News from the Target Service

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INFN
LNL
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Laboratori Nazionali di Legnaro

People and organization

Staff:

- Stefano Corradetti
- Matteo Campostrini#
- Sara Cisternino#
- Lorenzo Loriggiola#
- Massimo Loriggiola

Members and collaborators (in the Service meetings):

- Sara Carturan
- Juan Esposito
- Valentino Rigato

Activities

Activities of the service (Production)

- Targets for nuclear physics
- Targets for applications
- ISOL targets

} High-power targets

Collaboration activities

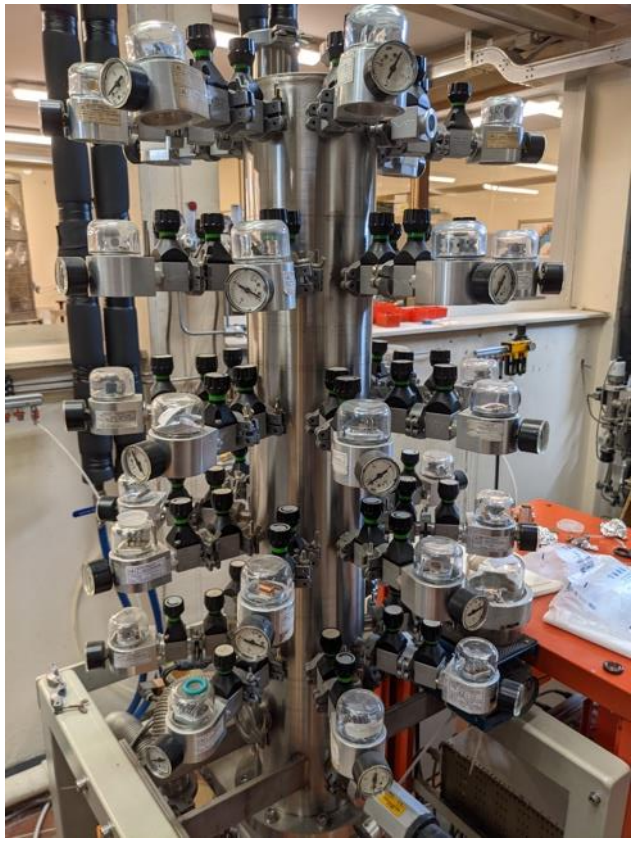
- Characterization of innovative targets

Targets for nuclear physics

Equipment and laboratories (Targets Laboratory)

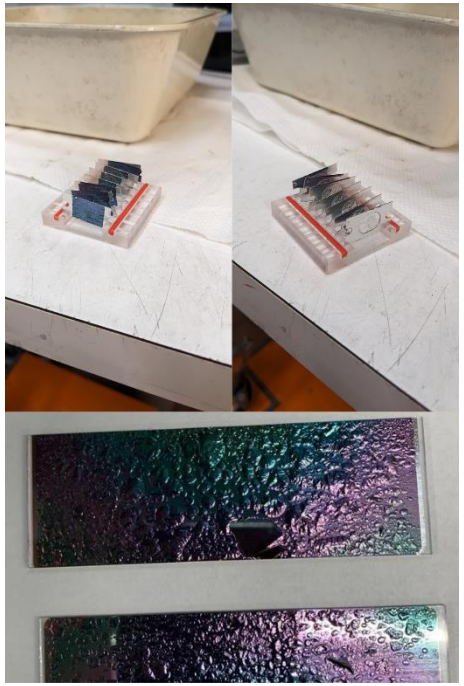
Rolling mill

Carbon evaporator



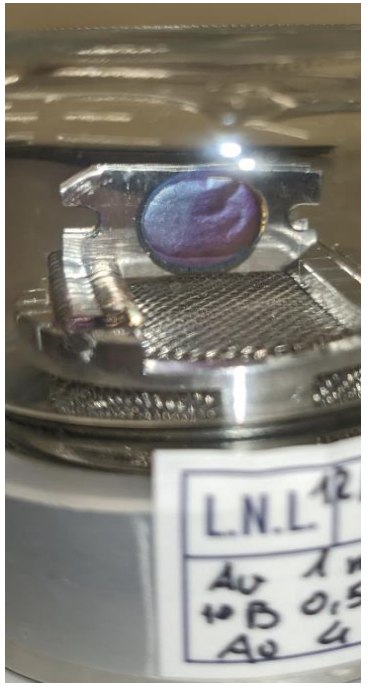
Cryogenic dryer

Targets with backing



A 250 µg/cm^2 ^{11}B film adhered to a 40 µg/cm^2 Al backing is shown in Fig. 1. The difficult evaporation of the B, carried out with e-gun, could create damage to the thin Al film, either due to discharges or due to internal film stresses due to thickness. Careful management of the evaporation parameters limited the damaging effects.

