This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101008324 (ChETEC-INFRA).

Astronuclear Laboratory (JRA1)

G. L. Guardo,

on behalf of

Marco La Cognata

WP3 coordinator

Marco La Cognata, INFN-LNS, lacognata@lns.infn.it, chetec-infra.eu

Overview

- **JRA1 –WP3** tackles four key challenges faced by the ChETEC-INFRA astronuclear laboratories that limit progress:
  - **solid targets** (**task 3.1**, PI R. Spartà/INFN, participants: IFIN-HH, ATOMKI, UKE, UoC, CNRS, UNIPD, about 43 person-months)
  - **gas targets** (**task 3.2**, PI T. Szücs/ATOMKI, participants: HZDR, CNRS, TUD, UMIL, UNIPD, about 17 person-months)
  - **neutron detection** (**task 3.3**, PI L. Swiderski/NCBJ, participants: INFN, PTB, ISMA*, UNIPD, about 32 person-months)
  - **accelerator mass spectrometry**: production of nuclear charge separated beams (**task 3.4**, PI Robin Golser/UNIVIE, participants: HZDR, about 12 person-months)

*External collaboration – no person-months

GUF IS INVOLVED IN ALL THE ACTIVITIES CONCERNING THE WEBSITE

Deliverables

D3.1	Report on the experimental techniques used for solid target production on the project web site
D3.2	Report on the development of a gas-jet target with in-beam target thickness diagnostic, on the project web site and in a scientific journal
D3.3	Provide to the community, upon request, one sample each of three possible scintillator materials for neutron detector in cooperation with industry
D3.4	Report on testing by radioactive sources and beam bombardment of the solid targets produced
D3.5	Report, on ChETEC-INFRA web site, on community-accepted methods to measure two non-routine AMS isotopes of astrophysical relevance
D3.6	Scientific publication on isobar suppression by ion-gas or ion-laser-interaction
D3.7	Publication on ChETEC-INFRA web site and in a scientific journal of target production protocols, characterization procedures, and results
D3.8	Report on the development of a gas cell target to be used for angular distribution measurements, on the project web site and in a scientific journal
D3.9	Report on the ChETEC-INFRA web site on different materials studied for neutron detection and position sensitive neutron detectors

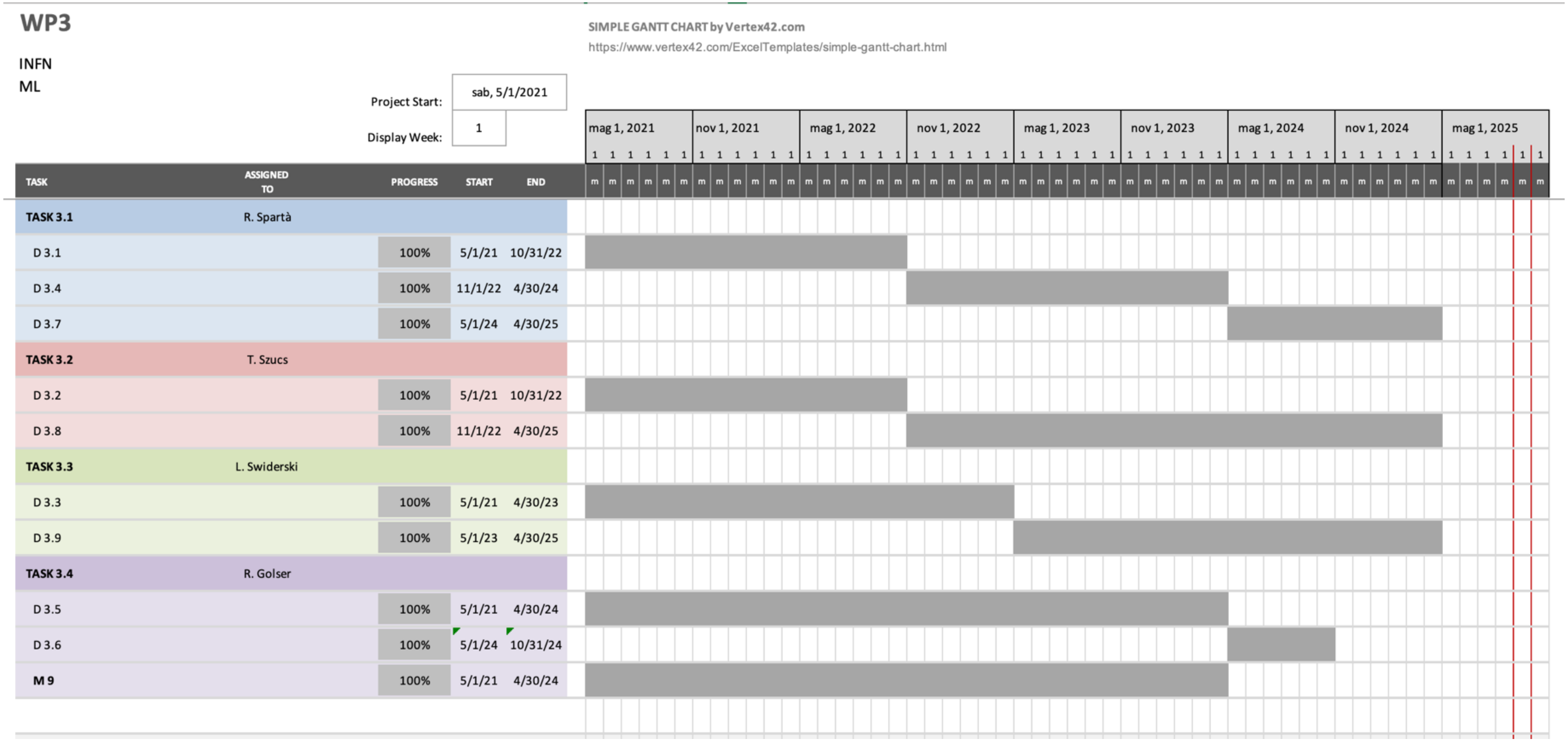
Milestones:

- **M9** Measurement capability for Hf-182 by AMS developed and ready for external users (Task 3.4, month 36)

Key performance indicators:

- 10 scientific publications from this WP.
- 5 accelerator laboratories (both from inside and outside the consortium) where one of the target- or detector production techniques developed here is taken to routine operation.
- 5 PhD students trained in at least two of the tasks developed in JRA1.

Gantt chart



WP3

INFN
ML

SIMPLE GANTT CHART by Vertex42.com
https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

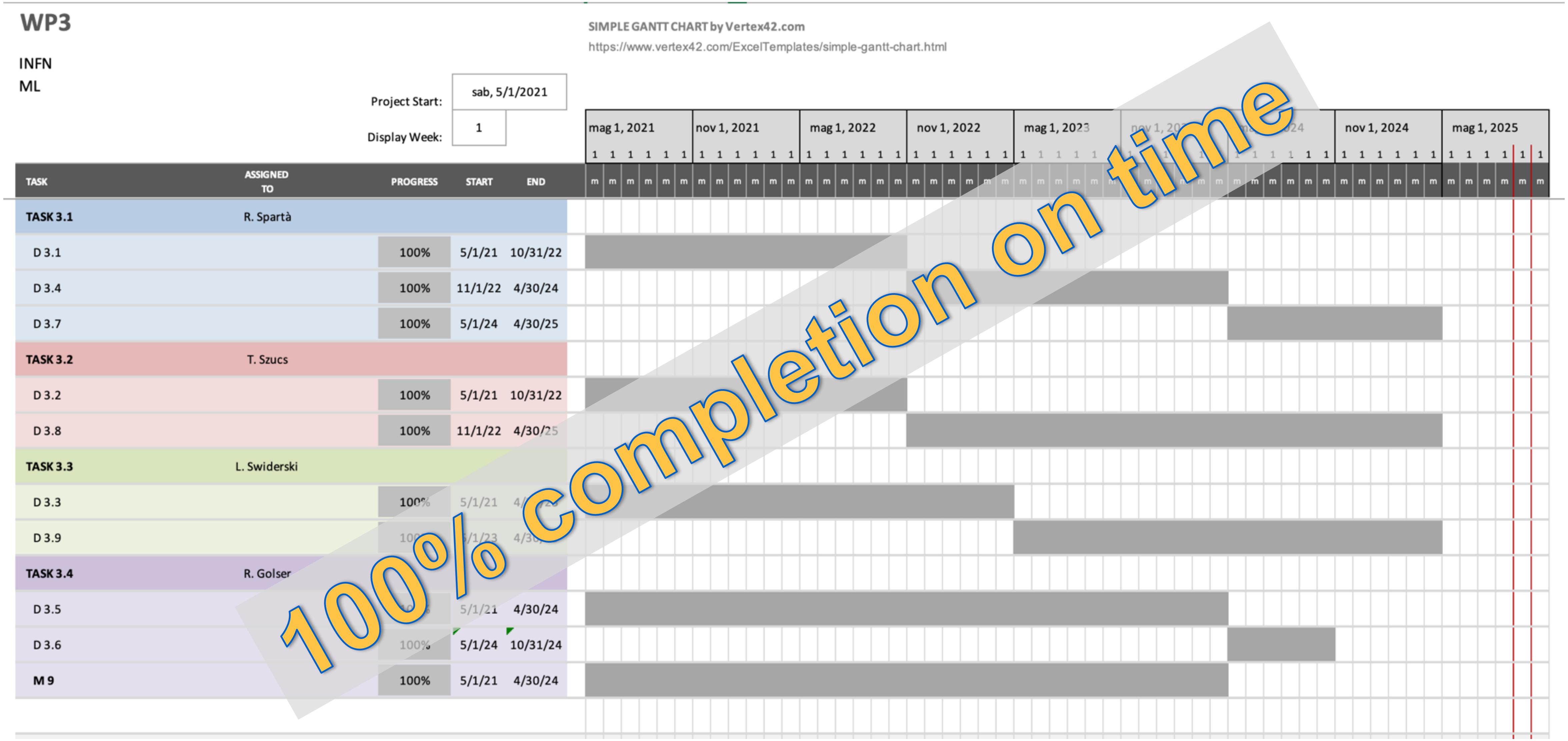
Project Start: sab, 5/1/2021

Display Week: 1

TASK	ASSIGNED TO	PROGRESS	START	END
TASK 3.1	R. Spartà			
D 3.1		100%	5/1/21	10/31/22
D 3.4		100%	11/1/22	4/30/24
D 3.7		100%	5/1/24	4/30/25
TASK 3.2	T. Szucs			
D 3.2		100%	5/1/21	10/31/22
D 3.8		100%	11/1/22	4/30/25
TASK 3.3	L. Swiderski			
D 3.3		100%	5/1/21	4/30/23
D 3.9		100%	5/1/23	4/30/25
TASK 3.4	R. Golser			
D 3.5		100%	5/1/21	4/30/24
D 3.6		100%	5/1/24	10/31/24
M 9		100%	5/1/21	4/30/24

Marco La Cognata, INFN-LNS, lacognata@lns.infn.it, chetec-infra.eu

Gantt chart



WP3

INFN
ML

SIMPLE GANTT CHART by Vertex42.com
https://www.vertex42.com/ExcelTemplates/simple-gantt-chart.html

Project Start: sab, 5/1/2021

Display Week: 1

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TASK 3.1	R. Spartà			
D 3.1		100%	5/1/21	10/31/22
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D 3.7		100%	5/1/24	4/30/25
TASK 3.2	T. Szucs			
D 3.2		100%	5/1/21	10/31/22
D 3.8		100%	11/1/22	4/30/25
TASK 3.3	L. Swiderski			
D 3.3		100%	5/1/21	4/30/23
D 3.9		100%	5/1/23	4/30/25
TASK 3.4	R. Golser			
D 3.5		100%	5/1/21	4/30/24
D 3.6		100%	5/1/24	10/31/24
M 9		100%	5/1/21	4/30/24

100% completion on time

Marco La Cognata, INFN-LNS, lacognata@lns.infn.it, chetec-infra.eu

Task 3.1 Starting point

- ultra-pure material targets for low reaction yields to be studied
- noble gases targets implanted into a host material
- Characterization of targets using sources and in-beam approaches (thickness, contaminants, long-term stability…)

Also (proposal to be implemented):

- thin self-supporting rotating target systems (1000 rpm)

R. Spartà, T. Szücs, M. Heine, M. Moukaddam, S. Courtin, L. Trache, M. La Cognata, A. Caciolli, D. Mengoni, A. Tumino, G. Lanzalone, A. Zilges, A. Blazhev, S. Prill, S. Wilden, F. Heim, …

Task 3.1 → STAR: Solid Targets for Astrophysics Research

Roberta Spartà – P.I. (KORE+INFN)

Task 3.1

1) Realization of ultra-pure material targets to allow for the measurement of low reaction yields, in which signals from parasitic reactions on impurities can limit experiments;

2) Noble elements solid targets (via implantation) to measure key reactions (i.e. for s-process nucleosynthesis in evolved stars) avoiding gas targets inconvenients.

+ a service for the community:
standardized testing of the produced targets (including contaminant checks and stability tests)

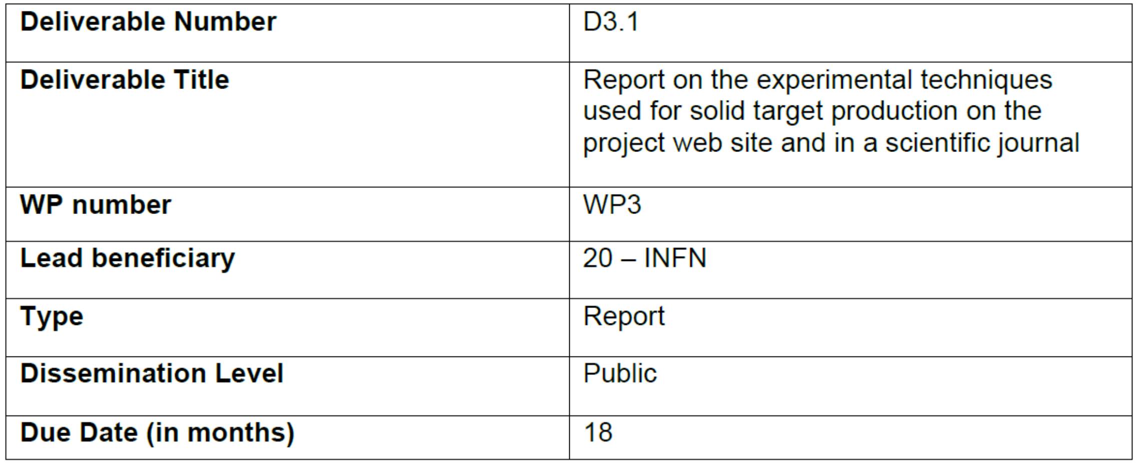
STAR people:

R. Spartà, G.L. Guardo, M. La Cognata, G. Lanzalone,
A. Massara, A. Tumino, …
T. Szücs, …
S. Courtin, M. Heine, M. Moukaddam, , J. Nippert
N. Florea,, A. Spiridon, L. Trache, …
A. Caciolli, R. Depalo, D. Mengoni, D. Piatti, J. Skowronski, …
F. Heim, M. Mullenmeister, …
…

participating institutions:

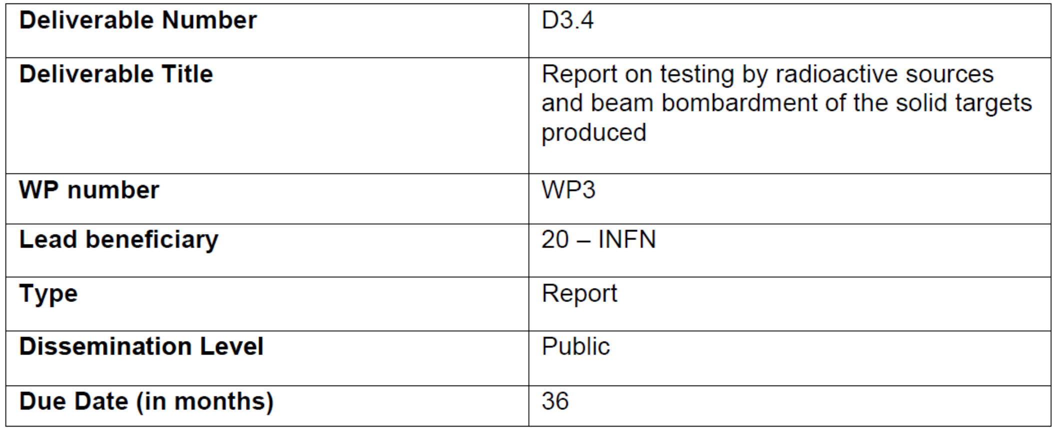
- *ATOMKI (Hungary)*
- *CNRS (France)*
- *IFIN-HH (Romania)*
- *INFN (Italy)*
- *University of Padua (Italy)*
- *University of Milan (Italy)*
- *University Kore (Italy)*
- *University of Cologne (Germany)*

