This project has received funding from the European Union's Horizon 2020 Research and Innovation programme under GA No 101004730.

AMIS

AM applications of refractory metals for Ion Sources

Beneficiaries:

- INFN – National Institute for Nuclear Physics (PD and LNL)
- CERN ISOLDE
- TANIOBIS GmbH

Industrial partners:

- GE UPPSALA
- SAES GETTERS S.p.A.
- EOS - Electro Optical Systems, Finland Oy
- TRIUMF

iFAST

Eng. Adriano Pepato – I.FAST-IF – 21st Apr, 2023

SUMMARY

1. **Project team, budget, timeline**
2. **Technical scope**
3. **Starting point and expected development at the end of the project**
4. **Milestones and Deliverables**
5. **Potential development and impacts for accelerator sustainability**
6. **AMIS IIF KOM (9th February 2023)**

1. Project Team and Budget

Organizational Expertise

- ***Material Characterization & Product Development*** — INFN DIAM Padova; INFN SPES LNL
- ***Production & Supply of Refractory Metals*** — TANiOBIS (inspiring metal evolution)
- ***Product OFF-LINE and ON-LINE testing*** — INFN SPES LNL; ISOLDE; CERN; TRIUMF
- ***Test on Potential application (Medical Radioisotope)*** — ISOLPHARM (SPES exotic beams for medicine); MEDICIS Promed; ***Supporting company***: GE Healthcare
- ***Commercialization and Market Analyses*** — saes group
- ***Final component AM production*** — eos (e-Manufacturing Solutions)

✓ ***THE FUNDING REQUIRED***: 100 k€

- **INFN-PD → 50 k€**
  - Personnel: 25 k€
  - Consumables: 15 k€
  - Travels: 10 k€
- **INFN-LNL → 25k€**
  - Personnel: 15 k€
  - Consumables: 4 k€
  - Travels: 6 k€
- **ISOLDE-FACILITY-CERN → 25k€**
  - Consumables: 20 k€
  - Travels: 5 k€

❖ ***TOTAL IN-KIND***: 345 k€

- ***TRIUMF (In-Kind)*** → **120000 EUR**
- ***TANIOBIS (In-Kind)*** → **54000 EUR**
- ***SAES-GETTERS (In-Kind)*** → **20000 EUR**
- ***GE-UPPSALA (In-Kind)*** → **14700 EUR**
- ***EOS (In-Kind)*** → **?????? EUR**

1. Timetable

WP1. Development and Characterization of Innovative Refractory Metals and their Alloys by AM Technology	year 1				year 2				End
	M3	M6	M9	M12	M15	M18	M21	M22	M26
T1.1. Production and characterization of Additively Manufactured Ta and/or Ta-based alloys.	■	■							MS.1
T1.2. Production and characterization of Additively Manufactured Nb and/or Nb-based alloys.			■	■					
T1.3. Identification and Development of refractory metal alloys and/or composite powders specifically designed for LPBF process.	■	■	■	■	■	■	■	■	
T1.4. Production and characterization of samples with innovative refractory metal alloys and/or composite powders.					■	■	■	■	

WP2. Development of Additively Manufactured Ion Source Components	year 1				year 2				End
	M3	M6	M9	M12	M15	M18	M21	M22	M26
T2.1. Multiphysics Simulation of Ion Sources with dedicated numerical models.	■	■	■	■	■	■	■	■	MS.2
T2.2. Redesign of specific Ion Source components for an improved assembly repeatability considering hybrid AM-traditional techniques.	■	■	■	■					
T2.3. Development of innovative AM free-form geometries to improve the performance of specific Ion Source components.			■	■	■	■	■	■	
T2.4. Development of a fully AM Ion Source prototype for off-line / on-line tests.					■	■	■	■	

WP3. High Temperature Tests and Beam Production with Additively Manufactured Ion Source Components	year 1				year 2				End
	M3	M6	M9	M12	M15	M18	M21	M22	M26
T3.1. High temperature tests of AM Ion Source components.	■	■	■	■	■	■			MS.3
T3.2. Thermionic emission tests of AM FEBIAD cathodes and anodes.			■	■	■	■			
T3.3. Stable ion beam production (off-line) with FEBIAD Ion Sources containing AM components at CERN and/or INFN-LNL.			■	■	■	■	■	■	
T3.4. Radioactive ion beam production (on-line) with FEBIAD Ion Sources containing AM components at CERN and/or TRIUMF.					■	■	■	■	

