

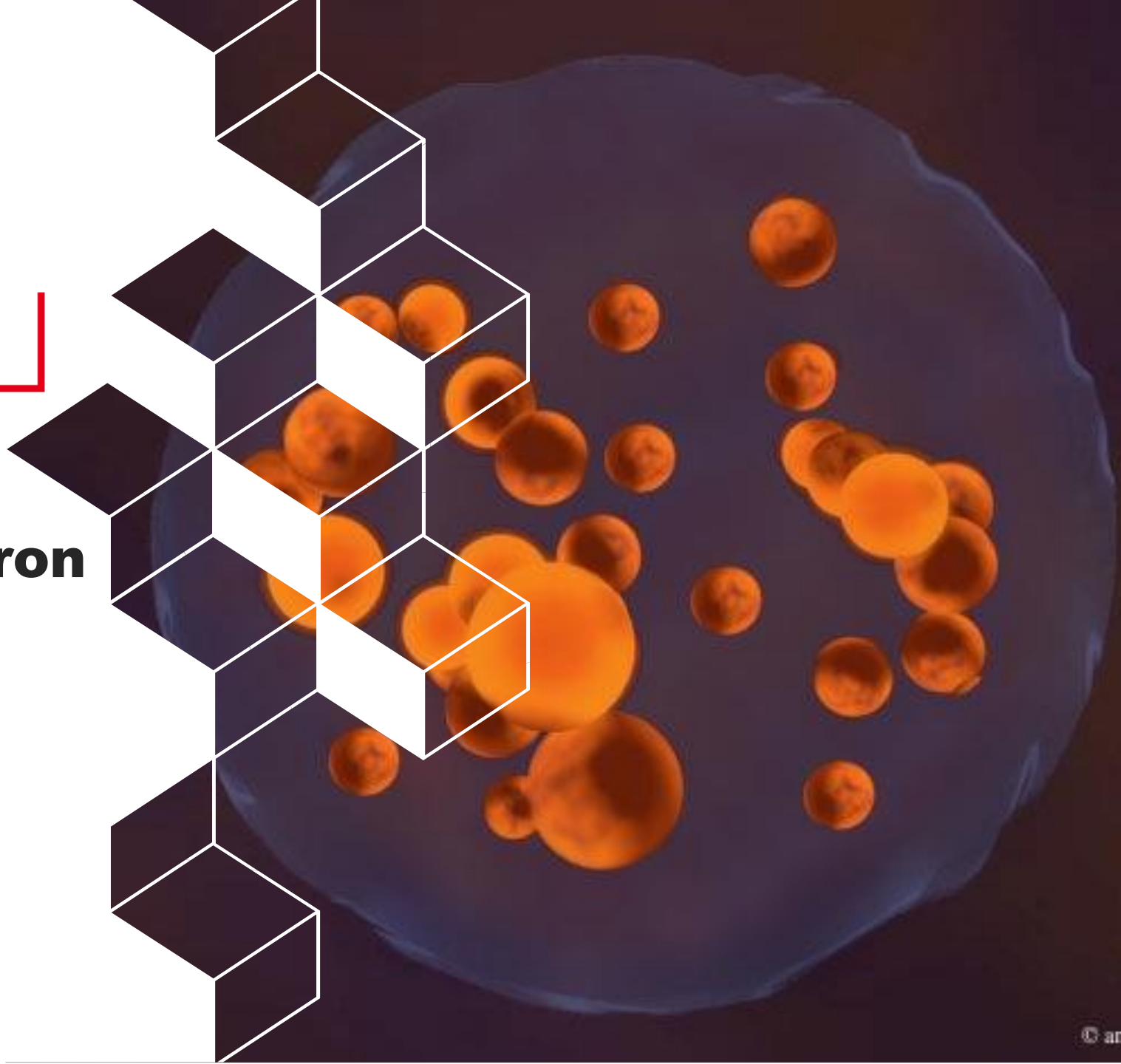


irfu

Status and prospects for hadron physics at IRFU

Hervé MOUTARDE

22 March 2023





1. IRFU

Fundamental nuclear physics within CEA.

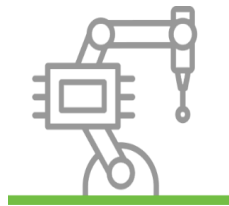
CEA at a glance (in 2021)



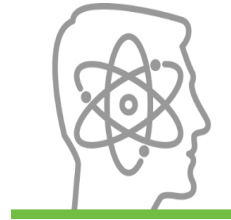
Defence
and security



Nuclear and renewable
energy



Technology research
for industry



Fundamental
research

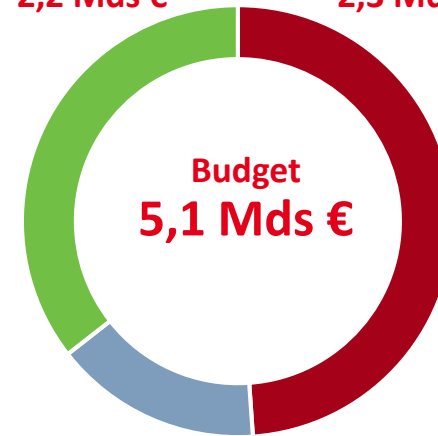
Staff: about 20000 persons

- 16500 permanent
- 1000 fixed-term
- 1500 PhD students
- 200 postdocs
- 1000 apprentices

