



SANDA
Supplying Accurate Nuclear Data for
energy and non-energy Applications



SANDA WP3

Target Preparation for Improvement of Nuclear Data Measurements

Tasks 3.2 and 3.3

Goedele Sibbens, EC-JRC Geel, Belgium

*SANDA final workshop
3-5 July 2024
CIEMAT Spain*

This presentation

Task 3.2: Fostering the network of target makers

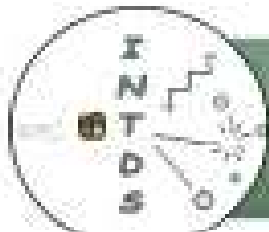
- D3.2 Report on the meeting in the frame of “Network of target producers”

Task 3.3: Target production

- D3.3 Report on produced targets

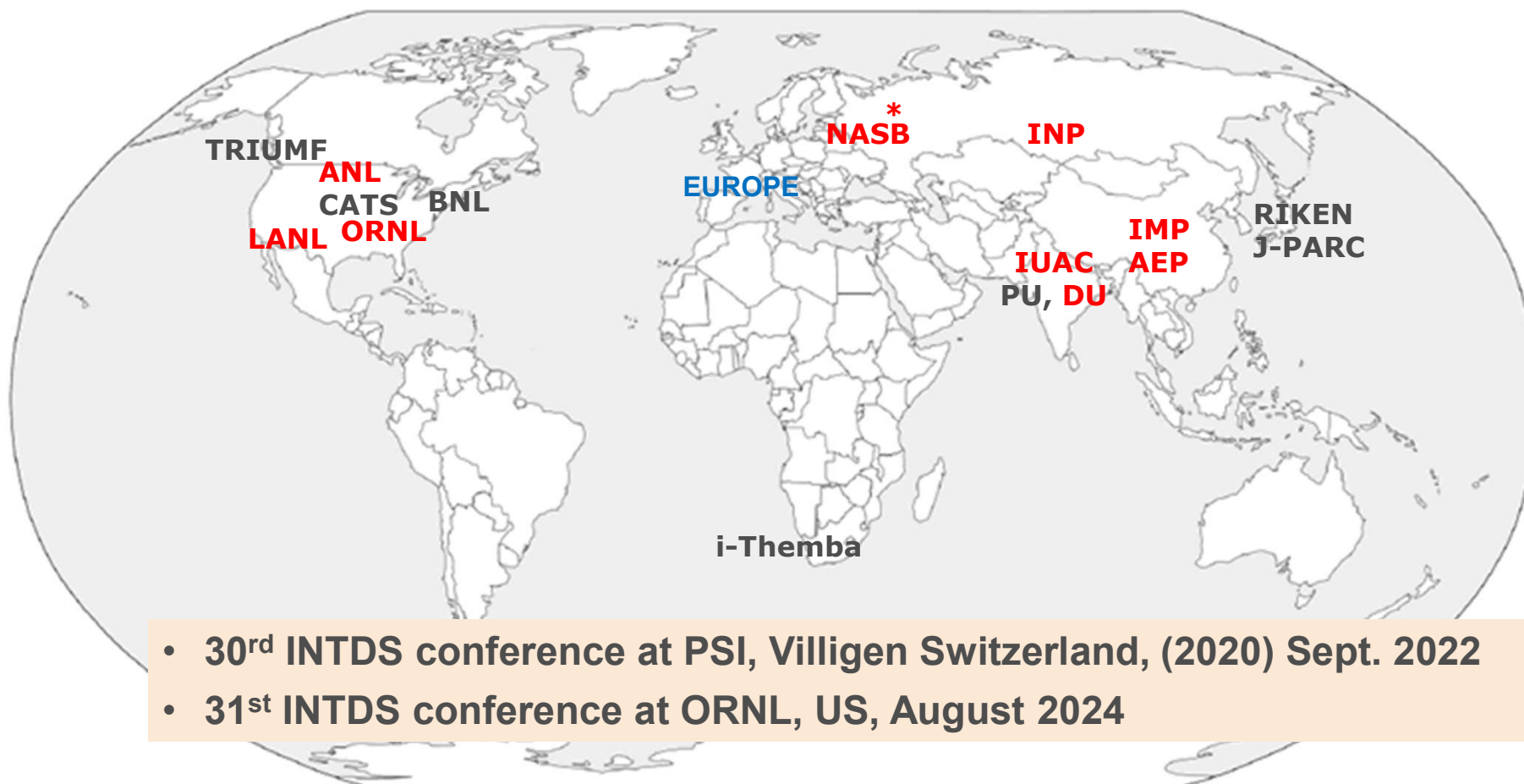
Task 3.2: Fostering the network of target makers

