International Research Laboratory Nuclear Physics and Astrophysics

IRL NPA

Jérôme Margueron, 22/06/2023

IN2P3 is present on 5 continents

Mostly based on major research infrastructure

IRL NPA

IRL CPB
Radek Stompor

IRL Ilance,
Michel Gonin

IRL Nuclear Physics and Astrophysics (NPA)
CNRS lab at FRIB, MSU

- **Creation agreement** between the following parties:
  - CNRS (represented by Antoine Petit, chief executive officer),
  - MSU (represented by Teresa K. Woodruff, interim president).
- **Location**: Facility for Rare Isotope Beams (FRIB) at 640 S. Shaw Lane, East Lansing, MI 48824, USA.
- **Duration**: 5 years, start in September 2023.
- **Director**: J. Margueron (IP2I Lyon); **co-director**: Oscar Naviliat-Cuncic (FRIB).
- **Steering committee**: two members representing the parties + two external experts.
- **Laboratory council** composed of all staffs of the IRL.

IRL Nuclear Physics and Astrophysics (NPA)

CNRS-IN2P3 laboratory at FRIB, MSU

- **Scientific motivation** for discoveries about the properties of rare isotopes, nuclear astrophysics, and fundamental interactions:

  - **Long-standing collaborations** between French nuclear scientists and US physicists at FRIB (in theoretical and experimental activities). The new IRL will provide **more opportunities** and a **higher visibility** to the already existing exchanges. *More opportunities for US scientists to visit French labs, e.g., GANIL.*

  - GANIL and FRIB are **connected facilities** with similar scientific interests, **complementary expertise**, and common interest in several instrumental developments. They have research and accelerator departments of comparable size. In 2022, the first experimental campaign was performed at FRIB and SPIRAL2 is under construction at GANIL.

  - The US **network** of nuclear **theorists** (Theory Alliance) is centered at FRIB.

—> It is timely to promote and enhance synergies based on mutual expertise and knowhow, reinforcing collaborations dedicated to the new facilities: FRIB and SPIRAL2-GANIL.

IRL Nuclear Physics and Astrophysics (NPA)
CNRS lab at FRIB, MSU

- **Added values** of the new IRL NPA:
  - **Instrumental developments** of common interests, where stronger synergies will be highly beneficial.
  - Common **theoretical activities** in nuclear physics and astrophysics.
  - More **opportunities** to meet, develop common projects, and work on joint publications.
  - **Co-training** of students and post-docs.

IRL Nuclear Physics and Astrophysics (NPA)

CNRS lab at FRIB, MSU

- Four **research topics** in nuclear physics:

  1. Nuclear **structure** and **reactions** from stability to rare isotopes,

  2. Nuclear **astrophysics** from nuclear reactions in the cosmos to extreme matter equation of state

  3. Nuclear **theory** from finite systems to uniform matter,

  4. **Instrumental** developments of common interest at GANIL and FRIB.

1- Nuclear structure and reactions from stability to rare isotopes

Diego Gruyer (LPC Caen) & Kyle Brown (FRIB)

The study of **stable** and **rare isotopes** is aimed to develop a **predictive model of atomic nuclei** and their **reactions**.
Profound implications for applications of nuclear technology and for the use of atomic nuclei to test our **fundamental understanding** of the **forces** and **constituents** of nature.

In more details:
- Structure and reactions in exotic regions.
- Equation of state an clusterization in atomic nuclei.
- Test of fundamental interactions and symmetries.

2- Nuclear astrophysics from nuclear reactions in the cosmos to extreme-matter equation of state

Faïrouz Hammache (IJCLab Orsay) & Hendrik Schatz (FRIB)

The understanding of the **evolution of stars**, the prediction of **compact star** properties and the QCD **phase diagram** along dense and large-isospin asymmetry region, the **gravitational waves** and their electromagnetic counterparts associated to the collision of **binary neutron stars**, and the **chemical evolution of galaxies**.
The modeling of astrophysical processes requires both the mastering of the underlying nuclear properties and the global astrophysical conditions.

In more details:
- Nuclear reactions for astrophysics.
- Exploration of the phase diagram through nuclear collisions.
- Global understanding of astrophysical observations.

