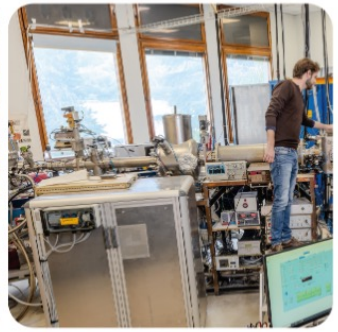
Journées et Inauguration de la plateforme mosaic

IJCLab Irène Joliot-Curie
Laboratoire de Physique des 2 Infinis

mosaic

cnrs NUCLÉAIRE & PARTICULES

université PARIS-SACLAY



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

Un grand merci aux sponsors de ces journées :

université PARIS-SACLAY GRADUATE SCHOOL Physique — P2I Physique des deux Infinis

INSTITUT INTÉGRATIF DES MATÉRIAUX — université PARIS-SACLAY

INSTITUT DE L'ÉNERGIE SOUTENABLE — université PARIS-SACLAY

https://indico.ijclab.in2p3.fr/event/10674

25 septembre 2024 - 10h au
26 septembre 2024 - 17h45

Auditorium Joliot Curie (IJCLab)
Bâtiment 100

MOSAIC, a multidisciplinary ion beam facility for research and training in Orsay

mosaic

Operations manager: Cyril Bachelet
Operations deputy manager: Isabelle Ribaud
Scientific leader: Aurélie Gentils

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

Creation of MOSAIC in 2023 = fusion of 2 platforms having an IN2P3 label

NUCLÉAIRE & PARTICULES

ANDROMEDE — Bât. 201 Hall super ACO

JANNUS SCALP — Bât. 108

Numerous ion accelerators and microscopes

mosaic

Facility open to

industrials
academics
students

Member of the EMIR&A French accelerator federation Research Infrastructure

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

https://mosaic.ijclab.in2p3.fr

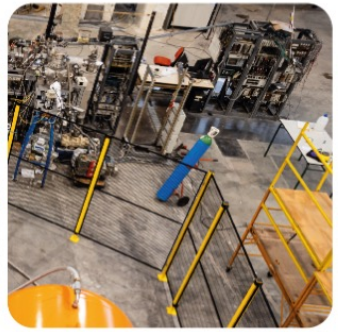
MOSAIC, a multidisciplinary platform with complementary equipment

mosaic

Ion beams for …

… synthesis, modification, and analysis of materials,

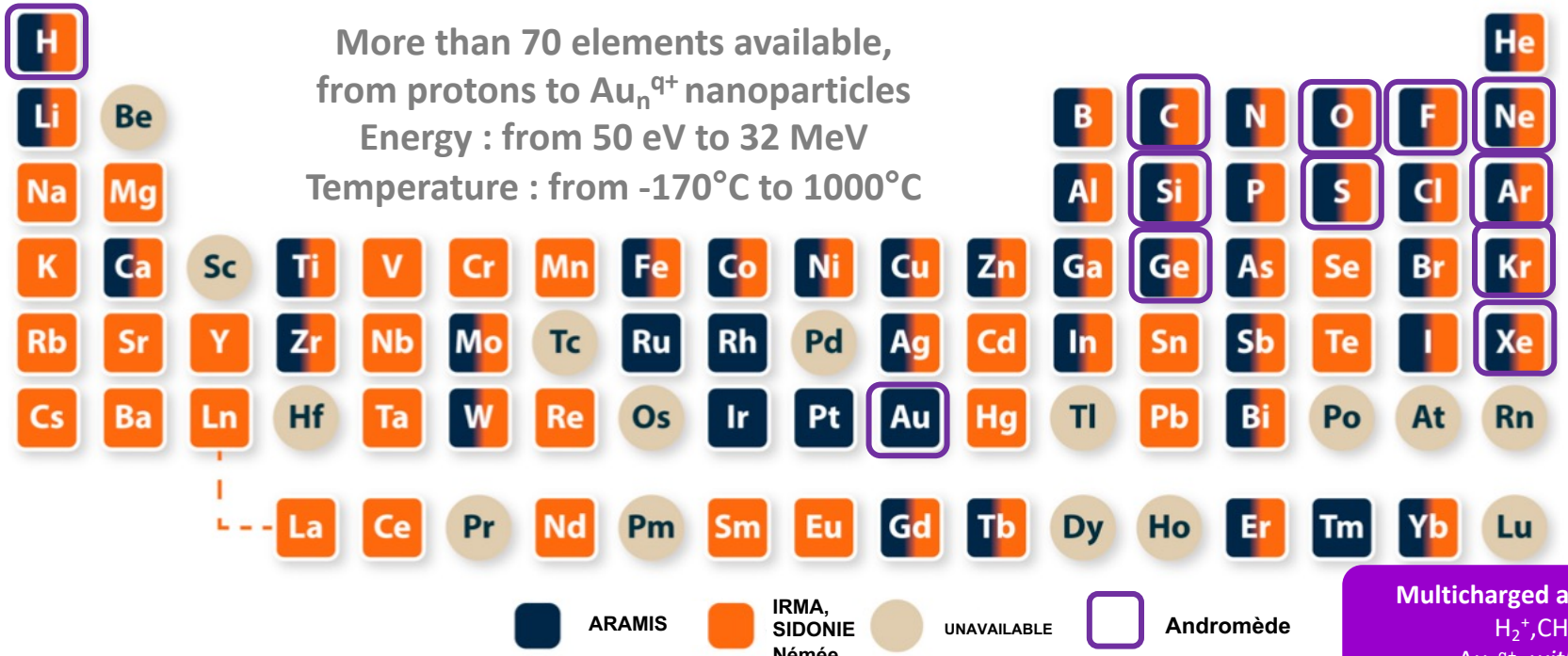
… and ion-matter interactions studies



A large variety of elements available

mosaic

More than 70 elements available,
from protons to Au_n^{q+} nanoparticles
Energy : from 50 eV to 32 MeV
Temperature : from -170°C to 1000°C



Complementary ion sources

Multicharged atomic and molecular ions
H_2^+, CH_n^{q+}, $C_2H_5^+$, SFn^+, …
Au_n^{q+} *with n/q from 1 to 1600*

