5th General Assembly and TA User Meeting

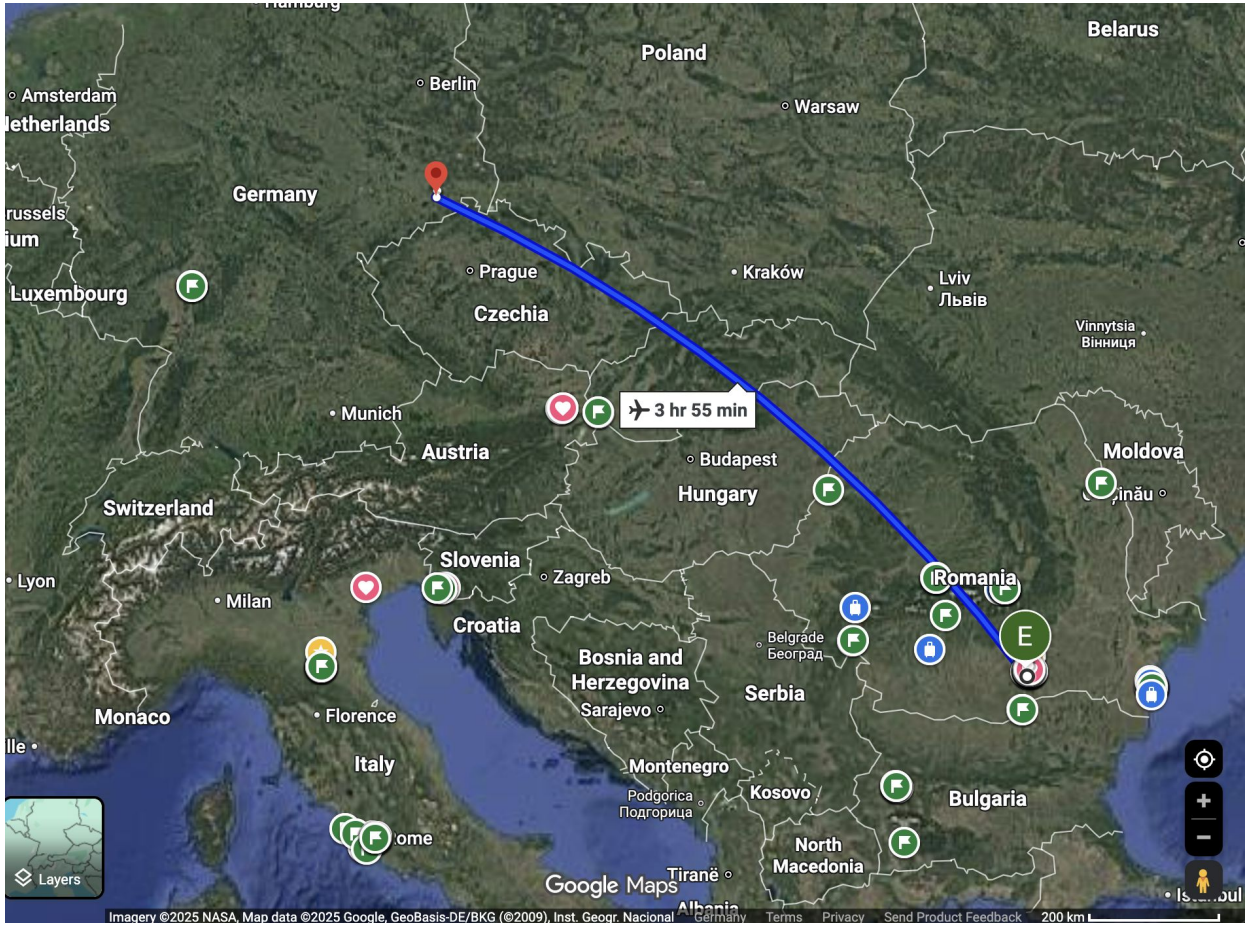
TNA @ IFIN-HH

Mihai Straticiuc
ChETEC-INFRA local contact at facility
on behalf of the NA Group (NAG)

REVEALING THE SECRETS OF NATURE

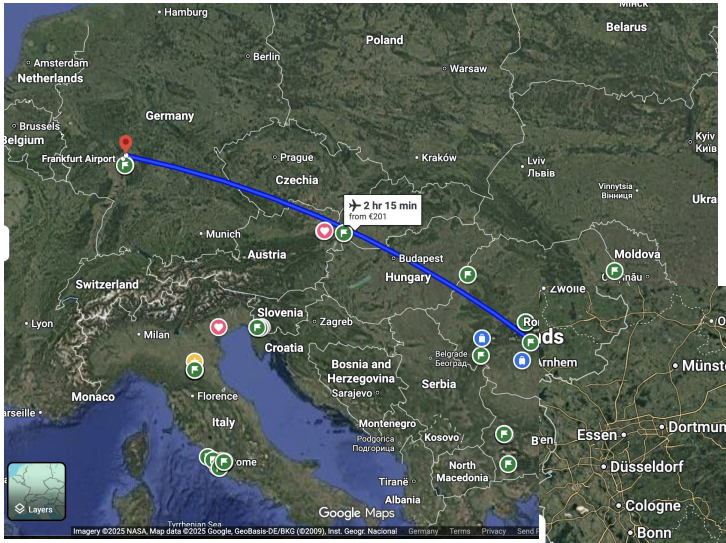
Applied Nuclear Physics Department
Horia Hulubei National Institute for R&D in Physics and Nuclear Engineering
https://dfna.nipne.ro/ https://www.facebook.com/DFNA.IFIN.HH

IFIN-HH to Dresden (~4h, in theory)



IFIN-HH to Dresden (via Frankfurt)

(~ 12 h, in practice)



