Laboratory of Subatomic Physics & Cosmology (LPSC)

Journées Réseau Instrumentation IN2P3

Laurent DEROME, June 3, 2024

Scientific and academic environment

- Dense and diverse research ecosystem:
  - More than 100 institutes covering all scientific domains.
  - Innovation-focused community (big innovative companies and hundreds of startups)
  - 25 000 researchers, 65 000 students including 3000 Phd students.
  - National and international organisations and advanced facilities (ILL, ESRF, EMBL, IRAM)
  - Particularly known for its expertise in science and technology, especially in the fields of physics, electronics, computer science, geoscience and energy.

→Concentration which fosters interdisciplinary collaborations


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7A
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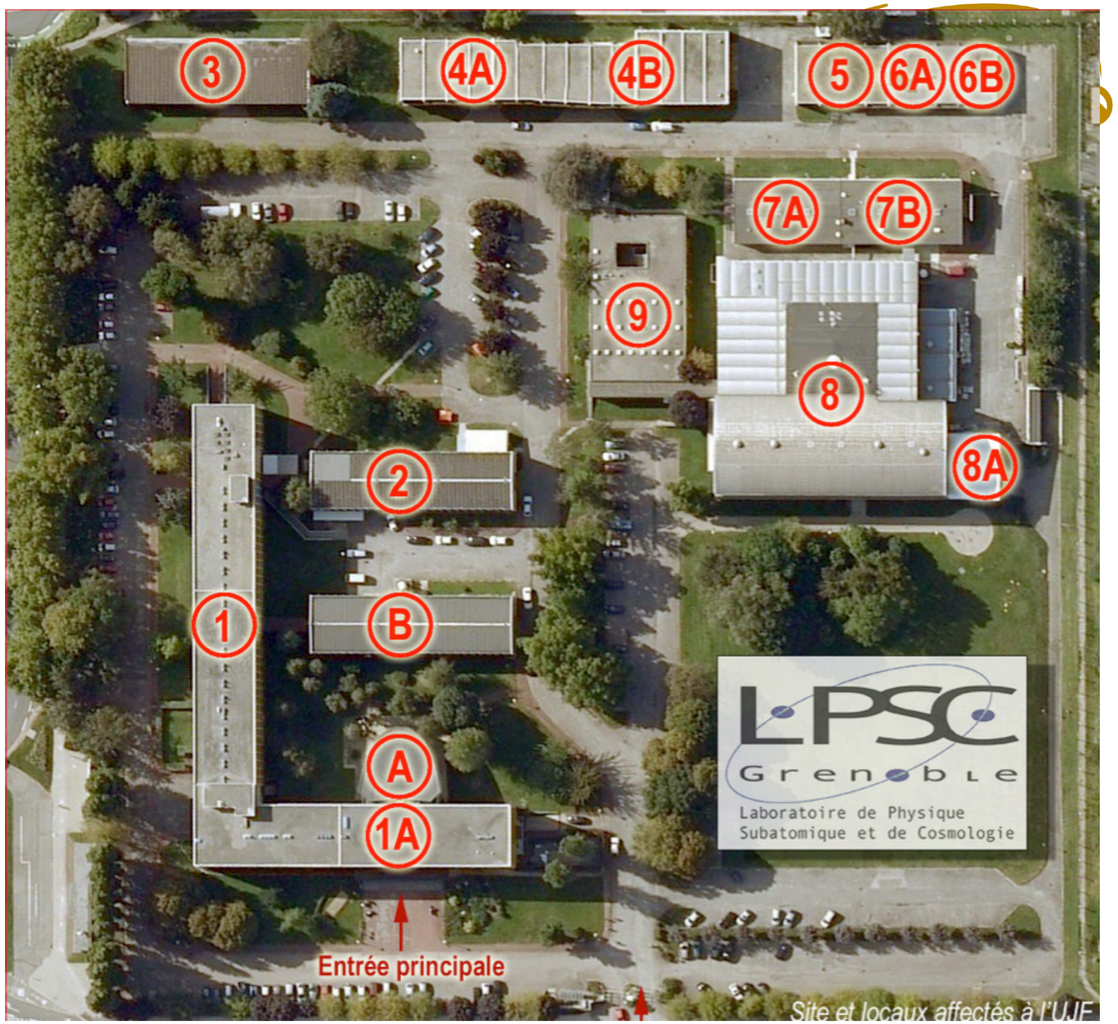
1A
LPSC
Grenoble
Laboratoire de Physique
Subatomique et de Cosmologie
Entrée principale
Site et locaux affectés à l'UJF
CNRS
LPSC
ILL
ESRF

