Impact of Ferromagnetic Detection on MRI Safety

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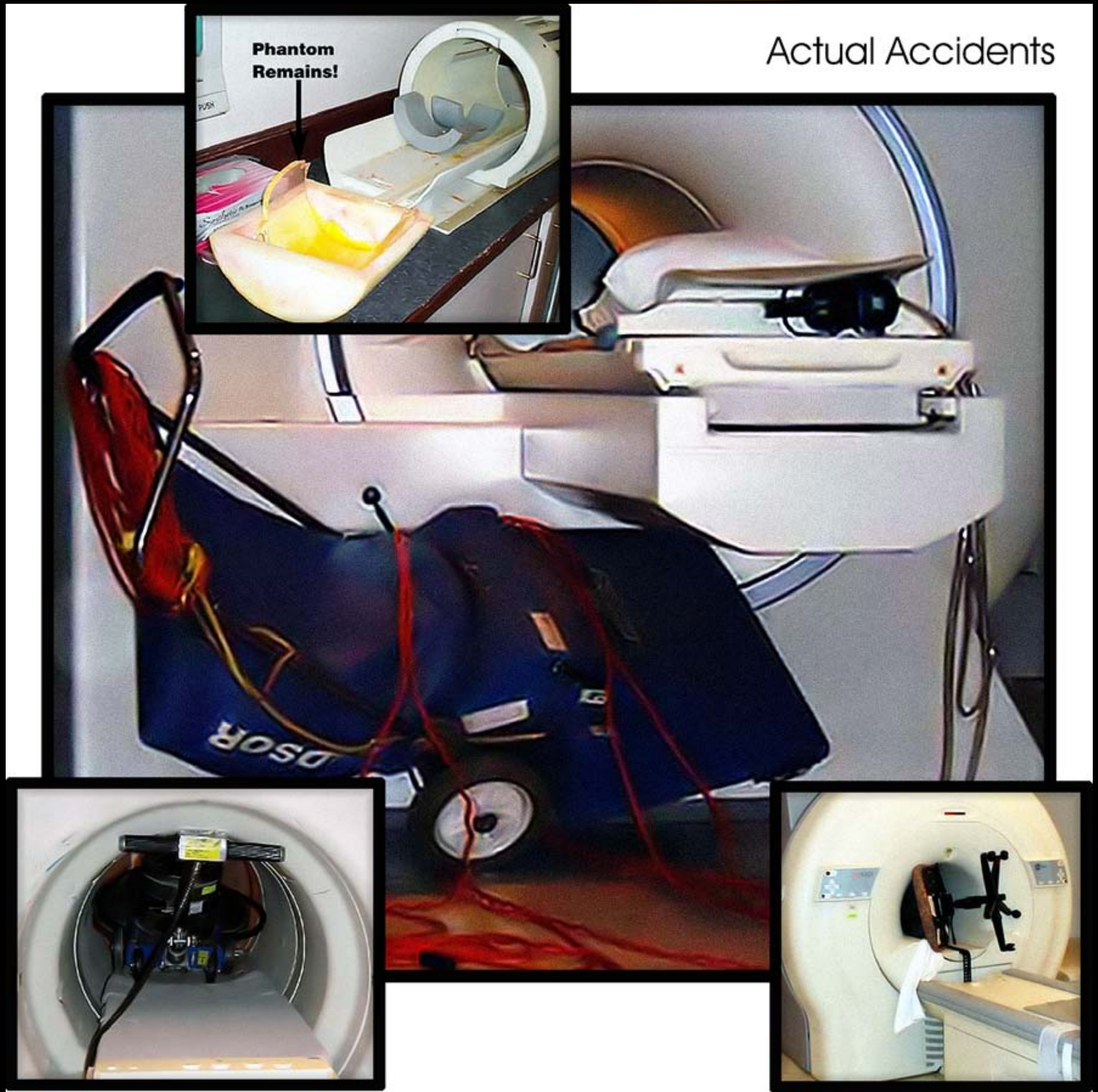
Ferromagnetic projectile incidents



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Small ferromagnetic objects that have caused projectile injuries

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Occurrence Rate of Projectile Incidents

- FDA MDR data base focused on clinical and not operational incidents[1]
- VA National Center for Patient Safety[2]
- Chaljub Survey[3]
- Pennsylvania Patient Safety Reporting System[4]
- Experts statements

VA NCPS Alert observed risk factors[5]

- Invisible magnetic field extends in 3 dimensions
- Impossible to tell if the magnet is “on”
- Many objects contain ferromagnetic material that do not appear to *(sand bags, wooden chair)*
- Labeling on devices or in documentation is confusing

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VA NCPS Alert observed risk factors
(continued)

- Combination of complacency, work-arounds for speed and diffuse responsibility
- Equipment and consumables that are "safe" 99% of the time become "unsafe" near the MRI
- People and equipment that are "new" to the MRI suite *(more interventions and surgeries)*
- It is difficult and inaccurate to make "simple" lists of unsafe materials

Chaljub Survey[6]

- 52% of the respondents had incidents involving airborne objects including: a defibrillator, wheelchair, respirator, ankle weights, IV pole, toolbox, sandbags containing metal pellets, vacuum cleaner, and mop buckets
- Survey conclusion: “Our experience suggests that despite MR safety education, projectile cylinder accidents and other incidents are on the increase. More sick patients are undergoing scanning while on life support equipment, as evidenced by four of the five accidents occurring within the past 3 years at our institution”.

