DEvelopmeNt and testIng of Medical physics instrumentation (DENIM)

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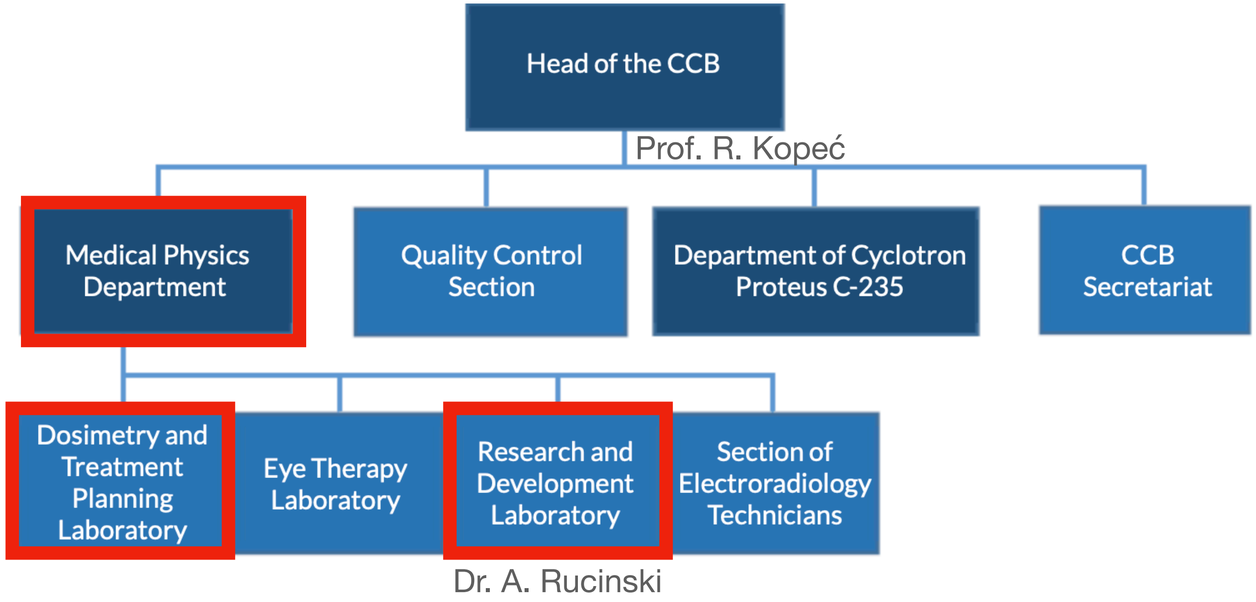
Dec 7, 2023

CCB Kraków proton center

Structure and relevant data/equipment



- Access to proton beams in Gantry rooms for experiments
- Anonymized patient data for TP studies and protocol development
- Radiobiology labs equipped to perform in vitro experiments (from 2023)

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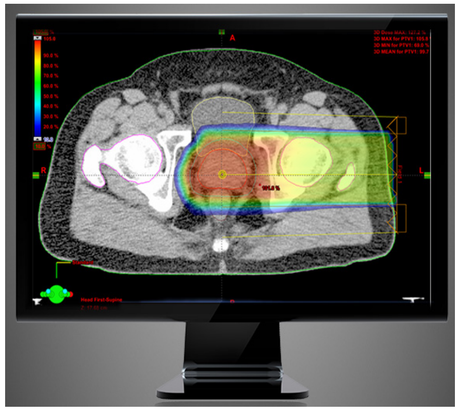
Translational research at CCB proton center

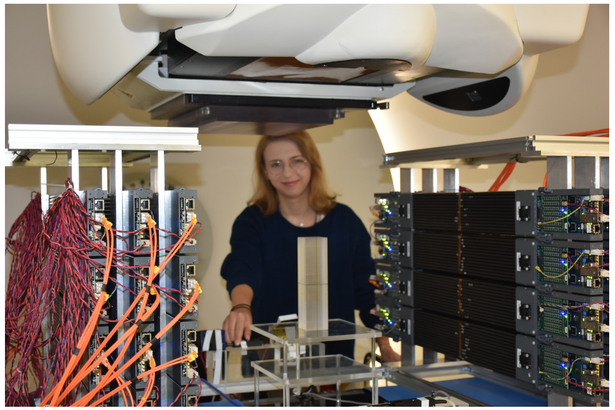
Physics, radiation biology, and oncology to improve clinical protocols