4 MV Andromède

2 MV ARAMIS

400 kV Némée

190 kV IRMA

40 kV SIDONIE

50 eV — 1 keV — 10 keV — 100 keV — 1 MeV — 10 MeV — 32 MeV

MOSAIC: ion beams for pluridisciplinary science

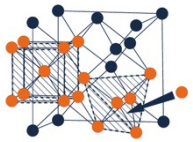
Deposition
High purity isotope deposition (eV)

Doping
Stable elements
Ion beam synthesis

Solid

Irradiation
Low energy ions (KeV)
'High' energy ions (MeV)

Ion-matter interactions
Nuclear reactions



Elemental and molecular composition, evolution of the microstructural modifications at the nanoscale

Characterization (*ex* & *in situ*)

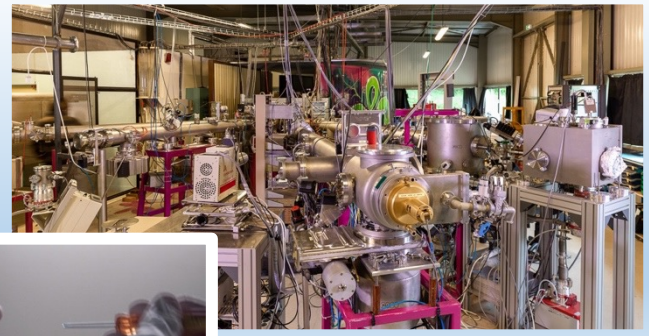
Ion Beam Analysis (RBS, channelling, ERDA, PIXE)
In situ RBS-C (with implantation)
Transmission Electron Microscopy (TEM)
In situ TEM (single/dual ion beam)
Mass spectrometry analysis (ToF-SIMS with MeV gold nanoparticles)
Surface analysis (SEM, AFM) & sample preparation

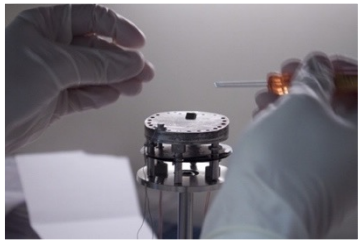
Ion beams for ….

… synthesis, modification of materials, and ion-matter interactionS

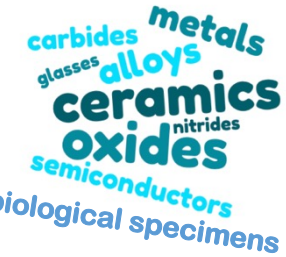
4 MV Andromède | 2 MV ARAMIS | 400 kV Némée | 190 kV IRMA | 40 kV SIDONIE | 30 kV Tancrède

Ion irradiations and implantations

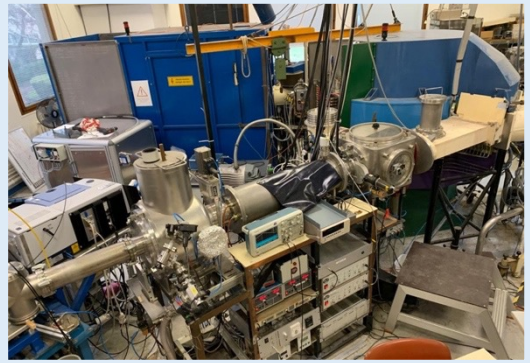




71 available elements,
from protons to Au_n^{q+} nanoparticles
Energy : from 50 eV to 32 MeV
Temperature : from -170°C to 1000°C



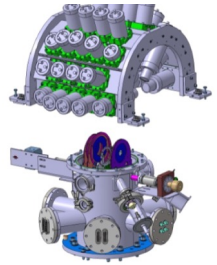
High purity isotopic deposition



In situ nuclear reactions measurements

NewJedi experiment

Stella experiment



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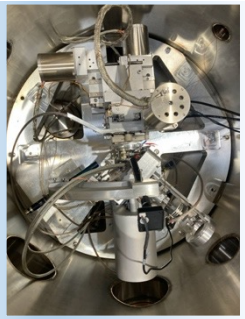
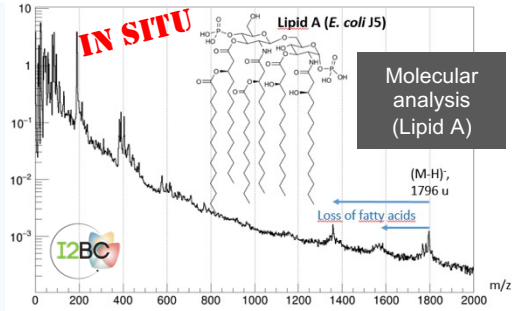
Ion beams and tools for ….

… analysis of materials and biological specimens

Mass spectrometry analysis

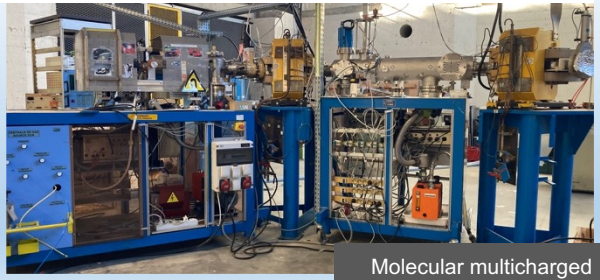
EVE : MeV Nanoparticles ToF SIMS @ Andromede