LPSC

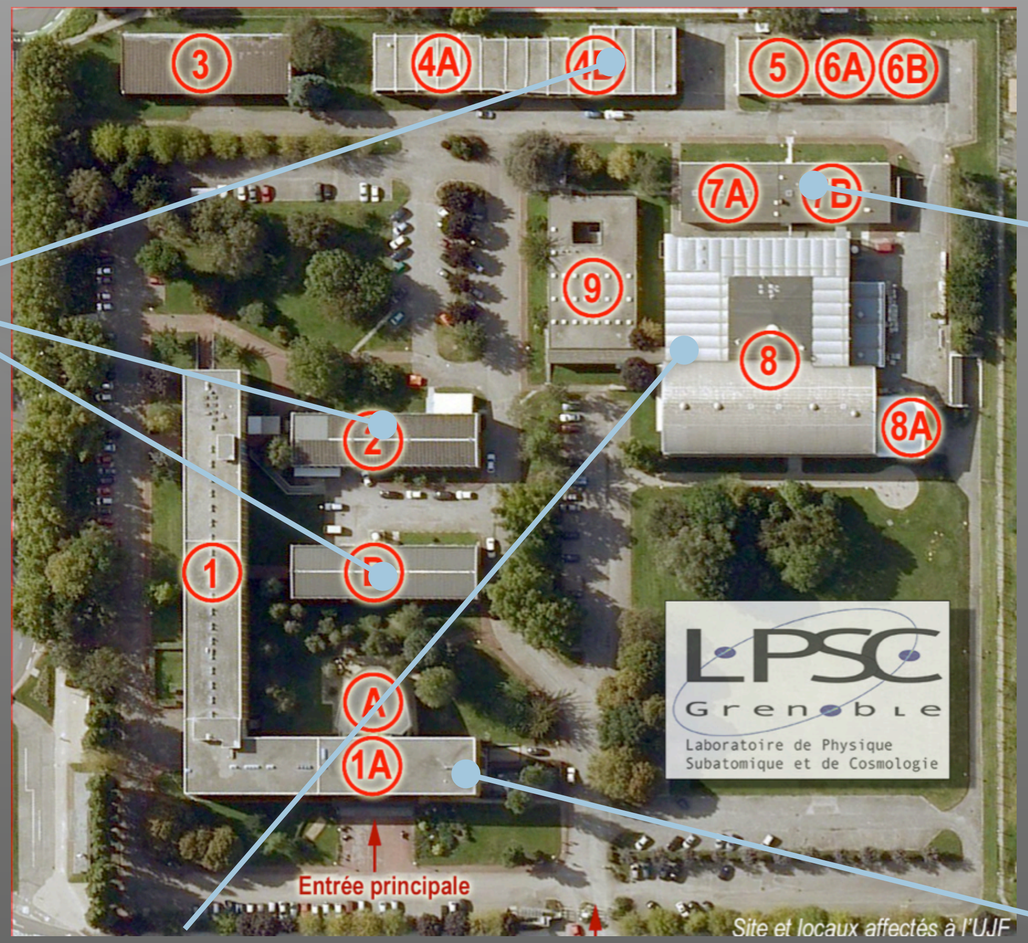
- Mixed Unit of Research supported by:
  - CNRS and the National Institute For Nuclear and Particle Physics (IN2P3)
  - Grenoble-Alpes University (UGA)
  - Engineering School Grenoble-INP (G-INP)
- Personnel (total ~220):
  - 65 researchers (38 CNRS, 27 Universities)
  - 40 PhD students & 15 Post-docs.
  - 90 engineers and technicians + 11 CDD
  - + > 60 internships / year
- 2 sites:
  - Grenoble : 9 buildings, 20 000 m2, (UGA)
  - Modane : surface building and underground site (CNRS)



