CERAD – A 30 MEV CYCLOTRON FOR MEDICAL ISOTOPE PRODUCTION IN POLAND

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3rd Workshop on Research & Innovation in Poland: Research Programme for Linear Accelerator - Radioisotopes and Applications

22–23 Oct 2026
Instutute of Nuclear Physics Polish Academy of Sciences

POLATOM



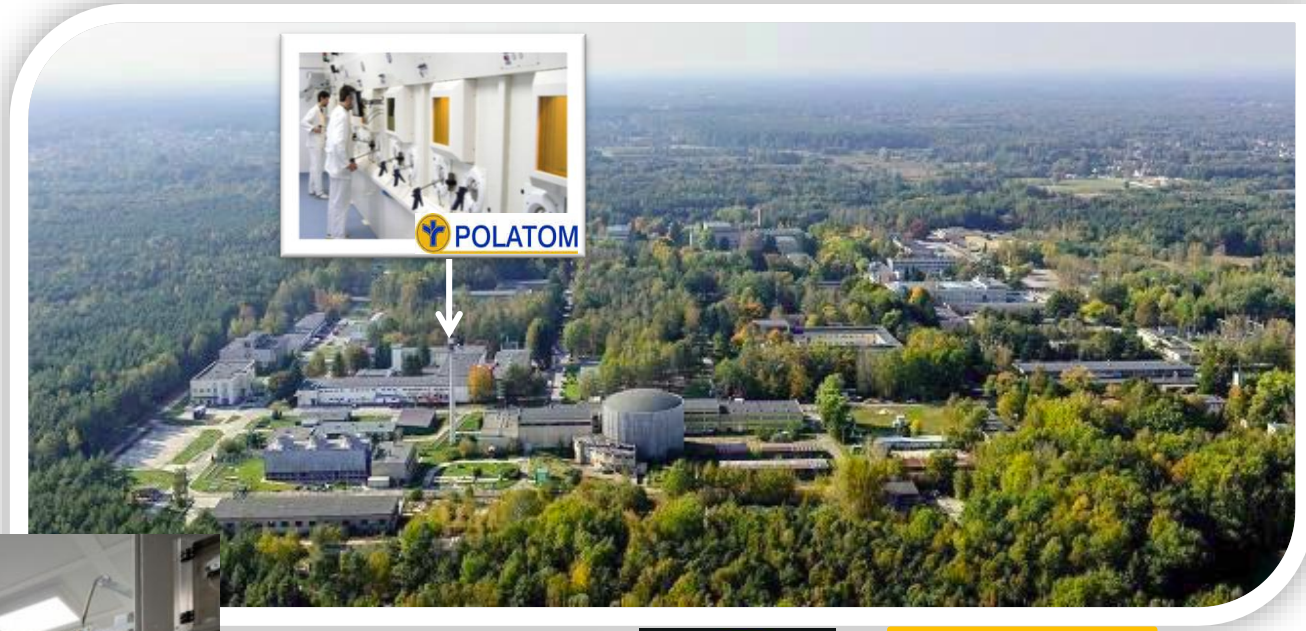
Nuclear Research Reactor Maria



NARODOWE CENTRUM BADAŃ JĄDROWYCH ŚWIERK

Radioisotope Centre POLATOM

NATIONAL CENTRE FOR NUCLEAR RESEARCH ŚWIERK



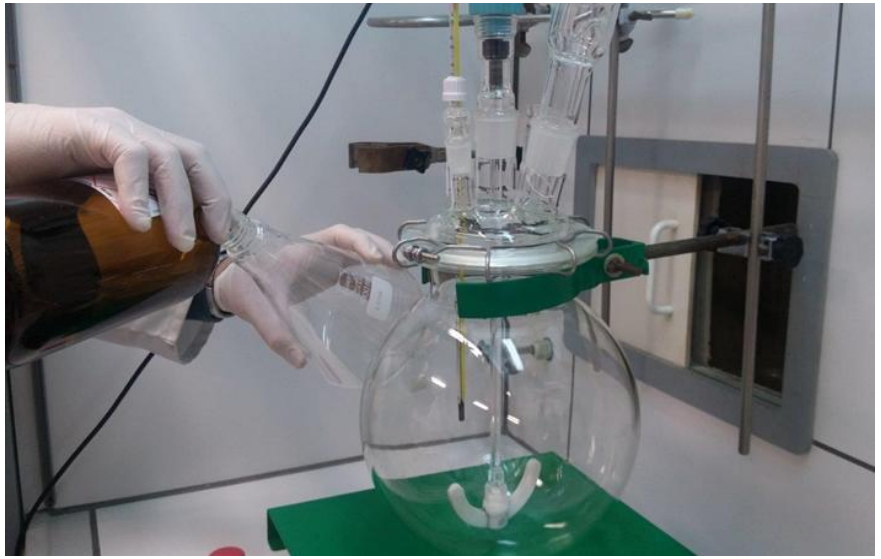








RESEARCH & DEVELOPMENT



Laboratory of Active Substances



Radionuclide Laboratory



Radiopharmaceuticals Laboratory



Preclinical Research Laboratory

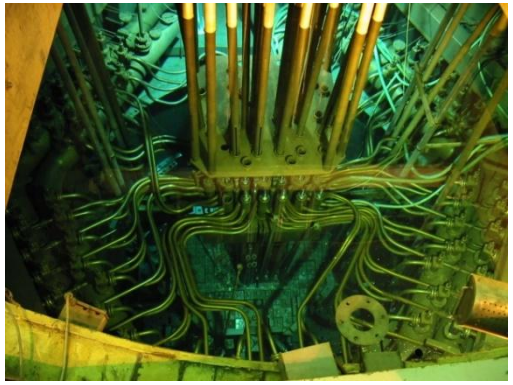
Potential of NCBJ for radiopharmaceutical development

Maria Research Reactor

30 MW, neutron flux 2 x 10^{14} n/cm^2s

Wide range of produced radionuclides:
^{32}P, ^{99}Mo, ^{131}I, ^{177}Lu ...

Material science, neutron irradiation investigations



Radioisotope Centre POLATOM

Pharmaceutical development
and validation

Hot-cells for handing radioisotopes

Research laboratories

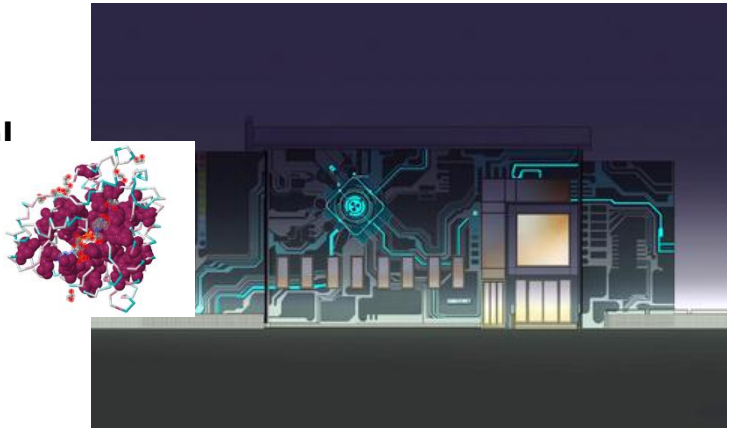
Preclinical animal studies



Świerk Computing Centre

HPC cluster on blade multicore servers,
large volume computational capacity

Specialized software for *in silico* computational simulations



CERAD
Center of Design and Synthesis of Radiopharmaceuticals for Molecular Targeting

Smart Growth Operational Programme 2014-2020

Priority axis IV:
INCREASING THE RESEARCH POTENTIAL

Action 4.2:
Development of modern research infrastructure of the science sector

Financing agreement: POIR 04.02.00-14-A001/16-00

CERAD

Coordinator: **National Centre for Nuclear Research**

Consortium members:

University of Warsaw

Institute of Nuclear Chemistry and Technology in Warsaw

Warsaw Medical University (WUM)

Jagiellonian University (UJ), Krakow

Medical University in Bialystok

Positive + negative ions combined cyclotron

Cyclone 30 XP

Protons (H- accelerated)

15 - 30 MeV, 350µA

Deuterons (D- accelerated)

9 - 15 MeV, 50 µA

Alphas (He2+ accelerated)

