Pure ^{90}Sr External Bremsstrahlung Spectra

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Abstract:

Beta particles emitted from a ^{90}Sr/^{90}Y source have two different end point energies; 546 keV for ^{90}Sr and 2274 keV for ^{90}Y. The external bremsstrahlung (EB) photons produced by the complete absorption of ^{90}Sr/^{90}Y betas stopped in thick targets will therefore be convoluted with both ^{90}Sr and ^{90}Y sources at the energy range less than 546 keV. In this investigation spectral distribution of pure ^{90}Sr EB was deduced for the first time from the matching between the measured spectrum of EB by ^{90}Sr/^{90}Y and the spectral distribution of ^{90}Y of the exact numerical screened calculations of Pratt et al. for energy range above 550 keV. The fraction of EB production probability in ^{90}Sr in that of ^{90}Sr/^{90}Y was determined as a function of EB photon energy. The results are quite necessary for accurate measurements of EB intensity and thereby the gamma dose produced by ^{90}Sr EB photons in different targets.

Introduction:

Accurate data for the radiative energy loss of beta particles ,in different media are required in many fields, particularly in the investigation of radiation damage of materials and tissues, dosimetry, radiology,health physics and other fields related to the environmental applications.The importance of the contribution of bremsstrahlung to gamma-ray energy deposition in bulk media have previously been reported [1].The phenomenon of external bre-msstrahlung (EB) has extensively been studied (e.g.,[2,3,4]). In particular, the EB photon spectra generated by beta particles of ^{90}Sr/^{90}Y and ^{90}Y in different targets thick enough to absorb all the beta particles have been experimentally measured by a number of workers [5,6,7,8,9, 10,11,12]. However there are no reliable measurements for EB spectra of pure ^{90}Sr, where the beta particles emitted from ^{90}Sr/^{90}Y source have two different end point energies; 546 keV for ^{90}Sr and 2274 keV for ^{90}Y. Therefore the EB photons produced by ^{90}Sr/^{90}Y betas are naturally convoluted with both ^{90}Sr and ^{90}Y source, at the energy range lower than 546 keV. In this investigation, spectral distribution of pure ^{90}Sr EB photons are extracted for the first time using the measured spectrum of EB by ^{90}Sr/^{90}Y and the spectral distribution of ^{90}Y of the exact numerical screened calculations of Pratt et al. for the energy range above 550 keV.

Experimental Details:

The geometrical setup used in the present measurements is shown in Fig.(1). The detector was 5.08x5.08 cm NaI(Tl) crystal coupled with a photomultiplier. This detector was surrounded by cylindrical lead blocks, and thus, adequately shielded from external background. The inner surface of the cylinder was lined with aluminum to minimize the production of x-ray and bremsstrahlung from the shielding material. The detector was coupled to a set of high sensitive electronic equipments with a 1024 multichannel analyzer to measure the EB spectra.

The beta source employed in this work was $^{90}Sr/^{90}Y$ supplied from AMERSHAM as a point source of about 190 MBq.

Targets of copper and lead with sufficient thickness were prepared with thickness enough to stop all beta particles emitted by the source. Energy calibration was performed with a set of standard gamma ray sources with energies covering the studied range of energy.

A very low Z beta stopper (Perspex sheet) was placed between the source and the detector with thickness sufficient to stop all beta particles of $^{90}Sr/^{90}Y$. The target was first placed above the Perspex, in which the accumulated counts represent the EB spectrum produced in the target plus the internal bremsstrahlung (IB) originated from the beta source plus the background radiation. The target was then placed below the beta stopper. The counts accumulated, for the same time as of the first step, represent the spectrum of IB plus the background radiation. The difference between these two spectra gives the raw spectrum of EB generated in the target.

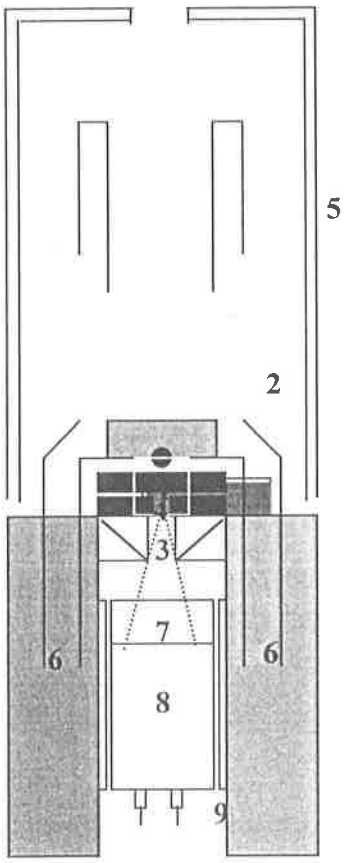


Fig.(1): Experimental Set-up
1- Beta source
2- Stainless steel cylinder
3- Target
4- Perspex sheet
5- Lead stand
6- Lead shielding
7- 2"x2" NaI(TI)crystal
8- Photomultiplier tube
9- Aluminum sheet