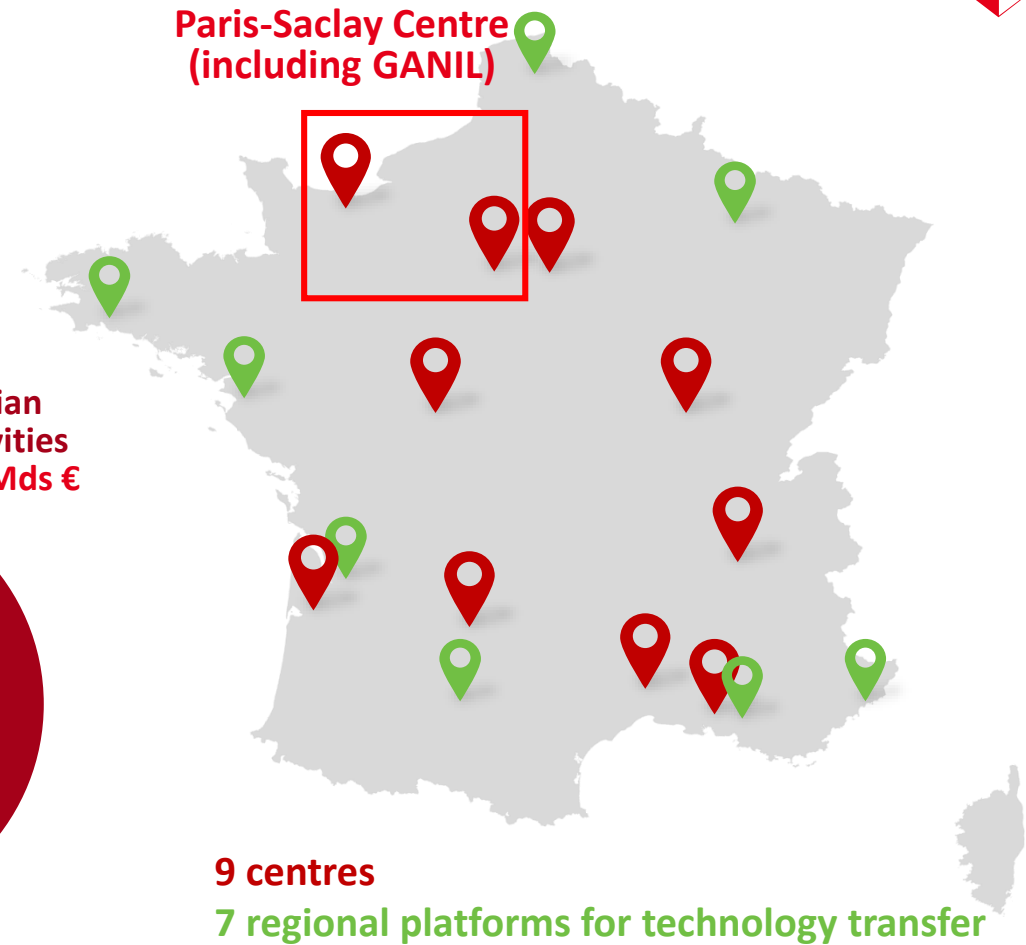


Military
applications
2,2 Mds €

Civilian
activities
2,3 Mds €



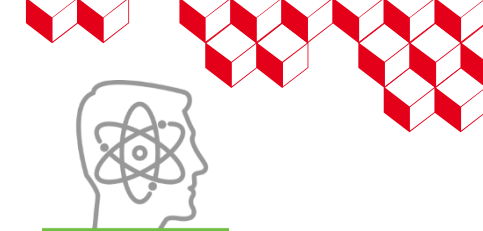
Decommissioning-
remediation
0,6 Md€



Science: about 5000 publications/year

- 65% international copublications
- 45% in fundamental research





Institute of research into the
fundamental laws of the Universe

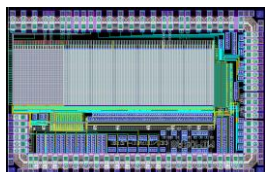
IRFU

Head: Franck Sabatié



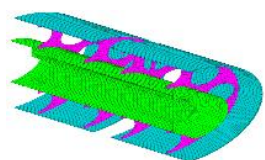
Accelerator, cryogenics and
magnetism

DACM



Electronics, detectors and
computing

DEDIP

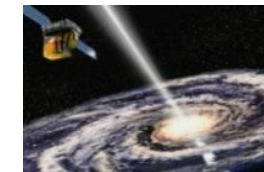


System engineering

DIS

Astrophysics

DAP



Nuclear physics

DPhN



Particle physics

DPhP



Grand accélérateur national d'ions
lourds

GANIL



- 670 permanent staff members
- 94 PhD students
- 44 postdocs



2 ■ 20 years with CLAS

Organisation of nuclear physics in Irfu: the example of the GPD program at Jefferson Lab.

From CLAS to CLAS12



Available online at www.sciencedirect.com

SCIENCE @ DIRECT®

Nuclear Instruments and Methods in Physics Research A 503 (2003) 513–553



The CEBAF large acceptance spectrometer (CLAS)

B.A. Mecking^a, G. Adams^b, S. Ahmad^c, **E. Anciant^d**, M. Anghinolfi^e,
B. Asavapibhop^f, G. Asryan^g, **G. Audit^d**, **T. Auger^d**, H. Avakian^{a,h},
J.P. Ballⁱ, F.J. Barbosa^a, S. Barrow^j, M. Battaglieri^e, K. Beard^{k,l},
B.L. Berman^m, N. Bianchi^h, S. Boiarinov^a, P. Bonneau^a, W.J. Briscoe^m,

2003

Nuclear Inst. and Methods in Physics Research, A 959 (2020) 163419

Contents lists available at ScienceDirect

Nuclear Inst. and Methods in Physics Research, A

journal homepage: www.elsevier.com/locate/nima



The CLAS12 Spectrometer at Jefferson Laboratory

V.D. Burkert^{40,*}, L. Elouadrhiri⁴⁰, K.P. Adhikari²⁸, S. Adhikari¹², M.J. Amarian³³,
D. Anderson⁴⁰, G. Angelini¹³, M. Antonioli⁴⁰, H. Atac³⁹, **S. Aune⁴**, H. Avakian⁴⁰,
C. Ayerbe Gayoso^{47,28}, N. Baltzell⁴⁰, L. Barion¹⁵, M. Battaglieri^{17,40}, V. Baturin⁴⁰,
I. Bedlinskiy²⁹, F. Benmokhtar⁸, A. Bianconi^{43,20}, A.S. Biselli¹⁰, P. Bonneau⁴⁰, **F. Bossù⁴**,

