GLOBAL CLINICAL ENGINEERING ALLIANCE™

WEBINAR

Imaging Equipment: MRI

Technology, usage, and service

WEDNESDAY OCTOBER 12

6 PM UNIVERSAL TIME (UTC)

2 PM NEW YORK TIME (ET)

REGISTER FOR FREE

https://bit.ly/3DC7BPC

MODERATOR

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Italian Clinical Engineering Association (AIIC), Italy

PRESENTERS

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State University of Campinas (UNICAMP), Brazil

LI BIN
Shanghai 6th People's Hospital Affiliated to Shanghai Jiaotong University, China

MR Introduction & Differences

Jim Zaput – Global MR Training Program Manager
GE Healthcare Institute, Waukesha, WI

MRI Introduction & How MR Differs from other Imaging Modalities

- Very briefly, in 15 "*New York Minutes*" we'll be covering….

- What is MR ?
- What are MR's Inherent Hazards
- Magnets, Superconductors & Cryogens
- Imaging System – Major Component Roles

Magnetic Resonance Imaging.. WHAT & WHY

- MR is the only Diagnostic Imaging Modality where patient tissue is the SOURCE of the image data.
  - XR, CT, XV, XM are based on an XR source attenuated thru tissue and the shadow detected.
  - NM & PET apply radioactive isotopes tagged to metabolites, following along for the ride to tissues of interest and the isotope decay is detected.
  - UL is based on acoustic waves of a propagating frequency reflecting off tissues and structures and the reflection is detected.
  - MR is profoundly different. How ?

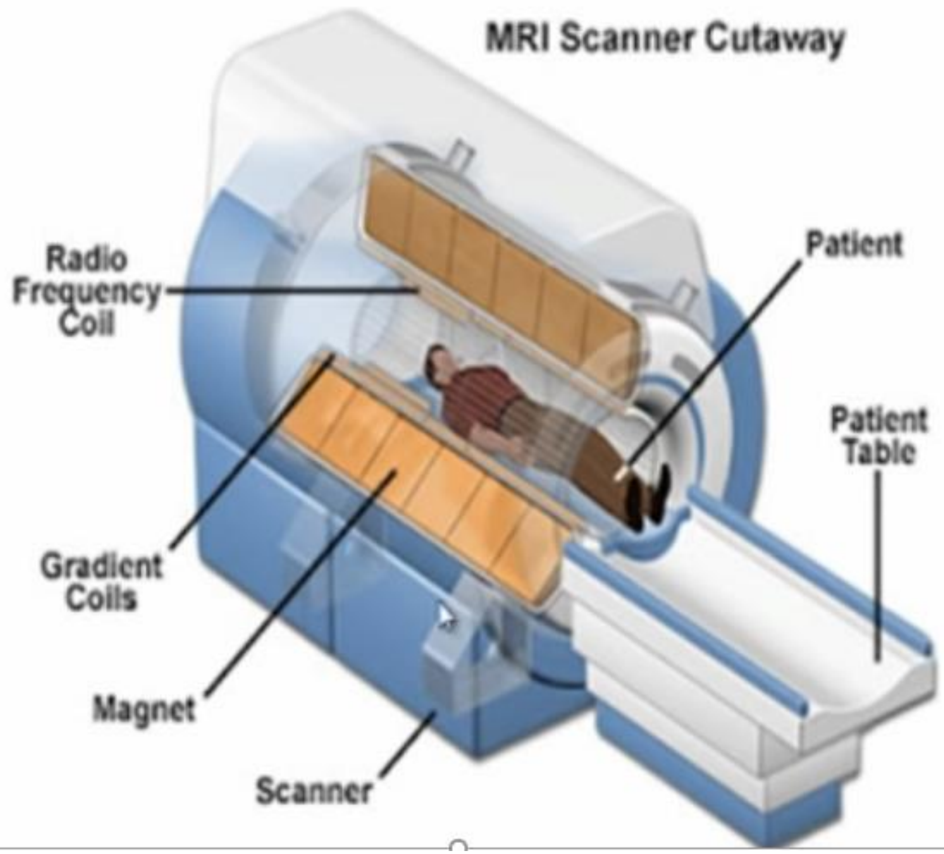
How is Magnetic Resonance Imaging different…

- MRI depends upon the efficient absorption & return of RF Energy at a patient’s tissue resonant frequency. Typically, 63.86MHz (1.5T) or 127.72MHz (3.0T).
  - This “Resonance” is very analogous to “The Child on the Swing”, impart energy to the system at the right frequency (push the child at the right time) the system will efficiently absorb and return that energy (less friction losses at the pivot point and air resistance of course)
- MRI depends upon the abundance of WATER in the human body (about 60%)
  - Thus, making MR ideal for soft tissue imaging and ineffective for bone imaging.
  - The SINGULAR purpose of the main magnetic field is to polarize/align the patients hydrogen protons to parallel & antiparallel orientations.
  - Only one in one million hydrogen nuclei contribute to the MRI Image.
    - Of those, only a small fraction are producing active MR image detail

The evolution of the Main Magnetic Field

- **Resistive** – Coils of conventional “resistive” copper / alloy wire
  - Energy Intensive, Heat Producing, Inherently unstable (current control)
  - Limited to low-moderate field strengths at human imaging volumes, < 0.5T .
  - Silver wire has been used in scientific magnet applications but impractical for imaging use, most notably The Manhattan Project.
- **Permanent** – Naturally occurring rare earth materials
  - Zero external energy to operate, sensitive to magnet material temperature variations.
  - Limited to low-moderate field strengths at human imaging volumes, < 1.0T.
  - As does not require a solenoid of wire, makes possible the “open” / “large gap” product geometries.
- **Superconductor** – Coils of “zero resistance” wire at ultralow temperature.
  - State of the Art for MRI across all major OEM’s.
  - Minimal external energy to operate (limited to coldhead and thermal support systems).
  - Inherently rock-solid main field stability 1.5T, 3.0T at human imaging volumes are now common. 7.0T is the next frontier now being explored.
  - Sensitive to environmental vibration & Electromagnetic Interference (EMI). Pre-siting qualification work is critical.
  - Massive amounts of stored energy, requires direct venting to outside.
  - ALWAYS “on” and SILENT, regardless of the local electrical state of observable systems.

Perhaps the biggest difference (literally) is the Superconducting Magnet…..



A look inside superconducting physics..

- The magnet is composed of usually 8 coils (6 Main + 2 Shield) of superconducting niobium-titanium alloy wire, several miles of which are all in series.

- When cooled to its critical temperature of 4.2 Kelvin and held there by an immersion in Liquid Helium, the 750 Amps of main field current flows with 0.000000000000000 Ohms of resistance. No resistive losses at all. Massive INDUCTANCE though, greater than 20 Henries (on an *air* core !!)

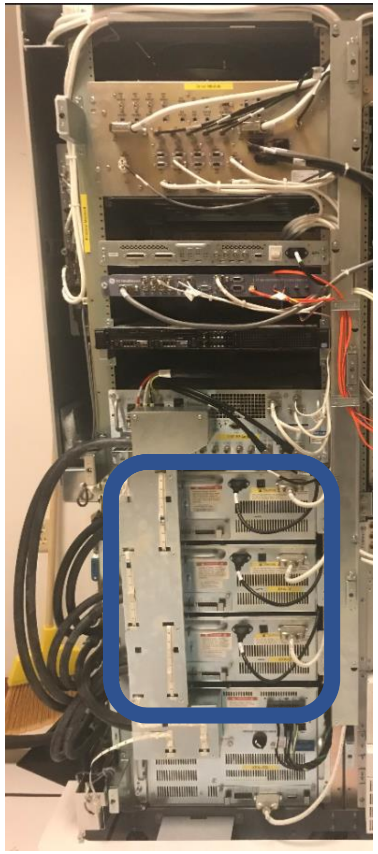
The first three Hazards of MR……

- #1 - The **stored energy** (3-10MJoules) that is the magnetic field. The **Translational Force** upon ferrous metal objects near an energized superconducting magnet is often well BEYOND a human's strength to counter. The object WILL travel, it's path **WILL** be unpredictable, it **WILL** injure persons or damage equipment in its path. For this reason,

ALL approach assumptions MUST be that the Magnet is ALWAYS ON

- #2 – The **stored energy, if released** into the liquid helium bath, is called a **Quench**. Can be purposefully initiated in response to an accident OR it can occur spontaneously. The resultant helium gas must be piped safely to OUTSIDE of the building. Helium is not reactive; it is not poisonous. The primary hazard of helium gas is displacement of oxygen. Helium gas is a simple asphyxiant.
- #3 – **Cryogenic Temperatures** – During service events or following quench events, the metal surfaces of the magnet and support plumbing can become extremely cold. Sufficiently cold, to cause frostbite on contact.

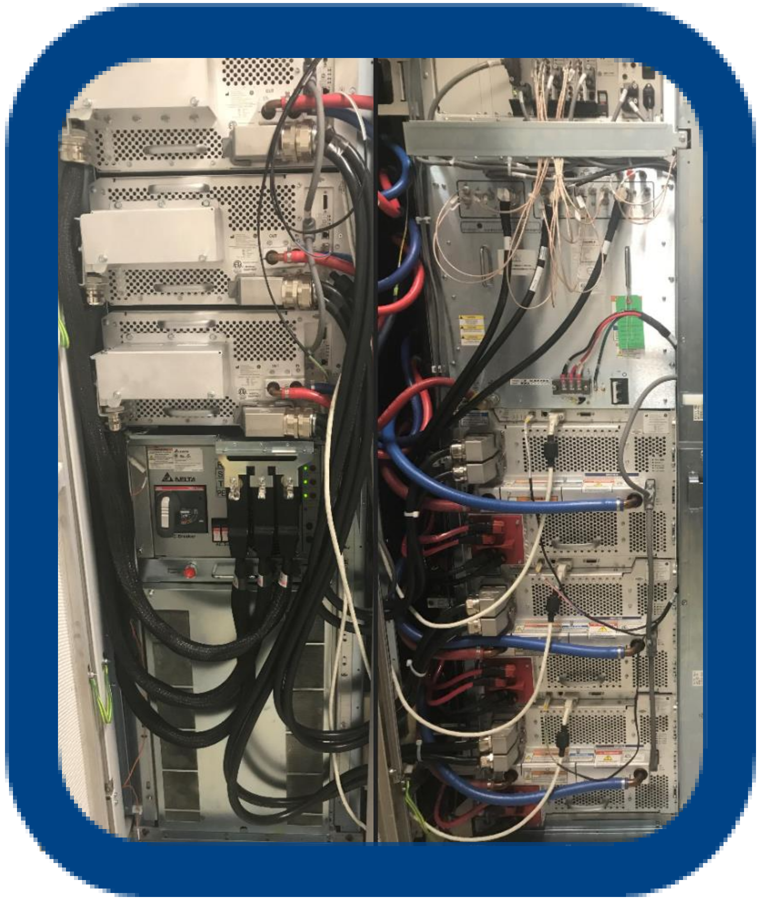
Gradient Amplifiers drive Scanner Performance



1/3 of a Cabinet

2/3's of a Cabinet

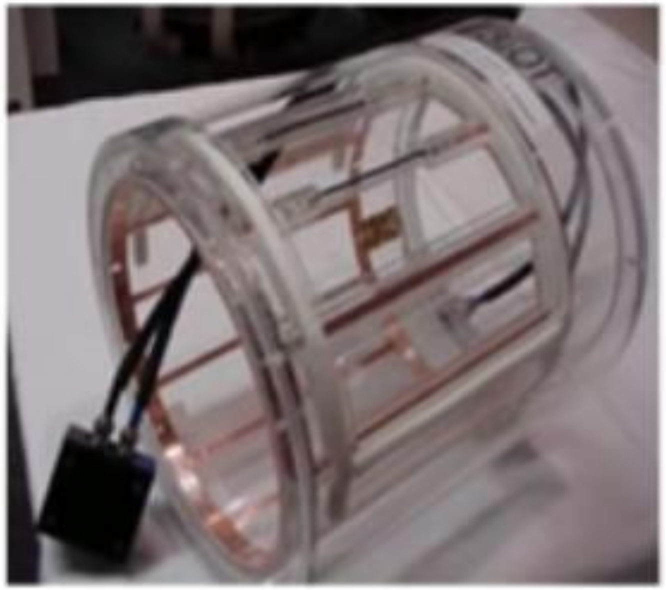
Full Cabinet



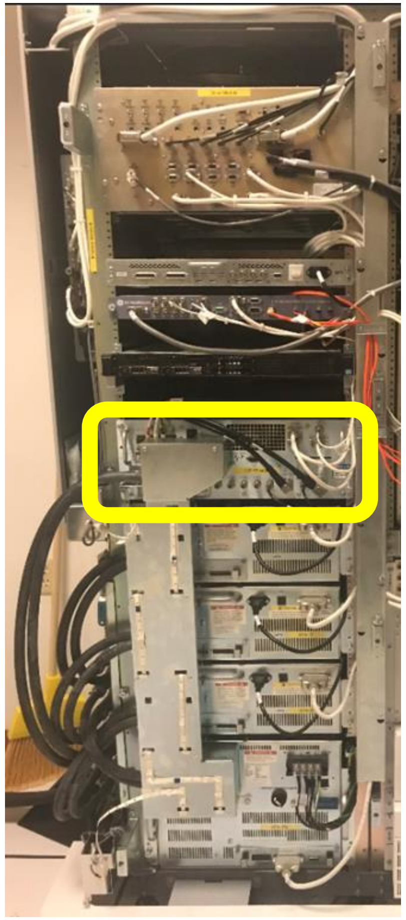
TWO Full Cabinets with a dedicated 150A / 480V Feeder

