Nationellt möte om sjukhusfysik 2013

Varbergs kurort

13-14 november

12 november kurs: MR och strålterapi

SVENSKA SJUKHUSFYSIKER FÖRBUNDET

SVENSK FÖRENING FÖR RADIOFYSIK
SWEDISH SOCIETY OF RADIATION PHYSICS
(Member of IOMP)

Nationellt möte om sjukhusfysik 2013 - Program

Onsdag 13/11

Förmiddagen	Cheffysikermöte, ämnesföreträdarna, arbetsgrupperna, MR-säkerhet	
11.30 - 12.30	**Lunch**	
12.30 - 12.45	Välkommen	*Lars Ideström och Anders Tingberg*
Session 1		***Moderator: Lars Ideström***
12.45 - 13.15	PET - igår, idag och imorgon	*Kurt Lidén-pristagare: Hans Lundqvist*
13.15 - 14.05	Tema: Sjukhusfysikerns roll i ett katastrofläge	
	Radiologiska och nukleära katastrofsituationer - vad kan hända?	*Therése Geber Bergstrand*
	Radiologiska och nukleära katastrofsituationer - vad är fysikerns roll?	*Robert Finck*
14.05 - 14.15	Developing a culture of radiation protection in the hospital environment	*Julie Haglund*
14.15 - 15.00	**Kaffe och utställning**	
Session 2		***Moderator: Therése Geber Bergstrand***
15.00 - 15.15	Bästa examensarbete 1: Dose planning from MRI using machine learning for automatic segmentation of skull and air	*Jens Sjölund*
15.15 - 15.30	Swerays Shooting Star: Evaluation of a technique to measure the amount of fat in skeletal muscle with magnetic resonance imaging	*Pernilla Peterson*
15.30 - 16.00	Kalle Vikterlöf-föreläsning: Internationellt arbete inom patientstrålskydd vid IAEA: terapi, diagnostik och interventionella procedurer	*Ola Holmberg*
16.00 - 16.15	ST-programmet - en statusuppdatering	*Lars Ideström och Sara Ohlsson*
16.15 - 17.00	Årsmöte: Svenska sjukhusfysikerförbundet	
	Spa & mingel	
19.30 - 20.00	**Fördrink**	
20.00 -	**Middag**	

Torsdag 14/11

Session 3	**Parallella sessioner: Röntgen, MR och strålskydd**	***Moderator: Anders Tingberg***
08:30 - 08.40	Calibration of clinical KAP meters	*Gudrun Alm Carlsson*
08.40 - 08.50	Quantitative tissue classification via dual-energy computed tomography	*Michael Sandborg*
08.50 - 09.00	Evaluation of six iterative reconstruction algorithms in Brain CT	*Marcus Söderberg*
09.00 - 09.10	On the mechanical imaging of breast lesions	*Magnus Dustler*
09.10 - 09.20	Accuracy of pulmonary nodule size measurement on chest tomosynthesis	*Christina Söderman*
09.20 - 09.30	Introduction to Monte Carlo simulations using PENELOPE: possibilities and limitations in modeling of breast tomosynthesis	*Hannie Petersson*
09.30 - 09.40	Comparison of different approaches of estimating the effective dose from CBCT examinations performed using interventional flouroscopy systems	*Jonny Hansson*
09.40 - 09.50	Evaluation of the impact of a system for real-time visualisation of occupational radiation dose rate during flouroscopically guided procedures	*Viktor Sandblom*
10.00 - 10.30	**Kaffe och utställning**	
Session 3	**Parallella sessioner: Strålbehandling och nuklearmedicin**	***Moderatorer: Agnetha Gustafsson och Per Nilsson***
08.30 - 08.40	A common nomenclature for radiotherapy parameters for efficient database handling	*Anders Montelius*
08.40 - 08.50	National database solution for radiotherapy quality registers and clinical studies	*Tufve Nyholm*
08.50 - 09.00	Risk analysis of the VMAT-workflow at the university hospital in Umeå	*Daniel Gälman*
09.00 - 09.10	A deliverability comparison of equivalent dual-arc VMAT plans generated in two different treatment planning systems	*Kristoffer Petersson*
09.10 - 09.20	IMRT patient-specific QA using the Delta4 dosimetry system and different evaluation methods	*Julia Götstedt*

09.20 - 09.30	Experiences from commisioning of a linear accelerator using a novel cylindrical 3D water tank - from electrons to flattening filter free beams	*Josef Lundman*
09.30 - 09.40	A 2D beam-quality specifier for flattening filter free beams	*Mårten Dalaryd*
09.40 - 09.50	Radioactive Iodine (I-131) for thyreotoxicosis: preparation, treatment and outcome	*Sven-Åke Stark*
10.00 - 10.30	**Kaffe och utställning**	
Session 4		***Moderator: Agnetha Gustafsson***
10.30 - 10.40	(How) can the communication with the ethical review board (EPN) get better?	*Lars Weber*
10.40 - 11.00	Rapport från arbetsgruppen inom nuklearmedicin	
11.00 - 11.20	Rapport från arbetsgruppen inom strålterapi	
11.20 - 11.30	A short report from the new radiotherapy unit in Lund	*Sofie Ceberg*
11.30 - 11.45	Rapport från ämnesföreträdarna och cheffysikergruppen	
11.45 - 12.30	Årsmöte: Svensk förening för radiofysik	
12.30 - 13.45	**Lunch och avslutning på tipspromenaden**	
Session 5		***Moderator: Anders Tingberg***
13.45 - 14.15	Mitt professionella liv med kvinnobröstet	*Holger Sköldborn-pristagare: Daniel Förnvik*
14.15 - 14.30	Bästa examensarbete 2: Biodistribution and dosimetry of ^{177}Lu-octreotate and evaluation of DMSA and lysine as kidney protecting agents in mice	*Andreas Österlund*
14.30 - 14.45	Bästa examensarbete 3: Evaluation of a metal artefact reduction algorithm in CT-studies used for radiotherapy treatment planning	*Karin Andersson*
14.45 - 15.15	**Kaffe**	

