



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

We have omitted some results that have been superseded by later experiments. The omitted results may be found in our 1988 edition Physics Letters **B204** (1988).

## η MASS

Recent measurements resolve the obvious inconsistency in previous  $\eta$  mass measurements in favor of the higher value first reported by NA48 (LAI 02). We use only precise measurements consistent with this higher mass value for our  $\eta$  mass average.

<u>VALUE (MeV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>547.862±0.017 OUR AVERAGE</b>				
547.865±0.031±0.062		NIKOLAEV	14	CRYB $\gamma p \rightarrow p\eta$
547.873±0.005±0.027	1M	GOSLAWSKI	12	SPEC $d p \rightarrow {}^3\text{He}\eta$
547.874±0.007±0.029		AMBROSINO	07B	KLOE $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$
547.785±0.017±0.057	16k	MILLER	07	CLEO $\psi(2S) \rightarrow J/\psi\eta$
547.843±0.030±0.041	1134	LAI	02	NA48 $\eta \rightarrow 3\pi^0$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
547.311±0.028±0.032		<sup>1</sup> ABDEL-BARY	05	SPEC $d p \rightarrow {}^3\text{He}\eta$
547.12 ±0.06 ±0.25		KRUSCHE	95D	SPEC $\gamma p \rightarrow \eta p$ , threshold
547.30 ±0.15		PLOUIN	92	SPEC $d p \rightarrow {}^3\text{He}\eta$
547.45 ±0.25		DUANE	74	SPEC $\pi^- p \rightarrow n$ neutrals
548.2 ±0.65		FOSTER	65C	HBC
549.0 ±0.7	148	FOELSCH	64	HBC
548.0 ±1.0	91	ALFF-...	62	HBC
549.0 ±1.2	53	BASTIEN	62	HBC

<sup>1</sup> ABDEL-BARY 05 disagrees significantly with recent measurements of similar or better precision. See comment in the header.

## η WIDTH

This is the partial decay rate  $\Gamma(\eta \rightarrow \gamma\gamma)$  divided by the fitted branching fraction for that mode. See the note at the start of the  $\Gamma(2\gamma)$  data block, next below.

<u>VALUE (keV)</u>	<u>DOCUMENT ID</u>
<b>1.31±0.05 OUR FIT</b>	

**$\eta$  DECAY MODES**

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level
<b>Neutral modes</b>		
$\Gamma_1$ neutral modes	$(72.12 \pm 0.34) \%$	S=1.2
$\Gamma_2$ $2\gamma$	$(39.41 \pm 0.20) \%$	S=1.1
$\Gamma_3$ $3\pi^0$	$(32.68 \pm 0.23) \%$	S=1.1
$\Gamma_4$ $\pi^0 2\gamma$	$(2.56 \pm 0.22) \times 10^{-4}$	
$\Gamma_5$ $2\pi^0 2\gamma$	$< 1.2 \times 10^{-3}$	CL=90%
$\Gamma_6$ $4\gamma$	$< 2.8 \times 10^{-4}$	CL=90%
$\Gamma_7$ invisible	$< 1.0 \times 10^{-4}$	CL=90%
<b>Charged modes</b>		
$\Gamma_8$ charged modes	$(28.10 \pm 0.34) \%$	S=1.2
$\Gamma_9$ $\pi^+ \pi^- \pi^0$	$(22.92 \pm 0.28) \%$	S=1.2
$\Gamma_{10}$ $\pi^+ \pi^- \gamma$	$(4.22 \pm 0.08) \%$	S=1.1
$\Gamma_{11}$ $e^+ e^- \gamma$	$(6.9 \pm 0.4) \times 10^{-3}$	S=1.3
$\Gamma_{12}$ $\mu^+ \mu^- \gamma$	$(3.1 \pm 0.4) \times 10^{-4}$	
$\Gamma_{13}$ $e^+ e^-$	$< 2.3 \times 10^{-6}$	CL=90%
$\Gamma_{14}$ $\mu^+ \mu^-$	$(5.8 \pm 0.8) \times 10^{-6}$	
$\Gamma_{15}$ $2e^+ 2e^-$	$(2.40 \pm 0.22) \times 10^{-5}$	
$\Gamma_{16}$ $\pi^+ \pi^- e^+ e^- (\gamma)$	$(2.68 \pm 0.11) \times 10^{-4}$	
$\Gamma_{17}$ $e^+ e^- \mu^+ \mu^-$	$< 1.6 \times 10^{-4}$	CL=90%
$\Gamma_{18}$ $2\mu^+ 2\mu^-$	$< 3.6 \times 10^{-4}$	CL=90%
$\Gamma_{19}$ $\mu^+ \mu^- \pi^+ \pi^-$	$< 3.6 \times 10^{-4}$	CL=90%
$\Gamma_{20}$ $\pi^+ e^- \bar{\nu}_e + \text{c.c.}$	$< 1.7 \times 10^{-4}$	CL=90%
$\Gamma_{21}$ $\pi^+ \pi^- 2\gamma$	$< 2.1 \times 10^{-3}$	
$\Gamma_{22}$ $\pi^+ \pi^- \pi^0 \gamma$	$< 5 \times 10^{-4}$	CL=90%
$\Gamma_{23}$ $\pi^0 \mu^+ \mu^- \gamma$	$< 3 \times 10^{-6}$	CL=90%
<b>Charge conjugation (C), Parity (P), Charge conjugation <math>\times</math> Parity (CP), or Lepton Family number (LF) violating modes</b>		
$\Gamma_{24}$ $\pi^0 \gamma$	C $< 9 \times 10^{-5}$	CL=90%
$\Gamma_{25}$ $\pi^+ \pi^-$	P, CP $< 1.3 \times 10^{-5}$	CL=90%
$\Gamma_{26}$ $2\pi^0$	P, CP $< 3.5 \times 10^{-4}$	CL=90%
$\Gamma_{27}$ $2\pi^0 \gamma$	C $< 5 \times 10^{-4}$	CL=90%
$\Gamma_{28}$ $3\pi^0 \gamma$	C $< 6 \times 10^{-5}$	CL=90%
$\Gamma_{29}$ $3\gamma$	C $< 1.6 \times 10^{-5}$	CL=90%
$\Gamma_{30}$ $4\pi^0$	P, CP $< 6.9 \times 10^{-7}$	CL=90%
$\Gamma_{31}$ $\pi^0 e^+ e^-$	C [a] $< 4 \times 10^{-5}$	CL=90%
$\Gamma_{32}$ $\pi^0 \mu^+ \mu^-$	C [a] $< 5 \times 10^{-6}$	CL=90%
$\Gamma_{33}$ $\mu^+ e^- + \mu^- e^+$	LF $< 6 \times 10^{-6}$	CL=90%

[a] C parity forbids this to occur as a single-photon process.

## CONSTRAINED FIT INFORMATION

An overall fit to 2 decay rate and 19 branching ratios uses 50 measurements and one constraint to determine 9 parameters. The overall fit has a  $\chi^2 = 43.8$  for 42 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.

