η

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

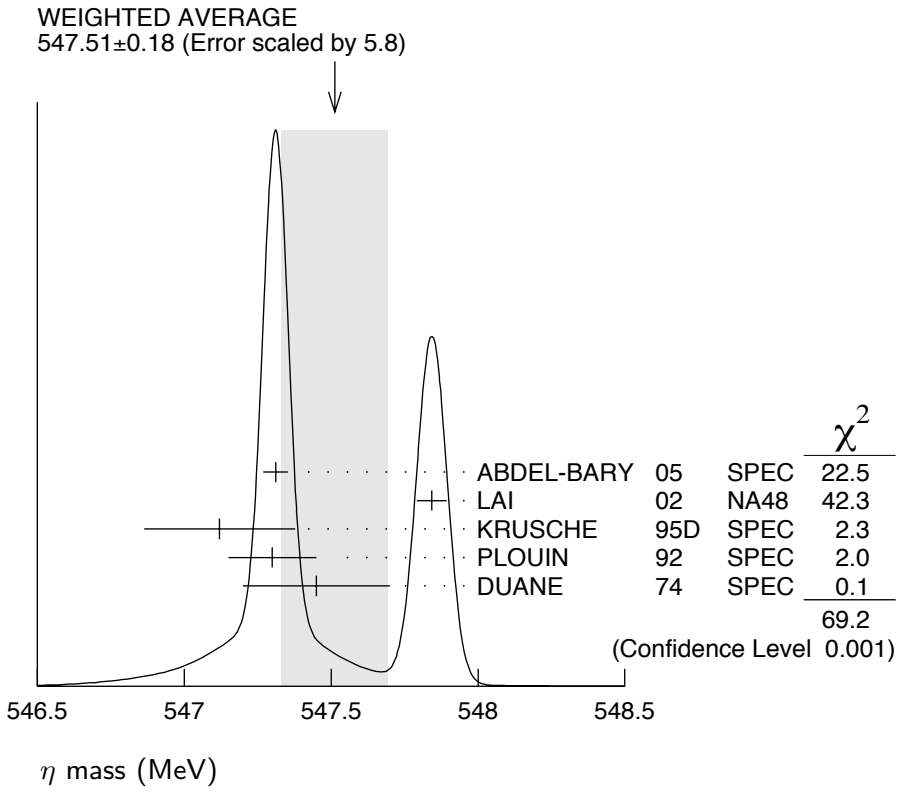
We have omitted some results that have been superseded by later experiments. The omitted results may be found in our 1988 edition Physics Letters **B204** (1988).

η MASS

We no longer use the bubble-chamber measurements from the 1960's, which seem to have been systematically high by about 1 MeV. (However, note that the latest measurement is midway between those old values and the newer ones.) Some early results have been omitted altogether.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
547.51 ±0.18 OUR AVERAGE		Error includes scale factor of 5.8. See the ideogram below.			
547.311±0.028±0.032		[1] ABDEL-BARY	05	SPEC	$d\,p \rightarrow {}^3\mathrm{He}\,X$
547.843±0.030±0.041	1134	[1] LAI	02	NA48	$\eta \rightarrow 3\pi^0$
547.12 ±0.06 ±0.25		KRUSCHE	95D	SPEC	$\gamma\,p \rightarrow \eta\,p$, threshold
547.30 ±0.15		PLOUIN	92	SPEC	$d\,p \rightarrow \eta\ {}^3\mathrm{He}$
547.45 ±0.25		DUANE	74	SPEC	$\pi^-\,p \rightarrow n$ neutrals
• • • We do not use the following data for averages, fits, limits, etc. • • •					
548.2 ±0.65		FOSTER	65C	HBC	
549.0 ±0.7	148	FOELSCHE	64	HBC	
548.0 ±1.0	91	ALFF-...	62	HBC	
549.0 ±1.2	53	BASTIEN	62	HBC	

[1] ABDEL-BARY 05 and LAI 02 disagree significantly.



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.

