

$\omega(1650)$

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

See also the $\omega(1420)$ particle listing. $\omega(1650)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
1670 ± 30 OUR ESTIMATE				
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1698 ± 10	267	¹ ACHASOV	20B SND	$e^+e^- \rightarrow \omega\eta \rightarrow \eta\pi^0\gamma$
1651 ± 3^{+16}_{-6}	183k	² ABLIKIM	19AQ BES	$J/\psi \rightarrow K^+K^-\pi^0$
1673 $^{+6}_{-7}$		ACHASOV	19 SND	$e^+e^- \rightarrow \pi^+\pi^-\pi^0\eta$
1671 ± 6 ± 10	824	³ AKHMETSHIN	17A CMD3	1.4–2.0 $e^+e^- \rightarrow \omega\eta$
1660 ± 10	898	⁴ ACHASOV	16B SND	1.34–2.00 $e^+e^- \rightarrow \omega\eta$
1680 ± 10	13.1k	⁵ AULCHENKO	15A SND	1.05–1.80 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
1667 ± 13 ± 6		AUBERT	07AU BABR	10.6 $e^+e^- \rightarrow \omega\pi^+\pi^-\gamma$
1645 ± 8	13	AUBERT	06D BABR	10.6 $e^+e^- \rightarrow \omega\eta\gamma$
1660 ± 10 ± 2		AUBERT,B	04N BABR	10.6 $e^+e^- \rightarrow \pi^+\pi^-\pi^0\gamma$
1770 ± 50 ± 60	1.2M	⁶ ACHASOV	03D RVUE	0.44–2.00 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
1619 ± 5		⁷ HENNER	02 RVUE	1.2–2.0 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$
1700 ± 20		EUGENIO	01 SPEC	18 $\pi^-p \rightarrow \omega\eta n$
1705 ± 26	612	⁸ AKHMETSHIN	00D CMD2	$e^+e^- \rightarrow \omega\pi^+\pi^-$
1820 $^{+190}_{-150}$		⁹ ACHASOV	98H RVUE	$e^+e^- \rightarrow \pi^+\pi^-\pi^0$
1840 $^{+100}_{-70}$		¹⁰ ACHASOV	98H RVUE	$e^+e^- \rightarrow \omega\pi^+\pi^-$
1780 $^{+170}_{-300}$		¹¹ ACHASOV	98H RVUE	$e^+e^- \rightarrow K^+K^-$
~ 2100		¹² ACHASOV	98H RVUE	$e^+e^- \rightarrow K_S^0 K^\pm \pi^\mp$
1606 ± 9		¹³ CLEGG	94 RVUE	
1662 ± 13	750	¹⁴ ANTONELLI	92 DM2	1.34–2.4 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$
1670 ± 20		ATKINSON	83B OMEG	20–70 $\gamma p \rightarrow 3\pi X$
1657 ± 13		CORDIER	81 DM1	$e^+e^- \rightarrow \omega 2\pi$
1679 ± 34	21	ESPOSITO	80 FRAM	$e^+e^- \rightarrow 3\pi$
1652 ± 17		COSME	79 OSPK	$e^+e^- \rightarrow 3\pi$

¹ From a fit with contributions from $\omega(1420)$, $\omega(1650)$, and $\phi(1680)$. The mass of $\omega(1420)$ is fixed to the PDG 18 value of 1420 MeV. Fixing also the width of $\omega(1420)$ to the PDG 18 value of 220 MeV results in 1694 ± 9 MeV measurement.

² Could also be $\rho(1700)$. Branching ratio $J/\psi \rightarrow X\pi^0 \rightarrow K^+K^-\pi^0 = (5.3 \pm 0.3^{+0.6}_{-0.5}) \times 10^{-5}$.

³ From a fit of the interfering $\omega(1420)$ and $\omega(1650)$ with a relative phase of π and other parameters floating.