Bucharest-Magurele Physics Campus

A Brief History of Accelerators at IFIN-HH

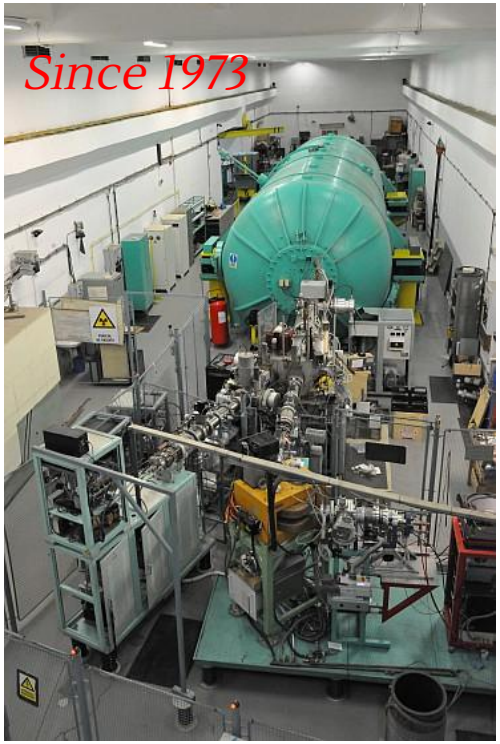
Cyclotrons

U-120 13 MeV/amu - p, d, α

ACSI TR19 19 MeV – protons

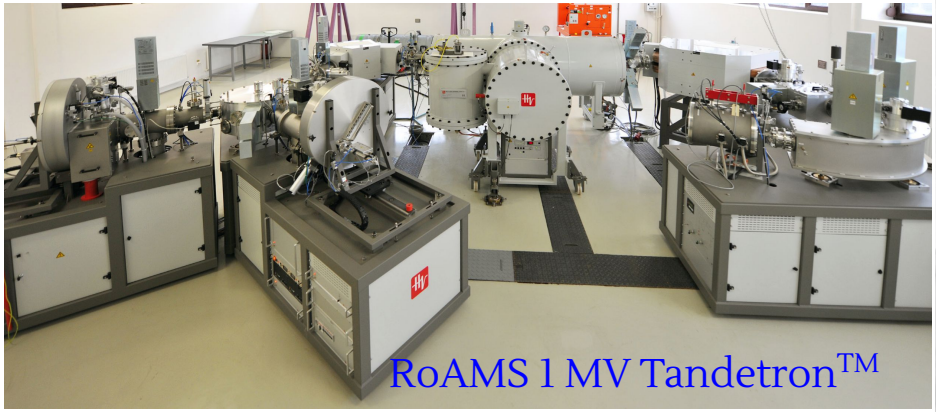
A Brief History of Accelerators at IFIN-HH

Tandems



9 MV FN Pelletron tandem

Since 2012



Tandem Accelerators Complex

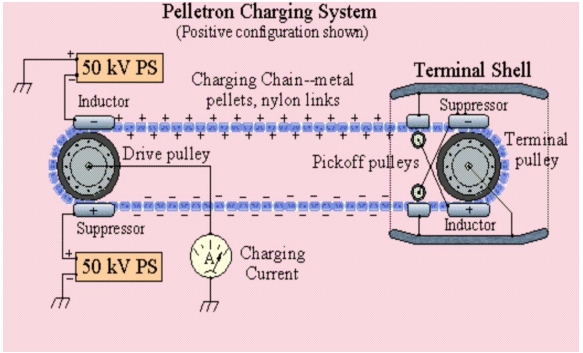
User Office - https://useroffice.nipne.ro/

Transnational Access:

https://www.chetec-infra.eu/ta/tna-labs/ifin-hh/

https://useroffice.nipne.ro/eurolabs.php

Status of the HVEC FN 9 MV Tandem



- 75 μA to terminal (150 μA in 6 atm of SF_6)
- 15 m/s

~ 6000 h/year , experimental program approved by a PAC.

Many requests (200% beam time) for basic research (nuclear structure studies)
 necessity for new accelerators dedicated to applied nuclear physics (IBA, AMS, ion implantation, etc.).

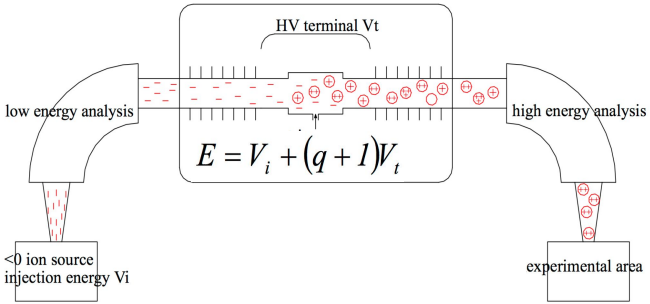
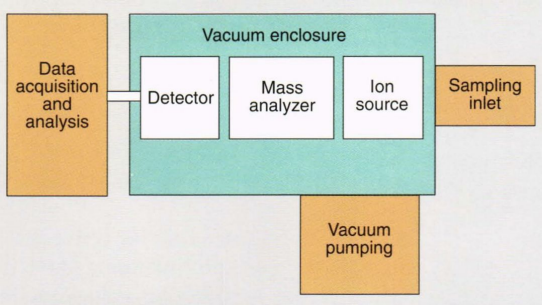


Fig. 2. View of the ROSPHERE array in the configuration used for the ^{119}Te experiment. The array is shown in the open position, with the endcap of the plunger device visible in the centre.

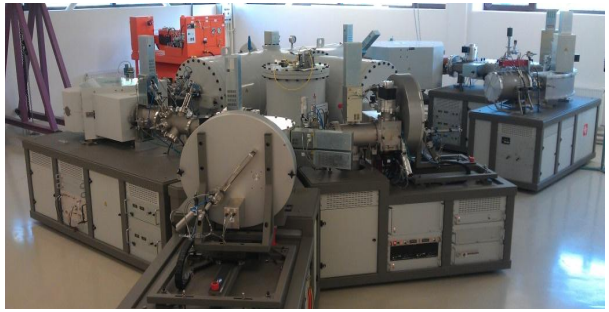
Ion Beams for Applications
Accelerator Mass Spectrometry (AMS)

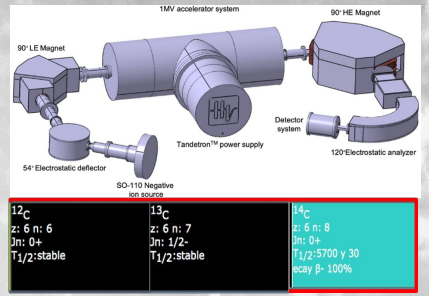


Block diagram of a mass spectrometer system

JOHNS HOPKINS APL TECHNICAL DIGEST, VOLUME 16, NUMBER 3 (1995)

