \rightarrow$	[d]	
$\Gamma_{44}$	$K^- \pi^+$ $\bar{K}^*(892)^0 \pi^+,$ $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	[d] ( 1.33 ± 0.11 ) %	
$\Gamma_{45}$	$\bar{K}_0^*(1430)^0 \pi^+,$ $\bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$	[d] ( 2.41 ± 0.24 ) %	
$\Gamma_{46}$	$\bar{K}_2^*(1430)^0 \pi^+,$ $\bar{K}_2^*(1430)^0 \rightarrow K^- \pi^+$	[d]	
$\Gamma_{47}$	$\bar{K}^*(1680)^0 \pi^+,$ $\bar{K}^*(1680)^0 \rightarrow K^- \pi^+$	[d] ( 4.0 ± 0.8 ) × 10 <sup>-3</sup>	
$\Gamma_{48}$	$K^- \pi^+ \pi^+$ nonresonant	[d] ( 9.0 ± 0.7 ) %	
$\Gamma_{49}$	$K_S^0 \pi^+ \pi^0$	[c] ( 7.0 ± 0.5 ) %	S=1.2
$\Gamma_{50}$	$K_S^0 \rho^+$	( 4.8 ± 1.1 ) %	
$\Gamma_{51}$	$\bar{K}^*(892)^0 \pi^+,$ $\bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0$	( 1.3 ± 0.6 ) %	
$\Gamma_{52}$	$K_S^0 \pi^+ \pi^0$ nonresonant	( 9 ± 7 ) × 10 <sup>-3</sup>	
$\Gamma_{53}$	$K^- \pi^+ \pi^+ \pi^0$	[c] ( 6.00 ± 0.28 ) %	S=1.1
$\Gamma_{54}$	$\bar{K}^*(892)^0 \rho^+$ total, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	( 1.3 ± 0.8 ) %	
$\Gamma_{55}$	$\bar{K}_1(1400)^0 \pi^+,$ $\bar{K}_1(1400)^0 \rightarrow K^- \pi^+ \pi^0$	( 1.8 ± 0.7 ) %	
$\Gamma_{56}$	$K^- \rho^+ \pi^+$ total	( 2.6 ± 1.6 ) %	

$\Gamma_{57}$	$K^- \rho^+ \pi^+$ 3-body	$( 9 \pm 6 ) \times 10^{-3}$	
$\Gamma_{58}$	$\bar{K}^*(892)^0 \pi^+ \pi^0$ total, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$( 4.2 \pm 0.6 ) \%$	
$\Gamma_{59}$	$\bar{K}^*(892)^0 \pi^+ \pi^0$ 3-body, $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$( 2.7 \pm 0.8 ) \%$	
$\Gamma_{60}$	$K^*(892)^- \pi^+ \pi^+$ 3-body, $K^*(892)^- \rightarrow K^- \pi^0$	$( 6 \pm 3 ) \times 10^{-3}$	
$\Gamma_{61}$	$K^- \pi^+ \pi^+ \pi^0$ nonresonant	[e] $( 1.0 \pm 0.7 ) \%$	
$\Gamma_{62}$	$K_S^0 \pi^+ \pi^+ \pi^-$	[c] $( 3.11 \pm 0.21 ) \%$	S=1.1
$\Gamma_{63}$	$K_S^0 a_1(1260)^+$ , $a_1(1260)^+ \rightarrow \pi^+ \pi^+ \pi^-$	$( 1.8 \pm 0.3 ) \%$	
$\Gamma_{64}$	$\bar{K}_1(1400)^0 \pi^+$ , $\bar{K}_1(1400)^0 \rightarrow K_S^0 \pi^+ \pi^-$	$( 1.8 \pm 0.7 ) \%$	
$\Gamma_{65}$	$K^*(892)^- \pi^+ \pi^+$ 3-body, $K^*(892)^- \rightarrow K_S^0 \pi^-$	$( 1.3 \pm 0.6 ) \%$	
$\Gamma_{66}$	$K_S^0 \rho^0 \pi^+$ total	$( 1.86 \pm 0.34 ) \%$	CL=90%
$\Gamma_{67}$	$K_S^0 \rho^0 \pi^+$ 3-body	$( 2.2 \pm 2.2 ) \times 10^{-3}$	
$\Gamma_{68}$	$K_S^0 \pi^+ \pi^+ \pi^-$ nonresonant	$( 3.7 \pm 1.9 ) \times 10^{-3}$	
$\Gamma_{69}$	$K^- 3\pi^+ \pi^-$	[c] $( 5.8 \pm 0.6 ) \times 10^{-3}$	S=1.1
$\Gamma_{70}$	$\bar{K}^*(892)^0 \pi^+ \pi^+ \pi^-$ , $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$( 1.2 \pm 0.4 ) \times 10^{-3}$	
$\Gamma_{71}$	$\bar{K}^*(892)^0 \rho^0 \pi^+$ , $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	$( 2.3 \pm 0.4 ) \times 10^{-3}$	
$\Gamma_{72}$	$\bar{K}^*(892)^0 \pi^+ \pi^+ \pi^-$ no- $\rho$ , $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$		
$\Gamma_{73}$	$K^- \rho^0 \pi^+ \pi^+$	$( 1.75 \pm 0.29 ) \times 10^{-3}$	
$\Gamma_{74}$	$K^- 3\pi^+ \pi^-$ nonresonant	$( 4.1 \pm 3.0 ) \times 10^{-4}$	
$\Gamma_{75}$	$K^+ 2K_S^0$	$( 4.7 \pm 2.1 ) \times 10^{-3}$	
$\Gamma_{76}$	$K^+ K^- K_S^0 \pi^+$	$( 2.4 \pm 0.6 ) \times 10^{-4}$	

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\Gamma_{77}$	$K_S^0 a_1(1260)^+$	$( 3.6 \pm 0.6 ) \%$	
$\Gamma_{78}$	$K_S^0 a_2(1320)^+$	$< 1.5 \times 10^{-3}$	CL=90%
$\Gamma_{79}$	$\bar{K}^*(892)^0 \rho^+$ total	[e] $( 1.8 \pm 1.4 ) \%$	
$\Gamma_{80}$	$\bar{K}^*(892)^0 \rho^+$ S-wave	[e] $( 1.4 \pm 1.5 ) \%$	
$\Gamma_{81}$	$\bar{K}^*(892)^0 \rho^+$ P-wave	$< 1 \times 10^{-3}$	CL=90%
$\Gamma_{82}$	$\bar{K}^*(892)^0 \rho^+$ D-wave	$( 8 \pm 7 ) \times 10^{-3}$	
$\Gamma_{83}$	$\bar{K}^*(892)^0 \rho^+$ D-wave longitudinal	$< 7 \times 10^{-3}$	CL=90%
$\Gamma_{84}$	$\bar{K}_1(1270)^0 \pi^+$	$< 7 \times 10^{-3}$	CL=90%
$\Gamma_{85}$	$\bar{K}_1(1400)^0 \pi^+$	$( 4.3 \pm 1.5 ) \%$	S=1.2

$\Gamma_{86}$	$\bar{K}^*(1410)^0 \pi^+$		
$\Gamma_{87}$	$\bar{K}^*(892)^0 \pi^+ \pi^0$ total	( 5.8 $\pm$ 2.9 ) %	
$\Gamma_{88}$	$\bar{K}^*(892)^0 \pi^+ \pi^0$ 3-body	[e] ( 3.6 $\pm$ 2.1 ) %	
$\Gamma_{89}$	$K^*(892)^- \pi^+ \pi^+$ total	—	
$\Gamma_{90}$	$K^*(892)^- \pi^+ \pi^+$ 3-body	( 1.8 $^{+1.1}_{-0.9}$ ) %	S=1.2
$\Gamma_{91}$	$K_S^0 f_0(980) \pi^+$		
$\Gamma_{92}$	$\bar{K}^*(892)^0 a_1(1260)^+$	( 9.4 $\pm$ 1.9 ) $\times 10^{-3}$	

### Pionic modes

$\Gamma_{93}$	$\pi^+ \pi^0$	( 1.28 $\pm$ 0.09 ) $\times 10^{-3}$	
$\Gamma_{94}$	$\pi^+ \pi^+ \pi^-$	( 3.31 $\pm$ 0.21 ) $\times 10^{-3}$	
$\Gamma_{95}$	$\rho^0 \pi^+$	( 1.07 $\pm$ 0.11 ) $\times 10^{-3}$	
$\Gamma_{96}$	$\pi^+ (\pi^+ \pi^-)_{S\text{-wave}}$	( 1.86 $\pm$ 0.18 ) $\times 10^{-3}$	
$\Gamma_{97}$	$\sigma \pi^+, \sigma \rightarrow \pi^+ \pi^-$	( 1.53 $\pm$ 0.32 ) $\times 10^{-3}$	
$\Gamma_{98}$	$f_0(980) \pi^+,$ $f_0(980) \rightarrow \pi^+ \pi^-$	( 2.1 $\pm$ 0.5 ) $\times 10^{-4}$	
$\Gamma_{99}$	$f_0(1370) \pi^+,$ $f_0(1370) \rightarrow \pi^+ \pi^-$	( 8 $\pm$ 6 ) $\times 10^{-5}$	
$\Gamma_{100}$	$f_2(1270) \pi^+,$ $f_2(1270) \rightarrow \pi^+ \pi^-$	( 4.8 $\pm$ 1.3 ) $\times 10^{-4}$	
$\Gamma_{101}$	$\rho(1450)^0 \pi^+,$ $\rho(1450)^0 \rightarrow \pi^+ \pi^-$		
$\Gamma_{102}$	$\pi^+ \pi^+ \pi^-$ nonresonant		
$\Gamma_{103}$	$\pi^+ 2\pi^0$	( 4.8 $\pm$ 0.4 ) $\times 10^{-3}$	
$\Gamma_{104}$	$\pi^+ \pi^+ \pi^- \pi^0$	( 1.18 $\pm$ 0.09 ) %	
$\Gamma_{105}$	$\eta \pi^+, \eta \rightarrow \pi^+ \pi^- \pi^0$	( 7.9 $\pm$ 0.7 ) $\times 10^{-4}$	
$\Gamma_{106}$	$\omega \pi^+, \omega \rightarrow \pi^+ \pi^- \pi^0$	< 3 $\times 10^{-4}$	CL=90%
$\Gamma_{107}$	$3\pi^+ 2\pi^-$	( 1.68 $\pm$ 0.17 ) $\times 10^{-3}$	S=1.1
$\Gamma_{108}$	$3\pi^+ 2\pi^- \pi^0$		

Fractions of some of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\Gamma_{109}$	$\eta \pi^+$	( 3.50 $\pm$ 0.32 ) $\times 10^{-3}$	
$\Gamma_{110}$	$\omega \pi^+$	< 3.4 $\times 10^{-4}$	CL=90%
$\Gamma_{111}$	$\eta \rho^+$	< 7 $\times 10^{-3}$	CL=90%
$\Gamma_{112}$	$\eta'(958) \pi^+$	( 5.3 $\pm$ 1.1 ) $\times 10^{-3}$	
$\Gamma_{113}$	$\eta'(958) \rho^+$	< 6 $\times 10^{-3}$	CL=90%

### Hadronic modes with a $K\bar{K}$ pair

$\Gamma_{114}$	$K^+ K_S^0$	( 2.96 $\pm$ 0.19 ) $\times 10^{-3}$	
$\Gamma_{115}$	$K^+ K^- \pi^+$	[c] ( 1.00 $\pm$ 0.04 ) %	S=1.2
$\Gamma_{116}$	$\phi \pi^+, \phi \rightarrow K^+ K^-$	( 3.2 $\pm$ 0.4 ) $\times 10^{-3}$	
$\Gamma_{117}$	$K^+ \bar{K}^*(892)^0,$ $\bar{K}^*(892)^0 \rightarrow K^- \pi^+$	( 3.02 $\pm$ 0.35 ) $\times 10^{-3}$	

$\Gamma_{118}$	$K^+ \bar{K}_0^*(1430)^0, \bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+$	$( 3.7 \pm 0.4 ) \times 10^{-3}$	
$\Gamma_{119}$	$K^+ K^- \pi^+$ nonresonant	—	
$\Gamma_{120}$	$K_S^0 K_S^0 \pi^+$	—	
$\Gamma_{121}$	$K^*(892)^+ K_S^0, K^*(892)^+ \rightarrow K_S^0 \pi^+$	$( 5.3 \pm 2.3 ) \times 10^{-3}$	
$\Gamma_{122}$	$K^+ K^- \pi^+ \pi^0$	—	
$\Gamma_{123}$	$\phi \pi^+ \pi^0, \phi \rightarrow K^+ K^-$	$( 1.1 \pm 0.5 ) \%$	
$\Gamma_{124}$	$\phi \rho^+, \phi \rightarrow K^+ K^-$	$< 7 \times 10^{-3}$	CL=90%
$\Gamma_{125}$	$K^+ K^- \pi^+ \pi^0$ non- $\phi$	$( 1.5^{+0.7}_{-0.6} ) \%$	
$\Gamma_{126}$	$K^+ K_S^0 \pi^+ \pi^-$	$( 1.75 \pm 0.21 ) \times 10^{-3}$	
$\Gamma_{127}$	$K_S^0 K^- \pi^+ \pi^+$	$( 2.39 \pm 0.23 ) \times 10^{-3}$	
$\Gamma_{128}$	$K^*(892)^+ \bar{K}^*(892)^0, K^{*+} \rightarrow K_S^0 \pi^+, \bar{K}^{*0} \rightarrow K^- \pi^+$	$( 5.8 \pm 2.4 ) \times 10^{-3}$	
$\Gamma_{129}$	$K_S^0 K^- \pi^+ \pi^+$ (non- $K^{*+} \bar{K}^{*0}$ )	$< 4 \times 10^{-3}$	CL=90%
$\Gamma_{130}$	$K^+ K^- \pi^+ \pi^+ \pi^-$	$( 2.3 \pm 1.2 ) \times 10^{-4}$	

Fractions of the following modes with resonances have already appeared above as submodes of particular charged-particle modes.

$\Gamma_{131}$	$\phi \pi^+$	$( 6.5 \pm 0.7 ) \times 10^{-3}$	
$\Gamma_{132}$	$\phi \pi^+ \pi^0$	$( 2.3 \pm 1.0 ) \%$	
$\Gamma_{133}$	$\phi \rho^+$	$< 1.5 \%$	CL=90%
$\Gamma_{134}$	$K^+ \bar{K}^*(892)^0$		
$\Gamma_{135}$	$K^*(892)^+ K_S^0$	$( 1.6 \pm 0.7 ) \%$	
$\Gamma_{136}$	$K^*(892)^+ \bar{K}^*(892)^0$	$( 2.6 \pm 1.1 ) \%$	

### Doubly Cabibbo-suppressed modes

$\Gamma_{137}$	$K^+ \pi^0$	$< 4.2 \times 10^{-4}$	CL=90%
$\Gamma_{138}$	$K^+ \pi^+ \pi^-$	$( 6.4 \pm 0.8 ) \times 10^{-4}$	
$\Gamma_{139}$	$K^+ \rho^0$	$( 2.5 \pm 0.7 ) \times 10^{-4}$	
$\Gamma_{140}$	$K^*(892)^0 \pi^+, K^*(892)^0 \rightarrow K^+ \pi^-$	$( 3.0 \pm 0.6 ) \times 10^{-4}$	
$\Gamma_{141}$	$K^+ f_0(980), f_0(980) \rightarrow \pi^+ \pi^-$	$( 5.7 \pm 3.5 ) \times 10^{-5}$	
$\Gamma_{142}$	$K_2^*(1430)^0 \pi^+, K_2^*(1430)^0 \rightarrow K^+ \pi^-$	$( 5.2 \pm 3.5 ) \times 10^{-5}$	
$\Gamma_{143}$	$K^+ \pi^+ \pi^-$ nonresonant		
$\Gamma_{144}$	$K^+ K^+ K^-$	$( 9.0 \pm 2.1 ) \times 10^{-5}$	
$\Gamma_{145}$	$\phi K^+$		

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

$\Gamma_{146}$	$\pi^+ e^+ e^-$	$C1$	$< 7.4$	$\times 10^{-6}$	CL=90%
$\Gamma_{147}$	$\pi^+ \phi, \phi \rightarrow e^+ e^-$		[f]	$( 2.7 \begin{smallmatrix} +3.6 \\ -1.8 \end{smallmatrix} ) \times 10^{-6}$	
$\Gamma_{148}$	$\pi^+ \mu^+ \mu^-$	$C1$	$< 8.8$	$\times 10^{-6}$	CL=90%
$\Gamma_{149}$	$\rho^+ \mu^+ \mu^-$	$C1$	$< 5.6$	$\times 10^{-4}$	CL=90%
$\Gamma_{150}$	$K^+ e^+ e^-$		[g]	$< 6.2$	$\times 10^{-6}$ CL=90%
$\Gamma_{151}$	$K^+ \mu^+ \mu^-$		[g]	$< 9.2$	$\times 10^{-6}$ CL=90%
$\Gamma_{152}$	$\pi^+ e^\pm \mu^\mp$	$LF$	[h]	$< 3.4$	$\times 10^{-5}$ CL=90%
$\Gamma_{153}$	$\pi^+ e^+ \mu^-$				
$\Gamma_{154}$	$\pi^+ e^- \mu^+$				
$\Gamma_{155}$	$K^+ e^\pm \mu^\mp$	$LF$	[h]	$< 6.8$	$\times 10^{-5}$ CL=90%
$\Gamma_{156}$	$K^+ e^+ \mu^-$				
$\Gamma_{157}$	$K^+ e^- \mu^+$				
$\Gamma_{158}$	$\pi^- e^+ e^+$	$L$	$< 3.6$	$\times 10^{-6}$	CL=90%
$\Gamma_{159}$	$\pi^- \mu^+ \mu^+$	$L$	$< 4.8$	$\times 10^{-6}$	CL=90%
$\Gamma_{160}$	$\pi^- e^+ \mu^+$	$L$	$< 5.0$	$\times 10^{-5}$	CL=90%
$\Gamma_{161}$	$\rho^- \mu^+ \mu^+$	$L$	$< 5.6$	$\times 10^{-4}$	CL=90%
$\Gamma_{162}$	$K^- e^+ e^+$	$L$	$< 4.5$	$\times 10^{-6}$	CL=90%
$\Gamma_{163}$	$K^- \mu^+ \mu^+$	$L$	$< 1.3$	$\times 10^{-5}$	CL=90%
$\Gamma_{164}$	$K^- e^+ \mu^+$	$L$	$< 1.3$	$\times 10^{-4}$	CL=90%
$\Gamma_{165}$	$K^*(892)^- \mu^+ \mu^+$	$L$	$< 8.5$	$\times 10^{-4}$	CL=90%

$\Gamma_{166}$  A dummy mode used by the fit.  $(30 \pm 5) \%$   $S=1.2$

[a] This is a weighted average of  $D^\pm$  (44%) and  $D^0$  (56%) branching fractions. See " $D^+$  and  $D^0 \rightarrow (\eta \text{ anything}) / (\text{total } D^+ \text{ and } D^0)$ " under " $D^+$  Branching Ratios" in these Particle Listings.

[b] An  $\ell$  indicates an  $e$  or a  $\mu$  mode, not a sum over these modes.

[c] 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.

[d] These subfractions of the  $K^- \pi^+ \pi^+$  mode are uncertain: see the Particle Listings.

[e] The two experiments measuring this fraction are in serious disagreement. See the Particle Listings.

[f] This is *not* a test for the  $\Delta C=1$  weak neutral current, but leads to the  $\pi^+ e^+ e^-$  final state.

[g] This mode is not a useful test for a  $\Delta C=1$  weak neutral current because both quarks must change flavor in this decay.

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

### CONSTRAINED FIT INFORMATION

An overall fit to 32 branching ratios uses 51 measurements and one constraint to determine 21 parameters. The overall fit has a  $\chi^2 = 30.9$  for 31 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 <sub>15</sub>	3										
x <sub>16</sub>	0	1									
x <sub>27</sub>	1	6	14								
x <sub>28</sub>	3	61	1	6							
x <sub>34</sub>	0	0	1	5	0						
x <sub>41</sub>	9	33	2	12	34	1					
x <sub>42</sub>	8	40	2	15	40	1	84				
x <sub>49</sub>	4	14	1	5	14	0	45	35			
x <sub>53</sub>	1	3	0	1	3	0	9	8	8		
x <sub>62</sub>	6	24	1	9	24	0	66	60	58	14	
x <sub>69</sub>	3	15	1	5	15	0	31	37	13	3	
x <sub>85</sub>	1	5	0	2	5	0	13	12	11	61	
x <sub>90</sub>	1	3	0	1	3	0	7	7	6	62	
x <sub>107</sub>	3	14	1	5	14	0	29	34	12	3	
x <sub>109</sub>	3	16	1	6	16	0	33	39	13	3	
x <sub>114</sub>	5	21	1	8	21	0	53	52	23	5	
x <sub>115</sub>	6	33	2	12	33	1	68	83	21	6	
x <sub>116</sub>	2	12	1	4	12	0	25	31	9	2	
x <sub>131</sub>	2	12	1	4	12	0	25	31	9	2	
x <sub>166</sub>	-12	-32	-19	-13	-29	-1	-35	-36	-28	-86	
	x <sub>14</sub>	x <sub>15</sub>	x <sub>16</sub>	x <sub>27</sub>	x <sub>28</sub>	x <sub>34</sub>	x <sub>41</sub>	x <sub>42</sub>	x <sub>49</sub>	x <sub>53</sub>	



x <sub>69</sub>	22									
x <sub>85</sub>	19	4								
x <sub>90</sub>	11	2	38							
x <sub>107</sub>	21	78	4	2						
x <sub>109</sub>	23	14	4	3	13					
x <sub>114</sub>	36	19	7	4	18	20				
x <sub>115</sub>	45	31	9	5	29	35	43			
x <sub>116</sub>	17	11	3	2	11	43	16	33		
x <sub>131</sub>	17	11	3	2	11	43	16	33	99	
x <sub>166</sub>	-37	-14	-73	-66	-13	-15	-21	-28	-13	-13
	x <sub>62</sub>	x <sub>69</sub>	x <sub>85</sub>	x <sub>90</sub>	x <sub>107</sub>	x <sub>109</sub>	x <sub>114</sub>	x <sub>115</sub>	x <sub>116</sub>	x <sub>131</sub>

### D<sup>+</sup> BRANCHING RATIOS

Some now-obsolete measurements have been omitted from these Listings.

#### c-quark decays

#### $\Gamma(c \rightarrow e^+ \text{ anything})/\Gamma(c \rightarrow \text{ anything})$

For the Summary Table, we only use the average of  $e^+$  and  $\mu^+$  measurements from  $Z^0 \rightarrow c\bar{c}$  decays; see the second data block below.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.103 ± 0.009<sup>+0.009</sup><sub>-0.008</sub></b>	378	<sup>3</sup> ABBIENDI	99K OPAL	$Z^0 \rightarrow c\bar{c}$

<sup>3</sup> ABBIENDI 99K uses the excess of right-sign over wrong-sign leptons opposite reconstructed  $D^*(2010)^+ \rightarrow D^0 \pi^+$  decays in  $Z^0 \rightarrow c\bar{c}$ .

#### $\Gamma(c \rightarrow \mu^+ \text{ anything})/\Gamma(c \rightarrow \text{ anything})$

For the Summary Table, we only use the average of  $e^+$  and  $\mu^+$  measurements from  $Z^0 \rightarrow c\bar{c}$  decays; see the next data block.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.082 ± 0.005 OUR AVERAGE</b>				
0.073 ± 0.008 ± 0.002	73	KAYIS-TOPAK.05	CHRS	$\nu_\mu$ emulsion
0.095 ± 0.007 <sup>+0.014</sup> <sub>-0.013</sub>	2829	ASTIER	00D NOMD	$\nu_\mu \text{ Fe} \rightarrow \mu^- \mu^+ X$
0.090 ± 0.007 <sup>+0.007</sup> <sub>-0.006</sub>	476	<sup>4</sup> ABBIENDI	99K OPAL	$Z^0 \rightarrow c\bar{c}$
0.086 ± 0.017 <sup>+0.008</sup> <sub>-0.007</sub>	69	<sup>5</sup> ALBRECHT	92F ARG	$e^+ e^- \approx 10 \text{ GeV}$
0.078 ± 0.009 ± 0.012		ONG	88 MRK2	$e^+ e^- 29 \text{ GeV}$
0.078 ± 0.015 ± 0.02		BARTEL	87 JADE	$e^+ e^- 34.6 \text{ GeV}$
0.082 ± 0.012 <sup>+0.02</sup> <sub>-0.01</sub>		ALTHOFF	84G TASS	$e^+ e^- 34.5 \text{ GeV}$

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.093 ± 0.009 ± 0.009	88	KAYIS-TOPAK.02	CHRS	See KAYIS-TOPAKSU 05
0.089 ± 0.018 ± 0.025		BARTEL	85J JADE	See BARTEL 87

<sup>4</sup> ABBIENDI 99K uses the excess of right-sign over wrong-sign leptons opposite reconstructed  $D^*(2010)^+ \rightarrow D^0 \pi^+$  decays in  $Z^0 \rightarrow c\bar{c}$ .

