PAUL SCHERRER INSTITUT

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CENTER FOR RADIOPHARMACEUTICAL SCIENCES

RADIONUCLIDE DEVELOPMENT

Target Preparation for Radionuclide Development Towards Medical Application at Paul Scherrer Institute

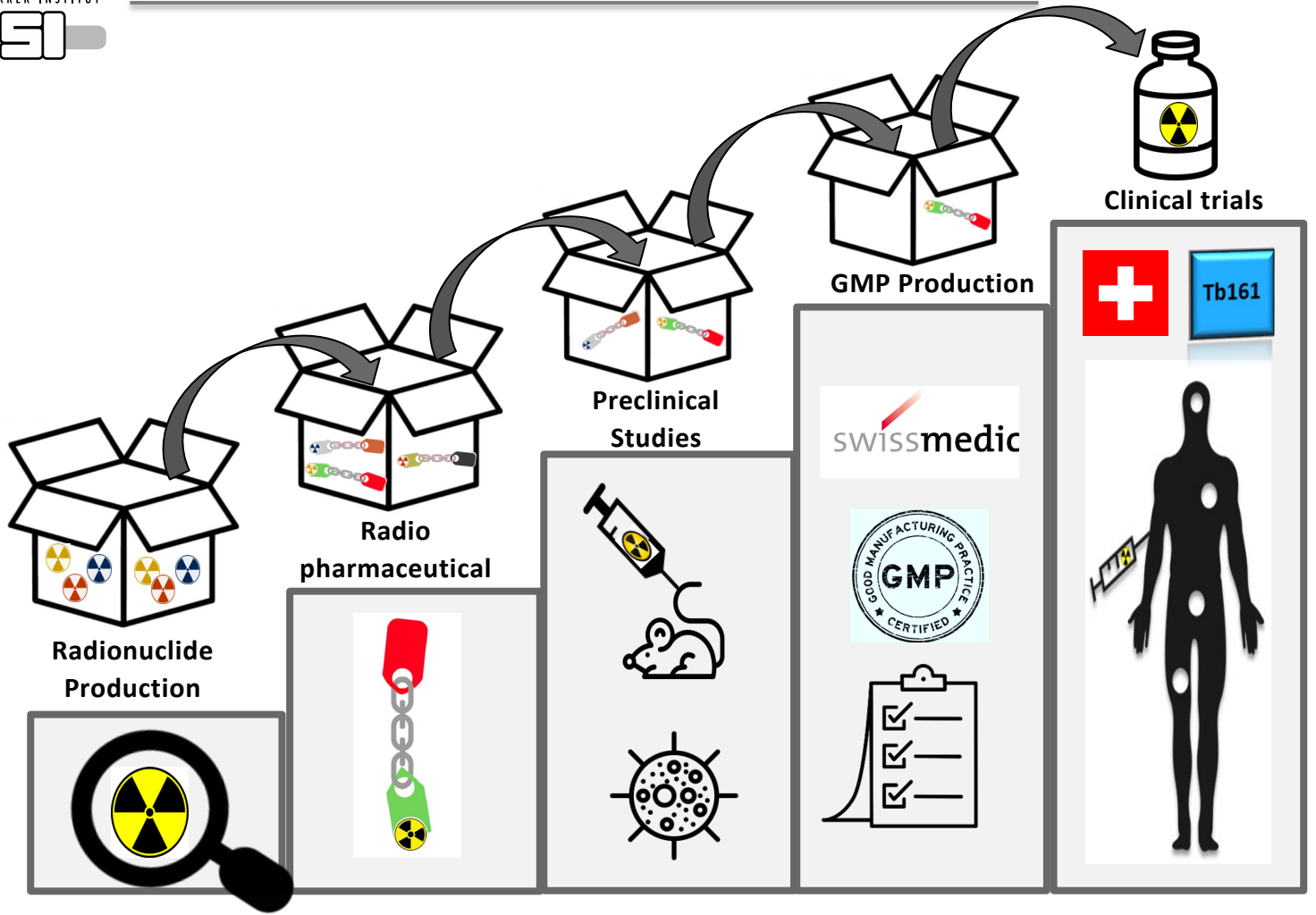
Dr. Zeynep Talip

