SATURDAY, MAY 3

Mammography Symposium Room: Congress
Clinical Perspectives on Mammography

SA-A-CONG-01
Digital Mammography – Current Capabilities and Limitations
J Parikh*

No abstract provided

SA-A-CONG-02
Stereotactic Breast Biopsy – Clinical Overview
J Parikh*

No abstract provided

Therapy Symposium Room: Metropole
Monte Carlo

SA-A-MET-01
Monte Carlo in Treatment Planning
C Ma*, Fox Chase Cancer Center, Philadelphia, PA

This presentation is aimed at facilitating participants with the clinical application of Monte Carlo dose calculation algorithms in radiotherapy treatment planning and dosimetry verification. Following a brief introduction to the Monte Carlo radiation transport method, detailed discussions will be given on the clinical implementation and commissioning of the Monte Carlo dose calculation software. Current and potential applications of Monte Carlo dose calculation in conventional electron therapy, energy- and intensity-modulated electron therapy and advanced mixed beam therapy will be presented. Patient treatment plans generated using conventional dose calculation algorithms and Monte Carlo simulations will be compared with the causes of the dose discrepancies discussed.

Educational Objectives:
1. To introduce the basics of Monte Carlo radiation transport simulation
2. To discuss important aspects of clinical implementation and commissioning of Monte Carlo dose calculation algorithms for radiotherapy treatment planning
3. To describe the role of Monte Carlo dose calculation in electron therapy and advanced mixed beam therapy treatment planning and dose verification

SA-A-MET-02
Monte Carlo Methods in Proton Beam Radiation Therapy
H Paganetti[1] *, (1) Massachusetts General Hospital, Boston, MA

The Monte Carlo method is considered to be the most accurate method to simulate absorbed dose in radiation therapy. Due to the increase in computer power, there is no doubt that Monte Carlo will be the dominant dose calculation method in the near future. The impact of Monte Carlo dose calculation could potentially be bigger in proton therapy than in conventional radiation therapy due to the highly conformal dose distributions caused by the sharp distal dose gradient. This presentation will discuss two examples for the application of Monte Carlo dose calculation in proton therapy:
1. Monte Carlo for treatment dose verification
The modeling of the beam delivery system itself opens various areas where Monte Carlo calculations prove extremely helpful, such as for design and commissioning of a therapy facility as well as for quality assurance verification. Monte Carlo calculations can help to understand the sensitivity of beam characteristics and how these influence the dose delivered. With the capability of reading CT data information, Monte Carlo codes are able to model patient anatomy. A software link of the Monte Carlo dose engine to the patient database and the commercial planning system can thus be established to allows to use Monte Carlo re-calculated dose distributions as a benchmark for analytically generated treatment plans or even to do full Monte Carlo based treatment planning. Using a simulation of the ionization chamber reading in the treatment head allows the Monte Carlo dose to be specified as dose to tissue in absolute units. This presentation will review the implementation of a proton Monte Carlo dose calculation engine in the clinic and discuss a few results, i.e. comparisons between Monte Carlo generated and analytically generated dose distributions for protons.
2. Secondary neutron dose
There is a growing concern for the risk of developing cancer due to radiation treatments, in particular for pediatric patients. Protons deposit secondary dose outside the treatment volume predominantly via neutrons (generated either in the patient or the treatment head). Organ dosimetry is necessary for epidemiological studies of secondary cancer risk, especially for body regions not imaged for treatment planning. However, organ equivalent doses and effective doses within human body are not directly measurable. One way of estimating organ dose distributions is through the use of computational anthropomorphic phantoms coupled with Monte Carlo algorithms. This presentation will demonstrate how Monte Carlo simulations are used to assess neutron doses on the example of age and gender specific whole-body phantoms. Some of the findings from a recent project aiming at assessing the dose from secondary radiation in patients undergoing proton treatment will be summarized. Neutron dose to the patient depends on several factors, for example the field size incident to the patient specific collimator and the patient's age. The estimation of cancer risk based on these data will be discussed.

Educational Objectives:
1. Understand the importance and challenges of Monte Carlo techniques in (proton) radiation therapy
2. Understand the use of whole-body computational phantoms for dose simulations and the risk associated with scattered neutron radiation

SA-A-MET-03
Clinical Implementation of Monte Carlo Methods for External Photon Beam Therapy
IJ Chetty[1] *, M Fragoso[2], (1) Henry Ford Health System , Detroit, MI , (2) Henry Ford Health System, Detroit, MI

The development of fast, accurate Monte Carlo (MC)-based codes has rejuvenated interest in the use of MC-based photon dose calculations in patient-specific geometries. In general, this class of "second generation" codes, including VMC++, XVMC, and DPM, among others, employ electron-step algorithms that converge faster, i.e. you are able to take fewer condensed-history steps for the same precision versus "first-generation" codes (such as MCNP and EGS). These advances, coupled with the use of sophisticated variance reduction techniques (e.g. directional bremsstrahlung splitting), have made it possible to perform MC-based photon beam dose calculations, in some instances, of the entire linear accelerator (linac) treatment head and patient-geometry, within minutes on a single processor. With the impending availability of MC-based dose calculations for routine clinical treatment planning, it is important that strategies and paradigms for clinical commissioning and implementation of these systems be formulated and discussed.

The educational objectives of this lecture can be summarized as follows:
1. Understand the differences between "first" and "second-generation" MC-based photon beam dose algorithms and the methods (e.g. variance reduction techniques) used to render "second-generation" codes fast enough for routine treatment planning
2. Understand the methods used for characterization and beam modeling of the linac
3. Understand approaches for commissioning and experimental verification of MC-based photon beam dose calculation systems
4. Understand the basic issues associated with clinical implementation of MC-based photon dose calculation algorithms, as discussed in the AAPM Task Group Report No. 105

Mammography Symposium Room: Congress
Physics Testing for Mammography Systems

SA-B-CONG-01

Q/C and Physics Testing of Stereotactic Breast

M Martin[1], (1) Therapy Physics, Inc., Bellflower, CA

The recommendation of the National Mammography Quality Assurance Advisory Committee to the FDA at the November 2007 meeting was that all Stereotactic Breast Biopsy units be included in the MQSA program. This will require that these units be tested annually by a qualified medical physicist in accordance with the ACR (American College of Radiology) Accreditation Program for SBB units as outlined in the SBB accreditation manual (1997) available from the ACR. The required 11 tests specified and outlined in this publication will be covered in detail along with the required forms. Methods of acquiring the required data and information to complete these tests will be covered with specific examples shown for performing each of these 11 tests.

Specific program requirements for personnel and equipment will be outlined in detail along with the required Quality Assurance Program with examples of expected results. Sample report formats will be shown with along with the required summary pages available from the ACR's website. Expected doses and image quality requirements will be covered relative specifically to the Stereotactic Breast Biopsy units along with the two types of acceptable accreditation phantoms.

Educational Objectives:
1. Attendees will be aware of the image quality requirements for digital and film/screen stereotactic breast biopsy units.
2. Attendees will be aware of the patient mid-glandular dose limits for SBB units.
3. Attendees will be familiar with the eleven required physicists tests and methods to perform these.

SA-B-CONG-02

Dose Measurement in Mammography; What Are We Measuring?

D Hintenlang, University of Florida, Gainesville, FL

The ACR specifies the protocol for measurement of breast entrance exposure and average glandular dose as a part of the annually required mammography quality control tests performed by the medical physicist. This presentation provides a review of the procedures that are used for measurement and the calculations that are performed to obtain the average glandular dose. The models and principles behind the conversion factors provided in the ACR Mammography Quality Control Manual are discussed to review the development and limitations of the prescribed calculations. The basis for extending dose calculations to patient specific cases is presented and examples of the general dose trends that may be expected for patients having variations of compressed breast thickness and glandular/adipose tissue compositions are presented.

At the conclusion of the presentation, participants should understand;
1. the dose measurement procedure prescribed for the annual physics testing of mammography equipment,
2. the background, rationale and limitations for the prescribed measurements,
3. techniques that permit patient specific doses to be measured, and
4. relative trends of glandular dose as a function of compressed breast thickness and glandularity.

SA-B-CONG-03

Annual and Acceptance Testing of Digital Mammography Equipment

W Geiser*[1], (1) M.D. Anderson Cancer Center, Houston TX

Digital mammography is growing in popularity as the modality of choice in breast imaging. According to the American College of Radiology the number of digital mammography systems in the United States as of November 2007 was increasing by approximately 6% per month with 27% of all mammography systems being full field digital mammography (FFDM) systems. As the number of FFDM systems grows the responsibilities of the medical physicist at facilities that perform mammography will become more challenging.

The medical physicist needs to understand the regulatory requirements for testing of FFDM equipment as well as how the overall role of the medical physicist will change in acceptance testing, annual testing and verification testing of equipment after major repairs or software upgrades. The medical physicist must also have a greater understanding of the software and computer-related issues that accompany any digital modality including RIS systems, PACS systems and softcopy display systems.

This lecture will provide a general overview of the role of the medical physicist in a facility that is new to digital mammography as well as the role played in continued support of facilities with digital mammography equipment.

Educational Objectives:
1. Understand MQSA regulations and State mammography regulations and how they affect the medical physicist
2. Understand minimum acceptance testing requirements for all types of FFDM equipment
3. Understand the requirements for annual testing and what testing is required for major repairs and software upgrades

Therapy Symposium Room: Metropole
IMRT/IGRT

SA-B-MET-01

Intensity Modulated Arc Therapy

D Cao[1] *, J Ye[1] , T Wong[1] , D Shepard[1] , (1) Swedish Medical Center-Tumor Institute, Seattle, WA

Intensity modulated arc therapy (IMAT) is a rotational approach to intensity modulated radiation therapy (IMRT). Unlike helical tomotherapy, which needs a dedicated machine to deliver IMRT, IMAT can be delivered on conventional linear accelerators with an integrated multi-leaf collimator (MLC). Despite the promising nature of IMAT, the full potential of IMAT has gone largely unrealized due to the lack of an appropriate linac control system and a robust inverse planning system.

Recently, the two major vendors of linear accelerators (Elekta and Varian) both introduced their new delivery control systems that will be able to change MLC leaf positions and dose rate while gantry is rotating. In addition, an arc sequencer was recently developed that is able to generate both single-arc and multi-arc IMAT plans. It has been shown that this arc sequencer can provide highly conformal dose distributions that are comparable to that provided by helical tomotherapy for most clinical cases.

This presentation will provide the audience an overview of the IMAT technology. The latest development of an IMAT arc-sequencer will be presented. Comparison of IMAT plans with conventional fix-field IMRT and helical tomotherapy plans will also be provided.

Educational Objectives:
1. Understand the basics of IMAT technology and its recent development
2. Understand the dosimetric benefit of rotational IMRT delivery
3. Understand the clinical benefits of IMAT technique

SA-B-MET-02

Real-Time Target Tracking With Calypso 4D Tracking System

J Ye, D Cao, T Wong, D Shepard, Swedish Cancer Institute, Seattle, WA

Image-guided radiotherapy (IGRT) can improve patient setup accuracy. However patient usually receives certain level of radiation dose from the imaging process. Most IGRT platforms lack of direct tumor tracking capability. Calypso system offers both target localization and real-time 4D tracking using non-ionizing electromagnetic signals. The inter- and intra-fraction motion of prostate was quantified by tracking three transponders embedded in the patient's prostate. The workflow and QA procedures for Calypso System were discussed in the talk. We also developed a stereotactic cone based method to evaluate the calibration accuracy of Calypso System. A disc with three transponders was placed on a moving platform to simulate target motion. Film attached to the disc was irradiated with different fields. The results showed that the Calypso System could be used for gated radiation treatment.

This lecture will provide an overview of the Calypso System operation and Quality Assurance procedures, clinical application in prostate cancer treatment, prostate inter- and intra-fraction motion measured by Calypso, and experimental use of Calypso in gated radiation therapy.