Ionic and electronic emissions

TANCREDE + UHV analysis chamber or EDEN

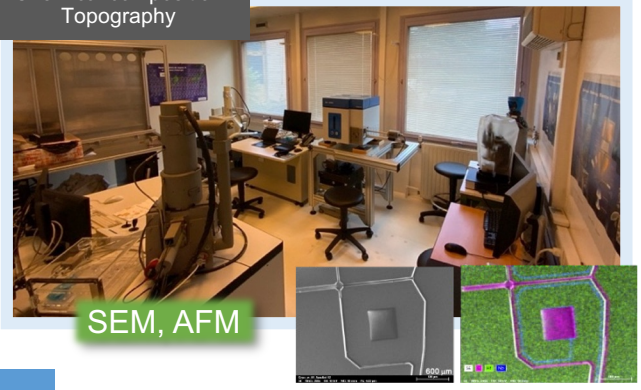


Molecular multicharged ions impact

Surface analysis

Scanning Electron Microscopy
Atomic Force Microscopy

Chemical composition
Topography

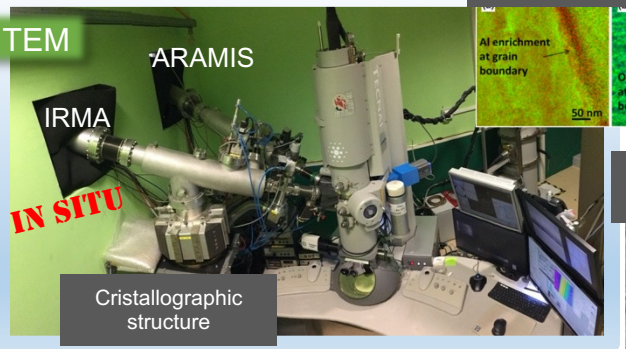


SEM, AFM

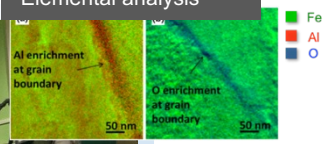
Observation and analysis of microstructure evolution of a material at the nanoscale

In situ dual ion beam Transmission Electron Microscopy

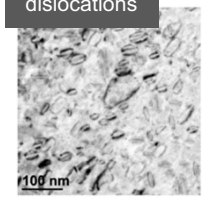
200 kV TEM



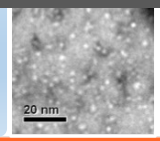
Elemental analysis



Loops, dislocations



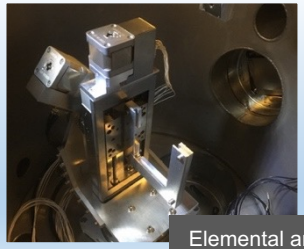
Cavities and bubbles



Cristallographic structure

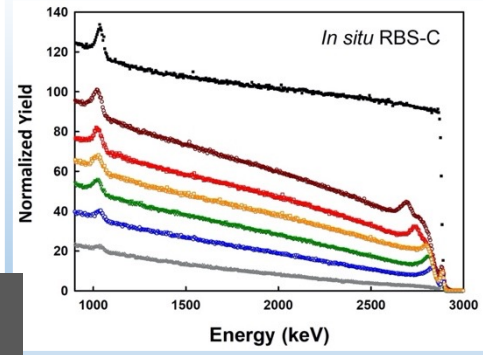
Ion Beam Analysis

ARAMIS, IRMA
RBS, channelling, ERDA, PIXE, PIGE



IN SITU

Elemental analysis, damage (displaced atoms), depth profiles…



https://mosaic.ijclab.in2p3.fr

Positioning outside the lab

IN2P3 / CNRS, Universities, national (GdRs), international

Academics | **Training** | **Industrials** | **European programmes**

Building 201
- Andromède
- Tancrède
- Némée

Building 108
- SIDONIE
- IRMA
- ARAMIS
- TEM

EQUIPEX ANR-10-EQPX-23 2011-2020

since 2021

mosaic

https://mosaic.ijclab.in2p3.fr

Scientific Interest Group
GIS JANNuS (since 2005)

- JANNuS-Saclay
  CEA, ISAS, DES/DRMP/S2CM/SRMP
- Hall JANNuS-Orsay

Joint Accelerators for Nano-science and Nuclear Simulation
https://jannus.in2p3.fr

founding members

French accelerators network for Irradiation and Analysis of Materials and Molecules