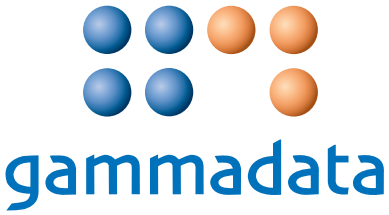
Session 6		***Moderator: Per Nilsson***

15.15 - 16.30	SSM informerar om föreskriftsarbete
	• Processen att ta fram och ändra föreskrifter
	• Koppling till lagar och internationella överenskommelser
	• Arbetet med kommande föreskrifter:
	  • Regelstruktur och tidsplan
	  • Generella strålsäkerhetsregler
	  • Strålsäkerhetsregler inom medicinska bestrålningar
	  • Referensgrupper och deras roll
		Catarina Danestig Sjögren och Ann-Louise Söderman

16.30 - 16.45	SSM informerar om pågående projekt	*Catarina Danestig Sjögren m.fl.*
16.45 - 17.00	Avslutning Utdelning av priser: • SSFF:s pris till bästa föreläsning • Vinnare i tipspromenaden	*Lars Ideström och Anders Tingberg*

Organisationskommittén	**Programkommittén**
Ylva Surac	Agnetha Gustafsson
Disa Åstrand	Anders Tingberg
Mattias Nickel	Per Nilsson
Lars Ideström	Therése Geber Bergstrand

Vi tackar våra sponsorer



PET - yesterday, today and tomorrow

Hans Lundqvist

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Positron Emission Tomography or Positron Emitting tracers are two possible interpretation of the acronym PET. The first is generally used while the other is used Uppsala in jest but with a certain seriousness. And it was also so it started in the late 1930th with the first ^{11}C-laboratory around the Lawrence cyclotron in Berkeley. The medical use of short-lived positron emitters was rediscovered in the 60th and got a ride forward with the development of the tomographic principle during the 70th. A personal view of the process going from an unrealistic idea to today's accepted diagnostic modality will be given.

As with any other diagnostic imaging methods, PET has undergone a remarkable technological development. Some highlights in this development will be given as well as an overview of the present status of the technology and trends in the development.

The future is shrouded in mystery and full of speculation. For the most, extrapolations of the present technology is used to look into the crystal ball. Although spatial resolution will improve, the main problem with the PET-detectors is sensitivity that probably will lead to systems covering larger solid angle and an improved time-of-flight technology. But above all, it is a paradox that handling of pico-moles of substances need to be made by a number of radiochemists working in today's expensive large clean-rooms filled with heavy equipments. The ongoing development of nano-technology will most likely change this, leading to systems that are integrating nuclear production and automated radiochemistry into one self-shielded unit. This will most likely lead to reduced costs of the radiopharmaceuticals, a necessary development if PET is going to reach outside the university hospitals. A personal colored guess of the future development of PET will be given.

Developing a Culture of Radiation Protection in the Hospital Environment

Julie Haglund*[1]

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The responsibility of the radiation protection coordinator is to help ensure that radiation safety at the hospital is safeguarded in accordance with applicable laws and regulations. In practice, this means equipment registration and maintenance, personnel dosimetry, and ensuring the competence of all who work with ionizing radiation. This work describes the oppositions met and improvements made during one year of work as radiation protection coordinator in a regional hospital with locations in five cities in Østfold County, Norway.

The position of radiation protection coordinator was long absent at Sykehuset Østfold, and bringing the topic of radiation protection into focus was met with resistance. Communication of a central coordinator to contact people in all departments is vital, and the first challenge of the job was to establish consistent and authoritative communication. This task was initially hindered by the organisational placement of the coordinator within the radiology department. Although radiation protection is a respected theme in radiology, ionizing radiation is unwittingly used in many departments, particularly in the form of c- arm equipment. The coordinator was perceived as having no authority in departments outside radiology. Changing the organisational structure of the hospital and placing the coordinator under the administrative director improved the status and thereby the message of radiation protection and the requirement of personal dosimeters in the daily workflow outside radiology.

Consistent communication was established with at least one designated radiation protection contact person in each department, and it was thereby possible to address the issue of competence. Norwegian law is clearly requires documented, yearly refreshment of basic radiation safety and regular intervals of equipment specific training. Adhering to the law requires a central coordinator who is consistently in place to drive an internal educational system. This was accomplished by creating e-learning classes, giving classroom lectures to every department, and educating contact people to give equipment specific training in their departments.

Of central importance in any work is documentation, and a central file was created in the internal computer system of the hospital in order to store classroom lectures, educational articles of interest, and equipment maintenance records.

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Dose planning from MRI using machine learning for automatic segmentation of skull and air

Jens Sjölund[1]

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The superior soft tissue contrast and inherent patient safety of MRI makes it preferable to CT for many imaging tasks. However, the electron density information provided by CT makes it useful for dose calculations in radiotherapy. If these could instead be based solely on MRI it would spare the patient from additional ionizing radiation as well as saving the health provider the time and cost of an additional examination.

In this thesis the possibility of achieving this using a machine learning algorithm called support vector machines to segment head MRI images into soft tissue, bone and air is investigated. To train the algorithm a large set of registered MRI and CT images corresponding to the same patients were used.

The results were evaluated on five test patients using Monte Carlo simulations. An important finding was that the threshold value used to segment the bone in the CT images was important for the prediction performance. Moreover, the results indicate that there are significant variations in bone density among patients, an aspect with important implications for the accuracy of the dose calculations.

Nevertheless, the dose calculations performed hold promise of drastically increased accuracy with relative errors reduced from 2-3 % to less than 1 % in regions where few rays pass through air-filled cavities. In regions where this is not the case the local prediction outcome in the target area has a large impact on the dose calculation accuracy.

Evaluation of a technique to measure the amount of fat in skeletal muscles with magnetic resonance imaging

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[2]Plastic and Reconstructive Surgery, Dep. of Clinical Sciences Malmö, Lund University

Introduction: Lymphedema is a common and potentially crippling and painful complication after e.g. breast cancer treatment. It has been shown that the excess volume consists mainly of adipose tissue, but it is not known if excess adipose tissue is present also within the muscle fascia. Fat quantification using magnetic resonance imaging (MRI) non-invasively provides both quantitative and spatial information, and may therefore be a suitable technique for research in this field.

