



Perspectives at the Bellotti IBF

Laboratori Nazionali del Gran Sasso

8-9-10 October 2025

Summary talk

Federico Ferraro (INFN-LNGS)



Perspectives at the Bellotti IBF



Workshop on Nuclear Physics, Astrophysics and Applications in Underground Laboratories



OCTOBER 8-10, 2025
Laboratori Nazionali del Gran Sasso
Assergi, L'Aquila, Italy

The workshop aims to bring together scientists interested in research at the deep underground Bellotti Ion Beam Facility (IBF) at INFN's Laboratori Nazionali del Gran Sasso (LNGS), to explore opportunities and challenges in an international context and to stimulate networking.

Topics

- Bellotti IBF in the international context of underground nuclear astrophysics
- Bellotti IBF for Physics beyond the standard model
- Perspectives in Applied Physics research at Bellotti IBF

Scientific advisory committee

- Sandrine Courtin, University of Strasbourg, France
- Federico Ferraro, INFN-LNGS, Italy
- Alba Formicola, INFN-Roma 1, Italy
- Jordi José, UPC Barcelona/IEEC, Spain
- Matthias Junker, INFN-LNGS, Italy
- Matthias Laubenstein, INFN-LNGS, Italy
- Marcello Messina, INFN-LNGS, Italy
- Valentino Rigato, INFN-LNL, Italy
- Daniel Robertson, University of Notre Dame, Indiana, USA

Local organizing committee

- Chair: Federico Ferraro, INFN-LNGS, Italy
- Riccardo Maria Gesùè, GSSI & INFN-LNGS, Italy
- Thomas Chillery, INFN-LNGS, Italy
- Dipali Basak, INFN-LNGS, Italy