VALUE (keV) *DOCUMENT ID*

1.30±0.07 OUR FIT

η DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
	Neutral modes			
Γ_1	neutral modes		(72.0 ±0.4) %	S=1.3
Γ_2	2γ	[a]	(39.39±0.24) %	S=1.2
Γ_3	$3\pi^0$		(32.52±0.26) %	S=1.2
Γ_4	$\pi^0 2\gamma$		(4.4 ±1.6) $\times 10^{-4}$	S=2.0
Γ_5	$\pi^0\pi^0\gamma\gamma$		< 1.2 $\times 10^{-3}$	CL=90%
Γ_6	invisible		< 6 $\times 10^{-4}$	CL=90%

Charged modes

Γ_7	charged modes		(28.0 ±0.4) %		S=1.3
Γ_8	$\pi^+\pi^-\pi^0$		(22.68±0.35) %		S=1.3
Γ_9	$\pi^+\pi^-\gamma$		(4.69±0.10) %		S=1.1
Γ_{10}	$e^+e^-\gamma$		(6.0 ±0.8)	$\times 10^{-3}$	S=1.4
Γ_{11}	$\mu^+\mu^-\gamma$		(3.1 ±0.4)	$\times 10^{-4}$	
Γ_{12}	e^+e^-		< 7.7	$\times 10^{-5}$	CL=90%
Γ_{13}	$\mu^+\mu^-$		(5.8 ±0.8)	$\times 10^{-6}$	
Γ_{14}	$e^+e^-e^+e^-$		< 6.9	$\times 10^{-5}$	CL=90%
Γ_{15}	$\pi^+\pi^-e^+e^-$		(4.2 ±1.2)	$\times 10^{-4}$	
Γ_{16}	$\pi^+\pi^-2\gamma$		< 2.0	$\times 10^{-3}$	
Γ_{17}	$\pi^+\pi^-\pi^0\gamma$		< 5	$\times 10^{-4}$	CL=90%
Γ_{18}	$\pi^0\mu^+\mu^-\gamma$		< 3	$\times 10^{-6}$	CL=90%

Charge conjugation (C), Parity (P), Charge conjugation × Parity (CP), or Lepton Family number (LF) violating modes

Γ_{19}	$\pi^0\gamma$	C		< 9	$\times 10^{-5}$	CL=90%
Γ_{20}	$\pi^+\pi^-$	P,CP		< 1.3	$\times 10^{-5}$	CL=90%
Γ_{21}	$\pi^0\pi^0$	P,CP		< 4.3	$\times 10^{-4}$	CL=90%
Γ_{22}	$\pi^0\pi^0\gamma$	C		< 5	$\times 10^{-4}$	CL=90%
Γ_{23}	$\pi^0\pi^0\pi^0\gamma$	C		< 6	$\times 10^{-5}$	CL=90%
Γ_{24}	3γ	C		< 1.6	$\times 10^{-5}$	CL=90%
Γ_{25}	$4\pi^0$	P,CP		< 6.9	$\times 10^{-7}$	CL=90%
Γ_{26}	$\pi^0e^+e^-$	C	[b]	< 4	$\times 10^{-5}$	CL=90%
Γ_{27}	$\pi^0\mu^+\mu^-$	C	[b]	< 5	$\times 10^{-6}$	CL=90%
Γ_{28}	$\mu^+e^- + \mu^-e^+$	LF		< 6	$\times 10^{-6}$	CL=90%

[a] Due to removing an old measurement from the average, this is 0.11 keV larger than the width we gave in our 2002 edition, 1.18 ± 0.11 keV. See the $\Gamma(2\gamma)$ data block in the Data Listings.

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

CONSTRAINED FIT INFORMATION

An overall fit to a decay rate and 19 branching ratios uses 45 measurements and one constraint to determine 9 parameters. The overall fit has a $\chi^2 = 21.9$ for 37 degrees of freedom.