Computations and modelling ⟷ Radiobiology & Experiments



Biologically weighted treatment planning (LET and other quantities)

Quality assurance



Detectors for range monitoring and therapy adaptation

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The IJClab health pole

3 research teams and 1 Bio Exp platform

21 Permanents

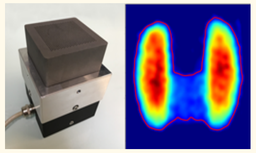
18 researches

3 Ing and Tech CNRS

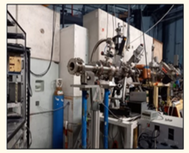
8 PH students et post-docs

Main research axes

➜ *Radiotherapy*

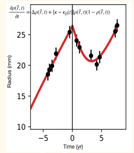


γ-caméra for dose control (thyrroid)

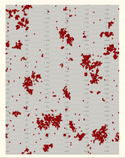


Irradiation Plateform for experimental radiotherapy

➜ *Modelling of living*



Model of the effect of radiotherapy treatment on low grade gliomas



$$D_{\text{eff}} = \frac{\gamma\sigma^2}{2\Gamma}\left(\frac{\Gamma}{\Gamma+\Lambda}\right)\left[1+\frac{2\gamma}{\Lambda}(1-\rho)(1-2\rho)\right]$$

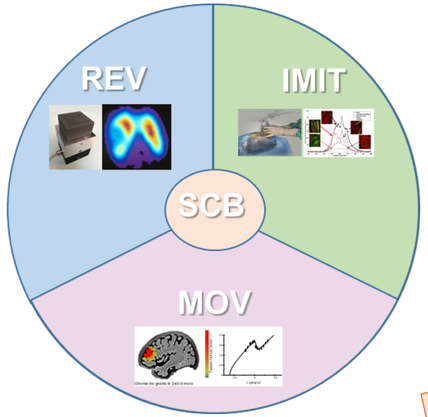
Collective migration of cells in interaction

➜ *biomedical imaging*

fibered multimodal endomicroscope and clinical analysis of brain tumors

intracerebral isotopic probe for behavioral neuro-imaging on awake animal

IJClab Heath Pole



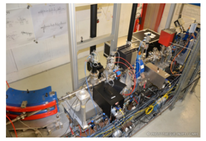
1 Pôle Ingénierie **4 Départements**

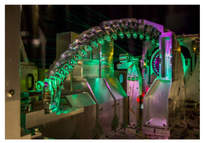
~ 250 IT/BIATSS
Instrumentation, informatique, électronique, mécanique

Scientific Challenges :

Propose new instrumental, methodological and theoretical approaches to promote the exploration and understanding of living organisms and enhance the diagnosis and treatment of pathologies.

