

WP2: Access to RI for Nuclear Physics

Task 2.1: Transnational Access to RIs offering Stable Ion Beams

Paul Greenlees, University of Jyväskylä
paul.greenlees@jyu.fi



This project has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No 101057511.

Facilities offering stable ion beams

GOAL: Provide Transnational Access to facilities which enable fundamental and applied Nuclear Physics research using stable ion beams

A total of twelve facilities offering a wide variety of stable ion beams and complementary services

- ALTO at IJCLabs – Orsay, France
- CLEAR – consortium of three facilities with common access procedure and PAC:
 1. CNA – Sevilla, Spain
 2. IST – Lisbon, Portugal
 3. AAC – Debrecen, Hungary
- GANIL – Caen, France
- GSI – Darmstadt, Germany
- IFIN-HH – Magurele, Romania
- JYFL – Jyväskylä, Finland
- LNL – Legnaro, Italy & LNS – Catania, Italy
- NLC-CCB – Kraków, Poland & NLC-SLCJ – Warsaw, Poland



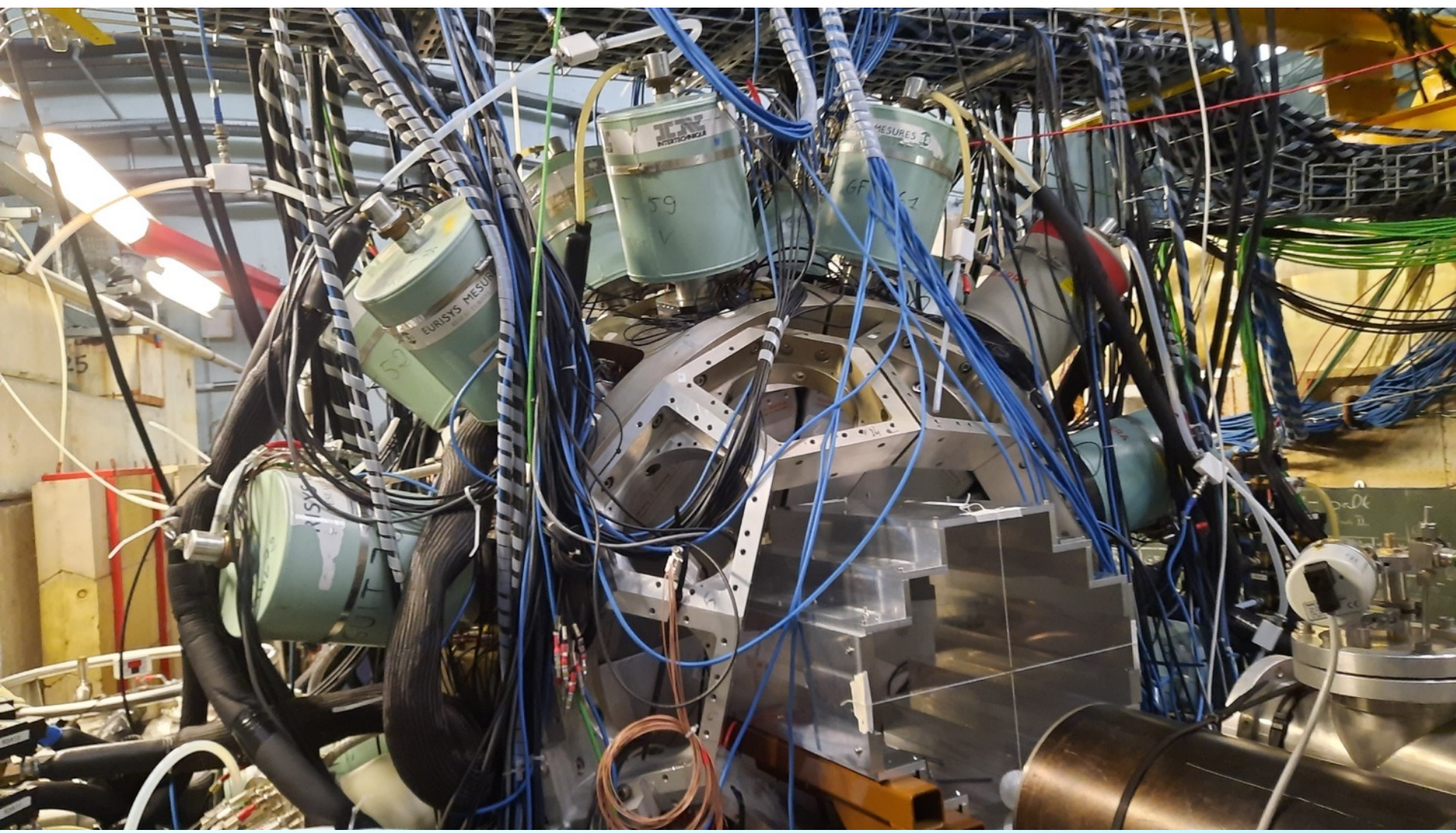
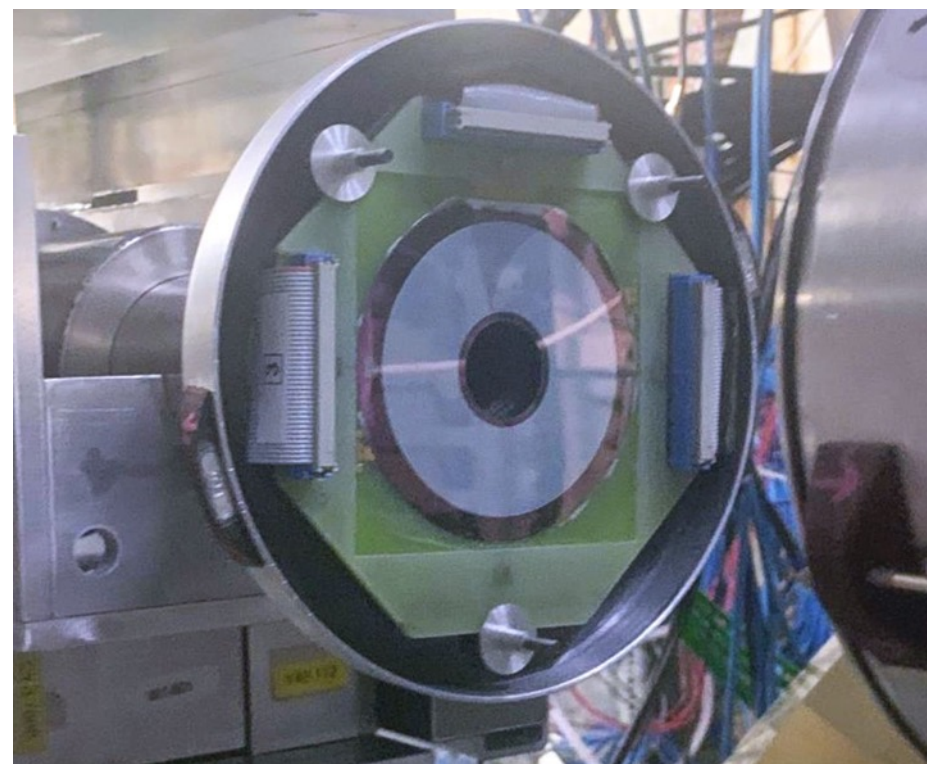
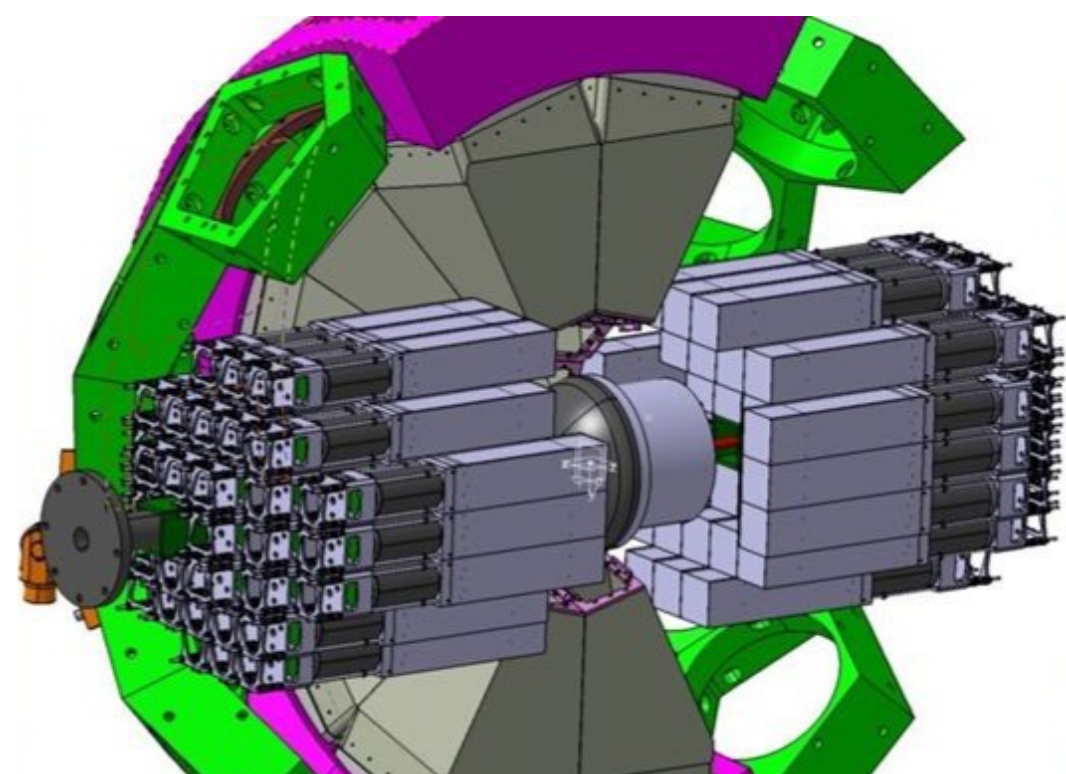
nu-Ball2 experimental campaign at ALTO

2022/2023 highlights

- 28 Clover Ge's (GammapoolEU consortium)
- 15 Coaxial Ge's (UK/France loan pool)
- 36 FATIMA LaBr3 (FATIMA collaboration)
- 72 PARIS phoswich (PARIS collaboration)

- ✓ Hybrid Spectrometer (Ge/BGO/LaBr3/PARIS) high resolution, high efficiency
- ✓ Different geometries and couplings
- ✓ Calorimetry for reaction studies/selection
- ✓ Fully digital, 300 channels, including BGO
- ✓ Modes Triggered or Triggerless
- ✓ **Coupling with PARIS array**
- ✓ Coupling with Warsaw DSSD

<https://alto.ijclab.in2p3.fr/>



Scientific program

- Nuclear fission
- Giant Dipole Resonances
- Nuclear moments (Coulomb excitation)
- Nuclear moments (fast timing)
- Fission shape isomerism

Results

PAC approved 16 experiments,
 12 ran, 10 successful, 300 Tb data collected
 8 experiments supported by EUROLABS
 160 international visitors total

