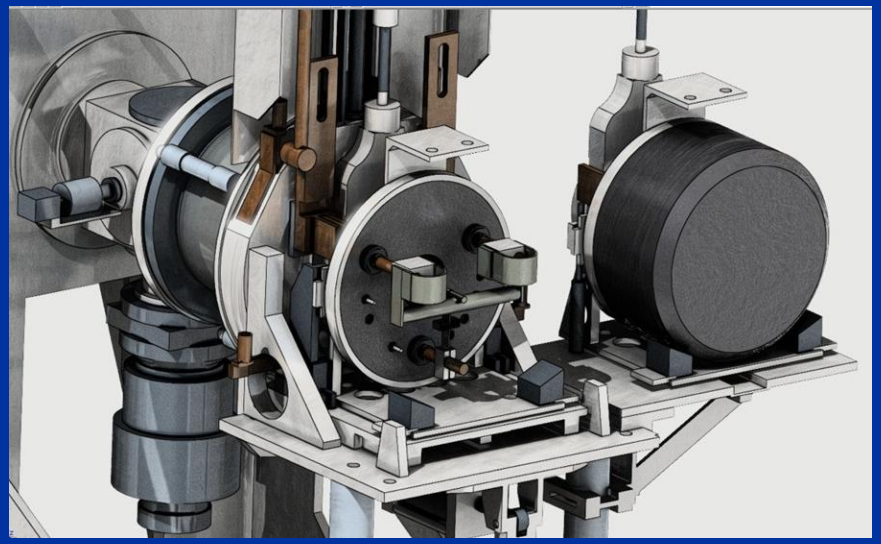


Radionuclide production by mass separation at CERN-MEDICIS for biomedical research and the PRISMAP European program

PhD Edgars MAMIS, CERN, SY-STI-RBS

On behalf of the MEDICIS local team, collaboration and all contributors

December 2025

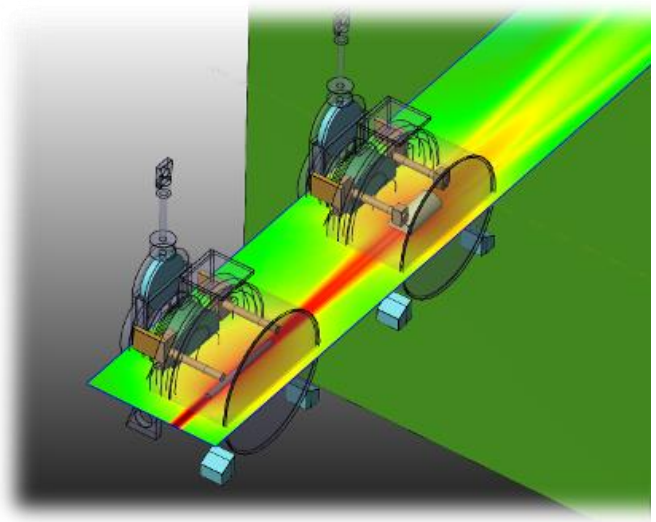
ISOLDE Workshop and Users meeting 2025

CERN-MEDICIS – synergy with ISOLDE

- **Special thanks to ISOLDE team for the support to a "new coordinator" !**

- **MEDICIS** was always taken into consideration
- **MEDICIS** collected samples measured at ISOLDE **in 2025** and **in LS-3** (Victoria Vedia @IDS)

- **Sharing**:
  - Protons
  - Targets (new and used)
  - Irradiation at HRS
  - KUKA robot
  - Experience (e.g. external samples)



Schedule 2025: weeks 13 - 23
Version: 25/02/2025 by H. Heylen and C. Duchemin

By C. DUCHEMIN 18/02/2025

GPS Physics	Target change	Stable
HRS physics	Pre-irradiation	

HRS indirect	External source
HRS direct	GPS ISIS

Production
Development

March

			GPS	HRS	RILIS	MEDICIS	MELISSA
	Sa	1					
	Su	2					
10	Mo	3					
	Tu	4					
	We	5					
	Th	6					
	Fr	7					
	Sa	8					
	Su	9					
11	Mo	10					
	Tu	11					
	We	12					
	Th	13					
	Fr	14					
	Sa	15					
	Su	16					
12	Mo	17					
	Tu	18					
	We	19					
	Th	20					
	Fr	21					
	Sa	22					
	Su	23					
13	Mo	24					
	Tu	25	#883-UCx-n-MK1				
	We	26					
	Th	27					
	Fr	28	IS771 - 83-85Ga		Ga		
	Sa	29					
	Su	30					
14	Mo	31		#892-ZrO2-MK1			

