EMIR&A

French national network of accelerators
for irradiation and analysis of molecules and materials

(http://emir.in2p3.fr)

Nathalie Moncoffre

About EMIR/EMIR&A

Research Federation created in January 2014 (FR 3618)
Research Infrastructure
Annual budget: 10 – 12 k€

Mainly attached to **INP**
Secondary attachment Institutes: **INC and IN2P3**

Until August 2019 : Director Serge Bouffard (CIMAP, Caen)
New Head: Nathalie Moncoffre (IP2I, Lyon)

EMIR: A network of irradiation platforms for the study of materials

In 2019: EMIR evolution → EMIR&A

Evolution of EMIR

Réseau national d'accélérateurs pour l'irradiation et l'analyse des molécules et matériaux

Until 2019 :

➡ Research topics focused on irradiation studies in a wide range of materials

Fundamental research ➡ applications including those for energy.

How to extend the scope of EMIR to other accelerators and other scientific topics: relevance of opening EMIR to new facilities?

The main objectives:

Federate the scientific community around accelerators

Make it more visible nationally and internationally.

In 2019 **To prepare the future of EMIR :**

Working Group : (GrAcc)
Group on Accelerators for Irradiation and Analysis

M. France Barthe (CEMHTI, Orléans)
Serge Bouffard (CIMAP, Caen)
Denis Jalabert (INAC, CEA, Grenoble)
Isabelle Monnet (CIMAP, Caen)
Nathalie Moncoffre (IP2I, Lyon)
Ian Vickridge (INSP, Paris)
Pascal Yvon (CEA, Saclay)
Sophie Le Caër (CNRS, CEA Saclay)

Which research around accelerators around 3 axes :

- **Irradiation of materials**
- **Radiolysis**
- **Ion beam analysis**

Réseau national d'accélérateurs pour l'irradiation et l'analyse des molécules et matériaux

Presentation of this project to the CNRS institutes (INP, INC, INP3) in June 2019

→ **EMIR evolves in two poles**

Pole 1: Irradiation of materials and molecules (including radiolysis)

Pole 2: Studies using Ion Beam Analysis (IBA)

↓

EMIR&A

National Federation of Accelerators for the Irradiation and Analysis of Molecules and Materials

EMIR&A platforms

CEMHTI - Orléans, UPR CNRS/INC, Université d'Orléans

Cyclotron 45 MV, Pelletron 3 MV

CIMAP -Caen, UMR CEA/DRF/IRAMIS, CNRS/INP, ENSICAEN, Univ. Caen-Normandie

SME, IRRSUD

IJCLab - Orsay - UMR CNRS/IN2P3, Université Paris-Saclay

JANNuS –Orsay, IRMA 190 keV implanter, ARAMIS, Tandem-VdG 2 MV

LSI - Palaiseau, UMR CEA/DRF/IRAMIS, CNRS/INP, École Polytechnique

SIRIUS, 2.5 MeV electron accelerator

SRMP - CEA Paris Saclay

JANNuS Saclay, EPIMETHEE, JAPET, PANDORE

SRMA - CEA Paris Saclay

HVTEM (1.2 MeV electrons)

