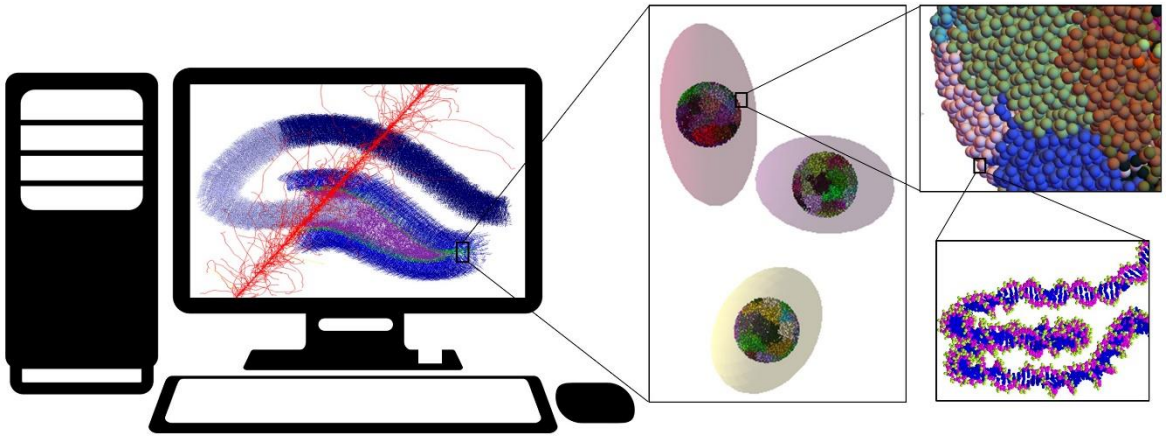
A 6-week hands-on research-educational project on cellular-scale radiobiological modeling



Graphical abstract.jpeg

Project name: Radiation biophysics modeling at cellular scale

Research area: Radiobiology

Abstract/brief description:

Understanding the biophysical mechanisms in irradiated cells is important for applications in radiotherapy and space radiation risk assessment. This project provides practical skills and modern simulation techniques for students who plan to work on cellular-scale radiobiological investigation. Students will focus on computer simulation of radiation–matter interactions at the molecular scale, the formation of free radicals, and resulting biological damage. Project results will be presented in a written report suitable as a draft scientific paper and as a basis for future collaboration with JINR.

Tasks: Individual tasks will be assigned to students based on their academic level (BSc, MSc, PhD) and prior experience. Potential tasks include:

- Study microscopic dose distributions from accelerated charged particles relievent to JINR beamlines.
- Investigate radiation effects (dose rate, beam structure) on chemical radical production.
- Reconstruct detailed biological geometries (from the molecular level to cells and tissues).
- Model radiobiological damage in different cell types and compare outcomes.

Each student will run, analyze, and refine simulations related to their assigned task.

Preliminary schedule by topics/tasks:

- Computer setup
- Hands-on training and guided simulation work
- Data analysis and compare scenarios
- Final runs and individual reports

Required skills:

- Basic knowledge of radiation–matter interactions and molecular radiobiology.
- Experience with Monte Carlo simulations (preferably C++ and Geant4).
- Familiarity with basic data analysis tools (e.g., Python/ROOT) is helpful.
- + Personal laptop

Acquired skills and experience: By the end of the project each student will be able to:

- Gain hands-on experience using specialized Monte Carlo methods as well as Geant4-DNA for radiation biophysics problems.
- Analyze and present reproducible simulation results and prepare material suitable for a technical note or research paper.

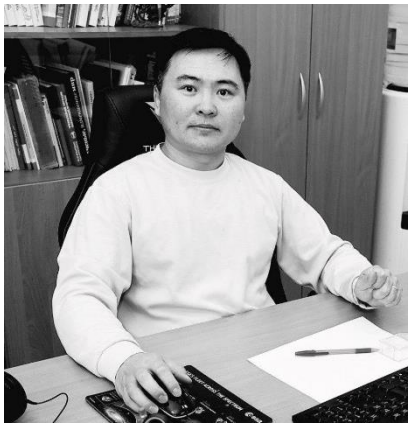
Recommended literature:

- Baeyens, A. et al. (2023). Basic Concepts of Radiation Biology. In: Baatout, S. (eds) Radiobiology Textbook. Springer, Cham. https://doi.org/10.1007/978-3-031-18810-7_2
- Batmunkh, M., Bayarchimeg, L. & Bugay, A.N. Mathematical Modeling of Radiation-Induced Effects in the Structures of the Central Nervous System under the Action of Accelerated Heavy Charged Particles. Phys. Part. Nuclei 56, 1030–1058 (2025). https://link.springer.com/article/10.1134/S1063779625700157

Maximum number of project vacancies: Maximum 4 participants**.**

Wave for publication: Wave 13 (20 October – 30 November, 2025)

Supervisor:



Batmunkh Munkhbaatar, Ph.D
Senior Research Associate, Department of Radiation Biophysics.
LABORATORY OF RADIATION BIOLOGY
International Organization Joint Institute for Nuclear Research
Joliot-Curie str.6, 141980 Dubna
E-mail: batmunkh@jinr.int
Phone: +7 (49621) 6-71-97
Fax: +7 (49621) 6-59-48