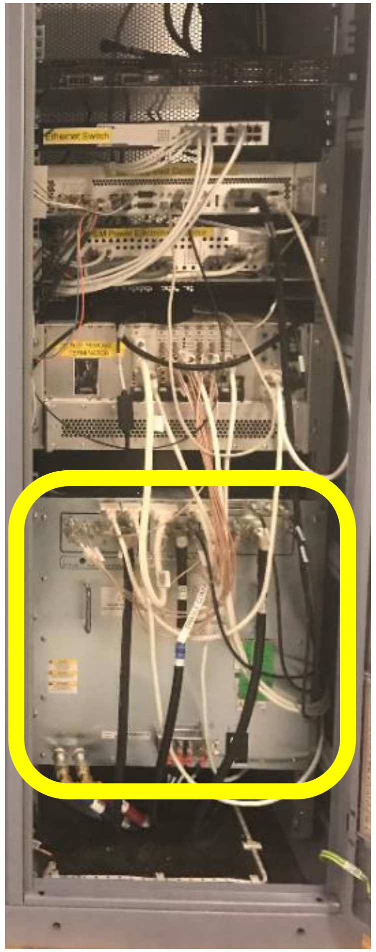
The rf coils

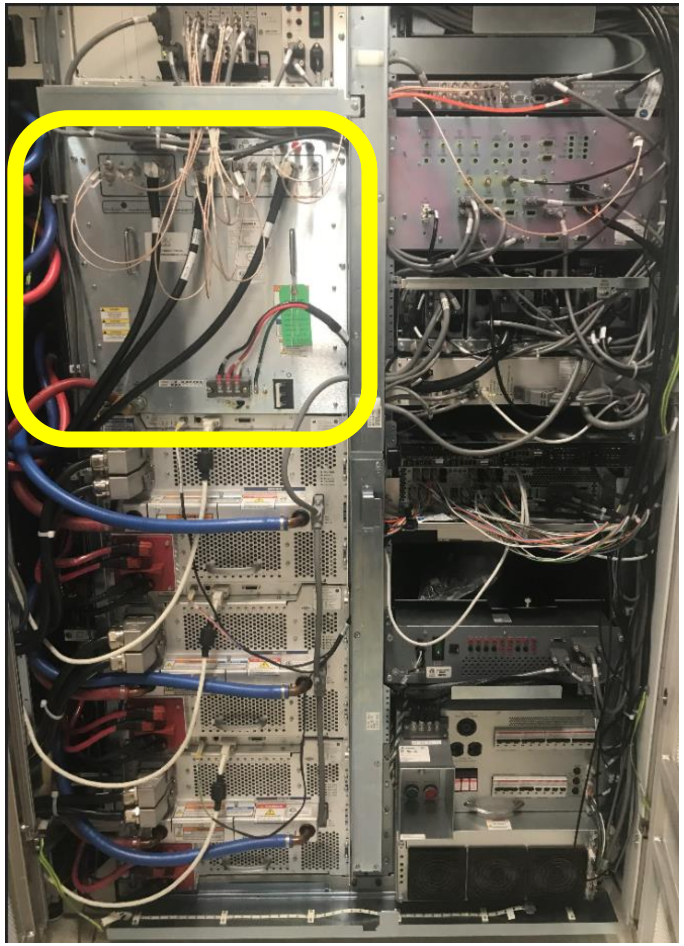
These are used to both transmit the rf EM pulse and receive the EM signal from the protons' transverse field as they precess in phase.



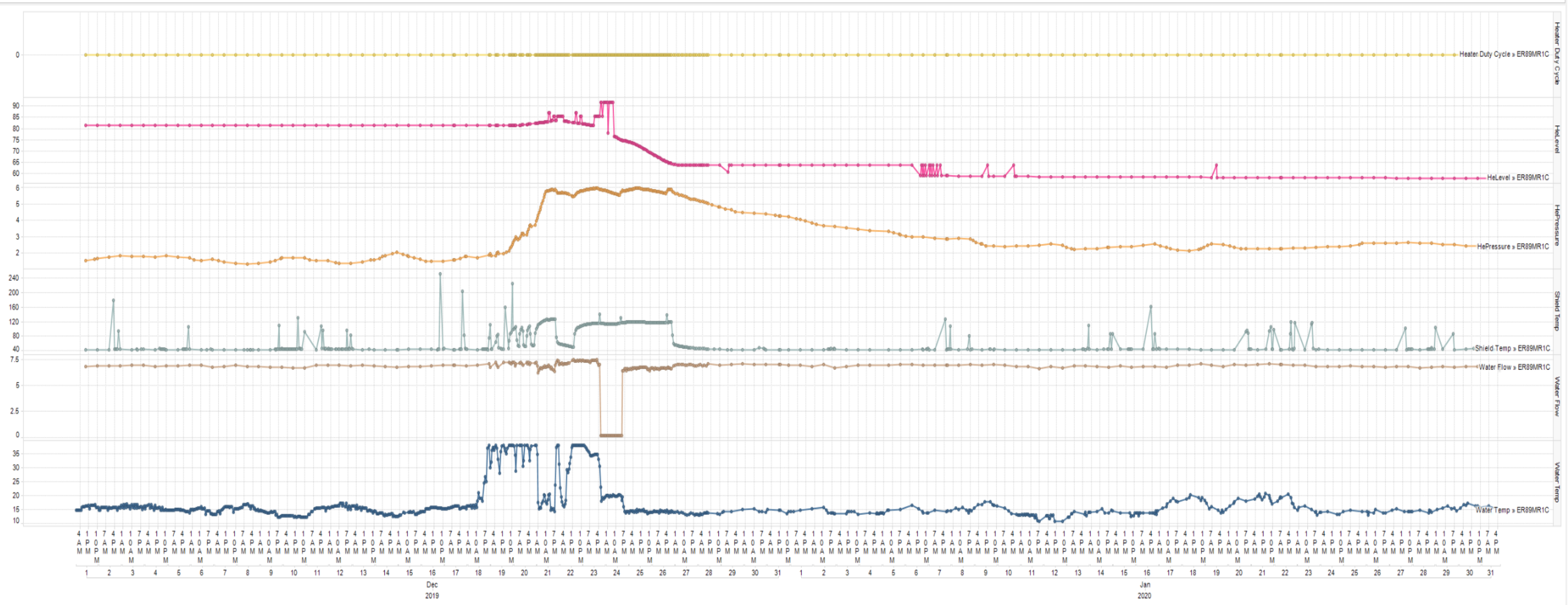
RF Amplifiers carry the image excitation information to the patient and need to scale to field strength 1.5T (16kW pk) or 3.0T (30kW pk)…







Example of a Magnet Service Event, Late Dec 2019: -21% = $9,000 wasted



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A common departmental precaution…

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Thank you !

Jim Zaput
James.Zaput@med.ge.com

MRI: Safety Aspects

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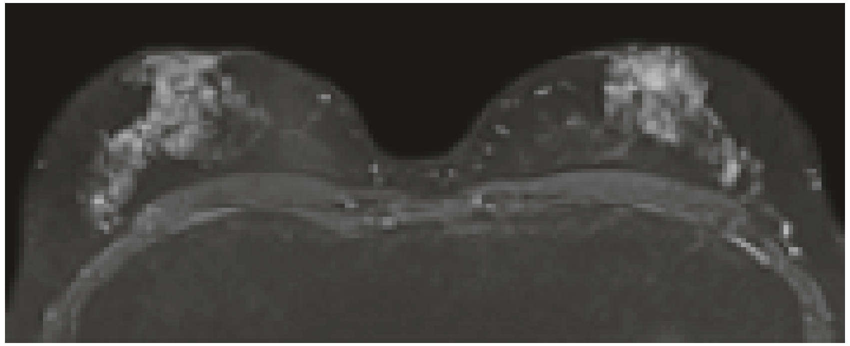
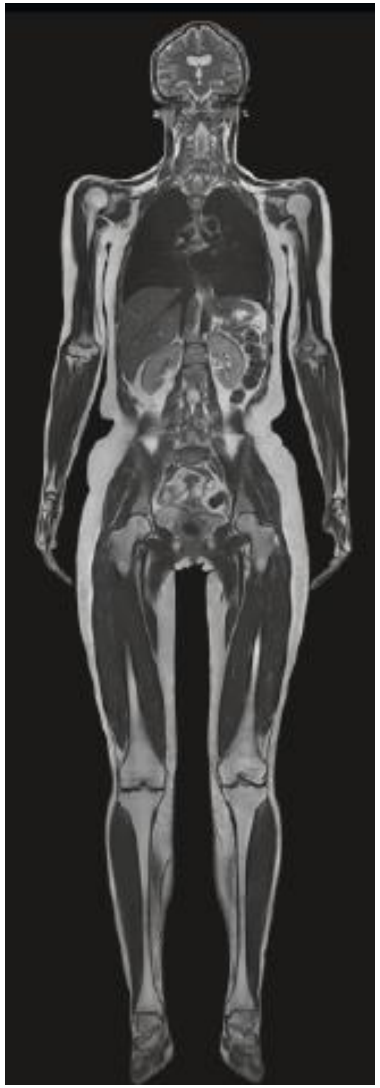
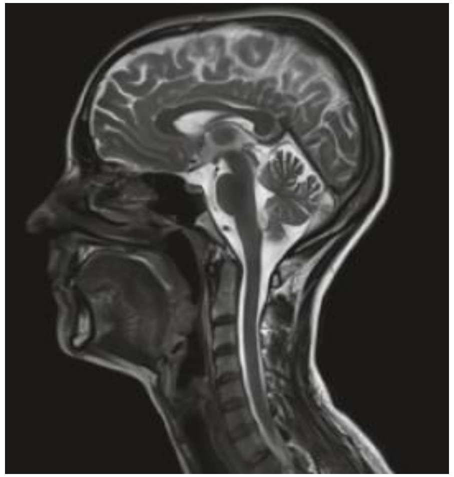
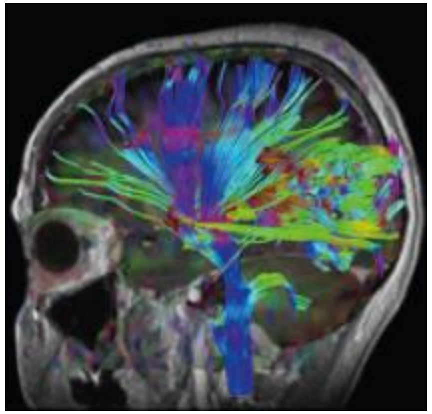
MRI

www.dicardiology.com/article/ge-healthcare-partners-tesla-engineering-produce-ultra-high-field-7t-mri-systems
Acess: 12/06/2019