Educational Objectives:
1. Understand the pitfalls of fiducial marker image-based IGRT platforms
2. Understand the Calypso System's operation, workflow and QA
3. Understand the issues related to clinical application of Calypso System in prostate treatment
4. Understand the potential use of Calypso System in gated radiotherapy

SA-B-MET-03

Clinical Implementation of Image Guided Radiation Therapy Using Cone Beam CT

T Wong[1] *, (1) Swedish Cancer Institute, Seattle, WA

The application of on-board imaging technology in the linear accelerator provides a valuable tool for image guided radiation therapy (IGRT). IGRT aims to reduce treatment uncertainties due to setup error, organ motion and deformation in radiation therapy. In addition to the conventional MV electronic portal imaging system, a kV imaging system can be mounted on the gantry of a linear accelerator to produce planar (computed radiography), motion (fluoroscopy) and volumetric (cone beam CT) images. The integration of the 3D imaging technology with a linear accelerator provides an opportunity to first study, and then implements treatment and correction strategies to improve treatment precision and offers the possibility of improved tumor control and reduces morbidity.

Evolving from our well-established IMRT and seed-based IGRT programs, this lecture will provide an overview of our clinical implementation of CBCT-based IGRT to further improve precision in radiation therapy.

Educational Objectives:
1. Understand the challenge of treatment uncertainties and the rationale of IGRT.
2. Understand the technical aspect of a KV cone-beam CT IGRT system and the patient doses from CBCT.
3. Understand the clinical implementation of CBCT-based IGRT in relation to clinical objective, margin design, correction strategy and action level.

Research sponsored by Elekta Corporation

Mammography Symposium Room: Congress
Physics Testing for Mammography Systems

SA-C-CONG-01

QC/Physics Testing of the Different Digital

M Martin[1], (1) Therapy Physics, Inc., Bellflower, CA

The requirements for Medical Physics testing of Full Field Digital Mammography (FFDM) Units is currently covered by the Mammography Quality Standards Act as administered by the FDA and recognized accrediting bodies. Some tests are uniform for all manufacturers while several of the units have specific tests for each particular manufacturer with limits specific to that model. These uniform and specific tests of the major manufacturers of FFDM units will be covered in detail in this presentation. Limits as established by each manufacturer and accepted by the FDA and the accrediting bodies will be discussed for each unit. The actual number of tests required for the medical physicists and the Quality Assurance Program that must be followed by the technologists are unique for each brand and type of equipment. Both Direct FFDM and CR FFDM units will be covered in this discussion.

The recommended frequency of testing and specific requirements as established by each vendor will be discussed with suggested methods to be used for each of the required tests. Sample reports for each unit will be shown along with the required summary pages that must be used to report the physicists test results. Expected results for image quality and mid-glandular dose will be given and discussed relative to each type of FFDM unit.

Educational Objectives:
1. Attendees will be aware of the image quality requirements for each of the FFDM units that are currently in use in the United States.
2. Attendees will be aware of the patient mid-glandular dose limits for FFDM units.
3. Attendees will be familiar with the required physicists tests and methods to perform these for each type of FFDM unit.

SA-C-CONG-02

MQSA Inspections: How to Prepare Your Facility

M Odlaug, M.S., M.P.H., Washington State Department of Health, Olympia, WA

A description is given of the conduct of a Mammography Quality Standards Act (MQSA) inspection by a state representative, as well as the requirements of training as an MQSA Inspector by the Food and Drug Administration (FDA). The topics covered during the inspection include radiologist, technologist and medical physicist qualifications, the medical audit requirement, the annual physics evaluation by physicists, as well as quality assurance tests, both digital and analog. Suggestions are given to help medical physicists serve their facilities better and increase their compliance with MQSA standards. In addition, information is provided in this presentation from FDA regarding printer and monitor Quality Control, medical physicists' responsibilities about laser printer mammography equipment, and pending inspection citations for failing phantom score for FFDM (full field digital mammographic) systems and patient doses above 300 mrad.

Therapy Symposium Room: Metropole
Cyberknife

SA-C-MET-01

Hypofractionated SBRT for Prostate Cancer Using the CyberKnife: Techniques and Clinical Outcomes

M-E Masterson McGary,

No abstract submitted

SA-C-MET-02

Stereotactic Body Radiotherapy for Lung Lesions Using the CyberKnife: State-Of-The-Art and New Innovations

C Lee, CyberKnife Centers of San Diego, San Diego, CA

The CyberKnife (Accuray, Sunnyvale, CA USA) consists of a compact linear accelerator mounted on a robotic arm capable of movement using six degrees of freedom, orthogonal diagnostic X-ray cameras and a couch capable of movement in three translational directions and two or three rotational directions. The adoption of this system for stereotactic radiosurgery (SRS) and stereotactic body radiotherapy (SBRT) has been rapid, especially in the treatment of early-stage and recurrent lung cancers. For these tumors, the unique non-isocentric delivery system for the 6 MV radiation has been coupled with a real-time updating system for breathing motion called Synchrony. Synchrony creates a correspondence model between the three-dimensional position of implanted gold fiducials, obtained using static, orthogonal X-ray images, and the real-time three-dimensional position of light emitting diodes on the patient's chest. This model, which is updated every 10-30 seconds throughout treatment, and the non-isocentric nature of the robotic delivery system allow continuous radiation delivery with breathing correction without sacrificing millimeter targeting accuracy. An overview of the CyberKnife system with particular emphasis on the operation of the Synchrony subsystem will be provided.

The rapidly changing area of SBRT now includes multiple prescription dose levels and fractionation schemes. This presentation will provide a summary of most common dose schemes, as well as newer schemes that may provide an alternative to complex clinical situations. Complicating the discussion of lung SBRT is tissue heterogeneity and how the treatment planning system accounts for the loss of electron equilibrium. The CyberKnife system has recently implemented a Monte Carlo dose computation method, and a brief overview will be provided.

The Synchrony system has recently evolved to permit tracking of certain lung tumors without the need to implant fiducials. For patients who meet the acceptance criteria for this approach (called Xsight Lung tracking), treatments may begin without delays for fiducial implantation and the risk of

pneumothorax is eliminated. The number of patients for whom Xsight Lung is a viable option is still uncertain, but may be as high as 50% (depending on tumor size and location). This lecture will provide a description of the Xsight Lung treatment method, including acceptance and rejection criteria.

Educational Objectives:
1. Understand the method for tracking of tumors the move with motion using the CyberKnife.
2. Understand the prescription doses and critical organ restrictions for SBRT of lung tumors.
3. Understand the acceptance and rejection criteria for CyberKnife lung tumor treatment without the use of fiducials.

Mammography Symposium Room: Congress
Mammography Technologies on the Horizon

SA-D-CONG-01
Advanced Applications of Digital Mammography: Breast Tomosynthesis
A Smith[1] *, (1) Hologic, Inc., Bedford, MA

Superimposed parenchyma can adversely affect the visibility of objects in both standard analog and digital mammography. This is due to the 2D nature of the imaging technology. Digital breast tomosynthesis is an emerging technology, not yet FDA approved, that offers the potential to improve the clinical performance of mammography. Early indications are that it will increase the true positive and decrease the false positive rates in mammography through the use of 3D imaging.

Some additional advantages of breast tomosynthesis are that it uses systems similar to existing digital mammography systems, generates images of comparable resolution to mammography, and requires no additional patient radiation exposure compared to conventional mammography.

In this talk, we shall cover the theory of tomosynthesis and its clinical rationale and projected use. Examples will be given showing the advantage of 3D imaging over 2D for breast mammography. Finally, we shall review the recent clinical results showing the performance of tomosynthesis.

Educational Objectives:
1. Understand the clinical reasons for breast tomosynthesis
2. Understand the methods of data acquisition, reconstruction, and display of breast tomosynthesis systems
3. Understand the clinical trial results of breast tomosynthesis

Disclosure: Andy Smith is an employee of Hologic, Inc.

SA-D-CONG-02
Opportunities and Innovations in Digital Mammography
J Sandrik*, (1) GE Healthcare

Mammography is recognized as a highly effective means of screening for and diagnosing breast cancer. But many opportunities remain for improving these processes and patient outcomes as well. Innovations that are expected to provide solutions to some of the problems in breast imaging have been facilitated by the introduction of digital mammography. Imaging of the dense breast has been improved by wide dynamic range detectors and automatic exposure schemes that optimize the image quality for a given patient dose. Image processing helps improve the conspicuity of abnormalities. Tomographic methods remove the overlapping of structures that may either obscure a lesion or mimic one. Time- and energy-difference imaging combined with contrast enhancement facilitate the detection and characterization of lesions. Multi-modality imaging may also contribute to the ability to differentiate between benign and malignant lesions. The presentation will focus on some of the modifications of mammography system components and system operation that have been made to take full advantage of the capabilities provided by the advent of digital mammography. It will also demonstrate imaging methods made practical by digital imaging that are expected to affect the detection, diagnosis, and treatment of breast cancer.

Educational Objectives:
1. Identify opportunities for improvement in breast imaging.
2. Demonstrate how digital systems are designed to provide solutions to breast imaging problems.
3. Discuss projects in development to provide new means to improve the screening and diagnosis of breast cancer.

Conflict of Interest Statement:

John Sandrik is an employee of GE Healthcare which manufactures and sells mammographic imaging equipment.

Therapy Symposium Room: Metropole
Tomotherapy

SA-D-MET-01
Dose Calculation and Verification for Tomotherapy
J Gibbons[1, 2] *, (1) Mary Bird Perkins Cancer Center, Baton Rouge, LA (2) Louisiana State University, Baton Rouge, LA

Helical tomotherapy IMRT technology has been implemented in the Hi-Art System developed by TomoTherapy, Inc. The Hi-Art system uses a linear accelerator mounted on a rotating CT gantry and a fan beam of 6 MV photons to deliver radiation along a helical path, obtained by continuous concurrent gantry rotation and couch/patient travel. Beam delivery during rotation of the gantry is subdivided into 51 distinct gantry segments of approximately 7º each. For each of these 51 projections, the beam intensity is modulated with a 64-leaf binary multileaf collimator (MLC), resulting in 3,264 possible beamlets for each helical rotation. The optimum MLC sequence is created using inverse treatment planning with a gradient search algorithm. Compared to conventional and other IMRT techniques, this greater number of degrees of freedom can potentially produce superior dose distributions, e.g. more uniform dose to the target and lower doses to normal tissues.

The treatment planning system utilizes a convolution/superposition algorithm to compute the delivered dose from the Hi-Art system. Users have the ability to select delivery parameters including jaw width, pitch and the degree of modulation (modulation factor) prior to plan optimization. Optimization may be performed utilizing different calculation techniques which may change the time for plan completion. Dose calculation is also affected by the choice of planning CT size and resolution, as well as the selected dose grid size.

Due to the increased complexity of TomoTherapy plans, well-designed quality assurance (QA) tests are needed to validate treatment plans for individual patients. In addition to phantom plan QA measurements, a technique has been for independently calculating dose to a point in a helical TomoTherapy treatment plan. This technique utilizes the planned treatment sinogram, along with dosimetry functions commonly used in standard MU calculations, obtained from gantry-static TomoTherapy beams. A comparison of this technique with phantom and patient treatment plans will be shown in this talk.

Research sponsored in part by TomoTherapy, Inc.

Educational Objectives:
1. To understand the principles of helical tomotherapy
2. To get an overview of the calculation technique employed by the Hi-Art treatment planning system
3. To understand the effect of different user-selectable parameters on the treatment plan optimization process
4. To understand the calculation technique used in an independent dose calculation technique for helical tomotherapy

SA-D-MET-02
Quality Assurance of MVCT Imaging
K Langen[1] * (1) M.D. Anderson Cancer Center Orlando

The TomoTherapy system (TomoTherapy, Inc., Madison, WI) is designed to deliver intensity modulated radiation therapy using a helical tomotherapy approach. In addition, megavoltage computed tomography (MVCT) images can be acquired with the system. MVCT images can be used to check the positioning of the patient prior to treatment. The acquired MVCT image is registered with planning CT to determine if corrections to the patient position are required.