$x_3$	24							
$x_4$	4	1						
$x_9$	-73	-80	-4					
$x_{10}$	-56	-60	-3	61				
$x_{11}$	-5	-5	0	-6	-4			
$x_{12}$	-1	0	0	-1	0	0		
$x_{16}$	0	0	0	0	0	0	0	
$\Gamma$	-14	-3	-32	11	8	1	0	0
	$x_2$	$x_3$	$x_4$	$x_9$	$x_{10}$	$x_{11}$	$x_{12}$	$x_{16}$

Mode	Rate (keV)	Scale factor
$\Gamma_2$ $2\gamma$	$0.515 \pm 0.018$	
$\Gamma_3$ $3\pi^0$	$0.427 \pm 0.015$	
$\Gamma_4$ $\pi^0 2\gamma$	$(3.34 \pm 0.28) \times 10^{-4}$	
$\Gamma_9$ $\pi^+ \pi^- \pi^0$	$0.299 \pm 0.011$	
$\Gamma_{10}$ $\pi^+ \pi^- \gamma$	$0.0551 \pm 0.0022$	
$\Gamma_{11}$ $e^+ e^- \gamma$	$0.0090 \pm 0.0006$	1.2
$\Gamma_{12}$ $\mu^+ \mu^- \gamma$	$(4.1 \pm 0.5) \times 10^{-4}$	
$\Gamma_{16}$ $\pi^+ \pi^- e^+ e^- (\gamma)$	$(3.50 \pm 0.19) \times 10^{-4}$	

## $\eta$ DECAY RATES

$\Gamma(2\gamma)$

$\Gamma_2$

See the table immediately above giving the fitted decay rates. Following the advice of NEFKENS 02, we have removed the Primakoff-effect measurement from the average. See also the "Note on the Decay Width  $\Gamma(\eta \rightarrow \gamma\gamma)$ ," in our 1994 edition, Phys. Rev. **D50**, 1 August 1994, Part I, p. 1451, for a discussion of the various measurements.

<u>VALUE (keV)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.515 \pm 0.018</math></b>				
<b><math>0.516 \pm 0.018</math></b>				
$0.520 \pm 0.020 \pm 0.013$		BABUSCI	13A	KLOE $e^+ e^- \rightarrow e^+ e^- \eta$
$0.51 \pm 0.12 \pm 0.05$	36	BARU	90	MD1 $e^+ e^- \rightarrow e^+ e^- \eta$
$0.490 \pm 0.010 \pm 0.048$	2287	ROE	90	ASP $e^+ e^- \rightarrow e^+ e^- \eta$
$0.514 \pm 0.017 \pm 0.035$	1295	WILLIAMS	88	CBAL $e^+ e^- \rightarrow e^+ e^- \eta$
$0.53 \pm 0.04 \pm 0.04$		BARTEL	85E	JADE $e^+ e^- \rightarrow e^+ e^- \eta$

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

0.476 ± 0.062		<sup>1</sup> RODRIGUES	08	CNTR	Reanalysis
0.64 ± 0.14 ± 0.13		AIHARA	86	TPC	$e^+ e^- \rightarrow e^+ e^- \eta$
0.56 ± 0.16	56	WEINSTEIN	83	CBAL	$e^+ e^- \rightarrow e^+ e^- \eta$
0.324 ± 0.046		BROWMAN	74B	CNTR	Primakoff effect
1.00 ± 0.22		<sup>2</sup> BEMPORAD	67	CNTR	Primakoff effect

<sup>1</sup> RODRIGUES 08 uses a more sophisticated calculation for the inelastic background due to incoherent photoproduction to reanalyze the  $\eta$  photoproduction data on Be and Cu at 9 GeV from BROWMAN 74B. This brings the value of  $\Gamma(\eta \rightarrow 2\gamma)$  in line with direct measurements of the width. The error here is only statistical.

<sup>2</sup> BEMPORAD 67 gives  $\Gamma(2\gamma) = 1.21 \pm 0.26$  keV assuming  $\Gamma(2\gamma)/\Gamma(\text{total}) = 0.314$ . Bemporad private communication gives  $\Gamma(2\gamma)^2/\Gamma(\text{total}) = 0.380 \pm 0.083$ . We evaluate this using  $\Gamma(2\gamma)/\Gamma(\text{total}) = 0.38 \pm 0.01$ . Not included in average because the uncertainty resulting from the separation of the coulomb and nuclear amplitudes has apparently been underestimated.

$\Gamma(\pi^0 2\gamma)$					$\Gamma_4$
VALUE (eV)	EVTS	DOCUMENT ID	TECN	COMMENT	
<b>0.334 ± 0.028 OUR FIT</b>					
<b>0.33 ± 0.03</b>	1200	NEFKENS	14	CRYB $\gamma p \rightarrow \eta p$	

## $\eta$ BRANCHING RATIOS

### Neutral modes

$\Gamma(\text{neutral modes})/\Gamma_{\text{total}}$		$\Gamma_1/\Gamma = (\Gamma_2 + \Gamma_3 + \Gamma_4)/\Gamma$			
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
<b>0.7212 ± 0.0034 OUR FIT</b>		Error includes scale factor of 1.2.			
<b>0.705 ± 0.008</b>	16k	BASILE	71D	CNTR	MM spectrometer
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.79 ± 0.08		BUNIATOV	67	OSPK	

$\Gamma(2\gamma)/\Gamma_{\text{total}}$		$\Gamma_2/\Gamma$			
VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT	
<b>39.41 ± 0.20 OUR FIT</b>		Error includes scale factor of 1.1.			
<b>39.49 ± 0.17 ± 0.30</b>	65k	ABEGG	96	SPEC	$pd \rightarrow {}^3\text{He}\eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
38.45 ± 0.40 ± 0.36	14k	<sup>1</sup> LOPEZ	07	CLEO	$\psi(2S) \rightarrow J/\psi\eta$

<sup>1</sup> Not independent of other results listed for LOPEZ 07. Assuming decays of  $\eta \rightarrow \gamma\gamma$ ,  $3\pi^0$ ,  $\pi^+\pi^-\pi^0$ ,  $\pi^+\pi^-\gamma$ , and  $e^+e^-\gamma$  account for all  $\eta$  decays within a contribution of 0.3% to the systematic error.

$\Gamma(2\gamma)/\Gamma(\text{neutral modes})$		$\Gamma_2/\Gamma_1 = \Gamma_2/(\Gamma_2 + \Gamma_3 + \Gamma_4)$			
VALUE	EVTS	DOCUMENT ID	TECN	COMMENT	
<b>0.5465 ± 0.0019 OUR FIT</b>					
<b>0.548 ± 0.023 OUR AVERAGE</b>		Error includes scale factor of 1.5.			
0.535 ± 0.018		BUTTRAM	70	OSPK	
0.59 ± 0.033		BUNIATOV	67	OSPK	

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

0.52 ±0.09	88	ABROSIMOV	80	HLBC	
0.60 ±0.14	113	KENDALL	74	OSPK	
0.57 ±0.09		STRUGALSKI	71	HLBC	
0.579 ±0.052		FELDMAN	67	OSPK	
0.416 ±0.044		DIGIUGNO	66	CNTR	Error doubled
0.44 ±0.07		GRUNHAUS	66	OSPK	
0.39 ±0.06	<sup>1</sup>	JONES	66	CNTR	

<sup>1</sup>This result from combining cross sections from two different experiments.

### $\Gamma(3\pi^0)/\Gamma_{\text{total}}$

$\Gamma_3/\Gamma$

<u>VALUE (units 10<sup>-2</sup>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>32.68±0.23 OUR FIT</b>				Error includes scale factor of 1.1.

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

34.03±0.56±0.49	1821	<sup>1</sup> LOPEZ	07	CLEO	$\psi(2S) \rightarrow J/\psi\eta$
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<sup>1</sup>Not independent of other results listed for LOPEZ 07. Assuming decays of  $\eta \rightarrow \gamma\gamma$ ,  $3\pi^0$ ,  $\pi^+\pi^-\pi^0$ ,  $\pi^+\pi^-\gamma$ , and  $e^+e^-\gamma$  account for all  $\eta$  decays within a contribution of 0.3% to the systematic error.