- AMS is a very **powerful spectrometric tool** (e.g. $^{129}I/^{127}I \sim 10^{-13}$; $^{14}C/^{12}C \sim 10^{-15}$)
- AMS requires **small samples** (~ mg) → (cvasi)nondestructive technique
- AMS **counts atom by atom** → short DAQ times (~ tens of minutes/sample)

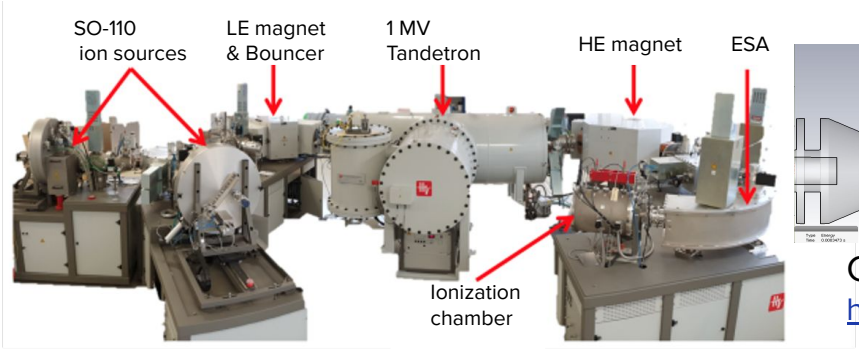


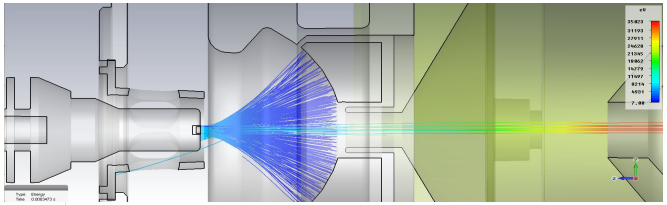


Accelerator Mass Spectrometry (AMS)

1 MV Tandetron™

~ 1500 h/y

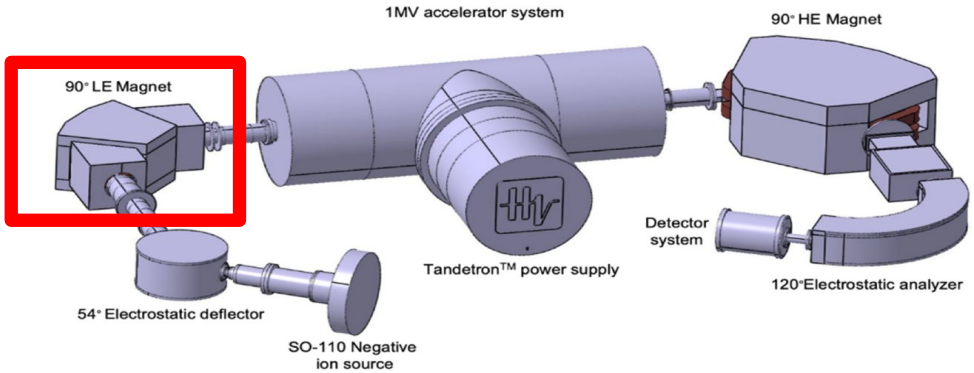




Cs Ion sputtering source simulation, https://www.cst.com/

Bouncing system

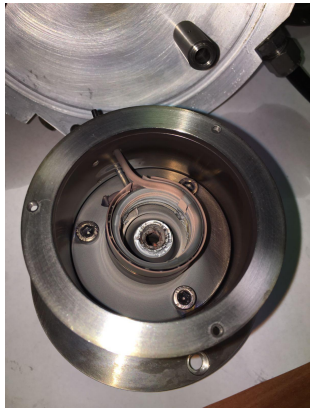
Quasi-simultaneous injection (^{129,127}I), (^{14,13,12}C), (^{10,9}Be), (^{26,27}Al)



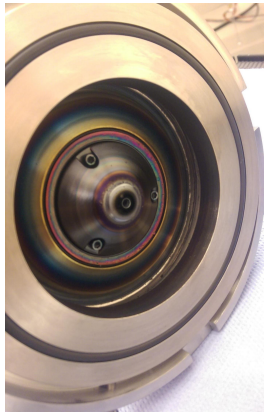
D.G. Pacesila, Accelerator Mass Spectrometry in the Actinides Field, Ph.D. Thesis, Polytechnic University of Bucharest, 2019.

Ions for "non-AMS" Applications

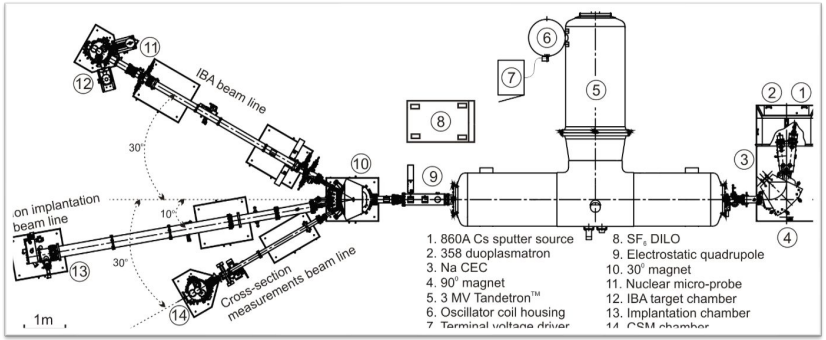
3 MV Tandetron™



860 Cs Sputtering Ion source



358 Duoplasmatron



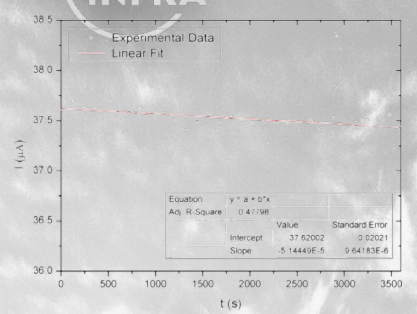
358 "Duoplasmatron" Source

$^{1}H^{-}$	> 40 μA
$^{4}He^{-}/^{3}He^{-}$	> 3 μA

860A Sputter Source

$^{11}B^{-}$	>40 μA
$^{12}C^{-}$	>80 μA
$^{16}O^{-}$	>80 μA
$^{28}Si^{-}$	>80 μA
$^{31}P^{-}$	>40 μA
$^{58}Ni^{-}$	>70 μA
$^{63}Cu^{-}$	>70 μA
$^{75}As^{-}$	>10 μA
$^{197}Au^{-}$	>80 μA