Upon acceptance the registration accuracy and precision should be evaluated. Phantom-based test are well suited for these tests. In addition the precision of registering clinical images should be evaluated. Standard phantom test can be used to monitor the image quality of MVCT images. The image noise,

Hounsfield unit (HU) consistency, image uniformity, and resolution can be tested. In addition the imaging dose should be monitored on a routine basis.

A daily and monthly QA procedure can be implemented to monitor the consistency of all relevant procedures. On a daily basis a phantom-based test patient can be scanned to test the consistency of the image registration. This image can also be inspected for gross image artifacts. On a monthly basis a scan of a modular phantom can be used to monitor image noise, Hounsfield units, image uniformity and resolution. The imaging dose can be measured simultaneously.

MVCT images are suitable for accurate dose recalculations. This requires the acquisition of a MVCT HU to electron density calibration curve. The accuracy of this calibration should be tested using an inhomogeneous rigid phantom.

Educational Objectives:
1. Identify tests to measure relevant QA parameters
2. Understand the difference between the inherent system and clinical accuracy and precision
3. Identify and implement test procedure for routine monitoring of relevant QA parameters

Conflict of interest: Research agreement with TomoTherapy, Inc.

SA-D-MET-03

Toolkits Developed for Tomotherapy Quality Assurance

C Shi[1] *, N Papanikolaou[1], (1) MC 7889/Radiation Oncology, Cancer Thearpy and Research Center, San Antonio, TX

Helical tomotherapy (HT) has been designed uniquely for intensity modulated radiation therapy (IMRT) with image guided radiation therapy (IGRT) ability. The special design of HT makes the quality assurance (QA) procedures even more challenge. Current existing QA protocols have to be adjusted to fit the need of new QA requirement. New procedures are also under development to fit the need of the special design. There is also need for toolkit development to assist the whole QA process.

Based on the hardware design and software requirement, several QA toolkits have been developed in the past three years to assist the QA process. Matlab programs and excel tools have been developed and used for tomotherapy daily, monthly, and annually QA. The following QA toolkits have been developed: ToPinnacle, TomoBin, TomoAnnual, Tomo-XML-DOM and several excel tools. The toolkits have been implemented in our clinical for the past three years. It has been demonstrated for usefulness and efficiency. Several potential machine mis-calibration and faults have been detected by the toolkits. Clinical problems have been solved by using those toolkits.

In this lecture, we will report the toolkits for the QA of HT unit. Existing QA procedures will also be reviewed.

Education objectives:Understanding the current status of HT QA

1. Understanding the issues related to the HT QA
2. Understanding the need for HT QA toolkits

Joint Symposium — Room: Metropole
Therapy Shielding

SU-A-MET-01
Therapy Shielding
M Martin1, (1) Therapy Physics, Inc., Bellflower, CA

The application of the structural shielding design techniques and goals as outlined in NCRP Report 147: Structural Shielding Design for Medical X-ray Imaging Facilities (November 2004) and NCRP Report 151: Structural Shielding Design and Evaluation for Megavoltage X- and Gamma-Ray Radiotherapy Facilities will be the basis for this practical course. Actual facility designs will be used as the example calculations of required shielding for Multi-Slice CT Simulators and Linear Accelerators to be installed in modern radiation therapy facilities. Examples of methods to minimize the amount of additional shielding needed for new departments due to well planned designs will be given.

As the equipment in radiation oncology departments has changed to CT simulators and linear accelerators with respiratory gating and IMRT as state of the art modalities, the requirements for adequate radiation shielding for these modalities has become more rigorous. Architectural designs no longer depend on standard maze design rectangular rooms. Innovative layouts and utilization of multiple layers of shielding materials allow much greater flexibility in room designs. Shielding calculations for these challenging designs will be covered in this presentation.

Educational Objectives:
1. Understand the workload and occupancy factors to be used for multi-slice CT scanners and dual energy linear accelerators with IMRT capability to determine required structural shielding to meet exposure limits for occupational personnel and the public.
2. Understand the effectiveness of existing and additional structural shielding materials to provide radiation protection and methods to calculate the required amounts of these materials.
3. Understand the calculation methods to be used in performing the shielding calculations of CT scanner and linear accelerator installations to insure adequate shielding is provided to meet applicable state and ALARA requirements.

Professional Symposium — Room: Congress
MOC Update

SU-B-CONG-01
Maintenance of Certification and the Role of CAMPEP
S Goetsch[1] *, (1) San Diego Medical Physics, Inc., La Jolla, CA

The Commission on Accreditation of Medical Physics Educational Programs evaluates and accredits Medical Physics Continuing Education Credits (MPCEC) in the radiological physics area. This has become critically important to many medical physicists since all medical physicists certified by the American Board of Radiology after 2002 are now required to participate in the Maintenance of Certification program. This program lasts 10 years and requires Diplomates to achieve specified goals in four component areas: Professional Standing (including licensure if appropriate), Lifelong Learning and Self-Assessment, Cognitive Experience and Practice Quality Improvement. These four component areas include six competencies: Medical Knowledge, Patient Care, Interpersonal and Communication Skills, Professionalism, Practice-based Learning and Improvement and Systems-based Practice.

On a practical level, each candidate is required to earn 250 MPCEC credits over the 10 year cycle, some of which may be Self-Directed Educational Projects (SDEP) of 15 credits each. CAMPEP will evaluate and award credits for meetings, seminars and online programs. Each Diplomate must also complete twenty Self-Assessment Modules (SAMS) over the 10 year period. SAMS credits are available from this ACMP meeting, AAPM meetings and other meetings to be designated. Seven SAMS modules were available online at AAPM but were temporarily discontinued. These will be available only if an AAPM member activates the optional Remote Directed Continuing Education (RDCE) utility.

The Cognitive Experience portion of MOC is demonstrated through taking one examination during year 8, 9 or 10. This exam is not available yet. Every Diplomate is expected to take part in Practice Quality Improvement throughout the 10 year cycle. Examples of PQI projects are available at the ABR web page.

It is the responsibility of each Diplomate to create their own username and profile at the ABR web page, and to maintain their MPCEC credits at the CME Gateway portal. Users may create their own username and password, log in and make sure that all credits have been correctly awarded.

Educational Objectives:
1. Understand the ABR Maintenance of Certification program.
2. Understand CAMPEP's role in MOC.
3. Begin to construct your own individual 10 year MOC program.

SU-B-CONG-02
The ABR MOC Part IV: Practice Quality Improvement (PQI)
S Thomas* (1) Associate Executive Director – Radiologic Physics, The American Board of Radiology

The overriding objective of Maintenance of Certification (MOC) is to improve the quality of health care through diplomate-initiated learning and quality improvement. There is a national imperative to measure what all medical professionals do, including radiologic physicists, as their practices impact patient outcomes. The MOC initiatives being implemented by the American Board of Radiology (ABR) as well as by all 23 other member boards of the American Board of Medical Specialties (ABMS), have arisen in part as a response to public concerns regarding the quality of medical care, medical errors and patient safety within the health care system of the United States. The fourth component of MOC is the focus of this presentation; namely, Part IV: Evaluation of Performance in Practice. Through this program, medical physicists demonstrate a commitment to practice quality improvement (PQI). The first year's activity involves documented education in the processes and procedures of quality improvement as they affect an individual's practice. Opportunities for obtaining this training as will be reviewed include among others: On-line courses from societies or commercial vendors; society-sponsored CME offerings, self- assessment modules (SAMs) on quality improvement. Diplomates must select a project in PQI to be completed over the 10-year cycle that has the potential for improving the quality of the individual or systems practice and enhancing the quality of care. PQI projects may be chosen from five categories: (1) Safety for patients, employees, and the public, (2) accuracy of analyses and calculations, (3) report turnaround time and communication issues, (4) practice guidelines and technical standards, (5) surveys (including peer review of self-assessment reports). For the project selected, the steps involved are: (1) Collect baseline data relevant to the chosen project, (2) review and analyze the data, (3) create and implement an improvement plan, (4) remeasure and track, and (5) report participation to the ABR. Specific examples of individual PQI projects for each of the three disciplines of radiologic physics will be presented.

SU-B-CONG-03
The Role of Task Group 127 in Maintenance of Certification
M Taylor[1] *, (1) Computerized Medical Systems, Inc., Saint Louis, MO

Unlike most Task Groups within the AAPM that establish and publish technical or procedural guidelines, Task Group 127 (TG127) was initiated to address the needs of AAPM members undertaking Maintenance of Certification (MOC) as required by the American Board of Radiology (ABR) and the American Board of Medical Specialties (ABMS). TG 127 serves as a resource to the ABR Physics Trustees and AAPM members. In an advisory role to the Physics Trustees, TG 127 provides information and suggestions on activities that meet MOC requirements. Additionally, TG 127 is aggressively developing activities within the AAPM structure to assist AAPM members in meeting the MOC requirements. The membership of TG 127 represents all disciplines of Medical Physics and includes both voluntary and involuntary MOC participants. Many of the recently implemented changes to the ABR's MOC requirements have originated from the AAPM membership, and AAPM

members are encouraged to contact TG 127 to address any concerns or provide suggestions for improvements.

SU-B-CONG-04

Panel Discussion

S Goetsch - San Diego Medical Physics, Inc., La Jolla, CA
M Taylor - Computerized Medical Systems, Inc., St. Louis, MO
S Thomas - Univ Cincinnati Medical Center, Cincinnati, OH

Professional Symposium — Room: Metropole

ABR Examination Update

SU-B-MET-01

ABR Update

G Ibbott[1] *, (1) Radiological Physics Center, Houston, TX

The American Board of Radiology (ABR) is one of 24 member boards of the American Board of Medical Specialties (ABMS). The ABR is governed by a Board of Trustees that includes three physicists. The ABR certifies medical physicists in three specialties: therapeutic radiologic physics, diagnostic radiologic physics, and medical nuclear physics. Each year, about 300 physicists begin the certification process by taking the Part 1 written exams, and about 200 take the oral exams. The training pathway taken by medical physicists has changed over the years, and today, most applicants for certification have completed a graduate program in medical physics and many have obtained clinical experience in a structured residency program. The ABR has implemented changes to the requirements for certification to reflect these changes. Recognition is given by the ABR to applicants for certification who have completed accredited training programs. Additional changes are on the horizon as more emphasis is placed on assessing the quality of training and residency programs. The decisions to implement these changes are supported by statistical data collected by the ABR over many years.

This presentation will review the current and proposed future requirements for admission to the exam, the exam process, and some statistics describing the results of examination.

Objectives:
1. Acquaint the attendee with the ABR and its relationship to other certification organizations.
2. Familiarize the attendee with the requirements for application to the exam process.
3. Describe recent and future proposed changes to the requirements.
4. Explain the different exams and their purposes.
5. Describe some statistics collected by the ABR.

Professional Symposium — Room: Metropole

Prof. Physics Education, Licensure Issues

SU-C-MET-01

Abt Study Round III

M Mills[1] *, (1) James Graham Brown Cancer Center, Louisville, KY

The *Abt study of medical physicist work values for radiation oncology physics services, Round III* is completed and is scheduled for publication in May of 2008. It supersedes the Abt II study of 2003. The 2008 Abt study measured qualified medical physicist (QMP) work associated with routine radiation oncology procedures as well as some special procedures. In the intervening years between Abt II and Abt III, medical physics practice has changed. Image-guided radiation therapy and image-guided stereotactic radiosurgery along with respiratory gating are emerging radiation oncology technologies. High dose rate afterloading brachytherapy is an important special procedure with a significant component of medical physicist work. These procedures lead to the request for an updated work and staffing study for qualified medical physicists. As before, a work model was created to allow the medical physicist to defend QMP work based on both routine and special procedures service mix. The work model can be used to develop a cost justification report for setting charges for radiation oncology physics services. Additionally, staffing patterns were surveyed and reported for a variety of practice settings. The work and cost justification models may in turn be used to defend medical physicist staffing and compensation. The Abt study round III was designed to empower the medical physicist to negotiate a service or employment contract with providers based on measured national QMP work force and staffing data.

