WELCOME

IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

A new European Laboratory.

Formed on 2020 by the merging of 5 Laboratories in Orsay-France

CSNSM	*Centre de Sciences Nucléaires et de Sciences de la Matière*
IPN	*Institut de Physique Nucléaire*
IMNC	*Imagerie et Modélisation en Neurobiologie et Cancérologie*
LAL	*Laboratoire de l'Accélérateur Linéaire*
LPT	*Laboratoire de Physique Théorique*

A few words about myself…

UNIVERSITE PARIS SUD 2020 université PARIS-SACLAY

09/99: Temporary research and education associate

10/2000: CNRS staff scientist at Institut de Physique Nucléaire d'Orsay (IPNO)

➢ Parity violation experiments:
PVA4 (Mainz, Germany), G0 (Jefferson

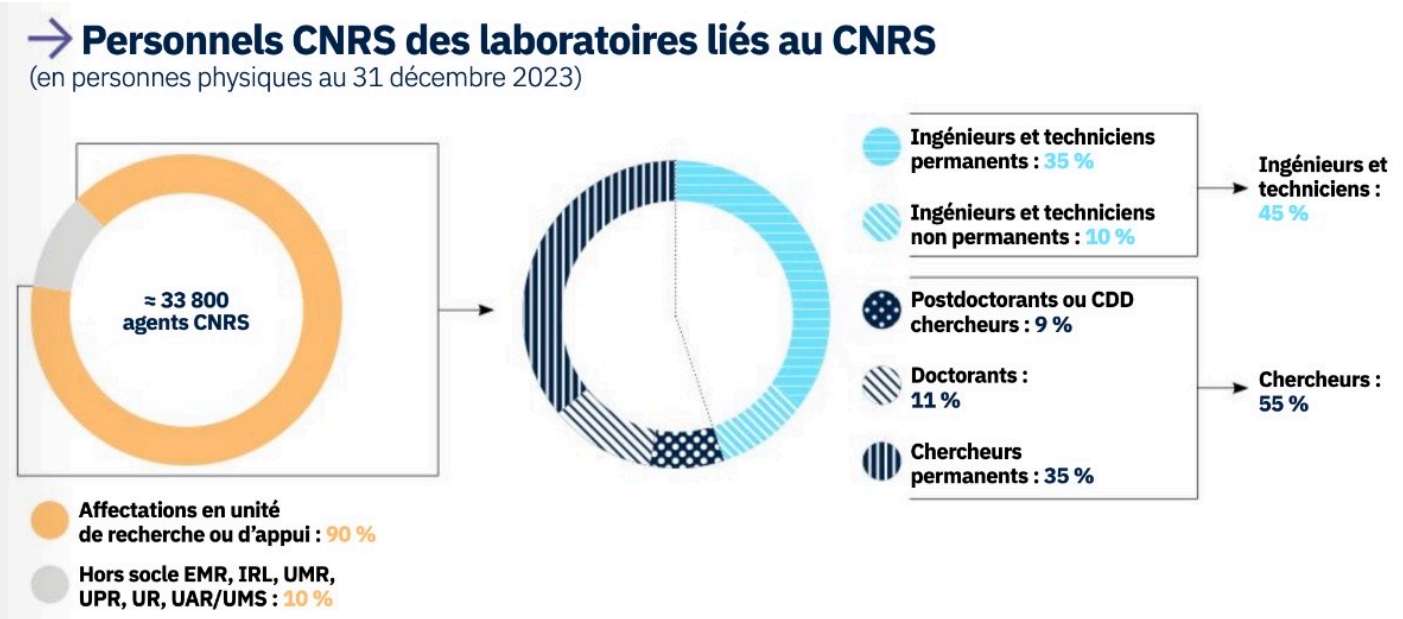
➢ Contribution to the analysis of the Jefferson Lab. (Hall A) VCS experiment.

➢ Radiative corrections to Virtual Compton Scattering
➢ Absolute enregy measurement of the electron beam of **Jefferson Lab**. (Hall A) through a magnetic method: the ARC project.

Up to Master 2 « Corpuscular Physics »

Since 2000: **G0 PV** exp.(Jlab/C), feasibility study for measuring proton Time-like EM Form Factors (**PANDA** exp. @FAIR, Darmstadt), **Jlab/B (p/nDVCS, HPS)**, **EIC @ BNL**

Centre
National de la
Recherche
Scientifique



Source : « Une année avec le CNRS », Rapport d'activité 2023, ISSN 1776-2154, juillet 2024.
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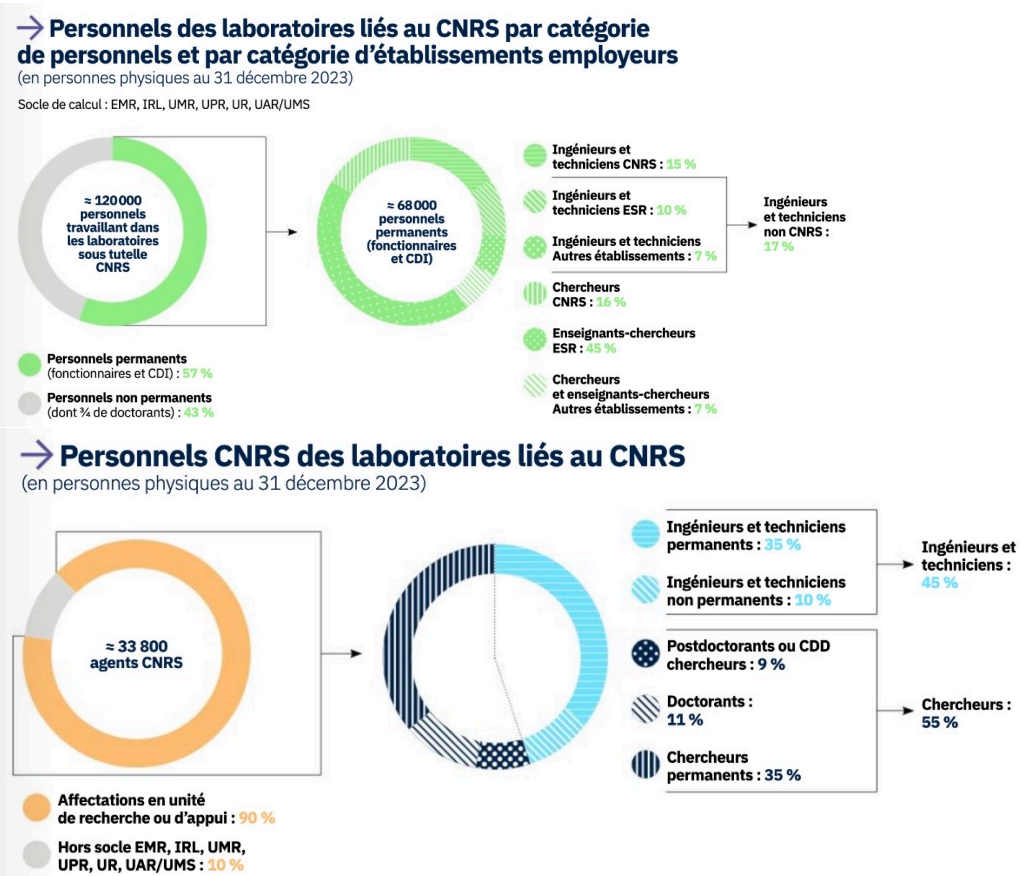
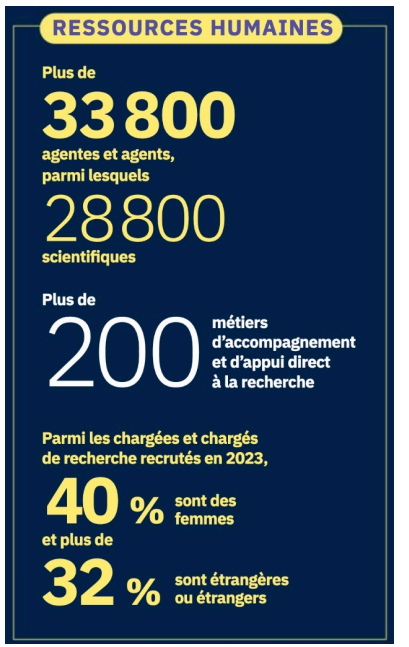
Centre National de la Recherche Scientifique





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Centre
National de la
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Scientifique

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Scientifique

- CNRS Biologie
- CNRS Chimie
- CNRS Écologie & environnement
- CNRS Ingénierie
- CNRS Mathématiques
- CNRS Nucléaire & particules
- CNRS Physique
- CNRS Sciences humaines & sociales
- CNRS Sciences informatiques
- CNRS Terre & Univers

Centre National de la Recherche Scientifique

Sonder les 2 infinis « Des particules au cosmos »

- CNRS Biologie
- CNRS Chimie
- CNRS Écologie & environnement
- CNRS Ingénierie
- CNRS Mathématiques
- **CNRS Nucléaire & particules**
- CNRS Physique
- CNRS Sciences humaines & sociales
- CNRS Sciences informatiques
- CNRS Terre & Univers

CNRS Nucléaire et particules

(Institut National de Physique Nucléaire et de Physique des Particules

Chiffres clés

1 050
Chercheurs et chercheuses titulaires dont

600 CNRS

450 universitaires

1 600
autres personnels permanents dont

600
ingénieurs et ingénieures de recherche

800
doctorants et doctorantes et post-doctorants et postdoctorantes

Situation au 30/04/2024

https://www.in2p3.cnrs.fr/sites/institut_in2p3/files/page/2024-06/FICHE_IN2P3_2024.pdf

NUCLÉAIRE
& PARTICULES

Chiffres clés

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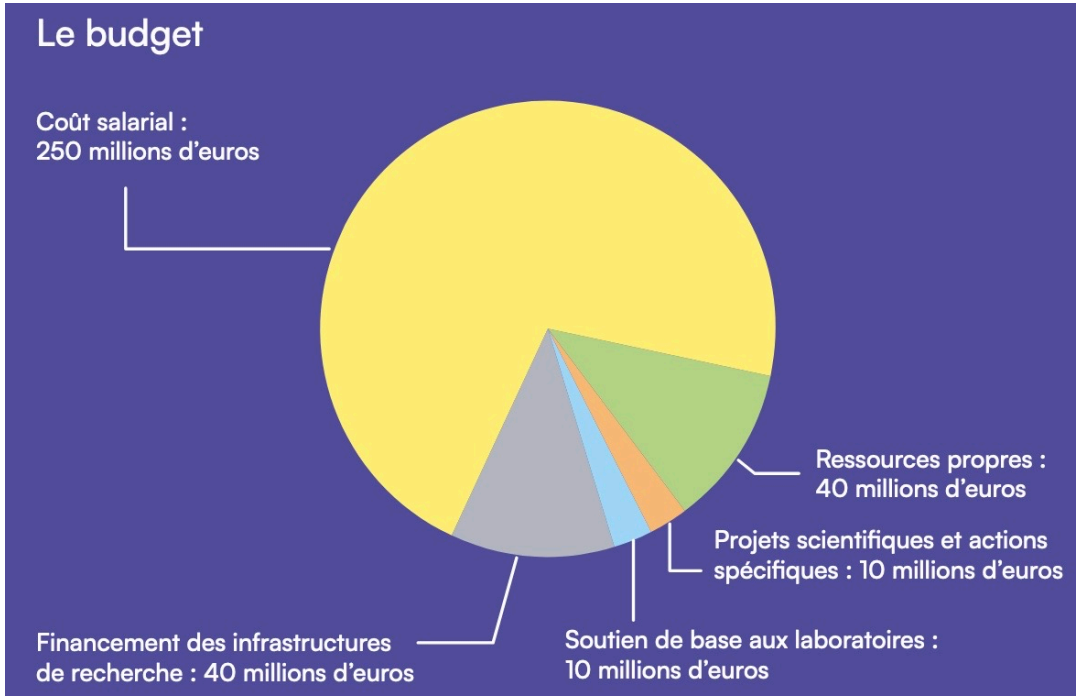


