

EIC from NuPECC perspective



*EICUG 2021, on-line
 August 2nd, 2021*



Marek Lewitowicz
Chair of NuPECC

Terms of Reference

<http://www.nupecc.org>

NuPECC is an Expert Committee hosted by European Science Foundation (ESF).
The Committee membership is formed from European institutions and research facilities involved in nuclear science. The Committee may appoint Associated Members and Observers.

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.

The European Expert Board for Nuclear Physics hosted by European Science Foundation

Representing
about 6000 scientists

Composition:

- 34 representatives from 21 countries, 3 ESFRI NP Infrastructures, JINR Dubna & ECT*
- 3 associated members (Israel, iThemba Labs and Nishina Center)
- 9 observers (ESF, NPD/EPS, ECFA, NSAC, ANPhA, ALAFNA, CINP, IAEA, APPEC)

3 regular Committee meetings/y

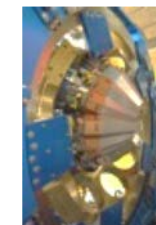
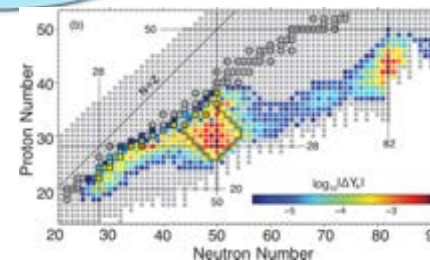
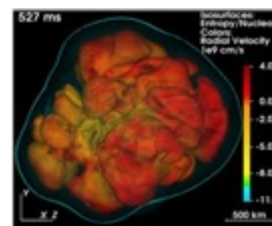
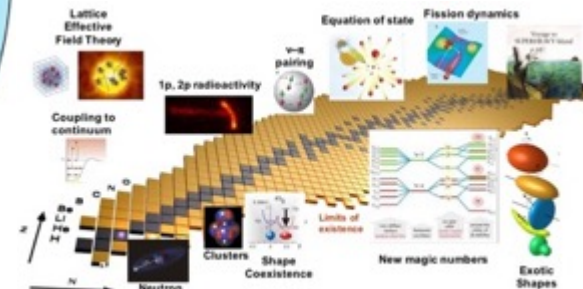
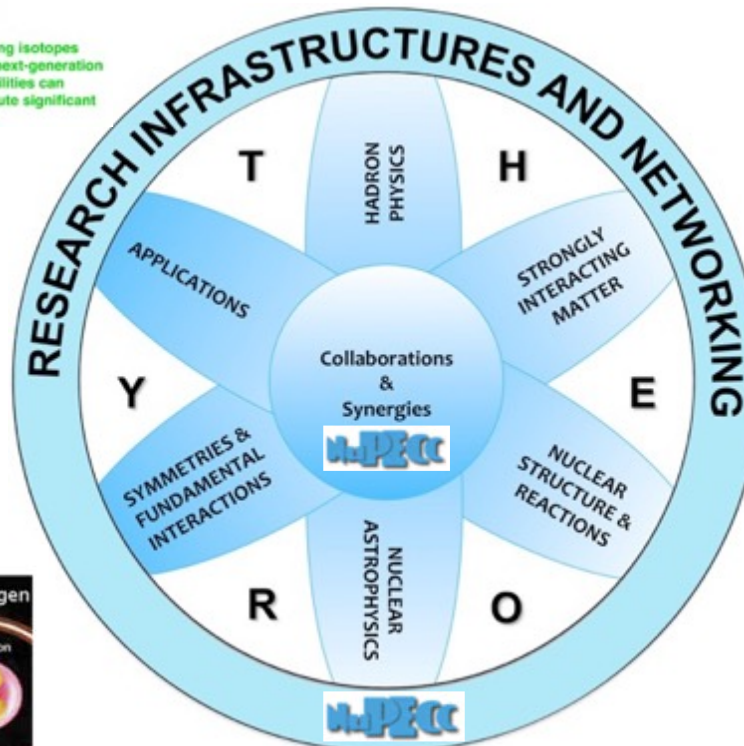
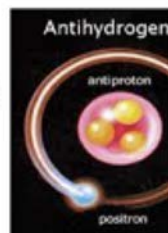
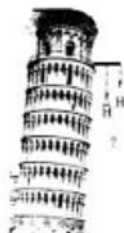
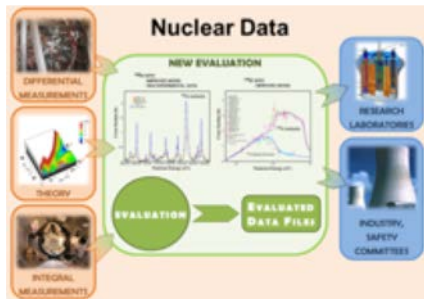
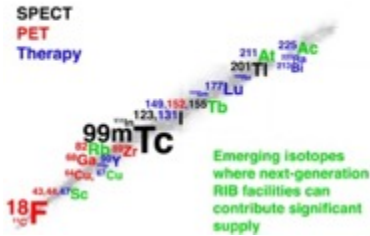
NuPECC meeting number 100 Sept. 17-18, 2021
in Venice, Italy



