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ANGULAR DISTRIBUTIONS FOR $N^{14}(d, d)N^{14}$ FROM 0.7--2.1 MeV

by Seiler, R.F.

Previously reported work of The Ohio State Van de Graaff Accelerator Laboratory involved $N^{14}(d, d)N^{14}$ absolute cross section measurements with a gas target in a differentially pumped scattering chamber. Excitation functions were measured at the center of mass angles of 90, 125.3, 140.8, and 166.5 degrees over the energy range from 650 keV to roughly 2.0 MeV. By way of summary, this data is presented in Figure 1. The solid line is the calculated Rutherford cross section and the dots, the experimental points. It can be seen that there is no pronounced resonant structure in the data although the cross sections are depressed below Rutherford over the whole energy range for all four angles. In particular, the 90 degree data is 5% below Rutherford at 700 keV and 12% low at 1.7 MeV.

Figure 2 presents angular distributions measured every two hundred kilovolts from .70 to 2.1 MeV for the center of mass angular range from 20 to 165 degrees. Here the data is presented as the ratio of the experimental cross section to the calculated Rutherford cross section. Error bars on the data indicate the total probable error in this ratio. Data for which there are no error bars is assigned a total probable error of ± 2.6%.

Attempts were made to fit the data from both the compound nucleus single level and optical model points of view. The suggestive L=1 shape of

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the angular distributions for 1.5 MeV and above motivated the compound nucleus approach while the lack of resonant structure in the excitation functions and anticipated high level density in the compound O^{16} nucleus at excitations in excess of 21 MeV with many outgoing channels available suggested possible validity of the optical model approach.

The single level compound nucleus calculations would not be expected to produce good fits to the experimental data if an odd parity resonant level is assumed since the 90 degree excitation function was depressed below the Rutherford cross section over the entire energy range of interest and odd parity resonant amplitudes are zero at 90 degrees. Extension of the formalism to include two independent levels was made, and a typical fit to the data is shown in Figure 3 for L=0, J=2 and L=1, J=1 levels. It can be seen that the large angle fit is not bad, but the fit near 40 degrees is much worse. Extraction of the resonant phase angles as a function of the deuteron energy based upon assumed resonant energies of 1.7 and 2.6 MeV for the odd and even parity levels, respectively, and assumption of level widths of about 800 keV produced fits to all eight angular distributions as shown in Figure 4. Strong departures from good fits for small angles and in the region near 150 degrees were characteristic of the calculations attempted.

Optical model calculations were executed using the DWBA codes Diana and Hunter of Drisko, Bassel, and Satchler from ORNL.

The potentials used had a Saxon form for the real part and either the Saxon or the surface peaked derivative of the Saxon were used for the imaginary part. A scalar spin-orbit option was also included in some of the calculations. Initial calculations were used to determine the general range of model parameters which produced fits to the data. Attempts were then made to fix the geometrical parameters of the potentials and find the energy dependence of the well strengths. The resultant fits to the data with the corresponding values of V and W are shown in Figure 5. If one plots these values of V and W as a function of the deuteron energy, the curves shown in Figure 6 are obtained. It can be seen that both V and W have relative maxima or minima at 1.7 MeV and that the variation in strengths is in excess of about 20%. Fixing the parameters and calculating fits to the data with what appears to be a reasonable average value for the parameters produces fits for volume absorption as shown in Figure 7.

Changing the imaginary well option from the Saxon form to the derivative or surface absorption form does not appreciably change the character of the fits to the data or the large variation in the well strengths as a function of deuteron energy. A set of angular distributions for the surface absorption model with fixed parameters is shown in Figure 8.

Inclusion of the spin-orbit force somewhat improves the fits, but a variation in the spin orbit strength from 0.14 to 39 MeV is required to do so.

In summary, the two level compound nuclear calculations were unable to produce consistent fits to the data. The optical model fits to the data are surprisingly good, but the well strengths display an energy variation greater than would be expected. Departure of the optical model from good fits can be taken as an indication that compound nuclear effects are not negligible near 1.7 MeV, while the compound nuclear calculations indicate resonant contributions from a number of levels in the O^{16} nucleus in this region of excitation.

Reaction cross sections measurements made at 1.1 MeV were found to be in good agreement with the predicted value from the optical model calculations.

The apparent success of the optical model calculations for the analysis of the experimental data makes it of interest to extend the cross section measurements to higher energies, which shall soon be undertaken at Ohio State.

