WP2 – Research Infrastructures for Nuclear Physics
Task 2.5 – Service Improvements
Subtask C2 – Targets for high intense beams

Latest news and projects from the GANIL Targets Laboratory

https://www.ganil-spiral2.eu/scientists/ganil-spiral-2-facilities/ganils-target-laboratory/target-laboratory/

Ch. Stodel, R. Rahali, G. Frémont, M. Bourges, F. Pérocheau

Second Meeting on "Targets for Nuclear Physics" within EURO-LABS

Outline

1. GANIL/SPIRAL2/S3 context
2. Development of targets at GANIL
    1. PALAIS Project
    2. GALACTIC Project
3. Conclusions

4. Few words on the database EUROLABS

1- GANIL/SPIRAL2/S^3 Context

SPIRAL2 and the new experimental rooms

NFS (NEUTRONS FOR SCIENCE)

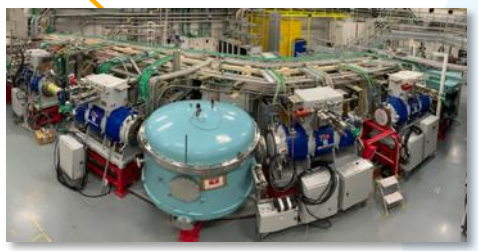
Salle convertisseur

Salle Temps de vol

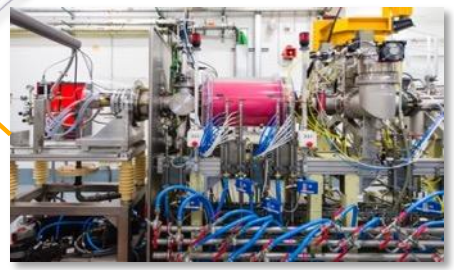
View of the DESIR construction site by mid-May 2024

DESIR (Decay, Excitation and storage of radioactive ions)

Accélérateur linéaire (LINAC)



S3 (SUPER SEPARATOR SPECTROMETER)



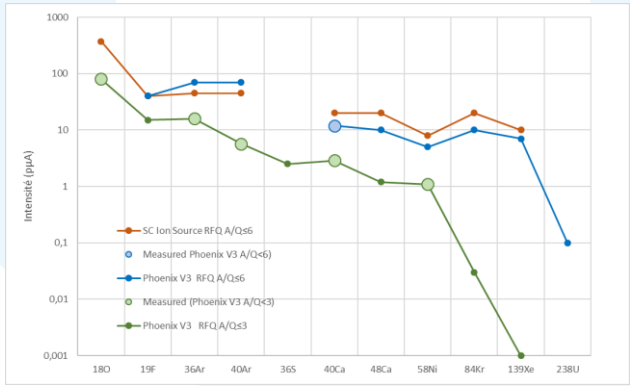
ION SOURCE

NEWGAIN NEW GANIL INJECTOR

Beams :
33 MeV protons
40 MeV deutons
<14,5 MeV/nucleon ions lourds

A new accelerator ramping up:

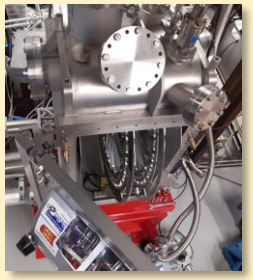
-Beam developments
-First operation experimental area and the first neutrons at GANIL/SPIRAL2: NFS first campaigns and results
-Super Separator Spectrometer
-DESIR project



Main equipment and detection setups

- High selectivity > 10^{13} - High efficiency 50% - In flight mass separation > 1/450
- Versatility & unique instrumentation (SIRIUS – LEB)

Target system



High power rotating targets

3 × M-dipoles

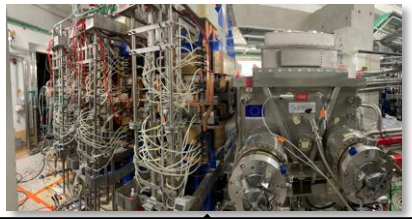
Large H & V gaps

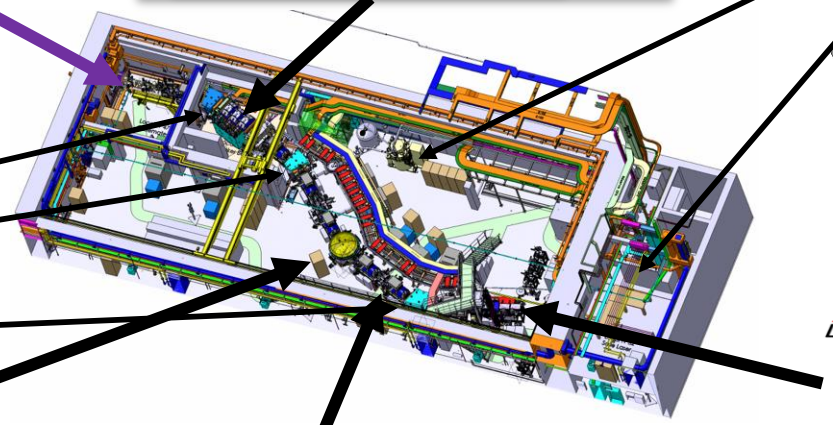
E-Dipole

20 cm gap & +/- 300 kV
Open slit in the anode

Dispersive zone

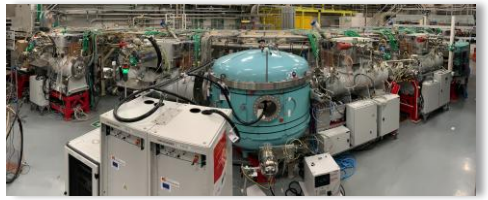
Open RT magnet & beam dump & Movable fingers