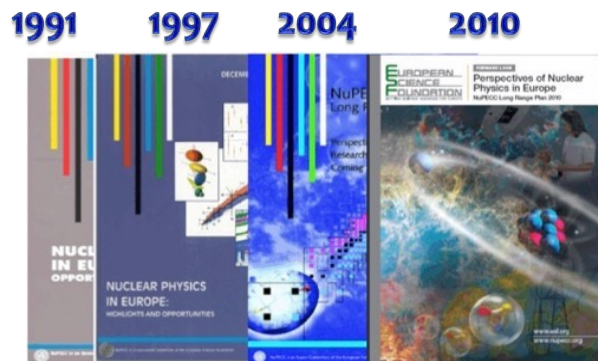
33 Years of NuPECC activities

<http://www.nupecc.org>

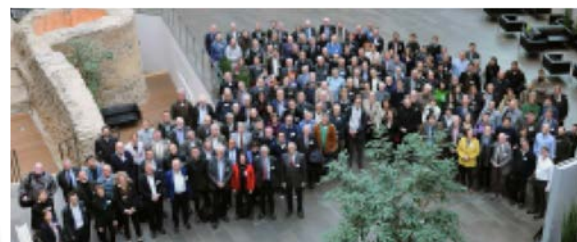
Nuclear medicine perspective



& schedule



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



Town meeting
in Darmstadt
January 2017



Report
June 2017



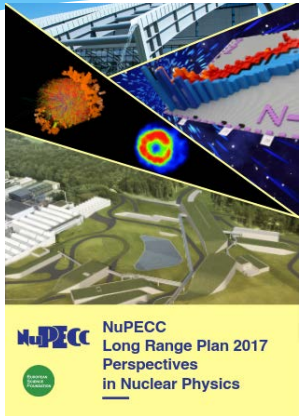
LRP presentation
in Brussels
Nov. 27, 2017

Beginning of
2016



End of 2017

<http://www.nupecc.org/lrp2016/Documents/lrp2017.pdf>



From the NuPECC 2017 LRP :

HADRON PHYSICS:

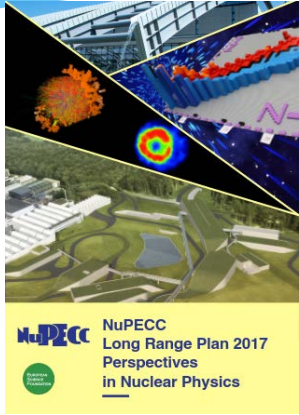
... Therefore, the best short-term option to pin down the Colour Glass Condensate (CGC) is by performing DIS experiments on nuclei at a future **Electron-Ion Collider (EIC)**, a project currently under consideration in the US. ...

... A significant step towards the full tomography of the nucleon will come from the realization of the **EIC** that will greatly extend the coverage in x and Q^2 while significantly increasing at the same time the accuracy of the measurements. ...

... 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....

PROPERTIES OF STRONGLY INTERACTING MATTER AT EXTREME CONDITIONS OF TEMPERATURE AND BARYON NUMBER DENSITY:

... A more comprehensive study of this regime of large nuclear gluon density will be possible at the **Electron-Ion Collider (EIC)** currently planned in the USA, by allowing a direct measurement of nucleonic and nuclear structure functions, and in particular the longitudinal one which is most directly sensitive to the gluon content....



From the NuPECC 2017 LRP :

INTERNATIONAL CONTEXT:

...The European groups working at JLAB and COMPASS provide a very valuable contribution to the R&D for the EIC project which is expected to have a worldwide dimension. **NuPECC highly recognizes the science of the EIC project, presently under study, representing an opportunity for a major step forward in the field of hadron physics....**

LRP Recommendations for Hadron Physics

1. **First recommendation: Completion of the PANDA experiment at FAIR without further delays**
2. **Second recommendation: Support for a research programme in precision physics at existing (European) facilities**
3. **Third recommendation: Support for theory and computing**

Countries that included EIC activities in their input to the EPPSU: France, Italy, UK, Czech Rep. and Germany put it as the "second highest priority of the European hadron physics community" after FAIR facility in Darmstadt.

Strategy statements of the Update of the ESPP



Synergies with neighbouring fields

A variety of research lines at the boundary between particle and nuclear physics require dedicated experiments and facilities. Europe has a vibrant nuclear physics programme at CERN, including the heavy-ion programme, and at other European facilities. In the global context, a new electron-ion collider, EIC, is foreseen in the United States to study the partonic structure of the proton and nuclei, in which there is interest among European researchers. ***Europe should maintain its capability to perform innovative experiments at the boundary between particle and nuclear physics, and CERN should continue to coordinate with NuPECC on topics of mutual interest.***

