SLAC-PUB-269
February 1967

COMPARISON OF MODERATE ENERGY PROTON-PROTON MODELS. III*

by

H. Pierre Noyes

Stanford Linear Accelerator Center, Stanford University, Stanford, California

and

Peter Signell and N. R. Yoder
Department of Physics
Michigan State University
East Lansing, Michigan

and

Robert M. Wright
Lawrence Radiation Laboratory
University of California
Livermore, California

ABSTRACT

The predictions of 12 proton-proton models and phase shift representations are compared to a selected but comprehensive set of 9-330 MeV scattering data. The best fit was found to be produced by a quadratic interpolation of Arndt and MacGregor's phase shift table, with a ratio of χ^2 to its expected value of 1.4. The best potential is that of Hamada and Johnston, with a ratio of 3.1. The ratio for the Tabakin potential is 28.

---

* Supported in part by the U. S. Atomic Energy Commission.

I. INTRODUCTION

In this paper we bring up to date the comparison[1,2,3] of published proton-proton models and energy-dependent phase shift analyses with data that, in our opinion, represent the most accurate experimental information currently available on proton-proton scattering between 9 and 330 MeV. The models we consider were constructed for a variety of purposes and were fitted to various other selections of the data, so that a simple χ^2 listing does not necessarily serve as a figure of merit as to how well the original authors' purposes were served. However, these models are often used for other purposes, accompanied by some statement to the effect that "this model agrees with existing scattering data". To the best of our knowledge, this is not true for existing models according to the usually accepted statistical criteria;[4] on the other hand the discrepancies may be irrelevant for some applications. This point obviously should be investigated in each case. For example, a small adjustment of the parameters might improve the fit to the data without affecting the calculation at hand; but it also might be extremely significant. In other cases, the model does provide a good fit over some energy ranges, but might be applied in an energy range where it is in violent disagreement with the data. Clearly this point should also always be investigated, and one of our purposes is to make this more obvious. Another is to give some indication of where the best existing models should be corrected. A third is to point up the fact that many popular models which are often used as if they were accurate representations of p-p scattering simply do not agree with existing information, and to urge caution in their application.

II. THE DATA

The data set used here was made by combining the independent sets maintained at the several institutions represented by the authors, with a closing date of September 1, 1966. Old data were dropped when they were clearly outclassed by more recent data on the basis of smallness of experimental standard deviations. The point here is that in any adjustment of model parameters for a least squares fit, data with large errors are effectively ignored if similar data with small errors are also present in the data set. In addition, some data have been eliminated on the basis of energy-independent phase shift analyses[5,6]. Such analyses provide the best possible test for inconsistencies in the data groups used, since they are virtually model-independent: they use only the short range of the strong force, the usual symmetries, and the one-pion-exchange (OPE) interaction for the longer-range part of the strong force.

Our final data set contained 648 individual values in the energy range 9-330 MeV laboratory energy. The upper limit was raised slightly from the value of 320 MeV used in the previous comparisons[1,2] in order to include a new group of data[7]; we believe it is still low enough to avoid complications due to pion production. The lower limit allows us to avoid examination of effects due to vacuum polarization, since a recent analysis[8] of the 9.69 MeV differential cross section[9] together with the ratio of A_{yy} to A_{xx} at 11.4 MeV[10] has shown that these effects are negligible at this energy. This analysis also shows that the well established fact that the longest range contribution to the strong interaction between two protons can be accurately computed from OPE allows one to fit all p-p scattering data at 10 MeV and below in terms of only two phenomenological parameters at each energy, namely the $^1S_0$ phase shift and the J-weighted average of the $^3P_{0,1,2}$ phase shifts.[11] It also shows that the energy variation of the former can be completely described by the scattering length and effective range, once the OPE effect is included, while the energy variation of the latter can be described by a single parameter which measures the ratio of the strength of the effective intermediate range central P-wave interaction to OPE. We therefore assume that anyone who wishes to use the p-p model for any application which requires good agreement with data at 10 MeV and below will first check to see whether it is in agreement with these three numbers, and confine our attention here to the agreement of the models with data at higher energy.

Where experiments quote both relative and absolute error, the normalization factor was included in the χ^2 calculation and χ^2 minimized with respect to all such parameters. Normalizations with experimental errors were not counted in the number of data, while those lacking errors were counted against the number of data. The data set was considered too extensive to list here: it is, however, available[12] in its entirety along with references.

III. MODELS AND COMPARISONS

The models of our previous communications which gave the poorest fit to the data of that time have been dropped.[13] An exception is the Brueckner-Gammel-Thaler (BGT)[14] hard core potential, which continues to be mentioned in occasional textbooks and calculations.

Table I lists the models considered, along with the goodness-of-fit parameter χ^2 for each of them. At the time of our last connumication, the best-fitting model was the 21-parameter phase shift representation CR21[2]. Arndt and MacGregor have adopted the procedures used by the CR21 authors[2], except for a change of representation, and have made a least squares fit to a recent data set. No record of Arndt and MacGregor's 35 T=1 representation parameters was saved by them[15], so we have used a quadratic interpolation to the phases in their published table[15]. The resulting phase shifts produced the best fit to our data set of any of the models tested, as can be seen in Table I. The next best fit is that of the Yale group's phase-shift-versus-energy curves labeled YRB1(K_0)[16]. The old 21-parameter phase shift representation CR21[2] is third, and the 12-parameter one-boson-exchange model of Scotti and Wong[17] is fourth. We note, however, that the phase shift table supplied to us by Scotti and Wong does not correspond precisely to the true predictions of their model parameters, since they used an incorrect coulomb correction in making their pp phase shift predictions[18]. The earlier fit from the Yale group (YLAM)[19] is not as good as their latest work[16], but is included because it has been used in a number of calculations.

The 15-parameter hard core Hamada-Johnston potential[20] is followed by the more recent version HJM[21], which is identical to the Hamada-Johnston potential except for a short range cut-off on the quadratic spin-orbit component. These potentials are followed by the similar 31-parameter Yale potential[22], and by the Bryan-Scott potential.

The one-boson-exchange Bryan-Scott[23] potential posed something of a problem since it was not intended to be used for S-states. The Livermore group has added the Bryan-Scott $L \geq 1$ phases to their latest $^1S_0$ energy-dependent representation[24] and have then adjusted the parameters of the latter for a least squares fit to their data set. We note that the more recent Bryan-Arndt[25] one-boson-exchange amplitude model uses <u>effective</u> scalar-and vector-boson-exchange coupling constants which differ by a factor of 10 from those of the corresponding Bryan-Scott proton-proton potentials.

The Tabakin potential[26] is non-local, with different parameters in each partial wave state. The partial-wave potentials are separable for the case of chargeless particles, but in order to include the local Coulomb potential, one must solve an integro-differential equation. This has been done for the current calculation. It is likely that a change in the published parameters would improve the fit to p-p data thus obtained; this question should obviously be investigated before the published model is used in other calculations. The well-known Brueckner-Gammel-Thaler (BGT)[14] potential is identical to the Gammel-Thaler[27] potential for proton-proton scattering and consists of hard cores with single-range Yukawa tails. The ranges of the latter were free parameters and so do not correspond to one-pion or one-boson exchange.

IV. DETAILS OF THE FITS

The partial χ^2 contributions to the leading three models from various energy ranges are shown in Table II. There are three obvious misfits: AMIV below 20 MeV, YRBI(K_0) in the 25-35 MeV range, and CR21 in the 310-330 MeV range. That the AMIV fit should not be extended below 24 MeV was known to the authors and was indicated in their paper. One way they could achieve a good low energy fit would be to add the effective range contributions to their representation[24], as was done in the CR21 representation.

Data which give large χ^2 contributions to any one of the three representations are shown in Table III. Nearly half the high χ^2 contribution to YRB1(K_0) in the second energy range is seen to result from the 25.7 MeV measurements of A_{xx} and A_{yy}. Since these are determined primarily by the ^3P phase parameters, we compare these parameters to the other models in Table IV. It is seen that $^3P_0$ is high and $^1S_0$ is low both compared to the other models and to single-energy phase shift analyses at that energy. Again, a correlated adjustment of parameters should remove this difficulty.

