PAUL SCHERRER INSTITUT

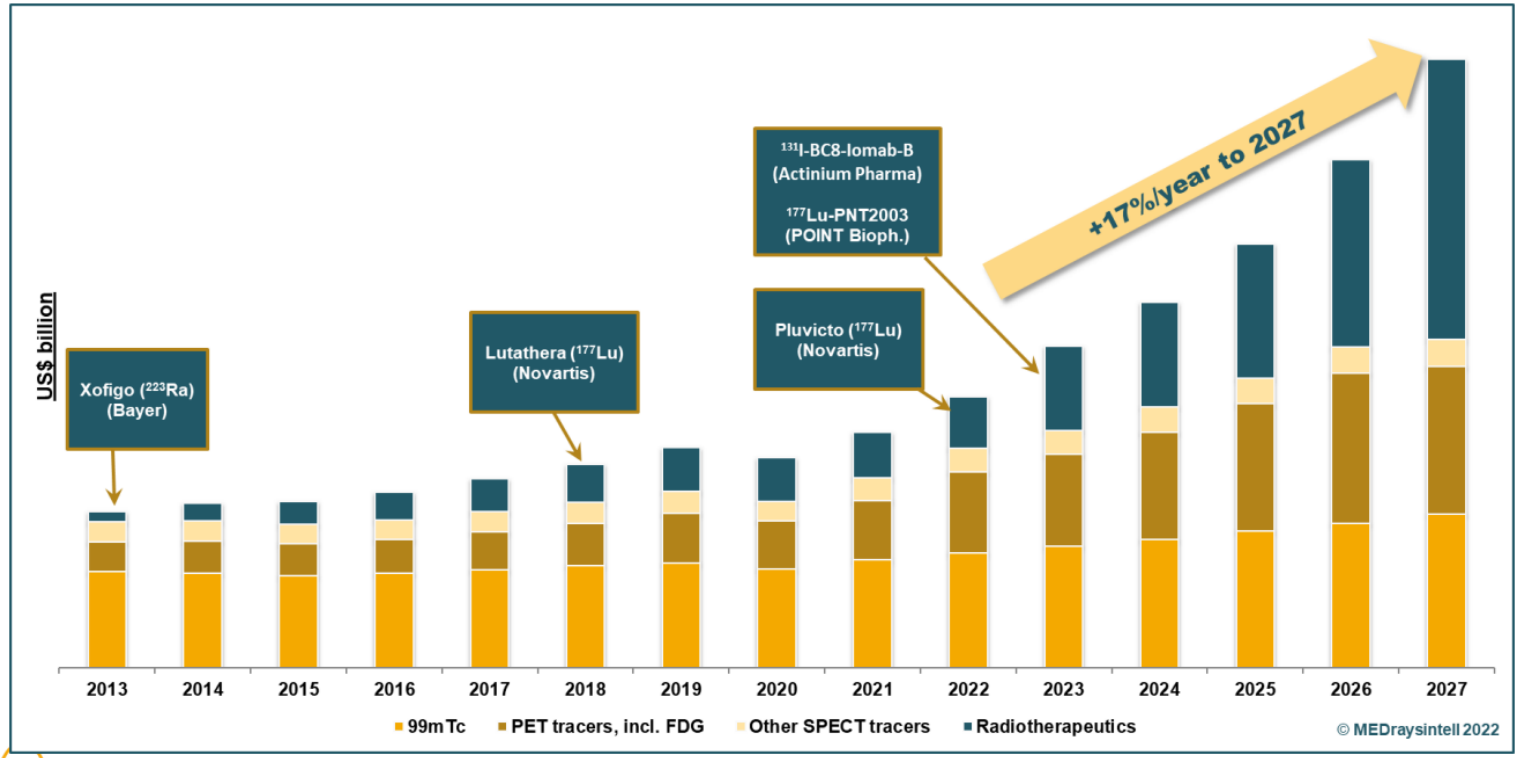
PSI

R. Eichler (LRC) for the IMPACT team

IMPACT-TATTOOS: Take radionuclide production and application at PSI to the next level

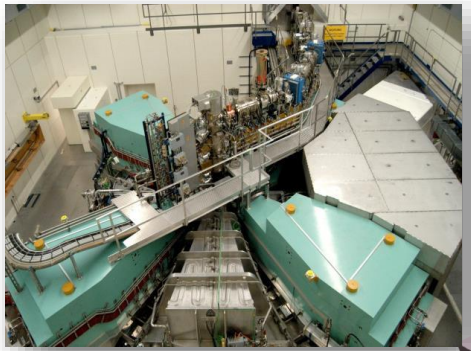
TATTOOS: Targeted Alpha Tumor Therapy and Other Oncological Solutions

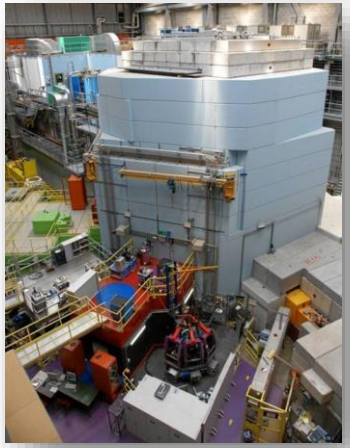
Radionuclides for radiopharmacy



MEDraysintell

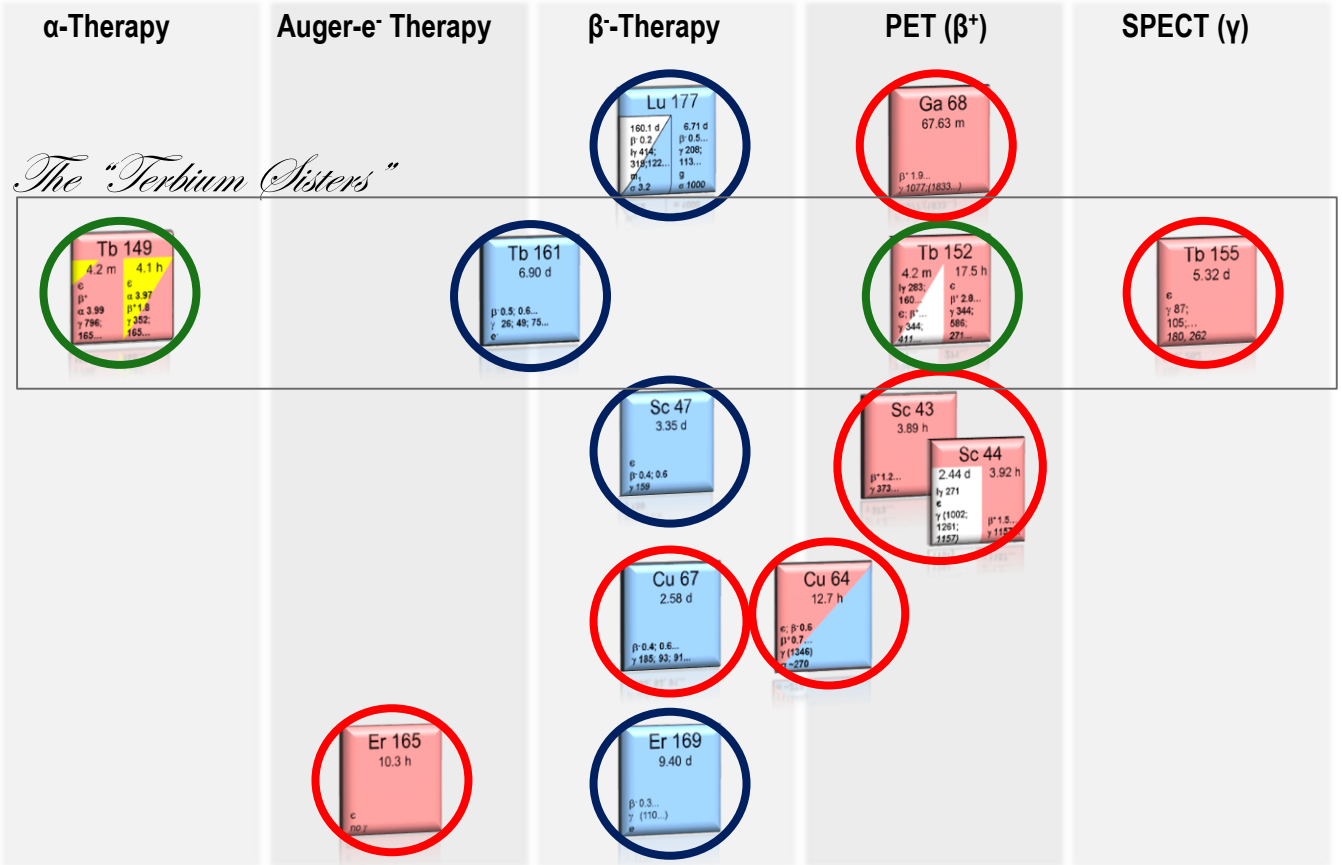
Current Isotope Production at PSI





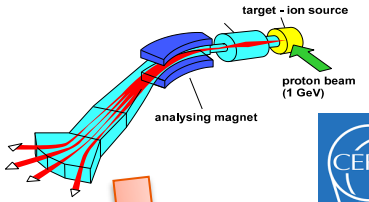
https://people.physics.anu.edu.au/~ecs103/chart3d/

