University of Wisconsin
School of Medicine
And Public Health

Residents' Handbook

Imaging Physics Residency Program

University of Wisconsin-Madison School of Medicine and Public Health

Department of Medical Physics

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Contents

Abbreviations:

AFCH	American Family Children's Hospital
HSLC	Health Sciences Learning Center – home of the UW School of Medicine & Public Health
SMPH	UW School of Medicine and Public Health – home of the Departments of Medical Physics, Radiology, and other Basic Science and Clinical departments
TAC	The American Center health and wellness center
UWHC	University of Wisconsin Hospitals and Clinics
UWHealth	This term describes the totality of clinical facilities at the University of Wisconsin, including those at AFHC, TAC, UWHC, UWMF, and WIMR
UWMF	University of Wisconsin Medical Foundation
WIMR	Wisconsin Institutes for Medical Research – physical home of the Department of Medical Physics and key classrooms, imaging laboratories, research laboratories, computational resources, *etc*.

1. Introduction

Program Evolution and History

The UW Imaging Physics Residency program developed from the Radiological Physics Services of the Department of Medical Physics at the University of Wisconsin-Madison. The Medical Physics Department has a long history of education and training in the application of physics in medicine and biology. Originally, Medical Physics was a section in the Department of Radiology in the UW School of Medicine. The section was founded by Professor John Cameron in 1958, and quickly grew in breadth and status as the number of faculty members and graduate students increased, graduate courses expanded, funded research programs became established, and clinical equipment required greater technical expertise among users. Independent department status was granted to Medical Physics in 1981, and the graduate program, in 1989, was one of the first to be accredited by CAMPEP. The UW-Madison Graduate Medical Physics Program is the largest such program in North America, and resources of this program are fully leveraged by the proposed Imaging Physics Residency Program. The greatest emphasis in the graduate program has been on preparing doctoral students for research careers in academia and industry. In addition, many Ph.D. and M.S. degree graduates, as well as many post-doctoral fellows, have gone on to careers in clinical medical physics in radiation oncology, nuclear medicine, and diagnostic imaging. Preparation for these careers has been through courses, lab work, and experience working side by side with physicists in the clinic.

Since it began in the early 1980's, the Radiological Physics Services (RPS) group within the Department of Medical Physics has participated in imaging physics education and training of graduate students. The RPS provides acceptance testing and quality control testing of imaging equipment, imaging protocol optimization services, radiation safety calculations, radiology resident physics teaching, PACS and DR/CR support services, and other imaging physics services to the UW Hospitals and Clinics (UWHC) as well as to surrounding imaging facilities. RPS faculty members lead the department's "RadLab" courses that focus on evaluating clinical imaging equipment, and they mentor their own graduate students who play a part in clinical testing. Until recently, our model has been to accept graduate students into this group for a period of two years, supported by funding generated through the provision of medical physics services. In addition to their course work, the graduate students participated in providing these services under the direction of board certified faculty. During a two-year period, they obtained valuable work experience in the clinic while completing a M.S. degree in medical physics. This program has a long list of alumni, many of whom are leading medical physics groups throughout the US.

In response to the American Board of Radiology's 2014 initiative, we are making a transition from RPS-based education and training of graduate students to establishing a clinical residency in imaging physics. The expertise and much of the support base for this program is in place, and we have received seed funding from the AAPM. Our first resident received 21 months of residency education and training, but, unfortunately, left the program before fully completing all requirements in order to join a medical physics group in a hospital in Chicago. (He completed his graduate work and entered the ABR examination process before the ABR 2014 initiative took effect.) We are now seeking initial accreditation of this program as we recruit his replacement.

2. Program Objective and Goals

The University of Wisconsin Imaging Physics Residency Program is a 24-month duration program designed for individuals with a M.S. or Ph.D. degree in Medical Physics, preferably from a CAMPEP-accredited program, who seek education and training in clinical medical imaging physics. The overall objective of the program is to provide comprehensive clinical, technical, and professional physics education and training to enable graduates to perform independently as clinical medical imaging physicists. Upon completion of the program, a Certificate of Completion will be issued. Graduates will be well prepared for ABR board certification and a professional career as a qualified medical physicist in a clinical imaging facility, imaging physics consulting group, *etc*. We will meet this objective through the following actions:

a. providing didactic instruction that focuses on medical imaging device operation principles, imaging physics tasks, and informatics, as well as hands-on experience with radiographic, MRI, nuclear medicine, and ultrasound equipment in the clinic to supplement previous medical physics graduate course material;

b. providing the resident with access to resource materials relevant to medical imaging, such as textbooks, accreditation manuals, task group reports, testing standards (such as those from the IEC and NEMA), state and federal regulations, and training the resident to be proficient in finding additional information using the internet and other sources and in using critical analysis to evaluate all these information resources;

c. exposing the resident to the process and availability of continuing experience and continuing education during a medical physics career;

d. educating the residents on the need for high-quality equipment testing protocols and methods and providing opportunities for independently carrying out proper equipment test procedures, applying principles of radiation protection as well as electrical and mechanical safety in equipment testing to avoid risks to themselves, others, and the equipment, and learning what can go wrong if inadequate test methods and techniques are used;

e. fostering critical thinking skills, problem solving skills, and the need for and enjoyment of life-long learning, focusing on medical imaging evaluation, protocol development, improvements in imaging technology, and advancing the application of physics principles to solving medical problems in general;

f. providing extensive interactions with clinical personnel in each modality through Grand Rounds participation, one-on-one interactions with physicians, and problem solving sessions with clinicians and technologists; having residents become familiar with the purposes and clinical needs of routine and advanced imaging procedures; enhancing resident communication skills through these activities as well as through their own teaching and reporting of test results;

g. instilling the highest level of professionalism, ethics, and leadership through reinforcement of course training, attendance of seminars on professionalism and leadership, and discussions of issues that affect professional behavior of medical physicists; and

h. familiarizing residents with, and ensuring they apply, principles of patient confidentiality and issues related to HIPAA laws and state and federal regulations.

3. Program Structure and Governance

Facilities: Imaging Physics Residency Program education and training takes place primarily in the UW Hospitals and Clinics (UWHC), Wisconsin Institutes for Medical Research (WIMR), and UW Medical Foundation (UWMF) facilities associated with the University of Wisconsin-Madison School of Medicine and Public Health (SMPH). The recently integrated UWHealth system is a nationally-recognized regional health system that includes the following facilities:

- UWHC, a large referral center hospital and associated clinics, located on the UW-Madison campus,
- UWHealth at The American Center (TAC), a 56-bed health and wellness facility located on Madison's east side,
- The American Family Children's Hospital (AFCH), an 87-bed facility adjacent to UWHC and supported by its own extensive medical imaging systems,
- UWMF clinics, with 3 outpatient medical imaging facilities located in and around the city of Madison, and
- WIMR Imaging Services, where PET/CT, PET/MR, ultrasound, MRI and CT facilities devoted both to basic, translational, and clinical research and to standard of care imaging are provided. WIMR is physically connected to UWHC and the University of Wisconsin Health Sciences Learning Center (HSLC), which houses the School of Medicine and Public Health and the Ebling Library.

Figure 1: Map of primary facilities involved in the Imaging Physics Residency Program (green labels) and other medical campus facilities (blue labels). The UWMF clinics and TAC facilities are within 5 and 10 miles from WIMR, respectively.

UWHC received and maintains a Gold Seal of Approval from the The Joint Commission, with several additional advanced certifications (comprehensive stroke, diabetes, palliative care, *etc*.). Imaging facilities at UWHC, UWMF, TAC, AFCH, and WIMR are accredited through the American College of Radiology and adhere to all state and federal regulations, including MQSA.

Administration and Admissions: The Imaging Physics Residency Program is a 24-month duration program administered by the Department of Medical Physics in cooperation with the Department of Radiology in the UW School of Medicine and Public Health (SMPH). The Program preferentially admits graduates of CAMPEP-accredited graduate medical physics programs. If an "alternative pathway" applicant, *e.g*., an applicant with a Ph.D. degree in physics, is admitted to the program, any remedial didactic coursework that must be addressed to satisfy the CAMPEP Standards for Graduate Education will be completed outside of the 24-month clinical imaging physic education and training, *i.e*., the duration of the education and training requirements for such an individual may require more than 24 months.

The program website (https://www.medphysics.wisc.edu/residency) provides general information about the program, admissions information, and a listing of current and previous residents. For previous residents, information on their achievements, employment following completion of the residency program, board certification status, *etc*. is provided, as required by CAMPEP standards.

Faculty and Steering Committee: All program faculty are members of the Department of Medical Physics and/or the Department of Radiology. The program faculty are appointed by the chairs of the Departments of Medical Physics and Radiology. The Steering Committee, which consists of the Medical Physics Program Faculty and one physician member from the Participating Clinical Faculty (Table I), oversees all affairs of the program. Minutes of all Steering Committee meetings are maintained electronically. The committee meets two times per year, or more frequently if needed.

The Steering Committee makes recommendations for appointment of residents after reviewing letters of application, letters of recommendation, and undergraduate and graduate education records. Transcripts are carefully reviewed to ensure adequate undergraduate physics preparation (as defined by CAMPEP standards) and completion of acceptable graduate medical physics education requirements. The Steering Committee reviews clinical rotation mentor reports on resident progress to assure consistency and fairness of evaluation procedures, and makes recommendations to the Program Director to improve the rotation organization and content. The Steering Committee also reviews all exit surveys submitted by graduates of the program, and uses such information to make recommendations to improve program content and processes. If a resident demonstrates unsatisfactory progress, a task group of the Steering Committee is appointed by the Program Director to address remedial action, or, if necessary, prepare a recommendation for dismissal from the program, which must be reviewed and approved by the entire Steering Committee. The Program Director will forward this recommendation to the chair of the Department of Medical Physics for final review and action.

4. Program Director and Associate Director

The Program Director and the Associate Director are appointed by the Chair of the Medical Physics Department, in consultation with the residency program Steering Committee. The Associate Program Director reports to the Program Director, and both report to the Chair of the Department of Medical Physics.

The current Program Director is Frank Ranallo, Ph.D., DABR, FAAPM. Dr. Ranallo received his Ph.D. in Physics from the University of Wisconsin-Madison in 1993. He obtained board certification in Diagnostic Radiological Physics from the American Board of Radiology in 1994. He has been associated with the Radiological Physics Services of the Medical Physics Department since its inception, being responsible for x-ray system testing (including that of CT systems), radiology resident physics training, and dealing with many image quality, safety, and radiation exposure questions. He has worked with several diagnostic imaging task groups of the American Association of Physicists in Medicine, including those that produced *Instrumentation Requirements of Diagnostic Radiological Physicists, AAPM Report No. 60* and *Quality Control in Diagnostic Radiology, AAPM Report No. 74*. Presently he is serving on Task Group #150, *Acceptance Testing and Quality Control of Digital Radiographic Imaging Systems* and on Task Group #233, *Performance Evaluation of Computed Tomography Systems*.

The current Program Associate Program Director is John Vetter, Ph.D., DABR. Dr. Vetter received his Ph.D. in Medical Physics from the University of Wisconsin-Madison in 1990. He obtained board certification in Diagnostic Radiological Physics from the American Board of Radiology in 1994. Dr. Vetter is the Director of the Radiological Physics Service (RPS) in the Department of Medical Physics, and chair of the X-ray Subcommittee and Executive Committee member of the UW-Madison Radiation Safety Committee.

The Program Director is responsible for recruiting clinical rotation mentors for each of the rotations. This is done in close collaboration with the Associate Program Director, the chair of the Department of Medical Physics, and the Steering Committee. As Program Director, Dr. Ranallo also has the primary responsibility for recruiting residents, evaluating applicants to determine whether they are fully qualified for a CAMPEP-accredited residency, working with graduate program faculty to arrange any remedial education if an otherwise highly qualified applicant does not meet Program prerequisites, advising residents, and conducting evaluations of each resident’s progress and of the residency program itself.

The Associate Director works in close collaboration with the Director, particularly in regard to the scheduling and monitoring of clinical rotations. Working closely with the Steering Committee and IT specialists in the Department of Medical Physics, the Director and Associate Director maintain the Imaging Physics Residency Program website for both internal documents and external viewing information, such as the type and nature of the training, program and graduate statistics, and important announcements.

5. Program Staff

The Department of Medical Physics currently has 21 tenured/tenure-track, 7 clinical track, and 9 active emeritus faculty. (Two additional faculty positions are currently being filled.) In addition, the program has 26 affiliate faculty (from the Departments of Radiology, Human Oncology, BME, Physics, Psychiatry) and two joint executive faculty (Radiology). The medical physics faculty involved in the Imaging Physics Residency Program are a subset of the departmental faculty. Additional residency program faculty, *i.e.*, participating clinical faculty, are recruited from the Department of Radiology. The Imaging Physics Residency Program faculty are appointed by their respective department chairs, following the recommendation of the Residency Program Director, Associate Program Director and the Steering Committee. In all cases, Imaging Physics Residency Program faculty are engaged in clinical physics activities in their areas of expertise. Four of the ten medical physics faculty are board certified by the American Board of Radiology and/or the American Board of Medical Physics, and all are qualified to provide equipment testing and other services as specified by American College of Radiology accreditation programs. (Two are in the process of completing ABR or ABSNM board certification requirements.) In addition, most program faculty are engaged in the UW Medical Physics Graduate Program as instructors, faculty mentors, and/or research directors, and several are active physics instructors in the UW Radiology Resident education programs.