Center for Radiopharmaceutical Sciences & Laboratory of Radiochemistry

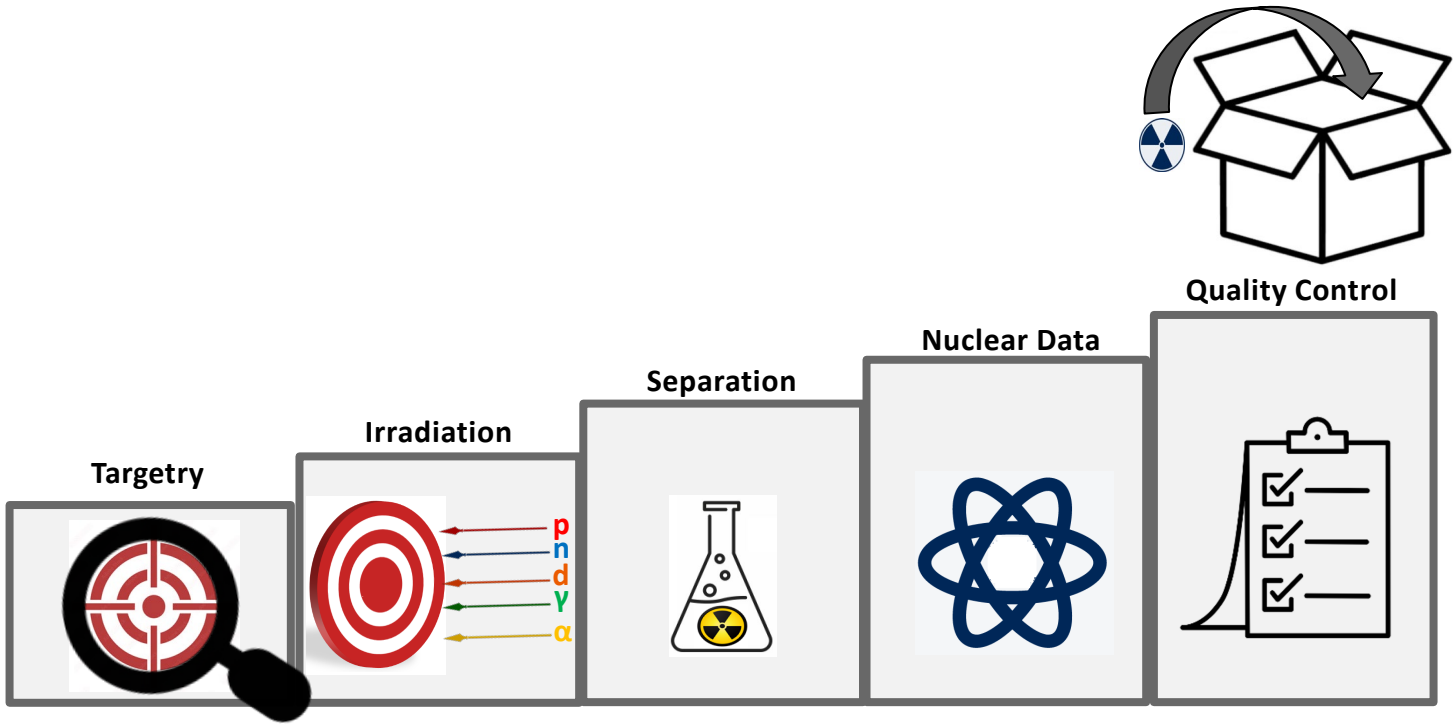
Radionuclide Development Group

INTDS 2022, September 2022

Production of Innovatiove Radiopharmaceuticals

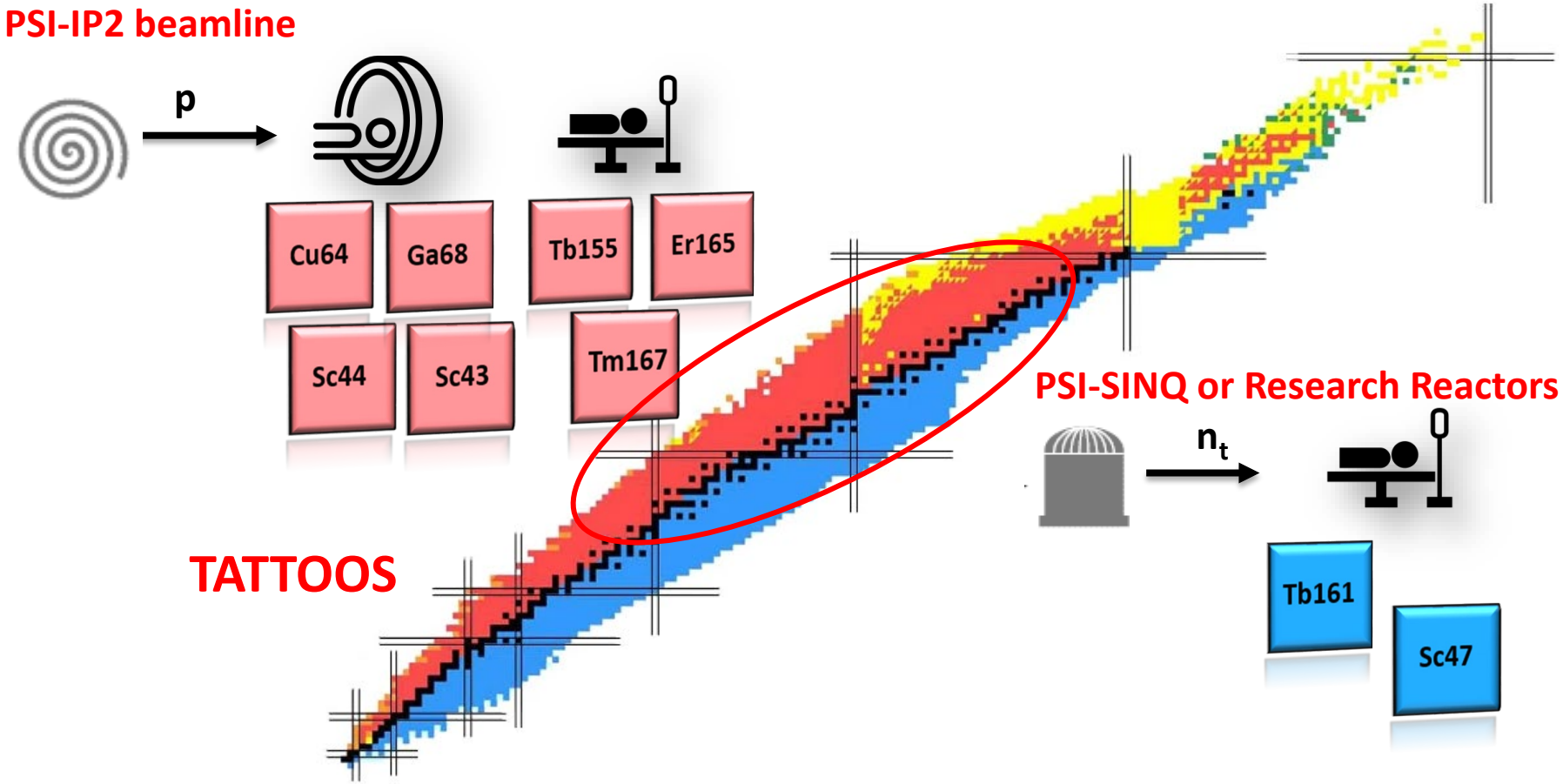


Production of Medical Radionuclides

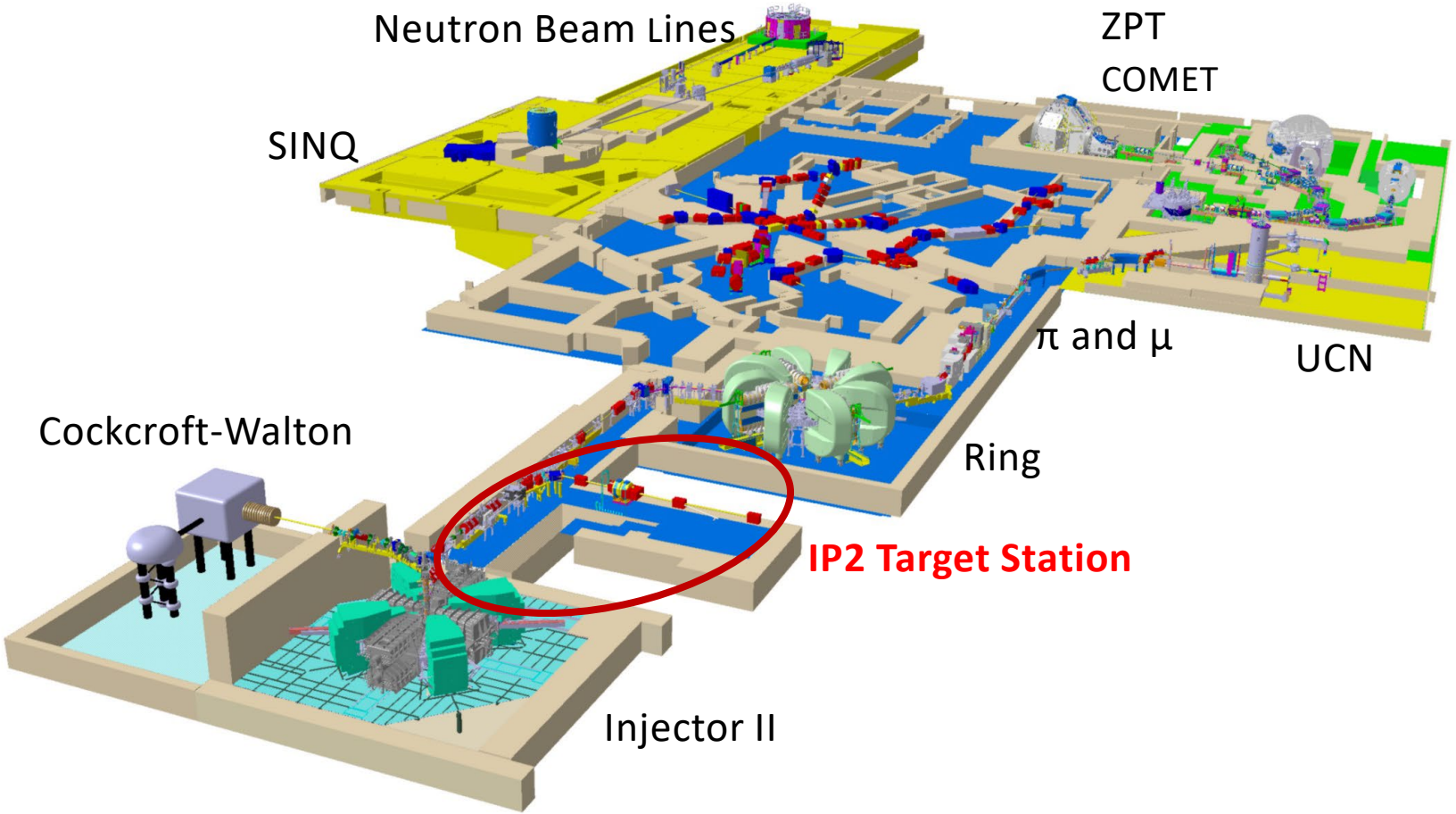