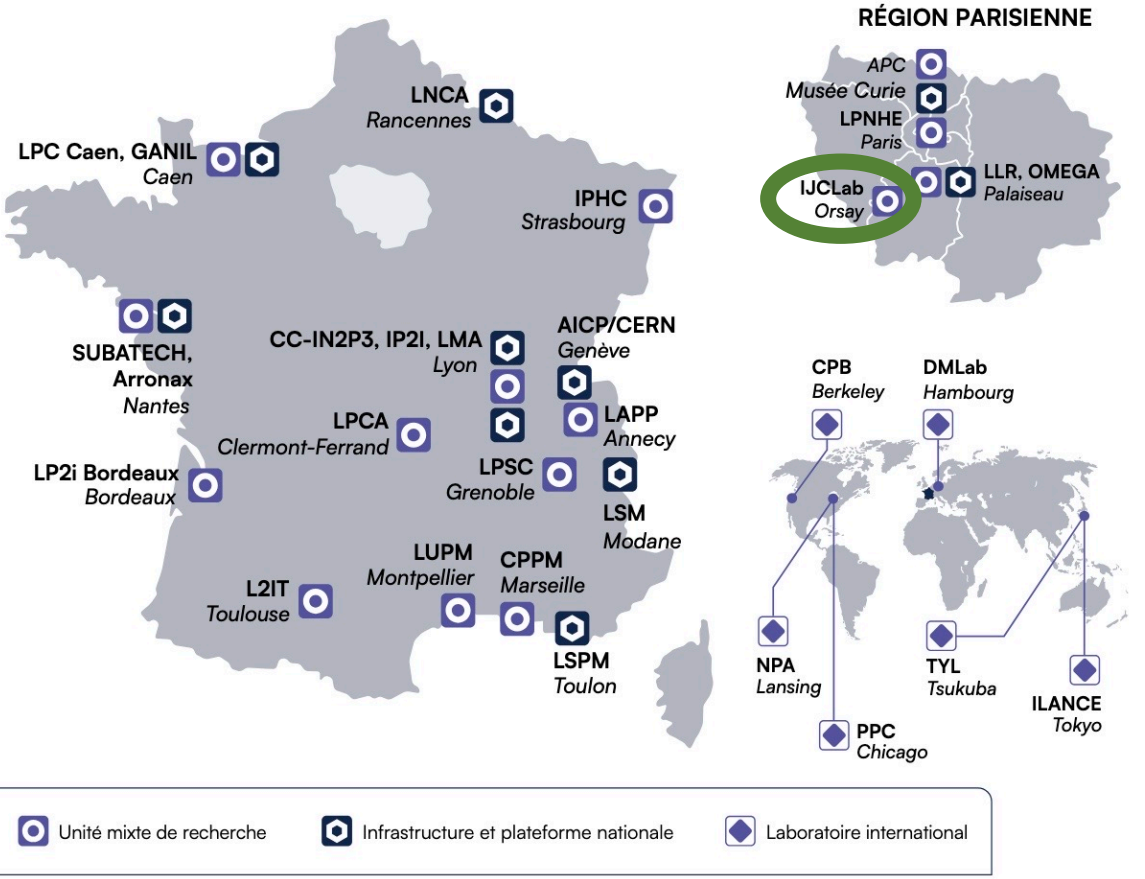
Guide pratique 2024 : https://www.in2p3.cnrs.fr/sites/institut_in2p3/files/page/2024-09/Guide%20IN2P3_2024_septembre_webHD.pdf

NUCLÉAIRE
& PARTICULES

10
infrastructures et plateformes nationales

16
grandes infrastructures de recherche

21
laboratoires nationaux et internationaux



Guide pratique 2024 : https://www.in2p3.cnrs.fr/sites/institut_in2p3/files/page/2024-09/Guide%20IN2P3_2024_septembre_webHD.pdf

Our Laboratory: *Institut de Physique des 2 Infinis Irène Joliot-Curie (IJCLab)*

https://www.ijclab.in2p3.fr/

created on 01/01/2020

Laboratoire de l'Accélérateur Linéaire

Laboratoire de l'Accélérateur Linéaire

Institut de Physique Nucléaire

Centre de Sciences Nucléaires et de Sciences de la Matière

Imagerie et Modélisation en Neurobiologie et Cancérologie

Laboratoire de Physique Théorique d'Orsay

Within the Orsay campus of Paris-Saclay University

IJCLab Irène Joliot-Curie Laboratoire de Physique des 2 Infinis

NUCLÉAIRE & PARTICULES

université PARIS-SACLAY

Université Paris Cité

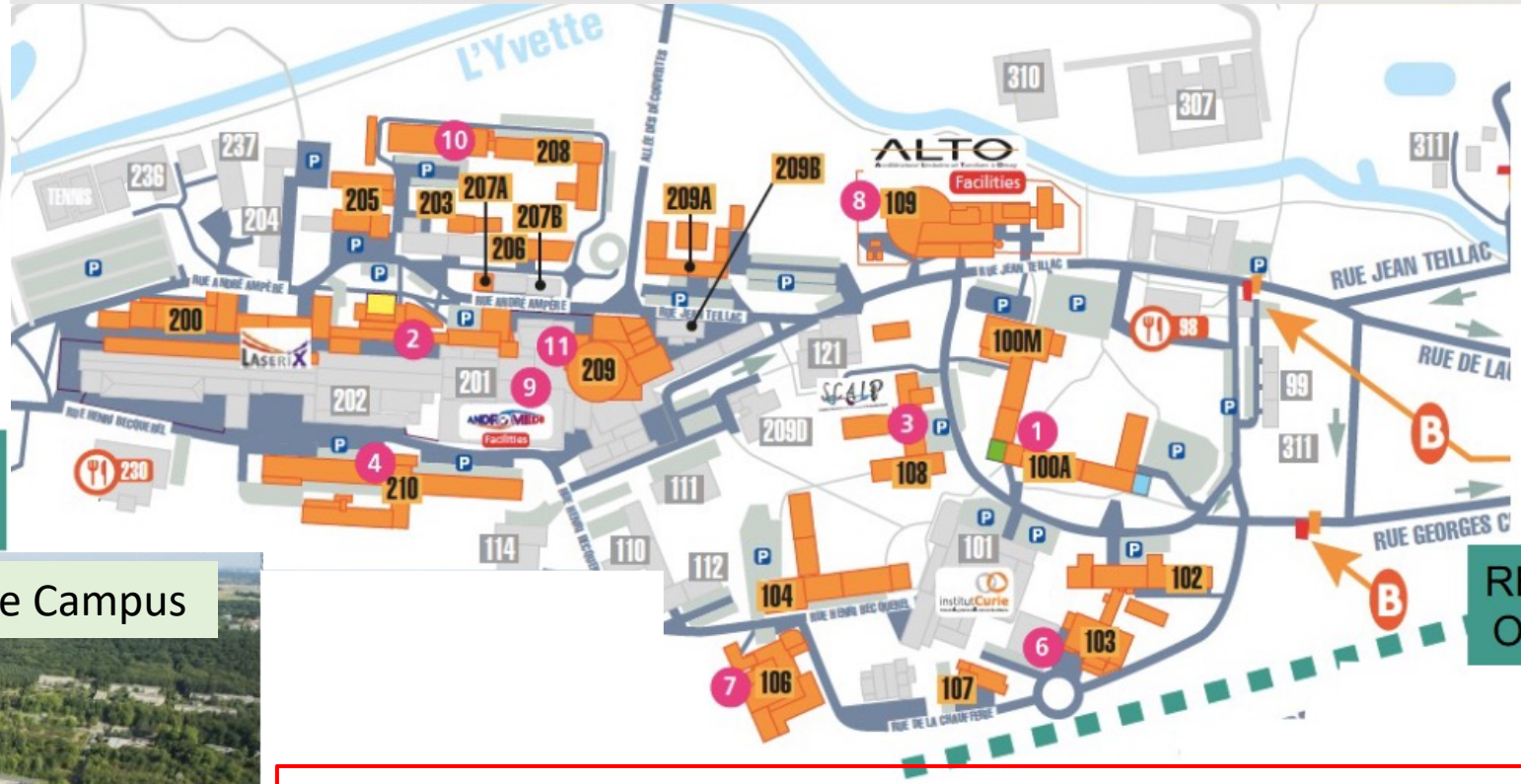
30 km from Central Paris (~30 minutes by regional train)

50000 m² of Buildings

IJCLab : Located in Orsay Campus, 30 Km South-Paris, Campus Paris-Saclay

RER B
Bures

IJCLab is occupying a large part of the Orsay Campus (~50000m²)



IRFU/CEA in the same Campus

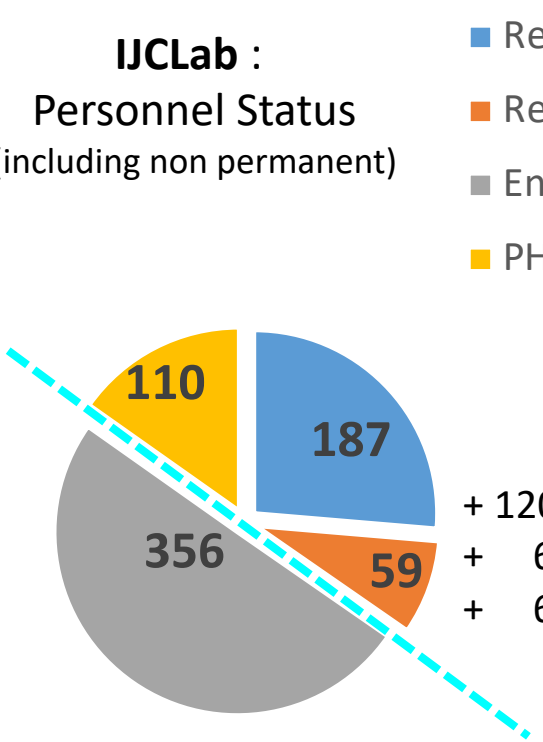
Financial plan (CPER) for renewing buildings and research infrastructures

20,6M€ **2016-2021**

9,1M€ **2022-2027**

IJCLab staff and guardianships

IJCLab :
Personnel Status
(including non permanent)



712 people
+ 120 Internships
+ 6 trainees (« Apprentis")
+ 6 Long term visitors

All in all >800 people present at the laboratory

CNRS (Centre National de la Recherche Scientifique)

- ~17000 researchers + 16000 technical staff
- 10 institutes among them **IN2P3 (Institut national de physique nucléaire et de physique des particules)**
- IN2P3 composed by ~20 large-scale laboratories
- IJCLab is a IN2P3 laboratory
- **IJCLab (~700 people) ~1/4 of HR of the IN2P3.**

University Paris-Saclay

- 275 laboratories : 9000 researchers, 11000 IT *(University and research organism altogether, comprising CNRS and CEA)*
- 13th Shanghai ranking (Physics : 9th World, 1st Europe)
- 48000 students (with 9000 Master, 4000 PHD)

University de Paris

- Specific links with IJCLab in Health Physics

…et voilà IJClab !