Grenoble : Buildings and infrastructures

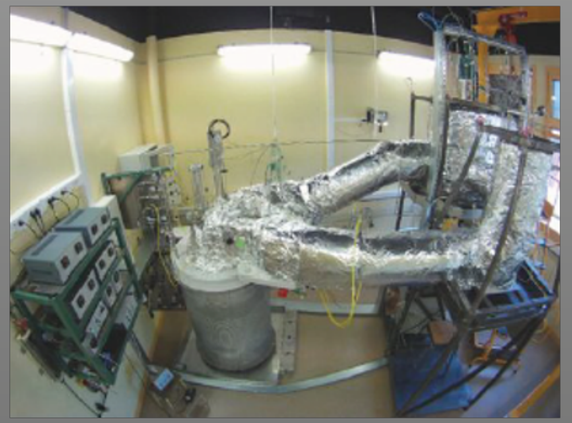
Assembling Mounting Hall

Assembling & Mounting
Testing, integrating



FEST Plateform

Molten Salt Reactor Install.



Accelerator Experimental facility

Accelerator Beam Lines
Ion Sources installation
Neutron Source Platform GENESIS
→ research and irradiations

Academic Training Plateform

>400 Master students / year
University, Eng. School,
Subatomic Physics & detection
Simulation of WPR nuclear reac

Research at LPSC

- Elementary constituants in the Universe and their fundamental interactions:

Particle & hadronic physics

Probes on and off accelerators: Production of new particles and new states of matter in colliders. Precision measurements, neutrino physics.

Astroparticles & cosmology

Astrophysical probes: Search for dark matter, vacuum energy, content and dynamics of the universe**.**

- Technological developments, applications, societal issues:

Nuclear Reactor Physics and Medical applications

Energy: next-generation reactors, scenarios
Medical Physics: innovative radiotherapies

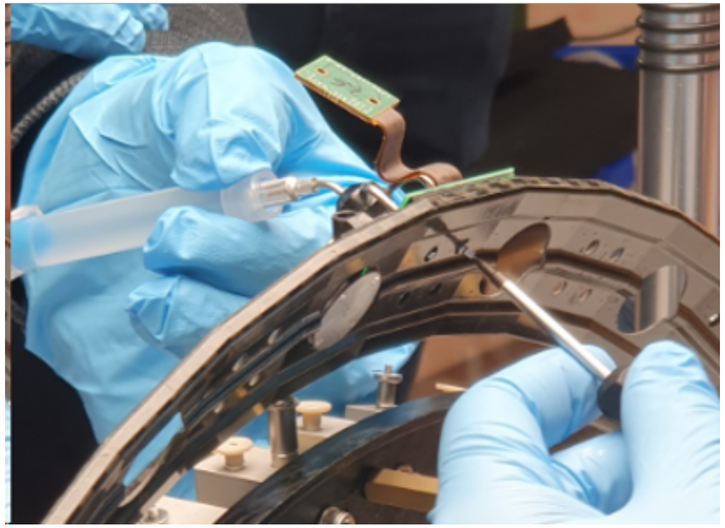
Accelerators and Ions Sources

Study and develop ion sources for accelerators and accelerator subsystems for science and society (energy & health)

Some examples of recent achievements or highlights illustrating our various activities…