2184 hrs provided / 1860 hrs (117%)
 45% of T&S used

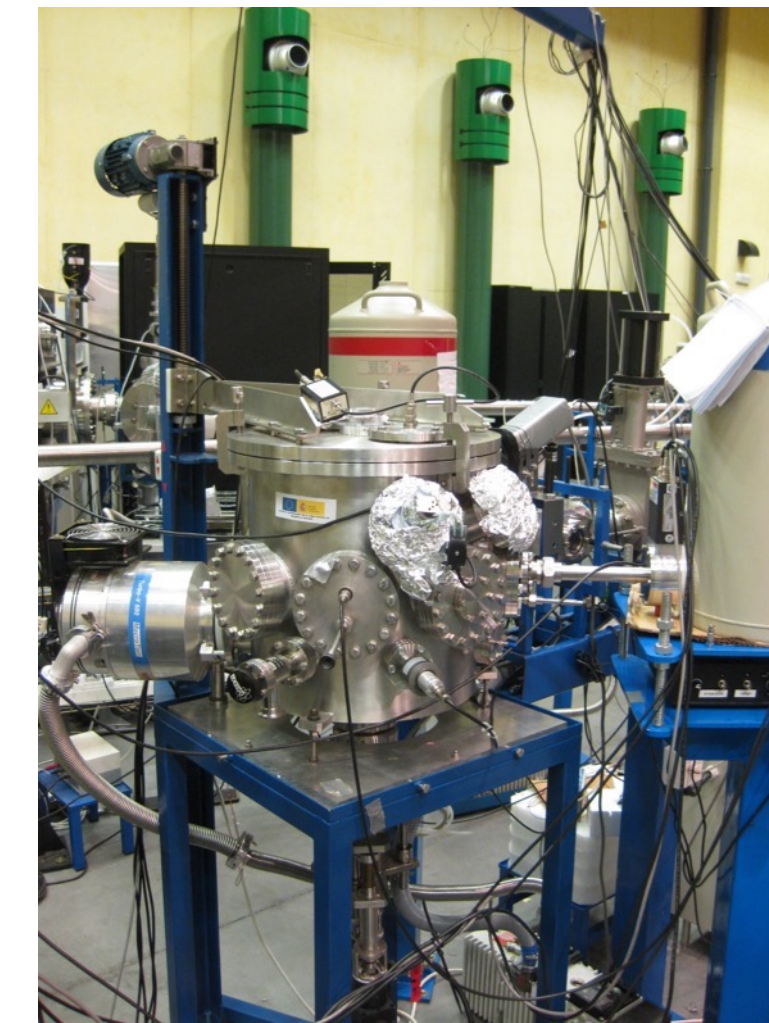


Facility: 3MV Tandem accelerator at CNA

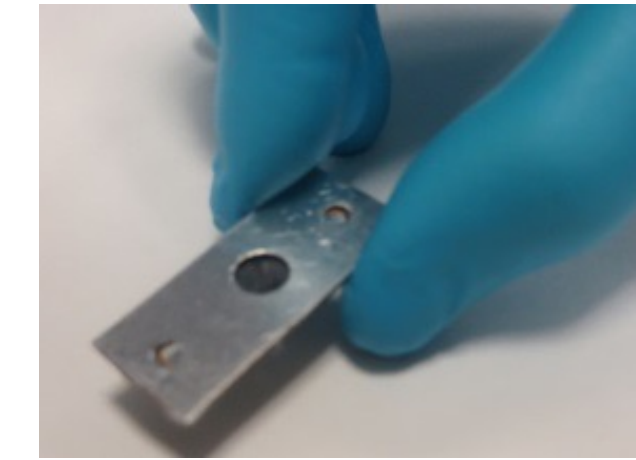
CLEAR-CNA-001 Characterization of Si:He solid targets for experiments as support for nuclear reaction experiments in big facilities

Transnational access: Call number 1 (1 January 2022 – 30 February 2022) 7 – 9 February, 2023 Beam time: 32 access units. Budget: 619 €, 4 users.

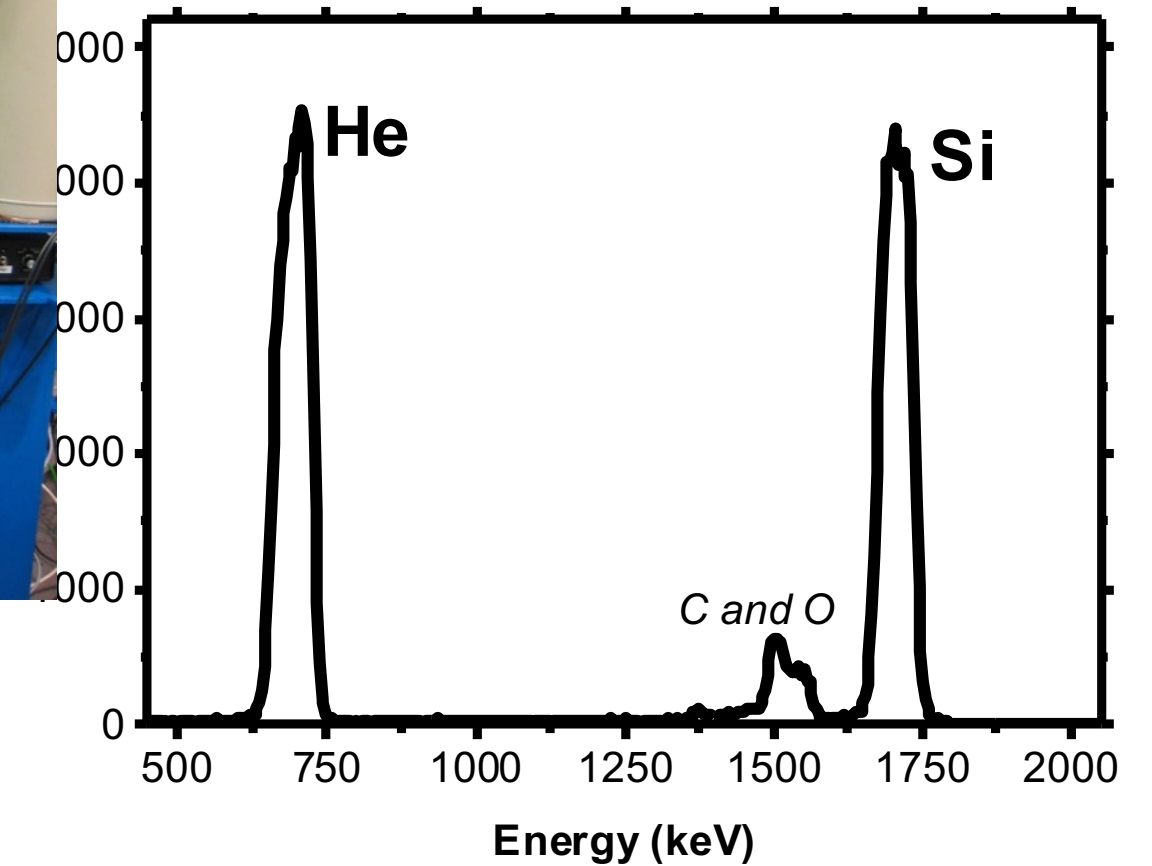
Back-scattered **CNA** 2.0 MeV protons (a) were used to determine the Si and He concentration in the **Si:He targets** (b), after a measurement with radioactive Sn beam at **HIE-ISOLDE**, to evaluate the loss of He (c) due to the irradiation and so extract Sn-He cross sections. Synergy between EURO-LABS facilities.



(a)



(b)



(c)

Facility: 1MV AMS system at CNA

CLEAR-CNA-002 Accelerator Mass Spectrometry determinations of ^{237}Np from seaweed samples

Transnational access: Call number 2 (1 January 2023 – 15 February 2023) 26 – 31 March, 2023. 32 access units. Budget 461€. 1 user

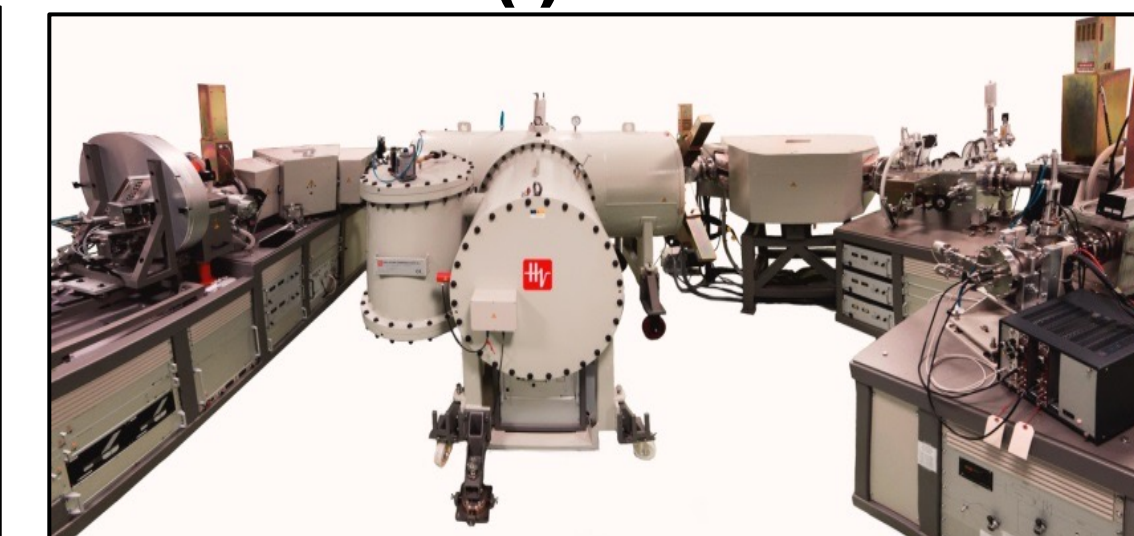
First external user measurement of ^{237}Np at **CNA-AMS** after commissioning. Study of the **impact of radioactive dumping** on seaweed samples (d) collected close to Gothenburg (Baltic Sea). They were radiochemically prepared in a cathode (e) which was used in the AMS accelerator (f)



(d)



(e)



(f)

Transnational access: Call number 2.

Title: **Damage induced by proton beam irradiation of cellulose-based materials**

Dates: 17 – 21 April, 2023

Access Units provided: 42 h of 640 h (~ 7%)

Budget: 0 € (participant has her own financial plan)

Conditions: Nuclear microprobe using the External beam set-up, 2 MeV proton beam irradiation

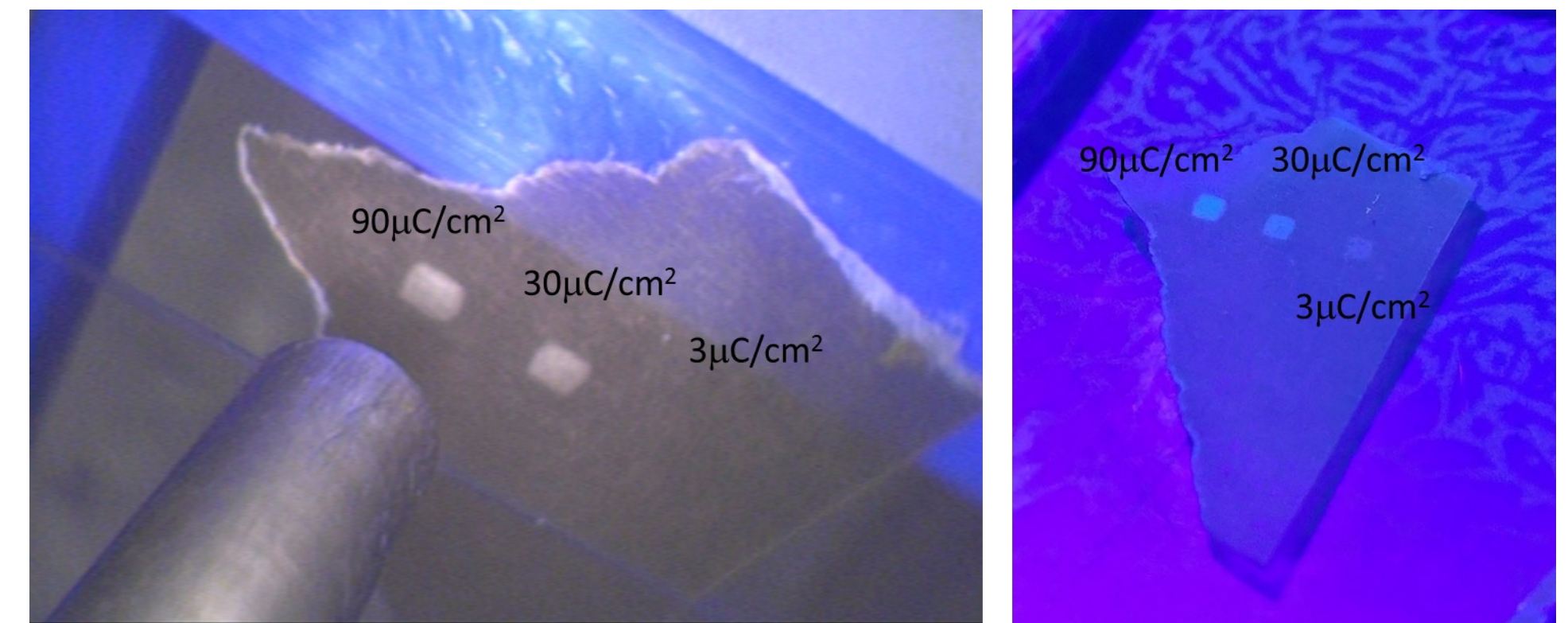
Call number 3 (1 to 31 May) and 4 (to 30 September), no Transnational Access.

