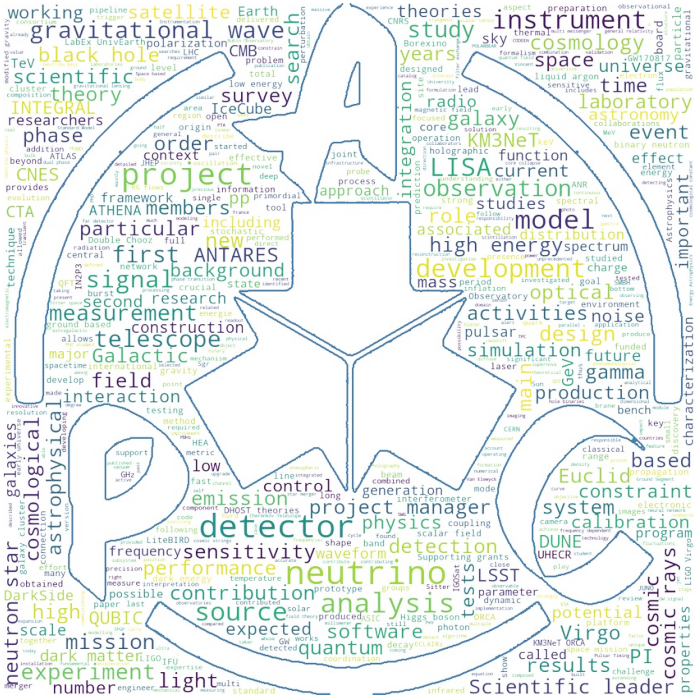
AstroParticule & Cosmologie



Bienvenue à APC !

Witamy w APC!

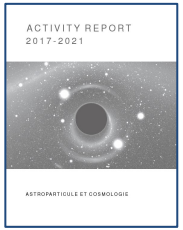
Welcome to APC!

Program and scope of the visit

- **Program of the visit**
  - 14:30-15:00 – Welcome address
  - 15:00-15:30 – Breakout group sessions on a selection of focused topics
  - 15:30-15:45 – Group picture

- **Presentation outline**
  - Lab AstroParticule & Cosmologie today
    Our science objectives, expertise and know-how

    https://apc.u-paris.fr



  - Our collaboration with Astrocent

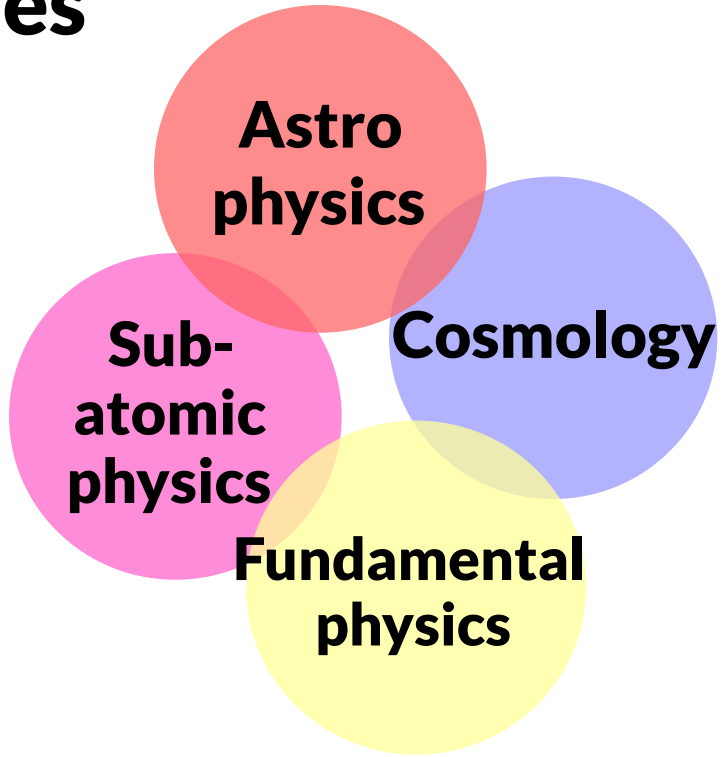
ASTROCENT

Governing bodies

A collective of 220+ staff members

80 researchers and faculties, 75 engineers and admin staff and 65 PhD students and postdocs

Physics of the two infinities



Experiments
Space-based instruments

Observations
Multimessenger astronomy

Theory

APC in few key numbers

- 25 world-class projects/experiments
- lab's annual budget : 13 M€ / yr
- 250 peer-review articles per year
- ~17 PhD theses per year

Key scientific questions (1)