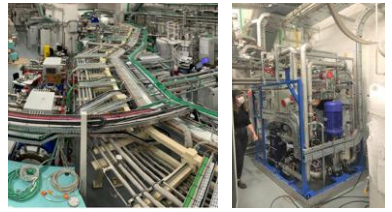
7 SC Multipoles

SMT, PSS, Coldbox & LTC



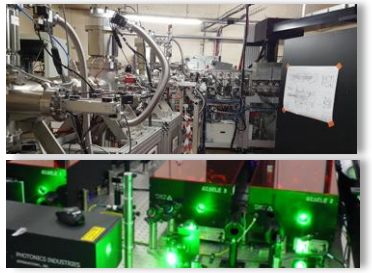
Infra / Interface

Lot C68, Cooling system, Laser room …



LEB

LEB @ LPC & GISELE Laser Lab

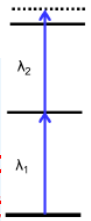


SIRIUS

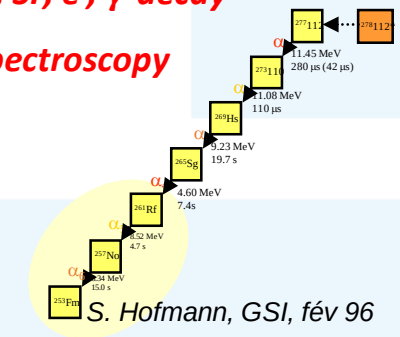
DSSD, SSD, FEE/BEE, DAQ & Diagbox

Laser & decay spectrosc
Mass measurement

- Nuclear Moments / Charge radii / Spin
- Mass
- Decay spectroscopy



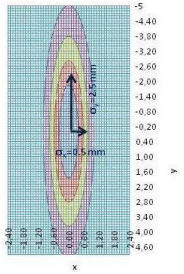
α, SF, e⁻, γ decay spectroscopy

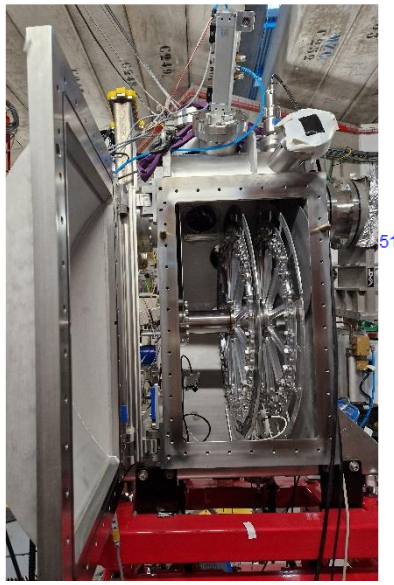


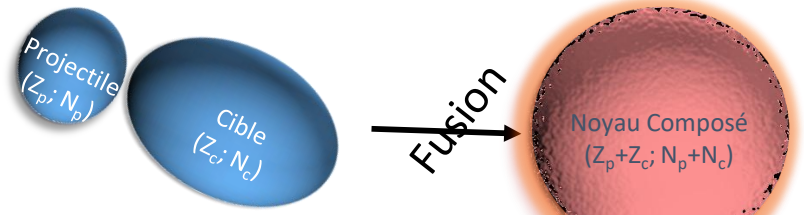
S. Hofmann, GSI, fév 96

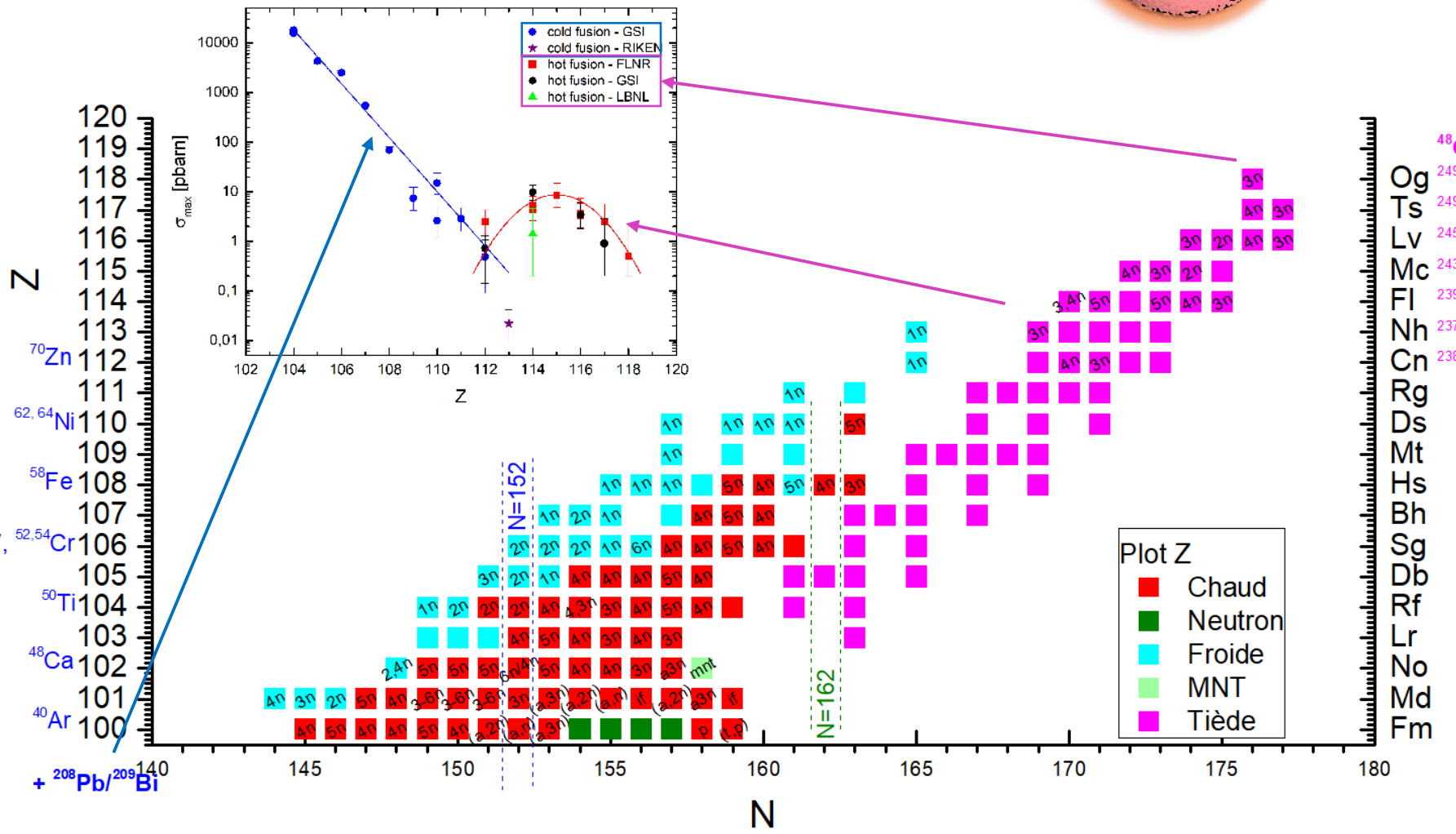
S³ Targets for SHE

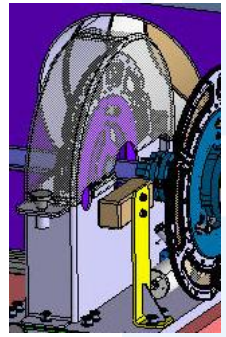
σ_t = 0.5 mm
σ_r = 2.5 mm
I=10 pμA











Rare / Radioactive
Available

89	90	91	92	93	94	95	96	97	98	99	100
Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm

TARDIS Project,
J. Piot, S. Pinabel

2- Development of targets at GANIL

2.1 PALAIS Project

Plateforme Cibles pour GANIL/SPIRAL2

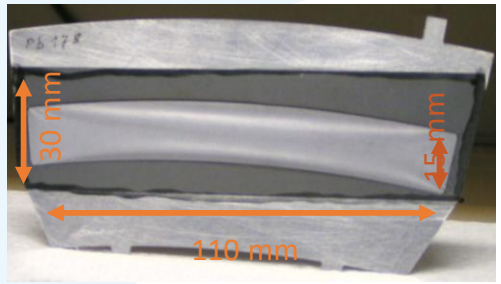
G. Frémont, M. Bourges, R. Rahali, targets' experts

F. Pérocheau, project manager & Ch. Stodel, pilote stratégique

Targets Needs

- **Stable** Targets @ S3 > 2025, 0,2-1 mg/cm² ± 5% ≈ 22 cm² - 1 wheel = 18 targets
  - Equilibrium charge states foils + backings: C @ 30 µg/cm²
  - Commissioning: ^{116}Sn, ^{174}Yb, ^{180}Hf, ^{175}Lu, ^{58}Ni, ^{197}Au, ^{206}Pb, ^{209}Bi,
  - Low Energy Branch : ^{50}Cr, ^{58}Ni, ^{nat}Zn, ^{96}Mo, ^{175}Lu, ^{178,180}Hf, $^{206\text{-}208}$Pb, ^{209}Bi, ^{208}Pb, ^{238}U,
  - SIRIUS: ^{58}Ni, ^{174}Yb/^{170}Er, ^{96}Ru, ^{92}Mo, ^{206}Pb, ^{209}Bi, $^{204, 207, 208}$Pb (PbS), ^{209}Bi (Bi203), ^{232}Th,^{238}U
  - ^{45}Sc, ^{170}Er, ^{160}Gd, ^{184,186}W, ^{181}Ta, ^{144,148}Sm, $^{160, 164}$Dy, …….

2025 – 2027 ≈ 600/year (15g)



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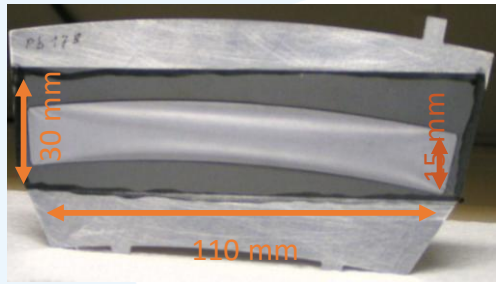
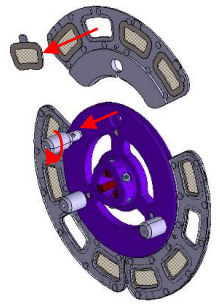




- **Actinide** Targets @ S3, > 2027-2028 Experiments **+ for NFS**

1 isotope per year

^{226}Ra*, (^{237}Np), ^{243}Am*, ^{248}Cm*, $^{239/242/244}$Pu* (≈ 25 mg ≈ 10^2 –10^8 Bq)

0,3 - 0,5 mg/cm² ; 1 wheel ≈ 12 targets of ≈ 3 cm² or 6 targets of ≈ 6 cm² ≈ 36 cm²

≈ **20 mg** ≈ 10^2 –10^8 Bq < 1 GBq

Isotopic enrichment >≈ 97%

Preparation of 3 wheels (30-40 targets) per year

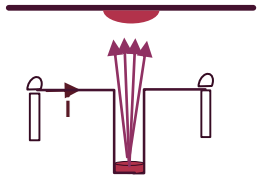
S³ Needs

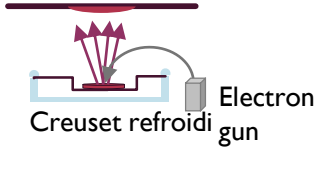
Done

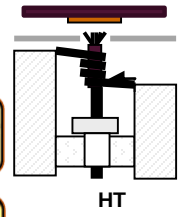
To be developed

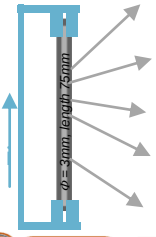
Tech 1 | Tech 2 | Tech 3

Tech 1 | Tech 2 | Tech 3









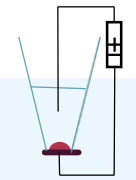
Sputtering

Thin layer deposited on substrate (backing)

H																	He
Li	Be											B	C **	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca *	Sc	^{46}Ti *	V	^{50}Cr *	Mn	Fe *	Co	^{58}Ni *	Cu	Zn *	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo *		Ru	Rh	Pd	Ag	Cd	In	^{118}Sn *	Sb	Te	I	Xe
Cs	Ba	Lanthanides	^{178,180}Hf *	Ta	^{182}W	Re	Os	Ir	Pt	Au *	Hg	Tl	^{iso}Pb *	Bi, Bi_2O_3 *	Po		Rn
Fr	Ra	actinides		Ta	^{182}W								^{iso}PbS				

La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	^{164}Dy	Ho	^{170}Er	Tm	^{174,176}Yb *	^{175}Lu *
Ac	Th *	Pa	U *	Np	Pu	Am	Cm	Bk	Cf	Es				

MP



Sputtering=
DC Magnetron for monoisotopic element
or focused ion beam for isotopic elements

* 2026/27 ≈270 (4g)

* 2026/27 – 2028 ≈ 600/year (15g)

PALAIS project

Need of a lot of targets (**stables**, ^{238}U)