7 Research Poles
31 research teams and 2 Departments

1 Engineering pole
4 Departments with 10 Services

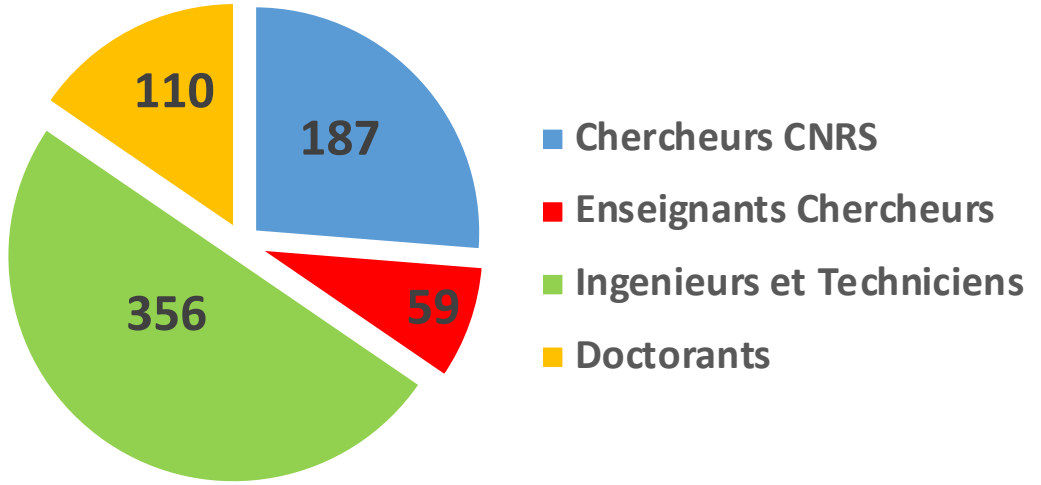
1 Administration Pole
3 Divisions + 1 Service

6 support Services

5 Platforms
(with external users)
+ several technical platforms

712 members (530 permanents)

One of the largest laboratories of the CNRS and Paris Saclay
In the network of 8 major European laboratories

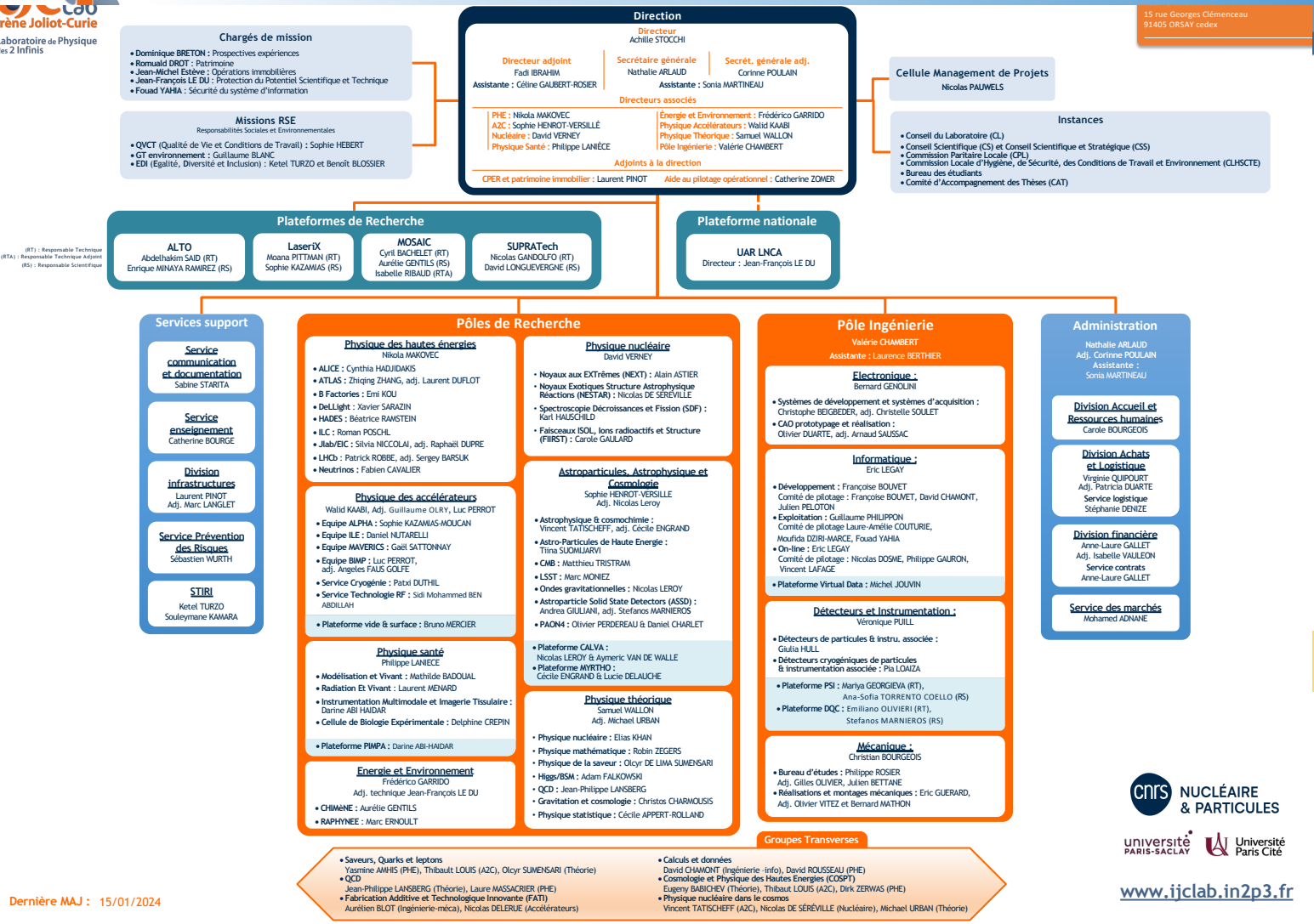


120+ internships/year
~800 people present in the laboratory

Instances

- CL
- CPL
- CSS
- CLHSCTE
- CAT
- ASTech
- COMUTI

New and different organization compared to the former laboratories + new “instances”



IJCLab : Organisation sur une 1 page !

6 GROUPES TRANSVERSES

Saveurs: Quarks et Leptons
Yasmine Amhis(PHE), Thibaut Louis (A2C), Olcyr Sumensari(TH)
QCD
Jean-Philippe Lansberg(TH), Laure Massacrier(PHE).
Fabrication Additive Technologies Innovantes (FATI)
Stéphane Jenzer(PI-Mécanique), Nicolas Delerue (PA)
Calculs et Données
David Chamont(PI-Informatique), David Rousseau (PHE)
Cosmologie et Physique des Hautes Energies (COSPT)
Eugeny Babichev(TH), Thibaut Louis (A2C), Dirk Zerwas(PHE)
Physique nucléaire dans le cosmos
Nicolas Leroy (A2C),Nicolas de Séréville(PN), Michael Urban(TH)

ARCO (Accelerator Research Center Orsay) pour animer la recherche et le développement en Accélérateurs

NUCLÉAIRE & PARTICULES

www.ijclab.in2p3.fr

Dernière MAJ : 15/01/2024

IJClab in a nutshell

7 Pôle Scientifiques

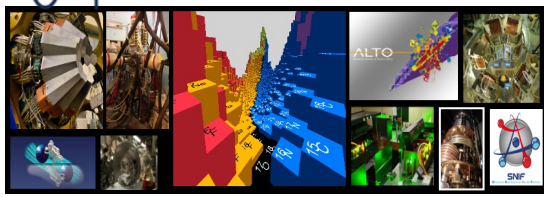
All the themes of the "physics of the two infinities" with the presence of strong historical/existing poles, emerging poles and activities at the interfaces.

A2C Astroparticles, Astrophysics & Cosmology

~ 58

PHYSIQUE NUCLÉAIRE NUCLEAR PHYSICS

~ 61

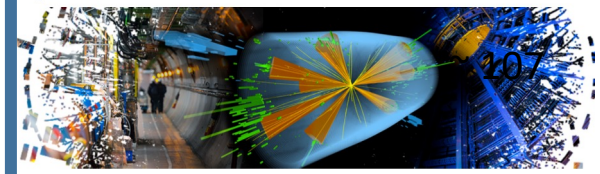


Theory

~ 72

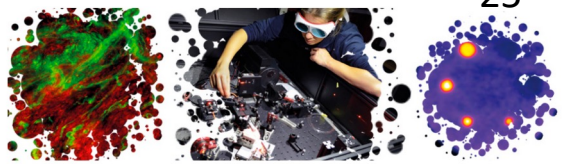
PHE Physique des Hautes Energies High Energy Physics

~ 106



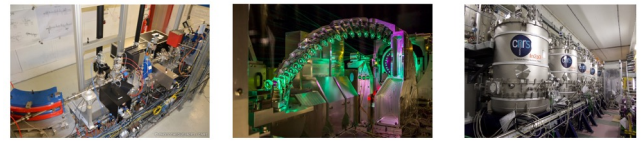
Health Physics

~ 25



Accelerator Physics

~ 87



Including RF and cryogenic services

Energy and Environnement

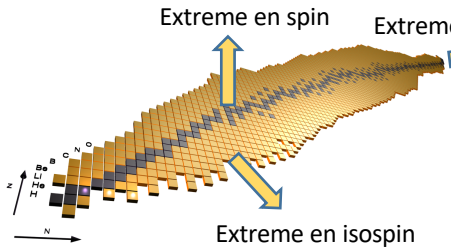
~ 34

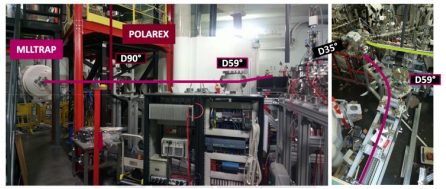
~ 110 PhD

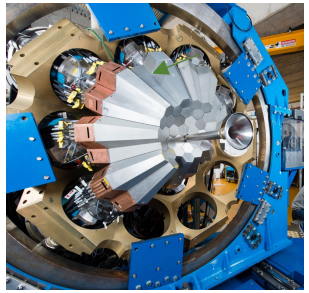
IJCLab : The Research Themes

Probing matter at small distances/high energy $E=hc/\lambda$, discover new particles $E=mc^2$

emergent properties of an effective interaction

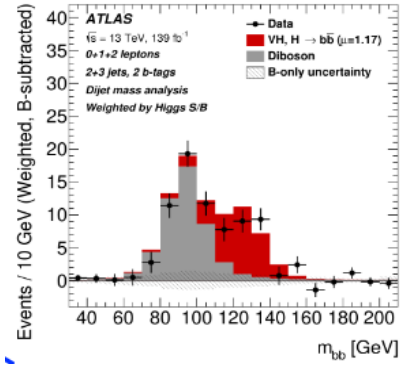


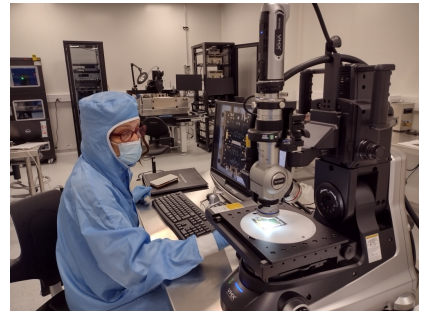




Nuclear Physics

The standard model and the discovery of the Higgs boson!
The missing piece of the standard model