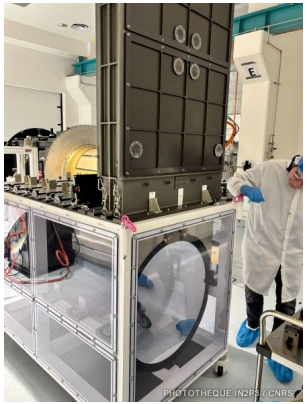
SciPol

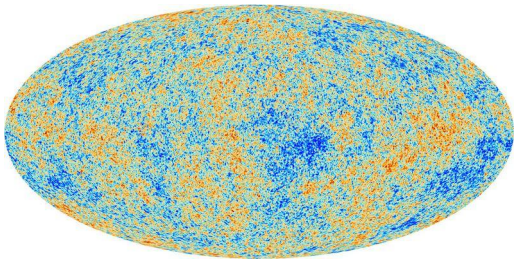
Science from the large scale cosmic microwave background polarization structure

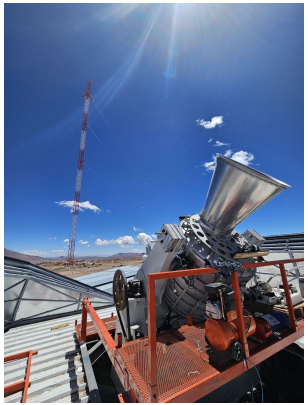
Cosmology

- Origin and fate of the Universe
- Cosmic inflation?
- Nature of dark matter and dark energy?
- Large structures in the Universe

- Large sky surveys (lensing, BAO)
- Cosmic Microwave Background



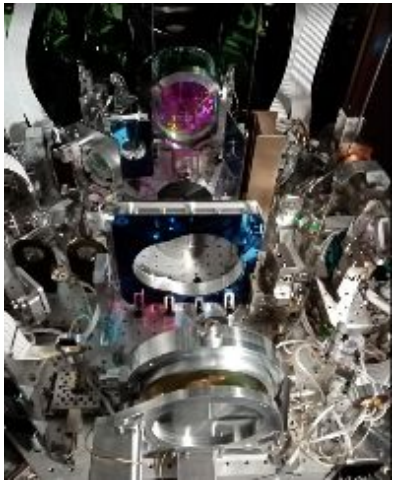




Key scientific questions (2)

Gravitation

- Gravitational-wave astronomy
- Theory of gravitation?
- How many black holes? What mass and spin?

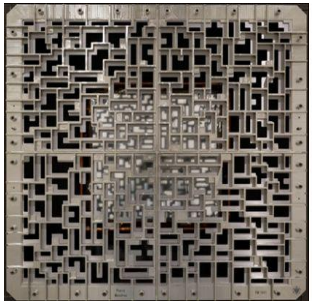


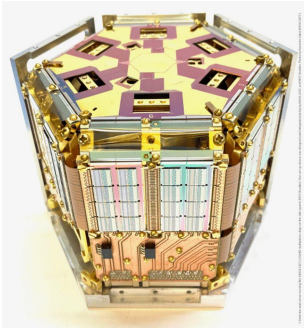
- Ground-based interferometers
- Space-based detector
- Pulsar timing arrays

Key scientific questions (3)

High-energy astrophysics

- Extreme transient phenomena in the Universe
- Mechanisms that accelerate particles to the highest energies
- Multimessenger astronomy: high-energy photons, neutrinos, cosmic rays



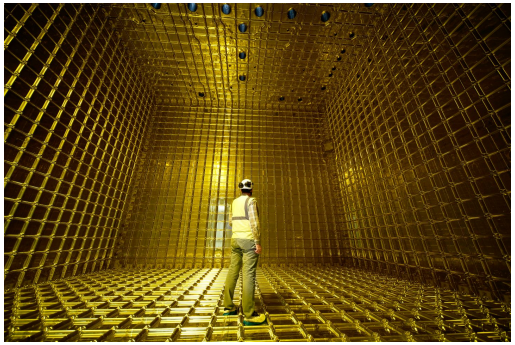


- Gamma-rays and X-rays
- Cosmic neutrinos
- Cosmic rays

Key scientific questions (4)

Particles

- Fundamental properties of neutrinos? Oscillations? Mass ordering? CP violation?
- Nature of dark matter? WIMP mass and cross-section?
- Properties of the Higgs boson? Self-coupling



- Time Projection Chamber-based detectors
- Underwater Cherenkov detector
- Large colliders

DUNE DARKSIDE KM3NeT ATLAS EXPERIMENT FUTURE CIRCULAR COLLIDER

Key scientific questions (5)