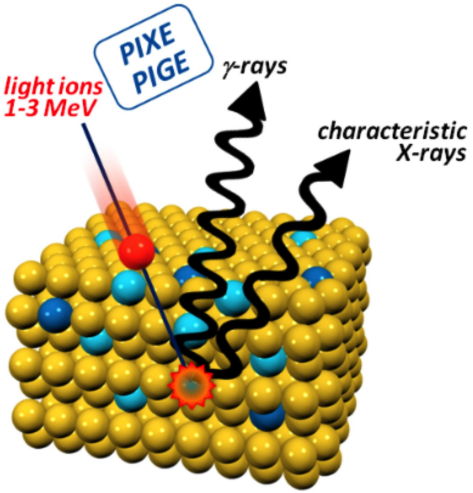
I. Burducea et al., NIM B, vol. 359, 15: 12–19, (2015)



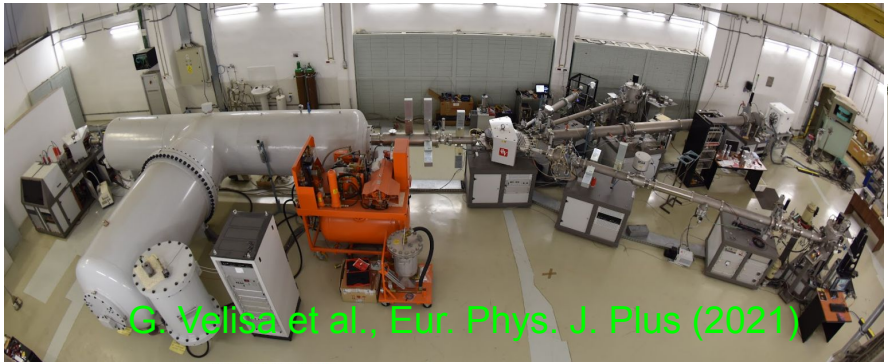
The intensity of H^{+} beam current versus time at 1 MV. Terminal voltage ripple measured by GVM ~10^{-5}.

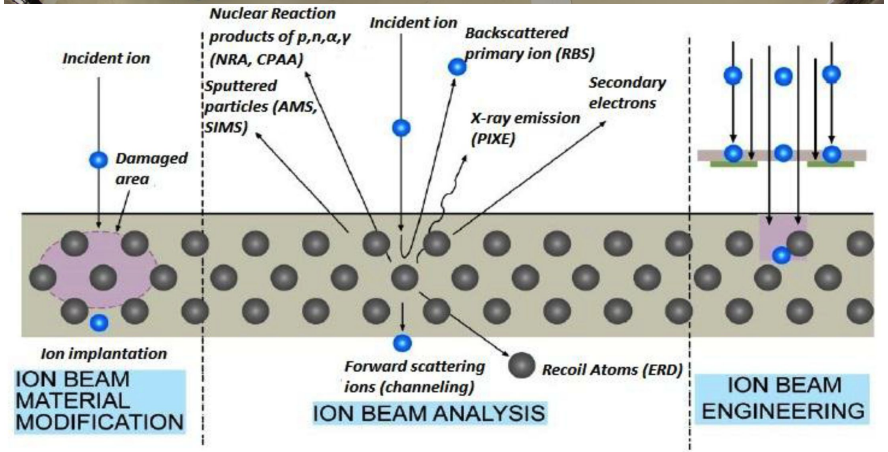
Ions for "non-AMS" Applications
Ion Beam Analysis (IBA)

~ 2000 h/y



https://www.hzdr.de/db/Cms?pOid=29856&pNid=3537

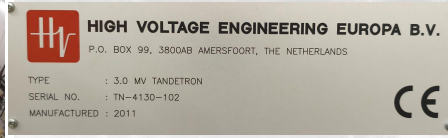




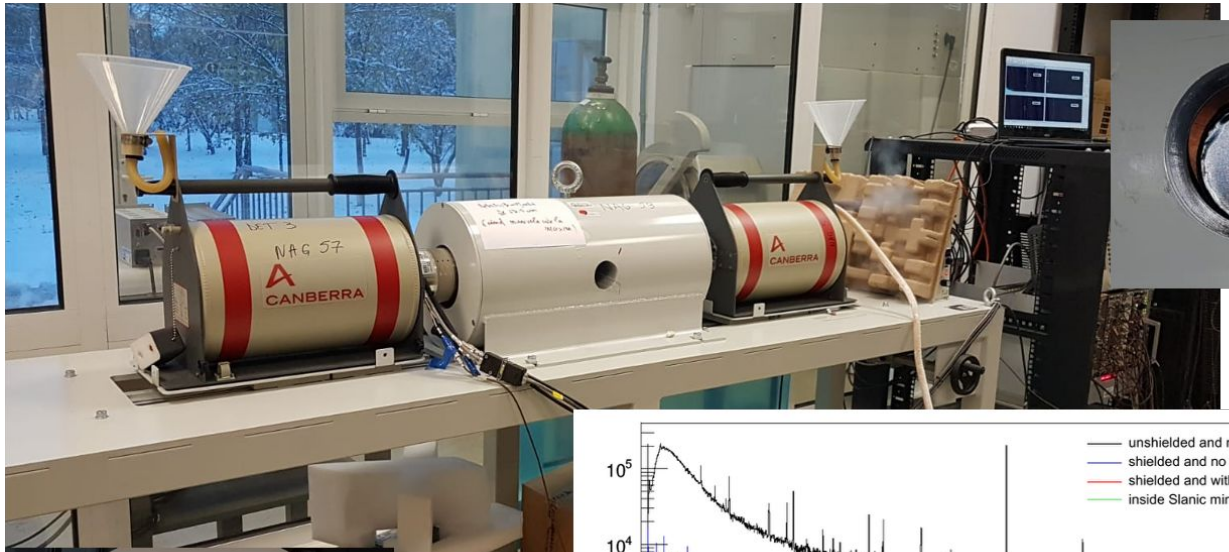
- ✧ **Non-destructive**
- ✧ **Simultaneous multi-element**
- ✧ **In vacuum or in air**

