Module MPE08: Role of the medical physicist in CT imaging and patient dose optimization) in Europe

ABSTRACT

Title: Role of the medical physicist in CT imaging and patient dose optimization: CT imaging and patient dose optimized with objective means

Module Code: MPE08

Module Level: EQF level 8

Aims: This module aims to help the future MPE acquire the knowledge, skills and competences necessary to exercise a leadership role within the profession in his own country and in Europe in the field of CT imaging. The content of the module will focus on the various ways of assessing objectively image quality in CT. The standard methods will be first reviewed. The concept of model observers will be then presented together with some background theory in psychophysics allowing the MPE to understand the strengths and weaknesses of the model observer approach. Practical examples will be given to show how an MPE could propose a patient dose optimization scheme in CT. This course should also help MPE to fully interpret the characteristics of CT units provided by manufacturers in situations where an Institution is willing to purchase a CT unit.

Learning Outcomes: At the end of the module the participants will be able to:

MPE08.01	Explain in detail the principles of image quality measurement: linear systems theory, types of contrast (subject, image and display), unsharpness (LSR, PSF, LSF, MTF), lag, noise (including sources, noise power spectra, effect of lag on noise, noise propagation in image subtraction), SNR (including Rose model), Wagner's taxonomy, CNR, relation to dose, NEQ, DQE.
MPE08.02	Discuss the limitations of image post-processing in CT imaging.
MPE08.04	Describe human visual characteristics and how they can be quantified.
MPE08.05	Explain the meaning of receiver operating characteristics (ROC), in particular the concepts of signal to noise ratio, sensitivity and specificity in medical imaging.
MPE08.06	Perform detection experiment in order to assess image quality linked to a task (M-AFC, yes/no, rating).
MPE08.03	Explain the strengths and the weaknesses of the standard image quality quantities when they are applied to the current CT technology.
MPE08.07	Compute the performance of different model observers (NPWE, CHO, ideal, etc.) and compare it with human observers.
MPE08.08	Carry out acceptance testing, commissioning and QC procedures in CT imaging.
MPE08.09	Evaluate image quality from psychophysical studies with human observers in CT imaging and estimate the uncertainties of the outcomes.
MPE08.10	Take responsibility for the protection of patients by optimization of practices, procedures and acquisition protocols.
MPE08.11	Take responsibility for the education of healthcare professionals (including Medical Physics trainees) in performing QC procedures related to CT imaging.
MPE08.12	Advise on the purchase of the most appropriate CT unit for specific clinical applications

Date and Location of Face-to-Face Component: **Lausanne 14 – 18 March 2016**

Module Leaders:

Prof. Francis R. Verdun (Francis.Verdun@chuv.ch)
FRV is a senior medical physicist working at the University hospital of Lausanne (CHUV) since about 20 years in the field of medical imaging. He is associate professor at the University of Lausanne (UNiL) and teaches medical physics at graduate and post-graduate level in Switzerland and France. His scientific contributions can be found at: ***https://applicationspub.unil.ch/interpub/noauth/php/Un/UnPers.php?PerNum=13861&LanCode=8&menu=coord***

Prof. François Bochud (Francois.Bochud@chuv.ch)
FB is a senior medical physicist working at the University hospital of Lausanne (CHUV) since about 20 years in the field of medical imaging. He is full professor at the University of Lausanne (UNiL) and teaches medical physics at graduate and post-graduate level in Switzerland. His scientific contributions can be found at: ***https://applicationspub.unil.ch/interpub/noauth/php/Un/UnPers.php?PerNum=23544&LanCode=37***

Faculty: Prof. Francis R. Verdun, Prof. François Bochud

Delivery of the module: The module will achieve its learning objectives using a combination of online and face-to-face readings, fora, presentations and discussions. The online phase will be mostly asynchronous so that participants would not need to take time off their clinical duties and there will not be a problem with time zones. If any synchronous learning is required this would be in the evening or weekend. The face-to-face component will be over a period of 1 week (3 days learning, 1 day free for revision, 1 day for assessment).

Total participant effort time: 80 hours

Assessment Mode: The assessment mode will consist of a 4 hour open-book examination consisting of 3 case scenarios of situations faced by the MPE when dealing with CT protocol optimization in which candidates are expected to demonstrate that they have achieved sufficient vision to act as future leaders of the MPE profession and act as good role models for younger members of the profession. Participants are expected to back their arguments with quotes from EU directives and other documentation. Participants will be provided with sample questions during the course.