3 deliverables – fulfilled on time



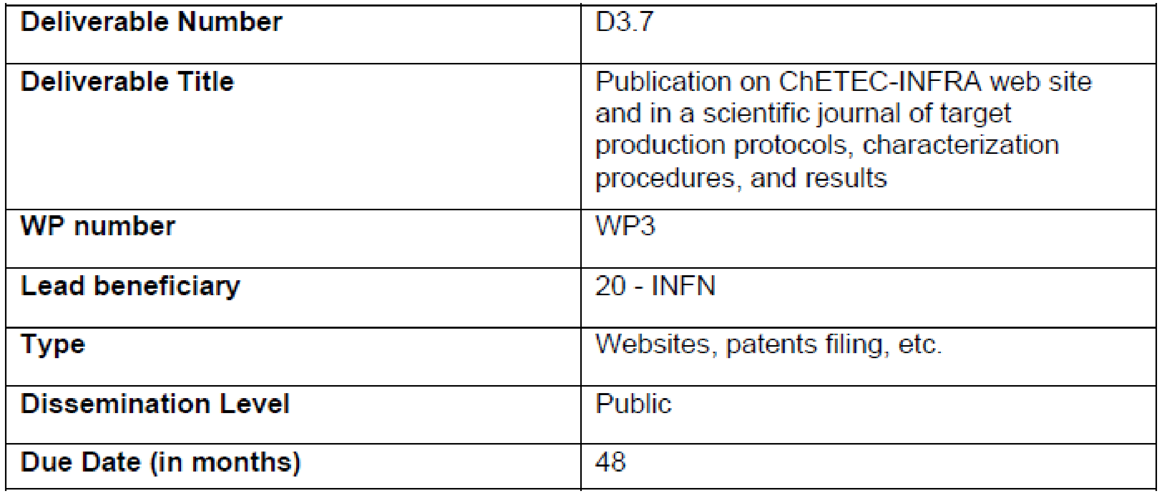
Deliverable Number	D3.1
Deliverable Title	Report on the experimental techniques used for solid target production on the project web site and in a scientific journal
WP number	WP3
Lead beneficiary	20 – INFN
Type	Report
Dissemination Level	Public
Due Date (in months)	18

https://www.chetec-infra.eu/jra/star



Deliverable Number	D3.4
Deliverable Title	Report on testing by radioactive sources and beam bombardment of the solid targets produced
WP number	WP3
Lead beneficiary	20 – INFN
Type	Report
Dissemination Level	Public
Due Date (in months)	36

https://www.chetec-infra.eu/jra/startest



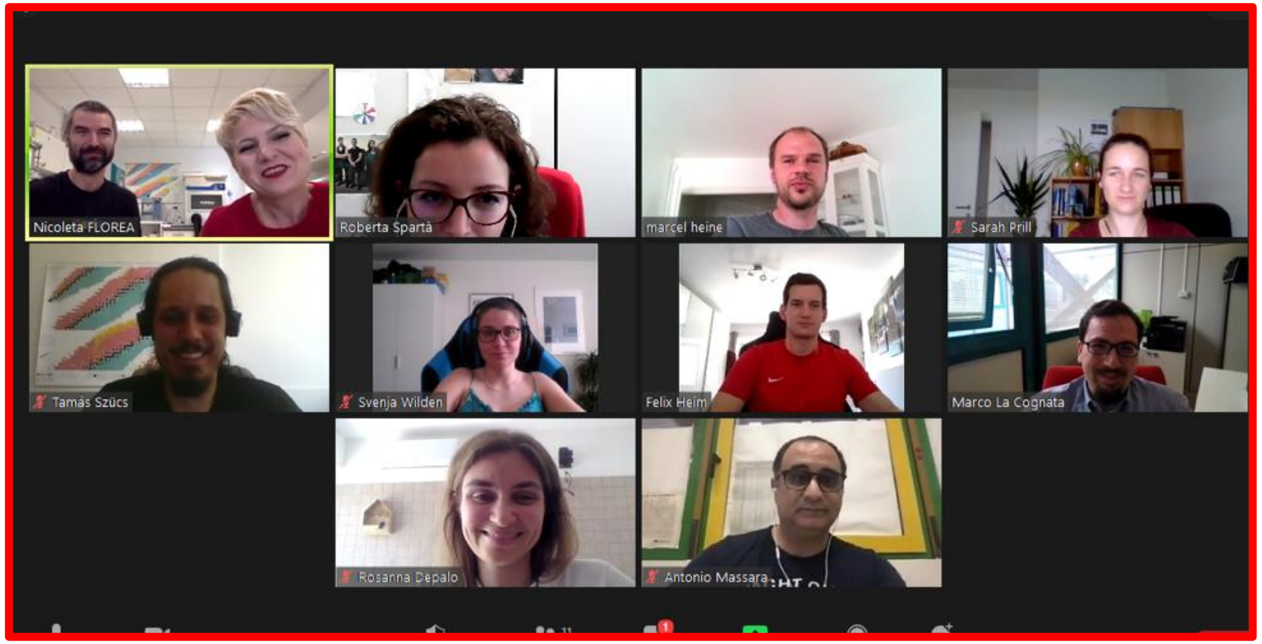
Deliverable Number	D3.7
Deliverable Title	Publication on ChETEC-INFRA web site and in a scientific journal of target production protocols, characterization procedures, and results
WP number	WP3
Lead beneficiary	20 - INFN
Type	Websites, patents filing, etc.
Dissemination Level	Public
Due Date (in months)	48

http://arxiv.org/abs/2504.16147 +
https://link.springer.com/article/10.1140/epja/s10050-025-01627-0

General task achievements and possible legacies

For the first time, European target labs:

- Have known each other formally and informally (online meetings)

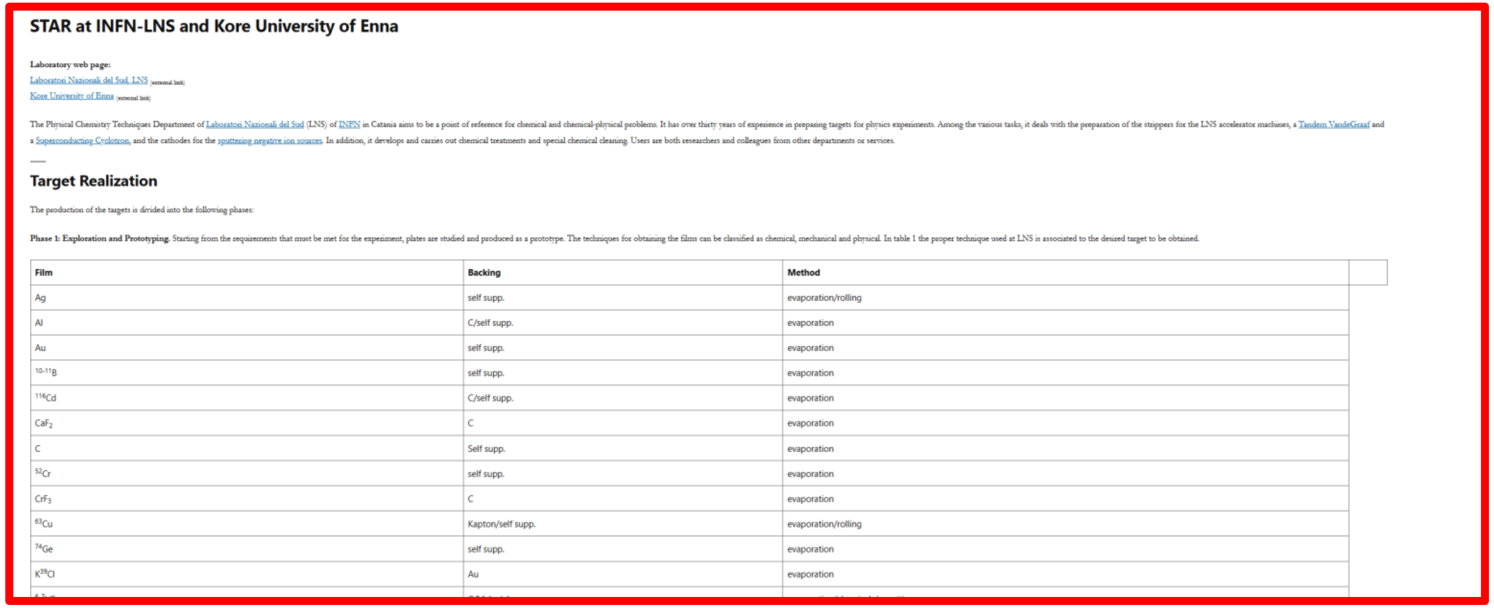


General task achievements and possible legacies

For the first time, European target labs:

- Have known each other formally and informally (online meetings)
- Opened the lab doors to show their equipment and possibilities → D3.1

i.e. https://www.chetec-infra.eu/jra/star/infn-lns_uke/



STAR at INFN-LNS and Kore University of Enna

Laboratory web page:

Laboratori Nazionali del Sud, LNS (external link)
Kore University of Enna (external link)

The Physical Chemistry Techniques Department of Laboratori Nazionali del Sud (LNS) of INFN in Catania aims to be a point of reference for chemical and chemical-physical problems. It has over thirty years of experience in preparing targets for physics experiments. Among the various tasks, it deals with the preparation of the strippers for the LNS accelerator machines, a Tandem VandeGraaf and a Superconducting Cyclotron, and the cathodes for the sputtering negative ion sources. In addition, it develops and carries out chemical treatments and special chemical cleaning. Users are both researchers and colleagues from other departments or services.

Target Realization

The production of the targets is divided into the following phases:

Phase 1: Exploration and Prototyping. Starting from the requirements that must be met for the experiment, plates are studied and produced as a prototype. The techniques for obtaining the films can be classified as chemical, mechanical and physical. In table 1 the proper technique used at LNS is associated to the desired target to be obtained.

Film	Backing	Method
Ag	self supp.	evaporation/rolling
Al	C/self supp.	evaporation
Au	self supp.	evaporation
$^{10-11}$B	self supp.	evaporation
^{116}Cd	C/self supp.	evaporation
CaF_2	C	evaporation
C	Self supp.	evaporation
^{52}Cr	self supp.	evaporation
CrF_3	C	evaporation
^{63}Cu	Kapton/self supp.	evaporation/rolling
^{74}Ge	self supp.	evaporation
K^{39}Cl	Au	evaporation

https://www.chetec-infra.eu/jra/star/

A page for each lab: target available/equipment/techniques…

Laboratory Equipment

- 2 PVD evaporators with thermal sources and electron beam (figures 10 and 11);
- 1 technical scale;
- 1 analytical balance with five decimal digits (fig. 12);
- 1 rolling mill (fig. 5);
- 1 automatic thickness measuring machine (fig. 7 and 8);
- 1 chemical hood.

Fig. 10: Leybold L300 evaporator with 2 thermic sources.
(Credit: INFN-LNS)

1: Leybold L560 evaporator with 1 thermic source and electron beam.
(Credit: INFN-LNS)

Fig. 12: 5 digits analytical balance.
(Credit: INFN-LNS)

In the case of metal targets with thicknesses greater than 1 μm, cold lamination is used [Tho75]. The metal foil is progressively thinned with a cold rolling mill (fig. 5) in a sandwich process between two hardened stainless steel plates until it reaches the desired thickness (fig.6).

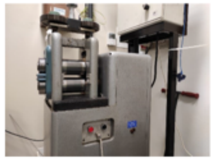


Fig. 5: Rolling mill.
(Credit: INFN-LNS)

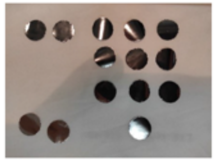


Fig. 6: ^{54}Fe disks of 10μm thickness, obtained via cold rolling.
(Credit: INFN-LNS)

During the realization of the prototype the natural material is used, not enriched.

Phase 2: Finding the material. Having developed the procedure for the realization of the targets, we take care of the purchase of the isotope of the required chemical element. The material to be used for making the film must have the highest possible chemical purity, higher than 99.99 %, to prevent interference from unwanted elements in the target. Furthermore, it must satisfy the condition of higher isotopic purity. In this context we refer to the relationship between the isotope of interest and the other isotopes of the same element. Today the availability of isotopes is severely limited due to the small number of producers. In some cases, a compromise must be found between the high cost of the necessary isotope and the percentage of enrichment that can be found on the market.

Phase 3: Production. Once the method has been developed and the necessary material has been found, we proceed with the creation of the required plates.

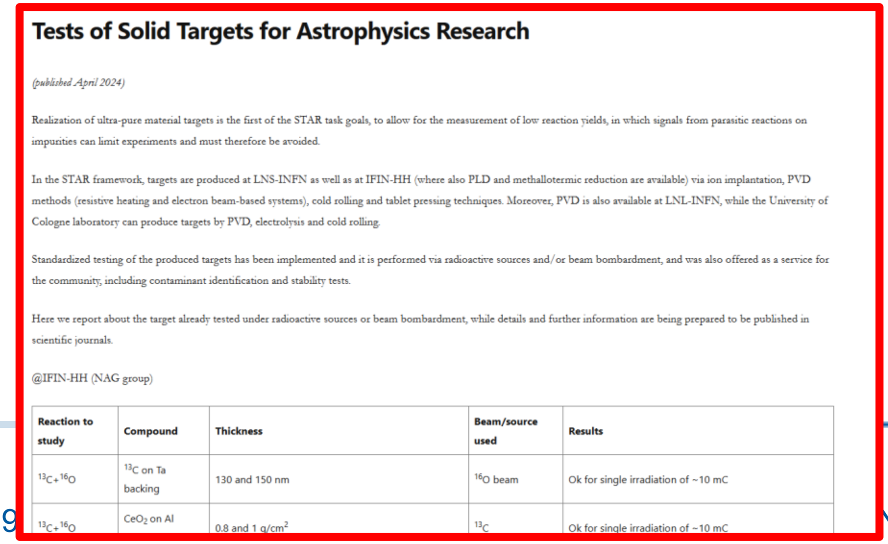
Characterization and size of the targets. Each plate produced in the laboratory is characterized with respect to its surface density, its thickness, its uniformity. During evaporation, the thickness of the deposited material is continuously monitored using a quartz micro-balance (Quartz Crystal Monitor), placed inside the evaporation chamber. It is an extremely mass-sensitive apparatus that measures variations at the level of the nano-gram and micro-gram of mass per unit area. The heart of the technology is a quartz disc. Quartz is a piezoelectric material that can be made to oscillate at a defined frequency by applying a suitable voltage. The frequency of oscillation is affected by the addition of small amounts of mass on its surface. This frequency variation, being dependent on the amount of matter deposited, provides the evaporation rate and the amount deposited over time. To have a more accurate measurement on the single plate or a thickness uniformity measurement, again for ultra-thin films, we proceed to a further characterization. It is known that when a beam of alpha particles of well-defined energy crosses a film, they lose an amount of energy that is directly proportional to the thickness of the material passed through [Tho75].

Fig. 7: Target thickness measuring setup.
(Credit: INFN-LNS)

General task achievements and possible legacies

For the first time, European target labs:

- Have known each other formally and informally (online meetings)
- Opened the lab doors to show their equipment and possibilities → D3.1
- Exchange know-how and support → meetings, characterization service, D3.4



Tests of Solid Targets for Astrophysics Research

(published April 2024)

Realization of ultra-pure material targets is the first of the STAR task goals, to allow for the measurement of low reaction yields, in which signals from parasitic reactions on impurities can limit experiments and must therefore be avoided.

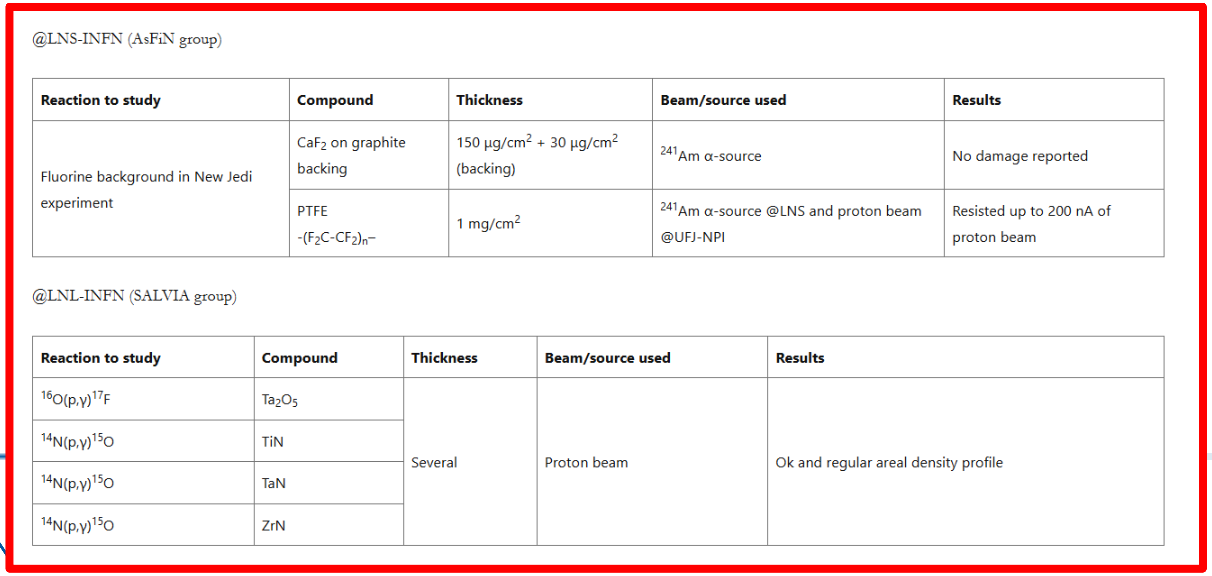
In the STAR framework, targets are produced at LNS-INFN as well as at IFIN-HH (where also PLD and methallotermic reduction are available) via ion implantation, PVD methods (resistive heating and electron beam-based systems), cold rolling and tablet pressing techniques. Moreover, PVD is also available at LNL-INFN, while the University of Cologne laboratory can produce targets by PVD, electrolysis and cold rolling.

