curve which is roughly exponential in form when plotted as a function of the aluminum absorber thickness. The coincidence rate reaches zero at 0.0235 g/cm^2, suggesting a maximum conversion electron energy of 0.135 Mev. It has been shown that tantalum (182) emits about sixteen converted gamma-rays.[2] $(N_{\beta\beta}/N_{\beta})/(N_{\beta\gamma}/N_{\gamma})$ at zero absorber thickness was found to be correspondingly large, about 0.7, and since the relative values of the individual conversion coefficients are not known, the total conversion coefficient could not be calculated.[3]

Beta-beta coincidences in the disintegration of Ir^{192} have been reinvestigated.[3] The beta-beta coincidences per beta-ray are shown in Fig. 2 as a function of aluminum absorber thickness. The beta-beta and beta-gamma coincidence rates were extrapolated to zero absorber thickness on a semilogarithmic plot, and the total conversion coefficient was found to be 32±3 percent, in agreement with the previous estimate.[3] Several different geometric arrangements were employed with extremely thin sources of radioactive iridium, and all of the curves were similar in form to that of Fig. 2. The maximum obtained in the region of low energy by Wiedenbeck and Chu[3] was not observed. Thus far, beta-beta coincidences have been measured in Ta^{182}, Ir^{192}, Os^{191}, and Au^{199}, and in every case an exponential curve has been obtained. Curves of this appearance have also been reported by Mitchell.[4]

No beta-beta coincidences were observed in Sc^{46}. This agrees with a previous report[5] that few or no conversion electrons are emitted by Sc^{46}, and demonstrates that there are no spurious beta-beta coincidences arising from scattering effects in the geometries employed.

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Search for Electrons in the Primary Cosmic Radiation*

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PRELIMINARY results have been obtained from an experiment designed to determine whether or not high energy electrons or photons are present in the primary cosmic radiation. The detector consisted of a cylindrical ionization chamber with a sensitive volume 5 cm in diameter and 15 cm long. Its collecting electrode was a wire 0.63 mm in diameter stretched along the axis of the chamber. The wire was grounded through a 10-megohm resistor, and the outer wall was maintained at −600 volts. Purified argon was used to fill the chamber to a pressure of six atmospheres. The voltage pulse resulting from each ionization burst was amplified and its size transmitted via radio to a receiving station on the ground. The amplifier used in these experiments was designed with a rise time of 2 μsec. and a decay time of 12 μsec.

The apparatus was borne aloft by balloons to a minimum atmospheric depth of 20 g cm^{-2}, data regarding temperature and pressure being transmitted intermittently during each flight. Two flights were made with half of a cylindrical shell of lead 10 cm long and 2.5 cm thick placed over the chamber, and two more were made with the chamber unshielded. In the latter arrangement the observed bursts were attributed to nuclear disintegrations in the walls or in the gas of the chamber. Of these four flights, only one of each kind stayed at high altitude long enough to give data with good statistics. One additional flight at 306 g cm^{-2} was made in a B-29. In this flight, measurements with and without lead were taken.

Calibrating pulses were obtained throughout the experiments from α-particles emitted from a thin polonium source on the inside wall of the chamber.

The experimental results are shown in Table I. A reasonable extrapolation of the unshielded chamber data indicates that at 20 g cm^{-2} the burst rate under lead is approximately 1.5 times the burst rate without lead. Since the absorption in 2.5 cm lead of the star producing radiation is negligible,[1] the increase in burst rate caused by the lead represents the effect of electronic showers produced in the lead and possibly of stars produced in the part of the lead adjacent to the chamber.

TABLE I. Rates of occurrence of pulses larger than 1.1 times the α-particle pulse.

Pressure (g cm^{-2})	Burst rate (hour^{-1})	Period of observations (hour)	Conditions of experiment
20	313	1.2	Lead shield
306	53	1.9	over chamber
45	183	0.6	Unshielded
306	36	2.7	chamber

It can be estimated that any electron or photon of energy larger than 4.5 Bev, traveling on a trajectory which crosses the chamber more than 1 cm inside the boundary of the sensitive volume and which forms an angle of less than 60° with the vertical, produces in the lead a shower of sufficient magnitude to give a pulse larger than 1.1 times the α-particle pulse.[2] Thus this chamber, acting as a detector of electrons or photons of energies greater than 4.5 Bev, has at least a sensitive area of 19 cm^2 over π-steradians of solid angle. The increase of burst rate caused by the lead, if attributed entirely to electron or photon initiated showers, yields therefore an upper limit of 5×10^{-4} cm^{-2} sec.$^{-1}$ sterad^{-1} for the intensity of electrons or photons of energies larger than 4.5 Bev. This intensity cannot be much greater at the top of the atmosphere since 20 g cm^{-2} is less than one-half of one radiation length in air. On the other hand, the primary cosmic-ray intensity has been estimated to be 7×10^{-2} cm^{-2} sec.$^{-1}$ sterad^{-1}.[3] Consequently it is safe to conclude that the ratio of electrons or photons of energies greater than 4.5 Bev to the total number of primary cosmic rays is less than 1 percent. This also represents an upper limit for the total number of electrons in the primary radiation, since the latitude effect[4] shows that no singly charged particles with momentum larger than 4.5 Bev/c are present.