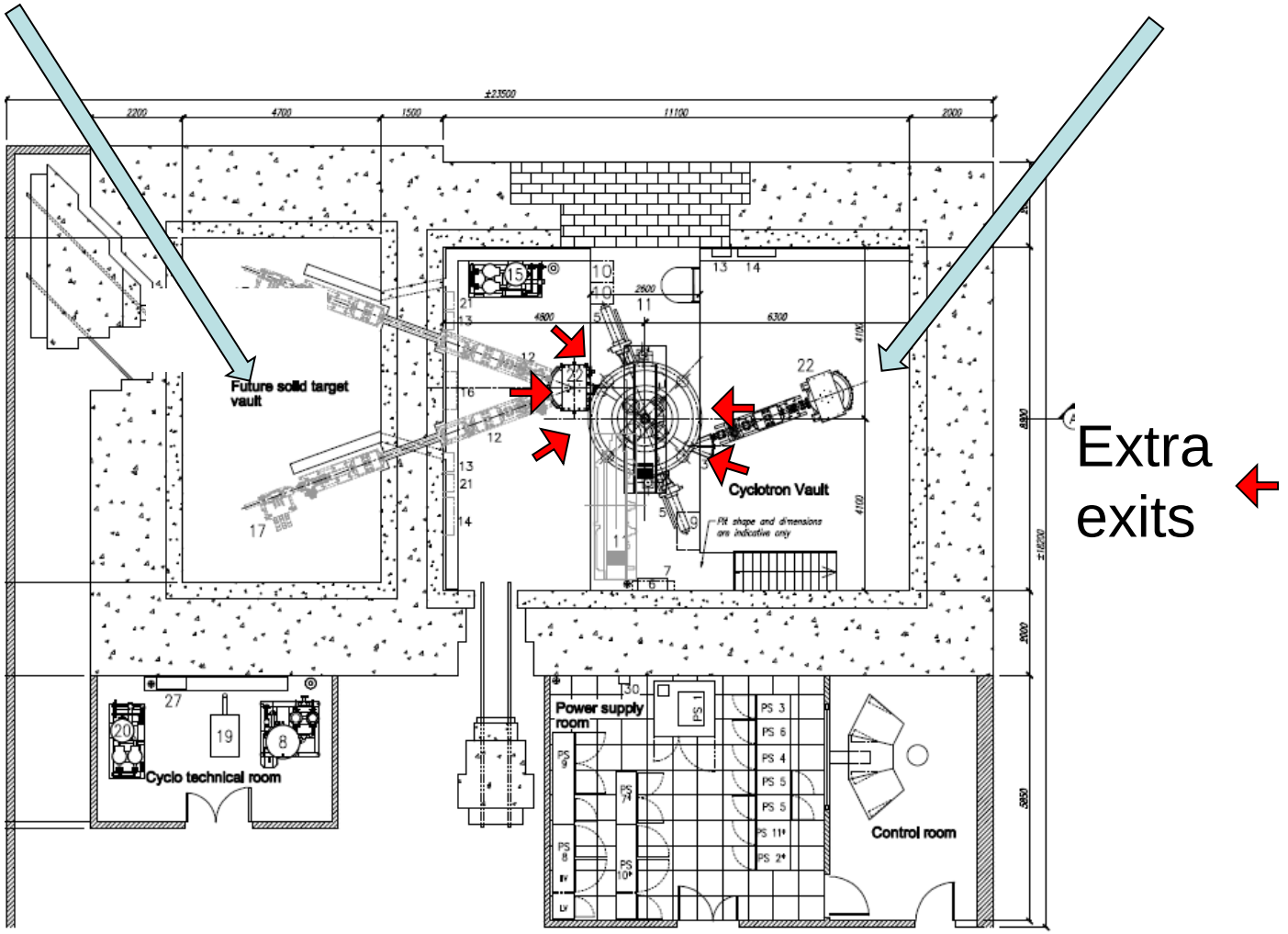
(29) - 30 MeV, 50 µAe



Compact Layout (23 * 18 m)

Research / solid target 2 ports

PET 5 ports

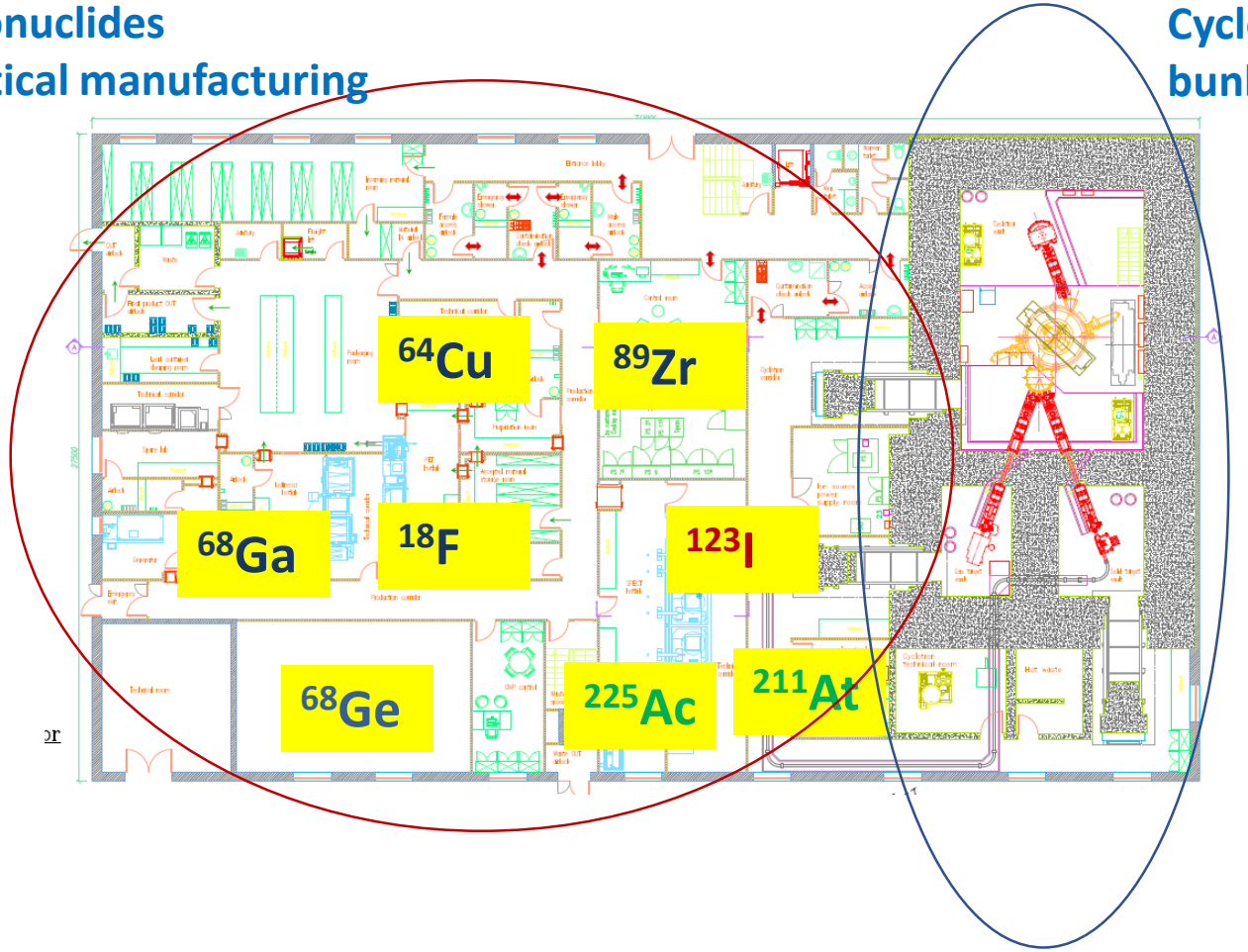


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Laboratories for radionuclides and radiopharmaceutical manufacturing

Cyclotron bunker





Cyclone ® 30 XP multi particles

Cyclone ® 30 XP accelerates protons and alpha particles to 30 MeV, and deuterons to 15 MeV

