Resolution

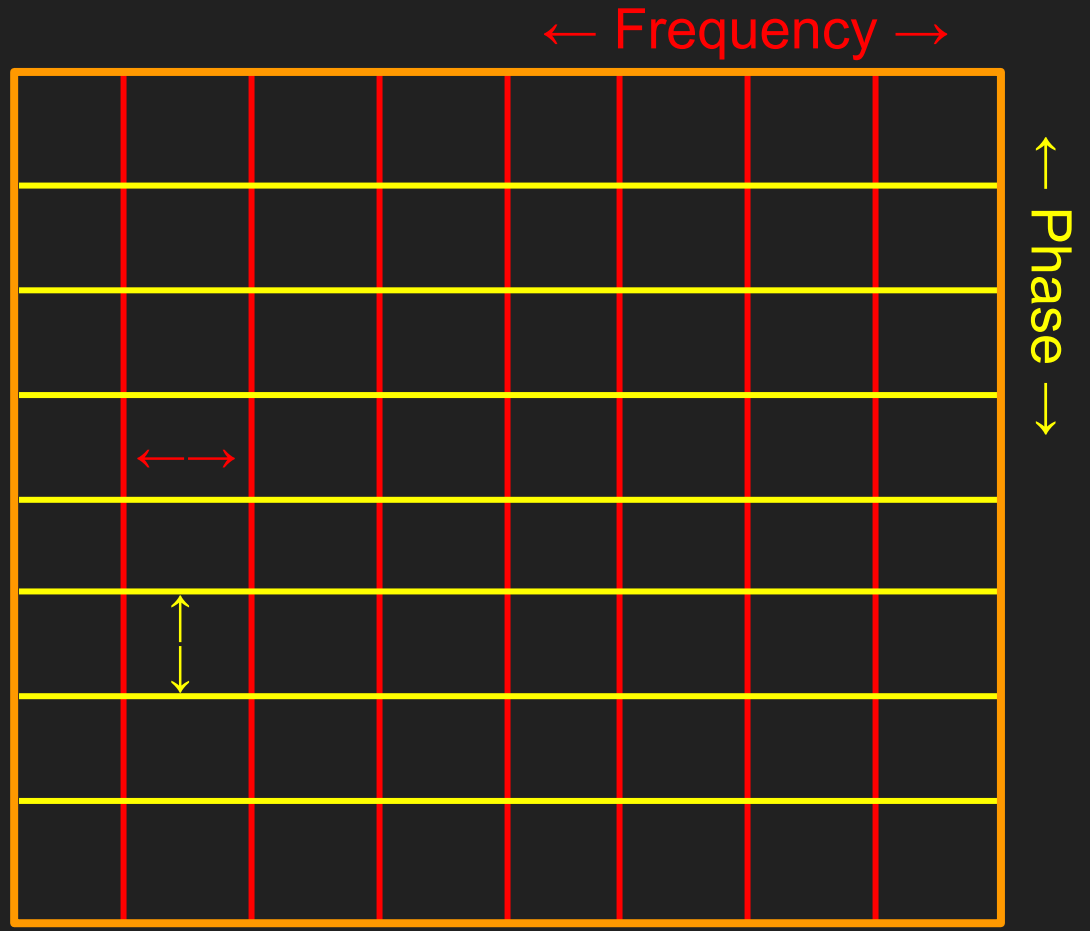
Pixel, Voxel, Slice Thickness, and more

User Controlled Parameters

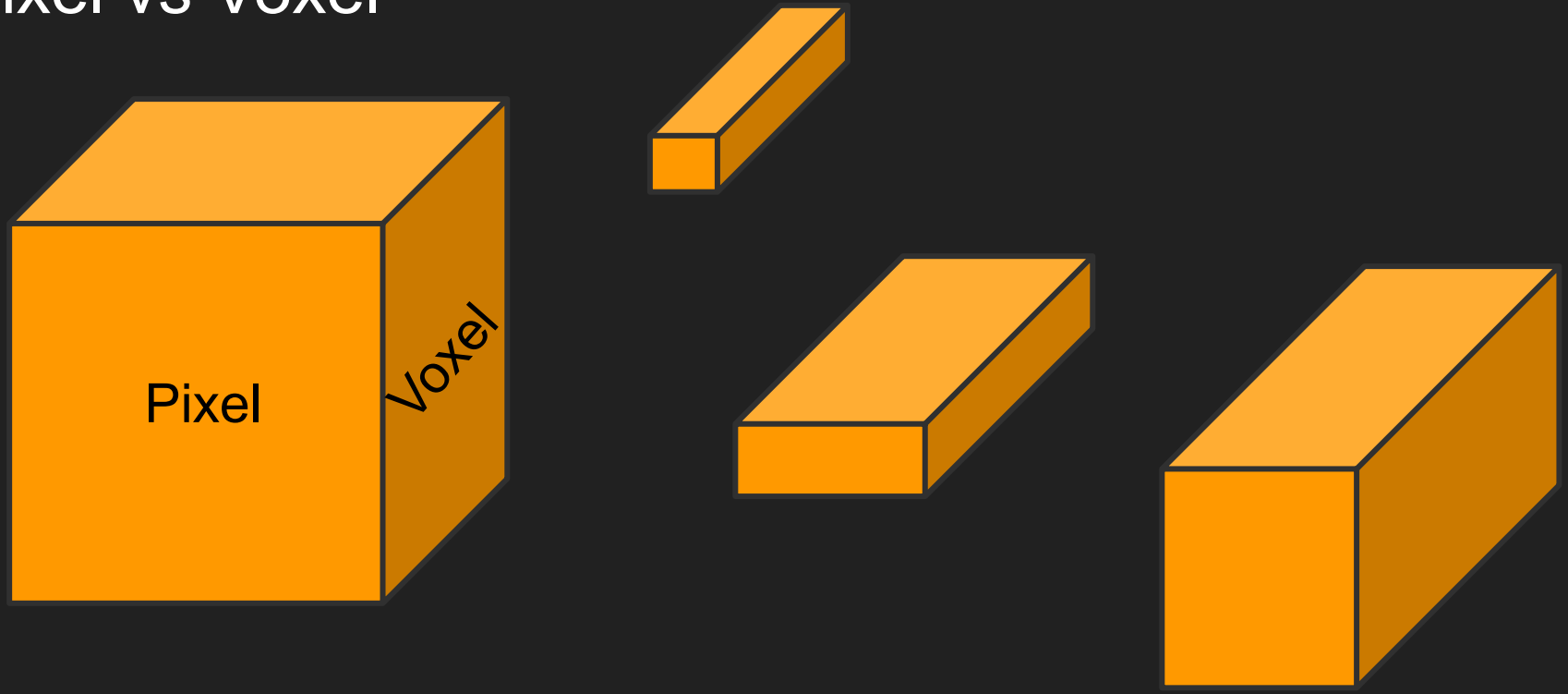
Field of View

Pix size in FE
(Matrix)