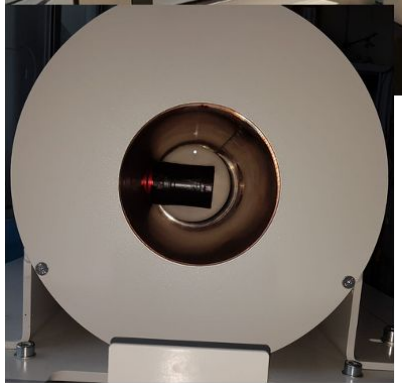
Typical parameters:

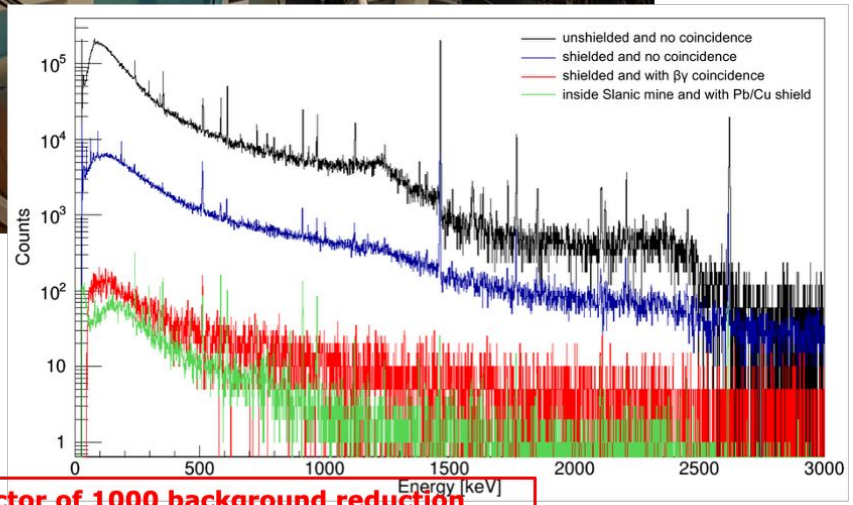
- ✧ **Analysable elements: Li to U**
- ✧ Detection limits: > 0.001 atom-% (tens of ppm)
- ✧ Analysing depth (max.): 0.5 - 50 µm



BeGa station – Bkg reduction using βγ coincidences







~ factor of 1000 background reduction

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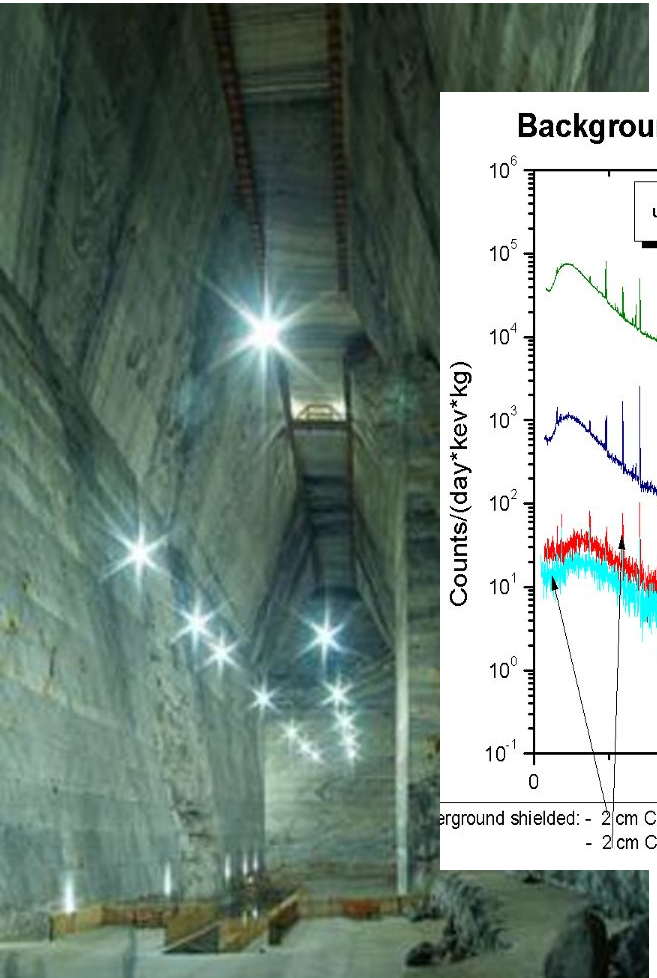
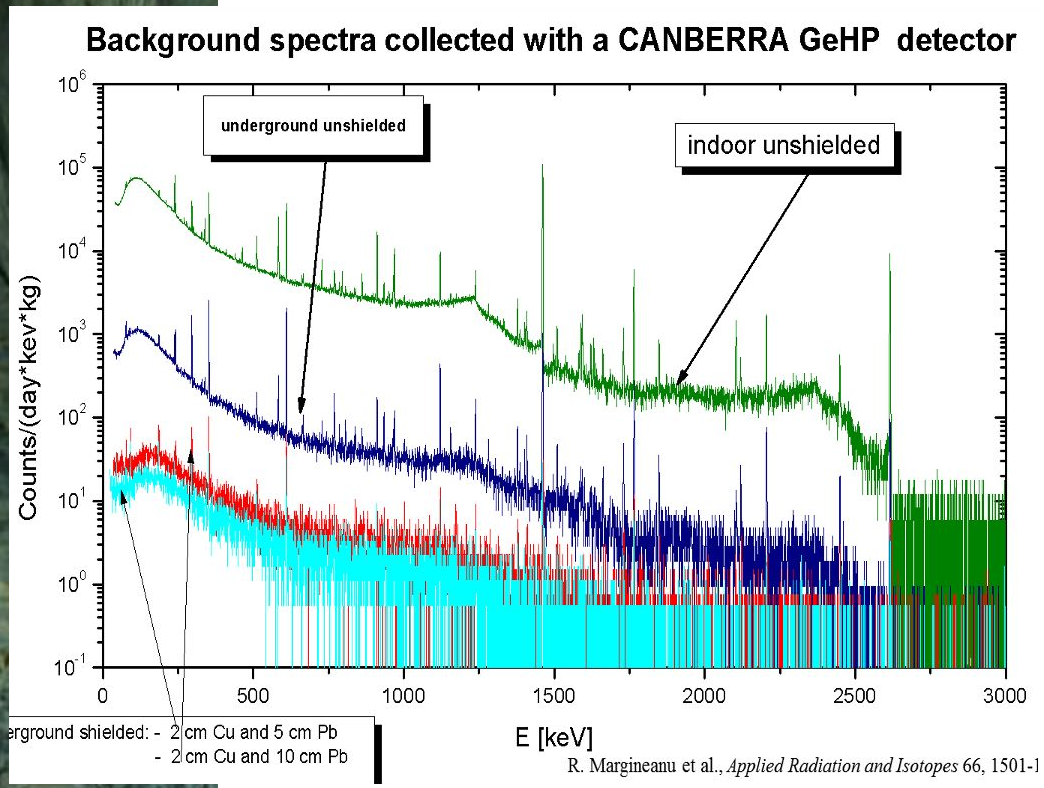
Ultra low background laboratory – Slanic salt mine