V. CONCLUSION

Examination of the existing fits to the best proton-proton scattering data reveals discrepancies in the fits which should be taken account of in any application where these discrepancies are potentially important. If this paper encourages more care to be taken in applying these models in specific cases, we will have accomplished our purpose.

VI. ACKNOWLEDGMENTS

The calculations of χ^2 were carried out in the Computer Laboratory of Michigan State University. We wish to thank our many colleagues in the various accelerator laboratories who have helped us in the compilation and treatment of the data. Receipt of the manuscript of the article by Breit and Haracz on nucleon-nucleon scattering[16] prior to publication is gratefully acknowledged.

TABLE I. The goodness-of-fit parameter χ^2 for various model and phase shift representation predictions compared to 648 proton-proton scattering data in the energy range 9-330 MeV.

No.	Model	Year	Origin of Phases	$\chi^2/648$	Ref.
1	Livermore: AMIV	1966	table	1.38	15
2	Yale: YRB1(K_0)	1966	table	1.94	16
3	CR21	1964	parameters	2.08	2
4	Scotti-Wong-2-σ	1965	table	2.53	17
5	Scotti-Wong-2-$\pi\pi$	1965	table	2.70	17
6	Yale: YLAM	1960	table	2.77	19
7	Hamada-Johnston	1962	potential	3.08	20
8	HJM	1965	potential	3.73	21
9	Bryan-Scott ($+^1S_0$)	1964	table	3.90	23
10	Yale potential	1962	potential	3.91	22
11	Tabakin	1964	potential	28.	26
12	BGT	1958	potential	106.	14

TABLE II. χ^2 contributions from various data energy ranges, for the three leading representations. Each value quoted is χ^2 divided by the number of data in the energy range (Column 2).

Energy Range (MeV)	No. data	AMIV	YRB1(K_0)	CR21
9.68 - 20.0	38	4.34	1.09	1.28
25.62 - 36.9	40	0.93	6.25	1.97
39.4 - 69.5	118	1.84	2.12	1.80
70. - 122.	116	1.74	1.67	2.24
127. - 155.	210	1.37	1.50	2.12
210. - 276.	50	1.10	1.86	1.94
310. - 330.	76	1.26	1.46	2.68

TABLE III. Data with a χ^2 contribution of 20 or more for any one of the three leading representations.

Energy	Angle	Type	χ^2: AMIV	χ^2: YRB1(K_0)	χ^2: CR21
9.68	----	N_σ	38	10	17
25.7	90^o	A_{yy}	0	96	0
25.7	90	A_{xx}	0	39	1
34.2	90	σ	5	24	6
45.04	90	σ	4	48	8
49.7	45	P	8	12	23
50.02	90	σ	0	30	2
68.3	13.2	σ	22	5	0
70.	----	$\sigma_{int.}$	22	8	9
98.	----	N_P	21	22	27
108.	----	$\sigma_{int.}$	19	12	28
310.	6.5	σ_{rel}	1	1	22
315.	21.7	σ_{rel}	1	1	37

TABLE IV. Phase shifts at 27.6 MeV from the three leading models and an energy-independent phase shift analysis (EIPSA).

Model	$^1S_0$	$^3P_0$	$^3P_1$	$^3P_2$
AMIV	48.0	8.2	- 4.8	2.7
YRB1(K_0)	49.2	12.1	- 5.8	2.6
CR21	46.6	8.7	- 5.7	3.2
EIPSA[a]	48.6 ± .4	7.6 ± .6	- 4.1 ± .5	2.4 ± .2

[a] P. Signell, Phys. Rev. 139, B315 (1965).

References

1. P. Signell and N. R. Yoder, Phys. Rev. 132, 1707 (1963).
2. P. Signell and N. R. Yoder, Phys. Rev. 134, B100 (1964).
3. A preliminary version of this paper was presented at the New York Meeting of the American Physical Society in January, 1967 (N. R. Yoder and P. Signell, Bull. Am. Phys. Soc. 12, 50 (1967)); numerical results given here supercede that report.
4. Since this work was completed, work by both the Yale and the Livermore groups as reported at the Special Topics Conference on the Nucleon-Nucleon Interaction, Gainsville, Florida, March 23-25, 1967, is in much closer agreement with the data and with each other than any phase representation discussed in this paper. Also a new potential model was reported from La Jolla, and a new revision of the boundary condition model from M.I.T. For this recent work the reader should consult the abstracts in the Bull. Am. Phys. Soc. (in press) and the appropriate papers in the July 1967 issue of the Rev. Mod. Phys. (in press).
5. P. Signell, N. R. Yoder, and J. E. Matos, Phys. Rev. 135, B1128 (1964).
6. P. Signell and D. L. Marker, Phys. Rev. 134, B365 (1964).
7. F. Betz, J. Arens, O. Chamberlain, C. Schultz and G. Shapiro, Phys. Rev. 148, 1289 (1966); D. Fischer and G. Goldhaber, Phys. Rev. 95, 1350 (1954), as listed in W. N. Hess, Rev. Mod. Phys. 30, 368 (1958); Chamberlain, Pettengill, Segre and Wiegand, Phys. Rev. 93, 1424 (1954).
8. H. P. Noyes and H. M. Lipinski, SLAC-PUB-268; submitted to Phys. Rev.
9. L. H. Johnston and D. E. Young, Phys. Rev. 116, 989 (1959).
10. P. Catillon, M. Chapellier, and D. Garreta, Paper 6.3 presented at the Gatlinburg Conference, 1966.

11. H. P. Noyes, Phys. Rev. Letters 12, 171 (1964).

12. The actual data used are included as an Appendix to the Stanford Linear Accelerator Center preprint (SLAC-PUB-269) version of this paper.

13. As reported at Gainsville by Lomon (cf. Ref. 4), a new adjustment of the parameters of the boundary condition model (H. Feshbach, E. Lomon, and A. Tubis, Phys. Rev. Letters 6, 635 (1961)) gives a χ^2 value comparable to that obtained by the model of Scotti and Wong(17) against the same data table.

14. K. A. Brueckner, J. A. Gammel, and R. M. Thaler, Phys. Rev. 109, 1023 (1958).

15. R. A. Arndt and M. H. MacGregor, Phys. Rev. 141, 873 (1966) and private communication from R. A. Arndt to P. S. Signell.

16. G. Breit and R. D. Haracz, Vol. I, "High Energy Physics", Academic Press, Inc., New York, 1966 (in press). This fit was reported at the Dubna Conference on High Energy Physics in 1964, but not in a form which allowed direct numerical comparison with the data. We are indebted to G. Breit for kindly supplying us with copies of this manuscript prior to publication.

17. A. Scotti and D. Y. Wong, Phys. Rev. 138, B145 (1965).

18. L. Heller and M. Rich, Phys. Rev. 144, 1324 (1966). Scotti and Wong (17) used N/D equations for the amplitude $e^{i\delta}\sin\delta/\mathcal{C}^2 q$, but included only the coulomb modification of the left cut computed from coulomb plus OPE in the first Born approximation; this ignored the coulomb modification of the higher mass one-boson-exchange cuts. The effect of the latter modification has been estimated by the use of a single scalar boson exchange with constants adjusted to fit the low energy $^1S_0$ phase shift. The full coulomb modification shifts the chargeless value of the $^1S_0$ phase shift at 10 MeV by -2.5°, while the Scotti-Wong-type modification shifts it by -5.3°. We are indebted to L. Heller and M. Rich for the discussion and numbers in this footnote (private communication from L. Heller to P. Signell).