Pix size in PE
(Matrix)



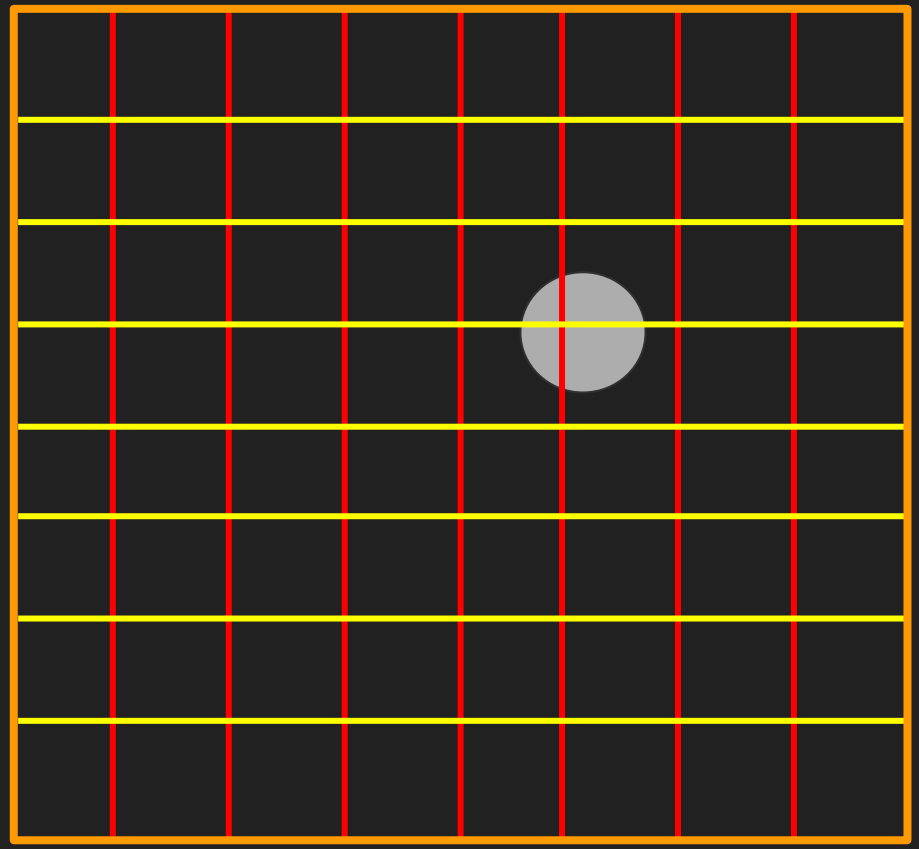
Pixel vs Voxel



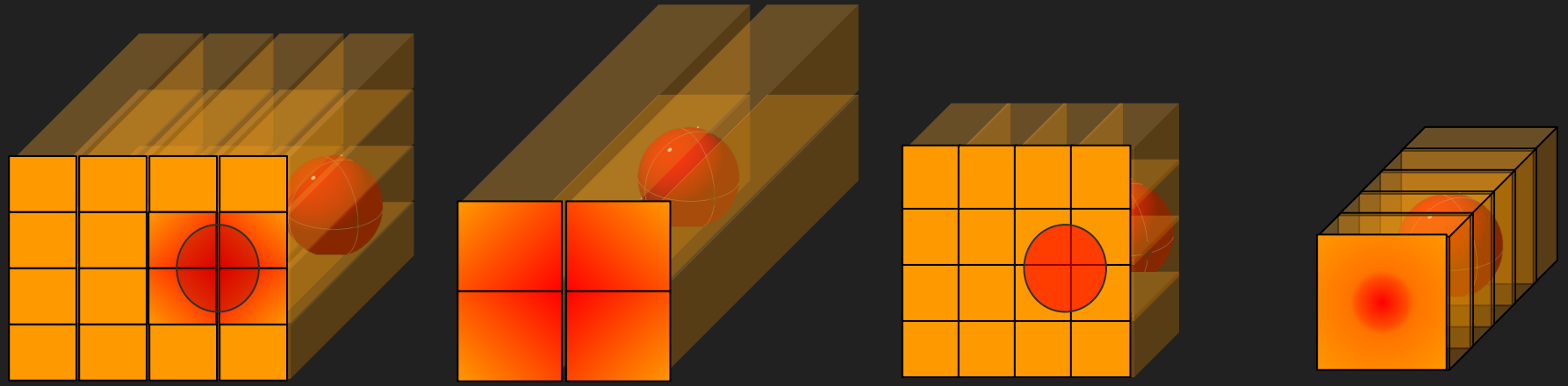
FOV and Resolution

Grab a corner and increase the size of the square!

