respectively, are higher than ours. This may be due, in addition to the foregoing reason (probably a minor one), to the fact that their experiments were performed at high altitudes where there are more primary particles of higher energies.

It is seen from Table I that the multiplicity distributions obtained under the same conditions for C and Pb are very similar to each other. This similarity may indicate that mesons are produced from nucleon-nucleon collisions according to the process of multiple production. The distribution for Be, C, or Pb is generally compatible with the theory[4] of multiple production for primary energies of a few Bev. If, on the other hand, successive interactions, each producing one meson,[5] occurred fairly frequently within the same nucleus of carbon, they would be very frequently within the Pb nucleus. Consequently, appreciably higher multiplicity of mesons would be expected from Pb than from C or Be. According to the mechanism of plural production, in order to have the same multiplicity for C, Be, and Pb, the mean free path, in the nuclear matter, of the primary particles must be so small that the primary particle could dissipate all of its energy within even the C or Be nucleus and certainly then within the Pb nucleus. However, this condition does not seem to be supported by other observations, such as successive events produced by a high energy particle from the first shower, which may be either the primary proton or a knock-on proton (see Fretter[2] and Green[3]). Moreover, the criterion of smaller mean free path as already defined would probably lead to the emission of more low energy charged particles from the same nucleus and hence to a larger angular spread. The angular distributions of shower particles for C and Pb as shown in Table III,[6] and for Be as given before, all show extremely strong preference for the forward direction of the primary particles.

We are thankful to Princeton University for the apparatus used in this work, which one of us (W.Y.C.) and his co-workers built at Princeton, and to our colleagues at Purdue for their interest and support in these experiments.

* Supported in part by Purdue Research Foundation and Mexican Research Commission C.I.C.I.C.

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[6] The shower axis is determined by the average angle with the vertical of the penetrating particles.

Gamma-Coincident Beta-Spectra of I^{131}

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(Received September 4, 1951)

In a study of I^{131} decay the beta-energy distributions coincident with particular gamma-rays were measured. This was done by mounting an essentially weightless iodine source on a Be disk in a thin magnetic lens spectrometer. The NaI—TlI crystal of a scintillation spectrometer was mounted immediately behind the beryllium disk. Coincidences between pulses in the proportional counter detector and pulses from the scintillation spectrometer corresponding to a definite gamma-ray energy were measured. A delay in the differential discriminator of the scintillation spectrometer was matched by a 1 μsec delay line between the proportional counter and the coincidence circuit. A resolving time of about 0.3 μsec was used in the coincidence circuit.

The pulse-height distribution from the scintillation counter is shown in Fig. 1C. It can be seen that pulses arising from the individual 720-kev, 635-kev, and 364-kev gamma-rays can be counted without including more than a few percent of pulses arising from a second gamma-ray. In the case of the 284-kev gamma-ray of the order of 10 percent of the pulses will be contributed by the 364-kev gamma-ray.

Only the 284-kev gamma-ray is definitely coincident with the *K*-conversion electrons of the 80-kev gamma-ray. The K-conversion peak of the 80-kev gamma-ray is shown in curve B of Fig. 1.

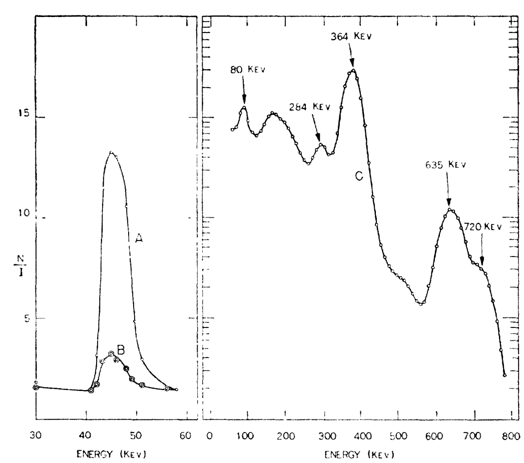

FIG. 1. Curve A. *K*-conversion electron peak of 80-kev gamma-ray coincident with the 284-kev gamma-ray; Curve B. *K*-conversion electron peak of 80-kev gamma-ray; Curve C. Scintillation spectrometer pulse-height distribution of I^{131} gamma-radiation.

