For MRI (magnetic resonance imaging):

Applied **field is deliberately made to *vary* across the sample**.

Frequency set to **ONLY MEASURE WATER**

Then, **protons in different parts of sample will resonate at different frequency**

Only because of *POSITION*;

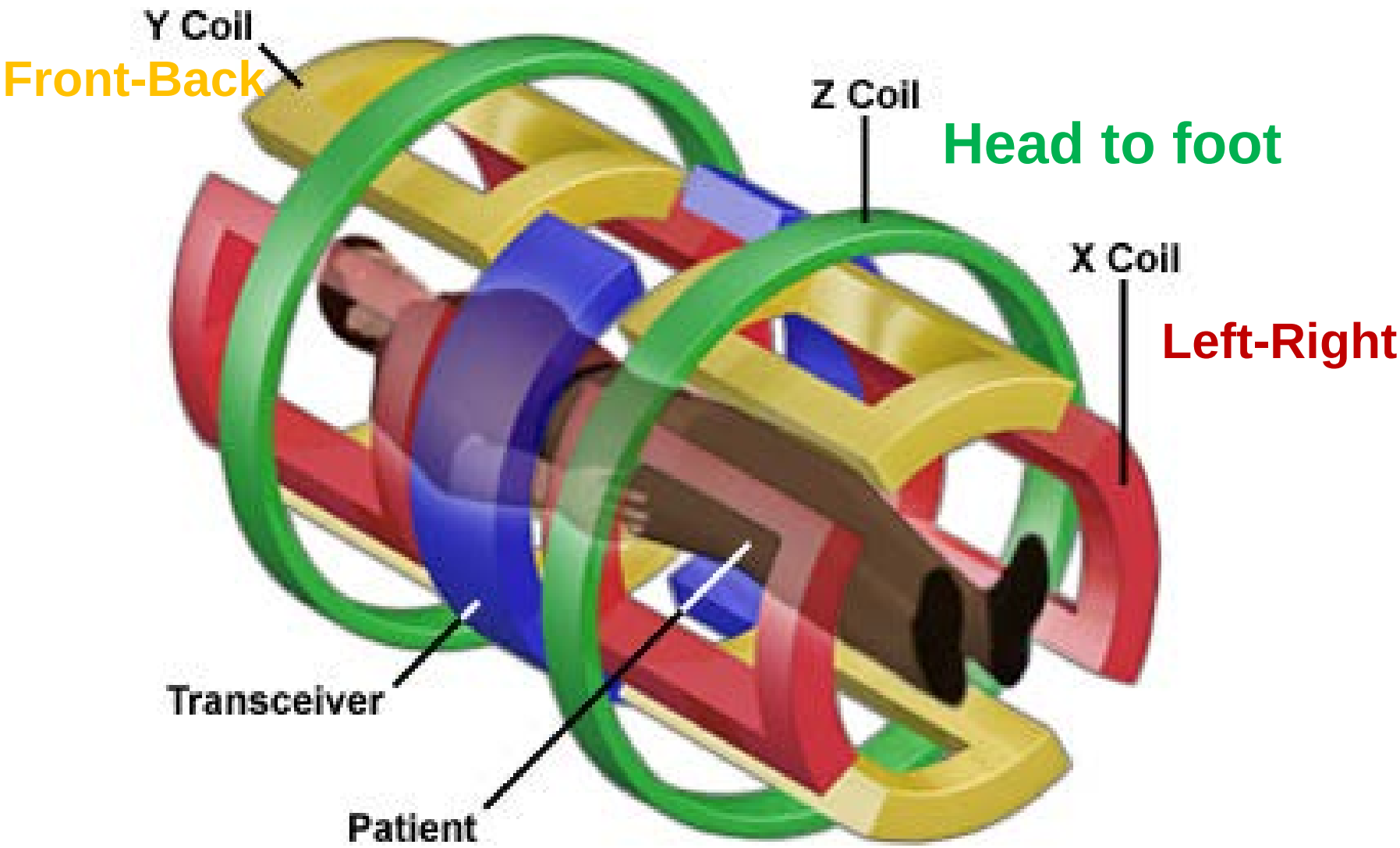
***NOT* because of different chemical shift**

MRI Detects primarily two things:

