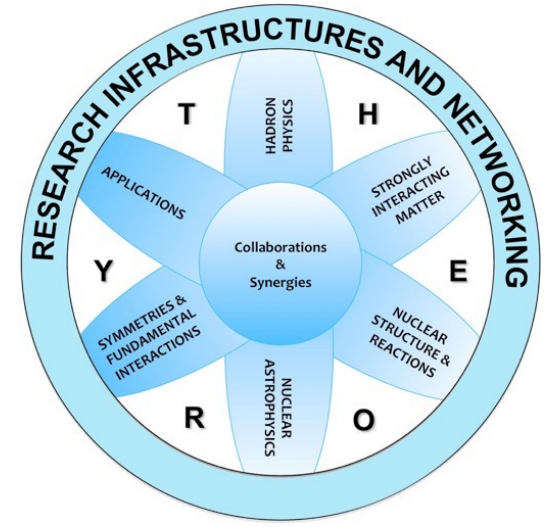


# Poland and France in NuPECC Long Range Plan 2024 for European Nuclear Physics

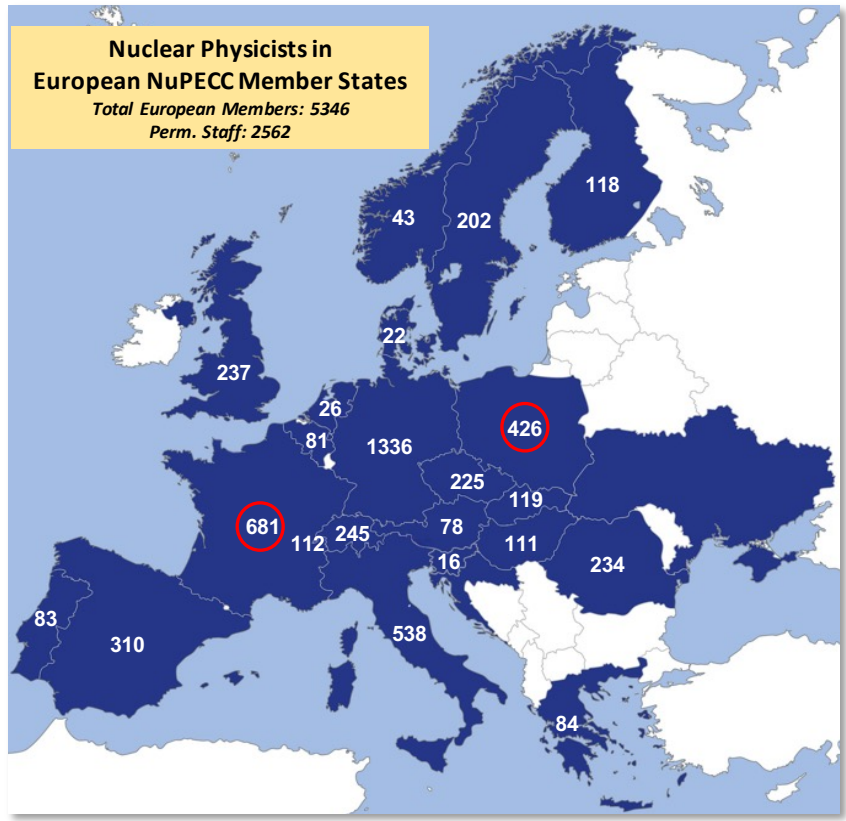


**Marek Lewitowicz**  
Nuclear Physics European Collaboration Committee (NuPECC)  
GANIL

**COPIGAL**  
November 28, 2024  
Paris



