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CONF-760424-6

STRONGLY-DAMPED COLLISIONS OF 164 AND 173-MeV ^{20}Ne ON Ni

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Experimental data are now available for reactions induced by beams of carbon through xenon at 6 - 10 MeV/nucleon on targets ranging from silver to uranium. The reaction process variously termed "strongly damped," "deeply inelastic," or "quasifission" appears to be present in most of the systems studied. We describe here an investigation of the reaction ^{20}Ne + Ni at incident energies of 8.2 and 8.9 MeV/nucleon.

In the first run, a target of 700 μg/cm^2 natural nickel was bombarded by 173-MeV $^{20}Ne^{6+}$. Reaction products were detected with a multiangle telescope consisting of a gas ionization chamber 10 cm long and a silicon position sensitive detector. The entrance window was of Formvar film about 50 μg/cm^2 thick. Methane flowed through the counter; the pressure was held at 75 or 48 mm Hg. Useful data were obtained on products with Z up to 20. In a later run at 164 MeV designed to provide data on the high-Z products, a thinner target (350 μg/cm^2) and lower gas pressure (27 mm) were used.

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The telescope provided nine spectra at 1° intervals for each setting. The (ΔE,E) data were recorded in nine two-parameter arrays. Energy spectra for each particle type were obtained from the arrays by appropriate masking of the (ΔE,E) contour maps. Adjacent Z-values were completely resolved to Z ∿ 28. Where statistics were poor, arrays from nine adjacent angles were in some cases combined before analysis.

The principal features of the spectra are illustrated in Figure 1. For products with Z well removed from that of the beam, a single broad peak (20 - 40 MeV width) is observed very far below the elastic region. The energy release of the reaction (Q value) was calculated under the assumptions of a two-body final state and a mass of the lighter fragment corresponding to the most abundant isotope of that Z. A preliminary sample of these Q-values is shown in Figure 2a at two angles as a function of Z. The Q-values at 19° are rather similar at 164 and 173 MeV.

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The Z-dependence in Figure 2b appears to correlate rather well with the ground-state Q-values for Z = 6, 8, 10 and 12, as shown by the lines to the right (these are plotted relative to that for Z = 10). However, the correlation does not hold for Z = 14. Moreover, the full set of ground-state Q-values, shown in Figure 2a, seems to bear little relation to the observed values.

The energy of the deep inelastic peak may be compared with the Coulomb separation energy for two fragments. Considering first two tangent spheres of separation $r_0(A_1^{1/3} + A_2^{1/3})$, the observed 33° Q values for Z = 6 to 10 correspond to $r_0 \sim 1.1$ fm. For higher Z the apparent value of r_0 increases steadily, passing 1.5 fm at Z = 13, suggesting that strong deformation effects may be occurring.

For products with Z near that of the beam, a sharper peak is seen at an energy corresponding to the same velocity as the beam. These particles may be due to decay of an excited projectile-like fragment; in support of this is the fact that they are much more intense for Z below 10.

The Z distributions for the deep inelastic peak show an odd-even effect, the even-Z products being more intense. See Figures 3 and 4. The cross section generally shows a decrease with Z, at least up to the vicinity of the symmetric fission point (Z = 19). The data in Fig. 4 show an increase in yield for higher Z.

Angular distributions at 173 MeV for selected Z values are shown in Figure 5. For $Z \geq 14$, $d\sigma/d\Omega$ is approximately $1/\sin\theta_{c.m.}$. The forward peaking is stronger for $Z < 14$.

Estimates of the 173-MeV cross section for each Z were made by extrapolating over the unmeasured angles. These in turn were summed over Z. The summed cross section for Z = 6 to 20 amounts to roughly 30% of the total reaction cross section as estimated from the quarter-point of the elastic scattering.

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*Work supported by Union Carbide Corp. under contract with the USERDA.