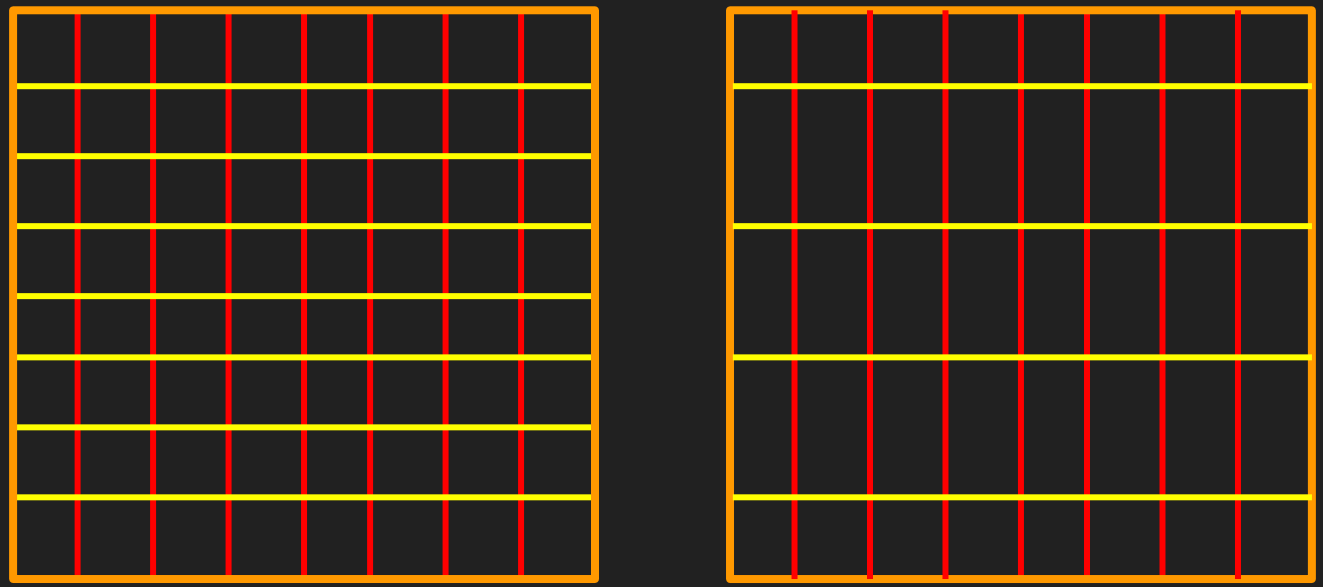
- What happens to pixel size as you increase FOV?
- What does this mean for resolution?
- Will the ‘lesion’ clearly visualized if we increase FOV?



In-Plane vs Through-Plane Resolution



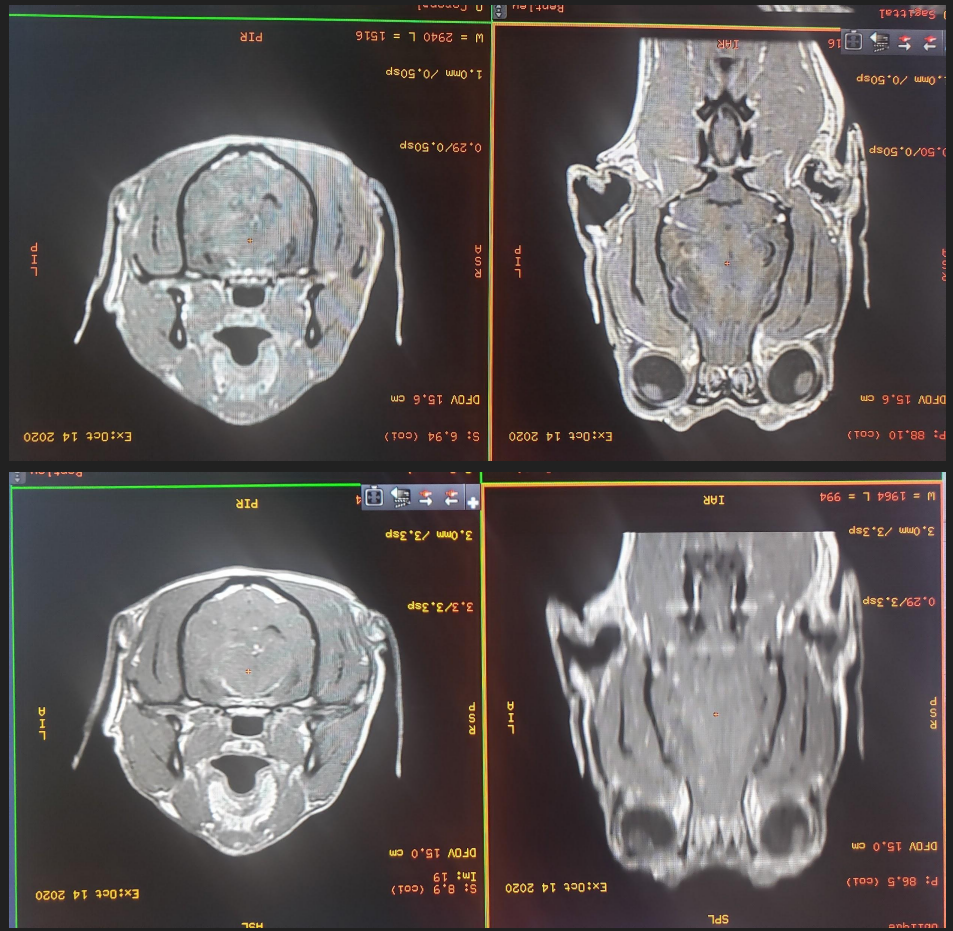
Asymmetric vs Square Pixels



Pix size in FE (Matrix)

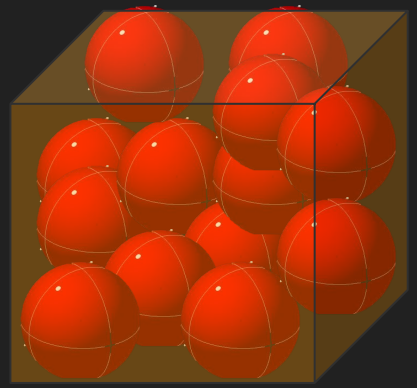
Pix size in PE (Matrix)

