CYCLOTRON TARGETS FOR PRODUCTION OF RADIONUCLIDES FOR MEDICAL APPLICATION

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LA RA MED

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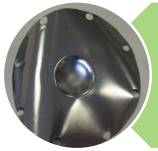
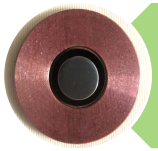
Istituto Nazionale di Fisica Nucleare

Outline

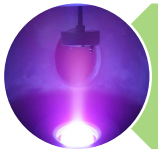


1. Protective coatings for liquid target

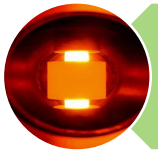
2. E-PLATE: low losses nuclear target deposition



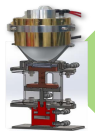
3. Patented target preparation method for Mo



4. Magnetron sputtering deposition for Y



5. SPS high efficiency technique for Mo target



6. High power target development

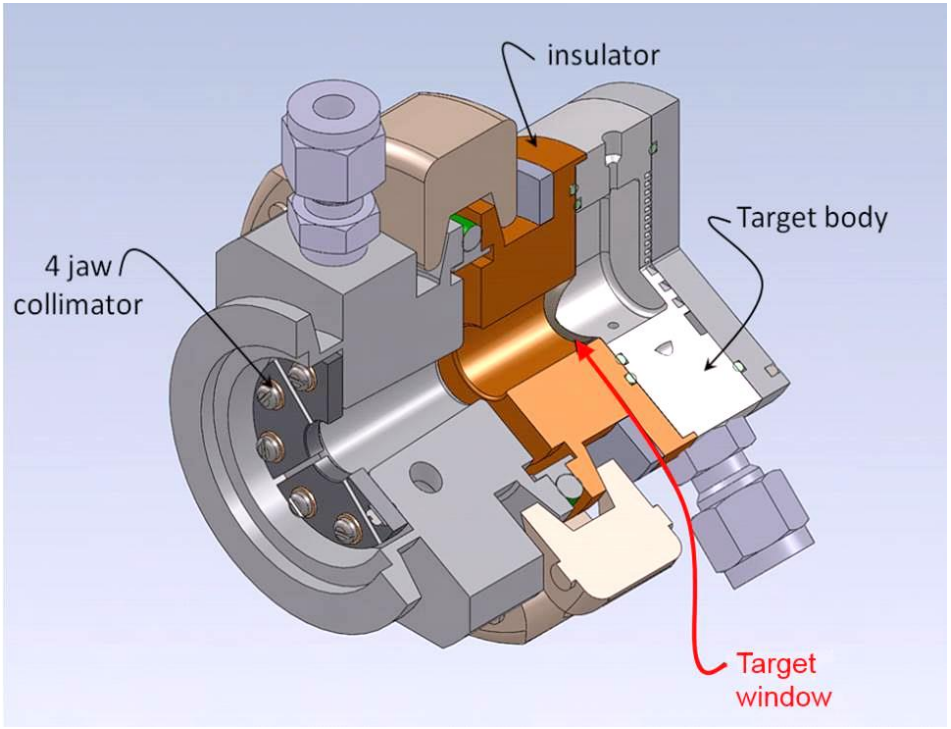
Target type: state of matter

From the point of view of state of matter of the material irradiated the targets can be:

- ***Liquid***
- ***Solid***
- *Gaseous*

$[^{18}O]H_2O$ target for $[^{18}F^-]$ production

Collaboration with Best Cyclotron Systems, Inc.



Protective coatings on HAVAR® beam window

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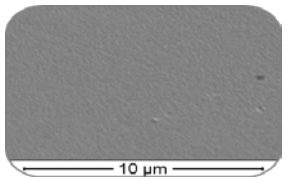
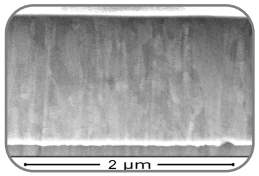
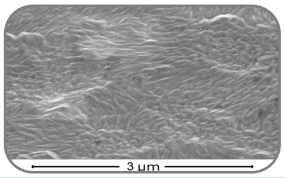
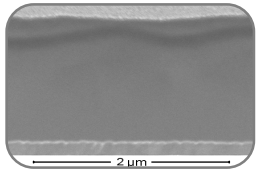
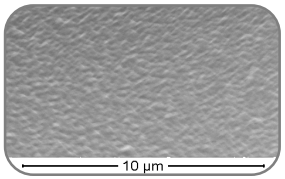
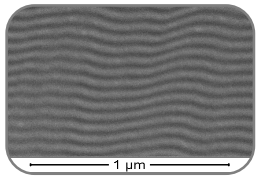
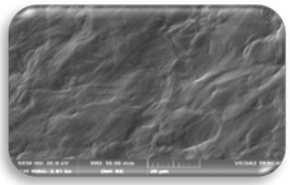
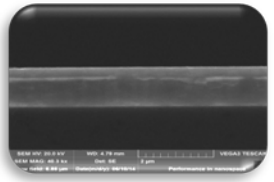
Laboratories for Surface & Material Treatments for Nuclear Physics (resp. V. Palmieri)