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

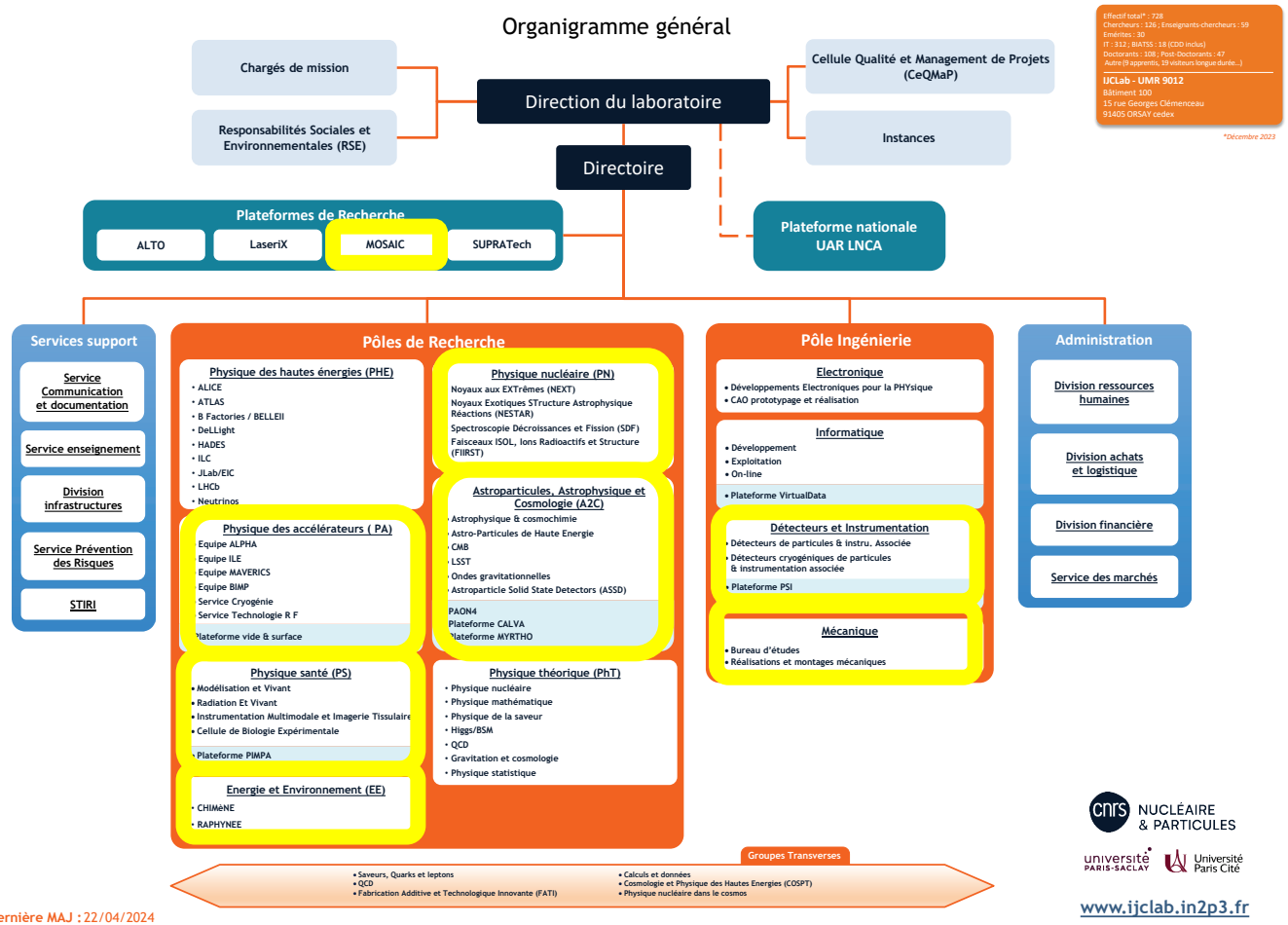
French Research Infrastructure

https://emira.in2p3.fr

CEA Saclay ISAS (JANNuS-Saclay, HVEM), NIMBE Saclay (ALIENOR, LEEL), CEMHTI Orléans (Pelletron), CIMAP Caen (GANIL), ICP Orsay (ELYSE), **IJCLab Orsay (MOSAIC)**, INSP Paris (SAFIR), LSI Palaiseau (SIRIUS), LP2I Bordeaux (AIFIRA)

EMIR&A president: Nathalie Moncoffre (IP2I Lyon)
Président of the EMIR&A International Scientific Committee: Robin Schaeublin (ETH Zurich)

Positioning within the lab



Strong implication of

- ✓ E&E pole (CHIMENE)
- ✓ Nuclear Physics pole (FIIRST)

Internal users :

- ✓ Energy & Environment pole (CHIMENE)
- ✓ Nuclear Physics pole (FIIRST)
- ✓ Physics for Health pole (REV)
- ✓ A2C pole (ASSD, Astrophys. and Cosmochemistry)
- ✓ Accelerators pole (MAVERICS)
- ✓ Engineering pole (detectors, mechanics/additive manufacturing,…)
- ✓ …

Staff and local contacts

10.3 FTE per year for operations and development of the facility

10 permanents (9 CNRS/IN2P3 and 1 Université Paris-Saclay employees)
+ 1 CNRS AI fixed-term funded by IJCLab in 2023 and 2024

Cyril Bachelet, Cédric Baumier, Philippe Benoit-Lamaitrie, Jérôme Bourçois, Bryan Bragance, François Daubisse, Laurent Delbecq, Silvin Hervé, Florian Pallier, Sandrine Picard, Isabelle Ribaud

2.75 FTE per year from *Nuclear Physics* and *Energy and Environment* poles, IJCLab

local contacts / scientific leading

Serge Della Negra, Frédérico Garrido, Aurélie Gentils, Stéphanie Jublot-Leclerc, Isabelle Ribaud

Average 2 FTE per year from Engineering pole and IJCLab support services

+ FTE on projects

Beam time attribution : call for proposals and paid services

Internal IJCLab users

Request beam time form

External academic users

E-mail + request beam time form

External users
(***in situ*** **TEM** or **Andromède/EVE**)

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

Online submission (EMIR&A web site)

Internal scientific committee
each 3 months / annual for Andromède

Internal Scientific Committee (CSI), composed of:

- Operation managers (Cyril Bachelet, Isabelle Ribaud)
- Scientific leader (Aurélie Gentils)
- Direction or a representative of the lab direction (Fadi Ibrahim / Frédérico Garrido)
- Representatives of internal users (E&E, Nucl. Phys., Health poles) Stéphanie Jublot-Leclerc, Faïrouz Hammache, Charles-Olivier Bacri
- Persons in charge of Microscopies and Accelerators (Jérôme Bourçois, Cédric Baumier)

Referees + EMIR&A international scientific council + internal technical review *(each year, approx. sept.-oct.)*

E-mail + form

Industrials

Programming

mosaic@ijclab.in2p3.fr

Urgent requests
Internal users

E-mail

Time sheets

European programmes

Beam time attribution - Programming

Programming

by the person in charge of the accelerators
and if needed, with help from facility managers
or/and committee