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

x_3	43							
x_4	−1	−1						
x_8	−81	−82	−2					
x_9	−62	−64	−2	63				
x_{10}	−9	−9	0	−7	−6			
x_{11}	0	0	0	−1	0	0		
x_{15}	−1	−1	0	−2	−1	0	0	
Γ	−12	−5	0	10	7	1	0	0
	x_2	x_3	x_4	x_8	x_9	x_{10}	x_{11}	x_{15}

	Mode	Rate (keV)	Scale factor
Γ_2	2γ	[a] 0.510 ±0.026	
Γ_3	$3\pi^0$	0.421 ±0.022	
Γ_4	$\pi^0 2\gamma$	$(5.7 \pm 2.0) \times 10^{-4}$	1.9
Γ_8	$\pi^+\pi^-\pi^0$	0.294 ±0.016	
Γ_9	$\pi^+\pi^-\gamma$	0.0608±0.0035	
Γ_{10}	$e^+e^-\gamma$	0.0078±0.0011	1.3
Γ_{11}	$\mu^+\mu^-\gamma$	$(4.0 \pm 0.6) \times 10^{-4}$	
Γ_{15}	$\pi^+\pi^- e^+ e^-$	$(5.5 \pm 1.5) \times 10^{-4}$	

η DECAY RATES

$\Gamma(2\gamma)$ Γ_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 $\Gamma(\eta \to \gamma\gamma)$," in our 1994 edition, Phys. Rev. **D50**, 1 August 1994, Part I, p. 1451, for a discussion of the various measurements.

VALUE (keV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.510±0.026 OUR FIT					
0.510±0.026 OUR AVERAGE					
0.51 ±0.12 ±0.05	36	BARU	90	MD1	$e^+e^- \to e^+e^-\eta$
0.490±0.010±0.048	2287	ROE	90	ASP	$e^+e^- \to e^+e^-\eta$
0.514±0.017±0.035	1295	WILLIAMS	88	CBAL	$e^+e^- \to e^+e^-\eta$
0.53 ±0.04 ±0.04		BARTEL	85E	JADE	$e^+e^- \to e^+e^-\eta$

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

0.64 ±0.14 ±0.13		AIHARA	86	TPC	$e^+e^- \to e^+e^-\eta$
0.56 ±0.16	56	WEINSTEIN	83	CBAL	$e^+e^- \to e^+e^-\eta$
0.324±0.046		BROWMAN	74B	CNTR	Primakoff effect
1.00 ±0.22		[2] BEMPORAD	67	CNTR	Primakoff effect

[2] 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.

η BRANCHING RATIOS

Neutral modes

Γ(neutral modes)/Γ_{total} **$\Gamma_1/\Gamma = (\Gamma_2+\Gamma_3+\Gamma_4)/\Gamma$**

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.720±0.004 OUR FIT	Error includes scale factor of 1.3.				
0.705±0.008	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	

$\Gamma(2\gamma)/\Gamma_{\text{total}}$ **Γ_2/Γ**

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.3939±0.0024 OUR FIT	Error includes scale factor of 1.2.				
0.3949±0.0017±0.0030	65k	ABEGG	96	SPEC	$pd \to {}^3\text{He}\eta$

$\Gamma(2\gamma)/\Gamma$(neutral modes) **$\Gamma_2/\Gamma_1 = \Gamma_2/(\Gamma_2+\Gamma_3+\Gamma_4)$**

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.5474±0.0019 OUR FIT					
0.548 ±0.023 OUR AVERAGE	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		[3] JONES	66	CNTR	

[3] This result from combining cross sections from two different experiments.

$\Gamma(3\pi^0)/\Gamma$(neutral modes) **$\Gamma_3/\Gamma_1 = \Gamma_3/(\Gamma_2+\Gamma_3+\Gamma_4)$**

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.4520±0.0019 OUR FIT					
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	

$\Gamma(3\pi^0)/\Gamma(2\gamma)$ Γ_3/Γ_2

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.826±0.006 OUR FIT					
0.826±0.007 OUR AVERAGE					
0.817±0.012±0.032	17.4k	[4] AKHMETSHIN	05	CMD2	$e^+e^- \to \phi \to \eta\gamma$
0.826±0.024		ACHASOV	00D	SND	$e^+e^- \to \phi \to \eta\gamma$
0.832±0.005±0.012		KRUSCHE	95D	SPEC	$\gamma p \to \eta p$, threshold
0.841±0.034		AMSLER	93	CBAR	$\overline{p}p \to \pi^+\pi^-\eta$ 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

[4] Uses result from AKHMETSHIN 01B.