Pennsylvania Patient Safety Reporting System

88 incidents reported by ECRI[7]
from June 2004 to September 2005

- 33 screening error *(e.g., wrong form used)*
- 28 contraindications discovered during screening
- 12 contraindications discovered during or after MR exam
- 12 incompatible equipment in MR *(i.e., potential projectiles)*
- 3 potential burns *(patient loops, redness)*

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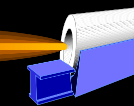
Expert Quotations[8]



- "Close calls in M.R. centers probably happen once a month."
  Dr. John Gosbee - Director of patient safety information systems at the VA NCPS

- "It's my opinion that the majority of the incidents that have occurred … have been as a result to what I referred to as pilot error or how the procedure was performed. I believe there is a strong *'it couldn't happen here'* mentality. I don't believe people are quite aware of the potential problems that can occur, the substantial severity that could occur."
  Dr. Emanuel Kanal - Director of MR Services and Professor, Department of Radiology at the University of Pittsburgh, a Chair of the ACR Blue Ribbon Panel on MR Safety

- "MRI Scanners' Strong Magnets Are Cited in a Rash of Accidents" Front Page New York Times August 19, 2005

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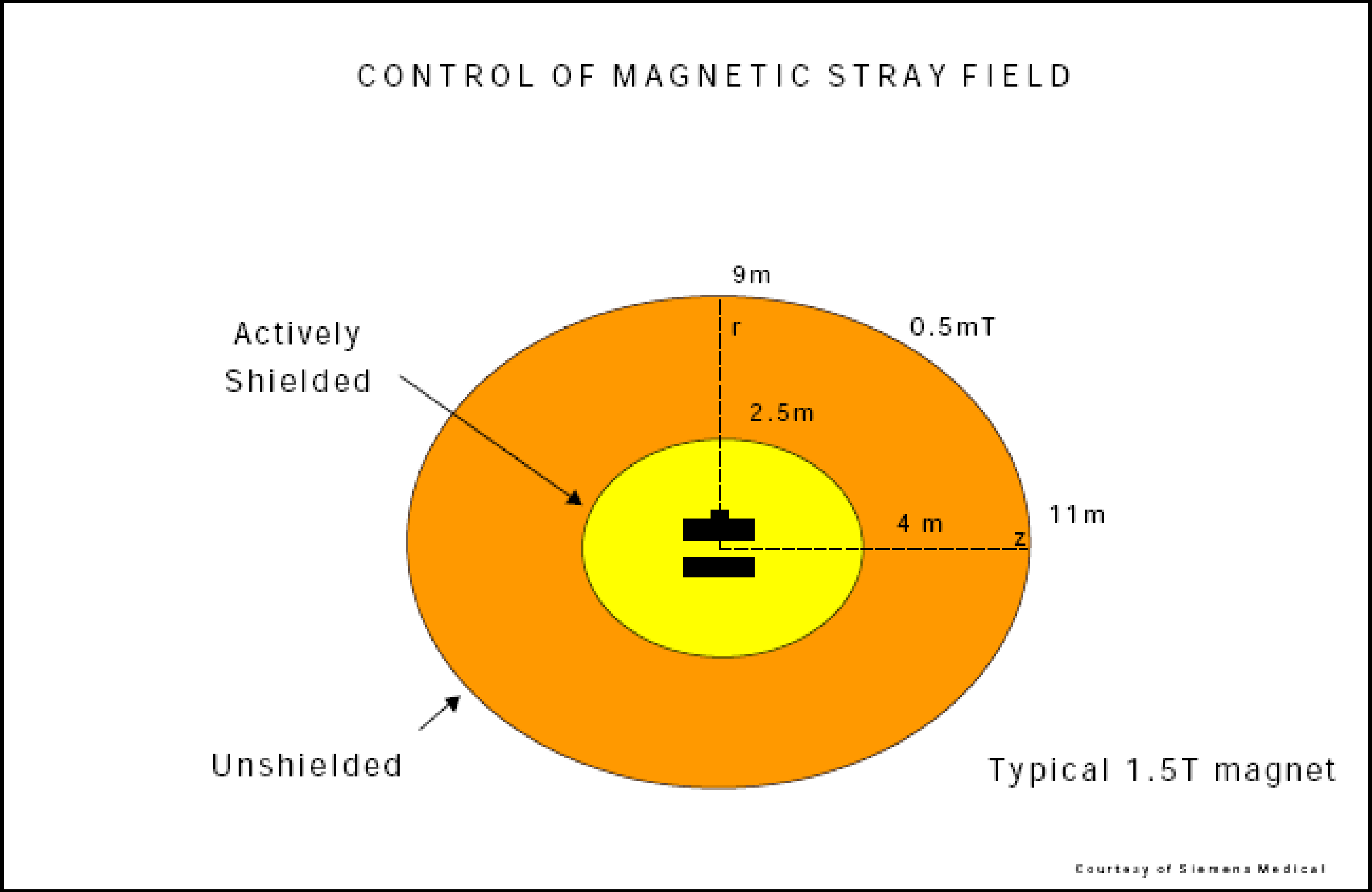
Why are Incidents increasing?