Isotropic vs Anisotropic Voxels

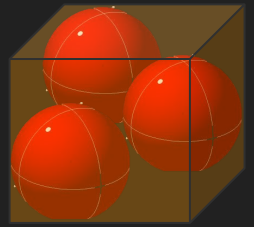


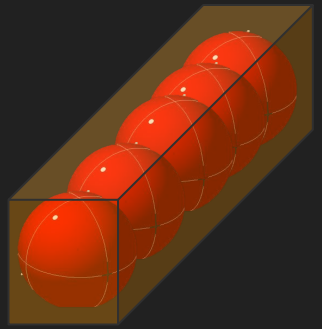
Voxel Size and SNR

- Larger voxel = More SNR
- Larger voxel = Less resolution



- Thin slices = Low SNR, high res
- Thick slices = high SNR , Volume averaging

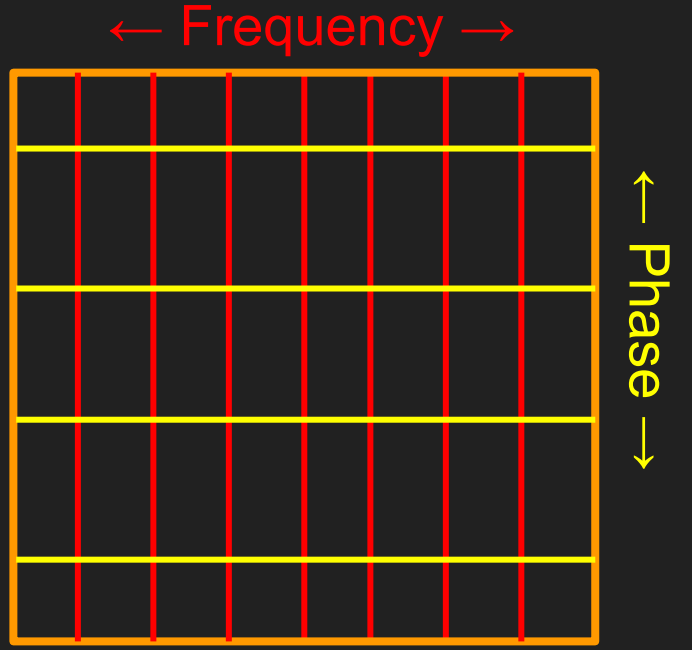




- Very asymmetric pixel = blurring

Phase and Frequency Encoding

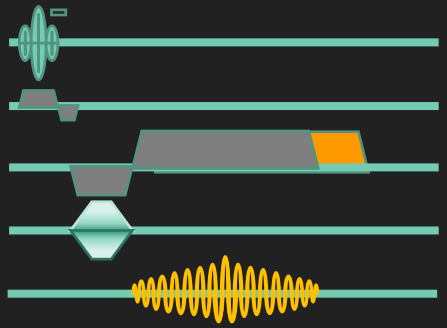
- Spatial localization of pixels in a given direction, x/y on your image
- You set a ‘matrix’; how many times you divide up your FOV
- Pixel size calculation
  - FOV (mm) / FE matrix =
  - FOV (mm) / PE matrix =
  - 160mm / 320 = .5mm
  - 160mm / 160 = 1mm
- Low matrix = less resolution = more SNR



Adjusting Phase and Frequency Encoding

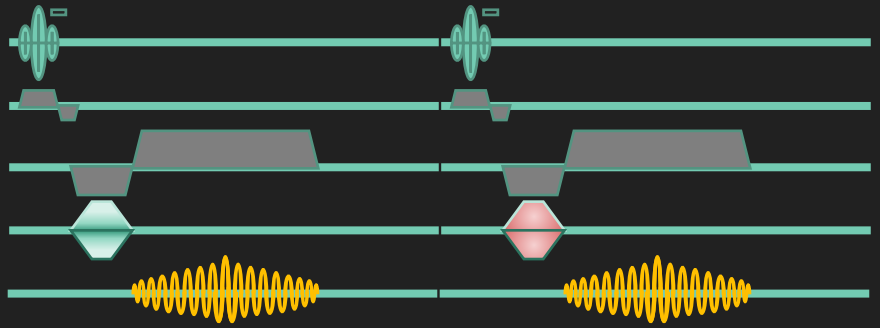
Increase Frequency Encoding:

1. Minimal time penalty
2. Inc max TE
3. Increase ESP
4. Reduce SNR
5. Fewer slices

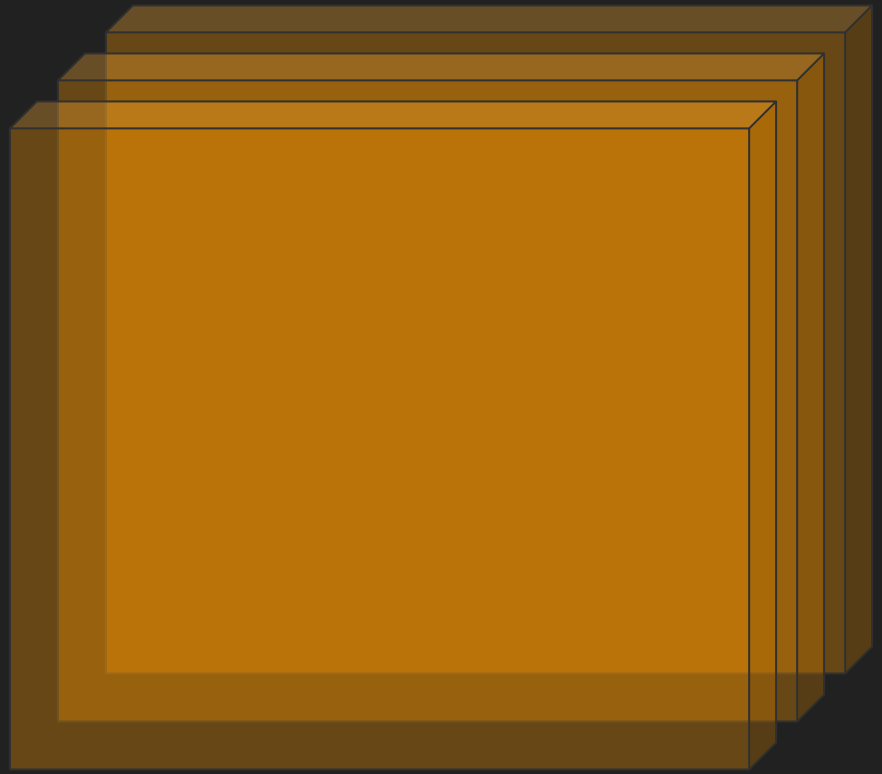


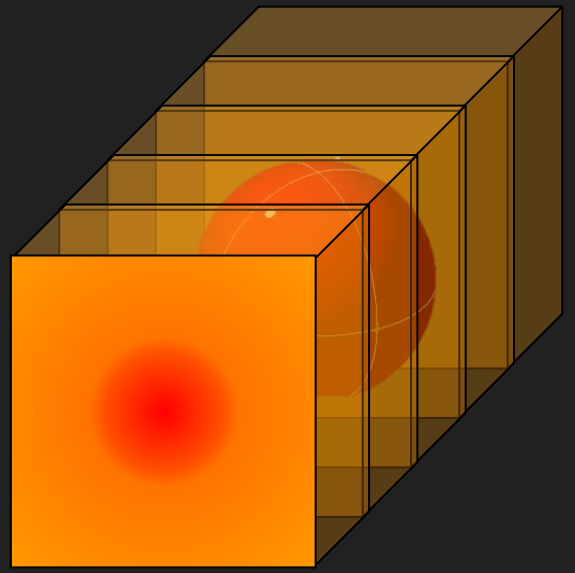
Increase Phase Encoding:

