| Day | Topics | (preliminary schedule) |
|---|---|---|
| 1 | Welcome | *Course presentation* |
| | Radiation Physics | *Interaction radiation-matter* |
| 2 | Biology | *DNA & cellular structures* |
| | Modelling Radiation Biophysics | *Time & space evolution of radiobiological damage (I)* |
| | Radiation Physics | *Cross section calculations for track structure simulations*<br>*Nuclear interactions (introduction)* |
| 3 | Modelling Radiation Biophysics | *Time & space evolution of radiobiological damage (II)* |
| | Radiation Physics | *Interaction neutron-matter*<br>*Visit to the nuclear reactor* |
| | Laboratory Sessions | *- Physics laboratory*<br>*- Biology laboratory* |
| 4 | Modelling Radiation Biophysics | *Track structure simulation, temporal evolution of track structure, pre-chemical phase, chemical phase, biological phase* |
| | Radiation Physics | *Radiation transport codes* |
| | Laboratory Sessions | *- Physics laboratory*<br>*- Biology laboratory* |
| 5 | Model Testing | *Statistical methods for model testing* |
| | Radiation Biology | *DNA damage and repair I* |
| | Physics and Biophysical Mechanisms, | *Space Radiation Risk Assessment and Countermeasures* |
| 6 | Radiation Biology | *Survival models* |
| | | *DNA damage and repair II* |
| | | *Non-targeted effects* |
| 7 | Complex systems | *Systems Radiation Biology (I)* |
| | Models & epidemiology) | *Cancer risk from human cohorts: from epidemiology to models of carcinogenesis (I)* |
| 8 | Models & epidemiology) | *Cancer risk from human.(III)* |
| | Complex systems | *Systems Radiation Biology (II)* |
| | Radiation Therapy | *Modelling in radiotherapy*<br>*Clinical radiobiology, TCP, NTCP* |
| 9 | Radiation Therapy | *Treatment plans and optimization* |
| | Biological response to radiation | *- Individual radiosensitivity*<br>*- Radiation as a probe to study the response of biological systems to external stimuli* |
| | Radiation Therapy | *Hadrontherapy* |
| | | *Second cancer in radiotherapy* |
| 10 | Complex systems | *Systems Radiation Biology (III)* |
| | *Short presentations by participants* | |
| | Summary and Final test | *Final test and Questionnaire* |

**CONCERT is a EURATOM-funded Horizon 2020 European Joint Programme** set up to promote and integrate European research into the risks of exposure to low doses of ionising radiation. In addition, CONCERT (http://www.concert-h2020.eu/) will facilitate and promote training and education in support of the research programmes within the project, and also make training opportunities more widely available, in order to help attract top-level students into the field. As part of this initiative, a short course of two weeks duration on **Modelling radiation effects from initial physical events** has been organized at the University of Pavia.

## Information for applicants:

There is no course fee. A limited number of free lodgings in Pavia colleges will be available. No financial support will be provided. A certificate will be issued to each participant.

People wishing to apply should submit preferably by email the following documents

- A letter of application
- A CV with a description of the scientific career
- A supporting letter from the supervisor/head of laboratory.

to the Directors of the course:

Andrea Ottolenghi and Giorgio Baiocco
Dipartimento di Fisica
Università degli Studi di Pavia
Via Bassi 6 I-27100 Pavia, Italy
andrea.ottolenghi@unipv.it and
giorgio.baiocco@unipv.it, with copy to
concert.training@unipv.it

## The deadline for applications is:

**April 15th, 2018** (information confirming the acceptance will be sent to the applicant).

For any questions please write an email to: concert.training@unipv.it

UNIVERSITÀ DI PAVIA

EUROPEAN JOINT PROGRAMME FOR THE INTEGRATION OF RADIATION PROTECTION RESEARCH
CONCERT

## A two week course on

# *Modelling radiation effects from initial physical events*

***Learning modelling approaches and techniques in radiation biophysics and radiobiology research, from basic mechanisms to applications***

***May 28th to June 8th, 2018***
**Physics Dept., University of Pavia,**
**Via Bassi 6, Pavia, Italy**

**The course is open to:**

- **students (*e.g.* MSc, PhD and specialization students),**
- **young investigators,**
- **continuing professional education,**

**in particular with interest in scientific disciplines related to:**

- **Radiation biophysics**
- **Radiobiology**
- **Radiation protection.**

## Course aims:

The general objective of the course (in its eighth edition) is to provide the theoretical bases for designing radiobiological research and to integrate experimental and theoretical activity, including experimental design and models.