Standardized testing of the produced targets has been implemented and it is performed via radioactive sources and/or beam bombardment, and was also offered as a service for the community, including contaminant identification and stability tests.

Here we report about the target already tested under radioactive sources or beam bombardment, while details and further information are being prepared to be published in scientific journals.

@IFIN-HH (NAG group)

Reaction to study	Compound	Thickness	Beam/source used	Results
$^{13}C+^{16}O$	^{13}C on Ta backing	130 and 150 nm	^{16}O beam	Ok for single irradiation of ~10 mC
$^{13}C+^{16}O$	CeO_2 on Al	0.8 and 1 g/cm^2	^{13}C	Ok for single irradiation of ~10 mC



@LNS-INFN (AsFiN group)

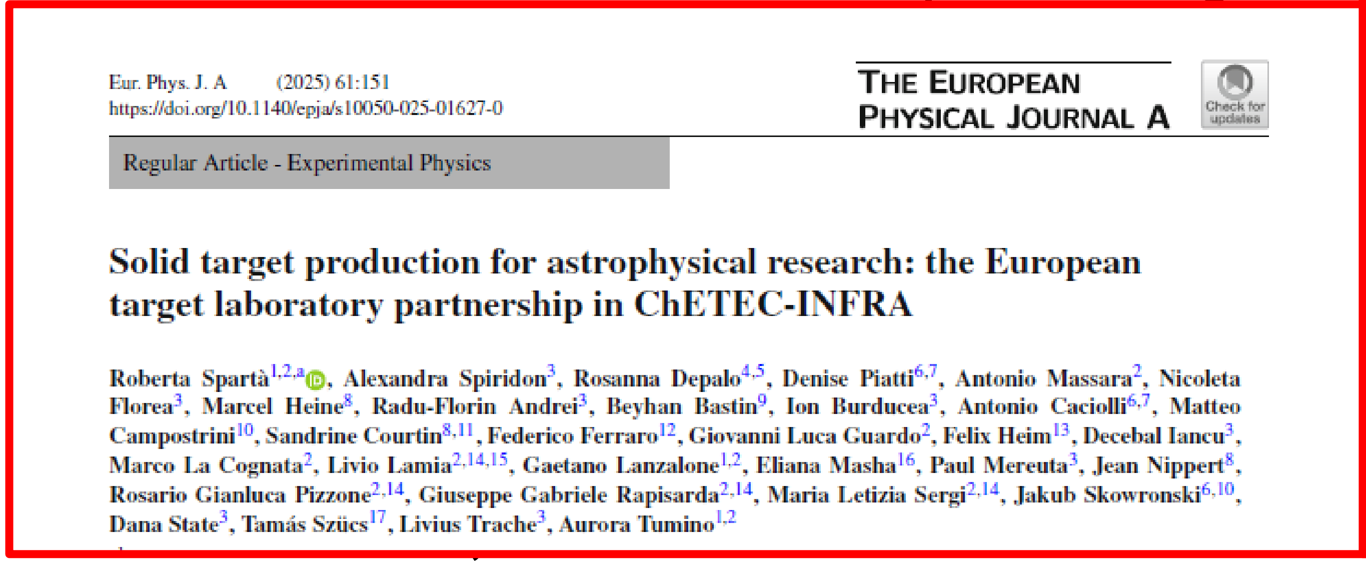
Reaction to study	Compound	Thickness	Beam/source used	Results
Fluorine background in New Jedi experiment	CaF_2 on graphite backing	150 µg/cm^2 + 30 µg/cm^2 (backing)	^{241}Am α-source	No damage reported
	PTFE -$(F_2C\text{-}CF_2)_n$–	1 mg/cm^2	^{241}Am α-source @LNS and proton beam @UFJ-NPI	Resisted up to 200 nA of proton beam

@LNL-INFN (SALVIA group)

Reaction to study	Compound	Thickness	Beam/source used	Results
$^{16}O(p,\gamma)^{17}F$	Ta_2O_5	Several	Proton beam	Ok and regular areal density profile
$^{14}N(p,\gamma)^{15}O$	TiN			
$^{14}N(p,\gamma)^{15}O$	TaN			
$^{14}N(p,\gamma)^{15}O$	ZrN			

General task achievements and possible legacies

For the first time, European target la



Eur. Phys. J. A (2025) 61:151
https://doi.org/10.1140/epja/s10050-025-01627-0

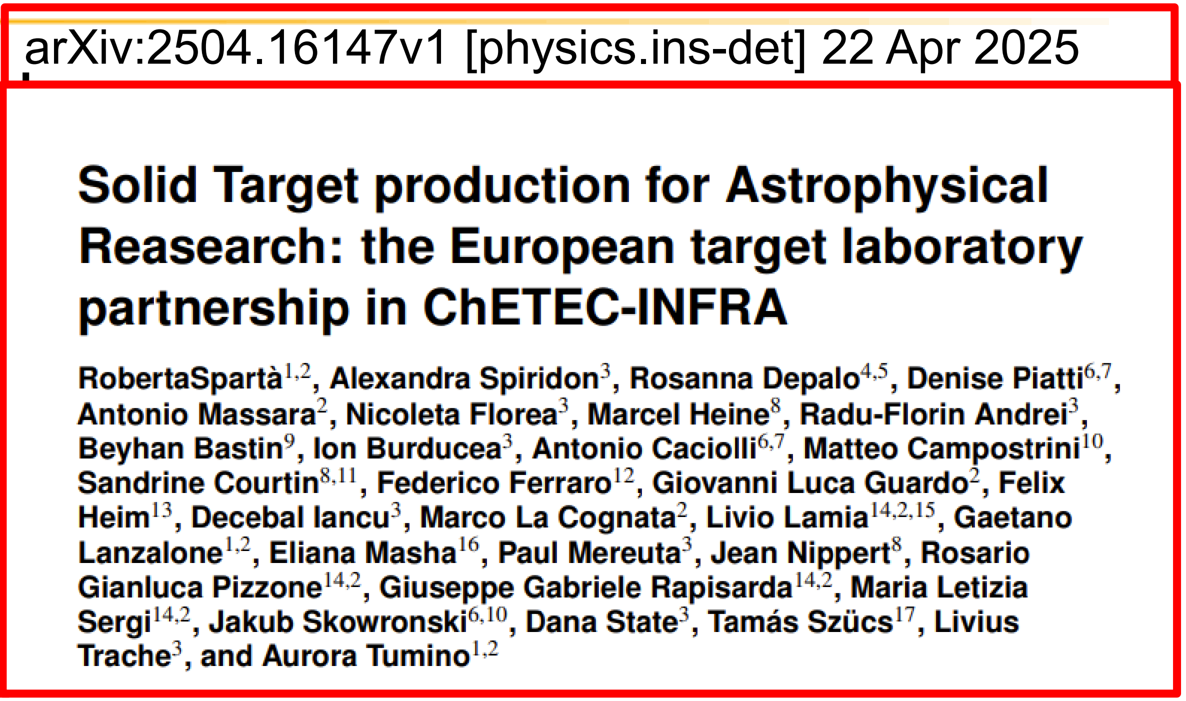
THE EUROPEAN PHYSICAL JOURNAL A

Check for updates

Regular Article - Experimental Physics

Solid target production for astrophysical research: the European target laboratory partnership in ChETEC-INFRA

Roberta Spartà[1,2,a], Alexandra Spiridon[3], Rosanna Depalo[4,5], Denise Piatti[6,7], Antonio Massara[2], Nicoleta Florea[3], Marcel Heine[8], Radu-Florin Andrei[3], Beyhan Bastin[9], Ion Burducea[3], Antonio Caciolli[6,7], Matteo Campostrini[10], Sandrine Courtin[8,11], Federico Ferraro[12], Giovanni Luca Guardo[2], Felix Heim[13], Decebal Iancu[3], Marco La Cognata[2], Livio Lamia[2,14,15], Gaetano Lanzalone[1,2], Eliana Masha[16], Paul Mereuta[3], Jean Nippert[8], Rosario Gianluca Pizzone[2,14], Giuseppe Gabriele Rapisarda[2,14], Maria Letizia Sergi[2,14], Jakub Skowronski[6,10], Dana State[3], Tamás Szücs[17], Livius Trache[3], Aurora Tumino[1,2]



arXiv:2504.16147v1 [physics.ins-det] 22 Apr 2025

Solid Target production for Astrophysical Reasearch: the European target laboratory partnership in ChETEC-INFRA

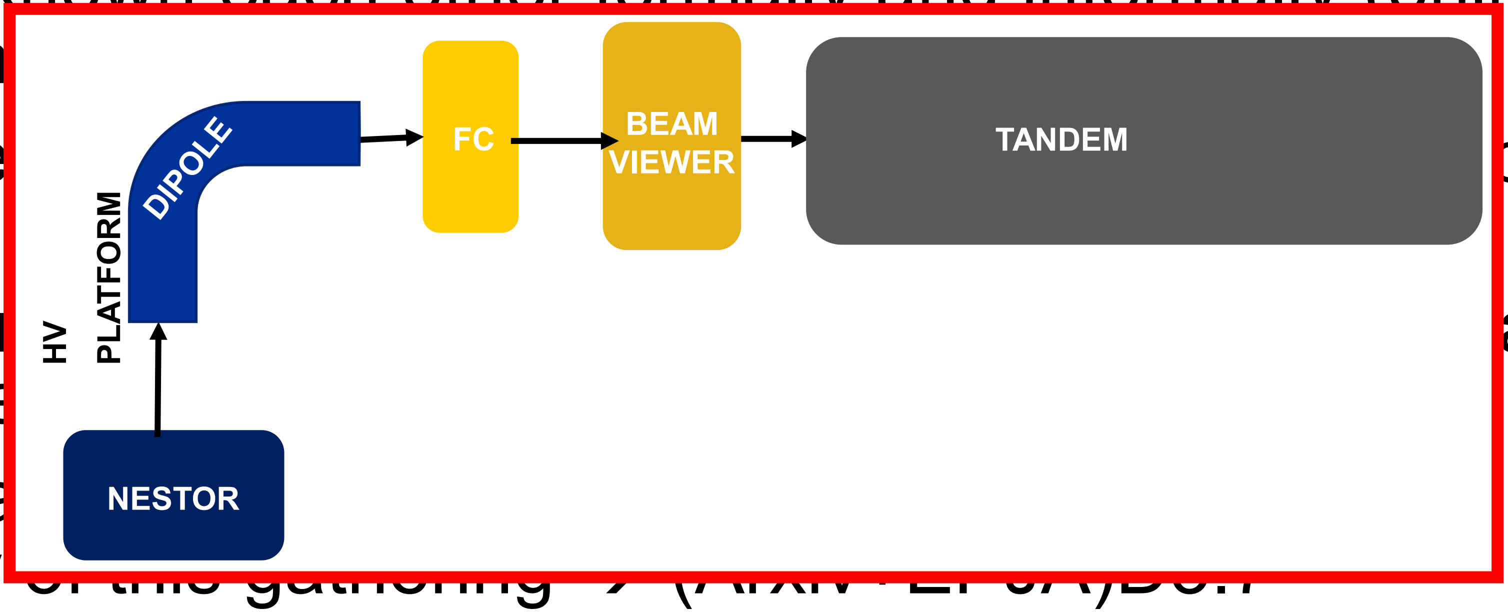
RobertaSpartà[1,2], Alexandra Spiridon[3], Rosanna Depalo[4,5], Denise Piatti[6,7], Antonio Massara[2], Nicoleta Florea[3], Marcel Heine[8], Radu-Florin Andrei[3], Beyhan Bastin[9], Ion Burducea[3], Antonio Caciolli[6,7], Matteo Campostrini[10], Sandrine Courtin[8,11], Federico Ferraro[12], Giovanni Luca Guardo[2], Felix Heim[13], Decebal Iancu[3], Marco La Cognata[2], Livio Lamia[14,2,15], Gaetano Lanzalone[1,2], Eliana Masha[16], Paul Mereuta[3], Jean Nippert[8], Rosario Gianluca Pizzone[14,2], Giuseppe Gabriele Rapisarda[14,2], Maria Letizia Sergi[14,2], Jakub Skowronski[6,10], Dana State[3], Tamás Szücs[17], Livius Trache[3], and Aurora Tumino[1,2]

- New targets have been produced and characterized + Left a legacy of this gathering → (Arxiv+EPJA)D3.7

General task achievements and possible legacies

For the first time, European target labs:

- Have known each other formally and informally (online meetin
- Opene possibilities → D3.
- Exchar acterization service
- New ta + Left a legacy of this gathering → (ArXiv-EPJA)DOI?

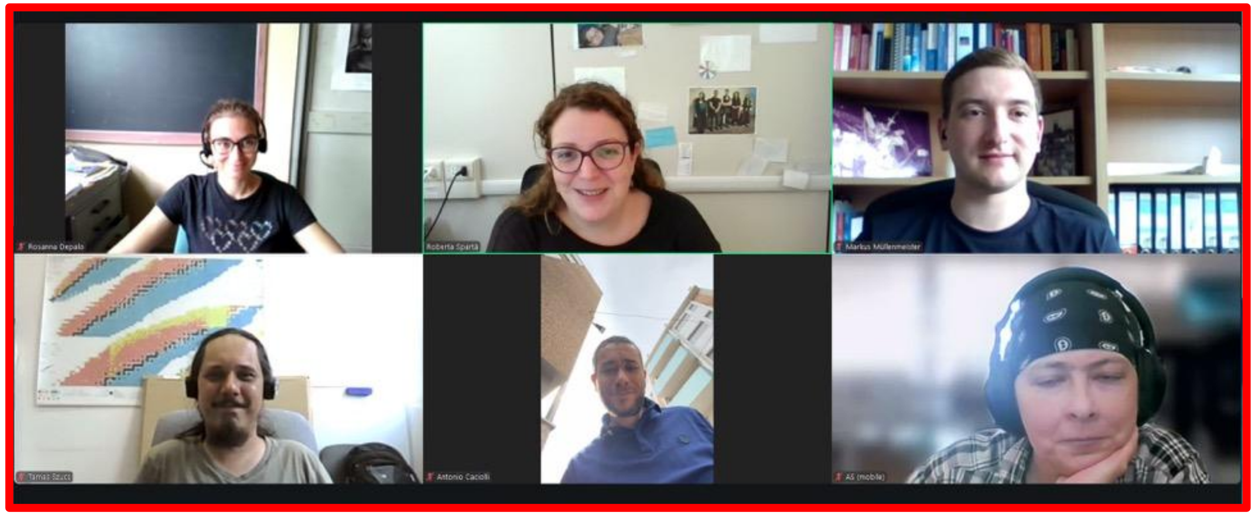


- Organization and know-how acquisition for the production of noble elements implanted solid targets @LNS-INFN (but POT-LNS is still in progress)

And what about the future?

The last STAR meeting (08 Sept 2025)

STAR has been a valuable experience and should not die with the end of the project



Target characterization service: used just once – maybe premature

Decided to keep in touch among European target labs and

- Search a host to keep a common webpage as the one done for D3.1 (accessible to be updated)
- Have an informal online meeting once per year … until we find another project-home

Task 3.2 General overview

- Windowless targets
- Thin-window gas-cell targets
- Diagnostics
  - effective gas thickness
  - Composition
  - Long term stability

Nuclear Resonance, off-beam XRF and in-beam PIXE, RBS setups. Cyclotron/tandetron accelerator for target analysis.

