cent of the 6 MeV. γ-rays, giving a radiation width of the order of 2 eV. for this level of Ne^{20}, and less than 0·1 eV. for the others up to 1 MeV. proton energy. This yield is consistent with our measurements with the copper detector if the (γ,n) cross-section of Cu^{63} is about $1 \cdot 5 \times 10^{-27}$ cm.² at this energy[6].

S. Devons
H. G. Hereward
Cavendish Laboratory, Cambridge.

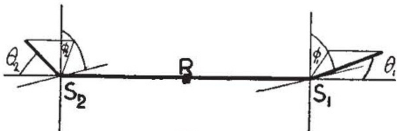
[1] Baldwin and Koch, *Phys. Rev.*, **67**, 1 (1945).
[2] Bonner and Evans, *Phys. Rev.*, **73**, 666 (1948).
[3] Burcham and Devons, *Proc. Roy. Soc.*, A, **173**, 555 (1939).
[4] Fowler and Lauritsen, *Phys. Rev.*, **56**, 840 (1939).
[5] Dee, Curran and Strothers, *Nature*, **143**, 759 (1939).
[6] Bothe and Gentner, *Z. Phys.*, **112**, 45 (1937).

Polarization of Annihilation Radiation

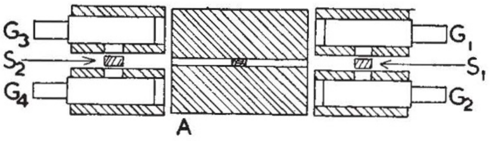
An attempt has been made to detect the relative polarization of the two photons of energy 0·51 MeV. produced in the annihilation of slow positrons. If pairs of quanta from a source of annihilation radiation at R (Fig. a) are scattered at S_1 and S_2, theory[1-3] predicts an angular distribution of quanta after Compton scattering given by the formula

$$N(\theta_1\varphi_1\theta_2\varphi_2)d\Omega_1 d\Omega_2 = k\left\{\frac{[(1-\cos\theta_1)^3+2]\,[(1-\cos\theta_2)^3+2]}{[2-\cos\theta_1]^3\,[2-\cos\theta_2]^3} - \frac{\sin^2\theta_1\,\sin^2\theta_2\,\cos 2\,(\varphi_1-\varphi_2)}{[2-\cos\theta_1]^2\,[2-\cos\theta_2]^2}\right\}d\Omega_1 d\Omega_2,$$

where θ_1 and θ_2 are the angles through which the quanta are scattered, φ_1 and φ_2 are the azimuthal angles measured in a plane perpendicular to the direction of incidence (S_1RS_2), and $N(\theta_1\varphi_1\theta_2\varphi_2)d\Omega_1 d\Omega_2$ the probability of the two quanta being scattered into elements of solid angle $d\Omega_1$ and $d\Omega_2$ in the directions $(\theta_1\varphi_1)$, $(\theta_2\varphi_2)$.



(a)



(b)

The apparatus for the experimental verification of this formula is sketched in Fig. b. Positron-active material, packed into an aluminium tube, is placed at the centre of the lead block A. Oppositely directed quanta pass down the collimating channel to strike the cylindrical scatterers S_1 and S_2. Lead shields define the solid angles into which quanta must be scattered to reach the Geiger counters G_1, G_2, G_3 and G_4. Coincident discharges of either G_1 or G_2 with either G_3 or G_4 are recorded when all four counters lie in the same plane (coplanar position), and when one pair of counters is rotated through 90° about $S_1 S_2$ (perpendicular position), corresponding to mean values of $(\varphi_1-\varphi_2)$ of 0° and 90° respectively. The total numbers of discharges in each pair of counters (of which 70 per cent are due to quanta scattered by S_1 or S_2) are recorded and used to calculate corrections for source decay and chance coincidences.

Sources of Cu^{64} (12·8 hr. half-life) were prepared by deuteron bombardment of copper in the Cambridge cyclotron; each had an initial activity of about 3×10^8 positrons per sec., and gave useful counting rates over a period of 36 hours after irradiation. The results from thirteen such sources are condensed into the accompanying table. The first results were obtained with brass scatterers 1 in. long and 0·6 in. in diameter; later, aluminium scatterers of the same dimensions were used to minimize the effect of double scattering. Two different arrangements of lead shields surrounding the counters were used, the first defining rather larger solid angles for detection of the scattered quanta than the second. Corrections have been made for source decay, chance coincidences, and a background-rate of 3 per hr. due to cosmic rays. The net coincidence-rates at the beginning of each run were of order 0·5 per min. The errors quoted are standard deviations calculated assuming normal statistical fluctuations, and are compatible with the variations in the results from individual sources.

Scatterer material		Brass	Brass	Aluminium
Lead shield arrangement		Wide angle	Narrow angle	Narrow angle
Counting-rate (perpendicular pos.) / Counting-rate (co-planar pos.)	(theory)	1·55	1·82	1·86
,, ,, ,, ,,	(experimental)	1·39 ± 0·07	1·31 ± 0·17	1·51 ± 0·10

The results establish the existence of a relative polarization. Further experiments are needed, however, to determine whether the discrepancies between theoretical prediction and experimental results are merely instrumental, or due to a breakdown of theory.

The deviations appear too large to be dismissed as due to statistical fluctuations, especially as the independent results using different scatterers are all consistently lower than the theoretical predictions. Any double scattering of quanta within the scatterers would tend to reduce the observed ratio; the increase in the observed ratio with the lower density scatterers may be significant. A rigorous calculation of such an effect is not feasible; rough calculations indicate that it should not be serious. The Geiger counters are being replaced by scintillation counters; an expected twenty-fold increase in detection efficiency will permit the use of smaller scatterers of low-density material, more close defined geometry, and increased counting-rates, and so settle definitely whether or not the theoretical predictions are quantitatively correct.

Note added in proof, August 21. The results of Bleuler and Bradt[4] are noted. Their value for the ratio of perpendicular to coplanar coincidence-rates, while in agreement with theory, has a sufficient margin of error to be compatible with the results quoted here.

R. C. Hanna
Cavendish Laboratory, Cambridge.

[1] Dirac, P. A. M., *Proc. Camb. Phil. Soc.*, **26**, 361 (1930).
[2] Pryce, M. H. L., and Ward, J. C., *Nature*, **160**, 435 (1947).
[3] Snyder, H. S., Pasternack, S., and Hornbostel, J., *Phys. Rev.*, **73**, 440 (1948).
[4] Bleuler, E., and Bradt, H. L., *Phys. Rev.*, **73**, 1398 (1948).