INSP - Paris-Sorbonne University

SAFIR, 2.5 MV VdG accelerator

LCP - Orsay Université Paris-Saclay

ELYSE, electron accelerator

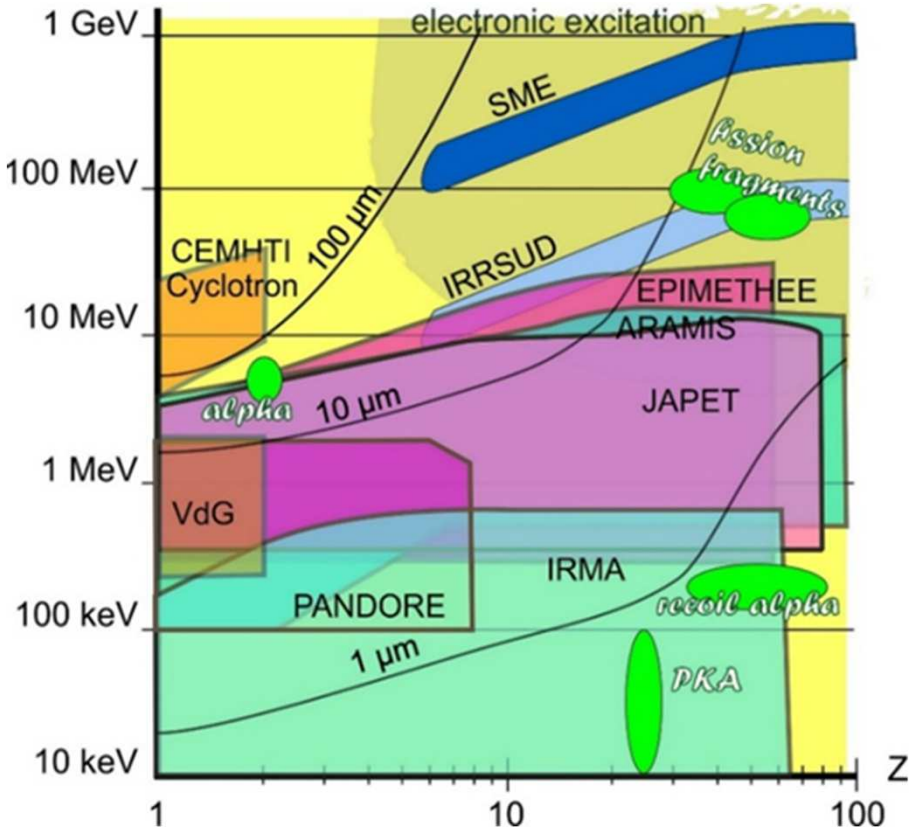
8 platforms
13 accelerators

Platforms	Accelerators	Beams	Commissioning/Age(years)	specifities
CEMHTI/INC	Cyclotron	p, d, He 10-45 MeV	1976 44	External beam/radiolysis
	Pelletron 3 MV	p, d, He, 0.5 - 3 MeV	2016 4	RBS, NRA, ERDA
IJCLab/IN2P3 JANNuS-Orsay	IRMA Implanter 190 kV	H – Bi 10 to 570 keV	1979 41	In-situ TEM
	ARAMIS Tandem - VdG 2 MV	H- Bi 0.5 to 11 MeV	1987 33	
CIMAP –GANIL INP	SME	C – U 4.5 to 13 MeV/A	1989 31	X-ray diffractometer High temp. furnace
	IRRSUD	C – U 0.3 to 1 MeV/A	2002 18	
SRMP/CEA JANNuS -Saclay	EPIMETHEE	H – Bi (source ECR) 0. 5 to 50 MeV	2006 14	Triple beam chamber In-situ Raman
	JAPET	H – Bi 0.5 to 18 MeV	2009 11	
	PANDORE	H, D, He 0.5 to 2.5 MeV	2016 4	
SRMA/CEA	HVTEM	Electrons 0.3 to 1.2 MeV	1981 39	
LSI/INP	SIRIUS	Electrons 0.15 to 2.5 MeV	2013 7	
INSP/INP	SAFIR VdG 2,5 MV	P, d, He, C, N, O 100 keV to 2.5 MeV	1968 52	RBS, NRA, ERDA, MEIS
LCP/INC	ELYSE 2.5 MeV	Electrons 3 to 9 MeV	2002 18	Impulsions ps

Large domain

Z – Energy

Z = 1 -> 92 and 10 keV to GeV



These platforms are very complementary (energy, ions) to study irradiation effects in materials

Objectives of EMIR&A

- Organize access to the facilities
- Structure the network of platforms and create a link between these facilities,
- Organize the welcome of research teams (also internationally) at the facilities.
- Promote their evolution in order to better meet the demands of users and research programs.
- Lead our scientific community