Objectives:
1. Understand the information documented in the Abt studies.
2. Understand what new information was provided in the Abt III study.
3. Understand how to use the Abt studies to justify medical physicist work and staffing

SU-C-MET-02

Medical Physics Licensure Update

J Limmer[1] *, (1) UW Cancer Center, Wausau, WI

To ensure that qualified individuals perform the job of clinical Medical Physics as outlined in the AAPM/ACMP Scope of practice. This is seen as important with or without the passage of the CARE Bill. The existence of the CARE Bill gives us the impetus to do this work. If we do not help the legislators define who is qualified to do our jobs, someone else will.

In this session the activities of the Joint Medical Physics Licensure Subcommittee will be discussed. Topics will range from the rationale for the effort, the new full time position at HQ to help with the effort, what has been accomplished, and future goals and plans.

Educational Objectives:
1. Be exposed to the rationale behind the effort for professional licensure
2. Understand what has been accomplished related to this effort
3. Hear what the near and long term goals are for the effort

SU-C-MET-03

Draft Report of TG-109: Code of Ethics

C Serago[1] *, (1) Mayo Clinic, Jacksonville, FL

AAPM TG-109 is nearing completion of writing a comprehensive Code of Ethics for the members of the AAPM. This new code of ethics will consolidate previous AAPM ethics policies into a single document, and expand the scope of ethical issues considered. Existing AAPM ethics policies are intended primarily for medical physicists. The new code of ethics will also encompass other member types such as health physicists, regulators, vendors, physicians, scientists, engineers, those in training, or other health care professionals. Other issues not specifically addressed in current policies are research, education, or business ethics. The Ethics Guidelines of this new Code of Ethics have four major sections: professional conduct, research ethics, education ethics, and business ethics. This Code of Ethics replaces the following AAPM policies: Ethical Guidelines for Vacating a Position (PP 4-B); Ethical Guidelines for Reviewing the Work of Another Physicist (PP 5-C); Guidelines for Ethical Practice for Medical Physicists (PP 8-D); and Ethics Complaint Procedure (PP 21-A).

Joint Symposium — Room: Metropole

NRC and Agreement State Requirements for Licensing

SU-D-MET-01

A Broad Regulatory Update

L Fairobent[1] *, (1) AAPM, College Park, MD, (2) AAPM, College Park, MD

There are many changes to the regulations affecting medical physicists. During this presentation, the changes regarding fingerprinting, granting unescorted access to category 1 and 2 material, current status of 10 CFR Part 35 and board recognition will be discussed. In addition, the current status and impact of the CARE legislation will be discussed. Finally the joint AAPM/ACMP grassroots initiative will be discussed and the importance of member participation in this activity will be presented.

Diagnostic Symposium — Room: Congress
CT and CR-DR

MO-A-CONG-01
MDCT Technology and Image Quality
K Kanal[1] *, (1) Univ Washington, Seattle, WA

In the last decade, computed tomography technology has progressed significantly. Multi-detector row CT (MDCT) scanners are becoming commonly available and are fast replacing single detector row CT (SDCT) scanners. Some of the advantages of MDCT over SDCT include faster acquisition speeds, isotropic resolution, improved 3D images and potential decrease in radiation dose. More and more exams are being done with CT now than ever before. MDCT is also being used in many instances as a screening tool.

MDCT has given rise to several new applications some of which are becoming increasingly popular such as cardiac CT. With MDCT, it is now possible to scan the heart in fine detail with short scan times. There are various ways in which the exam can be conducted either to get functional information or anatomical information which have tradeoffs with radiation dose

This lecture will review the history of CT, multi-detector technology, its advantages and disadvantages, overview of automatic tube current modulation as well as some aspects of cardiac CT application.

Educational Objectives:
1. Understand the physics of MDCT technology
2. Appreciate the advantages and disadvantages of MDCT
3. Understand how automatic tube current modulation works
4. Comprehend how CT is used for cardiac scanning
5. Recognize the advantages and disadvantages of cardiac CT

MO-A-CONG-02
Acceptance Testing and Quality Control of Digital Imaging Units
D Pfeiffer[1] *, (1) Boulder Community Hospital, Boulder, CO

As digital imaging becomes more common in both clinic and hospital settings, establishment of an appropriate quality assurance program is becoming increasingly important. Three primary aspects of digital imaging quality assurance will be discussed. Due to the highly technical nature of computed radiography and direct digital radiography systems, comprehensive acceptance testing is essential. Beyond verifying appropriate performance, commissioning will also establish baseline values for future physicist and technologist level testing and will provide information needed for other technologist quality assurance efforts. Regular quality control testing efforts will be shared between physicists and technologists. Part of the physicist's job will be to educate the technologists regarding the increased quality control efforts indicated for digital imaging systems. Finally, a possibility of greatly increased patient dose exists with digital systems, since, over a very large range, image quality improves with increased dose. Therefore, an essential aspect of a quality control program is constant review of image exposure indexes. On some systems, getting such an index can be problematic. The American Association of Physicists in Medicine (AAPM) currently has two task groups working on these areas. Task Group 150 is charged with developing a set of tests to be used in the acceptance testing and quality control of digital radiographic imaging systems. Task Group 150 is charged with developing consistency tests designed to be performed by a Medical Physicist or a generally supervised Radiologic Technologist to identify problems with an imaging system needing further evaluation by a Medical Physicist, including development of a fault action tree. The current status and plans of these task groups will be presented.

Therapy Symposium — Room: Metropole
Radiosurgery

MO-A-MET-01
Cyberknife: Treatment Planning, QA, and Clinical Applications
D Shepard*, C Cotrutz , Swedish Cancer Institute, Seattle, WA

The CyberKnife is a radiosurgery delivery system that uses an x-band linear accelerator mounted on a computer-controlled robotic arm. The robotic arm has 6-degrees of freedom and is used to sequentially deliver pencil beams of radiation as it moves around patient. The CyberKnife provides a frameless approach to both intracranial and extracranial radiosurgery. Real time image-guidance is accomplished using 2 kilovoltage imagers. During delivery, the patient position is monitored and the delivery is modified to correct for patient movement.

Orthogonal kilvoltage (kV) x-ray sources are mounted to the ceiling and directed at amorphous silicon detectors on both sides of the table. Kilovoltage images are obtained before and during the treatment to monitor the alignment of the patient. The CyberKnife delivers radiation at a discrete set of linac positions (called nodes). A typical treatment plan uses approximately 40-50 nodes (short path) or 60-75 nodes (full path). The nodes are distributed approximately uniformly over about one half of a sphere centered on the treatment site. This presentation will provide an overview of CyberKnife radiosurgery.

The educational objectives include:
1. Understand the physics of CyberKnife radiosurgery.
2. Understand the steps in CyberKnife treatment planning.
3. Understand the CyberKnife tumor tracking techniques
4. Understand the quality assurance requirements for the CyberKnife

MO-A-MET-02
Quality Assurance, Planning and Clinical Results for Gamma Knife Radiosurgery
S Goetsch[1] *, (1) San Diego Medical Physics, Inc., La Jolla, CA

The Leksell Gamma Knife was created in 1968 as a dedicated intracranial stereotactic radiosurgery device. By the mid 1980's linear accelerators had been modified to also perform this important function. Gamma Knife radiosurgery is extremely well accepted with nearly 400,000 treatments at more than 250 centers worldwide reported by December, 2006. Gamma Knife radiosurgery is recognized by hospitals in the United States as a form of surgery and as such must be treated with abundant caution. Successful radiosurgery requires a highly trained and disciplined team of surgeons, radiation oncologists, medical physicists, nurse and other medical personnel.

The AAPM Report 54 published in 1995 made specific recommendations for Quality Assurance of the Leksell Gamma Knife Model U. This device was rapidly succeeded by the Model B, Model 4C with Automatic Positioning System (2000) and the Perfexion (2007). Each of the new models features more motorized precision placement of the intracranial target under computer controlled. Thus, a whole new set of QA challenges faces the medical physicist and treatment staff.

Rigorous acceptance testing of a new Gamma Knife is mandatory, followed by a detailed characterization of all imaging equipment to be used in treatment planning. Small field dosimetry and characterization of beam profiles by a Qualified Medical Physicist is also necessary before treatments can begin. Remote dosimetry of both absorbed dose and beam profiles is highly recommended. It is important to attempt to analyze all systematic errors in the entire end-to-end process to establish limitations on treatment accuracy. Treatment of trigeminal neuralgia, which requires treatment of a nerve only 3mm in diameter with a beam only 4mm in diameter, is an ultimate test for Gamma Knife radiosurgery.

New gamma stereotactic radiosurgery units including the Gamma Knife Perfexion and the American Radiosurgery GammaART 6000 feature moving cobalt-60 radiation sources. These poses a difficult challenge for regulatory officials who must evaluate and safely license such devices, often without ever seeing them in operation. The U.S. Nuclear Regulatory Commission placed the Gamma Knife Perfexion in Part 35.1000 "Other medical uses of byproduct material" rather than 35.600, which specifically includes "gamma stereotactic radiosurgery". The NRC Advisory Committee on the Medical Use of Isotopes (ACMUI), with input from AAPM Task Group 172 is seeking to rewrite part 35.600 to be more inclusive and less prescriptive, enabling all gamma stereotactic radiosurgery units to fit within this section.

New protocols and recommendations need to be written to include the new motorized, computer controlled units which did not exist in 1995. Great care must be taken to ensure rigorous QA standards are created and maintained.

Educational Objectives:
1. Learn challenges of Gamma Knife radiosurgery
2. Important points to remember when beginning a new program
3. Challenges of new Gamma Knife Perfexion and rotating gamma units

MO-A-MET-03

SRS/SBRT Planning, QA and Clinical Applications On Linacs On Everything That's Not a CyberKnife Or GammaKnife

T Solberg[1] *, (1) University of Texas Southwestern Medical Center, Dallas, TX

Stereotactic radiosurgery has become the standard of care in the treatment of many cranial neoplasms. This success has stimulated significant interest in the application of such an approach for the treatment of extracranial tumors. With the development of image guidance technologies, there is a possibility that rigid-head fixation can be eliminated; image guidance is also accelerating the clinical implementation of the approach in extracranial sites. An essential prerequisite of “frameless” stereotactic systems is that they provide localization accuracy consistent with the safe delivery of a therapeutic dose of radiation given in one or few fractions. In this presentation we will review linac-based SRS/SBRT technologies for technologies with particular emphasis on the quality assurance aspects associated frame-based and frameless localization with establishing and maintaining a clinical program

Educational Objectives:
1. Understand localization principles for linac based radiosurgery
2. Review quality assurance processes for frame-based and frameless Radiosurgery

Diagnostic Symposium — Room: Congress

CT and MRI

MO-B-CONG-01

Estimating Patient Radiation Dose from Computed

C Cagnon1 *, J DeMarco2 , E Angel3 , M McNitt-Gray4 , (1) UCLA-David Geffen School of Medicine, Los Angeles, CA, (2) UCLA-David Geffen School of Medicine, Los Angeles, CA, (3) UCLA-Biomedical Physics, Los Angeles, CA, (4) UCLA-David Geffen School of Medicine, Los Angeles, CA

Continuing advances in CT technology coincide with increasing utilization of CT as a diagnostic tool. As a result, an increasing majority of the population’s exposure to diagnostic radiation results from CT examinations. Concerns about the increased associated stochastic risk from CT dose and changes in CT technology such as the advent of multi-detector CT and helical scanning has motivated the Medical Physics community to examine and refine their methods of measuring CT dose and assessing a patient’s effective dose and stochastic risk.