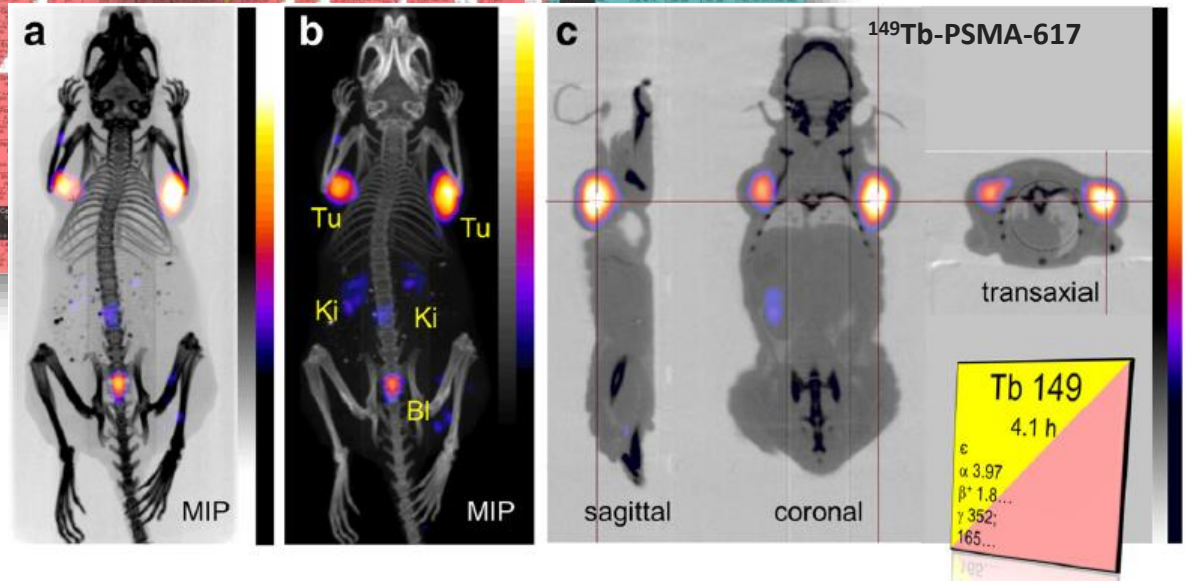
“Matched Pair” Radionuclides for Teragnostics



^{149}Tb: Progress So Far (CRS & LRC)

Isotope Separation Online (ISOLDE)





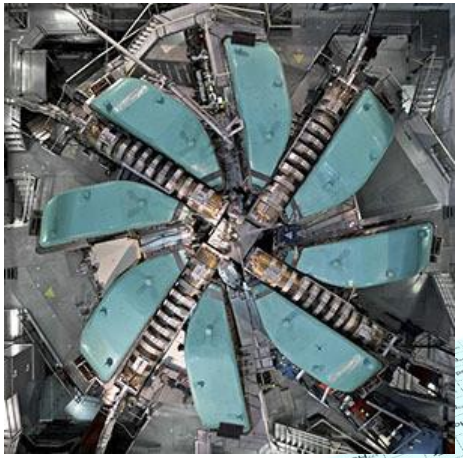
Umbricht et al. , Scientific Reports, 2019

Transport loss between Geneva and PSI: 50% → 100 MBq
→barely enough for preclinical (animal) studies

Preclinical Therapy Studies @ PSI

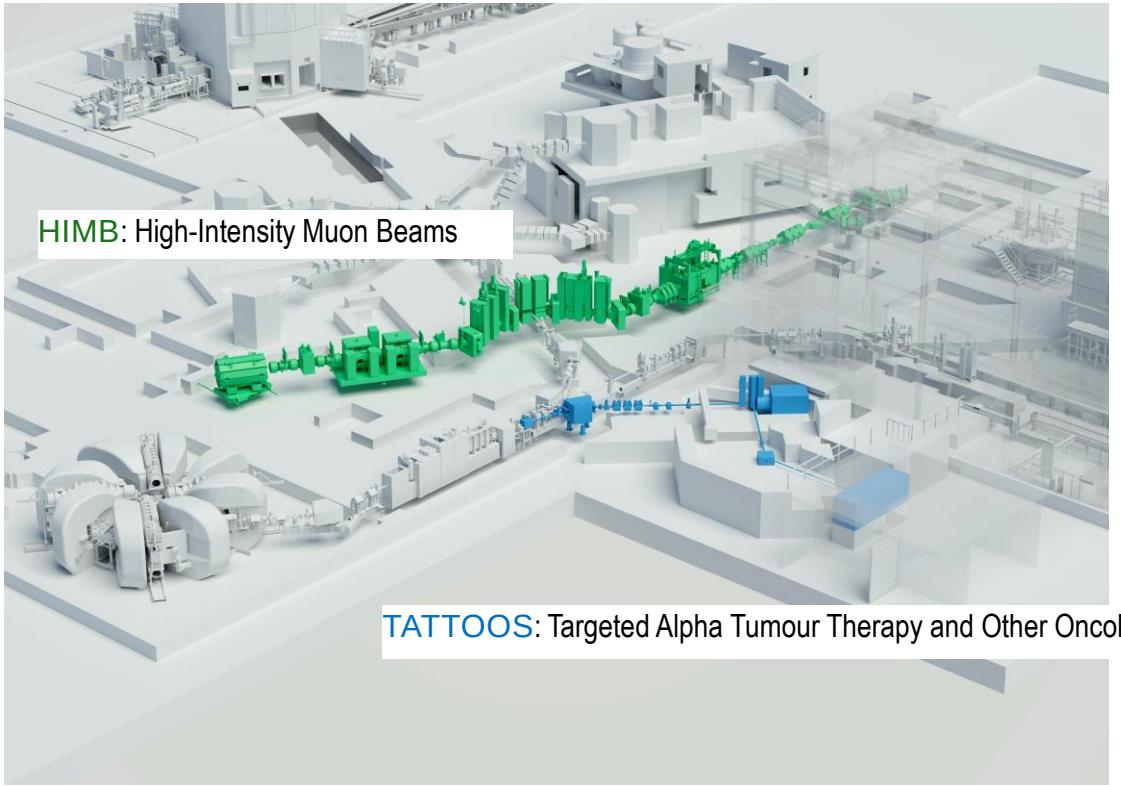
CRS & LRC: ^{149}Tb Production @ PSI-HIPA (50 fold beam dose (100µA))