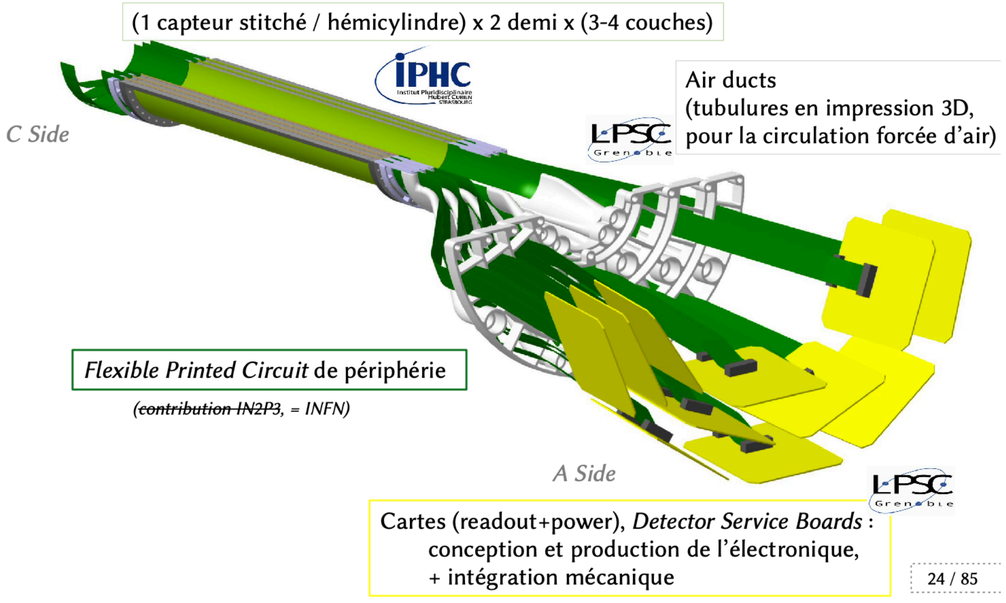
Particle & hadronic physics

- Particle Physics at LHC :
  - ATLAS:
    - Jet energy calibration & global energy flux reconstruction: Implementation of new AI techniques.
    - Search for new physics (dark matter): Dark QCD and long-lived particles, search for emerging jets, etc…
    - Participation in the integration of the modules for the new internal traker for HL-LHC (ITk)



  - ALICE :
    - Participation in the new ultra thin vertex detector (ITS3):
      - Electronic : readout + power
      - Mecanics and air-cooling: carbon foam, 3D printing

