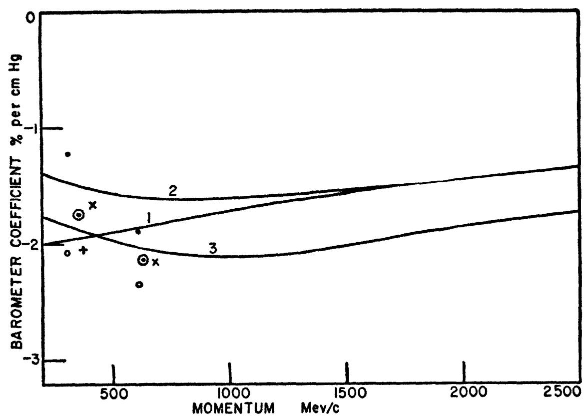

FIG. 1. The integral barometer effect. Curve 1: for the spectrum k/E^3. Curve 2: for the Wilson spectrum. Curve 3: for the Wilson spectrum altered at high energies. Observed points taken simultaneously are marked alike. ⊙ = mean values of the two groups of observed points.

Considering mesons moving downwards in the atmosphere it can be shown that the intensity at sea level N_G can be expressed by the equation

$$N_G=\frac{k}{E^\gamma}\exp\left[-\frac{\mu}{\tau}\int_{p_m}^{p_G}\frac{dp}{\rho\{P_G+\alpha(p_G-p)\}}\right], \quad (1)$$

where k/E^γ represents the spectral intensity at an effective level of production where the pressure is p_m. μ is the mass and τ the mean life of the meson at rest; p and ρ are the pressure (in grams per cm²) and the density in the atmosphere respectively, and P is the momentum. α is the momentum loss per gram per cm² and is considered constant over any range equivalent to the momentum loss in the atmosphere for values above minimum ionization. The subscript G refers to values at sea level and m to values at the meson production level.

By numerical integration of this equation for a standard atmosphere and again for an atmosphere differing in pressure only, "differential" barometer coefficients were calculated. For comparison with measured values "integral" coefficients were necessary. These were calculated by a further numerical integration.

Continuous recordings with counter telescopes have been taken for over a year at Ottawa and at Resolute (Canadian Arctic, geomagnetic latitude 83) and analyzed with respect to barometric variations. The measurements included herewith were taken from four series of over three months each. During three of the series two counter telescopes were operated together. One was shielded by sufficient absorber so that it would accept mesons above about 300 Mev/c; the second, above about 600 Mev/c.

The points marked in Fig. 1 show the measured barometer coefficients. The most significant feature of these results is that the barometer coefficient is lower in magnitude at lower momentum than at higher momentum. This was consistent in each series of measurements where two counter telescopes were used simultaneously.

The calculations based on Eq. (1) gave a number of unexpected results. If the production spectrum were flat, that is, if $\gamma=0$, the barometer coefficient would be very much smaller in magnitude than that observed, probably too small to measure. The integral barometer coefficient is very sensitive to the value of γ and not very sensitive to the values of the other quantities in the equation.

Curve 1 in Fig. 1 represents the calculated integral barometer coefficient based on a spectrum where $\gamma=3$ over a range of 1.8 to 40 Bev/c. Curve 2 is based on the Wilson spectrum[2] using a smooth curve through the Wilson points shown by Rossi[3] (Fig. 4). For this curve γ is close to 3 above 3 Bev/c but decreases rapidly to a value of about -1 at 1.8 Bev/c. Curve 3 corresponds to a spectrum identical to that of Wilson at the lower energies but for energies above 3 Bev/c $\gamma=3.5$. The production spectra for these three curves are shown in Fig. 2.

A simple power law spectrum such as curve 1 will not make the barometer effect curve upward at low momenta as is required by the experimental results. Though the accuracy is not great the results favor strongly a production spectrum of the type shown by curve 3. At low momenta this is derived from Wilson's measurements but above about 3 Bev/c the curve has a steeper slope than that corresponding to Wilson's spectrum. This greater slope at high momenta is in agreement with the corresponding part of the sea-level spectrum of Caro, Parry, and Rathgeber,[4] but curve 3 would not be as consistent with the lower momenta part of their spectrum.

The details of these calculations and measurements are being prepared for publication at an early date.

