

WP2 - Task 2.2 Radioactive Ion Beam Facilities

I. STEFAN (IJCLAB)



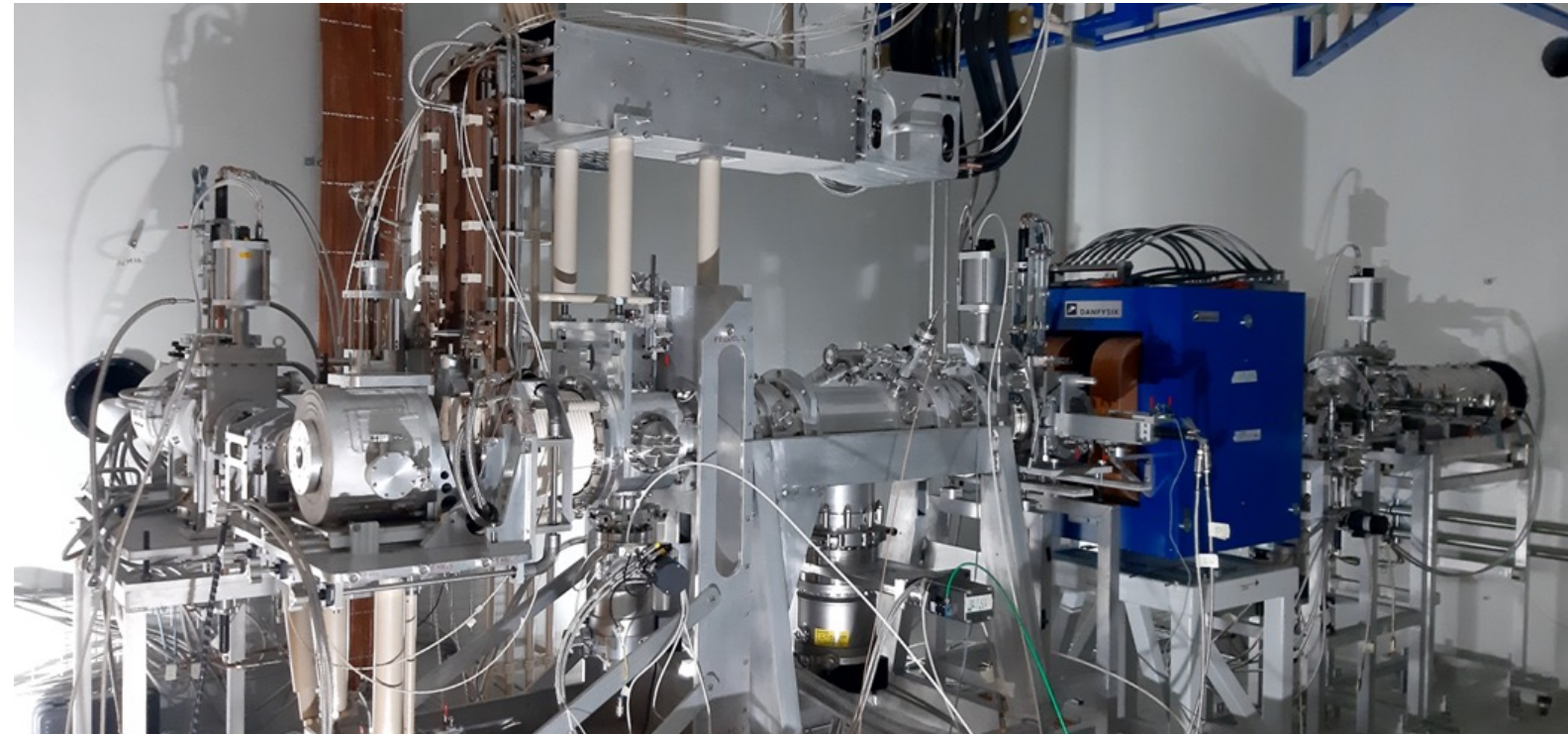
This project has received funding from the European Union's Horizon Europe Research and Innovation programme under Grant Agreement No 101057511.

Institution	Infrastructure	Country	Facility Coordinator
<u>INFN</u>	<u>LNL/LNS</u>	Italy	<u>Tommaso Marchi</u> <u>Alessia Di Pietro</u>
<u>GANIL</u>	<u>GANIL-SPIRAL2</u>	France	<u>Emmanuel Clement</u>
<u>IJCLab</u>	<u>ALTO</u>	France	<u>Enrique MINAYA</u>
<u>GSI</u>	<u>GSI/FAIR</u>	Germany	<u>Christoph Scheidenberger</u>
<u>CERN</u>	<u>ISOLDE</u>	International Organisation	<u>Sean Freeman</u>
<u>Univ. Jyväskylä</u>	<u>JYFL</u>	Finland	<u>Paul Greenlees</u>



Thank to all the facility coordinators

LNL: The SPES project



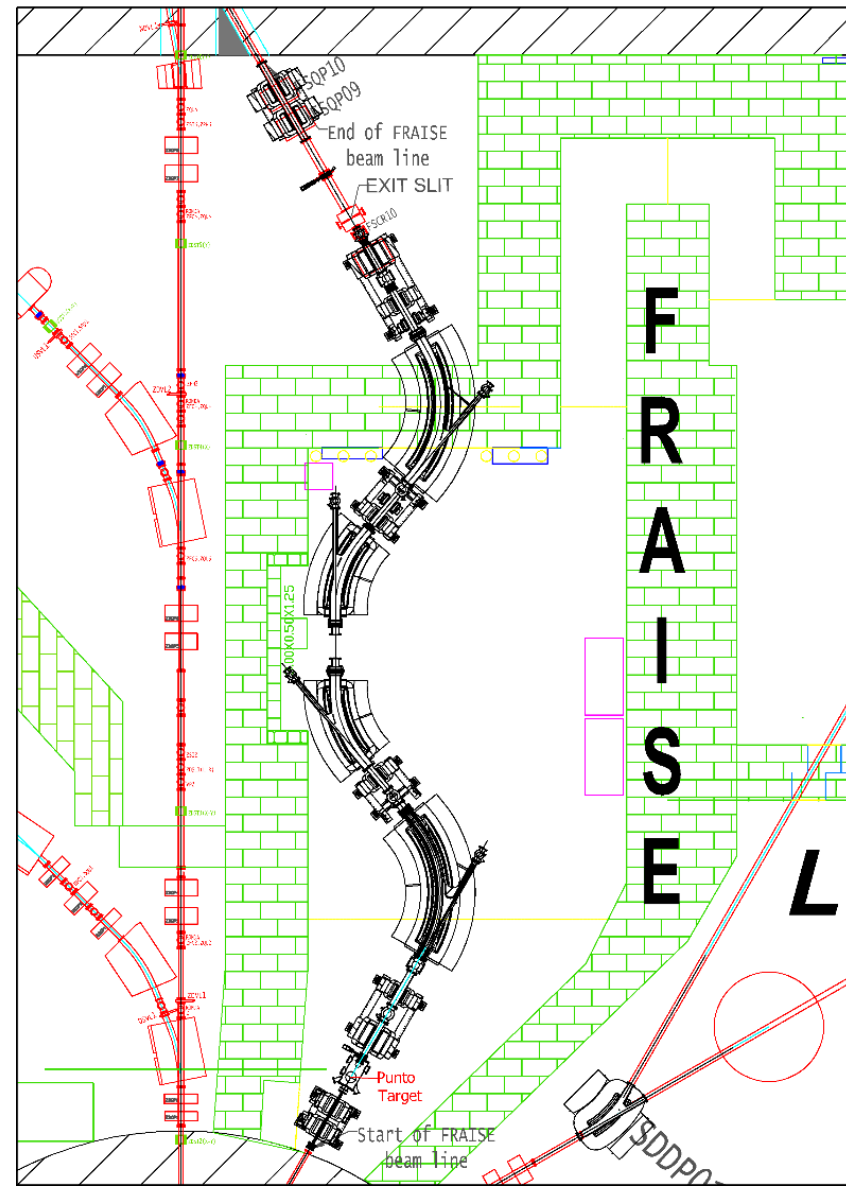
SPES Target Ion Source complex: installation completed

RIB production mechanism: **fission (ISOL)**
Post-acceleration up to 10 MeV/A



Access provided: The facility is not operational yet.
How the access to beam time is decided: 2 PAC meetings / yr.

<https://www.lnl.infn.it/en/eurolabs-financial-support/>



Means of production: In-Flight (fragmentation)
Energy range: 15 to 70 MeV/A

LNS: major laboratory upgrade in progress



Infrastructure for the fragment separator completed
Cyclotron and the permits under way.

