

Joint EICUG/ePIC Collaboration Meeting
Lehigh University 22-27 July 2024



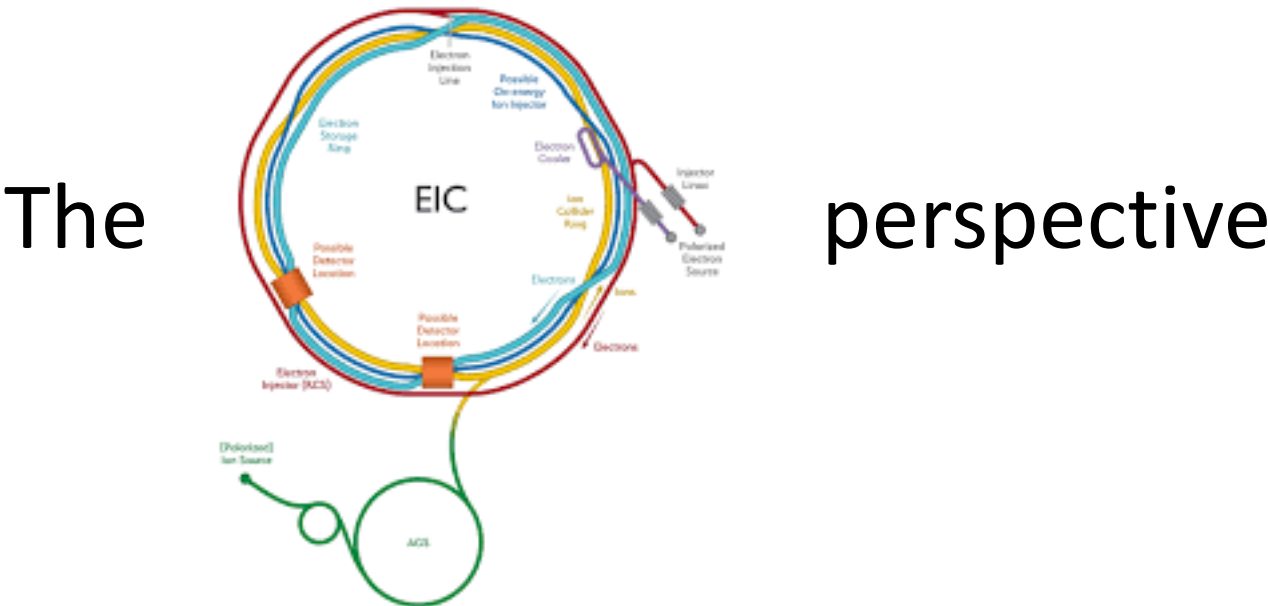
The NuPECC Long Range Plan 2024
(and the European EIC school)

P. Antonioli (INFN-Bologna)

Many perspectives to look at such a plan!



The **NuPECC** perspective



The perspective


About the NuPECC Long Range Plan 2024!

DISCLAIMER:
This is not about the **whole** plan, just some highlights, with emphasis on EIC

Many perspectives to look at such a plan!



The  perspective

The  perspective



perspective

About the NuPECC
Long Range Plan 2024!

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What is NuPECC?

What is NuPECC?

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

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.



NuPECC is just a committee of experts, but...
NuPECC is not related to UE but...

22 countries
4 associated members, incl. CERN and Israel
9 observers including NSAC, APPEC, ECFA

Remember: Europe is complicated, and physics too



ECFA
European Committee for Future Acc



NuPECC

APPECC

particle physics (HEP)

nuclear physics

astroparticle physics

- Each with its own "strategy", each with different timeline (ESPP update: 2018-2020, NuPECC: 2017-2023 APPECC: 2017-2026). Note: other animals like ESFRI (EU-led) are relevant
- Neutrinos, fundamental symmetries, DIS and $\beta\beta(0\nu)$ have different homes in US and Europe, and among different funding agencies
- CERN is a **big** one (and it is truly "European"): the periodic update of particle physics strategy is indeed run via CERN (ESG) <https://europeanstrategy.cern>, decided upon CERN Council initiative (<https://cerncourier.com/a/european-strategy-update/> 4 May 2024) and adopted by CERN Council