1. Large time penalty
2. Reduce motion
3. Reduce SNR
4. Greater penalty with lots of slices

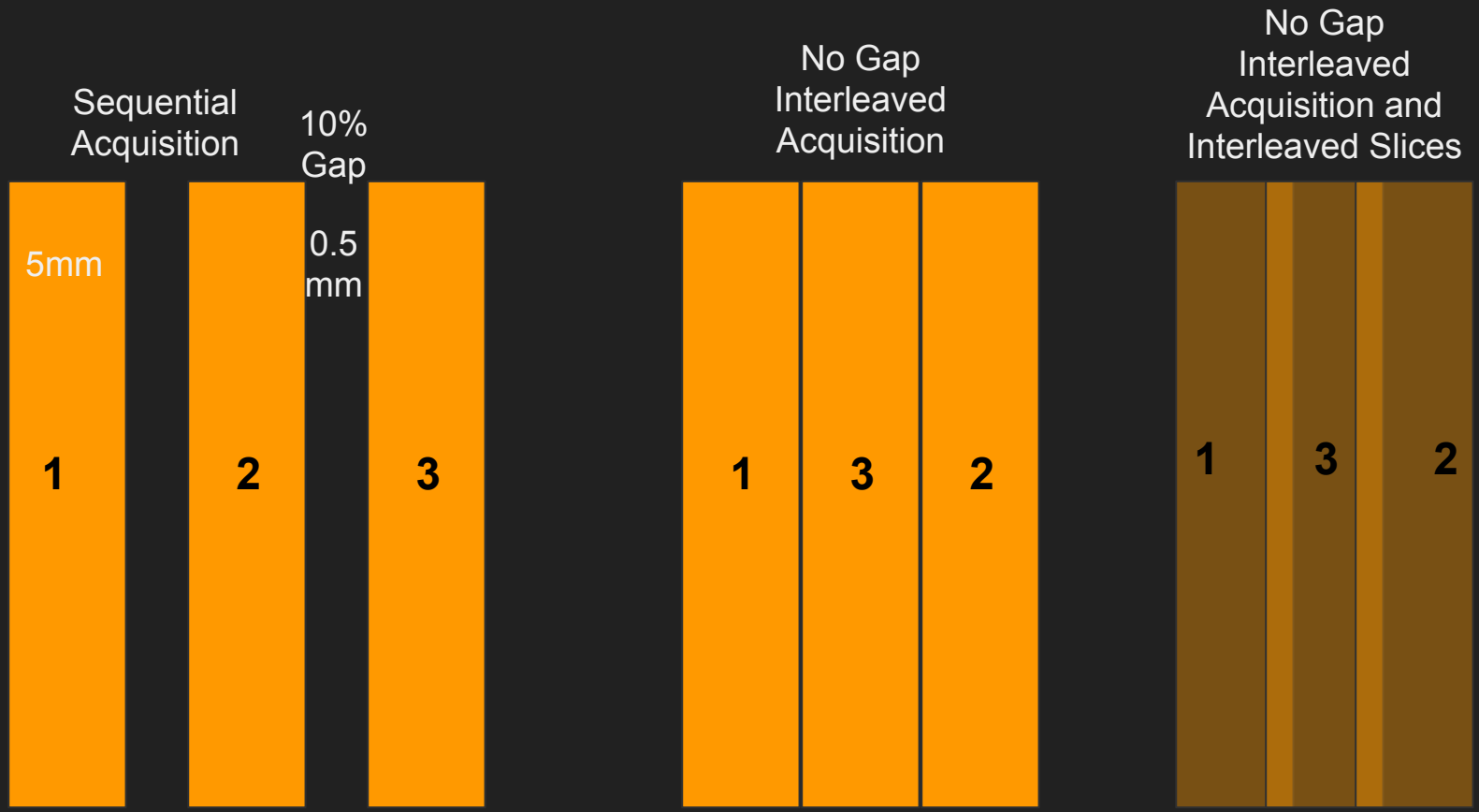


2D vs 3D





2D Imaging


Sequential Acquisition
10% Gap
5mm
0.5 mm
1
2
3
No Gap Interleaved Acquisition
1
3
2
No Gap Interleaved Acquisition and Interleaved Slices
1
3
2

3D Imaging

- No gap
- Ok for THIN slices
- Can reformat if isotropic
- Wrap in two directions: phase and slice directions
- GRE or specialized FSE
- Can have interpolation in-plane and through plane
- Typically single slab
- Very short TR’s with GRE (<10ms)
- Addnl time for each slice
- More slices = More SNR!