- Task coordinator: JRC, partners: PSI
- Maintaining and extending the existing network of target producers presented in the CHANDA project
- Use of the International Nuclear Targets Development Society (INTDS) internet platform
- D3.2 Report on the meetings performed in the frame of “Network of target producers”



INTDS *International Nuclear Targets Development Society*

SANDA final workshop
3-5 July 2024
CIEMAT Spain



*JINR
*RIAR JSC

Stable
Radioactive

- 30rd INTDS conference at PSI, Villigen Switzerland, (2020) Sept. 2022
- 31st INTDS conference at ORNL, US, August 2024



International Nuclear Targets Development Society (INTDS)

SANDA final workshop
3-5 July 2024
CIEMAT Spain

a non-profit, educational organization that:

- Encourages the **sharing of techniques** developed, or being developed, to provide research-quality targets and reference samples, mostly for basic research in physics, chemistry, and related sciences.
- Mentors people new to target and sample preparation.
- Provides modest financial support for hosts of INTDS **conferences** and for selected speakers.
- Publishes the techniques of target preparation and related topics. The INTDS **bibliography** index lists currently over 1160 articles.

<https://www.intds.org/>

INTDS conference topics

- Preparation and characterization of high-purity and special materials for target fabrication
- Preparation of thin films and foils (e.g., evaporation, sputtering, electrodeposition, rolling)
- Preparation of radioactive targets
- Preparation of liquid and gas targets
- Beam charge strippers (i.e., foil, liquid, gas, plasma)
- Targets for high-intensity beams
- Targets for special applications (e.g., medical, industrial, controlled fusion)
- Target characterization
- Target recycling and disposal