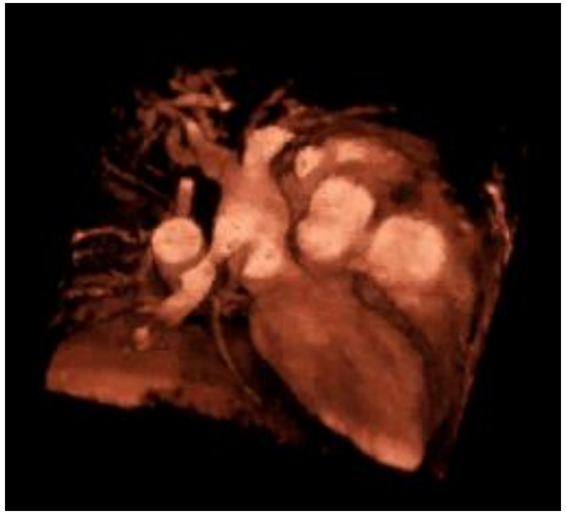


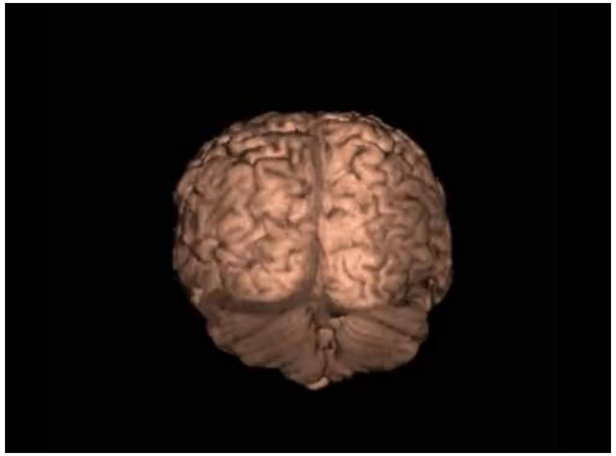


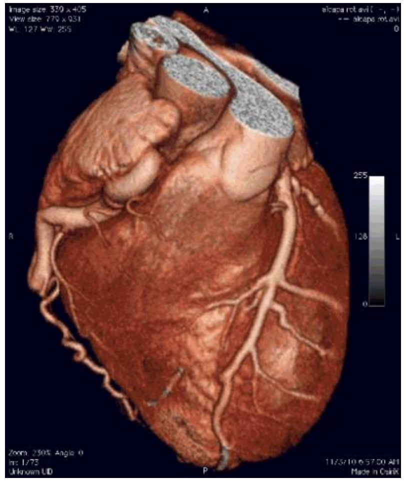




MRI





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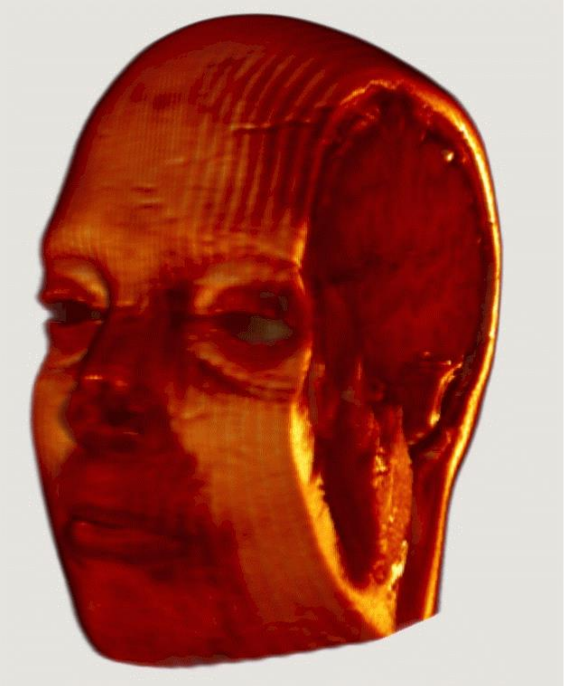
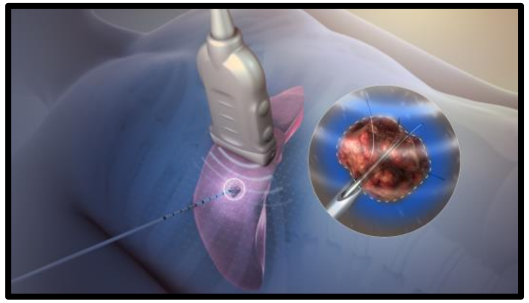


Biological Effects of the B_0 Magnetic Field

- FDA: up to 8T – no significant risk for adults
- 9.4 T – used in humans – sensory responses, from the vestibulocochlear system
- Studies: evaluate cell growth, DNA, hematological indices, neuron activities, blood-brain barrier...
- There were no adverse effects that justify restriction of use

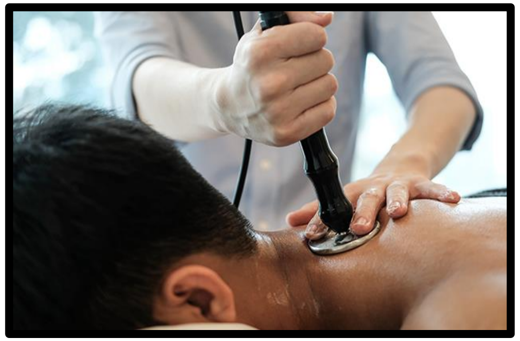
Biological Effects of Radiofrequency Pulses

- Most of transmitted power – converted to heat – resistive loss
- SAR – Specific Absorption Rate – measure of the power deposited by RF in tissues. Units (W/kg).
- RF dosimetry – non-trivial: to considerer many parameters of the pulse sequence.
- Body measurements: tympanic temperature, skin temperature at various points, heart rate, blood pressure, oxygen saturation...

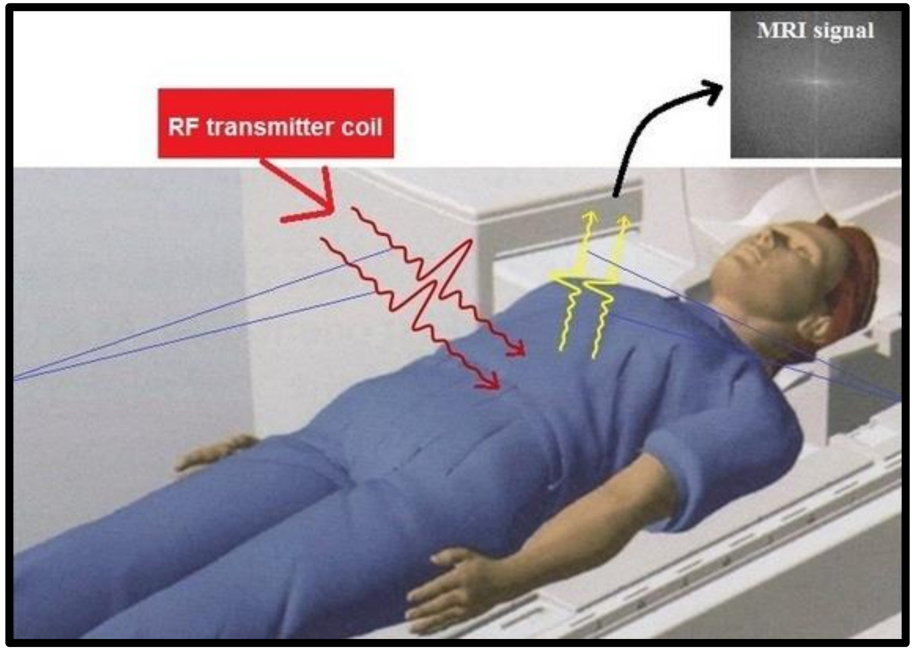


https://en.wikipedia.org/wiki/Radiofrequency_ablation
Acess: 12/06/2019

https://thebestorganicskincare.com/does-radio-frequency-skin-tightening-work/
Access 12/06/2019



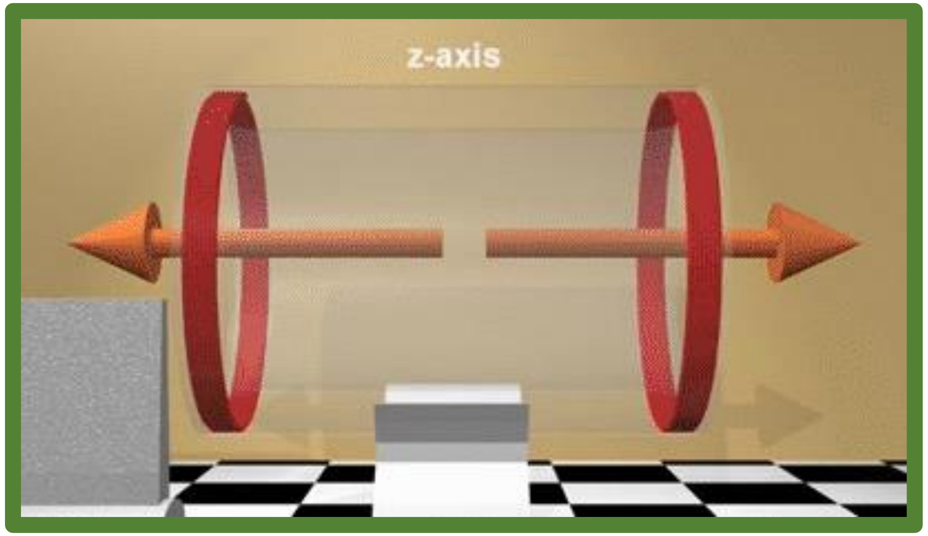
https://thepainreliefpractice.com/radiofrequency-therapy/
Acess: 12/06/2019



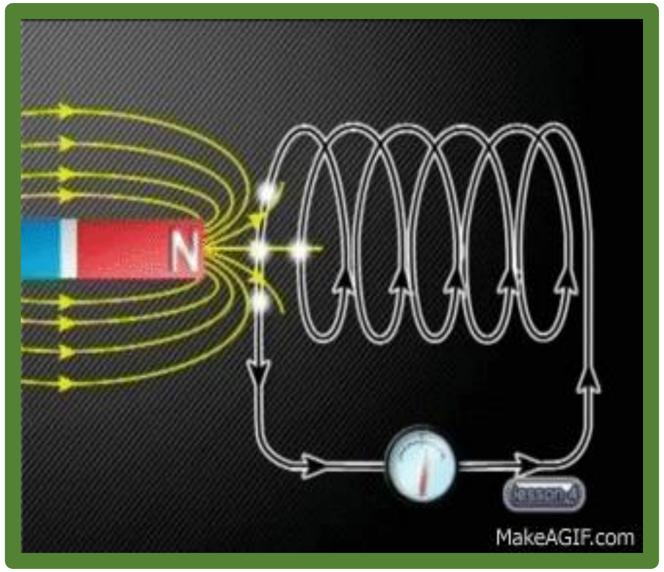
https://mrimaster.com/technique%20bandwidth.html
Acess: 12/06/2019

Biological Effects of the Gradients

- Stimulation of muscles and nerves – induction of electrical currents - uncomfortable
- Dependence on the distribution of electrical currents in the body, electrical properties of tissues, and characteristics of cell membranes



https://gifer.com/en/Dwyg
Access : 01/07/2019



https://makeagif.com/gif/physics-electromagnetism-faradays-law-gLfzWB
Access: 01/07/2019

https://gfycat.com/gifs/search/neuron
Access 01/07/2019

Interactions of Medical Devices with MRI Scanners

- Interaction with the magnetic field
- Induction of electrical currents
- Heating
- Induction of artifacts in images

https://www.mriequip.com/store/pc/MRI-Non-Magnetic-Dual-Oxygen-Tank-Cart-p224.htm
Access: 25/05/2019

http://www.newcastle-hospitals.org.uk/news/news-item-22809.aspx
Access 23/01/2019

http://mri-devices.com/3860-mri-infusion-pumps/
Access: 12/07/2019

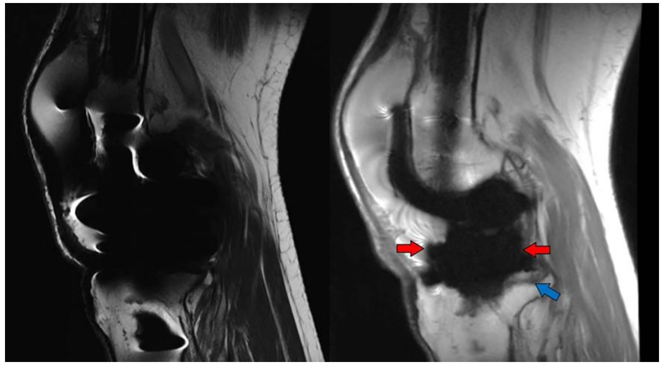
https://tenor.com/view/qoobee-agapi-tantrum-gif-11624386
Access 10/05/2019

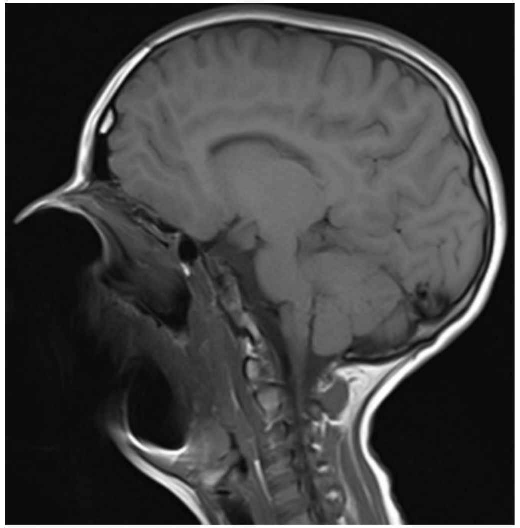
Watch Out!

https://www.medgadget.com/2014/01/medtronics-pacemakers-now-cleared-for-full-body-mri-compatibility.html
Access: 10/03/2018

https://www.gehealthcare.com.br/products/patient-monitoring/patient-monitors/b1x5m-patient-monitors
Access: 01/10/2022

https://www.somatechnology.com/Infusion-Pumps/ICU-Medical-Hospira-Plum-360.aspx
Access 01/10/2022





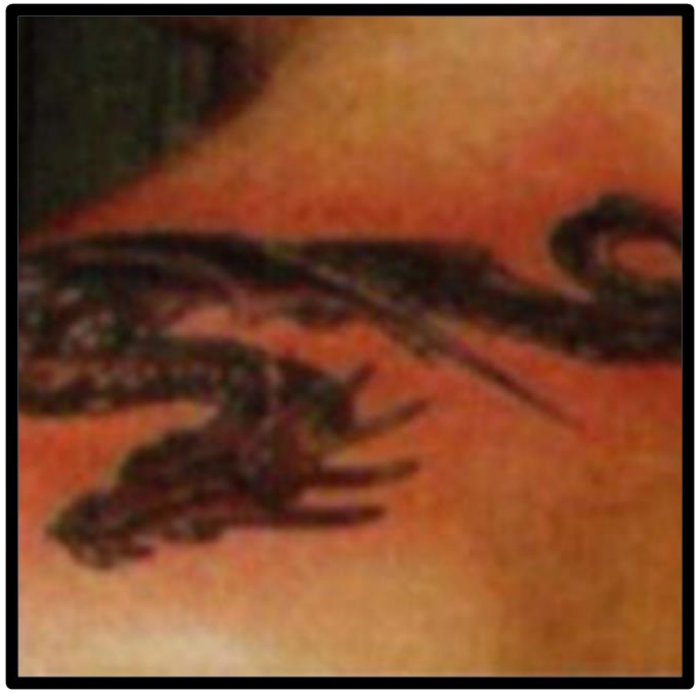
https://chinameddevice.com/un-ignorable-chinas-orthopedic-implant-industry/
Access: 28/07/2018

http://www.knoxvillesmilecenter.com/blog/post/fixed-or-removable-deciding-which-implant-supported-bridge-is-best-for-you.html
Access: em 23/03/2019

Watch Out!

http://hrlawinsider.com/category/dress-and-grooming-standards/
Access 10/06/2019

https://www.thejournal.ie/versatis-pain-patch-petition-3862449-Feb2018/
Access: 30/04/2019



https://www.livescience.com/32801-do-mri-machines-affect-tattoos.html
Access 30/12/2018

MRI Accidents Reported

- Missile effect – most common
- Heating and burning
- Hypoxia

Missile Effect

Boy, 6, Killed in Freak MRI Accident

July 31

A 6-year-old boy died after undergoing an MRI exam at a New York-area hospital when the machine's powerful magnetic field jerked a metal oxygen tank across the room, crushing the child's head.