Access provided: The facility is not operational yet.
Beam time is decided by 2 PAC meetings / yr.

<https://www.lnl.infn.it/en/eurolabs-financial-support/>

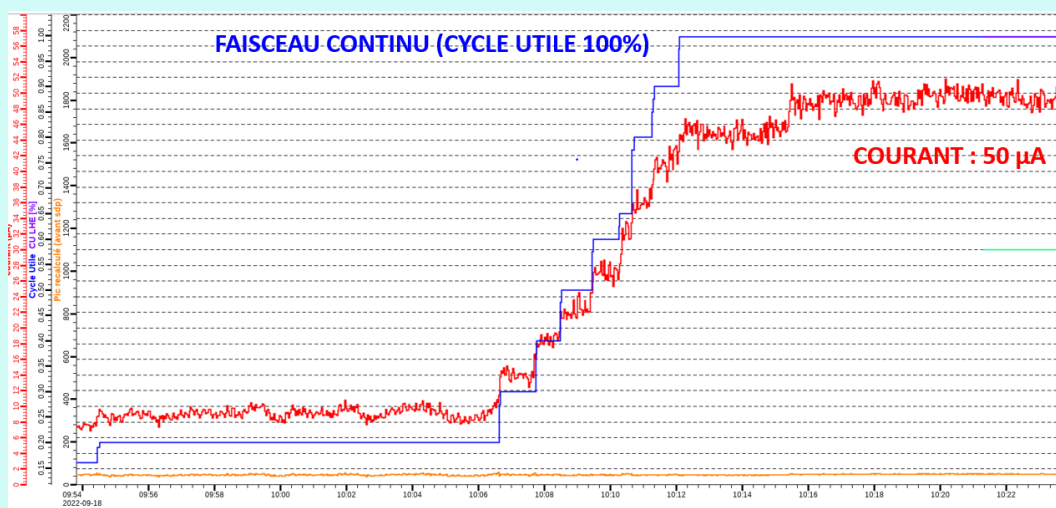


Means of production: fragmentation, fusion-evaporation (ISOL & In Flight)

ISOL: Low energy & Post-Accelerated up to 25 MeV/A

In-Flight: 30-70 MeV/A at the LISE fragment separator for $A < \sim 100$

In the future, **proton-rich nuclei** up to SHE at Low-Energy
after **fusion evaporation** (LINAG)



November 2022 :
Spiral 2 “heavy beam” $^{40}\text{Ar}^{14+}$ 80 uA,
7 MeV/nucleon



**Civil construction of
DESIR has started. Op. :
~2027-2028**

Construction phase
started 2023



**1540 hours of
beamtime
receiving TA.**



In-flight

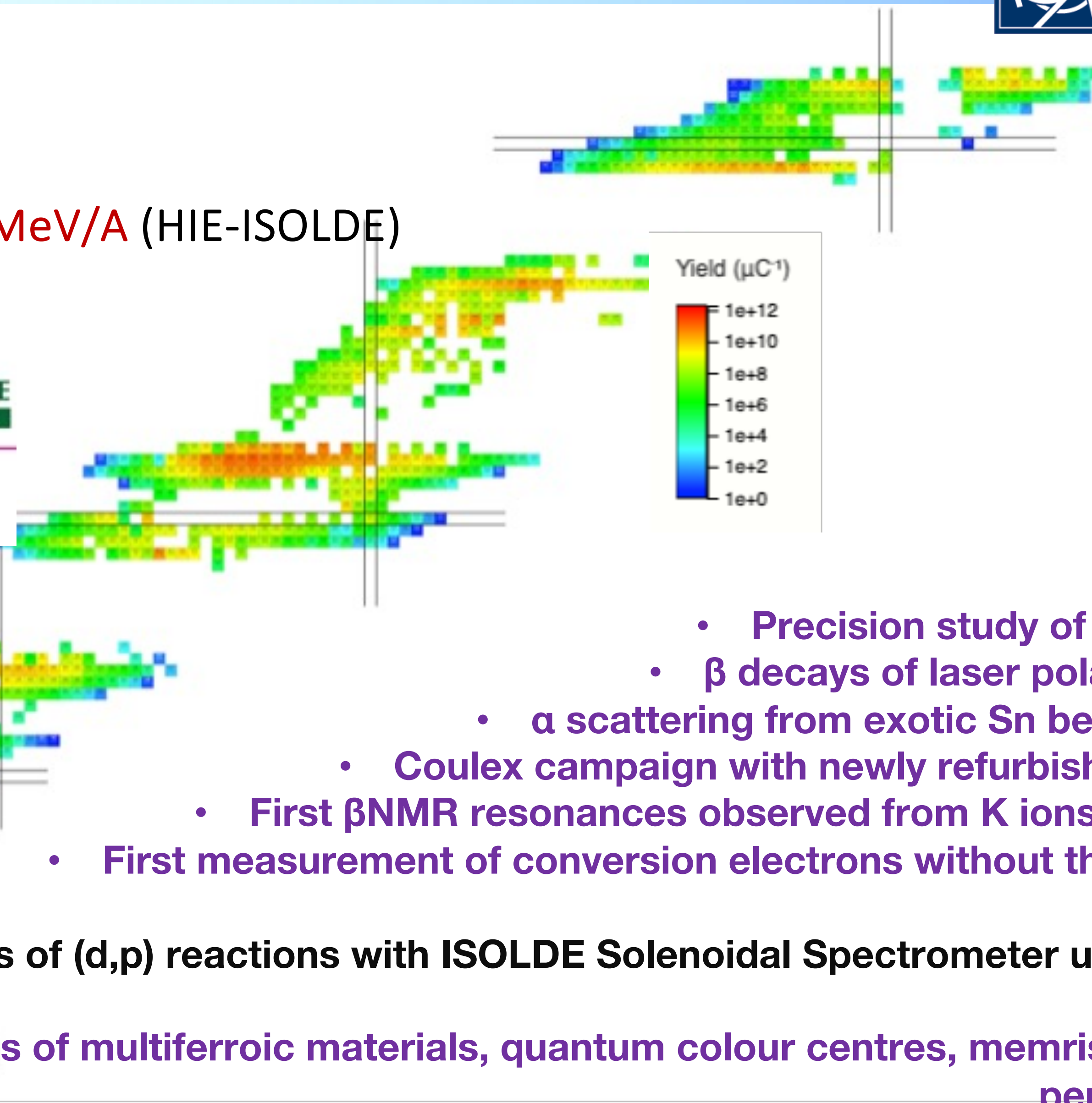
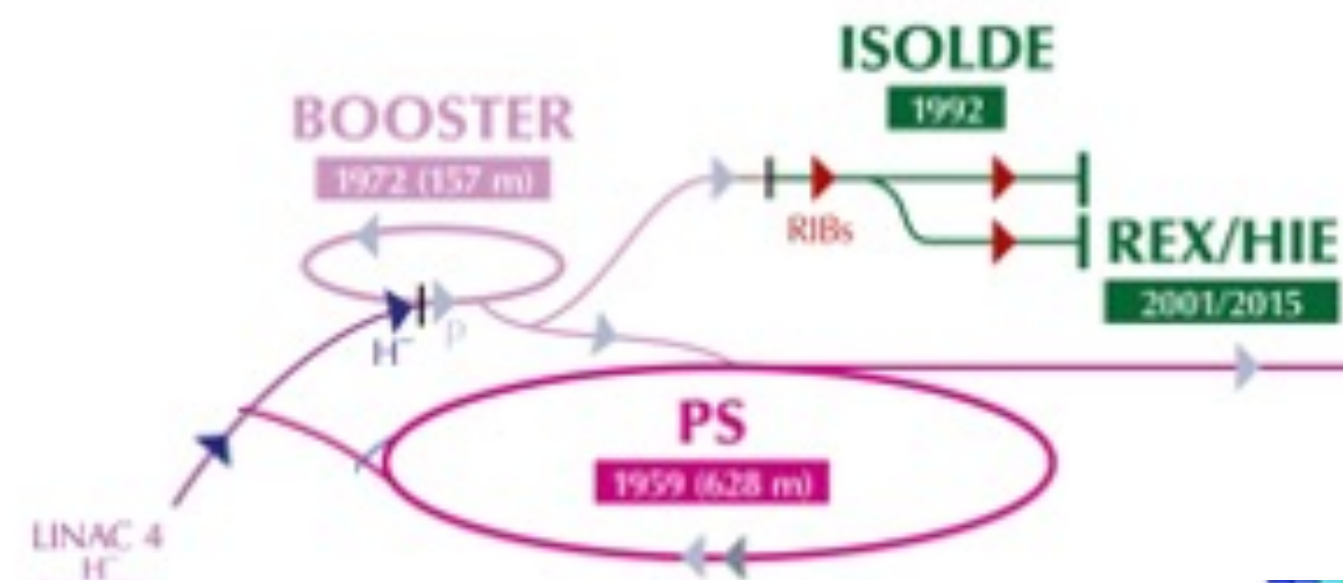
**LISE – Frag. Separator
2023-2025 MUGAST**

