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NOTE

	Description of the Introduction to medical radiation physics course		
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I. Introduction

The purpose of this document is to describe the main characteristics of the "Introduction to medical radiation physics" course given within the joint ETHZ/EPFL Master of nuclear engineering program.

II. Summary

II.1. English text

This course covers the basic physical principles underlying medical diagnostic imaging (radiography, fluoroscopy, CT, SPECT, PET, MRI), radiation therapy and radiopharmacy. The focus is not only on risk and dose to the patient and staff, but also on an objective description of the image quality.

II.2. French text

Ce cours présente les principes physiques à la base de l'imagerie médicale par radiations ionisantes (radiographie, scopie, CT, SPECT, PET). L'accent est non seulement porté sur le risque et la dose délivrée au patient et au personnel, mais également sur une description objective de la qualité d'image.

III. Content and schedule

We assumed that the lectures would be given as in the previous years, on Friday from 9:00 to 12:00.

Date	Subject and learning objectives	Who
21.09.2018	**Physics of radiography** • Describe the main parts of an x-ray device from a physical point of view • Describe and explain the x-ray spectra at different stages of the radiographic procedure • Briefly describe the main image receptors used in diagnostic radiography	FRV
28.09.2018	**Physics of radiation therapy 1** • Briefly present epidemiological data about cancer • Describe the general workflow of radiotherapy treatments • Describe beam production and beam characterization	RMo
05.10.2018	**Physics of radiation therapy 2** • Describe how to calculate a dose • Explain how a dose distribution is planned for a given patient • Present different high-level treatment techniques	RMo
12.10.2018	**Risk and radiation** • Briefly explain the effects of radiation on human health • Be able to compare in the day to day life acute and chronic risks • Understand some psychological aspects of risk perception • Understand the complexity of communicating about radiation risk	FBo
19.10.2018	**Radiopharmaceutical products** • Describe the different types of radiopharmaceuticals in nuclear medicine • Briefly explain the main needs for the infrastructure of radiopharmaceutical laboratories • Explain the different labeling approaches of radiopharmaceuticals • Describe how to perform a quality control applying thin layer chromatography	MStr
26.10.2018	**Physics of radioscopy** • Describe the main differences between the radiography units and the fluoroscopy units • Explain the challenges of radiation protection when dealing with fluoroscopy units • Describe the principle of the dose indicators used in fluoroscopy and their use	FRV
02.11.2018	**Physics of computer tomography (CT)** • Explain the principle of CT image acquisition • Describe the challenges of image quality assessment when dealing with CT imaging • Describe the principle of DECT	FRV
09.11.2018	**Physics of resonance magnetic imaging (MRI)** • Describe the principle of MRI acquisition • Explain the strategy used to weight proton density by relaxation characteristics of tissues • Explain the strategy used to localize the signal	FRV
16.11.2018	**Dose to the patient** • Describe the general method used to estimate the patient dose in radiodiagnostic and in nuclear medicine • Describe the dosimetric quantities and the methodology used in radiodiagnostic to estimate the dose • Explain the main difference between external irradiation and internal contamination • Explain the basic of the computation of dose with compartmental models	FBo

23.11.2018	**Physics of single-photon emission computed tomography (SPECT)** • Explain the principle of gamma camera imaging • Describe the parameters influencing resolution and sensitivity in gamma camera imaging • Describe the main steps involved in computer tomography applied to emission data (SPECT) • Describe the corrections needed to achieve quantitative imaging in SPECT	SGn
30.11.2018	**Physics of positron emission tomography (PET)** • Explain the operation of coincidence detection in PET with reference to time-of-flight systems. • Describe the parameters influencing resolution and sensitivity • Know the correction methods needed to achieve quantitative imaging in PET	SGn
07.12.2018	**Image quality** • Describe the main challenge of assessing image quality in radiology • Explain the meaning of the imaging quality parameters when using the signal theory • Describe the difference between the signal theory and the decision theory approaches when dealing with image quality in radiology	FRV
14.12.2018	**Receiver operating characteristics (ROC)** • Explain the meaning of a ROC curve • Know the basic principles of a detection experiment • Be able to build a ROC curve • Communicate efficiently the meaning of a ROC analysis	FBo
21.12.2018	**Model observers in medical imaging and human vision** • List the four properties that an objective image quality must satisfy • Explain how model observers are used to quantify image quality in medicine • Explain the difference between an ideal and an anthropomorphic observer • Describe the visual pathway from the retina image to the visual cortex • Describe how we look at an image and how a signal border is perceived	FBo

- *FBo: Prof François Bochud, UNIL/CHUV*
- *FRV: Prof Francis R. Verdun, UNIL/CHUV*
- *RMo : PD/MER Dr Raphaël Moeckli, UNIL/CHUV*
- *MStr : Dr Marietta Straub, CHUV*
- *SGn: Dr Silvano Gnesin, CHUV*

IV. Prerequisite

This course has many synergies with the RPRA course (Radiation protection and radiation applications) where the basics of radiation physics and some aspects of radiation protection are very useful to follow the present course.

V. Teaching method

Ex-cathedra with integrated individual exercises.

VI. Evaluation method

Oral exam.

VII. Bibliography

Subject	Reference

Course in general	• William R. Hendee and E. Russell Ritenour, "Medical Imaging Physics", Wiley-Liss, 4th edition, 2002 • The Essential Physics of Medical Imaging, Third Edition, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boone, Lippicott 2012
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Dose to the patient	• Effective Doses in Radiology and Diagnostic Nuclear Medicine: A Catalog, Fred A. Mettler et al. *Radiology:* Volume 248: Number 1—July 2008
Risk and radiation	• T. Rob Goodman, Maxwell Amurao, "Medical Imaging Radiation Safety for the Female Patient: Rationale and Implementation", RadioGraphics 2012; 32:1829–1837 • Francis R. Verdun, François Bochud, François Gudinchet, Abbas Aroua, Pierre Schnyder, Reto Meuli, "Radiation Risk: What You Should Know to Tell Your Patient", Radiographics 2008; 28:1807–1816
Physics of resonance magnetic imaging	• Robert A. Pooley, "Fundamental Physics of MR Imaging", RadioGraphics 2005; 25:1087–1099 • Michael A. Jacobs, Tamer S. Ibrahim, Ronald Ouwerkerk, "MR Imaging: Brief Overview and Emerging Applications", RadioGraphics 2007; 27:1213–1229
Image quality	• The Essential Physics of Medical Imaging, Third Edition, Jerrold T. Bushberg, J. Anthony Seibert, Edwin M. Leidholdt Jr., John M. Boone, Lippicott 2012
Receiver operating characteristics (ROC) and hypothesis testing	• Anvari A, Halpern EF, Samir AE. Statistics 101 for Radiologists. RadioGraphics 35:1789-1801 (2015)
Radiation therapy	•

VIII. Website

The documentation of the course will be posted on the official moodle platform of the MSc.

IX. Dates (short version)

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