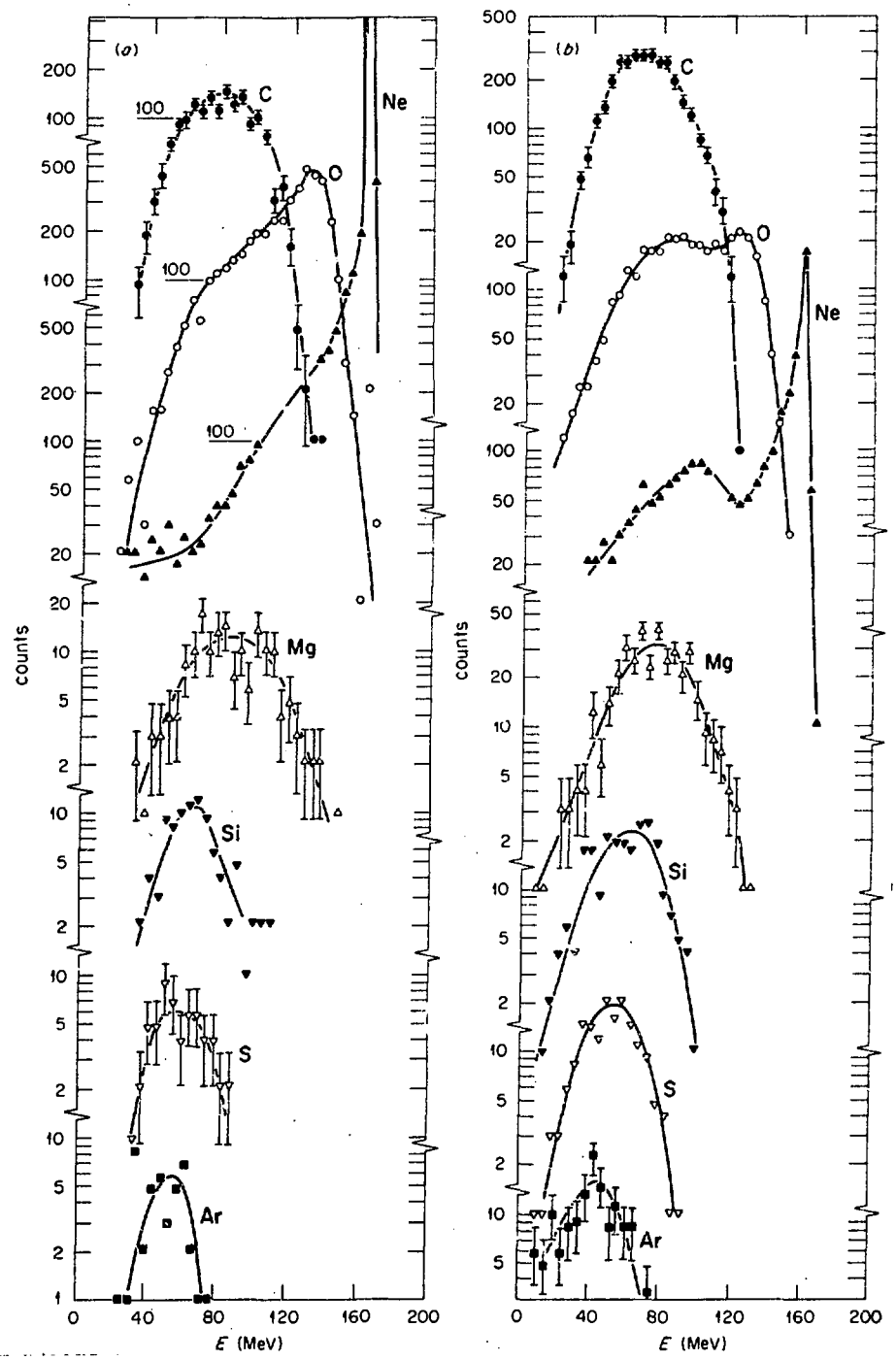

Figure 1. Spectra of even-Z products observed at 15° (left) and 22° from 173-MeV ^{20}Ne on Ni. The abscissa is not corrected for energy loss in the target or ionization chamber.