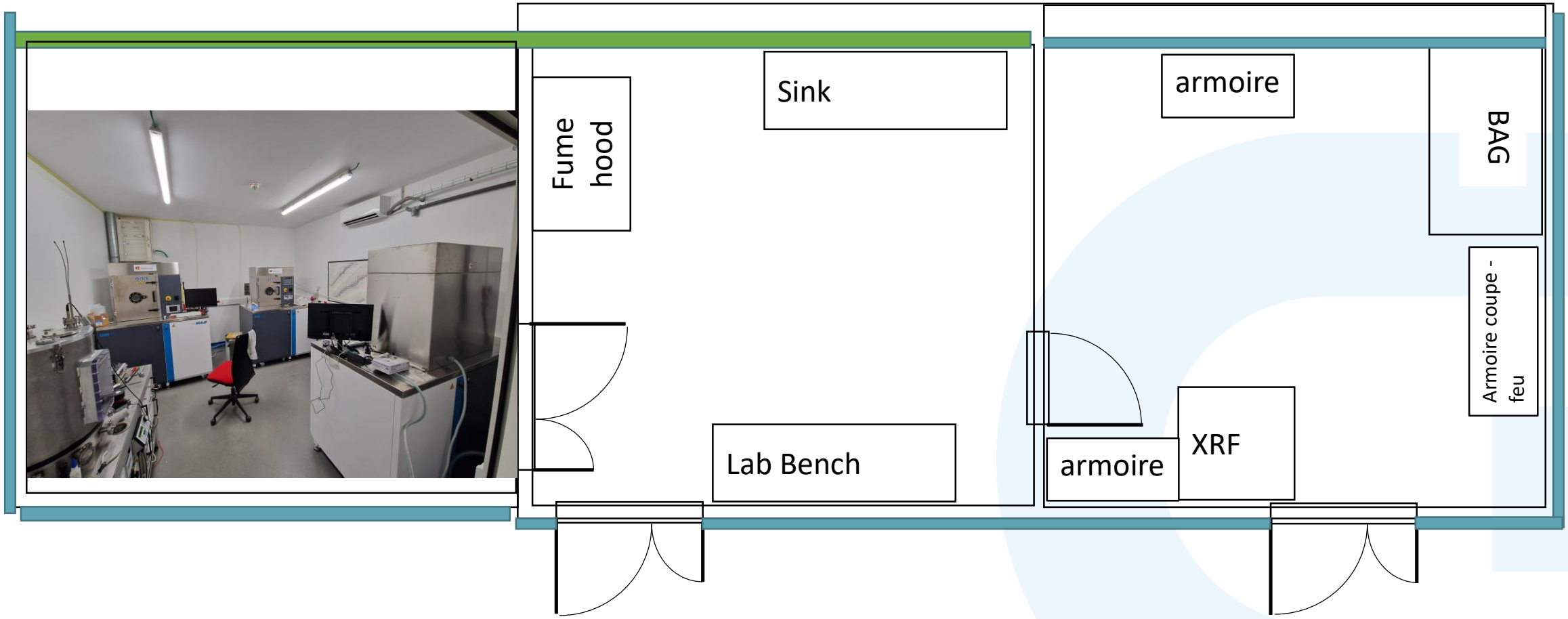
→ increase the production capacity, including development and caracterisation

- **PHASE1 (2023-2025) (STIL + SSRE):**
  - Refurbishment of the premises **3*25 m² to ~ 100 m²**
  - New equipment

  - 07/2025→ 2027 Post-doc, R&D lanthanide & characterisation (Radia Rahali, EURO-LABs + FP)

PALAIS project: refurbishment of the premises

Partitioning and insulation & Air conditioning-ventilation

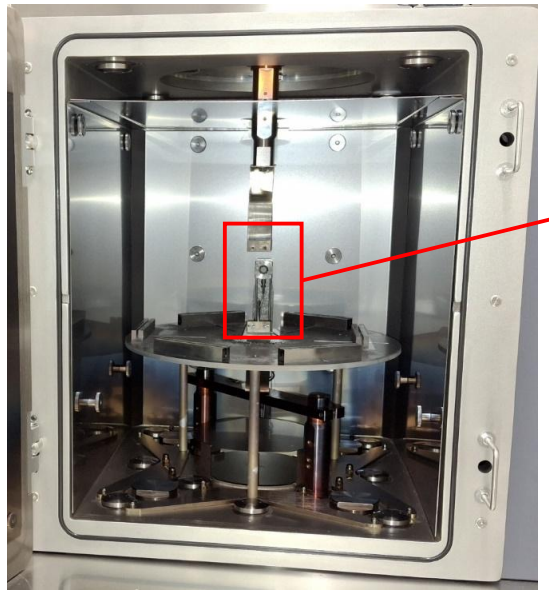


Ready in summer 2025

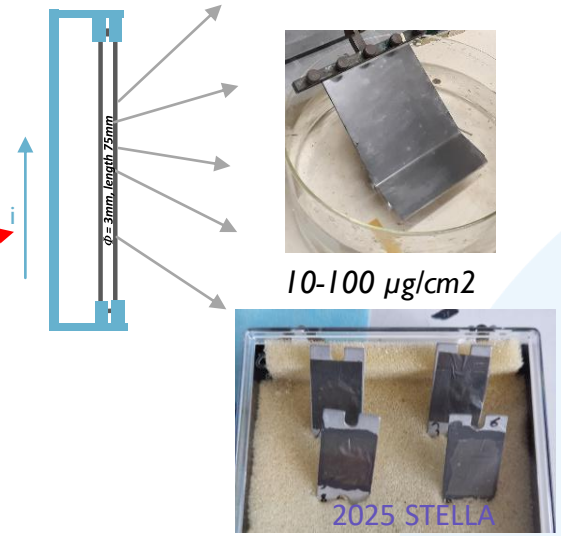
& transfer of target storage to « local 09 »

The 2025 target laboratory: new evaporators

Carbon Evaporator → Sublimation



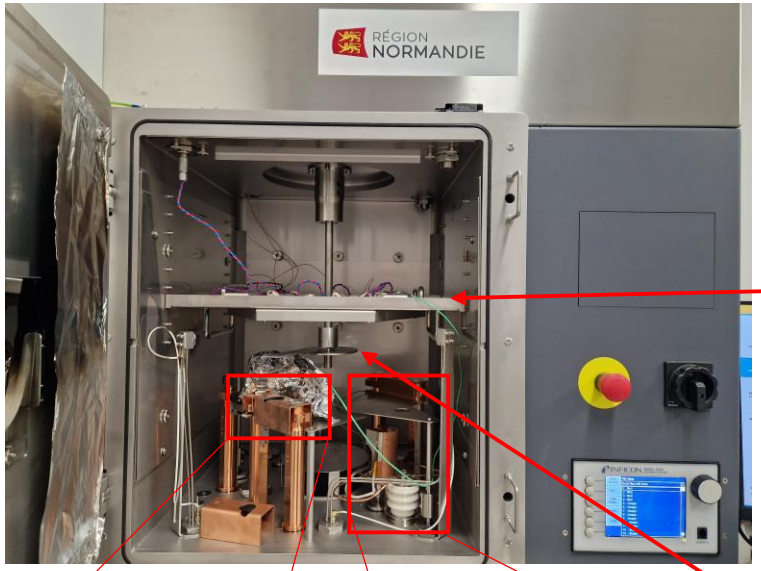
GSI method



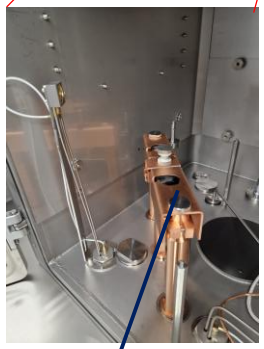
Carbon foils for S3 (backings or charged state equilibrium foils)

The 2025 target laboratory: new evaporators

→ Evaporator with resistive heating & Electron gun systems

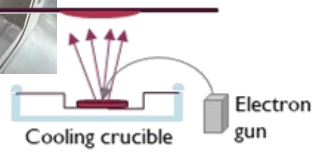


Rotating tray
for 7 targets

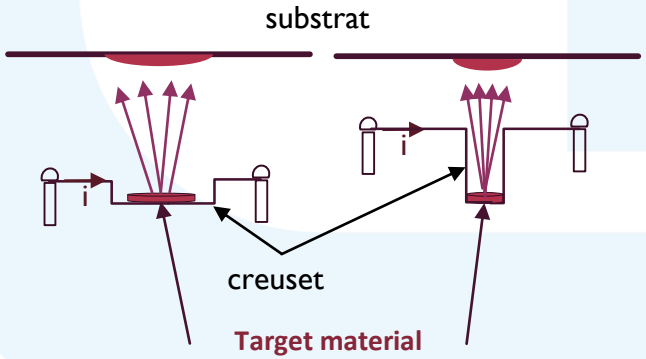


e-gun

Crucible/resistive heating



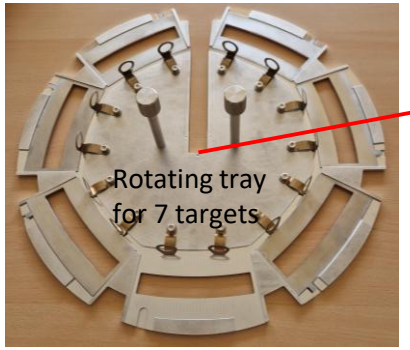
Multi-material Evaporator

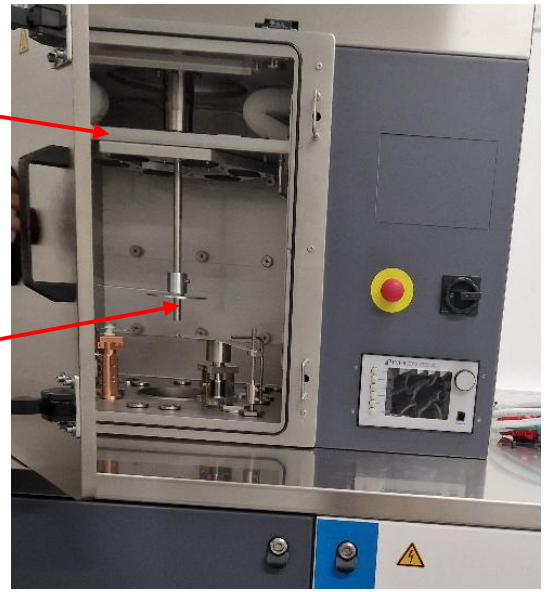


H.A.F. Muggleton, Vacuum 37 (1987) 785-817.

