

Before we begin...



And the aptly named Sir Not-appearing-in-this-film

# Before we begin

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Terminology can be confusing: too many “gradients”

- Some MRI safety conditions may refer to “maximum spatial gradient” or a “static magnetic field gradient”.
- This is not referring to the time-varying field created by the gradient coils: nothing to do with the imaging gradients.

Imaging gradients are

- Very small changes in field strength (e.g. 30mT/m)
- Time varying (very rapidly)
- Affect things in the bore of the scanner
- They are a completely different hazard (PNS, acoustic noise, induced currents etc).

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Imaging gradients are

- Very small (typically  $< 10\text{mT/m}$ )
- Time varying
- Affect the frequency of the signal
- They are the source of the acoustic noise, including the “clunk”



$10\text{mT/m}$ )

S, acoustic

# Spatial Gradient

**Sarah Allwood-Spiers**

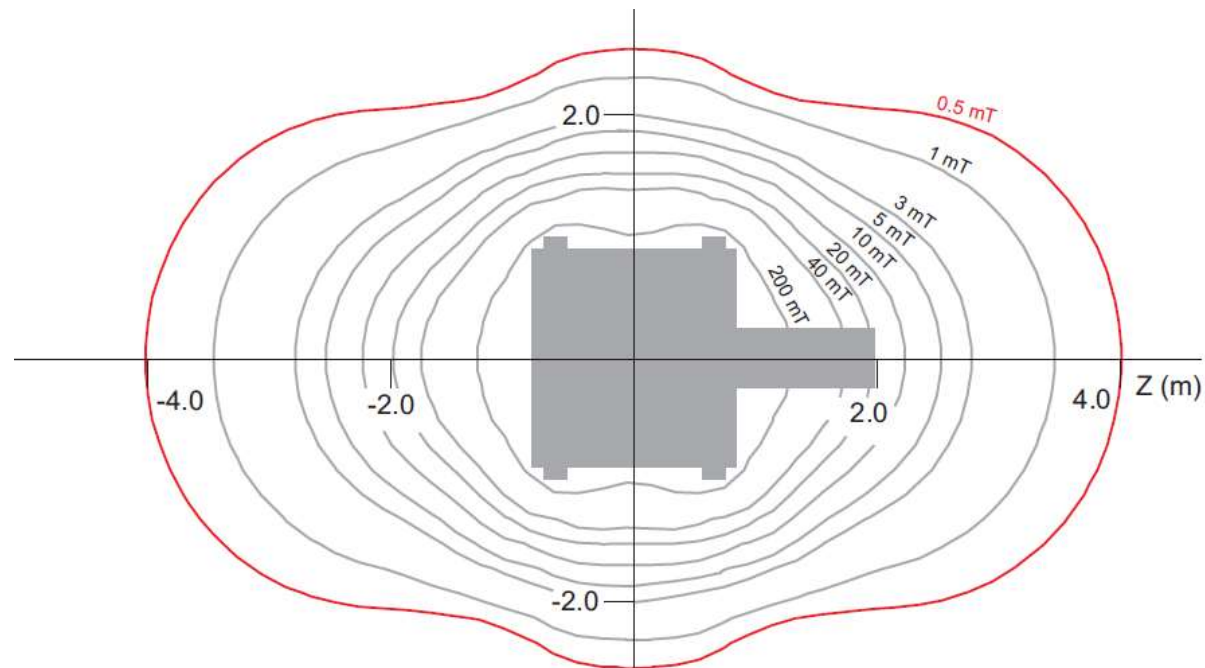
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# Magnetic field strength

- A 1.5 T scanner has a field strength of 1.5 Tesla at isocentre and inside the bore of the scanner.
- This drops quite rapidly with distance at the entrance to the bore of the scanner.



Example contour plot of magnetic field strength (in mT) around a 1.5T scanner.