$\Gamma(\pi^0 2\gamma)/\Gamma_{\text{total}}$ Γ_4/Γ

Early results are summarized in the review by LANDSBERG 85.

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
4.4±1.6 OUR FIT Error includes scale factor of 2.0.						
3.5±0.7±0.6		1.6k	[5,6] PRAKHOV	05	CRYB	p(720 MeV/c) $\pi^- \to n\eta$

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

<8.4	90	7	ACHASOV	01D	SND	$e^+e^- \to \phi \to \eta\gamma$
<30	90	0	DAVYDOV	81	GAM2	$\pi^- p \to \eta n$

[5] Normalized using $\Gamma(\eta \to 2\gamma)/\Gamma = 0.3943 \pm 0.0026$.

[6] 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 $\Gamma(\pi^0 2\gamma)/\Gamma(2\gamma)$.

$\Gamma(\pi^0 2\gamma)/\Gamma(2\gamma)$ Γ_4/Γ_2

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
1.1±0.4 OUR FIT Error includes scale factor of 2.0.						
1.8±0.4		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

$\Gamma(\pi^0 2\gamma)/\Gamma(3\pi^0)$ Γ_4/Γ_3

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
8.3±2.8±1.4	[7] KNECHT	04	CRYB	$\pi^- p \to n\eta$

[7] Independent analysis of same data as PRAKHOV 05.

$\Gamma(\pi^0\pi^0\gamma\gamma)/\Gamma_{total}$ Γ_5/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<1.2\times10^{-3}$	90	[8] NEFKENS	05A	CRYB	p(720 MeV/c) $\pi^- \to n\eta$

[8] Measurement is done in limited $\gamma-\gamma$ energy range.

$\Gamma(\text{invisible})/\Gamma(2\gamma)$ Γ_6/Γ_2

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<1.65\times10^{-3}$	90	[9] ABLIKIM	06Q	BES2	$J/\psi \to \phi\eta$

[9] Based on 58M J/ψ decays.

Charged modes

$\Gamma(\text{neutral modes})/\Gamma(\pi^+\pi^-\pi^0)$ $\Gamma_1/\Gamma_8=(\Gamma_2+\Gamma_3+\Gamma_4)/\Gamma_8$

VALUE	EVTS	DOCUMENT ID		TECN
3.17±0.07 OUR FIT Error includes scale factor of 1.3.				
3.26±0.30 OUR AVERAGE				
2.54±1.89	74	KENDALL	74	OSPK
3.4 ±1.1	29	AGUILAR-...	72B	HBC
2.83±0.80	70	[10] 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

[10] Error increased from published value 0.5 by Bloodworth (private communication).

$\Gamma(2\gamma)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_2/Γ_8

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
1.74±0.04 OUR FIT Error includes scale factor of 1.3.					
1.68±0.10 OUR AVERAGE					
1.61±0.14		ABLIKIM	06E	BES2	$e^+e^- \to J/\psi \to \eta\gamma$
1.78±0.10±0.13	1077	AMSLER	95	CBAR	$\overline{p}p \to \pi^+\pi^-\eta$ at rest
1.72±0.25	401	BAGLIN	69	HLBC	
1.61±0.39		FOSTER	65	HBC	