<sup>5</sup> ALBRECHT 92F uses the excess of right-sign over wrong-sign leptons in a sample of events tagged by fully reconstructed  $D^*(2010)^+ \rightarrow D^0 \pi^+$  decays.

### $\Gamma(c \rightarrow \ell^+ \text{ anything})/\Gamma(c \rightarrow \text{ anything})$

This is an average (not a sum) of  $e^+$  and  $\mu^+$  measurements.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.096 ± 0.004 OUR AVERAGE</b>				
0.0958 ± 0.0042 ± 0.0028	1828	<sup>6</sup> ABREU	000 DLPH	$Z^0 \rightarrow c\bar{c}$
0.095 ± 0.006 <sup>+0.007</sup> / <sub>-0.006</sub>	854	<sup>7</sup> ABBIENDI	99K OPAL	$Z^0 \rightarrow c\bar{c}$

<sup>6</sup> ABREU 000 uses leptons opposite fully reconstructed  $D^*(2010)^+$ ,  $D^+$ , or  $D^0$  mesons.

<sup>7</sup> ABBIENDI 99K uses the excess of right-sign over wrong-sign leptons opposite reconstructed  $D^*(2010)^+ \rightarrow D^0 \pi^+$  decays in  $Z^0 \rightarrow c\bar{c}$ .

### $\Gamma(c \rightarrow D^*(2010)^+ \text{ anything})/\Gamma(c \rightarrow \text{ anything})$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.255 ± 0.015 ± 0.008</b>	2371	<sup>8</sup> ABREU	000 DLPH	$Z^0 \rightarrow c\bar{c}$

<sup>8</sup> ABREU 000 uses slow pions opposite fully reconstructed  $D^*(2010)^+$ ,  $D^+$ , or  $D^0$  mesons as a signal of  $D^*(2010)^-$  production.

### ———— Inclusive modes ————

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

$\Gamma_1/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.172 ± 0.019 OUR AVERAGE</b>				
0.20 <sup>+0.09</sup> / <sub>-0.07</sub>		AGUILAR-...	87E HYBR	$\pi p, p p$ 360, 400 GeV
0.170 ± 0.019 ± 0.007	158	BALTRUSAIT..85B	MRK3	$e^+ e^-$ 3.77 GeV
0.168 ± 0.064	23	SCHINDLER	81 MRK2	$e^+ e^-$ 3.771 GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.220 <sup>+0.044</sup> / <sub>-0.022</sub>		BACINO	80 DLCO	$e^+ e^-$ 3.77 GeV

### $D^+$ and $D^0 \rightarrow (e^+ \text{ anything}) / (\text{total } D^+ \text{ and } D^0)$

If measured at the  $\psi(3770)$ , this quantity is a weighted average of  $D^+$  (44%) and  $D^0$  (56%) branching fractions. Only experiments at  $E_{\text{cm}} = 3.77$  GeV are included in the average here. We don't put this result in the Summary Table.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.110 ± 0.011 OUR AVERAGE</b>				Error includes scale factor of 1.1.
0.117 ± 0.011	295	BALTRUSAIT..85B	MRK3	$e^+ e^-$ 3.77 GeV
0.10 ± 0.032		<sup>9</sup> SCHINDLER	81 MRK2	$e^+ e^-$ 3.771 GeV
0.072 ± 0.028		FELLER	78 MRK1	$e^+ e^-$ 3.772 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.096±0.004±0.011	2207	<sup>10</sup> ALBRECHT	96C ARG	$e^+e^- \approx 10$ GeV
0.134±0.015±0.010		<sup>11</sup> ABE	93E VNS	$e^+e^- 58$ GeV
0.098±0.009 <sup>+0.006</sup> <sub>-0.005</sub>	240	<sup>12</sup> ALBRECHT	92F ARG	$e^+e^- \approx 10$ GeV
0.096±0.007±0.015		<sup>13</sup> ONG	88 MRK2	$e^+e^- 29$ GeV
0.116 <sup>+0.011</sup> <sub>-0.009</sub>		<sup>13</sup> PAL	86 DLCO	$e^+e^- 29$ GeV
0.091±0.009±0.013		<sup>13</sup> AIHARA	85 TPC	$e^+e^- 29$ GeV
0.092±0.022±0.040		<sup>13</sup> ALTHOFF	84J TASS	$e^+e^- 34.6$ GeV
0.091±0.013		<sup>13</sup> KOOP	84 DLCO	See PAL 86
0.08 ±0.015		<sup>14</sup> BACINO	79 DLCO	$e^+e^- 3.772$ GeV

<sup>9</sup> Isolates  $D^+$  and  $D^0 \rightarrow e^+X$  and weights for relative production (44%–56%).

<sup>10</sup> ALBRECHT 96C uses  $e^-$  in the hemisphere opposite to  $D^{*+} \rightarrow D^0\pi^+$  events.

<sup>11</sup> ABE 93E also measures forward-backward asymmetries and fragmentation functions for  $c$  and  $b$  quarks.

<sup>12</sup> ALBRECHT 92F uses the excess of right-sign over wrong-sign leptons in a sample of events tagged by fully reconstructed  $D^*(2010)^+ \rightarrow D^0\pi^+$  decays.

<sup>13</sup> Average BR for charm  $\rightarrow e^+X$ . Unlike at  $E_{\text{cm}} = 3.77$  GeV, the admixture of charmed mesons is unknown.

<sup>14</sup> Not independent of BACINO 80 measurements of  $\Gamma(e^+\text{anything})/\Gamma_{\text{total}}$  for the  $D^+$  and  $D^0$  separately.

### $\Gamma(K^- \text{ anything})/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.275±0.024 OUR AVERAGE</b>				

0.278 <sup>+0.036</sup> <sub>-0.031</sub>		<sup>15</sup> BARLAG	92C ACCM	$\pi^-$ Cu 230 GeV
0.271±0.023±0.024		COFFMAN	91 MRK3	$e^+e^- 3.77$ GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.17 ±0.07		AGUILAR-...	87E HYBR	$\pi p, pp$ 360, 400 GeV
0.16 <sup>+0.08</sup> <sub>-0.07</sub>		AGUILAR-...	86B HYBR	See AGUILAR-BENITEZ 87E
0.19 ±0.05	26	SCHINDLER	81 MRK2	$e^+e^- 3.771$ GeV
0.10 ±0.07	3	VUILLEMIN	78 MRK1	$e^+e^- 3.772$ GeV

<sup>15</sup> BARLAG 92C computes the branching fraction using topological normalization.

### $[\Gamma(\bar{K}^0 \text{ anything}) + \Gamma(K^0 \text{ anything})]/\Gamma_{\text{total}}$ $\Gamma_3/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.612±0.065±0.043</b>		COFFMAN	91 MRK3	$e^+e^- 3.77$ GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.52 ±0.18	15	SCHINDLER	81 MRK2	$e^+e^- 3.771$ GeV
0.39 ±0.29	3	VUILLEMIN	78 MRK1	$e^+e^- 3.772$ GeV

### $\Gamma(K^+ \text{ anything})/\Gamma_{\text{total}}$ $\Gamma_4/\Gamma$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.055±0.013±0.009</b>		COFFMAN	91 MRK3	$e^+e^- 3.77$ GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.08 <sup>+0.06</sup> <sub>-0.05</sub>		AGUILAR-...	87E HYBR	$\pi p, pp$ 360, 400 GeV
0.06 ±0.04	12	SCHINDLER	81 MRK2	$e^+e^- 3.771$ GeV
0.06 ±0.06	2	VUILLEMIN	78 MRK1	$e^+e^- 3.772$ GeV

$\Gamma(\bar{K}^*(892)^0 \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.232 \pm 0.045 \pm 0.030$	189 ± 36	ABLIKIM 05P	BES	$e^+e^- \approx 3773 \text{ MeV}$

$\Gamma(K^*(892)^0 \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<0.066$	90	ABLIKIM 05P	BES	$e^+e^- \approx 3773 \text{ MeV}$

$D^+ \text{ and } D^0 \rightarrow (\eta \text{ anything}) / (\text{total } D^+ \text{ and } D^0)$

If measured at the  $\psi(3770)$ , this quantity is a weighted average of  $D^+$  (44%) and  $D^0$  (56%) branching fractions. Only the experiment at  $E_{\text{cm}} = 3.77 \text{ GeV}$  is used.

VALUE	DOCUMENT ID	TECN	COMMENT
$<0.13$	PARTRIDGE 81	CBAL	$e^+e^- 3.77 \text{ GeV}$

• • • We do not use the following data for averages, fits, limits, etc. • • •

$<0.02$	<sup>16</sup> BRANDELIK 79	DASP	$e^+e^- 4.03 \text{ GeV}$
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<sup>16</sup>The BRANDELIK 79 result is based on the absence of an  $\eta$  signal at  $E_{\text{cm}} = 4.03 \text{ GeV}$ . PARTRIDGE 81 observes a substantially higher  $\eta$  cross section at  $4.03 \text{ GeV}$ .

$\Gamma(\phi \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_8/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<0.018$	90	<sup>17</sup> BAI	00c	BES $e^+e^- \rightarrow D\bar{D}^*, D^*\bar{D}^*$

<sup>17</sup>BAI 00c finds the average ( $\phi$  anything) branching fraction for the 4.03-GeV mix of  $D^+$  and  $D^0$  mesons to be  $(1.34 \pm 0.52 \pm 0.12)\%$ .

$\Gamma(\phi e^+ \text{ anything})/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<0.016$	90	BAI	00c	BES $e^+e^- \rightarrow D\bar{D}^*, D^*\bar{D}^*$

————— Leptonic and semileptonic modes —————

$\Gamma(e^+ \nu_e)/\Gamma_{\text{total}}$   $\Gamma_{11}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<2.4 \times 10^{-5}$	90	ARTUSO 05A	CLEO	$e^+e^-$ at $\psi(3770)$

$\Gamma(\mu^+ \nu_\mu)/\Gamma_{\text{total}}$   $\Gamma_{12}/\Gamma$

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
$4.40 \pm 0.66^{+0.09}_{-0.12}$	47 ± 7	<sup>18</sup> ARTUSO 05A	CLEO	$e^+e^-$ at $\psi(3770)$

• • • We do not use the following data for averages, fits, limits, etc. • • •

12.2 $^{+11.1}_{-5.3} \pm 1.0$	3	<sup>19</sup> ABLIKIM 05D	BES	$e^+e^- \approx 3.773 \text{ GeV}$
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3.5 ± 1.4 ± 0.6	7	<sup>20</sup> BONVICINI 04A	CLEO	Incl. in ARTUSO 05A
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8 $^{+16}_{-5} \ ^{+5}_{-2}$	1	<sup>21</sup> BAI 98B	BES	$e^+e^- \rightarrow D^{*+}D^-$
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- <sup>18</sup> ARTUSO 05A obtains  $f_{D^+} = 222.6 \pm 16.7^{+2.8}_{-3.4}$  MeV from this measurement.
- <sup>19</sup> ABLIKIM 05D finds a background-subtracted  $2.67 \pm 1.74$   $D^+ \rightarrow \mu^+ \nu_\mu$  events, and from this obtains  $f_{D^+} = 371^{+129}_{-119} \pm 25$  MeV.
- <sup>20</sup> BONVICINI 04A finds eight events with an estimated background of one, and from the branching fraction obtains  $f_{D^+} = 202 \pm 41 \pm 17$  MeV.
- <sup>21</sup> BAI 98B obtains  $f_{D^+} = (300^{+180+80}_{-150-40})$  MeV from this measurement.

$\Gamma(\overline{K}^0 e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{14} / \Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.086 ± 0.005 OUR FIT**

**0.087 ± 0.005 OUR AVERAGE**

0.0895 ± 0.0159 ± 0.0067	34 ± 6	<sup>22</sup> ABLIKIM	05A BES	$e^+ e^-$ at $\psi(3770)$
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0.0871 ± 0.0038 ± 0.0037	545 ± 24	<sup>23</sup> HUANG	05B CLEO	$e^+ e^-$ at $\psi(3770)$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.06 $^{+0.022}_{-0.013} \pm 0.007$	13	BAI	91 MRK3	$e^+ e^- \approx 3.77$ GeV
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<sup>22</sup> The ABLIKIM 05A result together with the  $D^0 \rightarrow K^- e^+ \nu_e$  branching fraction of ABLIKIM 04C and Particle Data Group lifetimes gives  $\Gamma(D^0 \rightarrow K^- e^+ \nu_e) / \Gamma(D^+ \rightarrow \overline{K}^0 e^+ \nu_e) = 1.08 \pm 0.22 \pm 0.07$ ; isospin invariance predicts the ratio is 1.0.

<sup>23</sup> HUANG 05B finds  $\Gamma(D^0 \rightarrow K^- e^+ \nu_e) / \Gamma(D^+ \rightarrow \overline{K}^0 e^+ \nu_e) = 1.00 \pm 0.05 \pm 0.04$ ; isospin invariance predicts the ratio is 1.0.

$\Gamma(\overline{K}^0 e^+ \nu_e) / \Gamma(K_S^0 \pi^+)$   $\Gamma_{14} / \Gamma_{41}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**5.8 ± 0.4 OUR FIT**

<b>5.20 ± 0.70 ± 0.52</b>	186	<sup>24</sup> BEAN	93C CLE2	$e^+ e^- \approx \Upsilon(4S)$
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<sup>24</sup> BEAN 93C uses  $\overline{K}^0 \mu^+ \nu_\mu$  as well as  $\overline{K}^0 e^+ \nu_e$  events and makes a small phase-space adjustment to the number of the  $\mu^+$  events to use them as  $e^+$  events. The value given is twice that in BEAN 93C because we are using  $K_S^0 \pi^+$  and not  $\overline{K}^0 \pi^+$ , in the denominator.

$\Gamma(\overline{K}^0 e^+ \nu_e) / \Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{14} / \Gamma_{42}$

VALUE	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.66 ± 0.09 ± 0.14	ANJOS	91C E691	$\gamma$ Be 80–240 GeV
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$\Gamma(\overline{K}^0 \mu^+ \nu_\mu) / \Gamma_{\text{total}}$   $\Gamma_{15} / \Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.07 $^{+0.028}_{-0.016} \pm 0.012$	14	BAI	91 MRK3	$e^+ e^- \approx 3.77$ GeV
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$\Gamma(\overline{K}^0 \mu^+ \nu_\mu) / \Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{15} / \Gamma_{42}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**1.00 ± 0.08 OUR FIT**

<b>1.019 ± 0.076 ± 0.065</b>	555 ± 39	LINK	04E FOCS	$\gamma$ nucleus, $\overline{E}_\gamma \approx 180$ GeV
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$\Gamma(\bar{K}^0 \mu^+ \nu_\mu) / \Gamma(\mu^+ \text{ anything})$   $\Gamma_{15} / \Gamma_{10}$

VALUE	EVTS	DOCUMENT ID	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.76 ± 0.06	84	<sup>25</sup> AOKI	88 $\pi^-$ emulsion
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<sup>25</sup> From topological branching ratios in emulsion with an identified muon.

$\Gamma(K^- \pi^+ e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{16} / \Gamma$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.045<sup>+0.010</sup><sub>-0.008</sub> OUR FIT** Error includes scale factor of 1.1.

<b>0.035<sup>+0.012</sup><sub>-0.007</sub> ± 0.004</b>	14	<sup>26</sup> BAI	91 MRK3	$e^+ e^- \approx 3.77$ GeV
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• • • We do not use the following data for averages, fits, limits, etc. • • •

< 0.057	90	<sup>27</sup> AGUILAR-...	87F HYBR	$\pi p, p p$ 360, 400 GeV
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<sup>26</sup> BAI 91 finds that a fraction  $0.79^{+0.15+0.09}_{-0.17-0.03}$  of combined  $D^+$  and  $D^0$  decays to  $\bar{K} \pi e^+ \nu_e$  (24 events) are  $\bar{K}^*(892) e^+ \nu_e$ .

<sup>27</sup> AGUILAR-BENITEZ 87F computes the branching fraction using topological normalization.

$\Gamma(\bar{K}^*(892)^0 e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{27} / \Gamma$

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.0561 ± 0.0031 OUR FIT** Error includes scale factor of 1.1.

<b>0.0556 ± 0.0027 ± 0.0023</b>	422 ± 21	<sup>28</sup> HUANG	05B CLEO	$e^+ e^-$ at $\psi(3770)$
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<sup>28</sup> HUANG 05B finds  $\Gamma(D^0 \rightarrow K^{*-} e^+ \nu_e) / \Gamma(D^+ \rightarrow \bar{K}^{*0} e^+ \nu_e) = 0.98 \pm 0.08 \pm 0.04$ ; isospin invariance predicts the ratio is 1.0.

$\Gamma(\bar{K}^*(892)^0 e^+ \nu_e) / \Gamma(K^- \pi^+ e^+ \nu_e)$   $\Gamma_{27} / \Gamma_{16}$

Unseen decay modes of the  $\bar{K}^*(892)^0$  are included. See the end of the  $D^+$  Listings for measurements of  $D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$  form-factor ratios.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**1.23<sup>+0.23</sup><sub>-0.26</sub> OUR FIT** Error includes scale factor of 1.2.

<b>1.0 ± 0.3</b>	35	ADAMOVICH	91 OMEG	$\pi^-$ 340 GeV
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$\Gamma(\bar{K}^*(892)^0 e^+ \nu_e) / \Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{27} / \Gamma_{42}$

Unseen decay modes of the  $\bar{K}^*(892)^0$  are included. See the end of the  $D^+$  Listings for measurements of  $D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$  form-factor ratios.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.590 ± 0.035 OUR FIT** Error includes scale factor of 1.2.

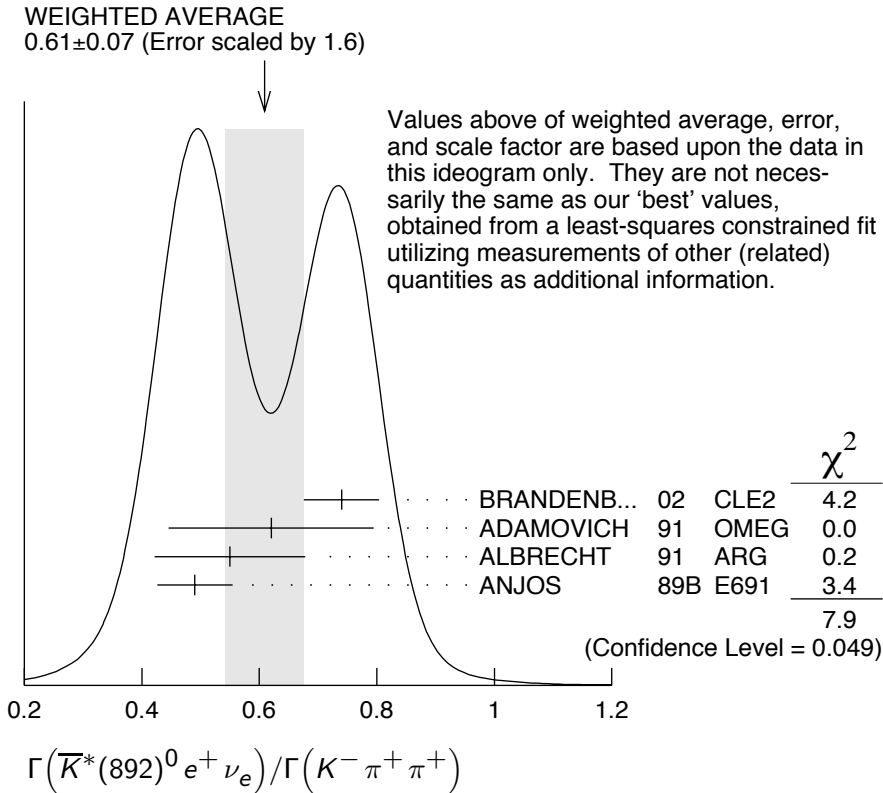
**0.61 ± 0.07 OUR AVERAGE** Error includes scale factor of 1.6. See the ideogram below.

0.74 ± 0.04 ± 0.05		BRANDENB...	02 CLE2	$e^+ e^- \approx \gamma(4S)$
0.62 ± 0.15 ± 0.09	35	ADAMOVICH	91 OMEG	$\pi^-$ 340 GeV
0.55 ± 0.08 ± 0.10	880	ALBRECHT	91 ARG	$e^+ e^- \approx 10.4$ GeV
0.49 ± 0.04 ± 0.05		ANJOS	89B E691	Photoproduction

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.67 ± 0.09 ± 0.07	710	<sup>29</sup> BEAN	93C CLE2	See BRANDENBURG 02
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<sup>29</sup> BEAN 93C uses  $\bar{K}^{*0} \mu^+ \nu_\mu$  as well as  $\bar{K}^{*0} e^+ \nu_e$  events and makes a small phase-space adjustment to the number of the  $\mu^+$  events to use them as  $e^+$  events.



**$\Gamma(K^- \pi^+ e^+ \nu_e \text{ nonresonant}) / \Gamma_{\text{total}}$   $\Gamma_{18} / \Gamma$**

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.007</b>	90	30 ANJOS	89B E691	Photoproduction

<sup>30</sup> ANJOS 89B assumes a  $\Gamma(D^+ \rightarrow K^- \pi^+ \pi^+) / \Gamma_{\text{total}} = 9.1 \pm 1.3 \pm 0.4\%$ .

**$\Gamma(K^- \pi^+ \mu^+ \nu_\mu) / \Gamma(\bar{K}^0 \mu^+ \nu_\mu)$   $\Gamma_{19} / \Gamma_{15}$**

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.417±0.030±0.023</b>	555 ± 39	LINK	04E FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV

**$\Gamma(\bar{K}^{*}(892)^0 \mu^+ \nu_\mu) / \Gamma_{\text{total}}$   $\Gamma_{28} / \Gamma$**

Unseen decay modes of the  $\bar{K}^{*}(892)^0$  are included. See the end of the  $D^+$  Listings for measurements of  $D^+ \rightarrow \bar{K}^{*}(892)^0 \ell^+ \nu_\ell$  form-factor ratios.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.0325±0.0071±0.0075    224    <sup>31</sup> KODAMA    92C E653     $\pi^-$  emulsion 600 GeV

<sup>31</sup> KODAMA 92C measures  $\Gamma(D^+ \rightarrow \bar{K}^{*0} \mu^+ \nu_\mu) / \Gamma(D^0 \rightarrow K^- \mu^+ \nu_\mu) = 0.43 \pm 0.09 \pm 0.09$  and then uses  $\Gamma(D^0 \rightarrow K^- \mu^+ \nu_\mu) = (7.0 \pm 0.7) \times 10^{10} \text{ s}^{-1}$  to get the quoted branching fraction. See also the footnote to KODAMA 92C in the second data block below.

$\Gamma(\overline{K}^*(892)^0 \mu^+ \nu_\mu) / \Gamma(\overline{K}^0 \mu^+ \nu_\mu)$   $\Gamma_{28} / \Gamma_{15}$

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

VALUE	EVTs	DOCUMENT ID	TECN	COMMENT
<b>0.58 ± 0.05 OUR FIT</b>				
<b>0.594 ± 0.043 ± 0.033</b>	555 ± 39	LINK	04E FOCS	$\gamma$ nucleus, $\overline{E}_\gamma \approx 180$ GeV

$\Gamma(\overline{K}^*(892)^0 \mu^+ \nu_\mu) / \Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{28} / \Gamma_{42}$

Unseen decay modes of the  $\overline{K}^*(892)^0$  are included. See the end of the  $D^+$  Listings for measurements of  $D^+ \rightarrow \overline{K}^*(892)^0 \ell^+ \nu_\ell$  form-factor ratios.

VALUE	EVTs	DOCUMENT ID	TECN	COMMENT
<b>0.58 ± 0.05 OUR FIT</b>				Error includes scale factor of 1.1.
<b>0.57 ± 0.06 OUR AVERAGE</b>				Error includes scale factor of 1.2.
0.72 ± 0.10 ± 0.05		BRANDENB...	02 CLE2	$e^+ e^- \approx \Upsilon(4S)$
0.56 ± 0.04 ± 0.06	875	FRABETTI	93E E687	$\gamma$ Be $\overline{E}_\gamma \approx 200$ GeV
0.46 ± 0.07 ± 0.08	224	<sup>32</sup> KODAMA	92C E653	$\pi^-$ emulsion 600 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.602 ± 0.010 ± 0.021	12k	<sup>33</sup> LINK	02J FOCS	$\gamma$ nucleus, $\approx 180$ GeV

<sup>32</sup>KODAMA 92C also uses the same  $\overline{K}^{*0} \mu^+ \nu_\mu$  events normalizing instead with  $D^0 \rightarrow K^- \mu^+ \nu_\mu$  events, as reported in the second data block above.