Z. Talip et al., Molecules, 25 (2020) 966.

Medical Radionuclides Production at PSI



Overview of proton based facilities



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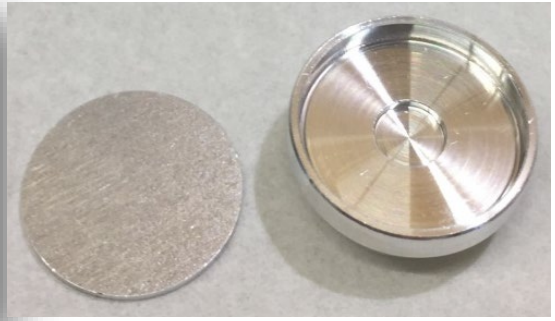
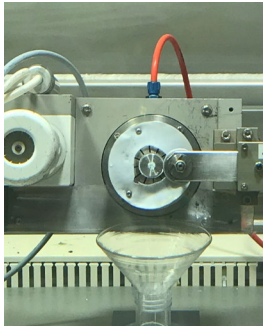
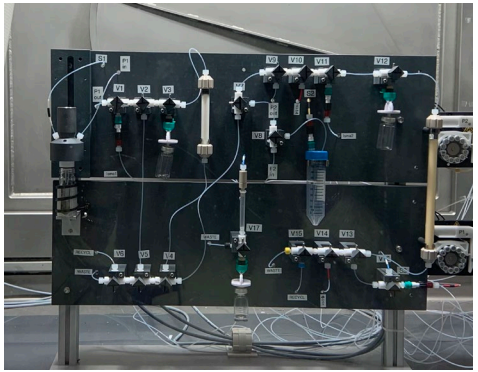
IP2 Target Station