Deliberation Document of the Update of the ESPP

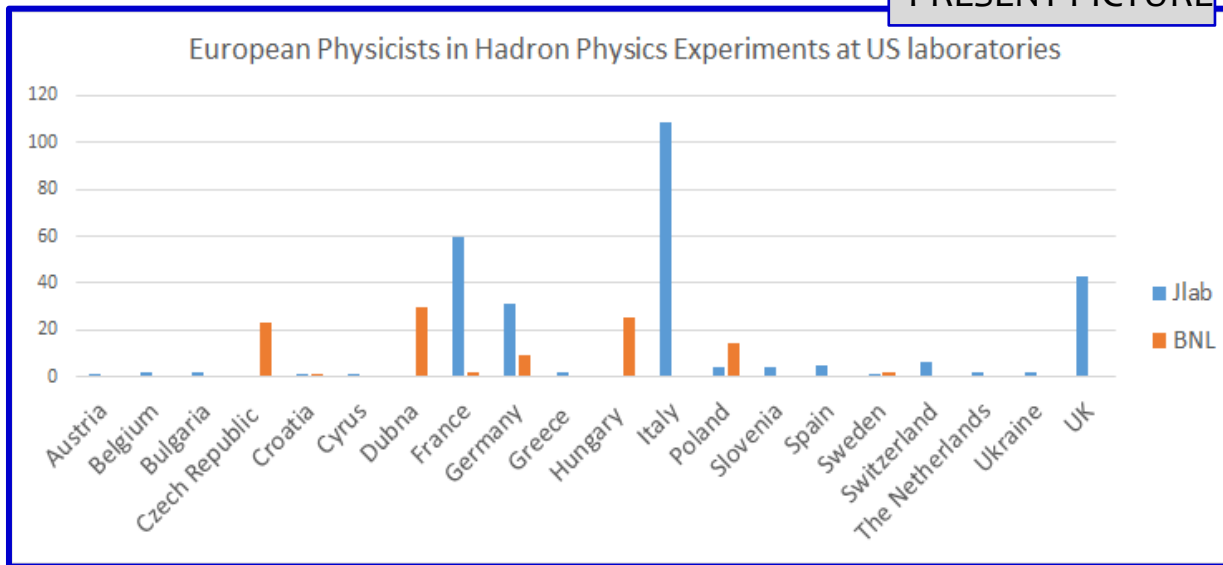
The synergies between particle and nuclear physics are driven by the ambition to achieve first-principle understanding of strong dynamics based on QCD. In addition, they share similar experimental tools. The CERN baseline programme includes not only the ISOLDE and n_TOF facilities but also the heavy-ion programme at the SPS and the LHC. Future European facilities such as FAIR, NICA and ESS envisage research programmes that are of interest to particle physics. **The nuclear physics roadmap in Europe is coordinated by the Nuclear Physics European Collaboration Committee (NuPECC) and there are well established communication lines between the nuclear and the particle physics communities.** NuPECC has expressed strong support for the extension of the heavy-ion programme into the HL-LHC era and beyond, should a high-energy hadron collider be built at CERN in the future. **Electron-proton colliders, such as LHeC or FCC-ep, with the option of including ion-targets, are also of interest to NuPECC, which is preparing a support statement for the participation of Europe in the Electron-Ion Collider in the United States.**

European participation in EIC

TALY

A long going tradition of collaboration btw Europe and USA in Hadron Physics

PRESENT PICTURE



* In total:

~ 380 physicists from Europe

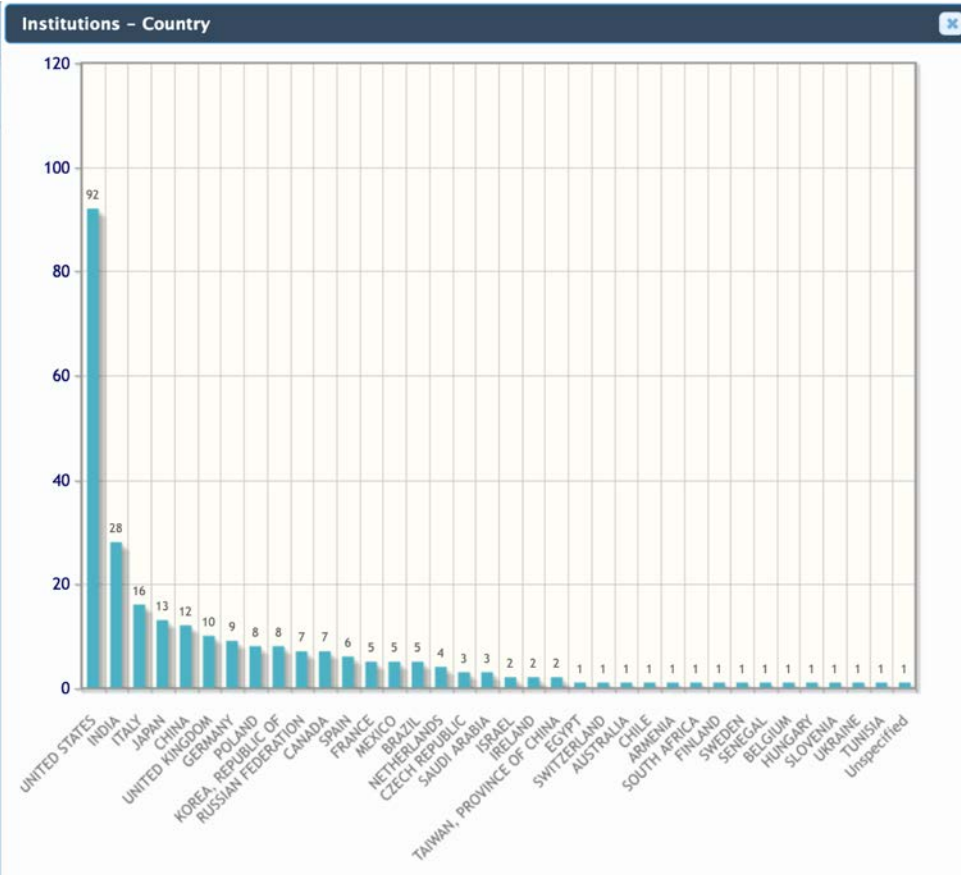
@ Jlab ~ 280

@BNL ~ 100

1,700 US scientists work on LHC experiments

ALICE: 75 US scientists; CMS & ATLAS – HI : ~400 US scientists

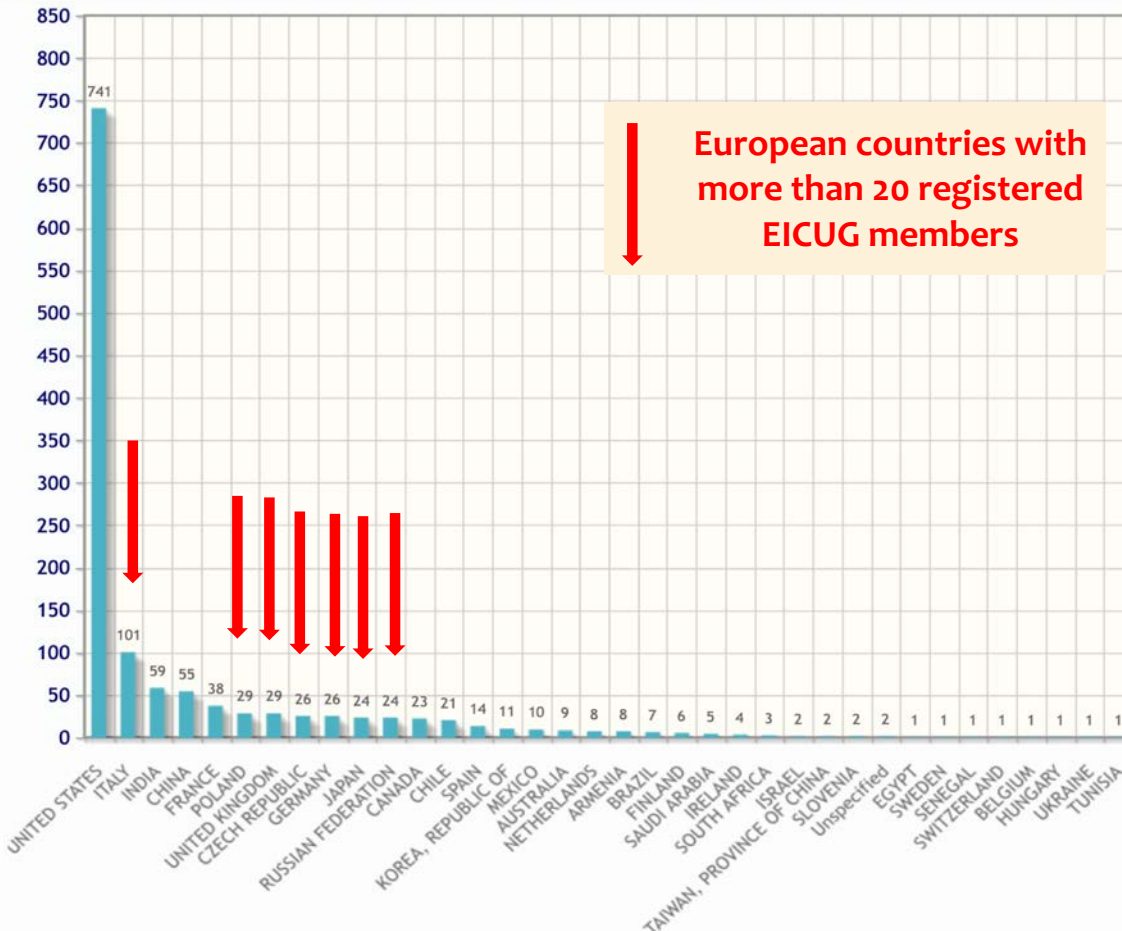
PRESENT PICTURE



EIC User Group (EICUG) has 80 (/262) institutions from Europe (includes Armenia, Israel, Russia)
 The countries with significant experimental involvement are :
 France, Italy, UK, Czech Republic, Poland