Fig.1 – ^{11}B on Al for Zagreb Lab. experiment



Electron-gun evaporation of ^{10}B 500 µg/cm^2 is slow and complex as is adhesion to Au 4 mg/cm^2 or 1 mg/cm^2 backing. Numerous tests have been conducted to determine the best evaporation parameters

Fig.2 – ^{10}B on Au PAC 22.72

Targets with backing

^{7}LiF 1,5 mg/cm^2 on C 40 µg/cm^2 for CERN (under vacuum)

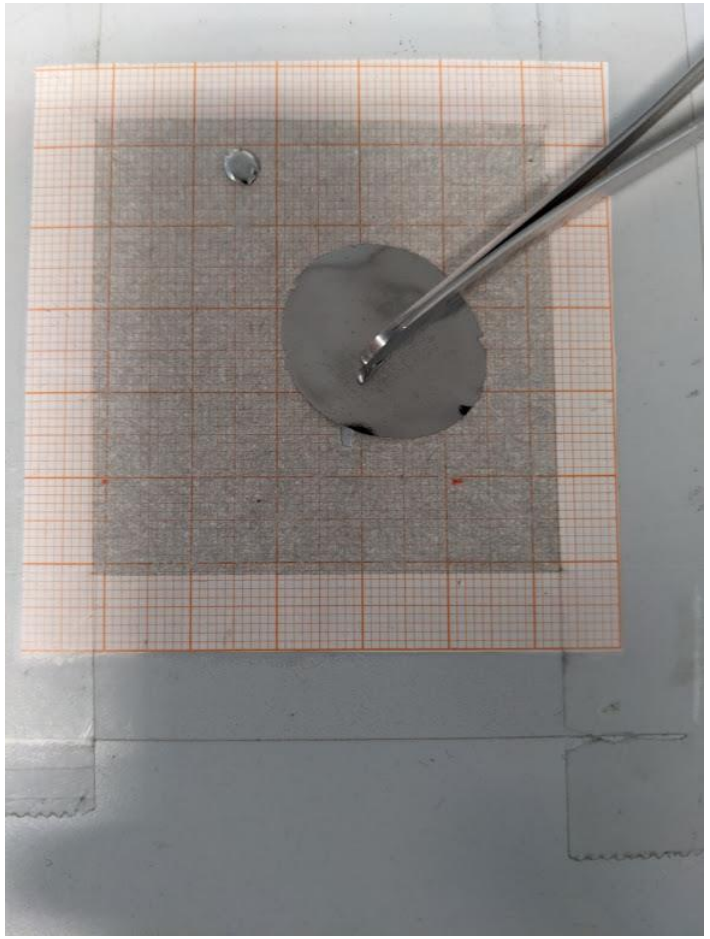
Thorough preparation by thermal evaporation of C backings from 40 µg/cm^2, thickness chosen in consultation with the user as a compromise between mechanical stress resistance and elasticity. Subsequently performed massive thermal evaporation of ^{7}LiF from 1.5 mg/cm^2. Adhesion was promoted by adequate heating of the backing.

Plunger target

Au 150 µg/cm^2 on ^{40}Ca 0,8 mg/cm^2 on Au 4 mg/cm^2 plunger target PAC 23.010

Plunger-type targets consisting of a sandwich film: ^{40}Ca 0.8 mg/cm^2 target on Au backing of 4 mg/cm^2 and then protected with Au 150 µg/cm^2 to prevent oxidation. Here the peculiarity of working with the size of the plunger target forced us to use a special geometry for sample placement. The shaded areas prevented measurement of the thicknesses with the microbalance, so we had to find other benchmarks such as current intensity, deposition time and sample weights. Metallic ^{40}Ca is obtained by reduction from $^{40}CaCO_3$ using Zr as the reducing agent. Slight heating of the Au backing improves adhesion.