MODULE DATA		
Module Homepage	www.eutempe-rx.eu	
Module Code	MPE08	
Module Leader/s Please limit CV to a max of 250 words and to what is relevant to this module.	Prof. Francis R. Verdun Head of the “Physics of medical imaging group – GIM” at the Institute of Radiation Physics (IRA), Department of Radiology, University Hospital of Lausanne (CHUV), Switzerland. Francis.Verdun@chuv.ch Mob: 0041795561641 FRV is a senior medical physicist working at the University hospital of Lausanne (CHUV) since about 20 years in the field of medical imaging. He is associate professor at the University of Lausanne (UNiL) and teaches medical physics at graduate and post-graduate level in Switzerland and France. His scientific contributions can be found at: ***https://applicationspub.unil.ch/interpub/noauth/php/Un/UnPers.php?PerNum=13861&LanCode=8&menu=coord*** Prof. François Bochud Head of the Institute of Radiation Physics (IRA), Department of Radiology, University Hospital of Lausanne (CHUV), Switzerland. Francois.Bochud@chuv.ch Mob: 0041795561505 FB is a senior medical physicist working at the University hospital of Lausanne (CHUV) since about 20 years in the field of medical imaging. He is full professor at the University of Lausanne (UNiL) and teaches medical physics at graduate and post-graduate level in Switzerland. His scientific contributions can be found at: ***https://applicationspub.unil.ch/interpub/noauth/php/Un/UnPers.php?PerNum=23544&LanCode=37***	
Teaching Staff Teaching staff should be either recognised MPEs or in possession of a PhD. If not please contact the Secretary of the QAC.	Prof. Francis R. Verdun, PhD Prof. François Bochud, PhD MSc. Julien Ott, (finishing his PhD training) MSc. Damien Racine, (in PhD training)	
Candidate Assessment (all assessments open book)	**Written Assessment (open book):**	Three scientific texts containing strengths and weaknesses of specific methods, possibly extended with ‘errors’ will be made available to each candidate for critical review and discussion. The participant has to show that he/she masters the concepts of optimization in CT and is able to reflect upon data and (so-called) achievements. Half a day will be spent with the texts; half a day will then

		be spent to establish a summary or a proposal for improvement or new and improved study plan
	Practical Assessment (open book):	None
Module Duration The TOTAL number of hours of participant effort should be about 80. (including lectures, reading of assigned compulsory texts, participation in online fora etc)	**Online phase** Asynchronous methods should be used whenever possible so that participants would not need to take time off their clinical duties and there will not be a problem with time zones. However synchronous methods (evenings or weekends only) should be used when crucial.	The online component will be spread over a period of approximately 3 - 4 weeks and would require approximately 56 hours of reading and effort by the participants. The online phase will be mostly asynchronous so that participants would not need to take time off their clinical duties and there will not be a problem with time zones. If any synchronous learning is required this would be in the evening or weekend.
	Face-to-face phase Must include 1 day for revision and 1 day for the assessment proper.	5 days: 3 days content delivery (24 hours), 1 day for revision, 1 day for assessment. *All modules: All learning materials including presentations will be sent to the participants 2 weeks before the first day of the face-to-face phase.*
Date and location of Face-to-Face	Lausanne 14 – 18 March 2016	
Date of Assessment Normally last day of face-to-face phase.	18 March 2016	
Breakdown of participant effort time	**Module Component**	**Estimated Time**
	Online lectures, seminars, tutorials, fora	10 hours
	Online compulsory reading	46 hours
	Face-to-face lectures, seminars, tutorials, fora	24 hours (over 3 days)
	Face-to-face technical demonstrations	0 hours

	Face-to-face laboratory/clinical exercises	0 hours
	Total participant effort time	**80 hours**
	Free day for exam preparation day (same for all modules)	**1 day**
	1 day for assessment (same for all modules)	**1 day**

<table>
<tr><th colspan="2">PRE-REQUISITES FOR THE MODULE</th></tr>
<tr><td>Minimum entry qualifications, training and years of experience for all modules

