plateaus were redetermined for each proton energy, to take into account new delays introduced to compensate for changes in time of travel for incident and scattered protons.

According to the second method, counter 3 was set at variable angle ($+\theta$) at 30-inch radius from the scattering center to detect the elastically scattered protons, and counter 4 was placed to extend from +5 to −20 degrees to detect deuterons. Counters 1, 2, and 3 were connected in coincidence and counter 4 was connected in anticoincidence (1, 2, 3, −4). Accordingly (1, 2, 3, −4) measured all charged particles scattered at angle θ in coincidence with an incident proton, if no charged particle reached counter 4 simultaneously. So all events $p+p\rightarrow d+\pi^+$ were eliminated, even when the deuteron was subjected to Rutherford scattering in the target.

Furthermore, counter 4 extended over much more than the solid angle in which deuterons could emerge in order to eliminate most of the events in which a pion is accompanied by a free proton and neutron. This occurs in only about 1 out of 5 pion productions[2] at 350 Mev and is probably infrequent at 429 Mev also. A third possible process is $p+p\rightarrow\pi^0+p+p$, but this was improbable of detection because (*a*) it is about 8 times less probable than charged pion production,[3] (*b*) the decay gamma ray was detected with very low probability in counter 3, and (*c*) due to the virtual diproton state the two protons tended to emerge in the same solid angle as the deuterons, and so very probably trigger counter 4.

The ratio $(1, 2, 3, -4)/(M, 2)$ was measured at high beam intensity and the ratio $(M, 2)/(1, 2)$ was measured at low beam intensity, with and without hydrogen. The cross section is proportional to the product of the ratios with hydrogen minus the product of the ratios without hydrogen.

At 54° the cross section obtained by the first method was found to be equal within experimental error to that obtained by the second method. The results are summarized in Table I. There is

TABLE I. Differential elastic p-p scattering cross section at 429 Mev. Method *a* is detection of two scattered protons. Method *b* is detection of the more energetic scattered proton in anticoincidence with a second charged particle emitted at small angles.

Millibarns per steradian	Method	Barycentric angle
3.42±0.13	*a*	90°
3.51±0.23	*a*	80°
3.11±0.19	*a*	65°
2.84±0.12	*a*	54°
2.80±0.21	*b*	54°
3.18±0.21	*b*	43°
2.86±0.20	*b*	28°

no certain deviation from isotropy within the statistical errors of these results, but there is an indication of some decrease in cross section at smaller angles. A similar behavior is suggested by the corresponding data at 345 Mev,[4] although there also the trend is not much larger than the experimental errors.

The isotropic character of the present data at 429 Mev is in considerable disagreement with the shape of the elastic-scattering curve observed by Mott *et al.*, at 435 Mev.[5] On the other hand, the absolute value of the cross section in the neighborhood of 90° is in good agreement with their data.

It is interesting to compute the total p-p cross section at 429 Mev using the present data. Assuming isotropy and a differential scattering cross section of 3.3 mb/sterad one computes 20.7 mb for the total elastic scattering. To this must be added the π^0 production cross section, 0.45 mb,[3] and the π^+ production cross section. A measurement of the latter is being made by A. H. Rosenfeld of this laboratory, who privately reported a preliminary value of 3 mb. One finds 24.2 mb for the sum of these data. This is to be compared with, and agrees well with, the value 24±1 mb determined by transmission at the same energy.[6]

The cross sections reported in Table II for lower energies are much smaller than values reported by previous workers[7-10] although in agreement with a new result, 3.5±0.4 mb/steradian for the energy interval 150 to 350 Mev, from the Berkeley group, written to us by Owen Chamberlain. Our work differs from previous counter experiments in that the incident protons are counted individually. Previous workers have used radioactive methods, Faraday cages, or ion chambers to determine the incident flux.

TABLE II. Differential elastic p-p scattering cross section at 90° barycentric angle.

Millibarns/steradian	Energy (Mev)
3.21±0.11	144±5
3.67±0.34	271±9
3.42±0.13	429±14

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The Attenuation Cross Sections of 37-Mev Pions in Hydrogen

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WE previously reported[1] 16.0±1.0 millibarns for the attenuation cross section of 37-Mev positive pions and 17.3±1.4 millibarns for negative pions in hydrogen. In arriving at these numbers we overlooked an important correction[2] due to the $\pi-\mu$ decays which occur between the second and third crystals of the telescope. Applying this correction and a further small correction due to a refinement in the calculation of our geometry, these numbers become $\sigma(\pi^+)=11.8\pm1.0$ millibarns and $\sigma(\pi^-)=12.9\pm1.7$ millibarns.[3] The π^+ value agrees with that obtained from our measured angular distribution.[4] The measurement of the π^- angular distribution at this energy is not yet completed.

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Neutron Total Cross Section for Bismuth and Uranium between 45 and 160 Mev*

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NEUTRON total cross sections for bismuth and uranium have been measured in a good geometry transmission experiment, using a time-of-flight instrumentation.[1,2] The source of neutrons was the stripped deuteron beam of the 184-inch synchrocyclotron. The results are shown in Fig. 1. Uncertainties are shown in terms of standard deviations, due to counting statistics only, and to energy channel width.

The distribution of values indicates a "dip" in cross section in the vicinity of 60 Mev for the two elements, similar to results first obtained by Taylor and Wood for lead.[2-4]