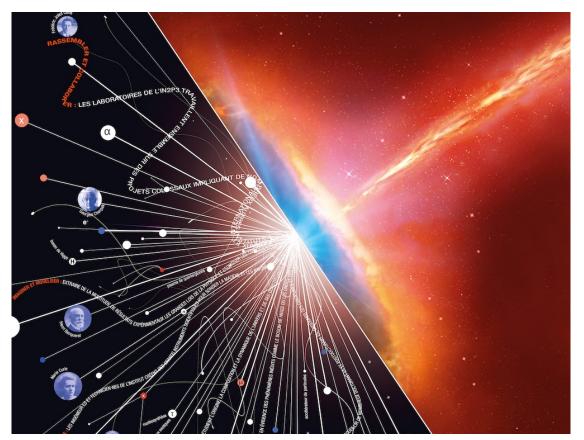


National Institute of Nuclear and Particle Physics



in2p3.cnrs.fr

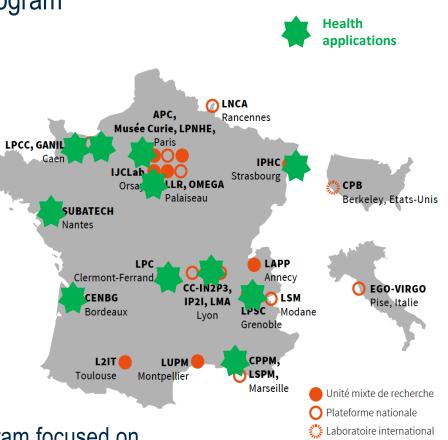
CNAO – IN2P3 Scientific strategy

Sébastien Incerti – scientific director for interdisciplinary research sebastien.incerti@in2p3.fr



« Nuclear physics for health » @ IN2P3

- At IN2P3, about 160 perm. researchers (CNRS & faculties), doctoral/postdoc fellows, and technicians & engineers are involved in the interdisciplinary research program « nuclear physics for health »
 - 4 priority topics
 - → Innovative radiotherapies, including hadrontherapy,
 - \rightarrow Innovative medical imaging,
 - \rightarrow Radionuclides for imaging and therapy,
 - \rightarrow Multi-scale radiobiology
 - 11 IN2P3 laboratories in France, including (often) s-o-a **irradiation PF** (see next)
 - Structured community (IN2P3 & beyond) thanks to the « GDR Mi2B : Nuclear tools and methods to fight cancer » science animation tool, led by Denis Dauvergne
- IN2P3 prospective exercice 2020-2030
 - « Improve the therapeutic efficiency of radiotherapy through innovative irradiation modalities » identified as a « Science Driver »
 - GDR Mi2B initiated in 2020 a brainstorming towards a national research program focused on hadrontherapy
 - Dedicated workshop (10/11/2020 including CNAO) <u>https://lpsc-indico.in2p3.fr/event/2534/overview</u>



At the heart : IN2P3 ion beam irradiation platforms

Coming soon



AIFIRA - Bordeaux p, d, alpha 3.5 MeV Microbeam cellular irradiation in single ion mode (<1.5 um, in vitro) On-line videomicroscopy « L2 » biology lab

deux infinis



Cyrcé - Strasbourg p, (alpha) < 25 MeV (in vitro, in vivo) 6 mm in water Up to 26 mm field Conventional (2 Gy/min) to Flash (6 kGy/min), 1 us pulses L2, small animal (contention, anesthaesia)



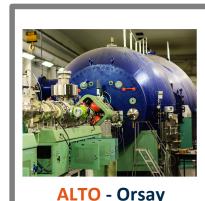
ARRONAX - Nantes p (70 MeV), d (35 MeV), alpha (68 MeV) (in vitro, in vivo) Up to 3,8 cm in water (p) Large field Conventional to Flash (60 kGy/s),



Cells, Zebra, s. anim.



GANIL - Caen from 95 MeV/A for light ions down to 24 MeV/A for uranium Cells irradiated with C, O, Ne, Ar, Ni, Pb... IRABAT line ARIA biology lab



H, ³He, ⁴He, ..., ¹⁴C, ... up to ¹²⁷I

1–14.5 MV (HV)

Hadronbiology NP-enhanced ther. Organs-on-chips FLASH...