$\Gamma(3\pi^0)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_3/Γ_8

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
1.434±0.033 OUR FIT Error includes scale factor of 1.3.					
1.48 ±0.05 OUR AVERAGE					
1.46 ±0.03 ±0.09		ACHASOV	06A	SND	$e^+e^- \to \eta\gamma$
1.52 ±0.04 ±0.08	23k	[11] AKHMETSHIN	01B	CMD2	$e^+e^- \to \phi \to \eta\gamma$
1.44 ±0.09 ±0.10	1627	AMSLER	95	CBAR	$\overline{p}p \to \pi^+\pi^-\eta$ at rest
$1.50\ ^{+0.15}_{-0.29}$	199	BAGLIN	69	HLBC	
$1.47\ ^{+0.20}_{-0.17}$		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	FOELSCHE	64	HBC	
0.83 ±0.32	CRAWFORD	63	HBC	

[11] AKHMETSHIN 01B uses results from AKHMETSHIN 99F.

$\Gamma(\pi^+\pi^-\pi^0)/[\Gamma(2\gamma)+\Gamma(3\pi^0)]$ $\Gamma_8/(\Gamma_2+\Gamma_3)$

VALUE	DOCUMENT ID	TECN	COMMENT
0.315 ±0.007 OUR FIT Error includes scale factor of 1.2.			
0.304 ±0.012	ACHASOV	00D SND	$e^+e^- \to \phi \to \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.3141±0.0081±0.0058	ACHASOV	00B SND	See ACHASOV 00D

$\Gamma(\pi^+\pi^-\gamma)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_9/Γ_8

VALUE	EVTS	DOCUMENT ID	TECN
0.207±0.004 OUR FIT Error includes scale factor of 1.1.			
0.207±0.004 OUR AVERAGE Error includes scale factor of 1.1.			
0.209±0.004	18k	THALER	73 ASPK
0.201±0.006	7250	GORMLEY	70 ASPK
• • • We do not use the following data for averages, fits, limits, etc. • • •			
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

$\Gamma(e^+e^-\gamma)/\Gamma_{total}$ Γ_{10}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
6.0 ±0.8 OUR FIT Error includes scale factor of 1.4.				
6.3 ±1.0 OUR AVERAGE Error includes scale factor of 1.6.				
5.15±0.62±0.74	283	ACHASOV	01B SND	$e^+e^- \to \phi \to \eta\gamma$
7.10±0.64±0.46	323	AKHMETSHIN	01 CMD2	$e^+e^- \to \phi \to \eta\gamma$

$\Gamma(e^+e^-\gamma)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_{10}/Γ_8

VALUE (units 10^{-2})	EVTS	DOCUMENT ID	TECN	COMMENT
2.65±0.35 OUR FIT Error includes scale factor of 1.5.				
2.1 ±0.5	80	JANE	75B OSPK	See the erratum

$\Gamma(\text{neutral modes})/[\Gamma(\pi^+\pi^-\pi^0)+\Gamma(\pi^+\pi^-\gamma)+\Gamma(e^+e^-\gamma)]$ $\Gamma_1/(\Gamma_8+\Gamma_9+\Gamma_{10}) = (\Gamma_2+\Gamma_3+\Gamma_4)/(\Gamma_8+\Gamma_9+\Gamma_{10})$

VALUE	EVTS	DOCUMENT ID	TECN
2.57±0.06 OUR FIT Error includes scale factor of 1.3.			
2.64±0.23		BALTAY	67B DBC
• • • We do not use the following data for averages, fits, limits, etc. • • •			
4.5 ±1.0	280	[12] JAMES	66 HBC
3.20±1.26	53	[12] BASTIEN	62 HBC
2.5 ±1.0	10	[12] PICKUP	62 HBC

[12] These experiments are not used in the averages as they do not separate clearly $\eta \to \pi^+\pi^-\pi^0$ and $\eta \to \pi^+\pi^-\gamma$ from each other. The reported values thus probably contain some unknown fraction of $\eta \to \pi^+\pi^-\gamma$.