Curve A of Fig. 1 shows the energy distribution of electrons coincident with the 284-kev gamma-ray. The two curves are normalized to have the underlying beta-distributions at the same level. Because of statistical fluctuations in the coincidence counting rates it cannot be stated that the 364-, 635-, or 720-kev gamma-rays are in no case coincident with conversion electrons of the 80-kev gamma-ray. The data do indicate that not more than 15 percent of the transitions of these gamma-rays are coincident with the 80-kev gamma-ray.

Kurie plots of the coincident electron energy distributions in Fig. 2 show that the 720-, 635-, and 364-kev gammas are in coincidence with beta-groups with maximum energies of 250, 335, and 606 kev, respectively. The 284-kev gamma-ray also is coincident with a 606-kev maximum energy beta-group. The excess of low energy electrons in the 606-kev beta-curve was shown to be the result of back scattering from the beryllium source mount. Energy distribution curves of several well-known beta-emitters mounted on beryllium indicate that the energy at which scattering becomes important is a function of the maximum energy of the beta-emitter. In the case of the 250-kev and 335-kev beta-groups this scattering becomes important only at energies lower than those plotted in Fig. 2.

These data support the decay scheme for I^{131} shown in Fig. 2. This scheme shows beta-transitions to both a 635-kev and a 720-kev level in Xe^{131} as postulated by Emery.[1] The scintillation spec-

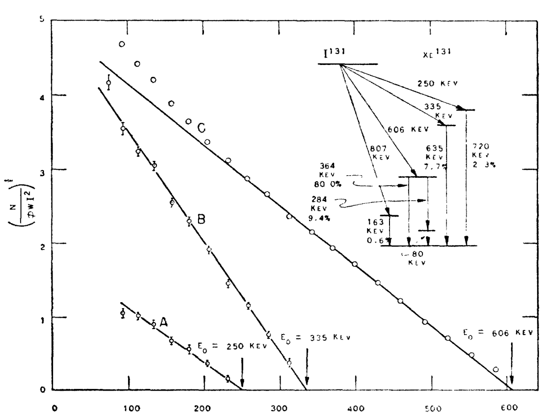

FIG. 2. Kurie plot of I^{131} beta-energy distribution. Curve A. Coincident with 720-kev gamma-rays; Curve B. Coincident with 635-kev gamma-rays; Curve C. Coincident with either 364-kev or 284-kev gamma-rays.

trometer was calibrated with known gamma-emitters to obtain the intensities shown in the decay scheme.

It is a pleasure to acknowledge the help of C. J. Borkowski and E. Fairstein in this work.

* This work was performed for the AEC.

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Au^{198} Decay

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(Received September 4, 1951)

A 1.09-MEV level in Hg^{198} has recently been reported[1-3] with gamma-transitions in Au^{198} decay between the 1.09-Mev and the 0.411-Mev levels and between the 1.09-Mev level and the ground state. These transitions have been confirmed using Oak Ridge National Laboratory reactor bombarded gold which was purified after bombardment by the method given by Noyes and Bray.[4] The NaI−TlI scintillation spectrometer pulse distribution in Fig. 1A shows the presence of the recently reported 1.09-Mev and 0.680-Mev gamma-rays in addition to the well-known 0.411-Mev gamma-ray. The shoulder on the curve corresponding to a gamma-ray energy of 0.820 Mev was shown to be the result of random coincidences between two 0.411-Mev gamma-rays.

Further evidence that the 0.680-Mev gamma-transition is part of the Au^{198} decay scheme was obtained by measuring the electron energy distribution coincident with it. This was done by mounting an essentially weightless source in a thin magnetic lens spectrometer on a beryllium disk thick enough to absorb the 0.97-Mev beta-group. A 13 g/cm² platinum absorber was placed between the beryllium disk and a NaI−TlI counter to reduce the counting rate of the 0.411-Mev gamma-ray relative to that of the 0.680-Mev gamma-ray by a factor of 25. With this reduction in intensity the random coincidences of the 0.411-Mev gamma-ray were essentially eliminated.