Further, concerns over risk and the emerging potential of CT as a screening tool raise the question of how accurately an individual patient’s radiation dose from CT can be estimated from current CT measurement methods using phantoms.

This lecture will review the evolution of dose calculation in CT and how Effective Dose can be estimated from standardized measurements. We will also look at how specific patient and organ doses can be estimated using Monte Carlo methodology that incorporates both the specific technology of the CT scanner and voxelized models of real patients. Finally we will make some comparison of patient specific Monte Carlo dose estimates against phantom based dose estimates.

Educational Objectives:
1. Define and review standard CT dose measurement methodology.
2. Understand current methods for estimating patient dose from CT dose measurements.
3. Learn how Monte Carlo techniques can be used to estimate dose to specific patients and patient organs with scanner and protocol specific modeling tools.

MO-B-CONG-02

Physicist Role in MRI Accreditation Program Submissions

C Keener[1] * (1) Medical & Radiation Physics, Inc., San Antonio, TX

In recent years, the American College of Radiology (ACR) Magnetic Resonance Accreditation Program (MRAP) has been adopted by close to 4000 site, with a large increase in the past year due to reimbursement changes. Those sites agree to follow a weekly QC program set up and monitored by a qualified medical physicist or MR scientist. They also agree to undergo initial and annual equipment performance evaluations by a qualified medical physicist/MR scientist. There are several published documents, including the *ACR Phantom Testing Guidance* and the *2004 ACR MRI QC Manual*, which describe the tests and the performance criteria. With the current rush for accreditation, the physicist may be asked to perform a large part of the initial accreditation tests on a very short notice. Many sites may view the physicist as the individual most experienced in the MRAP process.

This lecture will describe the physicist’s role in the MRAP program along with other tasks that may be requested of the physicist by the applicant. Required tests will be described along with potential pitfalls which may be avoided. The submission procession will be described, including deadlines, phantom tests, and electronic submissions.

Educational Objectives:
1. Learn the current status of the ACR MRAP program and the role of the medical physicist in that program.
2. Understand how to perform required phantom tests on various scanners and the performance criteria and pitfalls for those tests.
3. Understand how to successfully prepare site phantom data (paper, electronic, and film) for successful MRAP submission.
4. At the end of this lecture, the participant will be able to assess which part of the MRAP process he/she is willing to perform and which parts should be deferred to others.

Therapy Symposium — Room: Metropole

Proton Therapy

MO-B-MET-01

Opening Comments and Uniform Beam Scanning Systems: Clinical Commissioning of a Therapeutic Uniform Proton Beam Scanning System with Multi-element Detectors

J Farr[1] *, A Mascia[1], C Allgower[1], W Hsi[1] , F Jesseph[1] , D Nichiporov[2] , V Anferov[2] , (1) Midwest Proton Radiotherapy Institute, Bloomington, IN, (2) Indiana University Cyclotron Facility, Bloomington, IN

Purpose: A proton beam delivery system on a gantry with uniform scanning and dose layer stacking at the Midwest Proton Radiotherapy Institute has been commissioned and accepted for clinical use. This presentation reports on the main characteristics of dose fields produced by the system including transverse, longitudinal, penumbra and absolute dosimetry commissioning results. **Methods and Materials:** Using a 208 MeV cyclotron's proton beam, the system provides field sizes up to 20 cm and 30 cm in diameter for proton ranges in water up to 27 cm and 20 cm, respectively. The dose layer stacking method allows for the flexible construction of spread-out Bragg peaks with uniform modulation of up to 15 cm in water, at typical dose rates 1 - 3 Gy/min.

For relative field characterization, multi-element ion chamber arrays, small-volume ion chambers, and radiographic films were employed. Absolute dose measurements were done using calibrated ion chambers, thermoluminescent and alanine detectors.

Results and Discussion: Clinical commissioning of the system has shown that the lateral and longitudinal uniformity of ± 2.5\% or better can be achieved for all clinically important field sizes and ranges. Transverse penumbra measurement results compare favorably with those achieved with a double scattering beam spreading technique. Dose intercomparisons conducted using various types of detectors traceable to a national standards laboratory indicate that dosimetry results agree within 3\%. **Conclusions:** The uniform scanning and dose layer stacking system, the first of its kind in the Western Hemisphere, has been put into clinical practice. Practically the developed system provides a useful 1-2.5 cm increase in water range at the facility. It also allows fields up to 30 cm diameter to be treated. This may be

advantageous in reducing the number of matched fields required for large or long fields. Another advantage of the system is the flexible software and hardware scanning field delivery. For multiple treatment rooms having common beam entrance properties it may be possible to reduce commissioning time in comparison to passive beam spreading systems. In this way the versatility of the system allows one to regard it as an intermediate step toward the implementation of pencil beam scanning.

MO-B-MET-02

A Cyclotron Based Pencil Beam Scanning Delivery System

J Flanz[1] *, (1) Massachusetts General Hospital, Boston, MA

Pencil Beam Scanning encompasses methods of delivering a particle beam with arbitrary position and dose (within the constraints of the delivery system) to a target. A description of some of the various options will be presented along with a discussion of the factors that contribute to the choice of methods, and limitations and/or constraints of various systems. The technical requirements will be reviewed, as well as their effect on some aspects of a clinical beam delivery. To the extent possible, modeling results will be compared with measurement results, indicating actual performances.

The details of the technology used in an accelerator based particle therapy system affect the performance of the dose delivery system for Pencil Beam Scanning. Information from beam current, the time structure of the beam, beam position and size, to the performance of an Ionization chamber and associated electronics will affect the clinical capabilities including the time for a treatment. Knowing which parameters of the system are important in determining the clinical capabilities will help to optimize a system and help to determine the best scanning solution. Differences between continuous scanning and spot scanning will be discussed. Issues of multiple repainting and beam size will also be presented.

Educational Objectives:
1. Understand the beam delivery modality called Pencil Beam Scanning.
2. Understand the types of beam deliveries that are associated with this modality.
3. Review the parameters that determine the performance of a system that uses Pencil Beam Scanning.
4. Understand the impact of the technical systems on the clinical beam that is delivered.

MO-B-MET-03

Intensity Modulated Proton Therapy Delivery System with a Synchrotron

M Bues[1] *, (1) UT MD Anderson Cancer Center: Proton Therapy, Houston, TX

Since its inception in 1946, approximately 49000 patients have been treated worldwide with proton therapy. Of these patients a small number, less than 3%, have been treated using spot scanning techniques. There is, however, mounting evidence that proton therapy will reach its full potential benefit through spot scanning, which offers some distinct advantages over other proton therapy delivery techniques.

We discuss the promises and challenges inherent in the spot scanning technique. We review the approach taken at MD Anderson Cancer, where the proton accelerator is a synchrotron. Topics of discussion include treatment delivery hardware, treatment control systems, treatment planning, and beam measurements.

Educational Objectives:
1. To understand the potential benefits and challenges scanning beam proton therapy and intensity modulated proton therapy offer relative to other modes of proton therapy.
2. To understand various features of proton beam therapy with a scanned proton beam at MD Anderson Cancer Center in Houston.
3. To understand how spot scanning proton therapy with a synchrotron differs from spot scanning proton therapy with other proton accelerators.

MO-B-MET-04

Dielectric Wall Accelerator and Distal Edge Tracking Proton Delivery System

T Mackie[1] *, (1) University of Wisconsin - ADCL, Madison, WI

Purpose: A compact image-guided intensity modulated proton radiotherapy (IMPT) system is being developed based on the dielectric wall accelerator from Lawrence Livermore National Laboratory. The system will be designed to deliver fast IMPT and would be ideal for large and complex target volumes in young patients. **Method and Materials:** The dielectric wall accelerator uses fast switched high voltage transmission lines to generate pulsed electric fields on the inside of a high gradient insulating (HGI) acceleration tube. The system will produce individual pulses that can be individually varied in intensity, energy and spot width. The IMPT planning system will optimize individual delivery characteristics. The system will be capable of being sited in a conventional linac vault and provide intensity modulated rotational therapy. The system will include an in-room CT scanner. **Results:** A prototype is being designed and concept designs of the envelope and environmental needs of the unit are finished. A low energy benchtop prototype unit is in operation at Lawrence Livermore and electron acceleration has been demonstrated. A small scale prototype to accelerate protons is being designed. **Conclusion:** The dielectric wall accelerator based proton radiotherapy system is being designed from the ground up to be capable of image guided intensity modulated proton therapy and to be housed in a conventional linac vault.

Diagnostic Symposium — Room: Congress

Flouroscopy & Accreditation

MO-B-CONG-01

3D Rotational X-Ray - Technology and Application

S Boon[1] *, (1) Philips Healthcare, Bothell, WA

Since the introduction in 1998 of 3D rotational angiography, the concept of using X-ray projection imaging techniques to acquire 3D datasets has gained widespread adoption. The application started for neuro-angiography systems, where 3D has become the standard of care for performing complex interventions. With the introduction of the flat panel detector, the potential for 3D acquisition was enhanced even further. By 2008 the usage of 3D has expanded to a broad range of clinical applications, including peripheral interventional radiology, cardiology, oncology, surgery, orthopedics and gastro-intestinal.

This talk will explain the principles behind 3D acquisition, and give examples of where 3D X-ray imaging provided clinical added value. The associated X-ray dose of these acquisition techniques will be discussed. The talk will close with a brief outlook on what is on the horizon for 3D X-ray.

Educational Objectives:
1. Understand the principles of 3D reconstruction using a large area detector
2. Understand how 3D X-ray relates to CT , and which clinical applications benefit most from this technique
3. Understand the trade offs between dose and image quality for 3D X-ray.

Disclosure: presenter is employee of Philips Healthcare

MO-C-CONG-02

ACR Accreditation

D Hernandez[1] *, (1) American College of Radiology, Reston, VA

The American College of Radiology (ACR) is a membership organization comprised of over 32,000 radiology professions including medical physicists, diagnostic/interventional radiologists, nuclear medicine physicians and radiation oncologists. The primary mission of the ACR is to serve patients and society by advancing the science of radiology, improving the quality of patient care, providing continuing education and conducting research for the future of radiology.

ACR accreditation is a peer review process developed and monitored by experts and an educational process with self-assessment and peer review. During the ACR accreditation process, various aspects of imaging practice are assessed including staff qualifications, policies and procedures, equipment specifications, diagnostic image quality and therapeutic treatment quality.

Diagnostic Modality Accreditation Programs (DMAP) include CT, MR, PET, NM, Ultrasound, Breast Ultrasound, Stereotactic breast biopsy, and MR Cardiac.

ACR accreditation is a team process that involves everyone in the facility. The medical physicist plays a critical role in the accreditation process, along with the lead technologist and supervising physician.

