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Elastic Scattering of Alpha Particles from ^{12}C

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ELASTIC SCATTERING OF ALPHA PARTICLES FROM ^{12}C

by

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Hsi-chiu Liu

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INTRODUCTION

The elastic scattering of alpha particles from ^{12}C has been investigated in many laboratories.[1,2] Recently, by studying the $^{12}C(\alpha,p)$ and $^{12}C(\alpha,n_0)$ reactions, Bernstein *et al*[3] found an isospin-mixed doublet near an excitation energy of 18 Mev in ^{16}O. These states are excited by alpha particles with laboratory energies of 13.97 and 14.60 Mev. Hence, it is worthwhile to make a careful study in this region in an attempt to obtain more information about the states in this doublet. Using the Western Michigan University Van de Graaff accelerator, the elastic scattering process was studied in the bombarding energy range from 13 to 16 Mev. Sixteen excitation functions and twenty five detailed angular distributions were measured and these data will be presented in the thesis.

In addition to obtaining the data, a phase shift analysis of the angular distributions was started. Such an analysis will provide information regarding states in ^{16}O which have excitation energies between 17.05 and 18.89 Mev. Preliminary fits have been obtained to the angular distributions in the range from 17.05 to 17.89 Mev. These fits and the phase shifts will be displayed. The properties of three levels found in ^{16}O as a result of the phase shift analysis will be presented.

EXPERIMENTAL ARRANGEMENT

Target

A self-supporting carbon foil target of 50 $\mu g/cm^2$ thickness was used in this experiment. The carbon was evaporated onto a glass slide by the Yissum Research Development Co. (Cat. No. 1604B). The carbon foil was separated from the slide by immersion into distilled water. The foil, which floated on the surface, was then lifted by an aluminum target holder of 7/8 inches by 5/8 inches with a 3/8 inch diameter hole in the middle. The film adhered to the mount and was ready for use after a short drying time. Efforts had been directed to select the most uniform portion of the film and to obtain the smoothest possible target surface.

The major contaminants in this ^{12}C target are ^{16}O, ^{1}H and ^{13}C. The ^{16}O and ^{1}H may have come from the water used in floating off the film. The abundance of ^{13}C in natural C is 1.11%. These contaminants were identified in the spectra of scattered particles. The abundances of the contaminants are not large and, at most angles, the elastic scattering peaks due to the contaminants could be separated from the elastic scattering peak due to ^{12}C.

Accelerator

A beam of alpha particles was obtained from the Western Michigan University Model EN Tandem Van de Graaff accelerator. Helium gas was fed into the duo-plasmatron ion source. Hydrogen was used as an exchange gas in the electron pickup canal. The duo-plasmatron ion source and the deflection of the beam into the accelerator has been discussed in some detail by Carter and Davis.[4] The He^- ions coming from the ion source were first accelerated through a high potential difference of four or more millions of volts towards a high voltage terminal. At the high voltage terminal of the accelerator, located at the center of the machine, the beam passed through a stripping canal containing oxygen gas. Some of the beam then emerged from this canal as doubly-charged positive ions. The ions emerging from this canal were then accelerated through the same potential difference. The beam was then momentum analyzed by a magnet which was formerly calibrated by determining the threshold of the $^{27}Al(p,n)$ reaction as well as the thresholds of other reactions.[5] A switching magnet directed the analyzed beam into the scattering chamber. Energies ranging from 13 to 16 Mev were used in the experiment and beam currents were normally between 20 and 50 nanoamperes.

Scattering Chamber

The target and alpha-particle detectors were located in a 17-inch scattering chamber (Ortec Model 600 Series No. 25). In this experiment, the chamber pressure was kept at about 10^{-5} microns with a diffusion pump. The detectors were mounted on a turntable inside the chamber. The entire assembly could be rotated from the outside without breaking the vacuum seal of the chamber. Also the target, located at the center of the chamber, could be independently rotated from the outside. At the entrance to the chamber, the alpha beam was collimated by using two collimators, 0.107 inches in diameter, and separated by 17.25 inches.

Detectors

The elastically scattered alpha particles were detected at three angles simultaneously by using three solid state semiconductor detectors. They were mounted on the turntable in the chamber and separated by 20° (see Figure 1). A collimator of 3/16 inches in diameter was inserted in front of each detector. The distance from the collimator to the target was 5 and 61/64 inches. The half angle subtended at the target by the collimator aperture was 0.9°. With an ^{241}Am source positioned in the chamber, the resolutions of these three detectors for 5 Mev alpha particles were determined to be 27-, 34- and 32-kev.

At small angles, the elastic scattering due to impurities is difficult to separate from the elastic scattering due to ^{12}C. Hence the detector with the best resolution was used at the most forward angles. The resolution of 27 kev was achieved by cooling the detector to about -7°C with a thermoelectric device.

Electronics

The pulses from each detector were amplified by an Ortec Model 109A preamplifier and an Ortec Model 451 amplifier. These amplified pulses were monitored by a nuclear data Model ND-510 multichannel analyzer, an oscilloscope readout being used with the analyzer (see

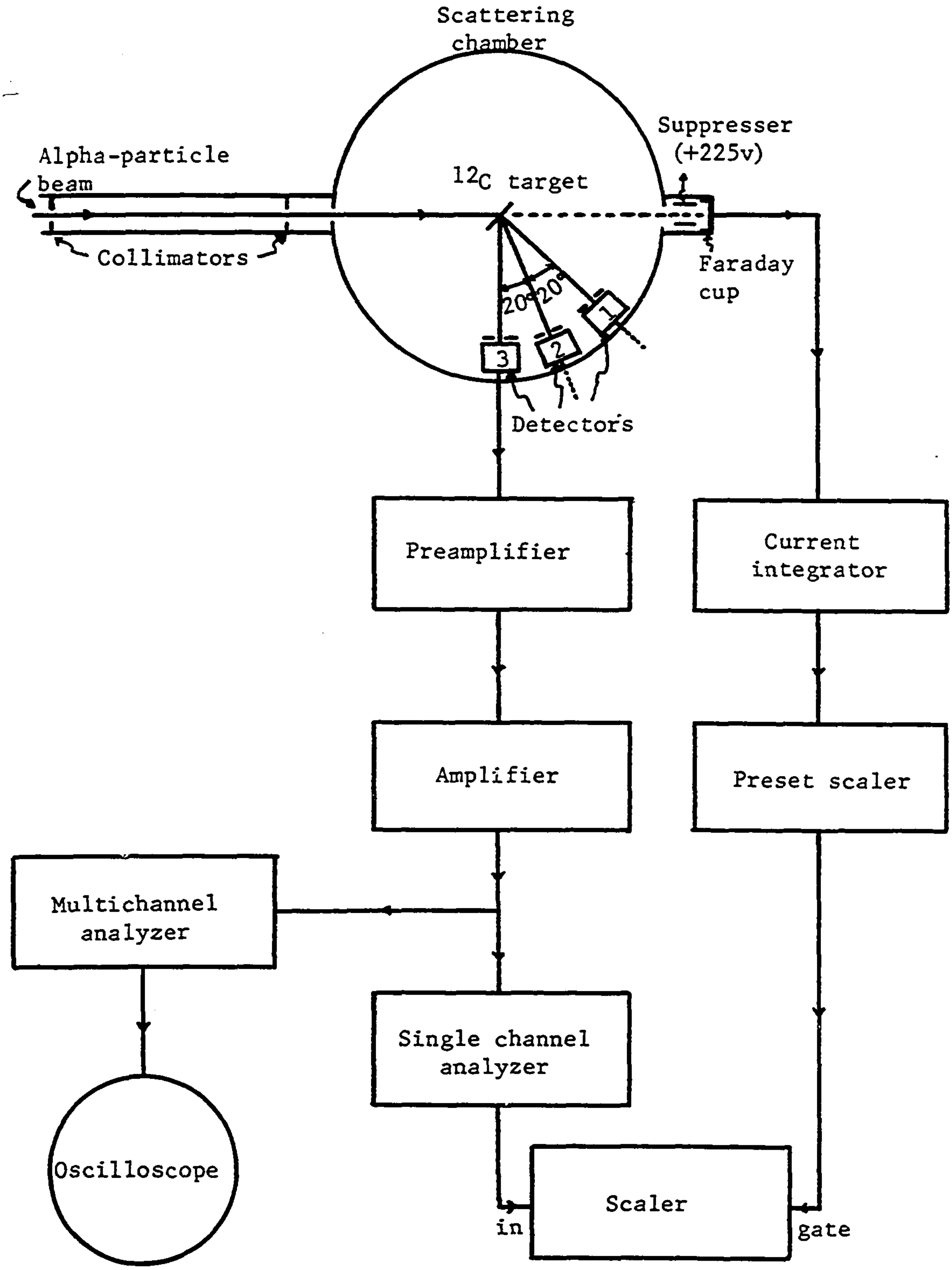


Figure 1. Electronics layout for data measurements

Figure 1). An Ortec Model 420A single channel analyzer was used to select an energy region about the elastic peak. The energy range of this window was preset using an Ortec Model 204 precision pulse generator (not shown in Figure 1). The pulses from the single channel analyzer which accompanied the detection of pulses within the energy "window" were then counted by an Ortec Model 484 scaler. The number of alpha particles passing through the target was determined by integrating the beam current with a Brookhaven Model 1000 current integrator. After the pre-selected amount of charge had been collected, a signal from the Ortec Model 431 preset scaler stopped the counting scalers.

Keeping the accumulated charge at a constant amount of 0.48 microcoulombs, excitation functions of the elastic scattering were measured at sixteen angles over a laboratory energy range from 13 to 16 Mev. The data were taken in energy steps of about 30 kev except over the range from 14.344 to 14.639 Mev where steps of 15 kev were taken. Using the same target and under the same conditions, twenty five angular distributions were measured with an angular step of 2.5° at the laboratory angles ranging from 11.5° through 166.5°. All data were taken using three detectors simultaneously. For the angular distributions, the settings of the laboratory angles of the three detectors were so arranged that the angles of the middle detector overlapped with the angular ranges of the other two detectors. This was done to help normalize the data from the three detectors.

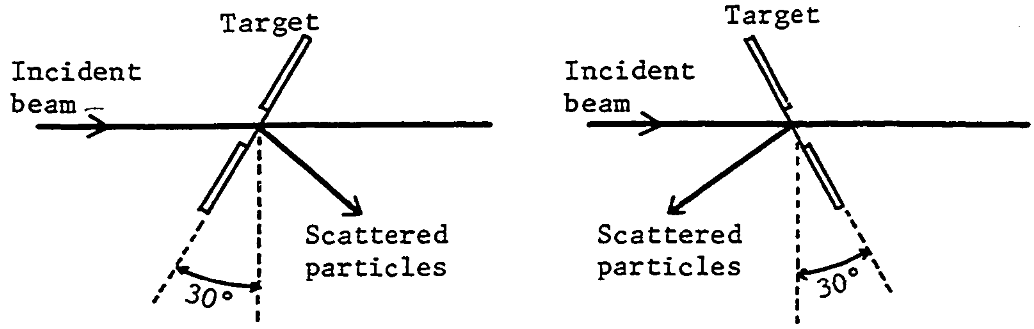
DATA REDUCTION

Excitation Functions

Three detectors were used so that three excitation functions would be obtained at the same time. Excitation functions were determined at laboratory angles of 14.5, 23, 34.5, 43, 54.5, 63, 72, 84, 92, 104, 115, 125, 135, 145, 155 and 165 degrees. The laboratory energy of the incident alpha particles was increased from 13.191 to 15.646 Mev in steps of about 30 kev, except between 14.344 and 14.639 Mev, where steps of about 15 kev were taken. As shown in Figure 2, two different target positions were used.

Since the solid angles subtended by the three detectors at the target were different, data collected by detectors 2 and 3 (see Figure 1) were multiplied by the ratios of the solid angles of dectors 2 to 1 and dectors 3 to 1 respectively. To obtain these ratios, each detector in turn was placed at a laboratory angle of 119° and the counting rates for the elastic scattering of 14.738 Mev alpha particles were determined. In this manner, solid angle ratios of 1.10 ± 0.01 and 0.98 ± 0.009 were obtained for detectors 2 to 1 and detectors 3 to 1 respectively.

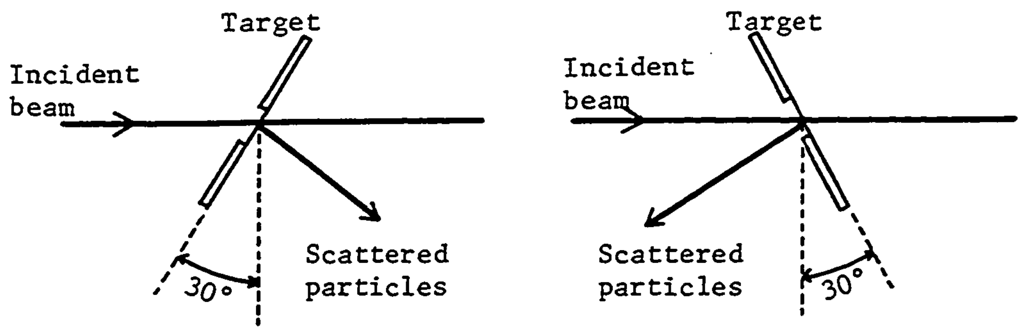
Since the beam did not strike exactly the same area on the target for the two positions shown in Figure 2, the target thicknesses were slightly different for the two positions. Data collected with the detector in the position shown in Figure 2(b) were normalized to the position shown in Figure 2(a) in the following



(Target scale = 300°) (Target scale = 60°)

(a) (b)

Figure 2. Target positions in taking excitation functions
(a) for forward-angle measurements
(b) for back-angle measurements



(Target scale = 300°) (Target scale = 240°)

(a) (b)

Figure 3. Target positions in taking angular distributions
(a) for forward-angle measurements
(b) for back-angle measurements

manner. Detector 1 was set at a laboratory angle of 84° and the counting rate determined with the target in the two different positions. This was done at several beam energies. The target thickness at position (a) divided by the target thickness at position (b) was determined to be 0.95 ± 0.02.

In this manner the 16 excitation functions were normalized to correspond to a single detector and single target position.

Angular Distributions

Twenty five angular distributions were measured in the laboratory energy range from 13.191 to 15.646 Mev. The three detectors were rotated in 2.5° steps from a laboratory angle of 11.5° to 166.5°. This resulted in some overlaps of the angular ranges covered by the three detectors. These overlap regions were quite useful in insuring that the energy windows were not inadvertently placed over the wrong peak, which occassionally occured in an angular region in which the $^{12}C(\alpha,\alpha)^{12}C$ cross section was low. This overlap also provided a check on the normalization to a single detector solid angle. Again, there were two target positions (see Figure 3). The target position in Figure 3(a) is the same as that in Figure 2(a), but the position shown in Figure 3(b) differs by 180° from that of Figure 2(b). So, a different ratio, 1.03 ± 0.02, was obtained in the same way as before to normalize the target position shown in Figure 3(b) to that shown in Figure 3(a). Unfortunately, normalizations due to different solid angles and different target positions were not the only ones necessary.

At the end of the experiment, it became clear, from discrepancies between the angular distributions and excitation functions, that carbon had been continuously accumulated on the target over the long period necessary to obtain the angular distribution data. To correct for the increased target thickness due to the carbon buildup, the angular distributions were normalized to the excitation functions.

Differential Cross Sections in the Laboratory System

Because it would be very difficult to measure the thickness of our target, conversion of the counting rates to cross sections was done by using the $^{12}C(p,p)^{12}C$ cross section measurements of Moss and Haeberli[6] at 5 Mev. The experimental arrangement used to measure the $^{12}C(\alpha,\alpha)^{12}C$ counting rates was used to measure the $^{12}C(p,p)^{12}C$ counting rates at 5 Mev and these results were compared with the following cross sections quoted by Moss and Haeberli:

$$\sigma_{cm}(84.7°) = 36.6 \pm 1.46 \text{ mb/sr}$$

$$\sigma_{cm}(133.7°) = 33.8 \pm 1.35 \text{ mb/sr}$$

The angles are in the center-of-mass system. We wish to determine K_p defined by

$$\sigma_{lab}(\psi) = K_p \times (\text{counts})_{lab}$$

This can be written as

$$K_p = \frac{\sigma_{cm}(\theta)}{\frac{\sigma_{cm}(\theta)}{\sigma_{lab}(\psi)} \times (\text{counts})_{lab}}$$

where θ is th$\frac{\sigma_{cm}(\theta)}{\sigma_{lab}(\psi)}$ in the center-of-mass system corresponding to ψ in the labortory system. Using our counting rates and the cross sections of Moss and Haeberli, we obtained

$$K_p(\theta = 84.7°) = 0.00260 \pm 0.00010$$

$$K_p(\theta = 133.7°) = 0.00286 \pm 0.00011$$

The averaged value of 0.00273 ± 0.00007 was used.

Next K_α, the factor for converting counting rates to cross sections in the alpha particle scattering experiment, was calculated from K_p by

$$K_\alpha = \frac{I_p}{I_\alpha} K_p$$

where I_p and I_α represent, respectively, the total number of protons and the total number of alpha particles collected during a single counting rate measurement. K_α was determined to be 0.0273 ± 0.0007.

In the $^{12}C(p,p)^{12}C$ measurements, the target used was not the one used in the $^{12}C(\alpha,\alpha)^{12}C$ measurements. Hence, a $^{12}C(\alpha,\alpha)^{12}C$ excitation function was obtained with the new target and, by comparing the results with the corresponding ones obtained with the old target, a K_α appropriate for the old garget was obtained. This result is

$$K_\alpha(\text{old target}) = 0.02775 \pm 0.00076$$

which was used to convert the counting rate data to cross sections.

Differential Cross Sections in the Center of Mass System

The cross sections in the laboratory frame of reference were then converted to the center-of-mass system using a computer program which generated the appropriate conversion ratios. A tabulation of these cross sections is given in Appendices I and II. In Table 1, the present results are compared with those of Carter, Mitchell and Davis.[2] Their results were presented graphically and the entries in Table 1 were obtained from these graphs. The agreement is generally quite good.

The total uncertainty in the cross sections is about 5% which includes a contribution of 1% for normalizing the various detectors to a single detector, a contribution of 2% for normalizing to a single target position, a contribution of 4% due to the uncertainties in the cross sections which were used to convert our relative cross sections to absolute cross sections, and a contribution of the statistical flunctuations. The total uncertainties, as listed in Appendices I and II, are calculated using the following formula:

$$(\text{total uncertainty}) = (\text{cross section}) \times \left\{ (1/100)^2 + (2/100)^2 + (4/100)^2 + (\sqrt{N}/N)^2 \right\}^{1/2}$$

Not included in the errors given in the Appendices are systematic errors due to the presence of contaminants. Contributions to the counting rates due to contaminants will result in systematically high cross sections at the forward angles. Also no attempt was made to correct the data for the angular range accepted by the detectors.

TABLE 1

Comparison of the Angular Distributions between the Experimental Data and Those from the Previous Work of Carter[2] at a Laboratory Alpha-particle Energy of 14.019 Mev

θ_{cm} (deg)	CM cross section (Carter) (mb/sr)	CM cross section (Experimental) (mb/sr)
30	270	275.0
45	13	12.0
60	75	68.0
75	8	8.5
90	20	19.8
105	18	20.2
120	9	5.0
135	19	19.0
150	0.4	0.5
165	120	109.0

PHASE SHIFT ANALYSIS THEORY

In a quantum mechanical treatment of the scattering process, an incident beam of uncharged particles, far from the scatterers, may be represented by a plane wave, e^{ikz}, propagating in the direction of increasing z. Far from the scatterer, the beam scattered into a small solid angle may be represented by a plane wave. The plane wave can be expanded in a series of partial waves,[7] each characterized by a particular value of angular momentum (ℓ). The interaction between a scatterer and an incoming particle is then represented by a shift in the phase of each outgoing partial wave with respect to the incident partial wave. It is, therefore, fruitful to parameterize the experimental scattering data in terms of phase shifts. The resultant phase shifts then provide information about the nuclear interaction. In the present case, the incident particles are charged, which result in more cumbersome expressions, since the Coulomb field must be taken into consideration. Nevertheless, a phase shift analysis is still possible and the expressions given below are correct for charged particles.

The cross section, $\frac{d\sigma}{d\Omega}(\theta)$, is obtained from the amplitude, $f(\theta)$, by the formula

$$\frac{d\sigma}{d\Omega}(\theta) = \left| f(\theta) \right|^2$$

with θ representing the scattering angle in the center-of-mass system. For spin zero charged particles (alpha particles in this case) on spin zero nuclei (^{12}C nuclei in this case), the scattering amplitude can be written as a sum of two terms, one term (f_c) accounting for the Coulomb potential and the second term (f_n) accounting for the nuclear potential. These amplitudes are given by the following expressions:

$$f_c(\theta) = -\frac{1}{2k}\eta \csc^2\frac{\theta}{2}\exp\left[i\eta \ln \csc^2\frac{\theta}{2}\right]$$

$$f_n(\theta) = \frac{i}{2k}\sum_{\ell=0}^{L}(2\ell+1)P_\ell(\cos\theta)e^{i\alpha_\ell}(1-e^{2id_\ell})$$

where $k = mv/\hbar$ = wave number of the incident particle

m = mass of incident particle

v = velocity of the incident particle in the center-of-mass system

d_ℓ = nuclear phase shifts

$\eta = ZZ'e^2/\hbar v$

$\hbar$ = Planck constant divided by 2π

Ze = charge of incident particle

$Z'e$ = charge of target nucleus

α_ℓ = Coulomb phase shift = $2\sum_{j=1}^{\ell}\arctan(\eta/j)$, with $\alpha_0 = 0$

P_ℓ = Legendre polynomial of order ℓ, and

L = the maximum value of ℓ.

When the energy of the incident alpha particles is sufficiently large for inelastic events to occur, the phase shifts are complex and will be written

$$d_\ell = \delta_\ell + i\beta_\ell$$

The term e^{2id_ℓ} in the expression for f_n is now written as $\gamma_\ell e^{2i\delta_\ell}$ with $\gamma_\ell = e^{-2\beta_\ell}$. The imaginary part of the phase shift accounts for the loss of particles from the elastic scattering channel. The total reaction cross section is given by

$$\sigma_{RT} = \frac{\pi}{k^2} \sum_{\ell=0}^{\infty} (2\ell+1)(1 - |\gamma_\ell|^2)$$

A value of unity for a γ_ℓ then indicates that no inelastic scattering takes place for that partial wave.

Since angular momentum and parity are conserved in nuclear reactions and since, in the present experiment, the projectile and the target both have spin zero, the spin and parity of a level excited in the compound nucleus (^{16}O in the present case) are given by $J = \ell$ and $\pi = (-1)^\ell$. The behavior of the ℓ^{th} phase shift as a function of energy in the vicinity of a compound nucleus resonance depends on the ratio Γ_e/Γ, where Γ_e is the elastic width and Γ the total width[8] of the resonance. On Figure 4 is shown the change in the ℓ^{th} phase shift with energy in the vicinity of an isolated level with $J = \ell$ for several values of Γ_e/Γ. In principle, then, a phase shift analysis will provide J values for levels in the compound nucleus and an estimate for Γ_e/Γ.

