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## Abbreviations:

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<th>Description</th>
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<tbody>
<tr>
<td>AFCH</td>
<td>American Family Children's Hospital</td>
</tr>
<tr>
<td>HSLC</td>
<td>Health Sciences Learning Center – home of the UW School of Medicine &amp; Public Health</td>
</tr>
<tr>
<td>SMPH</td>
<td>UW School of Medicine and Public Health – home of the Departments of Medical Physics, Radiology, and other Basic Science and Clinical departments</td>
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<tr>
<td>TAC</td>
<td>The American Center health and wellness center</td>
</tr>
<tr>
<td>UPMH</td>
<td>UnityPoint - Meriter Hospital</td>
</tr>
<tr>
<td>UWHC</td>
<td>University of Wisconsin Hospitals and Clinics</td>
</tr>
<tr>
<td>UWHHealth</td>
<td>This term describes the totality of clinical facilities at the University of Wisconsin, including those at AFHC, TAC, UWHC, UWMF, and WIMR</td>
</tr>
<tr>
<td>UWMF</td>
<td>University of Wisconsin Medical Foundation</td>
</tr>
<tr>
<td>WIMR</td>
<td>Wisconsin Institutes for Medical Research – physical home of the Department of Medical Physics and key classrooms, imaging laboratories, research laboratories, computational resources, etc.</td>
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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 Department of Medical Physics 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 Medical Physics Graduate Program is the largest such program in North America, and resources of this program are fully leveraged by the 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 was 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 have made a transition from RPS-based education and training of graduate students to a clinical residency in imaging physics. The expertise and much of the support base for this program has been in place for over six years. The support base began with seed funding from the AAPM and has increased over time to now having ongoing commitments, from sources outside of the Department of Medical Physics, to fully support two full time residents in our program. 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.) Since then, four residents have graduated from our accredited program, with another two currently in our program. The four graduates from our residency program were quickly able to obtain positions within radiology departments at academic institutions, three as assistant professors, and all involved in clinical medical imaging work.
Summary of Program Changes Since Last Review

The model that we originally proposed for our residency training program was to recruit one resident each year into a program that would have a total of two residents. We would concurrently train a junior and a senior resident. We initially recruited two residents with the intention to transition to this model. However, we have found that having two residents at the same level has many advantages that, at least for our program, seem to outweigh the advantages of having a senior resident who can help mentor a junior resident. We have found that residents working together at the same level very effectively complement each other and provide a level of comradery that enhances their learning environment. The feedback we have received from residents and mentors has reinforced our assessment of this model, so our intention is to continue to recruit two residents every other year rather than transitioning to the alternate year recruitment of a single resident.

Since our previous review we have added two new rotations: 1) X-ray Imaging Review and Introduction to Methods of Imaging Equipment Evaluation; and 2) Radiation Safety. The first rotation is designed to provide incoming residents with the background information that they need to effectively participate in quality assurance testing of x-ray equipment from the beginning. This introductory training was implemented in response to feedback from one of our early residents who suggested that we provide more instruction on the methods and goals of quality assurance testing prior to working with x-ray equipment for the first time. Another purpose of this rotation is to fill in any background information that residents may not have obtained in their graduate program, to ensure that the two residents are at approximately the same level as they begin the other rotations. Our reasons for creating a new rotation specifically in radiation safety is to leverage the strong Radiation Safety/Health Physics team that we have at our institution, to provide the radiation safety staff with recognition for their efforts in training our residents, and to provide our residents the opportunity to work closely with health physicists and the radiation safety officer. Many of the radiation safety related activities are already part of several modality specific rotations, but the radiation safety rotation also has unique activities such as participating in radiation safety committee meetings and developing institutional radiation safety policies and training modules.

Other changes include adding new faculty as mentors who have joined our department and replacing those who have left. One of our new faculty mentors is Professor Ivan Rosado-Mendez, PhD. Dr. Rosado-Mendez is an ultrasound physicist with considerable experience providing ultrasound physics support in the clinic. Another new mentor is Jason Timm, MPH, CHP, the radiation safety officer for UW Madison and UW Hospital and Clinics. Mr. Timm has many years of experience in health physics and as a radiation safety officer. His enthusiasm for teaching residents and willingness to offer participation with his team of health physicists is also a great asset to our program. Unfortunately, a great loss for our program is the passing of our department Chair and colleague, Dr. Edward Jackson, PhD, FAAPM, FACR, who also participated as a mentor in MRI and ultrasound.

Since our last review, we have identified new sources of funding for the residency program, which have enabled it to achieve increased financial stability. The UW Hospital and Clinics provides our residency program with one slot in its medical resident pool, which is likely a unique situation for an imaging physics residency. The University of Wisconsin Departments of Radiology and Medical Physics have entered into an agreement with GE Healthcare to create and provide protocols to be used on all their CT scanner. The great success of this collaboration, the “UW-GE CT Protocol Project” has led to this project providing funding for a second residency position. An advantage of partially funding the residency through the UW-GE CT Protocol Project is that it enables our residents to be involved in this very important aspect of clinical service for diagnostic imaging physicists.

We have also added a new community hospital, with 7 external clinics, to the clinical facilities in which the residents work and in which we provide medical physics services, including the testing of medical imaging equipment.
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 is issued. Graduates are well prepared for ABR board certification and a professional career as a qualified medical physicist in an academic institution, a clinical imaging facility, an imaging physics consulting group, etc. We 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;

f. focusing on medical imaging evaluation, protocol development, improvements in imaging technology, and advancing the application of physics principles to solving medical problems in general;

g. 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;

h. fostering communication and interpersonal skills necessary to be successful in a collaborative, clinical environment in which medical physicists must work in cooperation with physicians, nurses, technologists, and other healthcare professionals;

i. 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

j. 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). Training also occurs in a new partner with the UWHealth system, UnityPoint-Meriter Hospital (UPMH). The recently integrated UWHealth system is a nationally recognized regional health system that includes the following facilities:

- UWHC, a large, 500 bed, referral center hospital and associated clinics, located on the UW-Madison campus,
- UWHC 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), a 111-bed facility adjacent to UWHC and supported by its own extensive medical imaging systems,
- UWMF clinics, with 18 outpatient medical imaging facilities located in and around the city of Madison,
- 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,
- UPMH, a 448-bed community hospital in Madison, Wisconsin, which has become a partner of UW Health, and whose radiology department is staffed by UW radiologists, and
- UPMH clinics, with 7 outpatient medical imaging facilities located in and around the city of Madison.