Educational Objectives
1. Understand the basics of the ACR accreditation program
2. Understand the basics of the individual diagnostic modality accreditation programs
    a. CT accreditation
    b. MR accreditation
    c. Nuclear Medicine accreditation
    d. PET accreditation
    e. US accreditation
    f. Breast Ultrasound
3. Understand some of the most common pitfalls in the accreditation process

Therapy Symposium Room: Metropole
Small Field Dosimetry

MO-C-MET-01
Small Field Dosimetry: Monte Carlo Assessment of Perturbation and Correction Factors for Ionization Chamber and Solid State Detectors
S Cora[1] *, P Francescon[2], C Cavedon[3], Vicenza Hospital, IT

In recent years the introduction of novel techniques in radiation treatment such as beamlet based Intensity Modulated Radiation Therapy (IMRT), Image-Guided Radiation Therapy (IGRT), Tomotherapy, Cyberknife and Gamma Knife, has lead to the reduction of the treatment field sizes to a sub-centimeters scale. In particular, Stereotactic Radiosurgery (SRS) rely on very small field sizes on the order of a few millimeters to treat tumours. IMRT is based on the superposition of several beamlets with a very narrow size and pronounced penumbra. The dosimetry of small beams has several issues to take into account: the lack of charge particle equilibrium (CPE), associated with the range of secondary particles that is comparable with these field sizes, the availability of small detectors and the related choice of the most suitable dosimeter, the increased penumbra innarrow beams, the presence of perturbation effects in the dosimeter cavity. The common way of comparing measurements made with several detectors and to take the one which shows the highest output factors or to take the average response among the detectors, does not take into account the possible perturbation and correction factors to be applied to the response of the detectors. The knowledge of these correction factors, as provided by the standard dosimetry protocols, is limited to a certain number of dosimeters, and, above all, doesn't take into account all the perturbation effects of the radiation field in presence of the detectors. Also the method of comparing Monte Carlo simulation with measurements has some drawback: in fact it is not correct to compare simulation in water with the response of the detector. Instead, a direct simulation of the detector together with the simulation of the treatment head should be made. In this way the correct parameters which characterize the source, i.e. the radial distribution and the energy of the electron beam incident on the target, that are not usually known, can be found in a univocal way.

This lecture will provide an overview of the issues related to the small beam dosimetry and the deviation from the standard cavity theory, usually applicable in condition of electronic equilibrium. Furthermore, it will be shown the method used to determine the correction factors necessary for different commercially available dosimeters (2 microchambers, a diode, and a diamond) by using Monte Carlo simulation. In particular, it will be shown the application of the method to the dosimetry of small collimators of the Cyberknife. It will be also shown how this method can be generalized to other dosimeters and different linear accelerators. Finally, a short indication on the problem of small field dosimetry in the presence of low Z inhomogeneities will be given.

Educational Objectives:
1. Understand the issues related to the dosimetry when the electronic equilibrium condition is not achieved.
2. Understand the issues related to the application of Monte Carlo for the determination of correction factors of detectors.
3. Discussion of low z in small fields

MO-C-MET-02
The Need for New Approaches in Dosimetry and Calibration of Small Beams for Radiotherapy
T Mackie[1] *, (1) University of Wisconsin - ADCL, Madison, WI

International Atomic Energy Agency (IAEA) Working Party on Small and Novel Field Dosimetry in Cooperation with the AAPM Therapy Physics Committee

A working party has been formed by the International Atomic Energy Agency (IAEA) with cooperation of the AAPM Therapy Physics Committee to examine the issues of dosimetry of small fields and systems for which careful dosimetry techniques must be applied and which cannot be calibrated according to calibration standards like the IAEA TRS-398 or the AAPM TG-51 calibration protocols. This committee has documented the need for fine resolution when determining the dose in small fields to overcome partial volume effects which can lead to a severe underprediction of dose. There is a need to calibrate commercially available beams which cannot open their field sizes to the required 10 cm x 10 cm as stipulated in official protocols. In addition even those delivery systems which can be calibrated are often utilized, for example for stereotactic radiosurgery or IMRT which is often composed of large numbers of small and irregular fields. This talk will summarize the issues of small field dosimetry and calibration and document the need for a change in approach. It is hoped that the committee can recommend modifications and additions to standard protocols and measurement procedures to improve the dosimetry of small fields.

Young Investigator's Symposium Room: Metropole

MO-D-MET-01
A Phantom-Based Study for Recreating a 4D Dynamic Dose to Account for Organ Motion in Radiotherapy
T Roland[1] *, Y Liu[1] , N Papanikolaou[1] , (1) CTRC at The University of Texas Health Science Center at San Antonio, San Antonio, TX

Purpose: To recreate a 4D dose distribution from the planned dose based on one phase of a 4D-CT image and compare with results from 4D dose reconstructed from multiple phases of the 4D-CT image and phantom measurements. **Materials and Methods:** The transformation assumes a 1-D sinusoidal tumor motion with amplitude (A) in the inferior-superior(y) direction. Let ${}^{3D}D_r(x,y,z)$ be the 3D static dose distribution based on the rth phase and ${}^{4D}D(x,y,z)$ the corresponding 4D dynamic dose distribution. Then assuming phantom symmetry in the tumor direction,

$$ {}^{4D}D_r(x,y,z) = \sum_{i=1}^{N} W_i * {}^{3D}D_r[x,(y + A\sin\theta_i),z] \quad (1) $$

We used ADAC pinnacle TPS to plan on a respiratory motion phantom. Eight plans were developed on 8 phases of the tumor cycle. The optimized dose distribution from one phase was then used in (1) to compute the 4D dose distribution for a planar film assumed to move with the tumor center. A weighted average of all the plans constituted the multi-phase dynamic dose. The plan was delivered on a LINAC and measurements made using EBT Gafchromic film. **Results and Conclusions:** Using gamma index analysis, the number of pixels exceeding a gamma index of 1 was 7% and 0% for the single–phase dose versus the measurement and the reconstructed multi-phase dose respectively (dose difference tolerance-5%, DTA tolerance-5mm, dose gradient threshold-30%/cm). The close agreement shows that with knowledge of the tumor trajectory and by assuming symmetry in the tumor trajectory direction, a 4D dynamic dose distribution can be recreated fairly well based-on a 3D static dose using a single set of CT images.

MO-D-MET-02
Improving the Utility of In-Room Video Camera Systems for Continuous Surveillance of Patient Motion During Radiation Treatment
C Kut *, C Chen , J Wong , R Taylor, Johns Hopkins University, Baltimore, MD

Purpose: To improve the utility of in-room video-based system for continuous quantitative monitoring of patient motion independent of environmental changes in lighting and geometry. **Method and Materials:** A video-based tracking system was developed using a webcam with 600 by 450 pixels and Microsoft Visual C++. It is mounted at the end of the treatment couch to constantly view a specified region on the patient's torso of 50 cm by 30 cm. Small high contrast "sticky" markers are placed within the viewing region for easy detection. Environmental disturbances are minimized through appropriate real-time image subtraction and processing techniques. An alarm is activated when the patient movement is deemed out-of-tolerance. For validation, a lead ball phantom and a flat "sticky" marker of 1 cm diameter were used to determine detectable target displacements. Each tracking session was automatically recorded for further data analysis. **Results:** Target displacements of (2, 2, 5)mm for the lead ball phantom and (4,4,7)mm for the flat phantom are readily detected in the lateral, superior-inferior and vertical directions respectively. Most importantly, the system detects these changes in the presence of environmental disturbances which include large changes in room lighting, and couch and gantry positions. **Conclusion:** Our system provides an effective approach to track and monitor patient position after highly accurate setup, such as using cone-beam CT. It is considerably lower in cost relative to existing commercial tracking systems. With further refinement, the system can be adapted for routine clinical use that is superior to present in-room video-monitoring systems.

MO-D-MET-03

New Generation Portal Sensor Based On Thin-Film Cadmium Telluride for Clinical High Energy X-Ray Imaging

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Purpose: Currently most popular EPIDs are manufactured from hydrogenated amorphous silicon, a material with low atomic number and electron density, exhibiting low quality images and poor radiation hardness. We propose new generation portal imager based on thin-film Cadmium Telluride (CdTe), offering device improvement in both imaging and dosimetric applications. We evaluate material/thickness combinations for the proposed device and estimate its output under typical radiation treatment conditions. **Method and Materials:** Due to very small thickness (in a range of 100 microns) the sensor has to be combined with a metal plate facilitating conversion of high-energy photons to charge carriers directly, maximizing the dose deposited in the sensor layer. We employed Monte Carlo (MC) package MCNP5 to model the image detection procedure under 6MV photon beam of the linear accelerator Eleckta-SL25. Several metals in a broad thickness range were analyzed in conjunction with CdTe to find the optimum combinations. We also evaluated the effect of CdTe layer thickness on frequency-dependent detective quantum efficiency DQE(f) of the device. **Results:** Based on calculations of DQE(f) we proved CdTe-based detector system to have higher performance than those using amorphous silicon or selenium. We established the optimal material/thickness combinations for thin-film CdTe/metal plate detector and found that resultant charge carrier generation leads to the voltage output of 0.2 - 0.3 Volts. We confirmed this voltage output range with our measurements. **Conclusion:** We found the thin-film CdTe-based detector is well suited for imaging with high energy x-rays used in clinical radiation therapy.

MO-D-MET-04

Normalized Bragg Peak Curves for Various Proton Incident Energies in Water Phantom: A Simulation with GEANT4 Monte Carlo Code

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Purpose: To simulate proton interaction (energy from 60 to 250 MeV with intervals of 10 MeV) in water using GEANT4 (version 4.8.3) Monte Carlo code that utilizes electromagnetic and hadronic physics to determine accurately the proton ranges from Bragg peak. **Method and Materials:** A cylindrical water phantom (length=100 cm, diameter= 30 cm, density = 1 g/cm3) consisted of 1000 circular sensitive detector discs (diameter = 2 cm, thickness= 1mm) was used. The simulations were carried out each by 2 million incident protons for each energy with pencil beam; and for five energies (60, 100, 150, 200 and 250 MeV) with 5cm x 5cm beam. The low energy electromagnetic process (Protons 1 keV, electrons and photons 250 eV) was used to simulate ionization around Bragg peak. Range cut is lowered from the default value of 1mm to 15μm to improve the accuracy of simulation. The hadronic process includes low energy elastic and inelastic scattering that consists of a pre-compound nuclear interaction below 170 MeV, and a Bertini cascade model for energies above 150 MeV.
Results: Our simulated normalized Bragg peak curves when compared with the CSDA data from NIST are in excellent agreement. The proton beam penetrates further with increasing energy broadening the Bragg peak with proximal shoulder dose increase from 20% to 40%.
Conclusions: We have demonstrated that the GEANT4 tool kit has the ability for the radiation therapy proton beam simulation and will be used for proton facility design in our institution.

MO-D-MET-05

Monte Carlo Simulation of Depth Dose in Water Phantom for Multi-Energy Protons

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Purpose: The purpose is to simulate depth dose spatial distribution in water phantom for multi-energy therapeutic proton beams using Monte Carlo simulation. **Method and Material:** The depth dose for a multi-energy proton beam was first calculated by mathematical linear approximation, based on pre-calculated depth dose curves of monochromic proton beams from a wide rang of energies. The result was compared to Monte Carlo simulation of three-dimensional dose distributions generated by the multi-energy proton beams in water. The isodose lines and the dose volume histogram to the target were acquired by superimposing the 3D dose matrix to the water phantom's CT scan**. Results:** The mathematical linear approximation and the Monte Carlo calculation for depth dose distribution gave very close results (R^2=0.9998). The 3D dose distribution shown at the axial, coronal and sagittal plane attested the uniformity of dose distribution for proton beam with appropriate spectrum setting. The isodose lines and the dose volume histogram showed that for a sphere target, by simply changing the spectrum of protons, a multi-energy proton beam can produce a comparable coverage to target and sufficiently sparing the structure surrounding. **Conclusion:** Proton therapy can deliver high uniform dose to target while sparing dose to the surrounding health tissue. By varying the energy spectrum, the depth dose peak range can be adjusted according to the target shape. Monte Carlo method provides a reliable tool for dose calculation for multi-energy proton beams. Monte Carlo calculation provides an accurate 3D depth dose distribution and offers basic and benchmarking data.