**Transfer reactions (d,p), (p,d),
(d,t), (d,3He), (p,3He)**

ISOL

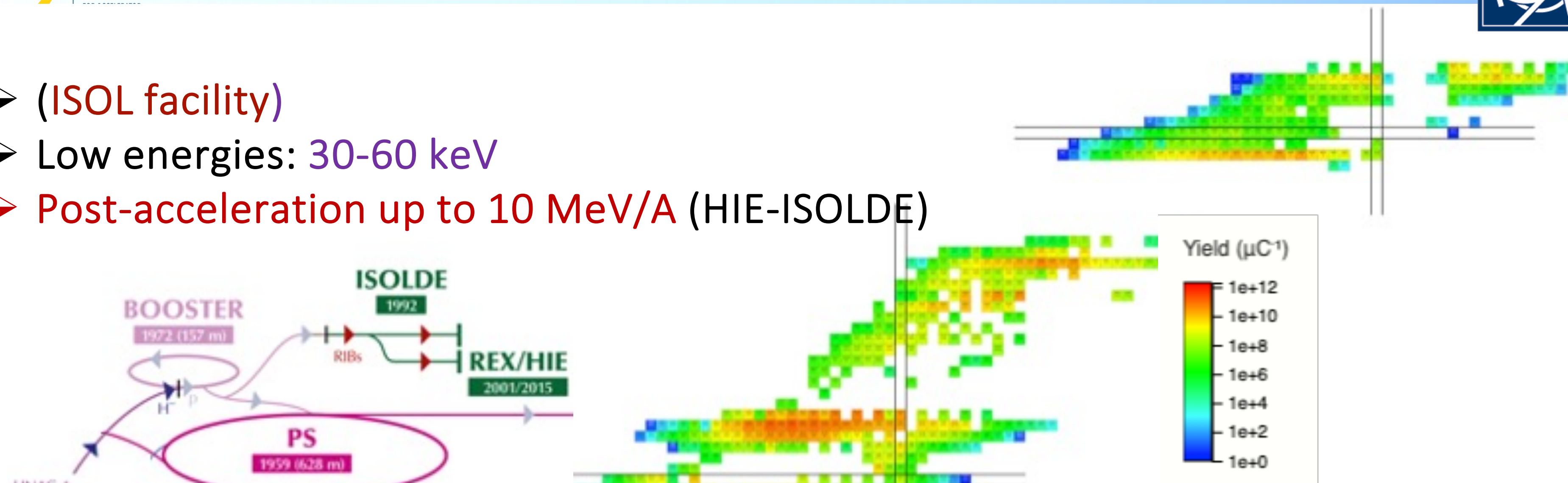
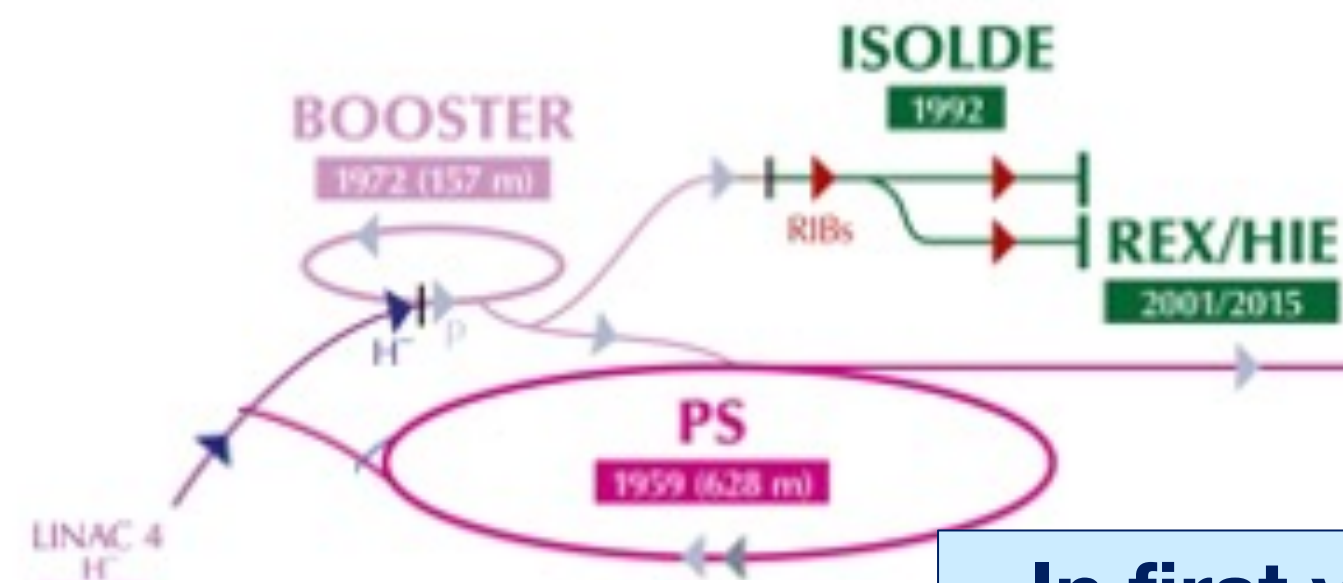
**Impact of neutron excess on near-barrier
fusion in $^{19,20}\text{O} + ^{12}\text{C}$ (R. De Souza et al,
Performed in June 2023, submitted to PRL)**

- (ISOL facility)
- Low energies: 30-60 keV
- Post-acceleration up to 10 MeV/A (HIE-ISOLDE)



- Search for double α decay.
- Precision study of ^{229}Th isomer for nuclear clock.
- β decays of laser polarised neutron-rich potassium.
- α scattering from exotic Sn beams with novel helium targets.
- Coulex campaign with newly refurbished Miniball $^{182-185}\text{Hg}$ and ^{130}Sn .
- First βNMR resonances observed from K ions implanted into DNA solutions.
- First measurement of conversion electrons without the use of transporting magnets in a radioactive-beam
- Series of (d,p) reactions with ISOLDE Solenoidal Spectrometer using ^{30}Mg , $^{49,50}\text{Ca}$, ^{68}Ni , ^{92}Kr and ^{108}Sn beams.
- Solid-state studies of multiferroic materials, quantum colour centres, memristive devices, energy efficient perovskites, and tracer diffusion.

- (ISOL facility)
- Low energies: 30-60 keV
- Post-acceleration up to 10 MeV/A (HIE-ISOLDE)



In first year of EURO-LABS, 51 experiments with EURO-LABS support with a total of 3336 hours of beamtime and 157 researchers receiving TA, mainly early-career researchers and/or first-time users.

- α scattering from exotic Sn beams with novel helium targets.
- Coulex campaign with newly refurbished Miniball $^{182-185}\text{Hg}$ and ^{130}Sn .
- First βNMR resonances observed from K ions implanted into DNA solutions.
- First measurement of conversion electrons without the use of transporting magnets in a radioactive-beam
- Series of (d,p) reactions with ISOLDE Solenoidal Spectrometer using ^{30}Mg , $^{49,50}\text{Ca}$, ^{68}Ni , ^{92}Kr and ^{108}Sn beams.
- Solid-state studies of multiferroic materials, quantum colour centres, memristive devices, energy efficient perovskites, and tracer diffusion.

