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THE MECHANISM OF PROTON POLARIZATION IN HIGH-ENERGY COLLISIONS

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THE MECHANISM OF PROTON POLARIZATION IN HIGH-ENERGY COLLISIONS

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Recently experimental evidence has accumulated showing that high-energy collisions of protons with various nuclei induce a considerable polarization in proton beams[1, 2, 3] and a mechanism has been proposed to account for this effect.[4-7]

We have tried to investigate this phenomenon experimentally and we present here a brief summary of our results.

For the sake of discussion we shall distinguish three types of collisions:

a) Elastic collisions in which the struck nucleus is left unexcited;

b) Inelastic collisions in which the struck nucleus is left in an excited state;

c) The limiting case (quasi elastic) in which the impinging proton can be considered to collide with a specific nucleon of the target and recoils almost as in a free nucleon-nucleon collision.

The theory proposed in References 4 through 7 applies specifically to elastic collisions and should be applicable especially to diffraction scattering.

This we have tested by measuring the differential cross section for left and right scattering for a polarized proton beam obtained as described in Ref. 2. The scatterers studied are carbon, aluminum and iron, as well as several others less completely.

One of the important requirements of the experiment is that the scattering be elastic. This is at least partially achieved by using a detecting telescope with enough absorber to exclude all protons that have suffered an appreciable energy loss in the target. In Fig. 1, we show absorption curves for the scattered protons taken at an angle $\theta = 9^{\circ}$ for left and for right scattering from carbon. The curves show the effect of nuclear absorption and also the end of the range of the protons. From curves of this type one can derive values of the asymmetry $\underline{e}$ as a function of the energy of the scattered protons. This is shown in Fig. 2. The asymmetry shows as increase at high energy which indicates a high degree of polarization of the protons scattered elastically as predicted.[4-7] However, our resolution in energy (limited by range straggling) is insufficient to distinguish the fluctuations in cross section corresponding to the levels of the residual nucleus. Fortunately, for small θ diffraction scattering accounts for most of the scattering cross section and it is possible, by using a thick absorber in the telescope, to obtain scattering curves that show the characteristic diffraction pattern (10). This is shown in Fig. 3, in which left and right scattering are plotted separately. The corresponding values of e are plotted in Fig. 4 and show fluctuations which we think are due to the operation of the L.S coupling as expected.[4-7] The minimum is not as pronounced as predicated by the simplified theories,[4-7] but there are probably two causes for this: Experimentally the lack of energy and angular resolution does not permit measuring elastic scattering only; theoretically the simplified models used are too crude (as pointed out by some of the authors) and the true minima may be less prominent than calculated on the simplified assumptions.

Even scattering that is definitely inelastic shows a considerable degree of polarization. This is revealed by Fig. 2 e.g. In the case of quasi elastic scattering this corresponds, qualitatively at least, to the results of n-p[9] and p-p[2] scattering, as is to be expected.

For the intermediate region a study should be made to try to discern the influence on the polarization of the excitation state of the residual nucleus. This, however, is beyond our present experimental possibilities.

A detailed account of these experiments will be published later.[12]

This work was done under the auspices of the Atomic Energy Commission.

The notations are the same as used in Ref. 2.

