$\eta(1440)$

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

See also the mini-review under non-$q\overline{q}$ candidates. (See the index for the page number.)

THE $\eta(1440)$, $f_1(1420)$, AND $f_1(1510)$

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The first observation of $\eta(1440)$ was made in $p\overline{p}$ annihilation at rest into $\eta(1440)\pi^+\pi^-$, $\eta(1440) \rightarrow K\overline{K}\pi$ (BAILLON 67). This state was reported to decay through $a_0(980)\pi$ and $K^*(892)\overline{K}$ with roughly equal contributions. The $\eta(1440)$ has also been observed in radiative $J/\psi(1S)$ decay to $K\overline{K}\pi$ (SCHARRE 80, EDWARDS 82E, AUGUSTIN 90).

The $f_1(1420)$, decaying to $K^*\overline{K}$ was reported in π^-p reactions at 4 GeV/c (DIONISI 80). However, later analyses found that the 1400–1500 MeV region is far more complex. In π^-p experiments (CHUNG 85, REEVES 86, BIRMAN 88) reported 0^{-+} with a dominant $a_0(980)\pi$ contribution to $K\overline{K}\pi$. The π^-p data of RATH 89 at 21 GeV/c suggest the presence of two pseudoscalars decaying to $K\overline{K}\pi$, one around 1410 MeV decaying through $a_0(980)\pi$ and the other around 1470 MeV, decaying to $K^*\overline{K}$. A reanalysis of the MARK III data in radiative $J/\psi(1S)$ decay to $K\overline{K}\pi$ (BAI 90C) also claims the existence of two pseudoscalars in the 1400–1500 MeV range, the lower mass state decaying through $a_0(980)\pi$ and the higher mass state decaying via $K^*\overline{K}$. In addition, $f_1(1420)$ is observed to decay into $K^*\overline{K}$.

In $\pi^-p \rightarrow \eta\pi\pi n$ charge-exchange reactions at 8–9 GeV/c the $\eta\pi\pi$ mass spectrum is dominated by $\eta(1440)$ and $\eta(1295)$ (ANDO 86, FUKUI 91C) and at 100 GeV ALDE 97B report $\eta(1295)$ and $\eta(1440)$ decaying to $\eta\pi^0\pi^0$ with a weak $f_1(1285)$ and no evidence for $f_1(1420)$.

An experiment in $\overline{p}p$ annihilation at rest into $K\overline{K}3\pi$ (BERTIN 95) reports two pseudoscalars with decay properties similar to BAI 90C, although the lower state shows, apart from $a_0(980)\pi$, a large contribution from the direct decay $\eta(1440) \to K\overline{K}\pi$. We note that the data from AUGUSTIN 92 also suggest two states but their intermediate states, $a_0(980)\pi$ and $K^*\overline{K}$, are reversed relative to BAI 90C.

In $J/\psi(1S)$ radiative decay $\eta(1440)$ decays to $K\overline{K}\pi$ through $a_0(980)\pi$ and hence a signal is also expected in the $\eta\pi\pi$ mass spectrum. This has indeed been observed by MARK III in $\eta\pi^+\pi^-$ (BOLTON 92B) which report a mass of 1400 MeV, in line with the existence of a low mass pseudoscalar in the $\eta(1440)$ structure, decaying to $a_0(980)\pi$. This state is also observed in $\overline{p}p$ annihilation at rest into $\eta\pi^+\pi^-\pi^0\pi^0$ where it decays to $\eta\pi\pi$ (AMSLER 95F). The intermediate $a_0(980)\pi$ accounts for roughly half of the $\eta\pi\pi$ rate, in accord with MARK III (BOLTON 92B) and DM2 (AUGUSTIN 90). However, ALDE 97B reports only a very small contribution of $a_0(980)\pi$.

One of these two pseudoscalars could be the first radial excitation of the η', with $\eta(1295)$ the first radial of the η. Ideal mixing suggested by the $\eta(1295)$ and $\pi(1300)$ mass degeneracy would then imply that the second isoscalar in the nonet is mainly $s\overline{s}$ and hence couples to $K^*\overline{K}$, in accord with observations for the upper $\eta(1440)$ state. This scheme then favors an exotic interpretation of the lower state, perhaps gluonium mixed with $q\overline{q}$ (CLOSE 97B) or a bound state of gluinos (FARRAR 96). The gluonium interpretation is, however, not favoured by lattice gauge theories, which predict the 0^{-+} state above 2 GeV (BALI 93).

Axial (1^{++}) mesons are not observed in $\overline{p}p$ annihilation at rest in liquid hydrogen which proceeds dominantly through

S-wave annihilation. However, in gaseous hydrogen P-wave annihilation is enhanced and, indeed, BERTIN 97 report $f_1(1420)$ decaying to $K^*\overline{K}$ in gaseous hydrogen, while confirming their earlier evidence for two pseudoscalars (BERTIN 95).