Aim: To evaluate the accuracy and repeatability of an MRI-based technique for investigation of fatty infiltration in skeletal muscle in lymphedema.

Materials and methods: MRI examinations in a 1.5-T Siemens scanner were conducted of an Intralipid phantom (fat concentrations 0.6-20 %), and of a 15-mm section of both forearms of six patients with arm lymphedema and ten healthy volunteers. The imaging of the right arm of volunteers was repeated for estimation of repeatability. From each image and in each image pixel, the fat fraction (FF) was estimated according to FF = Fat/(Fat +Water) and a total fat volume within the muscle fascia was calculated.

Results: The phantom experiment indicated a high accuracy of the FF quantification and the healthy volunteer experiment revealed a coefficient of repeatability smaller than 0.3 ml. This value may be related to the median (range) fat volume difference between the right and left forearm of healthy controls of 0.9 ml (0.0-1.4 ml) and of the difference between the oedematous and healthy arms of the six patients of 1.6 ml (≈2.0-2.6 ml). As a reference, the fat volume of the right arm of healthy volunteers was 2.2 ml (1.9-5.4 ml) and of the healthy arm of patients 5.8 ml (3.8-7.3 ml).

Conclusion: The accuracy and precision of the investigated MRI technique is satisfactory for estimation of fatty infiltration in skeletal muscle in lymphedema patients and controls.

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International work in radiation protection of patients at the IAEA: Therapeutic, diagnostic and interventional procedures

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The International Atomic Energy Agency (IAEA) is an organization within the United Nations family, authorized by its Statute to establish standards of safety for protection of health and minimization of danger to life, to provide for the application of those standards and to foster the exchange of scientific and technical information in the field of peaceful uses of atomic energy.

The Radiation Protection of Patients Unit serves as the focal point of the IAEA for all issues connected with the radiation protection of patients, covering radiography, interventional procedures and therapeutic and diagnostic practices, and is responsible for the development and implementation of activities related to this area.

The exposure of patients is by far the largest type of exposure to the world's population from man-made radiation sources. It has been estimated that the number of medical procedures using radiation grew from about 1.7 billion in 1980 to almost 4 billion in 2007. Too little or too much absorbed dose is problematic and the risk of any given procedure ranges from negligible to potentially fatal. Radiation protection of patients must deal with the issues of not having dose limits, purposely exposing sensitive subgroups, and purposely using doses that could cause deterministic effects. Radiation accidents involving medical uses have accounted for more acute radiation deaths than from any other source including Chernobyl.

The IAEA addresses radiation protection of patients through the International Action Plan for the Radiation Protection of Patients, updated with the Bonn Call-for-Action, which was released as a Joint Position Statement between the IAEA and the World Health Organization (WHO) in July 2013. The classes of activities performed to strengthen radiation protection of patients in therapeutic, diagnostic and interventional procedures internationally, include providing standards, guidance and training; facilitating knowledge exchange; giving technical assistance and building awareness.

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Calibration of clinical KAP meters

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Introduction: The recommendation of IAEA for lower than 7% uncertainty (k=2) associated with doses measured in diagnostic radiology poses a challenge for kerma-area-product (KAP) measurements, where the uncertainty of 20-25% is common. This large uncertainty stems from the energy dependence of commercially available KAP meters.

Aim: To develop a method for improved accuracy in clinical measurements of the kerma-area- product using built-in KAP meters.

Method: To improve the measurement accuracy, the authors propose a new approach to the calibration of built-in KAP meters that is based on: (i) in-situ tandem calibration with a reference KAP meter, (ii) determination of beam quality correction factors for the reference KAP meter via a combination of measurements at SSM and Monte Carlo (MC) simulations, and (iii) in-situ validation of energy dependence of built-in and reference KAP meters via an ionization chamber with air equivalent walls.

Results: The method was tested on a KAP meter built in a Siemens Aristos x-ray stand. A Vacutec 70157 KAP meter was used as the reference KAP meter, the energy dependence was measured with an Exradin A3 ionization chamber. Both chambers were calibrated at SSM for the RQR 5 beam quality. Beam quality correction factors transferring from RQR 5 to clinical beam qualities were calculated using the Monte Carlo code Penelope. The computational model was tested by comparing the calculated energy dependence of the reference KAP meter to values measured in-situ with the Exradin A3 chamber. The KAP values measured by the built-in KAP meter and those measured with the reference KAP meter in a tandem calibration setup were compared. Relative errors in the calibration coefficients of the built-in KAP meter were up to 26%.

Summary: The proposed method for calibration of built-in KAP meters can significantly reduce uncertainties in measured values of the kerma-area-product associated with the energy dependency of KAP meters.

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Quantitative tissue classification via dual-energy computed tomography

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Introduction: The introduction of DECT to clinical practice during the last several years raises a question whether this modality can be used to improve the accuracy of radiation treatment planning by providing information on elemental composition of imaged tissues. Of special interest is the situation in brachytherapy, where high Z elements like calcium may noticeably affect the spatial distribution of absorbed dose, and proton therapy, where proton ranges are affected by ionization potentials of individual tissues. It turns out that the problem can only be solved by using image reconstruction algorithms specially designed to suppress artefacts resulting from the use of polyenergetic beams. The authors are working on a model based iterative image reconstruction algorithm (DIRA) that has the potential to determine elemental composition of tissues.

Aim: To present the algorithm and demonstrate its performance for the determination of the amount of calcium in a prostate tissue.

Method: A mathematical model consisting of elliptical regions approximating selected slices of the ICRP 110 male phantom was created. Tabulated material composition of the prostate region was modified to contain extra 5% of calcium. The Drasim computer code (Siemens, Erlangen, Germany) was used to simulate projections of the mathematical model for tube voltages of 80 and 140 kV. The projections were processed with the DIRA algorithm and the resulting mass fractions of regions of interest were compared to true values. Errors in predicted mass energy absorption coefficients and mass attenuation coefficients were evaluated for the prostate region.