Remember: Europe is complicated, and physics too



ECFA
European Committee for Future Accel



NuPECC

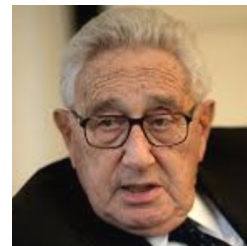
APPECC

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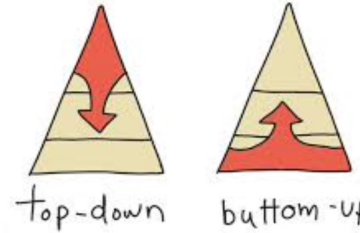
P. Antonioli – NuPecc LRP

“Who do I call if I want to call Europe?”
(H. Kissinger famous quote, perhaps an urban legend)

NuPECC Long Range Plan is "bottom up"

Every six years "bottom up" process is started (from the top...):

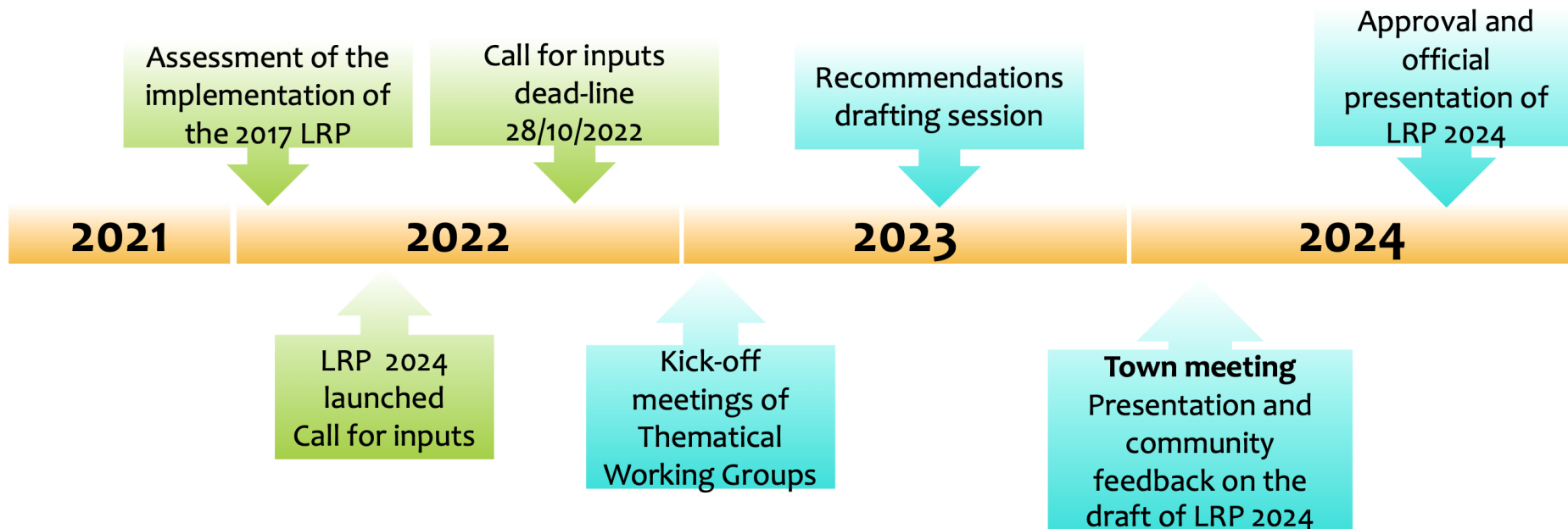
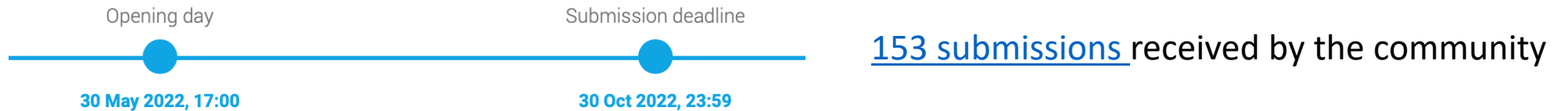
<https://www.nupecc.org/?display=lrp2024/main>



[Announcement](#) May 2020

Steering Committee (mix of funding agencies rep., NuPECC members, lab directors)