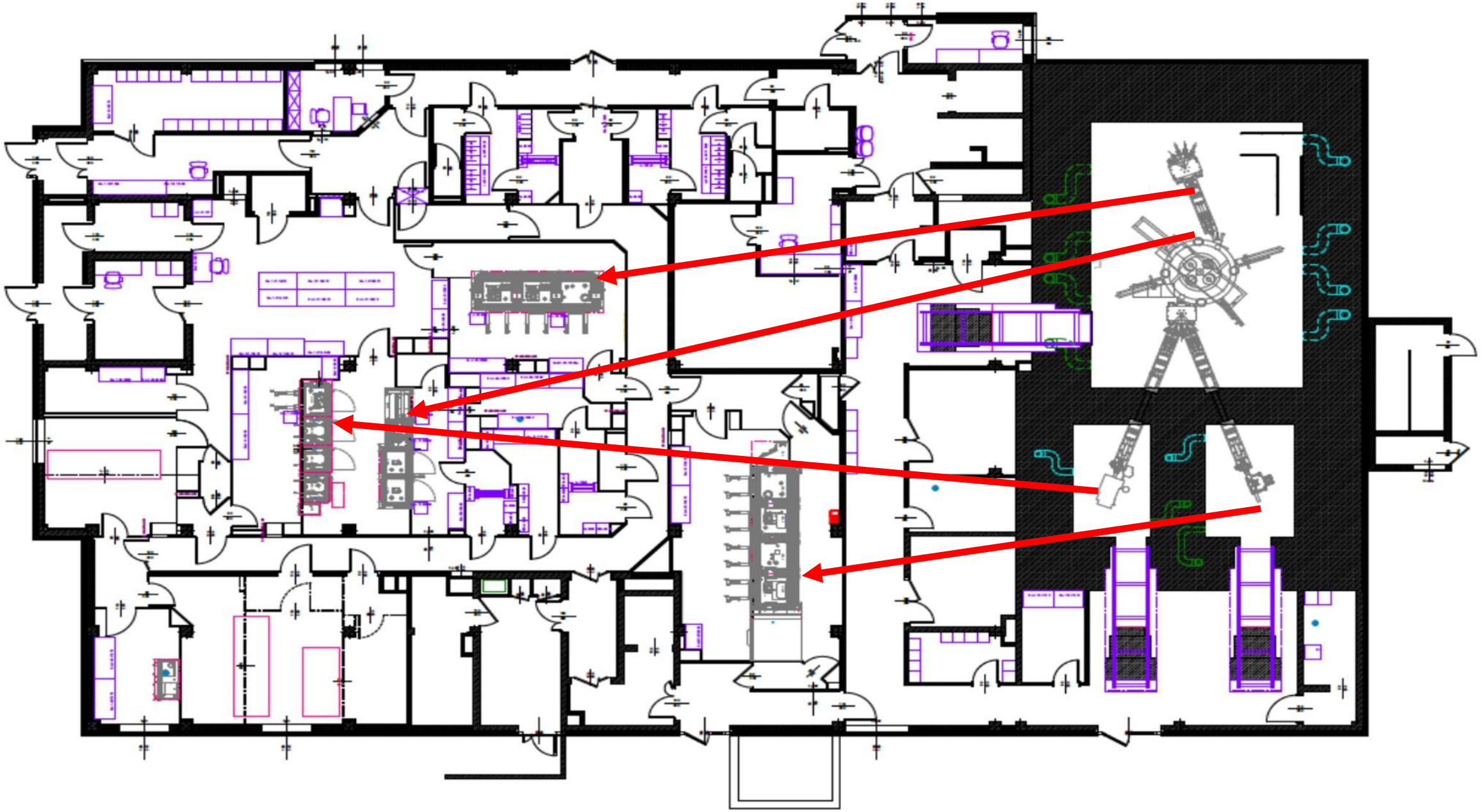
General layout of CERAD facility



Ground floor layout



Ground floor layout



Shielded hot cells for radionuclide and radiopharmaceutical manufacture








Galaxy S23 Ultra

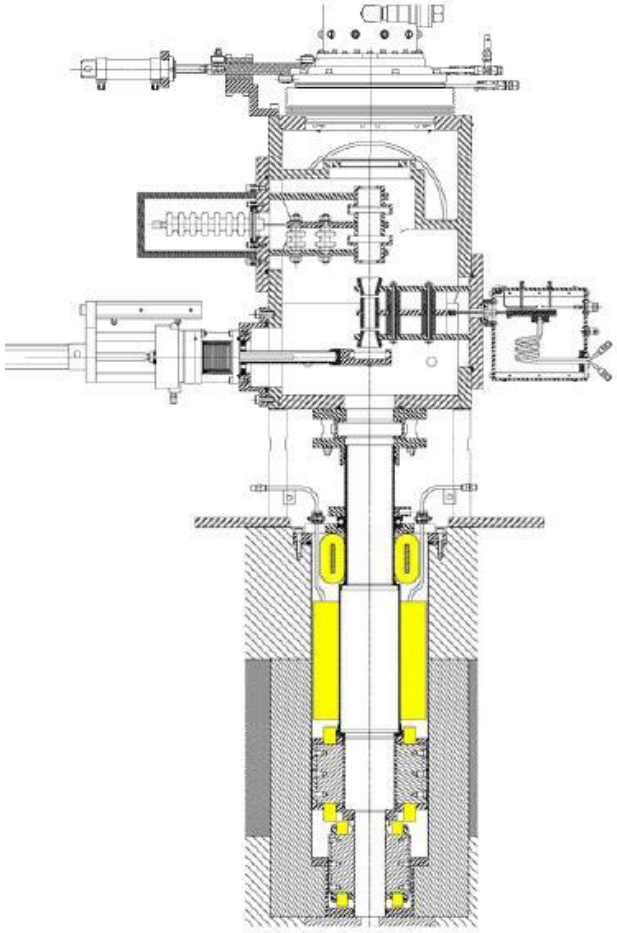

Galaxy S23 Ultra

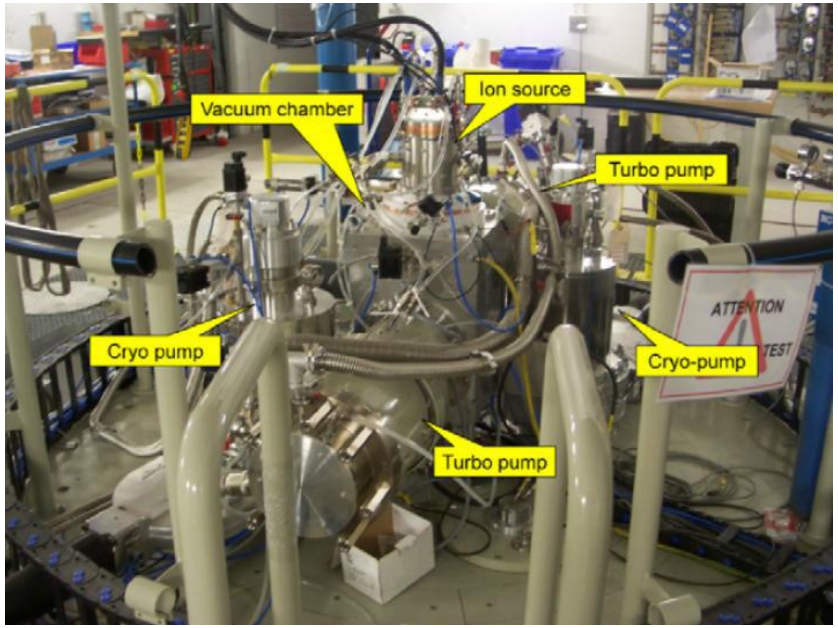
TECHNICAL SPECIFICATIONS

Proton and deutron acceleration system	
Ion source	external source 35 kV
Acceleration energy of protons	15-30 MeV (with continous energy range variation)
Maximum proton intensity	400 µA
Proton extraction system	Stripping System; 2 ports; double beam
Deutron acceleration energy	9-15MeV (with smooth regulation)
Maximum deutron intensity	50 µA
Deutron extraction system	Stripping System; 2 ports; double beam

Alpha particle acceleration system	
Ion source	external source 35 kV
The acceleration energy of alpha particles	30 MeV
Maximum alpha particle intensity	50 µAe
Alpha particle extraction system	Electrostatic deflector; 1 port

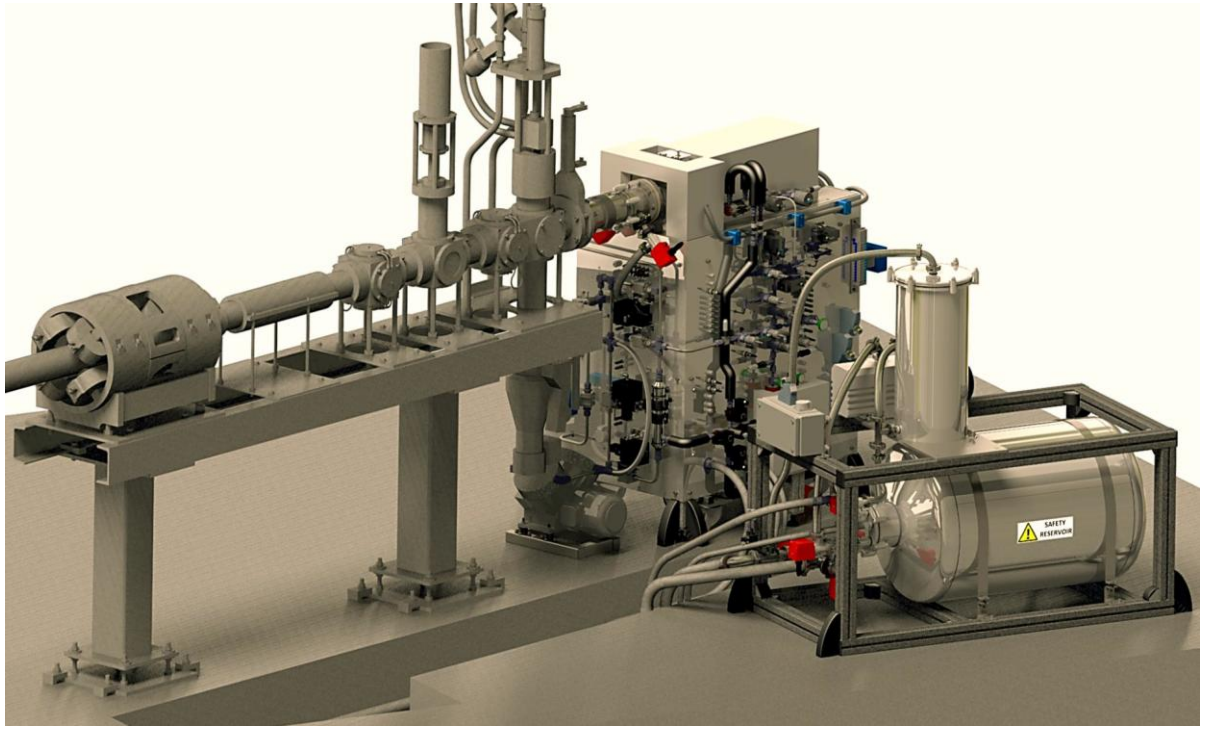
Injection line for alpha ions

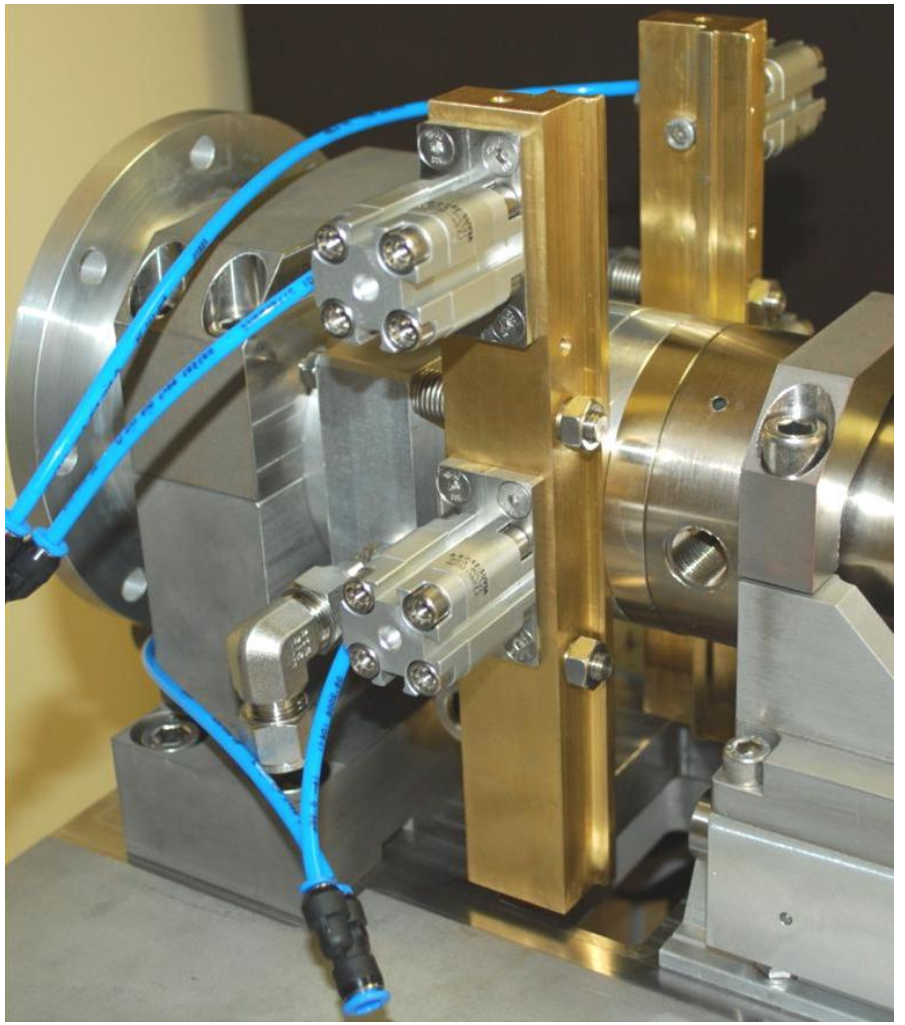




ECPM09_ IBA C30 Cyclotron Beam Intensity Upgrade W. Kleeven, S. Zaremba, M. Abs and B. Nactergal

Gas target system
(IBA-ELEX patent)





Cyclone 30: high power solid target

- **High power targets 400 µA to 600 µA 30 MeV**
- **Any plated material:**
  - ^{203}Tl -> ^{201}Pb -> ^{201}Tl
  - ^{68}Zn -> ^{67}Ga
  - ^{112}Cd -> ^{111}In
  - …^{70}Zn -> ^{67}Cu
  - …Ga -> ^{68}Ge