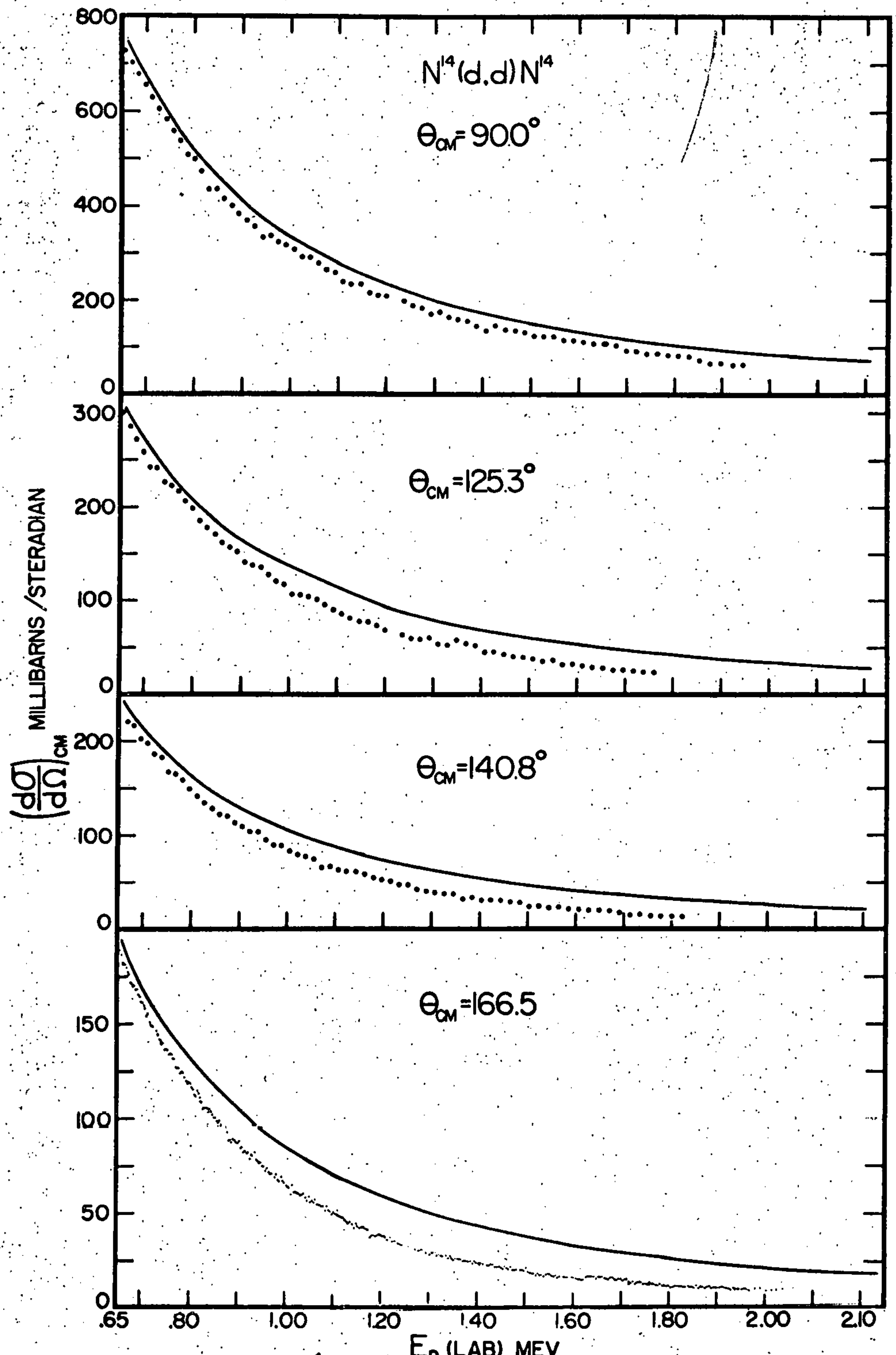

Figure 1. $N^{14}(d,d)N^{14}$ Excitation Curves

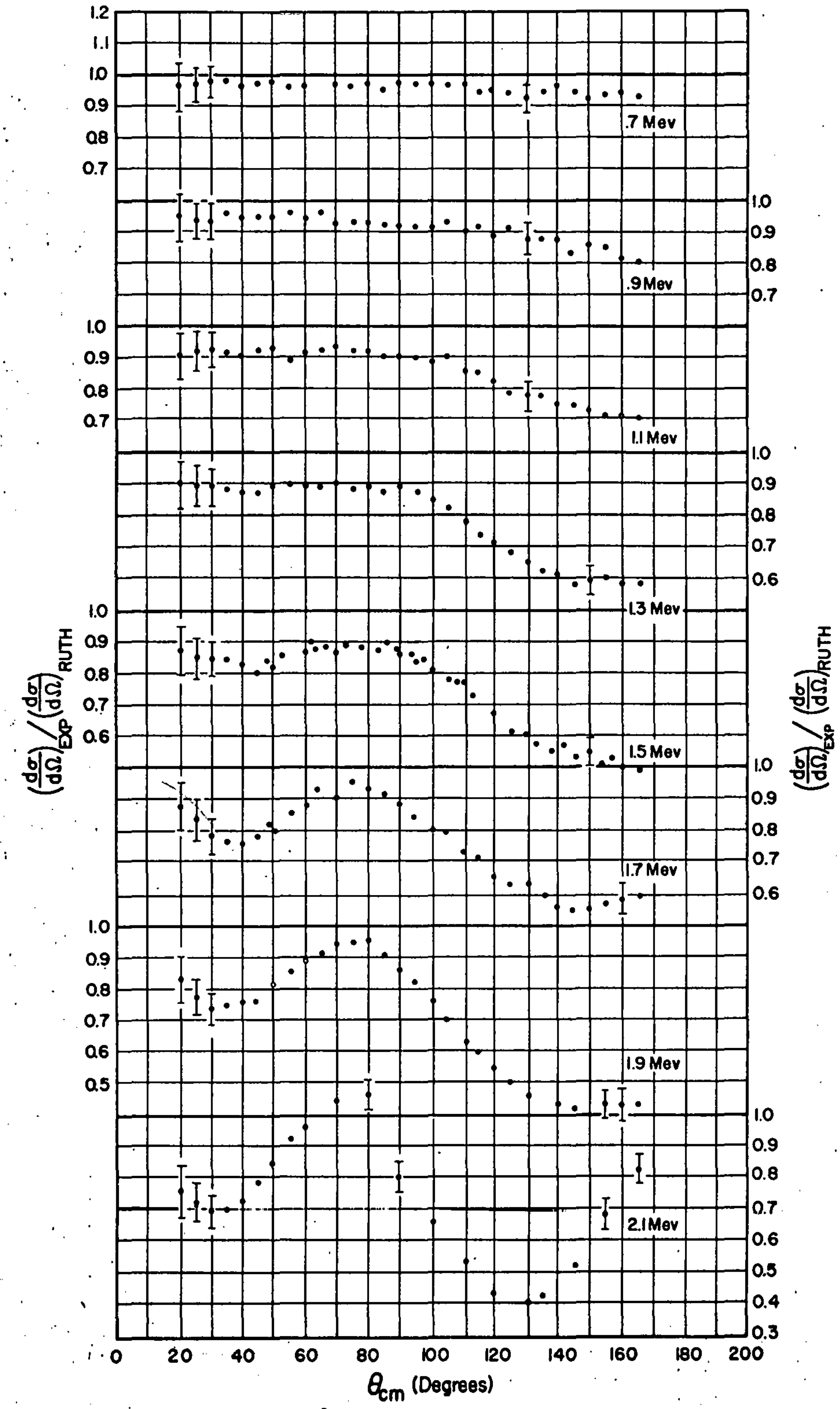