- VA NCPS Points[9]
- Shared staff and facilities between modalities
- Magnet design – shorter bores, higher fields, active shielding of magnetic field

Comparison
Active shielded – unshielded



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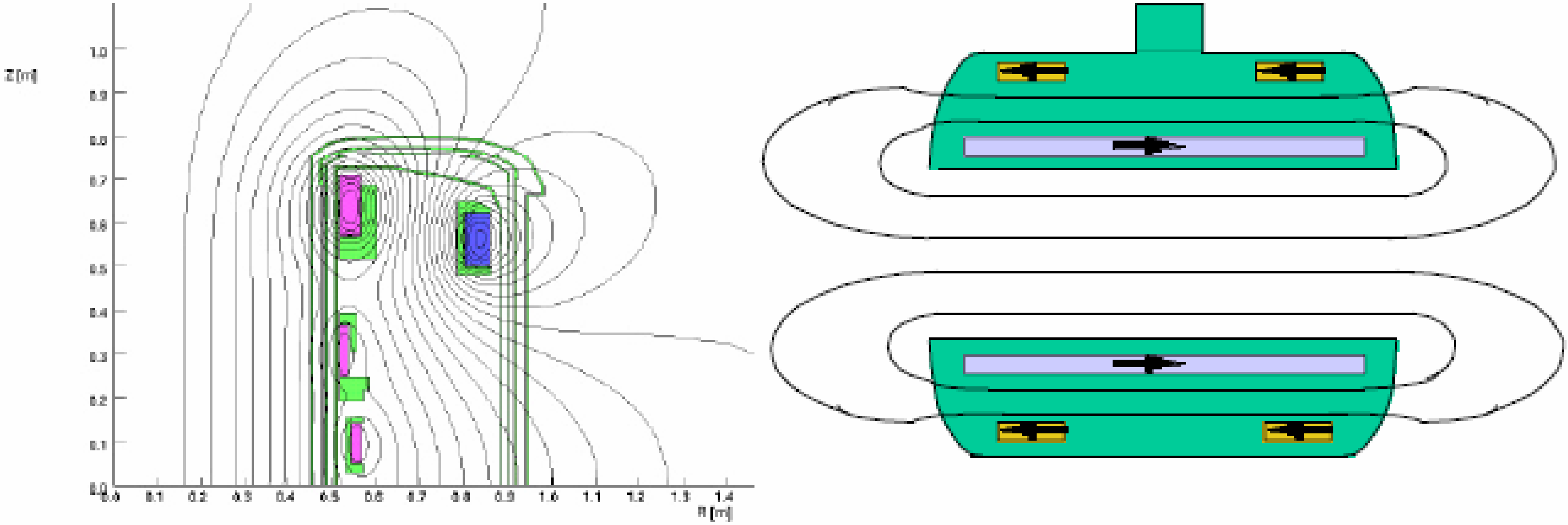
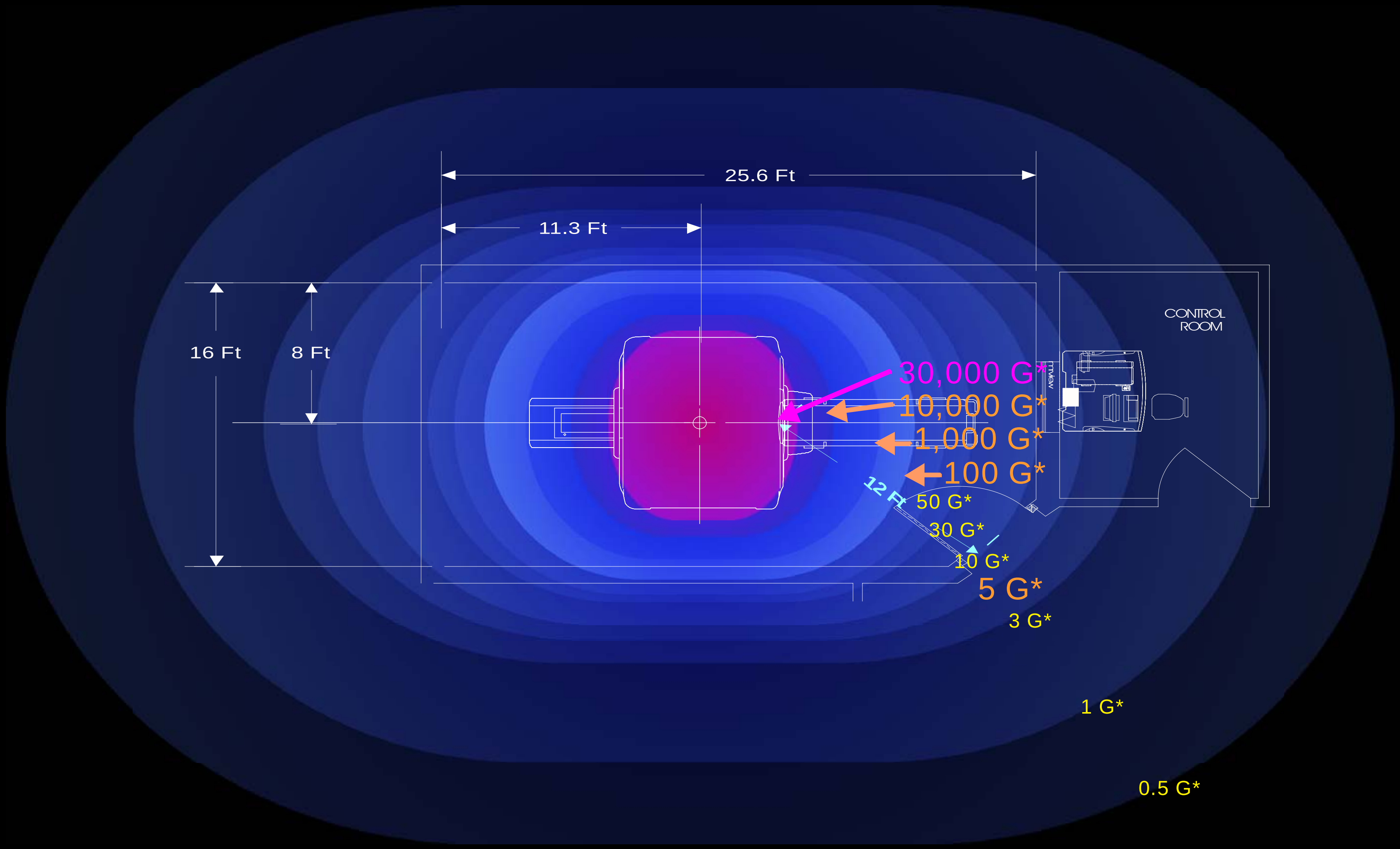
Typical active shielding