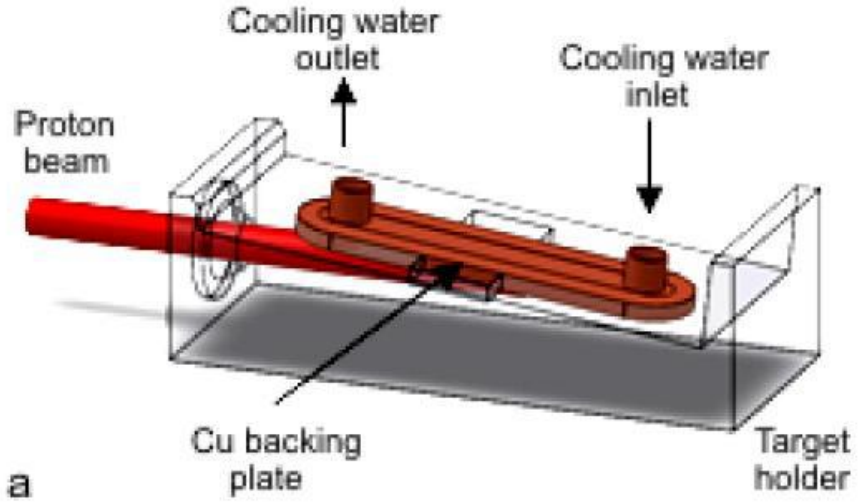
More than 25 reference sites worldwide using the system

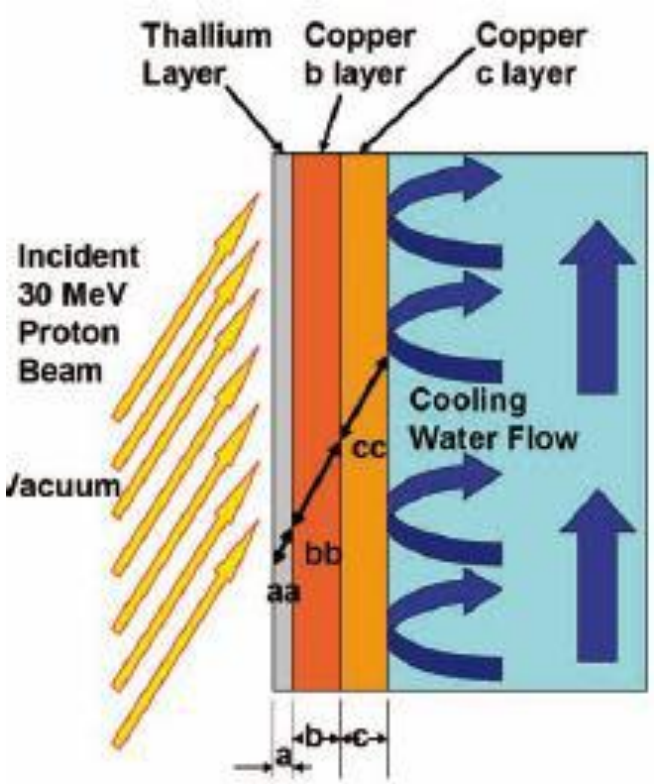
Solid target & beam line – target vault



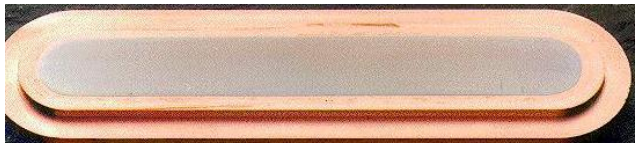
© 2006

Solid target process and constraints





Element	Density ($g \cdot cm^{-3}$)	Melting point (°C)	Thermal conductivity ($W \cdot cm^{-1} \cdot K^{-1}$)
Copper	8.96	1083	4.03
Thallium	11.85	303	0.46




CERAD
CERAD
CERAD
CYCLONE
30 XP
SYGNALISTA


CERAD
UWAGA, TYŁ ZACHODZI

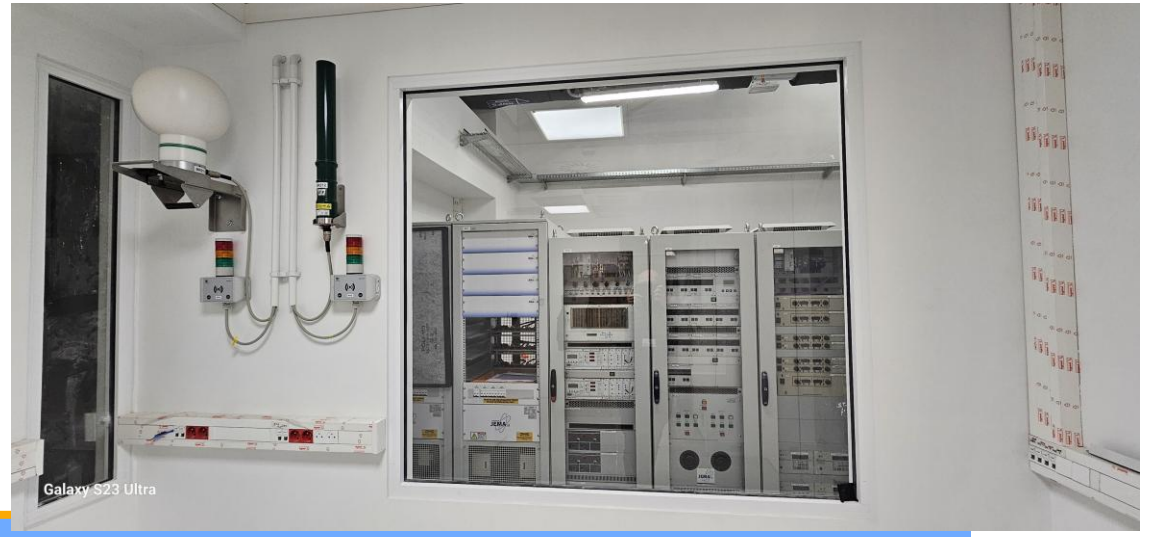

HAKOWY
SYGNALISTA


CERAD
CERAD
CYCLONE
30 XP
CONTROL PROCESS

Installation and commissioning







- **Access to all PET radionuclides at 15-18 MeV**
  - ^{11}C, ^{18}F, ^{124}I, ^{64}Cu,…
  - Specific target and chemistry available

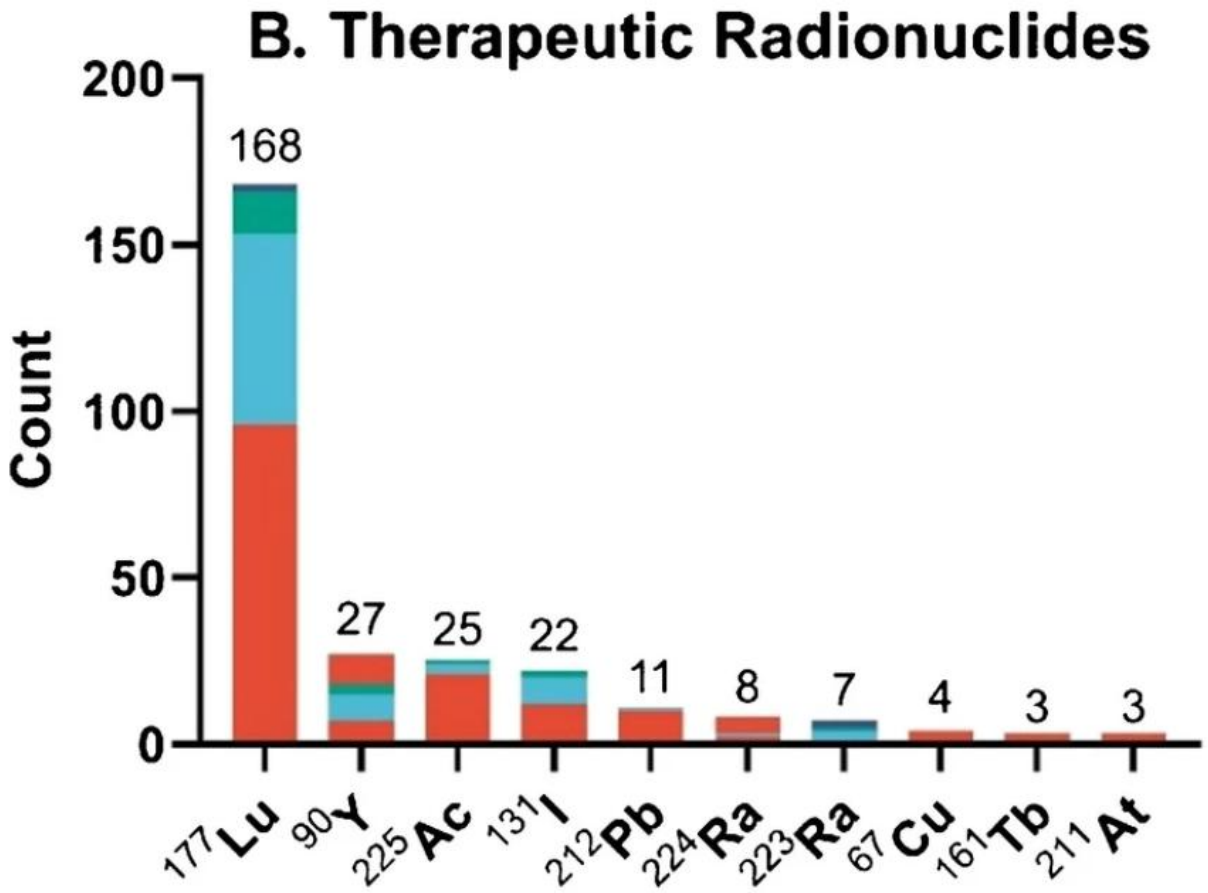
- **Access to SPECT radionuclides at 25-30 MeV**
  - ^{201}Tl, ^{67}Ga, ^{111}In on IBA solid target & chemistry
  - Specific IBA solution for ^{68}Ge (generator for ^{68}Ga)
  - ^{123}I on gas target Xenon-124

