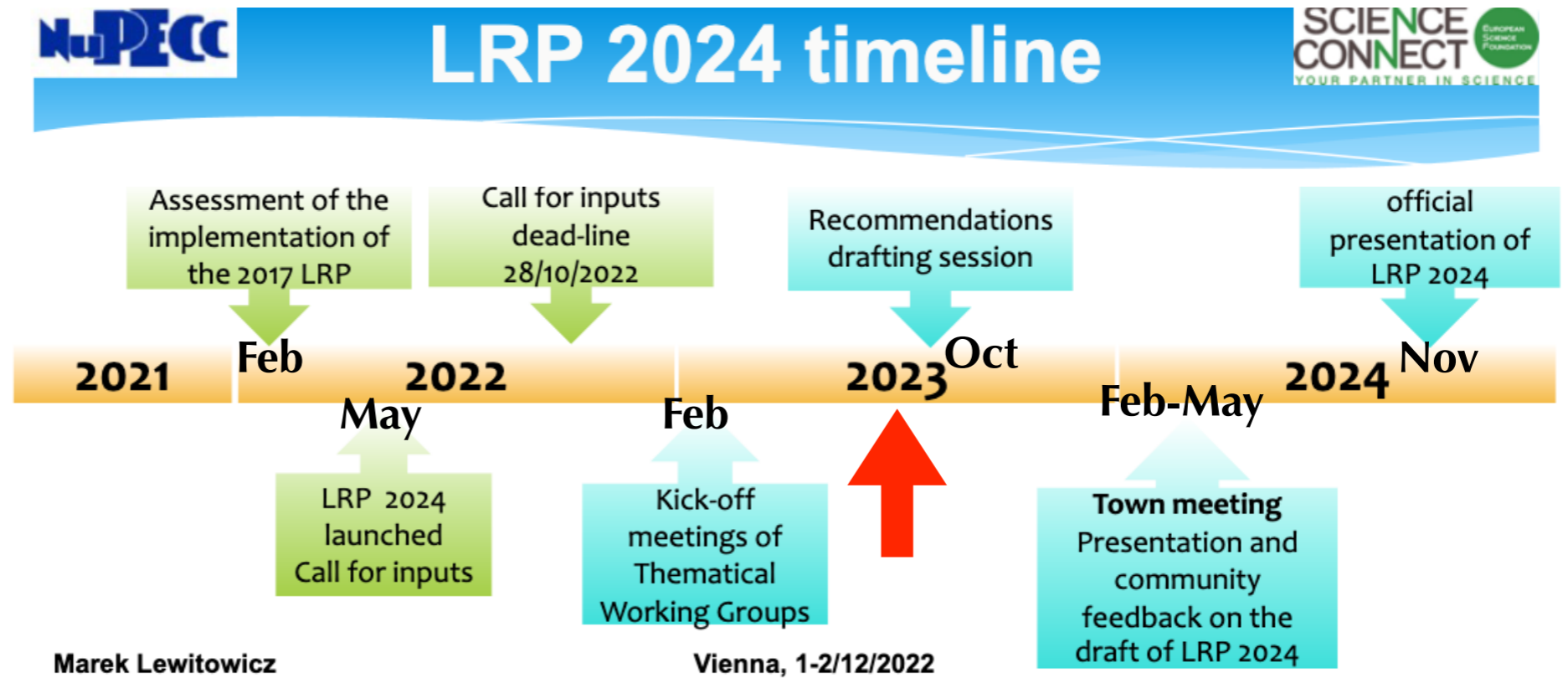


# NuPECC LRP 2024

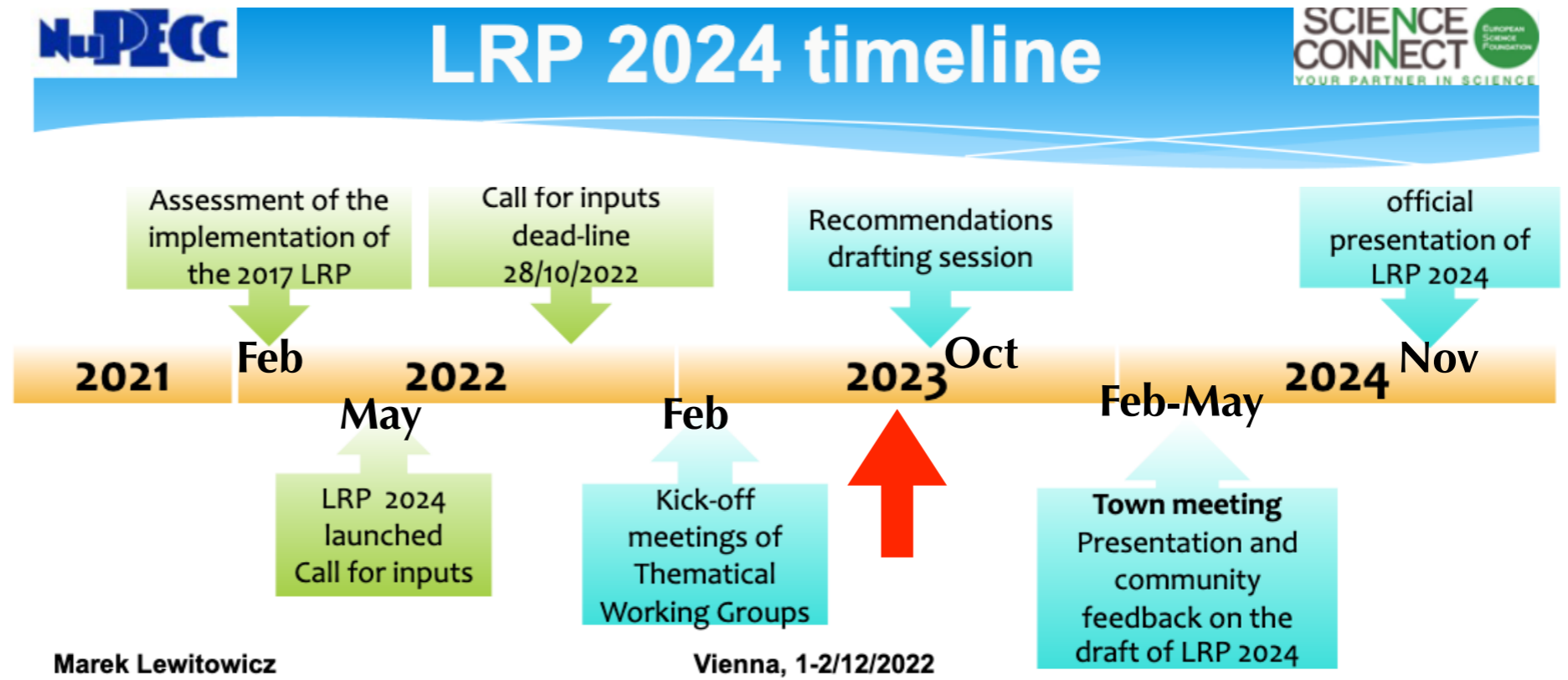
M. Radici    INFN-Pavia  
P. Antonioli    INFN-Bologna  
S. Dalla Torre    INFN-Trieste



# Timeline



# Timeline



153 total inputs,  
3 inputs directly related to EIC

**n.64** - The Electron Ion Collider - Exploring the mysteries of the building blocks of matter  
BNL & JLab contact: E. Aschenauer

**n.135** - The Electron Ion Collider: A U.S. facility for the European community to explore the mysteries of the building blocks of matter  
EICUG contact: M. Radici, S. Dalla Torre, D. Sokhan

**n.143** - Input of the INFN community involved in the EIC to the NuPECC LRP 2024  
INFN contact: P. Antonioli, M. Radici

**n.67** - French input on Hadron Physics contact: C. Muñoz Camacho

# Thematically Working Groups

**TWG-1 Hadron Physics** coordinators  
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C. Alexandrou (Cyprus Univ.)  
K. Schönning (Uppsala Univ.)

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C. Diget (York)



# TWG-6 Infrastructures

## The team

Coordinator:

- [Wolfram Korten](#) (CEA, Saclay)

NuPECC Liaisons:

- [Joaquin Gomez Camacho](#)
- [Patricia Roussel-Chomaz](#)

**24** members

inputs on **29** Research Infrastructures (RIs)  
+ small-scale facilities

Since March,  
**2** open kick-off meetings  
+ **5** internal meetings

Members:

- Navin Alahari, GANIL, France
- Angela Bracco, INFN & Univ. Milano, Italy
- Francesca Cavanna, INFN Torino, Italy
- Letitia Cunqueiro, Univ. Roma, Italy
- Bogdan Fornal, IFJ-PAN Krakow, Poland
- Sean Freeman, ISOLDE & Univ. Manchester, CERN/UK
- Zsolt Fülöp, ATOMKI Debrecen, Hungary
- Tetyana Galatyuk, GSI & TU Darmstadt, Germany
- Frank Gunsing, IRFU CEA Saclay, France
- Alexander Philipp Kalweit, CERN
- Ari Jokinen, JYFL Jyväskylä, Finland
- Andreas Knecht, PSI Villigen, Switzerland
- Ulli Koester, ILL Grenoble, France
- Razvan Lica, IFIN-HH Bucharest, Romania
- Frank Maas, HI Mainz, Germany
- Carlos Munoz Camacho, IJCLab Orsay, France
- Catarina Quintans, LIPP Lisboa, Portugal
- Marco Radici, INFN Pavia, Italy
- Berta Rubio, IFIC Valencia, Spain
- Konrad Schmidt, HZDR Dresden, Germany
- Paul Schuurmans, SCK-CEN & Univ. Hasselt, Belgium
- Nathal Severijns, KU Leuven, Belgium
- Thomas Stöhlker, HI Jena & GSI/FAIR, Germany

# TWG-6 Infrastructures

- Chapter organized in sections according to the beam type provided by the RI:

Lepton and photon facilities  
Hadron and Ion facilities

Neutron facilities  
Small-scale facilities

**International facilities**  
(EIC, JLab,..)

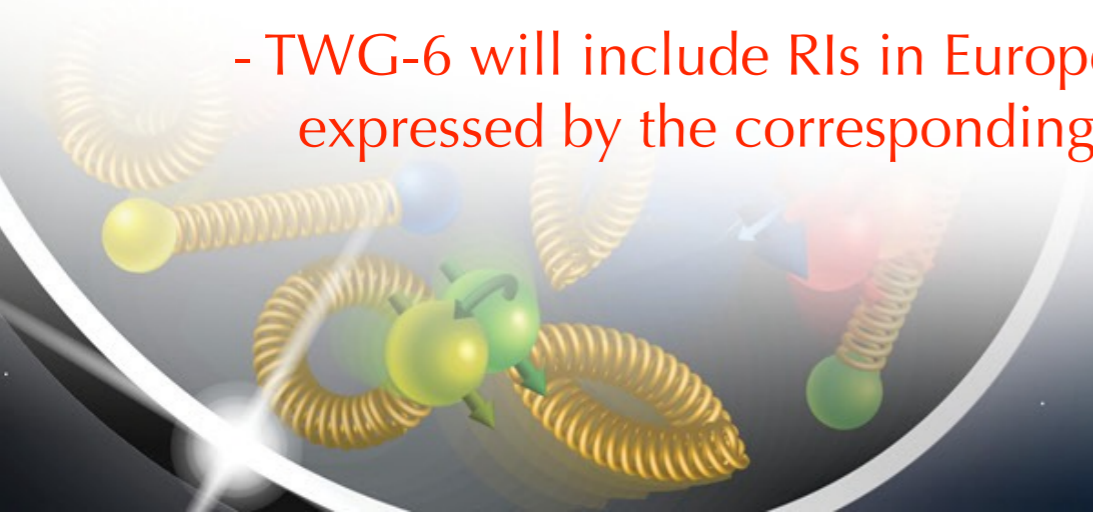
- Each section should have: short introduction summarizing common features and complementarities;  
table summarizing properties;  
positioning in international context;  
scientific mission and research program;  
recent achievements (if any);  
future plans

- General recommendations are under discussion, but agreement on the following:

- TWG-6 will concentrate on RIs and not describe detectors and experimental techniques (interactions and meeting with TWG-8)

- TWG-6 will include RIs in Europe and certain international RIs if there is a strong interest expressed by the corresponding scientific TWG (for EIC, it is TWG-1)

(deliberately excluded in LRP 2017!)