- **Think tank, a place for scientific exchanges**
- **Catalyst for collaborations**
- **Force to respond to calls for proposals, ANR, European projects, ……**

Increase the visibility of the scientific community

Organisation

Direction

Nathalie Moncoffre, IP2I, Lyon
Marie-France Barthe, CEMHTI, Orléans,
Isabelle Monnet, CIMAP, Caen

Coordination Committee

Cédric Baumier, IJCLab, Orsay
Eymeric Briand, INSP, Paris
Céline Cabet, CEA SRMP, Jannus, Saclay
Amine Cassimi, CIMAP, Caen
Sergey Denisov, LCP, Orsay
Aurélie Gentils, IJCLab, Orsay
Mehran Mostafavi (LCP, Orsay)
Michèle Raynaud, LSI, Palaiseau
Thierry Sauvage, CEMHTI, Orléans
Ollivier Tissot, CEA SRMA, Saclay
Ian Vickridge, INSP, Paris

Scientific Committee

- Serge Bouffard, Caen,
- Krzysztof Bobrowski (Institute of Nuclear Chemistry and Technology, Warsaw, PL)
- Stephen Donnelly (University of Huddersfield, West Yorkshire, GB)
- Denis Jalabert (CEA, Grenoble)
- Katharina Lorenz (Technical University, Lisbonne, P)
- **Robin Schaeublin** (Centre of Research in Plasma Physics, PSI, Villigen, CH), **Président**
- Shamashis Sengupta, (IJCLab, Orsay)
- Guy Terwagne (Université de Namur, B)
- Thierry Wiss (JRC, Karlsruhe, D)

Scientific issues

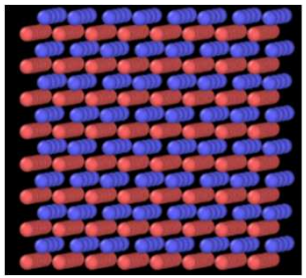
Fundamental research

Irradiation : A unique tool to create controled damage
⟶ understand the evolution of material microstructure and properties under irradiation

- **Nuclear materials**
  - Interactions defects-impurities
  - Role of grain boudaries
  - Chemical segregations
  - Irradiation induced-processes (diffusion, corrosion,radiolysis)
  - Evolution of properties /mechanical, magnetic, …

- **Theory – simulation**
  - Multi-scale modelling
  - Mesoscopic approach
  - Radiolysis effects (solids, interfaces solids/liquids)

Material modelling
Control of irradiation parameters (T, flux, dose)
Separate effect studies ⟶ mechanisms



- **Solid state physics**

Irradiation = tool to understand solid properties

- **Intrinsic properties- defects**
  - Defect trapping, …
  - Role of balistic damage/electronic excitation, synergetic effets
  - Defect annealing
  - Defect impact on supraconductivity/ferromagnetism
  - …

- **Material characterization**

Irradiation + i*n-situ* characterization
Damage evolution (SEM, TEM)

MET Jannus-Orsay
(© C. Baumier (CSNSM))

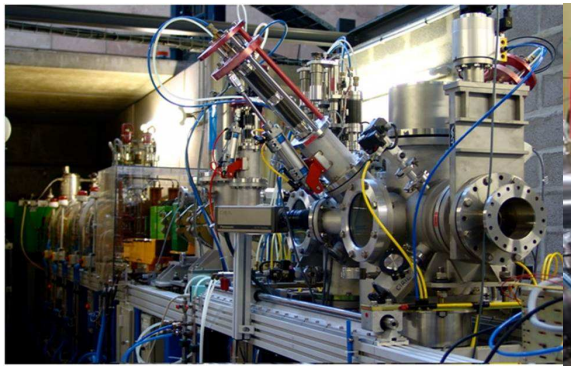
Applications

Nuclear energy (fission, fusion)