Target holder

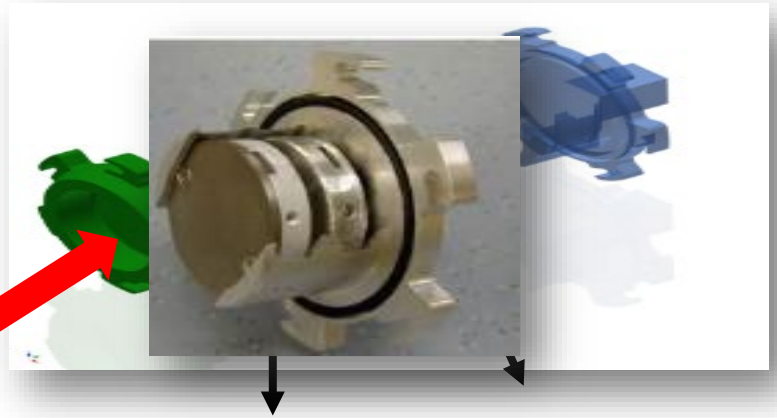


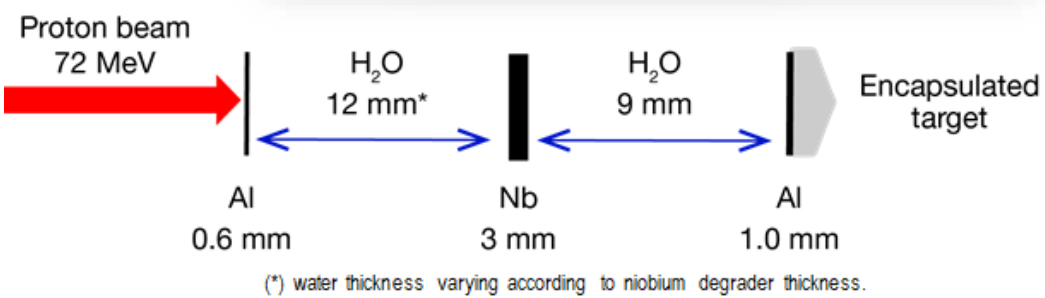
Target capsule





Proton energy





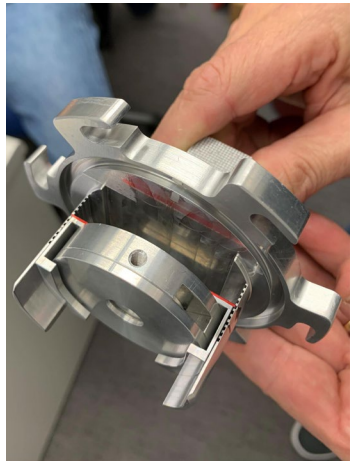
(*) water thickness varying according to niobium degrader thickness.

Degrader Nb thickness [mm]	Average proton energy [MeV]
0.0	**41**
1.0	**34**
1.8	**28**
2.0	**26**
2.2	**24**
2.4	**23**
2.8	**18**
3.0	**16**
3.1	**15**
3.2	**13**
3.3	**12**
3.4	**10**
3.5	**8**

Calculated using SRIM

Proton energy

Proton energy: 8-41 MeV



Proton energy: 51-63 MeV

$^{159}Tb(p,\mathbf{5n})^{155}Dy \rightarrow {}^{155}Tb$

$^{171}Yb(p,\mathbf{5n})^{167}Lu \rightarrow {}^{167}Yb \rightarrow {}^{167}Tm$

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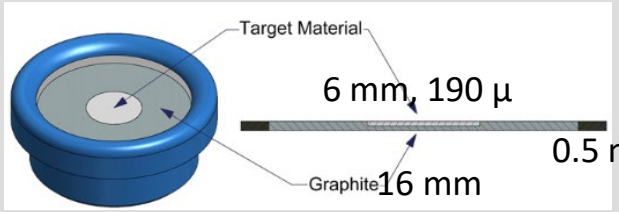
Target Material

$^{44}CaCO_3$ (97% enriched)

$^{44}Ca(p,n)^{44}Sc$

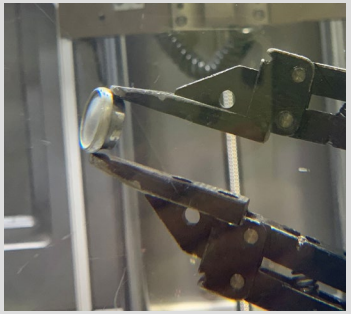
Sc 41	Sc 42	Sc 43	Sc 44	Sc 45	Sc 46	Sc 47	Sc 48	Sc 49
596.3 ms	61.7 s / 681 ms	3.891 h	58.61 h / 3.97 h	100	18.75 s / 83.79 d	3.3492 d	43.67 h	57.18 m
β+ 5.5... γ (2575, 2959)	β+ 2.8 γ 438 1524 1227... / β+ 5.4... γ (1524 313)	β+ 1.2... γ 373...	IT 271 ε γ 1002 1126 1157 / β+ 1.5... γ 1157...	σ 9.8 + 17.4	β- 0.4 1.5 γ 1121 889... σ 8.0 / IT 143	β- 0.4, 0.6 γ 159	β- 0.7... γ 984, 1312 1038...	β- 2.0... γ (1762, 1623)
Ca 40 96.941	**Ca 41** $9.94 \cdot 10^4$ a	**Ca 42** 0.647	**Ca 43** 0.135	**Ca 44** 2.086	**Ca 45** 162.61 d	**Ca 46** 0.004	**Ca 47** 4.536 d	**Ca 48** 0.187 $1.9 \cdot 10^{19}$ a
σ 0.41 $\sigma_{n,\alpha}$ 0.0025	ε, no γ σ ~4 $\sigma_{n,\alpha}$ 0.18 $\sigma_{n,p}$ 0.007	σ 0.680	σ 6.2	σ 0.88	β- 0.258... γ (12), e- σ ~15	σ 0.74	β- 0.7, 2.0... γ 1297, 808 489...	2β-, β- σ 1.09



$^{44}CaCO_3$ pressed on to graphite

(160 mg graphite, 10 mg $CaCO_3$)

