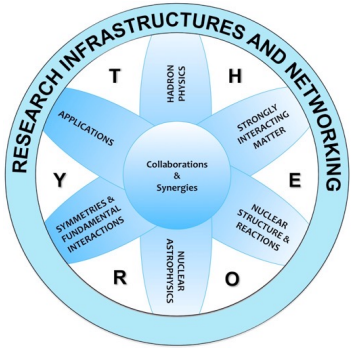
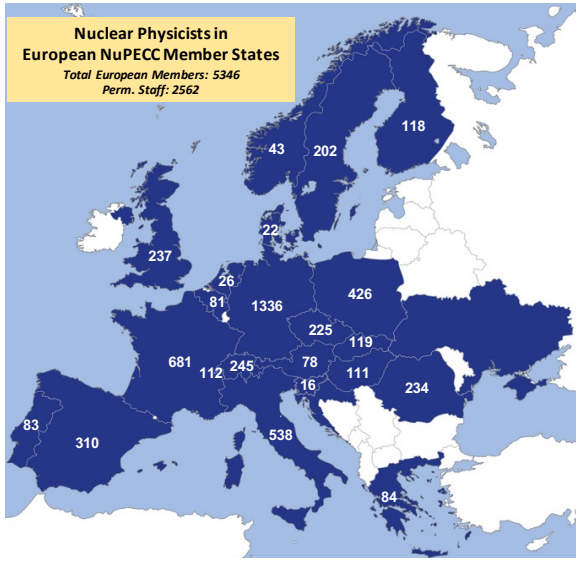
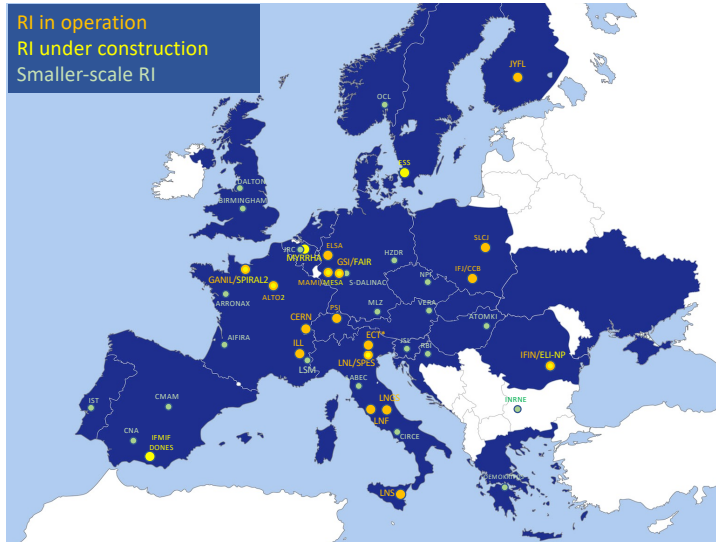


NuPECC Long Range Plan 2024
for European Nuclear Physics



Marek Lewitowicz
Nuclear Physics European Collaboration Committee (NuPECC)

114th Plenary ECFA Meeting
Frascati



- **NuPECC and Long Range Plan**
- **LRP2024 Recommendations**

See LRP Executive Summary at: https://www.nupecc.org/lrp2024/Draft_Executive_Summary_LRP2024.pdf

What is NuPECC ?

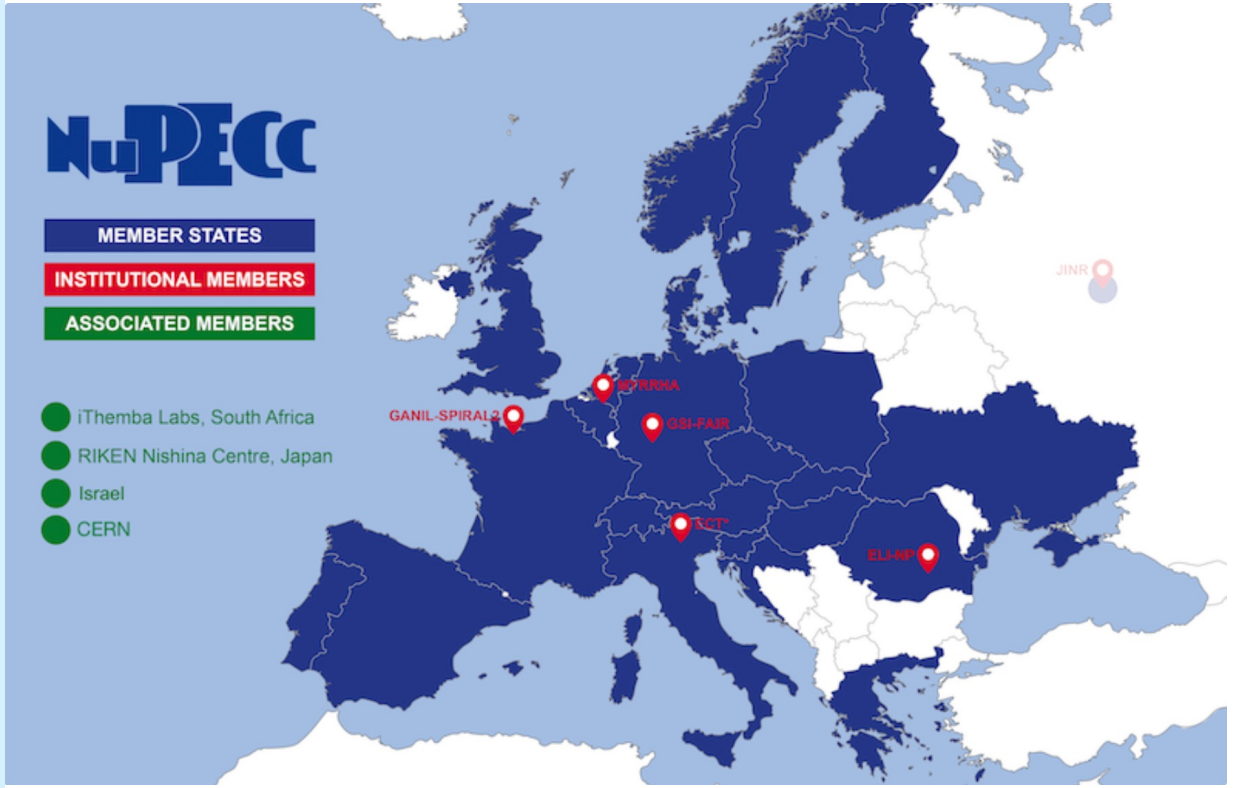
Nuclear Physics European Collaboration Committee (NuPECC)
Is the European Expert Board for Nuclear Physics
hosted by the European Science Foundation

Representing

> 5000 scientists

Composition:

- 35 representatives from 23 countries (new member Ukraine), 3 ESFRI NP Infrastructures & ECT*
  JINR Dubna – suspended in March 2022
- 4 associated members
  - CERN
  - Israel
  - iThemba Labs
  - Nishina Center
- 10 observers: ALAFNA, ANPhA, APPEC, CINP, ECFA, ESF, EPS-NPD, EPS-HEPPD (new observer), IAEA, NSAC

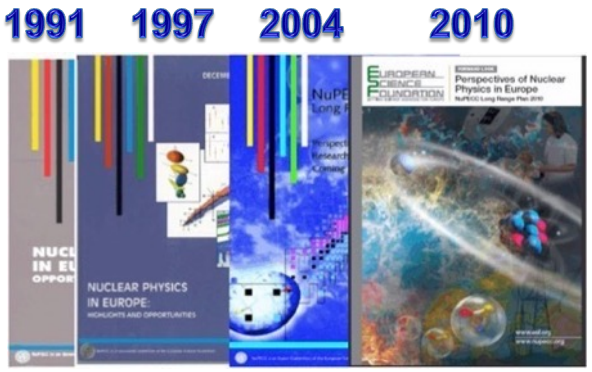


3 regular Committee meetings/y

36 Years of NuPECC activities

https://nupecc.org

Towards NuPECC Long Range Plan 2024



- **The LRP identifies opportunities and priorities for nuclear science in Europe**
- **The LRP provides national funding agencies, ESFRI and the European Commission with a framework for coordinated advances in nuclear science in Europe**

NuPECC LRP 2017

https://www.nupecc.org/lrp2016/Documents/lrp2017.pdf

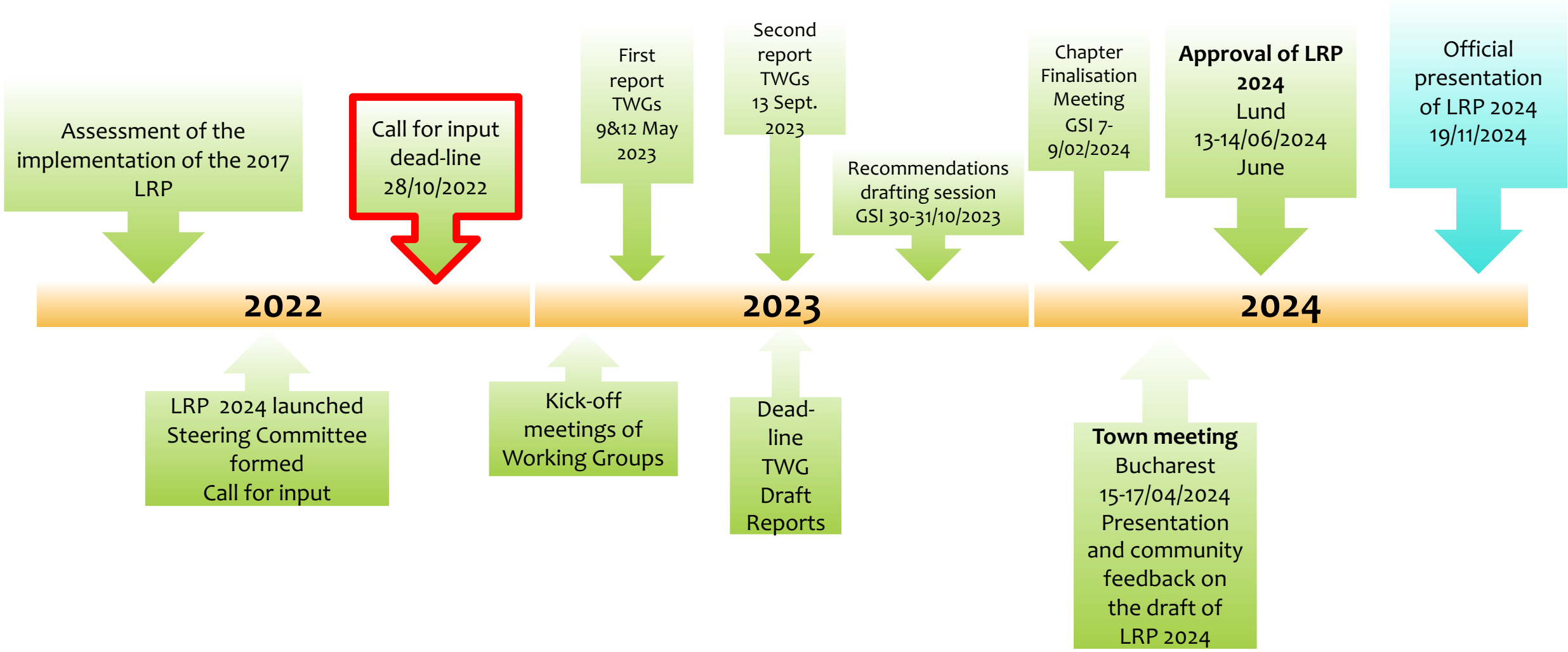
Assessment of implementation of LRP 2017