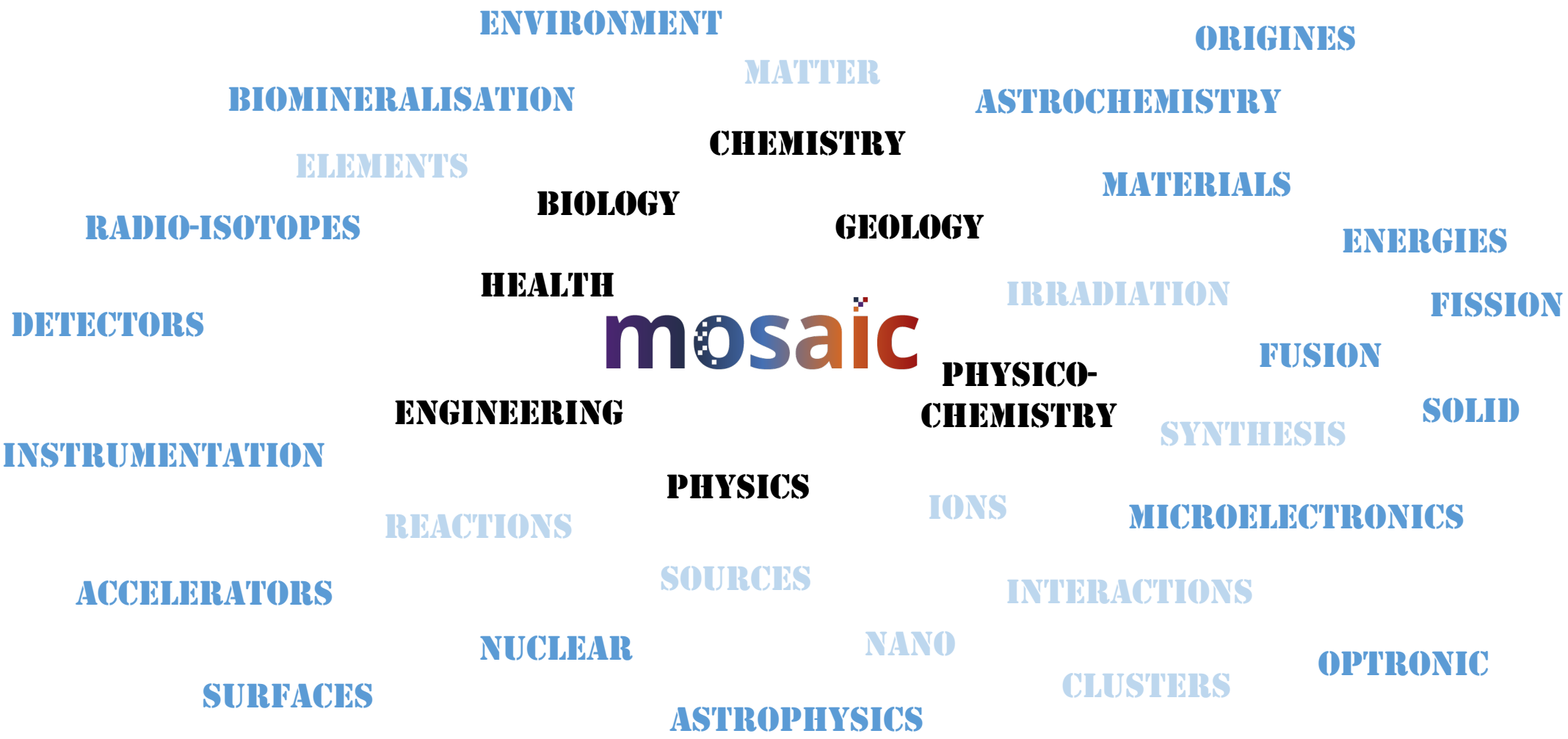
mosaic@ijclab.in2p3.fr

Sidonie	IRMA	ARAMIS	TEM	Andromède
ARAMIS+IRMA	TEM+ARAMIS+IRMA			Tancrède
TEM+IRMA	TEM+ARAMIS			Némée

8h per day
from Monday to Friday

except some experiments 24/7 at Andromede

Scientific themes



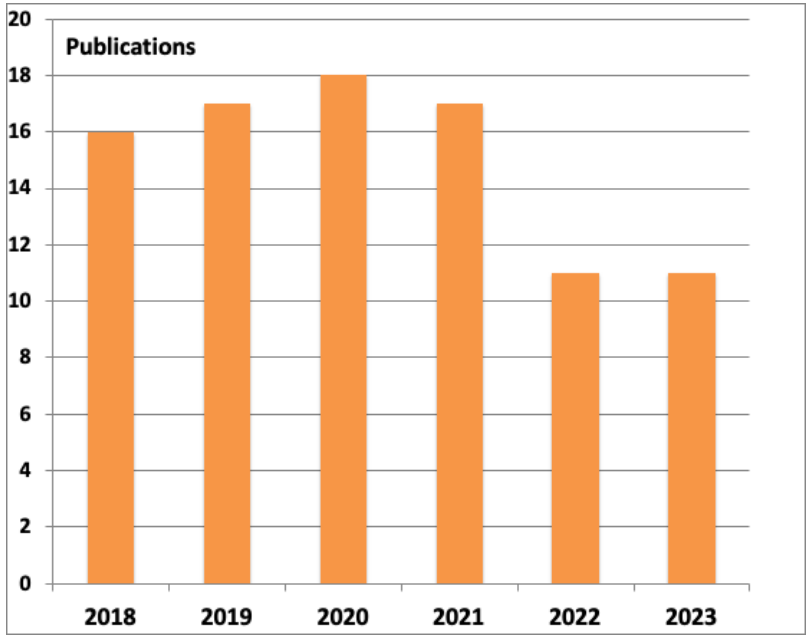
Publications and PhD thesis

- Yearly distribution of peer-reviewed publications related to experiments performed at MOSAIC

✓ Users must send the **DOI** of each publication to mosaic@ijclab.in2p3.fr

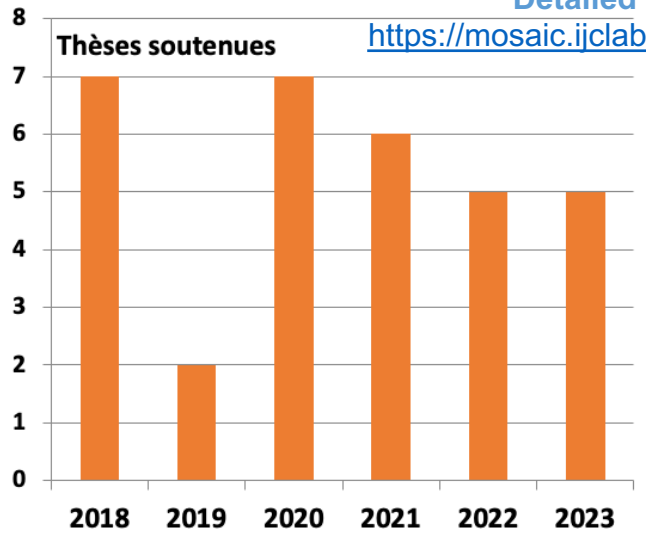
✓ MOSAIC collection created in HAL https://hal.science/IJCLAB-MOSAIC/

✓ This collection is automatically linked to the facility web site Publications page



- Number of PhD thesis defence per year, to our knowledge, during which MOSAIC beam time has been used

Detailed list at https://mosaic.ijclab.in2p3.fr/theses/



Mainly **Université Paris-Saclay**
But also Université Paris Sciences et Lettres, Université d'Orléans, Université de Caen, Université de Toulouse, Université de Lyon, Université de Poitiers, Université de Limoges, Université Grenoble Alpes, Université de Strasbourg, EPFL Switzerland, Queen's University Canada, Univ Wisconsin-Madison USA, NRNU MEPhI Russia, Université des Sciences et de la Technologie Houari-Boumédiène, Algeria

How it started …

- 1967 Mise en service de Sidonie

NUCLEAR INSTRUMENTS AND METHODS 84 (1970) 37–44; © NORTH-HOLLAND PUBLISHING CO.