In $\gamma\gamma$ fusion from e^+e^- annihilations, a signal around 1420 MeV is seen in single-tag events (GIDAL 87B, AIHARA 88B, BEHREND 89, HILL 89) where one of the two photons is off-shell. However, it is totally absent in the untagged events where both photons are real. This points to a spin 1 object which is not produced by two real (massless) photons (Yang-Landau theorem). The 2γ decays also implies $C = +1$. For the parity, AIHARA 88C and BEHREND 89 both find angular distributions with positive parity preferred, but negative parity cannot be excluded.

The $f_1(1420)$ is definitively observed in $K\overline{K}\pi$ in pp central production at 300 and 450 GeV, together with $f_1(1285)$. The latter decays via $a_0(980)\pi$ and the former only via $K^*\overline{K}$, while $\eta(1440)$ is absent (ARMSTRONG 89, BARBERIS 97C). The $K_SK_S\pi^0$ decay mode of $f_1(1420)$ establishes unambiguously that C=+1. On the other hand, there is no evidence for any state decaying to $\eta\pi\pi$ around 1400 MeV and hence the $\eta\pi\pi$ mode of $f_1(1420)$ is suppressed (ARMSTRONG 91B).

We now turn to the experimental evidence for $f_1(1510)$. Two states, $f_1(1420)$ and $f_1(1510)$, decaying to $K^*\overline{K}$, compete for the $s\overline{s}$ assignment in the 1^{++} nonet. The $f_1(1510)$ was seen in $K^-p \rightarrow \Lambda K\overline{K}\pi$ at 4 GeV/c (GAVILLET 82) and at 11 GeV/c (ASTON 88C). Evidence is also reported in π^-p at 8 GeV/c, based on the phase motion of the 1^{++} $K^*\overline{K}$ wave (BIRMAN 88).

The absence of $f_1(1420)$ in K^-p (ASTON 88C) argues against $f_1(1420)$ being the $s\overline{s}$ member of the 1^{++} nonet. However, $f_1(1420)$ has been reported in K^-p but not in

$\pi^- p$ (BITYUKOV 84) while two experiments do not observe $f_1(1510)$ in $K^- p$ (BITYUKOV 84, KING 91). It is also not seen in radiative $J/\psi(1S)$ decay (BAI 90C, AUGUSTIN 92), central collisions (BARBERIS 97C), nor in $\gamma\gamma$ collisions (AIHARA 88C), although and surprisingly for an $s\overline{s}$ state, a signal is reported in 4π decays (BAUER 93B). These facts led to the conclusion that $f_1(1510)$ is not well established and that its assignment as $s\overline{s}$ member of the 1^{++} nonet is premature (CLOSE 97D). The Particle Data Group agrees and has removed this state from the Summary Table. Assigning instead $f_1(1420)$ to the 1^{++} nonet one finds a nonet mixing angle of $\sim 50°$ (CLOSE 97D). This is derived from the mass formula and from $f_1(1285)$ radiative decays to $\phi\gamma$ (BITYUKOV 88) and $\rho\gamma$ (AMELIN 95).

Arguments favoring $f_1(1420)$ being a hybrid $q\overline{q}g$ meson or a four-quark state are put forward by ISHIDA 89 and by CALDWELL 90, respectively, while LONGACRE 90 argues that this particle is a molecular state formed by the π orbiting in a P-wave around an S-wave $K\overline{K}$ state.

Summarizing, there is strong evidence for $f_1(1420)$, mostly produced in central collisions and decaying to $K^*\overline{K}$, and for $\eta(1440)$ mostly produced in radiative $J/\psi(1S)$ decay and $\overline{p}p$ annihilation at rest, decaying to $K^*\overline{K}$ and $a_0(980)\pi$. Confusion remains as to which states are observed in $\pi^- p$ interactions. The $f_1(1510)$ is not well established. Furthermore, there are experimental indications for the presence of two pseudoscalars in the $\eta(1440)$ structure. Accordingly, the Particle Data Group has split the $K\overline{K}\pi$ entry for $\eta(1440)$ into $a_0(980)\pi$ and $K^*\overline{K}$.