https://www.nupecc.org/2017_LRP_Assessment_of_Implementation_final.pdf

Launched in May 2022 in Madrid

NuPECC LRP 2024

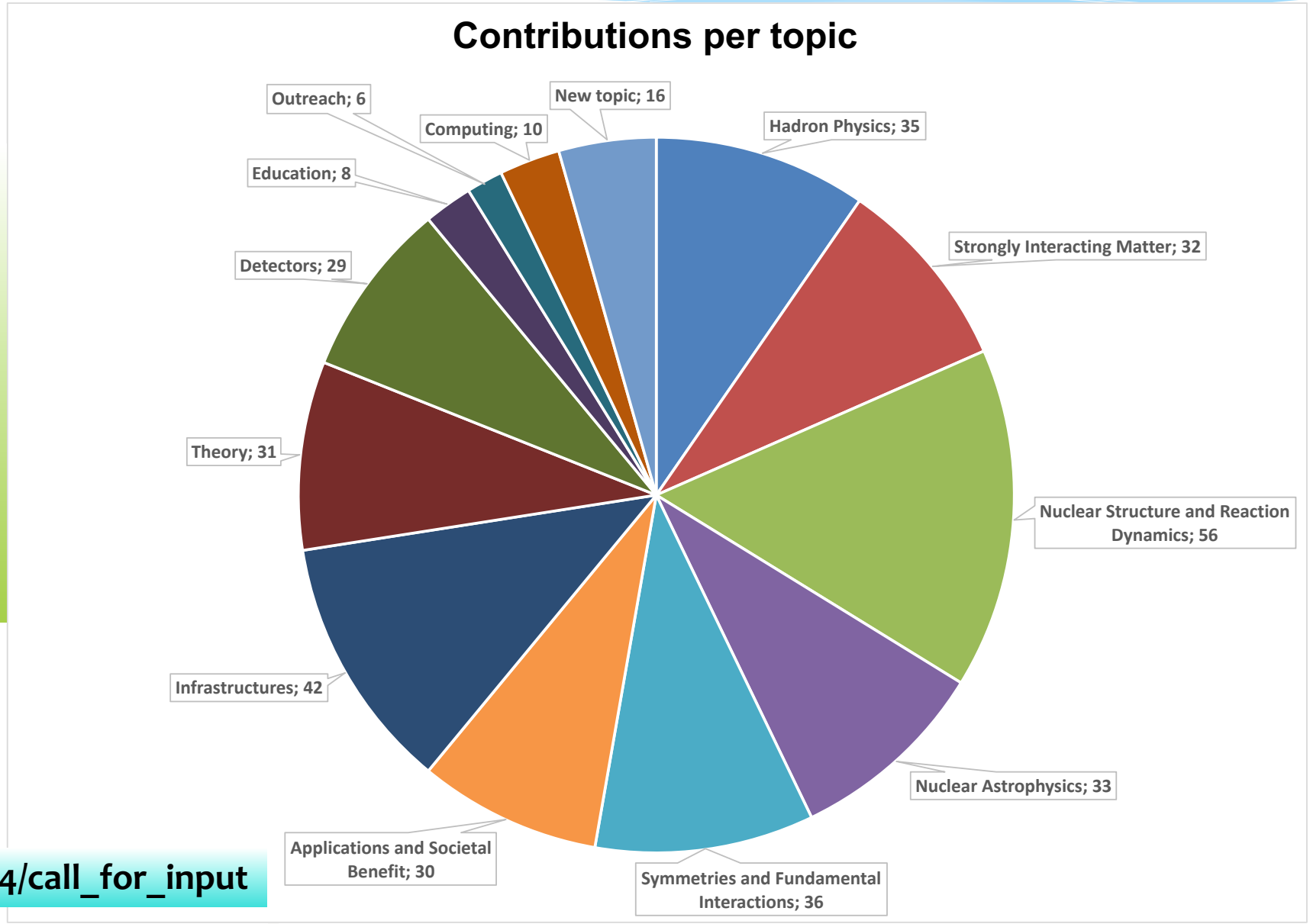
NuPECC LRP2024 Timeline



NuPECC LRP 2024 – Contributions of the community

LRP Contributions:

- 159 contributions
- Submitted by > 400 individual scientists, collaborations, infrastructures, and research institutions in Europe



https://nupecc.org/?display=lrp2024/call_for_input

TWG coordinators and SC liaisons

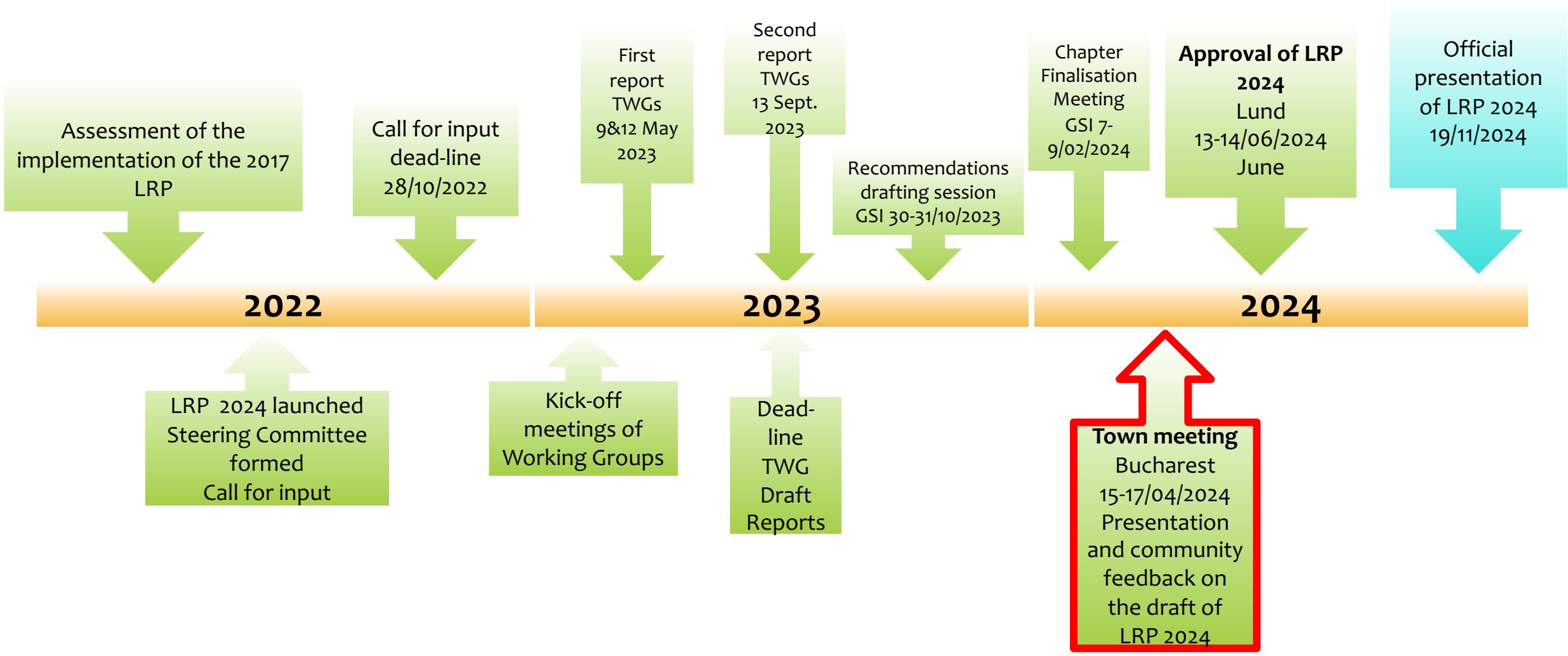
Theory/Exp.

TWG Number	TWG	Coordinators	Coord. e-mails	Liaisons	Liaisons e-mails
1	Hadron Physics	Karin Schönning (Uppsala)	karin.schonning@physics.uu.se	Diego Bettoni	bettoni@fe.infn.it
		Constantia Alexandrou (CY)	c.alexandrou@cyi.ac.cy alexand@ucy.ac.cy	Dave Ireland	david.ireland@glasgow.ac.uk
2	Strongly Interacting Matter at Extreme Conditions	Laura Fabbietti (TUM)	laura.fabbietti@ph.tum.de	Gert Aarts	g.aarts@swansea.ac.uk
		Urs Wiedemann (CERN)	Urs.Wiedemann@cern.ch	Raimond Snellings	R.Snellings@uu.nl
3	Nuclear Structure and Reaction Dynamics	Silvia Leoni (Univ. Milano)	silvia.leoni@mi.infn.it	Adam Maj	adam.maj@ifj.edu.pl
		Tomas Rodriguez(UCM)	tomasrro@ucm.es	Jelena Vesic	jelena.vesic@ijs.si
4	Nuclear Astrophysics	Anu Kankainen (JYFL)	anu.kankainen@jyu.fi	Daniel Bemmerer	d.bemmerer@hzdr.de
		Jordi Jose (Barcelona)	jordi.jose@upc.edu	Sandrine Courtin	sandrine.courtin@iphc.cnrs.fr
5	Symmetries and Fundamental Interactions	Pierre Delahaye (GANIL)	pierre.delahaye@ganil.fr	Eberhard Widmann	Eberhard.Widmann@oeaw.ac.at
		Paolo Crivelli (ETH)	Paolo.Crivelli@cern.ch	Klaus Kirch	klaus.kirch@psi.ch
6	Infrastructures	Wolfram Korten (CEA, Saclay)	w.korten@cea.fr	Joaquin Gomez-Camacho	gomez@us.es
				Patricia Roussel-Chomaz	patricia.chomaz@ganil.fr
7	Applications and Societal Benefit	Thomas Cocolios (KU Leuven)	thomas.cocolios@kuleuven.be	Lucia Popescu	lucia.popescu@sckcen.be
		Charlot Vandevoorde (GSI)	C.Vandevoorde@gsi.de	Vladimir Wagner	wagner@ujf.cas.cz
8	Nuclear Physics Tools Detectors and experimental techniques Computing, Machine Learning and Artificial Intelligence	Silvia Dalla Torre (INFN)	Silvia.DallaTorre@cern.ch	Eugenio Nappi	Eugenio.Nappi@ba.infn.it
		Valerio Bertone (CEA Saclay)	valerio.bertone@cea.fr	Hervé Moutarde	herve.moutarde@cea.fr
		Jana Guenther (U. Wuppertal)	jguenther@uni-wuppertal.de		
9	Open Science and Data	Antoine Lemasson (GANIL)	antoine.lemasson@ganil.fr	Marek Lewitowicz	marek.lewitowicz@ganil.fr
10	Nuclear Science - People and Society Training, Careers & Diversity Education and Outreach	María García Borge (Madrid)	mj.borge@csic.es	Rolf-Dietmar Herzberg	rdh@liverpool.ac.uk
		Christian Diget (York)	christian.diget@york.ac.uk	Yvonne Leifels	Y.Leifels@gsi.de

11 Thematic Working Groups
266 Members and NuPECC Liaisons

Important role of liaisons during the work of TWG and in preparation of their reports