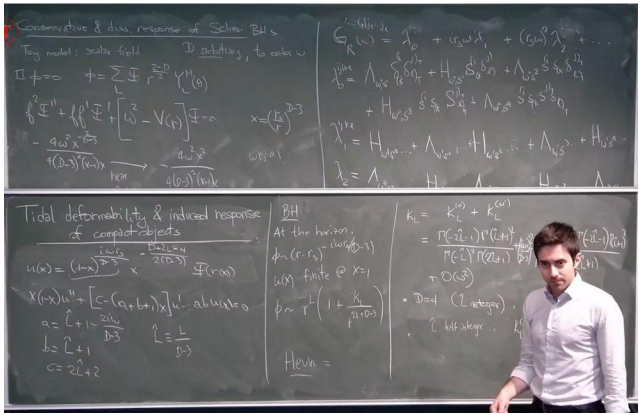
Funded by the European Union

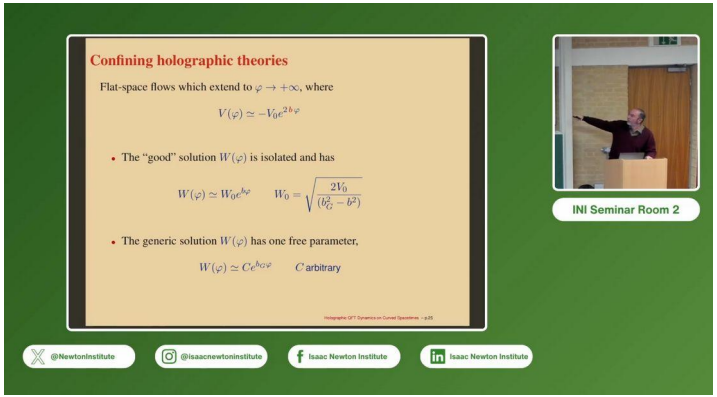
European Research Council
Established by the European Commission

Cosmomag

Theory

- Quantum foundations of gravity and spacetime
  Modified gravity and scalar–tensor theories
- Quantum physics of the early Universe
  Nature of dark energy and cosmic acceleration
  Cosmological and fundamental physics encoded in gravitational waves
- Astroparticle physics: neutrino and cosmic rays
  Origins and propagation mechanisms of high-energy particles. Primordial magnetic fields





Organization

Governing bodies: CNRS/IN2P3, Université Paris Cité, CEA, Observatoire de Paris, CNES

Scientific Council

Laboratory Council

Management team
Jean-Christophe Hamilton **(director interim)**
Georgette Diaby (administrative director)
Guillaume Prévôt (technical director)
Eric Chassande-Mottin (deputy director)
Davide Franco (deputy director)
Antoine Kouchner (deputy director)

CSP Cellule Suivi Projets
Guillaume Prévôt (chair)– Corinne Juffroy

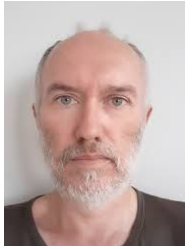
Cosmos, sciences et Sociétés
Anne Lemière (director)

InIdex Hermes
Razvan Caracas

Research teams	Technical departments	Administration and transversal activities	Platforms
Cosmology Cyrille Rosset	**Mechanics** Alain Givaudan	**Finance and budget** Béatrice Silva	**François Arago Center** Cécile Cavet, Andrii Neronov
Gravitation Stanislav Babak	**Electronics & µelectronics** Sylvie Blin	**Human resources** Georgette Diaby	**Low-noise meas room** Pierre Prat, Damien Prêle
High-energy astrophysics Alexis Coleiro	**Instrumentation** Miles Lindsey-Clark	**Communication** Sarodia Vydelingum	**Cryomat** Michel Piat, Jean-Pierre Thermeau
Particles Giovanni Marchiori	**Computing and IT** Andrea Sartirana	**Health & Safety – Radiation protect.** Lydie Pavilli, Ronan Oger Damien Pailot, Guillaume Prévôt	
Theory Dmitri Semikoz	**Quality & project monitoring** Corinne Juffroy	**Continuing training** Catherine Hugon	

Intern advisor: Floriane Cangemi
Sustainable dev referent: Sarodia Vydelingum
Equality referent: Giulia Vannoni, Matthieu Laporte
Open science referents: Bruno Khelifi, Catherine Hugon
Correspondents Europe: Julie Epas, Alicia Orhan
Thesis referents: R Stompor, M Barsuglia, F Cangemi, A Tonazzo, D Langlois



