EJC 2024

Report of Contributions

Contribution ID: **1** Type: **not specified**

Conference: principles, present and futur goals of anti-cancer radiotherapy

Sunday, September 8, 2024 9:30 PM (1h 30m)

Cancer radiotherapy is a locoregional treatment of cancer using physical processes. Its place has continued to be consolidated for more than a century with very rapid technological developments in recent years driven by the evolution of the possibilities of medical imaging and faster and more accurate dose calculations. It has continuously developed in close association with surgery and systemic cancer treatments and its current evolution remains characterized by this therapeutic cooperation aiming to cure cancer. The current objectives are to continue to increase cure rates while reducing toxicities which remain significant in the medium and long term and represent a limiting element of this therapy. Furthermore, in the era of personalization of care, the anatomical and dosimetric adaptation to the tumor which has always existed for radiotherapy must today integrate other dimensions such as the radio sensitivity of tumors, the radio sensitivity of patients, and the objective choice of different technical treatment possibilities. These different aspects from the basic principle of radiotherapy to the objectives for the years to come will be presented in this conference

Presenters: Prof. BALOSSO, Jacques (Centre François BACLESSE à Caen, France); BALOSSO, Jacques (Université Joseph Fourier, Grenoble)

Contribution ID: **2** Type: **not specified**

Innovative radiotherapies (1)

Monday, September 9, 2024 8:30 AM (1 hour)

These lectures will cover an ntroduction to the physical and radiobiological characteristics of the different approaches and technological issues associated with their development.

The approach in developing new radiotherapy (RT) approaches is to succeed in increasing the therapeutic window for different types of cancer, either by sparing healthy tissues, or by being more effective on the tumor tissue to be treated, ideally both at the same time. An introduction will be given presenting different developments in modern X-ray RT with successive generations of irradiation techniques improving the conformation of the dose to the tumor and optimized dose delivery for the patient's response. The limits of external RT will be discussed and a broad description of development strategies developed to overcome these limits will be given, in particular to see how we can play on the physical aspects of irradiation to induce a different biological response. We will emphasize the interest of using beams different from photons, such as light ions (H, C) used in hadrontherapy, which have the dual advantage of providing better irradiation ballistics and increased biological efficiency for radioresistant cancers. Other approaches also play on the temporal and spatial aspects of dose delivery, such as "FLASH"radiotherapy using a very high dose rate and "spatial fractionation"using very heterogeneous irradiation with micrometric beams, to induce better tolerance of healthy tissues to irradiation for the same tumor control. Finally, non-localized or metastatic cancers can benefit from combined approaches with the use of a pharmaceutical agent allowing molecular targeting of cancer cells, as is the case with internal radiotherapy or boron neutron capture (BNCT). Finally, we will briefly introduce the questions that these RT raises, whether in terms of understanding the induced radiobiological mechanisms or the technological developments that they require in terms of production, dosimetry or detection, these different aspects being the subject of specific courses in the following.

Presenter: DELORME, Rachel (Univ. Grenoble Alpes, CNRS, Grenoble INP, LPSC-IN2P3, 38000 Grenoble, France)

Contribution ID: **3** Type: **not specified**

Dosimetry: determining the absorbed dose in photon and electron beams with ionization chambers

Thursday, September 12, 2024 9:45 AM (1 hour)

Radiotherapy uses ionising radiation to damage the DNA of tumour cells. According to international recommendations (ICRU), the doses delivered during treatment must not deviate by -5%/+7% from the doses prescribed by the radiation oncologist in order to maximize local control and limit complications. To achieve this, it is necessary to describe the properties of the radiation beams precisely. The first part of the course (1 hour) will explain the methodology used by medical physicists to accurately assess the absolute doses generated by linear accelerators under reference conditions. The 2nd part of the course will describe the operating principles of the main relative dosimeters used to characterise longitudinal and transverse dose distributions and/or point doses. The limitations of these detectors for new irradiation strategies (ultra-high dose rate, mini-beams) will be discussed.

