

$f_0(500)$

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

also known as σ ; was $f_0(600)$, $f_0(400-1200)$
See the related review(s):

Scalar Mesons below 1 GeV

$f_0(500)$ T-MATRIX POLE \sqrt{s}

Note that $\Gamma = -2 \text{Im}(\sqrt{s})$.

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|-------------------------------|------|--|
| (400–550)–i(200–350) OUR ESTIMATE (see Fig. 64.3 in the review) | | | |
| $(458 \pm 7^{+4}_{-10}) - i(245 \pm 6^{+7}_{-10})$ | ¹ DANILKIN | 21 | RVUE Compilation |
| $(410 \pm 20) - i(240 \pm 15)$ | SARANTSEV | 21 | RVUE $J/\psi(1S) \rightarrow \gamma(\pi\pi, K\bar{K}, \eta\eta, \omega\phi)$ |
| $(512 \pm 15) - i(188 \pm 12)$ | ² ABLIKIM | 17 | BES3 $J/\psi \rightarrow \gamma 3\pi$ |
| $(440 \pm 10) - i(238 \pm 10)$ | ³ ALBALADEJO | 12 | RVUE Compilation |
| $(445 \pm 25) - i(278^{+22}_{-18})$ | ^{4,5} GARCIA-MAR..11 | RVUE | Compilation |
| $(457^{+14}_{-13}) - i(279^{+11}_{-7})$ | ^{4,6} GARCIA-MAR..11 | RVUE | Compilation |
| $(442^{+5}_{-8}) - i(274^{+6}_{-5})$ | ⁷ MOUSSALLAM11 | RVUE | Compilation |
| $(452 \pm 13) - i(259 \pm 16)$ | ⁸ MENNESSIER | 10 | RVUE Compilation |
| $(448 \pm 43) - i(266 \pm 43)$ | ⁹ MENNESSIER | 10 | RVUE Compilation |
| $(455 \pm 6^{+31}_{-13}) - i(278 \pm 6^{+34}_{-43})$ | ¹⁰ CAPRINI | 08 | RVUE Compilation |
| $(463 \pm 6^{+31}_{-17}) - i(259 \pm 6^{+33}_{-34})$ | ¹¹ CAPRINI | 08 | RVUE Compilation |
| $(552^{+84}_{-106}) - i(232^{+81}_{-72})$ | ¹² ABLIKIM | 07A | BES2 $\psi(2S) \rightarrow \pi^+\pi^- J/\psi$ |
| $(466 \pm 18) - i(223 \pm 28)$ | ¹³ BONVICINI | 07 | CLEO $D^+ \rightarrow \pi^-\pi^+\pi^+$ |
| $(472 \pm 30) - i(271 \pm 30)$ | ¹⁴ BUGG | 07A | RVUE Compilation |
| $(484 \pm 17) - i(255 \pm 10)$ | GARCIA-MAR..07 | RVUE | Compilation |
| $(430) - i(325)$ | ¹⁵ ANISOVICH | 06 | RVUE Compilation |
| $(441^{+16}_{-8}) - i(272^{+9}_{-12.5})$ | ¹⁶ CAPRINI | 06 | RVUE $\pi\pi \rightarrow \pi\pi$ |
| $(470 \pm 50) - i(285 \pm 25)$ | ¹⁷ ZHOU | 05 | RVUE |
| $(541 \pm 39) - i(252 \pm 42)$ | ¹⁸ ABLIKIM | 04A | BES2 $J/\psi \rightarrow \omega\pi^+\pi^-$ |
| $(528 \pm 32) - i(207 \pm 23)$ | ¹⁹ GALLEGOS | 04 | RVUE Compilation |
| $(533 \pm 25) - i(249 \pm 25)$ | ²⁰ BUGG | 03 | RVUE |
| $517 - i240$ | BLACK | 01 | RVUE $\pi\pi \rightarrow \pi\pi$ |
| $(470 \pm 30) - i(295 \pm 20)$ | ¹⁶ COLANGELO | 01 | RVUE $\pi\pi \rightarrow \pi\pi$ |
| $(535^{+48}_{-36}) - i(155^{+76}_{-53})$ | ²¹ ISHIDA | 01 | $\Upsilon(3S) \rightarrow \Upsilon\pi\pi$ |
| $610 \pm 14 - i(310 \pm 13)$ | ²² SUROVTSEV | 01 | RVUE $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $(540^{+36}_{-29}) - i(193^{+32}_{-40})$ | ISHIDA | 00B | $p\bar{p} \rightarrow \pi^0\pi^0\pi^0$ |
| $445 - i235$ | HANNAH | 99 | RVUE π scalar form factor |
| $(523 \pm 12) - i(259 \pm 7)$ | KAMINSKI | 99 | RVUE $\pi\pi \rightarrow \pi\pi, K\bar{K}, \sigma\sigma$ |
| $442 - i 227$ | OLLER | 99 | RVUE $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $469 - i203$ | OLLER | 99B | RVUE $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $445 - i221$ | OLLER | 99C | RVUE $\pi\pi \rightarrow \pi\pi, K\bar{K}, \eta\eta$ |
| $420 - i 212$ | LOCHER | 98 | RVUE $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $440 - i245$ | ²³ DOBADO | 97 | RVUE Compilation |