- **Other..**

© 2006

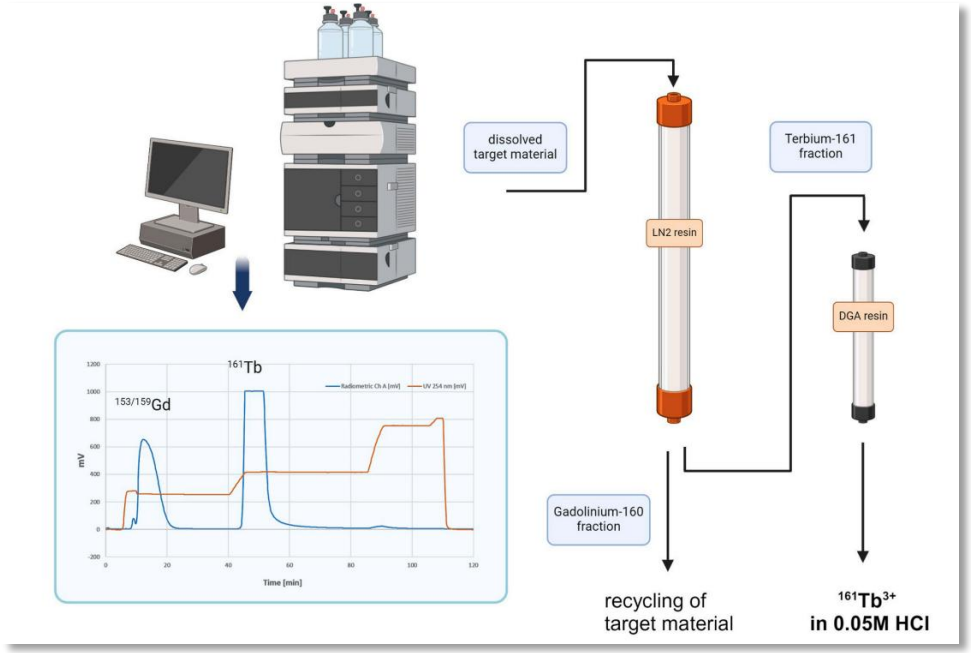
Clinical trials

$^{212}Pb/^{203}Pb$
$^{161}Tb/^{155}Tb$
^{211}At
^{67}Cu
Auger emitters



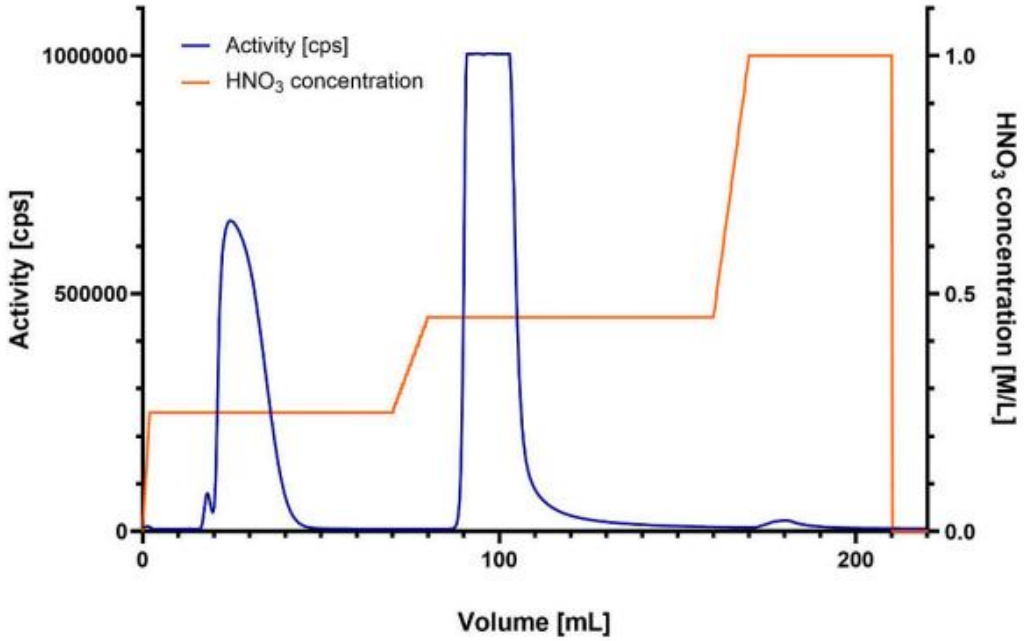
Tran, H.H., Yamaguchi, A. & Manning, H.C. Radiotheranostic landscape: A review of clinical and preclinical development. *Eur J Nucl Med Mol Imaging* **52**, 2685–2709 (2025). https://doi.org/10.1007/s00259-025-07103-7

^{161}Tb separation from ^{160}Gd target



Extraction chromatography system for Tb-161 separation

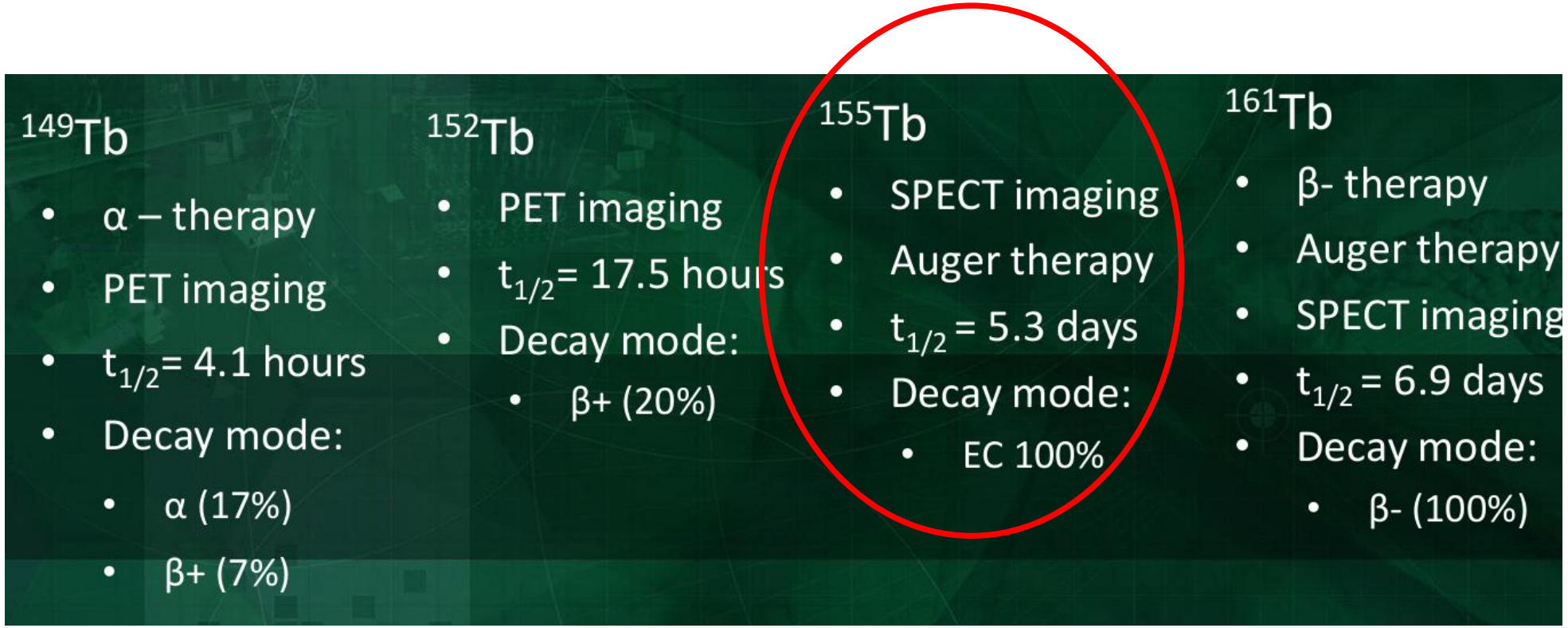
Tb-161 elution yield >98 %



^{161}Tb elution profile from LN2 column following sequential elution with 0.25 M, 0.45 M, and 1 M HNO_3

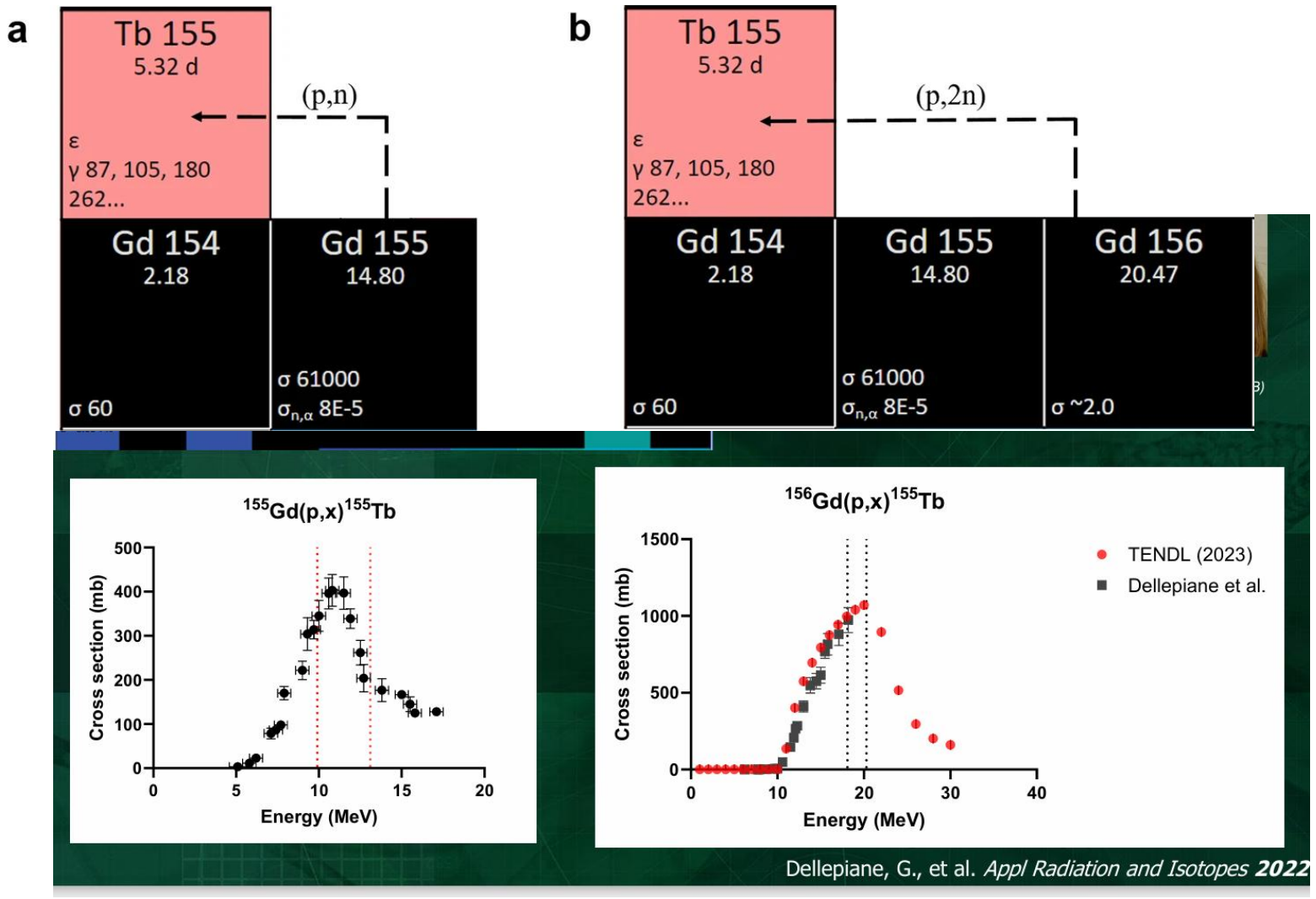
Żółtowska M., et al Two-step extraction chromatography separation of ^{161}Tb from ^{160}Gd-enriched irradiated target material and verification of the [^{161}Tb]TbCl3 suitability for radiolabelling, Applied Radiation and Isotopes, 2025, 112144, https://doi.org/10.1016/j.apradiso.2025.112144.