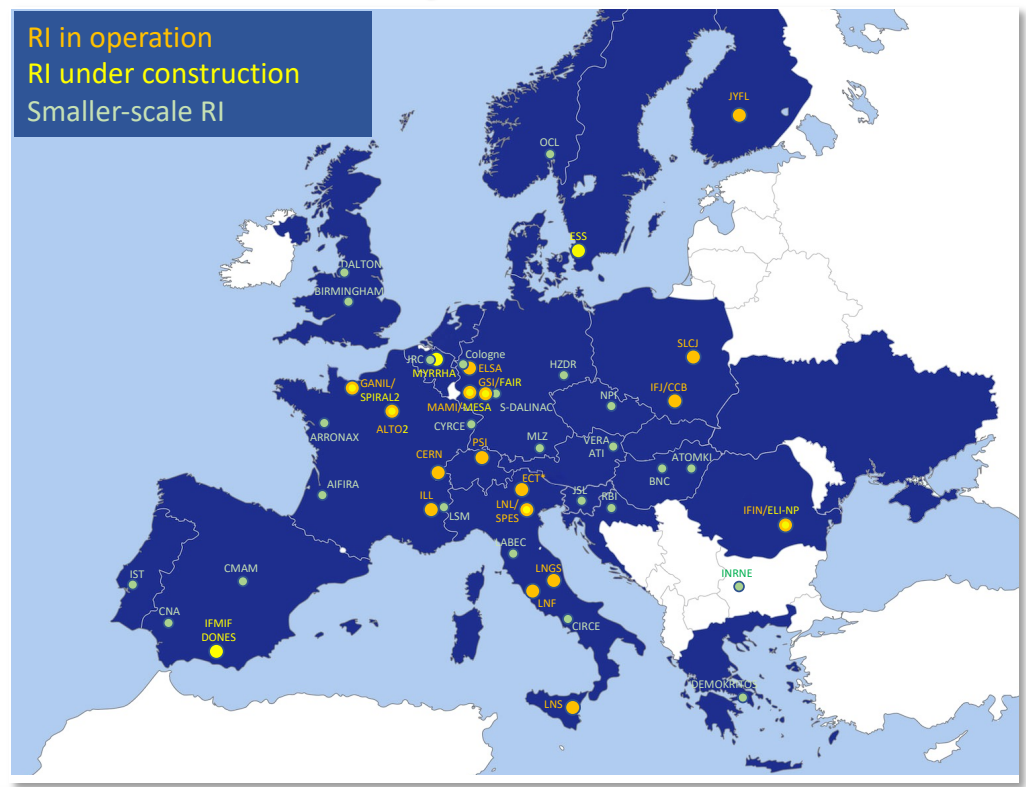
## Nuclear Physics Workforce in Europe



**5346** - total number of Nuclear Physicists (Exp. & Theory) in the European NuPECC Member States and the Associated Member CERN  
**2546** – permanent staff  
**2800** – PhD students and non-permanent staff