(1) **amount of water at different positions**

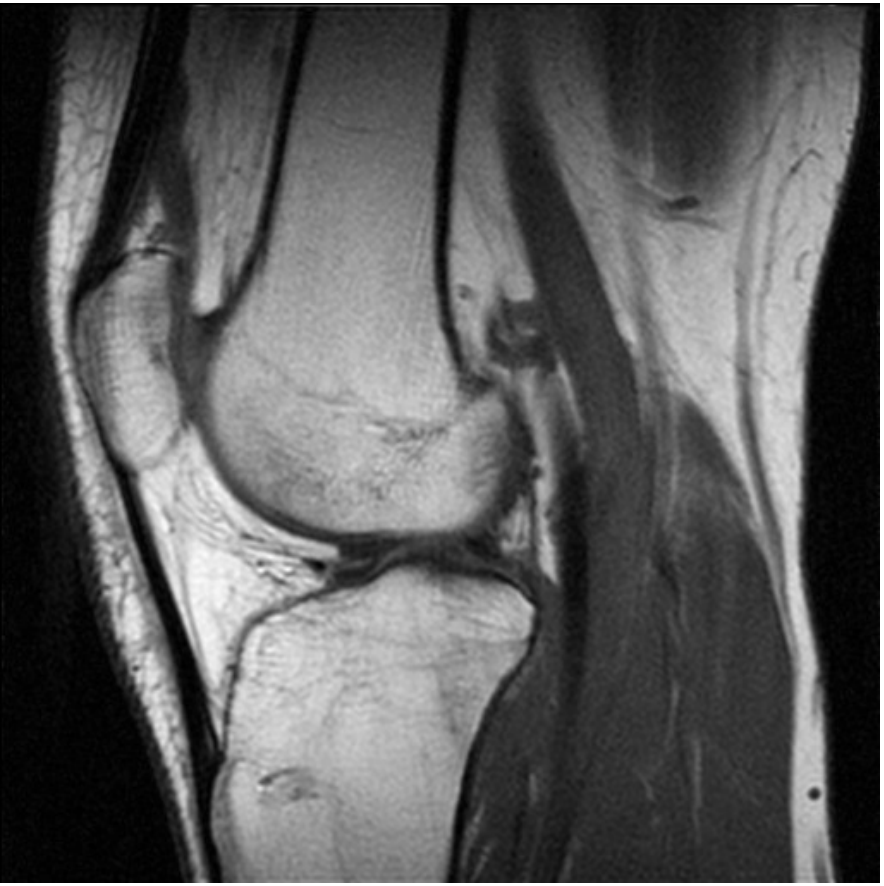
(2) and **direction of diffusion (more difficult)**