Accelerator issues, not beam time available till October 30.

Expected more user in the next call (1 to 31 January, 2024).



Photograph of the experiment while proton irradiation.



Beam damage caused on cellulose-based materials during proton irradiation in open air atmosphere. Damage depends on the deposited charge.

Transnational access:

Calls 1,3 and 4: no applicant

Call 2: 1 applicant

Title: **Search for emission of bound identical nucleons**

Dates: 15 –19 May, 2023

Access Units provided: 70 h of 640 h (~ 11%)

Budget: 468,27 €

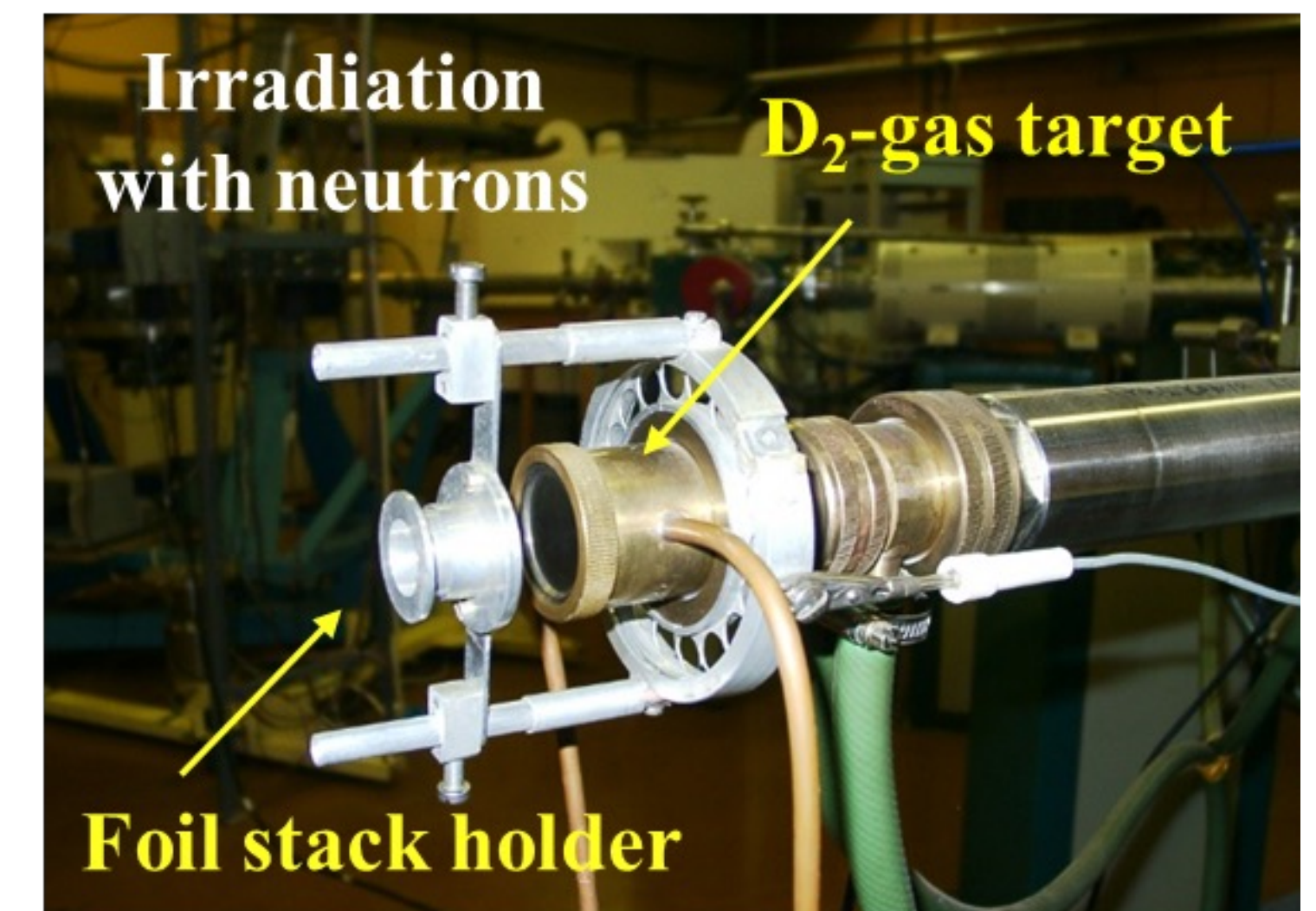
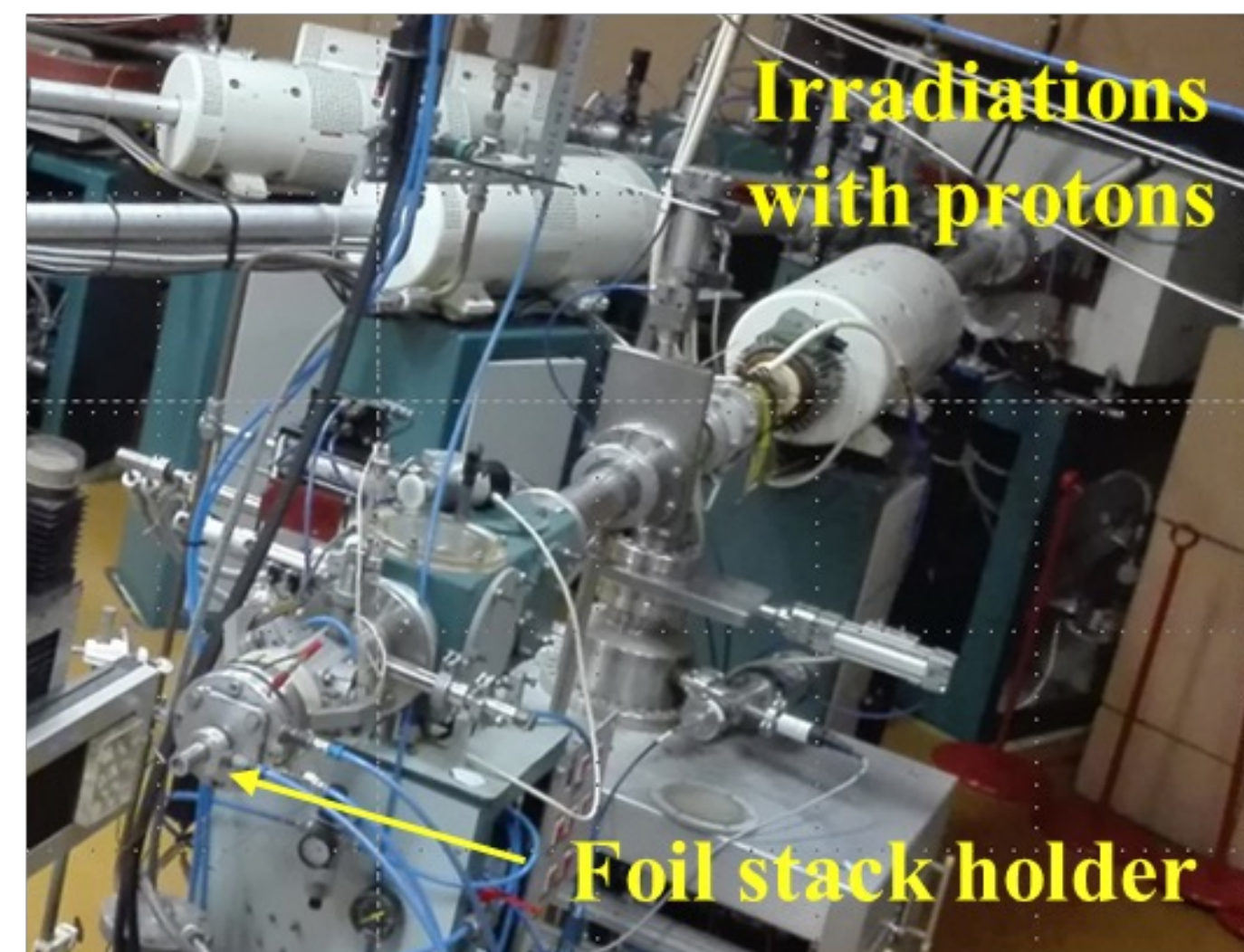
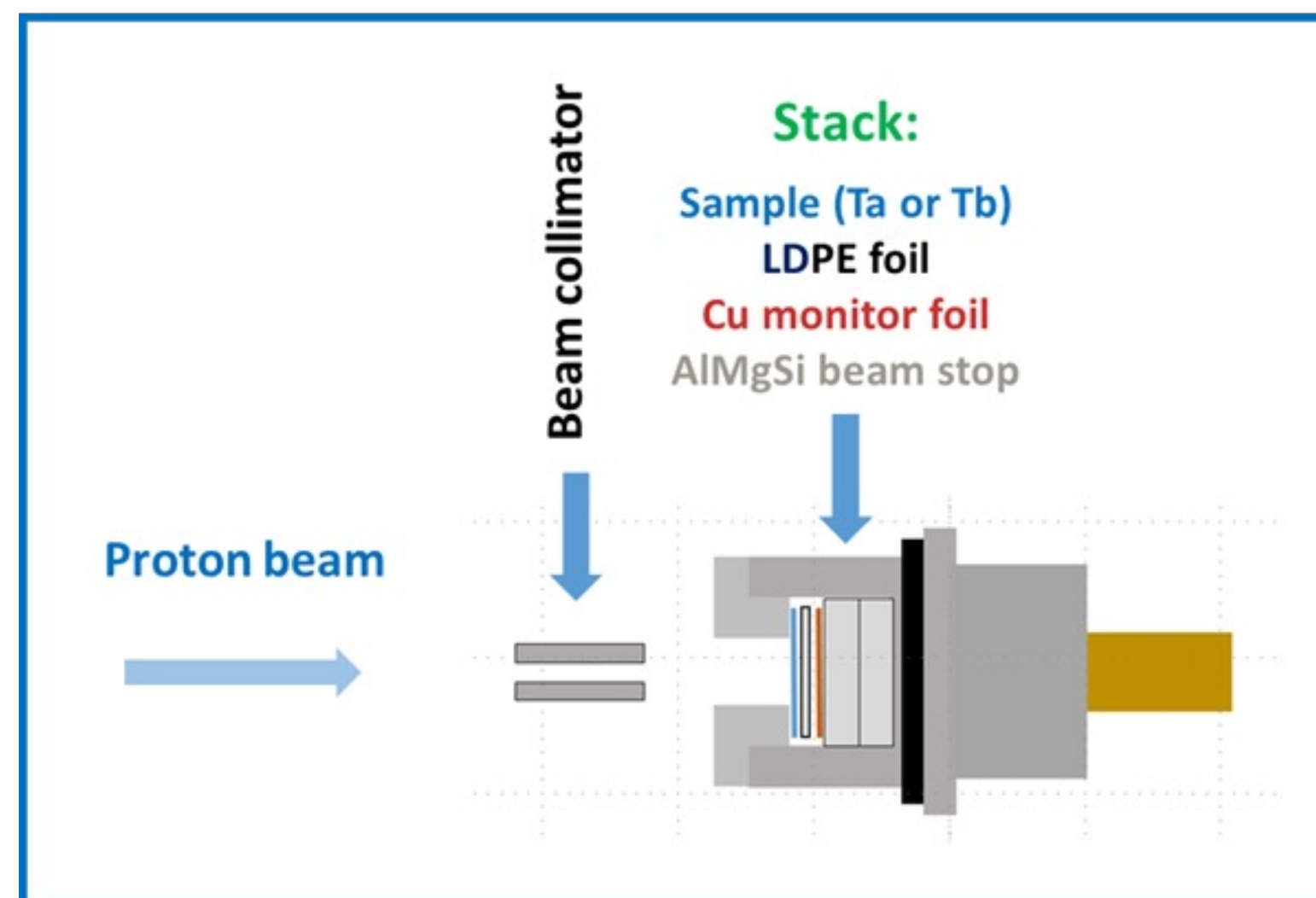
Participants:

I. M. Kadenko, N. Sakhno (Int. Nucl. Safety Center of Ukraine & Dept. Nucl. Phys., Taras Shevchenko National University of Kyiv, Ukraine)
ATOMKI staff: A. Fenyvesi, B. Biró and the staff of the cyclotron

Experiments:

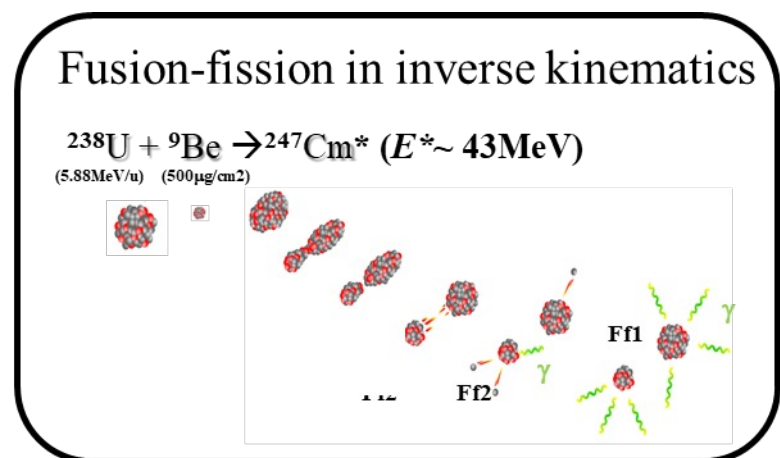
6 activation experiments with protons

1 irradiation with quasi-monoenergetic d+D neutrons

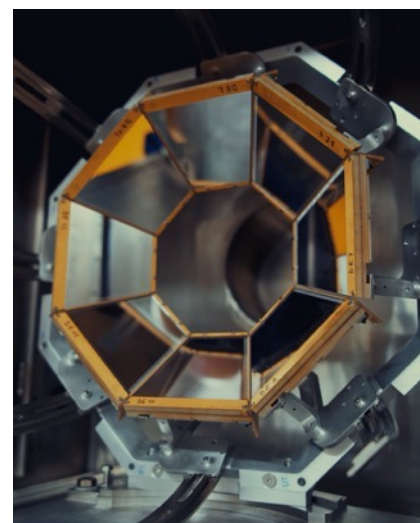


GANIL – Stable beam

- Developments and performance assessment of high-intensity thin targets for SHE production S3 at the Cyclotron
- Fission program at the VAMOS++ magnetic spectrometer and heavy beams (^{238}U) at the Cyclotron

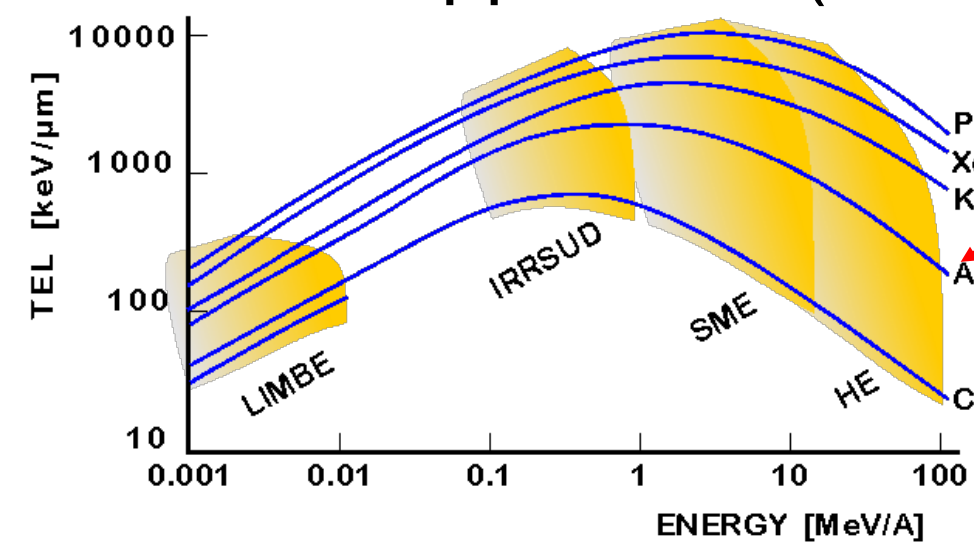


VAMOS++



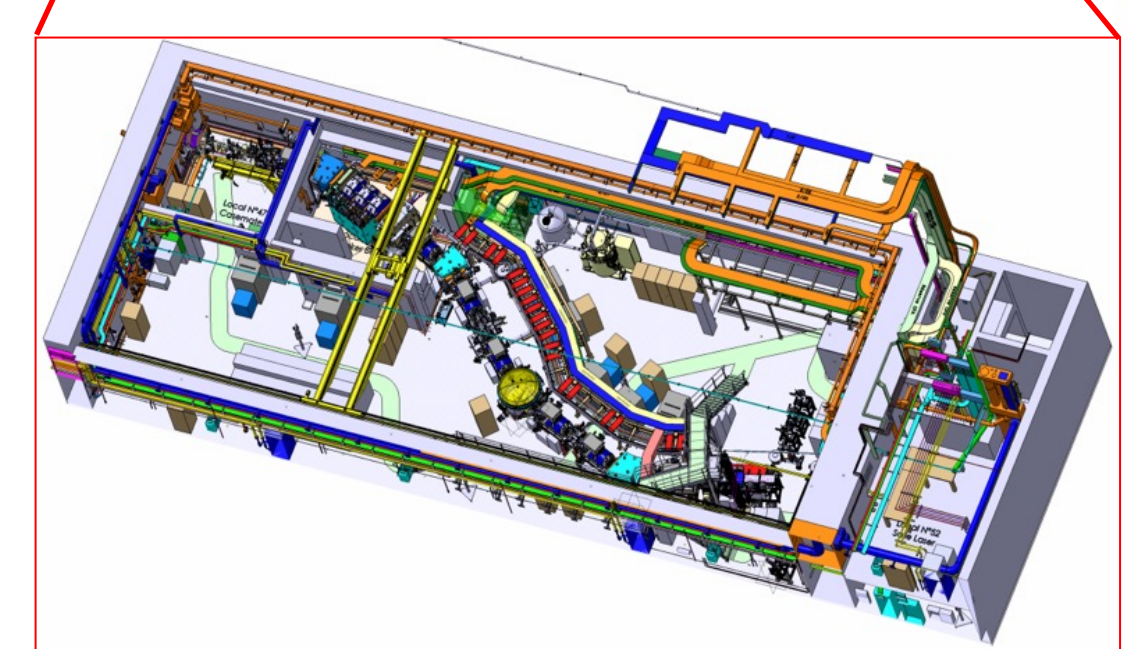
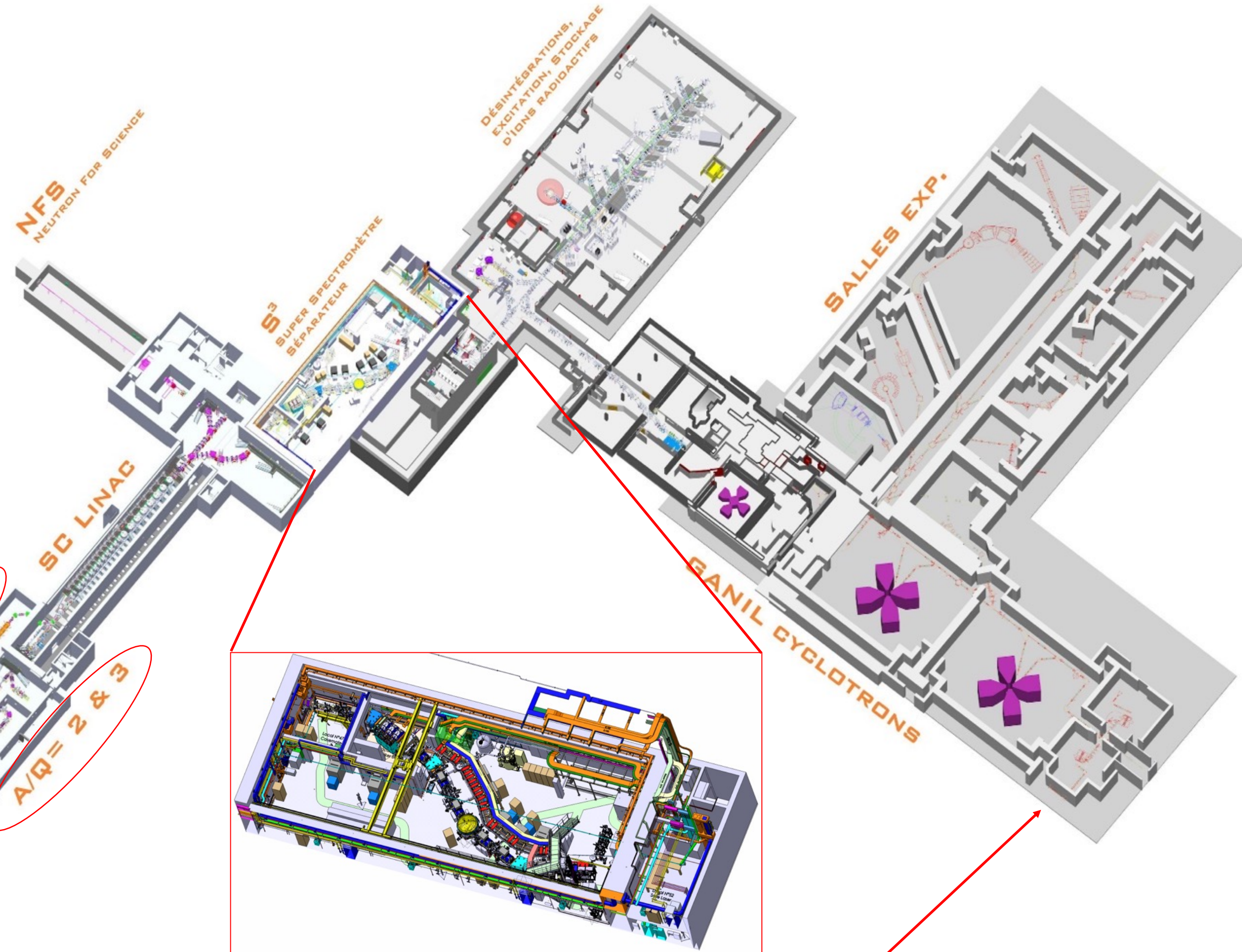
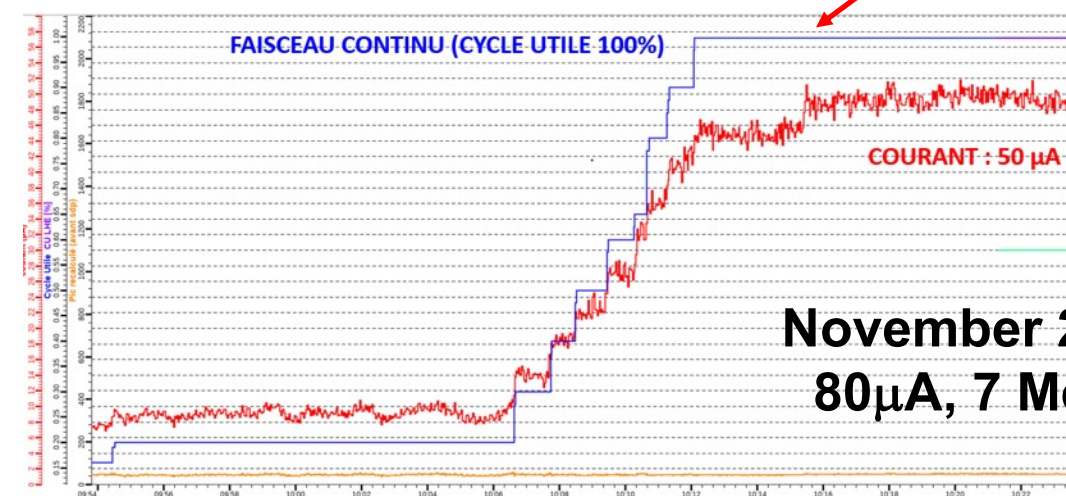
New PISTA array
For E* and fissioning system identification