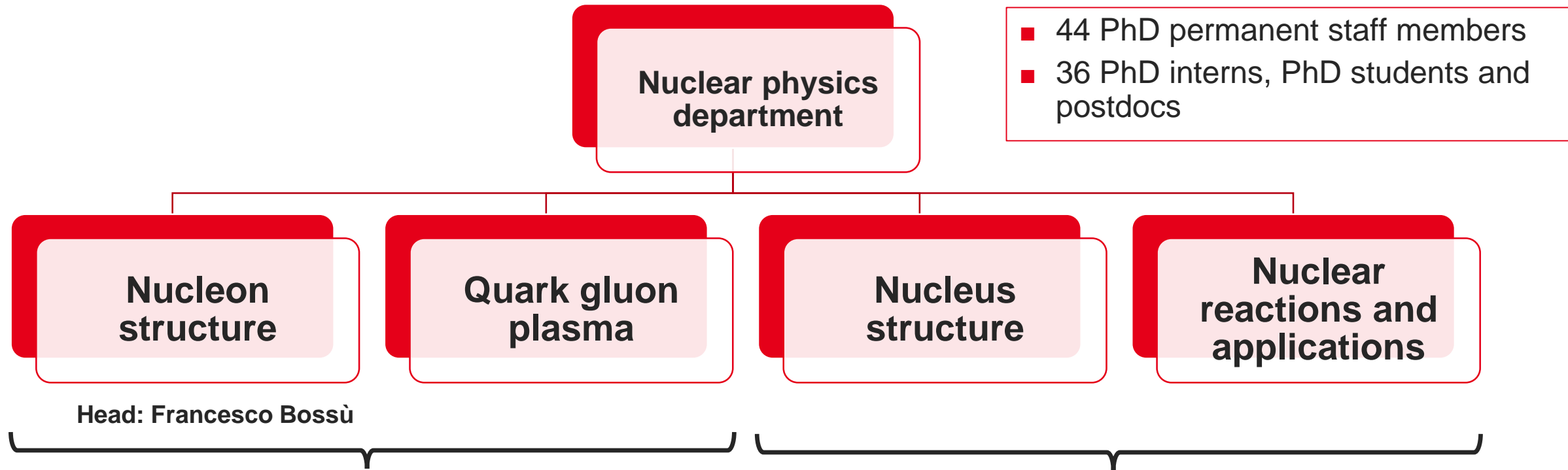
2020



Long-standing involvement of Irfu in Jefferson Lab

- Mostly DPhN and DEDIP
- Experiments in Halls A, B and C
- 1 former chair of the CLAS Coll.
- Various other responsibilities in the CLAS Coll.

Nuclear physics, from quarks to nuclei



Cold and hot QCD

Theory

- Model building
- Phenomenology
- Computing codes

Experiments

- Detector R&D
- Design and data taking
- Data analysis

Low energy nuclear physics

Applications

- Nuclear data evaluation
- Compact neutron sources
- Beyond nuclear physics: neutrinos and gravitation

Synergies



Quantitative Challenges in Short-Range Correlations in nuclei

[Back to the ESNT page](#)

30th January- 3rd February 2023

PROGRAM  [ProgramSRC2023ESNTjanvTAB.pdf](#)

Quantitative Challenges in Short-Range Correlations in nuclei

Organizers: T. Aumann (TU Darmstadt, GSI), S. Typel (TUD, GSI), A. Corsi (CEA DPhN, [contact](#)), Or Hen (MIT), J. Kahlbow (Tel Aviv Univ., MIT), E. Piasezky (Tel Aviv Univ).

The main **goals of the workshop** are:

1. To review the recent experimental results on SRC and EMC effect from Jefferson Lab, Dubna and GSI using different experimental probes,
2. To present the different theoretical approaches in the description of SRC in nuclear structure calculations (contact formalism, quasi-deuteron approach, ab-initio approaches),
3. To survey appropriate methods of reaction theory, with specific focus on hadron induced reactions,
4. To isolate the most relevant observables that should be measured / calculated,
5. To discuss the roadmap for future experimental and theoretical developments.

Synergies between

- Departments in Irfu.
- Labs in DPhN.
- Experimentalists and theorists.
- Research topics in DPhN.

3D proton structure, from hardware to theory

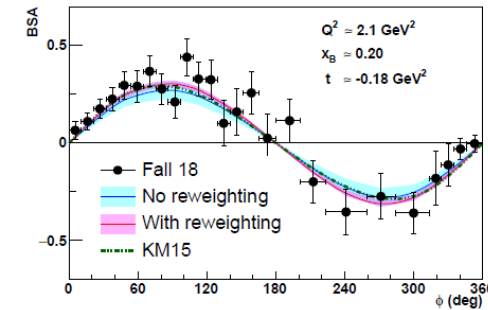
Hall B Group Meeting Minutes: May 7, 2018

You can view this document and the minutes of previous meetings on the web at http://clasweb.jlab.org/group_meeting_minutes/Physics/

Present: David Anderson Harut Avakian, Nathan Baltzell, Francesco Bossu, Sergey Boyarinov, Volker Burkert (chair), Daniel Carman, Morgan Cook, Diehl, Latifa Elouadrhiri, Todd Ewing, Ruben Fair, Ed Folts, Gagik Gavalian, Probir Ghoshal, François-Xavier Girod, Yuri Gotra, Lei Guo, Vardan Gys Denny Insley, Latif Kabir, Tsuneo Kageya, Michael Lowry, Calvin Mealer, Mac Mestayer, Victor Mokeev, Rafayel Paremyan, Eugene Pasyuk, Renu Rajput-Ghoshal, Joshua Artem Tan Andrew Sandorfi, Cole Smith, Stepan Stepanyan, Maurizio Ungaro, Veronique Ziegler