Figure 2. $N^{14}(d,d)N^{14}$ Angular Distributions

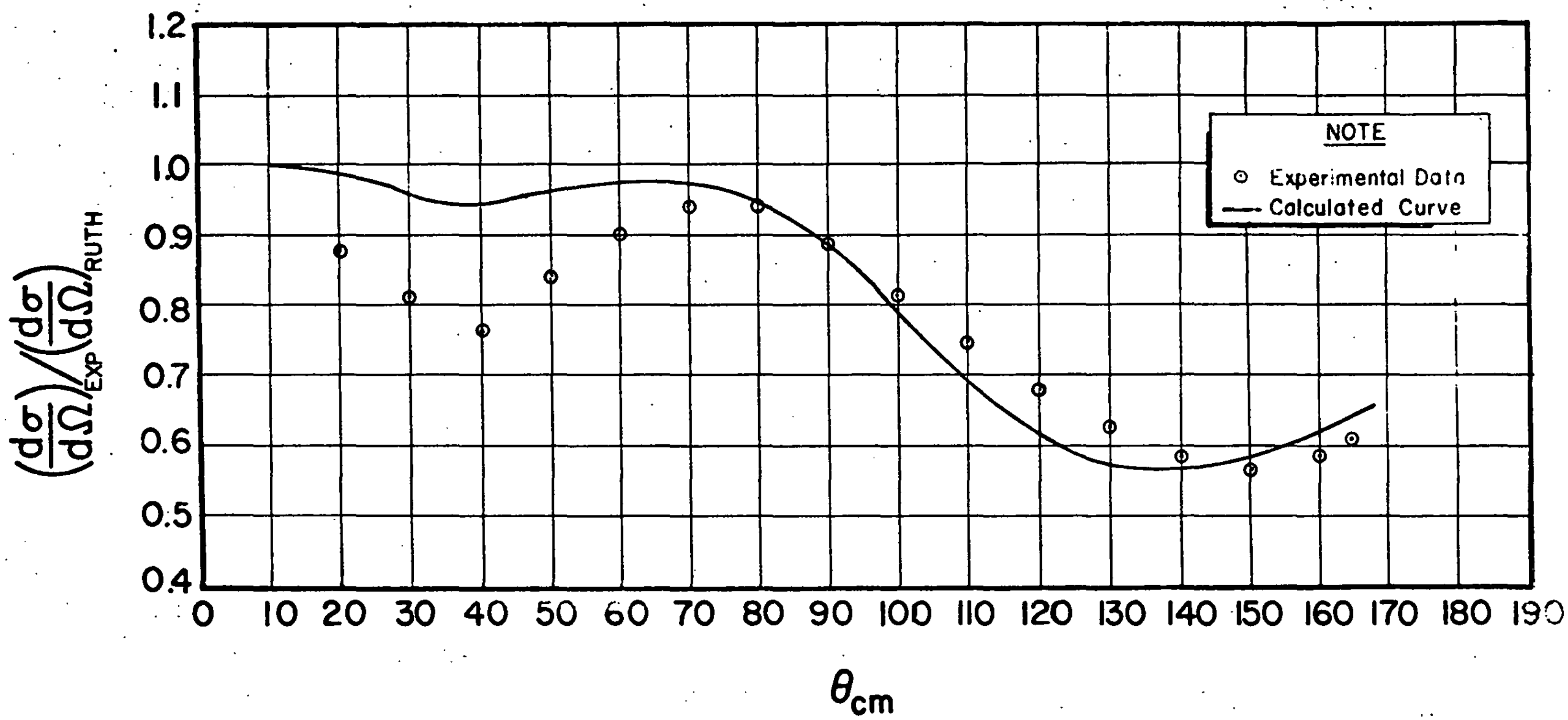

Figure 3. Angular Distribution — E_d = 1.7 Mev, L=0 & L=1 Resonant Amplitudes.