Gas release



50 µA, 90 min irradiation EOB: **1.9 GBq** ^{44}Sc

N. van der Meulen, Nucl. Med. Biol. ***2015****, 42, 745–751.*

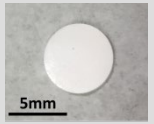
Scandium-44

Target material: $CaCO_3$

1 h 900°C

CaO

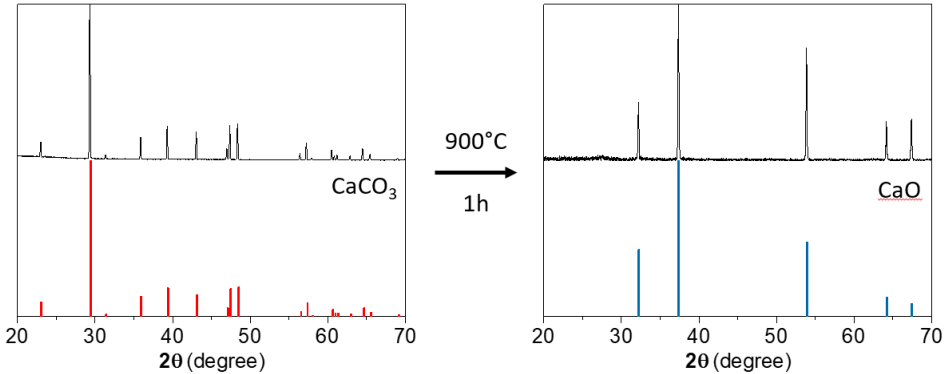
30 mg (2 tons, 5s)



Ø = 6 mm

t = 0.5 mm

XRD



50 µA, 90 min EOB: **3.9 GBq ^{44}Sc**

N. P. van der Meulen, Molecules (2020) 25: 4706.

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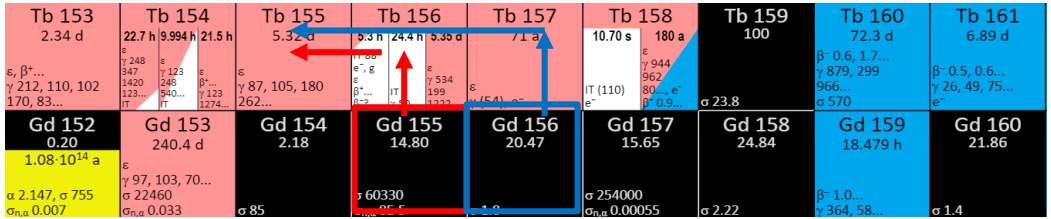
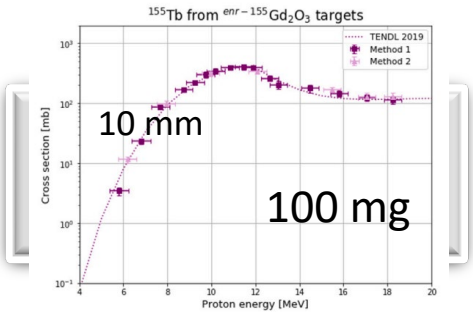
Terbium-155



Target Material: $^{155}Gd_2O_3$ (91.9 % enriched)

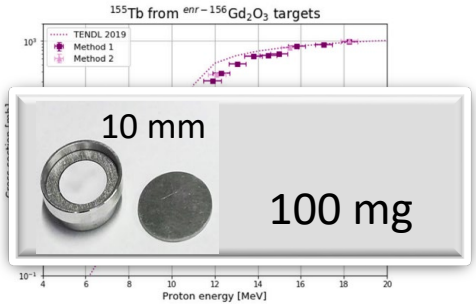
$^{155}Gd(p,n)^{155}Tb$



50 µA, 8 h irradiation EOB: **200 MBq ^{155}Tb**

$^{156}Gd_2O_3$ (93.3 % enriched)

$^{156}Gd(p,2n)^{155}Tb$



50 µA, 8 h irradiation EOB: **4.4 GBq ^{155}Tb**

G. Dellepiane et al., Applied Radiation and Isotopes 184 (2022) 110175

C. Favaretto et al., *EJNMMI Radiopharmacy and Chemistry* (2021) 6:37.

Copper-64

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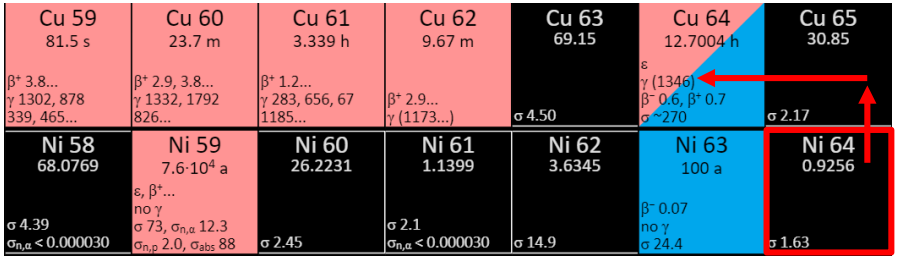
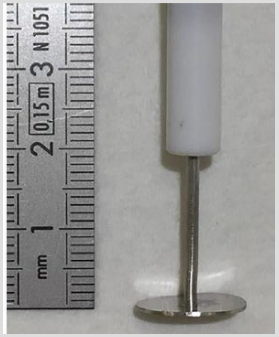
Target Material:

^{64}Ni (99.1 metal powder)

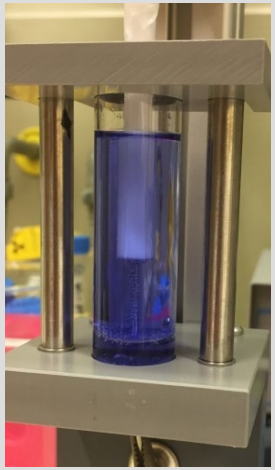
^{64}Ni(p,n)^{64}Cu





Pt electrode

13 mm diameter



dark blue

Time

(16 h)