NuPECC LRP2024 Timeline



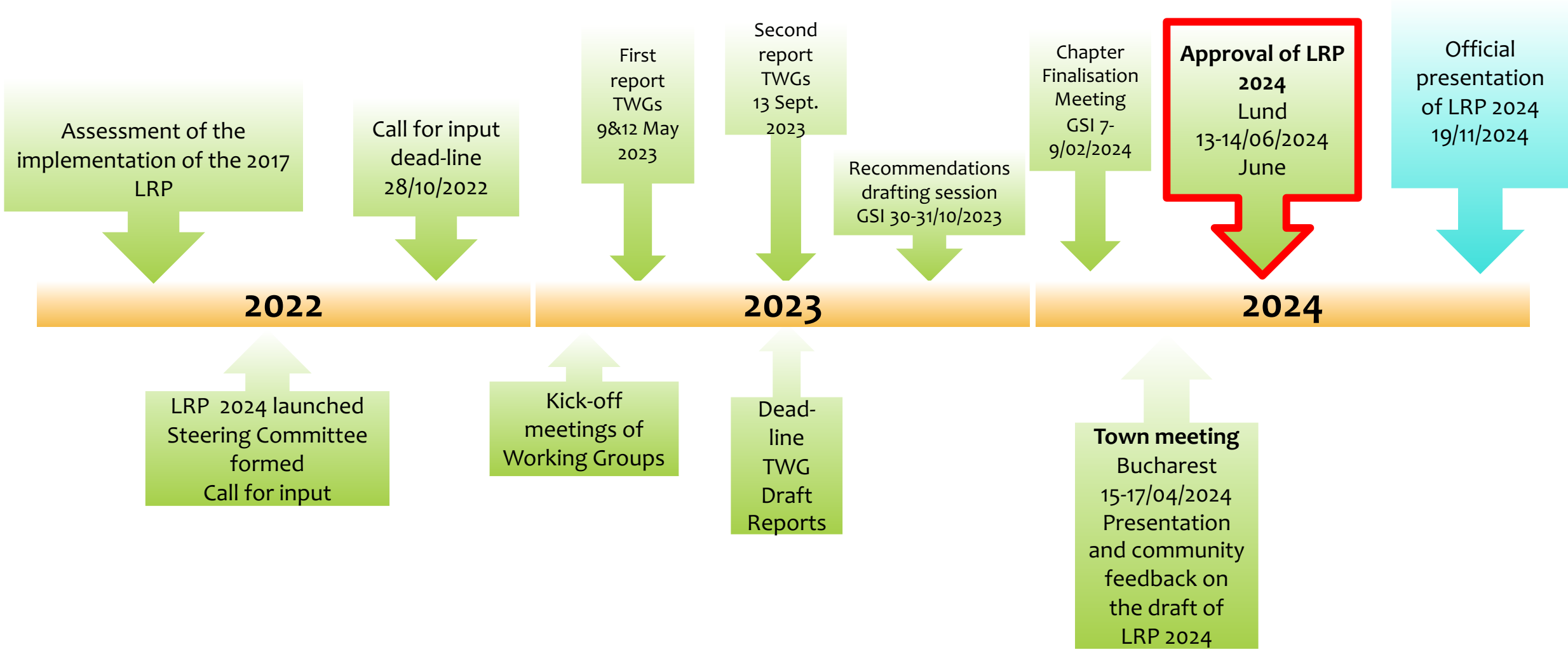
LRP2024 Town Meeting

LRP2024 Town Meeting 15 April (noon) - 17 April (noon) 2024 in Marriott Hotel, Bucharest

The is meeting aimed to bring together the Nuclear Physics community in Europe to discuss the long-range perspectives in our field and decide how best to develop it in the next ten to fifteen years. A draft of the LRP2024 Report and its Recommendations were presented and discussed during the meeting.
This was an excellent opportunity for you to learn about and discuss the strategic choices of the community for the future of Nuclear Physics research in Europe.

- **Open to all community**
- **The meeting was in person only to favour the lively discussion**

NuPECC LRP2024 Timeline



Executive Summary

- Introduction
- What does Nuclear Physics stand for?
- Nuclear Physics and Society
- European landscape of nuclear physics
- **Recommendations for Nuclear Physics Infrastructures**
- International and Interdisciplinary Context
- Recommendations
  - Fundamental Nuclear Physics
    - Hadron Physics
    - Strongly Interacting Matter at Extreme Conditions
    - Nuclear Structure and Reaction Dynamics
    - Nuclear Astrophysics
    - Symmetries and Fundamental Interactions
  - Applications and Societal Benefits
  - Nuclear Physics Tools
    - Detectors and experimental techniques
    - Machine learning (ML) and artificial intelligence (AI), Quantum computing (QC), Numerical tools, techniques and resources
  - Open Science and Data
  - Nuclear Science - People and Society

LRP2024 approved at the NuPECC meeting in Lund 13/06/2024

Full LRP2024 has 360 pages

What does Nuclear Physics stand for?

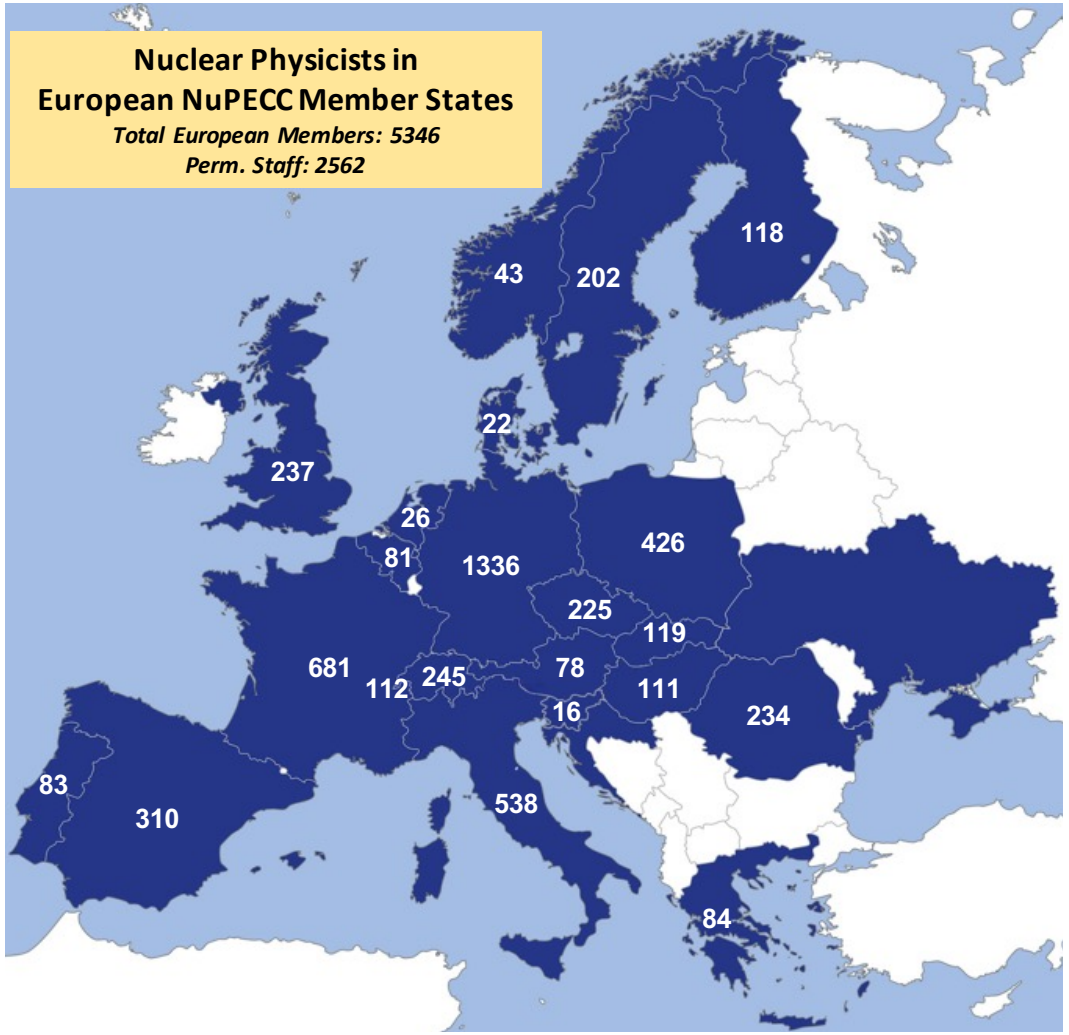
Nuclear physics is the study of the atomic nucleus, its constituents, structure, and behaviour. It is a key basic scientific field that investigates the properties of matter at the subatomic level.
This domain of research affects not only our fundamental understanding of nature but also has many peaceful applications in all areas of modern life. Nuclear physics research originally started in Europe in the late 19th century. Now, in the 21st century, Europe is still at the forefront of nuclear physics research and applications. This leading European role is due to a rich and diverse landscape of research institutions and infrastructures in all European countries.

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



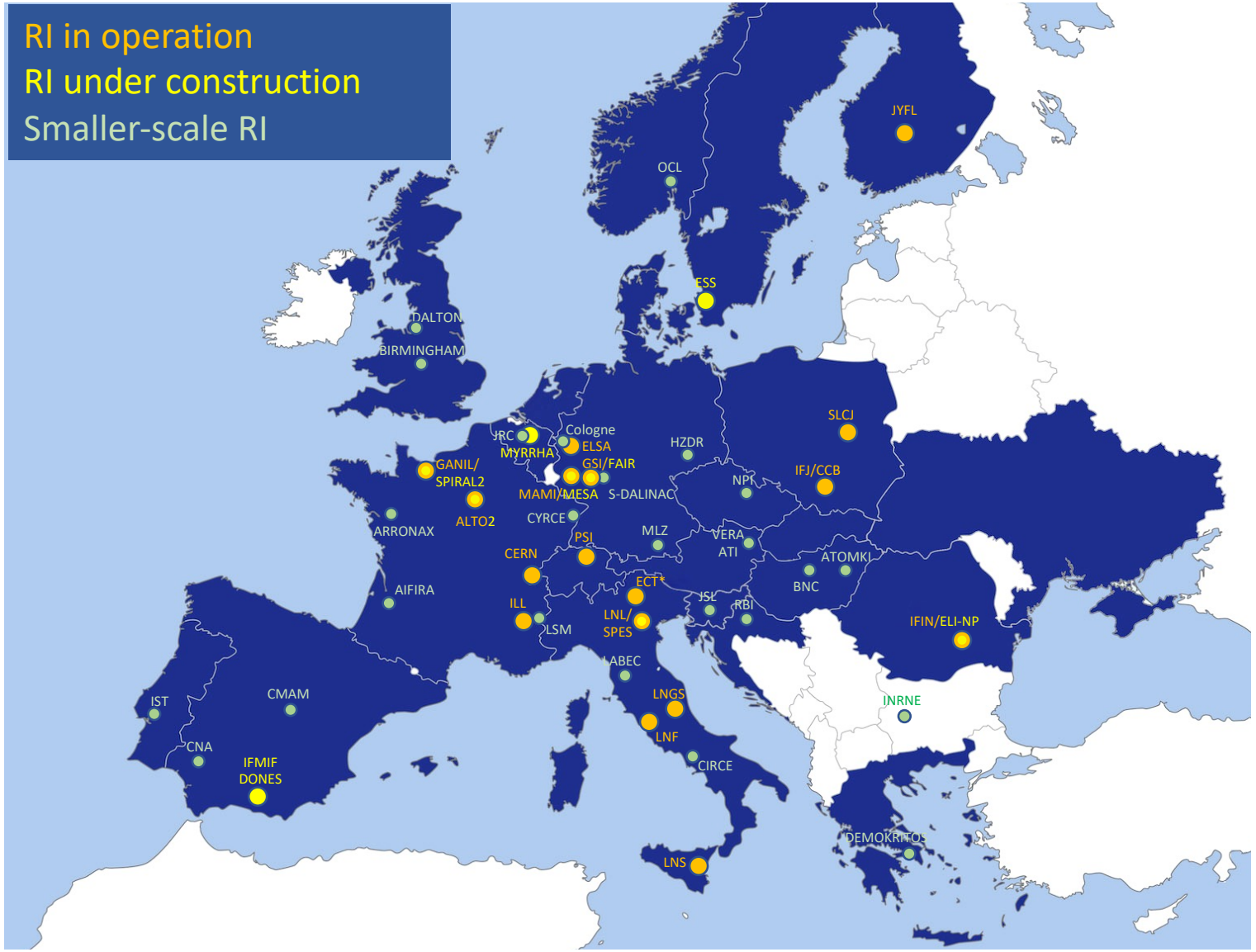
J. J. Gomez Camacho, Ulf-G. Meißner et al.