Faculty members, along with their specialties, are listed in the Table I. An inspection of faculty biosketches in Appendix G will demonstrate each medical physics faculty member is heavily engaged in education, research, and service efforts of the institution as well as scientific and/or professional organization committee work and other professional medical physics activities.

Table I: Imaging Physics Residency Program Faculty

Medical Physics Faculty	Area(s) of Expertise	Certification
Frank Ranallo, Ph.D., FAAPM (Medical Physics and Radiology) – Program Director	Radiography, fluoroscopy, angiography, CT, radiation safety, optimization of imaging protocols	ABR, Diagnostic Radiological Physics
John Vetter, Ph.D. (Medical Physics) – Program Associate Director	Radiography, fluoroscopy, angiography, mammography, nuclear medicine, radiation safety	ABR, Diagnostic Radiological Physics
Edward Jackson, Ph.D., FAAPM, FACR. (Chair, Medical Physics, also Radiology and Human Oncology)	MR, ultrasound; interface with Graduate Medical Physics Program, as Program Director	ABR, Diagnostic Radiological Physics; ABMP, MR Physics
Tyler Bradshaw, Ph.D. (Radiology)	Nuclear medicine	
Timothy Hall, Ph.D. (Medical Physics)	Ultrasound	
Walter Peppler, Ph.D. (Medical Physics)	Informatics, PACS, teleradiology	
Michael Speidel, Ph.D. (Medical Physics and Medicine)	Radiography, angiography	
Timothy Szczykutowicz, Ph.D. (Radiology, Medical Physics, BME)	CT	
Karl Vigen, Ph.D. (Radiology)	MR	ABMP, MR Physics
James Zagzebski, Ph.D., FAAPM (Medical Physics)	Ultrasound	

Participating Clinical Faculty	Area of Expertise	Certification
Thomas Grist, M.D., FACR (Chair, Radiology)	Cardiovascular imaging; MRI	ABR, Diagnostic Radiology
Jeffrey Kanne, M.D.	Chief, Thoracic Imaging	ABR, Diagnostic Radiology
Mark Kliewer, M.D.	Chief, Ultrasound; abdominal imaging imaging and intervention	ABR, Diagnostic Radiology
Scott Nagle, M.D., Ph.D.	Thoracic imaging, cardiovascular imaging	ABR, Diagnostic Radiology
Lonie Salkowski, M.D.	Breast imaging; anatomy, medical education	ABR, Diagnostic Radiology
Gary Wendt, M.D., M.B.A.	Vice Chair, Informatics; neuroradiology; PACS, teleradiology	ABR, Diagnostic Radiology

Note: All physics faculty are members of the Steering Committee, which also includes one physician representative. The current physician representative is Thomas Grist, MD, FACR, chair of the Department of Radiology.

6. Institutional Support

Administrative support for the Residency Program is provided by the Department of Medical Physics. Each resident has access to administrative personnel and desktop, workstation, database, and web IT support personnel, and has office space, access to conference rooms and audiovisual resources, telephone and copier access, and access to a variety of computational facilities (image processing workstations, compute-node servers, *etc*.). Desktop computers are provided to allow access to the intranet/internet, e-mail, library resources, *etc*., and have any necessary software (Office 365, Matlab, Mathematica, ImageJ, R, SPSS, *etc*.).

With regard to test equipment, the RPS maintains two Radcal diagnostic X-ray measurement systems (including dosimeters and other electronic test equipment for performing equipment evaluations of all x-ray systems and radiation safety measurements), non-electronic phantoms and equipment for performing equipment evaluations of radiographic, mammographic, fluoroscopic, and angiography systems (including focal spot star patterns and pinhole and slit cameras, HVL filters, collimation test tools, resolution patterns and low contrast phantoms, water/patient equivalent phantoms), a Catphan CT testing phantom, a CTDI Dosimetry phantom, uniform cylindrical CT phantoms from 20 to 48 cm diameter, mammography ACR accreditation phantoms and breast tissue equivalent phantoms. RPS also has two Gammex 403 gray scale ultrasound phantoms, a Gammex 404 and a CIRS Model 050 small parts phantom, an ATS Model 539 general purpose phantom, a CIRS Doppler string test object, and a Gammex 425 flow phantom. The Department of Medical Physics maintains a machine shop and electronics laboratory that can be used, as necessary, for the fabrication of custom phantoms, test devices, *etc*. The department also maintains a large laboratory for fabrication of phantoms, and residents have access to a wide variety of research phantoms and have the ability to fabricate novel phantoms for clinically-directed projects, if needed. For MRI system testing, the Department of Radiology possesses a number of MRI phantoms, including the large ACR MRI Phantom, a luminance meter for basic MRI operator console luminance testing, and a 3-axis Hall-probe gaussmeter (Metrolab THM 7025, GMW Associates, San Carlos, CA). The Department of Medical Physics has additional MR phantoms, including the ISMRM/NIST MR System Phantom (High Precision Devices, Boulder, CO) and the RSNA QIBA/NIST ADC Diffusion Phantom (High Precision Devices, Boulder, CO).

The Department of Medical Physics provides percent effort support for the Program Director and the Associate Director, and the department is committed to continuing this support in the future. Office space, IT, equipment, and administrative support for these program leaders are also provided by the department and the RPS.

The Imaging Physics Residency Program stipend rates are based on the Graduate Medical Education (GME) rates of the UW SMPH. Currently, those rates are $55,900 for PG1 residents and $57,967 for PG2 residents. The SMPH GME rates are based on the Council of Teaching Hospitals survey and are adjusted annually. Each resident is also provided with health and dental benefits. Resident stipends are currently derived from funding graciously provided by an AAPM grant. For fiscal year 2017, the Department of Radiology has requested support from the UWHC for one resident position per year. A second potential source of funding for resident stipends is revenue from services provided by the RPS to the UWHC and UWMF. However, we are investigating any other options for additional support. We anticipate having two residents in the program in FY2017, and our expectation is to have a minimum of two residents in the program continuously.

Residents in the Imaging Physics Residency Program are expected to present and publish results of clinically-directed projects completed during the program. As such, the program commits to funding travel to at least one scientific / professional meeting per year, *e.g.,* annual meetings of the AAPM, RSNA, SPIE, *etc*.

Resident orientation activities include introductions to program faculty, tours of facilities in the UWHC and UWMF clinics, the AFCH, and WIMR, an overview of expectations and requirements during years 1 and 2, and review of the support structure for the residency program (program administrative staff, clinical rotation mentors, clinical faculty, etc.). Information on computational support, phantoms and test objects, and HIPAA training requirements is provided. An introduction to mechanical and electrical safety, including high-voltage safety, and to MR safety is also provided during the orientation and subsequently supplemented by additional training by medical physics mentors during the relevant rotations. Each resident must complete the institutional radiation safety training as part of his/her orientation, and additional radiation safety training is provided in the relevant rotations. In addition to the verbal communication of the orientation materials, the residents will have online access to the *UW-Madison Imaging Physics Residency Program Handbook*, which is being finalized and will be posted to the program website. The material in the handbook will be reviewed annually by the Program Director and Associate Director, who will report recommended changes to the Steering Committee at a regularly scheduled meeting. Changes to the handbook that are approved by the Steering Committee will be implemented, posted, and communicated by email to all residents.

7. Educational Environment

As noted in Section 3, resident education and training occurs primarily in the Department of Medical Physics, in imaging suites within the adjacent UWHC and the AFCH, in imaging facilities within The American Center (TAC) Hospital on the East Side of Madison, and in UWMF imaging suites in the city of Madison, and in imaging suites within WIMR.

Imaging physics residents have office space among the faculty, post-docs, and graduate students in WIMR Tower 1 (WIMR 1), which opened in 2008 and houses the Department of Medical Physics. This interdisciplinary research tower is connected to UWHC and has its own CT, MRI, ultrasound, PET/CT, and PET/MR imaging facilities, which are used both for standard of care and in basic, translational, and clinical research performed by Radiology and Medical Physics faculty. WIMR 1 also houses the UW Carbone Cancer Center (UWCCC), the McPherson Eye Research Institute, the Department of Medical Physics Medical Radiation Research Center (and its Accredited Dosimetry Calibration Laboratory, ADCL), the Small Animal Imaging Facility, a PETtrace cyclotron and associated radiochemistry and radiation detection research space, a GMP Radiopharmaceutical Production Facility (which opened in 2016), and the Image Analysis Core (IMAC). WIMR Tower 2, which opened in 2014, is immediately adjacent to WIMR 1 and houses 10,000 ft^2 of additional shared Radiology and Medical Physics office space, a second IMAC facility, the McArdle Laboratory for Cancer Research, the Cardiovascular Research Center, and the Department of Cell and Regenerative Biology. Most Medical Physics graduate classes meet in WIMR 1 or WIMR 2.

WIMR 1 and WIMR 2, as well as the UWHC, are contiguous with the HSLC, which houses the UW School of Medicine and Public Health (SMPH) administrative offices, large and small classrooms, and the Ebling Library. Weekly Medical Physics research seminars and some Radiology Grand Rounds are held in the HSLC facility. Other Grand Rounds, including the UWCCC Grand Rounds, are held in the UWHC.

As with graduate medical physics students and department personnel, all imaging physics residents have access to a vast array of online resources through their desktop computers and/or mobile devices and at a number of UW facilities. Among these are the Ebling Library for the Health Sciences with its extensive on-line and physical journal archives, the UW College of Engineering with its availability of computational software, DoIT (UW-Madison's Department of Information Technology) software resources, and the Department of Medical Physics software resources.

Most resident rotations are mentored by faculty who regularly interact with clinical personnel in their own modality, and opportunities for resident interactions with clinical personnel are emphasized. Residents are required to participate in lectures to physicians as part of the Radiology Residency Program educational courses provided by members of RPS. This participation will include attendance at lectures and participation in aspects of the teaching. Physics residents are expected to attend at least four Radiology Grand Rounds seminar presentations each year. They will also be invited to journal club presentations of medical physics research groups wherever interests coincide.

Including imaging systems located in all facilities to which the residents have access (UWHC, UWMF, AFCH, TAC, WIMR), the installed base currently includes the following systems: 11 CT scanners, 34 radiographic CR/DR systems, 17 angiography systems, 44 fluoroscopy systems, 9 mobile radiography CR/DR units, 15 mammography systems, 3 stereotactic biopsy mammography systems, 3 bone densitometry systems, 2 dental units, 25 ultrasound units, 13 MR systems, 6 gamma camera /SPECT systems, 3 PET/CT systems, and 1 PET/MR system.

8. Scholarly Activities

Residents will participate in one or more clinically-directed projects closely related to specific rotations or to other tasks that are agreed on by the Steering Committee. Examples of such projects include, but are not limited to, developing, testing, and communicating results of new CT and other modality imaging protocols, development of objective performance testing methods, and development of new and more effective test methodologies. Table II provides a list of such projects completed by the first resident in the program and illustrates the types of projects expected of all residents.

A log of the clinically-directed project activities will be maintained by each resident in a LabArchives Electronic Lab Notebook (ELN). (UW-Madison has contracted with LabArchives for all university-sponsored ELN applications, and each resident has access to these applications.) Each resident's ELN will be shared with the Program Director, Associate Director, and Department Chair.

Residents are strongly encouraged to present and to publish results of their clinically-directed projects. Each resident is required to present a Medical Physics Seminar in their second year. These weekly seminars are attended by faculty, graduate students, post-doctoral fellows, and residents. Submissions to regional and national meetings of the AAPM and the RSNA are especially encouraged, and residents will attend at least one scientific / professional organization meeting per year. First authored or co-authored manuscripts are also strongly encouraged.

Residents are strongly encouraged to participate in one or more professional committee activities where issues of importance to the practice of diagnostic medical physics are discussed. Examples include AAPM task groups or any of the technical committees of organizations such as the International Society for Magnetic Resonance in Medicine (ISMRM) or the American Institute of Ultrasound in Medicine (AIUM).

Faculty mentors are encouraged to nominate their resident for peer review activities, such as reviews of journal articles closely related to their prior research and current areas of interest.

Table II: Clinically-Directed Projects and Publications / Presentations of Resident #1

Category	Description	Publications/Presentations
CT Protocol Management	A project to ensure all CT protocols being utilized by all UWHealth Imaging facilities achieve sufficient diagnostic image quality at the lowest possible dose. This project also seeks to make image quality homogeneous across the many different scanner models employed throughout these facilities.	1. CT protocol management: Simplifying the process by using a master protocol concept. T. Szczykutowicz, R. Bour, **N. Rubert**, G. Wendt, M. Pozniak, F Ranallo. J Applied Clin Med Phys (JACMP) 16(4) 2015. 2. Quantitative image quality metrics are for physicists, not radiologists: How to communicate to your radiologists using their language. Proffered Presentation MO-D-213-6, AAPM Annual Meeting 2015. T. Szczykutowicz, **N. Rubert**, F. Ranallo.

