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The total cross sections for scattering of high-energy protons by protons have been directly measured at the full and at one reduced energy of the Berkeley synchrocyclotron. Attenuation of the external proton beam in liquid hydrogen was measured with standard counting techniques in order to check, by an independent method, the results obtained in previous differential scattering experiments.

Fig. 1 shows the experimental setup. The counting rate of counters 1-2-3 in coincidence was subtracted from the 1-2 coincidence rate and divided by the latter to obtain the attenuation occurring between counters 2 and 3. The difference in this quantity for the target filled with liquid hydrogen and for the empty target is attributed to scattering of the beam through an angle greater than the average half-angle subtended by the rear counter (No. 3).

The experiments were made with the full-energy beam (340 Mev) and at an energy of 240 Mev. Reduction of the beam energy was achieved by inserting 7-1/8 inches of beryllium in the path of the emerging beam before the existing analyzing magnet inside the shielding. Counting difficulties arising from the low duty cycle of the synchrocyclotron were minimized by holding the average external beam level below 10 protons per second. The use of scintillation counters ensured counting efficiencies of substantially 100 percent and also allowed a pulse-height investigation of beam homogeneity. The target is constructed of polystyrene foam.

Thus we have measured directly the attenuation, f , and may calculate:

$$\sigma_{obs} = \frac{M\,(f_H - f_B)}{\rho t\left[1 - (1/2)\,(f_H + f_B)\right]} ,$$

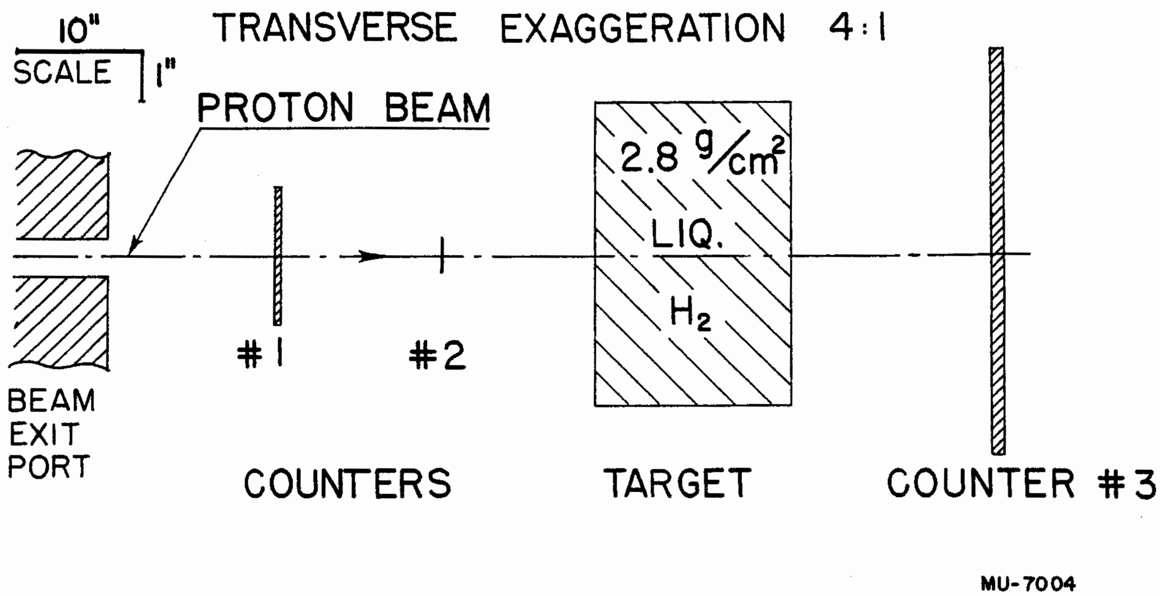

Fig. 1.
Schematic Diagram of the Experimental Geometry

where the subscripts H and B refer to target filled and empty, respectively, M is the mass of the hydrogen atom, and ρt is the surface density of the liquid hydrogen in the target. σ_{obs} is related to the differential scattering cross section through the expression:

$$\sigma_{obs} = \int_{\theta_{min}}^{90^o} \frac{d\sigma}{d\Omega} 2\pi \sin\theta \, d\theta = 2\pi \cos\theta_{min} \left.\frac{d\sigma}{d\Omega}\right._{avg}$$

where θ_{min} is the average half-angle subtended by the rear counter in the center-of-mass system and was varied around 18^o in this experiment. It should be noted that this angle is too large to include the Rutherford scattering at either energy, or the small contribution from the inelastic reaction $p + p \rightarrow \pi^+ + d$ at the full energy. The values obtained were:

Mean Energy (Mev)	$\frac{d\sigma}{d\Omega}_{avg}$ (millibarns/ster)
330	3.72 ± 0.15
225	3.56 ± 0.15

The errors shown include statistical and target-thickness uncertainties.

Since previous differential scattering work has shown, for the energies considered here, that $\frac{d\sigma}{d\Omega}$ is essentially constant over the range of angles included in σ_{obs}, $\frac{d\sigma}{d\Omega}_{avg}$ may be compared directly with the corresponding differential data. In this comparison our experimental results are consistent with references 1 and 2, but seem at variance with references 3 and 4.

Extension of this method to a lower energy is planned in the near future, after which a complete report will be submitted.

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

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3. Oxley and Schamberger, Phys. Rev. 85, 416 (1952)
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