News from NuPECC

Marek Lewitowicz
Chair of NuPECC

PECFA, 21 July 2022, CERN

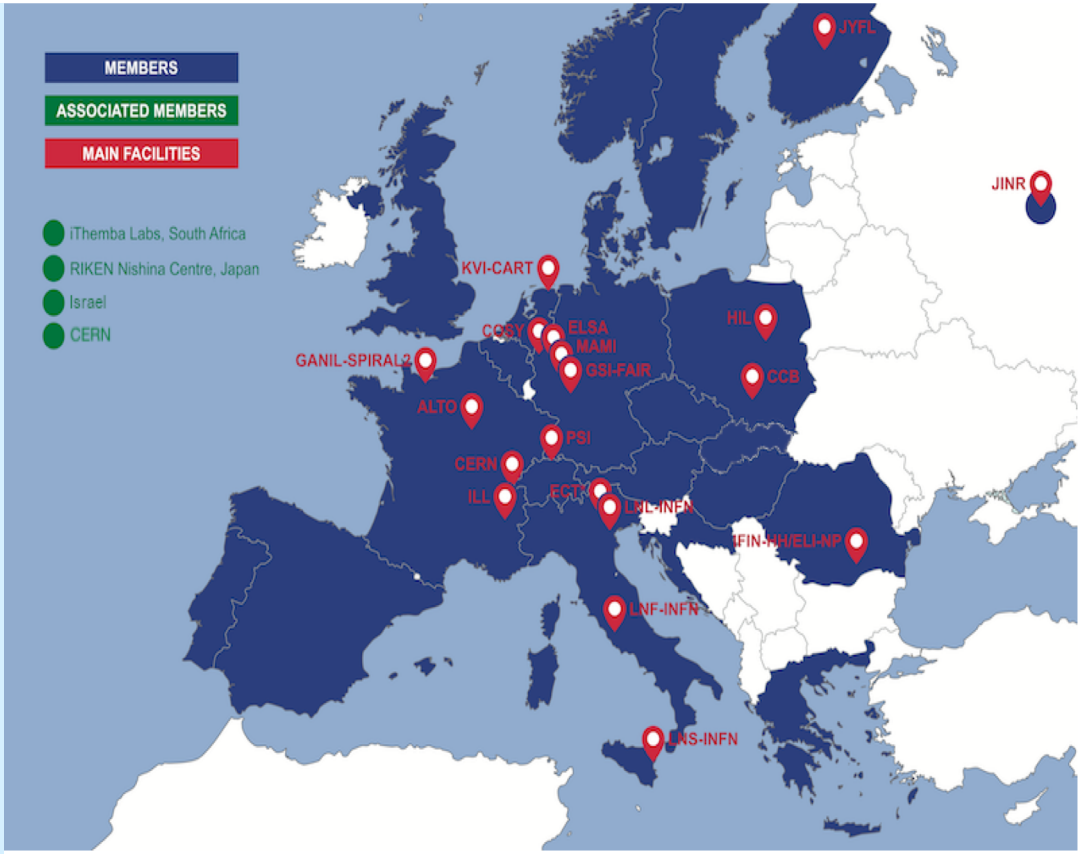
What is NuPECC ?

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

Representing
about 6000 scientists

Composition:

- 34 representatives from 22 countries (new members Slovakia, Slovenia), 3 ESFRI NP Infrastructures & ECT*
  JINR Dubna – suspended in March 2022
- 4 associated members
  - CERN
  - Israel
  - iThemba Labs
  - Nishina Center
- 9 observers (ESF, NPD/EPS, ECFA, NSAC, ANPhA, ALAFNA, CINP, IAEA, APPEC)



3 regular Committee meetings/y

33 Years of NuPECC activities

Towards NuPECC Long Range Plan 2024

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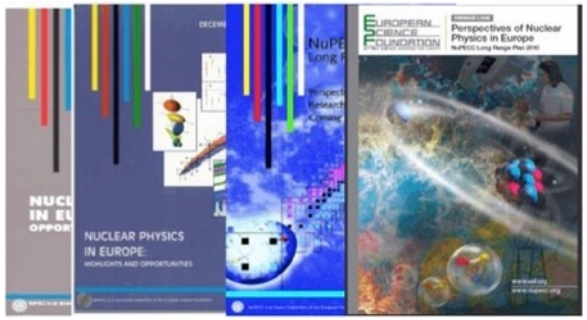

- **The LPR identifies opportunities and priorities for the nuclear science in Europe**
- **The LRP provides national funding agencies, ESFRI and European Commission with a framework for coordinated advances in nuclear science in Europe**

Assessment of Implementation of the NuPECC Long Range Plan 2017

February 2022

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Contributors: H. Abele, N. Alahari, W. Barth, D. Bemmerer, K. Blaum, F. Bossi A. Bracco, M. Chiossi, A. Denig, M. Doser, S. Freeman, M. Gazdzicki, F. Gélis, H. Goutte, M. Grecco, M. Harakeh, M. Hori, G. Imbriani, E. Khan, K. Kirch, W. Korten, A. Laird, J. P. Lansberg, D. Lunney, F. Maas, G. Martinez-Pinedo, S. Masciocchi, A. Mengoni, O. Navillat-Cuncic, D. Rifuggiato, P. Rossi, E. Scomparin, J. Simpson, H. Schmieden, O. Schneider, N. Severijns, Th. Stöhlker, J. Stroth, H. Ströher, U. Thoma, S. Ulmer, C. A. Ur, Ch. Weinheimer, U. Wiedner, H. Wittig

NuPECC LRP 2017

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

February 2022

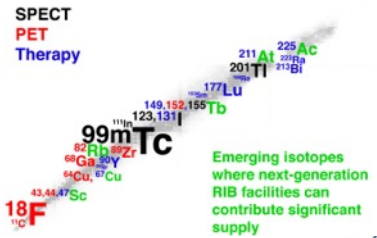
http://nupecc.org/2017_LRP_Assessment_of_Implementation_final.pdf

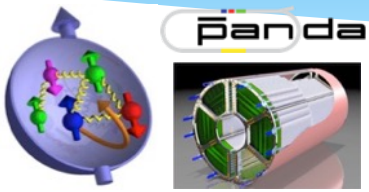
NuPECC LRP 2024

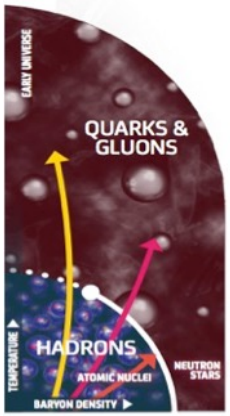
Launched in May
Call for inputs
dead-line Oct. 1st, 2022

