

$\phi(1020)$

$$I^G(J^{PC}) = 0^-(1^{--})$$

$\phi(1020)$ MASS

<u>VALUE (MeV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1019.461 ± 0.016 OUR AVERAGE				
1019.463 ± 0.061	2.3M	¹ KOZYREV 18	CMD3	$e^+e^- \rightarrow K^+K^-,$ $K_S^0 K_L^0$
1019.462 ± 0.042 ± 0.056	28k	² LEES 14H	BABR	$e^+e^- \rightarrow K_S^0 K_L^0 \gamma$
1019.51 ± 0.02 ± 0.05		³ LEES 13Q	BABR	$e^+e^- \rightarrow K^+K^-\gamma$
1019.30 ± 0.02 ± 0.10	105k	AKHMETSHIN 06	CMD2	$0.98-1.06 e^+e^- \rightarrow$ $\pi^+\pi^-\pi^0$
1019.52 ± 0.05 ± 0.05	17.4k	AKHMETSHIN 05	CMD2	$0.60-1.38 e^+e^- \rightarrow$ $\eta\gamma$
1019.483 ± 0.011 ± 0.025	272k	⁴ AKHMETSHIN 04	CMD2	$e^+e^- \rightarrow K_L^0 K_S^0$
1019.42 ± 0.05	1900k	⁵ ACHASOV 01E	SND	$e^+e^- \rightarrow K^+K^-,$ $K_S K_L, \pi^+\pi^-\pi^0$
1019.40 ± 0.04 ± 0.05	23k	AKHMETSHIN 01B	CMD2	$e^+e^- \rightarrow \eta\gamma$
1019.36 ± 0.12		⁶ ACHASOV 00B	SND	$e^+e^- \rightarrow \eta\gamma$
1019.38 ± 0.07 ± 0.08	2200	⁷ AKHMETSHIN 99F	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\geq$ 2γ
1019.51 ± 0.07 ± 0.10	11169	AKHMETSHIN 98	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
1019.5 ± 0.4		BARBERIS 98	OMEG 450	$pp \rightarrow$ $pp2K^+2K^-$
1019.42 ± 0.06	55600	AKHMETSHIN 95	CMD2	$e^+e^- \rightarrow$ hadrons
1019.7 ± 0.3	2012	DAVENPORT 86	MPSF 400	$pA \rightarrow 4KX$
1019.7 ± 0.1 ± 0.1	5079	ALBRECHT 85D	ARG 10	$e^+e^- \rightarrow$ K^+K^-X
1019.3 ± 0.1	1500	ARENTON 82	AEMS 11.8	polar. $pp \rightarrow$ KK
1019.67 ± 0.17	25080	⁸ PELLINEN 82	RVUE	
1019.52 ± 0.13	3681	BUKIN 78C	OLYA	$e^+e^- \rightarrow$ hadrons
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1019.469 ± 0.061	1.7M	KOZYREV 18	CMD3	$e^+e^- \rightarrow K^+K^-$
1019.457 ± 0.061	610k	KOZYREV 16	CMD3	$e^+e^- \rightarrow K_S^0 K_L^0$
1019.48 ± 0.01		LEES 13F	BABR	$D^+ \rightarrow K^+K^-\pi^+$
1019.441 ± 0.008 ± 0.080	542k	⁹ AKHMETSHIN 08	CMD2	$1.02 e^+e^- \rightarrow$ K^+K^-
1019.63 ± 0.07	12540	¹⁰ AUBERT,B 05J	BABR	$D^0 \rightarrow \bar{K}^0 K^+ K^-$
1019.8 ± 0.7		ARMSTRONG 86	OMEG 85	$\pi^+ / pp \rightarrow$ $\pi^+ / p4Kp$
1020.1 ± 0.11	5526	¹⁰ ATKINSON 86	OMEG 20-70	γp
1019.7 ± 1.0		BEBEK 86	CLEO	$e^+e^- \rightarrow \Upsilon(4S)$
1019.411 ± 0.008	642k	¹¹ DIJKSTRA 86	SPEC 100-200	$\pi^\pm, \bar{p}, p,$ $K^\pm, \text{ on Be}$
1020.9 ± 0.2		¹⁰ FRAME 86	OMEG 13	$K^+ p \rightarrow \phi K^+ p$
1021.0 ± 0.2		¹⁰ ARMSTRONG 83B	OMEG 18.5	$K^- p \rightarrow$ $K^- K^+ \Lambda$
1020.0 ± 0.5		¹⁰ ARMSTRONG 83B	OMEG 18.5	$K^- p \rightarrow$ $K^- K^+ \Lambda$

1019.7	± 0.3		¹⁰	BARATE	83	GOLI	190	$\pi^- \text{Be} \rightarrow 2\mu X$
1019.8	± 0.2	± 0.5	766	IVANOV	81	OLYA	1-1.4	$e^+ e^- \rightarrow K^+ K^-$
1019.4	± 0.5		337	COOPER	78B	HBC	0.7-0.8	$\bar{p} p \rightarrow K_S^0 K_L^0 \pi^+ \pi^-$
1020	± 1		383	¹⁰ BALDI	77	CNTR	10	$\pi^- p \rightarrow \pi^- \phi p$
1018.9	± 0.6		800	COHEN	77	ASPK	6	$\pi^\pm N \rightarrow K^+ K^- N$
1019.7	± 0.5		454	KALBFLEISCH	76	HBC	2.18	$K^- p \rightarrow \Lambda K \bar{K}$
1019.4	± 0.8		984	BESCH	74	CNTR	2	$\gamma p \rightarrow p K^+ K^-$
1020.3	± 0.4		100	BALLAM	73	HBC	2.8-9.3	γp
1019.4	± 0.7			BINNIE	73B	CNTR		$\pi^- p \rightarrow \phi n$
1019.6	± 0.5		120	¹² AGUILAR-...	72B	HBC	3.9,4.6	$K^- p \rightarrow \Lambda K^+ K^-$
1019.9	± 0.5		100	¹² AGUILAR-...	72B	HBC	3.9,4.6	$K^- p \rightarrow K^- p K^+ K^-$
1020.4	± 0.5		131	COLLEY	72	HBC	10	$K^+ p \rightarrow K^+ p \phi$
1019.9	± 0.3		410	STOTTLE...	71	HBC	2.9	$K^- p \rightarrow \Sigma / \Lambda K \bar{K}$

¹ Average of KOZYREV 16 and KOZYREV 18 values taking into account the correlated uncertainties. Supersedes individual KOZYREV 16 and KOZYREV 18 results.

² Using a vector meson dominance model with contribution from $\phi(1020)$ and higher mass excitations of $\rho(770)$, $\omega(782)$, and $\phi(1020)$.

³ Using a phenomenological model based on KUHN 90 with a sum of Breit-Wigner resonances for $\rho(770)$, $\omega(782)$, $\phi(1020)$ and their higher mass excitations.

⁴ Update of AKHMETSHIN 99D

⁵ From the combined fit assuming that the total $\phi(1020)$ production cross section is saturated by those of $K^+ K^-$, $K_S^+ K_L^-$, $\pi^+ \pi^- \pi^0$, and $\eta \gamma$ decays modes and using ACHASOV 00B for the $\eta \gamma$ decay mode.

⁶ Using a total width of 4.43 ± 0.05 MeV. Systematic uncertainty included.

⁷ Using a total width of 4.43 ± 0.05 MeV.

⁸ PELLINEN 82 review includes AKERLOF 77, DAUM 81, BALDI 77, AYRES 74, DE-GROOT 74.

⁹ Strongly correlated with AKHMETSHIN 04.

¹⁰ Systematic errors not evaluated.

¹¹ Weighted and scaled average of 12 measurements of DIJKSTRA 86.

¹² Mass errors enlarged by us to Γ/\sqrt{N} ; see the note with the $K^*(892)$ mass.

$\phi(1020)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
4.249\pm0.013 OUR AVERAGE		Error includes scale factor of 1.1.		
4.245 \pm 0.013	2.3M	¹ KOZYREV	18	CMD3 $e^+ e^- \rightarrow K^+ K^-$, $K_S^0 K_L^0$
4.205 \pm 0.103 \pm 0.067	28k	² LEES	14H	BABR $e^+ e^- \rightarrow K_S^0 K_L^0 \gamma$
4.29 \pm 0.04 \pm 0.07		³ LEES	13Q	BABR $e^+ e^- \rightarrow K^+ K^- \gamma$
4.30 \pm 0.06 \pm 0.17	105k	AKHMETSHIN	06	CMD2 0.98-1.06 $e^+ e^- \rightarrow \pi^+ \pi^- \pi^0$
4.280 \pm 0.033 \pm 0.025	272k	⁴ AKHMETSHIN	04	CMD2 $e^+ e^- \rightarrow K_L^0 K_S^0$
4.21 \pm 0.04	1900k	⁵ ACHASOV	01E	SND $e^+ e^- \rightarrow K^+ K^-$, $K_S^+ K_L^-, \pi^+ \pi^- \pi^0$
4.44 \pm 0.09	55600	AKHMETSHIN	95	CMD2 $e^+ e^- \rightarrow$ hadrons

4.5 ±0.7	1500	ARENTO	82	AEMS	11.8 polar.	$pp \rightarrow KK$
4.2 ±0.6	766	⁶ IVANOV	81	OLYA	1-1.4	$e^+e^- \rightarrow K^+K^-$
4.3 ±0.6		⁶ CORDIER	80	DM1		$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
4.36 ±0.29	3681	⁶ BUKIN	78c	OLYA		$e^+e^- \rightarrow \text{hadrons}$
4.4 ±0.6	984	⁶ BESCH	74	CNTR	2	$\gamma p \rightarrow pK^+K^-$
4.67 ±0.72	681	⁶ BALAKIN	71	OSPK		$e^+e^- \rightarrow \text{hadrons}$
4.09 ±0.29		BIZOT	70	OSPK		$e^+e^- \rightarrow \text{hadrons}$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
4.249±0.015	1.7M	KOZYREV	18	CMD3		$e^+e^- \rightarrow K^+K^-$
4.240±0.017	610k	KOZYREV	16	CMD3		$e^+e^- \rightarrow K_S^0 K_L^0$
4.37 ±0.02		LEES	13F	BABR		$D^+ \rightarrow K^+K^-\pi^+$
4.24 ±0.02 ±0.03	542k	⁷ AKHMETSHIN	08	CMD2	1.02	$e^+e^- \rightarrow K^+K^-$
4.28 ±0.13	12540	⁸ AUBERT,B	05J	BABR		$D^0 \rightarrow \bar{K}^0 K^+ K^-$
4.45 ±0.06	271k	DIJKSTRA	86	SPEC	100	$\pi^- \text{Be}$
3.6 ±0.8	337	⁶ COOPER	78B	HBC	0.7-0.8	$\bar{p}p \rightarrow K_S^0 K_L^0 \pi^+ \pi^-$
4.5 ±0.50	1300	^{6,8} AKERLOF	77	SPEC	400	$pA \rightarrow K^+K^-X$
4.5 ±0.8	500	^{6,8} AYRES	74	ASPK	3-6	$\pi^- p \rightarrow K^+K^-n, K^-p \rightarrow K^+K^-\Lambda/\Sigma^0$
3.81 ±0.37		COSME	74B	OSPK		$e^+e^- \rightarrow K_L^0 K_S^0$
3.8 ±0.7	454	⁶ BORENSTEIN	72	HBC	2.18	$K^- p \rightarrow K\bar{K}n$

¹ Average of KOZYREV 16 and KOZYREV 18 values taking into account the correlated uncertainties. Supersedes individual KOZYREV 16 and KOZYREV 18 results.

² Using a vector meson dominance model with contribution from $\phi(1020)$ and higher mass excitations of $\rho(770)$, $\omega(782)$, and $\phi(1020)$.

³ Using a phenomenological model based on KUHN 90 with a sum of Breit-Wigner resonances for $\rho(770)$, $\omega(782)$, $\phi(1020)$ and their higher mass excitations.

⁴ Update of AKHMETSHIN 99D

⁵ From the combined fit assuming that the total $\phi(1020)$ production cross section is saturated by those of K^+K^- , $K_S K_L$, $\pi^+\pi^-\pi^0$, and $\eta\gamma$ decays modes and using ACHASOV 00B for the $\eta\gamma$ decay mode.