European Landscape of Nuclear Physics Infrastructures

Nuclear Physics Facilities in Europe

Taking data > 30

Under construction or upgrade ≥ 9



LRP 2024 Introduction

Nuclear Physics and Society

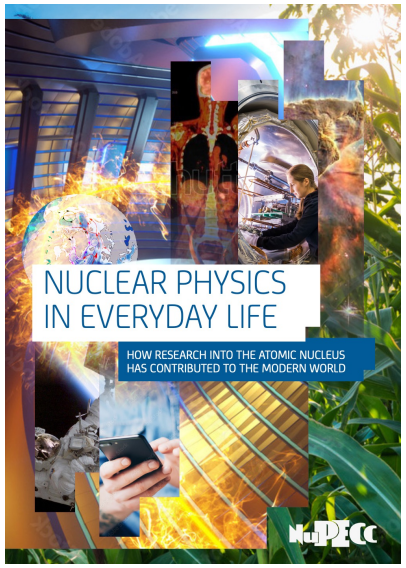
United Nations Sustainable Development Goals (SDGs) to which nuclear contribute the most.

NuPECC report on

Nuclear Physics in Everyday Life

(100 pages, open access on-line)

https://nupecc.org/pub/np_life_print.pdf



Nuclear science and technology have benefited human progress, culture, and our understanding of our delicate environment in general, as well as health, economic growth, and security in nations all over the world.

Recommendations for Hadron Physics

How does the major part of the visible mass of the universe emerge from the almost massless quarks? Can massless gluons form massive, exotic matter? What is the role of strong interactions in stellar objects, and in precision tests of the Standard Model?

Key Words & Topics

Support of existing facilities and experiments:

- **AMBER** at **CERN**
- **ELSA** in Bonn, **HADES** at GSI, **MAMI** and **MESA** in Mainz, Germany
- **Jefferson Laboratory** in Newport News, USA

The support for the multi-purpose facilities Belle II, BESIII and those at the LHC.

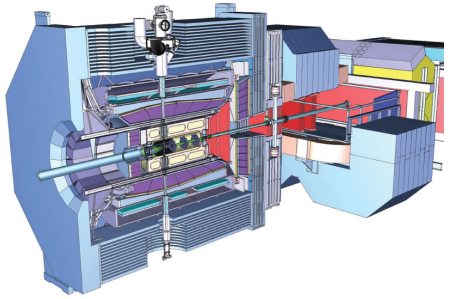
Future flagship facilities and experiments:

- We recommend the expedited realisation of the antiproton experiment **PANDA**, and the support of European groups to contribute to the electron-ion experiment **ePIC**. By virtue of their different beam species and energy regimes, PANDA and ePIC will explore complementary physics aspects.

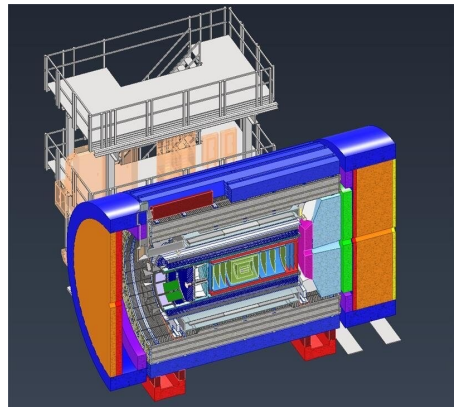
Theory / Computing:

- Support of theory groups at universities and research centres such as **ECT*** to prepare the community to benefit from European investments in supercomputing and quantum computing infrastructure.

PANDA @ FAIR



ePIC @ EIC



LRP 2024 Findings and Recommendations

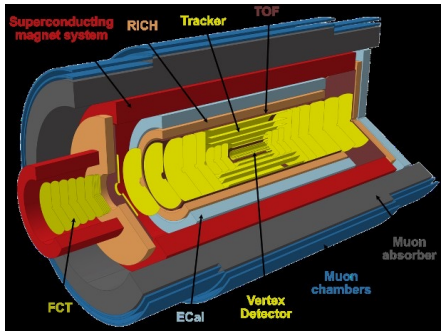
Recommendations for Strongly Interacting Matter at Extreme Conditions

What are the properties of the quark-gluon plasma, which is the qualitatively novel state of nuclear matter at extreme conditions of temperature and density?

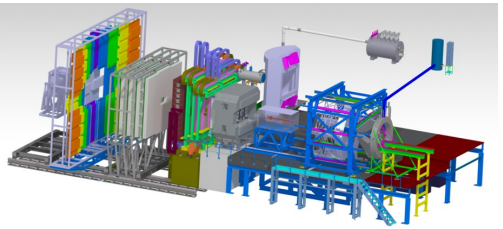
Key Words & Topics

Objectives: Discover in microscopic detail the material properties of the QGP at the highest temperature reached at the LHC and find the expected onset of the first-order phase transition at finite baryon density at FAIR.

ALICE 3 @ LHC



CBM @ FAIR



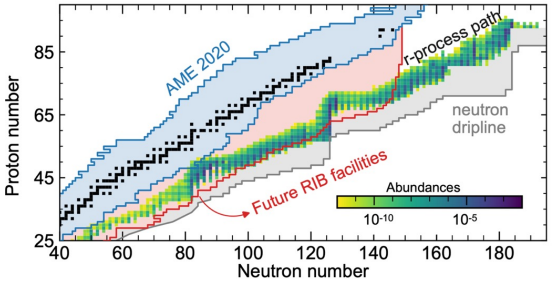
- **Future flagship facilities and experiments**
  - **ALICE 3** at **CERN**
  - **SIS-100** at **FAIR** and the realization of the **CBM** experiment
  - **CERN LHC** after 2035 (Run 5 and 6), the **LHCb Upgrade2** and the fixed-target setup **NA60+** detector at the **SPS**
- **Support of existing facilities and experiments**
  - maximise scientific output from the significant investment in current detector upgrades at the **LHC**
  - **HADES** and **R3B** at **SIS-18/SIS-100**, should receive full support.
  - The exploitation of **NA61** at **SPS** should receive full support
- **Theory developments**
  - Theoretical work in the field of heavy-ion collisions should be guaranteed continuous support
  - Collaborations should be particularly encouraged and nurtured in theoretical centres such as **ECT*** to strengthen the relation between heavy-ion physics and neighbouring fields

LRP 2024 Findings and Recommendations

Recommendations for Nuclear Structure and Reaction Dynamics

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?

Key Words & Topics



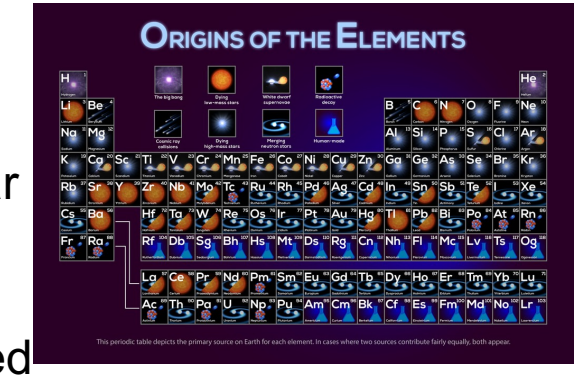
- **Support of existing facilities and experiments**
  - To ensure complementarity in experimental programs, it is essential to strongly support *large- and small-scale facilities* which guarantee access to the whole community
  - The coordinated effort amongst the **ISOL facilities** in Europe … will secure the leading position of Europe
  - The full completion of the European flagship gamma spectrometer **AGATA**-4π (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**
- **Theory developments**
  - Advance methods like Bayesian inference in combination with new computational techniques (e.g., Artificial Intelligence, Quantum Computing)
  - Theory centres should be strongly supported throughout Europe, in particular the **ECT*** and emerging virtual access facilities, which provide theory results for experimentalists (e.g., VA facility in the **EURO-LABS** project)

LRP 2024 Findings and Recommendations

Recommendations for Nuclear Astrophysics

How can we better understand the synthesis of heavy elements and the chemical evolution of the visible universe?

Key Words & Topics



Gravitational wave telescopes have opened a new window to astrophysics. These multi-messenger studies need a nuclear physics foundation. We recommend to strengthen nuclear astrophysics networks in Europe (e.g. **ChETEC-INFRA**) and to make them sustainable.

- **Support of existing facilities and experiments**
  - Small-scale facilities are key for nuclear astrophysics research and should be supported
  - European underground laboratories **(LNGS Bellotti** Ion Beam Facility and **Felsenkeller)** are essential
  - **CRYRING** and **ESR** storage rings at FAIR, which open important new physics cases, and **n_TOF** at CERN should be fully exploited
- **Future flagship facilities and experiments**
  - We strongly recommend the completion of Radioactive Beam Facilities in Europe, in particular the **Super-FRS** at FAIR, including the Low-Energy-Branch, the **upgrade of ISOLDE**, and **SPIRAL2**
  - A large (> 10MV) **AMS** system is currently missing in Europe
- **Theory developments**
  - Access to large and fast supercomputing facilities in Europe is essential to perform microscopic nuclear physics calculations as well as multidimensional astrophysics simulations
  - **ECT*** in Trento is an essential place for training and networking in nuclear astrophysics

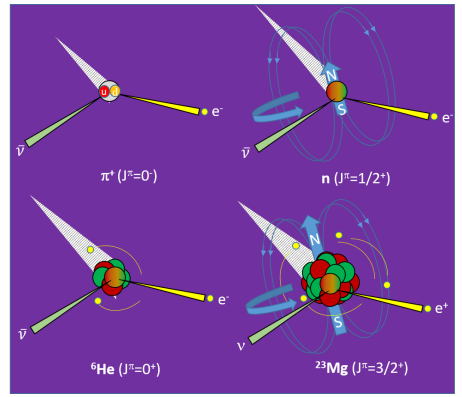
LRP 2024 Findings and Recommendations

Recommendations for Symmetries and Fundamental Interactions

What can nuclear physics teach us about the limits of the Standard Model of Particle Physics?

Key Words & Topics

- **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
- **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
- **Theory developments**
  - An inclusive theoretical framework fostering sustainable connections between nuclear theory, quantum chemistry, atomic and molecular physics, and particle physics must be encouraged and vigorously supported
  - The strong interdisciplinary program of the **ECT*** in Trento should be strongly supported



LRP 2024 Findings and Recommendations

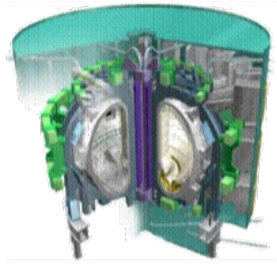
Recommendations for Applications and Societal Benefits

How might nuclear physics strengthen its role in society's sustainable development?