### $\Gamma(3\pi^0)/\Gamma(\text{neutral modes})$

$\Gamma_3/\Gamma_1 = \Gamma_3/(\Gamma_2+\Gamma_3+\Gamma_4)$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.4531±0.0019 OUR FIT</b>				

**0.439 ±0.024**

BUTTRAM 70 OSPK

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

0.44 ±0.08	75	ABROSIMOV	80	HLBC	
0.32 ±0.09		STRUGALSKI	71	HLBC	
0.41 ±0.033		BUNIATOV	67	OSPK	Not indep. of $\Gamma(2\gamma)/\Gamma(\text{neutral modes})$
0.177 ±0.035		FELDMAN	67	OSPK	
0.209 ±0.054		DIGIUGNO	66	CNTR	Error doubled
0.29 ±0.10		GRUNHAUS	66	OSPK	

### $\Gamma(3\pi^0)/\Gamma(2\gamma)$

$\Gamma_3/\Gamma_2$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.829±0.006 OUR FIT</b>				

**0.829±0.007 OUR AVERAGE**

0.884±0.022±0.019	1821	LOPEZ	07	CLEO	$\psi(2S) \rightarrow J/\psi\eta$
0.817±0.012±0.032	17.4k	<sup>1</sup> AKHMETSHIN	05	CMD2	$e^+e^- \rightarrow \phi \rightarrow \eta\gamma$
0.826±0.024		ACHASOV	00D	SND	$e^+e^- \rightarrow \phi \rightarrow \eta\gamma$
0.832±0.005±0.012		KRUSCHE	95D	SPEC	$\gamma p \rightarrow \eta p$ , threshold
0.841±0.034		AMSLER	93	CBAR	$\bar{p}p \rightarrow \pi^+\pi^-\eta$ at rest
0.822±0.009		ALDE	84	GAM2	

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

0.796±0.016±0.016		ACHASOV	00	SND	See ACHASOV 00D
0.91 ±0.14		COX	70B	HBC	
0.75 ±0.09		DEVONS	70	OSPK	
0.88 ±0.16		BALTAY	67D	DBC	
1.1 ±0.2		CENCE	67	OSPK	
1.25 ±0.39		BACCI	63	CNTR	Inverse BR reported

<sup>1</sup>Uses result from AKHMETSHIN 01B.

$\Gamma(\pi^0 2\gamma)/\Gamma_{\text{total}}$   $\Gamma_4/\Gamma$

Early results are summarized in the review by LANDSBERG 85.

VALUE (units $10^{-4}$ )	CL%	EVTS	DOCUMENT ID	TECN	COMMENT	
<b>2.56 ± 0.22</b>					<b>OUR FIT</b>	
<b>2.21 ± 0.24 ± 0.47</b>	≈ 500	1	PRAKHOV	08	CRYB $\pi^- p \rightarrow \eta n \approx$ threshold	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
3.5 ± 0.7 ± 0.6		1.6k	2,3	PRAKHOV	05	CRYB See PRAKHOV 08
<8.4	90	7	ACHASOV	01D	SND $e^+ e^- \rightarrow \phi \rightarrow \eta \gamma$	
<30	90	0	DAVYDOV	81	GAM2 $\pi^- p \rightarrow \eta n$	

<sup>1</sup> PRAKHOV 08 is a reanalysis of the data of PRAKHOV 05, using for the first time the invariant-mass spectrum of the two photons.

<sup>2</sup> Normalized using  $\Gamma(\eta \rightarrow 2\gamma)/\Gamma = 0.3943 \pm 0.0026$ .

<sup>3</sup> This measurement and the independent analysis of the same data by KNECHT 04 both imply a lower value of  $\Gamma(\pi^0 2\gamma)$  than the one obtained by ALDE 84 from  $\Gamma(\pi^0 2\gamma)/\Gamma(2\gamma)$ .

$\Gamma(\pi^0 2\gamma)/\Gamma(2\gamma)$   $\Gamma_4/\Gamma_2$

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	CHG	COMMENT
<b>0.65 ± 0.06</b>					<b>OUR FIT</b>
<b>1.8 ± 0.4</b>		ALDE	84	GAM2	0
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.5 ± 0.6	70	BINON	82	GAM2	See ALDE 84

$\Gamma(\pi^0 2\gamma)/\Gamma(3\pi^0)$   $\Gamma_4/\Gamma_3$

VALUE (units $10^{-4}$ )	DOCUMENT ID	TECN	COMMENT
<b>7.8 ± 0.7</b>			<b>OUR FIT</b>
• • • We do not use the following data for averages, fits, limits, etc. • • •			
8.3 ± 2.8 ± 1.4	<sup>1</sup> KNECHT	04	CRYB $\pi^- p \rightarrow n \eta$

<sup>1</sup> Independent analysis of same data as PRAKHOV 05.

$\Gamma(2\pi^0 2\gamma)/\Gamma_{\text{total}}$   $\Gamma_5/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;1.2 × 10<sup>-3</sup></b>	90	<sup>1</sup> NEFKENS	05A	CRYB $p(720 \text{ MeV}/c) \pi^- \rightarrow n \eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<4.0 × 10 <sup>-3</sup>	90	BLIK	07	GAM4 $\pi^- p \rightarrow \eta n$

<sup>1</sup> Measurement is done in limited  $\gamma\gamma$  energy range.

$\Gamma(4\gamma)/\Gamma_{\text{total}}$   $\Gamma_6/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.8 × 10<sup>-4</sup></b>	90	BLIK	07	GAM4 $\pi^- p \rightarrow \eta n$

$\Gamma(\text{invisible})/\Gamma(2\gamma)$   $\Gamma_7/\Gamma_2$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.6 × 10<sup>-4</sup></b>	90	<sup>1</sup> ABLIKIM	13	BES3 $J/\psi \rightarrow \phi \eta$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<1.65 × 10 <sup>-3</sup>	90	<sup>2</sup> ABLIKIM	06Q	BES2 $J/\psi \rightarrow \phi \eta$

<sup>1</sup> Based on 225M  $J/\psi$  decays.

<sup>2</sup> Based on 58M  $J/\psi$  decays.

————— Charged modes —————

$\Gamma(\pi^+\pi^-\pi^0)/\Gamma_{\text{total}}$   $\Gamma_9/\Gamma$

<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>22.92±0.28 OUR FIT</b>	Error includes scale factor of 1.2.			

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

22.60±0.35±0.29	3915	<sup>1</sup> LOPEZ	07	CLEO	$\psi(2S) \rightarrow J/\psi\eta$
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<sup>1</sup> Not independent of other results listed for LOPEZ 07. Assuming decays of  $\eta \rightarrow \gamma\gamma$ ,  $3\pi^0$ ,  $\pi^+\pi^-\pi^0$ ,  $\pi^+\pi^-\gamma$ , and  $e^+e^-\gamma$  account for all  $\eta$  decays within a contribution of 0.3% to the systematic error.

$\Gamma(\text{neutral modes})/\Gamma(\pi^+\pi^-\pi^0)$   $\Gamma_1/\Gamma_9 = (\Gamma_2+\Gamma_3+\Gamma_4)/\Gamma_9$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>3.15±0.05 OUR FIT</b>	Error includes scale factor of 1.2.		
<b>3.26±0.30 OUR AVERAGE</b>			

2.54±1.89	74	KENDALL	74	OSPK
3.4 ±1.1	29	AGUILAR-...	72B	HBC
2.83±0.80	70	<sup>1</sup> BLOODWO...	72B	HBC
3.6 ±0.6	244	FLATTE	67B	HBC
2.89±0.56		ALFF-...	66	HBC
3.6 ±0.8	50	KRAEMER	64	DBC
3.8 ±1.1		PAULI	64	DBC

<sup>1</sup> Error increased from published value 0.5 by Bloodworth (private communication).

$\Gamma(2\gamma)/\Gamma(\pi^+\pi^-\pi^0)$   $\Gamma_2/\Gamma_9$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.720±0.028 OUR FIT</b>	Error includes scale factor of 1.2.			
<b>1.70 ±0.04 OUR AVERAGE</b>				

1.704±0.032±0.026	3915	<sup>1</sup> LOPEZ	07	CLEO	$\psi(2S) \rightarrow J/\psi\eta$
1.61 ±0.14		ABLIKIM	06E	BES2	$e^+e^- \rightarrow J/\psi \rightarrow \eta\gamma$
1.78 ±0.10 ±0.13	1077	AMSLER	95	CBAR	$\bar{p}p \rightarrow \pi^+\pi^-\eta$ at rest
1.72 ±0.25	401	BAGLIN	69	HLBC	
1.61 ±0.39		FOSTER	65	HBC	

<sup>1</sup> LOPEZ 07 reports  $\Gamma(\eta \rightarrow \pi^+\pi^-\pi^0) / \Gamma(\eta \rightarrow 2\gamma) = \Gamma_9/\Gamma_2 = 0.587 \pm 0.011 \pm 0.009$ .