| | | | | |
|---------------------------------|---------------------------|-----|------|---|
| $(602 \pm 26) - i(196 \pm 27)$ | ²⁴ ISHIDA | 97 | | $\pi\pi \rightarrow \pi\pi$ |
| $(537 \pm 20) - i(250 \pm 17)$ | ²⁵ KAMINSKI | 97B | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}, 4\pi$ |
| $470 - i250$ | ^{26,27} TORNVIST | 96 | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}, K\pi,$ $\eta\pi$ |
| $387 - i305$ | ^{27,28} JANSSEN | 95 | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $420 - i370$ | ²⁹ ACHASOV | 94 | RVUE | $\pi\pi \rightarrow \pi\pi$ |
| $(506 \pm 10) - i(247 \pm 3)$ | KAMINSKI | 94 | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $370 - i356$ | ³⁰ ZOU | 94B | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $408 - i342$ | ^{27,30} ZOU | 93 | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $470 - i208$ | ³¹ VANBEVEREN | 86 | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}, \eta\eta,$ \dots |
| $(750 \pm 50) - i(450 \pm 50)$ | ³² ESTABROOKS | 79 | RVUE | $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $(660 \pm 100) - i(320 \pm 70)$ | PROTOPO... ³³ | 73 | HBC | $\pi\pi \rightarrow \pi\pi, K\bar{K}$ |
| $650 - i370$ | ³³ BASDEVANT | 72 | RVUE | $\pi\pi \rightarrow \pi\pi$ |

¹ Data driven analysis using partial-wave dispersion relations .

² S-matrix pole; 8595 events.

³ Applying the chiral unitary approach at NLO to the K_{e4} data of BATLEY 10 and $\pi N \rightarrow \pi\pi N$ data of HYAMS 73, GRAYER 74, and PROTOPOPESCU 73.

⁴ Uses the K_{e4} data of BATLEY 10C and the $\pi N \rightarrow \pi\pi N$ data of HYAMS 73, GRAYER 74, and PROTOPOPESCU 73.

⁵ Analytic continuation using Roy equations.

⁶ Analytic continuation using GKPY equations.

⁷ Using Roy equations.

⁸ Average of three variants of the analytic K-matrix model. Uses the K_{e4} data of BATLEY 08A and the $\pi N \rightarrow \pi\pi N$ data of HYAMS 73 and GRAYER 74.

⁹ Average of the analyses of three data sets in the K-matrix model. Uses the data of BATLEY 08A, HYAMS 73, and GRAYER 74, partially of COHEN 80 or ETKIN 82B.