19. G. Breit, M. H. Hull, Jr., K. E. Lassila, and K. D. Pyatt, Jr., Phys. Rev. 120, 2227 (1960).

20. T. Hamada and I. D. Johnston, Nucl. Phys. 34, 382 (1962).

21. T. Hamada, Y. Nakamura, and R. Tamagaki, Prog. Theor. Phys. 33, 769 (1965).

22. K. E. Lassila, M. H. Hull, Jr., H. M. Ruppel, F. A. McDonald, and G. Breit, Phys. Rev. 126, 881 (1962).

23. R. A. Bryan and B. L. Scott, Phys. Rev. 135, B434 (1964).

24. This representation goes to the correct scattering length and effective range at low energy; it has now been published (R. A. Arndt and M. H. MacGregor, Phys. Rev. 154, 1549 (1967).

25. R. A. Bryan and R. A. Arndt, Phys. Rev. 150, 1299 (1966).

26. F. Tabakin, Ann. Phys. 30, 51 (1964).

27. J. A. Gammel and R. M. Thaler, Phys. Rev. 107, 291 (1957).

APPENDIX

PROTON-PROTON SCATTERING DATA USED IN THE COMPARISON

Since we used published values for the results of various scattering experiments, repeating them in a published paper is in a sense redundant, so this appendix will not be submitted to the Physical Review. However, as anyone who has tried to make a quantitative confrontation between 648 diverse pieces of data and any representation knows, the possibility for clerical error, differences in judgement, readjustment or renormalization due to communication with the experimenters, etc., etc., etc.... is enormous. The only safe course, we believe, is to present an exact photo-duplicated record of the numbers as they existed in the computer at the time the calculations were made. This is done below, with journal references (including data omitted and the reasons for omission). We trust the notations are obvious to anyone who will wish to use this tabulation.

As an example of the need for detailed examination of data tables we note two corrections to that given below which slipped by us up to the point of preparing the preprint. The corrected data were used in computing the numbers in the χ^2 tables, but have not been corrected in the table given below.

49.9 MeV polarization measurement at 45° (RUTHERFORD 1963). The error should be increased from 0.0017 to 0.0020 to account for the 3% absolute error not included in the smaller number.

95 MeV differential cross section measurement, set which includes measurement at 35° (HARVARD 1956D). The errors listed in the data set are, as quoted in Table VI of the Reference (Phys. Rev. 101, 1079 (1956)), about 1% due to counting statistics only, whereas the relative errors listed in Table VIII are 3.7%; the latter figure should obviously be used. On consultation with Richard Wilson, we find that a better value to use, according to the thesis on which the paper is based, would be 3.0%. The last value was not used in the calculations quoted above, but should have at most a trivial effect on the results.

PP DATA SET IV

9.68 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	54.600	0.650

9.69 MEV DIFF CS, MINNESOTA (1959)B

CM ANGLE	VALUE	STD DEV
NORM	1.0000	0.0073
10.026	854.900	22.000
12.031	400.200	5.300
14.035	219.200	2.000
16.041	138.800	1.000
18.046	95.800	0.710
20.051	75.500	0.560
22.055	64.400	0.480
24.060	58.100	0.430
26.064	54.700	0.410
28.069	53.100	0.390
30.074	51.800	0.380
32.079	51.800	0.380
34.083	51.400	0.380
36.087	51.000	0.380
38.091	51.700	0.380
40.096	51.400	0.380
44.103	52.600	0.390
50.113	53.100	0.390
54.120	53.200	0.390
60.128	53.900	0.400
64.133	54.050	0.400
70.139	54.100	0.400
76.144	54.400	0.400
80.145	54.400	0.400
86.148	54.300	0.400
89.852	54.600	0.400

9.73 MEV CS, BERKELEY (1954)D

10. MEV AYY, SACLAY (1965)

CM ANGLE	VALUE	STD DEV
90.000	-0.975	0.020

16.20 MEV POL, PRINCETON (1959)

CM ANGLE	VALUE	STD DEV
50.200	0.006	0.007

18.20 MEV DIFF CS, PRINCETON (1954)

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.015
30.000	25.000	0.370
36.000	25.980	0.390
40.000	26.500	0.310
50.000	27.270	0.280
60.000	27.420	0.240
70.000	27.470	0.200
80.000	27.290	0.200
90.000	27.320	0.200

20.00 MEV CNN, SACLAY (1962)

CM ANGLE	VALUE	STD DEV

90.000	-0.910	0.050

21.95 MEV ABS CS, RUTHERFORD HIGH ENERGY LAB (1964)A

25.62 MEV ABS CS, RUTHERFORD HIGH ENERGY LAB (1964)B

CM ANGLE	VALUE	STD DEV
90.000	18.300	0.109

25.63 MEV DIFF CS, MINNESOTA (1960)

CM ANGLE	VALUE	STD DEV
NORM	1.0000	0.0093
10.070	109.600	2.900
12.080	56.310	0.920
14.090	33.200	0.300
16.110	23.760	0.180
18.120	19.900	0.150
19.130	18.700	0.140
20.130	17.980	0.130
22.150	17.330	0.130
24.160	17.090	0.130
25.160	17.160	0.130
26.170	17.170	0.130
28.180	17.300	0.130
30.190	17.430	0.130
32.210	17.680	0.130
34.220	17.800	0.130
36.230	17.930	0.130
40.250	18.200	0.140
44.270	18.330	0.140
50.300	18.520	0.140
60.340	18.560	0.140
70.370	18.650	0.140
80.380	18.600	0.140
89.610	18.590	0.140

25.7 MEV AYY, SACLAY (1965)

CM ANGLE	VALUE	STD DEV
90.000	-0.725	0.020

25.7 MEV AXX, SACLAY (1965)

CM ANGLE	VALUE	STD DEV
90.000	-0.920	0.020

27.05 CNN, LOS ALAMOS (1966)

CM ANGLE	VALUE	STD DEV
90.000	-0.689	0.070

27.4 MEV POL, HARWELL (1963)A

27.6 MEV R, RUTHERFORD HIGH ENERGY LAB (1965)A

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.030
23.200	-0.324	0.063
39.000	-0.187	0.030
54.600	-0.243	0.026

27.6 MEV A, RUTHERFORD HIGH ENERGY LAB (1965)A

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.030
23.200	0.012	0.030
39.000	0.037	0.025

54.600	0.090	0.022

28.16 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	16.270	0.310

30.00 MEV POL, RUTHERFORD HIGH ENERGY LAB (1963)

CM ANGLE	VALUE	STD DEV
45.000	-0.0004	0.0033

30.33 MEV ABS CS, RUTHERFORD HIGH ENERGY LAB (1964)B

CM ANGLE	VALUE	STD DEV
90.000	15.010	0.090

31.15 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	14.680	0.220

34.20 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	13.360	0.200

34.27 MEV ABS CS, RUTHERFORD HIGH ENERGY LAB (1964)B

CM ANGLE	VALUE	STD DEV
90.000	12.820	0.077

36.8 MEV POL, HARWELL (1963)A

36.90 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	12.140	0.180

38.3 MEV POL, HARWELL (1963)A

39.40 MEV DIFF CS, MINNESOTA (1958)

CM ANGLE	VALUE	STD DEV
NORM	1.0000	0.0093
8.080	103.800	6.200
10.100	40.850	1.030
12.120	20.630	0.280
14.150	13.500	0.120
16.170	10.870	0.081
17.180	10.260	0.076
18.180	10.010	0.074
19.200	9.980	0.074
20.200	9.790	0.073
21.220	9.820	0.073
22.230	9.850	0.073
23.230	9.930	0.074
24.250	9.940	0.074
25.250	10.070	0.075
27.270	10.270	0.076
30.300	10.520	0.078
36.350	10.750	0.080
40.380	10.860	0.081
44.420	10.980	0.081
50.450	11.100	0.082
56.500	11.130	0.083
60.520	11.160	0.083
64.530	11.180	0.083
70.570	11.170	0.083