$\Gamma(2\gamma)/[\Gamma(\pi^+\pi^-\pi^0)+\Gamma(\pi^+\pi^-\gamma)+\Gamma(e^+e^-\gamma)]$ $\Gamma_2/(\Gamma_8+\Gamma_9+\Gamma_{10})$

VALUE	EVTS	DOCUMENT ID		TECN
1.409±0.030 OUR FIT Error includes scale factor of 1.3.				
1.1 ±0.4 OUR AVERAGE				
1.51 ±0.93	75	KENDALL	74	OSPK
0.99 ±0.48		CRAWFORD	63	HBC

$\Gamma(\mu^+\mu^-\gamma)/\Gamma_{total}$ Γ_{11}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
3.1±0.4 OUR FIT					
3.1±0.4	600	DZHELYADIN	80	SPEC	$\pi^- p \to \eta n$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.5±0.75	100	BUSHNIN	78	SPEC	See DZHELYADIN 80

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

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<0.77	90	BROWDER	97B	CLE2	$e^+e^- \simeq$ 10.5 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2	90	WHITE	96	SPEC	$pd \to \eta\,^3$He
<3	90	DAVIES	74	RVUE	Uses ESTEN 67

$\Gamma(\mu^+\mu^-)/\Gamma_{total}$ Γ_{13}/Γ

VALUE (units 10^{-6})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
5.8±0.8 OUR AVERAGE						
5.7±0.7±0.5		114	ABEGG	94	SPEC	$pd \to \eta\,^3$He
6.5±2.1		27	DZHELYADIN	80B	SPEC	$\pi^- p \to \eta n$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$5.6^{+0.6}_{-0.7}\pm0.5$		100	KESSLER	93	SPEC	See ABEGG 94
<20	95	0	WEHMANN	68	OSPK	

$\Gamma(\mu^+\mu^-)/\Gamma(2\gamma)$ Γ_{13}/Γ_2

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

$\Gamma(e^+e^-e^+e^-)/\Gamma_{total}$ Γ_{14}/Γ

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<6.9	90	AKHMETSHIN	01	CMD2	$e^+e^- \to \phi \to \eta\gamma$

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

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	CHG	COMMENT
4.2±1.2 OUR FIT						
4.1±1.1 OUR AVERAGE						
4.3±1.3±0.4	16	BARGHOLTZ	07	CNTR	0	$pd \to\ ^3$He η
$3.7^{+2.5}_{-1.8}\pm0.3$	4	AKHMETSHIN	01	CMD2		$e^+e^- \to \phi \to \eta\gamma$

$\Gamma(\pi^+\pi^- e^+ e^-)/\Gamma(\pi^+\pi^-\gamma)$ Γ_{15}/Γ_9

VALUE (units 10^{-2})	EVTS	DOCUMENT ID		TECN
0.90±0.25 OUR FIT				
2.6 ±2.6	1	GROSSMAN	66	HBC

$\Gamma(\pi^+\pi^- 2\gamma)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_{16}/Γ_8

VALUE	CL%	DOCUMENT ID		TECN
<0.009		PRICE	67	HBC
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.016	95	BALTAY	67B	DBC

$\Gamma(\pi^+\pi^-\pi^0\gamma)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_{17}/Γ_8

VALUE (units 10^{-2})	CL%	EVTS	DOCUMENT ID		TECN
<0.24	90	0	THALER	73	ASPK
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.7	90		ARNOLD	68	HLBC
<1.6	95		BALTAY	67B	DBC
<7.0			FLATTE	67	HBC
<0.9			PRICE	67	HBC

$\Gamma(\pi^0\mu^+\mu^-\gamma)/\Gamma_{\text{total}}$ Γ_{18}/Γ

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

Forbidden modes

$\Gamma(\pi^0\gamma)/\Gamma_{\text{total}}$ Γ_{19}/Γ

Forbidden by angular momentum conservation.

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

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

Forbidden by P and CP invariance.

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
< 0.13	90	16M	AMBROSINO	05A	KLOE	$e^+e^- \to \phi \to \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •						
< 3.3	90		AKHMETSHIN	99B	CMD2	$e^+e^- \to \phi \to \eta\gamma$
< 9	90		AKHMETSHIN	97C	CMD2	See AKHMETSHIN 99B
<15		0	THALER	73	ASPK	

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

Forbidden by P and CP invariance.

