and often larger errors $\delta\overline{P}_i'$ are obtained. The scale factors we finally list in such cases are defined by $S_i = \delta\overline{P}_i'/\delta\overline{P}_i$. However, in line with our policy of not letting S affect the central values, we give the values of $\overline{P}_i$ obtained from the original (unscaled) fit.

There is one special case in which the errors that are obtained by the preceding procedure may be changed. When a fitted branching ratio (or rate) $\overline{P}_i$ turns out to be less than three standard deviations $(\delta\overline{P}_i')$ from zero, a new smaller error $(\delta\overline{P}_i'')^-$ is calculated on the low side by requiring the area under the Gaussian between $\overline{P}_i - (\delta\,\overline{P}_i'')^-$ and $\overline{P}_i$ to be 68.3% of the area between zero and $\overline{P}_i$. A similar correction is made for branching fractions that are within three standard deviations of one. This keeps the quoted errors from overlapping the boundary of the physical region.

4.3. ***Discussion***: The problem of averaging data containing discrepant values is nicely discussed by Taylor in Ref. 4. He considers a number of algorithms that attempt to incorporate inconsistent data into a meaningful average. However, it is difficult to develop a procedure that handles simultaneously in a reasonable way two basic types of situations: (a) data that lie apart from the main body of the data are incorrect (contain unreported errors); and (b) the opposite—it is the main body of data that is incorrect. Unfortunately, as Taylor shows, case (b) is not infrequent. He concludes that the choice of procedure is less significant than the initial choice of data to include or exclude.

We place much emphasis on this choice of data. Often we solicit the help of outside experts (consultants). Sometimes, however, it is simply impossible to determine which of a set of discrepant measurements are correct. Our scale-factor technique is an attempt to address this ignorance by increasing the error. In effect, we are saying that present experiments do not allow a precise determination of this quantity because of unresolvable discrepancies, and one must await further measurements. The reader is warned of this situation by the size of the scale factor, and if he or she desires can go back to the literature (via the Full Listings) and redo the average with a different choice of data.

Our situation is less severe than most of the cases Taylor considers, such as estimates of the fundamental constants like $\hbar$, *etc.* Most of the errors in his case are dominated by systematic effects. For our data, statistical errors are often at least as large as systematic errors, and statistical errors are usually easier to estimate. A notable exception occurs in partial-wave analyses, where different techniques applied to the same data yield different results. In this case, as stated earlier, we often do not make an average but just quote a range of values.

A brief history of early Particle Data Group averages is given in Ref. 3. Figure 0.2 shows some histories of our values of a few particle properties. Sometimes large changes occur. These usually reflect the introduction of significant new data or the discarding of older data. Older data are discarded in favor of newer data when it is felt that the newer data have smaller systematic errors, or have more checks on systematic errors, or have made corrections unknown at the time of the older experiments, or simply have much smaller errors. Sometimes, the scale factor becomes large near the time at which a large jump takes place, reflecting the uncertainty introduced by the new and inconsistent data. By and large, however, a full scan of our history plots shows a dull progression toward greater precision at central values quite consistent with the first data points shown.

We conclude that the reliability of the combination of experimental data and our averaging procedures is usually good, but it is important to be aware that fluctuations outside of the quoted errors can and do occur.

ACKNOWLEDGMENTS

The publication of the *Review of Particle Properties* is supported by the Director, Office of Energy Research, Office of High Energy and Nuclear Physics, Division of High Energy Physics of the U.S. Department of Energy under Contract No. DE–AC03–76SF00098, by the U.S. National Science Foundation under Agreement No. PHY-9320551, and by the Italian Istituto Nazionale di Fisica Nucleare (INFN). Partial funding to cover the cost of this *Review* is also provided by the European Laboratory for Particle Physics (CERN) and by an implementing arrangement between the governments of Japan (Monbusho) and the United States (DOE) on cooperative research and development.

We thank all those who have assisted in the many phases of preparing this *Review*. We particularly thank the many who have responded to our requests for verification of data entered in the Listings, and those who have made suggestions or pointed out errors. The Berkeley members of the Particle Data Group acknowledge the administrative and baking skills of Gail Harper and the graphics expertise of Charles Groom.

REFERENCES

1. The previous edition was Particle Data Group: K. Hikasa, K. Hagiwara, S. Kawabata, R.M. Barnett, D.E. Groom, T.G. Trippe, C.G. Wohl, G.P. Yost, B. Armstrong, G.S. Wagman, J. Stone, J.J. Hernández, F.C. Porter, R.J. Morrison, R.E. Cutkosky, L. Montanet, K. Gieselmann, M. Aguilar-Benitez, C. Caso, R.L. Crawford, M. Roos, N.A. Törnqvist, K.G. Hayes, G. Höhler, D.M. Manley, K.A. Olive, R.E. Shrock, S. Eidelman, R.H. Schindler, G. Conforto, and R.A. Eichler Phys. Rev. **D45**, 1 June 1992, Part II.
2. Particle Data Group: M. Aguilar-Benitez, F.C. Porter, J.J. Hernandez, L. Montanet, K.R. Schubert, M. Roos, N.A. Törnqvist, G. Höhler, R.M. Barnett, I. Hinchliffe, G.R. Lynch, A. Rittenberg, T.G. Trippe, G.P. Yost, B. Armstrong, G.S. Wagman, T. Shimada, G.P. Gopal, J. Primack, K.G. Hayes, R.H. Schindler, R.E. Shrock, R.A. Eichler, R. Frosch, L.D. Roper, and W.P. Trower, Phys. Lett. **170B** (1986).
3. A.H. Rosenfeld, Ann. Rev. Nucl. Sci. **25**, 555 (1975).
4. B.N. Taylor, "Numerical Comparisons of Several Algorithms for Treating Inconsistent Data in a Least-Squares Adjustment of the Fundamental Constants," U.S. National Bureau of Standards NBSIR 81-2426 (1982).