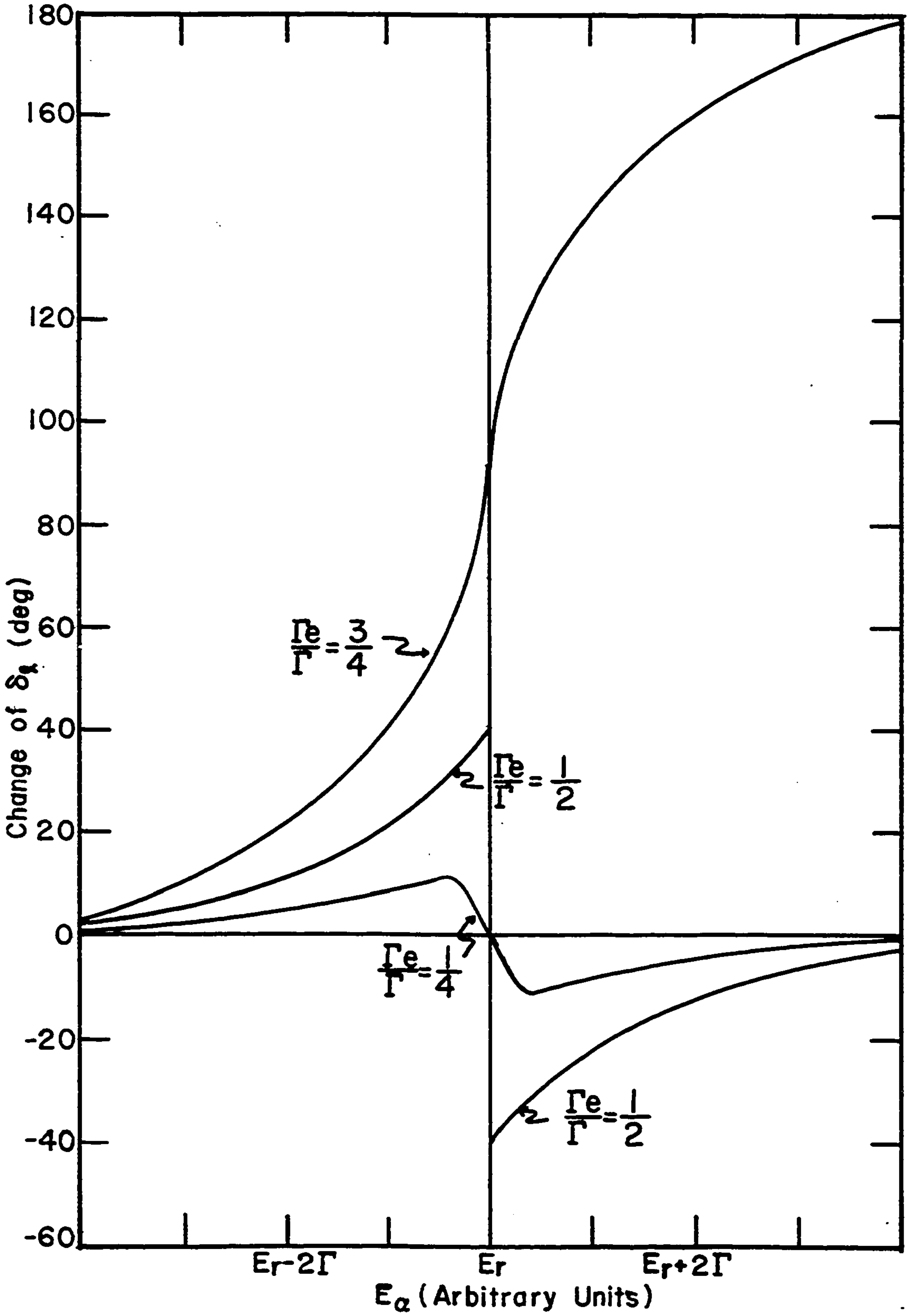


Figure 4. Variation in phase angles near the resonant energy

PHASE SHIFT ANALYSIS

Procedure

In seeking a set of phase shifts which will fit an angular distribution, the computer program minimizes an error function, X^2, defined by

$$X^2 = \left[\frac{\sigma_{TT} - \sigma_{ET}}{\Delta_{ET}}\right]^2 + \sum_{s=1}^{N}\left[\frac{(\frac{d\sigma}{d\Omega})_{TS} - (\frac{d\sigma}{d\Omega})_{ES}}{\Delta_{ES}}\right]^2$$

where σ_{TT} = calculated total reaction cross section

σ_{ET} = experimental total reaction cross section

Δ_{ET} = uncertainty in experimental total reaction cross section

$(\frac{d\sigma}{d\Omega})_T$ = calculated elastic scattering cross section

$(\frac{d\sigma}{d\Omega})_E$ = experimental elastic scattering cross section

Δ_E = uncertainty in experimental elastic scattering cross section, and

N = total number of scattering angles.

The computer program, BIG, was written by Mr. Jon Sledder under the supervision of Professor Larry Oppliger. Dr. Juan Ramirez added a subroutine which compares the experimental angular distribution with the angular distribution given by the phase shifts found in the search by plotting both distributions on the same graph. The program was used on the WMU PDP 10 time-sharing Computer.

The phase shift analyses were performed on the experimental angular distributions given in Appendix II. However the uncertainties used were, over part of the angular range, different from those listed in Appendix II. Since the peaks ~~due~~ to the elastic scattering from ^{13}C and ^{16}O were not resolved from the peak due to the elastic scattering from ^{12}C at small angles, and since it would be difficult to correct the data for the presence of these isotopes, the uncertainties were taken to be 50% for center-of-mass angles less than 41.55°. Also since no correction was made to the data for the finite angular resolution of the detector system and since this correction would have the largest effect in the regions of sharp minima, when the uncertainties listed in Appendix II dropped below 1.0 mb/sr, the uncertainties used to obtain a X^2 fit were set at 1.0 mb/sr. These are in no sense realistic errors but were used to de-emphasize these angular regions to avoid a false X^2 minimum. After a X^2 minimum was obtained, the experimental and theoretical angular distributions were compared visually to ensure that the fits at the forward angles and the minima in the angular distribution were reasonable. If they were not, another X^2 minimum was sought. Also since there are sixty three scattering angles and only one total reaction cross section, a low value for X^2 could be obtained which yielded an unreasonable value for the reaction cross section. Such fits were also rejected and other fits obtained.

The experimental "total" reaction cross section used was the sum of the cross sections for the $^{12}C(\alpha,p)$, $^{12}C(\alpha,n)$ and $^{12}C(\alpha,\alpha_1)$ reactions. The $^{12}C(\alpha,p)$ and $^{12}C(\alpha,n)$ total cross sections were obtained by fitting the differential cross sections of Bernstein <u>et al</u>[3] with a series of Legendre polynomials.[9] As is well known, the coefficient of the zeroeth order Legendre polynomial is simply related to the total cross section. The $^{12}C(\alpha,\alpha_1)$ total cross section was obtained by making a Legendre polynomial fit to the angular distributions of Carter et al.[10] The Legendre polynomial fits were made using the computer program LEGFIT supplied by Dr. Juan Ramirez. The total reaction cross sections used in the X^2 analysis are shown in Figure 5.

It is helpful to think of a X^2 surface generated by permitting all the phase shifts used in the analysis to take on their full range of values. A very large number of local minima can be found in such a surface. It is not only impossible, but unenlightening to investigate all of these minima as a large number would give acceptable fits to an experimental angular distribution. In fact, as pointed out by Gersten,[11] for the case of spin-zero particles on spin-zero nuclei, 2^{L+1} sets of phase shifts can be found which will give the identical angular distribution and total cross section, where L is the maximum value of the angular momentum. The problem is to find "physically meaningful" phase shifts. Jolivette[12] has shown that if a set of "unphysical" phase shifts are obtained as a function of energy, then partial waves with ℓ-values neighboring a partial wave going through a resonance will also exhibit resonance-like behavior. Jolivette then suggests that the physical set is the one which exhibits the fewest resonant states. A similar procedure was employed in the present analysis. It was insisted that a partial wave vary slowly and smoothly with energy unless it is going

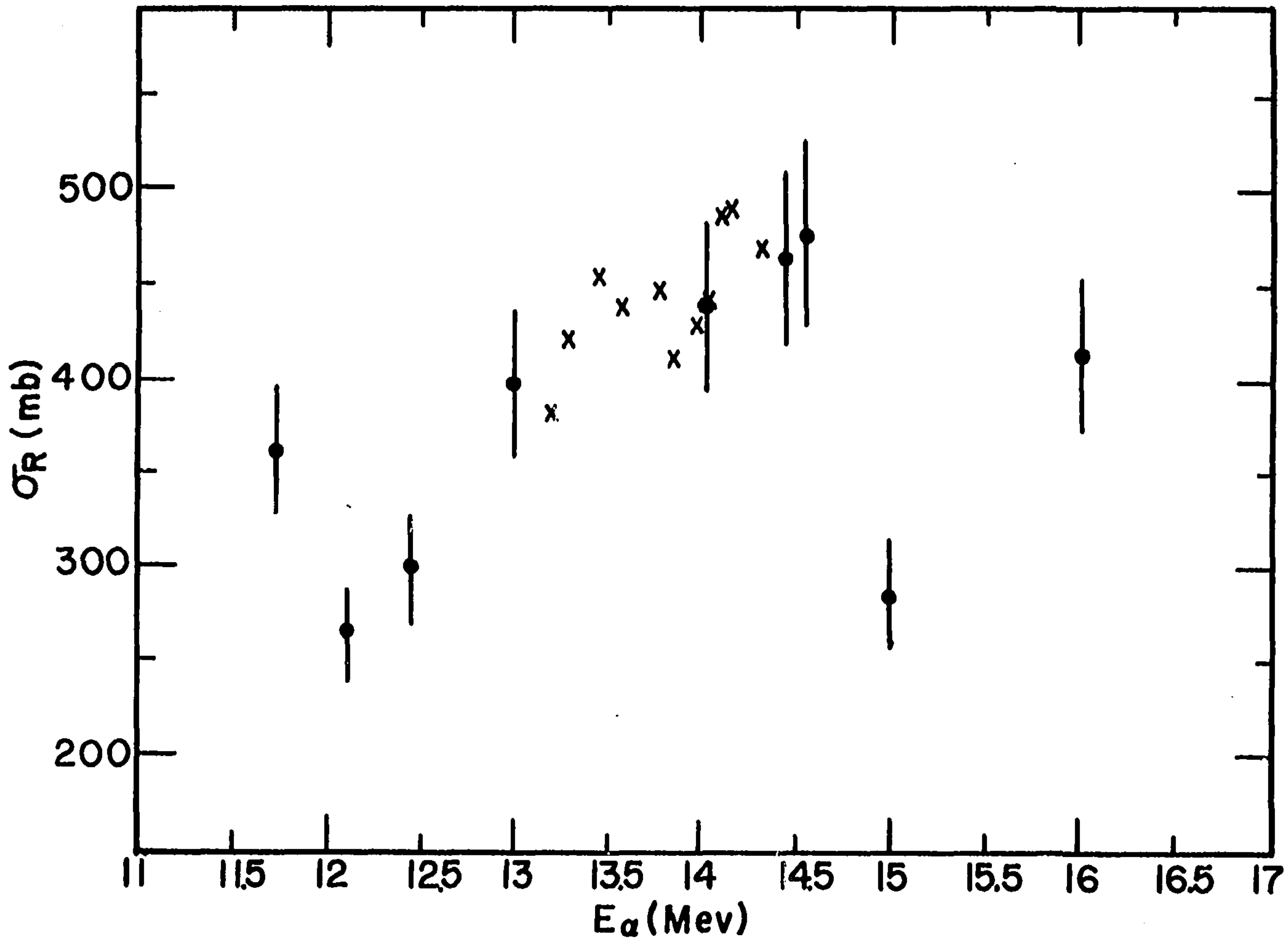


Figure 5. Experimental and calculated total reaction cross sections
● Experimental
X Calculated

through a resonance. If it is going through a resonance then it must behave in a reasonable manner, or else another solution was found. An attempt was made to avoid "resonances" for which there was no physical evidence.

The analysis was started at the lowest-energy angular distribution. Starting phase shifts were generated using the optical potential obtained by Brady et al[13] from a study of the $^{12}C(\alpha,\alpha_0)$ process at a laboratory energy of 8.00 Mev. A fit was then obtained by varying these phase shifts. The first nine partial waves were used in the present analysis. This means that eighteen parameters (since the phase shifts are complex) were varied to obtain a fit. After an acceptable fit was obtained, the next higher-energy angular distribution was studied. After this next angular distribution was fitted, the behavior of the phase shifts as a function of energy was noticed to see if the above criteria were satisfied. If they were, the next angular distribution was selected for study. If they were not, other sets of phase shifts were sought until the above criteria were met.

Results

Eleven angular distributions in the laboratory energy range from 13.191 to 14.311 Mev were fitted in the present analysis. The data points (dots) and the fits (solid curves) are shown in Figures 6 to 16. The corresponding cross sections are shown in Figure 5. The energy dependence of the real part of the phase shifts are shown in

Figures 17 to 20. A parameter γ_ℓ is defined by $\gamma_\ell = e^{-2\beta_\ell}$ where β_ℓ represents the imaginary part of the phase shift, and the energy dependence of the γ_ℓ are shown in Figures 21 and 22.

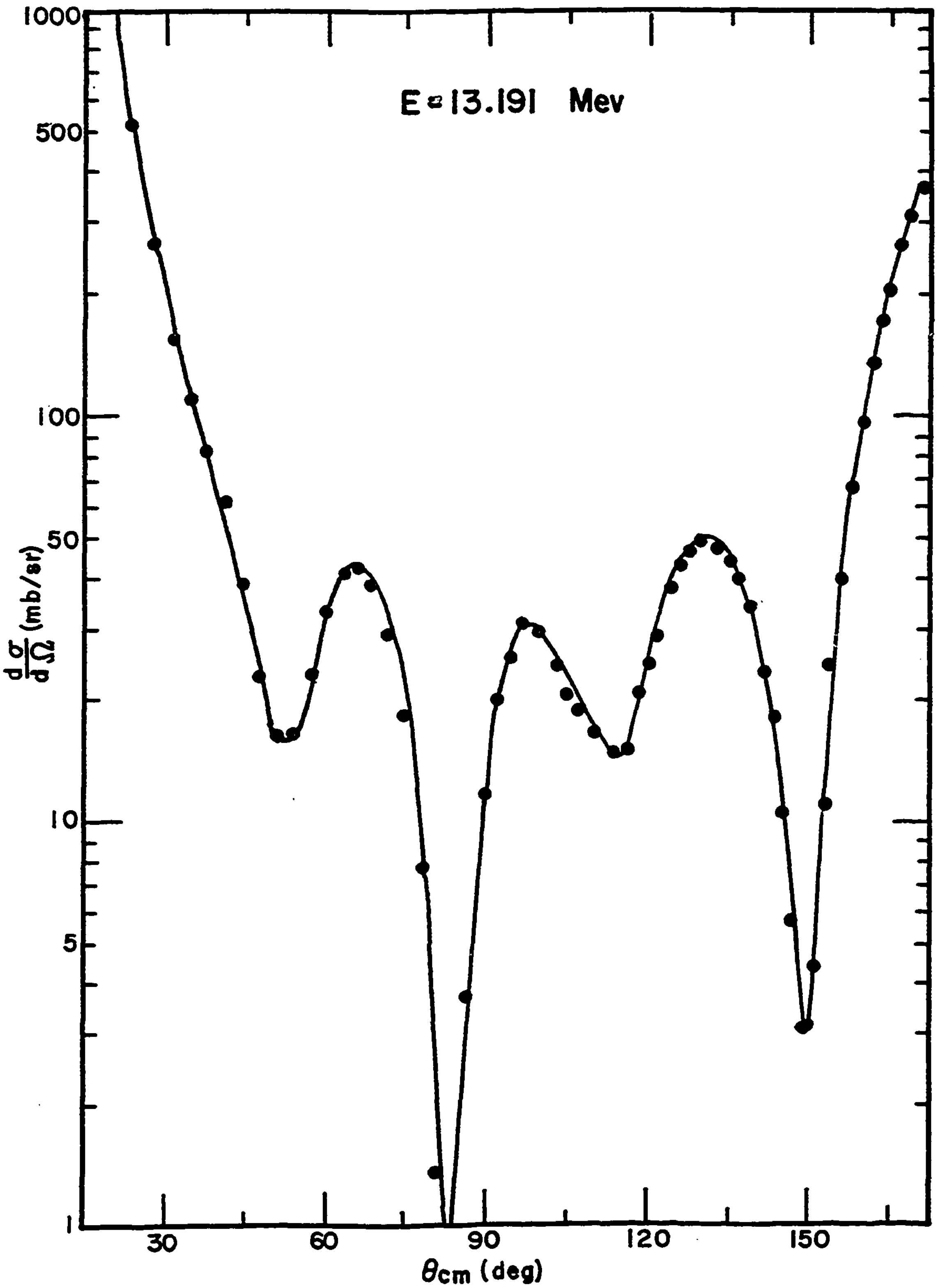


Figure 6. Fit to angular distribution at an alpha-particle energy of 13.191 Mev(● Experimental,— Calculated fit)

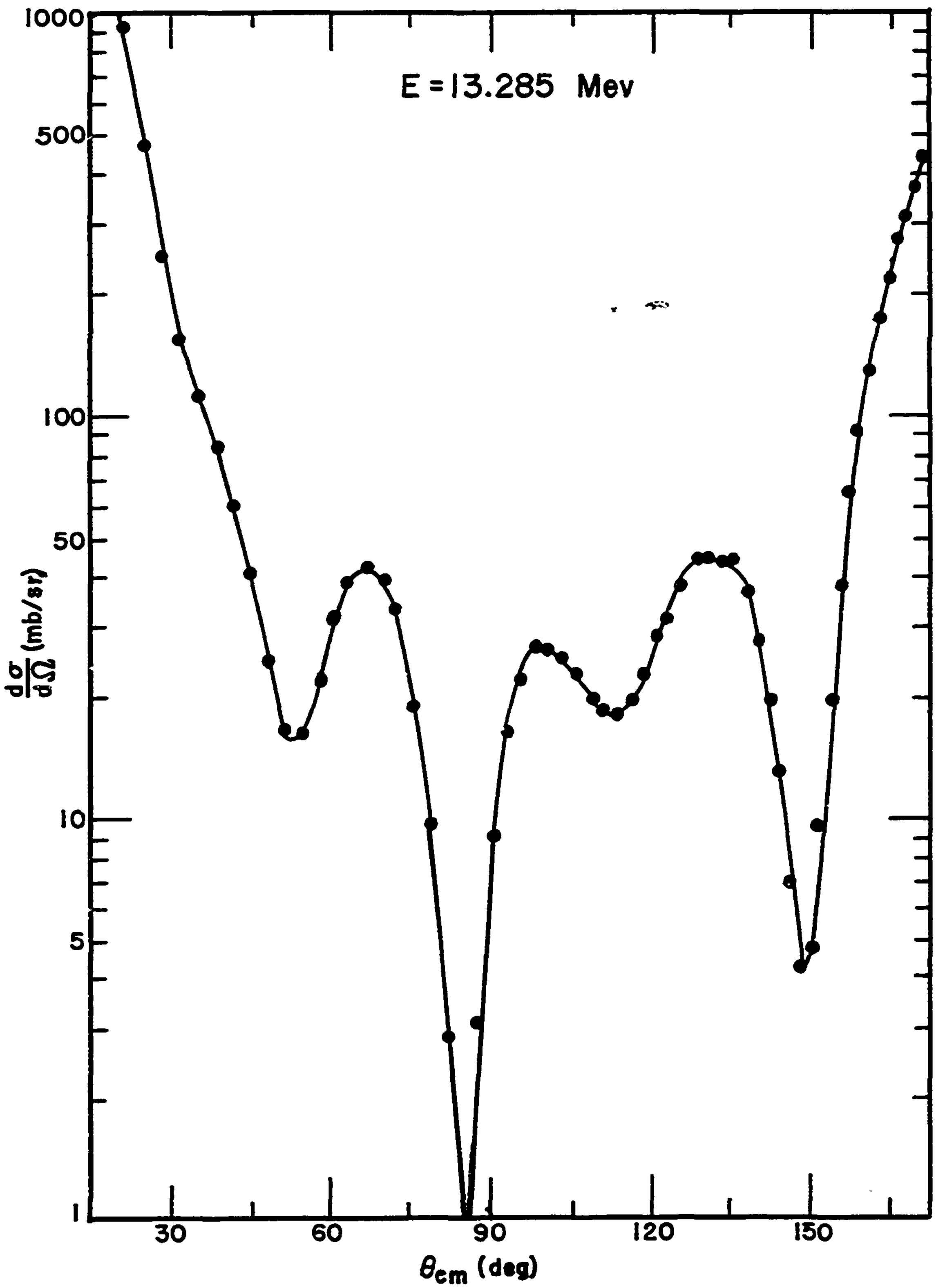


Figure 7. Fit to angular distribution at an alpha-particle energy of 13.285 Mev(● Experimental,— Calculated fit)

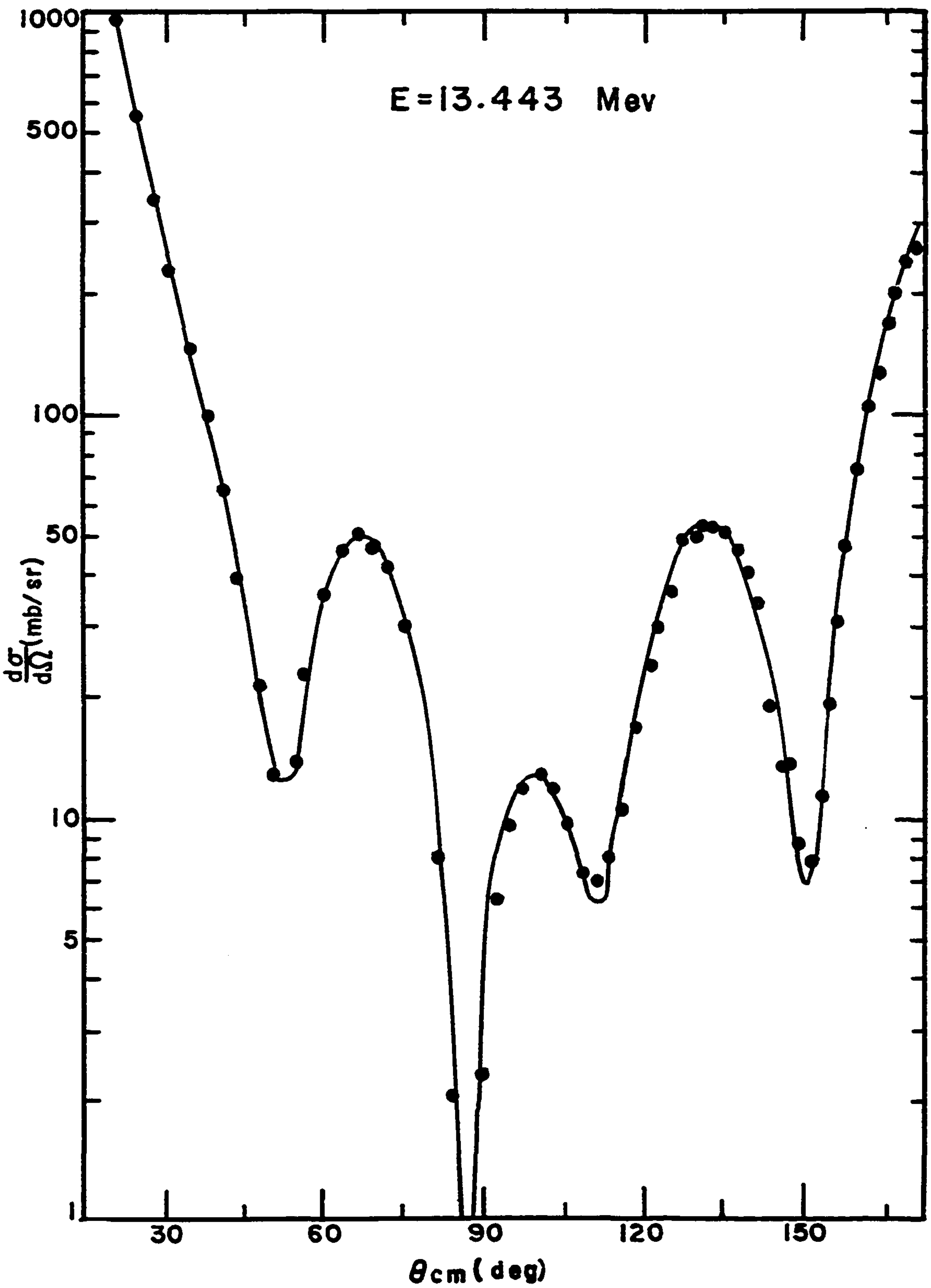


Figure 8. Fit to angular distribution at an alpha-particle energy of 13.443 Mev(● Experimental,—Calculated fit)