European target laboratories

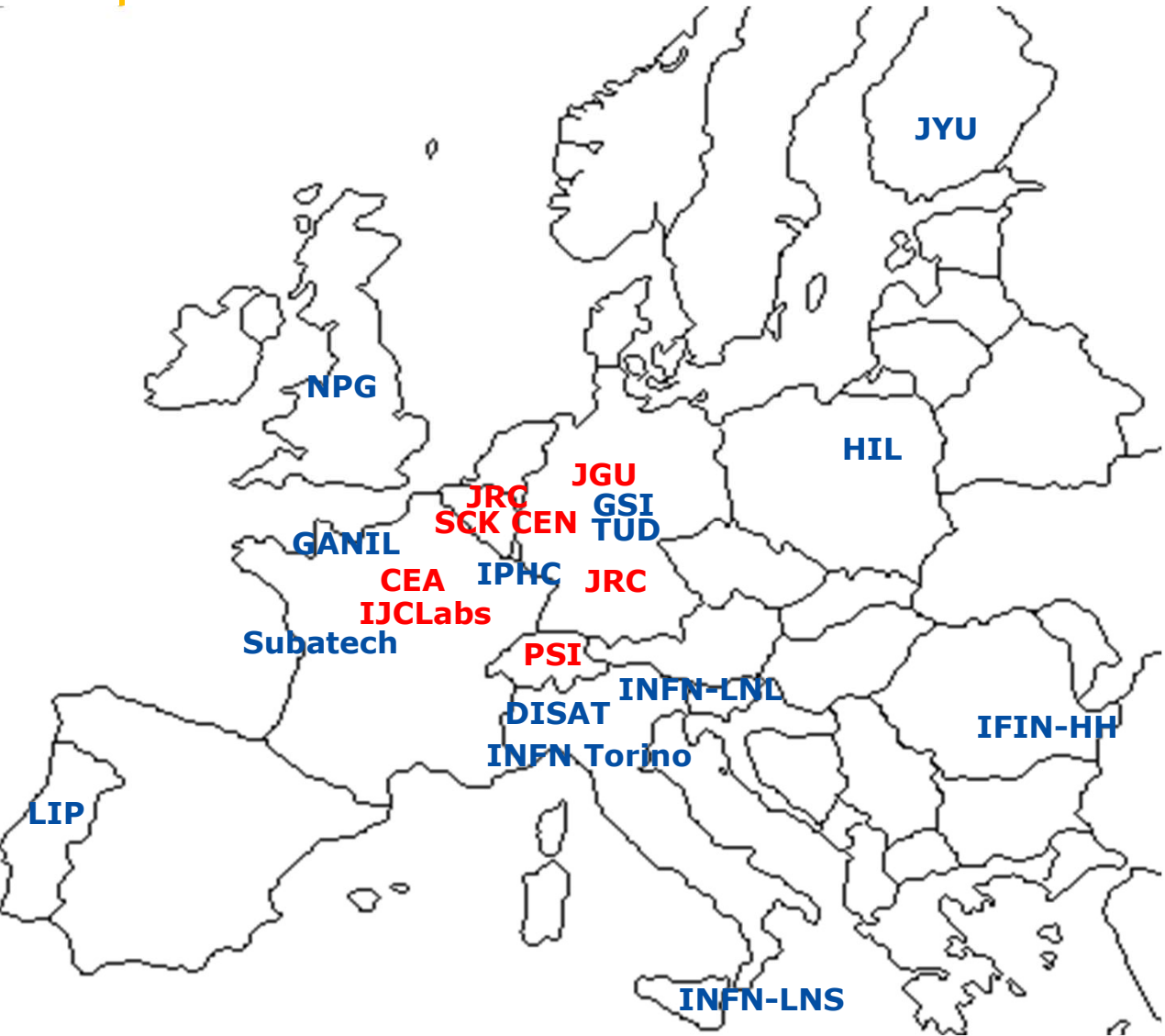
Stable

Radioactive

Boundary conditions:

For own experiments

In collaboration agreement



SANDA – workshop

SANDA – workshop on actinide target preparation and characterization – the need for radioanalytical chemistry

5-7 December 2023

JRC Geel site

Daniel Cano-Ott, CIEMAT, Spain

The SANDA project: high quality targets for successful experiments

Participating laboratories

JRC Geel, Belgium

SCK CEN, Belgium

JRC Karlsruhe, Germany

JGU Mainz, Germany

GSI Darmstadt, Germany

Triskem International, France

SANDA – workshop

HZDR, Germany

Sebastian Fichter, Accelerator Mass Spectrometry and Isotope Research Helmholtz-Zentrum Dresden-Rossendorf
Accelerator mass spectrometry of actinides – radiochemical separations and capabilities

Chalmers University of Technology, Sweden

Marcus Hedberg, Nuclear chemistry, Energy and Materials, Chemistry and Chemical Engineering
Nuclear chemistry at Chalmers University of Technology – capabilities and research areas

Czech Technical University, Czech Republic

Mojmír Němec, Nuclear Chemistry, Faculty of Nuclear Sciences and Physical Engineering
Nuclear chemistry and radioanalytics at CTU in Prague

NNL, UK

Robin Taylor, R&D leader in the field of actinide separations and storage chemistry
Actinide Separations Capabilities at the UK's National Nuclear Laboratory