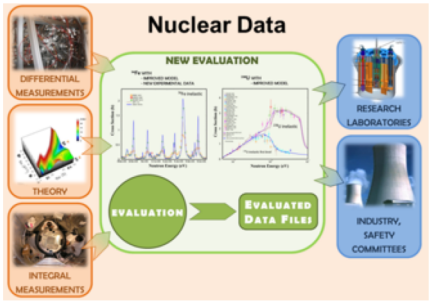
Nuclear Physics in Europe

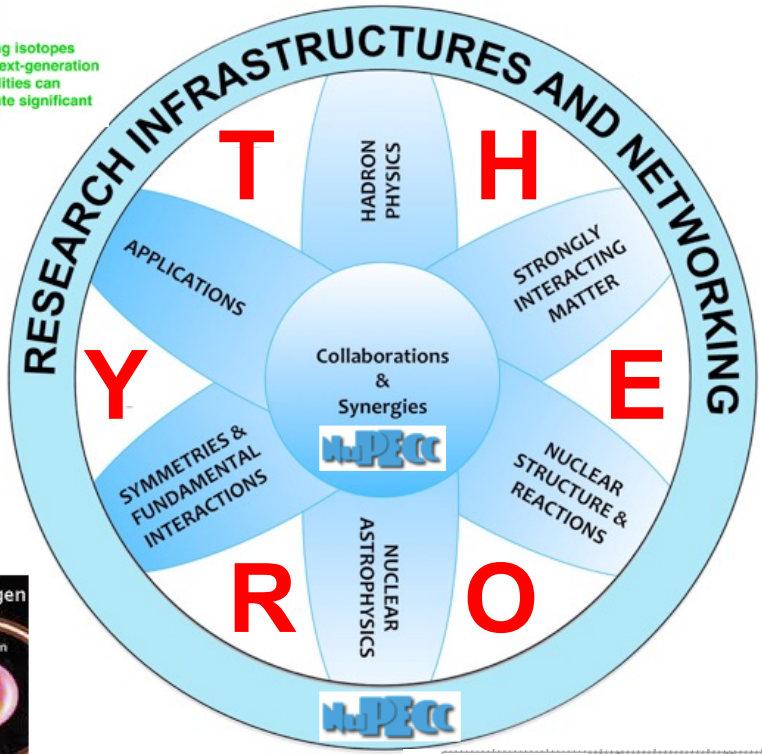
http://www.nupecc.org

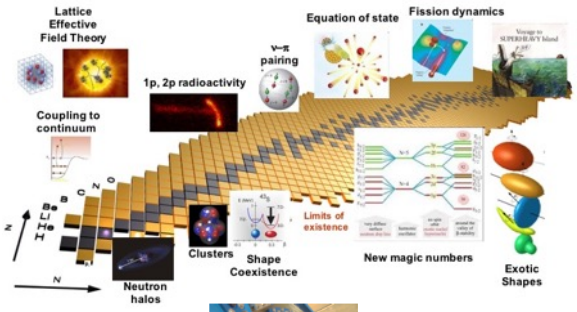


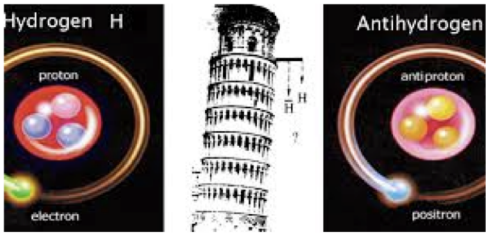


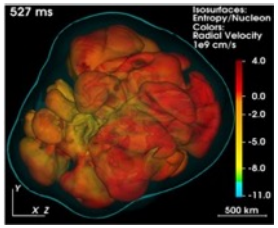


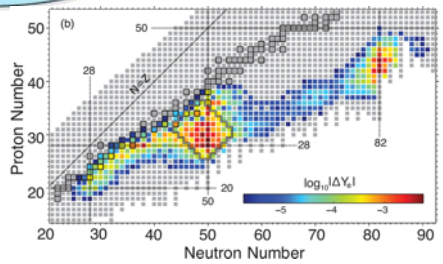


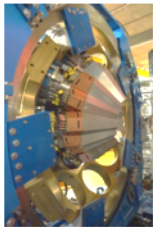




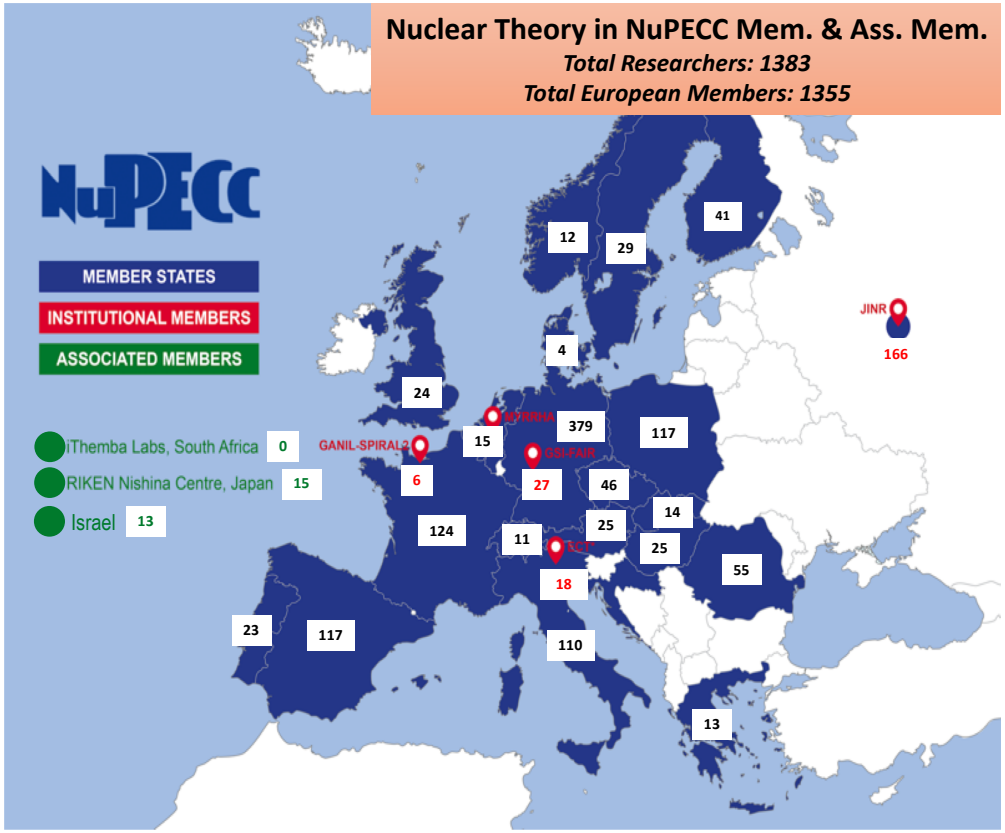




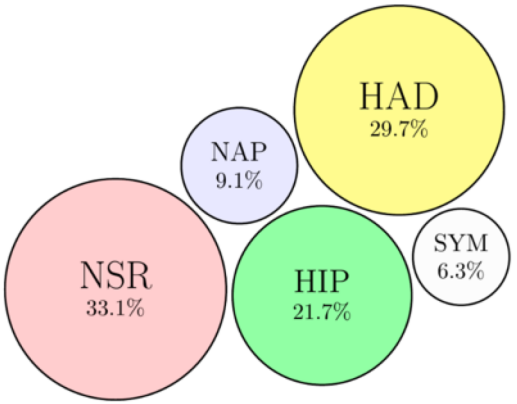




2021 NuPECC Survey of Nuclear Theory in Europe



- Nuclear structure and reactions (**NSR**)
- Nuclear astrophysics (**NAP**)
- Heavy-ion physics (**HIP**)
- Hadron physics (**HAD**)
- Nuclei as laboratories/symmetry tests (**SYM**)



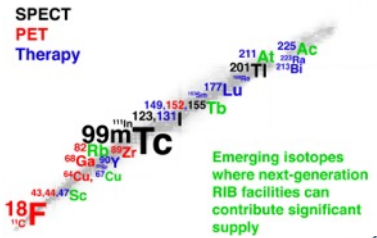
- **In order for the field to prosper, healthy nuclear theory is absolutely essential: the numbers show that this is indeed the fact**
- **There is an approximate equal partition among the big fields (except SYM)**
- **A concentration on specific sites/labs seems to occur (e.g. Germany, Czech Republic, Romania)**
- **Much lower number of PhD students & post-docs per permanent staff researcher in some countries**

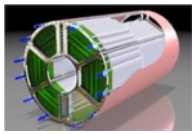
http://nupecc.org/snt/meissner_sep21.pdf

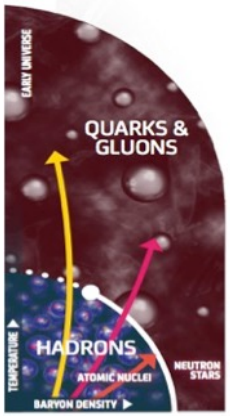
Ulf-G. Meißner et al.