Results: Errors in resulting mass fractions depended on the base material triplet. For the lipid, protein and water triplet, the errors in mass fractions of these base materials were less than 30%, error in the mass fraction of calcium was about 0.5%. Errors in mass energy absorption coefficients and mass energy attenuation coefficients were less than 6%.

Summary: The DIRA algorithm has the potential to improve accuracy in radiation treatment planning in brachytherapy. More work has to be done on the automatic selection of suitable triplets.

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Evaluation of six iterative reconstruction algorithms in brain CT

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Purpose: To evaluate image quality produced by six different iterative reconstruction (IR) algorithms in four CT-systems in the setting of brain CT, using different radiation dose levels and iterative image optimization levels.

Methods: An image quality phantom (Catphan 600), supplied with a bone mimicking annulus, was examined using four CT-systems from different vendors (GE, Philips, Siemens, and Toshiba) and four radiation dose levels (120, 84, 48, and 12 mGy). Acquisitions were reconstructed using conventional filtered back-projection (FBP), three levels of statistical IR, and when available a model-based IR algorithm. Evaluated image quality parameters were: CT-numbers, uniformity, noise, noise-power spectra (NPS), low-contrast resolution (objective and subjective), and spatial resolution.

Results: CT-numbers varied between CT-systems, but were stable between reconstructions within specific CT-systems. Uniformity was in all cases adequate. Compared with FBP, noise reduction was achieved by all six IR algorithms at all radiation dose levels, with further improvement seen at higher IR levels. NPS revealed changes in noise distribution relative to FBP for most statistical IR algorithms, and especially the two model-based IR algorithms. Compared with FBP, variable degrees of improvements were seen in both objective and subjective low-contrast resolution for all IR algorithms. Spatial resolution was improved with both model-based IR algorithms and one of the statistical IR algorithms.

Conclusions: The four statistical IR algorithms evaluated in the study all improved general image quality compared with FBP, with improvement seen for most or all evaluated quality criteria. Further improvement was achieved with one of the model-based IR algorithms.

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On the Mechanical Imaging of Breast Lesions

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Screening mammography is a primary tool for early detection of breast cancer. Women with suspicious mammographic findings are recalled for further clinical evaluation with e.g. additional mammography, ultrasound and needle biopsy. Roughly 10% of the recalled women are eventually diagnosed with cancer, while the rest are so-called “false positives”.

Malignant tumours are known to be mechanically stiffer than benign lesions. Therefore ultrasound and other techniques that measure mechanical properties of tissue are an important part of the examination of recalled patients.

We have previously employed a pressure-sensor matrix to measure the spatial distribution of pressure across the breast during mammographic compression in order to optimise the compression procedure. Pressure in every given position on the breast is a function of the applied force and the tissue stiffness. By matching the pressure distribution with the mammographic images the pressure over a suspicious area can be compared with the surrounding background pressure.

Method: Twenty-two recalled patients with high suspicion of breast cancer were included in the study to investigate pressure on tumours compared to normal tissue. Pressure sensors were applied beneath the compression paddle and the breast was compressed. A pressure distribution measurement was then acquired. Corresponding mammograms were used to find the pressure at the lesions.

Results: Of the 22 subjects, the pressure on the lesion was (after normalisation by mean breast pressure) on average 2.05±2.02 ($P < 0.05$) units higher than the background pressure. One subject had a benign lesion with pressure 0.18 units above the background. Of the subjects with malignant lesions, 20 (95%) had a maximum lesion pressure higher than the background average and 18 (86%) had a mean lesion pressure higher than the background.

Conclusion: Our results indicate that pressure sensors can distinguish malignant tumours in the compressed breast from other tissue. There is insufficient data to determine whether they can be distinguished from benign lesions. A further study on 150 recalled women will be started this autumn aiming at answering this question.

Accuracy of pulmonary nodule size measurement on chest tomosynthesis

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Incidentally detected pulmonary nodules are common secondary findings from chest CT examinations. In order to detect nodule growth, which is an indicator of malignancy for these lesions, it is common to perform repeated chest CT examinations at certain time intervals. The diameter of the nodule is manually measured in the images by the radiologist and if a significant size increase over time is detected, further diagnostic investigations are initiated. As CT resources at the clinic are often under pressure and since repeated CT examinations introduce patient dose concern, chest tomosynthesis has emerged as an interesting alternative for the task of pulmonary nodule monitoring. Previous studies have shown that the visibility of known nodules is relatively high on chest tomosynthesis images, and that manual nodule measurements are comparable between CT and tomosynthesis.
Results will be presented from a study investigating the accuracy of manual pulmonary nodule measurements on chest tomosynthesis images and its dependence on nodule size and examination dose. Data consist of measurements of the longest diameter of artificial ellipsoid shaped nodules, with known dimensions, inserted in to clinical chest tomosynthesis images. The measurements were performed by thoracic radiologists.
Inter- and intraobserver variability was analysed. To simulate different examination doses, a previously developed method for noise addition was applied on the images.

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Introduction to Monte Carlo simulations using PENELOPE: possibilities and limitations in modelling of breast tomosynthesis

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This presentation aims to give an idea of how the code system PENELOPE can be used for Monte Carlo simulations and generation of radiographic images. It will cover available software tools, material definition, geometry models, required simulation parameters and compromises that can be made in order to get a useful simulation procedure. The work was the start of a Master of Science dissertation where the possibilities of simulating the imaging chain of breast tomosynthesis was investigated.

PENELOPE performs simulation of electrons, positrons and electrons and was chosen due to its ability to simulate low energies (down to a few hundred eV). It is a free software, developed at the University of Barcelona, and the distribution package includes several software tools for configuration and visualization.

PenEasy_Imaging and penMesh are two main programs, provided with a tool to produce radiographic images, that operate the PENELOPE code and its subroutines. While the original geometry subroutine is limited to quadric surfaces, penEasy_Imaging and penMesh allow additional voxel and triangle mesh representation of the geometry. The radiation source can be modelled in several ways, such as a point, rectangular box or fan-beam. The detector can be configured to count the energy deposition distribution using Monte Carlo simulation or to produce images without scatter and noise by analytical ray tracing.