⁴ From a fit with contributions from $\omega(1420)$, $\omega(1650)$, and $\phi(1680)$.

⁵ From a fit with contributions from $\omega(782)$, $\phi(1020)$, $\omega(1420)$, and $\omega(1650)$. See ACHASOV 20A for a further analysis of the $\pi^+\pi^-\pi^0$ data.

- ⁶ From the combined fit of ANTONELLI 92, ACHASOV 01E, ACHASOV 02E, and ACHASOV 03D data on the $\pi^+\pi^-\pi^0$ and ANTONELLI 92 on the $\omega\pi^+\pi^-$ final states. Supersedes ACHASOV 99E and ACHASOV 02E.
- ⁷ Using results of CORDIER 81 and preliminary data of DOLINSKY 91 and ANTONELLI 92.
- ⁸ Using the data of AKHMETSHIN 00D and ANTONELLI 92. The $\rho\pi$ dominance for the energy dependence of the $\omega(1420)$ and $\omega(1650)$ width assumed.
- ⁹ Using data from BARKOV 87, DOLINSKY 91, and ANTONELLI 92.
- ¹⁰ Using the data from ANTONELLI 92.
- ¹¹ Using the data from IVANOV 81 and BISELLO 88B.
- ¹² Using the data from BISELLO 91C.
- ¹³ From a fit to two Breit-Wigner functions and using the data of DOLINSKY 91 and ANTONELLI 92.
- ¹⁴ From the combined fit of the $\rho\pi$ and $\omega\pi\pi$ final states.

$\omega(1650)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
315 ± 35 OUR ESTIMATE				
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
110 ± 16	267	¹ ACHASOV	20B SND	$e^+e^- \rightarrow \omega\eta \rightarrow \eta\pi^0\gamma$
194 ± 8 ⁺ ₇ 15 ⁻	183k	² ABLIKIM	19AQ BES	$J/\psi \rightarrow K^+K^-\pi^0$
95 ± 11		ACHASOV	19 SND	$e^+e^- \rightarrow \pi^+\pi^-\pi^0\eta$
113 ± 9 ± 10	824	³ AKHMETSHIN	17A CMD3	1.4–2.0 $e^+e^- \rightarrow \omega\eta$
110 ± 20	898	⁴ ACHASOV	16B SND	1.34–2.00 $e^+e^- \rightarrow \omega\eta$
310 ± 30	13.1k	⁵ AULCHENKO	15A SND	1.05–1.80 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
222 ± 25 ± 20		AUBERT	07AU BABR	10.6 $e^+e^- \rightarrow \omega\pi^+\pi^-\gamma$
114 ± 14	13	AUBERT	06D BABR	10.6 $e^+e^- \rightarrow \omega\eta\gamma$
230 ± 30 ± 20		AUBERT,B	04N BABR	10.6 $e^+e^- \rightarrow \pi^+\pi^-\pi^0\gamma$
490 ⁺ ₁₅₀ 200 ± 130	1.2M	⁶ ACHASOV	03D RVUE	0.44–2.00 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
250 ± 14		⁷ HENNER	02 RVUE	1.2–2.0 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$
250 ± 50		EUGENIO	01 SPEC	18 $\pi^-p \rightarrow \omega\eta n$
370 ± 25	612	⁸ AKHMETSHIN	00D CMD2	$e^+e^- \rightarrow \omega\pi^+\pi^-$
113 ± 20		⁹ CLEGG	94 RVUE	
280 ± 24	750	¹⁰ ANTONELLI	92 DM2	1.34–2.4 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$
160 ± 20		ATKINSON	83B OMEG	20–70 $\gamma p \rightarrow 3\pi X$
136 ± 46		CORDIER	81 DM1	$e^+e^- \rightarrow \omega 2\pi$
99 ± 49	21	ESPOSITO	80 FRAM	$e^+e^- \rightarrow 3\pi$
42 ± 17		COSME	79 OSPK	$e^+e^- \rightarrow 3\pi$

¹ From a fit with contributions from $\omega(1420)$, $\omega(1650)$, and $\phi(1680)$. The mass of $\omega(1420)$ is fixed to the PDG 18 value of 1420 MeV. Fixing also the width of $\omega(1420)$ to the PDG 18 value of 220 MeV results in 94 ± 13 MeV measurement.