MO-D-MET-06

Comprehensive Evaluation of Radiation Oncology Information Systems (ROIS)

L Fong *, M Herman, Mayo Clinic, Rochester, MN

Radiation Oncology Information Systems (ROIS) have become the bridge between the management of information, technological innovations, patient treatment and high quality patient care. There has been considerable interest from the radiation oncology community in identifying what ROIS best fits a given clinical practice (specific needs and goals). An objective tool to analyze site-specific clinical information flow and infrastructure, and measure its level of integration with a given ROIS is presented. The proposed methodology is based on identifying and understanding the components of a modern radiation oncology practice. These component objects were classified into: Clinical Processes, Information Management and Technological Innovations Integration. Comprehensive IS/IT infrastructure and clinical process maps were generated by a team of experts, representing clinical constituents. These maps served as the basis for evaluating connectivity and process flow and to guide the development of a quantitative survey with user's feedback-based qualitative information to assess the performance of a given ROIS. Clinical tasks and processes were: 1) ranked according to importance for patient care and 2) scored by the team members for performance. The combination of experiential feedback with survey data provided both global and detailed suggestions to improve ROIS integration and site-specific processes. The hierarchy and importance of various characteristics are customizable to a given clinical practice and thus allow the tool's broad applicability. Proper assessment of information flow and matching of an ROIS will provide a more efficient and more effective care delivery setting.

Conflict of Interest: Research supported in part by Varian Medical Systems

Joint Symposium Room: Spanish Ballroom
MRI & DTI

TU-A-SPBR-01
The Use of MRI for the Diagnosis and Treatment of Cancer
G Clarke[1] *, N Papanikolaou[2] *, Dept. of Radiology (1), Dept. of Radiation Oncology (2) UTHSCSA, San Antonio, TX

Magnetic resonance imaging (MRI) offers exceptional soft tissue contrast with good spatial resolution, but also is increasingly being used to elicit insights on physiological and bio-molecular processes. Because of these features, MRI is being adopted as tool, not only in the diagnosis of cancer, but also as an accessory for treatment planning and as a method for monitoring the efficacy of various cancer therapies.

This presentation will consider the use of MRI and focus on its expanding role with regard to cancer diagnosis and treatment. First, basic principles of how MRI contrast is manipulated will be reviewed. Then, specific examples showing MRI images of brain, breast, prostate and GI cancers will be presented. The utility of advanced methods including magnetic resonance spectroscopy (MRS), contrast-enhanced perfusion MRI and diffusion MR imaging for evaluating treatment efficacy will be discussed.

The utility of MRI as a tool for cancer treatment will then be presented. This will include a discussion of image registration methods, both rigid and deformable. Also the challenges of MR image artifacts that can hamper the use of MRI for treatment planning will be discussed and suggestions shall be made on how to alleviate these issues. Finally, of the use of MRI for a variety of clinical presentations of cancer will be demonstrated through specific examples.

By the end of this session the attendee should:
1. be familiar with the basic concepts of MR imaging and how it can be used to facilitate the diagnosis of cancer.
2. understand the role of advanced MRI methods for following the efficacy of cancer therapy.
3. be aware of the utility of MRI as an aid to treatment planning and the pitfalls associated with its use.

Some research projects included in this presentation have been sponsored by Philips Medical Systems and Tomotherapy, Inc.

Joint Symposium Room: Spanish Ballroom
Imaging for Radiation Oncology

TU-B-SPBR-01
Technical Advances in PET/CT Imaging of Lung Cancer
P Kinahan[1] *, (1) University of Washington, Seattle, WA

Respiratory motion degrades PET/CT lesion quantitation. The magnitude of the effect depends in a complex manner on location and magnitude of respiratory motion. Respiratory gated PET/CT is now clinically feasible. There are, however, difficulties with routine interpretation of respiratory gated PET image sets. In addition there are serval potential pitfalls from the introduction of image artifacts. We present recent developments for methods to compensate for respiratory motion during whole-body PET/CT imaging.

This project was supported by NIH grants CA74135 and CA115870 and GE Healthcare Technology

Learning Objectives:
1. Review qualitative and quantitative obstacles to PET/CT imaging of lung cancer.
2. Learn recent advances in respiratory motion compensation, most notably respiratory gating during PET and CT imaging.
3. Assess recent results estimating the impact of respiratory gating during PET/CT imaging of lung cancer.
4. Review current state of quantitative PET/CT imaging of lung cancer and recent
5. initiatives to improve quantitative imaging in multi-center trials of lung cancer imaging.

TU-B-SPBR-02
4D Imaging in XRT
L Xing[1] *, (1) Stanford Univ School of Medicine , Stanford, CA

Radiotherapy is an image-guided intervention and imaging is involved in every key step of the process, ranging from patient staging, simulation, treatment planning, and radiation delivery to patient follow up. The evolution of radiation therapy has been strongly correlated with the development of imaging techniques. The emergence of CT in the 1970s revolutionized radiation therapy and allowed us to use image data to build a 3D patient model and design 3D conformal radiation treatment. Recent technical advances in planning and delivering IMRT provide an unprecedented means for producing exquisitely shaped radiation doses that closely conform to the tumor dimensions while sparing sensitive structures. The utility of modern radiation technologies, such as 3D CRT and IMRT, cannot be fully exploited without eliminating or significantly reducing these uncertainties. The need to improve targeting in radiation treatment has recently spurred a flood of research activities in image-guided radiation therapy (IGRT).

Many IGRT solutions have been proposed to attack various aspects of the problem. Briefly, IGRT developments are focused in four major areas: (1) biological imaging tools for better definition of tumor volume; (2) time-resolved (4D) imaging techniques for modeling the intra-fraction organ motion; (3) on-board imaging system or imaging devices registered to the treatment machines for inter-fraction patient localization; and (4) new radiation treatment planning and delivery schemes incorporating the information derived from the new imaging techniques. In this talk I will highlight the recent developments of various available imaging techniques. After haring the talk, it is hoped that the audience will have an overall picture of IGRT, find it easier to navigate themselves through the vast literatures of IGRT, and get a brief idea on how to implement the new IGRT techniques in their clinics.

International Medical Physicists Symposium Room: Congress
Certification of Experienced Clinical Medical Physicists - an International Cooperative Effort

TU-C-SPBR-01
The Current Status of Medical Physics in Asia
Tae-Suk Suh, Ph.D[1], (1) The Catholic University of Korea, Seoul, KR

Since Asia has a diverse cultural, social, educational and economical background, the status of medical physics in Asia is also diversed. There is a shortage of medical physicists worldwide, especially in Asia region. The reason is that there are fewer educational and training medical physicists in Asia and more transfer of qualified medical physicists to more advanced countries.
The purpose of this presentation is to discuss the current status of education, clinical training and professional development for medical physicists in Asia. The lack of recognition of the medical physics standards of education is a common problem in many Asian countries. The most difficult part of medical physics is the area of clinical training. Many clinical places in Asia region cannot afford the time and investment in the clinical training of physicists. The large areas of Asia do not have accreditation at present. Although the quantitative and qualitative needs for medical physicists in Asia countries are increasing, the situation is still far from the goal in most of the countries.
One of major role of Asian-Oceania Federation of Medical Physics(AFOMP) is to support the development of medical physics in Asia region. To improve the status of medical physicists in Asia, a goal-oriented action plans is required: especially, promoting advancement of medical physics in developing countries, strengthening the education, training and professional development of medical physicists, and promoting good relations and the exchange of information with other international related organizations.

TU-C-SPBR-02

Medical Physicists in the Latinamerican Region

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IAEA has recently estimated that the shortage of qualified clinical medical physicists in Latin America is about 400 specialists, similar to the estimated 500 physicists currently working in hospitals in the region. The explanation for the situation is multi-factorial: lack of appropriate educational and training programs, absence of a formal recognition of the profession by labor and regulatory authorities, low salaries, poor recognition of the profession by colleague physicists, insuficient understanding of the habilities and responsibilities of this specialist, among others. In recent years, the region has seen an increase in the creation of educational programs, from the Bachelor to the Doctorate level, which has helped to alleviate the numerical shortcoming. However, these academic programs cannot satisfy the requirement of an appropriate clinical training, due to restrictions in the duration of the curricular program as well as practical difficulties for an activity which requires a clinical environment. The few existing hospital training programs can hardly deal with the needs. This talk will review the situation in the region and will focus on the needs related to the professional certification.

TU-C-SPBR-03

South East Asian Federation of Organizations for Medical Physics (SEAFOMP)

A Krisanachind[1] *, (1) Chulalongkorn University, Bangkok, TH

South East Asian Federation of Organizations for Medical Physics (SEAFOMP) was formed in 1996 but officially accepted as a regional chapter of the International Organization of Medical Physics (IOMP) in 2000 with five member countries, namely Indonesia, Malaysia, Philippines, Singapore and Thailand. Brunei joined in 2002 and Vietnam in 2006. The objectives of SEAFOMP are to promote co-operation and communication between medical physics organizations in South- East Asian region in different aspects. The major activity of SEAFOMP is organizing the South East Asian Congress of Medical Physics (SEACOMP). Five events had been successfully organized in Kuala Lumpur (2001), Bangkok (2003), Kuala Lumpur (2004), Jakarta (2006) and Manila (2007). The sixth congress will be held in October 2008 at Ho Chi Minh City, Vietnam. The education and training of medical physicists in this region is diverse. The established education and training program is available in Indonesia, Malaysia, Philippines and Thailand while Singapore hosts several training programs in advanced technology of medical physics. In 2007, the International Atomic Energy Agency (IAEA) offered the competency training program for Radiation Oncology Medical Physicists (ROMP) to the country members in Asia and Pacific Region under regional cooperative agreement (RCA/RAS 6038). The training material for medical imaging medical physics will be offered by the IAEA in 2009. Thailand was selected as a pilot country for this two year training to those who graduated the Master of Science degree. This program is leading to the establishment of the qualified medical physicist, and has been proposed officially to the University for the Higher Graduate Diploma of Clinical Science Program in Medical Physics. Thai Medical Physicists Society also planned for the set up of the Cerfication of Medical Physicist in different fields, radiation therapy, nuclear medicine and diagnostic radiology in 2008.

TU-C-SPBR-04

Medical Physicist Education in P. R. China

Yi-Min Hu*(1) President, Chinese Society of Medical Physics, Professor, Cancer Institute (Hospital), Chinese Academy of Medical Sciences, Beijing

Currently there are about 4,000 physicists in China working in various fields related to medical and clinical areas, in universities, medical schools, hospitals, and clinics. The Chinese Society of Medical Physics (CSMP) has eight committees covering the major medical physics fields. Since late 1980, several international meetings on medical physics in China helped to define the field and established the profession of medical physics. Several training programs began to form in China. One of the driving forces is from radiation oncology departments. The number of Radiation Oncology Centers increased almost 400% in the last 20 years. There are about 1200 radiation oncology physicists in China in 2006, and at least double the number is needed. Medical Imaging and Nuclear Medicine also need medical physicists. There are only four academic institutions that have degree programs in medical physics. The number of graduates will not be able to supply the demand. On the job trainings may produce some medical physicists who will help ease the pressure of demand. To ensure quality of the work force, certification process is in urgent need.

TU-C-SPBR-05

Development of Medical Imaging Physics in China

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After a well attended international meeting in Medical Physics in 1981 in Beijing, and the formation of a medical physics community, attention was focused on teaching the students in medical physics. The program of medical imaging physics for master and PhD degree in China was started in 1994 in Peking University. The Institute of Heavy Ion Physics in the University redirected its research interest in the physics of nuclear medicine, magnetic resonance imaging, X-ray imaging as well as the technologies on medical imaging processing and medical imaging information integration for tumor earlier diagnosis. Recently, research and teaching include topics related to the treatment planning system of radiotherapy and the imaging guided interventional system. Since 2005, other institutions, such Tsinghua University, Wu Han University, also started the programs for master degree students. The Society of Medical Physics under the China Physics College was also founded in 2007. The new organization is working closely with the Chinese Society of Medical Physics under the Chinese Society of Biomedical Engineering. The Regulation No 46 issued by the Health Minister of China in June, 2005 has defined the medical physicist positions in radiology, nuclear medicine, and radiotherapy departments in Chinese Hospitals. But, there are not enough qualified medical physicists working in hospitals yet. There is no established method to assist the hospitals to find out if a physicist is qualified to perform the medical physics responsibilities. The image guided radiotherapy procedures and digital imaging and multi-slice CT technology demand closer cooperation between the medical imaging physicists, radiologists and radiation oncologists. The efforts on international exchange program for radiotherapy medical physicists produced many qualified medical physicists over many years in the Cancer Institute Hospital of the Chinese Academy of Medical Science under the direction of Prof Yimin Hu. Also in Beijing, medical imaging physicist training was started in 1996, and again in 2001. In 2007, the AAPM-IOMP short course in Diagnostic Imaging Medical Physics, like previous training programs, was held in Peking University. At this time, the need to create a formal Board Certification mechanism for medical imaging physicists in China exists.