<sup>33</sup>This LINK 02J result includes the effects of an interference of a small  $S$ -wave  $K^- \pi^+$  amplitude with the dominant  $\overline{K}^{*0}$  amplitude. (The interference effect is reported in LINK 02E.) This result is redundant with results of LINK 04E elsewhere in these Listings.

$\Gamma(K^- \pi^+ \mu^+ \nu_\mu \text{ nonresonant}) / \Gamma(K^- \pi^+ \mu^+ \nu_\mu)$   $\Gamma_{21} / \Gamma_{19}$

VALUE	EVTs	DOCUMENT ID	TECN	COMMENT
<b>0.0530 ± 0.0074<sup>+0.0099</sup><sub>-0.0096</sub></b>	14k	LINK	05I FOCS	$\gamma$ nucleus, $\overline{E}_\gamma \approx 180$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.083 ± 0.029		FRABETTI	93E E687	< 0.12 (90% CL)

$\Gamma((\overline{K}^*(892)\pi)^0 e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{22} / \Gamma$

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.012</b>	90	ANJOS	92 E691	Photoproduction

$\Gamma((\overline{K}\pi\pi)^0 e^+ \nu_e \text{ non-}\overline{K}^*(892)) / \Gamma_{\text{total}}$   $\Gamma_{23} / \Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.009</b>	90	ANJOS	92 E691	Photoproduction

$\Gamma(K^- \pi^+ \pi^0 \mu^+ \nu_\mu) / \Gamma(K^- \pi^+ \mu^+ \nu_\mu)$   $\Gamma_{24} / \Gamma_{19}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.042</b>	90	FRABETTI	93E E687	$\gamma$ Be $\overline{E}_\gamma \approx 200$ GeV

$\Gamma(\overline{K}_1(1270)^0 \mu^+ \nu_\mu) / \Gamma(\overline{K}^*(892)^0 \mu^+ \nu_\mu)$   $\Gamma_{29} / \Gamma_{28}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.78</b>	95	ABE	99P CDF	$\overline{p}p$ 1.8 TeV



$\Gamma(\bar{K}^*(1410)^0 \mu^+ \nu_\mu) / \Gamma(\bar{K}^*(892)^0 \mu^+ \nu_\mu)$   $\Gamma_{30} / \Gamma_{28}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.60	95	ABE	99P CDF	$\bar{p}p$ 1.8 TeV
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$\Gamma(\bar{K}_0^*(1430)^0 \mu^+ \nu_\mu) / \Gamma(K^- \pi^+ \mu^+ \nu_\mu)$   $\Gamma_{31} / \Gamma_{19}$

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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<0.0064	90	LINK	05i FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
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$\Gamma(\bar{K}_2^*(1430)^0 \mu^+ \nu_\mu) / \Gamma(\bar{K}^*(892)^0 \mu^+ \nu_\mu)$   $\Gamma_{32} / \Gamma_{28}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<0.19	95	ABE	99P CDF	$\bar{p}p$ 1.8 TeV
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$\Gamma(\bar{K}^*(1680)^0 \mu^+ \nu_\mu) / \Gamma(K^- \pi^+ \mu^+ \nu_\mu)$   $\Gamma_{33} / \Gamma_{19}$

Unseen decay modes of the  $\bar{K}^*(1680)^0$  are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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<0.04	90	LINK	05i FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
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$\Gamma(\pi^0 e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{25} / \Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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<b>0.0044 ± 0.0006 ± 0.0003</b>	63 ± 9	<sup>34</sup> HUANG	05B CLEO	$e^+ e^-$ at $\psi(3770)$
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<sup>34</sup> HUANG 05B finds  $\Gamma(D^0 \rightarrow \pi^- e^+ \nu_e) / 2 \Gamma(D^+ \rightarrow \pi^0 e^+ \nu_e) = 0.75_{-0.11}^{+0.14} \pm 0.04$ ; isospin invariance predicts the ratio is 1.0.

$\Gamma(\pi^0 \ell^+ \nu_\ell) / \Gamma(\bar{K}^0 \ell^+ \nu_\ell)$   $\Gamma_{26} / \Gamma_{13}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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<b>0.046 ± 0.014 ± 0.017</b>	100	<sup>35</sup> BARTELT	97 CLE2	$e^+ e^- \approx \gamma(4S)$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.085 ± 0.027 ± 0.014	53	<sup>36</sup> ALAM	93 CLE2	See BARTELT 97
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<sup>35</sup> BARTELT 97 thus directly measures the product of ratios squared of CKM matrix elements and form factors at  $q^2=0$ :  $|V_{cd}/V_{cs}|^2 \cdot |f_+^\pi(0)/f_+^K(0)|^2 = 0.046 \pm 0.014 \pm 0.017$ .

<sup>36</sup> ALAM 93 thus directly measures the product of ratios squared of CKM matrix elements and form factors at  $q^2=0$ :  $|V_{cd}/V_{cs}|^2 \cdot |f_+^\pi(0)/f_+^K(0)|^2 = 0.085 \pm 0.027 \pm 0.014$ .

$\Gamma(\rho^0 e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{34} / \Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.0022 ± 0.0004 OUR FIT**

<b>0.0021 ± 0.0004 ± 0.0001</b>	27 ± 6	<sup>37</sup> HUANG	05B CLEO	$e^+ e^-$ at $\psi(3770)$
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<sup>37</sup> HUANG 05B finds  $\Gamma(D^0 \rightarrow \rho^- e^+ \nu_e) / 2 \Gamma(D^+ \rightarrow \rho^0 e^+ \nu_e) = 1.2_{-0.3}^{+0.4} \pm 0.1$ ; isospin invariance predicts the ratio is 1.0.

$\Gamma(\rho^0 e^+ \nu_e) / \Gamma(\bar{K}^*(892)^0 e^+ \nu_e)$   $\Gamma_{34} / \Gamma_{27}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.039 ± 0.007 OUR FIT**

<b>0.045 ± 0.014 ± 0.009</b>	49	<sup>38</sup> AITALA	97 E791	$\pi^-$ nucleus, 500 GeV
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<sup>38</sup> AITALA 97 explicitly subtracts  $D^+ \rightarrow \eta' e^+ \nu_e$  and other backgrounds to get this result.

$\Gamma(\rho^0 \mu^+ \nu_\mu) / \Gamma(\bar{K}^*(892)^0 \mu^+ \nu_\mu)$   $\Gamma_{35} / \Gamma_{28}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.061 ± 0.014 OUR AVERAGE</b>				
0.051 ± 0.015 ± 0.009	54	<sup>39</sup> AITALA	97 E791	$\pi^-$ nucleus, 500 GeV
0.079 ± 0.019 ± 0.013	39	<sup>40</sup> FRABETTI	97 E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.044 $^{+0.031}_{-0.025}$ ± 0.014	4	<sup>41</sup> KODAMA	93C E653	$\pi^-$ emulsion 600 GeV
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<sup>39</sup> AITALA 97 explicitly subtracts  $D^+ \rightarrow \eta' \mu^+ \nu_\mu$  and other backgrounds to get this result.

<sup>40</sup> Because the reconstruction efficiency for photons is low, this FRABETTI 97 result also includes any  $D^+ \rightarrow \eta' \mu^+ \nu_\mu \rightarrow \gamma \rho^0 \mu^+ \nu_\mu$  events in the numerator.

<sup>41</sup> This KODAMA 93C result is based on a final signal of  $4.0^{+2.8}_{-2.3} \pm 1.3$  events; the estimates of backgrounds that affect this number are somewhat model dependent.

$\Gamma(\omega e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{36} / \Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.0016 <math>^{+0.0007}_{-0.0006}</math> ± 0.0001</b>	7.6 $^{+3.3}_{-2.7}$	HUANG	05B CLEO	$e^+ e^-$ at $\psi(3770)$

$\Gamma(\phi e^+ \nu_e) / \Gamma_{\text{total}}$   $\Gamma_{37} / \Gamma$

Decay modes of the  $\phi$  not included in the search are corrected for.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.0209</b>	90	BAI	91 MRK3	$e^+ e^- \approx 3.77$ GeV

$\Gamma(\phi \mu^+ \nu_\mu) / \Gamma_{\text{total}}$   $\Gamma_{38} / \Gamma$

Decay modes of the  $\phi$  not included in the search are corrected for.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.0372</b>	90	BAI	91 MRK3	$e^+ e^- \approx 3.77$ GeV

$\Gamma(\eta \ell^+ \nu_\ell) / \Gamma(\pi^0 \ell^+ \nu_\ell)$   $\Gamma_{39} / \Gamma_{26}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 1.5</b>	90	BARTELT	97 CLE2	$e^+ e^- \approx \Upsilon(4S)$

$\Gamma(\eta'(958) \mu^+ \nu_\mu) / \Gamma(\bar{K}^*(892)^0 \mu^+ \nu_\mu)$   $\Gamma_{40} / \Gamma_{28}$

Decay modes of the  $\eta'(958)$  not included in the search are corrected for.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt; 0.20</b>	90	KODAMA	93B E653	$\pi^-$ emulsion 600 GeV

————— Hadronic modes with a  $\bar{K}$  or  $\bar{K} K \bar{K}$  —————

$\Gamma(K_S^0 \pi^+) / \Gamma_{\text{total}}$   $\Gamma_{41} / \Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.0147 ± 0.0006 OUR FIT</b>				Error includes scale factor of 1.1.
<b>0.0155 ± 0.0005 ± 0.0006</b>	2230 ± 60	<sup>42</sup> HE	05 CLEO	$e^+ e^-$ at $\psi(3770)$

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.016 ± 0.003 ± 0.001	161	ADLER	88C MRK3	$e^+ e^-$ 3.77 GeV
0.017 ± 0.004	36	<sup>43</sup> SCHINDLER	81 MRK2	$e^+ e^-$ 3.771 GeV
0.017 ± 0.006	17	<sup>44</sup> PERUZZI	77 MRK1	$e^+ e^-$ 3.77 GeV

<sup>42</sup> HE 05 uses single- and double-tagged events in an overall fit. The fraction here includes (unobserved) final-state photons.

<sup>43</sup> SCHINDLER 81 (MARK-2) measures  $\sigma(e^+e^- \rightarrow \psi(3770)) \times$  branching fraction to be  $0.14 \pm 0.03$  nb. We use the MARK-3 (ADLER 88C) value of  $\sigma = 4.2 \pm 0.6 \pm 0.3$  nb.

<sup>44</sup> PERUZZI 77 (MARK-1) measures  $\sigma(e^+e^- \rightarrow \psi(3770)) \times$  branching fraction to be  $0.14 \pm 0.05$  nb. We use the MARK-3 (ADLER 88C) value of  $\sigma = 4.2 \pm 0.6 \pm 0.3$  nb.

### $\Gamma(K_S^0 \pi^+)/\Gamma(K^- \pi^+ \pi^+)$ $\Gamma_{41}/\Gamma_{42}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.1548 ± 0.0032 OUR FIT</b> Error includes scale factor of 1.3.				
<b>0.1533 ± 0.0027 OUR AVERAGE</b>				
0.1530 ± 0.0023 ± 0.0016	10.6k	LINK	02B FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
0.174 ± 0.012 ± 0.011	473	<sup>45</sup> BISHAI	97 CLE2	$e^+e^- \approx \Upsilon(4S)$
0.137 ± 0.015 ± 0.016	264	ANJOS	90C E691	Photoproduction

<sup>45</sup> See BISHAI 97 for an isospin analysis of  $D^+ \rightarrow \bar{K} \pi$  amplitudes.

### $\Gamma(K^- \pi^+ \pi^+)/\Gamma_{\text{total}}$ $\Gamma_{42}/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.0951 ± 0.0034 OUR FIT</b> Error includes scale factor of 1.1.				
<b>0.0945 ± 0.0033 OUR AVERAGE</b>				
0.095 ± 0.002 ± 0.003	15.1k ± 130	<sup>46</sup> HE	05 CLEO	$e^+e^-$ at $\psi(3770)$
0.093 ± 0.006 ± 0.008	1502	<sup>47</sup> BALEST	94 CLE2	$e^+e^- \approx \Upsilon(4S)$
0.091 ± 0.013 ± 0.004	1164	ADLER	88C MRK3	$e^+e^-$ 3.77 GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.064 <sup>+0.015</sup> / <sub>-0.014</sub>		<sup>48</sup> BARLAG	92C ACCM	$\pi^-$ Cu 230 GeV
0.063 <sup>+0.028</sup> / <sub>-0.014</sub> ± 0.011	8	<sup>48</sup> AGUILAR-...	87F HYBR	$\pi p, pp$ 360, 400 GeV
0.091 ± 0.019	239	<sup>49</sup> SCHINDLER 81	MRK2	$e^+e^-$ 3.771 GeV
0.086 ± 0.020	85	<sup>50</sup> PERUZZI 77	MRK1	$e^+e^-$ 3.77 GeV

<sup>46</sup> HE 05 uses single- and double-tagged events in an overall fit. The fraction here includes (unobserved) final-state photons.

<sup>47</sup> BALEST 94 measures the ratio of  $D^+ \rightarrow K^- \pi^+ \pi^+$  and  $D^0 \rightarrow K^- \pi^+$  branching fractions to be  $2.35 \pm 0.16 \pm 0.16$  and uses their absolute measurement of the  $D^0 \rightarrow K^- \pi^+$  fraction (AKERIB 93).

<sup>48</sup> AGUILAR-BENITEZ 87F and BARLAG 92C compute the branching fraction by topological normalization.

<sup>49</sup> SCHINDLER 81 (MARK-2) measures  $\sigma(e^+e^- \rightarrow \psi(3770)) \times$  branching fraction to be  $0.38 \pm 0.05$  nb. We use the MARK-3 (ADLER 88C) value of  $\sigma = 4.2 \pm 0.6 \pm 0.3$  nb.

<sup>50</sup> PERUZZI 77 (MARK-1) measures  $\sigma(e^+e^- \rightarrow \psi(3770)) \times$  branching fraction to be  $0.36 \pm 0.06$  nb. We use the MARK-3 (ADLER 88C) value of  $\sigma = 4.2 \pm 0.6 \pm 0.3$  nb.

## DALITZ PLOT ANALYSIS FORMALISM

Written January 2006 by D. Asner (Carleton University)

**Introduction:** Weak nonleptonic decays of  $D$  and  $B$  mesons are expected to proceed dominantly through resonant two-body decays [1]; see Ref. [2] for a review of resonance phenomenology.

The amplitudes are typically calculated with the Dalitz-plot analysis technique [3], which uses the minimum number of independent observable quantities. For three-body decays of a spin-0 particle to all pseudo-scalar final states,  $D$  or  $B \rightarrow abc$ , the decay rate [4] is

$$\Gamma = \frac{1}{(2\pi)^3 32\sqrt{s^3}} |\mathcal{M}|^2 dm_{ab}^2 dm_{bc}^2, \quad (1)$$

where  $m_{ij}$  is the invariant mass of particles  $i$  and  $j$ . The coefficient of the amplitude includes all kinematic factors, and  $|\mathcal{M}|^2$  contains the dynamics. The scatter plot in  $m_{ab}^2$  versus  $m_{bc}^2$  is the Dalitz plot. If  $|\mathcal{M}|^2$  is constant, the kinematically allowed region of the plot will be populated uniformly with events. Any variation in the population over the Dalitz plot is due to dynamical rather than kinematical effects. It is straightforward to extend the formalism beyond three-body final states. For  $N$ -body final states with only spin-0 particles, phase space has dimension  $3N - 7$ . Other decays of interest include one vector particle or a fermion/anti-fermion pair (*e.g.*,  $B \rightarrow D^* \pi \pi$ ,  $B \rightarrow \bar{\Lambda}_c p \pi$ ,  $B \rightarrow K \ell \ell$ ) in the final state. For the first case, phase space has dimension  $3N - 5$ , and for the latter two the dimension is  $3N - 4$ .

**Formalism:** The amplitude for the process,  $R \rightarrow rc, r \rightarrow ab$  where  $R$  is a  $D$  or  $B$ ,  $r$  is an intermediate resonance, and  $a, b, c$  are pseudo-scalars, is given by

$$\begin{aligned} \mathcal{M}_r(J, L, l, m_{ab}, m_{bc}) &= \sum_{\lambda} \langle ab | r_{\lambda} \rangle T_r(m_{ab}) \langle cr_{\lambda} | R_J \rangle \quad (2) \\ &= Z(J, L, l, \vec{p}, \vec{q}) B_L^R(|\vec{p}|) B_L^r(|\vec{q}|) T_r(m_{ab}). \end{aligned}$$

The sum is over the helicity states  $\lambda$  of  $r$ ,  $J$  is the total angular momentum of  $R$  (for  $D$  and  $B$  decays,  $J=0$ ),  $L$  is the orbital

angular momentum between  $r$  and  $c$ ,  $l$  is the orbital angular momentum between  $a$  and  $b$  (the spin of  $r$ ),  $\vec{p}$  and  $\vec{q}$  are the momenta of  $c$  and of  $a$  in the  $r$  rest frame,  $Z$  describes the angular distribution of the final-state particles,  $B_L^R$  and  $B_L^r$  are the barrier factors for the production of  $rc$  and of  $ab$ , and  $T_r$  is the dynamical function describing the resonance  $r$ . The amplitude for modeling the Dalitz plot is a phenomenological object. Differences in the parametrizations of  $Z$ ,  $B_L$ , and  $T_r$ , as well as in the set of resonances  $r$ , complicate the comparison of results from different experiments.

Usually the resonances are modeled with a Breit-Wigner form, although some more recent analyses use a  $K$ -matrix formalism [5,6,7] with the  $P$ -vector approximation [8] to describe the  $\pi\pi$  S-wave.

The nonresonant (NR) contribution to  $D \rightarrow abc$  is parametrized as constant (S-wave) with no variation in magnitude or phase across the Dalitz plot. The available phase space is much greater for  $B$  decays, and the nonresonant contribution to  $B \rightarrow abc$  requires a more sophisticated parametrization. Theoretical models of the NR amplitude [9-12] do not reproduce the distributions observed in the data. Experimentally, several parametrizations have been used [13,14].

**Barrier Factor  $B_L$ :** The maximum angular momentum  $L$  in a strong decay is limited by the linear momentum  $q$ . Decay particles moving slowly with an impact parameter (meson radius)  $d$  of order 1 fm have difficulty generating sufficient angular momentum to conserve the spin of the resonance. The Blatt-Weisskopf [15,16] functions  $B_L$ , given in Table 1, weight the reaction amplitudes to account for this spin-dependent effect. These functions are normalized to give  $B_L = 1$  for  $z = (|q|d)^2 = 1$ . Another common formulation,  $B_L'$ , also in

Table 1, is normalized to give  $B'_L = 1$  for  $z = z_0 = (|q_0| d)^2$  where  $q_0$  is the value of  $q$  when  $m_{ab} = m_r$ .

**Table 1:** Blatt-Weisskopf barrier factors.

$L$	$B_L(q)$	$B'_L(q, q_0)$
0	1	1
1	$\sqrt{\frac{2z}{1+z}}$	$\sqrt{\frac{1+z_0}{1+z}}$
2	$\sqrt{\frac{13z^2}{(z-3)^2+9z}}$	$\sqrt{\frac{(z_0-3)^2+9z_0}{(z-3)^2+9z}}$

where  $z = (|q| d)^2$  and  $z_0 = (|q_0| d)^2$

**Angular distribution:** The tensor or Zemach formalism [17,18] and the helicity formalism [19,18] yield identical descriptions of the angular distributions for the decay process  $R \rightarrow rc, r \rightarrow ab$  when  $a, b$  and  $c$  all have spin-0. The angular distributions for  $L = 0, 1$ , and  $2$  are given in Table 2. For final-state particles with non-zero spin (*e.g.*, radiative decays), the helicity formalism is required.

**Dynamical Function  $T_r$ :** The dynamical function  $T_r$  is derived from the  $S$ -matrix formalism. In general, the amplitude that a final state  $f$  couples to an initial state  $i$  is  $S_{fi} = \langle f|S|i\rangle$ , where the scattering operator  $S$  is unitary and satisfies  $SS^\dagger = S^\dagger S = I$ . The Lorentz-invariant transition operator  $\hat{T}$  is defined by separating the probability that  $f = i$ , yielding

$$S = I + 2iT = I + 2i \{\rho\}^{1/2} \hat{T} \{\rho\}^{1/2}, \quad (3)$$

**Table 2:** Angular distributions for  $L = 0, 1, 2$  where  $\theta$  is the angle between particles  $a$  and  $c$  in the rest frame of resonance  $r$ ,  $\sqrt{1 + \zeta^2} = E_r/m_{ab}$  is a relativistic correction, and  $E_r = (m_R^2 + m_{ab}^2 - m_c^2)/2m_R$ .

$J \rightarrow L + l$	Angular distribution
$0 \rightarrow 0 + 0$	uniform
$0 \rightarrow 1 + 1$	$(1 + \zeta^2) \cos^2 \theta$
$0 \rightarrow 2 + 2$	$\left(\zeta^2 + \frac{3}{2}\right)^2 (\cos^2 \theta - 1/3)^2$

where  $I$  is the identity operator,  $\rho$  is the diagonal phase-space matrix, with  $\rho_{ii} = 2q_i/m$ , and  $q_i$  is the momentum of  $a$  in the  $r$  rest frame for decay channel  $i$ . In the single-channel S-wave case,  $S = e^{2i\delta}$  satisfies unitarity and

$$\hat{T} = \frac{1}{\rho} e^{i\delta} \sin \delta. \quad (4)$$

There are three common formulations of the dynamical function. The Breit-Wigner formalism—the first term in a Taylor expansion about a  $T$ -matrix pole—is the simplest formulation. The  $K$ -matrix formalism [5] is more general (allowing more than one  $T$ -matrix pole and coupled channels while preserving unitarity). The Flatté distribution [20] is used to parametrize resonances near threshold and is equivalent to a one-pole, two-channel  $K$ -matrix.

***Breit-Wigner Formulation:*** The common formulation of a Breit-Wigner resonance decaying to spin-0 particles  $a$  and  $b$  is

$$T_r(m_{ab}) = \frac{1}{m_r^2 - m_{ab}^2 - im_r \Gamma_{ab}(q)}. \quad (5)$$

The “mass-dependent” width  $\Gamma$  is

$$\Gamma = \Gamma_r \left( \frac{q}{q_r} \right)^{2L+1} \left( \frac{m_r}{m_{ab}} \right) B'_L(q, q_0)^2, \quad (6)$$

and  $B'_L(q, q_0)$  is the Blatt-Weisskopf barrier factor from Table 1. A Breit-Wigner parametrization best describes isolated, non-overlapping resonances far from the threshold of additional decay channels. For the  $\rho$  and  $\rho(1450)$  a more complex parametrization suggested by Gounaris-Sakurai [21] is often used [22-26]. Unitarity can be violated when the dynamical function is parametrized as the sum of two or more overlapping Breit-Wigners. The proximity of a threshold to a resonance distorts the line shape from a simple Breit-Wigner. Here the Flatté formula provides a better description and is discussed below.

***K-matrix Formalism:*** The  $T$  matrix can be written as

$$\hat{T} = (I - i\hat{K}\rho)^{-1}\hat{K}, \quad (7)$$

where  $\hat{K}$  is the Lorentz-invariant  $K$ -matrix describing the scattering process and  $\rho$  is the phase-space factor. Resonances appear as poles in the  $K$ -matrix:

$$\hat{K}_{ij} = \sum_{\alpha} \frac{\sqrt{m_{\alpha}\Gamma_{\alpha i}(m)m_{\alpha}\Gamma_{\alpha j}(m)}}{(m_{\alpha}^2 - m^2)\sqrt{\rho_i\rho_j}}. \quad (8)$$

The  $K$ -matrix is real by construction, and so the associated  $T$ -matrix respects unitarity.

For a single pole in a single channel,  $K$  is

$$K = \frac{m_0\Gamma(m)}{m_0^2 - m^2} \quad (9)$$

and

$$T = K(1 - iK)^{-1} = \frac{m_0\Gamma(m)}{m_0^2 - m^2 - im_0\Gamma(m)}, \quad (10)$$



which is the relativistic Breit-Wigner formula. For two poles in a single channel,  $K$  is

$$K = \frac{m_\alpha \Gamma_\alpha(m)}{m_\alpha^2 - m^2} + \frac{m_\beta \Gamma_\beta(m)}{m_\beta^2 - m^2}. \quad (11)$$

If  $m_\alpha$  and  $m_\beta$  are far apart relative to the widths, the  $T$  matrix is approximately the sum of two Breit-Wigners,  $T(K_\alpha + K_\beta) \approx T(K_\alpha) + T(K_\beta)$ , each of the form of Eq. (10). This approximation is not valid for two nearby resonances, in which case  $T$  can violate unitarity.