¹⁰ From the K_{e4} data of BATLEY 08A and $\pi N \rightarrow \pi\pi N$ data of HYAMS 73.

¹¹ From the K_{e4} data of BATLEY 08A and $\pi N \rightarrow \pi\pi N$ data of PROTOPOPESCU 73, GRAYER 74, and ESTABROOKS 74.

¹² From a mean of three different $f_0(500)$ parametrizations. Uses 40k events.

¹³ From an isobar model using 2.6k events.

¹⁴ Reanalysis of ABLIKIM 04A, PISLAK 01, and HYAMS 73 data.

¹⁵ Using the N/D method.

¹⁶ From the solution of the Roy equation (ROY 71) for the isoscalar S-wave and using a phase-shift analysis of HYAMS 73 and PROTOPOPESCU 73 data.

¹⁷ Reanalysis of the data from PROTOPOPESCU 73, ESTABROOKS 74, GRAYER 74, ROSSELET 77, PISLAK 03, and AKHMETSHIN 04.

¹⁸ From a mean of six different analyses and $f_0(500)$ parameterizations.

¹⁹ Using data on $\psi(2S) \rightarrow J/\psi\pi\pi$ from BAI 00E and on $\Upsilon(nS) \rightarrow \Upsilon(mS)\pi\pi$ from BUTLER 94B and ALEXANDER 98.

²⁰ From a combined analysis of HYAMS 73, AUGUSTIN 89, AITALA 01B, and PISLAK 01.

²¹ A similar analysis (KOMADA 01) finds $(580^{+79}_{-30}) - i(190^{+107}_{-49})$ MeV.

²² Coupled channel reanalysis of BATON 70, BENSINGER 71, BAILLON 72, HYAMS 73, HYAMS 75, ROSSELET 77, COHEN 80, and ETKIN 82B using the uniformizing variable.

²³ Using the inverse amplitude method and data of ESTABROOKS 73, GRAYER 74, and PROTOPOPESCU 73.

²⁴ Reanalysis of data from HYAMS 73, GRAYER 74, SRINIVASAN 75, and ROSSELET 77 using the interfering amplitude method.

²⁵ Average and spread of 4 variants (“up” and “down”) of KAMINSKI 97B 3-channel model.

²⁶ Uses data from BEIER 72B, OCHS 73, HYAMS 73, GRAYER 74, ROSSELET 77, CA-SON 83, ASTON 88, and ARMSTRONG 91B. Coupled channel analysis with flavor symmetry and all light two-pseudoscalars systems.

²⁷ Demonstrates explicitly that $f_0(500)$ and $f_0(1370)$ are two different poles.

- ²⁸ Analysis of data from FALVARD 88.
²⁹ Analysis of data from OCHS 73, ESTABROOKS 75, ROSSELET 77, and MUKHIN 80.
³⁰ Analysis of data from OCHS 73, GRAYER 74, and ROSSELET 77.
³¹ Coupled-channel analysis using data from PROTOPODESCU 73, HYAMS 73, HYAMS 75, GRAYER 74, ESTABROOKS 74, ESTABROOKS 75, FROGGATT 77, COR- DEN 79, BISWAS 81.
³² Analysis of data from APEL 72C, GRAYER 74, CASON 76, PAWLICKI 77. Includes spread and errors of 4 solutions.
³³ Analysis of data from BATON 70, BENSINGER 71, COLTON 71, BAILLON 72, PRO- TOPODESCU 73, and WALKER 67.