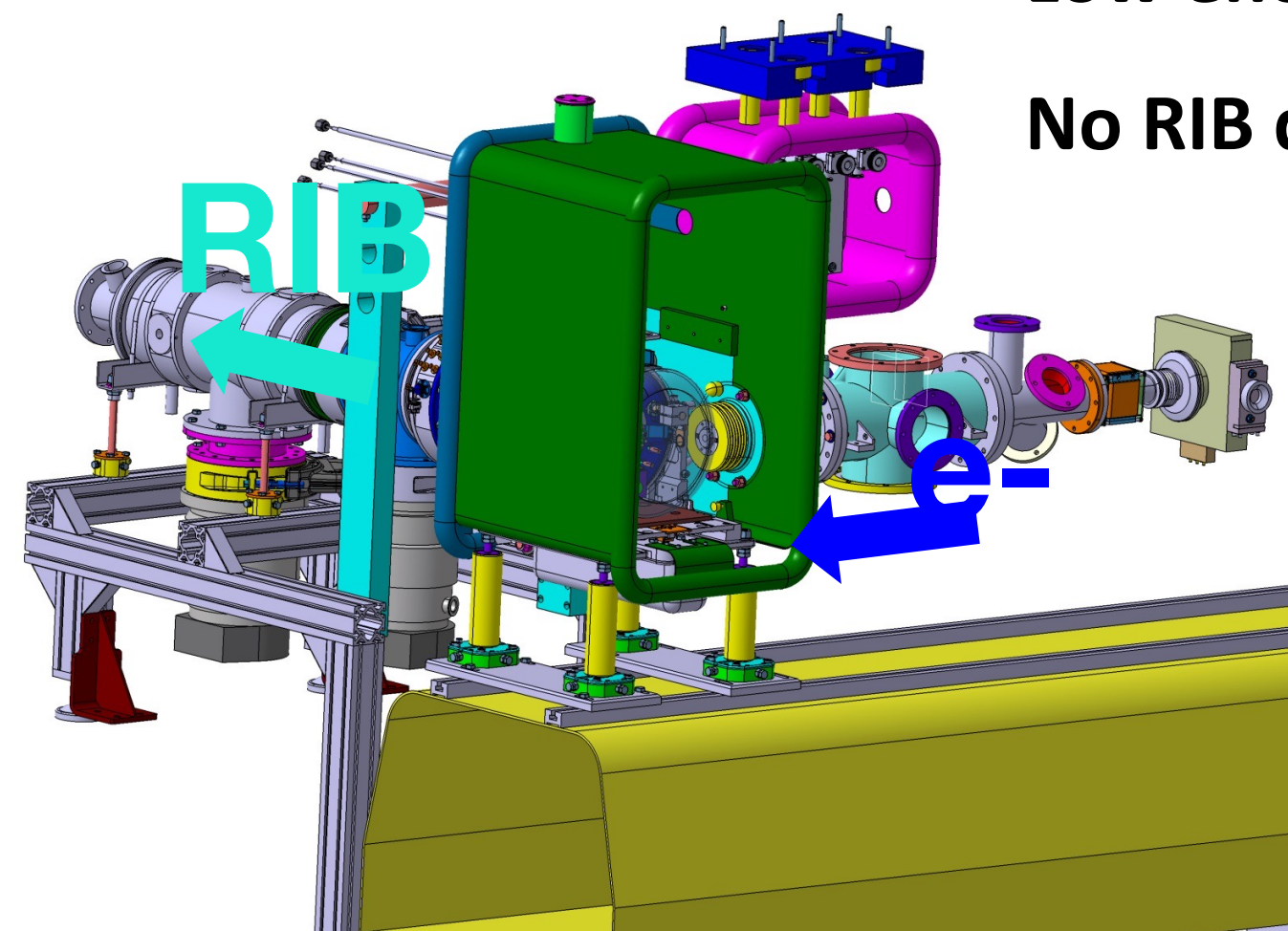
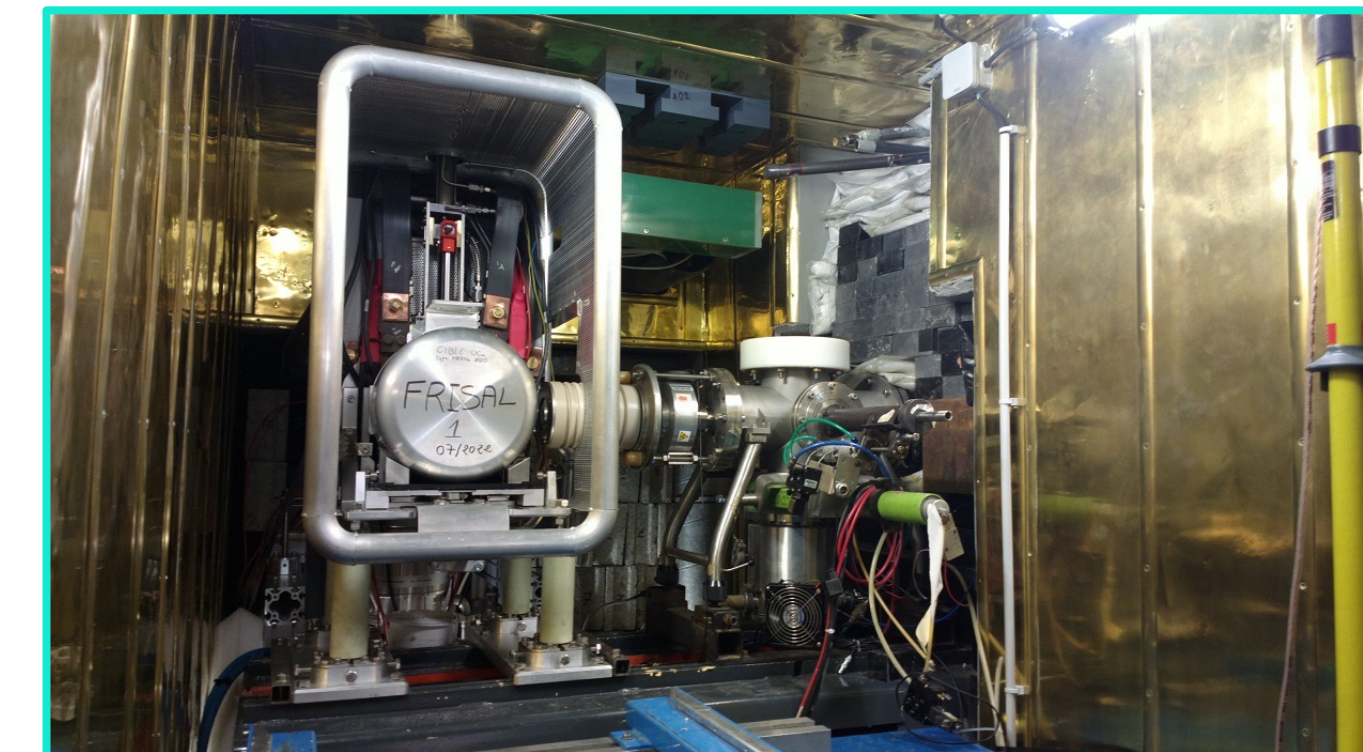


Photofission **ISOL RIB infrastructure** ($\sim 10^{11}$ fissions/s)

UCx target (~ 70 g)

Low energy RIB (60 keV)

No RIB delivered in 2023/2024



October 2022 : online commissioning of new ALTO RIB front end

Stable and radioactive beams in parallel!