Call for inputs



➤ 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

Credits: [C. Munoz Camacho](#) at 12th July ePIC General Meeting

Hadron Physics → where EIC and ePIC are in NuPECC LRP

Research infrastructure → the conundrum/battle of non-European research infrastructure

Nuclear Physics Tools → emphasize synergies on R&D for detectors/sensors (along the lines of ECFA Detector R&D roadmap)

What is inside the draft plan? (I)

Executive Summary

<https://indico.ph.tum.de/event/7598/timetable/?view=nicecompact>

- 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
- Main 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 Benefit
 - 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

Bucharest LRP24 Town Meeting 15-17 April

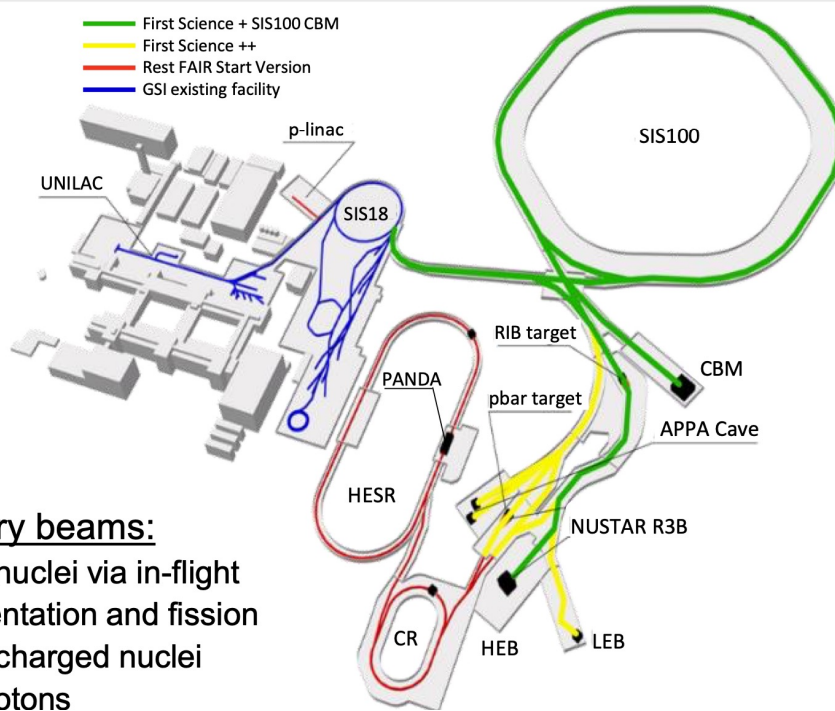


Credits: [D. Bettoni](#) at 6-7 May EC RRB

What is inside the plan ? (II)

Plenty of nuclear physics infrastructure in Europe!

FAIR Accelerator facilities



Secondary beams:

- exotic nuclei via in-flight fragmentation and fission
- highly charged nuclei
- anti-protons

SIS100 primary beams:

- $10^9/s$ Au up 11 GeV/u
- $10^9/s$ C, Ca, ... upto 14 GeV/u
- $10^{11}/s$ p up to 29 GeV/u

Timeline

- 2018 start of FAIR Phase-0 at upgraded GSI facilities
- 2023 concrete construction completed
- 2024 start of accelerator installation
- 2027 first experiments with SIS18 beam
- 2028 start of operation with SIS100

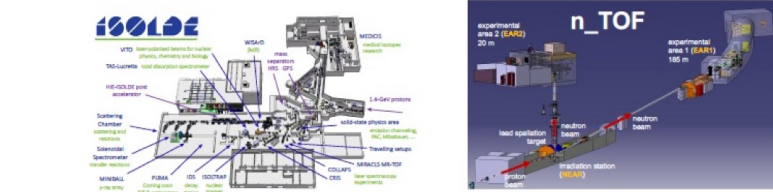
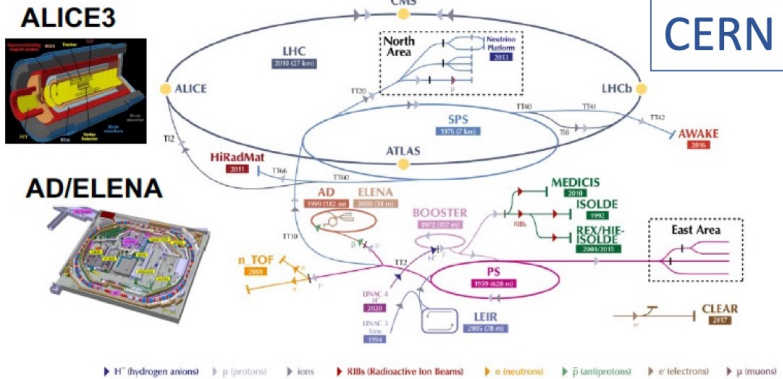
GSI facilities continue operation