Announcements

- On Sunday at 5 a.m. the first part of the RG-A run came to a conclusion. This first physics running period in Hall B with the new CLAS12 spectrometer lasted from Feb. 14 to May 5. Many thanks to all who contributed to make this run so successfully for Hall B and for Jefferson Lab. We particularly acknowledge the efforts of:
 - B-coordinators, PDL, CLAS Collaborators, Hall B Engineering, Magnet Engineering, and Hall B staff
 - Awards for most shifts taken: **Gold - Lei Guo**, **Silver - Achyut Khunai**, **Bronze - Francesco Bossu, Guillaume Christiaens**



Christiaens *et al.*
arXiv:2211.11274

1

Detector R&D

2

Data taking

3

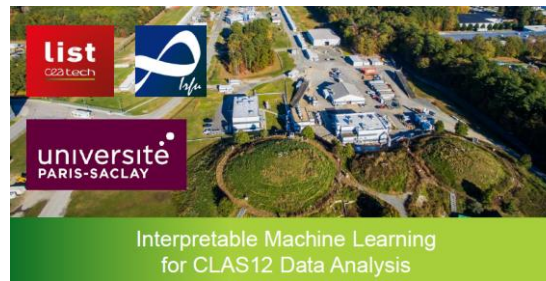
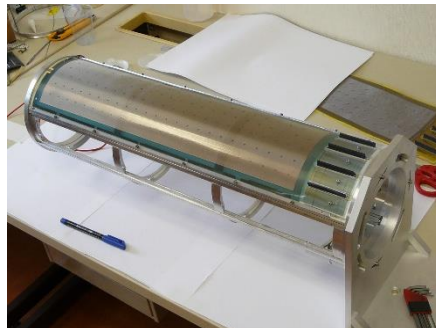
Data analysis

4

Data release

5

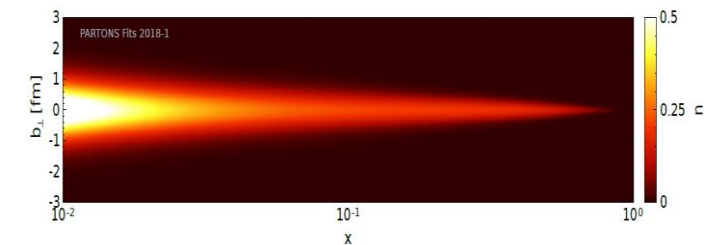
Phenomenology



Noëlie CHERRIER
Thesis defense
1st March 2021

Supervisors:
Maxime DEFURNE
Jean-Philippe POLI

Director:
Franck SABATIE



PARTONS

Moutarde *et al.*
arXiv:1807.07620

22/03/2023

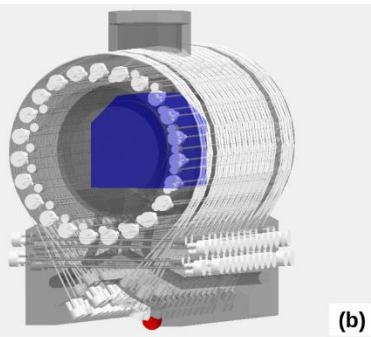


3 ■ Extensions

Applications and further developments in other projects:
sPHENIX, EIC, theory.