Presenter: ROBERT, Charlotte (Hopital Villejuif)

Contribution ID: **4** Type: **not specified**

Radiation dose-effect relationship: an old story? (1)

Monday, September 9, 2024 9:45 AM (1 hour)

The DNA centered view of radiobiology was comforted in the last century by the finding that the level of unrepaired DNA lesions can be correlated with the cell sensitivity to radiation. This drove efforts to improve tumor cell killing, by focusing on enhancing tumors radiation dose and producing deleterious DNA damage. However, events occurring in the cytoplasm or at the cell membrane also have consequences on nuclear DNA. The contribution of these extranuclear effects to cell death needs to be accurately assessed.
In addition, a paradigm shift that recognizes the essential role of the immune system in cancer development and progression has become broadly accepted. Several clinical cases support revisiting the radiobiology DNA-centered view, by demonstrating for instance that targeted alpha therapy is efficient in quite large tumors, which sizes are beyond the radiation range, with biological effects observed also away from irradiated cells. These distant effects are called bystander effects when occurring at short distance (< 1mm), and systemic effects when occurring at much longer distance, implicating the immune system. Altogether, these findings showed that cells can die without receiving any radiation dose, and that a more complex and integrated view of radiobiology is required. Finally, these immune stimulatory effects of radiation have become clinically relevant in the current era of cancer immunotherapy, rendering systemic responses in patients an attainable aim.

The first hour of these lectures will focus on the in vitro aspects and its limitations entitled "From cancer cell to tumor microenvironment", and the second hour will focus on the in vivo aspects entitled "From rodent to clinical radiobiology".

Presenter: COSTANZO, Julie (ICM Montpellier)

Contribution ID: **5** Type: **not specified**

Geant4-DNA: Modelling biological damage induced by ionising radiation at the DNA level

Tuesday, September 10, 2024 5:15 PM (1 hour)

Geant4-DNA is an extension of the Geant4 Monte Carlo toolkit designed for mechanistic studies of cellular radiobiological effects at the DNA scale. It simulates the physical, chemical, and biological stages of ionizing radiation, including electrons, protons, alpha particles, and heavier ions, for various applications. The applications of Geant4-DNA range from predicting radiotherapy outcomes to radiation protection and space applications. These lectures provide an overview of the progress achieved with physical, physicochemical, chemical, and biological geometry models integrated into Geant4-DNA. The latest developments are highlighted, including user-friendly applications such as 'molecularDNA' and 'dsbandrepair', which are based on these models. These applications allow for quantitative predictions of early DNA damage, such as single-strand breaks (SSBs), double-strand breaks (DSBs), and the complexity of clustered lesions across different levels of DNA structure, from the DNA base to the full genome of a human cell. The lectures will present sets of models, functionalities, and user examples in Geant4-DNA. These capabilities allow for the investigation of radiation quality across a range of ionizing radiations, covering a broad spectrum of radiotherapeutic modalities. This spectrum includes high-energy hadron beams, as well as low-energy gamma, beta, or alpha emitters used in brachytherapy sources and radiopharmaceuticals.

Presenter: TRAN, Hoang (LP2iB)

Contribution ID: **6** Type: **not specified**

Innovative radioisotopes (1)

Wednesday, September 11, 2024 3:30 PM (1 hour)

Pour une imagerie et des traitements combinés (approche théranostique), vers une médecine personnalisée. Enjeux de production quantitative et qualitative

Presenter: Dr GUERTIN, Arnaud (CNRS/IN2P3)

Contribution ID: **7** Type: **not specified**

Simulation tools

Thursday, September 12, 2024 4:00 PM (3h 30m)

Plateforme GATE en imagerie et en radiothérapie (Travaux pratiques prolongeant le cours, sur un serveur déporté)

Presenters: Dr VERDIER, Marc-Antoine (IJCLab - Université Paris Cité); VANSTALLE, Marie (IPHC)

Contribution ID: **8** Type: **not specified**

Detectors: specific challenges for medical applications (1)

Tuesday, September 10, 2024 9:45 AM (1 hour)

Since the middle of the last century nuclear detectors have been used in medical application as well for diagnostic or treatment, especially in cancer patient course.
Beside the conventional X-rays imaging for diagnostic, scintillators are used for single photon (SPECT: Single-Photon Emission Computed Tomography) or double photon (PET: Positron Emission Tomograpghy) 3D image reconstruction. In the last decade, liquid xenon detectors were developed for a 3-gamma image reconstruction.