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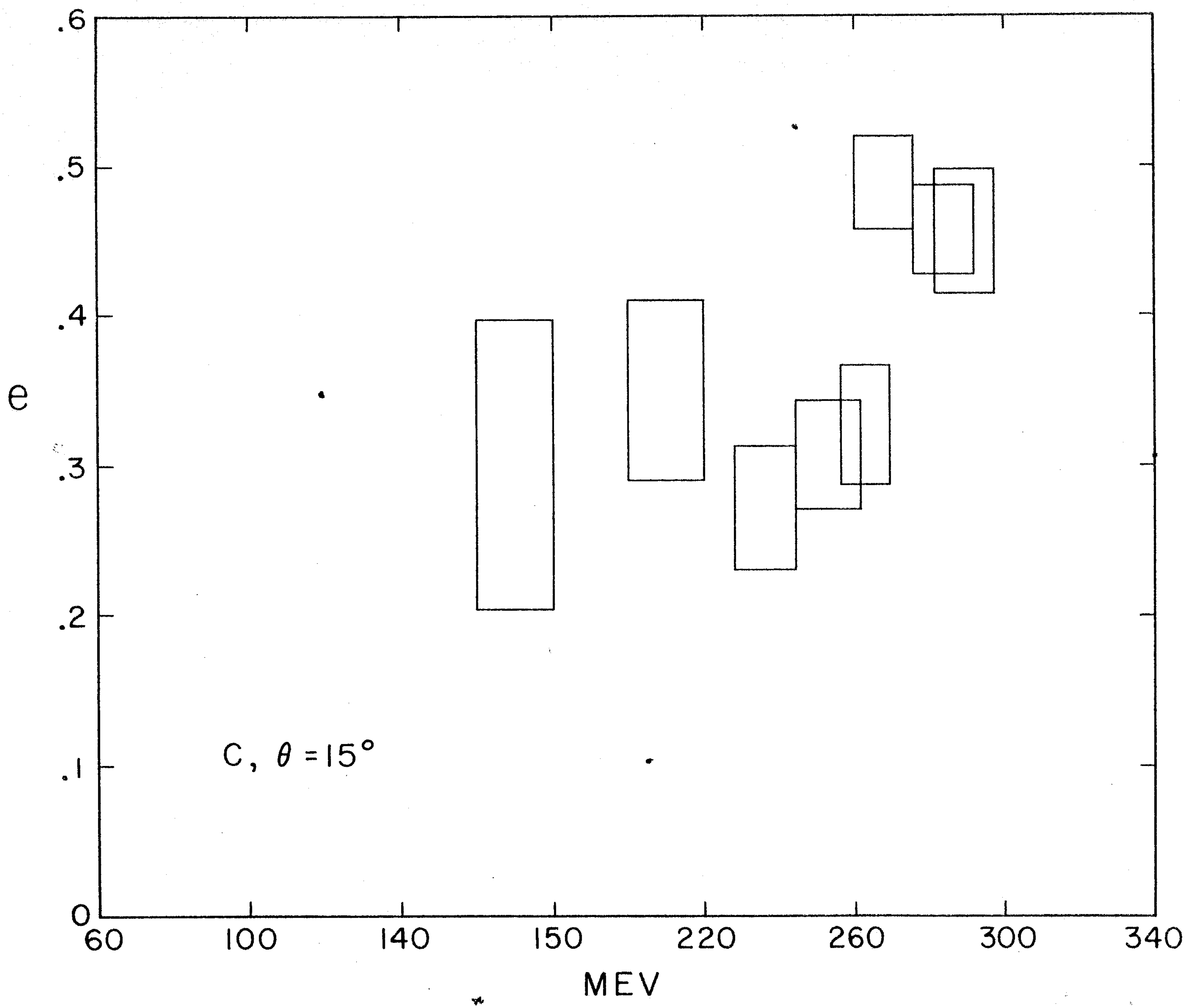
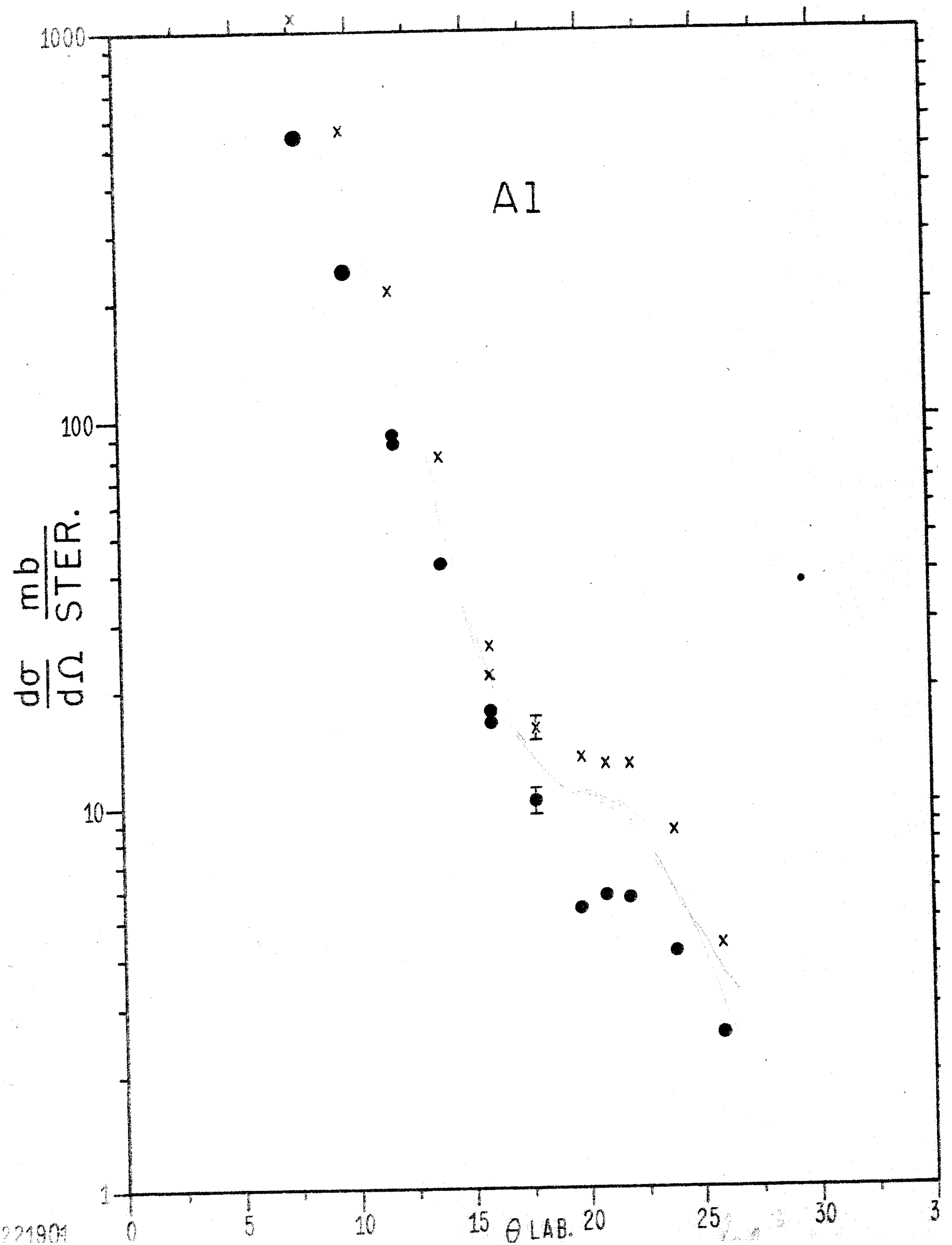