76.580	11.180	0.083
80.580	11.160	0.083
89.400	11.160	0.083

39.6 MEV ABS CS, MINESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	11.190	0.170

40.75 MEV ABS CS, RUTHERFORD HIGH ENERGY LAB (1964)B

CM ANGLE	VALUE	STD DEV
90.000	10.540	0.064

41.0 MEV ABS CS, HARVARD (1956)

CM ANGLE	VALUE	STD DEV
90.000	11.400	0.800

44.66 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	9.510	0.160

45.04 MEV ABS CS, RUTHERFORD HIGH ENERGY LAB (1964)B

CM ANGLE	VALUE	STD DEV
90.000	9.270	0.054

46.0 MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
45.500	0.011	0.012

47.5 MEV A, RUTHERFORD HIGH ENERGY LAB (1965)

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.050
23.500	-0.061	0.031
39.000	-0.011	0.034
54.700	-0.009	0.025
71.300	0.088	0.027
87.100	0.166	0.022

47.8 MEV R, RUTHERFORD HIGH ENERGY LAB (1965)A

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.050
23.500	-0.318	0.046
39.000	-0.327	0.044
54.700	-0.367	0.031
71.300	-0.435	0.032
87.100	-0.488	0.033

47.8 MEV A, RUTHERFORD HIGH ENERGY LAB (1965)A

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.050
23.500	0.017	0.044
39.000	-0.001	0.038
54.700	-0.000	0.033
71.300	0.084	0.029
87.100	0.223	0.028

49.7 MEV POL, HARWELL (1963)B

CM ANGLE	VALUE	STD DEV
45.000	0.0207	0.0033

49.9 MEV POL, RUTHERFORD HIGH ENERGY LAB (1963)

CM ANGLE	VALUE	STD DEV

45.000	0.0316	0.0017

50.00 MEV D, HARWELL (1963)C

CM ANGLE	VALUE	STD DEV
70.000	-0.241	0.075

50.02 MEV ABS CS, RUTHERFORD HIGH ENERGY LAB (1964)B

CM ANGLE	VALUE	STD DEV
90.000	8.340	0.049

50.17 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	8.400	0.140

51.5 MEV DIFF CS, INSTITUTE OF NUCLEAR SCIENCE (1961)A

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.045
16.200	6.700	0.470
17.200	6.400	0.290
18.200	6.400	0.250
20.300	6.500	0.260
22.300	6.600	0.270
24.300	7.000	0.270
26.300	7.100	0.280
30.400	7.700	0.150
35.500	7.700	0.150

51.7 MEV POL, HARWELL (1963)B

CM ANGLE	VALUE	STD DEV
60.000	0.0364	0.0089

51.8 MEV DIFF CS, INSTITUTE OF NUCLEAR SCIENCE (1961)B

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.025
35.500	7.700	0.150
40.500	7.900	0.160
45.500	7.600	0.150
50.600	7.900	0.160
55.600	7.700	0.150
60.700	7.800	0.160
70.700	7.600	0.150
80.800	8.000	0.160
90.800	8.000	0.160

52.0 MEV CS, HARVARD (1956)A

52.0 MEV CNP, INSTITUTE OF NUCLEAR SCIENCE (1963)

CM ANGLE	VALUE	STD DEV
90.000	-0.034	0.095

52.0 MEV CKP, INSTITUTE OF NUCLEAR SCIENCE (1963)

CM ANGLE	VALUE	STD DEV
90.000	0.130	0.110

53.2 MEV POL, HARWELL (1963)B

CM ANGLE	VALUE	STD DEV
75.000	0.0075	0.0077

56.00 MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
45.600	0.043	0.006

56.15 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	7.450	0.120

58.5 MEV POL, HARWELL (1963)B

CM ANGLE	VALUE	STD DEV
45.000	0.0384	0.0098

61.92 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	6.760	0.110

66.0 MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
NORM	0.933	0.028
20.400	0.050	0.014
25.500	0.047	0.009
30.500	0.077	0.010
35.600	0.078	0.008
40.700	0.062	0.008
45.700	0.069	0.008
50.800	0.067	0.008
55.900	0.059	0.008
60.900	0.058	0.007
65.900	0.053	0.007
71.000	0.038	0.007

68.3 MEV DIFF CS, MINNESOTA 1960)A

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.011
10.180	12.840	0.320
12.210	7.050	0.094
13.230	6.140	0.073
14.250	5.530	0.049
16.280	5.190	0.038
18.320	5.230	0.039
20.350	5.500	0.041
22.390	5.660	0.042
24.420	5.810	0.043
26.450	5.940	0.044
28.480	6.110	0.045
30.520	6.230	0.046
32.550	6.280	0.047
34.580	6.330	0.047
36.610	6.300	0.047
40.660	6.340	0.047
44.720	6.300	0.047
50.790	6.320	0.047
54.830	6.300	0.047
60.890	6.340	0.047
64.920	6.290	0.047
70.970	6.210	0.046
74.980	6.160	0.046
78.990	6.160	0.046
81.010	6.170	0.046
88.980	6.160	0.046

68.42 MEV ABS CS, MINNESOTA (1959)A

CM ANGLE	VALUE	STD DEV
90.000	6.130	0.100

69.5 MEV ABS CS, HARVARD (1956)

CM ANGLE	VALUE	STD DEV
90.000	5.960	0.360

70.0 MEV POL, HARWELL (1963)B

CM ANGLE	VALUE	STD DEV
45.000	0.0579	0.0058

70.0 MEV INT CS, HARVARD (1964)

CM ANGLE	VALUE	STD DEV
12.100	38.510	0.480
90.000		

71.0 MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
45.800	0.063	0.008

78.0 MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
45.800	0.088	0.007

78.5 MEV ABS CS, HARVARD (1956)B

CM ANGLE	VALUE	STD DEV
90.000	5.400	0.320

86.0 MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
45.900	0.097	0.007

91. MEV INT CS, HARVARD (1964)

95. MEV REL CS, HARVARD (1956)C

CM ANGLE	VALUE	STD DEV
40.000	4.930	0.180
50.000	4.810	0.170
60.000	4.810	0.170
70.000	4.680	0.170
80.000	4.530	0.160
90.000	4.540	0.160

95. MEV REL CS, HARVARD (1956)D

CM ANGLE	VALUE	STD DEV
30.000	4.860	0.030
35.000	4.870	0.040
40.000	4.910	0.040
80.000	4.620	0.030
90.000	4.650	0.060

95. MEV ABS CS, HARVARD (1956)E

CM ANGLE	VALUE	STD DEV
90.000	4.650	0.250

95. MEV REL CS, HARVARD (1958)A

CM ANGLE	VALUE	STD DEV
25.700	4.511	0.080
30.700	4.709	0.080
35.800	4.771	0.080
40.900	4.678	0.080
46.000	4.740	0.080
51.100	4.740	0.080

56.200	4.660	0.080
61.200	4.638	0.080
66.300	4.629	0.080
71.300	4.608	0.080
76.400	4.581	0.080
81.400	4.511	0.080
86.400	4.458	0.080

95. MEV POL, HARVARD (1958)B

CM ANGLE	VALUE	STD DEV
NORM	0.933	0.028
20.600	0.092	0.010
25.700	0.111	0.008
30.700	0.130	0.007
35.800	0.131	0.007
40.900	0.112	0.007
46.000	0.126	0.007
51.100	0.115	0.007
56.200	0.096	0.007
61.200	0.099	0.007
66.300	0.087	0.007
71.300	0.069	0.008
76.400	0.058	0.007
81.400	0.038	0.007
86.400	0.023	0.007

97. MEV POL, HARWELL (1963)B

CM ANGLE	VALUE	STD DEV
45.000	0.1114	0.0053

98. MEV REL CS, HARWELL (1960)

CM ANGLE	VALUE	STD DEV
25.600	4.050	0.100
40.900	4.470	0.100
51.100	4.460	0.100
61.300	4.450	0.100
71.400	4.460	0.100
81.400	4.390	0.100

98. MEV POL, HARWELL (1960)A

CM ANGLE	VALUE	STD DEV
NORM	0.911	0.020
10.200	0.029	0.031
12.300	-0.004	0.033
14.300	0.024	0.039
16.400	0.085	0.035
18.500	0.123	0.035
20.500	0.110	0.019
22.600	0.104	0.018
25.600	0.113	0.015
30.700	0.125	0.013
40.900	0.121	0.010
51.100	0.105	0.010
61.300	0.107	0.015
71.400	0.073	0.012
81.400	0.043	0.011