This formulation, which applies to  $S$ -channel production in two-body scattering,  $ab \rightarrow cd$ , can be generalized to describe the production of resonances in processes such as the decay of charm mesons. The key assumption here is that the two-body system described by the  $K$ -matrix does *not* interact with the rest of the final state [8]. The validity of this assumption varies with the production process and is appropriate for reactions such as  $\pi^- p \rightarrow \pi^0 \pi^0 n$  and semileptonic decays such as  $D \rightarrow K \pi \ell \nu$ . The assumption may be of limited validity for production processes such as  $p\bar{p} \rightarrow \pi\pi\pi$  or  $D \rightarrow \pi\pi\pi$ . In these cases, the two-body Lorentz-invariant amplitude,  $\hat{F}^i$ , is given by

$$\hat{F}^i = (I - i\hat{K}\rho)_{ij}^{-1} \hat{P}_j = (\hat{T}\hat{K}^{-1})_{ij} \hat{P}_j, \quad (12)$$

where  $P$  is the production vector that parametrizes the resonance production in the open channels.

For the  $\pi\pi$  S-wave, a common formulation of the  $K$ -matrix [7,24,25] is

$$K_{ij}(s) = \left[ \sum_\alpha \left( \frac{g_i^{(\alpha)} g_j^{(\alpha)}}{m_\alpha^2 - s} \right) + f_{ij}^{sc} \frac{1 - s_0^{sc}}{s - s_0^{sc}} \right] \left[ \frac{(s - s_A m_\pi^2/2)(1 - s_{A0})}{(s - s_{A0})} \right]. \quad (13)$$

The factor  $g_i^{(\alpha)}$  is the real coupling constant of the  $K$ -matrix pole  $m_\alpha$  to meson channel  $i$ ; the parameters  $f_{ij}^{sc}$  and  $s_0^{sc}$  describe a smooth part of the  $K$ -matrix elements; the second factor in square brackets suppresses a false kinematical singularity near the  $\pi\pi$  threshold (the Adler zero); and the number 1 has units  $\text{GeV}^2$ .

The production vector, with  $i = 1$  denoting  $\pi\pi$ , is

$$P_j(s) = \left[ \sum_\alpha \left( \frac{\beta_\alpha g_j^{(\alpha)}}{m_\alpha^2 - s} \right) + f_{1j}^{pr} \frac{1 - s_0^{pr}}{s - s_0^{pr}} \right] \left[ \frac{(s - s_A m_\pi^2 / 2)(1 - s_{A0})}{(s - s_{A0})} \right]. \quad (14)$$

where the free parameters of the Dalitz plot fit are the complex production couplings  $\beta_\alpha$  and the production-vector background parameters  $f_{1j}^{pr}$  and  $s_0^{pr}$ . All other parameters are fixed by scattering experiments. Ref. [6] describes the  $\pi\pi$  scattering data with a 4-pole, 2-channel ( $\pi\pi$ ,  $K\bar{K}$ ) model, while Ref. [7] describes the scattering data with 5-pole, 5-channel ( $\pi\pi$ ,  $K\bar{K}$ ,  $\eta\eta$ ,  $\eta'\eta'$  and  $4\pi$ ) model. The former has been implemented by CLEO [27] and the latter by FOCUS [25] and BABAR [24]. In both cases, only the  $\pi\pi$  channel was analyzed. A more complete coupled-channel analysis would simultaneously fit all final states accessible by rescattering.

**Flatté Formalism:** The Flatté formulation is used when a second channel opens close to a resonance:

$$\hat{T}(m_{ab}) = \frac{1}{m_r^2 - m_{ab}^2 - i(\rho_1 g_1^2 + \rho_2 g_2^2)}, \quad (15)$$

where  $g_1^2 + g_2^2 = m_0 \Gamma_r$ . This situation occurs in the  $\pi\pi$  S-wave where the  $f_0(980)$  is near the  $K\bar{K}$  threshold, and in the  $\pi\eta$  channel where the  $a_0(980)$  also lies near the  $K\bar{K}$  threshold. For the  $a_0(980)$  resonance, the relevant coupling constants are

$g_1 = g_{\pi\eta}$  and  $g_2 = g_{KK}$ , and the phase space terms are  $\rho_1 = \rho_{\pi\eta}$  and  $\rho_2 = \rho_{KK}$ , where

$$\rho_{ab} = \sqrt{\left(1 - \left(\frac{m_a - m_b}{m_{ab}}\right)^2\right) \left(1 + \left(\frac{m_a - m_b}{m_{ab}}\right)^2\right)}. \quad (16)$$

For the  $f_0(980)$  the relevant coupling constants are  $g_1 = g_{\pi\pi}$  and  $g_2 = g_{KK}$ , and the phase space terms are  $\rho_1 = \rho_{\pi\pi}$  and  $\rho_2 = \rho_{KK}$ . The charged and neutral  $K$  channels are usually assumed to have the same coupling constant but different phase space factors, due to  $m_{K^+} \neq m_{K^0}$ ; the result is

$$\rho_{KK} = \frac{1}{2} \left( \sqrt{1 - \left(\frac{2m_{K^\pm}}{m_{KK}}\right)^2} + \sqrt{1 - \left(\frac{2m_{K^0}}{m_{KK}}\right)^2} \right). \quad (17)$$

**Branching Ratios from Dalitz Plot Fits:** A fit to the Dalitz plot distribution using either a Breit-Wigner or a  $K$ -matrix formalism factorizes into a resonant contribution to the amplitude  $\mathcal{M}_j$  and a complex coefficient,  $a_j e^{i\delta_j}$ , where  $a_j$  and  $\delta_j$  are real. The definition of a rate of a single process, given a set of amplitudes  $a_j$  and phases  $\delta_j$ , is the square of the relevant matrix element (see Eq. (1)). The “fit fraction” is usually defined as the integral over the Dalitz plot ( $m_{ab}$  vs.  $m_{bc}$ ) of a single amplitude squared divided by the integral over the Dalitz plot of the square of the coherent sum of all amplitudes, or

$$\text{fit fraction}_j = \frac{\int |a_j e^{i\delta_j} \mathcal{M}_j|^2 dm_{ab}^2 dm_{bc}^2}{\int \left| \sum_k a_k e^{i\delta_k} \mathcal{M}_k \right|^2 dm_{ab}^2 dm_{bc}^2}, \quad (18)$$

where  $\mathcal{M}_j$  is defined in Eq. (2) and described in Ref. [28]. In general, the sum of the fit fractions for all components will not be unity due to interference.

When the  $K$ -matrix of Eq. (12) is used to describe a wave (*e.g.*, the  $\pi\pi$  S-wave), then  $\mathcal{M}_j$  refers to the entire wave. In

this case, it may not be straightforward to separate  $\mathcal{M}_j$  into a sum of individual resonances unless these are narrow and well separated.

***Reconstruction Efficiency and Resolution:*** The efficiency for reconstructing an event as a function of position on the Dalitz plot is in general non-uniform. Typically, a Monte Carlo sample generated with a uniform distribution in phase space is used to determine the efficiency. The variation in efficiency across the Dalitz plot varies with experiment and decay mode. Most recent analyses utilize a full GEANT [29] detector simulation.

Finite detector resolution can usually be safely neglected as most resonances are comparatively broad. Notable exceptions where detector resolution effects must be modeled are  $\phi \rightarrow K^+K^-$ ,  $\omega \rightarrow \pi^+\pi^-$ , and  $a_0 \rightarrow \eta\pi^0$ . One approach is to convolve the resolution function in the Dalitz-plot variables  $m_{ab}^2$  and  $m_{bc}^2$  with the function that parametrizes the resonant amplitudes. In high-statistics data samples, resolution effects near the phase-space boundary typically contribute to a poor goodness of fit. The momenta of the final-state particles can be recalculated with a  $D$  or  $B$  mass constraint, which forces the kinematic boundaries of the Dalitz plot to be strictly respected. If the three-body mass is not constrained, then the efficiency (and the parametrization of background) may also depend on the reconstructed mass.

***Backgrounds:*** The contribution of background to the  $D$  and  $B$  samples varies by experiment and final state. The background naturally falls into five categories: (i) purely combinatoric background containing no resonances; (ii) combinatoric background containing intermediate resonances, such as a real  $K^{*-}$  or  $\rho$ , plus additional random particles; (iii) final states

containing identical particles as in  $D^0 \rightarrow K_S^0 \pi^0$  background to  $D^0 \rightarrow \pi^+ \pi^- \pi^0$  and  $B \rightarrow D\pi$  background to  $B \rightarrow K\pi\pi$ ; (iv) mistagged decays such as a real  $\bar{D}^0$  or  $\bar{B}^0$  incorrectly identified as a  $D^0$  or  $B^0$ ; and (v) particle misidentification of the decay products such as  $D^+ \rightarrow \pi^- \pi^+ \pi^+$  or  $D_s^+ \rightarrow K^- K^+ \pi^+$  reconstructed as  $D^+ \rightarrow K^- \pi^+ \pi^+$ .

The contribution from combinatoric background with intermediate resonances is distinct from the resonances in the signal because the former do *not* interfere with the latter since they are not from true resonances. Similarly,  $D^0 \rightarrow \rho\pi$  and  $D^0 \rightarrow K_S^0 \pi^0$  do not interfere since strong and weak transitions proceed on different time scales. The usual identification tag of the initial particle as a  $D^0$  or a  $\bar{D}^0$  is the charge of the distinctive slow pion in the decay sequence  $D^{*+} \rightarrow D^0 \pi_s^+$  or  $D^{*-} \rightarrow \bar{D}^0 \pi_s^-$ . Another possibility is the identification or “tagging” of one of the  $D$  mesons from  $\psi(3770) \rightarrow D^0 \bar{D}^0$ , as is done for  $B$  mesons from  $\Upsilon(4S)$ . The mistagged background is subtle and may be mistakenly enumerated in the *signal* fraction determined by a  $D^0$  mass fit. Mistagged decays contain true  $\bar{D}^0$ 's or  $\bar{B}^0$ 's and so the resonances in the mistagged sample exhibit interference on the Dalitz plot.

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## REVIEW OF CHARM DALITZ PLOT ANALYSES

Written January 2006 by D. Asner (Carleton University)

For references given here in the form SMITH 05, see the references at the end of the  $D^+$ ,  $D^0$ , and  $D_s^+$  Listings.

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The formalism of Dalitz-Plot analysis is reviewed in the preceding note. Table 1 lists reported analyses of  $D$  mesons. In the following, we discuss a number of subjects of current interest: (1)  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$ ; (2)  $D \rightarrow \pi \pi \pi$ : a  $\sigma(500)$  or  $f_0(600)$ ; (3)  $D^+ \rightarrow K^- \pi^+ \pi^+$ : a  $\kappa(800)$ ? (4) the  $f_0(980)$ ,  $f_0(1370)$  and  $f_0(1500)$ ; (5) doubly Cabibbo-suppressed decays; and (6)  $CP$  violation.

$D^0 \rightarrow K_S^0 \pi^+ \pi^-$ : Several experiments have analyzed  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$  decay (see Table 1). The most precise results are from CLEO (BABAR and Belle, discussed below, have not yet evaluated systematic uncertainties). The CLEO analysis included ten resonances:  $K_S^0 \rho^0$ ,  $K_S^0 \omega$ ,  $K_S^0 f_0(980)$ ,  $K_S^0 f_2(1270)$ ,  $K_S^0 f_0(1370)$ ,  $K^*(892)^- \pi^+$ ,  $K_0^*(1430)^- \pi^+$ ,  $K_2^*(1430)^- \pi^+$ ,  $K^*(1680)^- \pi^+$ , and the doubly Cabibbo-suppressed mode  $K^*(892)^+ \pi^-$ . CLEO found a much smaller nonresonant contribution than did the earliest experiments.

**Table 1:** Reported Dalitz plot analyses.

Decay	Experiment(s)
$D^0 \rightarrow K_S^0 \pi^+ \pi^-$	Mark II <sup>a</sup> , Mark III <sup>b</sup> , E691 <sup>c</sup> , E687 <sup>d,e</sup> , ARGUS <sup>f</sup> , CLEO <sup>g</sup> , Belle [10,11], BABAR [12,13]
$D^0 \rightarrow K^- \pi^+ \pi^0$	Mark III <sup>b</sup> , E687 <sup>e</sup> , E691 <sup>c</sup> , CLEO <sup>h</sup>
$D^0 \rightarrow \bar{K}^0 K^+ \pi^-$	BABAR [14]
$D^0 \rightarrow K^0 K^- \pi^+$	BABAR [14]
$D^0 \rightarrow K_S^0 \eta \pi^0$	CLEO <sup>i</sup>
$D^0 \rightarrow \pi^+ \pi^- \pi^0$	CLEO <sup>j</sup>
$D^0 \rightarrow K_S^0 K^+ K^-$	BABAR <sup>k</sup>
$D^0 \rightarrow K^- K^+ K^- \pi^+$	FOCUS <sup>l</sup>
$D^0 \rightarrow K^- K^+ \pi^- \pi^+$	FOCUS <sup>m</sup>
$D^+ \rightarrow K^- \pi^+ \pi^+$	Mark III <sup>b</sup> , E687 <sup>e</sup> , E691 <sup>c</sup> , E791 <sup>n</sup>
$D^+ \rightarrow \bar{K}^0 \pi^+ \pi^0$	Mark III <sup>b</sup>
$D^+ \rightarrow \pi^+ \pi^+ \pi^-$	E687 <sup>o</sup> , E791 <sup>p</sup> , FOCUS [5] <sup>q</sup>
$D^+ \rightarrow K^+ K^- \pi^+$	FOCUS [15], E687 <sup>r</sup> , BABAR <sup>s</sup>
$D^+ \rightarrow K^+ \pi^+ \pi^-$	E791 <sup>t</sup> , FOCUS <sup>u</sup>
$D_s^+ \rightarrow K^+ K^- \pi^+$	E687 <sup>r</sup> , FOCUS [15]
$D_s^+ \rightarrow \pi^+ \pi^+ \pi^-$	E687 <sup>o</sup> , E791 <sup>v</sup> , FOCUS [5]
$D_s^+ \rightarrow K^+ \pi^+ \pi^-$	FOCUS <sup>u</sup>

See the end of the  $D^+$ ,  $D^0$  and  $D_s^+$  Listings for these references: <sup>a</sup>SCHINDLER 81, <sup>b</sup>ADLER 87, <sup>c</sup>ANJOS 93, <sup>d</sup>FRABETTI 92B, <sup>e</sup>FRABETTI 94G, <sup>f</sup>ALBRECHT 93D, <sup>g</sup>MURAMATSU 02, <sup>h</sup>KOPP 01, <sup>i</sup>RUBIN 04, <sup>j</sup>CRONIN-HENNESSY 05, <sup>k</sup>AUBERT 05B, <sup>l</sup>LINK 03G, <sup>m</sup>LINK 05C, <sup>n</sup>AITALA 02, <sup>o</sup>FRABETTI 97D, <sup>p</sup>AITALA 01B, <sup>q</sup>LINK 04, <sup>r</sup>FRABETTI 95B, <sup>s</sup>AUBERT 05A, <sup>t</sup>AITALA 97C, <sup>u</sup>LINK 04F, <sup>v</sup>AITALA 01A.

The source of the nonresonant component found in the early



experiments has been attributed to the broad scalar resonances, the  $K_0^*(1430)^-$  and  $f_0(1370)$ , found in the later, larger data samples. The observation of a small but significant nonresonant component in the largest data samples suggests the presence of additional broad scalar resonances, the  $\kappa(800)$  and  $\sigma(500)$ . The CLEO analysis could accommodate the  $\sigma(500)$  in lieu of the nonresonant component, but found no evidence for the  $\kappa(800)$ .

The ten quasi-two-body intermediate states in the CLEO analysis include both  $CP$ -even and  $CP$ -odd eigenstates and one doubly Cabibbo-suppressed channel. A time-dependent analysis of the Dalitz plot allows simultaneous determination of the strong transition amplitudes and phases and the mixing parameters  $x$  and  $y$  without phase or sign ambiguity. Using  $9 \text{ fb}^{-1}$ , CLEO obtained  $(-4.5 < x < 9.3)\%$  and  $(-6.4 < y < 3.6)\%$  [1].

The decay  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$ , important for the study of the CKM angle  $\gamma/\phi_3$  [6], is under study by Belle [10,11] and BABAR [12,13]. The CLEO model does not provide a good description of the higher-statistics BABAR and Belle data samples. An improved description is obtained in two ways: First, by adding more Breit-Wigner resonances, including two  $\pi\pi$  resonances with arbitrary mass and width, denoted as  $\sigma_1$  and  $\sigma_2$ . Second, following the methodology of FOCUS [LINK 04], by applying a  $K$ -matrix model to the  $\pi\pi$  S-wave [12].

Charm Dalitz-plot analyses might also prove useful for calibrating tools used to study  $B$  decays: specifically, to extract  $\alpha$  from  $B^0 \rightarrow \pi^+ \pi^- \pi^0$ ,  $\beta$  from  $b \rightarrow s$  penguin decays (*e.g.*,  $B^0 \rightarrow \bar{K}^0 K^+ K^-$ ), and  $\gamma$  from  $B^\pm \rightarrow DK^\pm$  followed by  $D^0 \rightarrow \pi^+ \pi^- \pi^0$  or  $K_S^0 K^+ K^-$  or  $K^+ K^- \pi^0$ , in addition to the well-studied  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$  [2, 3].

**$D \rightarrow \pi\pi\pi$ :  $\sigma(500)$  or  $f_0(600)$** : The decay  $D^+ \rightarrow \pi^+\pi^+\pi^-$  has been studied by the E687, E791 and FOCUS experiments (see Table 1). The E687 analysis considered the modes  $\rho(770)^0\pi^+$ ,  $f_0(980)\pi^+$ ,  $f_2(1270)\pi^+$ , and a nonresonant component. E791 included, in addition,  $f_0(1370)\pi^+$  and  $\rho(1450)^0\pi^+$ . Both analyses found a very large fraction ( $\sim 50\%$ ) for the nonresonant component, perhaps indicating a broad scalar contribution. E791 found the nonresonant amplitude to be consistent with zero if a broad scalar resonance was included. FOCUS analyzed its data using both the Breit-Wigner formalism and the  $K$ -matrix formalism for the  $\pi^+\pi^-$  S-wave, following a 5-pole, 5-resonance model of Anisovich and Sarantsev [16]. The Breit-Wigner analysis included  $\rho(770)^0$ ,  $f_0(980)$ ,  $f_2(1270)^0$ ,  $f_0(1500)$ ,  $\sigma(500)$ , and a nonresonant component. The  $K$ -matrix formalism, with Breit-Wigner forms for the  $\rho(770)$  and  $f_2(1270)$ , also describe the FOCUS data well. None of these analyses has modeled the dynamics of the  $\pi^+\pi^+$  interaction. Consideration of the  $I = 2$  S- and D-wave phase shifts, also measured in  $\pi^+p \rightarrow \pi^+\pi^+n$  [18], could affect the  $\pi^+\pi^-$  S-wave result.

Using the E791 data, Bediaga and Miranda [19] found additional evidence that the low-mass  $\pi^+\pi^-$  feature is resonant by examining the phase of the  $\pi^+\pi^-$  amplitude in the vicinity of the reported  $\sigma(500)$  mass. The phase variation with invariant mass is consistent with a resonant interpretation.

Table 1 gives the parameters of the  $\sigma(500)$  determined in charm Dalitz-plot analyses. A consistent relative phase between the  $\sigma(500)$  and  $\rho(770)$  resonances is observed.

**Table 2:** Parameters of the  $\sigma(500)$  resonance. The amplitude and phase are relative to the  $\rho(770)$ .

Experiment	E791 <sup>a</sup>	CLEO <sup>b</sup>	FOCUS [5]
Decay mode	$D^+ \rightarrow \pi^+\pi^+\pi^-$	$D^0 \rightarrow K_S^0\pi^+\pi^-$	$D^+ \rightarrow \pi^+\pi^+\pi^-$
Amplitude	$1.17 \pm 0.13 \pm 0.06$	$0.57 \pm 0.13$	—
Phase ( $^\circ$ )	$205.7 \pm 8.0 \pm 5.2$	$214 \pm 11$	$200 \pm 31$
$m$ (MeV/c <sup>2</sup> )	$478_{-23}^{+24} \pm 17$	$513 \pm 32$	$443 \pm 27$
$\Gamma$ (MeV/c <sup>2</sup> )	$324_{-40}^{+42} \pm 21$	$335 \pm 67$	$443 \pm 80$

See the end of the  $D^+$  and  $D^0$  listings for these references: <sup>a</sup>AITALA 01B, <sup>b</sup>MURAMATSU 02.

CLEO has studied  $D^0 \rightarrow \pi^+\pi^-\pi^0$  (see Table 1). Only the three  $\rho(770)\pi$  resonant contributions are observed. No evidence is found for any  $\pi\pi$   $S$ -wave, either with the Breit-Wigner or with a  $K$ -matrix parametrization, using the 4-pole, 2-resonance model of Au, Morgan, and Pennington [17].

**$D^+ \rightarrow K^-\pi^+\pi^+$ :  $\alpha\kappa(800)$ ?** Evidence for a broad  $K\pi$  scalar resonance has been found by E791 in  $D^+ \rightarrow K^-\pi^+\pi^+$  (see Table 1). Fitting the Dalitz plot with  $\overline{K}^*(892)^0\pi^+$ ,  $\overline{K}_0^*(1430)^0\pi^+$ ,  $\overline{K}_2^*(1430)^0\pi^+$ , and  $\overline{K}^*(1680)^0\pi^+$ , plus a constant nonresonant component, E791 found results consistent with earlier analyses by E691 and E687, with a nonresonant fit fraction of over 90%. With more events than the other experiments, E791 was then led to include an extra low-mass  $S$ -wave  $\overline{K}\pi$  resonance to account for the poor fit already seen by earlier experiments. A  $\kappa(800)$  with mass  $797 \pm 19 \pm 43$  MeV and width  $410 \pm 43 \pm 87$  MeV much improved the fit. The  $\kappa(800)$  became the dominant resonance and the nonresonant fit fraction was reduced from  $90.9 \pm 2.6\%$  to  $13.0 \pm 5.8 \pm 4.4\%$ .

In addition, E791 modeled the  $K\pi$  S-wave phase variation as a function of  $K\pi$  mass with only the  $K_0^*(1430)$  resonance and a nonresonant component following a parametrization of LASS [20]. It was necessary to relax the unitarity constraint to describe the data [21]. The  $K\pi$  S-wave phase behavior in this model was consistent with the model that included the  $\kappa$  resonance.

Finally, E791 performed a model-independent partial-wave analysis [AITALA 05] of the  $S$ -wave component of the  $K\pi$  system, finding the amplitude and phase from the  $K\pi$  threshold up to 1.72 GeV. No assumptions were made regarding dependence on invariant mass, but the analysis did use the relatively well-understood  $P$ - and  $D$ -waves, described by the  $K^*(892)$  and  $K^*(1680)$  and by the  $K_2(1430)$ , respectively. The results were similar to those obtained by AITALA 02, which parametrized the  $S$ -wave with  $\kappa$  and  $K_0(1430)$  Breit-Wigner forms and a constant complex non-resonant term. As with the  $\sigma(500)$ , the  $K^-\pi^+$  S-wave result could be affected by including dynamics of the  $I = 2$   $\pi^+\pi^+$  interaction; however in AITALA 05, the  $I = 2$  elastic amplitude was found to be negligible compared to the  $\kappa$ .

CLEO allowed scalar  $K\pi$  resonances in fits to  $D^0 \rightarrow K^-\pi^+\pi^0$  and  $D^0 \rightarrow K_S^0\pi^+\pi^-$  (see Table 1), and observed a significant contribution from only the  $K_0^*(1430)$  [22]. BABAR fit  $D^0 \rightarrow K^0K^-\pi^+$  with both positively charged and neutral  $\overline{K}^*(892)$ ,  $\overline{K}_0^*(1430)$ ,  $\overline{K}_2^*(1430)$ , and  $\overline{K}^*(1680)$  resonances, as well as the  $a_0(980)^-$ ,  $a_0(1450)^-$ , and  $a_2(1310)^-$  resonances, and a nonresonant component [14]. BABAR also fit  $D^0 \rightarrow \overline{K}^0K^+\pi^-$  with the same resonances except for the  $a_2(1310)^-$ . In both cases, a good fit was obtained without including the  $\kappa$ .

FOCUS has conclusively observed a  $K\pi$  S-wave as a distortion of the  $K^*(892)$  line-shape in semileptonic charm decays [LINK 02E, LINK 05D].

