Thin titanium targets for nuclear cross section measurements of the $^{49,50}Ti(p,x)^{47}Sc$ reactions

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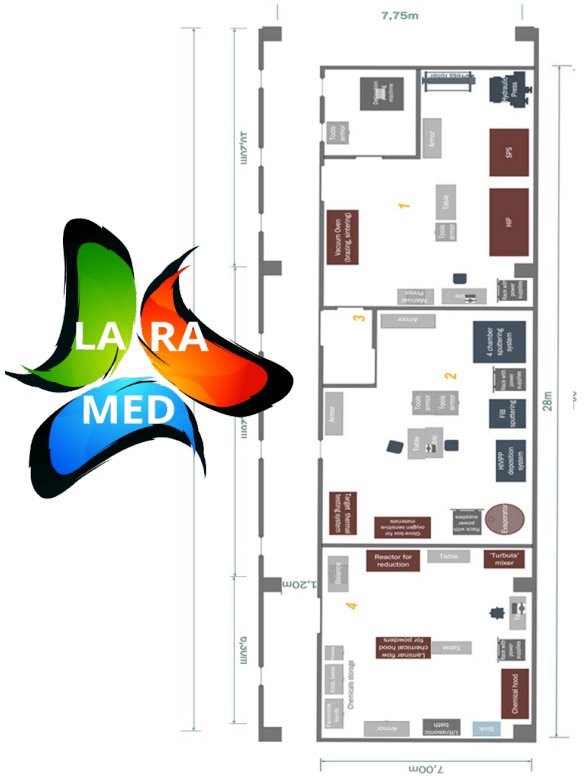
INFN-LNL – LARAMED project

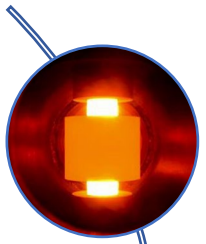
18th Workshop on Targetry and Target Chemistry (WTTC18)- Whistler, BC - August 22, 2022

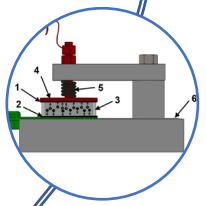
R&D on innovative target manufacturing techniques

in the framework of the LARAMED project

to overcome the limits of standard techniques







Spark Plasma Sintering

Oral presentation by S. Cisternino – h.08:40

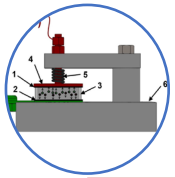
Magnetron Sputtering

Oral presentation by A. Kotliarenko – h.10:30

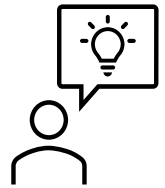
High Energy Vibrational Powder Plating

Thick targets for production

Thin targets for nuclear XS studies

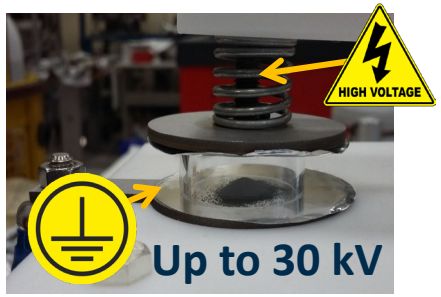


Why HIVIPP technique?



Sugai, I.
doi:10.1016/0029-554X(77)90570-5

vibrational motion of metallic **powder in a static electric field**



Advantages:

- ✓ Two targets are deposited simultaneously
- ✓ **Efficiency 95-98%**
- ✓ **Deposition of refractory metals starting from powder**
- ✓ Uniform thickness

Requirements:

- Metal substrates
- Metal powder with irregular shape and small size (<10 µm for uniform deposition)

For the REMIX project (2022-2023):
^{49,50}**Ti** targets (on Al) for nuclear cross-section measurements for ^{47}Sc production needed

Titanium:

- difficult to work with standard technique (rolling, evaporation..)
- Enriched materials :
  - Expensive and supplied in powder form