WP4. Commercialization and Market Analysis	year 1				year 2				End
	M3	M6	M9	M12	M15	M18	M21	M22	M26
T4.1. Evaluation of expected impact of the project in term of: addressable and obtainable market	■	■	■	■	■	■	■	■	■
T4.2. Intellectual Properties evaluation					■	■	■	■	■

2. Technical Scope

Main goal:
Development of a **new generation of High Performance ISOL Ion Sources** with cutting edge technologies available within INFN and its collaboration network.

1. **Development of new Refractory Metals Alloys specifically Design for Additive Manufacturing** (LPBF process)
   → Define the best element choice in order to improve the physical performance of the ion sources (Ta-based and/or Nb-based alloys) or to solve the fabrication defects related to pure metals production (W-based and/or Mo-based alloys). ***WP1***

2. **Development and Off-line/On-line test of a New ION source designed for Additive Manufacturing production** in order to: ***WP2***
   → Improve the Assembly phase: components n° reduction (from n°components>20 → to max 8 components) ***WP3***
   → Develop a topological optimized design for the Ion source physical performance improvement

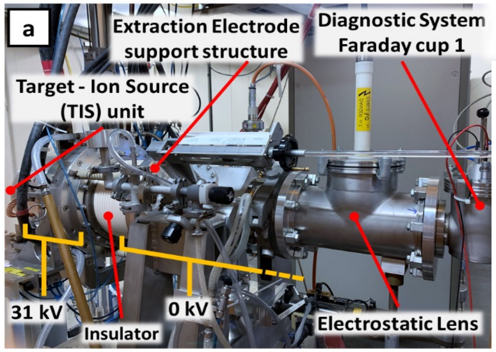
3. **Map** the existing facilities, **evaluate** the applicability and advantages of the FEBIAD design, **quantity** the potential needs and the technical requirements. This should provide a clear perspective about the potential market, the requirements and also a viable route to the technology diffusion. ***WP4***

3. Starting point and expected development at the end of the project

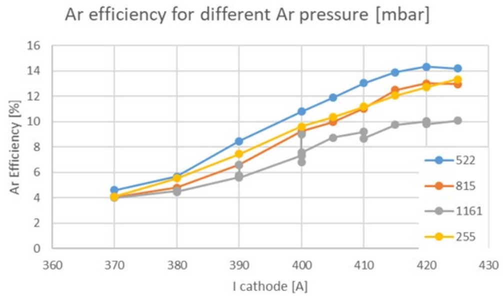
2022

The current TRL

→ TRL 4



Ionization efficiency using AM Mo Anode comparable to STD Ta Anode

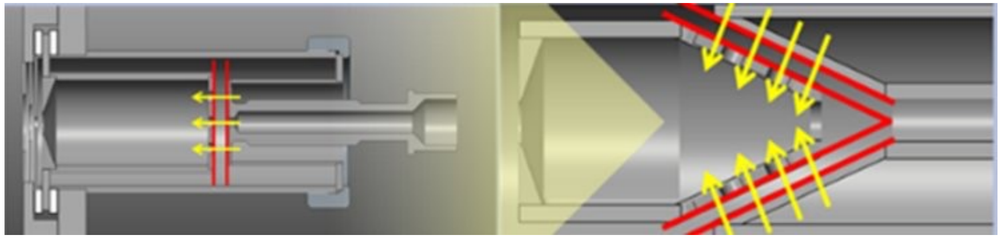


- **AM Ta Cathode and Mo Anode traditional geometry production**
- **Proof of Concept Test of the AM ION Source and Prototype production**
- **Off-line Test of the AM Mo Anode with the traditional geometry**

2025

The TRL at the end of the Project

→ TRL 5



- **Production and characterization of samples with innovative refractory metal alloys and/or composite powders.**
- **Development of a fully refractory metals Ion Source with new Design for AM for off-line / on-line tests.**
- **Radioactive ion beam production (on-line) with FEBIAD Ion Sources containing AM components at CERN and/or TRIUMF.**