Most effective protective coatings developed:

Coating	SEM surface	SEM cross-section
Nb crystalline		
Nb_2O_5 amorphous		
Nb-Nb_2O_5 multilayer		
Ta-Zr amorphous		

1. **Niobium-based sputtered thin films for Corrosion Protection of proton-irradiated liquid water targets for [^{18}F] production ,** H. Skliarova, O. Azzolini, O. Dousset, R. R. Johnson, V. Palmieri, *Journal of Physics D Applied Physics* 08/2013; 47(4).
2. **Niobium-niobium oxide multilayered coatings for corrosion protection of proton-irradiated liquid water targets for [^{18}F] production ,** H. Skliarova, M. Renzelli, O. Azzolini, D. de Felicis, E. Bemporad, Ri R. Johnson, V. Palmieri, *Thin Solid Films* 03/2015; 42.
3. **Co-sputtered amorphous Nb–Ta, Nb–Zr and Ta–Zr coatings for corrosion protection of cyclotron targets for [^{18} F] production ,** H. Skliarova, O. Azzolini, R. R. Johnson, V. Palmieri, *Journal of Alloys and Compounds* 08/2015; 639:488-495.

Possible customers:

- ✓ Hospitals producing **[$^{18}F^-$]**FDG with [^{18}O]H_2O target using **Havar** foil, not equipped with the purification module for **[$^{18}F^-$]**.
- ✓ Other industries where chemically inert coatings are required

Electrostatic Powder pLating for Accelerator TargEts

Target thickness differs with application:

- **Nuclear reactions study**

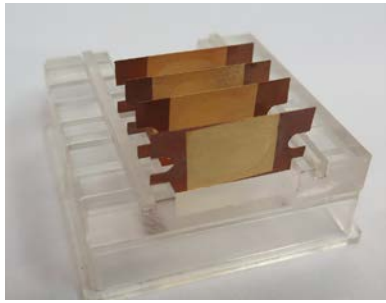
  10s nm – µm

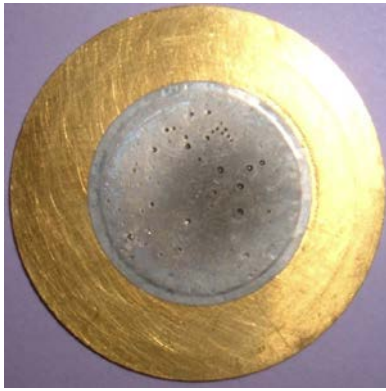
- **Cross-section measurements**

  10s µm

- **Radionuclide production**

  100s µm – mm





One of the main requirements for isotopic targets is high efficiency of deposition (minimizing losses of material)

Electrostatic Powder pLating for Accelerator TargEts

Deposition technique: HIVIPP - HIgh energy VIbrational Powder Plating

Method is described in literature, but has been used only for nuclear spectroscopy study, because of **thickness limitation**

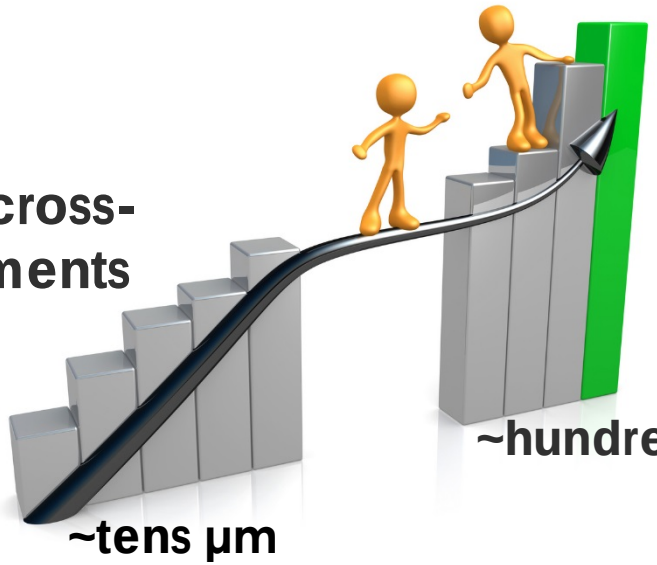
This effect limitates application **radionuclide production** targets