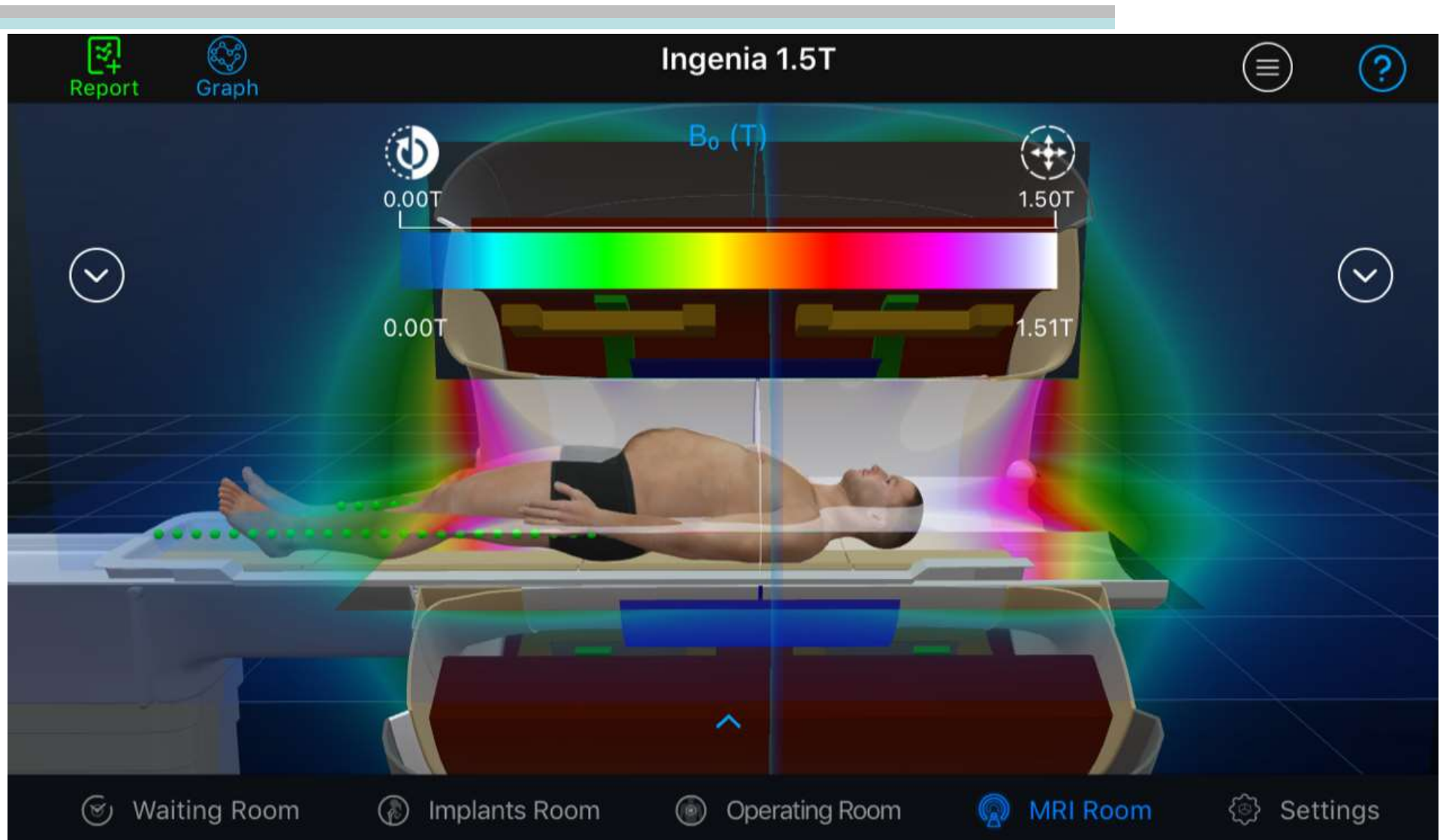


Illustration of magnetic field strength in a 1.5T scanner. Taken from MagnetVision app.



# Translational force

- The translational force on an object depends on
  - The volume  $V$  and magnetic susceptibility  $\chi$  of the object.
  - the field strength  $B$
  - the spatial rate of change  $dB/dz$  of the magnetic field: spatial gradient.



# Spatial Gradient

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- Also known as “static field gradient”.
- Rate of change of magnetic field with distance
- Spatial gradient may be stated in units of T/m, e.g. 7.4 T/m, or G/cm, e.g. 740 G/cm.
- 100 G/cm is 1 T/m.
- Typical size: 0-20 T/m. Does not vary with time.
- Maximum close to bore entrance



# Example Implant Conditions

- For a device that is “MR conditional”, the conditions may include a requirement on the maximum spatial gradient.
- E.g. Maximum spatial gradient field of 720 G/cm.
  - To be compliant with these conditions, the device should not go into a region with a higher spatial gradient than this value.