$\Gamma(3\pi^0)/\Gamma(\pi^+\pi^-\pi^0)$   $\Gamma_3/\Gamma_9$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.426±0.026 OUR FIT</b>	Error includes scale factor of 1.2.			
<b>1.48 ±0.05 OUR AVERAGE</b>				

1.46 ±0.03 ±0.09		ACHASOV	06A	SND	$e^+e^- \rightarrow \eta\gamma$
1.52 ±0.04 ±0.08	23k	<sup>1</sup> AKHMETSHIN	01B	CMD2	$e^+e^- \rightarrow \phi \rightarrow \eta\gamma$
1.44 ±0.09 ±0.10	1627	AMSLER	95	CBAR	$\bar{p}p \rightarrow \pi^+\pi^-\eta$ at rest
1.50 <sup>+0.15</sup> <sub>-0.29</sub>	199	BAGLIN	69	HLBC	
1.47 <sup>+0.20</sup> <sub>-0.17</sub>		BULLOCK	68	HLBC	

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

1.3 ±0.4		BAGLIN	67B	HLBC
0.90 ±0.24		FOSTER	65	HBC
2.0 ±1.0		FOELSCH	64	HBC
0.83 ±0.32		CRAWFORD	63	HBC

<sup>1</sup> AKHMETSHIN 01B uses results from AKHMETSHIN 99F.

$$\Gamma(\pi^+\pi^-\pi^0)/[\Gamma(2\gamma)+\Gamma(3\pi^0)] \qquad \Gamma_9/(\Gamma_2+\Gamma_3)$$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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**0.318 ± 0.005 OUR FIT** Error includes scale factor of 1.2.

**0.304 ± 0.012** ACHASOV 00D SND  $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$

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

0.3141 ± 0.0081 ± 0.0058 ACHASOV 00B SND See ACHASOV 00D

$$\Gamma(\pi^+\pi^-\gamma)/\Gamma_{\text{total}} \qquad \Gamma_{10}/\Gamma$$

<u>VALUE (units 10<sup>-2</sup>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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**4.22 ± 0.08 OUR FIT** Error includes scale factor of 1.1.

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

3.96 ± 0.14 ± 0.14 859 <sup>1</sup> LOPEZ 07 CLEO  $\psi(2S) \rightarrow J/\psi\eta$

<sup>1</sup> Not independent of other results listed for LOPEZ 07. Assuming decays of  $\eta \rightarrow \gamma\gamma$ ,  $3\pi^0$ ,  $\pi^+\pi^-\pi^0$ ,  $\pi^+\pi^-\gamma$ , and  $e^+e^-\gamma$  account for all  $\eta$  decays within a contribution of 0.3% to the systematic error.

$$\Gamma(\pi^+\pi^-\gamma)/\Gamma(\pi^+\pi^-\pi^0) \qquad \Gamma_{10}/\Gamma_9$$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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**0.1842 ± 0.0027 OUR FIT**

**0.1847 ± 0.0030 OUR AVERAGE** Error includes scale factor of 1.1.

0.1856 ± 0.0005 ± 0.0028 200k BABUSCI 13 KLOE  $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$

0.175 ± 0.007 ± 0.006 859 LOPEZ 07 CLEO  $\psi(2S) \rightarrow J/\psi\eta$

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

0.209 ± 0.004 18k THALER 73 ASPK

0.201 ± 0.006 7250 GORMLEY 70 ASPK

0.28 ± 0.04 BALTAY 67B DBC

0.25 ± 0.035 LITCHFIELD 67 DBC

0.30 ± 0.06 CRAWFORD 66 HBC

0.196 ± 0.041 FOSTER 65C HBC

$$\Gamma(e^+e^-\gamma)/\Gamma_{\text{total}} \qquad \Gamma_{11}/\Gamma$$

<u>VALUE (units 10<sup>-3</sup>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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**6.9 ± 0.4 OUR FIT** Error includes scale factor of 1.3.

**6.7 ± 0.5 OUR AVERAGE** Error includes scale factor of 1.2.

6.6 ± 0.4 ± 0.4 1345 BERGHAUSER 11 SPEC  $\gamma p \rightarrow p\eta$

7.8 ± 0.5 ± 0.8 435 ± 31 BERLOWSKI 08 WASA  $pd \rightarrow {}^3\text{He}\eta$

5.15 ± 0.62 ± 0.74 283 ACHASOV 01B SND  $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$

7.10 ± 0.64 ± 0.46 323 AKHMETSHIN 01 CMD2  $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$

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

9.4 ± 0.7 ± 0.5 172 <sup>1</sup> LOPEZ 07 CLEO  $\psi(2S) \rightarrow J/\psi\eta$

<sup>1</sup> Not independent of other results listed for LOPEZ 07. Assuming decays of  $\eta \rightarrow \gamma\gamma$ ,  $3\pi^0$ ,  $\pi^+\pi^-\pi^0$ ,  $\pi^+\pi^-\gamma$ , and  $e^+e^-\gamma$  account for all  $\eta$  decays within a contribution of 0.3% to the systematic error.

$$\Gamma(e^+e^-\gamma)/\Gamma(\pi^+\pi^-\gamma) \qquad \Gamma_{11}/\Gamma_{10}$$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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**0.163 ± 0.011 OUR FIT** Error includes scale factor of 1.2.

**0.237 ± 0.021 ± 0.015** 172 LOPEZ 07 CLEO  $\psi(2S) \rightarrow J/\psi\eta$



$\Gamma(e^+e^-\gamma)/\Gamma(\pi^+\pi^-\pi^0)$   $\Gamma_{11}/\Gamma_9$

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.00±0.19 OUR FIT</b>				Error includes scale factor of 1.3.
2.1 ±0.5	80	JANE	75B	OSPK See the erratum

$\Gamma(\text{neutral modes})/[\Gamma(\pi^+\pi^-\pi^0) + \Gamma(\pi^+\pi^-\gamma) + \Gamma(e^+e^-\gamma)]$   
 $\Gamma_1/(\Gamma_9+\Gamma_{10}+\Gamma_{11}) = (\Gamma_2+\Gamma_3+\Gamma_4)/(\Gamma_9+\Gamma_{10}+\Gamma_{11})$

VALUE	EVTS	DOCUMENT ID	TECN
<b>2.59±0.04 OUR FIT</b>			Error includes scale factor of 1.2.
2.64±0.23		BALTAY	67B DBC

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

4.5 ±1.0	280	<sup>1</sup> JAMES	66	HBC
3.20±1.26	53	<sup>1</sup> BASTIEN	62	HBC
2.5 ±1.0	10	<sup>1</sup> PICKUP	62	HBC

<sup>1</sup> These experiments are not used in the averages as they do not separate clearly  $\eta \rightarrow \pi^+\pi^-\pi^0$  and  $\eta \rightarrow \pi^+\pi^-\gamma$  from each other. The reported values thus probably contain some unknown fraction of  $\eta \rightarrow \pi^+\pi^-\gamma$ .