Both UWHC and UPMH received and maintain a Gold Seal of Approval from The Joint Commission. UWHC has several additional advanced certifications (comprehensive stroke, diabetes, palliative care, etc.). Imaging facilities at UWHC, UPMH, 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 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 or the UW Radiation Safety Department. The program faculty are appointed by the director of the residency program in collaboration with the Steering Committee and 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 and was elected a fellow of the AAPM in 2018. 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. Dr. Ranallo is a member of the Radiation Safety Committee of UnityPoint-Meriter Hospital. He has worked with several diagnostic imaging task groups of the American Association of Physicians in Medicine, including those that produced *Instrumentation Requirements of Diagnostic Radiological Physicists, AAPM Report No. 60, Quality Control in Diagnostic Radiology, AAPM Report No. 74*, and Performance Evaluation of Computed Tomography Systems, AAPM Report No. 233. Presently he is serving on Task Group #150, *Acceptance Testing and Quality Control of Digital Radiographic Imaging Systems*, on Task Group #233, *Performance Evaluation of Computed Tomography Systems*, and Task Group #309, *Imaging - Protocol Management System Design*.

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. For all residents, the Program Director is also responsible for providing an introductory rotation of the basic physics and instrumentation for medical x-ray imaging systems, providing additional material to which the new residents had not been previously exposure, and also providing actual clinical problems to challenge the residents. Important components of the testing of medical imaging equipment are covered along with various aspects of safety for both the residents and the equipment they are testing.

The Associate Director works in close collaboration with the Director, particularly regarding 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 23 tenured/tenure-track, 4 clinical track, and 12 active emeritus faculty. In addition, the program has 28 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 and the Radiation Safety Department of the University of Wisconsin. The Imaging Physics Residency Program faculty are appointed by the Residency Program Director, in collaboration with their respective department chairs, the Associate Program Director, and the Steering Committee. In all cases, Imaging Physics Residency Program faculty are engaged in clinical imaging activities in their areas of expertise. Five of the ten 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. 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 faculty member is heavily engaged in the education, research, and service efforts of the institution as well as scientific and/or professional organizations, committee work, and other professional medical physics and radiology activities.
### Table I: Imaging Physics Residency Program Faculty

<table>
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<tr>
<th>Physics Faculty</th>
<th>Area(s) of Expertise</th>
<th>Certification</th>
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<tbody>
<tr>
<td>Frank Ranallo, Ph.D., FAAPM (Medical Physics and Radiology) – Program Director</td>
<td>Radiography, fluoroscopy, angiography, CT, radiation safety, optimization of imaging protocols</td>
<td>ABR, Diagnostic Radiological Physics</td>
</tr>
<tr>
<td>John Vetter, Ph.D. (Medical Physics) – Program Associate Director</td>
<td>Radiography, fluoroscopy, angiography, mammography, nuclear medicine, radiation safety</td>
<td>ABR, Diagnostic Radiological Physics</td>
</tr>
<tr>
<td>Tyler Bradshaw, Ph.D. (Radiology)</td>
<td>Nuclear medicine</td>
<td>American Board of Science in Nuclear Medicine, Physics &amp; Instrumentation</td>
</tr>
<tr>
<td>Timothy Hall, Ph.D. (Medical Physics)</td>
<td>Ultrasound</td>
<td></td>
</tr>
<tr>
<td>Walter Peppler, Ph.D. (Medical Physics)</td>
<td>Informatics, PACS, teleradiology</td>
<td></td>
</tr>
<tr>
<td>Ivan Rosado-Mendez, PhD (Medical Physics)</td>
<td>Ultrasound</td>
<td></td>
</tr>
<tr>
<td>Michael Speidel, Ph.D. (Medical Physics and Medicine)</td>
<td>Radiography, angiography, cardiology</td>
<td></td>
</tr>
<tr>
<td>Timothy Szczykutowicz, Ph.D. (Radiology, Medical Physics, BME)</td>
<td>Informatics, CT</td>
<td>ABR, Diagnostic Radiological Physics</td>
</tr>
<tr>
<td>Jason Timm, MPH (UW Environmental Health &amp; Safety)</td>
<td>Radiation Safety, Environmental Health and Safety</td>
<td></td>
</tr>
<tr>
<td>Karl Vigen, Ph.D. (Radiology)</td>
<td>MR</td>
<td>ABMP, MR Physics</td>
</tr>
<tr>
<td>James Zagzebski, Ph.D., FAAPM (Medical Physics)</td>
<td>Ultrasound</td>
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<table>
<thead>
<tr>
<th>Participating Clinical Faculty</th>
<th>Area of Expertise</th>
<th>Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richard Bruce, M.D.</td>
<td>Neuroradiology</td>
<td>ABR, Diagnostic Radiology</td>
</tr>
<tr>
<td>Thomas Grist, M.D., FACR (Chair, Radiology)</td>
<td>Cardiovascular imaging; MRI</td>
<td>ABR, Diagnostic Radiology</td>
</tr>
<tr>
<td>Jeffrey Kanne, M.D.</td>
<td>Chief, Thoracic Imaging</td>
<td>ABR, Diagnostic Radiology</td>
</tr>
<tr>
<td>Mark Kliewer, M.D.</td>
<td>Chief, Ultrasound; abdominal imaging and intervention</td>
<td>ABR, Diagnostic Radiology</td>
</tr>
<tr>
<td>Scott Nagle, M.D., Ph.D.</td>
<td>Thoracic imaging, cardiovascular imaging</td>
<td>ABR, Diagnostic Radiology</td>
</tr>
<tr>
<td>Lonie Salkowski, M.D.</td>
<td>Breast imaging; anatomy, medical education</td>
<td>ABR, Diagnostic Radiology</td>
</tr>
<tr>
<td>Gary Wendt, M.D., M.B.A.</td>
<td>Vice Chair, Informatics; neuroradiology; PACS, teleradiology</td>
<td>ABR, Diagnostic Radiology</td>
</tr>
</tbody>
</table>

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. Each resident also 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 installed (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 $60,090 for PG1 residents and $62,126 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 2022, the Department of Radiology has requested support from the UWHC for one resident position per year. A second source of funding is the UW-GE CT Protocol Project of the Medical Physics and Radiology Departments which is supporting one resident position per year. A third source of funding for the residency program is revenue from services provided by the RPS to the UWHC, UWMF, and UPMH.