98. MEV D, HARVARD (1960)

CM ANGLE	VALUE	STD DEV
20.500	0.000	0.080
30.700	0.000	0.070

40,900	0,000	0.080
51.100	-0,120	0.100
61.300	-0,110	0,160

98. MEV R, HARWELL (1965)

CM ANGLE	VALUE	STD DEV
31,300	-0,220	0.110
41,600	-0,400	0,100
51,700	-0,390	0.090
61,900	-0,120	0.130
72,000	-0,180	0.200

98. MEV RPR, HARWELL (1965)

CM ANGLE	VALUE	STD DEV	
31,600	0,260	0,140	CHI= 44,60
41,900	0,180	0.110	CHI= 44,40
52,000	0,210	0.110	CHI= 44,50
62.600	0.270	0.180	CHI= 43,90

102. MEV REL CS, HARVARD (1958)C

CM ANGLE	VALUE	STD DEV
30.800	4,500	0,080
46,100	4,500	0,080
66.400	4,620	0,080

102. MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
NORM	0,933	0,028
30,800	0,136	0,008
46.100	0,149	0,007
66.400	0,102	0,007

107. MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
NORM	0,933	0,028
30.800	0,157	0,009
46,100	0,131	0,007
66.500	0,103	0,007

108. MEV INT CS, HARVARD (1964)

CM ANGLE	VALUE	STD DEV
12.220	28,250	0,290
90,000		

118. MEV REL CS, HARVARD (1958)C

CM ANGLE	VALUE	STD DEV
20.600	3,630	0,060
25.800	3,990	0,060
30.900	4,070	0,060
36.000	4,130	0,060
41.100	4,120	0,060
46,200	4,080	0,060
51.400	4,050	0,060
56.500	4,040	0,060
61.500	3,920	0,060
66.600	3,970	0,060
71.700	3,910	0,060
76.700	4,020	0,060
81.700	4,000	0,060
83.300	3,970	0,060
86.800	4,110	0,060

88.200	4.020	0.060

118. MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
NORM	0.933	0.028
20.600	0.112	0.010
25.800	0.146	0.010
30.900	0.152	0.008
36.000	0.173	0.008
41.100	0.170	0.008
46.200	0.149	0.007
51.400	0.169	0.007
56.500	0.134	0.007
61.500	0.126	0.008
66.600	0.110	0.008
71.700	0.108	0.008
76.700	0.080	0.008
81.700	0.038	0.008
83.300	0.028	0.009
86.800	0.029	0.009

122. MEV INT CS, HARVARD (1964)

CM ANGLE	VALUE	STD DEV
12.260	25.850	0.210
90.000		

127. MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
NORM	0.933	0.028
31.000	0.193	0.008
46.300	0.187	0.007
66.700	0.104	0.008

134. MEV INT CS, HARVARD (1964)

CM ANGLE	VALUE	STD DEV
12.300	24.890	0.220
90.000		

137. MEV POL, HARVARD (1958)

CM ANGLE	VALUE	STD DEV
NORM	0.933	0.028
31.100	0.195	0.005
46.400	0.212	0.007
66.900	0.133	0.008

137.5 MEV RP, HARVARD (1963)

CM ANGLE	VALUE	STD DEV
43.000	0.562	0.052
52.500	0.472	0.054
62.000	0.376	0.068
72.500	0.238	0.084
82.100	0.251	0.121

138.0 MEV POL, ORSAY (1963)

138. MEV D, ORSAY (1963)A

CM ANGLE	VALUE	STD DEV
31.000	0.130	0.030
41.300	0.190	0.060
61.400	0.230	0.130
82.000	0.360	0.200

139.0 MEV A, HARVARD (1963)A

CM ANGLE	VALUE	STD DEV
NORM	1,000	0,040
31,100	-0,368	0,029
41,400	-0,344	0,029
51,700	-0,311	0,033
61,900	-0,231	0,046
72,000	-0,187	0,055
82,100	-0,099	0,079

140, MEV CNN, HARWELL (1965)A

CM ANGLE	VALUE	STD DEV
NORM	0,900	0,050
60,000	0,880	0,030
90,000	1,00000	0,00001

140.4 MEV RPR, HARWELL (1964)

CM ANGLE	VALUE	STD DEV	
31,400	0,306	0,026	CHI= 45,50
41,700	0,264	0,033	CHI= 45,60
52,000	0,190	0,039	CHI= 45,60
61,800	0,101	0,032	CHI= 46,10
72,100	0,208	0,048	CHI= 45,80
82,200	0,035	0,077	CHI= 45,90

140.5 MEV R, HARVARD (1960)A

CM ANGLE	VALUE	STD DEV
31,100	-0,252	0,030
41,400	-0,227	0,028
51,700	-0,271	0,035
61,900	-0,146	0,037
72,000	-0,151	0,055
82,100	-0,047	0,080

140.7 MEV POL, HARWELL (1966)

CM ANGLE	VALUE	STD DEV
NORM	1,0000	0,0085
16,600	0,1657	0,0091
18,700	0,1672	0,0089
20,700	0,177	0,007
25,900	0,1896	0,0044
31,100	0,2114	0,0049
36,200	0,2057	0,0047
41,400	0,2089	0,0025
46,500	0,2006	0,0032
51,600	0,1981	0,0028
56,800	0,183	0,003
61,900	0,1564	0,0032
66,900	0,1316	0,0032
72,000	0,1068	0,0032
73,000	0,0977	0,0034
77,100	0,081	0,003
77,900	0,0718	0,0034
82,100	0,0532	0,0034
82,900	0,0466	0,0036
87,100	0,0157	0,0034
87,900	0,0144	0,0034

142.0 MEV CS, HARWELL (1960)B

142.0 MEV POL, HARWELL (1960)C

CM ANGLE	VALUE	STD DEV
NORM	0,911	0.020
5,190	-0,037	0.034
8.300	0,031	0.024
9.340	0,089	0.023
10,380	0,107	0,021
10,380	0,153	0.035
12,460	0,130	0.033
14,530	0,180	0.031
16,610	0,155	0.028
20,760	0,189	0,009
24.800	0,216	0.037
25,950	0,225	0.011
31,060	0,241	0,010
37,200	0,283	0,030
41,340	0,238	0,010
45,450	0,242	0,005
49,550	0,240	0,004
51,620	0,229	0,006
53,650	0,213	0,004
57.700	0,205	0,006
59.750	0,197	0,005
61,840	0,183	0,005
65,900	0,170	0,005
69,950	0,141	0,005
71,980	0,118	0,005
74,050	0,097	0,006
82,060	0,060	0,009
82,100	0,051	0,015

142.0 MEV D, HARVARD (1960)B

CM ANGLE	VALUE	STD DEV
12,460	-0,262	0,063
20,760	-0,008	0,038
31,060	0,137	0,033
41.340	0,156	0,031
51,620	0,178	0,033
61,840	0,076	0,031
71,980	0,147	0.070
82.060	0,286	0,099

142.0 MEV R, HARWELL (1960)D

CM ANGLE	VALUE	STD DEV
24,000	-0,224	0,051
32,700	-0,203	0,051
45,700	-0,178	0,031
54,400	-0,212	0.042
67,200	-0,213	0.040
76,100	-0,147	0.063
84,000	-0,142	0.136
90,000	0,110	0,131

143.0 MEV D, HARWELL (1961)

CM ANGLE	VALUE	STD DEV
31,100	0,082	0.077
41,400	0,162	0,040
51,700	0,110	0,050
61,900	0,045	0,060
72,000	0,019	0,100

82.100	-0.037	0.133
92.200	-0.027	0.170

143.0 MEV A, HARWELL (1963)D

CM ANGLE	VALUE	STD DEV
32.200	-0.405	0.032
43.200	-0.377	0.037
54.600	-0.342	0.050
65.000	-0.355	0.075
74.300	-0.198	0.079
84.800	0.022	0.154