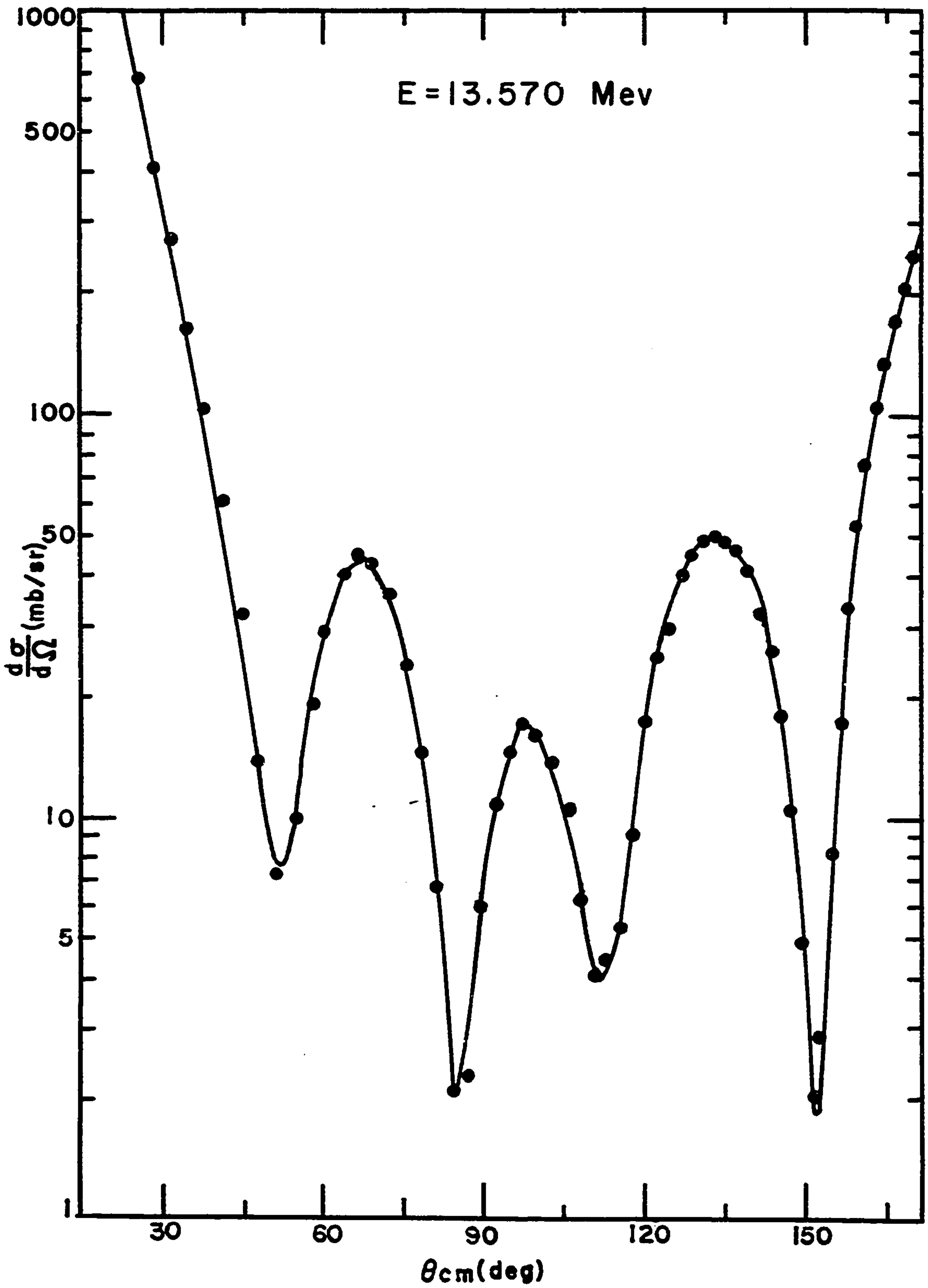


Figure 9. Fit to angular distribution at an alpha-particle energy of 13.570 Mev(● Experimental,— Calculated fit)

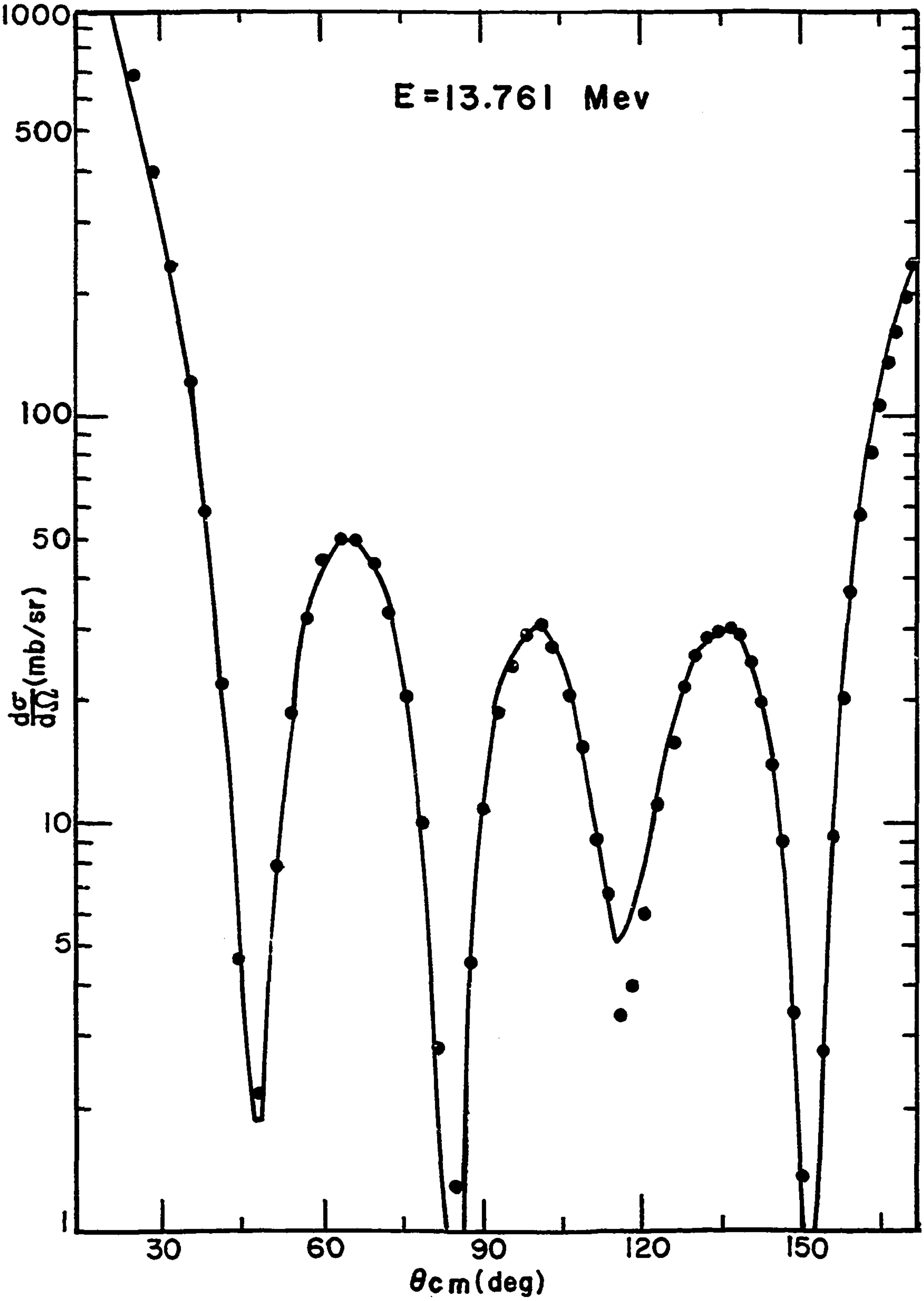


Figure 10. Fit to angular distribution at an alpha-particle energy of 13.761 Mev(● Experimental,— Calculated fit)

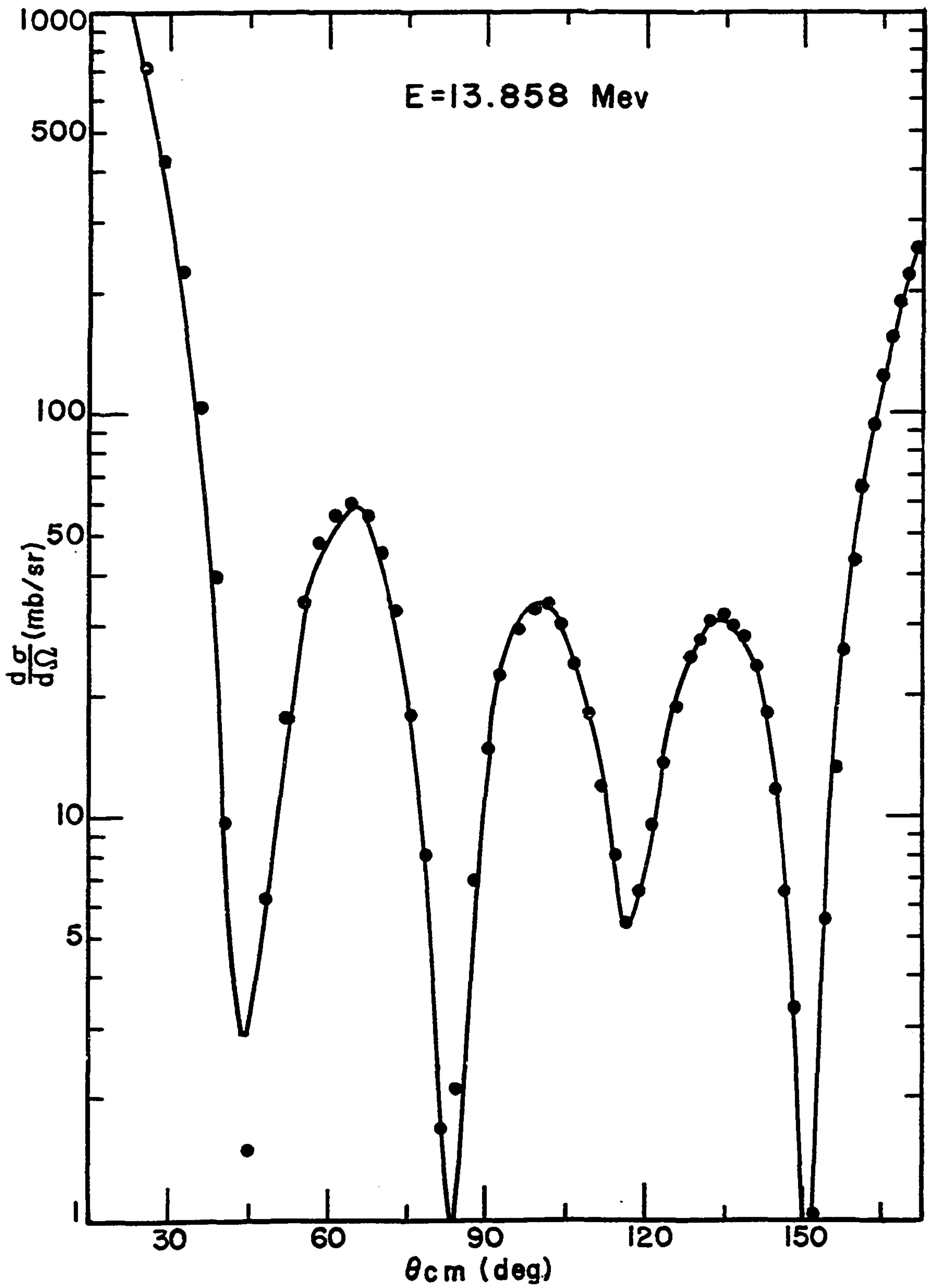


Figure 11. Fit to angular distribution at an alpha-particle energy of 13.858 Mev(● Experimental,— Calculated fit)

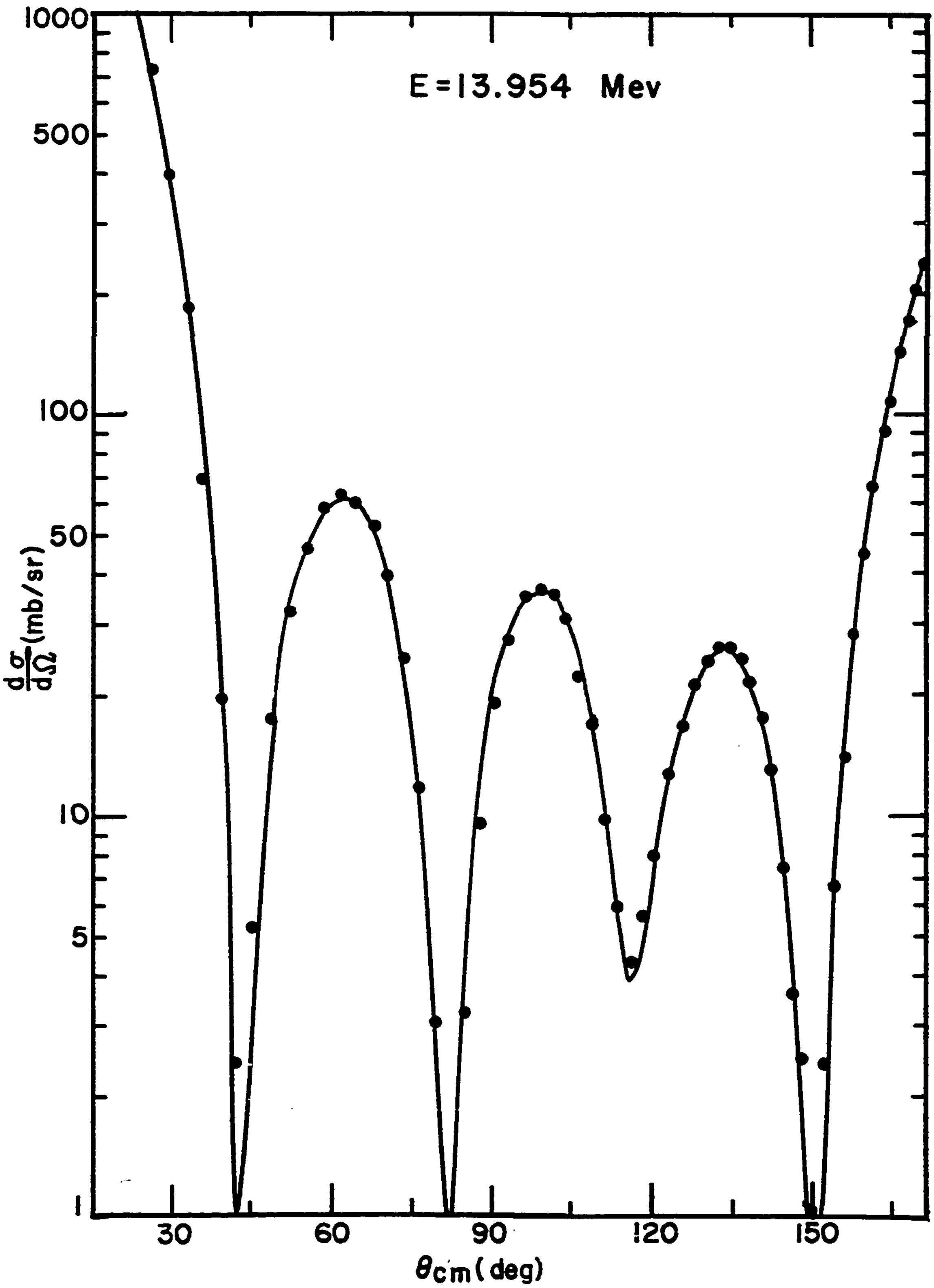


Figure 12. Fit to angular distribution at an alpha-particle energy of 13.954 Mev(● Experimental, — Calculated fit)

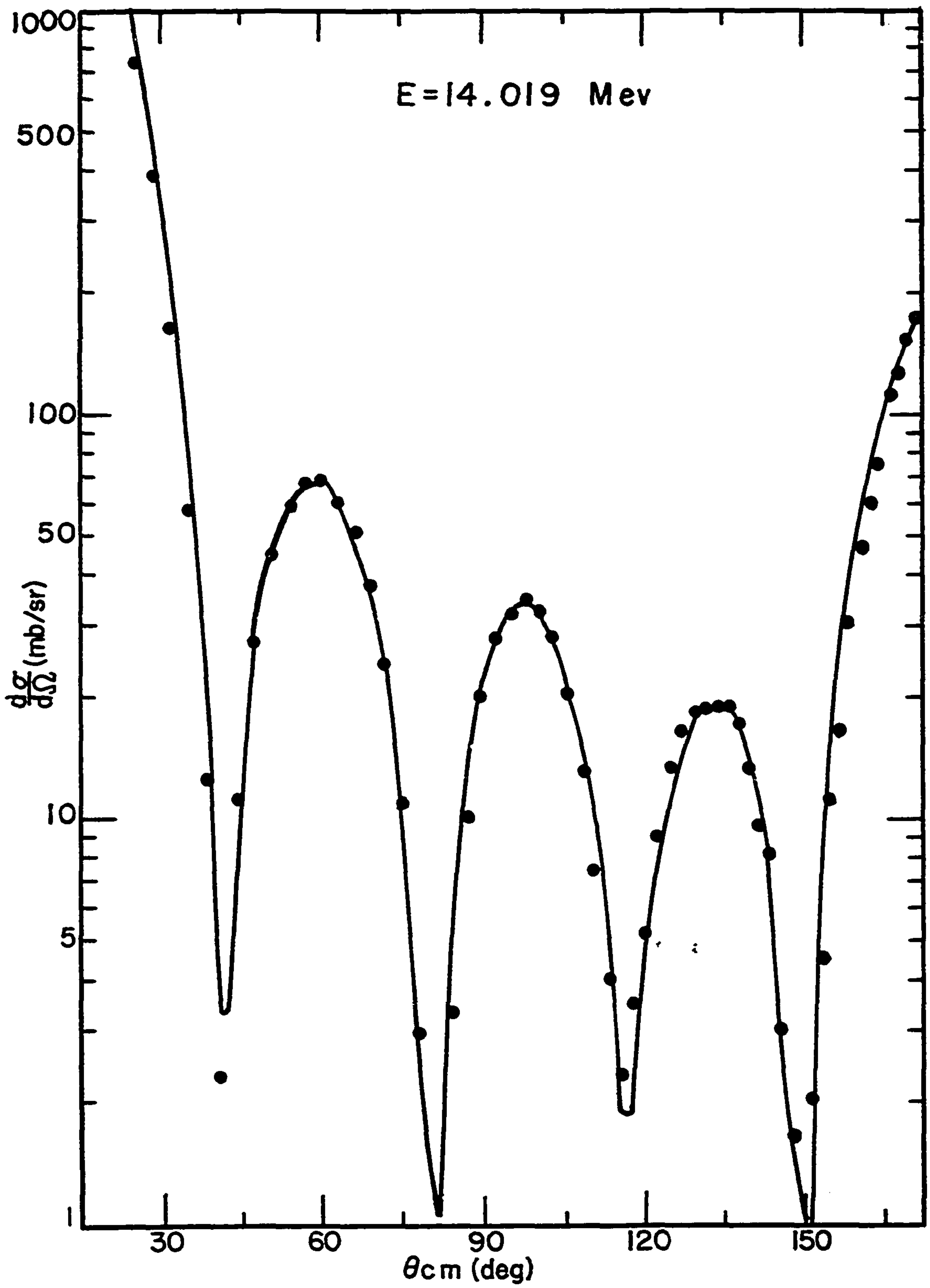


Figure 13. Fit to angular distribution at an alpha-particle energy of 14.019 Mev(● Experimental,—Calculated fit)

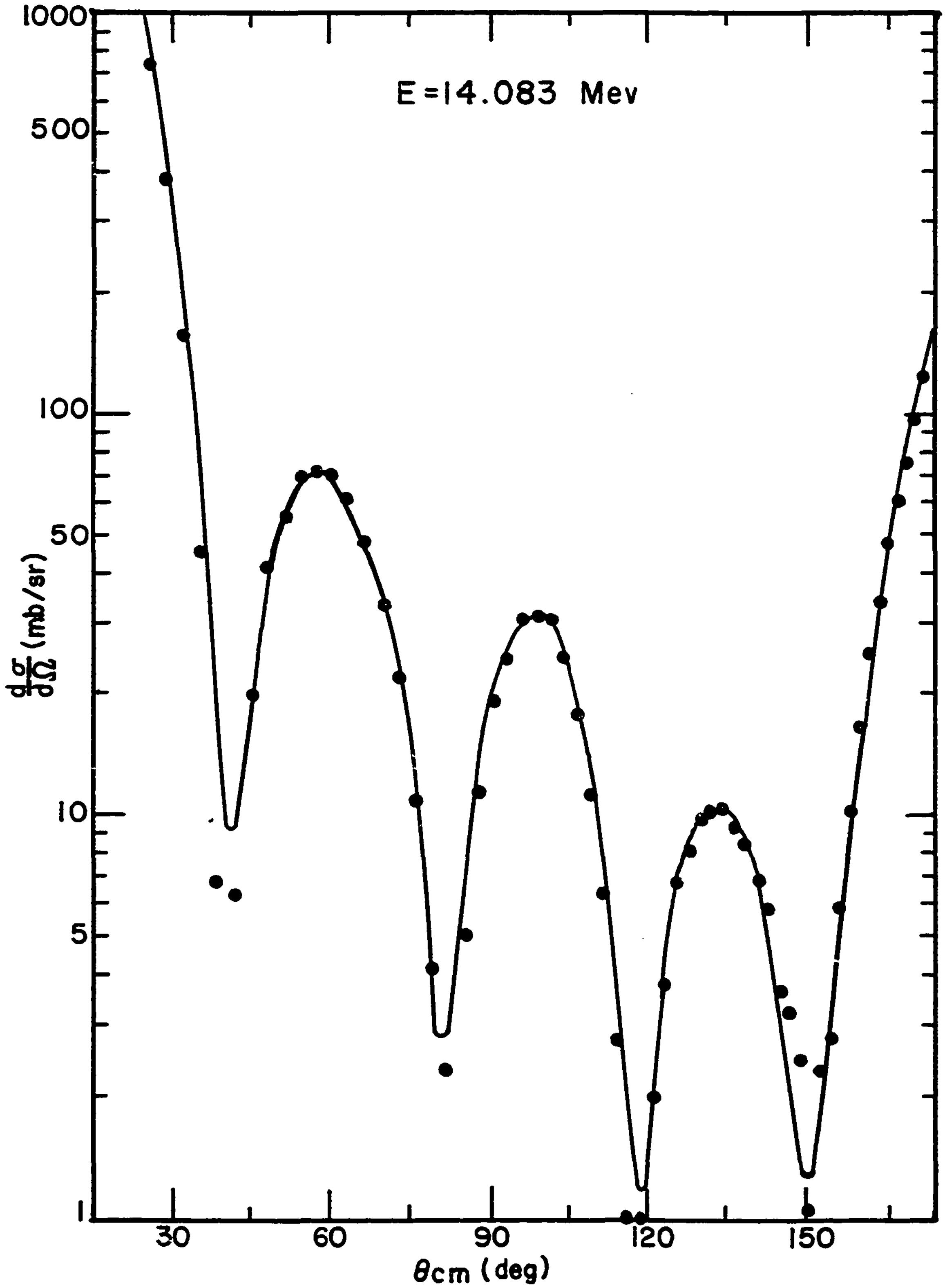


Figure 14. Fit to angular distribution at an alpha-particle energy of 14.083 Mev(● Experimental,—Calculated fit)

