

# The NuPECC Long Range Plan 2024

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**ePIC General Meeting**  
**July 12, 2024**

The Nuclear Physics European Collaboration Committee  
is an Expert Committee of the European Science Foundation

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The objective of NuPECC is to:

- develop the strategy for European Collaboration in nuclear science by supporting collaborative ventures between research groups within Europe, and
- promote nuclear physics and its trans-disciplinary use in applications for societal benefit.

In pursuing this objective the Committee shall:

- **provide advice** and make strategic recommendations to funding agencies and decision-making bodies;
- **define a network** of complementary facilities within Europe and encourage optimisation of their usage;
- **provide a forum** for the discussion of the provision of future facilities and instrumentation;
- **contribute to public** education and awareness.



At its meeting in Madrid in May 2022, NuPECC took the decision to launch the process of creating a new Long Range Plan (LRP) for Nuclear Physics in Europe, identifying opportunities and priorities for nuclear science in Europe, with the aim of publishing the document in 2024.

- **May 30, 2022: Call for community input** (5 pages) for the NuPECC Long Range Plan 2024 – Deadline: Oct 1<sup>st</sup>, 2022
- January 2023: Formation of Thematic Working Groups (TWG) to analyze contribution received (153)
  1. **Hadron Physics**
  2. Strongly Interacting Matter under Extreme Conditions
  3. Nuclear Structure and Reaction Dynamics
  4. Nuclear Astrophysics
  5. Symmetries and Fundamental Interactions
  6. **Research Infrastructures**
  7. Applications and Societal Benefit
  8. **Nuclear Physics Tools**
  9. Open Science and Data
  10. Nuclear Science – People and Society
- April 3, 2024: [Draft document](#) released to the community (370 pages)
- **April 15-17, 2024: Town Meeting** (Bucharest, Romania) - <https://indico.ph.tum.de/event/7593/>
- **Approval of LRP 2024 (NuPECC meeting on June 13-14, Lund)**
- Final document: Fall 2024
- Official presentation of the LRP 2024 in Brussels on Nov 19, 2024

A total of **153 contributions** submitted, 7 of which explicitly mention EIC/ePIC:

1. The EIC (by Elke Aschenauer on behalf of BNL and JLab)
2. The EIC (by Marco Radici on behalf of the EICUG)
3. French input on hadron physics (by C.M.C. on behalf of the French QCD network)
4. Italian input on EIC (by Pietro Antonioli & Marco Radici on behalf of the INFN EIC community)
5. UK contribution on hadron structure (Birmingham, Glasgow, Oxford, York)
6. UK contribution on hadron interaction (Birmingham, Glasgow, Oxford, York)
7. UK contribution on hadron spectroscopy (Birmingham, Glasgow, Oxford, York)

