Expanding the reach of nuclear medicine with ISOL radioisotopes

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NUCLEAR AND RADIATION PHYSICS

Chair Roger Van Geen
Lecture 4 – 22 November 2021

Outline

- Basics of nuclear medicine

- Theranostics opportunities with novel radioisotopes
  - ➢Tb quadruplet in greater details

- The place of ISOL
  - ➢CERN MEDICIS
  - ➢Tb-IRMA-V
  - ➢PRISMAP

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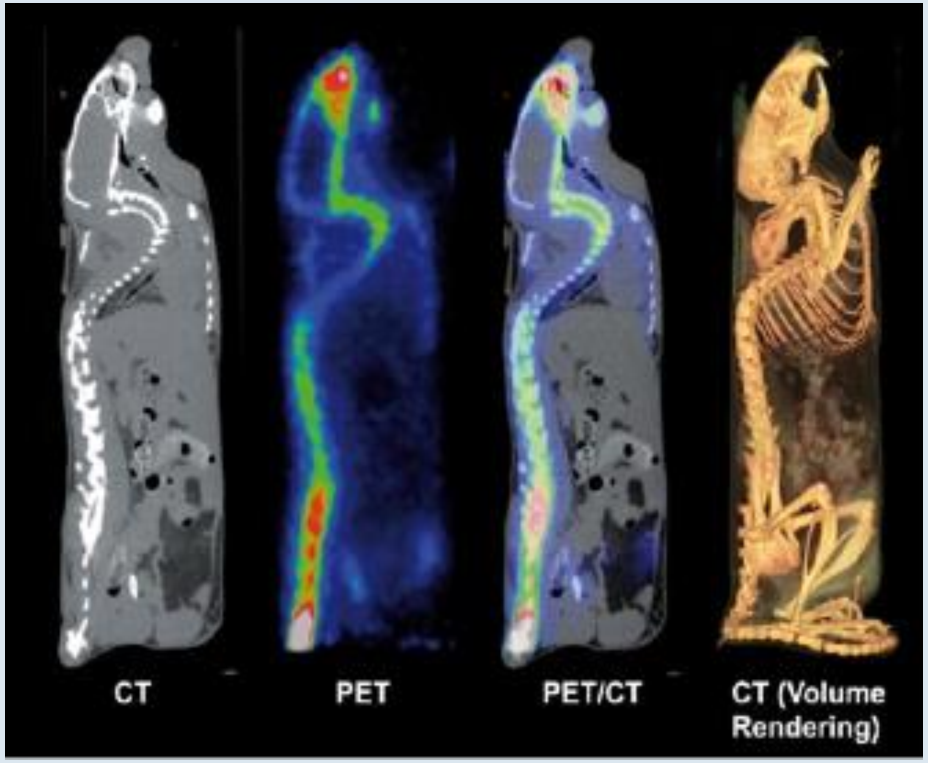

Basics of nuclear medicine

From molecular imaging ...

... to targeted radionuclide therapy

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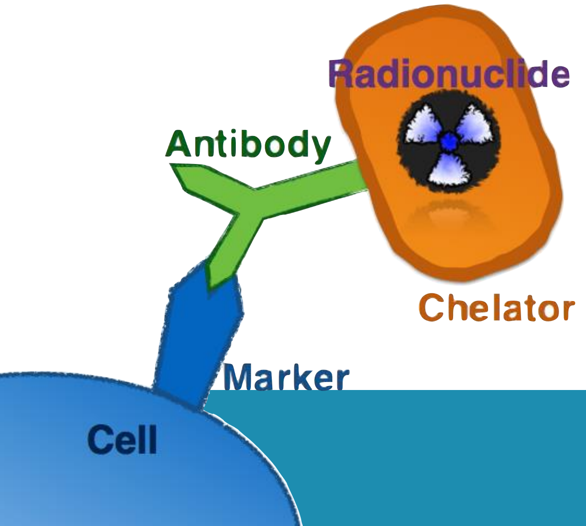
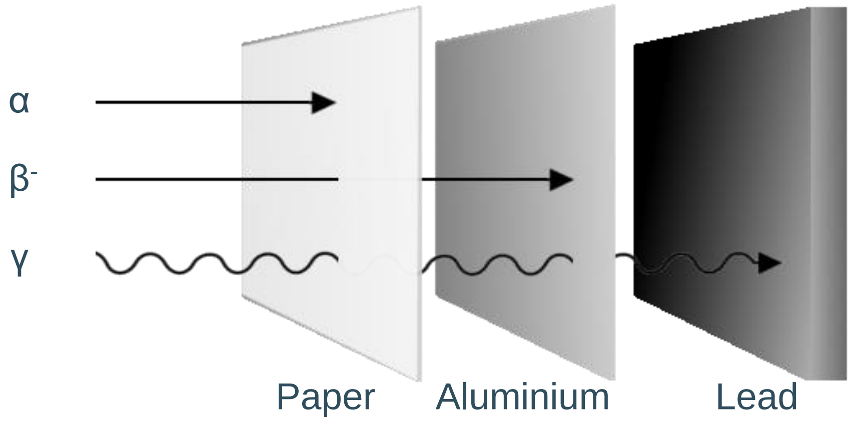
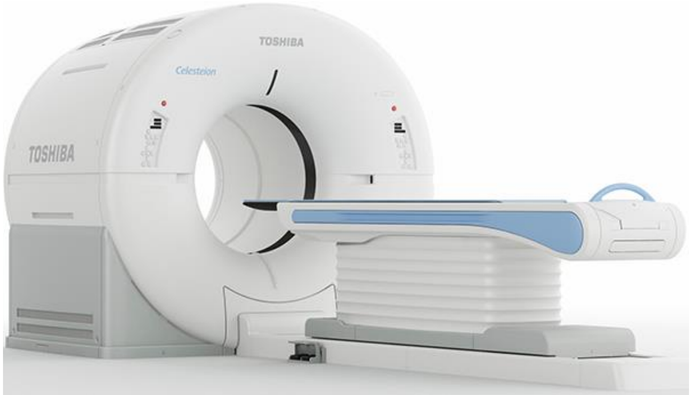
Molecular imaging

- A radionuclide is transported to a specific location in the body where it decays with the emission of a γ ray.
- The γ ray penetrates the tissues and exits the body so that it may be recorded externally to visualize where it decayed.
- Multiple orientations (patient or camera) yield a 3D tomographic reconstruction of the image.

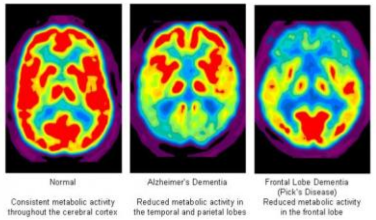




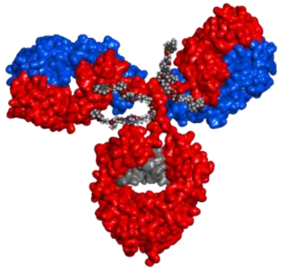


Targeted action

The body uses some trace elements for specific actions:
- iodine for thyroid functions
- calcium in the bones



A radioactive isotope can be included in a molecule involved in metabolic activities:
- sugar-equivalent FDG



Cells may display receptors that are specific and can be linked to by targeting molecules:
- peptides
- hormones
- antibodies

Important to match biodistribution to half-life!

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Molecular imaging

- SPECT
- PET
- CT
- Molecubes

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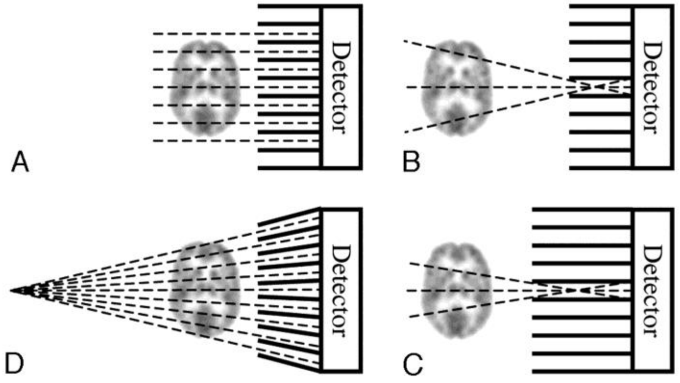
SPECT

Single Photon Emission Computed Tomography



- Using low-energy γ rays
  - ^{99m}Tc = 140 keV
  - ^{111}In = 171 keV, 245 keV
  - ^{177}Lu = 208 keV
- No need for high-energy resolution, but rather for sensitivity
  - Scintillators are best suited
- The image resolution requires that the radiation comes orthogonally onto the detector
  - The lead masks in front of the detectors are crucial in the technique!

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PET image?

Failed Google Image search...

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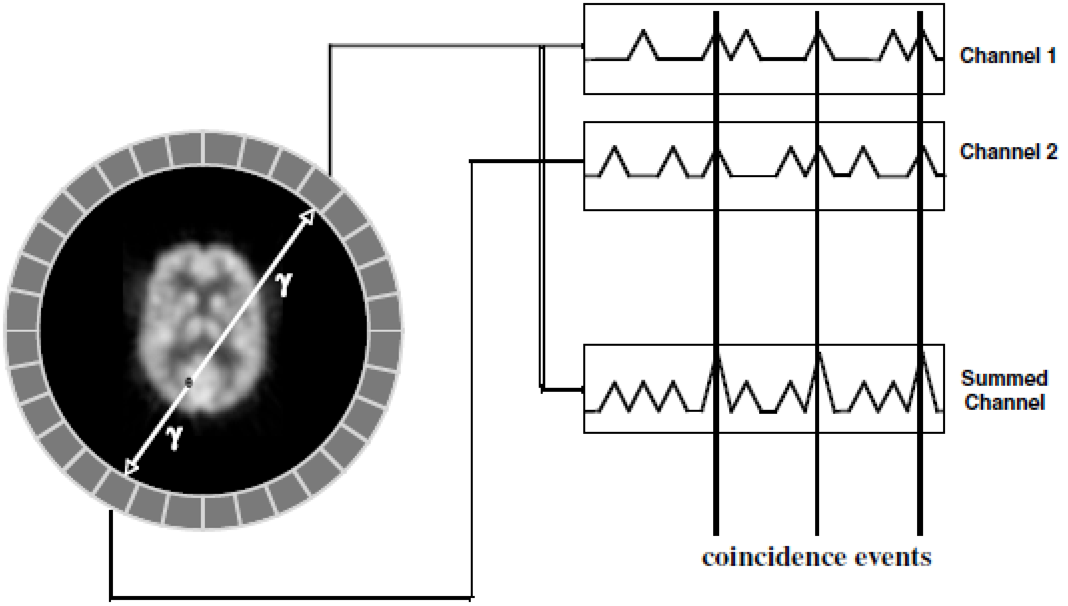
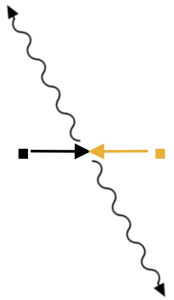
Positron Emission Tomography

- The source of the radiation is determined on the basis of the coincidence between the two 511 keV γ-ray photons
  - This requires an array of detectors
  - They must be efficient at 511 keV
  - The position resolution of the image depends on the detector granularity
- The time information between the two photons provides information on the depth of the source
  - ➢ TOF-PET
- Typical isotopes are ^{18}F, ^{11}C, ^{15}O and ^{68}Ga





<u>electron-positron annihilation:</u>
When a positron encounters an electron, they form a positronium, spiral down towards one another and annihilates each other, like two neutron stars, emitting in the process two γ-rays with an energy of 511 keV.

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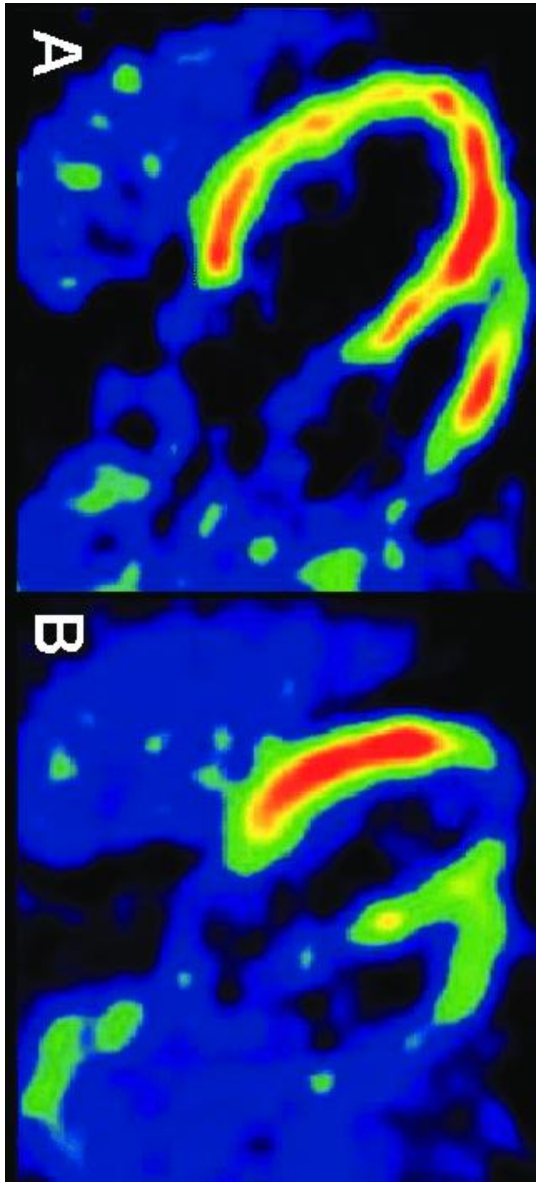
Functional imaging

- SPECT and PET allow to image where a radioisotope has decayed in the body. As such, it does not provide any information about the structure of the body, but only about the location of that isotope.
- By combining the isotope with a targeting action, it allows to image where that molecule travels in the body, e.g., sugar uptake for brain activity or searching for active cancer cells, identifying inflammations, increased uptake in the bones, ...
- The images themselves do not provide sufficient information as it only highlights a function, but not where in the body that action takes place.



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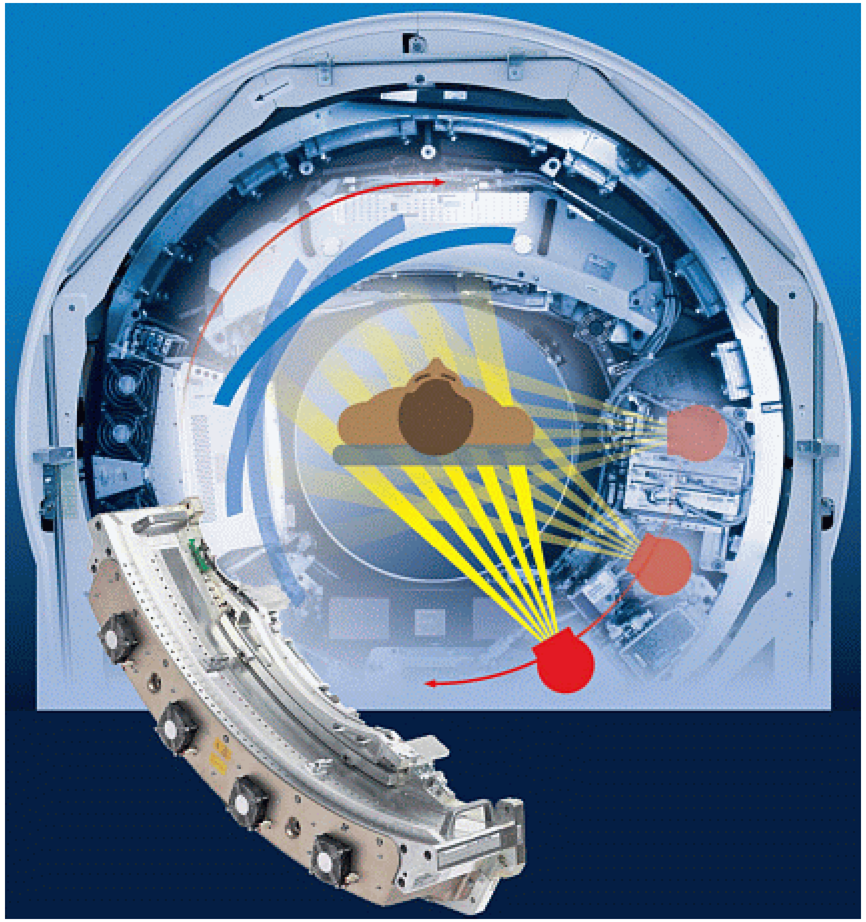
Computed Tomography

- Shining an external photon source, like x rays between 20-200 keV
- It consists in an absorption measurement: how much are the x rays attenuated by the material it has to penetrate.
- The most important is the position resolution, so that one may extract the density information from different path the photons cross.
- The multiple orientations are analyzed by an algorithm to create a 3D image.



Structural image

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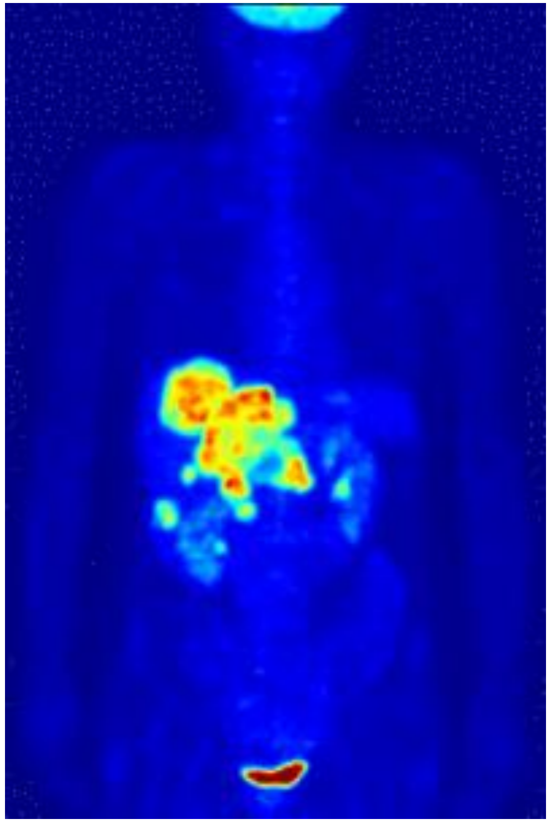
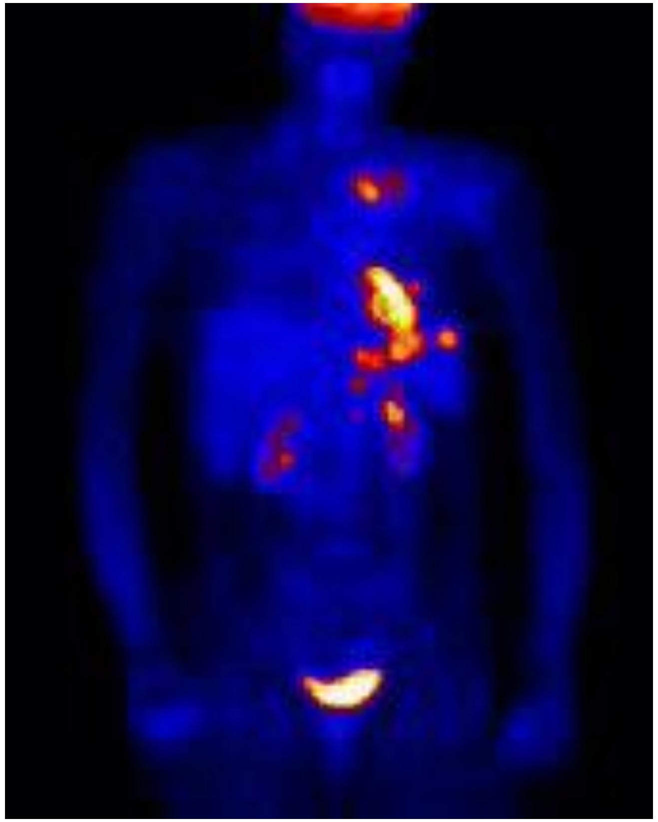
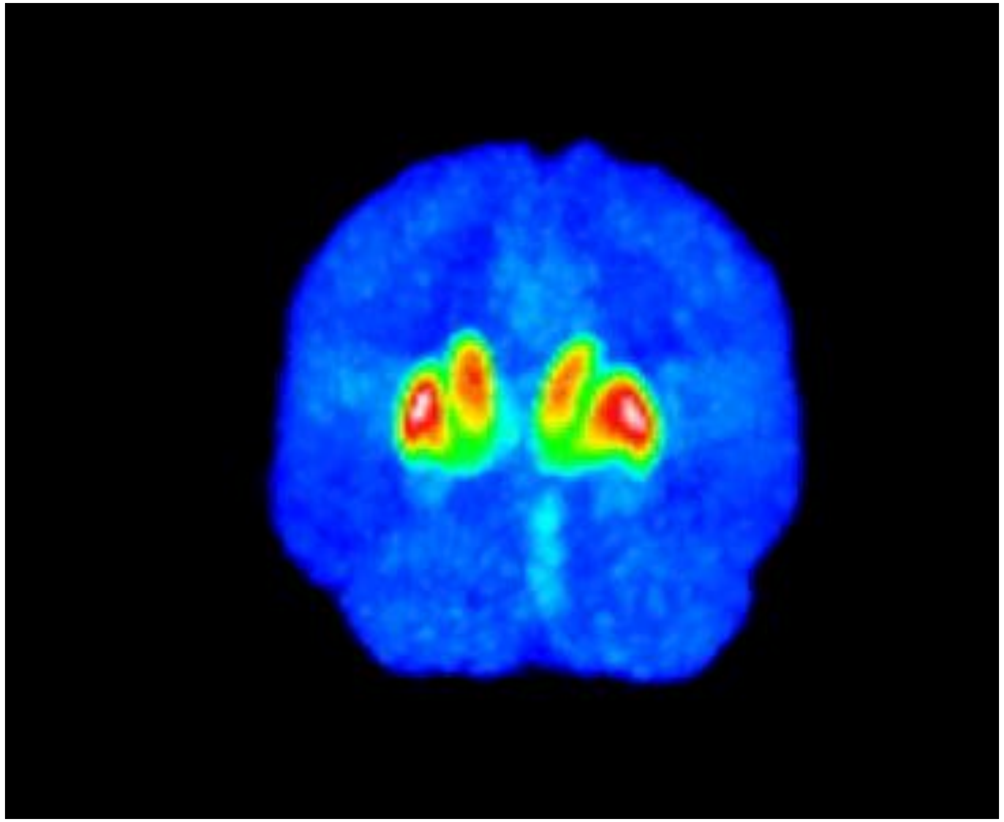
Combining functional and structural images

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In which direction do the bodies turn?