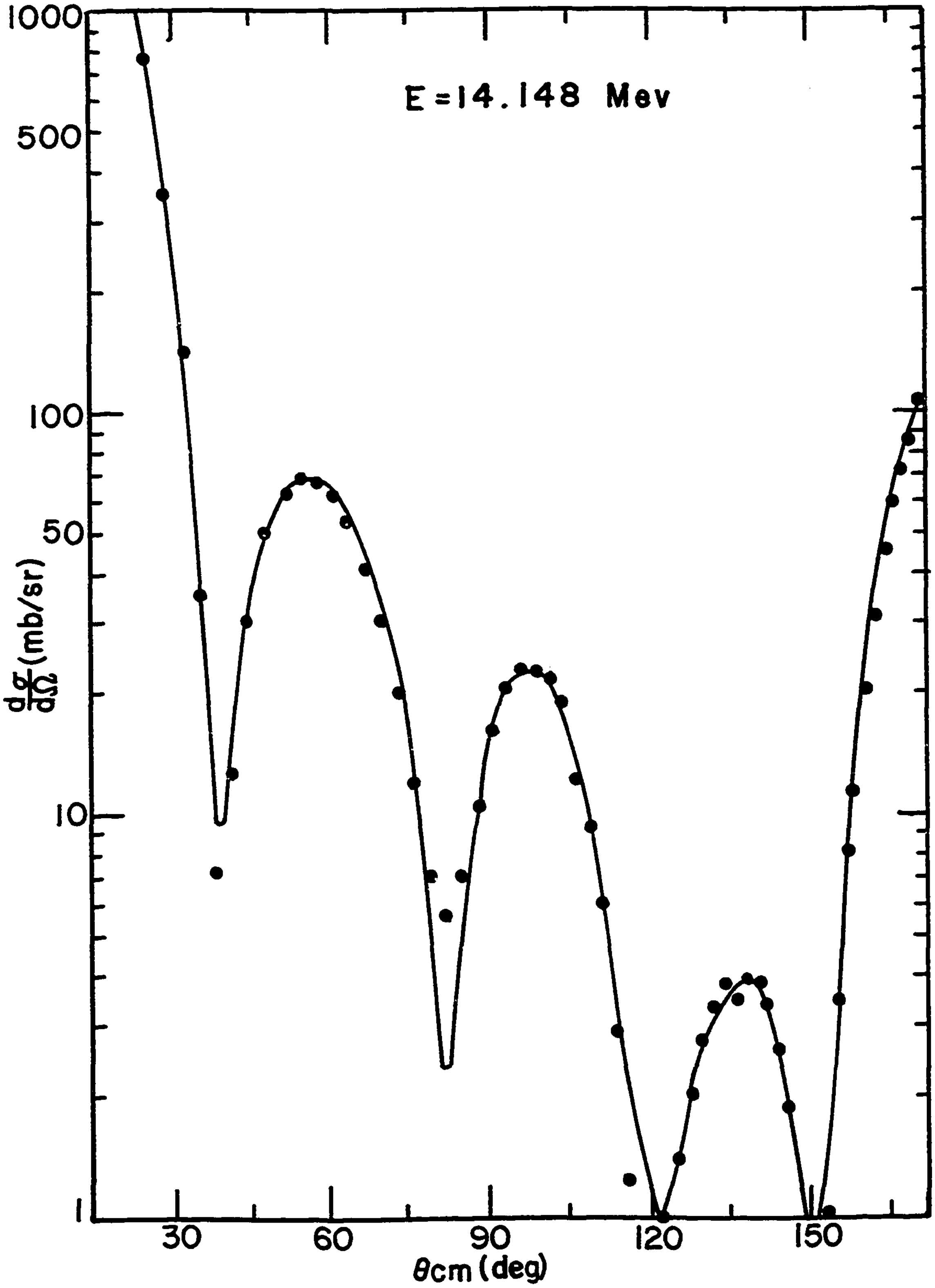


Figure 15. Fit to angular distribution at an alpha-particle energy of 14.148 Mev(● Experimental,—Calculated fit)

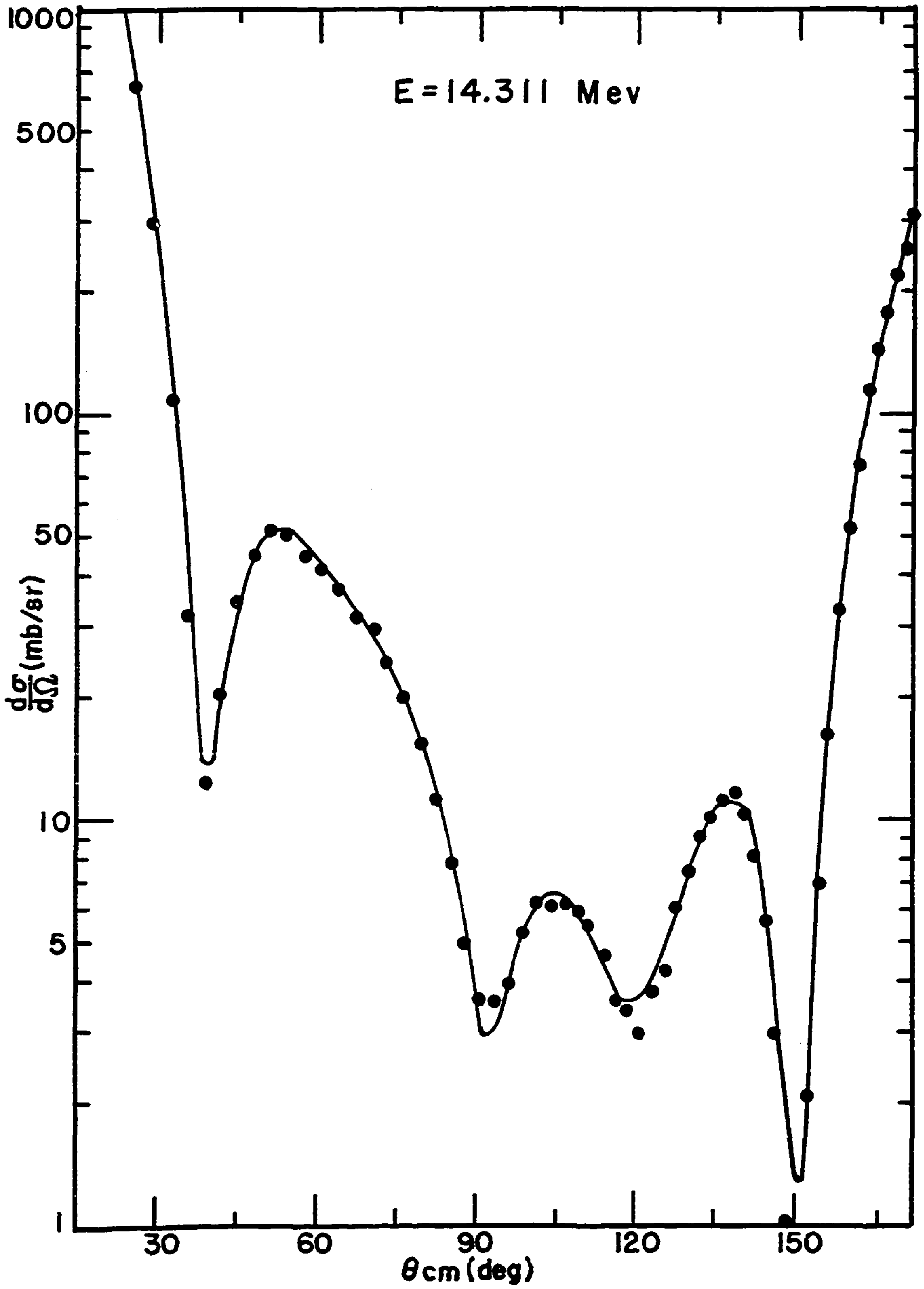


Figure 16. Fit to angular distribution at an alpha-particle energy of 14.311 Mev(● Experimental,— Calculated fit)