$\Gamma(2\gamma)/[\Gamma(\pi^+\pi^-\pi^0) + \Gamma(\pi^+\pi^-\gamma) + \Gamma(e^+e^-\gamma)]$   $\Gamma_2/(\Gamma_9+\Gamma_{10}+\Gamma_{11})$

VALUE	EVTS	DOCUMENT ID	TECN
<b>1.417±0.023 OUR FIT</b>			Error includes scale factor of 1.2.
<b>1.1 ±0.4 OUR AVERAGE</b>			
1.51 ±0.93	75	KENDALL	74 OSPK
0.99 ±0.48		CRAWFORD	63 HBC

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

VALUE (units $10^{-4}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>3.1±0.4 OUR FIT</b>				
<b>3.1±0.4</b>	600	DZHELYADIN	80	SPEC $\pi^- p \rightarrow \eta n$
1.5±0.75	100	BUSHNIN	78	SPEC See DZHELYADIN 80

$\Gamma(e^+e^-)/\Gamma_{\text{total}}$   $\Gamma_{13}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b>&lt;2.3 × 10<sup>-6</sup></b>	90	AGAKISHIEV	14	$pp \rightarrow \eta + X$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<5.6 × 10 <sup>-6</sup>	90	<sup>1</sup> AGAKISHIEV	12A	SPEC $pp \rightarrow \eta + X$
<2.7 × 10 <sup>-5</sup>	90	BERLOWSKI	08	WASA $pd \rightarrow {}^3\text{He} \eta$
<0.77 × 10 <sup>-4</sup>	90	BROWDER	97B	CLE2 $e^+e^- \simeq 10.5 \text{ GeV}$
<2 × 10 <sup>-4</sup>	90	WHITE	96	SPEC $pd \rightarrow \eta {}^3\text{He}$
<3 × 10 <sup>-4</sup>	90	DAVIES	74	RVUE Uses ESTEN 67

<sup>1</sup> AGAKISHIEV 12A uses a data sample of 3.5 GeV proton beam collisions on liquid hydrogen target collected by the HADES detector.

$\Gamma(\mu^+ \mu^-)/\Gamma_{\text{total}}$   $\Gamma_{14}/\Gamma$

<u>VALUE (units <math>10^{-6}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>5.8±0.8 OUR AVERAGE</b>					
5.7±0.7±0.5		114	ABEGG 94	SPEC	$pd \rightarrow \eta^3\text{He}$
6.5±2.1		27	DZHELADIN 80B	SPEC	$\pi^- p \rightarrow \eta n$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
5.6 <sup>+0.6</sup> <sub>-0.7</sub> ±0.5		100	KESSLER 93	SPEC	See ABEGG 94
< 20	95	0	WEHMANN 68	OSPK	

$\Gamma(\mu^+ \mu^-)/\Gamma(2\gamma)$   $\Gamma_{14}/\Gamma_2$

<u>VALUE (units <math>10^{-5}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
• • • We do not use the following data for averages, fits, limits, etc. • • •		
5.9±2.2	HYAMS 69	OSPK

$\Gamma(2e^+ 2e^-)/\Gamma_{\text{total}}$   $\Gamma_{15}/\Gamma$

<u>VALUE (units <math>10^{-5}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2.4±0.2±0.1</b>					
	362		<sup>1</sup> AMBROSINO 11B	KLOE	$e^+ e^- \rightarrow \phi \rightarrow \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<9.7	90		BERLOWSKI 08	WASA	$pd \rightarrow ^3\text{He} \eta$
<6.9	90		AKHMETSHIN 01	CMD2	$e^+ e^- \rightarrow \phi \rightarrow \eta\gamma$
<sup>1</sup> This measurement is fully inclusive (includes "2e <sup>+</sup> 2e <sup>-</sup> γ" channel).					

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>CL%</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2.68±0.11 OUR FIT</b>					
<b>2.68±0.09±0.07</b>		1555 ± 52	<sup>1</sup> AMBROSINO 09B	KLOE	$e^+ e^- \rightarrow \phi \rightarrow \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.3 <sup>+2.0</sup> <sub>-1.6</sub> ± 0.4		16	BERLOWSKI 08	WASA	$pd \rightarrow ^3\text{He} \eta$
4.3 ± 1.3 ± 0.4		16	BARGHOLTZ 07	CNTR	See BERLOWSKI 08
3.7 <sup>+2.5</sup> <sub>-1.8</sub> ± 0.3		4	AKHMETSHIN 01	CMD2	$e^+ e^- \rightarrow \phi \rightarrow \eta\gamma$
<sup>1</sup> This AMBROSINO 09B value includes radiative events.					

$\Gamma(e^+ e^- \mu^+ \mu^-)/\Gamma_{\text{total}}$   $\Gamma_{17}/\Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;1.6 × 10<sup>-4</sup></b>	90	BERLOWSKI 08	WASA	$pd \rightarrow ^3\text{He} \eta$

$\Gamma(2\mu^+ 2\mu^-)/\Gamma_{\text{total}}$   $\Gamma_{18}/\Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;3.6 × 10<sup>-4</sup></b>	90	BERLOWSKI 08	WASA	$pd \rightarrow ^3\text{He} \eta$

$\Gamma(\mu^+ \mu^- \pi^+ \pi^-)/\Gamma_{\text{total}}$   $\Gamma_{19}/\Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;3.6 × 10<sup>-4</sup></b>	90	BERLOWSKI 08	WASA	$pd \rightarrow ^3\text{He} \eta$

$\Gamma(\pi^+ e^- \bar{\nu}_e + \text{c.c.})/\Gamma(\pi^+ \pi^- \pi^0)$   $\Gamma_{20}/\Gamma_9$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 7.3 \times 10^{-4}$	90	ABLIKIM	13G	BES3 $J/\psi \rightarrow \phi \eta$

$\Gamma(\pi^+ \pi^- 2\gamma)/\Gamma(\pi^+ \pi^- \pi^0)$   $\Gamma_{21}/\Gamma_9$

VALUE	CL%	DOCUMENT ID	TECN
$< 9 \times 10^{-3}$		PRICE	67 HBC

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

$< 16 \times 10^{-3}$	95	BALTAY	67B DBC
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$\Gamma(\pi^+ \pi^- \pi^0 \gamma)/\Gamma(\pi^+ \pi^- \pi^0)$   $\Gamma_{22}/\Gamma_9$

VALUE	CL%	EVTS	DOCUMENT ID	TECN
$< 0.24 \times 10^{-2}$	90	0	THALER	73 ASPK

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

$< 1.7 \times 10^{-2}$	90		ARNOLD	68 HLBC
$< 1.6 \times 10^{-2}$	95		BALTAY	67B DBC
$< 7.0 \times 10^{-2}$			FLATTE	67 HBC
$< 0.9 \times 10^{-2}$			PRICE	67 HBC

$\Gamma(\pi^0 \mu^+ \mu^- \gamma)/\Gamma_{\text{total}}$   $\Gamma_{23}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 3 \times 10^{-6}$	90	DZHELYADIN	81	SPEC $\pi^- p \rightarrow \eta n$

————— Forbidden modes —————

$\Gamma(\pi^0 \gamma)/\Gamma_{\text{total}}$   $\Gamma_{24}/\Gamma$

Forbidden by angular momentum conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 9 \times 10^{-5}$	90	NEFKENS	05A	CRYB $p(720 \text{ MeV}/c) \pi^- \rightarrow n \eta$

$\Gamma(\pi^+ \pi^-)/\Gamma_{\text{total}}$   $\Gamma_{25}/\Gamma$

Forbidden by  $P$  and  $CP$  invariance.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$< 1.3 \times 10^{-5}$	90	16M	AMBROSINO	05A	KLOE $e^+ e^- \rightarrow \phi \rightarrow \eta \gamma$

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

$< 1.6 \times 10^{-5}$	90	25M	AAIJ	17D	LHCB in $D \rightarrow \pi \pi \pi$ decays
$< 3.9 \times 10^{-4}$	90	225M	ABLIKIM	11G	BES3 $e^+ e^- \rightarrow J/\psi \rightarrow \eta \gamma$
$< 3.3 \times 10^{-4}$	90		AKHMETSHIN	99B	CMD2 $e^+ e^- \rightarrow \phi \rightarrow \eta \gamma$
$< 9 \times 10^{-4}$	90		AKHMETSHIN	97C	CMD2 See AKHMETSHIN 99B
$< 15 \times 10^{-4}$		0	THALER	73	ASPK

$\Gamma(2\pi^0)/\Gamma_{\text{total}}$   $\Gamma_{26}/\Gamma$

Forbidden by  $P$  and  $CP$  invariance.

