UCLouvain

lgbio2070

2017

Engineering challenges in protontherapy

5 credits	30.0 h + 30.0 h	Q2

Teacher(s)	Janssens Guillaume ;Lee John ;Sterpin Edmond ;
Language :	English
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. 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: arc-proton therapy • Emerging treatments: introduction to ion beam therapy ' • Emerging treatments: combining radiations and medication
Aims	1 — With respect to the AA referring system defined for the Master in Electrical Engineering, the course contributes to the develoopment, mastery and assessment of the following skills : • 1.1, 1.2, 1.3, • 2.1, 2.2, 2.3, 2.4, 2.5, • 3.1, 3.2, 3.3, • 5.3, 5.4, • 6.1, 6.2 At the end of this course, students will be able to: <u>Disciplinary Learning Outcomes :</u>

	• Describe and explain the working principles of all components of a proton therapy facility (hardware and software components) (knowledge) • Enumerate the key concepts of treatment planning (target volumes, organs at risk, margins, uncertainties, organ motion management) (knowledge) • State a critical opinion about pros, cons, and tradeoffs of hardware/software solutions (e.g. some configuration of a treatment room, with specific imaging devices, or some treatment workflow) • Express an expert point of view on the effective quality of a treatment workflow, depending on the implemented medical technologies (hardware and software) (analytical skill). • Solve engineering problems specific to protontherapy (image processing, dose calculation) [e.g. HU to SP conversion, "virtual CT", etc.] • Tackle R&D or research problems in protontherapy (translate clinical needs into requirements/ specifications) (through group projects) <u>Transversal skills:</u> • Communicate with other engineers, physicians, and physicists working in protontherapy (both technical and clinical sides) • Search and read scientific papers and technical documentation about protontherapy, and extract useful information from them • Report findings/results in a short oral presentation, and provide a critical opinion about them. - - - - *The contribution of this Teaching Unit to the development and command of the skills and learning outcomes of the programme(s) can be accessed at the end of this sheet, in the section entitled “Programmes/courses offering this Teaching Unit”.*
Evaluation methods	Oral examination with preparation time
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). 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	See list of main themes above. The visit of a proton therapy centre can be replaced with a visit of IBA's assembly line in LLN, until the construction of the Leuven centre.
Inline resources	Moodle https://moodleucl.uclouvain.be/course/view.php?id=11642
Faculty or entity in charge	GBIO

Programmes containing this learning unit (UE)

Program title	Acronym	Credits	Prerequisite	Aims
Master [120] in Biomedical Engineering	GBIO2M	5		