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M.G. Borge (Madrid)  
C. Diget (York)



# TWG-1 Hadron Physics

## Coordinators:

- [Karin Schönning](#) (Uppsala University)
- [Constantia Alexandrou](#) (University of Cyprus)

## NuPECC Liaisons:

- [Diego Bettoni](#) (INFN Ferrara)
- [Dave Ireland](#) (University of Glasgow)

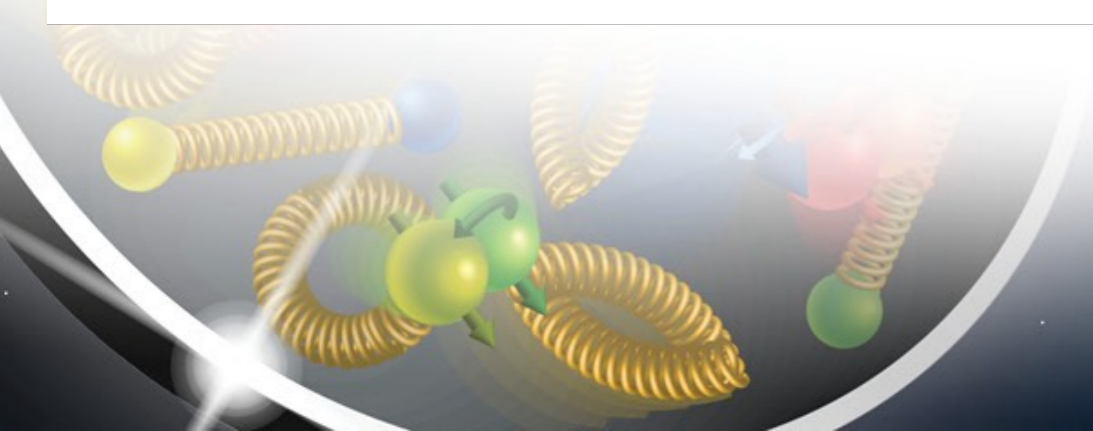
one of the most "EIC-relevant" TWG!

## The team

## Members:

- Luis Alvarez-Ruso, Valencia, Spain
- Pietro Antonioli, Bologna, Italy
- Gilberto Colangelo, Bern, Switzerland
- Annalisa D'Angelo, Rome Tor Vergata, Italy
- Luigi Del Debbio, Edinburgh, UK
- Achim Denig, JGU Mainz, Germany
- Gernot Eichmann, Graz, Austria
- Jeremy Green, DESY, Germany
- Bernhard Ketzer, Bonn, Germany
- Jan Matousek, Charles Univ. Prague, Czech Republic
- Silvia Nicolai, Orsay, France
- Elena Perez del Rio, Jagiellonian Univ., Poland
- Caterina Quintans, Lisbon, Portugal
- Marc Vanderhaeghen, Mainz, Germany

- As usual a good mix of theoreticians and experimentalists
- "Low"/"High" energy communities represented
- EIC/JLab communities well represented



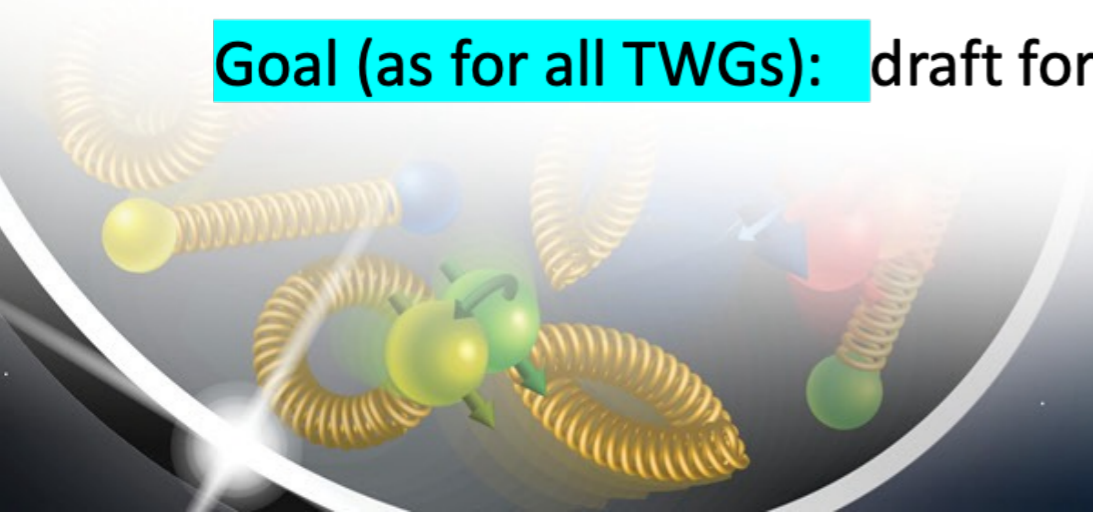
# TWG-1 Hadron Physics

## Activity:

- 3 "plenary" meetings (Zoom) of the full WG (since April) discussing structure of the document/consolidating it
- Between May and June we worked as sub-WG developing the different parts of the document (sub-sections of hadron physics chapter)
- The work is progressing with the help of a shared document in GoogleDoc. Advanced draft (with no recommendations yet)