$f_0(500)$ BREIT-WIGNER MASS

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|----------------------------|----------|--|
| 400 to 800 OUR ESTIMATE | | | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| 513 ± 32 | ³⁴ MURAMATSU 02 | CLEO | $e^+ e^- \approx 10 \text{ GeV}$ |
| $478^{+24}_{-23} \pm 17$ | AITALA | 01B E791 | $D^+ \rightarrow \pi^- \pi^+ \pi^+$ |
| 563^{+58}_{-29} | ³⁵ ISHIDA | 01 | $\Upsilon(3S) \rightarrow \Upsilon \pi \pi$ |
| 555 | ³⁶ ASNER | 00 CLE2 | $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$ |
| 540 ± 36 | ISHIDA | 00B | $p \bar{p} \rightarrow \pi^0 \pi^0 \pi^0$ |
| 750 ± 4 | ALEKSEEV | 99 SPEC | $1.78 \pi^- p_{\text{polar}} \rightarrow \pi^- \pi^+ n$ |
| 744 ± 5 | ALEKSEEV | 98 SPEC | $1.78 \pi^- p_{\text{polar}} \rightarrow \pi^- \pi^+ n$ |
| 759 ± 5 | ³⁷ TROYAN | 98 | $5.2 n p \rightarrow n p \pi^+ \pi^-$ |
| 780 ± 30 | ALDE | 97 GAM2 | $450 p p \rightarrow p p \pi^0 \pi^0$ |
| 585 ± 20 | ³⁸ ISHIDA | 97 | $\pi \pi \rightarrow \pi \pi$ |
| 761 ± 12 | ³⁹ SVEC | 96 RVUE | $6-17 \pi N_{\text{polar}} \rightarrow \pi^+ \pi^- N$ |
| ~ 860 | ^{40,41} TORNQVIST | 96 RVUE | $\pi \pi \rightarrow \pi \pi, K \bar{K}, K \pi, \eta \pi$ |
| 1165 ± 50 | ^{42,43} ANISOVICH | 95 RVUE | $\pi^- p \rightarrow \pi^0 \pi^0 n,$ $\bar{p} p \rightarrow \pi^0 \pi^0 \pi^0, \pi^0 \pi^0 \eta, \pi^0 \eta \eta$ |
| 414 ± 20 | ³⁹ AUGUSTIN | 89 DM2 | |

- ³⁴ Statistical uncertainty only.
³⁵ A similar analysis (KOMADA 01) finds 526^{+48}_{-37} MeV.
³⁶ From the best fit of the Dalitz plot.
³⁷ 6σ effect, no PWA.
³⁸ Reanalysis of data from HYAMS 73, GRAYER 74, SRINIVASAN 75, and ROSSELET 77 using the interfering amplitude method.
³⁹ Breit-Wigner fit to S-wave intensity measured in $\pi N \rightarrow \pi^- \pi^+ N$ on polarized targets. The fit does not include $f_0(980)$.
⁴⁰ Uses data from ASTON 88, OCHS 73, HYAMS 73, ARMSTRONG 91B, GRAYER 74, CASON 83, ROSSELET 77, and BEIER 72B. Coupled channel analysis with flavor symmetry and all light two-pseudoscalars systems.
⁴¹ Also observed by ASNER 00 in $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$ decays.
⁴² Uses $\pi^0 \pi^0$ data from ANISOVICH 94, AMSLER 94D, and ALDE 95B, $\pi^+ \pi^-$ data from OCHS 73, GRAYER 74 and ROSSELET 77, and $\eta \eta$ data from ANISOVICH 94.
⁴³ The pole is on Sheet III. Demonstrates explicitly that $f_0(500)$ and $f_0(1370)$ are two different poles.