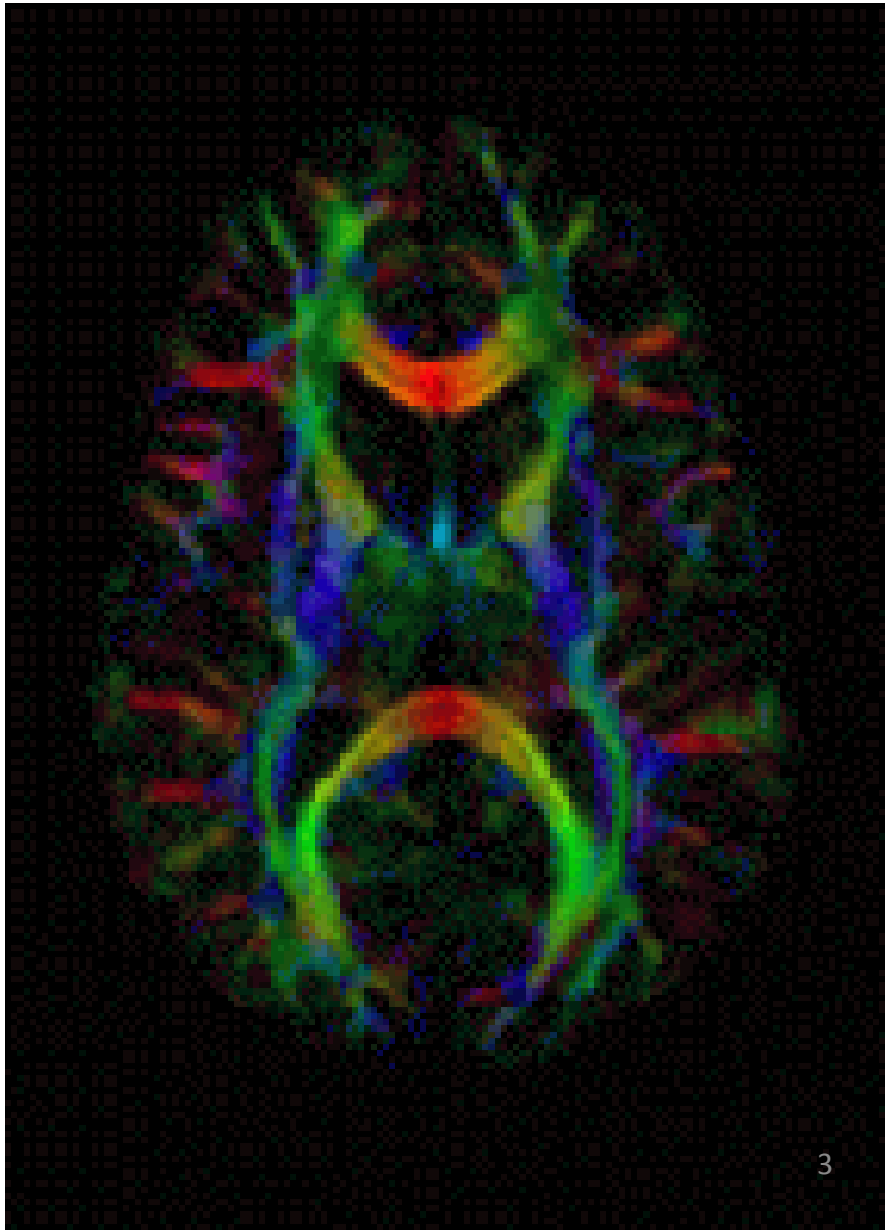
MRI Scanner Gradient Magnets

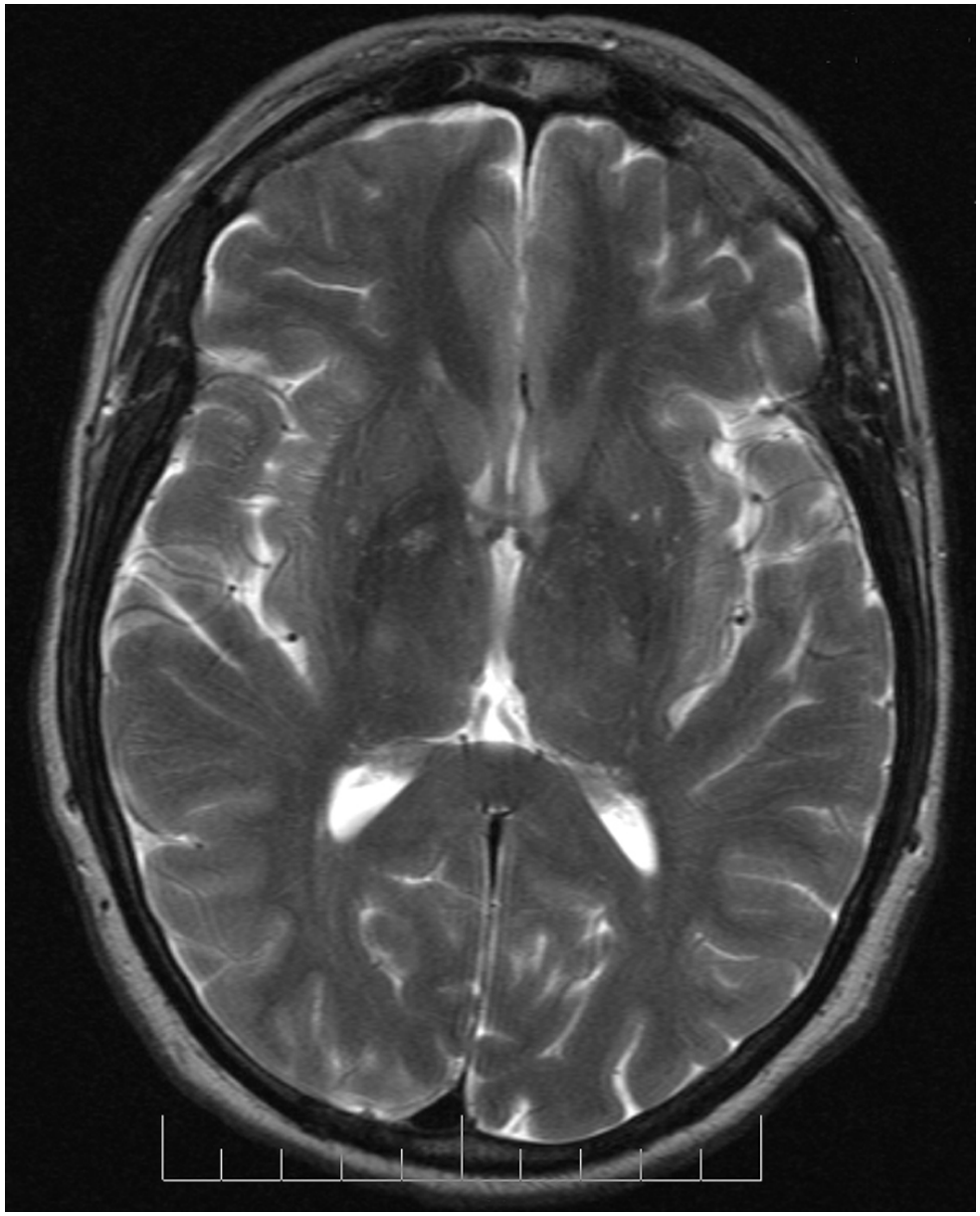


diffusion tensor imaging (DTI)[

http://en.wikipedia.org/wiki/Magnetic_resonance_imaging







File:MRI T2 Brain axial image.jpg From Wikipedia, the free encyclopedia

http://en.wikipedia.org/wiki/Magnetic_resonance_imaging

Magnetic resonance angiography (MRA) generates pictures of the arteries to evaluate them for stenosis (abnormal narrowing) or aneurysms

Using color to indicate frequency *that is absorbed* in different parts of the sample