p-p program in "limbo"
PANDA after CBN

[Y. Leifels](#) @QNP2024

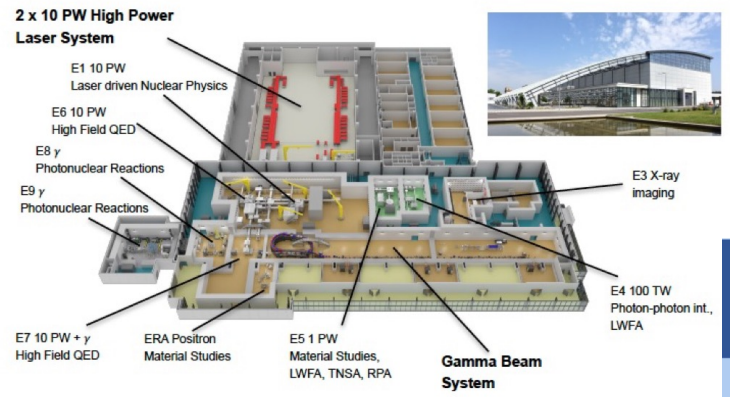


What is inside the plan ? (III)



Romania

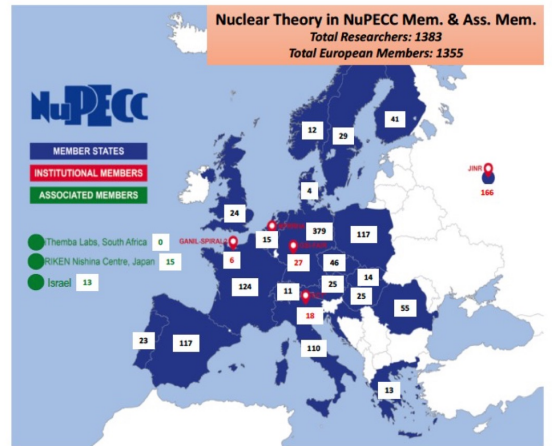
ELI-NP



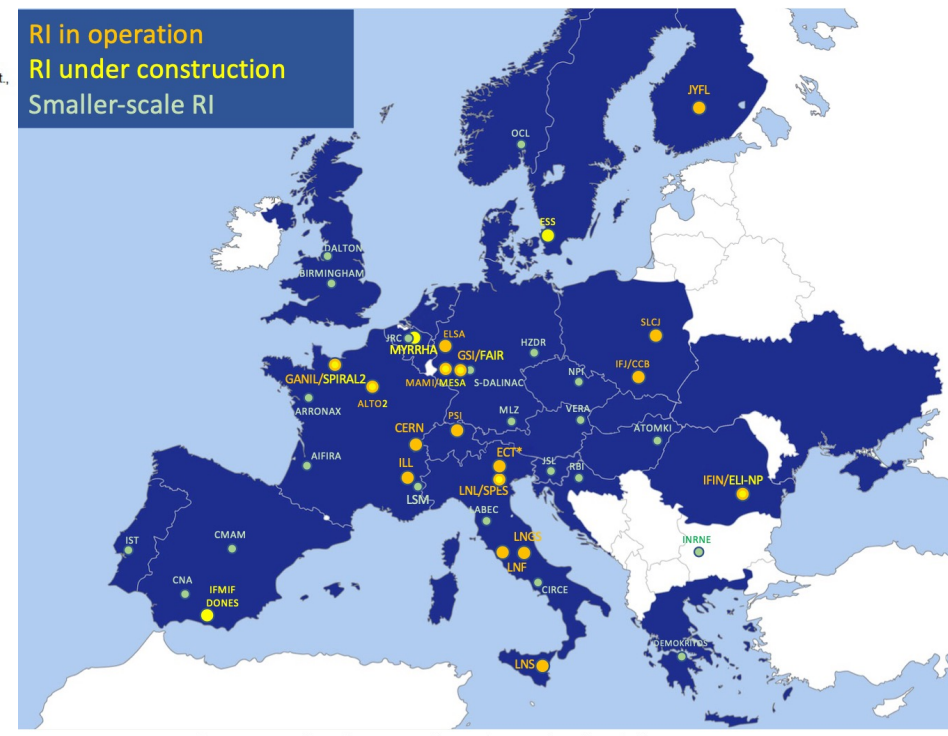
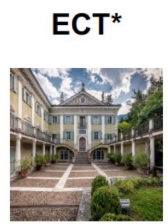
- Many other small-medium scale research infrastructures (see D. Bettoni presentation for a full list.. and many pictures)
- ECT* is an "open space" → EIC