		3. A Wiki-based solution to managing your institution's imaging protocols. T. Szczykutowicz, **N. Rubert**, D. Belden, A. Ciano, A. Duplissis, A. Hermmans, S. Monette, E.J. Saldivar. J Am College Radiol (JACR), 2016. 4. A Wiki-based CT protocol management system. T. Szczykutowicz, **N. Rubert**, D. Belden, A. Ciano, A. Duplissis, A. Hermanns, S. Monette, E.J. Saldivar. Radiology Management 37(6):25-9, 2015.
Objective CT Quality Assurance	This project involved developing objective, computerized tests for several image quality metrics that are determined either less precisely or subjectively in traditional QA testing. This project focused on the development of MTF assessment and low contrast detectability assessment.	1. Position Dependent MTF improvement in CT Imaging using a High Resolution Scan Mode. Paper Under Revision. **N. Rubert,** T. Szczykutowicz, F. Ranallo. 2. Avoiding a Common Pitfall in Performing MTF Measurements with High Resolution Kernels. Poster Discussion SU-E-I-14, AAPM Annual Meeting 2015. **N. Rubert,** T. Szczykutowicz, F. Ranallo. 3. Technical Note: Confirming the prescribed angle of CT localizer radiographs and c-arm projection acquisitions. T. Szczykutowicz, Z. Labby, **N. Rubert**, C. Wallace. Med Phys 43(2):865-69, 2016.
Objective US Quality Assurance	Maximum depth of penetration (DOP) is an image quality metric commonly used to assess the overall health of a transducer. This metric is a required part of Annual Survey for ACR testing. This project sought to demonstrate the utility of replacing a subjective test of DOP by an automated, objective standard recommended by the IEC.	1. Automated Depth of Penetration Measurements for Quality Assurance in Ultrasound. Proffered Presentation SU-D-210-1, AAPM Annual Meeting 2015. **N. Rubert**, J. Zagzebski.

9. Residency Curriculum

Table III lists each rotation module with the approximate percent of time spent in each. Table VI (pages 23-24) matches each element of the CAMPEP imaging physics residency program standards with the rotation(s) in which the topics is(are) addressed. Approximately thirty-five percent of each resident's time will be spent on two or more clinical projects of particular importance to actual clinical practice, with each project reviewed and approved by the Steering Committee.

The overview listing in Table III is provided in conjunction with the detailed rotation descriptions contained in Appendix C. In each description, the competency goals are described, the method of evaluation is presented, reference materials are provided, and the duration of the rotation is defined. Common basic requirements across all 10 rotations are provided below.

Table III: Overview of the Imaging Physics Residency Program Rotations

Imaging Physics Residency Fundamental Rotations (1-9) and Additional Topics	Approx Percent of Residency
1. Radiography, including digital (CR/DR) imaging systems	10
2. Fluoroscopy, including image intensifiers and digital systems	5
3. Angiography, including interventional and cardiology applications	5
4. Mammography, including tomosynthesis and stereotactic breast biopsy systems	5
5. CT	10
6. MR	8
7. US	7
8. Nuclear medicine, including PET/CT (overview, not an area of specialization)	5
9. Informatics, including PACS, computer networks, and teleradiology	5
Ethics, leadership, and professionalism	5
Extended experience in two or more of the above modalities (following Steering Committee approval), including clinical projects	35
Total	100

<u>Basic Requirements for Education and Training in Each Modality:</u>

Testing of imaging systems will include understanding of state and federal regulations and testing requirements (including testing frequency), any Joint Commission requirements, and any accreditation program requirements, *e.g.*, ACR.

Residents will learn proper documentation of test results.

Residents will learn proper interpretation and reporting of test results. This comprises the creation of an accurate and understandable test report, including recommendations for improvements in image quality and safety as well as documentation of any deficiencies involving state and federal regulations and testing requirements, any Joint Commission requirements, and/or any accreditation program requirements.

Residents must demonstrate the ability to interpret reports for clinical staff and answer questions about the report from the clinical staff.

Residents also must demonstrate an ability to understand clinical problems encountered in each medical imaging modality, along with problem solving methods.

Table IV: Sample Training Plan – First Year Rotation Schedule

Month	Intro to Imaging Systems*	Intro to PACS, Informatics	Radio-graphy	Fluoro	Angio	Mammo	CT	MRI	US	NM
1	X	X								
2			X							
3			X							
4			x	X						
5				x	X					
6					x	X				
7						x	X			
8							X			
9							x	X		
10								X		
11									X	
12									x	X

*Includes review and assessment of imaging physics fundamentals using the *Essential Physics of Medical Imaging, Third Edition* by Bushburg, *et al.* and other relevant materials.

X: Initial clinical introduction to modality

x: Partial month overlap

Notes:

1) The specific timings of some of these rotations will change year-to-year depending on availability of equipment and personnel. The total time allocated to each rotation, however, will remain constant.

2) Continuing education and training and further testing experience as imaging systems are scheduled for acceptance testing and/or annual system performance testing will be provided in the second year, along with clinically-directed projects, *etc*.

In addition to the log of clinically-directed project activities discussed in Section 8, a log of activities for each clinical modality rotation is maintained by the resident in a separate folder in his/her LabArchives ELN and shared with the clinical rotation mentor for the modality. Each week, the clinical rotation mentor will review and sign off on completed activities, noting any deficiencies or concerns. In this manner, the resident will have frequent feedback during the rotation. The ELN will also be shared with the Associate Director to allow his/her review at least twice during each rotation.

The log of activities details the description of the task, date of performance, site where primary activity took place, model and description of imaging instrument tested, and role the resident played. A column is provided for the mentor to indicate his/her approval for successful completion of a particular activity (column 6, "Mentor Eval").

Competencies that involve the testing and evaluation imaging systems, analysis of the test data, and the creation of test reports shall be evaluated at three successive levels of completion. Each level of completion will be documented by the preceptor:

(1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis,

(2) Participation in the testing and in data collection under the supervision of the preceptor and assistance in report writing,

(3) Performing testing tasks without significant oversight, and the creation of an entire report with only review by the preceptor.

Table V: Elements of the log used by our first resident for the CT rotation are shown in this table

Date	Description	Site	Model	Role	Mentor/Eval
12/18/2013	Acceptance Test/ ACR Accreditation Tests	WIMR basement	GE Discovery 710 PET/CT.	Testing - Level 1: Observation and Minor Assistance, No Report Writing	FR/Passed
etc.					

Specific rotations emerged out of the lists of tasks that are performed by clinical imaging physicists at UWHealth as well as from the CAMPEP residency standards. As new imaging techniques come online, rotations will be adapted or new rotations will be implemented to accommodate the need.

Evaluations of the current rotation schedule and content will occur annually during regular meetings of the Steering Committee. Input from current residents and, whenever possible, from previous residents, will be important when considering modifications to the program.

As listed in Section 3, "Program Structure and Governance", imaging facilities in UWHC, AFCH, TAC, WIMR, and imaging clinics of the UWMF are employed in this residency. Each year, a Memorandum of Understanding (MOU) between the Department of Medical Physics RPS and the UWHC is executed. The MOU defines the services to be provided by the RPS to the UWHC, AFCH, TAC, and UWMF and the compensation to the RPS for such services. Beginning with the 2016-17 version of the MOU, explicit inclusion of imaging physics resident education and training has been included.

Appendix C provides detailed outlines for each scheduled rotation. The specific training objectives are presented in the competencies section. Each rotation has a description of the methods that will be used to assess progress. At the beginning of each rotation, the clinical rotation mentor and resident will meet to discuss the objectives, assess the degree of familiarity the resident has with the rotation topic, and agree on any additional didactic material that may be required prior to initial work with the imaging device(s) at hand. In most cases, prerequisites for the rotation will have been met, and the initial meetings will be review and extension of graduate level knowledge. The mentor will also help the resident become familiar with clinical conferences pertaining to the rotation. For example, ultrasound rotation periods will be enhanced through attendance at the bimonthly sonographer meetings in the city of Madison, reading room collaborations with physician interpreters, and, where appropriate, direct observations of clinical scan procedures.

Each rotation module also contains a reading list to supplement the testing and report experience.

In addition to the modules listed above, each resident is required to attend at least three meetings of the Radiation Safety Committee.

Evaluation of Resident Progress

Residents are monitored through the program by the various faculty with whom they work and by the Associate Director and the Program Director. In addition to review of the activity logs, described above, annual meetings are held between the physics resident and the Steering Committee, which includes the Department of Medical Physics chair, to provide mutual evaluations and to discuss any issues related to resident education and training. Mentoring is also done in these meetings. Written and/or oral examination of the resident is performed by the clinical rotation mentors after the resident completes a given modality rotation. Failure of any of these exams will require the resident to address the deficiencies and be retested. Upon completion of each rotation, the clinical rotation mentor completes an online Qualtrics Survey Evaluation of the resident (Appendix J1). The evaluations are reviewed quarterly by the Associate Director and the Program Director and annually by the Steering Committee. The Program Director will meet quarterly with the resident to evaluate the resident's progress and will provide a written summary of the meeting to the resident. The resident also evaluates the clinical rotation mentor following each rotation (Appendix J2). The evaluations of the faculty by the resident are reviewed quarterly by the Program Director, Associate Program Director and the chair of the Department of Medical Physics. The chair of the Medical Physics Department will meet twice a year with each resident, the Program Director, and the Associate Program Director to discuss the resident evaluations of the faculty and provide feedback for the resident.

At the end of the first year of the program, the resident is given an oral examination that is coordinated by the Program Director and the Associate Director and involves the Residency Program physics faculty. If the resident does not pass the exam, the resident is placed on probation for 60 days. During that period, the resident is directed to concentrate in the area(s) of demonstrated weakness. At the end of the probation period, an oral exam is again conducted. If the resident does not pass the second offering of the exam, he/she is terminated from the Residency Program.

By the end of the first year, the resident is expected to be able to perform most quality assurance tests and prepare professional quality reports on the testing results under the supervision of the mentors but with significant self-sufficiency. Additionally, the senior resident is expected to be able to assist the mentors in demonstrating correct testing procedures and explaining physics concepts to a junior resident. By the completion of the second year, the resident is expected to be able to properly perform all the functions of an imaging physicist, as contained in the program modules, without the need for supervision.

A final oral examination is required at the end of the second year and will be administered by the Residency Program physics faculty in a setting similar to the ABR Part III oral examination.

In the event a resident does not make acceptable progress in completing the program, the Program Director and Associate Director will meet with the resident and discuss his/her deficiencies. Supplemental materials and guidance will be provided to the resident to make up for the deficiencies. The resident can be encouraged to audit courses to make up for his/her deficits, if appropriate. If, in spite of all these efforts, the resident shows lack of motivation or inability to follow up, the candidate's performance is reviewed by the Steering Committee. The committee can recommend the resident be placed on probation, with clear statement of the means by which the resident can end the probationary period, or can recommend to the chair of the Department of Medical Physics that the resident be expelled from the program.

Ethics and Professionalism Curriculum

Residents will take the UW-Madison Medical Physics Program graduate course, MP 701 *Ethics and Responsible Conduct of Research and in the Practice of Medical Physics*. The course will be waived for residents who provide transcripts showing evidence of having taken an equivalent graduate course. Additionally, residents will participate in the workshop *Leadership* offered by the University of Wisconsin Office of Continuing Studies.

Table VI: Specific Topics in Ethics and Professionalism Addressed During the Residency

Professionalism and Ethics	How covered	Comments
Professionalism	MP701 *Ethics and the Responsible Conduct of Research and Practice of Medical Physics*. Professionalism is a constant topic throughout the MP701 course.	
Definition of a profession and professionalism	Each clinical rotation/module	
Elements of a profession	Each clinical rotation/module	
Definition of a professional	Each clinical rotation/module	
Elements of professionalism	MP701, discussed in each lecture	
How is professionalism judged?	MP701, discussed in each lecture	
Do's and don'ts of professionalism	MP701, discussed in each lecture	
Physician's charter and applicability to physicists	MP701, Class 8, Ethics in a medical setting	
Leadership	MP701, The importance of ethics and leaderships is discussed in class 1 and classes throughout the semester. Elements of leadership in Medical Physics is discussed during each clinical rotation, both during introductory discussions and during hands on clinical work and summaries of reports.	
Vision and charisma		
Qualities of leaders		
Rules of leadership		
Causes of leadership failure		
Ethics	MP 701	
Ethics of a profession	MP701, Class 1 and 7 From the first class discussion, we aim to illuminate the role the resident will have in society and the importance of ethics in daily life.	
Ethics of an individual	MP701, Classes 1 and 5 The class on human subjects (class 5) specifically discusses issues of ethics in individuals.	
Interactions with colleagues and co-workers	MP701, Classes 1-3 and 8 Interaction with colleagues is analyzed from different angles, including authorship and negotiation of decisions that affect patients as well as professional societies.	
Interactions with patients and the public	MP701, Classes 1, 3, 5-6 on clinical research and human	

	subjects. This topic is analyzed from the point of view of a resident interacting with patients, and addresses COI as well as an issue for confidentiality and trust.	
Confidentiality	MP701, Classes 1-6 and 8 In depth discussion with relationship to human subjects but also as an important aspect of being a professional, including reviewing papers, and using social media.	
Peer review	MP701, Classes 2 and 3 What defines a peer review, when it is applied, and how it affects our gaining of knowledge is covered mainly in classes 2 and 3, but also throughout the course.	
Negotiation skills	MP701, Classes 1, 3 and 4 The class on law and ethics (class 4) provides particular insight on contracts.	
Relationships with employers	MP701, Classes 1, 4, and 8	
Conflicts of interest	MP701, Class 3 is devoted to COI	
Ethics in research	MP701, Ethics in research is discussed throughout the course	
Use of animals in research	MP701, Class 7. A key practical aspect is the point by point analysis of what an IACUC does and case studies of IACUC protocols to see how they are filled out.	
Use of humans in research	MP701, Classes 5 and 6. Both classes are devoted to clinical research, providing historical background as well as practical information.	
Relationships with vendors	MP701, Class 3	This topic is covered in depth in class 3, which focuses on COI.
Publication ethics	MP701, Classes 2 and 3	Class 2 analyzes in depth the issues in data reporting, while class 3 further discusses how COI affects publications.
Ethics in graduate and resident education	MP701, Classes 1 and 8	Class 1 analyzes the role of mentor and mentees, while class 8 provides insight on resident life.
Selected case studies	MP701, discussed in each lecture	In every class different case studies and ethical questions are presented for discussion.