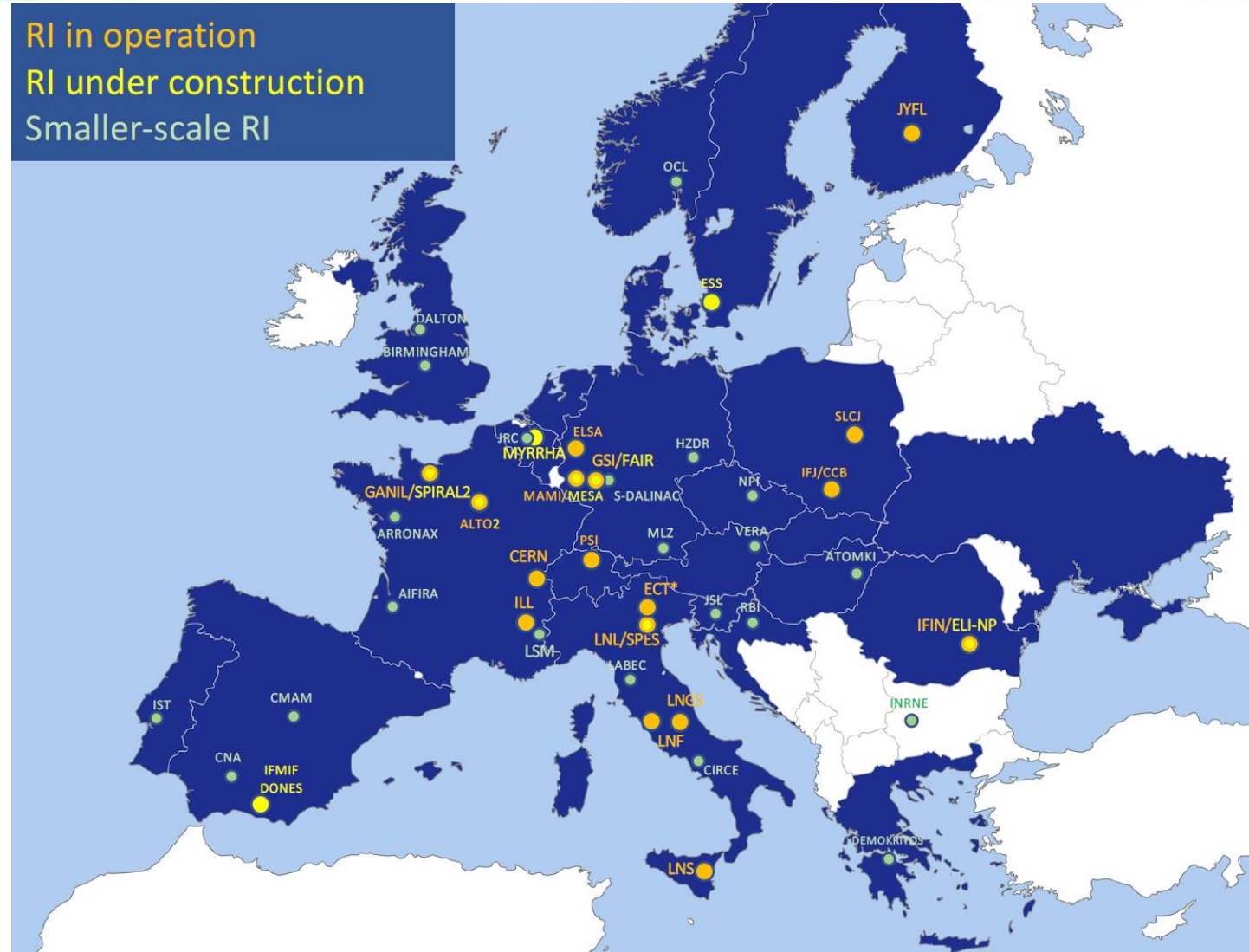
### Many ePIC collaborators members of the TWGs:

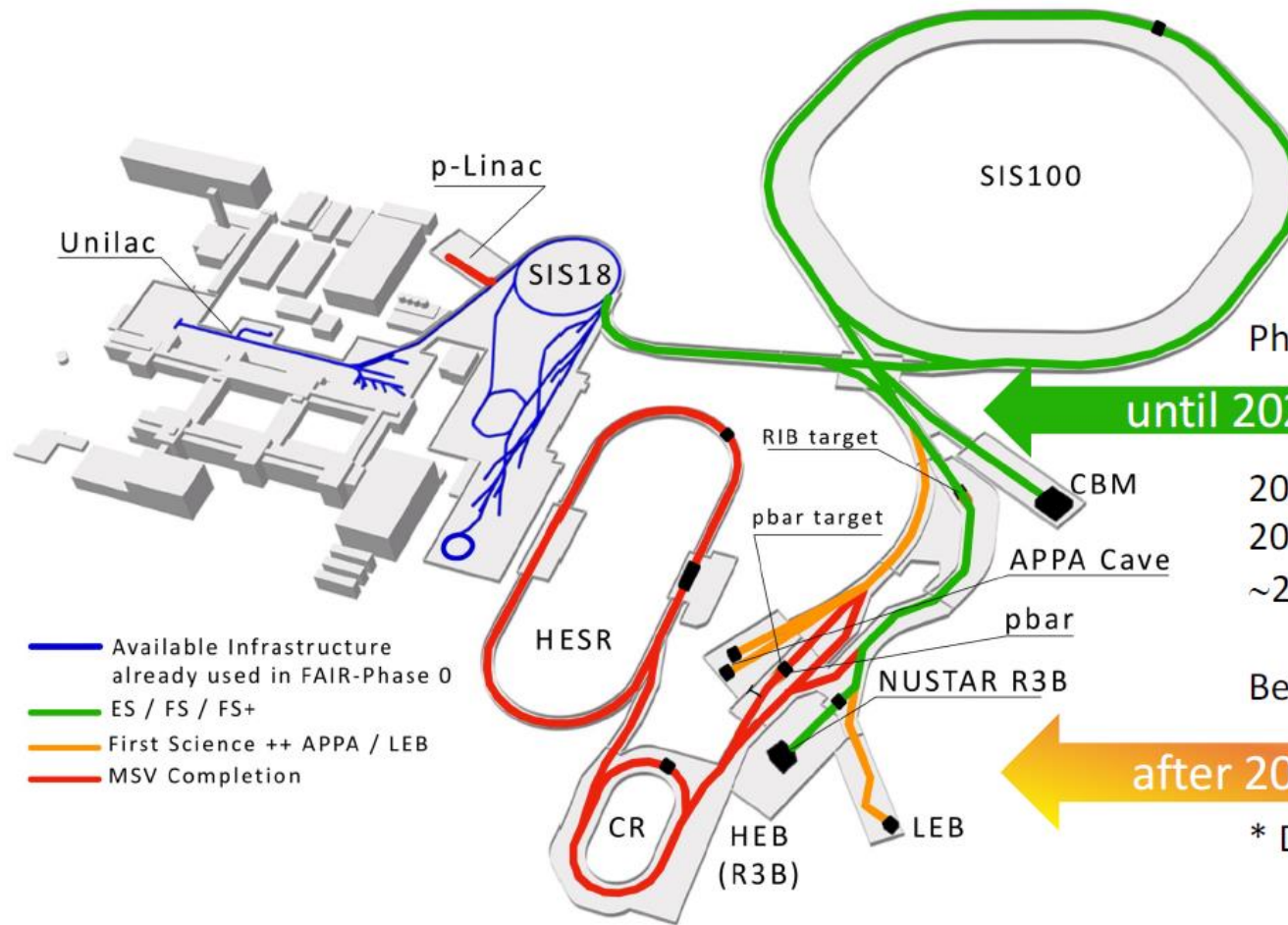
- TWG-1 (hadron physics): P. Antonioli, A. D'Angelo, S. Niccolai & D. Ireland (NuPECC, liason)
- TWG-6 (infrastructures): C.M.C. & M. Radici
- TWG-8 (tools/detectors): S. Dalla Torre (coordinator)
- TWG-8 (tools/computing): V. Bertone (coordinator)