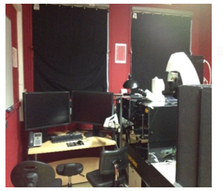
Accélérator Pole





Associated Plateforms associées

ALTO
Accélérateur Linéaire et Tandem à Orsay

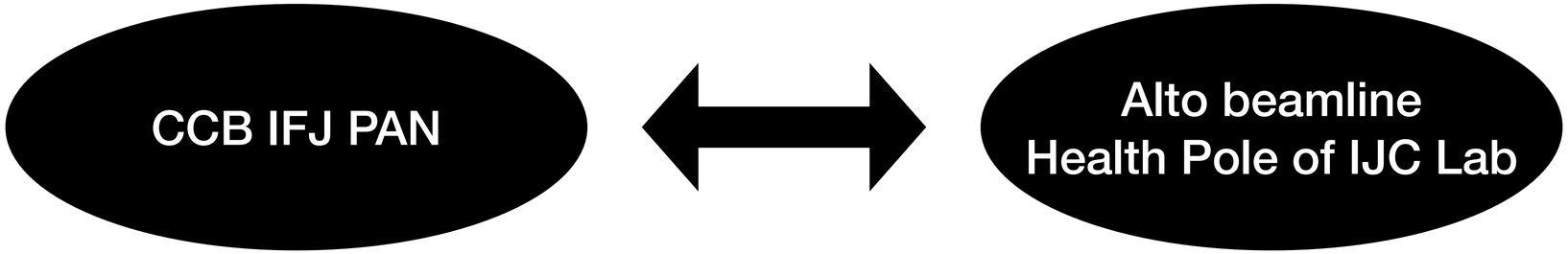


PIMPA
Plateforme d'imagerie Multiphotonique du Petit Animal

SCALP/Sidonie

virtualdata

Irradiation facilities



- Clinical proton beams 70-230 MeV/u
- Scanned proton pencil beams operated at therapeutic, low and FLASH beam rates

- From 2025 different ion beams at energy ranges relevant for radiobiology and detector characterization
- Passive scattering and a variety of beam rates including FLASH

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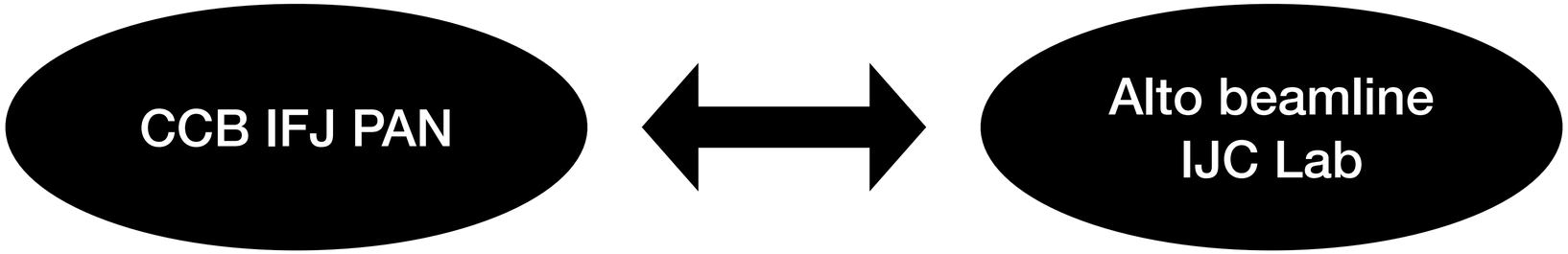
Monte Carlo simulation methods



- Clinical beam model and clinical/DICOM data interface with GATE and GPU/FRED MC codes
- Modeling and characterization of Bio-ALTO facility beamline

Scientific committee of GATE/Geant4 collaboration

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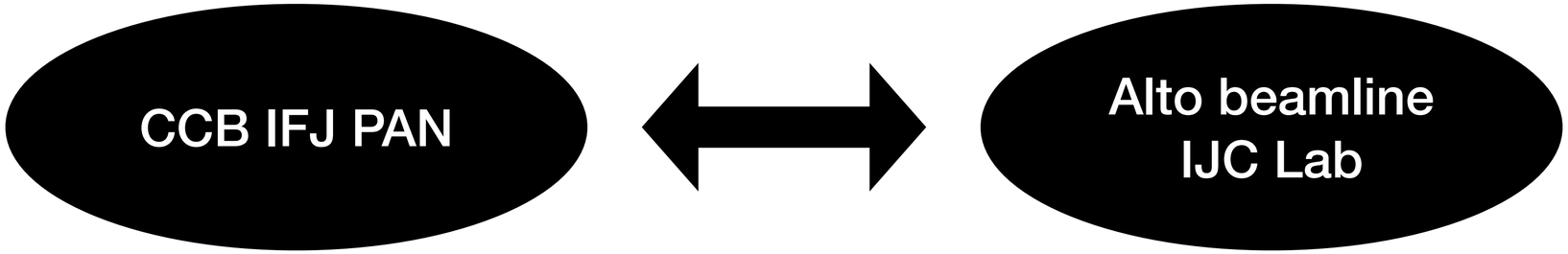
Detector characterization and calibration