^{181}Ta(p,10p & 20/23 n)^{149,152}Tb



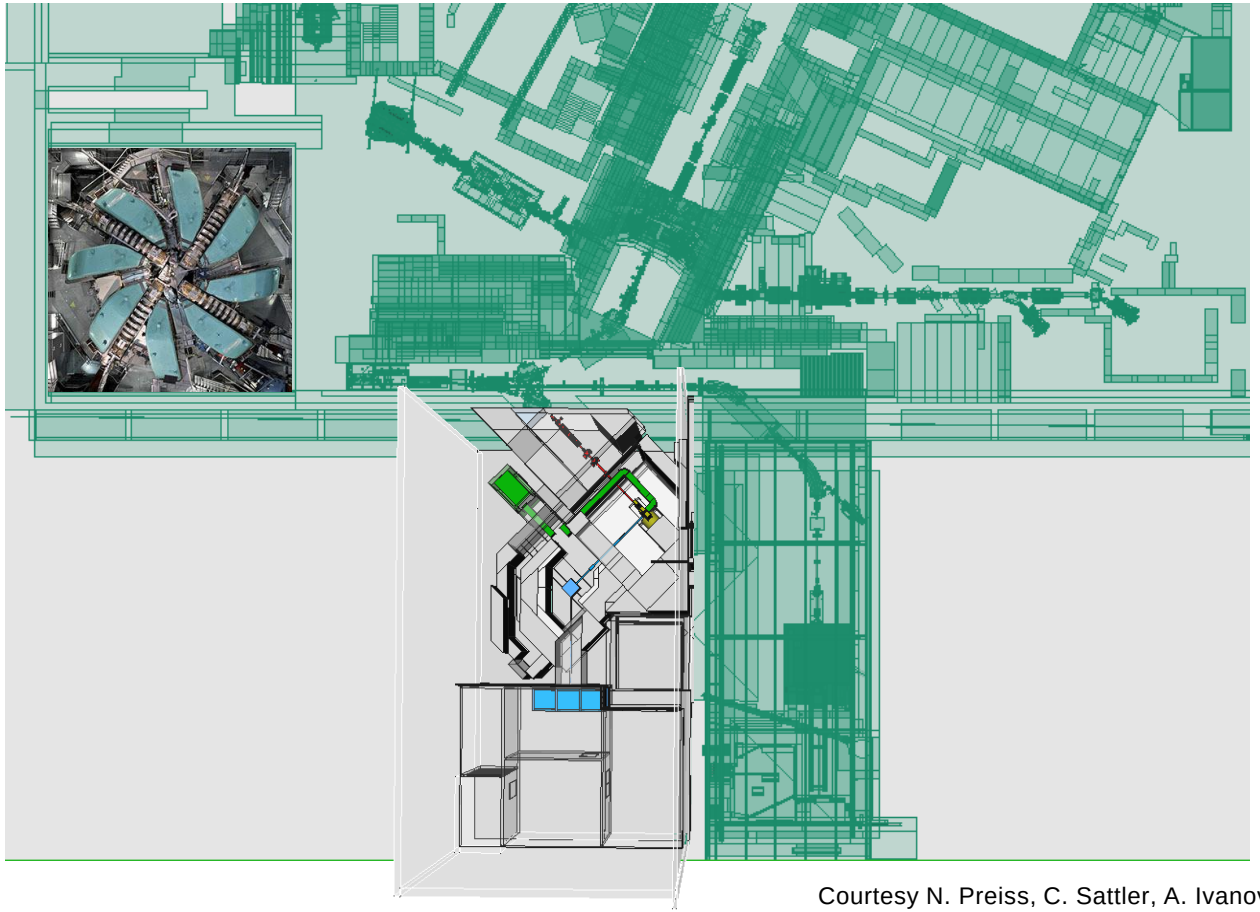
https://people.physics.anu.edu.au/~ecs103/chart3d/

The IMPACT Project



Courtesy M. Dezebegovich, C. Sattler, A. Ivanov et al.

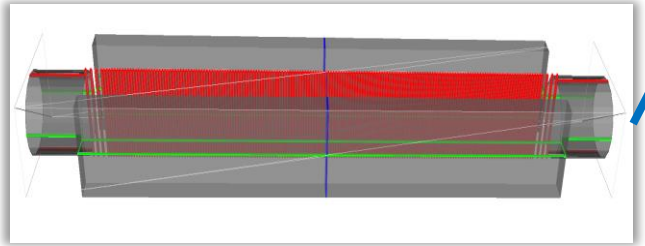
New TATTOOS Facility Design

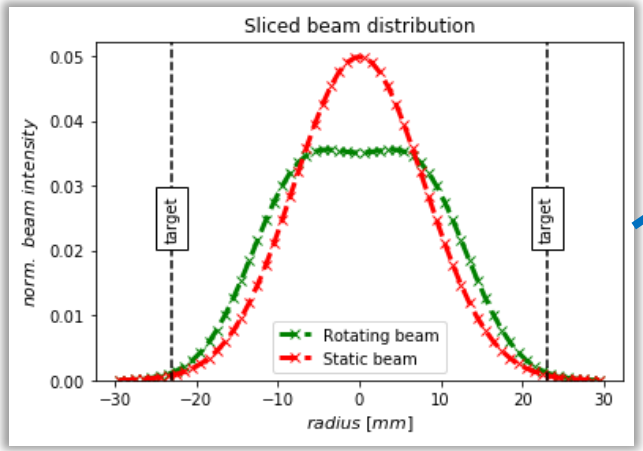


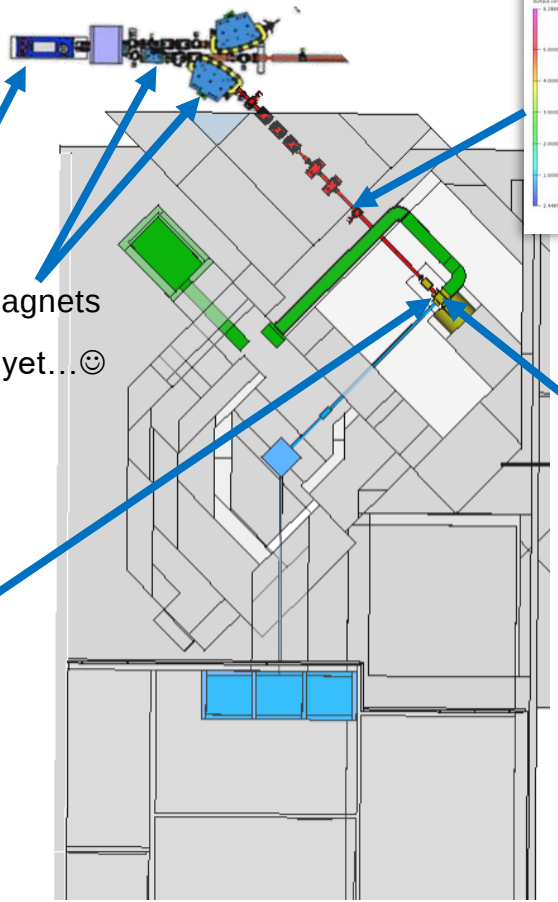
Courtesy N. Preiss, C. Sattler, A. Ivanov et al.

Beam

Beam splitter for 100 µA 590 MeV p

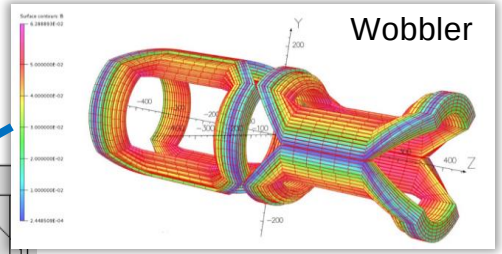




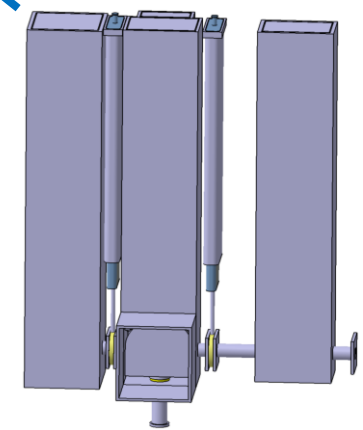


2 Magnets

not yet…☺

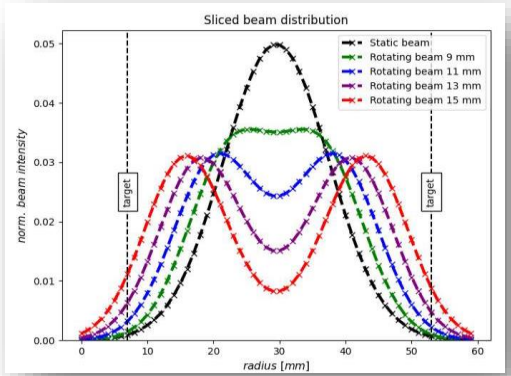


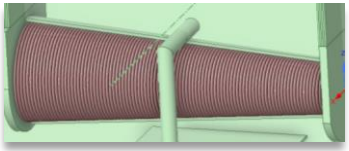
Exchange flasks

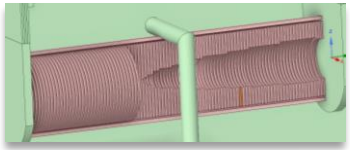


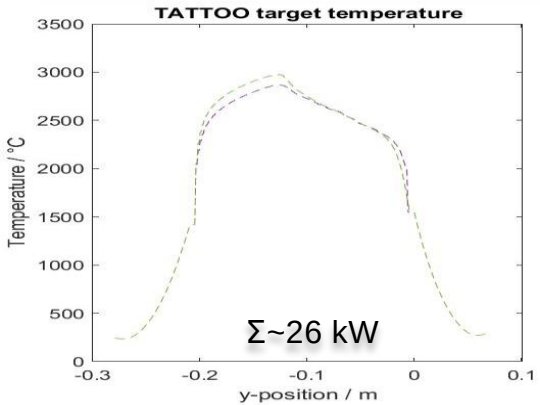
Courtesy D. Reggiani, J. Snuverink, R. Martinie, M. Hartmann, C. Sattler, A. Ivanov et al.