Selected Key Words & Topics

- Improving **nuclear data**, including both the measurement and the evaluation of nuclear data is needed to support research in the fields of energy, health, space, and material science.
- **Capacity building**: in radiochemistry and radiobiology maintaining nuclear application competencies, developing the landscape of smaller-scale facilities, in coordination with the large-scale facilities
- New generations of nuclear energy sources and the management of nuclear waste through partition and transmutation, depend on sustained technological developments in the present facilities, as well as the completion of **MYRRHA** and **IFMIF-DONES.**
- **Upscaling the production capacity of novel medical radionuclides: MEDICIS** separator at CERN, the expansion of the EU **PRISMAP** project, and the completion **ISOLPHARM** at SPES, **ISOL@MYRRHA, IMPACT-TATTOOS** at PSI, and **SMILES** at Subatech
- Completion of the first **galactic cosmic ray simulator** in Europe at GSI/FAIR
- The installation of a **high-energy AMS** in Europe (>10 MV) is recommended.
- Isotope-sensitive techniques in environmental, heritage, and material science: sustained operation of research reactors

AI nuclear clock



ITER

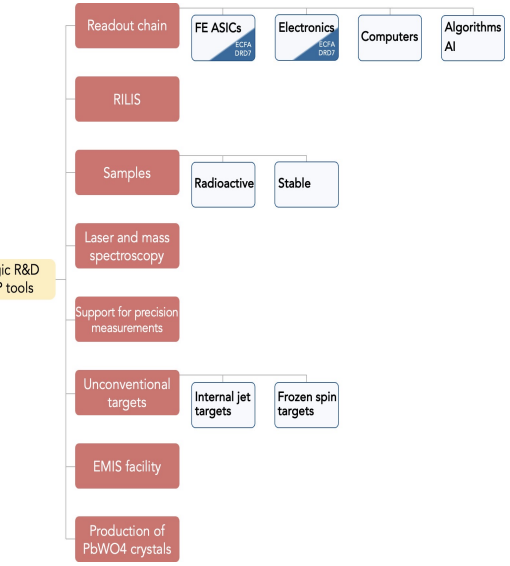
A PET–CT scan of the human body.

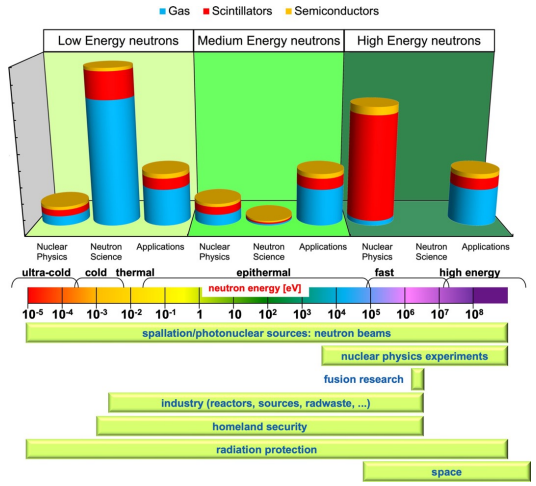
LRP 2024 Findings and Recommendations

Recommendations for Nuclear Physics Tools - Detectors and experimental techniques

Selected Key Words & Topics

- Elaboration of a **roadmap for detector R&D dedicated to the specific needs of low-energy nuclear physics and applications in radiation monitoring and heritage science** must be supported.
- **Strengthening of the collaborative effort in developing cutting-edge detector technology** for identified applications in accelerator experiments with respective activities in high-energy particle physics and other adjacent research fields.
- Enhance precision and efficiency in **high-resolution laser spectroscopy and mass spectrometry**, to study the structure of rare isotopes and test fundamental symmetries.
- Establish infrastructures to **ensure the provision of stable and radioactive targets**, such as **a dedicated mass separator** for providing radioactive samples and targets – **foreseen to be built at PSI**
- Secure a strategic **supply of stable enriched isotopes** for fundamental research and applications as is the case for the installation of a **European Electro-Magnetic Ion Separation facility**, providing material of the highest enrichment in rare stable isotopes.
- To develop **novel efficient neutron detectors** to replace those based on ^{3}He;





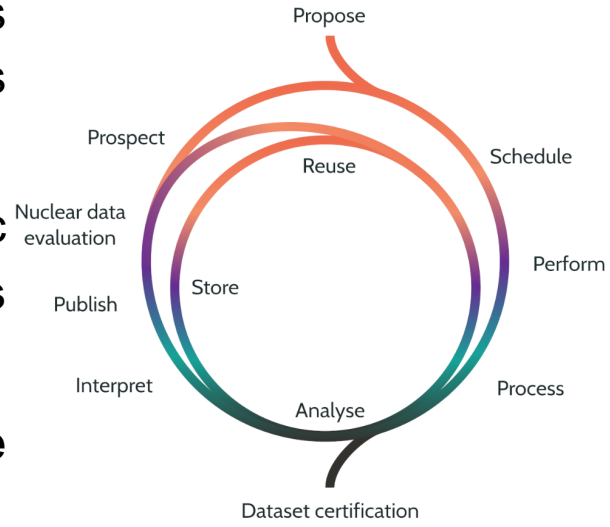
LRP 2024 Findings and Recommendations

Recommendations for Open Science and Data

Selected Key Words & Topics

Vigorously endorse and adopt open science practices, be actively involved in shaping the necessary policies, and lead the way in their implementation. The results of the **ESCAPE** and **OSCARS** EU projects should be fully deployed by and for the nuclear physics community.
The importance of Joint ECFA-NuPECC-APPEC (JENA) activities is underlined.

- The **creation and adoption of open science policies and guidelines** … as well as **promoting best practices** within individual institutes and research infrastructures should be strongly encouraged.
- Strongly support the application of the FAIR principles and common scientific computing frameworks: **encourage training and investment in human resources for data management**
- **Creation of coordination bodies to pursue standardization of the Data Life Cycle** to ensure data FAIRness should be supported.
- Combine forces of the European nuclear physics research and applications communities to **establish a comprehensive European nuclear data program** with well-defined priorities defined by stakeholders and sustainable funding to fulfil the needs in nuclear structure and dynamics, astrophysics and applications.

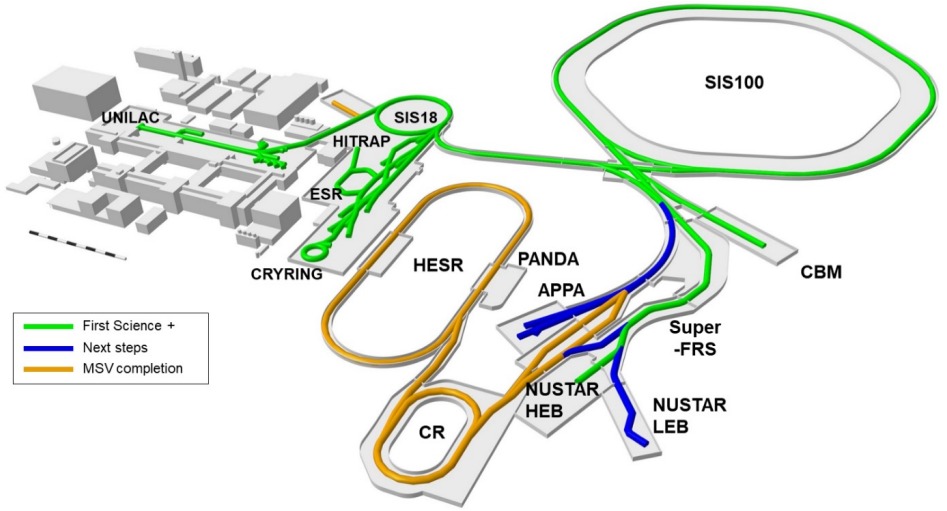


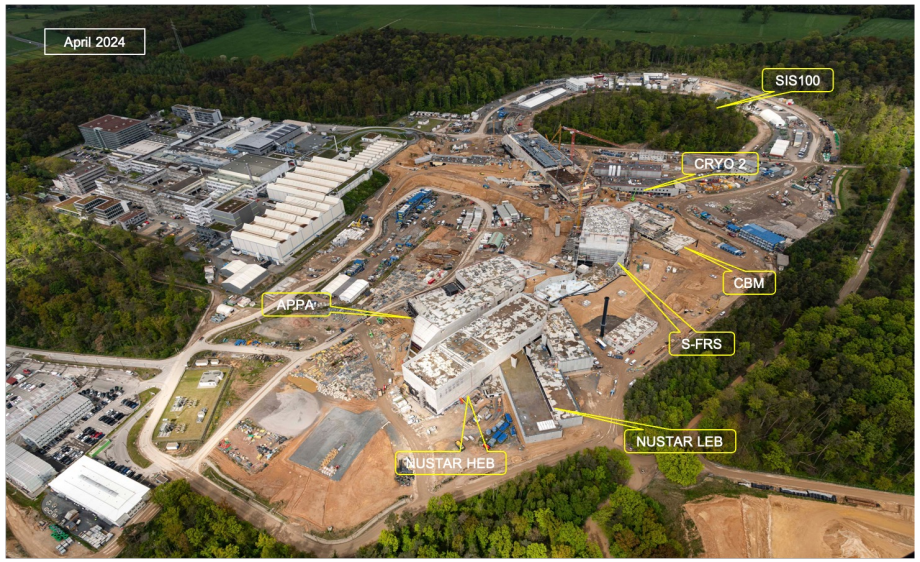
Data life cycle in nuclear physics

Recommendations for Nuclear Physics Infrastructures

ESFRI

- **The first phase of the international FAIR facility is expected to be operational by 2028, facilitating experiments with SIS100 using the High-Energy Branch of the Super-FRS, the CBM cave and the current GSI facilities. Completing the full facility including the APPA, CBM, NUSTAR and PANDA programs will provide European science with world-class opportunities for decades and is highly recommended.**





Recommendations for Nuclear Physics Infrastructures

ESFRI

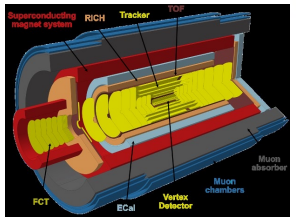
- **At GANIL/SPIRAL2 the Super-Separator Spectrometer S^3 is in an advanced stage of completion and the low-energy DESIR facility and heavy-ion injector NEWGAIN, will be operational from 2027/28. The refurbishing of the cyclotrons will ensure their operation for the next decades. Timely completion and 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.**

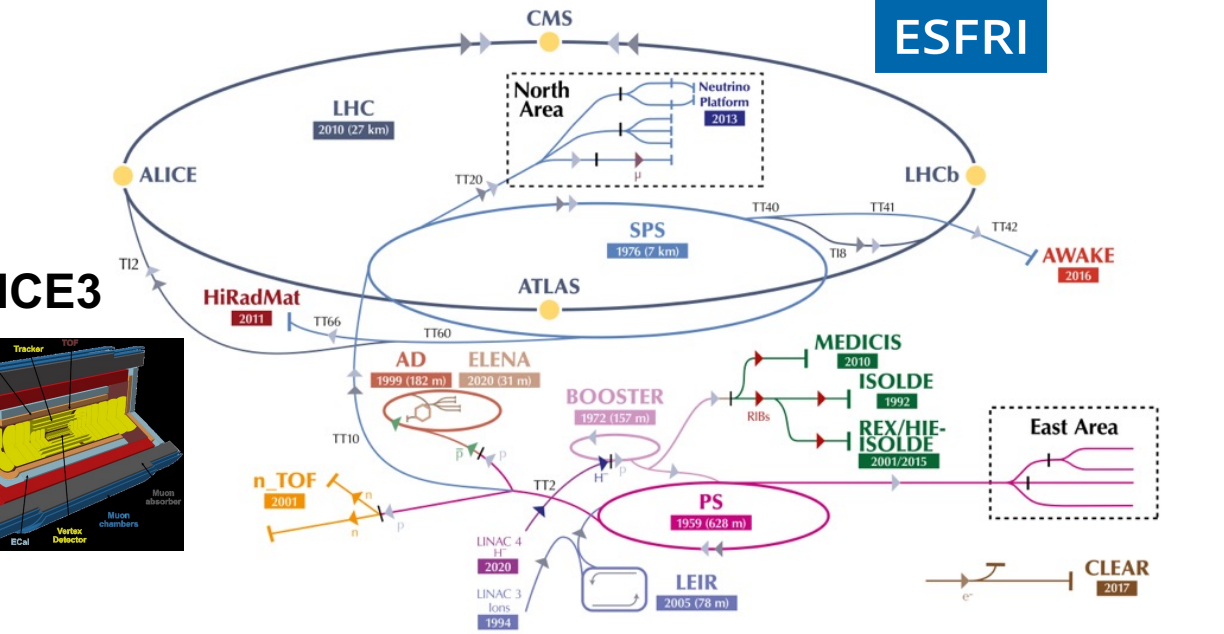
Recommendations for Nuclear Physics Infrastructures