- TimePix / microdosimetry
- Passive detectors
- Grounding nanodosimetry lab

- Microdosimeter /collab. CSIC
- Diamond detector /collab. Grenoble

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Inconsistency of clinical trials

Comparing proton vs carbon ion therapy

Contents lists available at ScienceDirect

Radiotherapy and Oncology

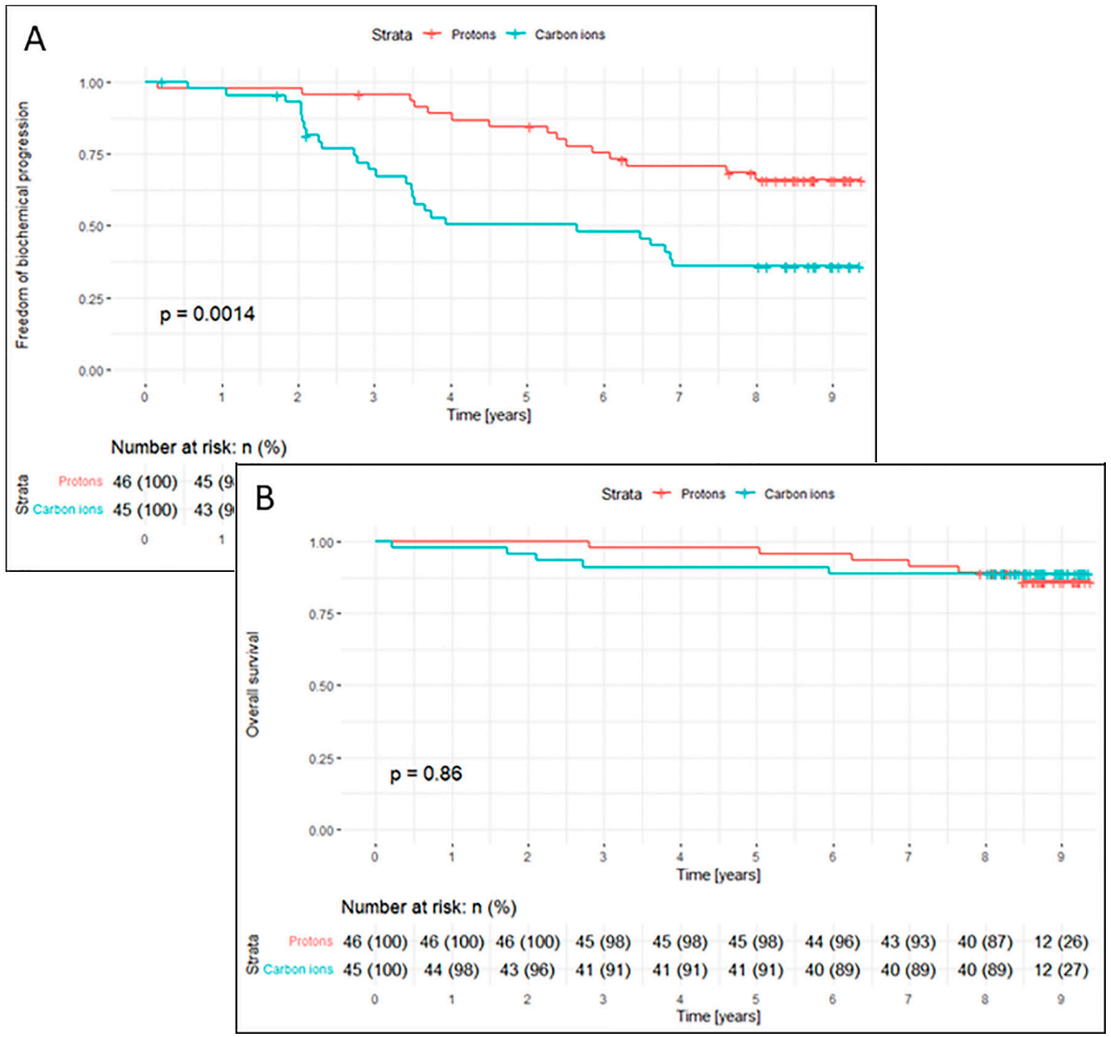
journal homepage: www.thegreenjournal.com