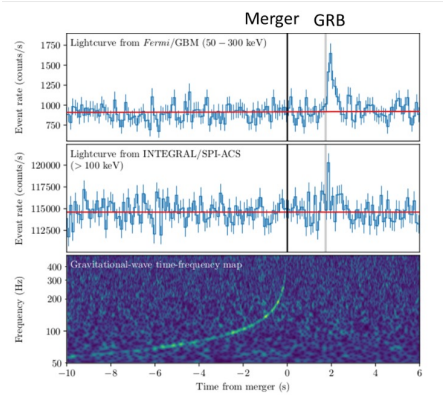
Particle/Hadronic

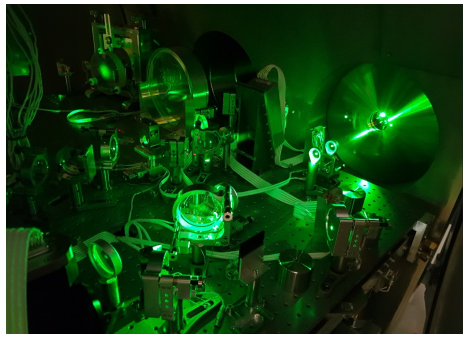
Understand the constituent elements of matter, their interactions
and how the properties of matter are derived from them

IJCLab : The Research Themes

To understand the evolution of the Universe and to study the violent phenomena that occur in it, in connection with high energy physics

The observation of gravitational waves LIGO/VIRGO
Space-time waves, direct observation of black holes / other compact objects

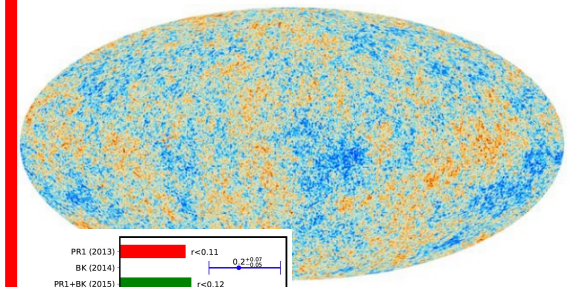


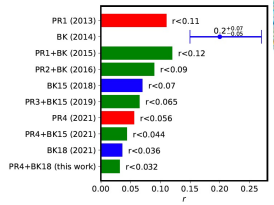


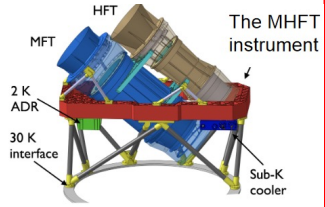
ASTROPARTICLES

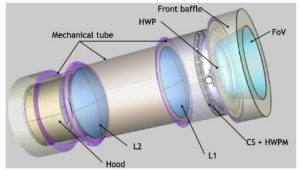
Astrophysical events (high energy cosmic rays, black hole fusion, general relativity...)

The early universe seen by the CMB!
The first picture of the universe









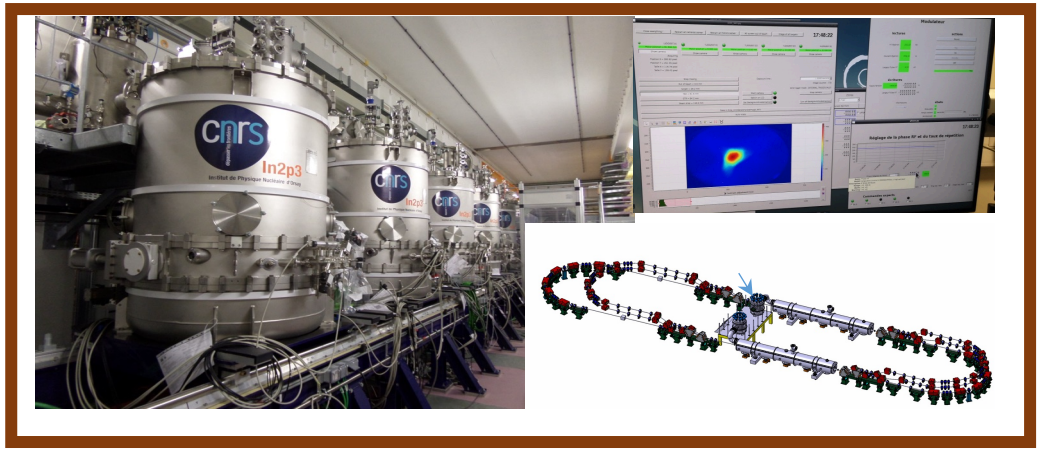
Cosmology

(evolution of the Universe, inflation, large structures, dark matter and energy)

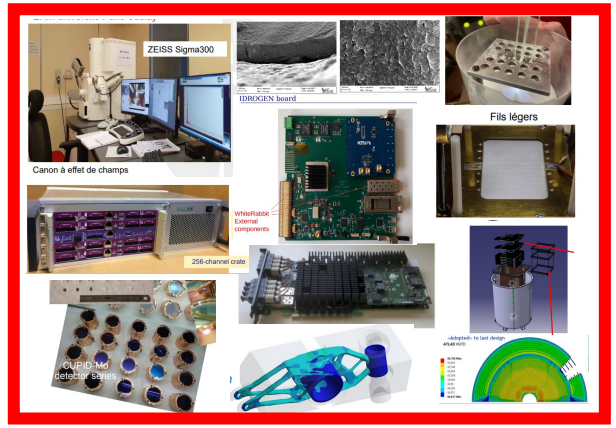
Liens avec le cnes CENTRE NATIONAL D'ÉTUDES SPATIALES

IJCLab : The Research Themes

Design, develop and build tools to carry out this research

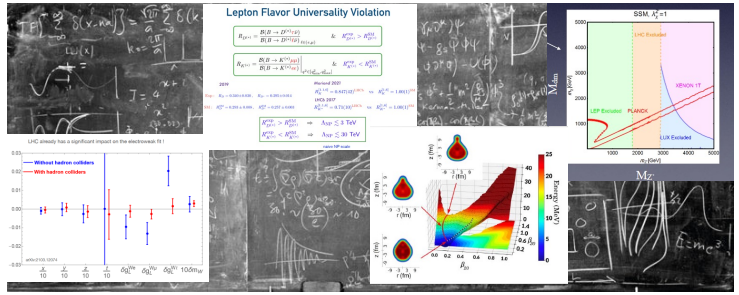


Accélérators



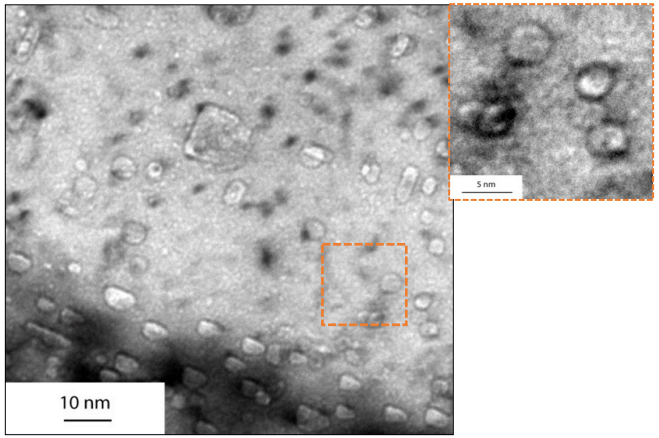
Detectors/Instrumentation

Theory

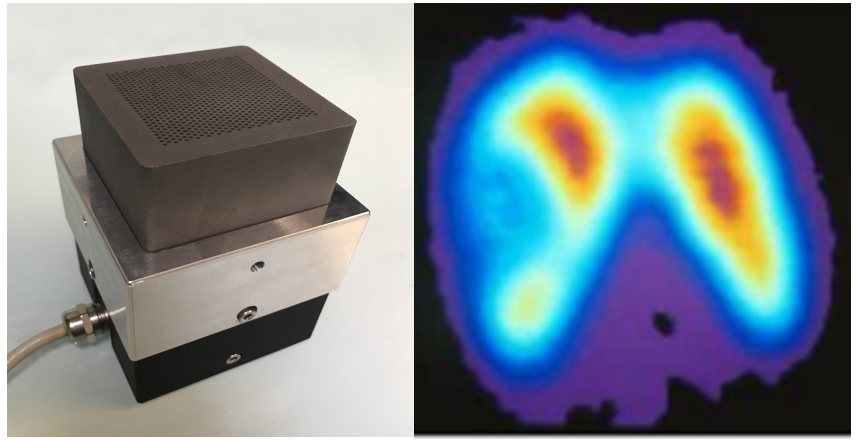


IJCLab : The Research Themes

Tools and concepts applied in areas that have an impact on society



Energy and environment: nuclear energy, radiochemistry and materials



Health physics:
Imaging, radiation therapy, life modeling

IJClab in a nutshell – III : Technical Skills

1 Pôle Ingénierie **4 Départements**

~180 staff members

4 Departments :

Electronics / Computing
Instrumentation / Mechanics

with 10 Services

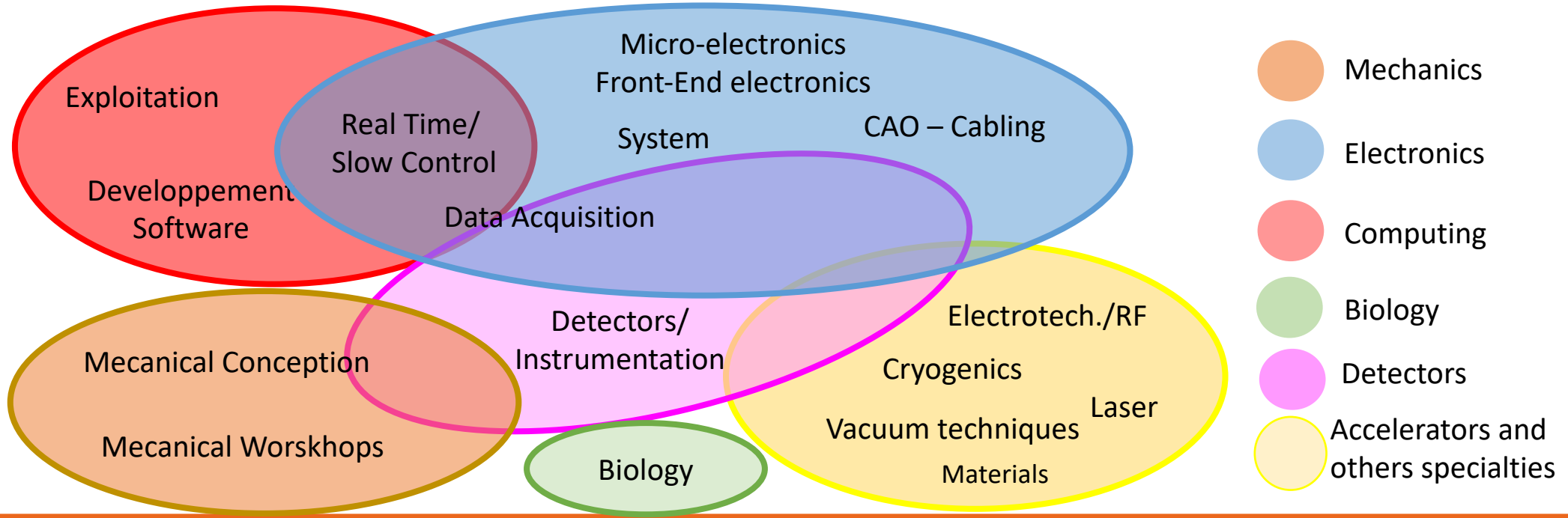
Services in accelerator Pole

- **RF**
- **Cryogenics**

~30 staff members

Technical staff with technical skills/expertise
essential pillars for the laboratory to design, draw and build instruments.