From NuPECC 2021& 2023 surveys

## European Landscape of Nuclear Physics Infrastructures



**All infrastructures are multidisciplinary !**

Taking data **> 30**;  
 Under construction or upgrade **≥ 9**

From NuPECC LRP 2024





2024

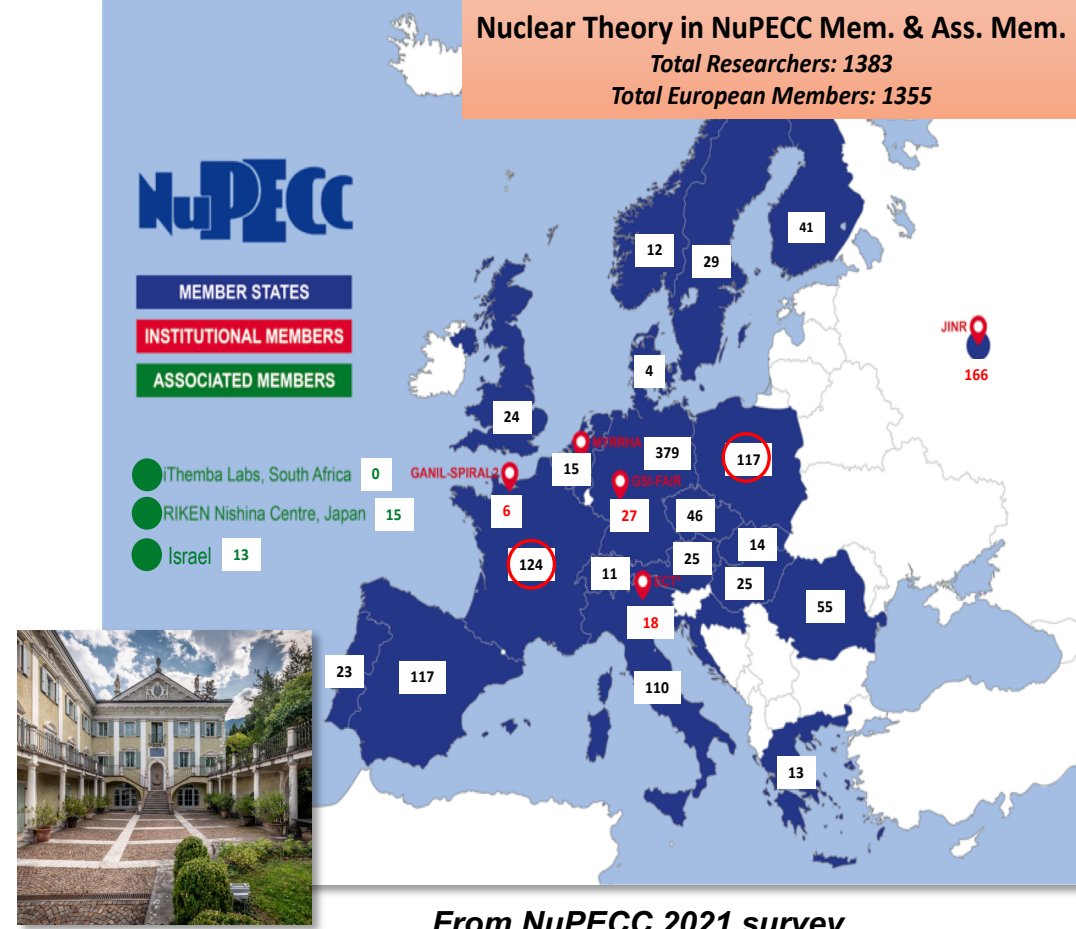
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7. Applications and Societal Benefits *(see presentation of Thomas Cocolios)*
8. Research Infrastructures
9. Nuclear Physics Tools - Detectors and Experimental Techniques
10. Nuclear Physics Tools - Machine Learning, Artificial Intelligence, and Quantum Computing
11. Open Science and Data
12. Nuclear Science – People and Society

## Fast development of theory is essential for all sub-fields of nuclear physics

### Recommendations

- Theory centres and groups should be strongly supported throughout Europe, in particular the European Centre for Theoretical Studies (**ECT\***, **Trento, Italy**), which is a unique European centre dedicated to theoretical nuclear physics in the broadest sense.
- Support of theory groups ... to benefit from European investments in supercomputing and quantum computing infrastructure
- Support emerging virtual access facilities, which provide theory results for experimentalists (e.g., Virtual Access facilities in the **STRONG 2020** and **EURO-LABS** projects)



ECT\*, Trento, Italy

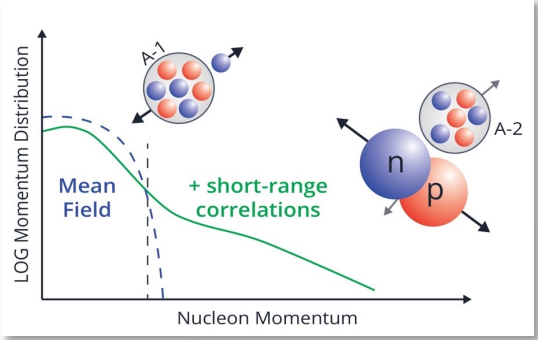
From NuPECC 2021 survey



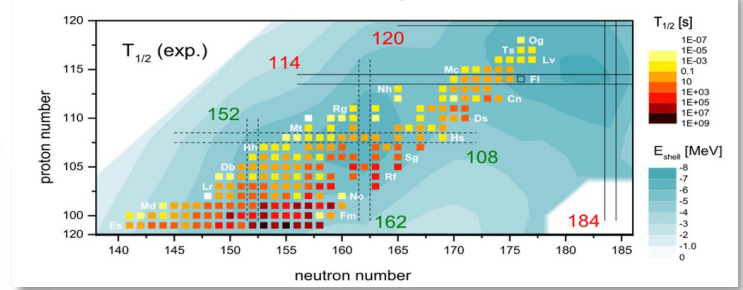
## Key Questions & Goals

The main goals of Nuclear Structure and Reaction Dynamics in the next decade will be to answer the following questions: How do nuclei and nuclear matter emerge from the underlying fundamental interactions? What is the limit of nuclear existence and which phenomena arise from open quantum systems? How do nuclear shells evolve across the nuclear landscape, what kind of shapes can nuclei take, and what is the role of nuclear correlations? What are the mechanisms behind nuclear reactions and nuclear fission?

