Johns Hopkins University
Department of Radiation Oncology
Clinical Medical Physics Residency

Guidelines for Clinical Rotations

The core of the medical physics residency program is a series of ten rotations designed to cover the educational objectives of the program. The training goals for each rotation are outlined below.

The resident will have a mentor for each rotation who is a faculty or staff physicist who regularly works in the clinical area for that rotation. The mentor interacts regularly with the resident, usually daily, and serves as the primary person that the resident goes to with questions relating to that rotation. At the end of each rotation the resident will be examined and evaluated on the material in that rotation. This evaluation consists of a one-hour presentation by the resident in front of senior physicists with questions. Following this presentation the mentor is responsible for providing a written evaluation of the resident.

Rotation 1: Clinic Introduction (month 1)

Training objective: Understand clinical aspects of patient simulation, setup and treatment.

The resident will observe and participate in CT simulation and treatment delivery. During this rotation the resident will observe cases in all of the major disease sites and all of the immobilization devices used in the clinic. Clinical disease sites include the following: head and neck, brain, craniospinal, breast, lung, pancreas, prostate. They will follow patients through from simulation to treatment and will observe treatment setup, imaging and delivery. They will gain experience with all of the external beam delivery devices available in the clinic.

Imaging modalities will include the following: CT (simulation), respiratory-correlated 4D-CT, PET/CT and MRI. The resident will observe clinical cases in each of these areas, and will gain experience with how these data are used in the treatment planning process. Treatment imaging and delivery will include the following: linear accelerator with EPID imaging and cone-beam CT, 3D-conformal and IMRT techniques, and Tomotherapy.

The resident will also spend several days in brachytherapy, observing cases and calibration and QA procedures.

Key concepts (should be able to discuss details about each of these):

- Immobilization techniques and tools: alpha cradles, thermoplastic masks, head rests, breast boards, wingboards, combi-fix devices, etc.
- Isocenter
- Lasers and three-point setup
- Basic concepts in CT (e.g. use of contrast, 4D-CT, etc.)
- DRR
- Basic concepts in treatment planning: DVH, IMRT plans, 3D-conformal plans, beam energies, how prescriptions are written
- Concepts of GTV, CTV and PTV

- Familiarity with most important normal tissue structures: cord, kidney, liver, lung, rectum. Be able to pick them out on CT scans.
- Concepts of treatment fractionation and typical doses
- Stereotactic treatments
- Implanted seeds for tracking
- ABC breath-hold treatment
- Basic familiarity with equipment: linacs, EPID, cone-beam CT imaging (IGRT), tomotherapy, CT scanners, MRI
- Brachytherapy
    - types of cancers treated
    - permanent vs. HDR: what are the basic differences
    - types of seeds
    - typical doses

<u>Reading materials:</u>

- Chapter 1 of Perez and Brady
- The Physics of Radiation Therapy, F. Kahn, Pub: Lippincott Williams & Wilkins, 4th Ed., 2009. Chapter 4 (linacs, etc)
- Treatment Planning in Radiation Oncology, F. M. Khan, Pub: Lippincott Williams & Wilkins, 2nd Ed. 2006. Chapters 1-3.

<u>Rotation 2: Treatment planning # 1 for EBRT</u>

The objective of this rotation is for the resident to gain experience with basic conformal radiotherapy planning and simple IMRT/VMAT, including a self-proficient use of the Pinnacle planning system. The resident will be mentored by a senior staff physicist along with help from the treatment planning dosimetry group.

The rotation begins with a series of practice plans of increasing complexity as outlined below (Pinnacle Institution: PhysicsResidents, based on JHU v.8.0 Institution circa 8/2009). Each of these plans will be reviewed with the rotation mentor:

1. spine AP/PA
2. L-S spine AP/PA
3. Whole-brain
4. C spine 3-field
5. 4 field breast
6. simple electron plans
7. simple prostate IMRT/VMAT

Following these practice plans, the resident will begin observing new cases with the dosimetry team and, after observing a plan for each site, will begin planning of their own. The resident’s plans will be reviewed by a treatment planning dosimetrist and/or a physicist before being finalized.