⁶ Width errors enlarged by us to $4\Gamma/\sqrt{N}$; see the note with the $K^*(892)$ mass.

⁷ Strongly correlated with AKHMETSHIN 04.

⁸ Systematic errors not evaluated.

$\phi(1020)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1 K^+K^-	(49.2 ±0.5) %	S=1.3
Γ_2 $K_L^0 K_S^0$	(34.0 ±0.4) %	S=1.3
Γ_3 $\rho\pi + \pi^+\pi^-\pi^0$	(15.24 ±0.33) %	S=1.2
Γ_4 $\rho\pi$		
Γ_5 $\pi^+\pi^-\pi^0$		
Γ_6 $\eta\gamma$	(1.303±0.025) %	S=1.2
Γ_7 $\pi^0\gamma$	(1.30 ±0.05) × 10 ⁻³	
Γ_8 $\ell^+\ell^-$	—	

Γ_9	e^+e^-	$(2.973 \pm 0.034) \times 10^{-4}$	S=1.3
Γ_{10}	$\mu^+\mu^-$	$(2.86 \pm 0.19) \times 10^{-4}$	
Γ_{11}	ηe^+e^-	$(1.08 \pm 0.04) \times 10^{-4}$	
Γ_{12}	$\pi^+\pi^-$	$(7.3 \pm 1.3) \times 10^{-5}$	
Γ_{13}	$\omega\pi^0$	$(4.7 \pm 0.5) \times 10^{-5}$	
Γ_{14}	$\omega\gamma$	< 5 %	CL=84%
Γ_{15}	$\rho\gamma$	< 1.2 $\times 10^{-5}$	CL=90%
Γ_{16}	$\pi^+\pi^-\gamma$	$(4.1 \pm 1.3) \times 10^{-5}$	
Γ_{17}	$f_0(980)\gamma$	$(3.22 \pm 0.19) \times 10^{-4}$	S=1.1
Γ_{18}	$\pi^0\pi^0\gamma$	$(1.12 \pm 0.06) \times 10^{-4}$	
Γ_{19}	$\pi^+\pi^-\pi^+\pi^-$	$(3.9 \begin{smallmatrix} +2.8 \\ -2.2 \end{smallmatrix}) \times 10^{-6}$	
Γ_{20}	$\pi^+\pi^+\pi^-\pi^-\pi^0$	< 4.6 $\times 10^{-6}$	CL=90%
Γ_{21}	$\pi^0e^+e^-$	$(1.33 \begin{smallmatrix} +0.07 \\ -0.10 \end{smallmatrix}) \times 10^{-5}$	
Γ_{22}	$\pi^0\eta\gamma$	$(7.27 \pm 0.30) \times 10^{-5}$	S=1.5
Γ_{23}	$a_0(980)\gamma$	$(7.6 \pm 0.6) \times 10^{-5}$	
Γ_{24}	$K^0\bar{K}^0\gamma$	< 1.9 $\times 10^{-8}$	CL=90%
Γ_{25}	$\eta'(958)\gamma$	$(6.22 \pm 0.21) \times 10^{-5}$	
Γ_{26}	$\eta\pi^0\pi^0\gamma$	< 2 $\times 10^{-5}$	CL=90%
Γ_{27}	$\mu^+\mu^-\gamma$	$(1.4 \pm 0.5) \times 10^{-5}$	
Γ_{28}	$\rho\gamma\gamma$	< 1.2 $\times 10^{-4}$	CL=90%
Γ_{29}	$\eta\pi^+\pi^-$	< 1.8 $\times 10^{-5}$	CL=90%
Γ_{30}	$\eta\mu^+\mu^-$	< 9.4 $\times 10^{-6}$	CL=90%
Γ_{31}	$\eta U \rightarrow \eta e^+e^-$	< 1 $\times 10^{-6}$	CL=90%
Γ_{32}	invisible	< 1.7 $\times 10^{-4}$	CL=90%

Lepton Family number (LF) violating modes

Γ_{33}	$e^\pm\mu^\mp$	LF < 2 $\times 10^{-6}$	CL=90%
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CONSTRAINED FIT INFORMATION

An overall fit to 30 branching ratios uses 82 measurements and one constraint to determine 14 parameters. The overall fit has a $\chi^2 = 63.7$ for 69 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_2	-78										
x_3	-59	-4									
x_6	-23	19	6								
x_7	-15	14	4	10							
x_9	54	-52	-17	-38	-27						
x_{10}	-7	7	2	5	3	-13					
x_{12}	-3	3	1	2	2	-6	1				
x_{13}	-5	4	1	3	2	-8	1	1			
x_{17}	0	0	0	0	0	0	0	0	0		
x_{18}	-11	10	3	19	5	-20	2	1	2	0	
x_{19}	-1	1	0	1	0	-2	0	0	0	0	
x_{23}	0	0	0	0	0	0	0	0	0	0	
x_{25}	-8	6	2	33	3	-12	2	1	1	0	
	x_1	x_2	x_3	x_6	x_7	x_9	x_{10}	x_{12}	x_{13}	x_{17}	

x_{19}	0										
x_{23}	0	0									
x_{25}	6	0	0								
	x_{18}	x_{19}	x_{23}								

$\phi(1020)$ PARTIAL WIDTHS

$\Gamma(\eta\gamma)$ Γ_6

VALUE (keV)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$58.9 \pm 0.5 \pm 2.4$	ACHASOV	00	SND $e^+ e^- \rightarrow \eta\gamma$

$\Gamma(\pi^0\gamma)$ Γ_7

VALUE (keV)	DOCUMENT ID	TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •			
$5.40 \pm 0.16^{+0.43}_{-0.40}$	ACHASOV	00	SND $e^+ e^- \rightarrow \pi^0\gamma$

$\Gamma(\ell^+ \ell^-)$ Γ_8

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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• • • We do not use the following data for averages, fits, limits, etc. • • •

1.320 ± 0.017 ± 0.015	¹ AMBROSINO 05	KLOE	1.02 $e^+ e^- \rightarrow \mu^+ \mu^-$
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¹ Weighted average of Γ_{ee} and $\sqrt{\Gamma_{ee}\Gamma_{\mu\mu}}$ from AMBROSINO 05 assuming lepton universality.

$\Gamma(e^+ e^-)$ Γ_9

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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1.27 ± 0.04 OUR EVALUATION

1.251 ± 0.021 OUR AVERAGE Error includes scale factor of 1.1.

1.235 ± 0.006 ± 0.022	¹ AKHMETSHIN 11	CMD2	1.02 $e^+ e^- \rightarrow \phi$
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1.32 ± 0.05 ± 0.03	² AMBROSINO 05	KLOE	1.02 $e^+ e^- \rightarrow e^+ e^-$
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1.28 ± 0.05	AKHMETSHIN 95	CMD2	1.02 $e^+ e^- \rightarrow \phi$
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¹ Combined analysis of the CMD-2 data on $\phi \rightarrow K^+ K^-, K_S^0 K_L^0, \pi^+ \pi^- \pi^0, \eta \gamma$ assuming that the sum of their branching fractions is 0.99741 ± 0.00007 .

² From forward-backward asymmetry and using $\Gamma_{\text{total}} = 4.26 \pm 0.05$ MeV from the 2004 edition of this Review.

$(\Gamma(e^+ e^-) \times \Gamma(\mu^+ \mu^-))^{1/2}$ $(\Gamma_9 \Gamma_{10})^{1/2}$

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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1.320 ± 0.018 ± 0.017	AMBROSINO 05	KLOE	1.02 $e^+ e^- \rightarrow \mu^+ \mu^-$
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$\phi(1020) \Gamma(i) \Gamma(e^+ e^-) / \Gamma(\text{total})$

$\Gamma(K^+ K^-) \times \Gamma(e^+ e^-) / \Gamma_{\text{total}}$ $\Gamma_1 \Gamma_9 / \Gamma$

<u>VALUE (keV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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0.6340 ± 0.0070 ± 0.0039	1	LEES	13Q BABR	$e^+ e^- \rightarrow K^+ K^- \gamma$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.669 ± 0.001 ± 0.023	1.7M	KOZYREV	18 CMD3	$e^+ e^- \rightarrow K^+ K^-$
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¹ Using a phenomenological model based on KUHN 90 with a sum of Breit-Wigner resonances for $\rho(770), \omega(782), \phi(1020)$ and their higher mass excitations. The first error combines statistical and systematic uncertainties. The second one is due to the parametrization of the charged kaon form factor and mass calibration.

$\Gamma(K_L^0 K_S^0) \times \Gamma(e^+ e^-) / \Gamma_{\text{total}}$ $\Gamma_2 \Gamma_9 / \Gamma$

<u>VALUE (keV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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0.4200 ± 0.0033 ± 0.0123	28k	¹ LEES	14H BABR	$e^+ e^- \rightarrow K_S^0 K_L^0 \gamma$
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¹ Using a vector meson dominance model with contribution from $\phi(1020)$ and higher mass excitations of $\rho(770), \omega(782),$ and $\phi(1020)$.

$\phi(1020) \Gamma(i)\Gamma(e^+ e^-)/\Gamma^2(\text{total})$

$\Gamma(K^+ K^-)/\Gamma_{\text{total}} \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}$ $\Gamma_1/\Gamma \times \Gamma_9/\Gamma$

VALUE (units 10^{-5}) EVTS DOCUMENT ID TECN COMMENT

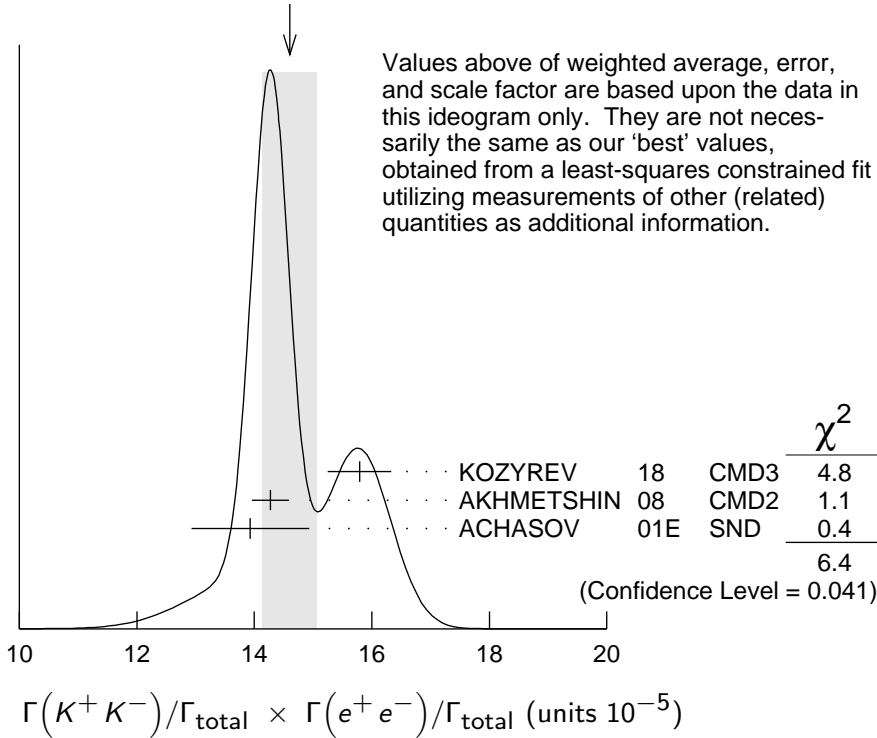
14.63 ± 0.29 OUR FIT Error includes scale factor of 1.5.

14.6 ± 0.5 OUR AVERAGE Error includes scale factor of 1.8. See the ideogram below.

15.789 ± 0.541	1.7M	KOZYREV	18	CMD3	$e^+ e^- \rightarrow K^+ K^-$
14.27 ± 0.05 ± 0.31	542k	AKHMETSHIN	08	CMD2	1.02 $e^+ e^- \rightarrow K^+ K^-$
13.93 ± 0.14 ± 0.99	1000k	¹ ACHASOV	01E	SND	$e^+ e^- \rightarrow K^+ K^-,$ $K_S K_L, \pi^+ \pi^- \pi^0$

¹From the combined fit assuming that the total $\phi(1020)$ production cross section is saturated by those of $K^+ K^-$, $K_S K_L$, $\pi^+ \pi^- \pi^0$, and $\eta\gamma$ decays modes and using ACHASOV 00B for the $\eta\gamma$ decay mode.