The used of charged particle to treat cancer tumor was already proposed end of the 40'. It is a modality that is now widely used to treat specific types of cancer (mostly neck and head, or pediatric cancers). The incident energy is provided to the particle by nuclear accelerators (cyclotron or synchrotron). The beam quality is assessed by dedicated sensors, based on thin solid detectors (e.g.: scintillator) or gaseous detectors (e.g.: drift chamber).

Detectors are also used to assess quality of treatment planning system (TPS), as the reduction of TPS uncertainties is one of the major challenges in particle therapy. For example, the beam undergoes, beside energy losses, nuclear reactions, which have to be taken into account in the treatment planning system (TPS) before irradiation. Dedicated experiments were carried out to measure nuclear cross sections foreseen as input for the TPS. Furthermore, to limit uncertainties due to the computing of energy losses from X-rays imaging during TPS, a new idea raised up to use the same particle for diagnostic and for treatment. Thus, proton or carbon imaging [2] was developed in the last decade using solid detectors (e.g.: silicon or scintillator sensors).

In the lectures, the different detectors will be presented in the context of medical application.

Presenter: FINCK, Christian (CNRS - IPHC)

Contribution ID: **9** Type: **not specified**

Imaging techniques (1)

Monday, September 9, 2024 5:15 PM (1 hour)

Medical imaging: from physical measurement to clinical diagnosis

In this course, we will review the principle and evolution of anatomical, functional and molecular imaging modalities used in clinical research. After recalling the major dates in the history of medical imaging, the various techniques will be described in terms of their physical principles of detection and the clinical information to which they give access (radiography and ion tomography, magnetic resonance imaging, ultrasound and nuclear imaging). The differences and complementarities of these methods will be highlighted and illustrated by various clinical examples. The main technological or conceptual developments likely to improve the performance of medical imaging will also be discussed.

Presenter: MENARD, Laurent (IJCLab - Pôle Physique Santé)

Contribution ID: **10** Type: **not specified**

PET Image Reconstruction: from Convex Optimisation to Deep Learning (1)

Thursday, September 12, 2024 11:15 AM (1 hour)

Iterative PET Image Reconstruction, from Convex Optimization to Deep Learning

In this course we will review the principles of tomographic image reconstruction with a focus on Positron Emission Tomography (PET). We will first present the context of nuclear medical imaging, review the basics of ill-posed tomographic inverse problems before introducing the specificities of iterative PET image reconstruction (tomographic reconstruction with Poisson data, specific or generic regularization). Classical iterative reconstruction techniques (Maximum Likelihood, Bayesian reconstruction) will be covered, as well as more recent reconstruction techniques using in particular (deep) learning. The need for robust reconstruction and trustworthy AI in this medical context will also be discussed.

Presenter: Dr SUREAU, Florent (CEA Saclay)

Contribution ID: **11** Type: **not specified**

PET Image Reconstruction: from Convex Optimisation to Deep Learning (2)

Friday, September 13, 2024 11:15 AM (1 hour)

Iterative PET Image Reconstruction, from Convex Optimization to Deep Learning

In this course we will review the principles of tomographic image reconstruction with a focus on Positron Emission Tomography (PET). We will first present the context of nuclear medical imaging, review the basics of ill-posed tomographic inverse problems before introducing the specificities of iterative PET image reconstruction (tomographic reconstruction with Poisson data, specific or generic regularization). Classical iterative reconstruction techniques (Maximum Likelihood, Bayesian reconstruction) will be covered, as well as more recent reconstruction techniques using in particular (deep) learning. The need for robust reconstruction and trustworthy AI in this medical context will also be discussed.