$\eta(1440)$ MASS

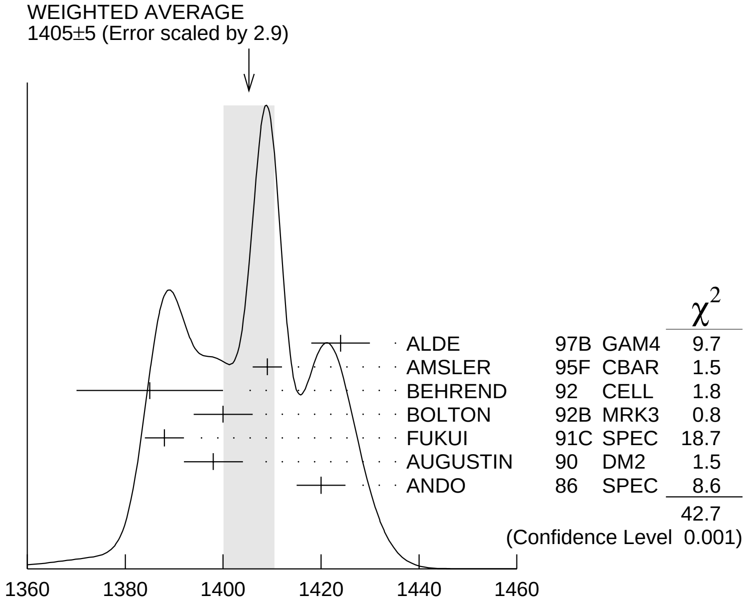
VALUE (MeV)	*DOCUMENT ID*
1400 - 1470 OUR ESTIMATE	Contains possibly two overlapping pseudoscalars.

$\eta\pi\pi$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1405± 5 OUR AVERAGE	Error includes scale factor of 2.9. See the ideogram below.				
1424± 6	2200	ALDE	97B	GAM4	$100\ \pi^- p \to \eta\pi^0\pi^0 n$
1409± 3		AMSLER	95F	CBAR	$0\ \overline{p}p \to \pi^+\pi^-\pi^0\pi^0\eta$
1385±15		[1] BEHREND	92	CELL	$J/\psi \to \gamma\eta\pi^+\pi^-$
1400± 6		[1] BOLTON	92B	MRK3	$J/\psi \to \gamma\eta\pi^+\pi^-$
1388± 4		FUKUI	91C	SPEC	$8.95\ \pi^- p \to \eta\pi^+\pi^- n$
1398± 6	261	[2] AUGUSTIN	90	DM2	$J/\psi \to \gamma\eta\pi^+\pi^-$
1420± 5		ANDO	86	SPEC	$8\ \pi^- p \to \eta\pi^+\pi^- n$

[1] From fit to the $a_0(980)\pi\ 0^{-+}$ partial wave.

[2] Best fit with a single Breit Wigner.



$\eta(1440)$ mass, $\eta\pi\pi$ mode (MeV)

$\pi\pi\gamma$ MODE

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1401±18	[3,4] AUGUSTIN	90	DM2	$J/\psi \to \pi^+\pi^-\gamma\gamma$
1440±20	[4] COFFMAN	90	MRK3	$J/\psi \to \pi^+\pi^- 2\gamma$

[3] Best fit with a single Breit Wigner.

[4] This peak in the $\gamma\rho$ channel may not be related to the $\eta(1440)$.

4π MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1420 ± 20		BUGG 95	MRK3	$J/\psi \to \gamma \pi^+ \pi^- \pi^+ \pi^-$
1489 ± 12	3270	[5] BISELLO 89B	DM2	$J/\psi \to 4\pi\gamma$

[5] Estimated by us from various fits.

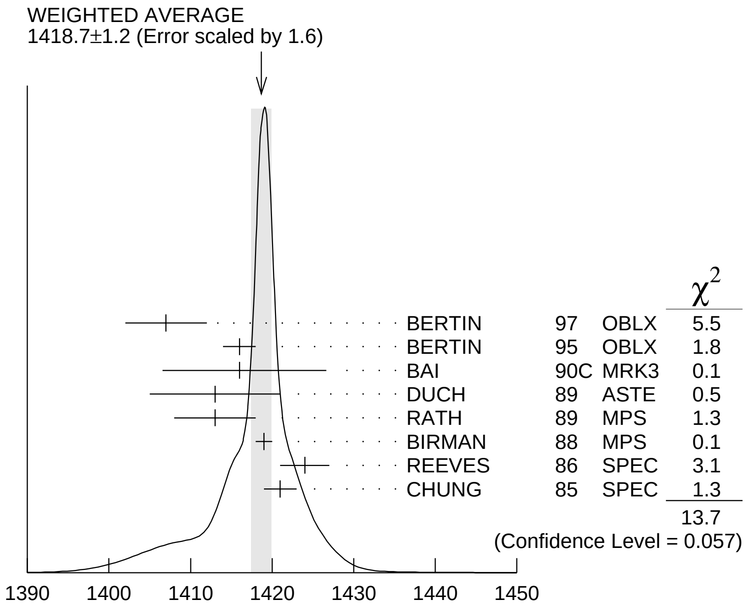
$K\overline{K}\pi$ MODE ($a_0(980)\,\pi$ dominant)

