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New nuclear data for online and offline PET monitoring in proton therapy

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In proton therapy, Positron Emission Tomography (PET) range verification, which is based on the detection of the short-lived (online monitoring) or the long-lived (offline monitoring) β^+ emitters produced in the body of the patient, has been proved to be a well-suited technique to monitor the beam range [1]. This technique requires the comparison of the observed activity distribution with a simulated one using a Monte Carlo code. As the reliability of the simulated activity distribution depends on the accuracy of the underlying cross sections for producing the β^+ emitters of interest [2][3][4], several studies confirm the need for more and better measurements and evaluations [4][5}[6]. Indeed, new data related to the production of the short-lived nuclides involved in real-time verification [7][8][9] are especially needed, as there are no data available yet in the energy range of interest, up to 200 MeV.

The objective of this work is to measure the production cross sections of the mentioned long-lived (^{11}C with $t_{1/2}$ = 20.4 min, ^{13}N with $t_{1/2}$ = 9.97 min and ^{15}O with $t_{1/2}$ = 122 s) and short-lived (^{12}N with $t_{1/2}$ = 11 ms, ^{29}P with $t_{1/2}$ = 4.14 s and ^{38mK} with $t_{1/2}$ = 924 ms) β^+ emitters. In order to measure the long-lived β^+ emitters, the multifoil activation technique combined with dynamic PET scanner imaging performed outside the irradiation room is applied. The technique has been first validated at the 18 MeV cyclotron of CNA in Spain [10], and then applied up to a nominal proton beam energy of 200 MeV at the WPE and HIT clinical facilities in Germany [11]. In order to measure the short-lived isotopes, single-foil irradiations with online monitoring using $LaBr_3$ detectors have been performed at HIT. The results from both experimental campaigns will be presented and the relevance of the new data for PET range verification will be discussed.

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