April

			GPS	HRS	RILIS	MEDICIS	MELISSA
14	Tu	1					
	We	2				#886M-Ta-VD5 HIGH tr.	
	Th	3		IS767 - 61-63Ga - TAS	Ga	Indirect #886M HIGH trolley	
	Fr	4					
	Sa	5					
	Su	6					
15	Mo	7				Recuperate #886M	
	Tu	8					
	We	9					
	Th	10		#893-CaO-VD7		Direct possible	
	Fr	11	IS630,670,681,683,7 49,751,754,755 - 57Mn, 119In - GLM		Mn	TBC	Tb
	Sa	12					
	Su	13					
16	Mo	14					
	Tu	15					
	We	16		IS678 - 32Ar - WISArD	In		
	Th	17					
	Fr	18					
	Sa	19					
	Su	20					
17	Mo	21					
	Tu	22	*TBC-IS673-119In-GLM*	#894-UCx-VD7	In	#880M-ThC-Re HIGH tr.	Laser dev.
	We	23	Cold irradiation				
	Th	24		IS766 - 49,50Ar - ISOLTRAP		Indirect #880M HIGH trolley	
	Fr	25					
	Sa	26					
	Su	27					
18	Mo	28	#891-UCx-n-MK1				
	Tu	29				Recuperate #880M - send sample holder	Ra
	We	30	IDS				

May

			GPS	HRS	RILIS	MEDICIS	MELISSA
18	Th	1					
	Fr	2	IS705 - 135In - IDS	#862-Ta-LIST	In	Direct possible - TBC	Ra
	Sa	3					
	Su	4					
19	Mo	5					
	Tu	6					
	We	7					
	Th	8				#848M-ThC-RE HIGH tr.	
	Fr	9		IS740 - 150-152Tm - COLLAPS	Tm	Indirect #848M HIGH trolley	
	Sa	10					
	Su	11				Recuperate #848M	
20	Mo	12	7Li - VITO		In		
	Tu	13	*TBC-IS673-130In-GLM*			#885M-Ta-Ta LOW tr.	Cu
	We	14					
	Th	15		IS770 - Pm - IDS/in-source	Pm	Direct 1 uA max.	
	Fr	16	#897-ThCx-MK1			Indirect #885M HIGH trolley	
	Sa	17					
	Su	18					
21	Mo	19				Recuperate #885M ASAP!	
	Tu	20				Send sample holder	Tm
	We	21	IS715 + LOI281, 229-231Fr, 229-231Ra, GLM/GHM/LA1				
	Th	22					
	Fr	23		TBD - target change			Dev. Run
	Sa	24					
	Su	25					
22	Mo	26					
	Tu	27					
	We	28		CRIS		#880M-ThC-Re HIGH tr.	
	Th	29	*TBC - IS668 - GLM/GHM*				
	Fr	30		IS759 - 45-48 Ar - CRIS		Indirect #880M - HIGH tr.	
	Sa	31					

June

			GPS	HRS	RILIS	MEDICIS	MELISSA
	Su	1		IS759 cont.		Indirect #880M	
23	Mo	2	TBD - target change				
	Tu	3				Recuperate #880M	
	We	4					Ra
	Th	5					
	Fr	6	IS764 - 8Li - VITO				
	Sa	7					
	Su	8					
24	Mo	9					
	Tu	10					

MEDICIS team is growing larger and stronger!

This year:

- We welcome 2x next generation members ;)
- A new MEDICIS machine supervisor from RP team
- A new RP team member
- Support from 3 + 2 PhD students - Patrīcija, Lisa, Ralitsa, Elise and Laurine

CERN-MEDICIS
KPI DASHBOARD 2025

TARGETS
11 new targets built
8 reused from previous years

ACTIVITY
3.04 GBq collected total
1.32 GBq from CERN produced
1.72 GBq from External sources

EFFICIENCY
Up to 72% (for Ra-225 in 2024)

PROTONS ON TARGET
(excluding external sources)
4.77E19 (so far)
2.25E19 from direct irradiations