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
1418.7±1.2 OUR AVERAGE	Error includes scale factor of 1.6. See the ideogram below.			
1407 ± 5		[6] BERTIN 97	OBLX	$0\ \overline{p}p \to K^{\pm}(K^0)\pi^{\mp}\pi^+\pi^-$
1416 ± 2		[6] BERTIN 95	OBLX	$0\ \overline{p}p \to K\overline{K}\pi\pi\pi$
$1416 \pm 8\ {}^{+7}_{-5}$	700	[7] BAI 90C	MRK3	$J/\psi \to \gamma K^0_S K^{\pm}\pi^{\mp}$
1413 ± 8	500	DUCH 89	ASTE	$\overline{p}p \to \pi^+\pi^- K^{\pm}\pi^{\mp}K^0$
1413 ± 5		[7] RATH 89	MPS	$21.4\ \pi^- p \to n K^0_S K^0_S \pi^0$
1419 ± 1	8800	BIRMAN 88	MPS	$8\ \pi^- p \to K^+\overline{K}^0\pi^- n$
1424 ± 3	620	REEVES 86	SPEC	$6.6\ p\overline{p} \to K\overline{K}\pi X$
1421 ± 2		CHUNG 85	SPEC	$8\ \pi^- p \to K\overline{K}\pi n$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1459 ± 5		[8] AUGUSTIN 92	DM2	$J/\psi \to \gamma K\overline{K}\pi$

[6] Decaying into $(K\overline{K})_S\pi$, $(K\pi)_S\overline{K}$, and $a_0(980)\pi$.

[7] From fit to the $a_0(980)\pi\ 0^{-+}$ partial wave. Cannot rule out a $a_0(980)\pi\ 1^{++}$ partial wave.

[8] Excluded from averaging because averaging would be meaningless.



$\eta(1440)$ mass, $K\overline{K}\pi$ mode ($a_0(980)\,\pi$ dominant) (MeV)

$K\overline{K}\pi$ MODE ($K^*(892)$ K dominant)

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1473± 4 OUR AVERAGE Error includes scale factor of 1.1.					
1464 ± 10		BERTIN	97	OBLX	$0\ \overline{p}p \rightarrow K^{\pm}(K^0)\pi^{\mp}\pi^+\pi^-$
1460 ± 10		BERTIN	95	OBLX	$0\ \overline{p}p \rightarrow K\overline{K}\pi\pi\pi$
$1490^{+14}_{-\ 8}{}^{+\ 3}_{-16}$	1100	BAI	90C	MRK3	$J/\psi \rightarrow \gamma K^0_S K^{\pm}\pi^{\mp}$
$1475\pm\ 4$		RATH	89	MPS	$21.4\ \pi^- p \rightarrow n K^0_S K^0_S \pi^0$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1421 ± 14		[9] AUGUSTIN	92	DM2	$J/\psi \rightarrow \gamma K\overline{K}\pi$

[9] Excluded from averaging because averaging would be meaningless.

$K\overline{K}\pi$ MODE (unresolved)

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$1445\pm\ 8$	693	AUGUSTIN	90	DM2	$J/\psi \rightarrow \gamma K^0_S K^{\pm}\pi^{\mp}$
$1433\pm\ 8$	296	AUGUSTIN	90	DM2	$J/\psi \rightarrow \gamma K^+ K^- \pi^0$
$1453\pm\ 7$	170	RATH	89	MPS	$21.4\ \pi^- p \rightarrow K^0_S K^0_S \pi^0 n$
1440^{+20}_{-15}	174	EDWARDS	82E	CBAL	$J/\psi \rightarrow \gamma K^+ K^- \pi^0$
1440^{+10}_{-15}		SCHARRE	80	MRK2	$J/\psi \rightarrow \gamma K^0_S K^{\pm}\pi^{\mp}$
$1425\pm\ 7$	800	[10] BAILLON	67	HBC	$0\ \overline{p}p \rightarrow K\overline{K}\pi\pi\pi$

[10] From best fit of 0^{-+} partial wave , 50% $K^*(892)K$, 50% $a_0(980)\pi$.

η(1440) WIDTH

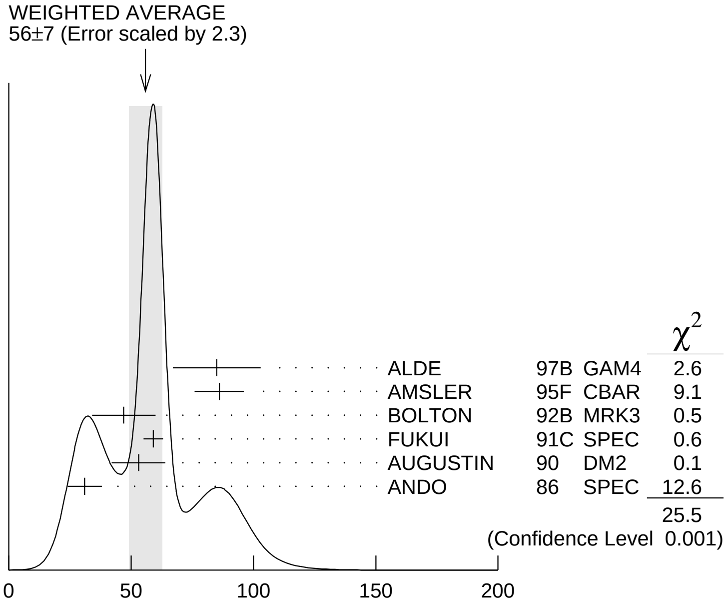
VALUE (MeV)	*DOCUMENT ID*
50 - 80 OUR ESTIMATE	Contains possibly two overlapping pseudoscalars.