VALUE	CL%	EVTS	DOCUMENT ID	TECN	COMMENT
$< 3.5 \times 10^{-4}$	90		BLIK	07	GAM4 $\pi^- p \rightarrow \eta n$

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

$< 6.9 \times 10^{-4}$	90	225M	ABLIKIM	11G	BES3 $e^+ e^- \rightarrow J/\psi \rightarrow \eta \gamma$
$< 4.3 \times 10^{-4}$	90		AKHMETSHIN	99C	CMD2 $e^+ e^- \rightarrow \phi \rightarrow \eta \gamma$
$< 6 \times 10^{-4}$	90		<sup>1</sup> ACHASOV	98	SND $e^+ e^- \rightarrow \phi \rightarrow \eta \gamma$

<sup>1</sup>ACHASOV 98 observes one event in a  $\pm 3\sigma$  region around the  $\eta$  mass, while a Monte Carlo calculation gives  $10 \pm 5$  events. The limit here is the Poisson upper limit for one observed event and no background.

**$\Gamma(2\pi^0\gamma)/\Gamma_{\text{total}}$**   **$\Gamma_{27}/\Gamma$**

Forbidden by  $C$  invariance.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
$< 5 \times 10^{-4}$	90	NEFKENS	05	CRYB	0 $\rho(720 \text{ MeV}/c) \pi^- \rightarrow n\eta$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
$< 17 \times 10^{-4}$	90	BLIK	07	GAM4	$\pi^- p \rightarrow \eta n$

**$\Gamma(3\pi^0\gamma)/\Gamma_{\text{total}}$**   **$\Gamma_{28}/\Gamma$**

Forbidden by  $C$  invariance.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
$< 6 \times 10^{-5}$	90	NEFKENS	05	CRYB	0 $\rho(720 \text{ MeV}/c) \pi^- \rightarrow n\eta$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
$< 24 \times 10^{-5}$	90	BLIK	07	GAM4	$\pi^- p \rightarrow \eta n$

**$\Gamma(3\gamma)/\Gamma_{\text{total}}$**   **$\Gamma_{29}/\Gamma$**

Forbidden by  $C$  invariance.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●					
$< 16 \times 10^{-5}$	90	BLIK	07	GAM4	$\pi^- p \rightarrow \eta n$
$< 4 \times 10^{-5}$	90	NEFKENS	05A	CRYB	$\rho(720 \text{ MeV}/c) \pi^- \rightarrow n\eta$

**$\Gamma(3\gamma)/\Gamma(2\gamma)$**   **$\Gamma_{29}/\Gamma_2$**

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>CHG</u>
$< 1.2 \times 10^{-3}$	95	ALDE	84	GAM2 0

**$\Gamma(3\gamma)/\Gamma(3\pi^0)$**   **$\Gamma_{29}/\Gamma_3$**

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$< 4.9 \times 10^{-5}$	90	ALOSIO	04	KLOE $\phi \rightarrow \eta\gamma$

**$\Gamma(4\pi^0)/\Gamma_{\text{total}}$**   **$\Gamma_{30}/\Gamma$**

Forbidden by  $P$  and  $CP$  invariance.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$< 6.9 \times 10^{-7}$	90	PRAKHOV	00	CRYB $\pi^- p \rightarrow n\eta, 720 \text{ MeV}/c$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$< 200 \times 10^{-7}$	90	BLIK	07	GAM4 $\pi^- p \rightarrow \eta n$

**$\Gamma(\pi^0 e^+ e^-)/\Gamma_{\text{total}}$**   **$\Gamma_{31}/\Gamma$**

$C$  parity forbids this to occur as a single-photon process.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
$< 1.6 \times 10^{-4}$	90	MARTYNOV	76 HLBC
$< 8.4 \times 10^{-4}$	90	BAZIN	68 DBC
$< 70 \times 10^{-4}$		RITTENBERG	65 HBC

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

$\Gamma_{31}/\Gamma_9$

C parity forbids this to occur as a single-photon process.

VALUE	CL%	EVTS	DOCUMENT ID	TECN
< $1.9 \times 10^{-4}$	90		JANE 75	OSPK
< 42 $\times 10^{-4}$	90		BAGLIN 67	HLBC
< 16 $\times 10^{-4}$	90	0	BILLING 67	HLBC
< 77 $\times 10^{-4}$		0	FOSTER 65B	HBC
<110 $\times 10^{-4}$			PRICE 65	HBC

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

$\Gamma_{32}/\Gamma$

C parity forbids this to occur as a single-photon process.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< $5 \times 10^{-6}$	90	DZHELYADIN 81	SPEC	$\pi^- p \rightarrow \eta n$
<500 $\times 10^{-6}$		WEHMANN 68	OSPK	

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

$\Gamma_{33}/\Gamma$

Forbidden by lepton family number conservation.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< $6 \times 10^{-6}$	90	WHITE 96	SPEC	$pd \rightarrow \eta {}^3\text{He}$

**$\eta$  C-NONCONSERVING DECAY PARAMETERS**

**$\pi^+ \pi^- \pi^0$  LEFT-RIGHT ASYMMETRY PARAMETER**

Measurements with an error  $> 1.0 \times 10^{-2}$  have been omitted.

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN
<b><math>0.09^{+0.11}_{-0.12}</math> OUR AVERAGE</b>			
$+0.09 \pm 0.10$	$^{+0.09}_{-0.14}$ 1.34M	AMBROSINO 08D	KLOE
$0.28 \pm 0.26$	165k	JANE 74	OSPK
$-0.05 \pm 0.22$	220k	LAYTER 72	ASPK
$1.5 \pm 0.5$	37k	<sup>1</sup> GORMLEY 68C	ASPK

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

<sup>1</sup>The GORMLEY 68C asymmetry is probably due to unmeasured ( $\mathbf{E} \times \mathbf{B}$ ) spark chamber effects. New experiments with ( $\mathbf{E} \times \mathbf{B}$ ) controls don't observe an asymmetry.

**$\pi^+ \pi^- \pi^0$  SEXTANT ASYMMETRY PARAMETER**

Measurements with an error  $> 2.0 \times 10^{-2}$  have been omitted.

VALUE (units $10^{-2}$ )	EVTS	DOCUMENT ID	TECN
<b><math>0.12^{+0.10}_{-0.11}</math> OUR AVERAGE</b>			
$+0.08 \pm 0.10$	$^{+0.08}_{-0.13}$ 1.34M	AMBROSINO 08D	KLOE
$0.20 \pm 0.25$	165k	JANE 74	OSPK
$0.10 \pm 0.22$	220k	LAYTER 72	ASPK
$0.5 \pm 0.5$	37k	GORMLEY 68C	WIRE

### $\pi^+\pi^-\pi^0$ QUADRANT ASYMMETRY PARAMETER

<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b><math>-0.09 \pm 0.09</math> OUR AVERAGE</b>			
$-0.05 \pm 0.10^{+0.03}_{-0.05}$	1.34M	AMBROSINO 08D	KLOE
$-0.30 \pm 0.25$	165k	JANE 74	OSPK
$-0.07 \pm 0.22$	220k	LAYTER 72	ASPK

### $\pi^+\pi^-\gamma$ LEFT-RIGHT ASYMMETRY PARAMETER

Measurements with an error  $> 2.0 \times 10^{-2}$  have been omitted.