Same for all modules</td><td>EQF Level 6 in Physics (BSc Physics or equivalent)
EQF Level 7 in Medical Physics (MSc Medical Physics or equivalent)
2 year equivalent clinical training in D&IR for clinical Medical Physicists
2 year equivalent Industry/Radiation Authority experience for Industry/Radiation Authority personnel
Preparing a PhD study related to the topic of the module</td></tr>
<tr><td>Assumed previous KSC for all modules from the ‘Inventory of Learning Outcomes for the MPE in Europe’ (Annex I of the ‘European Guidelines on the MPE’)

Same for all modules</td><td>GENERIC SKILLS : Generic Skills Required at EQF level 7
KSC FOR THE MPE AS PHYSICAL SCIENTIST: All Knowledge learning outcomes to EQF level 7
KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL: All Knowledge learning outcomes to EQF level 7
KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION: All Knowledge learning outcomes to EQF level 7
KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY: All Knowledge learning outcomes to EQF level 7
The Skills and Competences included in the IAEA document ‘Clinical Training of Medical Physicists Specializing in Diagnostic Radiology’ (IAEA Training Course Series, 47, 2010) to EQF level 7.</td></tr>
<tr><td>Pre-requisite EUTEMPE-RX online summary modules for all modules</td><td>On line summary version of the Module MPE01, namely: The profession and the challenges for the MPE (D&IR) in Europe</td></tr>
<tr><td>Additional pre-requisite EUTEMPE-RX online summary modules for this module

Different for each module.</td><td>None required</td></tr>
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MODULE CONTENT: AIM and SUMMARY LEARNING OUTCOMES	
Aim	This module aims to help the future MPE acquire the knowledge, skills and competences necessary to exercise a leadership role within the profession in his own country and in Europe in the field of CT imaging. Assessing current CT image quality is a challenge for several reasons, including the push towards very low dose acquistions, the implementation of complicated exposure control mechanism and iterative reconstruction. The content of the module will focus on the various ways of assessing objectively image quality in CT. The standard methods will first be reviewed. The concept of model observers will then be presented together with some background theory in psychophysics allowing the MPE to understand the strengths and weaknesses of the model observer approach. Practical examples will be given to show how an MPE could propose a patient dose optimization scheme in CT. This course should also help MPE to fully interpret the characteristics of CT units provided by manufacturers and give substantial and valuable advice at the moment of purchasing CT equipment (in the hospital), making specific regulations (in competent authorities) and or when taking responsibility in the further development of new scanners (in medical device industry). .
Learning Outcomes (10 – 15 learning outcomes which provide an overview of the KSC addressed in the module)	MPE08.01 Explain in detail the principles of image quality measurement: linear systems theory, types of contrast (subject, image and display), unsharpness (LSR, PSF, LSF, MTF), lag, noise (including sources, noise power spectra, effect of lag on noise, noise propagation in image subtraction), SNR (including Rose model), Wagner's taxonomy, CNR, relation to dose, NEQ, DQE. MPE08.02 Discuss the limitations of image post-processing in CT imaging. MPE08.04 Describe human visual characteristics and how they can be quantified. MPE08.05 Explain the meaning of receiver operating characteristics (ROC), in particular the concepts of signal to noise ratio, sensitivity and specificity in medical imaging. MPE08.06 Perform detection experiment in order to assess image quality linked to a task (M-AFC, yes/no, rating). MPE08.03 Explain the strengths and the weaknesses of the standard image quality quantities when they are applied to the current CT technology. MPE08.07 Compute the performance of different model observers (NPWE, CHO, ideal, etc.) and compare it with human observers. MPE08.08 Carry out acceptance testing, commissioning and QC procedures in CT imaging. MPE08.09 Evaluate image quality from psychophysical studies with human observers in CT imaging and estimate the uncertainties of the outcomes. MPE08.10 Take responsibility for the protection of patients by optimization of practices, procedures and acquisition protocols. MPE08.11 Take responsibility for the education of healthcare professionals (including Medical Physics trainees) in performing QC procedures related to CT imaging. MPE08.12 Advise on the purchase of the most appropriate CT unit for specific clinical applications