DISPATCH TO PARTNER INSTITUTES
20 radioactive transports + 3 more pending

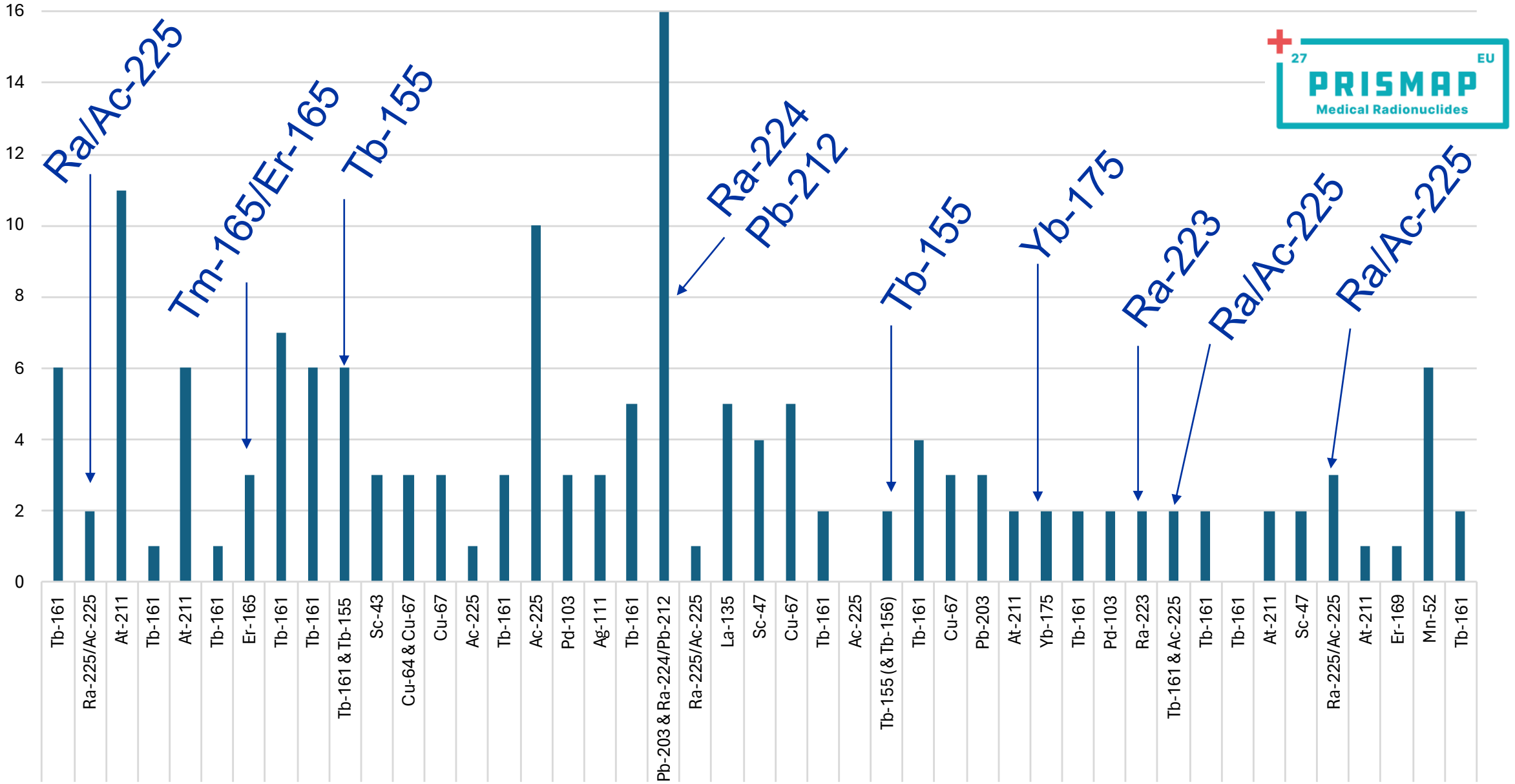
DOSE EXPOSURE
Maximum 224 μSv individual
612 μSv collective over the year

CERN-MEDICIS – deliveries done in 2025 (so far)