GANIL/SPIRAL2

France

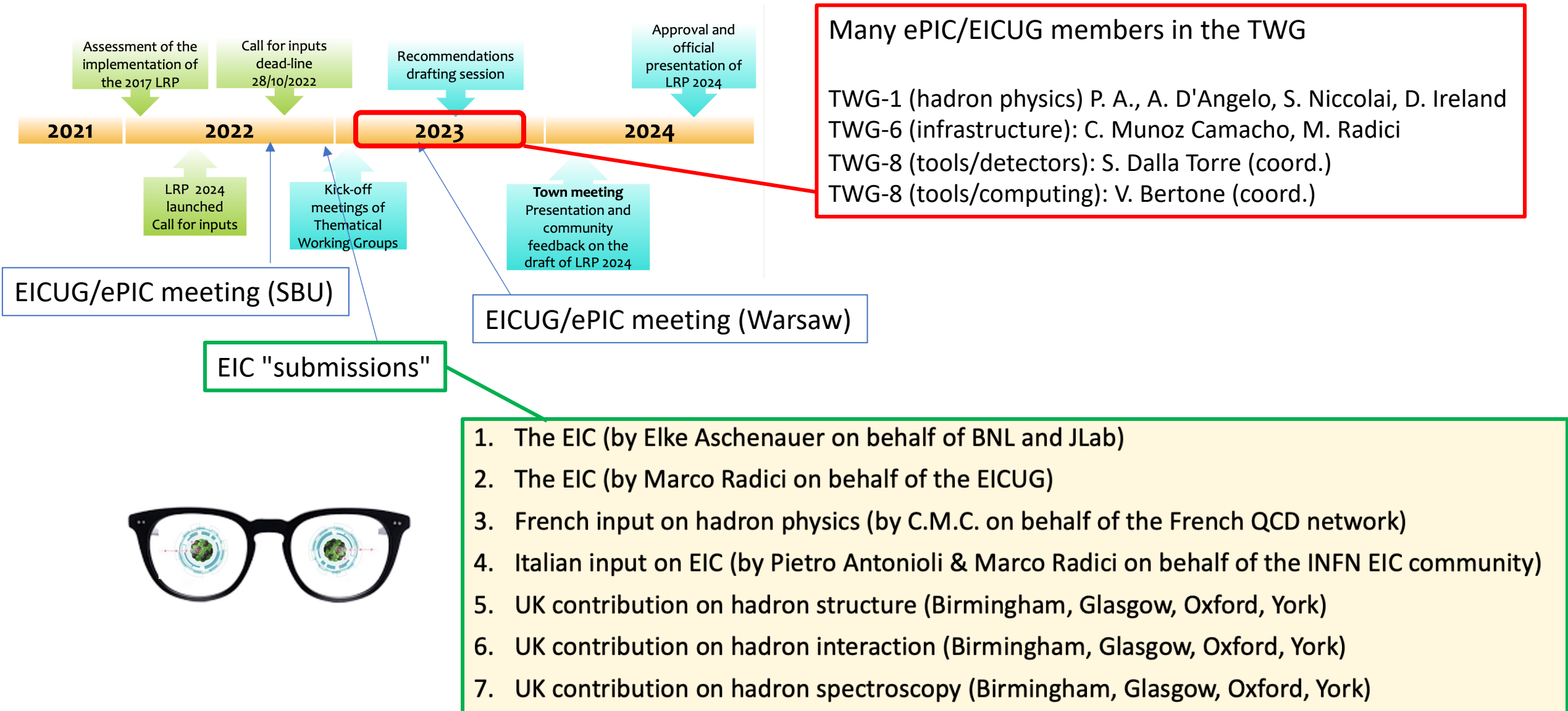


THEORY



European landscape of nuclear physics infrastructures.