The 2025 target laboratory: new evaporators

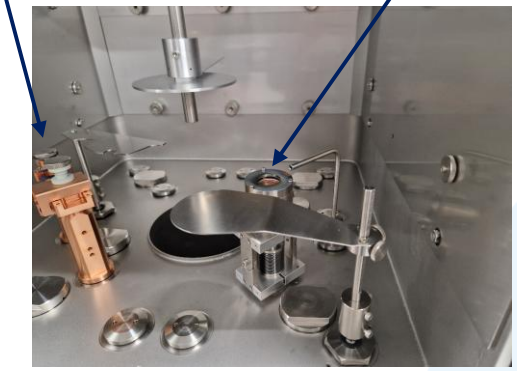
evaporator for sputtering method for ^{238}U and monoisotopic materials.

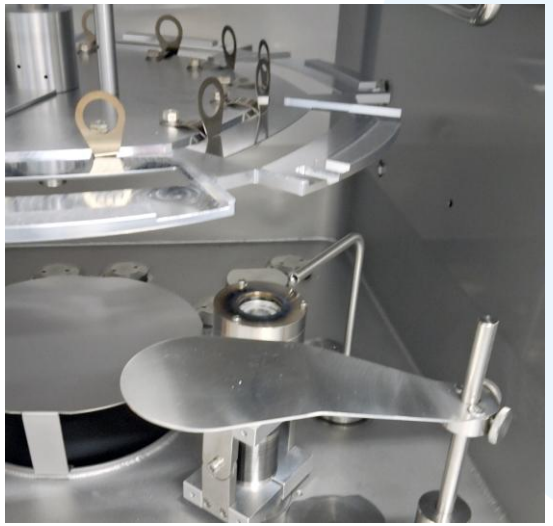




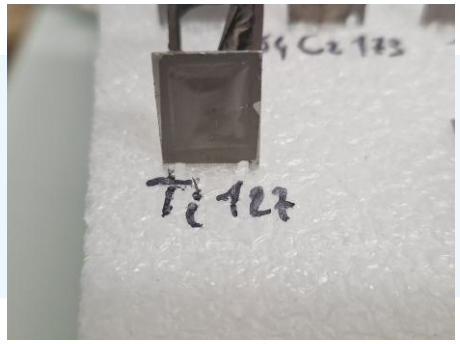
Crucible/resistive heating

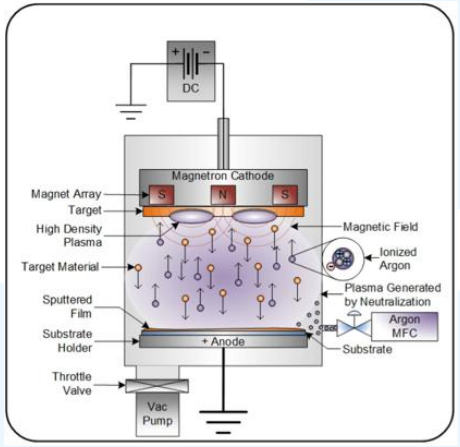
DC Magnetron sputtering





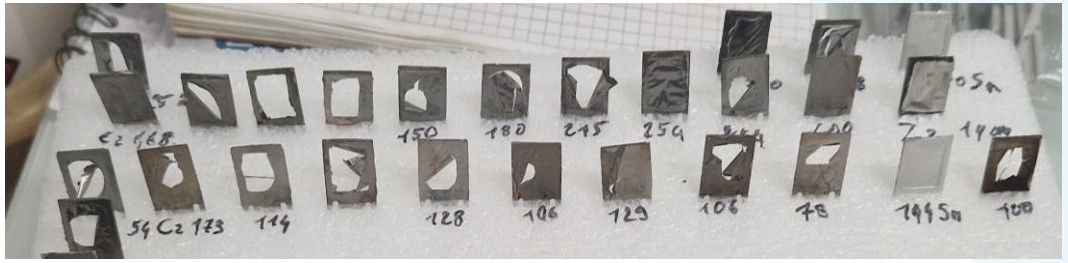
1st test with titanium
E900_24 – VAMOS 2026



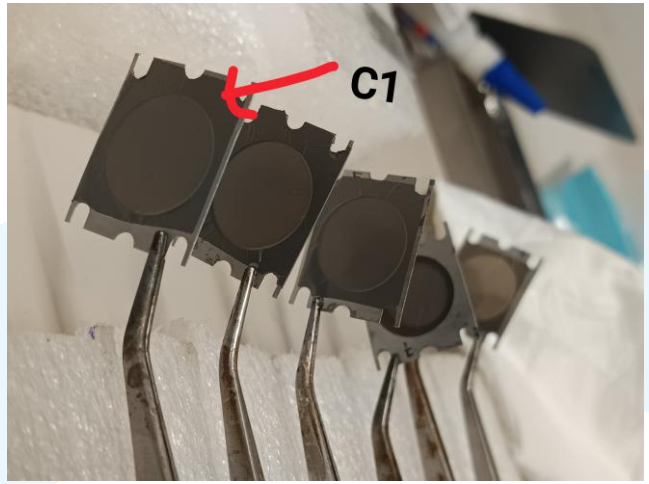


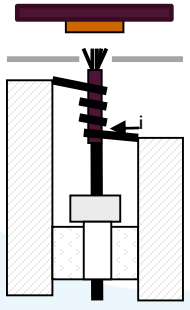
The 2025 target laboratory: *Old Multi-material Evaporator*

^{54}Cr and ^{nat}Cr targets
E900_24 – VAMOS 2026

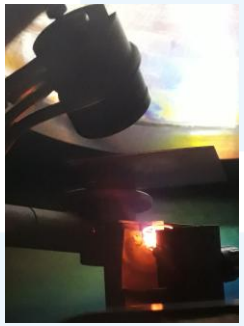


^{nat}Yb targets (C+C)
JYFL 2025





Tech-Evap 3: Electronic bombardment of the crucible
I_{fil} → e^- + dV → dP

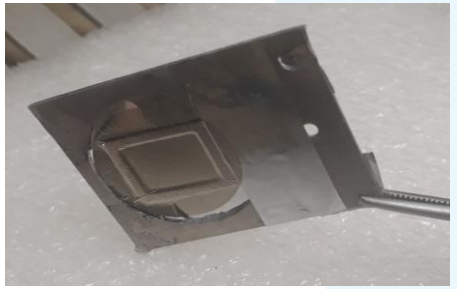


L. Westgaard et al, Nucl. Inst. Meth. 42 (1966) 77-81
A. Stolarz, *Journal of Radioanalytical and Nuclear Chemistry* vol. 299, pages 913–931 (2014)

The 2025 target laboratory – Chemical method

Molecular Plating

Preparation of osmium targets with carbon backing
Georges Fremont, Yvette Ngono-Ravache et al
AIP Conf. Proc. 1962, 030002-1–030002-4;
https://doi.org/10.1063/1.5035519



^{60}Ni ~150 µg/cm² (M. Bourges, 2024)

Existing Mechanical Systems

Mechanical Shaping

Tablet pressing

~20 mg/cm2 - > g/cm2

Rolling

0.5 mg/cm² - > g/cm²

F.J. Karasek, Nucl. Sci. Eng. 17(3) (1963) 16-19.

Press for pellets:

- Metallic powders before evaporation
- Mixture of powders (i.e. oxyde element + reductant) before evaporation
- Thick targets

2 Rolling mills

Manual for common metals

Motorized for fragile material to be worked under inert atmosphere in glove box

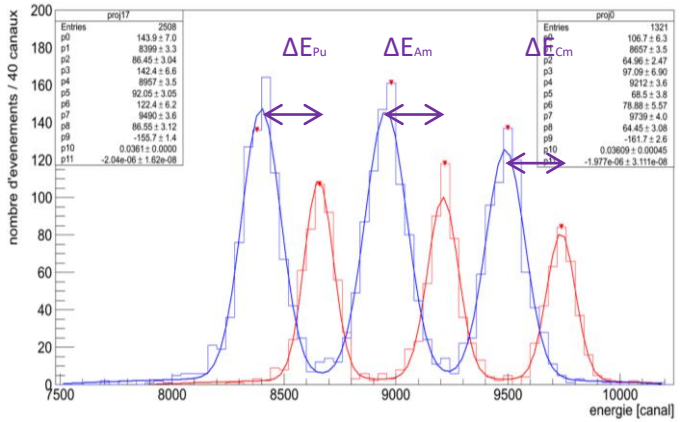
A. Stolarz, Nucl. Instr. and Meth. A 397 (1997) 114-116.