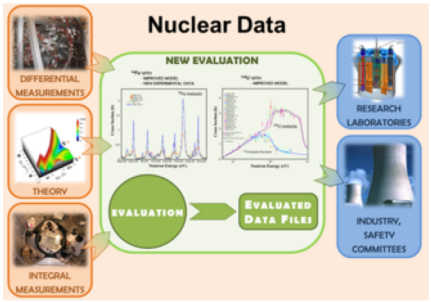
Nuclear Physics in Europe

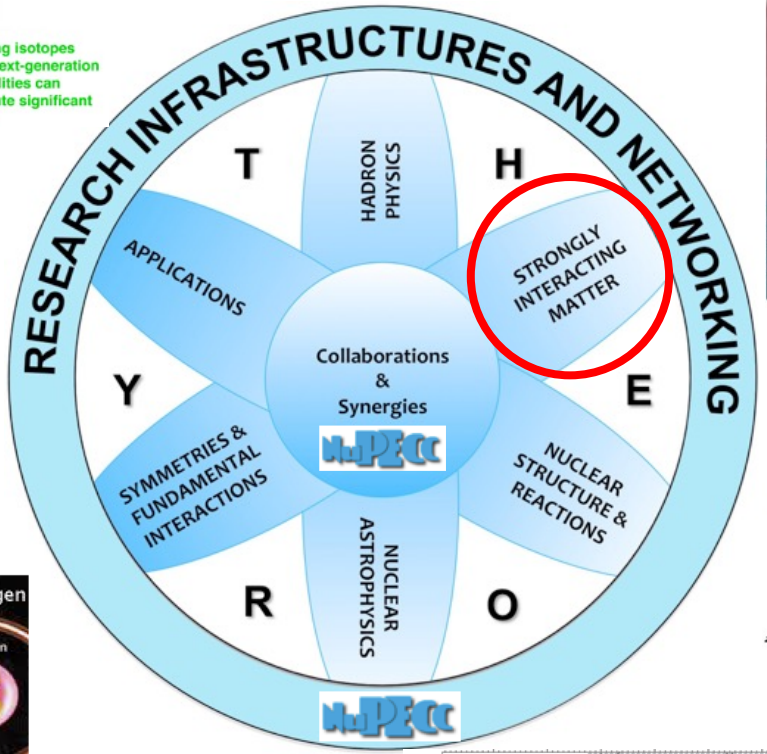
http://www.nupecc.org

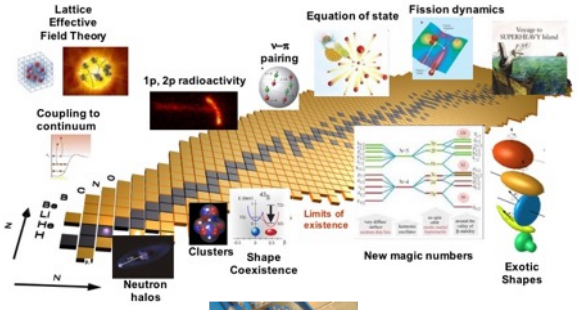


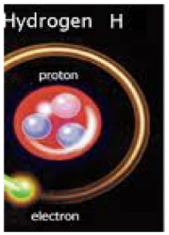


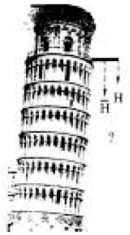


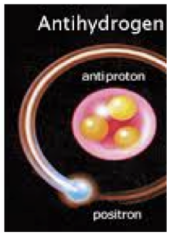


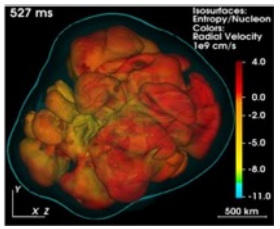


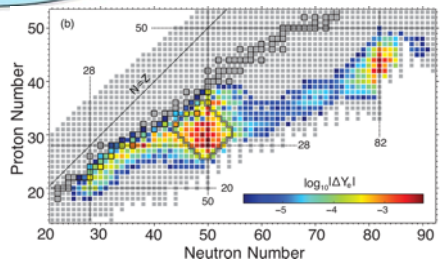


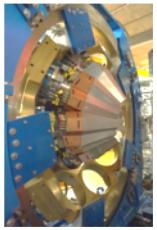




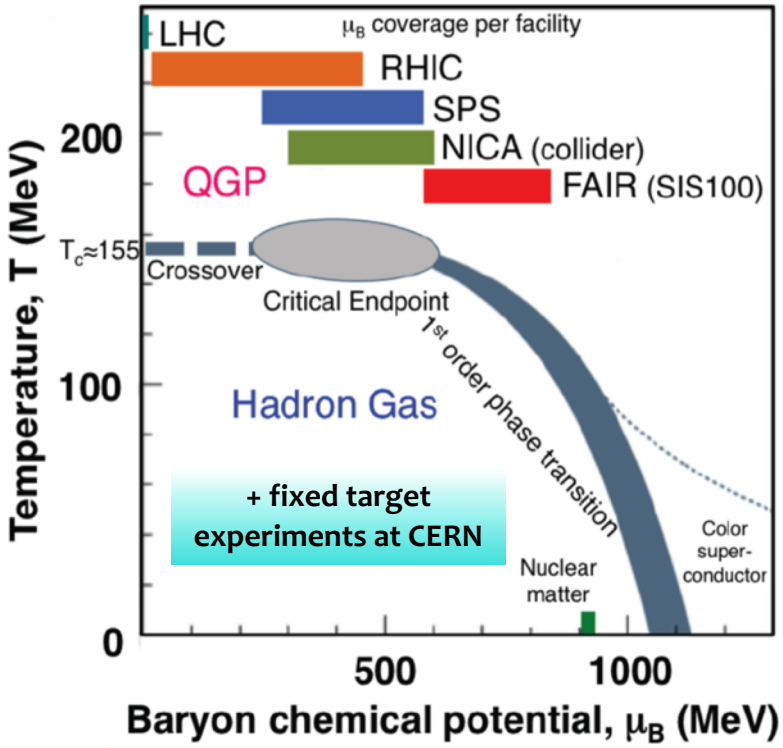


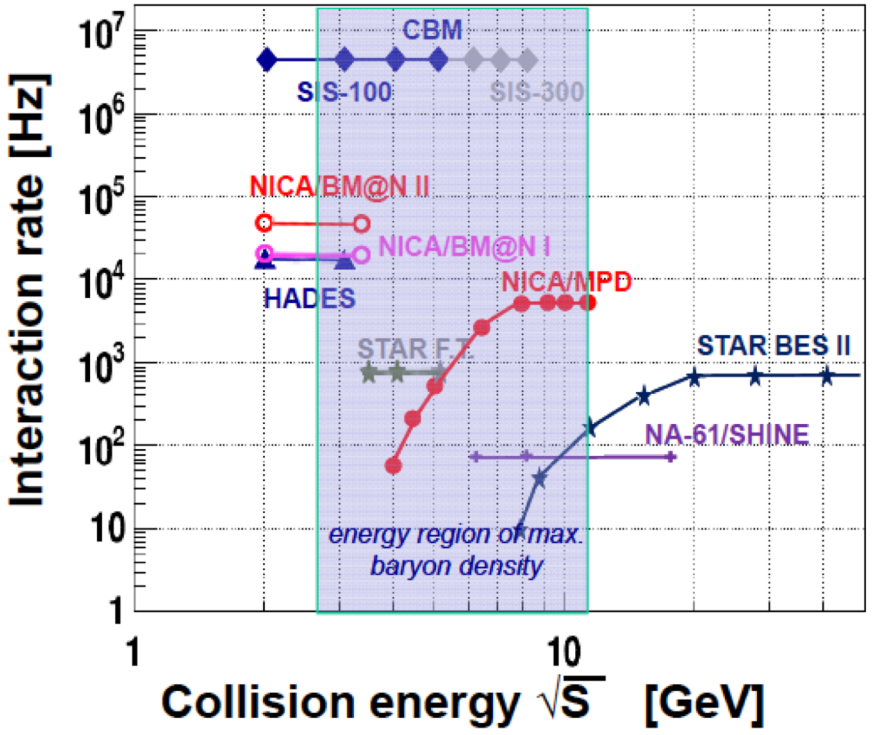






Hadronic Matter at the very extremes



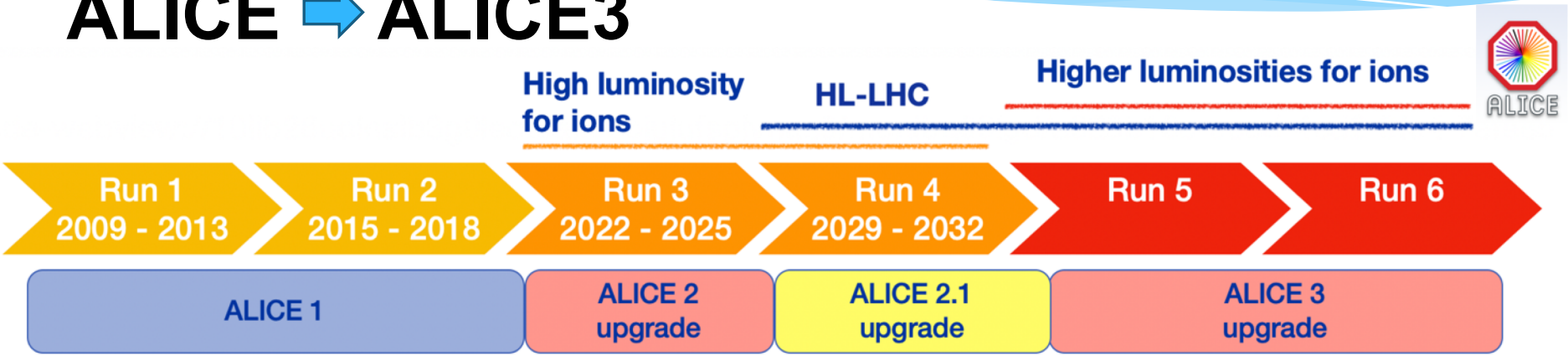


NuPECC LRP recommendation:
Fully develop synergies between ALICE, NICA, FAIR and fixed target experiments at CERN

NuPECC has expressed its support for the hh and heavy-ion programs at FCC

Hadronic Matter at the very extremes

ALICE ⇨ ALICE3



Fundamental questions will remain open after LHC Run 3 & 4
→ **next-generation heavy-ion programme for LHC Run 5 & 6**

- What is the nature of interactions between highly energetic quarks and gluons and the quark-gluon plasma?
- To what extent do quarks of different mass reach thermal equilibrium?
- How do quarks and gluons transition to hadrons as the quark-gluon plasma cools down?
- What are the mechanisms for the restoration of chiral symmetry in the quark-gluon plasma?

Curtesy of B. Erazmus

Letter of Intent for ALICE 3 endorsed by LHCC

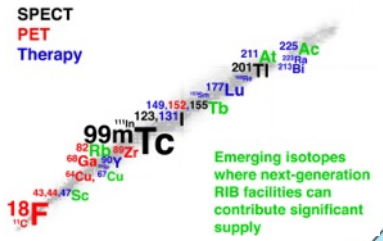
provides "a road map for exciting heavy-ion physics starting in 2035"

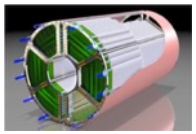
"ALICE 3 detector concept […] is well matched to the proposed, ambitious physics program"

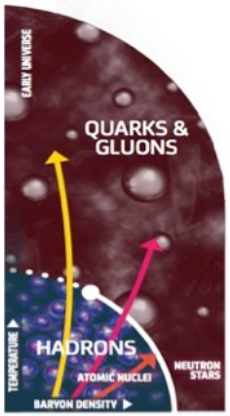
Letter of Intent: CERN-LHCC-2022-009
LHCC minutes: LHCC-149