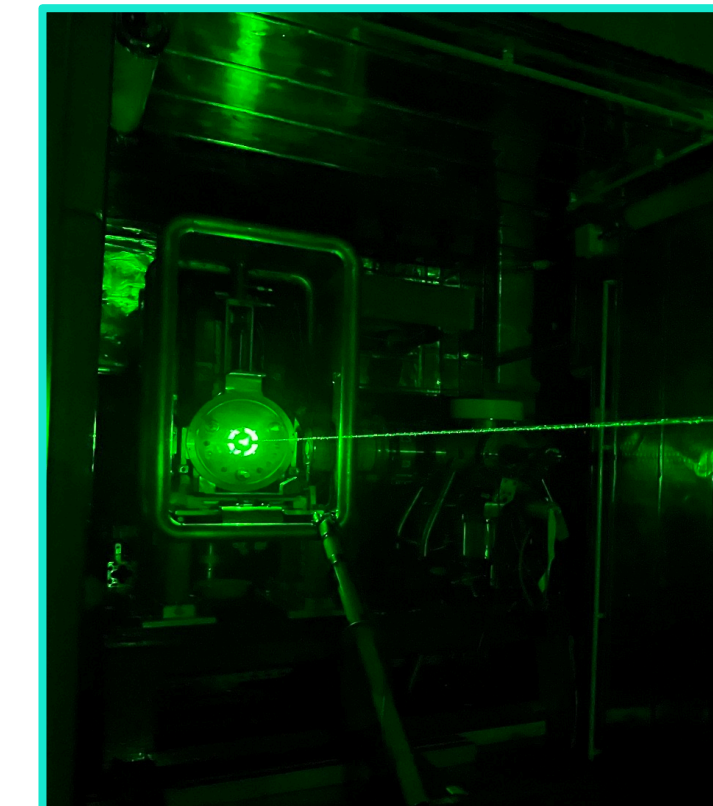
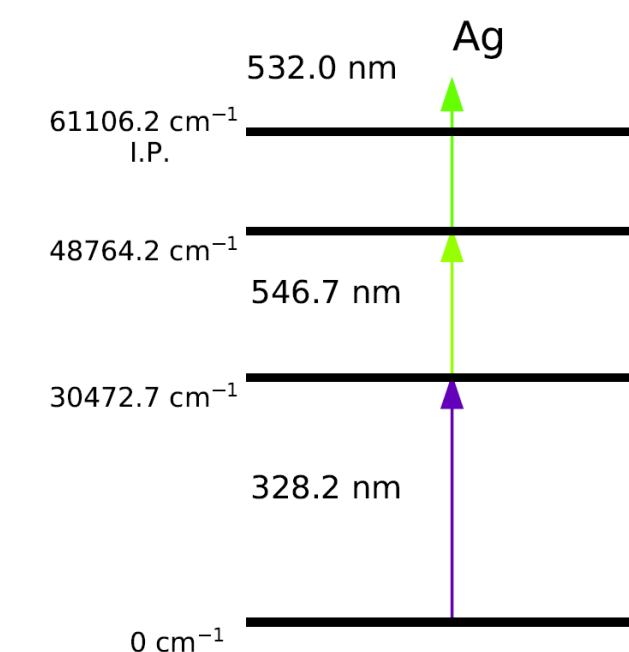
minaya - 14 October 2022 - ALTO (EN) / ALTO-LEB (EN) / Communication



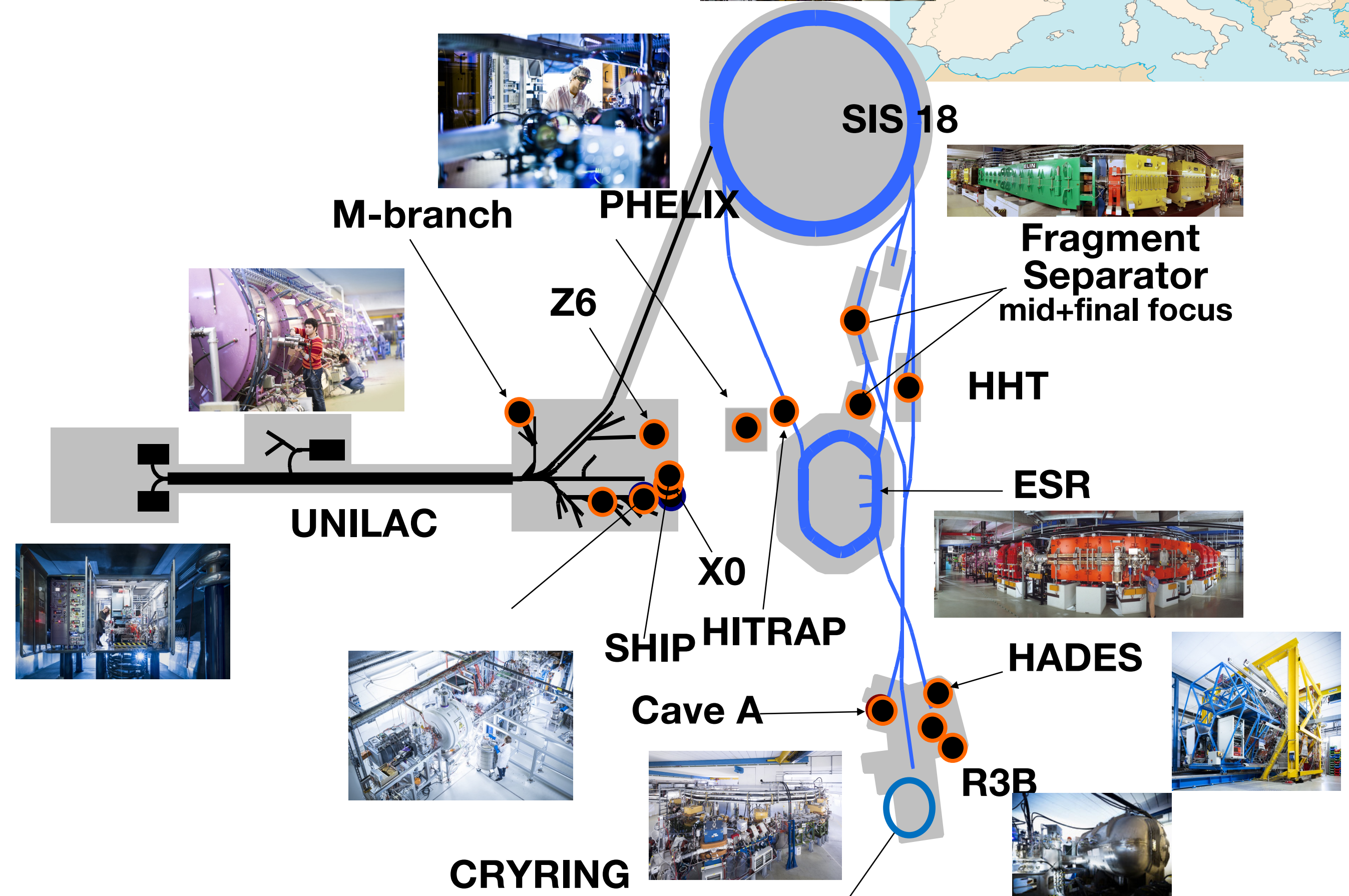
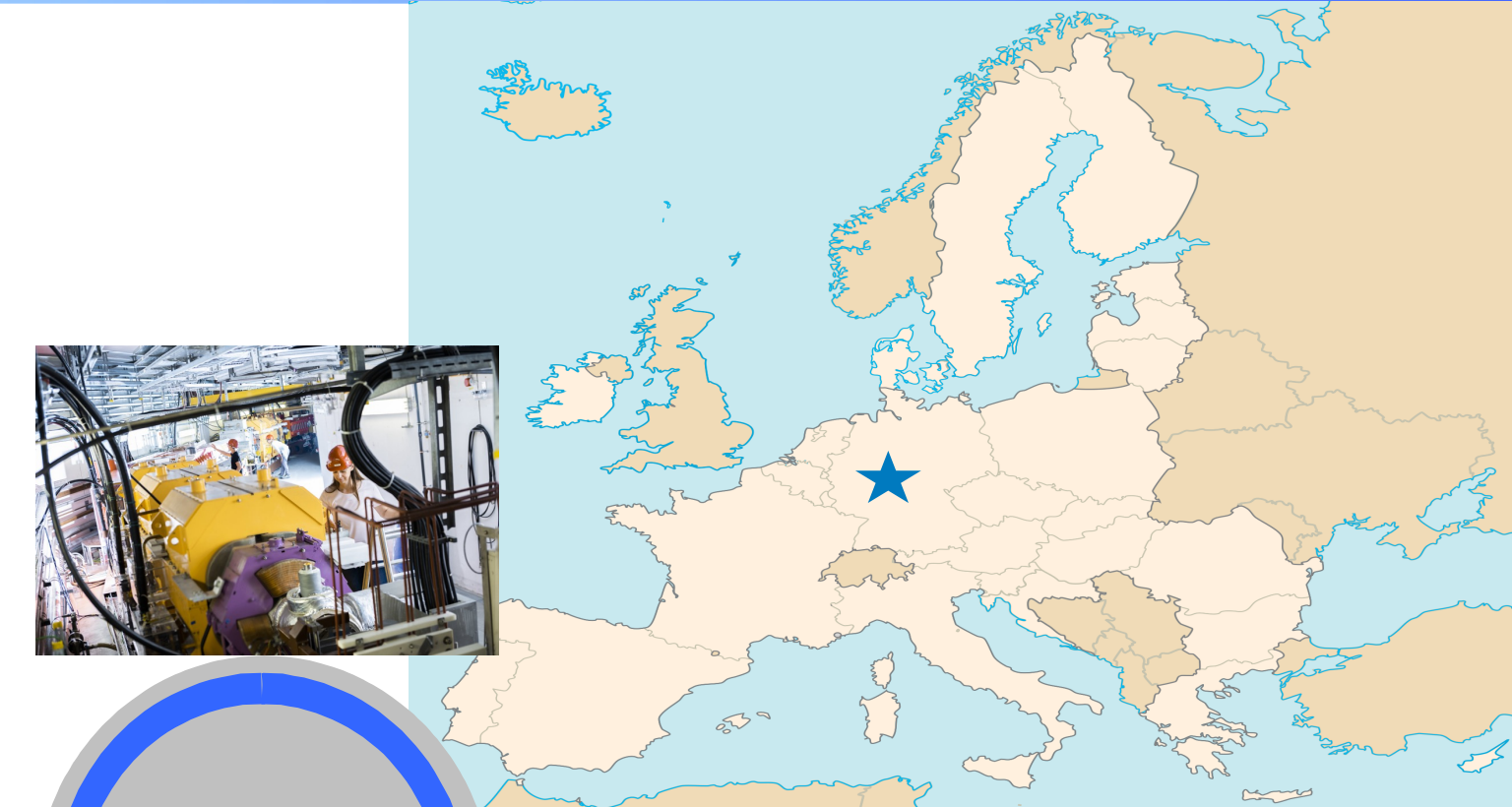
During weeks 41 and 42, the Tandem and the LINAC will operate in parallel. The nu-Ball 2 experiment takes advantage of the lithium 7 beam produced by the Tandem and the secondary beam of neutrons produced by LICORNE. The COeCO experiment will exploit the radioactive gallium and silver elements produced by photofission using the LINAC and ionized by the laser ion source of ALTO.