The force of the device's 10-ton magnet is about 30,000 times as powerful as Earth's magnetic field, and 200 times stronger than a common refrigerator magnet.

The canister fractured the skull and injured the brain of the young patient, Michael Colombini, of Croton-On-Hudson, N.Y., during the procedure Friday. He died of the injuries on Sunday, the hospital said.

The routine imaging procedure was performed after Colombini underwent surgery for a benign brain tumor last week. Westchester Medical Center officials said he was under sedation at the time of the deadly accident.

Hospital Takes 'Full Responsibility'

https://www.nytimes.com/2001/07/31/nyregion/boy-6-dies-of-skull-injury-during-mri.html
Access 31/01/2018

https://www.justdial.com/Trichy/Oxygen-Cylinder-Dealers
Access 21/01/2019

Missile Effect – Hospital Bed

https://nursing-illustration.com/05-free-download/052-medical-treatment.html
Access 04/07/2019

India – 2014

www.timesofindia.indiatimes.com/city/raipur
Access 26/10/2015

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Missile Effect – Oxygen Cylinder

https://www.dailymail.co.uk/news/article-2890088/Two-hospital-workers-spend-FOUR-HOURS-pinned-MRI-machine-metal-oxygen-tank-catapulted-room-device-s-giant-magnet-turned-on.html
Access 25/03/2018

Noah’s Case – Thermal Blanket Burns

https://wonderfulengineering.com/10-best-emergency-blankets/
Access 10/04/2019

https://www.prayfornoah.com/
Access 13/02/2017

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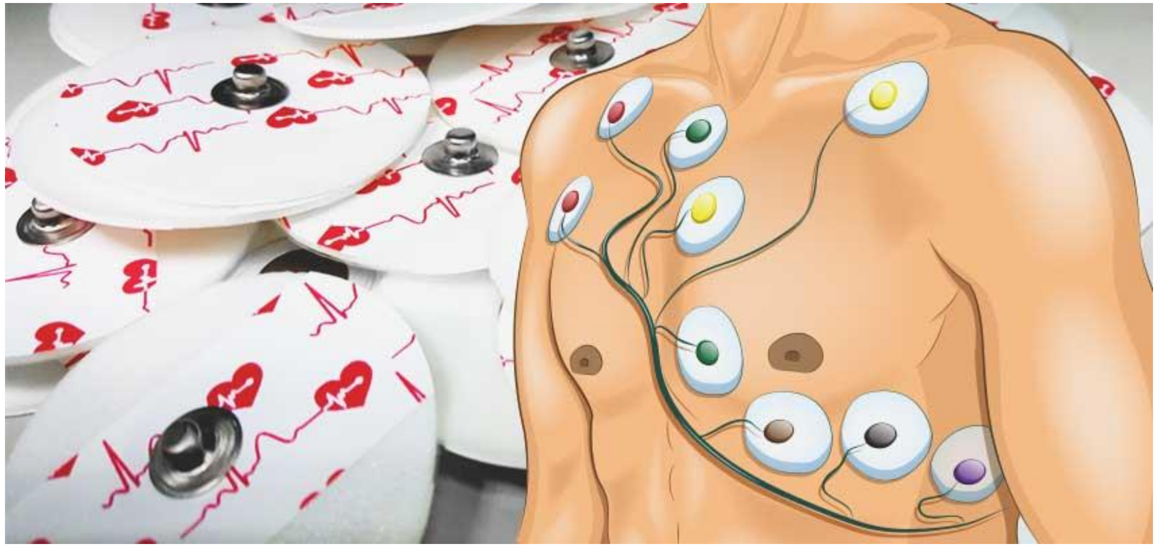
Electrodes Burns



https://www.ausmed.com/cpd/articles/ecg-lead-placement
Access 31/08/2018

https://www.danleemedical.com/
Access 31/08/2018

MRI Machine Injury Accidents on the Rise

OAKLAND, CALIFORNIA (May 30, 2015)- According to Fox KTVU, a family is suing Children's Hospital Oakland after their 17-year-old teenage girl, **Betty Cummings**, suffered moderate burns during an MRI examination.

Cummings was admitted after experiencing pains in both her chest and abdomen. After receiving an electrocardiogram, she was placed inside an MRI machine, however, the technician servicing the 17-year-old teenage girl forgot to remove several lead patches that were still stuck on the young girl.

Per KTVU, Cummings initially felt a mild burning sensation which steadily worsened as the examination continued. A short while later, a nurse noticed smoke fuming out of the machine and was finally able to free the teenager.

https://www.jacobyandmeyers.com/blog/oakland-teenage-girl-injured-during-mri-examination/
Access 20/06/2017

Severe Finger Burns

MRI accident leads to loss of thumb for French boy
By Eric Barnes, AuntMinnieEurope.com staff writer

August 11, 2015 — A 13-year-old French boy lost his thumb during a routine MRI examination of the pancreas, according to a report in the *Courrier Picard* newspaper.

An apparent error at the CHU hospital in Amiens, France, left patient Florian Barreiros in the scanner with a monitoring device attached to his thumb, which the report said was "burned through to the bone."

Florian Barreiros and his mother Fanny. Image courtesy of David Vandevoorde, Courrier Picard.

https://www.auntminnieeurope.com/index.aspx?sec=log&itemID=611872
Access 20/03/2017

https://www.indiamart.com/proddetail/fingertip-pulse-oximeter-11011791097.html
Access 14/06/2019

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Hypoxia – Helium Leaking in MRI Room

5-Year-Old Girl Dies During MRI In Sri Lanka

February 13, 2013
Written by: Steve Millburg, Filed in: Diagnostic Imaging, Medical Ethics, Neuroradiology, Pediatric Radiology

- ADD COMMENTS
-
-
- BOOKMARK

.

A mother pleaded Monday with a Sri Lankan magistrate not to let "the money power" obstruct an investigation into the death of her 5-year-old daughter during an MRI procedure.

The woman, Indumathi Ekanayake of Heiyantuduwa, Sri Lanka, said she took her daughter on January 31 to the Nawaloka Hospital in Colombo, Sri Lanka, because the girl, Buddhini Ratnayake, was suffering from a possible epileptic fit. Ekanayake said a doctor recommended three blood tests and an MRI scan. She said her daughter was anesthetized and put into the scanner. After 30 minutes, she said, she heard a sound.

The *Daily Mirror,* an English-language newspaper in Colombo, quoted Ekanayake as testifying:

> I heard the doctor shouting that the balloon had exploded and nobody was there to assist him. I pushed off a ward attendant towards the room because there was nobody inside the room to help the doctor. When my daughter was pulled out from the machine, I saw she had turned blue and the belly had become swollen.

The *Daily Mirror* quotes Ekanayake as saying that the girl was admitted to the intensive care unit and "put on a vacuum machine"—apparently a reference to a ventilator. Ekanayake said the child was kept on the ventilator for four days, even though she had already died. "On the fourth day," Ekanayake said, "I saw ants entering her nose."

http://www.radiologydaily.com/daily/diagnostic-imaging/5-year-old-girl-dies-during-mri-in-sri-lanka/
Access em 14/04/2014

https://www.emirates247.com/news/sri-lanka/5-year-old-dies-after-faulty-mri-scan-2013-02-12-1.494681
Access 14/04/2014

How to Avoid MRI Accidents

- Trainning
- Classification of Areas
- Metal detectors
- Access restriction
- Organized Workflow



Thank You!!

emsouza@unicamp.br



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How to Manage a MRI project in hospital

Libin
Shanghai， China
2022.10.12

The Team / Workgroup

Li Bin | Senior Engineer (Professor level), Doctoral supervisor

Chairman of Clinical engineering Society of Chinese Medical Association
Vice-Director of Shanghai 6th People's Hosp East affiliated to SJTU
IFMBE CED Board member ,
Chief of Shanghai Medical Equipment Management Quality Control Centre
Former Chief of Clinical Engineering Committee of Shanghai Medical Association
Vice-chief of Medical Engineering Committee of China Medical Association
Chief expert of Shanghai Research Base for CE Technology of Hospital Management Institute of MOH

Professional Background

2y	17y	20y	
International Medical Company	SHMDQCC	Department Head	Professional Training on MRI, CT

Research field

- **Quality:** Regional management & QC
- **Major:** MRI and medical imaging technology
- **Suppliers:** Assessment & Management
- **Service:** quality evaluation & Satisfaction
- **Economy:** Value & Cost evaluation
- **Technology:** Maturity Assessment

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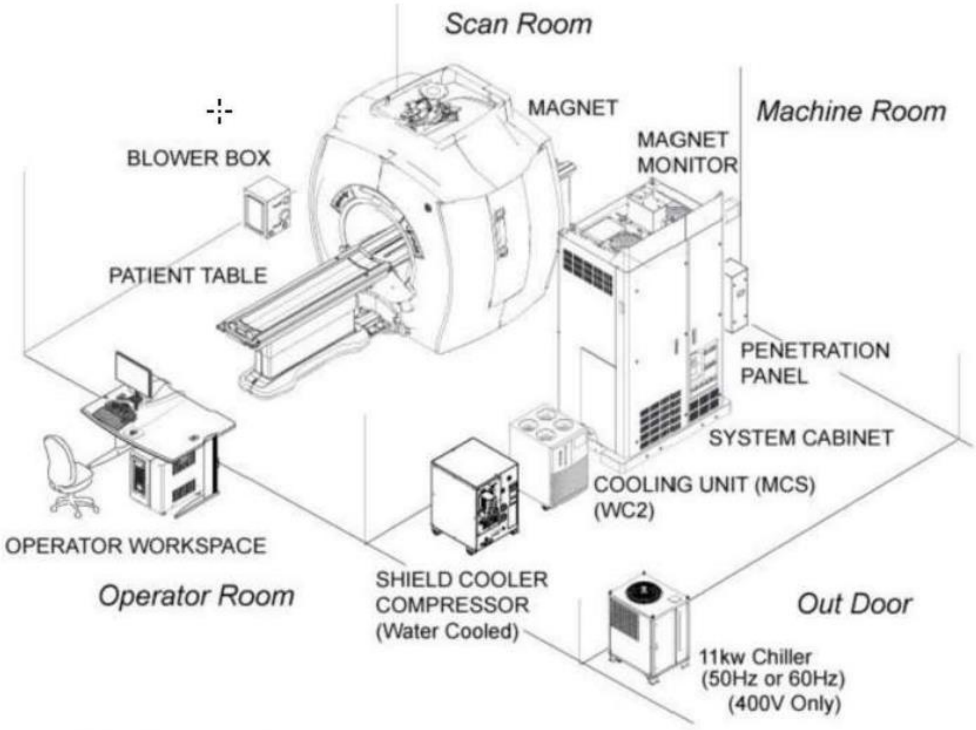
What are Challenges of MRI project？



1. System is expensive & complex
2. It has a strong magnetic field
3. It is sensitive to change of magnetic fiel
4. It is sensitive to RF
5. The magnet is heavy
6. Superconducting
7. Ultra-low temperature
8. Integrated system poor stability