- **Nuclear physics opportunities at CERN constitute a world-leading research programme. The construction of ALICE 3 as part of the HL-LHC plans is strongly recommended. Continued support for exploitation and new developments are recommended to maximise the scientific output of ISOLDE, n_TOF, SPS fixed-target program and AD/ELENA. As the roadmap for the post-LHC future of CERN is developed, a strategy should be prepared to secure future opportunities for continuing world-leading nuclear-physics programmes that are unique to CERN.**

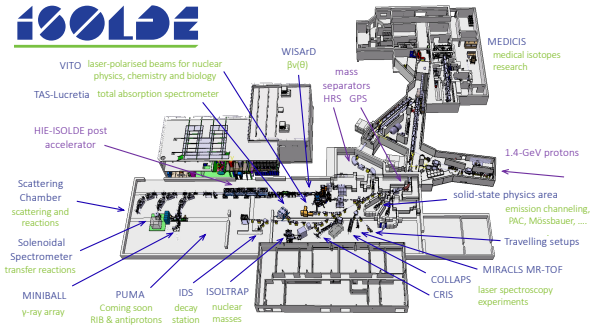
ESFRI

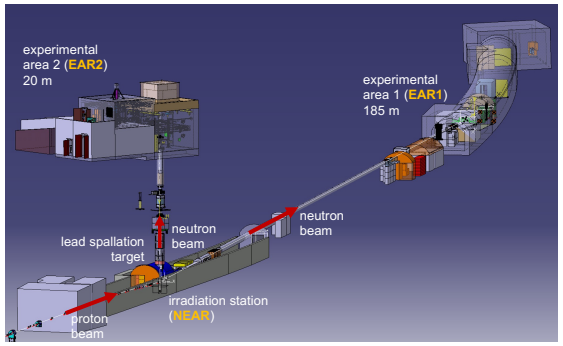
ALICE3





H⁻ (hydrogen anions) · p (protons) · ions · RIBs (Radioactive Ion Beams) · n (neutrons) · p̄ (antiprotons) · e⁻ (electrons) · μ (muons)

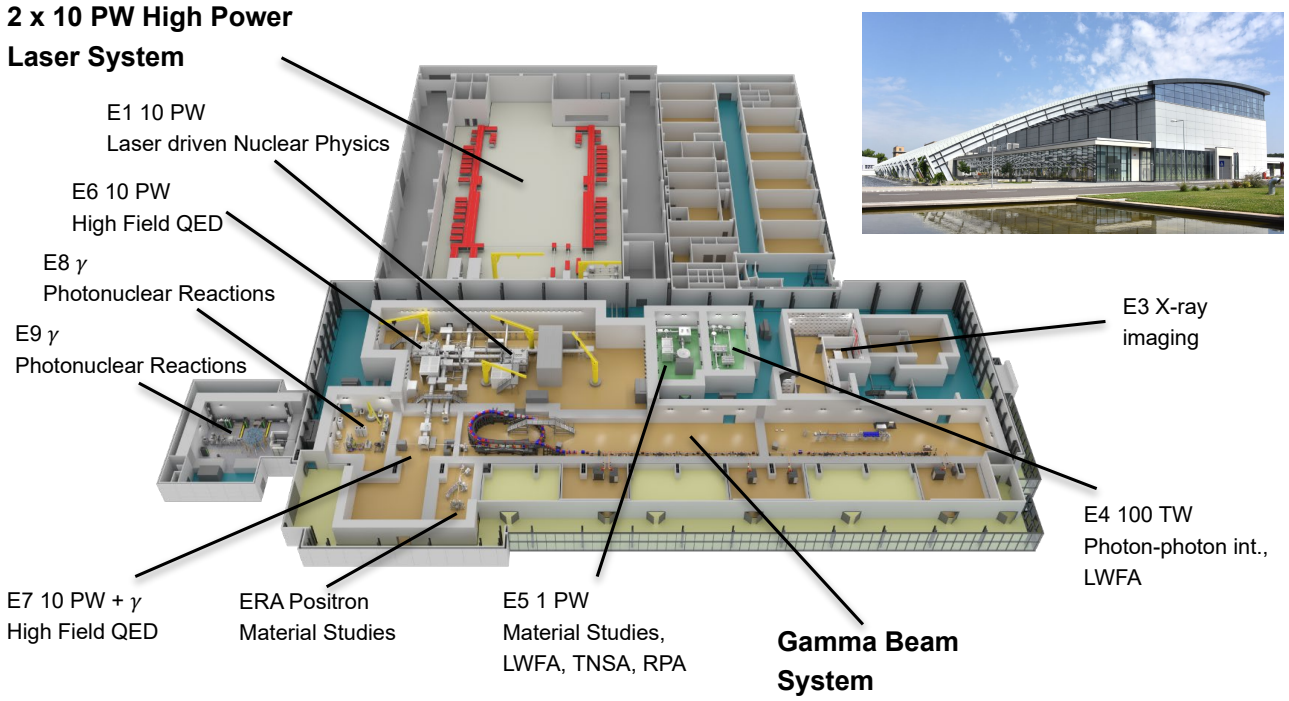




Recommendations for Nuclear Physics Infrastructures

ESFRI

- **At ELI-NP studies will focus on addressing key topics, such as laser-driven ion and electron acceleration. Implementing the gamma beam system to achieve the full completion of the facility to allow breakthrough results in the field of nuclear photonics is of high importance and is strongly recommended.**

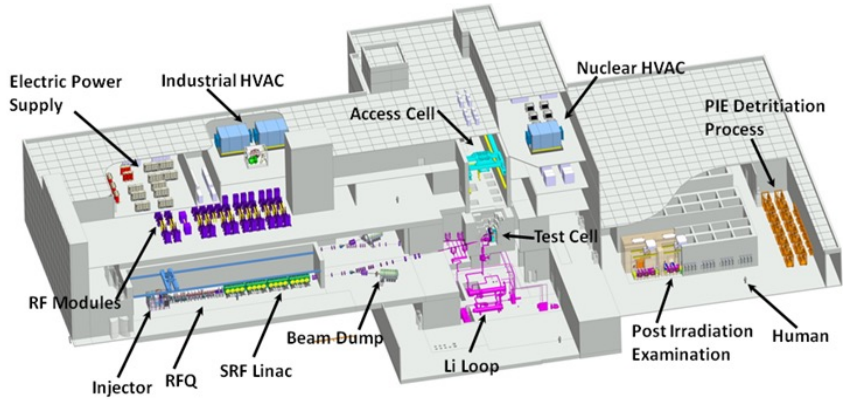


Recommendations for Nuclear Physics Infrastructures

- **Neutron facilities are playing a significant role in nuclear fundamental research and applications, producing unique and valuable experimental outcomes. The new NFS facility, located at SPIRAL2, is now providing a highly intense neutron flux of fast neutrons, attracting a broad scientific community. It is crucial and strongly recommended to maintain the operation of exceptional neutron facilities like ILL and n_ToF at CERN. ESS facility and the future infrastructure IFMIF-DONES will provide advanced tools for interdisciplinary research and their unique capabilities to serve advances in nuclear physics should be explored.**