<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b><math>0.9 \pm 0.4</math> OUR AVERAGE</b>			
$1.2 \pm 0.6$	35k	JANE 74B	OSPK
$0.5 \pm 0.6$	36k	THALER 72	ASPK
$1.22 \pm 1.56$	7257	GORMLEY 70	ASPK

### $\pi^+\pi^-\gamma$ PARAMETER $\beta$ (*D-wave*)

Sensitive to a *D-wave* contribution:  $dN/d\cos\theta = \sin^2\theta (1 + \beta \cos^2\theta)$ .

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b><math>-0.02 \pm 0.07</math> OUR AVERAGE</b>		Error includes scale factor of 1.3.	
$0.11 \pm 0.11$	35k	JANE 74B	OSPK
$-0.060 \pm 0.065$	7250	GORMLEY 70	WIRE
$0.12 \pm 0.06$	<sup>1</sup>	THALER 72	ASPK

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

<sup>1</sup>The authors don't believe this indicates *D-wave* because the dependence of  $\beta$  on the  $\gamma$  energy is inconsistent with the theoretical prediction. A  $\cos^2\theta$  dependence can also come from *P-* and *F-wave* interference.

## $\eta$ CP-NONCONSERVING DECAY PARAMETER

### $\pi^+\pi^-e^+e^-$ DECAY-PLANE ASYMMETRY PARAMETER $A_\phi$

In the  $\eta$  rest frame, the total momentum of the  $e^+e^-$  pair is equal and opposite to that of the  $\pi^+\pi^-$  pair. Let  $\hat{z}$  be the unit vector along the momentum of the  $e^+e^-$  pair; let  $\hat{n}_{ee}$  and  $\hat{n}_{\pi\pi}$  be the unit vectors normal to the  $e^+e^-$  and  $\pi^+\pi^-$  planes; and let  $\phi$  be the angle between the two normals. Then

$$\sin\phi \cos\phi = [(\hat{n}_{ee} \times \hat{n}_{\pi\pi}) \cdot \hat{z}] (\hat{n}_{ee} \cdot \hat{n}_{\pi\pi}),$$

and

$$A_\phi \equiv \frac{N_{\sin\phi \cos\phi > 0} - N_{\sin\phi \cos\phi < 0}}{N_{\sin\phi \cos\phi > 0} + N_{\sin\phi \cos\phi < 0}}.$$

<u>VALUE (units <math>10^{-2}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>-0.6 \pm 2.5 \pm 1.8</math></b>	$1555 \pm 52$	AMBROSINO 09B	KLOE	$e^+e^- \rightarrow \phi \rightarrow \eta\gamma$

## ENERGY DEPENDENCE OF $\eta \rightarrow 3\pi$ DALITZ PLOTS

### PARAMETERS FOR $\eta \rightarrow \pi^+ \pi^- \pi^0$

See the "Note on  $\eta$  Decay Parameters," page 1454, in our 1994 edition (Physical Review **D50** 1173 (1994)). The following experiments fit to one or more of the coefficients  $a, b, c, d, e, f$  or  $g$  for  $|\text{matrix element}|^2 = 1 + ay + by^2 + cx + dx^2 + exy + fy^3 + gx^2y$ .

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
4.7M		<sup>1</sup> ANASTASI	16A	KLOE $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$
79k		ABLIKIM	15G	BES3 $e^+e^- \rightarrow J/\psi \rightarrow \gamma\eta$
174k		ADLARSON	14A	WASA $p d \rightarrow \eta \text{ } ^3\text{He}$
1.34M		AMBROSINO	08D	KLOE
3230		<sup>2</sup> ABELE	98D	CBAR $\bar{p}p \rightarrow \pi^0\pi^0\eta$ at rest
1077		<sup>3</sup> AMSLER	95	CBAR $\bar{p}p \rightarrow \pi^+\pi^-\eta$ at rest
81k		LAYTER	73	ASPK
220k		LAYTER	72	ASPK
1138		CARPENTER	70	HBC
349		DANBURG	70	DBC
7250		GORMLEY	70	WIRE
526		BAGLIN	69	HLBC
7170		CNOPS	68	OSPK
37k		GORMLEY	68C	WIRE
1300		CLPWY	66	HBC
705		LARRIBE	66	HBC

<sup>1</sup> ANASTASI 16A measure the Dalitz parameters  $a, b, d, f,$  and  $g$ . This is the first measurement of  $g$ .

<sup>2</sup> ABELE 98D obtains  $a = -1.22 \pm 0.07$  and  $b = 0.22 \pm 0.11$  when  $c$  (or  $d$ ) is fixed at 0.06.

<sup>3</sup> AMSLER 95 fits to  $(1+ay+by^2)$  and obtains  $a = -0.94 \pm 0.15$  and  $b = 0.11 \pm 0.27$ .

### $\alpha$ PARAMETER FOR $\eta \rightarrow 3\pi^0$

See the "Note on  $\eta$  Decay Parameters" in our 1994 edition, Phys. Rev. **D50**, 1 August 1994, Part I, p. 1454. The value here is of  $\alpha$  in  $|\text{matrix element}|^2 = 1 + 2\alpha z$ .

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>-0.0318 ± 0.0015 OUR AVERAGE</b>				
-0.055 ± 0.014 ± 0.004	33k	ABLIKIM	15G	BES3 $e^+e^- \rightarrow J/\psi \rightarrow \gamma\eta$
-0.0301 ± 0.0035 <sup>+0.0022</sup> / <sub>-0.0035</sub>	512k	AMBROSINO	10A	KLOE $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$
-0.027 ± 0.008 ± 0.005	120k	<sup>1</sup> ADOLPH	09	WASA $p p \rightarrow p p \eta$
-0.0322 ± 0.0012 ± 0.0022	3M	<sup>2</sup> PRAKHOV	09	CRYB $\gamma p \rightarrow p \eta$
-0.032 ± 0.002 ± 0.002	1.8M	<sup>2</sup> UNVERZAGT	09	CRYB $\gamma p \rightarrow p \eta$
-0.026 ± 0.010 ± 0.010	75k	BASHKANOV	07	WASA $p p \rightarrow p p \eta$
-0.010 ± 0.021 ± 0.010	12k	ACHASOV	01C	SND $e^+e^- \rightarrow \phi \rightarrow \eta\gamma$
-0.031 ± 0.004	1M	TIPPENS	01	CRYB $\pi^- p \rightarrow n \eta, 720 \text{ MeV}$
-0.052 ± 0.017 ± 0.010	98k	ABELE	98C	CBAR $\bar{p}p \rightarrow 5\pi^0$
-0.022 ± 0.023	50k	ALDE	84	GAM2
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
-0.038 ± 0.003 <sup>+0.012</sup> / <sub>-0.008</sub>	1.34M	<sup>3</sup> AMBROSINO	08D	KLOE
-0.32 ± 0.37	192	BAGLIN	70	HLBC

<sup>1</sup>This ADOLPH 09 result is independent of the BASHKANOV 07 result.

<sup>2</sup>The PRAKHOV 09 and UNVERZAGT 09 results are independent.

<sup>3</sup>This AMBROSINO 08D value is an indirect result using  $\eta \rightarrow \pi^+ \pi^0 \pi^-$  events and a rescattering matrix that mixes isospin decay amplitudes.

## PARAMETER $\Lambda$ IN $\eta \rightarrow \ell^+ \ell^- \gamma$ DECAY

In the pole approximation the electromagnetic transition form factor for a resonance of mass  $M$  is given by the expression:

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

where for the parameter  $\Lambda$  vector dominance predicts  $\Lambda \approx 0.770$  GeV.