- ESFRI (European Strategy Forum for Research Infrastructures) facilities
  - FAIR, GANIL/SPIRAL2, ELI and CERN
- Large-scale facilities
  - Hadron and Heavy Ion facilities
  - Lepton and Photon facilities
  - Neutron facilities
- Small-scale facilities
- New facilities in Europe
- Facilities outside Europe

RI in operation  
 RI under construction  
 Smaller-scale RI





Phase-0: FAIR equipment at UNILAC & SIS18

**until 2028**

2027/28: First experiments with S-FRS and SIS18

2028/29: SIS100 and CBM

~2030\*: Completion APPA cave and S-FRS  
 low-energy branch (with AGATA)

Beyond 2030: p-LINAC, CR & HESR

**after 2028**

\* Depending on the availability of funding



## MAMI (University of Mainz)

### Plans and priorities:

- Major hadron physics program with **polarized electron beams**
- Parity violating nuclear physics program
- Upgrade of instruments
- Test bench for MESA

Electron Accelerator  $E_{\max} = 1.6 \text{ GeV}$  (CW)  
 operated at JGU Mainz

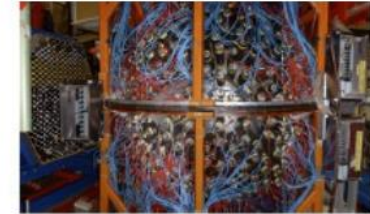
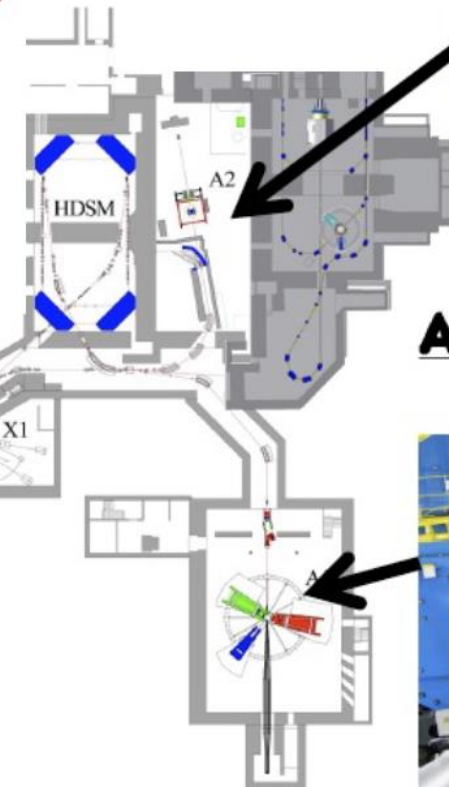
### Hallmarks