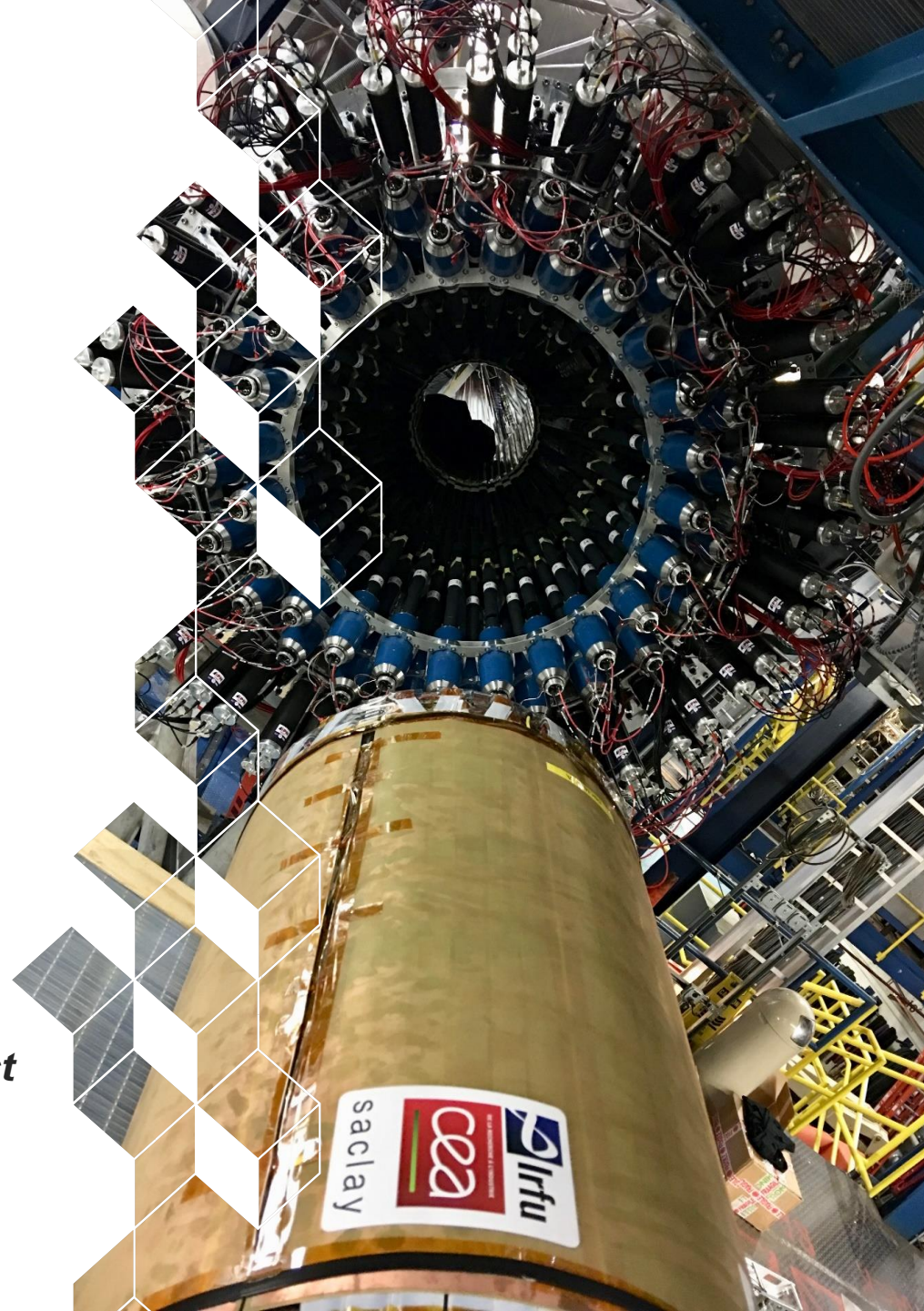
Micromegas tracker

- **First resistive** Micromegas detector for physics experiments
 - 75 man.year project started in 2006.
 - 18 cylindrical detectors in a 5T magnetic field.
 - 25000 channels, readout DREAM.
 - Off-detector frontend electronics 2 m away.
- Applications to:
 - Hadron physics (EIC, sPHENIX, etc.).
 - Muon tomography.



**Nuclear and renewable
energy division**

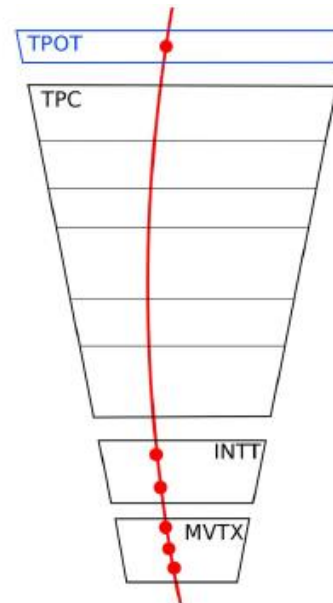
*"The first challenge in adapting muography to a **decommissioning project** is that, compared to a stone pyramid with a simple geometry, there are over 20,000 components in a reactor" (H. Gomez Maluenda, Irfu/DEDIP)*



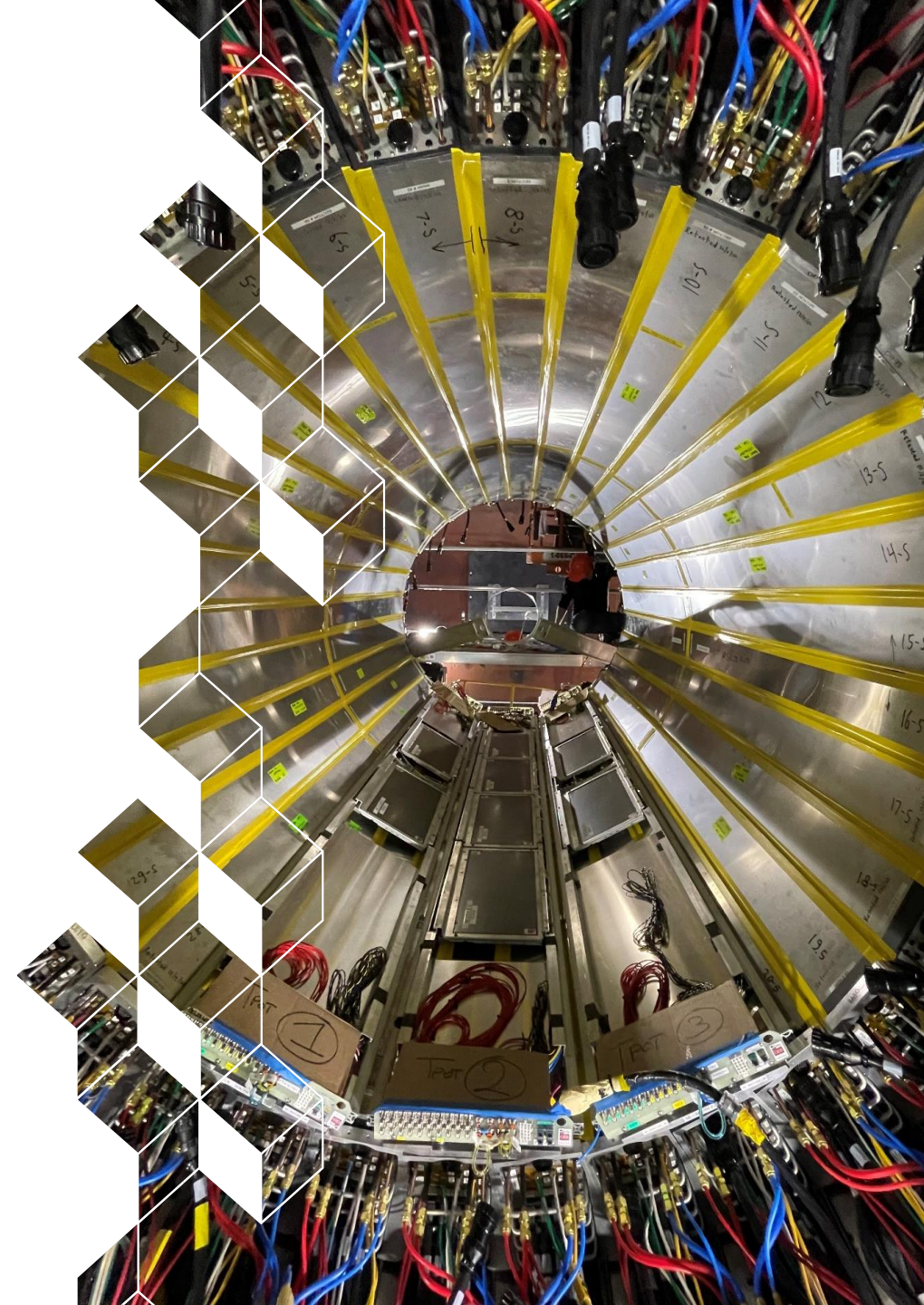
sPHENIX

Gaseous tracking detectors

- Micromegas detector with resistive strips: 55cmx32cm.
- SAMPA streaming read-out (50kHz in Au-Au collisions).
- Challenging project with the need for a **high reliability** - no access to the detector after installation until the end of the sPHENIX physics program (3years).
- 10 modules with 2 layers (z et rphi direction): 8 installed and 2 spares.
- **Detector realisation achieved in a narrow window:**
 - Contract signed on January 2022.
 - Delivery of the detectors at BNL end of July 2022.
- Design, prototypes, resistive layers and detector production entirely at CEA.
- Installation in sPHENIX in December 2022.