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

Ag laser ionization schemes successfully validated



- UNILAC: p to U, Energy <math>< 11.4 \text{ MeV/A}</math>
facilities: SHIP/SHIPTRAP, TASCA, M-Branch, irradiation cave
- SIS18: p to U, max. energy 1.0 (U)... 2.0 (^{12}C)
GeV/A, 4.2 GeV (p)
Fragmentation and fission



No RIB in until now
USP took place in September 2023, where there were 21 applications, they were all approved;

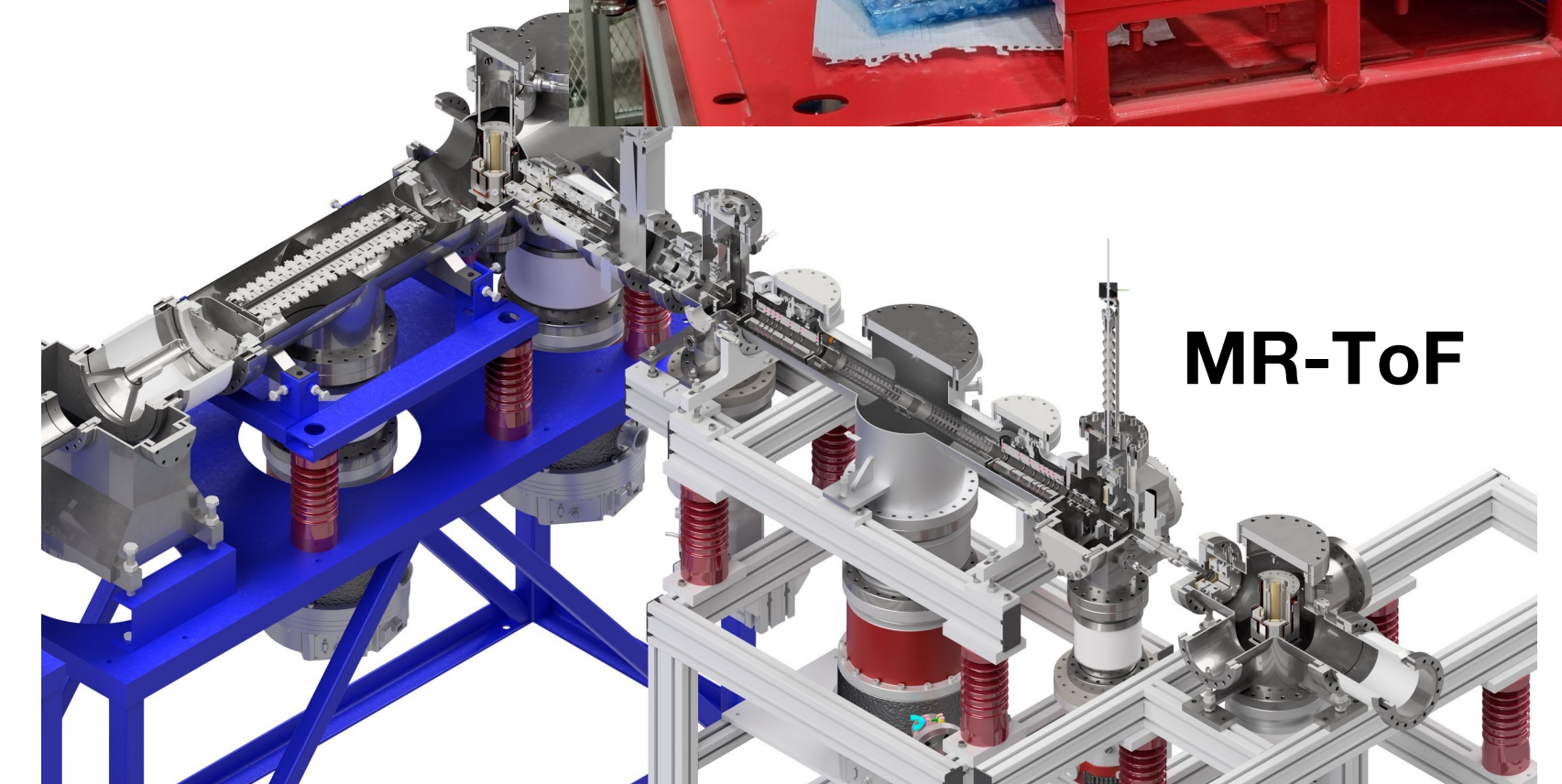
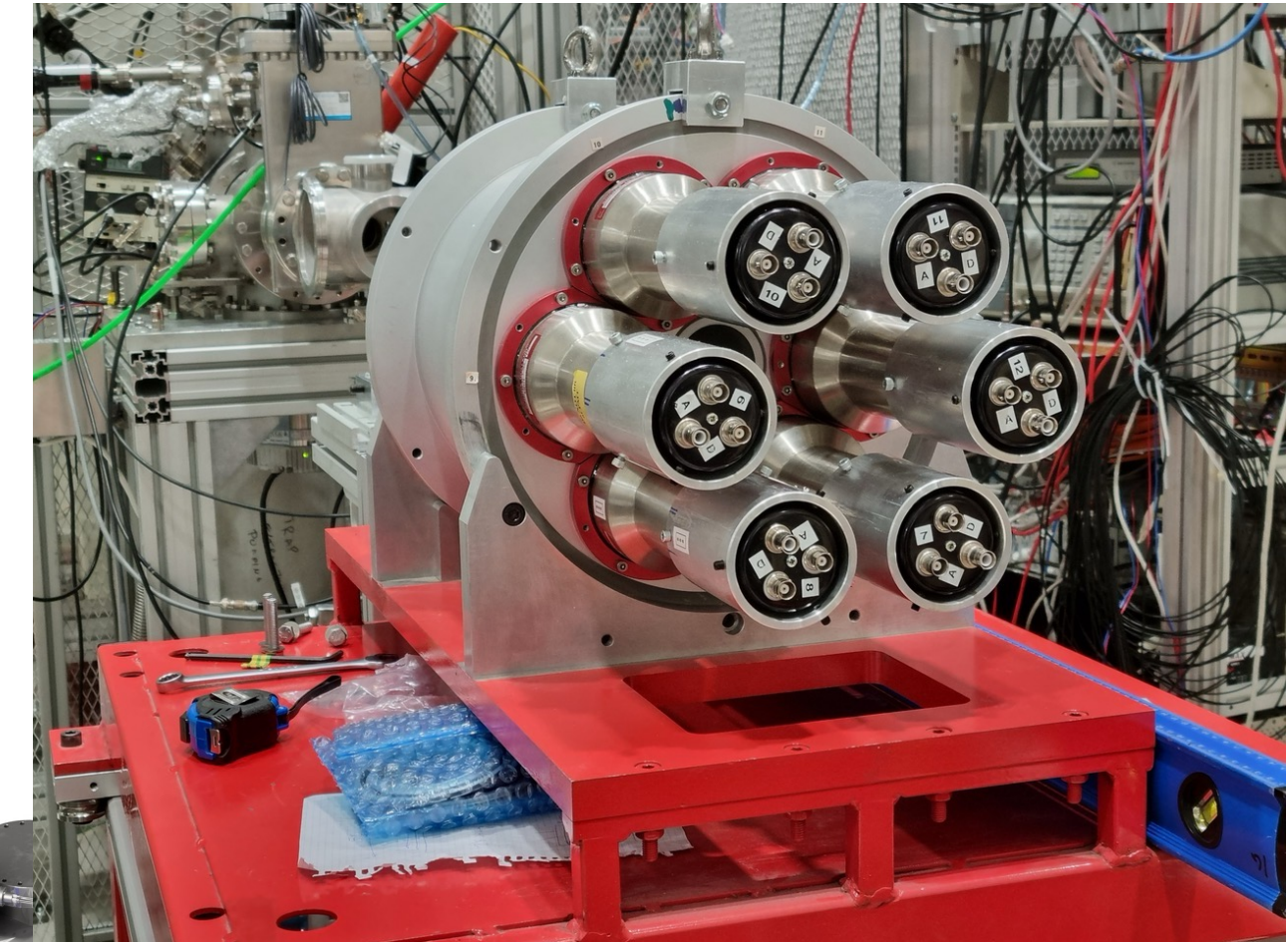
Low energy (keV) RIBs produced via **proton-induced fission, heavy-ion fusion, multi-nucleon transfer**