WEIGHTED AVERAGE
14.6 ± 0.5 (Error scaled by 1.8)



$\Gamma(K_L^0 K_S^0)/\Gamma_{\text{total}} \times \Gamma(e^+ e^-)/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma \times \Gamma_9/\Gamma$

VALUE (units 10^{-5}) EVTS DOCUMENT ID TECN COMMENT

10.10 ± 0.12 OUR FIT Error includes scale factor of 1.1.

10.07 ± 0.13 OUR AVERAGE

10.078 ± 0.223	610k	¹ KOZYREV	16	CMD3	$e^+ e^- \rightarrow K_S^0 K_L^0$
10.01 ± 0.04 ± 0.17	272k	² AKHMETSHIN	04	CMD2	$e^+ e^- \rightarrow K_L^0 K_S^0$
10.27 ± 0.07 ± 0.34	500k	³ ACHASOV	01E	SND	$e^+ e^- \rightarrow K^+ K^-,$ $K_S K_L, \pi^+ \pi^- \pi^0$

¹ KOZYREV 16 also reports $\Gamma(e^+e^-) B(\phi \rightarrow K_S^0 K_L^0) = (0.428 \pm 0.001 \pm 0.009)$ keV.

² Update of AKHMETSHIN 99D

³ From the combined fit assuming that the total $\phi(1020)$ production cross section is saturated by those of K^+K^- , $K_S K_L$, $\pi^+\pi^-\pi^0$, and $\eta\gamma$ decays modes and using ACHASOV 00B for the $\eta\gamma$ decay mode.

$[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}} \quad \Gamma_3/\Gamma \times \Gamma_9/\Gamma$

<u>VALUE (units 10^{-5})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
4.53 ± 0.10 OUR FIT	Error includes scale factor of 1.1.			
4.46 ± 0.12 OUR AVERAGE				
4.51 ± 0.16 ± 0.11	105k	AKHMETSHIN 06	CMD2	0.98–1.06 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
4.30 ± 0.08 ± 0.21		AUBERT,B 04N	BABR	10.6 $e^+e^- \rightarrow \pi^+\pi^-\pi^0\gamma$
4.665 ± 0.042 ± 0.261	400k	¹ ACHASOV 01E	SND	$e^+e^- \rightarrow K^+K^-, K_S K_L, \pi^+\pi^-\pi^0$
4.35 ± 0.27 ± 0.08	11169	² AKHMETSHIN 98	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
4.38 ± 0.12		BENAYOUN 10	RVUE	0.4–1.05 e^+e^-

¹ From the combined fit assuming that the total $\phi(1020)$ production cross section is saturated by those of K^+K^- , $K_S K_L$, $\pi^+\pi^-\pi^0$, and $\eta\gamma$ decays modes and using ACHASOV 00B for the $\eta\gamma$ decay mode.

² Recalculated by us from the cross section in the peak.

$\Gamma(\eta\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}} \quad \Gamma_6/\Gamma \times \Gamma_9/\Gamma$

<u>VALUE (units 10^{-6})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
3.87 ± 0.07 OUR FIT	Error includes scale factor of 1.2.			
3.93 ± 0.09 OUR AVERAGE	Error includes scale factor of 1.3. See the ideogram below.			
4.050 ± 0.067 ± 0.118	33k	¹ ACHASOV 07B	SND	0.6–1.38 $e^+e^- \rightarrow \eta\gamma$
4.093 ^{+0.040} _{-0.043} ± 0.247	17.4k	² AKHMETSHIN 05	CMD2	0.60–1.38 $e^+e^- \rightarrow \eta\gamma$
3.850 ± 0.041 ± 0.159	23k	^{3,4} AKHMETSHIN 01B	CMD2	$e^+e^- \rightarrow \eta\gamma$
4.00 ± 0.04 ± 0.11		⁵ ACHASOV 00	SND	$e^+e^- \rightarrow \eta\gamma$
3.53 ± 0.08 ± 0.17	2200	^{6,7} AKHMETSHIN 99F	CMD2	$e^+e^- \rightarrow \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
4.19 ± 0.06		⁸ BENAYOUN 10	RVUE	0.4–1.05 e^+e^-

¹ From a combined fit of $\sigma(e^+e^- \rightarrow \eta\gamma)$ with $\eta \rightarrow 3\pi^0$ and $\eta \rightarrow \pi^+\pi^-\pi^0$, and fixing $B(\eta \rightarrow 3\pi^0) / B(\eta \rightarrow \pi^+\pi^-\pi^0) = 1.44 \pm 0.04$. Recalculated by us from the cross section at the peak. Supersedes ACHASOV 00D and ACHASOV 06A.

² From the $\eta \rightarrow 2\gamma$ decay and using $B(\eta \rightarrow \gamma\gamma) = 39.43 \pm 0.26\%$.

³ From the $\eta \rightarrow 3\pi^0$ decay and using $B(\eta \rightarrow 3\pi^0) = (32.24 \pm 0.29) \times 10^{-2}$.

⁴ The combined fit from 600 to 1380 MeV taking into account $\rho(770)$, $\omega(782)$, $\phi(1020)$, and $\rho(1450)$ (mass and width fixed at 1450 MeV and 310 MeV respectively).

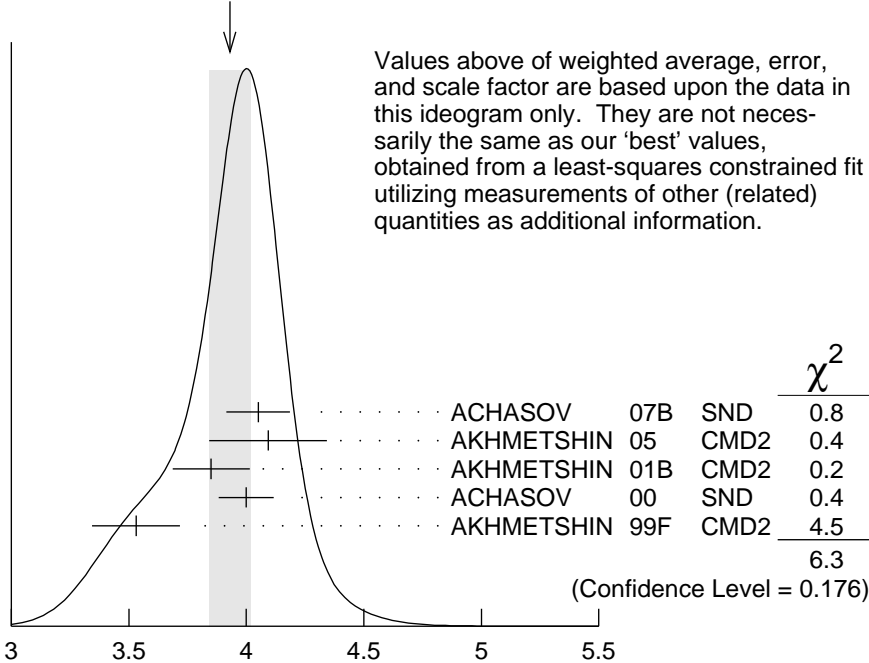
⁵ From the $\eta \rightarrow 2\gamma$ decay and using $B(\eta \rightarrow 2\gamma) = (39.21 \pm 0.34) \times 10^{-2}$.

⁶ Recalculated by the authors from the cross section in the peak.

⁷ From the $\eta \rightarrow \pi^+\pi^-\pi^0$ decay and using $B(\eta \rightarrow \pi^+\pi^-\pi^0) = (23.1 \pm 0.5) \times 10^{-2}$.

⁸ A simultaneous fit of $e^+e^- \rightarrow \pi^+\pi^-, \pi^+\pi^-\pi^0, \pi^0\gamma, \eta\gamma$ data.

WEIGHTED AVERAGE
3.93±0.09 (Error scaled by 1.3)



Values above of weighted average, error, and scale factor are based upon the data in this ideogram only. They are not necessarily the same as our 'best' values, obtained from a least-squares constrained fit utilizing measurements of other (related) quantities as additional information.

$$\Gamma(\eta\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}} \qquad \Gamma_6/\Gamma \times \Gamma_9/\Gamma$$

$$\Gamma(\pi^0\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}} \qquad \Gamma_7/\Gamma \times \Gamma_9/\Gamma$$

VALUE (units 10^{-7})	EVTS	DOCUMENT ID	TECN	COMMENT
3.88±0.14 OUR FIT				
3.87±0.15 OUR AVERAGE				
4.04±0.09±0.19		¹ ACHASOV 16A	SND	0.60–1.38 $e^+e^- \rightarrow \pi^0\gamma$
3.75±0.11±0.29	18k	AKHMETSHIN 05	CMD2	0.60–1.38 $e^+e^- \rightarrow \pi^0\gamma$
3.67±0.10 ^{+0.27} _{-0.25}		² ACHASOV 00	SND	$e^+e^- \rightarrow \pi^0\gamma$

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

4.29±0.11		³ BENAYOUN 10	RVUE	0.4–1.05 e^+e^-
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¹ From the VMD model with the interfering $\rho(770)$, $\omega(782)$, $\phi(1020)$ resonances, and an additional resonance describing the total contribution of the $\rho(1450)$ and $\omega(1420)$ states. Supersedes ACHASOV 00.

² From the $\pi^0 \rightarrow 2\gamma$ decay and using $B(\pi^0 \rightarrow 2\gamma) = (98.798 \pm 0.032) \times 10^{-2}$.

³ A simultaneous fit of $e^+e^- \rightarrow \pi^+\pi^-$, $\pi^+\pi^-\pi^0$, $\pi^0\gamma$, $\eta\gamma$ data.

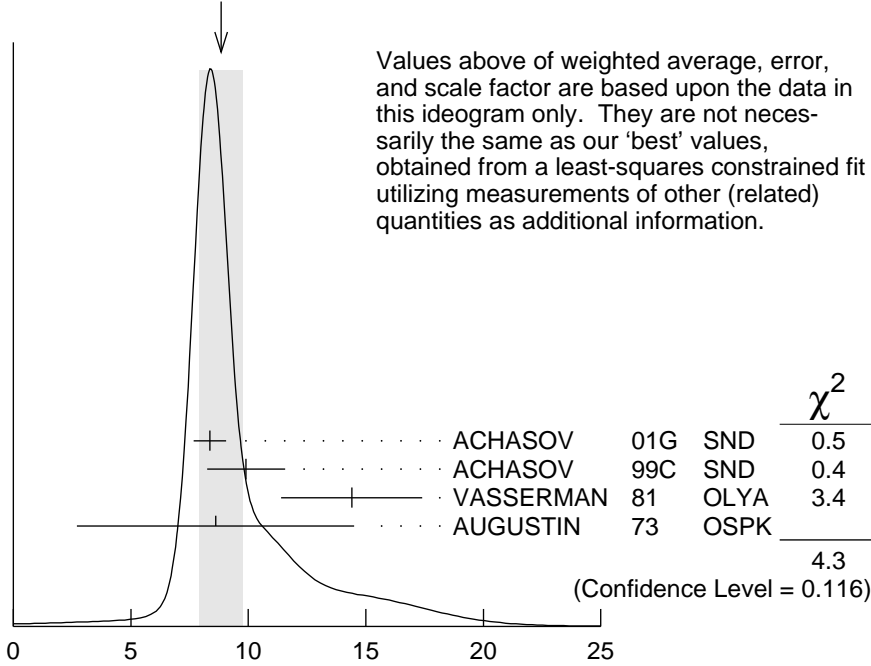
$$\Gamma(\mu^+\mu^-)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}} \qquad \Gamma_{10}/\Gamma \times \Gamma_9/\Gamma$$

VALUE (units 10^{-8})	DOCUMENT ID	TECN	COMMENT
8.5^{+0.5}_{-0.6} OUR FIT			
8.8 ±0.9 OUR AVERAGE	Error includes scale factor of 1.5. See the ideogram below.		
8.36±0.59±0.37	ACHASOV 01G	SND	$e^+e^- \rightarrow \mu^+\mu^-$
9.9 ±1.4 ±0.9	¹ ACHASOV 99C	SND	$e^+e^- \rightarrow \mu^+\mu^-$
14.4 ±3.0	² VASSERMAN 81	OLYA	$e^+e^- \rightarrow \mu^+\mu^-$
8.6 ±5.9	² AUGUSTIN 73	OSPK	$e^+e^- \rightarrow \mu^+\mu^-$

¹ Recalculated by the authors from the cross section in the peak.