An EIC perspective: engagement in the process



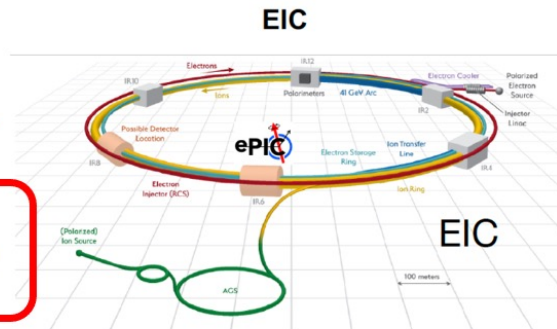
Key recommendations EIC related

NuPECC Long Range Plan (to be issued in 2024)

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 ePIC at the future international flagship facility EIC is recommended.



[note: this slide is taken by my presentation "selling ePIC "to INFN NP committee last June]



"First time to my knowledge a non-European infrastructure is recommended at this level in the NuPECC Long Range Plan"

D. Bettoni at EIC RRB, May 2024

Recommendations for Hadron Physics



• 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. In a ten-year perspective, these two next-generation experiments must be made ready to launch.

- PANDA: The physics program, including the prospect of unravelling exotic matter, remains unique and compelling. PANDA will strengthen the European position on the global scene and act as a unifying force for the community. Therefore, we recommend support for its construction and for the development of instrumentation, software and analysis tools.
- ePIC: Here, European researchers will be able to explore unknown features of quarks and gluons inside nucleons and nuclei. We recommend supporting the participation of European groups in ePIC and reinforcing scientific and technological activities which synergize with European projects.

More on hadron physics

- Introduction
- Hadron Spectroscopy
- Hadron Structure
- Hadron Interactions
- Hadronic effects in precision physics and rare processes

European experimental facilities

CERN [AMBER/LHCb/ALICE), ELSA, MAMI, MESA, HADES, PANDA@FAIR

Global perspectives

BelleII@SuperKEK, BESIII@BEPC-II, GlueX@JLab, CLAS12@JLab, **ePIC@EIC**

"Boxes" [Highlights] on:

- Proton radius
- The Λ hyperon decay parameter
- Hadronic contributions to the muon $g-2$
- Lattice QCD
- Effective field theories

Hadron Physics

Coordinators: Constantia Alexandrou and Karin Schönning

Working group members: Luis Alvarez-Ruso, Pietro Antonioli, Gilberto Colangelo, Annalisa D'Angelo, Luigi del Debbio, Achim Denig, Gernot Eichmann, Jeremy Green, Bernhard Ketzer, Jan Matousek, Silvia Niccolai, Elena Perez del Rio, Catarina Quintans, Marc Vanderhaeghen.