In particular, at the end of the course, the students will be able to understand the basics relative to:

- the principal mechanisms of interaction between radiation and matter, with attention to experimental techniques in radiation detection;
- the processes leading to the formation of radiobiological damage, starting from physical early events, to DNA and chromosomal damage;
- the Monte Carlo method, with the example of radiation transport and track structure codes;
- different modelling approaches to investigate radiobiological damage at different levels, such as:
    - DNA damage and repair
    - Mutation
    - Chromosomal aberration
    - Transformation
    - Cell survival
    - Non-targeted effects
- models developed in the context of radiotherapy, such as:
    - TCP and NTCP
    - Models to estimate the RBE of mixed fields
    - Secondary cancers
- modelling radiation risks with human cohorts;
- modelling systemic response with a systems biology approach and bioinformatic insights;
- statistical model testing and best fit methods

## Course topics and contents

The course will introduce students ***to mechanisms and theoretical modelling*** approaches relative to the physical, chemical and biological effects of radiation at sub-cellular, cellular, and organism level. The course will start with an introduction on atomic and nuclear structures, on the DNA structure and on the general features of the radiobiological damage. The interaction of radiation with matter (ions, electrons, photons and neutrons) will be described in detail, with the support of a ***laboratory session on detection techniques*** and in particular gamma spectroscopy. A parallel laboratory session is planned in the ***radiobiology laboratory***, to support the coordination between experimental and theoretical research.

After this preliminary description of the physical stage of radiation-matter interaction, the investigation of the early events of the radiobiological damage will be explained ***during the first week***, covering also the chemical (radiation chemistry of water and DNA solutions) and biological effects (radiation damage to DNA in a cellular environment).

In parallel, during these lectures, ***the problem of modelling the biological phenomena*** induced by irradiation will be introduced, focusing in particular on the different approaches and methods adopted, *e.g.* Monte Carlo *vs* deterministic, discrete *vs* continuous, macroscopic *vs* microscopic, predictive *vs* exploratory etc. The Monte Carlo techniques and the track structure simulation codes will be presented as an example of the possible models developed to theoretically investigate physico-biological processes. Modelling radiation transport on a macroscopic scale will be also introduced to build the bridge between cellular effects and applications as *e.g.* medical applications or radiation protection (also specifically for space radiation). Statistical methods of general interest for model testing will also be addressed.

***During the second week*** more specific lectures will be given on modelling radiation induced biological processes at molecular, cellular and systemic levels.

**Modelling Radiation Biology.** Lectures will focus as an example on models of DNA damage (and repair) with different approaches: Monte Carlo (PARTRAC) or phenomenological (based on differential equations). Damage evolution will be studied with mechanistic (such as radiation perturbed cell communication, adaptive response), and phenomenological (such as models for optimizing medical uses) approaches.

**Modelling Radiation Therapy.** During this session an introduction to the basic modelling approach adopted in radiation therapy will be presented. In particular a detailed description of Tumour Control Probability (TCP) and Normal Tissue Control Probability (NTCP) models will be given, with also a general introduction on the approaches adopted to model secondary tumour formation. The modelling activity to include the different radiation qualities within the radiation therapy framework will be presented (*e.g.* RBE quantification for mixed fields)

**Modelling Radiation Risks.** Methods and models to establish cancer risks from human cohorts with epidemiology studies will be presented.

**Modelling systemic responses.** An introduction on systems biology (and systems radiation biology) and their methods (*e.g.* top-down *vs* bottom-up approach) will be presented. Definitions of complexity, robustness, and modularity of the biological systems will be given and discussed.

A multi-scale approach will be a characteristic feature of the modelling methods covered by the course. During the last session of the course the general and theoretical questions arising from modelling activity will be presented, focusing on the general features of the models developed so far.