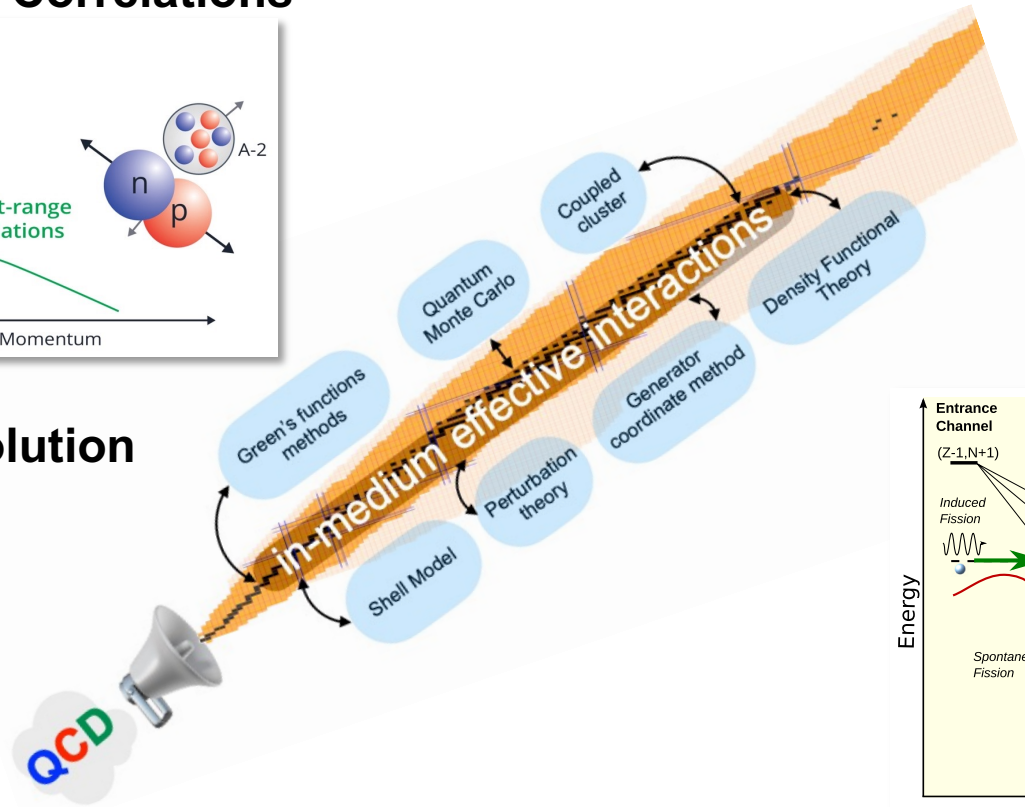
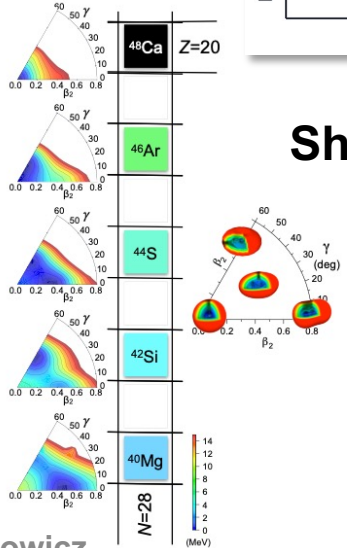
### Short Range Correlations