² Recalculated by us from the cross section in the peak.

WEIGHTED AVERAGE
8.8±0.9 (Error scaled by 1.5)



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

$$\Gamma_{10} / \Gamma \times \Gamma_9 / \Gamma$$

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

$$\Gamma_{12} / \Gamma \times \Gamma_9 / \Gamma$$

VALUE (units 10^{-8})	DOCUMENT ID	TECN	COMMENT
2.2 ± 0.4 OUR FIT			
2.2 ± 0.4 OUR AVERAGE			
2.1 ± 0.3 ± 0.3	¹ ACHASOV	00C SND	$e^+ e^- \rightarrow \pi^+ \pi^-$
1.95 ^{+1.15} _{-0.87}	² GOLUBEV	86 ND	$e^+ e^- \rightarrow \pi^+ \pi^-$
6.01 ^{+3.19} _{-2.51}	² VASSERMAN	81 OLYA	$e^+ e^- \rightarrow \pi^+ \pi^-$

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

3.31 ± 0.99	³ BENAYOUN	13 RVUE	0.4–1.05 $e^+ e^-$
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¹ Recalculated by the authors from the cross section in the peak.

² Recalculated by us from the cross section in the peak.

³ A simultaneous fit to $e^+ e^- \rightarrow \pi^+ \pi^-, \pi^+ \pi^- \pi^0, \pi^0 \gamma, \eta \gamma, K \bar{K}$, and $\tau^- \rightarrow \pi^- \pi^0 \nu_\tau$ data.

$$\Gamma(\omega \pi^0) / \Gamma_{\text{total}} \times \Gamma(e^+ e^-) / \Gamma_{\text{total}}$$

$$\Gamma_{13} / \Gamma \times \Gamma_9 / \Gamma$$

VALUE (units 10^{-8})	DOCUMENT ID	TECN	COMMENT
1.40 ± 0.15 OUR FIT			
1.37 ± 0.17 ± 0.01	^{1,2} AMBROSINO	08G KLOE	$e^+ e^- \rightarrow \pi^+ \pi^- 2\pi^0, 2\pi^0 \gamma$

¹ Recalculated by the authors from the cross section at the peak.

² AMBROSINO 08G reports $[\Gamma(\phi(1020) \rightarrow \omega\pi^0)/\Gamma_{\text{total}} \times \Gamma(\phi(1020) \rightarrow e^+e^-)/\Gamma_{\text{total}}] \times [B(\omega(782) \rightarrow \pi^+\pi^-\pi^0)] = (1.22 \pm 0.13 \pm 0.08) \times 10^{-8}$ which we divide by our best value $B(\omega(782) \rightarrow \pi^+\pi^-\pi^0) = (89.3 \pm 0.6) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

$\Gamma(\pi^0\pi^0\gamma)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$				$\Gamma_{18}/\Gamma \times \Gamma_9/\Gamma$
VALUE (units 10^{-8})	DOCUMENT ID	TECN	COMMENT	
3.34±0.17 OUR FIT				
3.33^{+0.04+0.19}_{-0.09-0.20}	¹ AMBROSINO 07	KLOE	$e^+e^- \rightarrow \pi^0\pi^0\gamma$	

¹ Calculated by the authors from the cross section at the peak.

$\Gamma(\pi^+\pi^-\pi^+\pi^-)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$				$\Gamma_{19}/\Gamma \times \Gamma_9/\Gamma$
VALUE (units 10^{-9})	EVTS	DOCUMENT ID	TECN	COMMENT
1.2^{+0.8}_{-0.7} OUR FIT				
1.17±0.52±0.64	3285	¹ AKHMETSHIN 00E	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-$

¹ Recalculated by the authors from the cross section in the peak.

$\phi(1020)$ BRANCHING RATIOS

$\Gamma(K^+K^-)/\Gamma_{\text{total}}$					Γ_1/Γ
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
0.492±0.005 OUR FIT				Error includes scale factor of 1.3.	
0.493±0.010 OUR AVERAGE					
0.492±0.012	2913	AKHMETSHIN 95	CMD2	$e^+e^- \rightarrow K^+K^-$	
0.44 ±0.05	321	KALBFLEISCH 76	HBC	2.18 $K^-p \rightarrow \Lambda K^+K^-$	
0.49 ±0.06	270	DEGROOT 74	HBC	4.2 $K^-p \rightarrow \Lambda\phi$	
0.540±0.034	565	BALAKIN 71	OSPK	$e^+e^- \rightarrow K^+K^-$	
0.48 ±0.04	252	LINDSEY 66	HBC	2.1–2.7 $K^-p \rightarrow \Lambda K^+K^-$	
• • •				We do not use the following data for averages, fits, limits, etc. • • •	
0.493±0.003±0.007		¹ AKHMETSHIN 11	CMD2	1.02 $e^+e^- \rightarrow K^+K^-$	
0.476±0.017	1000k	² ACHASOV 01E	SND	$e^+e^- \rightarrow K^+K^-, K_S^0K_L^0, \pi^+\pi^-\pi^0$	

¹ Combined analysis of the CMD-2 data on $\phi \rightarrow K^+K^-, K_S^0K_L^0, \pi^+\pi^-\pi^0, \eta\gamma$ assuming that the sum of their branching fractions is 0.99741 ± 0.00007 .

² Using $B(\phi \rightarrow e^+e^-) = (2.93 \pm 0.14) \times 10^{-4}$.

$\Gamma(K_L^0K_S^0)/\Gamma_{\text{total}}$					Γ_2/Γ
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
0.340±0.004 OUR FIT				Error includes scale factor of 1.3.	
0.331±0.009 OUR AVERAGE					
0.335±0.010	40644	AKHMETSHIN 95	CMD2	$e^+e^- \rightarrow K_L^0K_S^0$	
0.326±0.035		DOLINSKY 91	ND	$e^+e^- \rightarrow K_L^0K_S^0$	
0.310±0.024		DRUZHININ 84	ND	$e^+e^- \rightarrow K_L^0K_S^0$	

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

0.336±0.002±0.006		¹ AKHMETSHIN 11	CMD2	1.02	$e^+e^- \rightarrow K_S^0 K_L^0$
0.351±0.013	500k	² ACHASOV	01E	SND	$e^+e^- \rightarrow K^+ K^-, K_S^0 K_L^0, \pi^+ \pi^- \pi^0$
0.27 ±0.03	133	KALBFLEISCH 76	HBC	2.18	$K^- p \rightarrow \Lambda K_S^0 K_L^0$
0.257±0.030	95	³ BALAKIN	71	OSPK	$e^+e^- \rightarrow K_L^0 K_S^0$
0.40 ±0.04	167	LINDSEY	66	HBC	2.1–2.7 $K^- p \rightarrow \Lambda K_L^0 K_S^0$

¹ Combined analysis of the CMD-2 data on $\phi \rightarrow K^+ K^-, K_S^0 K_L^0, \pi^+ \pi^- \pi^0, \eta\gamma$ assuming that the sum of their branching fractions is 0.99741 ± 0.00007 .

² Using $B(\phi \rightarrow e^+ e^-) = (2.93 \pm 0.14) \times 10^{-4}$.

³ Balakin error increased by Paul.

$\Gamma(K_L^0 K_S^0)/\Gamma(K^+ K^-)$

Γ_2/Γ_1

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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0.690±0.015 OUR FIT Error includes scale factor of 1.3.

0.740±0.031 OUR AVERAGE

0.70 ±0.06	2732	BUKIN	78C	OLYA	$e^+e^- \rightarrow K_L^0 K_S^0$
0.82 ±0.08		LOSTY	78	HBC	4.2 $K^- p \rightarrow \phi$ hyperon
0.71 ±0.05		LAVEN	77	HBC	10 $K^- p \rightarrow K^+ K^- \Lambda$
0.71 ±0.08		LYONS	77	HBC	3–4 $K^- p \rightarrow \Lambda \phi$
0.89 ±0.10	144	AGUILAR-...	72B	HBC	3.9,4.6 $K^- p$

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

0.638±0.022	2.3M	¹ KOZYREV	18	CMD3	$e^+e^- \rightarrow K_L^0 K_S^0, K^+ K^-$
0.68 ±0.03		² AKHMETSHIN 95	CMD2		$e^+e^- \rightarrow K_L^0 K_S^0, K^+ K^-$

¹ The prediction taking into account phase-space difference, radiative corrections, isospin breaking, and the Sommerfeld-Gamow-Sakharov factor gives 0.630.

² Theoretical analysis of BRAMON 00 taking into account phase-space difference, electromagnetic radiative corrections, as well as isospin breaking, predicts 0.62. FLOREZ-BAEZ 08 predicts 0.63 considering also structure-dependent radiative corrections. FISCHBACH 02 calculates additional corrections caused by the close threshold and predicts 0.68. See also BENAYOUN 01 and DUBYNSKIY 07. BENAYOUN 12 obtains 0.71 ± 0.01 in the HLS model.

$\Gamma(K_L^0 K_S^0)/\Gamma(K\bar{K})$

$\Gamma_2/(\Gamma_1+\Gamma_2)$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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0.408±0.005 OUR FIT Error includes scale factor of 1.3.

0.45 ±0.04 OUR AVERAGE

0.44 ±0.07		¹ LONDON	66	HBC	2.24 $K^- p \rightarrow \Lambda K\bar{K}$
0.48 ±0.07	52	BADIER	65B	HBC	3 $K^- p$
0.40 ±0.10	34	SCHLEIN	63	HBC	1.95 $K^- p \rightarrow \Lambda K\bar{K}$

¹ This is probably not affected by their controversial background subtraction; the value is from their numbers of $K_1 K_2$ vs $K^+ K^-$ events.

$[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma_{\text{total}}$ Γ_3/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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0.1524 ± 0.0033 OUR FIT Error includes scale factor of 1.2.

0.151 ± 0.009 OUR AVERAGE Error includes scale factor of 1.7.

0.161 ± 0.008	11761	AKHMETSHIN 95	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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0.143 ± 0.007		DOLINSKY 91	ND	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

0.155 ± 0.002 ± 0.005		¹ AKHMETSHIN 11	CMD2	$1.02 e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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0.159 ± 0.008	400k	² ACHASOV 01E	SND	$e^+e^- \rightarrow K^+K^-, K_S^0K_L^0, \pi^+\pi^-\pi^0$
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0.145 ± 0.009 ± 0.003	11169	³ AKHMETSHIN 98	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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0.139 ± 0.007		⁴ PARROUR 76B	OSPK	e^+e^-
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¹ Combined analysis of the CMD-2 data on $\phi \rightarrow K^+K^-, K_S^0K_L^0, \pi^+\pi^-\pi^0, \eta\gamma$ assuming that the sum of their branching fractions is 0.99741 ± 0.00007 .

² Using $B(\phi \rightarrow e^+e^-) = (2.93 \pm 0.14) \times 10^{-4}$.

³ Using $B(\phi \rightarrow e^+e^-) = (2.99 \pm 0.08) \times 10^{-4}$.

⁴ Using $\Gamma(\phi) = 4.1$ MeV. If interference between the $\rho\pi$ and 3π modes is neglected, the fraction of the $\rho\pi$ is more than 80% at the 90% confidence level.

$[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma(K^+K^-)$ Γ_3/Γ_1

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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0.310 ± 0.009 OUR FIT Error includes scale factor of 1.2.

0.28 ± 0.09	34	AGUILAR-...	72B HBC	3.9,4.6 K^-p
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$[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma(K\bar{K})$ $\Gamma_3/(\Gamma_1+\Gamma_2)$

VALUE	DOCUMENT ID	TECN	COMMENT
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0.183 ± 0.005 OUR FIT Error includes scale factor of 1.2.