144.1 MEV DIFF CS, HARWELL (1966)

CM ANGLE	VALUE	STD DEV
NORM	1.0000	0.0088
16.600	3.574	0.029
18.700	3.703	0.032
20.700	3.779	0.026
25.900	3.940	0.023
31.100	4.041	0.024
36.200	4.018	0.018

144.1 MEV DIFF CS, HARWELL (1966)

CM ANGLE	VALUE	STD DEV
NORM	1.0000	0.0056
41.400	4.014	0.013
46.500	4.019	0.014
51.600	3.977	0.012
56.800	3.944	0.011
61.900	3.914	0.011
66.900	3.907	0.015
68.000	3.859	0.017
72.000	3.880	0.014
73.000	3.850	0.018
77.100	3.875	0.015
77.900	3.838	0.017
82.100	3.813	0.014
82.900	3.837	0.016
87.100	3.819	0.016
87.900	3.833	0.015

147.0 MEV RFL CS, HARVARD (1958)D

CM ANGLE	VALUE	STD DEV
12.400	3.790	0.100
14.500	3.880	0.100
16.600	4.020	0.100
18.700	4.030	0.100
20.700	4.150	0.100
22.800	4.140	0.110
24.900	4.260	0.110
31.100	4.220	0.110

147.0 MEV RFL CS, HARVARD (1958)D

CM ANGLE	VALUE	STD DEV
20.700	4.170	0.080
25.900	4.290	0.080
31.100	4.390	0.080
36.300	4.310	0.080
41.400	4.210	0.040
46.500	4.210	0.040
51.700	4.160	0.040

56.800	4.140	0.040
61.900	4.120	0.040
67.000	4.120	0.040
68.000	4.090	0.050
72.000	4.070	0.040
72.900	4.140	0.050
77.100	4.060	0.050
77.900	4.120	0.050
82.100	4.070	0.050
82.900	4.130	0.050
87.200	4.110	0.050
87.600	4.120	0.050

147.0 MEV INT CS, HARVARD (1964)

CM ANGLE	VALUE	STD DEV
12.360	23.690	0.150
90.000		

147.0 MEV POL, HARVARD (1958)E

CM ANGLE	VALUE	STD DEV
NORM	0.933	0.028
6.200	-0.004	0.014
8.340	0.045	0.014
10.400	0.103	0.014
12.400	0.126	0.011
14.500	0.155	0.014
16.600	0.180	0.010
18.700	0.193	0.015
20.700	0.198	0.009
22.800	0.183	0.015
24.900	0.227	0.014
25.900	0.203	0.011
31.100	0.228	0.009
36.300	0.247	0.011
41.400	0.239	0.006
46.500	0.233	0.006
51.700	0.229	0.006
56.800	0.205	0.006
61.900	0.171	0.006
67.000	0.154	0.006
68.000	0.144	0.009
72.000	0.131	0.006
72.900	0.109	0.008
77.100	0.098	0.006
77.900	0.068	0.008
82.100	0.052	0.008
82.900	0.041	0.007
87.200	0.030	0.008
87.800	0.006	0.009

155. MEV DIFF CS, ORSAY (1961)

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.040
10.400	3.950	0.090
12.500	3.370	0.090
14.500	3.300	0.130
16.600	3.350	0.130
18.700	3.490	0.140
20.800	3.660	0.140
22.900	3.870	0.070
25.000	3.580	0.060

26.000	3,620	0.060
27.000	3,840	0.060
29.000	3,750	0.060
31.100	3,870	0.050
35.500	3,850	0.050
37.300	3,740	0.090
41.500	3,880	0.050
46.600	3,830	0.050
51.700	3,820	0.050
62.000	3,700	0.040
68.000	3,760	0.050
72.000	3,710	0.040
77.800	3,750	0.050
82.200	3,670	0.040
89.800	3,710	0.060

210. MEV POL, ROCHESTER (1961)

CM ANGLE	VALUE	STD DEV
NORM	1,000	0.022
30.000	0,312	0.006
40.000	0,3190	0.0085
50.000	0,3030	0.0075
60.000	0,240	0.006
70.000	0,163	0.007
80.000	0,084	0.007

213. MEV REL CS, ROCHESTER (1961)A

CM ANGLE	VALUE	STD DEV
30.000	3,800	0.106
40.000	3,833	0.046
50.000	3,740	0.041
60.000	3,648	0.038
70.000	3,665	0.035
80.000	3,662	0.031
90.000	3,615	0.035

213. MEV D, ROCHESTER (1962)

CM ANGLE	VALUE	STD DEV
30.000	0,200	0.016
40.000	0,232	0.026
50.000	0,240	0.018
60.000	0,319	0.021
70.000	0,297	0.030
80.000	0,360	0.070
90.000	0,500	0.180

213. MEV R, ROCHESTER (1961)C

CM ANGLE	VALUE	STD DEV
30.000	-0,203	0.012
40.000	-0,133	0.017
50.000	-0,041	0.018
60.000	0,071	0.026
70.000	0,147	0.029
80.000	0,248	0.042
90.000	0,223	0.055

213. MEV AR, ROCHESTER (1961)D

CM ANGLE	VALUE	STD DEV	
30.000	-0,449	0.016	CHI= 63,30
40.000	-0,343	0.015	CHI= 63,30
50.000	-0,202	0.017	CHI= 63,30

60.000	-0.059	0.018	CHI= 63.30
70.000	0.053	0.029	CHI= 63.30
80.000	0.032	0.036	CHI= 63.30

213. MEV RPP, ROCHESTER (1964)

CM ANGLE	VALUE	STD DEV	
30.000	0.331	0.021	CHI= 61.22
40.000	0.277	0.019	CHI= 61.13
50.000	0.135	0.017	CHI= 61.07
80.000	-0.307	0.053	CHI=121.87
90.000	-0.406	0.082	CHI=122.82

217. MEV POL, ROCHESTER (1961)B

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.022
60.000	0.246	0.008
60.000	0.218	0.010
70.000	0.153	0.008
70.000	0.153	0.009
80.000	0.079	0.008
80.000	0.090	0.009

225. MEV INT CS, BERKELEY (1954)

CM ANGLE	VALUE	STD DEV
18.000	21.300	0.700
90.000		

276. MEV POL, BERLELEY (1957)

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.075
19.300	0.314	0.028
27.800	0.324	0.033
32.000	0.329	0.013
49.900	0.295	0.016
63.400	0.251	0.016
76.800	0.122	0.019

310. MEV D, BERKELEY (1957)A

CM ANGLE	VALUE	STD DEV
23.100	0.245	0.079
25.800	0.299	0.055
36.500	0.456	0.081
52.000	0.533	0.060
65.200	0.503	0.048
80.500	0.472	0.063

310. MEV R, BERKELEY (1957)A

CM ANGLE	VALUE	STD DEV
22.400	-0.324	0.139
34.400	-0.167	0.080
41.800	0.104	0.071
54.100	0.287	0.052
70.900	0.310	0.072
80.100	0.576	0.087

310. MEV REL CS, BERKELEY (1954)A

CM ANGLE	VALUE	STD DEV
6.500	10.710	0.740
7.600	7.460	0.580
8.700	4.850	0.370
11.000	4.420	0.270

13.000	4.130	0.200
17.300	3.880	0.170
21.700	3.750	0.180

310. MEV POL, BERKELEY (1954)B

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.043
6.500	-0.210	0.270
7.600	0.110	0.280
8.700	0.020	0.130
11.000	0.190	0.070
13.000	0.250	0.050
17.300	0.250	0.040
21.700	0.370	0.040

315. MEV REL CS, BERKELEY (1957)A

CM ANGLE	VALUE	STD DEV
21.600	3.640	0.060
32.300	3.600	0.070
42.900	3.750	0.050
53.400	3.680	0.070
63.900	3.650	0.070
76.200	3.700	0.070
89.400	3.600	0.070