fig 2



Al
$\frac{d\sigma}{d\Omega}$ $\frac{mb}{STER.}$
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1
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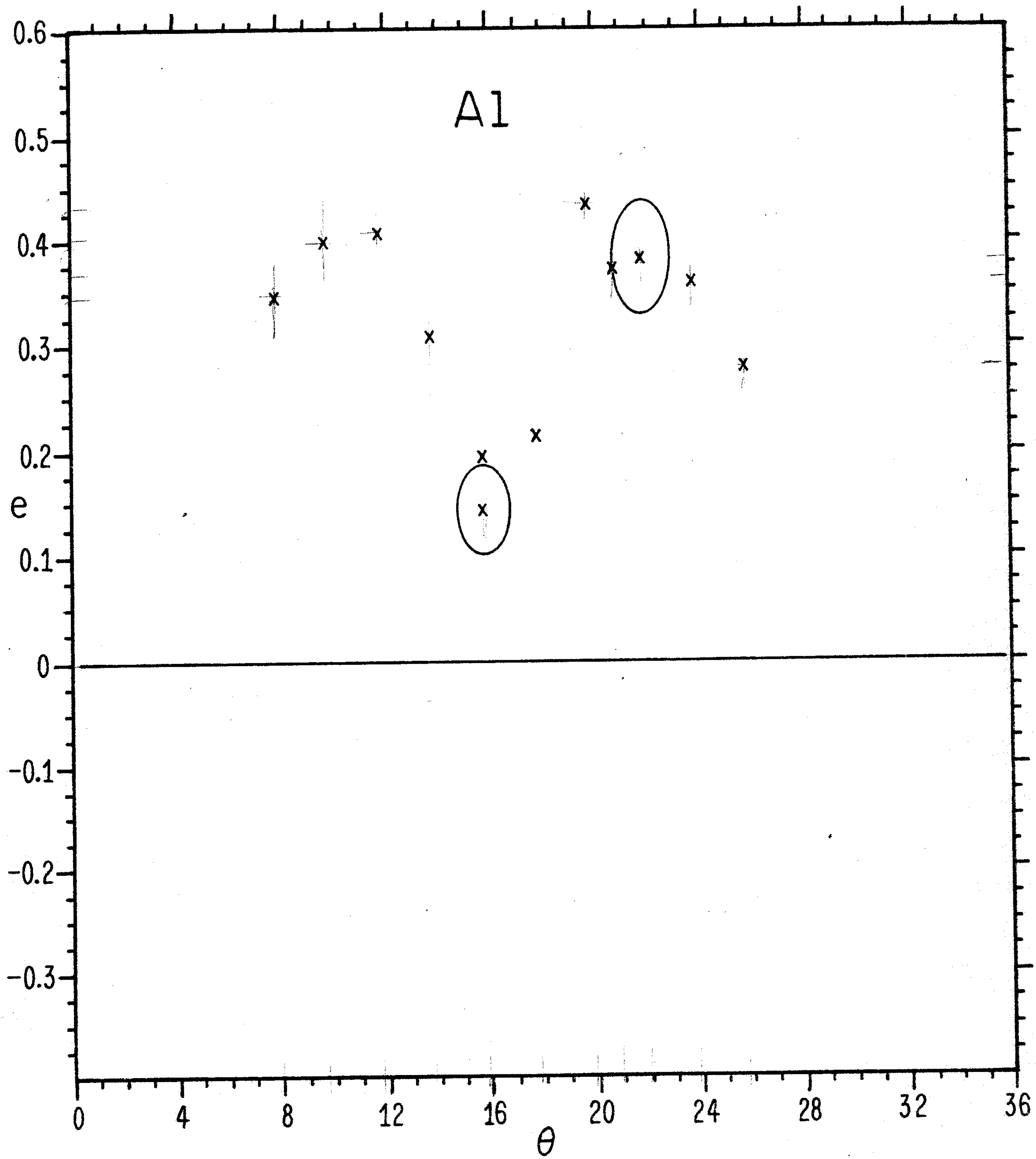