The specific objectives of this rotation include the following:

- Observe patient setup and imaging, including the following:
    - Immobilization techniques, CT sim, BBs and shifts, MRI data, Cone-beam CT guidance, 4D-CT and ABC breath-hold
- Perform simple calculations including the following:

    - SSD Hand Calculation, SAD Hand Calculation, Electron Beam hand calculation
- Perform simple plans including the following:
    - AP/PA plan, Brain - 3 field, Lats + Vertex, 4 field whole pelvis or abdomen
- Perform 3D conformal plans including the following:
    - Breast with nodes, Electron/photon mixed beam plan, Brain (multiple non-coplanar fields), extremity, forward plan with segments
- Perform basic IMRT/VMAT plans
    - Prostate, brain, GYN etc…

Reading List

- The Physics of Radiation Therapy, F. Kahn, Pub: Lippincott Williams & Wilkins, 4th Ed., 2009. Chapters 9-14.
- Treatment Planning in Radiation Oncology, F. M. Khan, Pub: Lippincott Williams & Wilkins, 2nd Ed. 2006. Chapters 4, 6, 17, 20, 23
- Oelfke, U and Scholz, C. Dose Calculation Algorithms. 2006.

Rotation 3: Treatment planning #2 for EBRT with Special Procedures

This rotation builds on and extends treatment planning #1. During this rotation the resident will perform more complex plans including: IMRT and VMAT plans for a variety of sites, craniospinal plans, ABC/Breath-hold plans, and plans performed under cone-beam CT guidance.

Planning Expectations

It is expected that the resident will manage a workload of approximately 1 plan per day. The resident will complete at least the following number of plans outlined below.

Plan Type	**No.**
Cone-beam Guided IMRT (including observation of delivery)	3
Head and Neck IMRT	3
Partial Breast IMRT	3
Craniospinal	1
Sarcoma (any site)	3
ABC Case (Lung)	1
Tomotherapy Prostate and/or Head and Neck	4
Total Body Irradiation	2

Reading List

- Treatment Planning in Radiation Oncology, F. M. Khan, Pub: Lippincott Williams & Wilkins, 2nd Ed. 2006
- Principles and Practice of Radiation Therapy, C.M. Washington & D.T. Leaver, Pub: Mosby, 3rd Ed. 2009

Rotation 4: Stereotactic radiosurgery (SRS) and fractionated radiosurgery (FSR)

Training objective: Understand the all major aspects of SRS and FSR. The resident will observe and participate in planning and treatment with the CyberKnife and with cone-beam CT-guided stereotactic brain, spine, lung and pancreas etc.

CyberKnife-based SRS:

The CyberKnife has been used at Johns Hopkins since 2012 to treat a vareity of intra-cranial tumors and conditions including metastatic tumors, AVMs, meningiomas, and trigeminal neuralgia. The resident will observe and then participate in all aspects of planning and treatment. Specific tasks include the following:

- Observe immobilization and orthogonal KV image guidace and understand the considerations involved.
- Oberve MRI, CT and angiography images and understand the considerations involved.
- Observe, practice and then perform treatment planning and treatment for the full variety of disease indications treated with the CyberKnife.
- Participate in daily and monthly QA

Planning requirements:

1. Single met SRS plan
2. Multiple metastasis
3. Post-op FSR boost
4. SRT plan for benign tumor (pituitary, optical meninigioma etc.)
5. FSR/SRS plan for benign tumor/symptom (Acoustic Neuroma, AVM etc.)
6. Spine SRS plan

Conventional LINAC-based SRS, FSR and SBRT:

The resident will participate in each step of the cone-beam CT (CBCT)-guided LINAC based stereotactic spine and brain radiosurgery (SRS), fractionated radiosurgery and radiotherapy (FSR and SRT). Specific tasks include the following:

- Image registration. The resident will learn the importance of MRI images on defining treatment targets and organ at risk (OARs) in stereotactic treatment and will perform CT and MRI registration routinely in this rotation.
- Treatment planning. The resident will perform both conformal and IMRT based stereotactic plans on different types of brain and spine tumor. The objective is to understand the specific consideration and planning techniques in stereotactic planning including margin setup, non-coplanar beam arrangement and different isodose normalization, etc.
- Stereotactic treatment. The resident will participate stereotactic treatments and understand various specifics of stereotactic treatment including: CBCT guidance, inter- and intra-fraction motion monitoring and management, using of 6-degree freedom couch to correct patient setup uncertainty, etc.
- Stereotactic treatment and devices QA. The resident will perform patient specific treatment QA and stereotactic treatment devices QA routinely during this rotation.