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. The actual checklist of the On-Boarding and Orientation Activities for the new residents is provided in Appendix K.
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, in UWMF imaging suites in the city of Madison, in imaging suites within WIMR and in the UPMH and its associated clinics.

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 ft² 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, UPMH), the installed base currently includes the following systems: 18 CT scanners, 61 radiographic CR/DR systems, 24 angiography systems, 64 fluoroscopy systems, 21 mobile radiography CR/DR units, 15 mammography systems, 2 stereotactic biopsy mammography systems, 5 bone densitometry systems, 2 dental units, 25 ultrasound units, 16 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 Residents # 3 and 4:

<table>
<thead>
<tr>
<th>Category</th>
<th>Description</th>
<th>Publications/Publications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CT Protocol Management</td>
<td>Projects 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. Also investigated is the source and reduction of repeat scans.</td>
<td>Apparatus for Tomography Repeat Rate/Reject Rate Capture TP Szczykutowicz, BT Viggiano, SD Rose, US Patent App. 16/403,857., 2020.</td>
</tr>
</tbody>
</table>
Another set of projects looks at the specific effects of varying scan and reconstruction settings on the resultant image quality. These settings include kV, scan time, pitch, table speed, AEC (mA modulation), scan field of view, display field of view. These have a number of effects on dose and image quality including image sharpness (MTF), image noise, low contrast detectability, slice sensitivity profile, scan time (motion) and artifacts.


The Effects of Varying the Display Field of View (Reconstruction Field of View) On MTF. Lipford, M, Rose, S, Ranallo, F, Scientific Abstract, American Association of Physicians in Medicine 61st Annual Meeting, San Antonio, Texas, July 2019

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-three 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

<table>
<thead>
<tr>
<th>Imaging Physics Residency Fundamental Rotations (1-9) and Additional Topics</th>
<th>Approx. Percent of Residency</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. X-ray Imaging Review and Introduction to Methods of Image Equipment Evaluation</td>
<td>4</td>
</tr>
<tr>
<td>2. Radiography, including digital (CR/DR) imaging systems</td>
<td>8</td>
</tr>
<tr>
<td>3. Fluoroscopy, including image intensifiers and digital systems</td>
<td>5</td>
</tr>
<tr>
<td>4. Angiography, including interventional and cardiology applications</td>
<td>4</td>
</tr>
<tr>
<td>5. Mammography, including tomosynthesis and stereotactic breast biopsy systems</td>
<td>5</td>
</tr>
<tr>
<td>6. Computed Tomography (CT)</td>
<td>8</td>
</tr>
<tr>
<td>7. Magnetic Resonance Imaging (MRI)</td>
<td>8</td>
</tr>
<tr>
<td>8. Ultrasound</td>
<td>6</td>
</tr>
<tr>
<td>9. Nuclear medicine, including PET/CT (overview, not an area of specialization)</td>
<td>5</td>
</tr>
<tr>
<td>10. Informatics, including PACS, computer networks, and teleradiology</td>
<td>5</td>
</tr>
<tr>
<td>11. Radiation Safety</td>
<td>4</td>
</tr>
<tr>
<td>Ethics, leadership, and professionalism</td>
<td>5</td>
</tr>
<tr>
<td>Extended experience in two or more of the above modalities (following Steering Committee approval), including clinical projects</td>
<td>33</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
</tr>
</tbody>
</table>

Basic Requirements for Education and Training in Each Modality:

In addition to the basic medical imaging systems operation and the methods of testing of imaging systems with testing equipment, also included is the 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 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 reports 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

<table>
<thead>
<tr>
<th>Month</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
<th>11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intro to Imaging Systems</td>
<td>Radiography</td>
<td>Fluoro</td>
<td>Angio</td>
<td>Mammography</td>
<td>CT</td>
<td>MRI</td>
<td>Ultrasound</td>
<td>Nuclear Medicine</td>
<td>Radiation Safety</td>
<td>PACS, Informatics</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td>2</td>
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<td>5</td>
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<td>X</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>6</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>7</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>8</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>9</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<tr>
<td>10</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>X</td>
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<tr>
<td>11</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td></td>
<td></td>
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<tr>
<td>12</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*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: Continuing testing and involvement with modality

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 the clinical facilities that are part of the residency program, testing is required throughout the year. To maximize the amount of testing in which the residents can participate, the testing for each rotation continues throughout the residency from a point after a specific rotation has begun.

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

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

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, the imaging clinics of the UWMF, UPMC and its clinics 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. There is an addition agreement between the Department of Medical Physics RPS and the UPMH, which also explicitly includes the participation of the residents in testing.

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 semi-annually 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.

At 10 months after beginning a rotation, 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 mentor of that residency, but with significant self-sufficiency. 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**