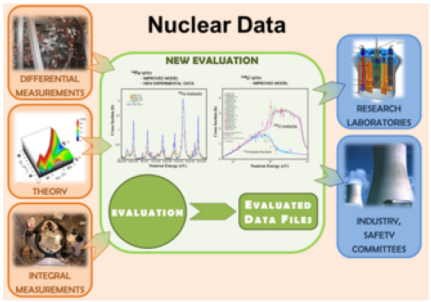
Nuclear Physics in Europe

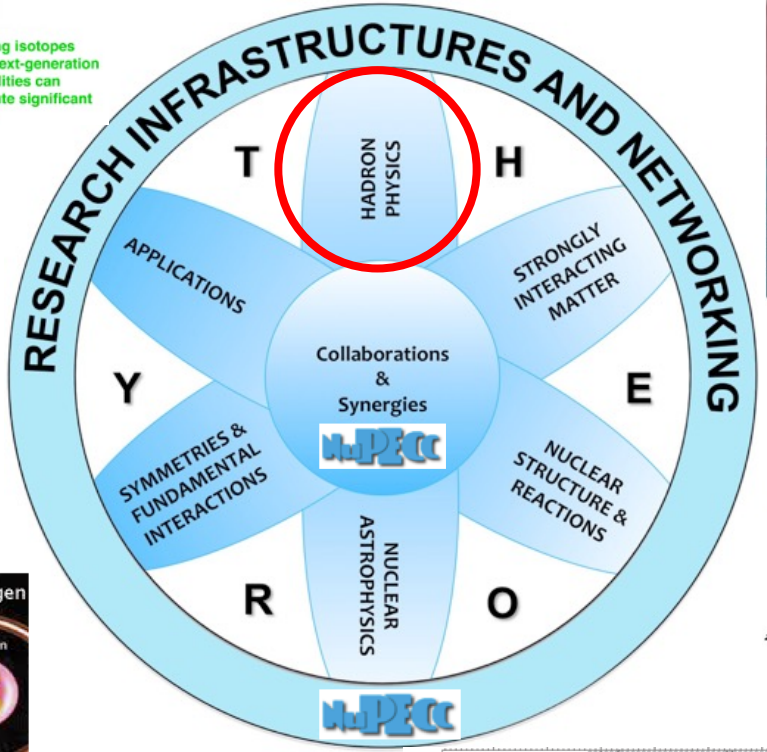
http://www.nupecc.org

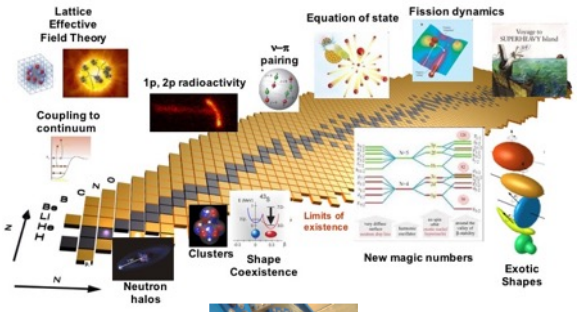


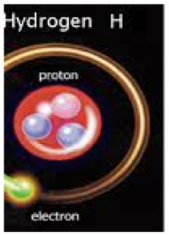


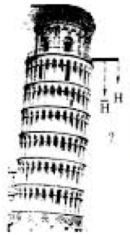


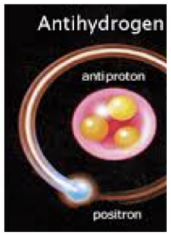


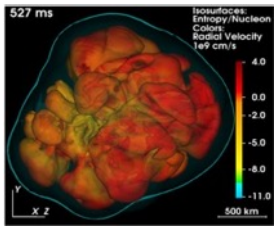


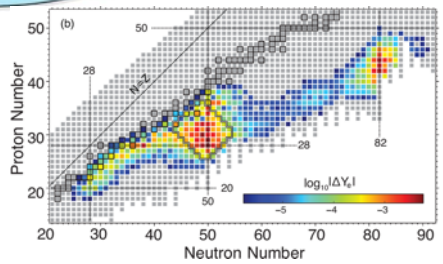


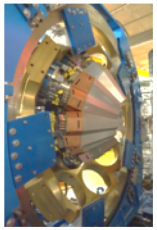












The Physics of Hadrons

- 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

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).

Synergies between the Electron-Ion Collider and the Large Hadron Collider

Kick-off meeting of the JENA EoI: «Synergies between the Electron-Ion Collider and the Large Hadron Collider »

Monday, June 20th

09:00	Welcome and introduction	Daniel Boer et al.	09:00 - 09:05
	EIC Project Overview & Snowmass 2021 conclusions	Prof. Abhay Deshpande	09:05 - 09:35
	Proton and nuclear structure at the cross-road between LHC and EIC	Dr Juan Rojo	09:35 - 10:00
10:00	Latest constraints on proton PDFs with LHC data	Prof. Paul Newman	10:00 - 10:25
	TMD global fits	Alessandro Bacchetta	10:25 - 10:50
11:00	Coffee Break		10:50 - 11:20
	Latest constraints on nuclear PDFs with LHC data	Prof. Michael Murray	11:20 - 11:45
	Latest results on photon-induced processes with heavy-ions at the LHC	Prof. Iwona Grabowska-Bold	11:45 - 12:10
12:00	Heavy Ions & Saturation Physics	Heikki Mäntysaari	12:10 - 12:35
	Photon-hadron (jet) production in pA collisions at the LHC and its connection to DIS at EIC	Dr Jamal Jalilian-Marian	12:35 - 13:00
	The EIC detector and R&D plans	Dr Dalla Torre Silvia	14:30 - 15:00
15:00	ECFA detector R&D roadmap and synergy with EIC	Philip Patrick Allport	15:00 - 15:30
	ALICE ITS3 project and R&D	Dr Magnus Mager	15:30 - 15:55
16:00	SiPM R&D roadmap for LHC and EIC	Prof. Samo Korpar	15:55 - 16:20
	Coffee Break		16:20 - 16:45
	Far-forward BSM and neutrino physics program at the LHC and beyond	Dr Sebastian Trojanowski	16:45 - 17:10
17:00	Muon puzzle in air showers and its connection to the LHC	Dr Hans Dembinski	17:10 - 17:35
	Charm production in collisions at the EIC, LHC, and in the atmosphere	Maria Vittoria Garzelli	17:35 - 18:00

All entries: Room Bohr, CERN

Tuesday, June 21st

09:00	High-x proton PDFs: current status and expected LHC&EIC constraints	Dr Lucian Harland-Lang	09:00 - 09:25
	EW and BSM physics between the LHeC and the EIC	Prof. Stefano Forte	09:25 - 09:50
10:00	Lepton Flavor Violation results at the LHC	Giulia Frau	09:50 - 10:15
	QGP in small systems at the LHC: synergies among eA, p-p and pA systems	Dr David Dobrigkeit Chinellato	10:15 - 10:40
11:00	Coffee Break		10:40 - 11:15
	GPDs and GTMDs	Dr Cédric Mezrag	11:15 - 11:40
	Exotic XYZ states at the LHC	Liupan An	11:40 - 12:05
12:00	Quarkonia photo- and electro-production	Jean-Philippe Lansberg	12:05 - 12:30
	Physics with tagged forward protons at the LHC	Prof. Christophe Royon	12:30 - 12:55
	Fixed target at LHC	Dr Cynthia Hadjidakis	14:15 - 14:40
	Jets as a tool at LHC and EIC	Ignazio Scimemi	14:40 - 15:05
15:00	Fragmentation Functions (ee,SIDIS at EIC)	Valerio Bertone	15:05 - 15:30
	Discussion and Closing		15:30 - 16:00

All entries: Room Bohr, CERN

- ❑ Hybrid meeting
- ❑ Up to 90 participants, 60 in-person
- ❑ Lively discussions

https://indico.ph.tum.de/e/EIC-LHC

PECFA, 21 July 2022, CERN

Synergies between the Electron-Ion Collider and the Large Hadron Collider

Highlights

Synergies - topics of mutual interest — D. Boer

- The flavor and spin structure of the proton: PDFs
- Three-dimensional structure of nucleons and nuclei in momentum and configuration space (TMDs, GPDs, GTMDs) and their evolution
- QCD in nuclei: nuclear PDFs and gluon saturation phenomena
- Heavy Ion Collisions: Quark-Gluon Plasma studies & Ultra-Peripheral Collisions
- Diffractive processes and distributions
- Jet physics, Jet substructure
- Heavy flavor physics, quarkonia, exotic states
- Electroweak physics and beyond the Standard Model physics
- EFT studies, SMEFT
- Neutrino cross-sections at low and high-energy
- High energy cosmic rays and Dark Matter
- Detector R&D
- Computational physics, Monte Carlo simulations, machine learning techniques

SUMMARY — S. Forte

"Nature does not distinguish 'Nuclear' vs. 'High Energy' physics"

(Abhay Deshpande)

- RICH SET OF OPPORTUNITIES FOR EW AND BSM STUDIES AT EIC UNRELATED TO PDFS/NUCLEON STRUCTURE
- CURRENT EIC STUDIES ONLY SCRATCHED THE SURFACE OF FUTURE OPPORTUNITIES
- EXPLOIT KNOW-HOW ACCUMULATED OVER 15 YEARS OF LHEC STUDIES

Conclusions and Observations — P. Allport

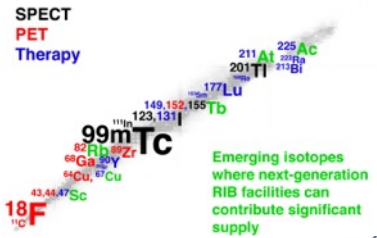
- Major R&D funding for the LHC detector R&D programme was in place from 1986.
- The ECFA Detector R&D Roadmap starts from the principle of needing to identify the mission critical detector R&D for all the future programmes considered as viable options in the 2020 Update to the European Strategy for Particle Physics.
- Mission critical for different facilities means different things:
  - For HL-LHC beyond LS2, (mainly ALICE and LHCb) ultra-thin sensors and supports; PID + ToF; high rate gaseous detectors; rad-hard CMOS; ultra-fine granularity timing; rad-hard LGAD; rad-hard ECAL; SiPMs; fast-timing R/O; 28nm CMOS; low power; 100Gbps; … (see presentations by C. Parkes and L. Musa at https://indico.cern.ch/event/994685/).
  - For EIC, given the high precision physics targets, the issue is not to be systematics limited by the detector performance and to extract maximum information from every collision event.
    - However, many requirements (apart from extreme rad-hardness) overlap with R&D priorities for the LHC programme, as well as requirements for future lepton colliders and other strong interaction physics facilities.

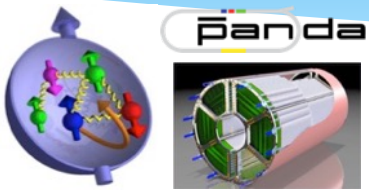
→ Of order decadal R&D lead-times should be anticipated for most demanding technology aspects for future facilities, so, for the most critical EIC requirements (eg PID, fast timing, ultra-low mass vertexing & tracking, …), suggest R&D programme should link closely with work for other facilities.