## MR Conditional

Non-clinical testing has demonstrated that the Carpentier-Edwards PERIMOUNT Magna Mitral Ease pericardial bioprosthesis is MR Conditional. A patient with the PERIMOUNT Magna Mitral Ease bioprosthesis can be scanned safely immediately after placement of this implant under the following conditions:

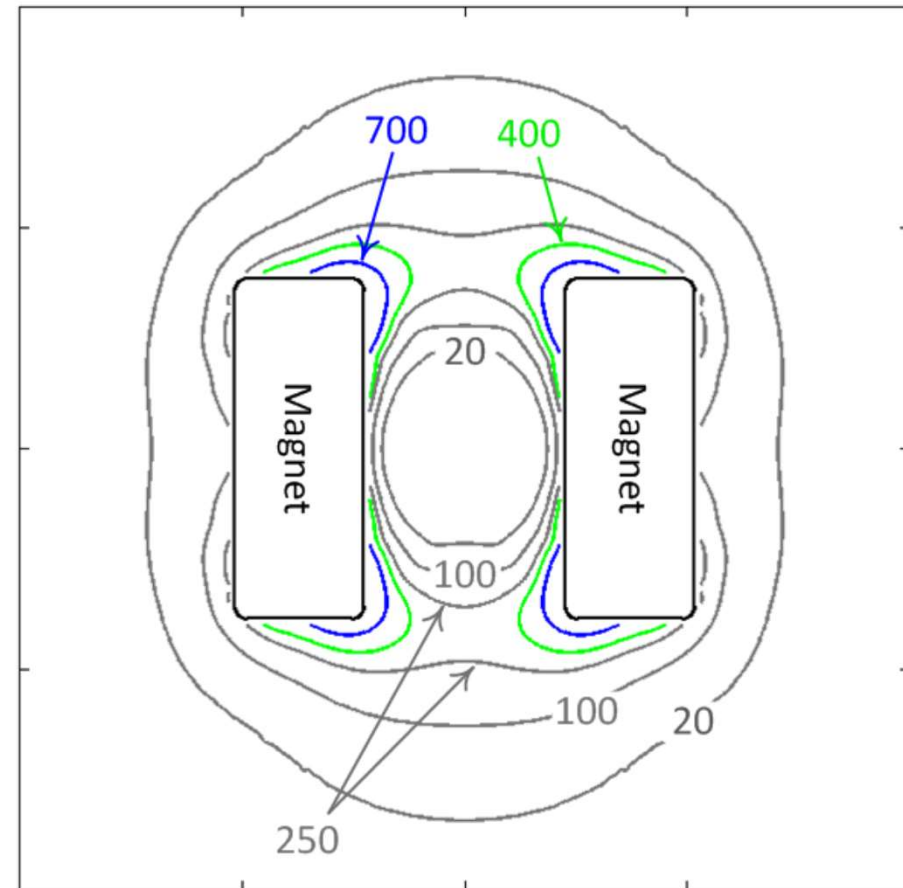
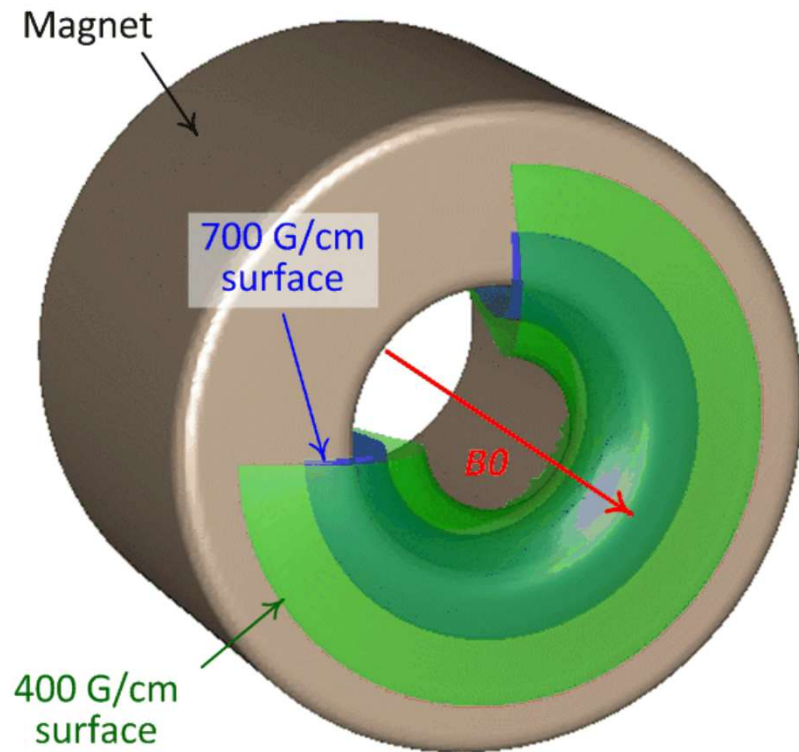
- Static magnetic field of 3 tesla or less.
- Maximum spatial gradient field of 720 gauss/cm.
- Maximum MR system-reported whole-body-averaged specific absorption rate (SAR) of 3W/kg for 15 minutes of scanning.