GANIL, France

Christelle Stodel, Researcher at GANIL
The need for an actinide laboratory

SANDA workshop participants



SANDA

Supplying Accurate Nuclear Data for
energy and non-energy Applications



Task 3.3: Target production

- Task coordinator: JRC, partners: PSI
- Target requests related to energy and non-energy applications are considered.
- During the first 12 months of the project, target requests from collaborators were collected.
- D3.3 Report on produced targets

Target requests: status

	SANDA Domain other	Target user				Target production		
		Spokeslab	Facility	Target request	Request sent to	Target producer	Status of target preparation	Delivery
Ta-179	non-energy application	Ruchi Garg et al. University of Edinburgh, UK ruchi.garg@ed.ac.uk	TRIGA reactor Mainz	Separation of Ta-179 from irradiated Hf	PSI	PSI	finished	First target delivered, experiment performed; preparatory studies for target with higher activity under discussion
Pb-205	non-energy application	Adrià Casanovas Universitat Politècnica de Catalunya (UPC) adria.casanova@upc.edu	CERN n_TOF	Production of sufficient amount; manufacturing of a suitable target	PSI	PSI	cancelled	Isotope production currently not feasible
Se-79	Both energy and non-energy application	V. Babiano Instituto de Física Corpuscular (IFIC), Spain vbabiano@ific.uv.es	CERN n_TOF	PbSe on a support foil Isolating Se from PbSe	PSI	PSI	finished	Preparatory studies for isolating Se from Pb done. For the already irradiated target not feasible. The target is provided as PbSe on a support foil
Nb-94	Non-energy application	V. Babiano Instituto de Física Corpuscular (IFIC), Spain vbabiano@ific.uv.es	CERN n_TOF	elemental Nb; target in spiral shape	PSI	PSI	finished	Target delivered, experiment performed

Target requests: status

	SANDA Domain other	Target user				Target production		
		Spokeslab.	Facility	Target request	Request sent to	Target producer	Status of target preparation	Delivery
Be-10	Non-energy application	M. Petri University of York	NL Argonne	Thin target ~160ug/cm2	PSI	PSI	finished	target delivered, first experiment performed; targets with higher activity in discussion
Ho-163	Non-energy application	C. Guerrero Univ. Sevilla & CNA, Spain cguerrero4@us.es	CERN n_TOF	¹⁶³ Ho target of at least 5 mg	PSI	PSI	cancelled	cancelled
Cr-50/Cr-53	Energy-application /structure material	C. Guerrero Univ. Sevilla & CNA, Spain cguerrero4@us.es	CERN n_TOF	Thin and thick targets (up to 80 mg/cm2)	PSI	PSI	under discussion	under discussion
Sr-87	Non-energy related	F. Gunsing CEA Saclay	CERN n_TOF	Recovery of partially oxidized sample	PSI	PSI	on hold	preparation for further use, foreseen 2025

Target requests: status

	SANDA Domain other	Target user				Target production		
		Spokeslab.	Facility	Target request	Request sent to	Target producer	Status of target preparation	Delivery
Pu-239	SANDA 2.2.1	Daniel Cano-Ott et al. CIEMAT, Spain daniel.cano@ciemat.es	CERN n_TOF	10x ²³⁹ Pu 320-330 µg/cm ² + 1x ²³⁹ Pu 100 µg/cm ² Ø20mm on 20 µm thick Al foil	JRC-Geel	JRC-Geel	finished	targets mounted in ionisation chamber and delivered at GELINA in May 2022, delivered at CERN in September 2022
				1x ²³⁹ Pu target of 100 mg			finished	target delivered at CERN in September 2022
Pu-242		Beatriz Jurado et al. CENBG, France jurado@cenbg.in2p3.fr	IPNO France	on 100 µg/cm ² thick C-nat foil	SANDA/WP3		Project withdrawn from SANDA	NA
U-238	SANDA 1.2.3	Gilbert Bélier et al. CEA/DAM-DIF gilbert.belier@cea.fr	NFS France	3x ²³⁸ U deposits (total 10 mg ²³⁸ U) Ø30mm on aluminized 70-80 µg/cm ² PI foil	JRC-Geel	JRC-Geel CEA	finished	delivered June 2021
				2x 40 µg/cm ² PI foil on test frames (one golded, and one silvered frame received from CEA).			finished	delivered June 2021
				5x 70-80µg/cm ² PI foil on special 1mm thick Al-ring Øout 60mm Øin 40mm			finished	delivered Oct 2021