² Could also be $\rho(1700)$. Branching ratio $J/\psi \rightarrow X\pi^0 \rightarrow K^+K^-\pi^0 = (5.3 \pm 0.3^{+0.6}_{-0.5}) \times 10^{-5}$.

³ From a fit of the interfering $\omega(1420)$ and $\omega(1650)$ with a relative phase of π and other parameters floating.

⁴ From a fit with contributions from $\omega(1420)$, $\omega(1650)$, and $\phi(1680)$.

⁵ From a fit with contributions from $\omega(782)$, $\phi(1020)$, $\omega(1420)$, and $\omega(1650)$. See ACHASOV 20A for a further analysis of the $\pi^+\pi^-\pi^0$ data.

⁶ From the combined fit of ANTONELLI 92, ACHASOV 01E, ACHASOV 02E, and ACHASOV 03D data on the $\pi^+\pi^-\pi^0$ and ANTONELLI 92 on the $\omega\pi^+\pi^-$ final states. Supersedes ACHASOV 99E and ACHASOV 02E.

⁷ Using results of CORDIER 81 and preliminary data of DOLINSKY 91 and ANTONELLI 92.

⁸ Using the data of AKHMETSHIN 00D and ANTONELLI 92. The $\rho\pi$ dominance for the energy dependence of the $\omega(1420)$ and $\omega(1650)$ width assumed.

⁹ From a fit to two Breit-Wigner functions and using the data of DOLINSKY 91 and ANTONELLI 92.

¹⁰ From the combined fit of the $\rho\pi$ and $\omega\pi\pi$ final states.

$\omega(1650)$ DECAY MODES

Mode	Fraction (Γ_i/Γ)
Γ_1 $\rho\pi$	seen
Γ_2 $\rho(1450)\pi$	seen
Γ_3 $\omega\pi\pi$	seen
Γ_4 $\omega\eta$	seen
Γ_5 e^+e^-	seen
Γ_6 $\pi^0\gamma$	not seen

$\omega(1650)$ $\Gamma(i)\Gamma(e^+e^-)/\Gamma^2(\text{total})$

$\Gamma(\rho\pi)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$					$\Gamma_1/\Gamma \times \Gamma_5/\Gamma$	
VALUE (units 10^{-6})	EVTS	DOCUMENT ID	TECN	COMMENT		
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●						
1.56 ± 0.23	13.1k	¹ AULCHENKO	15A SND	$1.05\text{--}1.80 e^+e^- \rightarrow \pi^+\pi^-\pi^0$		
$1.3 \pm 0.1 \pm 0.1$		AUBERT,B	04N BABR	$10.6 e^+e^- \rightarrow \pi^+\pi^-\pi^0\gamma$		
$1.2 \begin{smallmatrix} +0.4 \\ -0.1 \end{smallmatrix} \pm 0.8$	1.2M	^{2,3} ACHASOV	03D RVUE	$0.44\text{--}2.00 e^+e^- \rightarrow \pi^+\pi^-\pi^0$		
0.921 ± 0.230		^{4,5} CLEGG	94 RVUE			
0.479 ± 0.050	750	^{6,7} ANTONELLI	92 DM2	$1.34\text{--}2.4 e^+e^- \rightarrow \rho\pi, \omega\pi\pi$		

¹ From a fit with contributions from $\omega(782)$, $\phi(1020)$, $\omega(1420)$, and $\omega(1650)$. See ACHASOV 20A for a further analysis of the $\pi^+\pi^-\pi^0$ data.

² Calculated by us from the cross section at the peak.