- 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: 2 RIB
- Supported visits: 80 (134 total)
- Total access hours delivered: 2928 (from 3500)
- Currently 7 eligible experiments pending
- Next PAC Meeting 15th November – 10 eligible experiments, 2280 hours requested

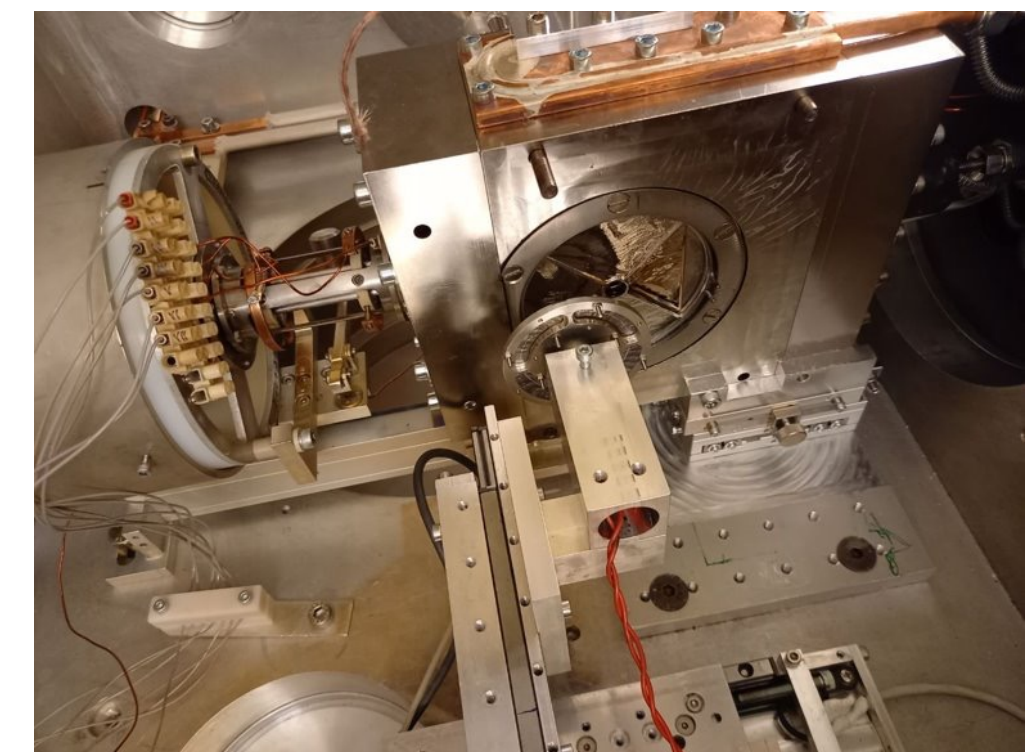
Total absorption spectroscopy measurements for the prediction of the reactor antineutrino spectra

Mass measurements in the vicinity of ^{78}Ni

Total Absorption Spectrometer



New gas cell for MNT



Infrastructure

[LNL Legnaro/LNS Catania](#)

[GANIL-SPIRAL2](#)

[ALTO](#)

[GSI/FAIR](#)

[ISOLDE](#)

[JYFL](#)

Publicity concerning the opportunities for access

<https://www.inl.infn.it/en/eurolabs-financial-support/>

<https://www.ganil-spiral2.eu/scientists/running-an-experiment-in-ganil/preparing-an-experiment/transnational-access-ensar2/>

<https://alto.ijclab.in2p3.fr/beam-time-access/>

https://www.gsi.de/work/organisation/wissenschaftliche_gremien/user/funding/euro-labs

<https://isolde.web.cern.ch/index.php/euro-labs-financial-support>

<https://www.jyu.fi/science/en/physics/research/infrastructures/accelerator-laboratory/access/visitors-and-outside-users>

Name of facility	Number of eligible applications	Number of selected applications	Number of user groups with majority of users not working in an EU member state of HE associate country
LNL Legnaro/LNS Catania	0	0	0
GANIL-SPIRAL2	55*	55*	1
ALTO	0	0	0
GSI/FAIR	0	0	0
ISOLDE	41	41	9
JYFL	15*	15*	1