$f_0(500)$ BREIT-WIGNER WIDTH

| VALUE (MeV) | DOCUMENT ID | TECN | COMMENT |
|---|----------------------------|----------|--|
| 100 to 800 OUR ESTIMATE | | | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | |
| 335 ± 67 | ⁴⁴ MURAMATSU 02 | CLEO | $e^+ e^- \approx 10 \text{ GeV}$ |
| $324^{+42}_{-40} \pm 21$ | AITALA | 01B E791 | $D^+ \rightarrow \pi^- \pi^+ \pi^+$ |
| 372^{+229}_{-95} | ⁴⁵ ISHIDA | 01 | $\Upsilon(3S) \rightarrow \Upsilon \pi \pi$ |
| 540 | ⁴⁶ ASNER | 00 CLE2 | $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$ |
| 372 ± 80 | ISHIDA | 00B | $p \bar{p} \rightarrow \pi^0 \pi^0 \pi^0$ |
| 119 ± 13 | ALEKSEEV | 99 SPEC | $1.78 \pi^- p_{\text{polar}} \rightarrow \pi^- \pi^+ n$ |
| 77 ± 22 | ALEKSEEV | 98 SPEC | $1.78 \pi^- p_{\text{polar}} \rightarrow \pi^- \pi^+ n$ |
| 35 ± 12 | ⁴⁷ TROYAN | 98 | $5.2 n p \rightarrow n p \pi^+ \pi^-$ |
| 780 ± 60 | ALDE | 97 GAM2 | $450 p p \rightarrow p p \pi^0 \pi^0$ |
| 385 ± 70 | ⁴⁸ ISHIDA | 97 | $\pi \pi \rightarrow \pi \pi$ |
| 290 ± 54 | ⁴⁹ SVEC | 96 RVUE | $6\text{--}17 \pi N_{\text{polar}} \rightarrow \pi^+ \pi^- N$ |
| ~ 880 | ^{50,51} TORNQVIST | 96 RVUE | $\pi \pi \rightarrow \pi \pi, K \bar{K}, K \pi, \eta \pi$ |
| 460 ± 40 | ^{52,53} ANISOVICH | 95 RVUE | $\pi^- p \rightarrow \pi^0 \pi^0 n,$ $\bar{p} p \rightarrow \pi^0 \pi^0 \pi^0, \pi^0 \pi^0 \eta, \pi^0 \eta \eta$ |
| 494 ± 58 | ⁴⁹ AUGUSTIN | 89 DM2 | |

⁴⁴ Statistical uncertainty only.⁴⁵ A similar analysis (KOMADA 01) finds 301^{+145}_{-100} MeV.⁴⁶ From the best fit of the Dalitz plot.⁴⁷ 6σ effect, no PWA.⁴⁸ Reanalysis of data from HYAMS 73, GRAYER 74, SRINIVASAN 75, and ROSSELET 77 using the interfering amplitude method.⁴⁹ Breit-Wigner fit to S-wave intensity measured in $\pi N \rightarrow \pi^- \pi^+ N$ on polarized targets. The fit does not include $f_0(980)$.⁵⁰ Uses data from ASTON 88, OCHS 73, HYAMS 73, ARMSTRONG 91B, GRAYER 74, CASON 83, ROSSELET 77, and BEIER 72B. Coupled channel analysis with flavor symmetry and all light two-pseudoscalars systems.⁵¹ Also observed by ASNER 00 in $\tau^- \rightarrow \pi^- \pi^0 \pi^0 \nu_\tau$ decays.⁵² Uses $\pi^0 \pi^0$ data from ANISOVICH 94, AMSLER 94D, and ALDE 95B, $\pi^+ \pi^-$ data from OCHS 73, GRAYER 74 and ROSSELET 77, and $\eta \eta$ data from ANISOVICH 94.⁵³ The pole is on Sheet III. Demonstrates explicitly that $f_0(500)$ and $f_0(1370)$ are two different poles. **$f_0(500)$ DECAY MODES**

| Mode | Fraction (Γ_i/Γ) |
|--------------------------------|--------------------------------|
| $\Gamma_1 \quad \pi \pi$ | seen |
| $\Gamma_2 \quad \gamma \gamma$ | seen |