0.24 ± 0.04 OUR AVERAGE

0.237 ± 0.039	CERRADA 77B	HBC	4.2 $K^-p \rightarrow \Lambda 3\pi$
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0.30 ± 0.15	LONDON 66	HBC	2.24 $K^-p \rightarrow \Lambda \pi^+\pi^-\pi^0$
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$[\Gamma(\rho\pi) + \Gamma(\pi^+\pi^-\pi^0)]/\Gamma(K_L^0K_S^0)$ Γ_3/Γ_2

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
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0.448 ± 0.011 OUR FIT Error includes scale factor of 1.1.

0.51 ± 0.05 OUR AVERAGE

0.56 ± 0.07	3681	BUKIN 78C	OLYA	$e^+e^- \rightarrow K_L^0K_S^0, \pi^+\pi^-\pi^0$
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0.47 ± 0.06	516	COSME 74	OSPK	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$ Γ_5/Γ

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

$\simeq 0.0087$	1.98M	^{1,2} ALOISIO 03	KLOE	1.02 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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< 0.0006	90	³ ACHASOV 02	SND	1.02 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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< 0.23	90	³ CORDIER 80	DM1	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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< 0.20	90	³ PARROUR 76B	OSPK	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
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¹ From a fit without limitations on charged and neutral ρ masses and widths.

² Adding the direct and $\omega\pi$ contributions and considering the interference between the $\rho\pi$ and $\pi^+\pi^-\pi^0$.

³ Neglecting the interference between the $\rho\pi$ and $\pi^+\pi^-\pi^0$.

$\Gamma(\eta\gamma)/\Gamma_{\text{total}}$ **Γ_6/Γ**

VALUE (units 10^{-2}) EVTS DOCUMENT ID TECN COMMENT

1.303 ± 0.025 OUR FIT Error includes scale factor of 1.2.

1.26 ± 0.04 OUR AVERAGE

1.246 ± 0.025 ± 0.057	10k	¹ ACHASOV	98F	SND	$e^+e^- \rightarrow 7\gamma$
1.18 ± 0.11	279	² AKHMETSHIN	95	CMD2	$e^+e^- \rightarrow \pi^+\pi^-3\gamma$
1.30 ± 0.06		³ DRUZHININ	84	ND	$e^+e^- \rightarrow 3\gamma$
1.4 ± 0.2		⁴ DRUZHININ	84	ND	$e^+e^- \rightarrow 6\gamma$
0.88 ± 0.20	290	KURDADZE	83C	OLYA	$e^+e^- \rightarrow 3\gamma$
1.35 ± 0.29		ANDREWS	77	CNTR	6.7–10 γ Cu
1.5 ± 0.4	54	³ COSME	76	OSPK	e^+e^-

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

1.38 ± 0.02 ± 0.02		⁵ AKHMETSHIN	11	CMD2	$1.02 e^+e^- \rightarrow \eta\gamma$
1.36 ± 0.05 ± 0.02	33k	⁶ ACHASOV	07B	SND	$0.6\text{--}1.38 e^+e^- \rightarrow \eta\gamma$
1.373 ± 0.014 ± 0.085	17.4k	^{7,8} AKHMETSHIN	05	CMD2	$0.60\text{--}1.38 e^+e^- \rightarrow \eta\gamma$
1.287 ± 0.013 ± 0.063		^{9,10} AKHMETSHIN	01B	CMD2	$e^+e^- \rightarrow \eta\gamma$
1.338 ± 0.012 ± 0.052		¹¹ ACHASOV	00	SND	$e^+e^- \rightarrow \eta\gamma$
1.18 ± 0.03 ± 0.06	2200	¹² AKHMETSHIN	99F	CMD2	$e^+e^- \rightarrow \eta\gamma$
1.21 ± 0.07		¹³ BENAYOUN	96	RVUE	$0.54\text{--}1.04 e^+e^- \rightarrow \eta\gamma$

¹ Using $B(\phi \rightarrow e^+e^-) = (2.99 \pm 0.08) \times 10^{-4}$ and $B(\eta \rightarrow 3\pi^0) = (32.2 \pm 0.4) \times 10^{-2}$.

² From $\pi^+\pi^-\pi^0$ decay mode of η .

³ From 2γ decay mode of η .

⁴ From $3\pi^0$ decay mode of η .

⁵ Combined analysis of the CMD-2 data on $\phi \rightarrow K^+K^-, K_S^0 K_L^0, \pi^+\pi^-\pi^0, \eta\gamma$ assuming that the sum of their branching fractions is 0.99741 ± 0.00007 .

⁶ ACHASOV 07B reports $[\Gamma(\phi(1020) \rightarrow \eta\gamma)/\Gamma_{\text{total}}] \times [B(\phi(1020) \rightarrow e^+e^-)] = (4.050 \pm 0.067 \pm 0.118) \times 10^{-6}$ which we divide by our best value $B(\phi(1020) \rightarrow e^+e^-) = (2.973 \pm 0.034) \times 10^{-4}$. Our first error is their experiment's error and our second error is the systematic error from using our best value. Supersedes ACHASOV 00D and ACHASOV 06A.

⁷ Using $B(\phi \rightarrow e^+e^-) = (2.98 \pm 0.04) \times 10^{-4}$ and $B(\eta \rightarrow \gamma\gamma) = 39.43 \pm 0.26\%$.

⁸ Not independent of the corresponding $\Gamma(e^+e^-) \times \Gamma(\eta\gamma)/\Gamma_{\text{total}}^2$.

⁹ Using $B(\phi \rightarrow e^+e^-) = (2.99 \pm 0.08) \times 10^{-4}$ and $B(\eta \rightarrow 3\pi^0) = (32.24 \pm 0.29) \times 10^{-2}$.

¹⁰ The combined fit from 600 to 1380 MeV taking into account $\rho(770), \omega(782), \phi(1020)$, and $\rho(1450)$ (mass and width fixed at 1450 MeV and 310 MeV respectively).

¹¹ From the $\eta \rightarrow 2\gamma$ decay and using $B(\phi \rightarrow e^+e^-) = (2.99 \pm 0.08) \times 10^{-4}$.

¹² From $\pi^+\pi^-\pi^0$ decay mode of η and using $B(\phi \rightarrow e^+e^-) = (2.99 \pm 0.08) \times 10^{-4}$.

¹³ Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution.

$\Gamma(\pi^0\gamma)/\Gamma_{\text{total}}$ **Γ_7/Γ**

VALUE (units 10^{-3}) EVTS DOCUMENT ID TECN COMMENT

1.30 ± 0.05 OUR FIT

1.31 ± 0.13 OUR AVERAGE

1.30 ± 0.13		DRUZHININ	84	ND	$e^+e^- \rightarrow 3\gamma$
1.4 ± 0.5	32	COSME	76	OSPK	e^+e^-

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

1.367±0.072		¹ ACHASOV	16A	SND	0.60–1.38	$e^+e^- \rightarrow \pi^0\gamma$
1.258±0.037±0.077	18k	^{2,3} AKHMETSHIN	05	CMD2	0.60–1.38	$e^+e^- \rightarrow \pi^0\gamma$
1.226±0.036 ^{+0.096} _{-0.089}		⁴ ACHASOV	00	SND		$e^+e^- \rightarrow \pi^0\gamma$
1.26 ±0.17		⁵ BENAYOUN	96	RVUE	0.54–1.04	$e^+e^- \rightarrow \pi^0\gamma$

¹ Using $B(\phi \rightarrow e^+e^-)$ from PDG 15. Supersedes ACHASOV 00.

² Using $B(\phi \rightarrow e^+e^-) = (2.98 \pm 0.04) \times 10^{-4}$.

³ Not independent of the corresponding $\Gamma(e^+e^-) \times \Gamma(\pi^0\gamma)/\Gamma_{\text{total}}^2$.

⁴ From the $\pi^0 \rightarrow 2\gamma$ decay and using $B(\phi \rightarrow e^+e^-) = (2.99 \pm 0.08) \times 10^{-4}$.

⁵ Reanalysis of DRUZHININ 84, DOLINSKY 89, and DOLINSKY 91 taking into account a triangle anomaly contribution.

$\Gamma(\eta\gamma)/\Gamma(\pi^0\gamma)$

Γ_6/Γ_7

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

10.9±0.3 ^{+0.7} _{-0.8}	ACHASOV	00	SND	$e^+e^- \rightarrow \eta\gamma, \pi^0\gamma$
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$\Gamma(e^+e^-)/\Gamma_{\text{total}}$

Γ_9/Γ

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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2.973±0.034 OUR FIT Error includes scale factor of 1.3.

2.98 ±0.07 OUR AVERAGE Error includes scale factor of 1.1.

2.93 ±0.14	1900k	¹ ACHASOV	01E	SND	$e^+e^- \rightarrow K^+K^-, K_S K_L, \pi^+\pi^-\pi^0$
2.88 ±0.09	55600	AKHMETSHIN	95	CMD2	$e^+e^- \rightarrow \text{hadrons}$
3.00 ±0.21	3681	BUKIN	78C	OLYA	$e^+e^- \rightarrow \text{hadrons}$
3.10 ±0.14		² PARROUR	76	OSPK	e^+e^-
3.3 ±0.3		COSME	74	OSPK	$e^+e^- \rightarrow \text{hadrons}$
2.81 ±0.25	681	BALAKIN	71	OSPK	$e^+e^- \rightarrow \text{hadrons}$
3.50 ±0.27		CHATELUS	71	OSPK	e^+e^-

¹ From the combined fit assuming that the total $\phi(1020)$ production cross section is saturated by those of $K^+K^-, K_S K_L, \pi^+\pi^-\pi^0$, and $\eta\gamma$ decays modes and using ACHASOV 00B for the $\eta\gamma$ decay mode.

² Using total width 4.2 MeV. They detect 3π mode and observe significant interference with ω tail. This is accounted for in the result quoted above.

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

Γ_{10}/Γ

<u>VALUE (units 10^{-4})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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2.86±0.19 OUR FIT

2.5 ±0.4 OUR AVERAGE

2.69±0.46	¹ HAYES	71	CNTR	8.3,9.8	$\gamma C \rightarrow \mu^+\mu^- X$
2.17±0.60	¹ EARLES	70	CNTR	6.0	$\gamma C \rightarrow \mu^+\mu^- X$

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

2.87±0.20±0.14	² ACHASOV	01G	SND	$e^+e^- \rightarrow \mu^+\mu^-$
3.30±0.45±0.32	³ ACHASOV	99C	SND	$e^+e^- \rightarrow \mu^+\mu^-$
4.83±1.02	⁴ VASSERMAN	81	OLYA	$e^+e^- \rightarrow \mu^+\mu^-$
2.87±1.98	⁴ AUGUSTIN	73	OSPK	$e^+e^- \rightarrow \mu^+\mu^-$

¹ Neglecting interference between resonance and continuum.

² Using $B(\phi \rightarrow e^+ e^-) = (2.91 \pm 0.07) \times 10^{-4}$.

³ Using $B(\phi \rightarrow e^+ e^-) = (2.99 \pm 0.08) \times 10^{-4}$.

⁴ Recalculated by us using $B(\phi \rightarrow e^+ e^-) = (2.99 \pm 0.08) \times 10^{-4}$.

$\Gamma(\eta e^+ e^-)/\Gamma_{\text{total}}$ **Γ_{11}/Γ**

<u>VALUE (units 10^{-4})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
1.08 ± 0.04 OUR AVERAGE				
1.075 ± 0.007 ± 0.038	30k	¹ BABUSCI 15	KLOE	1.02 $e^+ e^- \rightarrow \eta e^+ e^-$
1.19 ± 0.19 ± 0.12	213	² ACHASOV 01B	SND	$e^+ e^- \rightarrow \eta e^+ e^-$
1.14 ± 0.10 ± 0.06	355	³ AKHMETSHIN 01	CMD2	$e^+ e^- \rightarrow \eta e^+ e^-$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1.13 ± 0.14 ± 0.07	183	⁴ AKHMETSHIN 01	CMD2	$e^+ e^- \rightarrow \eta e^+ e^-$
1.21 ± 0.14 ± 0.09	130	⁵ AKHMETSHIN 01	CMD2	$e^+ e^- \rightarrow \eta e^+ e^-$
1.04 ± 0.20 ± 0.08	42	⁶ AKHMETSHIN 01	CMD2	$e^+ e^- \rightarrow \eta e^+ e^-$
1.3 ^{+0.8} _{-0.6}	7	GOLUBEV 85	ND	$e^+ e^- \rightarrow \eta e^+ e^-$

¹ Using $B(\eta \rightarrow 3\pi^0) = (32.57 \pm 0.23)\%$ from PDG 12.