- Technical services are fuelled by the challenges of research (R&D and projects)
- The proximity of technical and research teams (integrated teams)
- The ability to combine and make coexist versatility and specialization



IJCLab in a nutshell: Support Services Support

The Support Services are essential to support all scientific and technical activities of the laboratory

Administration

- Division accueil et ressources humaines
- Division achats et logistique
  Service logistique
- Division financière
  Service contrats
- Service des marchés

47 members

A strong and newly structured administrative department
3 divisions
2 departments

3 **CeMaP**

Project Management Unit. Accompanies and supports project leaders, provides input and advises IJCLab management.

38 members

Management of libraries, common digital library, simplified access to all documentary resources and laboratory productions.

National/international visibility of the IJCLab: external and internal communication, organization of events, heritage activities...).

Support to teaching activities: make the IJCLab a meeting place for students.

Essential for a "laboratory builder". for the success of the new implementation of IJCLab.

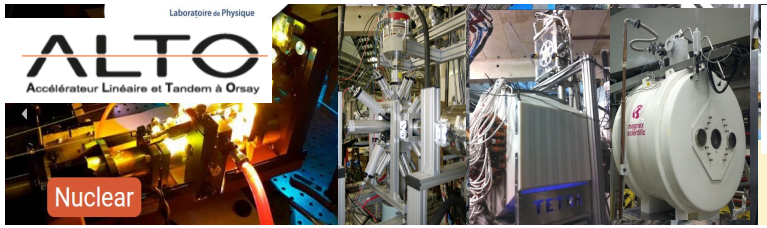
Key role, given the specificity of our research activities and all the facilities involved.

International cooperation and links with companies: two pillars of IJCLab

Services support

- Documentation
- Communication & Événementiel
- Enseignement
- Infrastructures
- Prévention des risques
- STIRI

IJClab in a nutshell – IV : The Platforms



- **15 MV Tandem** (from proton to aggregates)
- **electron linac** -> radioactive beams by photofission

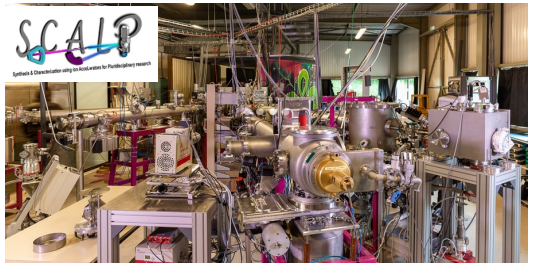
Nuclear, Health physics, Irradiation

Opened to external users

Several MeV protons, multicharged atomic ions, gold molecules and nanoparticles

Nuclear/A2C, Health physics, Irradiation

Opened to external users



Ion irradiation / implantation and *in situ* characterization techniques (TEM, IBA)

Energy, nuclear materials, Health physics, Irradiation physics and chemistry

Opened to external users

IJClab in a nutshell – V : The Platforms

Semiconductor Platform :
Silicon Detector Characterisation/Production

VIRTUAL DATA
Advanced computing resources infrastructure
Grid / Cloud

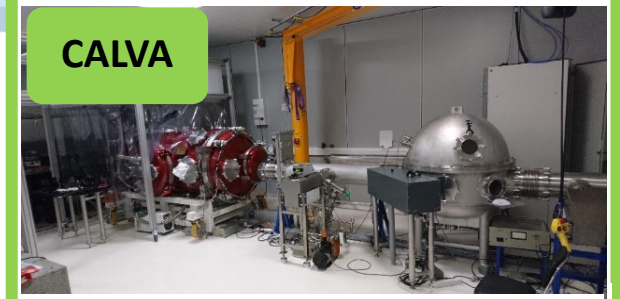
Health research themes

PIMPA
Plateforme d'imagerie Multiphotonique du Petit Animal

non linear optical biphotonique imaging

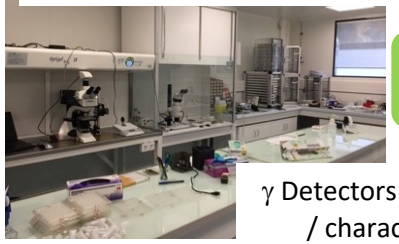
A2C Research themes

CALVA



Cavity locking/Squeezing for VIRGO and ET

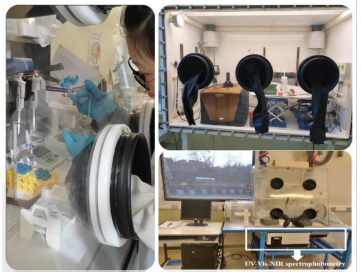
Micrometeorite Preparation/analysis



Myrtho

γ Detectors development / characterization

Radiochemistry laboratory
Actinides - Bat 107

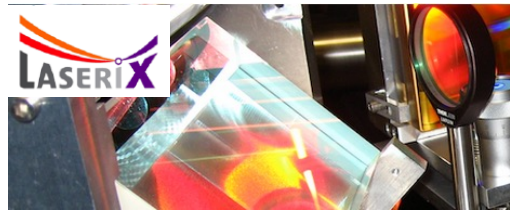


Accelerators research themes/technologies

Opening to Materials, atomic physics, detectors

SUPRATECH

R&D on the superconducting cavities (prepare, package, assemble & testof the superconducting RF cavities).



LaseriX

coherent, intense, brief (50fs to 10 ps) **sources in near-infrared** (800nm) **and EUV** (30 to 90 eV)

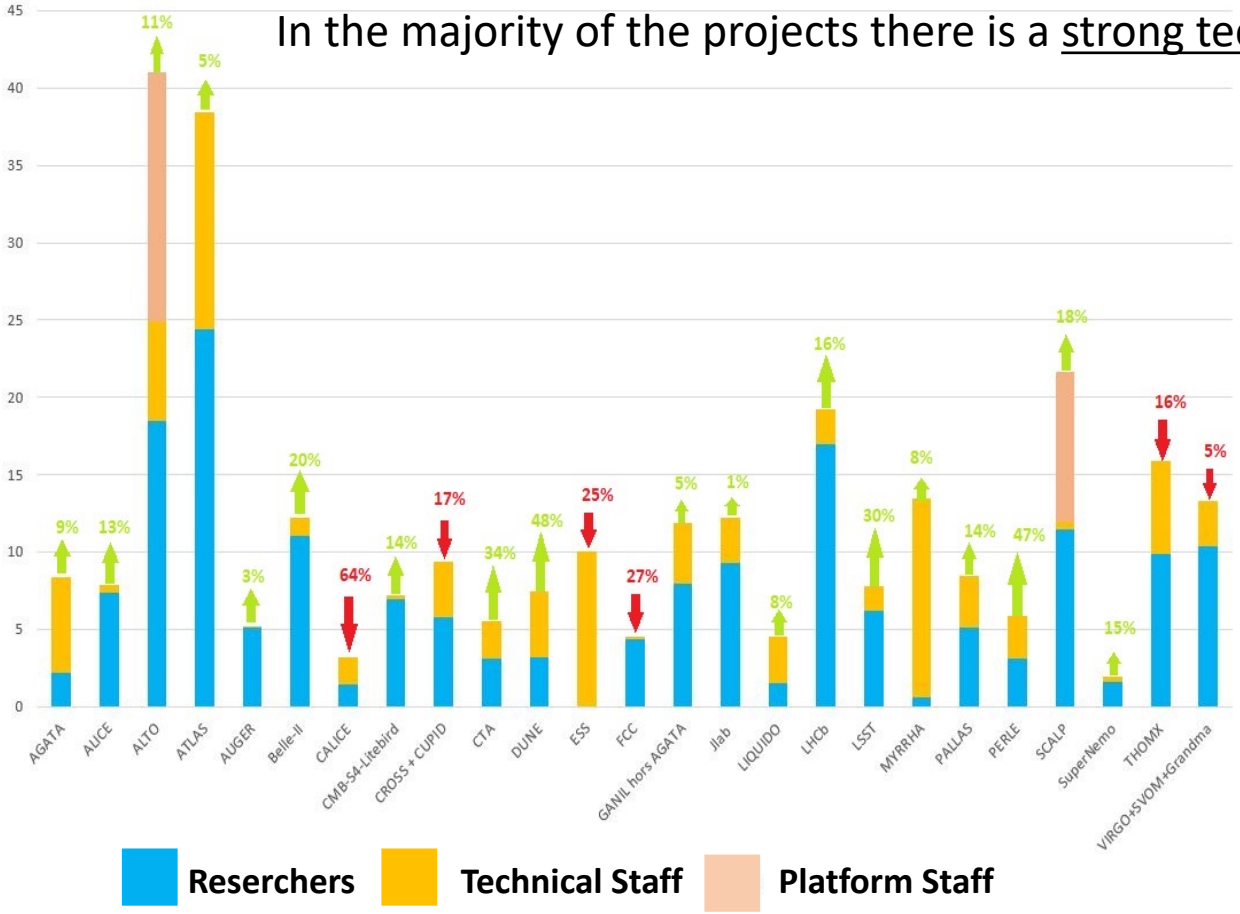
Vide et Surfaces

In construction

Large Project at IJCLab on PHE, Nuclear, A2C, Accelerator Physics

Implications of IJCLab in the largest projects (most with increasing forces)

In the majority of the projects there is a strong technical implications



Some comments/example

AGATA	-National Technical Leader
ALTO	-National Platforms/leaders most exp.
Belle II	-New Spokesperson of IJCLab
CALICE	-IJCLab Spokeperson
DUNE	-National Technical Leader
ESS	-National responsibility with IRFU
JLab	-CLAS12 Spokesperson
LiquidO	-Spokesperson
LHCb	-New Physics Coordinator
MyRRHA	-National responsibility with IRFU
PERLE	-International Technical coordination
AstroGam	- CoPI M7 Call

Major laboratoires with facilities or facilities in the world where IJCLab is involved