- Intensity max.  $100 \mu\text{A}$
- Resolution  $\sigma_E < 0.100 \text{ MeV}$
- Polarization 85%
- Reliability: up to 7000 h / year



**X1**  
 Test beam facility;  
 Radiation physics

**MAMI**



**A2**

Tagged Photon Scattering (A2 hall)  
 Crystal Ball / TAPS calorimeters;  
 Polarized frozen-spin target  
 → currently at Univ. Bonn



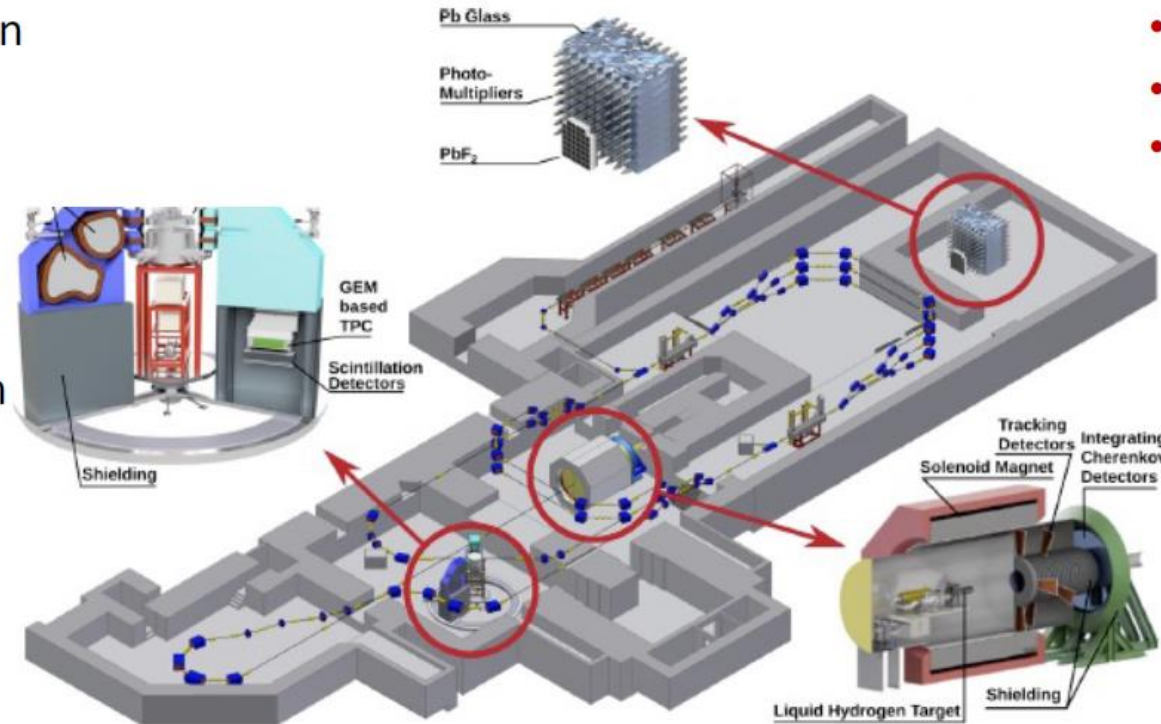
Electron scattering (A1 hall)  
 High resolution  
 Magnetic spectrometers



## MESA: Mainz Energy-recovering Superconducting Accelerator

### Plans and priorities:

- New accelerator installation
- First and only ERL operation for physics experiments
- Start of operation in 2025
- Major physics program in hadron- nuclear, particle-, and Astro-physics
- Upgrade to 10 mA electron current