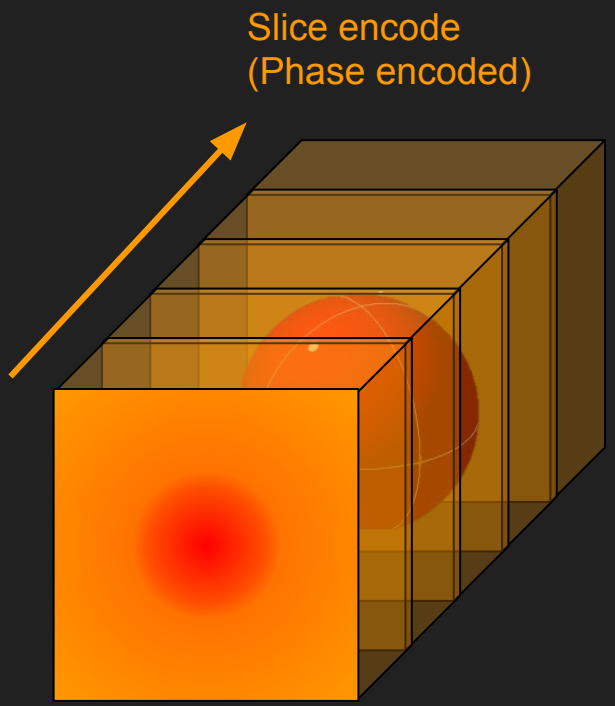
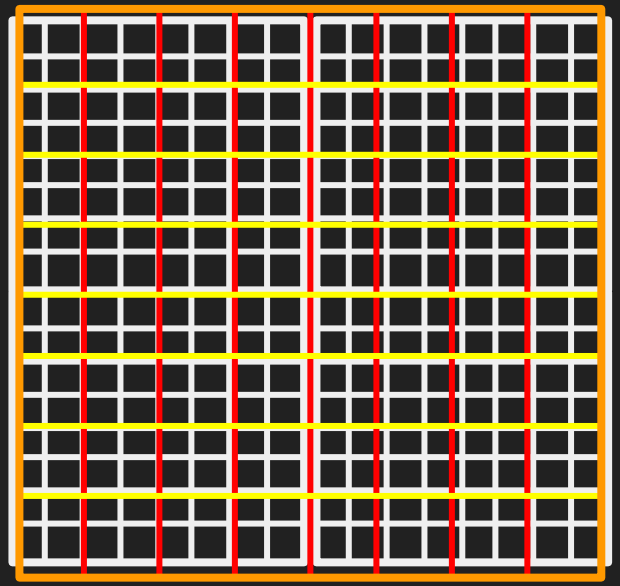
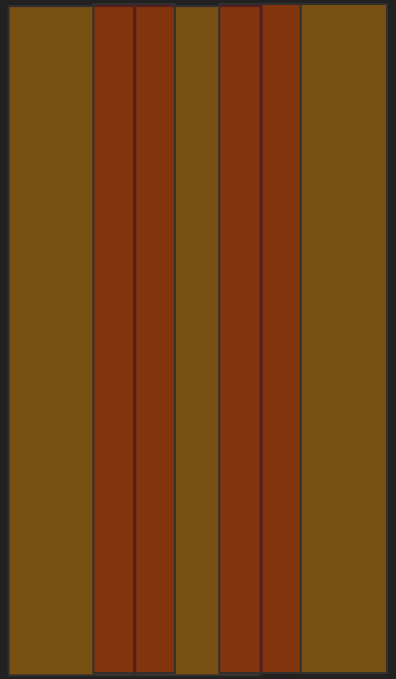


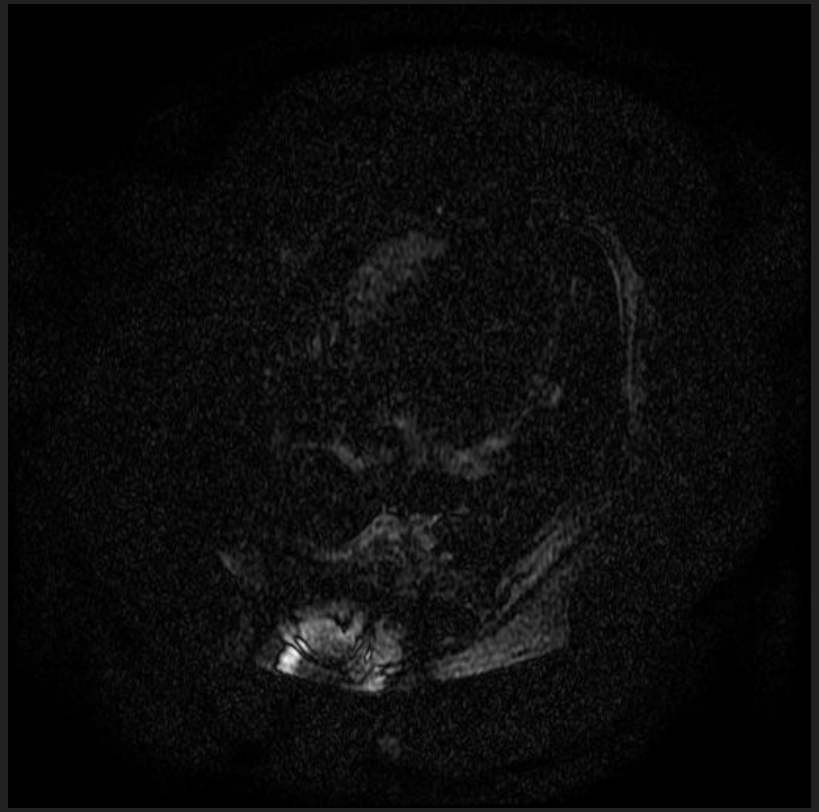
Image Reconstruction: Zipx512 and Zipx2

- Artificially increase resolution
  - In-plane Zipx512
  - Through plane Zipx2
- Zipx2 only on 3D
- Not ‘REAL’ data
- Generally* harmless addition
- Can make some motion or gibbs artifacts worse