The initial simulations lead to the development of a simulation procedure for modelling of a MAMMOMAT Inspiration breast tomosynthesis system, which was used for a pilot comparison of different acquisition parameters.

Figure: Example of voxel breast phantom (left) and projection image simulated with penEasy_Imaging (right).

Comparison of different approaches of estimating the effective dose from CBCT examinations performed using interventional fluoroscopy systems

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Three-dimensional (3D) imaging with interventional fluoroscopy systems is today a common examination. The examination includes the collection of a large number of two-dimensional projection images of the patient. The projection images are then used to reconstruct CT like images of the patient. The technique is often referred to as cone-beam CT (CBCT). The resulting patient radiation doses from CBCT examinations have previously been reported to be comparable to the radiation doses from conventional CT examinations. However, determining the radiation doses from CBCT examinations is not a straight-forward task. Especially as detailed exposure parameters from the examinations are not provided by the system commercially available. Hence, variations in exposure parameters between the different projection images included in the examination can not always be accounted for. The aim of this study was therefore to evaluate the errors connected to using different methods for calculating the radiation doses from CBCT examinations performed using interventional fluoroscopy systems. In the study the Siemens Artis Zee interventional fluoroscopy system (Siemens Medical Solutions, Erlangen, Germany) was used. An eight-second DynaCT digital radiography protocol was used to collect images of the anthropomorphic pelvis phantom. The exposure values obtained from the examination was used to perform Monte Carlo based calculations of the effective doses resulting from the examination, using the computer software PCXMC (STUK, Helsinki, Finland). Both individual exposure values (kV and mAs) for each projection image included in the examination and constant mean values (kV/mAs and DAP) for all projections were used as input for the dose calculations. In addition, the effects of not including all the projection images in the dose calculations were investigated. Preliminary results show that the effective dose from a pelvis examination using this system is approximately 6 mSv. Only very small variations in resulting effective doses were found between the different methods used for dose calculations (variations smaller than 4%). The results thereby indicate that simplified dose calculations, e.g. using mean exposure values and/or not accounting for each projection image included in the examination, can be used to estimate the radiation doses from CBCT examinations performed using interventional fluoroscopy systems with reasonable accuracy.

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Evaluation of the impact of a system for real-time visualisation of occupational radiation dose rate during fluoroscopically guided procedures

Viktor Sandblom*[1,2], Tu Mai[2], Anja Almén[1], Hans Rystedt[3], Åke Cederblad[1], Magnus Båth[1,2] and Charlotta Lundh[1]

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Optimisation of radiological protection for operators working with fluoroscopically guided procedures has to be performed during the procedure, under varying and difficult conditions. The aim of this study was to evaluate the impact of a system for real-time visualisation of radiation dose rate on optimisation of occupational radiological protection during fluoroscopically guided procedures. Individual radiation dose measurements, using a system for real-time visualisation, were performed in a cardiology laboratory for three cardiologists and ten assisting nurses. Radiation doses collected when the radiation dose rates were not displayed to the staff (period 1) were compared to radiation doses collected when the radiation dose rates were displayed (period 2). The results showed that when the radiation dose rates were displayed to the staff, one cardiologist and the assisting nurses (as a group) significantly reduced their personal radiation doses. The median radiation dose ((Hp(10)) per procedure decreased from 68 to 28 µSv (p=0.003) for this cardiologist and from 4.3 to 2.5 µSv (p=0.001) for the assisting nurses. The results of the present study indicate that a system for real-time visualisation of radiation dose rate may have a positive impact on optimisation of occupational radiological protection. In particular, this may affect the behaviour of staff members practising inadequate personal radiological protection.

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A common nomenclature for radiotherapy parameters for efficient database handling

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Access to structured databases containing relevant quality parameters is necessary for efficient research, clinical evaluation and reporting. So far, much of the work to retrieve and coordinate radiotherapy (RT) data has been done manually.
The aim of the project is to expand national quality registries for RT and to create local, hospital based RT-databases with relevant information on delivered irradiations. The work with local databases is carried out in Umeå and Uppsala where a platform already has been established within the U-Can project.
One important prerequisite for efficient database handling is a common nomenclature for RT-information adapted to current national and international standards. A reference group representing a number of Swedish university hospitals has suggested a common Swedish nomenclature for RT-information which currently is implemented and tested in Umeå and Uppsala. The proposed nomenclature will be presented and discussed.
The project is supported by the Swedish Radiation Safety Authority (SSM) and the Swedish Governmental Agency for Innovation Systems (Vinnova).

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National database solution for radiotherapy quality registers and clinical studies

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An IT-infrastructure for a national Swedish quality registry is under development within a project funded by SSM and Vinnova. The project is lead from Uppsala by Anders Montelius and the software development is shared between Cureos AB, Uppsala, and the University hospital in Umeå. The idea is to store all information about the treatments of individual patients in local databases at each clinic in a standardized format. Key parameters describing the treatment are then determined by a specially developed application, which sends the parameters to INCA. The radiotherapy quality registry will be a parallel database to the existing diagnoses specific databases already present within the INCA platform. The goal is to strengthen the clinical radiotherapy research in Sweden, by enabling association between the radiotherapy data in the database under development and the clinical data in the existing databases.

The technical solution, with local storage at each individual hospital, has the benefit that is allows for retrospective updating of the INCA database with new key-parameters. Another benefit is that it could serve as a storage area for local or national clinical radiotherapy studies. Therefore, we develop tools for export of subsets of patients to an identical database but where all information which could be used to identify the individual patient is removed or replaced.

Risk analysis of the VMAT-workflow at the university hospital in Umeå

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A risk analysis of the VMAT-workflow at Umeå University Hospital has been done. The purpose was to investigate how errors are introduced into the information systems used in the workflow, see how they propagate and what the potential consequences for the patients are. Mechanisms and procedures for error detection are examined to see if they are sufficient or if errors can slip through undetected. This is carried out as a project course included in the medical physicist education at Umeå University hospital with the intention to get understanding about radiotherapy and risk analysis. Interviews and auscultations with the personnel at the radiotherapy department was the main information source.