- Interdisciplinary research program at the cyclotron (~15%)
- Industrial application (~15%)



NEWGAIN
NEW GANIL INJECTOR

First beam 2028



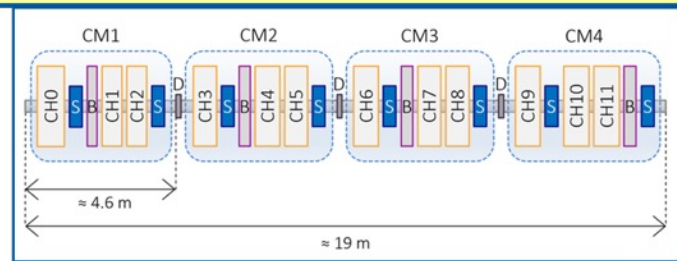
Commissioning of the Super Separator Spectrometer (S3) planned in 2024

CSS complex (C→U)
New beam : ^{232}Th !

CYREN : CYCLOTRON RENOVATION PROJECT
PREPARE THE CYCLOTRON FOR THE NEXT 2 DECADES

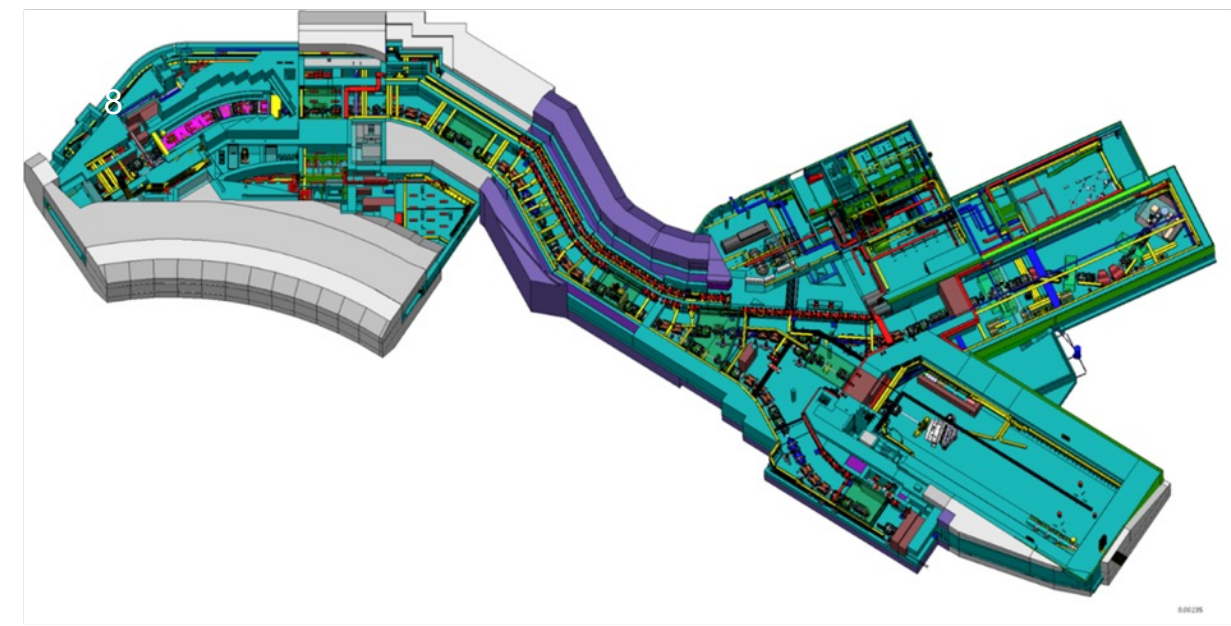
Overall TNA : 15%used
GANIL/Stable : 4 projects covered
distributed on 14 users

Superheavy elements
 SHIP, SHIPTRAP, TASCA
Under construction: HELIAC

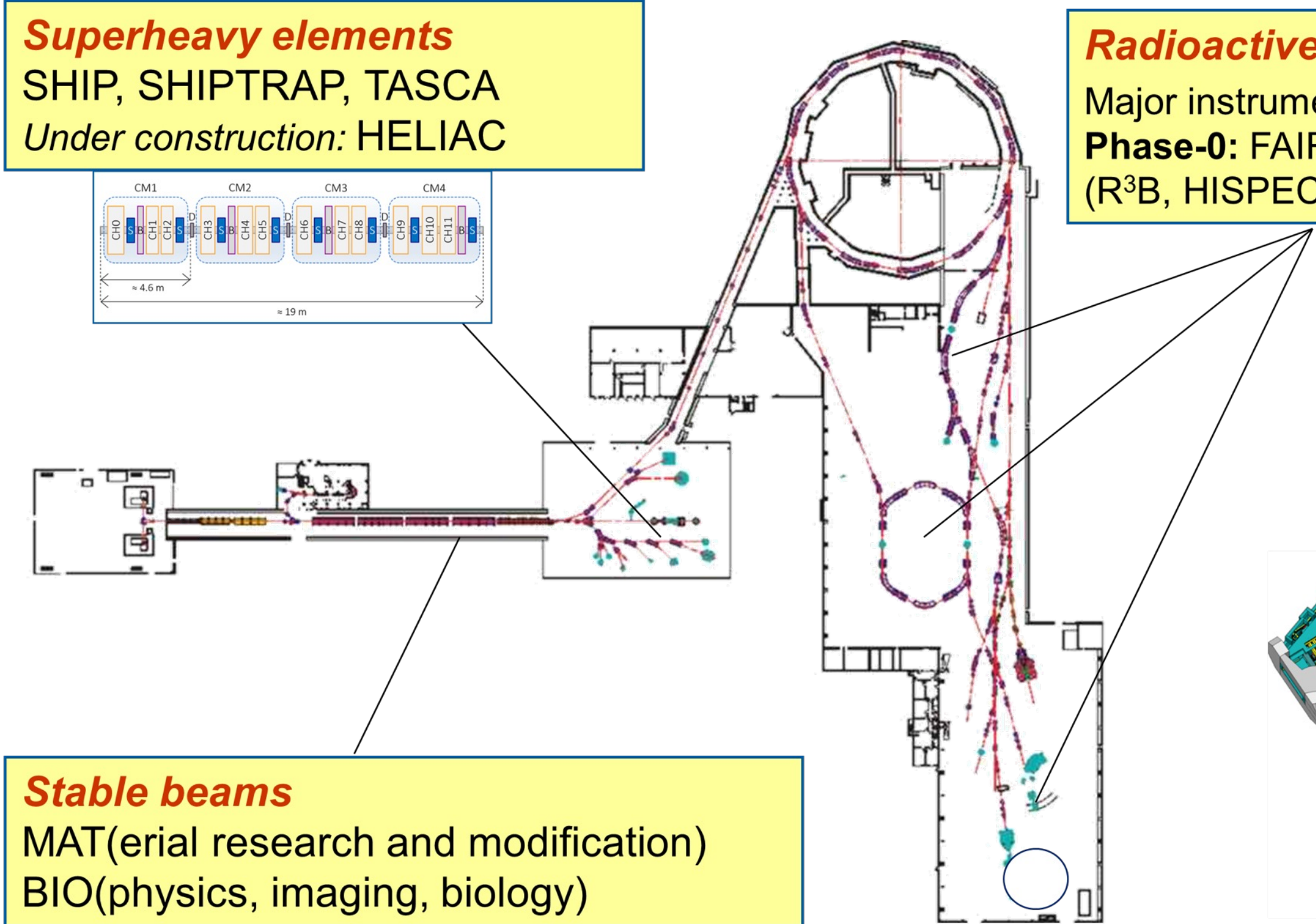


Radioactive beams
 Major instruments: FRS, ESR, CRYRING
Phase-0: FAIR precursor experiments
 (R³B, HISPEC/DESPEC, EXL, ILIMA, Super-FRS EC)

NUSTAR with Super-FRS at FAIR
In preparation: Early Science, First Science



Stable beams
 MAT(erial research and modification)
 BIO(ysics, imaging, biology)



Beams: H...U, parallel operation of different „virtual accelerators“ (i.e.: species, energy, intensity, target station)

Energy: keV/u...MeV/u...GeV/u, stopped secondary beams, incl. SHE

Fusion, fragmentation, fission

In-flight separation (vacuum and gas-filled separators)