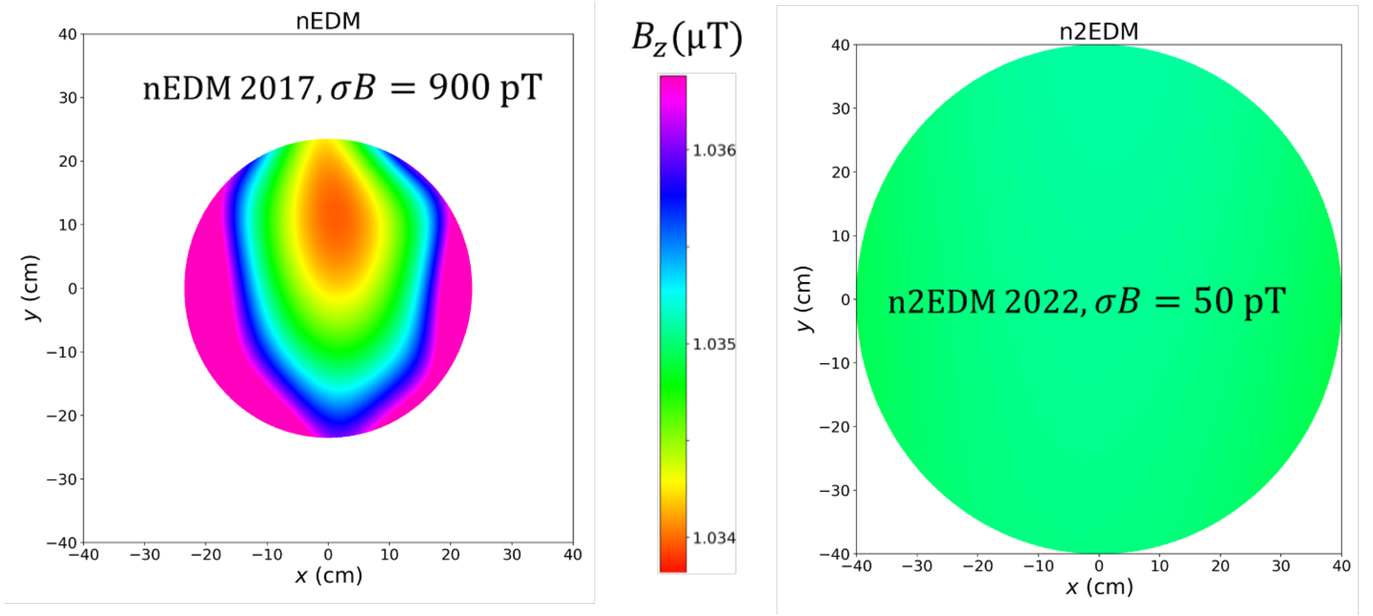
Stéréolithographie / résine



Particle & hadronic physics

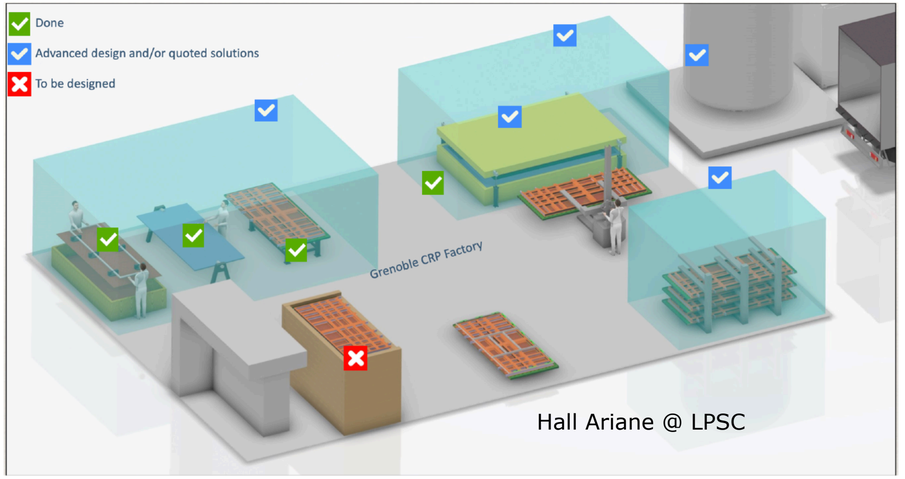
- Electric dipole moment of the neutron: n2EDM experiment at PSI to achieve a sensitivity of 10^{-27} e.cm to probe CP violation and new physics.
  - Participation in the construction and in the ongoing commissioning of n2EDM.
  - Quantum magnetometry: Implementation of the mercury co-magnetometer and development of the mercury laboratory at LPSC.
  - Magnetic field mapping of the n2EDM chamber.

n2EDM: Internal magnetic field mapping : world record for magnetic field uniformity in a large volume.



Particle & hadronic physics

- Neutrino Physics :
  - DUNE (FermiLab-Sanford / USA) :
    - Participation in Proto-DUNE @ CERN
    - Important contribution: assembly of 90% of the 80 TOP CRPs of the Large Vertical Drift LAr-TPC (2024-2026).



DUNE: Responsibility for the production chain of the top charge readout plans (CRP) for the vertical drift module.

  - RICOCHET (ILL) :
    - Testing new physics with coherent low-energy neutrino scattering.