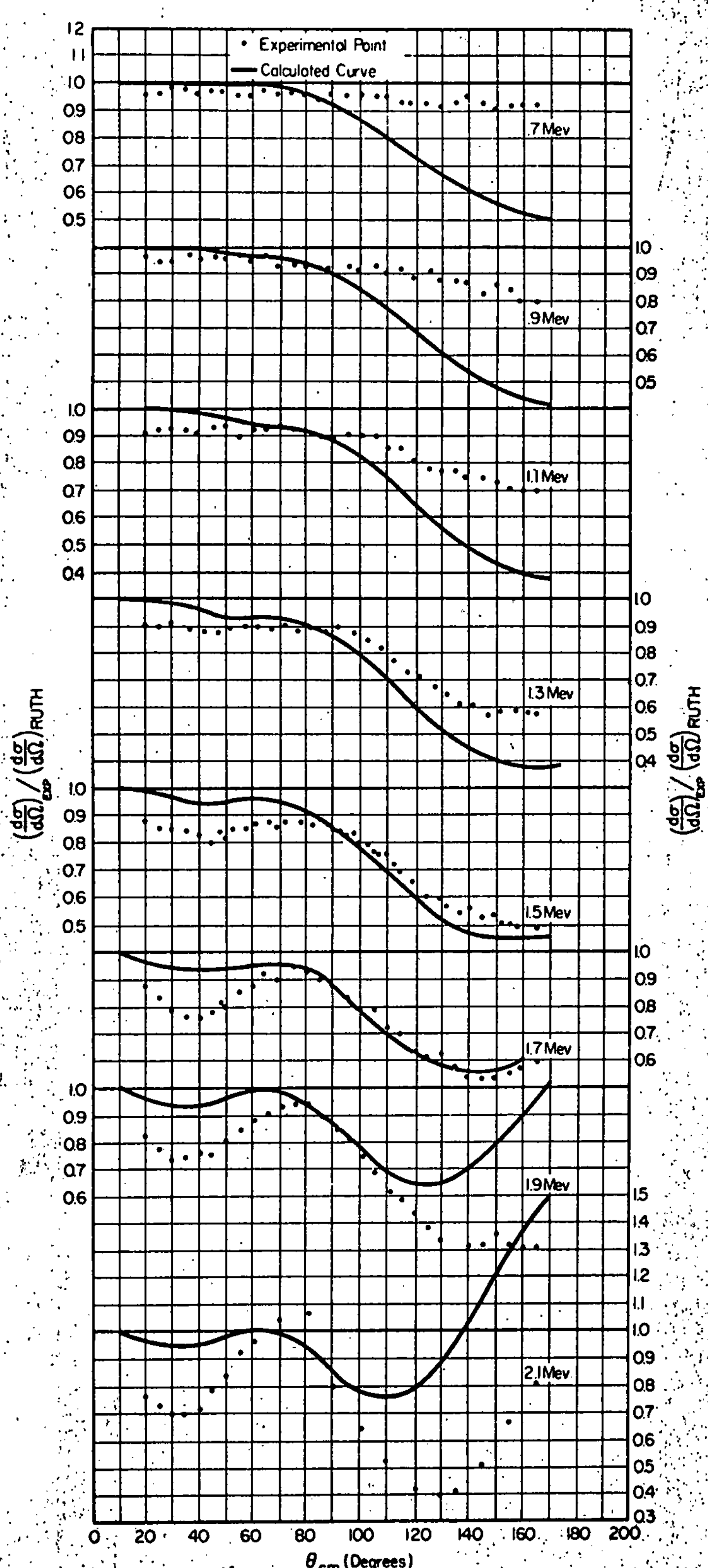

Figure 4. Compound Nucleus Fits — Angular Distributions with Energy Dependent Phase Shifts.