SIDONIE, THE NEW ELECTROMAGNETIC ISOTOPE SEPARATOR AT ORSAY

PART I: DESIGN AND CONSTRUCTION

J. CAMPLAN, R. MEUNIER and J. L. SARROUY

Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse du Centre National de la Recherche Scientifique, B.P. n° 1, 91–Orsay, France

Received 16 March 1970

A new electromagnetic isotope separator designed for the separation of transplutonium elements as well as for the preparation of extremely pure samples of stable isotopes is described. The analysing magnet is a sector type with inhomogeneous field ($n \approx 0.5$). As a consequence the dispersion and the transmission are high. Shims have been added which allow a wide mass range to be focused simultaneously. Correcting profiles, set on the entrance face of the magnet, decrease its radial aberration to about 0.2 mm. With a 7 mA beam, the intensity distribution at the focus, obtained with the improved magnet and a new electrode geometry, is such that about 90% of the intensity passes through a 1 mm wide slit. A liner is enclosed inside the vacuum chamber in order to facilitate the decontamination or the recovery of expensive materials. Plastic bags can be adapted to all openings so as to avoid contaminating external surfaces of the separator.

How it started …

- 1967 Mise en service de Sidonie
- 1979 Mise en service d'IRMA, couplage avec un MET au début des années 80

Nuclear Instruments and Methods 189 (1981) 193–198
North-Holland Publishing Company

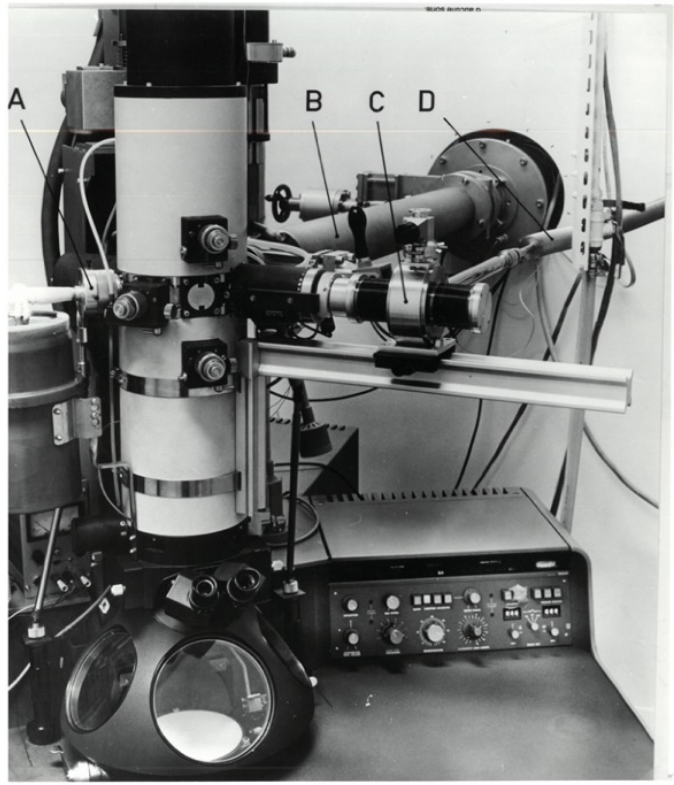
A MEDIUM ENERGY FACILITY FOR VARIABLE TEMPERATURE IMPLANTATION AND ANALYSIS

Jacques CHAUMONT, François LALU, Michel SALOME, Anne-Marie LAMOISE
Laboratoire René Bernas, 91406 Orsay, France

and

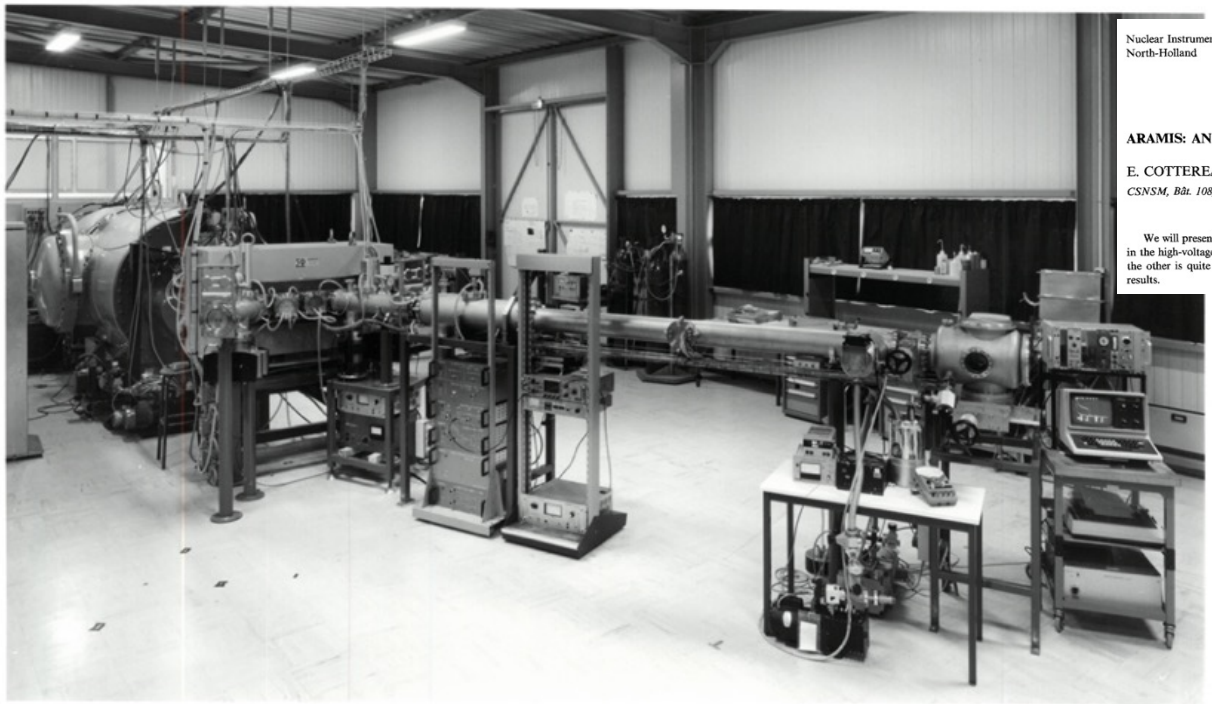
Harry BERNAS
Institut de Physique Nucléaire, 91406 Orsay, France

