

FIG. 3. Sum-energy spectrum,  $T_p + T_d$ , for all coincident events in which the ratio of proton to deuteron kinetic energies,  $T_p/T_d$ , lies between 0.084 and 0.145. The dashed curve is the sum-energy resolution as determined from free  $p$ - $d$  coincidences. This curve has been displaced by 27 MeV, which is the binding energy of the deuteron in the  $^{12}\text{C}$  nucleus. The arrow G. S. shows the location of the ground state of  $\text{B}^{10}$ .

proximity. From the scattering kinematics

and the large average kinetic energy of these clusters—about half that of the individual nucleons—we conclude that  $n$ - $p$  pairs can move rather freely through the nucleus.

\*Work supported by the U. S. Atomic Energy Commission.

†Work partially supported by the National Science Foundation.

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<sup>3</sup>The energy resolution of the spectrometer was 3-MeV full width at half-maximum, which is a factor of 10 better than that used in the experiment discussed in Ref. 2. For more details on this spectrometer, see J. L. Friedes, R. J. Sutter, H. Palevsky, G. W. Bennett, George Igo, W. D. Simpson, R. L. Stearns, and D. M. Corley, to be published.

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#### COMPARISON OF ELASTIC POSITRON-PROTON AND ELECTRON-PROTON SCATTERING CROSS SECTIONS\*

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(Received 25 September 1967)

We have measured the ratio of positron-proton and electron-proton elastic-scattering differential cross sections at 1700-MeV incident beam energy. This ratio gives information about the magnitude of the interference term between one- and two-photon exchange amplitudes.

The positron and the electron beams were made by allowing the external bremsstrahlung  $\gamma$  beam from the Cornell 2-GeV synchrotron to strike a one-radiation-length lead target. Electrons or positrons were then selected by a beam transport system which momentum analyzed the particles and focused them to a 46-cm-long liquid-hydrogen target. The transport system (see Fig. 1) is similar to the Stanford Linear Accelerator Center  $B$  transport

system in design<sup>1</sup> and is free of second-order chromatic aberrations. The image of the pos-

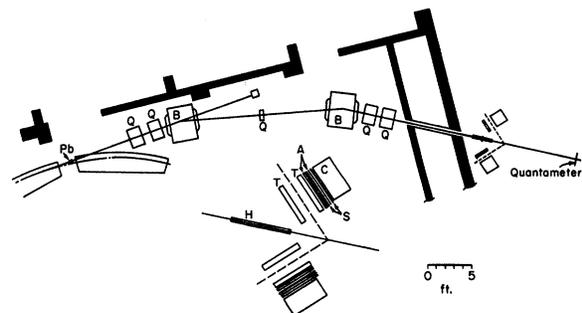


FIG. 1. Schematic drawing of the transport system and the detection apparatus.  $H$ , hydrogen target;  $T$ , thin-foil optical spark chambers;  $S$ , scintillation counters;  $C$ , Cherenkov counters.

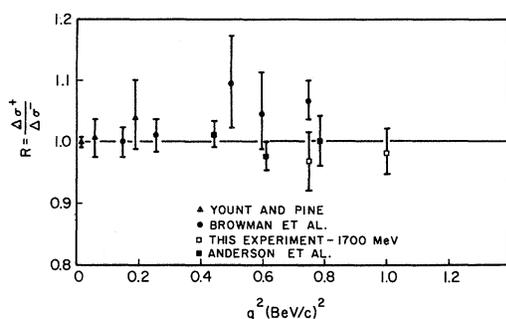


FIG. 2. Summary of experimentally obtained values of  $R$ .

itron and the electron beams had the same physical shape of  $0.7 \text{ cm} \times 1.5 \text{ cm}$  at the hydrogen target. The energies of the two beams differed by less than 0.2%. The momentum distribution is normal and has a  $\sigma$  of 42 MeV/c. We kept the  $\pi$ -meson contamination of the beams to a negligible amount by maintaining the synchrotron energy below 1875 MeV. The average positron- or electron-beam intensity was about  $2 \times 10^6 \text{ sec}^{-1}$ .

Figure 1 shows the detection apparatus which consisted of thin-foil spark chambers to measure angles of scattered particles and scintillation counters and total-absorption lead-glass Cherenkov counters, arranged symmetrically on opposite side of the liquid-hydrogen target. The spark chambers were triggered by simultaneous observation of an electron from one side and a proton from the other. The photographed spark-chamber tracks were measured and digitized onto cards on a Micrometric SP5000 image plane digitizer. Each measured event was then kinematically reconstructed with the aid of a CDC 1604 computer. By placing limits on the polar and azimuthal angles of each event and by examining the pulse height of the electrons in the Cherenkov counter, we were able to select the elastically scattered events from the inelastic events. The external radiative correction which arises from the emission and absorption of photons real

or virtual contains a term which changes sign for the two scattering processes. This correction modifies the measured ratio  $R_m \equiv \Delta\sigma(e^+p) / \Delta\sigma(e^-p)$  in the following way:

$$R(\text{corrected}) = R_m (1 - 2|\delta|),$$

where  $\delta$  is given as

$$\delta = (\alpha/\pi) \ln \eta \ln [ (p_e \cdot p_e')^2 \Lambda^4 / (M_p^2 E_e E_e') ].$$

The variables in the expression of  $\delta$  are defined by Yennie and Meiser.<sup>2</sup> In the  $q^2$  and energy regions with our detection geometry, the correction  $2|\delta|$  can be considered a constant and is found to be 0.038. The estimated error of  $2|\delta|$  is about  $\pm 0.005$ .

The values of  $R$  after radiative correction are plotted in Fig. 2 together with all other published data.<sup>3-5</sup> Our result is consistent with a recent distorted-wave-approximation calculation by Greenhut,<sup>6</sup> who, using static magnetic-moment and charge distributions, predicted  $R$  to be less than 1.01.

We wish to thank Professor D. Yennie for many illuminating discussions. We are grateful to Dr. G. Rouse and the synchrotron staff for their help. We also wish to thank Mrs. M. Johnson and Miss G. Jackson for scanning the film.

\*Work supported in part by the National Science Foundation.

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