PRESENT PICTURE

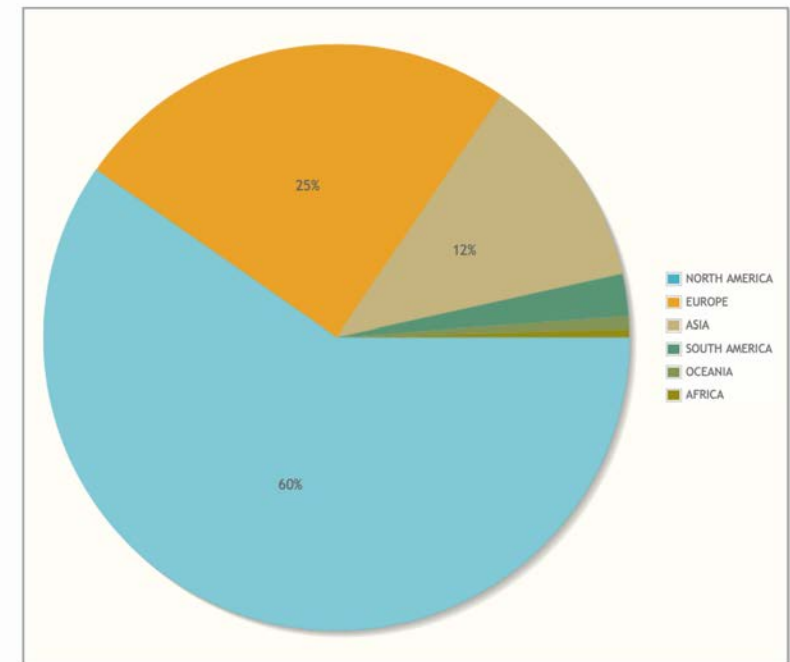
Members – Country



* In total:

322 (/ 1296)
physicists from Europe

Members – Region of the World



A relevant fraction of the total community:
About 25% of EICUG members are from European Institutions

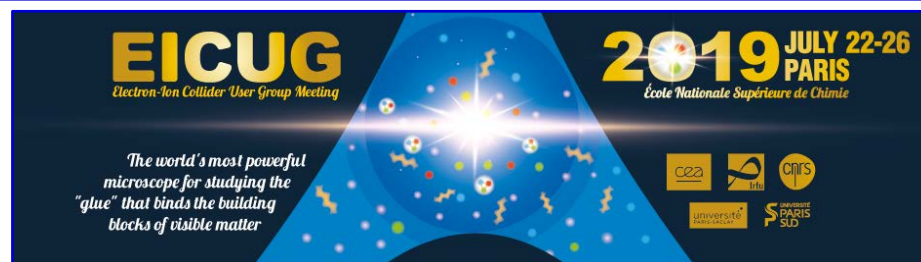
Europeans serving on the EICUG:

PRESENT PICTURE

- * **Institutional Board, Vice Chair:** Andrea Bressan (INFN - Trieste, Italy)
- * **2 members of the Steering Committee:** Daniel Boer (University Groningen, NL), Silvia Dalla Torre (INFN, Italy)

EICUG annual meetings organized in Europe

- 2017: Trieste (Italy), 18-22 July 2017
- 2019: Paris (France), 22-26 July 2019



- * **MCEG for future ep and eA facilities** (<https://indico.cern.ch/event/663878/program>)

- * Regensburg, Germany, 20-22 February 2018

POETIC-8 Satellite Workshop on Monte Carlo Event Generators

- * **The spectroscopy program at EIC and future accelerators** (<https://indico.ectstar.eu/event/29/>)

- * Trento, Italy 19-21 December 2018

ECT The spectroscopy program at EIC and future accelerators

- * **MCEG for future ep and eA facilities** (<https://indico.desy.de/indico/event/22030/>)

- * Desy, Hamburg, Germany, 20-22 February 2019

MCEGs MCEGs for future ep and eA facilities
for future ep and eA facilities
20-22 February 2019
Bldg 3
European Berlin timezone

- * **EIC software meeting** (<https://agenda.infn.it/event/17249/>)

- * Trieste, Italy 20-21 May 2019

EIC EIC Software Meeting
Software Meeting
20-21 May 2019

- * **Meeting of the EIC Streaming Readout consortium** (<https://agenda.infn.it/event/18179/>)

- * Camogli, Italy 22-24 May 2019

Streaming readout IV
22-24 May 2019
Camogli

- * **MCEG for future ep and eA facilities** (<https://indico.cern.ch/event/845653/>)

- * Vienna, 20-22 November 2019

MCEGs for future ep and eA facilities
20-22 November 2019
Erwin Schrödinger Institut, Wien
Europe/Zurich timezone

European physicists & the programme : “Generic R&D for the EIC”

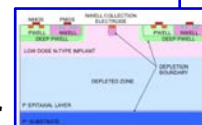
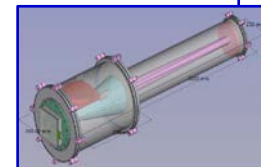
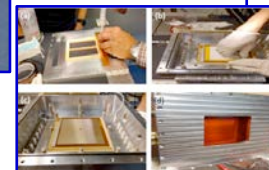
- * Started in 2011
- * Address the requirements for the EIC experiments
- * The program is supported through R&D funds provided to BNL by the DOE Office of Nuclear Physics