Scientific secretary

- Fausto Chiarizia, INFN-LNGS, Italy

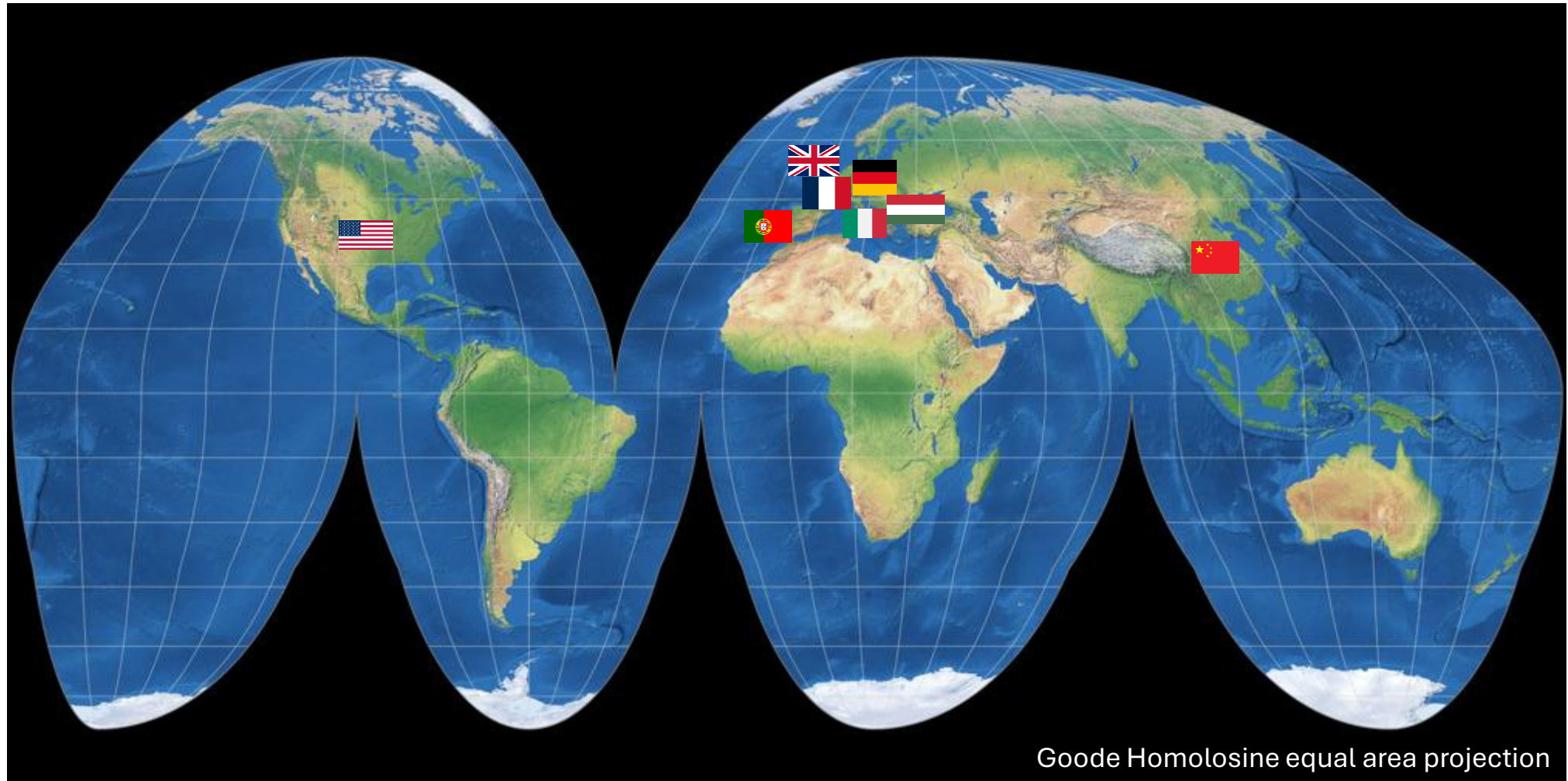
Contacts

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ibf-workshop-loc@lts.infn.it

Poster design: Riccardo Maria Gesùè

44 participants from 8 countries





Ai Laboratori Nazionali del Gran Sasso si apre una nuova frontiera della fisica sotterranea con il workshop internazionale "Perspectives at the Bellotti IBF"

Dall'8 fino al 10 ottobre 2025 i Laboratori Nazionali del Gran Sasso dell'Istituto Nazionale di Fisica Nucleare (INFN) ospitano il workshop internazionale "Perspectives at the Bellotti IBF", un incontro scientifico... [Read More](#)

Ai Laboratori Nazionali del Gran Sasso si apre una nuova frontiera della fisica sotterranea con il workshop internazionale "Perspectives at the Bellotti IBF"



Perspectives at the Bellotti IBF - Federico Ferraro
Dall'8 fino al 10 ottobre 2025 i Laboratori Nazionali del Gran Sasso dell'Istituto Nazionale di Fisica Nucleare (INFN) ospitano il workshop internazionale

Useful Links



10 October 2025





10 October 2025

Perspectives at the Bellotti IBF - Federico Ferraro

Photo by Sandra Zavatarelli

What would I say if Rai asked me what the objectives of this workshop are?



