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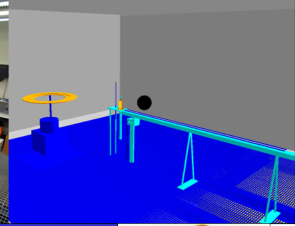

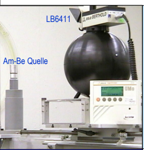

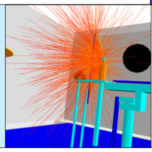

IRPA 13

Photons from ^{252}Cf and ^{241}Am-Be neutron sources

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At the accredited PSI calibration laboratory neutron reference fields traceable to the standards of the Physikalisch-Technische Bundesanstalt (PTB) in Germany are available for the calibration of ambient and personal dose equivalent (rate) meters and passive dosimeters. The photon contribution to *H*(10)* in the neutron fields of the ^{252}Cf and ^{241}Am-Be sources was measured using various photon dose rate meters and active and passive dosimeters. Measuring photons from a neutron source involves considerable uncertainties due to the presence of neutrons, due to a non-zero neutron sensitivity of the photon detector and due to the energy response of the photon detectors. Therefore eight independent detectors and methods were used to obtain a reliable estimate for the photon contribution as an average of the individual methods. For the ^{241}Am-Be source a photon contribution of approximately 4.9% was determined and for the ^{252}Cf source a contribution of 3.6%.

1) Photon detectors

Fig. 1: Tissue Equivalent Proportional Counter (TEPC) of the Austrian Seibersdorf Laboratories: allows to discriminate between γ- and neutron signals by means of their pulse-height distributions.

Fig. 2: The Automess 6150 AD2 and Teletector use Geiger counters. k_n was measured by means of a lead shield blocking photons from the neutron sources.

Fig. 3: Active personal dosimeter (APD) from MGP instruments with independent detectors for n and γ radiation. The residual neutron sensitivity of the photon sensor is known from the German homologation of the device at PTB.

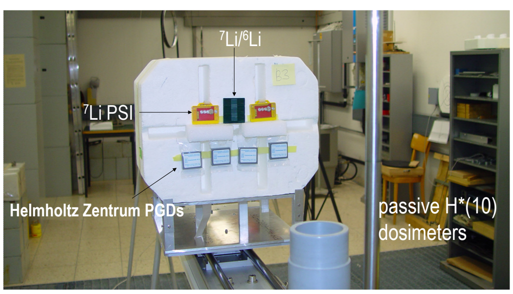

Fig. 4: Passive *H*(10)* dosimeters: PSI standard ^{7}Li TLDs, ^{6}Li/^{7}Li TLD dosimeters and phosphate glass dosimeters (PGDs) of the Helmholtz Zentrum Munich. The residual neutron sensitivity of the PDGs is known from the German homologation at PTB.

2) Photons from ^{252}Cf and ^{241}Am-Be neutron sources

^{252}Cf decays through α-emission (~97%) and through spontaneous fission (~3%) with a half-life of 2.65 y. Both processes are accompanied by photon radiation. Furthermore the spectrum of fission products contains radioactive elements that produce additional gamma photons. In the ^{241}Am-Be source ^{241}Am decays through α-emission and various low energy γ emissions: $^{241}Am \rightarrow ^{237}Np + \alpha + \gamma$ with a half life of 432.6 y. The α particle is captured by ^{9}Be followed by the emission of a neutron, $\alpha + ^9Be \rightarrow ^{12}C^* + n$, and the resulting excited ^{12}C* emits a 4.4 MeV photon. As the ratio between α decays and neutron emissions is in the order of 10^5, there are much more low energy photons from the α decay than 4.4 MeV photons from the de-excitation of ^{12}C*. The most prominent line is the 60 keV line. The low energy photons are absorbed to some extent inside the source and its container. Thermal neutron capture reactions followed by gamma emission such as $^1H(n, \gamma)^2H$ can be a further source for photons in a neutron irradiation room.

3) Measurement of photons in neutron fields

To measure photons from a neutron source the neutron sensitivity of the photon detector should be as small as possible. A detector with a photon sensitivity k_γ and a residual neutron sensitivity $k_n << k_\gamma$ will show a reading $M = k_\gamma H_\gamma + k_n H_n$ when exposed to a neutron dose rate H_n and a photon dose rate H_γ. H_γ can be determined if H_n and both sensitivities k_γ and k_n are known. H_γ/H_n is typically a few %. k_n ~ 1%, therefore it can lead to a neutron induced signal of the same order of magnitude as the signal from the photons. The uncertainty of k_n is typically rather large and additional uncertainties arise from the energy response of the detector. Consequently the photon contributions obtained from such a measurement exhibit large combined uncertainties. Therefore a number of detectors using different detection principles have been used to measure the photon contribution of the PSI neutron sources in order to obtain independent results for comparison. The detectors are summarized in Fig. 1-4.

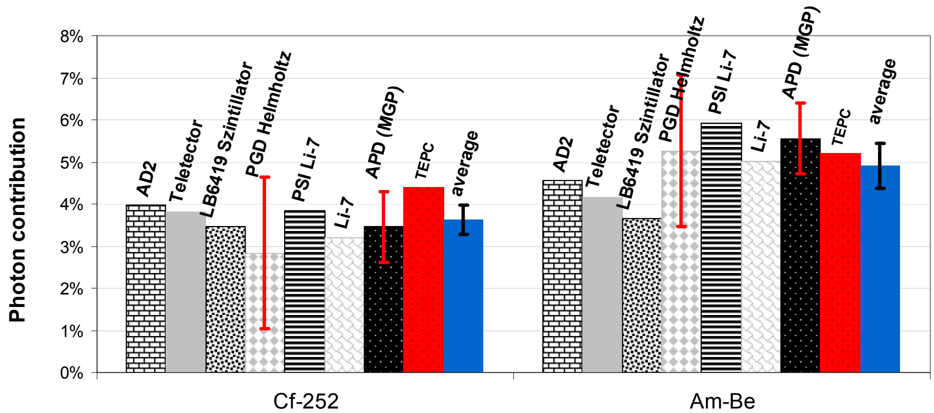

Fig. 5: Results for the photon contribution for the two sources obtained with various detectors. All contributions determined in terms of *H*(10)*, except APDs in terms of $H_p(10)$

4) Results

The results of the measurements of the photon contribution to *H*(10)* for the ^{241}Am-Be and ^{252}Cf sources are summarized in Fig. 5. The uncertainties (k=2) given for the APD and PGD detectors are based on the uncertainties of k_n and the uncertainties of the dose readings. They do not take energy response into account. **The average result of all methods shown in the graph is a photon contribution of 4.9% for the ^{241}Am-Be source and 3.6% for the ^{252}Cf source.** The relative uncertainty of these values obtained from the standard deviation of the eight results is ~ 11%.

Acknowledgements

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