

Terbium-149 production and separation: IS688 and beyond

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Terbium-149 has been regarded as an attractive candidate for Targeted Alpha Therapy (TAT) since the 1990's [1], due to its favourable physical decay properties ($T_{1/2} = 4.1$ h, $E_{\alpha} = 3.97$ MeV, 17%; $E_{\beta} + \text{mean} = 720$ keV, 7%) [2]. Preclinical studies have demonstrated its therapeutic potential [3-6], as well as its potential for therapy monitoring via positron emission tomography (PET) [4]. The absence of its daughter nuclides emitting relevant quantities of α -particles, make it particularly promising for therapy despite its current limited availability.

Terbium-149 was produced at ISOLDE/CERN via spallation induced in a tantalum target using high-energy (1.4 GeV) protons, followed by release and ionization of the spallation products, which were mass-separated online. The mass 149 isobars were collected in zinc-coated Au/Pt/Ta foils and, subsequently, transported to PSI for processing. The desired Tb nuclide was chemically separated from its isobaric impurities, as well as the collection material, using cation exchange and extraction chromatography, employing an optimized process [7]. The quality of the radionuclide produced was assessed analytically and by means of radiolabelling experiments. To date, up to 1.9 GBq terbium-149 were collected and transported to PSI. Upon arrival, the foil was placed into a dedicated hot cell and processed. The four-hour radiochemical separation process yielded up to 400 MBq final product. The product radiochemical purity, measured by γ -spectrometry, was determined to be 99.8%. Quality control was performed using DOTATATE, which was successfully labeled at molar activities up to 50 MBq/nmol with >99% radiochemical purity [7]. The chemical purity was further proven by ICP-MS measurements, which showed Pb, Cu, Fe and Zn contaminants at ppb levels.

Based on the successful collaboration between PSI and ISOLDE, the TATTOOS project (Targeted Alpha Tumour Therapy and Other Oncological Solutions) as part of the Swiss Large Facilities project IMPACT [8] was submitted and, subsequently, approved by the Swiss parliament in December 2024. TATTOOS intends to address the means of producing 149/152/155Tb in large quantities towards potential clinical application.

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[1] Allen. *Australasian Radiology* 1999, 43:480.

[2] Singh & Chen. *Nuclear Data Sheets* 2022, 185:2

[3] Beyer et al. *Radiochim Acta* 2002, 90:247.

[4] Muller et al. *EJNMMI Radiopharm Chem* 2016, 1:5.

[5] Umbricht et al. *SciRep* 2019, 9:17800.

[6] Mapanao et al. *EJNMMI* 2025, 52:1383.

[7] Favaretto et al. *SciRep* 2024,14:3284

[8] IMPACT Project: <https://www.psi.ch/en/impact>

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MULTIPAC and PACBit - Third Generation TDPAC Spectroscopy

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With its unique combination of an external magnetic field of up to 8.5 Tesla and the ability to heat and cool samples during measurements, the MULTIPAC Time-Differential Perturbed Angular Correlation (TDPAC) setup creates new possibilities for studying materials and their phase transitions. Building on this advanced instrumentation, the dedicated control and analysis software PACBit enables high-performance data acquisition, streamlined experiment control, and efficient post-processing. An outline of the detector configuration is given, followed by an exposition on how the system increases the effective resolution beyond the 10-bit limit of the U5310A digitizer through advanced signal processing techniques. Operating in streaming mode, the data acquisition (DAQ) delivers high throughput and allows the collection of more data than in previous setups. Post-processing features include signal smoothing, removal of secondary pulses, precise timestamp calculation and integration. These processes are all automated, to achieve a real-time R(t) spectrum. Finally, a coincidence search algorithm is presented that exploits the increased dataset to deliver more accurate event correlations, paving the way for better experimental results and new opportunities in high-resolution TDPAC spectroscopy.

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Radionuclide production by mass separation at CERN-MEDICIS for biomedical research and the PRISMAP European program

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CERN-MEDICIS aims at producing and purifying by mass separation non-conventional radionuclides for research and development in diagnostics and radiation therapy.

It triggered PRISMAP and PRISMAP+ EU projects –furthering the European medical radionuclides programme, supporting the ongoing research across Europe and beyond in radiopharmaceutics.

CERN-MEDICIS exploits in a dedicated classified nuclear work sector, an isotope mass separator, a radiochemistry laboratory, a target irradiation station receiving 1.4 GeV protons from the Proton Synchrotron Booster (PSB). It also receives activated targets from external institutes, notably during the forthcoming CERN Long Shut-Down LS3.

Medical radionuclides are collected by implantation of the radioactive ion beam (RIB) into foils that are afterwards dispatched to a research center.

CERN-MEDICIS has been providing collaborating institutes in Europe, Pakistan and USA with several mass separated radionuclides among this non-exhaustive list: K-43, Sc-43/44/47, Eu-145, Tb/Gd-149, Sm-153, Tb-155, Tm-165/Er-165, Tm-167, Er-169, Yb-175, Ra-223/224/225, Ac-225 and for the first time Cu-67 and Ac-226. They have been produced both from irradiated targets at CERN as well