NuPECC liaisons: Dave Ireland, Diego Bettoni

16 times EIC occurrences, ePIC 5 times

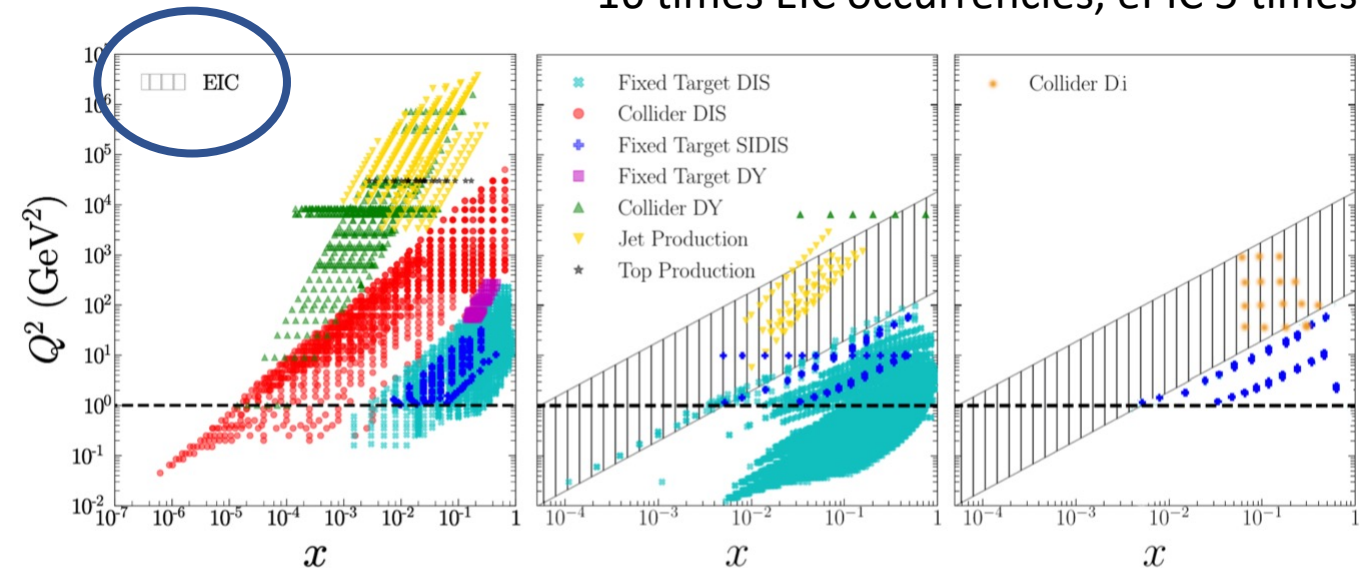


Fig. 7: The kinematic coverage in the (x, Q^2) plane of the hadronic cross-section data for the processes commonly included in global QCD analyses of collinear unpolarized, helicity, and transversity PDFs [Based on arXiv: [2006.08636](https://arxiv.org/abs/2006.08636) [hep-ph] using the arXiv distribution license; published in PPNP 121 (2021) 103908]. The extended kinematic ranges attained by the EIC are also displayed.

More on hadron physics (II)

Hadron Physics

The goal of hadron physics is to understand the rich and complex features of the strong interaction. 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? Answering these questions requires a diverse set of experimental and theoretical approaches. At present, European hadron physicists conduct experiments at facilities within and outside Europe, with great success. These facilities, their planned upgrades, and the approved flagships PANDA at FAIR, Germany and ePIC at EIC, USA, open new avenues for ground-breaking discoveries.

1

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

2

Furthermore, we recommend the support of ongoing hadron physics activities at the multi-purpose facilities Belle II, BESIII and the LHC.

Future flagships: 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. In a ten-year perspective, these two next-generation experiments must be made ready to launch.

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- **PANDA:** The physics program, including the prospect of unravelling exotic matter, remains unique and compelling. PANDA will strengthen the European position on the global scene and act as a unifying force for the community. Therefore, we recommend support for its construction and for the development of instrumentation, software and analysis tools.
- **ePIC:** Here, European researchers will be able to explore unknown features of quarks and gluons inside nucleons and nuclei. We recommend supporting the participation of European groups in ePIC and reinforcing scientific and technological activities which synergize with European projects.

Sustain running experiments (JLab included)

Indicate **two superpriorities on equal foot:**



Theory / Computing:

4

- Theorists play an essential role not only in interpreting hadronic physics experiments but also in providing input and predictions for new experiments, particularly in the challenging transition between quark/gluon and hadronic degrees of freedom. Support for theoretical groups in terms of positions and career prospects is thus essential for progress in hadron physics.
- To match experimental progress, sophisticated approaches need to be developed. In lattice QCD, the rapid evolution of computational techniques and hardware calls for new algorithms and software. We recommend the support of theory groups at universities and research centres to prepare the community to benefit from the European investment in supercomputing and quantum computing.

An EIC perspective: where we were two years ago? what next?



[Frank Sabatié](#) @ EICUG meeting 2022

NuPECC - European Nuclear Long Range Plan Process

Wang Center, CFNS Stony Brook University

Franck Sabatié



09:00 - 09:25

Electron-Ion Collider User Group Meeting - 2022
CFNS, Stony Brook University, July 26 - 29, 2022



NuPECC The Physics of Hadrons

- How is mass generated in QCD and what are the static and dynamical properties of hadrons?
- How does the strong force emerge from the underlying quark-gluon structure of nucleons?