red is low frequency *absorbed* because ***low*** field on left)
blue is high frequency *absorbed* because ***high*** field on righ

Protons in different places absorb different frequencies.

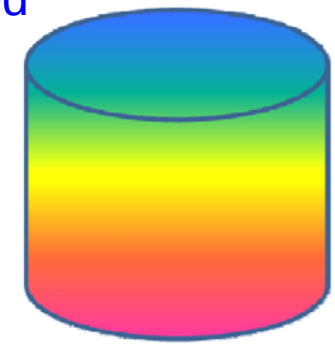
Field increasing in x → **x**

Resonant frequency ν_r increasing in x

(ν_r is the frequency the water **absorbs** because of where it resides)

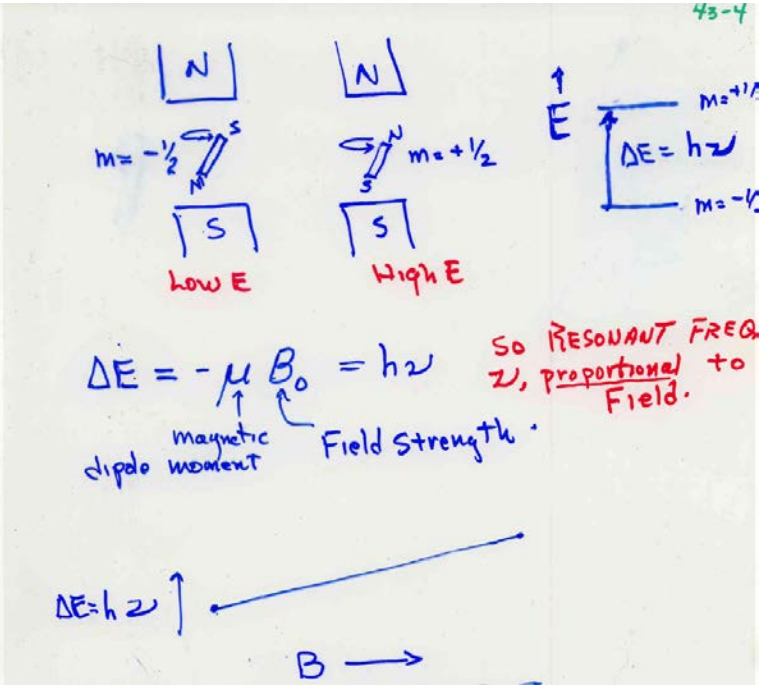
The object is bathed with ALL frequencies.
The detector tells how strongly each frequency is absorbed

z



Field increasing in z

Resonant frequency ν_r increasing in z



(MRI)

