BRIEF REPORTS

Brief Reports are accounts of completed research which do not warrant regular articles or the priority handling given to Rapid Communications; however, the same standards of scientific quality apply. (Addenda are included in Brief Reports.) A Brief Report may be no longer than four printed pages and must be accompanied by an abstract.

Pion-nucleon coupling constant

Richard A. Arndt, Zhujun Li, L. David Roper, and Ron L. Workman
Department of Physics, Virginia Polytechnic Institute and State University, Blacksburg, Virginia 24061
(Received 5 December 1990)

We confirm a recent determination of the pion-nucleon coupling constant. We relate the accuracy of our result to the abundance of low-energy polarization data. Our result has been extracted from a modified dispersion relation and is compared to the Karlsruhe-Helsinki result. The effect of charge-exchange data on this result is also examined.

In a recent analysis [1] of elastic pion-nucleon scattering data, the charged-pion–nucleon coupling constant was found to have a value much below the "canonical" value given by Koch and Pietarinen [2]. The extracted value [1] of f^2 was 0.0735 ± 0.0015 compared to 0.079 ± 0.001 from Koch and Pietarinen [2] and Bugg, Carter, and Carter [3]. When paired with the value of the $\pi^0 pp$ coupling found in the recent Nijmegen analysis [4] of pp scattering, the evidence for large charge-independence-breaking effects [4] was removed with both analyses claiming a reduced coupling.

It is also interesting to note that this lower value for the πNN coupling essentially removes the Goldberger-Treiman discrepancy [5]. The discrepancy arises when one compares the value of πNN coupling, coming from analyses of experimental data, to the value predicted by the Goldberger-Treiman relation, given values for the pion decay constant and axial-vector coupling. (Of course, the combination of a softer πNN form factor and a larger coupling constant could also remove the discrepancy.)

In order to check our result [1] for f^2, we have utilized the symmetric invariant amplitude $B^+(\nu,t)$ in an unsubtracted dispersion relation:

$$\frac{g^2}{M}=\frac{\nu_B^2-\nu^2}{\nu}\left[\mathrm{Re}B^+(\nu,t)-\frac{2\nu}{\pi}\int_{\nu_{th}}^{\infty}d\nu'\frac{\mathrm{Im}B^+(\nu',t)}{\nu'^2-\nu^2}\right], \tag{1}$$

for the πNN coupling g^2, with $g^2=16\pi M^2 f^2/\mu^2$, the quantities M and μ being, respectively, the nucleon and charged-pion masses. This differs from the dispersion relation used in our previous determination [1]. The relation, given in Eq. (1), was used in the analysis of Bugg, Carter, and Carter [3] to extract f^2 from fits to data between the laboratory kinetic energies of 100 and 280 MeV and provides the means for an additional consistency check on our results [1].

Our determination of f^2 relies on partial-wave pion-nucleon amplitudes [6] which are obtained with a minimum of dispersion-relation constraints. (Forward-dispersion-relation and scattering-length constraints are used, as described in Ref. [6].) Thus, it is essential that the determination takes place in a kinematic region which has been thoroughly explored experimentally. On examining the available low-energy polarization data, it is clear that very few forward-angle measurements exist. As such measurements are required to determine the spin-flip amplitude, one should avoid the near-forward (and backward) regions when determining f^2. (The invariant amplitude B^+ depends upon [5] the spin-flip amplitude divided by sine of the center-of-mass scattering angle.)

In the present work, we have calculated an average value for f^2 from a grid of 86 kinematic points. A region between 100 and 600 MeV in the laboratory kinetic energy and between 30° and 150° in the center-of-mass scattering angle was covered. The result for f^2 from our most recent partial-wave solution [6], which we have named SM90, is 0.0735 ± 0.0015. Here we have quoted the average value with a root-mean-square error. In Fig. 1, we display a grid of deviations from the mean value of $g^2/4\pi$. The boundaries define a region well populated by polarization measurements. Notice that the deviations are largest near the boundaries and are small in the central region. This is what one would expect. In Fig. 2, we display an identical plot for the Karlsruhe-Helsinki solution [5,7]. Notice that here there is no indication that the region with abundant polarization data is giving a better value of $g^2/4\pi$. This is also to be expected, as the Karlsruhe-Helsinki solution has been constrained by dispersion relations, with an assumed value of $f^2=0.079$. Thus the extracted πNN coupling should be essentially independent of the chosen kinematic region.