Target requests: status

	SANDA Domain other	Target user				Target production		
		Spokeslab.	Facility	Target request	Request sent to	Target producer	Status of target preparation	Delivery
U-235		Alexander Prokofiev et al. Uppsala, Sweden alexander.prokofiev@physi.cs.uu.se	NFS France	3x ²³⁵ U 400 µg/cm ² Ø25mm on 40 µg/cm ² PI foil	CHANDA/WP3 SANDA/WP3	JRC-Geel	delay because of late commissioning of new U235 evaporator	Q4 2024
				2x 30-50 µg/cm ² polyimide foils on 1mm thick Al-ring Ø _{out} 90mm Ø _{in} 70mm + 2 rings (1mm thick Al-ring Ø _{out} 90mm Ø _{in} 70mm)			finished	delivered at Uppsala University Jan 2022
U-238		Alexander Prokofiev et al. Uppsala, Sweden alexander.prokofiev@physi.cs.uu.se	NFS France	3x ²³⁸ U 400 µg/cm ² Ø25mm on 40 µg/cm ² PI foil	CHANDA/WP3 SANDA/WP3	JRC-Geel	finished	delivered June 2021
				2x 40 µg/cm ² PI foil on 1mm thick Al-ring Ø _{out} 90mm Ø _{in} 70mm	CHANDA/WP3 SANDA/WP3	JRC-Geel	finished	delivered Jan 2022
Pu-239	SANDA T2.3	Maëlle Kerveno et al. CNRS IPHC France maelle.kerveno@iphc.cnrs.fr	GELINA JRC-Geel	2 g Pu powder in Al container with Ø 50 mm and thickness of 0.5 mm	JRC-Geel	JRC-Geel	finished	delivered April 2022

Targets produced within SANDA

${}^7\text{Be}(\text{NO}_3)_2$ layer by drop deposition at PSI

Backing

0.635 μm thick polyethylene film

Deposit

$\text{Be}(\text{NO}_3)_2$ thickness: 0.36 μm

${}^7\text{Be}$ activity: 24.5 GBq

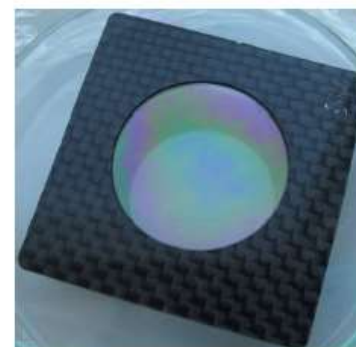


Figure 2. sLD-PE film glued onto a carbon fibre frame.

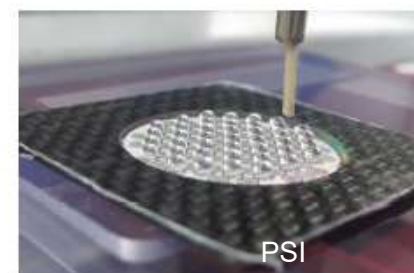


Figure 4. Droplets of $\text{Be}(\text{NO}_3)_2$ 0.01 M HNO_3 placed onto the sLD-PE film.