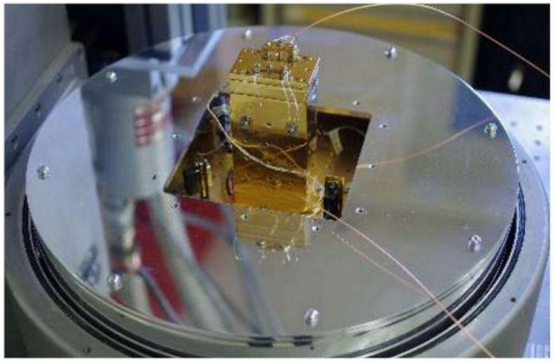
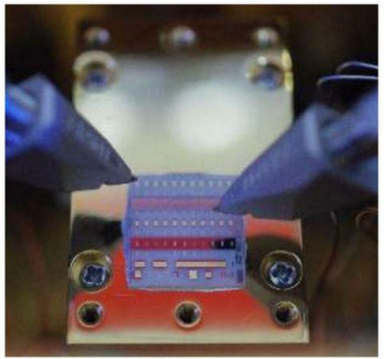



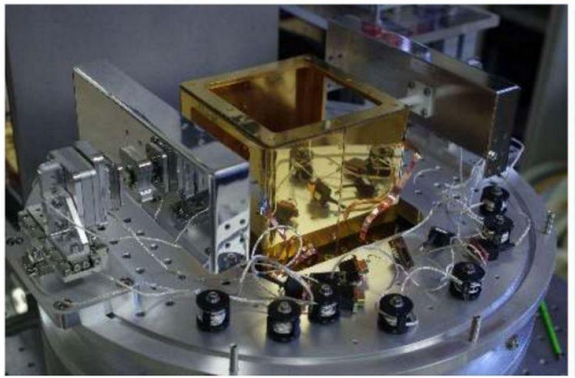
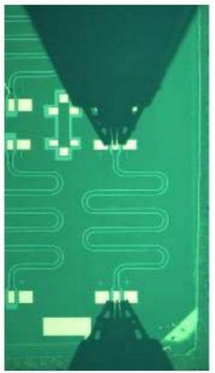
Shared technical facilities

- Measurement & Characterization Labs
  - Low-noise measurement lab
  - Millimetric laboratory
  - Photodetection lab
  - Metrology lab
- Optics & Clean Environments
  - Clean rooms and optics labs
- Testing & Simulation Facilities
  - Thermal vacuum vessel
  - Integration hall
- Fabrication & Prototyping
  - Mechanical workshop
- Computational Infrastructure
  - DANTE: Computer cluster

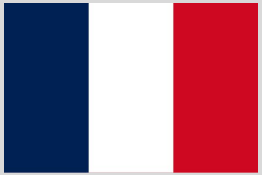
Technical platform CRYOMAT

CRYOMAT is a **material characterization platform** at **sub-Kelvin temperatures** providing **thermal, mechanical, and electrical measurements** with advanced cryostats, supporting scientific and industrial applications and delivering **open-access high-precision cryogenic material property data**.

Our collaboration with Astrocent



ASTROCENT

At the origin of the 7-year partnership with Astrocent

2018 Creation of AstroCeNT

- Established as an autonomous department of CAMK PAN
- Foundation for Polish Science: 38 M PLN (~8.3 M€) for 5 years
- Initiated by Prof. Leszek Roszkowski, **inspired by the scientific vision and model of APC**
- **Key role of Stavros Katsanevas** (former Director of APC) in shaping the concept and launching the collaboration
- **Partnership agreement between CNRS/IN2P3 and CAMK/PAN**
  - Regular joint meetings
  - Joint research projects
  - Co-supervision of interns and PhD students
  - Collaboration visits in Paris and Warsaw

Astrocent's mission:
develop advanced technologies and instrumentation for particle astrophysics

Focus on the hidden Universe
dark matter, rare events, gravitational waves, ultra-sensitive detectors

At the origin of the 7-year partnership with Astrocent

2019 APC–Astrocent at the "Particle Astrophysics in Poland" conference

- Keynote by A. McDonald (Nobel Prize 2015)
- VIP participation: ambassadors of France and Italy
- **AstroCeNT announced joining the Global Dark Matter Collaboration (DarkSide-20k)**

2020 Visit of Alain Schuhl, CNRS science director

- Strengthening institutional collaboration with AstroCeNT

2024 Visit of Aurélien Le Chevalier

- Directeur général de la mondialisation du **Ministère des Affaires étrangères**, accompanied by Prof. Jean-Luc Schneider, Attaché at the French Embassy in Poland