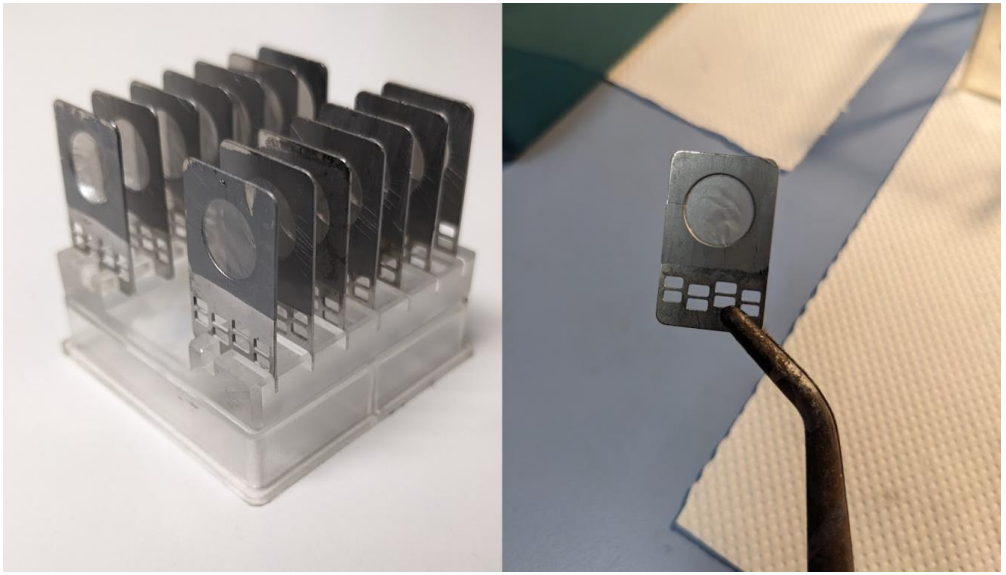
Rolled self-supporting target



Zr pill and Zr 1 mg/cm^2 for plunger target – PAC 23.011

Many tests have been performed for the melting, distillation and rolling of Zr as an extremely hard and brittle material in the presence of minute amounts of impurities (on the order of ppm). The user required the expensive and unobtainable ^{96}Zr isotope in "crystal bar" form, but available in powder form from oxide reduction. With careful control of vacuum, temperature and evaporation "rate" parameters, we melted and distilled natural Zr with e-gun. The photo shows the behavior at press crushing test and rolling. The tests showed a loss of material around 30%.

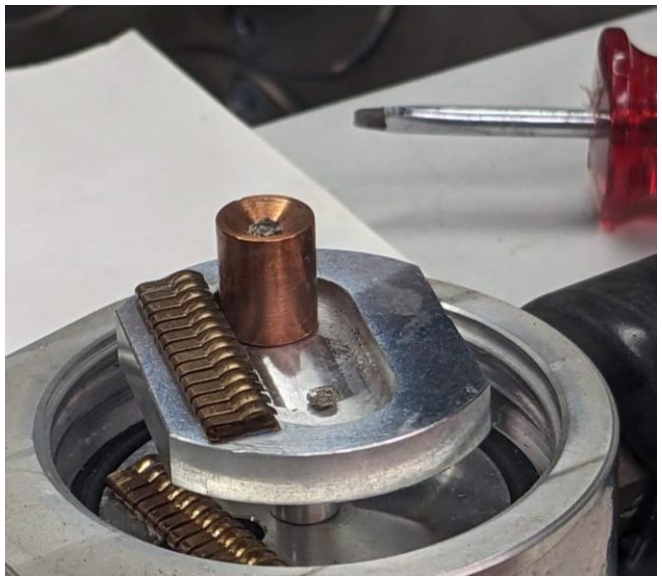
LNL-Carbon stripper foils



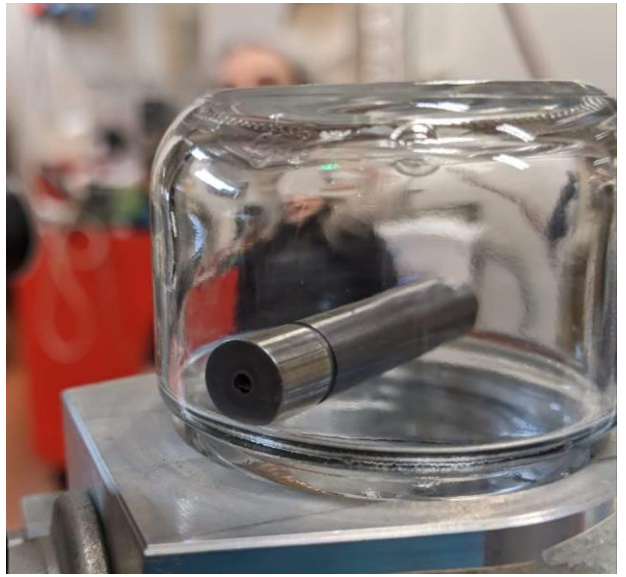
The preparation and assembly of stripper-foils for the XTU Tandem has always been the prerogative of the Targets Laboratory, which sourced and processed locally the films produced in Munich using the Laser Ablation technique. Now the Munich Laboratories have closed this activity so it has become necessary to provide it themselves. We therefore started local production of stripper-foils using the thermal evaporation technique of our carbon evaporator

Support on preparation of sources for accelerators

48Ca pill by 48CaCO3 reduction – PAC 22.81



44Ca XTU-tandem source – pac 23.006



48Ca ECR source – PAC 22.81

The laboratory provides its expertise on dry oxidation-reduction reactions of metal oxides and carbonates for the preparation of sources for LNL accelerators. In particular, an ECR source of ^{48}Ca from $^{48}CaCO_3$ and a source of ^{44}Ca from $^{44}CaCO_3$ were produced.