^{161}Tb and ^{155}Tb – theranostic pair



Cristina Müller et al. A Unique Matched Quadruplet of Terbium Radioisotopes for PET and SPECT and for α- and β⁻-Radionuclide Therapy: An In Vivo Proof-of-Concept Study with a New Receptor-Targeted Folate Derivative Journal of Nuclear Medicine. 2012, 53 (12) 1951-1959; DOI: 10.2967/jnumed.112.107540

^{155}Tb – cyclotron production routes

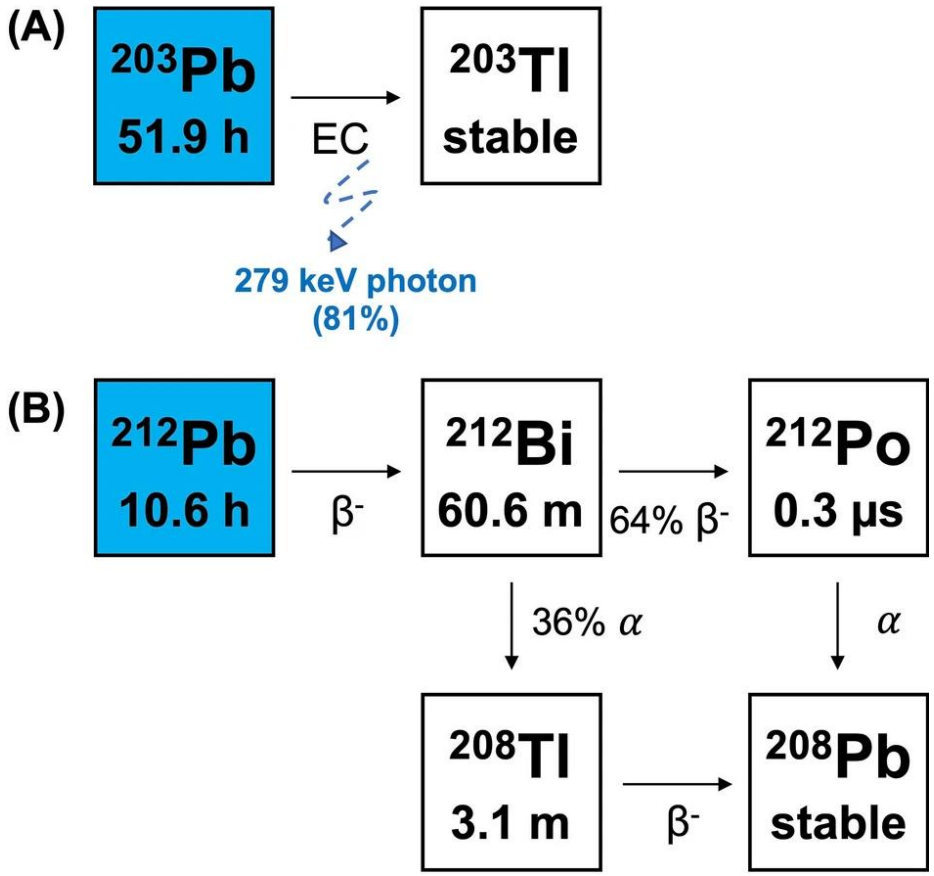


Favaretto, C., Talip, Z., Borgna, F. *et al.* Cyclotron production and radiochemical purification of terbium-155 for SPECT imaging. *EJNMMI radiopharm. chem.* **6**, 37 (2021). https://doi.org/10.1186/s41181-021-00153-w

Pb-203 and Pb-212 – theranostic pair

SPECT

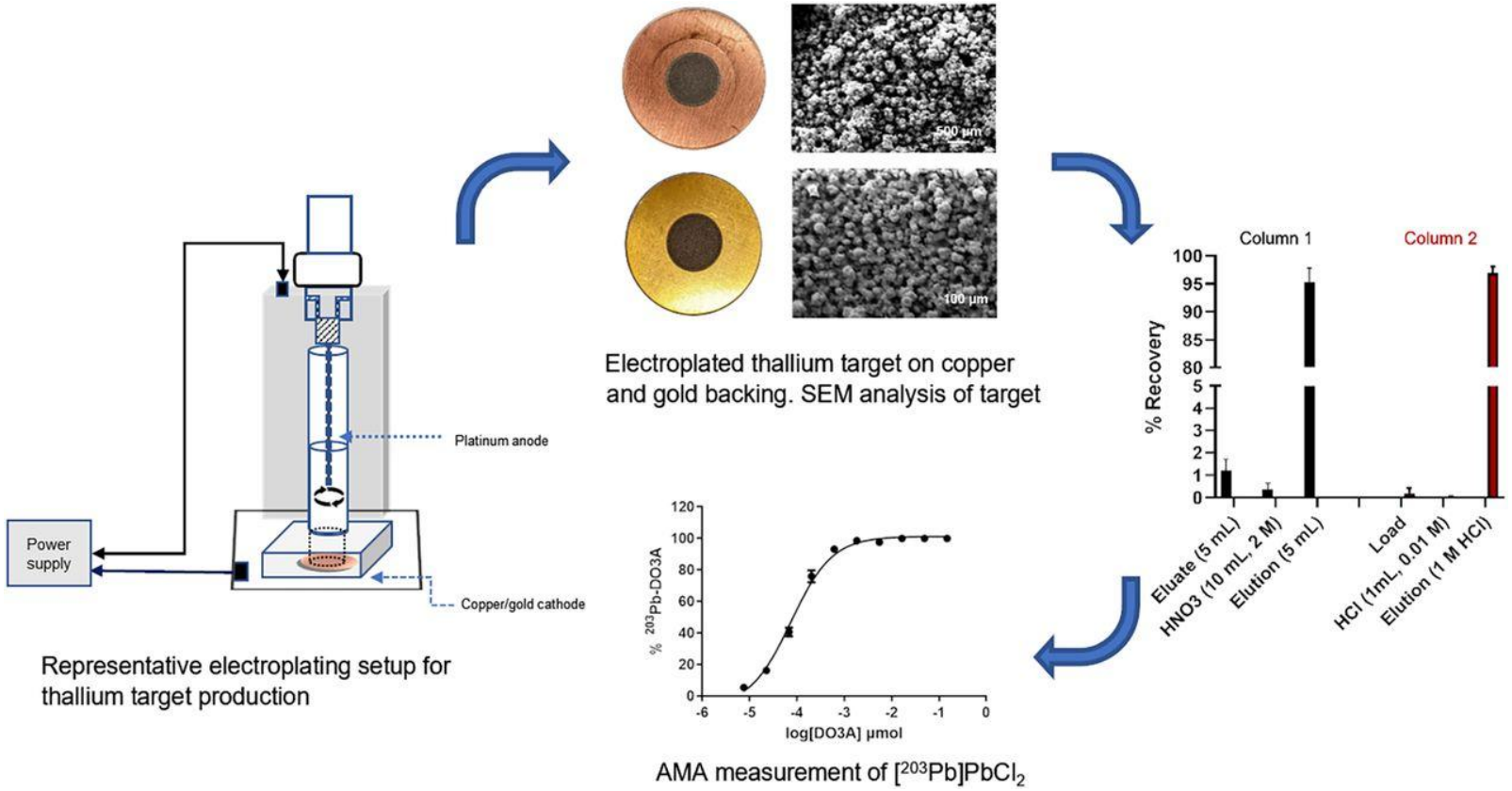
TAT



McNeil, *et al.* Optimized production, purification, and radiolabeling of the ^{203}Pb/^{212}Pb theranostic pair for nuclear medicine. *Sci Rep* **13**, 10623 (2023). https://doi.org/10.1038/s41598-023-37313-8

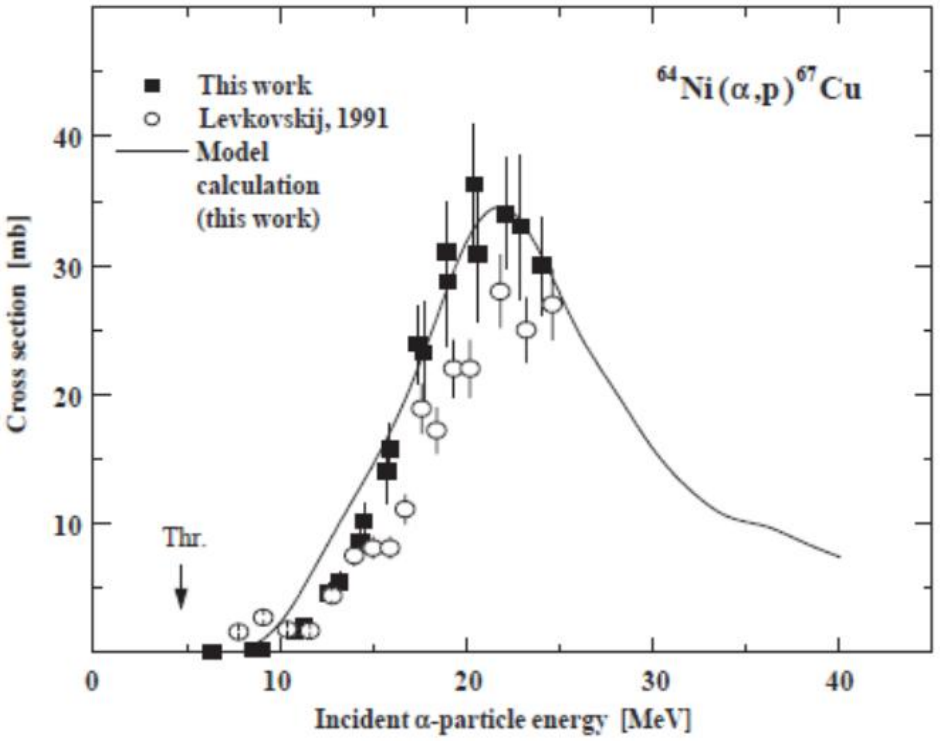
^{203}Pb

$^{205}Tl(p,3n)^{203}Pb$ at 24 meV



Shefali Saini, et al. Optimized Methods for the Production of High-Purity ^{203}Pb Using Electroplated Thallium Targets. Journal of Nuclear Medicine. 2023, 64 (11) 1791-1797; DOI: 10.2967/jnumed.123.265976

Alpha beams to produce ^{67}Cu for therapy



Main decay characteristics of ^{67}Cu and $^{64/61/60}$Cu-radionuclides [7].

