to about 200 kev. Even below 200 kev, the deviation from the straight line is very small. The upper energy limit determined from the forbidden Fermi plot is 1.55±0.01 Mev and is in good agreement with the result of Langer and Price.[3]

This investigation demonstrated the distinct difference between Cl^{36} and Y^{91} spectra. It is also interesting to observe that two completely different types of spectrometers and one spectrometer using two different resolutions can reproduce a forbidden spectrum such as that of Y^{91} in complete detail.[3]

The theoretical interpretation of the forbidden spectrum of Y^{91} is based on Feenberg and Hammack's analysis[4] of the shell structure in nuclei and was presented in detail in the Letter to the Editor by Langer and Price.[3] However, in view of the findings in the case of Cl^{36}, it would be highly desirable to have the spin of Y^{91} actually determined experimentally.

We wish to thank Dr. W. W. Havens, Jr., Dr. L. J. Rainwater, and Professor J. R. Dunning for the kind interest and valuable help rendered to us throughout this work. To Dr. C. Longmire, his enlightening discussions are deeply appreciated.

1 C. S. Wu and L. Feldman, Phys. Rev. **76**, 693 (1949).
2 E. J. Konopinski and G. E. Uhlenbeck, Phys. Rev. **60**, 308 (1941).
3 L. M. Langer and H. C. Price, Jr., Phys. Rev. **75**, 1109 (1949).
4 E. Feenberg and K. C. Hammack, Phys. Rev. **75**, 1877 (1949).

Interpretation of Beta-Spectra from Thick Sources*

L. FELDMAN AND C. S. WU
Pupin Physics Laboratories, Columbia University, New York, New York
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It has been demonstrated[1] in the past that the beta-spectrum of an allowed transition as obtained from a thick source shows definite deviation from the expected straight line on the Fermi plot. The effect of the source thickness is to shift the energy of some of the electrons to lower values and to give an increased (energy dependent) back scattering effect. Therefore, a thick source invariably distorts an allowed straight Fermi plot to a convex curve toward the energy axis; its exact curvature depending on the upper energy limit, shape of the spectrum and the thickness of the source.

By this reasoning, one would therefore conclude that when a spectrum obtained from a thick source shows an allowed distribution, it is most likely that the Fermi plot of the true distribution is actually a concave curve towards the energy axis, at least in the high energy region.

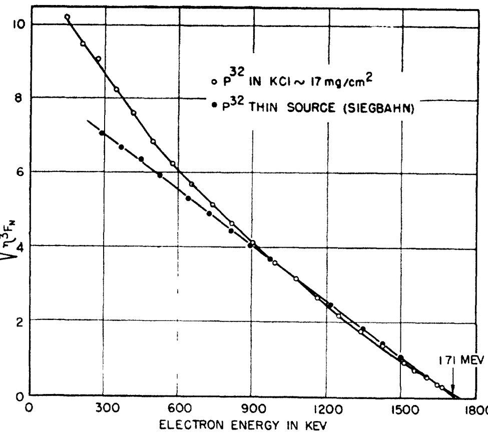

FIG. 2. Kurie plots of P^{32} from thin and thick sources. The thick source is in KCl of 17 mg/cm².

We have investigated the spectrum of three beta-emitters having radically different spectrum shapes, under exactly the same experimental conditions except for the thickness of the source. The same diluting material (KCl) was used in all cases to increase the thickness of the source.

In our investigation, the beta-spectra of Y^{91}, P^{32} and RaE were used. The upper energy limit of these three spectra are 1.55, 1.71 and 1.17 Mev respectively. Small amounts (less than 100 μg/cm²) of each of these radioactive substances are mixed thoroughly with inactive KCl to make sources of thickness around 15–20 mg/cm². While the thin source of Y^{91} gives a spectrum[2] according to the $(p^2+q^2)^{\frac{1}{2}}$ correction factors, a source of ~20 mg/cm² exhibits straight Fermi plot to 600 kev (Fig. 1). The P^{32} is known to show straight Fermi plot,[3] but a thick source of 17 mg/cm² distorted the spectrum to a convex curve (Fig. 2). The spectrum obtained from a thick source of RaE~22 mg/cm² also shows much greater curvature than that[4] of the thin sources (Fig. 3).