Sputtered targets for nuclear physics and astrophysics experiments

Magnetron and reactive magnetron sputtering technologies are used as complementary techniques to evaporation when nuclear targets require specific compositional or structural characteristics

Characteristics:

- 3 sputtering source (50mmx140mm)
- 2 sputtering source (150mmx230mm)
- Active gettering system
- Optical emission plasma diagnostics for reactive processes
- Different power supply technologies (HiPIMS, DC, pulsed-DC, RF)
- 2 different sample holder

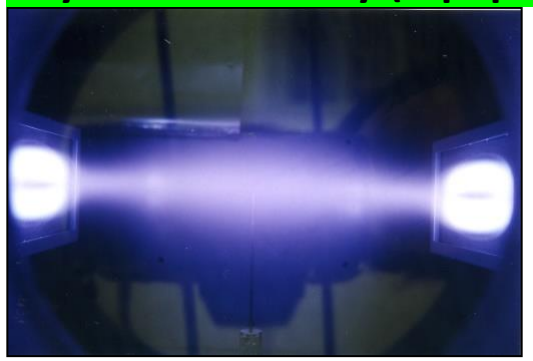
Materials:

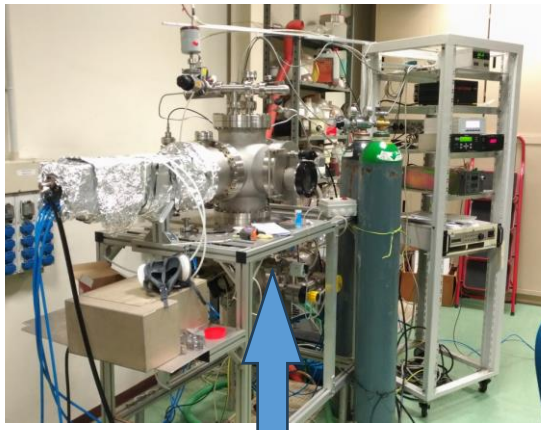
Pure materials (Ta, Ti, Zr, Cr, Cu, Nb….)

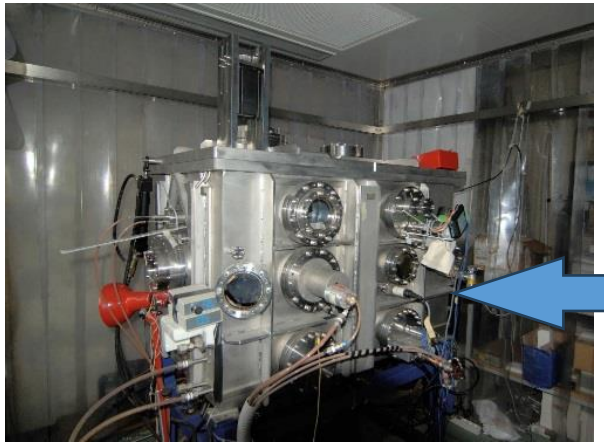
Compounds:

- Oxides (natural O, ^{16}O, ^{17}O and ^{18}O)
- Nitrides (natural N, ^{14}N, ^{15}N)
- Hydrides (natural H, D)

All the deposition system are part Materials Physics For Nuclear Physics Laboratory (equipment founded by CSN5 and CSN3)

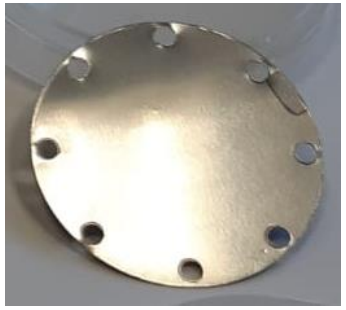






2 different sputtering system used for target synthesis and other CSN5 exeriments

Targets for nuclear physics and astrophysics experiments 2023/2024

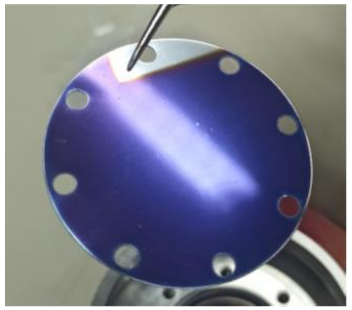


Sputtered $Ta^{14}N$ on tantalum backing

LNL $Ta^{14}N$ targets have been used in the first experiment $^{14}N(p,\gamma)^{15}O$ at Bellotti Facility