T. Szücs, M. Heine, M. Moukaddam, S. Courtin, D. Bemmerer, U. Bilow, K. Zuber, A. Guglielmetti, A. Caciolli, D. Mengoni, R. Depalo, …

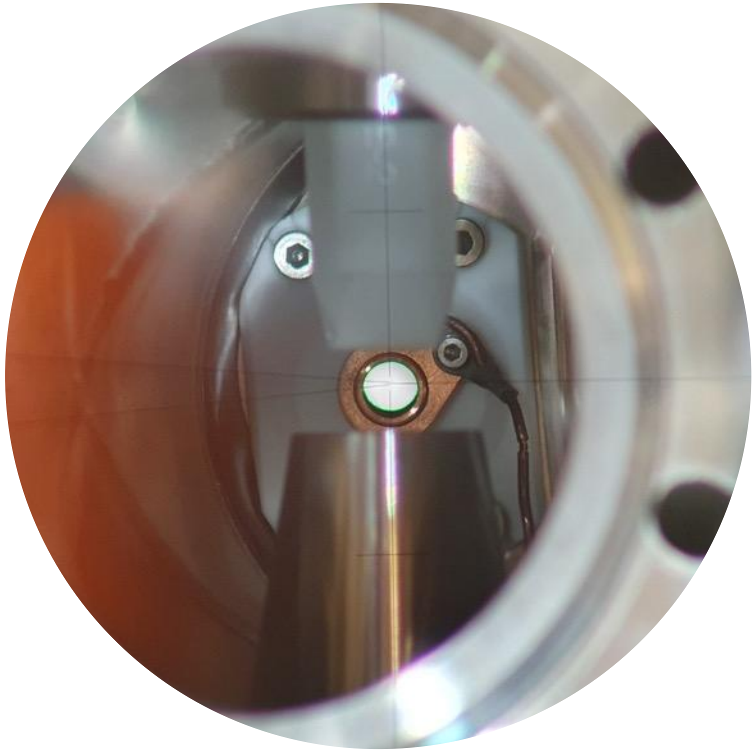
Gas Targets for Nuclear astrophysics → PI: Tamás Szücs

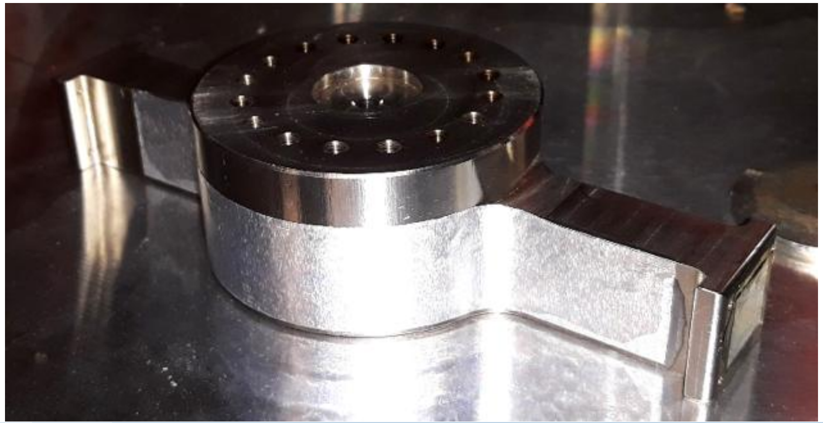
2 Deliverables:
D3.2 Report on the development of a gas-jet target with in-beam target thickness diagnostic, on the project web site and in a scientific journal (resp: HZDR, month 18)
D3.8 Report on the development of a gas cell target to be used for angular distribution measurements, on the project web site and in a scientific journal (resp: ATOMKI, month 48)

Results of Task 3.2

1. A working gas-jet target in the Dresden Felsenkeller laboratory.

2. Thin windowed gas cell targets was developed:
   a. one tested for particle scattering experiment in Atomki.
   b. another one produced to be used for gamma ray angular distribution measurements..

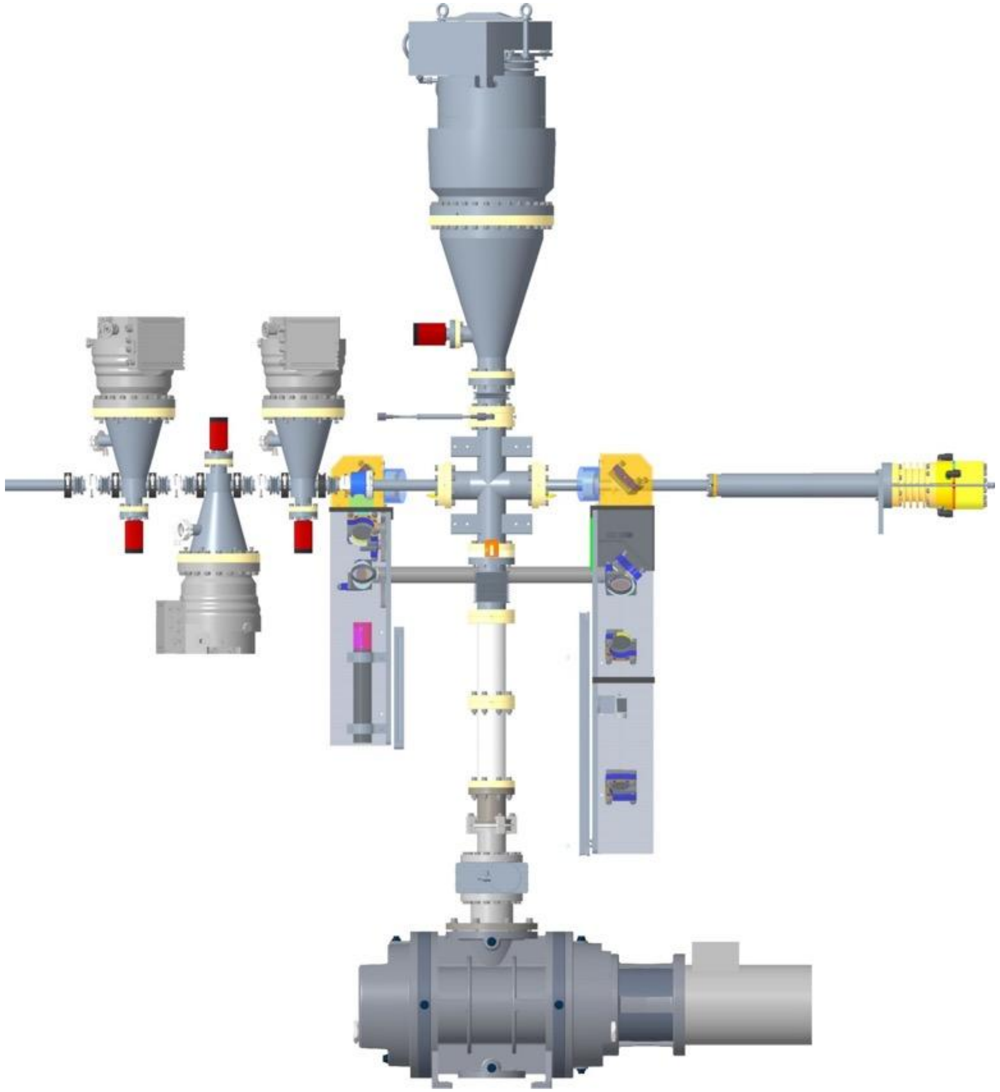




Gas-jet target developed at HZDR: (PI: Konrad Schmidt)

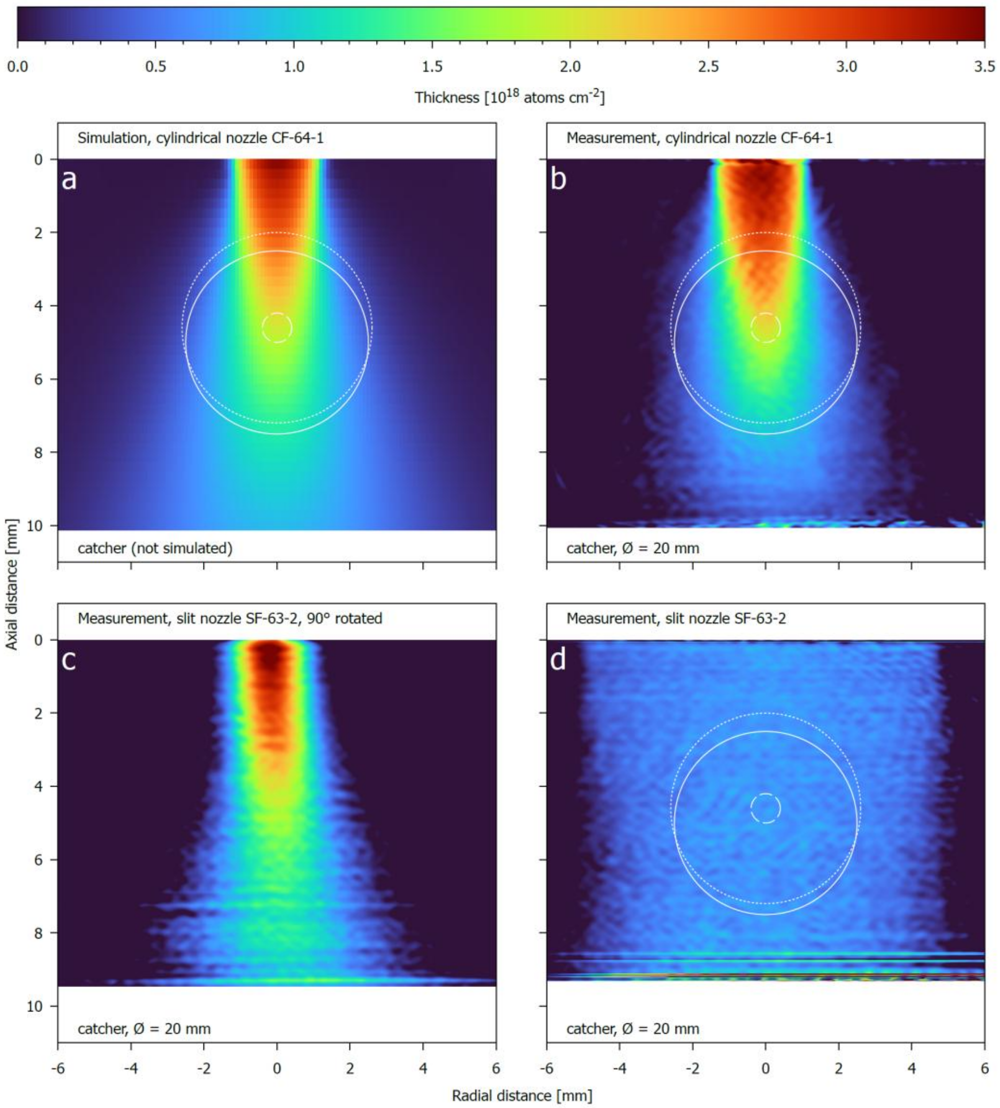
- Delivery 3.2 is fulfilled on time for the 24th month: Publication is published as a proceedings contribution of the Nuclear Physics in Astrophysics - X conference (NPA-X) EPJ Web of Conferences 279, 13002 (2023) and the paper is also available on arXiv: https://arxiv.org/abs/2210.15218

- Slit-type nozzles have been developed and tested.
- Continues gas-jet is achieved with suitable vacuum levels at other parts of the setup.
- Gas jet density dependence of the inlet pressure was measured with alpha energy loss and laser interferometry.
- Setup was installed and commissioned at Felsenkeller September 2024 to March 2025.
- First beam-time in April 2025 on $^{14}N(\alpha,\gamma)^{18}F$ using the new jet target.



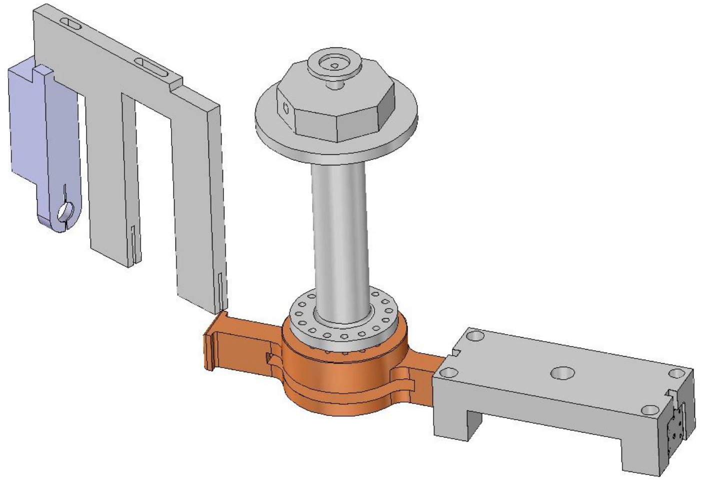
Gas-jet target developed at HZDR: (PI: Konrad Schmidt)

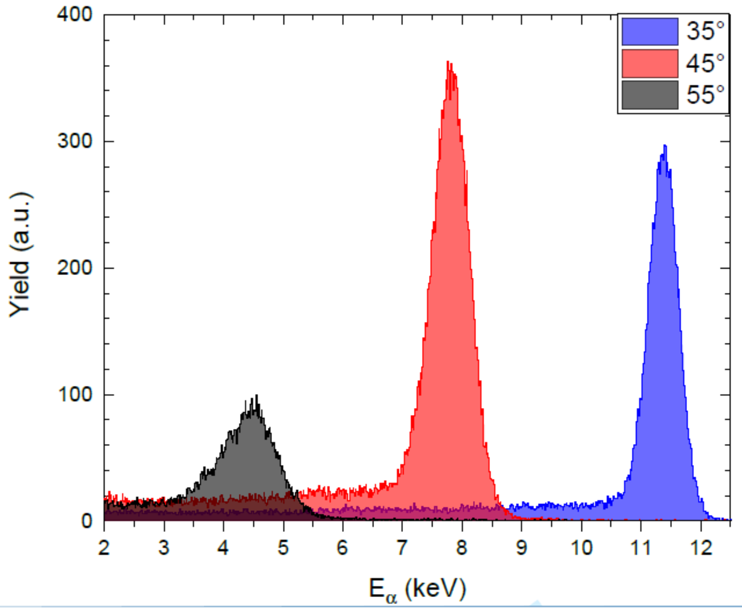
- A new publication (NIM A) is under way.
- Current setup status: On hold, since ongoing solid target experiments (**FelICITAS**, STELLA) are installed behind the gas target setup.
- Ongoing: Fine tuning the data reductions for the interferometric jet profile measurements.
- Planned for November 2025:
  - upgrading the system with a compressor, to achieve recirculation for the jet.
  - commissioning of the static gas target.
- Long term tasks:
  - Improve profiles of the slit-type nozzle to increase density of the homogeneous wall jet (new set of nozzles ordered from FMTC, Lithuania)
  - Improve shape of the catcher to reduce the residual gas (one new shape available and to be tested in November

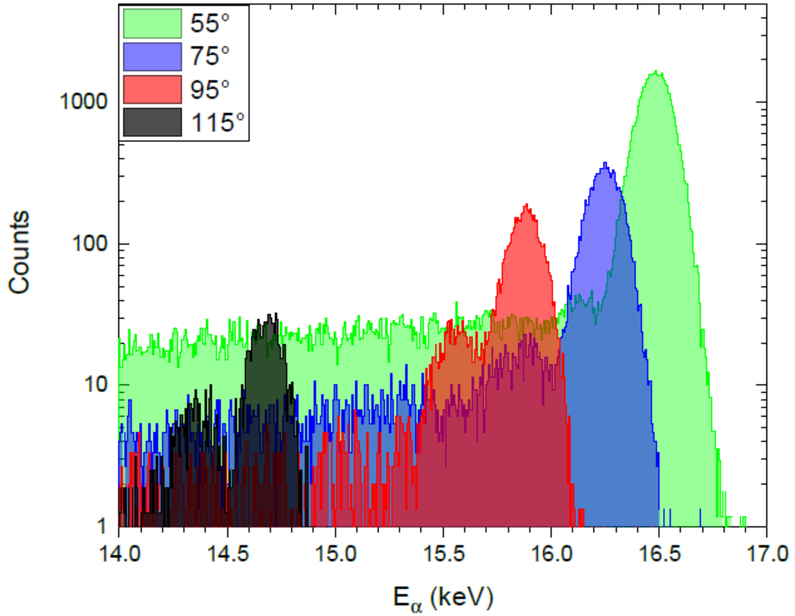


Gas-cell target developed at Atomki: (PI: Tamás Szücs)

- Delivery 3.8 is fulfilled on time for the 48th month:
  Publication is submitted as a regular article to EPJA and the paper is available on arXiv: https://arxiv.org/abs/2504.20128
- Angular distribution of alpha particles scattered on ^{4}He and on ^{124}Xe have been measured as pilot experimen.
- Further test and experiments are planned for this autumn.