- Both to the right
- Right & left
- Left & right
- Both to the left
- ARGHHH!

Start the presentation to see live content. For screen share software, share the entire screen. Get help at **pollev.com/app**

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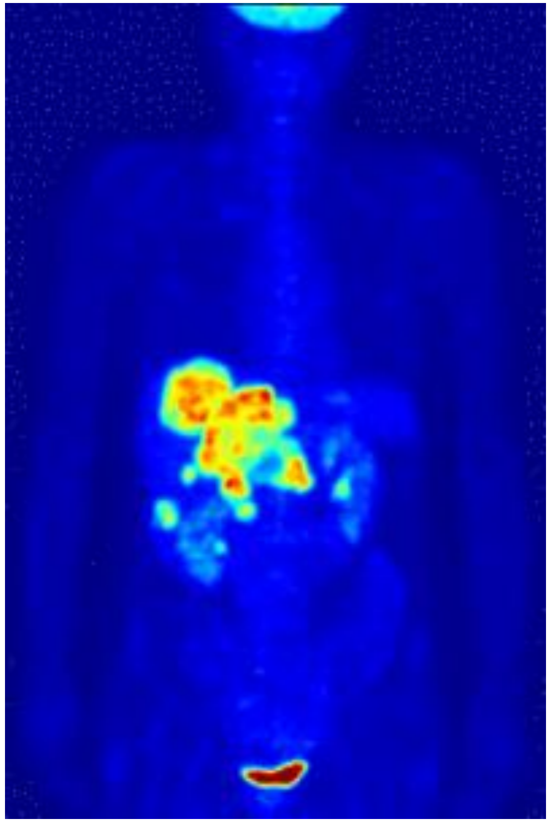
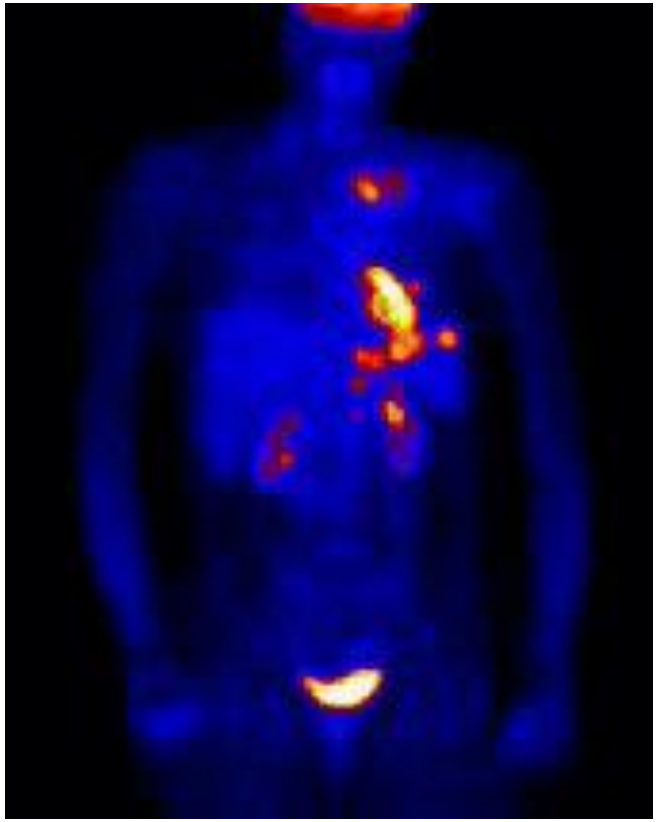
Combining functional and structural images





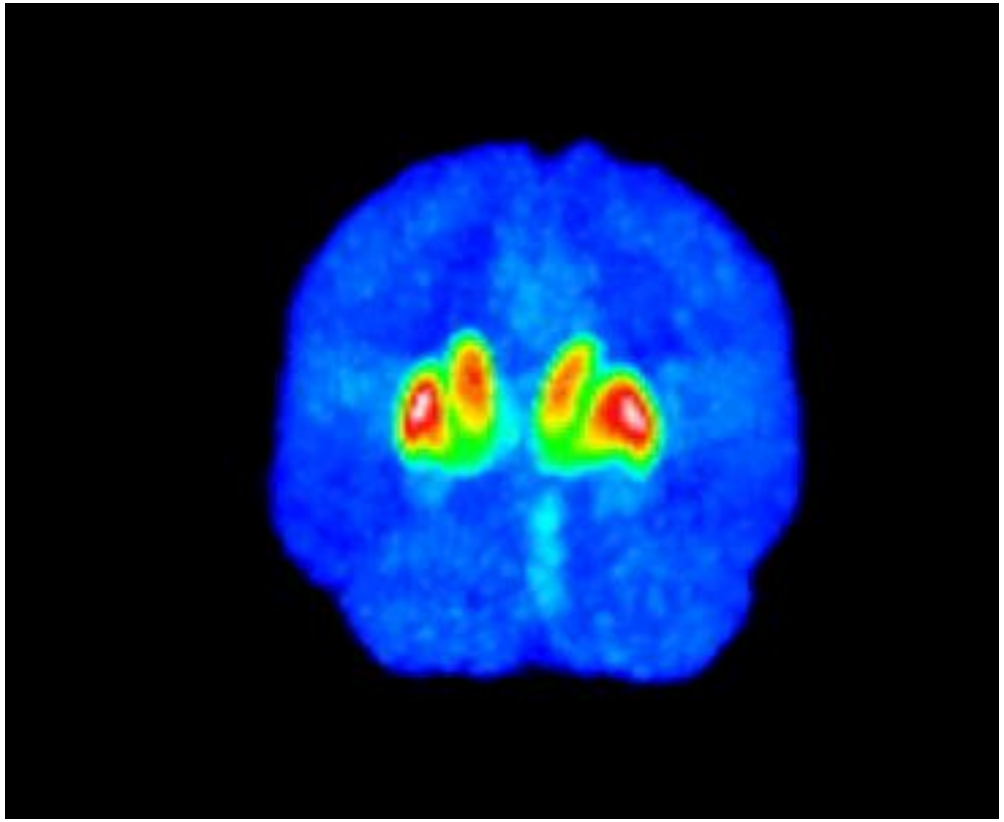


Image alignment is not trivial!

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Molecubes

- Pre-clinical research on small animals is key to research into nuclear medicine, be it for determine the behaviour of a new vector with known isotopes, or the behaviour of a novel isotope.
- Pre-clinical imaging is performed with μ-SPECT and μ-PET machines that can be rather bulky and require quite some attention.
- UGent has developed new setups that combine multiple imaging capabilities in a single device – the Molecube – for efficient imaging capabilities.

 https://www.molecubes.com/

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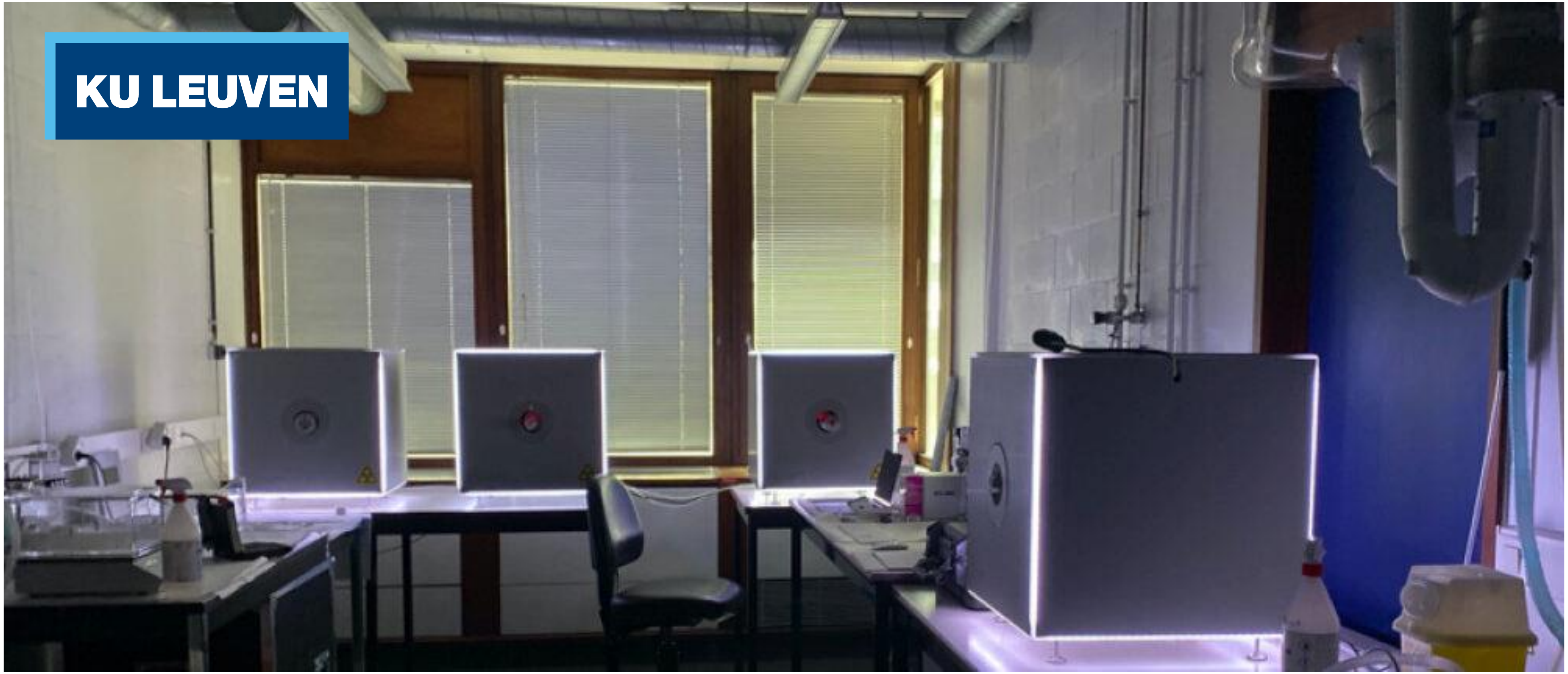
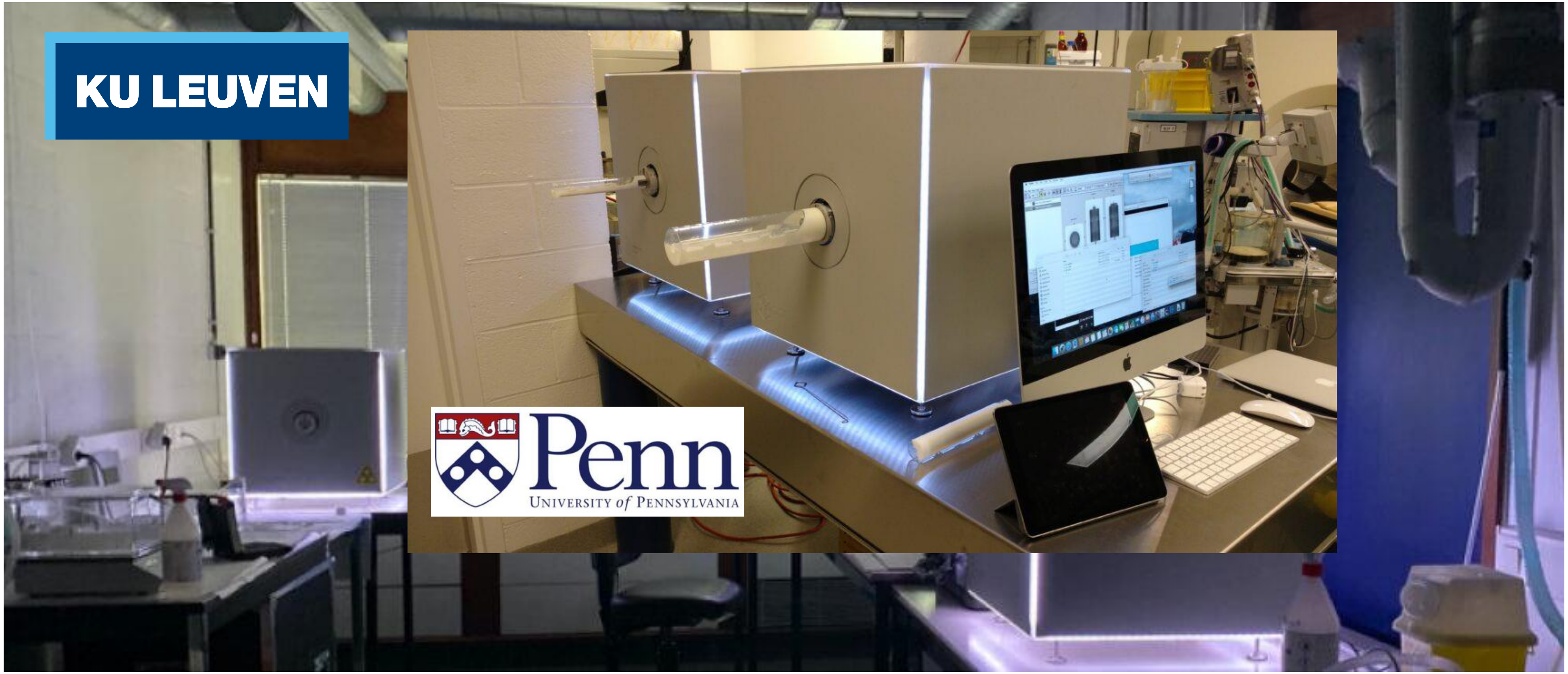
Molecubes in the wild

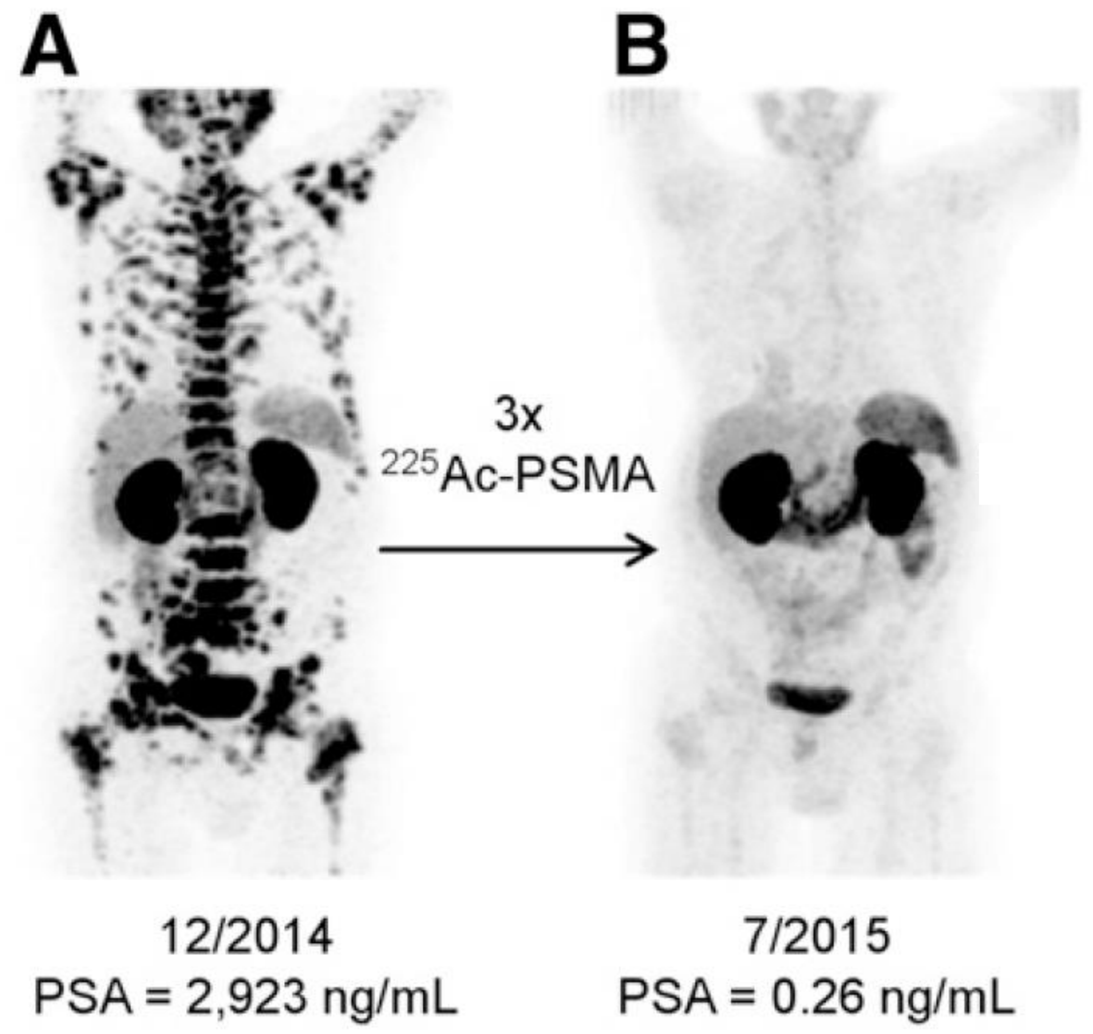


Molecubes in the wild



TRNT

Targeted RadioNuclide Therapy



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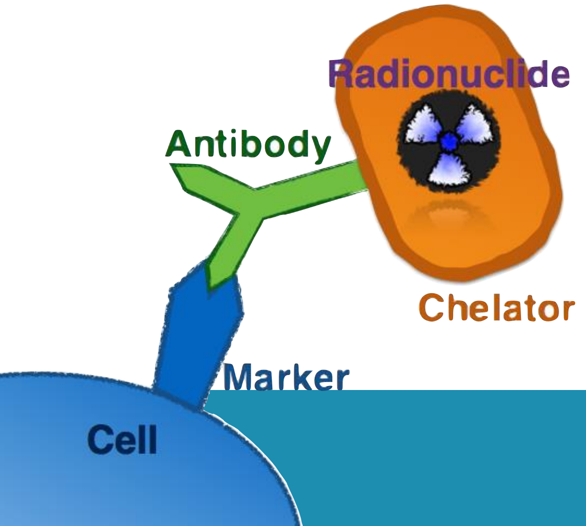
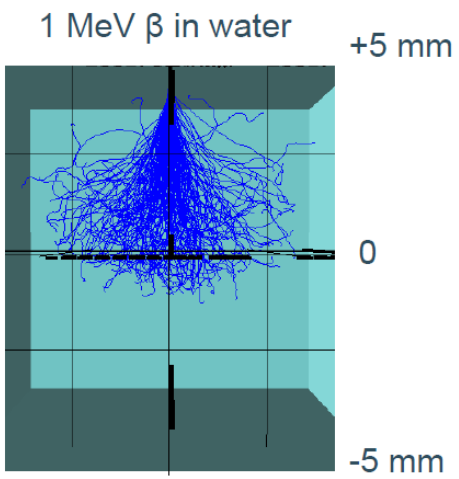
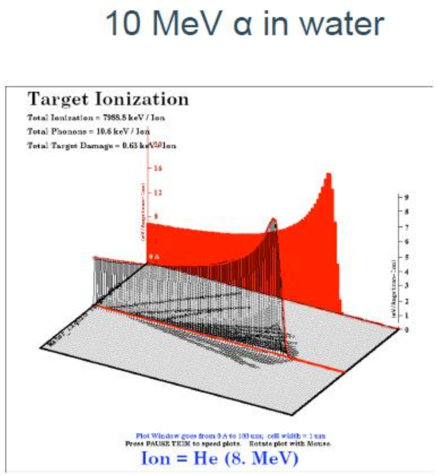
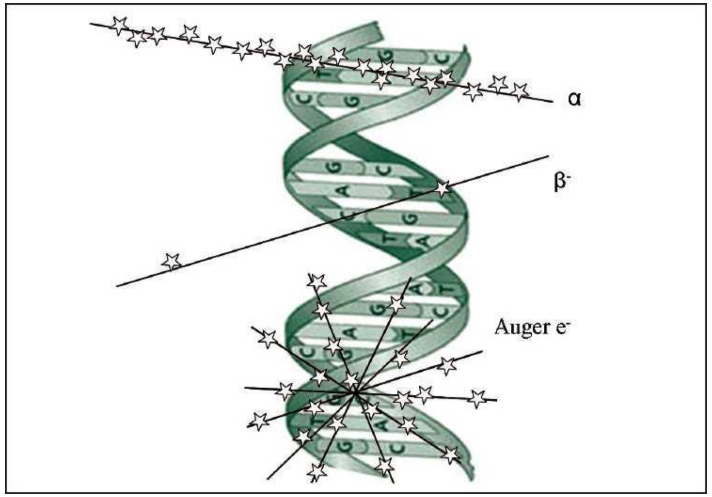
Switching to therapy

