18-Month Post-Doctoral Position in Simulation for Medical Physics

Multi-Scale Digital Twins Using Monte Carlo Simulations for Targeted Internal Radiotherapy of Glioblastoma with a Radiolabeled Hydrogel

Supervisor: Lydia Maigne, PU
Laboratoire de Physique de Clermont Auvergne, UMR 6533 CNRS-UCA
4, avenue Blaise Pascal, 63178 – Aubière, France
lydia.maigne@clermont.in2p3.fr

Collaborations :
CRAN, Université de Lorraine, Nancy
Nano-H, Lyon

Context

The **IRHydroBRAIN project**, funded by the ANR (French National Research Agency), aims to propose an innovative strategy for intraoperative internal radiotherapy of glioblastomas (GBM) by leveraging the functionalization characteristics of a radiolabeled chitosan hydrogel. Within a complementary consortium comprising two research laboratories, CRAN (UMR7039, Nancy) and LPCA (UMR6533, Clermont), and the company Nano-H (Lyon), the goal is to provide proof of concept that this radiolabeled hydrogel improves local control and reduces post-surgical recurrence of GBM in in vivo situations.

The project is organized into **4 complementary and interdisciplinary work packages** in chemistry, radiochemistry, radiobiology, cell biology, and medical physics:

WP1. Radiolabeling of the Hydrogel

WP1 focuses on **optimizing the hydrogel composition** to ensure its physicochemical properties and biocompatibility for targeted medical applications. It also involves **evaluating the stability of the hydrogel ex vivo and in vivo**, a critical criterion for ensuring its efficacy and safety once implanted in a biological environment. Finally, it aims to ensure that the radiolabeled hydrogel meets strict safety and efficacy standards.

WP2. Treatment Planning and Dosimetry

The **GATE 10 Monte Carlo simulation platform**, based on Geant4, will be used to perform treatment planning in small animals (rats) and humans to evaluate doses to the tumor and organs at risk.

WP3. Radiobiological Effects

This work package (WP) aims to study the ex vivo and in vitro radiobiological impacts of radiolabeled hydrogel on the migration, invasion, and adhesion of GBM cells. An organotypic culture model will be used to investigate the invasive capacities of tumor cells within decellularized brain tissue and to analyze the impact of irradiation on their invasive properties.

The in vitro radiobiological effects of radiolabeled hydrogel have already been characterized, particularly through the analysis of DNA damage, as well as the study of mitotic catastrophe and clonogenic survival. These experimental data provide a foundation for better understanding the cellular mechanisms induced by the treatment. Building on these experimental results, the postdoctoral researcher will develop Monte Carlo simulations (GATE 10, Geant4-DNA) to model

DNA damage and the production of radiolytic species, thereby contributing to the construction of a multi-scale digital twin of the treatment.

WP4. Preclinical Study

The radiolabeled hydrogel will be implanted in rats after excision of a GBM tumor at an orthotopic site. The F98 GBM model was selected for its invasive capabilities in the brain parenchyma (model and excision protocol in place, CRAN). Treatment efficacy will be evaluated using PET imaging, MR spectroscopy, MR imaging, and immunohistochemistry analyses. Tumor survival and control data will be compared to the reference therapeutic protocol of surgical resection alone. At the end of the IRHydroBRAIN project, the technological readiness level should make it possible to consider a phase 1 clinical trial.

Research Topic

The candidate will develop **multi-scale digital twins using Monte Carlo simulations** as part of WP3 and WP4. They will use the open-source Monte Carlo simulation platform **GATE 10** and the **Geant4-DNA library**. The main objective will be to model and simulate the impact of the radiolabeled hydrogel on biological tissues, integrating experimental and preclinical data produced by CRAN. This work will optimize treatment protocols and predict radiobiological responses at different scales (cellular, tissue, and patient).

Main Responsibilities

- Integrate cellular, tissue, and macroscopic (patient) models into a unified simulation platform.
- Use Monte Carlo simulation tools (e.g., GATE, Geant4-DNA) to model dose distribution, hydrogel diffusion, and radiobiological effects.
- Collaborate with experimental teams to validate models using in vitro and in vivo data.
- Interpret simulation results to propose optimized protocols.
- Write scientific articles and present findings at international conferences.

Required Profile

- PhD in medical physics, particle physics, radiobiology, bioengineering, scientific computing, or a related field.
- **Proven experience in:**
  - Monte Carlo simulations (GATE, Geant4, etc.).
  - Development of multi-scale models or digital twins.
  - Programming (C++, Python) and data analysis.
  - Distributed computing.
- **Personal qualities:**
  - Autonomy, rigor, and team spirit.
  - Ability to work in an interdisciplinary environment (physicists, biologists, clinicians).

Compensation and Contract Details

- Salary: €2300 net/month
- Employer: Université Clermont Auvergne
- Workplace: Laboratoire de Physique de Clermont Auvergne, LPCA

- Contract Duration: 18 months

Application Process

To apply, please send a complete CV, a copy of your latest research work (thesis and publications), and a motivation letter by email to: lydia.maigne@clermont.in2p3.fr

If your application is selected, you will be contacted for an interview.

Application Deadline: March 20, 2026