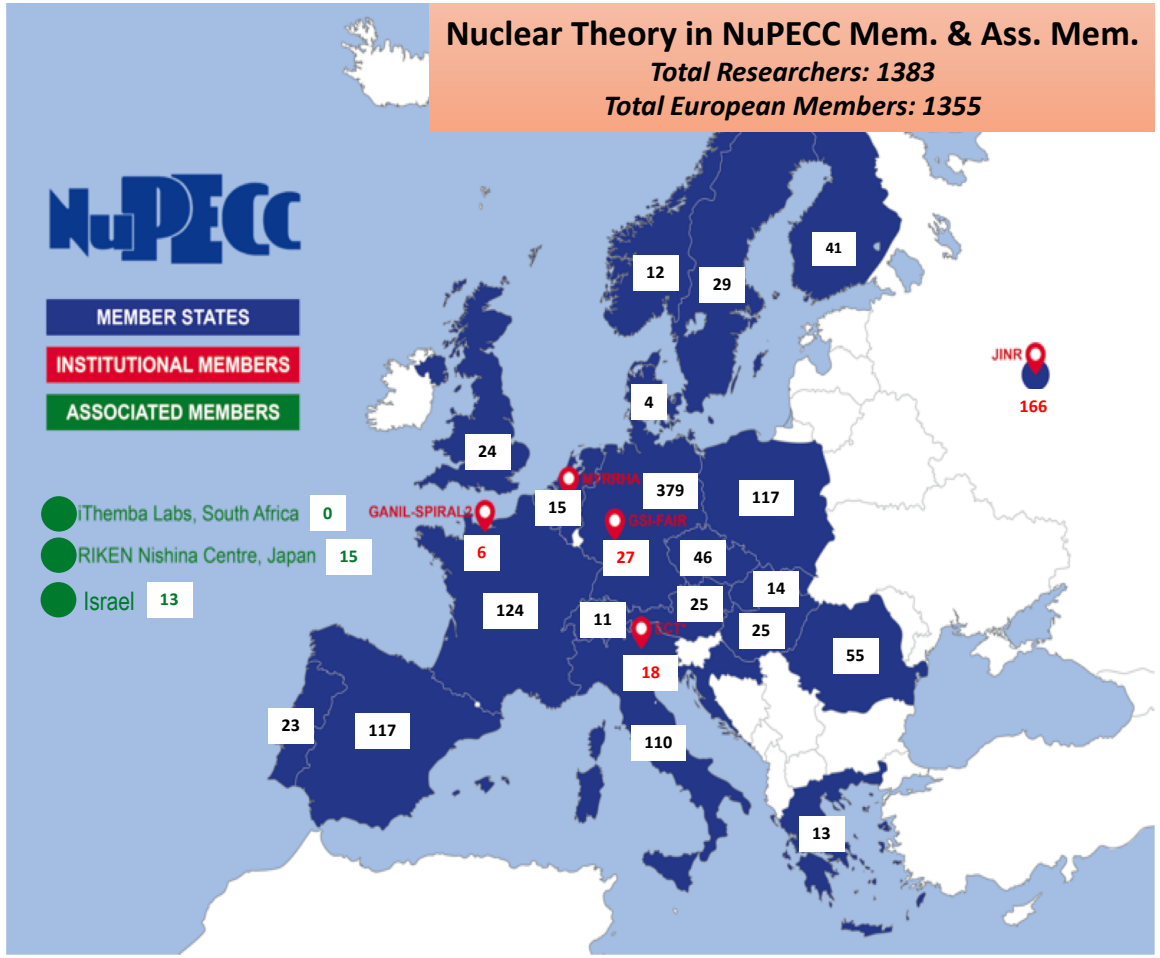
ILL

IFMIF-DONES



Recommendations for Nuclear Physics Infrastructures

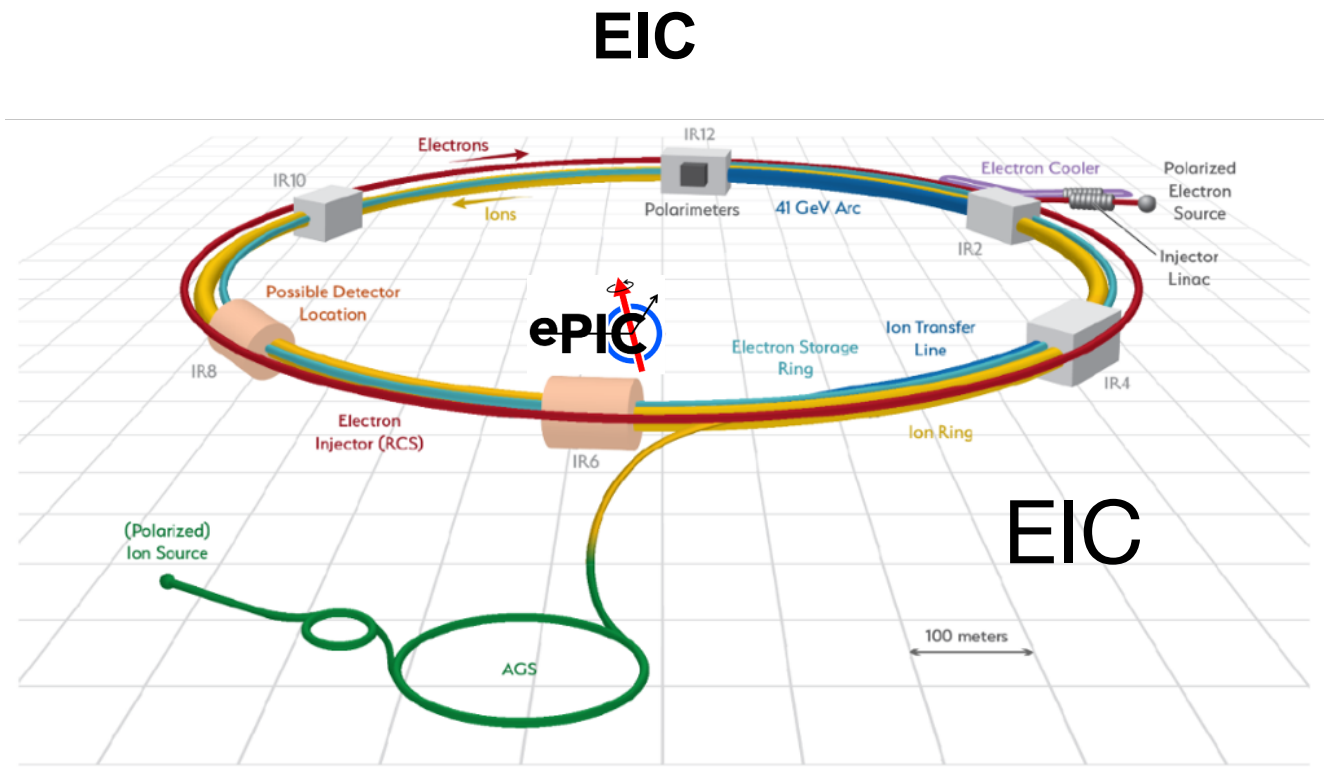
- **Theory centres and groups should be strongly supported throughout Europe, in particular the European Centre for Theoretical Studies (ECT*, Trento, Italy), which is a unique European centre dedicated to theoretical nuclear physics in the broadest sense. A stronger pan-European support which will ensure that ECT* activities continue to play a strategic role in the development of nuclear physics in Europe is recommended.**



ECT*

Recommendations for Nuclear Physics Infrastructures

- **Collaboration with non-European infrastructures should be fostered in all areas of nuclear research to seize unique scientific opportunities and synergies that complement scientific programmes based in Europe. In particular, European participation in the construction of the ePIC experiment at the future international flagship facility EIC is recommended.**



NuPECC LRP2024 Timeline

- ***Still to be done: proofreading by science writer, graphic design, colourful brochure***
- ***Executive Summary of the LRP2024 is available on the NuPECC Web site***
  - ***https://www.nupecc.org/lrp2024/Draft_Executive_Summary_LRP2024.pdf***
- ***The PDF version of the full document will be available on the NuPECC Web site by September 2024***
- **Official presentation of LRP 2024 on 19/11/2024 at the University Foundation in Brussels**

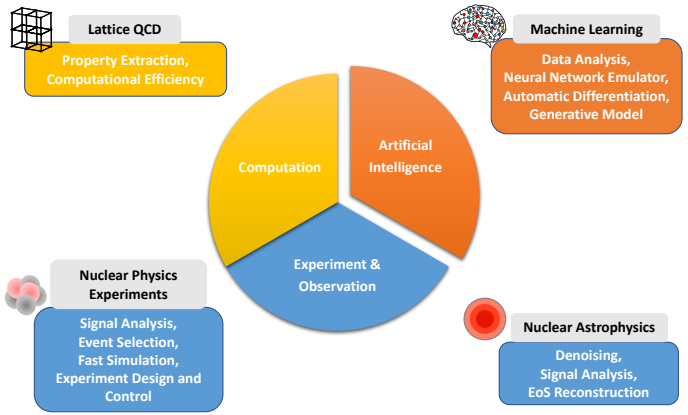
Thank you for your attention!

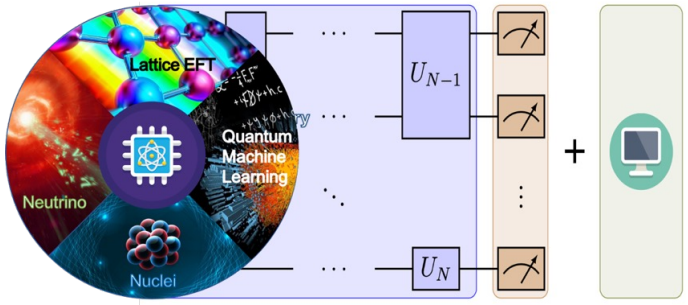
LRP 2024 Findings and Recommendations

Recommendations for Nuclear Physics Tools – Computing, AI/ML & QC

Selected Key Words & Topics

- Provide **long-term career perspectives for software developers** in the field
- Educate and train in software development
- Call for more **long-term storage solutions for gauge ensembles for lattice QCD**
- **Facilitate and strengthen access for nuclear physics researchers to large HPC centres**
- Support **virtual access infrastructures** (as in HE **STRONG-2020** & **EURO-LABS**)
- Transform ML prototypes into applications for production
- Invest in training and fine-tuning of models tailored for scientific purposes, such as **GPT models specialized for nuclear science.**
- Develop research into explainable AI; **Enhance transparency and interpretability in scientific AI applications in nuclear physics and adjacent fields.**
- Facilitate **access to quantum platforms**.
- Establish a **European network on quantum activities related to nuclear physics**.





LRP 2024 Findings and Recommendations

Recommendations for Nuclear Science - People and Society

Selected Key Words & Topics

- **Outreach:** We recommend that funding agencies, national and international bodies, and the community of European nuclear physicists emphasise the critical societal investment inspiring the public about nuclear science and its impacts.

Binding Blocks initiative in UK

- **Education:** We recommend that national educational accreditation bodies, funding agencies, universities and educational institutions, in collaboration with the community of European nuclear physicists work to embed nuclear science across all levels of education, highlighting its interdisciplinary nature and impact.

- **Training:** We recommend that the community of European nuclear physicists in collaboration with funding bodies and other stakeholders resource and support the training of new generations of nuclear scientists, to provide the broad skills base required across experimental and theoretical nuclear physics research, as well as all disciplines and industries in our society, commonly relying on expertise, techniques and skills from the nuclear sciences. This includes the provision of training for technical and engineering staff as well as interdisciplinary researchers.

Training at EURO-LABS facilities

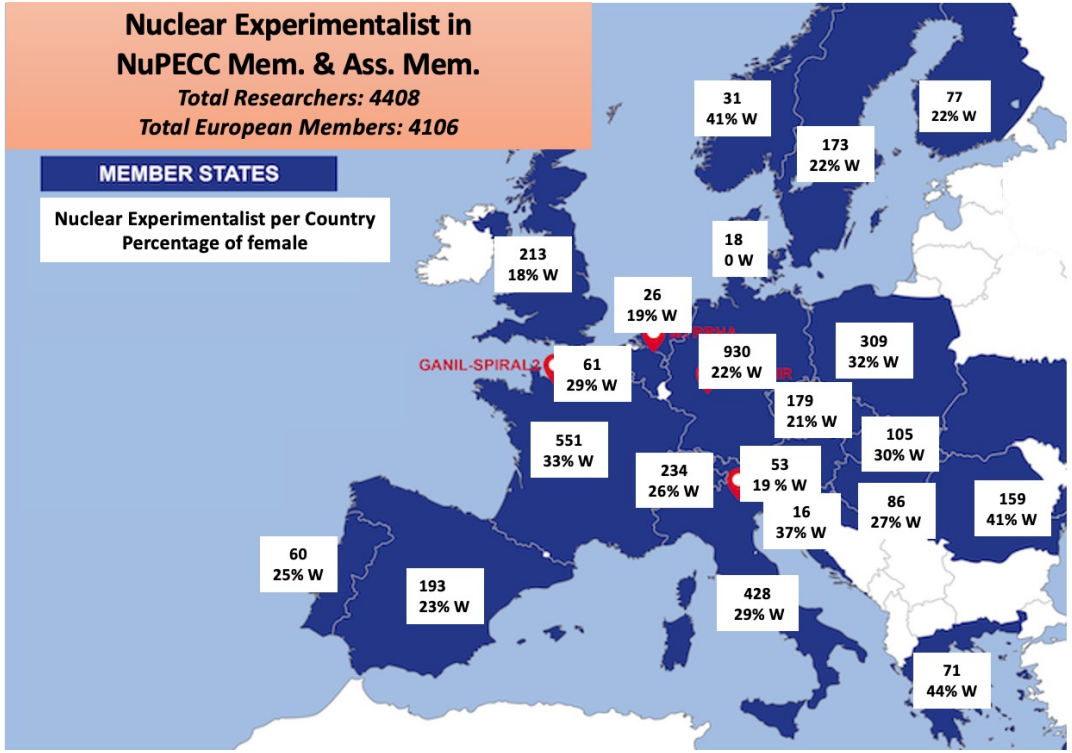
LRP 2024 Findings and Recommendations

Recommendations for Nuclear Science - People and Society

Selected Key Words & Topics

- **Diversity**: We recommend that the network of research organisations, funding agencies, as well as scientific collaborations and conference committees should **sign up to and promote a diversity charter**, such as the one prepared by NuPECC together with APPEC and ECFA.

- **Careers**: We recommend that equitable and inclusive career development is further prioritised by stakeholders across the European nuclear physics community, giving recognition and visibility to the critical contributions of **early career researchers**, as the future of nuclear physics and its impact on society.
  - support tenure track programs giving highly qualified early career researchers (**ECR**) the opportunity to lead their own group and establish scientific independence (e.g. permanent staff position openings for ECR, ERC Starting Grants).

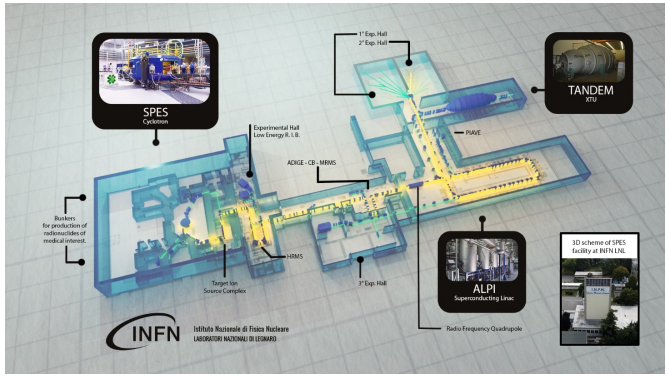


The map shows the community of experimental researchers within NuPECC. For each Country the total number and the ratio of women are given.