VALUE (units 10^{-4})	CL%	DOCUMENT ID		TECN	COMMENT
<4.3	90	AKHMETSHIN	99C	CMD2	$e^+e^- \to \phi \to \eta\gamma$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<6	90	[13] ACHASOV	98	SND	$e^+e^- \to \phi \to \eta\gamma$

[13] ACHASOV 98 observes one event in a $\pm 3\sigma$ region around the η mass, while a Monte Carlo calculation gives 10 ± 5 events. The limit here is the Poisson upper limit for one observed event and no background.

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

Forbidden by C invariance.

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
$<5\times10^{-4}$	90	NEFKENS	05	CRYB	0	p(720 MeV/c) $\pi^-\to n\eta$

$\Gamma(\pi^0\pi^0\pi^0\gamma)/\Gamma_{total}$ Γ_{23}/Γ

Forbidden by C invariance.

VALUE	CL%	DOCUMENT ID		TECN	CHG	COMMENT
$<6\times10^{-5}$	90	NEFKENS	05	CRYB	0	p(720 MeV/c) $\pi^-\to n\eta$

$\Gamma(3\gamma)/\Gamma_{total}$ Γ_{24}/Γ

Forbidden by C invariance.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4\times10^{-5}$	90	NEFKENS	05A	CRYB	p(720 MeV/c) $\pi^-\to n\eta$

$\Gamma(3\gamma)/\Gamma(2\gamma)$ Γ_{24}/Γ_2

VALUE (units 10^{-3})	CL%	DOCUMENT ID		TECN	CHG
<1.2	95	ALDE	84	GAM2	0

$\Gamma(3\gamma)/\Gamma(3\pi^0)$ Γ_{24}/Γ_3

VALUE (units 10^{-5})	CL%	DOCUMENT ID		TECN	COMMENT
<4.9	90	ALOISIO	04	KLOE	$\phi\to\eta\gamma$

$\Gamma(4\pi^0)/\Gamma_{total}$ Γ_{25}/Γ

Forbidden by P and CP invariance.

VALUE (units 10^{-7})	CL%	DOCUMENT ID		TECN	COMMENT
<6.9	90	PRAKHOV	00	CRYB	$\pi^- p\to n\eta$, 720 MeV/c

$\Gamma(\pi^0e^+e^-)/\Gamma_{total}$ Γ_{26}/Γ

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

VALUE (units 10^{-2})	CL%	EVTS	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.016	90	0	MARTYNOV	76	HLBC
<0.084	90		BAZIN	68	DBC
<0.7			RITTENBERG	65	HBC

$\Gamma(\pi^0e^+e^-)/\Gamma(\pi^+\pi^-\pi^0)$ Γ_{26}/Γ_8

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

VALUE (units 10^{-4})	CL%	EVTS	DOCUMENT ID		TECN
< 1.9	90		JANE	75	OSPK
• • • We do not use the following data for averages, fits, limits, etc. • • •					
< 42	90		BAGLIN	67	HLBC
< 16	90	0	BILLING	67	HLBC
< 77		0	FOSTER	65B	HBC
<110			PRICE	65	HBC

$\Gamma(\pi^0\mu^+\mu^-)/\Gamma_{total}$ Γ_{27}/Γ

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

VALUE (units 10^{-4})	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<0.05	90	DZHELYADIN	81	SPEC	$\pi^- p \rightarrow \eta n$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<5		WEHMANN	68	OSPK	

$[\Gamma(\mu^+ e^-) + \Gamma(\mu^- e^+)]/\Gamma_{total}$ Γ_{28}/Γ

Forbidden by lepton family number conservation.