The true EB spectra produced by $^{90}Sr/^{90}Y$ were obtained by correcting the raw spectrum for photons absorption, iodine k x-ray escape peak, detection efficiency, Compton electron distribution, backscattering photons, characteristic x-ray and for the production of EB in Perspex, using the method described elsewhere [10,11]

The EB spectra of ^{90}Y of the exact numerical screened calculations of Pratt et al. in the energy range beyond 550 keV [12,13] used to deduce the EB spectra of pure ^{90}Sr. This was achieved by a suitable matching between the measured EB by $^{90}Sr/^{90}Y$ in the energy range above 550 keV and ^{90}Y of Pratt et al.

Results and Discussion:

The experimentally measured EB spectra from $^{90}Sr/^{90}Y$ in Cu and Pb targets after being corrected for various factors are obtained as the number of photons per keV energy interval per beta disintegration.These spectra are plotted in Figs.(2) and (3) with the spectral distribution of EB by ^{90}Y of Pratt et al. in addition to the deduced spectral distribution of pure ^{90}Sr EB . From these figures, one can notice that the measured spectrum of EB by $^{90}Sr/^{90}Y$ betas is exactly coincident with the spectrum of EB by ^{90}Y at energies above 500 keV , while it deviates at energies less than 540 keV where the EB photons produced by the complete absorption of $^{90}Sr/^{90}Y$ betas stopped in the targets is convoluted with both ^{90}Sr and ^{90}Y emitters. Above 540 keV the spectrum is referred to ^{90}Y only , where the spectral distribution of pure ^{90}Sr EB photons vanishes.

Figs. (4) and (5) illustrate the fraction of EB photons production by ^{90}Sr from that by $^{90}Sr/^{90}Y$ as a function of photon energy. This ratio is decreased with increasing energy. The fraction of EB production probability for Pb target is higher than for Cu target, where it reaches (90%,48%,10%) for Pb and (56%,28%,8%) for Cu at energies (100,200,400) keV respectively.

The present results are quite necessary for accurate measurements of EB intensity and thereby gamma doses related to ^{90}Sr EB.

References:

[1]Subbaiah, K. V., Natarajan, A., Gopiuath, D. V. and Trubey, D. K.; (1982) Contribution of bremsstrahlung to the gamma-ray energy deposition in bulk media, Nucl. Sci, Eng. 81, 172 .

[2]Power, M. S., Ahmad S. and Singh, M.; (1980). External bremsstrahlung spectra excited by ^{204}Tl beta particels in thick targets , Phys. ReV, 21, 1884-1889.

[3]Gopala, K., Rudraswamy, B., Ven-kataramaiah , P., and Sanjeeviah, H.; (1987). Bremsstrahlung yields of ^{147}Pm and ^{170}Tm in thick targets, J. Phys. G: Nucl. Phys. 13, 509-513.

[4]Dhaliwal, A. S., Powar, M. S. and Singh, M.; (1990). Attenuation of external bremsstrahlung in metallic absorber. Nucl. Sci. Eng. 106, 452-456.

[5]Shivaramu; (1984). External bremsstrahlung spectra generated by the complete absorption of beta particles from $^{90}_{38}Sr \rightarrow ^{90}_{39}Y + e^-$ in thick targets of Cu,Cd,Te and Pb, Phys. Rev. A, 30, 3066-3071.

[6]Shivaramu; (1987). Photon and energy yields of bremsstrahlung produced by beta particles from ^{90}Sr,^{90}Y,and ^{204}Tl in thick targets of Cu, Cd, Ta and Pb, Phys. Rev.A,36, 3457-3460.

[7]Rudraswamy, B., Gopala, K., GunduRao, K. S., Venkatara-maiah, P. and Sanjeeviah,H.; (1983).Z dependence of thick-target external bremsstrahlung produced by beta particles of ^{90}Sr-^{90}Y, Phys. Rev. 28 , 2802-2805.

[8]Shivaramu; (1984). External bre-msstrahlung generated by the

complete absorptio of beta particles i thick targets, I dia J. Phys. 58, A, 265-275.