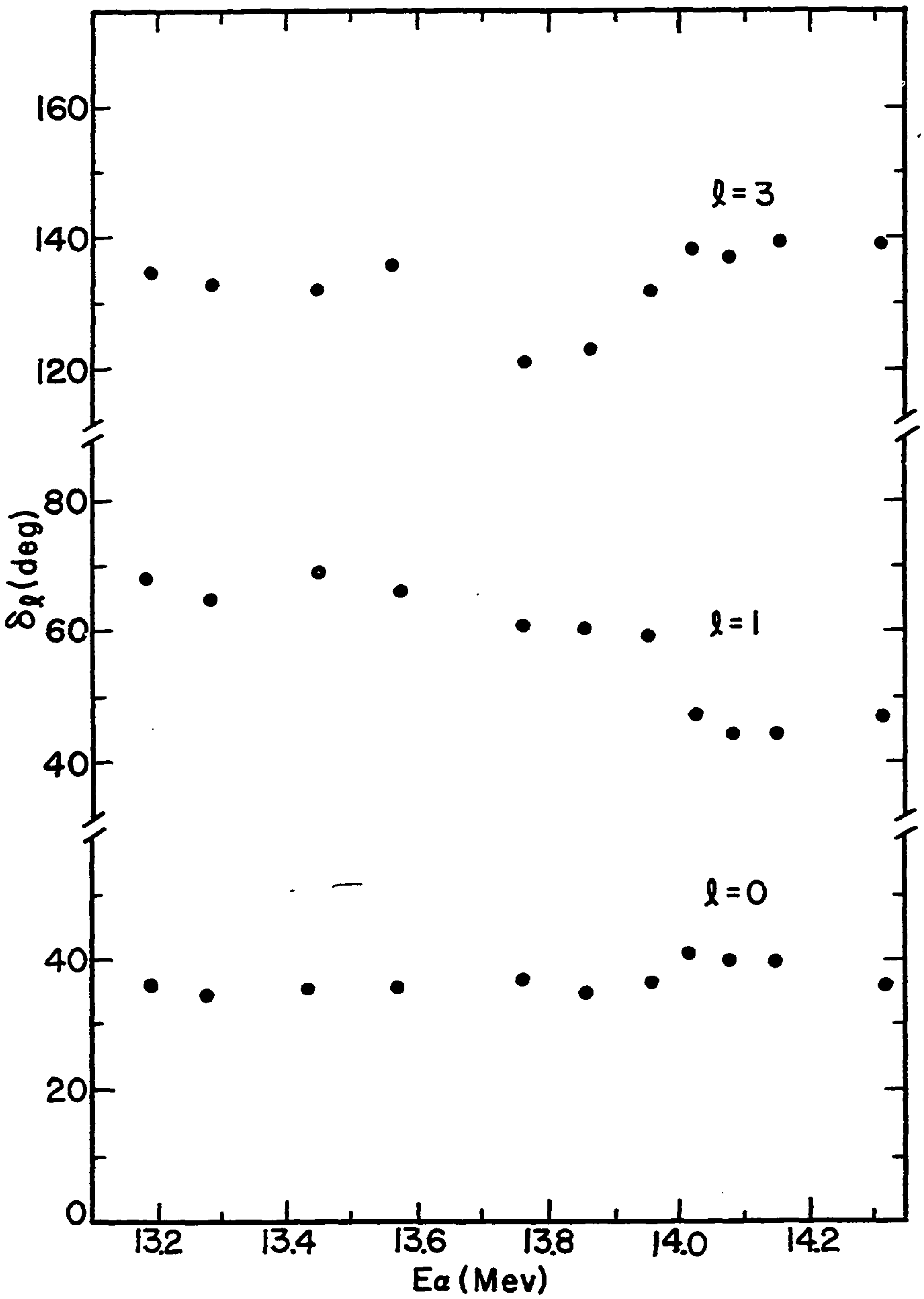


Figure 17. Energy dependence of phase angles for ℓ = 0, 1, and 3

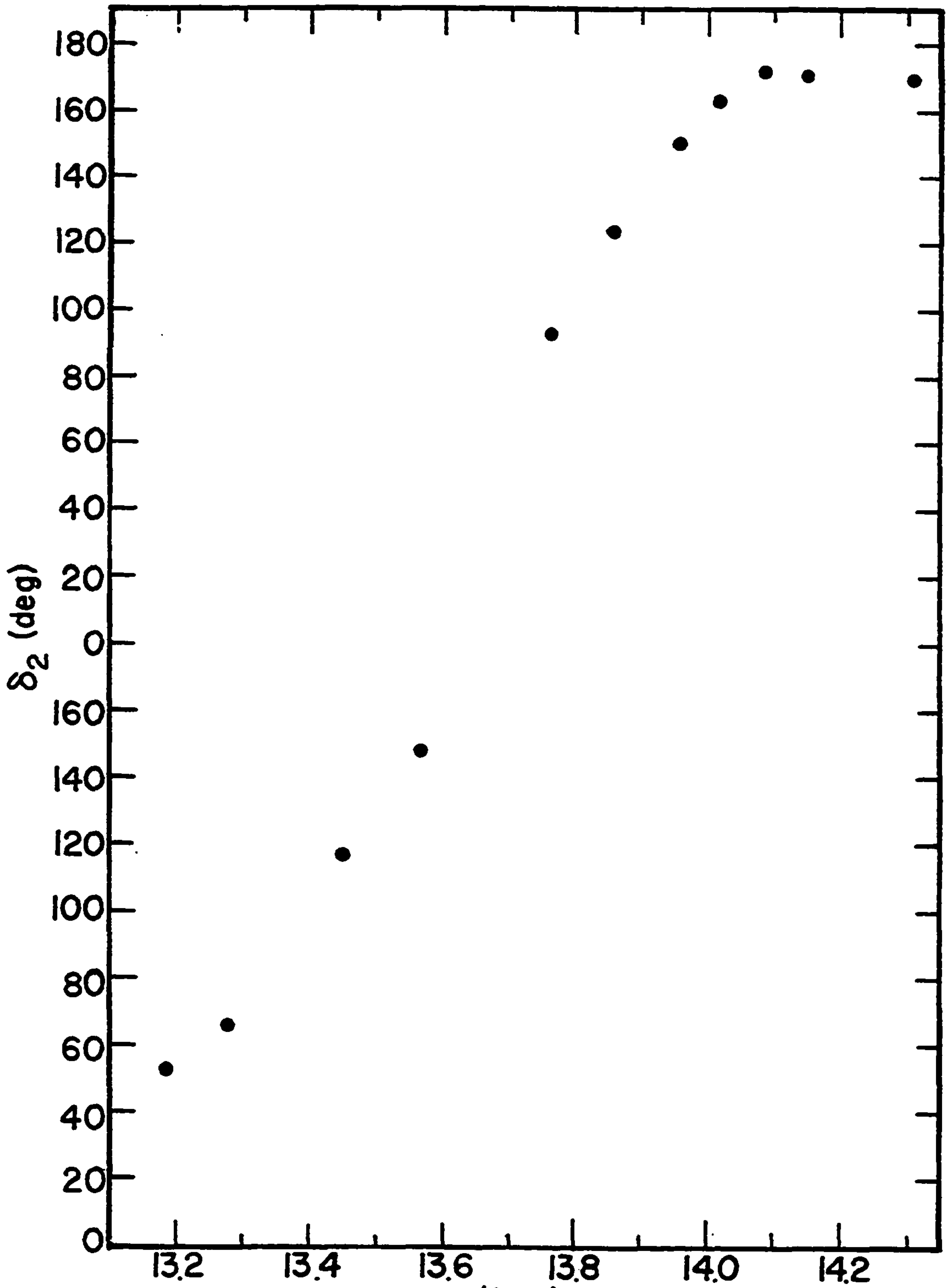


Figure 18. Energy dependence of phase angles for ℓ = 2

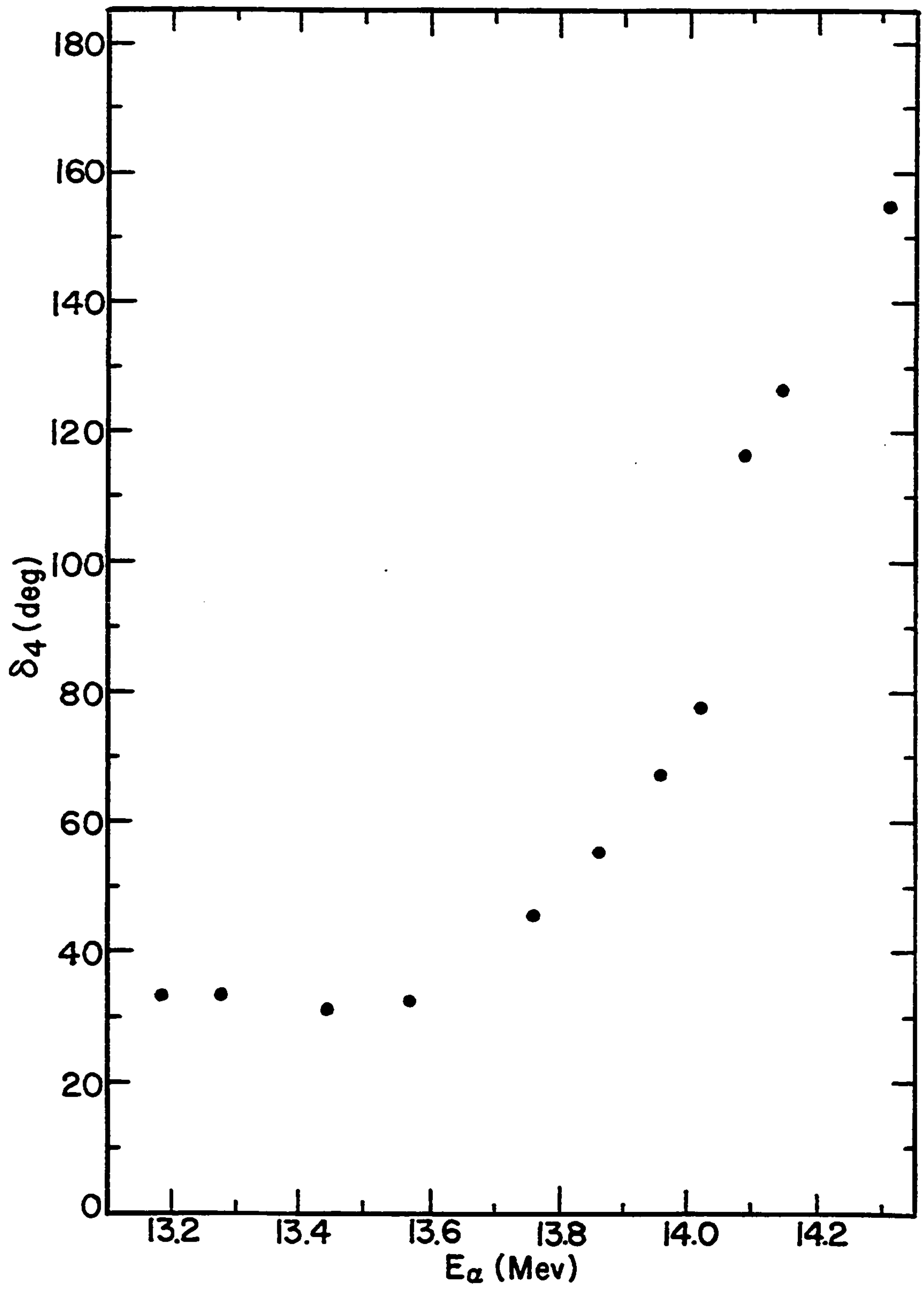


Figure 19. Energy dependence of phase angles for ℓ = 4

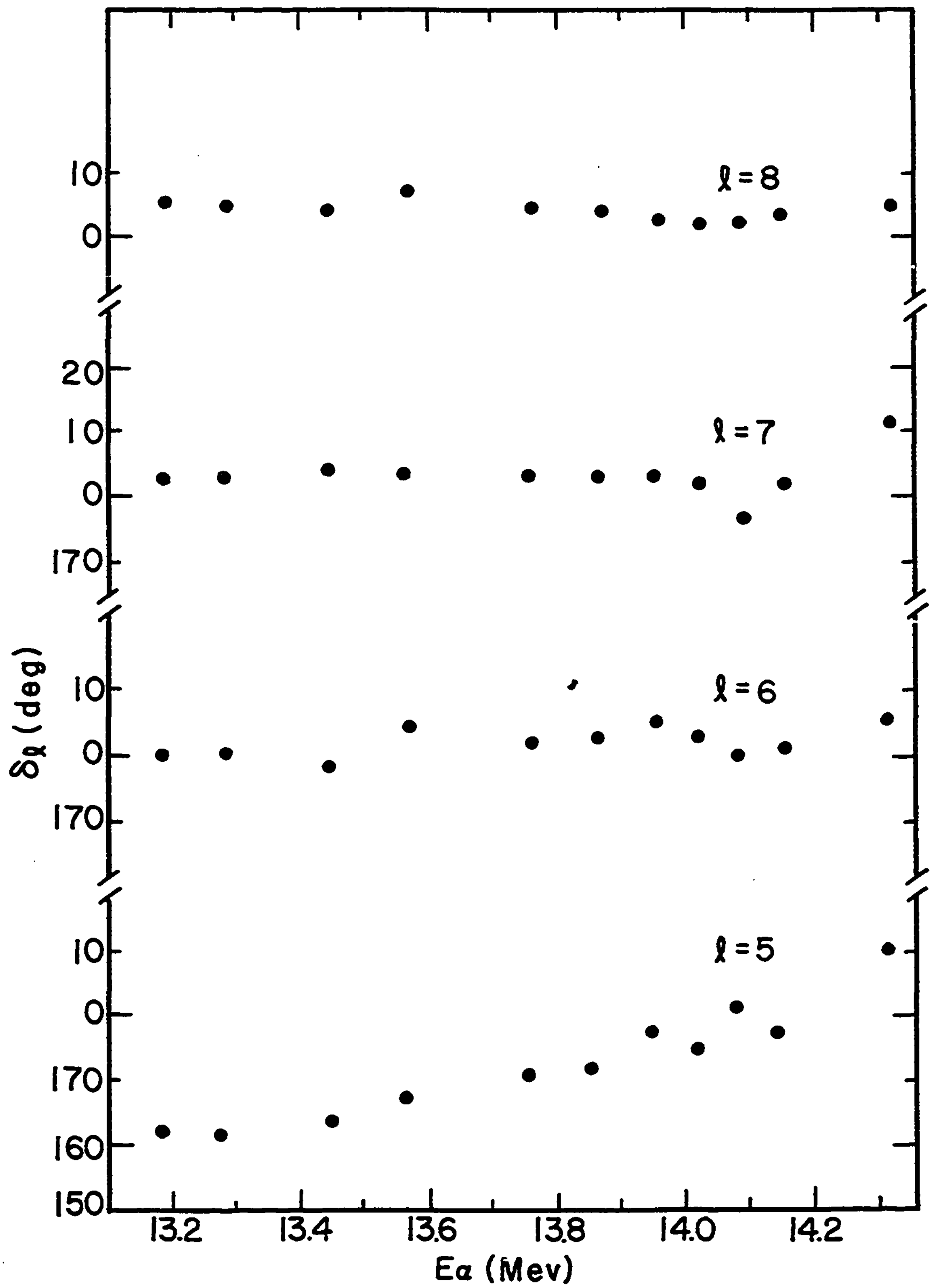


Figure 20. Energy dependence of phase angles for ℓ = 5,6,7 and 8

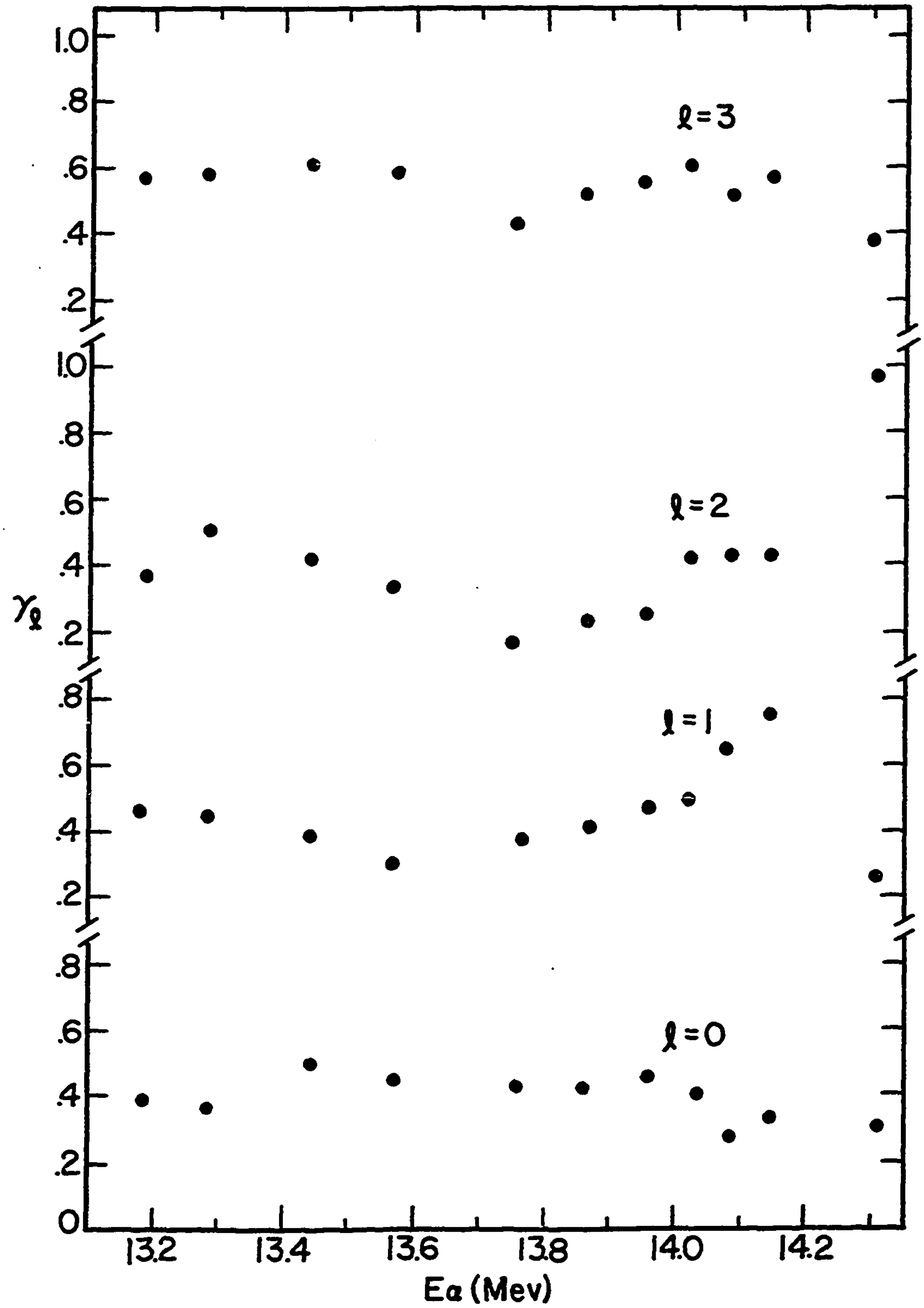


Figure 21. Energy dependence of γ_ℓ for ℓ = 0, 1, 2, and 3

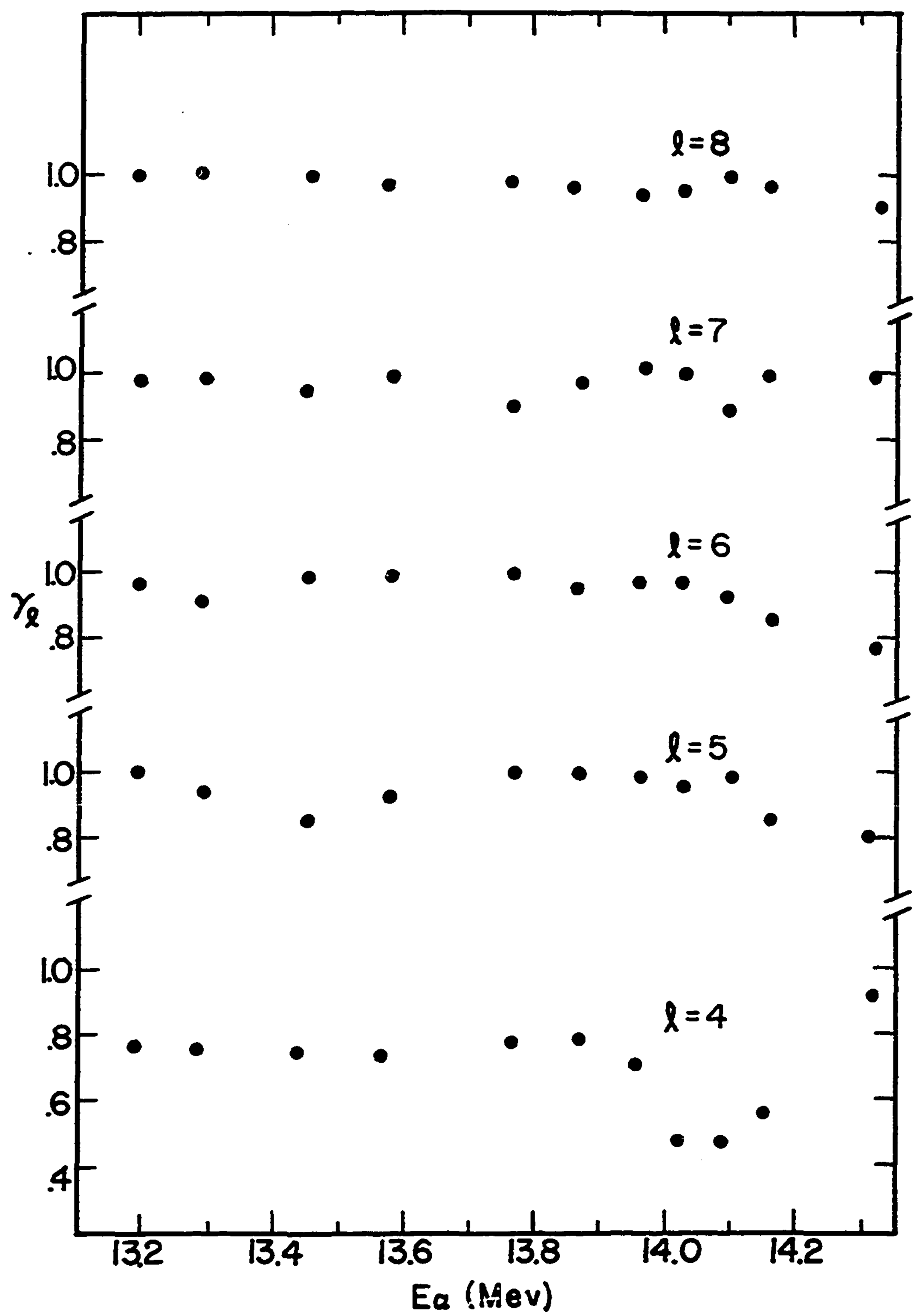


Figure 22. Energy dependence of γ_l for l = 4, 5, 6, 7 and 8

DISCUSSION AND CONCLUSIONS

Although the phase shift analysis is far from being completed, some comments can be made and some conclusions can be drawn. It has been possible to obtain good fits to the eleven angular distributions in the energy range from 13.19 to 14.31 Mev. These fits have been obtained with a set of phase shifts which vary smoothly and, except for three resonances, slowly with energy. This small number of resonances is a result of strenuous efforts to keep this number as small as possible.

A compilation[14] of information on the (α + ^{12}C) system indicates eight levels in the region of the present phase shift analysis. One resonance at an incident alpha-particle energy of 13.26 Mev with a width of 110 kev, one at 13.86 Mev with a width of 165 kev and one at 13.95 Mev with a width of 110 kev were reported[2,10] as evident in the elastic channel. However, the three resonances determined by the present analysis are not at these energies and do not have these widths.

The present analysis indicates a 4^+ resonance at an incident alpha-particle energy of 14.12 $\pm$ 0.05 Mev. Not only does δ_4 display typical resonance behavior, but Υ_4 dips, indicating appreciable strength in other channels.

The plot of δ_2 as a function of energy (Figure 18) indicates the presence of two closely spaced 2^+ levels. The lack of information on the behavior of δ_2 at lower energies and the closeness of these two levels makes difficult an estimate of their positions and widths. However, the lower 2^+ resonance is evident in excitation functions taken at center-of-mass angles of 70.26°, 80.29° and 148.64°. From a study of the behavior of σ_2 with energy and these excitation functions, the lower 2^+ resonance was determined to be at 13.45 ± 0.05 Mev. The higher 2^+ level is at 13.80 ± 0.10 Mev. All three of these levels have widths between 200 and 300 kev.

The above information is summarized in Table 2 below.

TABLE 2 Levels in ^{16}O

Excitation energy(Mev) Reference	Present work	Γ_{cm} (kev)	J^π
17.11		110	$(1^-, 2^+, 0^+)$
17.17		200	2^+
	17.25 ± 0.04	188 ± 38	2^+
17.29		<100	
17.35		150	
	17.51 ± 0.08	188 ± 38	2^+
17.56		165	(4^+)
17.62		110	
17.7			$0^+, 2^+$
	17.75 ± 0.04	188 ± 38	4^+
17.82		225	4^+

APPENDIX I

EXCITATION FUNCTIONS OF 12C(ALPHA,ALPHA)12C

ENERGY = LABORATORY ENERGY OF ALPHA PARTICLES AT CENTER
OF TARGET.

ANGCM = CENTER OF MASS ANGLES.

X-SEC = CENTER OF MASS CROSS SECTIONS.

ERROR = TOTAL UNCERTAINTY IN CROSS SECTIONS.

ANGCM = 19.29 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	2042.448	93.678	14.458	1857.279	85.284
13.223	1946.449	89.371	14.475	1797.931	82.565
13.254	1873.734	86.038	14.491	1717.249	78.867
13.285	1773.622	81.451	14.507	1823.606	83.741
13.317	1651.317	75.846	14.524	2027.217	93.072
13.348	1708.466	78.465	14.540	1985.476	91.205
13.380	1647.552	75.673	14.557	1942.621	89.195
13.412	1600.744	73.528	14.573	1903.214	87.389
13.443	1637.053	75.192	14.606	1867.921	85.772
13.475	1621.489	74.479	14.639	1839.664	84.477
13.507	1637.784	75.226	14.672	1882.327	86.432
13.538	1661.736	76.323	14.705	1844.921	84.716
13.570	1675.127	76.983	14.738	1815.029	83.348
13.602	1678.795	77.105	14.772	1729.829	79.444
13.634	1744.506	80.116	14.805	1743.807	80.084
13.666	1794.777	82.420	14.838	1694.727	77.835
13.698	1798.780	82.604	14.871	1699.365	78.046
13.729	1827.656	83.927	14.904	1629.334	74.832
13.761	1839.664	84.477	14.938	1613.435	74.112
13.794	1877.371	86.205	14.971	1593.771	73.209
13.826	1923.831	88.334	15.005	1565.212	71.902
13.858	1965.700	90.253	15.038	1550.758	71.238
13.890	1968.289	90.371	15.071	1551.298	71.263
13.922	1925.340	88.403	15.105	1555.396	71.450
13.954	1907.012	87.563	15.138	1557.842	71.562
13.986	2017.544	92.629	15.172	1553.871	71.380
14.019	2053.234	94.264	15.206	1520.516	69.852
14.051	2112.067	96.960	15.239	1580.556	72.603
14.083	2091.339	96.010	15.273	1571.216	72.175
14.116	2166.611	99.460	15.307	1584.225	72.771
14.148	2275.683	104.458	15.340	1563.844	71.720
14.181	2295.553	105.369	15.374	1515.656	69.629
14.213	2308.784	105.975	15.408	1534.144	70.476
14.246	2301.129	105.624	15.442	1493.720	68.624
14.278	2202.095	101.086	15.476	1448.881	66.569
14.311	2236.895	102.681	15.510	1450.247	66.632
14.344	2186.418	100.367	15.544	1393.289	64.022
14.376	2085.684	95.751	15.578	1379.645	63.396
14.409	1979.963	90.906	15.612	1383.536	63.575
14.425	1927.246	88.491	15.646	1385.125	63.647
14.442	1869.541	85.846			

ANGCM = 60.49 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	225.579	10.514	14.458	132.557	6.250
13.223	213.863	9.977	14.475	136.946	6.451
13.254	199.505	9.319	14.491	134.646	6.346
13.285	188.377	8.809	14.507	143.473	6.750
13.317	173.871	8.144	14.524	144.941	6.818
13.348	227.765	10.614	14.540	146.182	6.875
13.380	236.072	11.453	14.557	146.475	6.888
13.412	253.358	12.268	14.573	145.398	6.839
13.443	275.002	12.779	14.606	145.186	6.829
13.475	285.200	13.246	14.639	146.638	6.896
13.507	295.528	13.722	14.672	141.074	6.642
13.538	308.827	14.329	14.705	137.991	6.499
13.570	322.174	14.941	14.738	130.452	6.154
13.602	333.073	15.440	14.772	119.014	5.629
13.634	330.430	15.319	14.805	107.413	5.097
13.666	336.304	15.583	14.838	98.553	4.691
13.698	335.341	15.544	14.871	100.234	4.768
13.729	331.556	15.377	14.904	97.949	4.663
13.761	336.027	15.576	14.938	94.082	4.485
13.794	331.083	15.349	14.971	94.664	4.512
13.826	324.458	15.046	15.005	93.413	4.455
13.858	321.397	14.891	15.038	97.492	4.642
13.890	310.719	14.416	15.071	98.439	4.686
13.922	288.104	13.379	15.105	95.798	4.702
13.954	269.259	12.516	15.138	124.248	4.950
13.986	270.937	12.591	15.172	123.823	4.933
14.019	263.075	12.232	15.206	107.886	5.119
14.051	255.683	11.894	15.239	110.595	5.243
14.083	244.832	11.396	15.273	106.695	5.064
14.116	231.238	10.772	15.307	125.618	5.015
14.148	222.136	10.356	15.340	122.110	4.834
14.181	212.346	9.907	15.374	97.182	4.626
14.213	205.884	9.611	15.408	89.824	4.291
14.246	201.593	9.415	15.442	85.630	4.098
14.278	184.934	8.651	15.476	78.108	3.753
14.311	174.475	8.171	15.510	71.647	3.457
14.344	163.787	7.682	15.544	68.924	3.327
14.376	148.792	6.994	15.578	69.836	3.373
14.409	140.259	6.603	15.612	70.602	3.409
14.425	138.480	6.522	15.646	70.493	3.679
14.442	134.513	6.344			

ANGCM = 45.39 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	39.344	1.982	14.456	37.741	1.909
13.223	34.998	1.782	14.475	33.705	1.722
13.254	34.015	1.737	14.491	27.357	1.433
13.285	36.344	1.844	14.507	54.231	2.667
13.317	36.465	1.853	14.524	69.945	3.335
13.348	39.697	1.993	14.540	53.093	2.614
13.380	38.369	1.923	14.557	44.761	2.232
13.412	36.716	1.829	14.573	39.535	1.991
13.443	35.447	1.803	14.606	32.808	1.651
13.475	33.325	1.705	14.639	29.548	1.531
13.507	31.031	1.599	14.672	26.357	1.363
13.538	28.685	1.491	14.705	26.529	1.341
13.570	26.374	1.384	14.738	26.633	1.345
13.602	21.924	1.178	14.772	29.944	1.549
13.634	18.715	1.229	14.805	30.134	1.555
13.666	15.492	0.878	14.838	32.290	1.520
13.698	11.143	0.673	14.871	33.222	1.720
13.729	7.155	0.480	14.904	33.067	1.693
13.761	3.898	0.315	14.938	34.740	1.770
13.794	2.625	0.243	14.971	36.344	1.844
13.826	1.949	0.204	15.005	37.327	1.889
13.858	1.759	0.192	15.038	37.362	1.891
13.890	2.760	0.252	15.071	37.707	1.907
13.922	5.295	0.387	15.105	35.706	1.815
13.954	8.711	0.557	15.138	35.944	1.821
13.986	11.212	0.676	15.172	34.188	1.745
14.019	15.110	0.861	15.206	34.102	1.741
14.051	19.526	1.066	15.239	32.532	1.668
14.083	27.788	1.449	15.273	30.859	1.591
14.116	32.239	1.655	15.307	30.790	1.583
14.148	38.155	1.927	15.340	27.478	1.435
14.181	42.036	2.106	15.374	27.081	1.417
14.213	42.933	2.148	15.408	25.891	1.362
14.246	42.761	2.140	15.442	24.149	1.281
14.278	42.467	2.126	15.476	24.563	1.300
14.311	41.657	2.089	15.510	24.011	1.275
14.344	40.270	2.015	15.544	24.270	1.287
14.376	42.156	2.020	15.578	24.097	1.279
14.409	38.448	1.941	15.612	25.753	1.355
14.425	41.605	2.086	15.646	25.943	1.364
14.442	40.070	2.316			

ANGCM = 55.15 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	22.396	1.209	14.458	35.242	1.813
13.223	23.052	1.239	14.475	25.846	1.528
13.254	20.774	1.133	14.491	55.488	2.735
13.285	22.560	1.216	14.507	57.693	2.875
13.317	20.355	1.114	14.524	39.798	2.013
13.348	22.377	1.205	14.540	31.653	1.637
13.380	21.630	1.173	14.557	26.988	1.422
13.412	21.347	1.146	14.573	23.799	1.274
13.443	21.193	1.153	14.606	20.245	1.109
13,475	19.917	1.093	14.639	19.170	1.059
13.507	19.407	1.070	14.672	17.202	0.967
13.538	17.166	0.965	14.705	16.510	0.934
13,570	16.236	0.922	14.738	16.218	0.921
13.602	15.372	0.914	14.772	16.182	0.919
13.634	16.564	0.937	14.805	15.999	0.921
13.666	17.134	0.966	14.838	16.437	0.931
13.698	19.662	1.082	14.871	15.653	0.894
13.729	24.546	1.309	14.904	16.455	0.932
13.761	29.942	1.558	14.938	15.125	0.873
13.794	37.539	1.909	14.971	15.362	0.881
13.826	44.427	2.226	15.005	15.125	0.872
13.858	46.395	2.316	15.038	15.288	0.868
13,890	48.417	2.409	15.071	12.610	0.751
13.922	53.028	2.621	15.105	12,574	0.740
13,954	58.385	2.867	15.138	11.972	0.727
13.986	61.331	3.001	15.172	10.551	0.652
14,019	66.749	3.252	15.206	10.114	0.632
14,051	72.653	3.523	15.239	8.182	0.535
14,083	75.788	3.666	15.273	8.822	0.569
14.116	77.719	3.755	15.307	6.961	0.475
14.148	77.574	3.748	15.340	6.050	0.433
14.181	75.970	3.675	15.374	5.266	0.393
14.213	70.649	3.431	15,408	4.756	0.366
14,246	65.219	3.181	15.442	4.246	0.339
14,278	55.378	2.729	15.476	3.790	0.315
14.311	50.167	2.490	15.510	3.736	0.312
14.344	47.124	2.350	15.544	3.353	0.291
14,376	46.796	2.335	15.578	3.171	0.281
14.409	41.912	2.110	15.612	3.663	0.328
14.425	39.798	2.013	15.646	3.809	0.316
14,442	37.065	1.887			

ANGCM = 72.26 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	43.675	2.209	14.458	20.001	1.113
13.223	42.261	2.051	14.475	16.754	0.962
13.254	38.863	1.950	14.491	15.225	0.890
13.285	39.362	2.010	14.507	13.008	0.784
13.317	44.877	2.264	14.524	12.686	0.769
13.348	48.014	2.403	14.540	12.568	0.763
13.380	51.271	2.558	14.557	12.108	0.742
13.412	52.090	2.596	14.573	12.488	0.760
13.443	50.412	2.519	14.606	14.146	0.839
13.475	50.032	2.501	14.639	14.266	0.844
13.507	49.173	2.462	14.672	15.645	0.929
13.538	43.835	2.216	14.705	14.906	0.874
13.570	43.878	2.218	14.738	14.346	0.846
13.602	42.261	2.051	14.772	15.665	0.912
13.634	39.222	2.003	14.805	16.184	0.935
13.666	39.622	2.022	14.838	16.464	0.946
13.698	42.601	2.067	14.871	16.464	0.948
13.729	44.897	2.265	14.904	18.242	1.031
13.761	44.198	2.233	14.938	18.922	1.063
13.794	47.754	2.397	14.971	19.222	1.077
13.826	49.033	2.455	15.005	19.741	1.121
13.858	46.553	2.433	15.038	19.901	1.129
13.890	44.557	2.250	15.071	19.561	1.093
13.922	40.941	2.083	15.105	17.903	1.015
13.954	37.784	1.937	15.138	19.921	1.129
13.986	36.985	1.901	15.172	20.587	1.147
14.019	36.125	1.861	15.206	21.120	1.166
14.051	34.787	1.799	15.239	19.122	1.072
14.083	32.928	1.712	15.273	20.620	1.142
14.116	33.248	1.728	15.307	19.761	1.122
14.148	31.730	1.658	15.340	21.659	1.191
14.181	31.092	1.628	15.374	21.519	1.164
14.213	29.312	1.532	15.408	22.399	1.225
14.246	29.172	1.539	15.442	24.856	1.342
14.278	30.031	1.579	15.476	24.277	1.312
14.311	29.192	1.541	15.510	26.215	1.473
14.344	27.993	1.485	15.544	29.312	1.546
14.376	26.075	1.396	15.578	31.670	1.655
14.409	26.814	1.430	15.612	31.230	1.635
14.425	24.736	1.334	15.646	32.729	1.704
14.442	22.558	1.232			

ANGCM = 80.29 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	4.179	0.357	14.458	5.737	0.439
13.223	3.724	0.331	14.475	3.139	0.298
13.254	3.377	0.311	14.491	5.369	0.420
13.285	5.239	0.414	14.507	8.898	0.599
13.317	7.686	0.539	14.524	8.855	0.597
13.348	9.396	0.624	14.540	8.617	0.585
13.380	11.756	0.738	14.557	9.180	0.613
13.412	12.233	0.761	14.573	9.201	0.614
13.443	11.670	0.734	14.606	9.272	0.629
13.475	11.843	0.742	14.639	9.440	0.626
13.507	11.475	0.724	14.672	9.396	0.624
13.538	9.721	0.640	14.705	9.526	0.637
13.570	9.137	0.611	14.738	9.613	0.634
13.602	8.292	0.569	14.772	9.052	0.627
13.634	4.828	0.392	14.805	10.436	0.674
13.666	6.647	0.486	14.838	11.020	0.722
13.698	6.907	0.500	14.871	11.193	0.711
13.729	5.997	0.453	14.904	13.791	0.835
13.761	5.694	0.437	14.938	13.640	0.838
13.794	5.672	0.436	14.971	14.809	0.884
13.826	4.525	0.375	15.005	15.827	0.932
13.858	3.897	0.341	15.038	16.173	0.949
13.890	2.752	0.275	15.071	15.805	0.931
13.922	1.494	0.193	15.105	15.567	0.920
13.954	0.714	0.128	15.138	16.996	0.987
13.986	0.563	0.113	15.172	16.151	0.947
14.019	0.779	0.135	15.206	16.801	0.978
14.051	1.104	0.163	15.239	18.836	1.074
14.083	2.338	0.249	15.273	18.901	1.077
14.116	3.507	0.319	15.307	18.706	1.067
14.148	5.478	0.426	15.340	18.468	1.056
14.181	8.206	0.564	15.374	20.113	1.134
14.213	9.505	0.629	15.408	22.849	1.163
14.246	12.276	0.763	15.442	21.694	1.207
14.278	13.164	0.806	15.476	23.637	1.307
14.311	13.726	0.832	15.510	24.747	1.350
14.344	12.925	0.794	15.544	27.431	1.475
14.376	12.536	0.776	15.578	28.687	1.533
14.409	11.323	0.717	15.612	29.705	1.580
14.425	9.894	0.646	15.645	31.610	1.569
14.442	7.383	0.524			