Dressed and highly-charged resp. bare ions up to uranium

Storage-cooler rings

GSI-FAIR beam-time schedule during Euro-Labs and USP 2023

2024

2025

2026

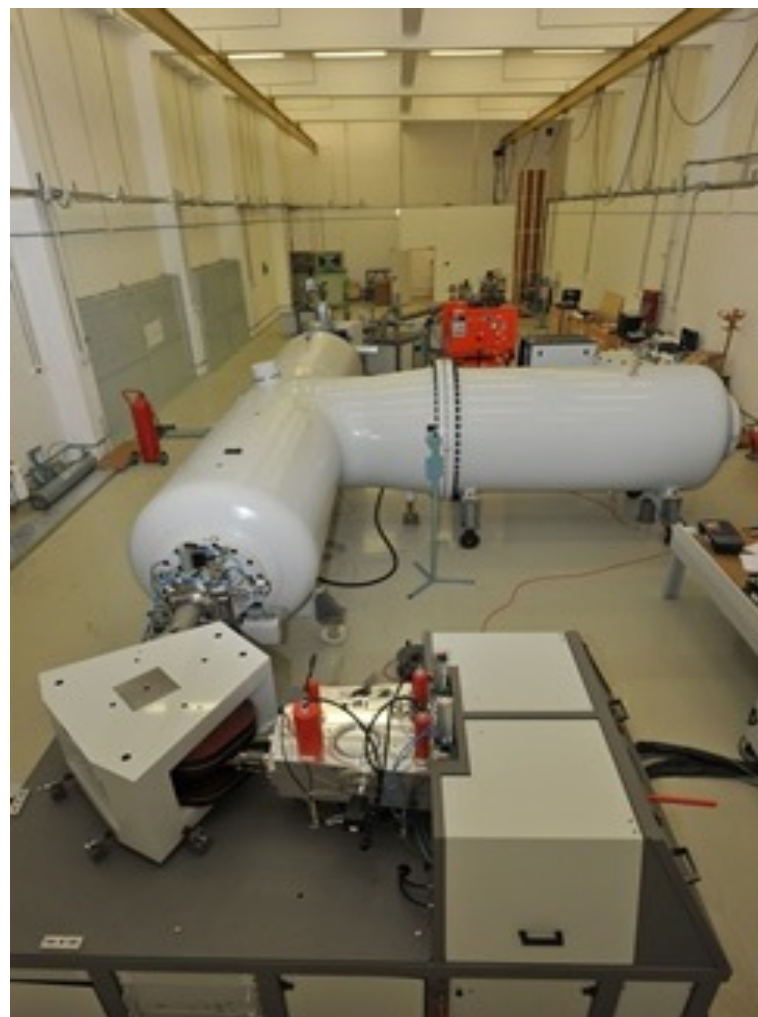
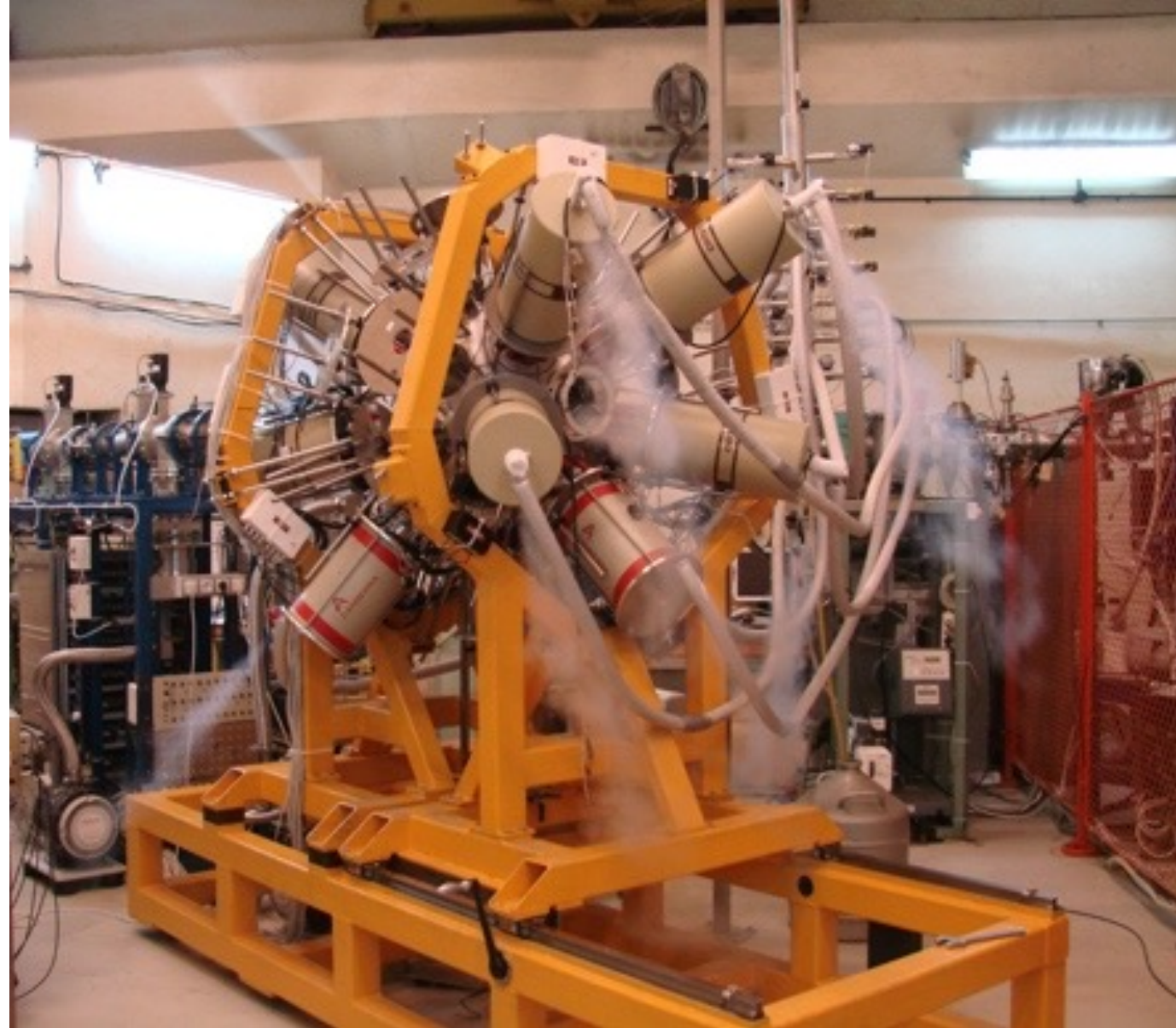
- 80 days of beamtime planned in spring 2026
- G-PAC (+USP) presumably in late 2024/early 2025

G-PAC meeting held in Sept. 2022
Call for Proposals: July 2023
 USP-Meeting: Sept. 2023
21 user projects approved:

- 7 stable-beam projects
- 14 radioactive-beam projects

80% of available budget allocated

TANDEM Accelerators: 9 MV, 3 MV, 1 MV



3 MV status:

Support granted through EURO-LABS since Sep 2022:

- 2 nuclear astrophysics experiments
- 360 hours
- 4 users

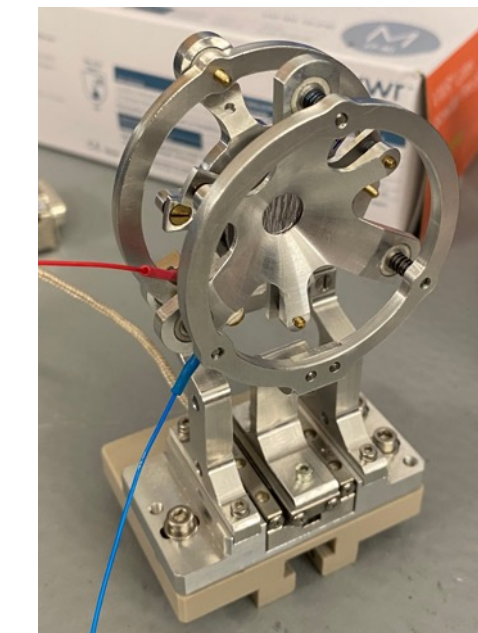
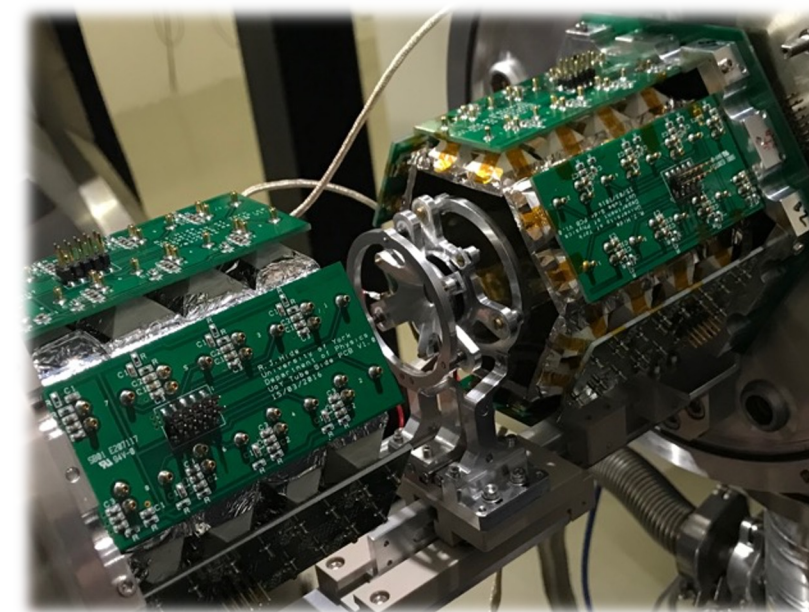
9 MV status:

Support granted through EURO-LABS since Sep 2022:

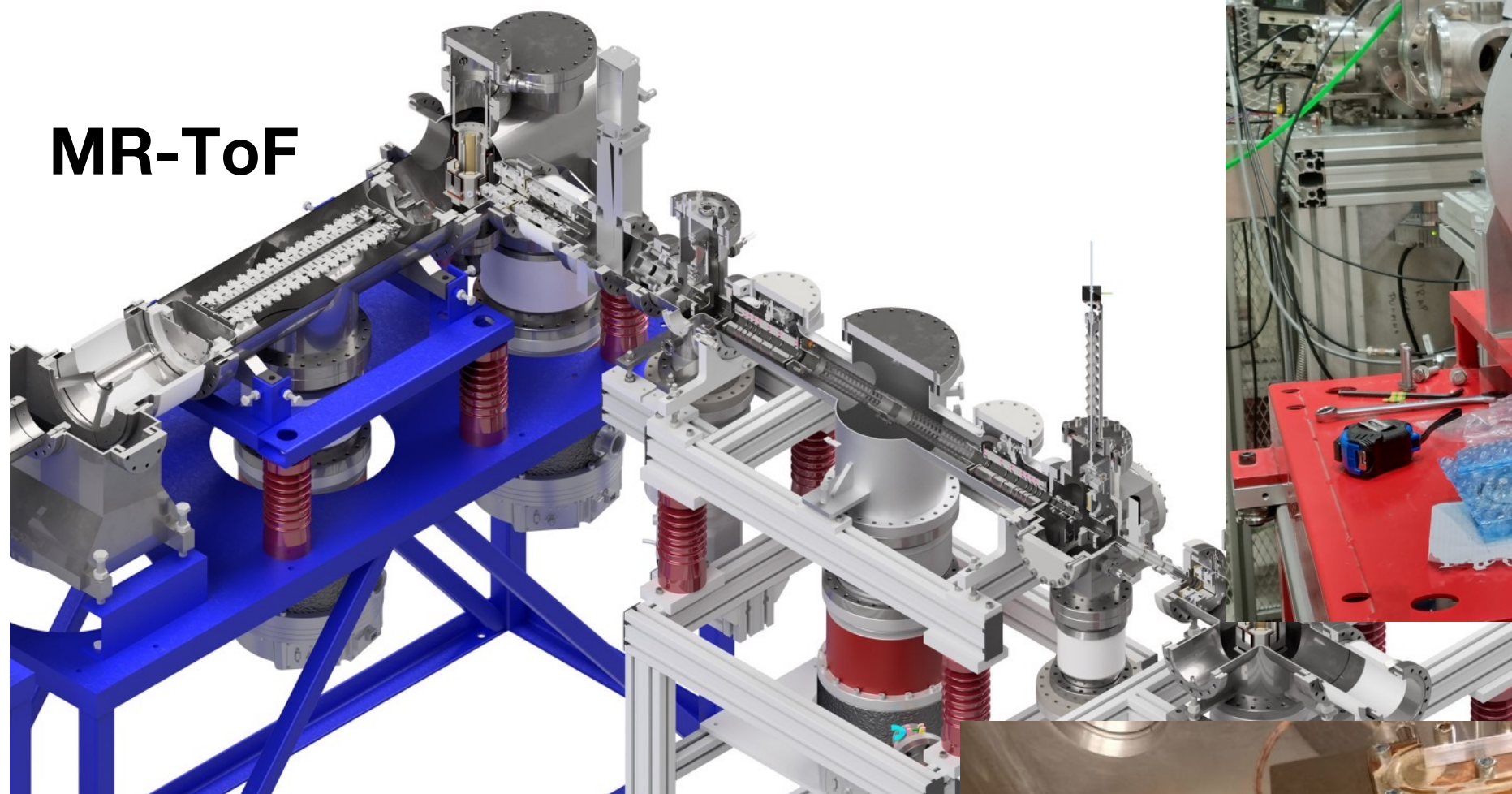
- 8 gamma-ray spectroscopy experiments at ROSPHERE
- 1944 hours
- 36 users