MODULE CONTENT: TARGET KSC TO BE DEVELOPED TO EQF LEVEL 8 From the 'Inventory of Learning Outcomes for the MPE in Europe' (Annex I of the 'European Guidelines on the MPE')	
KSC targeted in *all* modules These learning outcomes are common to and permeate *all* modules, although to a varying degree according to the topic of the module.	GENERIC SKILLS : All 'Generic Skills Required at EQF level 8' KSC FOR THE MPE AS PHYSICAL SCIENTIST: All Skills and Competences to EQF level 8 KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL: All Skills and Competences to EQF level 8 KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE): All KSC for Scientific Problem Solving Service to EQF level 8 KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY: All KSC for Scientific Problem Solving Service to EQF level 8
***PRIMARY KSC* targeted in *this* module** These are the KSC which would be developed to Level 8 during this module. These should be mostly Skills and Competences. However, Knowledge learning outcomes should also be included when the knowledge normally acquired during Level 7 programmes is insufficient for the development of the skills and competences to level 8. The KSC codes from the 'European Guidelines on the MPE' should be inserted for easy reference.	**<u>KSC FOR THE MPE AS A HEALTHCARE PROFESSIONAL</u>** K4. Explain in detail the principles of image quality measurement: linear systems theory, types of contrast (subject, image and display), unsharpness (LSR, PSF, LSF, MTF), lag, noise (including sources, noise power spectra, effect of lag on noise, noise propagation in image subtraction), SNR (including Rose model, Wagner's taxonomy, CNR, relation to dose, NEQ, DQE; K9. Discuss the limitations of image post-processing; K18. Explain the meaning and the concepts of sensitivity and specifity in medical imaging; K19. Explain the use of Signal Detection and Psychophysical theories (including concepts of sensitivity, specificity and ROC analysis) in medical imaging; K89. Explain the uses of medical imaging in diagnosis and therapy; Kxx. Explain the signal detection theory in the context of medical imaging; Kxx. Explain the strengths and the weaknesses of the standard image quality quantities when they are applied to the current CT technology; Kxx. Explain the basis of linear model observers; Kxx. Explain the link between some outcomes of NPWE or CHO model observers with the results one can obtain with target detection in images performed by human observers; S1. For each modality, operate imaging devices at the level necessary for give advice on optimization of imaging protocols, quality control, image quality manipulation, and carry out research when the available evidence for advice is not sufficient; S4. Manipulate acquisition parameters for all forms of CT imaging (e.g., kV, bowtie filter, mA, rotation time, tube current modulation, noise index, pitch, collimation, scanned field of view, slice thickness, beam collimation, over beaming, over scanning), explain the effect on image quality and relevant patient dose quantities (and occupational dose particularly when this is correlated with patient dose) and

	relevance to specific clinical studies; S25. Evaluate imaging device performance for each imaging modality, from the measurement of suitable performance indicators using suitable test objects / phantoms; S26. For each imaging modality, carry out acceptance testing, commissioning and QC procedures; S31. Carry out acceptance testing, commissioning and constancy testing procedures in own area of medical physics practice; S40. For each imaging modality, evaluate image quality from psychophysical studies with human observers; Sxx. Be able to estimate the standard image quality quantities (noise and spatial resolution in particular) in the image and Fourier domains using the most common accepted methodologies. Sxx. Use appropriate physical / software test objects / phantoms, data acquisition protocols, data recording forms, to collect data that can feed the model observers provided in the framework of the course; Sxx. Explain the parameters that should be modify if the detection task to be handle by the model observer has to be changed; Sxx. Estimate the uncertainties of the outcomes; C1. Practise responsibly within the legal, regulatory and ethical boundaries of the profession. C3. Collaborate with other healthcare professionals, support staff and service users, relatives, carers and comforters within own area of medical physics practice. C4. Take responsibility for the management of own workload to ensure effective and efficient input to the work of the healthcare team in own area of medical physics practice. C5. Organise the various aspects of the routine service within own area of medical physics practice. C6. Work responsibly within national / local professional codes of practice and own competence limitations. C7. Take responsibility for appropriate behaviour towards colleagues, patients and relatives as stipulated by organizational policies and national legislation. C8. Take responsibility for own input within mono-disciplinary and multi-disciplinary research teams. C9. Take responsibility for making the best use of available resources to provide optimum healthcare to patients and members of society. C11. Assume responsibility to ensure that all activities are based on current best evidence or own scientific research when the available evidence is not sufficient. C12. Take responsibility to maintain one’s knowledge and skills current through an appropriate continuous professional development programme. C13. Facilitate learning of peers, other healthcare professionals, students (including Medical Physics trainees). C14. Take responsibility for the development of effective, safe and efficient teams (including multi-professional teams) in own area of medical physics practice. C15. Show respect towards the ethical, religious and cultural perspectives of patients. C16. Adhere to the Code of Ethics of the profession. C17. Assume responsibility for ethical issues associated with research involving human subjects.

KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE)

Educ. of Healthcare Professionals (including Medical Physics trainees)

K119. Explain statutory and institutional requirements for Medical Physics Services with respect to the education and training of healthcare professionals (including Medical Physics trainees) in own area of medical physics practice.
K120. Discuss the application of the principles of knowledge transfer to the case of healthcare professionals.
K121. Discuss the principles of modern adult pedagogy and apply them to the medical device and ionizing radiations and other physical agents educational needs of healthcare professionals (including continuous professional development activities) and including training associated with the introduction of new devices and techniques.

S67. Set up an inventory of learning outcomes tailored to the specific learning needs of specific healthcare professionals in specific clinical environments in conjunction with the leaders of the respective healthcare professions.
S70. Carry out own pedagogical research when the evidence base for education and training of healthcare professions is insufficient.

C66. Take responsibility for statutory and institutional requirements for Medical Physics Services in own area of medical physics practice with respect to the Education (including continuous professional development) of Healthcare Professionals (including Medical Physics trainees).
C67. Take responsibility for the education of healthcare professionals (including Medical Physics trainees) regarding the optimised clinical use of medical devices and safety from ionizing radiations and other physical agents in specific clinical environments in own area of medical physics practice.
C68. Take responsibility for the education of healthcare professionals (including Medical Physics trainees) in performing QC procedures related to medical devices in own area of medical physics practice.
C69. Take responsibility for the education of healthcare professionals (including Medical Physics trainees) regarding protection from ionizing radiations and other physical agents including the use of personal dose monitors and personal protection equipment.
C70. In conjunction with other healthcare professionals take responsibility for ensuring that referrers are knowledgeable of current referral criteria in own area of medical physics practice.
C71. Take responsibility for raising public awareness of safety issues regarding ionizing radiations and other physical agents in own area of medical physics practice.

Health Technology Assessment

S71. Perform a systematic review of the existing evidence base to evaluate the clinical effectiveness and safety of a new medical device or new procedure involving medical devices / ionizing radiations and other physical agents.

	C76. Take responsibility and communicate with relevant authorities with regards to safety from ionizing radiations and other physical agents in the case of clinical trials. C77. Apply for approval from a hospital and /or university based ethics committee for a clinical trial involving medical devices and /or ionizing radiations and other physical agents. C78. Take responsibility for the evaluation of a clinical trial protocol. C79. Ensure good clinical practice (GCP) compliance of activities within clinical trials. C80. Advise on and take responsibility for the preclinical device aspects of the ethical review of a clinical trial. C81. Assume the responsibility of statistical and other mathematical data processing and recording in a clinical trial. **Innovation** K136. Explain statutory and institutional requirements for Medical Physics Services with respect to Innovation in own area of medical physics practice. K137. Define innovation as the development of new devices (including software), modification of existing devices (including software) and the development of new techniques using devices for the solution of hitherto unresolved clinical problems. K138. Explain the importance of ongoing horizon scanning for new and emerging technologies. K139. Explain the methodology of horizon scanning for new and emerging technologies. K140. Discuss the opportunities for innovation in own area of medical physics practice. S78. Apply the methodology of horizon scanning (including survey of specific information sources) for new and emerging technologies to own area of medical physics practice. C82. Take responsibility for statutory and institutional requirements for Medical Physics Services with respect to Innovation in own area of medical physics practice. C83. Take responsibility for the development of new devices (including software) and modification of existing devices (including software), including their implementation and evaluation in response to clinical needs in own area of medical physics practice. C84. Take responsibility for legal issues involved in the development of medical devices (including software) in own area of medical physics practice. **KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY** **Education of Healthcare Professionals (including Medical Physics trainees) in D&IR** K113. Explain statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with

