

# **Controlling the MRI Image Quality**

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# Formation of MRI

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- **Source of MR signals, RF excitation, signal detection**
- **Spatial encoding, image reconstruction**
- **Image contrast (PD, T1, & T2)**
- **How to get a good and clear image ?**

# What Is a Good Image ?

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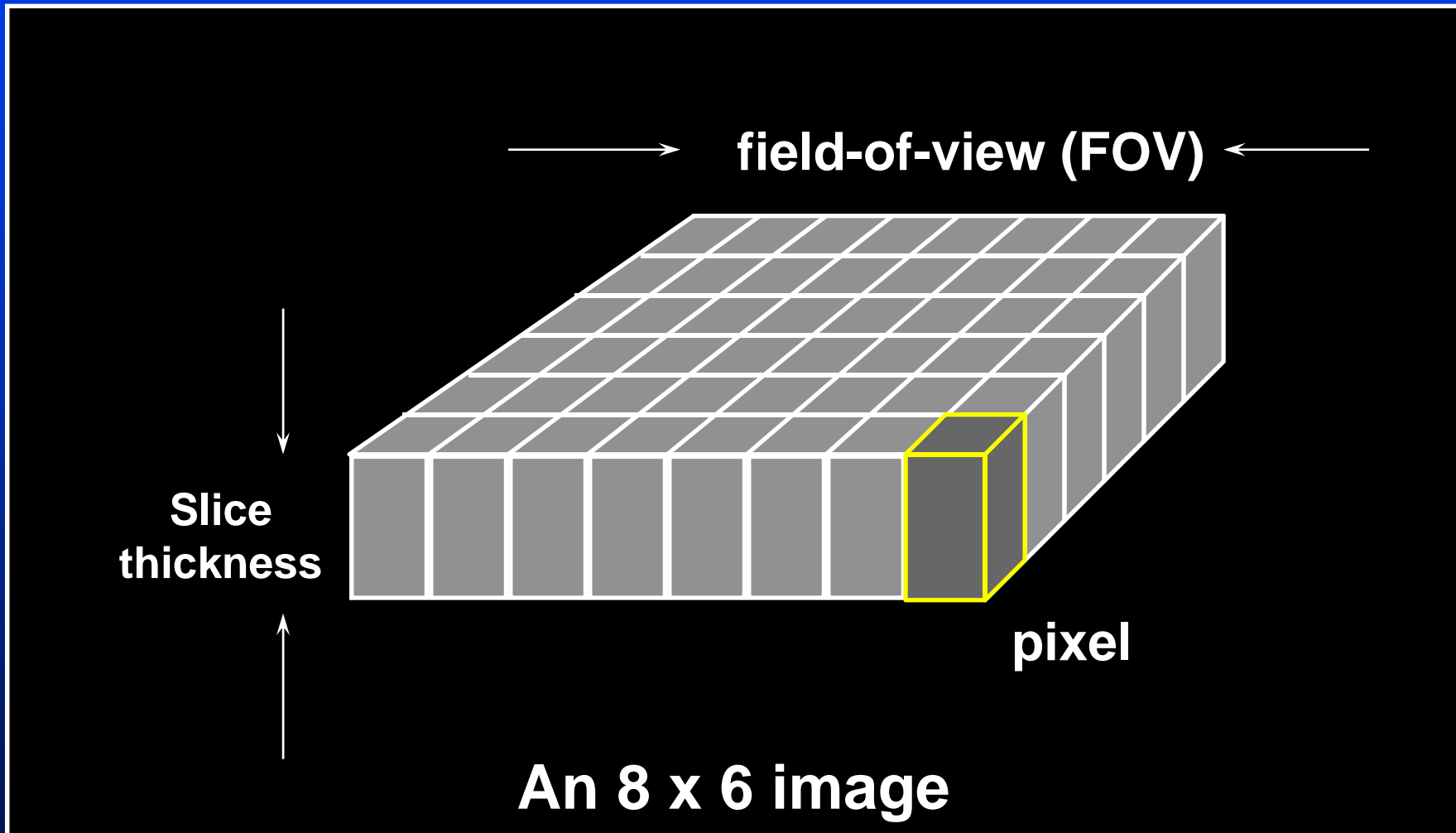
- **Fine details -- high resolution**
- **Low noise -- high SNR**
- **Lesion depiction -- high contrast**
- **Unfortunately often mutually conflict !**

# What Is a Good Image ?

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- **Fine details -- high resolution**
- **Low noise -- high SNR**
- **Lesion depiction -- high contrast**