3- Nuclear theory for finite systems and uniform matter

Denis Lacroix (IJCLab Orsay) & Dean Lee (FRIB)

The understanding of the **nuclear interaction** and the development of sophisticated **many-body models**. Recent advances in **effective field theory** applied to the low-energy QCD sector have defined new interactions employed in nuclear modelling, which challenge the description of nuclear properties through the entier mass table, the nuclear-processes and the equation of state for astrophysics and the test of fundamental symmetries.

In more details:

- Developments of nuclear energy-density-functional (EDF),
- Developments of ab-initio approaches,
- Machine learning and quantum computing.

4- Instrumental developments of common interest at GANIL and FRIB

Hervé Savajols (GANIL Caen) & Daniel Bazin (FRIB)

Develop **synergies** between the IRL partners to design and construct **high-efficiency** and **high-resolution detectors**.

In more details, exchanges and complementary expertise will be highly beneficial for the following developments:

- **Spectrometers** to separate very rare events from intense backgrounds: S800 and future HRS (High Rigidity Spectrometer) at FRIB, S3 (Super Separator Spectrometer) at SPIRAL2.
- In-beam **gamma ray** spectroscopy with tracking: GRETA (Gamma-Ray Energy Tracking Array) in the US and AGATA (Advanced Gamma ray Tracking Array) in Europe.
- **Precise measurements** of rare isotopes with traps: LEBIT (Low Energy Beam Ion Trap) at FRIB, PIPERADE (double Penning trap device) for the future DESIR facility at SPIRAL2, MORA (Matter's Origin from the RadioActivity of trapped and oriented ions).

IRL Nuclear Physics and Astrophysics (NPA)

CNRS lab at FRIB, MSU

- **Publications**:
  - Name of author(s), International Research Laboratory on Nuclear Physics and Astrophysics, Michigan State University and CNRS, East Lansing, MI 48824, USA.
  - The agreement of the parties is requested prior to any publication/communication to the public.
  - pre-prints visible in open archive system such as HAL.
- **Scientific records**: mandatory and owned jointly by the Parties.
- **Partnership agreements**: with French or European agencies managed by CNRS, with US agencies managed by MSU.
- **Ownership of results**: joint property of the Parties (30%) + inventor's employers (70%); patent, software, etc, subject to rules of co-ownership; Administrator Institution for the protection and exploitation of the results designated among the parties; confidentiality.

IRL Nuclear Physics and Astrophysics (NPA)
CNRS lab at FRIB, MSU

- **Human ressources** (in evolution):
  - Researchers: 2 FTE from CNRS, 1 FTE from FRIB.
  - Postdoc, PhD, Master: TBD.
- **Financial ressources** (Operations and Mobility, no Equipment):
  - 30k euros (from CNRS)
  - 30k USD (from MSU).
- **External collaborations**:
  - Specific collaboration agreements.
  - Nuclear physics laboratories in France: IPHC Strasbourg, IP2I Lyon, LP2I Bordeaux, Subatech Nantes, LPC Caen, IJCLab Orsay, GANIL Caen.

Activities of the IRL NPA

- We will encourage regular **joint workshops** on well **identified questions** (about 2 per years, the community will be invited to make suggestions), and increase **collaborations** on developments related to SPIRAL2, e.g.,:
  - spectrometer S3, where very heavy and superheavy elements will be produced,
  - devices for the DESIR project, where tests for fundamental interactions will be performed.
- For theoretical activities, we expect an increase of the number of joint **publications** and new **collaborations** on the use of quantum computing for calculations in nuclear many-body models.
- We expect two to three French **permanent scientists** to be based in the IRL. Several French permanent scientists will perform **short-** and **long-term visits** at FRIB.
- We also expect **students and postdocs** to work at the IRL or to be jointly supervised by French and US scientist.
- The IRL will also be a **window of the French community** at FRIB and will help to increase its visibility, for instance by promoting job positions in France (ANR, ERC, CNRS, Universities), by re-directing to the French GdR RESANET, by providing information for scientific visits.
- A **website** for the IRL will contain relevant informations.

Activities of the IRL NPA

The next actions

- July 18th: Official inauguration of the IRL at MSU, with:
  - From CNRS: Alain Schuhl (Director of CNRS) (to be confirmed), Reynald Pain (Director IN2P3) and Marcella Grasso (DAS IN2P3),
  - From MSU: Teresa K. Woodruff (interim president of MSU),
  - Direction of FRIB,
  - Direction of the IRL NPA.

- September: Start of the IRL, subject to the common agreement for the creation of the IRL.

- October-November: first workshop (currently being organised).