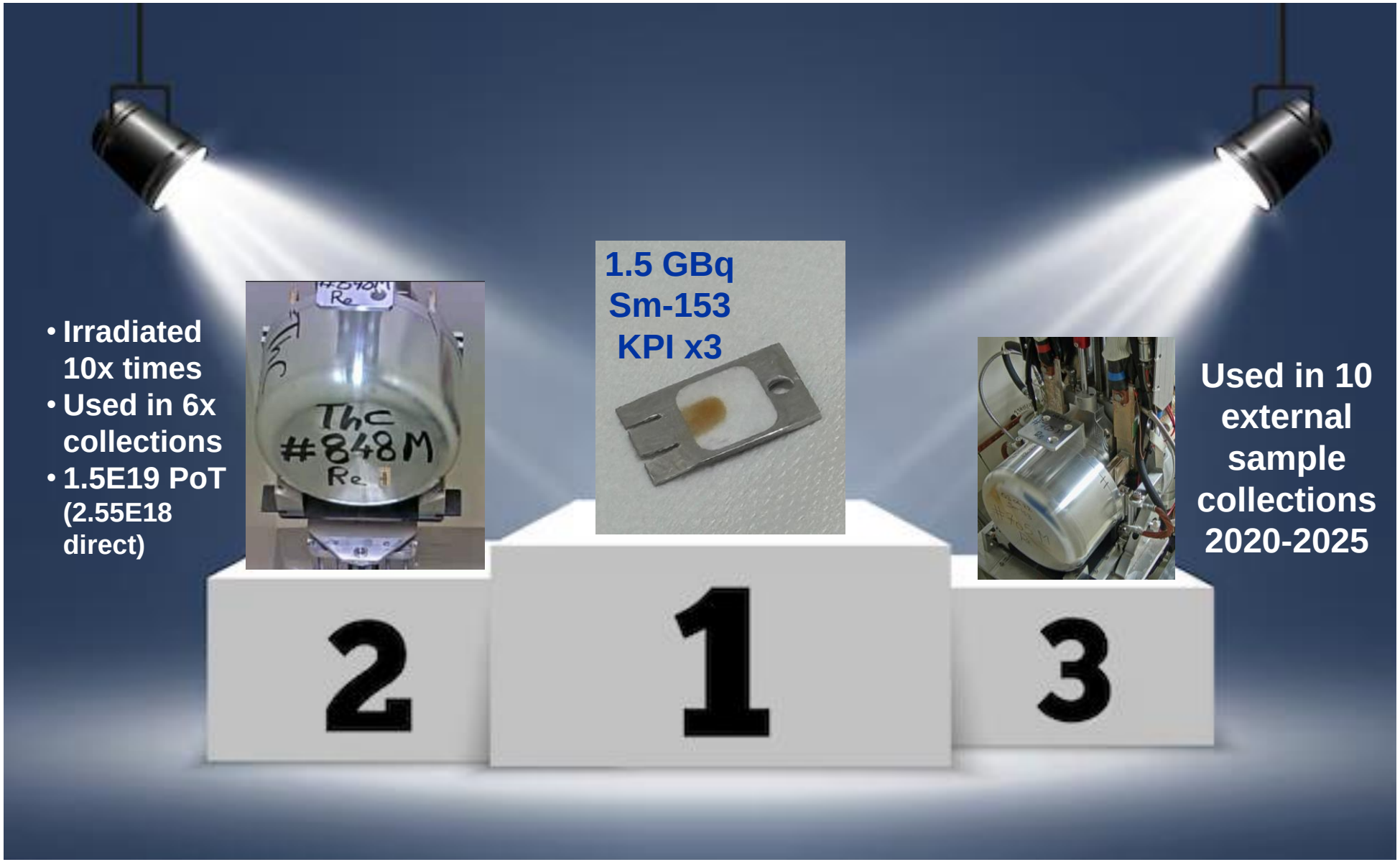
- **Ra/Ac-225** delivery (x7) for both PRISMAP and MEDICIS
  - As far as Belgium, Czech Republic, USA or Pakistan
- **Ra-224** delivery (x3) for PRISMAP User (Call 4)
- **Ra-223** delivery (x2) for PRISMAP User (Call 5)
- **Yb-175** delivery (x1) for PRISMAP User (Call 5)
- **Tb-155** delivery (x2) for CHUV and NPL
- **Gd-149** delivery (x1) for NPL
- **Tm-165** delivery (x1) for PRISMAP User (Call 1)
- **Sm-153** delivery (x1) for advancement of clinical applications
- **Sc-47** delivery *pending* (x1) for UoL

- **RTU (LV)** delivery to **K-43 @MEDICIS** (x1)
- **NPL (UK)** delivery to **Tb-149 @MEDICIS** (x2)
- **NPL (UK)** delivery to **Ac-226 @MEDICIS**(x1)
- **HUG (CH)** delivery to **Ac-225 @MEDICIS** (x1)
  - Olivia Bejuy PhD on Ac radiochemistry

Dispatch of radionuclides across projects in Europe (and beyond)