FIELD HAS x or y or z GRADIENT

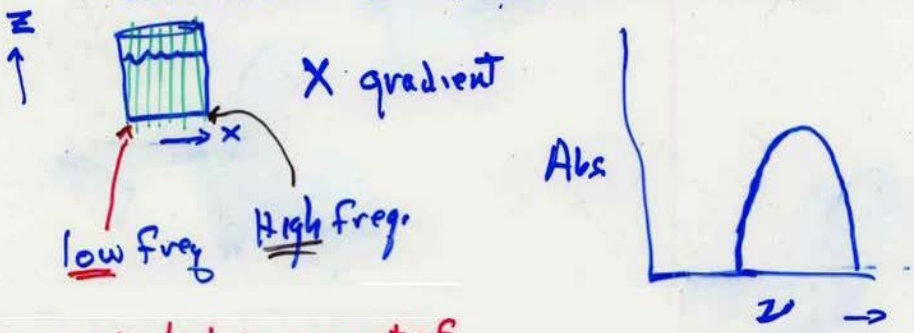
i.e. increases linearly as x or y or z increases.

So ν also increases linearly as x or y or z increases

Different parts of sample resonate at different frequency.

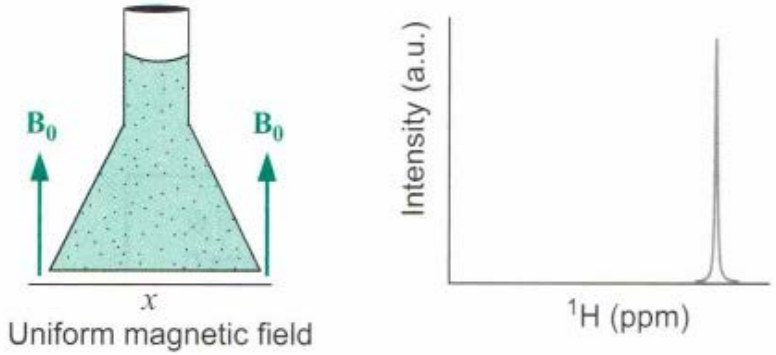
Absorption strength depends on How many protons in resonance.

Consider a beaker of water

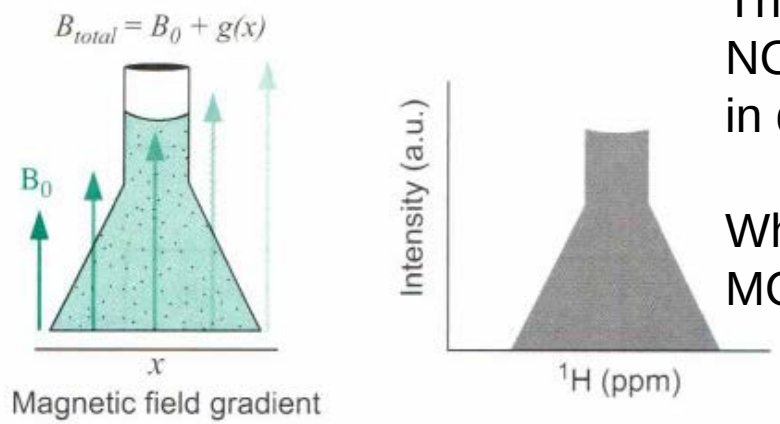


Abs proportial to amount of water in slices perpendicular to x

NMR



MRI



This image is NOT CORRECT in detail.

Which position has the MOST water???

URE 14.29 Magnetic resonance imaging of a flask of water placed in a magnetic field that increases arly from left to right. A magnetic field gradient means that the resonance frequency of a proton ends on its position in the field. In a magnetic field gradient, a spectrum of intensity of absorption versus uency represents the number of protons versus position in the field. The spectrum is thus a projection of mage of the water in the flask.