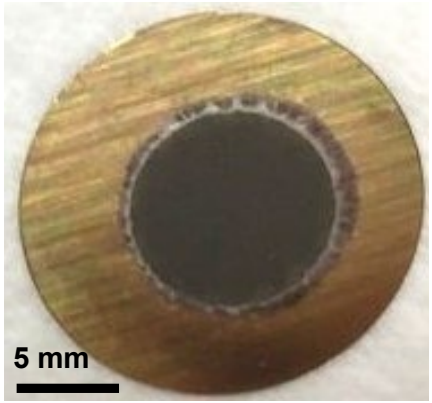
2.6 V

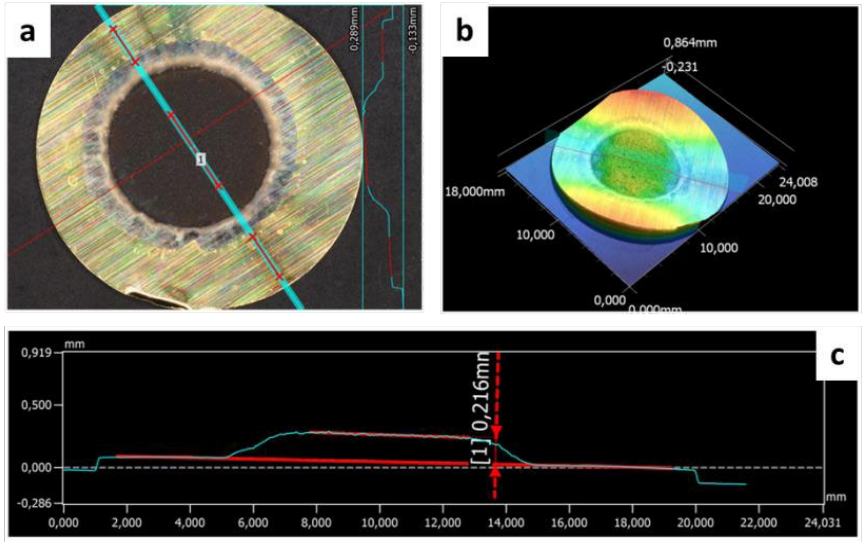
30 mA

Clear/colorless

N. Van der Meulen et al., Label Compd Radiopharm. 2019;62:460–470.

Copper-64





Thickness of the target: 215 µm (Keyence VR-3200)

60 mg target material

50 µA, 5 h irradiation EOB: **5-6 GBq ^{64}Cu**

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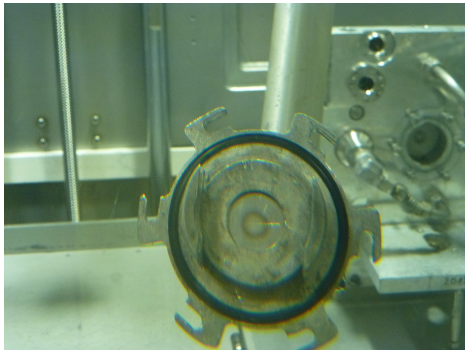
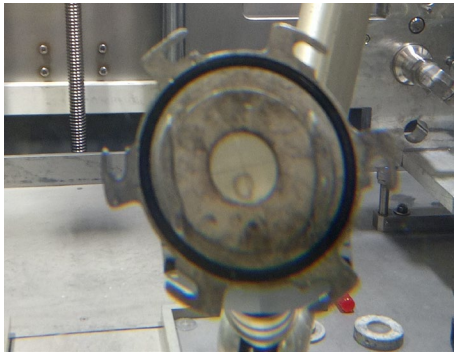
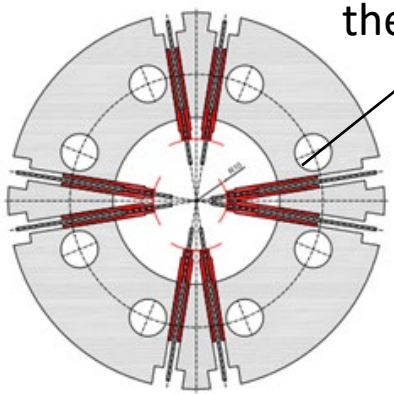
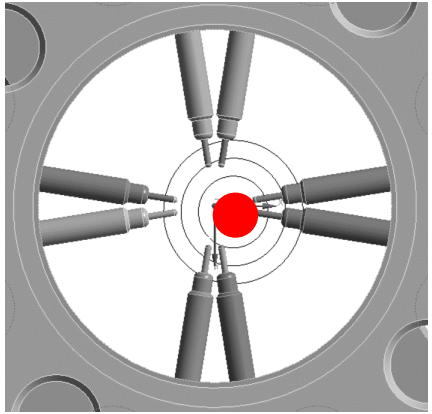
Test target