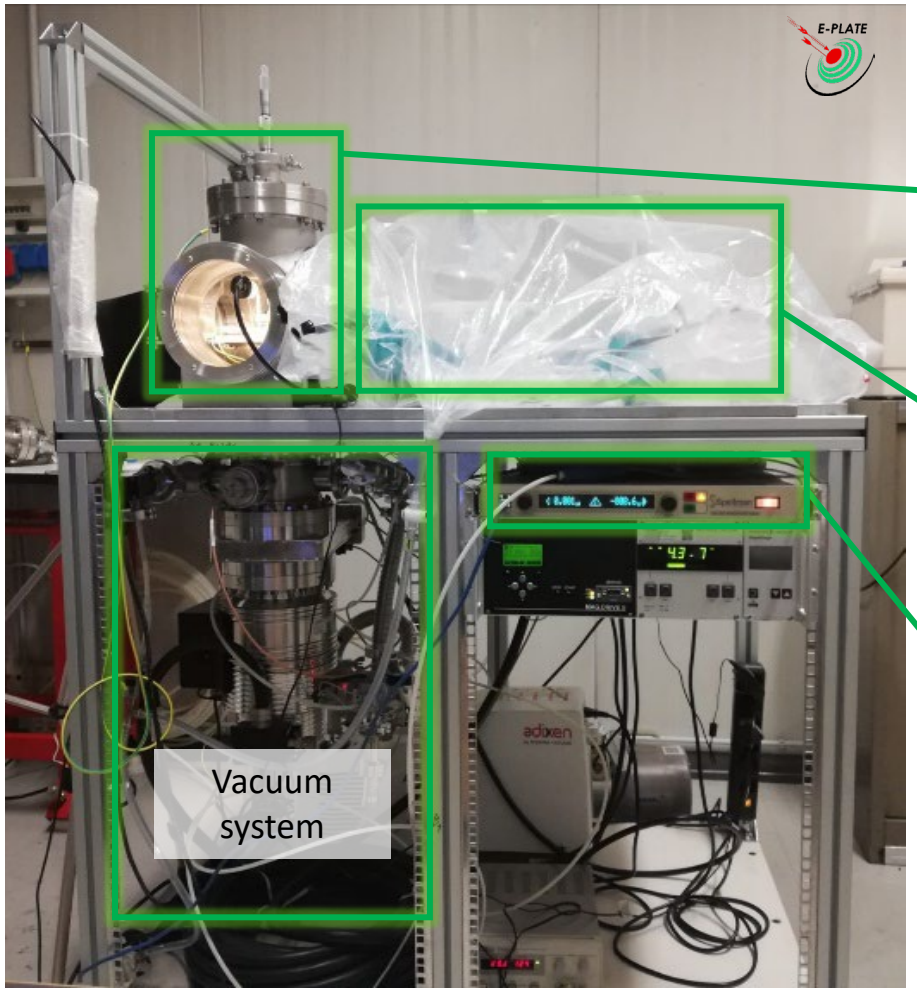
0.2-3.9 mg/cm^2

Succesfully used for ^{48}Ti(p,x)^{47}Sc nuclear XS measurmentes

Oral presentation by G. Pupillo – August 23, h.9:30

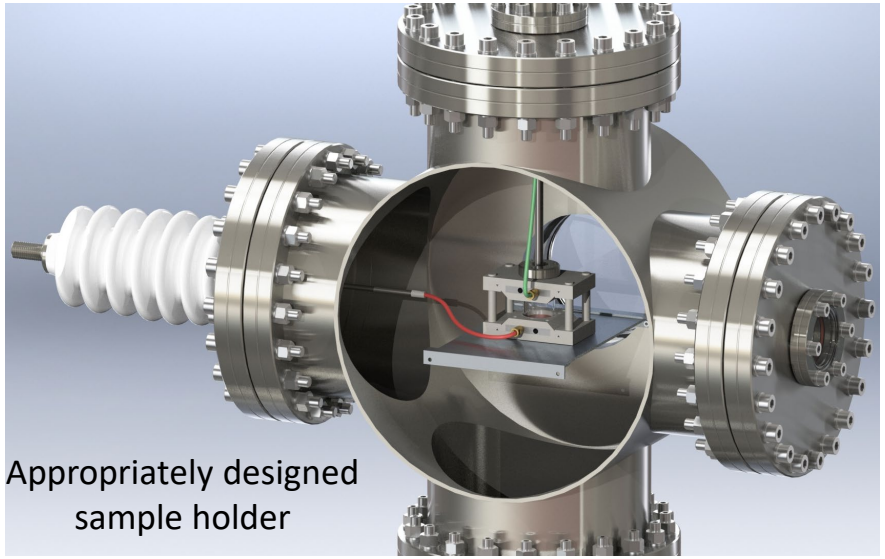
Mou, L. : submitted
Skliarova, H. : doi:10.1016/j.nima.2020.164371