11 projects presently on going,
 Europeans collaborate in six of themes:

- eRD1 - EIC Calorimeter Development
 - INFN Genova, Italy; IPN Orsay, France
- eRD6 - Tracking & PID detector R&D towards an EIC detector
 - INFN Trieste, Italy
- eRD14 - PID Consortium for an integrated program for Particle Identification (PID) at a future Electron-Ion Collider
 - INFN Ferrara, Italy; INFN Roma, Italy
- eRD18 - Precision Central Silicon Tracking & Vertexing for the EIC
 - University of Birmingham, UK
- eRD20 - developing Simulation and Analysis Tools for the EIC
 - INFN Trieste, Italy
- eRD23 - Streaming Readout for EIC Detectors
 - INFN Genova, Italy; INFN Roma, Italy



PRESENTLY



STRONG-2020 (Budget 10M€)

The strong interaction at the frontier of knowledge: fundamental research and applications

- 32 Work Packages, 10 related (also) to the EIC
 - **2 virtual access:**
 - VA1-NLOAccess for heavy ions and quarkonia
 - VA2-3DPartons: Virtual Access to 3DPartons
 - **1 networking activity:**
 - NA6-LatticeHadrons: Lattice Hadrons
 - **7 Joint research activities**
 - JRA4-TMD-neXt: 3D structure of the nucleon in momentum space
 - JRA5-GPD-ACT: Generalized Parton Distributions
 - JRA6-next-DIS: Challenges for next generation DIS facilities
 - JRA7-HaSP: Light-and heavy-quark hadron spectroscopy
 - JRA9-TIIMM: Tracking and Ions Identifications with Minimal Material budget
 - JRA13-P3E: Polarized Electrons, Positrons and Polarimetry
 - JRA14-MPGD_HP: Micropattern Gaseous Detectors for Hadron Physics



STATUS:
STARTED
in 2019 for 5 years

AIDAnna (Budget 12.6M€)

Advancement and Innovation for Detectors at Accelerators

- Task included in WP7: “ *Photon detectors for hadron particle identification at high momenta with compact RICHes* ”



STATUS:
STARTED
in 2021 for 4 years



Horizon2020
European Union Funding
for Research & Innovation

Horizon Europe 2021-2027 Framework Program of the European Union



Pillar 1: EXCELLENT SCIENCE:

reinforcing and extending the excellence of the Union's science base
European Research Council

- Frontier research by the best researchers and their teams

Budget: € 16.0 billion

Marie Skłodowska- Curie Actions

- Equipping researches with new knowledge and skills through mobility and training

Budget: € 6.6 billion

Research Infrastructures

- Integrated and inter-connected world-class research infrastructures

Commission proposal: € 2.4 billion

Applications from European researchers and institutions involved in the EIC project are welcome !

9 EoI submitted from Europe in November 2020

4 Countries

[Expression of Interest \(EOI\) of the INFN community](#) (INFN, Italy)

[CEA-Saclay/Irfu \(France\) - Expression of Interest \(EOI\)](#) (Irfu/CEA, France)

[Expression of Interest \(EOI\) Laboratories of CNRS-IN2P3 \(France\)](#) (IN2P3, France)

[EoI for UK](#) (UK)

[Expression of Interest Czech Republic](#) (Czech Republic)

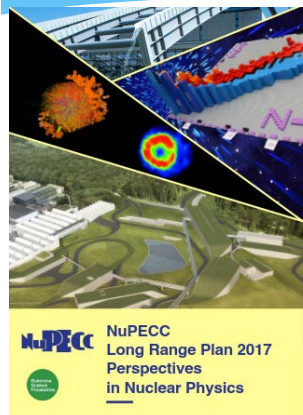
3 Institutions

[EoI for NCBJ](#) (NCBJ, Poland)

[EIC Forward Instrumentation in the Electron Hemisphere](#) (AGH/Poland)

[EoI for Eotvos University](#) (Eotvos, Hungary)

[EoI for DIMA Mihai-Octavian](#) (Individual, Romania)

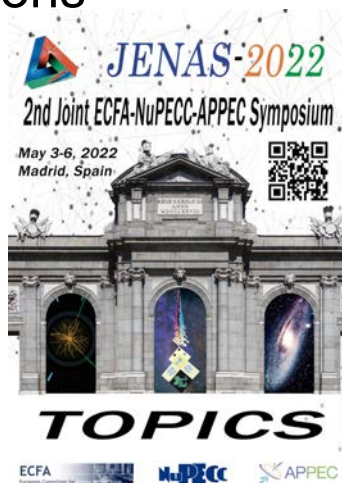


- Presentation of Tim Hallman at the NuPECC meeting in Valencia in March 2020
- Presentation of E. Nappi “European participation in EIC” at the NuPECC meeting in Valencia in March 2020
- A dedicated NuPECC working group composed of Dave Ireland, Franck Sabatié and Eugenio Nappi was formed in July 2020 in order to explore a possibility that European users/institutions join their efforts and present a coherent view on the participation in the EIC experiments for example expressed through one or several EoI.
- NuPECC can play in this initiative a catalyzing role, for example organizing dedicated meetings and facilitate contacts with European funding agencies and DOI representatives.