² Using $B(\eta \rightarrow \gamma\gamma) = (39.25 \pm 0.32)\%$, $B(\phi \rightarrow \eta\gamma) = (1.26 \pm 0.06)\%$, and $B(\phi \rightarrow e^+ e^-) = (3.00 \pm 0.06) \times 10^{-4}$.

³ The average of the branching ratios separately obtained from the $\eta \rightarrow \gamma\gamma$, $3\pi^0$, $\pi^+ \pi^- \pi^0$ decays.

⁴ From $\eta \rightarrow \gamma\gamma$ decays and using $B(\eta \rightarrow \gamma\gamma) = (39.33 \pm 0.25) \times 10^{-2}$, $B(\eta \rightarrow \pi^+ \pi^- \gamma) = (4.75 \pm 11) \times 10^{-2}$, and $B(\phi \rightarrow \eta\gamma) = (1.297 \pm 0.033) \times 10^{-2}$.

⁵ From $\eta \rightarrow 3\pi^0$ decays and using $B(\pi^0 \rightarrow \gamma\gamma) = (98.798 \pm 0.033) \times 10^{-2}$, $B(\eta \rightarrow 3\pi^0) = (32.24 \pm 0.29) \times 10^{-2}$, $B(\eta \rightarrow \pi^+ \pi^- \gamma) = (4.75 \pm 0.11) \times 10^{-2}$, and $B(\phi \rightarrow \eta\gamma) = (1.297 \pm 0.033) \times 10^{-2}$.

⁶ From $\eta \rightarrow \pi^+ \pi^- \pi^0$ decays and using $B(\pi^0 \rightarrow \gamma\gamma) = (98.798 \pm 0.033) \times 10^{-2}$, $B(\pi^0 \rightarrow e^+ e^- \gamma) = (1.198 \pm 0.032) \times 10^{-2}$, $B(\eta \rightarrow \pi^+ \pi^- \pi^0) = (23.0 \pm 0.4) \times 10^{-2}$, $B(\phi \rightarrow \pi^+ \pi^- \pi^0) = (15.5 \pm 0.6) \times 10^{-2}$, and $B(\phi \rightarrow \eta\gamma) = (1.297 \pm 0.033) \times 10^{-2}$.

$\Gamma(\pi^+ \pi^-)/\Gamma_{\text{total}}$ **Γ_{12}/Γ**

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
0.71 ± 0.11 ± 0.09		¹ ACHASOV 00C	SND	$e^+ e^- \rightarrow \pi^+ \pi^-$
0.65 ^{+0.38} _{-0.29}		¹ GOLUBEV 86	ND	$e^+ e^- \rightarrow \pi^+ \pi^-$
2.01 ^{+1.07} _{-0.84}		¹ VASSERMAN 81	OLYA	$e^+ e^- \rightarrow \pi^+ \pi^-$
<6.6	95	BUKIN 78B	OLYA	$e^+ e^- \rightarrow \pi^+ \pi^-$
<2.7	95	ALVENSLEB... 72	CNTR	6.7 $\gamma C \rightarrow C \pi^+ \pi^-$

¹ Using $B(\phi \rightarrow e^+ e^-) = (2.99 \pm 0.08) \times 10^{-4}$.

$\Gamma(\omega \pi^0)/\Gamma_{\text{total}}$ **Γ_{13}/Γ**

<u>VALUE (units 10^{-5})</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
4.7 ± 0.5 OUR FIT			
5.2 ^{+1.3}_{-1.1}	^{1,2} AULCHENKO 00A	SND	$e^+ e^- \rightarrow \pi^+ \pi^- \pi^0 \pi^0$

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

4.4 ± 0.6	³ AMBROSINO 08G	KLOE	$e^+e^- \rightarrow \pi^+\pi^-2\pi^0, 2\pi^0\gamma$
~ 5.4	⁴ ACHASOV 00E	SND	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
$5.5^{+1.6}_{-1.4} \pm 0.3$	^{2,5} AULCHENKO 00A	SND	$e^+e^- \rightarrow \pi^+\pi^-\pi^0\pi^0$
$4.8^{+1.9}_{-1.7} \pm 0.8$	⁴ ACHASOV 99	SND	$e^+e^- \rightarrow \pi^+\pi^-\pi^0\pi^0$

¹ Using the 1996 and 1998 data.

² $(2.3 \pm 0.3)\%$ correction for other decay modes of the $\omega(782)$ applied.

³ Not independent of the corresponding $\Gamma(\omega\pi^0) \times \Gamma(e^+e^-) / \Gamma^2(\text{total})$.

⁴ Using the 1996 data.

⁵ Using the 1998 data.

$\Gamma(\omega\gamma)/\Gamma_{\text{total}}$					Γ_{14}/Γ
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
<0.05	84	LINDSEY 66	HBC	2.1–2.7 $K^-p \rightarrow \Lambda\pi^+\pi^-$ neutrals	

$\Gamma(\rho\gamma)/\Gamma_{\text{total}}$					Γ_{15}/Γ
VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT	
< 0.12	90	¹ AKHMETSHIN 99B	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma$	

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

< 7	90	AKHMETSHIN 97C	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
<200	84	LINDSEY 66	HBC	2.1–2.7 $K^-p \rightarrow \Lambda\pi^+\pi^-$ neutrals

¹ Supersedes AKHMETSHIN 97C.

$\Gamma(\pi^+\pi^-\gamma)/\Gamma_{\text{total}}$					Γ_{16}/Γ
VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
0.41 ± 0.12 ± 0.04		30175	¹ AKHMETSHIN 99B	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma$

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

< 0.3	90	² AKHMETSHIN 97C	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
<600	90	KALBFLEISCH 75	HBC	2.18 $K^-p \rightarrow \Lambda\pi^+\pi^-\gamma$
< 70	90	COSME 74	OSPK	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
<400	90	LINDSEY 65	HBC	2.1–2.7 $K^-p \rightarrow \Lambda\pi^+\pi^-$ neutrals

¹ For $E_\gamma > 20$ MeV and assuming that $B(\phi(1020) \rightarrow f_0(980)\gamma)$ is negligible. Supersedes AKHMETSHIN 97C.

² For $E_\gamma > 20$ MeV and assuming that $B(\phi(1020) \rightarrow f_0(980)\gamma)$ is negligible.

$\Gamma(f_0(980)\gamma)/\Gamma_{\text{total}}$					Γ_{17}/Γ
VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
3.22 ± 0.19 OUR FIT					Error includes scale factor of 1.1.
3.21 ± 0.19 OUR AVERAGE					

3.21^{+0.03}_{-0.09} ± 0.18 ¹ AMBROSINO 07 KLOE $e^+e^- \rightarrow \pi^0\pi^0\gamma$

2.90 ± 0.21 ± 1.54 ² AKHMETSHIN 99C CMD2 $e^+e^- \rightarrow \pi^+\pi^-\gamma, \pi^0\pi^0\gamma$

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

4.47±0.21	2438	³ ALOISIO	02D	KLOE	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
3.5 ±0.3 ^{+1.3} / _{-0.5}	419	^{4,5} ACHASOV	00H	SND	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
1.93±0.46±0.50	27188	⁶ AKHMETSHIN	99B	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
3.05±0.25±0.72	268	⁷ AKHMETSHIN	99C	CMD2	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
1.5 ±0.5	268	⁸ AKHMETSHIN	99C	CMD2	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
3.42±0.30±0.36	164	⁴ ACHASOV	98I	SND	$e^+e^- \rightarrow 5\gamma$
< 1	90	⁹ AKHMETSHIN	97C	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
< 7	90	¹⁰ AKHMETSHIN	97C	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma$
< 20	90	DRUZHININ	87	ND	$e^+e^- \rightarrow \pi^0\pi^0\gamma$

¹ Obtained by the authors taking into account the $\pi^+\pi^-$ decay mode. Includes a component due to $\pi\pi$ production via the $f_0(500)$ meson. Supersedes ALOISIO 02D.

² From the combined fit of the photon spectra in the reactions $e^+e^- \rightarrow \pi^+\pi^-\gamma, \pi^0\pi^0\gamma$.

³ From the negative interference with the $f_0(500)$ meson of AITALA 01B using the ACHASOV 89 parameterization for the $f_0(980)$, a Breit-Wigner for the $f_0(500)$, and ACHASOV 01F for the $\rho\pi$ contribution. Superseded by AMBROSINO 07.

⁴ Assuming that the $\pi^0\pi^0\gamma$ final state is completely determined by the $f_0\gamma$ mechanism, neglecting the decay $B(\phi \rightarrow K\bar{K}\gamma)$ and using $B(f_0 \rightarrow \pi^+\pi^-) = 2B(f_0 \rightarrow \pi^0\pi^0)$.

⁵ Using the value $B(\phi \rightarrow \eta\gamma) = (1.338 \pm 0.053) \times 10^{-2}$.

⁶ For $E_\gamma > 20$ MeV. Supersedes AKHMETSHIN 97C.

⁷ Neglecting other intermediate mechanisms ($\rho\pi, \sigma\gamma$).

⁸ A narrow pole fit taking into account $f_0(980)$ and $f_0(1200)$ intermediate mechanisms.

⁹ For destructive interference with the Bremsstrahlung process

¹⁰ For constructive interference with the Bremsstrahlung process

$\Gamma(f_0(980)\gamma)/\Gamma(\eta\gamma)$

Γ_{17}/Γ_6

<u>VALUE (units 10^{-2})</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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2.47^{+0.15}/_{-0.16} OUR FIT Error includes scale factor of 1.1.

2.6 ±0.2 ^{+0.8}/_{-0.3}	419	¹ ACHASOV	00H	SND	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
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¹ Assuming that the $\pi^0\pi^0\gamma$ final state is completely determined by the $f_0\gamma$ mechanism, neglecting the decay $B(\phi \rightarrow K\bar{K}\gamma)$ and using $B(f_0 \rightarrow \pi^+\pi^-) = 2B(f_0 \rightarrow \pi^0\pi^0)$.

$\Gamma(\pi^0\pi^0\gamma)/\Gamma_{\text{total}}$

Γ_{18}/Γ

<u>VALUE (units 10^{-4})</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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1.07 ±0.06 OUR AVERAGE

1.07 ^{+0.01 +0.06} / _{-0.03 -0.06}		¹ AMBROSINO	07	KLOE	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
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1.08 ±0.17 ±0.09	268	AKHMETSHIN	99C	CMD2	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
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• • • We do not use the following data for averages, fits, limits, etc. • • •

1.09 ±0.03 ±0.05	2438	ALOISIO	02D	KLOE	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
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1.158±0.093±0.052	419	^{2,3} ACHASOV	00H	SND	$e^+e^- \rightarrow \pi^0\pi^0\gamma$
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<10	90	DRUZHININ	87	ND	$e^+e^- \rightarrow 5\gamma$
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¹ Supersedes ALOISIO 02D.

² Using the value $B(\phi \rightarrow \eta\gamma) = (1.338 \pm 0.053) \times 10^{-2}$.

³ Supersedes ACHASOV 98I. Excluding $\omega\pi^0$.

$\Gamma(\pi^0\pi^0\gamma)/\Gamma(\eta\gamma)$ Γ_{18}/Γ_6

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
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0.86 ± 0.04 OUR FIT

0.865 ± 0.070 ± 0.017 419 ¹ACHASOV 00H SND $e^+e^- \rightarrow \pi^0\pi^0\gamma$

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

0.90 ± 0.08 ± 0.07 164 ACHASOV 98I SND $e^+e^- \rightarrow 5\gamma$

¹Supersedes ACHASOV 98I. Excluding $\omega\pi^0$.

