



MRI Safety: MR and PET-MR

Anshuman Panda, PhD

Mayo Arizona: Yuxiang Zhou, PhD
Mayo Florida: Robert Pooley, PhD
Mayo Rochester: Brad Kemp, PhD

AAPM Annual Meeting 2018
Nashville, TN

No conflict of interest to declare

©2018 MEDICAL L. 000001



MR and PET-MR Safety Components



Technology

Engineering Controls

1. Siting
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

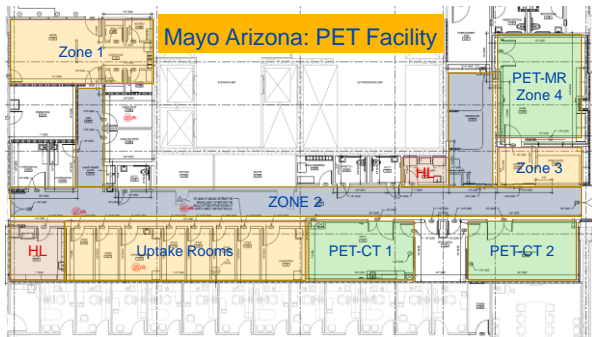


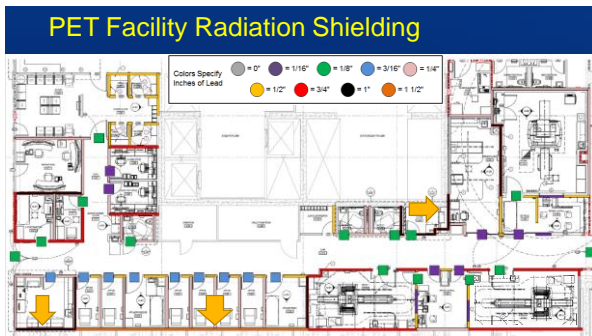
©2018 MEDICAL L. 000001

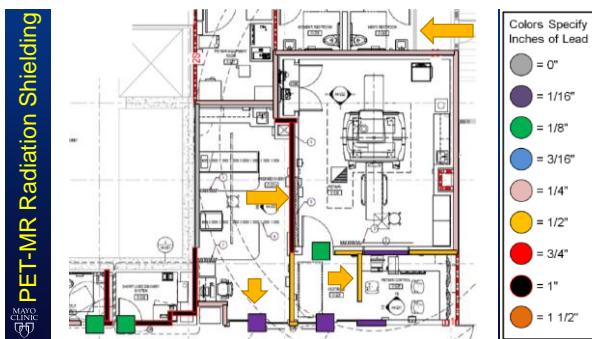
Safety Considerations – Siting PET-MR

MR	PET
<ul style="list-style-type: none">• Magnetic Fringe Field• Static Magnetic Field• Quench• MR Scanner Operations<ul style="list-style-type: none">• RF Shielding• Vibration	<ul style="list-style-type: none">• Ionizing Radiation• Injection/ Uptake• Patient Handling• PET Scanner Operations<ul style="list-style-type: none">• Radiation Interference (external sources)

MAYO CLINIC



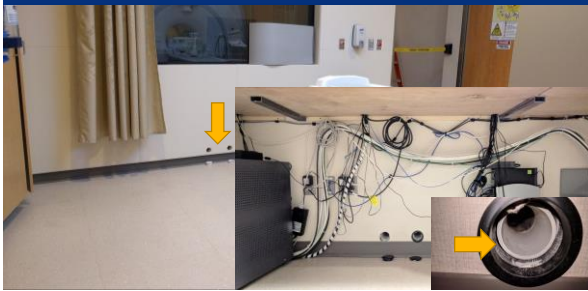


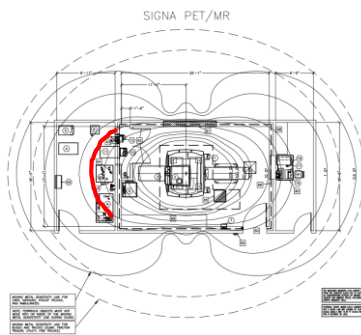


PET-MR Radiation Shielding: MR Waveguides



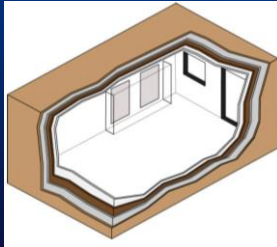
PET-MR Radiation Shielding: MR Waveguides





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

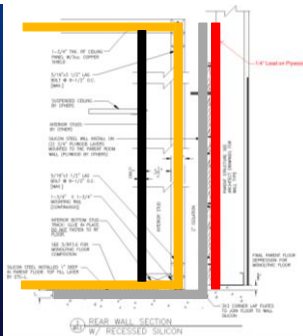


2013.07.02 | 10:11:13

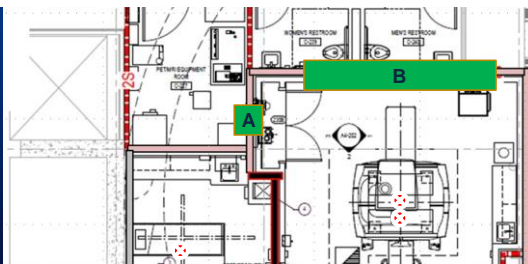
Shielding Layers

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

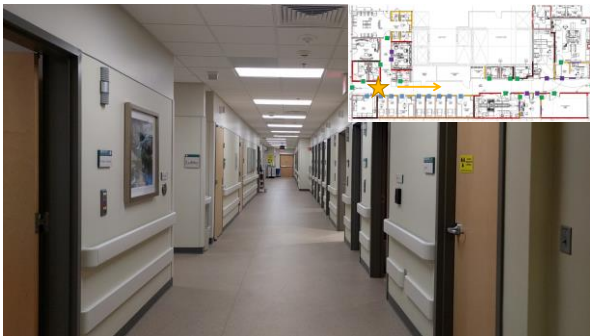


- A. Penetration panel from scan room to MRI equipment room: No lead floor to ceiling
- B. Back wall attachment screws for silicon steel penetrating lead barrier did not need lead plugs