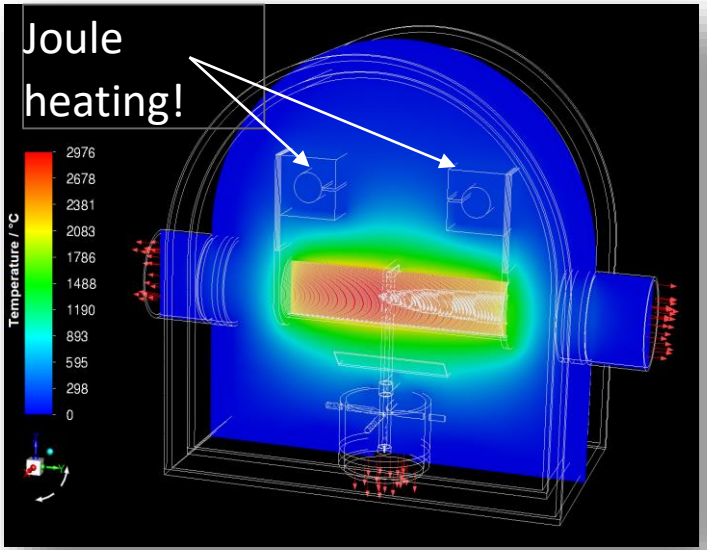
High power Target optimization







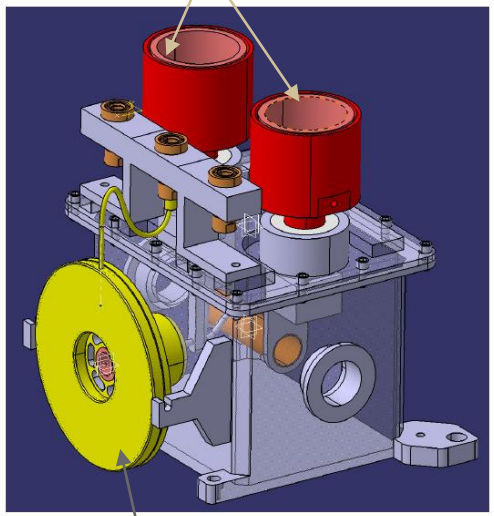


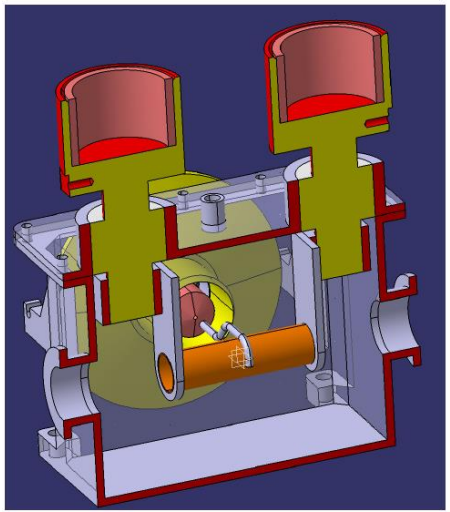


Courtesy S. Jollet, A. Ivanov et al.

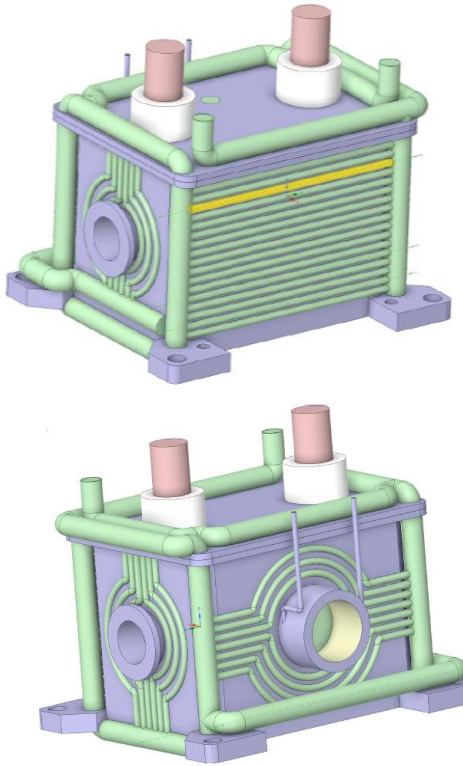
Target Chamber Design and Cooling

6000A Connectors



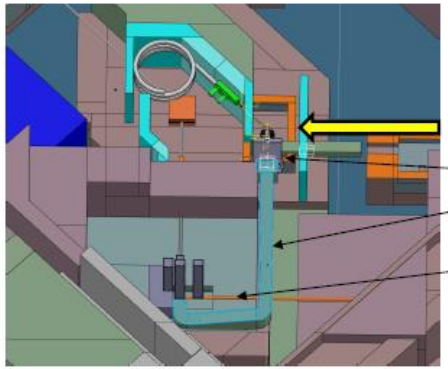


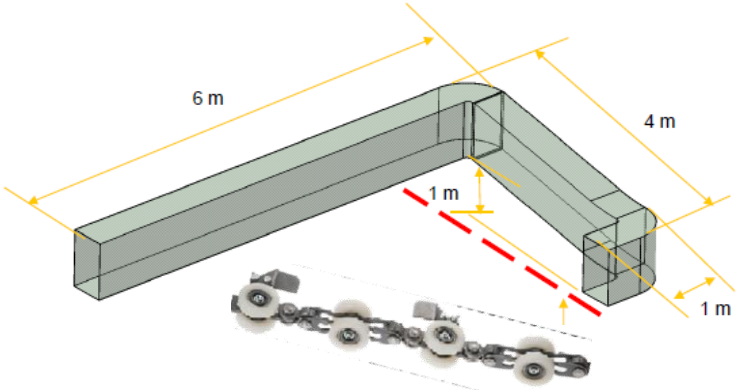
Pillow seal

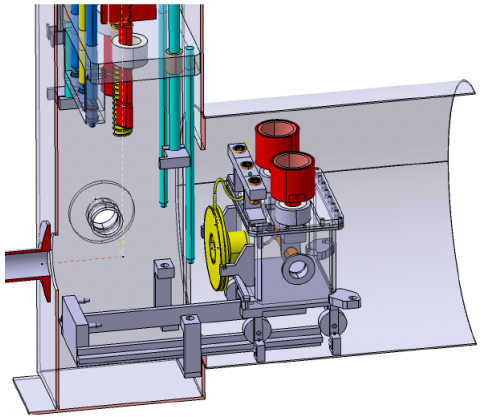


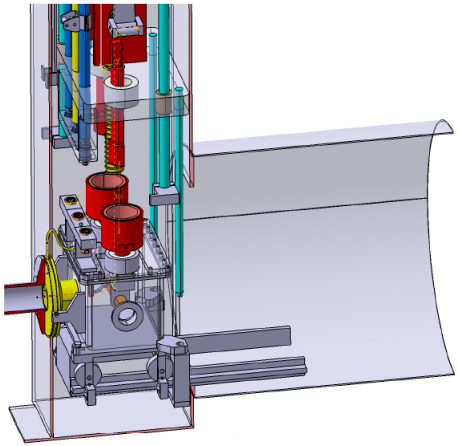
courtesy U. Wellenkamp, S. Jollet, D.Laube