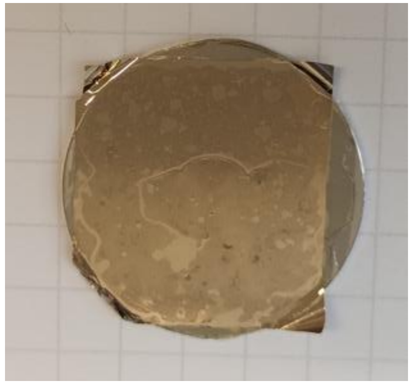


Gas-cell target developed at Atomki: (PI: Tamás Szücs)

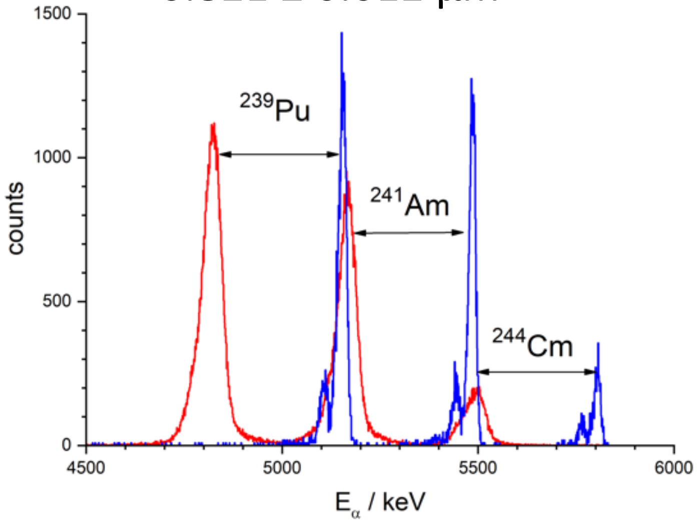
- Test version of the gas cell planned to be used for gamma-ray angular distribution measurement is produced.

- So far failing to have vacuum tight thin window, which is not produce disturbing beam induced background.

- Started to produce 1 µm thick nickel foils by electroplating copper.
- Promising results in terms of thickness, however the foil have still pinholes.



0.821 ± 0.012 µm



Task 3.3 General overview

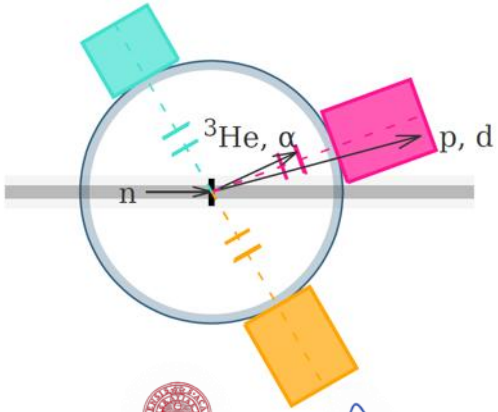
- Develop and test new neutron detector materials, such as composite scintillators, new plastics, etc. especially with low afterglow
- neutron-gamma discrimination capabilities
- new methodologies and algorithms for neutron/gamma discrimination
- Develop a read-out system based on SiPM or Photomultipliers that will allow to obtain a spatial resolution and to be used in environments with intense gamma flash

L. Swiderski, J.J. Valiente Dobon, R. Nolte, E. Pirovano, M. Dietz, A. Caciolli, D. Mengoni, R. Depalo, A. Gottardo, M. Grodzicka-Kobylka, J. Iwanowska-Hanke…

https://www.chetec-infra.eu/jra/neutrondetectordevelopment/

T3.3 – Neutron Detector Development

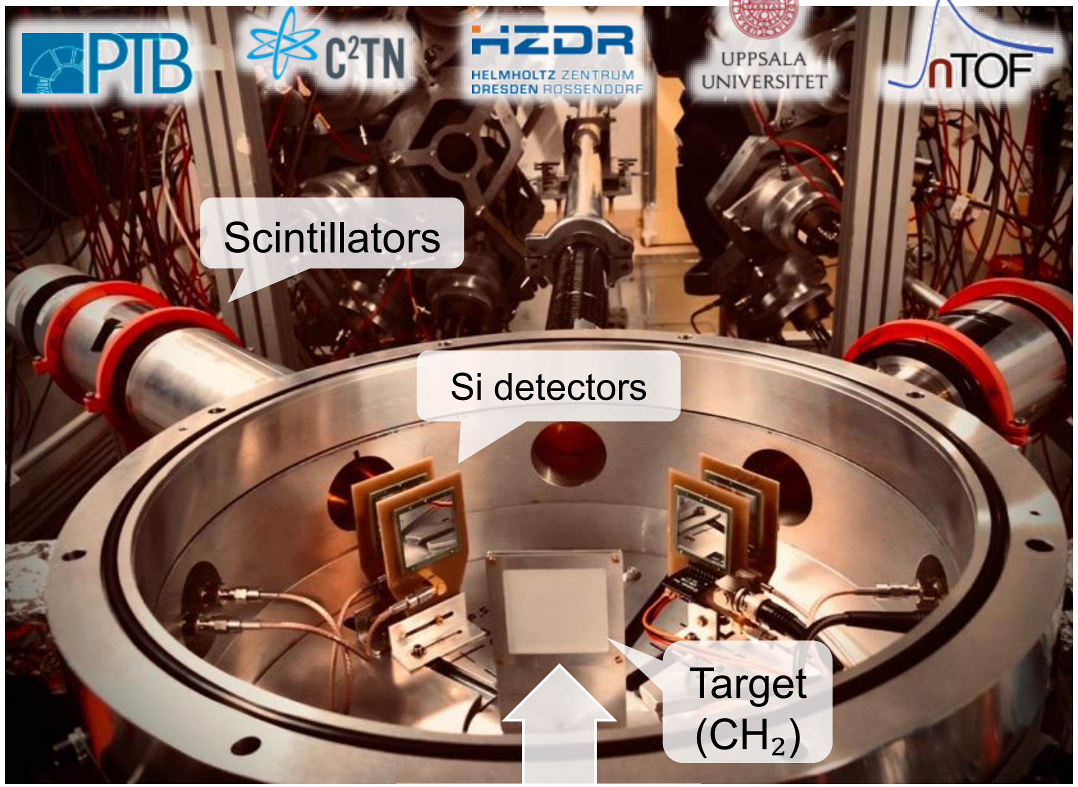
Neutron Detector Development at Pulsed Ultra-Strong Neutron Sources



- Development of instrumentation to be used at CERN, at the neutron spallation source n_TOF
- Detection of the neutron-induced emission of light charged particles, for high-energy incident neutrons (E_n > 100 MeV)

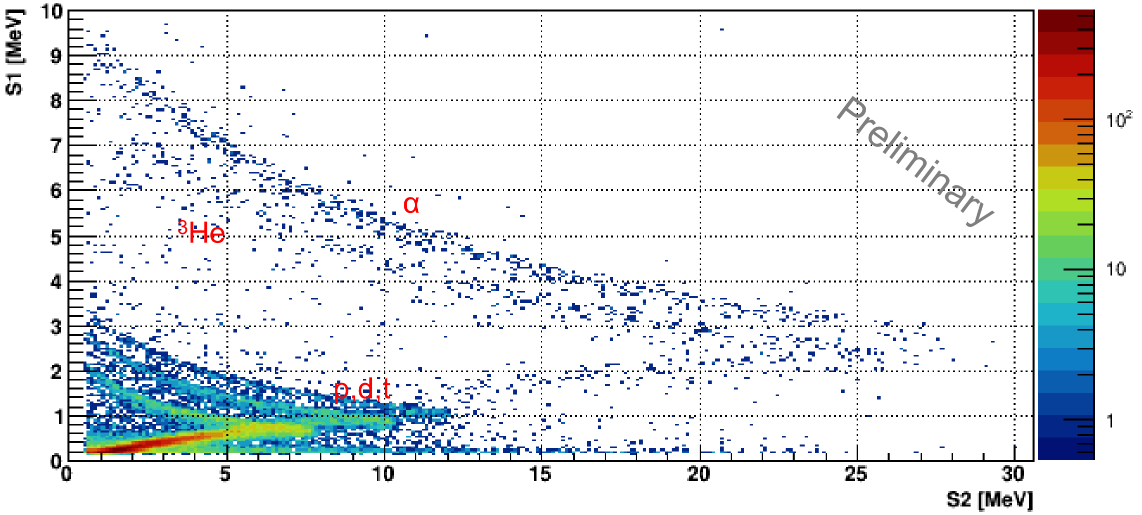
Main challenge:

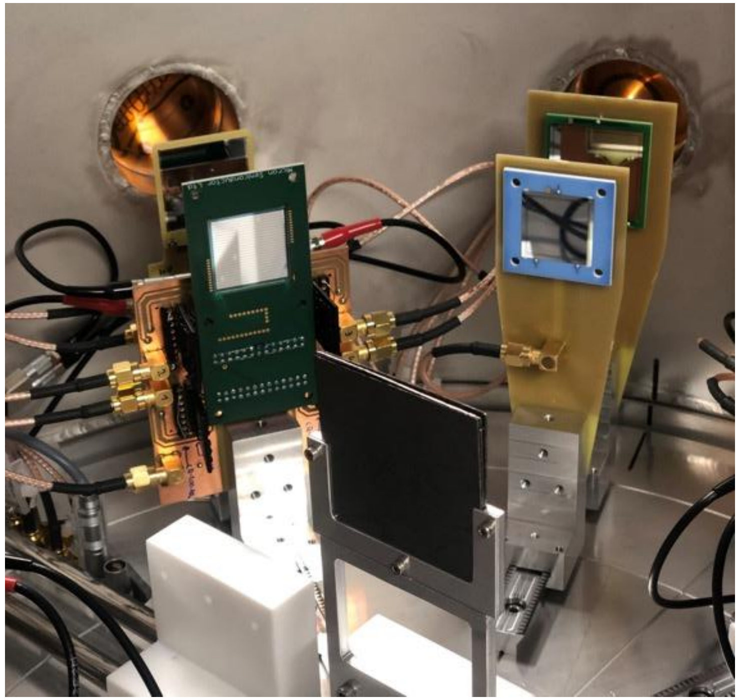
- E.m. interferences induced by the gamma flash (RF noise)
- Silicon semiconductor detectors are especially sensitive to it

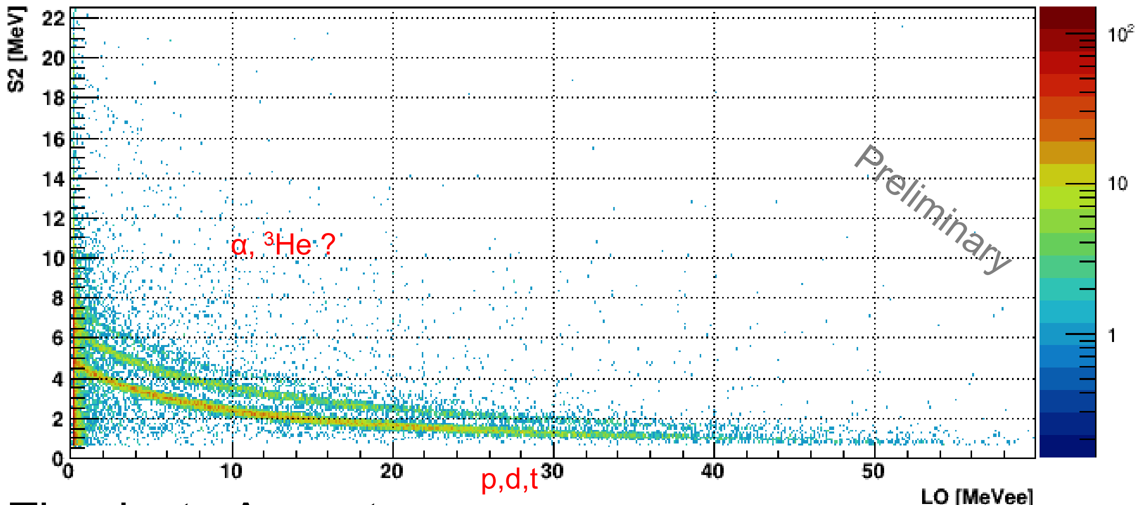


Neutron beam direction

Analysis:2 mm C-PTM2
S1: 60 μm (Stripped 4 ch.)
S2: 500 μm, E: EJ 10 cm





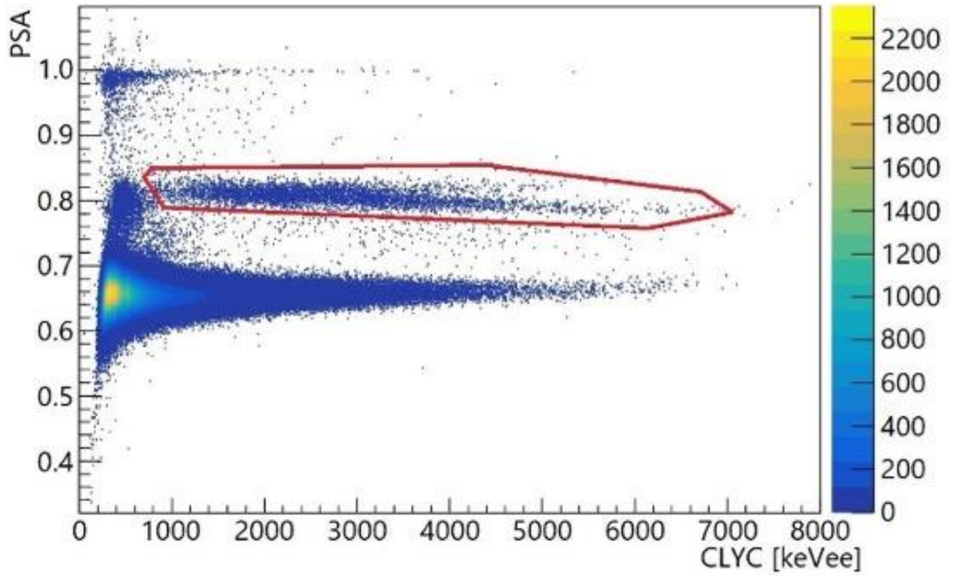


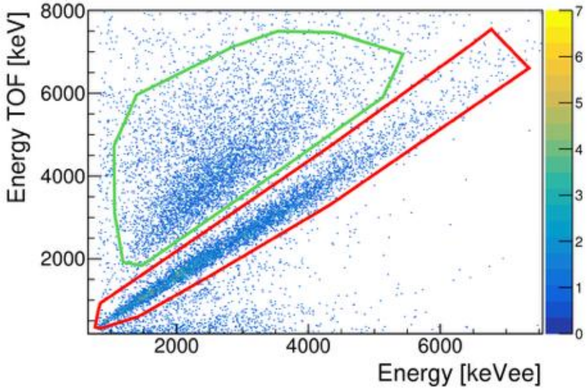
- Preliminary Results:
  - ➢ Excellent particle identification in the coincidence data between S1 and S2.
  - ➢ Good Light Output for E and good identification of H ions.