EXPLORE NEW OPPORTUNITIES
AT THE BELLOTTI IBF



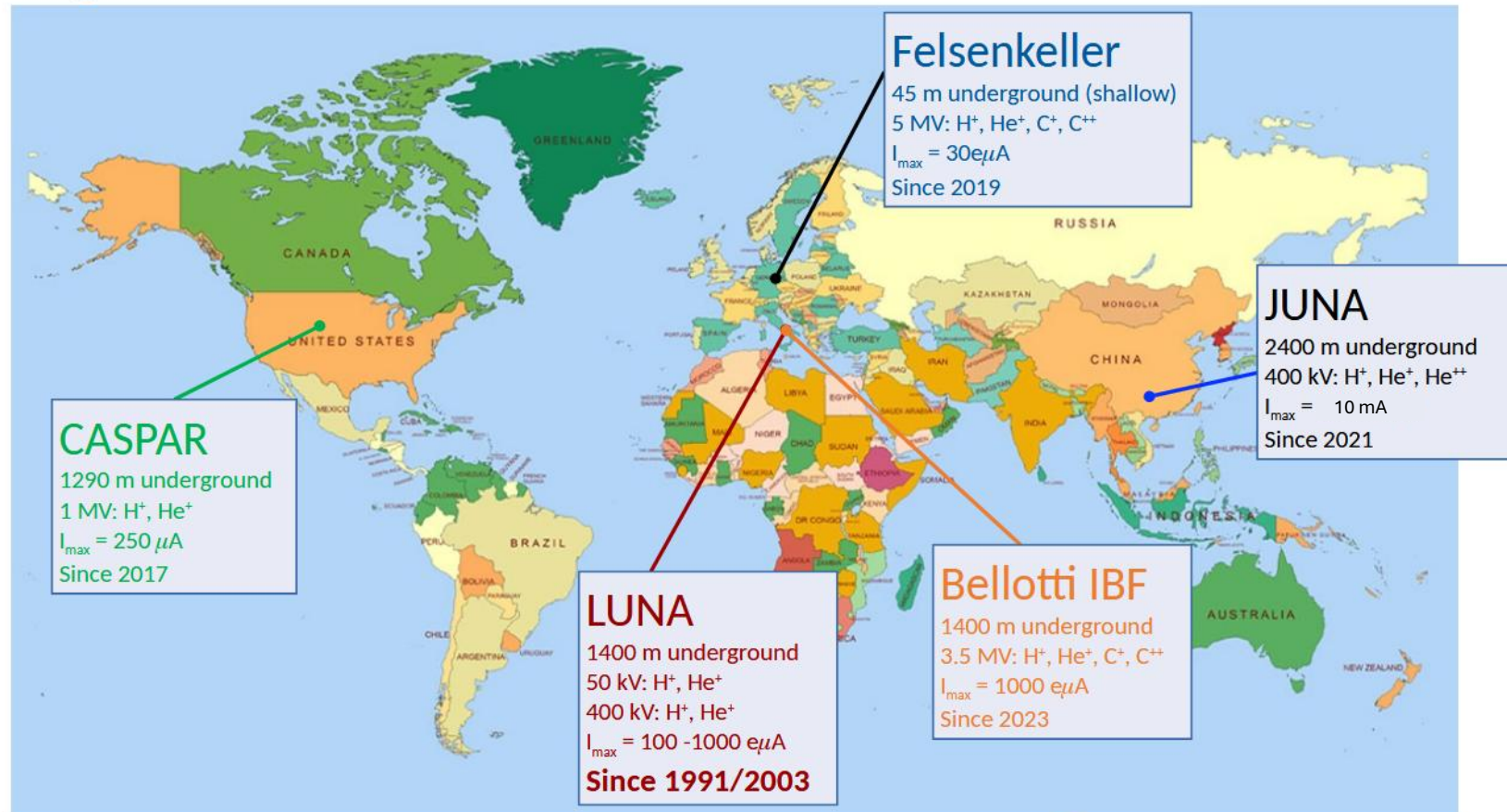
UNDERSTAND THE NEEDS OF THE
LARGER SCIENTIFIC COMMUNITY



FOSTER COLLABORATION AND
NETWORKING

Experiments/facilities worldwide

Underground accelerators worldwide



The Bellotti IBF

Features

- 3.5 MV Singletron accelerator
- 2 beamlines
- Only deep underground user facility
- Calls for proposals every year
- Priceless effort of the Accelerator Service (both the responsible and the operators)

Ion	Max Current (on target)
H ⁺	1000 μA
⁴ He ⁺	500 μA
¹² C ⁺	150 μA
¹² C ²⁺	100 eμA

Ideas for discussion

- The facility needs a target station and detectors, whose definition and construction are priority topics
- Ongoing program is based on the approved LUNA proposal (LUNA has a longer list for the coming years)
- Due to the very particular location, projects must pay particular attention to certain aspects (e.g. neutron production due to contaminants) and a staged approach is warmly suggested
- The Director of LNGS is open to possible developments to enhance the facility's equipment, based on the **needs of the community**

Targets

What Denise and Matteo told us

- There's no one-size-fits-all recipe, each target is a world of its own
- most important features:
 - resistance to irradiation
 - stability
 - absence of contaminants
 - uniformity
 - possibility of monitoring
- Target production needs
 - Infrastructures
 - know-how
- Material science is extremely valuable in this business
- producers, distributors, different batches, ...