LNGS 2023 LUNA collaboration

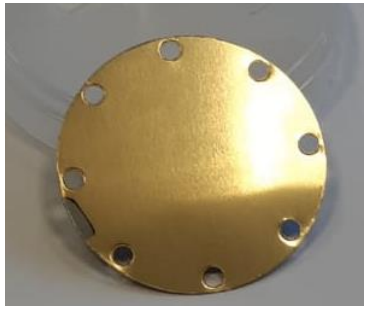
Premial project LUNA-MV



Sputtered $NaNbO_3$ targets for $^{23}Na(p,\alpha)^{20}Ne$

LNGS 2023-2024 LUNA collaboration

Starting ERC project ELDAR: P.I. Carlo Bruno

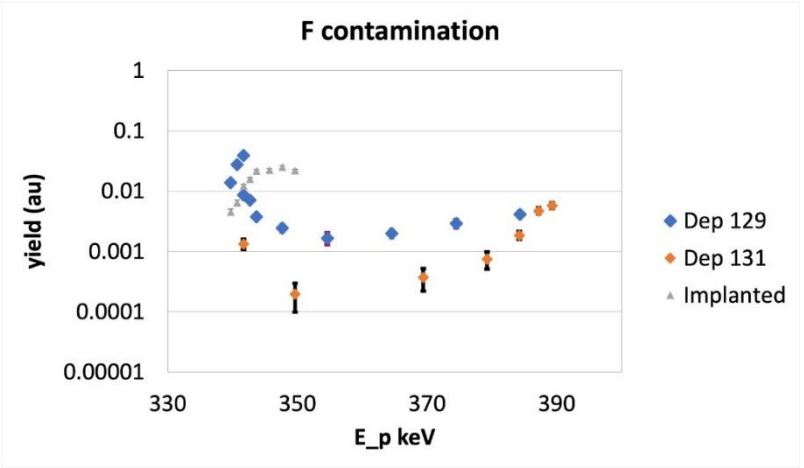


Sputtered $Ti^{nat/14}N$ targets for $^{14}N(p,\gamma)^{15}O$ at LUNA400

LNGS 2023-2024 LUNA collaboration

PRIN 2022 project SOCIAL: P.I. Francesca Cavanna

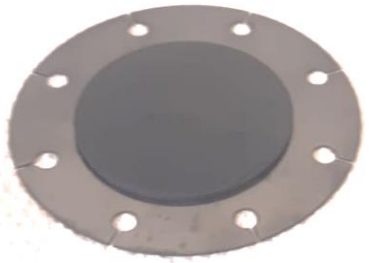
Target for astrophysics experiments required high purity materials and very low contaminant (O,C,D,F)



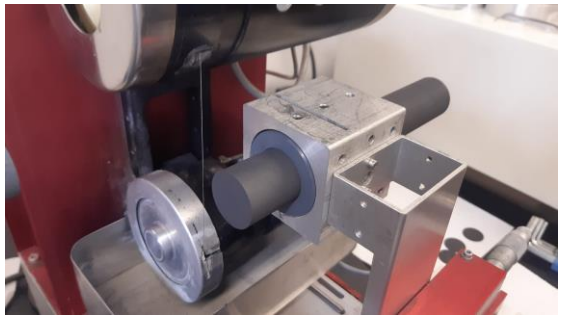
Fluorine contamination
~10-100 times less than implanted target

(P,γ) Analysis performed by A. Compagnucci @ LNGS LUNA 400 facility

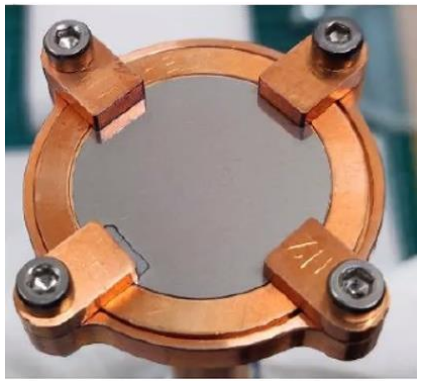
Targets for nuclear physics and astrophysics experiments 2023/2024



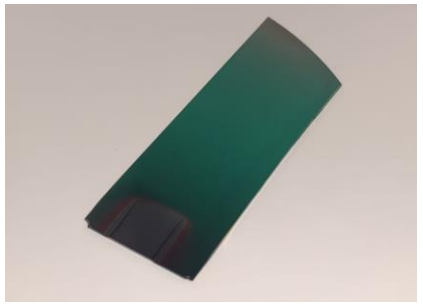
Graphite bulk target (1-4mm thick) on Tantalum backing $^{12}C+^{12}C$
LNGS 2023-2024 LUNA collaboration
PRIN 2022 project CaBS: P.I. Gianluca Imbriani
Experiment proposed to LNGS PAC 2023: P.I. Federico Ferraro



Prepared using diamond wire saw from high purity graphite bar



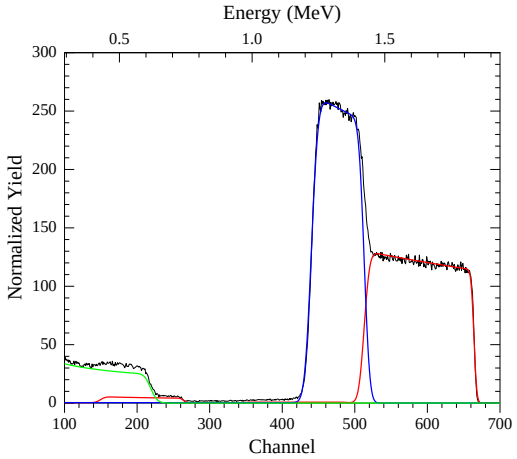
Sputtered ZrD_2 on Tantalum backing $^{2}H(p,\gamma)^{3}He$ reaction above 300 keV
Experiment at Felseskeller Laboratory (Dresden)
P.I. Eliana Masha



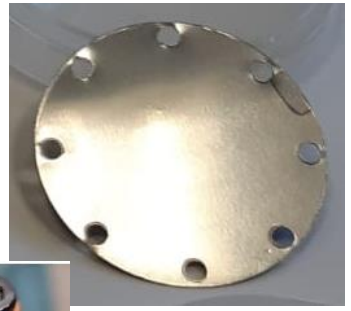
Sputtered $Ta_2{}^{18}O_5$ on Tantalum backing using plunger configuration TBD
Experiment proposed for next AGATA campaign
P.I. Giovanna Benzoni