1 Site planning of MRI equipment room

2 Installation of MRI equipment system

3 Management of MRI patient Scanning

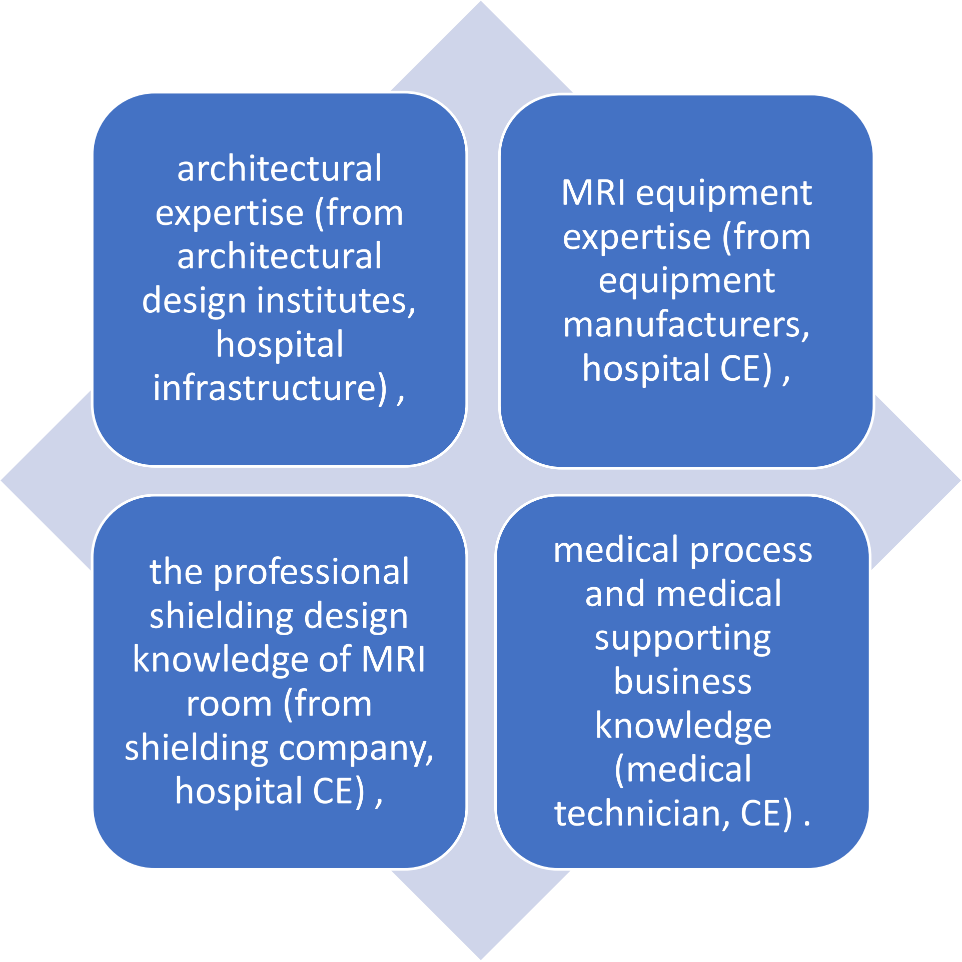
4 Regular maintenance of MRI system

How to Plan Magnetic Resonance Site

A team should be setup of people with a variety of knowledge including:

1. architectural expertise (from architectural design institutes, hospital infrastructure) ,
2. MRI equipment expertise (from equipment manufacturers, hospital CE) ,
3. the professional shielding design knowledge of MRI room (from shielding company, hospital CE) ,
4. medical process and medical supporting business knowledge (medical technician, CE) .

To complete the construction and operation management of the MRI platform in radiology department, a team of multiple personnel is needed. The project manager is the leader and decision maker of the whole design team.



There are two type MRI system room

One type is without equipment room

Another type is with equipment room

Figure 2-1 System without equipment room (Type A)

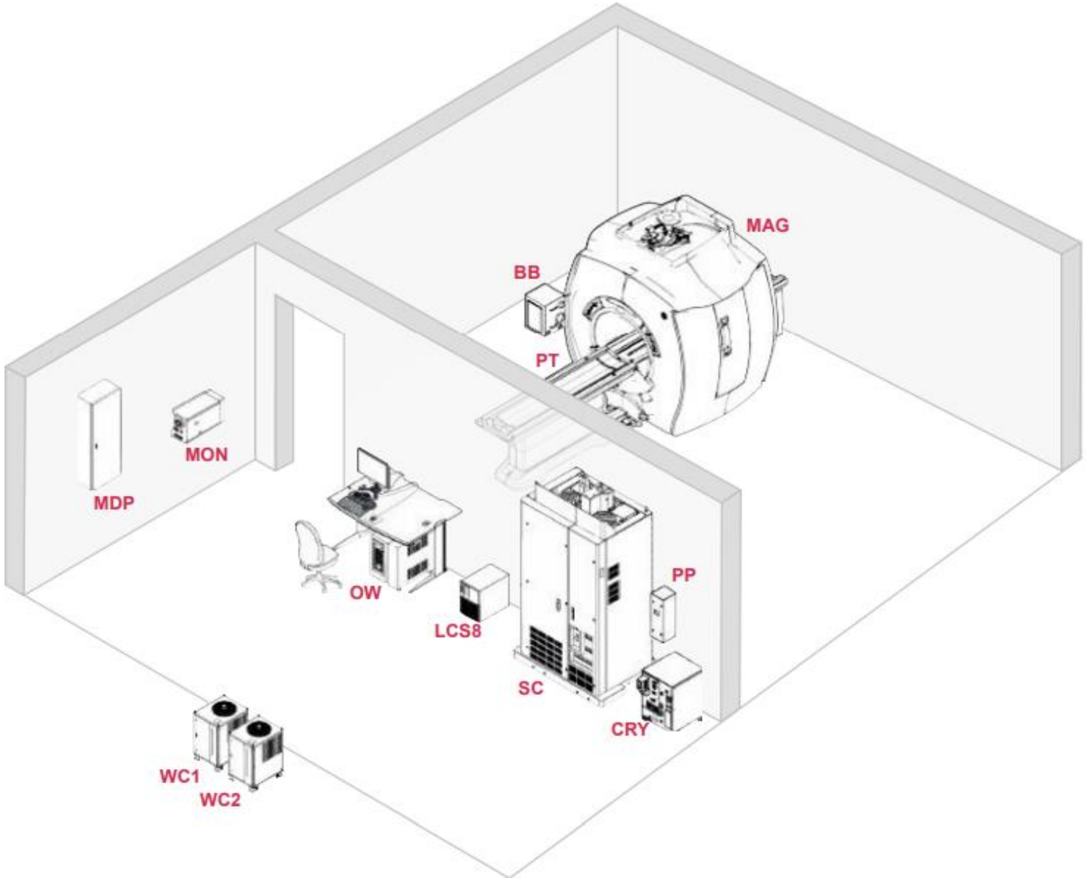
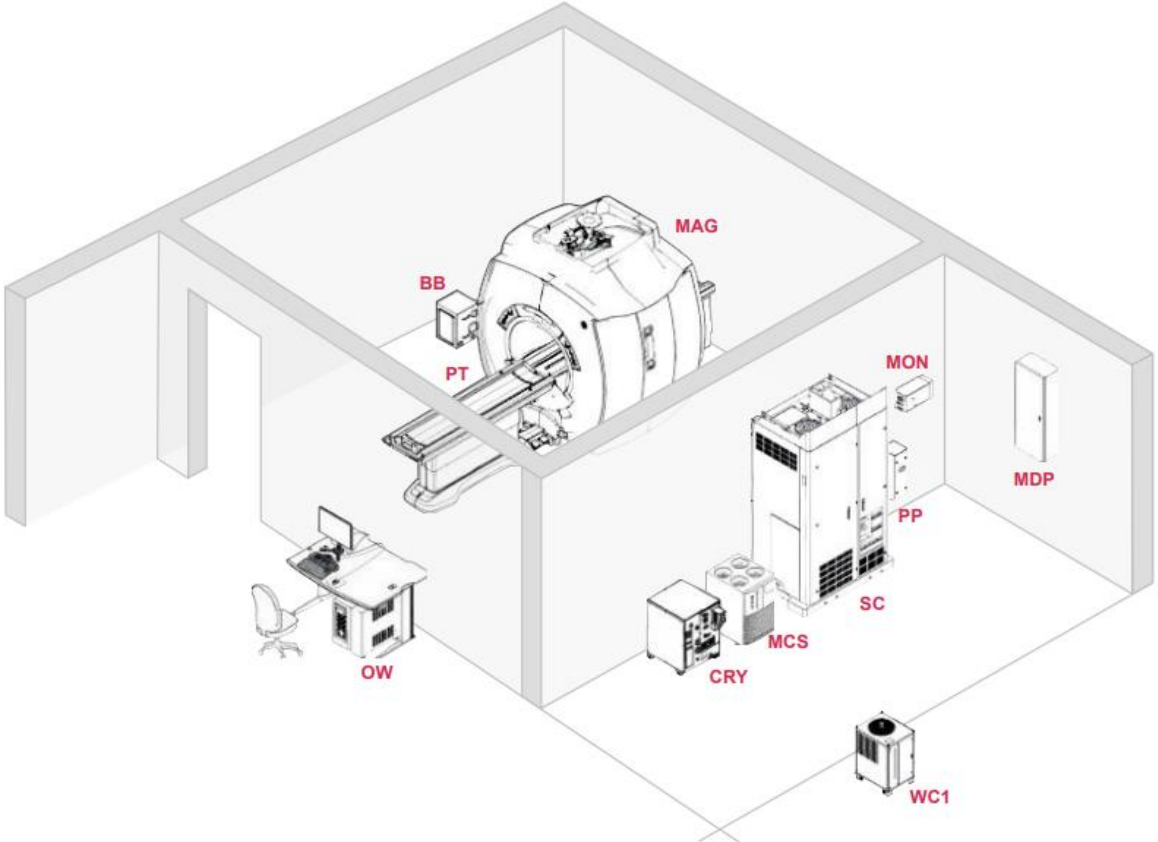


Figure 2-4 System with equipment room (Type C)



MRI system has minimum service area requirements

The Magnet Room; Control Room; Equipment Room have it's minimum dimension size and Square area.

Different type site has different requirements

Table 2-1 Room Dimensions to Satisfy Minimum Service Area Requirements 1.5T MRI

Configuration	Equipment Room		Magnet Room (See the illustrations below for specific dimensions)			Control Room		Total System Area m^2 (ft^2)
	W x D mm (in)	Area m^2 (ft^2)	W x D mm (in)	Area m^2 (ft^2)	Finished Ceiling Height mm (in)	W x D mm (in)	Area m^2 (ft^2)	
System without Equipment Room (Type A, B (B'))	N/A	N/A	3490 x 5750 (137.4 x 226.4)	20.1 (222.7)	2500 (98.4) See Figure 2-8 Minimum Magnet Ceiling Height (Top View) on page 27	3334 x 1900 (131.3 x 74.8)	6.335 (68.53)	26.43 (291.23)
System with Equipment Room (Type C, D, E)	2439 x 2500[1] (96 x 98.4)	6.10 (67.6)				1520 x 2130 (59.8 x 83.9)	3.252 (35)	29.45 (325.3)

NOTE

- This Equipment Room dimension is for Type C. Refer to 4.1 Equipment Room Overview on page 106 for other Type dimensions.

1.5T MRI system minimum service area dimensions

Figure 2-7 Minimum Magnet Service Area (Top View)