ACTIVE SHIELDING



Courtesy of Siemens Medical

3.0 T MR Scanner



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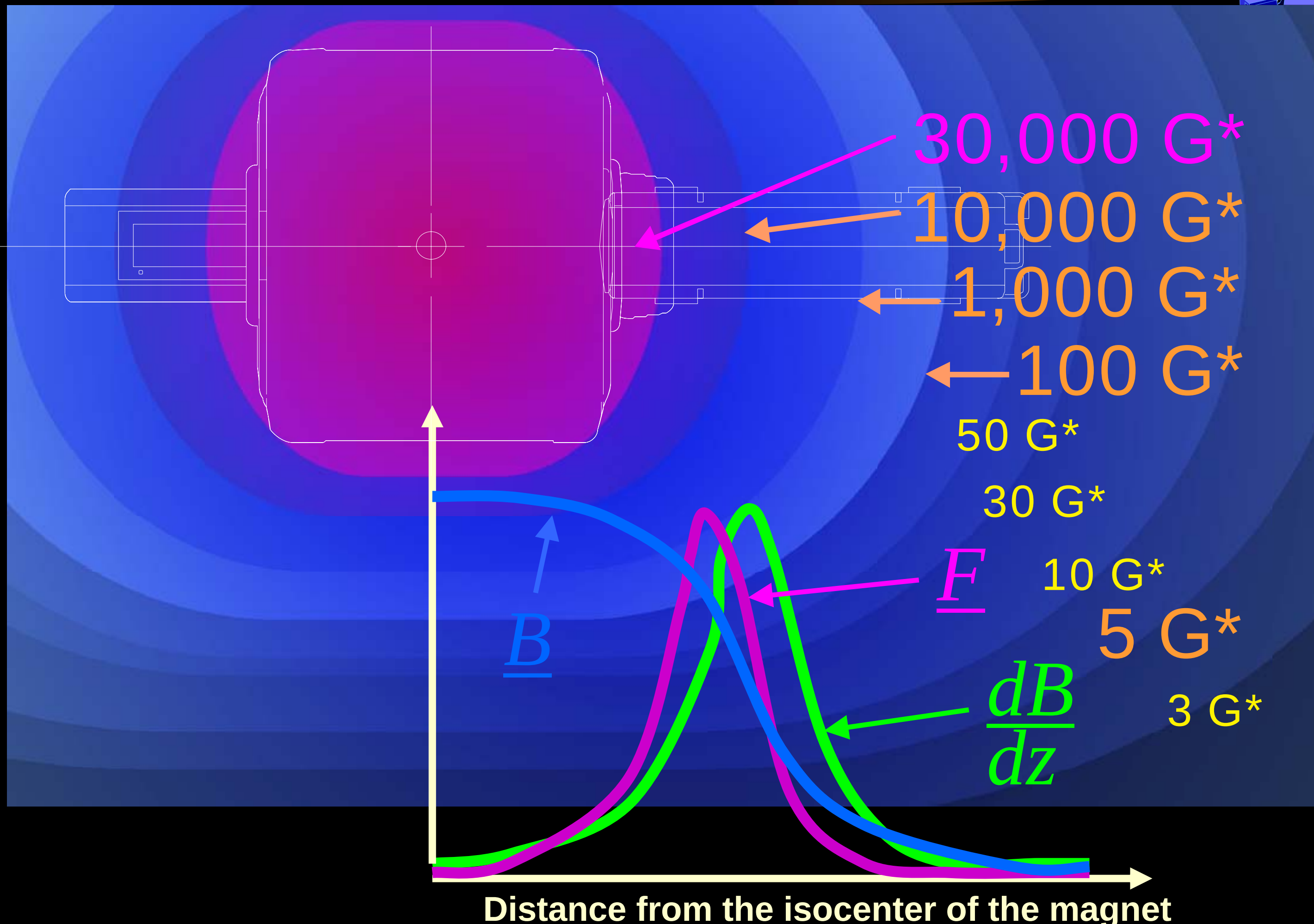
Local spatial gradient