A strong partnership: grants and collaborative projects

Long-standing French–Polish collaboration

- **COPIN** grant awarded every year since 2019
  - DarkSide-focused joint projects, sustained bilateral support
- **POLONIUM** programme funded in 2020–2021
  - French–Polish mobility scheme for collaborative research

⇒ Strong, continuous **partnership** enabling student exchanges, joint analysis, and shared development across APC and Astrocent

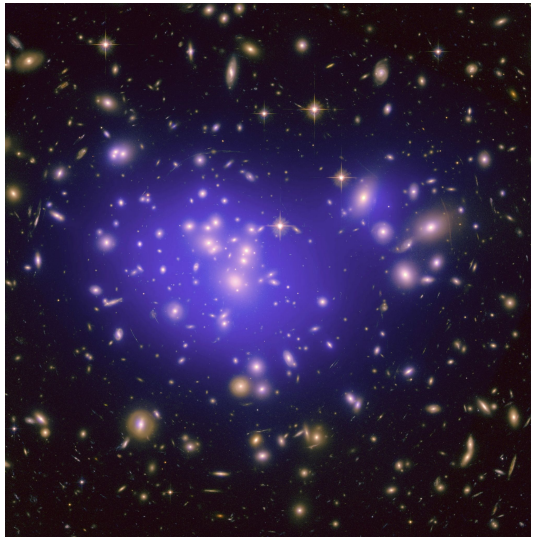
H2020 Twinning: **DarkWave** (2018–2022)

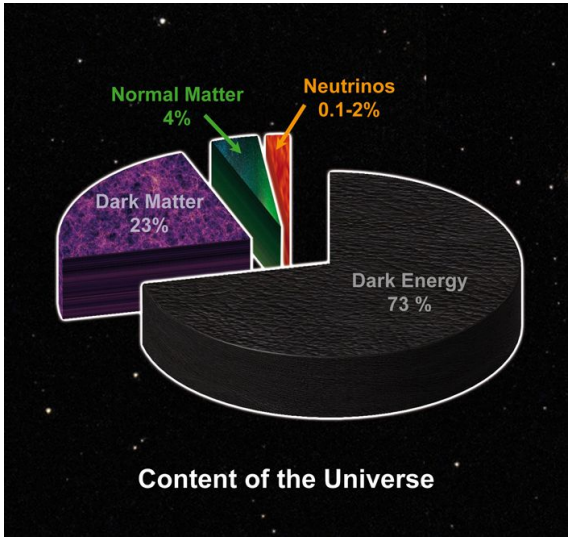
- EU Twinning grant to strengthen European expertise in low-background & LAr technologies
- Partnership between **Astrocent**, **APC**, GSSI, LNGS
- Training programmes, researcher exchanges, and coordinated R&D
- Foundation for long-term collaboration networks (including Astrocent+)

A joint scientific programme toward dark matter detection

The Global Argon Dark Matter Collaboration

Over **400 scientists** from more than **100 institutions** worldwide, working together to build **DarkSide-20k** the **biggest** and **most sensitive experiment to** **detect dark matter particles**



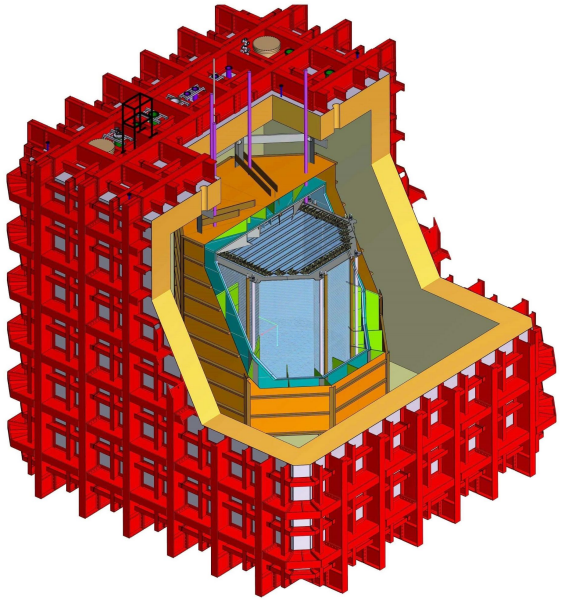


A joint scientific programme toward dark matter detection

Astrocent and APC cooperate on science and technology

DarkSide-20k: a concentration of **cutting-edge technologies** to detect a few events in 10 years

50 tons of liquid argon
First time us of argon extracted from underground sources at 2-km depth



Detecting light
200,000 SiPMs — tiny “eyes” designed to catchfaint flashes from dark matter interactions