- Replacing the γ-ray emission with charged particle emission yields therapeutic effect.
- β^- particles may reach up to a few mm, α particles reach but a few cells, Auger electrons act within a cell.
- For an efficient treatment, the DNA of the targeted cell must be damaged beyond repair









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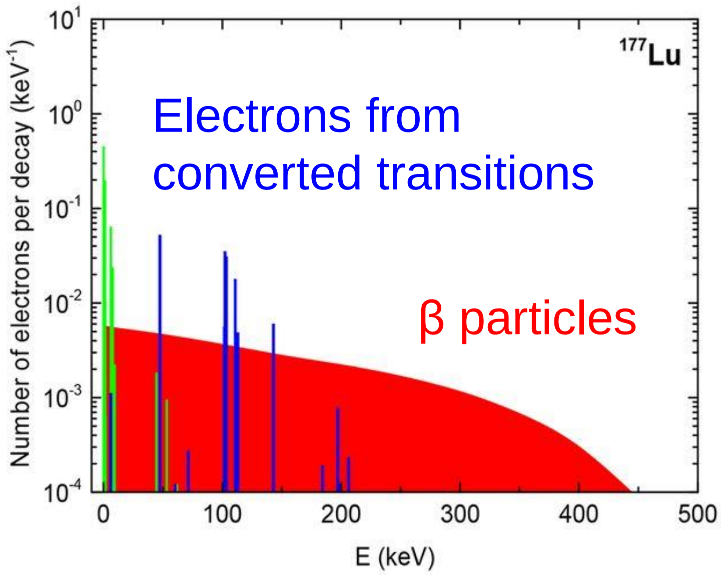
Beta decay

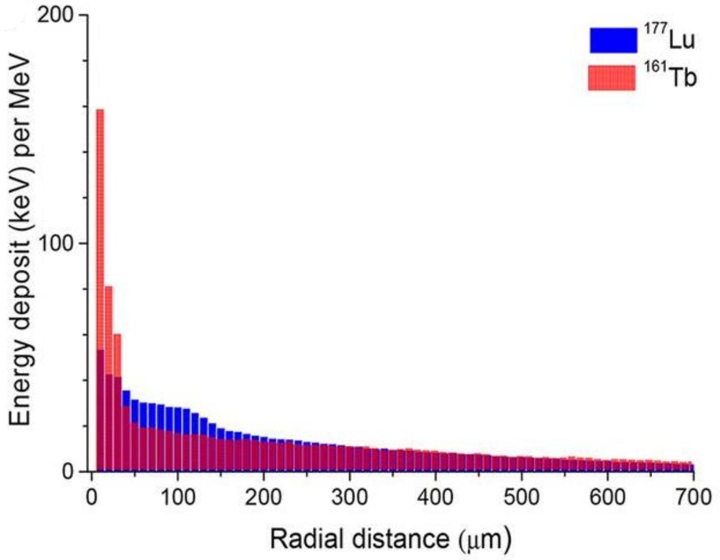
- Charge = - 1
- Mass = ~0.0005u
- Energy = MeV

β^- decay

- A neutron transforms into a proton with the emission of an electron and an antineutrino
- The energy is shared between the multiple particles so that it may be distributed over a continuous range

$$ {}^{A}_{Z}X \rightarrow {}^{A}_{Z+1}Y + e^{-} + \bar{\nu} $$





*E. Hindie et al., Dose deposits from 90Y, 177Lu, 111In, and 161Tb in micrometastases of various sizes..., The Journal of Nuclear Medicine **57** (2016) 759-764,*

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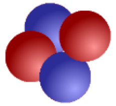
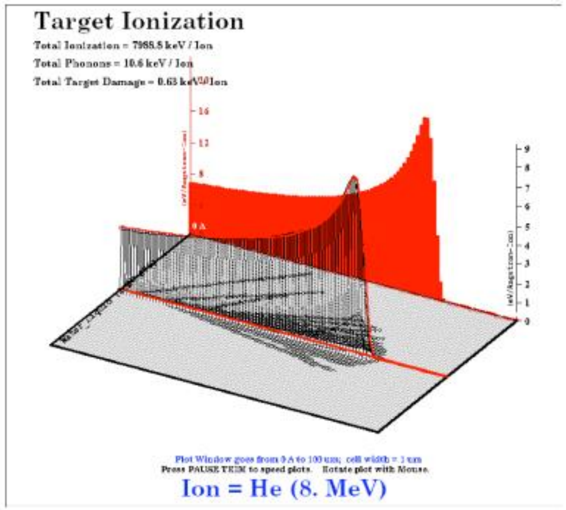
Alpha decay

$${}^{A}_{Z}X \rightarrow {}^{A-4}_{Z-2}Y + {}^{4}_{2}He$$

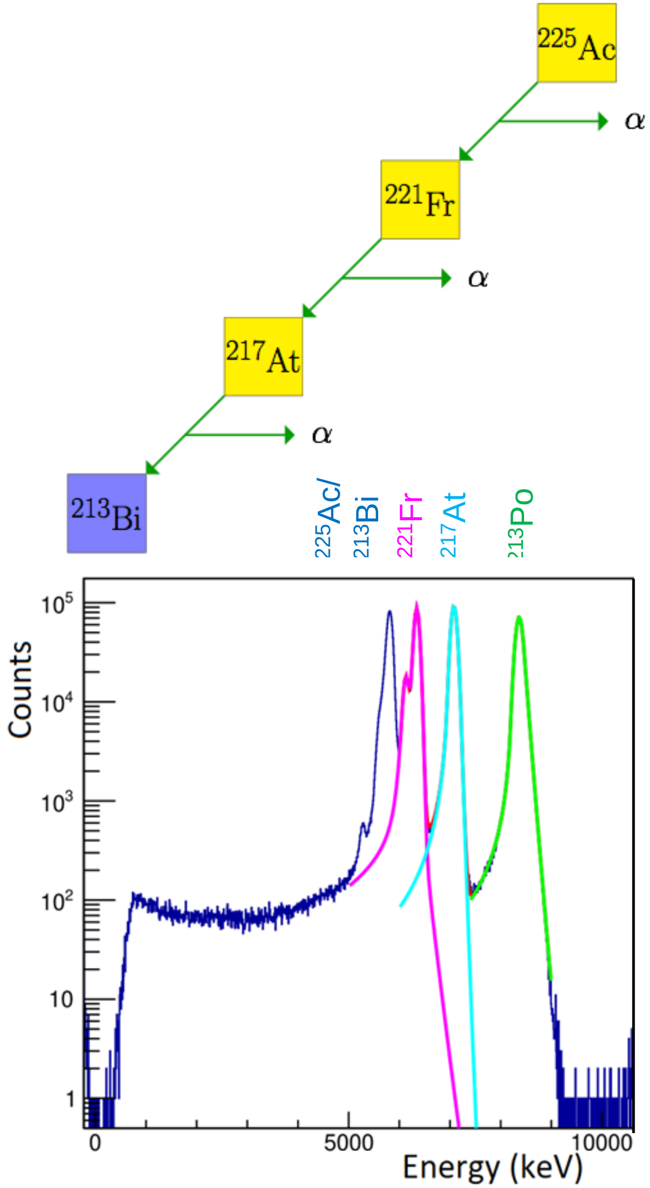
- Emission of a heavy charged particle in the form of a ^{4}He nucleus
  - 2 protons
  - 2 neutrons
  - No electron
    - Charge +2
    - Mass 4u
    - Energy ~few MeV



10 MeV α in water



- 2-body process
  - Single energy given to the α particle
  - Fingerprint of the decay



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Theranostics

- If a single vector molecule can be identified with interchangeable radioisotopes, then its efficacy and properties can be **tested with molecular imaging** and then **applied with therapy**.
- If a single radioisotope decay by both γ-ray or β^+ emission and α or β^- emission, then that single radioisotope can be used to **treat** and at the same time **monitor the patient dose** and the treatment's efficacy.

Final aim: personalized medicine where the treatment is tailored to the needs of the patient

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When poll is active, respond at **pollev.com/thomaseliasc687**

Text **THOMASELIASC687** to **+32 460 20 00 56** once to join

Is theranostics or theragnostics?

- Theranostics
- Theragnostics
- That's not even a word!
- None of the above

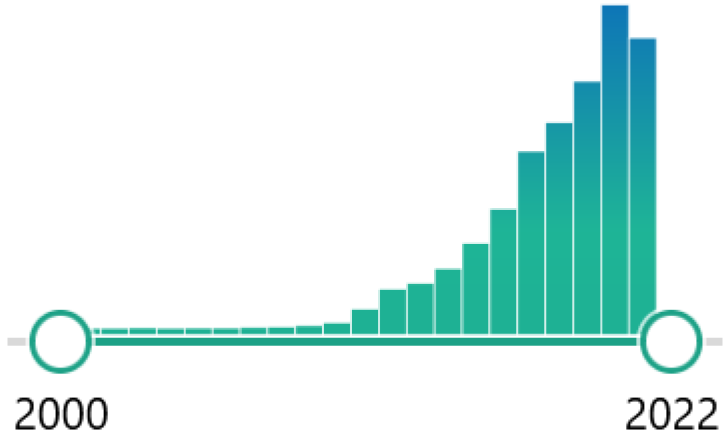
Is it theranostics or theragnostics?

Theragnostics

- Thera-py + dia-gnostics
- From an etymological point, it is actually how this word should be constructed
- PubMed returns 195 articles

Theranostics

- Thera-py + diag-nostics
- Rolls better on the tongue
- PubMed returns 9108 articles



https://pubmed.ncbi.nlm.nih.gov/?term=theranostics

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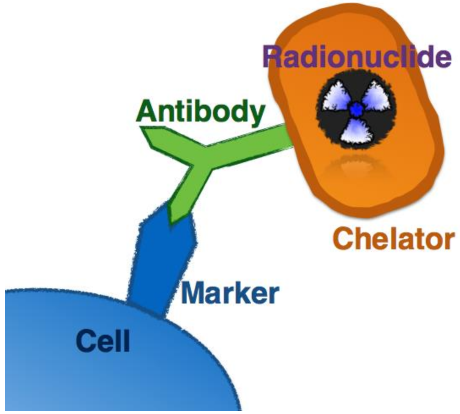
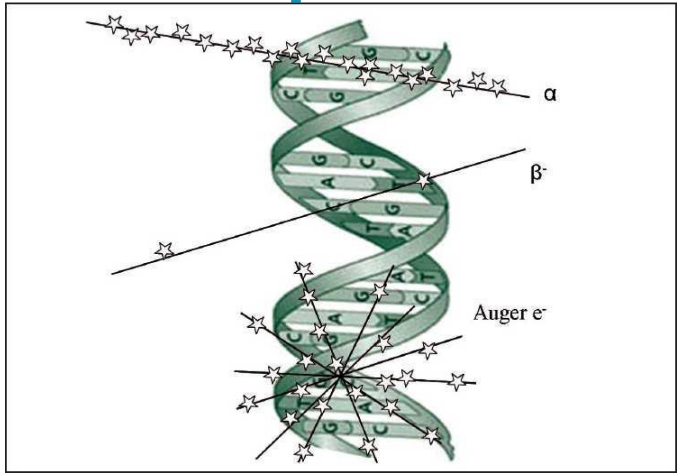
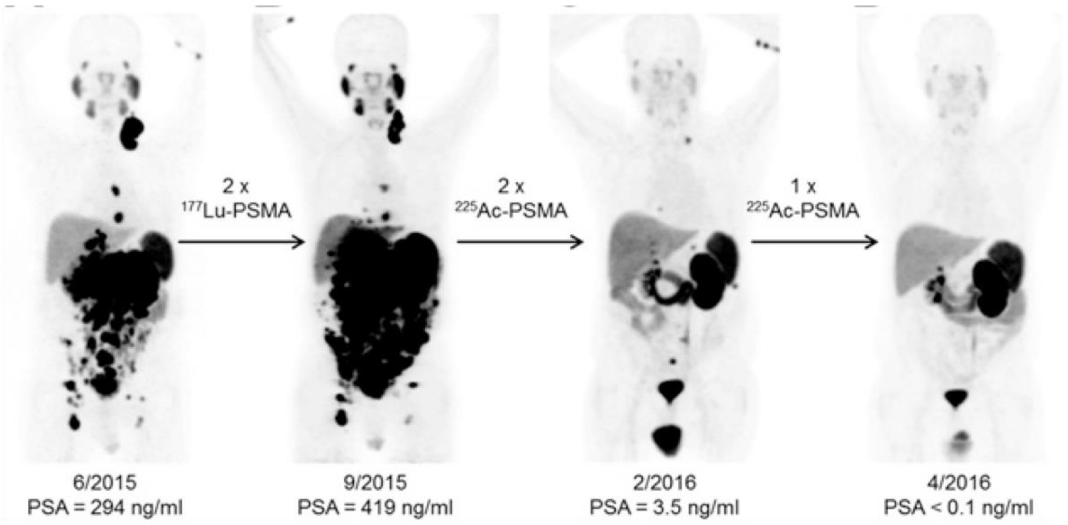
Theranostics in practice







- Distributed cancers cannot be accessed by surgical means (e.g. cancer of the endocrine system and metastatic cancers).
- A targeted approach is required, e.g. using metabolic functions or over-expressed markers.
- Radioisotopes can be used for imaging (β^+, γ) or for therapy (α , β^+)

*C. Kratochwil et al, The Journal of Nuclear Medicine **57** (2016) 1941-1944*

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BREAK

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Theranostics opportunities with novel radioisotopes

- Quick overview
- Deep dive into Tb research

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Historical theranostics: Iodine

Imaging

- ^{123}I for SPECT imaging
  - $T_{1/2} = 13.2$ h
  - Pure electron capture, no β
  - γ ray at 159 keV
- ^{124}I for PET imaging
  - $T_{1/2} = 4.15$ d
  - β^+ decay at 2.1 MeV

Therapy

- ^{131}I for targeted therapy
  - $T_{1/2} = 8$ d
  - β^- decay < 1 MeV
  - γ ray at 264 keV

Iodine therapy has treated **10x more cancer patients** for just the thiroid than all nuclear incidents (military or industrial) combined!

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Pseudo theranostics

^{68}Ga PET imaging

- Unconventional PET isotope compared to the standard ones
- As radiometal, it can be chelated by DOTA and thus may resemble the way therapy isotopes are prepared
  - ➢ $T_{1/2} = 68$ min
  - ➢ β^+ decay at 1.9 MeV

^{177}Lu therapy

- Following the success of the NETTER1 trial, Lutathera is the first drug marketed using ^{177}Lu
- Radiometal, typically chelated with DOTA
  - ➢ $T_{1/2} = 6.65$ d
  - ➢ β^- decay ~0.5 MeV
  - ➢ γ ray at 113 & 208 keV

Looking for more options

44 Sc Scandium | 47 Sc Scandium

$T_{1/2}$ = 4 h and 3.35 d
PET imaging
β- therapy

64 Cu Copper | 67 Cu Copper

$T_{1/2}$ = 12.7 h and 62 h
PET imaging
β- therapy

149 Tb Terbium | 152 Tb Terbium | 155 Tb Terbium | 161 Tb Terbium

165 Er Erbium | 169 Er Erbium

$T_{1/2}$ = 10 h and 9.4 d
SPECT imaging
β- and Auger therapy

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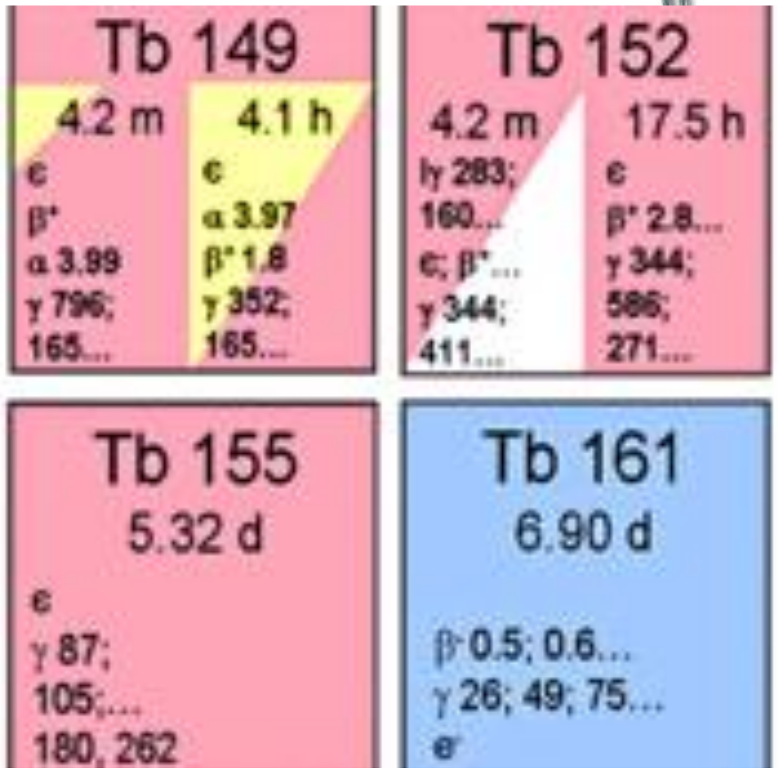
Tb: holy grail quadruplet

- ^{161}Tb: β^-, Auger e^-, low-E γ
- ^{155}Tb: pure electron capture (no β^+), low-E γ
- ^{152}Tb: β^+
- ^{149}Tb: α, β^+
- Once an appropriate molecule is found, it can be used with either choice of Tb radioisotope according to the need!



Important to match biodistribution to half-life!