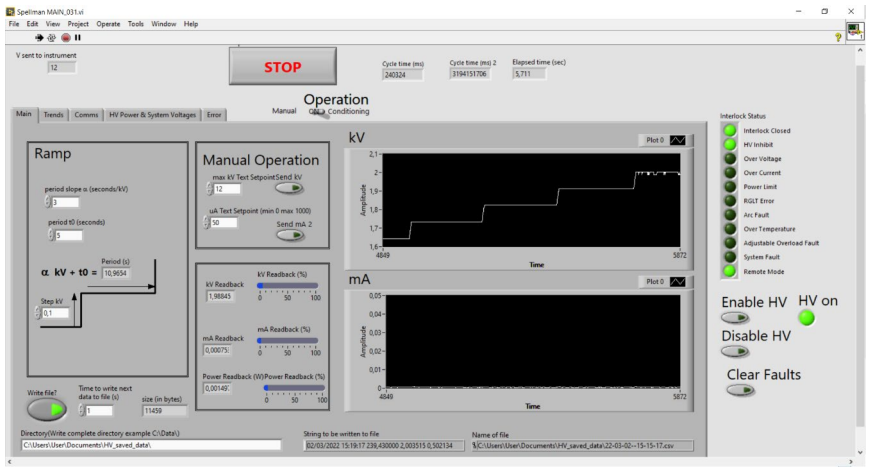
HIVIPP set up at INFN-LNL



Glove bag to work in protective atmosphere

Remotely controlled power supply and dedicated LabView program

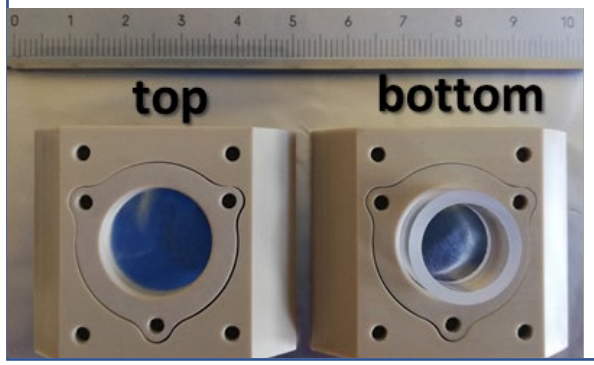


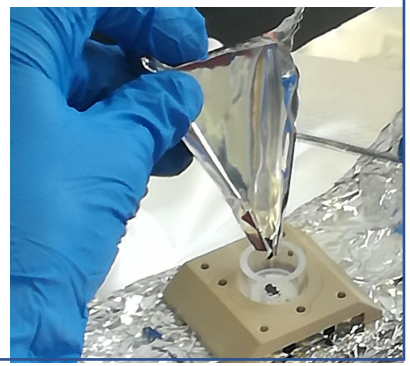


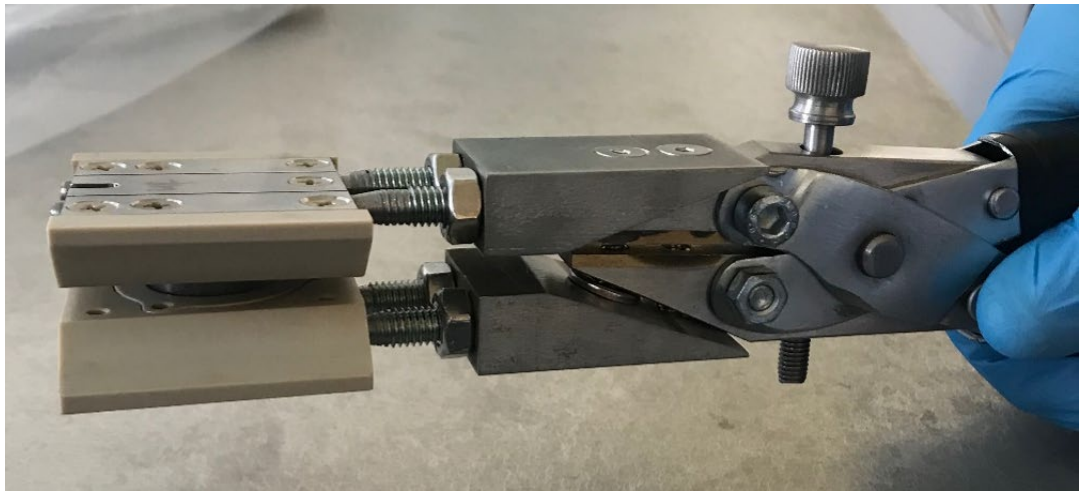
S. Cisternino et al., Instruments 2022, DOI:10.3390/instruments6030023

HIVIPP process steps

Deposition preparation

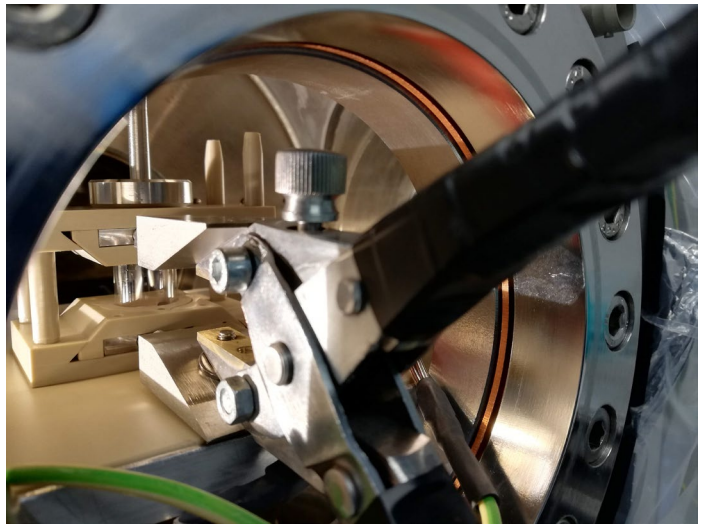






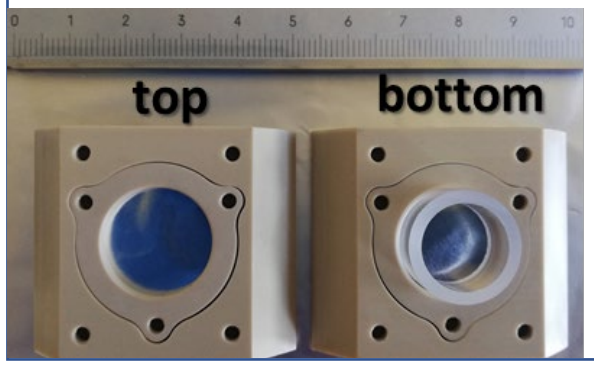
- ✓ Easy sample-holder manupulation by one person
- ✓ Avoid enriched powder escaping from the cylinder

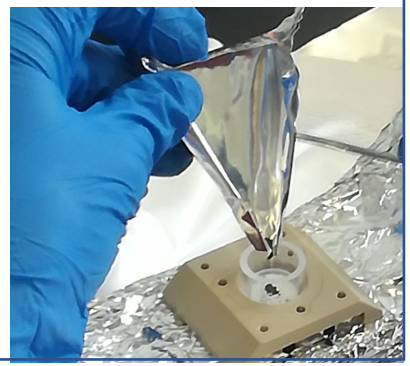
Dedicated clamp to insert (extract) the sample holder