Future

Estimated time for TRL 6

"Technology demonstrated in relevant environment (industrially relevant environment in the case of key enabling technologies)"

2026-2027

4. Milestones and Deliverables

WP1 milestones		Date
MS.1	Production and characterization of Additively Manufactured Ta and/or Ta-based alloys.	M26
	Production and characterization of Additively Manufactured Nb and/or Nb-based alloys.	
	Identification and development of refractory metal alloys and/or composite powders specifically designed for LPBF process.	
	Production and characterization of samples with innovative refractory metal alloys and/or composite powders.	

WP2 milestones		Date
MS.2	Development of Multiphysics numerical models for the simulation of FEBIAD Ion Sources.	M26
	Redesign of specific FEBIAD Ion Source components for an improved assembly repeatability.	
	Multiphysics Simulation of FEBIAD Ion Sources with innovative free-form geometries.	
	Production of free-form cathodes and anodes for ISOL FEBIAD Ion Sources.	
	Production of a fully AM FEBIAD Ion Source prototype.	

WP3 milestones		Date
MS.3	High temperature tests of AM Ion Source components.	M26
	Thermionic emission tests of AM FEBIAD cathodes and anodes.	
	First off-line ionization tests with a hybrid AM-traditional ion source prototype.	
	First off-line ionization tests with a fully AM ion source prototype.	
	On-line beam production at CERN-ISOLDE and/or TRIUMF with a FEBIAD Ion Source containing AM components.	

WP1 milestones		Date
MS.1	Map the existing facilities	M26
	Evaluate the applicability and advantages of the FEBIAD Design for AM (DfAM)	
	Quantity the potential needs and the technical requirements	
	Exploring the IP matter	

WP1, D1 (M24): Written report on the production and characterization of samples with innovative refractory metal alloys and/or composite powders.

WP2, D1 (M24): Production of a fully AM FEBIAD Ion Source prototype with related CAD documentation.

WP3, D1 (M24): Written report on test with FEBIAD Ion Sources containing AM components.

WP4, D1 (M24): Written report on the commercialization and market analysis evaluation.

5. Potential development and impacts for accelerator sustainability

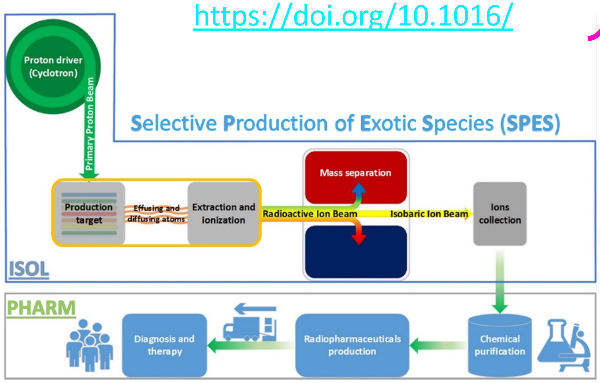
MEDICIS Promed

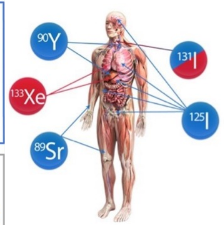
Palenzuela et al., 2021
https://doi.org/10.3389/fmed.2021.689281

ISOLPHARM
SPES exotic beams for medicine

Ballan et al., 2021
https://doi.org/10.1016/

investigate the feasibility of using ISOL technology to produce radionuclides as radiopharmaceutical precursors.





expected impact of the project in term of:
addressable and obtainable market

Commercialization and Market Analysis:

The goal is to confirm the AM production of FEBIAD-like ion sources for:
- MEDICAL RADIO THERAPY
- RADIOACTIVE ION BEAMS

saes group

how the project addresses the
environmental challenges

- **AM technology reduced the amount of wasted material**
- **The un-melted powder can be entirely recycled**
- **Post-processing, which involved material waste and high energy consumption, are almost completely avoided.**
- **ISOL technologies for production of medical radionuclides can become a green alternative to nuclear fission reactors.**

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Thank you for your attention!

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