### Planned experiments:

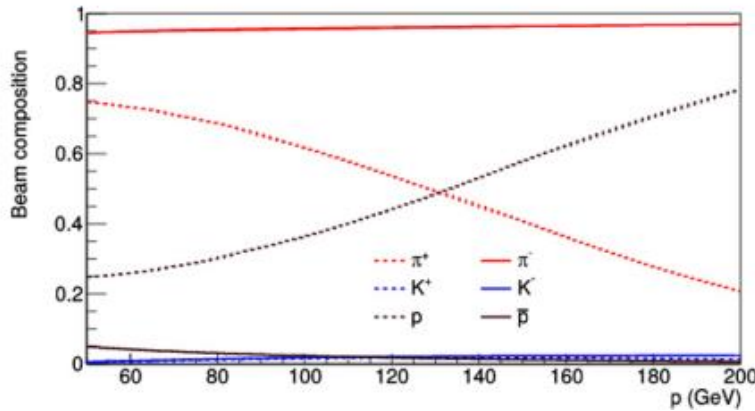
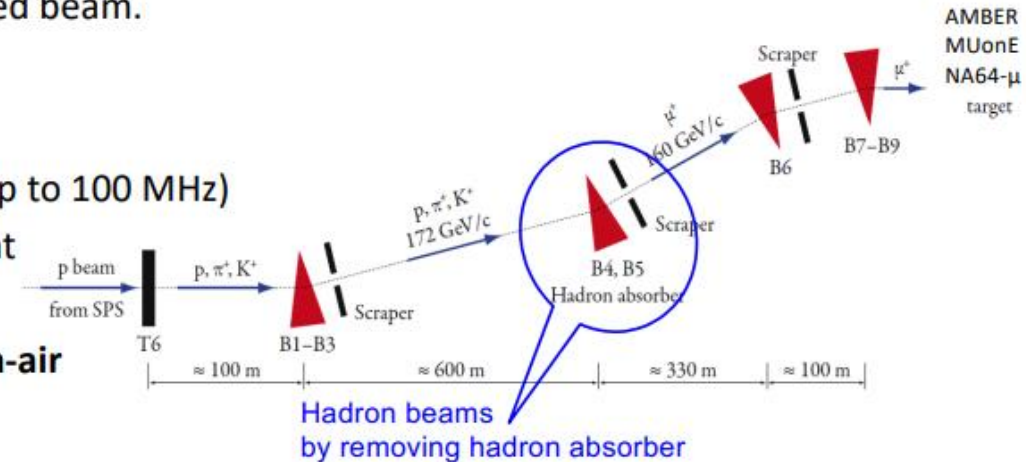
- **MAGIX** (ERL mode)
- **Dark MESA** (beam dump)
- **P2** (extracted beam mode)





Located in the CERN North Area, it has **secondary (hadron)** and **tertiary (muon)** beams obtained from the protons@400 GeV SPS extracted beam.

- Unique **high-energy muon beam**
- Hadron beams in the range 50 – 280 GeV
- Both beam charges, and high intensity (100 kHz up to 100 MHz)
- Hadron beam composition momentum dependent
- Planned upgrades :  
**reduce beam divergence and beam scattering-on-air**

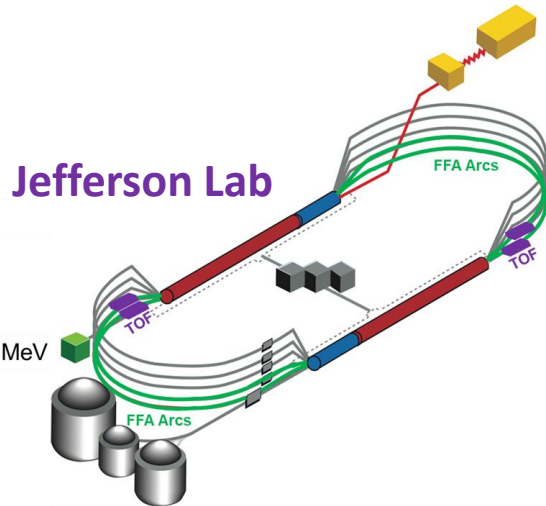


**AMBER, MUonE and NA64- $\mu$**  are operating at the M2 beamline:

- AMBER focusses on **hadron structure & spectroscopy**
- MUonE hadronic contribution to **muon anomalous magnetic moment**
- NA64- $\mu$  search for **Light Dark Matter** candidates