sPHENIX + TPOT



EIC studies after CLAS12

Gaseous tracking detectors

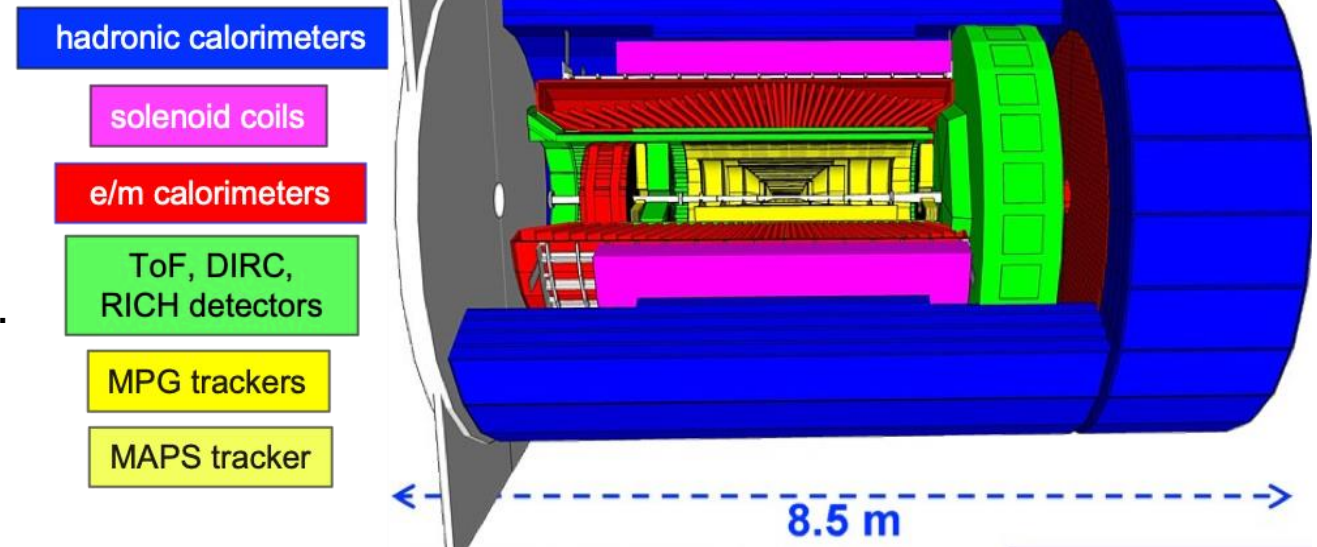
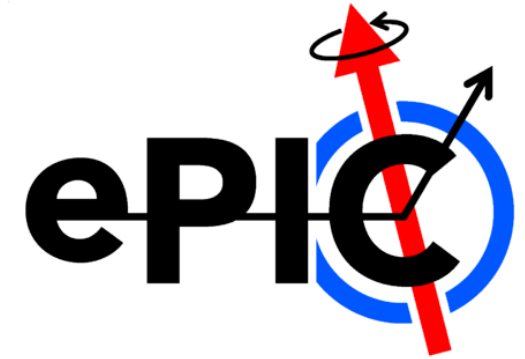
- Low material budget Micromegas 2D detectors.
- Based on the technology developed for the CLAS12 experiment at Jlab and taking data since 2017.
- Capacity to design and produce the whole system: experience from CLAS12, ATLAS NSW, T2K and more.