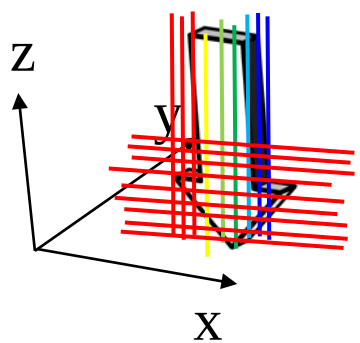
Homework #7 Problem: draw absorbance spectrum for the 3 field gradients

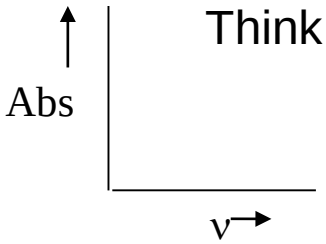
If the shape depicted below is filled with water, draw curves that indicate the intensity of absorbed radio frequency energy during an MRI of this object when the magnetic field gradient is in the x, y, z directions. (Field strength increases with increasing x, or y, or z.)

The long axis of the arrow is parallel to z. The plane of the arrow is perpendicular to the y axis.

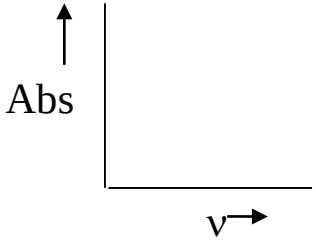
3 different experiments:
One for each field gradient

Think: **Vertical slices perp. to X**

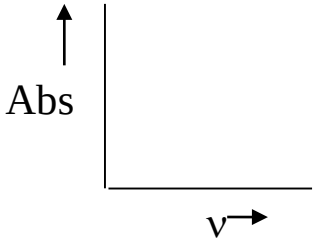




Field gradient in x direction



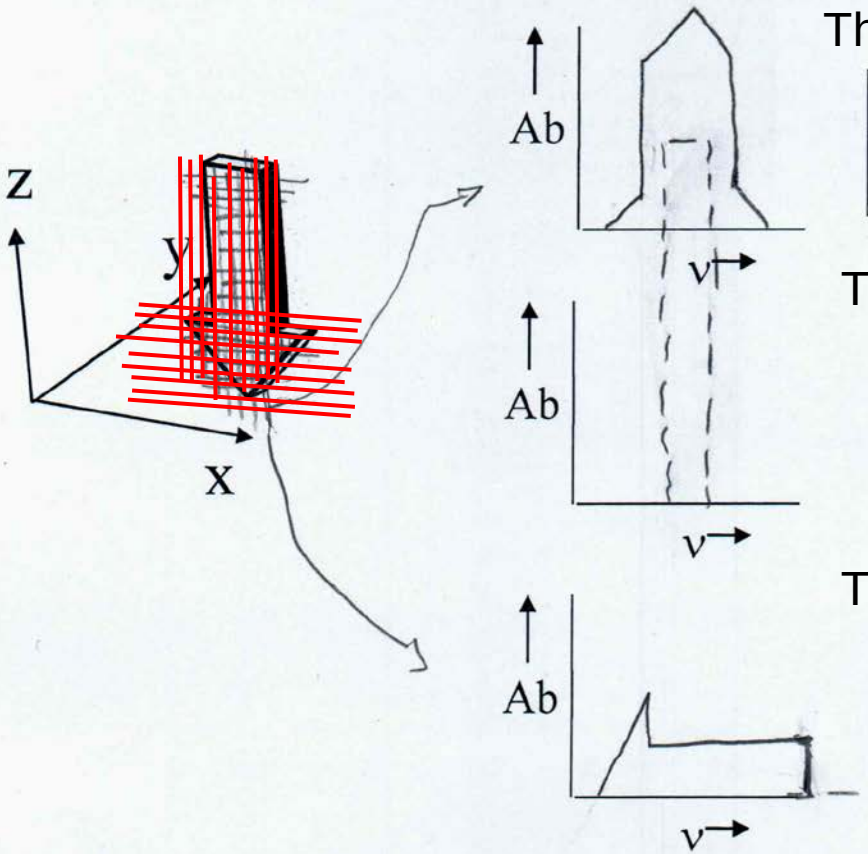
Field gradient in y direction



Field gradient in z direction

(11 pts) 9. If the shape depicted below is filled with water, draw curves that indicate the intensity of absorbed radio frequency energy during an MRI of this object when the magnetic field gradient is in the x, y, z directions. (Field strength increases with increasing x, or y, or z.)
The long axis of the arrow is parallel to z. The plane of the arrow is perpendicular to the y axis.

What is the x spectrum?