Sample Training Plan – Please see Table IV

Imaging Physics Residency Curriculum

Minimum requirements are described below for completing a residency in imaging physics. For tests to be conducted, the number of systems to be tested to demonstrate competency is left to the discretion of the Program Director, the Associate Director, and the clinical rotation mentor, except for systems where accrediting agencies define the minimum number of systems that must be tested for an individual to be considered a qualified medical physicist, *e.g.,* MQSA. In these cases, the minimum number of systems to be tested shall be at least the number specified by the accrediting/regulatory agency. For topics that define quantities that may be measured or computed, the resident should perform actual measurements or computations to demonstrate familiarity with the quantities and their uses.

The following topics, listed in their order of appearance in the CAMPEP Standard for Residency Training, are covered as part of this Imaging Physics Residency. Please refer to the individual modules in Appendix C for details of each module.

Table VII: Mapping of CAMPEP Residency Program Standards to UW Imaging Physics Residency Rotations

System performance evaluations and quality control, safety and compliance tests, including vendor recommendations

Training Topic	Rotation(s) in Appendix C
Radiography	Radiography
Computed Radiography	Radiography; Mammography
Fluoroscopy	Fluoroscopy
Interventional/angiography	Angiography
Mammography	Mammography
Stereotactic breast biopsy	Mammography
Computed Tomography	CT
Magnetic Resonance	MR
Ultrasound	Ultrasound
Image Processors/printers	Mammography

Safety evaluations

Training Topic	Rotation(s) in Appendix C
Entrance exposure estimates	Radiography; Fluoroscopy; Angio; Mammography; CT
Organ dose estimates	Radiography; Fluoroscopy; Angio; Mammography; CT; Nuclear Medicine
Computed tomography dose index (CTDI) and dose length product (DLP)	CT

Mean glandular dose	Radiography; Fluoroscopy; Angio; Mammography; CT
Effective dose	Radiography; Fluoroscopy; Angio; Mammography; CT; Nuclear Medicine
Risk estimates	Radiography; Fluoroscopy; Angio; Mammography; CT; Nuclear Medicine
Personnel exposure estimates and reduction	Radiography; Fluoroscopy; Angio; Mammography; CT; Nuclear Medicine
Fetal dose	Radiography; Fluoroscopy; Angio; CT
Contrast agents	Fluoroscopy; Angiography; CT; MRI; Ultrasound
Protocol optimization	Radiography; Fluoroscopy; Angio; Mammography; CT; MR
MRI hazards	MR
Organ/fetal dose with MIRD system	Nuclear Medicine
Radiopharmaceutical applications and risks	Nuclear Medicine
Shielding design	Radiography; Fluoroscopy; Angio; Mammography; CT; MR; Nuclear Medicine
Personnel shielding/monitoring	Radiography
Calibration and survey instruments	Radiography, Fluoroscopy; Nuclear Medicine
Radiation surveys	Radiography; Fluoroscopy; Angio; Mammography; CT
Safety/policies	Radiography; Fluoroscopy; Angio; Mammography; CT; MR; Ultrasound; Nuclear Medicine
Compliance audits	Radiography; Fluoroscopy; Angio; Mammography; CT; MR; Ultrasound; Nuclear Medicine
Dose limits	Radiography; Fluoroscopy; Angio; Mammography; CT; Nuclear Medicine

<u>Informatics</u>

Training Topic	**Rotation in Appendix C**
Picture archiving and communication systems (PACS) and radiology information systems (RIS)	Informatics
Digital imaging and communication systems (DICOM) standards	Informatics
Information acquisition from PACS/images	Informatics
Informatics variations among modalities	Informatics
Dose reporting	Informatics
Use of Integrating the Healthcare Enterprise (IHE) radiology profiles	Informatics
Open source software resources	Informatics
Quality/maintenance of imaging workstations	Informatics
Evaluation of viewing conditions	Informatics
Image registration, fusion, segmentation, processing	Informatics
Computer-aided detection (CAD) and computer-aided diagnosis (CADx) systems	Informatics

10. Admissions

As noted in Section 2, the Program preferentially admits graduates of CAMPEP-accredited graduate medical physics programs. If an applicant who is not a graduate of a CAMPEP-accredited medical physics graduate program or is an "alternative pathway" Ph.D. degree applicant is admitted to the program, any remedial didactic coursework that must be addressed to satisfy the CAMPEP Standards for graduate education will be completed outside of the 24-month clinical imaging physic education and training, *i.e.,* the duration of the education and training requirements for such an individual may require more than 24 months.

The current recruitment goal is to admit one resident per year to maintain two residents, one junior and one senior, in the program at all times. If additional stipend funding is obtained, the number of residents in the program at steady state would still not exceed 3-4 given current faculty time and availability.

The UW-Madison Imaging Physics Residency Program will, beginning in fall 2016, utilize the AAPM Medical Physics Residency Application Program (MP-RAP) for the application and review process for admissions. Applicants will be referred to the Imaging Physics Residency Program information on the Department of Medical Physics website for basic information on the residency program, descriptions of the program faculty and resources, information on the program rotations and other requirements for completion, financial information (including stipend and benefit specifics), and contact information for the Program Director and the Associate Director.

Resident application materials obtained through the MP-RAP are reviewed by the Steering Committee, which identifies top applicants to be invited for an on-site interview. The interview process involves one-on-one interviews with the Program Director, the Associate Program Director, and the chair of the Department of Medical Physics. The applicant will also interview with each of the medical physics members, and at least one physician member, of the Steering Committee. Following all interviews for a given cycle, the Steering Committee will meet to prepare a prioritized admissions list which will be submitted for the MedPhys Match process. Once the matched resident(s) is(are) identified, the offer letter(s) will be prepared by the Program Director and Associate Director and reviewed/approved and distributed by the chair of the Department of Medical Physics. The offer letter states the matriculation date, stipend and benefit levels, *etc*. A sample letter is provided in Appendix I.

11. Future Plans

Current Strengths:

Current strengths of the program include the leveraging of one of the largest and oldest medical physics graduate programs in North America, an extensive and advanced installed base of medical imaging equipment in a large academic hospital as well as regional clinic environments, and active participation by both medical physics faculty and academic radiology faculty.

Future Goals:

Once CAMPEP accreditation of the program is achieved, we will actively seek to identify sources of additional funding with which to expand the number of resident positions from the current goal of two at any time to a future goal of 3-4 residents. If this is achieved, we will also investigate options to offer a nuclear medicine specialization option.

Appendix B - Documentation of Institutional Accreditation

The Joint Commission "Quality Check" documentation of the accreditation of the UWHC is provided below. Other clinics cited in this self study are included as DBA affiliates of UWHC. Any additional documentation of accreditation will be provided on request.

The Joint Commission

HELPING HEALTH CARE ORGANIZATIONS HELP PATIENTS

Quality Check

Accreditation Quality Report

> Summary of Accreditation Quality Information

> Accredited Programs

> Accreditation National Patient Safety Goals

> Sites and Services

> Accreditation History

> Download Accreditation PDF Report

> Download Accreditation PDF Report - Include Quarterly Data

> Accreditation Quality Report User Guide

> Organization's Commentary

Certification Quality Report

> View Certification Quality Report

Quality Report

Summary of Quality Information

University of Wisconsin Hospitals and Clinics Authority
Org ID: 7656
600 Highland Avenue
Madison, WI 53792
(608)890-7609
www.uwhealth.org

Accreditation Programs	Accreditation Decision	Effective Date	Last Full Survey Date	Last On-Site Survey Date
Home Care	Accredited	11/20/2014	11/19/2014	1/28/2016
Hospital	Accredited	11/22/2014	11/21/2014	11/21/2014
Laboratory Accreditation Program	Accredited	10/29/2015	10/28/2015	10/28/2015

Accreditation programs recognized by the Centers for Medicare and Medicaid Services (CMS)

Pathology and Clinical Laboratory
Home Health Agency
Durable Medical Equipment, Prosthetics, Orthotics, and Supplies (DMEPOS)
Hospital

Advanced Certification Programs	Certification Decision	Effective Date	Last Full Review Date	Last On-Site Review Date
Advanced Comprehensive Stroke Center	Certification	10/22/2014	10/21/2014	10/21/2014
Advanced Palliative Care	Certification	8/15/2015	8/14/2015	8/14/2015
Inpatient Diabetes	Certification	5/29/2014	3/20/2014	3/20/2014
Ventricular Assist Device	Certification	7/18/2014	7/17/2014	7/17/2014

Certification programs recognized by the Centers for Medicare and Medicaid Services (CMS)

Ventricular Assist Device

Other Accredited Programs / Services

Laboratory Accreditation Program - Accredited by American Society for Histocompatibility and Immunogenetics (ASHI)

Special Quality Awards

- 2014 Top Performer on Key Quality Measures®
- 2015 Metabolic and Bariatric Surgery Accreditation and Quality Improvement Program
- 2014 Hospital Magnet Award
- 2013 Gold Get With The Guidelines - Stroke
- 2012 ACS National Surgical Quality Improvement Program
- 2012 Silver - The Medal of Honor for Organ Donation

Appendix C – Clinical Rotation Summaries

Rotation Title: Radiography

Preceptor/Mentor: **John Vetter, PhD, DABR, Frank Ranallo, PhD, DABR**

Duration: **10 Weeks**

≈ 200 hours – Physics Surveys and Report Generation

≈ 170 hours – Study: technical considerations of radiographic imaging, modality testing, dose considerations, exposure and patient dose calculations, facility design considerations, components of image quality, image quality vs. patient dose

≈ 30 hours – Presentation of in-service training for clinical staff, Radiology Resident physics training, attendance of Radiology Grand Rounds and Medical Physics Seminars, other interactions with clinical staff.

Recommended References:

The Essential Physics of Medical Imaging – 3rd Edition, Bushberg JT, *et al.*, Chapters 1-4, 6-7, 11, 21.

Imaging Systems for Medical Diagnostics – 4th Edition, Oppelt A (ed).

Specifications, Performance Evaluation, and Quality Assurance of Radiographic and Fluoroscopic systems in the Digital Era, Goldman LW and Yester MV (ed), AAPM Monograph No. 30.

Practical Digital Imaging and PACS, Seibert JA, et. al. (ed), AAPM Monograph No. 25.

Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment, Seibert JA, *et al.* (ed), AAPM Monograph No. 20.

Advances in Digital Radiography, Categorical Course in Diagnostic Radiology Physics, Samei, E (ed), RSNA.

Ongoing Quality Control in Digital Radiography: Report of AAPM Imaging Physics Task Group 151, AAPM Report #151.

Acceptance Testing and Quality Control of Photostimulable Storage Phosphor Imaging Systems, AAPM Report #93.

Quality Control in Diagnostic Radiology, AAPM Report #74.

Code of Federal Regulations, Title 21, Chapter 1, Subchapter J, Part 1020

Wisconsin Chapter DHS 157 – Radiation protection, and other state radiation protection regulations

Evaluation Scheme:

Competencies 1 and 2 involve achieving an understanding of the basic technical and physics principles of radiography. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident. The preceptor will document in the ELN the date on which the resident has satisfied each of these competencies. They should be satisfied during first part of the radiography rotation

Competencies 3 through 7 involve the testing and evaluation of actual radiographic systems, analysis of the test data, and the creation of test reports. These competencies are evaluated at three successive levels of completion. Each level of completion will be documented by the preceptor:

(1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis,

(2) Participation in the testing and in data collection under the supervision of the preceptor and assistance in report writing,

(3) Performing testing tasks without significant oversight, and the creation of an entire report with only review by the preceptor.

Levels 1 and 2 should be satisfied by the completion of the radiography rotation. Level 3 must be completed before the end of the residency. The resident will normally participate in the testing of at least 4 radiographic systems at level 2 and at least 4 radiographic systems at level 3.

Competencies 8 through 12 involve activities beyond simply testing radiographic systems and creating reports. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident, and/or satisfactory completion of its stated activities, as appropriate. The preceptor will determine the date on which the resident has satisfied each of these competencies. Many may be satisfied during the radiography rotation, but they must be satisfied by the end of the residency.

For each competency the completion of the competency is documented, signed and dated by the resident and preceptor upon its completion. Additionally the completion of each of the first two levels of completion of competencies 7 and 8 is also documented, signed and dated by the resident and preceptor upon its completion.

Materials produced during the course of the rotation, such as final test reports and any presentations, will be assessed for completion and accuracy and graded as “complete” or “incomplete”.

List of Competencies:

1. Understand the process of x-ray generation and the proper testing methods and data analysis for testing involving evaluation of the x-ray tube, collimator, cassette tray, and generator. Perform accurate testing and analysis of these components.
2. Understand the physics and technology of various image receptors: screen-film, CR, and DR and of the exposure indicators for digital image receptors. Understand the proper testing methods and data analysis for the testing of these image receptors. Perform accurate testing and analysis of these image receptors including evaluation of the exposure indicators and also the processor for CR.
3. Understand how to test for the presence of image artifacts due to the imaging system or to the image receptor. Understand the proper testing methods and data analysis for the

detection of image artifacts. Perform accurate testing and analysis to identify image artifacts and to determine their causes.