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[2] J. G. Wilson, Nature **158**, 414 (1946).
[3] B. Rossi, Rev. Mod. Phys. **20**, 537 (1948).
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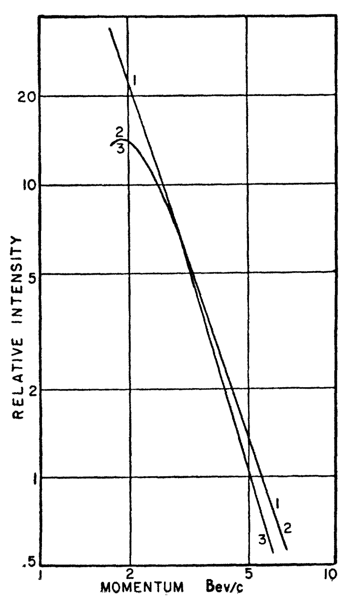

FIG. 2. The production spectrum of mesons. Curve 1: the spectrum k/E^3. Curve 2: computed from the Wilson spectrum at sea level. Curve 3: computed from the Wilson spectrum altered at high energies.

Gamma-Ray Resonances Produced by the Bombardment of Phosphorus with Protons*

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August 18, 1950

PHOSPHORUS has been bombarded with protons from the Ohio State University electrostatic generator and eleven narrow gamma-ray resonances have been observed for proton energies between 1000 and 1650 kev. Both thick and thin targets of zinc phosphide, evaporated on tantalum disks, have been studied. The excitation curve obtained from a target of approximately 10-kev thickness at 1.3 Mev is shown in Fig. 1. The peaks of the eleven resonances correspond to proton energies of 1.075, 1.105, 1.140, 1.168, 1.270, 1.427, 1.472, 1.500, 1.543, 1.592, and 1.615 Mev, respectively. The relative spacings of the levels are estimated to be accurate within 3 kev and the absolute values of the energies are believed to be not more than 10 kev in error. The energies of the protons were obtained by measuring the current through the coils of the analyzing magnet by use of a standard resistance and a Leeds and Northrup Type K potentiometer. Calibration of the magnet current was made in terms of the accurately known lithium and fluorine resonances.[1]

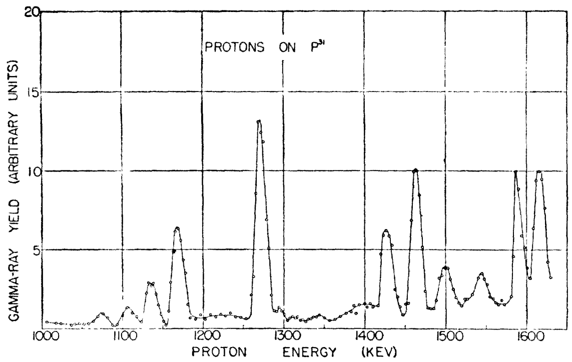

FIG. 1. Gamma-ray yield from a thin (87 micrograms/cm^2) zinc phosphide target.

Thick targets both of tantalum and of zinc have been bombarded to make sure that none of the observed peaks can be attributed to either of these elements. Tantalum gave a very small yield which increased slowly with proton energy. The yield from the thick zinc target was much greater than that from the tantalum, but there was no indication that any of the reported resonances could be attributed to zinc.

Absorption measurements of the radiation from the 1.270-Mev resonance have been made with lead, copper, and aluminum. The results are consistent with a gamma-ray of approximately 12-Mev energy. This suggests that the reaction under consideration is $P^{31}(p,\gamma)S^{32}$, since the gamma-rays from $P^{31}(p,\alpha\gamma)Si^{28}$ would be of much lower energy. The proton capture process is 10.7-Mev exothermic; consequently, a 12-Mev gamma-ray is indicated if the excited sulfur nucleus decays to the ground state by a single transition.

The natural half-width of the 1.270-Mev resonance is estimated to be 6.5 kev; this corresponds to a mean life of the excited state of the compound nucleus of approximately 10^{-19} sec. The cross section for this resonance is calculated to be about 6×10^{-28} cm^2.