ANGCM = 92.50 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	13.260	0.828	14.458	1.095	0.149
13.223	14.117	0.869	14.475	3.214	0.314
13.254	13.474	0.838	14.491	15.426	0.931
13.285	10.879	0.712	14.507	14.378	0.881
13.317	7.642	0.552	14.524	3.980	0.352
13.348	5.309	0.430	14.540	1.785	0.222
13.380	3.047	0.305	14.557	2.190	0.249
13.412	3.404	0.325	14.573	1.381	0.192
13.443	2.595	0.276	14.626	0.976	0.154
13.475	3.809	0.348	14.639	0.619	0.124
13.507	4.952	0.411	14.672	0.476	0.108
13.538	5.713	0.452	14.705	0.829	0.144
13.570	6.380	0.487	14.738	0.861	0.151
13.602	8.427	0.591	14.772	0.714	0.134
13.634	8.903	0.615	14.805	0.881	0.151
13.666	8.784	0.609	14.838	1.024	0.163
13.698	11.284	0.732	14.871	0.833	0.146
13.729	12.307	0.782	14.904	0.571	0.120
13.761	12.457	0.788	14.938	0.762	0.139
13.794	14.593	0.891	14.971	0.809	0.144
13.826	15.378	0.929	15.005	0.690	0.132
13.858	16.568	1.060	15.038	0.476	0.108
13.890	19.616	1.129	15.071	0.333	0.091
13.922	19.259	1.112	15.105	0.405	0.100
13.954	21.187	1.203	15.138	0.428	0.103
13.986	20.663	1.178	15.172	0.357	0.093
14.019	22.377	1.165	15.206	0.309	0.087
14.051	21.306	1.208	15.239	0.309	0.087
14.083	20.116	1.153	15.273	0.428	0.103
14.116	22.306	1.161	15.307	0.024	0.024
14.148	17.592	1.034	15.340	0.262	0.080
14.181	15.069	0.914	15.374	0.167	0.063
14.213	11.189	0.727	15.408	0.190	0.068
14.246	8.808	0.610	15.442	0.214	0.072
14.278	5.856	0.460	15.476	0.286	0.083
14.311	3.697	0.341	15.510	0.452	0.105
14.344	2.023	0.238	15.544	0.500	0.111
14.376	1.071	0.167	15.578	0.524	0.115
14.409	0.143	0.058	15.612	1.071	0.167
14.425	0.048	0.034	15.646	1.214	0.179
14.442	0.714	0.134			

ANGCM = 103.38 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	27.657	1.488	14.458	12.091	0.799
13.223	29.627	1.629	14.475	17.699	1.069
13.254	28.314	1.568	14.491	23.143	1.325
13.285	26.317	1.474	14.507	14.307	0.906
13.317	19.943	1.175	14.524	11.498	0.769
13.348	16.165	0.996	14.540	11.025	0.745
13.380	13.240	0.855	14.557	11.271	0.754
13.412	12.174	0.823	14.573	11.298	0.760
13.443	11.107	0.750	14.606	9.684	0.667
13.475	12.201	0.804	14.639	8.891	0.640
13.507	11.353	0.762	14.672	9.547	0.673
13.538	12.693	0.828	14.705	10.423	0.716
13.570	12.422	0.815	14.738	9.032	0.692
13.602	14.288	0.896	14.772	10.122	0.701
13.634	16.386	1.006	14.805	9.200	0.645
13.666	19.614	1.160	14.838	10.231	0.727
13.698	21.912	1.268	14.871	9.903	0.690
13.729	25.879	1.454	14.904	8.239	0.679
13.761	26.973	1.505	14.938	7.550	0.571
13.794	29.162	1.607	14.971	6.237	0.512
13.826	30.037	1.648	15.005	7.324	0.558
13.858	31.761	1.728	15.038	6.046	0.491
13.890	32.636	1.769	15.071	6.374	0.517
13.922	32.967	1.691	15.105	6.128	0.495
13.954	30.420	1.666	15.138	5.800	0.479
13.986	30.311	1.661	15.172	6.374	0.510
14.019	26.043	1.462	15.206	7.249	0.555
14.051	28.533	1.578	15.239	7.277	0.557
14.083	23.472	1.341	15.273	7.742	0.581
14.115	21.037	1.227	15.307	8.535	0.621
14.148	18.192	1.092	15.340	10.261	0.707
14.181	17.754	1.071	15.374	10.778	0.734
14.213	13.459	0.865	15.408	11.517	0.772
14.246	8.891	0.640	15.442	12.228	0.825
14.278	8.097	0.600	15.476	11.955	0.792
14.311	6.237	0.502	15.510	12.502	0.819
14.344	5.909	0.485	15.544	12.256	0.827
14.376	5.692	0.473	15.578	12.830	0.834
14.409	8.289	0.609	15.612	13.022	0.844
14.425	7.605	0.574	15.646	14.827	0.931
14.442	10.970	0.744			

ANGCM = 111.47 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	15.540	0.968
13.223	16.777	1.048
13.254	16.536	1.036
13.285	17.230	1.069
13.317	15.027	0.963
13.348	13.307	0.882
13.382	10.378	0.719
13.412	8.871	0.658
13.443	6.880	0.554
13.475	5.462	0.477
13.507	4.918	0.446
13.538	4.888	0.445
13.570	3.661	0.373
13.602	3.591	0.368
13.634	3.048	0.334
13.666	3.561	0.366
13.698	4.868	0.445
13.729	6.850	0.553
13.761	9.294	0.683
13.794	10.934	0.765
13.826	11.466	0.789
13.858	10.984	0.765
13.890	10.621	0.746
13.922	10.018	0.716
13.954	8.328	0.630
13.986	7.785	0.602
14.019	6.578	0.538
14.051	5.854	0.498
14.083	5.552	0.482
14.116	5.492	0.479
14.148	5.220	0.463
14.181	5.522	0.480
14.213	5.703	0.490
14.246	5.220	0.463
14.278	5.371	0.472
14.311	5.341	0.470
14.344	4.617	0.429
14.376	5.824	0.497
14.409	6.216	0.518
14.425	7.513	0.587
14.442	8.238	0.626
14.458	10.048	0.71[illegible]
14.475	10.712	0.751
14.491	10.410	0.736
14.507	10.772	0.754
14.524	14.182	0.922
14.540	13.367	0.[illegible]
14.557	13.096	0.86[illegible]
14.573	12.311	0.8[illegible]
14.606	9.867	0.7[illegible]
14.639	9.475	0.68[illegible]
14.672	8.449	0.636
14.705	7.996	0.61[illegible]
14.738	7.845	0.60[illegible]
14.772	7.634	0.59[illegible]
14.805	7.725	0.600
14.838	6.397	0.528
14.871	5.281	0.4[illegible]7
14.904	5.009	0.452
14.938	3.742	0.3[illegible]
14.971	3.380	0.3[illegible]
15.005	2.022	0.264
15.038	1.810	0.24[illegible]
15.071	1.358	0.211
15.105	0.996	0.17[illegible]
15.138	1.056	0.1[illegible]
15.172	1.237	0.221
15.206	1.358	0.211
15.239	2.535	0.3[illegible]
15.273	2.686	0.31[illegible]
15.307	2.987	0.33[illegible]
15.340	4.617	0.429
15.374	5.281	0.4[illegible]7
15.408	5.643	0.487
15.442	5.431	0.475
15.476	6.638	0.542
15.510	7.051	0.564
15.544	7.162	0.571
15.578	8.811	0.655
15.612	10.290	0.730
15.646	11.527	0.792

ANGCM = 122.69 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	28.499	1.644	14.458	8.027	0.645
13.223	31.934	1.606	14.475	10.236	0.761
13.254	25.869	1.520	14.491	6.064	0.538
13.285	25.659	1.510	14.507	8.904	0.692
13.317	38.919	2.048	14.524	13.355	0.918
13.348	31.163	1.770	14.540	14.267	0.965
13.380	30.987	1.761	14.557	15.285	1.149
13.412	29.831	1.727	14.573	15.774	1.037
13.443	28.218	1.632	14.606	19.244	1.205
13.475	25.834	1.519	14.639	19.735	1.229
13.507	26.626	1.555	14.672	19.770	1.230
13.538	24.643	1.462	14.705	18.473	1.163
13.570	22.434	1.358	14.738	20.647	1.278
13.602	19.139	1.200	14.772	19.034	1.195
13.634	16.896	1.092	14.805	19.244	1.205
13.666	14.127	0.956	14.838	21.172	1.297
13.698	11.708	0.836	14.871	20.857	1.282
13.729	9.464	0.721	14.904	21.768	1.325
13.761	10.130	0.755	14.938	20.506	1.265
13.794	10.867	0.793	14.971	18.088	1.149
13.826	13.531	0.927	15.005	18.754	1.182
13.858	13.916	0.945	15.038	19.455	1.215
13.890	15.424	1.020	15.071	20.216	1.242
13.922	12.584	0.879	15.105	20.366	1.259
13.954	12.935	0.897	15.138	17.527	1.122
13.986	10.306	0.764	15.172	16.405	1.063
14.019	5.658	0.679	15.206	15.984	1.048
14.051	5.293	0.495	15.239	14.197	0.959
14.083	3.996	0.416	15.273	11.778	0.840
14.116	1.823	0.266	15.307	11.147	0.827
14.148	0.771	0.168	15.342	9.710	0.733
14.181	0.140	0.070	15.374	9.570	0.725
14.213	0.456	0.128	15.408	10.130	0.755
14.246	1.297	0.221	15.442	8.375	0.664
14.278	2.138	0.291	15.476	7.642	0.625
14.311	3.015	0.353	15.510	9.815	0.740
14.344	4.487	0.447	15.544	10.411	0.770
14.376	4.837	0.468	15.578	8.308	0.661
14.409	6.345	0.554	15.612	8.623	0.677
14.425	7.537	0.619	15.646	7.712	0.629
14.442	6.870	0.583			

ANGCM = 132.60 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	47.152	2.561	14.458	23.536	1.451
13.223	45.949	2.505	14.475	26.864	1.612
13.254	44.225	2.425	14.491	22.052	1.380
13.285	41.419	2.294	14.507	12.871	0.929
13.317	43.945	2.412	14.524	23.947	1.471
13.348	42.541	2.347	14.540	30.392	1.777
13.380	45.629	2.491	14.557	35.204	2.003
13.412	48.796	2.638	14.573	40.015	2.229
13.443	46.070	2.511	14.606	44.787	2.451
13.475	48.435	2.621	14.639	44.346	2.430
13.507	47.513	2.578	14.672	47.553	2.580
13.538	50.360	2.710	14.705	50.360	2.710
13.570	44.225	2.425	14.738	53.527	2.857
13.602	44.386	2.432	14.772	55.893	2.967
13.634	38.572	2.161	14.805	55.780	3.100
13.666	37.128	2.094	14.838	57.296	3.232
13.698	32.598	1.881	14.871	58.379	3.082
13.729	30.352	1.775	14.904	57.978	3.063
13.761	27.706	1.650	14.938	59.502	3.134
13.794	31.315	1.821	14.971	60.063	3.160
13.826	30.031	1.760	15.005	60.745	3.191
13.858	30.112	1.764	15.038	60.424	3.177
13.890	28.829	1.703	15.071	59.542	3.136
13.922	26.984	1.616	15.105	58.419	3.083
13.954	23.897	1.469	15.138	57.296	3.232
13.986	21.170	1.338	15.172	54.089	2.883
14.019	17.883	1.179	15.206	51.242	2.751
14.051	15.116	1.042	15.239	49.317	2.562
14.083	10.705	0.818	15.273	47.473	2.576
14.116	5.894	0.556	15.307	42.822	2.359
14.148	3.007	0.373	15.340	44.025	2.416
14.181	2.085	0.304	15.374	40.376	2.245
14.213	2.366	0.327	15.408	40.857	2.265
14.246	3.969	0.438	15.442	37.168	2.095
14.278	6.415	0.586	15.476	38.010	2.135
14.311	8.260	0.688	15.510	36.447	2.062
14.344	11.989	0.884	15.544	35.083	1.995
14.376	14.635	1.018	15.578	32.678	1.885
14.409	15.116	1.042	15.612	31.555	1.832
14.425	17.883	1.179	15.646	30.031	1.760
14.442	22.133	1.384			

ANGCM = 140.86 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	30.252	1.811	14.458	19.914	1.314
13.223	28.454	1.726	14.475	22.616	1.445
13.254	25.173	1.569	14.491	15.418	1.092
13.285	21.352	1.385	14.507	12.586	0.943
13.317	25.173	1.569	14.524	23.285	1.478
13.348	26.926	1.653	14.542	30.537	1.[illegible]
13.380	31.152	1.854	14.557	33.714	1.9[illegible]
13.412	36.681	2.115	14.573	33.624	1.971
13.443	36.320	2.098	14.606	39.468	2.245
13.475	39.243	2.236	14.639	40.906	2.314
13.507	37.535	2.155	14.672	44.817	2.496
13.538	37.535	2.155	14.705	44.232	2.469
13.570	34.882	2.030	14.738	42.300	2.37[illegible]
13.602	32.995	1.942	14.772	44.502	2.482
13.634	28.569	1.733	14.805	43.783	2.446
13.666	28.904	1.748	14.838	47.829	2.637
13.698	24.499	1.536	14.871	46.210	2.561
13.729	24.858	1.554	14.904	44.682	2.49[illegible]
13.761	22.792	1.454	14.938	44.817	2.495
13.794	22.296	1.430	14.971	45.716	2.559
13.826	21.127	1.374	15.005	45.421	2.524
13.858	19.824	1.310	15.038	45.087	2.529
13.890	17.711	1.206	15.071	46.750	2.557
13.922	17.666	1.204	15.105	45.131	2.511
13.954	15.014	1.072	15.138	44.727	2.492
13.986	12.946	0.967	15.172	41.176	2.325
14.019	11.103	0.870	15.206	40.861	2.311
14.051	9.395	0.780	15.239	37.535	2.155
14.083	7.237	0.659	15.273	33.983	1.966
14.116	5.574	0.562	15.307	34.972	2.[illegible]
14.148	4.291	0.468	15.340	34.927	2.[illegible]
14.181	3.551	0.432	15.374	29.668	1.754
14.213	4.540	0.498	15.408	35.017	2.037
14.246	5.889	0.581	15.442	30.702	1.833
14.278	7.642	0.683	15.476	29.938	1.797
14.311	8.900	0.753	15.510	28.050	1.777
14.344	9.889	0.806	15.544	28.095	1.7[illegible]
14.376	12.946	0.967	15.578	25.611	1.638
14.409	13.845	1.012	15.612	24.049	1.515
14.425	14.969	1.069	15.646	23.240	1.476
14.442	16.183	1.130			

ANGCM = 146.64 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	5.776	0.598	14.458	2.490	0.370
13.223	3.884	0.475	14.475	3.834	0.471
13.254	3.237	0.428	14.491	3.187	0.424
13.285	3.535	0.450	14.507	4.083	0.468
13.317	4.482	0.515	14.524	5.229	0.563
13.348	7.220	0.685	14.540	5.428	0.576
13.380	8.415	0.753	14.557	6.175	0.622
13.412	12.059	0.845	14.573	5.428	0.576
13.443	9.662	0.823	14.606	6.224	0.626
13.475	9.710	0.825	14.639	6.424	0.636
13.507	8.565	0.762	14.672	6.374	0.634
13.538	8.565	0.762	14.705	4.033	0.445
13.570	7.917	0.725	14.738	4.930	0.544
13.602	6.374	0.634	14.772	4.382	0.508
13.634	4.731	0.531	14.805	4.133	0.492
13.666	3.436	0.443	14.838	3.535	0.450
13.698	2.938	0.405	14.871	3.685	0.460
13.729	2.191	0.345	14.904	3.336	0.436
13.761	2.440	0.366	14.938	3.237	0.428
13.794	1.394	0.271	14.971	3.535	0.450
13.826	0.847	0.209	15.005	4.382	0.508
13.858	1.095	0.239	15.038	3.834	0.471
13.890	0.647	0.182	15.071	3.635	0.456
13.922	0.747	0.196	15.105	4.133	0.492
13.954	0.598	0.174	15.138	2.639	0.383
13.986	0.349	0.133	15.172	3.356	0.439
14.019	0.847	0.209	15.206	2.490	0.370
14.051	1.295	0.261	15.239	3.535	0.450
14.083	0.797	0.202	15.273	1.842	0.315
14.116	0.747	0.196	15.307	2.042	0.332
14.148	0.797	0.202	15.340	1.992	0.326
14.181	0.946	0.221	15.374	1.494	0.281
14.213	0.498	0.159	15.408	1.842	0.315
14.246	0.349	0.133	15.442	1.494	0.281
14.278	0.498	0.159	15.476	1.693	0.300
14.311	0.448	0.150	15.510	1.046	0.233
14.344	0.498	0.159	15.544	1.494	0.281
14.376	0.249	0.112	15.578	2.141	0.341
14.409	0.299	0.123	15.612	2.390	0.362
14.425	1.245	0.255	15.646	3.834	0.471
14.442	2.739	0.390			

ANGCM = 156.23 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	26.822	1.723	14.458	47.292	2.695
13.223	33.392	2.038	14.475	46.369	2.652
13.254	36.595	2.191	14.491	37.193	2.219
13.285	47.787	2.718	14.507	23.510	1.561
13.317	47.183	2.690	14.524	25.465	1.55[illegible]
13.348	44.143	2.547	14.540	30.282	1.8[illegible]
13.382	34.369	2.085	14.557	31.817	1.963
13.412	27.923	1.775	14.573	31.980	1.971
13.443	22.752	1.524	14.606	31.274	1.937
13.475	17.918	1.283	14.639	28.451	1.801
13.507	14.388	1.123	14.672	33.283	2.036
13.538	11.891	0.971	14.705	32.252	1.984
13.570	10.099	0.873	14.738	35.564	2.142
13.602	12.162	0.936	14.772	36.758	2.1[illegible]
13.634	12.379	0.997	14.805	39.906	2.345
13.666	14.228	1.083	14.838	45.554	2.614
13.698	14.497	1.108	14.871	45.229	2.598
13.729	12.868	1.023	14.904	48.866	2.76[illegible]
13.761	13.954	1.030	14.938	44.903	2.583
13.794	16.777	1.225	14.971	46.260	2.64[illegible]
13.826	17.829	1.278	15.005	53.604	2.851
13.858	19.275	1.352	15.038	52.658	2.853
13.890	17.918	1.283	15.071	46.966	2.682
13.922	19.492	1.363	15.105	48.486	2.752
13.954	19.547	1.365	15.138	49.519	2.8[illegible]
13.986	19.166	1.346	15.172	45.337	2.603
14.019	13.248	1.043	15.206	47.563	2.728
14.051	11.294	0.939	15.239	40.586	2.662
14.083	8.633	0.791	15.273	46.206	2.644
14.116	6.353	0.655	15.307	47.835	2.721
14.148	6.227	0.635	15.340	43.654	2.525
14.181	8.253	0.769	15.374	47.020	2.693
14.213	9.719	0.852	15.408	47.455	2.703
14.246	14.551	1.111	15.442	51.201	2.878
14.278	18.569	1.316	15.476	51.038	2.871
14.311	22.098	1.491	15.510	53.264	2.975
14.344	27.419	1.751	15.544	52.450	2.937
14.376	35.835	2.155	15.578	51.092	2.874
14.409	38.007	2.258	15.612	49.572	2.822
14.425	38.984	2.304	15.646	46.097	2.639
14.442	47.346	2.698			

ANGCM = 163.10 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	148.893	7.430	14.458	213.493	12.393
13.223	149.726	7.467	14.475	223.659	12.865
13.254	165.508	8.194	14.491	190.894	9.368
13.285	184.853	9.083	14.507	113.747	5.812
13.317	179.101	8.819	14.524	144.129	7.211
13.348	166.147	8.223	14.540	173.234	8.549
13.380	138.610	6.957	14.557	175.500	8.653
13.412	117.465	5.983	14.573	187.757	9.216
13.443	107.937	5.544	14.606	184.620	9.072
13.475	95.447	4.968	14.639	193.244	9.459
13.507	88.244	4.634	14.672	222.978	9.915
13.538	84.351	4.455	14.705	213.260	10.387
13.570	80.459	4.274	14.738	214.538	10.446
13.602	83.131	4.398	14.772	221.684	10.774
13.634	76.218	4.078	14.805	235.045	11.367
13.666	83.712	4.425	14.838	239.254	11.571
13.698	83.015	4.393	14.871	249.859	12.067
13.729	77.903	4.156	14.904	251.834	12.159
13.761	79.646	4.237	14.938	256.307	12.363
13.794	89.522	4.693	14.971	259.735	12.520
13.826	99.339	5.147	15.005	258.050	12.443
13.858	98.817	5.123	15.038	262.640	12.654
13.890	103.406	5.335	15.071	255.843	12.342
13.922	98.203	5.086	15.105	247.593	11.963
13.954	92.974	4.761	15.138	245.760	11.926
13.986	82.266	4.350	15.172	247.129	11.942
14.019	64.425	3.530	15.206	238.937	11.566
14.051	53.388	3.014	15.239	232.605	11.275
14.083	42.931	2.523	15.273	226.796	11.009
14.116	33.926	2.095	15.307	224.414	10.899
14.148	34.275	2.111	15.340	227.145	11.025
14.181	43.744	2.561	15.374	220.754	10.731
14.213	54.609	3.072	15.408	222.381	10.826
14.246	73.023	3.930	15.442	234.929	11.382
14.278	96.086	4.997	15.476	239.228	11.579
14.311	119.672	6.085	15.510	232.082	11.251
14.344	136.112	6.842	15.544	234.464	11.361
14.376	164.520	8.149	15.578	222.439	10.829
14.409	192.231	9.422	15.612	212.796	10.366
14.425	194.554	9.528	15.646	200.073	9.782
14.442	205.941	10.051			

ANGCM = 169.95 DEG

ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)	ENERGY (MEV)	X-SEC (MB/SR)	ERROR (MB/SR)
13.191	326.274	15.602	14.458	452.658	21.397
13.223	331.021	15.819	14.475	471.948	22.231
13.254	358.281	17.069	14.491	379.152	18.027
13.285	377.509	17.951	14.507	253.803	12.277
13.317	370.147	17.614	14.524	341.791	16.313
13.348	339.722	16.218	14.540	393.391	18.680
13.380	292.199	14.039	14.557	408.604	19.377
13.412	267.372	12.900	14.573	416.879	19.757
13.443	239.747	11.631	14.606	426.919	20.217
13.475	221.978	10.816	14.639	435.256	20.599
13.507	207.557	10.154	14.672	452.902	21.426
13.538	205.184	10.045	14.705	473.408	22.348
13.570	208.227	10.185	14.738	484.057	22.837
13.602	221.512	10.766	14.772	518.680	24.424
13.634	201.046	9.855	14.805	534.014	25.127
13.666	199.829	9.799	14.838	552.391	25.959
13.698	197.091	9.673	14.871	557.319	26.195
13.729	200.803	9.844	14.904	557.198	26.190
13.761	212.303	10.372	14.938	566.508	26.616
13.794	218.510	10.657	14.971	562.796	26.445
13.826	227.516	11.070	15.005	569.063	26.733
13.858	226.177	11.009	15.038	560.240	26.329
13.890	223.013	10.863	15.071	544.480	25.627
13.922	218.875	10.673	15.105	547.279	25.735
13.954	205.793	10.073	15.138	531.276	25.001
13.986	184.434	9.092	15.172	529.694	24.929
14.019	156.383	7.802	15.206	516.611	24.309
14.051	134.599	7.277	15.239	511.074	24.075
14.083	112.259	5.678	15.273	489.168	23.071
14.116	99.732	5.192	15.307	485.438	23.037
14.148	102.470	5.318	15.340	494.219	23.372
14.181	118.230	6.045	15.374	481.927	22.739
14.213	145.065	7.281	15.408	488.499	23.043
14.246	186.747	9.198	15.442	482.475	22.764
14.278	231.714	11.263	15.476	486.186	22.934
14.311	271.692	13.098	15.512	495.375	23.355
14.344	311.245	14.912	15.544	472.982	22.329
14.376	362.054	17.243	15.578	459.291	21.721
14.409	404.344	19.182	15.612	431.726	20.437
14.425	419.191	19.862	15.646	420.408	19.918
14.442	439.819	20.808			

APPENDIX II

ANGULAR DISTRIBUTIONS OF 12C(ALPHA,ALPHA)12C

ENERGY = LABORATORY ENERGY OF ALPHA PARTICLES AT CENTER
OF TARGET.
ANGCM = CENTER OF MASS ANGLES.
X-SEC = CENTER OF MASS CROSS SECTIONS.
ERROR = TOTAL UNCERTAINTY IN CROSS SECTIONS.