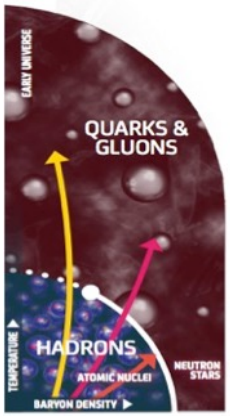
- ❑ Many MANY topics of mutual interest: the synergy is quite real
- ❑ Bread and butter: PDF, nPDF, TMDs, FF, jets, UPCs, etc.
- ❑ BSM of high interest to the Particle Physics community but..
- ❑ Muon detector is strongly requested by the community
- ❑ Link with detector R&D efforts started within ECFA to be strengthened

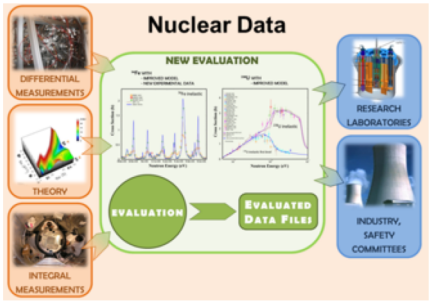
Nuclear Physics in Europe

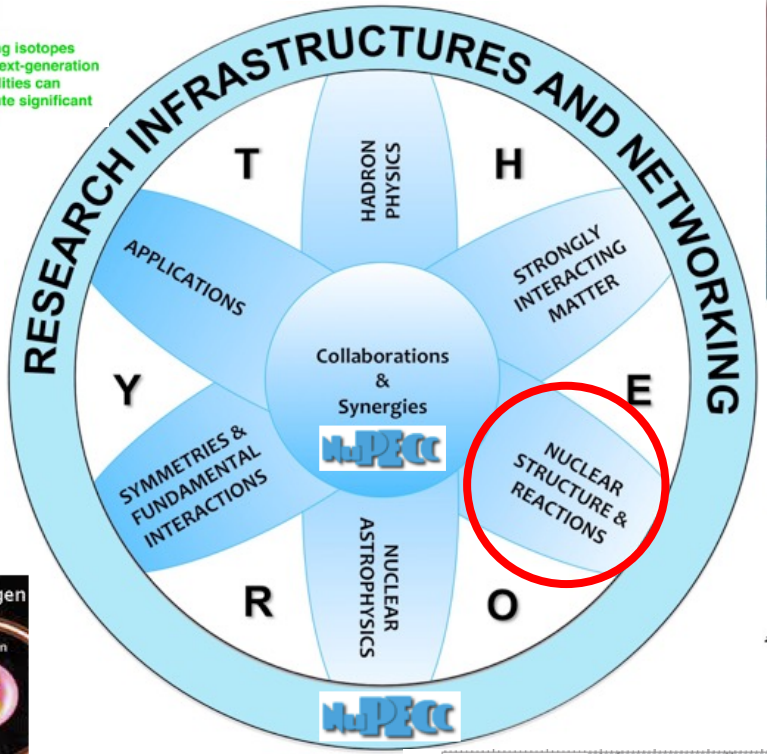
http://www.nupecc.org

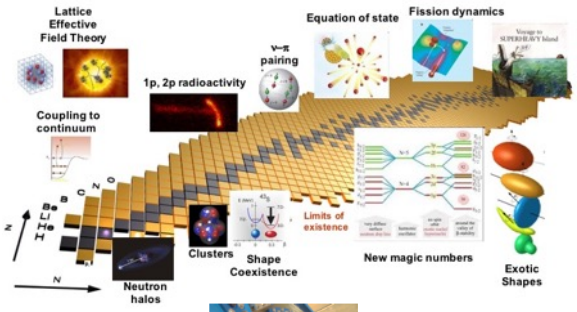


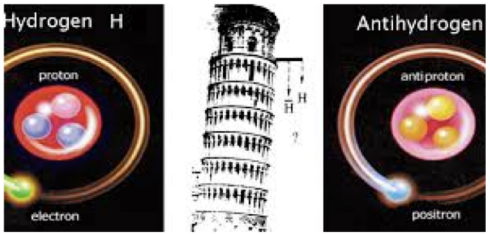


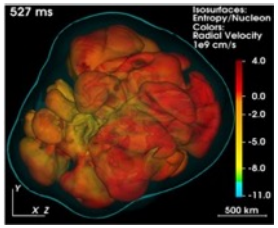


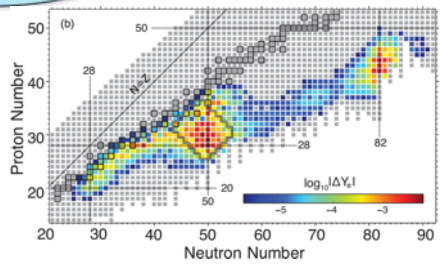


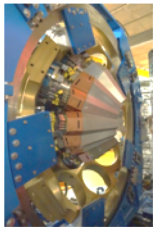




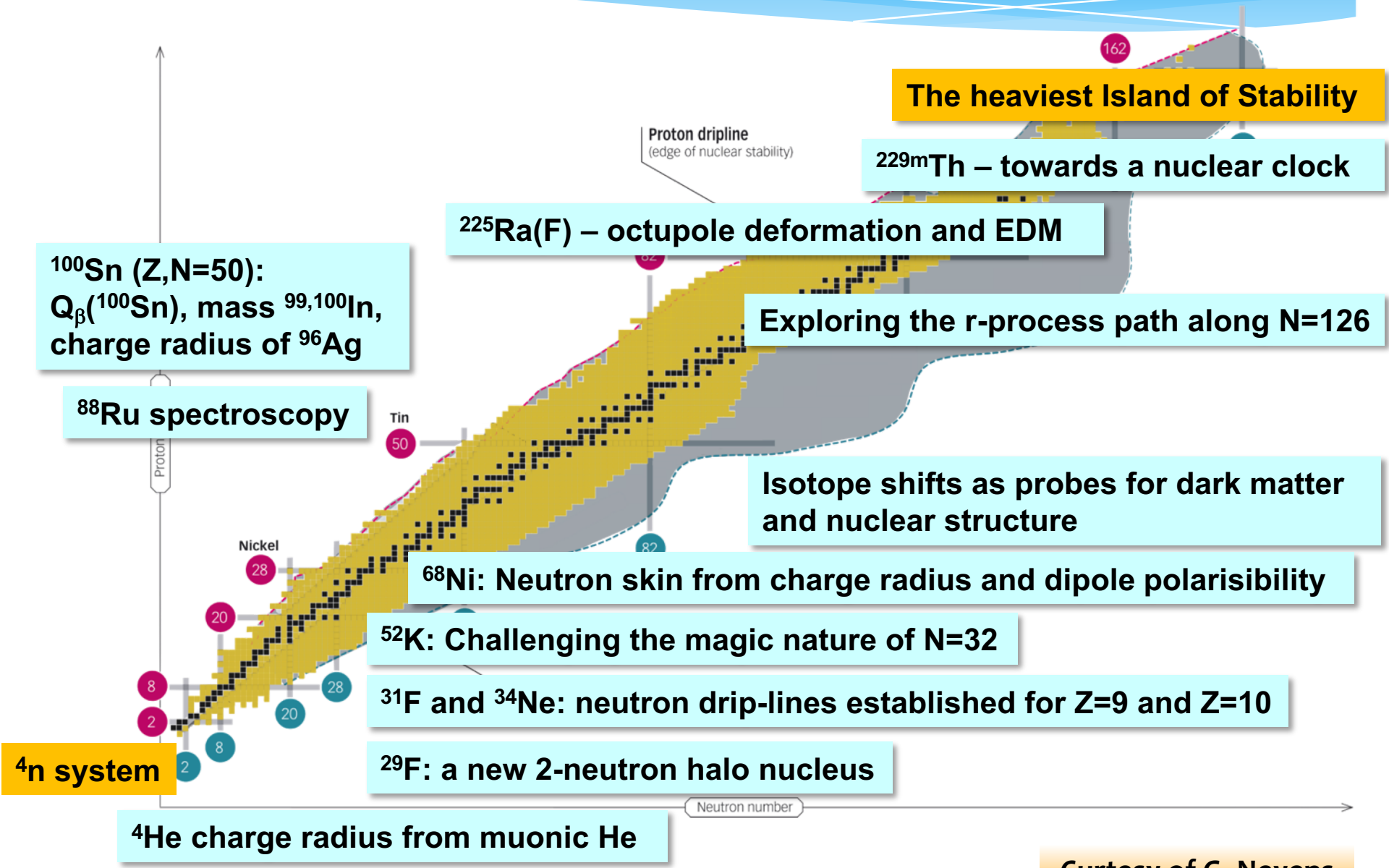








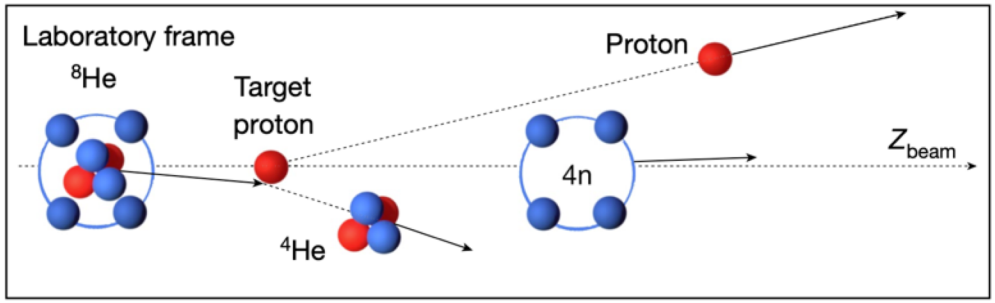
Nuclear structure - recent experiments

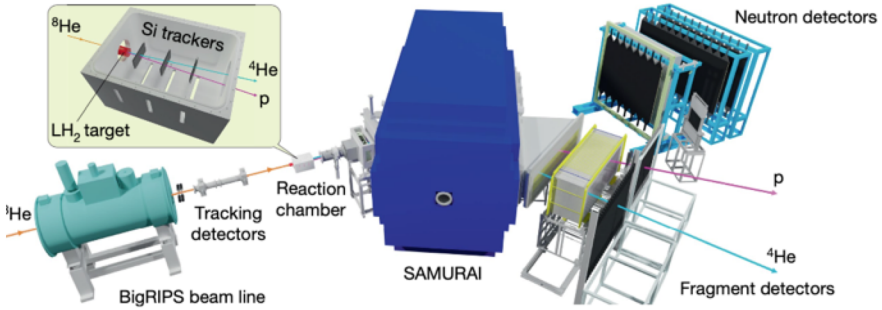


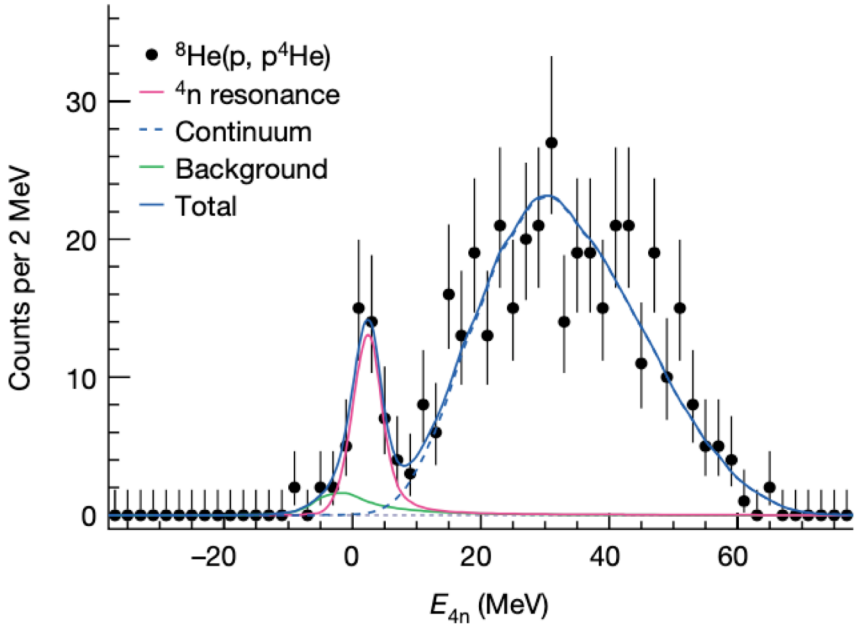
Curtesy of G. Neyens

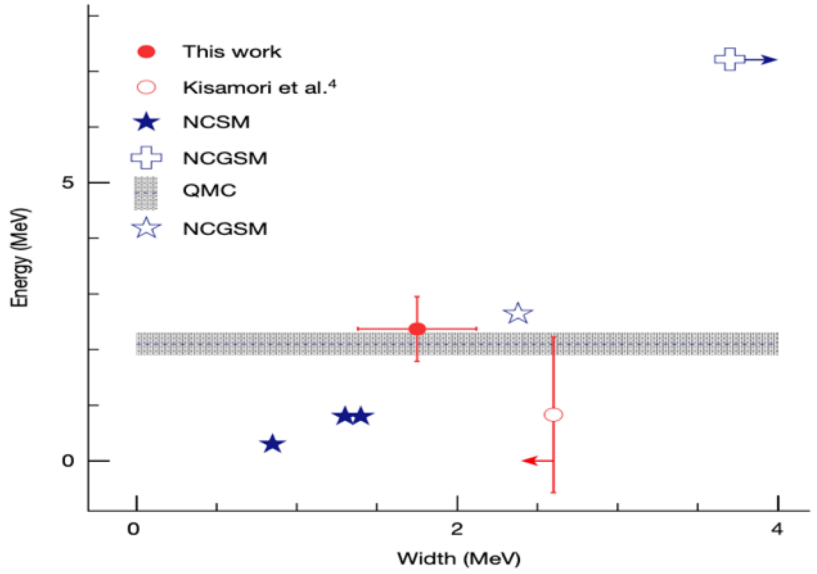
Observation of a correlated free four-neutron system

