User project report

Impact of Tb-156 pollution on image quality and quantitative accuracy of gamma camera imaging with Tb-155

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008571 (PRISMAP). This document reflects only the view of the author(s). The Agency is not responsible for any use that may be made of the information it contains.

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2. Context of the project (800 characters max. including spaces)

The ^{155}Tb is a radionuclide with high potential in theranostic use. This Tb isotope is characterized by gamma emission in the energy range of interest for SPECT imaging ($T_{1/2}$ = 5.32 d, E_γ = 87 keV (32%), 105 keV (25%)), for possible pre-therapeutic assessments, prior to therapeutic administration Tb-radiolabeled compounds, such as ^{161}Tb in a perfect pair theranostic configuration. Production of ^{155}Tb in cyclotrons is however typically polluted by the concomitant generation of ^{156}Tb of similar half-life. ^{156}Tb is characterized by high energy γ-ray emissions which can limit the image quality and may lead to dosimetric issues. This project aims at evaluating the hindering of ^{155}Tb SPECT imaging based on the contaminating fraction of ^{156}Tb based on both SPECT measurements and Monte Carlo simulations.

3. Results and discussion (1000 characters max. including spaces)

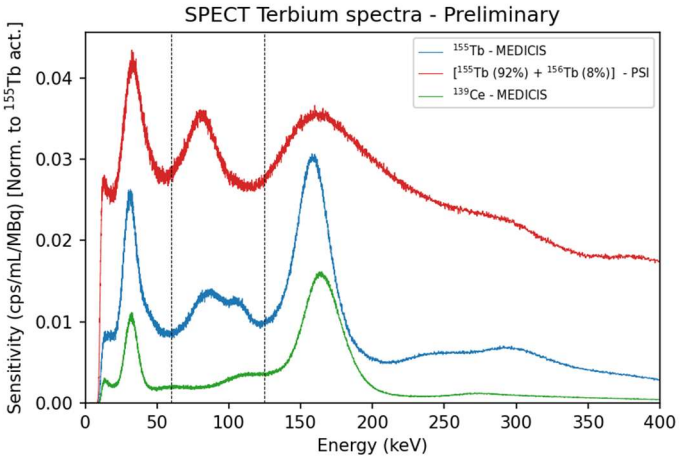

Figure 1. Sensitivity spectra of pure ^{155}Tb (after subtraction of the ^{139}Ce) (blue) and contaminated by ^{156}Tb (red), and ^{139}Ce spectrum only after total ^{155}Tb decay. All spectra are normalized to the activity of ^{155}Tb.

The project was carried out at Nuclear Medicine and Molecular Imaging department of the CHUV on the Albira micro-SPECT preclinical camera (Bruker). A NEMA-NU4 phantom (Fig. 2 right) was measured with: i) a

solution of about 5 MBq of pure (in terms of Tb) ^{155}Tb but contaminated with 12 MBq of ^{139}Ce produced by CERN MEDICIS and ii) a solution of about 3.4 MBq of ^{155}Tb and 0.3 MBq of ^{156}Tb (8%) produced by PSI. Fig. 1 shows the spectra ^{155}Tb spectra obtained for the two solutions after subtraction of ^{139}Ce, as well as the pure ^{139}Ce spectrum ($T_{1/2}$=137 d) measured after complete decay of the ^{155}Tb. One can see a strong contribution of the contaminant to the Compton background, in the energy region of interest (60-125 keV). This is mainly due to the weak shielding and collimation of the camera to high energy γ-rays (>140 keV). Fig. 2 shows various cross sections of a tomographic reconstruction of a NEMA-NU4 phantom filled with the ^{155}Tb/^{139}Ce solution and performed thanks to the CASToR platform. One can see that the reconstruction is correctly achieved, with the phantom rods down to 3 mm diameter clearly visible. Reconstruction improvement is currently undergoing to address the contamination of ^{139}Ce which reduce the signal to noise ratio. Reconstruction for solution of ^{155}Tb/^{156}Tb is currently under evaluation.