**The  $f_0(980)$ ,  $f_0(1370)$  and  $f_0(1500)$ :** The meson content of the  $0^{++}$  nonet and the quark content of the  $f_0(980)$ ,  $a_0(980)$ ,  $f_0(1370)$ ,  $f_0(1500)$ , and  $f_0(1710)$  mesons are current puzzles in light-meson spectroscopy [22]. Measuring branching fractions and couplings to different final states and comparing scalar-meson production rates among  $D^0$ ,  $D^+$ , and  $D_s^+$  mesons may help solve these puzzles.

For example: A large contribution of  $f_0(980)$  to  $D^0 \rightarrow K_S^0 K^+ K^-$  was reported by ARGUS [ALBRECHT 87E] and by BABAR [14]. This is inconsistent with the smaller contribution of  $f_0(980)$  observed in  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$  by CLEO. The explanation is that  $D^0 \rightarrow K_S^0 K^+ K^-$  has a large contribution from  $a_0(980)^0 \rightarrow K^+ K^-$ . Therefore CLEO studied  $D^0 \rightarrow K_S^0 \eta \pi^0$  [RUBIN 04], where the dominant contribution is from  $K_S^0 a_0(980)^0$ ,  $a_0(980)^0 \rightarrow \eta \pi^0$ , and there can be no  $f_0(980)$ . A more recent BABAR analysis of  $D^0 \rightarrow K_S^0 K^+ K^-$  found a large amount of  $a_0(980) \rightarrow K \bar{K}$  and little  $f_0(980)$  [AUBERT 05B].

The proximity of the  $K \bar{K}$  threshold requires either a coupled-channel Breit-Wigner function [23] or a Flatte parametrization [24] of the  $f_0(980)$ . The width of the  $f_0(980)$  is poorly known. E791 and FOCUS [LINK 05C] [5] used a coupled-channel Breit-Wigner function to describe the  $f_0(980)$  in  $D_s^+ \rightarrow \pi^+ \pi^+ \pi^-$ . BESII studied the  $f_0(980)$  in  $J/\psi \rightarrow \phi \pi^+ \pi^-$  and  $\phi K^+ K^-$  [25]. The values found for the couplings to the  $\pi\pi$  and  $K \bar{K}$  channels,  $g_{\pi\pi}$  and  $g_{KK}$ , were not consistent. Results such as these are desirable for input to the analysis of  $D_s^+ \rightarrow K^+ K^- \pi^+$  [15], which includes both the  $f_0(980)$  and  $a_0(980)$ .

The quark content of the  $f_0(1370)$  and  $f_0(1500)$  can perhaps be inferred from how they populate various Dalitz plots. Results so far are confusing. The E791 analysis of

$D^+ \rightarrow \pi^+\pi^+\pi^-$  [AITALA 01B] found some  $f_0(1370)$  but no  $f_0(1500)$ , while the FOCUS analysis [5] of this mode found little  $f_0(1370)$ . In  $D_s^+ \rightarrow \pi^+\pi^+\pi^-$ , E687 and FOCUS [5] found no  $f_0(1370)$ , but did find a resonance with parameters similar to the  $f_0(1500)$ , whereas E791 found a  $\pi^+\pi^-$  resonance with mass  $1434 \pm 18 \pm 9$  MeV and width  $172 \pm 32 \pm 6$  MeV, consistent with neither the  $f_0(1370)$  or  $f_0(1500)$ . BABAR [AUBERT 05B] in  $D^0 \rightarrow \bar{K}^0 K^+ K^-$  found neither the  $f_0(1370)$  nor the  $f_0(1500)$ , but did observe a  $K^+ K^-$  resonance consistent with the values from E791 given above, while CLEO has observed the  $f_0(1370)$  in  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$ . The FOCUS analysis that used the  $K$ -matrix formalism for the  $\pi\pi$  S-wave observed significant couplings to five  $T$ -matrix poles— $f_0(980)$ ,  $f_0(1300)$ ,  $f_0(1200-1600)$ ,  $f_0(1500)$ ,  $f_0(1750)$ —in both  $D^+ \rightarrow \pi^+\pi^-\pi^+$  and  $D_s^+ \rightarrow \pi^+\pi^-\pi^+$ . Again, the quark content of each pole might be inferred from the coupling to various Dalitz plots.

It is noteworthy that the S-wave observed in  $B$  Dalitz-plot analyses appears to be different than that observed in  $D$ -meson decays.

***Doubly Cabibbo-Suppressed Decays:*** There are two classes of multibody doubly Cabibbo-suppressed (DCS) decays of  $D$  mesons. The first consists of those in which the DCS and corresponding Cabibbo-favored (CF) decays populate distinct Dalitz plots: the pairs  $D^0 \rightarrow K^+\pi^-\pi^0$  and  $D^0 \rightarrow K^-\pi^+\pi^0$ , or  $D^+ \rightarrow K^+\pi^+\pi^-$  and  $D^+ \rightarrow K^-\pi^+\pi^+$ , are examples. CLEO [BRANDENBURG 01] and Belle [TIAN 05] have reported  $\Gamma(D^0 \rightarrow K^+\pi^-\pi^0)/\Gamma(D^0 \rightarrow K^-\pi^+\pi^0) = (0.43_{-0.10}^{+0.11} \pm 0.07)\%$  and  $(0.229 \pm 0.015_{-0.009}^{+0.013})\%$ , respectively. E791 and FOCUS have reported  $\Gamma(D^+ \rightarrow K^+\pi^-\pi^+)/\Gamma(D^+ \rightarrow K^-\pi^+\pi^+) = (0.77 \pm 0.17 \pm 0.08)\%$  and  $(0.65 \pm 0.08 \pm 0.04)\%$ , respectively.

The second class consists of decays in which the DCS and CF modes populate the same Dalitz plot; for example,  $D^0 \rightarrow K^{*-}\pi^+$  and  $D^0 \rightarrow K^{*+}\pi^-$  both contribute to  $D^0 \rightarrow K_S^0\pi^+\pi^-$ . In this case, the potential for interference of DCS and CF amplitudes increases the sensitivity to the DCS amplitude. CLEO found the relative amplitude and phase to be  $(7.1 \pm 1.3_{-0.6}^{+2.6+2.6})\%$  and  $(189 \pm 10 \pm 3_{-5}^{+15})^\circ$ , corresponding to  $\Gamma(D^0 \rightarrow K^*(892)^+\pi^-)/\Gamma(D^0 \rightarrow K^*(892)^-\pi^+) = (0.5 \pm 0.2_{-0.1}^{+0.5+0.4})\%$ . In addition to  $D^0 \rightarrow K^*(892)^+\pi^-$ , Belle [10,11] and BABAR [12,13] have found evidence for  $D^0 \rightarrow K_0(1430)^+\pi^-$  and  $K_2(1430)^+\pi^-$ , and Belle has also found evidence for  $K^*(1680)^+\pi^-$ .

***CP Violation:*** In the limit of *CP* conservation, charge conjugate decays will have the same Dalitz-plot distribution. The  $D^{\pm}$  tag enables the discrimination between  $D^0$  and  $\bar{D}^0$ . The integrated *CP* violation across the Dalitz plot is determined in two ways. The first uses

$$\mathcal{A}_{CP} = \int \left( \frac{|\mathcal{M}|^2 - |\bar{\mathcal{M}}|^2}{|\mathcal{M}|^2 + |\bar{\mathcal{M}}|^2} \right) dm_{ab}^2 dm_{bc}^2 \bigg/ \int dm_{ab}^2 dm_{bc}^2, \quad (1)$$

where  $\mathcal{M}$  and  $\bar{\mathcal{M}}$  are the  $D^0$  and  $\bar{D}^0$  Dalitz-plot amplitudes. The second uses the asymmetry in the efficiency-corrected  $D^0$  and  $\bar{D}^0$  yields,

$$\mathcal{A}_{CP} = \frac{N_{D^0} - N_{\bar{D}^0}}{N_{D^0} + N_{\bar{D}^0}}. \quad (2)$$

These expressions are less sensitive to *CP* violation than are the individual resonant submodes [ASNER 04A]. Table 3 lists the results for *CP* violation. No evidence of *CP* violation has been observed in *D*-meson decays.

**Table 3:** Dalitz-plot-integrated  $CP$  violation. Measurements computing  $\mathcal{A}_{CP}$  with Eq. (2) rather than Eq. (1) are denoted  $\dagger$ .

Experiment	Decay mode	$\mathcal{A}_{CP}(\%)$
BABAR <sup>a</sup>	$D^+ \rightarrow K^+ K^- \pi^+$	$1.4 \pm 1.0 \pm 0.8$
Belle <sup>b\dagger</sup>	$D^0 \rightarrow K^+ \pi^- \pi^0$	$-0.6 \pm 5.3$
Belle <sup>b\dagger</sup>	$D^0 \rightarrow K^+ \pi^- \pi^+ \pi^-$	$-1.8 \pm 4.4$
CLEO <sup>c</sup>	$D^0 \rightarrow K^- \pi^+ \pi^0$	$-3.1 \pm 8.6$
CLEO <sup>d\dagger</sup>	$D^0 \rightarrow K^+ \pi^- \pi^0$	$+9_{-25}^{+22}$
CLEO <sup>e</sup>	$D^0 \rightarrow K_S^0 \pi^+ \pi^-$	$-0.9 \pm 2.1_{-4.3-3.7}^{+1.0+1.3}$
CLEO <sup>f</sup>	$D^0 \rightarrow \pi^+ \pi^- \pi^0$	$+1_{-7}^{+9} \pm 9$

See the end of the  $D^+$  and  $D^0$  Listings for these references: <sup>a</sup>AUBERT 05A, <sup>b</sup>TIAN 05, <sup>c</sup>KOPP 01, <sup>d</sup>BRANDENBURG 01, <sup>e</sup>ASNER 04A, <sup>f</sup>CRONIN-HENNESSY 05.

The possibility of interference between  $CP$ -conserving and  $CP$ -violating amplitudes provides a more sensitive probe of  $CP$  violation. The constraints on the square of the  $CP$ -violating amplitude obtained in the resonant submodes of  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$  range from  $3.5 \times 10^{-4}$  to  $28.4 \times 10^{-4}$  at 95% confidence level [ASNER 04A].

## References

1. See the note on “ $D^0$ - $\bar{D}^0$  Mixing” in this *Review*.
2. See the note on “The CKM Quark Mixing Matrix” in this *Review*.
3. See the note on “ $CP$  Violation in Meson Decays” in this *Review*.
4. Dalitz plot analysis of the wrong sign rate  $D^0 \rightarrow K^+ \pi^- \pi^0$  [BRANDENBURG 01] and the time dependence of Dalitz



plot analysis of  $D^0 \rightarrow K_S^0 \pi^+ \pi^-$  [ASNER 05] are two candidate processes.

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$\Gamma(\overline{K}_0^*(800)^0 \pi^+, \overline{K}_0^*(800) \rightarrow K^- \pi^+)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{43}/\Gamma_{42}$

This is the “fit fraction” from the Dalitz-plot analysis. The  $K_0^*(800)$  is a broad scalar resonance that may not exist and is not included in the Summary Tables. AITALA 02 finds that including such a resonance in the fit to the  $D^+ \rightarrow K^- \pi^+ \pi^+$  Dalitz plot greatly improves the fit. However, the results of AITALA 02 for the  $D^+ \rightarrow K^- \pi^+ \pi^+$  Dalitz plot analysis so disagree with earlier analyses that averaging the results makes no sense. For now, we exclude AITALA 02 from the average.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.478 \pm 0.121 \pm 0.053$	AITALA	02 E791	$\pi^-$ nucleus, 500 GeV

$\Gamma(\overline{K}^*(892)^0 \pi^+, \overline{K}^*(892)^0 \rightarrow K^- \pi^+)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{44}/\Gamma_{42}$

This is the “fit fraction” from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>0.140 \pm 0.010</math> OUR AVERAGE</b>			
$0.137 \pm 0.006 \pm 0.009$	FRABETTI	94G E687	$\gamma$ Be, $\overline{E}_\gamma \approx 220$ GeV
$0.170 \pm 0.009 \pm 0.034$	ANJOS	93 E691	$\gamma$ Be 90–260 GeV
$0.14 \pm 0.04 \pm 0.04$	ALVAREZ	91B NA14	Photoproduction
$0.13 \pm 0.01 \pm 0.07$	ADLER	87 MRK3	$e^+ e^-$ 3.77 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.123 \pm 0.010 \pm 0.009$	<sup>51</sup> AITALA	02 E791	$\pi^-$ nucleus, 500 GeV

<sup>51</sup>AITALA 02 includes a broad scalar  $K_0^*(800)$  in the fit to the  $D^+ \rightarrow K^- \pi^+ \pi^+$  Dalitz plot. This (a) greatly improves the fit, and (b) gives results in other channels that greatly disagree with previous analyses. The disagreement is so large that it makes no sense to average the results with those of earlier experiments. For now, we exclude AITALA 02 from the average.

$\Gamma(\overline{K}_0^*(1430)^0 \pi^+, \overline{K}_0^*(1430)^0 \rightarrow K^- \pi^+)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{45}/\Gamma_{42}$

This is the “fit fraction” from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>0.253 \pm 0.024</math> OUR AVERAGE</b>			
$0.284 \pm 0.022 \pm 0.059$	FRABETTI	94G E687	$\gamma$ Be, $\overline{E}_\gamma \approx 220$ GeV
$0.248 \pm 0.019 \pm 0.017$	ANJOS	93 E691	$\gamma$ Be 90–260 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$0.125 \pm 0.014 \pm 0.005$	<sup>52</sup> AITALA	02 E791	$\pi^-$ nucleus, 500 GeV

<sup>52</sup>AITALA 02 includes a broad scalar  $K_0^*(800)$  in the fit to the  $D^+ \rightarrow K^- \pi^+ \pi^+$  Dalitz plot. This (a) greatly improves the fit, and (b) gives results in other channels that greatly disagree with previous analyses. The disagreement is so large that it makes no sense to average the results with those of earlier experiments. For now, we exclude AITALA 02 from the average.

$\Gamma(\overline{K}_2^*(1430)^0 \pi^+, \overline{K}_2^*(1430)^0 \rightarrow K^- \pi^+)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{46}/\Gamma_{42}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.005 ± 0.001 ± 0.002 <sup>53</sup> AITALA 02 E791  $\pi^-$  nucleus, 500 GeV

<sup>53</sup> AITALA 02 includes a broad scalar  $K_0^*(800)$  in the fit to the  $D^+ \rightarrow K^- \pi^+ \pi^+$  Dalitz plot. This (a) greatly improves the fit, and (b) gives results in other channels that greatly disagree with previous analyses. The disagreement is so large that it makes no sense to average the results with those of earlier experiments. For now, we exclude AITALA 02 from the average.

$\Gamma(\overline{K}^*(1680)^0 \pi^+, \overline{K}^*(1680)^0 \rightarrow K^- \pi^+)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{47}/\Gamma_{42}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
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**0.042 ± 0.008 OUR AVERAGE**

0.047 ± 0.006 ± 0.007 FRABETTI 94G E687  $\gamma$ Be,  $\overline{E}_\gamma \approx 220$  GeV

0.030 ± 0.004 ± 0.013 ANJOS 93 E691  $\gamma$ Be 90–260 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.025 ± 0.007 ± 0.003 <sup>54</sup> AITALA 02 E791  $\pi^-$  nucleus, 500 GeV

<sup>54</sup> AITALA 02 includes a broad scalar  $K_0^*(800)$  in the fit to the  $D^+ \rightarrow K^- \pi^+ \pi^+$  Dalitz plot. This (a) greatly improves the fit, and (b) gives results in other channels that greatly disagree with previous analyses. The disagreement is so large that it makes no sense to average the results with those of earlier experiments. For now, we exclude AITALA 02 from the average.

$\Gamma(K^- \pi^+ \pi^+ \text{ nonresonant})/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{48}/\Gamma_{42}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
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**0.95 ± 0.07 OUR AVERAGE**

0.998 ± 0.037 ± 0.072 FRABETTI 94G E687  $\gamma$ Be,  $\overline{E}_\gamma \approx 220$  GeV

0.838 ± 0.088 ± 0.275 ANJOS 93 E691  $\gamma$ Be 90–260 GeV

0.79 ± 0.07 ± 0.15 ADLER 87 MRK3  $e^+ e^-$  3.77 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.130 ± 0.058 ± 0.044 <sup>55</sup> AITALA 02 E791  $\pi^-$  nucleus, 500 GeV

<sup>55</sup> AITALA 02 includes a broad scalar  $K_0^*(800)$  in the fit to the  $D^+ \rightarrow K^- \pi^+ \pi^+$  Dalitz plot. This (a) greatly improves the fit, and (b) gives results in other channels that greatly disagree with previous analyses. The disagreement is so large that it makes no sense to average the results with those of earlier experiments. For now, we exclude AITALA 02 from the average.

$\Gamma(K_S^0 \pi^+ \pi^0)/\Gamma_{\text{total}}$   $\Gamma_{49}/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.070 ± 0.005 OUR FIT** Error includes scale factor of 1.2.

**0.072 ± 0.002 ± 0.004** 5090 ± 100 <sup>56</sup> HE 05 CLEO  $e^+ e^-$  at  $\psi(3770)$

• • • We do not use the following data for averages, fits, limits, etc. • • •

0.051 ± 0.013 ± 0.008 159 ADLER 88C MRK3  $e^+ e^-$  3.77 GeV

0.09 ± 0.06 10 <sup>57</sup> SCHINDLER 81 MRK2  $e^+ e^-$  3.771 GeV

<sup>56</sup> HE 05 uses single- and double-tagged events in an overall fit. The fraction here includes (unobserved) final-state photons.

<sup>57</sup> SCHINDLER 81 (MARK-2) measures  $\sigma(e^+ e^- \rightarrow \psi(3770)) \times$  branching fraction to be  $0.78 \pm 0.48$  nb. We use the MARK-3 (ADLER 88C) value of  $\sigma = 4.2 \pm 0.6 \pm 0.3$  nb.

$\Gamma(K_S^0 \rho^+)/\Gamma(K_S^0 \pi^+ \pi^0)$   $\Gamma_{50}/\Gamma_{49}$   
 This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.68 ± 0.08 ± 0.12</b>	ADLER	87 MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(\bar{K}^*(892)^0 \pi^+, \bar{K}^*(892)^0 \rightarrow K_S^0 \pi^0)/\Gamma(K_S^0 \pi^+ \pi^0)$   $\Gamma_{51}/\Gamma_{49}$   
 This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.19 ± 0.06 ± 0.06</b>	ADLER	87 MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(K_S^0 \pi^+ \pi^0 \text{ nonresonant})/\Gamma(K_S^0 \pi^+ \pi^0)$   $\Gamma_{52}/\Gamma_{49}$   
 This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.13 ± 0.07 ± 0.08</b>	ADLER	87 MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(K^- \pi^+ \pi^+ \pi^0)/\Gamma_{\text{total}}$   $\Gamma_{53}/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.060 ± 0.002 ± 0.002</b>	4840 ± 100	<sup>58</sup> HE	05 CLEO	$e^+ e^-$ at $\psi(3770)$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.058 ± 0.012 ± 0.012	142	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV
0.063 <sup>+0.014</sup> <sub>-0.013</sub> ± 0.012	175	BALTRUSAIT..86E	MRK3	See COFFMAN 92B

<sup>58</sup> HE 05 uses single- and double-tagged events in an overall fit. The fraction here includes (unobserved) final-state photons.

$\Gamma(K^- \pi^+ \pi^+ \pi^0)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{53}/\Gamma_{42}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.76 ± 0.11 ± 0.12	91	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
0.69 ± 0.10 ± 0.16		ANJOS	89E E691	See ANJOS 92C

$\Gamma(\bar{K}^*(892)^0 \rho^+ \text{ total})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{79}/\Gamma_{53}$

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.33 ± 0.165 ± 0.12</b>	<sup>59</sup> ANJOS	92C E691	$\gamma$ Be 90–260 GeV

<sup>59</sup> See, however, the next entry, where the two experiments disagree completely.

$\Gamma(\bar{K}^*(892)^0 \rho^+ \text{ S-wave})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{80}/\Gamma_{53}$

Unseen decay modes of the  $\bar{K}^*(892)^0$  are included. The two experiments here disagree completely.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.26 ± 0.25 OUR AVERAGE</b>	Error includes scale factor of 3.1.		
0.15 ± 0.075 ± 0.045	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
0.833 ± 0.116 ± 0.165	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(\bar{K}^*(892)^0 \rho^+ \text{ P-wave})/\Gamma_{\text{total}}$   $\Gamma_{81}/\Gamma$

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.001</b>	90	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.005	90	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(\bar{K}^*(892)^0 \rho^+ D\text{-wave})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{82}/\Gamma_{53}$

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.15 ± 0.09 ± 0.045</b>	ANJOS	92C E691	$\gamma$ Be 90–260 GeV

$\Gamma(\bar{K}^*(892)^0 \rho^+ D\text{-wave longitudinal})/\Gamma_{\text{total}}$   $\Gamma_{83}/\Gamma$

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.007</b>	90	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(\bar{K}_1(1400)^0 \pi^+)/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{85}/\Gamma_{53}$

Unseen decay modes of the  $\bar{K}_1(1400)^0$  are included.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.79 ± 0.32 OUR FIT</b> Error includes scale factor of 1.2.			
<b>0.907 ± 0.218 ± 0.180</b>	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(K^- \rho^+ \pi^+ \text{total})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{56}/\Gamma_{53}$

This includes  $\bar{K}^*(892)^0 \rho^+$ , etc. The next entry gives the specifically 3-body fraction.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.48 ± 0.13 ± 0.09</b>	ANJOS	92C E691	$\gamma$ Be 90–260 GeV

$\Gamma(K^- \rho^+ \pi^+ 3\text{-body})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{57}/\Gamma_{53}$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.17 ± 0.06 OUR AVERAGE</b>			
0.18 ± 0.08 ± 0.04	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
0.159 ± 0.065 ± 0.060	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(\bar{K}^*(892)^0 \pi^+ \pi^0 \text{total})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{87}/\Gamma_{53}$

This includes  $\bar{K}^*(892)^0 \rho^+$ , etc. The next two entries give the specifically 3-body fraction. Unseen decay modes of the  $\bar{K}^*(892)^0$  are included.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>1.05 ± 0.11 ± 0.08</b>	ANJOS	92C E691	$\gamma$ Be 90–260 GeV

$\Gamma(\bar{K}^*(892)^0 \pi^+ \pi^0 3\text{-body})/\Gamma_{\text{total}}$   $\Gamma_{88}/\Gamma$

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.008                      90                      <sup>60</sup> COFFMAN                      92B MRK3                       $e^+ e^-$  3.77 GeV

<sup>60</sup> See, however, the next entry: ANJOS 92C sees a large signal in this channel.

$\Gamma(\bar{K}^*(892)^0 \pi^+ \pi^0 3\text{-body})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{88}/\Gamma_{53}$

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.66 ± 0.09 ± 0.17</b>	ANJOS	92C E691	$\gamma$ Be 90–260 GeV

$\Gamma(K^*(892)^- \pi^+ \pi^+ 3\text{-body})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{90}/\Gamma_{53}$

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.32 ± 0.16 OUR FIT</b> Error includes scale factor of 1.2.			
<b>0.24 ± 0.12 ± 0.09</b>	ANJOS	92C E691	$\gamma$ Be 90–260 GeV

$\Gamma(K^- \pi^+ \pi^+ \pi^0 \text{ nonresonant})/\Gamma_{\text{total}}$   $\Gamma_{61}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.002	90	<sup>61</sup> ANJOS	92C E691	$\gamma$ Be 90–260 GeV
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<sup>61</sup>Whereas ANJOS 92C finds no signal here, COFFMAN 92B finds a fairly large one; see the next entry.

$\Gamma(K^- \pi^+ \pi^+ \pi^0 \text{ nonresonant})/\Gamma(K^- \pi^+ \pi^+ \pi^0)$   $\Gamma_{61}/\Gamma_{53}$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b>0.184 ± 0.070 ± 0.050</b>	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV
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$\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)/\Gamma_{\text{total}}$   $\Gamma_{62}/\Gamma$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.0311 ± 0.0021 OUR FIT** Error includes scale factor of 1.1.

<b>0.032 ± 0.001 ± 0.002</b>	3210 ± 85	<sup>62</sup> HE	05 CLEO	$e^+ e^-$ at $\psi(3770)$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.021	+0.010 −0.009	<sup>63</sup> BARLAG	92C ACCM	$\pi^-$ Cu 230 GeV
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0.033	±0.008 ±0.002	168 ADLER	88C MRK3	$e^+ e^-$ 3.77 GeV
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0.122	+0.032 −0.021 ±0.021	11 <sup>63</sup> AGUILAR...	87F HYBR	$\pi p, p p$ 360, 400 GeV
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0.06	±0.03	21 <sup>64</sup> SCHINDLER	81 MRK2	$e^+ e^-$ 3.771 GeV
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<sup>62</sup>HE 05 uses single- and double-tagged events in an overall fit. The fraction here includes (unobserved) final-state photons.