Think: **Vertical slices perp. to X**

Field gradient in x direction

Think: **Vertical slices perp. to Y**

Field gradient in y direction

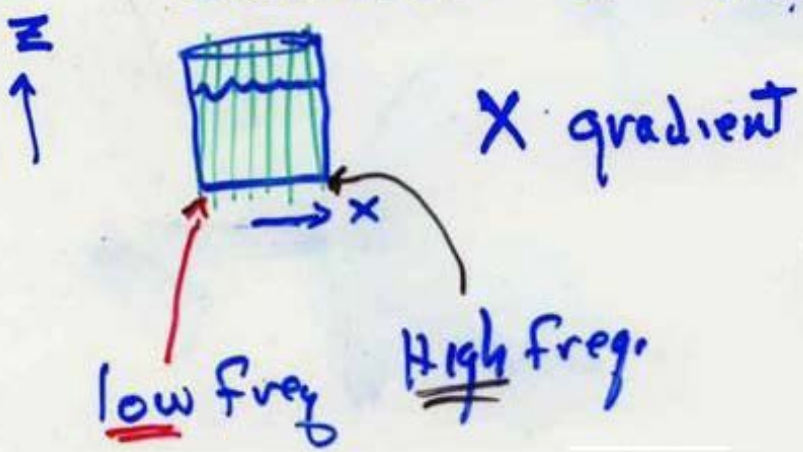
Think: **Vertical slices perp. to Z**

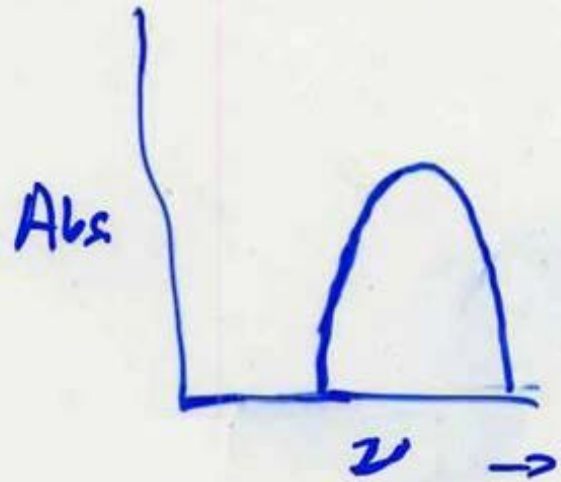
Field gradient in z direction

Different parts of sample resonate at different frequency.

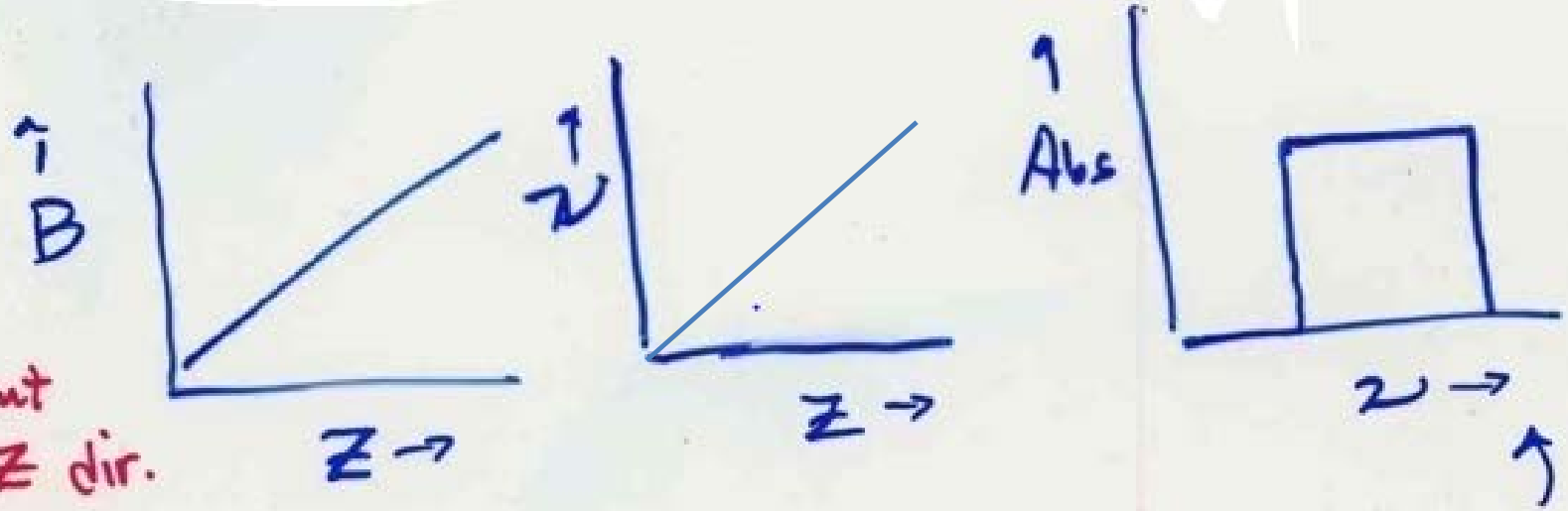
Absorption strength depends on How many protons in resonance.