2013.07.02 | 10:11:13











PET Annulus Phantom Shield

- Wheels feature swivel casters for easy mobility and wheel locks for added stability (catalog EB008P5)
- Mobile applications phantom shield does not have wheels so it can be rolled directly to the MRU (Mobile Medical Unit) floor (catalog EB008P7)
- Lid features a handle for easier opening
- Spring loaded covered hinge assists when lifting the lid
- Container latch seals the phantom inside to ensure radiation gases are contained
- Latch includes option to use a padlock to secure the phantom in the container
- Mount holes allow the facility to secure the shield to the site with a chain or cable
- The container's interior walls feature a soft plastic for easier insertion and removal of the phantom
- Shield features foam cushioning on the lid's top and container's bottom as required for mobile applications (catalog EB008P7)
- Lid may be secured in the closed position for mobile transportation using the integrated lobe (catalog EB008P7)
- Weight - approximately 300 lb/136 kg



Container - EB008P5



Container - EB008P7

PET-MR Phantom



PET-MR Annulus Phantom Storage - MCA



PET-MR Annulus Phantom Storage - MCF



Courtesy: Dr. Robert Pooley

Radiation Oncology: Laser Positioning



Courtesy: Dr. Yanle Hu

Technology - Summary

- **Siting**
 - MRI Safety Zones
 - PET Workflow (ALARA)
- **Shielding**
 - MR and Radiation
- **Facilities Design**
 - MRI
 - Nuclear Medicine
 - Radiation Oncology



©2018 Mayo Clinic | 4/10/18

Process – Procedural Controls

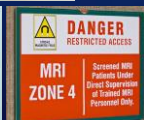
- Signs and Labels
- Staff Workflow
- Patient Workflow
- Access Control



©2018 Mayo Clinic | 4/10/18

Administrative Control: Signs and Labels

- Access and Zone signs
- Workflow signs
- Personnel safety signs
- Safety markers – 200 Gauss
- Equipment labels



©2018 Mayo Clinic | 4/10/18









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:
 - Verbally, inspired pat down (self-screening) – Zone 2
 - Visually (Ferrogaurd) – Zone 2 or 3
 - CEIA white hand-held (if Ferrogaurd senses metal)
 - Respect final barrier yellow tape or Techgate
 - Only MR technologist can open or close
 - MR technologist has final authority



MR Safety Screening Process



Patient Screening



Staff Screening

Final Barrier – Step 4

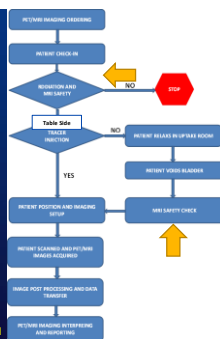


Yellow barrier tape



PET-MR Safety Screening

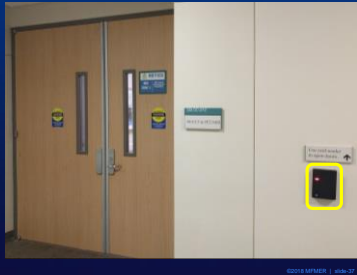
- PET-MR Imaging Order
- Patient Safety Screen
 - 1st MR safety screening
- Tracer Injection
 - Table side → proceed with PET-MR
 - Uptake room
- PET-MR Imaging



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!



CONTROLLED ACCESS | JULY 18

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



PROCESS SUMMARY | JULY 18

People – Operational Controls

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



PEOPLE OPERATIONAL CONTROLS | JULY 18

[illegible]

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

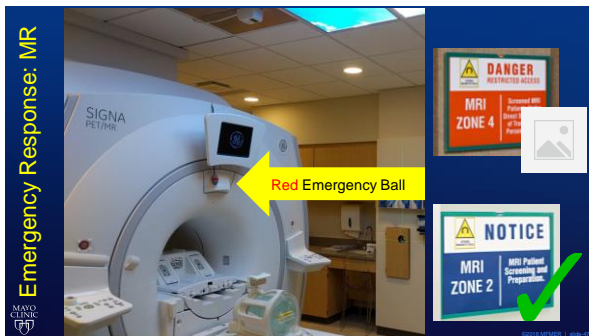


Emergency Response

- **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



Emergency Response: MR



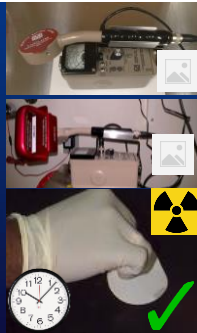
Emergency Response: Contaminated Patient

- 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



MR and PET-MR Safety Components



Technology

Engineering Controls

1. Siting
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



PET-MR Safety Incident



Joint MR and PET-MR Safety Committee



- Radiologist (MRMD)
- Nuc Med Radiologist
- MR Technologist (MRSO)
- Nuc Med Technologist
- MR Physicist (MRSE)
- PET-MR (Nuc) Physicist
- Administrators (Supervisors and Managers)
 - MR and Nuc Med Ops



© 2018 Mayo Clinic