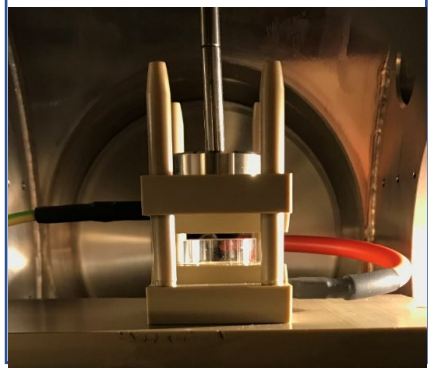
HIVIPP process steps

Deposition preparation

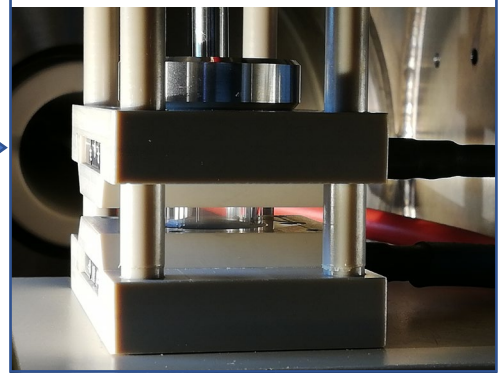




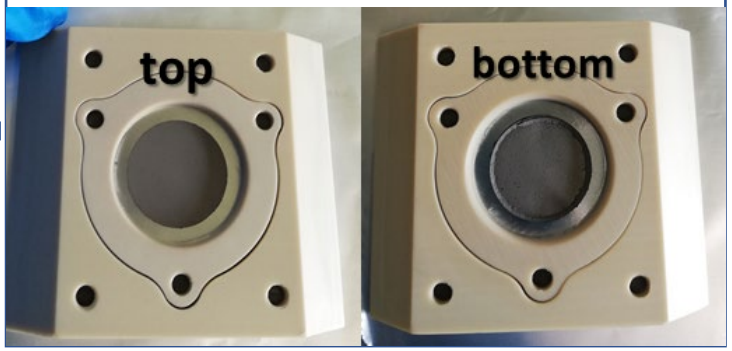
Vacuum system ON



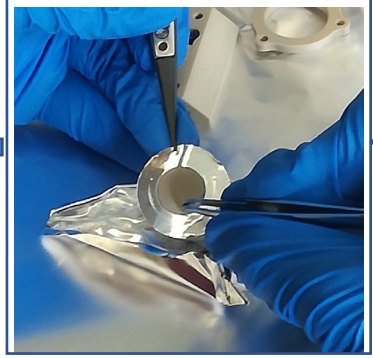
Close cylinder and High Voltage ON



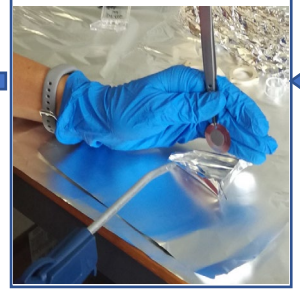
After deposition



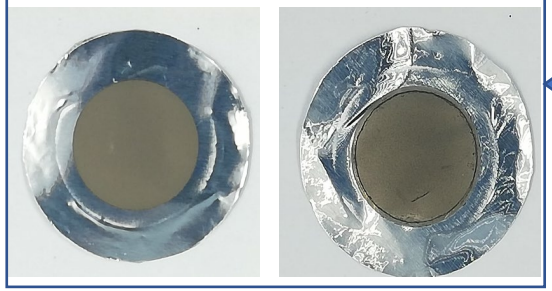
Powder recovery



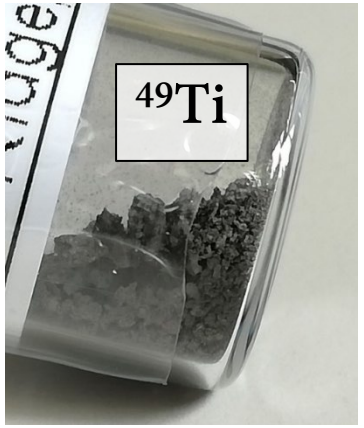
Sample cleaning

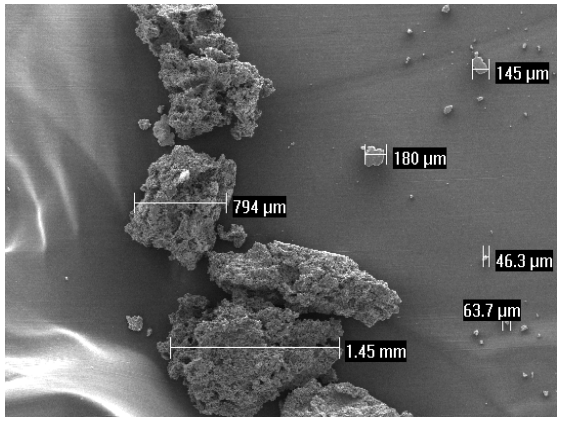


Targets ready

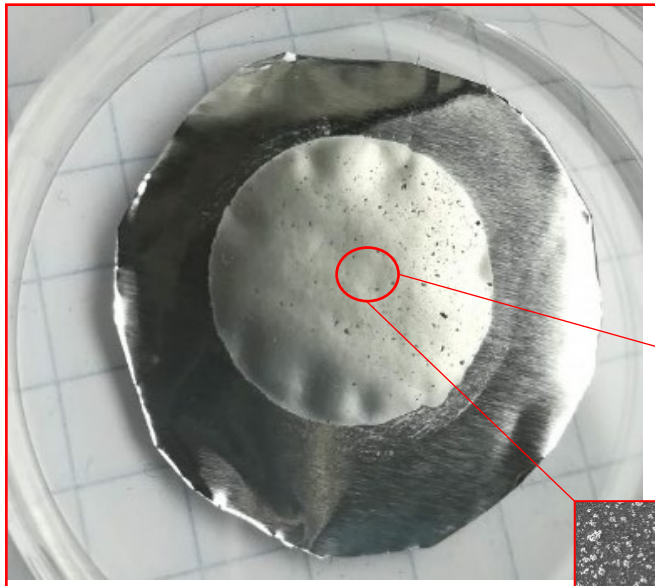


Enriched ^{49,50}Ti materials shape



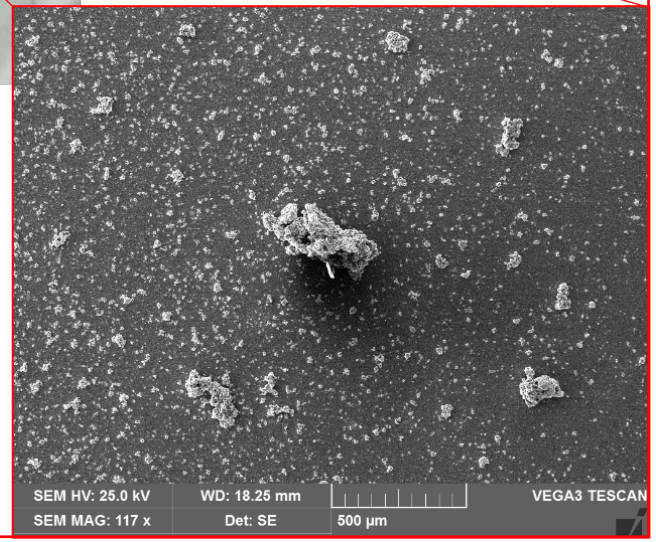


Sponge-like shape powder



First deposition tests...