Original Article

Results of a prospective randomized trial on long-term effectiveness of protons and carbon ions in prostate cancer: LEM I and α/β = 2 Gy overestimates the RBE

Tanja Eichkorn [a,b,c,e,*], Christian P. Karger [b,g], Stephan Brons [b], Stefan Alexander Koerber [a,b,c,e], Thomas Mielke [a,e], Thomas Haberer [b,e], Juergen Debus [a,b,c,d,e,f], Klaus Herfarth [a,b,c,e]

[a] *Department of Radiation Oncology, Heidelberg University Hospital, Germany;* [b] *National Center for Radiation Oncology (NCRO), Heidelberg Institute for Radiation Oncology (HIRO);* [c] *National Center for Tumor Diseases (NCT), Heidelberg;* [d] *Clinical Cooperation Unit Radiation Oncology (E050), German Cancer Research Center (DKFZ), Heidelberg;* [e] *Heidelberg Ion Beam Therapy Center (HIT), Heidelberg;* [f] *German Cancer Consortium (DKTK), Partner Site Heidelberg, German Cancer Research Center (DKFZ); and* [g] *Dept. of Medical Physics in Radiation Oncology, German Cancer Research Center, Heidelberg, Germany*



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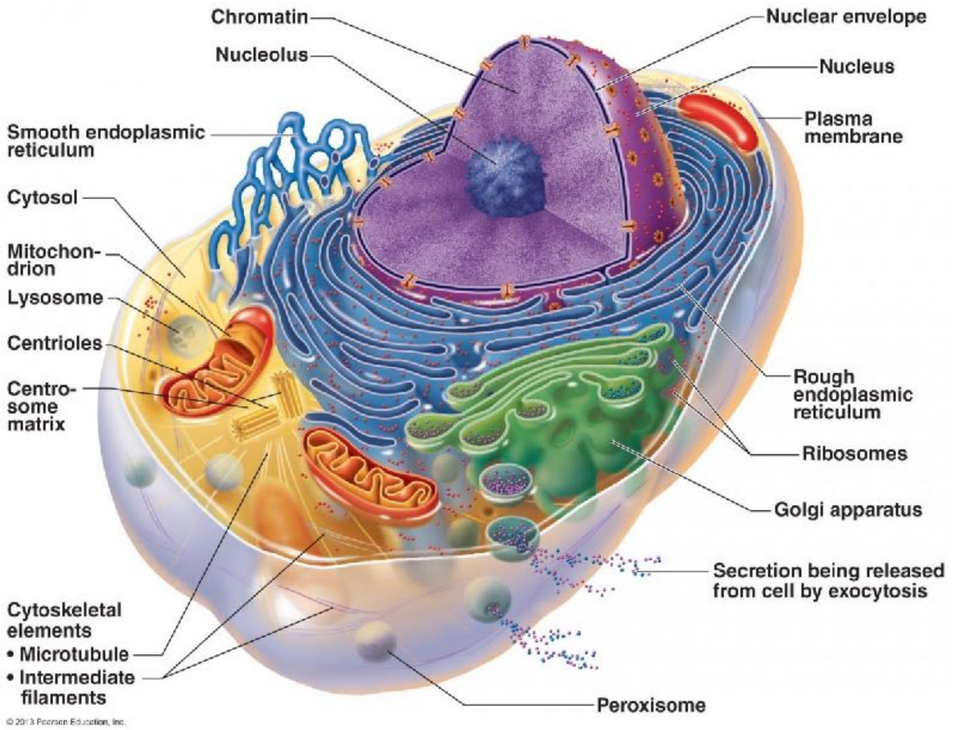
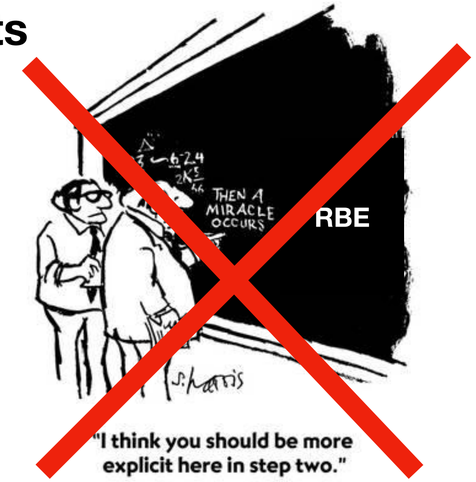
Dose becomes inadequate at microscopic levels