<table>
<thead>
<tr>
<th>Professionalism and Ethics</th>
<th>How covered</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Professionalism</td>
<td>MP701 <em>Ethics and the Responsible Conduct of Research and Practice of Medical Physics</em>. Professionalism is a constant topic throughout the MP701 course.</td>
<td></td>
</tr>
<tr>
<td>Definition of a profession and professionalism</td>
<td>Each clinical rotation/module</td>
<td></td>
</tr>
<tr>
<td>Elements of a profession</td>
<td>Each clinical rotation/module</td>
<td></td>
</tr>
<tr>
<td>Definition of a professional</td>
<td>Each clinical rotation/module</td>
<td></td>
</tr>
<tr>
<td>Elements of professionalism</td>
<td>MP701, discussed in each lecture</td>
<td></td>
</tr>
<tr>
<td>How is professionalism judged?</td>
<td>MP701, discussed in each lecture</td>
<td></td>
</tr>
<tr>
<td>Do’s and don’ts of professionalism</td>
<td>MP701, discussed in each lecture</td>
<td></td>
</tr>
<tr>
<td>Physician’s charter and applicability to physicists</td>
<td>MP701, Class 8, Ethics in a medical setting</td>
<td></td>
</tr>
<tr>
<td>Leadership</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Vision and charisma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Qualities of leaders</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rules of leadership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Causes of leadership failure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ethics</td>
<td>MP 701</td>
<td></td>
</tr>
<tr>
<td>Ethics of a profession</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Ethics of an individual</td>
<td>MP701, Classes 1 and 5 The class on human subjects (class 5) specifically discusses issues of ethics in individuals.</td>
<td></td>
</tr>
<tr>
<td>Topic</td>
<td>Course and Classes</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>--------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>Interactions with colleagues and co-workers</td>
<td>MP701, Classes 1-3 and 8</td>
<td>Interaction with colleagues is analyzed from different angles, including authorship and negotiation of decisions that affect patients as well as professional societies.</td>
</tr>
<tr>
<td>Interactions with patients and the public</td>
<td>MP701, Classes 1, 3, 5-6 on clinical research and human subjects.</td>
<td>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.</td>
</tr>
<tr>
<td>Confidentiality</td>
<td>MP701, Classes 1-6 and 8</td>
<td>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.</td>
</tr>
<tr>
<td>Peer review</td>
<td>MP701, Classes 2 and 3</td>
<td>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.</td>
</tr>
<tr>
<td>Negotiation skills</td>
<td>MP701, Classes 1, 3 and 4</td>
<td>The class on law and ethics (class 4) provides particular insight on contracts.</td>
</tr>
<tr>
<td>Relationships with employers</td>
<td>MP701, Classes 1, 4, and 8</td>
<td></td>
</tr>
<tr>
<td>Conflicts of interest</td>
<td>MP701, Class 3</td>
<td>Is devoted to COI</td>
</tr>
<tr>
<td>Ethics in research</td>
<td>MP701, Ethics in research is discussed throughout the course</td>
<td></td>
</tr>
<tr>
<td>Use of animals in research</td>
<td>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.</td>
<td></td>
</tr>
<tr>
<td>Use of humans in research</td>
<td>MP701, Classes 5 and 6. Both classes are devoted to clinical research, providing historical background as well as practical information.</td>
<td></td>
</tr>
<tr>
<td>Relationships with vendors</td>
<td>MP701, Class 3</td>
<td>This topic is covered in depth in class 3, which focuses on COI.</td>
</tr>
<tr>
<td>Publication ethics</td>
<td>MP701, Classes 2 and 3</td>
<td>Class 2 analyzes in depth the issues in data reporting, while class 3 further discusses how COI affects publications.</td>
</tr>
<tr>
<td>Ethics in graduate and resident education</td>
<td>MP701, Classes 1 and 8</td>
<td>Class 1 analyzes the role of mentor and mentees, while class 8 provides insight on resident life.</td>
</tr>
<tr>
<td>Selected case studies</td>
<td>MP701, discussed in each lecture</td>
<td>In every class different case studies and ethical questions are presented for discussion.</td>
</tr>
</tbody>
</table>
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

<table>
<thead>
<tr>
<th>Training Topic</th>
<th>Rotation(s) in Appendix C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Radiography</td>
<td>Radiography</td>
</tr>
<tr>
<td>Computed Radiography</td>
<td>Radiography, Mammography</td>
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<tr>
<td>Fluoroscopy</td>
<td>Fluoroscopy, Angiography</td>
</tr>
<tr>
<td>Interventional/angiography</td>
<td>Angiography</td>
</tr>
<tr>
<td>Mammography</td>
<td>Mammography</td>
</tr>
<tr>
<td>Stereotactic breast biopsy</td>
<td>Mammography</td>
</tr>
<tr>
<td>Computed Tomography</td>
<td>Computed Tomography</td>
</tr>
<tr>
<td>Magnetic Resonance</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>Ultrasound</td>
<td>Ultrasound</td>
</tr>
<tr>
<td>Image Processors/printers</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography,</td>
</tr>
<tr>
<td></td>
<td>Computed Tomography</td>
</tr>
<tr>
<td>Safety evaluations</td>
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</tr>
<tr>
<td><strong>Training Topic</strong></td>
<td><strong>Rotation(s) in Appendix C</strong></td>
</tr>
<tr>
<td>Entrance exposure estimates</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Radiation Safety</td>
</tr>
<tr>
<td>Orgin dose estimates</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Computed tomography dose index (CTDI) and dose length product (DLP)</td>
<td>Computed Tomography, Radiation Safety</td>
</tr>
<tr>
<td>Mean glandular dose</td>
<td>Mammography, Radiation Safety</td>
</tr>
<tr>
<td>Effective dose</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Risk estimates</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Personnel exposure estimates and reduction</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Fetal dose</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Contrast agents</td>
<td>Fluoroscopy, Angiography, Computed Tomography, Magnetic Resonance Imaging, Ultrasound</td>
</tr>
<tr>
<td>Protocol optimization</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>MRI hazards</td>
<td>Magnetic Resonance Imaging</td>
</tr>
<tr>
<td>Organ/fetal dose with MIRD system</td>
<td>Nuclear Medicine</td>
</tr>
<tr>
<td>Radiopharmaceutical applications and risks</td>
<td>Nuclear Medicine</td>
</tr>
<tr>
<td>Shielding design</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Magnetic Resonance Imaging, Radiation Safety</td>
</tr>
<tr>
<td>Personnel shielding/monitoring</td>
<td>Radiology, Fluoroscopy, Angiography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Calibration and survey instruments</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Radiation surveys</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Safety/policies</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Magnetic Resonance Imaging, Ultrasound, Radiation Safety</td>
</tr>
<tr>
<td>Compliance audits</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Ultrasound, Radiation Safety</td>
</tr>
<tr>
<td>Dose limits</td>
<td>Radiology, Fluoroscopy, Angiography, Mammography, Computed Tomography, Nuclear Medicine, Radiation Safety</td>
</tr>
<tr>
<td>Training Topic</td>
<td>Rotation in Appendix C</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------------</td>
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</tr>
<tr>
<td>Picture archiving and communication systems (PACS) and radiology information systems (RIS)</td>
<td>Informatics</td>
</tr>
<tr>
<td>Digital imaging and communication systems (DICOM) standards</td>
<td>Informatics</td>
</tr>
<tr>
<td>Information acquisition from PACS/images</td>
<td>Informatics</td>
</tr>
<tr>
<td>Informatics variations among modalities</td>
<td>Informatics</td>
</tr>
<tr>
<td>Dose reporting</td>
<td>Informatics</td>
</tr>
<tr>
<td>Use of Integrating the Healthcare Enterprise (IHE) radiology profiles</td>
<td>Informatics</td>
</tr>
<tr>
<td>Open source software resources</td>
<td>Informatics</td>
</tr>
<tr>
<td>Quality/maintenance of imaging workstations</td>
<td>Informatics</td>
</tr>
<tr>
<td>Evaluation of viewing conditions</td>
<td>Informatics</td>
</tr>
<tr>
<td>Image registration, fusion, segmentation, processing</td>
<td>Informatics</td>
</tr>
<tr>
<td>Computer-aided detection (CAD) and computer-aided diagnosis (CADx) systems</td>
<td>Informatics</td>
</tr>
</tbody>
</table>
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 physics 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 two residents per year to maintain two residents, so that two residents are always in the program. 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 utilizes 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.
Appendix A – Clinical Rotation Summaries

Rotation Title:  X-ray Imaging Review and Introduction to Methods of Image Equipment Evaluation.