Errors may be related to system components, personnel or a combination of the two. Systemic errors seem to be well handled by present security barriers; however, some systemic deficiencies may be classified as workflow errors when personnel have to be involved. The main finding here is connected to the Localization Trend Review (LTR) function in Mosaiq. The LTR merely gives a mean value of a set of localization displacements. The derived localization offset is presented completely without any information about the variance in the sample. This, in combination with unobservant or unaware personnel and personnel redistribution, can introduce erroneous conclusions regarding patient positioning and hence also faulty treatment.

Various examples of inadequate information exchange in connection with personnel redistribution can be given. In Umeå the radiotherapy registration is printed and used physically rather than electronically. The goal is to obtain an efficient workflow to handle more patients. Should the radiotherapy registration be changed post-printing, however, dose planning might accidentally be made referring to an outdated version of the radiotherapy registration.

Minimizing human errors seems to be the main concern. There are many security barriers; however, more can still be introduced, for example taking the variance into account in the LTR. Systematic errors of various kinds regarding patient positioning are something that seems to be very complex to manage. Periods that are extra sensitive to workflow discrepancies are summer holiday periods when personnel is redistributed in a higher rate than normal.

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A deliverability comparison of equivalent dual-arc VMAT plans generated in two different treatment planning systems

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Purpose: Compare deliverability of equivalent 6MV dual-arc volumetric modulated arc therapy (VMAT) plans generated with Eclipse and RayStation treatment planning systems, at a Varian TrueBeam linac.

Method: A total of a 102 optimal plans for eight different patient cases were generated in Eclipse. The plans were exported to RayStation and equivalent plans were generated using the systems back-up tool. All 204 plans were delivered with a Varian TrueBeam linac and measured with a Delta4 system. Measurements were compared and evaluated with dose calculations using γ-analysis, 3% and 2 mm, with a threshold level of 15%. The numbers of MUs needed to deliver the dose were also compared. The Wilcoxon signed-rank test was used to statistically analyse the results.

Results: The fraction of approved data points from the γ-analysis were significantly higher ($p<0.001$) for the RayStation plans compared to the Eclipse plans. The fractions varied between 93.0% and 100.0% for the Eclipse plans, and between 98.6% and 100.0% for the RayStation plans. All RayStation plans had the same or higher fraction of approved data points than the corresponding Eclipse plans. Of all the measured plans only three plans (Eclipse) had fractions of approved data points below our current clinical criteria of 95.0%. The numbers of MUs needed to deliver the plans were significantly higher ($p<0.001$) for the Eclipse plans than the RayStation plans. The number of MUs in the Eclipse plans were on average 31% higher than for the corresponding RayStation plan. The highest numbers of MUs for a plan correlated with the lowest values in the γ-analysis.

Conclusions: The deliverability was significantly higher for the RayStations plans compared to the Eclipse plans. Though, only three of the Eclipse plans did not fulfil our clinical quality control (QC) criteria of ≥ 95.0% approved data points. The numbers of MUs in the RayStation plans were significantly lower than in the corresponding Eclipse plans.

IMRT patient-specific QA using the Delta^4 dosimetry system and different evaluation methods

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Background: Patient-specific IMRT QA is dependent on the dosimetry system and the evaluation procedure. A recommended evaluation in ICRU 83 is to evaluate the low dose gradient region (<20%/cm) with a dose difference criterion of 5%, and the high dose gradient region (≥20%/cm) with a distance-to-agreement criterion of 5mm with a 85% pass rate in each region. A more recognized method is gamma evaluation, most often used with 3% and 3mm criteria.

Purpose: The result of doing IMRT patient-specific QA with the Delta^4 dosimetry system using the evaluation methods described is studied.

Method: H&N IMRT treatment plans of four patients were modified within the TPS to create 17 modified plans with dose deviations of ±5% in at least two interesting structures, such as the max dose in the spinal cord or brainstem, mean dose in the parotid glands and mean, min or max dose in the target volumes. The four original treatment plans were measured with the Delta^4 phantom and compared to the calculated dose distributions of the modified plans. In the gamma evaluation a dose cut off at 20% is used.

Result: The ICRU 83 evaluation resulted in a pass rate higher than 85% in both the low and the high gradient region in four of the 17 modified plans, the rest failed in the low gradient region. Twelve plans pass global gamma evaluation with criteria 5%/5mm and pass rate 85%. Nine plans pass using local gamma with the same criteria. Setting the criteria to 3%/3mm and pass rate 97% detects all but two plans. There was no difference between global and local gamma evaluation when using criteria 3%/3mm.

Conclusion: This study indicates that patient-specific QA with the Delta^4 dosimetry system and the evaluation method recommended by ICRU 83 cannot be used to unequivocally distinguish differences between planned and measured dose larger than ±5% in interesting structures. Gamma evaluation with 3%/3mm and pass rate 97% detected more erroneous plans but still did not detect 2 plans with dose deviations >±5%.
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Experiences from commissioning of a linear accelerator using a novel cylindrical 3D water tank - from electrons to flattening filter free beams

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Commissioning of a linear accelerator has mainly been performed using a cuboid water tank. A cylindrical water tank, 3DS (Sun Nuclear), is now available on the market which the manufacturer says has the benefits of extended scanning ranges without tank movement and consistent detector orientation for profile scans independent of scanning angle. The commissioning of the TrueBeam in Kalmar has been performed using the 3DS water tank together with the first and second version of the 3DS software.

Measurements of depth doses, in-axis, cross axis and diagonal dose profiles and output factors have been performed in the tank for three flattened photon beams, 6, 10 and 15 MV, and two flattening filter free (FFF) beams, 6 and 10 MV. Depth dose and dose profile measurements were also carried out for five electron beams, 6, 9, 12, 15 and 18 MeV. The results from the measurements were used to configure Varians dose planning software Eclipse and the configuration of the software was tested, with the help of 7σ, using Sun Nuclears 2D diode array, Mapcheck.

In FFF beams there is a difference in the collection efficiency of ionization chambers in different parts of the dose profile. At present no corrections for this effect have been applied to our measurements.

We will present our experiences from performing measurements with the 3DS and the 3DS software, e.g. setting up measurement protocols, filling and emptying the water tank, the auto-setup feature, post-processing data in the 3DS-software and exporting data for use in configuration of Eclipse and measuring at shorter SSDs.