High resolution experiments with antiprotons (PANDA) at FAIR to test QCD in detail

European contribution to the EIC project in US

-> NuPECC EIC Task Force
D. Ireland, E. Nappi, FS

EoI 6 - Synergies between EIC and LHC experiments

kick off workshop June 20-21, 2022

Main NuPECC LRP 2017 priority for this topic:

The antiproton programme at the FAIR/PANDA facility combined with programmes with polarised protons in Dubna (NICA) and those with lepton and hadron beams at existing facilities (MAMI, Bonn, INFN-Frascati).

We had two years of work, sometimes visible sometimes not, but pretty **successfull!** Let's celebrate success

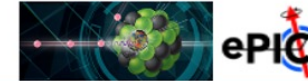
The meeting about synergies between EIC and LHC was ok in 2022, "sub-optimal" in 2023

Haviing EIC well placed in next ESPP is the new challenge now!

Highlight from 2023: EIC School!



Our best investment for the future



- IAC decided to have it every second year
- Establish a system of EICschools (CFSN, Europe, Asia...)

- nice mix of experimental and theoretical communities
- 28 participants: 2 from India (+1), 1 from Poland, 1 from Germany, 3 "from fisica applicata + chemistry", **the rest (22) from INFN** at large (participants: 33%F – 67%M, lecturers: 40%F – 60%M, organizers: 45%F – 55%M) – 3 undergraduates
- excellent synergies among Universities and groups, good sponsorships, a superthank to Abhay and CFNS



June 22, 2025 – July 2, 2025

Venue: Albergue juvenil Argentina of Benicàssim, Benicàssim (Castellón), **Spain**
(Valencia region)

LOC contacts: Charlotte Van Hulse – Francesco G. Celiberto (Univ. Alcalà de Henares – Madrid)

Residential school: lodging, meals, lectures are all provided at the Albergu juvenil Argentina

Organizing Committee

- Francesco Giovanni Celiberto (UAH Madrid)
- Clara Peset Martín (UCM Madrid)
- Ignazio Scimemi (UCM Madrid)
- Charlotte Van Hulse (UAH Madrid)
- Alexey Vladimirov (UCM Madrid)
- Pia Zurita (UCM Madrid)



2nd European School on the Physics of the EIC and Related Topics

22 June 2025 to 2 July 2025

Europe/Madrid timezone

Overview

Committees

Participant List

The Second European School on the Physics of the EIC and Related Topics will take place at the Albergue juvenil Argentina of Benicàssim, located right at the beach, in the small town of Benicàssim (Castellón), Spain. Lodging, lectures and meals are all provided at the Albergue juvenil Argentina. The foreseen arrival date for the participants is June 22, 2025 and the departure date is July 2, 2025. Lectures will take place from 23rd of June until 1st of July, with an excursion day on Sunday, June 29.



Starts 22 Jun 2025, 09:00

Ends 2 Jul 2025, 18:00

Europe/Madrid



Francesco Giovanni Celiberto

Clara Peset Martin

Ignazio Scimemi

Alexey Vladimirov

Charlotte Van Hulse

Pia Zurita

Web page:

<https://indico.fis.ucm.es/event/30/>

(follow updates here!)

Foreseen opening date of registration: **January 30, 2025**

My final two cents...



- It was professionally enriching to be part of the NUPECC LRP process
- NuPECC LRP represents the "wishes of the community", sorry it is not a plan
- It is representational, but it is really strategic?
- Too much mediation to make everyone happy: negotiation of "my bits" is priority
- Compromise in hadron physics recommendation was reasonably ok
- European "fragmentation" doesn't help, really complex environment
- NSAC LRP is a different animal, I'm told, but...

Do we want a snapshot or a path?



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Science is not political, funding of science is

And some links



Input Contributions

<https://indico.ph.tum.de/event/7050/contributions/>

Bucharest LRP2024 Town Meeting

<https://indico.ph.tum.de/event/7593/>

Executive Summary LRP2024:

https://www.nupecc.org/lrp2024/Draft_Executive_Summary_LRP2024.pdf

Full draft LRP2024 available here:

https://indico.ph.tum.de/event/7629/contributions/8953/attachments/6020/8072/Full_LRP2024_Report_03042024_clean.pdf