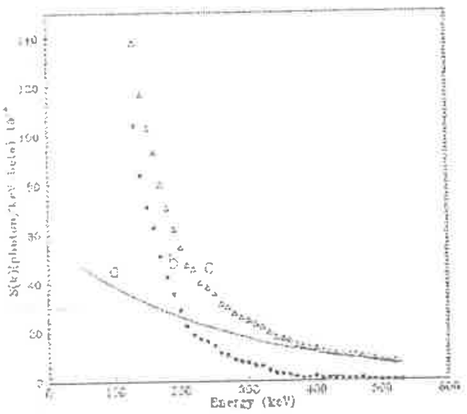
[9]Che , W. L., Yeha d, C. H. a d Chou , D. P.; (1992). Bremsstrahlu g spectra a a lysis for the i tera ctio of ^{90}Sr-^{90}Y beta with lead, Nucl. Sci, J. 29, 407-413.

[10]Elias, M. M., Rasheed, F. F., a d Lateef, A. A.; (2000). Z depe de c e of exter a l bre-msstrahlu g photo a d e erg y yields of ^{90}Sr/^{90}Y beta particles i thick targets, J. Milt. E g. Coll. 23, 266-270.

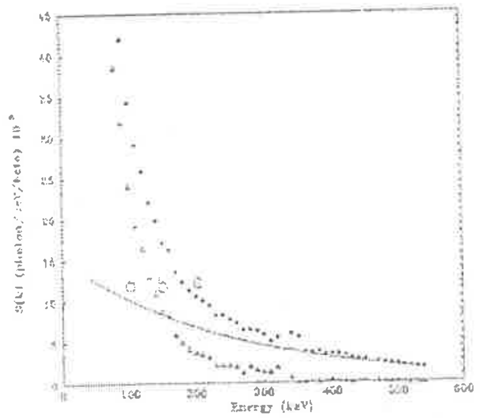
[11]Al-Rawi, N. B.; (2000). I v estigatio of low e ergy regio of exter a l bremsstrahlu g spectra, M. Sc. Thesis, U iv ersity of Baghdad

[12]Shivaramu; (1986). Spectral shapes for atomic-field bre-msstrahlu g produced by beta particles of Y-90 i thick targets of Cu, Cd, Ta, a d Pb, J. Phys. B. 19, 1935-1944.

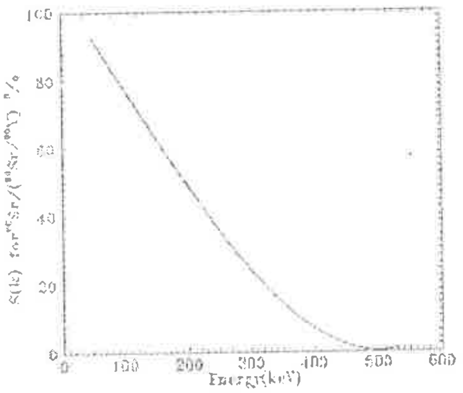
[13]Pratt, R. H., Tse g, H. K. Lee, C. M. , Kissel, L., MacCallum, C., a d Riley, M.; (1977).Exact ume rical scree e d calculatio of bre-msstrahlu g photo s of e erg ies from 1 keV to 2 MeV, At. Data Nucl. Data Tables 20, 175.



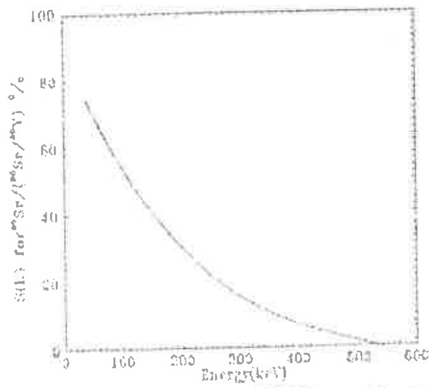
Fig(2): EB Distributio for Pb target a): ^{90}Y (Pratt et al.), b) ^{90}Sr (deduced), c): ^{90}Sr/^{90}Y (measured).



Fig(3): EB Distributio for Cu target a): ^{90}Y (Pratt et al.), b) ^{90}Sr (deduced), c): ^{90}Sr/^{90}Y (measured).



Fig(4): The fractio of EB productio probability i ^{90}Sr i that of ^{90}Sr/^{90}Y for Pb target as a fu c tio of photo e ergy.



Fig(5): The fractio of EB productio probability i ^{90}Sr i that of ^{90}Sr/^{90}Y for Cu target as a fu c tio of photo e er gy.