$\eta\pi\pi$ MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
56± 7 OUR AVERAGE		Error includes scale factor of 2.3. See the ideogram below.		
85±18	2200	ALDE 97B	GAM4	100 $\pi^- p \rightarrow \eta\pi^0\pi^0 n$
86±10		AMSLER 95F	CBAR	0 $\overline{p}p \rightarrow \pi^+\pi^-\pi^0\pi^0\eta$
47±13		[11] BOLTON 92B	MRK3	$J/\psi \rightarrow \gamma\eta\pi^+\pi^-$
59± 4		FUKUI 91C	SPEC	8.95 $\pi^- p \rightarrow \eta\pi^+\pi^- n$
53±11		[12] AUGUSTIN 90	DM2	$J/\psi \rightarrow \gamma\eta\pi^+\pi^-$
31± 7		ANDO 86	SPEC	8 $\pi^- p \rightarrow \eta\pi^+\pi^- n$
• • • We do not use the following data for averages, fits, limits, etc. • • •				
~ 50		[12] BEHREND 92	CELL	$J/\psi \rightarrow \gamma\eta\pi^+\pi^-$

[11] From fit to the $a_0(980)\pi$ 0^{-+} partial wave.

[12] From $\eta\pi^+\pi^-$ mass distribution - mainly $a_0(980)\pi$ - no spin–parity determination available.



η(1440) width $\eta\pi\pi$ mode (MeV)

$\pi\pi\gamma$ MODE

VALUE (MeV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
174±44	AUGUSTIN	90	DM2	$J/\psi \rightarrow \pi^+\pi^-\gamma\gamma$
60±30	[13] COFFMAN	90	MRK3	$J/\psi \rightarrow \pi^+\pi^- 2\gamma$

[13] This peak in the $\gamma\rho$ channel may not be related to the $\eta(1440)$.

4π MODE

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
160±30		BUGG	95	MRK3	$J/\psi \rightarrow \gamma\pi^+\pi^-\pi^+\pi^-$
144±13	3270	[14] BISELLO	89B	DM2	$J/\psi \rightarrow 4\pi\gamma$

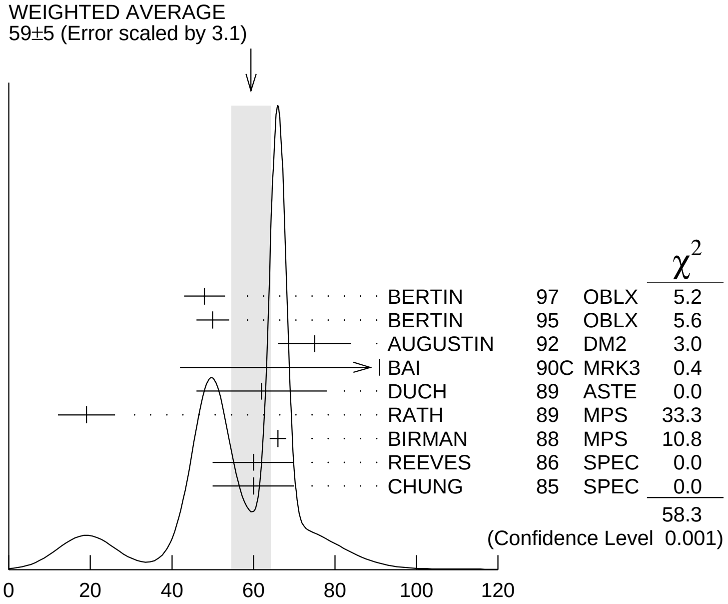
[14] Estimated by us from various fits.

$K\overline{K}\pi$ MODE ($a_0(980)\,\pi$ dominant)

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
59± 5 OUR AVERAGE	Error includes scale factor of 3.1. See the ideogram below.				
48± 5		[15] BERTIN	97	OBLX	$0.0\ \overline{p}p \rightarrow K^\pm(K^0)\pi^\mp\pi^+\pi^-$
50± 4		[15] BERTIN	95	OBLX	$0\ \overline{p}p \rightarrow K\overline{K}\pi\pi\pi$
75± 9		AUGUSTIN	92	DM2	$J/\psi \rightarrow \gamma K\overline{K}\pi$
$91^{+67}_{-31}{}^{+15}_{-38}$		[16] BAI	90C	MRK3	$J/\psi \rightarrow \gamma K^0_S K^\pm\pi^\mp$
62±16	500	DUCH	89	ASTE	$\overline{p}p \rightarrow K\overline{K}\pi\pi\pi$
19± 7		[16] RATH	89	MPS	$21.4\ \pi^- p \rightarrow n K^0_S K^0_S \pi^0$
66± 2	8800	BIRMAN	88	MPS	$8\ \pi^- p \rightarrow K^+\overline{K}^0\pi^- n$
60±10	620	REEVES	86	SPEC	$6.6\ p\overline{p} \rightarrow K K\pi X$
60±10		CHUNG	85	SPEC	$8\ \pi^- p \rightarrow K\overline{K}\pi n$

[15] Decaying into $(K\overline{K})_S\pi$, $(K\pi)_S\overline{K}$, and $a_0(980)\pi$.