Consider a beaker of water





Abs proportial to amount of water in slices perpendicular to x

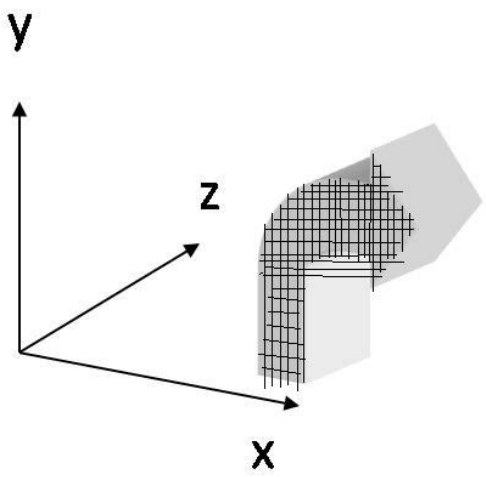


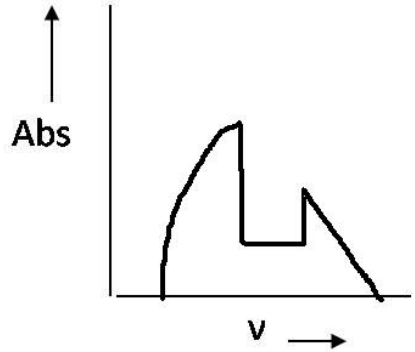
!
adient
n Z dir.

Slice perpendicular to Z

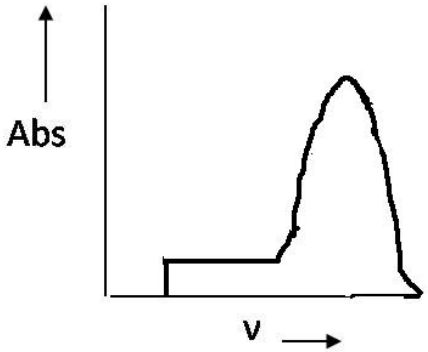
all slices have same amount of water

IMAGE is mathematically constructed from the 3 spectra (the y spectrum = x spectrum)

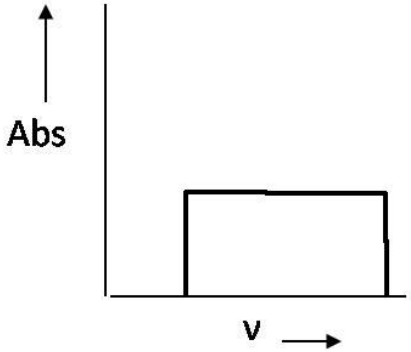




Field gradient in x direction



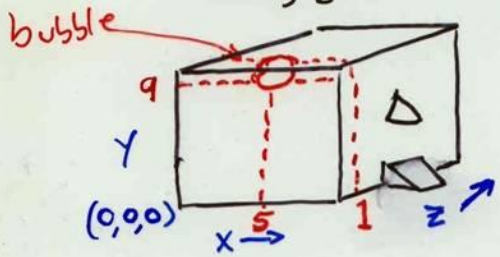
Field gradient in y direction



Field gradient in z direction

MRI - Magnetic Resonance Imaging.

Consider a 10 × 10 × 10 inch "Beaker" of water with "nose", "jaw", and "tumor" ← bubble of air.



"Tumor" is located at:

$X = 5$
$Y = 9$
$Z = 1$

Take 3 spectra with magnetic field (B_0) gradient along X, Y, or Z.

Remember, ν_r (resonant frequency for water) proportional to magnetic field strength