We describe the new ion implantation system at Orsay, which operates from 5 to 190 kV. Sixty-five elements from H to U have been implanted in insulators, semiconductors or metals. Significant currents (several μA) of three-fold ionized elements have been implanted at energies up to 570 keV. Details are provided on the target-holders used, particularly on a variable temperature (1.7–300 K) cryostat and a variable temperature (80–300 K) goniometer, and on an in situ Rutherford back-scattering analysis set-up (using the 380 keV He^{2+} beam) used in conjunction with all these target-holders. The latter system is used for studies of metastable low-temperature implanted alloys: specific examples will be given.



How it started …

- 1967 Mise en service de Sidonie
- 1979 Mise en service d'IRMA, couplage avec un MET au début des années 80
- 1987 Mise en service d'ARAMIS



Nuclear Instruments and Methods in Physics Research B45 (1990) 293–295
North-Holland

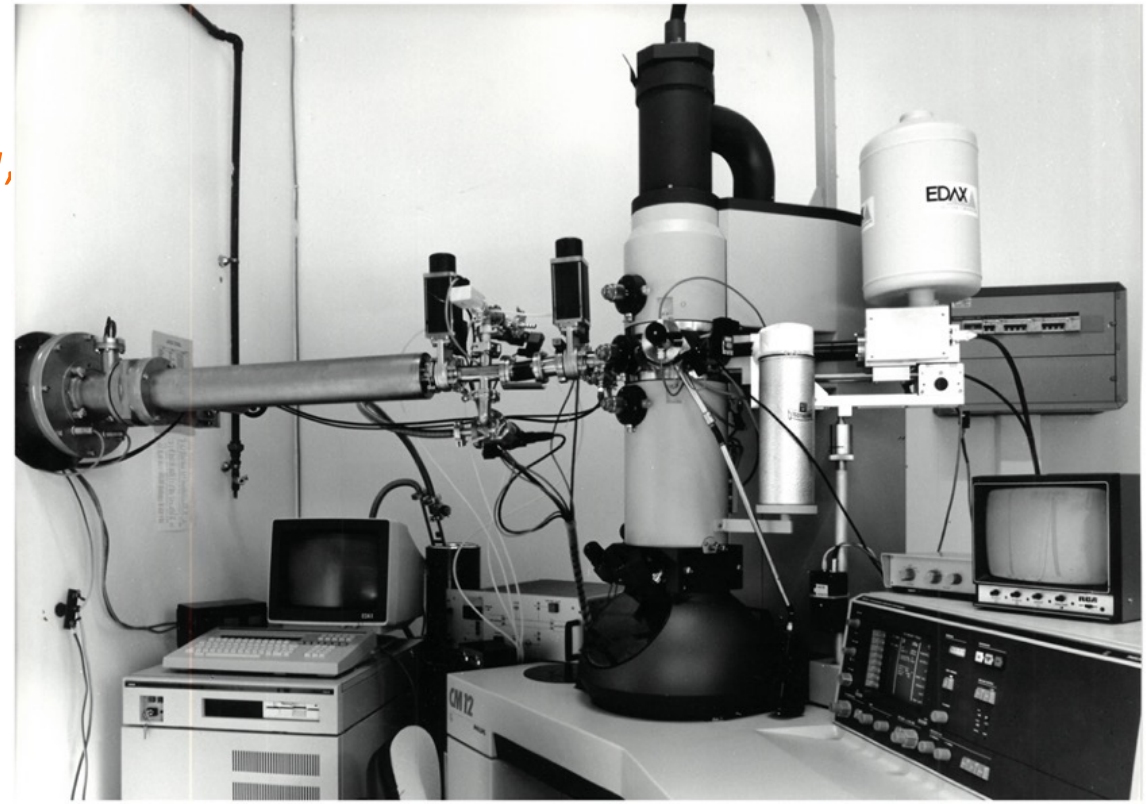
ARAMIS: AN AMBIDEXTROUS 2 MV ACCELERATOR FOR IBA AND MeV IMPLANTATION

E. COTTEREAU, J. CAMPLAN, J. CHAUMONT, R. MEUNIER and H. BERNAS
CSNSM, Bât. 108, F-91405 Orsay Campus, France

We will present the 2 MV accelerator that we built at our laboratory. ARAMIS is a tandem accelerator with a positive-ion source in the high-voltage terminal so that it can be operated both in the tandem and in the single-ended mode. Tuning from one mode to the other is quite easy so that the implantation or irradiation of samples can be followed periodically with RBS. We show some results.

How it started …

- 1967 Mise en service de Sidonie
- 1979 Mise en service d'IRMA, couplage avec un MET au début des années 80
- 1987 Mise en service d'ARAMIS
- 1994 Mise en service d'un nouveau MET *in situ*, couplé à IRMA



How it started …

- 1967 Mise en service de Sidonie
- 1979 Mise en service d'IRMA, couplage avec un MET au début des années 80
- 1987 Mise en service d'ARAMIS
- 1994 Mise en service d'un nouveau MET *in situ*, couplé à IRMA
- 1997 Développement de Tancrède