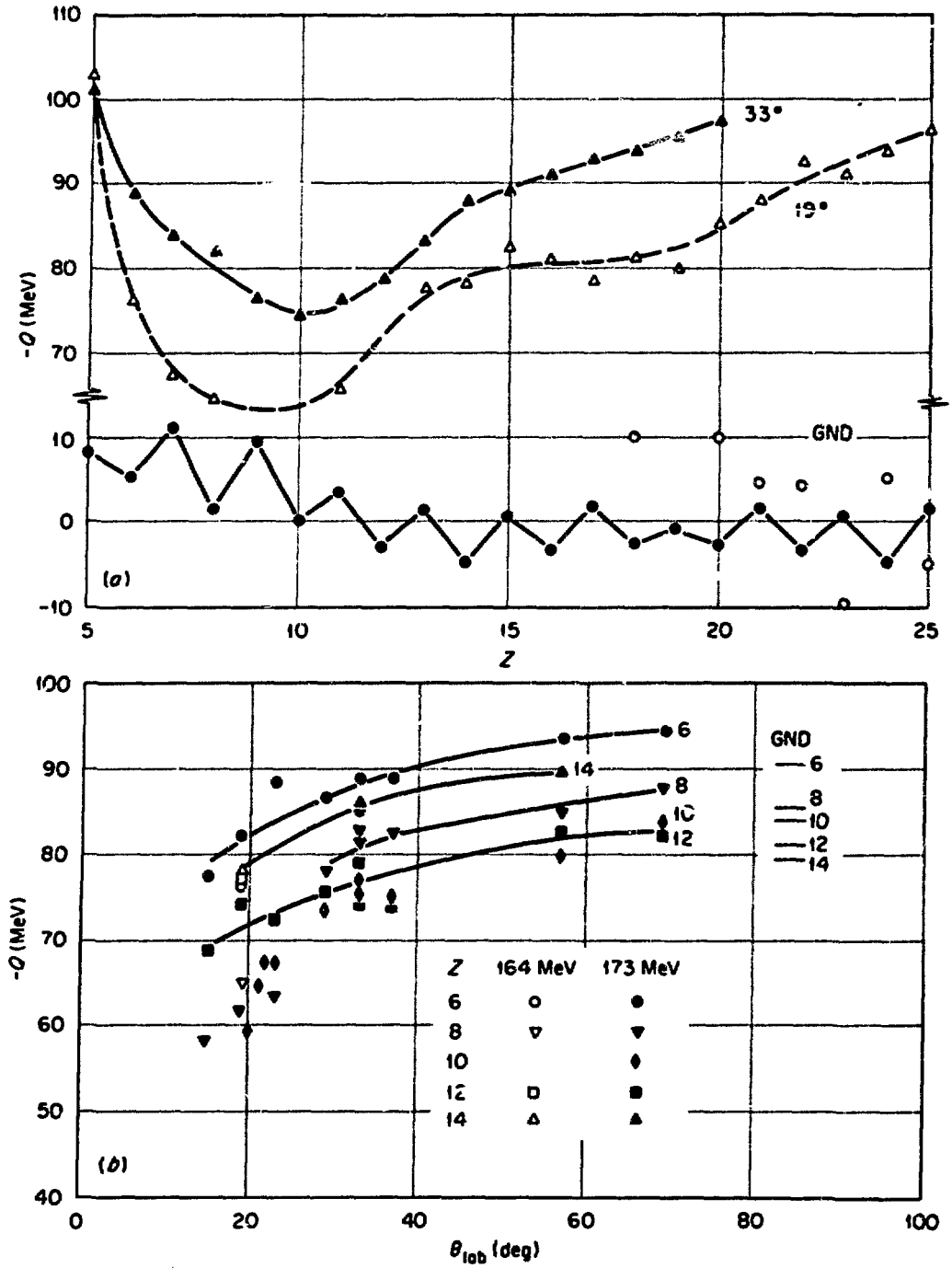

Figure 2. Dependence of Q-value on Z and θ. The 19° points in (a) were obtained at 164 MeV, those for 33° at 173 MeV. The full circles show ground-state Q-values for product pairs in which the lighter fragment is taken to be the most abundant isotope of that Z; the open circles result if the most abundant heavy fragment is used.