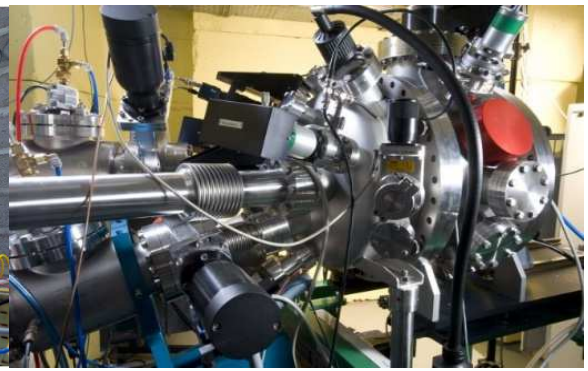
- **Material ageing: ions to simulate neutrons**
  all kinds of materials in the nuclear fuel cycle
- **Damage effects in different energy domains (dE/dx)**
- **Corrosion**
- **…**

Electronic

- **implantation**
- **smart-cut process**



In situ X-ray diffractometer
IRRSUD-GANIL



Triple beam chamber
JANNuS Saclay

Radiation environment

Robots for nuclear applications, satellites,
Space applications

Nanostructuration

Trace formation , nanopores for functionalisation …

Polymer reticulation

Cables, claddings, …

Ion beam analysis

- Light element analysis (H, He, C, O)
- Isotopic tracing for corrosion studies,
- Diffusion mechanisms,
- ….

- **Pulsed beams**
  - Radiolysis studies
  - Rapid kinetics processes

- **Importance of *in-situ* characterization tools**

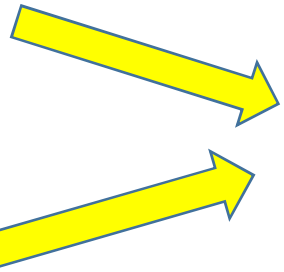
Experimental hall© INSP

Proposal evaluation

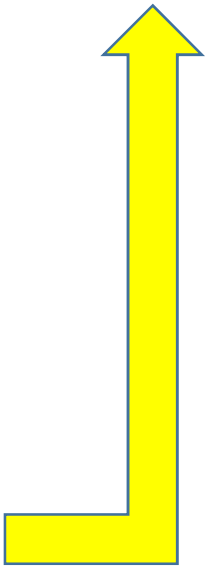
Réseau national d'accélérateurs pour l'irradiation et l'analyse des molécules et matériaux