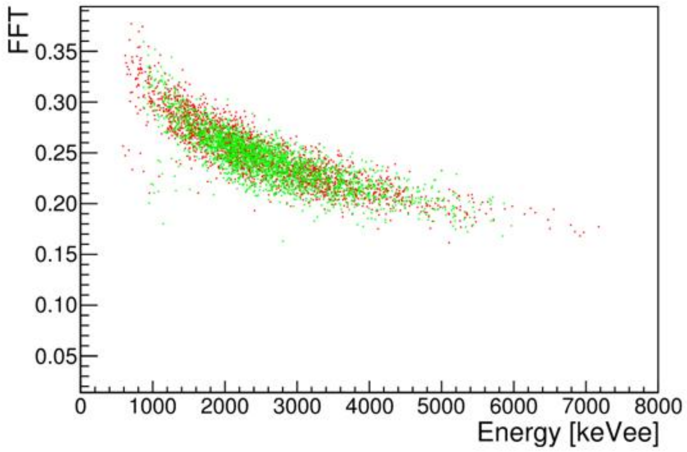
Thanks to Augusto

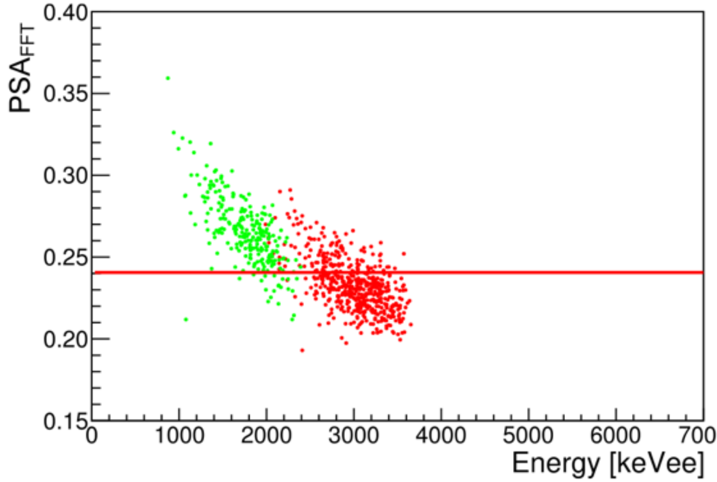
PSA for CLYC detectors

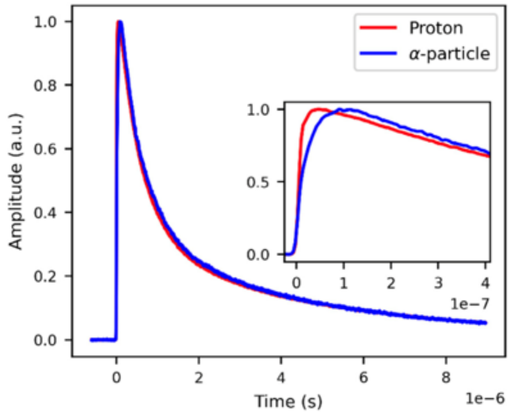
- ^{252}Cf source with CLYC and BaF$_2$ scintillator for gamma-particle coincidences
- TOF vs energy/light allows an event-by-even discrimination.
- Neutron-gamma discrimination with short vs long integration shows impressive results
- ^{35}Cl(n,p) and ^{35}Cl(n, alpha) discrimination is evident only above 4 MeVee





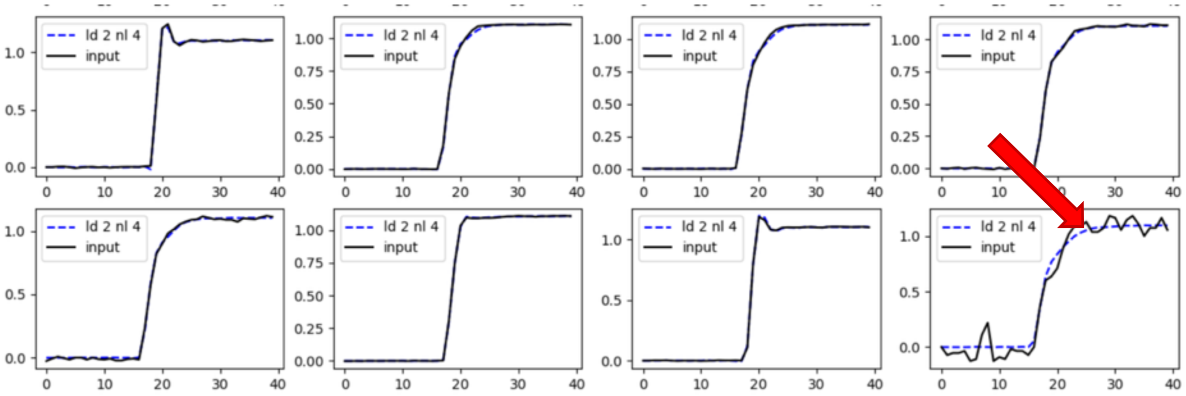


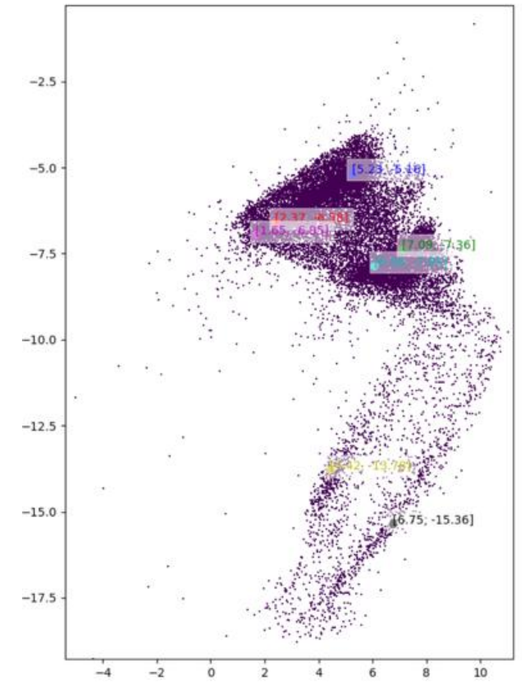


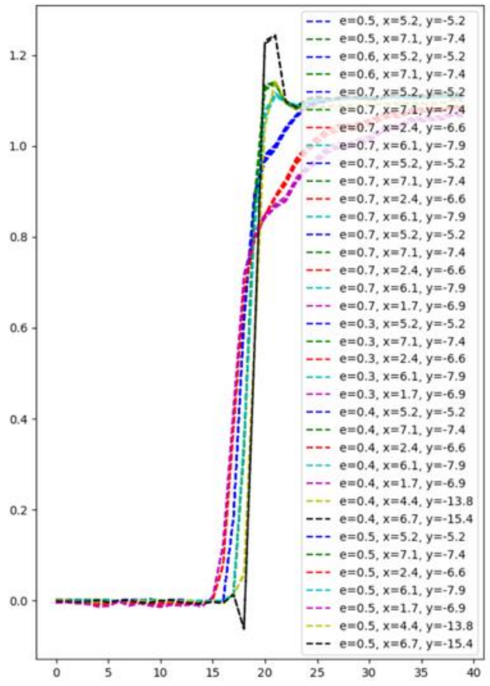


More sophisticated approaches based on FFT can separate only if the neutrons are restricted in a precise energy range

Unsupervised learning for PSA

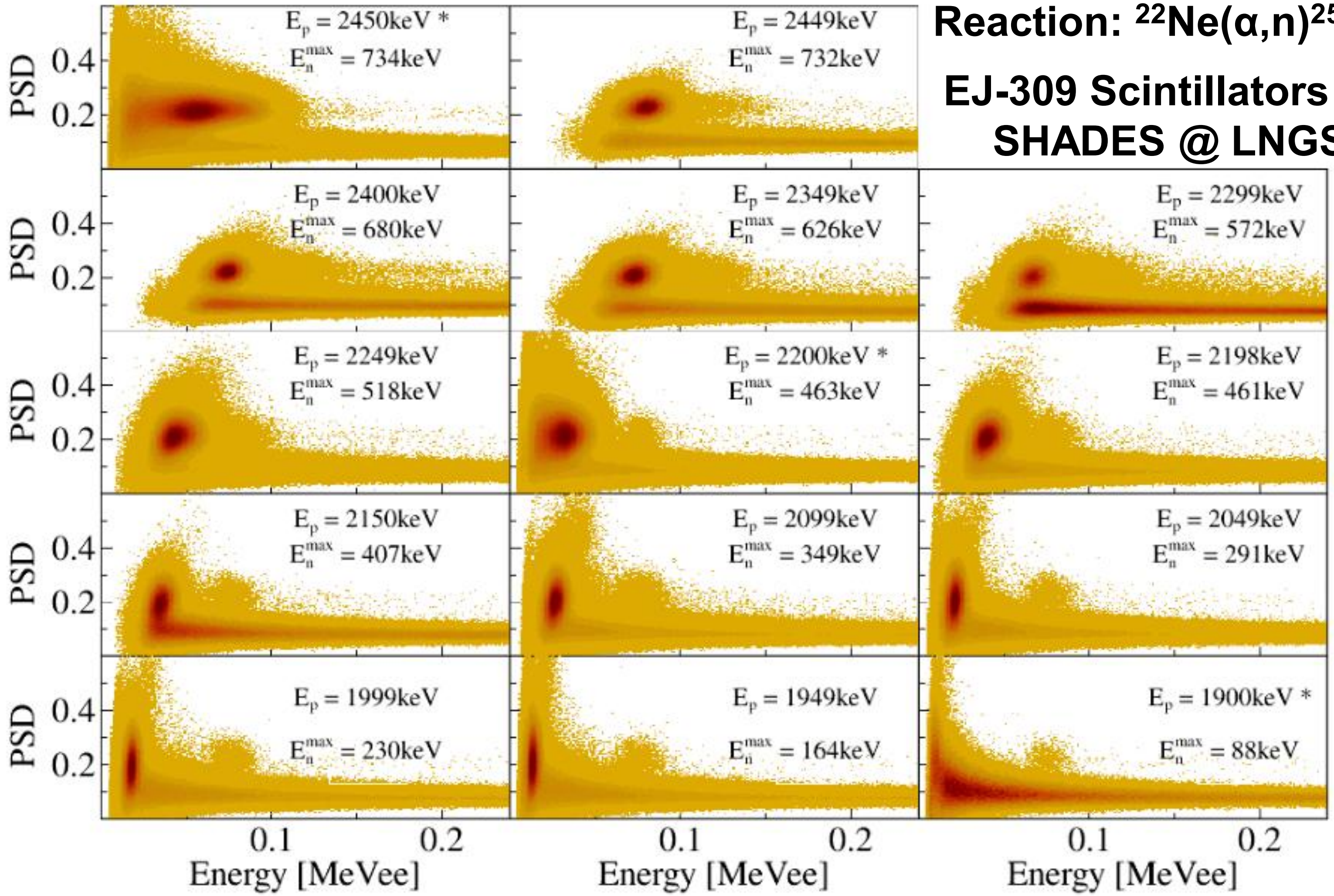






- Collaboration with the UNIPD team
- We have tested unsupervised learning on signals of silicon detectors
- The results indicate that a two-dimensional latent space is enough to encode all observed signals
- One can observe that different regions are correlated with different types of signal (different particles).
- Good performance for noise reduction
- Substituting the convolutional layers with fully connected ones seems to decrease the performance

Autoencoder for γ/n Discrimination



Reaction: ^{22}Ne(α,n)^{25}Mg

EJ-309 Scintillators for SHADES @ LNGS

Problem

Where to cut to discriminate between γ-rays and neutrons?

Autoencoder for γ/n Discrimination

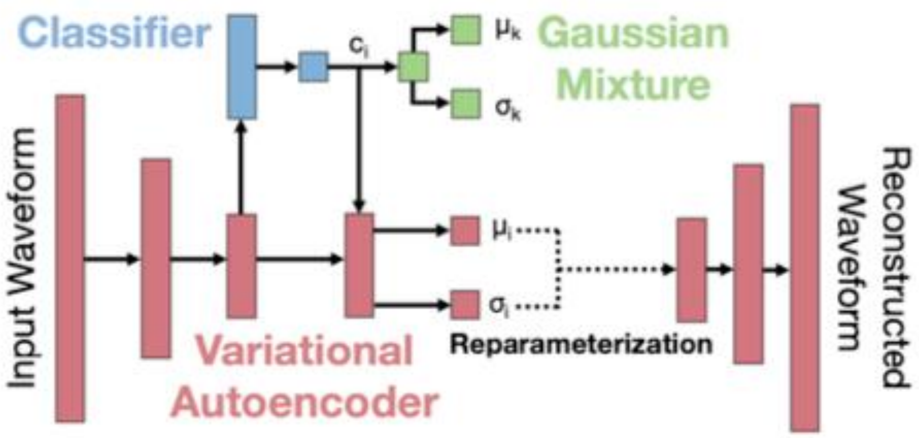


Figure 7: The architecture of the GMVAE developed for the purpose of PSD discrimination of the waveforms.

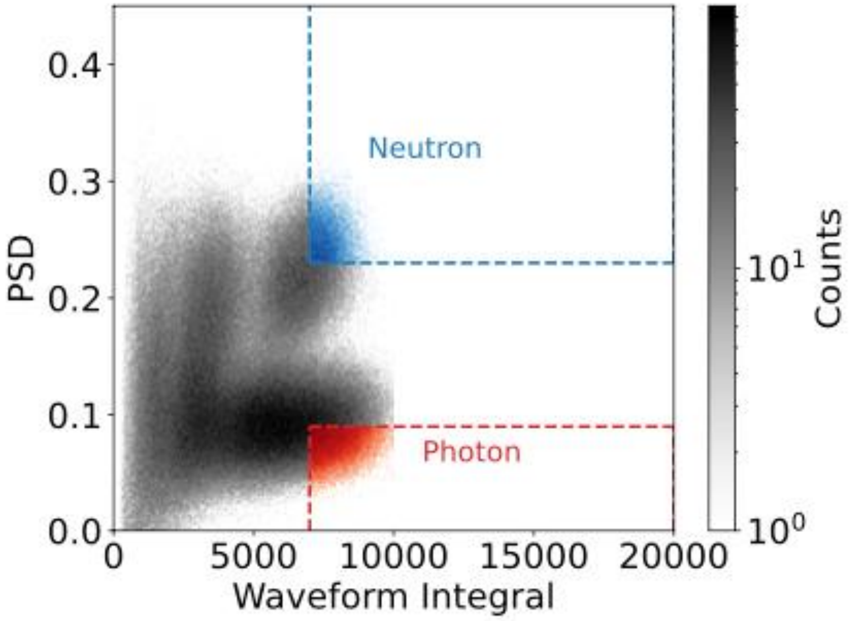
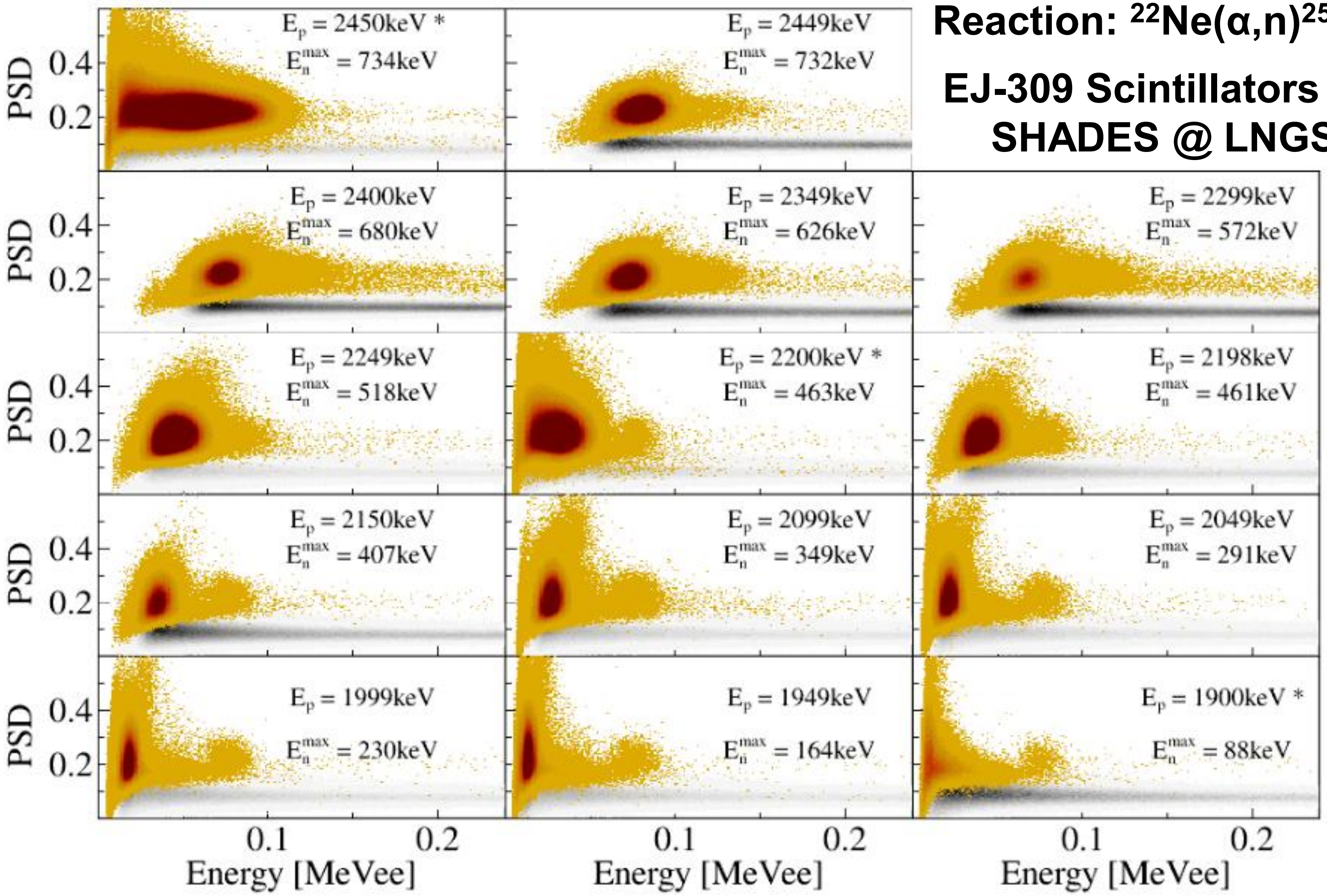


Figure 8: The data used to train the GMVAE model. The colored regions are the pre-tagged part of the data. (Refer to online plots for color).