Recently calcium phosphide targets have been prepared by vacuum evaporation. With these targets it is planned to repeat measurements in the region covered in Fig. 1 and to extend the energy range downward to overlap the regions previously studied by Curran and Strothers[2] and by Tangen.[3]

The authors are deeply indebted to Professor R. G. Herb of the University of Wisconsin for his generous help and especially for making available to us the results of his unpublished preliminary work on the phosphorus resonances.

* Assisted by the joint program of the ONR and AEC.
† AEC Predoctoral Fellow.

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New Evidence for the Existence of Positively Charged Particles Appearing near Beta-Ray Emitters*

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August 17, 1950

A SERIES of investigators[1–6] have reported in cloud chambers the appearance of tracks of positively charged particles emerging from beta-ray emitters, which by energy considerations should not decay by the emission of positrons. Two objections against the cloud-chamber evidence of these positive particles have been brought forward,[7–9] which seem, however, not to be valid.[1,2,5,6] The observed momentum loss in foils and the multiple scattering of the particles producing these tracks in cloud chambers have been shown to be consistent with a mass of about twice the electron mass.[3,6]

The fact remained, however, that the existence of these particles could not be ascertained with other means than the cloud chamber. Especially, experiments using beta-ray spectrometers have led to negative results.[10] A tentative explanation that the lack of a production layer—it is customary to mount the radioactive substance in spectrographs on a thin film—might be responsible for the non-appearance of these particles was disproved.[11]

Assuming as another alternative a finite lifetime which does not allow the particles to traverse a path length of a conventional spectrograph, we were led to experiments with a 180-degree (non-evacuated) spectrograph of only 4.4 cm path length. The spectrograph had slits of 2 mm width and was operated with a P^{32} source[12] deposited on aluminum and an Ilford G5 Nuclear Track plate as a detector.[13] The plate to be exposed was wrapped in a layer of paper and placed with one edge against the exit slit so that particles emerging from the spectrograph after being further deflected by the magnetic field outside the spectrograph would hit various parts of the plate at a glancing angle of approximately 17 degrees.

Plate 1 was exposed one minute with a magnetic field of a direction and strength to support the passage of electrons with a momentum corresponding to 1600 gauss-cm. Plate 2 was exposed for 13.5 hours with a field of the same strength but of opposite direction. Plate 3 was exposed for 13 hours under the same conditions as plate 2 with respect to the field, but with a $\frac{1}{16}$-in. thick aluminum plate obstructing the passage of particles through the spectrograph. The three plates were simultaneously developed using the temperature variation method[14] 17 days after their manufacture. They were scanned along three lines (a, b, and c) perpendicular to the direction of the particles at the position of the exit slit. These lines had a distance of 4.2, 8.5, and 11.9 mm respectively from the edge of the plate closest to the exit slit. The points where particles traversing the spectrograph were expected to hit the plates at the position of these lines are indicated by the letters A, B and C respectively.

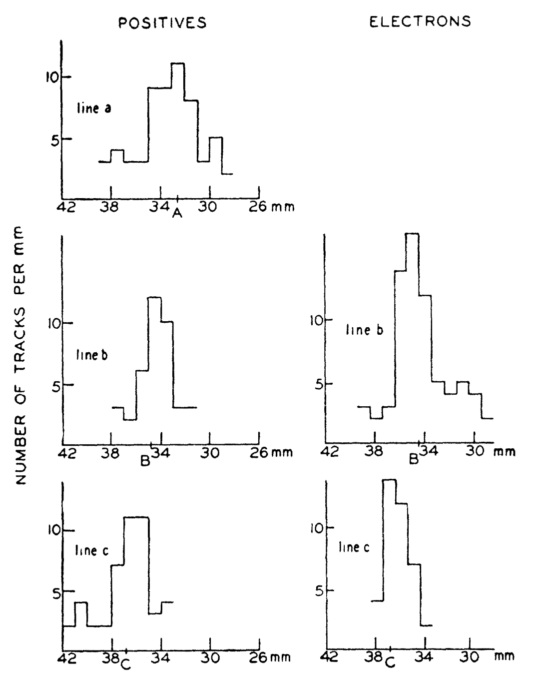

FIG. 1. Distribution of tracks due to electrons (right side) and positive particles (left side) in the photographic plates along three lines (a, b, and c). A, B, and C represent points on these lines where particles traversing the spectrograph are expected to enter the plate.