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Challenges in the modeling of nuclear reactions for theranostic applications

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The production of innovative radionuclides in the context of theranostics (i.e. the combined therapy and diagnostics) is currently a topic of great interest and the new generation of proton cyclotrons is offering many new routes for their production with charged particle beams, as an alternative to the more traditional neutron reactions at reactors. Many candidates have been identified by international committees, as for instance the IAEA recommended 67Cu, 47Sc or 186Re: they can be produced at cyclotrons with different nuclear reactions and together with other contaminants, as for example 64Cu in case of copper or 46Sc in case of scandium. Other promising isotopes are currently being proposed, as 52Mn for example. Other techniques, like for example the isotope separation online method, could also be investigated for the potentially higher purity of the reaction products.

The optimal conditions for the production of a given isotope depend on various factors, like the irradiation conditions, the target properties, the beam type and energy and the nuclear reaction cross section: preliminary studies are required to identify the best reaction channels and the optimal energy windows that maximize the desired isotope yield, minimizing at the same time the contaminants. Often experimental data are missing or uncertain and nuclear models and codes have to be exploited for this purpose, in particular when the reaction products are stable or difficult to measure.

In this talk we review the most recent activities in the context of the new LNL SPES/Laramed facility and we present the results obtained for a selection of nuclear reactions of interest (see Figure for an example) with state-of-art nuclear codes (Talys, Empire, Fluka and others).

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