Electrostatic Powder pLating for Accelerator TargEts

CSN5 financement for 2018-2019

Goal:
- ✓ understanding better HIVIPP process
- ✓ pushing to max thickness

for **nuclear cross-section measurements**



for **medical radionuclides production**

Ex. laboratory ITALRAD (resp. J. Esposito)

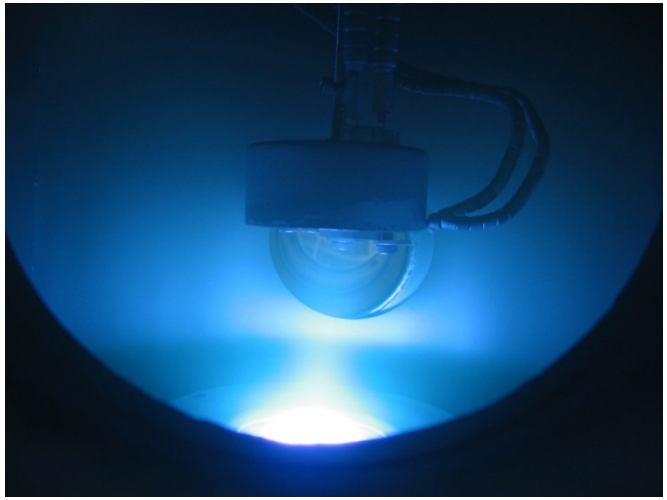
INFN LNL
Istituto Nazionale di Fisica Nucleare

Possible customers:

- ✓ Other laboratories of Nuclear Physics
- ✓ Hospitals/private companies producing radiopharmaceuticals with solid cyclotron targets
- ✓ Private company interested in industrialization of deposition system

Deposition method

MAGNETRON SPUTTERNG



Problem of intrinsic stress!

- choice of appropriate sputtering pressure
- deposition at elevated temperature 500^{0}C
- multilayer deposition for stress relaxation

>300µm thick films

Problem of stress solved

Possible applications:

- ✓ Solid cyclotron targets
- ✓ W thick coating on graphite for TOKAMAK
- ✓ W thick film for X-ray emitting cathodes
- ✓ Coatings of Nb and alloys for corrosion protection
- ✓ Nb thick film for superconducting cavities

Novel cyclotron solid target

- >100μm dense Mo material
- directly deposited (sputtering)
- onto chemically inert backing plate

Patent applied by INFN:

V. Palmieri, H. Skliarova, S. Cisternino, M. Marengo, G. Cicoria.
Metodo per l'ottenimento di un target solido per la produzione di radiofarmaci.
N 102017000102990, presentation data **14.09.2017**

Possible customers:

- ✓ Hospitals/private companies producing radiopharmaceuticals with solid cyclotron targets
- ✓ Private company interested in production of particular solid targets for hospitals

Production Y targets for ^{89}Zr production

Agreement with S. Cuore Hospital, Negrar for Y targets production

ACCORDO DI RICERCA COLLABORATIVA N° TTB_17LNL_017

TRA

Istituto Nazionale di Fisica Nucleare (di seguito INFN), C.F. 84001850589, P.I. 04430461006, con sede in Frascati, via Enrico Fermi, n. 40, in persona del Direttore dei Laboratori Nazionali di Legnato (LNL) autorizzato ai sensi dell'art. 14 del Disciplinare per la tutela, lo sviluppo, la valorizzazione delle conoscenze dell'INFN

E

Ospedale Sacro Cuore - Don Calabria (di seguito Ospedale), C.F. e P.I. 00280090234 con sede in Negrar (VR), via Don Angelo Sempreboni, n. 5 in persona dell'Amministratore Delegato Dott. Mario Piccinini di seguito denominate congiuntamente Parti e disgiuntamente Parte