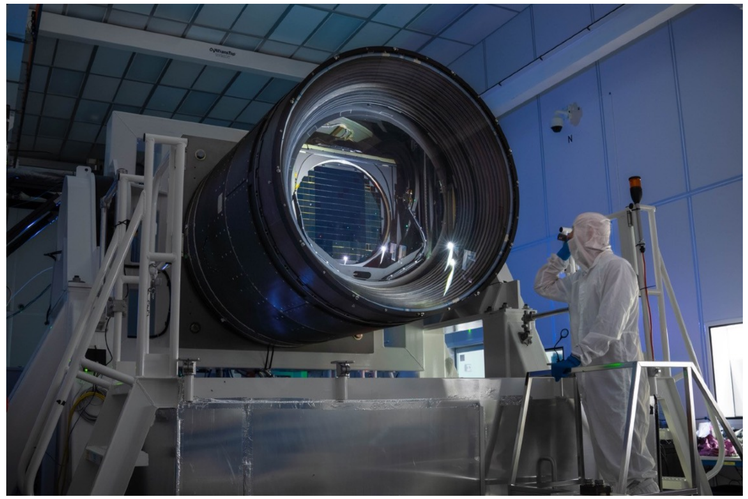
RICOCHET: Installation of the shielding designed and built at LPSC.

Ongoing commissioning

Start of data taking in 2024

Astroparticles & cosmology

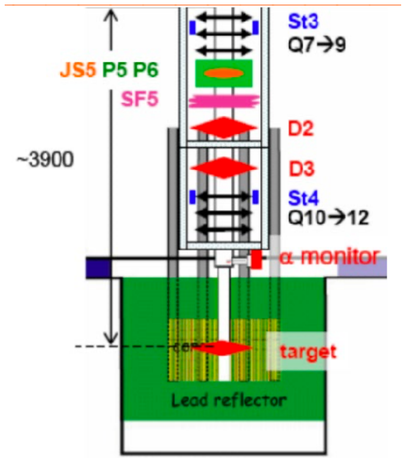
- Cosmology : Large structures as cosmological probes of the recent universe from both ground and space: Large surveys (visible and near-infrared) from ground (Rubin-LSST) and space (EUCLID).
  - Rubin-LSST:
    - Installation of the filter charger in Chile,
    - Data taking, and analysis with the CCOB fine beam.
    - Participation in commissioning and optimization of processing.
  - EUCLID : Successful launch in July 2024.
    - Development of the pipeline and preparation of analyses.



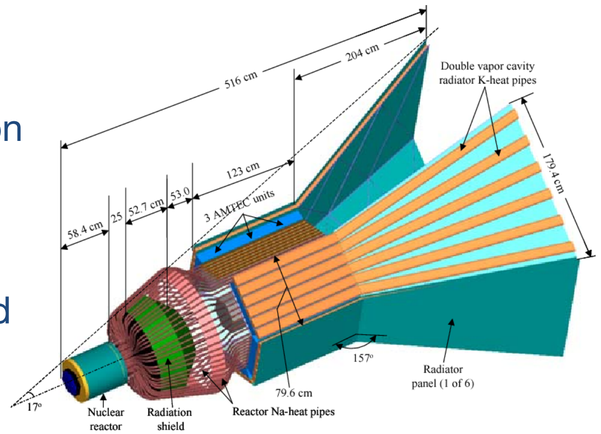
Nuclear Reactor Physics and Medical applications

- Nuclear Reactor Physics: Development of reactor models for the future of nuclear energy. Integrated approach: Energy scenarios, fuel cycle (Th,U), GEN-IV reactor design.