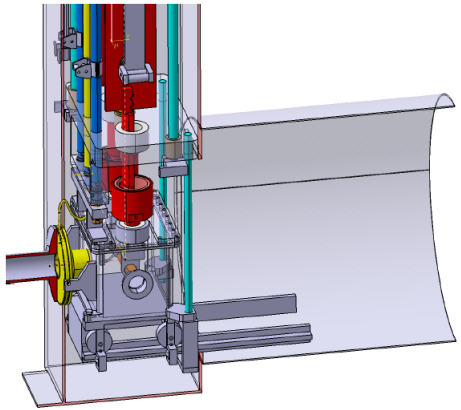
Overall view TATTOOS Target exchange







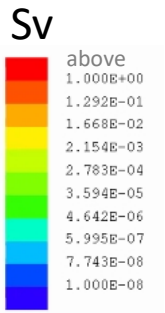




Courtesy U. Wellenkamp, A. Ivanov, D. Laube

In-situ Dose & Shielding Target

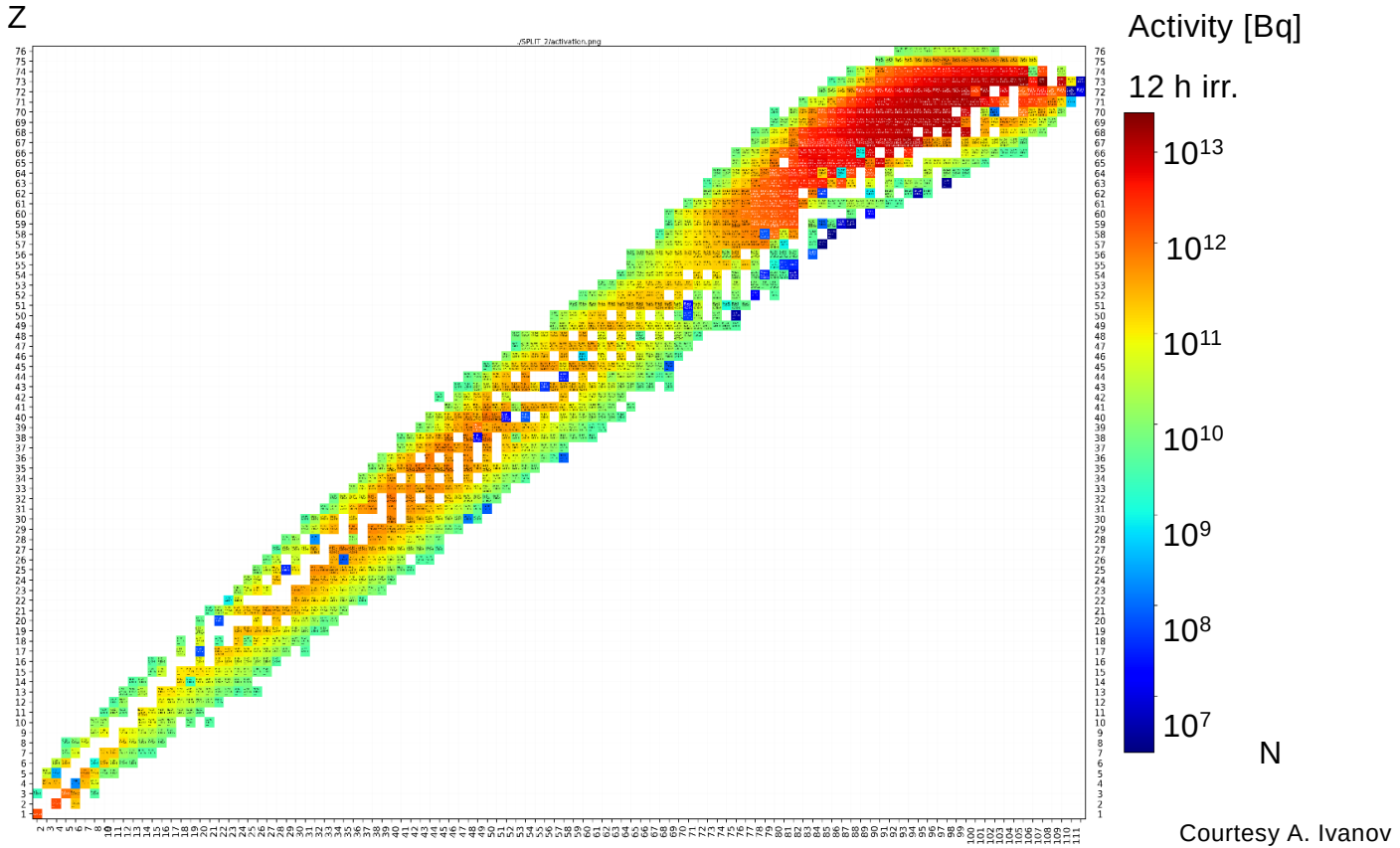
Gamma



Neutrons

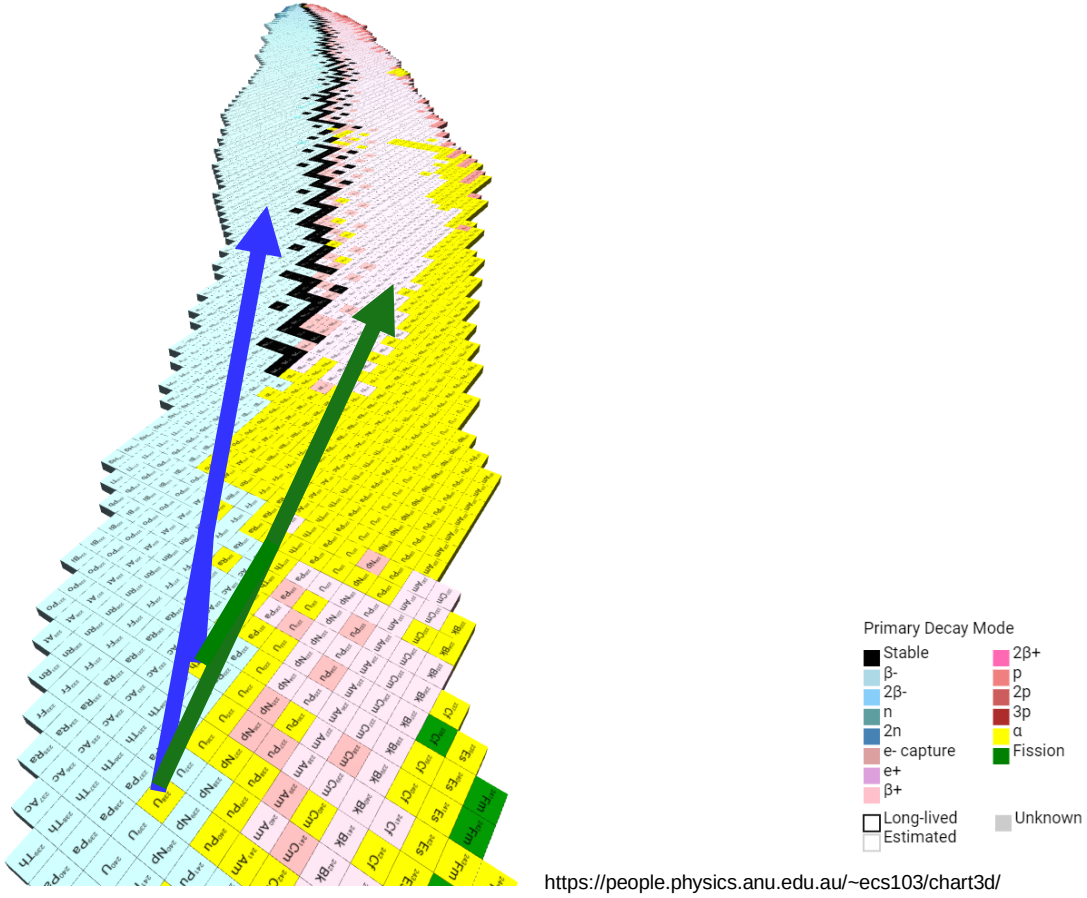
Courtesy A. Ivanov

Production of Radionuclides in Spallation of Ta



Courtesy A. Ivanov

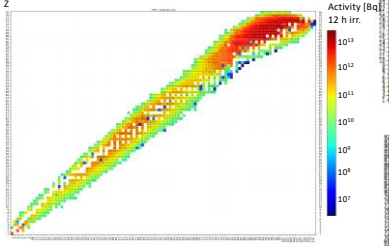
Production of Radionuclides in Spallation of U/Th

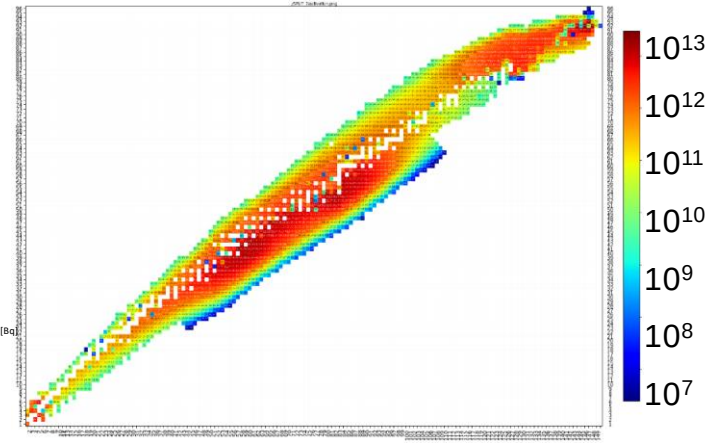


https://people.physics.anu.edu.au/~ecs103/chart3d/

Production of Radionuclides in Spallation of U/Th

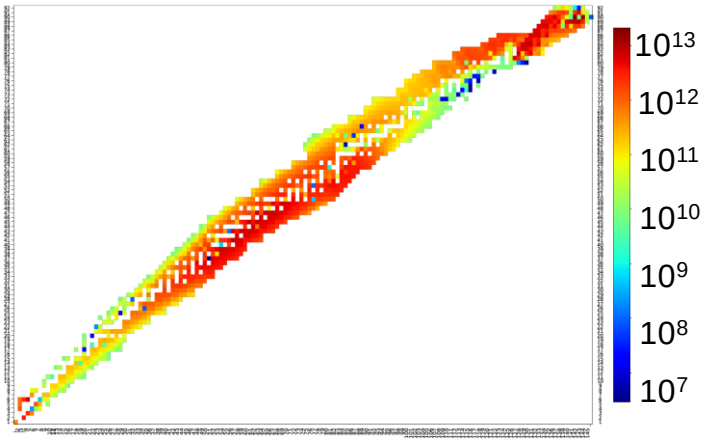
Tantalum





Activity [Bq]