The 2025 target laboratory: Characterization « Global » Thickness

Micro balance - Weighting

α source – Energy Loss

(Maria Fisichella)



$$x\ [\mu g.cm^{-2}] = \frac{\Delta E\ [keV]}{S(E)\ [(keV.cm^2).\mu g^{-1}]}$$

+ Unifromity

Motorized for large foils

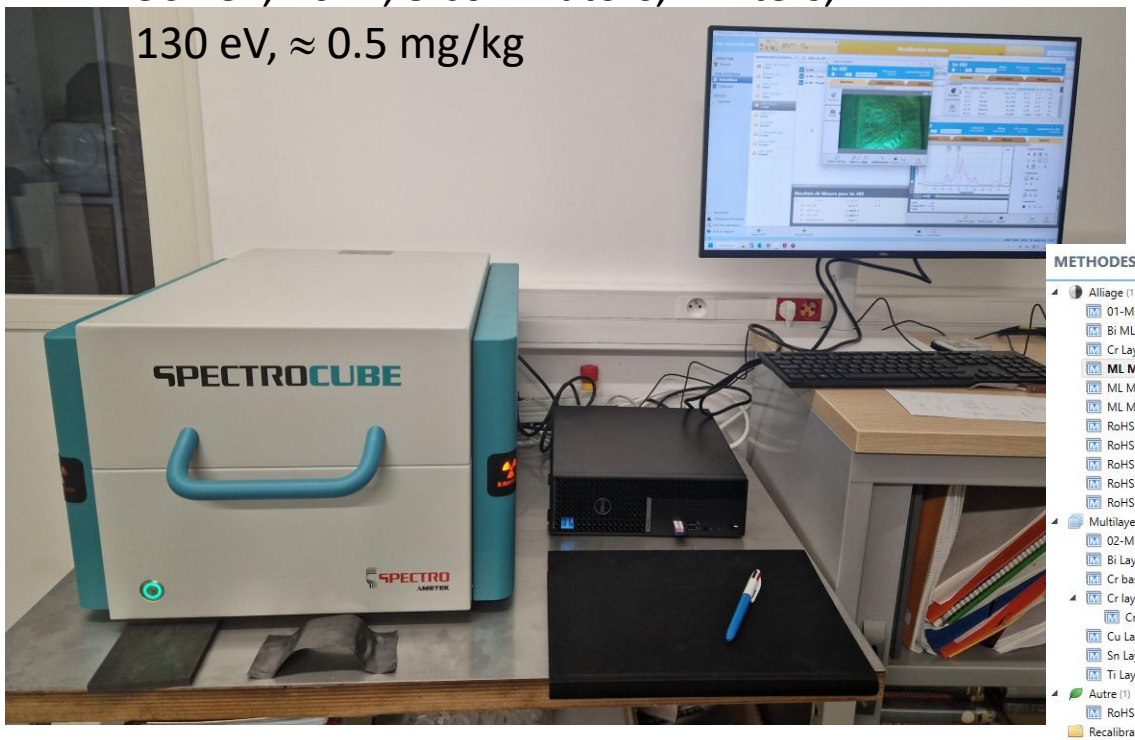
Under development

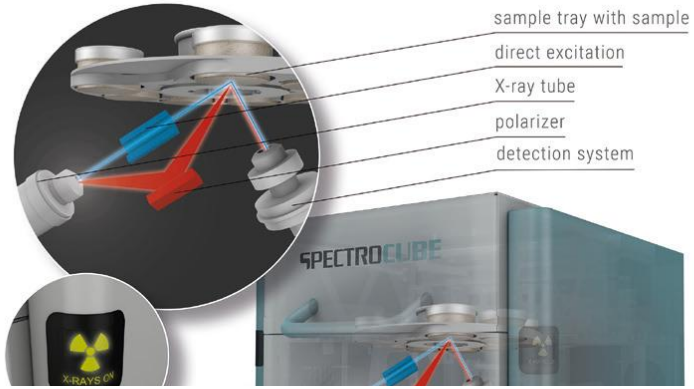
The 2025 target laboratory: Characterization
Elemental composition & thickness