³ From the combined fit of ANTONELLI 92, ACHASOV 01E, ACHASOV 02E, and ACHASOV 03D data on the $\pi^+\pi^-\pi^0$ and ANTONELLI 92 on the $\omega\pi^+\pi^-$ final states. Supersedes ACHASOV 99E and ACHASOV 02E.

⁴ From a fit to two Breit-Wigner functions and using the data of DOLINSKY 91 and ANTONELLI 92.

⁵ From the partial and leptonic width given by the authors.

⁶ From the combined fit of the $\rho\pi$ and $\omega\pi\pi$ final states.

⁷ From the product of the leptonic width and partial branching ratio given by the authors.

$\Gamma(\omega\pi\pi)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_3/\Gamma \times \Gamma_5/\Gamma$

VALUE (units 10^{-7})	EVTS	DOCUMENT ID	TECN	COMMENT
7.0 \pm 0.5		AUBERT	07AU BABR	10.6 $e^+e^- \rightarrow \omega\pi^+\pi^-\gamma$
4.1 \pm 0.9 \pm 1.3	1.2M	^{1,2} ACHASOV	03D RVUE	0.44–2.00 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
5.40 \pm 0.95		³ AKHMETSHIN	00D CMD2	1.2–1.38 $e^+e^- \rightarrow \omega\pi^+\pi^-$
3.18 \pm 0.80		^{4,5} CLEGG	94 RVUE	
6.07 \pm 0.61	750	^{6,7} ANTONELLI	92 DM2	1.34–2.4 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$

- • • We do not use the following data for averages, fits, limits, etc. • • •
- ¹ Calculated by us from the cross section at the peak.
- ² From the combined fit of ANTONELLI 92, ACHASOV 01E, ACHASOV 02E, and ACHASOV 03D data on the $\pi^+\pi^-\pi^0$ and ANTONELLI 92 on the $\omega\pi^+\pi^-$ final states. Supersedes ACHASOV 99E and ACHASOV 02E.
- ³ Using the data of AKHMETSHIN 00D and ANTONELLI 92. The $\rho\pi$ dominance for the energy dependence of the $\omega(1420)$ and $\omega(1650)$ width assumed.
- ⁴ From a fit to two Breit-Wigner functions and using the data of DOLINSKY 91 and ANTONELLI 92.
- ⁵ From the partial and leptonic width given by the authors.
- ⁶ From the combined fit of the $\rho\pi$ and $\omega\pi\pi$ final states.
- ⁷ From the product of the leptonic width and partial branching ratio given by the authors.

$\Gamma(\omega\eta)/\Gamma_{\text{total}} \times \Gamma(e^+e^-)/\Gamma_{\text{total}}$ $\Gamma_4/\Gamma \times \Gamma_5/\Gamma$

VALUE (units 10^{-7})	EVTS	DOCUMENT ID	TECN	COMMENT
6.4 \pm 0.9	267	¹ ACHASOV	20B SND	$e^+e^- \rightarrow \omega\eta \rightarrow \eta\pi^0\gamma$
5.62 ^{+0.45} _{-0.42}		ACHASOV	19 SND	$e^+e^- \rightarrow \pi^+\pi^-\pi^0\eta$
4.5 \pm 0.3 \pm 0.3	824	² AKHMETSHIN	17A CMD3	1.4–2.0 $e^+e^- \rightarrow \omega\eta$
4.4 \pm 0.5	898	³ ACHASOV	16B SND	1.34–2.00 $e^+e^- \rightarrow \omega\eta$
5.7 \pm 0.6	13	AUBERT	06D BABR	10.6 $e^+e^- \rightarrow \omega\eta\gamma$
< 60 at 90% CL		⁴ AKHMETSHIN	03B CMD2	$e^+e^- \rightarrow \eta\pi^0\gamma$