# Scanner information

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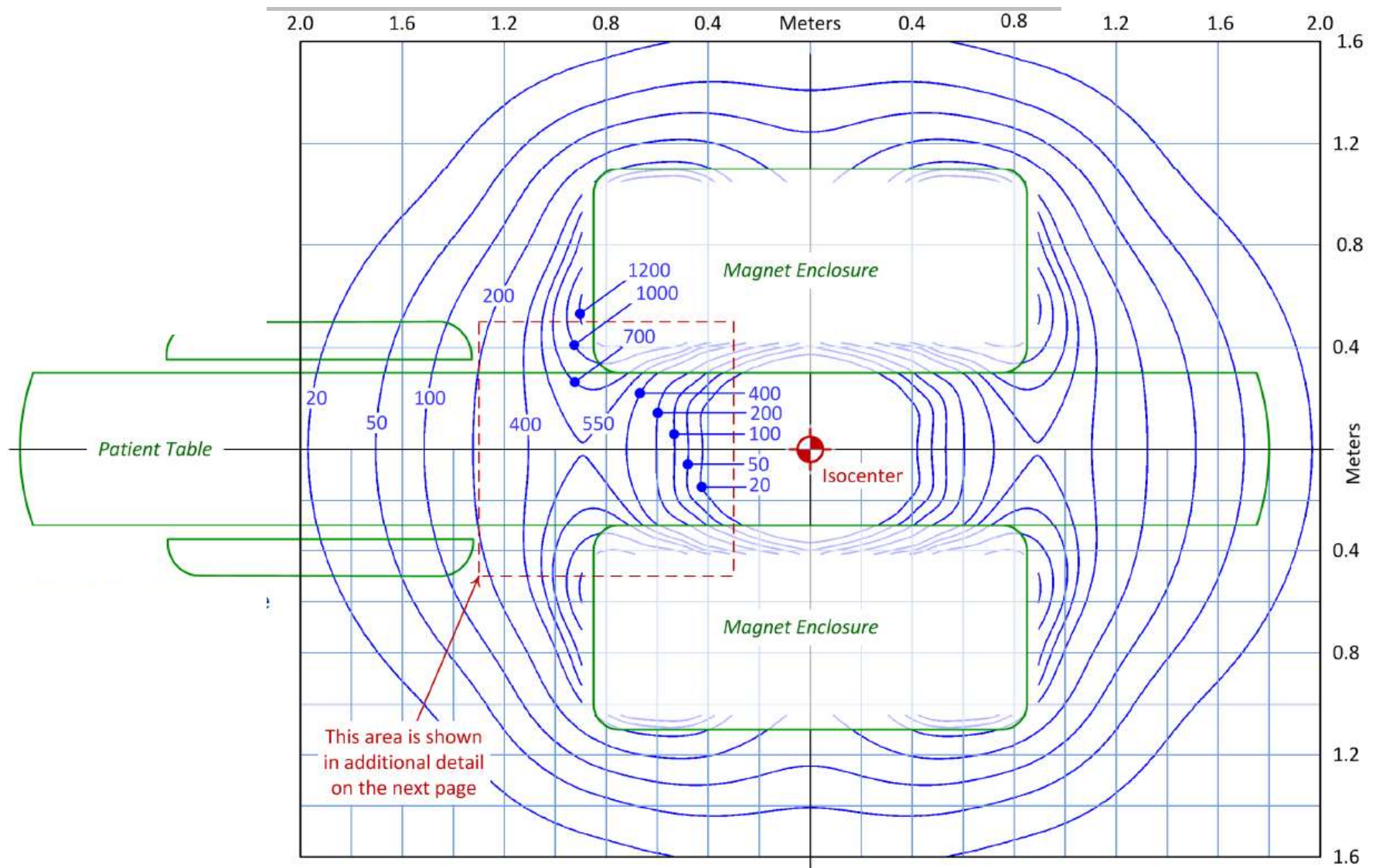
- Scanner manual may tell you the maximum spatial gradient, or peak static field gradient, for the system:
  - E.g. MSG 1300G/cm.
  - Not very useful. 🙄
- Where is it 1300G/cm? Will the patient/implant pass through this region?