6 d irr. **Uranium**



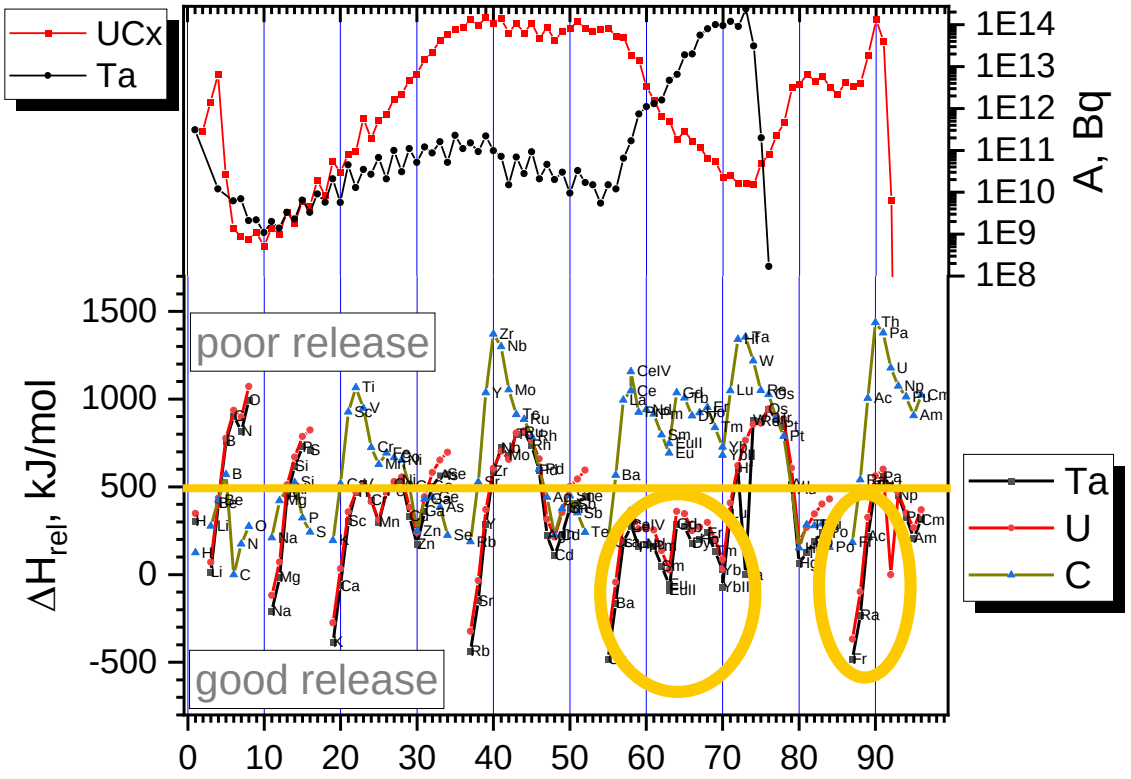
Activity [Bq]

6 d irr. **Thorium**

>50% of known radionuclides assessable!

Courtesy A. Ivanov

Production vs. Atomic Release from Target

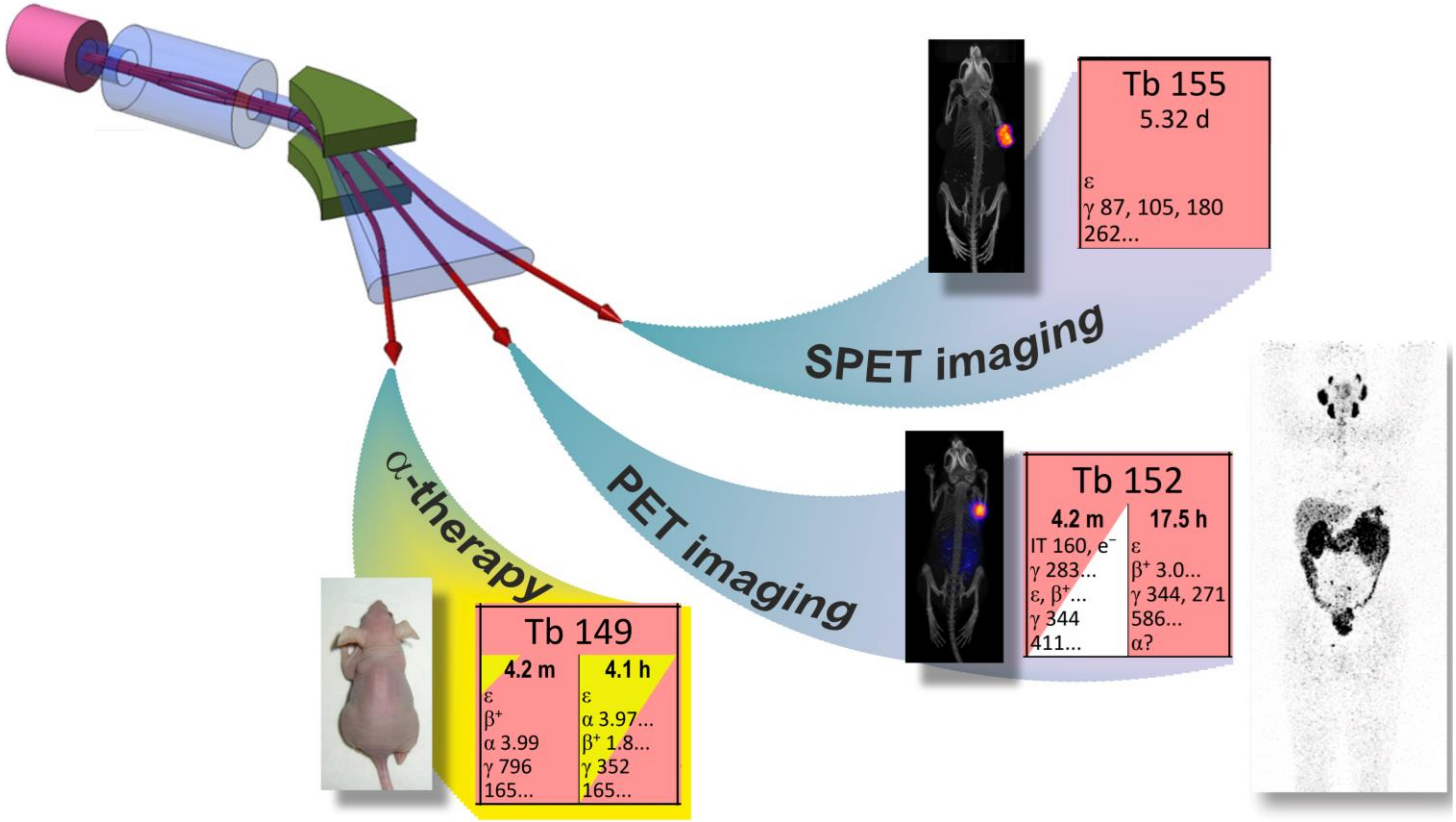


MIEDEMA calculations

Adsorption data of lanthanides on Ta

work in progress JAEA/PSI.

Mass separation under design



Support by Stuart Warren (PSI)

Ionization

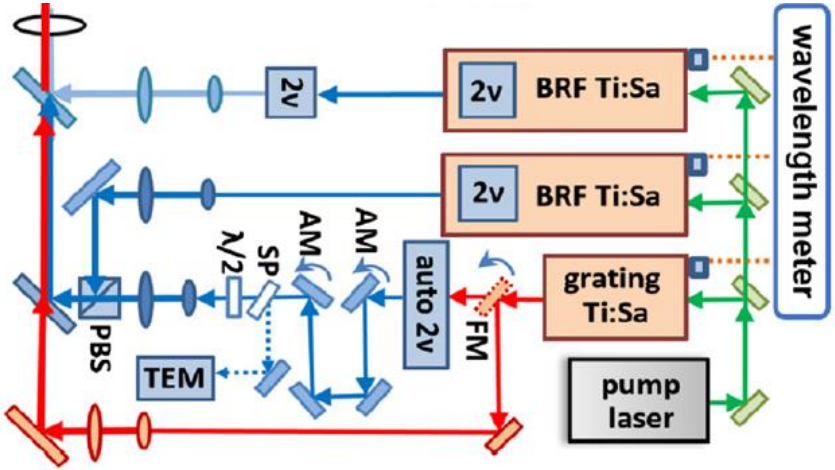
Non-specific:

Surface Ionization

(Saha-Langmuir) Ip<6 eV

Specific:

RILIS-like



Phys. Scr. 85 (2012) 058104

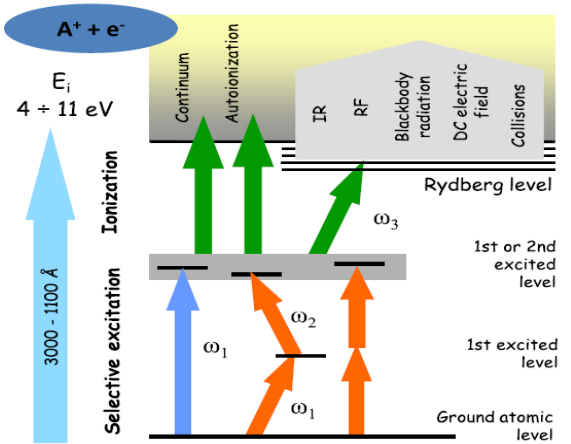


Figure 1. Schemes of resonance ionization.