TANCREDE : DES IONS MOLECULAIRES MULTICHARGES AVEC UNE SOURCE ECR

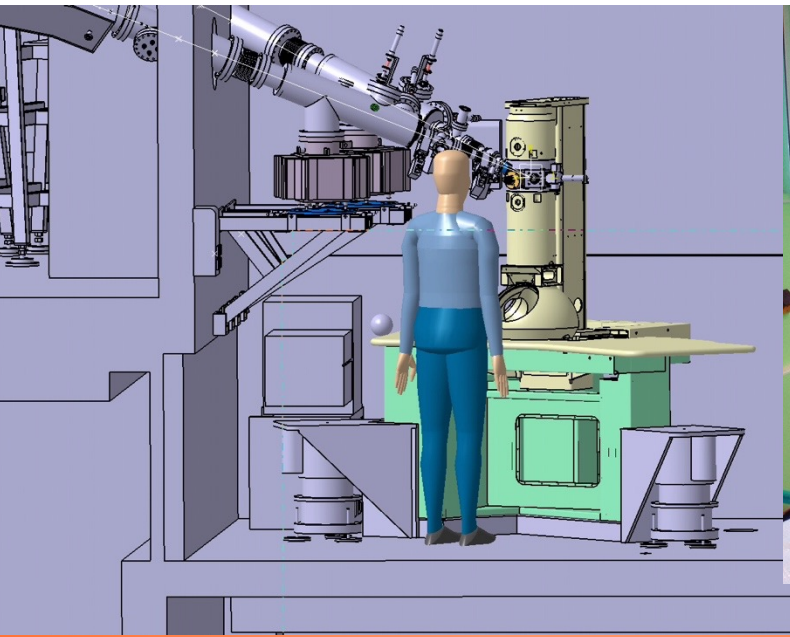
S. DELLA-NEGRA, J. DEPAUW, D. JACQUET, X. BIQUARD[a], D. HITZ[a]

TANCREDE : multicharged molecular ions produced by 16 GHz electron cyclotron resonance (ecr) ion source

The fullerene ions were produced by evaporating fullerene powder to introduce into the secondary stage of a 16 GHz ECR ion source. In order to limit fragmentation of fullerene ions in the source, the RF power was kept below 20 W. Relative intense multicharged ion beams of a few nA (C_{60}^{2+}) and a several hundred pA (C_{60}^{3+5+}) have been extracted.. The role of gas (He, Ne, Ar) has been studied.

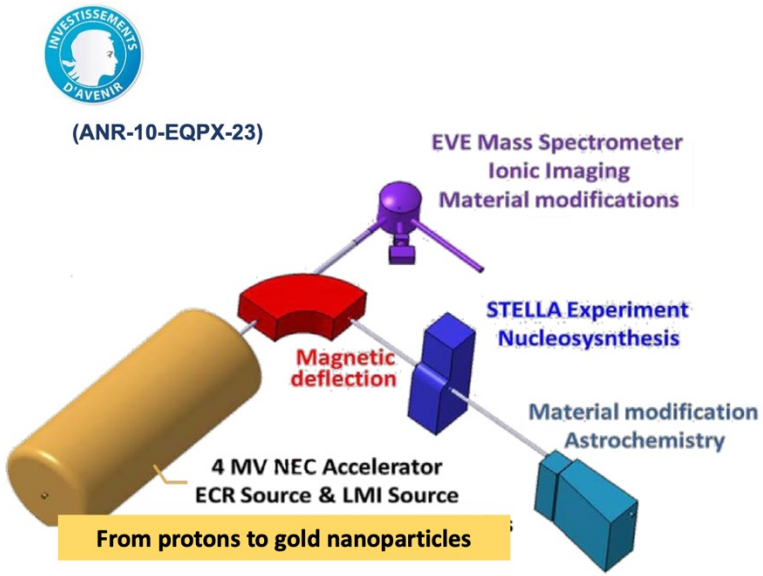
How it started …

- 1967 Mise en service de Sidonie
- 1979 Mise en service d'IRMA, couplage avec un MET au début des années 80
- 1987 Mise en service d'ARAMIS
- 1994 Mise en service d'un nouveau MET *in situ*, couplé à IRMA
- 1997 Développement de Tancrède
- 2009 Mise en service d'un nouveau MET *in situ*, couplé à IRMA et ARAMIS



How it started …

- 1967 Mise en service de Sidonie
- 1979 Mise en service d'IRMA, couplage avec un MET au début
- 1987 Mise en service d'ARAMIS
- 1994 Mise en service d'un nouveau MET *in situ*, couplé à IRMA
- 1997 Développement de Tancrède
- 2009 Mise en service d'un nouveau MET *in situ*, couplé à IRMA
- 2011 Equipex Andromède (ANR-10-EQPX-23)
- 2017 Labellisation IN2P3, ouverture de l'accès à Andromède
- 2020 Clôture de l'Equipex Andromède



How it started …

- 2021 Extension du hall expérimental JANNuS-Orsay (ARAMIS, IRMA, MET et lignes associées)

Coordination CPER P2IO L. Pinot, *V. Chambert*	Suivi opération (IJCLab) C.Bachelet, L.Delbecq, A. Gentils, *N.Pauwels, C.O. Bacri*
Suivi administratif Université Paris-Saclay C. Georges	Maitrise d'ouvrage Université Paris-Saclay, L. Larthe

Extension of 280 m^2
⇒ 415 m^2 experimental hall + 1 room (users/ pratical lab works) + 1 staff room + 1 office

How it started …

- 1967 Mise en service de Sidonie
- 1979 Mise en service d'IRMA, couplage avec un MET au début des années 80
- 1987 Mise en service d'ARAMIS
- 1994 Mise en service d'un nouveau MET *in situ*, couplé à IRMA
- 1997 Développement de Tancrède
- 2009 Mise en service d'un nouveau MET *in situ*, couplé à IRMA et ARAMIS
- 2011 Equipex Andromède (ANR-10-EQPX-23)
- 2017 Labellisation IN2P3, ouverture de l'accès à Andromède
- 2020 Clôture de l'Equipex Andromède
- 2021 Extension du hall expérimental JANNuS-Orsay (ARAMIS, IRMA, MET et lignes associées)
- 2023 Création de MOSAIC
- 2023 Remise en service de Tancrède
- 2023 Déménagement de l'implanteur 400 kV Némée (IP2I Lyon)
- 2024 Inauguration de MOSAIC !

Creation in 2023 of a “new” facility

mosaic

- ✓ Having a large variety of ion and cluster beams
- ✓ Experts of specific *in situ* analysis devices, known worldwide
- ✓ Keeping the facility at the state-of-the-art with upgrades and developments associated to scientific projects
- ✓ Attractive interdisciplinary platform for research internships and PhD thesis
- ✓ A dedicated team welcoming all users (collaborations, services, practical works)

Merci pour votre attention

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Serge Della Negra, Frédérico Garrido, Aurélie Gentils, Stéphanie Jublot-Leclerc, Isabelle Ribaud

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