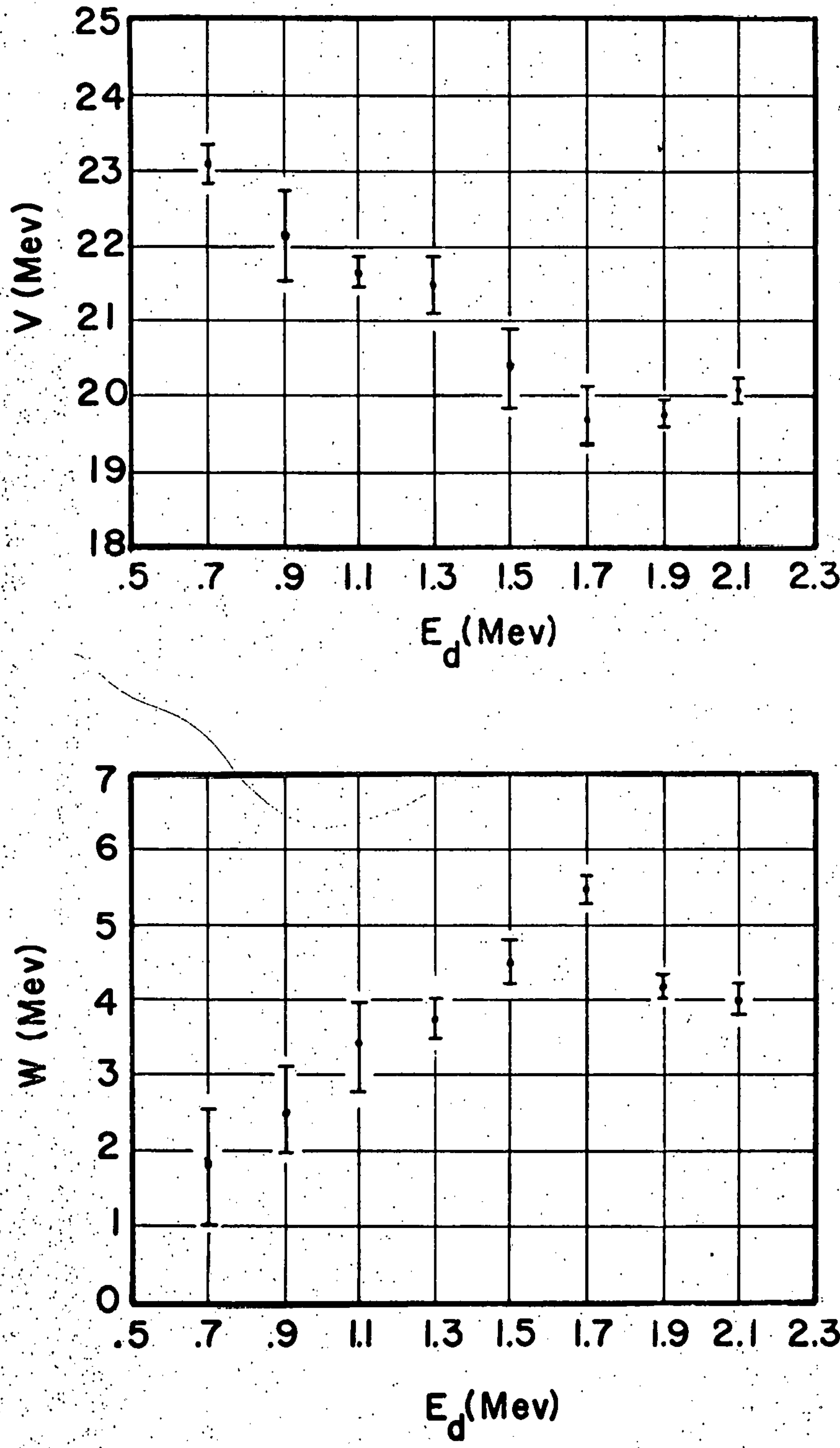

Figure 25. Optical Model Parameters vs. E_d.