Presenter: SUREAU, Florent (CEA Saclay)

Contribution ID: **12** Type: **not specified**

Accelerators (1)

Monday, September 9, 2024 11:15 AM (1 hour)

Accélérateurs pour la radiothérapie et l'hadronthérapie, systèmes de délivrance isocentriques, accélérateurs pour la BNCT et la production de radioisotopes, contraintes cliniques

Presenter: PULLIA, Marco (CNAO)

Contribution ID: **13** Type: **not specified**

Accelerators (2)

Wednesday, September 11, 2024 5:55 PM (1 hour)

Accélérateurs pour la radiothérapie et l'hadronthérapie, systèmes de délivrance isocentriques, accélérateurs pour la BNCT et la production de radioisotopes, contraintes cliniques

Presenter: PULLIA, Marco (CNAO)

Contribution ID: **14** Type: **not specified**

Accelerators (3) : laser-plasma acceleration for medical applications

Friday, September 13, 2024 9:45 AM (1 hour)

Electrons and light ions have been accelerated following the interaction of an intense laser pulse with a plasma for about 30 years. Nowadays, Laser Plasma Accelerators (LPA) are versatile sources capable of producing energetic electron and ion bunches with remarkable propreties. LPA benefited from the constantly increasing repetition rates of high intensity lasers that increased from a shot per hour to the Hz firing rate today and 100 Hz is foreseen within the next 5 years. Indeed LPA can be tuned to deliver particles with kinetic energies of up to several GeV for electrons and that reach 10 s of MeV for ions with charges approaching the µC level over accelerating distances of less than 20 cm or a few µm respectively. In the near future, they are poised to become complementary to conventional accelerators for specific purposes.
Fundamental investigations are still necessary to understand the non linear processes at play in some of these acceleration mechanisms but the vast potential for usage led to the study of a number of applications in the past two decades. After briefly describing the most common acceleration processes and the properties of the obtained particle beams, the focus of this course will be the generation of medical radio isotopes from the multi-particles LPA sources [3] for internal radiotherapy and imaging. External radiotherapy using LPA bunches will also be discussed as well as phase contrast imaging that benefits from the unprecedented characteristics of these beams.

Presenters: MAITRALLAIN, Antoine (CENBG); MAITRALLAIN, Antoine (CNRS/LP2iB)

Contribution ID: **16** Type: **not specified**

Innovative radiotherapies (2)

Monday, September 9, 2024 4:00 PM (1 hour)

These lectures will cover an ntroduction to the physical and radiobiological characteristics of the different approaches and technological issues associated with their development.

The approach in developing new radiotherapy (RT) approaches is to succeed in increasing the therapeutic window for different types of cancer, either by sparing healthy tissues, or by being more effective on the tumor tissue to be treated, ideally both at the same time. An introduction will be given presenting different developments in modern X-ray RT with successive generations of irradiation techniques improving the conformation of the dose to the tumor and optimized dose delivery for the patient's response. The limits of external RT will be discussed and a broad description of development strategies developed to overcome these limits will be given, in particular to see how we can play on the physical aspects of irradiation to induce a different biological response. We will emphasize the interest of using beams different from photons, such as light ions (H, C) used in hadrontherapy, which have the dual advantage of providing better irradiation ballistics and increased biological efficiency for radioresistant cancers. Other approaches also play on the temporal and spatial aspects of dose delivery, such as "FLASH"radiotherapy using a very high dose rate and "spatial fractionation"using very heterogeneous irradiation with micrometric beams, to induce better tolerance of healthy tissues to irradiation for the same tumor control. Finally, non-localized or metastatic cancers can benefit from combined approaches with the use of a pharmaceutical agent allowing molecular targeting of cancer cells, as is the case with internal radiotherapy or boron neutron capture (BNCT). Finally, we will briefly introduce the questions that these RT raises, whether in terms of understanding the induced radiobiological mechanisms or the technological developments that they require in terms of production, dosimetry or detection, these different aspects being the subject of specific courses in the following.