Solution

Train a **Gaussian-Mixture Variational Autoencoder**

Autoencoder for γ/n Discrimination

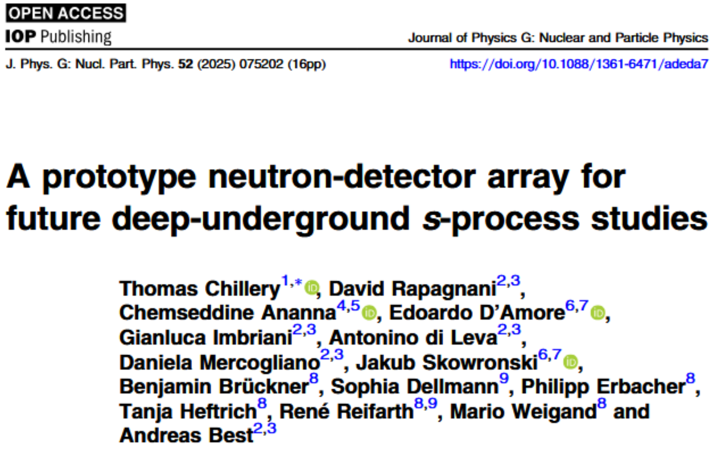


Reaction: $^{22}Ne(\alpha,n)^{25}Mg$

EJ-309 Scintillators for SHADES @ LNGS

It easily disentangles the two contributions even at lowest energies where classic PSD fails!

Bachelor Thesis – E. D'Amore



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Journal of Physics G: Nuclear and Particle Physics

J. Phys. G: Nucl. Part. Phys. **52** (2025) 075202 (16pp)

https://doi.org/10.1088/1361-6471/adeda7

A prototype neutron-detector array for future deep-underground *s*-process studies

Thomas Chillery[1,*], David Rapagnani[2,3], Chemseddine Ananna[4,5], Edoardo D'Amore[6,7], Gianluca Imbriani[2,3], Antonino di Leva[2,3], Daniela Mercogliano[2,3], Jakub Skowronski[6,7], Benjamin Brückner[8], Sophia Dellmann[9], Philipp Erbacher[8], Tanja Heftrich[8], René Reifarth[8,9], Mario Weigand[8] and Andreas Best[2,3]

T3.3 – Neutron Detector Development

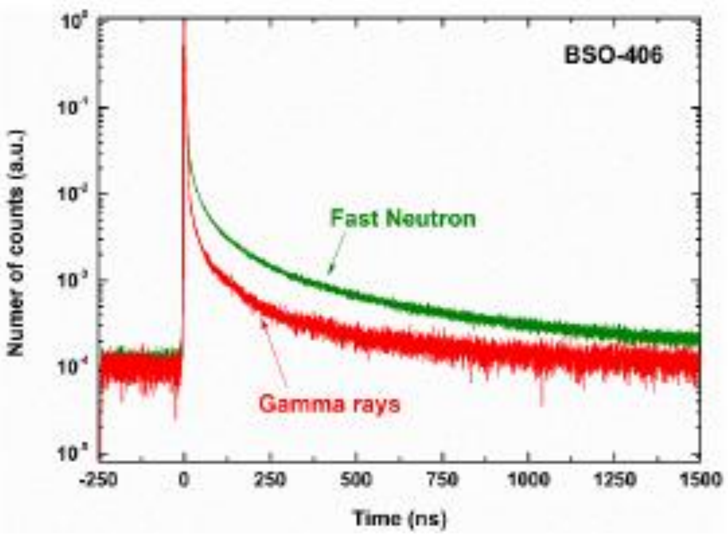
Comparison of an OGS/Polystyrene scintillator (BSO-406) with pure OGS (BSO-100), EJ-276, EJ-309, and M600 scintillators.

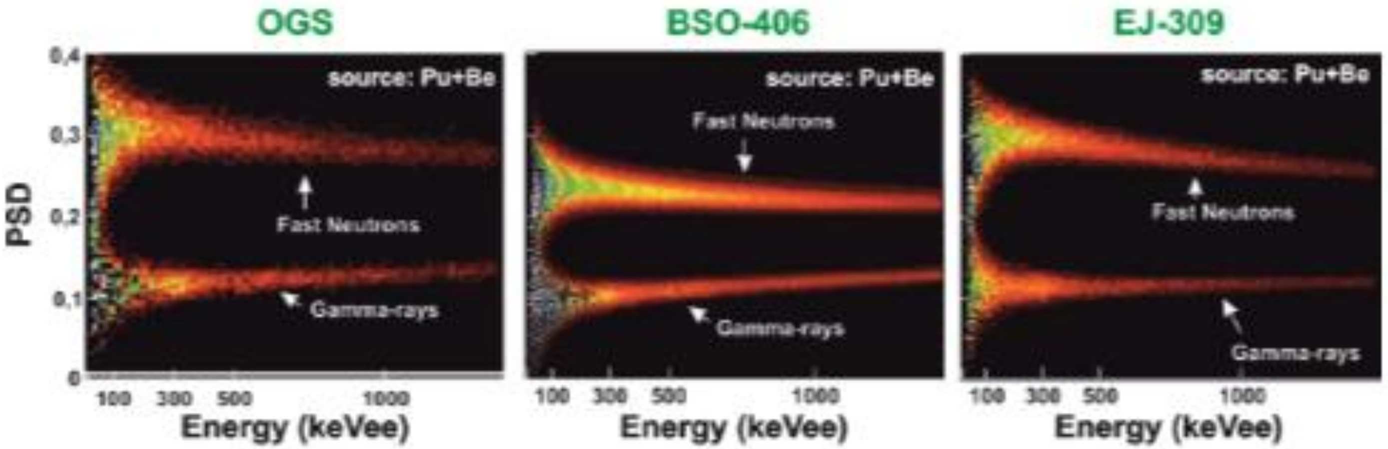
M. Grodzicka- Kobylka [a 1], T. Szczesniak [a], L. Adamowski [a], L. Swiderski [a], K. Brylew [a], A. Syntfeld-Każuch [a], W.K. Warburton[b], J.S. Carlson [b], J.J. Valiente-Dobón [c],

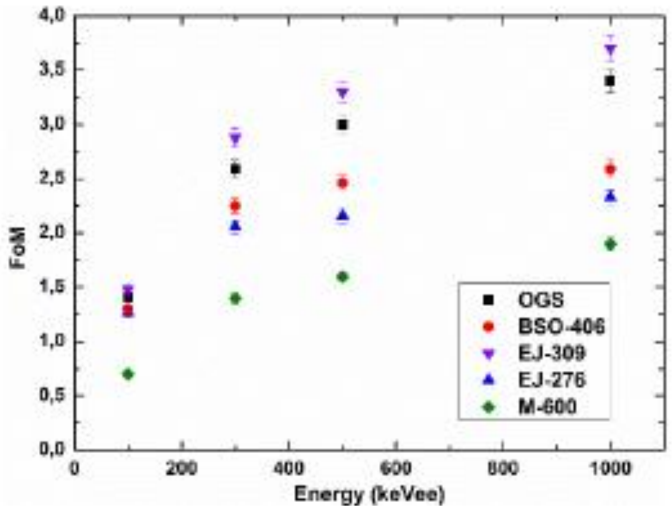
[a] *National Centre for Nuclear Research, A. Soltana 7, PL 05-400 Świerk-Otwock, Poland*

[b] *Blueshift Optics LLC, 2744 E 11th St., Ste H2, Oakland, CA 94601-1443, United States of America*

[c] *INFN, Laboratori Nazionali di Legnaro, I-35020 Legnaro, Italy*

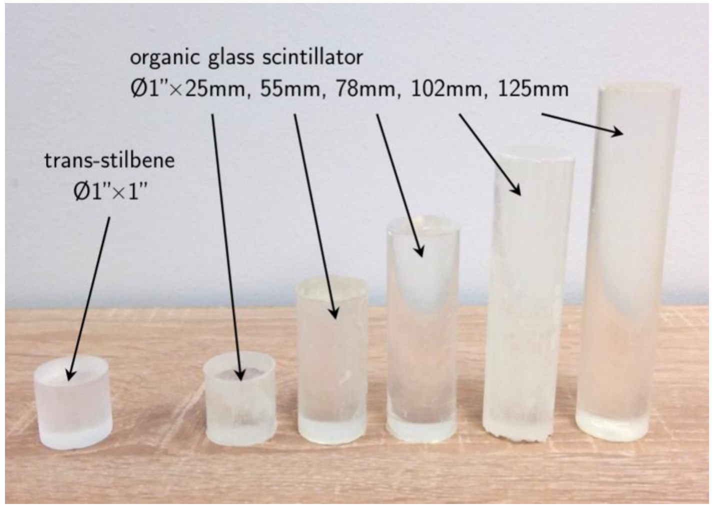






NCBJ ŚWIERK

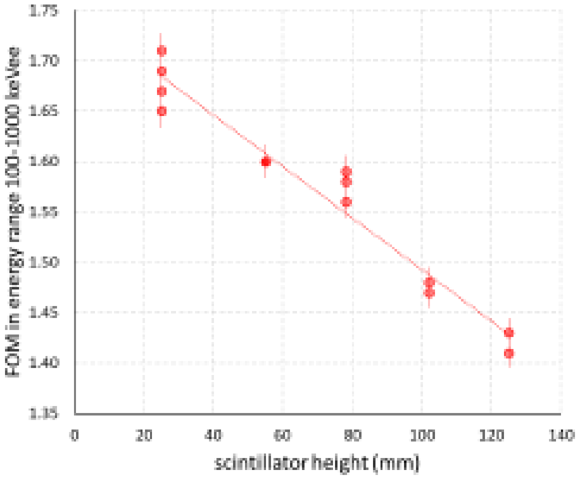
T3.3 – Neutron Detector Development

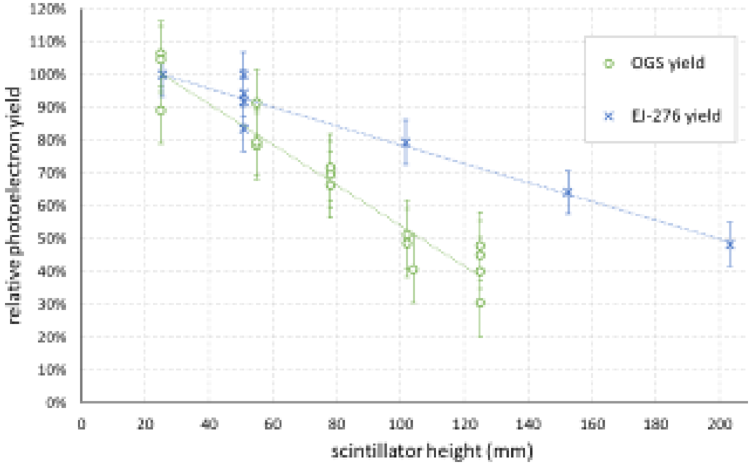


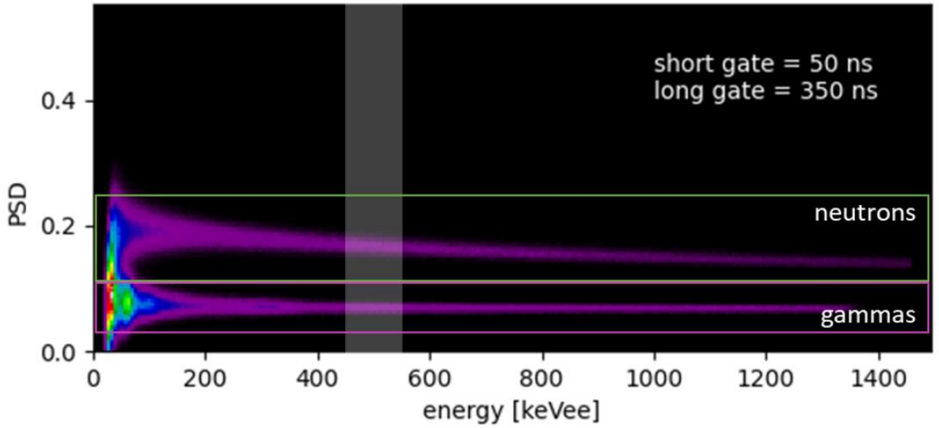
Influence of Self-Absorption on Pulse Shape Discrimination in Organic Glass Scintillators

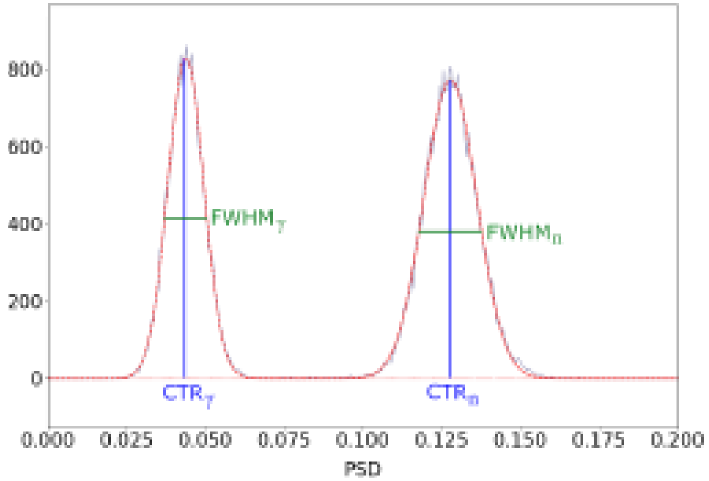
Lukasz Adamowski[1,2], Martyna Grodzicka-Kobylka[1], Tomasz Szczesniak[1], Agnieszka Syntfeld-Każuch[1], Lukasz Swiderski[1], and Adam Kisiel[2]

[1]National Centre for Nuclear Research (NCBJ), Otwock-Swierk, Poland
[2]Faculty of Physics, Warsaw University of Technology, Warsaw, Poland







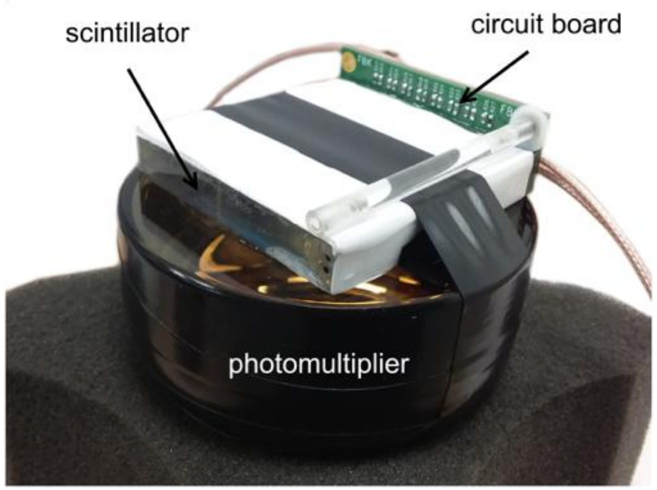


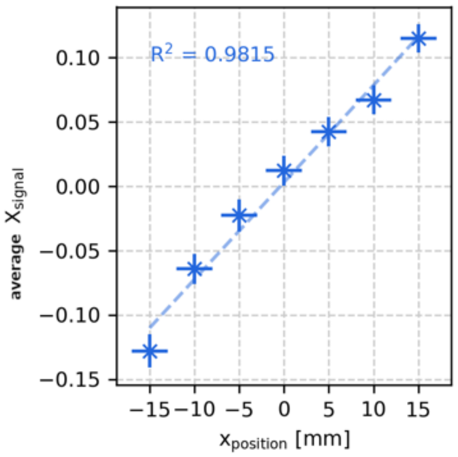
T3.3 – Neutron Detector Development

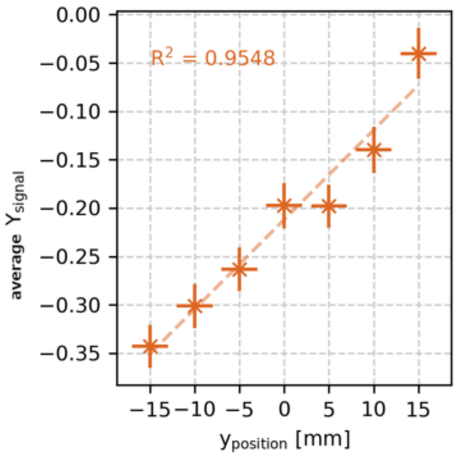
Positional signals can be approximated by linear combinations of 4 positional outputs.