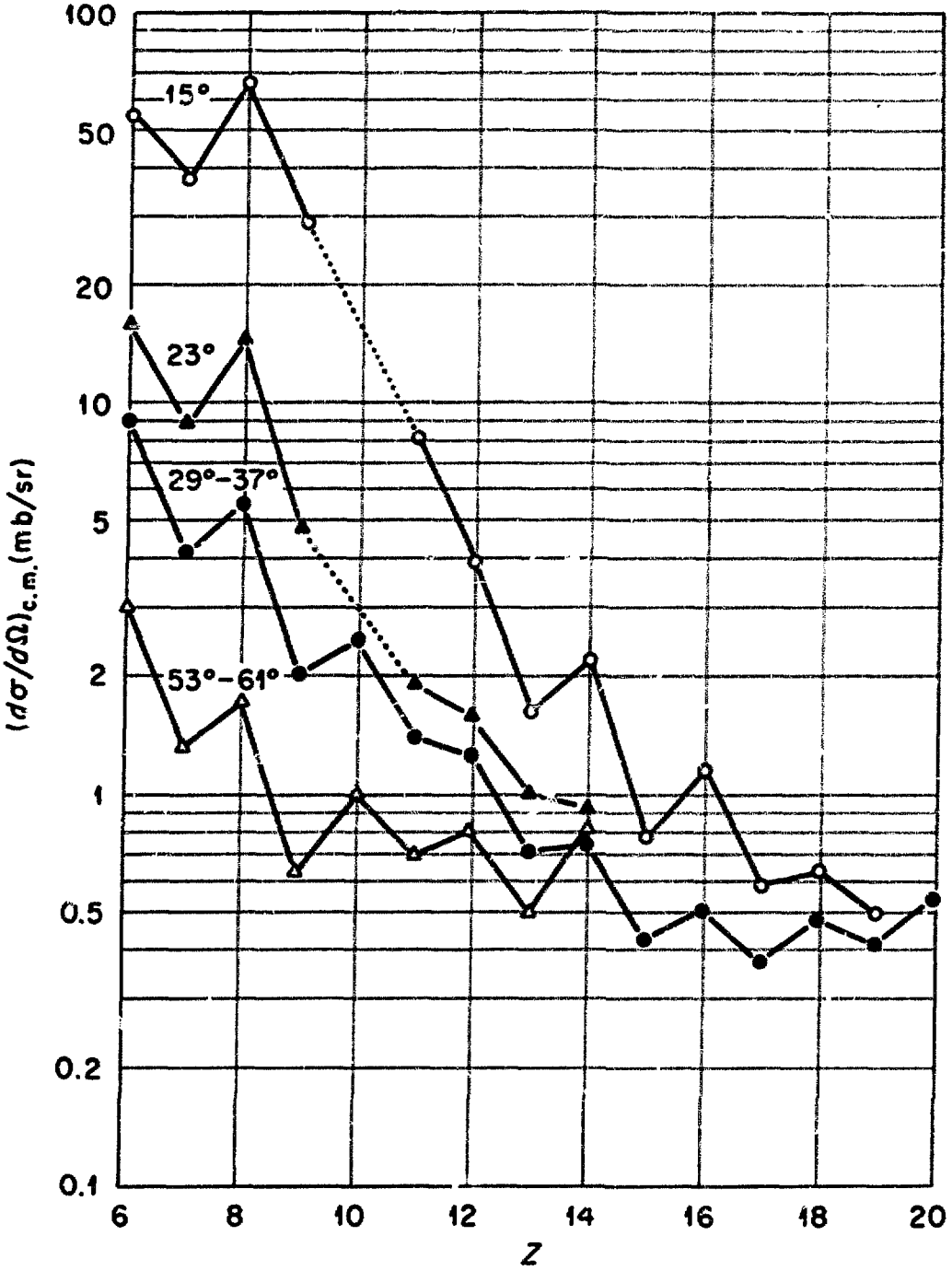

Figure 3. Z distribution (c.m.) of reaction products at 173 MeV.