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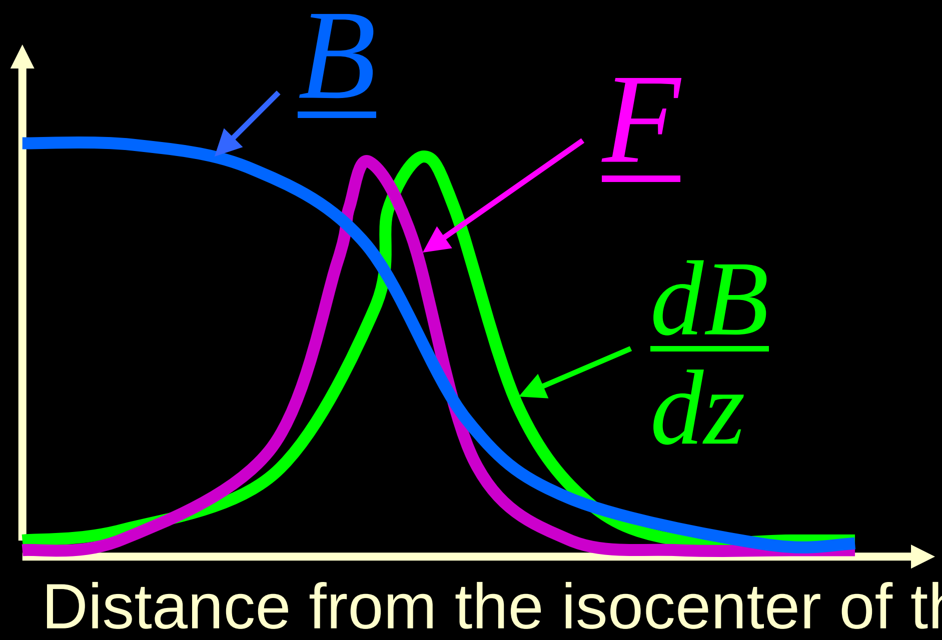
Translational Magnetic Forces

- **The Force, <u>*F*</u> on an object depends on**
  - **the magnetic field strength, <u>*B*</u>**
  - **the magnetic field gradient, *dB/dz***
  - **the object's susceptibility and shape**



$$\underline{F} \propto \underline{B}\,\frac{dB}{dz}$$

<u>*NO*</u> Translational force at isocenter

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Effect of active shielded magnets on Projectile risk

- No gentle, slowly increasing pull to provide feedback of ferromagnetic properties.
- Maximum force much greater than for the same field strength unshielded magnet.
- Distance / time to react to force can be shorter than reaction time
- A 3 T magnet with the same magnetic footprint as a 1.5 T has ***four times the force***

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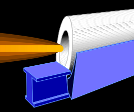
What affects an object's potential as a ferromagnetic threat?



- **The *ferromagnetic mass***
- **The *shape* of the object**
- **The ratio of *ferromagnetic mass* to *<u>non</u>-ferromagnetic mass* of the object**

What affects ferromagnetic mass?

- ***How much*** **ferromagnetic material *(weight)***
- ***The type*** **of ferromagnetic material *(permeability)***

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Why does the shape of an object effect its ferromagnetic threat potential?

- A ***pointed object*** **of a given mass and composition** ***will be attracted to the magnet more strongly*** **than a round object of the same mass and composition**

- **The long (pointed) dimension** ***will line up with the bore*** **of the magnet** ***<u>causing greater damage and risk of injury</u>***

