lgbio2070 — Engineering challenges in protontherapy

2024

5.00 credits	30.0 h + 30.0 h	Q2

Teacher(s)	Janssens Guillaume ;Lee John ;Sterpin Edmond ;
Language :	English > French-friendly
Place of the course	Louvain-la-Neuve
Main themes	Protontherapy gains more and more importance as an alternative treatment modality to radiotherapy with photons for specific types of patients and cancers. Compared to photons, protons deposit their energy in a much more localized area, which allows for both more focused tumor targeting and reduced side effects, mainly regrading healthy tissues. The course builds upon 4 pillars: Pillar 1: radiation oncology. - Basis of cancer and carcinogenesis - Treating cancer with radiations: principles and elements of radiobiology - Main steps of a radiotherapy workflow - Introduction to particle therapy: principles and current status - Radioprotection: treatment facility shielding, personnel and patient protection - Health economics: treatment options and patient referral, reimbursement and impact on social security services Pillar 2: technologies for protontherapy. This pillar provides a specific focus on the proton beam delivery process, i.e. from proton generation and acceleration (synchrotron/cyclotron) to energy deposition into a well-defined location in the patient, including magnetic beam steering. - Producing and accelerating protons: cyclotrons and synchrotrons - Detailed design of cyclotrons (and synchro-cyclotrons) - Beamlines, magneto-optics - Robotics: rotating structures, positioning systems - Therapeutic beam: pencil beam scanning - Safety and quality assurance in medical technologies : safety automats, interlocks, redundancies, beam measurement devices (monitor ion chambers) and beam data analysis Pillar 3: ancillary technologies for proton therapy. This pillar covers the devices and data flows associated with treatment preparation, execution, and verification, with all their specificities, compared to conventional radiotherapy treatment (X-rays). - Treatment planning system (TPS), oncology information system (OIS), imaging; the role of software integration - Dose calculation including analytical and Monte Carlo dose engines, treatment optimization, treatment robustness against uncertainties, and robust optimization - Imaging in or out of the room (computed tomography (CT), on-board cone-beam CT (CBCT), magnetic resonance imaging (MRI)). Image reconstruction and analyses. - Range verification: prompt gamma camera, proton radiography, positron emission tomography (PET)) Pillar 4: treatments of the future. - Image guidance: status and perspectives, and the way towards adaptive treatments - Overcoming challenges of PT: innovation tracks (range uncertainties, proton imaging, etc.) - Emerging treatments: introduction to ion beam therapy - Emerging treatments: combining radiations and medication
Learning outcomes	
Evaluation methods	Group projects account for 50% of the mark. For each project, the evaluation focuses on the quality of the programming and the report provided. Reports must be given back two weeks after the last lab session of each project. If the deadline is not respected there is a 2 point penalty every 48 hours after the deadline. It is NOT possible to give the reports or to improve their score during the second session in August The final exam counts for 50% of the mark. It is an oral exam with time for preparation. The preparation is open-book

Teaching methods	The course combines a series of ex-cathedra lectures - giving a strong emphasis on the system aspects of the proton therapy facility - and group projects (Problem-Based Learning, PBL) conducted by the students. Groups are made of X students (to be determined). Practical modalities depend on the sanitary conditions (presential/ comodal/distancial). Possible topics for group projects (PBL): - Main equipment pre-design (accelerator, beam line magnets, global energy/power/mass ratios, ...) - Basic CT/CBCT reconstruction - Basic dose calculation engine - Strategies to manage uncertainties (e.g. with margins and/or robust planning) - Last but not least, some practical activities could be envisaged within the Leuven/Louvain protontherapy center in the horizon 2019-2020. An on-site visit of a protontherapy facility in the neighborhood (max. 3 hours by car) might be planned.
Content	Protontherapy gains more and more importance as an alternative treatment modality to radiotherapy with photons for specific types of patients and cancers. Compared to photons, protons deposit their energy in a much more localized area, which allows for both more focused tumor targeting and reduced side effects. The course builds upon 4 pillars: Pillar 1: radiation oncology. • Basis of cancer and carcinogenesis • Treating cancer with radiations: principles and elements of radiobiology • Main steps of a radiotherapy workflow • Introduction to particle therapy: principles and current status • Radioprotection: treatment facility shielding, personnel and patient protection • Health economics: treatment options and patient referral, reimbursement and impact on social security service. Pillar 2: technologies for protontherapy. This pillar provides a specific focus on the proton beam delivery process, i.e. from proton generation and acceleration (synchrotron/cyclotron) to energy deposition into a well-defined location in the patient, including magnetic beam steering. • Producing and accelerating protons: cyclotrons and synchrotrons • Detailed design of cyclotrons (and synchro-cyclotrons) • Beamlines, magneto-optics • Robotics: rotating structures, positioning systems • Therapeutic beam: pencil beam scanning • Safety and quality assurance in medical technologies : safety automats, interlocks, redundancies, beam measurement devices (monitor ion chambers) and beam data analysis Pillar 3: ancillary technologies for proton therapy. This pillar covers the devices and data flows associated with treatment preparation, execution, and verification, with all their specificities, compared to conventional radiotherapy treatment (X-rays). • Treatment planning system (TPS), oncology information system (OIS), imaging; the role of software integration • Dose calculation including analytical and Monte Carlo dose engines, treatment optimization, treatment robustness against uncertainties, and robust optimization • Imaging in or out of the room (computed tomography (CT), on-board cone-beam CT (CBCT), magnetic resonance imaging (MRI)). Image reconstruction and analyses. • Range verification: prompt gamma camera, proton radiography, positron emission tomography (PET)) Pillar 4: treatments of the future. • Image guidance: status and perspectives, and the way towards adaptive treatments • Overcoming challenges of PT: innovation tracks (range uncertainties, proton imaging, etc.) • Emerging treatments: introduction to ion beam therapy • Emerging treatments: combining radiations and medication
Inline resources	See the Moodle website: https://moodleucl.uclouvain.be/course/view.php?id=11642
Bibliography	Harald Paganetti "Proton Therapy Physics" CRC Press
Other infos	All courses are given in hybrid format (physical and remote). Physical lectures are given on the Louvain-la-Neuve site
Faculty or entity in charge	GBIO

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Biomedical Engineering	GBIO2M	5		🔍
Master [120] in Physics [professional focus of Medical Physics : UCLouvain-KULeuven]	PHYS2M	5		🔍
Master [120] in Medical Physics	PHMD2M	5		🔍