Ideas for discussion

- we all need good targets
- Infrastructures producing targets are extremely important
- People with know-how are even more important
- we can't afford to lose the know-how

Detectors

Notes on Giovanni's talk

- Different detectors for different radiation/particles
- Main features:
 - efficiency (validated with MC)
 - energy calibration
 - energy resolution
 - intrinsic background
- Material selection is important
- Shielding helps (even more so underground)
- Simulations are needed, but codes often have to be carefully tuned to work in the low-energy regime
- Good DAQ and careful analysis are key to excellent results

Ideas for discussion

- New detectors can open new possibilities
- Detectors are often “owned” by experimental collaborations
- Leasing can be a chance
- Shipping large, heavy detectors around the world is everything but easy
- Detectors are not the whole story! Electronics and software should be considered too!

Physics Beyond the Standard Model

Notes from Claudio's talk

- The low-energy regime is becoming increasingly interesting in the quest for new physics (e.g. QCD axion)
- Nuclear transitions can probe the existence of light scalar bosons
- Potential synergy with underground nuclear facilities (low background)

Notes from Simone's talk

- Pauli Exclusion Principle (PEP) violation can be tested with nuclear reactions (very intense p beam on a graphite target)
- forbidden transitions would prove PEP violation
- existing limits on PEP violation in nuclei can be improved by about one order of magnitude, placing new constraints on beyond-Standard-Model physics predicting small PEP violations.

Ideas for discussion

- Possible use of nearby detectors to look for scalar bosons
 - existing large detectors (XENON1T)
 - small bespoke detectors (parasitically?)
- Background due to contaminants in the target can spoil the feasibility of some very interesting measurements!

Applications

Notes on Joao's talk

- IBA consists of different techniques
- PIGE is the only one that can benefit from the underground low-radiation environment
- Irradiation of biological samples grown in a low-radiation environment would be another interesting science case

Ideas for discussion

- Beam currents might be too high and difficult to be lowered
- What are the components that the IBF would need to be able to perform such measurements?

Nuclear Astrophysics

Notes from a few talks

- There are now both experiments and facilities. We can't go through all of them again now. Long story short: the community is getting larger.
- each experiment has its own very solid scientific program and dedicated people
- each experiment/facility has its own features and dedicated people
 - Beams
 - Background
 - Instrumentation
 - access rules
 - beam time availability
 - ...
- Direct and indirect methods
- There are complementarities within different measurement methods, different experiments, different facilities, ...

Ideas for discussion

- Facilities need their own detectors and instrumentation to allow activities by external users
- Synergies between facilities/experiments
- Common program?
- Shared software infrastructure

$^{15}\text{N}(\alpha,\gamma)^{19}\text{F}$

- ✓ Many resonant states in the ^{19}F compound nucleus
- ✓ At astrophysical relevant energies three of them are dominant
- ✓ Other resonances can be also studied at IBF
- ✓ The lowest resonant only measured with indirect methods

«A revision of this reaction rate therefore looks mandatory for minimizing the uncertainty on the ^{19}F nucleosynthesis related to this nuclear process.»

Cristallo et al., A&A 570, A46 (2014)