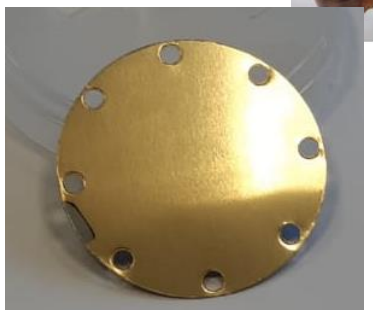
IBA characterization @ AN2000/CN [Target for Astrophysics]

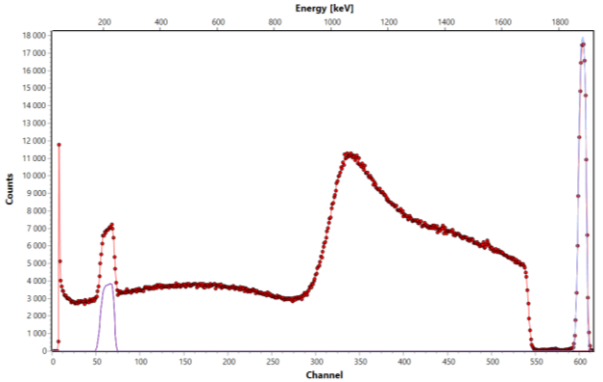
IBA is an essential tool for deposition process development, and it drives Nuclear target manufacturing with PVD techniques



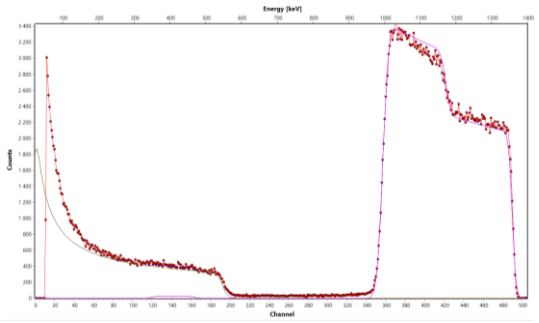
RBS (α, α) 1.8MeV, AN2000 Ta_2O_5 with Ta(interlayer) deposited on Silicon substrate



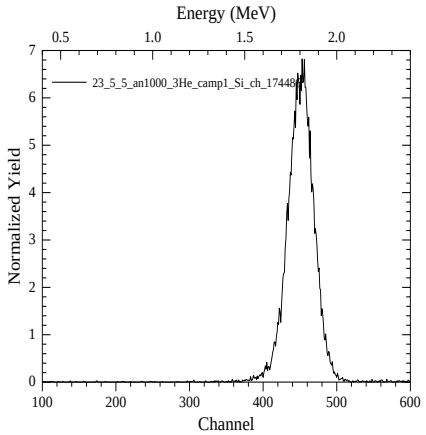




EBS (p,p) 2MeV, AN2000 of ZrD_2 target deposited on silicon substrate

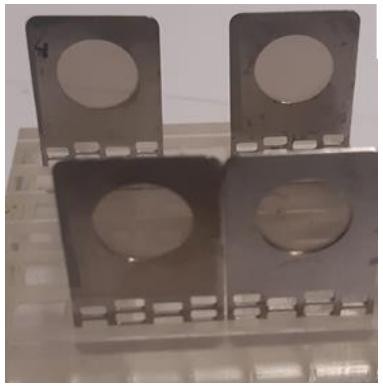


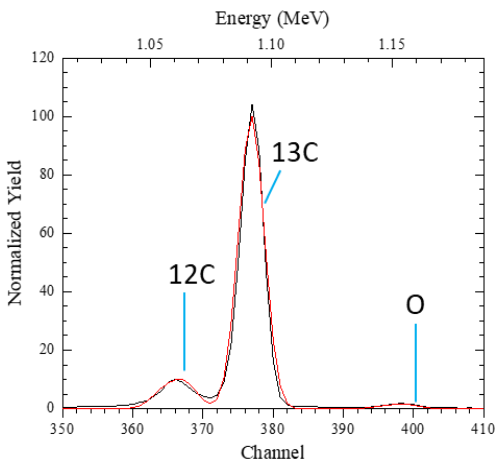
RBS (α, α) 1.5MeV, AN2000 $Ta^{14}N$ with Ta(interlayer) deposited on Silicon substrate

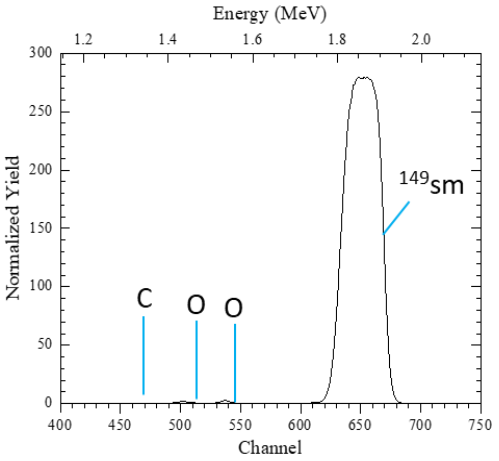


D(^{3}He, p)^{4}He spectrum, NRA, Beam ^{3}He 1MeV On pristine sample deposited on silicon wafer backing