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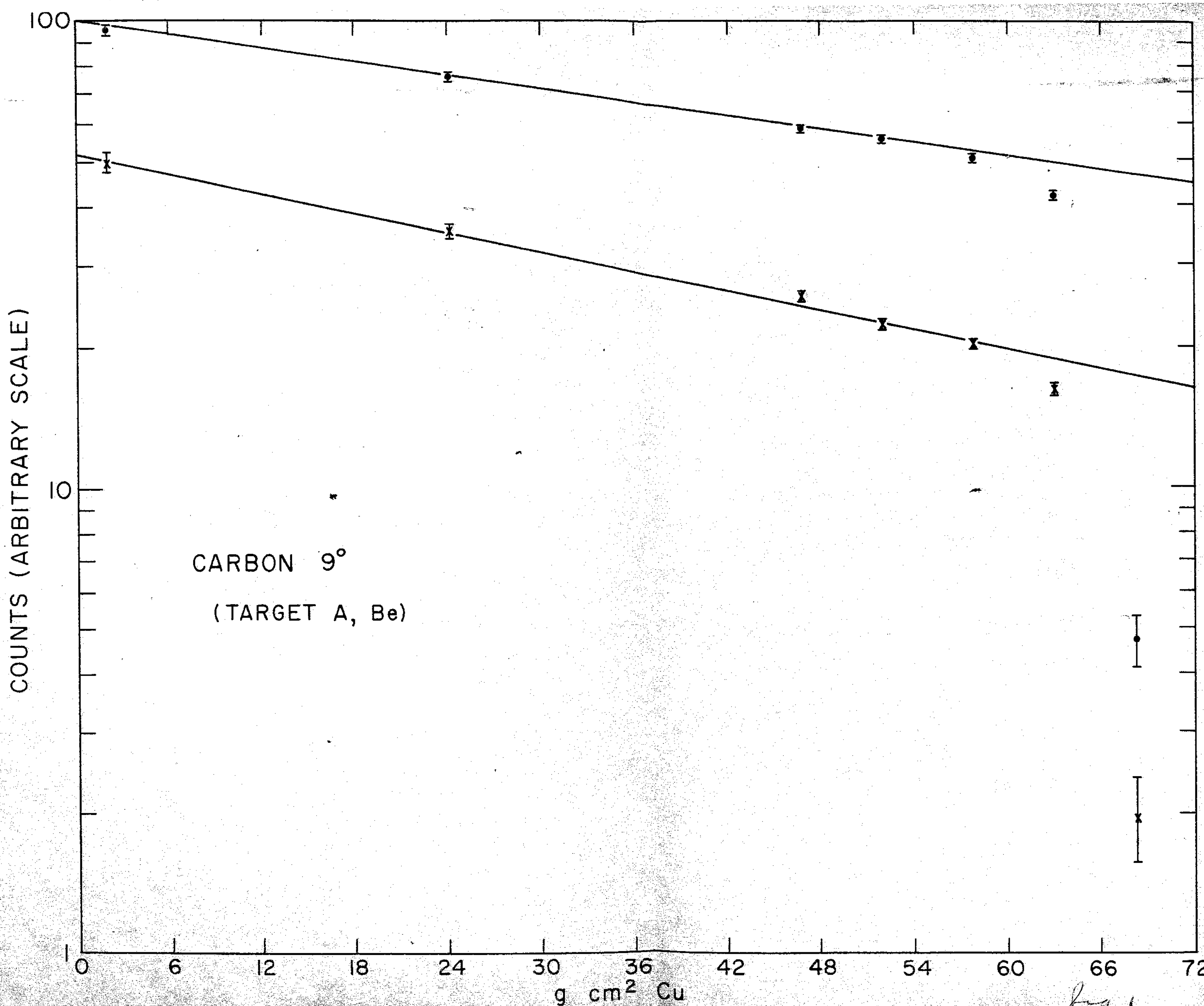
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10
1
CARBON 9°
(TARGET A, Be)
0
6
12
18
24
30
36
42
48
54
60
66
72
g cm^2 Cu