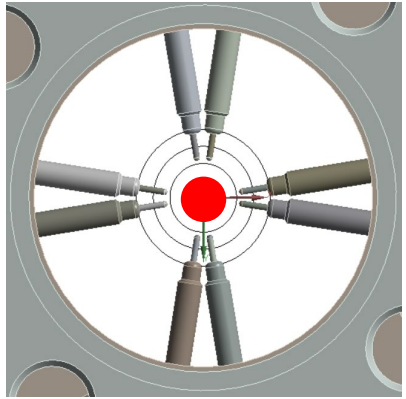




Position optimisation → Higher production yields







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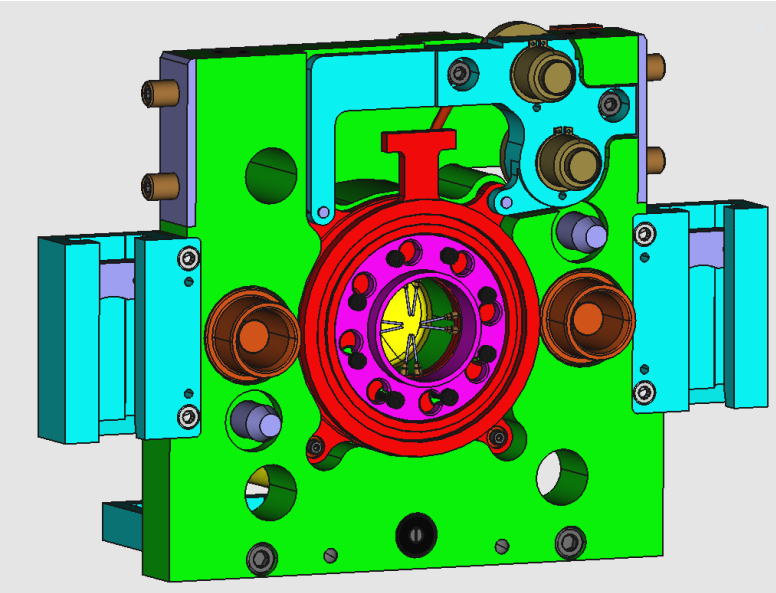
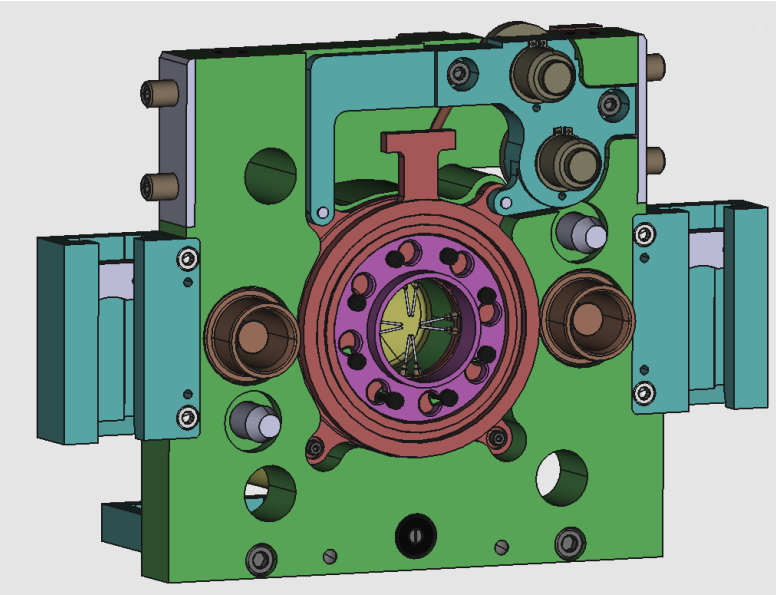
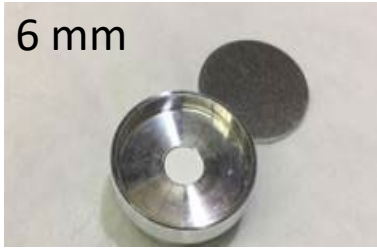
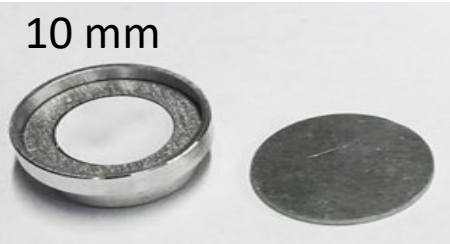
Optimisation of the IP2 Beam Monitor System









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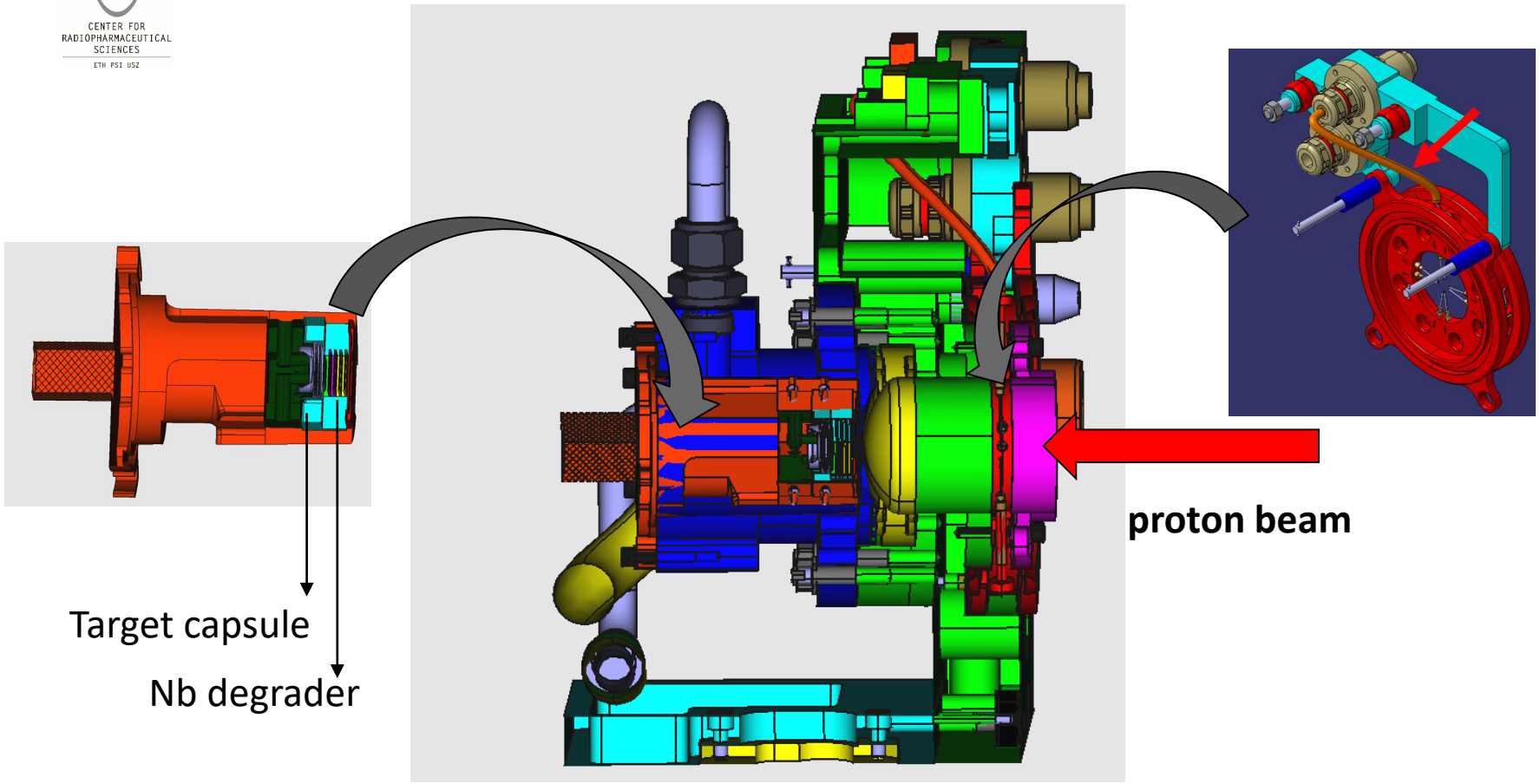