53% of access hours provided (2184/4100), 15% of T&S used

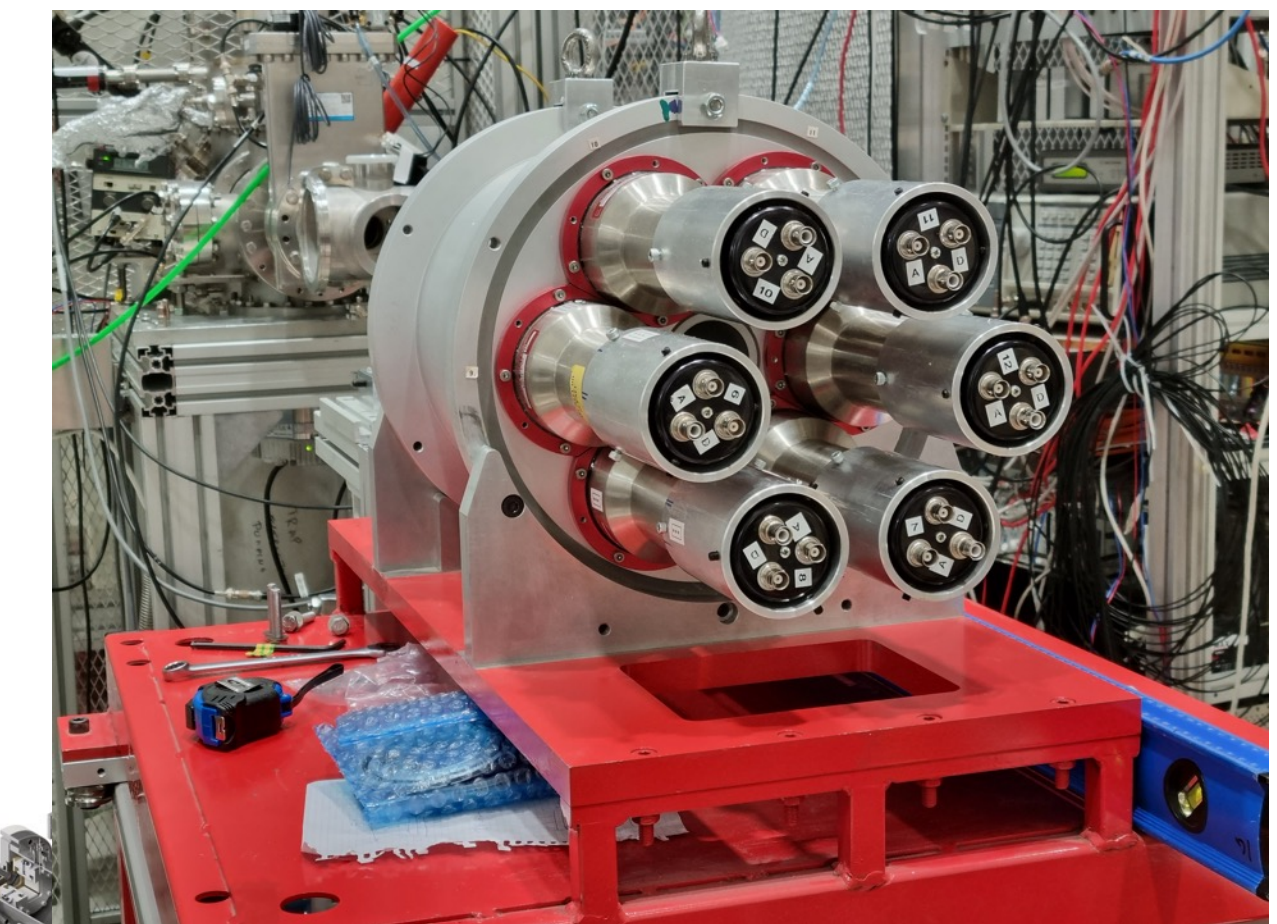
- Large number of experiments from backlog eligible for support under terms of GA
- First supported experiment carried out 16.09.2022-26.09.2022
- Two calls for proposals in reporting period (15th September 2022 / 15th March 2023)
- Supported experiments: 14 (12 Stable, 2 RIB)
- Supported visits: 80
- Total visits: 134
- Total T&S expenditure: 41019€ (from 240000€ - 17.1%)
- Total access hours delivered:
 - 2928 (from 3500 84%)
 - 2424 Stable / 504 RIB
- Currently **6528** hours of eligible experiments pending
- Next PAC Meeting 15th November – 10 eligible experiments, 2280 hours requested



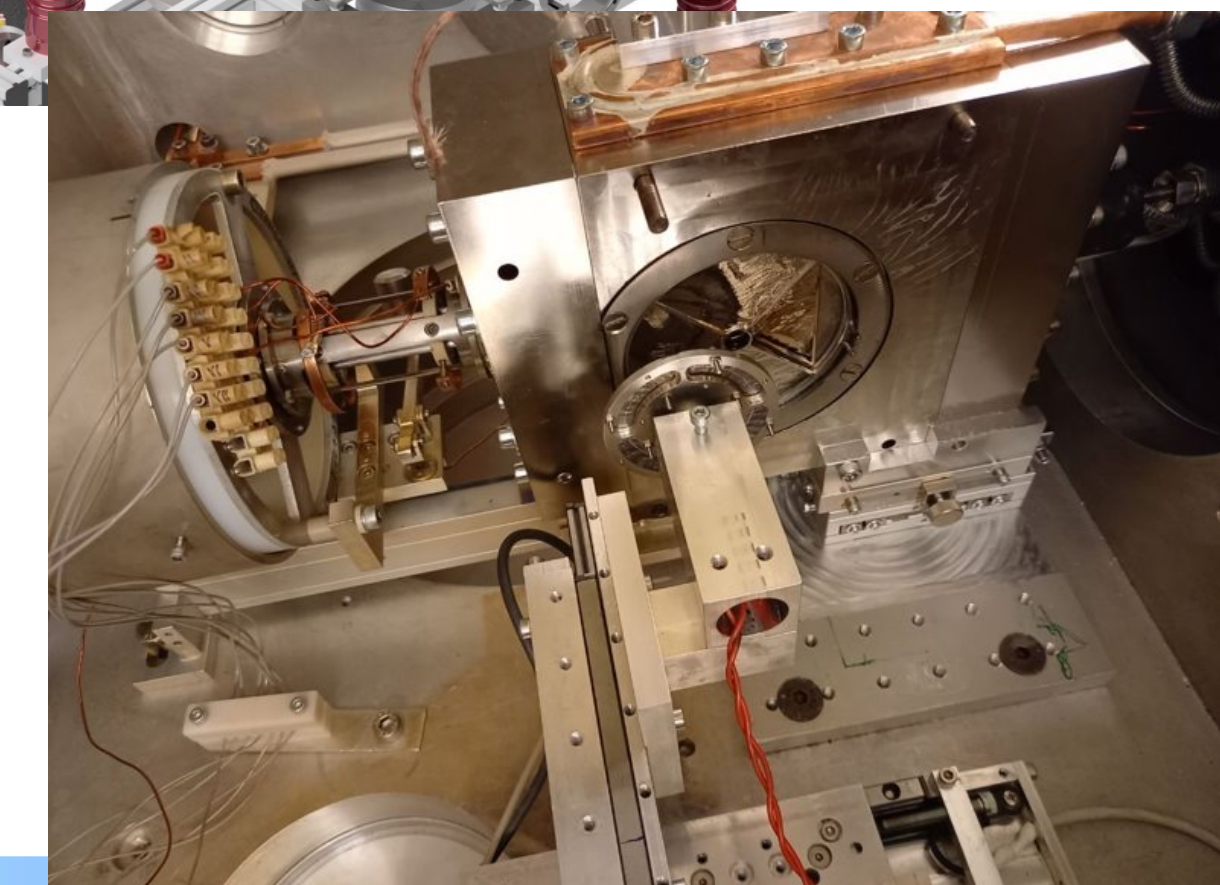
**APPA Plunger + CPD
Lifetime measurements**



MR-ToF



TAS



New gas cell for MNT

USP nominated on October 26th, 2022. Members:

- A. Di Pietro INFN-LNS
- T. Marchi INFN-LNL
- M. Aliotta (Univ. of Edinburgh)
- K. Hagino (Kyoto University)

LNL (<https://www.lnl.infn.it/>):

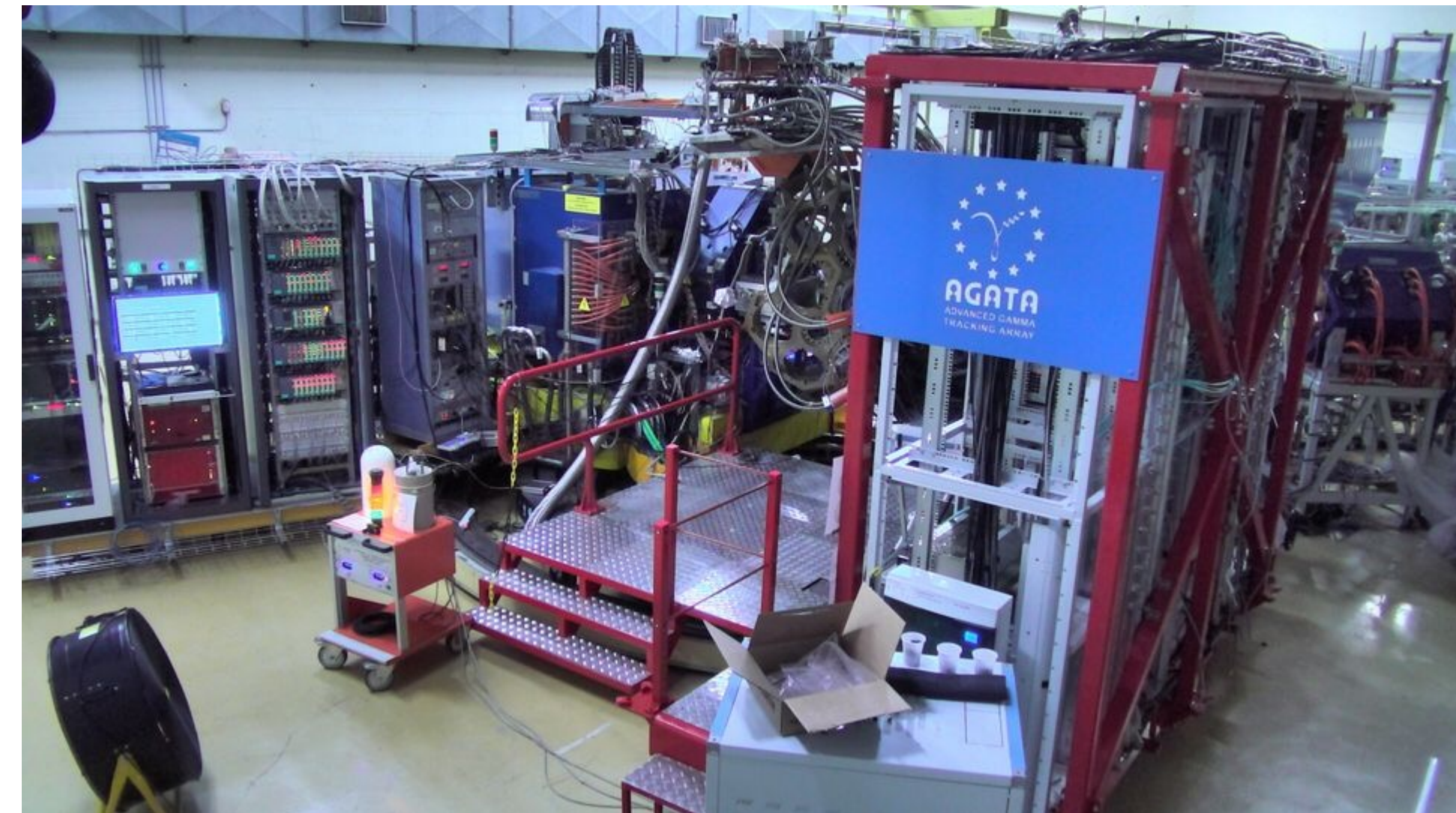
2 experimental campaigns at LNL Tandem-Piave-ALPI facility: September 2022- June 2023

On EUROLABS: 6 experiments supported for 859 access units.

