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# A study of neutron flux from 20 MeV medical linear accelerators

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Currently, photon beams obtained from linear electron accelerators are used for radiation therapy. The most widely used bremsstrahlung is ones with a maximum energy of 6, 10, 15, 18, and 20 MeV. The main advantages of radiation therapy with high-energy photons (15, 18 and 20 MeV) are high penetrating ability, the ability to create a maximum dose at almost any depth of the tumor in the patient's body, a reduced dose for the skin and a reduced peripheral dose due to lower angular dispersion. However, the interaction of photons with an energy of more than 8 MeV with the structural elements of the accelerator made of materials with a high atomic number is accompanied by the formation of secondary neutron radiation through (γ, $Xn$) reactions, subsequent neutron capture is a source of induced gamma radioactivity, which does not generate a dose taken into account in radiotherapeutic treatment.

The neutron flux intensity of the Varian Trilogy linear medical accelerator with a maximum electron energy of 20 MeV was estimated by the activation method by irradiating tantalum targets with brake beams under conditions close to clinical. Because fast neutrons make the main contribution to the patient's dose, the targets were irradiated as part of the tantalum –cadmium –tantalum –cadmium foil assembly to cut off thermal neutrons.

The spectra of irradiated targets were measured by Canberra and Ortec gamma spectrometers with ultra-pure semiconductor detectors with a (15–40)% detection efficiency compared to a 3′×3″ NaI(Tl) detector. The energy resolution of the spectrometers was 1.8–2.0 keV on the 1332 keV $^{60}$Co γ-line.

The gamma transitions from the $^{180}$Ta formed in the $^{180}$Ta(γ, $n$)$^{181}$Ta reaction and $^{182}$Ta formed in the $^{181}$Ta($n$, γ)$^{182}$Ta reaction were reliably distinguished in the studied spectra.

The average fast neutron energy was calculated from the reconstructed spectrum obtained by a modified Bonner activation spectrometer. The energy distribution of the secondary neutron flux density in the neutron energy range 0.1–15 MeV were obtained by the SDMF-1608PRO spectrometer-dosimeter. After analyzing the spectra, it was found that the average fast neutron energy of the Varian Trilogy linear medical accelerator is 0.89±0.02 MeV. Experimental data of neutron energy and activation of tantalum monitor targets were used to estimate the fast neutron flux. It was found that the flux of fast neutrons on the tantalum monitor target is from 5 to 10% during the accelerator operates with a 20 MeV bremsstrahlung maximum energy.

Taking into account the coefficient of relative biological efficiency of neutron radiation for neutrons with energies from 100 keV to 2 MeV, equal to 20, compared with the coefficient for gamma rays (equal to 1), even in preliminary studies, there is a significant underestimation of the contribution radiation of secondary neutrons in the total dose received by the patient during radiation therapy with 20 MeV bremsstrahlung maximum energy.

A discussion of the findings is ongoing. The reported study was funded by RFBR according to the research project №18-00-00745.

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