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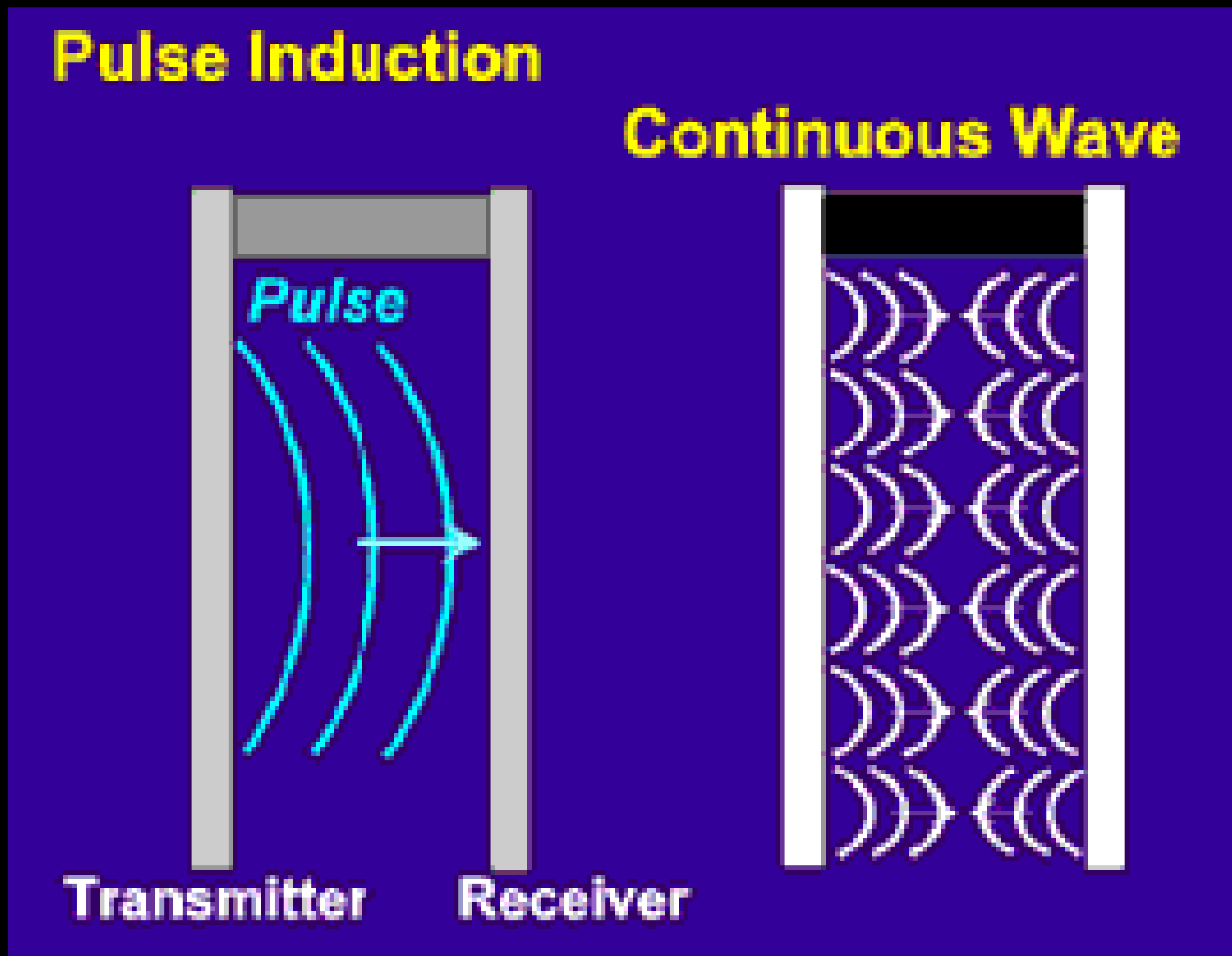
Conventional “airport type” Detector



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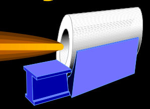
Conventional Metal detector efficacy



- Alarms for *ALL* conductive objects
- *False Positives* for non-ferromagnetic objects *(aluminum, brass, titanium etc.)*
- *False Negatives* for non-conductive ferromagnetic projectiles *(ceramic magnets)*
- Alarm sensitivity *not* related to threat potential
- Transmitter source of potential interference
- Both ACR and ECRI recommend against use

Ferromagnetic detection efficacy

- Responds *only* to ferromagnetic threats
- Response proportional to threat potential
- Can detect ferromagnetic material buried inside of any other material
- No electromagnetic transmitter to interfere with MRI
- Greatly reduced false positives and negatives

Two detection applications

- **Prevent ferrous material from accidentally entering the magnet room. Reduce the risk of an ordinary object, thought to be OK, from suddenly becoming an *unintended missile***

- **Reduce the risk for personnel bringing undiscovered objects that can become dangerously magnetically attracted**

SAFESCAN Ferromagnetic MR Target Scanner™

MEDNOVUS • SAFESCAN® Imaging Systems

SAFESCAN ferromagnetic screening instruments are developed by Mednovus, Inc. in alliance with Quantum Magnetics (a GE Infrastructure Security company) and the National Research Council, Canada

- Passive device
- Handheld
- Generates local magnetic field
  (100 gauss @ 1 inch)

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SAFESCAN® Portal 9000-C

- Passive device
- Separate portal and control console
- Generates local magnetic field
  (50 gauss inside portal)

MEDNOVUS • SAFESCAN® Imaging Systems

SAFESCAN ferromagnetic screening instruments are developed by Mednovus, Inc. in alliance with Quantum Magnetics (a GE Infrastructure Security company) and the National Research Council, Canada

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QinetiQ Ferroguard® MRI System

- Passive system
- Boxes mount on opposite walls
- Generates no local magnetic field

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FERRALERT™ ENTRY

Ferromagnetic Detection System

- **Passive Device**
- ***NO* magnetic field generated**
- **Green GO, Amber STOP with Audio**
- **High Output Audio Alarm for Unattended periods**
- **Activated by motion sensor**