Planning requirements:

1. Spine SRS plan
2. Pancreas SBRT plan
3. Lung SBRT plan
4. Other SBRT plans if cases show up

5. Single or Multi isocenter brain metastasis

Reading List:

1. AAPM TG 42 report: Stereotactic Radiosurgery

Rotation 5: Quality Assurance for EBRT

Training objective: Become self-proficient in all aspects of EBRT quality assurance.

In this rotation the resident learn how to perform and evaluate quality assurance (QA) tests of patient-specific IMRT plans, regular monthly and annual QA of linacs, and QA of simulators.

The specific rotation expectations:

- The resident will perform patient-specific IMRT QA routinely through out the whole residency. The QA includes patient-specific measurement, result analysis and report generation.
- The resident will perform regular monthly QA of Linac through out the whole residency. The QA will rotate through different LINACs at JHH including Varian, Elekta and TOMO machines.
- The resident will perform regular monthly QA of Simulators through out the whole residency.
- The resident will perform regular annual QA of Linac through out the whole residency. The QA will rotate through different LINACs at JHH includingElekta and TOMO machines.
- The resident is expected to fully understand the EBRT dosimetric calibration prtocols for photon and electron beams.;

Reading List:

- AAPM TG142: The QA of linear accelerators
- AAPM TG106: Accelerator beam data commissioning equipment and procedures.
- AAPM TG10: Code of Practice for radiotherapy accelerators
- AAPM TG 51 report: AAPM's TG-51 protocol for clinical reference dosimetry of high energy photon and electron beams
- AAPM TG 21 report: A protocol for the determination of absorbed dose from high energy photon and electron beams
- AAPM TG 39 report : The Calibraton and Use of Plane-Parallel Ionization Chambers for Dosimetry of Electron Beams
- AAPM TG 40 report: Comprehensive QA for Radiation Oncology
- AAPM TG 45 report: AAPM Code of Practice for Radiotherapy Accelerators
- AAPM TG53 report: QA for clinical radiation therapy treatment planning

Rotation 6: Linear accelerator acceptance testing and commissioning

Training objective: The resident will commission a new linear accelerator for treatment. Working with a staff physicist they will be responsible for all aspects of the acceptance testing and commissioning measurements.

Tasks for acceptance include the following:

Mechanical alignment tests

- Crosshair/Collimator adjustment.
- Light alignment test.
- Mechanical isocenter test.
- ODI calibration
- Gantry angle readout test.
- Table rotation test.
- Table vertical accuracy test.
- Table movement test.
- Table deflection test.
- Stop button and ring guard test.
- Table brake test.
- Emergency stop button test.
- Table specifications:
- Field size test.
- Light field/Radiation field coincidence
- Diaphragm spoke films
- Couch spoke films
- Gantry spoke films
- Opposed field test
- Laser alignment test:
- Scaling convention
- Touchguard interlock
- Table movement assistant check
- Table longitudinal motion check
- Check table rotation limits
- Table vertical motion double check
- MLC Position tests (static and dynamic motion)

Alignment tests and image quality tests of the imaging system

- 2-D resolution test
- 3-D spatial resolution test
- CT Uniformity test
- CBCT HU check
- iViewGT tests.
- CT Low contrast visibility test
- Medium and Large CBCT test
- CT Geometry test
- XVI interlock test
- Time test
- BB alignment test (kV)
- BB alignment test (MV)
- Imaging isocenter checks
- 2D planar image isocenter checks
- Table Assist Check

Beam output determination with TG51

Leakage determination and surveying

Beam data acquisition

- Photon Beam Data within acceptance parameters
- Electron Beam Data within acceptance parameters
- Dose Repeatability Test
- Output, flatness, symmetry with gantry angle
- Output and dose rate linearity