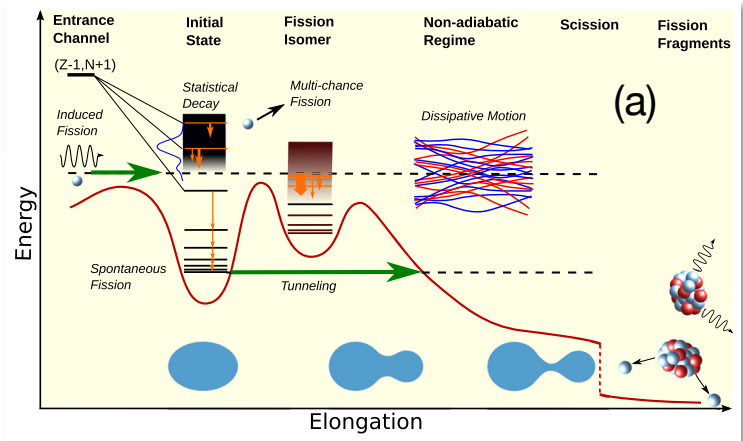
### Super Heavy Nuclei



### Shell Evolution

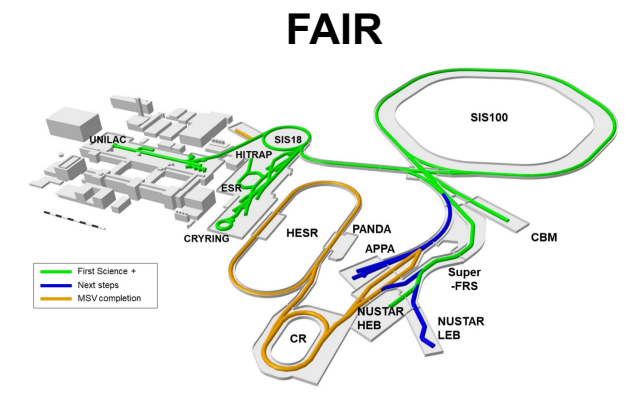


### Fission of nuclei



## Recommendations (experiments)

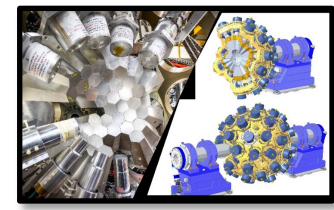
- **Support of existing facilities and experiments**
  - To ensure complementarity in experimental programmes, it is essential to strongly support *large- and small-scale facilities* which guarantee access to the whole community
  - The coordinated effort amongst the **ISOL facilities** in Europe ... will secure the leading position of Europe
  - The full completion of the European flagship gamma spectrometer **AGATA-4 $\pi$**  (with ancillaries) is mandatory
- **Future flagship facilities and experiments**
  - **FAIR** facility (with Low-Energy-Branch), **SPIRAL2**, **SPES**, **ELI-NP**, **ISOL@MYRRHA**, and **ISOLDE** upgrades
  - Future rings at **FAIR** and **HIE-ISOLDE**