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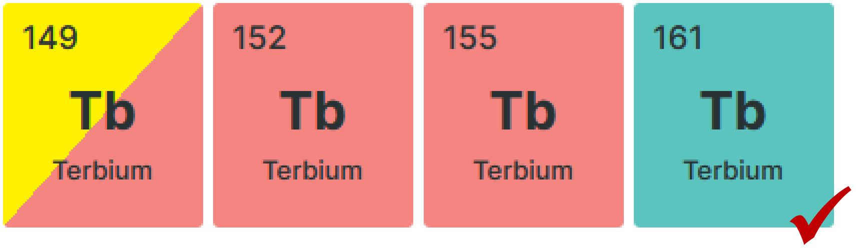
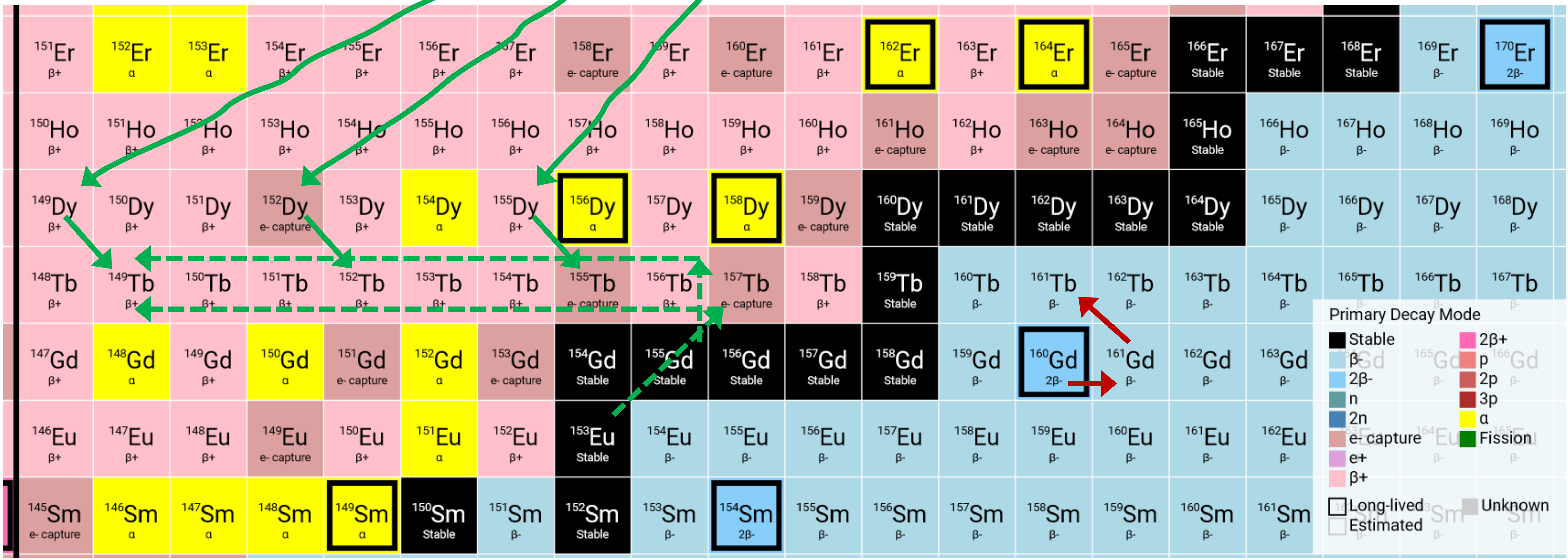
Producing the Tb isotopes





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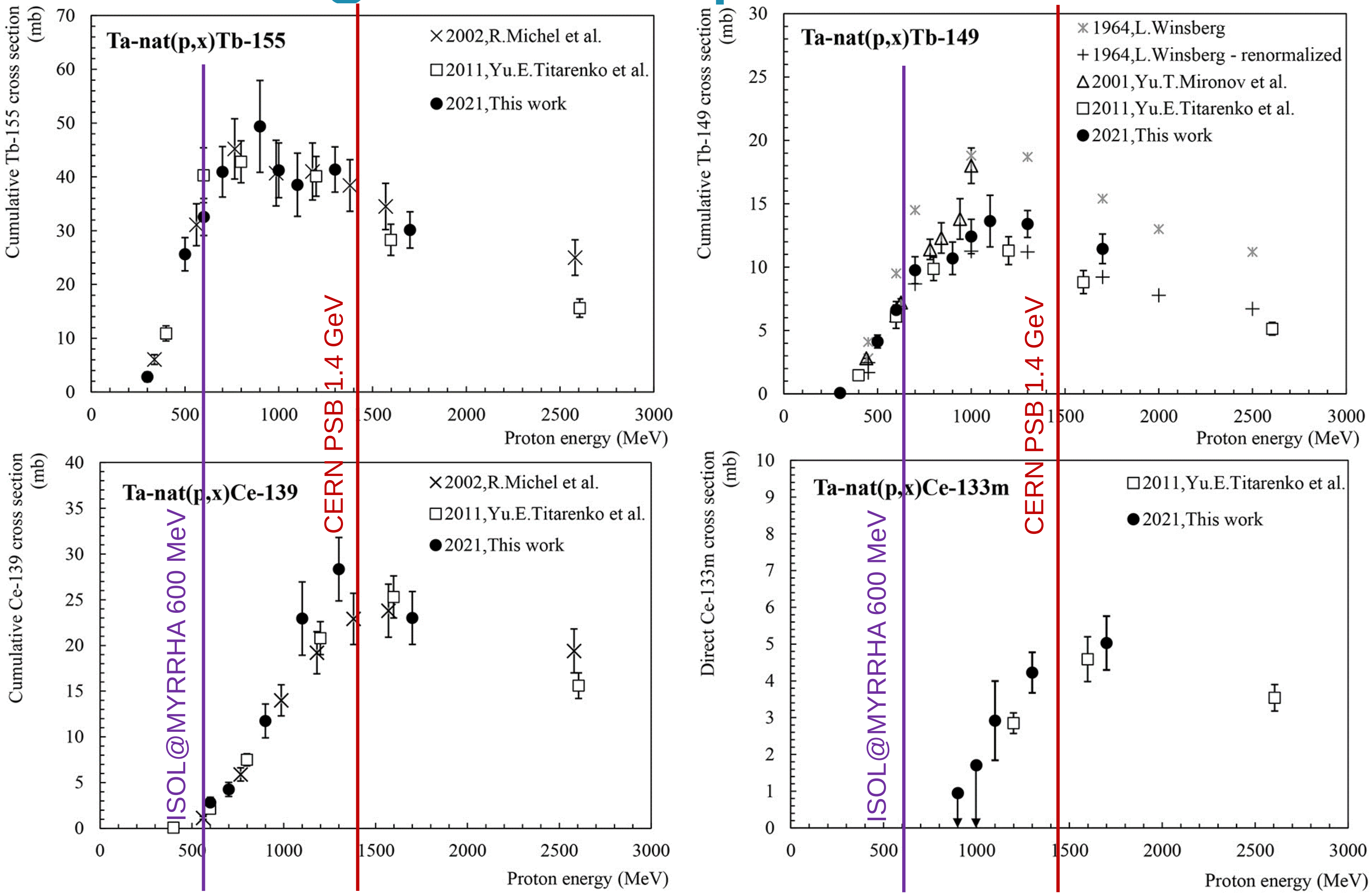
Looking into the production



Cross sections are the first step in studying the production of any radioisotopes. For Tb, many paths are open, none of which are sufficiently understood to go to large-scale production, thus requiring in-depth investigations.

*H. Verhoeven et al, Measurement of spallation cross sections of terbium… NIMB **463** (2020) 327-329.*
*C. Duchemin et al, Production cross section measurements for terbium …, Frontiers in Medicine **8** (2021) .*

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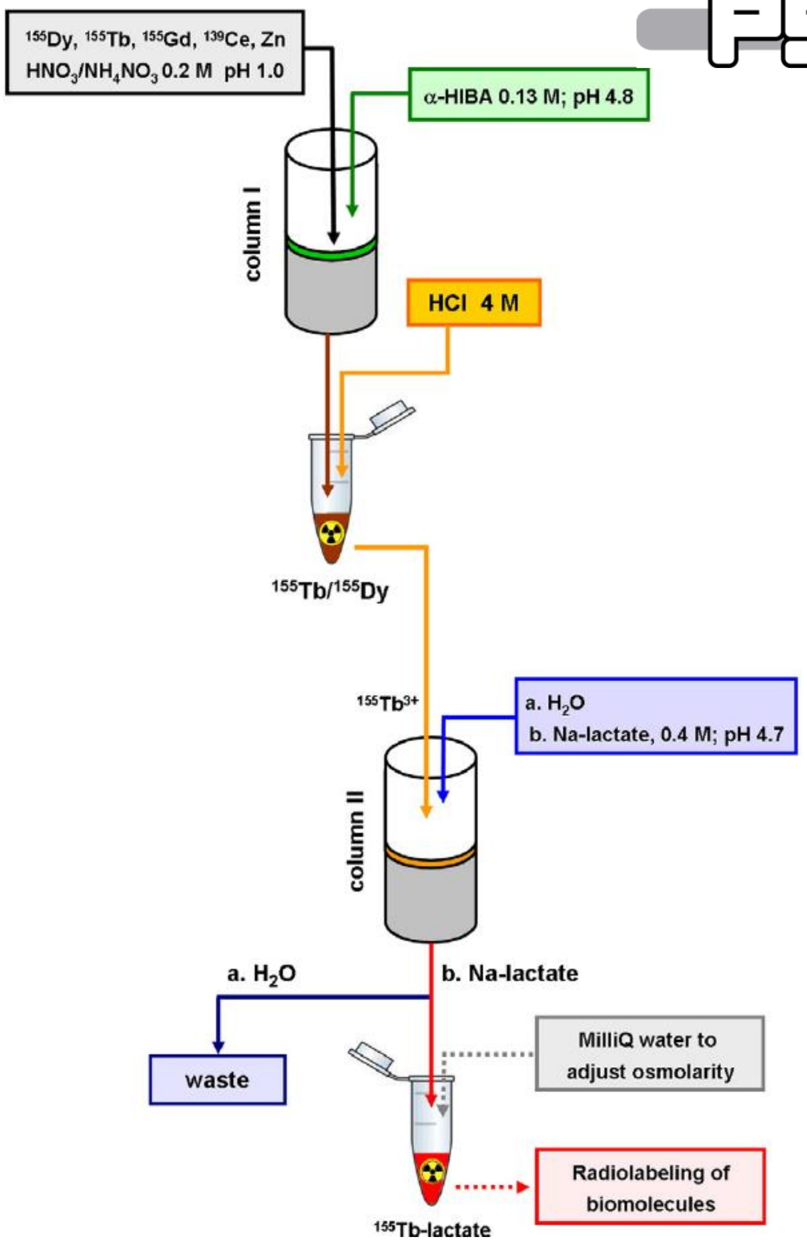
Radiochemistry

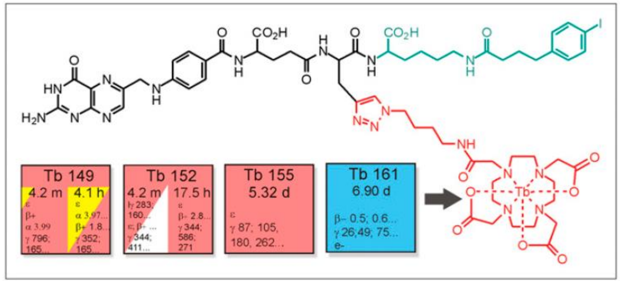
- Once the radioisotopes are collected, they must be isolated from their substrate, separated, and finally attached to the distribution vector.
- The different steps in radiochemistry and radiolabelling determine the purity of the final product.
- Radiometals tend to have complex chemistry that renders their separation challenging.

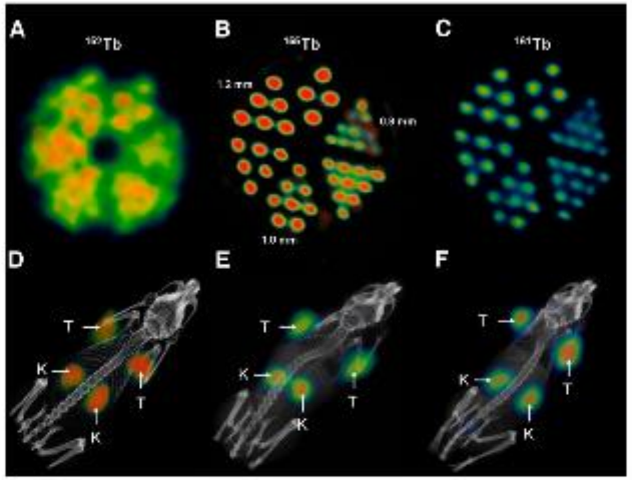


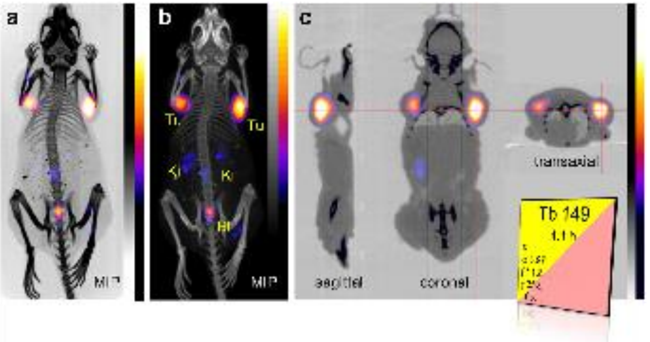
*C. Müller et al, Nuclear Medicine and Biology **41** (2014) e58-e65.*

Pre-clinical studies with Tb

- Once the radiopharmaceuticals are ready, pre-clinical studies can begin, in-vitro and in-vivo.
- These include the study of the biodistribution, efficacy and toxicity in animal models.
- Based on the outcome of those studies, predictions can be made on the response in human bodies and proposals can be drawn for clinical studies.



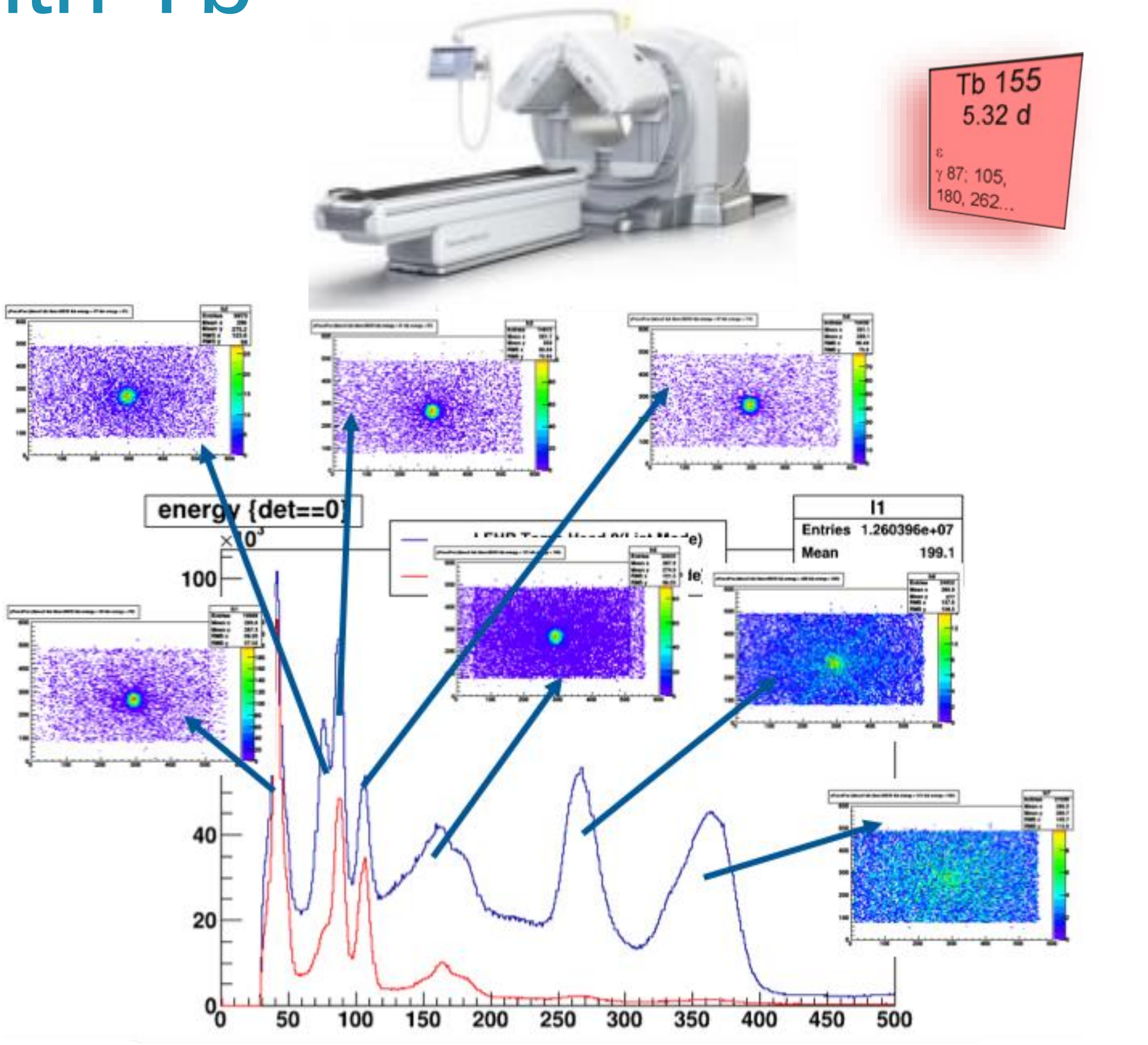




C. Müller et al, The Journal of Nuclear Medicine, ***53*** *(2012) 1951-1959.*
C. Müller et al, Letter to European Journal of Nuclear Medicine & Molecular Imaging - Radiopharmacy & Chemistry ***1*** *(2016) 5.*

Towards clinical studies with Tb

- Before bridging from pre-clinical to clinical studies, not only the biological aspects have to be addressed but also the technological ones.
- Nuclear data and equipment studies are essential to assess the best operating conditions towards their application.



PhD work Sophia Pells, The University of Manchester & NPL (UK).
A.P. Robinson et al., ^{155}Tb: isotope specific SPECT imaging…, in preparation.

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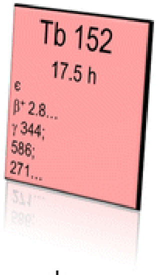
First human trial

- A in-human comparison of ^{152}Tb-PSMA-617 and ^{68}Ga-PSMA-11 was performed.
- The ^{152}Tb half-life (17.5 hrs) is more favorable than that of ^{68}Ga (68 min) with respect to biodistribution.
- Bone metastasis and cancerous node can clearly be identified.



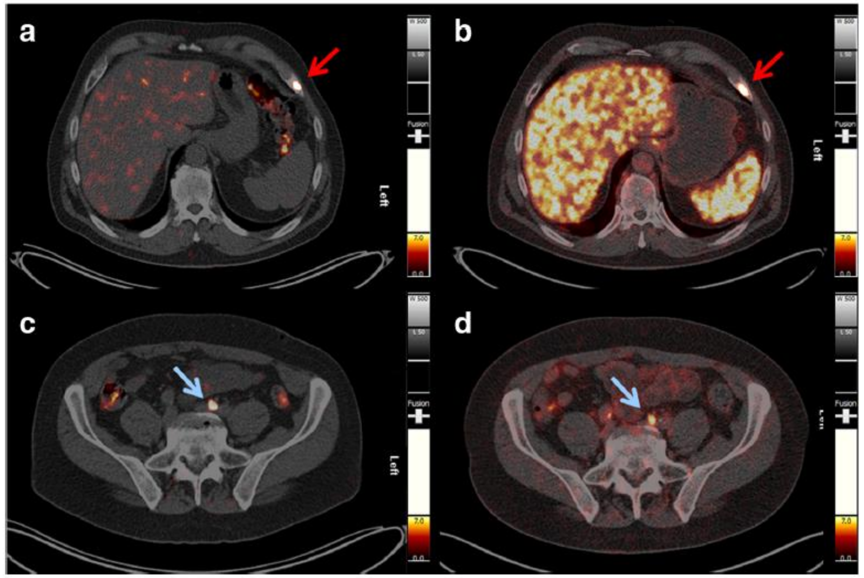


Fig. 6 Comparison of PET/CT scans obtained with ^{152}Tb-PSMA-617 and ^{68}Ga-PSMA-11, respectively. **a**, **c** PET/CT image acquired 18.5 h after injection of 140 MBq of ^{152}Tb-PSMA-617. **b**, **d** PET/CT image acquired 45 min after injection of 160 MBq of ^{68}Ga-PSMA-11. Red arrows show a bone metastasis in the ventrolateral part of the left 7th rib, and blue arrows show a small lymph node metastasis along the left common iliac artery

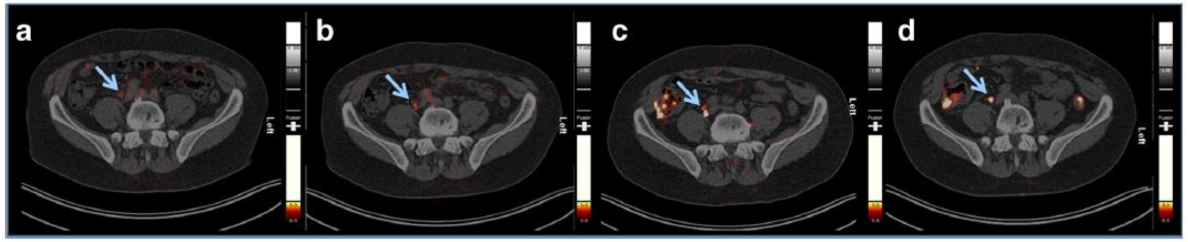


Fig. 5 PET/CT scans (transversal slices through the lower abdomen at the entrance level of the pelvis) obtained at **a** 50 min, **b** 2 h, **c** 18.5 h, and **d** 25 h, respectively after injection of 140 MBq ^{152}Tb-PSMA-617, revealing a small lymph node metastasis (< 8 mm in size) near the right common iliac artery (blue arrow) with maximum uptake observed at 18.5 and 25 h p.i.