Presenter: DELORME, Rachel (Univ. Grenoble Alpes, CNRS, Grenoble INP, LPSC-IN2P3, 38000 Grenoble, France)

Contribution ID: **17** Type: **not specified**

Dosimetry: detectors for assessing dose distributions

Friday, September 13, 2024 8:30 AM (1 hour)

Radiotherapy uses ionising radiation to damage the DNA of tumour cells. According to international recommendations (ICRU), the doses delivered during treatment must not deviate by -5%/+7% from the doses prescribed by the radiation oncologist in order to maximize local control and limit complications. To achieve this, it is necessary to describe the properties of the radiation beams precisely. The first part of the course (1 hour) will explain the methodology used by medical physicists to accurately assess the absolute doses generated by linear accelerators under reference conditions. The 2nd part of the course will describe the operating principles of the main relative dosimeters used to characterise longitudinal and transverse dose distributions and/or point doses. The limitations of these detectors for new irradiation strategies (ultra-high dose rate, mini-beams) will be discussed.

Presenter: ROBERT, Charlotte (Hopital Villejuif)

Contribution ID: **18** Type: **not specified**

Radiation dose-effect relationship: an old story? (2)

Tuesday, September 10, 2024 8:30 AM (1 hour)

The DNA centered view of radiobiology was comforted in the last century by the finding that the level of unrepaired DNA lesions can be correlated with the cell sensitivity to radiation. This drove efforts to improve tumor cell killing, by focusing on enhancing tumors radiation dose and producing deleterious DNA damage. However, events occurring in the cytoplasm or at the cell membrane also have consequences on nuclear DNA. The contribution of these extranuclear effects to cell death needs to be accurately assessed.
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Contribution ID: **19** Type: **not specified**

Geant4-DNA examples for radiobiology

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Presenter: TRAN, Hoang (LP2iB)

Contribution ID: **20** Type: **not specified**

Innovative radioisotopes (2)

Thursday, September 12, 2024 8:30 AM (1 hour)

Pour une imagerie et des traitements combinés (approche théranostique), vers une médecine personnalisée. Enjeux de production quantitative et qualitative

Presenter: Dr GUERTIN, Arnaud (CNRS/IN2P3)

Contribution ID: **21** Type: **not specified**

Detectors: specific challenges for medical applications (2)

Wednesday, September 11, 2024 4:40 PM (1 hour)

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Presenter: FINCK, Christian (CNRS - IPHC)

Contribution ID: **22** Type: **not specified**

Imaging techniques (2)

Tuesday, September 10, 2024 11:15 AM (1 hour)

Medical imaging: from physical measurement to clinical diagnosis

In this course, we will review the principle and evolution of anatomical, functional and molecular imaging modalities used in clinical research. After recalling the major dates in the history of medical imaging, the various techniques will be described in terms of their physical principles of detection and the clinical information to which they give access (radiography and ion tomography, magnetic resonance imaging, ultrasound and nuclear imaging). The differences and complementarities of these methods will be highlighted and illustrated by various clinical examples. The main technological or conceptual developments likely to improve the performance of medical imaging will also be discussed.

Presenter: MENARD, Laurent (IJCLab - Pôle Physique Santé)

Contribution ID: **23** Type: **not specified**

Poster session 1 / Beers and Appetizers

Monday, September 9, 2024 6:30 PM (1h 30m)

Contribution ID: **24** Type: **not specified**

Poster session 2 / Beers

Tuesday, September 10, 2024 9:40 PM (1h 30m)

Contribution ID: **25** Type: **not specified**

Excursion

Wednesday, September 11, 2024 9:00 AM (3 hours)

Boat trip or catamaran session

Contribution ID: **26** Type: **not specified**

Biophysical modeling of radiation effects

Tuesday, September 10, 2024 4:00 PM (1 hour)

One of the main challenges in using ionizing radiation to treat cancer is translating physical quantities into biological endpoints and, ideally, into predictable clinical outcomes. The earliest mathematical models explaining radiation effects were proposed about a century ago. In recent decades, thanks to the development of hadrontherapy, new models have emerged to describe the enhanced biological effectiveness of heavy ions compared to conventional photon radiotherapy. These models, starting from a variable number of parameters and postulates, focus on predicting relevant quantities that can be employed to assess radiotherapy treatments, such as biological dose to the tumor, tumor control probability, and normal tissue complication probability. This lecture provides an overview of the main features, assumptions, and limitations of some of the best-known biophysical models.

Author: Dr ALCOCER, Mario

Presenter: Dr ALCOCER, Mario