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A 2D beam-quality specifier for flattening filter free beams

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Purpose: There are now several clinical radiotherapy treatment units available without a flattening filter in the beam line, e.g. the TomoTherapy®, CyberKnife® and TrueBeam™ units. These beams have an energy distribution that is different from conventional beams and thus the shape of the depth dose distributions will differ. For flattening filter free (FFF) beams the beam-quality specifier $TPR_{20/10}$ is unable to predict the $S_{w,air}$-ratio as accurately as for beams with a flattening filter. The purpose of this work was to investigate the possibility of increasing the precision in determining $S_{w,air}$ by adding another beam quality metric, $TPR_{10/5}$, and applying a two-dimensional surface fit.

Materials: A total of 24 realistic photon beams (10 FF and 14 FFF) from three different treatment units have been used to calculate $S_{w,air}$, $TPR_{20/10}$ and $TPR_{10/5}$. The energy range of the beams was 6 to 10 MV. The relationship between $S_{w,air}$ and the dual beam-quality specifiers $TPR_{20/10}$ and $TPR_{10/5}$, were then investigated by fitting the data to a two-dimensional surface described by:
$S_{w,air} = a1+a2(TPR_{20/10})+a3(TPR_{20/10})^2+a4(TPR_{20/10})^3+b1(TPR_{10/5})$ Eq.(1).

Results: The difference between calculated $S_{w,air}$ for beams with and without flattening filter at the same $TPR_{20/10}$ was on average 0.3 %. By fitting Eq. (1) to the MC-calculated data the constants were determined. Using this model the RMSD between calculated and predicted $S_{w,air}$ for FFF beams was 0.00067 with a maximum difference of 0.1 % and for the conventional beams the RMSD was 0.00038 with a maximum difference of 0.06 %. For all beams the RMSD were 0.00056. Using only $TPR_{20/10}$ and the fit used in IAEA TRS398 the RMSD was 0.0024 and the maximum deviation was 0.43 %.

Conclusions: An additional parameter for determining $S_{w,air}$ has been presented. This parameter is easy to measure; it requires only an additional dose measurement at 5 cm depth with SSD 95 cm, and provides information for accurate determination of the $S_{w,air}$ ratio for beams with and without a flattening filter at the investigated energies.

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Radioactive Iodine (I-131) for thyrotoxicosis: preparation, treatment and outcome

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Purpose: The aim of the present study was to evaluate the outcome of radioiodine treatment in thyrotoxicosis.

Method: This was a retrospective study of 71 patients (58 female and 13 male) with thyrotoxicosis of three subgroups; Graves disease (38), multinodular goitre (26) and toxic adenoma (7) who received iodine-131 (I-131) treatment in 2011. One patient in the adenoma group and four in the goitre group were excluded from the study (poor follow-up or moved).

The thyroid volume was approximated with a planar thyroid scintigraphy (110 MBq Tc- 99m pertechnetate) with rotational ellipsoids (long and short axis, ≈LT10) corresponding to thyroid lobes (Graves), or one ellipsoid for an adenoma and multiple ellipsoids for multinodular goitre. The thyroid uptake of I-131 was measured after 5 days on a given activity of 0.3 MBq. The given activity was calculated, using the uptake value and thyroid volume, for the prescribed doses according to H Jönsson[1]. The prescribed doses were 120 Gy for Graves disease, 150 Gy for multinodular goitre and 300 Gy for toxic adenoma.
In the study; gender, duration of antithyroid drug treatment, 5 day thyroid uptake value, thyroid volume, given activity, number of treatments and thyroid status before and until 12 months after treatment were recorded.

Results: One year after the treatment with I-131, this study showed that euthyroid status was achieved in 5 of 6 patients with toxic adenoma, 22 of 25 patients with multinodular goitre but only 2 of 38 patients with Graves disease. The rest of the patients reached hypothyroid status and thyroid replacement therapy was inserted. Three patients in the goitre group and four patients in the Graves group were given another treatment before the desired effect (eu/hypo) could be reached.

Conclusion: Treatment of goitre and adenoma with I-131 is working well. The result for Graves disease is depending on the intention of treatment, euthyroid or hypothyroid. If hypothyroid is the intent, the treatment is working well. To reach euthyroid status for Graves disease the possibility is either to lower the prescribed dose (100 Gy) or a better determination of the thyroid volume with another threshold value or perhaps a volume determination with SPECT or SPECT/CT.

[1]Single uptake measurement for absorbed dose planning for radioiodine treatment of hyperthyroidism. Cancer Biother Radiopharm, 2003;18:473-479

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(How) can the communication with the ethical review board (EPN) get better?

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Background: A research project involving human beings is governed by several laws and regulations in Sweden. A great deal of these projects involves ionizing radiation from different modalities for follow up and treatment evaluation purposes. In some cases radiology examinations are also performed prior to the start of the trial to verify that the patient is fit for enough to be admitted to the study.
From a medical physicists perspective we may be involved through the procedure were the project application is handled in the radiation protection committee at the hospital as requested by SSMFS 2008:35 or in assisting the local ethical review board with their case file.

Current situation: Radiation protection committee members include several different specialties from the medical and technical staff. We do however lack the expertise to make statements with our ethical eyes as we have never had any such training. Our expertise lies within the field of radiological science. At the same time EPN assumes us to make the go/no go decision without their involvement. Can we make a good job?
Many projects today involve multi-centre studies to achieve a sufficient number of people to recruit for the study. This makes it complicated because SSMFS 2008:35 states that every study site must make their own ethical assessment but EPN only requests the answer from one radiation protection committee.

Discussion: How can we achieve a fruitful discussion with EPN on the one hand and all the counties in Sweden to get better harmonization in-between committees? What role can the Swedish Radiation Safety Authority play in the current situation?