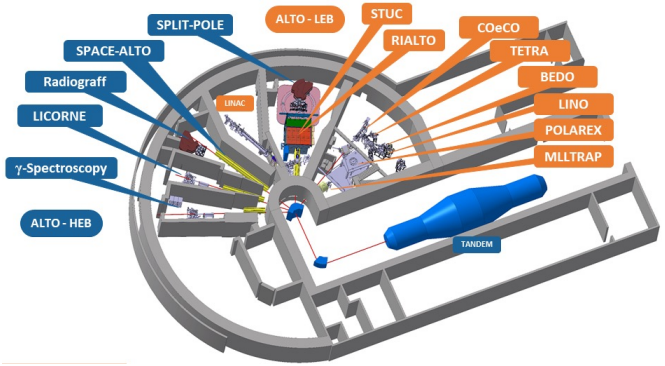
Recommendations for Nuclear Physics Infrastructures

- **Timely completion of the SPES facility and continuing coordinated efforts in developing the ALTO, IGISOL, ISOLDE, SPES, and SPIRAL ISOL facilities in Europe, will be key to maintaining their world-leading position in many areas of radioactive isotope science and are strongly recommended. Extending these efforts towards future facilities, such as ISOL@MYRRHA, TATTOOS@PSI, and RIB@IFIN, together with the development of common instrumentation, will secure the European leading position for radioisotope production, separation, and acceleration techniques, and create new avenues for the future and should therefore be actively pursued.**

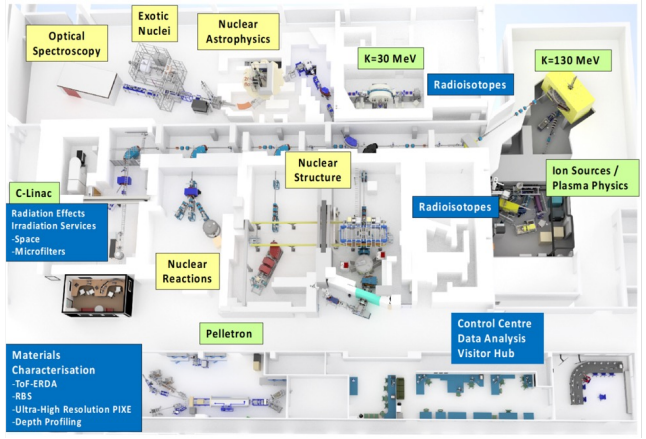
SPES/LNL



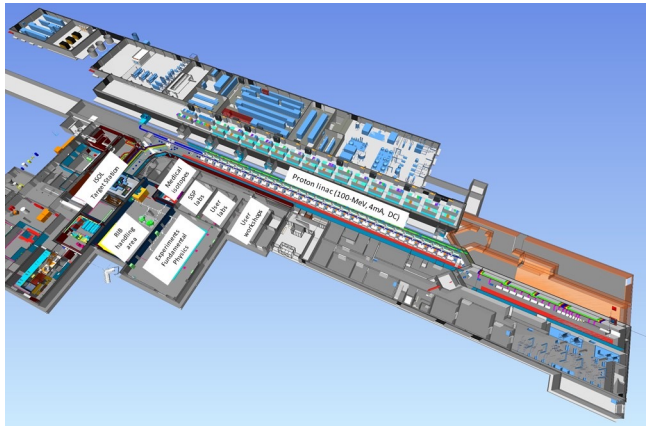
ALTO/IJCLab



IGISOL/JYFL



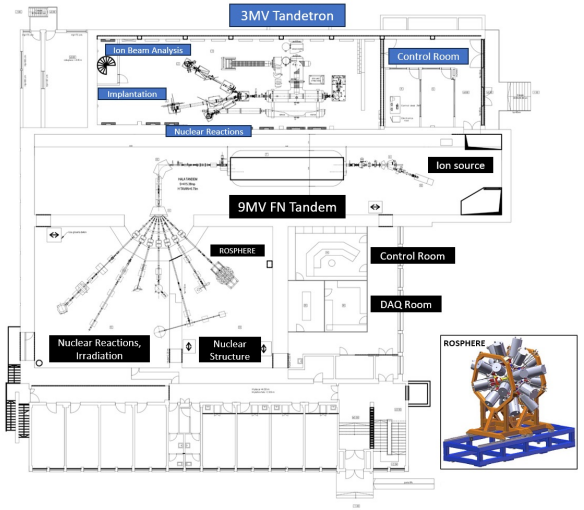
ISOL@MYRRHA



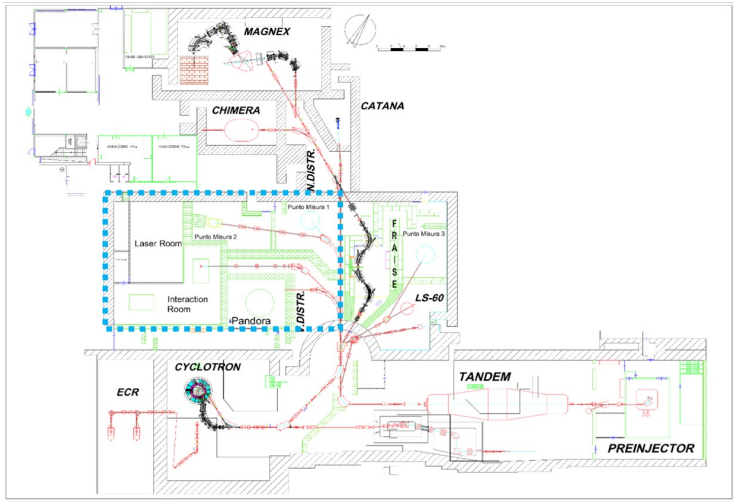
Recommendations for Nuclear Physics Infrastructures

- **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.**

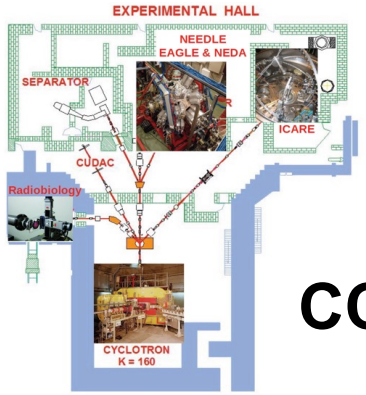
IFIN-HH



LNS

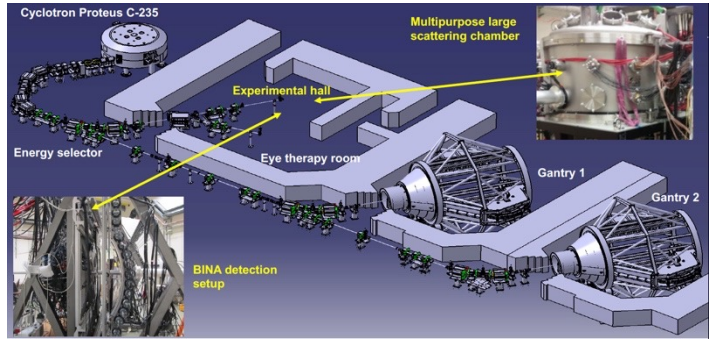


NLC



SLCJ

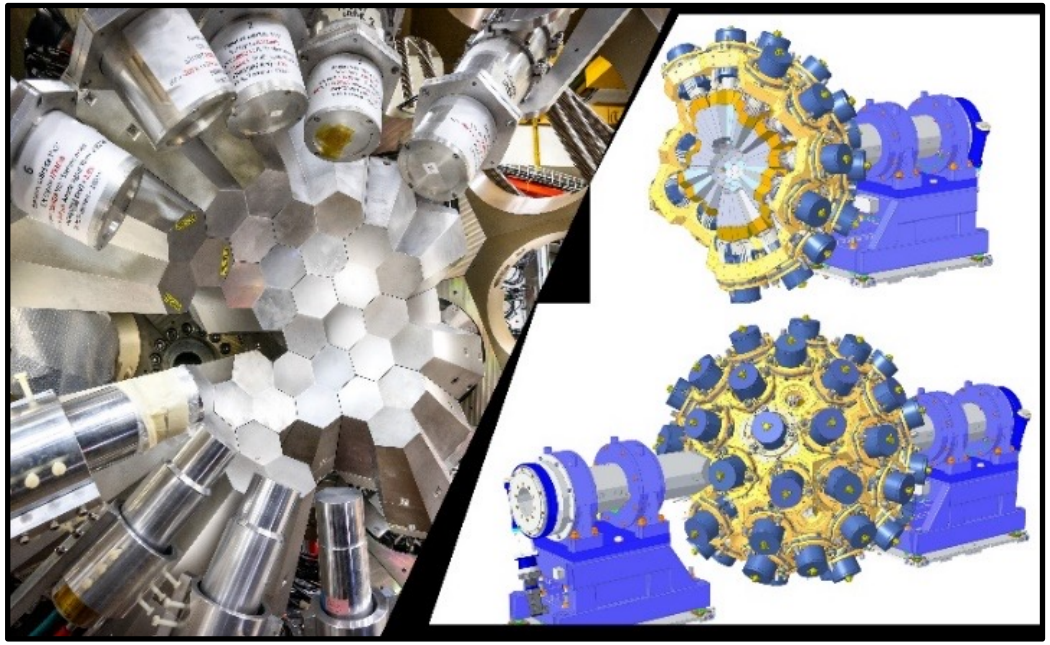
CCB



Recommendations for Nuclear Physics Infrastructures

- **It is strongly recommended to complete the AGATA gamma tracking array to its full configuration as a key instrument for studying atomic nuclei in both stable and radioactive ion beam facilities.**

AGATA gamma tracking array

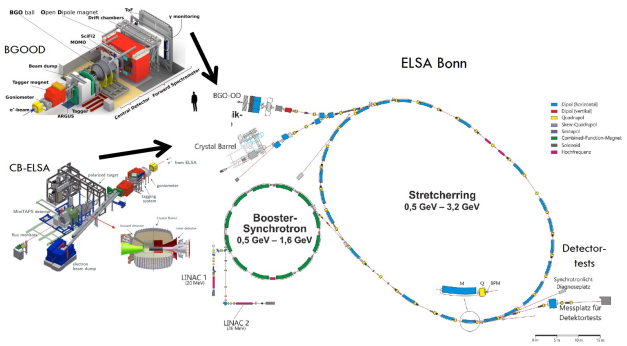


LRP 2024 Findings and Recommendations

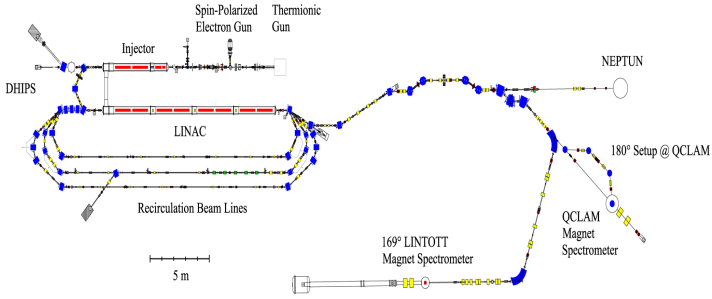
Recommendations for Nuclear Physics Infrastructures

- **Exploitation and optimisation of the European lepton beam facilities, including ELSA, MAMI, and S-DALINAC, are needed to realise their full physics potential. The completion of the MESA facility and the High-Intensity Muon Beams project at PSI, are recommended.**

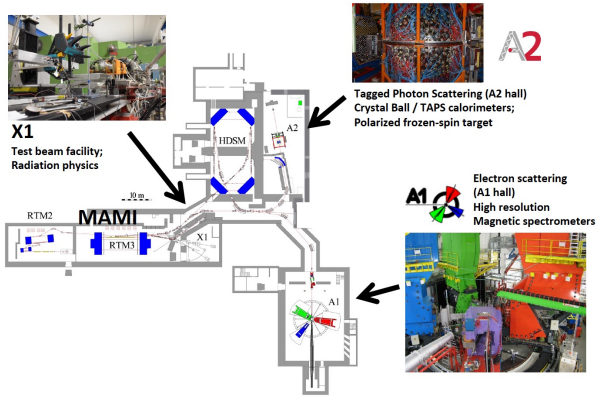
ELSA



S-DALINAC



MAMI



MESA