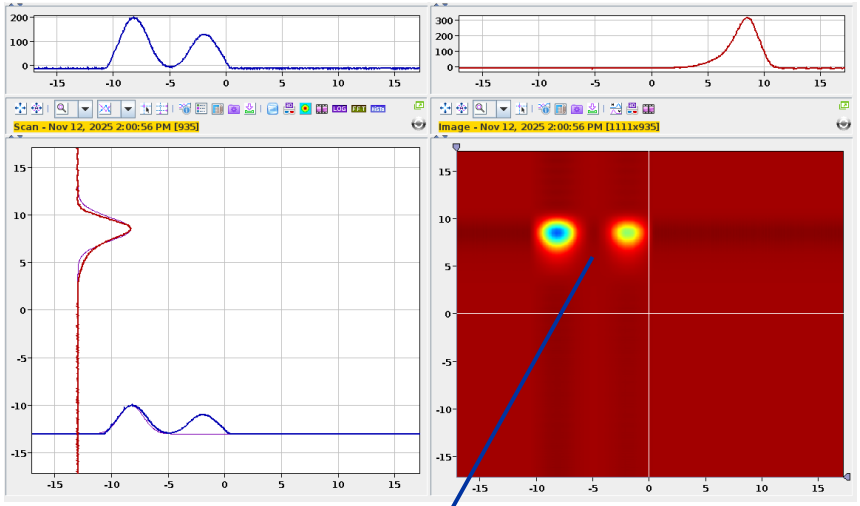


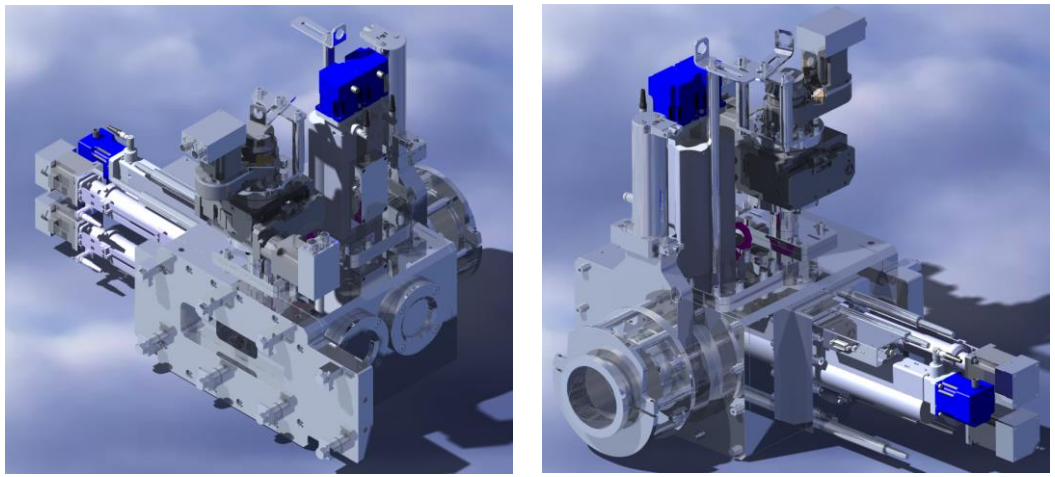
Some honourable mentions of this year

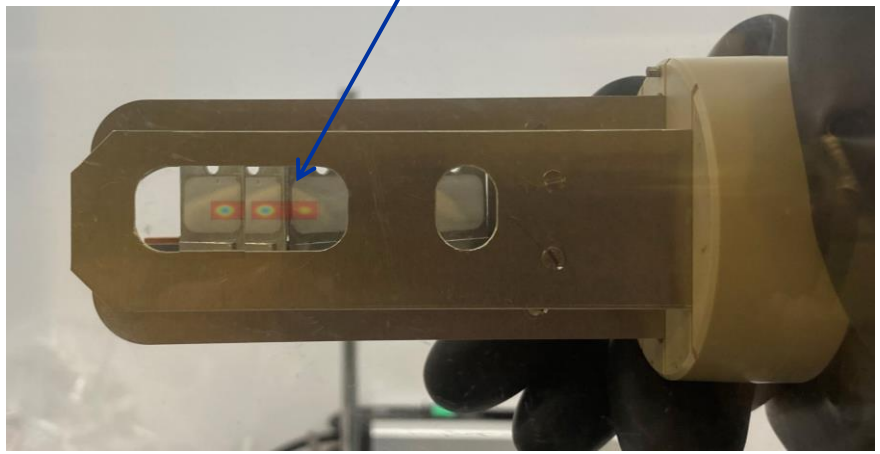


Ra-223/224/225 mass separation and collection

- **324 MBq** of Ra-225 and **673 MBq** of Ra-224 collected this year
- Laser ionization scheme developed by the MELISSA team to enhance the efficiency (see **Anjali Ajayakumar** talk later)
- **12x** (in 2024) and **10x** (in 2025) sample deliveries
- New supplier for ThO_2 to produce the ThC (1x every 10-20 years)
  - Material commissioning and testing with irradiated targets
- Prospects for a **triple-beam collection**
- **Change of the diagnostic box**







Courtesy of S. Sorlut (SY-STI-TCD)

Marc Pretze: $^{203/212}$Pb-mcp-D-PSMA for an improved tumor therapy: Preclinical evaluation, automatization and translation to clinical application.

[^{203}Pb]Pb-mcp-alb-PSMA
1 h – 7 d p.i.

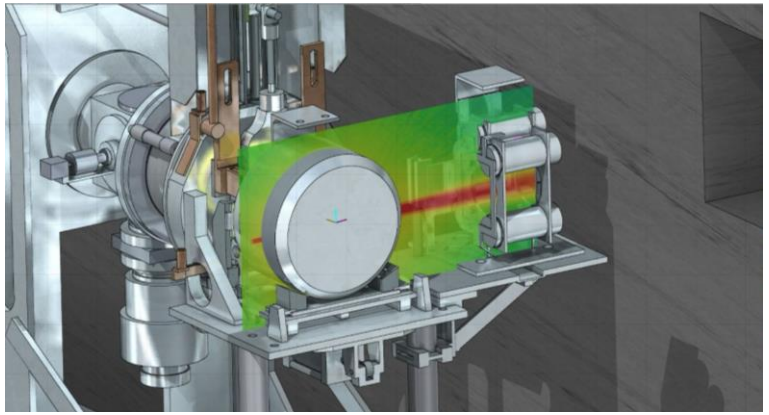
Therapy study with
[^{212}Pb]Pb-PSMA-617,
[^{212}Pb]Pb-mcp-D-PSMA (FR56),
[^{212}Pb]Pb-mcp-alb-PSMA (FR94) and saline
(800 kBq per animal)

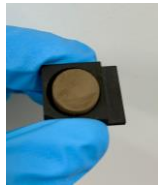
[^{203}Pb]Pb-mcp-D-PSMA
25 h p.i.