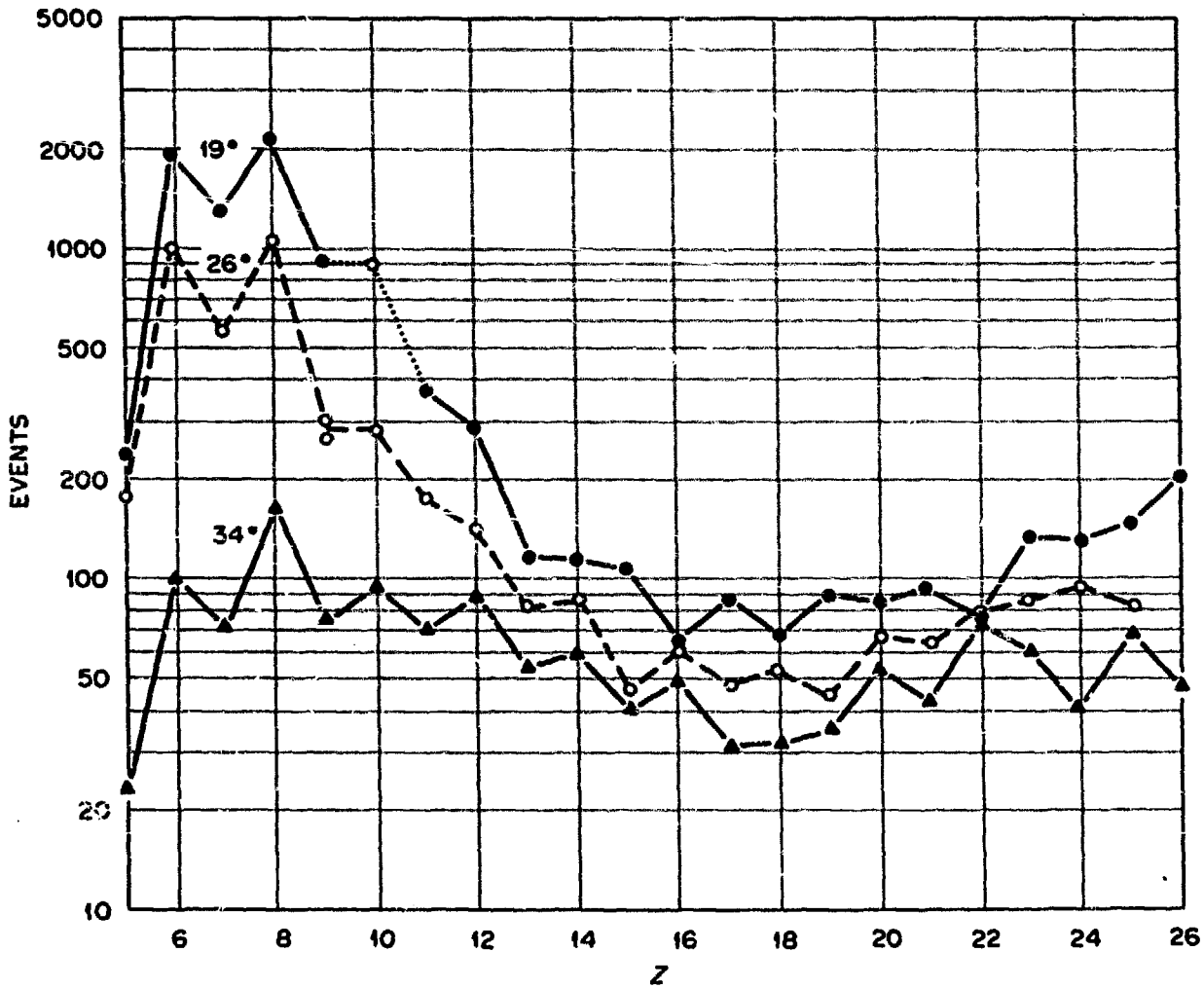

Figure 4. Z-distribution (lab) of reaction products at 164 MeV.

