NEUTRON FLUENCE RATES DUE TO PRODUCTION OF N-13 IN A PET CYCLOTRON

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Abstract

PET (Positron Emission Tomography) radiopharmaceutical production has increasing substantially in recent years. Nitrogen-13 (N-13) is one of the four main PET radioisotopes. It is utilized not only for radiopharmaceutical production but, also, for irradiation tests (or pre-irradiations). N-13 is produced during the bombardment of a target with "normal" water (which has more than 99.5% of oxygen-16).

The reaction $^{16}O(p,\alpha)^{13}N$, differently of the $^{18}O(p,n)^{18}F$ reaction, widely utilized for Fluorine-18 production, do not contribute directly for neutron production. However, interactions of the high energies protons with the target body and other constituent elements of the cyclotron machine generate a high intensity radiation field around it, including a high flux of neutrons [Lacerda *et. al.,* 2013].

To completely describe the neutron radiation field, in several points around a cyclotron, Monte Carlo simulations can be utilized with advantages. Simulated spectra and calculated dosimetric quantities can also be compared with those obtained experimentally at few points, for validation purposes. Some papers have shown the use of the Monte Carlo to calculate

neutron spectra in cyclotrons rooms [Vega-Carrillo, 2001; Mendez *et. al*., 2005; Lacerda *et. al*., 2013].

In this work, the neutron spectra were calculated in 4 points around a PET cyclotron, during the production of N-13. The MCNPX version 2.7 with ENDF/B-VII.0 nuclear data library was used for calculation of the radiation neutron flux normalized to 1 μA.

The ambient dose equivalent rates (H*(10)) were obtained by multiplying the flux by the dose conversion factors of the ICRP publication 74 (ICRP, 1996). The H*(10) rates were also measured in the same 4 points utilizing the dose rate meter Berthold LB6411 and compared with the simulated ones. Experimental measurements showed a relatively good agreement with the simulated dosimetric quantities.

References

ICRP. (1996). *Conversion coefficients for use in radiological protection against external radiation*. International Commission on Radiological Protection publication 74. Annals of the ICRP **26**: 199.

Lacerda, M.A.S.; Campolina, D. A.M.; Guimaraes, A.M.; Benavente, J.A. and da Silva, T. A. (2014). *Use of the MCNPX to calculate the neutron spectra around the GE-PETtrace 8 cyclotron of the CDTN/CNEN, Brazil*. Applied Radiation and Isotopes **83**: 235-241.

Mendez, R.; Iñiguez, M.P.; Martí-Climent, J.M.; Peñuelas, I.; Vega-Carrillo, H.R. and Barquero, R. (2005). *Study of the neutron field in the vicinity of an unshielded PET cyclotron*. Physics Medicine and Biology **50**: 5141–5152.

Vega-Carrillo, H.R. (2001). *Neutron energy spectra inside a PET cyclotron vault room*. Nuclear Instruments and Methods in Physics Research A **463**: 375–386.