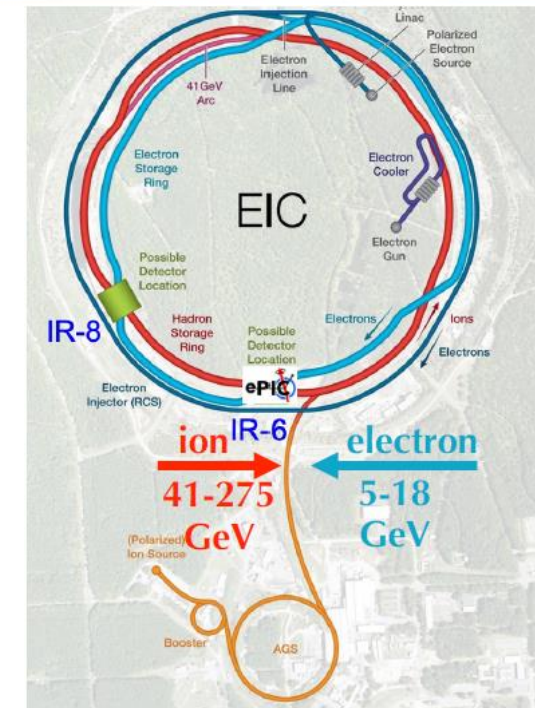
## Criteria for inclusion:

- Complementarity with facilities in Europe or additional capabilities
- Strong interest and contributions to experiments from European research groups (or contribution to LRP call)
- **CEBAF@TJNAF**, **EIC@BNL**, FRIB@MSU, ISAC@TRIUMF, RIBF@RIKEN



## Priorities of the European community:

1. Exploitation of the **existing** (recent) upgraded facility JLab12
  - Many recent and future detector contributions to the program
  - Strong involvement in data analysis & upcoming experiments for >10-15 years
2. Unique **future** program with polarized positrons
  - Physics case is compelling and timely
  - Possible detector contributions for new experiments
3. Explore the physics opportunities of a 22 GeV **upgrade**
  - Support in various ways connections between the EIC, NuPECC and EU high-energy communities (both exp. and th.) to maximize synergies
  - A proper design of WPs of pertinent EU projects to favor such exchanges
  - Support training of a new generation of students / early career researchers expert in Hadron Physics with special programs
  - Favor ePIC to become a recognized experiment at main EU Nuclear facilities



- The first phase of the international **FAIR** facility is expected to be operational by 2028... The completion of the full facility including the program of APPA, CBM, NUSTAR and PANDA should be vigorously pursued
- Timely completion and full exploitation of [] **GANIL/SPIRAL2** projects should be vigorously pursued.
- Nuclear physics opportunities at **CERN** (ALICE3, AMBER, ISOLDE, nTOF, Anti-Proton Decelerator).
- **ELI-NP** (Extreme Light Infrastructure) – nuclear photonics
- Facilities for **Hadron and Lepton Beams**: PANDA & **ePIC** (+ exploitation of ELSA, LNF, MAMI, S-DALINAC & realization of MESA at Mainz and HIMB at PSI)
- **ISOL facilities** in Europe (ALTO, IGISOL, ISOLDE, SPES, and SPIRAL) and future upgrades (ISOL@MYRRHA, TATTOOS@PSI, and RIB@IFIN)
- **Exploitation of large-scale stable beam facilities** (FAIR/GSI, GANIL/SPIRAL2, IFIN, JYFL, LNL, LNS, NLC), and smaller ones...
- **Neutron facilities** like ILL, and n\_ToF at CERN...
- **Theory centres** and groups should be strongly supported throughout Europe, in particular the European Centre for Theoretical Studies (ECT\*, Trento, Italy).
- Collaboration with **non-European infrastructures** should be fostered. In particular, **European participation in the construction of the ePIC experiment at the future [...] EIC is recommended**. [FRIB, JLab, RIKEN & TRIUMF also mentioned]



**Existing facilities:** We recommend the continuing support of the successful hadron physics programs in Europe and the participation of European groups at global facilities. Particularly important hadron physics facilities are:

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

Furthermore, we recommend the support of ongoing hadron physics activities at the multipurpose facilities **Belle II**, **BESIII** and the **LHC**.

**Future flagships:** We recommend the expedited realization of the antiproton experiment **PANDA**, and the support of European groups to contribute to the electron-ion experiment **ePIC**.