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2022: Study of ion-ion fusion mechanisms at very low energies for nuclear astrophysics

Study of ion-ion fusion mechanisms at very low energies for nuclear astrophysics

Proposal submitted for the ChETEC-INFRA PAC session by:

Giovanni Luca Guardo, G. D'Agata, M. La Cognata, L. Lamia, D. Lattuada, R. G. Pizzone, G.G. Rapisarda, S. Romano, M.L. Sergi, A. Tumino
Laboratori Nazionali del Sud, INFN, Catania, Italy

Alexandra Spiridon, D. Tudor, M. Straticiuc, I. Burducea,
IFIN-HH, Bucharest-Magurele, Romania

Accelerator: 3 MV tandetron of IFIN-HH Bucharest-Magurele
Beam: 13C, Energy = 5-15 MeV, intensity = > 200-1000 pnA
Time requested: 10 days (can be split in pairs), in 2022

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2022 Summary

Experiment started on:

November 21st, 2022

Allocated ChETEC-INFRA access (units)

120 hours

Experiment finished on:

November 25th, 2022

Access time provided by the facility (including overprovisioning)

92 hours *120 hours (92 + 28)*

Did you encounter any difficulties or have you any remarks concerning the experiment?

Experiment needed to end prematurely due to equipment malfunction (specifically with the cesium source used to produce the 19F beam). *Remaining 28 hours were recovered in 2023 with the help of the local collaborating group.*

2023 Proposal

ChETEC-INFRA Transnational Access Proposal
Science Part *(please upload as "Project Description" in GATE)*

Study of ion-ion fusion mechanisms at very low energies for nuclear astrophysics (II). Production, characterization and test of NA solid targets

1. Relation to the scientific objectives of ChETEC-INFRA

This proposal is part of a joint program focused on studying reactions between light ions important for **nuclear astrophysics**. It is a collaboration between INFN-LNS Catania and IFIN-HH born from similar interests in such reactions and previous successful studies with complementary methods, Trojan Horse Method (THM) and Thick-Target Activation, respectively. The goal is to use the infrastructure at IFIN-HH Bucharest-Magurele, specifically the 3MV Tandetron and the ultra-low background laboratory (μBq) at Slanic salt mine, to study ion-ion fusion reactions and sub-barrier fusion mechanisms using the thick-target activation method. Starting from the results and difficulties we encountered in the prior phases we ask for support for the **production, characterization, and test of solid Oxygen targets** to be used in the **study of ion-ion fusion reactions at very low energies important in nuclear astrophysics**.

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2023 Summary

Experiment started on:

December 4th, 2023

Allocated ChETEC-INFRA access (units)

200 hours

Experiment finished on:

December 12th, 2023

Access time provided by the facility (including overprovisioning)

144 hours *200 hours (144 + 56)*

Did you encounter any difficulties or have you any remarks concerning the experiment?

A different recipe was used to produce the 19F beam (a mix of Ag and CaF2 in a 1:1 ratio, instead of the pure CaF2 that was used in Nov 2022 for the previous proposal) which was found to be significantly more stable and more productive (roughly by a factor of 2). As such less night shifts were necessary to obtain the needed statistics leading to the number of hours stated above. *Remaining 56 hours were used later in 2024 to perform further testing of solid targets.*

2024 …

2025 Proposal

Study of ion-ion fusion mechanisms at sub-barrier energies for nuclear astrophysics. 15-26 September 2025 Session (16O+13C, 19F+12,13C)