4. Understand the design and function of anti-scatter grids and the proper testing methods and data analysis for evaluating grid. Perform accurate testing and test analysis of grids.
5. Understand the physics and technology of automatic exposure control (AEC) systems. Understand the proper testing methods and data analysis for the testing of these systems. Perform accurate testing and analysis of AEC systems.
6. Understand federal and state regulations applicable to radiographic systems including operational tolerances and requirements for compliance with these regulations.
7. Understand how each of the previous six items is properly combined into a complete system test. Understand how to identify and analyze problems detected in these tests and the corrective actions that can be performed for operational improvements. Understand how to report system deficiencies that do not comply with government regulations. Understand how to report other types of system deficiencies that are detected. Understand how to create an accurate and understandable report for the health care faculty responsible for the radiographic equipment. Create actual reports of the results of system testing.
8. Understand design considerations for a new or remodeled facility including reading room design, radiation shielding requirements, and equipment selection. Participate in these activities with other clinical personnel.
9. Understand the requirements for reviewing radiation shielding designs for new or remodeled rooms, inspections during the actual construction process, and the creation of a radiation shielding report for submission to the health care facility and to the state. Assist in each of these processes.
10. Understand the processes for obtaining approval to operate radiographic imaging facilities and modalities including state licensing and the legal requirements. Assist in these processes as opportunities arise.
11. Understand how to calculate estimates of entrance exposures, organ doses, effective doses, and fetal doses. Perform calculations of these exposures/doses.
12. Understand the principles of personnel radiation safety and monitoring both for the clinical personnel and for the persons performing equipment evaluations. Answer radiation safety questions and provide guidance in radiation safety to the clinical staff. Use proper radiation safety techniques while performing medical physics duties.

Rotation Title: Fluoroscopy

Preceptor/Mentor: **John Vetter, PhD, DABR, Frank Ranallo, PhD, DABR**

Duration: **5 Weeks**

≈ 100 hours – Physics Surveys and Report Generation

≈ 75 hours – Study: technical considerations of radiographic imaging, modality testing, dose considerations, exposure and patient dose calculations, facility design considerations, components of image quality, image quality *vs*. patient dose

≈ 25 hours – Presentation of in-service training for clinical staff, Radiology Resident physics training; attendance of Radiology Grand Rounds and Medical Physics Seminars; interactions with clinical staff.

Recommended References:

The Essential Physics of Medical Imaging – 3rd Edition, Bushberg JT, *et al.*, Chapters 4, 9, 11, 21.

Imaging Systems for Medical Diagnostics – 4th Edition, Oppelt A (ed).

Specifications, Performance Evaluation, and Quality Assurance of Radiographic and Fluoroscopic systems in the Digital Era, Goldman LW and Yester MV (ed), AAPM Monograph No. 30.

Practical Digital Imaging and PACS, Seibert JA, *et al*. (ed), AAPM Monograph No. 25.

Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment, Seibert JA, *et al.* (ed), AAPM Monograph No. 20.

Advances in Digital Radiography, Categorical Course in Diagnostic Radiology Physics, Samei, E (ed), RSNA.

Ongoing Quality Control in Digital Radiography: Report of AAPM Imaging Physics Task Group 151, AAPM Report #151.

Acceptance Testing and Quality Control of Photostimulable Storage Phosphor Imaging Systems, AAPM Report #93.

Quality Control in Diagnostic Radiology, AAPM Report #74.

Code of Federal Regulations, Title 21, Chapter 1, Subchapter J, Part 1020

Wisconsin Chapter DHS 157 – Radiation protection, and other state radiation protection regulations

Evaluation Scheme:

Competencies 1 and 2 involve achieving an understanding of the basic technical and physics principles of fluoroscopy. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident. The preceptor will document in the ELN the date on which the resident has satisfied each of these competencies. They should be satisfied during the first part of the fluoroscopy rotation

Competencies 3 through 11 involve the testing and evaluation of actual fluoroscopic systems, analysis of the test data, and the creation of test reports. These competencies are evaluated at three successive levels of completion. Each level of completion will be documented by the preceptor (for an example see Table V):

(1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis,

(2) Participation in the testing and in data collection under the supervision of the preceptor and assistance in report writing,

(3) Performing testing tasks without significant oversight, and the creation of an entire report with only review by the preceptor.

Levels 1 and 2 should be satisfied by the completion of the fluoroscopy rotation. Level 3 must be completed before the end of the residency. The resident will normally participate in the testing of at least 4 fluoroscopic systems at level 2 and at least 3 fluoroscopic systems at level 3.

Competencies 12 through 16 involve activities beyond simply testing fluoroscopic systems and creating reports. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident, and/or satisfactory completion of its stated activities, as appropriate. The preceptor will determine the date on which the resident has satisfied each of these competencies. Many may be satisfied during the fluoroscopy rotation, but they must be satisfied by the end of the residency.

For each competency the completion of the competency is documented, signed and dated by the resident and preceptor upon its completion. Additionally the completion of each of the first two levels of completion of competencies 7 and 8 is also documented, signed and dated by the resident and preceptor upon its completion.

Materials produced during the course of the rotation, such as final test reports and any presentations, will be assessed for completion and accuracy and graded as “complete” or “incomplete”.

List of Competencies:

1. Understand all of the competencies that are listed in the radiographic imaging section since the evaluation of fluoroscopic systems includes a subcomponent of radiographic imaging; fluoroscopic systems produce radiographic images (spot images or digital acquisition images). These competencies most importantly include:
   a. Understand the process of x-ray generation and the proper testing methods and data analysis for testing involving evaluation of the x-ray tube, collimator, and generator. Perform accurate testing and analysis of these components.
   b. Understand the physics and technology of various image receptors: screen-film, CR, and DR and of the exposure indicators for digital image receptors. Understand the proper testing methods and data analysis for the testing of these image receptors. Perform accurate testing and analysis of these components.
2. Understand the equipment technology and physics of fluoroscopic systems, beyond those of radiographic systems. This includes the production of real time images and the technology required to accomplish this: Image intensifiers and TV cameras as image receptors and also digital flat panel detectors with the ability to properly produce multiple images per second at

lower dose rates; technology dealing with patient motion and image noise reduction; the functioning of automatic exposure rate control (AERC) to control fluoro doses.

3. Additionally understand how to test for the accuracy of fluoro image receptor diameters, fluoro collimator adjustments, image/ x-ray field congruence, and fluoro image distortions. Perform accurate testing when indicated.
4. Understand how to test for the presence of image artifacts due to the imaging system or to the image receptor. Understand the differences in test methods and in the causes of artifacts occurring during fluoroscopic operation and those occurring during spot film or digital image acquisition. Understand the proper testing methods and data analysis for the detection of image artifacts. Perform accurate testing and analysis to identify image artifacts and to determine their causes.
5. Understand the design and function of anti-scatter grids and the proper testing methods and data analysis for evaluating grid. Understand the difference in grid use for fluoroscopic imaging and spot film or digital image acquisition. Understand how to remove the grid from the fluoroscopic system and when this is appropriate. Perform accurate testing and test analysis of grids when indicated.
6. Understand the physics and technology of automatic exposure rate control (AERC) systems for fluoroscopic operation and automatic exposure control (AEC) systems for spot film or digital imaging acquisition. Understand the proper testing methods and data analysis for the testing of these systems. Perform accurate testing and analysis of these systems.
7. Understand how to properly measure high contrast resolution and sharpness uniformity over the images. Perform accurate testing and analysis of this function.
8. Understand how to properly measure low contrast detectability over different exposure rate conditions. Perform accurate testing and analysis of this function.
9. Understand how to properly measure the x-ray fluoro entrance exposure rates with different phantoms during x-ray fluoroscopy and to how to properly measure the maximum fluoroscopy x-ray entrance exposure rate according to government regulations. Perform accurate testing and analysis of these functions.
10. Understand federal and state regulations applicable to fluoroscopic systems including operational tolerances and requirements for compliance with these regulations.
11. Understand how each of the previous items is properly combined into a complete system test. Understand how to identify and analyze problems detected in these tests and the corrective actions that can be performed for operational improvements. Understand how to report system deficiencies that do not comply with government regulations. Understand how to report other types of system deficiencies that are detected. Understand how to create an accurate and understandable report for the health care faculty responsible for the radiographic equipment. Create actual reports of the results of system testing.
12. Understand design considerations for a new or remodeled facility including reading room design, radiation shielding requirements, and equipment selection. Participate in these activities with other clinical personnel.
13. Understand the requirements for reviewing radiations shielding designs for new or remodeled rooms, inspecting shielding installation during the actual construction process, and the creation of

a radiation shielding report for submission to the health care facility and to the state. Assist in each of these processes.

14. Understand the processes for obtaining approval to operate radiographic and fluoroscopic imaging facilities and modalities including state licensing and the legal requirements. Assist in these processes as opportunities allow.
15. Understand how to calculate estimates of entrance exposures, organ doses, effective doses, and fetal doses. Perform calculations of these exposures/doses.
16. Understand the principles of personnel radiation safety and monitoring both for the clinical personnel and for the persons performing equipment evaluations. Answer radiation safety questions and provide guidance in radiation safety to the clinical staff. Use proper radiation safety techniques while performing medical physics duties.

Rotation Title: Angiography and Interventional Radiology

Preceptor/Mentor: **John Vetter, PhD, DABR, Michael Speidel, PhD, Frank Ranallo, PhD, DABR**

Duration: **5 Weeks**

≈ 50 hours – Physics surveys and report generation

≈ 50 hours – Study: technical considerations of angiographic imaging, staff and patient dose considerations, components of image quality, image quality vs. patient dose

≈ 50 hours – Study: clinical considerations of angiographic imaging, observation of clinical procedures in Radiology and Cardiology, patient dose calculations, facility design considerations

≈ 50 hours – Presentation of training for clinical staff, Radiology residents, and Cardiology fellows, other interactions with staff and hospital managers.

Recommended References:

The Essential Physics of Medical Imaging – 3rd Edition, Bushberg JT, *et al.*, Chapters 4, 9, 11, 21.

Imaging Systems for Medical Diagnostics – 4th Edition, Oppelt A (ed).

Specifications, Performance Evaluation, and Quality Assurance of Radiographic and Fluoroscopic systems in the Digital Era, Goldman LW and Yester MV (ed), AAPM Monograph No. 30.

Radiation Dose Management for Fluoroscopically-Guided Interventional Medical Procedures, NCRP Report No. 168, 2013.

Accuracy and calibration of integrated radiation output indicators in diagnostic radiology, AAPM Report 190, 2015.

A Guide for Establishing a Credentialing and Privileging Program for Users of Fluoroscopic Equipment in Healthcare Organizations, AAPM Report 124, 2012

Cardiac Catheterization Equipment Performance, AAPM Report 70, 2001

Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment, Seibert JA, et. al. (ed), AAPM Monograph No. 20.

Advances in Digital Radiography, Categorical Course in Diagnostic Radiology Physics, Samei, E (ed), RSNA.

Ongoing Quality Control in Digital Radiography: Report of AAPM Imaging Physics Task Group 151, AAPM Report #151.

Quality Control in Diagnostic Radiology, AAPM Report #74.

Code of Federal Regulations, Title 21, Chapter 1, Subchapter J, Part 1020

Wisconsin Chapter DHS 157 – Radiation protection, and other state radiation protection regulations

Evaluation Scheme:

Competencies 1(a)-(b) and 2 involve achieving an understanding of the basic technical and physics principles of x-ray imaging. These competencies will be evaluated by the preceptor by oral examination of the resident. The preceptor will document in the ELN the date on which the resident has satisfied this competency. It should be satisfied during first part of the angiography rotation.

Competencies 3(a)-(h) involve the testing and evaluation of actual angiographic systems, analysis of the test data, and the creation of test reports. These competencies are evaluated at three successive levels of completion which will be documented by the preceptor: (1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis, (2) Participation in the testing and in data collection under the supervision of the preceptor and assistance in report writing, and (3) Performing testing tasks without significant oversight, and the creation of an entire report with only review by the preceptor. Levels 1 and 2 should be satisfied by the completion of the fluoroscopy rotation. Level 3 must be completed before the end of the residency. The resident will normally participate in the testing of at least 2 fluoroscopic systems at level 2 and at least 2 fluoroscopic systems at level 3.

Competencies 4(a)-(d) involve learning the unique features of an x-ray angiographic system and gaining in-depth knowledge of the application of angiographic systems. Residents will study the design of actual angiographic systems used for cardiology, electrophysiology, pediatric cardiology, peripheral vascular, interventional radiology, and neuro-interventional radiology. The resident will learn the use of the angiographic system in each setting through observation of clinical procedures. In initial sessions, the preceptor will be present, and the resident's knowledge will be evaluated through oral examination. After the resident has gained sufficient competency, additional observation sessions will be performed by the resident alone. The resident will normally observe at least 5 procedures each in 6 different clinical settings by the end of residency. A presentation for physics training of radiology residents and cardiology fellows will be used to evaluate competency.