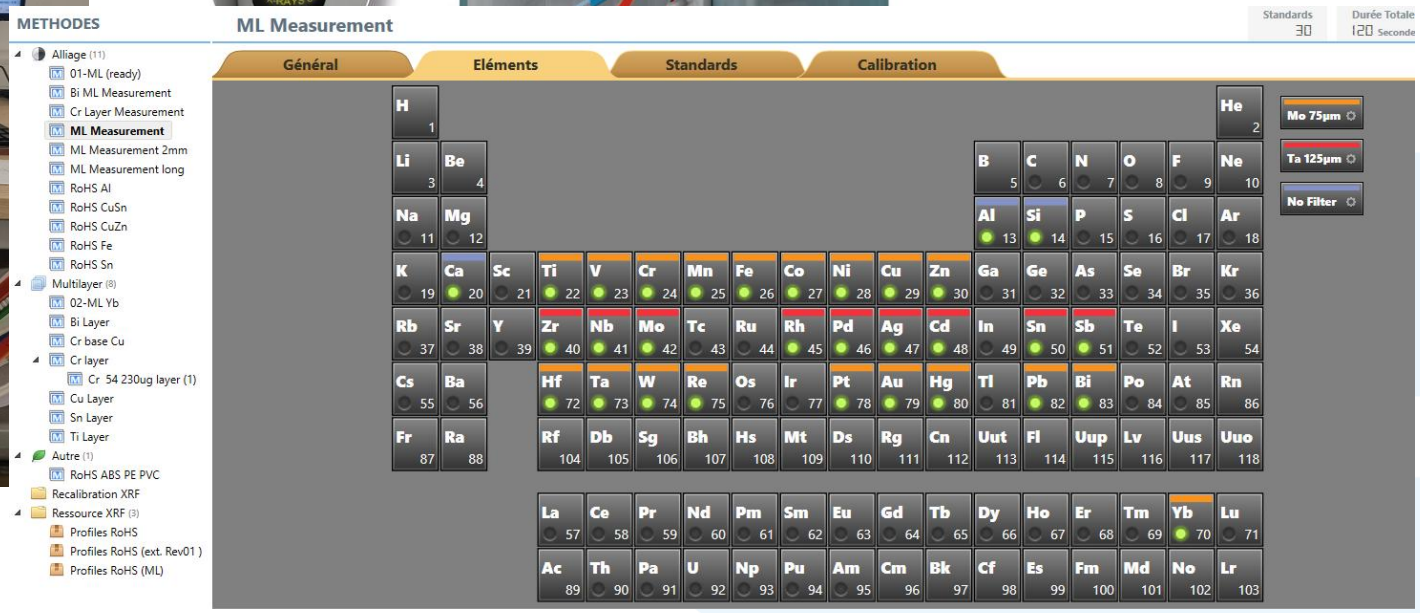
XRF

From February 2026

50 keV, 40 W, 5 collimators, 2 filters,
130 eV, ≈ 0.5 mg/kg



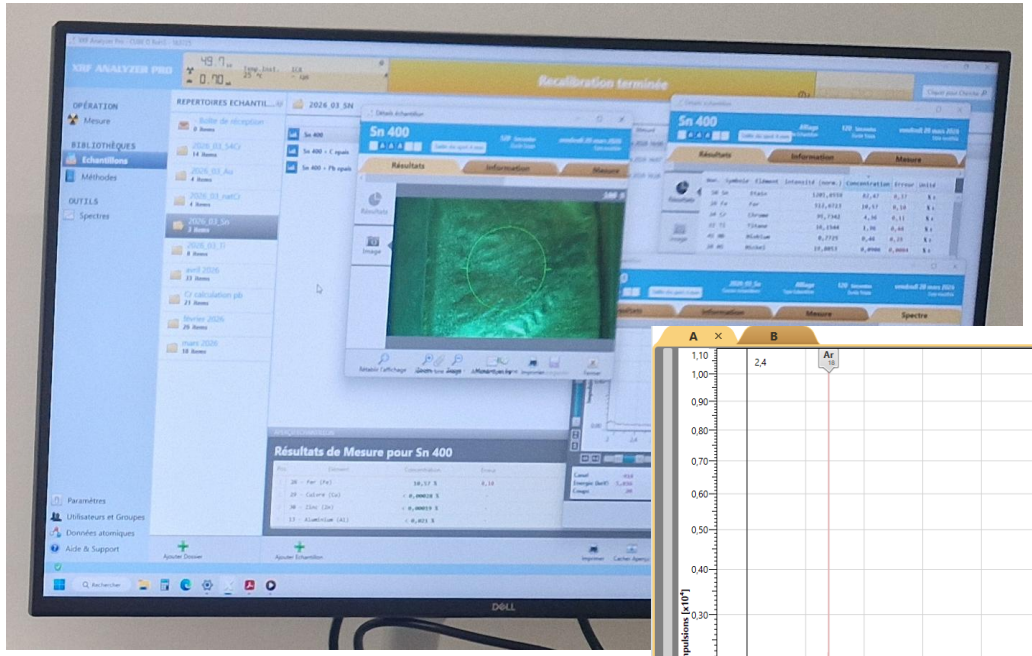


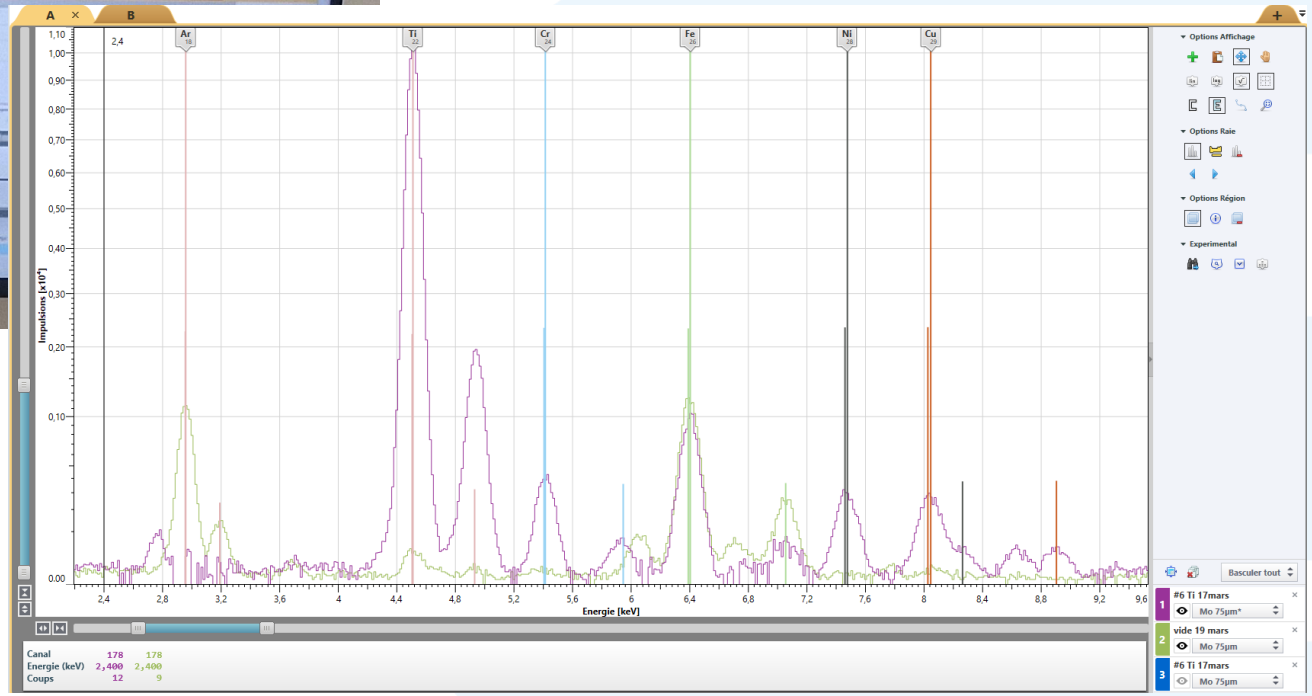


The 2025 target laboratory: Characterization
Elemental composition & thickness

XRF

From February 2026





Under Test

Comparative studies :

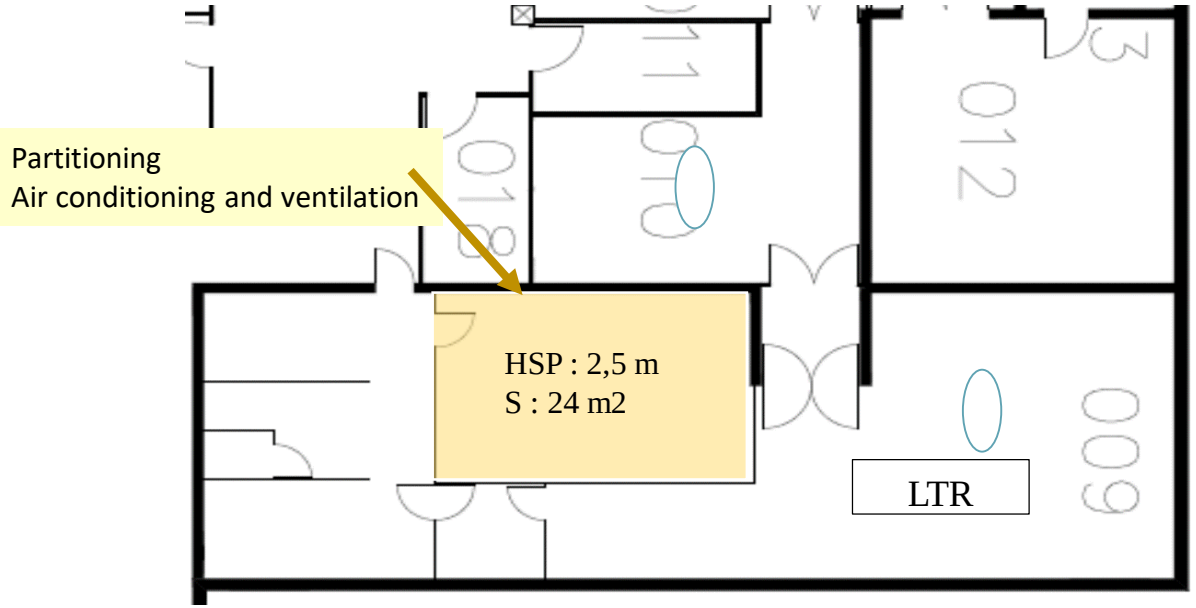
- ✓ with PIXE & RBS measurements (IP2IB & IJCLab)
- ✓ Cr case :
  - Weight 110µg/cm² « fresh »
  - XRF 116 µg/cm²
  - 3 alphas 190 µg/cm² for Cr pur ??
    110 For pure Cr + 55 for 0 == 165 µg/cm² Cr2O3

PALAIS Project

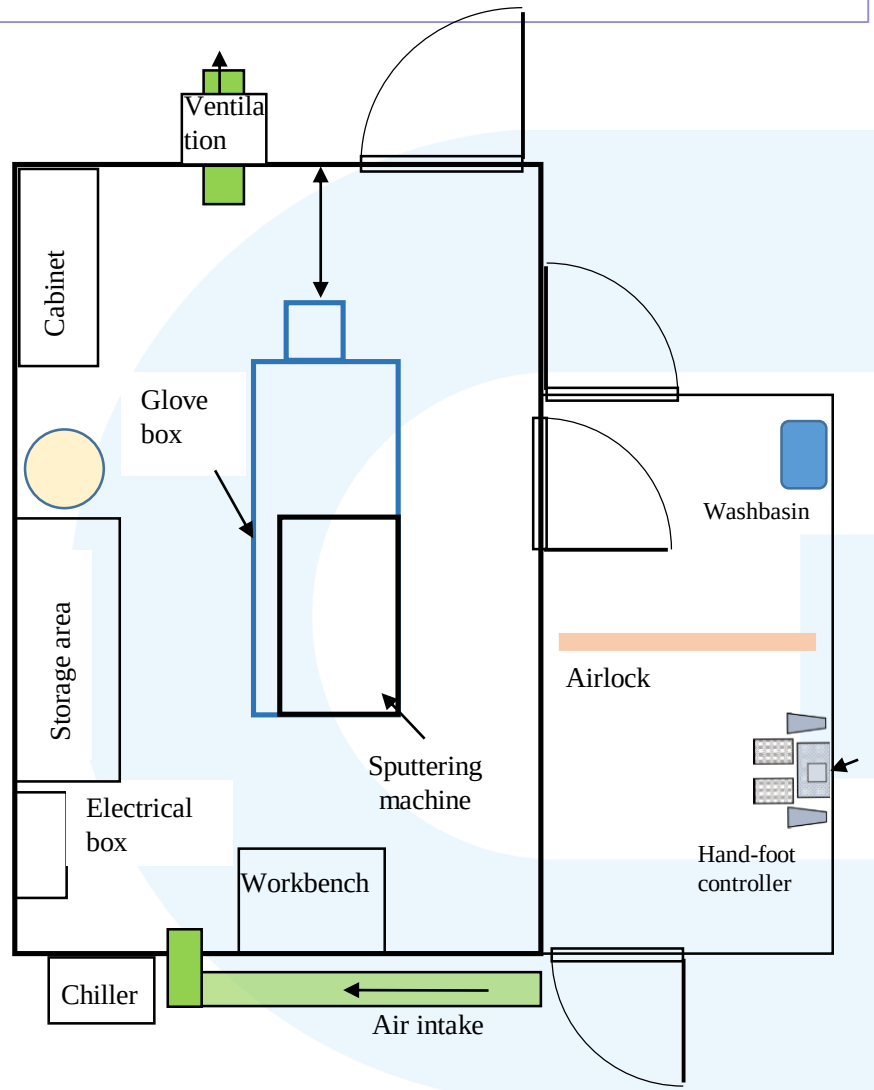
Need of a lot of targets (stables, ^{238}U)

→ increase the production capacity, including development and caracterisation

- **PHASE 2 (2024-2026) (STIL + SSRE):**
  - Modification & furnishing of the Radiation Laboratory (LTR) for ^{238}U targets & maybe ^{232}Th