*C. Müller et al, EJNMMI Research **9** (2019) 68.*

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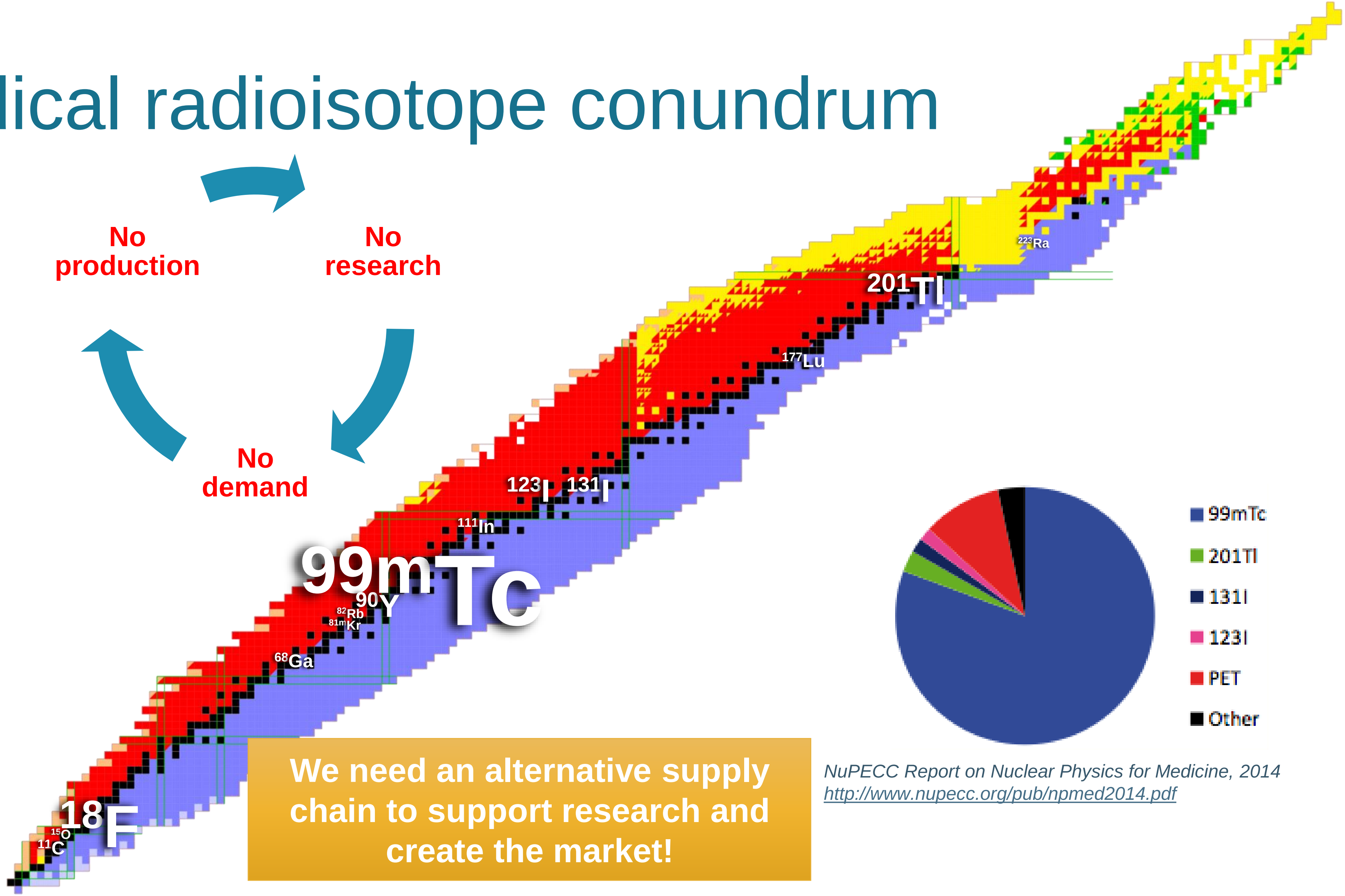
Medical radioisotope conundrum



We need an alternative supply chain to support research and create the market!

NuPECC Report on Nuclear Physics for Medicine, 2014
http://www.nupecc.org/pub/npmed2014.pdf

BREAK

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Producing novel radioisotopes with the ISOL technique

- CERN MEDICIS: right now, today
- Tb-IRMA-V: the Flanders dimension
- PRISMAP: the European perspective

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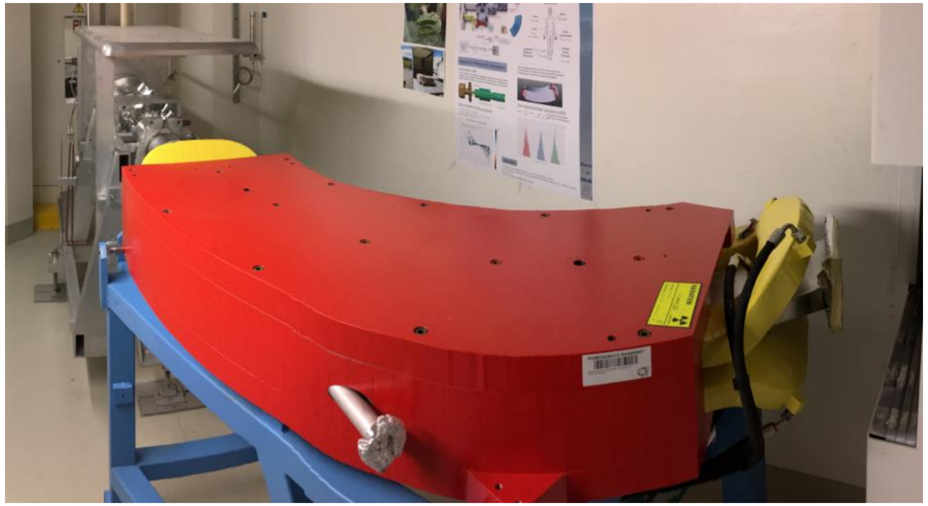
MEDICIS

MEDical Isotopes Collected from ISolde



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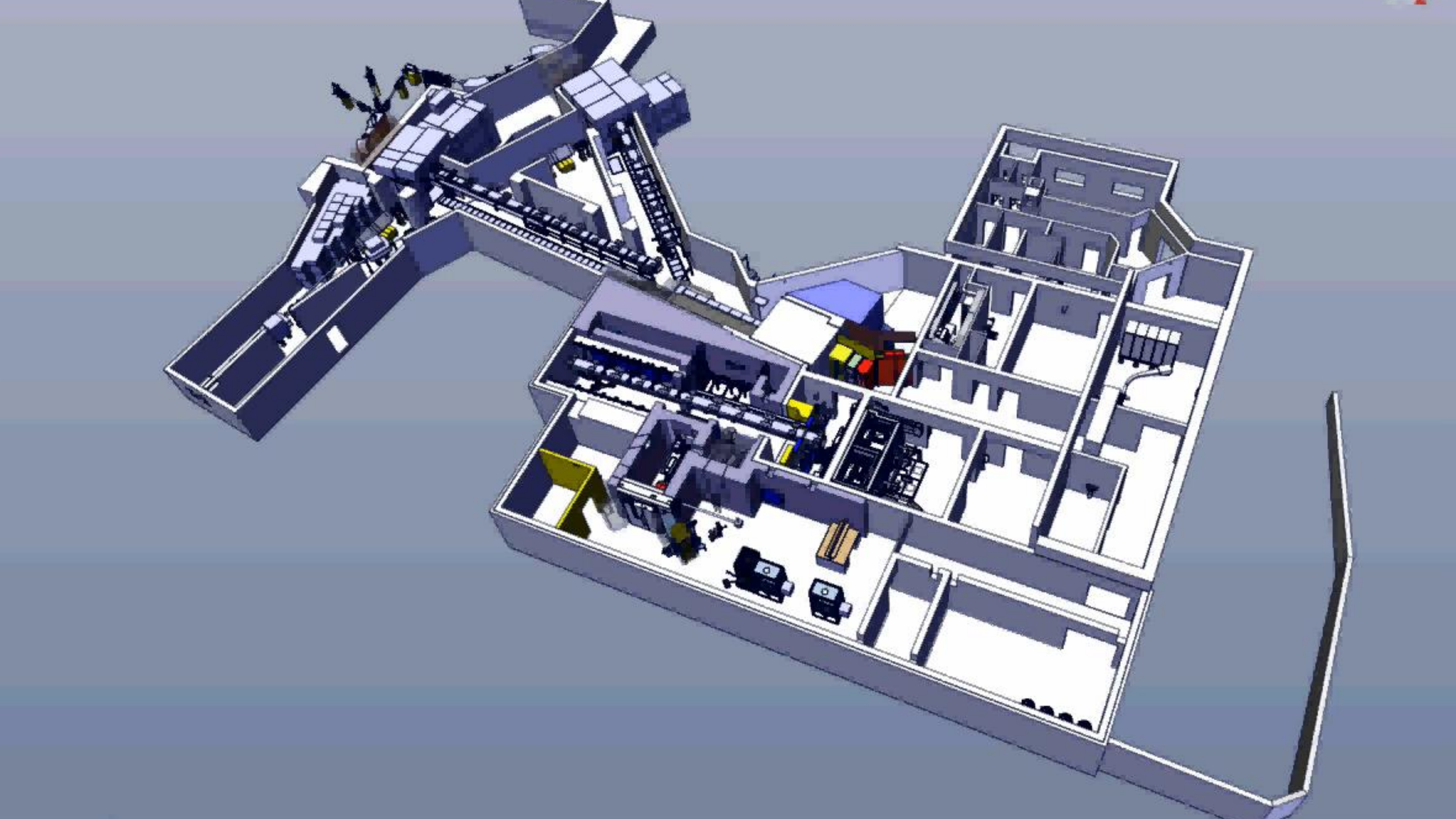
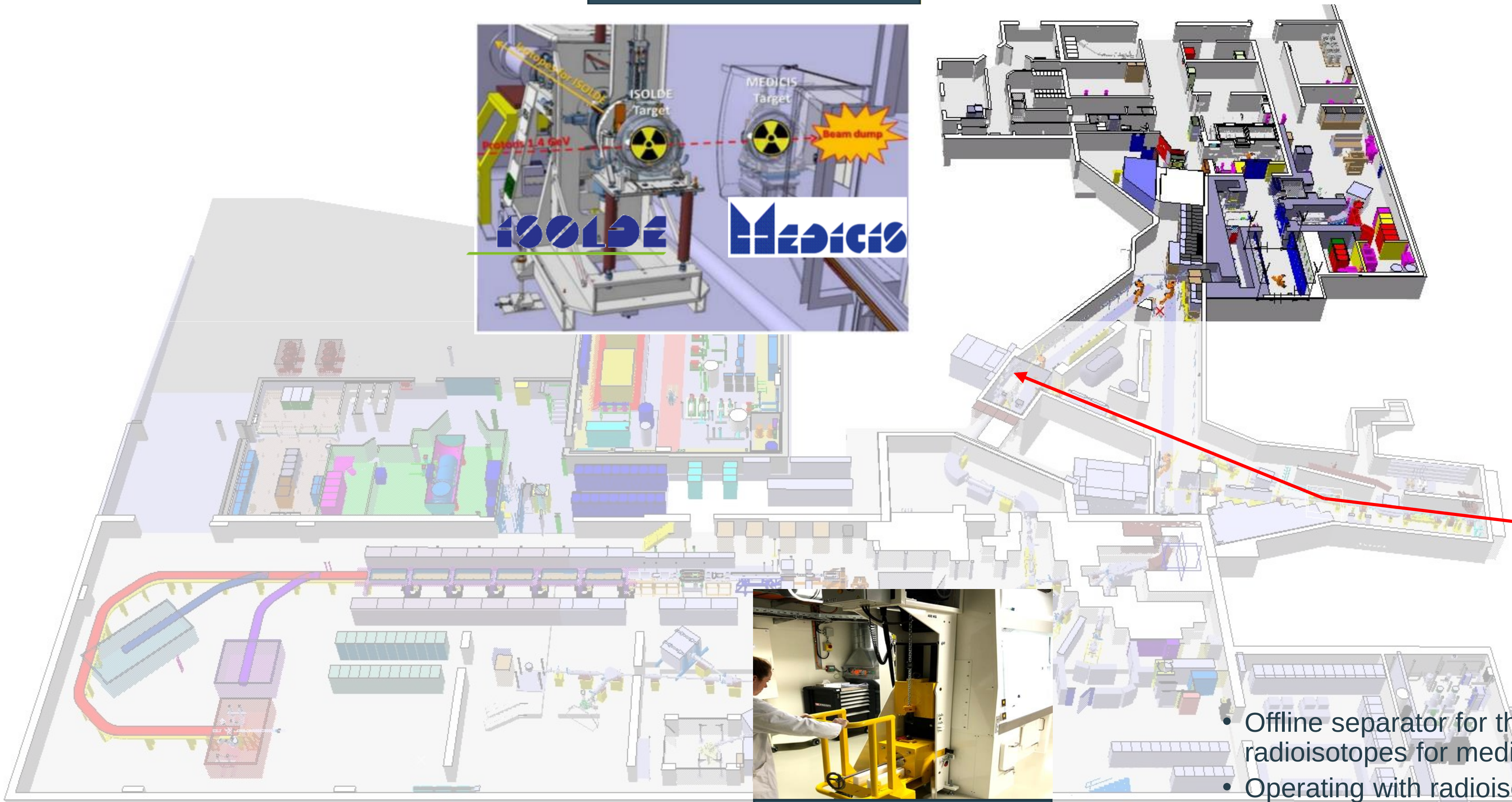


CERN MEDICIS

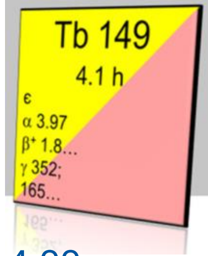
CERN MEDICIS

KUKA® handling arm



Collection point

- Offline separator for the collection of radioisotopes for medical research
- Operating with radioisotopes produced at CERN as well as with external sources

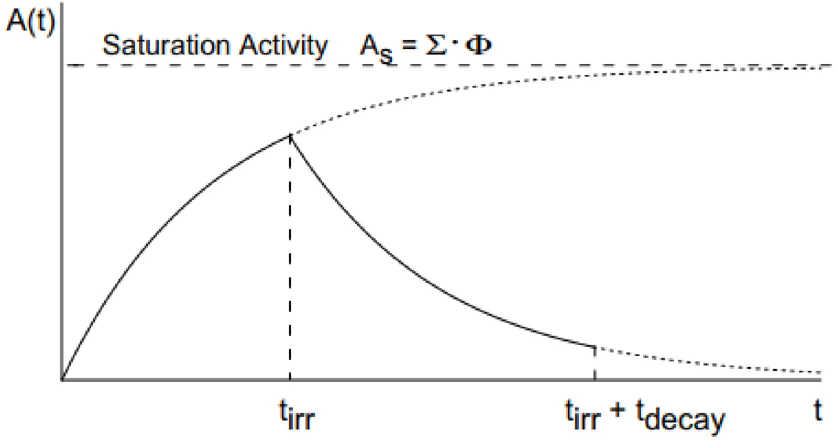


Producing ^{149}Tb: racing the half-life

day before 17:30 — 7:30 — 10:30 — 13:30 — 14:00

Irradiation → **Frontend setup** → **Collection** → **Shipping**

- Irradiation: 12-16 h – ideal
  Saturation
- Frontend setup: ~3 h (used to be 6 h+)
- Collection: 3 h



- Setup includes vacuum pumping (30 min), water cooling for HV operation (15 min), target heating (90 min) and beam optimization (before final temperature) (60 min).
- Between collection and shipping, minimum quality controls are necessary: decay spectroscopy, packaging, loading.

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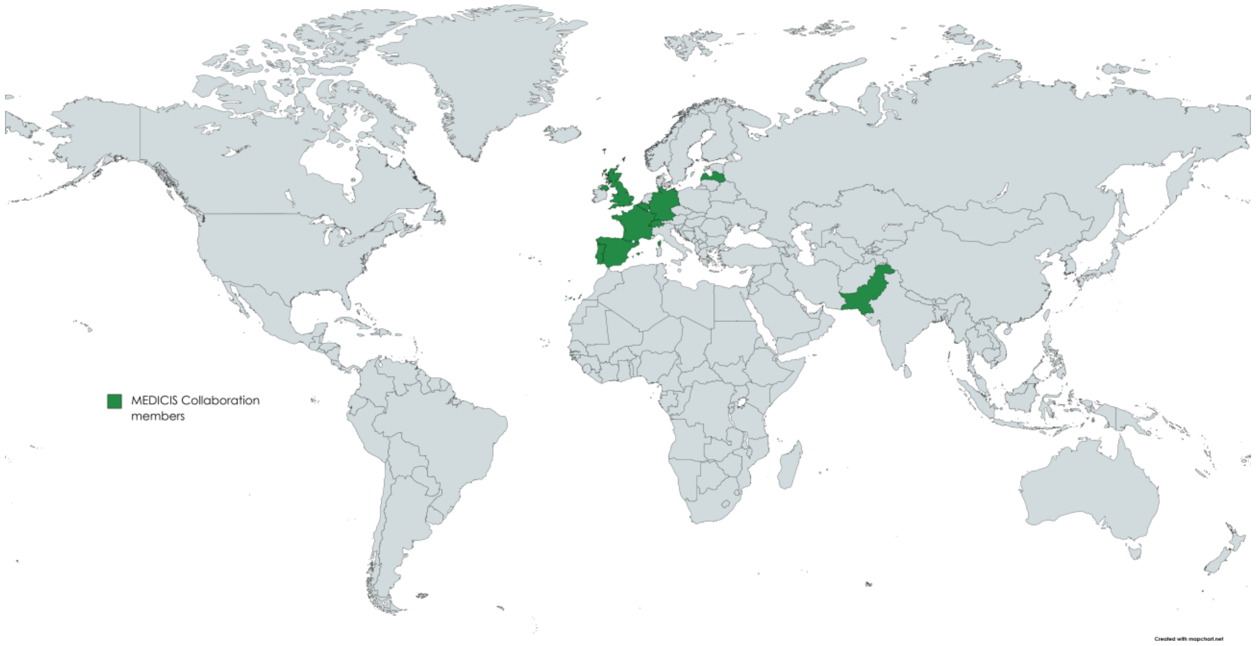
The MEDICIS Collaboration

- Born from ISOLDE but separate entity.
  - Approved in 2013
  - Commissioned in 2017
  - Operated in 2019-2020 in spite of LS2
- 2 annual Collaboration Boards to report on progress and discuss scientific proposals.
- 31 approved projects (4 completed)



- The MEDICIS Collaboration includes CERN and 12 institutes from BE, DE, FR, LV, PK, PR, ES, CH, UK
- The European Association of Nuclear Medicine acts as an advisory member