- No Carbon (& other ion) beams in clinical conditions (120 400 MeV/A) : entrance up to Bragg peak
- Very limited beam time @ GANIL...
- Limited access to preclinical experiments or clinical trials
- Carbons and protons at the same facility

Weikene by N2P3 S. Hoord CMO 0010-0420 CMO 0020-0420 CMO 0000-0410 CMO 0010-0410 CMO 0020-0410 CMO 0020-0410 <th>Welcome by CNAO</th> <th>G. Vago et al.</th> <th>6</th>	Welcome by CNAO	G. Vago et al.	6
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- Highly motivated to reinforce CNAO and IN2P3 scientific collaboration
 - **Priority : innovative projects involving carbon beams for hadrontherapy**
 - Goals : more effective for radioresistant tumors, better sparing of healthy tissues, combined treatments (radio-, immuno-...)
 - Experiments from fundamental physics measurements to patient studies, including instrument dev. & simulations •

Our ambition

- Open to other **future** promising opportunities : BNCT, alternative ions for hadrontherapy (He, O, ...)
- Historical links between CNAO & IN2P3 teams
 - LPSC Grenoble : tests of the synchrotron dipoles, construction of the betatron magnet, design & construction of the low-level electronics of the accelerator cavity and beam dynamics studies
 - IPHC Strasbourg : charge identification of nuclear fragments with the FOOT TOF system (p, C, & O @ GSI)
- A stimulating international context
 - Heavy Ion Therapy Research Integration (HITRI+, https://www.hitriplus.eu) H2020 TNA : beam time @ CNAO
 - International Biophysics Collaboration inititiative (IBC, https://doi.org/10.3389/fphy.2020.00380) _

We proposed to organize a brainstorming (« acculturation & ideation ») workshop on 26/11/2021 @ CNAO

- 49 participants, including IN2P3, INSB, INS2I
- 4 sessions : beam monitoring + online control + dosimetry; radiobiology; BNCT; simulations

Outcome

- Letter of intent 1.
- 2. Basis of the IN2P3 – CNAO Collaboration framework agreement
 - Specific agreements
 - Coordination committee : A. Facoetti & M. Pullia, M. Vanstalle & D. Dauvergne





Letter of intent : 6 research axes

Thanks to this « ideation » workshop, six collaborative research topics have been identified

short/mid term, representatives for IN2P3 (+ other CNRS institutes) & CNAO

1. Innovative instrumental developments for beam monitoring and control of carbon therapy treatments

- M.-L. Gallin-Martel (LPSC- Grenoble) and/or E. Testa (IP2I-Lyon) + M. Donetti (CNAO-Italy)
- PEPITES in clinical C beam conditions, prompt gamma detection including timing detection (CLaRyS, TIARA)

2. Instrumentation and modeling challenges for BNCT

- N. Arbor (IPHC- Strasbourg) and R. Delorme (LPSC-Grenoble) + M. Ferrarini (CNAO-Italy)
- Neutron spectrometry, dosimetry, modelling of biological effects (eg. RBE) up to TPS : links to targeted alpha-therapy

3. Radiobiology with carbon ions and in BNCT

- C. Rodriguez-Lafrasse (IP2I-Lyon) and L. Sancey (IAB-Grenoble) + A. Facoetti (CNAO-Italy)
- Biological processes & endpoints (eg. cell survival), including combined therapies for different models : cell lines, bio-scaffolds, brain tumors, in ovo, small animals

4. New radiolysis measurements and simulation benchmarking in carbon therapy:

- 1. Radiolysis project, J. Vandenborre (Subatech-Nantes), M. Pullia for organization and access to beamtime (CNAO-Italy) : build reference data for radiolysis under several irradiation qualities (type of incident particle & energy, dose rates) input & validation of mechanistic simulation codes
- 2. Benchmarking of Monte Carlo codes for treatment planning in carbon therapy project, L. Maigne (LPC-Clermont) + G. Magro (CNAO-Italy) : comparative evaluation of state-of-the-art codes (GATE-Nanox, FLUKA, UNIVERSE...) for carbon therapy treatment planning

5. Moving organs

deux infinis

- H. Ladjal (LIRIS-Lyon) and G. Baroni (Politecnico di Milano-Italy)
- Optimize irradiation of moving organs, using tumor tracking by external motion monitors and associated biophysical modelling

6. Accelerator studies

- M. Baylac (LPSC-Grenoble) and M. Pullia (CNAO-Italy).
- Open to proposals

Towards the first two « specific agreements »

Identification of two collaborative projects : we are « ready to start »

- Science : « Multi-scale hadronbiology with Carbon ions »
 - Angelica Facoetti et al. (CNAO)
 - Claire Rodriguez-Lafrasse et al. (LP2i Lyon)
- **R&T : « Beam monitoring @ CNAO with PEPITES »** by Marie
 - Marco Donetti et al. (CNAO)
 - Marc Verderi et al. (LLR Palaiseau)

... paving the way to other innovative research & R&T projects :

« Collaboration topics between CNAO and IN2P3 partners » by Denis

An ambitious workplan for the years to come ! Thank you