IOP PUBLISHING PHYSICA SCRIPTA
Phys. Scr. 85 (2012) 058104 (14pp) doi:10.1088/0031-8949/85/05/058104

Resonance laser ionization of atoms for nuclear physics

V N Fedosseev[1], Yu Kudryavtsev[2] and V I Mishin[3]

doi:10.1088/0031-8949/85/05/058104

Hyperfine Interactions (2020) 241: 22
https://doi.org/10.1007/s10751-020-1694-4

Recent RILIS developments at the TRIUMF offline laser ion source test stand

Check for updates

Ruohong Li[1] · Maryam Mostamand[1,2] · Jekabs Romans[1,3] · Bianca Bettina Reich[1,4] · Jens Lassen[1,2]

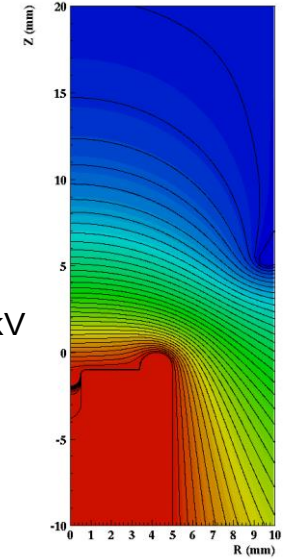
Published online: 10 February 2020

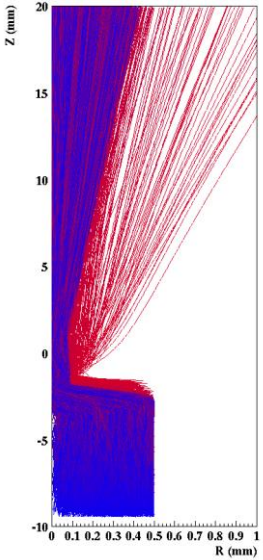
Stability of the laser :

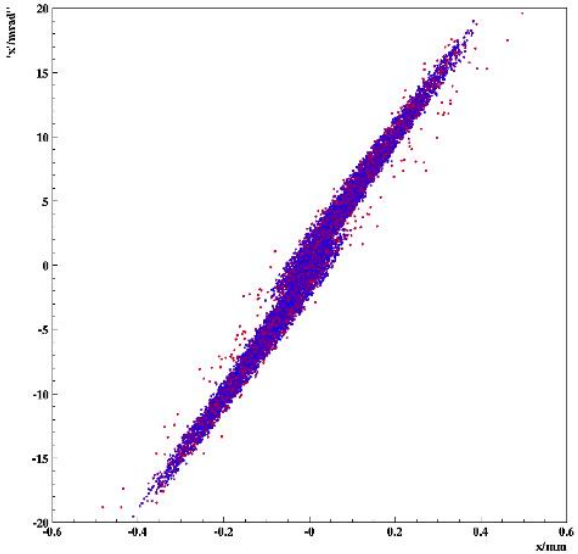
- temperature stabilization to +/- 0.2 C.
- laser cleanroom: A dust free operation environment

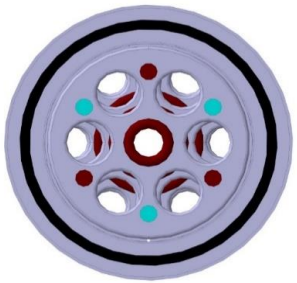
Extraction of Ions

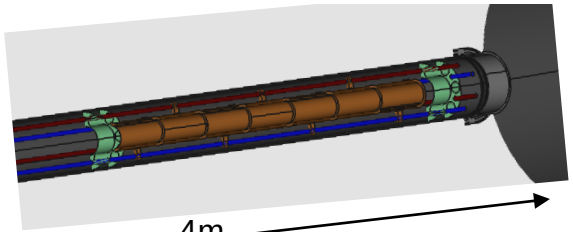
35 kV









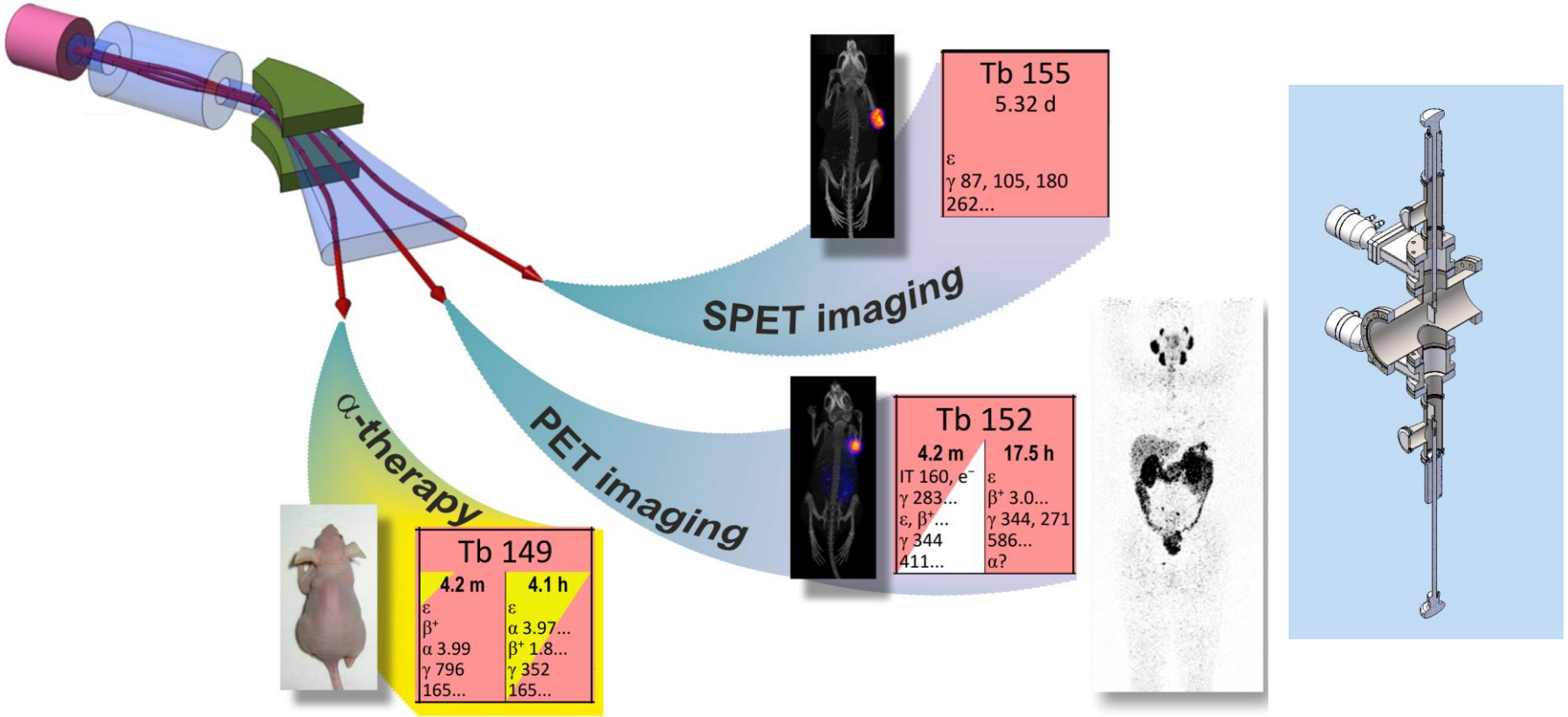


4m

Einzellenses (6kV) / HV-Quadrupoles and HV steerer

Courtesy H. Zhang,C. Baumgarten, D. Herrmann

Mass separation and sampling



Courtesy Nick van der Meulen, D. Herrmann

Collection & Radiochemistry

IMPACT: TATTOOS collaborations 2022

- ISAAC TRIUMF… Collaboration established in 2022/ MOU will be discussed in April 2023 in Vancouver