ENERGY = 13.191 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	4826.222	221.304	110.980	15.623	0.944
18.630	2132.610	97.868	113.440	15.119	2.926
21.940	1051.883	48.344	115.360	14.981	2.926
25.230	501.571	23.126	118.240	20.555	1.197
28.520	270.790	12.551	120.580	25.428	1.434
31.800	159.391	7.447	122.890	25.928	1.615
35.060	110.623	5.213	125.150	37.324	2.224
38.310	82.580	3.929	127.390	43.484	2.298
41.540	59.119	2.854	129.580	45.855	2.416
44.750	38.616	1.915	131.740	49.493	2.594
47.940	22.663	1.182	133.870	47.758	2.522
51.120	16.360	0.892	135.960	44.394	2.376
54.270	16.447	0.898	138.020	39.891	2.176
57.420	23.801	1.241	140.050	34.924	1.952
60.500	32.606	1.651	142.050	23.433	1.422
63.520	40.606	2.022	144.030	18.309	1.182
66.630	42.597	2.117	145.970	10.672	0.808
69.660	39.834	1.993	147.880	5.687	0.543
72.650	29.023	1.498	149.770	3.177	0.385
75.610	18.656	1.022	151.640	4.375	0.471
78.550	7.310	0.513	153.490	11.152	0.858
81.450	1.358	0.166	155.310	24.373	1.519
84.310	0.416	0.089	157.110	40.324	2.280
87.150	3.716	0.312	158.890	66.607	3.510
89.940	11.894	0.724	160.660	96.443	4.894
92.700	20.651	1.141	162.410	135.399	6.694
95.430	25.325	1.363	164.140	171.773	8.371
98.110	30.602	1.614	165.870	205.671	9.933
100.760	29.762	1.580	167.580	263.322	12.584
103.380	24.642	1.348	169.280	319.866	15.182
105.950	20.534	1.163	170.970	366.338	17.318
108.480	19.578	1.125			

ENERGY = 13.285 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	4613.045	197.785	110.960	18.207	1.043
18.630	1935.240	91.112	113.440	17.849	1.052
21.940	976.942	41.699	115.860	19.453	1.135
25.230	456.112	21.041	118.240	22.241	1.273
28.520	245.425	11.386	120.580	27.937	1.547
31.820	151.635	7.089	122.890	30.908	1.693
35.260	119.038	5.138	125.150	37.392	2.022
38.310	61.681	3.885	127.390	43.771	2.306
41.540	58.113	2.806	129.580	45.400	2.391
44.750	39.515	1.954	131.740	44.242	2.345
47.940	24.063	1.245	133.870	44.345	2.359
51.120	16.126	0.860	135.960	40.254	2.169
54.270	15.656	0.859	138.020	35.518	1.967
57.420	21.399	1.128	140.052	27.560	1.602
60.520	31.599	1.622	142.050	19.327	1.215
63.580	39.098	1.950	144.030	12.769	0.905
66.630	41.473	2.262	145.970	6.760	0.595
69.660	39.391	1.956	147.880	4.228	0.451
72.650	41.759	1.622	149.770	4.650	0.461
75.610	18.724	1.022	151.640	9.429	0.757
78.550	9.531	0.594	153.490	19.605	1.275
81.450	2.812	0.256	155.310	36.899	2.126
84.310	0.641	0.111	157.110	61.981	3.282
87.150	3.162	0.253	158.890	90.759	4.619
89.940	6.962	0.580	160.660	127.678	6.324
92.720	15.996	0.920	162.410	171.569	8.347
95.430	21.803	1.196	164.140	216.423	10.413
98.110	26.311	1.412	165.870	268.526	12.809
100.760	26.192	1.411	167.580	306.445	14.553
103.380	24.556	1.341	169.280	362.424	17.125
105.950	22.223	1.239	170.970	426.484	20.360
108.480	19.798	1.131			

ENERGY = 13.443 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3957.441	182.860	110.980	7.059	0.517
18.630	1848.273	87.123	113.440	7.924	0.567
21.940	963.625	44.293	115.860	10.336	0.692
25.230	543.397	25.059	118.240	16.566	0.995
28.520	335.386	15.505	120.580	23.574	1.335
31.800	224.252	10.413	122.890	29.499	1.620
35.060	146.680	6.859	125.150	36.604	1.957
38.310	98.573	4.656	127.390	40.706	2.526
41.540	64.377	3.069	129.580	49.623	2.458
44.750	38.369	1.897	131.740	51.872	2.689
47.940	21.094	1.103	133.870	51.206	2.667
51.120	12.235	0.693	135.960	50.878	2.661
54.270	13.724	0.765	138.020	46.032	2.445
57.400	22.548	1.177	140.050	40.700	2.217
60.500	35.762	1.789	142.050	33.843	1.896
63.580	45.378	2.234	144.030	15.763	1.190
66.630	49.842	2.442	145.970	16.252	0.927
69.660	47.544	2.340	147.880	13.620	0.951
72.650	41.117	2.248	149.770	8.663	0.724
75.610	29.664	1.524	151.640	7.709	0.656
78.550	17.492	0.964	153.490	11.085	0.842
81.450	8.291	0.523	155.310	18.854	1.235
84.310	2.054	0.210	157.110	30.628	1.807
87.150	0.428	0.087	158.890	47.272	2.594
89.940	2.331	0.232	160.660	71.477	3.722
92.700	6.179	0.442	162.410	100.317	5.055
95.430	9.690	0.620	164.140	125.272	6.213
98.110	11.739	0.722	165.870	165.050	8.047
100.760	13.050	0.791	167.580	196.549	9.498
103.380	11.847	0.737	169.280	237.850	11.397
105.950	9.501	0.629	170.970	255.488	12.210
108.480	7.358	0.527			

ENERGY = 13.570 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	4244.686	194.654	112.980	3.870	0.354
18.630	1905.966	87.481	113.440	4.266	0.381
21.940	1069.360	49.143	115.860	5.122	0.432
25.230	652.068	32.022	118.240	8.658	0.622
28.520	424.838	18.693	120.580	16.769	1.025
31.800	261.330	12.117	122.890	24.142	1.422
35.060	158.999	7.430	125.150	28.693	1.602
38.310	99.736	4.716	127.390	39.894	2.094
41.540	58.722	2.836	129.580	43.994	2.330
44.750	30.655	1.549	131.740	46.829	2.470
47.940	13.682	0.765	133.870	48.548	2.558
51.120	6.907	0.446	135.960	46.765	2.465
54.270	9.525	0.574	138.020	45.156	2.420
57.400	18.458	0.994	140.050	39.335	2.156
60.500	28.157	1.446	142.050	31.171	1.756
63.580	38.899	1.943	144.030	24.930	1.499
66.630	43.367	2.152	145.970	17.270	1.138
69.660	41.025	2.047	147.880	10.361	0.800
72.650	34.142	1.735	149.770	4.602	0.462
75.610	22.771	1.213	151.640	2.083	0.329
78.550	13.969	0.806	153.490	2.724	0.362
81.450	6.367	0.444	155.310	7.299	0.655
84.310	2.053	0.215	157.110	16.432	1.135
87.150	2.174	0.224	158.890	32.288	1.979
89.940	5.824	0.426	160.660	50.354	2.764
92.700	10.482	0.661	162.410	74.383	3.854
95.430	13.955	0.831	164.140	101.098	5.122
98.110	16.322	0.949	165.870	129.347	6.426
100.760	15.480	0.914	167.580	161.624	7.917
103.380	13.053	0.805	169.280	202.368	9.701
105.950	10.234	0.675	170.970	236.365	11.356
108.480	5.932	0.462			

ENERGY = 13.761 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	33[illegible]5.041	151.593	110.960	9.161	0.626
18.630	1852.189	84.097	113.440	6.719	0.5[illegible]5
21.940	1143.916	52.557	115.860	3.366	0.328
25.230	7[illegible]1.655	32.291	118.240	4.039	0.372
28.520	4[illegible]5.654	18.727	120.580	6.225	0.486
31.800	2[illegible]8.686	11.077	122.890	11.255	0.758
35.260	122.869	5.770	125.150	15.622	0.977
38.310	59.191	2.852	127.390	21.733	1.275
41.540	22.068	1.147	129.580	25.589	1.464
44.750	4.730	0.332	131.740	25.942	1.632
47.940	2.195	0.220	133.870	29.494	1.663
51.120	7.993	0.495	135.960	30.334	1.711
54.270	18.976	1.012	138.020	29.119	1.663
57.420	32.636	1.645	140.050	24.767	1.465
60.520	44.444	2.190	142.050	19.702	1.232
63.560	50.541	2.473	144.030	13.780	0.950
66.630	49.541	2.431	145.970	8.948	0.729
69.660	44.775	2.183	147.880	3.378	0.417
72.650	32.868	1.671	149.770	1.341	0.237
75.610	20.839	1.116	151.640	0.443	0.135
78.550	10.316	0.628	153.490	2.804	0.363
81.450	2.802	0.254	155.310	9.344	0.759
84.310	1.297	0.161	157.110	19.907	1.298
87.150	4.590	0.356	158.890	37.265	2.132
89.940	11.023	0.677	160.660	55.955	3.056
92.720	18.979	1.057	162.410	81.217	4.186
95.430	25.082	1.346	164.140	105.582	5.314
98.110	29.505	1.556	165.870	136.059	6.722
100.760	31.134	1.638	167.560	159.574	7.808
103.380	27.484	1.474	169.250	193.586	9.374
105.950	22.863	1.172	172.970	236.308	11.339
108.480	15.492	0.925			

ENERGY = 13.858 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	37[illegible]4.986	172.662	110.980	11.949	0.759
18.630	21[illegible]2.521	96.483	113.440	8.066	0.573
21.940	1204.851	55.347	115.860	5.451	0.443
25.230	739.988	34.245	118.240	6.510	0.524
28.520	432.641	19.870	120.580	9.592	0.666
31.800	225.795	10.530	122.890	13.779	0.878
35.060	1?3.926	4.899	125.150	18.802	1.125
38.310	40.374	1.972	127.390	23.299	1.429
41.540	9.827	0.575	129.580	27.443	1.546
44.750	1.495	0.157	131.740	31.056	1.723
47.940	6.378	0.413	133.870	32.526	1.800
51.120	17.642	0.955	135.960	30.190	1.699
54.270	34.219	1.713	138.020	26.071	1.629
57.400	48.046	2.351	140.050	23.702	1.411
60.520	56.534	2.743	142.050	18.275	1.160
63.580	60.342	2.921	144.030	11.836	0.850
66.630	56.282	2.738	145.970	6.551	0.575
69.660	45.572	2.249	147.880	3.377	0.389
72.650	32.722	1.662	149.770	0.622	0.158
75.610	18.267	0.987	151.640	0.994	0.204
78.550	8.073	0.519	153.490	5.643	0.544
81.450	1.783	0.191	155.310	13.261	0.959
84.310	2.106	0.214	157.110	26.223	1.588
87.150	7.336	0.478	158.890	43.788	2.431
89.940	14.862	0.557	160.660	65.922	3.466
92.720	22.507	1.219	162.410	94.762	4.823
95.430	29.164	1.533	164.140	123.695	6.140
98.110	33.390	1.756	165.870	158.888	7.763
100.760	34.025	1.768	167.580	190.870	9.237
103.380	30.639	1.617	169.280	222.694	10.702
105.950	24.294	1.329	170.970	268.895	12.825
108.480	18.362	1.258			

ENERGY = 13.954 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3689.789	169.221	110.950	9.857	0.554
18.630	2144.202	98.394	113.440	5.875	0.462
21.940	1242.795	57.087	115.860	4.281	0.380
25.230	730.585	33.615	118.240	5.590	0.456
28.520	395.969	18.282	120.590	7.981	0.565
31.800	164.491	8.592	122.890	12.989	0.841
35.060	69.269	3.311	125.150	16.930	1.238
38.310	19.634	1.032	127.390	21.304	1.256
41.540	2.433	0.211	129.580	24.229	1.346
44.750	5.320	0.362	131.740	26.321	1.574
47.940	17.441	0.935	133.870	26.387	1.515
51.120	32.551	1.640	135.960	24.463	1.433
54.270	46.450	2.275	138.020	21.820	1.316
57.400	58.848	2.848	140.050	17.785	1.130
60.500	62.844	3.034	142.050	12.998	0.902
63.580	60.350	2.924	144.030	7.527	0.626
66.630	52.626	2.571	145.970	3.581	0.401
69.660	38.907	1.944	147.860	2.485	0.327
72.650	24.822	1.298	149.770	0.510	0.144
75.610	11.961	0.703	151.640	2.442	0.332
78.550	3.125	0.269	153.490	6.710	0.607
81.450	0.169	0.055	155.310	13.906	0.994
84.310	3.253	0.281	157.110	26.269	1.697
87.150	9.645	0.606	158.890	44.735	2.473
89.940	19.032	1.054	160.660	62.817	3.325
92.700	27.663	1.459	162.410	91.110	4.633
95.430	35.002	1.803	164.140	107.398	5.394
98.110	37.050	1.903	165.870	143.101	7.042
100.760	35.647	1.844	167.580	171.643	8.353
103.380	31.089	1.640	169.280	203.975	9.847
105.950	22.230	1.234	170.970	238.743	11.446
108.480	16.905	0.990			

ENERGY = 14.019 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3755.565	173.622	110.980	7.496	0.555
18.630	2212.411	121.532	113.440	4.263	0.376
21.940	1570.592	62.960	115.860	2.326	0.273
25.230	745.029	34.427	118.240	3.460	0.344
28.520	387.761	17.920	120.580	5.125	0.457
31.800	153.331	7.635	122.890	9.861	0.544
35.260	58.257	2.819	125.150	13.391	0.8[illegible]
38.310	12.745	0.723	127.390	16.338	1.208
41.540	2.236	0.210	129.580	18.376	1.143
44.750	10.976	0.643	131.740	18.668	1.166
47.940	27.351	1.405	133.870	18.864	1.185
51.120	45.022	2.221	135.960	19.752	1.201
54.270	59.246	2.877	138.020	17.038	1.111
57.400	67.476	3.258	140.050	13.149	0.923
60.500	67.894	3.280	142.050	9.602	0.751
63.560	67.918	2.963	144.030	6.129	0.679
66.630	51.363	2.527	145.970	3.017	0.376
69.660	37.561	1.896	147.880	1.630	0.271
72.650	23.965	1.273	149.770	0.557	0.157
75.610	11.117	0.675	151.640	2.257	0.314
78.550	2.593	0.264	153.490	4.517	0.494
81.450	0.519	0.101	155.310	11.139	0.873
84.310	3.389	0.293	157.110	16.383	1.151
87.150	10.212	0.647	158.890	30.519	1.345
89.940	19.302	1.105	160.560	47.133	2.67[illegible]
92.720	27.972	1.490	162.410	59.468	3.216
95.430	32.025	1.684	164.140	74.616	3.924
98.110	34.474	1.803	165.870	109.523	5.54[illegible]
100.760	32.265	1.706	167.580	125.741	6.292
103.380	27.366	1.508	169.280	151.777	7.495
105.950	22.145	1.155	170.970	170.146	8.343
108.480	13.153	0.829			

ENERGY = 1-.083 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	4240.700	194.474	110.980	6.514	0.499
18.630	2235.332	122.578	113.440	2.815	0.297
21.940	1331.562	61.162	115.860	0.837	0.153
25.230	751.352	34.575	118.240	0.864	0.155
28.520	383.193	17.705	120.580	2.261	0.253
31.800	137.022	7.341	122.890	3.821	0.374
35.060	46.101	2.256	125.150	7.024	0.556
38.310	6.934	0.443	127.390	8.436	0.633
41.540	6.383	0.418	129.580	9.958	0.722
44.750	20.132	1.065	131.740	10.327	0.749
47.940	41.749	2.063	133.870	10.572	0.767
51.120	55.755	2.709	135.960	9.609	0.724
54.270	70.191	3.374	138.020	8.612	0.679
57.400	72.515	3.483	140.050	7.106	0.605
60.520	71.110	3.422	142.050	5.991	0.548
63.580	61.625	2.990	144.030	3.729	0.416
66.630	48.035	2.369	145.970	3.352	0.395
69.660	34.111	1.732	147.880	1.497	0.254
72.650	22.345	1.192	149.770	1.036	0.212
75.610	11.145	0.672	151.640	1.355	0.245
78.550	4.214	0.333	153.490	2.899	0.373
81.450	2.349	0.232	155.310	5.917	0.578
84.310	5.169	0.389	157.110	10.398	0.834
87.150	11.671	0.711	158.890	17.750	1.181
89.940	19.221	1.072	160.660	25.636	1.614
92.700	24.860	1.339	162.410	34.559	2.036
95.430	31.181	1.638	164.140	48.401	2.691
98.110	32.456	1.702	165.870	62.303	3.344
100.760	31.512	1.665	167.580	76.897	4.025
103.380	25.092	1.373	169.280	97.653	4.987
105.950	17.889	1.042	170.970	125.067	6.254
108.480	11.322	0.735			

ENERGY = 14.148 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	4362.755	220.887	110.980	6.163	0.474
18.630	2492.859	114.373	113.440	2.923	0.298
21.940	1369.915	63.831	115.860	1.257	0.187
25.230	776.628	35.727	118.240	0.182	0.070
28.520	358.984	16.590	120.580	0.348	0.095
31.800	144.155	6.747	122.890	0.773	0.151
35.060	36.634	1.615	125.150	1.424	0.212
38.310	7.439	0.463	127.390	2.056	0.263
41.540	13.338	0.729	129.580	2.815	0.319
44.750	32.892	1.556	131.740	3.401	0.361
47.940	52.977	2.481	133.870	3.921	0.397
51.120	63.555	3.066	135.960	3.540	0.379
54.270	69.686	3.345	138.020	3.983	0.411
57.420	69.183	3.324	140.050	3.956	0.414
60.500	63.377	3.061	142.050	3.382	0.382
63.580	54.784	2.669	144.030	2.659	0.336
66.630	43.354	2.147	145.970	1.932	0.285
69.660	31.484	1.635	147.880	0.233	0.097
72.650	20.632	1.127	149.770	0.359	0.121
75.610	12.461	0.728	151.640	0.652	0.165
78.550	7.138	0.476	153.490	1.080	0.217
81.450	5.717	0.409	155.310	3.522	0.418
84.310	7.173	0.485	157.110	8.259	0.706
87.150	12.740	0.662	158.890	11.667	0.894
89.940	16.292	0.928	160.660	20.956	1.364
92.700	22.758	1.142	162.410	31.469	1.874
95.430	23.328	1.265	164.140	46.449	2.583
98.110	22.937	1.254	165.870	59.524	3.197
100.760	21.972	1.213	167.580	73.445	3.846
103.380	19.386	1.099	169.280	87.172	4.466
105.950	12.544	0.780	170.970	109.597	5.522
108.480	9.569	0.641			

ENERGY = 14.311 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERRCR (MB/SR)
15.310	4055.331	187.362	110.980	5.455	0.451
18.630	2293.650	125.257	113.440	4.720	0.415
21.940	1320.793	59.760	115.360	3.632	0.357
25.230	650.243	29.949	118.240	3.379	0.347
28.520	293.326	13.594	120.580	3.017	0.329
31.800	109.955	5.191	122.890	3.838	0.384
35.060	32.328	1.630	125.150	4.272	0.414
38.310	12.361	0.707	127.390	6.236	0.531
41.540	20.578	1.091	129.580	7.523	0.607
44.750	34.312	1.726	131.740	9.188	0.701
47.940	45.338	2.236	133.870	9.851	0.741
51.120	50.690	2.484	135.960	11.375	0.827
54.270	50.335	2.457	138.020	11.593	0.846
57.400	45.079	2.232	140.050	10.464	0.794
60.500	41.352	2.064	142.050	8.232	0.684
63.580	37.026	1.867	144.030	5.661	0.544
66.630	31.556	1.633	145.970	3.028	0.383
69.660	29.668	1.535	147.880	0.892	0.228
72.650	24.641	1.307	149.770	0.304	0.116
75.610	20.464	1.117	151.640	2.092	0.320
78.550	15.391	0.883	153.490	7.007	0.650
81.450	11.215	0.690	155.310	16.301	1.147
84.310	7.912	0.533	157.110	33.282	1.975
87.150	5.065	0.393	158.890	52.401	2.580
89.940	3.735	0.325	160.660	76.035	3.983
92.700	3.567	0.319	162.410	114.066	5.745
95.430	3.973	0.344	164.140	145.341	7.194
98.110	5.333	0.423	165.870	173.167	8.725
100.760	6.317	0.478	167.580	220.995	10.677
103.380	6.132	0.473	169.280	256.732	12.322
105.950	6.322	0.487	170.970	316.004	15.045
108.480	5.941	0.472			

ENERGY = 14.425 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	4164.819	190.995	110.980	7.762	0.525
18.630	2214.039	121.144	113.440	5.514	0.449
21.940	1188.761	54.616	115.860	5.508	0.453
25.230	565.492	26.255	118.240	5.604	0.464
28.520	246.491	11.466	120.580	5.069	0.439
31.820	91.625	4.340	122.890	6.191	0.515
35.260	25.552	1.323	125.150	8.235	0.563
38.310	12.914	0.725	127.390	11.187	0.775
41.540	22.589	1.175	129.580	13.362	0.889
44.750	35.537	1.773	131.740	16.124	1.029
47.940	43.314	2.133	133.870	17.740	1.116
51.120	42.302	2.089	135.960	17.046	1.092
54.270	41.793	2.068	138.020	16.620	1.174
57.400	38.169	1.925	140.050	16.027	1.255
60.500	33.762	1.705	142.050	11.900	0.856
63.580	30.131	1.540	144.030	8.247	0.674
66.630	26.551	1.377	145.970	4.656	0.476
69.660	23.679	1.248	147.880	1.829	0.286
72.650	21.507	1.155	149.770	2.240	0.319
75.610	17.179	0.953	151.640	6.241	0.572
78.550	12.561	0.745	153.490	14.473	1.026
81.450	8.554	0.552	155.310	33.125	1.934
84.310	5.123	0.384	157.110	61.626	3.271
87.150	1.699	0.193	158.890	93.799	4.765
89.940	0.229	0.068	160.660	143.496	7.254
92.700	0.432	0.094	162.410	194.645	9.416
95.430	1.858	0.212	164.140	245.046	11.734
98.110	3.970	0.340	165.870	310.852	14.758
100.760	5.588	0.430	167.560	379.881	17.929
103.380	7.192	0.517	169.260	443.715	20.860
105.950	7.596	0.542	170.970	522.038	24.455
108.480	7.281	0.521			