ASIC for MPGDs

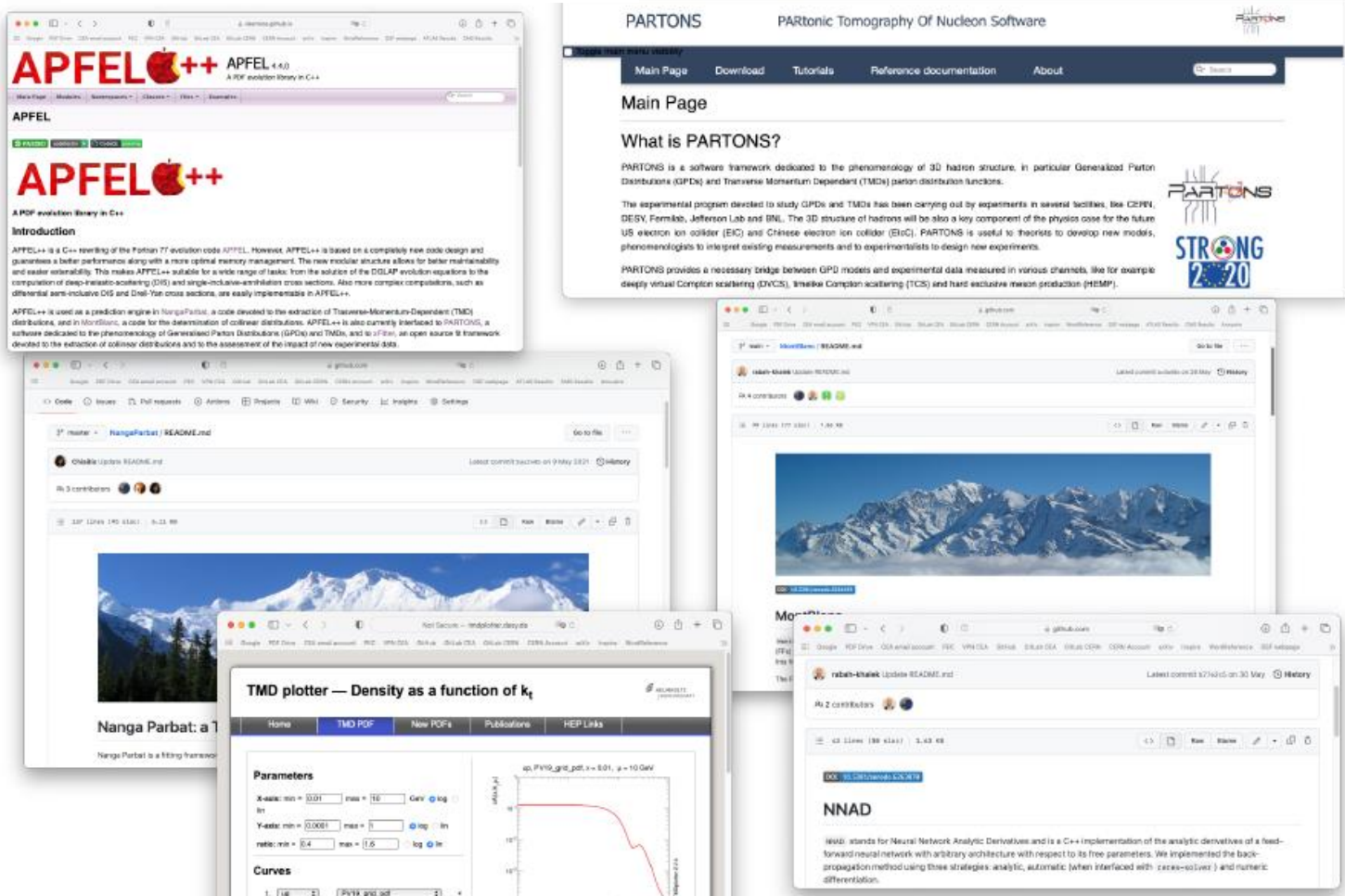
- Development of a new versatile ASIC for Micromegas and μ RWELL readout.
- Partnership with Sao Paulo University.
- Close synergy with the detector development.
- Integration with the DAQ system.

Magnet

- Design of the solenoid for the ePIC detector in collaboration with Jefferson Lab magnet engineers.



The PARTONS ecosystem



- Computing framework for 3D hadron structure
 - Open-source codes.
 - Modular and open architecture.
 - GPDs, TMDs, PDFs, QCD evolution, etc.
 - Generic exclusive event generator.
- From Jefferson Lab to EIC physics.

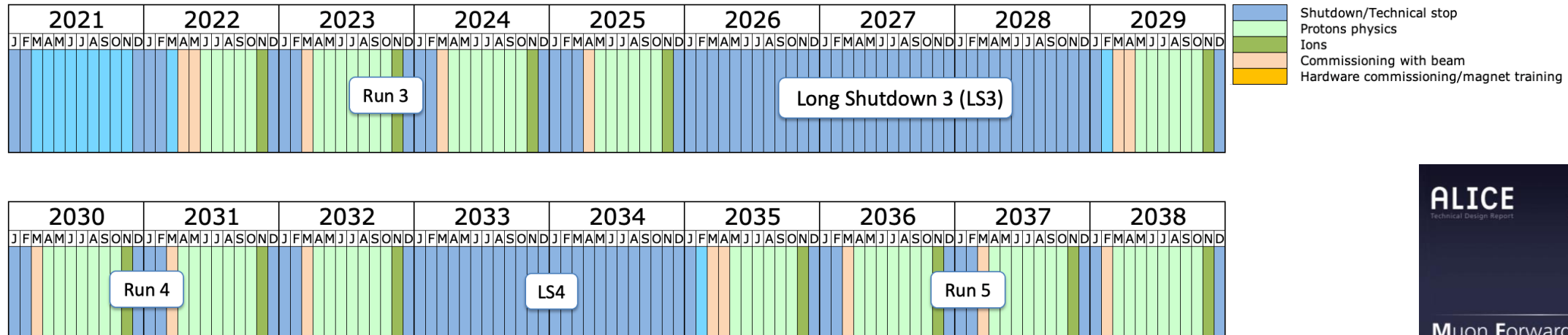




4. **Future plans in QCD**

An aside on heavy ions and DPhN hiring plans.

Timeline

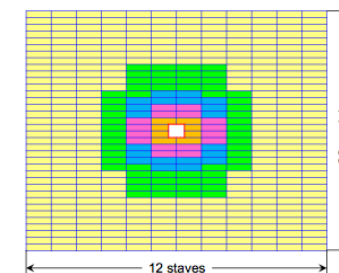
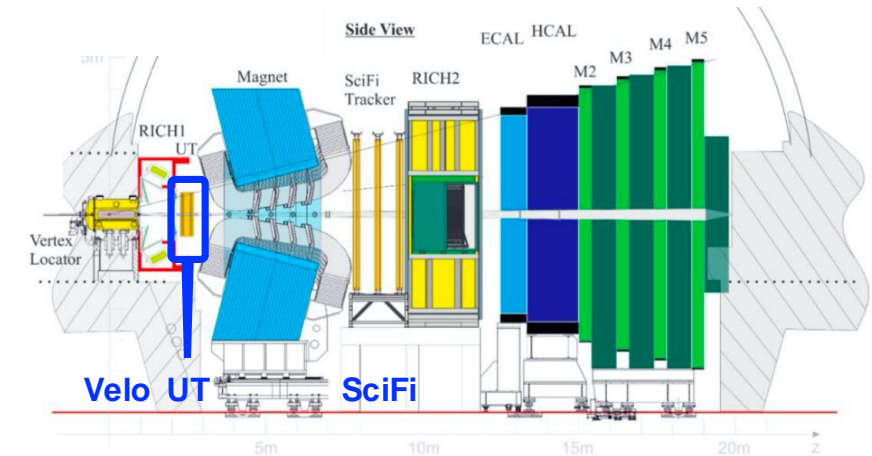