The details of commissioning tests are spelled out in separate documents, but specific tests will include the following:

Beam Data Acquistion

- Photon output factor measurements
- Photon depth measurements
- Electron depth measurements
- Electron output factor measurements
- Jaw Transmission
- Tray Transmission
- Block + Tray Transmission
- MLC Leaf Transmission
- TPR Data (from PDD data converted to TPR)
- OAR Data (from scanning data)
- In-Air Output Factors (Sc)
- Photon beam profile measurements
- Electron beam profiles
- Electron virtual SSD measurements

Treatment Planning System Commissioning

- Modeling of Beam data in Pinnacle
- Verification measurements for a variety of clinically relevant fields.

Setup accelerator for future QA and use

- Establish a daily and monthly QA program
- Develop hand calculation tables for use with second check programs or hand calculations.

Reading Materials:

- AAPM TG142: The QA of linear accelerators
- AAPM TG106: Accelerator beam data commissioning equipment and procedures.
- AAPM TG10: Code of Practice for radiotherapy accelerators
- AAPM TG 51 report: AAPM's TG-51 protocol for clinical reference dosimetry of high energy photon and electron beams
- AAPM TG 21 report: A protocol for the determination of absorbed dose from high energy photon and electron beams
- AAPM TG 39 report : The Calibraton and Use of Plane-Parallel Ionization Chambers for Dosimetry of Electron Beams
- AAPM TG 40 report: Comprehensive QA for Radiation Oncology
- AAPM TG 45 report: AAPM Code of Practice for Radiotherapy Accelerators
- AAPM TG53 report: QA for clinical radiation therapy treatment planning

- A Primer on Theory and Operation of Linear Accelerators in Radiation Therapy, C.J. Karzmark, R.J. Morton, Pub: Medical Physics Publishing Corporation, 2nd Ed. 1997
- The Physics of Radiotherapy X-Rays from Linear Accelerators, P. Metcalfe, T. Kron, P. Hoban, Pub: Medical Physics Publishing Corporation, 1st Ed., 1997
- The Q Book: The Physics of Radiotherapy X-Rays Problems and Solutions, P. Metcalfe, T. Kron, P. Hoban, Pub: Medical Physics Publishing Corporation, Workbook Edition, 1998

Rotation 7: Brachytherapy

A. General

The objective of the brachytherapy rotation within the radiation oncology physics residency training program is to educate and to train physicists to a competency level sufficient to practice brachytherapy physics independently. To accomplish this goal, the residents are exposed to a multitude of tasks, related to both clinical needs and quality assurance. Reading of the documents pertinent to brachytherapy and infrequent but important tasks like commissioning of a new radioactive source for a treatment planning system is also emphasized.

The number of brachytherapy patients treated at JHU per year is greater than 100 and includes high dose-rate (HDR), seed implants and radiopharmaceuticals. Typical sites are prostate (LDR), cervix (both HDR). Other more infrequent brachytherapy treatments are sarcomas (HDR and LDR), abdominal intraoperational, bone, and lung (endobronchial HDR) and eye plaques(LDR).

The Radiation Oncology Department at JHU does handle unsealed radiation sources, safe handling and delivering agents with one includeded. The receiving and shipment of sealed sources is handled by the Radiation Safety service, but residents are also exposed to issues related to documentation needed for transportation of radioactive sources as well as testing of the sources (leak testing and other requirements of regulatory agencies) and dose rate measurements outside of transportation containers.

The Department no longer has an active intravascular brachytherapy service, due to the advent of chemically coated stents.

The Brachytherapy service at JHU has a typical new Brachytherapy suite, equipped with state of the art equipment: an Nucletron HDR afterloader system and Oncentra planning system, an 3D B&K ultrasound scanner with a number of transcretal probes.

The residents are expected to learn all the brachytherapy procedures, and also specific QA procedures updated to the above therapies.