# Example Spatial Gradient map



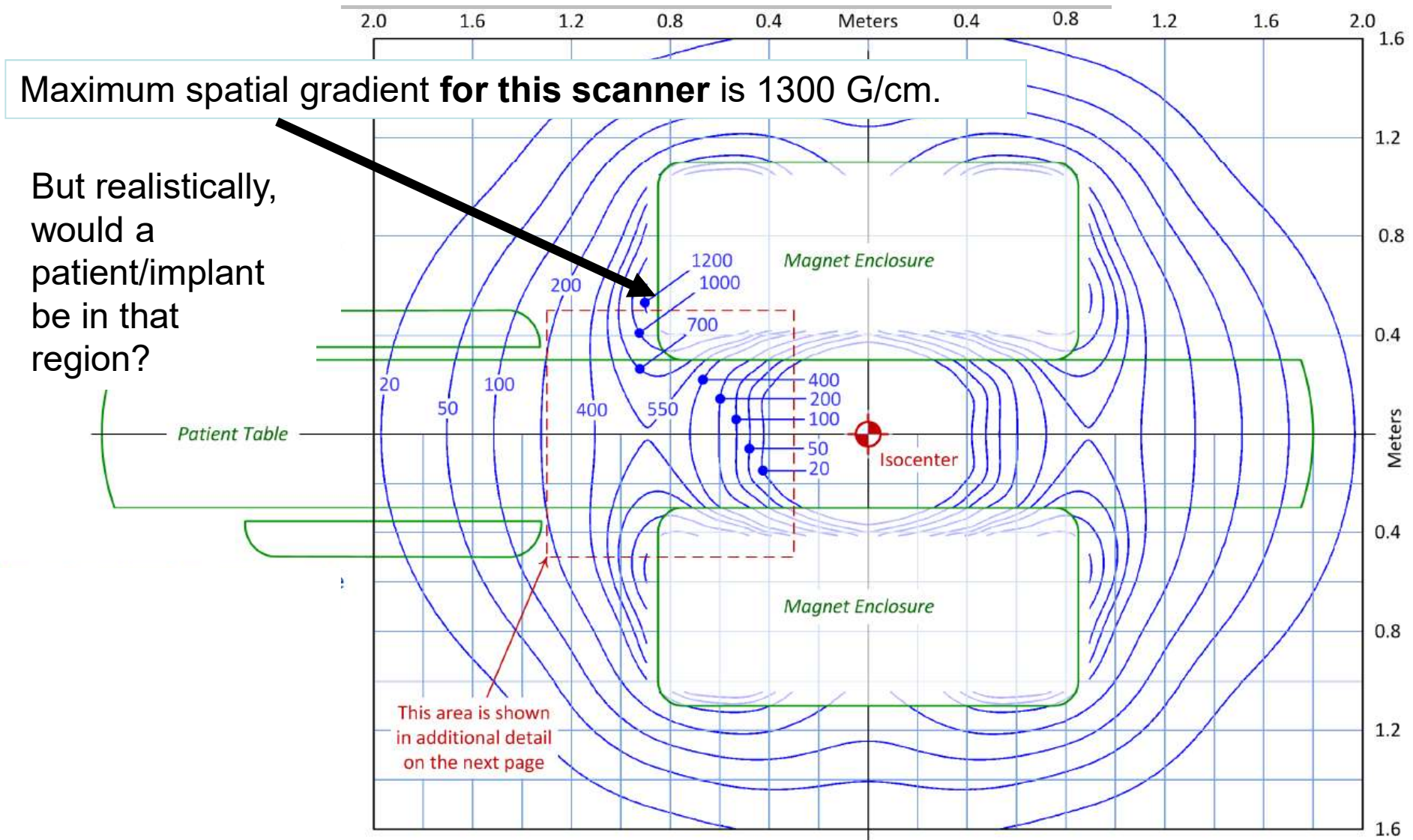
Contour map of spatial gradient for an example 1.5T magnet