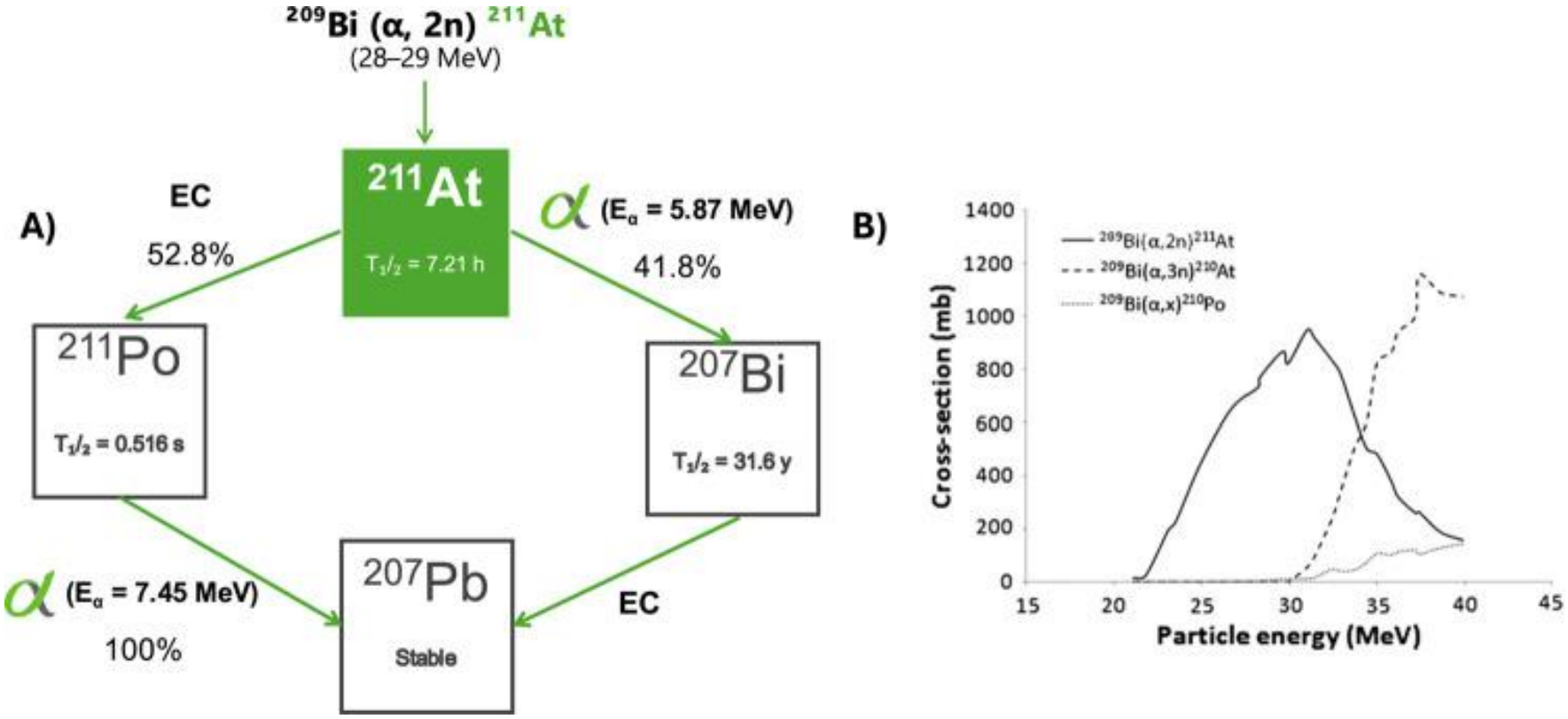
	Half-Life	Main γ-ray Energy, Intensity (keV) (%)	Mean β^+ Energy, Intensity (keV) (%)	Mean β^- Energy, Intensity (keV) (%)	Auger and IC Electrons
^{67}Cu	61.83 h	184.577 (48.7)	-	141 (100)	Yes
^{64}Cu	12.701 h	1345.77 (0.475)	278 (17.6)	191 (38.5)	Yes
^{61}Cu	3.336 h	282.956 (12.7) 656.008 (10.4)	500 (61)	-	Yes
^{60}Cu	23.7 m	826.4 (21.7) 1332.5 (88.0) 1791.6 (45.4)	970 (93)	-	Yes

Mou L, Martini P, Pupillo G, Cieszykowska I, Cutler CS, Mikołajczak R. ^{67}Cu Production Capabilities: A Mini Review. Molecules. 2022 Feb 23;27(5):1501. doi: 10.3390/molecules27051501.

Rodriguesz C, Liles GK, Lapi SE, Lewis JS. Expanding the Theranostic Toolbox: Emerging Therapeutic Isotopes. Journal of Nuclear Medicine Sep 2026, 67 (Supplement 2) 5S-16S; DOI: 10.2967/jnumed.125.269487

Zimmermann R. The Supply Chain Conundrum. Journal of Nuclear Medicine September 2026, 67 (Supplement 2) 17S-19S; DOI: https://doi.org/10.2967/jnumed.125.269609

Alpha beams to produce ^{211}At for therapy



Lindegren, S., Jensen, H., Van de Maele, H. *et al.* Solving the limited availability of Astatine-211 from a European perspective: from production to the end user. *EJNMMI radiopharm. chem.* 11, 15 (2026). https://doi.org/10.1186/s41181-026-00428-0

Levillain H, et al. ^{211}At targeted alpha therapy in Europe: overcoming clinical, regulatory, and infrastructure challenges. Eur J Nucl Med Mol Imaging. 2026 Aug;53(10):5999-6008. doi: 10.1007/s00259-026-07950-y.





Levillain H, et al. **^{211}At targeted alpha therapy in Europe: overcoming clinical, regulatory, and infrastructure challenges**.
Eur J Nucl Med Mol Imaging. 2026 Aug;53(10):5999-6008. doi: 10.1007/s00259-026-07950-y.

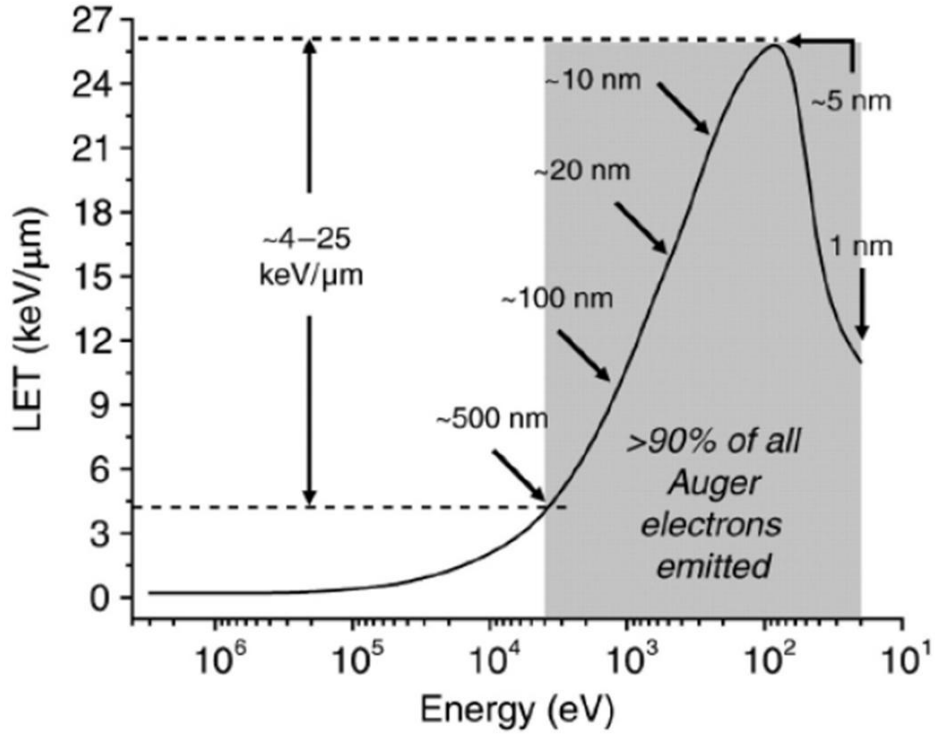




This project is partly supported by the Innovative Health Initiative Joint Undertaking (IHI JU) under grant agreement No 101173001. — Accelerate.EU. The JU receives support from the European Union's Horizon Europe research and innovation programme and COCIR, EFPIA, Europa Bío, MedTech Europe, and Vaccines Europe and IBA, Tetrakit and LabLogic.

