MRI Safety: MR and PET-MR

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MR and PET-MR Safety Components

**Technology**

- Engineering Controls
  1. String
  2. Shielding
  3. Facilities Design

**Process**

- Procedural Controls
  1. Signs
  2. Access
  3. Workflow Design

**People**

- Operational Controls
  1. Personnel
  2. Training
  3. Emergency Response
Technology – Engineering Controls

- Siting and Shielding
  - MR and Radiation
- Facility Design – Operations
  - MRI
  - Nuclear Medicine
  - Radiation Oncology

Safety Considerations – Siting PET-MR

**MR**
- Magnetic Fringe Field
- Static Magnetic Field
- Quench
- MR Scanner Operations
  - RF Shielding
  - Vibration

**PET**
- Ionizing Radiation
- Injection/ Uptake
- Patient Handling
- PET Scanner Operations
  - Radiation Interference (external sources)

Site Design Foundation – Three Key Documents

<table>
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<tr>
<th>ACR 2013 - Design</th>
<th>Manufacturer - MR</th>
<th>AAPM 108 - PET</th>
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<tr>
<td>Site Design</td>
<td>MR and PET</td>
<td>PET and PET/CT Design, Planning, and Operations</td>
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PET-MR Radiation Shielding: MR Waveguides

Typical MR Room Waveguide location

PET-MR Radiation Shielding: MR Waveguides

Fringe Fields (5 Gauss)
PET-MR: Shielding Layers

1. Radiation shielding (Lead):
   Radiation protection for the planned system

2. Magnetic shielding (Steel):
   Contain MR Magnet fringe field within a confined space

3. Acoustic shielding (Air):
   Attenuate noise produced during scan

4. RF shielded (Copper):
   Prevents interference from external RF sources

Shielding Layers

Shielding layer order (from outside in):

1. Radiation shielding (Lead)
2. Magnetic shielding (Steel)
3. Acoustic shielding (Air)
4. RF shielded (Copper)

PET-MR Lead Shielding

A. Penetration panel from scan room to MRI equipment room: No lead floor to ceiling
B. Back wall attachment screws for silicon steel penetrating lead barrier did not need lead plugs
PET Annulus Phantom Shield

- Integrate features several options for easy capability and wheel
  - Skids in two sections for easy portability
  - Shield for each section for easy portability
  - Mobile registration phantom shield does not have wheels, so can be rolled or moved by hand without incline
  - Flattening phantom
  - All features in hand for easier operation
  - Convenient side cups for phantoms’ order or custom
  - Complex features options can easily be removed to secure the phantom and the container

PET-MR Phantom

- Special hooks allow the facility to secure the shield to the bed
  - Vertical in series of windows
  - The container also modified to fit under the phantom
  - Shield features both cushions on the top and bottom
  - For the top and bottom cushions
  - 3D view the second for the phantom for modular configuration using the integration of radiology phantom
  - Height - approximately 50" (130 cm)
Technology - Summary

• Siting
  - MRI Safety Zones
  - PET Workflow (ALARA)

• Shielding
  - MR and Radiation

• Facilities Design
  - MRI
  - Nuclear Medicine
  - Radiation Oncology

Process – Procedural Controls

• Signs and Labels
• Staff Workflow
• Patient Workflow
• Access Control

Administrative Control: Signs and Labels

• Access and Zone signs
• Workflow signs
• Personnel safety signs
• Safety markers – 200 Gauss
• Equipment labels
Staff Screening Process – Equipment Need

- Any staff with possibility of entering Zone 4 for patient care is screened
- Four step process to enter Zone 4:
  1. Verbally, inspired pat down (self-screening) – Zone 2
  2. Visually (Ferroguard) – Zone 2 or 3
  3. CEIA white hand-held (if Ferroguard senses metal)
  4. Respect final barrier yellow tape or Techgate
     - Only MR technologist can open or close
     - MR technologist has final authority

MR Safety Screening – Four Step Process

Step 1  Step 2  Step 3  Step 4
MR Safety Screening Process

Patient Screening  Staff Screening

Final Barrier – Step 4

Yellow barrier tape

PET-MR Safety Screening

- PET-MR Imaging Order
- Patient Safety Screen
  - 1st MR safety screening
  - Tracer Injection
    - Table side → proceed with PET-MR
    - Uptake room
  - 2nd MR safety screening
- PET-MR Imaging

Courtesy: Dr. Yuxiang Zhou
Controlled Access

- Badge access
  - Level 1
  - Level 2
- Who grants access?
  - Security after MR safety committee review
- Annual review
  - Disable access
  - Diligence!