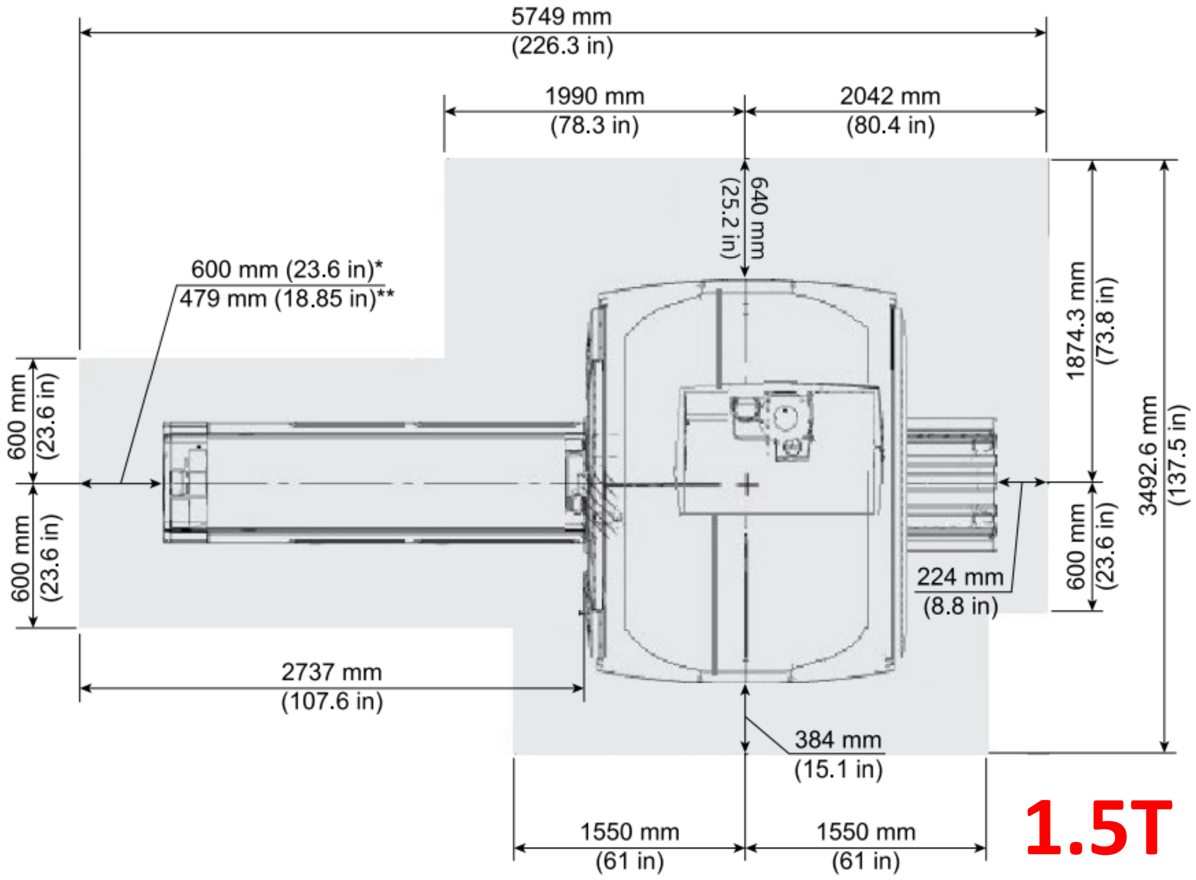
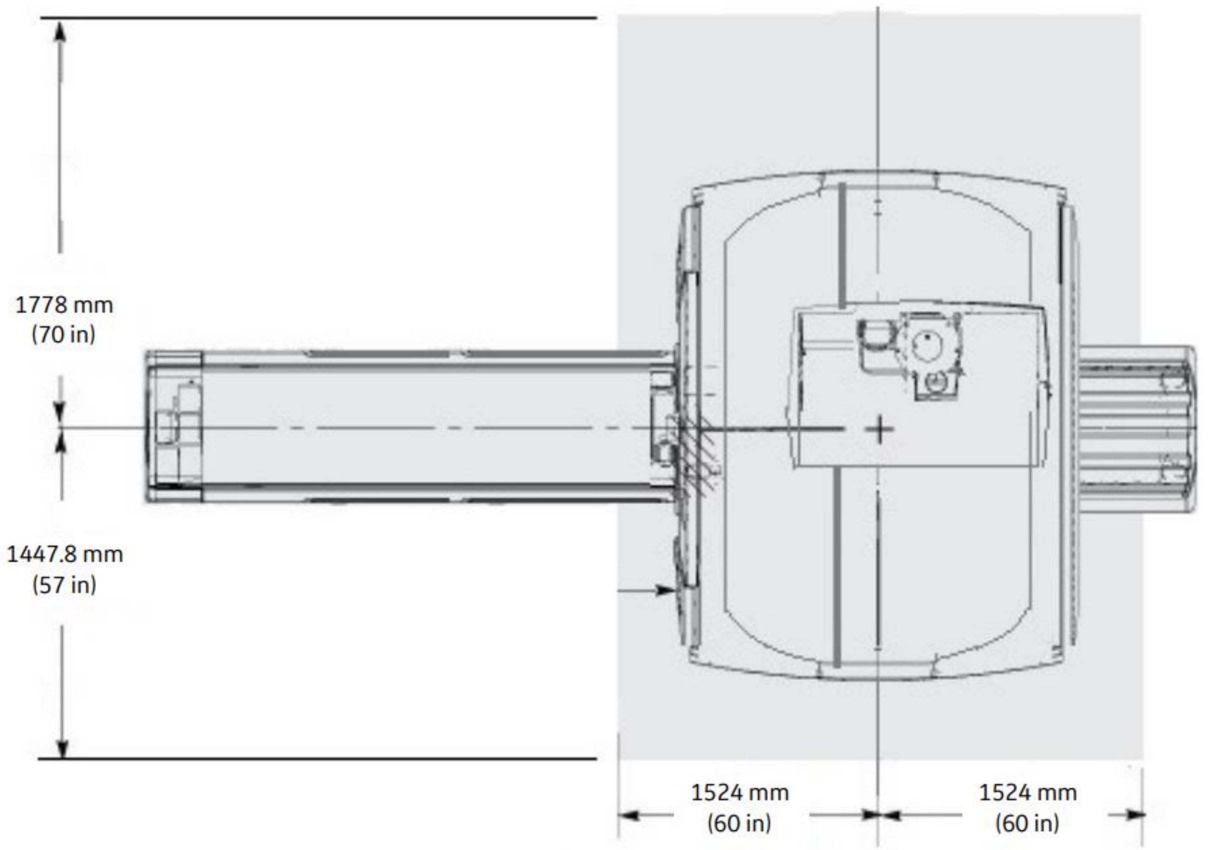


Figure 2-8 Minimum Magnet Ceiling Height (Top View)



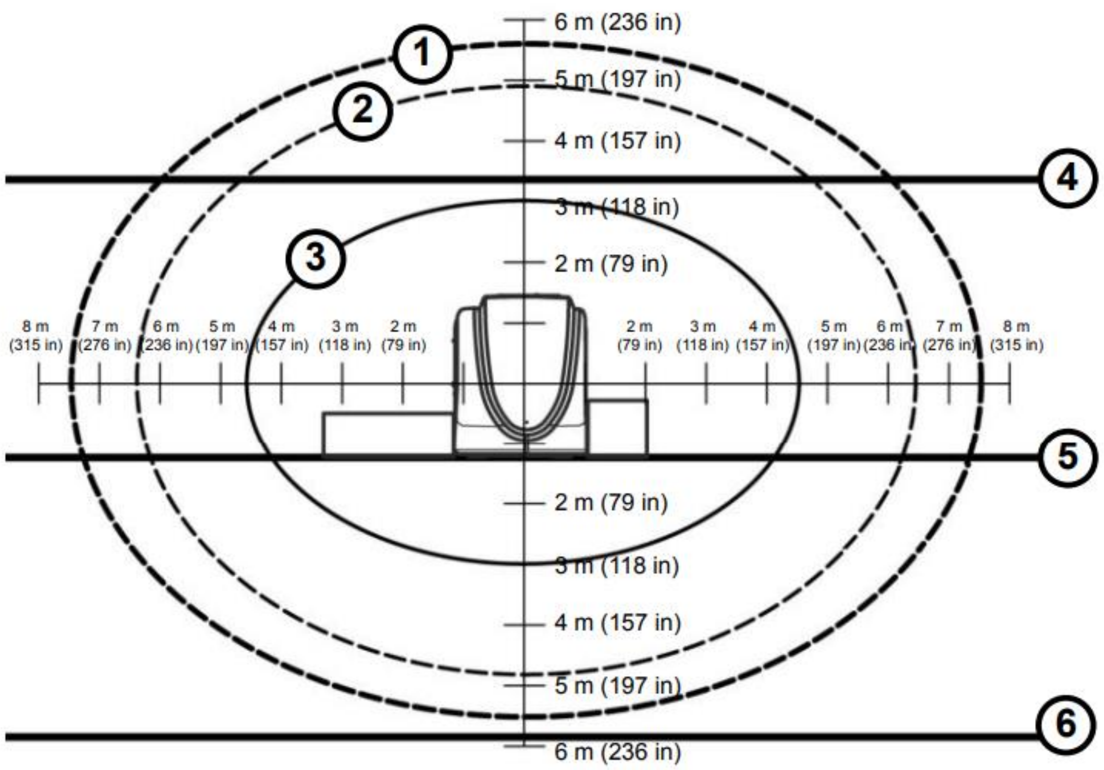
interference of environment on magnetic field

- The change of the environment around the magnet will affect the uniformity of the magnetic field. The magnetic field interference (source) have two types.
- **Static interference:** Ferromagnetic reinforcements such as steel beams and steel bars in buildings belong to static interference. The influence of such interference on the magnetic field can be generally overcome by active or passive shimming.
- **Dynamic interference**: Moving or changing magnetic field interference source. Its characteristic is that it cannot be estimated before MRI installation. There are two types of dynamic interference: moving ferromagnetic objects, such as wheelchairs and cars; Devices that can generate alternating magnetic fields, such as transformersThe degree of influence on the magnetic field depends on their weight, distance from the magnet and the strength of the alternating magnetic field.

The static magnet isogauss plot lines for the magnet.

This information
must be used to evaluate potential site interaction of MRI equipment with other equipment, interaction with ferrous materials on the site, and to locate personnel and equipment within the site.

Figure 2-14 Magnet Moving Metal Sensitivity Line Plot (Side View)



Item	Description	Item	Description
1	Trucks, Buses	4	Floor Above
2	Cars, Pickups, Vans, Ambulances	5	Magnet Room Floor
3	3 Gauss line	6	Floor Below

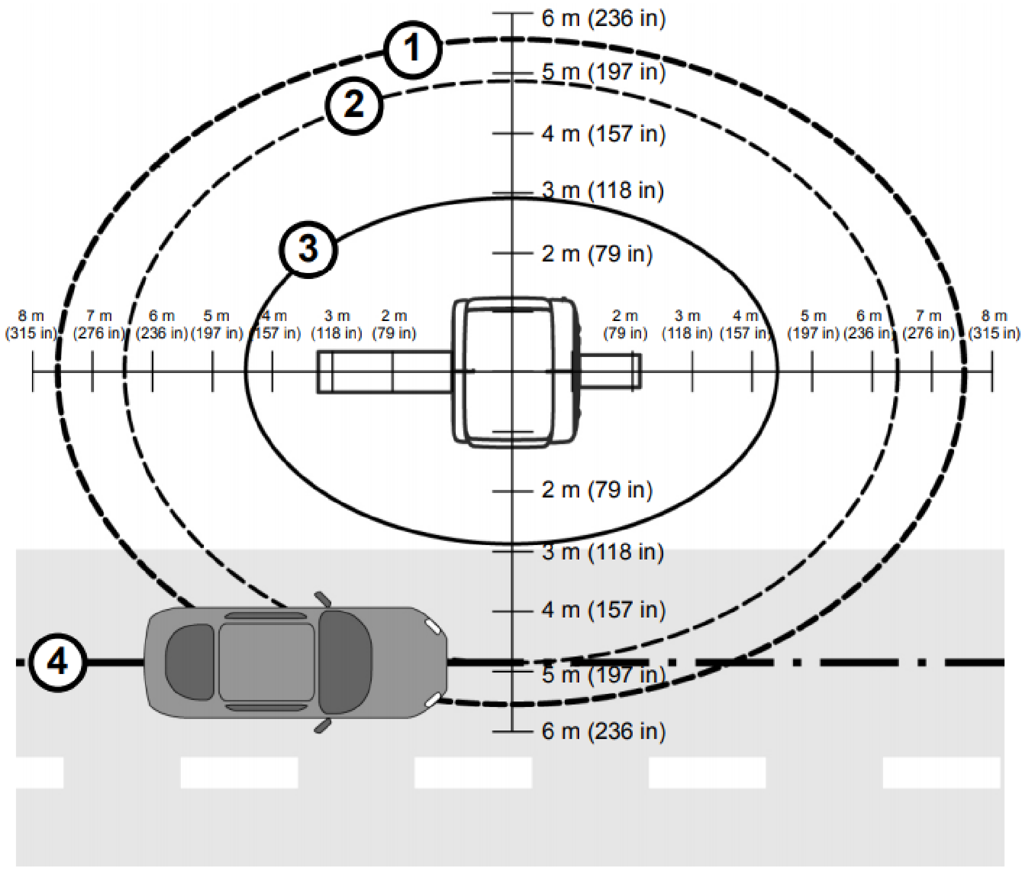
Magnet isogauss plot lines can be affected by moving met

The isogauss plots show an idealized magnetic field relative to magnet isocenter.

The actual field strength can be affected by any of the following:

- Magnetic shielding
- Earth's magnetic field
- Other magnetic fields
- Stationary or moving met

Figure 2-15 Magnet Moving Metal Sensitivity Line Plot (Top View)

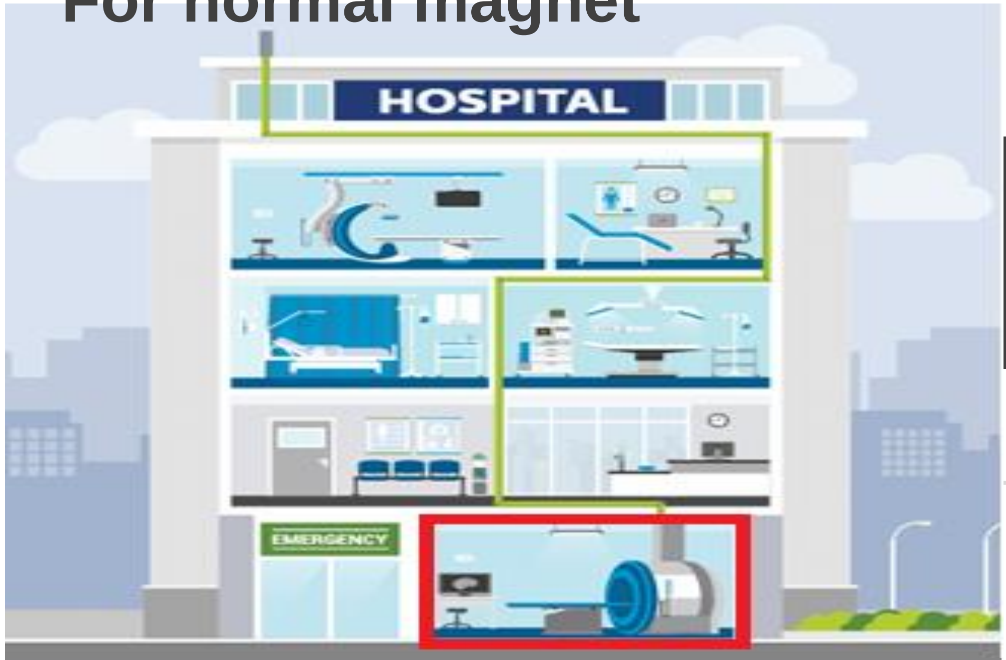


Item	Description	Item	Description
1	Trucks, Buses	3	3 Gauss line
2	Cars, Pickups, Vans, Ambulances	4	Center of Driving Lane

