

**THE  $\rho(770)$** 

Updated May 2012 by S. Eidelman (Novosibirsk) and G. Venanzoni (Frascati).

The determination of the parameters of the  $\rho(770)$  is beset with many difficulties because of its large width. In physical region fits, the line shape does not correspond to a relativistic Breit-Wigner function with a  $P$ -wave width, but requires some additional shape parameter. This dependence on parameterization was demonstrated long ago [1]. Bose-Einstein correlations are another source of shifts in the  $\rho(770)$  line shape, particularly in multiparticle final state systems [2].

The same model-dependence afflicts any other source of resonance parameters, such as the energy-dependence of the phase shift  $\delta_1^1$ , or the pole position. It is, therefore, not surprising that a study of  $\rho(770)$  dominance in the decays of the  $\eta$  and  $\eta'$  reveals the need for specific dynamical effects, in addition to the  $\rho(770)$  pole [3,4].

The cleanest determination of the  $\rho(770)$  mass and width comes from  $e^+e^-$  annihilation and  $\tau$ -lepton decays. Analysis of ALEPH [5] showed that the charged  $\rho(770)$  parameters measured from  $\tau$ -lepton decays are consistent with those of the neutral one determined from  $e^+e^-$  data [6]. This conclusion is qualitatively supported by the later studies of CLEO [7] and Belle [8]. However, model-independent comparison of the two-pion mass spectrum in  $\tau$  decays, and the  $e^+e^- \rightarrow \pi^+\pi^-$  cross section, gave indications of discrepancies between the overall normalization:  $\tau$  data are about 3% higher than  $e^+e^-$  data [7,9]. A detailed analysis using such two-pion mass spectra from  $\tau$  decays measured by OPAL [10], CLEO [7], and ALEPH [11,12], as well as recent pion form factor measurements in  $e^+e^-$  annihilation by CMD-2 [13,14], showed that the discrepancy can be as high as 10% above the  $\rho$  meson [15,16]. This discrepancy remains after recent measurements of the two-pion cross section in  $e^+e^-$  annihilation at KLOE [17,18] and SND [19,20]. This effect is not accounted for by isospin breaking [21–24], but the accuracy of its calculation may be overestimated [25,26].

This problem seems to be solved after a recent analysis in [27] which showed that after correcting the  $\tau$  data for the missing  $\rho - \gamma$  mixing contribution, besides the other known isospin symmetry violating corrections, the  $\pi\pi$  I=1 part of the hadronic vacuum polarization contribution to the muon  $g - 2$  is fully compatible between  $\tau$  based and  $e^+e^-$  based evaluations including more recent BaBar [28] and KLOE [29] data. Further proof of the consistency of the data on  $\tau$  decays to two pions and  $e^+e^-$  annihilation is given by the global fit of the whole set of the  $\rho$ ,  $\omega$ , and  $\phi$  decays, taking into account mixing effects in the hidden local symmetry model [30].

## References

1. J. Pisut and M. Roos, Nucl. Phys. **B6**, 325 (1968).
2. G.D. Lafferty, Z. Phys. **C60**, 659 (1993).
3. A. Abele *et al.*, Phys. Lett. **B402**, 195 (1997).
4. M. Benayoun *et al.*, Eur. Phys. J. **C31**, 525 (2003).
5. R. Barate *et al.*, Z. Phys. **C76**, 15 (1997).
6. L.M. Barkov *et al.*, Nucl. Phys. **B256**, 365 (1985).
7. S. Anderson *et al.*, Phys. Rev. **D61**, 112002 (2000).
8. M. Fujikawa *et al.*, Phys. Rev. **D78**, 072006 (2008).
9. S. Eidelman and V. Ivanchenko, Nucl. Phys. (Proc. Supp.) **B76**, 319 (1999).
10. K. Ackerstaff *et al.*, Eur. Phys. J. **C7**, 571 (1999).
11. M. Davier *et al.*, Nucl. Phys. (Proc. Supp.) **B123**, 47 (2003).
12. S. Schael *et al.*, Phys. Reports **421**, 191 (2005).
13. R.R. Akhmetshin *et al.*, Phys. Lett. **B527**, 161 (2002).
14. R.R. Akhmetshin *et al.*, Phys. Lett. **B578**, 285 (2004).
15. M. Davier *et al.*, Eur. Phys. J. **C27**, 497 (2003).
16. M. Davier *et al.*, Eur. Phys. J. **C31**, 503 (2003).
17. A. Aloisio *et al.*, Phys. Lett. **B606**, 12 (2005).
18. F. Ambrosino *et al.*, Phys. Lett. **B670**, 285 (2009).
19. M.N. Achasov *et al.*, Sov. Phys. JETP **101**, 1053 (2005).
20. M.N. Achasov *et al.*, Sov. Phys. JETP **103**, 380 (2006).
21. R. Alemany *et al.*, Eur. Phys. J. **C2**, 123 (1998).
22. H. Czyz and J.J. Kuhn, Eur. Phys. J. **C18**, 497 (2001).
23. V. Cirigliano *et al.*, Phys. Lett. **B513**, 361 (2001).
24. V. Cirigliano *et al.*, Eur. Phys. J. **C23**, 121 (2002).

25. K. Maltman and C.E. Wolfe, Phys. Rev. **D73**, 013004 (2006).
26. C.E. Wolfe and K. Maltman, Phys. Rev. **D80**, 114024 (2009).
27. F. Jegerlehner and R. Szafron, Eur. Phys. J. **C71**, 1632 (2011).
28. B. Aubert *et al.*, Phys. Rev. Lett. **103**, 231801 (2009).
29. F. Ambrosino *et al.*, Phys. Lett. **B700**, 102 (2011).
30. M. Benayoun *et al.*, Eur. Phys. J. **C72**, 1848 (2012).