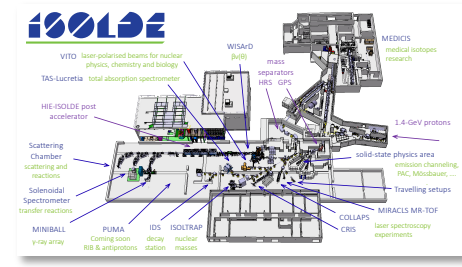
**GANIL/SPIRAL2 France**



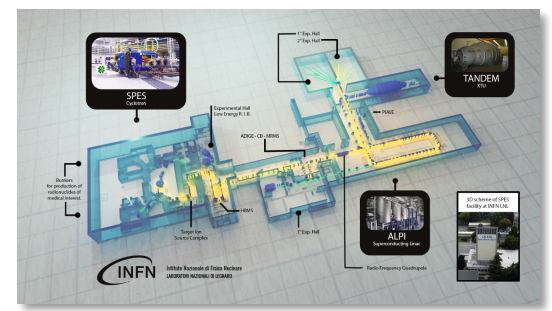
**AGATA**



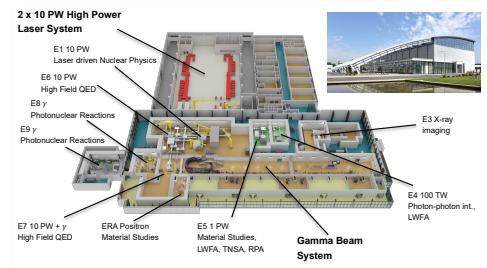
**ISOLDE CERN**



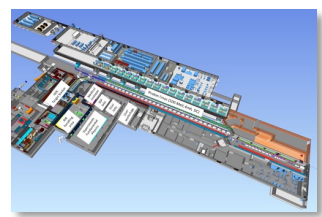
**SPES/LNL Italy**



**ELI – NP Romania**



**ISOL@MYRRHA Belgium**





## GANIL/SPIRAL2 facility, Caen, France

- At **GANIL/SPIRAL2** the Super-Separator Spectrometer **S<sup>3</sup>** is in an advanced stage of completion and the low-energy **DESIR** facility and heavy-ion injector **NEWGAIN** will be operational from 2027/28. The refurbishing of the cyclotrons will ensure their operation for the next decades. Timely completion and full exploitation of these GANIL/SPIRAL2 projects are recommended. The future evolution of the infrastructure towards a very high-intensity reaccelerated RIB facility of up to 100 MeV/u should be actively planned.

## GANIL/SPIRAL2 France

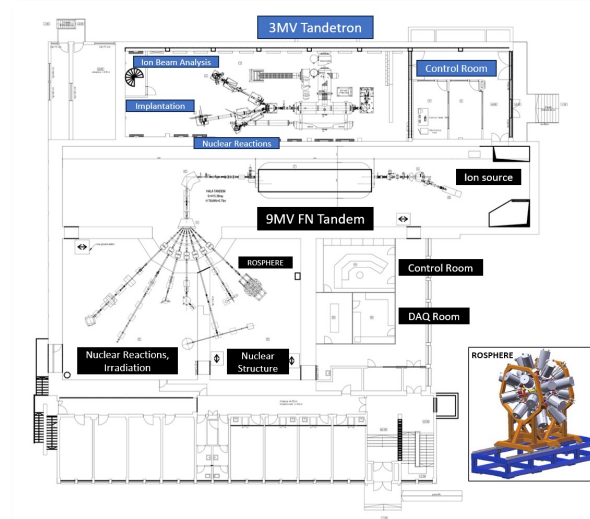
ESFRI



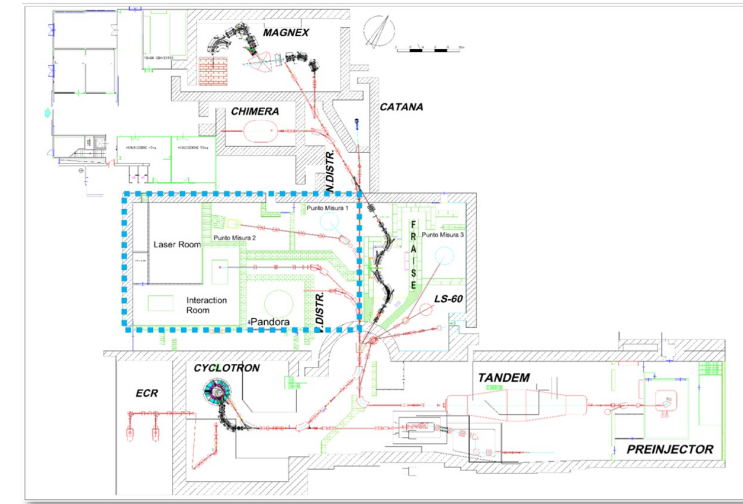
## Stable Ion Beam facilities

- Large-scale **stable beam facilities**, such as **FAIR/GSI**, **GANIL/SPIRAL2**, **IFIN**, **JYFL-ACCLAB**, **LNL**, **LNS**, **NLC (SLCJ and IFJ-PAN)**, and smaller ones, such as tandems, underground facilities and AMS systems, should be optimally exploited. Developments of novel and more intense beams and capabilities are also recommended to open new opportunities for basic science and applications. It is recommended that synergies between all these facilities, irrespective of size, be reinforced.