Selection of MRI installation floor

For magnet was heavy (5000—10000kg), MRI is generally installed on first floor or basement
Since the liquid helium free technology is adopted, the magnet weight is greatly reduced

For normal magnet



MR is much heavier than CT, and it can only be installed on low floors in general

For liquid helium free magent

Some type MRI system can be installed on higher floors without special reinforcement and loding

1. Site planning of MRI equipment room

2. **Installation of MRI equipment system**

3. Management of MRI system patient scanning

4. Regular maintenance of MRI system

Magnet Shielding

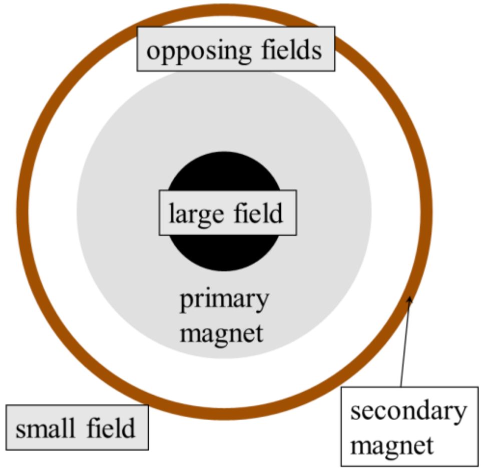
- Need to minimize the amount of space outside the magnet to minimize building costs. There are passive shielding and active shielding

Passive Shielding Past…

1. Construction of thick steel to enclose the magnet room
2. Could bolt the metal to the magnet itself

Active Shielding Now…

1、A secondary magnet is wrapped around the primary magnet to reverse the external field effects)
2、Susceptible to “moving metal,” e.g. elevators, cars, trucks, and trains



Medical equipment needs to avoid being affected by MRI

Figure 2-12 Magnetic Fringe Field Top View

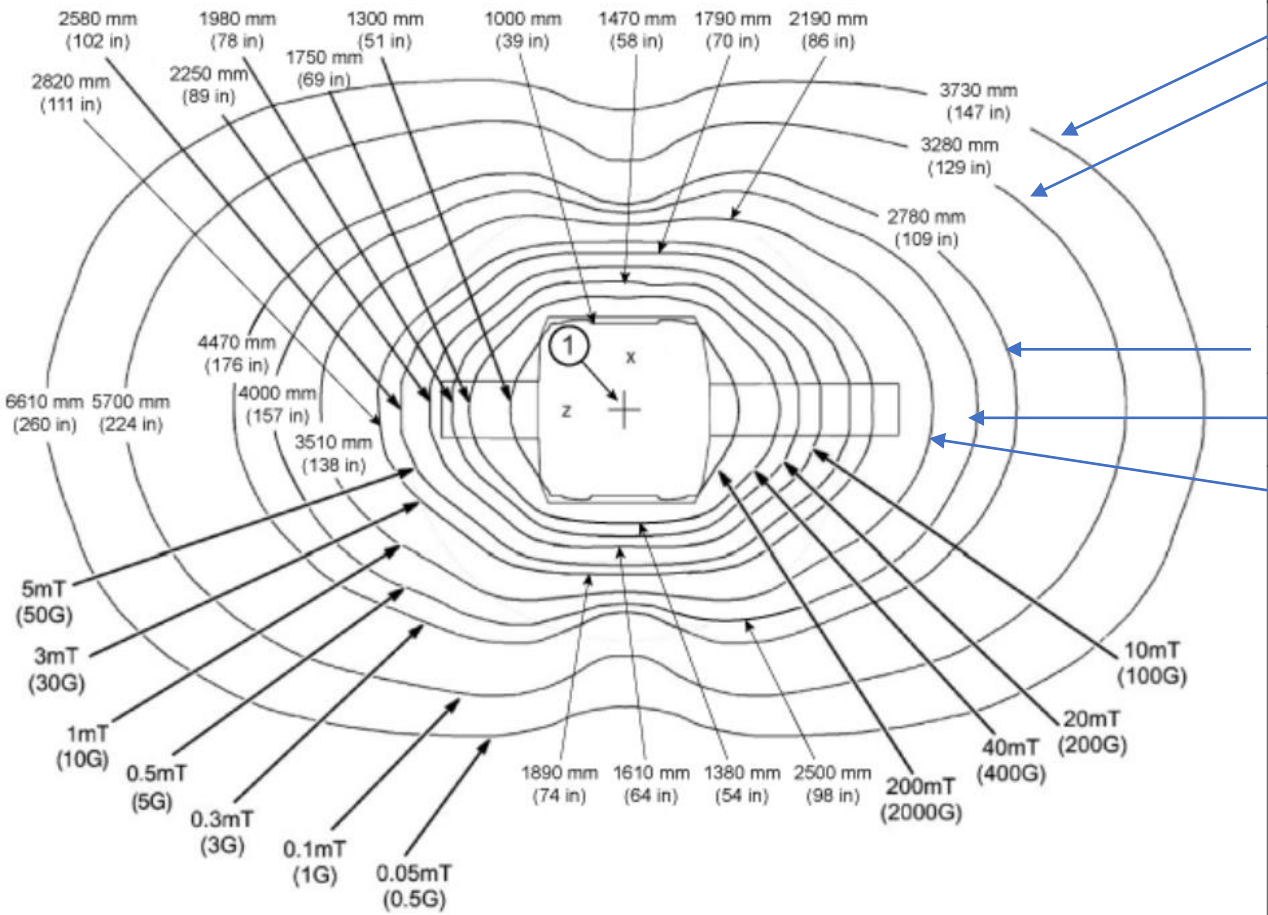


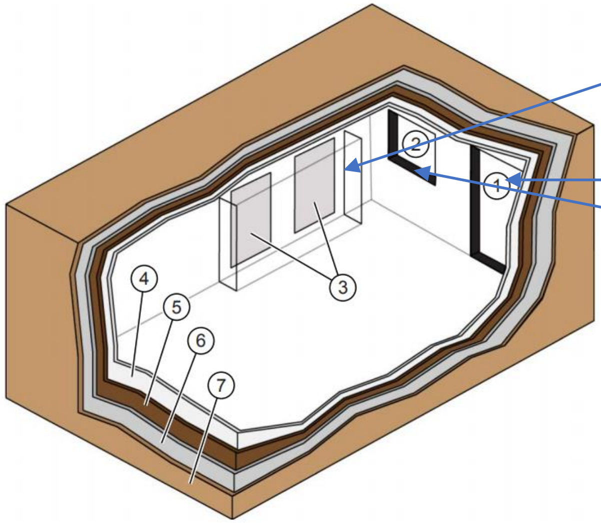
Table 2-3 Magnetic Proximity Limits (For Reference Only)

mT (Gauss) Limit	Equipment	
0.05mT (0.5 G)	Nuclear camera	
0.1mT (1 G)	Positron Emission Tomography scanner	Video display (tube)
	Linear Accelerator	CT scanner
	Cyclotrons	Ultrasound
	Accurate measuring scale	Lithotriptor
	Analog image intensifiers	Electron microscope
	Bone Densitometers	
0.3mT (3 G)	Power transformers	Main electrical distribution transformers
0.5mT (5 G)	Cardiac pacemakers	Biostimulation devices
	Neurostimulators	
1mT (10 G)	Magnetic computer media	Telephone switching stations
	Hard copy imagers	Water cooling equipment
	Line printers	HVAC equipment
	Video Cassette Recorder (VCR)	Major mechanical equipment room
	Film processor	Credit cards, watches, and clocks
	X-ray tubes	
	Large steel equipment, including:	
	Emergency generators	Air conditioning equipment
	Commercial laundry equipment	Fuel storage tanks
	Food preparation area	Motors greater than 5 horsepower

Scaning room need RF shielding

- The amplitude of MR signal is very small, which is of UV level, and is easily interfered by tens of MHz radio waves from outside.
- To avoid external interference, it is necessary to isolate the magnetic resonance signal detection system from the outside world
- The scanning room is often wrapped with thin copper sheet to form an RF shielding room.

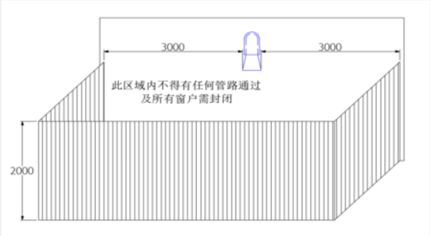
- Generally, electromagnetic wave attenuation shall reach 90-100 db
- The doors and windows of the scanning room need special RF shielding



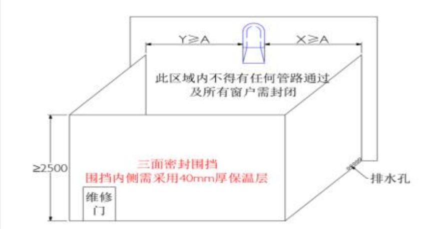
Quench exhaust pipe should be installed for safety

quench of superconducting magnet

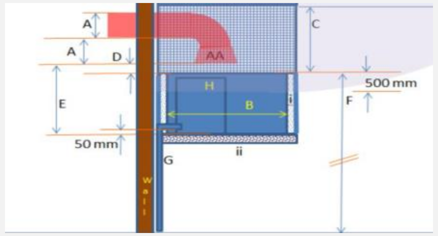
01
Grid fence



02
Half Grid fence



03
Semi closed cage



The quench exhaust pipe must be installed outdoors and must be provided with fences and relevant signs to prevent personnel from entering by mistake and causing personal injury

1 Site planning of MRI equipment room

2 Installation of MRI equipment system

3 Management of MRI system patient scanning

4 Regular maintenance of MRI system

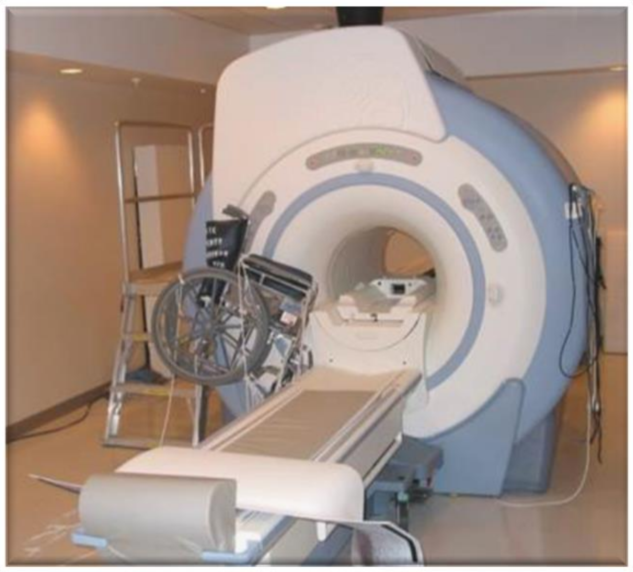
Safety for Patients who take MR examination

- Those who wear clothes with such accessories as metal leads, buttons and zippers.
- Those who carry metal objects such as watch, bracelet, necklace and coin.
- Those who have medical patches on the body. To avoid electric shocks:
- Do not wear wet clothes during scanning.
- Avoid the formation of a closed RF loop. For example, avoid contact between the inner thighs, between the legs, between the hands, between the hand and body, and between the ankles.
- Avoid the formation of a closed loop between the RF coil cable and the ECG cable.

Safety for scanning room

The scanning room entrance should be affixed with warning labels indicating the following warning information:

- A sign indicating the presence of strong magnetic field



a. No entry of ferromagnetic materials

b. No entry of personnel with cardiac pacemaker implantation

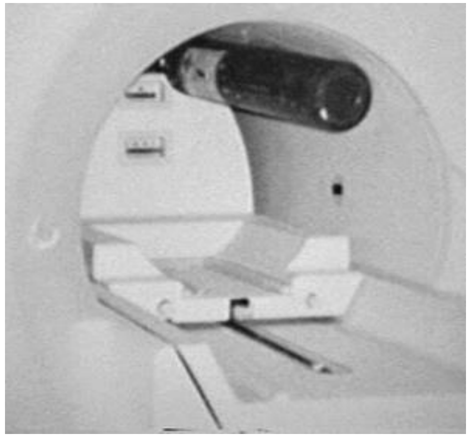
c. No entry of open flames or inflammable substances

d. No entry of mechanical/electronic watch, electronic calculator

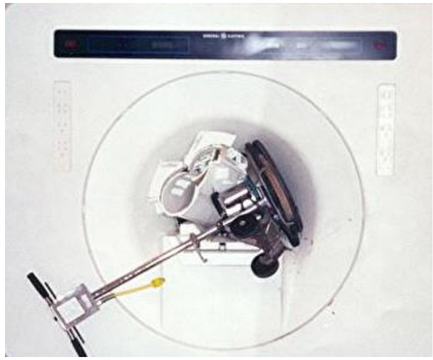
e. No entry of magnetic card

f. No use of ferromagnetic fire extinguisher

Avoid patient & staff injuries and equipment damage

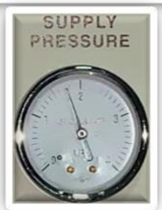




The magnetic field of MRI is very powerful and never disappears
Never underestimate the power of a magnetic field

Precautions and maintenance for daily work

MRI system is complex system. It is recommended to check and record the working conditions of the magnet refrigeration system, the outdoor water cooler, and the temperature and humidity of the equipment room and the magnet room at the beginning and end of each day's work



- Magnet pressure and liquid helium level;
- The normal pressure range is 0.9~4.2PSI;
- The liquid helium level shall not be less than 60%, and the short-term (1-2 days) change shall not exceed 2%.