Purifying argon
A world-record 350-m cryogenic distillation column

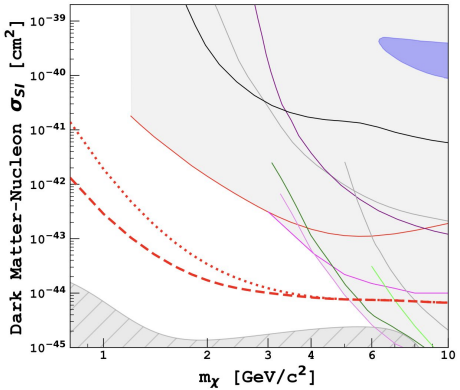
Acquiring 500 GB/s of data
A continuous, triggerless waveform acquisition system

APC–Astrocent: strong scientific & technological productivity

About 20 peer-reviewed publications born from APC and AstroCeNT cooperation in 7 years

AstroParticle Physics

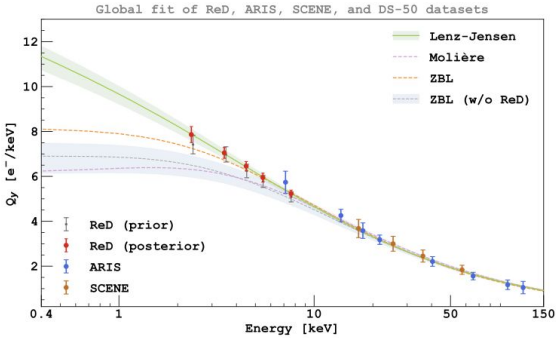
Opening a new window on light dark matter



Nature Commun Phys 7, 422 (2024

Atomic Physics

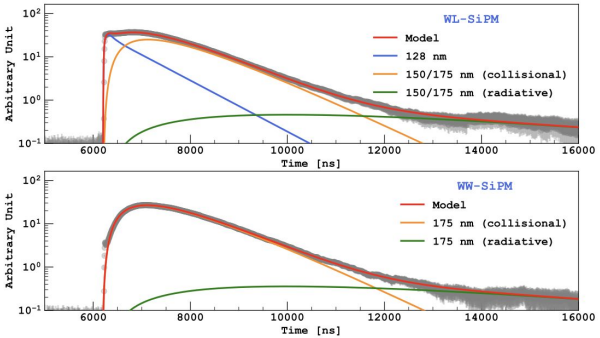
Understanding atomic screening in liquid argon



Submitted to PRL (2025)

Particle Detection

Enhancing the glow: Xenon's impact on argon scintillation



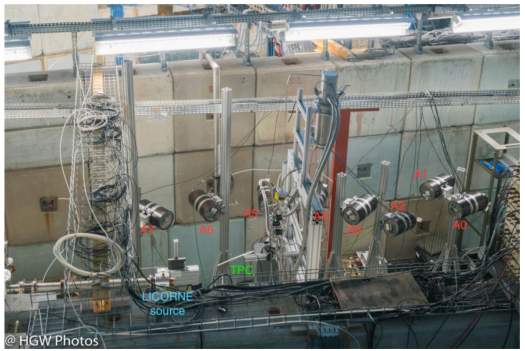
Phys Rev D 111 (2025) 10, 102001

APC–Astrocent: strong scientific & technological productivity

About 20 peer-reviewed publications born from APC and AstroCeNT cooperation

Nuclear Physics

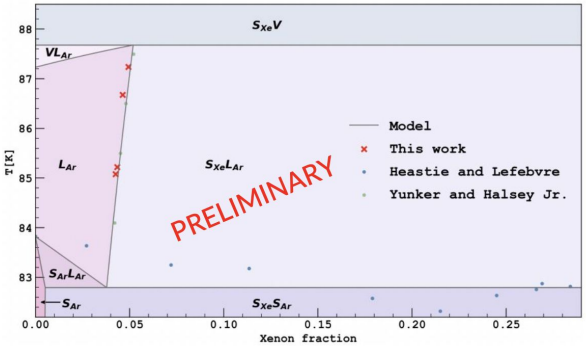
Probing liquid argon response with accelerator neutrons



Phys Rev D97 (2018) 11 112005

Thermodynamics

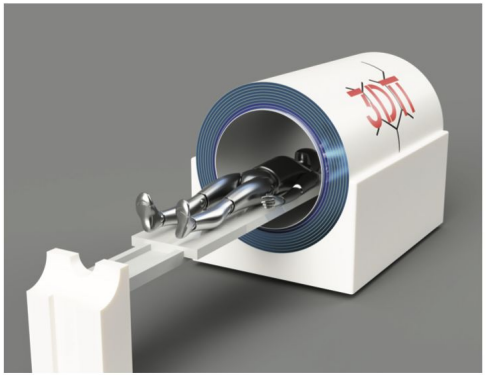
X-ArT: exploring the Xe–Ar phase frontier