M. Duer et al. 678 | Nature | Vol 606 | 23June2022





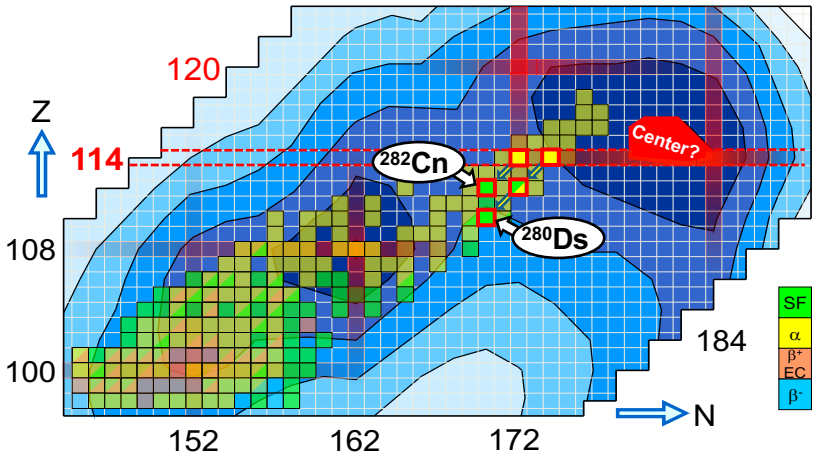




SHE island of stability

The centre of the Island of Stability: it is not at Z = 114

Chart of nuclei of superheavy nuclei

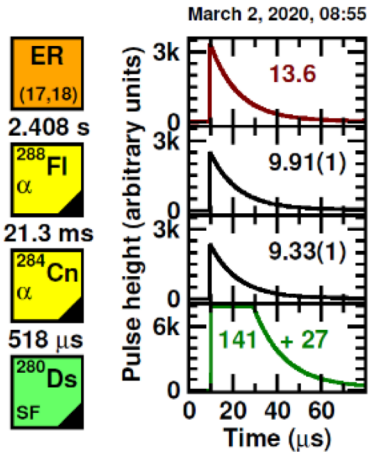


Calculated shell stabilization energy (Sobiczewski *et al.*)
Colored boxes: known nuclei

- First detailed nuclear spectroscopy of flerovium (Z=114) decay chains with TASISpec+ at *TASCA* recoil separator
- Discovery of new isotope ^{280}Ds (Z=110) provides first sequence of α-decay energies across Z=114 shell gap
- Discovery of excited 0^+ state in ^{282}Cn (Z=112): shape coexistence

➔ together with extensive triaxial beyond mean-field theory these findings suggest that there is no pronounced shell gap at proton number Z=114

- Focus shifts to heavier elements: 120? 126?

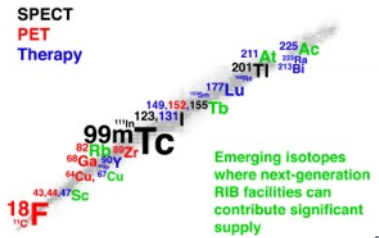


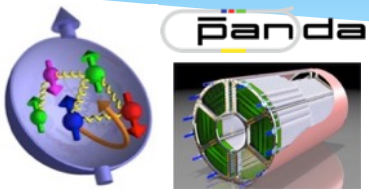
A. Såmark-Roth *et al.*, Phys. Rev. Lett. 126 (2021) 032503
J.L. Egido & A. Jungclaus, Phys. Rev. Lett. 125 (2020) 192504; *ibid.*, 126 (2021) 192501