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

η *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*
0.09±0.17 OUR AVERAGE				
0.28±0.26	165k	JANE	74	OSPK
−0.05±0.22	220k	LAYTER	72	ASPK
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.5 ±0.5	37k	[14] GORMLEY	68C	ASPK

[14] 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*
0.18±0.16 OUR AVERAGE				
0.20±0.25	165k	JANE	74	OSPK
0.10±0.22	220k	LAYTER	72	ASPK
0.5 ±0.5	37k	GORMLEY	68C	WIRE

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

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*
−0.17±0.17 OUR AVERAGE				
−0.30±0.25	165k	JANE	74	OSPK
−0.07±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.

VALUE (units 10^{-2})	*EVTS*	*DOCUMENT ID*		*TECN*
0.9 ±0.4 OUR AVERAGE				
1.2 ±0.6	35k	JANE	74B	OSPK
0.5 ±0.6	36k	THALER	72	ASPK
1.22±1.56	7257	GORMLEY	70	ASPK

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

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

VALUE	EVTS	DOCUMENT ID		TECN
−0.02 ±0.07 OUR AVERAGE		Error includes scale factor of 1.3.		
0.11 ±0.11	35k	JANE	74B	OSPK
−0.060±0.065	7250	GORMLEY	70	WIRE
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.12 ±0.06		[15] THALER	72	ASPK

[15] The authors don't believe this indicates *D*-wave because the dependence of β on the γ energy is inconsistent with the theoretical prediction. A $\cos^2\theta$ dependence can also come from *P*- and *F*-wave interference.

ENERGY DEPENDENCE OF $\eta \to 3\pi$ DALITZ PLOTS

PARAMETERS FOR $\eta \to \pi^+\pi^-\pi^0$

See the "Note on η Decay Parameters" in our 1994 edition, Phys. Rev. **D50**, 1 August 1994, Part I, p. 1454. The following experiments fit to one or more of the coefficients *a*, *b*, *c*, *d*, or *e* for $|\text{matrix element}|^2 = 1 + ay + by^2 + cx + dx^2 + exy$.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
	3230	[16] ABELE	98D	CBAR	$\overline{p}p \to \pi^0\pi^0\eta$ at rest
	1077	[17] AMSLER	95	CBAR	$\overline{p}p \to \pi^+\pi^-\eta$ 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	

[16] ABELE 98D obtains $a = -1.22 \pm 0.07$ and $b = 0.22 \pm 0.11$ when *c* (our *d*) is fixed at 0.06.

[17] AMSLER 95 fits to $(1+ay+by^2)$ and obtains $a=-0.94 \pm 0.15$ and $b=0.11 \pm 0.27$.

α PARAMETER FOR $\eta \to 3\pi^0$

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.031±0.004 OUR AVERAGE		Error includes scale factor of 1.1.			
−0.010±0.021±0.010	12k	ACHASOV	01C	SND	$e^+e^- \to \phi \to \eta\gamma$
−0.031±0.004	1M	TIPPENS	01	CRYB	$\pi^- p \to n\eta$, 720 MeV/c
−0.052±0.017±0.010	98k	ABELE	98C	CBAR	$\overline{p}p \to 5\pi^0$
−0.022±0.023	50k	ALDE	84	GAM2	
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.32 ±0.37	192	BAGLIN	70	HLBC	

η REFERENCES

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AKHMETSHIN	05	PL B605 26	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
AMBROSINO	05A	PL B606 276	F. Ambrosino *et al.*	(KLOE Collab.)
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ACHASOV	01D	NP B600 3	M.N. Achasov *et al.*	(Novosibirsk SND Collab.)
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AKHMETSHIN	01B	PL B509 217	R.R. Akhmetshin *et al.*	(Novosibirsk CMD-2 Collab.)
TIPPENS	01	PRL 87 192001	W.B. Tippens *et al.*	(BNL Crystal Ball Collab.)
ACHASOV	00	EPJ C12 25	M.N. Achasov *et al.*	(Novosibirsk SND Collab.)
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ABELE	98C	PL B417 193	A. Abele *et al.*	(Crystal Barrel Collab.)
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ABEGG	96	PR D53 11	R. Abegg *et al.*	(Saturne SPES2 Collab.)
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ROE	90	PR D41 17	N.A. Roe *et al.*	(ASP Collab.)
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