- • • We do not use the following data for averages, fits, limits, etc. • • •
- ¹ From a fit with contributions from $\omega(1420)$, $\omega(1650)$, and $\phi(1680)$. The mass of $\omega(1420)$ is fixed to the PDG 18 value of 1420 MeV. Fixing also the width of $\omega(1420)$ to the PDG 18 value of 220 MeV results in $(5.4 \pm 0.6) \times 10^{-7}$ measurement.
- ² From a fit of the interfering $\omega(1420)$ and $\omega(1650)$ with a relative phase of π and other parameters floating. From an alternative fit $\Gamma(\omega(1650) \rightarrow \omega\eta)/\Gamma_{\text{total}} \times \Gamma(\omega(1650) \rightarrow e^+e^-) = 51 \pm 3$ eV.
- ³ From a fit with contributions from $\omega(1420)$, $\omega(1650)$, and $\phi(1680)$.
- ⁴ $\omega(1650)$ mass and width fixed at 1700 MeV and 250 MeV, respectively.

$\omega(1650)$ BRANCHING RATIOS

$\Gamma(\rho\pi)/\Gamma_{\text{total}}$ Γ_1/Γ

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
\sim 0.65	1.2M	¹ ACHASOV	03D RVUE	0.44–2.00 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
0.380 \pm 0.014		² HENNER	02 RVUE	1.2–2.0 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$

- • • We do not use the following data for averages, fits, limits, etc. • • •
- ¹ From the combined fit of ANTONELLI 92, ACHASOV 01E, ACHASOV 02E, and ACHASOV 03D data on the $\pi^+\pi^-\pi^0$ and ANTONELLI 92 on the $\omega\pi^+\pi^-$ final states. Supersedes ACHASOV 99E and ACHASOV 02E.
- ² Assuming that the $\omega(1650)$ decays into $\rho\pi$ and $\omega\pi\pi$ only.

$\Gamma(\rho(1450)\pi)/\Gamma_{\text{total}}$ Γ_2/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
seen	ACHASOV	20A	SND 1.15–2.00 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$

 $\Gamma(\omega\pi\pi)/\Gamma_{\text{total}}$ Γ_3/Γ

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

~ 0.35	1.2M	¹ ACHASOV	03D	RVUE 0.44–2.00 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
0.620 ± 0.014		² HENNER	02	RVUE 1.2–2.0 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$

¹From the combined fit of ANTONELLI 92, ACHASOV 01E, ACHASOV 02E, and ACHASOV 03D data on the $\pi^+\pi^-\pi^0$ and ANTONELLI 92 on the $\omega\pi^+\pi^-$ final states. Supersedes ACHASOV 99E and ACHASOV 02E.

²Assuming that the $\omega(1650)$ decays into $\rho\pi$ and $\omega\pi\pi$ only.

 $\Gamma(e^+e^-)/\Gamma_{\text{total}}$ Γ_5/Γ

VALUE (units 10^{-7})	EVTS	DOCUMENT ID	TECN	COMMENT
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• • • We do not use the following data for averages, fits, limits, etc. • • •

~ 18	1.2M	^{1,2} ACHASOV	03D	RVUE 0.44–2.00 $e^+e^- \rightarrow \pi^+\pi^-\pi^0$
32 ± 1		² HENNER	02	RVUE 1.2–2.0 $e^+e^- \rightarrow \rho\pi, \omega\pi\pi$

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

²Assuming that the $\omega(1650)$ decays into $\rho\pi$ and $\omega\pi\pi$ only.

 $\Gamma(\pi^0\gamma)/\Gamma_{\text{total}}$ Γ_6/Γ

VALUE	DOCUMENT ID	TECN	COMMENT
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not seen ¹ACHASOV 10D SND 1.075–2.0 $e^+e^- \rightarrow \pi^0\gamma$

¹From a fit of a VMD model with two effective resonances with masses of 1450 MeV and 1700 MeV to describe the excited vector states $\omega(1420)$, $\rho(1450)$, $\omega(1650)$, and $\rho(1700)$. The width of the highest mass effective resonance is fixed at 315 MeV.

