

EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Letter of Intent to the ISOLDE and Neutron Time-of-Flight Committee

Optimisation of clinical SPECT imaging with ^{155}Tb for
theragnostic radionuclide therapy

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Abstract: In this letter of intent we propose to study the feasibility of SPECT/CT imaging for ^{155}Tb with a current state-of-the-art clinical camera at The Christie NHS Foundation Trust. For this purpose, we request to collect samples of $^{155}\text{Tb}/\text{Dy}$ at ISOLDE. These collections will be performed with a newly designed prototype collection chamber for use at the new CERN-MEDICIS facility. This work will form the basis of an ongoing research collaboration, with the ultimate aim of exploiting the full theragnostic potential of the terbium isotopes.

Requested shifts: 0 shift, as these collections will be performed within the shifts of IS528.

1 Scientific and clinical context

1.1 Theragnostic applications of the terbium isotopes

Interest in the element terbium (${}_{65}\text{Tb}$) for medical application has grown recently [1]. Four Tb isotopes have been identified with the potential to provide unique theragnostic treatment strategies which combine cancer therapy with diagnostic imaging. The isotopes ${}^{155}\text{Tb}$ and ${}^{152}\text{Tb}$ can provide SPECT and PET imaging respectively [2], whilst ${}^{161}\text{Tb}$ can be used for β^- therapy [3] and ${}^{149}\text{Tb}$ for α therapy [4, 5]. Using a combination of these isotopes as labels for radio-pharmaceuticals can provide both pre-therapy diagnostic imaging and post-therapy dosimetry and treatment optimisation using the same delivery vector. In particular α therapy has been recently highlighted as a promising approach in the treatment of cancer [6, 7]. In order to validate the use of these isotopes for patient treatments extensive pre-clinical studies are required to provide the foundation for future clinical trails, this pre-clinical work is already ongoing [1].

Clinical SPECT camera systems are typically optimised for imaging with ${}^{99m}\text{Tc}$ ($E_\gamma = 140$ keV) and use a range of collimator geometries to reduce scatter and enhance the peak to background ratio. In contrast to ${}^{99m}\text{Tc}$, the decay of ${}^{155}\text{Tb}$ produces gamma rays of 87 keV ($I_\gamma = 32\%$), 105 keV ($I_\gamma = 25\%$), 180 keV ($I_\gamma = 7.5\%$) and 262 keV ($I_\gamma = 5.3\%$). Establishing optimised SPECT imaging protocols for ${}^{155}\text{Tb}$ with a clinical camera system is a crucial first step in demonstrating the efficacy of ${}^{155}\text{Tb}$ for clinical applications. **We therefore propose to collecting samples of ${}^{155}\text{Tb}$ isotopes in order to image them using a state-of-the-art clinical SPECT/CT camera in the nuclear medicine department at The Christie NHS Foundation Trust. This will provide essential imaging data sets which can be used to optimise ${}^{155}\text{Tb}$ SPECT for future diagnostic imaging.** These tests will form the basis for a comprehensive programme of work, with the ultimate aim of exploiting the full theragnostic potential of the terbium isotopes.

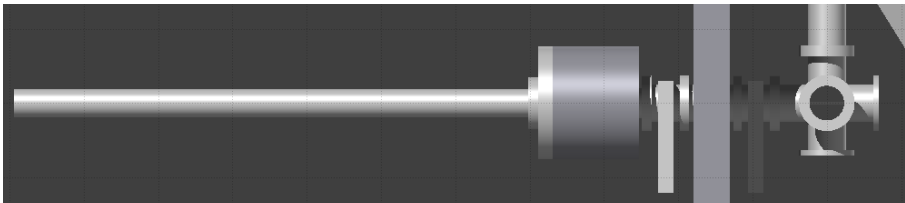


Figure 1: Prototype collection chamber for CERN-MEDICIS.

2 Experiment

2.1 The CERN-MEDICIS collection chamber prototype

CERN-MEDICIS (MEDical Isotopes Collected from ISOLDE) is the new facility for the parasitic production of radioisotopes at ISOLDE [8]. It consists of a secondary irradiation point, where the dumped beam from the PSBooster through the ISOLDE target is used

to irradiate targets, a rail system to extract these irradiated targets, an off-line mass separator, and a suite of class-A chemical laboratories. The aim of the CERN-MEDICIS facility is to provide radioisotopes for medical research that are not readily available through commercial routes.

A key item in the CERN-MEDICIS facility is the collection chamber where the radioisotopes will be collected after mass separation. A new chamber is currently under design at KU Leuven (see Fig. 1), based upon radiation simulations made at The University of Manchester [9]. It consists of a steel vacuum 6-way cross, housing a ladder with up to 5 metal collection foils, which is electrically insulated so that the impinging beam current can be read and the rate of implantation be monitored continuously and integrated. The ladder can be actuated to collect up to 5 different samples without requiring to extract them one at a time. The extraction protocol has been designed to minimise the vacuum intervention and avoid contamination risks.

The back port of the chamber can be exchanged to house a charged-particle detector or a for a thin flange to install a high-purity germanium detector if monitoring of the radioactivity is required for a specific collection. **We will test the prototype chamber and its associated protocols for future collections at CERN-MEDICIS.** The new chamber will be installed at the end of the GLM beam line where appropriate concrete shielding can be foreseen if necessary. Alternatively, the chamber can be installed at either LA1 or LA2.