Targets produced within SANDA

Implantation of ^7Be into aluminium foils at PSI

Backing

50 × 50 × 0.018 mm Al foil
placed between two Al frames
with a 40 mm diameter central hole

Implantation

^7Be activity: 1 GBq



Fig. 3. Panel (a): Target_1 GBq

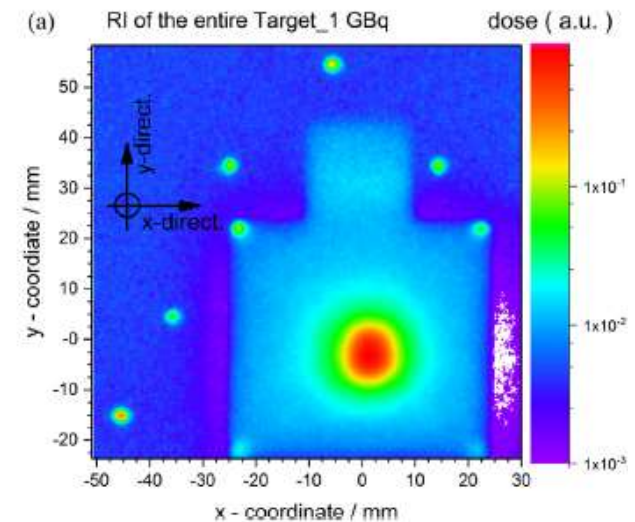


Fig. 4. Panel (a): Two-dimensional radiographic image of Target_1 GBq. Pane

Targets produced within SANDA



A 304 mg of high purity ^{93}Nb wires were shaped in a spiral pattern **at PSI** and afterwards activated at the high-flux nuclear ILL-Grenoble reactor for 51 days.

The target was then analyzed at PSI by a customized HPGe gamma-ray spectroscopy set-up.

^{94}Nb activity: 10.1 MBq

Targets produced within SANDA

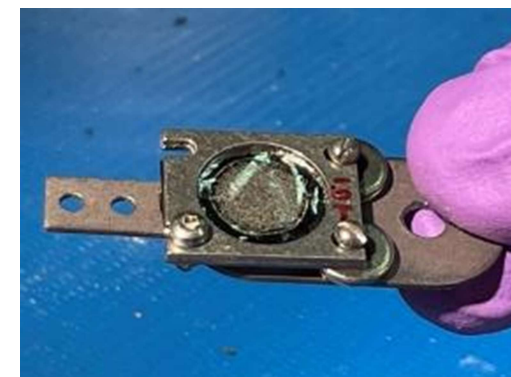
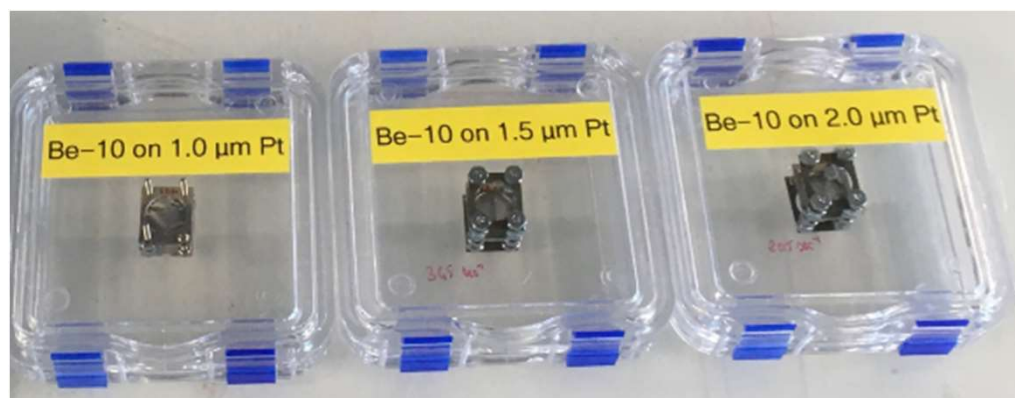
molecular plating of $\text{Be}(\text{OH})_2$ solution on thin Pt foils at PSI

Backing

1 μm , 1.5 μm and 2 μm thick Pt foil, \varnothing 7 mm

Deposit

160 $\mu\text{g}/\text{cm}^2$ ^{10}Be (500 $\mu\text{g}/\text{cm}^2$ Be)