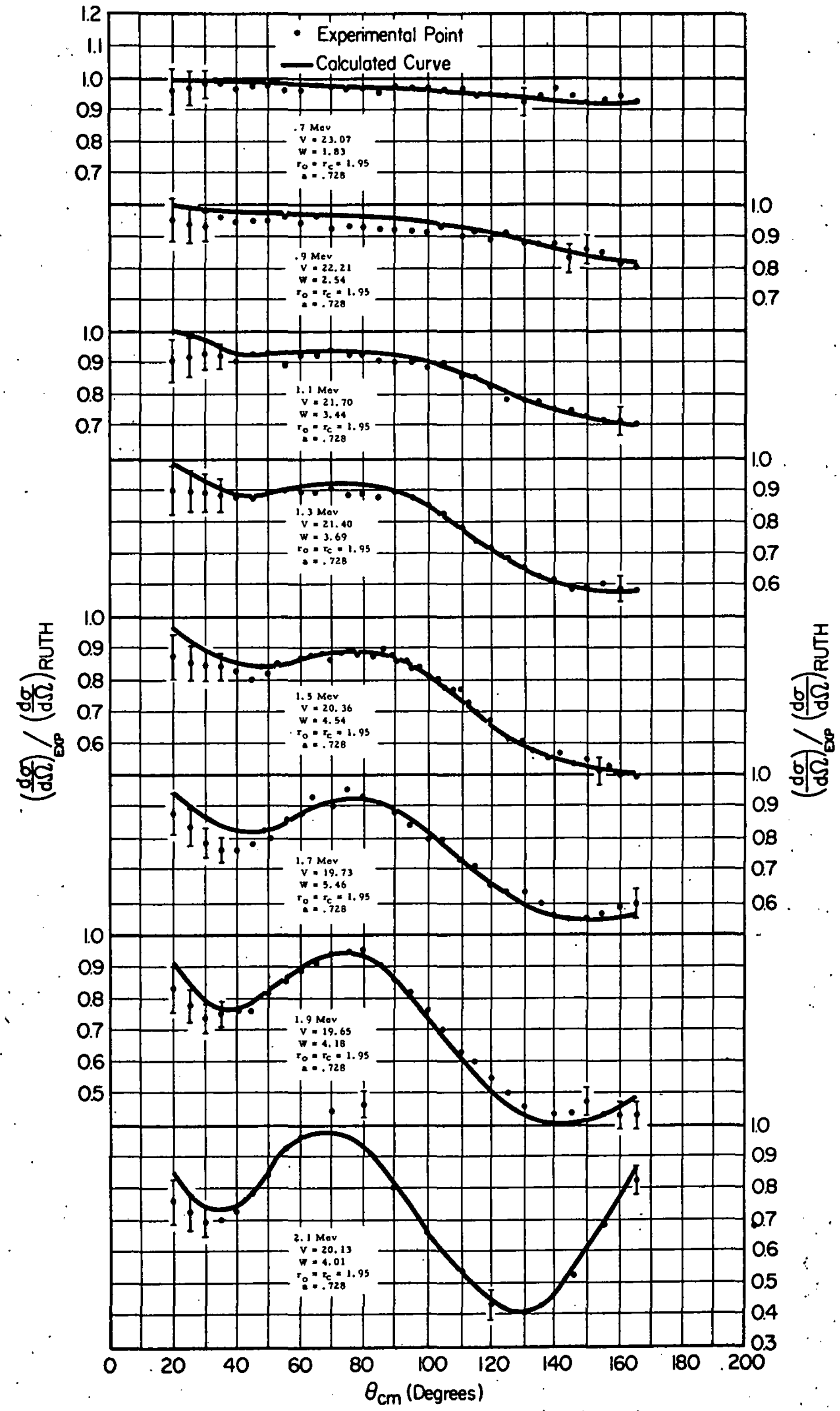

Figure 6. Optical Model Fits—Volume Absorption with Fixed Geometry.