Submitted to Physics of Fluids (2025)

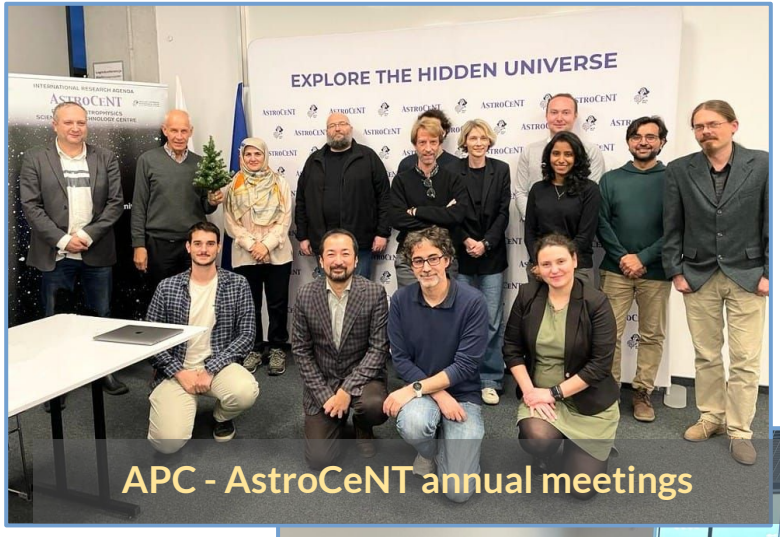
Medical Imaging

3DPi: a new way to think about PET with liquid argon

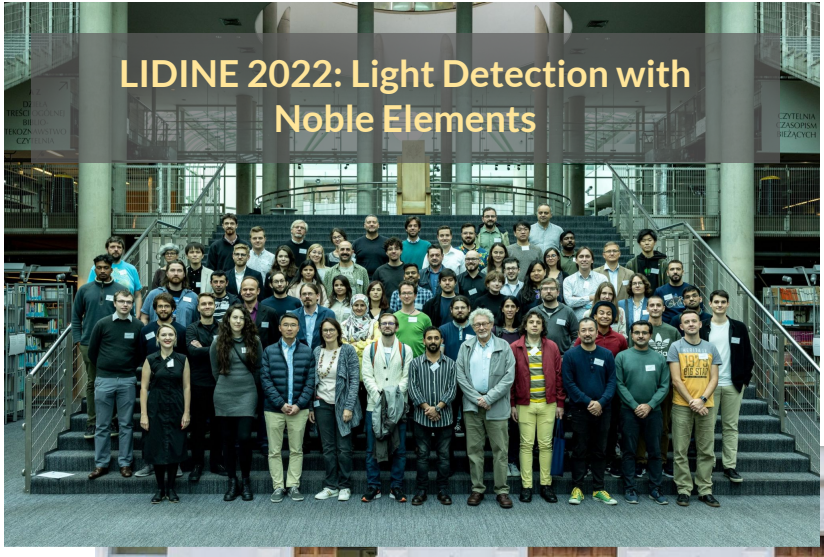


Phys. Med. Biol. 70 065015

7 years of a rich and successful collaboration with Astrocent



APC - AstroCeNT annual meetings



LIDINE 2022: Light Detection with Noble Elements

DarkSide Collaboration Meetings

7 years of a rich and successful collaboration with Astrocent

APPEC

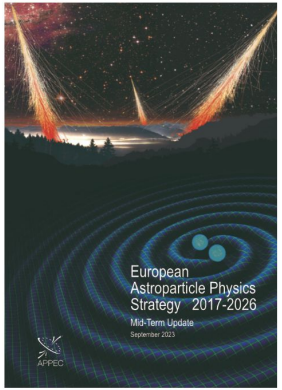
General Assembly

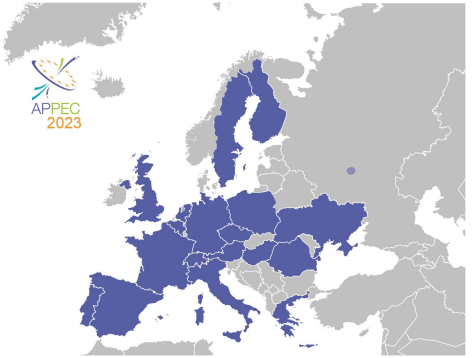
Chair: **Carlos Peña Garay** (LSC)

Deputy chair: **Antoine Kouchner** (APC)

Deputy chair: **Leszek Roszkowski** (AstroCeNT)