<sup>63</sup>AGUILAR-BENITEZ 87F and BARLAG 92C compute the branching fraction by topological normalization.

<sup>64</sup>SCHINDLER 81 (MARK-2) measures  $\sigma(e^+ e^- \rightarrow \psi(3770)) \times$  branching fraction to be  $0.51 \pm 0.08$  nb. We use the MARK-3 (ADLER 88C) value of  $\sigma = 4.2 \pm 0.6 \pm 0.3$  nb.

$\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{62}/\Gamma_{42}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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**0.327 ± 0.018 OUR FIT** Error includes scale factor of 1.1.

<b>0.39 ± 0.04 ± 0.06</b>	229 ± 17	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
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$\Gamma(K_S^0 a_1(1260)^+)/\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{77}/\Gamma_{62}$

Unseen decay modes of the  $a_1(1260)^+$  are included, assuming that the  $a_1(1260)^+$  decays entirely to  $\rho\pi$  [or at least to  $(\pi\pi)_{I=1}\pi$ ].

VALUE	DOCUMENT ID	TECN	COMMENT
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**1.15 ± 0.19 OUR AVERAGE** Error includes scale factor of 1.1.

1.66	±0.28 ±0.40	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
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1.078	±0.114 ±0.140	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV
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$\Gamma(K_S^0 a_2(1320)^+)/\Gamma_{\text{total}}$   $\Gamma_{78}/\Gamma$

Unseen decay modes of the  $a_2(1320)^+$  are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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<b>&lt;0.0015</b>	90	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.004	90	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV
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$\Gamma(\bar{K}_1(1270)^0 \pi^+)/\Gamma_{\text{total}}$   $\Gamma_{84}/\Gamma$

Unseen decay modes of the  $\bar{K}_1(1270)^0$  are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.007</b>	90	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.011	90	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(\bar{K}_1(1400)^0 \pi^+)/\Gamma_{\text{total}}$   $\Gamma_{85}/\Gamma$

Unseen decay modes of the  $\bar{K}_1(1400)^0$  are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.009	90	<sup>65</sup> ANJOS	92C E691	$\gamma$ Be 90–260 GeV
<sup>65</sup> ANJOS 92C sees no evidence for $\bar{K}_1(1400)^0 \pi^+$ in either the $\bar{K}^0 \pi^+ \pi^+ \pi^-$ or $K^- \pi^+ \pi^+ \pi^0$ channels, whereas COFFMAN 92B finds the $\bar{K}_1(1400)^0 \pi^+$ branching fraction to be large; see the next entry.				

$\Gamma(\bar{K}_1(1400)^0 \pi^+)/\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{85}/\Gamma_{62}$

Unseen decay modes of the  $\bar{K}_1(1400)^0$  are included.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>1.4 ± 0.5 OUR FIT</b>	Error includes scale factor of 1.2.		
<b>1.246 ± 0.212 ± 0.360</b>	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(\bar{K}^*(1410)^0 \pi^+)/\Gamma_{\text{total}}$   $\Gamma_{86}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.007	90	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(K^*(892)^- \pi^+ \pi^+ \text{total})/\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{89}/\Gamma_{62}$

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.82 ± 0.28	14	ALEEV	94 BIS2	$n N$ 20–70 GeV

$\Gamma(K^*(892)^- \pi^+ \pi^+ \text{3-body})/\Gamma_{\text{total}}$   $\Gamma_{90}/\Gamma$

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.013	90	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV

$\Gamma(K^*(892)^- \pi^+ \pi^+ \text{3-body})/\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{90}/\Gamma_{62}$

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.57<sup>+0.35</sup><sub>-0.30</sub> OUR FIT</b>	Error includes scale factor of 1.2.		
<b>1.00 ± 0.18 ± 0.42</b>	ANJOS	92C E691	$\gamma$ Be 90–260 GeV

$\Gamma(K_S^0 \rho^0 \pi^+ \text{ total}) / \Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{66} / \Gamma_{62}$

This includes  $\bar{K}^0 a_1(1260)^+$ . The next two entries give the specifically 3-body reaction.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>0.60 ± 0.10 ± 0.17</b>	90	ANJOS	92C E691	$\gamma$ Be 90–260 GeV

$\Gamma(K_S^0 \rho^0 \pi^+ \text{ 3-body}) / \Gamma_{\text{total}}$   $\Gamma_{67} / \Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.002	90	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV
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$\Gamma(K_S^0 \rho^0 \pi^+ \text{ 3-body}) / \Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{67} / \Gamma_{62}$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b>0.07 ± 0.04 ± 0.06</b>	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
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$\Gamma(K_S^0 f_0(980) \pi^+) / \Gamma_{\text{total}}$   $\Gamma_{91} / \Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

<0.0025	90	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
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$\Gamma(K_S^0 \pi^+ \pi^+ \pi^- \text{ nonresonant}) / \Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{68} / \Gamma_{62}$

VALUE	DOCUMENT ID	TECN	COMMENT
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**0.12 ± 0.06 OUR AVERAGE**

0.10 ± 0.04 ± 0.06	ANJOS	92C E691	$\gamma$ Be 90–260 GeV
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0.17 ± 0.056 ± 0.100	COFFMAN	92B MRK3	$e^+ e^-$ 3.77 GeV
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$\Gamma(K^- 3\pi^+ \pi^-) / \Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{69} / \Gamma_{42}$

VALUE	EVTs	DOCUMENT ID	TECN	COMMENT
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**0.061 ± 0.005 OUR FIT** Error includes scale factor of 1.1.

**0.062 ± 0.008 OUR AVERAGE** Error includes scale factor of 1.3.

0.058 ± 0.002 ± 0.006	2923	LINK	03D FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
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0.077 ± 0.008 ± 0.010	239	FRABETTI	97C E687	$\gamma$ Be, $\bar{E}_\gamma \approx 200$ GeV
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.09 ± 0.01 ± 0.01	113	ANJOS	90D E691	Photoproduction
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$\Gamma(\bar{K}^*(892)^0 \pi^+ \pi^+ \pi^-, \bar{K}^*(892)^0 \rightarrow K^- \pi^+) / \Gamma(K^- 3\pi^+ \pi^-)$   $\Gamma_{70} / \Gamma_{69}$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b>0.21 ± 0.04 ± 0.06</b>	LINK	03D FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
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$\Gamma(\bar{K}^*(892)^0 \rho^0 \pi^+, \bar{K}^*(892)^0 \rightarrow K^- \pi^+) / \Gamma(K^- 3\pi^+ \pi^-)$   $\Gamma_{71} / \Gamma_{69}$

VALUE	DOCUMENT ID	TECN	COMMENT
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<b>0.40 ± 0.03 ± 0.06</b>	LINK	03D FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
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$\Gamma(\bar{K}^*(892)^0 \rho^0 \pi^+, \bar{K}^*(892)^0 \rightarrow K^- \pi^+) / \Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{71} / \Gamma_{42}$

VALUE	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.016 ± 0.007 ± 0.004	FRABETTI	97C E687	$\gamma$ Be, $\bar{E}_\gamma \approx 200$ GeV
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$$\Gamma(\bar{K}^*(892)^0 \pi^+ \pi^+ \pi^- \text{no-}\rho, \bar{K}^*(892)^0 \rightarrow K^- \pi^+) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{72}/\Gamma_{42}$$

VALUE	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.032 \pm 0.010 \pm 0.008$	FRABETTI	97C E687	$\gamma$ Be, $\bar{E}_\gamma \approx 200$ GeV
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$$\Gamma(K^- \rho^0 \pi^+ \pi^+) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{73}/\Gamma_{42}$$

VALUE	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.034 \pm 0.009 \pm 0.005$	FRABETTI	97C E687	$\gamma$ Be, $\bar{E}_\gamma \approx 200$ GeV
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$$\Gamma(K^- \rho^0 \pi^+ \pi^+) / \Gamma(K^- 3\pi^+ \pi^-) \quad \Gamma_{73}/\Gamma_{69}$$

VALUE	DOCUMENT ID	TECN	COMMENT
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$0.30 \pm 0.04 \pm 0.01$	LINK	03D FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
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$$\Gamma(\bar{K}^*(892)^0 a_1(1260)^+) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{92}/\Gamma_{42}$$

Unseen decay modes of the  $\bar{K}^*(892)^0$  and  $a_1(1260)^+$  are included.

VALUE	DOCUMENT ID	TECN	COMMENT
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$0.099 \pm 0.008 \pm 0.018$	LINK	03D FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
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$$\Gamma(K^- 3\pi^+ \pi^- \text{nonresonant}) / \Gamma(K^- 3\pi^+ \pi^-) \quad \Gamma_{74}/\Gamma_{69}$$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
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$0.07 \pm 0.05 \pm 0.01$		LINK	03D FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
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• • • We do not use the following data for averages, fits, limits, etc. • • •

$< 0.026$	90	FRABETTI	97C E687	$\gamma$ Be, $\bar{E}_\gamma \approx 200$ GeV
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$$\Gamma(K^+ 2K_S^0) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{75}/\Gamma_{42}$$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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$0.049 \pm 0.022$  OUR AVERAGE Error includes scale factor of 2.4.

$0.035 \pm 0.010 \pm 0.005$	$39 \pm 9$	ALBRECHT	94I ARG	$e^+ e^- \approx 10$ GeV
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$0.085 \pm 0.018$	$70 \pm 12$	AMMAR	91 CLEO	$e^+ e^- \approx 10.5$ GeV
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$$\Gamma(K^+ K^- K_S^0 \pi^+) / \Gamma(K_S^0 \pi^+ \pi^+ \pi^-) \quad \Gamma_{76}/\Gamma_{62}$$

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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$7.7 \pm 1.5 \pm 0.9$	$35 \pm 7$	LINK	01C FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
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### Pionic modes

$$\Gamma(\pi^+ \pi^0) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{93}/\Gamma_{42}$$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
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$1.35 \pm 0.08$  OUR AVERAGE

$1.33 \pm 0.07 \pm 0.06$	$914 \pm 46$	RUBIN	06 CLEO	$e^+ e^-$ at $\psi(3770)$
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$1.44 \pm 0.19 \pm 0.10$	$171 \pm 22$	ARMS	04 CLEO	$e^+ e^- \approx 10$ GeV
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• • • We do not use the following data for averages, fits, limits, etc. • • •

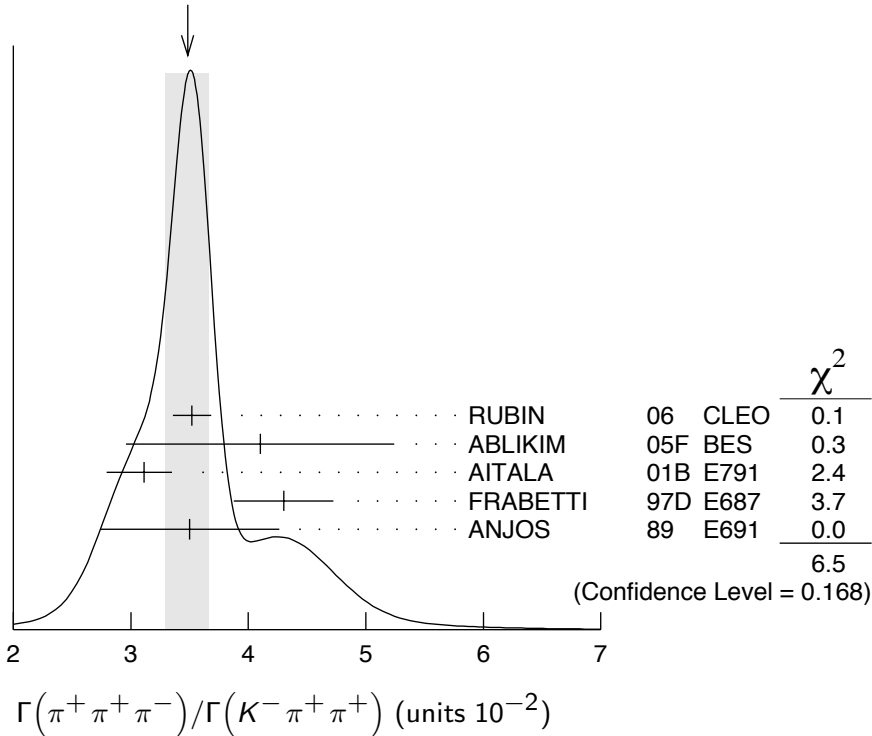
$2.8 \pm 0.6 \pm 0.5$	34	SELEN	93 CLE2	See ARMS 04
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$\Gamma(\pi^+\pi^+\pi^-)/\Gamma(K^-\pi^+\pi^+)$

$\Gamma_{94}/\Gamma_{42}$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.48±0.19 OUR AVERAGE</b>		Error includes scale factor of 1.4. See the ideogram below.		
3.52±0.11±0.12	3303 ± 95	RUBIN	06 CLEO	$e^+e^-$ at $\psi(3770)$
4.1 ±1.1 ±0.3	85 ± 22	ABLIKIM	05F BES	$e^+e^- \approx \psi(3770)$
3.11±0.18 <sup>+0.16</sup> <sub>-0.26</sub>	1172	AITALA	01B E791	$\pi^-$ nucleus, 500 GeV
4.3 ±0.3 ±0.3	236	FRABETTI	97D E687	$\gamma$ Be $\approx$ 200 GeV
3.5 ±0.7 ±0.3	83	ANJOS	89 E691	Photoproduction
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
3.2 ±1.1 ±0.3	20	ADAMOVICH	93 WA82	$\pi^-$ 340 GeV
4.2 ±1.6 ±1.0	57	BALTRUSAIT..85E	MRK3	$e^+e^-$ 3.77 GeV

WEIGHTED AVERAGE  
3.48±0.19 (Error scaled by 1.4)



$\Gamma(\rho^0\pi^+)/\Gamma(\pi^+\pi^+\pi^-)$

$\Gamma_{95}/\Gamma_{94}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.322 ±0.027 OUR AVERAGE</b>			
0.3082±0.0314±0.0230	LINK	04 FOCS	Dalitz fit, 1527 ± 51 evts
0.336 ±0.032 ±0.022	AITALA	01B E791	Dalitz fit, 1172 evts
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.289 ±0.055 ±0.058	<sup>66</sup> FRABETTI	97D E687	$\gamma$ Be $\approx$ 200 GeV
<sup>66</sup> FRABETTI 97D also includes $f_2(1270)\pi^+$ and $f_0(980)\pi^+$ modes in the fit, but the resulting decay fractions are not statistically significant.			

$\Gamma(\pi^+(\pi^+\pi^-)_{S\text{-wave}})/\Gamma(\pi^+\pi^+\pi^-)$   $\Gamma_{96}/\Gamma_{94}$ 

This is the “fit fraction” from the Dalitz-plot analysis. See also the next three data blocks.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.5600 ± 0.0324 ± 0.0214</b>	<sup>67</sup> LINK	04	FOCS Dalitz fit, 1527 ± 51 evts

<sup>67</sup> LINK 04 borrows a K-matrix parametrization from ANISOVICH 03 of the full  $\pi\text{-}\pi$  S-wave isoscalar scattering amplitude to describe the  $\pi^+\pi^-$  S-wave component of the  $\pi^+\pi^+\pi^-$  state. The fit fraction given above is a sum over five  $f_0$  mesons, the  $f_0(980)$ ,  $f_0(1300)$ ,  $f_0(1200\text{--}1600)$ ,  $f_0(1500)$ , and  $f_0(1750)$ . See LINK 04 for details and discussion.

 $\Gamma(\sigma\pi^+, \sigma \rightarrow \pi^+\pi^-)/\Gamma(\pi^+\pi^+\pi^-)$   $\Gamma_{97}/\Gamma_{94}$ 

This is the “fit fraction” from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.463 ± 0.090 ± 0.021</b>	AITALA	01B E791	Dalitz fit, 1172 evts

 $\Gamma(f_0(980)\pi^+, f_0(980) \rightarrow \pi^+\pi^-)/\Gamma(\pi^+\pi^+\pi^-)$   $\Gamma_{98}/\Gamma_{94}$ 

This is the “fit fraction” from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.062 ± 0.013 ± 0.004</b>	AITALA	01B E791	Dalitz fit, 1172 evts

 $\Gamma(f_0(1370)\pi^+, f_0(1370) \rightarrow \pi^+\pi^-)/\Gamma(\pi^+\pi^+\pi^-)$   $\Gamma_{99}/\Gamma_{94}$ 

This is the “fit fraction” from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.023 ± 0.015 ± 0.008</b>	AITALA	01B E791	Dalitz fit, 1172 evts

 $\Gamma(f_2(1270)\pi^+, f_2(1270) \rightarrow \pi^+\pi^-)/\Gamma(\pi^+\pi^+\pi^-)$   $\Gamma_{100}/\Gamma_{94}$ 

This is the “fit fraction” from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.15 ± 0.04 OUR AVERAGE</b>	Error includes scale factor of 2.4.		
0.1174 ± 0.0190 ± 0.0029	LINK	04	FOCS Dalitz fit, 1527 ± 51 evts
0.194 ± 0.025 ± 0.004	AITALA	01B E791	Dalitz fit, 1172 evts

 $\Gamma(\rho(1450)^0\pi^+, \rho(1450)^0 \rightarrow \pi^+\pi^-)/\Gamma(\pi^+\pi^+\pi^-)$   $\Gamma_{101}/\Gamma_{94}$ 

This is the “fit fraction” from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.007 ± 0.007 ± 0.003	AITALA	01B E791	Dalitz fit, 1172 evts

 $\Gamma(\pi^+\pi^+\pi^- \text{ nonresonant})/\Gamma(\pi^+\pi^+\pi^-)$   $\Gamma_{102}/\Gamma_{94}$ 

This is the “fit fraction” from the Dalitz-plot analysis. The big difference between the results here of AITALA 01B and FRABETTI 97D is the addition of the  $\sigma\pi^+$  channel to the AITALA 01B fit. LINK 04 (see earlier data blocks), in agreement with AITALA 01B, finds no evidence for a large nonresonant fraction.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.078 ± 0.060 ± 0.027	AITALA	01B E791	Dalitz fit, 1172 evts
0.589 ± 0.105 ± 0.081	<sup>68</sup> FRABETTI	97D E687	$\gamma$ Be $\approx$ 200 GeV

<sup>68</sup> FRABETTI 97D also includes  $f_2(1270)\pi^+$  and  $f_0(980)\pi^+$  modes in the fit, but the resulting decay fractions are not statistically significant.

$\Gamma(\pi^+ 2\pi^0)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{103}/\Gamma_{42}$ 

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>5.0±0.3±0.3</b>	1535 ± 89	RUBIN 06	CLEO	$e^+ e^-$ at $\psi(3770)$

 $\Gamma(\pi^+ \pi^+ \pi^- \pi^0)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{104}/\Gamma_{42}$ 

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>12.4±0.5±0.6</b>	5701 ± 205	RUBIN 06	CLEO	$e^+ e^-$ at $\psi(3770)$

 $\Gamma(\eta\pi^+)/\Gamma(\phi\pi^+)$   $\Gamma_{109}/\Gamma_{131}$ Unseen decay modes of the  $\eta$  are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.54±0.06 OUR FIT</b>				
<b>0.49±0.08</b>	275	JESSOP 98	CLE2	$e^+ e^- \approx \Upsilon(4S)$

 $\Gamma(\eta\pi^+)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{109}/\Gamma_{42}$ Unseen decay modes of the  $\eta$  are included.

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.68±0.31 OUR FIT</b>				

<b>3.81±0.26±0.21</b>	377 ± 26	RUBIN 06	CLEO	$e^+ e^-$ at $\psi(3770)$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

8.3 ± 2.3 ± 1.4	99	DAOUDI 92	CLE2	See JESSOP 98
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 $\Gamma(\omega\pi^+)/\Gamma_{\text{total}}$   $\Gamma_{110}/\Gamma$ Unseen decay modes of the  $\omega$  are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;3.4 × 10<sup>-4</sup></b>	90	RUBIN 06	CLEO	$e^+ e^-$ at $\psi(3770)$

 $\Gamma(3\pi^+ 2\pi^-)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{107}/\Gamma_{42}$ 

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.77±0.17 OUR FIT</b>				

<b>1.73±0.20±0.17</b>	732 ± 77	RUBIN 06	CLEO	$e^+ e^-$ at $\psi(3770)$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

2.3 ± 0.4 ± 0.2	58	FRABETTI 97C	E687	$\gamma$ Be, $\bar{E}_\gamma \approx 200$ GeV
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 $\Gamma(3\pi^+ 2\pi^-)/\Gamma(K^- 3\pi^+ \pi^-)$   $\Gamma_{107}/\Gamma_{69}$ 

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.289±0.019 OUR FIT</b>				

<b>0.290±0.017±0.011</b>	835	LINK 03D	FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
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 $\Gamma(\eta\rho^+)/\Gamma(\phi\pi^+)$   $\Gamma_{111}/\Gamma_{131}$ Unseen decay modes of the  $\eta$  are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.11</b>	90	JESSOP 98	CLE2	$e^+ e^- \approx \Upsilon(4S)$

 $\Gamma(\eta'(958)\pi^+)/\Gamma(\phi\pi^+)$   $\Gamma_{112}/\Gamma_{131}$ Unseen decay modes of the  $\eta'(958)$  are included.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.82±0.14</b>	126	JESSOP 98	CLE2	$e^+ e^- \approx \Upsilon(4S)$

$\Gamma(\eta'(958)\rho^+)/\Gamma(\phi\pi^+)$   $\Gamma_{113}/\Gamma_{131}$

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.86</b>	90	JESSOP	98 CLE2	$e^+e^- \approx \Upsilon(4S)$

————— **Hadronic modes with a  $K\bar{K}$  pair** —————

$\Gamma(K^+K_S^0)/\Gamma(K_S^0\pi^+)$   $\Gamma_{114}/\Gamma_{41}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.201 ± 0.011 OUR FIT</b>				
<b>0.206 ± 0.014 OUR AVERAGE</b>				
0.222 ± 0.037 ± 0.013	63 ± 10	ABLIKIM	05F BES	$e^+e^- \approx \psi(3770)$
0.1892 ± 0.0155 ± 0.0073	278 ± 21	ARMS	04 CLEO	$e^+e^- \approx 10$ GeV
0.25 ± 0.04 ± 0.02	129	FRABETTI	95 E687	$\gamma$ Be $\bar{E}_\gamma \approx 200$ GeV
0.271 ± 0.065 ± 0.039	69	ANJOS	90C E691	$\gamma$ Be
0.317 ± 0.086 ± 0.048	31	BALTRUSAIT..85E	MRK3	$e^+e^- 3.77$ GeV
0.25 ± 0.15	6	SCHINDLER	81 MRK2	$e^+e^- 3.771$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.1996 ± 0.0119 ± 0.0096	949	<sup>69</sup> LINK	02B FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
0.222 ± 0.041 ± 0.019	70	<sup>70</sup> BISHAI	97 CLE2	See ARMS 04

<sup>69</sup> This LINK 02B result is redundant with a result in the next datablock.

<sup>70</sup> This BISHAI 97 result is redundant with results elsewhere in the Listings.

$\Gamma(K^+K_S^0)/\Gamma(K^-\pi^+\pi^+)$   $\Gamma_{114}/\Gamma_{42}$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.11 ± 0.17 OUR FIT</b>				
<b>3.02 ± 0.18 ± 0.15</b>	949	LINK	02B FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
3.86 ± 0.69 ± 0.37	70	<sup>71</sup> BISHAI	97 CLE2	See ARMS 04

<sup>71</sup> See BISHAI 97 for an isospin analysis of  $D^+ \rightarrow K\bar{K}$  amplitudes.