for the Chetec-INFRA Trans-National Access (TNA) proposal **24303659-ST**

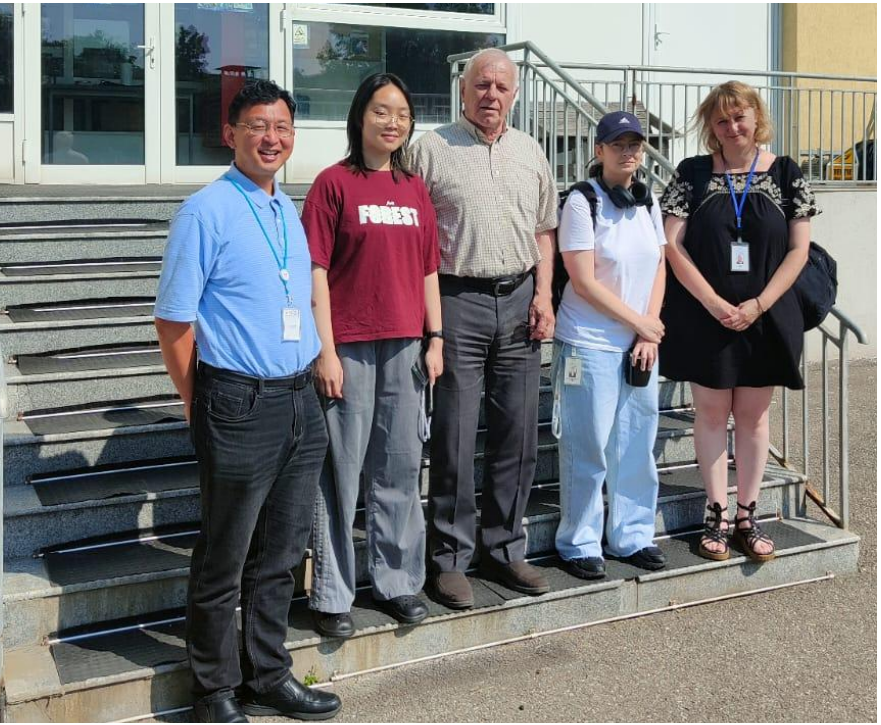
collaboration with Xiaodong Tang and IMP Lanzhou, China

and Roberta Sparta and the LNS-INFN Group, Catania

NAG

Nuclear Astrophysics Group

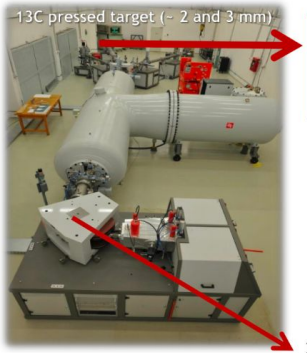
2025 - 1st round (May-June)



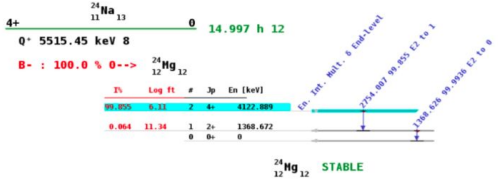
2025 - 1st round (May-June)

The $^{16}O+^{13}C$ Reaction @ 3 MV – CSM line - 17-20 June 2025

In beam irradiation of thick 13C targets followed by deactivation measurements. Focus on the 24Na + ap channel.



$^{16}O(^{13}C,ap)\,^{24}Na$, $T_{1/2}$ = 14.9 hrs



^{16}O beam @ 8 - 10 MeV and 5-10 pμA

Issue: Channel threshold is at E_{Lab} = 6.5 MeV / E_{CM} = 2.9 MeV
- cross-sections can be assumed to be very low!
- results from our prev experiments cannot be trusted
- data in lit does not go that low

$^{13}C + ^{16}O$
(E_{lab} = 13000 keV)

Reaction Products	Q-Value (keV)		Threshold (keV)	
$^{29}Si + \gamma$	20283.0887	6	0	
$^{28}Si + NN$	11809.4862	5	0	
$^{25}Mg + \alpha$	9155.87	5	0	
$^{28}Al + p$	7949.76	5	0	
$^{27}Al + d$	2449.15	5	0	
$^{24}Mg + NN + \alpha$	1825.351	13	0	
$^{27}Al + NN + p$	224.58	5	0	
$^{26}Mg + ^{3}He$	-328.67	3	734.13	7
$^{21}Ne + 2\alpha$	-730.05	4	1630.67	9
$^{27}Mg + 2p$	-1603.34	5	3581.30	11
$^{24}Na + p + \alpha$	-2907.979	17	6495.41	4
$^{26}Al + t$	-4351.67	7	9720.10	15
$^{27}Si + 2NN$	-5370.12	11	11994.98	24

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2025 - 2nd round (ongoing)

(theory)

Overall Beam-time plan

Beamline: CSM @ 3 MV
Beam: **^{16}O, ^{19}F (and maybe ^{12,13}C if there is time)**
Energy = ~7 - 21 MeV, intensity=0.02 - 25 μA.
Targets: **^{13}C pressed pellets x 2** (for **^{16}O, ^{19}F**)
BaF_2 pressed pellets (for **^{12,13}C**)

Detection setups:
- **online / prompt:** HPGe Det #1, HV = +4000 V, rel. eff. 100%
- **offline/ decay:** (1) BEGA station (no scintillator)
(2) Slanic uBq lab

Participants: - **Alex Spiridon, Dana State, Livius Trache, Andrei Opinca (NAG group)**
- **Giuseppe Rapisarda (17 Sept), Luca Guardo (23,24 Sept)**
- **Decebal Iancu, Radu Florin, Mircea Lechintan, ? (3 MV operators)**