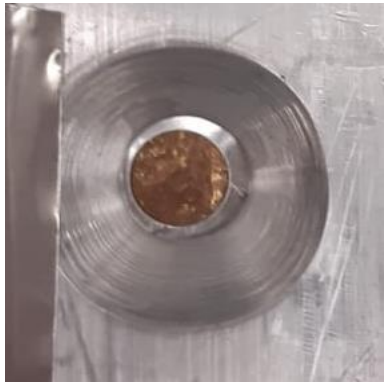
IBA characterization @ AN2000/CN [target for nuclear physics]

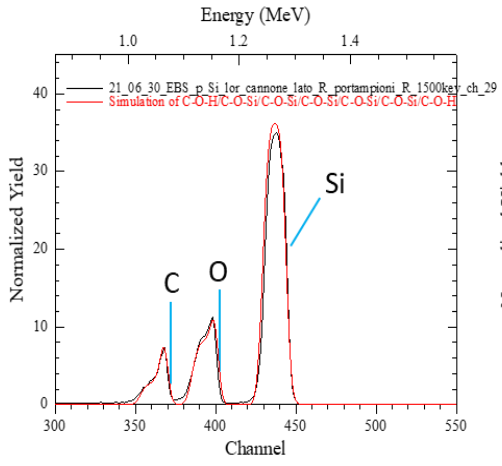


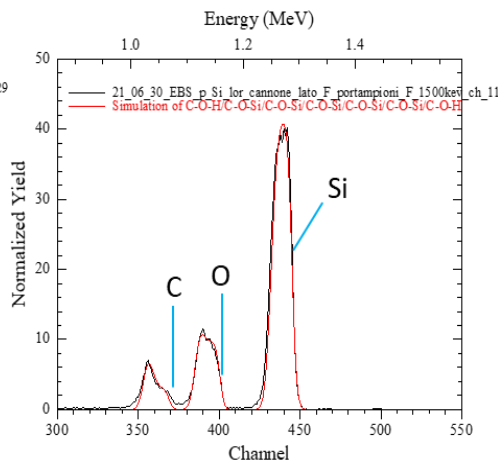




The LNL Target Service produces most of targets used in nuclear experiments of AGATA campaign, it also prepares target for Italian and foreign laboratories

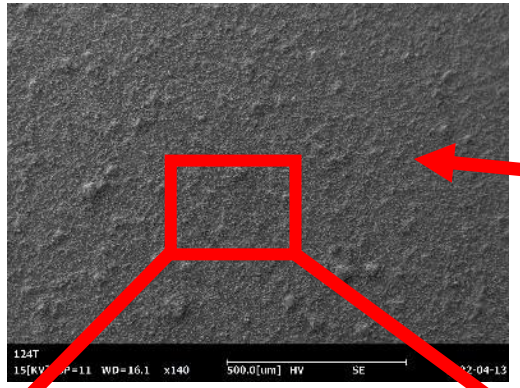


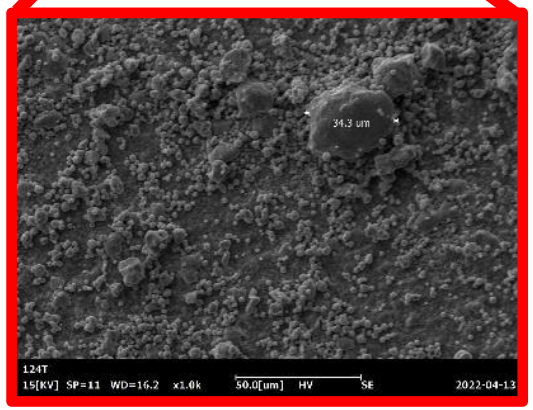




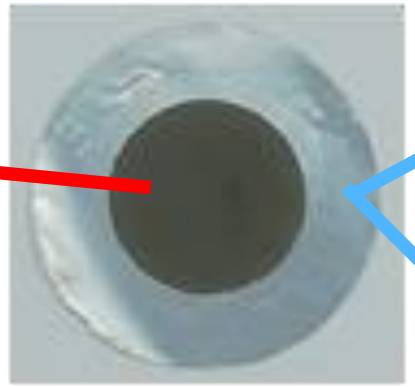
IBA characterization @ AN2000/CN [target for radioisotope cross section measurement]