Theory / Computing

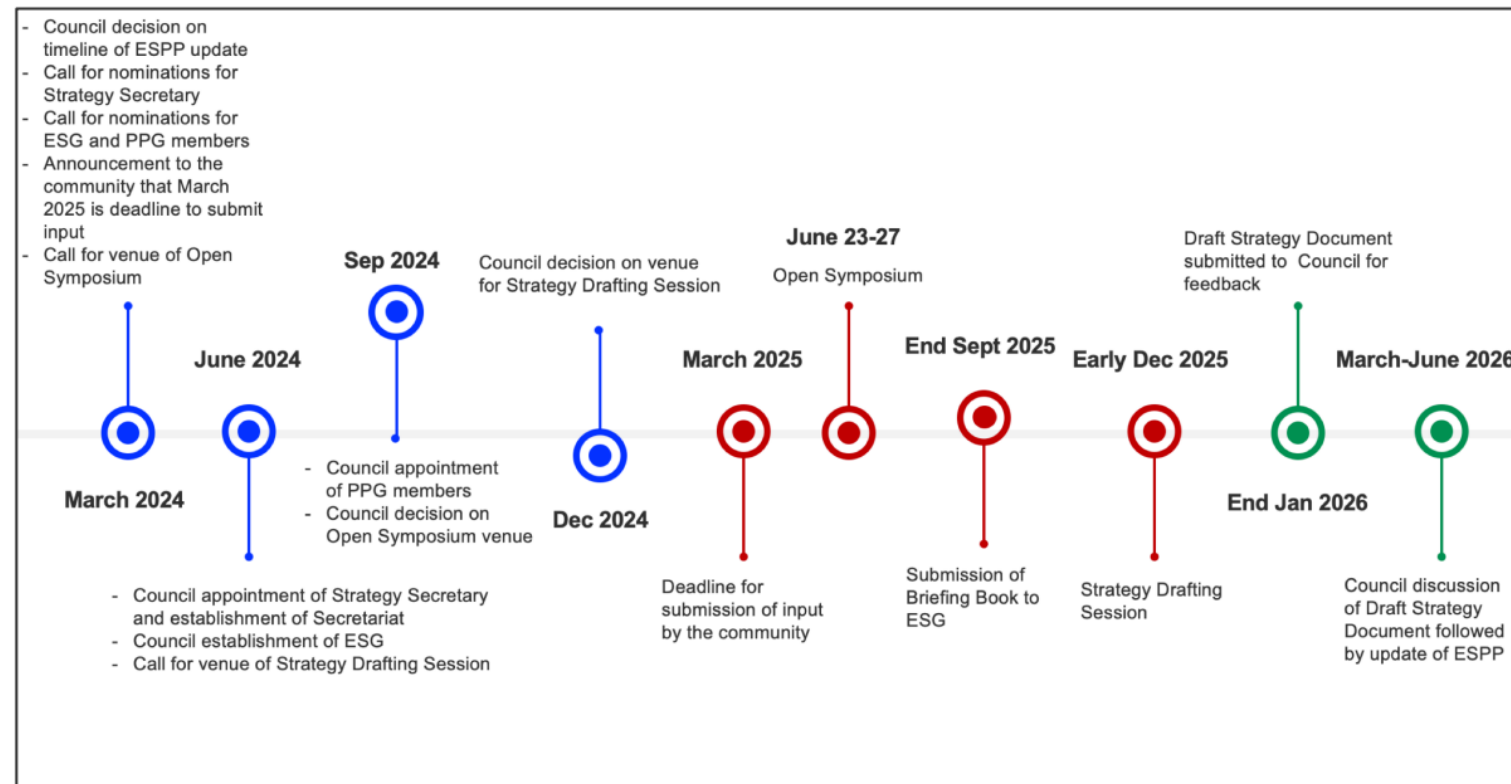
- The 2024 NuPECC LRP process has (almost) concluded
- Strong engagement from EU community working in ePIC
- Facilities outside Europe are part of the recommendations explicitly (**new**)
- **EIC/ePIC** is highlighted many times in the document and is part of the **recommendations** of both the **hadron physics** and the **infrastructures** TWGs.
- Also part of TWG-2 (strongly interacting matter) and TWG-8/detectors & TWG-8/computing



NuPECC LRP Town Meeting,  
Bucharest – Apr 15-17, 2024

- **March 2025:** deadline for submission of community input
- **June 23-27, 2025:** Open Symposium
- **Early Dec 2025:** Strategy Drafting Session
- **June 2026:** Strategy update by CERN Council → end of the process

- Heavy-ion physics is part of the ESPP, as competing for beam time for particle physics at CERN
- EIC/ePIC will/should participate to the ESPP Update process



Fabiola Gianotti, [FCC week 2024](#)