### IFIN-HH Romania

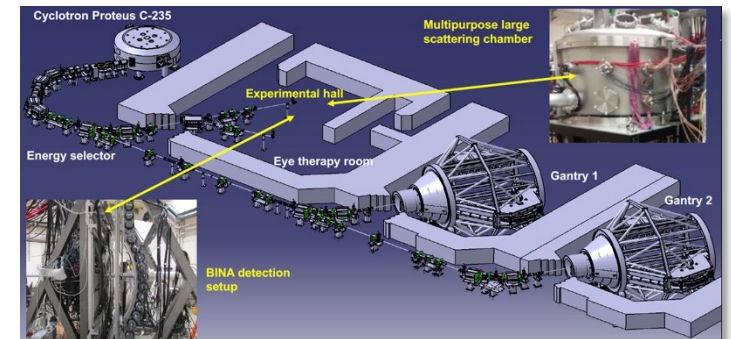
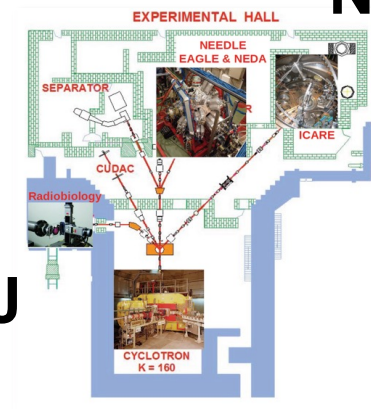


### LNS Italy



### NLC Poland

### SLCJ



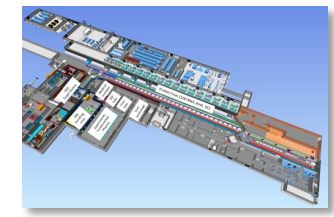
### CCB



## Recommendations (experiments)

- **Support of existing facilities and experiments**
  - The multidisciplinary research infrastructures **ILL**, **FRM-II** and **PSI** provide unique opportunities. Operation of **ILL** should be ensured beyond **2033**
  - Continued support for **ESR**, **CRYRING** and **HITRAP** at GSI/FAIR, and high-energy **EBITs** in other labs
  - The **AD/ELENA** physics program at CERN should be strongly supported
  - Customised instrumentation and beam time availability should be guaranteed for fundamental tests at RIB facilities like ISOLDE, GANIL-SPIRAL2, and JYFL-ACCLAB/IGISOL
  - **Multiple and complementary experimental searches for neutrino-less double beta decay** have to be encouraged as they can reach into the inverted hierarchy in the next decade
  
- **Future flagship facilities and experiments**
  - Specialization of upcoming Radioactive Ion Beam facilities such as **ISOL@MYRRHA** and **DESIR at GANIL-SPIRAL2** should be regarded as an opportunity not to be missed
  - At **ESS**, a fundamental neutron physics beamline should be installed
  - The realisation of future **CR** and **HESR** at FAIR should be vigorously pursued

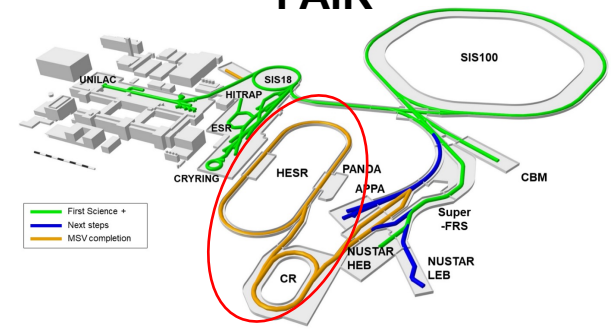
### ISOL@MYRRHA Belgium



### GANIL/SPIRAL2 France



### FAIR



# Warm thanks to all contributors to the NuPECC LRP 2024!



[https://www.nupecc.org/lrp2024/Documents/nupecc\\_lrp2024.pdf](https://www.nupecc.org/lrp2024/Documents/nupecc_lrp2024.pdf)

## Thank you for your attention!



NuPECC LRP 2024 Town Meeting, Bucharest, April 2024