$\Gamma(\pi^+\pi^-\pi^+\pi^-)/\Gamma_{total}$ Γ_{19}/Γ

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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6.5 ± 2.7 ± 1.6 6.8k ¹AKHMETSHIN 17 CMD3 $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-$

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

3.93 ± 1.74 ± 2.14 3.3k AKHMETSHIN 00E CMD2 $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-$

< 870 90 CORDIER 79 WIRE $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-$

¹Using the cross section at the ϕ meson peak $\sigma(\phi) = 4172 \pm 42$ nb, the nonresonant cross section $\sigma(0) = 1.263 \pm 0.027$ nb and $\text{Re}(Z) = 0.146 \pm 0.030$, $\text{Im}(Z) = -0.002 \pm 0.024$ for the complex amplitude of the $\phi \rightarrow \pi^+\pi^-\pi^+\pi^-$ transition.

$\Gamma(\pi^+\pi^+\pi^-\pi^-\pi^0)/\Gamma_{total}$ Γ_{20}/Γ

VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT
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< **4.6** 90 AKHMETSHIN 00E CMD2 $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-\pi^0$

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

< 150 95 BARKOV 88 CMD $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-\pi^0$

$\Gamma(\pi^0e^+e^-)/\Gamma_{total}$ Γ_{21}/Γ

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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1.33^{+0.07}_{-0.10} OUR AVERAGE

1.35 ± 0.05^{+0.05}_{-0.10} 9.5k ¹ANASTASI 16B KLOE $e^+e^- \rightarrow \pi^0e^+e^-$

1.01 ± 0.28 ± 0.29 52 ²ACHASOV 02D SND $e^+e^- \rightarrow \pi^0e^+e^-$

1.22 ± 0.34 ± 0.21 46 ³AKHMETSHIN 01C CMD2 $e^+e^- \rightarrow \pi^0e^+e^-$

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

< 12 90 DOLINSKY 88 ND $e^+e^- \rightarrow \pi^0e^+e^-$

¹Using $B(\pi^0 \rightarrow \gamma\gamma)$ from the 2014 Edition of this Review (PDG 14).

²Using various branching ratios from the 2000 Edition of this Review (PDG 00).

³Using $B(\pi^0 \rightarrow \gamma\gamma) = 0.98798 \pm 0.00032$, $B(\phi \rightarrow \eta\gamma) = (1.297 \pm 0.033) \times 10^{-2}$, and $B(\eta \rightarrow \pi^+\pi^-\gamma) = (4.75 \pm 0.11) \times 10^{-2}$.

$\Gamma(\pi^0\eta\gamma)/\Gamma_{total}$ Γ_{22}/Γ

VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
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7.27 ± 0.30 OUR AVERAGE Error includes scale factor of 1.5. See the ideogram below.

7.06 ± 0.22 16.9k ¹AMBROSINO 09F KLOE $1.02 e^+e^- \rightarrow \eta\pi^0\gamma$

8.51 ± 0.51 ± 0.57 607 ²ALOISIO 02C KLOE $e^+e^- \rightarrow \eta\pi^0\gamma$

7.96 ± 0.60 ± 0.40 197 ³ALOISIO 02C KLOE $e^+e^- \rightarrow \eta\pi^0\gamma$

8.8 ± 1.4 ± 0.9 36 ⁴ACHASOV 00F SND $e^+e^- \rightarrow \eta\pi^0\gamma$

9.0 ± 2.4 ± 1.0 80 AKHMETSHIN 99C CMD2 $e^+e^- \rightarrow \eta\pi^0\gamma$

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

$7.01 \pm 0.10 \pm 0.20$	13.3k	^{2,5} AMBROSINO	09F	KLOE	$1.02 e^+ e^- \rightarrow \eta \pi^0 \gamma$
$7.12 \pm 0.13 \pm 0.22$	3.6k	^{3,6} AMBROSINO	09F	KLOE	$1.02 e^+ e^- \rightarrow \eta \pi^0 \gamma$
$8.3 \pm 2.3 \pm 1.2$	20	ACHASOV	98B	SND	$e^+ e^- \rightarrow 5\gamma$
<250	90	DOLINSKY	91	ND	$e^+ e^- \rightarrow \pi^0 \eta \gamma$

¹ Combined results of $\eta \rightarrow \gamma\gamma$ and $\eta \rightarrow \pi^+ \pi^- \pi^0$ decay modes measurements.

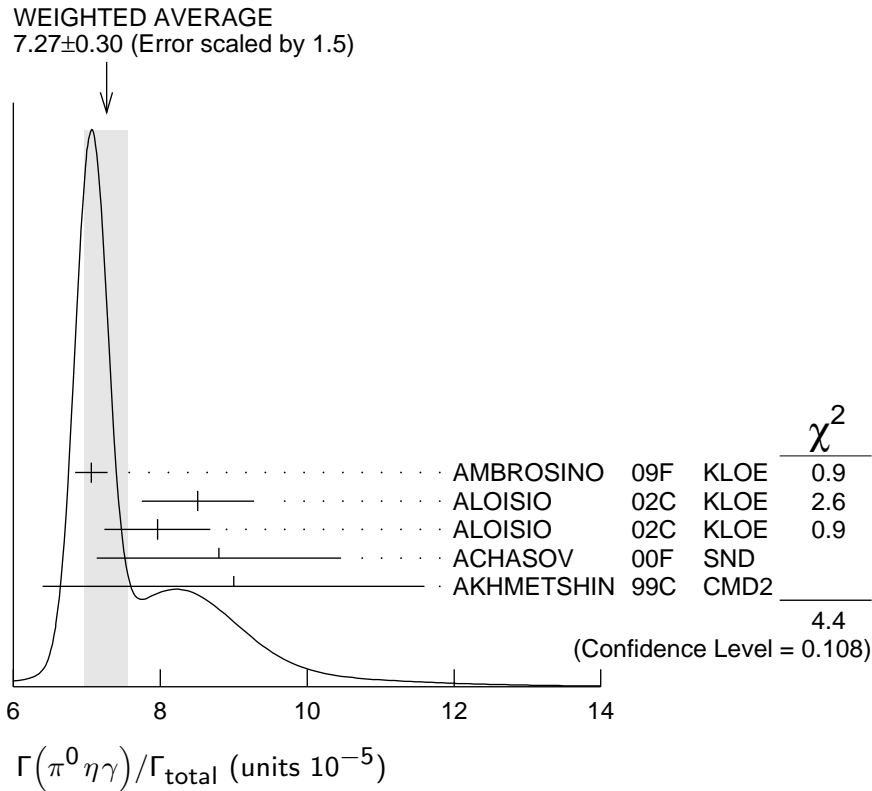
² From the decay mode $\eta \rightarrow \gamma\gamma$.

³ From the decay mode $\eta \rightarrow \pi^+ \pi^- \pi^0$.

⁴ Supersedes ACHASOV 98B.

⁵ Using $B(\phi \rightarrow \eta\gamma) = (1.304 \pm 0.025)\%$, $B(\eta \rightarrow 3\pi^0) = (32.56 \pm 0.23)\%$, and $B(\eta \rightarrow \gamma\gamma) = (39.31 \pm 0.20)\%$.

⁶ Using $B(\phi \rightarrow \eta\gamma) = (1.304 \pm 0.025)\%$, $B(\eta \rightarrow 3\pi^0) = (32.56 \pm 0.23)\%$, and $B(\eta \rightarrow \pi^+ \pi^- \pi^0) = (22.73 \pm 0.28)\%$.



$\Gamma(a_0(980)\gamma)/\Gamma_{\text{total}}$				Γ_{23}/Γ	
VALUE (units 10^{-5})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
7.6±0.6					OUR FIT
7.6±0.6					OUR AVERAGE

7.4 ± 0.7	¹	ALOISIO	02C	KLOE	$e^+ e^- \rightarrow \eta \pi^0 \gamma$
8.8 ± 1.7	36	² ACHASOV	00F	SND	$e^+ e^- \rightarrow \eta \pi^0 \gamma$

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

11 ± 2	³	GOKALP	02	RVUE	$e^+ e^- \rightarrow \eta \pi^0 \gamma$
<500	90	DOLINSKY	91	ND	$e^+ e^- \rightarrow \pi^0 \eta \gamma$

¹ Using $M_{a_0(980)} = 984.8$ MeV and assuming $a_0(980)\gamma$ dominance.

² Assuming $a_0(980)\gamma$ dominance in the $\eta \pi^0 \gamma$ final state.

³ Using data of ACHASOV 00F.

$\Gamma(f_0(980)\gamma)/\Gamma(a_0(980)\gamma)$ Γ_{17}/Γ_{23}

VALUE	DOCUMENT ID	TECN	COMMENT
6.1±0.6	¹ ALOISIO	02C	KLOE $e^+e^- \rightarrow \eta\pi^0\gamma$

¹ Using results of ALOISIO 02D and assuming that $f_0(980)$ decays into $\pi\pi$ only and $a_0(980)$ into $\eta\pi$ only.

$\Gamma(K^0\bar{K}^0\gamma)/\Gamma_{\text{total}}$ Γ_{24}/Γ

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.9 × 10⁻⁸	90	AMBROSINO	09C	KLOE $e^+e^- \rightarrow K_S^0 K_S^0 \gamma$

$\Gamma(\eta'(958)\gamma)/\Gamma_{\text{total}}$ Γ_{25}/Γ

VALUE (units 10 ⁻⁵)	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
6.22±0.21 OUR FIT					
6.22±0.30 OUR AVERAGE					
6.22±0.27±0.12	3407		¹ AMBROSINO	07A	KLOE $1.02 e^+e^- \rightarrow \pi^+\pi^-7\gamma$
6.7 ^{+2.8} / _{-2.4} ±0.8	12		² AULCHENKO	03B	SND $e^+e^- \rightarrow \eta'\gamma$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
6.7 ^{+5.0} / _{-4.2} ±1.5	7		AULCHENKO	03B	SND $e^+e^- \rightarrow 7\gamma$
6.10±0.61±0.43	120		³ ALOISIO	02E	KLOE $1.02 e^+e^- \rightarrow \pi^+\pi^-3\gamma$
8.2 ^{+2.1} / _{-1.9} ±1.1	21		⁴ AKHMETSHIN	00B	CMD2 $e^+e^- \rightarrow \pi^+\pi^-3\gamma$
4.9 ^{+2.2} / _{-1.8} ±0.6	9		⁵ AKHMETSHIN	00F	CMD2 $e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^- \geq 2\gamma$
6.4 ±1.6	30		⁶ AKHMETSHIN	00F	CMD2 $e^+e^- \rightarrow \eta'(958)\gamma$
6.7 ^{+3.4} / _{-2.9} ±1.0	5		⁷ AULCHENKO	99	SND $e^+e^- \rightarrow \pi^+\pi^-3\gamma$
<11	90		AULCHENKO	98	SND $e^+e^- \rightarrow 7\gamma$
12 ⁺⁷ / ₋₅ ±2	6		⁴ AKHMETSHIN	97B	CMD2 $e^+e^- \rightarrow \pi^+\pi^-3\gamma$
<41	90		DRUZHININ	87	ND $e^+e^- \rightarrow \gamma\eta\pi^+\pi^-$

¹ AMBROSINO 07A reports $[\Gamma(\phi(1020) \rightarrow \eta'(958)\gamma)/\Gamma_{\text{total}}] / [B(\phi(1020) \rightarrow \eta\gamma)] = (4.77 \pm 0.09 \pm 0.19) \times 10^{-3}$ which we multiply by our best value $B(\phi(1020) \rightarrow \eta\gamma) = (1.303 \pm 0.025) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value.

² Averaging AULCHENKO 03B with AULCHENKO 99.

³ Using $B(\phi \rightarrow \eta\gamma) = (1.297 \pm 0.033)\%$.

⁴ Using the value $B(\phi \rightarrow \eta\gamma) = (1.26 \pm 0.06) \times 10^{-2}$.

⁵ Using $B(\phi \rightarrow K_L^0 K_S^0) = (33.8 \pm 0.6)\%$.

⁶ Averaging AKHMETSHIN 00B with AKHMETSHIN 00F.

⁷ Using the value $B(\eta' \rightarrow \eta\pi^+\pi^-) = (43.7 \pm 1.5) \times 10^{-2}$ and $B(\eta \rightarrow \gamma\gamma) = (39.25 \pm 0.31) \times 10^{-2}$.