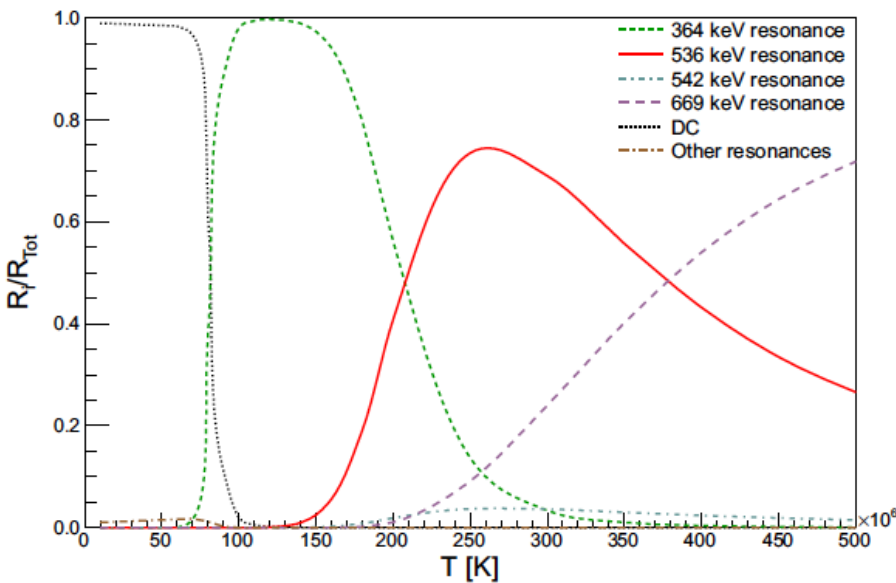


Fig. 1. Fractional contribution of the different resonances and the DC to the $^{15}\text{N}(\alpha,\gamma)^{19}\text{F}$ reaction rate. Data from Cristallo et al. (2014).

TABLE I. Resonance strengths $\omega\gamma$ for the resonances between $E_\alpha=461$ and 2642 keV ($4378\text{ keV}\leq E_x\leq 6100\text{ keV}$). The results show overall good agreement with the literature data $\omega\gamma_{\text{Lit}}$ [18]; detailed references are given in the last column. All energies E_α and E_x are given in keV.

E_α	E_x	J^π	$\omega\gamma^a$	$\omega\gamma_{\text{Lit}}^b$	Ref.
461	4378	$7/2^+$		6_{-3}^{+6} neV^c	[20]
679	4550	$5/2^+$	$(95.5\pm 11.7)\text{ }\mu\text{eV}$	$(97\pm 20)\text{ }\mu\text{eV}$	[10]
687	4556	$3/2^-$	$(6.4\pm 2.5)\text{ }\mu\text{eV}$	$<10\text{ }\mu\text{eV}$	[10]
847	4683	$5/2^-$	$(5.6\pm 0.6)\text{ meV}$	$(6\pm 1)\text{ meV}$	[11]
1384	5107	$5/2^+$	$(9.7\pm 1.6)\text{ meV}$	$(13\pm 8)\text{ meV}$	[15,26]
1676	5337	$1/2^+$	$(1.69\pm 0.14)\text{ eV}$	$(1.64\pm 0.16)\text{ eV}$	[13]
1778	5418	$7/2^-$	$(380\pm 44)\text{ meV}$	$(420\pm 90)\text{ meV}$	[15,26]
1837	5464	$7/2^+$	$(2.10\pm 0.14)\text{ eV}$	$(2.5\pm 0.4)\text{ eV}$	[14]
1884	5501	$3/2^+$	$(3.56\pm 0.34)\text{ eV}$	$(4.2\pm 1.1)\text{ eV}$	[16,26]
1927	5535	$5/2^+$	$(344\pm 40)\text{ meV}$	$(480\pm 110)\text{ meV}$	[15,26]
2036	5621	$5/2^-$	$(323\pm 38)\text{ meV}$	$(370\pm 90)\text{ meV}$	[12]
2437	5938	$1/2^+$	$(416\pm 48)\text{ meV}$	$(530\pm 130)\text{ meV}$	[12]
2604	6070	$7/2^+$	$(2.10\pm 0.26)\text{ eV}$	$(2.7\pm 0.54)\text{ eV}$	[12]
2627	6088	$3/2^-$	$(5.0\pm 0.6)\text{ eV}$	$(4.5\pm 0.9)\text{ eV}$	[12]
2642	6100	$9/2^-$	$(440\pm 69)\text{ meV}$		

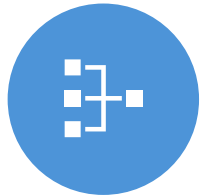
^aThis work.

^bReference [18].

^cFrom $^{15}\text{N}(^7\text{Li},t)^{19}\text{F}$ transfer experiment [20].