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A short report from the new radiotherapy unit in Lund

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Following the centralisation of radiotherapy at Skåne University Hospital (SUS), a new four storey radiotherapy building was inaugurated in May 2013. Adding the newly purchased imaging- and treatment units to the former existing in Lund and to those which been transferred from Malmö, the total machinery consists of 13 treatment units for external radiotherapy (7 Varian, 4 Elekta, 1 ThomoTherapy and 1 Gulmay X-ray), 3 units for Brachytherapy (2 GammaMed HDR and 1 125-I seeds), and 4 imaging units (3 Siemens CT and 1 GE 3T MRI).
The staff at the Radiotherapy Physics unit consist of 24 medical physicists, 11 treatment planners/oncology nurses, and 11 engineers (part-time and substitute workers included). Clinically oriented radiotherapy physics research is carried out together with the Medical Radiation Physics departments at Lund University, with 2 professors and 6 PhD students. The presentation will report a bit from the construction phase of the new radiotherapy building and some of the work going on today. The talk will also describe a selection of ongoing clinical development projects and research activities in collaboration with Lund University.

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Mitt professionella liv med kvinnobröstet

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This presentation will give a brief history of mammography and illustrate a few concerns with the current technique and how to overcome them. Clinical images and physical inherent properties will highlight these concerns, with a special focus on breast tomosynthesis and its potential to replace 2D mammography in the near future. My research contribution to the mammography field will be emphasized. This includes tumour size measurement with different imaging modalities, studies on breast compression and malignant tumour cell shedding of the primary breast cancer.

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Biodistribution and dosimetry of ^{177}Lu-octreotate and evaluation of DMSA and lysine as kidney protecting agents in mice

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^{177}Lu-octreotate is used in treatments of patients with neuroendocrine tumours expressing somatostatin receptors (SSTR). To be able to optimize this treatment so more patients will undergo complete remission, more knowledge about the biodistribution is needed. The aims of this study was to study how the biodistribution of ^{177}Lu-octreotate in C57BL/6N mice depends on time after injection and quantity of injected amount, and to study the potential of DMSA as a kidney protector, alone and together with lysine, during treatment with ^{177}Lu- octreotate.

C57BL/6N female mice were injected with 15 MBq ^{177}Lu-octreotate and killed 15 minutes, 30 minutes, 1 hour, 4 hours, 8 hours, 24 hours, 3 days, 7 days and 14 days after injection, or injected with 0.1, 1, 5, 45, 90 and 150 MBq and killed 4 hours, 24 hours or 7 days after injection. Another group of mice were injected with 3.5 MBq ^{111}In-octreotide alone, or co-administrated with 1, 2, 4 or 8 mg DMSA, 4 or 8 mg lysine or with both DMSA and lysine, and killed 24 hours after injection. Radioactivity measurements were performed on blood, bone marrow, kidney, pancreas, spleen, lung and liver. Uptake as %IA/g and absorbed dose per unit injected activity was calculated.

The results show, as expected, the highest absorbed dose in the kidneys. An uptake peak during the first hour, mainly due to the high activity concentration in the blood, was seen in lung, liver, pancreas and spleen. A second peak between 4 h and 8 h due to other uptake mechanisms such as binding to SSTR was seen. No limit for saturation of SSTR for ^{177}Lu-octreotate was found. The %IA/g uptake decreased when the amount of injected activity increased from 0.1 MBq for all studied organs except the kidneys. No clear relationship between amount of injected activity and kidney uptake was found, but injection of 4 mg DMSA seems to reduce the kidney uptake of ^{111}In-octreotide by 35 %. Injection with 8 mg lysine reduced the kidney uptake with 46 %, but when it was co- administrated with 2 mg DMSA no significant different from the control was seen, but there was a large variation in activity concentration in blood in these groups. DMSA may be used as kidney protector, but not when co-administered with lysine. More studies are needed to further elucidate kidney protection regimens.

Evaluation of a metal artefact reduction algorithm in CT-studies used for radiotherapy treatment planning

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Purpose: To evaluate the usefulness of the metal artefact reduction algorithm O-MAR in dose calculations, mainly for proton therapy but also for X-ray radiation therapy.

Background: Metal objects in the body, like hip prostheses and dental fillings, cause severe artefacts in CT-images. CT-images degraded by metal artefacts are not only an issue in diagnostics, but also in the radiotherapy treatment planning where they may cause severe inaccuracies. Dose distributions from proton beams are more sensitive to tissue heterogeneities than X-ray beams and were therefore the main focus in the evaluation.

Material and methods: The evaluation was mainly based on phantom measurements. A hip prostheses phantom and a dental filling phantom were designed. Reference images with no metal present in the phantom were acquired. The O-MAR images, the uncorrected images and the reference images were compared, both in terms of HU-statistics and dose calculations. Proton dose calculations were performed for several beam directions. Some X-ray dose calculation comparisons were included as well. Finally, two patient cases, one with hip prosthesis and one with dental fillings, planned for radiation therapy with X-rays were studied to illustrate the O-MAR algorithm.

Results: The evaluation of the HU-values showed that when O-MAR was used the mean HU- values in ROIs were in general closer to the reference values and the standard deviations of HU-values were decreased. The proton range differences between the phantoms with metal objects present and the reference phantoms were decreased significantly when O-MAR was used. Even severe artefacts were reduced. The proton range differences were larger for the hip prostheses phantom than the dental filling phantom. The highest proton range difference was seen when beams were applied along streaks near the hip prostheses. The range difference was for one of these oblique beams 1.44 cm for the uncorrected case and 0.40 cm for the O- MAR case. When P-A and lateral beams were applied to the phantoms, the range differences between the O-MAR corrected and the reference case were below 0.14 cm. X-ray dose calculations showed a dose difference, at 15 cm depth, of maximum 2% for the uncorrected case and 0.3% for the O-MAR case. The patient cases did not show any significant difference in dose to the PTV when O-MAR images were used instead of uncorrected images.

Conclusions: The evaluation shows that the O-MAR algorithm significantly improves the accuracy in proton dose calculations. Proton beams applied along streaks should, however, be used with caution.

Nationellt möte om sjukhusfysik, Varbergs kurort 13-14 november 2013

Caroline Adestam Minnhagen	Göteborg
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Nationellt möte om sjukhusfysik, Varbergs kurort 13-14 november 2013

Peter Sjölander	Jönköping
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