B. Training Objectives and Experience to Be Gained

Each physics resident rotates through Brachytherapy Physics Services, during their two year program. The objective of this facet is to learn the steps involved in preparation of materials and equipment for procedures using LDR sources, LDR sources and HDR sources. This aspect of the clinical throughput involves planning by dosimetrists and/or physicists, and hands-on assistance to the physicians in the administration of the treatments. Hence, the resident will be required to learn and perform all steps in these different processes.

Quality Assurance is of primary importance in Brachytherapy. Therefore, the resident will be involved in this process, most proactively: via participating in the calibration and assimilation of all new sources and devices, and routine QA of all current devices and equipment. The resident should demonstrate an ability to maintain all source inventory, applicator inventory competencies completed, and radiation delivery equipment involving radioactive sources for brachytherapy. A checklist will also be kept of reading and writing assignments and of all. The supervision of the progress of the resident in this important area will be by the head brachytherapy physicist (rotation supervisor) with the assistance of the other clinical physics faculty involved in the brachytherapy service, upon the discretion of the head brachytherapy physicist.

The resident will have more time between supervised and/or side-by-side work during this rotation. Hence, this rotation will demand that the resident use his/her time to further work on the QA duties outlined in section (d).

<u>B1. Dosimetry:</u>

1. <u>Pre-TG-43 Dosimetry Formalism</u>
    a. Source strength
        i. Apparent Activity vs. contained activity: mCi
        ii. Radium Mass Equivalent: mgRaEq
    b. Build-up Factor: B
    c. Seivert Integral
    d. Data sources

2. <u>Full understanding of the TG43 formalism & its parameters</u>
    a. Source strength
       Air Kerma Strength: S_K
    b. Dose Rate Constant: □
    c. Radial Dose Function: g(r)
       Normalization point
    d. Geometrical Factor: G(r,□)
       Line source vs point source: inverse square
       Seivert Integral
    e. Anisotrpy Function, F(r,□) □

3. <u>Systems of Activity Loading and Dose Specification</u>
    a. Paris
    b. Quimby → Memorial
    c. Paterson-Parker (Manchester)
        i. Loading Scheme
        ii. Use of Tables

4. <u>Computerized Brachytherapy Planning (Pinnacle, Plato and Variseed)</u>
    a. LDR procedures –Pinnacle^3 system
    b. HDR procedures – Plato system

5. <u>Knowledge of Brachy Applicators</u>

a. Tandem & Tandem with ring
b. Vaginal cylinder
c. Syed
d. Catheters
e. Balloons
f. Plaque
g. Mold
h. Beta-cath
i. Heyman Capsules

6. <u>Implant Types</u>
    a. Duration
        i. Permanent
        ii. Temporary
    b. Dose Rate
        i. LDR
        ii. HDR
        iii. PDR
    c. Source Type
        i. Sealed Source
        ii. Unsealed Source
    d. Location
        i. Surface
        ii. Interstitial
        iii. Intracavitary
        iv. Intratumoric
    e. Anatomical Site
        i. Prostate
            1. Rate
                a. LDR (I125, Pd103, Cs131)
                b. HDR
            2. Ultrasound volume study
        ii. Breast
            1. Interstitial
            2. Mammosite HDR Procedure

        iii. Base of Tongue
        iv. Cheek
        v. Vagina
        vi. Urethra
        vii. Uterine-Cervix
        viii. Endobronchial
        ix. Esophogeal
        x. Biliary Tree
        xi. Brain
        xii. Eye plaque (I-125 only, infrequent procedure)
        xiii. Lung HDR Procedure
        xiv. GYN HDR Procedure (vaginal cuff)
        xv. Sarcoma LDR Procedure
        xvi. Cervix LDR Procedure
        xvii. Osseous LDR Procedure with Sm-153

xviii. Y-90 Therasphere Treatment
xix. Sm-153 Osseoces
xx. I-125 Gliacytes

f. Arrangement
   i. Point Source
      Fall-off with distance
   ii. Line Source
      Fall-off with distance
   iii. Area Implants
      Loading schema
   iv. Volume Implants
      Loading schema