The TWG will meet in Paris 28-29 August to finalize the document and discuss recommendations

**Goal (as for all TWGs):** draft for mid September for conveners' meeting



# TWG-1 Hadron Physics

(intermezzo) Back to LRP2017-2023....

The Hadron Physics chapter 6 years ago

Introduction

Theoretical framework

Experimental Methods

Hadron Spectroscopy

Hadron Structure

Hadron Interactions

Lattice QCD

Physics perspectives (facilities) + Recommendations

**Plus highlight boxes:** Lattice/HPC, Effective field theories, Meson form factors, Functional methods, Hypernuclei

Each of these sub-chapters with structure:

- (short introduction)
- Recent achievements and Hot Topics
- Future prospects

All what we had about EIC in NuPECC LRP in 2017 in Hadron Physics [ in Hadron Structure sub-chapter (inside "Future Prospects") ]

The large communities working on hadron structure both in Europe and the US are working towards and eagerly waiting for the approval of the first polarised Electron-Ion Collider (EIC). This machine will enable precision measurements over a largely extended kinematic phase-space with light polarised and heavy unpolarised ions. The EIC will be capable of accessing the gluon content of the proton and make significant progress on the knowledge of the proton spin content, TMDs and GPDs. It may also advance our understanding of the non-perturbative structure of the strong interaction by discovering evidence for the mixed quark-gluon condensate.

# TWG-1 Hadron Physics

The structure of the document,  
which will become a chapter of the NuPECC LRP2024

1 Introduction

no separate part for theory + no facilities (discussed before)

2 Hadron spectroscopy

*EIC mentioned within the context of exotic states photoproduction*

3 Hadron structure

*highlights cover EM form factors, polarisabilities, proton gluonic radius, PDF (+ spin structure and gluon saturation), GPD, TMD). EIC in the context of next steps and future for many of these topics*

4 Hadron interactions

5 Precision measurements

6 Recommendations

still to be discussed. JLaB/EIC "synergy" here

**Plus boxes:** on LatticeQCD / EFT / proton radius + ...

**Each sub-chapter** with this sub-structure:

- Introduction
- Recent achievements and highlights ( → what happened in LRP 2017-2023)
- Next steps and future ( → what will happen in LRP 2024-2030 **and beyond**)

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# TWG-8 Nuclear Physics Tools

## TWG-8 Nuclear Physics Tools

- Detectors and Experimental Techniques
- Computing, Machine Learning and Artificial Intelligence

### The team

**Convener:**

Silvia Dalla Torre (INFN, Sezione di Trieste, Trieste, Italy)

**NuPECC Liaison:**

Eugenio Nappi (INFN, Sezione di Bari, Bari, Italy)

**WG members:**

Dieter Ackermann (GANIL, Caen, France)

Andrew Boston (University of Liverpool, Liverpool, UK)

Paolo Finocchiaro (INFN, Laboratori Nazionali del Sud, Catania, Italy)

Piotr Gasik (GSI, Darmstadt, Germany)

Paola Gianotti (INFN, Laboratori Nazionali di Frascati, Frascati, Italy)

Andrea Gottardo (INFN, Laboratori Nazionali di Legnaro, Legnaro, Italy)

Fritz-Herbert Heinsius (Ruhr University, Bochum, Germany)

Silvia Masciocchi (Heidelberg University, Heidelberg, Germany)

Thomas Peitzmann (Utrecht university, Utrecht, Netherlands)

Tina Pollmann (University of Amsterdam, Amsterdam, Netherlands)

Veronique Puill (IN2P3, IJCLab, Orsay, France)

Joachim Schwiening (GSI, Darmstadt, Germany)

Maria Dorothea Schumann (PSI, Villingen, Switzerland)

Monica Sisti (INFN, Sezione di Milano Bicocca, Milano, Italy)

Joachim Stroth (Goethe University, Frankfurt, Germany)