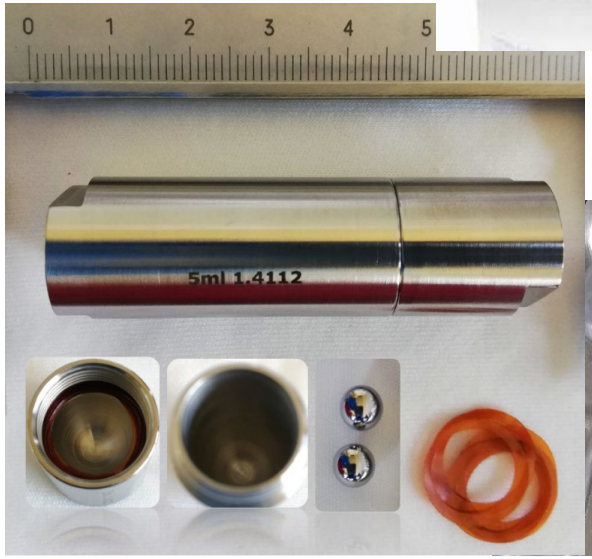
...not uniform Ti layer

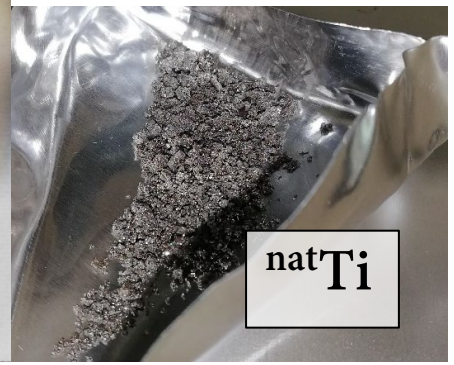


Solution: preliminary powder preparation step

Cryomilling process

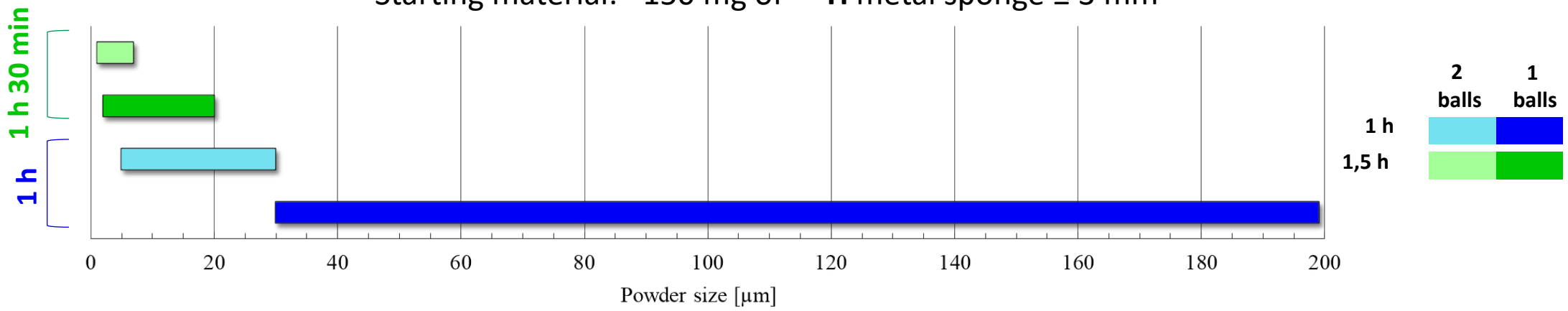
- ✓ Reduction of the powder size through the milling at liquid nitrogen temperature for temperature sensitive material to avoid melting
- ✓ Liquid nitrogen is not in contact with the material of interest to avoid contamination
- ✓ Small jar to reduce/avoid the contamination from the jar and sphere materials

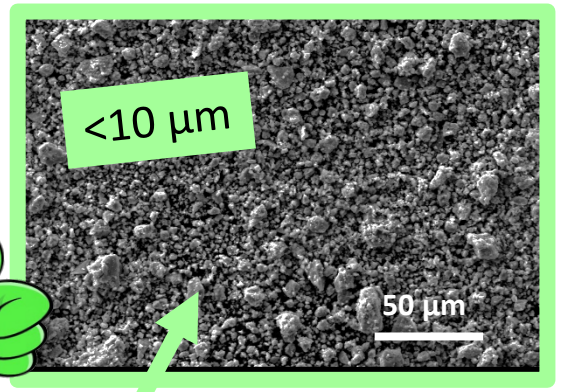


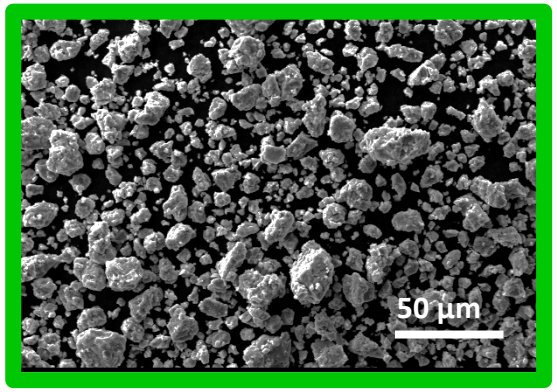


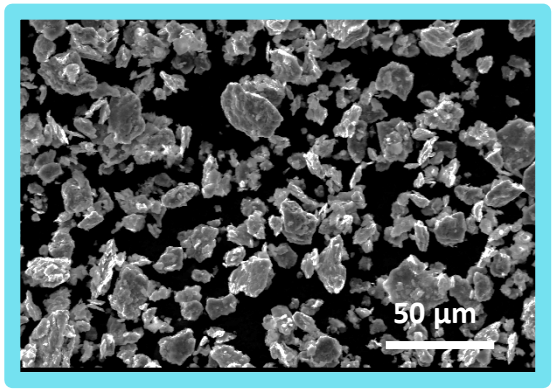
Optimization of cryomilling process for powder size reduction