VALUE (GeV/c <sup>2</sup> )	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.716 ± 0.011 OUR AVERAGE</b>				
0.712 ± 0.020		<sup>1</sup> ADLARSON 17B	A2MM	$\gamma p \rightarrow \eta p$
0.7191 ± 0.0125 ± 0.0093		<sup>2</sup> ARNALDI 16	NA60	400 GeV $p$ -A collisions
0.716 ± 0.031 ± 0.009		<sup>3</sup> ARNALDI 09	NA60	158A In-In collisions
0.72 ± 0.09	600	DZHELYADIN 80	SPEC	$\pi^- p \rightarrow \eta n, \eta \rightarrow \gamma \mu^+ \mu^-$

<sup>1</sup>ADLARSON 17B reports  $\Lambda^{-2}(\eta \rightarrow \gamma e^+ e^-) = 1.97 \pm 0.11$  (GeV/c<sup>2</sup>)<sup>-2</sup> which we converted to the quoted  $\Lambda$  value and uncertainty (total=statistical plus systematic).

<sup>2</sup>ARNALDI 16 reports  $\Lambda^{-2}(\eta \rightarrow \gamma \mu^+ \mu^-) = 1.934 \pm 0.067 \pm 0.050$  (GeV/c<sup>2</sup>)<sup>-2</sup> which we converted to the quoted  $\Lambda$  value.

<sup>3</sup>ARNALDI 09 reports  $\Lambda^{-2}(\eta \rightarrow \gamma \mu^+ \mu^-) = 1.95 \pm 0.17 \pm 0.05$  (GeV/c<sup>2</sup>)<sup>-2</sup> which we converted to the quoted  $\Lambda$  value.

## $\eta$ REFERENCES

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ARNALDI 16	PL B757 437	R. Arnaldi <i>et al.</i>	(NA60 Collab.)
ABLIKIM 15G	PR D92 012014	M. Ablikim <i>et al.</i>	(BES III Collab.)
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AGAKISHIEV 14	PL B731 265	G. Agakishiev <i>et al.</i>	(HADES Collab.)
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NIKOLAEV 14	EPJ A50 58	A. Nikolaev <i>et al.</i>	(MAMI-B, MAINZ, BONN)
ABLIKIM 13	PR D87 012009	M. Ablikim <i>et al.</i>	(BES III Collab.)
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AGAKISHIEV 12A	EPJ A48 64	G. Agakishiev <i>et al.</i>	(HADES Collab.)
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AMBROSINO 11B	PL B702 324	F. Ambrosino <i>et al.</i>	(KLOE Collab.)
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ABDEL-BARY	05	PL B619 281	M. Abdel-Bary <i>et al.</i>	(GEM Collab.)
AKHMETSHIN	05	PL B605 26	R.R. Akhmetshin <i>et al.</i>	(Novosibirsk CMD-2 Collab.)
AMBROSINO	05A	PL B606 276	F. Ambrosino <i>et al.</i>	(KLOE Collab.)
NEFKENS	05	PRL 94 041601	B.M.K. Nefkens <i>et al.</i>	(BNL Crystal Ball Collab.)
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AKHMETSHIN	97C	PL B415 452	R.R. Akhmetshin <i>et al.</i>	(Novosibirsk CMD-2 Collab.)
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AIHARA	86	PR D33 844	H. Aihara <i>et al.</i>	(TPC-2 $\gamma$ Collab.)
BARTEL	85E	PL 160B 421	W. Bartel <i>et al.</i>	(JADE Collab.)
LANDSBERG	85	PRPL 128 301	L.G. Landsberg	(SERP)
ALDE	84	ZPHY C25 225	D.M. Alde <i>et al.</i>	(SERP, BELG, LAPP)
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WEINSTEIN	83	PR D28 2896	A.J. Weinstein <i>et al.</i>	(Crystal Ball Collab.)
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DAVIES	74	NC 24A 324	J.D. Davies, J.G. Guy, R.K.P. Zia	(BIRM, RHEL+)
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BAGLIN	70	NP B22 66	C. Baglin <i>et al.</i>	(EPOL, MADR, STRB)
BUTTRAM	70	PRL 25 1358	M.T. Buttram, M.N. Kreisler, R.E. Mischke	(PRIN)
CARPENTER	70	PR D1 1303	D.W. Carpenter <i>et al.</i>	(DUKE)
COX	70B	PRL 24 534	B. Cox, L. Fortney, J.P. Golson	(DUKE)
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GORMLEY	70	PR D2 501	M. Gormley <i>et al.</i>	(COLU, BNL)
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BAGLIN	69	PL 29B 445	C. Baglin <i>et al.</i>	(EPOL, UCB, MADR, STRB)
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ARNOLD	68	PL 27B 466	R.G. Arnold <i>et al.</i>	(STRB, MADR, EPOL+)
BAZIN	68	PRL 20 895	M.J. Bazin <i>et al.</i>	(PRIN, QUKI)
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CNOPS	68	PRL 21 1609	A.M. Cnops <i>et al.</i>	(BNL, ORNL, UCND+)
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BEMPORAD	67	PL 25B 380	C. Bemporad <i>et al.</i>	(PISA, BONN)
Also		Private Comm.	I. Ion	
BILLING	67	PL 25B 435	K.D. Billing <i>et al.</i>	(LOUC, OXF)
BUNIATOV	67	PL 25B 560	S.A. Bunyatov <i>et al.</i>	(CERN, KARL)
CENCE	67	PRL 19 1393	R.J. Cence <i>et al.</i>	(HAWA, LRL)
ESTEN	67	PL 24B 115	M.J. Esten <i>et al.</i>	(LOUC, OXF)
FELDMAN	67	PRL 18 868	M. Feldman <i>et al.</i>	(PENN)
FLATTE	67	PRL 18 976	S.M. Flatte	(LRL)
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PRICE	67	PRL 18 1207	L.R. Price, F.S. Crawford	(LRL)
ALFF-...	66	PR 145 1072	C. Alff-Steinberger <i>et al.</i>	(COLU, RUTG)
CLPWY	66	PR 149 1044	C. Baltay	(SCUC, LRL, PURD, WISC, YALE)
CRAWFORD	66	PRL 16 333	F.S. Crawford, L.R. Price	(LRL)
DIGIUGNO	66	PRL 16 767	G. di Giugno <i>et al.</i>	(NAPL, TRST, FRAS)
GRUNHAUS	66	Thesis	J. Grunhaus	(COLU)
JAMES	66	PR 142 896	F.E. James, H.L. Kraybill	(YALE, BNL)
JONES	66	PL 23 597	W.G. Jones <i>et al.</i>	(LOIC, RHEL)
LARRIBE	66	PL 23 600	A. Larribe <i>et al.</i>	(SACL, RHEL)
FOSTER	65	PR 138 B652	M. Foster <i>et al.</i>	(WISC, PURD)
FOSTER	65B	Athens Conf.	M. Foster, M. Good, M. Meer	(WISC)
FOSTER	65C	Thesis	M. Foster	(WISC)
PRICE	65	PRL 15 123	L.R. Price, F.S. Crawford	(LRL)
RITTENBERG	65	PRL 15 556	A. Rittenberg, G.R. Kalbfleisch	(LRL, BNL)
FOELSCH	64	PR 134 B1138	H.W.J. Foelsche, H.L. Kraybill	(YALE)
KRAEMER	64	PR 136 B496	R.W. Kraemer <i>et al.</i>	(JHU, NWES, WOOD)
PAULI	64	PL 13 351	E. Pauli, A. Muller	(SACL)
BACCI	63	PRL 11 37	C. Bacci <i>et al.</i>	(ROMA, FRAS)

CRAWFORD	63	PRL 10 546	F.S.Jr. Crawford, L.J. Lloyd, E.C. Fowler	(LRL+)
Also		PRL 16 907	F.S. Crawford, L.J. Lloyd, E.C. Fowler	(LRL+)
ALFF-...	62	PRL 9 322	C. Alff-Steinberger <i>et al.</i>	(COLU, RUTG)
BASTIEN	62	PRL 8 114	P.L. Bastien <i>et al.</i>	(LRL)
PICKUP	62	PRL 8 329	E. Pickup, D.K. Robinson, E.O. Salant	(CNRC+)

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