Courtesy of F. Pérocheau



2- Development of targets at GANIL

2.1 PALAIS Project

Plateforme Cibles pour GANIL/SPIRAL2

2.2 GALACTIC Project

GANIL Laboratory for Actinide Target and Radiochemistry

G. Frémont, M. Bourges, R. Rahali, targets' experts

F. Pérocheau, project manager & Ch. Stodel, pilote stratégique

From PALAIS project to GALACTIC

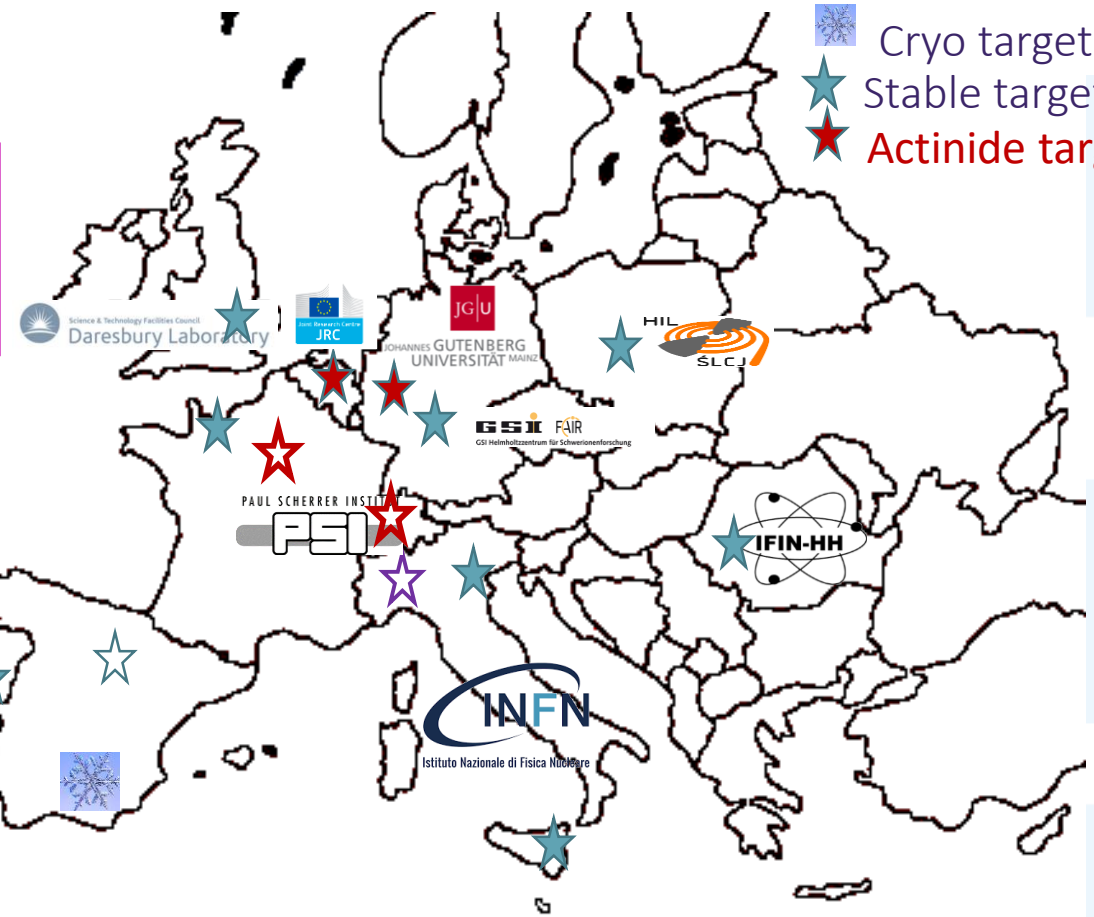
Need of a lot of targets (stables, ^{238}U) & actinides

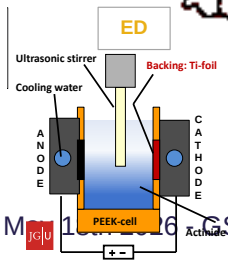
- *Limits on outsourcing target fabrication*

- **PHASE 3 (2023-202x)**

  GALACTIC = *GANIL Laboratory for Actinide Target and Radiochemistry*

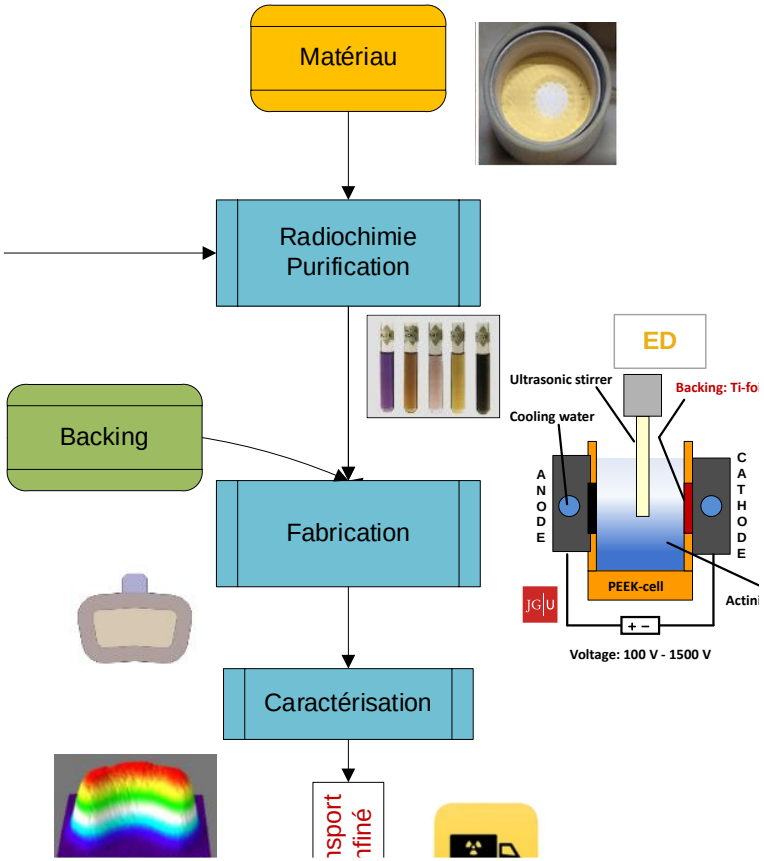
- **Process of actinide targets fabrication & characterization**
  - **New skills (radiochemistry)**
  - **Identification of material needs (building, protection systems…)**
  - **Identification and request of authorizations & licenses**





Projet GALACTIC

PHASE 3 (2023-202x) : Actinide Targets Fabrication



Visits & Discussions with European (JRC Geel, JGU Mainz, PSI) & National labs (IJCLab, CYCERON, LPC Caen, IMOGERE/CERMN, Subatech, PSI…)

→ Technical input data

→ Identification of synergies & complementarities

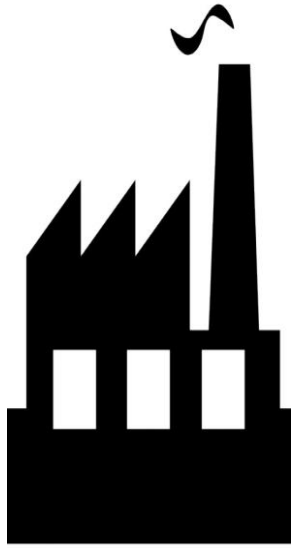
➢ **New skills (radiochemistry)**

Postdoctoral Researcher in Actinide Targets for Nuclear Physics Experiments at GANIL with Training at Geel, Mainz, univ. Orsay + ….

➢ ***New building, Preliminary layout drawings, costs estimates***

need for input data on environmental impacts, dosimetry for sizing equipment (ex nuclear ventilation, flux, glove box, control systems..)

4- Take-Home



- PALAIS (stable + ^{238}U)
  - ✓ Refurbishment of the space, new evaporators, XRF , , /)
  - ✓ Storage to be improved
  - ✓ U Lab under “construction”
  - ✓ Development of Isotopic $^{54,\ nat}$Cr or Ni, LiC, Lu, Yb, (Gd), Hf (?) targets (++ EUROLABS)
  - ✓ “Standard” CD2, CH2, Sn, Au, C, Pb …
  - ✓ Request of specific targets to partners: U, ^{96}Zr
  - ✓ Difficulties to assess light contaminants (H, O) in targets (C) → RBS, PIXE, ERDA @ MOSAIC or IP2IB

- GALACTIC (actinide) :
  - ✓ Radiochemistry skills → post-doc position
  - ✓ Laboratory equipments, New building → From draft to final design for accurate cost estimate
  - ✓ Safety files, authorization…..→ Manpower

  - ❑ **Feedback of users : other actinide targets request?, …..**
    - ❑ Next step: Approval & Funding

- Collaborations : Targets labs, INTDS, HPTW, material physics department….

DATA BASE TARGETS EUROLABS

Vasilis Soukeras, INFN-LNS &

Radia Rahali, Arthur Farietti, Titouan Louvet, Laurent Fortin, GANIL

DATABASE EUROLABS

Follow-up of Vasili's talk:
Outcome of WP2.5.2

Radia Rahali (GANIL) and Vasilis Soukeras (INFN-LNS) Targets database within EURO-LABS

Database, publicly available, containing the information about the preparation and the characteristics of available targets and those newly developed in various laboratories within this subtask. The first version of the database will be ready after the first year of the project and will be continuously updated during the duration of the project

INTDS International Nuclear Targets Development Society

Bibliography/data-base available online

The data are only available to members (not all content is in open access mode)

It concerns only the contribution within INTDS.
Limited search filters/parameters.

Organized as a library, it brings together 'published' data such as articles, conference papers.