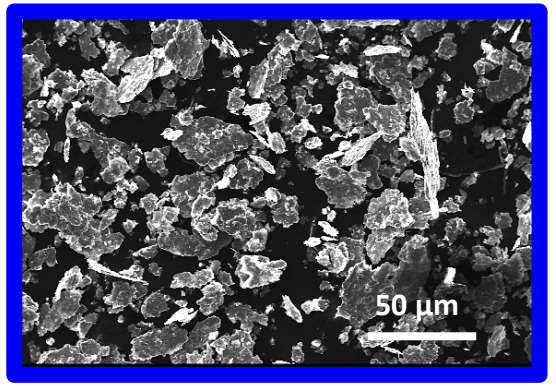
Starting material: ~150 mg of ^{nat}Ti metal sponge ≤ 3 mm











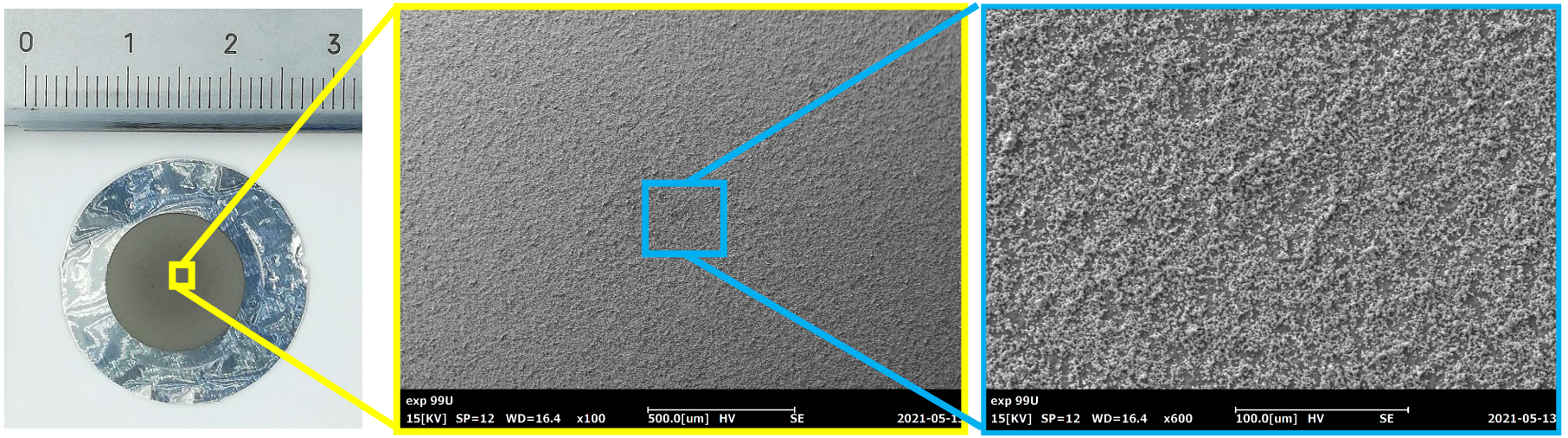
Powder size fits HIVIPP requirement

About 30% of powder lost should be considered

Any contamination from EDS analysis

HIVIPP deposition and analysis of ^{nat}Ti targets

^{nat}Ti on Al



HIVIPP parameters	
Voltage	10-15 kV
Time	10-15 h
Cylinder	Ø14 mm x 10mm

Results:

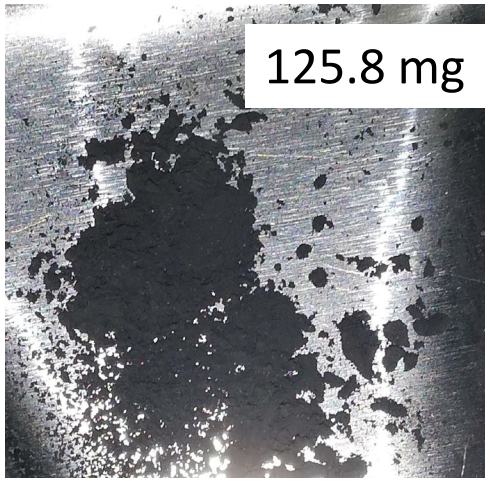
- ✓ Similar thickness for top and bottom
- ✓ Uniform deposition (430±82 µg/cm^2, n=8)
- ✓ Any contaminants from EDS analysis

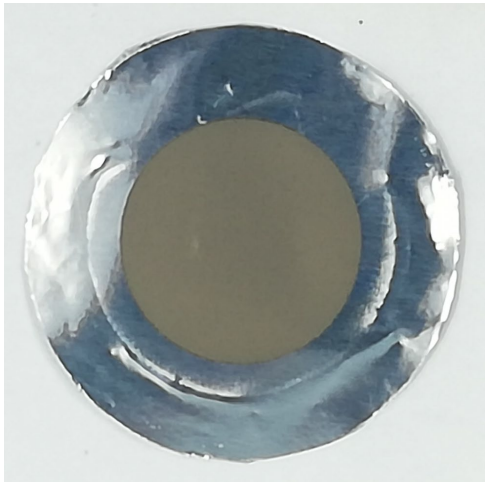
^{49,50}Ti materials

Before cryomilling

After cryomilling

^{49}Ti

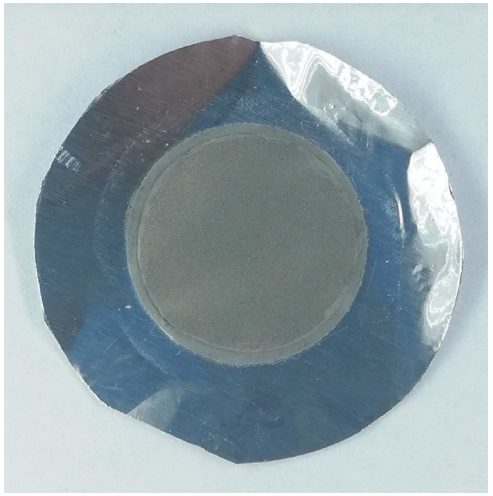




No. 20 ^{49}Ti targets

Mass thickness
measured by weigh
486±110 µg/cm^2
(n=20)