Main user: groups exploiting the AGATA array.

LNS (<https://www.lns.infn.it/>):

The facility is undergoing a major upgrade.



23% of access hours provided (1018/4400), 0% of T&S used

Experiments supported by EURO-LABS project, performed in the period September 2022- September 2023:

1. Proton irradiation of CALIFA Forward Endcap detector modules* (Cederkall) – **5.5 shifts**, Nov. 2022
2. Testing of charged-particle tracking detectors for R3B and SFRS - FAIR Phase-0 experimental program* (Stephanos Paschalis) – **5.5 shifts**, Nov. 2022
3. Proton CT scanner prototype tests* (Jose Briz) – **5 shifts**, Dec. 2023

30% of the money for the visitors and 20% of promised beam-time used

Already accepted (in 2022) by International Advisory Committee – eligible for EURO-LABS project:

1. Study of PDR in Ni isotopes using the inelastic proton scattering at CCB (O. Wieland) – 35 shifts
(planned for Dec. 2023 – Mar. 2024)
2. Study of M4 stretched state in ^{14}N (N. Cieplicka) – 25 shifts
(planned for Apr. 2024 – May 2024)

International Advisory Committee meeting – 31.08.2023

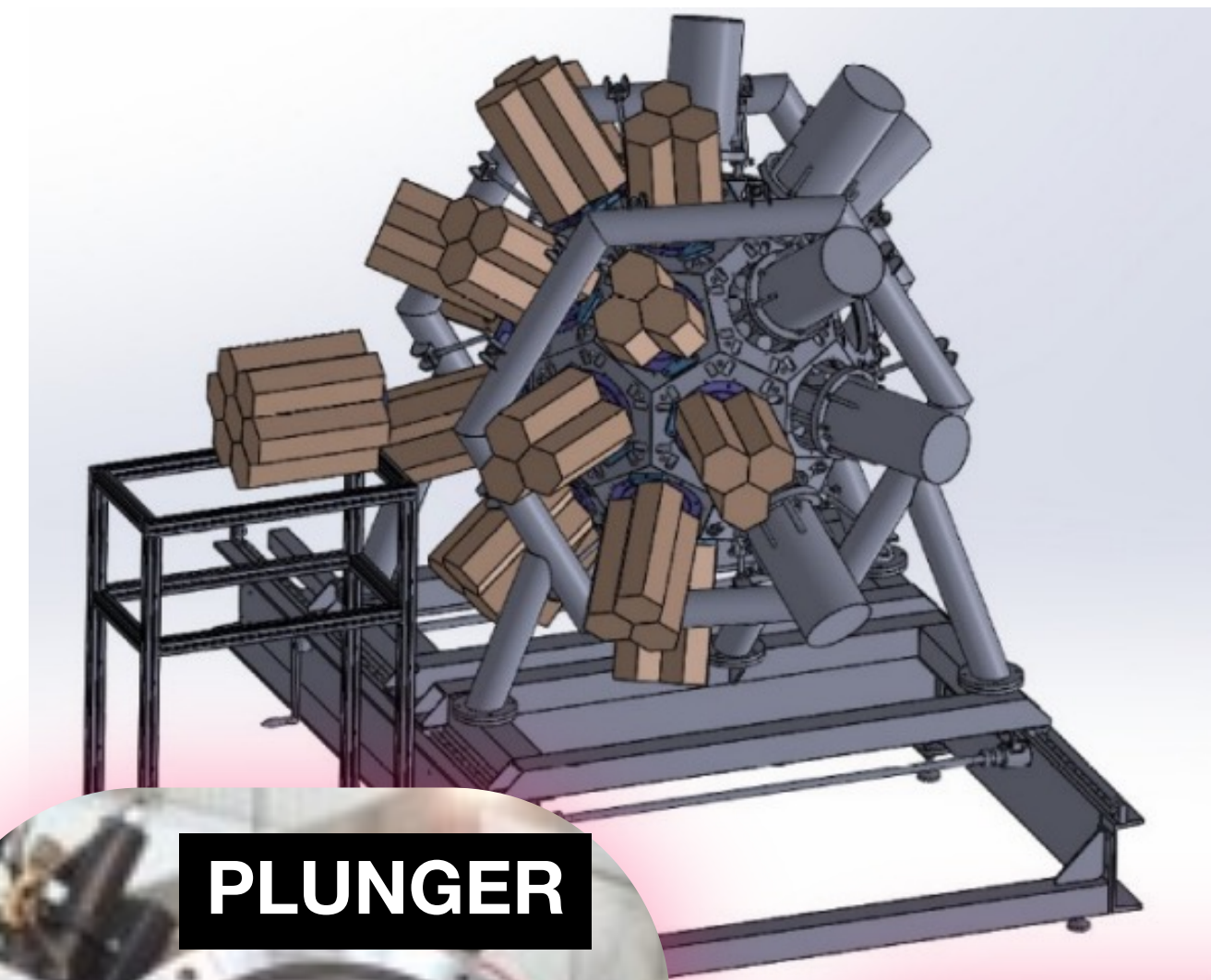
USP meetings (M. Harakeh, A.Maj) – online, when needed

4 proposed experiments eligible for EURO-LABS recommended by IAC for 2024



5 experiments performed at HIL, 4 with NEEDLE (EAGLE+NEDA):

HIL097	Shape coexistence and octupole correlations in the light Xe, Cs and Ba nuclei
HIL098	Quasielastic barrier distributions for the $^{20}\text{Ne} + ^{92,94,95}\text{Mo}$: Influence of dissipation
HIL099	Lifetime measurement of excited states in ^{134}Sm
HIL101	Commissionings of EAGLE-NEDA and EAGLE-NEDA-DIAMANT setups
HIL106	Shape coexistence and octupole correlations in the light Xe, Cs and Ba nuclei



EAGLE (HPGe):

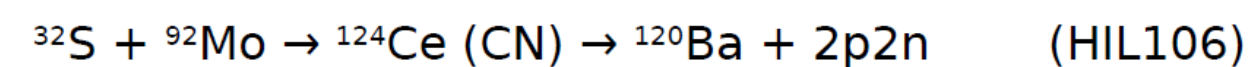
- 5 dets @ 101°
- 5 dets @ 117°
- 5 dets @ 143°

NEDA:

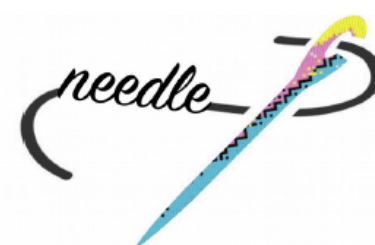
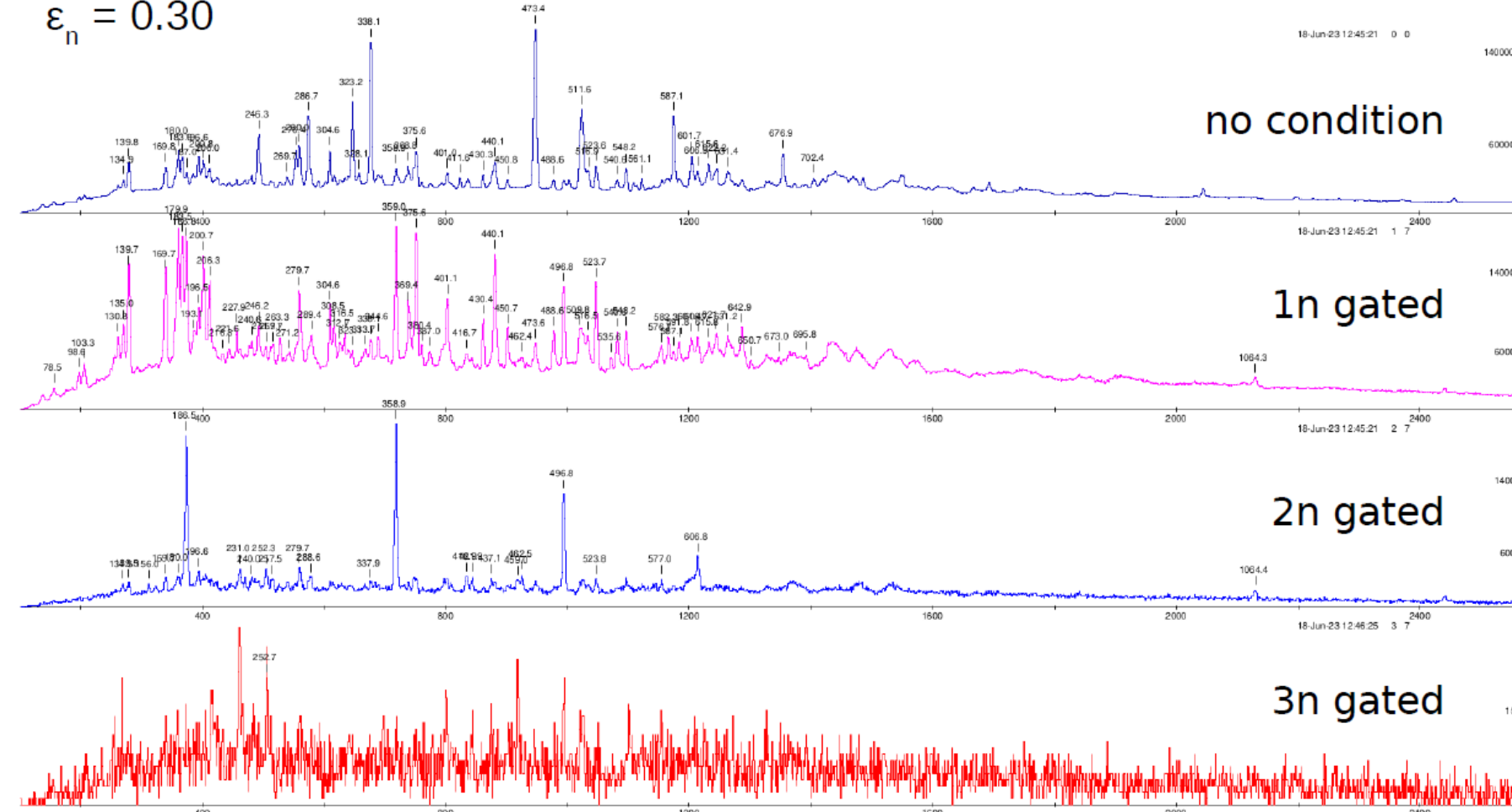
- 6/7 dets ~0°
- 15 dets @ 37°
- 15 dets @ 63°
- 15 dets @ 79°



NEEDLE Performance



$\epsilon_n = 0.30$



- 3 lifetime measurements performed with plunger (HIL097, 099, 106)
- The installation of NEDA at HIL and its coupling with the EAGLE γ -detector array resulted in a very capable setup
- The integration of DIAMANT (HIL 101) opens a wide range of possibilities to study exotic neutron-deficient nuclei, especially towards N=Z line.

Summary – Period 1

- Milestone – all facilities have arranged calls for proposals in accordance with the GA:
- **MS2** - Preparation of calls for submission of proposals to stable beam access facilities completed Task 2.1 Status: Achieved (Delivery date: 28/02/2023). Link to the Milestone Report: <https://data.192.135.24.99.myip.cloud.infn.it/s/SIXslyV6xTHNXIq>
- All facilities except GSI have executed supported experiments in the first reporting period – GSI will exhaust allocated resources in 2024-2025
- Two facilities have already provided more than 100% of the promised access hours - ALTO (134%) and NLC-SLCJ (117%) – JYU has provided 84%
- Approximately 50% of promised access hours already delivered overall
- More than 50 projects and around 225 visits supported
- Clear that demand and possibility to supply access far greater than the level promised in the GA
- Ratio of provision of access hours to T&S support (if nominal at this point 25%) not in balance at some facilities