$\Gamma(K^+K^-\pi^+)/\Gamma_{total}$   $\Gamma_{115}/\Gamma$

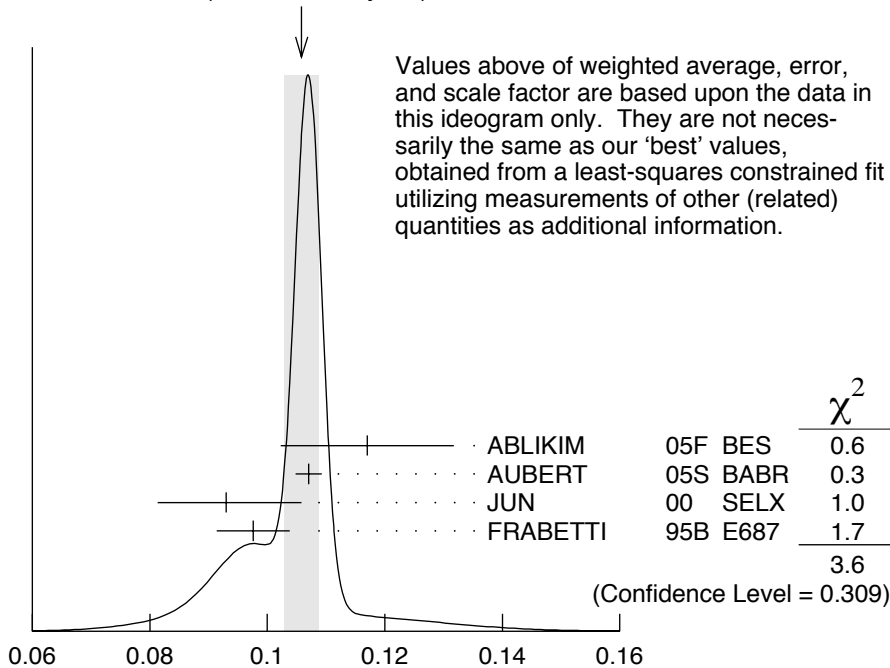
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.0100 ± 0.0004 OUR FIT</b>				Error includes scale factor of 1.2.
<b>0.0097 ± 0.0004 ± 0.0004</b>	1250 ± 40	<sup>72</sup> HE	05 CLEO	$e^+e^-$ at $\psi(3770)$

<sup>72</sup> HE 05 uses single- and double-tagged events in an overall fit. The fraction here includes (unobserved) final-state photons.

$\Gamma(K^+K^-\pi^+)/\Gamma(K^-\pi^+\pi^+)$   $\Gamma_{115}/\Gamma_{42}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.1054 ± 0.0025 OUR FIT</b>				Error includes scale factor of 1.3.
<b>0.1058 ± 0.0029 OUR AVERAGE</b>				Error includes scale factor of 1.4. See the ideogram below.
0.117 ± 0.013 ± 0.007	181 ± 20	ABLIKIM	05F BES	$e^+e^- \approx \psi(3770)$
0.107 ± 0.001 ± 0.002	43k	AUBERT	05S BABR	$e^+e^- \approx \Upsilon(4S)$
0.093 ± 0.010 <sup>+0.008</sup> <sub>-0.006</sub>		JUN	00 SELX	$\Sigma^-$ nucleus, 600 GeV
0.0976 ± 0.0042 ± 0.0046		FRABETTI	95B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 200$ GeV

WEIGHTED AVERAGE  
 $0.1058 \pm 0.0029$  (Error scaled by 1.4)



$$\Gamma(K^+K^-\pi^+)/\Gamma(K^-\pi^+\pi^+) \quad \Gamma_{115}/\Gamma_{42}$$

$$\Gamma(\phi\pi^+, \phi \rightarrow K^+K^-)/\Gamma(K^+K^-\pi^+) \quad \Gamma_{116}/\Gamma_{115}$$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.317 ± 0.034 OUR FIT</b>			
<b>0.292 ± 0.031 ± 0.030</b>	FRABETTI	95B E687	Dalitz fit, 915 evts

$$\Gamma(\phi\pi^+, \phi \rightarrow K^+K^-)/\Gamma(\phi\pi^+) \quad \Gamma_{116}/\Gamma_{131}$$

VALUE	DOCUMENT ID
<b>0.491 ± 0.006 OUR FIT</b>	
<b>0.491 ± 0.006</b>	<sup>73</sup> PDG 06

<sup>73</sup> This is, of course, just the  $\phi \rightarrow K^+K^-$  branching fraction, but we need it to connect other modes in the fit.

$$\Gamma(\phi\pi^+)/\Gamma(K^-\pi^+\pi^+) \quad \Gamma_{131}/\Gamma_{42}$$

Unseen decay modes of the  $\phi$  are included. However, we now get branching fractions for resonant submodes of  $K^+K^-\pi^+$  decays from Dalitz-plot analyses.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$0.062 \pm 0.017 \pm 0.006$	19	ADAMOVICH 93	WA82	$\pi^-$ 340 GeV
$0.077 \pm 0.011 \pm 0.005$	128	DAOUDI 92	CLE2	$e^+e^- \approx 10.5$ GeV
$0.098 \pm 0.032 \pm 0.014$	12	ALVAREZ 90C	NA14	Photoproduction
$0.071 \pm 0.008 \pm 0.007$	84	ANJOS 88	E691	Photoproduction
$0.084 \pm 0.021 \pm 0.011$	21	BALTRUSAIT..85E	MRK3	$e^+e^-$ 3.77 GeV

$$\Gamma(K^+ \bar{K}^*(892)^0, \bar{K}^*(892)^0 \rightarrow K^- \pi^+) / \Gamma(K^+ K^- \pi^+) \quad \Gamma_{117} / \Gamma_{115}$$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.301 ± 0.020 ± 0.025</b>	FRABETTI	95B E687	Dalitz fit, 915 evts

$$\Gamma(K^+ \bar{K}_0^*(1430)^0, \bar{K}_0^*(1430)^0 \rightarrow K^- \pi^+) / \Gamma(K^+ K^- \pi^+) \quad \Gamma_{118} / \Gamma_{115}$$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.370 ± 0.035 ± 0.018</b>	FRABETTI	95B E687	Dalitz fit, 915 evts

$$\Gamma(K^+ \bar{K}^*(892)^0) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{134} / \Gamma_{42}$$

Unseen decay modes of the  $\bar{K}^*(892)^0$  are included. However, we now get branching fractions for resonant submodes of  $K^+ K^- \pi^+$  decays from Dalitz-plot analyses.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
• • •				We do not use the following data for averages, fits, limits, etc. • • •
0.058 ± 0.009 ± 0.006	73	ANJOS	88 E691	Photoproduction
0.048 ± 0.021 ± 0.011	14	BALTRUSAIT..85E	MRK3	$e^+ e^-$ 3.77 GeV

$$\Gamma(K^+ K^- \pi^+ \text{ nonresonant}) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{119} / \Gamma_{42}$$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
• • •				We do not use the following data for averages, fits, limits, etc. • • •
0.049 ± 0.008 ± 0.006	95	ANJOS	88 E691	Photoproduction
0.059 ± 0.026 ± 0.009	37	BALTRUSAIT..85E	MRK3	$e^+ e^-$ 3.77 GeV

$$\Gamma(K^*(892)^+ K_S^0) / \Gamma(K_S^0 \pi^+) \quad \Gamma_{135} / \Gamma_{41}$$

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.1 ± 0.3 ± 0.4</b>	67	FRABETTI	95 E687	$\gamma$ Be $\bar{E}_\gamma \approx 200$ GeV

$$\Gamma(\phi \pi^+ \pi^0) / \Gamma_{\text{total}} \quad \Gamma_{132} / \Gamma$$

Unseen decay modes of the  $\phi$  are included.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.023 ± 0.010</b>	<sup>74</sup> BARLAG	92C ACCM	$\pi^-$ Cu 230 GeV

<sup>74</sup> BARLAG 92C computes the branching fraction using topological normalization.

$$\Gamma(\phi \pi^+ \pi^0) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{132} / \Gamma_{42}$$

Unseen decay modes of the  $\phi$  are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
• • •				We do not use the following data for averages, fits, limits, etc. • • •
<0.58	90	ALVAREZ	90C NA14	Photoproduction
<0.28	90	ANJOS	89E E691	Photoproduction

$$\Gamma(\phi \rho^+) / \Gamma(K^- \pi^+ \pi^+) \quad \Gamma_{133} / \Gamma_{42}$$

Unseen decay modes of the  $\phi$  are included.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;0.16</b>	90	DAOUDI	92 CLE2	$e^+ e^- \approx 10.5$ GeV

$\Gamma(K^+ K^- \pi^+ \pi^0 \text{ non-}\phi)/\Gamma_{\text{total}}$   $\Gamma_{125}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$0.015^{+0.007}_{-0.006}$		<sup>75</sup> BARLAG	92C ACCM	$\pi^-$ Cu 230 GeV

<sup>75</sup> BARLAG 92C computes the branching fraction using topological normalization.

$\Gamma(K^+ K^- \pi^+ \pi^0 \text{ non-}\phi)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{125}/\Gamma_{42}$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.25	90	ANJOS	89E E691	Photoproduction

$\Gamma(K^+ K_S^0 \pi^+ \pi^-)/\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{126}/\Gamma_{62}$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
$5.62 \pm 0.39 \pm 0.40$	469 $\pm$ 32	LINK	01C FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV

$\Gamma(K_S^0 K^- \pi^+ \pi^+)/\Gamma(K_S^0 \pi^+ \pi^+ \pi^-)$   $\Gamma_{127}/\Gamma_{62}$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
$7.68 \pm 0.41 \pm 0.32$	670 $\pm$ 35	LINK	01C FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV

$\Gamma(K^*(892)^+ \bar{K}^*(892)^0)/\Gamma_{\text{total}}$   $\Gamma_{136}/\Gamma$

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

VALUE	DOCUMENT ID	TECN	COMMENT
$0.026 \pm 0.008 \pm 0.007$	ALBRECHT	92B ARG	$e^+ e^- \simeq 10.4$ GeV

$\Gamma(K_S^0 K^- \pi^+ \pi^+ (\text{non-}K^{*+} \bar{K}^{*0}))/\Gamma_{\text{total}}$   $\Gamma_{129}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<0.004	90	ALBRECHT	92B ARG	$e^+ e^- \simeq 10.4$ GeV

$\Gamma(K^+ K^- \pi^+ \pi^+ \pi^-)/\Gamma(K^- 3\pi^+ \pi^-)$   $\Gamma_{130}/\Gamma_{69}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.040 \pm 0.009 \pm 0.019$	38	LINK	03D FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV

———— Doubly Cabibbo-suppressed modes ————

$\Gamma(K^+ \pi^0)/\Gamma_{\text{total}}$   $\Gamma_{137}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< $4.2 \times 10^{-4}$	90	ARMS	04 CLEO	$e^+ e^- \approx 10$ GeV

$\Gamma(K^+ \pi^+ \pi^-)/\Gamma(K^- \pi^+ \pi^+)$   $\Gamma_{138}/\Gamma_{42}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.0068 \pm 0.0008</math> OUR AVERAGE</b>				
$0.0065 \pm 0.0008 \pm 0.0004$	189 $\pm$ 24	LINK	04F FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV
$0.0077 \pm 0.0017 \pm 0.0008$	59 $\pm$ 13	AITALA	97C E791	$\pi^-$ A, 500 GeV
$0.0072 \pm 0.0023 \pm 0.0017$	21	FRABETTI	95E E687	$\gamma$ Be, $\bar{E}_\gamma = 220$ GeV



$\Gamma(K^+\rho^0)/\Gamma(K^+\pi^+\pi^-)$   $\Gamma_{139}/\Gamma_{138}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.39 ± 0.09</b> <b>OUR AVERAGE</b>			
0.3943 ± 0.0787 ± 0.0815	LINK	04F FOCS	Dalitz fit, 189 evts
0.37 ± 0.14 ± 0.07	AITALA	97C E791	Dalitz fit, 59 evts

$\Gamma(K^+f_0(980), f_0(980) \rightarrow \pi^+\pi^-)/\Gamma(K^+\pi^+\pi^-)$   $\Gamma_{141}/\Gamma_{138}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.0892 ± 0.0333 ± 0.0412</b>	LINK	04F FOCS	Dalitz fit, 189 evts

$\Gamma(K^*(892)^0\pi^+, K^*(892)^0 \rightarrow K^+\pi^-)/\Gamma(K^+\pi^+\pi^-)$   $\Gamma_{140}/\Gamma_{138}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.47 ± 0.08</b> <b>OUR AVERAGE</b>			
0.5220 ± 0.0684 ± 0.0638	LINK	04F FOCS	Dalitz fit, 189 evts
0.35 ± 0.14 ± 0.01	AITALA	97C E791	Dalitz fit, 59 evts

$\Gamma(K_2^*(1430)^0\pi^+, K_2^*(1430)^0 \rightarrow K^+\pi^-)/\Gamma(K^+\pi^+\pi^-)$   $\Gamma_{142}/\Gamma_{138}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.0803 ± 0.0372 ± 0.0391</b>	LINK	04F FOCS	Dalitz fit, 189 evts

$\Gamma(K^+\pi^+\pi^- \text{ nonresonant})/\Gamma(K^+\pi^+\pi^-)$   $\Gamma_{143}/\Gamma_{138}$

This is the "fit fraction" from the Dalitz-plot analysis.

VALUE	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.36 ± 0.14 ± 0.07	<sup>76</sup> AITALA	97C E791	Dalitz fit, 59 evts

<sup>76</sup>LINK 04F, with three times as many events, finds no need for a nonresonant amplitude.

$\Gamma(K^+K^+K^-)/\Gamma(K^-\pi^+\pi^+)$   $\Gamma_{144}/\Gamma_{42}$

VALUE (units 10 <sup>-4</sup> )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>9.49 ± 2.17 ± 0.22</b>		65	<sup>77</sup> LINK	02I FOCS	$\gamma$ nucleus, $\approx$ 180 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

<16	90		<sup>78</sup> FRABETTI	95F E687	$\gamma$ Be, $\bar{E}_\gamma \approx$ 220 GeV
570 ± 200 ± 70		13	ADAMOVICH	93 WA82	$\pi^-$ 340 GeV

<sup>77</sup>LINK 02I finds little evidence for  $\phi K^+$  or  $f_0(980)K^+$  submodes.

<sup>78</sup>Using the  $\phi\pi^+$  mode to normalize, FRABETTI 95F gets  $\Gamma(K^+K^+K^-)/\Gamma(\phi\pi^+) < 0.025$ .

$\Gamma(\phi K^+)/\Gamma(\phi\pi^+)$   $\Gamma_{145}/\Gamma_{131}$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.021	90		FRABETTI	95F E687	$\gamma$ Be, $\bar{E}_\gamma \approx$ 220 GeV
0.058 <sup>+0.032</sup> <sub>-0.026</sub> ± 0.007		4	<sup>79</sup> ANJOS	92D E691	$\gamma$ Be, $\bar{E}_\gamma =$ 145 GeV

<sup>79</sup>The evidence of ANJOS 92D is a small excess of events ( $4.5^{+2.4}_{-2.0}$ ).

————— Rare or forbidden modes —————

$\Gamma(\pi^+ e^+ e^-)/\Gamma_{\text{total}}$   $\Gamma_{146}/\Gamma$

A test for the  $\Delta C = 1$  weak neutral current. Allowed by higher-order electroweak interactions.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$<7.4 \times 10^{-6}$	90		HE	05A CLEO	$e^+ e^-$ at $\psi(3770)$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<5.2 \times 10^{-5}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV
$<1.1 \times 10^{-4}$	90		FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<6.6 \times 10^{-5}$	90		AITALA	96 E791	$\pi^- N$ 500 GeV
$<2.5 \times 10^{-3}$	90		WEIR	90B MRK2	$e^+ e^-$ 29 GeV
$<2.6 \times 10^{-3}$	90	39	HAAS	88 CLEO	$e^+ e^-$ 10 GeV

$\Gamma(\pi^+ \phi, \phi \rightarrow e^+ e^-)/\Gamma_{\text{total}}$   $\Gamma_{147}/\Gamma$

This is *not* a test for the  $\Delta C = 1$  weak neutral current, but leads to the  $\pi^+ e^+ e^-$  final state.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$(2.7^{+3.6}_{-1.8} \pm 0.2) \times 10^{-6}$	2	80 HE	05A CLEO	$e^+ e^-$ at $\psi(3770)$

<sup>80</sup> This HE 05A result is consistent with the branching fraction for  $D^+ \rightarrow \phi \pi^+, \phi \rightarrow K^+ K^-$ .

$\Gamma(\pi^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$   $\Gamma_{148}/\Gamma$

A test for the  $\Delta C = 1$  weak neutral current. Allowed by higher-order electroweak interactions.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$<8.8 \times 10^{-6}$	90		LINK	03F FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1.5 \times 10^{-5}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV
$<8.9 \times 10^{-5}$	90		FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<1.8 \times 10^{-5}$	90		AITALA	96 E791	$\pi^- N$ 500 GeV
$<2.2 \times 10^{-4}$	90	0	KODAMA	95 E653	$\pi^-$ emulsion 600 GeV
$<5.9 \times 10^{-3}$	90		WEIR	90B MRK2	$e^+ e^-$ 29 GeV
$<2.9 \times 10^{-3}$	90	36	HAAS	88 CLEO	$e^+ e^-$ 10 GeV

$\Gamma(\rho^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$   $\Gamma_{149}/\Gamma$

A test for the  $\Delta C = 1$  weak neutral current. Allowed by higher-order electroweak interactions.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$<5.6 \times 10^{-4}$	90	0	KODAMA	95 E653	$\pi^-$ emulsion 600 GeV

$\Gamma(K^+ e^+ e^-)/\Gamma_{\text{total}}$   $\Gamma_{150}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<6.2 \times 10^{-6}$	90	HE	05A CLEO	$e^+ e^-$ at $\psi(3770)$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<2.0 \times 10^{-4}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV
$<2.0 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<4.8 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

$\Gamma(K^+ \mu^+ \mu^-)/\Gamma_{\text{total}}$   $\Gamma_{151}/\Gamma$

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$<9.2 \times 10^{-6}$	90		LINK	03F FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

$<4.4 \times 10^{-5}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV
$<9.7 \times 10^{-5}$	90		FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<3.2 \times 10^{-4}$	90	0	KODAMA	95 E653	$\pi^-$ emulsion 600 GeV
$<9.2 \times 10^{-3}$	90		WEIR	90B MRK2	$e^+ e^-$ 29 GeV

$\Gamma(\pi^+ e^\pm \mu^\mp)/\Gamma_{\text{total}}$   $\Gamma_{152}/\Gamma$

A test of lepton-family-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<3.4 \times 10^{-5}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

$\Gamma(\pi^+ e^+ \mu^-)/\Gamma_{\text{total}}$   $\Gamma_{153}/\Gamma$

A test of lepton-family-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.1 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<3.3 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

$\Gamma(\pi^+ e^- \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{154}/\Gamma$

A test of lepton-family-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.3 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<3.3 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

$\Gamma(K^+ e^\pm \mu^\mp)/\Gamma_{\text{total}}$   $\Gamma_{155}/\Gamma$

A test of lepton-family-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<6.8 \times 10^{-5}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV

$\Gamma(K^+ e^+ \mu^-)/\Gamma_{\text{total}}$   $\Gamma_{156}/\Gamma$

A test of lepton-family-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.3 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<3.4 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

$\Gamma(K^+ e^- \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{157}/\Gamma$

A test of lepton-family-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.2 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<3.4 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

$\Gamma(\pi^- e^+ e^+)/\Gamma_{\text{total}}$   $\Gamma_{158}/\Gamma$ 

A test of lepton-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;3.6 \times 10^{-6}</math></b>	90	HE	05A CLEO	$e^+ e^-$ at $\psi(3770)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$<9.6 \times 10^{-5}$	90	AITALA	99G E791	$\pi^- N$ 500 GeV
$<1.1 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<4.8 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

 $\Gamma(\pi^- \mu^+ \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{159}/\Gamma$ 

A test of lepton-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;4.8 \times 10^{-6}</math></b>	90		LINK	03F FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
$<1.7 \times 10^{-5}$	90		AITALA	99G E791	$\pi^- N$ 500 GeV
$<8.7 \times 10^{-5}$	90		FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<2.2 \times 10^{-4}$	90	0	KODAMA	95 E653	$\pi^-$ emulsion 600 GeV
$<6.8 \times 10^{-3}$	90		WEIR	90B MRK2	$e^+ e^-$ 29 GeV

 $\Gamma(\pi^- e^+ \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{160}/\Gamma$ 

A test of lepton-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;5.0 \times 10^{-5}</math></b>	90	AITALA	99G E791	$\pi^- N$ 500 GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$<1.1 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<3.7 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

 $\Gamma(\rho^- \mu^+ \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{161}/\Gamma$ 

A test of lepton-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;5.6 \times 10^{-4}</math></b>	90	0	KODAMA	95 E653	$\pi^-$ emulsion 600 GeV

 $\Gamma(K^- e^+ e^+)/\Gamma_{\text{total}}$   $\Gamma_{162}/\Gamma$ 

A test of lepton-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;4.5 \times 10^{-6}</math></b>	90	HE	05A CLEO	$e^+ e^-$ at $\psi(3770)$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$<1.2 \times 10^{-4}$	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<9.1 \times 10^{-3}$	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

 $\Gamma(K^- \mu^+ \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{163}/\Gamma$ 

A test of lepton-number conservation.

<u>VALUE</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;1.3 \times 10^{-5}</math></b>	90		LINK	03F FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
$<1.2 \times 10^{-4}$	90		FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
$<3.2 \times 10^{-4}$	90	0	KODAMA	95 E653	$\pi^-$ emulsion 600 GeV
$<4.3 \times 10^{-3}$	90		WEIR	90B MRK2	$e^+ e^-$ 29 GeV

$\Gamma(K^- e^+ \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{164}/\Gamma$

A test of lepton-number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.3 × 10<sup>-4</sup></b>	90	FRABETTI	97B E687	$\gamma$ Be, $\bar{E}_\gamma \approx 220$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<4.0 × 10 <sup>-3</sup>	90	WEIR	90B MRK2	$e^+ e^-$ 29 GeV

$\Gamma(K^*(892)^- \mu^+ \mu^+)/\Gamma_{\text{total}}$   $\Gamma_{165}/\Gamma$

A test of lepton-number conservation.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
<b>&lt;8.5 × 10<sup>-4</sup></b>	90	0	KODAMA	95 E653	$\pi^-$ emulsion 600 GeV

**$D^\pm$  CP-VIOLATING DECAY-RATE ASYMMETRIES**

**$A_{CP}(K_S^0 \pi^\pm)$  in  $D^\pm \rightarrow K_S^0 \pi^\pm$**

This is the difference between  $D^+$  and  $D^-$  partial widths for these modes divided by the sum of the widths.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>-0.016 ± 0.015 ± 0.009</b>	10.6k	<sup>81</sup> LINK	02B FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV

<sup>81</sup> LINK 02B measures  $N(D^+ \rightarrow K_S^0 \pi^+)/N(D^+ \rightarrow K^- \pi^+ \pi^+)$ , the ratio of numbers of events observed, and similarly for the  $D^-$ .

**$A_{CP}(K_S^0 K^\pm)$  in  $D^\pm \rightarrow K_S^0 K^\pm$**

This is the difference between  $D^+$  and  $D^-$  partial widths for these modes divided by the sum of the widths.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>+0.071 ± 0.061 ± 0.012</b>	949	<sup>82</sup> LINK	02B FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV

• • • We do not use the following data for averages, fits, limits, etc. • • •

+0.069 ± 0.060 ± 0.015	949	<sup>83</sup> LINK	02B FOCS	$\gamma$ nucleus, $\bar{E}_\gamma \approx 180$ GeV
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<sup>82</sup> LINK 02B measures  $N(D^+ \rightarrow K_S^0 K^+)/N(D^+ \rightarrow K_S^0 \pi^+)$ , the ratio of numbers of events observed, and similarly for the  $D^-$ .

<sup>83</sup> LINK 02B measures  $N(D^+ \rightarrow K_S^0 K^+)/N(D^+ \rightarrow K^- \pi^+ \pi^+)$ , the ratio of numbers of events observed, and similarly for the  $D^-$ .

**$A_{CP}(K^+ K^- \pi^\pm)$  in  $D^\pm \rightarrow K^+ K^- \pi^\pm$**

This is the difference between  $D^+$  and  $D^-$  partial widths for these modes divided by the sum of the widths.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.007 ± 0.008 OUR AVERAGE</b>				
+0.014 ± 0.010 ± 0.008	43k ± 321	<sup>84</sup> AUBERT	05S BABR	$e^+ e^- \approx \Upsilon(4S)$
+0.006 ± 0.011 ± 0.005	14k	<sup>85</sup> LINK	00B FOCS	
-0.014 ± 0.029		<sup>85</sup> AITALA	97B E791	-0.062 < $A_{CP}$ < +0.034 (90% CL)
-0.031 ± 0.068		<sup>85</sup> FRABETTI	94I E687	-0.14 < $A_{CP}$ < +0.081 (90% CL)

<sup>84</sup> AUBERT 05S measures  $N(D^+ \rightarrow K^+ K^- \pi^+)/N(D_S^+ \rightarrow K^+ K^- \pi^+)$ , the ratio of the numbers of events observed, and similarly for the  $D^-$ .

<sup>85</sup> FRABETTI 94I, AITALA 98C, and LINK 00B measure  $N(D^+ \rightarrow K^- K^+ \pi^+)/N(D^+ \rightarrow K^- \pi^+ \pi^+)$ , the ratio of numbers of events observed, and similarly for the  $D^-$ .