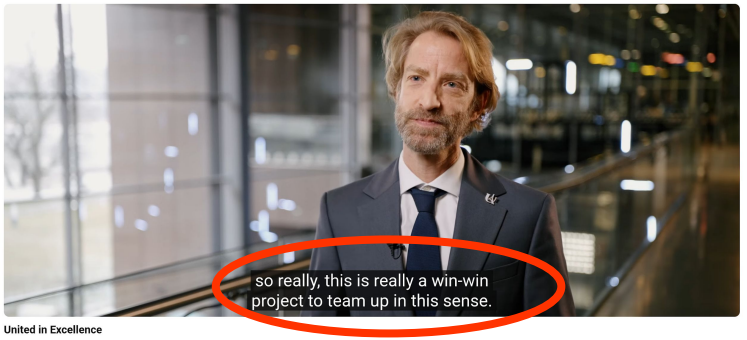
General Secretary: **Julie Epas** (APC)





Horizon Europe WIDERA Teaming for Excellence in 2025

2025-30: 15 M€ from the EC + 15 M€ from Polish complementary funds



United in Excellence

United in Excellence

See https://www.youtube.com/watch?v=UqV-jkxN858&t=14s or https://astrocent.camk.edu.pl/

Horizon Europe WIDERA Teaming for Excellence in 2025

Astrocent Plus – A new European hub for Astroparticle science

Consortium Members

- **NCAC** (Poland) — *Coordinator*
- **CNRS** (France)
- **U Paris Cité** (France) — *Affiliated*
- **GSSI** (Italy)
- **DESY** (Germany)
- **Łukasiewicz Centre (LC)** (Poland)
- **McDonald Institute (MI)** (Canada)

A transformative upgrade for European excellence

- Builds **Poland's (and region's) first autonomous institute in astroparticle physics**, in partnership with leading EU and international institutions.
- Develops **breakthrough research** on dark matter, neutrinos, gravitational waves, SiPMs, LAr detectors, and quantum technologies.
- **Strengthens Europe's innovation capacity** through technology transfer, advanced training, mobility, and strong industry cooperation.

Horizon Europe WIDERA Teaming for Excellence in 2025

APC participation in Astrocent+ Teaming

1.2 Managerial and administrative structure
1.3 Recruitment to key positions
1.4 Software framework
2.4 Professional development
3.1 Research project APP theory
3.4 Conferences and publications
3.7 Proposal writing mentorship
5.1 ESR mentorship and supervision
5.2 Summer school participation & organisation
5.3 Internships, postdoc and PhD student training
6.1 Media presence
6.2 Public outreach
6.4 Work with advisory and policy-making bodies

PAS - CNRS agreement (in progress, today)

Agreement on the partnership for the establishment of the Astrocent institute

official name: **International Institute for Particle Astrophysics of the Polish Academy of Sciences**

Article 2

1. **APC** will share knowledge and experience with **Astrocent** based on the principles of good practice in science.
2. **APC** will share its knowledge and experience with **Astrocent** in coordinating research activities at Astrocent and provide full support and advice to **Astrocent** in the process of establishing and managing **Astrocent**.
3. **APC** will support **Astrocent** with its long-standing experience in carrying out a standardised and transparent recruitment process and evaluation procedures for group leaders and laboratory managers in **Astrocent**.
4. **APC** will share with **Astrocent** its know-how on patent application and commercialisation of research results.
5. **APC** will support **Astrocent** in defining principles, identifying and prioritising research topics, based on scientific excellence and strategic relevance.

Focus and Strengths of the Agreement

- **Expertise Transfer:** APC shares advanced scientific know-how and best practices
- **Research & Management Support:** Guidance in organising activities and building a strong, well-structured centre
- **Transparent Recruitment:** Proven APC procedures for fair selection of group leaders and managers
- **Innovation Pipeline:** Support on patents and commercialisation of research results
- **Strategic Vision:** Joint definition of high-impact, excellence-driven research priorities

Conclusions and guided tour

Longue vie à notre collaboration avec AstroCeNT !

Niech żyje nasza współpraca z AstroCeNT!

Long-live to our partnership with AstroCeNT!

Split into two groups A and B

Each group will meet two stands with different topics

- **Group A : EU strategy and science communication**
  - This room: Discussion about Einstein telescope (gravitational waves)
  - Library (4th floor) : Cosmos, sciences and societies (link to society, outreach)
- **Group B : Key technological expertise**
  - Low-noise lab : Athena (low-noise electronic readout)
  - Photodetection lab : KM3NeT (photomultipliers for neutrino astro)

15 minutes per stand