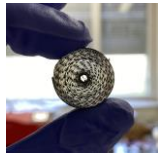
Marc Pretze[1], Carmen Wängler[2], Constantin Mamat[3]

[1] Klinik und Poliklinik für Nuklearmedizin, Universitätsklinikum Carl Gustav Carus, Dresden
[2] Biomedical Chemistry, Clinic of Radiology and Nuclear Medicine, Medical Faculty Mannheim of Heidelberg University, Mannheim
[3] Institut für Radiopharmazeutische Krebsforschung, Helmholtz-Zentrum Dresden-Rossendorf, Dresden

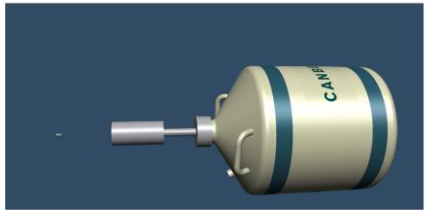
Radionuclide release studies



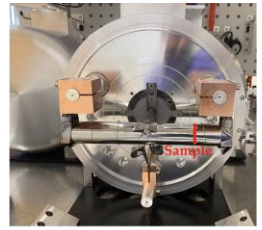




Sample irradiation at CERN-ISOLDE facility by indirect proton beam



Gamma spectrometry to determine sample activity before and after release

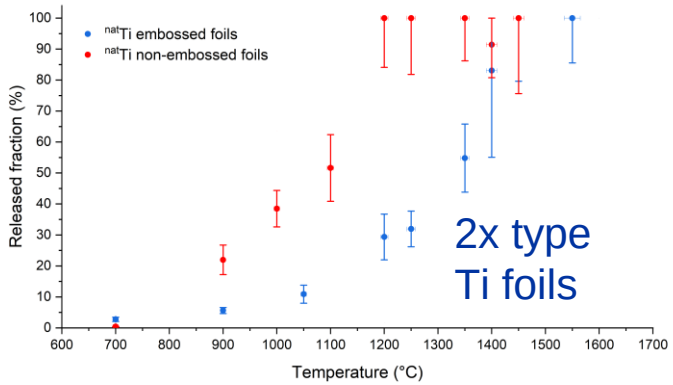


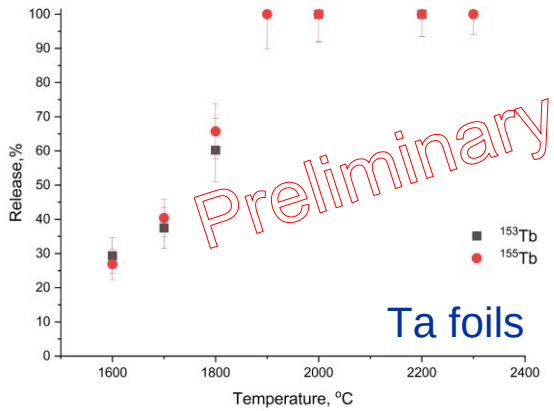
View of a sample placed inside the target container of a typical ISOL target unit. The vacuum and heating is controlled. Temperature up to 2000°C can be reached with a vacuum around 1E-6 mbar

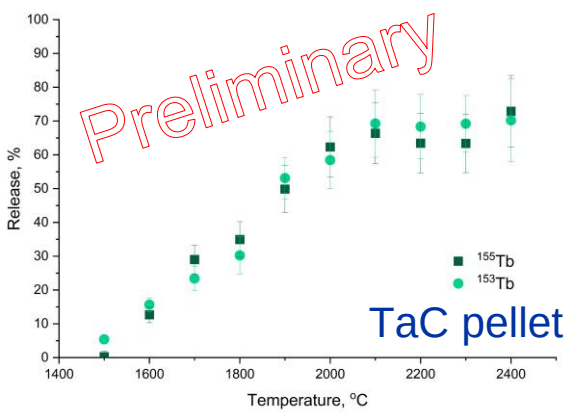
Experimental setup for thermal release studies

1h heating at the desired T

- Irradiated **Ti, Ta foils and TaC, TiC** (also 200nm TaC) pellets
- Total of **>70** individual samples analyzed
  - 1 sample per 3 days
- Release studied up to **2400 °C**
- Please stop by the poster of **Patricija Kalnina!**