$f_0(500)$ PARTIAL WIDTHS

| $\Gamma(\gamma\gamma)$ | | | | | Γ_2 |
|------------------------|--------------------|------------------|------|---|---|
| VALUE (keV) | | DOCUMENT ID | TECN | COMMENT | |
| • • • | | | | We do not use the following data for averages, fits, limits, etc. | • • • |
| 1.37 ± 13 | $+0.09$ -0.06 | 54 DANILKIN | 21 | RVUE | Compilation |
| 2.05 ± 0.21 | | 55 DAI | 14A | RVUE | Compilation |
| 1.7 ± 0.4 | | 56 HOFERICHT... | 11 | RVUE | Compilation |
| 3.08 ± 0.82 | | 57 MENNESSIER | 11 | RVUE | Compilation |
| 2.08 ± 0.2 | $+0.07$ -0.04 | 58 MOUSSALLAM | 11 | RVUE | Compilation |
| 2.08 | | 59 MAO | 09 | RVUE | Compilation |
| 1.2 ± 0.4 | | 60 BERNABEU | 08 | RVUE | |
| 3.9 ± 0.6 | | 57 MENNESSIER | 08 | RVUE | $\gamma\gamma \rightarrow \pi^+\pi^-, \pi^0\pi^0$ |
| 1.8 ± 0.4 | | 61 OLLER | 08 | RVUE | Compilation |
| 1.68 ± 0.15 | | 61,62 OLLER | 08A | RVUE | Compilation |
| 3.1 ± 0.5 | | 63,64 PENNINGTON | 08 | RVUE | Compilation |
| 2.4 ± 0.4 | | 64,65 PENNINGTON | 08 | RVUE | Compilation |
| 4.1 ± 0.3 | | 66 PENNINGTON | 06 | RVUE | $\gamma\gamma \rightarrow \pi^0\pi^0$ |
| 3.8 ± 1.5 | | 67,68 BOGLIONE | 99 | RVUE | $\gamma\gamma \rightarrow \pi^+\pi^-, \pi^0\pi^0$ |
| 5.4 ± 2.3 | | 67 MORGAN | 90 | RVUE | $\gamma\gamma \rightarrow \pi^+\pi^-, \pi^0\pi^0$ |
| 10 ± 6 | | COURAU | 86 | DM1 | $e^+e^- \rightarrow \pi^+\pi^-e^+e^-$ |

54 Using the value of the coupled channel analysis.

55 Using dispersive analysis with phases from GARCIA-MARTIN 11A and BUETTAKER 04 as input.

56 Using Roy-Steiner equations with $\pi\pi$ phase shifts from an update of COLANGELO 01 and from GARCIA-MARTIN 11A.

57 Using an analytic K-matrix model.

58 Using dispersion integral with phase input from Roy equations and data from MARSISKE 90, BOYER 90, BEHREND 92, UEHARA 08A, and MORI 07.

59 Used dispersion theory. The value quoted used the $f_0(500)$ pole position of $457 - i276$ MeV.

60 Using p , n polarizabilities from PDG 06 and fitting to $\pi\pi$ phase motion from GARCIA-MARTIN 07 and σ -poles from GARCIA-MARTIN 07 and CAPRINI 06.

61 Using twice-subtracted dispersion integrals.

62 Supersedes OLLER 08.

63 Solution A (preferred solution based on χ^2 -analysis).

64 Dispersion theory based amplitude analysis of BOYER 90, MARSISKE 90, BEHREND 92, and MORI 07.

65 Solution B (worse than solution A; still acceptable when systematic uncertainties are included).

66 Using unitarity and the σ pole position from CAPRINI 06.

67 This width could equally well be assigned to the $f_0(1370)$. The authors analyse data from BOYER 90 and MARSISKE 90 and report strong correlation with $\gamma\gamma$ width of $f_2(1270)$.