Meetings and join actions



- The first European joint Particle Physics – Nuclear Physics – Astroparticle Physics seminar
- 230 Participants
- Topics: Physics highlights, scientific strategy, computing and open science, technology and detector R&D, education, outreach, diversity, applications



**Next JENA Seminar in Madrid
May 3-6, 2022**

(JENAA)

Expressions of Interest (following 2019 JENAS meeting at Orsay) <http://nupecc.org/jenaa/>

1. Dark Matter - iDMEu – Kick-off meeting in May 2021
2. Gravitational Waves for fundamental physics
3. Machine-Learning Optimized Design of Experiments - MODE - Kick-off workshop in September 2021 (financial support from NuPECC)
4. Nuclear Physics at the LHC
5. Storage Rings for the Search of Charged-Particle Electric Dipole Moments (EDM) - online workshop March 29-31, 2021

New JENAA Expression of Interest submitted to ECFA, NuPECC and APPEC in July 2021:

“Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments”

JENAA Expression of Interest submitted to ECFA, NuPECC and APPEC in July 2021:

“Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments”

People expressing support for this EoI: Valerio Bertone, Daniël Boer, Silvia Dalla Torre, Markus Diehl, Pasquale Di Nezza, Jean-Philippe Lansberg, Cyrille Marquet, Pierre van Mechelen, Paul Newman, Marco Radici, Juan Rojo, Marta Ruspa, Andreas Schaefer, Laurent Schoeffel, Daria Sokhan, Franck Sabatié, Ralf Ulrich, Werner Vogelsang, Michael Winn

Contact Persons: Daniël Boer and Franck Sabatié

Objectives:

To stimulate and strengthen collaboration among the European nuclear, particle and astroparticle physics communities, to mutually benefit from the many synergies between experiments at the planned U.S.-based Electron-Ion Collider (EIC) and the Large Hadron Collider (LHC) at CERN.

Aim: exploit the synergy between EIC and HL-LHC and LHeC/FCC-eh, like discussed in detail in the input document for the European Strategy for HL-LHC and in the synergies with neighbouring fields for LHeC.

Topic: unified/global QCD studies at collider experiments (both ep/eA and pp/pA) in the period 2030-2040. The objective is to bring together a community that has much overlap in research questions but that is now split because of the focus on different colliders.

“Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments”

Examples of synergies on detector R&D:

The EIC detectors pose challenging requirements concerning a variety of sub-detector systems and require up-to-date approaches for all the components of the experimental set-up. A large fraction of these needs partially or completely coincide with requirements for the experimental program at the LHC and its upgrades. The opportunities for synergy in this respect are recognized in the development of the ECFA Detector R&D Roadmap (<https://indico.cern.ch/event/957057/>), to be published in the fall of 2021.

“Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments”

Examples of synergies on detector R&D:

Some specific examples of shared detector components and requirements:

- Tracking and vertexing using ultra-light silicon detectors is a must at EIC. The currently favoured (MAPS) technology is aligned with the needs for ALICE-3, such that a joint development programme is already in place.
- Tracking using Micro-Pattern Gaseous Detectors (MPGDs) such as Micromegas or GEMS nicely complements silicon detectors to cover larger areas. They are used in most LHC experiments already and are planned for both barrel and forward/backward tracking at the EIC.
- Particle identification in a wide momentum range is also essential at both EIC and LHC, e.g. for spectroscopy studies at LHCb or for the identification of low momentum hadrons at ALICE.
- Silicon detectors offering extremely high time resolution $O(10 \text{ ps})$, such as LGAD or ARCADIA, are needed at the EIC (for time-of-flight applications) and the LH-LHC (for mitigating the ‘pile-up’ overlap of events).
- The development of novel ASICs for Front-End detector readout such as MPGDs, matching both the sensor characteristics and the needs of largely streaming-readout-based data acquisition systems.