It is interesting to observe that the effect of the source thickness has definitely demonstrated the tendency to increase the second derivative of the conventional Fermi plot and therefore strongly supports the reasoning outlined above.

In view of this conclusion, it is interesting to reexamine the results recently reported by Alburger[5] on the beta-ray spectrum of K^{40}. The average thickness of the source used is around 18.5 mg/cm². The Fermi plot is straight from the upper energy limit 1.40 Mev to 450 kev. In view of the findings presented above, it seems reasonable to conclude that the true distribution of the

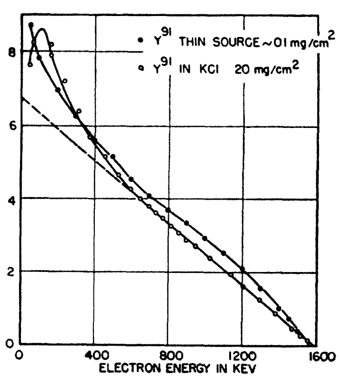

FIG. 1. Kurie plots of Y^{91} from thin and thick sources. The thin source is less than 0.1 mg/cm². The thick source is in KCl of 20 mg/cm².

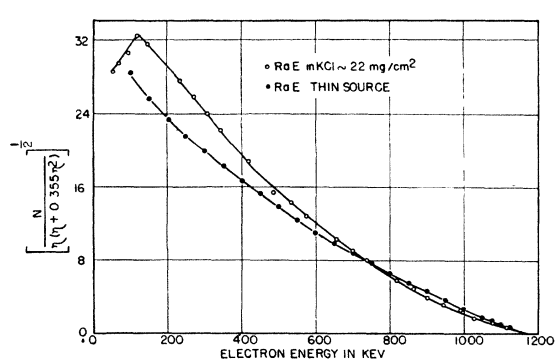

FIG. 3. Kurie plots of RaE from thin and thick sources. The thin source is in <0.1 mg/cm². The thick source is KCl of 22 mg/cm².

K^{40} beta-radiation is most likely not allowed but actually exhibits a concave curve which has been distorted to nearly a straight line due to the source thickness. In order to investigate its true distribution without distortion, a highly enriched K^{40} source ($\sim$50 percent) is desirable.

In all these investigations, the thick sources were prepared by precipitating the KCl inactive salts from alcohol on a plastic film of 2 mg/cm^2. The source area is circular in form with a radius of 1 cm. The resolution under this operating condition is calibrated by using internal conversion lines and is around 8–9 percent defined as the full width at the half-value of the maximum intensity. The thin sources were investigated with a resolution of 4 percent of the same spectrometer.

We wish to express our appreciation to Dr. W. W. Havens, Jr., Dr. L. J. Rainwater and Professor J. R. Dunning for their help and advice throughout this investigation.

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[1] A. W. Tyler, Phys. Rev. **56**, 125 (1939); J. C. Lawson, Phys. Rev. **56**, 131 (1939).
[2] L. Langer and H. Price, Jr., Phys. Rev. **75**, 1109 (1949); C. S. Wu and L. Feldman, Phys. Rev. **76**, 696 (1949).
[3] K. Sieghahn, Phys. Rev. **70**, 127 (1946).
[4] L. Langer, Phys. Rev. **75**, 328 (1949); R. Morrissey and C. S. Wu, Phys. Rev. **75**, 1288 (1949).
[5] D. E. Alburger, Phys. Rev. **75**, 1442 (1949).

The Beta-Spectrum of Be^{10}*

C. S. Wu and L. Feldman
Pupin Physics Laboratories, Columbia University, New York, New York

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Recent determination[1] of the spin of the ground state of B^{10} of three units has aroused great interest concerning the energy distribution of the beta-ray spectrum from Be^{10}. According to Marshak's theoretical investigation,[2] the beta-spectrum of Be^{10} should be fitted by an unique D_2 spectrum (using Marshak's notation) which is very different from an allowed spectrum. On the other hand, Hughes[3] and his co-workers investigated the beta-spectrum of Be^{10} by absorption methods and found its distribution in disagreement with the D_2 shape but in agreement with the allowed spectrum within experimental error. If the allowed distribution interpreted from the absorption method is real, then the present theories of beta-decay will have to undergo serious revision.