68 Supersedes MORGAN 90.

$f_0(500)$ REFERENCES

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| HANNAH | 99 | PR D60 017502 | T. Hannah |
| KAMINSKI | 99 | EPJ C9 141 | R. Kaminski, L. Lesniak, B. Loiseau (CRAC, PARIN) |
| OLLER | 99 | PR D60 099906 (errat.) | J.A. Oller <i>et al.</i> |
| OLLER | 99B | NP A652 407 (errat.) | J.A. Oller, E. Oset |
| OLLER | 99C | PR D60 074023 | J.A. Oller, E. Oset |
| ALEKSEEV | 98 | PAN 61 174 | I.G. Alekseev <i>et al.</i> |
| ALEXANDER | 98 | PR D58 052004 | J.P. Alexander <i>et al.</i> (CLEO Collab.) |
| LOCHER | 98 | EPJ C4 317 | M.P. Locher <i>et al.</i> (PSI) |
| TROYAN | 98 | JINRRC 5-91 33 | Yu. Troyan <i>et al.</i> |
| ALDE | 97 | PL B397 350 | D.M. Alde <i>et al.</i> (GAMS Collab.) |
| DOBADO | 97 | PR D56 3057 | A. Dobado, J.R. Pelaez |
| ISHIDA | 97 | PTP 98 1005 | S. Ishida <i>et al.</i> (TOKY, MIYA, KEK) |