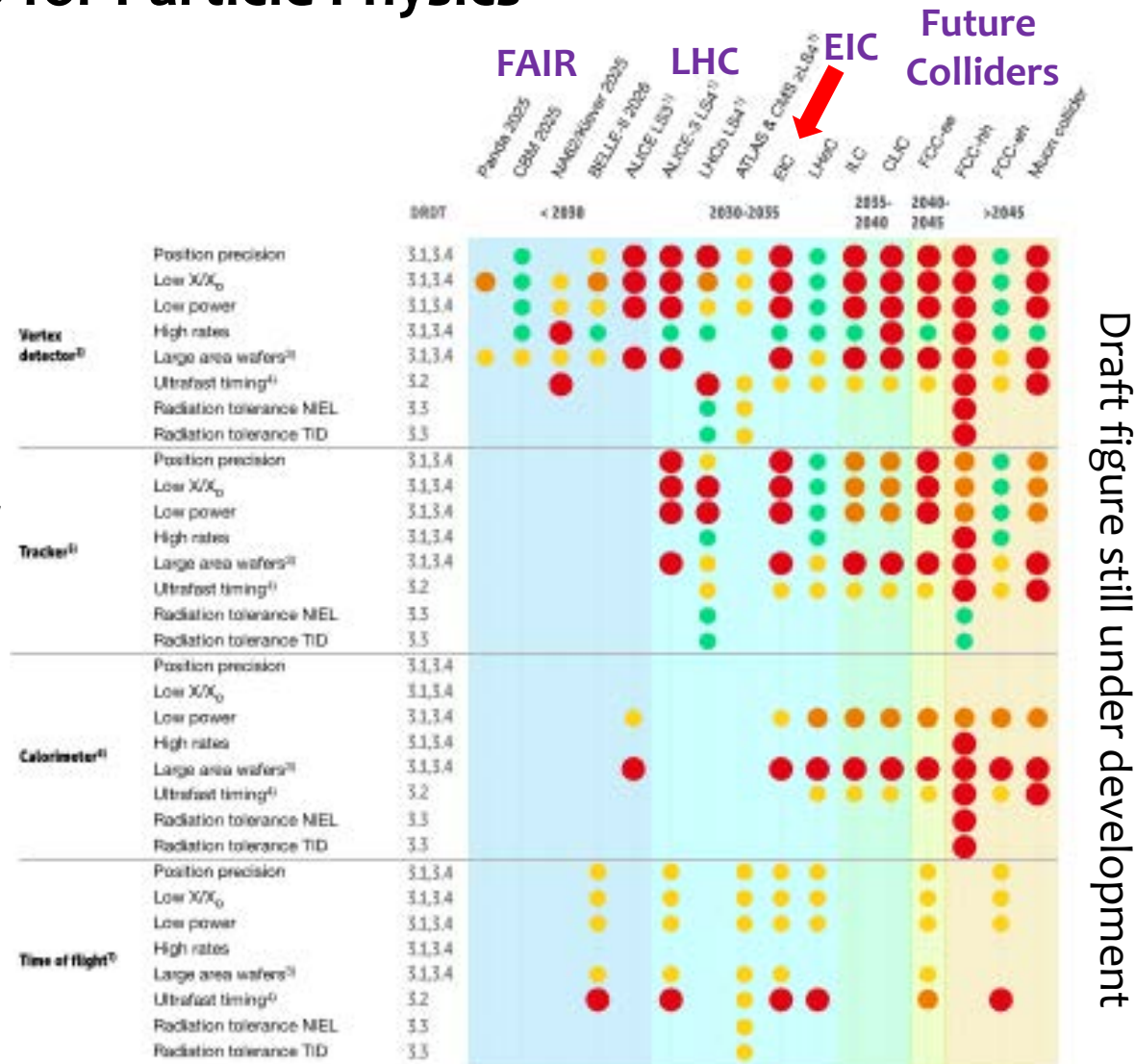
ECFA Detector R&D Roadmap for Particle Physics

Example figure from the Task Force 3 Solid State Detectors

- Must happen or main physics goal cannot be met
- Important to meet several physics goals
- Desirable to enhance physics reach
- R&D needs being met

Note the dots relate to the importance to the listed facilities of the R&D activity not the intensity of effort needed to meet these requirements.

The idea is to illustrate the way requirements could evolve over time to help define the planning for the corresponding detector R&D **to ensure the main physics goals of the updated strategy for particle physics do not risk being compromised by detector readiness.**



- **NuPECC EIC Task Force**
 - catalyzing role in contacts with European funding agencies and DOE representatives helping in transformation of the EoI into firm commitments
 - help in the coherent organization of the European EIC user community
- **Joint ECFA-NuPECC-APPEC Expression of interest for EIC**
 - attracting European Particle Physics and Astroparticle Physics communities to EIC
 - developing synergies in physics and detector R&D between EIC and LHC experiments
 - facilitate applications for the EU grants
- **Next NuPECC Long Range Plan to be organized by 2022-2023**
 - ambition of the European nuclear physics community for its participation in the EIC project

Thank you for your attention

“Synergies between the Electron-Ion Collider and the Large Hadron Collider experiments”

Examples of physics synergies among the EIC and LHC experiments:

The EIC is expected to start operation around 2030 and run concurrently for about a decade with the LHC after its high-luminosity upgrade (the HL-LHC is foreseen in Run 4). Although the Bjorken x range probed at EIC and the HL-LHC overlap to a large extent, the impact of the experiments at EIC and the HL-LHC will be quite complementary. For instance, the uncertainty on the gluon parton distribution function (PDF) for protons and for lead nuclei are expected to improve much due to the HL-LHC data, whereas the gluon PDFs for other heavy nuclei are expected to improve much due to EIC data. Simultaneous fits to data for the proton and for the various nuclei will be most beneficial for our understanding of the gluon content of protons and nuclei.

Improvements of proton PDFs with respect to existing fits will occur at EIC especially at large x and Q^2 for the light quark flavors, in particular the s -quark distribution. Knowing these distributions better at large x and Q^2 will assist in new physics searches at the LHC.