^{10}Be target on a 1 μm platinum foil that was used in the experiment

Collaboration with University of York, UK and Argonne National Laboratory, Illinois, USA

Targets produced within SANDA

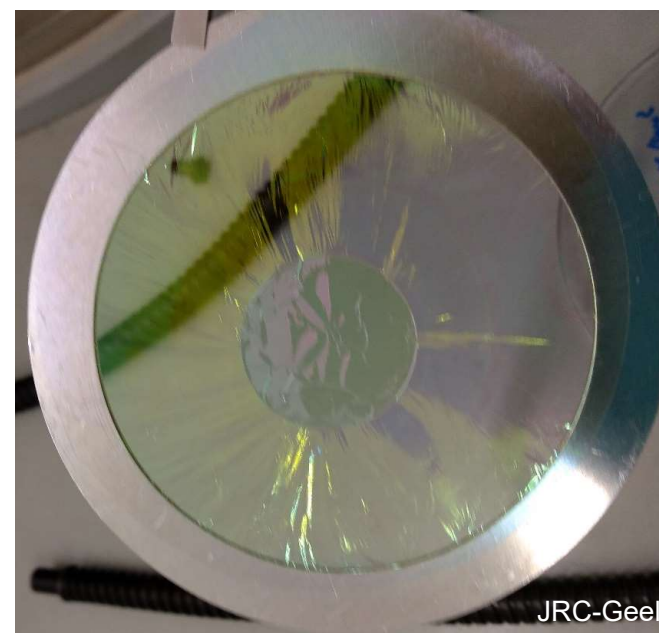
$^{238}\text{UF}_4$ deposits by physical vapour deposition at JRC Geel

Backing

34 $\mu\text{g}/\text{cm}^2$ polyimide foil
on 1 mm thick Al ring Ø_{out} 90 mm Ø_{in} 70 mm

Deposit

^{238}U diameter: 20 mm
 ^{238}U areal density: 377 $\mu\text{g}/\text{cm}^2$
 ^{238}U mass: 1.84 mg



Targets produced within SANDA

^{238}U deposits prepared by physical vapour deposition at JRC Geel



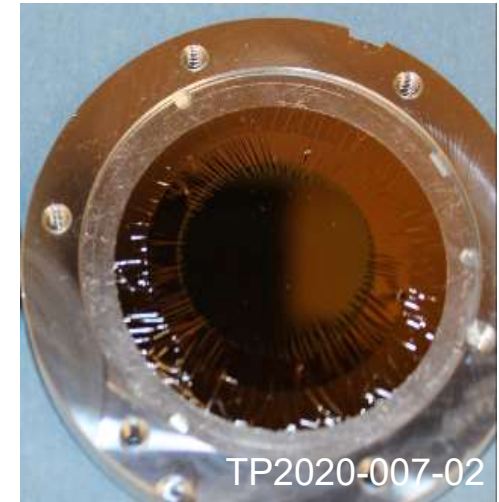
Al-ring 1mm thick
 \O_{out} 60mm \O_{in} 40mm
CEA, JRC-Geel



Polyimide foil
Areal density: $60 \mu\text{g}/\text{cm}^2$
In-situ polymerisation
JRC-Geel



Al layer 87nm
Physical vapour deposition
CEA



Material: 99.998 at% ^{238}U
Deposited layer: UF_4
Mass ^{238}U : 4.43 mg
Areal density ^{238}U : $628 \mu\text{g}/\text{cm}^2$
Deposit diameter: 29.96 mm
Physical vapour deposition
JRC-Geel