# Example Spatial Gradient Map for GE Discovery MR750w (3T, 70cm bore)



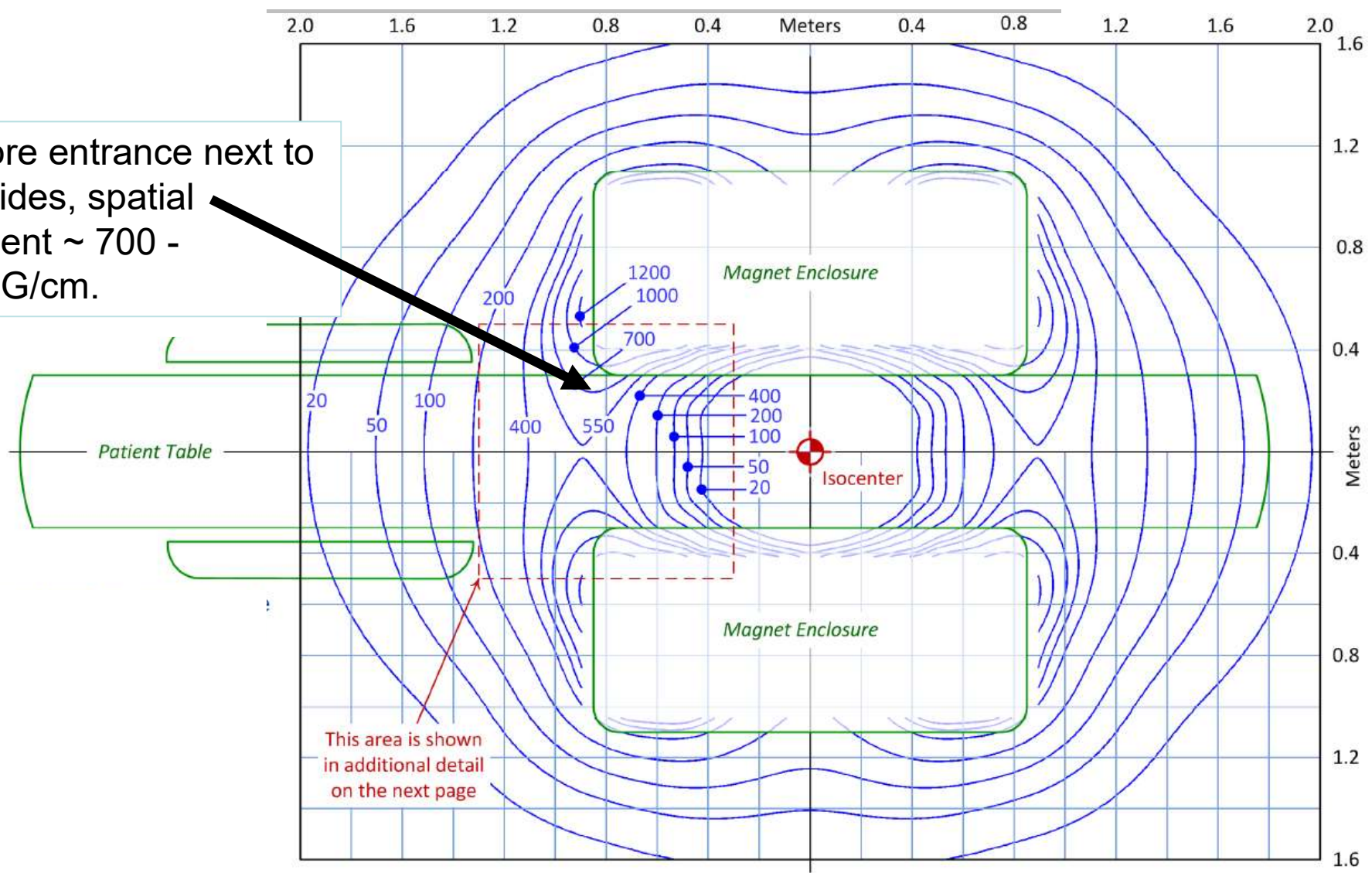


# Example Spatial Gradient Map for GE Discovery MR750w (3T, 70cm bore)