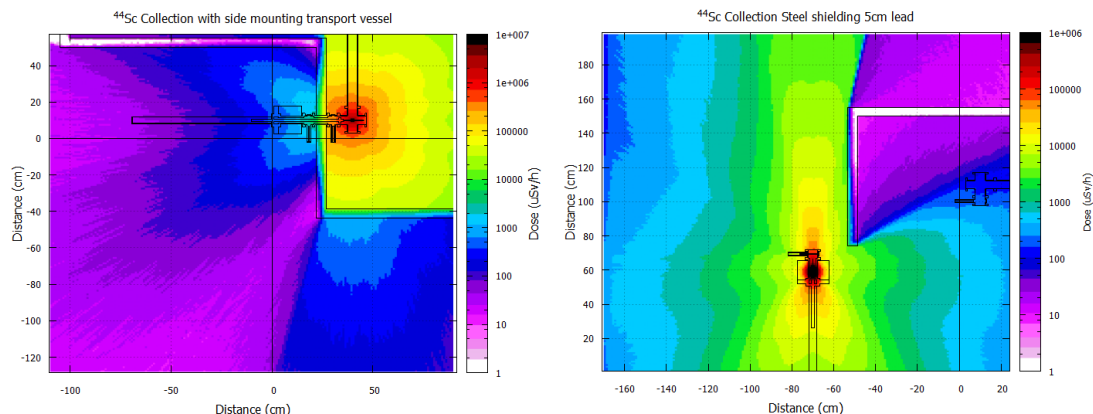


Figure 2: Left: FLUKA simulation of the collection chamber at the implantation point of CERN-MEDICIS. Right: FLUKA simulation of the transport vessel while the sample is moved from the collection towards the radiochemistry laboratory. ^{44}Sc is used in these simulations as it has been evaluated as the most critical case that may be encountered at CERN-MEDICIS [9].

2.2 SPECT/CT imaging

The Christie NHS Foundation trust in Manchester, UK, is the largest single-site cancer centre in Europe, treating more than 44,000 patients a year. With over 550 open clinical trials, it is also a leader in cancer research. The University of Manchester nuclear-physics group and the nuclear-medicine group at The Christie has established a fruitful interdisci-

plinary research programme addressing the problem of providing accurate patient specific dosimetry for radionuclide therapy.

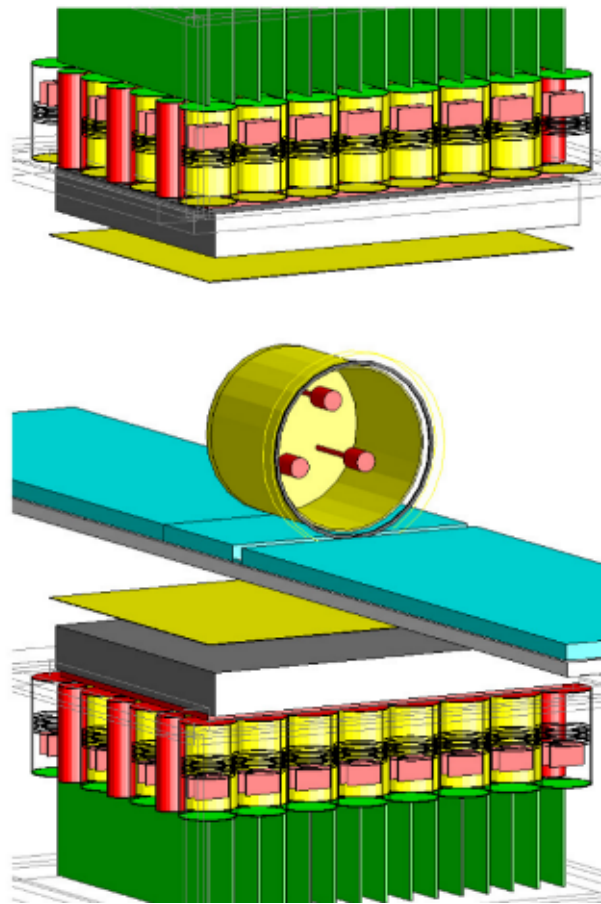


Figure 3: Details of Monte Carlo simulation SPECT camera geometry from The Christie. The collimator is shown in grey with the touch plates in yellow. Details of the photo multiplier tube array are shown in red with representative back compartment electronics shown in green. [10]

The ^{155}Tb samples will be imaged using a GE Discovery 670 SPECT/CT camera with diagnostic CT at The Christie. An existing Monte Carlo simulation of the Discovery 670 camera will be used to optimise the energy windows and collimators used to acquire ^{155}Tb SPECT images. Acquiring the SPECT data from the camera in 'list-mode' will enable new retrospective projected SPECT images to be produced from the initial scan data after the initial samples have decayed.

Summary of request: We shall collect samples $^{155}\text{Tb/Dy}$ during other collections for IS528 with the prototype MEDICIS collection chamber at GLM/LA1/LA2 and use with the SPECT/CT camera at The Christie in the UK.

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Appendix

DESCRIPTION OF THE PROPOSED EXPERIMENT

The experimental setup comprises:

Part of the	Availability	Design and manufacturing
MEDICIS Collection Chamber	<input type="checkbox"/> Existing	<input type="checkbox"/> To be used without any modification <input type="checkbox"/> To be modified
	<input checked="" type="checkbox"/> New	<input type="checkbox"/> Standard equipment supplied by a manufacturer <input checked="" type="checkbox"/> CERN/collaboration responsible for the design and/or manufacturing

HAZARDS GENERATED BY THE EXPERIMENT

Collection of radioisotopes

Isotope	Half-life	Activity	Number of samples	Destination
^{155}Tb	5.32 days	1 MBq	5	The Christie Hospital (UK)

Hazard identification:

The ^{155}Tb samples will have to be cleared and shipped to The Christie Hospital in the United Kingdom under the supervision of the RadioProtection Services.

Average electrical power requirements negligible

The new setup will require a support at the end of GLM.