	respect to Education of Healthcare Professionals (including Medical Physics trainees). K114. Discuss the particular ethical issues involved in expert consultancy in the education of healthcare professionals (including Medical Physics trainees) in areas involving a high level of collective patient doses. C30. Take responsibility for statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with respect to Education of Healthcare Professionals (including Medical Physics trainees). **Health Technology Assessment in D&IR** K115. Explain statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with respect to Health Technology Assessment. K116. Discuss the particular ethical issues involved in HTA in areas involving radiation, in particular ionizing radiation. K117. Explain how research medical exposures are managed in the context of Diagnostic and Interventional Radiology including the processes of ethical review and clinical trials administration and governance (GCP) and the use of appropriate dose constraints. C31. Take responsibility for statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with respect to Health Technology Assessment. **Innovation in D&IR** K118. Explain statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with respect to Innovation. C32. Take responsibility for statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with respect to Innovation.
SECONDARY KSC **targeted in** ***this*** **module** (EQF Level 8) These are the KSC that are included in the module but would be given less attention owing to time constraints. Please insert the KSC code	 **KSC FOR THE MPE AS EXPERT IN CLINICAL MEDICAL RADIOLOGICAL DEVICES & RADIATION PROTECTION (AND OTHER PHYSICAL AGENTS AS APPROPRIATE)** **Expert Consultancy** K114. Explain statutory and institutional requirements for Medical Physics Services in own area of medical physics practice with respect to Expert Consultancy. K115. Explain the role of a consultant. K116. Explain the role of scientists as consultants in healthcare.

from the 'European Guidelines on the MPE' project KSC Inventory.	K117. Explain the general role of the MPE as consultant in own area of medical physics practice. K118. Discuss the specific ethical issues involved in delivering a consultancy service in own area of medical physics practice (including conflict of interest issues). S65. Apply MPE consultancy skills to specific scenarios in own area of medical physics practice. S66. Identify and manage ethical issues involved in delivering a consultancy service in own area of medical physics practice (including conflict of interest issues). C63. Take responsibility for statutory and institutional requirements for Medical Physics Services in own area of medical physics practice with respect to Expert Consultancy including responsibility for associated ethical issues commensurate with level of personal expertise. C64. Produce and/or audit reports as an independent provider for organizations other than one's own. C65. Design and evaluate continuous professional courses in own area of medical physics practice for organizations other than one's own. **KSC SPECIFIC FOR THE MPE IN DIAGNOSTIC & INTERVENTIONAL RADIOLOGY** **Expert Consultancy in D&IR** K111. Explain statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with respect to Expert Consultancy. K112. Discuss the particular ethical issues involved in expert consultancy in areas involving a high level of collective dose. C29. Take responsibility for statutory and institutional requirements for Medical Physics Services in Diagnostic and Interventional Radiology with respect to Expert Consultancy.
***NEW KSC* which are NOT** INCLUDED in the 'Inventory of Learning Outcomes for the MPE in Europe'.	Liaise with the Radiation Protection Expert.

OUTLINE TEACHING PLAN	
Online phase	-Definitions of image quality and the standard ways to assess image quality in CT (revision): Explain in detail the principles of image quality measurement: linear systems theory, types of contrast (subject, image and display), unsharpness (LSR, PSF, LSF, MTF), lag, noise (including sources, noise power spectra, effect of lag on noise, noise propagation in image subtraction), SNR (including Rose model), Wagner's taxonomy, CNR, relation to dose, NEQ, DQE. -Image quality assessment with human observers: the ROC theory and M-AFC: Describe human visual characteristics and how they can be quantified, Explain the meaning of receiver operating characteristics (ROC), in particular the concepts of signal to noise ratio, sensitivity and specificity in medical imaging, Perform detection experiment in order to assess image quality linked to a task (M-AFC, yes/no, rating). -Theory of ideal model observer: Compute the performance of different model observers (NPWE, CHO, ideal, etc.) and compare it with human observers. -How to match a model observer to human outcome: Evaluate image quality from psychophysical studies with human observers in CT imaging and estimate the uncertainties, take responsibility for the protection of patients by optimization of practices, procedures and acquisition protocols. Teaching methods : reading of a few selected review articles, Powerpoint presentations containing Screencasts, short videos
Face-to- Face Phase	Face to face Monday afternoon Repetition on ROC methodology and M-AFC Tuesday morning Repetition on Model observer Tuesday afternoon Let's be practical : M-AFC topic,How to set-up a study : 2-AFC, 4-AFC, M-AFC Practice of an AFC study and results interpretation (statistic tests to be applied) Wednesday morning Example of model observer in the Fourier domain (high contrast target for example) Wednesday afternoon Example of model observer in the image domain (low contrast target for example) Thursday (whole day) Each participants will receive 3 scientific publications with strengths and weaknesses and will be asked to report on those articles as if they were referees Friday morning

	Common discussions on the 3 papers studied the day before Friday afternoon Answer to questions