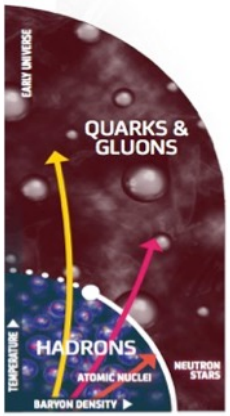
Curtesy of G. Neyens

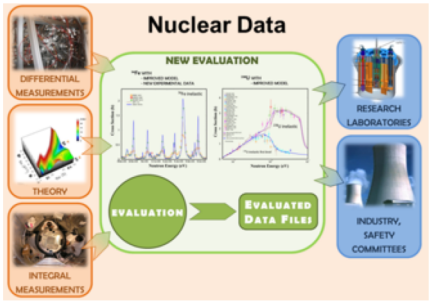
Nuclear Physics in Europe

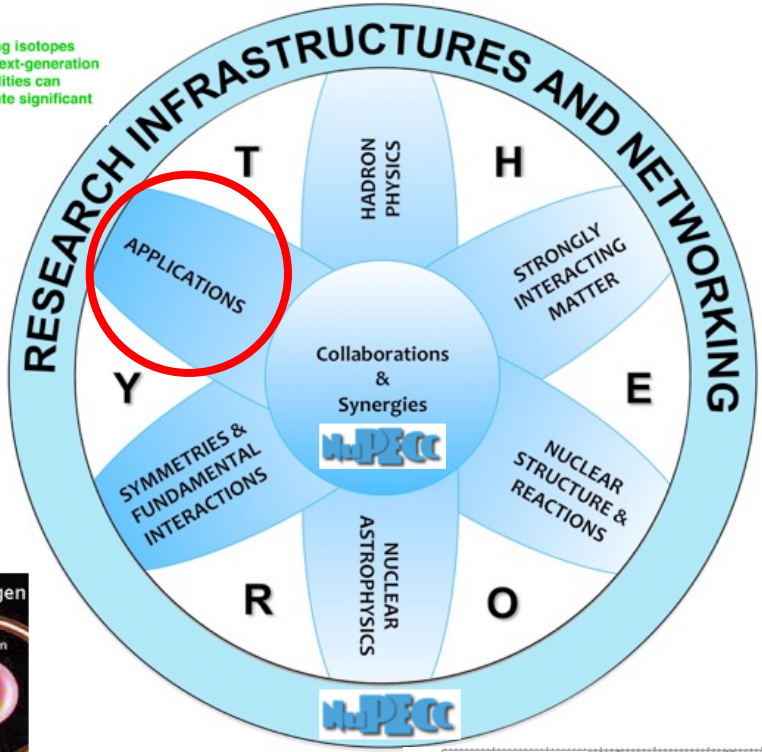
http://www.nupecc.org

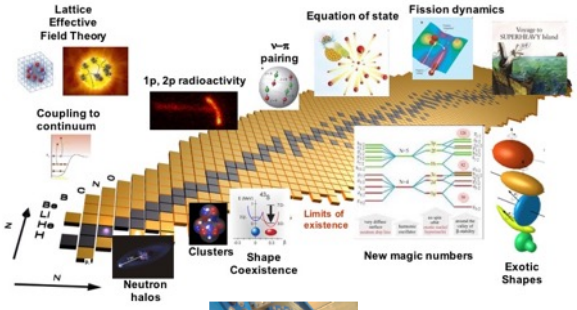


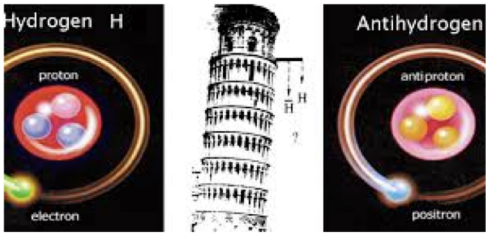


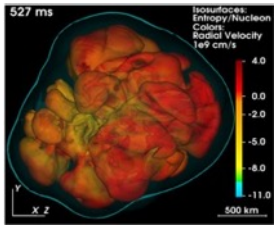


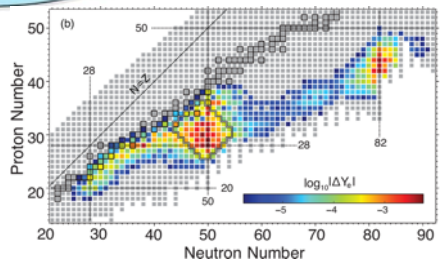


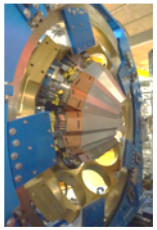






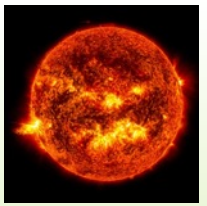




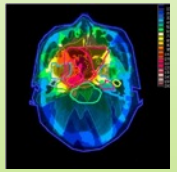


Applications of nuclear science

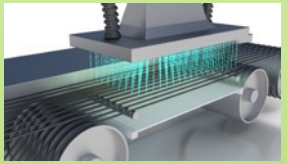
- Climate & Environment (Sun activity, heat in the Earth interior, ocean monitoring, wastewater treatment, mapping of groundwater resources, ...)



- Energy (electric power generation, waste management, nuclear data)



- Health (radioisotopes for therapy and diagnosis, hadrontherapy)
- Everyday life products (sterilization, radiation processing, cross-linked coatings, material modification, food and agriculture)

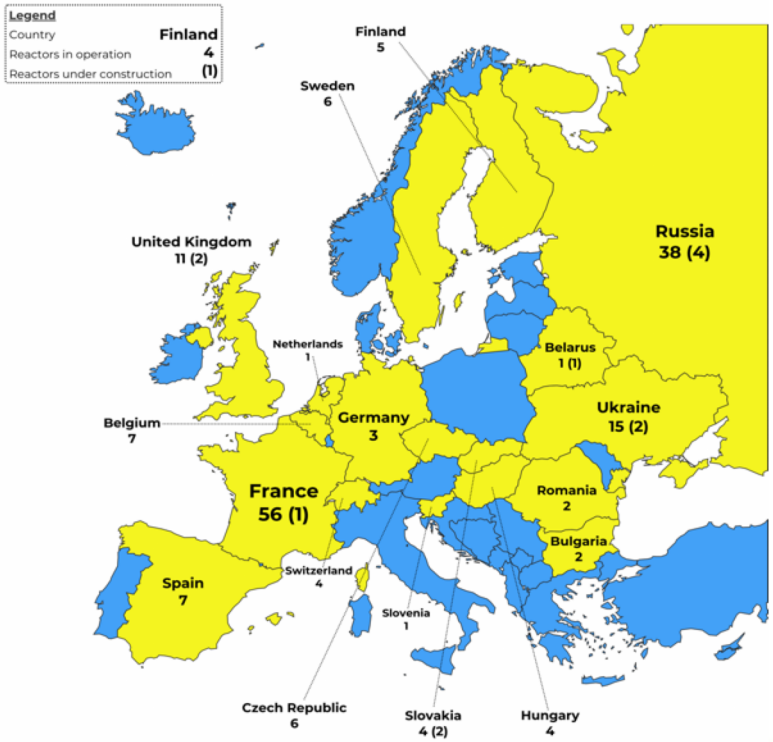


- Cultural heritage and Forensics
- Space technology & exploration

Important role of large and smaller scale facilities

NuPECC report on Nuclear Physics in Everyday Life (soon)

Nuclear Energy in Europe



In 2019, nuclear plants generated 25 % of the electricity produced in the European Union, with nuclear reactors operating in 13 Member States

128 nuclear power reactors (119 GWe)
Under construction:
3 reactors in EU & 2 in UK

New reactors will be constructed in Bulgaria, France (14), Poland and UK

The Complementary Delegated Act on climate change mitigation and adaptation covering certain gas and nuclear activities approved by the European Parliament on **July 6, 2022**. The criteria for the specific gas and nuclear activities are **in line with EU climate and environmental objectives** and will help accelerating the shift from solid or liquid fossil fuels, including coal, towards a climate-neutral future.

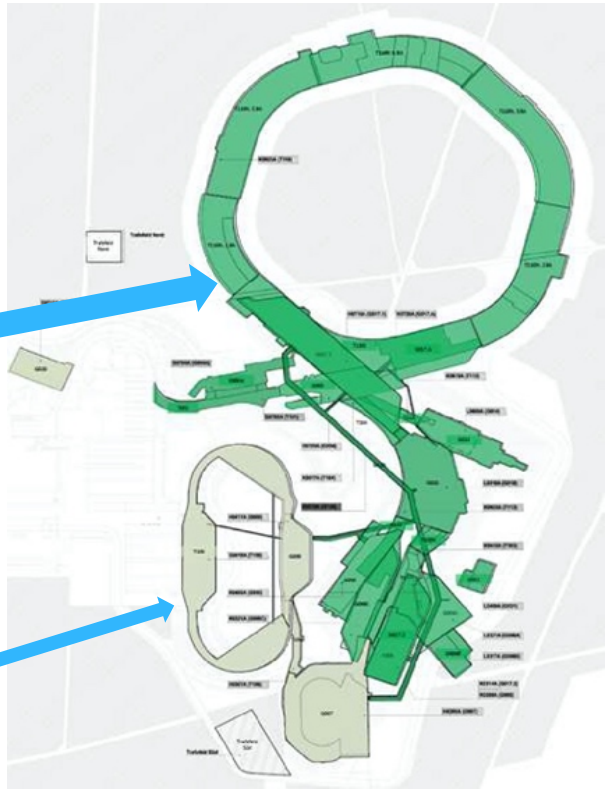
ESFRI

First phase of MYRRHA ADS facility under construction in Belgium

IFMIF-DONES - test facility for fusion materials under design

Full facility MSV and Intermediate Objective

- **All FAIR shareholders remain committed to the realization of the full facility („Modularized Start Version“ – MSV) enabling the comprehensive scientific research program**
- **FAIR Council defined in 2019 the Intermediate Objective (IO) as an interim step towards full MSV. The IO comprises**
  - **full scope of accelerator and experiments for the MSV**
  - **realization of the buildings for MSV except the buildings for CR, HESR and p-Linac.**
- **The international shareholders are at various stages of their national approval processes to obtain the financial resources of the three buildings of CR, HESR, and p-Linac (highlighted in light green).**



Courtesy of P. Giubellino and Y. Leifels

Roadmap NP facilities

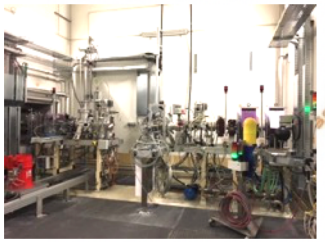
FAIR- Construction Site
(May 2022)

FAIR - Construction Site South
(April 2022)

Courtesy of P. Giubellino and Y. Leifels

Roadmap NP facilities

NFS - running

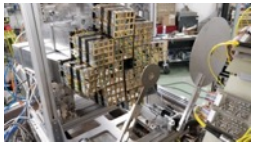


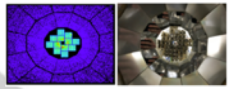
S3 operational by 2023

DESIR civil construction by 2023

AGATA VAMOS

FAZIA INDRA





HI SC LINAC operational

5mA 14-20 MeV/n light and 1mA heavy ions

New High-intensity heavy-ion injector under development

LINAC nominal light-beam intensity capabilities demonstrated in 2021
Routine operation of SPIRAL2 with experiments at Neutron For Science since 2021