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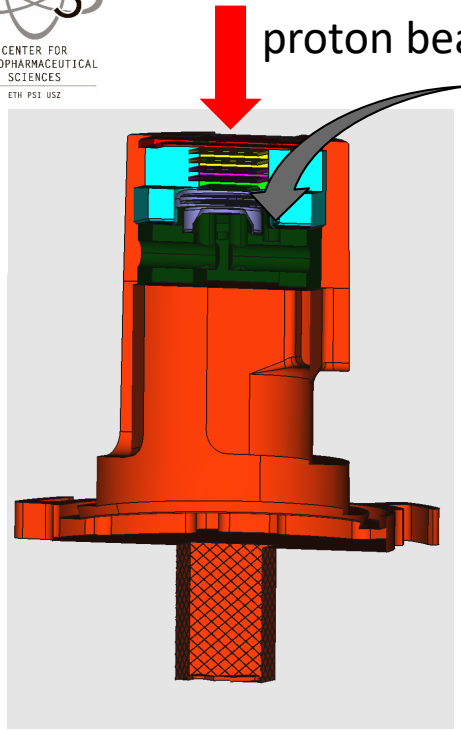

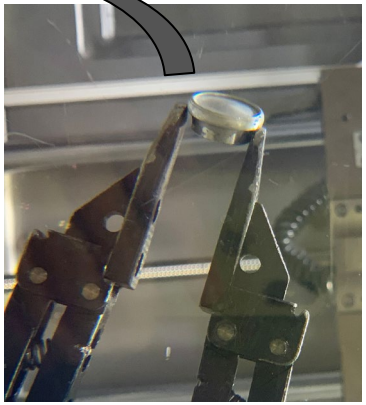

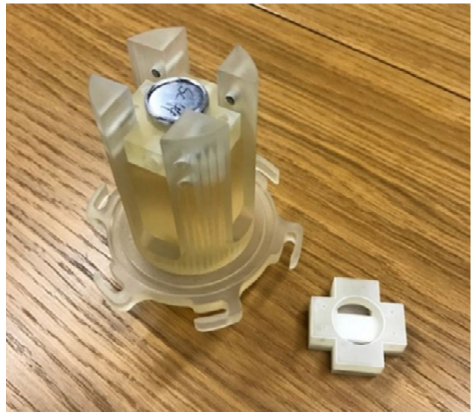

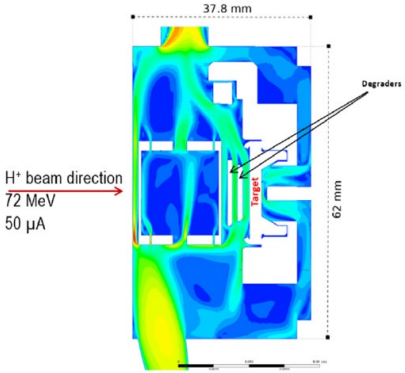

More efficient cooling

Summary

- **Targetry** is **the first and a crucial step** for medical radionuclide production.
- **The choice of target material and backing material** is key, as the irradiation parameters, as well as the subsequent devised chemical separation, are affected.
- **Targetry for ^{44}Sc, ^{155}Tb and ^{64}Cu** production.
- **Optimisation of IP2 Beam Monitor System** (beam profile and position)

Acknowledgement

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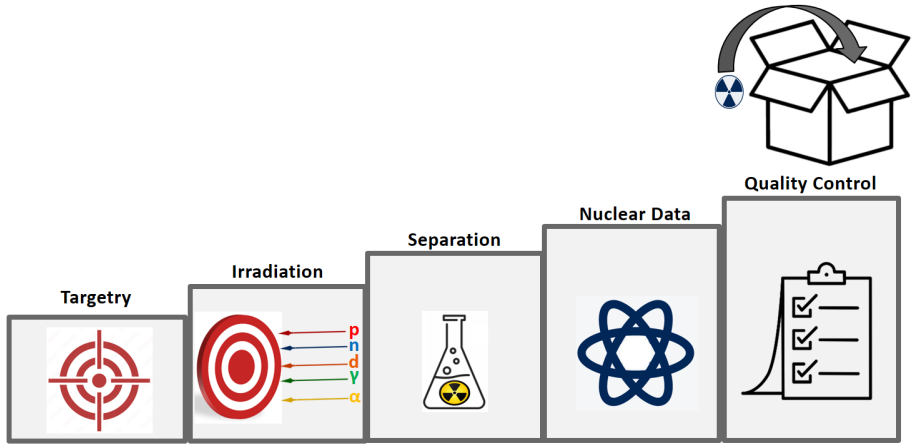
Dr. Stefan Joray

Swiss National Science Foundation

Thank You For Your Attention



Radionuclide Development Group

Dr. Zeynep Talip