Two evaluation modes

- **Pole 1:**
  Irradiation, Radiolysis
- **Pole 2:**
  Ion beam analysis



Scientific Committee

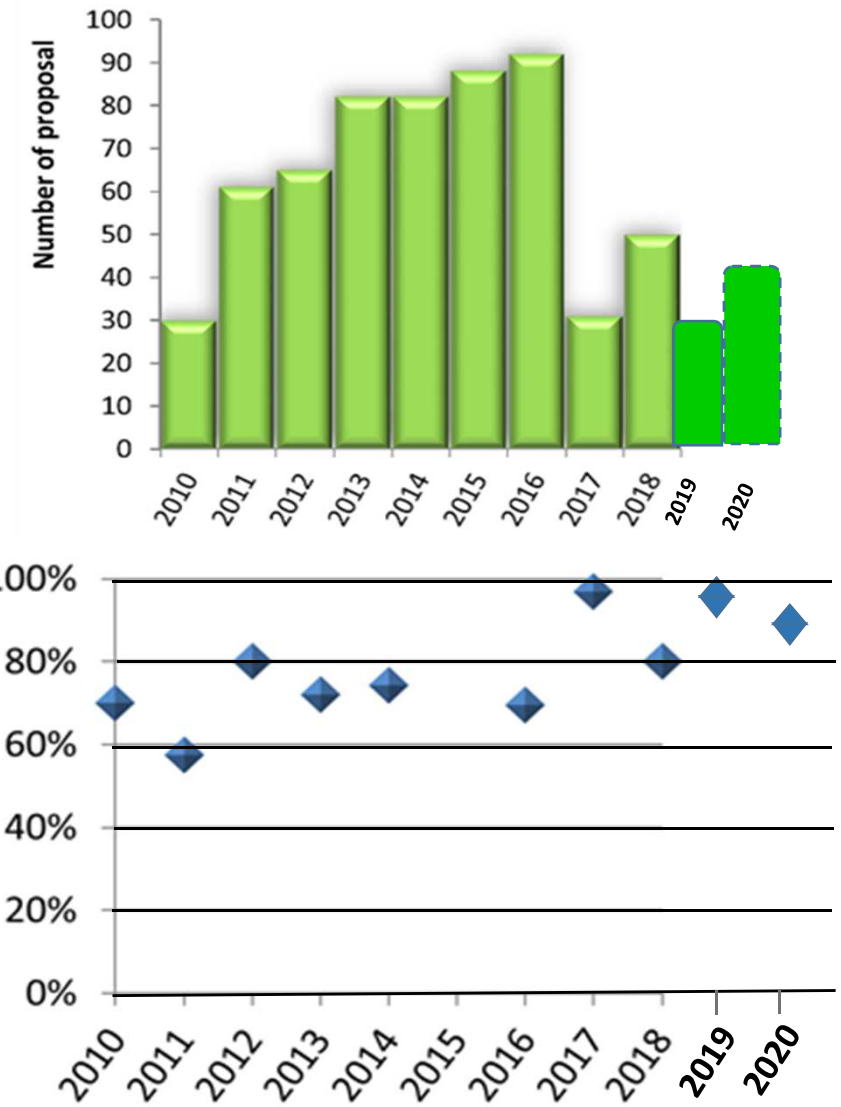


-> **A pump priming evaluation for short experiments**
< 3 days ------> **Platform team**

-> **For longer duration proposals**
(thesis, post-docs, ANR, European projects ...)

EMIR&A – some data

Platforms	Rates	EMIR&A Allocated beam time
CEMHTI	Free	10 weeks
CIMAP-GANIL	Free	~60 days
HVTEM	Free	5 days
LSI	1500 €/day	50 days
JANNuS-Orsay	2000€/exp.	5 (+1) weeks
JANNuS-Saclay	2000€/exp.	5 weeks
SAFIR	Free	A few weeks
ELYSE	Free	50 days



Communication - dissemination

Réseau national d'accélérateurs pour l'irradiation et l'analyse des molécules et matériaux

- **The EMIRUM workshop (EMIR User Meeting)**
  - allows users to present their results.
  - opportunity for informal and very fruitful exchanges.

The next EMIRUM is planned in January 2021 at LSI, Ecole Polytechnique

Set up a session dedicated to technical aspects / accelerator operation
→ invite the engineers and technicians of EMIR&A's installations.

IBAF's RASTA (Réseau d'Aides Scientifiques et Techniques des Acélérateurs) network could be extended to EMIR&A.

- **To organize thematic schools for students and young researchers**

- **Develop the website** http://emir.in2p3.fr
  Sébastien Grégoire, Cédric Baumier, IJCLab

Projects for EMIR&A

Réseau national d'accélérateurs pour l'irradiation et l'analyse des molécules et matériaux

Frame: Renewal of the research infrastructure

➡ New platforms ?

→ Improve national and international attractiveness

→ Federate the scientific community around accelerators for the study of materials and molecules

→ Provide the scientific community with unique on line irradiation

→ facilities and instrumentation : original, complementary

Conditions : - opening rate at least of 30 %
- enhanced help to experiments for non-specialists

Equipex+ ?

Structuring equipments for research – PIA3

TEM, DRX line-IJCLab, Baby Pelletron-CEMHTI, VdG-CIMAP, Acc. Compact-INSP

Thank you !

http://emir.in2p3.fr