Map generated on mapchart.net

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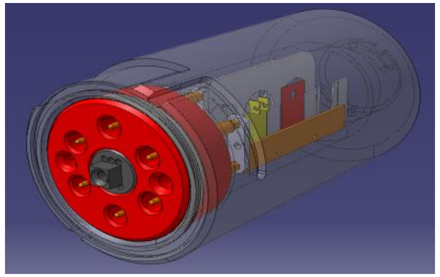
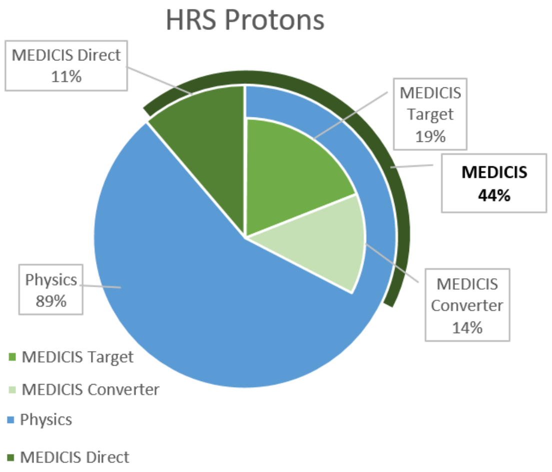
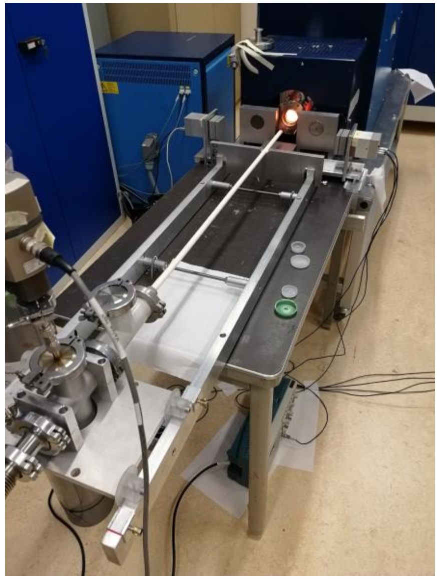
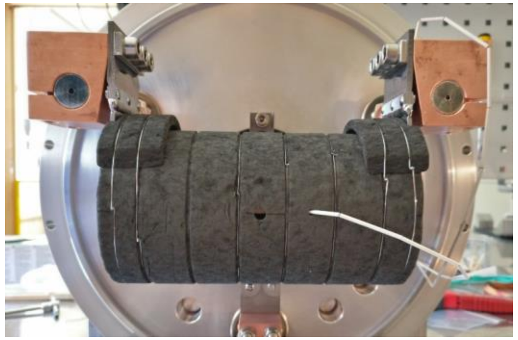
2018 achievements

- 26 target irradiations over the 2018 campaign.
- Separation of radioisotopes produced with the nuclear reactor from Institut Laue-Langevin (Grenoble, France).
- Activities up to 75 MBq for ^{155}Tb and 100 MBq for ^{149}TbO & 120 MBq for ^{165}Tm. **1 GBq extracted in total**.
- 5% surface ionization reached
- Radiochemistry performed at NPL
- Samples distributed to HUG, CHUV, IST, …



 Images courtesy of the MEDICIS Collaboration

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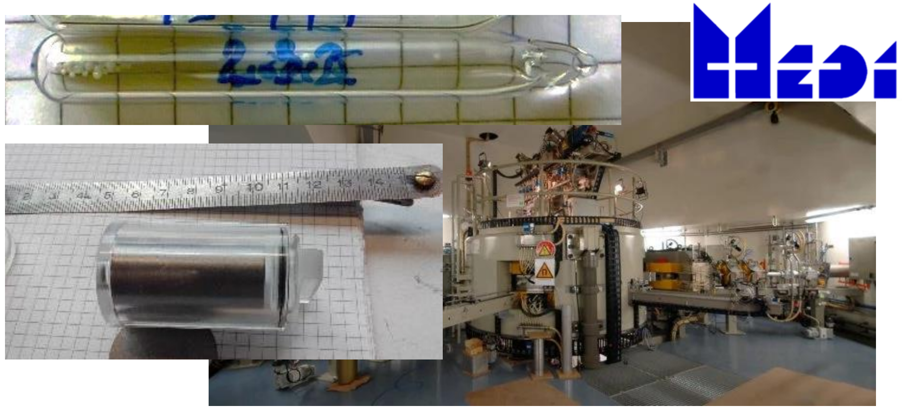
2019 achievements

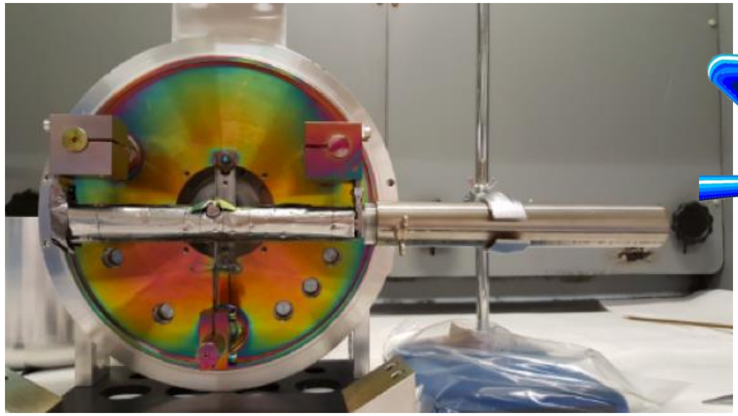


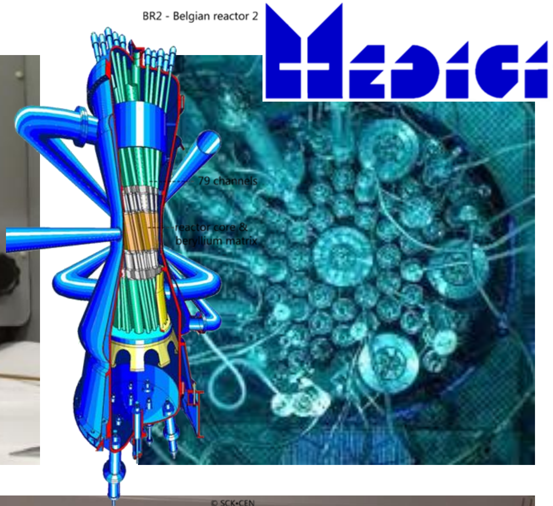
- 100% operation with imported sources from ILL and from the ARRONAX cyclotron (Nantes, France) [30-70 MeV, ^{1}H, ^{2}H, ^{4}He]
- Installation of the MELISSA laser laboratory for laser ionization and of a dedicated fume hood for samples
- Tb/Gd radiochemistry pre-separation and new laser ionization scheme
- 15 collections of ^{155}Tb, ^{169}Er, ^{175}Yb over 15 weeks for a total of 870 MBq delivered to KUL, HUG, NPL, PSI

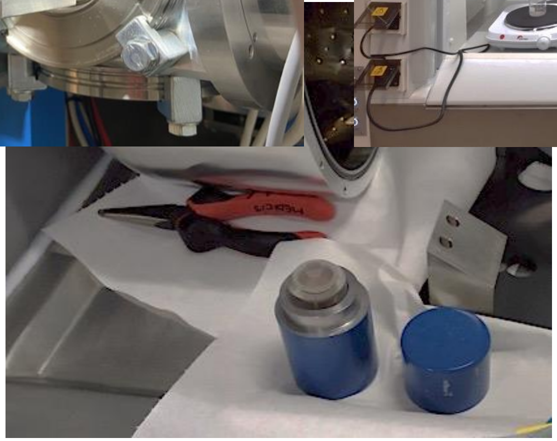
Images courtesy of the MEDICIS Collaboration

2020 achievements

- 100% operation with imported sources again, from ARRONAX, from the Proton Injector 2 cyclotron at PSI (Villigen, Switzerland), from the SCK CEN BR2 (Mol, Belgium), and the European Commission’s Joint Research Centre (Karlsruhe, Germany)
- Adding a CZT gamma-ray detector at the collection point to monitor the growth of activity; developing on-site radiochemistry for radiolanthanides
- 17 collections of ^{153}Sm, ^{155}Tb, ^{167}Tm, and ^{225}Ac, for 540 MBq for KUL, NPL, PSI







Images courtesy of the MEDICIS Collaboration

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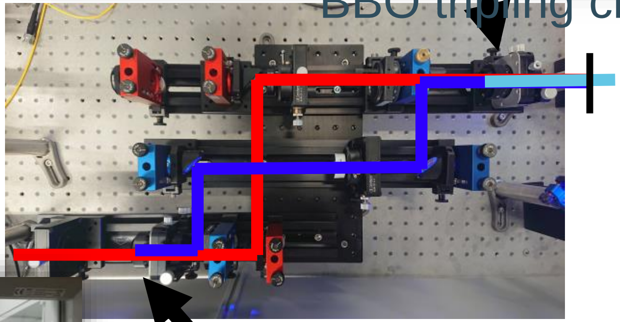
2021 achievements

- Mixed operation with CERN-produced radioisotopes and external sources from ILL, BR2 and PSI
- Investigating new implantation substrate to accommodate high throughput, new Ti target & gas injection system for ScF_2 extraction, new possibilities for UV-light at MELISSA, systematic radiochemistry of lanthanides
- Record-breaking collections of $^{44,47}Sc$, ^{128}Ba, ^{153}Sm, ^{155}Tb, ^{167}Tm, ^{175}Yb, ^{191}Hg and ^{225}Ac, amounting to **over 1.3 GBq** for PSI, KUL, SCK CEN, NPL, CHUV… and collections are still ongoing!





Images courtesy of the MEDICIS Collaboration

Tb-IRMA-V

Terbium ISOL Radioisotopes for Medical Applications in Flanders (Vlaanderen)

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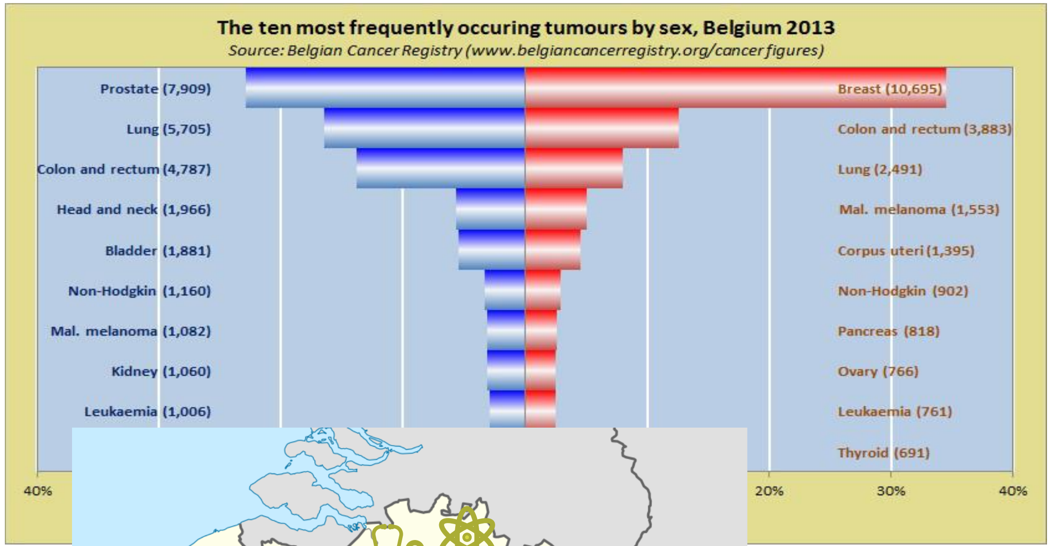
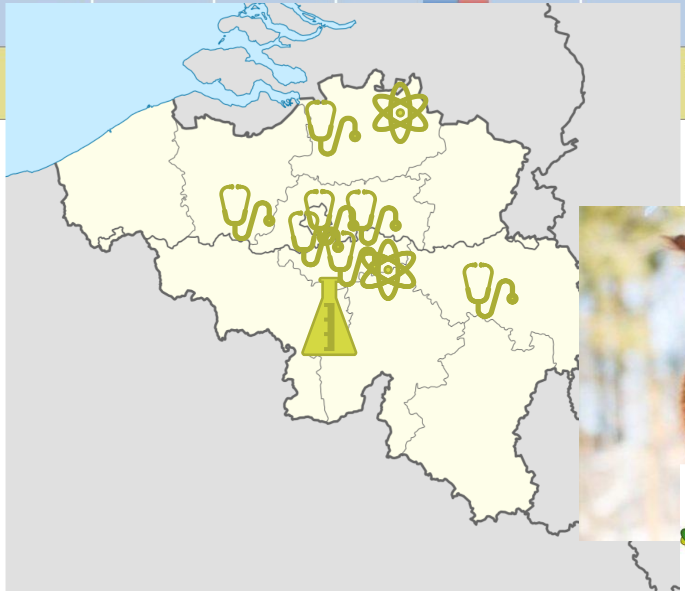
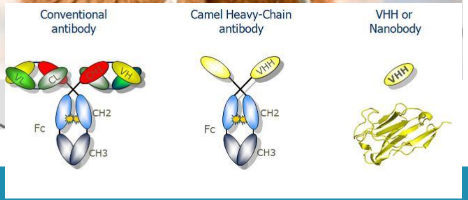
Department of Physics & Astronomy

Belgium: innovation leader







- Belgium has a very strong molecular imaging community: UZ Leuven, UZ Gent, UZ Brussel, UZ Antwerpen, Institut Jules Bordet (Bruxelles), UZ Louvain, UZ Liège with many ongoing nuclear medicine clinical trials and technology transfers.
- Belgium has the largest production capacity for ^{99}Mo in the world at the BR2 reactor and one of the few authorized facility to produce the ^{99m}Tc generator.
- IBA is world-leader in cyclotrons and accelerator-based radioisotope production solutions.

https://kankerregister.org/
http://www.bmicmeeting.be/

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Tb-IRMA-V: towards a sustainable supply

ISOL Production → Purification & Distribution → Radiopharma & pre-clinic → Clinical practice

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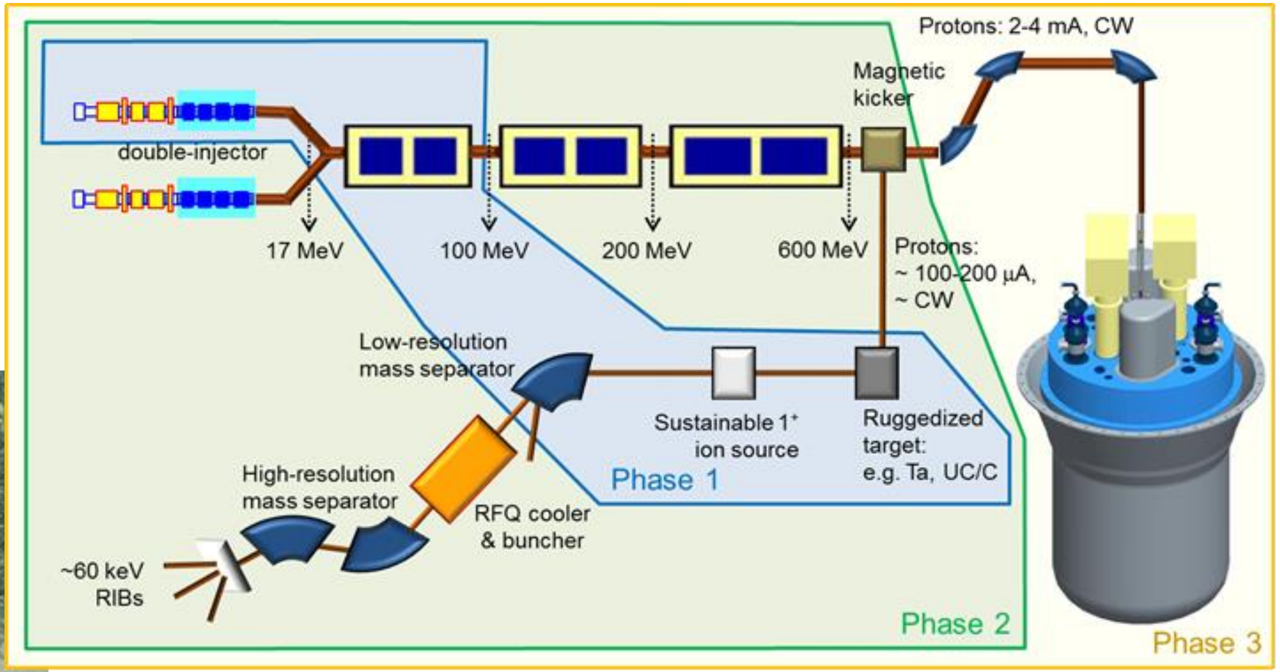
ISOL@MYRRHA: a new facility

- Up to 600 MeV protons, 4 mA
- Phase 1 with 100 MeV, 0.5 mA
- Fundamental and applied program



Power(MEDICIS) = 2.8 kW
Power (MYRRHA) = 50 kW

Phase 1 funded by the Belgium gvt in 2018!!
€ 353 M for construction + 10 year operation

 https://myrrha.be/myrrha-applications/nuclear-science/isolmyrrha

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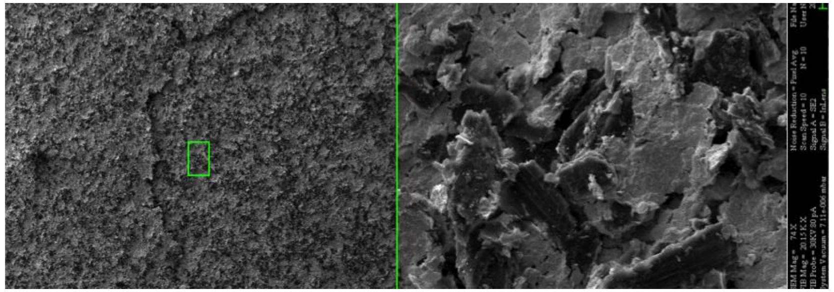
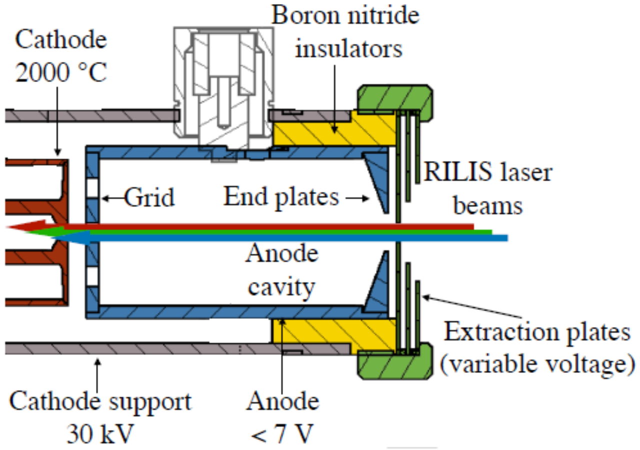
Tb-IRMA-V: ISOL Production

Power(MEDICIS) = 2.8 kW
Power (MYRRHA) = 50 kW

ISOL Production

- Investigate the necessary developments towards the ISOL@MYRRHA facility
  - High-power target systems
  - Ion source to handle high-intensity radioactive ion beam production





Tb-IRMA-V

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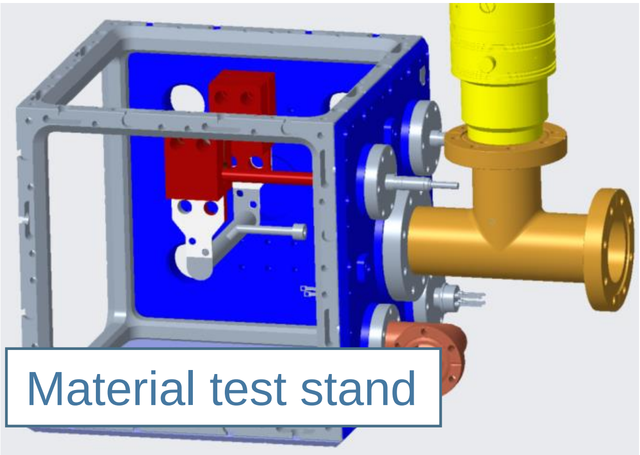
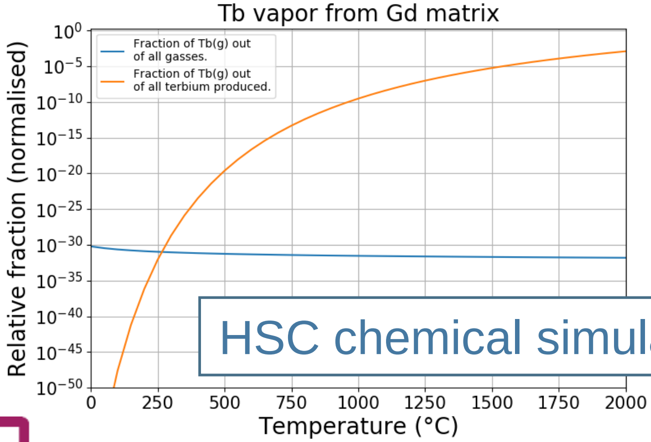
Tb-IRMA-V: Production

