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SATURATION BACKSCATTERING CORRECTION FOR WINDOWLESS PROPORTIONAL COUNTER WITH 2π GEOMETRY

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January 7, 1953

Berkeley, California

SATURATION BACKSCATTERING CORRECTION FOR WINDOWLESS PROPORTIONAL COUNTER WITH 2π GEOMETRY

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ABSTRACT

The saturation backscattering correction factor for pure beta-emitters for 2π counting geometry was determined using a methane-filled proportional counter with samples introduced internally. Samples of Sr^{90} (with Y^{90} in equilibrium) and of Pm^{147} were used. Backing plates of lead, brass, aluminum, polystyrene, and beryllium were used. Noteworthy is the fact that the backscattering factor is considerably lower for 2π geometry than for 3 percent of 4π geometry, particularly for backing materials of large atomic number.

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*This work was performed under the auspices of the AEC.

†Now at the Institute for Nuclear Studies, University of Chicago, Chicago, Illinois.

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In order to use the Mark 12 Nucleometer Chamber[1] (windowless proportional counter) for absolute beta counting, the saturation backscattering correction is needed. This was studied using methane at atmospheric pressures as the counting gas. The backing materials used were lead, brass, aluminum, beryllium, and polystyrene. A hard and a soft beta emitter (with no gamma radiation) were used: (1) a mixture of Sr^{90}-Y^{90} in equilibrium (E_{max} = 0.61 and 2.2 Mev, respectively) and (2) Pm^{147} (E_{max} = 0.223 Mev). The samples were mounted on thin tygon films made conducting with thin films of silver and counted in 4π proportional counter of the type developed by Borkowski[2] to determine the absolute disintegration rate and then in the 2π counter to obtain the backscattering correction.

The method of calculating the backscattering coefficient is as follows: let y equal the counting rate in the 2π counter, x equal

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[1]Radiation Counter Laboratories, Skokie, Illinois.

[2]"Report of Conference on Absolute Beta Counting," National Research Council (February 28, 1949).

that in the 4π counter, and z equal that on the sample side of the film (i.e., counts recorded in only one-half of 4π counter chamber) in the 4π counter for a particular sample.

The calculation of the backscattering coefficient B, the fraction of beta particles starting into the backing material which are scattered out into the counting volume, is straightforward, if scattering and absorption by the tygon and silver films for sample mounting are negligible. That is,

$$B = (y - \frac{x}{2}) / \frac{x}{2}$$

The assumption of negligible scattering and absorption by the mounting was verified in the case of the hard beta sample (Sr^{90}-Y^{90}) by a second method; namely, the backscattering correction was determined for Sr^{90}-Y^{90} also by depositing (directly on polystyrene, covered with conducting layer of carbon and on lead and aluminum) 50 microliter aliquots from a solution whose specific activity was determined in the 4π counter. The thickness of each of these samples was about 0.25 mg/cm^2, whereas that of the corresponding film sample was about 0.5 mg/cm^2. The corrections as determined by the methods of the tygon film and by depositing directly on the backing are essentially the same (Fig. 1).

In the case of the soft Pm^{147} radiation, the scattering and absorption by the mounting film is not negligible, as evidenced by the fact that the counting rate of the sample film with activity up was higher than when the film was activity side down.

An attempt was made to correct the data for the effect of the mounting film in order to calculate a backscattering factor to compare

with Sr^{90}-Y^{90} results. That is, for the Pm^{147} results, it was assumed that

$$B = (y-z)/(x-z).$$

The Pm^{147} results should be checked as were the others by mounting the sample directly on the backing.

The backscattering factors determined in this investigation are plotted against the atomic number of the backscattering material in Fig. 1. Also plotted for comparison are the data of Zumwalt[3] for the saturation backscattering of Co^{60} (E_{max} = 0.31 Mev) at 2π geometry. There is a considerable discrepancy between his and our results for the lighter elements. These differences might be due to such causes as differences in the threshold electron energy necessary to produce a count.

Noteworthy is the fact that for large Z, the 2π geometry backscattering factor is noticeably lower than for a 3 percent 4π geometry, thus indicating the anisotropy of backscattered radiation with preferential scattering in a direction perpendicular to the backing plate. This anisotropy has been pointed out previously by Yaffe.[4] It is to be expected that the self-scattering, self-absorption correction also will be different for 2π than for lower geometries.

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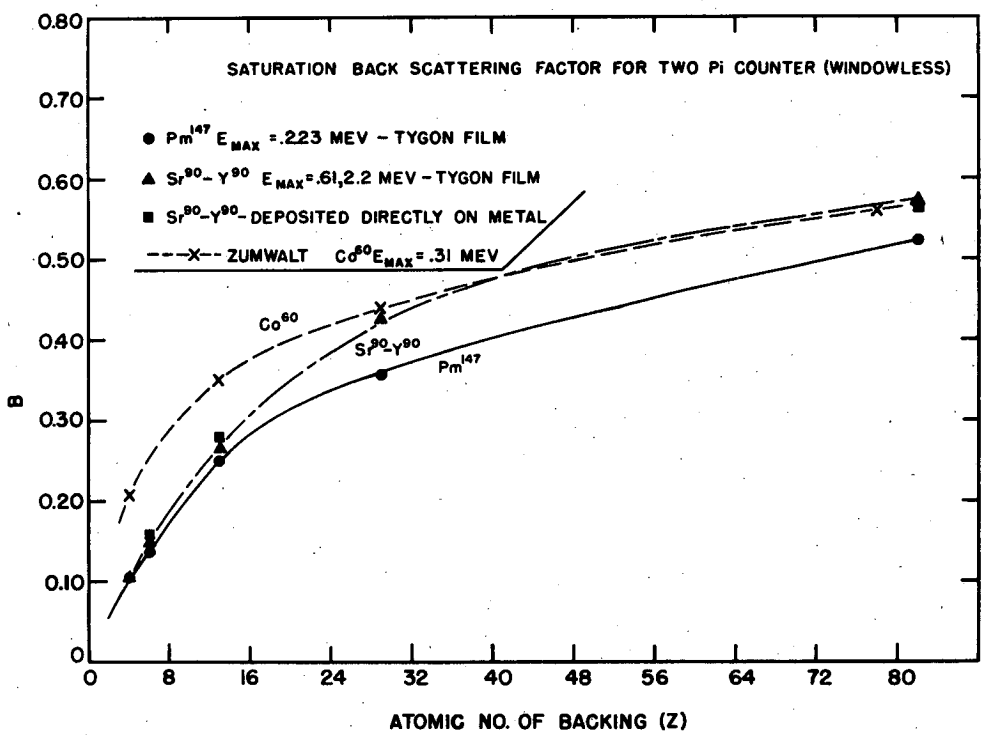
[3]"Report of Conference on Absolute Beta Counting," National Research Council (February 28, 1949), page 23.

[4]Ibid., page 27.


SATURATION BACK SCATTERING FACTOR FOR TWO Pi COUNTER (WINDOWLESS)
● Pm^{147} E_{MAX} =.223 MEV - TYGON FILM
▲ Sr^{90}-Y^{90} E_{MAX}=.61,2.2 MEV - TYGON FILM
■ Sr^{90}-Y^{90}- DEPOSITED DIRECTLY ON METAL
---X-- ZUMWALT Co^{60} E_{MAX} = .31 MEV
Co^{60}
Sr^{90}-Y^{90}
Pm^{147}
B
0.80
0.70
0.60
0.50
0.40
0.30
0.20
0.10
0
0
8
16
24
32
40
48
56
64
72
80
ATOMIC NO. OF BACKING (Z)

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