### $A_{CP}(K^\pm K^{*0})$ in $D^+ \rightarrow K^+ \bar{K}^{*0}$ , $D^- \rightarrow K^- K^{*0}$

This is the difference between  $D^+$  and  $D^-$  partial widths for these modes divided by the sum of the widths.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.005 ± 0.017 OUR AVERAGE</b>				
+0.009 ± 0.017 ± 0.007	11k ± 122	<sup>86</sup> AUBERT	05S BABR	$e^+ e^- \approx \Upsilon(4S)$
-0.010 ± 0.050		<sup>87</sup> AITALA	97B E791	$-0.092 < A_{CP} < +0.072$ (90% CL)
-0.12 ± 0.13		<sup>87</sup> FRABETTI	94I E687	$-0.33 < A_{CP} < +0.094$ (90% CL)

<sup>86</sup> AUBERT 05S measures  $N(D^+ \rightarrow K^+ \bar{K}^{*0})/N(D_S^+ \rightarrow K^+ K^- \pi^+)$ , the ratio of the numbers of events observed, and similarly for the  $D^-$ .

<sup>87</sup> FRABETTI 94I and AITALA 97B measure  $N(D^+ \rightarrow K^+ \bar{K}^*(892)^0)/N(D^+ \rightarrow K^- \pi^+ \pi^+)$ , the ratio of numbers of events observed, and similarly for the  $D^-$ .

### $A_{CP}(\phi\pi^\pm)$ in $D^\pm \rightarrow \phi\pi^\pm$

This is the difference between  $D^+$  and  $D^-$  partial widths for these modes divided by the sum of the widths.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>-0.001 ± 0.015 OUR AVERAGE</b>				
+0.002 ± 0.015 ± 0.006	10k ± 136	<sup>88</sup> AUBERT	05S BABR	$e^+ e^- \approx \Upsilon(4S)$
-0.028 ± 0.036		<sup>89</sup> AITALA	97B E791	$-0.087 < A_{CP} < +0.031$ (90% CL)
+0.066 ± 0.086		<sup>89</sup> FRABETTI	94I E687	$-0.075 < A_{CP} < +0.21$ (90% CL)

<sup>88</sup> AUBERT 05S measures  $N(D^+ \rightarrow \phi\pi^+)/N(D_S^+ \rightarrow K^+ K^- \pi^+)$ , the ratio of the numbers of events observed, and similarly for the  $D^-$ .

<sup>89</sup> FRABETTI 94I and AITALA 97B measure  $N(D^+ \rightarrow \phi\pi^+)/N(D^+ \rightarrow K^- \pi^+ \pi^+)$ , the ratio of numbers of events observed, and similarly for the  $D^-$ .

### $A_{CP}(\pi^+ \pi^- \pi^\pm)$ in $D^\pm \rightarrow \pi^+ \pi^- \pi^\pm$

This is the difference between  $D^+$  and  $D^-$  partial widths for these modes divided by the sum of the widths.

VALUE	DOCUMENT ID	TECN	COMMENT
<b>-0.017 ± 0.042</b>	<sup>90</sup> AITALA	97B E791	$-0.086 < A_{CP} < +0.052$ (90% CL)

<sup>90</sup> AITALA 97B measure  $N(D^+ \rightarrow \pi^+ \pi^- \pi^+)/N(D^+ \rightarrow K^- \pi^+ \pi^+)$ , the ratio of numbers of events observed, and similarly for the  $D^-$ .

### $A_{CP}(K_S^0 K^\pm \pi^+ \pi^-)$ in $D^\pm \rightarrow K_S^0 K^\pm \pi^+ \pi^-$

This is the difference between  $D^+$  and  $D^-$  partial widths for these modes divided by the sum of the widths.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>-0.042 ± 0.064 ± 0.022</b>	523 ± 32	LINK	05E FOCS	$\gamma A, \bar{E}_\gamma \approx 180$ GeV

## $D^+-D^-$ T-VIOLATING DECAY-RATE ASYMMETRIES

### $A_{Tviol}(K_S^0 K^\pm \pi^+ \pi^-)$ in $D^\pm \rightarrow K_S^0 K^\pm \pi^+ \pi^-$

$C_T \equiv \vec{p}_{K^+} \cdot (\vec{p}_{\pi^+} \times \vec{p}_{\pi^-})$  is a  $T$ -odd correlation of the  $K^+$ ,  $\pi^+$ , and  $\pi^-$  momenta for the  $D^+$ .  $\bar{C}_T \equiv \vec{p}_{K^-} \cdot (\vec{p}_{\pi^-} \times \vec{p}_{\pi^+})$  is the corresponding quantity for the  $D^-$ .  $A_T \equiv [\Gamma(C_T > 0) - \Gamma(C_T < 0)] / [\Gamma(C_T > 0) + \Gamma(C_T < 0)]$  would, in the absence of strong phases, test for  $T$  violation in  $D^+$  decays (the  $\Gamma$ 's are partial widths). With  $\bar{A}_T \equiv [\Gamma(-\bar{C}_T > 0) - \Gamma(-\bar{C}_T < 0)] / [\Gamma(-\bar{C}_T > 0) + \Gamma(-\bar{C}_T < 0)]$ , the asymmetry  $A_{Tviol} \equiv \frac{1}{2}(A_T - \bar{A}_T)$  tests for  $T$  violation even with nonzero strong phases.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>+0.023±0.062±0.022</b>	523 ± 32	LINK	05E FOCS	$\gamma$ A, $\bar{E}_\gamma \approx 180$ GeV

### $D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$ FORM FACTORS

#### $r_V \equiv V(0)/A_1(0)$ in $D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.62 ± 0.08 OUR AVERAGE</b>		Error includes scale factor of 1.5. See the ideogram below.		
1.504 ± 0.057 ± 0.039	15k	<sup>91</sup> LINK	02L FOCS	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
1.45 ± 0.23 ± 0.07	763	ADAMOVICH	99 BEAT	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
1.90 ± 0.11 ± 0.09	3000	<sup>92</sup> AITALA	98B E791	$\bar{K}^*(892)^0 e^+ \nu_e$
1.84 ± 0.11 ± 0.09	3034	AITALA	98F E791	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
1.74 ± 0.27 ± 0.28	874	FRABETTI	93E E687	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
2.00 <sup>+0.34</sup> / <sub>-0.32</sub> ± 0.16	305	KODAMA	92 E653	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$

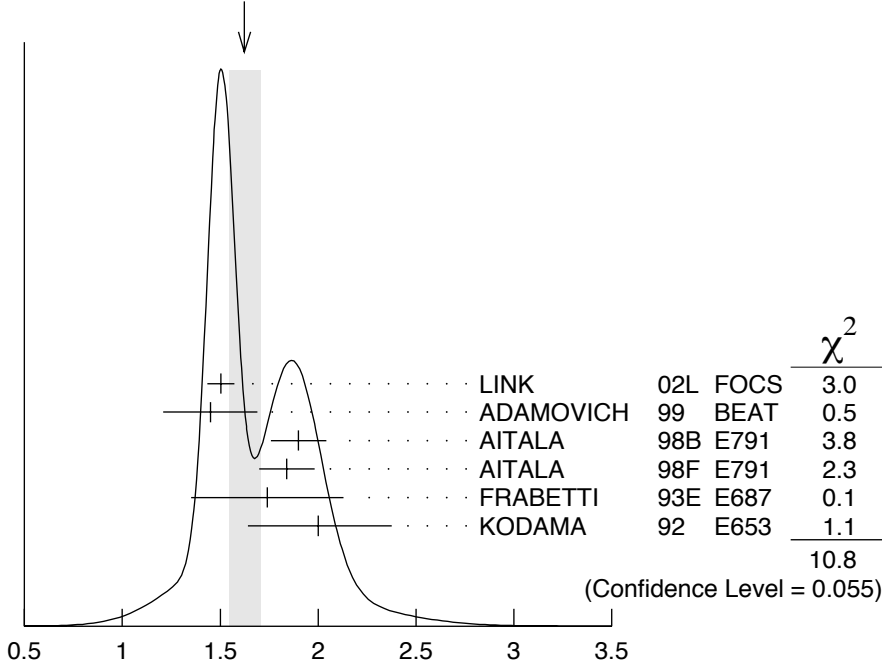
• • • We do not use the following data for averages, fits, limits, etc. • • •

2.0 ± 0.6 ± 0.3	183	ANJOS	90E E691	$\bar{K}^*(892)^0 e^+ \nu_e$
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<sup>91</sup> LINK 02L includes the effects of interference with an  $S$ -wave background. This much improves the goodness of fit, but does not much shift the values of the form factors.

<sup>92</sup> This is slightly different from the AITALA 98B value: see ref. [5] in AITALA 98F.

WEIGHTED AVERAGE  
 $1.62 \pm 0.08$  (Error scaled by 1.5)



$$r_V \equiv V(0)/A_1(0) \text{ in } D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$$

$$r_2 \equiv A_2(0)/A_1(0) \text{ in } D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.83 \pm 0.05</math> OUR AVERAGE</b>				
$0.875 \pm 0.049 \pm 0.064$	15k	<sup>93</sup> LINK	02L FOCS	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
$1.00 \pm 0.15 \pm 0.03$	763	ADAMOVICH	99 BEAT	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
$0.71 \pm 0.08 \pm 0.09$	3000	AITALA	98B E791	$\bar{K}^*(892)^0 e^+ \nu_e$
$0.75 \pm 0.08 \pm 0.09$	3034	AITALA	98F E791	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
$0.78 \pm 0.18 \pm 0.10$	874	FRABETTI	93E E687	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
$0.82 \begin{smallmatrix} +0.22 \\ -0.23 \end{smallmatrix} \pm 0.11$	305	KODAMA	92 E653	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$

• • • We do not use the following data for averages, fits, limits, etc. • • •

$0.0 \pm 0.5 \pm 0.2$	183	ANJOS	90E E691	$\bar{K}^*(892)^0 e^+ \nu_e$
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<sup>93</sup> LINK 02L includes the effects of interference with an S-wave background. This much improves the goodness of fit, but does not much shift the values of the form factors.

$$r_3 \equiv A_3(0)/A_1(0) \text{ in } D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.04 \pm 0.33 \pm 0.29</math></b>	3034	AITALA	98F E791	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$

$$\Gamma_L/\Gamma_T \text{ in } D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>1.13 \pm 0.08</math> OUR AVERAGE</b>				
$1.09 \pm 0.10 \pm 0.02$	763	ADAMOVICH	99 BEAT	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
$1.20 \pm 0.13 \pm 0.13$	874	FRABETTI	93E E687	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
$1.18 \pm 0.18 \pm 0.08$	305	KODAMA	92 E653	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$

• • • We do not use the following data for averages, fits, limits, etc. • • •



1.8  $^{+0.6}_{-0.4} \pm 0.3$       183      ANJOS      90E E691       $\bar{K}^*(892)^0 e^+ \nu_e$

$\Gamma_+/\Gamma_-$  in  $D^+ \rightarrow \bar{K}^*(892)^0 \ell^+ \nu_\ell$

VALUE	EVTs	DOCUMENT ID	TECN	COMMENT
<b>0.22 ± 0.06 OUR AVERAGE</b>		Error includes scale factor of 1.6.		
0.28 ± 0.05 ± 0.02	763	ADAMOVICH 99	BEAT	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
0.16 ± 0.05 ± 0.02	305	KODAMA 92	E653	$\bar{K}^*(892)^0 \mu^+ \nu_\mu$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.15 $^{+0.07}_{-0.05} \pm 0.03$	183	ANJOS	90E E691	$\bar{K}^*(892)^0 e^+ \nu_e$

**D<sup>±</sup> REFERENCES**

PDG	06	JPG 33 1	W.-M. Yao <i>et al.</i>	(PDG Collab.)
RUBIN	06	PRL 96 081802	P. Rubin <i>et al.</i>	(CLEO Collab.)
ABLIKIM	05A	PL B608 24	M. Ablikim <i>et al.</i>	(BEPC BES Collab.)
ABLIKIM	05D	PL B610 183	M. Ablikim <i>et al.</i>	(BEPC BES Collab.)
ABLIKIM	05F	PL B622 6	M. Ablikim <i>et al.</i>	(BEPC BES Collab.)
ABLIKIM	05P	PL B625 196	M. Ablikim <i>et al.</i>	(BEPC BES Collab.)
ARTUSO	05A	PRL 95 251801	M. Artuso <i>et al.</i>	(CLEO Collab.)
AUBERT	05S	PR D71 091101R	B. Aubert <i>et al.</i>	(BABAR Collab.)
HE	05	PRL 95 121801	Q. He <i>et al.</i>	(CLEO Collab.)
HE	05A	PRL 95 221802	Q. He <i>et al.</i>	(CLEO Collab.)
HUANG	05B	PRL 95 181801	G.S. Huang <i>et al.</i>	(CLEO Collab.)
KAYIS-TOPAK...	05	PL B626 24	A. Kayis-Topaksu <i>et al.</i>	(CERN CHORUS Collab.)
LINK	05E	PL B622 239	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	05I	PL B621 72	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
ABLIKIM	04C	PL B597 39	M. Ablikim <i>et al.</i>	(BEPC BES Collab.)
ARMS	04	PR D69 071102R	K. Arms <i>et al.</i>	(CLEO Collab.)
BONVICINI	04A	PR D70 112004	G. Bonvicini <i>et al.</i>	(CLEO Collab.)
LINK	04	PL B585 200	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	04E	PL B598 33	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	04F	PL B601 10	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
ANISOVICH	03	EPJ A16 229	V.V. Anisovich <i>et al.</i>	
LINK	03D	PL B561 225	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	03F	PL B572 21	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
AITALA	02	PRL 89 121801	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
BRANDENB...	02	PRL 89 222001	G. Brandenburg <i>et al.</i>	(CLEO Collab.)
KAYIS-TOPAK...	02	PL B549 48	A. Kayis-Topaksu <i>et al.</i>	(CERN CHORUS Collab.)
LINK	02B	PRL 88 041602	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
Also		PRL 88 159903 (erratum)	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	02E	PL B535 43	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	02F	PL B537 192	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	02I	PL B541 227	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	02J	PL B541 243	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
LINK	02L	PL B544 89	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
AITALA	01B	PRL 86 770	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
LINK	01C	PRL 87 162001	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
ABREU	00O	EPJ C12 209	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ASTIER	00D	PL B486 35	P. Astier <i>et al.</i>	(CERN NOMAD Collab.)
BAI	00C	PR D62 052001	J.Z. Bai <i>et al.</i>	(BEPC BES Collab.)
JUN	00	PRL 84 1857	S.Y. Jun <i>et al.</i>	(FNAL SELEX Collab.)
LINK	00B	PL B491 232	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
Also		PL B495 443 (erratum)	J.M. Link <i>et al.</i>	(FNAL FOCUS Collab.)
ABBIENDI	99K	EPJ C8 573	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABE	99P	PR D60 092005	F. Abe <i>et al.</i>	(CDF Collab.)
ADAMOVICH	99	EPJ C6 35	M. Adamovich <i>et al.</i>	(CERN BEATRICE Collab.)
AITALA	99G	PL B462 401	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
BONVICINI	99	PRL 82 4586	G. Bonvicini <i>et al.</i>	(CLEO Collab.)
AITALA	98B	PRL 80 1393	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
AITALA	98C	PL B421 405	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
AITALA	98F	PL B440 435	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
BAI	98B	PL B429 188	J.Z. Bai <i>et al.</i>	(BEPC BES Collab.)
JESSOP	98	PR D58 052002	C.P. Jessop <i>et al.</i>	(CLEO Collab.)
AITALA	97	PL B397 325	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)

AITALA	97B	PL B403 377	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
AITALA	97C	PL B404 187	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
BARTELT	97	PL B405 373	J. Bartelt <i>et al.</i>	(CLEO Collab.)
BISHAI	97	PRL 78 3261	M. Bishai <i>et al.</i>	(CLEO Collab.)
FRABETTI	97	PL B391 235	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	97B	PL B398 239	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	97C	PL B401 131	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	97D	PL B407 79	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
AITALA	96	PRL 76 364	E.M. Aitala <i>et al.</i>	(FNAL E791 Collab.)
ALBRECHT	96C	PL B374 249	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
FRABETTI	95	PL B346 199	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	95B	PL B351 591	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	95E	PL B359 403	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	95F	PL B363 259	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
KODAMA	95	PL B345 85	K. Kodama <i>et al.</i>	(FNAL E653 Collab.)
ALBRECHT	94I	ZPHY C64 375	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
ALEEV	94	PAN 57 1370	A.N. Aleev <i>et al.</i>	(Serpukhov BIS-2 Collab.)
		Translated from YF 57 1443.		
BALEST	94	PRL 72 2328	R. Balest <i>et al.</i>	(CLEO Collab.)
FRABETTI	94D	PL B323 459	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	94G	PL B331 217	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
FRABETTI	94I	PR D50 R2953	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
ABE	93E	PL B313 288	K. Abe <i>et al.</i>	(VENUS Collab.)
ADAMOVICH	93	PL B305 177	M.I. Adamovich <i>et al.</i>	(CERN WA82 Collab.)
AKERIB	93	PRL 71 3070	D.S. Akerib <i>et al.</i>	(CLEO Collab.)
ALAM	93	PRL 71 1311	M.S. Alam <i>et al.</i>	(CLEO Collab.)
ANJOS	93	PR D48 56	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
BEAN	93C	PL B317 647	A. Bean <i>et al.</i>	(CLEO Collab.)
FRABETTI	93E	PL B307 262	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
KODAMA	93B	PL B313 260	K. Kodama <i>et al.</i>	(FNAL E653 Collab.)
KODAMA	93C	PL B316 455	K. Kodama <i>et al.</i>	(FNAL E653 Collab.)
SELEN	93	PRL 71 1973	M.A. Selen <i>et al.</i>	(CLEO Collab.)
ALBRECHT	92B	ZPHY C53 361	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
ALBRECHT	92F	PL B278 202	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
ANJOS	92	PR D45 R2177	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
ANJOS	92C	PR D46 1941	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
ANJOS	92D	PRL 69 2892	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
BARLAG	92C	ZPHY C55 383	S. Barlag <i>et al.</i>	(ACCMOR Collab.)
	Also	ZPHY C48 29	S. Barlag <i>et al.</i>	(ACCMOR Collab.)
COFFMAN	92B	PR D45 2196	D.M. Coffman <i>et al.</i>	(Mark III Collab.)
DAOUDI	92	PR D45 3965	M. Daoudi <i>et al.</i>	(CLEO Collab.)
KODAMA	92	PL B274 246	K. Kodama <i>et al.</i>	(FNAL E653 Collab.)
KODAMA	92C	PL B286 187	K. Kodama <i>et al.</i>	(FNAL E653 Collab.)
ADAMOVICH	91	PL B268 142	M.I. Adamovich <i>et al.</i>	(WA82 Collab.)
ALBRECHT	91	PL B255 634	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
ALVAREZ	91B	ZPHY C50 11	M.P. Alvarez <i>et al.</i>	(CERN NA14/2 Collab.)
AMMAR	91	PR D44 3383	R. Ammar <i>et al.</i>	(CLEO Collab.)
ANJOS	91C	PRL 67 1507	J.C. Anjos <i>et al.</i>	(FNAL-TPS Collab.)
BAI	91	PRL 66 1011	Z. Bai <i>et al.</i>	(Mark III Collab.)
COFFMAN	91	PL B263 135	D.M. Coffman <i>et al.</i>	(Mark III Collab.)
FRABETTI	91	PL B263 584	P.L. Frabetti <i>et al.</i>	(FNAL E687 Collab.)
ALVAREZ	90	ZPHY C47 539	M.P. Alvarez <i>et al.</i>	(CERN NA14/2 Collab.)
ALVAREZ	90C	PL B246 261	M.P. Alvarez <i>et al.</i>	(CERN NA14/2 Collab.)
ANJOS	90C	PR D41 2705	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
ANJOS	90D	PR D42 2414	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
ANJOS	90E	PRL 65 2630	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
BARLAG	90C	ZPHY C46 563	S. Barlag <i>et al.</i>	(ACCMOR Collab.)
WEIR	90B	PR D41 1384	A.J. Weir <i>et al.</i>	(Mark II Collab.)
ANJOS	89	PRL 62 125	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
ANJOS	89B	PRL 62 722	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
ANJOS	89E	PL B223 267	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
ADLER	88C	PRL 60 89	J. Adler <i>et al.</i>	(Mark III Collab.)
ALBRECHT	88I	PL B210 267	H. Albrecht <i>et al.</i>	(ARGUS Collab.)
ANJOS	88	PRL 60 897	J.C. Anjos <i>et al.</i>	(FNAL E691 Collab.)
AOKI	88	PL B209 113	S. Aoki <i>et al.</i>	(WA75 Collab.)
HAAS	88	PRL 60 1614	P. Haas <i>et al.</i>	(CLEO Collab.)
ONG	88	PRL 60 2587	R.A. Ong <i>et al.</i>	(Mark II Collab.)
RAAB	88	PR D37 2391	J.R. Raab <i>et al.</i>	(FNAL E691 Collab.)
ADAMOVICH	87	EPL 4 887	M.I. Adamovich <i>et al.</i>	(Photon Emulsion Collab.)
ADLER	87	PL B196 107	J. Adler <i>et al.</i>	(Mark III Collab.)

AGUILAR-...	87E	ZPHY C36 551	M. Aguilar-Benitez <i>et al.</i>	(LEBC-EHS Collab.)
Also		ZPHY C40 321	M. Aguilar-Benitez <i>et al.</i>	(LEBC-EHS Collab.)
AGUILAR-...	87F	ZPHY C36 559	M. Aguilar-Benitez <i>et al.</i>	(LEBC-EHS Collab.)
Also		ZPHY C38 520 (erratum)	M. Aguilar-Benitez <i>et al.</i>	(LEBC-EHS Collab.)
BARTEL	87	ZPHY C33 339	W. Bartel <i>et al.</i>	(JADE Collab.)
AGUILAR-...	86B	ZPHY C31 491	M. Aguilar-Benitez <i>et al.</i>	(LEBC-EHS Collab.)
BALTRUSAIT...	86E	PRL 56 2140	R.M. Baltrusaitis <i>et al.</i>	(Mark III Collab.)
PAL	86	PR D33 2708	T. Pal <i>et al.</i>	(DELCO Collab.)
AIHARA	85	ZPHY C27 39	H. Aihara <i>et al.</i>	(TPC Collab.)
BALTRUSAIT...	85B	PRL 54 1976	R.M. Baltrusaitis <i>et al.</i>	(Mark III Collab.)
BALTRUSAIT...	85E	PRL 55 150	R.M. Baltrusaitis <i>et al.</i>	(Mark III Collab.)
BARTEL	85J	PL 163B 277	W. Bartel <i>et al.</i>	(JADE Collab.)
ADAMOVICH	84	PL 140B 119	M.I. Adamovich <i>et al.</i>	(CERN WA58 Collab.)
ALTHOFF	84G	ZPHY C22 219	M. Althoff <i>et al.</i>	(TASSO Collab.)
ALTHOFF	84J	PL 146B 443	M. Althoff <i>et al.</i>	(TASSO Collab.)
DERRICK	84	PRL 53 1971	M. Derrick <i>et al.</i>	(HRS Collab.)
KOOP	84	PRL 52 970	D.E. Koop <i>et al.</i>	(DELCO Collab.)
PARTRIDGE	81	PRL 47 760	R. Partridge <i>et al.</i>	(Crystal Ball Collab.)
SCHINDLER	81	PR D24 78	R.H. Schindler <i>et al.</i>	(Mark II Collab.)
TRILLING	81	PRPL 75 57	G.H. Trilling	(LBL, UCB) J
BACINO	80	PRL 45 329	W.J. Bacino <i>et al.</i>	(DELCO Collab.)
ZHOLENTZ	80	PL 96B 214	A.A. Zholents <i>et al.</i>	(NOVO)
Also		SJNP 34 814	A.A. Zholents <i>et al.</i>	(NOVO)
		Translated from YAF 34	1471.	
BACINO	79	PRL 43 1073	W.J. Bacino <i>et al.</i>	(DELCO Collab.)
BRANDELIK	79	PL 80B 412	R. Brandelik <i>et al.</i>	(DASP Collab.)
FELLER	78	PRL 40 274	J.M. Feller <i>et al.</i>	(Mark I Collab.)
VUILLEMIN	78	PRL 41 1149	V. Vuillemin <i>et al.</i>	(Mark I Collab.)
GOLDHABER	77	PL 69B 503	G. Goldhaber <i>et al.</i>	(Mark I Collab.)
PERUZZI	77	PRL 39 1301	I. Peruzzi <i>et al.</i>	(Mark I Collab.)
PICCOLO	77	PL 70B 260	M. Piccolo <i>et al.</i>	(Mark I Collab.)
PERUZZI	76	PRL 37 569	I. Peruzzi <i>et al.</i>	(Mark I Collab.)

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