Courtesy of Patricia Chomaz

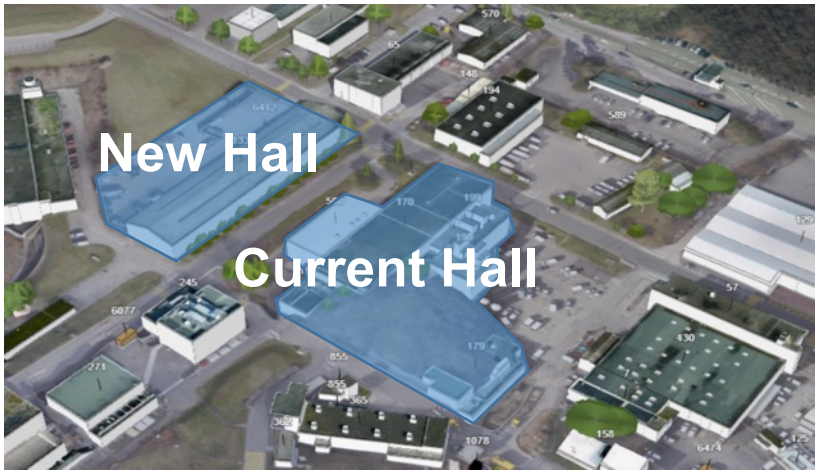
CERN / ISOLDE
World-leading ISOL facility

Mid-term goals (up to and including LS3 2026-28)

- New lab for nano-material based targets
- Parallel RIB operation
- Upgrades to receive higher energy protons at higher intensity
- Upgrade of transfer line from Booster to ISOLDE to deliver 2-GeV
- …

Long-term goals (> LS3): EPIC

- A new ISOLDE building + target stations.
- Dedicated space and facilities for new (and existing) low-energy experiments.
- Improved beam purity (mass resolution) and quality (time structure).
- Parallel operation with existing (HIE-ISOLDE) facility.
- Improvements to post-accelerators
- Extra space for new re-accelerated RIB experiments, including a compact storage ring.

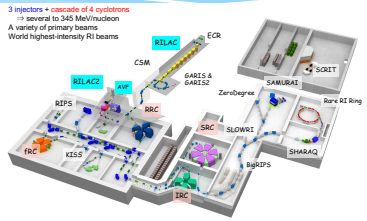


Collaboration working on science case before considering funding strategies

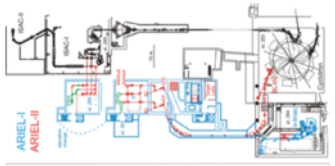
Courtesy of S. Freeman

European involvement in the overseas Nucl. Phys. facilities

RIBF RIKEN, Japan (operational) – strong involvement including advanced detectors

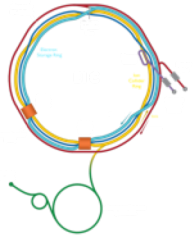


TRIUMF, Vancouver, Canada (operational & construction of ARIEL) - involvement in experiments & instrumentation

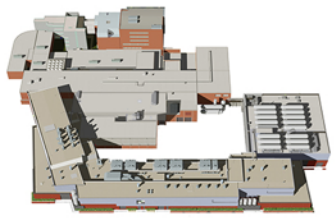


iThemba Labs, South Africa (operational & construction of SAIF) – involvement in experiments

EIC, Brookhaven, New York, US (construction) – strong interest of the European community



FRIB, East Lansing, Mi, US (beginning of operation) – involvement of European groups



AGATA: THE ultimate γ-ray spectrometer

AGATA is operated under a Memorandum of Understanding

All partners have signed on the 25th of March 2022

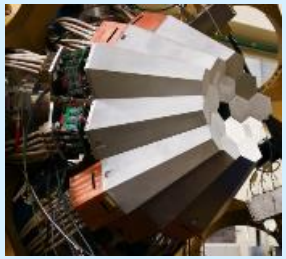
New AGATA Spokesperson, chair of the steering :
A. Bracco (INFN-Milano) since 31st of March

Core investment ~22 M€

MoU Phase 1 + Addendum

MoU Phase 2

2010-2012
Legnaro, Italy
Intense stable beams
15 detectors

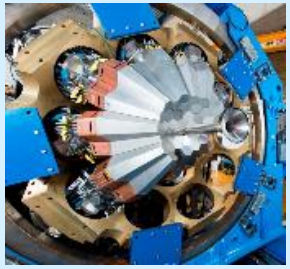


AGATA Demonstrator + PRISMA at LNL

2012-2014
GSI, Germany
Fast fragmentation beams
25 detectors

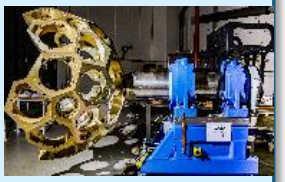
AGATA at GSI

2014- 2021
GANIL, France
ISOL and stable beams
approaching 1π (45)



AGATA at GANIL

2021--
LNL, Italy
Stable beams
SPES radioactive beams



AGATA at LNL 2.0

>2026
FAIR, Germany
ISOLDE, CERN
GANIL, France
RIB at low and high energies

Courtesy of E. Clement

Integrating community with EU projects

Support for users and facilities

New! Joint Particle Physics – Nuclear Physics EU project EURO-LABS

Contract 2022-2026 (14,5M€)

Starts on September 1st 2022

Coord. Navin Alahari
GANIL, France
Coordinating institution INFN, Italy
39 Research Infrastructures

- CERN
- GANIL (France)
- LNL-LNS (Italy)
- JYFL (Finland)
- IJCLab (CNRS, France)
- FAIR/GSI (Germany)
- NLC (HIL/IFJ PAN, Poland)
- IFIN-HH(Romania)
- ECT* (Italy)
- …

Hadron physics STRONG-2020

Contract 2019 -2023 (10M€)

Coord. Barbara Erazmus IN2P3, France
Coordinating Inst. IN2P3/CNRS, France

- CERN
  LHC & fixed target exp.
- GSI/FAIR (Germany)
- LNF, Frascati (Italy)
- MAMI, Mainz (Germany)
- ECT*, Trento (Italy)
- ELSA, Bonn (Germany)
- COSY, Jülich (Germany)

NuPECC Strategy for Nuclear Physics

Strategy Pillars

- **Science: Interplay between strong Theory & ambitious Experiments**
- **Applications - huge societal impact**
- **Facilities – in Europe (FAIR, SPIRAL2, ELI-NP, ISOLDE, SPES,…) and at other continents (RIBF, TRIUMF, iThemba, EIC, FRIB)**
- **Detectors - ex. ALICE3 and AGATA**
- **Data and Open Science – ex. ESCAPE H2020 program**
- **Synergies with neighbouring fields - DM, GW, neutrinos, EDMs, detectors,…**

Strategy Development

- The 2017 NuPECC Long Range Plan defined an ambitious strategy for European Nuclear Physics
- NuPECC efforts to transform the LR Plan into reality -> Task Force meetings in European countries
- **Next NuPECC LRP 2024 begins now!**
  - **Call for inputs with a dead-line on October 1st, 2022**

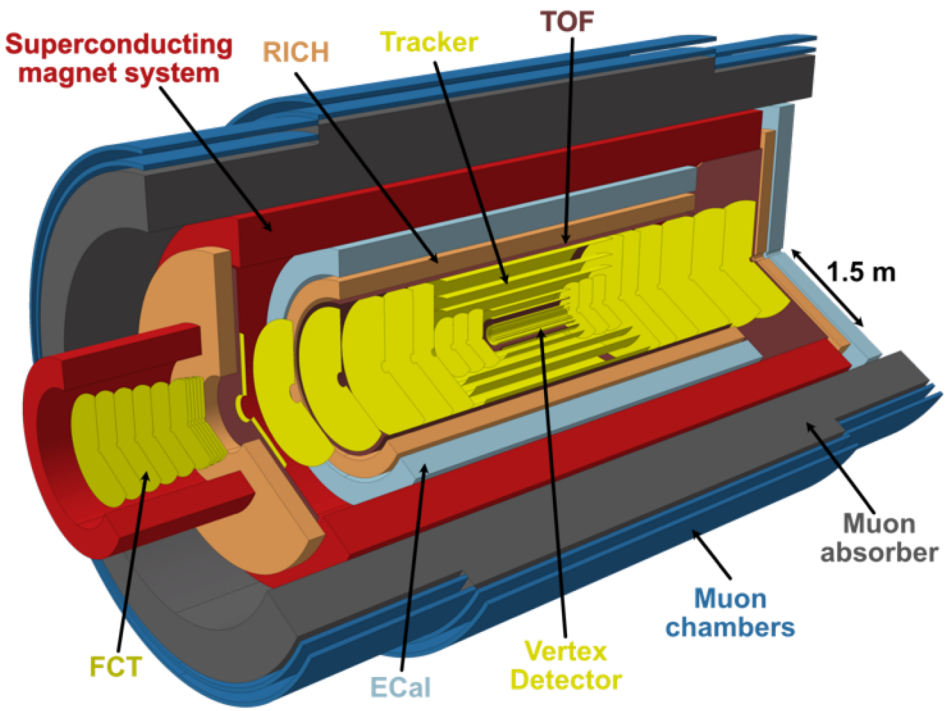
http://nupecc.org/?display=lrp2024/main

Warm thanks to all colleagues for their contributions

Thank you for your attention

ALICE ⇨ ALICE3

- Compact all-silicon tracker
  → clean separation of signal and background
- Vertex detector with excellent pointing resolution
  → clean reconstruction of decay chains
- Particle identification
  → background suppression
- Large acceptance
  → statistics and correlations
- Superconducting magnet system
  → effective provision of required magnetic field
- Continuous read-out and online processing
  → large data sample to access rare signals



Novel detector concept based on innovative technologies relevant for all future HEP experiments

Curtesy of B. Erazmus