We wish to emphasize that it is not necessary to postulate the existence of any electrons or photons in the primary radiation since cascade showers have been observed to be produced in lead by penetrating particles believed to be high energy protons.[5]

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The Effect of Non-Central Forces on the Collisions of High Energy Neutrons with Protons

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As it is now possible to investigate experimentally[1] the collisions of high energy (~100 Mev) neutrons with protons, it is important to have detailed information about the effects to be expected on the assumption of different types of interaction between neutron and proton. Camac and Bethe[2] have already taken the first step in this direction by calculating the angular distributions of projected protons for various incident neutron energies, assuming central interactions of spherical well type. As, however, the quadrupole moment of the deuteron shows that a strong non-central component of the interaction exists, it is necessary to carry out such calculations with this component included. This is particularly important because for neutrons with energies of 50–100 Mev the scattering of the d component of the incident waves is quite strong. The non-central admixture is therefore likely to have a much greater influence than in phenomena involving neutrons of lower energy. In this note we wish to report the results of the first cases investigated in pursuance of this program.

Following Rarita and Schwinger[3] three forms of the neutron-proton interaction $V(r)$ were assumed:

TABLE I.

Type of interaction	Central forces ratio $I_{180°}/I_{90°}$	Non-central forces ratio $I_{180°}/I_{90°}$
I	159*	9.56
II	234	3.80
III	9.7**	0.58

* We have calculated the angular distribution for central forces only in the case of interactions II and III. For interaction I the value quoted is that given by Camac and Bethe (see reference 2).

** The value for $I_{180°}/I_{90°}$ obtained by us with central forces and interaction III is almost exactly one-tenth of that given in Table III of Camac and Bethe's paper. Our value appears to follow from the constants given in Table II of their paper, however.

$$I.\quad V(r)=\tfrac{1}{3}\tau_1\cdot\tau_2\left\{1+\tfrac{1}{2}g(\sigma_1\cdot\sigma_2-1)+\gamma\left(\frac{3\sigma_1\cdot r\sigma_2\cdot r}{r^2}-\sigma_1\cdot\sigma_2\right)\right\}D\cdots r<a$$
$$=0 \qquad\qquad \cdots r>a.$$

σ_1, σ_2 are the spin and τ_1, τ_2 the isotopic spin operators of the two nucleons, r their relative position vector. In the present calculation the constants a, g, γ, and D were taken the same as those used by Rarita and Schwinger, namely, $a=2.8\times10^{-13}$ cm, $g=0.0715$, $\gamma=0.775$, and $D=13.8$ Mev.

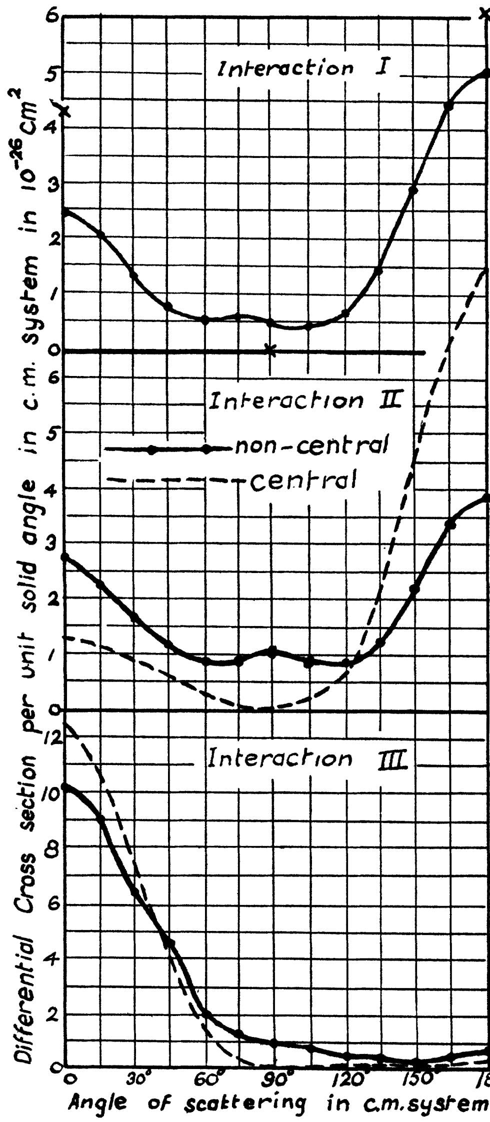

FIG. 1. Comparison of angular distribution of scattered neutrons in the c.m. system for non-central and central forces, and for the three interaction types. The total incident neutron energy assumed is 83 Mev. The circles shown on the curves represent actual calculated values.
In the case of central forces, interaction I, the crosses represent points calculated by Camac and Bethe.