7. <u>Knowledge and Demonstration of Assay Equipment</u>
   a. Reentrant well chambers
      i. Correction factors
      ii. Calibration frequency
   b. Dose calibrators
      i. QA frequency
      ii. Check sources
   c. Source holders
      i. HDR
      ii. Single source
      iii. Multiple source

   d. Geometric Efficiency

8. Pre-implant and Post-implant quality assurance
9. Observing all types of OR.
10. Observing and participating in prostate interstitial brachytherapy procedures
11. Plan evaluation and double checks

<u>B2. Quality Assurance</u>

1. Remote afterloader periodic QA
   i. monthly protocol
   ii. temporal, positional accuracy
   iii. source calibration
   iv. functional/safety tests
2. Source QA
   i. calibration
   ii. radiography/autoradiography
   iii. dose calibrator QA
   iv. unsealed source handling and calibration procedures
3. Treatment planning system QA
4. Treatment plan review
   i. manual calculations
   ii. GYN treatment policies and dosimetry/prescription systems
   iii. positional and geometric accuracy
5. Transrectal ultrasound imaging device and implant template system
6. Training

B3. Radiation Safety:

1. Understanding of
    a. Dose limits
    b. Personnel Monitor
    c. Area alerts
    d. Signs and placards
    e. Radiation protection
        i. Time
        ii. Distance
        iii. Shielding
    f. ALARA
2. Source storage
    a. Storage
    b. Shielding
3. Source Handling
4. Radiation Protection: Radiation surveys, leak testing and other requirements of regulatory agencies
5. Regulations
6. Transportation

C. Other Activites:

1. Flouroscopic Units (AAPM Report 58) with emphasis on Acuity
2. Ultrasound Quality Control (AAPM Report 65) elements of the report with applicability on ultrasound imaging with the B&K equipment
3. Chart Second Check – review and development of independent check methods
4. CT or Cone-Beam CT based evaluation for PBI, B-39
5. Calibration: Acceptance testing and commissioning of brachytherapy sources, applicators, and HDR Ir-192 sources.
6. Source Preparation: Preparation of sources and applicators for implantation.
7. NRC-Mandated Quality Management Program: Detailed Review of QMP document, implementation and audit.
8. Acceptance and commissioning (TG 59)
9. Treatment planning commissioning (TG 43)
10. Treatment planning commissioning (VariSeed)

D. Reading List:

1. Selected chapters from Brachytherapy Physics, Williamson, J.F., Thomadsen, B.T. and Nath, R., Medical Physics Publishing Company, Madison, WI., 1995.

2. "Brachytherapy Physics", Williamson, J.F. [In] Principles and Practice of Radiation Oncology, 3rd Edition, edited by Perez, C.A and Brady, L.W., J.B. Lippincott Company, Philadelphia,1998.

3. "Quality Assurance for High Dose-Rate Brachytherapy," Williamson, J.F., Ezzell, G.A., Olch, A. and Thomadsen, B.R. [In] Textbook on High Dose Rate Brachytherapy, edited by S. Nag, Futura Publishing Company, Armonk, NY; 1994:147-212.

4. "Practical Quality Assurance in Low-Dose Rate Brachytherapy," Williamson, J.F., [In] Proceedings of American College of Medical Physics-sponsored Symposium on Quality Assurance in Radiotherapy Physics, Medical Physics Publishing Company, Madison, WI, 1991, pp. 139-182.

5. Selected chapters from Brachytherapy Physics, ed. by Williamson, J.F., Thomadsen, B.T. and Nath, R. Medical Physics Publishing Company, Madison, WI., 1995.
Relevant AAPM Task Group Reports: TG-43 (Interstitial source dosimetry), TG-56 (Brachytherapy physics code of practice), TG-59 (HDR brachytherapy safety), TG-32; TG-41; TG-60; TG-64.