- Dynamic pressure of helium compressor, normal range: 2.1~2.3MPa

- The normal temperature range of outdoor water cooler is 17~22 ℃.

- The normal range of temperature is 18~22 ℃, and the normal range of humidity is 35~65% RH

1 Site planning of MRI equipment room

2 Installation of MRI equipment system

3 Management of Application of MRI system

4 **Regular maintenance of MRI system**

Preventive maintenance of MRI system

MRI system is integrated system with poor stability. It need regularly carry out preventive maintenance. The maintenance items and contents will be carried out according to the maintenance manual. After the maintenance professional maintenance report should be formed,

- ❖ **Security items**
  - ❖ **MRU connection, magnet monitoring, ultrasound tube loss, patient alarm**
- ❖ **System performance parameters**
  - ❖ **Magnetic field uniformity, system signal-to-noise ratio, stability, DQA**
- ❖ **General data check**
  - ❖ **Liquid helium level, magnet pressure, water-cooled liquid, helium pressure**
- ❖ **Various mechanical movements**
  - ❖ **Whether various linkages are normal and whether the bed moving is smooth**
- ❖ **Dust removal/use recommendations**
  - ❖ **Filter screen cleaning, cleaning, etc**

	indicate tests that can be performed by scanning the ACR MRI Phantom)	QC (Weekly)	MR Scientist (Annually)
1	Setup and Table Position Accuracy	X	X
2	Center Frequency	X	X
3	Transmitter Gain or Attenuation	X	X
4	*Geometric Accuracy Measurements*	X	X
5	*High-Contrast Spatial Resolution*	X	X
6	*Low-Contrast Detectability*	X	X
7	Artifact Evaluation	X	X
8	Film Printer Quality Control (if applicable)	X	X
9	Visual Checklist	X	X
10	Magnetic Field Homogeneity		X
11	*Slice-Position Accuracy*		X
12	*Slice-Thickness Accuracy*		X
13	Radiofrequency Coil Checks		X
	a. SNR		X
	b. Percent Image Uniformity (PIU)		X
	c. Percent Signal Ghosting (PSG)		X
14	Soft-Copy (Monitor) Quality Control		X
15	MR Safety Program Assessment		X

Quality control testing frequency

A. Quality Control Testing Frequency

The technologist's QC testing procedure frequencies given in Table 1 and in the rest of this manual are the minimum recommended frequencies. However, we strongly recommend that the tests be done on a daily basis. If problems are detected often, if the equipment is unstable, or if the system has just been subject to a significant repair or upgrade, then it may be necessary to carry out some of the procedures more frequently.

Table 1. Minimum Frequencies of Performing Technologist's QC Tests

Procedure	Minimum Frequency	Approx. Time (min)
Setup	Weekly	7*
Table Position Accuracy	Weekly	3
Center Frequency/Transmitter Gain or Attenuation	Weekly	1
Geometric Accuracy Measurements	Weekly	2*
High-Contrast Spatial Resolution	Weekly	1
Low-Contrast Detectability	Weekly	2
Artifact Evaluation	Weekly	1
Film Printer Quality Control (if applicable)	Weekly	10
Visual Checklist	Weekly	5

*Some measurement can be performed simultaneously.

MRI Image Analysis using Magphan phantom

Scan with the Magphan phantom

- **scan setting：**

  Technical parameters such as FOV, matrix, average times, scanning sequence, scanning sequence time parameter setting, layer thickness series

- **Phantom positioning**

  Place the phantom horizontally in the head coil installed on the scanning table, and check whether it is horizontal with a level gauge. Its axis is parallel to the axis of the scanning hole, and the positioning ray is aligned with the center of the phantom.

  First, scan the positioning image of the cross section, determine the sagittal plane scanning through the center of the phantom from the obtained positioning image of the cross section, and determine the scanning of each layer of the phantom from the obtained sagittal plane image.

- SMR100
- SMR170

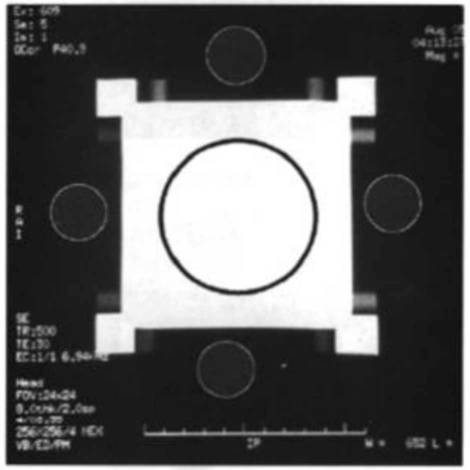
MRI Image Analysis using Magphan phantom

Image parameter analysis

1、signal to noise ratio

The average value and standard deviation of ROI (region of interest) pixels are measured at the center of the cube image and the outside of the cylindrical container image, respectively..The signal to noise ratio (SNR) can be obtained by the following formula:

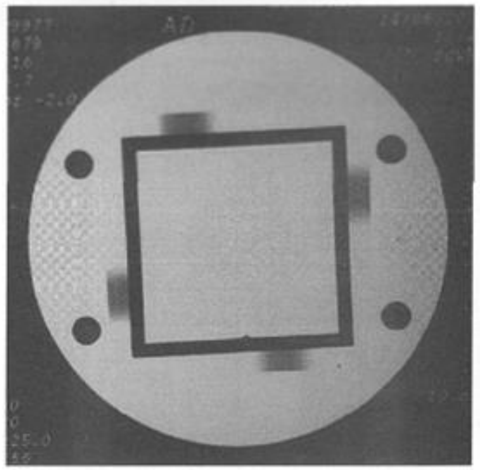
$$SNR=(S-S')/SD \qquad (1)$$



2、 uniformity of image

Nine regions are taken as test points in the above uniform field image, and the average pixel value of each region is measured with ROI. Find out the maximum and minimum values from nine regions. The uniformity U can be calculated by the following formula:

$$U=[1-(S_{max}-S_{min})/(S_{max}+S_{min})]\times 100\% \qquad (2)$$

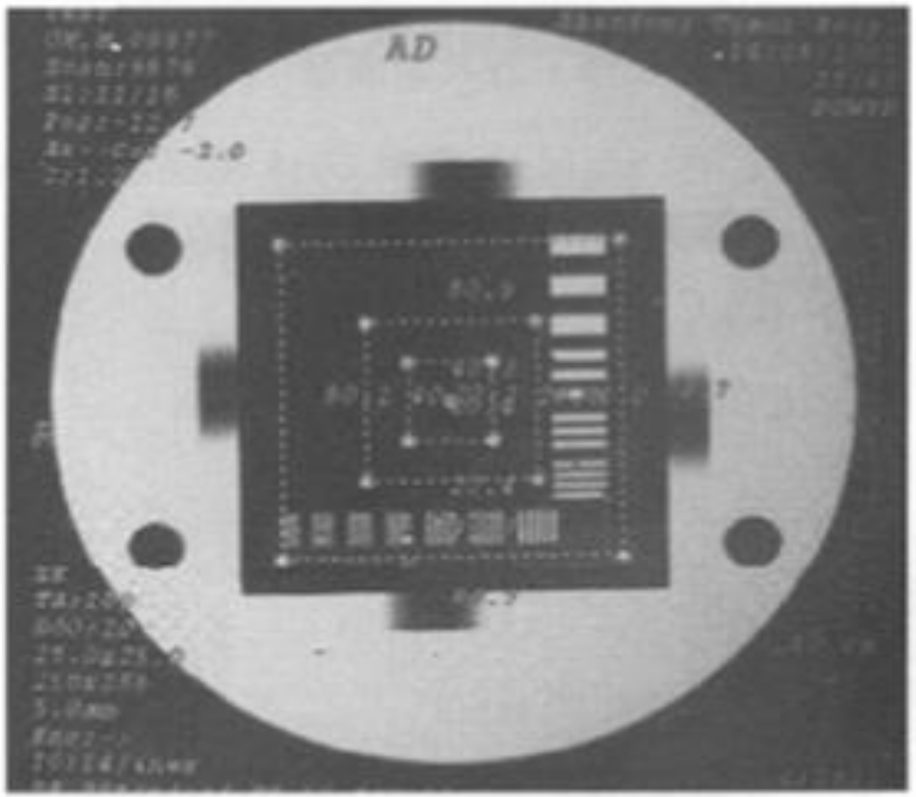


MRI Image Analysis using Magphan phantom

3、slice thickness

The sensitivity profile line is made on the outside of the square image of each layer of the phantom along the four bevel edges, and the maximum half width (FWHM) of the sensitivity profile line is measured. The layer thickness Z of the imaging layer can be calculated using the following formula:

$$Z(mm)=(FWHM)\times 0.25$$



4、 spatial resolution

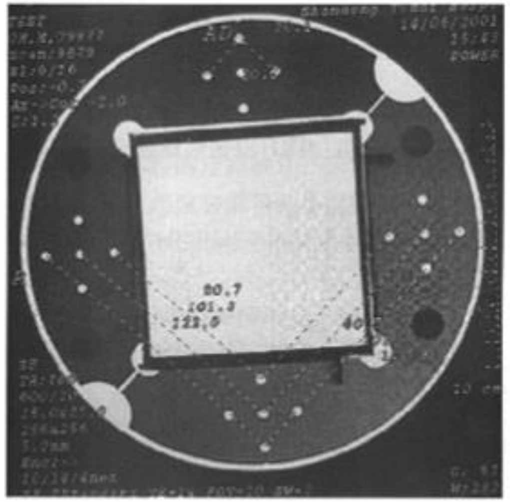
- Third level scanning of the phantom. The third level of the phantom cube is a module engraved with high-resolution patterns and regularly distributed holes, with a beveled edge around each side. Adjust the window width and window level to make the image details display most clearly, and use vision to determine the maximum number of lines that can be resolved in the image, that is, spatial resolution.

MRI Image Analysis using Magphan phantom

5、 linearity (L) of image

In the lower image, measure the hole spacing in X direction and Y direction respectively, and compare with the measured actual distance, and calculate the linearity (L) with the following formula:

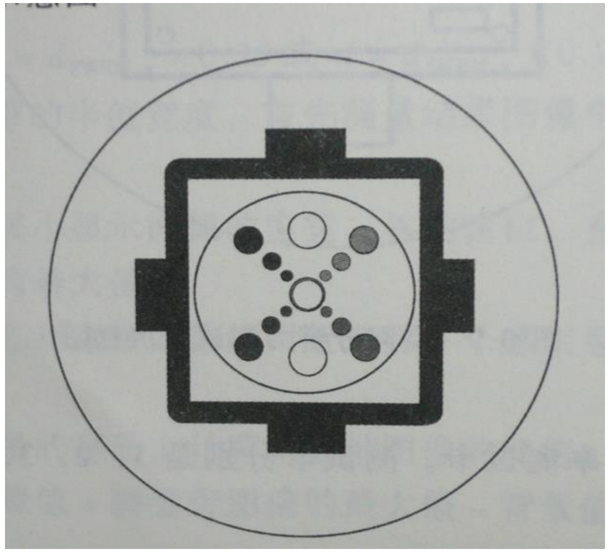
$$L = (D0 - D)/ D0 \qquad (3)$$



6、Low contrast resolution

Scan the fourth layer of the phantom. The fourth level of the phantom cube is a module composed of four groups of circular holes.

Adjust the window width and window level to make the image details clearest. Use vision to determine the image of the circular hole with the smallest depth and diameter that can be clearly distinguished, that is, low contrast resolution.



Conclusion of management of MRI project

Facing challenges:

MRI is expensive & complex

Strong magnetic field

Sensitive to magnetic field

Sensitive to RF

Magnet is heavy

Superconducting

Ultra-low temperature

Integrated system poor stability

Key point:

Requiring team, planning and training

Suitable allocation for MRI site

Magnetic field shielding

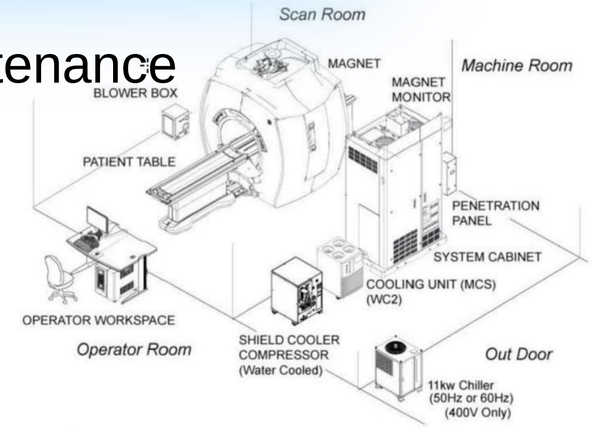
RF shielding room

Housing load and magnet transportation

Quench prevention

Cooling system maintenance

Requiring regular maintenance



System is expensive & complex
It has a strong magnetic field
It is sensitive to change of magnetic field
It is sensitive to RF
The magnet is heavy
Superconducting
Ultra-low temperature
Integrated system poor stability

Thank you!

LI Bin

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Shanghai Jiao Tong University Affiliated Sixth People's Hospital, CHINA


Q&A


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