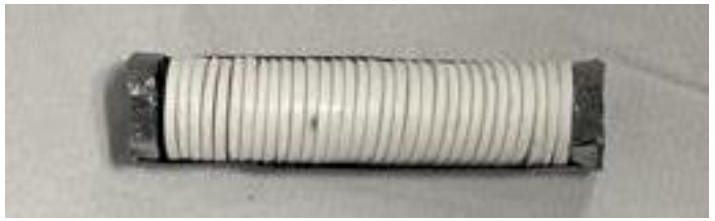
Mamis, E; et. al. Scandium thermal release from activated nat-Ti and nat-V target materials in mixed particle fields: Investigation of parameters relevant for isotope mass separation. https://doi.org/10.1016/j.nimb.2024.165400

Courtesy P. Kalnina

SCK CEN ThO_2 target material development for ^{225}Ac release

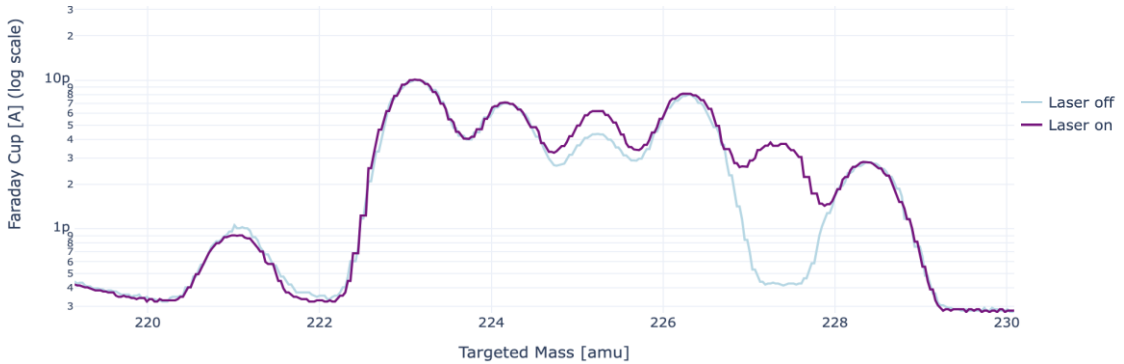
Target was produced (50g at SCK CEN) and tested at MEDICIS early November

The first ISOL@MYRRHA target tested at CERN-MEDICIS



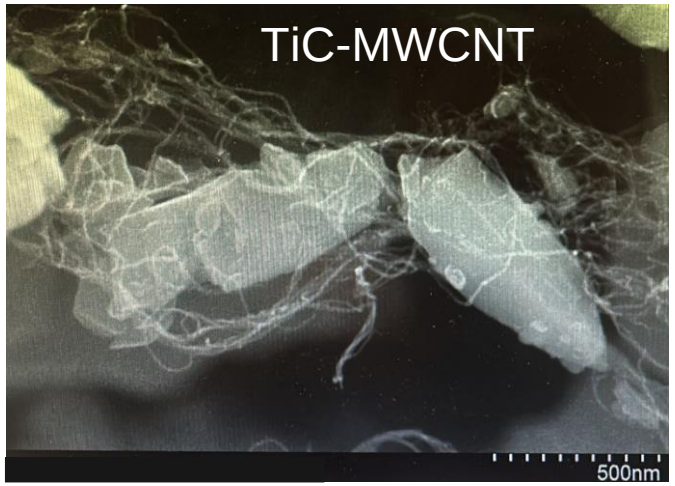
Preliminary analysis

- ^{225}Ac extraction was attempted between 2050 to 2400 °C
- 2nd "hot" experiment ongoing
- ^{129}Cs release onset at 1000°C and max release at 1780 °C
- Release temperature onset for ^{225}Ra was 1300°C, max release ~ 2000°C