Target roughness evaluation

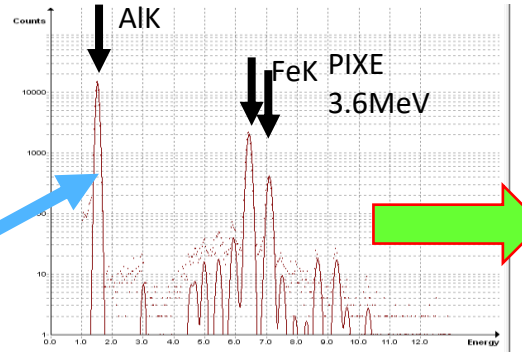




^{49}Ti powder deposited on aluminum backing

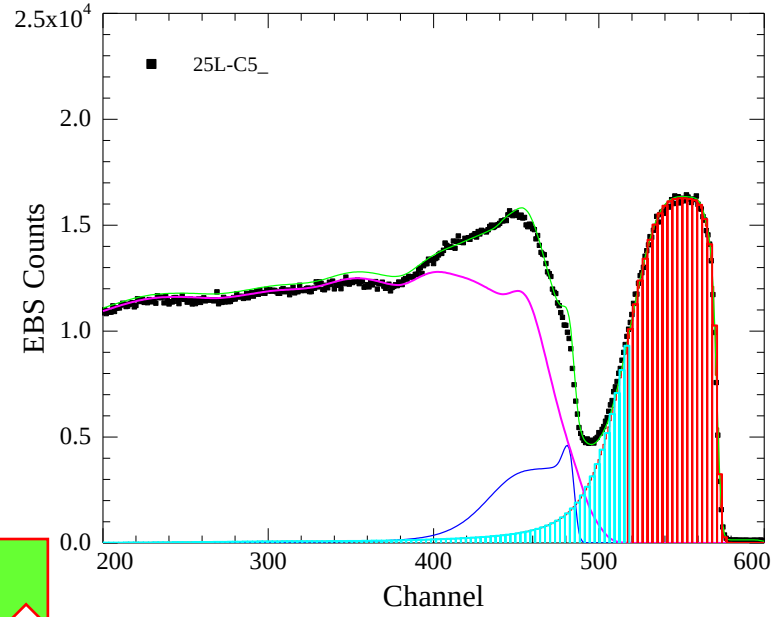


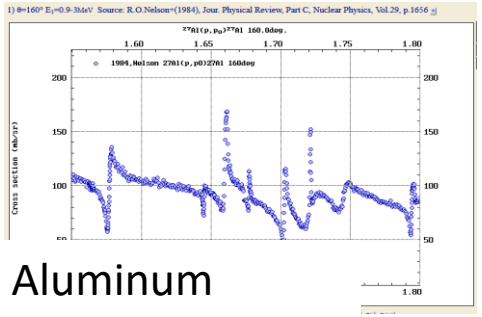
Aluminum backing PIXE and EBS analysis



Other trace elements: Cr,Mn,Zn,Ga

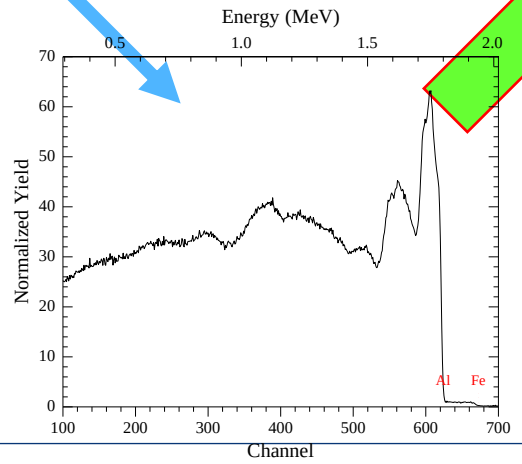
^{49}Ti EBS analysis





Aluminum Cross section

Nelson et al. (Phys. Rev. C29 (1984) 1656)



Analysis

- Thickness distribution
- Composition
- Contaminants

Targets request for 2023/2024 experiments

ALL THESE TARGETS ARE SYNTETIZED IN THE "MATERIALS PHYSICS FOR NUCLEAR PHYSICS LABORATORY "

LUNA collaboration:

- ✓ Complete N° 25 targets of Ta^{14}N deposited on tantalum backing, FIRST EXPERIMENT at Bellotti facility (LNGS) for ^{14}N(p,γ)^{15}O [MUR Progetto premiale]
- ➢ N° 25-30 targets of $NaNbO_3$ for LUNA400 (LNGS) experiment ^{23}Na(p,α)^{20}Ne [ERC]
  - ➢ Target production ongoing
- ➢ N° 25 target of TiN for LUNA400 (LNGS) ^{14}N(p,γ)^{15}O experiment, planned in 2024 [PRIN]
  - ➢ First batch under preparation (test planned November 2023)
  - ➢ Final batch (2024)
- ➢ N° 50 target preparation Carbon disk on Tantalum backing for ^{12}C+^{12}C experiment [PRIN]
  - ➢ Target production ongoing

Other experiments

- ➢ N° 15 of ZrD_2, ^{2}H(p,γ)^{3}He reaction, Felsenkeller Laboratory (Dresden) [2024]
- ➢ TaN for 14N-pg-AN2000 planned experiment 2023 (complete)
- ➢ N° 20 of Ta^{15}N, ^{15}N(α,γ)^{19}F / ^{14}N(α,γ)^{18}F reaction, Felsenkeller Laboratory (Dresden) [2024]
- ➢ $Ta_2{}^{18}O_5$ proposed experiment AGATA-LNL (TBD 2024)

Thank you!