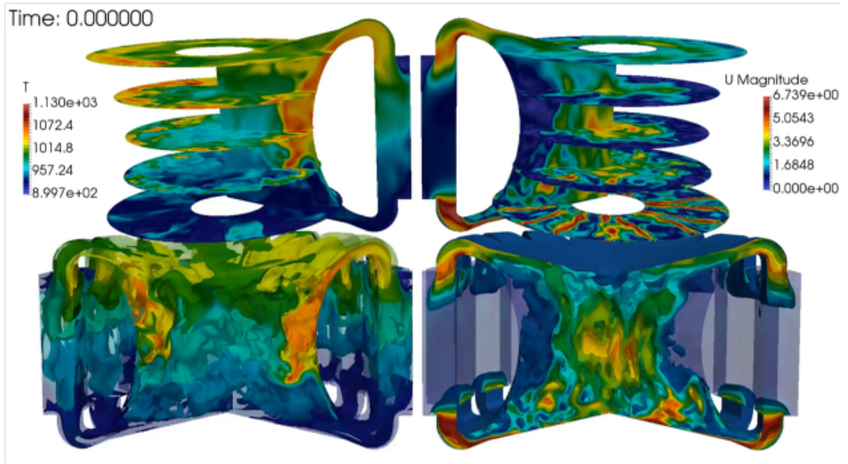
SPATIAL projet (SKN-CEN): Understanding space-energy effects in Accelerator-Driven Systems (ADS) reactors.



Nuclear Space Electric Propulsion (in collaboration with CNES and ESA): Development of numerical tools for testing various nuclear reactor concepts (MSR, HPR and LMRs)

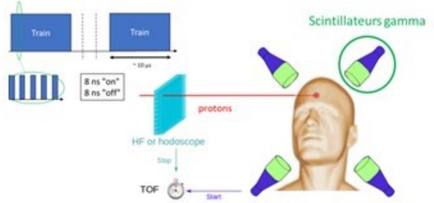


Molten salts reactor concepts: Improvement of high-fidelity calculation tools for characterizing reactor core power stability.



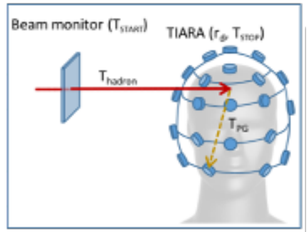
Nuclear Reactor Physics and Medical applications

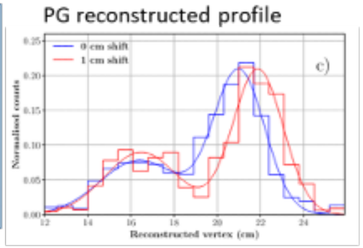
- Medical applications : Ionizing radiation for treatment and imaging.

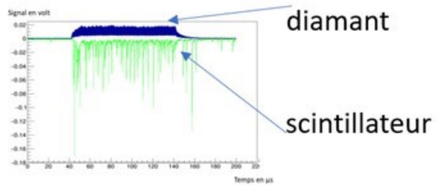


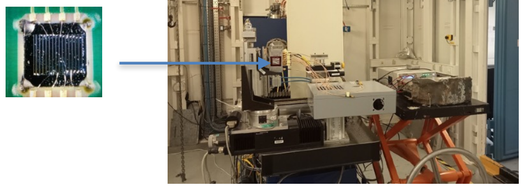
Hadron therapy (proton, carbon): beam monitoring and online control with prompt gamma rays;

- Projet CLaRyS-S2C2
- ERC Starting Grant PGTI TIARA







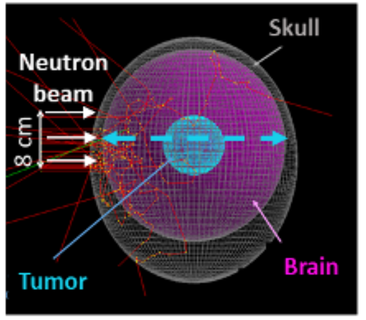


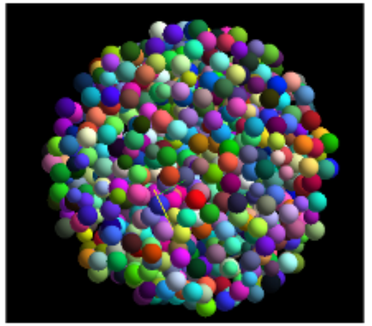
X-ray radiotherapies with spatially fractionated dose.