- Upgraded ALICE muon spectrometer (with MFT) for Run 3 and after.
 - **Much higher statistics** (~10 nb⁻¹ in Pb-Pb): rare signals: Psi (2S), Upsilon,...
 - **J/Psi separation** between prompt and non-prompt (B → J/Psi + X).
 - **Improved Psi(2S)** due to the increase of S/B ratio (thanks to the MFT).
 - **B measurements** using non-prompt J/Psi.
- LHCb for Run 5: installation in LS4
 - High precision **heavy flavors** and **quarkonia** measurements (including χ_c family).
 - Complete study of **small systems** (including high multiplicity pp).
 - **Upgraded apparatus** for heavy-ion collisions (collider & fixed target).



LHCb and the upstream tracker (UT) upgrade

- From a versatile flavor physics experiment to a general purpose detector.
- Planned and discussed upgrades:
 - Full software trigger.
 - Improvement of **heavy-flavor reconstruction**.
 - Development of a **small-system** program.
 - Development of a fixed-target program.
 - Extension to heavy-ion running conditions: **UT critical**.
- Increasingly important actor for QGP physics:
 - From Run 3: **small systems** and fixed target (SMOG2).
 - From Run 4: central and semi-central Pb-Pb.
 - From Run 5: full light- and **heavy-ion program**.
- Key expected physics achievements
 - Precise experimental assessment of **in-medium QCD** features and **hadronization** mechanism.
 - Precise measurement of the **temperature** and **time evolution** of the system.



UT: Challenging readout

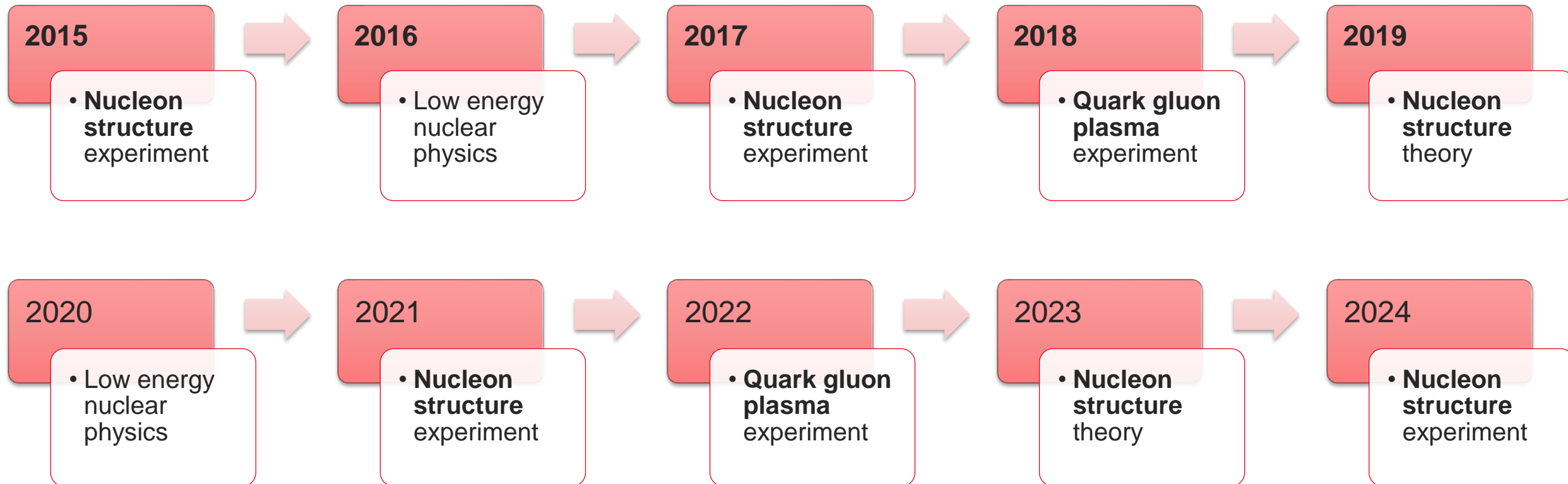
Ring	5	4	3	2	1
e-links / chip	1	1	1	1-3	2-7
Gbps / e-link	0.32	0.64	1.28	1.28	1.28
IpGBT / module	0.5	1	2	7	14/10
Num of modules	1312	240	80	64	32
Num of IpGBTs	656	240	160	448	384

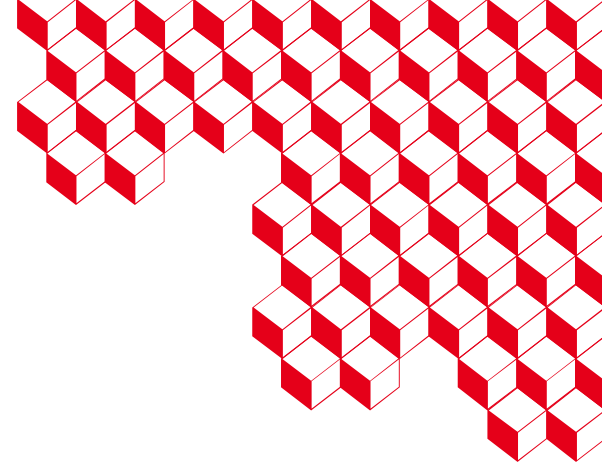
Simulations and CMOS solutions

Hiring plans

Current involvement in CLAS, EIC, sPHENIX, ALICE and LHCb

- Need to **strengthen** the experimental teams to build groups with a **critical size**.
- About **1 permanent research staff position / year in QCD** during the last decade.
- One permanent position tagged “*Nucleon structure, EIC, experiment*” **foreseen in 2024**.





Thank you!

Any questions?

Hervé MOUTARDE

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Fundamental Research Division
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France

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