315. MEV POL, BERKELEY (1957)

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.040
21.600	0.305	0.020
32.300	0.378	0.022
42.900	0.379	0.013
53.400	0.303	0.022
63.900	0.251	0.025
76.200	0.142	0.025

315. MEV CNN, DUBNA (1964)A

CM ANGLE	VALUE	STD DEV
90.000	0.760	0.150

315. MEV CNN, DUBNA (1965)

CM ANGLE	VALUE	STD DEV
45.000	0.900	0.510

315. MEV CKP, DUBNA (1965)

CM ANGLE	VALUE	STD DEV
45.000	0.740	0.510

316. MEV A, BERKELEY (1956)

CM ANGLE	VALUE	STD DEV
25.400	-0.339	0.064
51.400	0.007	0.045
76.300	0.236	0.050

320. MEV CNN, LIVERPOOL (1961)

CM ANGLE	VALUE	STD DEV
90.000	0.770	0.110

328 MEV POL, BERKELEY (1964)

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.062
49.100	0.389	0.045

52.200	0.349	0.031
55.300	0.324	0.025
58.400	0.317	0.022
61.600	0.255	0.020
64.800	0.256	0.027
68.100	0.191	0.024
71.400	0.165	0.023
74.700	0.187	0.023
79.400	0.094	0.027
83.500	0.054	0.024
85.300	0.163	0.035
87.400	0.008	0.025
88.900	0.016	0.027

330. MEV DIFF CS, BERKELEY (1954)C

CM ANGLE	VALUE	STD DEV
NORM	1.000	0.100
6.520	8.590	0.820
7.280	6.340	0.610
8.570	4.150	0.330
9.200	3.620	0.310
10.160	3.290	0.330
11.120	4.560	0.250
11.430	3.140	0.360
12.930	3.450	0.310
14.800	3.490	0.290
16.770	3.580	0.230
18.630	3.440	0.270
20.870	4.020	0.240
22.800	3.620	0.290
24.270	3.750	0.310
26.030	3.660	0.310
27.570	3.630	0.350
29.700	3.810	0.350

330. MEV INT CS, BERKELEY (1954)

CM ANGLE	VALUE	STD DEV
18.000	22.240	0.700
90.000		

345. MEV DIFF CS, BERKELEY (1951)

REFERENCES AND COMMENTS

BERKELEY (1951), CHAMBERLAIN ET AL, PR 83, 923 (1951)
DROPPED BECAUSE OF ABNORMALLY HIGH CHI SQUARED IN PHASE SHIFT ANALYSES

BERKELEY (1954), CHAMBERLAIN ET AL, PR 93, 1424 (1954)

BERKELEY (1954)A, CHAMBERLAIN ET AL, PR 95, 1348 (1954)

BERKELEY (1954)B, CHAMBERLAIN ET AL, PR 95, 1348 (1954)
NORMALIZATION FROM PR 105, 288 (1957)

BERKELEY (1954)C, FISCHER ET AL, PR 95, 1350 (1954) (GRAPH ONLY)
DATA FROM HESS, RMP 30, 368 (1958)
REMOVED 330 MEV DIFF CS BELOW 6.0 DEG (3) / BECAUSE OF COULOMB EFFECTS

BERKELEY (1954)D, CORK ET AL, PR 94, 1300 (1954)
IMPOSSIBLE TO FIT. VARIES TOO FAST WITH ANGLE

BERKELEY (1956), SIMMONS, PR 104, 416 (1956)

BERKELEY (1957), CHAMBERLAIN, PR 105, 288 (1957)
WILSON HAS ABSOLUTE ERRORS MARKED AS RELATIVE

BERKELEY (1957)A, CHAMBERLAIN, PR 105, 288 (1957)

BERKELEY (1964), BETZ, THESIS, UCRL-11565
NORMALIZATION ERROR GIVEN AS +0.065 -0.058 IN ORIGINAL PAPER

DUBNA (1964)A, VASILEVSKY ET AL, SOVIET PHYSICS, JETP 18, 327 (1964)

DUBNA (1965), KAZARINOV ET AL, SOVIET PHYSICS, JETP 20, 565 (1965)

HARVARD (1956), KRUSE ET AL, PR 101, 1079 (1956)
WILSON HAS 3 PER CENT ABSOLUTE ERROR

HARVARD (1956)A, KRUSE ET AL, PR 101, 1079 (1956)
REMOVED BECAUSE ERROR IS MUCH GREATER THAN FOR NEARBY MINN, AND RHEL DATA

HARVARD (1956)B, KRUSE ET AL, PR 101, 1079 (1956)

HARVARD (1956)C, KRUSE ET AL, PR 101, 1079 (1956)
TABLE III, HYDROCARBON TARGET
WILSON (IN HIS BOOK) HAS CS NORM=0.03
WILSON (IN HIS BOOK) HAS COMBINED THE HYDROCARBON AND LIQUID HYDROGEN RUNS

HARVARD (1956)D, KRUSE ET AL, PR 101, 1079 (1956)
TABLE VI, LIQUID HYDROGEN TARGET
WILSON (IN HIS BOOK) HAS COMBINED THE HYDROCARBON AND LIQUID HYDROGEN RUNS
WE HAVE NOT USED CS(25.) (MULTIPLE SCATTERING)

HARVARD (1956)E, KRUSE ET AL, PR 101, 1079 (1956)

HARVARD (1958), PALMIERI ET AL, AP 5, 299 (1958)
RENORMALIZED AS RECOMMENDED IN PREPRINT FROM JARVIS AND ROSE

HARVARD (1958)A, PALMIERI ET AL, AP 5, 299 (1958)
WILSON (IN HIS BOOK) HAS WITHDRAWN CS NORM
WE HAVE REMOVED CS(20.6) DUE TO CORMACKS MULTIPLE SCATTERING CALCULATION

HARVARD (1958)B, PALMIERI ET AL, AP 5, 299 (1958)
RENORMALIZED AS RECOMMENDED IN PREPRINT FROM JARVIS AND ROSE
POL NORM ERROR IS FROM WILSONS BOOK

HARVARD (1958)C, PALMIERI ET AL, AP 5, 299 (1958)

HARVARD (1958)D, PALMIERI ET AL, AP 5, 299 (1958)
WILSON (IN HIS BOOK) HAS WITHDRAWN ALL CS NORMS AND CS(4.13) AND POL(4.13)
WILSON (IN HIS BOOK) HAS RAISED ALL OF THE LOW ANGLE CS DATA BY 1.04, AND HAS LOWERED ALL OF THE ASSOCIATED ERRORS BY 0.01 EXCEPT FOR CS(6.2)
THE FIRST IS IN VAIN, SINCE CS NORM = 0
H1 AND H8 WERE COMBINED FOR CS
CS(6.2), CS(8.34), CS(10.4), REMOVED BY US BECAUSE OF CORMACKS MULTIPLE SCATTERING CALCULATION

HARVARD (1958)E, PALMIERI ET AL, AP 5, 299 (1958)
RENORMALIZED AND NORMALIZATION ERROR CHANGED AS RECOMMENDED IN PRIVATE COMMUNICATION FROM WILSON AND PALMIERI
H1, H8, AND H14 WERE COMBINED FOR POL
WILSON (IN HIS BOOK) HAS 0.104 FOR POL(68.)