Competencies 5(a)-(c) involve learning and applying radiation safety principles in the angiographic / interventional setting. Residents will study the components of a radiation safety program for protection of patient and staff. A presentation on radiation safety and best practices will be used to document and evaluate the competency of the resident. Experience in the interpretation of patient dose reports will be gained through analysis of a series of cases from a cath lab. Written reports with dose calculations will be reviewed by the preceptor to document competency.

Competencies 6(a)-(c) involve learning the process of purchasing, planning, and installing an x-ray angiographic system. The residents and preceptor will meet hospital managers to discuss clinical needs and, as opportunities arise, attend meetings on the planning of room construction. Residents will participate in room layout and shielding calculations. Meeting activities and shielding reports will be documented by the preceptor.

For each competency the completion of the competency is documented, signed and dated by the resident and preceptor upon its completion. Materials produced during the course of the rotation, such as final test reports and any presentations, will be assessed for completion and accuracy and graded as "complete" or "incomplete".

List of Competencies:

1. Understand the competencies in the radiographic and fluoroscopic imaging sections related to the technical and physics principles of x-ray image generation. In particular,
    a. Understand the process of x-ray generation and the tests used to evaluate the x-ray tube, collimator, and generator.
    b. Understand the physics and technology of various image receptors and the methods used to test these image receptors.
2. Additionally, understand the technology and physics of fluoroscopic systems, beyond those of radiographic systems. This includes the production of real time images and the technological requirements to accomplish this.
3. Understand and apply the competencies listed in the fluoroscopic imaging section. An angiographic system is essentially a fluoroscopic system specialized for the imaging of contrast-enhanced vasculature and interventional devices. The following competencies need to be demonstrated on angiographic systems:
    a. Understand how to test for image/ x-ray field congruence, image distortion, and image artifacts. Perform accurate testing when indicated.
    b. Understand how to remove the anti-scatter grid from the system and when this is appropriate. Perform accurate testing of grids when indicated.
    c. Understand how to measure high contrast resolution and sharpness uniformity over the images. Perform accurate testing and analysis of this function.
    d. Understand how to measure low contrast detectability over different exposure rate conditions. Perform accurate testing and analysis of this function.
    e. Understand how to measure the maximum fluoroscopic entrance exposure rate, the accuracy of dose monitoring equipment and half value layer according to government regulations. Perform accurate testing and analysis of these functions.
    f. Understand the physics and technology of automatic exposure control (AEC) and how AEC behavior varies by imaging modes (e.g. fluoro vs. cine vs. DSA) and detector modes. Perform testing in different imaging modes.
    g. Understand federal and state regulations applicable to fluoroscopic systems including operational tolerances and requirements for compliance with these regulations.
    h. Understand how each of the previous items is properly combined into a complete system test. Understand how to identify and analyze problems and determine corrective actions. Understand how to report system deficiencies. Create an accurate and understandable report for the health care facility responsible for the radiographic equipment.
4. Understand differences in the design of an x-ray angiographic system versus a general fluoroscopic system, and how these systems are tailored to different clinical applications. Specifically,
    a. Understand mechanical architectures and their advantages and disadvantages. E.g. floor-mounted versus ceiling-hung C-arms, detector size, single-plane versus bi-plane, typical uses of biplane imaging.

b. Know the appropriate performance specifications of an angiographic x-ray tube (power level, filtration) and image receptor (frame rates, detector element size) for different clinical applications.

c. Understand all 2D imaging modes: fluoro, cine, digital subtraction angiography (DSA), rotational angiography. Understand all available 3D rotational modes, including rotational angiography, C-arm CT and 3D DSA.

d. Understand how AEC behavior and image processing varies by imaging mode (fluoro, cine, DSA). Know appropriate detector exposure rates for each mode.

e. Understand the operating principles of a contrast agent power injector.

5. Understand and apply principles of radiation safety for both the patient and staff.

   a. Understand the technology used to monitor patient dose during a procedure. Interpret dose information provided by an angiographic system and know typical threshold doses for radiation-induced effects. Calculate estimates of entrance exposures, organ doses, effective doses, and fetal doses.

   b. Understand the principles of personnel radiation safety and monitoring both for the clinical personnel and for the persons performing equipment evaluations. Answer radiation safety questions and provide guidance in radiation safety to the clinical staff.

   c. Understand the components of a program for managing patient and personnel dose information, and appropriate management of patients who have received high radiation doses, approaching or exceeding the threshold for skin reactions.

6. Understand and participate in activities associated with the purchase and installation of an x-ray angiographic system in a new or remodeled facility.

   a. Objectively compare different x-ray angiographic equipment and review their appropriateness for a given clinical application. Communicate a recommendation to the manager(s) responsible for equipment purchases.

   b. Understand design considerations for room layout, including review of radiation shielding requirements and creation of a radiation shielding report to the health care facility and to the state. Assist in these activities.

   c. Inspect the radiation shielding installation during the actual construction process, verify adequacy of shielding and understand the processes for obtaining approval to operate fluoroscopic imaging facilities including state licensing and the legal requirements. Assist in these processes as opportunities allow.

Rotation Title: Mammography

Preceptor/Mentor: **John R. Vetter, PhD, DABR, Frank N. Ranallo, PhD, DABR**

Duration: **5 Weeks**

≈ 100 hours – Physics Surveys and Report Generation

≈ 50 hours – Study: Mammography Quality Standards Act (MQSA) regulations, accreditation requirements, technical considerations of mammographic imaging, dose considerations, modality testing, facility design considerations,

≈ 25 hours – Mammography Continuing Medical Education (CME) completion

≈ 25 hours – Presentation of in-service training for clinical staff, Radiology Resident physics training, attendance of Radiology Grand Rounds and Medical Physics Seminars, other interactions with clinical staff.

Recommended References:

ACR Mammography Quality Control Manual, 1999

ACR Stereotactic Breast Biopsy Quality Control Manual, 1999

Selenia Dimensions Quality Control Manual

GE Senographe 2000D Quality Control Manual

Siemens Inspiration Quality Control Manual

MQSA Policy Guidance Help System

Dome MQSA Manual

McKesson MQSA Quality Control Manual

CareStream 5850 Quality Control Manual

The Essential Physics of Medical Imaging 3rd ed, Bushberg, *et al*., Chapter 8

Code of Federal Regulations, Title 21, Chapter 1, Subchapter J, Part 1020

Wisconsin Chapter DHS 157 – Radiation protection, and other state radiation protection regulations

Evaluation Scheme:

Competencies 1 and 2 involve achieving an understanding of basic technical and physics principles of mammography, radiation safety, ACR recommendations, and MQSA regulations. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident. The preceptor will document in the ELN the date on which the resident has satisfied each of these competencies. They should be satisfied early in the mammography rotation.

Competencies 3- 6 involve the testing and evaluation of mammography systems, analysis of the test data, and the creation of test reports. These competencies are evaluated at three successive levels of completion. Each level of completion will be documented by the preceptor:

(1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis,

(2) Participating in the testing and data collection with the preceptor and assisting in report writing,

(3) Performing testing with oversight by preceptor, and creating reports to be reviewed by the preceptor.

Competencies 7-14 involve activities beyond simply testing mammography systems and creating reports. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident, and/or satisfactory completion of the stated activities, as appropriate. The preceptor will determine the date on which the resident has satisfied each of these competencies. They may be satisfied during the mammography rotation, but they must be satisfied by the end of the residency.

Materials produced during the course of the rotation, including final survey reports and any presentations, will be documented in the electronic lab notebook, assessed for completion and accuracy and graded as “complete” or “incomplete”.

List of Competencies:

1. Understand technical requirements for different breast x-ray imaging modalities including film-screen, full-field digital, tomosynthesis, stereotactic biopsy, and contrast enhanced mammography.
2. Identify common artifacts in mammographic imaging and corrective action (if any) required.
3. Perform Annual MQSA and/or ACR Physics Survey on available units including full-field digital, tomosynthesis and stereotactic breast biopsy units, independently and without errors.
4. Perform reading room and workstation evaluation including monitor calibration.
5. Perform a Technologist’s QC program review.
6. Complete sufficient training to meet the initial training and experience requirements under MQSA. This includes a minimum of 20 contact hours of facility survey training including a minimum of 8 hours related to full-field digital mammography and 8 hours on digital tomosynthesis, with participation in a minimum of 10 physics surveys of mammography units and one complete facility survey.
7. Identify requirements for physics involvement resulting from repairs, upgrades and other changes to mammographic equipment and facilities, including lists of tests to be performed, by whom and at what time as well as any requirements for review of test results.
8. Obtain a working knowledge of requirements and recommendations related to accreditation and MQSA regulation of the mammography modalities.
9. Obtain a working knowledge of personnel requirements for Physicists, Technologists and Radiologists related to accreditation and MQSA certification.
10. Understand design considerations for a new or remodeled facility including reading room design, radiation shielding requirements and equipment selection.
11. Understand the processes for obtaining approval to operate mammographic imaging facilities and modalities including state licensing, accreditation, and MQSA certification for each modality.

12. Complete at least 15 hours of approved continuing medical education (CME) credits in mammography, including 3 credits related to stereotactic breast imaging.
13. Demonstrate the ability to measure and calculate skin dose, average glandular dose and effective dose related to mammographic x-ray imaging modalities and make meaningful comparisons to other sources of radiation exposure and risks.
14. Prepare and deliver presentations for clinical staff on mammography physics topics of interest such as radiation doses and risks, quality control procedures and technical aspects of x-ray mammographic imaging.

Rotation Title: CT

Preceptor/Mentor: **Frank Ranallo, PhD, DABR, Timothy Szczykutowicz, PhD**

Duration: **10 Weeks**

≈ 200 hours – Physics Surveys and Report Generation

≈ 170 hours – Study: technical considerations of radiographic imaging, modality testing, dose considerations, exposure and patient dose calculations, facility design considerations, components of image quality, image quality vs. patient dose

≈ 30 hours – Presentation of in-service training for clinical staff, Radiology Resident physics training, attendance of Radiology Grand Rounds and Medical Physics Seminars, other interactions with clinical staff.

Recommended References:

The Essential Physics of Medical Imaging – 3rd Edition, Bushberg JT, *et al.*, Chapters 10, 11.

Computed Tomography, 2nd Edition, Hsieh J.

Computed Tomography, 3rd Edition, Kalendar W.

ACR Quality Computed Tomography Quality Control Manual, 2012.

Other materials from the ACR regarding ACR accreditation of CT scanners.

Catphan® 500 and 600 Manual, The Phantom Laboratory.

MDCT Physics – The Basics, Mahesh M.

MDCT – From Protocols to Practice, Kalra MK, *et al.*, (ed).

Multislice CT – Principles and Protocols, Knollmann FK, Coakley FV (ed)

Imaging Systems for Medical Diagnostics – 4th Edition, Oppelt A (ed).

Use of Water Equivalent Diameter for Calculating Patient Size and Size-Specific Dose Estimates (SSDE) in CT: Report of AAPM Task Group 220, AAPM Report #220.

Size-Specific Dose Estimates (SSDE) in Pediatric and Adult Body CT Examinations, AAPM Report #204.

Comprehensive Methodology for the Evaluation of Radiation Dose in X-Ray Computed Tomography: Report of AAPM Task Group 111: The Future of CT Dosimetry, AAPM Report #111.

The Measurement, Reporting, and Management of Radiation Dose in CT, AAPM Report #96.

Specification, Acceptance Testing and Quality Control of Diagnostic X-ray Imaging Equipment, Seibert JA, *et al*. (ed), AAPM Monograph No. 20.

Operator and Technical manuals for various CT scanners.

Code of Federal Regulations, Title 21, Chapter 1, Subchapter J, Part 1020

Wisconsin Chapter DHS 157 – Radiation protection, and other state radiation protection regulations

Evaluation Scheme:

Competencies 1 through 6 involve achieving a basic understanding of the basic technical and physics principles of computed tomography. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident. The preceptor will document in the ELN the date on which the resident has satisfied each of these competencies. They should be satisfied during first part of the CT rotation

Competencies 7 and 8 involve the testing and evaluation of actual CT systems, analysis of the test data, and the creation of test reports. These competencies are evaluated at three successive levels of completion. Each level of completion will be documented by the preceptor (for an example see Table V):

(1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis,

(2) Participation in the testing and in data collection under the supervision of the preceptor and assistance in report writing,

(3) Performing testing tasks without significant oversight, and the creation of an entire report with only review by the preceptor.

Levels 1 and 2 should be satisfied by the completion of the CT rotation. Level 3 must be completed before the end of the residency. The resident will normally participate in the testing of at least 4 CT systems at level 2 and at least 3 CT systems at level 3.

Competencies 9 through 19 involve activities beyond simply testing CT systems and creating reports. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident, and/or satisfactory completion of its stated activities, as appropriate. The preceptor will determine the date on which the resident has satisfied each of these competencies. Many may be satisfied during the CT rotation, but they must be satisfied by the end of the residency.

For each competency the completion of the competency is documented, signed and dated by the resident and preceptor upon its completion. Additionally the completion of each of the first two levels of completion of competencies 7 and 8 is also documented, signed and dated by the resident and preceptor upon its completion.

Materials produced during the course of the rotation, such as final test reports and any presentations, will be assessed for completion and accuracy and graded as “complete” or “incomplete”.

List of Competencies:

1. Understand the principles, design, and recent advances of CT, including all of its major components, such as the x-ray tube, collimator, and detectors, and their functions.
2. Understand the principles of CT image reconstruction, including nonlinear denoising methods.
3. Understand the concepts of dose and image quality (including artifacts) and their relationship in CT.
4. Understand how automatic exposure control systems operate in CT.