FERRALERT™ ENTRY

Ferromagnetic Detection System

DISPLAY CONSOLE

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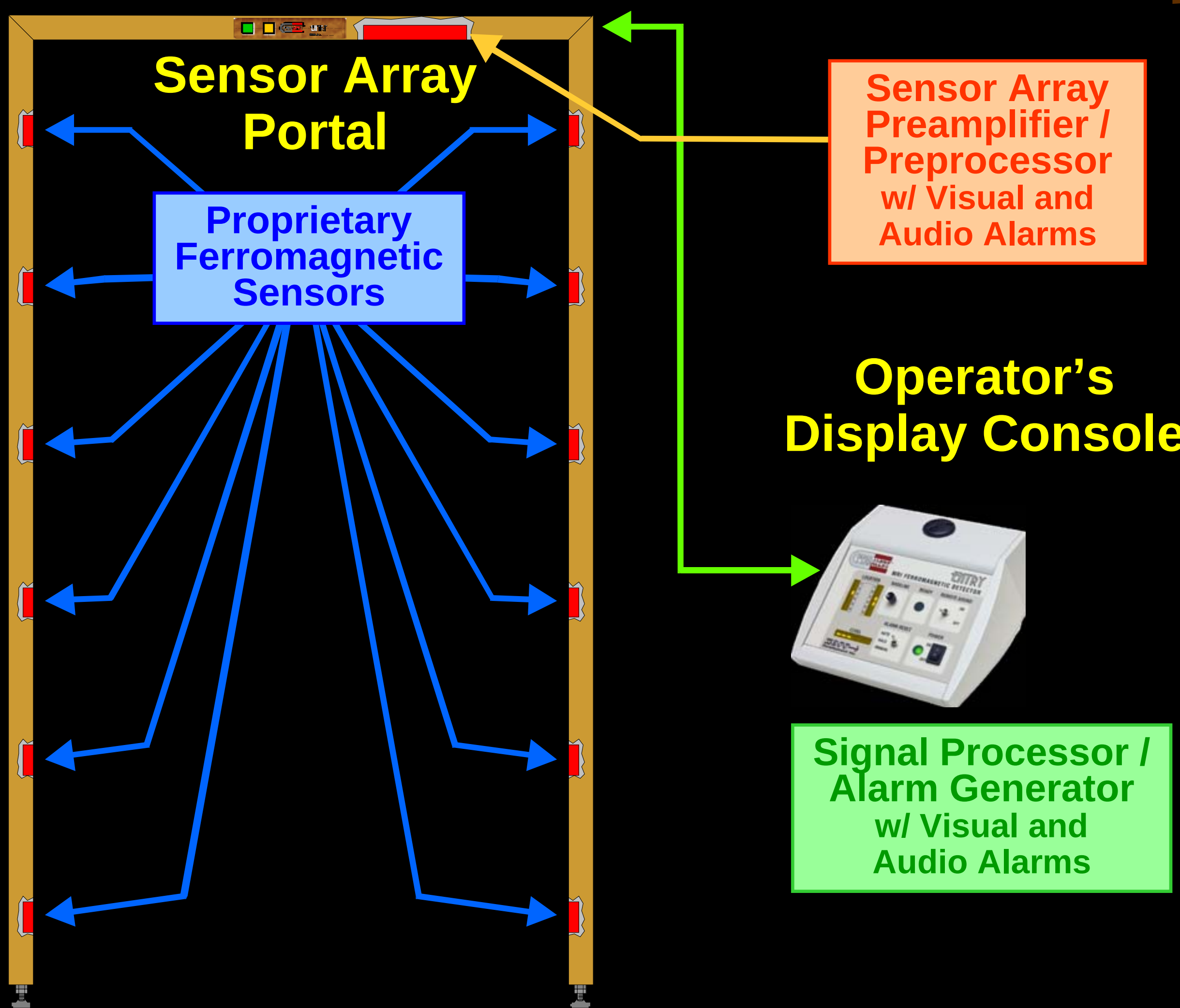
FERRALERT™ ENTRY Ferromagnetic Detection System

Block Diagram



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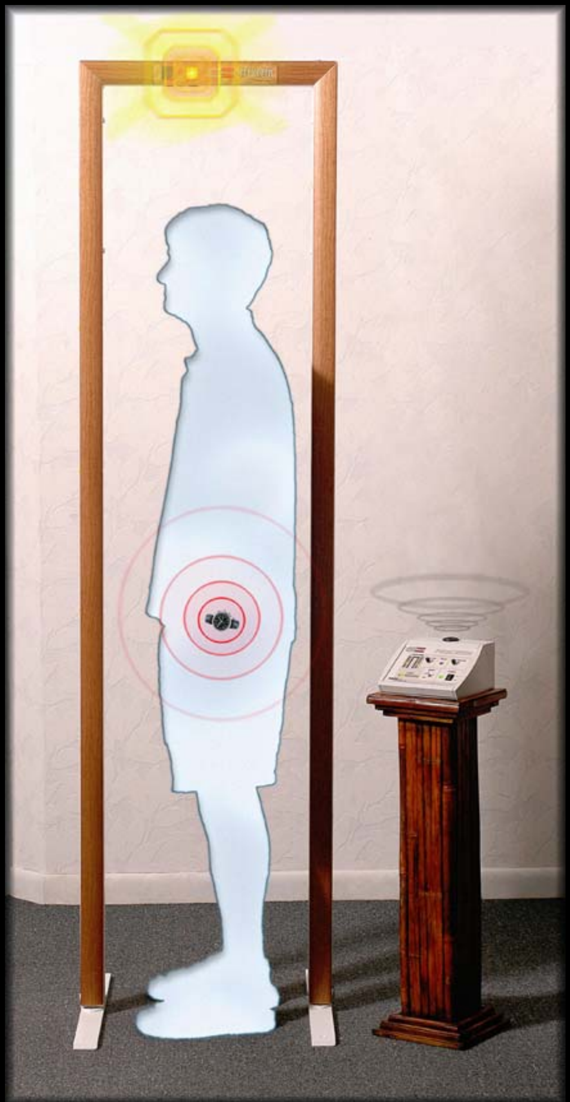
FERRALERT™ PRESCREEN