HARVARD (1960), THORNDIKE, PR 119, 362 (1960)

HARVARD (1960)A, THORNDIKE, PR 120, 1819 (1960)

HARVARD (1960)B, HWANG, PR 119, 352 (1960)

HARVARD (1963), HEE, PR 132, 2236 (1963)

HARVARD (1963)A, HEE, PR 132, 744 (1963)
DATA CONTAINS SYSTEMATIC ERROR OF 4 PERCENT SAY AUTHORS
WILSONS BOOK HAS SLIGHTLY DIFFERENT ERRORS

HARVARD (1964), PALMIERI, NP 55, 463 (1964)
REMOVED 91 MEV INT CS / EXPERIMENTALISTS SAY IT IS OUT OF LINE

HARWELL (1960), TAYLOR ET AL, NP 16, 320 (1960)
CS NORM (ST. DEV. = 0.05) AND CS(30.7) REMOVED BECAUSE OF LARGE CHI SQUARED IN 95 MEV ENERGY INDEPENDENT PHASE SHIFT ANALYSIS

HARWELL (1960)A, TAYLOR ET AL, NP 16, 320 (1960)
RENORMALIZED AS RECOMMENDED IN PREPRINT FROM JARVIS AND ROSE

HARWELL (1960)B, TAYLOR ET AL, NP 16, 320 (1960)
REJECTED-- SEE PR 134B, 365 (1964)

HARWELL (1960)C, TAYLOR ET AL, NP 16, 320 (1960)
RENORMALIZED AS RECOMMENDED IN PREPRINT FROM JARVIS AND ROSE
POL HAS BEEN OBTAINED BY COMBINING TWO RUNS
WILSON HAS 0.05 FOR POL NORM IN HIS BOOK
WILSON HAS 0.11 FOR THE ERROR ON POL(82.06) IN HIS BOOK
6.23 DEGREE DATUM REMOVED BECAUSE OF ABNORMALLY LARGE CHI SQUARED IN PHASE SHIFT ANALYSIS
REMOVED 142 MEV REL POL AT 78 DEG / NOT FIT BY PHASE ANALYSIS

HARWELL (1960)D, BIRD, PRL 4, 302 (1960)

HARWELL (1961), BIRD, NP 27, 586 (1961)
CM ANGLES CORRECTED BY US

HARWELL (1963)A, CHRISTMAS AND TAYLOR, NP 41, 388 (1963)
REMOVED BECAUSE OF EXCESSIVE ENERGY SPREAD

HARWELL (1963)B, CHRISTMAS AND TAYLOR, NP 41, 388 (1963)
RENORMALIZED AS RECOMMENDED IN PREPRINT FROM JARVIS AND ROSE

HARWELL (1963)C, HANNA ET AL, PLA PROGRESS REPORT (1963) RUTHERFORD HIGH
ENERGY LAB, PAGE 34, UNPUBLISHED,
MORE RECENT THAN RESULT GIVEN BY WILSON

HARWELL (1963)D, JARVIS, NP 42, 294 (1963)

HARWELL (1964), JARVIS ET AL, NP 50, 529 (1964)
72,1 DEGREE DATUM QUESTIONABLE SAY AUTHORS

HARWELL (1965), JARVIS ET AL, NP 61, 194 (1965)

HARWELL (1965)A, BROGDEN ET AL, PRESENTED AT THE INTERNATIONAL CONFERENCE
ON POLARIZED PHENOMENA OF NUCLEONS AT KARLSRUHE, PAPER 8/5-5

HARWELL (1966), COX ET AL, WILLIAMSBURG CONFERENCE ON INTERMEDIATE
ENERGY PHYSICS
PRELIMINARY VALUES

INSTITUTE OF NUCLEAR SCIENCE (1961)A, NISIMURA, INSJ 45 (1961) AND PRIVATE
COMMUNICATION FROM NISIMURA, SEE PR 133, B1495 (1964)
CS(12.2) NOT USED BY US BECAUSE OF AMBIGUOUS TREATMENT OF BEAM WIDTH
ON FORWARD RISE

INSTITUTE OF NUCLEAR SCIENCE (1961)B, NISIMURA, INSJ 45 (1961) AND PRIVATE
COMMUNICATION FROM NISIMURA, SEE PR 133, B1495 (1964)

INSTITUTE OF NUCLEAR SCIENCE (1963), NISIMURA ET AL,
PROG THEO PHYS 30, 719 (1963)

LIVERPOOL (1961), ALLABY ET AL, PROC, PHYS, SOC, 77, 234 (1961)

LOS ALAMOS (1966), JARMIE ET AL, PRIVATE COMMUNICATION, TO BE PUBLISHED

MINNESOTA (1958), JOHNSTON ET AL, PR 111, 212 (1958)
WILSON HAS WRONG (PROBABLE) ERROR

MINNESOTA (1959)A, JOHNSTON ET AL, PR 115, 1293 (1959)
WILSON HAS WRONG (PROBABLE) ERROR

MINNESOTA (1959)B, JOHNSTON ET AL, PR 116, 989 (1959)
WILSON HAS WRONG (PROBABLE) ERROR

MINNESOTA (1960), JOHNSTON ET AL, PR 118, 1080 (1960)
WILSON HAS WRONG (PROBABLE) ERROR

MINNESOTA (1960)A, JOHNSTON ET AL, PR 119, 313 (1960)
WILSON HAS WRONG (PROBABLE) ERROR

ORSAY (1961), CAVERSAZIO, JOURNAL DE PHYSIQUE 22, 628 (1961)
WILSON GIVES ENERGY AS 156, MEV (WRONG)
WILSON GIVES TENTHS OF A DEGREE AS MINUTES (WRONG)
WILSONS ERROR WRONG FOR 68, AND 77,8 DEGREE DATA
REMOVED 155 MEV DIFF CS AT 8,3 DEG / NOT FIT BY PHASE ANALSIS

ORSAY (1963), CAVERSAZIO ET AL, JOURNAL DE PHYSIQUE 24, 1048 (1963)

DROPPED BECAUSE OF ABNORMALLY HIGH CHI SQUARED IN PHASE SHIFT ANALYSES

ORSAY (1963)A, CAVERSAZIO ET AL, JOURNAL DE PHYSIQUE 24, 1048 (1963)

PRINCETON (1954), YNTEMA, PR 95, 1226 (1954)
WILSON HAS WRONG (PROBABLE) ERROR

PRINCETON (1959), BLANPIED, PR 116, 738 (1959)
WILSON HAS WRONG (PROBABLE) ERROR

ROCHESTER (1961), TINLOT, PR 124, 890 (1961)
WILSON HAS ABSOLUTE ERRORS MARKED AS RELATIVE

ROCHESTER (1961)A, KONRADI, THESIS (1961)
WILSON (IN HIS BOOK) HAS WRONG CS NORM ERROR

ROCHESTER (1961)B, TINLOT, PR 124, 890 (1961)

ROCHESTER (1961)C, ENGLAND, PR 124, 561 (1961)

ROCHESTER (1961)D, ENGLAND, PR 124, 561 (1961)
AR(90.0) REMOVED BECAUSE OF LARGE CHI SQUARE IN ENERGY INDEPENDENT PHASE SHIFT ANALYSIS. SEE PR 135, B1128 (1964)

ROCHESTER (1962), GOTOW ET AL, PR 127, 2206 (1962)

ROCHESTER (1964), GOTOW ET AL, PR 136, B1345 (1964)
RPR(60.0) AND RPR(70.0) REMOVED BECAUSE OF LARGE CHI SQUARE IN ENERGY INDEPENDENT PHASE SHIFT ANALYSIS. SEE PR 135, B1128 (1964)

RUTHERFORD HIGH ENERGY LAB (1963), BATTY ET AL, NP 45, 481 (1963)

RUTHERFORD HIGH ENERGY LAB (1964)A, BATTY, NP 51, 225 (1964)
VALUE SEEMS LOW SAYS AUTHOR
DROPPED BECAUSE OF ABNORMALLY LARGE CHI SQUARE (=57) IN ENERGY DEPENDENT ANALYSIS

RUTHERFORD HIGH ENERGY LAB (1964)B, BATTY, NP 51, 225 (1964)

RUTHERFORD HIGH ENERGY LAB (1965), ASHMORE ET AL, NP 65, 305 (1965)

RUTHERFORD HIGH ENERGY LAB (1965)A, ASHMORE ET AL, NP 73, 256 (1965)

SACLAY (1962), ABRAGAM ET AL, PL 2, 310 (1962)

SACLAY (1965), CATILLON ET AL, PROCEEDINGS OF THE INTERNATIONAL CONFERENCE ON POLARIZED PHENOMENA OF NUCLEONS, KARLSRUHE, 1965, PAPER 8-4

WILSON, THE NUCLEON-NUCLEON INTERACTION, INTERSCIENCE, 1963