Auger electron emitters

Radionuclide	Half-life	MAE Yield	MAE Energy (keV)
^{67}Ga	3.26 d	4.7	6.264
^{99m}Tc	6.01 h	4.0	0.889
^{111}In	2.8 d	14.7	6.75
^{123}I	13.2 h	14.9	7.419
^{125}I	60.1 days	24.9	12.241
^{197m}Hg	23.8 h	19.4	7.6
^{197}Hg	2.67 d	23.2	7.4
^{119}Sb	1.59 d	23.68	8.86

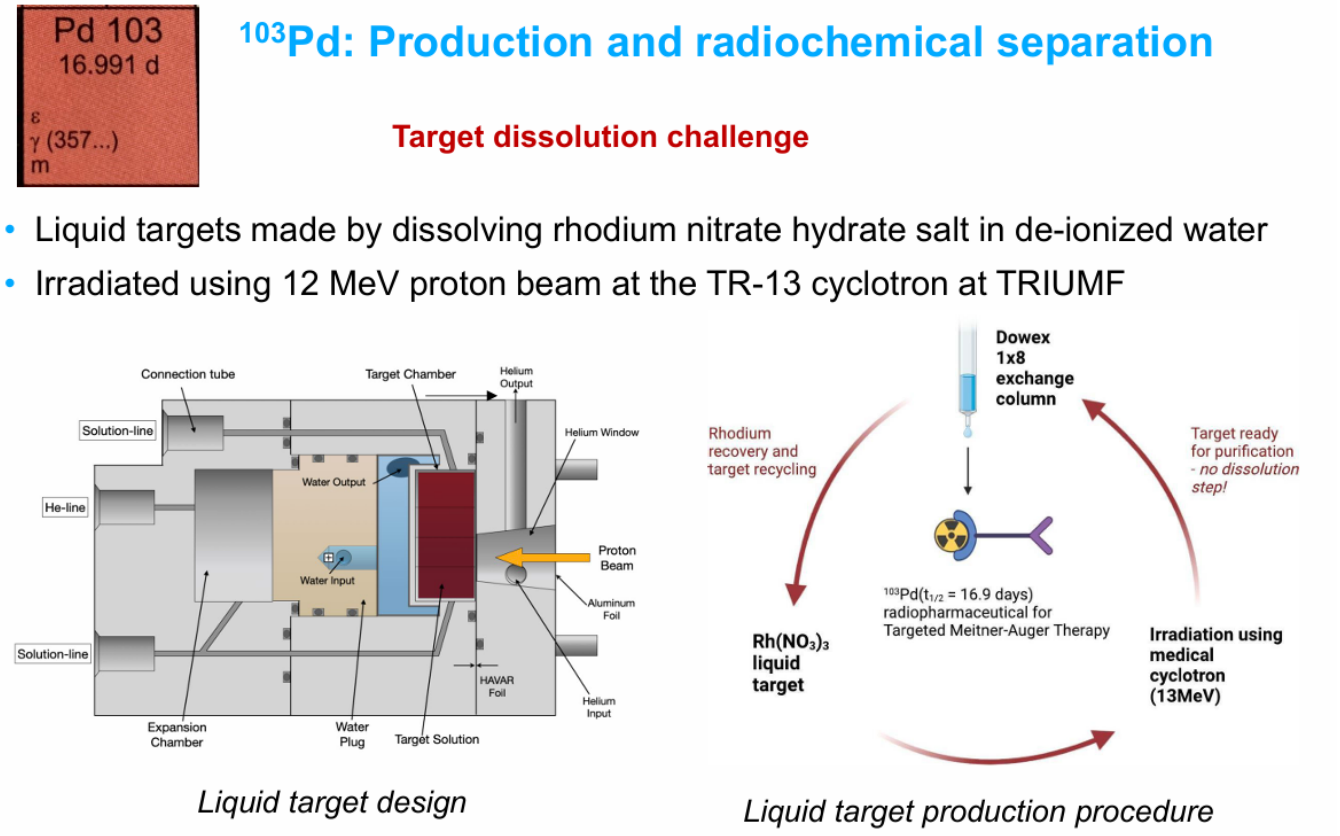


Bolcaen J., et al.Marshalling the Potential of Auger Electron Radiopharmaceutical Therapy. J Nucl Med 2023, 64 (9) 1344-1351;
DOI: 10.2967/jnumed.122.265039

Auger electron emitter ^{103}Pd

^{103}Rh(p,n)^{103}Pd

14 - 18 MeV



Courtesy V. Radchenko

Deuterons 9-15 MeV

$^{64}Ni(d,2n)^{64}Cu$

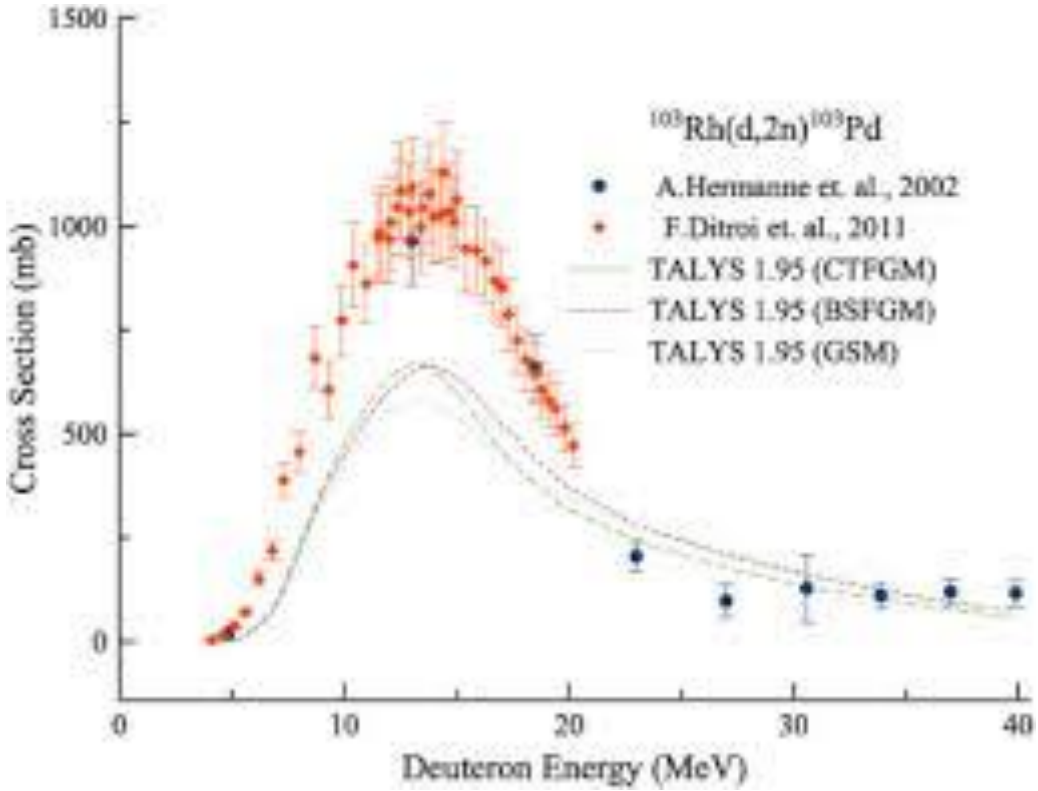
$^{103}Rh(d,2n)^{103}Pd$

$^{124}Te(d,2n)^{124}I$

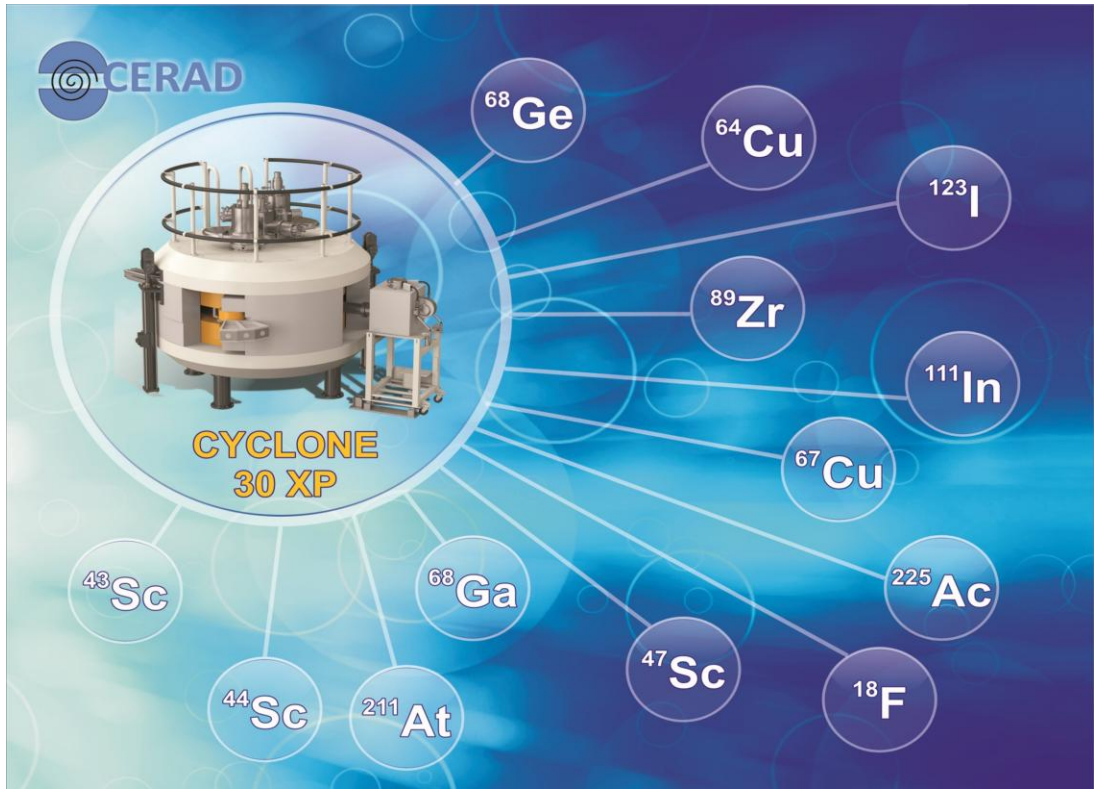
$^{160}Gd(d,n)^{161}Tb$

$^{176}Yb(d,n)^{177}Lu$

$^{186}W(d,2n)^{186}Re$



CERAD
30 MeV cyclotron facility for medical isotope production



Open for international collaboration !!!

CERAD project is co-financed under the Smart Growth Operational Programme 2014-2020,
Priority IV: INCREASING THE RESEARCH POTENTIAL, Measure 4.2. Development of modern research infrastructure of the science sector.

Contribution to a stable supply of medical radioisotopes

IAEA coordinated research projects

TOURR

SECURE

PRISMAP

IAEA International Atomic Energy Agency

SECURE

TOURR nuclear research reactors

Towards Optimized Use of Research Reactors in Europe