Preceptor/Mentor: Frank Ranallo, PhD, DABR, FAAPM

Duration: 4 Weeks – First 4 weeks of residency

  ≈ 160 hours – Review of X-ray Imaging principles and introduction to the evaluation of x-ray imaging systems.

Recommended References:


  Diagnostic Radiology Physics, IAEA, Dance DR, et al., 2014, Chapters 1-7, 16.


Description and Evaluation Scheme:

This rotation ensures that the residents have the requisite knowledge and understanding of the basic x-ray imaging principles needed for the following four rotations involving imaging with x-rays. It also introduces them to the method of imaging equipment evaluation. The rotation occurs during the first month of the residency. It involves (1) instruction, (2) quizzing, (3) discussion between mentor and resident of concepts and methods of both the technology and its evaluation, and (4) presenting the residents with actual clinical physics problems encountered in medical imaging for them to analyze and solve.

Detailed List of Competencies:

  Demonstrate an understanding of the following basic concepts:

1.  The basic physics of radiation and the atom.
2.  Interactions of radiation with matter.
3.  Radiation Quantities and Units
4.  Image quality, including contrast, noise, sharpness, and artifacts.
6.  Patient attenuation of x-rays, anti-scatter grids and AEC systems.
7.  Image receptors – CR and DR.
8.  Image artifacts and methods of prevention
10. Fluoroscopy, Angiography, and Digital Subtraction Angiography.
12. Instrumentation used in the evaluation of medical imaging systems.
13. Principles of the evaluation of medical imaging systems.
Milestones and deliverables

Initial oral examination.

Participation in lectures and discussion sessions on the topics of the competencies.

Directed study on the topics of the competencies.

Presentation of solutions to presented clinical problems.

Final oral examination.
Rotation Title: Radiography

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

Duration: 8 Weeks. Starting in the second month of the residency and extending throughout the residency.

≈ 200 hours – Physics Surveys and Report Generation.

≈ 100 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.

≈ 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:


Diagnostic Radiology Physics, IAEA, Dance DR, et al., 2014, Chapters 1 – 7, 10, 16.


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


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


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.
Detailed 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 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 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 competencies 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.
Description and 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 rotation, such as final test reports and any presentations, will be assessed for completion and accuracy and graded as “complete” or “incomplete”.

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

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

Duration: 5 Weeks. Starting in the second month of the residency and extending throughout the residency.

≈ 120 hours – Physics Surveys and Report Generation

≈ 60 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

≈ 20 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:


Diagnostic Radiology Physics, IAEA, Dance DR, et al., 2014, Chapters 4, 8, 24.


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


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


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
Detailed List of Competencies:

Understanding the instrumentation of fluoroscopy systems and the method of evaluations of these systems is built upon the competencies listed in the radiographic imaging section. Therefore, these competencies are also need for this rotation. 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.

The competencies specific to this rotation:

1. 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 digital flat panel detectors, with the ability to properly produce multiple images per second at fluoroscopic and acquisition dose rates; technology dealing with patient motion and image noise reduction.

2. Understand how to test for the accuracy of fluoro image receptor size, fluoro collimator adjustments, image/ x-ray field congruence, and fluoro image distortions. Perform accurate testing when indicated.

3. 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.

4. 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.

5. 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.

6. Understand how to properly measure high contrast resolution and sharpness uniformity over the images. Perform accurate testing and analysis of this function.

7. Understand how to properly measure low contrast detectability over different exposure rate conditions. Perform accurate testing and analysis of this function.

8. 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.
9. Understand federal and state regulations applicable to fluoroscopic systems including operational tolerances and requirements for compliance with these regulations.

10. 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.

11. 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.

12. Understand the requirements for reviewing radiation 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.

13. 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.

14. Understand how to calculate estimates of entrance exposures, organ doses, effective doses, and fetal doses. Perform calculations of these exposures/doses.

15. 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.
**Evaluation Scheme:**

Competency 1 involves 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 2 through 10 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 11 through 15 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 rotation, such as final test reports and any presentations, will be assessed for completion and accuracy and graded as “complete” or “incomplete.”
Rotation Title: Angiography and Interventional Radiology

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

Duration: 5 Weeks

- ≈ 100 hours – Physics surveys and report generation
- ≈ 40 hours – Study: technical considerations of angiographic imaging, staff and patient dose considerations, components of image quality, image quality vs. patient dose
- ≈ 40 hours – Study: clinical considerations of angiographic imaging, observation of clinical procedures in Radiology and Cardiology, patient dose calculations, facility design considerations
- ≈ 20 hours – Presentation of training for clinical staff, Radiology residents, and Cardiology fellows, other interactions with staff and hospital managers.

Recommended References:


Cardiac Catheterization Equipment Performance, AAPM Report 70, 2001


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


*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*
Description and Evaluation Scheme:

This rotation focuses on x-ray fluoroscopic equipment dedicated to interventional procedures, found primarily in interventional cardiology (“cath lab”) and interventional radiology (“IR”) settings. These x-ray systems are designed specifically for contrast-enhanced angiography and fluoroscopic guidance of catheter-based devices. The rotation competencies are divided into 5 general areas, as described below. The subsequent section titled “Detailed List of Competencies” provides a breakdown of each competency area.

**Competency Area 1** involves demonstrating an understanding of the basic technical and physics principles of x-ray projection imaging, as well as features specific to fluoroscopic / angiographic x-ray systems. It should be completed during first part of the rotation. An initial oral exam will be conducted to evaluate the resident’s baseline knowledge. This will be followed by guided study and hands-on training. After an appropriate period, competencies will be evaluated by the preceptor by a final oral examination of the resident. The preceptor will document in the ELN the date on which the resident has satisfied this competency.