Coincidences were recorded between pulses from the detector on the thin lens spectrometer and the pulses produced by the 0.680-Mev gamma-ray in the NaI−TlI scintillation spectrometer. The energy distribution of the coincident electron pulses is shown as an N/I *vs* *E* plot in Fig. 1B. These data show that the 0.680-Mev gamma-ray is coincident with both a low energy beta-group and the *K*-conversion electron peak of the 0.411-Mev gamma-ray. The Kurie plot of the beta-energy distribution shown in Fig. 2 indicates a maximum energy of 290±15 kev for the coincident beta-group. These results are consistent with the coincidence absorption measurements of Cavanagh[2] and the decay scheme shown in Fig. 2. No attempt was made to confirm the low intensity beta-transition to the ground state reported by Elliott and Wolfson.[3]

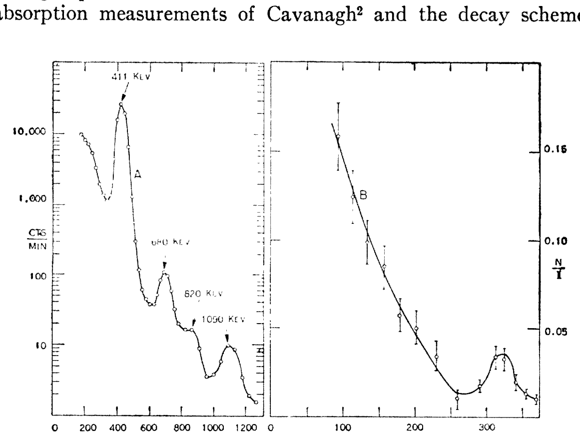

FIG. 1. Curve A: Scintillation spectrometer pulse-height distribution of Au^{198} gamma-radiation; curve B: electron energy distribution coincident with 680-kev gamma-radiation.

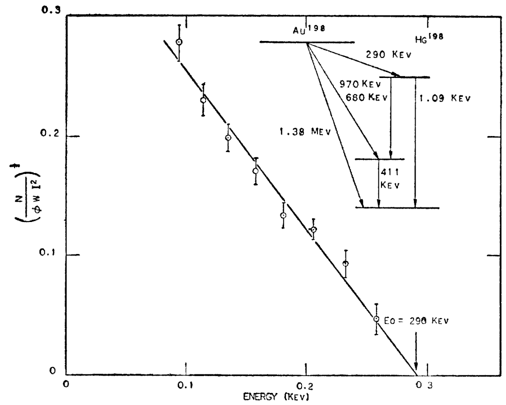

FIG. 2. Kurie plot of Au^{198} beta-energy distribution coincident with 680-kev gamma-radiation.

Approximate measurements indicate that about 1 percent of the disintegrations are through the 0.680-Mev gamma-ray and about 0.2 percent are through the 1.09-Mev gamma-ray.

It is a pleasure to acknowledge the help of C. J. Borkowski and R. A. Dandl in this work.

* This work was performed for the AEC.

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Computation of Photonuclear Resonance Curves from Relative Activity Curves Monitored by Induced Radioactivity

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IN preference to the "total spectrum method," Katz and Cameron[1] have recently presented their "photon difference method" for obtaining photonuclear cross sections from observed bremsstrahlung activation curves. It is the purpose of the present note to point out that it is possible to obtain results of equal or better accuracy in the energy region of 20 to 100 Mev by monitoring with induced radioactivity. This latter method is relatively simple and may be extended to energies as low as 10–12 Mev if suitable monitor activities, characterized by low energy resonances, are used. To obtain good accuracy the activation curves must, of course, be measured carefully and it is preferable to employ two or three different radioactive monitors simultaneously.

The radioactivity induced in a monitor sample is proportional to the integral, over the resonance, of $\sigma_M \times N_{h\nu}$ (cross section times number of quanta). The character of the resonance curves for various suitable monitors is known with some accuracy and the relative number of bremsstrahlung quanta has been given by a number of authors.[2-4] The use of a monitor radioactivity in effect serves to normalize the bremsstrahlung spectra in terms of the area under the $\sigma_M \times N_{h\nu}$ curves. Schiff curves corresponding to $E_{max} > 20$ Mev and normalized in this way on the basis of the reported resonance curves[5] for Ta are shown in Fig. 1, which turned out to be substantially equivalent to normalization at 13.5 Mev.

When an activation curve is determined with the use of a radioactivity monitor, the change of relative activity ΔI attendant upon