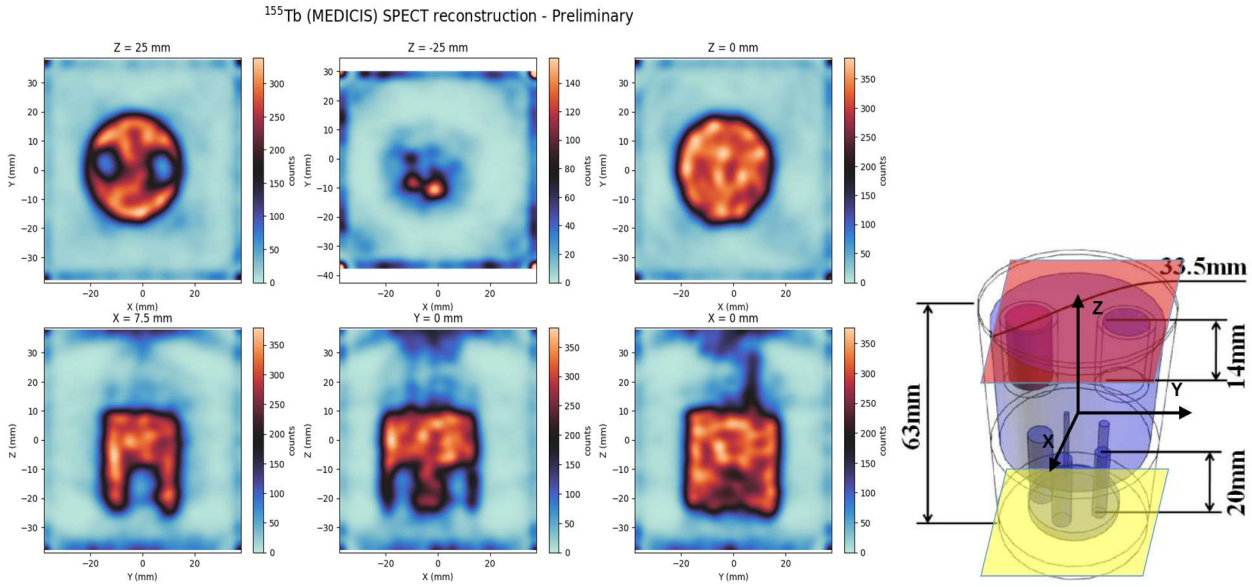

Figure 2. Left: SPECT tomographic reconstruction of a NEMA-NU4 phantom filled with a solution of about 17 MBq of ^{155}Tb (33%) and ^{139}Ce (67%). Right: Schematic of the NEMA-NU4 phantom showing the cross-section planes.

4. Conclusions (800 characters max. including spaces)

Thanks to the PRISMAP program, we were able to perform the desired experiments at CHUV with two ^{155}Tb solution with different contaminants. Repeated measurements at various times also allowed us to determine contributions for these contaminant, taking advantage of the decay period of isotopes. In addition, we were able to evaluate the camera geometrical features, calibration and detection capabilities with various other isotopes available at CHUV in order to produce Monte Carlo simulations with the most accurate simulated device. This will allow us: i) to produce simulations of any solution with various concentration of ^{139}Ce or ^{156}Tb to evaluate contamination effect on images, ii) determine appropriate shielding and SPECT collimation for these contamination levels and, iii) use Monte-Carlo simulation to hinder contamination background from the experimental measurements. This work is currently undergoing as Mohammed Hussein PhD.

5. Involvement of the PRISMAP services (600 characters max. including spaces)

The project got a strong involvement of many of the PRISMAP actors. First at CHUV with David Viertl who has been strongly involved both through many meetings we got to prepare the experiment and during them where he welcomed us at Lausanne and carried himself most of the experiments. Secondly for production, both on the MEDICIS side, lead by Charlotte Duchemin, with the production of the pure ^{155}Tb which required

several trials to be able to produce the required activity. Same comment for the PSI side managed by Zeynep Talip and Nicholas Van der Meulen who were able to provide us a large activity source allowing us to perform several measurements.

6. Feedback to PRISMAP (600 characters max. including spaces)

This PRISMAP project was a great opportunity to gather isotope productions with different contamination from two production facilities allowing us to evaluate the effect of contaminants of SPECT imaging. As a complementary suggestion, in addition to the list of available isotopes and facilities provided by PRISMP we would suggest to also add a list of available detectors and nuclear imaging systems. Also a list of the potential contamination by-product to be expected for each facility would be helpful when writing down a project. In addition the interest of this kind of project is the collaboration opportunities this can lead, as in our case we plan to keep collaborating with the CHUV for future work.

7. Publications and other dissemination activities (conferences etc.)

Preliminary results of this work was presented as a poster at the PRISMAP Radiolanthanide Workshop in September 2024 at PSI. While this work is currently still under analysis as a part of Mohammed Hussein PhD thesis and should lead in addition to a future publication in a peer reviewed journal.

Appendix 1. Dissemination guidelines for user projects as agreed in the signed User Agreement

Dissemination rules

Only user groups that are allowed to disseminate the results which they have generated under the project may benefit from the access, unless they are working for SMEs.

For each user group project, a publishable project summary and a publishable summary of the results will be published on the European Union Horizon 2020 PRISMAP project website www.prismap.eu. The publication of results in journals or at conferences is strongly encouraged.

To ensure the long-term sustainability of the PRISMAP initiative, proper recognition of the contributing facilities, their services and the involved persons is necessary. All participating PRISMAP facilities shall be acknowledged in the publication. Acknowledgement and co-authorship of PRISMAP staff members who participated in the experiment shall be considered according to the research field best practices and verified with the PRISMAP Technical Manager before any publication.

The user group shall contact the PRISMAP Technical Manager 30 days prior to submission of publications or other communications of results that were obtained by making use of services provided by PRISMAP (radionuclides delivered or medical services provided). The Technical Manager will communicate to the user group the list of PRISMAP facilities and persons that have contributed to each specific project and the way this contribution must be acknowledged in the publication/communication or where co-authorship is required to reflect specific scientific contributions.

Users must comply with Horizon 2020 dissemination rules (i.e. acknowledge that their work was financially supported by the European Union's Horizon 2020 Research and Innovation Programme by including the following acknowledgement: "This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008571 (PRISMAP)"), and grant open access to resulting publications and related data.

Dissemination shall take place only once legitimate interests regarding intellectual property have been safeguarded. A maximum publication delay of 90 days may be granted for this purpose.

Acknowledgements

The list of name(s) to be mentioned in the acknowledgment section is sent to the technical manager by the main contact of the involved facilities.

A general sentence will be added by the corresponding author of the article (user side):

"The authors would like to thank the members of the PRISMAP consortium and of the PRISMAP user selection panel, coordination and management team for their advice and support."

Funding acknowledgement

"This work was supported by the European Union's Horizon 2020 research and innovation programme as a user project of PRISMAP – The European medical radionuclides programme (GA 101008571)".