ENERGY = 14.475 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3758.769	172.409	110.980	12.370	0.719
18.630	2016.632	92.575	113.440	8.442	0.627
21.940	1087.537	50.000	115.860	7.240	0.543
25.230	515.678	23.795	118.240	8.218	0.628
28.520	228.183	10.621	120.580	6.096	0.521
31.800	82.398	3.939	122.890	11.269	0.799
35.260	27.512	1.420	125.150	12.943	0.849
38.310	15.045	0.843	127.390	18.420	1.165
41.540	20.644	1.106	129.560	23.497	1.416
44.750	21.347	1.140	131.740	27.828	1.629
47.940	32.007	1.635	133.870	29.141	1.7[illegible]
51.120	34.235	1.740	135.960	30.945	1.746
54.270	30.115	1.553	138.020	29.176	1.723
57.400	27.769	1.449	140.050	25.845	1.574
60.500	21.585	1.164	142.050	19.215	1.263
63.580	17.522	0.978	144.030	13.765	1.002
66.630	19.433	1.071	145.970	8.365	0.724
69.660	17.253	0.972	147.880	5.549	0.436
72.650	14.773	0.860	149.770	3.824	0.459
75.610	10.333	0.653	151.640	8.980	0.777
78.550	6.040	0.444	153.490	20.472	1.374
81.450	2.841	0.274	155.310	40.329	2.334
84.310	0.860	0.140	157.110	65.339	3.51[illegible]
87.150	0.215	0.069	158.890	109.435	5.550
89.940	1.902	0.224	160.560	156.304	7.720
92.700	5.346	0.426	162.410	176.667	8.565
95.430	8.238	0.579	164.140	273.302	13.108
98.110	12.528	0.794	165.870	336.950	16.035
100.760	14.516	0.896	167.560	413.366	19.545
103.380	14.777	0.915	169.250	479.024	22.562
105.950	14.863	0.925	170.970	512.445	24.009
108.480	13.016	0.842			

ENERGY = 1-.491 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3658.202	169.168	112.950	11.570	0.787
18.630	2046.328	93.938	113.440	8.375	0.626
21.940	1071.376	49.261	115.860	4.908	0.445
25.230	537.602	24.801	118.240	4.753	0.441
28.520	232.678	10.828	120.580	5.449	0.487
31.800	[illegible]9.961	3.829	122.890	6.911	0.573
35.260	22.182	1.175	125.150	10.861	0.785
38.310	10.951	0.652	127.390	14.670	0.984
41.540	19.862	1.071	129.580	18.279	1.169
44.750	36.233	1.829	131.740	21.418	1.328
47.940	50.274	2.477	133.870	25.181	1.517
51.120	46.171	2.291	135.960	24.181	1.479
54.270	45.658	2.270	138.020	24.393	1.496
57.420	37.782	1.911	140.050	20.302	1.311
60.500	34.244	1.751	142.050	16.162	1.116
63.580	22.473	1.210	144.030	11.195	0.870
66.630	19.910	1.095	145.970	6.446	0.616
69.660	14.432	0.841	147.880	4.095	0.476
72.650	9.481	0.629	149.770	4.812	0.527
75.610	6.620	0.472	151.640	8.528	0.753
78.550	2.918	0.276	153.490	20.466	1.378
81.450	2.744	0.269	155.310	37.914	2.224
84.310	4.890	0.392	157.110	60.981	3.312
87.150	9.043	0.627	158.890	84.355	4.474
89.940	14.652	0.882	160.660	123.229	6.235
92.700	18.506	1.070	162.410	163.186	8.051
95.430	23.838	1.326	164.140	223.655	10.835
98.110	27.311	1.494	165.870	283.364	13.583
100.760	27.101	1.490	167.580	356.789	16.957
103.380	24.727	1.354	169.280	430.750	20.354
105.950	21.231	1.231	170.970	489.299	23.043
108.480	16.265	1.001			

ENERGY = 14.587 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3587.443	164.546
18.630	1962.495	92.082
21.940	1106.766	50.868
25.230	544.317	25.095
28.520	230.131	10.697
31.800	67.294	3.225
35.060	21.681	1.139
38.310	21.979	1.154
41.540	39.108	1.945
44.750	59.532	2.886
47.940	69.732	3.354
51.120	69.394	3.329
54.270	61.262	2.972
57.420	49.699	2.444
60.500	38.353	1.925
63.580	25.863	1.353
66.630	17.925	0.985
69.660	12.382	0.731
72.650	9.122	0.579
75.610	6.953	0.642
78.550	6.859	0.474
81.450	7.447	0.506
84.310	8.879	0.581
87.150	11.382	0.705
89.940	13.613	0.817
92.700	16.179	0.943
95.430	16.710	0.973
98.110	20.957	1.178
100.760	19.432	1.113
103.380	19.126	1.104
105.950	16.165	0.971
108.480	15.089	0.925
110.980	11.789	0.772
113.440	10.428	0.711
115.860	8.310	0.611
118.240	8.119	0.626
120.580	6.884	0.549
122.890	7.495	0.587
125.150	9.632	0.704
127.390	10.351	0.745
129.550	11.733	0.823
131.740	12.637	0.876
133.870	15.587	1.029
135.960	16.192	1.066
138.020	17.967	1.161
140.050	16.022	1.073
142.050	15.361	1.046
144.030	12.172	0.897
145.970	8.504	0.711
147.880	5.485	0.544
149.770	3.962	0.453
151.640	4.319	0.482
153.490	7.916	0.722
155.310	16.625	1.163
157.110	31.105	1.872
158.890	52.062	2.864
160.660	74.416	3.909
162.410	106.051	5.376
164.140	141.098	6.995
165.870	175.864	8.599
167.580	219.079	10.589
169.280	265.825	12.739
170.970	320.380	15.246

ENERGY = 14.524 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3814.338	174.948	110.980	13.021	0.836
18.630	2099.182	96.345	113.440	12.998	0.841
21.940	1144.713	52.610	115.860	12.066	0.802
25.230	553.598	25.523	118.240	12.508	0.831
28.520	234.169	10.885	120.580	12.250	0.825
31.800	82.555	3.937	122.890	12.607	0.850
35.060	29.410	1.498	125.150	16.080	1.026
38.310	25.332	1.311	127.390	18.645	1.158
41.540	43.216	2.137	129.580	19.290	1.196
44.750	58.313	2.832	131.740	23.634	1.413
47.940	62.853	3.043	133.870	26.171	1.541
51.120	58.563	2.849	135.960	27.682	1.622
54.270	46.456	2.295	138.020	27.194	1.606
57.400	35.195	1.780	140.050	25.546	1.538
60.500	26.050	1.361	142.050	21.720	1.364
63.580	19.006	1.038	144.030	15.636	1.076
66.630	14.466	0.829	145.970	12.073	0.903
69.660	11.394	0.687	147.880	7.397	0.659
72.650	10.921	0.667	149.770	4.430	0.486
75.610	10.046	0.629	151.640	4.939	0.524
78.550	9.486	0.605	153.490	9.352	0.785
81.450	7.827	0.528	155.310	19.423	1.307
84.310	6.692	0.475	157.110	36.324	2.126
87.150	5.214	0.403	158.890	59.941	3.238
89.940	4.797	0.385	160.660	92.833	4.767
92.700	5.189	0.408	162.410	133.343	6.641
95.430	7.666	0.541	164.140	180.983	8.837
98.110	8.005	0.561	165.870	225.951	10.908
100.760	9.782	0.655	167.560	276.784	13.246
103.380	13.678	0.849	169.250	324.524	15.441
105.950	12.368	0.792	170.970	385.599	18.247
108.480	13.161	0.836			

ENERGY = 14.540 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	4033.120	184.982	110.980	13.733	0.883
18.630	2144.956	98.455	113.440	13.212	0.865
21.940	1198.754	55.096	115.860	11.902	0.828
25.230	569.037	26.240	118.240	13.049	0.872
28.520	251.171	11.674	120.580	14.702	0.959
31.800	93.161	4.433	122.890	15.528	1.006
35.060	36.316	1.825	125.150	18.654	1.167
38.310	26.410	1.370	127.390	24.848	1.471
41.540	35.897	1.810	129.580	27.809	1.623
44.750	45.700	2.263	131.740	34.066	1.924
47.940	49.282	2.430	133.870	34.405	1.949
51.120	45.524	2.260	135.960	37.387	2.098
54.270	37.109	1.875	138.020	36.652	2.074
57.400	26.794	1.403	140.050	33.783	1.949
60.500	19.959	1.088	142.050	29.633	1.763
63.580	13.885	0.808	144.030	21.481	1.382
66.630	12.646	0.752	145.970	16.190	1.131
69.660	11.623	0.707	147.880	8.896	0.759
72.650	12.321	0.744	149.770	4.390	0.497
75.610	12.104	0.737	151.640	4.684	0.521
78.550	9.928	0.636	153.490	9.915	0.835
81.450	7.828	0.537	155.310	22.607	1.458
84.310	4.532	0.371	157.110	43.627	2.497
87.150	2.842	0.279	158.890	73.584	3.901
89.940	2.434	0.257	160.660	110.651	5.620
92.700	3.299	0.313	162.410	174.614	8.571
95.430	4.962	0.410	164.140	216.583	12.525
98.110	7.348	0.539	165.870	274.561	13.173
100.760	10.009	0.677	167.580	324.174	15.456
103.380	12.349	0.798	169.280	392.558	18.597
105.950	12.333	0.803	170.970	462.207	21.795
108.480	12.935	0.838			

ENERGY = 14.590 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3561.943	166.365	110.980	10.162	0.677
18.630	1922.211	58.224	113.440	9.526	0.652
21.940	1069.173	49.134	115.860	10.462	0.704
25.230	516.042	23.787	118.240	12.283	0.798
28.520	227.770	10.577	120.580	14.831	0.929
31.800	87.616	4.154	122.890	21.254	1.241
35.060	30.459	1.532	125.150	24.191	1.387
38.310	19.995	1.052	127.390	31.370	1.730
41.540	24.020	1.239	129.580	35.577	1.935
44.750	30.017	1.517	131.740	41.633	2.225
47.940	32.347	1.626	133.870	43.114	2.332
51.120	29.174	1.483	135.960	45.222	2.499
54.270	24.071	1.250	138.020	46.224	2.464
57.400	17.563	0.951	140.050	41.568	2.257
60.500	12.953	0.733	142.050	33.902	1.978
63.580	10.520	0.626	144.030	25.837	1.537
66.630	11.064	0.654	145.970	16.536	1.298
69.660	12.346	0.723	147.880	10.568	0.865
72.650	12.384	0.722	149.770	4.850	0.493
75.610	11.783	0.697	151.640	3.526	0.413
78.550	9.482	0.591	153.490	9.971	0.792
81.450	6.943	0.471	155.310	23.686	1.480
84.310	3.740	0.310	157.110	42.976	2.399
87.150	1.847	0.202	158.890	75.268	3.941
89.940	1.259	0.164	160.660	112.423	5.623
92.720	1.835	0.207	162.410	169.095	8.234
95.430	3.597	0.314	164.140	224.187	10.769
98.110	4.583	0.372	165.870	288.582	13.362
100.760	7.986	0.550	167.580	355.321	16.795
103.380	10.247	0.665	169.280	429.356	22.193
105.950	10.518	0.684	170.970	493.658	23.146
108.480	10.153	0.671			

ENERGY = 14.672 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3653.676	168.960	110.987	9.235	0.651
18.630	2039.766	92.252	113.440	7.994	0.594
21.940	1120.224	51.489	115.860	8.643	0.634
25.230	534.680	24.657	118.240	11.132	0.765
28.520	237.519	11.040	120.580	15.034	0.962
31.800	73.21[illegible]	3.509	122.890	19.822	1.202
35.260	25.993	1.341	125.150	26.687	1.533
38.310	13.519	0.765	127.390	34.880	1.925
41.540	18.857	1.015	129.580	42.118	2.271
44.750	25.221	1.312	131.740	49.262	2.612
47.940	28.144	1.448	133.870	54.538	2.866
51.120	25.265	1.318	135.960	56.188	2.953
54.270	20.154	1.084	138.020	55.253	2.920
57.400	14.976	0.845	140.050	50.757	2.722
60.520	11.327	0.676	142.050	41.360	2.294
63.580	11.309	0.678	144.030	30.594	1.799
66.630	12.295	0.718	145.970	19.547	1.278
69.660	13.223	0.774	147.880	10.431	0.827
72.650	14.259	0.827	149.770	2.651	0.367
75.610	14.378	0.822	151.640	1.692	0.285
78.550	11.100	0.684	153.490	7.848	0.704
81.450	7.277	0.502	155.310	20.213	1.348
84.310	3.813	0.326	157.110	47.288	2.167
87.150	1.325	0.175	158.890	83.829	4.130
89.940	0.629	0.119	160.660	119.821	6.015
92.700	1.573	0.198	162.410	127.010	6.353
95.430	3.834	0.340	164.140	253.606	12.175
98.110	5.703	0.445	165.870	317.797	15.125
100.760	8.623	0.599	167.580	394.000	18.626
103.380	10.216	0.683	169.280	178.000	9.534
105.950	9.727	0.663	170.970	453.912	21.476
108.480	12.421	0.705			

ENERGY = 14.738 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3479.7[illegible]5	159.604	110.980	7.509	0.552
18.630	1942.536	59.161	113.440	7.772	0.571
21.940	1054.811	49.856	115.860	9.390	0.658
25.230	516.905	23.832	118.240	10.913	0.740
28.520	220.528	10.251	120.580	15.894	0.989
31.800	77.495	3.696	122.890	23.003	1.333
35.260	21.772	1.137	125.150	32.241	1.681
38.310	12.113	0.689	127.390	39.570	2.123
41.540	18.185	0.974	129.580	46.991	2.476
44.750	25.956	1.335	131.740	53.863	2.803
47.940	28.188	1.441	133.870	60.310	3.110
51.120	25.089	1.300	135.960	64.038	3.292
54.270	19.790	1.057	138.020	58.354	3.039
57.420	13.576	0.770	140.050	52.840	2.794
60.500	11.653	0.692	142.050	43.874	2.387
63.580	11.254	0.666	144.030	30.510	1.771
66.630	12.776	0.740	145.970	19.209	1.240
69.660	14.303	0.815	147.880	10.557	0.815
72.650	15.082	0.855	149.770	2.588	0.350
75.610	14.005	0.808	151.640	1.964	0.304
78.550	11.388	0.686	153.490	9.073	0.755
81.450	7.411	0.499	155.310	25.332	1.573
84.310	3.765	0.315	157.110	55.737	3.029
87.150	1.123	0.155	158.890	92.705	4.726
89.940	0.685	0.120	160.660	145.785	7.175
92.700	1.670	0.198	162.410	223.099	9.814
95.430	4.367	0.361	164.140	270.536	12.915
98.110	6.498	0.477	165.870	351.907	16.653
100.760	9.326	0.623	167.580	427.395	20.120
103.380	10.310	0.676	169.280	517.398	24.251
105.950	10.650	0.697	170.970	612.340	28.515
108.480	9.824	0.661			

ENERGY = 14.805 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3263.416	150.608	110.980	6.748	0.514
18.630	1712.297	78.611	113.440	5.543	0.455
21.940	937.932	43.125	115.860	6.995	0.537
25.230	438.363	20.234	118.240	9.660	0.679
28.520	161.587	8.468	120.580	14.272	0.903
31.800	57.882	2.797	122.890	22.025	1.289
35.060	15.522	0.849	125.150	30.855	1.711
38.310	11.656	0.669	127.390	38.346	2.065
41.540	18.987	1.013	129.550	47.863	2.519
44.750	25.957	1.337	131.740	53.124	2.772
47.940	27.361	1.404	133.870	58.159	3.013
51.120	24.042	1.253	135.960	59.880	3.123
54.270	17.792	0.965	138.020	59.021	3.073
57.420	13.232	0.755	140.050	48.648	2.603
60.500	10.099	0.610	142.050	40.356	2.227
63.560	10.061	0.610	144.030	28.300	1.669
66.630	11.890	0.700	145.970	17.886	1.178
69.660	14.372	0.820	147.860	7.726	0.665
72.650	14.122	0.811	149.770	1.767	0.285
75.610	14.211	0.819	151.640	1.636	0.276
78.550	11.181	0.679	153.490	10.513	0.834
81.450	8.073	0.533	155.310	30.257	1.811
84.310	4.357	0.348	157.110	56.626	3.147
87.150	1.747	0.202	158.390	96.415	4.901
89.940	0.552	0.107	160.660	144.582	7.124
92.700	1.937	0.215	162.410	206.955	9.995
95.430	3.527	0.316	164.140	249.699	11.964
98.110	6.402	0.473	165.870	345.394	16.359
100.760	8.629	0.589	167.580	429.555	20.223
103.380	11.695	0.745	169.280	521.811	24.457
105.950	9.282	0.632	170.970	609.328	28.473
108.480	8.529	0.600			

ENERGY = 15.005 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3268.522	149.936	110.980	2.785	0.301
18.630	1715.835	78.782	113.440	1.823	0.239
21.940	929.911	42.769	115.860	2.964	0.321
25.230	424.623	19.614	118.240	7.263	0.569
28.520	177.998	8.313	120.580	13.106	0.871
31.800	56.502	2.744	122.890	22.347	1.322
35.060	21.169	1.120	125.150	32.704	1.817
38.310	19.563	1.047	127.390	45.081	2.422
41.540	29.583	1.512	129.580	55.195	2.880
44.750	35.045	1.766	131.740	63.852	3.290
47.940	33.819	1.711	133.870	68.216	3.501
51.120	27.612	1.428	135.960	68.021	3.503
54.270	19.094	1.036	138.020	62.078	3.239
57.400	11.242	0.670	140.050	55.458	2.943
60.500	9.239	0.568	142.050	43.238	2.386
63.580	9.162	0.576	144.030	29.318	1.742
66.630	13.107	0.767	145.970	17.917	1.201
69.660	17.104	0.958	147.850	7.134	0.648
72.650	19.890	1.092	149.770	1.532	0.271
75.610	21.250	1.159	151.640	3.183	0.410
78.550	16.608	0.947	153.490	14.610	1.066
81.450	12.536	0.758	155.310	36.363	2.127
84.310	7.213	0.504	157.110	72.523	3.821
87.150	3.024	0.285	158.890	119.228	5.984
89.940	1.036	0.155	160.660	179.434	8.759
92.700	0.891	0.145	162.410	241.232	11.604
95.430	2.326	0.252	164.140	326.848	15.538
98.110	3.706	0.338	165.870	414.939	19.585
100.760	5.453	0.438	167.580	504.344	23.690
103.380	6.180	0.480	169.280	589.615	27.604
105.950	5.665	0.459	170.970	661.404	30.899
108.480	3.756	0.356			

ENERGY = 15.206 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3056.253	140.205	110.980	2.294	0.266
18.630	1767.308	81.139	113.440	0.323	0.295
21.940	974.589	44.812	115.860	0.611	0.133
25.230	459.186	21.195	118.240	3.437	0.350
28.520	192.755	8.986	120.580	8.096	0.614
31.820	67.023	3.223	122.890	15.240	0.976
35.060	25.627	1.322	125.150	24.902	1.444
38.310	22.767	1.192	127.390	36.512	1.996
41.540	28.487	1.457	129.580	45.464	2.421
44.750	32.126	1.627	131.740	54.537	2.851
47.940	29.324	1.500	133.870	59.161	3.074
51.120	22.574	1.191	135.960	57.880	3.025
54.270	13.955	0.792	138.020	56.585	2.975
57.400	7.469	0.486	140.050	50.183	2.688
60.520	5.090	0.371	142.050	37.980	2.130
63.580	7.397	0.488	144.030	26.147	1.582
66.630	13.493	0.782	145.970	14.646	1.031
69.660	17.973	0.995	147.880	6.562	0.609
72.650	22.820	1.224	149.770	1.844	0.296
75.610	24.299	1.296	151.640	3.414	0.421
78.550	20.423	1.120	153.490	12.483	0.949
81.450	15.347	0.887	155.310	33.589	1.985
84.310	7.785	0.529	157.110	65.234	3.472
87.150	3.065	0.284	158.890	114.950	5.774
89.940	0.412	0.094	160.660	163.923	8.033
92.700	0.318	0.083	162.410	232.728	11.200
95.430	2.439	0.256	164.140	333.909	15.848
98.110	4.775	0.393	165.870	358.296	16.973
100.760	7.203	0.525	167.560	428.294	20.188
103.360	7.946	0.567	169.280	513.867	24.117
105.950	6.130	0.479	170.970	597.992	27.978
108.480	4.045	0.370			

ENERGY = 15.408 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	3069.638	140.824	110.980	7.456	0.563
18.630	1762.835	80.939	113.440	3.233	0.335
21.940	970.179	44.616	115.860	2.185	0.270
25.230	429.515	19.840	118.240	1.602	0.230
28.520	178.608	8.343	120.580	5.295	0.470
31.800	56.347	2.738	122.890	8.905	0.670
35.260	18.193	0.983	125.150	17.558	1.124
38.310	13.008	0.743	127.390	26.204	1.524
41.540	21.138	1.123	129.560	35.189	1.954
44.750	23.909	1.254	131.740	41.869	2.275
47.940	21.323	1.136	133.870	46.880	2.518
51.120	15.703	0.877	135.960	45.769	2.476
54.270	7.976	0.513	138.020	43.355	2.374
57.420	3.324	0.279	140.050	38.654	2.165
60.500	2.426	0.231	142.050	30.128	1.773
63.580	6.409	0.443	144.030	20.665	1.331
66.630	14.506	0.834	145.970	10.838	0.846
69.660	19.857	1.083	147.880	3.466	0.424
72.650	25.292	1.344	149.770	0.728	0.185
75.610	25.513	1.359	151.640	5.166	0.544
78.550	21.792	1.190	153.490	15.502	1.114
81.450	16.905	0.966	155.310	35.672	2.099
84.310	10.532	0.668	157.110	67.833	3.609
87.150	4.193	0.352	158.890	115.567	5.819
89.940	0.619	0.118	160.660	162.556	7.988
92.700	0.285	0.080	162.410	224.517	10.841
95.430	3.159	0.304	164.140	297.441	14.195
98.110	6.572	0.494	165.870	371.902	17.616
100.760	10.213	0.681	167.580	435.077	20.519
103.380	12.323	0.739	169.280	522.664	24.540
105.950	12.854	0.820	170.970	559.763	26.246
108.480	10.268	0.701			

ENERGY = 15.646 MEV

ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)	ANGCM (DEG)	X-SEC (MB/SR)	ERROR (MB/SR)
15.310	2658.756	121.987	110.980	12.225	0.792
18.630	1526.982	69.206	113.440	9.889	0.684
21.940	817.637	37.617	115.860	6.738	0.529
25.230	361.454	16.713	118.240	5.460	0.465
28.520	137.511	6.451	120.580	6.359	0.519
31.800	43.572	2.144	122.890	8.419	0.634
35.060	11.773	0.676	125.150	14.495	0.943
38.310	14.389	0.801	127.390	20.302	1.230
41.540	19.851	1.056	129.580	25.038	1.463
44.750	23.198	1.213	131.740	29.122	1.664
47.940	21.289	1.127	133.870	32.371	1.825
51.120	13.792	0.782	135.960	34.190	1.919
54.270	6.843	0.452	138.020	31.894	1.821
57.400	2.761	0.243	140.050	28.729	1.681
60.500	3.436	0.283	142.050	21.203	1.331
63.580	9.373	0.581	144.030	14.152	0.995
66.630	18.088	0.994	145.970	8.925	0.732
69.660	27.428	1.429	147.880	4.806	0.501
72.650	35.680	1.815	149.770	3.927	0.449
75.610	36.275	1.837	151.640	8.786	0.743
78.550	32.835	1.692	153.490	17.594	1.201
81.450	25.159	1.342	155.310	37.434	2.160
84.310	16.436	0.939	157.110	62.711	3.347
87.150	7.660	0.524	158.890	93.439	4.775
89.940	2.044	0.224	160.660	138.619	6.862
92.700	0.354	0.088	162.410	181.164	8.824
95.430	2.183	0.239	164.140	240.231	11.542
98.110	5.663	0.438	165.870	301.860	14.376
100.760	10.983	0.709	167.580	363.313	17.200
103.380	14.252	0.862	169.260	407.818	19.246
105.950	16.341	0.977	170.970	473.423	22.217
108.480	15.656	0.950			

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