José Javier Valiente Dobón (INFN, Laboratori Nazionali di Legnaro, Legnaro, Italy)

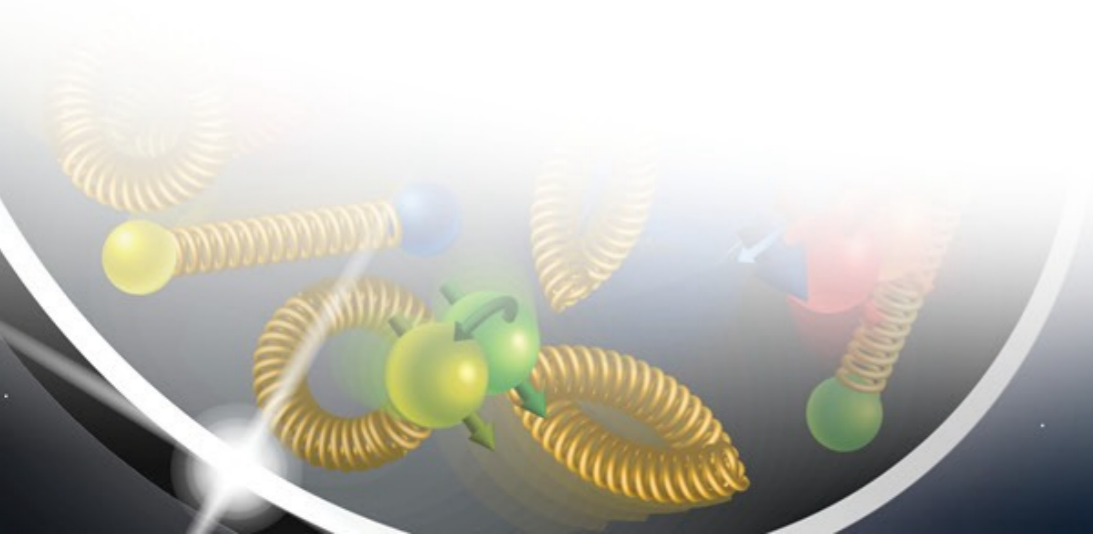
# TWG-8 Nuclear Physics Tools

## Activity:

- 3 meetings, the kick-off one in presence (LNF - Frascati, April 17)
- The work is progressing with the help of a shared document in overleaf

## Goal:

- A draft for mid September





# TWG-8 Nuclear Physics Tools

The structure of the document,  
which will become a chapter of the NuPECC LRP2024

Sections 2, 3 and 4  
Dedicated to methods

## 1 Introduction

## 2 Experimental methods at the major coming/upgrading experiments/facilities - Low Energy Nuclear Physics

- 2.1 High granularity  $\gamma$ -ray detectors
- 2.2 High granularity particle and ions detectors
- 2.3 Neutron production and detection
- 2.4 Separators/spectrometers
- 2.5 Radioactive ion–electron colliders

## 3 Experimental methods at the major coming/upgrading experiments/facilities - High Energy Nuclear Physics

- 3.1 High energy HI Collisions
- 3.2 Hadron Physics at the energy and intensity frontier

## 4 Experimental methods at the major coming/upgrading experiments/facilities - Fundamental Physics

- 4.1 Test of fundamental physics

# TWG-8 Nuclear Physics Tools

The structure of the document,  
which will become a chapter of the NuPECC LRP2024, cont.

## 5 Technological tools and related R&D - Low Energy Nuclear Physics

- 5.1 Neutron detectors
- 5.2 Developments for highly segmented Si detectors
- 5.3 high counting rate focal plane detectors
- 5.4 Active targets
- 5.5 Superconducting storage ring for reaction recoil detection
- 5.6 p-type highly segmented Ge detectors
- 5.7 traps for exotic nuclei

Sections 5,6,7 and 8  
dedicated to technologies and  
related R&D

## 6 Technological tools and related R&D - Sample and target supply

- 6.1 Production and availability of enriched stable isotopes

## 7 Technological tools and related R&D - High Energy Nuclear Physics

- 7.1 Gaseous detectors
- 7.2 Silicon detectors
- 7.3 Photon detectors
- 7.4 Calorimeters
- 7.5 Data acquisition
- 7.6 Targets (polarized targets, jet targets)

## 8 Technological tools and related R&D - Fundamental Physics

- 8.1 Neutrinos and dark matter

## 9 Summary