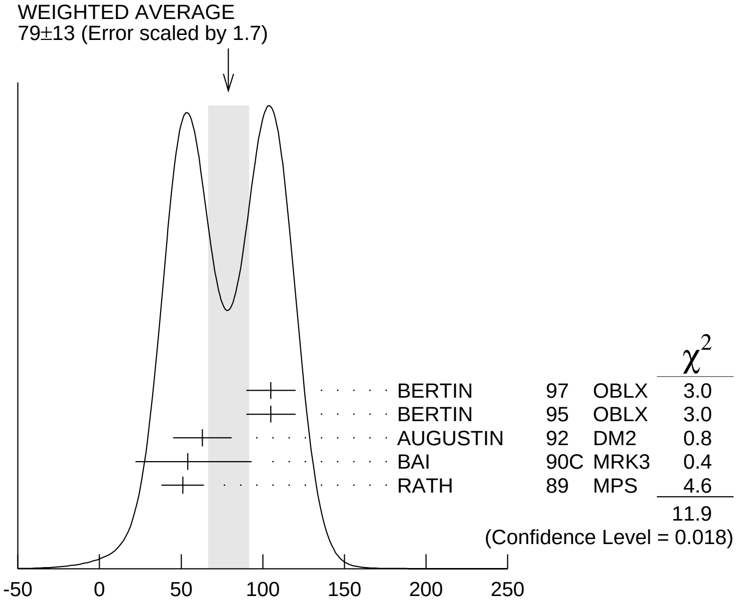
[16] From fit to the $a_0(980)\pi\ 0^{-+}$ partial wave , but $a_0(980)\pi\ 1^{++}$ cannot be excluded.



$\eta(1440)$ width $K\overline{K}\pi$ mode ($a_0(980)\ \pi$ dominant)

$K\overline{K}\pi$ MODE ($K^*(892)$ K dominant)

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
79±13 OUR AVERAGE	Error includes scale factor of 1.7. See the ideogram below.			
105 ± 15	BERTIN	97	OBLX	0.0 $\overline{p}p \to K^{\pm}(K^0)\pi^{\mp}\pi^+\pi^-$
105 ± 15	BERTIN	95	OBLX	0 $\overline{p}p \to K\overline{K}\pi\pi\pi$
63 ± 18	AUGUSTIN	92	DM2	$J/\psi \to \gamma K\overline{K}\pi$
$54^{+37}_{-21}{}^{+13}_{-24}$	BAI	90C	MRK3	$J/\psi \to \gamma K^0_S K^{\pm}\pi^{\mp}$
51 ± 13	RATH	89	MPS	21.4 $\pi^- p \to n K^0_S K^0_S \pi^0$



$\eta(1440)$ width $K\overline{K}\pi$ mode ($K^*(892)$ K dominant)

$K\overline{K}\pi$ MODE (unresolved)

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
93 ± 14	296	AUGUSTIN 90	DM2	$J/\psi \rightarrow \gamma K^+ K^- \pi^0$
105 ± 10	693	AUGUSTIN 90	DM2	$J/\psi \rightarrow \gamma K^0_S K^\pm \pi^\mp$
100 ± 11	170	RATH 89	MPS	21.4 $\pi^- p \rightarrow K^0_S K^0_S \pi^0 n$
55^{+20}_{-30}	174	EDWARDS 82E	CBAL	$J/\psi \rightarrow \gamma K^+ K^- \pi^0$
50^{+30}_{-20}		SCHARRE 80	MRK2	$J/\psi \rightarrow \gamma K^0_S K^\pm \pi^\mp$
80 ± 10	800	[17] BAILLON 67	HBC	0.0 $\overline{p}p \rightarrow K\overline{K}\pi\pi\pi$

[17] From best fit to 0^{-+} partial wave , 50% $K^*(892)K$, 50% $a_0(980)\pi$.