**Competency Area 2** involves the testing and evaluation of fluoroscopic / 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 may be satisfied through completion of the fluoroscopy rotation. Level 3 must be completed by testing equipment designed for interventional procedures. 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. This competency must be completed before the end of the residency.

**Competency Area 3** involves 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 angiographic systems used for

1. cardiology,
2. electrophysiology,
3. pediatric cardiology,
4. peripheral vascular,
5. interventional radiology, and
6. neuro-interventional radiology.

The resident will learn the use of the angiographic system in each setting through observation of clinical procedures and hands-on instruction with the preceptor. In initial clinical observations, 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 3 procedures in each of 6 different clinical settings by the end of residency. Each observation session will be documented with a short writeup that follows a template provided by the preceptor.
**Competency Area 4** involves learning and applying radiation safety principles in the interventional setting. Residents will study the components of a radiation safety program for protection of patient and staff. The resident will attend lectures on radiation safety (delivered by the preceptor) and then prepare PowerPoint presentations on these topics. 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.

**Competency Area 5** involves 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.

**Detailed List of Competencies:**

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

1. Understand the technical and physics principles of x-ray image generation in radiography and fluoroscopy. In particular,
   a. Understand the process of x-ray generation, including x-ray tube, collimator, and high voltage generator.
   b. Understand the physics and technology of various image receptors, including indirect versus direct conversion methods, and flat panel versus image intensifier detectors.
   c. Understand the operating principles of an automatic exposure control (AEC) and how the behavior of this system varies by imaging mode (e.g. fluoro vs. cine vs. DSA) and detector mode.

   **Milestones and deliverables:**
   i. Initial oral examination
   ii. Directed study on the principles of x-ray imaging
   iii. Hands-on training on an interventional system
   iv. Final oral examination

2. Apply the equipment testing competencies learned in the fluoroscopic rotation to x-ray equipment designed specifically for the interventional setting:
   a. Understand how to test for image/ x-ray field congruence, image distortions, 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 properly measure high contrast resolution and sharpness uniformity over the images. Perform accurate testing and analysis of this function.
   d. Understand how to properly measure low contrast detectability over different exposure rate conditions. Perform accurate testing and analysis of this function.
e. Understand how to properly measure the maximum fluoroscopy entrance exposure rate and half value layer according to government regulations. Perform accurate testing and analysis of these functions.

f. Understand 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 requirement for compliance to 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 faculty responsible for the radiographic equipment.

Milestones and deliverables:

i. At least 2 tests at level 1
ii. At least 2 tests at level 2
iii. At least 2 tests at level 3, including completed reports
iv. Documented review of federal and state regulations

3. 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.

Milestones and deliverables:

i. Hands-on training / demonstration on an interventional bi-plane system
ii. Initial clinical observation session followed by oral examination
iii. 3 clinical observations in each of the 6 operational areas, documented by writeup (template will be provided)
4. 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.

Milestones and deliverables:
   i. Attendance of at least 1 lecture on radiation safety, delivered by preceptor, followed by oral examination on content.
   ii. Preparation of 1 PowerPoint on radiation safety for patient and staff during fluoroscopically guided procedures, and 1 PowerPoint on the components of a radiation safety program in the cardiac cath lab.
   iii. Documented review of patient dose information from at least 5 cases in the cath lab.

5. Understand and participate in activities associated with the purchase and installation of an x-ray angiographic system in a new or remodeled facility. If the opportunity to participate in an actual purchase & installation does not arise during the residency, these competencies will be gained through review of existing facilities.
   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 actual construction process 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.

Milestones and deliverables:
   i. Prepare spreadsheet comparing 3 different x-ray system options for a cardiac cath lab.
   ii. Attend weekly meetings on purchasing, planning, and construction of a new cath lab.
   iii. Perform shielding calculations and prepare shielding report.
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
≈ 60 hours – Study: Mammography Quality Standards Act (MQSA) regulations, accreditation requirements, technical considerations of mammographic imaging, dose considerations, modality testing, facility design considerations,
≈ 30 hours – Mammography Continuing Medical Education (CME) completion
≈ 10 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 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: Computed Tomography (CT)

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

Duration: 8 Weeks

≈ 200 hours – Physics Surveys and Report Generation
≈ 160 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
≈ 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:

*Computed Tomography, 2nd Edition, Hsieh J.*
*Computed Tomography, 3rd Edition, Kalendar W.*

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.


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


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


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


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 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 considering 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: Magnetic Resonance Imaging (MRI)

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).


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:


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 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/Mentors: James Zagzebski, PhD, Ivan Rosado-Mendez, PhD, Timothy Hall, PhD

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


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.


Evaluation Scheme:

Competencies 1, 2, 3, 4, 5 involve achieving an understanding of basic technical and physics principles of diagnostic ultrasound, IEC, ACR and AAPM quality control 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, including one that involves a hands-on lab. 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 6, and 7, 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 6 and 7 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 8 and 9 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 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 basic ultrasound physics, including propagation, attenuation, reflection and scattering in tissue;

2) Demonstrate understanding of the operation of clinical ultrasound scanners, including, the pulse-echo principle, types of transducers, 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;

3) Demonstrate knowledge of the characteristics of phantoms from major manufacturers and how phantom properties might affect performance measurements;
4) Demonstrate ability to independently scan phantoms and test objects on at least 2 different manufacturer’s scanners (choose from GE Logiq 8, Logiq E9 or Logiq E10; Siemens Acuson Sequoia; 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;

5) Understand the implementation of a robust acceptance testing and quality control program for ultrasound systems based on AAPM, AIUM, and ACR recommendations;

6) 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;

7) 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;

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

9) Demonstrate knowledge of personnel requirements for Physicists and lead Technologists related to ACR and AIUM laboratory accreditation tests;
**Rotation Title:** Nuclear Medicine  

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

**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  
- 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  
- 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,
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:


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 cannot 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.
Rotation Title: Radiation Safety

Preceptor/Mentor: John Vetter, PhD, DABR, Jason Timm, MHP, MPH, CHP

Duration: **5 Weeks.** Beginning in the third month of the residency and extending throughout the remainder of the residency program.