PREMESSO CHE

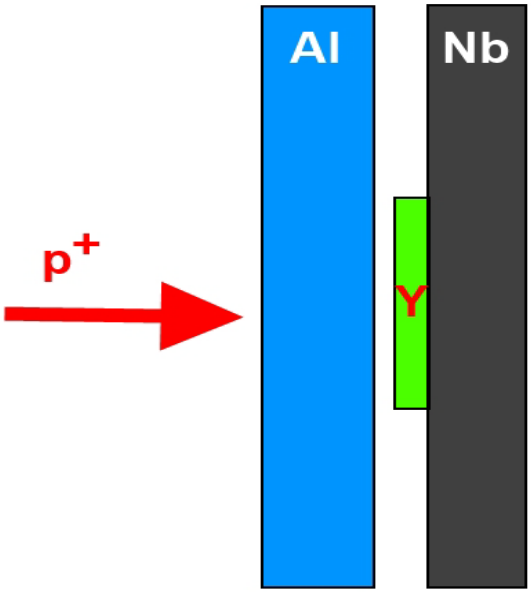
L'Istituto Nazionale di Fisica Nucleare è Ente pubblico nazionale di ricerca che promuove, coordina ed effettua la ricerca scientifica nel campo della fisica nucleare, subnucleare, astroparticellare e delle interazioni fondamentali, nonché la ricerca e lo sviluppo tecnologico pertinenti alle attività in tali settori prevedendo forme di sinergia con altri enti di ricerca e il mondo dell'impresa.
L'INFN, in base all'art. 2 del proprio Statuto, promuove e partecipa a collaborazioni, stipula convenzioni e contratti in materia di studio, ricerca e servizi con enti, società ed imprese, pubbliche e private, nazionali, comunitari, stranieri e organizzazioni internazionali.

**Verbale riunione del Consiglio dei LNL del 31.05.17*

Production Y targets for ^{89}Zr production

Target structure:

1mm Al, 120µm sputtered Y, 0.5-1mm Nb backing



Ongoing work…

Next week first batch of cyclotron target preparation is planned

Competitors:

- ✓ ACSI Advanced Cyclotron Systems, Inc.

(They have Y sputtered on Nb cyclotron target as a commercial product)

Spark Plasma Sintering

Particular sintering technology (patented+published)

Tecnology has never been used for radionuclide production target prepation

We have successfully applied for efficient and fast ^{100}Mo target preparation

Collaboration with external company

Possible customers:

- ✓ Hospitals/private companies producing radiopharmaceuticals with solid cyclotron targets
- ✓ Private company interested in production of particular solid targets for hospitals