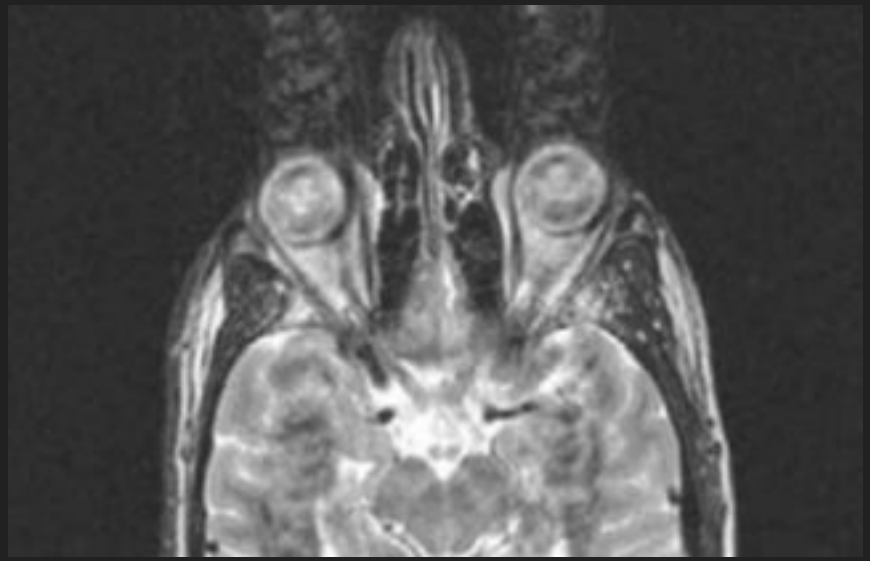


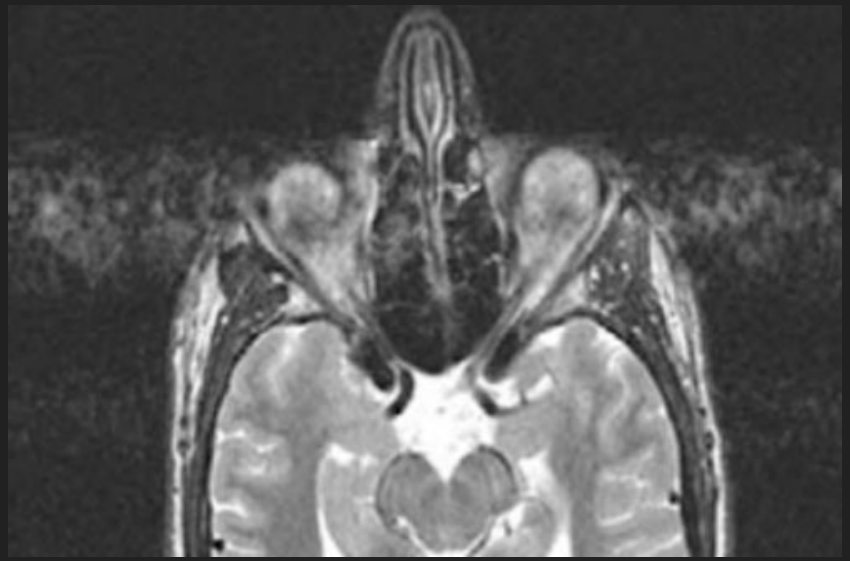


Examples of Interpolation



PE Direction is Important!