Targets produced within SANDA

^{239}Pu deposits prepared by molecular plating at JRC Geel

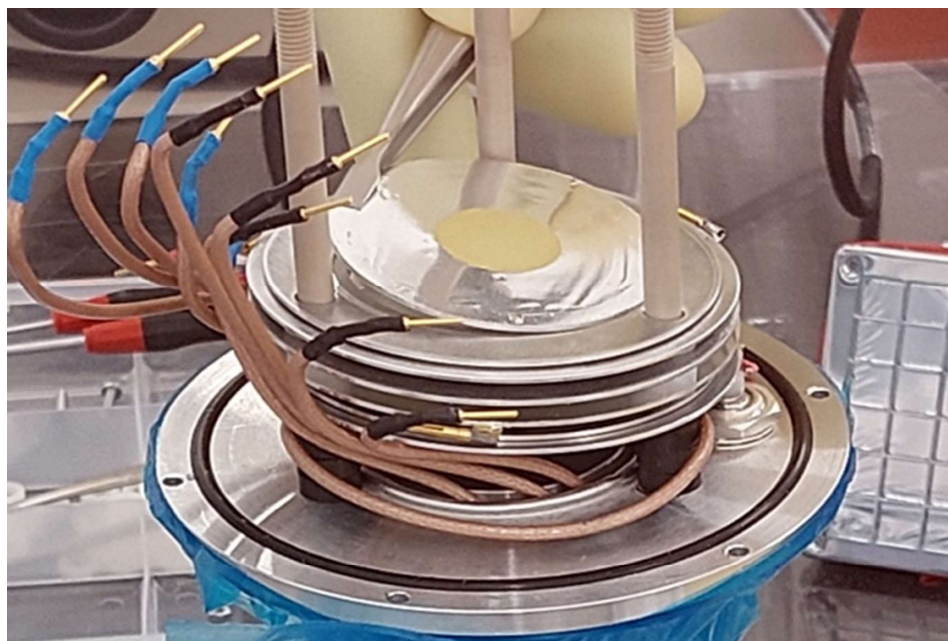
Deposit

^{239}Pu diameter: 20 mm

^{239}Pu areal density: 320-330 $\mu\text{g}/\text{cm}^2$

Backing

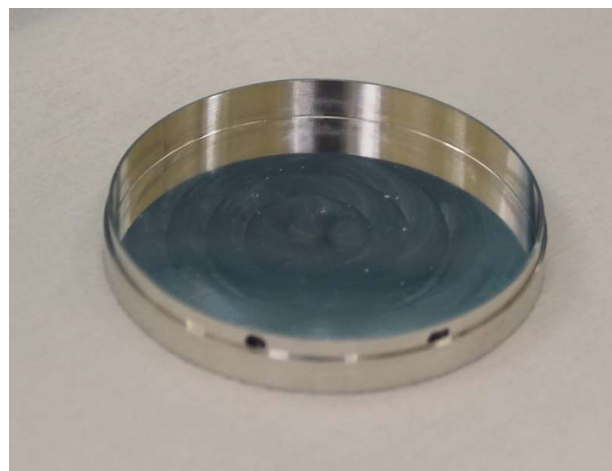
20 μm Al foil



^{239}Pu target during the mounting process at the JRC in Geel.

Targets produced within SANDA

2 g of ^{239}Pu powder canned in a container,
Ø 50mm, thickness 0.5 mm at JRC-Geel



Purification of powder for Am done at SCK CEN Belgium by peroxide precipitation, re-dissolution of the plutonium peroxide in nitric acid, oxalate precipitation and calcination at 735 °C

Summary SANDA WP3 Task 3.2 and 3.3

Task 3.2 Fostering the network of target makers



SANDA – workshop on actinide target preparation and characterization – the need for radioanalytical chemistry
5-7 December 2023, JRC Geel

Task 3.3 Target production

Target requests: 19

- Withdrawn/cancelled: 3
- On hold: 1
- Finished: 13
- Pending: 2



Summary: Deliverables and Milestones

Deliverables		Delivered
D3.2	Report on the meeting in the frame of “Network of target producers”	Jan. 2024
D3.3	Report on produced targets	Oct. 2022

Milestones		Delivered
MS28	Scheduling regular target – maker meetings	Oct. 2022
MS29	Decision on targets to be manufactured	Oct. 2022

My thanks go to
Target users and producers
SANDA and WP3 partners
EC for funding



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