 $\omega(1650)$ REFERENCES

ACHASOV	20A	EPJ C80 993	M.N. Achasov <i>et al.</i>	(SND Collab.)
ACHASOV	20B	EPJ C80 1008	M.N. Achasov <i>et al.</i>	(SND Collab.)
ABLIKIM	19AQ	PR D100 032004	M. Ablikim <i>et al.</i>	(BESIII Collab.)
ACHASOV	19	PR D99 112004	M.N. Achasov <i>et al.</i>	(SND Collab.)
PDG	18	PR D98 030001	M. Tanabashi <i>et al.</i>	(PDG Collab.)
AKHMETSHIN	17A	PL B773 150	R.R. Akhmetshin <i>et al.</i>	(CMD-3 Collab.)
ACHASOV	16B	PR D94 092002	M.N. Achasov <i>et al.</i>	(SND Collab.)
AULCHENKO	15A	JETP 121 27	V.M. Aulchenko <i>et al.</i>	(SND Collab.)
		Translated from ZETF 148 34.		
ACHASOV	10D	PR D98 112001	M.N. Achasov <i>et al.</i>	(SND Collab.)
AUBERT	07AU	PR D76 092005	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT	06D	PR D73 052003	B. Aubert <i>et al.</i>	(BABAR Collab.)
AUBERT,B	04N	PR D70 072004	B. Aubert <i>et al.</i>	(BABAR Collab.)
ACHASOV	03D	PR D68 052006	M.N. Achasov <i>et al.</i>	(Novosibirsk SND Collab.)
AKHMETSHIN	03B	PL B562 173	R.R. Akhmetshin <i>et al.</i>	(Novosibirsk CMD-2 Collab.)
ACHASOV	02E	PR D66 032001	M.N. Achasov <i>et al.</i>	(Novosibirsk SND Collab.)
HENNER	02	EPJ C26 3	V.K. Henner <i>et al.</i>	
ACHASOV	01E	PR D63 072002	M.N. Achasov <i>et al.</i>	(Novosibirsk SND Collab.)
EUGENIO	01	PL B497 190	P. Eugenio <i>et al.</i>	
AKHMETSHIN	00D	PL B489 125	R.R. Akhmetshin <i>et al.</i>	(Novosibirsk CMD-2 Collab.)

ACHASOV	99E	PL B462 365	M.N. Achasov <i>et al.</i>	(Novosibirsk SND Collab.)
ACHASOV	98H	PR D57 4334	N.N. Achasov, A.A. Kozhevnikov	
CLEGG	94	ZPHY C62 455	A.B. Clegg, A. Donnachie	(LANC, MCHS)
ANTONELLI	92	ZPHY C56 15	A. Antonelli <i>et al.</i>	(DM2 Collab.)
BISELLO	91C	ZPHY C52 227	D. Bisello <i>et al.</i>	(DM2 Collab.)
DOLINSKY	91	PRPL 202 99	S.I. Dolinsky <i>et al.</i>	(NOVO)
BISELLO	88B	ZPHY C39 13	D. Bisello <i>et al.</i>	(PADO, CLER, FRAS+)
BARKOV	87	JETPL 46 164	L.M. Barkov <i>et al.</i>	(NOVO)
		Translated from ZETFP 46 132.		
ATKINSON	83B	PL 127B 132	M. Atkinson <i>et al.</i>	(BONN, CERN, GLAS+)
CORDIER	81	PL 106B 155	A. Cordier <i>et al.</i>	(ORSAY)
IVANOV	81	PL 107B 297	P.M. Ivanov <i>et al.</i>	(NOVO)
ESPOSITO	80	LNC 28 195	B. Esposito <i>et al.</i>	(FRAS, NAPL, PADO+)
COSME	79	NP B152 215	G. Cosme <i>et al.</i>	(IPN)