- ≈ 50 hours – Radiation Safety activities, shielding design, surveys, and report generation
- ≈ 50 hours – Study: technical considerations and regulatory requirements related to radiation safety
- ≈ 50 hours – Attendance at Radiation Safety Committee meetings, planning meetings for construction of new facilities, meetings with managers and other staff regarding the development and implementation of radiation related policies and procedures.
- ≈ 50 hours – Preparation and Presentation of training for clinical staff, Radiology residents, and Cardiology fellows, and other faculty, trainees, and staff with the use of radiation in clinical settings.

Recommended References:

*Structural Shielding Design for Medical X-Ray Imaging Facilities, NCRP Report No. 147, 2005.*

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


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


*Radiation Protection, Wisconsin Department of Health Services Chapter DHS 157.*

*Health Risks from Exposure to Low Levels of Ionizing Radiation: BEIR VII – Phase 2, Committee to Assess Health Risks from Exposure to Low Levels of Ionizing Radiation, National Research Council, National Academy of Sciences, 2006.*

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

*UW Health Policies and Procedures related to radiation safety.*
Description and Evaluation Scheme:

This rotation focuses on the radiation safety aspects of the use of x-rays and radioactive materials for diagnostic and screening purposes in the clinical setting. Many of the activities and competencies are described in modality specific rotations, and not reproduced here. These activities generally include room shielding designs, inspections and surveys, patient dosimetry monitoring and calculations, radiation safety presentations and consultations. Unique to this rotation are participation in University of Wisconsin, UW Health and Meriter-Unity Point Health radiation safety committees, and participation in activities carried out by the team of health physicists under the direction of the Radiation Safety Officer, Jason Timm. These activities generally include managing the personnel dosimetry program, x-ray device and radioactivity material licenses, the radioactive waste program, and providing training and dosimetry support for clinical and research radiation use. Lists of activities and topics for each of these sections are as follows:

Medical Physics Team (John Vetter and other Medical Physics mentors)

- Radiation Shielding design and verification: CT, Rad/Fluoro, PET/CT, bone mineral scanners, nuclear pharmacies, radionuclide therapy suites.
- Patient dose estimates (peak skin dose, fetal radiation dose, other patient dose estimates, human subject radiation dose estimates).
- Radiation Safety in Fluoroscopy.
- Radiation Safety in CT.
- Radiation safety training (provided by Medical Physics) for clinical staff and physicians.

Radiation Safety Team (Jason Timm and other Health Physicists)

- Personnel dosimetry (shadow Bindu/UW Asst. RSO): Dose records review, high dose investigations, new technology evaluations. Evaluation of personnel protective equipment.
- Nuclear Medicine: audits, surveys, and therapies (I-131 thyroid ablation, I-131 CLR, I-131 MIBG)
- Radiology therapies (IR: Y-90 Therasphere).
- Radiation and Human Oncology: audits, surveys, and participation in therapies (Ra-223 Xofigo, Ir-192 HDR, Sr-90 BetaCath).
- Veterinary Medicine Radiology: Lg. animal Tc-99m equine bone scans, feline I-131 hyperthyroidism.
- Participation in Radiation Safety related Committees: Policy development and review, Authorized PI, AU and AMP approval processes.
- Radiation safety training (provided by ORS) for staff, physicians.
- Radioactive material licensing and inspections.
- Radioactive waste program.
- Spills and emergencies.

Evaluation of competency in activities performed with the Radiation Safety Team will primarily consist of checklists documenting participation in committee meetings, audits and inspections, and observation of cleanup and survey activities. In addition, dependent on available opportunities, a report documenting the results and recommendations of at least one of each of the following activities will be produced by the resident: an inspection and audit of a laboratory or clinical service, a survey of radiation levels, an investigation of a high dose incident on a personnel radiation monitor, and response to a radiation emergency.
Detailed List of Competencies:

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

1. Describe radiation biology and public health principles that form the basis of recommendations, policies, and regulations on limits to radiation exposure for patients, radiation workers and the general public.

2. Use an understanding of good radiation safety practices to instruct and counsel operators of x-ray producing equipment and personnel handling radioactive sources to promote best practices in radiation safety.

3. Demonstrate knowledge of limits on exposure to ionizing radiation and the scientific and governing bodies that produce those limits.

4. Use knowledge of radiation safety principles to assist in the development of institutional policies related to the use of radiation.

5. Develop educational materials for patients, staff and physicians related to radiation safety.

6. Use methods described by NCRP, AAPM and other organizations to calculate appropriate radiation shielding designed to limit exposure to acceptable levels.

7. Use knowledge of regulations and accreditation standards to inspect laboratories and clinical services using ionizing radiation, and audit radiation safety practices of license holders, x-ray device operators and users of radioactive materials.

8. Use knowledge of radiation dosimetry and dosimeters to effectively measure levels of radiation exposure in surveys of imaging suites, radiopharmacies, laboratories, and other areas where radiation is used, and to evaluate levels of activity in radiation emergencies.
Appendix B – List of Residents Admitted

Please provide a reverse chronological list of residency program admissions for the past 5 years.

<table>
<thead>
<tr>
<th>Ref #</th>
<th>Start Year</th>
<th>Graduate Degrees</th>
<th>Dates</th>
<th>Institution</th>
<th>CAMPEP accreditation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Graduate</td>
</tr>
<tr>
<td>1</td>
<td>2020</td>
<td>PhD-Med Phys</td>
<td>2020</td>
<td>University at Buffalo SUNY</td>
<td>X</td>
</tr>
<tr>
<td>2</td>
<td>2020</td>
<td>PhD-Med Phys</td>
<td>2019</td>
<td>UTHealth Graduate School</td>
<td>X</td>
</tr>
<tr>
<td>3</td>
<td>2018</td>
<td>PhD-Med Phys</td>
<td>2018</td>
<td>University of Chicago</td>
<td>X</td>
</tr>
<tr>
<td>4</td>
<td>2018</td>
<td>Biomedical</td>
<td>2018</td>
<td>Wake Forest University</td>
<td>X</td>
</tr>
<tr>
<td>5</td>
<td>2016</td>
<td>PhD-Med Phys</td>
<td>2016</td>
<td>University of Wisconsin - Madison</td>
<td>X</td>
</tr>
<tr>
<td>6</td>
<td>2016</td>
<td>PhD-Med Phys</td>
<td>2016</td>
<td>University of Wisconsin - Madison</td>
<td>X</td>
</tr>
<tr>
<td>7</td>
<td>2014</td>
<td>PhD-Med Phys</td>
<td>2006</td>
<td>University of Wisconsin - Madison</td>
<td>X</td>
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</tbody>
</table>