FLASH radiotherapies (very high dose rate) with Diamond detectors.

Targeted radiotherapies (internal vectorized α and BNCT): Multi-scale modeling of the delivery of physical and biological dose and experimental program (Bio-Alto)

Simulation de conditions BNCT/RIV macro

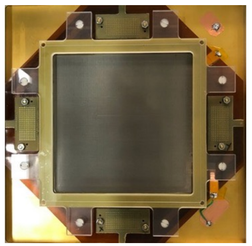




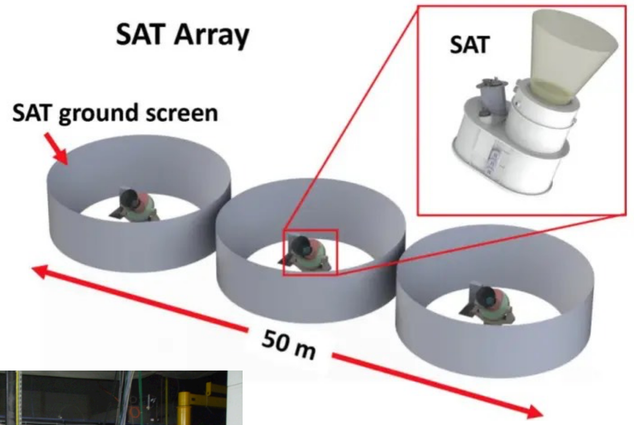
Ex: irradiation cérébrale BNCT ; Ex: irradiation tumorale RIV-α

Technologies and Platforms at LPSC…

- Neutron Detectors … from Dark Matter experiments
  - MIMAC –Fast N : Neutron spectrometry (incident energy & location of neutrons)
  - COMIMAC : Modular Measurement of quenching factor

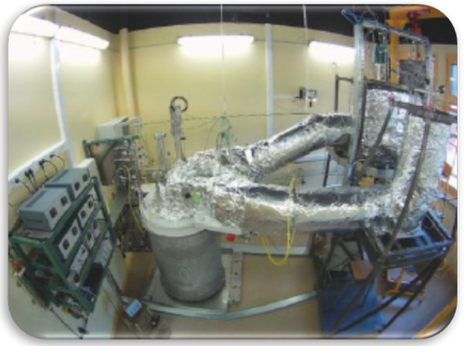


- Kinetic Inductance Detectors… from cosmology (CMB) projects
  - Cryogenic millimetric detectors for cosmology & beyond – Collaboration with Néel, IPAG, IRAM.
  - Instrumental contribution : Readout electronics (NIKA, NIKA2, etc..)
    → New KIDS SAT for CMB-SO



- Diamond based detector for beam monitoring in hadron therapy
  - Alternative to scintillating fiber hodosope at a few MHz with <100 ps resolution
  - Innovative Diamond detectors
  - Instrumental contribution :
    - Metalization of thin electrods by PCVD; (5x5 to 20x20 mm) surface
    - Study of charge transport
    - Readout electronics; measurements at ESRF

- FEST (Fluids Experiments and Simulations in Temperature) Molten salt platform:
  - Numerical models to account for all physical phenomena.
  - Experimental developments designed to validate certain aspects of numerical models (turbulence models, radiative effects...).



LSM & Underground Physics

- Subatomic/Astroparticle physics Platform Hosting fundamental physics experiments (Light Dark Matter, $0\nu\beta\beta$, …)
  - SuperNEMO (data-taking in September)
  - BINGO (on-going installation)
  - DAMIC-M (kg-stage installation in 2024)
  - EDELWEISS (dismantling completed)
  - Future project : TESSERACT (RI2 funding approved)
- Host R&D and detector physics for future experiments (larger detector deployed in larger DUL).
- Develop R&D around underground physics.
- Germanium gamma-ray material assaying for Very low radioactivity measurements.
- Open to interdisciplinary applications