Ferromagnetic Detection System

- **Passive Device**
- **NO magnetic field generated**
- **Green GO, Amber STOP w/Audio Alarm**
- **Sensitive to _very small_ objects**
- **Activated by motion sensor**



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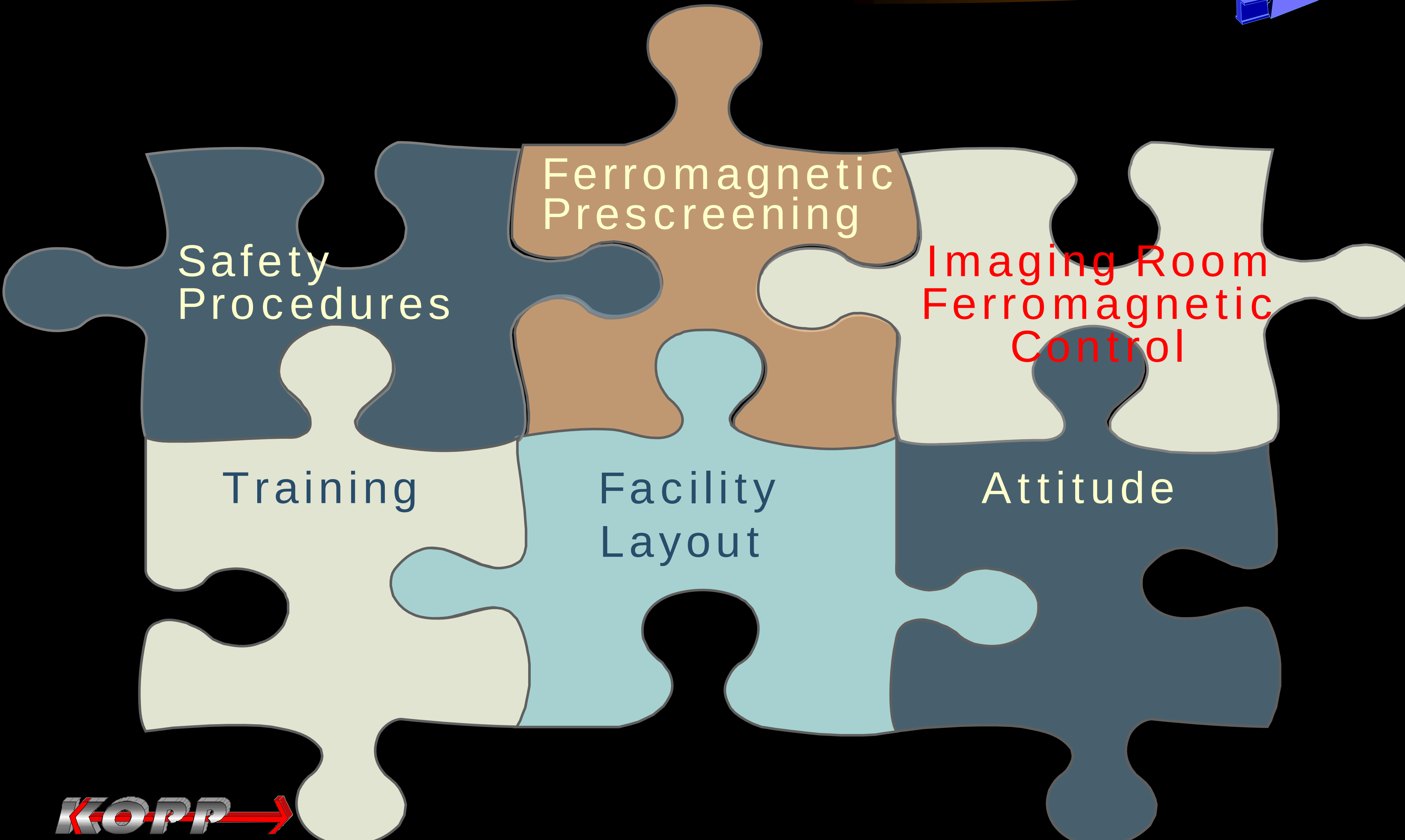
Ferromagnetic Detection
– A part of the MR safety puzzle



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Conclusion

- Ferromagnetic risks are increasing
- Ferromagnetic detection systems when used to supplement a comprehensive screening procedure have the potential of significantly reducing the risk of a projectile incident.
- "These detectors at least have the potential to reduce the risk of patient injury and damage to equipment, as well as to reduce MR downtime that could occur as a result of an incident"

ECRI Guidance Article 2005[10]

References

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4 Pennsylvania Patient Safety Reporting System http://www.psa.state.pa.us/psa/cwp/view.asp?a=1165&q=441808

7 Launders JH MRI Safety and Medical Devices SEPTEMBER 21, 2005 ECRI MRI audio conference

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10 What’s new in MRSafety: The Latest on the Safe Use of Equipment in the Magnetic Resonance Environment [Guidance Article]. Health Devices 2005 Oct 34 (10)

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