Europe

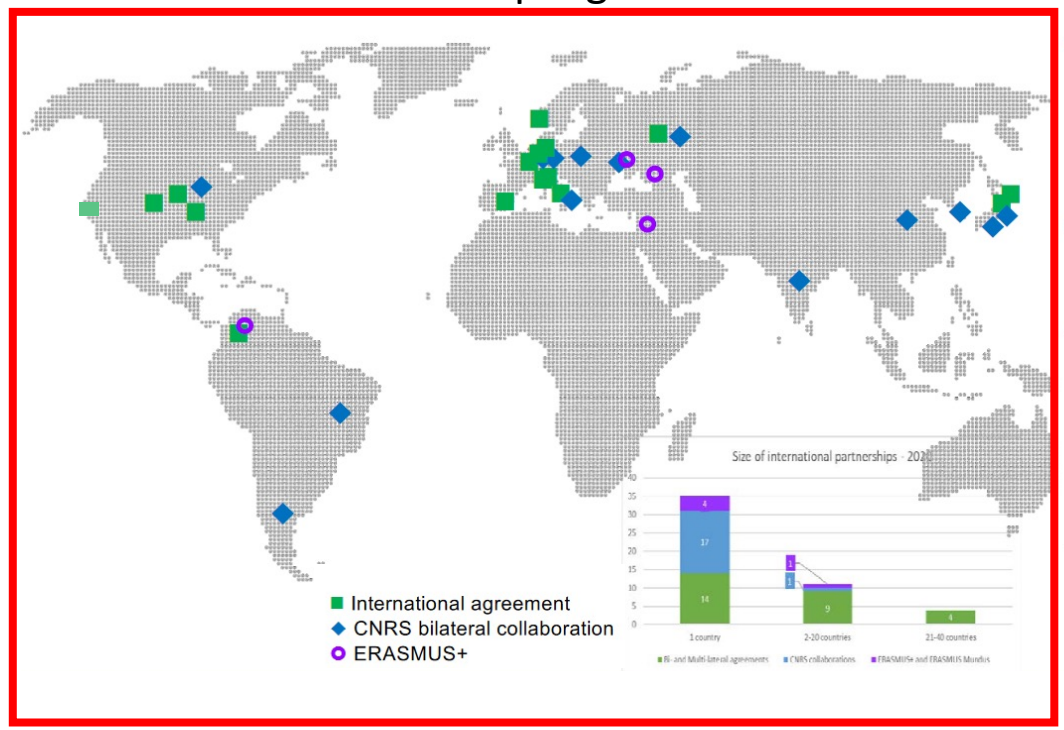
SCK-CEN-Belgium
CERN
CTA-Spain
DESY-Germany
Dubna-Russia
EGO/VIRGO-Italy
ESS-Sweden
GANIL-France
GSI-Germany
Jyväskylä -Finland
LNCA-France
LNGS-Italy
LNL-Italy
LSM-France

World

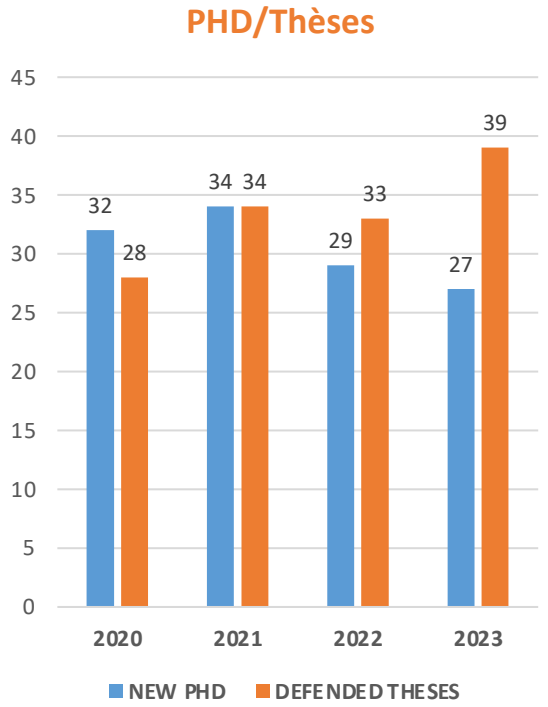
Auger-Argentina
LBNL/SLAC-US
Fermilab-US
JLab-US
KEK-Japan
LSST-Chili
Riken-Japan

Each year, several bilateral international collaborations are signed with research centers and universities.

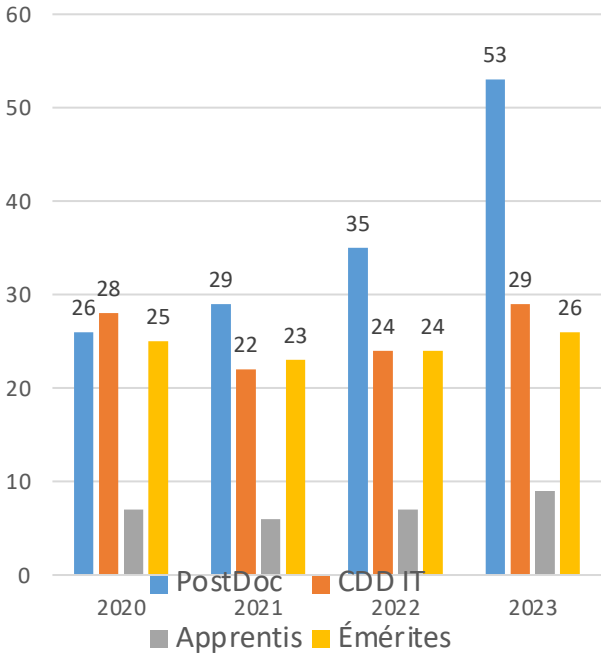
Recent example given below



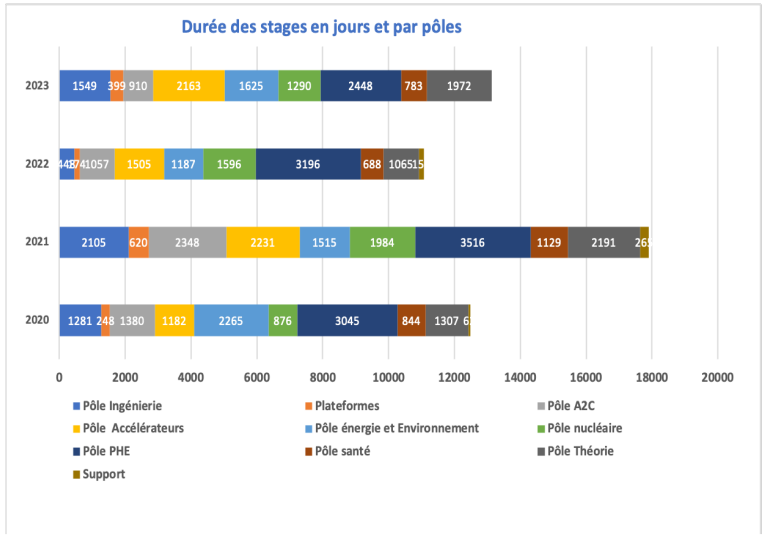
Some significant figures on "students" / young people



~30 doctorants entrants/an
~30 soutenances de doctorats/an



Une augmentation timide des PostDocs, à confirmer avec le succès croissant des différents appels nationaux/européens.



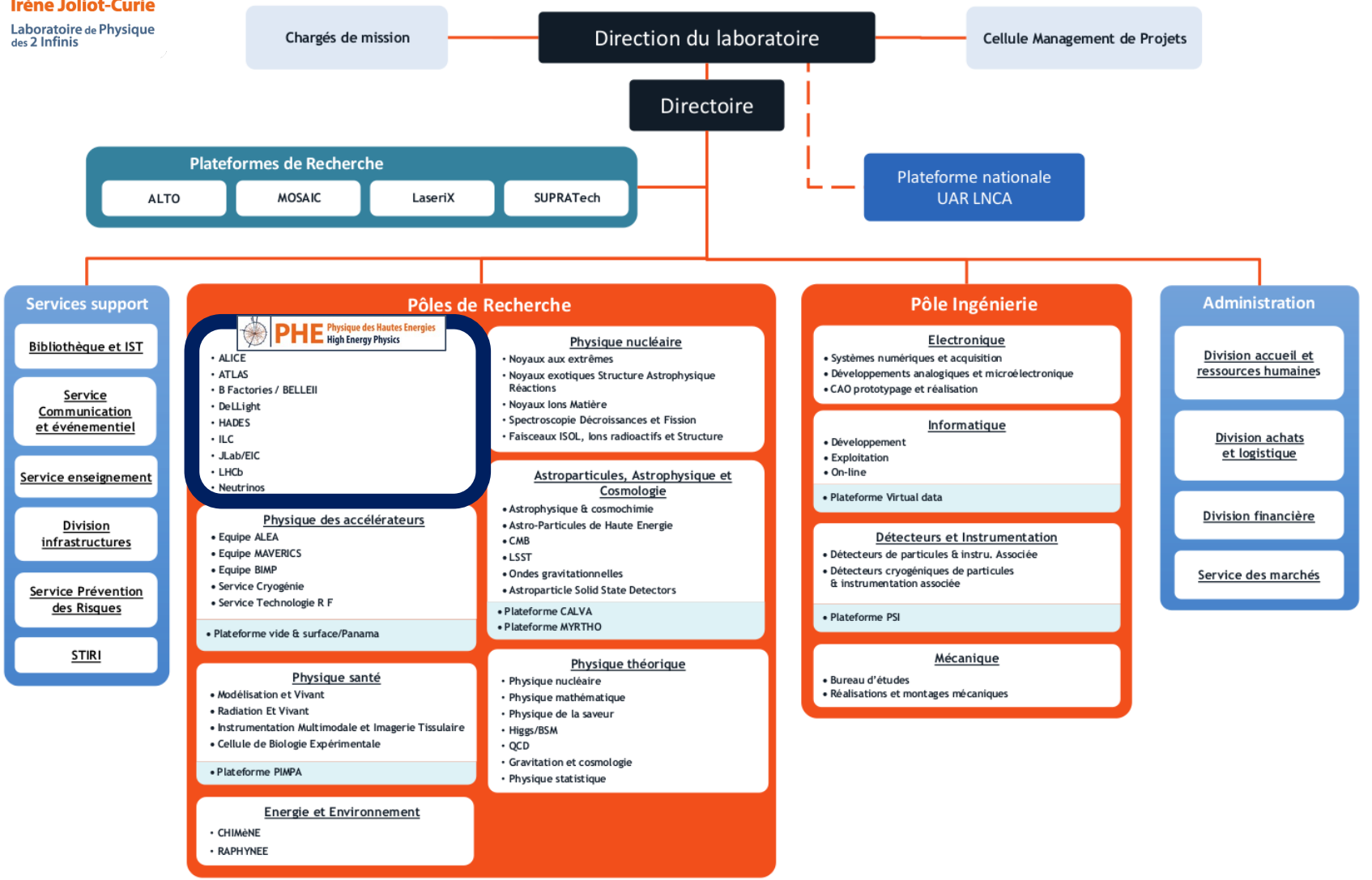
	2020	2021	2022	2023
Nombre de stagiaires	151	210	148	169
Nombre de mois	530	664	436	505
% L	25%	32%	24%	43%
% M1	28%	36%	32%	30%
% M2	47%	32%	34%	27%