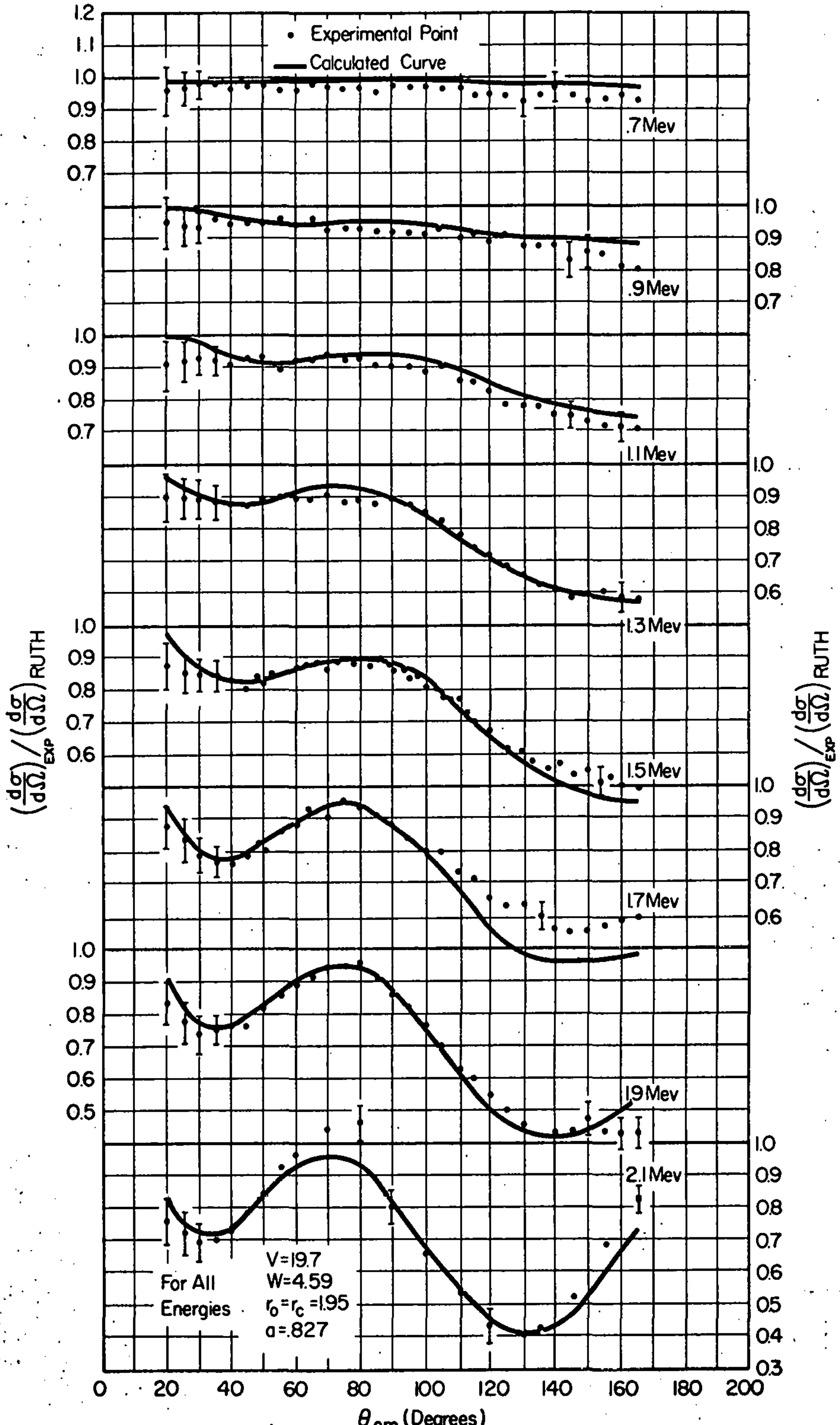

Figure 7. Optical Model Fits—Volume Absorption with Fixed Parameters.