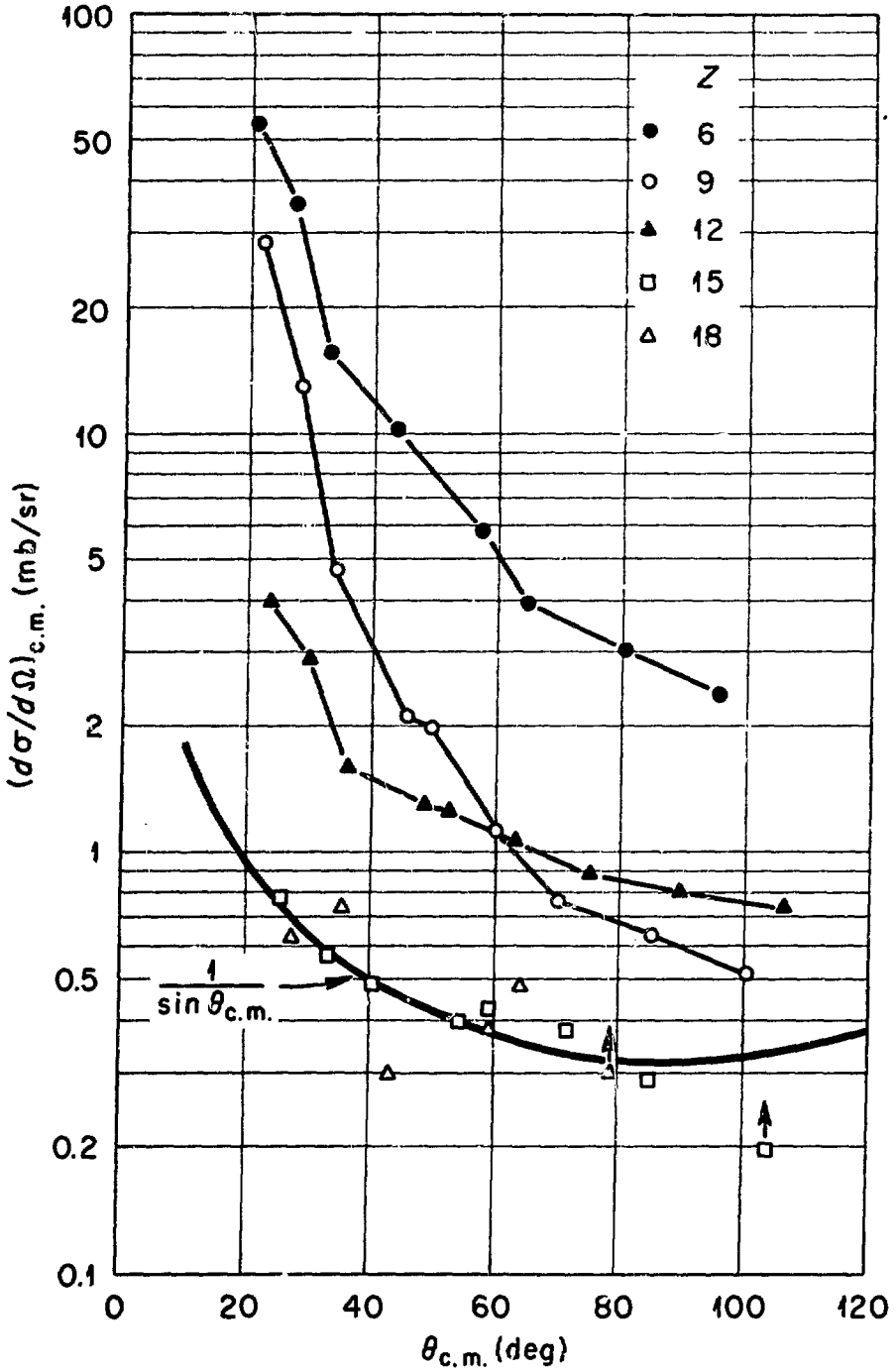

Figure 5. Angular distributions at 173 MeV of selected Z-values.