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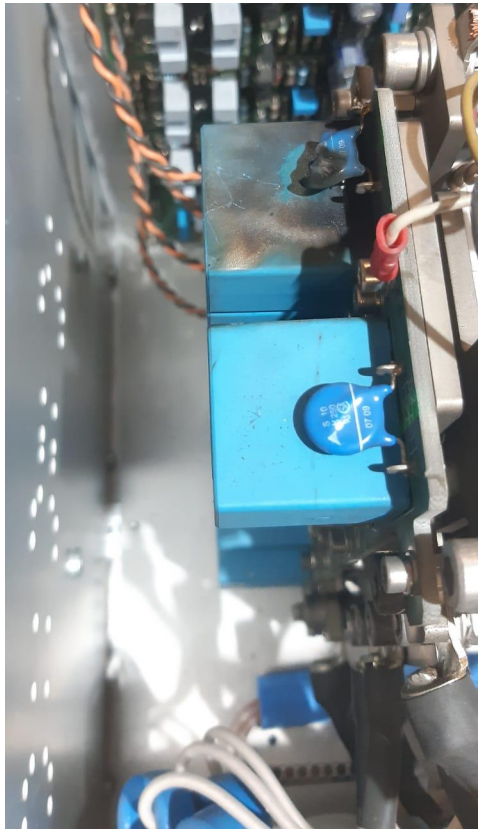
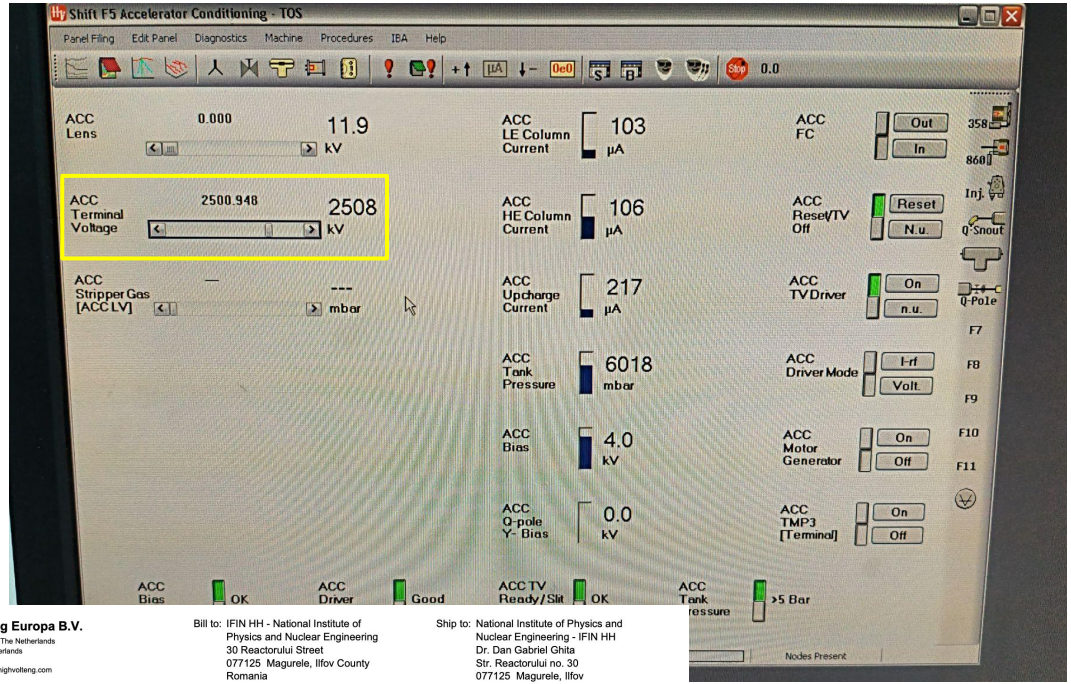
Nuclear Astrophysics Group

2025, 16th of September

(in practice)



2025, 17th of September



High Voltage Engineering Europa B.V.
Amsterdamseweg 63, 3812 RR Amersfoort, The Netherlands
P.O.Box 99, 3800 AB Amersfoort, The Netherlands
Phone +31 33 4619741
E-mail: info@highvolteng.com - Web: www.highvolteng.com

Bill to: IFIN HH - National Institute of Physics and Nuclear Engineering
30 Reactorului Street
077125 Magurele, Ilfov County
Romania

Ship to: National Institute of Physics and Nuclear Engineering - IFIN HH
Dr. Dan Gabriel Ghita
Str. Reactorului no. 30
077125 Magurele, Ilfov
Romania

Customer reference	Currency	Delivery (Inco terms 2010)	Ship via	Payment terms	Date
Email 19-09-2025	EUR	EXW HVE, Amersfoort, NL	BEST WAY	Bank - 100% NET - 30 DAYS	17-09-2025

Item	Partnumber	Description	Quantity	Delivery date dd-mm-yyyy	Unit price	UM	Extended Amount
010/000	ORDER HANDLING	Order Handling Cost	4,00				
020/000	R119001	IGBT CM200DU-24H 200A 1200V	2,00				

To prevent incorrect processing in our administration, we request that you check the Bill to and Ship to addresses.
Payment must be made in the currency stated.
If the client wants changes after the invoice has been sent, an amount of Euro 250, excluding VAT, will be charged for administration costs.

~ 1 k€

2025 Summary (94h of beamtime in June + ~100h next week)

Irradiation Plan - Week 1

* Continue with original plan to focus on the 24Na channel, but measure lower energies

$^{16}O+^{13}C$ (15 - 19 Spt 2025)								
Date	**Energy Lab (CM)**	**U terminal**	**Irradiation time**	**Target**	**Beam**	**Current**	**Decay meas time**	
Mon 15.09	8.0 MeV 8.5 9.0 10.0	**kV**	**short (10-30 min)**	13C T1	^{16}O (2,3+)	~10-20 uA	short (10-30 min) (Det #1)	2-10 Cycles of short prompt/decay measurements for each energy
Tue 16.09	8.0 MeV	**2667 kV**	**24 h**	13C T2	^{16}O (2+)	15-20 uA	--	Overnight irradiation, to be measured at Slanic on Wednesday (17.09)
Wed 17.09	8.5 MeV	**2850 kV**	**24 h**	13C T1	^{16}O (2+)	15-20 uA	24 hr (Slanic)	(stop T2 @ 8 MeV ~ 10 a.m; start T1 @ 8.5 Mev ~ 11 am) Overnight irradiation, to be measured at Slanic on Thursday (18.09)
Thr 18.09	10.0 MeV	**2500 kV**	**24h**	13C T2	^{16}O (3+)	15uA	24 hr (Slanic)	(stop T1 @ 8.5 MeV ~ 11 a.m; and wait for T2) T1 to be measured at Slanic and T2 to be brought back for overnight irrad; start ~4-6 pm
Fri 19.09	10.0 MeV	**2500 kV**	**-**	13C T1	^{16}O (3+)	15uA	24 hr (BEGA)	Finish overnight irradiation at 10 MeV and measure T2 in BEGA

Acknowledgments to:

*The entire work and the nice results are possible due to the work done by these **wonderful people and many others previously listed**. Experiments were mostly carried out at the 3 MV Tandetron™ accelerator from "Horia Hulubei" National Institute for Physics and Nuclear Engineering (IFIN-HH) and were supported by ChETEC-INFRA and the Romanian Government Programme through the National Programme for Infrastructure of National Interest (IOSIN).*