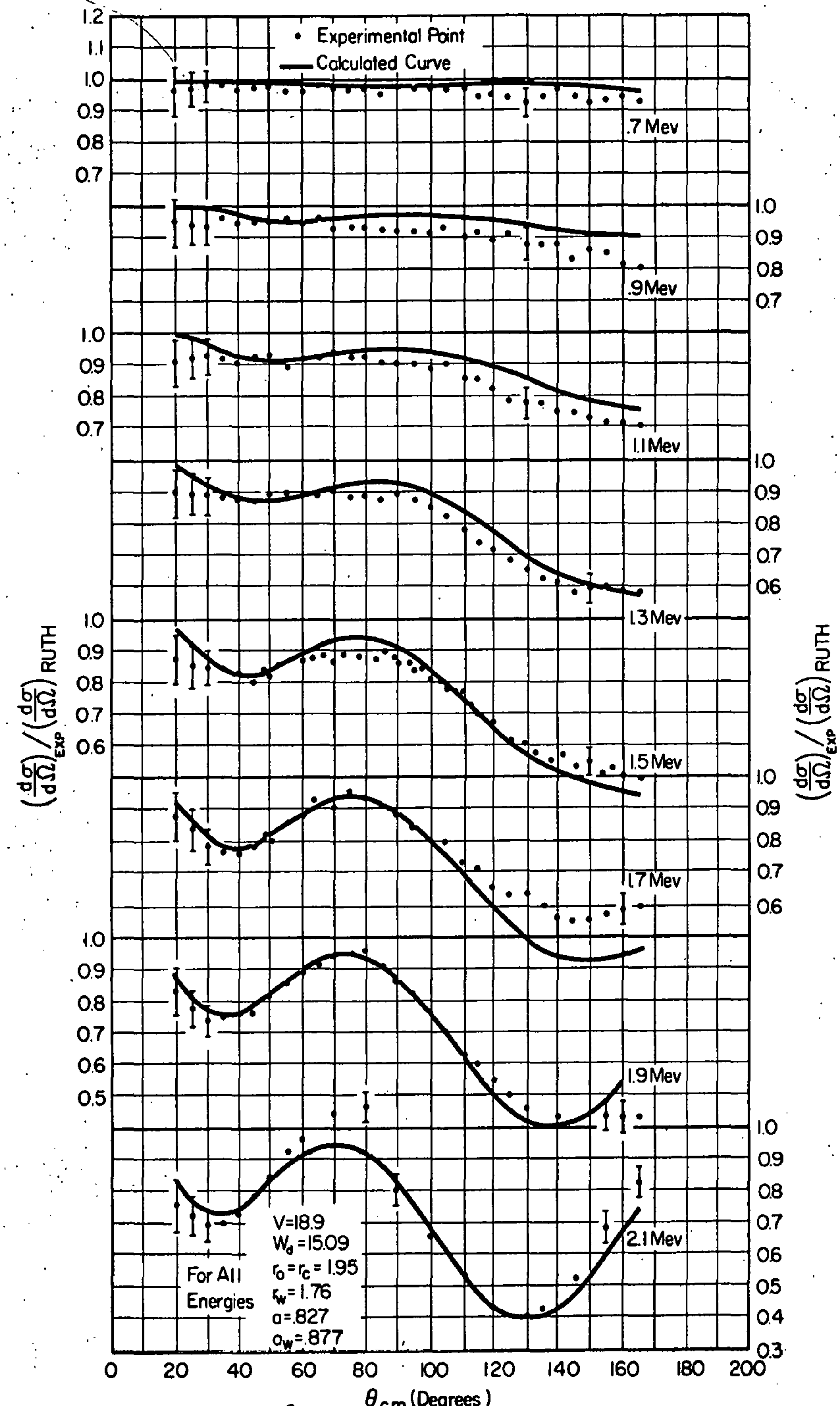

Figure 8. Optical Model Fits — Surface Absorption with Fixed Parameters.