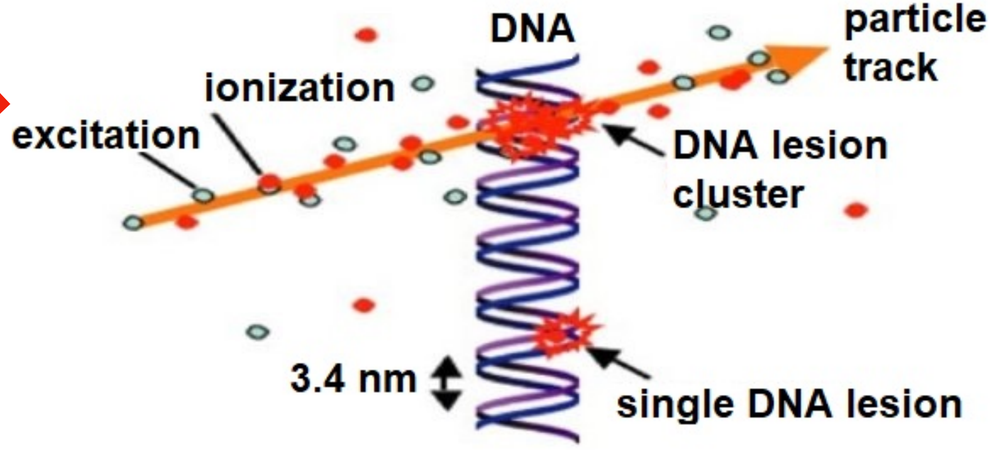
The hypothesis: Similar clustering leads to similar biological effect

Cell/DNA damage: Micro/nano-scopic concepts





Local ionization cluster size on the nanometer scale is the starting condition for all subsequent processes that lead to the observed DNA damage



- **Radiation damage is a stochastic quantity on the micro- and nanoscopic level, there fore the modeling solution must use micro- and/or nanodosimetric distributions rather than average quantities (LET, absorbed dose).**

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Biology weighted treatment planning beyond RBE-LET

Objectives: Detectors, biology, and modeling in micro and nano scales

Long-term objectives !!!

- Applying microscale TimePix detectors for LET-RBE characterization in proton and ion beams (CCB IFJ PAN, IJCLab)
- Development of nanoscale detectors for characterization of ionization detail and cluster dose in nanoscale for proton and ion beam therapy (CCB IFJ PAN)
- Development of new radiobiology assays for quantification of simple and complex DNA double-strand breaks in proton, ion, and FLASH beams (CCB IFJ PAN, IJCLab)
- Development of condensed history and track structure Monte Carlo simulation methods (IJCLab, CCB IFJ PAN)
- Experimental validation of detectors, radiobiological assays, nanoparticle effects, and simulation methods in proton (CCB), ion (IJCLab), and FLASH (CCB) beams.

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Summary

- Both facilities show synergetic and complementary expertise and infrastructure
    - Irradiation facilities
    - Monte Carlo simulation methods
    - Detectors
- We request 2k€ per facility per year (8k€ in total for 2 years) for traveling required to detailed specific research goals
- CCB IFJ PAN team: A. Rucinski, J. Gajewski, P. Bilski, R. Kopec
- IJC Lab Health Pole: M.-A. Verdier, Q. Mouchard, A. Leite, P. Laniece