^{50}Ti

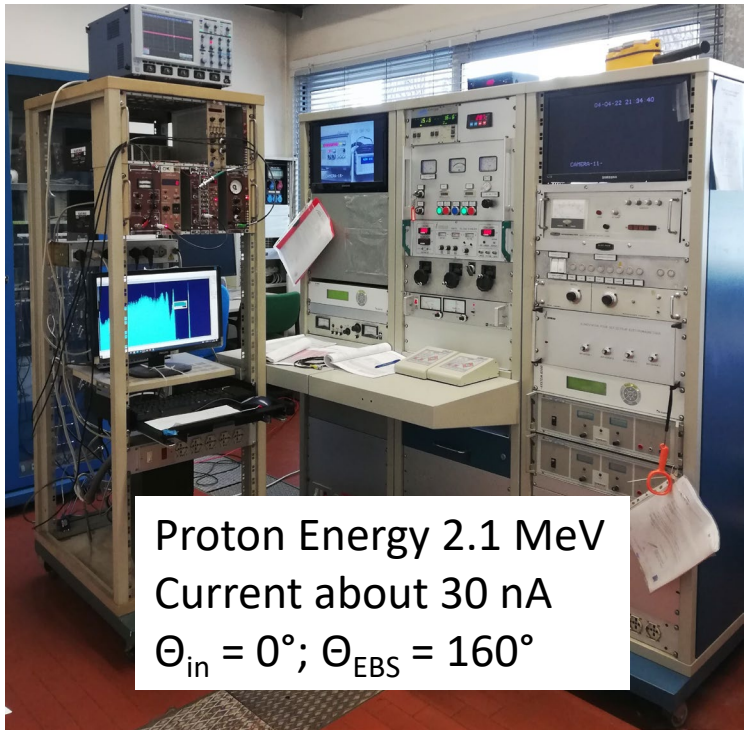


No. 20 ^{50}Ti targets

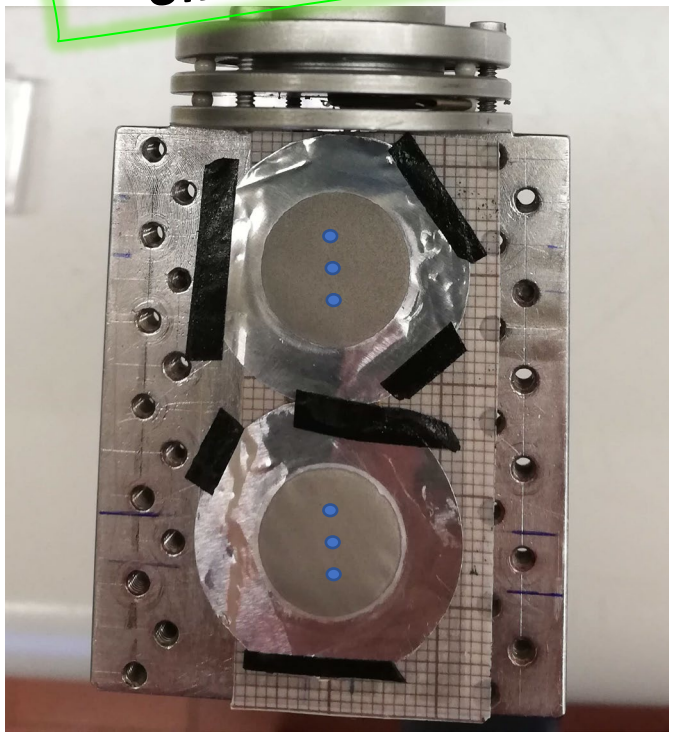
Mass thickness
measured by weigh
637±200 µg/cm^2
(n=20)

Elastic backscattering spectroscopy analysis…
…for the exact quantification of the Ti amount deposited

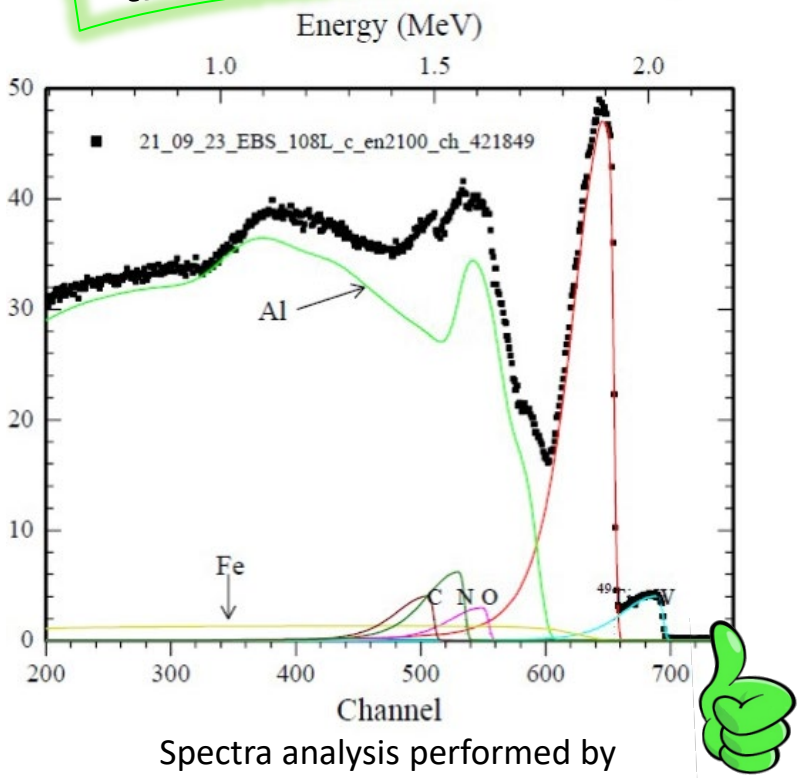
AN2000 accelerator at INFN LNL Istituto Nazionale di Fisica Nucleare Laboratori Nazionali di Legnaro