6. Selected articles from "Brachytherapy Physics, 2nd Edition", Ed. By Thomadsen, Rivard, and Butler

I. AAPM TG reports, ICRU reports and NRC reports

- ICRU 38: Dose and Volume Specifications for Intracavitary Brachytherapy
- ICRU 58: Dose and Volume Specifications for Interstitial Brachytherapy
- AAPM TG 32: Specification of Brachytherapy Source strength
- AAPM TG 43: Dosimetry of Interstitial Brachytherapy Sources
- AAPM TG 43U: Revised Protocol for Brachytherapy Dose Calculations.
- AAPM TG 56: Code of practice for Brachytherapy
- AAPM TG 59: HDR Treatment Delivery
- AAPM TG 64: Physics Aspects of Permanent Prostate Implants
- AAPM TG 40: Comprehensive QA for Radiation Oncology
- AAPM TG 41: Remote Afterloading Technology
- NUREG 10 CFR Part 19: Notices, instructions and reports to workers: inspection and investigations
- NUREG 10 CFR Part 20: Standards for protection against radiation
- NUREG 10 CFR Part 35: Medical use of byproduct material
- NUREG 1556 (Vol 9): Consolidated Guidance about Materials Licenses
- USNRC Regulatory Guide 8.39: Release of Patients administered radioactive materials

Rotation 8: Radiation Safety

Training objective: Gain experience with aspects of radiation safety including exposure risk evaluation and monitoring, surveying and shielding. This rotation will also include training in the patient safety improvement efforts of the department.

The resident will be responsible for the material in NCRP report number 151 (shielding), ICRP report number 103 (recommendations on protection levels) and 10CFR35 and 10CFR20. All are available on the network drive. The resident will also understand all aspects of dose and dose equivalent as well as exposure limits for various organs and whole body, and the details of how exposure is measured with film badges.

The resident will perform at least one shielding calculation for a new linear accelerator facility and for a diagnostic room. If none are under construction at the time of the training, example plans will be used.

This rotation will also include safety aspects related to brachytherapy and radioactive source, for example: wipe tests, personal protection, shipping, and source disposal protocols.

Training with patient safety improvement efforts will include understanding of the FMEA process for prospective error identification, as well as a small analysis project that involves the departmental web-based incident reporting system.

Reading list:

- The Physics of Radiation Therapy, F. Kahn, Pub: Lippincott Williams & Wilkins, 4th Ed., 2009
- Radiation Protection: A guide for scientists, regulators and physicians, J. Shapiro, Pub: Harvard University Press, 4th Ed. 2002
- Shielding Techniques for Radiation Oncology Facilities, P.H. McGinley, Pub: Medical Physics Publishing Corporation, 2nd Ed., 2002
- NCRP Report Number 151
- ICRP Report Number 103
- NUREG 10 CFR Part 20: Standards for protection against radiation
- NUREG 10 CFR Part 35: Medical use of byproduct material
- WHO report “Risk Profile in Radiotherapy”

Rotation 9: Imaging

Training objective: Understand the basic aspects of medical physic imaging including: CT, cone-beam CT, ultrasound, MR, PET/CT.

This two-month rotation will focus on the practical aspects of medical physics imaging as related to the practice of radiation oncology. This is meant as an addition to the standard didactic background in medical physics imaging as outlined above.

In this rotation the resident will spend time learning about and calibrating the department MR simulator, CT simulator, cone-beam CT devices, and brachytherapy ultrasound devices. They will present two imaging-related papers at physics journal club. The will also spend at least one week in a rotation with radiology which will include physics aspects of MRI and PET/CT. Our physics contacts in radiology will act as laisons for this rotation.

The resident will also perform image fusion for multiple purposes.

- Multi-modality image fusion for contouring and target definition.
- Treatment plan fusion with deformation for dose compositing and replanning.

Reading List:

- TG 132: Use of Image Registration and Data Fusion Algorithms and Techniques in Radiotherapy Treatment Planning
- The Essentials of Physics of Medical Imaging, J.T. Bushberg, J.A. Seibert, E.M. Leidholdt, J.M. Boone, Pub: Lippincott Williams & Wilkins, 3rd Ed., 2012
    - Image Quality: Chapter 4
    - Tubes and X-ray Production: Chapter 6
    - Radiography (CR Plates, CCD, flat panel imagers): Chapter 7
    - Mammography: Chapter 8

- Fluoroscopy: Chapter 9
- Computed Tomography: Chapter 10
- MRI: Chapters 12-13
- Ultrasound: Chapter 14
- PET: Chapter 19