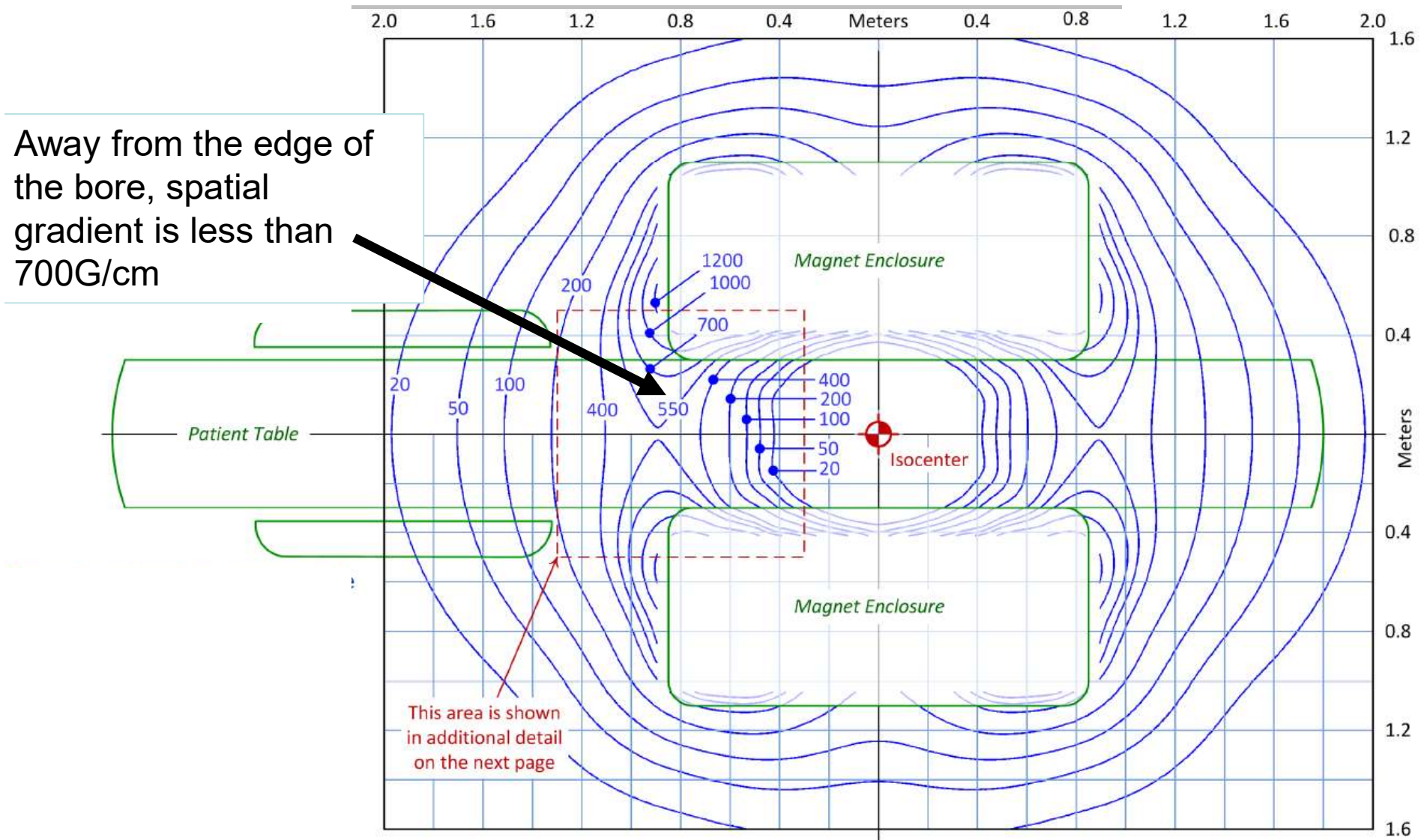
# Example Spatial Gradient Map for GE Discovery MR750w (3T, 70cm bore)

At bore entrance next to the sides, spatial gradient  $\sim 700 - 1000\text{G/cm}$ .