Because of the extremely long life and small activation cross section, the specific activity of Be^{10} by the ordinary method of preparation is rather poor. When a thick beta-source is used in investigating its spectrum, the true distribution is inevitably distorted due to the effects of slowing down, absorption and back scattering of the electrons in the source itself. Nevertheless, the distortion of the Kurie plot due to source thickness follows a definite trend. This trend can be reasonably explained and interpreted as presented in the preceding letter[4] in the case of Y^{91}, P^{32} and RaE.

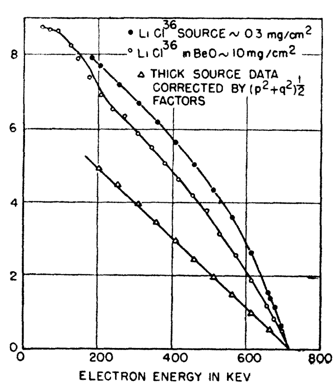

Fig. 1. Kurie plots of beta-spectra of Cl^{36} in thin and thick sources.

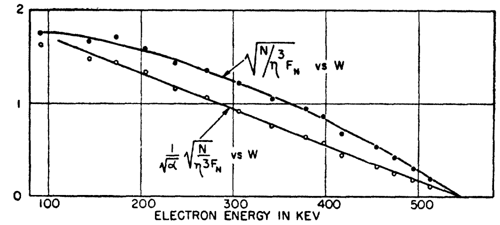

Fig. 2. The upper concave curve represents the conventional Fermi plot of Be^{10} beta-spectrum from a thick source of BeO of 12 mg/cm^2. The lower linear curve represents the forbidden Fermi plot after being corrected by the α-factor $[\alpha^{\frac{1}{2}}\sim(p^2+q^2)^{\frac{1}{2}}]$.

The beta-spectrum of Be^{10} has an upper energy limit of around 550 kev, a comparative study of the spectra of Cl^{36} (713 kev), Be^{10} (550 kev) and Cu^{64} (e^- 571 kev; e^+ 657 kev) in thick BeO sources should shed some lights on the true distribution of the beta-spectrum from Be^{10}.

The active $Be^{10}O$ source used in this investigation was kindly loaned to us through the courtesy of Professor Stephens of the University of Pennsylvania. No more chemistry was done on the BeO after it was received. The specific activity of Be^{10} used in this investigation in only $3\times10^{-4}\,\mu$c/mg of BeO. A rather thick source of around 10 mg/cm^2 of an area of 3 cm^2 has to be used. For comparison, both the Cl^{36} and Cu^{64} are thoroughly mixed with inactive BeO to form beta-sources of around 10 mg/cm^2 of an area of 3 cm^2. The resolution under this operating condition is 8–9 percent.

Figure 1 shows the Kurie plots of Cl^{36} from thin and thick sources. The spectrum of Cl^{36} from thin source has been shown[5] to follow the unique D_2 spectrum closely, but the curvature of the Kurie plot from a thick source shows much less concave toward the energy axis as compared with that from a thin source. In fact, the Kurie plot is well matched by an α-spectrum[6] $[\alpha\sim(p^2+q^2)^{\frac{1}{2}}]$. Although the exact fitting of the α-correction factors is rather a chance coincidence, it does strongly demonstrate the general trend that a thick source invariably distorts a D_2 spectrum to a less concave curve such as an α-spectrum.

Figure 2 shows the Kurie plot of the beta-spectrum of Be^{10} from a BeO source of around 12 mg/cm^2. The upper energy limit of the spectrum is 550 ± 10 kev. The Kurie plot is definitely concave toward the energy axis and is well fitted by an α-spectrum. By comparing the data on Be^{10} with the Kurie plot of Cl^{36} from a thick source, one is inclined to conclude that the true distribution of the Be^{10} beta-spectrum is more concave than an α-spectrum and may well be a D_2 spectrum as predicted theoretically.

We also investigated the Cu^{64} electron and positron spectra from a thick BeO source. In this case, the straight allowed shapes are both distorted to convex curves due to the finite source thickness. Therefore, it seems to us that the spectrum of Be^{10} can not be interpreted as an allowed spectrum.

Although this type of comparative studies does not give the detailed distribution of a spectrum, it does help to guide the interpretation of a spectrum obtained from a thick source. At least, it serves to limit the shape of the spectrum to only a few possible known shapes. It is needless to say that a highly enriched Be^{10} source would be most desirable for further investigation in this case.