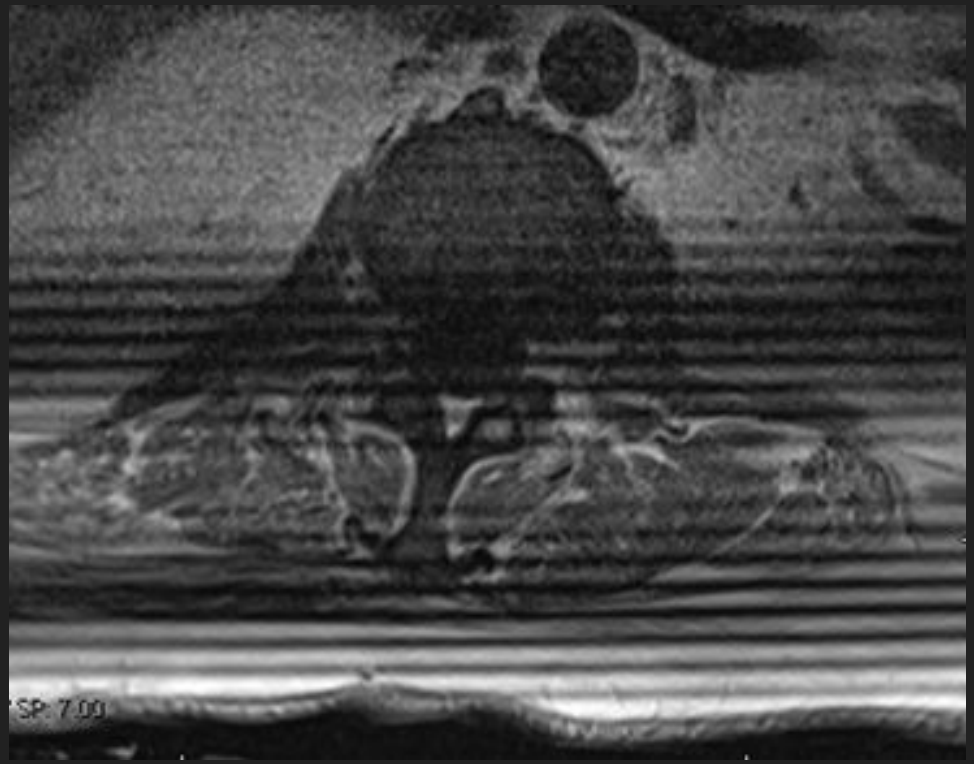




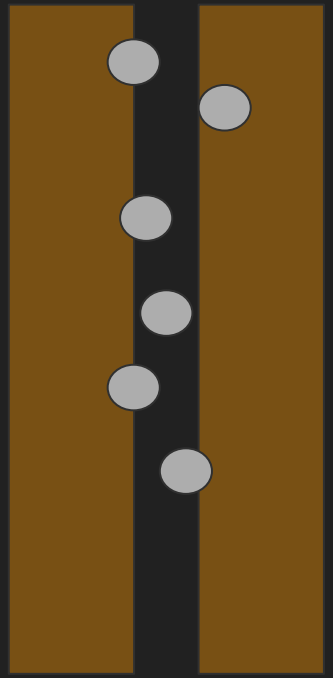
Gibbs Truncation

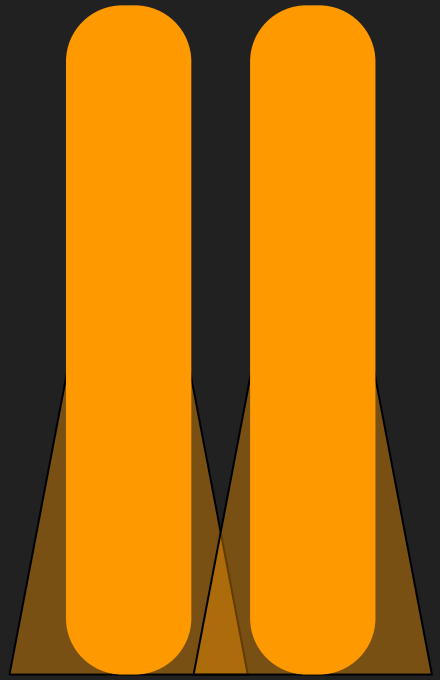
Volume Averaging

Slice Overlap

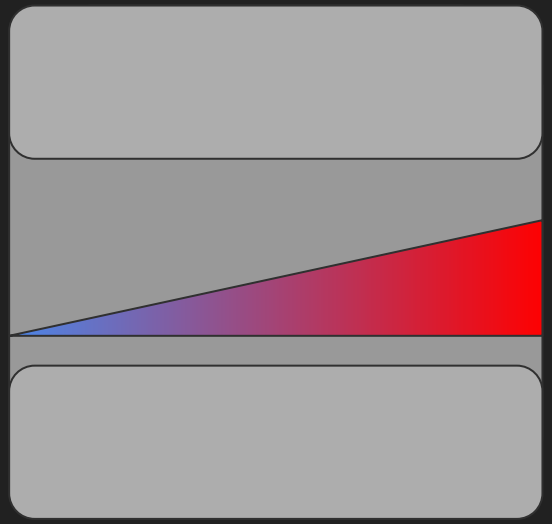


Cross Talk vs Cross Excitation



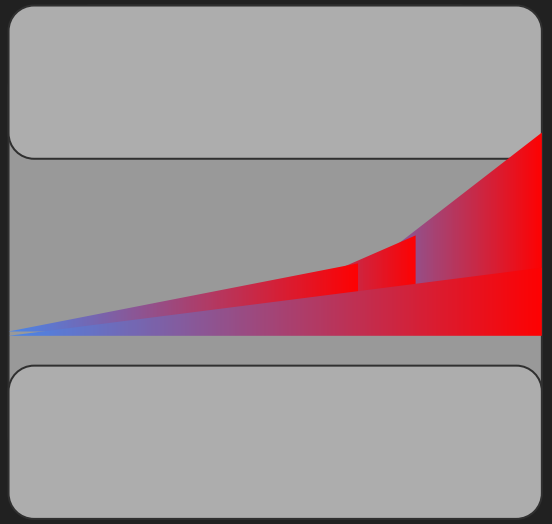


Gradient Linearity



Linear Gradient

- Equal increments of change in larmor freq
- No distortion
- Good fatsat
- Small FOV's

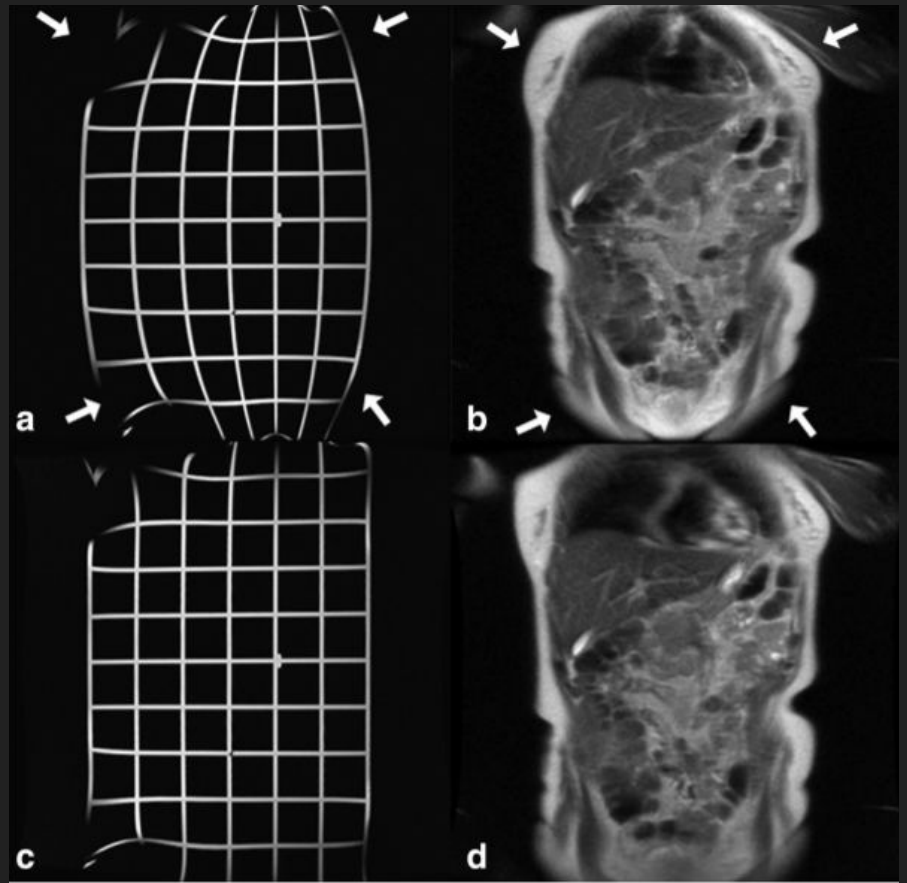


Nonlinear Gradient

- Uneven increments of change in larmor freq
- Image smearing or distortion
- Large FOV's
- Off center exams
- Bad Fatsat

Courtesy of Allen D. Elster, MRIquestions.com

Geometric Distortion and Gradient Non-Linearity



What is the ideal pixel size? Slice thickness?

- Depends on the body part
- Depends on your coil
- What size of pathology do you expect?
- What sequences do you have to use to visualize your expected pathology?
- 2D or 3D?

GENERAL GUIDELINES

Neuro (Brain/Spine): 3-5mm 10% gap, .5-.8mm in plane resolution

MSK: 2-3mm no gap, .5-.8mm in plane resolution

Body: 5-7mm, 10% gap, 1-2mm in plane resolution

Review Q's

1. Which will have more SNR?
    1.1. A: FOV 250x250 PE 256 FE 320 5mm thick B: FOV 300 PE 256 FE 256 5mm thick
    1.2. A: FOV 120 PE 256 FE 256 3mm thick B: FOV 120 PE 224 FE 224 2mm thick
2. What is the difference between isotropic and anisotropic?
3. What is the purpose of the slice gap in 2D imaging?
4. What is the advantage of a rectangular pixel? Disadvantage?
5. What are some advantages /disadvantages 3D sequences might have over 2D?
6. Describe interpolation
7. What the size of the pixel: FOV 160mm PE 320 FE 320
8. Describe how a single slice is selected and excited
9. What will happen to your SNR and resolution if:
    9.1. FOV is increased
    9.2. PE is decreased
    9.3. FE and PE are increased
    9.4. Slice thickness is halved
10. Bonus: how do you make an isotropic voxel? Give FOV, PE, FE and slice thickness
11. Bonus bonus: It's possible to have a 50% overlap with some 2D imaging...how??