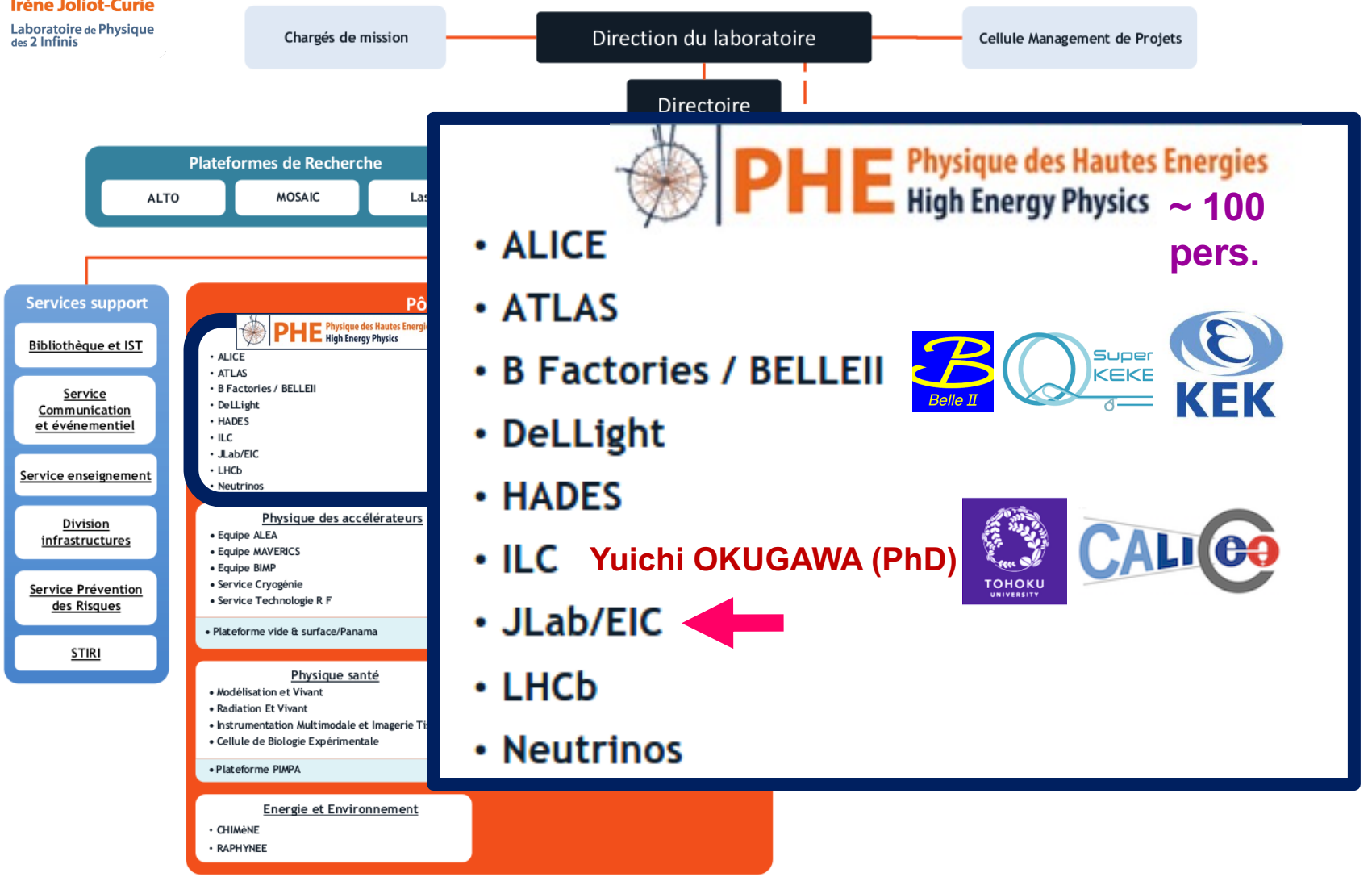
Stages - Stratégie visible du laboratoire

IJCLab : “A Year budget”

Assigned by governing bodies	Laboratory operation	~4,0M€
	Specific programs	~4,0M€
Contracts : ANR/Europe/industry/Region…		~6,0M€
Own Resources (overheads, services, ..)		~2.0M€
TOTAL RESOURCES		**~16M€**

Salary of permanent staff	~40.5M€
Salary of non permanant	~2.5M€
The salaries of the permanent staff are not in the laboratory budget : directly payed by the employers (CNRS/Universities)	


Chargés de mission
Direction du laboratoire
Cellule Management de Projets
Directoire
Plateformes de Recherche
ALTO
MOSAIC
LaseriX
SUPRATech
Plateforme nationale
UAR LNCA
Services support
Bibliothèque et IST
Service Communication et événementiel
Service enseignement
Division infrastructures
Service Prévention des Risques
STIRI
Pôles de Recherche
PHE Physique des Hautes Energies High Energy Physics
• ALICE
• ATLAS
• B Factories / BELLEII
• DeLLight
• HADES
• ILC
• JLab/EIC
• LHCb
• Neutrinos
Physique nucléaire
• Noyaux aux extrêmes
• Noyaux exotiques Structure Astrophysique Réactions
• Noyaux Ions Matière
• Spectroscopie Décroissances et Fission
• Faisceaux ISOL, Ions radioactifs et Structure
Physique des accélérateurs
• Equipe ALEA
• Equipe MAVERICS
• Equipe BIMP
• Service Cryogénie
• Service Technologie R F
• Plateforme vide & surface/Panama
Astroparticules, Astrophysique et Cosmologie
• Astrophysique & cosmochimie
• Astro-Particules de Haute Energie
• CMB
• LSST
• Ondes gravitationnelles
• Astroparticle Solid State Detectors
• Plateforme CALVA
• Plateforme MYRTHO
Physique santé
• Modélisation et Vivant
• Radiation Et Vivant
• Instrumentation Multimodale et Imagerie Tissulaire
• Cellule de Biologie Expérimentale
• Plateforme PIMPA
Physique théorique
• Physique nucléaire
• Physique mathématique
• Physique de la saveur
• Higgs/BSM
• QCD
• Gravitation et cosmologie
• Physique statistique
Energie et Environnement
• CHIMèNE
• RAPHYNEE
Pôle Ingénierie
Electronique
• Systèmes numériques et acquisition
• Développements analogiques et microélectronique
• CAO prototypage et réalisation
Informatique
• Développement
• Exploitation
• On-line
• Plateforme Virtual data
Détecteurs et Instrumentation
• Détecteurs de particules & instru. Associée
• Détecteurs cryogéniques de particules & instrumentation associée
• Plateforme PSI
Mécanique
• Bureau d'études
• Réalisations et montages mécaniques
Administration
Division accueil et ressources humaines
Division achats et logistique
Division financière
Service des marchés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• ILC Yuichi OKUGAWA (PhD)
• JLab/EIC
• LHCb
• Neutrinos
Belle II
Super KEKE
KEK
TOHOKU UNIVERSITY
CALICE

Our team « JLab - EIC » : 12 members

Staff members: 6

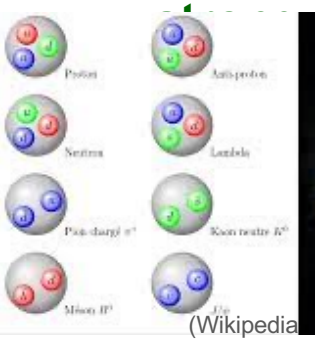
R. Dupré,
M. Hoballah,
D. Marchand,
C. Munoz-Camacho,
S. Niccolai,
E. Voutier

PhD students: 4

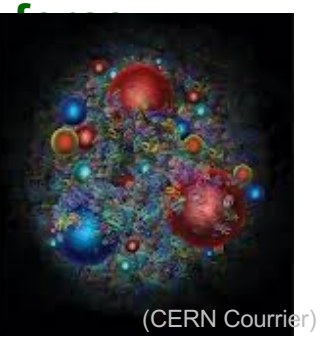
Postdocs: 2

Hadronics physics

« Study of baryons and mesons » interacting by the



(Wikipedia)


(CERN Courrier)

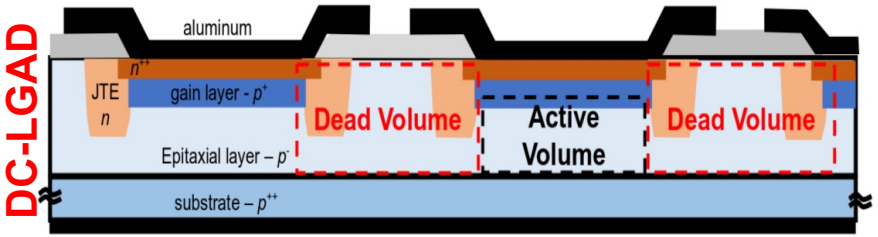
Since '70s, nucleons are made up of fractionnally charged valence quarks + dynamically produced quark-antiquark pairs.

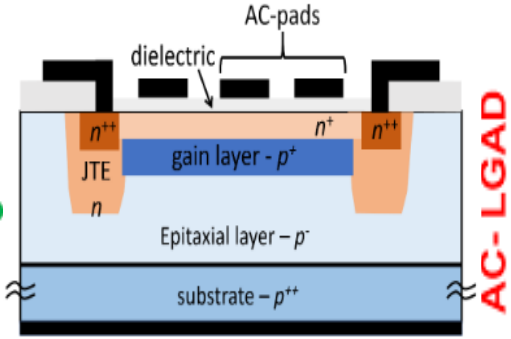
- **Understanding internal structure and intrinsic properties of nucleons (proton and neutron) from the dynamics of their subconstituents (quarks and gluons): the partons**

Low Gain Avalanche Diode (LGAD)

- Silicon sensors fabricated in a thin (≈50 μm) high resistive p-type substrate
- Charge gain (up to 100) to achieve very high timing resolution (20-30 ps)
- Size of the pads must be larger than the substrate thickness to achieve a uniform amplification

→ limitation for fine pixelation (< 1 x 1 mm^2)



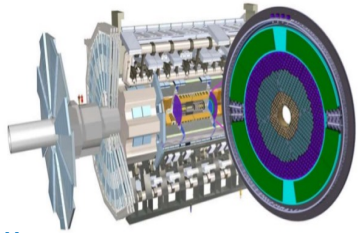


1D (timing) → **4D** reconstruction (timing & position)

- **AC-LGAD** sensors include metal electrodes placed over a thin insulating at a fine pitch, signals are induced capacitively.
- Insensitive area (edges) can be minimized
- Charge sharing → barycenter computation

ATLAS EXPERIMENT

Upgrade phase II



High Granularity Timing Detector (HGTD)

(also CMS Endcap Timing Layer - ETL)

- Based on pixellated **DC**-LGAD 4 x 2 cm^2
- Pixel size: 1.3 x 1.3 mm^2

Brookhaven National Laboratory

"Fabrication and performance of AC-coupled LGADs", G. Giacomini *et al.*, JINST 14 (2019) 09, P09004,ArXiv: 1906.11542