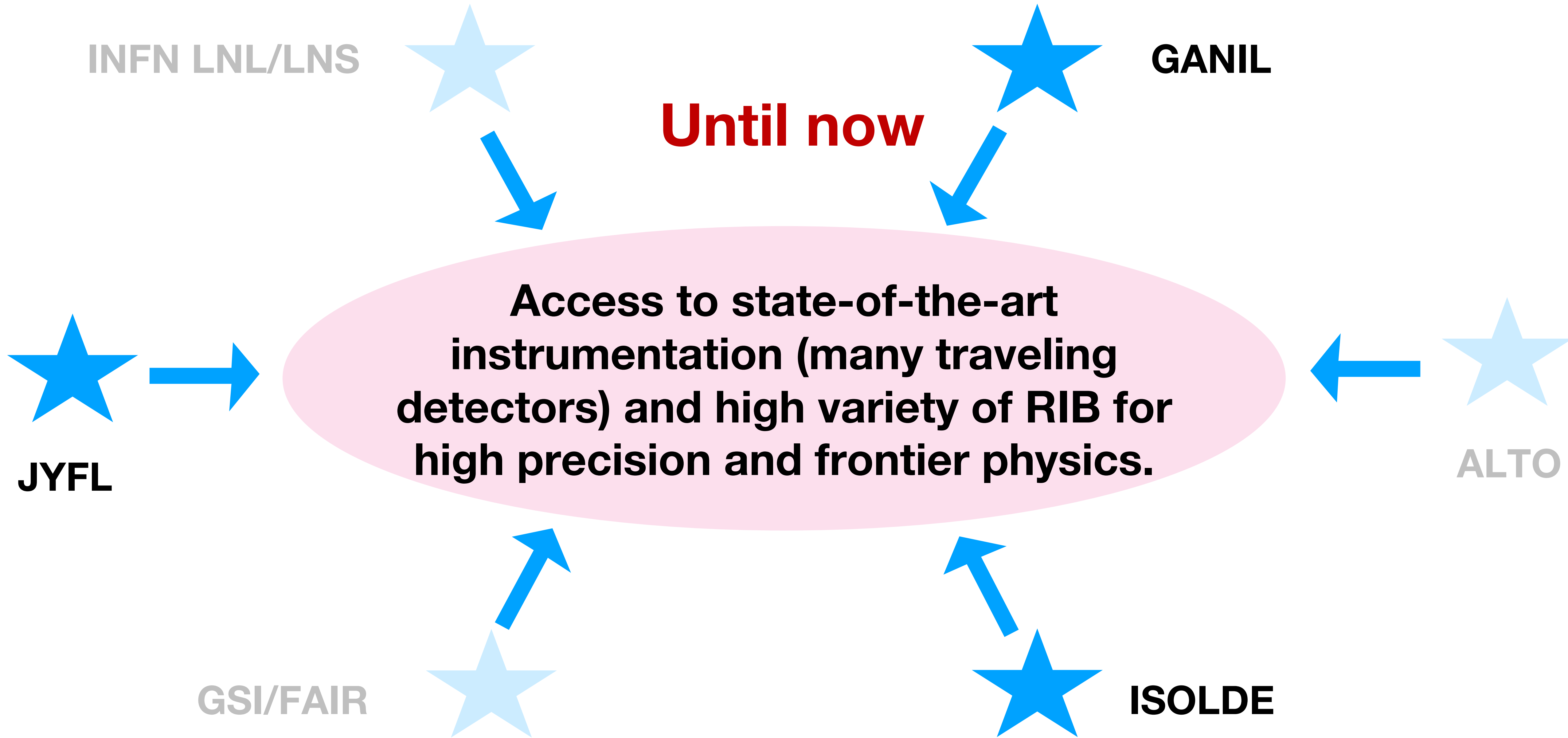
* - Radioactive and stable beam

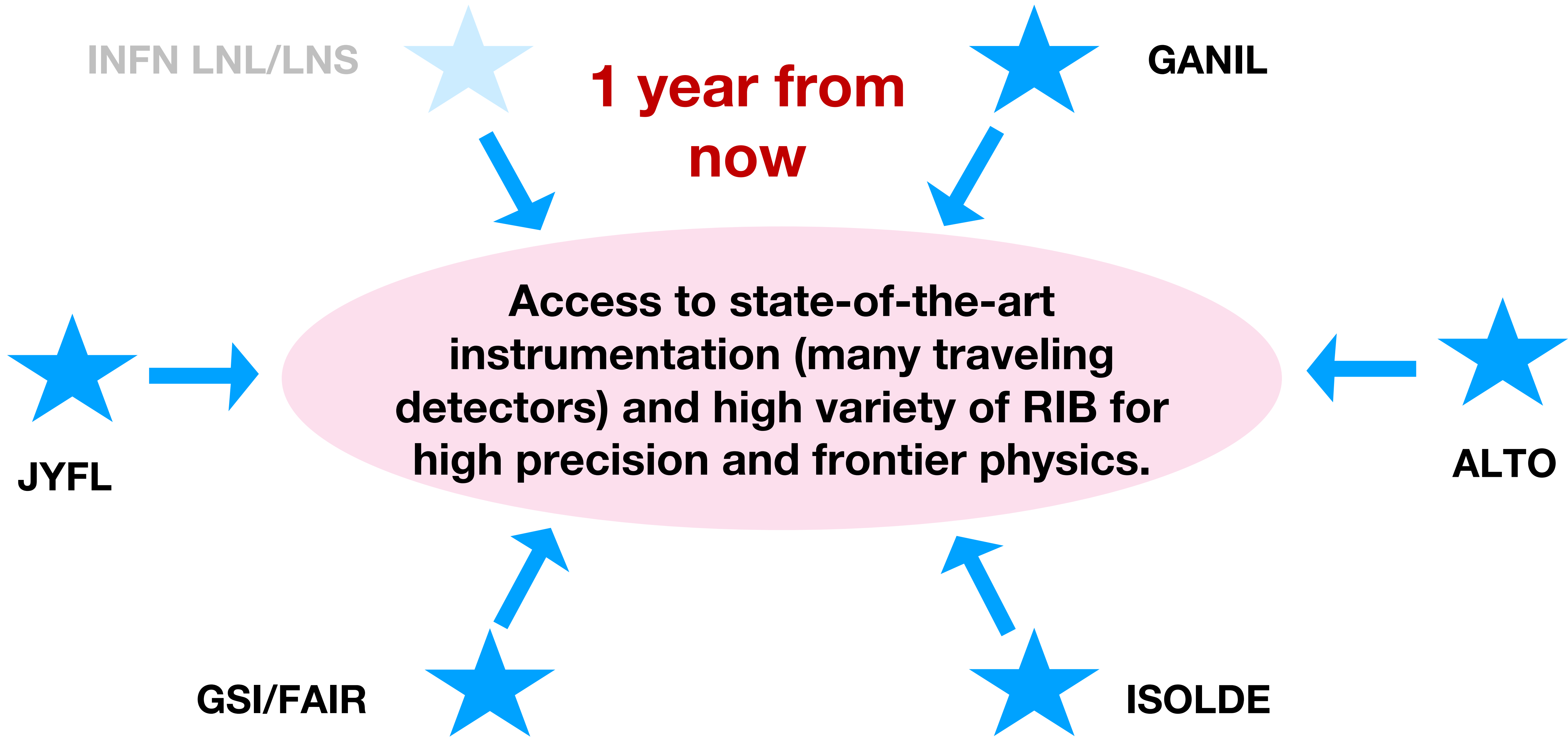
100% selection rate

Infrastructure	Estimated Quantity of Access (hours)	Access Units provided by 31/08/2023 (RP1)	Allocated users support for T&S (Euro)	% (and amount) of allocated user's reimbursement spent
LNL Legnaro/LNS Catania	0	0	0	
GANIL-SPIRAL2	3254*	1540*	351 403*	15% (55 102€)*
ALTO	0	0	0	
GSI/FAIR	2150*	0	0	
ISOLDE	4500	3336	330 000	26.7% (88 182€)
JYFL	3500*	2928* (504 RIB)	240 000*	17.1% (41 019€)*

* - Radioactive and stable beam

About 50% achieved access



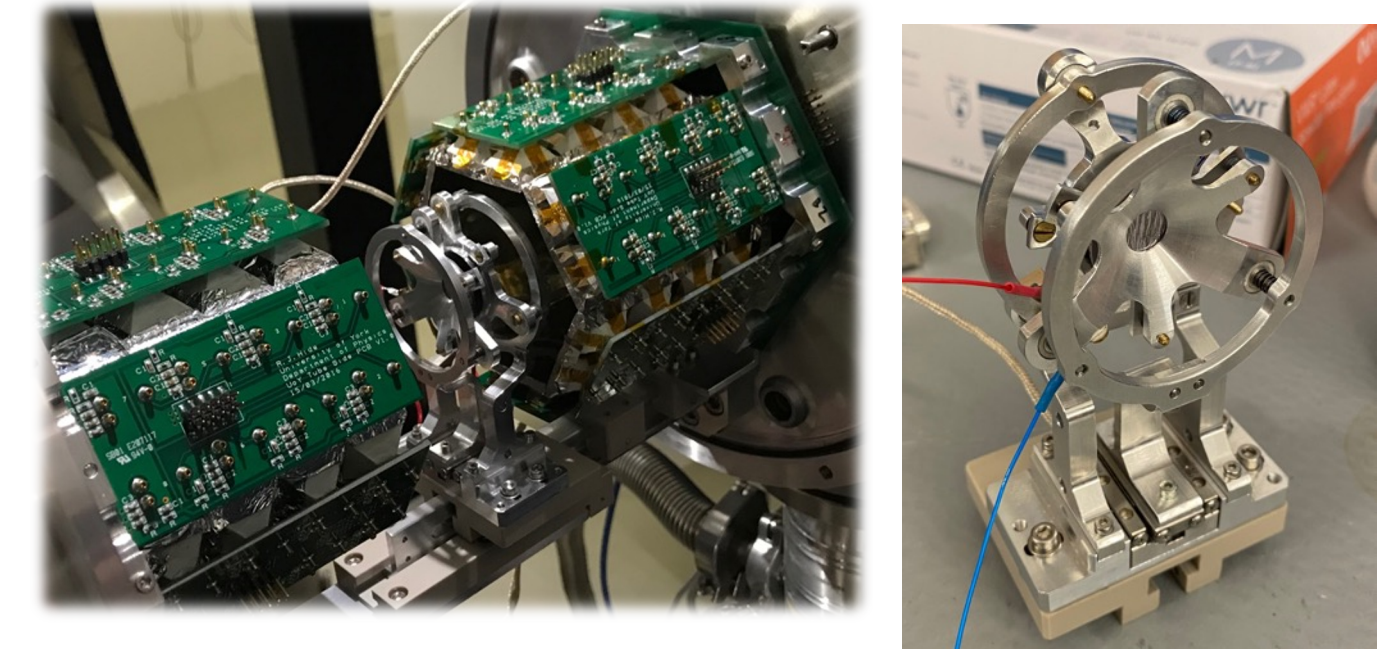


Thank you

Low energy (keV) RIBs produced via
proton-induced fission, heavy-ion fusion, multi-nucleon transfer

- 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:, 2 RIB
- Supported visits: 80
- Total visits: 134
- Total access hours delivered: 2928 (from 3500)
- Currently 7 eligible experiments pending
- Next PAC Meeting 15th November – 10 eligible experiments, 2280 hours requested

**APPA Plunger + CPD
Lifetime measurements**



MR-ToF



New gas cell for MNT