Process – Summary

- Signs and Labels
  - Access and Zone signs
  - Workflow and safety signs
  - Equipment labels
- Clinical Workflow Design
  - Staff and Patients
  - Safety screening
- Controlled Access
  - Levels of access
  - Periodic review and update access list

People – Operational Controls

- Personnel – Level 1, Level 2
- Safety Education and Training
- Unique Workflow – PET-MR
- Emergency Response – MR and Radiation
Personnel Classification

- **Level 1: Enhanced MRI safety knowledge**
  - Staff who access Zones 2, 3 and 4
  - Responsible for their own safety
  - Security, Facilities, Clinical Engineering, Rad Nursing, SWAT, Anesthesia, CRNA, Radiation Oncology Therapist, Physicists, Radiologists

- **Level 2: Advanced MR safety knowledge**
  - Radiology staff working Zone 3 and Zone 4
  - Responsible for their own safety and safety of others
  - MR Technologists and PET-MR Nuclear Medicine Technologists

MR and Radiation Safety Training

- **Level 1: Enhanced PET-MR safety knowledge**
  - Online LEVEL 1 module on hire (initial) and then annually
  - Initial and ongoing (every 3 years) hands-on training
  - MR and Radiation safety awareness
  - Emergency procedures
  - Equipment labels (safe, unsafe, conditional)

- **Level 2: Advanced PET-MR safety knowledge**
  - Annual LEVEL 2 competency and inservice
  - Patient and staff screening – screeners
  - Burn prevention, PNG
  - Scanning sedated patients
  - Radiation and MR emergency response

Rad Onc Therapist Training

- PET-MR Environment
- Safety Screening
- Infection Control
- Clinical Workflow
- Roles and Responsibilities
- Rad Onc Specifics
  - Coils
  - Immobilization devices
  - SIM planning protocols
PET-MR Workflow Radiation Safety

- PET injections are administered in adjacent holding area to avoid contamination in PET-MR room
- MR-conditional syringe shields are used for table-side injection

Courtesy: Dr. Yuxiang Zhou

Unique Radiation Safety Aspects

- Table side PET-MR scans
- Coils placement and MR localizer scans are performed prior to PET injection

Courtesy: Dr. Yuxiang Zhou

PET-MR Zone 4 Injection

- Most of prep work is performed prior to injecting patients
  - Coil positioning
  - MR scout scans for patient positioning
- Chux is placed under injection area to minimize chance of contamination
- After leaving the scanning room, chux is immediately checked for contamination using a GM meter
Emergency Response

- **MR:** patient codes, fire, quench, RF burn, projectile
- **Radiation:** area surveys, spills, patient contamination

Who do you call and who will respond?
- Radiation Safety
- Code
- Fire
- Security

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Emergency Response: Contaminated Patient

- If PET injection occurs in the PET-MR suite and chux is contaminated
  - Complete patient scan and monitor patient and gurney in Zone 2
- If patient is contaminated
  - Remove patient gown
  - Use conventional cleansing techniques
  - Mild soap and lukewarm water preferred
  - Decontamination performed only by trained personnel
PET-MR Decontamination

- Determine extent of contamination using wipes
- Radiation meters **can not be** brought into scanning room
- Decontamination vs. Closing Room
  - Most PET radiopharmaceuticals have short half-lives
  - Wipe tests post decontamination
- Call Radiation Safety Officer

People – Summary

- MR Safety Training
  - ‘Non-MR’ personnel – Level 1
  - ‘MR’ personnel – Level 2
- Unique Workflow
  - PET-MR: Short-lived radioisotopes
- Emergency Response – MR, Radiation
  - Code, quench, fire, smoke
  - Radiation spill, decontamination

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