5. Understand federal and state regulations applicable to CT systems including operational tolerances and requirement for compliance to these regulations.
6. Understand the requirements of the Joint Commission, the ACR, and other accreditation bodies for the testing of CT scanners.
7. Understand the proper methods of performance testing of CT scanners for acceptance testing and quality assurance in light of the requirement of the above accrediting bodies and organizations. Perform these performance tests on CT scanners in compliance with all relevant standards.
8. Understand how to identify and analyze problems detected in these tests and the corrective actions that can be performed for operational improvements. Understand how to report system deficiencies that do not comply with government regulations and requirement of the joint commission and accrediting bodies. Understand how to report other types of system deficiencies that are detected. Understand how to create an accurate and understandable report for the health care faculty responsible for the CT equipment. Create actual reports of the results of CT system testing.
9. Have a working knowledge of the accreditation requirements for CT scanners along with the requirements of the Joint Commission and federal regulations, beyond simply the requirements for CT testing. Assist clinical personnel in the process of accreditation of CT scanners and in satisfying the requirements of the Joint Commission and federal regulations. Understand the issues to be addressed in setting up a QC program for CT technologists.
10. Develop a working knowledge of the requirements of the Joint Commission and the accreditation bodies for personnel requirements for Physicists, Technologists, and Radiologists.
11. Complete the number of hours of approved continuing medical education (CME) credits as required by the Joint Commission and the accreditation bodies for a Physicist who is testing CT scanners.
12. Understand how to test for the presence of CT image artifacts and to recognize their presence in both phantom and clinical images. Perform analysis of images with possible artifacts including identifying the artifact and its possible causes.
13. Understand how to analyze CT images with suboptimal quality and provide recommendations for correction or improvement of the imaging process. This includes providing instructions for improving the images of scans already performed by modifications of the reconstruction parameters.
14. Understand design considerations for a new or remodeled facility including reading room design, radiation shielding requirements, and equipment selection. Participate in these activities in assisting the clinical personnel.
15. Understand the requirements for reviewing radiations shielding designs for new or remodeled rooms, inspecting the actual construction process, the creation of a radiation shielding report for submission to the health care facility and to the state. Assist in each of these processes.
16. Understand the processes for obtaining approval to operate CT imaging facilities including state licensing and the legal requirements. Assist in these processes as opportunities allow.

17. Understand how to calculate estimates of CT doses including CTDI, organ doses, effective doses, and fetal doses. Perform calculations of these doses.
18. Understand the principles of personnel radiation safety and monitoring both for the clinical personnel and for the persons performing equipment evaluations. Answer radiation safety questions and provide guidance in radiation safety to the clinical staff. Use proper radiation safety techniques while performing medical physics duties.
19. Prepare and deliver presentations for clinical staff on CT physics topics of interest such as radiation doses and risks, quality control procedures and technical aspects of CT imaging.

Rotation Title: MR

Preceptor/Mentor: **Karl K. Vigen, PhD, DABMP, Edward F. Jackson, DABR, DABMP**

Duration: **8 weeks**

≈ 100 hours - Annual MRI Physics surveys; acceptance testing (as available); checks of weekly technologist QC.

≈ 120 hours - Additional as-needed MRI clinical support; MRI protocol development with radiologists, attendance at Dept. of Radiology MRI Safety Committee meetings; attend conference calls and discussions with MRI vendor service personnel.

≈ 60 hours - Study: ACR MRI Quality Control Manual; MRI Safety; and topics related to references listed below; attendance at MRI Physics lectures, as needed.

≈ 10 hours - MRI Continuing Medical Education (CME).

≈ 30 hours - Attendance at Medical Physics Seminars; Radiology Grand Rounds with MRI topics.

Recommended References:

Basic MRI Physics (as needed):

D Nishimura, *Principles of Magnetic Resonance Imaging* (available from lulu.com).

Series of MRI Physics review articles from *Journal of Magnetic Resonance Imaging* (in packet).

The Essential Physics of Medical Imaging, 3rd ed., Bushberg *et al*., Chapters 12-13

MRI Safety:

Current GE Scanner User's Manual Safety Section (in packet, and available at this link).

Shellock and Crues, *MRI Safety* (available for purchase).

ACR Guidance Document on MR Safe Practices: 2013, J Magn Reson Imag 37:501-530, 2013.

www.mrisafety.com - Frank Shellock's website, which serves as the most common source of information on the safety of implanted active or passive devices as well as information on other potential sources of MR safety concerns.

MRI QA/QC/Acceptance Testing:

AAPM Report 100 *Acceptance Testing and Quality Assurance Procedures for Magnetic Resonance Imaging Facilities*, Jackson E, Bronskill M, *et al*., 2010 (in packet).

2015 ACR MRI Quality Control Manual (available from acr.org).

Additional documentation related to the ACR MRI Accreditation Program (routinely updated at acr.org).

Evaluation Scheme:

Checklist of items listed for each competency, signed and dated by the resident and preceptor upon successful completion of each item.

Significant assistance in two written survey reports, and two independently produced written survey reports over two years. Because only a limited number of surveys may be available based on the number of MRI units and the timing of the surveys, the resident will likely be asked to perform these outside of the initial MRI rotation.

Materials produced during the course of the rotation, such as final survey reports and any presentations, to be included in the resident's ELN.

List of Competencies:

1) Demonstrate knowledge of basic MRI physics and common clinical MR acquisition sequences and techniques.
2) Demonstrate understanding of MRI system hardware basics.
3) Demonstrate understanding of all aspects of MRI safety.
4) Demonstrate ability to operate an MRI system without supervision. Training will be provided through the MRI Research Laboratory's process for MRI system operation, under the supervision of the Research Program Manager for MRI, *i.e*., lead research MRI technologist.
5) Understand of the implementation of a robust MR acceptance testing program and quality control program, including detection of common failure modes, based on AAPM and ACR recommendations.
6) Demonstrate understanding of common MRI artifacts and potential remedies.
7) Demonstrate knowledge of ACR MR Accreditation Program and Joint Commission accreditation requirements.
8) Complete 10 hours/year of MRI-related CME.
9) Develop one (1) successful protocol modification session with a medical physicist and radiologist.
10) Provide significant assistance in two (2) annual system performance tests, based on ACR MR accreditation program requirements.
11) Complete two (2) independent annual surveys of MRI scanners, based on ACR MR accreditation program requirements.
12) Develop and present a QC program for technologists based on ACR MR accreditation program requirements.

Rotation Title: Ultrasound

Preceptor/Mentor: **James Zagzebski, PhD, Timothy Hall, PhD, Edward Jackson, DABR, DABMP**

Duration: 7 weeks

≈ 140 hours – Physics Surveys and Report Generation

≈ 120 hours – Study: technical considerations of ultrasound imaging, modality testing, safety issues, components of image quality, image quality metrics

≈ 20 hours – Presentation of in-service training for clinical staff, Radiology Resident physics training, attendance of Radiology Grand Rounds and Medical Physics Seminars, other interactions with clinical staff.

Recommended References:

Essentials of Ultrasound Physics, JA Zagzebski, Elsevier, Chapters 1-5

Ultrasound Accreditation Program Requirements, American College of Radiology, available at http://www.acr.org/Quality-Safety/Accreditation/Ultrasound

Methods and Effects of Transducer Degradation on Image Quality and the Clinical Efficacy of Diagnostic Sonography, J Diagnostic Medical Sonography, 19: 3-13, 2003.

IEC61391-1 Pulse-echo scanners - Techniques for calibrating spatial measurement systems and measurement of point-spread function response.

IEC 61391-2 Ed.1.0: Pulse- echo scanners – Techniques for measurement of maximum depth of visualization and the displayed dynamic range.

Hangiandriou *et al*., Four-year experience with a clinical ultrasound quality control program. Ultrasound Med & Biol. 2011, 37(8):1350-1357.

Browne, J. A review of Doppler ultrasound quality assurance protocols and test devices. Physica Medica 30 (7): 742-751, 2014.

Hall, T., *et al*., RSNA/QIBA: Shear wave speed as a biomarker for liver fibrosis staging. IEEE International Ultrasonics Symposium, 397-400, 2013.

The Essential Physics of Medical Imaging, Bushberg, *et al*. Chapters 14-15.

Evaluation Scheme:

Competencies 1, 2, 3, and 4 involve achieving an understanding of basic technical and physics principles of diagnostic ultrasound, IEC, ACR and AAPM recommendations, and AIUM as well as ACR standards for clinical laboratory accreditation. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident. The preceptor will document in the ELN the date on which the resident has satisfied each of these competencies. They should be satisfied during the first part of the US rotation.

For competencies 5, and 6, the resident shall provide significant assistance in four written survey reports, and independently author four additional survey reports over two years. Because only a limited number of surveys may be available based on the number of ultrasound units and the timing of the surveys, the resident will likely be asked to perform these outside of the initial ultrasound rotation.

Competencies 5 and 6 involve the testing and evaluation of actual US systems, analysis of the test data, and the creation of test reports. These competencies are evaluated at three successive levels of completion. Each level of completion will be documented by the preceptor (for an example see Table V):

(1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis,

(2) Participation in the testing and in data collection under the supervision of the preceptor and assistance in report writing,

(3) Performing testing tasks without significant oversight, and the creation of an entire report with only review by the preceptor.

Competencies 7 and 8 involve activities beyond simply testing US systems and creating reports. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident, and/or satisfactory completion of its stated activities, as appropriate. The preceptor will determine the date on which the resident has satisfied each of these competencies. They may be satisfied during the US rotation, but they must be satisfied by the end of the residency.

Materials produced during the course of the rotation, such as final survey reports and any presentations, will be assessed for completion and accuracy and graded as “complete” or “incomplete”.

List of Competencies:

1) Demonstrate understanding of the principles of operation of clinical US scanners, including propagation and scatter in tissue, the pulse-echo principle, beam-forming, formation of A-line signals, construction of B-mode images, frame rate limitations, common image artifacts, bioeffects, Doppler and color flow, strain imaging and shear wave imaging;
2) Demonstrate knowledge of the characteristics of phantoms from major manufacturers and how phantom properties might affect performance measurements;
3) Ability to independently scan phantoms and test objects on at least 2 different manufacturer’s scanners (choose from GE Logiq 8 or 9; Phillips IU22; Siemens S2000 or S3000; Supersonic Imagine Aixplorer); mount and select available transducers on the scanner, including 3-D transducers; optimize control settings to generate acceptable images; save images to PACS; activate B-mode, harmonics, PW Doppler, and color flow modes; where available activate and demonstrate special operating modes, including strain imaging and shear wave imaging;
4) Understand the implementation of a robust acceptance testing and quality control program for ultrasound systems based on AAPM, AIUM, and ACR recommendations;
5) Independently perform annual ACR Physics surveys on ultrasound scanners in UWHC-Radiology, the UW Breast Center, WIMR, or American Family Children’s Hospital, including qualitative assessments of PACS workstation/imaging system monitor fidelity; author test reports for the clinical facilities;

6) Assess safety factors and identify artifacts on ultrasound images that are caused by transducer flaws, such as cracked lens material, dead transducer elements, cable flaws, and inadequate focusing/TGC settings; understand how acquisition features, such as spatial compounding, and processing such as speckle smoothing, can conceal flaws;

7) Evaluate Doppler mode on US systems using flow phantom; tests strain and/or shear wave velocity imaging using phantoms;

8) Demonstrate knowledge of personnel requirements for Physicists and lead Technologists related to ACR and AIUM laboratory accreditation tests;

Rotation Title: Nuclear Medicine

Preceptor/Mentor: **John Vetter, PhD, DABR, Tyler Bradshaw, PhD**

Duration: 5 weeks

≈ 50 hours – Acceptance and Annual tests of gamma cameras, PET scanners, Dose Calibrators and bone density scanners, including report generation.

≈ 60 hours – Study technical considerations of nuclear medicine imaging, modality testing, dose considerations, exposure and patient dose calculations, facility design and shielding considerations, components of image quality, image quality *vs*. patient dose and imaging time, characteristics and selection of radionuclides.

≈ 40 hours – Participation in radiation dose surveys, observation of technologists' daily and weekly quality control activities, preparation of radiopharmaceuticals, and other routine tasks in the nuclear medicine department.

≈ 50 hours – Presentation of in-service training for nuclear medicine staff, Radiology Resident physics training, participation in radiation safety committee meetings, attendance at Radiology Grand Rounds and Medical Physics Seminars.

Recommended References:

NEMA NU 1-2012 Performance measurements of Scintillation Cameras. NEMA, Rosslyn, Virginia 2013

The Selection, Use, Calibration, and Quality Assurance of Radionuclide Calibrators Used in Nuclear Medicine. AAPM Report 181, 2012

PET and PET/CT Shielding Requirements. AAPM Report 108, 2006

GE Optima NM/CT 640 Systems Test Manual

GE Discovery IQ NEMA Test Procedures and Detector Performance Test Manual

Physics in Nuclear Medicine, Cherry SR, Sorenson JA, Phelps ME., Grune & Stratton, Orlando, 2003

Christian PE, Bernier D, Langan JK, *Nuclear Medicine and PET Technology and Techniques,* Mosby, St. Louis, 2004

Radiation Safety in Nuclear Medicine, Lombardi, MH, CRC Press, Boca Raton, 2007

The Essential Physics of Medical Imaging, 3rd ed., Bushberg, *et al*., Chapters 15-19

Evaluation Scheme:

Written survey reports produced independently by the resident and reviewed by the preceptor with evaluations. The preceptor provides guidance in the production of accurate reports and suggestions for improvement of the submitted reports. A list of all survey reports in which the resident has participated is kept along with a record of the degree of resident participation:

(1) Observation of the testing procedures performed by the preceptor with attention to learning the proper methods of testing and analysis,

(2) Participation in the testing and in data collection under supervision of the preceptor and assistance in report writing,

(3) Performing testing tasks without significant oversight and the creation of an entire report with only review by the preceptor.