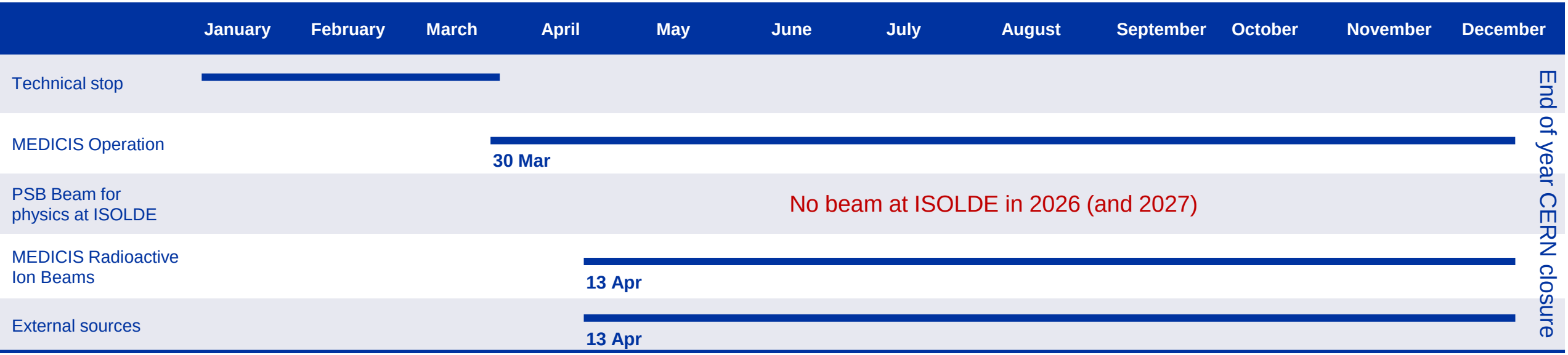


Molecular ion beam developments for Sc and Tb isotopes

- **Sc-47** and **Tb-155** obtained as **di-fluoride molecular ion beams**
  - No **Ce-139** contamination in collected Tb-155 samples
- **Main issue to solve - sintering effect at high temperatures (2000 oC)**
- TiC-MWCNT and TaC-MWCNT target material preparation in cooperation with **University of Latvia**
  - Reduced sintering at higher temperatures
  - Successfully used in fluoride molecular beam developments for Tb-155 and Sc-47 collections
- **The reduction of collected activity for new/reused targets**
  - Regular micrometric TaC **~1/0.05**
  - MWCNT-TaC **~1/0.5**



CERN-MEDICIS – Yearly technical stop & planning 2026



- Always a period of **2 to 3 weeks of stable beam tests** before starting with radioactive ions beams (magnet calibration checks, beam alignment **gafchromic® film** tests following change of diagnostic box etc.)
- **Planning built** considering already approved projects + new MEDICIS projects to come (+ PRISMAP+ projects)

- **External sources** will be scheduled **all along the year** according to the needs of the community & our partner institutes availability
  - Routine production runs: Sm-153
    - Once every 6 weeks as targeted pace - *1.5 GBq batch reached in 2025 for Sm-153 and delivered to Heidelberg Hospital (not yet used for clinical)*
  - Machine development runs and irregular deliveries: Sc-43/44/47; Ce-134; Tb-155; Er-169

CERN-MEDICIS – yearly shutdown (YETS)

- The facility will be **switched-off on Tuesday 09th of Dec morning** for the yearly technical stop
  - Cleaning/emptying of the **MEDICIS Glovebox/fume-hood/storage cupboard**;
  - **Target movement/eliminations**;
  - **Operation controls update** between 09/12 and the Christmas closure.

CHRISTMAS CLOSURE: 19/12/2025 – 04/01/2026

  - **Maintenance of the rails/MONTRAC system**;
  - Yearly **Electrical work and verification**;
  - **Frontend yearly maintenance** with change of electrode tip, vacuum pumps check;
  - **Robot** trajectory tests & maintenance;
  - 3 weeks **ventilation** cut for maintenance;
  - Final deployment of **new interlock system** – tested all year.
  - **Yearly faraday cup** and **vacuum pump** check;
  - **Integration of the new diagnostic box and scanner;**
  - Integrate a **collimator system** on top of one of our two **KROMEK** detectors *(publication in progress)*;
  - Yearly **RP detector** checks and **access system** maintenance.

FINAL safety tests for restart planed on 26th of March 2026!

THANK YOU everyone for the help, advice, patience and protons given this year!

Feedback of PRISMAP projects

“The application process was smooth”

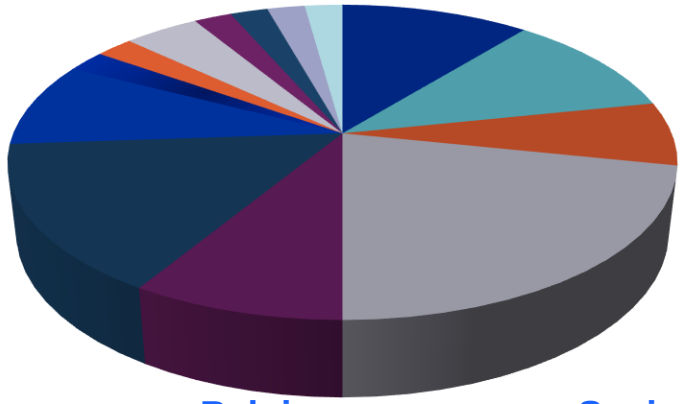
“Our experience with PRISMAP services has been exceptionally positive”

“The interest of this kind of project is the collaboration opportunities this can lead”

“Thanks to the excellent communication and flexibility demonstrated by all involved partners, minor issues were effectively addressed”

“The materials provided were of excellent quality, which underlines the uniqueness of the PRISMAP initiative”

Call 1-5: 46 (43 services) projects



Top Rated Oral Presentations @ EANM’25 congress in:
Combination Therapy - Shaping the Future of TRT
Innovations in Translational Oncology
Improving Radionuclide Production for Tracer Development

Congrat’s to our users !
and our PRISMAP R&D institutes !