TU-C-SPBR-06

Board Certification Mechanism - Taiwan's Experience

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Div. of Medical Informatics, National Taiwan University Taipei, Taiwan, TW

The legislative process of establishing the proper regulations for a board certification mechanism for medical physicists in Taiwan is very difficult. After many years of hard work with very little results, the Chinese Society of Medical Physics, Taipei in 1999 decided to set up the board certification process without government involvement. After studying the American and European experience, and with the help of some members who had obtained board certification status overseas, a qualifying process including the academic preparation, clinical experience, and examinations was established,. With the support of the Taiwan Society for Therapeutic Radiology and Oncology, and the Atomic Energy Council, the board certification mechanism was formed. The early certificates were given with emphasis on radiation therapy physics. At present, this mechanism is widely recognized by the medical community in Taiwan even without government sanction. Hospital based medical physicists are encouraged by their employers to go through the board certification process. Many radiation oncology training programs have incorporated the concept of qualified medical physicists. Some hospital departments specify board certification as one of the requirements for employment. As the radiological physics field becomes more highly sophisticated, the need for keeping up with the knowledge becomes even more important. Hence, the certification program started the continuing education extension to promote the maintenance of professional competence. The rules for continuing professional development for certificate renewal had been revised by the board certification committee in 2003. This rule change further improves the board certification mechanism. In 2007, the certification process for diagnostic imaging medical physics was established. We hope this will help to improve the quality of the fast growing medical imaging practice in Taiwan.

TU-C-SPBR-07

Medical Physics Certification Process in Mexico: a Brief Report of the Actual Situation –

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In last march 29th the Mexican Federation of Organizations of Medical Physics (FMOFM) met in México City, among the issues addressed in the meeting, it was discussed the certification of Clinical Medical Physicists (CMP) in México. One of the decisions made to that end, was the creation of what we called the Task Group Zero (TG 0) that was appointed to address all the issues concerning the design and development of the Mexican Council of Medical Physics, entity yet to be created and to be responsible for the certification of the CMP´s in México. To provide a mechanism for certification for a CMP, there were several proposals to begin with; one of them was based in the evaluation of Professional Competences. We believe that this kind of evaluation is extremely important for certifying Clinical Competences in medical physics. It was outlined a framework with a tentative time schedule to accomplish the task. This will be briefly discussed.

TU-C-SPBR-08

Education and Training of Medical Physics in Japan

K Inamura[1], **K**ansai Univ. of International Studies, Professor Emeritus Osaka University

Japan has a board certification process already been in place. JRS (Japan Radiological Society) has a committee for certification of "Medical Physicist" by her own definition. Such "Medical Physicist" does not always mean clinical medical physicist. Paper examination by JRS is rather in high level with wide spectrum. Only two to seven years of clinical job experience depending on examinee's original profession or academic history is required to take the board certification after the paper examination. Content, level and scope of the clinical experience are not required to be presented and examined, but verification by head of the clinical organization is mandatory. The board certified physicists need to be re-certified every 2 years by submitting proposition with their list of research works during those 2 years.

The number of "medical physicists" is now 383 as of 2007. Many of the recent new members are radiological technologists who have been actually taking charge of medical practices in hospitals.

Ministry of Education, Culture, Sports, Science and Technology started a program of development of professionals involving medical physicists for cancer therapy in 2007. JRS has been trying to fix Medical Physics Education/Training Guideline in accordance with the Governmental approach above mentioned. AAPM Reports No.79, No.90 and CAMPEP methodology are the basis of this guideline.

On the other hand, IAEA.RCA project RAS6038 "Strengthening medical physics through education and training" which started 6 years ago is now really in intensive activity. If we could discuss the way of implementation of international board certification process, my unofficial opinion is that IAEA's program for training medical physicists could be one of possible candidates, because the program is aiming at the global standard in addition to flexibility to cope with requirement from developing countries.

Young Investigator Poster Displays
Exhibit Area

PO-YI-EXH-01

A Computer Program to Manage Dosimetry Data and to Verify Monitor Unit of Treatment Planning System

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Purpose: For an independent procedure to verify monitor units (MU) calculated by treatment planning system (TPS), we developed a computer program, which shares the same beam database with TPS, and thus can be used to verify the accuracy and integrity of TPS. **Method and Materials:** The program can read and process raw ascii files directly from 3D water scanners. In addition, a customized txt file format was used to apply other parameters relevant to the program, such as scatter factors, wedge transmission factors, tray factors. To enhance the accuracy of calculations, the program considered off-axis ratios and wedge hardening effects that are often disregarded in routine hand calculations. Some correction algorithms were incorporated into the program to transform data of a certain measurement condition to those of the standard condition. The program can also automatically generate beam data as a format of dosimetry book, which can be often used for reference in clinic. **Results:** Because of the sharing beam database with TPS and automatic file based procedure, the program realized systematic management and periodic update of beam data to maintain the accuracy of TPS. **Conclusions:** It is expected that with this program, MU calculated from TPS can be independently verified and beam data of TPS can be systematically managed.

PO-YI-EXH-02

CT Resolution for Lung Treatment Planning: An Application of a 2 ½-D Random Lung Model Using MC Method

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Purpose: To investigate the effects of CT resolution on treatment planning where heterogeneities exist, such as in the lung, using a recently developed, realistic random lung model and Monte Carlo method. **Methods**: A thoracic phantom with a realistic random lung model embedded was built and two representative realizations with two different sizes of tumors were generated. The MC code DPM was employed to calculate dose distributions in the phantom with different CT resolutions. The three-field conformal setup used a 6MV photon beam. Both qualitative and quantitative dose evaluation metrics were applied. **Results**: A reference CT resolution of 1x1 cm^2 was established by comparing the CAX depth doses between a detailed lung model and its voxelized version. The fine details revealed in high resolution can be smoothed, especially when the geometrical voxels cross the heterogeneities, hence introducing a potential systematic error. Visible difference, up to 1%, can be seen in the DVHs of the cases with a small tumor. The insensitive relative absolute differential dose shows the DVH's disadvantage of lack of positional information of the dose distribution. **Conclusion**: A realistic random lung model was applied to show the effect of the accuracy of the geometrical representation on dose distribution in heterogonous sites, such as the lung. Our results show that a CT resolution up to 2x2 mm^2 may be sufficient while a 4x4 mm^2 could lead to significant perturbations. This may be especially problematic for treatment planning involving small tumors and tissue heterogeneities.

PO-YI-EXH-03

Dose Optimization of MammoSite Balloon Partial Breast Brachytherapy Treatment

K Prescott[1] *, S Ahmad[1] , T Herman[1] , L Syzek[1] , (1) Oklahoma University Health Sciences Center, Oklahoma City,

Objective: To report our experience from the treatment plans of twenty patients with early stage breast cancer using MammoSite partial breast brachytherapy applicator. **Materials and Methods:** CT images through the lumpectomy cavity of 2.5 mm slices were used. A 1 cm expanded volume from the balloon surface was designed to define PTV with chest wall and skin as limiting structures. The dose (34 Gy in 10 fractions BID) is optimized to the PTV based on one, four, or six points with one, two, or three dwell positions. Values of V_{90}, V_{100}, V_{150}, V_{200} and dose homogeneity index DHI = $(V_{100}-V_{150})/V_{100}$ were calculated and compared. **Results:** The balloon and the PTV volumes range from 31.12 to 80.18 cc and 76.55 to 127.73 cc, respectively. The mean V_{90} (94%) for six and four point with single dwell position was higher compared to that of all single point positions. The mean V_{100} was 87%, for six points, compared to 85% for four point prescription. However, the average DHI (0.66) was higher with four points for one or two dwell positions, compared to 0.64 for six and 0.63 for single point prescription. About 30% of the PTV gets 150% of the dose, average maximum skin and heart doses were 68.5% and 43.8%, respectively of the prescription dose with less than 3.9% of average lung volume getting 17 Gy. **Conclusions:** We conclude that optimized treatment plans with four point prescriptions with single dwell position are best for clinical use in our facility.

PO-YI-EXH-04

A Decision Aid for IMRT Treatment Plan Selection Combining a Bayesian Network, a Markov Model, and Patient Preferences

W Smith[1] *, J Doctor[2] , I Kalet[1] , M Phillips[1] , (1) University of Washington, Seattle, WA, (2) University of Southern California, Los Angeles, CA

Purpose: To develop the decision making component of a multiobjective IMRT optimization procedure for prostate cancer that incorporates disparate sources of information used in clinical decision making, the uncertain outcomes inherent in medical prognosis and the preferences of the patient. **Methods:** Currently, many IMRT plans are developed for each patient without indication of which plan provides the optimal balance between tumor control and complication probability. We chose a Bayesian Network (BN) coupled with a Markov Model (MM) and utility theory to calculate Quality Adjusted Life Expectancy (QALE) for IMRT treatment of prostate cancer. The BN was constructed with the advice of experts; conditional probabilities were obtained from the literature and expert opinion. Local, regional, and distant control were included as were complications to bladder and rectum. The MM relied on transition probabilities derived from the BN, published clinical trials and life expectancy tables. Utilities were obtained from the literature. **Results:** Probabilities of disease control matched published values well, as did life expectancies. Sensitivity analyses highlighted critical nodes in the network. Analysis of outcomes versus probability of lymph node involvement provided a basis for decisions regarding pelvic irradiation. A BN is well-suited to handle the disparate nature of clinical variables. QALE provides a method for ranking plans based on clinically relevant criteria that incorporates the probabilistic nature of the outcome. **Conclusion:** A decision aid was constructed using a Bayesian Network coupled to a Markov Model. This resulted in the ability to rank plans based either on QALE or specific outcomes.

PO-YI-EXH-05

Impact of Respiratory Gating Using 4DCT On Therapeutic Gain (TG) in Patients with Thoracic Malignancies

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Objective: To evaluate the therapeutic gain calculated from the Dosimetry of 4DCT gated treatment plans as compared to traditional non-gated treatment plans. **Methods:** Ten patients underwent treatment planning. Gated CT images were obtained at full inspiration, full expiration and at 25^{th}, 50^{th} and 75^{th} percentile of respiration. For non-gated plans, planning target volume (PTV) included an all around 1 cm margin for tumor motion and 0.5 cm for set-up error. For gated plans, tumor volumes of individual CT images were superimposed with a 0.5 cm margin for set-up error. The prescription dose was 60-70 Gy at 2 Gy per fraction. Dose Volume Histograms were generated for PTV, heart, spinal cord, esophagus, and total lung in each treatment plan. Rival treatment plans with gated and non-gated planning were compared on the basis of TCP, NTCP and TG. **Results:** TCP was higher for gated plans, 95.42% and 90.38% versus 93.52% and 85.36% for non-gated plans with CCD of 10M and 220 M, respectively. NTCPs for lung, esophagus, heart and spinal cord were 7.96%, 5.23%, 1.66% and 0.38% with gating versus 26%, 8.25%, 9.36% and 0.52% without gating. The differences in TG between gated and non gated plans were 26.21% and 24.98% for CCDs of 10M and 220 M, respectively indicating clear superiority for gated compared to non gated plans. **Conclusions:** 4DCT respiratory gating allows for radiation field reduction, also decreasing doses to lung and other normal tissues and may limit the incidence of radiation induced late toxicity in long term survivors.