Checklist of items listed under each competency, signed and dated by the resident and preceptor upon demonstrated completion of each item.

Materials produced in conjunction with activities undertaken to achieve competencies. Examples include: Presentations for clinical staff, CME certificates, reports or correspondence related to dose calculations, etc. These materials will be reviewed by the preceptor with suggestions for improvements where appropriate.

List of Competencies:

1. Understand the physical and technical requirements of nuclear imaging systems including planar, single photon emission computed tomography (SPECT) and positron emission tomography (PET) systems.
2. Perform annual physics surveys and calibration procedures on SPECT and PET imaging systems and dose calibrators.
3. Understand principles and practices related to the safe handling of radioactive materials and the performance of imaging and therapy procedures. Perform review of radiation safety policies and practices within the radiopharmacy and SPECT and PET/CT imaging suites.
4. Perform radiation surveys of imaging suites, patient treatment rooms and radiopharmacies.
5. Know emergency procedures relevant to the nuclear medicine department. Know the procedures and regulations regarding the containment and cleanup of radioactive material spills.
6. Understand and be able to discuss recommendations regarding the administration of radiopharmaceuticals to pregnant and possibly pregnant patients, and patients who are nursing mothers.
7. Understand and review staff radiation monitoring policies, procedures and dose reports. Discuss procedures involved with investigations into personnel dose readings that are above the threshold for investigation.
8. Understand design considerations for a new or remodeled facility including imaging room designs, radiopharmacy design considerations, radiation shielding requirements and equipment selection. Perform a radiation shielding design for a PET/CT facility.
9. Understand and perform estimates of organ doses from any administered radiopharmaceutical using the MIRD method.
10. Be familiar with ACR requirements for accreditation of nuclear medicine and PET facilities and Joint Commission accreditation requirements related to nuclear imaging.
11. Be familiar with the administration of a broad scope radioactive material license, the activities of the radiation safety committee overseeing the license, and the associated federal and state regulations.
12. Prepare and deliver presentations for clinical staff on nuclear medicine physics topics of interest such as the health effects of radiation exposure, radiation doses and risks from various procedures, quality control procedures and technical aspects of nuclear imaging.

Rotation Title: Informatics

Preceptor/Mentor: **Walter Peppler, PhD, Gary Wendt, MD, MBA**

Duration: 3 weeks

≈ 30 hours – Course MP 671, includes didactic and hands on participation

≈ 50 hours – Setup, configuration, and installation of new modalities onto PACS system

≈ 20 hours – Solving connectivity issues on an ongoing basis, as needed.

≈ 20 hours – PACS workstation display calibration, setup and testing

Recommended References:

Digital Imaging and Communications in Medicine (DICOM), Oleg Pianykh, Springer-Verlag Berlin Heidelberg, 2008.

The Essential Physics of Medical Imaging: Third edition, Bushberg, *et al*. Chapter 5.

http://medical.nema.org

http://dcm4che.org

http://www.dclunie.com

http://dicom.offis.de/dcmtk

http://support.dcmtk.org/docs

http://www.ihe.net

http://www.rsna.org/ihe

http://www.dvtk.org/index.php

http://rsbweb.nih.gov/ij

https://www.virtualbox.org

http://www.dicomlibrary.com

http://www.dicomtags.com/

http://pacsdisplay.org/

Evaluation Scheme:

Competencies 1, 2, and 3 involve achieving an understanding DICOM and Integrating the Healthcare Enterprise (IHE). Competencies 9 and 10 similarly involve an understanding of dose reporting and advanced imaging functionality. The evaluation of these competencies will be determined by the preceptor by oral examination of the resident. The preceptor will document in the ELN notebook the date on which the resident has satisfied each of these competencies.

Competency 4 will be evaluated as follows. New and replacement modalities are constantly being added to the UWHealth PACS system. The resident will be expected to: 1) observe the configuration and validation testing of approximately 5 modalities performed by the preceptor with attention to learning the proper methods, 2) participate in the configuration and validation testing under supervision of the preceptor, and 3) perform configuration and validation testing without significant oversight.

No formal reports are required when configuring a new system. The resident will be required to keep a record of all systems they were involved with in the ELN notebook. The preceptor will confirm the successful implementation of the systems that the resident completes with minimal oversight. If any deficiencies are noted, additional installations will be assigned.

Modality connectivity problems frequently arise significantly after the initial configuration. These may be due to software updates or may just be recognized as an issue at a later date. Since these problems are not scheduled or planned, the resident will be expected to participate throughout the residency period when available. It will be the resident's responsibility to ensure that they accumulate 3-4 such experiences. Some problems are critical and the resident will be evaluated by the preceptor on whether they were able to actively participate in the solution. Other problems are more long term and may require intervention by the equipment vendor; including backend configuration or software patches. The resident will be expected to take the lead role on at least one such situation; continuing to follow up to make sure the problem is adequately resolved. The final step of which is generally to confirm with the end user that a satisfactory solution has been achieved (or in some cases that it can't be resolved). The preceptor will ask the end user for a report of satisfactory or unsatisfactory communication skills and overall handling of the issue.

Competency 5 will be evaluated as follows. The resident will install and configure open source display calibration software on a non-clinical workstation. The resident will be expected to work with the preceptor to test a clinical reading station. Finally the resident will be expected to test 3 or more clinical reading stations with minimal or no supervision. The completion of these tasks will be entered in the ELN by the resident and confirmed by the preceptor.

The resident will be expected to assist the instructor with the hands on lab portion of the informatics course offered by the department. This consists of 2-3 hours of lab participation demonstrating open source DICOM and HL7 tools and applications. Competencies 6, 7, and 8 will be evaluated during these laboratories. The preceptor will evaluate the resident's ability to perform the assigned functions on a satisfactory/unsatisfactory basis. The results will be recorded in the ELN. If any deficiencies are found the preceptor will work with the resident to remedy them. The date that resident satisfactorily performs the assigned functions will be entered in the ELN.

List of Competencies:

1) Demonstrate ability to find pertinent information within the DICOM standard publication; including SOP classes, transfer syntaxes, IOD modules and definitions, and value representations (VR).
2) Demonstrate understanding of DICOM conformance statement, including supported SOP classes.
3) Demonstrate a familiarity with Integrating the Healthcare Enterprise (IHE) initiative and relevant domains, including radiology and mammography.
4) Demonstrate ability to connect new or replacement modalities to the UWHealth PACS system. This will include configuring the modality and the PACS system as well as solving configuration problems.

5) Demonstrate ability to test monitor conformance to DICOM Grayscale Display Function. This testing will also be performed in the mammography rotation, but the resident will be expected to install and test open source software for testing workstations outside of mammography.
6) Demonstrate ability to interpret HL7 messages. This will include a familiarity with the UWHealth Cloverleaf HL7 interface engine and a basic understanding of the various threads and their purpose.
7) Demonstrate ability to use open source DICOM toolkits, including command line implementation of dcm4che tools (dicom send, dicom move, etc.)
8) Demonstrate ability to use open source utilities for clinical trial processing and anonymization, such as Dicom Editor, RSNA's CTP, and Dcm4chee.
9) Demonstrate knowledge of radiation dose reporting systems including internal and external (e.g. ACR Triad).
10) Demonstrate understanding of advanced applications (3D modeling, image fusion, CAD, etc.) and the ability to support the clinical use of those applications.

Appendix D – List of Current Residents

Please provide an alphabetical list of current residents in your program.

Resident	Supervisor	Year Entered	Funding Source
Brunnquell, Christina	Ranallo, Vetter	2016	AAPM Grant and Department of Medical Physics
Li, Zhimin	Ranallo, Vetter	2016	AAPM Grant and Department of Medical Physics

Appendix F – Program Graduates

Please provide a reverse chronological list of residency program graduates for the past 10 years.

Name	***Time in Program (dates)***	***Supervisor***	***Current Occupation***	***Board Certification***
Nicholas Rubert. Ph.D.	1/15/2014- 11/14/2015	Frank Ranallo, Ph.D.	Medical Imaging Physicist, Lurie Children's Hospital, Chicago	In Progress

Appendix F - Faculty and Staff Biographical Sketches and Primary Clinical Interests

Alphabetical List of Faculty/Staff

Name	Primary Clinical Interest
Bradshaw, Tyler, Ph.D.	Nuclear medicine physics
Grist, Thomas MD FACR / Chair, Radiology	Cardiovascular imaging, MRI
Hall, Timothy, PhD	Ultrasound physics
Jackson, Edward PhD, DABR, DABMP, FAAPM, FACR / Chair, Med Physics	MR and ultrasound physics
Kanne, Jeffrey, MD	Thoracic imaging
Kliewer, Mark, MD	Abdominal imaging imaging and intervention
Nagle, Scott, MD, PhD	Thoracic imaging, cardiovascular imaging
Peppler, Walter, PhD	Informatics, PACS, teleradiology
Ranallo, Frank, PhD, DABR, FAAPM / Program Director)	Physics of radiography, fluoroscopy, angiography, and CT; radiation safety, optimization of imaging protocols
Salkowski, Lonie, MD	Breast imaging; anatomy, medical education
Spiedel, Michael, PhD	Physics of radiography and angiography
Szczykutowicz, Timothy, PhD	CT physics
Vetter, John, PhD, DABR / Associate Program Director	Physics of radiography, fluoroscopy, angiography, mammography, and nuclear medicine; radiation safety
Vigen, Karl, PhD, DABMP	MR physics
Wendt, Gary, MD, MBA	Vice Chair, Informatics; neuroradiology; PACS, teleradiology
Zagzebski, James PhD, FAAPM	Ultrasound physics

Appendix J – Example of Resident's Evaluation

J1: Faculty Evaluation of Resident

IP Residency Program - Resident Evaluation

Resident Name:

Clinical Rotation Mentor Name:

Rotation/Module:

Rotation Start Date (mm/dd/yyyy):

Rotation End Date (mm/dd/yyyy):

Evaluation of Technical Skills (0=N/A; 1=poor/needs improvement; 5=top 10% of residents)

	0	1	2	3	4	5
Use of Appropriate Procedures						
Equipment						

Operation						
Appropriate Knowledge of Safety Issues						

Evaluation of Data Acquisition and Analysis Skills (0=N/A; 1=poor/needs improvement; 5=top 10% of residents)

	0	1	2	3	4	5
Data Acquisition						
Data Analyses						
Report Generation						

Evaluation of Communication Skills (0=N/A; 1=poor/needs improvement; 5=top 10% of residents)

	0	1	2	3	4	5
Listening Skills						
Oral Communication / Presentation Skills						
Quality of Written Reports						

Integrity (0=N/A; 1=poor/needs improvement; 5=top 10% of residents)

	0	1	2	3	4	5
Reliability						
Complies with Privacy and Confidentiality Policies						

Complies with Residency Program Policies / Procedures

Work Ethic (0=N/A; 1=poor/needs improvement; 5=top 10% of residents)

	0	1	2	3	4	5
Arrived for Rotation Assignments On Time						
Attended Required / Recommended Seminars, Grand Round, etc.						
Completed Tasks By Stated Due Date						

Personal Conduct (0=N/A; 1=poor/needs improvement; 5=top 10% of residents)

	0	1	2	3	4	5
Collegiality						
Accepts / Acts Upon Constructive Criticism						

Engagement / Commitment to Self-Learning (0=N/A; 1=poor/needs improvement; 5=top 10% of residents)

	0	1	2	3	4	5
Actively Seeks Information / Resources						
Asks Appropriate						

Questions

Level of Engagement / Commitment

Quality of Time Management Skills

Did the Resident Successfully Complete All Requirements of the Rotation?

Yes

No

Which Specific Competencies of the Rotation Are Yet To Be Demonstrated Before The Rotation Can Be Considered To Be Complete?

Please Provide Any Additional Comments:

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Appendix J – Example of Resident's Evaluation

J2: Resident Evaluation of Faculty

IP Residency Program - Faculty Evaluation

Resident Name:

Rotation/Module:

Date (mm/dd/yyyy):

Faculty Interactions (0=N/A; 1=poor/needs improvement; 5=top 10% of faculty)

	0	1	2	3	4	5
Faculty Professionalism						
Faculty Engagement						
Faculty Enthusiasm / Encouragement						
Faculty Mentor is Approachable						
Faculty Availability						

Learning Environment (0=N/A; 1=poor/needs improvement; 5=top 10% of faculty)

	0	1	2	3	4	5
Expectations of the Rotation Were Clearly Defined						
Procedures Were Clearly Defined						
Adequate Reference Materials Were Provided						
Feedback on Resident's Progress Was Regularly Provided						

Overall Evaluation of the Rotation (0=N/A; 1=poor/needs improvement; 5=top 10%)

	0	1	2	3	4	5
Overall Assessment of the Rotation Module						
What is Your Level of Confidence with Rotation Objectives / Material?						

Please Provide Any Comments and/or Recommendations for Improvement