Resident #4’s degree was not from a CAMPEP-accredited program. Following is a list of where the required didactic courses were taken:

<table>
<thead>
<tr>
<th>Ref #</th>
<th>Course</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>Radiological physics and dosimetry</td>
<td>Wake Forest University</td>
</tr>
<tr>
<td></td>
<td>Radiation protection and safety</td>
<td>Wake Forest University</td>
</tr>
<tr>
<td></td>
<td>Fundamentals of medical imaging</td>
<td>Wake Forest University</td>
</tr>
<tr>
<td></td>
<td>Radiobiology</td>
<td>Wake Forest University</td>
</tr>
<tr>
<td></td>
<td>Anatomy and physiology</td>
<td>Wake Forest University</td>
</tr>
<tr>
<td></td>
<td>Radiation therapy physics</td>
<td>Wake Forest University</td>
</tr>
</tbody>
</table>
## Appendix C – List of Current Residents

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

<table>
<thead>
<tr>
<th>Resident</th>
<th>Supervisor</th>
<th>Year Entered</th>
<th>Funding Sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jordan Krebs</td>
<td>Frank Ranallo, Ph.D.</td>
<td>2020</td>
<td>RPS – Department of Medical Physics</td>
</tr>
<tr>
<td></td>
<td>John Vetter Ph.D.</td>
<td></td>
<td>UWHC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>UW-GE CT Protocol Project</td>
</tr>
<tr>
<td>Joseph Meier</td>
<td>Frank Ranallo, Ph.D.</td>
<td>2020</td>
<td>RPS – Department of Medical Physics</td>
</tr>
<tr>
<td></td>
<td>John Vetter Ph.D.</td>
<td></td>
<td>UWHC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>UW-GE CT Protocol Project</td>
</tr>
</tbody>
</table>
# Appendix D – Program Graduates

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

<table>
<thead>
<tr>
<th>Name</th>
<th>Time in Program (dates)</th>
<th>Supervisor</th>
<th>Current Occupation</th>
<th>Board Certification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sean Rose</td>
<td>7/1/2018 - 6/30/2020</td>
<td>Frank Ranallo, Ph.D. John Vetter, Ph.D.</td>
<td>Assistant Professor, University of Texas at Houston Medical School</td>
<td>In Process</td>
</tr>
<tr>
<td>Megan Lipford</td>
<td>7/1/2018 - 6/30/2020</td>
<td>Frank Ranallo, Ph.D. John Vetter, Ph.D.</td>
<td>Assistant Professor, Imaging Physicist, Department of Radiology, Wake Forest Baptist Health</td>
<td>In Process</td>
</tr>
<tr>
<td>Christina Brunnquell</td>
<td>7/1/2016 - 6/30/2018</td>
<td>Frank Ranallo, Ph.D. John Vetter, Ph.D.</td>
<td>Assistant Professor, Medical Physics, University of Washington</td>
<td>ABR-Diagnostic Medical Physics</td>
</tr>
<tr>
<td>Zhimin Li</td>
<td>4/1/2016 - 3/30/2018</td>
<td>Frank Ranallo, Ph.D. John Vetter, Ph.D.</td>
<td>Diagnostic Medical Physicist, Northwestern Memorial Hospital</td>
<td>ABR-Diagnostic Medical Physics</td>
</tr>
</tbody>
</table>
## Appendix E - Faculty and Staff and Primary Clinical Interests

### Alphabatical List of Faculty/Staff

<table>
<thead>
<tr>
<th>Name</th>
<th>Primary Clinical Interest</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bradshaw, Tyler, Ph.D.</td>
<td>Nuclear medicine physics</td>
</tr>
<tr>
<td>Richard Bruce, MD</td>
<td>Neuro Imaging and informatics</td>
</tr>
<tr>
<td>Grist, Thomas MD FACR / Chair, Radiology</td>
<td>Cardiovascular imaging, MRI</td>
</tr>
<tr>
<td>Hall, Timothy, PhD</td>
<td>Ultrasound physics</td>
</tr>
<tr>
<td>Kanne, Jeffrey, MD</td>
<td>Thoracic imaging</td>
</tr>
<tr>
<td>Kliewer, Mark, MD</td>
<td>Abdominal imaging and intervention</td>
</tr>
<tr>
<td>Nagle, Scott, MD, PhD</td>
<td>Thoracic imaging, cardiovascular imaging</td>
</tr>
<tr>
<td>Peppler, Walter, PhD</td>
<td>Informatics, PACS, teleradiology</td>
</tr>
<tr>
<td>Ranallo, Frank, PhD, DABR, FAAPM /</td>
<td>Physics of radiography, fluoroscopy, angiography, and CT; radiation safety, optimization of imaging protocols</td>
</tr>
<tr>
<td>Program Director)</td>
<td></td>
</tr>
<tr>
<td>Rosado-Mendez, Ivan, M, PhD</td>
<td>Ultrasound physics</td>
</tr>
<tr>
<td>Salkowski, Lonie, MD</td>
<td>Breast imaging; anatomy, medical education</td>
</tr>
<tr>
<td>Spiedel, Michael, PhD</td>
<td>Physics of radiography and angiography</td>
</tr>
<tr>
<td>Szczykutowicz, Timothy, PhD</td>
<td>CT physics</td>
</tr>
<tr>
<td>Timm, Jason D.</td>
<td>Environmental and Radiation Safety</td>
</tr>
<tr>
<td>Vetter, John, PhD, DABR / Associate</td>
<td>Physics of radiography, fluoroscopy, angiography, mammography, and nuclear medicine; radiation safety</td>
</tr>
<tr>
<td>Program Director</td>
<td></td>
</tr>
<tr>
<td>Vigen, Karl, PhD, DABMP</td>
<td>MRI physics</td>
</tr>
<tr>
<td>Wendt, Gary, MD, MBA</td>
<td>Vice Chair, Informatics; neuroradiology; PACS, teleradiology</td>
</tr>
<tr>
<td>Zagzebski, James PhD, FAAPM</td>
<td>Ultrasound physics</td>
</tr>
</tbody>
</table>