High radionuclide production
=
high current of cyclotron beam

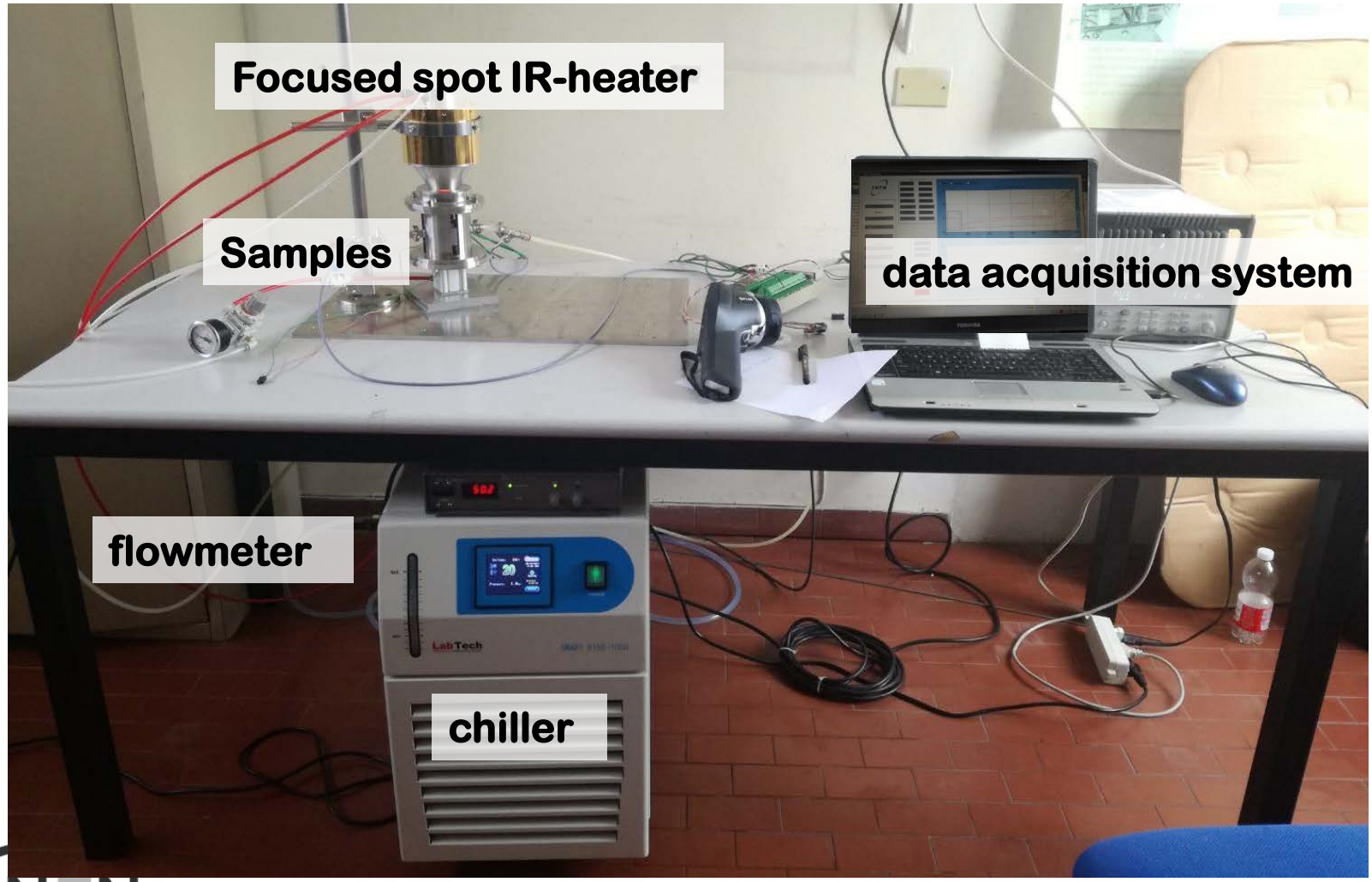
↓

high efficiency of heat dissipation required

↓

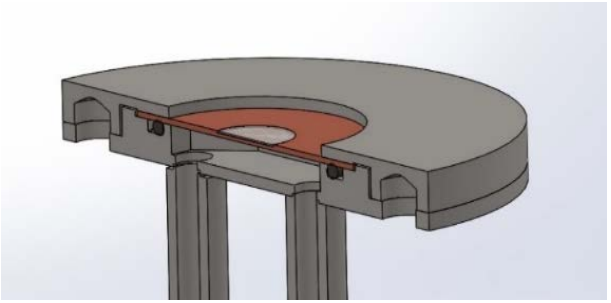
particular materials or configurations

Not cyclotron-based testing system

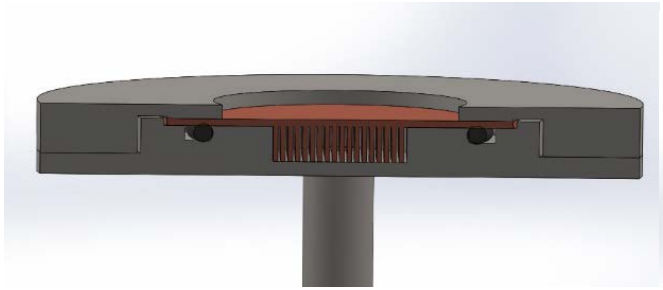


Ex. laboratory ITALRAD (resp. J. Esposito)

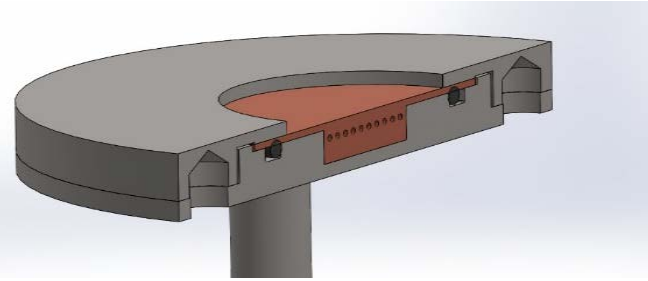
Interest to test particular configurations



Ceramics-metal brazed



Microlamellas



Microchannels

+ 3D-printed configurations

OFFICINA DEI MATERIALI

Collaboration with ***Officina dei Materiali Sas.***

Possible customers:

- ✓ Companies producing cyclotrons and targets
- ✓ Companies interested in efficient heat exchange configurations