The couplings obtained here and previously [1] were extracted from our most recent analysis of $\pi^\pm p$ elastic-

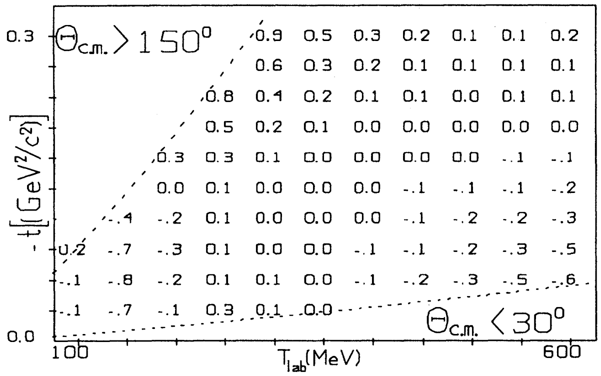

FIG. 1. Deviations from the mean (13.3) value of $g^2/4\pi$ for SM90 at a grid of laboratory-kinetic-energy (T_{lab}) and four-momentum-transfer (t) points. The lower and upper boundaries define a region between 30° and 150° in the center-of-mass scattering angle.

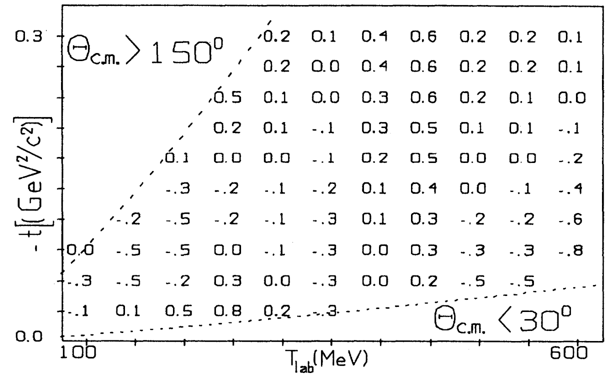

FIG. 2. Notation as in Fig. 1. Deviations from the mean (14.2) value of $g^2/4\pi$ for the Karlsruhe-Helsinki Ref. [7] solution.

scattering plus charge-exchange data. Excluding the possibility of charge-independence-breaking effects, one should in principle be able to predict the charge-exchange results from $\pi^{\pm}p$ elastic-scattering data alone. In practice, however, charge-exchange data are the major contributor to χ^2 in partial-wave analyses. It should also be noted that the charge-exchange reaction involves both neutral- and charged-pion–nucleon couplings, whereas the elastic-scattering reactions require only the charged coupling.

We have thus reanalyzed our data base excluding the existing charge-exchange data. The results are quite interesting. We find that the removal of charge-exchange data results in only a minimal improvement of the fit to $\pi^{\pm}p$ elastic-scattering data. From the resulting amplitudes, we find for f^2 a value within a percent of the above quoted value.

In summary, we have found further evidence in favor of a value of f^2 which is much lower than the "canonical" value of Koch and Pietarinen [2]. We have also found a correlation between the error in f^2 and the abundance of polarization data in regions where the extraction takes place. These results are not sensitive to the existing charge-exchange data.

We acknowledge useful communications with D. V. Bugg. This work was supported in part by a U.S. Department of Energy Grant No. DE-AS05-76ER04928.

[1] R. A. Arndt, Z. Li, L. D. Roper, and R. L. Workman, Phys. Rev. Lett. **65**, 157 (1990).
[2] R. Koch and E. Pietarinen, Nucl. Phys. **A336**, 331 (1980).
[3] D. V. Bugg, A. A. Carter, and J. R. Carter, Phys. Lett. **44B**, 278 (1973).
[4] J. R. Bergervoet *et al.*, Phys. Rev. C **41**, 1435 (1990).
[5] G. Höhler, in *Pion-Nucleon Scattering,* edited by H. Schopper, Landolt-Börnstein, Vol. I/9b (Springer, New York, 1983).
[6] R. A. Arndt, Z. Li, L. D. Roper, R. L. Workman, and J. M. Ford, Phys. Rev. D **43**, 2131 (1991).
[7] R. Koch (private communication).