ISOL Production

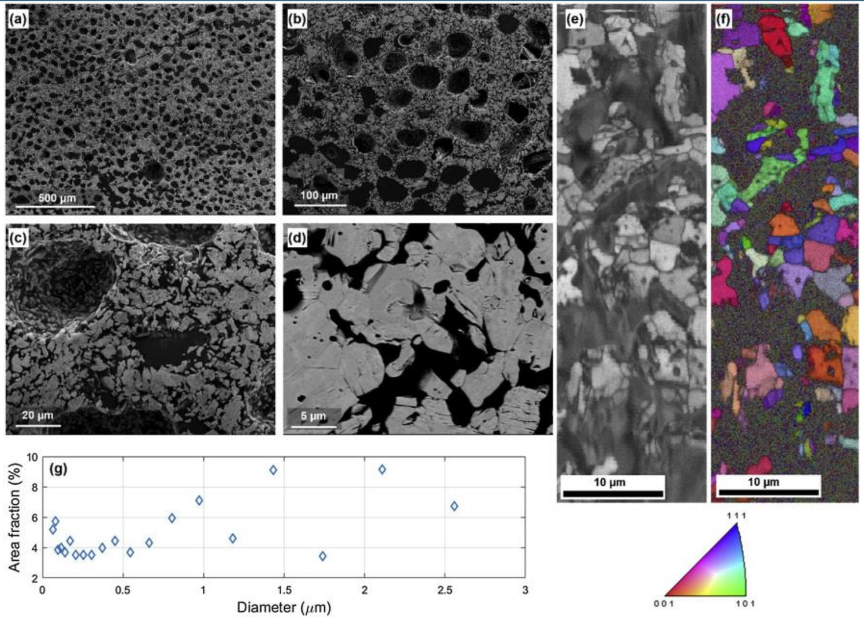


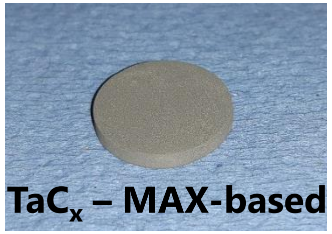
Material test stand

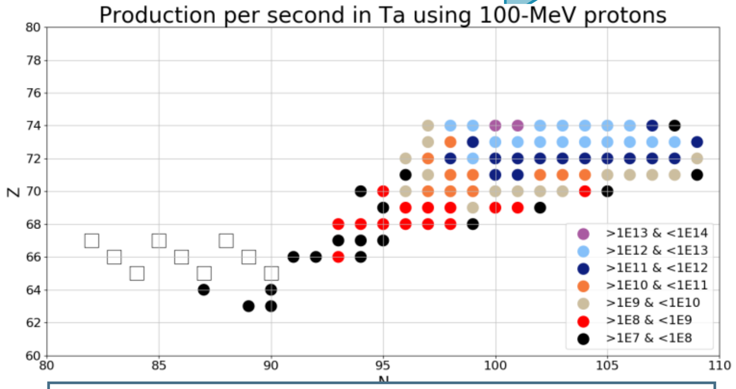


HSC chemical simulations

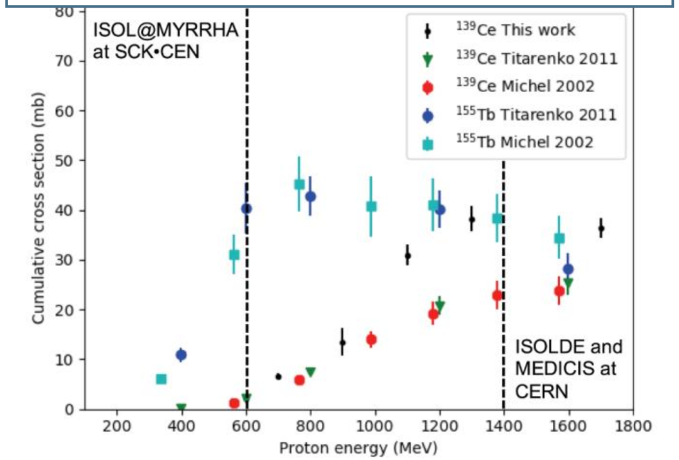
New material design and characterization







Cross section measurements & simulations



Tb-IRMA-V

M.Sc. Thesis Hannelore Verhoeven, KU Leuven (2018).
PhD work Benji Leenders, UGent & SCK CEN.
*M. Griseri et al., Porous TaCx ISOL target materials ..., The Journal of the European Ceramic Society **41** (2021) 3947,*

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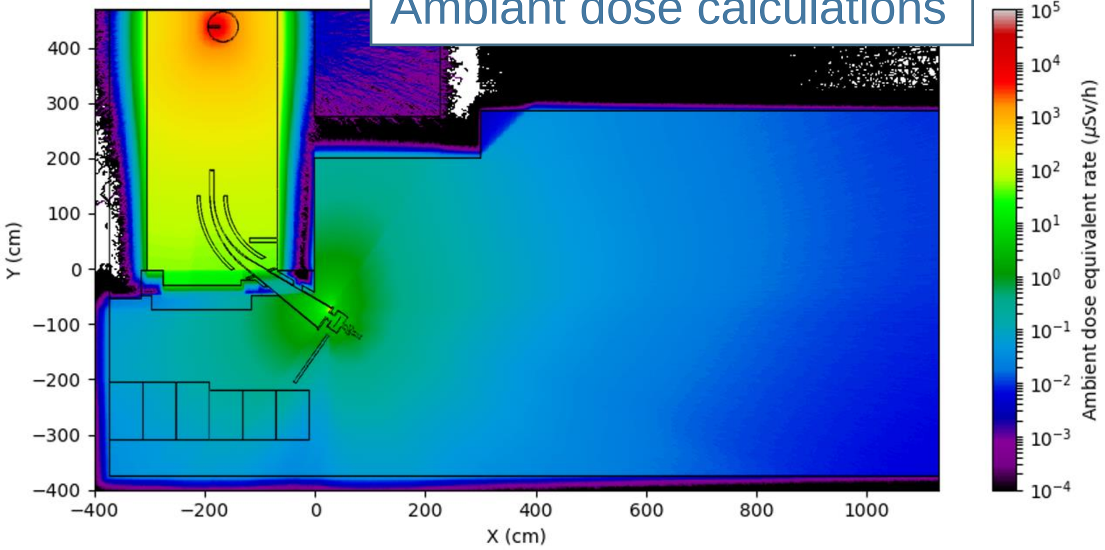
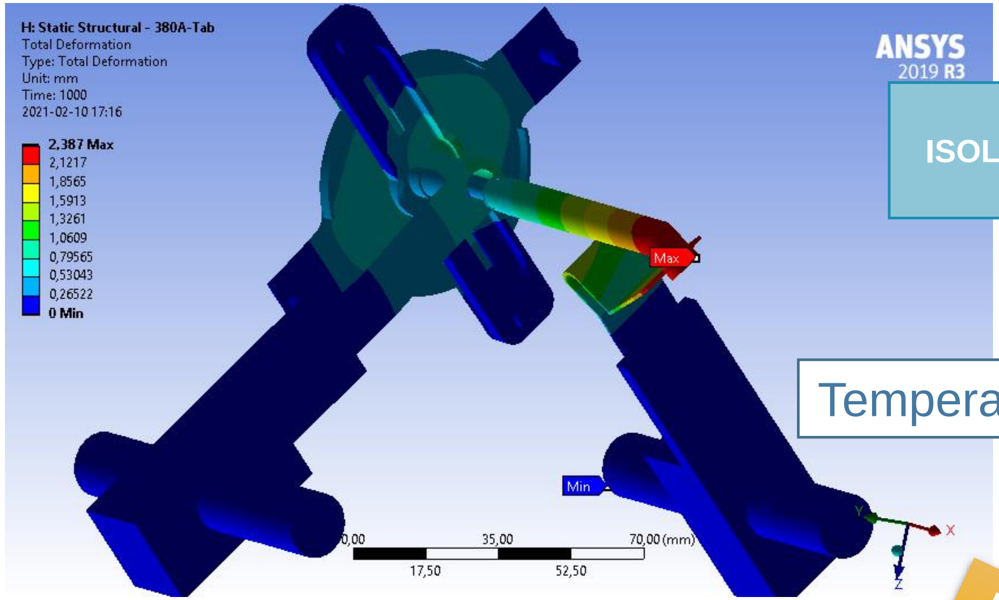
Tb-IRMA-V: ISOL

ISOL Production

Ambiant dose calculations



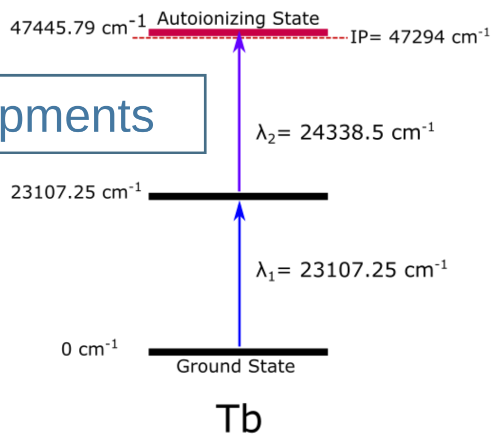


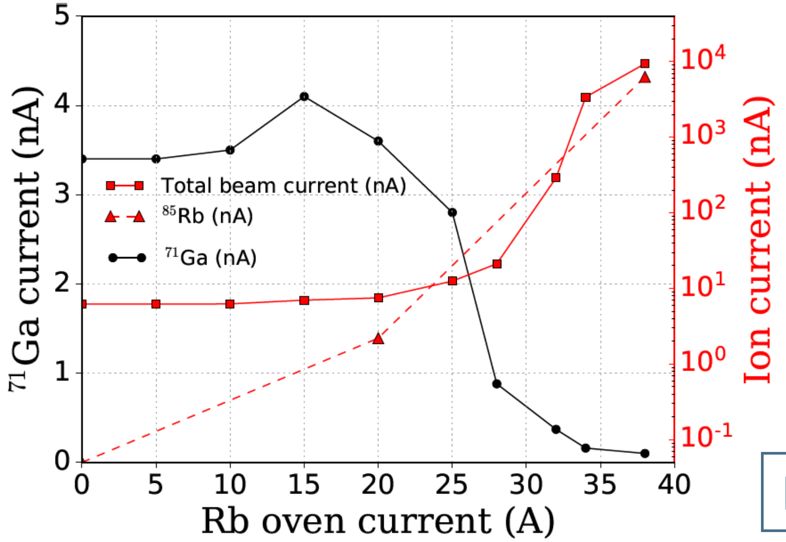
Temperature profiles

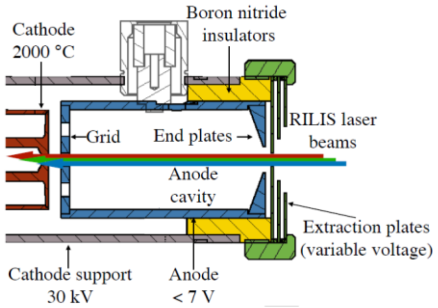
Ion source research

Recall from Lecture 2

Laser scheme developments







Handling the ion load

Tb-IRMA-V

M.Sc. Thesis Hannelore Verhoeven, KU Leuven (2018).
Predoc work Esraa Ahmed, KU Leuven (2020).
PhD work Sophie Hurier, KU Leuven & SCK CEN.

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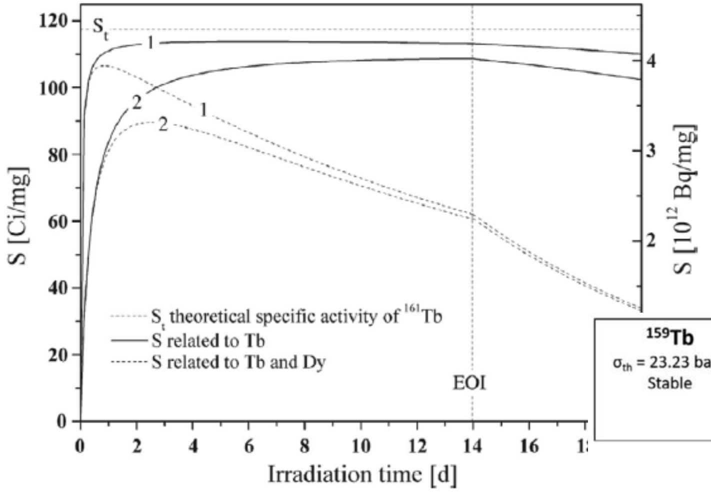
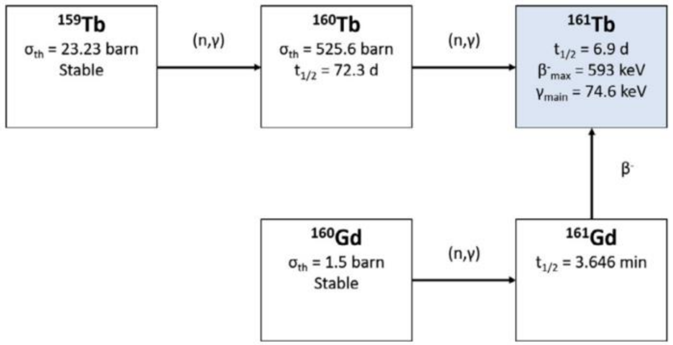
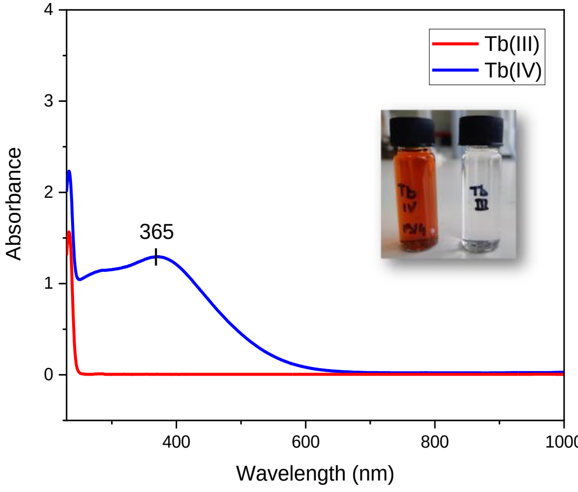
Tb-IRMA-V: Purification

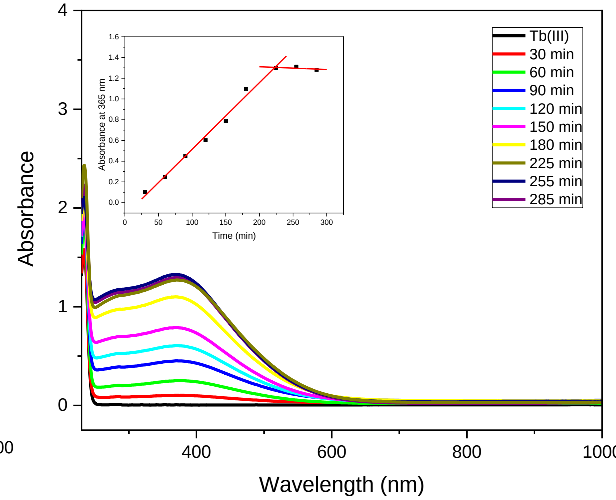
Purification

- Concentrating on the Tb/Gd separation
  - ^{161}Tb production in the BR2 reactor at SCK, already delivering radioisotopes
  - Working on oxidizing Tb(III) to Tb(IV) to go beyond the existing state-of-the-art with α-HIBA









Tb-IRMA-V

M. Van de Voorde et al., *Coordination Chemistry Review* ***382*** *(2019) 103-125.*
PhD work Meryem Arman , KU Leuven & SCK•CEN.

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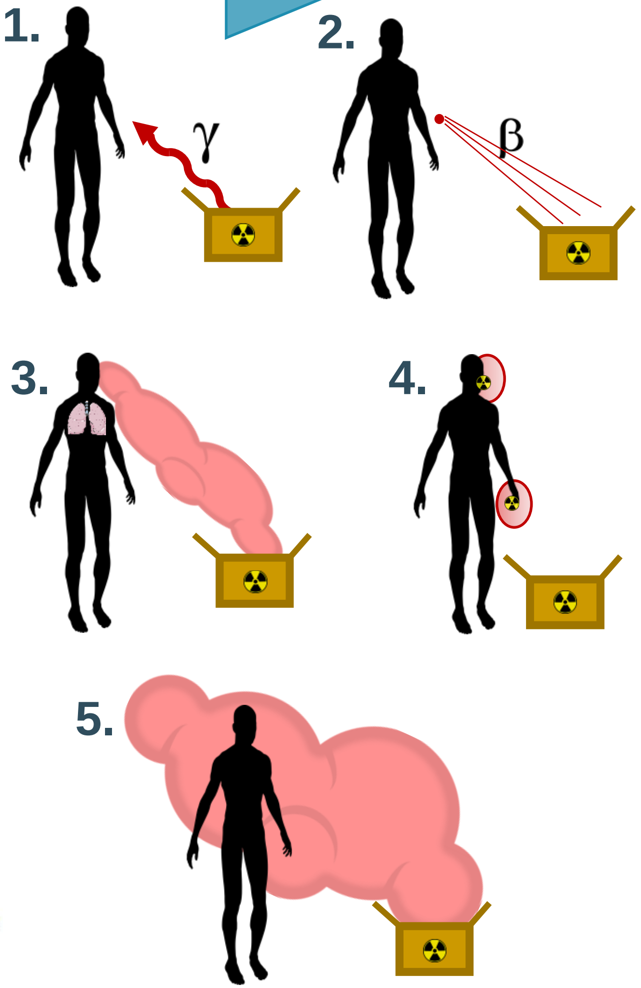
Tb-IRMA-V: Distribution

Distribution

- Limited international regulation on the transport of Tb radioisotopes
  - Basic regulations are very stringent and impractical for medical practice
  - New regulations from IAEA since 2019 on $^{149,161}Tb$
  - Calculations completed and to be submitted to the Federal Agency for Nuclear Control for $^{152,155}Tb$
  - All values appropriate for medical use

Isotope	IAEA	New A2
^{149}Tb	800 GBq	800 GBq
^{152}Tb	(20 GBq)	800 GBq
^{155}Tb	(20 GBq)	2 000 GBq
^{161}Tb	700 GBq	700 GBq



Tb-IRMA-V

M.Sc. thesis Vincent Verelst, KU Leuven (2019).