$\eta(1440)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)
Γ_1	$K\overline{K}\pi$	seen
Γ_2	$K\overline{K}^*(892)+$ c.c.	seen
Γ_3	$\eta\pi\pi$	seen
Γ_4	$a_0(980)\pi$	seen
Γ_5	$\eta(\pi\pi)_{S\text{-wave}}$	seen
Γ_6	4π	seen
Γ_7	$\gamma\gamma$	
Γ_8	$\rho^0\gamma$	

$\eta(1440)$ $\Gamma(i)\Gamma(\gamma\gamma)/\Gamma(\text{total})$

$\Gamma(K\overline{K}\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_1\Gamma_7/\Gamma$

VALUE (keV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<1.2	95	BEHREND	89	CELL	$\gamma\gamma \to K^0_S K^\pm\pi^\mp$
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.6	95	AIHARA	86D	TPC	$e^+e^- \to e^+e^- K^0_S K^\pm\pi^\mp$
<2.2	95	ALTHOFF	85B	TASS	$e^+e^- \to e^+e^- K\overline{K}\pi$
<8.0	95	JENNI	83	MRK2	$e^+e^- \to e^+e^- K\overline{K}\pi$

$\Gamma(\eta\pi\pi) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_3\Gamma_7/\Gamma$

VALUE (keV)	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<0.3	ANTREASYAN	87	CBAL	$e^+e^- \to e^+e^-\eta\pi\pi$

$\Gamma(\rho^0\gamma) \times \Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ $\Gamma_8\Gamma_7/\Gamma$

VALUE (keV)	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.5	95	ALTHOFF	84E	TASS	$e^+e^- \to e^+e^-\pi^+\pi^-\gamma$

$\eta(1440)$ BRANCHING RATIOS

$\Gamma(\eta\pi\pi)/\Gamma(K\overline{K}\pi)$ Γ_3/Γ_1

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.5	90	EDWARDS	83B	CBAL	$J/\psi \to \eta\pi\pi\gamma$
<1.1	90	SCHARRE	80	MRK2	$J/\psi \to \eta\pi\pi\gamma$
<1.5	95	FOSTER	68B	HBC	0.0 $\overline{p}p$

$\Gamma(a_0(980)\pi)/\Gamma(K\overline{K}\pi)$ Γ_4/Γ_1

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$\sim$ 0.15		[18] BERTIN	95	OBLX	$0\ \overline{p}p \to K\overline{K}\pi\pi\pi$
$\sim$ 0.8	500	[18] DUCH	89	ASTE	$\overline{p}p \to \pi^+\pi^-K^\pm\pi^\mp K^0$
$\sim$ 0.75		[18] REEVES	86	SPEC	$6.6\ p\overline{p} \to KK\pi X$

[18] Assuming that the $a_0(980)$ decays only into $K\overline{K}$.

$\Gamma(a_0(980)\pi)/\Gamma(\eta\pi\pi)$ Γ_4/Γ_3

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.19±0.04	2200	[19] ALDE	97B	GAM4	$100\ \pi^- p \to \eta\pi^0\pi^0 n$
0.56±0.04±0.03		[19] AMSLER	95F	CBAR	$0\ \overline{p}p \to \pi^+\pi^-\pi^0\pi^0\eta$

[19] Assuming that the $a_0(980)$ decays only into $\eta\pi$.

$\Gamma(K\overline{K}^*(892)+\text{c.c.})/\Gamma(K\overline{K}\pi)$ Γ_2/Γ_1

VALUE	DOCUMENT ID		TECN	COMMENT
0.50±0.10	BAILLON	67	HBC	$0.0\ \overline{p}p \to K\overline{K}\pi\pi\pi$

$\Gamma(K\overline{K}^*(892)+\text{c.c.})/\left[\Gamma(K\overline{K}^*(892)+\text{c.c.})+\Gamma(a_0(980)\pi)\right]$ $\Gamma_2/(\Gamma_2+\Gamma_4)$

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<0.25	90	EDWARDS	82E	CBAL	$J/\psi \to K^+K^-\pi^0\gamma$

$\Gamma(\rho^0\gamma)/\Gamma(K\overline{K}\pi)$ Γ_8/Γ_1

VALUE	DOCUMENT ID		TECN	COMMENT
0.0152±0.0038	[20] COFFMAN	90	MRK3	$J/\psi \to \gamma\gamma\pi^+\pi^-$

[20] Using $B(J/\psi \to \gamma\eta(1440) \to \gamma K\overline{K}\pi)=4.2 \times 10^{-3}$ and $B(J/\psi \to \gamma\eta(1440) \to \gamma\gamma\rho^0)=6.4\times 10^{-5}$ and assuming that the $\gamma\rho^0$ signal does not come from the $f_1(1420)$.