The EICROC Project

O. Brand-Foissac, V. Chaumat, D. Marchand, C. Munoz, L. Serin, B.-Y. Ky, A. Sharma, A.-S. Torrento, (IJCLab)
F. Dulucq, C. de La Taille, N. Seguin,-Moreau, A. Verplancke (OMEGA)
F. Bouyjou (CEA/Irfu/DEDIP)

Objective: **Development** and **characterization** of an **ASIC EICROC (32 x 32)** able to read-out the new generation of pixelated (500 x 500 μm^2) silicon sensors: **AC-LGAD** (**L**ow-**G**ain **A**valanche **D**iode) coupled **AC** for the **Electron Ion Collider** (EIC)

1st intention: optimized for **Far Forward detectors:** the **Roman Pots**

Stepping up through succesive ASIC iterations to control performances fulfilling ePIC detector requirements

- **EICROC0 prototype** (16 channels; 4 x 4): under test since March '23

EICROC0 requirements and design: 16 channels (4x4)

Requirements:

- pixel size **0.5 x 0.5 mm²** *(HGTD 1.3x1.3 mm²)*
- low power consumption < **2 mW/channel**
- low jitter **~ 20 ps**
- low noise **~ 1 mV/channel**
- sensitivity to low charge **(2 fC)**
- time resolution: **30 ps**
- spatial resolution: **50 microns**

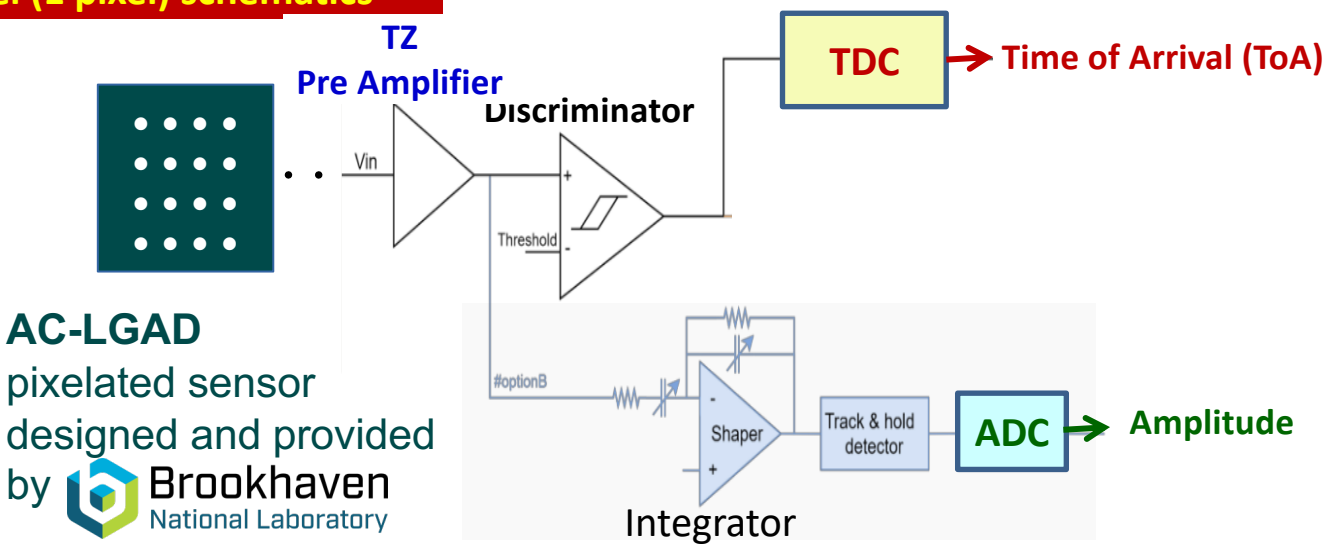
Charge sharing studies

(simulation + β source w/ **ALTIROC1**_v2)

EICROC0 design:

- **TZ Pre Amplifiers** from ALTIROC (ATLAS/HGTD)
- 10 bit **TDC** from HGCROC (CMS, CEA/Irfu)
- **8 bit ADC** for time-walk correction (AGH Krakow, adapted from HGCROC)

1 channel (1 pixel) schematics



Compared to ALTIROC (ATLAS/HGTD), ToT TDC (non-linear behavior versus the deposited charge) replaced by an ADC

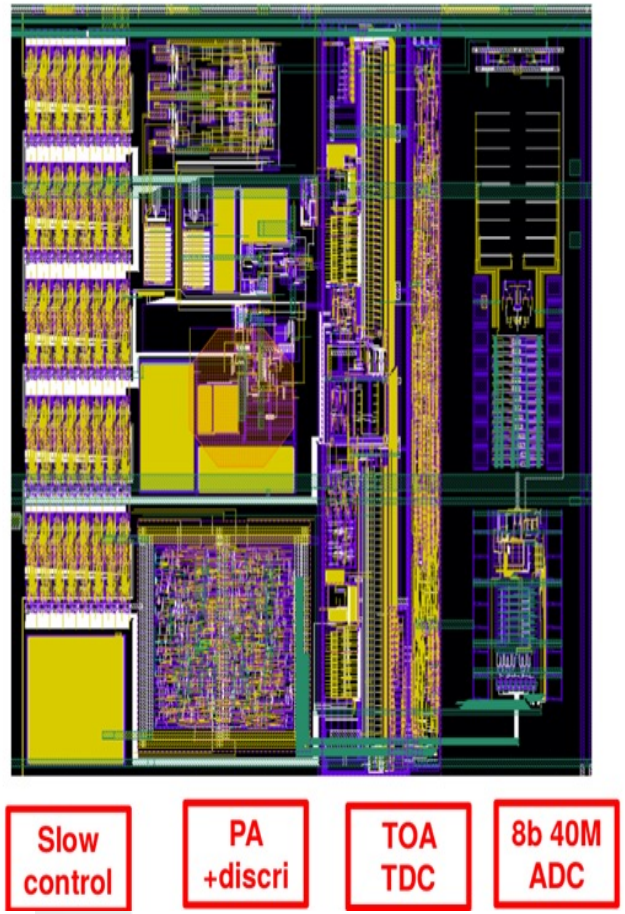
EICROC0: 1 pad (500 x 500 µm²) overview

- High speed TZ PA and discriminator (from ALTIROC)
- I²C slow control (from CMS HGCROC)
- 8 bits 40 MHz ADC (adapted from HGCROC 10 bits ADC,
  M. Idzik *et al.,* AGH Krakow)
- Digital readout FIFO (depth 8, 200 ns)
- 10 bits **TDC** (TOA) designed by **CEA Irfu/DEDIP**:
- HGCROC TDC (1 mm x 120 µm):
  - spatially adapted to fit in a pixel of 0.5 x 0.5 mm²
  - optimization in terms of dynamic range and resolution (10 ps rms) as well as power consumption
  - common block for calibration of all TDC channels

✸ 5 slow control bytes/pixel:

- 6 bits local threshold
- 6 bits ADC pedestal
- 16 TDC calibration bits
- Various on/off and probes

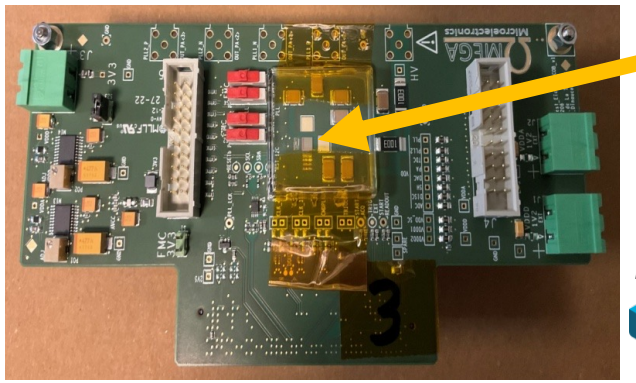
EICROC0 layout (1 pad = 1 channel)

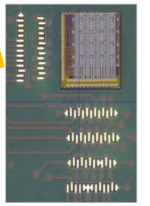


Status of EICROC0 Test Bench at IJCLab

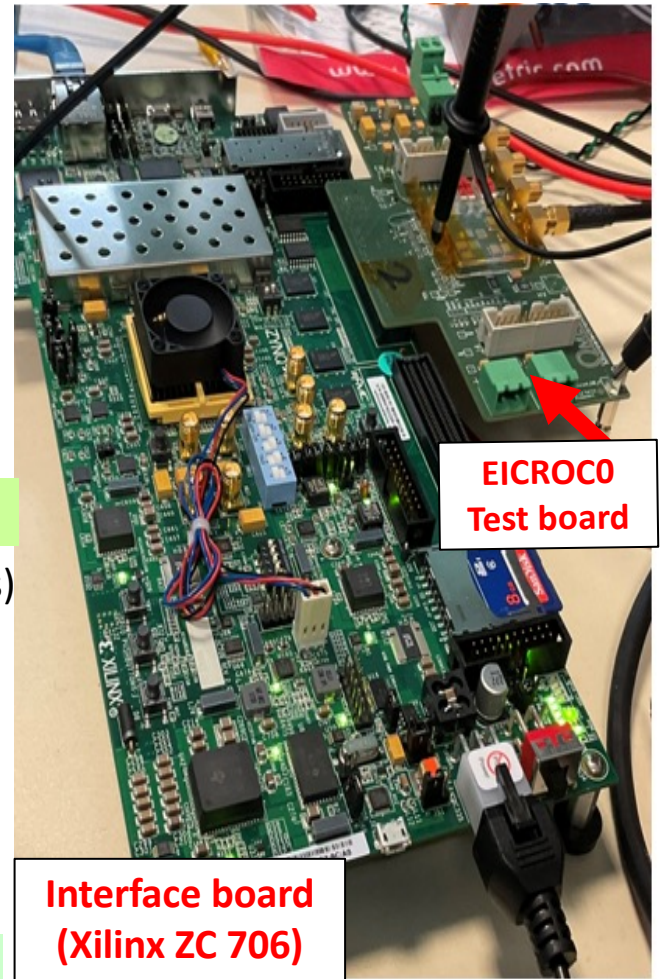
EICROC0 chip

EICROC0 Test board





Wire-bonding by Brookhaven National Laboratory



Interface board (Xilinx ZC 706) (FPGA)

EICROC0 test bench operational at IJCLab since March '23

- ✓ I^2C communication (firmware + software developments)
- ✓ Data stream written/read
- ✓ EICROC0 DC levels
- ✓ Discri. threshold exploration
- ✓ **EICROC0 charge injection system (0 to 25 fC)**
- ✓ **EICROC0 decoding (TDC, ADC) Firmware + software**
- ✓ **External trigger**: *signal directly injected into TDC*

Additional EICROC0 test benches operational at:
OMEGA (May '23), CEA/Irfu (Sept. '23),
BNL (Sept. '23), Hiroshima University (Sept. '23)

In conclusions, our Manifesto

- **Contributing to projects at all stages**: proposal, design, construction, operation, data analysis, theory
- **Playing a major role in the conception, design and construction of current and future accelerators**.
- **Developing and operating research infrastructures and technological platforms** supporting these research areas as well as original research in health physics and energy
- **Promoting the development of new technologies for science for the benefit of society** and thus supporting national and European industrial competitiveness
- **Welcoming students that the laboratory trains through and for research** in the heart of a world-class academic environment.