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| KAMINSKI | 97B | PL B413 130 | R. Kaminski, L. Lesniak, B. Loiseau | (CRAC, IPN) |
| Also | | PTP 95 745 | S. Ishida <i>et al.</i> | (TOKY, MIYA, KEK) |
| SVEC | 96 | PR D53 2343 | M. Svec | (MCGI) |
| TORNQVIST | 96 | PRL 76 1575 | N.A. Tornqvist, M. Roos | (HELSE) |
| ALDE | 95B | ZPHY C66 375 | D.M. Alde <i>et al.</i> | (GAMS Collab.) |
| ANISOVICH | 95 | PL B355 363 | V.V. Anisovich <i>et al.</i> | (PNPI, SERP) |
| JANSSEN | 95 | PR D52 2690 | G. Janssen <i>et al.</i> | (STON, ADLD, JULI) |
| ACHASOV | 94 | PR D49 5779 | N.N. Achasov, G.N. Shestakov | (NOVM) |
| AMSLER | 94D | PL B333 277 | C. AMSler <i>et al.</i> | (Crystal Barrel Collab.) |
| ANISOVICH | 94 | PL B323 233 | V.V. Anisovich <i>et al.</i> | (Crystal Barrel Collab.) |
| BUTLER | 94B | PR D49 40 | F. Butler <i>et al.</i> | (CLEO Collab.) |
| KAMINSKI | 94 | PR D50 3145 | R. Kaminski, L. Lesniak, J.P. Maillet | (CRAC+) |
| ZOU | 94B | PR D50 591 | B.S. Zou, D.V. Bugg | (LOQM) |
| ZOU | 93 | PR D48 3948 | B.S. Zou, D.V. Bugg | (LOQM) |
| BEHREND | 92 | ZPHY C56 381 | H.J. Behrend | (CELLO Collab.) |
| ARMSTRONG | 91B | ZPHY C52 389 | T.A. Armstrong <i>et al.</i> | (ATHU, BARI, BIRM+) |
| BOYER | 90 | PR D42 1586 | J. Boyer <i>et al.</i> | (Mark II Collab.) |
| MARSISKE | 90 | PR D41 3324 | H. Marsiske <i>et al.</i> | (Crystal Ball Collab.) |
| MORGAN | 90 | ZPHY C48 623 | D. Morgan, M.R. Pennington | (RAL, DURH) |
| AUGUSTIN | 89 | NP B320 1 | J.E. Augustin, G. Cosme | (DM2 Collab.) |
| ASTON | 88 | NP B296 493 | D. Aston <i>et al.</i> | (SLAC, NAGO, CINC, INUS) |
| FALVARD | 88 | PR D38 2706 | A. Falvard <i>et al.</i> | (CLER, FRAS, LALO+) |
| COURAU | 86 | NP B271 1 | A. Courau <i>et al.</i> | (CLER, LALO) |
| VANBEVEREN | 86 | ZPHY C30 615 | E. van Beveren <i>et al.</i> | (NIJM, BIEL) |
| CASON | 83 | PR D28 1586 | N.M. Cason <i>et al.</i> | (NDAM, ANL) |
| ETKIN | 82B | PR D25 1786 | A. Etkin <i>et al.</i> | (BNL, CUNY, TUFTS, VAND) |
| BISWAS | 81 | PRL 47 1378 | N.N. Biswas <i>et al.</i> | (NDAM, ANL) |
| COHEN | 80 | PR D22 2595 | D. Cohen <i>et al.</i> | (ANL) IJP |
| MUKHIN | 80 | JETPL 32 601 | K.N. Mukhin <i>et al.</i> | (KIAE) |
| | | Translated from ZETFP 32 616. | | |
| CORDEN | 79 | NP B157 250 | M.J. Corden <i>et al.</i> | (BIRM, RHEL, TELA+) JP |
| ESTABROOKS | 79 | PR D19 2678 | P. Estabrooks | (CARL) |
| FROGGATT | 77 | NP B129 89 | C.D. Froggatt, J.L. Petersen | (GLAS, NORD) |
| PAWLICKI | 77 | PR D15 3196 | A.J. Pawlicki <i>et al.</i> | (ANL) IJ |
| ROSSELET | 77 | PR D15 574 | L. Rosselet <i>et al.</i> | (GEVA, SACL) |
| CASON | 76 | PRL 36 1485 | N.M. Cason <i>et al.</i> | (NDAM, ANL) IJ |
| ESTABROOKS | 75 | NP B95 322 | P.G. Estabrooks, A.D. Martin | (DURH) |
| HYAMS | 75 | NP B100 205 | B.D. Hyams <i>et al.</i> | (CERN, MPIM) |
| SRINIVASAN | 75 | PR D12 681 | V. Srinivasan <i>et al.</i> | (NDAM, ANL) |
| ESTABROOKS | 74 | NP B79 301 | P.G. Estabrooks, A.D. Martin | (DURH) |
| GRAYER | 74 | NP B75 189 | G. Grayer <i>et al.</i> | (CERN, MPIM) |
| ESTABROOKS | 73 | Tallahassee | P.G. Estabrooks <i>et al.</i> | (CERN, MPIM) |
| HYAMS | 73 | NP B64 134 | B.D. Hyams <i>et al.</i> | (CERN, MPIM) |
| OCHS | 73 | Thesis | W. Ochs | (MPIM, MUNI) |
| PROTOPOP... | 73 | PR D7 1279 | S.D. Protopopescu <i>et al.</i> | (LBL) |
| APEL | 72C | PL 41B 542 | W.D. Apel <i>et al.</i> | (KARLK, KARLE, PISA) |
| BAILLON | 72 | PL 38B 555 | P.H. Baillon <i>et al.</i> | (SLAC) |
| BASDEVANT | 72 | PL 41B 178 | J.L. Basdevant, C.D. Froggatt, J.L. Petersen | (CERN) |
| BEIER | 72B | PRL 29 511 | E.W. Beier <i>et al.</i> | (PENN) |
| BENSINGER | 71 | PL 36B 134 | J.R. Bensinger <i>et al.</i> | (WISC) |
| COLTON | 71 | PR D3 2028 | E.P. Colton <i>et al.</i> | (LBL, FNAL, UCLA+) |
| ROY | 71 | PL 36B 353 | S.M. Roy | |
| BATON | 70 | PL 33B 528 | J.P. Baton, G. Laurens, J. Reignier | (SACL) |
| WALKER | 67 | RMP 39 695 | W.D. Walker | (WISC) |