$\Gamma(\eta(\pi\pi)_{S\text{-wave}})/\Gamma(\eta\pi\pi)$ Γ_5/Γ_3

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.81±0.04	2200	ALDE	97B	GAM4	$100\ \pi^- p \to \eta\pi^0\pi^0 n$

$\eta(1440)$ REFERENCES

ALDE	97B	PAN 60 386 Translated from YAF 60 458.	D. Alde, Binon, Bricman+	(GAMS Collab.)	
BERTIN	97	PL B400 226	+Bruschi, Capponi+	(OBELIX Collab.)	
AMSLER	95F	PL B358 389	+Armstrong, Urner+	(Crystal Barrel Collab.)	
BERTIN	95	PL B361 187	+Bruschi+	(OBELIX Collab.)	
BUGG	95	PL B353 378	+Scott, Zoli+	(LOQM, PNPI, WASH)	
AUGUSTIN	92	PR D46 1951	+Cosme	(DM2 Collab.)	
BEHREND	92	ZPHY C56 381		(CELLO Collab.)	
BOLTON	92B	PRL 69 1328	+Brown, Bunnell+	(Mark III Collab.)	
FUKUI	91C	PL B267 293	+	(SUGI, NAGO, KEK, KYOT, MIYA, AKIT)	
AUGUSTIN	90	PR D42 10	+Cosme+	(DM2 Collab.)	
BAI	90C	PRL 65 2507	+Blaylock+	(Mark III Collab.)	
COFFMAN	90	PR D41 1410	+De Jongh+	(Mark III Collab.)	
BEHREND	89	ZPHY C42 367	+Criegee+	(CELLO Collab.)	
BISELLO	89B	PR D39 701	Busetto+	(DM2 Collab.)	
DUCH	89	ZPHY 45 223	+Heel, Bailey+	(ASTERIX Collab.)	JP
RATH	89	PR D40 693	+Cason+	(NDAM, BRAN, BNL, CUNY, DUKE)	
BIRMAN	88	PRL 61 1557	+Chung, Peaslee+	(BNL, FSU, IND, MASD)	JP
ANTREASYAN	87	PR D36 2633	+Bartels, Besset+	(Crystal Ball Collab.)	
AIHARA	86D	PRL 57 51	+Alston-Garnjost+	(TPC-2γ Collab.)	
ANDO	86	PRL 57 1296	+Imai+	(KEK, KYOT, NIRS, SAGA, INUS, TSUK+)	IJP
REEVES	86	PR 34 1960	+Chung, Crittenden+	(FLOR, BNL, IND, MASD)	JP
ALTHOFF	85B	ZPHY C29 189	+Braunschweig, Kirschfink+	(TASSO Collab.)	
CHUNG	85	PRL 55 779	+Fernow, Boehnlein+	(BNL, FLOR, IND, MASD)	JP
ALTHOFF	84E	PL 147B 487	+Braunschweig, Kirschfink, Luebelsmeyer+	(TASSO Collab.)	
EDWARDS	83B	PRL 51 859	+Partridge, Peck+	(CIT, HARV, PRIN, STAN, SLAC)	
JENNI	83	PR D27 1031	+Burke, Telnov, Abrams, Blocker+	(SLAC, LBL)	
EDWARDS	82E	PRL 49 259	+Partridge, Peck+	(CIT, HARV, PRIN, STAN, SLAC)	
Also	83	PRL 50 219	Edwards, Partridge+	(CIT, HARV, PRIN, STAN+)	
SCHARRE	80	PL 97B 329	+Trilling, Abrams, Alam, Blocker+	(SLAC, LBL)	
FOSTER	68B	NP B8 174	+Gavillet, Labrosse, Montanet+	(CERN, CDEF)	
BAILLON	67	NC 50A 393	+Edwards, D'Andlau, Astier+	(CERN, CDEF, IRAD)	

OTHER RELATED PAPERS

CLOSE	97B	PR D55 5749	F. Close+	(RAL, RUTG, BEIJT)
BERTIN	96	PL B385 493	+Bruschi+	(Obelix Collab.)
FARRAR	96	PRL 76 4111	G.R. Farrar	(RUTG)
AMELIN	95	ZPHY C66 71	+Berdnikov+	(VES Collab.)
GENOVESE	94	ZPHY C61 425	+Lichtenberg, Pedrazzi	(TORI, IND)
BALI	93	PL B309 378	+Schilling, Hulsebo, Irving, Michael+	(LIVP)
LONGACRE	90	PR D42 874		(BNL)
AHMAD	89	NP B (PROC.)8 50	+Amsler, Auld+	(ASTERIX Collab.)
ARMSTRONG	89	PL B221 216	+Benayoun+	(CERN, CDEF, BIRM, BARI, ATHU, CURIN+)
ARMSTRONG	87	ZPHY C34 23	+Bloodworth+	(CERN, BIRM, BARI, ATHU, CURIN+)
ASTON	87	NP B292 693	+Awaji, D'Amore+	(SLAC, NAGO, CINC, INUS)
ARMSTRONG	84	PL 146B 273	+Bloodworth, Burns+	(ATHU, BARI, BIRM, CERN)
DIONISI	80	NP B169 1	+Gavillet+	(CERN, MADR, CDEF, STOH)
DEFOIX	72	NP B44 125	+Nascimento, Bizzarri+	(CDEF, CERN)
DUBOC	72	NP B46 429	+Goldberg, Makowski, Donald+	(PARIS, LIVP)
LORSTAD	69	NP B14 63	+D'Andlau, Astier+	(CDEF, CERN)