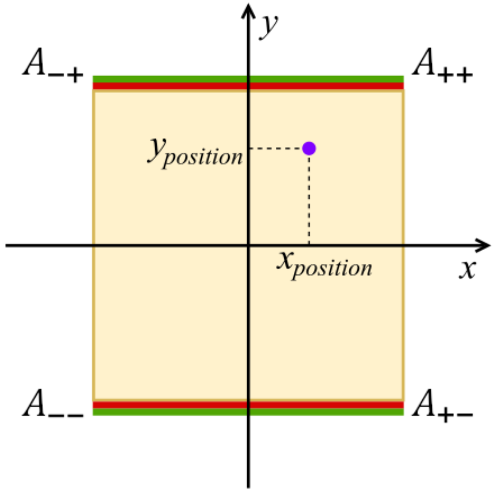
$$X_{signal} = -A_{-+} + A_{++} + A_{+-} - A_{--}$$
$$Y_{signal} = +A_{-+} + A_{++} - A_{+-} - A_{--}$$

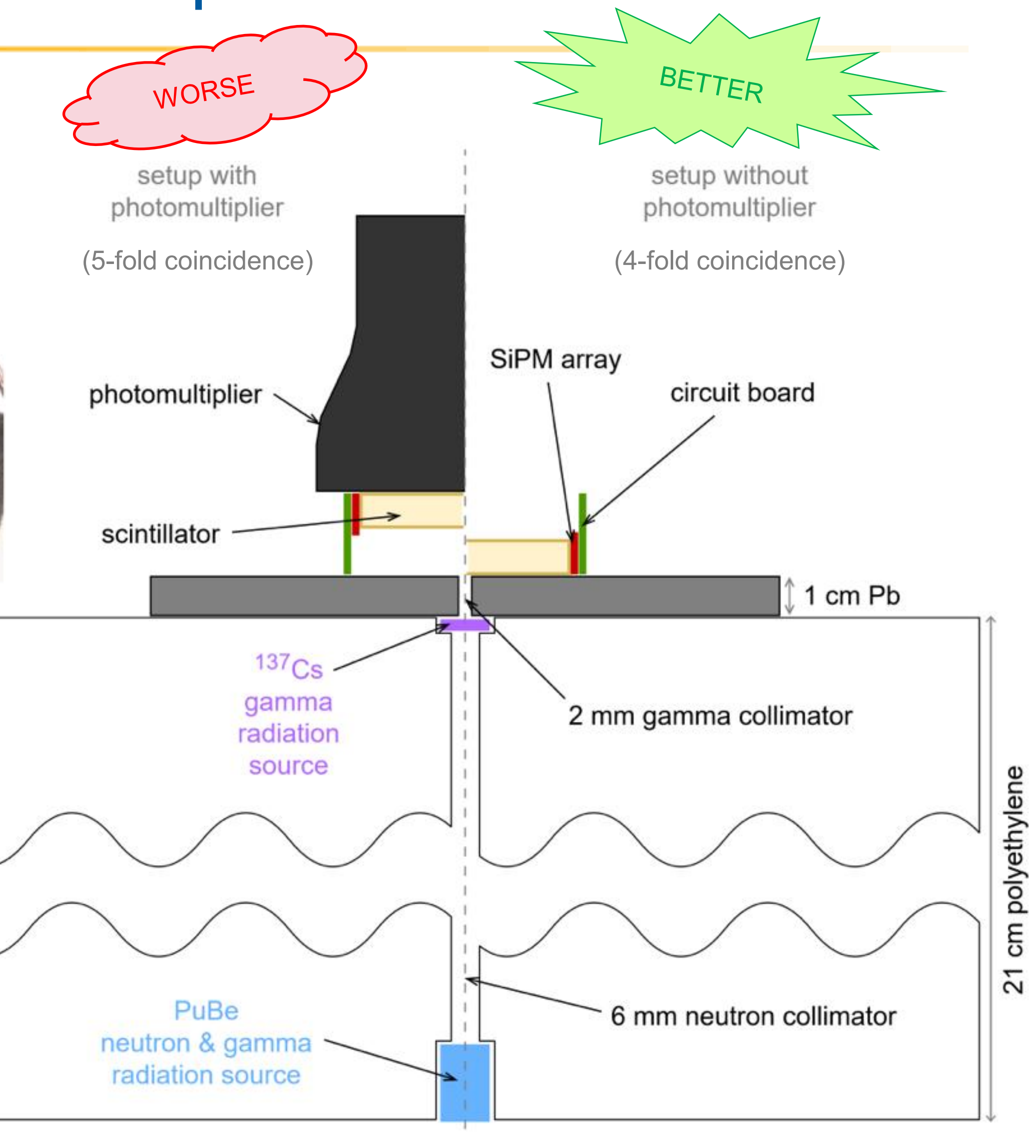
Averaged positional signals exhibit correlation with real position of ^{137}Cs gamma radiation in the detector.











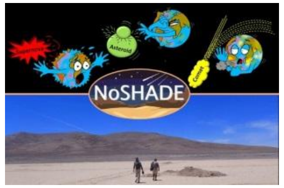
Task 3.4 General overview

Chemical element sensitive accelerator mass spectrometry

(PI: Robin Golser/UNIVIE, participants: HZDR)

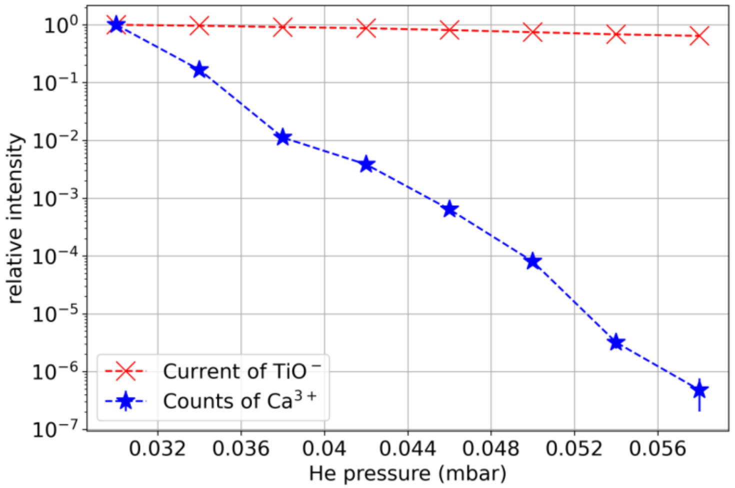
- development of techniques to access the nuclear charge of the isotope to be provided for accelerator mass spectrometry (AMS), e.g., by ion-gas or ion-laser-interaction
- development of shared, community-accepted protocols for extracting non-routine AMS isotopes, which have high astronuclear relevance such as ^{7}Be, ^{44}Ti and ^{55}Fe

Task 3.4 – Cosmogenic nuclides (some via TNA) – using ILIAMS



- **^{26}Al** with J. Feige, Berlin
  "Detection of past close-by Supernovae:
  Depositional age dating of Atacama Desert soils with meteoric ^{26}Al"

- **^{44}Ti** with Felsenkeller & U Vienna MSc
  produced in core collapse supernovae via ^{40}Ca(α,γ)^{44}Ti
  - $t_{1/2}$ ~59 a → AMS to validate γ-data (Schmidt et al., 2013)
  - challenging as ^{44}Ca is isobar of ^{44}Ti
    - → 10^6 suppression of $CaO^–$ by gas cell (He)
    - → 10^5 suppression of $CaO^–$ by OPO laser (420 mW)
    - → 10^2 suppression of Ca^{3+} in detector



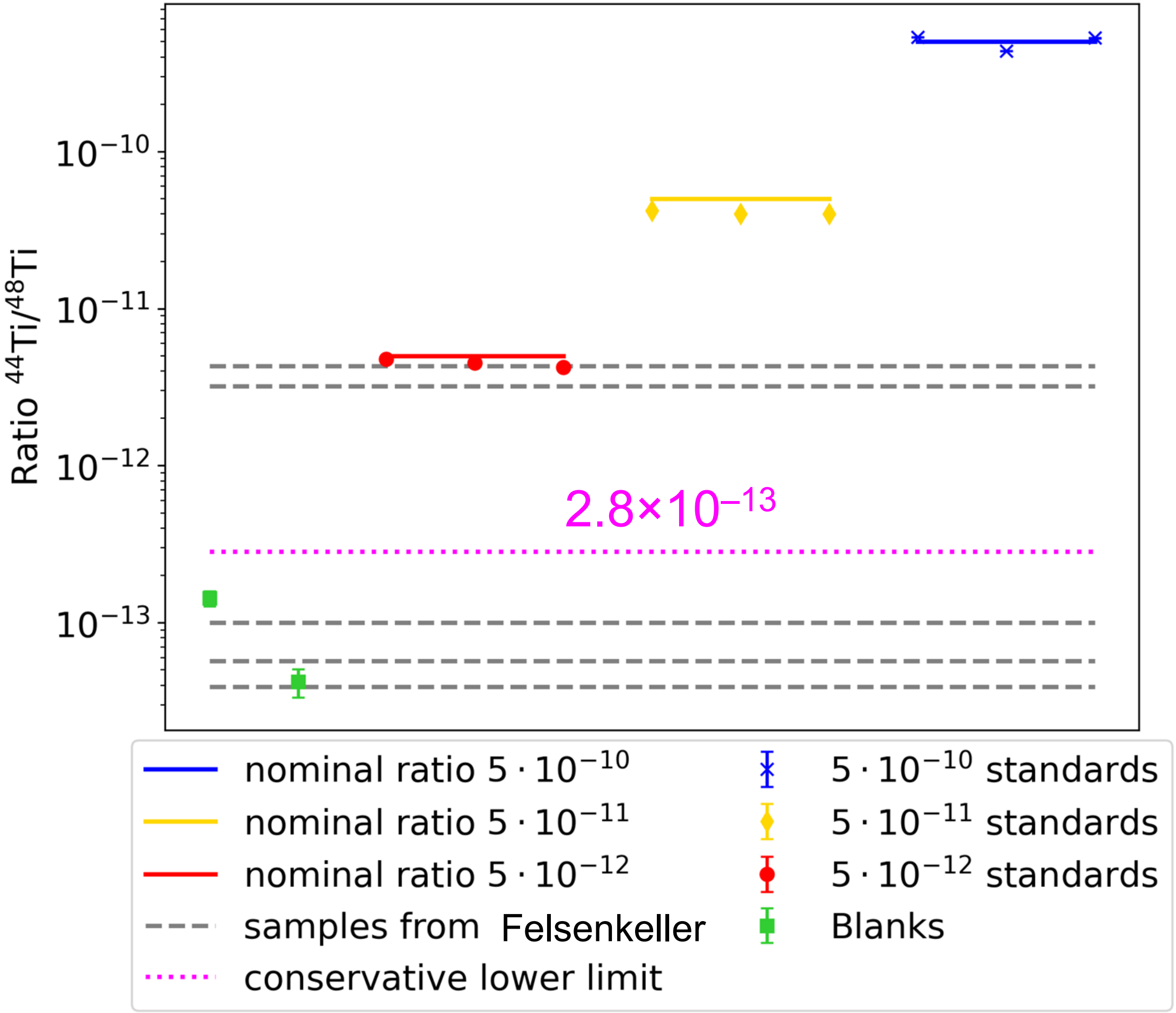
https://www.museumfuernaturkunde.berlin/en/science/novel-perspectives-our-solar-system-history-recorded-atacama-desert-noshade
https://www.sabre-experiment.org.au/
https://idw-online.de/de/image?id=391934

Task 3.4 – Cosmogenic nuclides (some via TNA) – using ILIAMS

- **^{44}Ti** with Felsenkeller & U Vienna produced in core collapse supernovae a ^{40}Ca(α,γ)^{44}Ti

→ ^{44}Ti AMS measurements of irradiated Ca samples possible @VERA when using He gas, laser & segmented detector

→ very low ratio samples not yet



https://www.museumfuernaturkunde.berlin/en/science/novel-perspectives-our-solar-system-history-recorded-atacama-desert-noshade
https://www.sabre-experiment.org.au/
https://idw-online.de/de/image?id=391934

Task 3.4 – Cosmogenic nuclides (some via TNA) – using ILIAMS

- **^{26}Al** & **^{41}Ca** in stony meteorites for meteoroid geometry & identification of meteor-wrongs
  - Elmshorn (H3-6) **Bischoff et al., *MAPS* 2024**
  - Ribbeck (aubrite) **Bischoff et al., *MAPS* 2024b**
  - Haag (LL4-6) **Bischoff et al., subm. to *MAPS*.**
  - “not-Dyalpur” (terrestrial) **Pittarello et al., *MAPS* 2025**
  - asteroid 2023 CX1 → Saint-Pierre-le-Viger **Egal et al., accept. *Nature Astronomy* 2025**

Universität Münster

Meteoritics & Planetary Science

naturhistorisches museum wien

- **^{36}Cl** & **^{41}Ca** in iron meteorites for terrestrial age
  - “Issigau-Reitzenstein” (29.1 ka)
  - Agoudal, El Ali, Hoba,… & “ebay-fakes”

Bayerisches Landesamt für Umwelt

Sonderausgabe

Meteorit Issigau-Reitzenstein

Ergänzung zum Buch

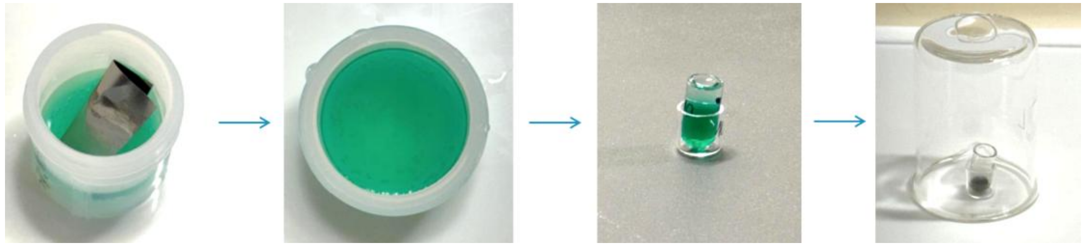
Nicht von dieser Welt

Bayerns Meteorite

→ **^{59}Ni test materials**

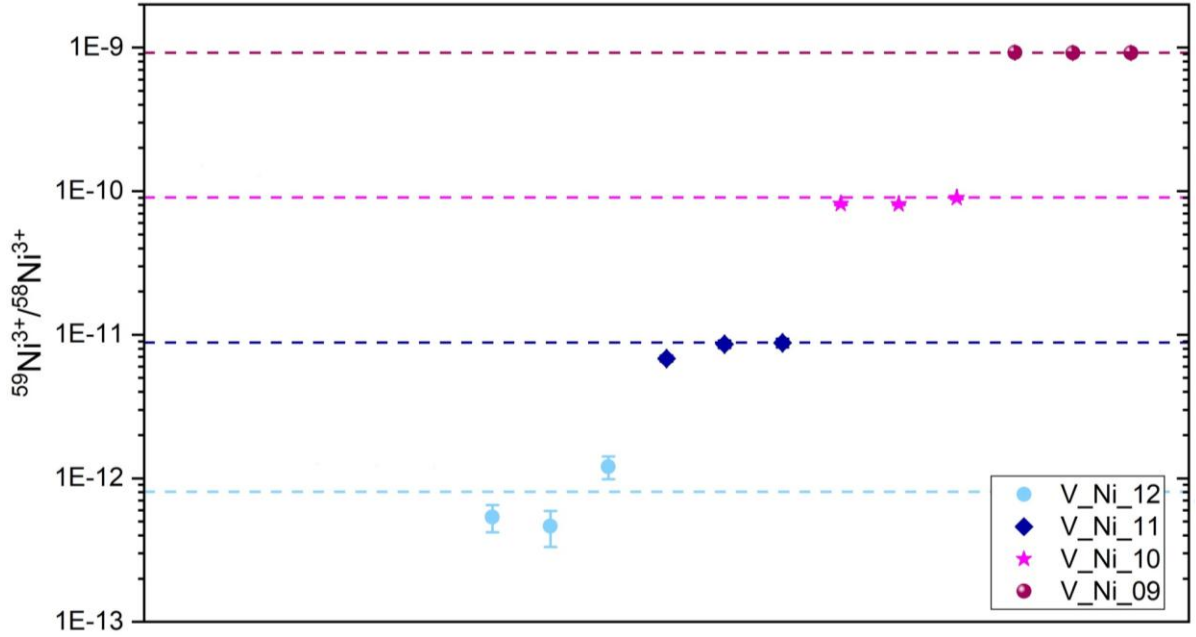
Task 3.4 – Cosmogenic nuclides – using ILIAMS

- **^{59}Ni** ($t_{1/2}$ ~0.1 Ma) for determination of long terrestrial ages of meteorites



→ production of standards
via $^{58}Ni(n,\gamma)^{59}Ni$

→ NiF_2^-
most promising isobar suppression with 532 nm laser; yield not optimal



→ detection limit @10^{-12}

→ samples @10^{-11} – $5·10^{-13}$

Task 3.4 – "Other" nuclides (via TNA)

- **^{210}Bi** with A. Wallner, HZDR-AMS
  "Precise measurement of the ^{209}Bi(n,γ)^{210m}Bi cross section at thermal and keV neutron energies using AMS"

- **^{210}Pb** with D. Koll, HZDR-AMS
  "Pb-210 AMS development for the key background in the search for dark matter"
  - 1 kg NaI detector material + 1 mg ^{nat}Pb → $1 \cdot 10^{-14}$
  - lowest detection limit world-wide,
    i.e. @1 MV AMS, ANSTO (Fröhlich et al., 2022): $2 \cdot 10^{-14}$
  - blank level of Roman lead @VERA: $< 3 \cdot 10^{-16}$

https://www.museumfuernaturkunde.berlin/en/science/novel-perspectives-our-solar-system-history-recorded-atacama-desert-noshade
https://www.sabre-experiment.org.au/
https://idw-online.de/de/image?id=391934

THANKS FOR YOUR ATTENTION