PHYSICAL REVIEW C **66**, 065802 (2002)
WILMES, WILMES, STAUDT, MOHR, AND HAMMER

What we can easily agree on:



LUNA, Felsenkeller, JUNA, LEAF, CASPAR have complementary capabilities



direct measurements in the Gamow window remain challenging



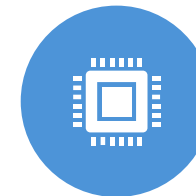
indirect methods are needed below a certain limit



targets and the know-how to produce them are crucial



It is useful to understand what the Laboratory should invest on



users need ready-to-use setups (hardware and software) and transnational access

What can we do now?

- Foster collaborations: LUNA, Felsenkeller, JUNA, CASPAR, ASFIN, and other fields
- Promote new actions and networks for transnational access
- suggest user support package (target stations, detectors, software, storage, guest house, ...)
- ...

Discussion



Discussion notes

- ChETEC WP on targets has been effective so far. This has been a very good example of networking! Every facility has its own know-how.
- PIGE can be an interesting use, but maybe not today. Pilot project can be useful to understand how to better prepare this service with a step-by-step approach. It's now difficult to imagine a short PIGE measurement while usually experiments need a very long time...
- Pooling resources for external users would be very beneficial. In other INFN laboratories the pool is managed by the Research Division
- We can think about the needs of external users to perform their research in whatever fields they are interested to
- How can we push to get inside a network that provides transnational access?
- External users need support to actually participate in the scientific life of the IBF
- Having multiple beamlines can enable the coexistence of long-lasting experiments and short ones
- Participation in NuPECC and EURO-LABS is key to obtain user support.
- Automation and software tools are key to the operation of facilities like the Bellotti IBF
- Bellotti IBF entered ChETEC-INFRA last year and worked very well
- Unfortunately, Nuclear Astrophysics is outside STRONG2030, but there is a chance EURO-LABS and ChETEC-INFRA can do something for small scale facilities, as the Long Range Plan is suggesting
- Bilateral programs involving Italy and Germany (or other countries) can be of help in supporting users.
- Are we ready, as a community, to participate to the preparation of the funding schemes being prepared? Apparently, we are in good shape!
- Access to underground labs is not always easy. Access rules too are sometimes playing their role... remote operation would help.
- Exchange of people and knowledge is important.
- Collaboration between research facilities is of great importance. In this spirit, JUNA actively welcomes partners to join its ongoing experimental programs. Furthermore, with the support of the NSFC for international collaboration, JUNA is poised to become a user facility in the near future.
- We appreciate the support offered by the LNGS Director to further improve the capabilities of the Bellotti IBF.
- $^{15}\text{N}(\alpha, \gamma)^{19}\text{F}$ can really be a joint effort, as well as the the alpha channel in $^{12}\text{C}+^{12}\text{C}$ (in a longer term). A very good by-product would be related to the exchange of students. Measurements of stopping powers is another point we can investigate together. Maybe we can get an idea where the largest problems with the stopping powers are by looking at the data that we already have.
- Competition is good when the goal is to obtain better science, but we should not compete just for papers. We can probably think about a network of underground laboratories, so that we can grow stronger and maybe have a better chance to establish support plans.
- We can submit a proposal for a COST action next year. This will be able to provide support for mobility (only).

1. Collaboration, Networking, and Community Building

- ChETEC WP on targets has been effective so far. This has been a very good example of networking! Every facility has its own know-how.
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- Exchange of people and knowledge is important.
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2. Access, User Support, and Funding Opportunities

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- External users need support to participate in the scientific life of the IBF.
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3. Facility Operation and Development

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- Automation and software tools are key to the operation of facilities like the Bellotti IBF.
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4. Experimental Programs and Joint Projects

- $^{15}\text{N}(\alpha, \gamma)^{19}\text{F}$ can really be a joint effort, as well as the the alpha channel in $^{12}\text{C}+^{12}\text{C}$ (in a longer term). A very good by-product would be related to the exchange of students. Measurements of stopping powers is another point we can investigate together. Maybe we can get an idea where the largest problems with the stopping powers are by looking at the data that we already have.
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- Searches for QCD axion and PEP violation

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LNGS, 8-10 October 2025