- CERN-ISOLDE… MOU to be signed in 02/23 : PSI Part of ISOLDE Collaboration (60 kCHF/a)

- CERN-MEDICIS…PSI Partner since 2017 (20 kCHF/a)

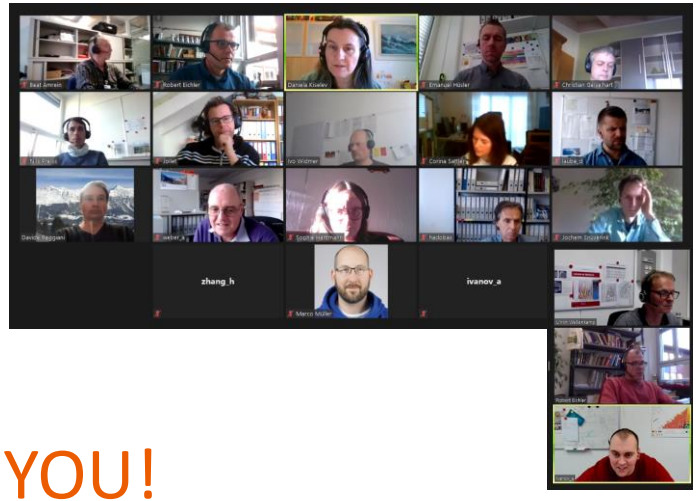
TATTOOS EAB as of 2023

TATOOS	Expertise
Klaus Wendt, Prof. Uni Mainz	RILIS (Resonance Ionization Laser Ion Source)
Ulli Köster, ILL	ISOL und Massenseparation
Alexander Gottberg, TRIUMF	Target & Handling, Accelerator, ISOL
Mikael Jensen, DTU	Radionuclide development
Richard Baum, Wiesbaden	Nuclear medicine, Theranostik

Many topics not addressed here with pictures

- Dose to personnel & shielding
- Ventilation design & filtering
- Aqueous waste disposal & cooling water
- Target disposal
- Construction & Design
- Risk management

•••



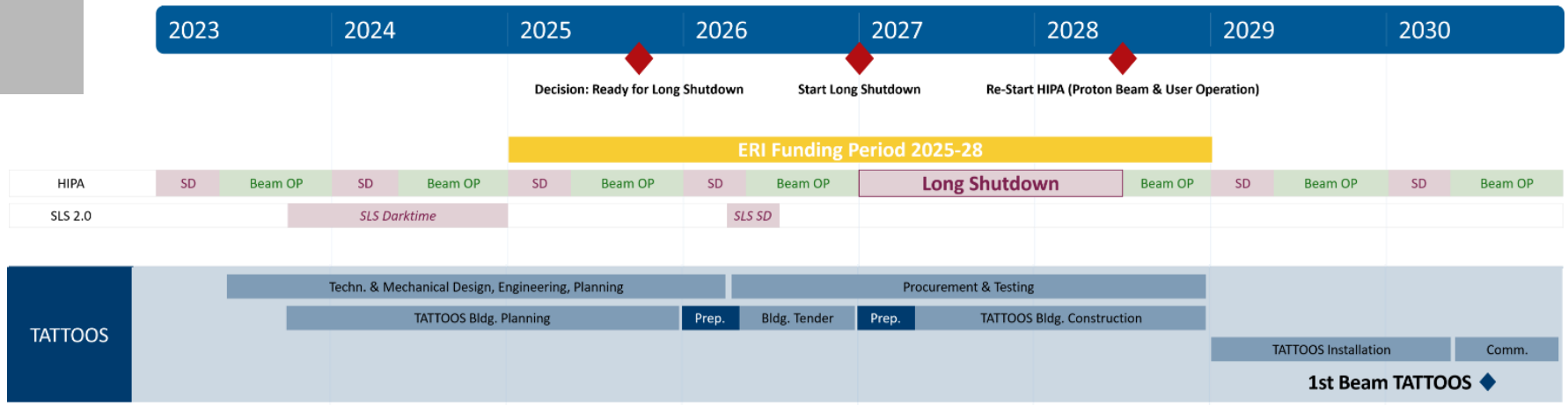
Big THANK YOU!

C. Schmid, N. Preiss, S. Harzmann, A. Weber, J. Hadobas, S. Staudenmann,

P. Meier, T. Stapf, A. Gabbard, E. Hüsler, L. Pedrazzi, E. Hartmann, E. Zehnder, W. Rendler …

and their teams!

Timeline TATTOOS



More time but still challenging!

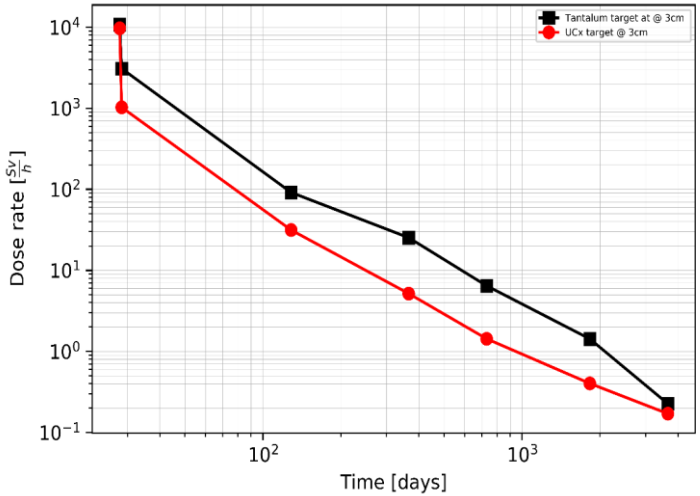
TATTOOS is Part of the 60 MCHF-IMPACT Proposal accepted by SNF & ETH-Rat to be included in Roadmap of Swiss Research Infrastructures in 2023

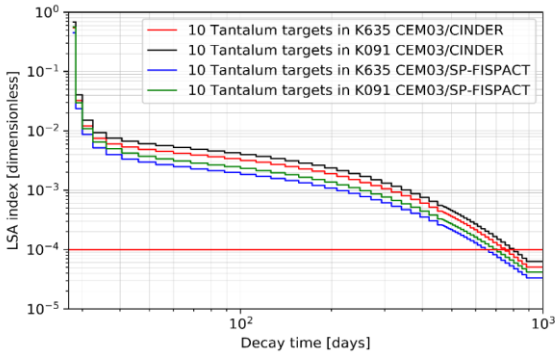
How Much ^{149}Tb Can Be Made @ PSI?

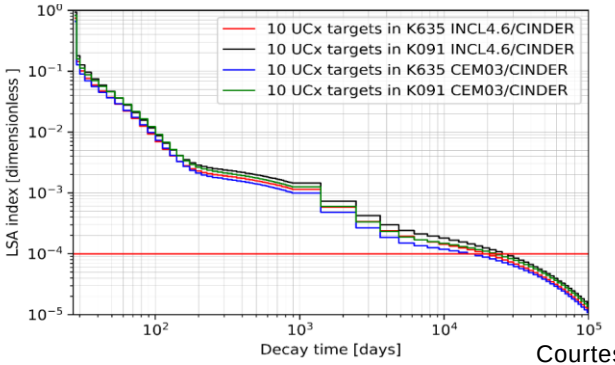
Radionuclide Produced				CERN 2uA 600MeV	TATTOOS 100uA 590MeV*	Calculated patient doses
Element	Mass number	Target material	$T_{1/2}$	Irradiation time: 12h	Irradiation time: 6d	
					GBq**	
Tb	***149***	***Ta***	***4.118 h***	***0.375***	***21***	*No reference*
Tb	***152***	***Ta***	***17.5h***	***0.038***	***5***	*No reference*
Tb	***155***	***Ta***	***5.32d***	***0.006***	***3***	*No reference*
Tm	*165*	*Ta*	*30.06 h*	*0.532*	*106*	*No reference*
Er	*165*	*Ta*	*10.36 h*	*0.662*	*60*	*No reference*
Ac	***225***	***UCx***	***9.92d***	***0.021***	***10***	***Ca. 1'300***
Ra	225	UCx	14.9d	0.014	7	Ca. 700
Ac	***225***	***ThCx***	***9.92d***	***0.024***	***12***	***Ca. 1'500***
Ra	225	ThCx	14.9d	0.012	6	Ca. 800
Rn	*211*	*ThO2*	*14.6h*	*0.139*	*12*	*Ca. 50*
Ra	***223***	***ThCx***	***11.43d***	***0.036***	***19***	***Ca. 4'500***

* theoretical calculations; ** assuming ISOLDE yields

Storage and Disposal TATTOOS targets







Courtesy A. Ivanov