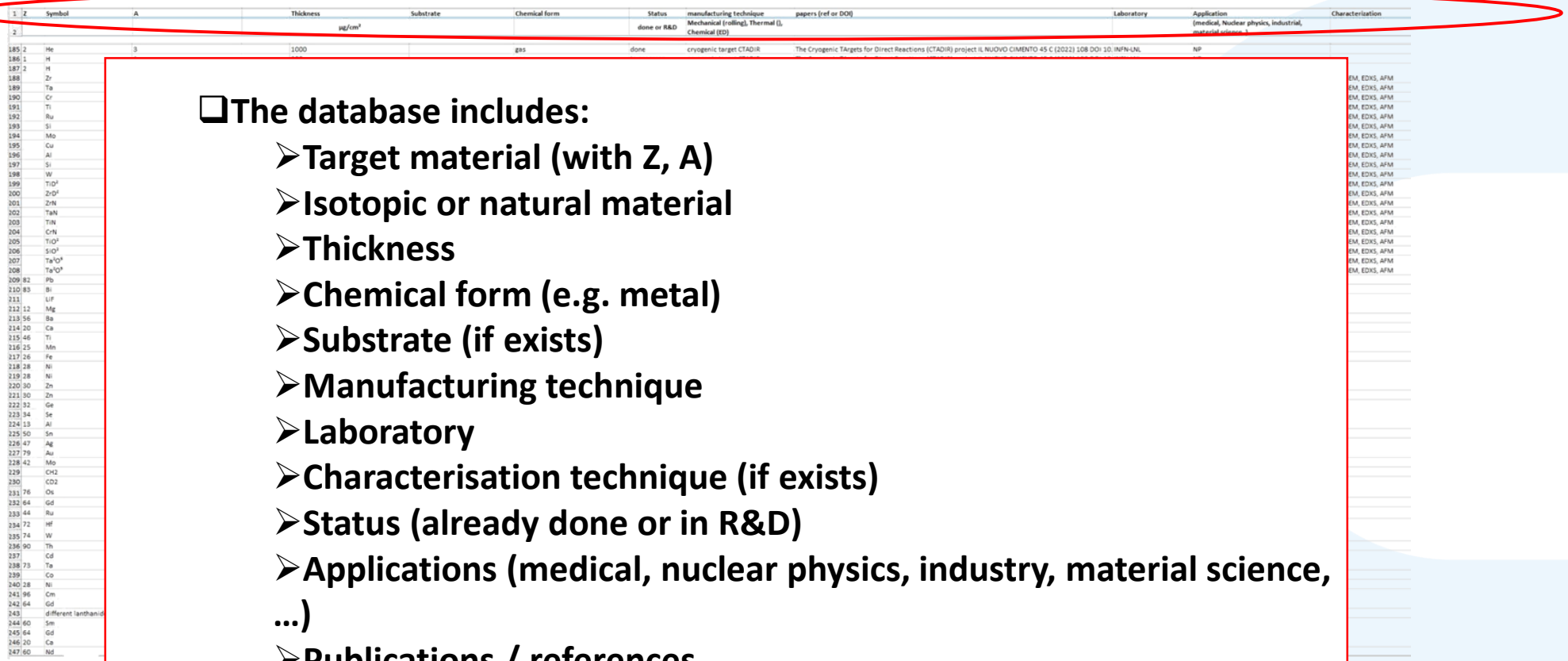
DATABASE EUROLABS

« Brainstorming »
Dixit Noemi

Follow-up of Vasili's talk:
Outcome of WP2.5.2

Database, publicly available, containing the information about the preparation and the characteristics of available targets and those newly developed in various laboratories within this subtask. The first version of the database will be ready after the first year of the project and will be continuously updated during the duration of the project

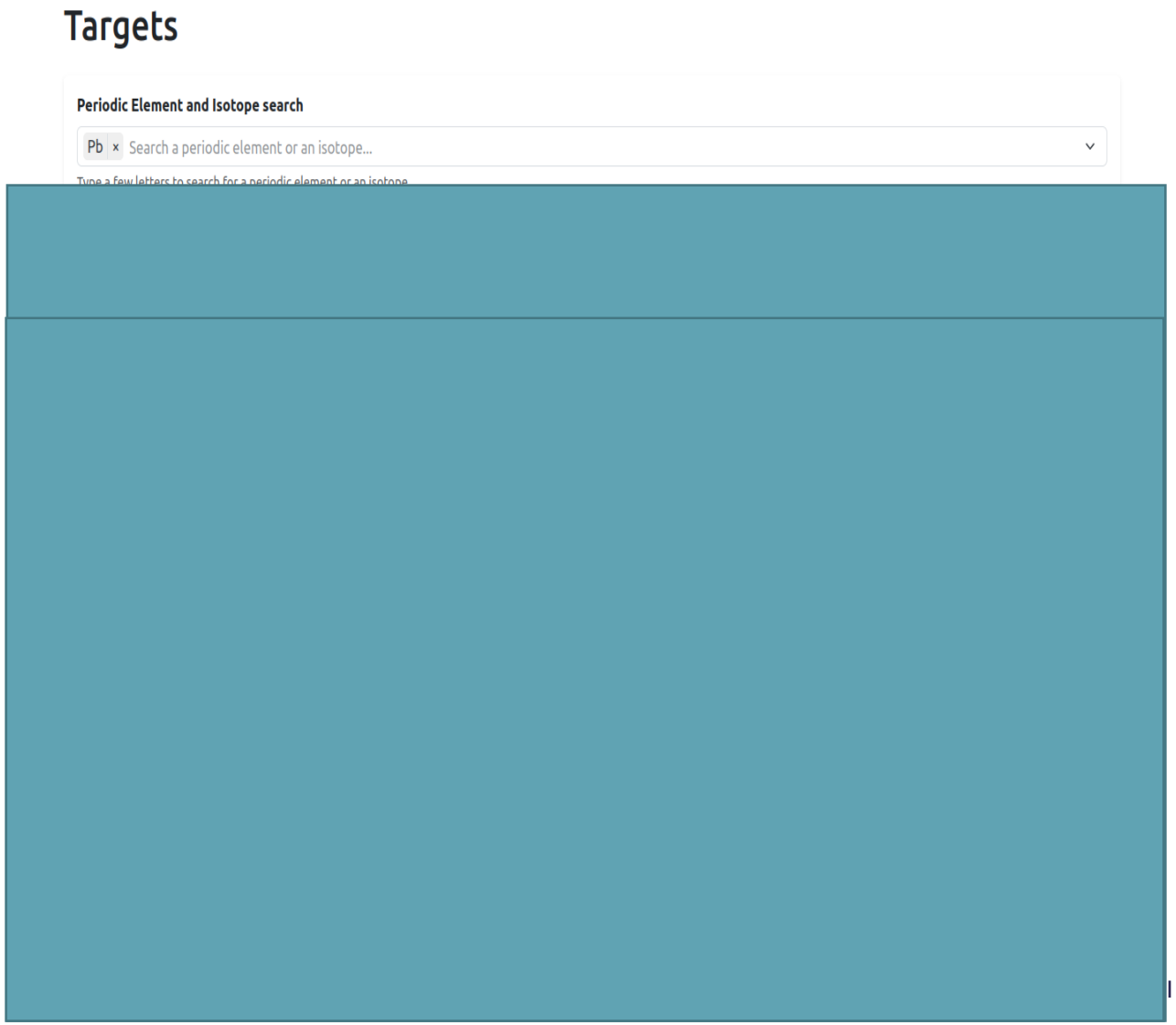
Excel file with the various parameters/information – Vasilis & Radia



- **The database includes:**
  - **Target material (with Z, A)**
  - **Isotopic or natural material**
  - **Thickness**
  - **Chemical form (e.g. metal)**
  - **Substrate (if exists)**
  - **Manufacturing technique**
  - **Laboratory**
  - **Characterisation technique (if exists)**
  - **Status (already done or in R&D)**
  - **Applications (medical, nuclear physics, industry, material science, …)**
  - **Publications / references**

DATABASE EUROLABS from the excel file to a user-friendly application

Arthur Farietti, *project manager/ Computer Engineer &* ***Titouan Louvet :*** *Intern (April-July 2026) in IT development*



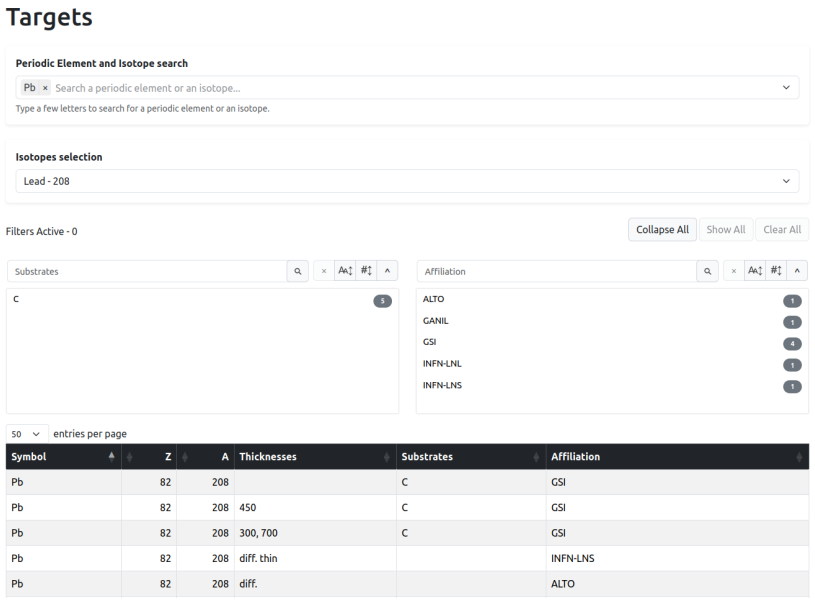
Project Objectives

application built around two core modules:

- **Search Module**: An interface enabling targeted queries (filtering by element, isotope, substrate, and affiliation) on specific datasets (the targets).
- **Management Module (Admin Dashboard)**: A dashboard allowing users to manipulate the data entered into the application (add, delete, and edit).

DATABASE EUROLABS from the excel file to a user-friendly application

Arthur Farietti, *project manager/ Computer Engineer &* ***Titouan Louvet :*** *Intern (April-July 2026) in IT development*



1- Suggestions for the name of the application

Which Recipe for my target?

Bibliography For Nuclear Physics Targets ?

……

Acronyms ?

2- Accessibility and Security Considerations

A key decision to be made concerns access to the application. We need to set the balance between user experience and data protection (risk of scraping):

- ***Option 1:*** Full Accessibility
  No restrictions, but data remains vulnerable.
- ***Option 2:*** Semi-Accessibility (Hybrid)
  Users are allowed 3–5 free searches per day. After that, they must provide their email to receive a single-use access link.
- ***Option 3:*** Restricted Accessibility
  Mandatory login via an account to access any data.

Thanks for your attention

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