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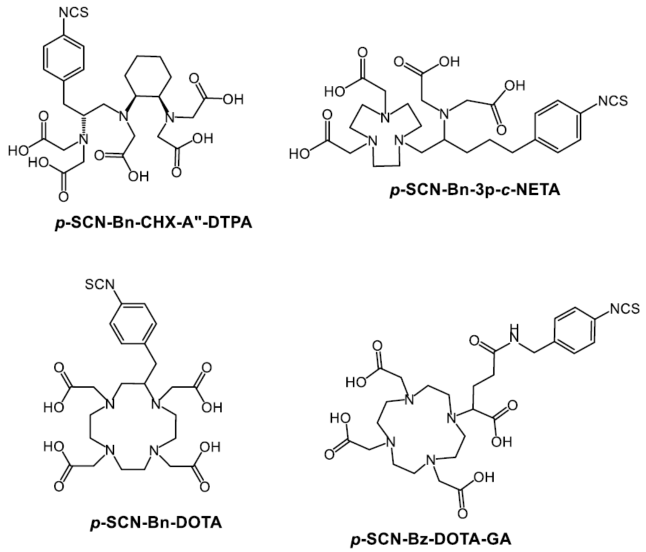
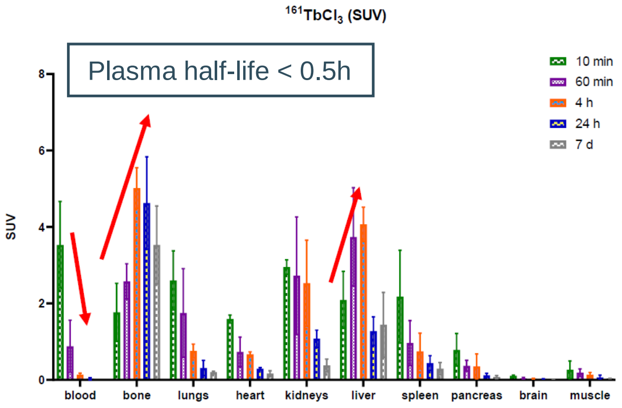
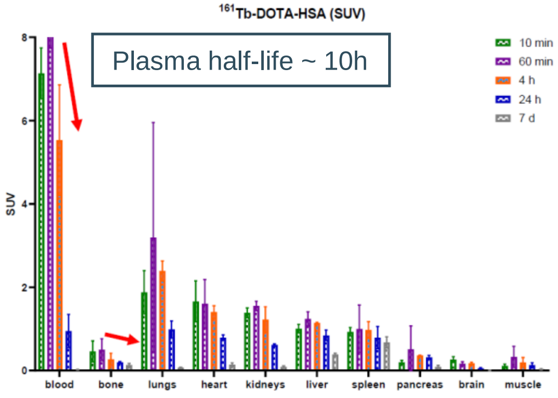
Tb-IRMA-V: Radiopharma

Radiopharm & pre-clinic

- Devising new radiopharmaceuticals
  - How to use the samples after the new radiochemistry
  - Producing peptides-based radiopharma that are heat sensitive (max 40°C), starting with Human Serum Albumin
  - Linking with nanobodies
  - Demonstrating the process with cold isotopes, then in-vitro, and finally in-vivo in mice models





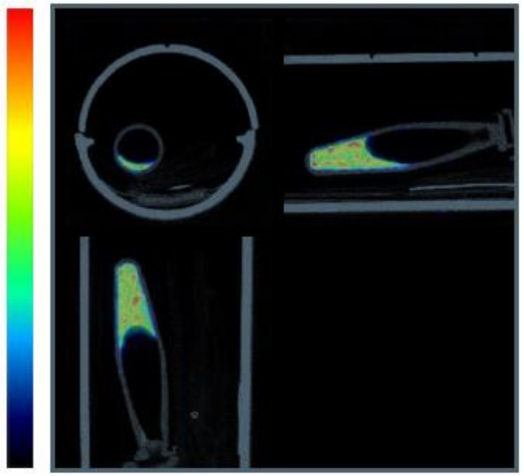


Tb-IRMA-V

 PhD work Irwin Cassells, KU Leuven & SCK CEN.

Tb-IRMA-V: ^{155}Tb-DOTAGA-Nb

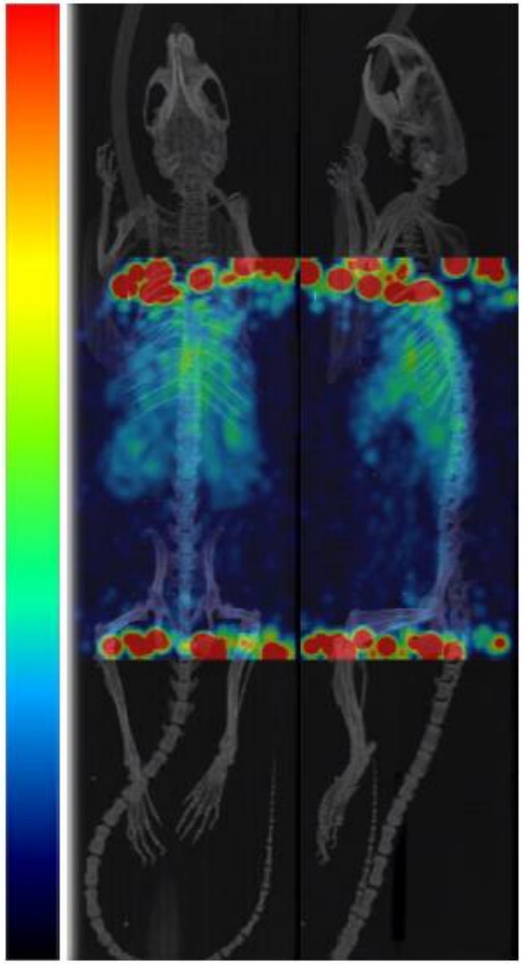
Radiopharm & pre-clinic



^{155}Tb-labelled Nanobody®
Single SPECT FOV
~0.6 MBq
Fused SPECT/CT

30 minutes acquisition

γ(^{155}Tb)/keV = 87 (32%), 105 (25%)



Tb-IRMA-V

Images acquired with the Molecubes systems from the pre-clinical laboratory.

PhD work Irwin Cassells, KU Leuven & SCK CEN.

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Tb-IRMA-V

Tb-IRMA-V

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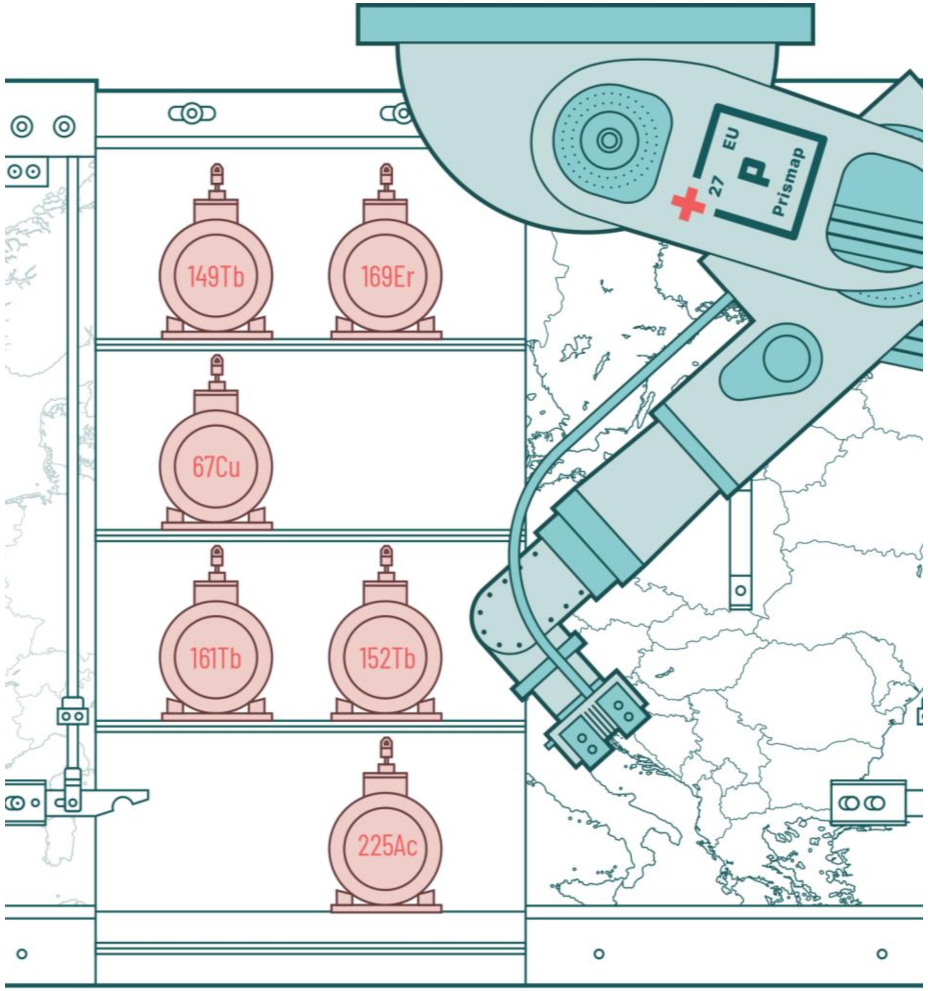
Department of Physics & Astronomy

PRISMAP

The European Medical Radioisotope Programme



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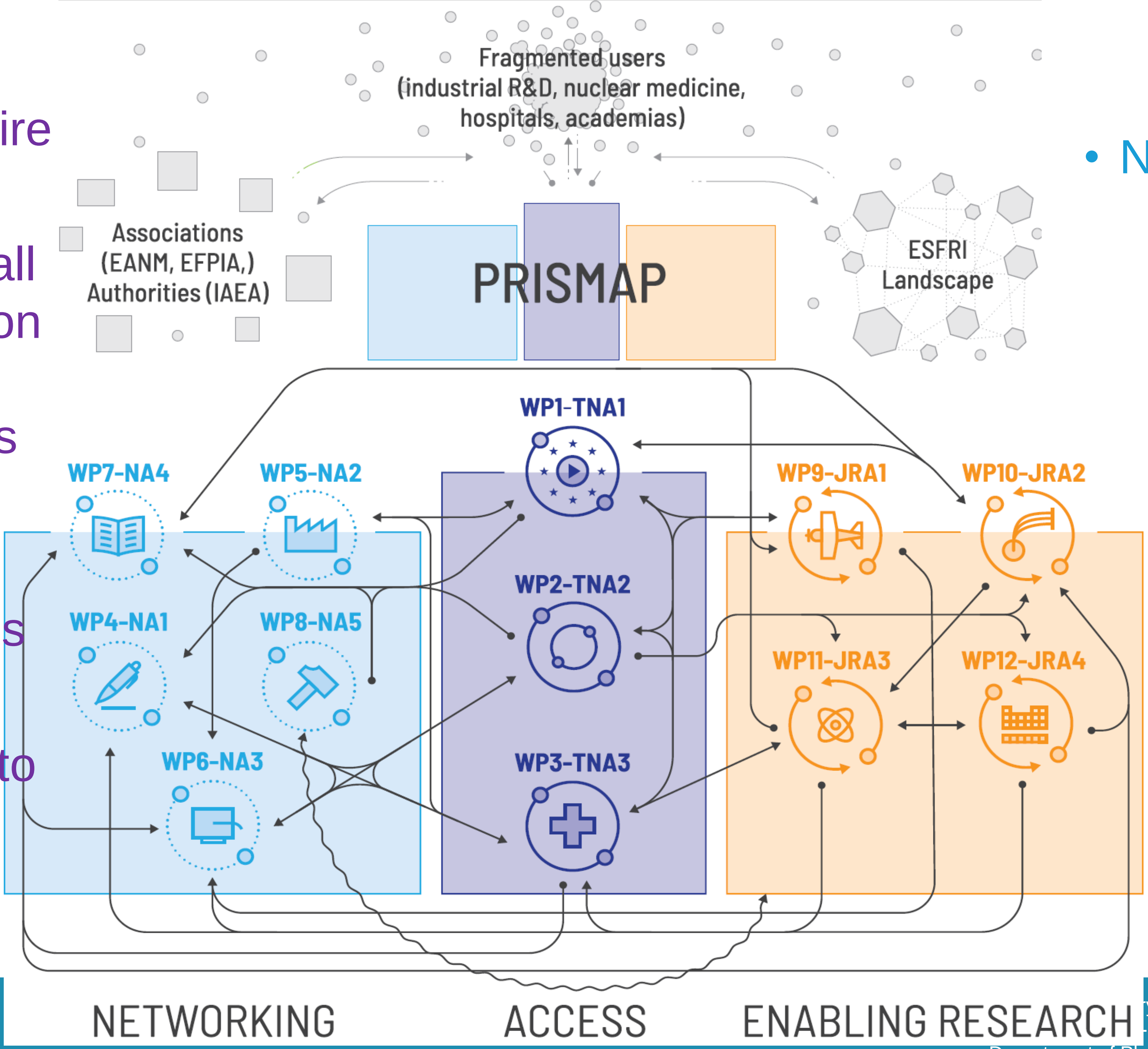
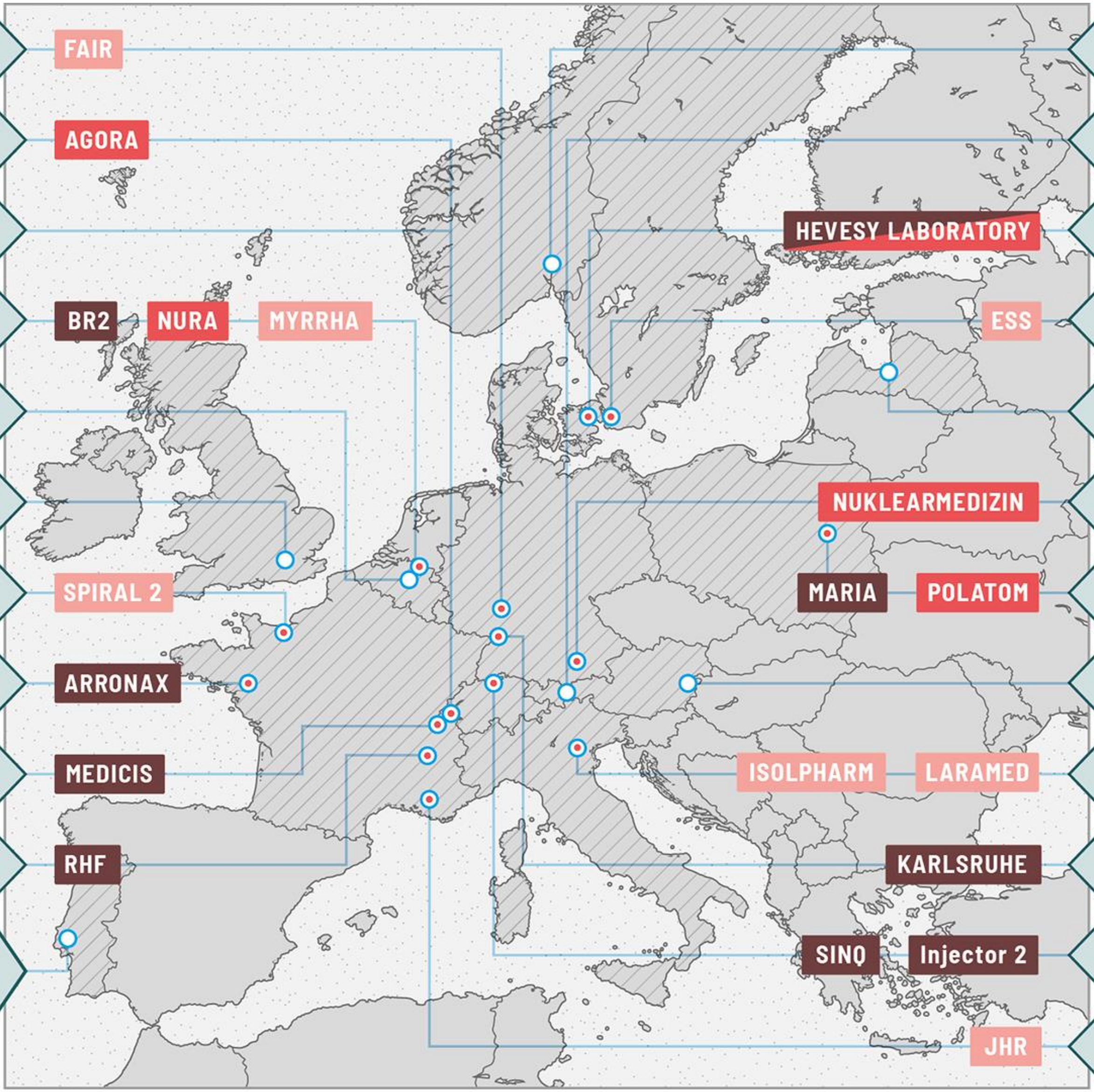
- Single access point for the entire community
- Full access for all across Europe on scientific excellence basis
- Distributed production for improved access and reliability
- Shared access to pre-clinical facilities



27 EU PRISMAP Medical Radionuclides

- Network activities to enhance visibility, harmonize legislation, and train new generations
- Joint research projects to improve the supply and showcase the possibilities

GSI	GSI Helmholtzzentrum für Schwerionenforschung GmbH
CHUV	Centre hospitalier universitaire vaudois
SCIPROM	SCIPROM Sàrl
SCK CEN	Studiecentrum voor Kernenergie / Centre d'étude de l'énergie nucleaire
KULeuven	Katholieke Universiteit Leuven
NPL	National Physical Laboratory
GANIL	Grand Accélérateur National d'Ions Lourds
ARRONAX	Groupement interet public ARRONAX
CERN	European organization for nuclear research
ILL	Institut Max von Laue - Paul Langevin
IST-ID	Associação do Instituto Superior Técnico para a Investigação e Desenvolvimento



Universitetet i Oslo	UiO
Medizinische Universität Innsbruck	MUI
Danmarks Tekniske Universitet	DTU
European Spallation Source ERIC	ESS
Latvijas Universitāte	LU
Klinikum rechts der Isar der Technischen Universität München	TUM
Narodowe Centrum Badań Jądrowych	NCBJ
Entwicklungs- und Betriebs-gesellschaft MedAustron GmbH	MedAustron
Istituto Nazionale di Fisica Nucleare	INFN
Joint Research Centre - European Commission	JRC
Paul Scherrer Institut	PSI
Commissariat à l'energie atomique et aux énergies alternatives	CEA

Production facility **Translation facility** **Future facility**

PRISMAP Day-1 isotopes

44 Sc Scandium	47 Sc Scandium	64 Cu Copper	67 Cu Copper	111 Ag Silver	135 La Lanthanum	153 Sm Samarium
149 Tb Terbium	152 Tb Terbium	155 Tb Terbium	161 Tb Terbium	165 Er Erbium	169 Er Erbium	175 Yb Ytterbium
211 At Astatine	213 Bi Bismuth	225 Ac Actinium				

https://www.prismap.eu/radionuclides/portfolio/

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PRISMAP Transnational access

First call is open!!

What PRISMAP offers

We offer trans-national access to the following goods, facilities, and services:

- Production and delivery of high-purity grade radionuclides for medical research
- Access to a selection of medical research laboratories to perform the associated research
- Selection of preclinical research techniques fully performed as a service

To whom PRISMAP offers

- The user group leader and the majority of the users must work in a country other than the country(ies) where the installation(s) providing the services are located. (CERN & JRC excluded)
- Users need to be affiliated to an academic research institution, to a non-academic research institution, to a research hospital, or to the research department of an SME.
- The research project must relate to the use of radionuclides in medical applications.

https://www.prismap.eu/access/

Who we are and what we offer — *a PRISMAP public information event*

We are very pleased to announce that our first PRISMAP call for user projects is now open.

At this occasion we invite all to join us for this public event to learn more about the project and the available services. This event is organised in hybrid format and you are welcome to join in person or remotely.

Register now

https://www.prismap.eu/event/

24 NOV 2021 | 8.45—11.30

8.45	Online reception
9.00	Welcome address by the coordinator
9.20	Meeting overview
9.30	PRISMAP public info event

CERN campus, Esplanade des Particules 1, 1217 Meyrin

Conference room 222/R-001 (Filtration plant Meyrin)

- ✓ We discussed some basics of nuclear medicine:
  - ➢ Functional imaging and how it has to be combined with structural imaging
  - ➢ Targeted radionuclide therapy
  - ➢ Combining both towards personalized medicine with theranostics
    - ✓ With existing isotopes like $^{123,124,131}I$ or $^{68}Ga/^{177}Lu$
    - ❖ With novel isotopes like $^{44,47}Sc$, $^{64,67}Cu$, $^{165,169}Er$ or the Tb quadruplet
  - ➢ Access to radioisotopes is holding those developments back

- ✓ Breaking the void with the largest radioisotope catalog: ISOL
  - ➢ 4 years of operation at CERN MEDICIS have delivered 3.7 GBq of novel radioisotopes for research
  - ➢ Tb-IRMA-V upscales the research into the Tb isotopes at all stages towards new opportunities in Flanders, in particular via ISOL@MYRRHA
  - ➢ PRISMAP offers a European-wide opportunity that should not be missed

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To be continued in the next lecture series

4 – Expanding the reach of nuclear medicine with ISOL radioisotopes

- Nuclear medicine with existing isotopes
- Novel isotopes: theranostics prospects
- CERN MEDICIS
- Tb-IRMA-V
- PRISMAP

✓ 22 Nov 2021 ONLINE

5 – From research to patient care – Challenges and prospects

- Distribution of radioisotopes
- After the collection...
  - Radiochemistry
  - Radiopharmacy
  - Pre-clinical research
- Bringing radioisotopes to the clinic
  - Decay properties
  - Detector response

➢ 29 Nov 2021 ONLINE

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