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Measurement of spallation cross sections for the production of terbium radioisotopes for medical applications from tantalum targets

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Terbium has 4 interesting isotopes for usage in the context of nuclear medicine: ^{149}Tb, ^{152}Tb, ^{155}Tb and ^{161}Tb, sometimes referred to as the Swiss army knife of nuclear medicine [1]. Their chemical identity means that radiopharmaceuticals for imaging and therapy respectively will have identical pharmacokinetics and pharmacodynamics, an important advantage for so-called theranostics applications.
^{161}Tb is best produced by irradiating ^{160}Gd with thermal neutrons to form ^{161}Gd which quickly decays into ^{161}Tb. For the neutron deficient isotopes mentioned above, one of the most promising production methods is high-energy proton-induced spallation of tantalum foil targets, coupled with isotope separation on-line or off-line [2]. However, the collection of isobaric contaminants is unavoidable, which includes pseudo-isobars such as monoxide ions with the same total mass [3]. For example for ^{155}Tb, it was found that the main impurity was ^{139}Ce in the form of ^{139}CeO+ [4]. Often these byproducts need to be chemically removed before the terbium isotopes can be used. It is therefore beneficial to optimize the production protocol such that these isobaric contaminants are minimized. One way is to select the most appropriate proton energy for the isotopes of interest, while minimizing molecular sidebands. Indeed a lower proton energy reduces the number of nucleons evaporated in the spallation process and limits production of Ce isotopes with respect to Tb isotopes. Unfortunately the cumulative spallation cross sections for some of the isotopes of interest are not well known or conflicting data exist in literature, e.g. for ^{149}Tb [5,6] and ^{152}Tb [6,7].
Here we present new measurements of cumulative cross sections for production of ^{149}Tb, ^{152}Tb, ^{155}Tb and other nuclides from A=100 to 180 by proton-induced spallation of tantalum foil targets at different proton energies between 300 and 1700 MeV, using the COSY synchrotron at FZ Jülich.

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