Uniform thickness



Low contamination traces (about 10s ppm)



Spectra analysis performed by
V. Rigato and M. Campostrini

For the nuclear cross-section measuremnt only the Ti amount was considered

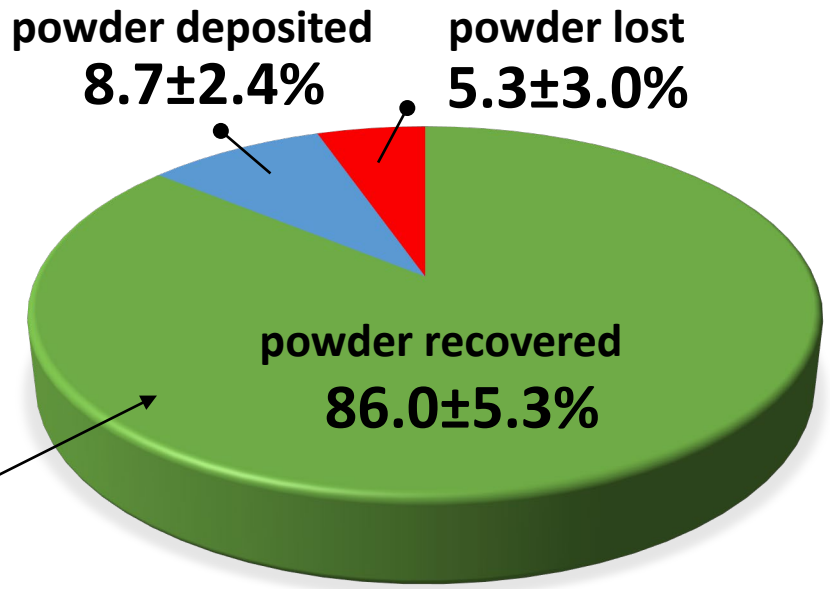
Efficiency of the HIVIPP technique

- Total no. of HIVIPP depositions = 20
- ^{49}Ti and ^{50}Ti powder (cryomilled powder size <10 µm)
- HIVIPP parameters: 10-12 kV, 10-15 h

For each exp.

Starting material ca. 19.5 mg (100%)

✓ **#targets = 40 → Mass thickness = 552.9±120.1 µg/cm²**



$$\boldsymbol{Recovery\ efficiency}\ \% = \mathbf{94.2 \pm 3.4}\ \%$$

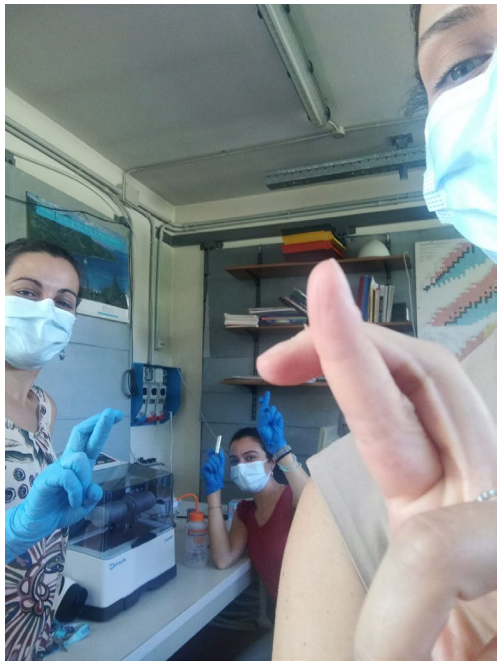
$$\frac{P_{rec}\,[mg]}{P_{start}[mg] - P_{dep}[mg]} \cdot 100$$

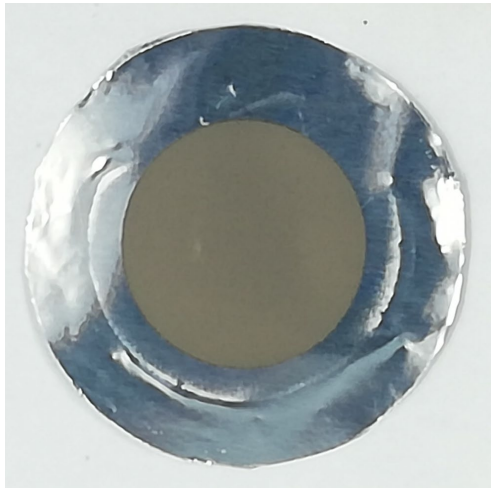
We succesfully reused it!

Conclusions

- ✓ The cryomilling process is suitable for pre-treatment of enriched material
  - *No contaminations and desiderable powder size*
- ✓ HIVIPP technique allows for uniform Ti deposition
  - *High efficiency → expensive material saved!*
- ✓ EBS analysis used for the extact quantification of Ti before irradiation at Arronax Nantes
- ✓ The enriched targets are suitable for the **nuclear cross section measurements** →

  for the results see the presentation by G. Pupillo (tomorrow morning)





Thank you for the attention

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