$\Gamma(\eta'(958)\gamma)/\Gamma(K_L^0 K_S^0)$ Γ_{25}/Γ_2

VALUE (units 10^{-4})	EVTS	DOCUMENT ID	TECN	COMMENT
1.83±0.06 OUR FIT				
$1.46^{+0.64}_{-0.54} \pm 0.18$	9	¹ AKHMETSHIN 00F	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^- \geq 2\gamma$

¹ Using various branching ratios of K_S^0 , K_L^0 , η , η' from the 2000 edition (The European Physical Journal **C15** 1 (2000)) of this Review.

$\Gamma(\eta'(958)\gamma)/\Gamma(\eta\gamma)$ Γ_{25}/Γ_6

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
4.77±0.15 OUR FIT				
4.78±0.20 OUR AVERAGE				
$4.77 \pm 0.09 \pm 0.19$	3407	AMBROSINO 07A	KLOE	$1.02 e^+e^- \rightarrow \pi^+\pi^- 7\gamma$
$4.70 \pm 0.47 \pm 0.31$	120	¹ ALOISIO 02E	KLOE	$1.02 e^+e^- \rightarrow \pi^+\pi^- 3\gamma$
$6.5^{+1.7}_{-1.5} \pm 0.8$	21	AKHMETSHIN 00B	CMD2	$e^+e^- \rightarrow \pi^+\pi^- 3\gamma$

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

$9.5^{+5.2}_{-4.0} \pm 1.4$	6	² AKHMETSHIN 97B	CMD2	$e^+e^- \rightarrow \pi^+\pi^- 3\gamma$
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¹ From the decay mode $\eta' \rightarrow \eta\pi^+\pi^-$, $\eta \rightarrow \gamma\gamma$.

² Superseded by AKHMETSHIN 00B.

$\Gamma(\eta\pi^0\pi^0\gamma)/\Gamma_{\text{total}}$ Γ_{26}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
<2	90	AULCHENKO 98	SND	$e^+e^- \rightarrow 7\gamma$

$\Gamma(\mu^+\mu^-\gamma)/\Gamma_{\text{total}}$ Γ_{27}/Γ

VALUE (units 10^{-5})	EVTS	DOCUMENT ID	TECN	COMMENT
1.43±0.45±0.14	27188	¹ AKHMETSHIN 99B	CMD2	$e^+e^- \rightarrow \mu^+\mu^-\gamma$

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

2.3 ± 1.0	824 ± 33	² AKHMETSHIN 97C	CMD2	$e^+e^- \rightarrow \mu^+\mu^-\gamma$
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¹ For $E_\gamma > 20$ MeV. Supersedes AKHMETSHIN 97C.

² For $E_\gamma > 20$ MeV.

$\Gamma(\rho\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{28}/Γ

VALUE (units 10^{-4})	CL%	DOCUMENT ID	TECN	COMMENT
<1.2	90	AULCHENKO 08	CMD2	$\phi \rightarrow \pi^+\pi^-\gamma\gamma$

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

<5	90	AKHMETSHIN 98	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma\gamma$
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$\Gamma(\eta\pi^+\pi^-)/\Gamma_{\text{total}}$ Γ_{29}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID	TECN	COMMENT
< 1.8	90	AKHMETSHIN 00E	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\pi^+\pi^-\pi^0$

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

< 6.1	90	AULCHENKO 08	CMD2	$\phi \rightarrow \eta\pi^+\pi^-$
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<30	90	AKHMETSHIN 98	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma\gamma$
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$\Gamma(\eta\mu^+\mu^-)/\Gamma_{\text{total}}$					Γ_{30}/Γ
VALUE (units 10^{-6})	CL%	DOCUMENT ID	TECN	COMMENT	
<9.4	90	AKHMETSHIN 01	CMD2	$e^+e^- \rightarrow \eta e^+e^-$	

$\Gamma(\eta U \rightarrow \eta e^+e^-)/\Gamma_{\text{total}}$					Γ_{31}/Γ
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
<1 × 10⁻⁶	90	¹ BABUSCI	13B	KLOE	1.02 $e^+e^- \rightarrow \eta e^+e^-$

¹ For a narrow vector U with mass between 5 and 470 MeV, from the combined analysis of $\eta \rightarrow \pi^+\pi^-\pi^0$ and $\eta \rightarrow \pi^0\pi^0\pi^0$ from ARCHILLI 12. Measured 90% CL limits as a function of m_U range from 2.2×10^{-8} to 10^{-6} .

$\Gamma(\text{invisible})/\Gamma(K^+K^-)$					Γ_{32}/Γ_1
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
<3.4 × 10⁻⁴	90	ABLIKIM	18S	BES3	$J/\psi \rightarrow \phi\eta \rightarrow \phi\pi^+\pi^-\pi^0$

———— Lepton Family number (LF) violating modes ————

$\Gamma(e^\pm\mu^\mp)/\Gamma_{\text{total}}$					Γ_{33}/Γ
VALUE	CL%	DOCUMENT ID	TECN	COMMENT	
<2 × 10⁻⁶	90	ACHASOV	10A	SND	$e^+e^- \rightarrow e^\pm\mu^\mp$

$\pi^+\pi^-\pi^0 / \rho\pi$ AMPLITUDE RATIO a_1 IN DECAY OF $\phi \rightarrow \pi^+\pi^-\pi^0$

NIECKNIG 12 describes final-state interactions between the three pions in a dispersive framework using data on the $\pi\pi$ P -wave scattering phase shift.

VALUE (units 10^{-2})	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
9.1±1.2 OUR AVERAGE					
10.1±4.4±1.7		80k	¹ AKHMETSHIN 06	CMD2	1.017–1.021 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
9.0±1.1±0.6		1.98M	^{2,3} ALOISIO	03	KLOE 1.02 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$

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

$-6 < a_1 < 6$		500k	³ ACHASOV	02	SND $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
$-16 < a_1 < 11$	90	9.8k	^{1,4} AKHMETSHIN 98	CMD2	$e^+e^- \rightarrow \pi^+\pi^-\gamma\gamma$

¹ Dalitz plot analysis taking into account interference between the contact and $\rho\pi$ amplitudes.

² From a fit without limitations on charged and neutral ρ masses and widths.

³ Recalculated by us to match the notations of AKHMETSHIN 98.

⁴ Assuming zero phase for the contact term.

PARAMETER β IN $\phi \rightarrow P e^+ e^-$ DECAYS

In the one-pole approximation the electromagnetic transition form factor for $\phi \rightarrow P e^+ e^-$ ($P = \pi, \eta$) is given as a function of the $e^+ e^-$ invariant mass squared, q^2 , by the expression:

$$|F(q^2)|^2 = (1 - q^2/\Lambda^2)^{-2},$$

where vector meson dominance predicts parameter $\Lambda \approx 0.770$ GeV ($\Lambda^{-2} \approx 1.687$ GeV $^{-2}$). The slope of this form factor, $\beta = dF/dq^2(q^2=0)$, equals Λ^{-2} in this approximation.

The measurements below obtain β in the one-pole approximation.

PARAMETER β IN $\phi \rightarrow \pi^0 e^+ e^-$ DECAY

VALUE (GeV $^{-2}$)	EVTS	DOCUMENT ID	TECN	COMMENT
2.02±0.11	9.5k	¹ ANASTASI	16B	KLOE 1.02 $e^+ e^- \rightarrow \pi^0 e^+ e^-$

¹The error combines statistical and systematic uncertainties.

PARAMETER β IN $\phi \rightarrow \eta e^+ e^-$ DECAY

VALUE (GeV $^{-2}$)	EVTS	DOCUMENT ID	TECN	COMMENT
1.29±0.13 OUR AVERAGE				
1.28±0.10 ^{+0.09} _{-0.08}	30k	BABUSCI	15	KLOE 1.02 $e^+ e^- \rightarrow \eta e^+ e^-$
3.8 ±1.8	213	¹ ACHASOV	01B	SND 1.02 $e^+ e^- \rightarrow \eta e^+ e^-$

¹The uncertainty is statistical only. The systematic one is negligible, in comparison.

 $\phi(1020)$ REFERENCES

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KOZYREV	18	PL B779 64	E.A. Kozyrev <i>et al.</i>	(CMD3 Collab.)
AKHMETSHIN	17	PL B768 345	R.R. Akhmetshin <i>et al.</i>	(CMD-3 Collab.)
ACHASOV	16A	PR D93 092001	M.N. Achasov <i>et al.</i>	(SND Collab.)
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LEES	14H	PR D89 092002	J.P. Lees <i>et al.</i>	(BABAR Collab.)
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NIECKNIG	12	EPJ C72 2014	F. Niecknig, B. Kubis, S.P. Schneider	(BONN)
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Translated from ZETFP 88 93.

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BARATE	83	PL 121B 449	R. Barate <i>et al.</i>	(SACL, LOIC, SHMP, IND)
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CERRADA	77B	NP B126 241	M. Cerrada <i>et al.</i>	(AMST, CERN, NIJM+)
COHEN	77	PRL 38 269	D. Cohen <i>et al.</i>	(ANL)
LAVEN	77	NP B127 43	H. Laven <i>et al.</i>	(AACH3, BERL, CERN, LOIC+)
LYONS	77	NP B125 207	L. Lyons, A.M. Cooper, A.G. Clark	(OXF)
COSME	76	PL 63B 352	G. Cosme <i>et al.</i>	(ORSAY)
KALBFLEISCH	76	PR D13 22	G.R. Kalbfleisch, R.C. Strand, J.W. Chapman	(BNL+)
PARROUR	76	PL 63B 357	G. Parrou <i>et al.</i>	(ORSAY)
PARROUR	76B	PL 63B 362	G. Parrou <i>et al.</i>	(ORSAY)
KALBFLEISCH	75	PR D11 987	G.R. Kalbfleisch, R.C. Strand, J.W. Chapman	(BNL+)
AYRES	74	PRL 32 1463	D.S. Ayres <i>et al.</i>	(ANL)
BESCH	74	NP B70 257	H.J. Besch <i>et al.</i>	(BONN)
COSME	74	PL 48B 155	G. Cosme <i>et al.</i>	(ORSAY)
COSME	74B	PL 48B 159	G. Cosme <i>et al.</i>	(ORSAY)
DEGROOT	74	NP B74 77	A.J. de Groot <i>et al.</i>	(AMST, NIJM)
AUGUSTIN	73	PRL 30 462	J.E. Augustin <i>et al.</i>	(ORSAY)
BALLAM	73	PR D7 3150	J. Ballam <i>et al.</i>	(SLAC, LBL)
BINNIE	73B	PR D8 2789	D.M. Binnie <i>et al.</i>	(LOIC, SHMP)
AGUILAR-...	72B	PR D6 29	M. Aguilar-Benitez <i>et al.</i>	(BNL)
ALVENSLEB...	72	PRL 28 66	H. Alvensleben <i>et al.</i>	(MIT, DESY)
BORENSTEIN	72	PR D5 1559	S.R. Borenstein <i>et al.</i>	(BNL, MICH)
COLLEY	72	NP B50 1	D.C. Colley <i>et al.</i>	(BIRM, GLAS)
BALAKIN	71	PL 34B 328	V.E. Balakin <i>et al.</i>	(NOVO)
CHATELUS	71	Thesis LAL 1247	Y. Chatelus	(STRB)
Also		PL 32B 416	J.C. Bizot <i>et al.</i>	(ORSAY)
HAYES	71	PR D4 899	S. Hayes <i>et al.</i>	(CORN)
STOTTLE...	71	Thesis ORO 2504 170	A.R. Stottlemyer	(UMD)
BIZOT	70	PL 32B 416	J.C. Bizot <i>et al.</i>	(ORSAY)
Also		Liverpool Sym. 69	J.P. Perez-y-Jorba	
EARLES	70	PRL 25 1312	D.R. Earles <i>et al.</i>	(NEAS)
LINDSEY	66	PR 147 913	J.S. Lindsey, G. Smith	(LRL)
LONDON	66	PR 143 1034	G.W. London <i>et al.</i>	(BNL, SYRA) IGJPC
BADIER	65B	PL 17 337	J. Badier <i>et al.</i>	(EPOL, SACL, AMST)

LINDSEY	65	PRL 15 221	J.S. Lindsey, G.A. Smith	(LRL)
LINDSEY	65	data included in LINDSEY 66.		
SCHLEIN	63	PRL 10 368	P.E. Schlein <i>et al.</i>	(UCLA) IGJP