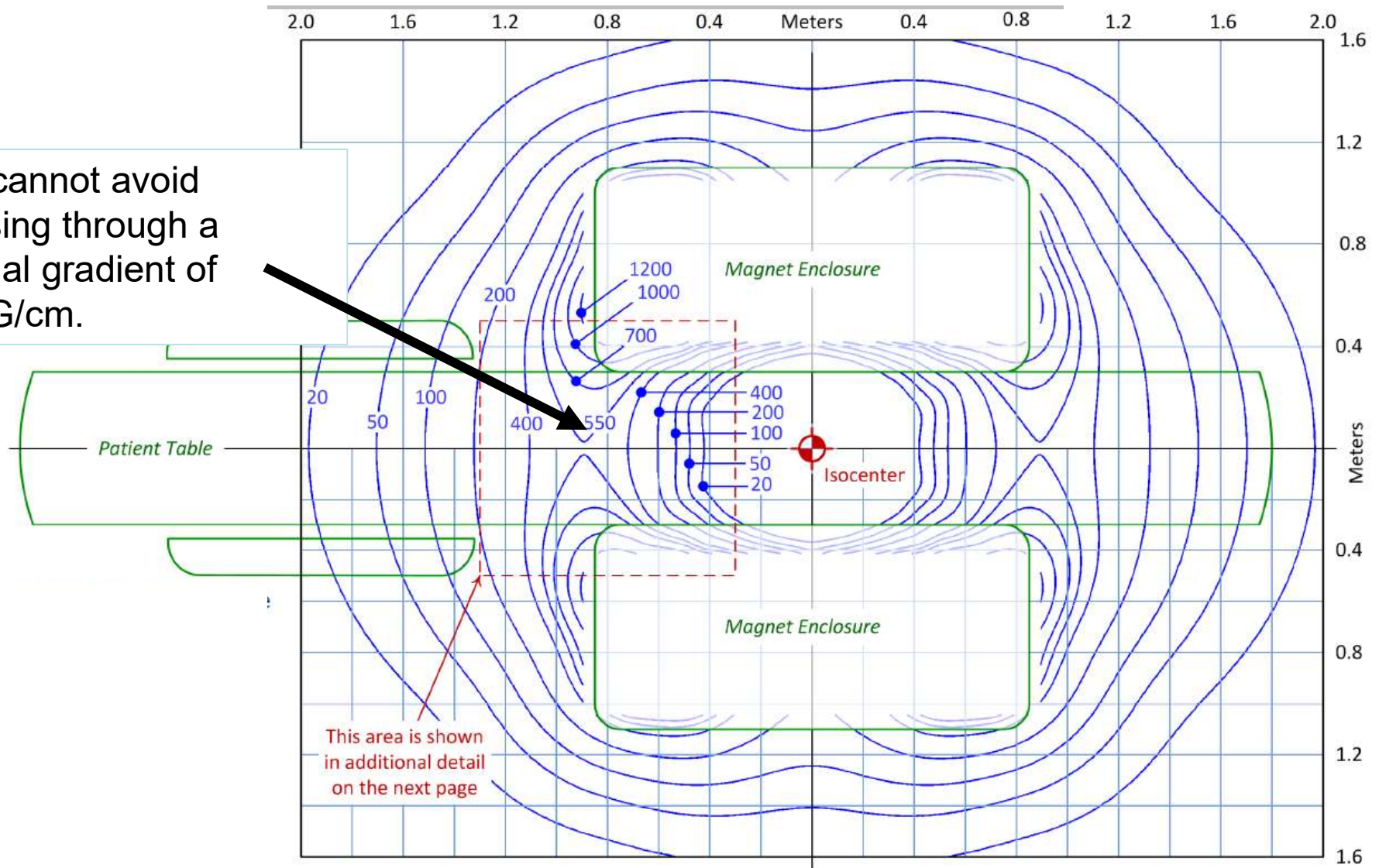
# Example Spatial Gradient Map for GE Discovery MR750w (3T, 70cm bore)





# Example Spatial Gradient Map for GE Discovery MR750w (3T, 70cm bore)

We cannot avoid passing through a spatial gradient of 550G/cm.



# Spatial Gradient Example

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Should you scan the patient?

What do you think?

- No!!! The scanner's maximum spatial gradient is 1300G/cm. The condition is not met. This patient must never get an MRI.
- Probably: What spatial gradient will the implant pass through? To answer this we may need to know:
  - Where in the body is the implant?
  - How large is the patient?

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# Variations with Scanner

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- Spatial gradient contour maps will have different values for different scanners. In general, a 3T scanner reaches higher values than a 1.5T scanner.
- A wide bore scanner will have higher values than a 60cm scanner, but those higher values might be quite far away from the patient.
- When assessing whether MR conditions on spatial gradient are met for a particular implant, we have to decide whether the region the implant passes through has a higher spatial gradient than the MR conditions allow.

# Conclusion

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- The static field gradient or “spatial gradient field” describes how quickly the magnetic field changes with distance.
- It is important because the attractive force on ferromagnetic objects is determined by this static field gradient.
- It strongest close to the opening of the scanner, next to the bore walls.
- If interpreted correctly, the maximum spatial gradient in the MRI conditions for an implant is rarely the limiting factor.
- If you think an implant doesn't meet the conditions for spatial gradient – contact MR physics.