# Image Matrix Size and the Pixel



# (Spatial) Resolution

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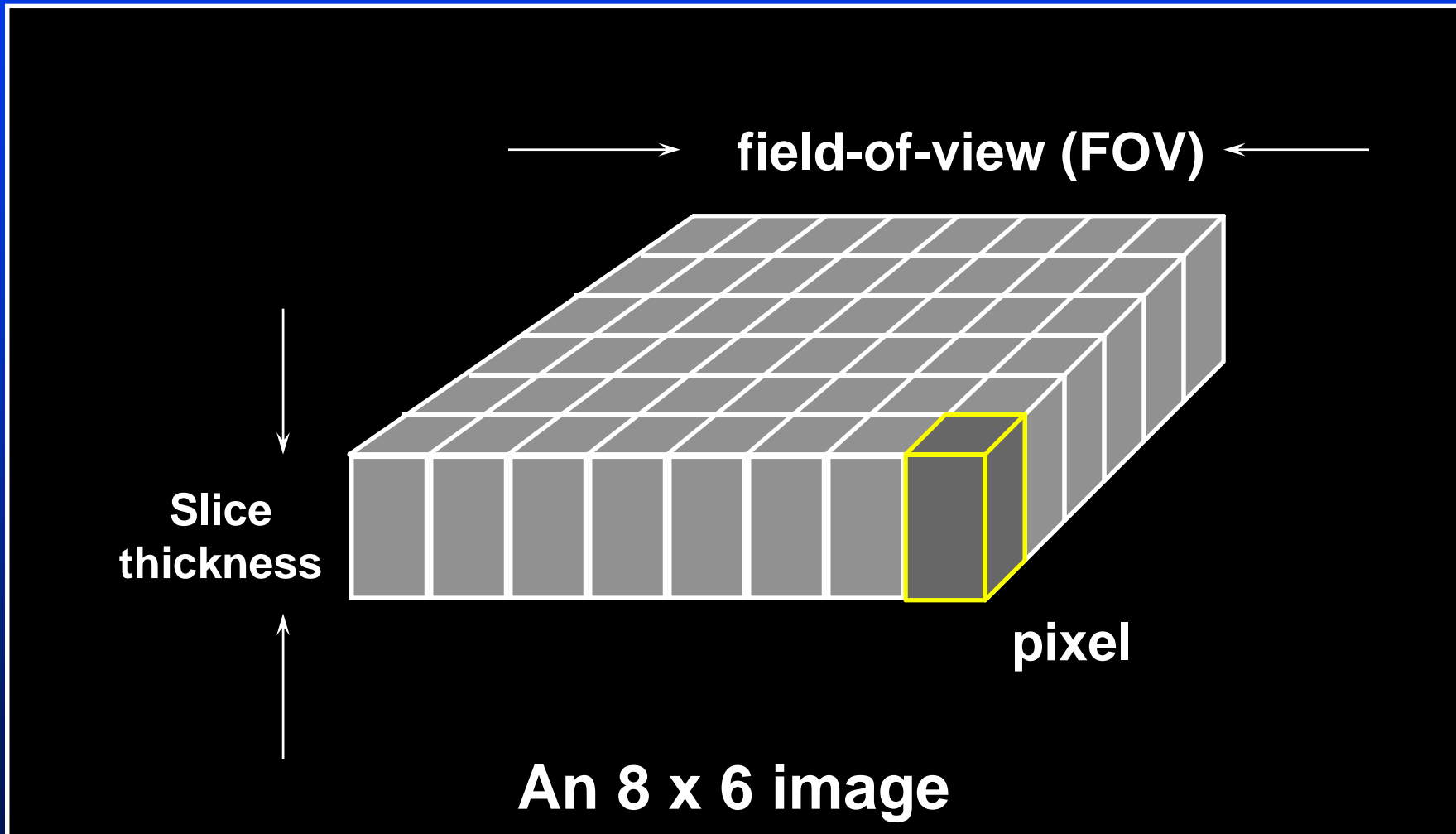
- **Smallest tissue that can be differentiated**
- **Image composed of lots of pixels**
- **Resolution is higher if the pixels are smaller or more in number**
  - **256 x 256 → 1024 x 1024 ?**

# Why Not 1024 Imaging ?

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- **FOV = 24 cm → differentiate tissue as small as 0.24 mm !**
- **Noise becomes strong (lowered SNR)**
- **Scan becomes long (TR \* 1024)**

# Image Matrix Size and the Pixel



# What Is a Good Image ?

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- **Fine details -- high resolution**
- **Low noise -- high SNR**
- **Lesion depiction -- high contrast**
- **Be practical -- short scan time**

# What Is a Good Image ?

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# What Is SNR ?

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- **Relative strength of the signal**
- **Signal-to-Noise Ratio**
- **Signal intensity divided by noise intensity**
- **The larger the better**

# SNR Determining Factors

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- **Number of protons (voxel volume)**
- **TR and TE (T1 and T2)**
- **Number of sampling points**

# SNR Determining Factors

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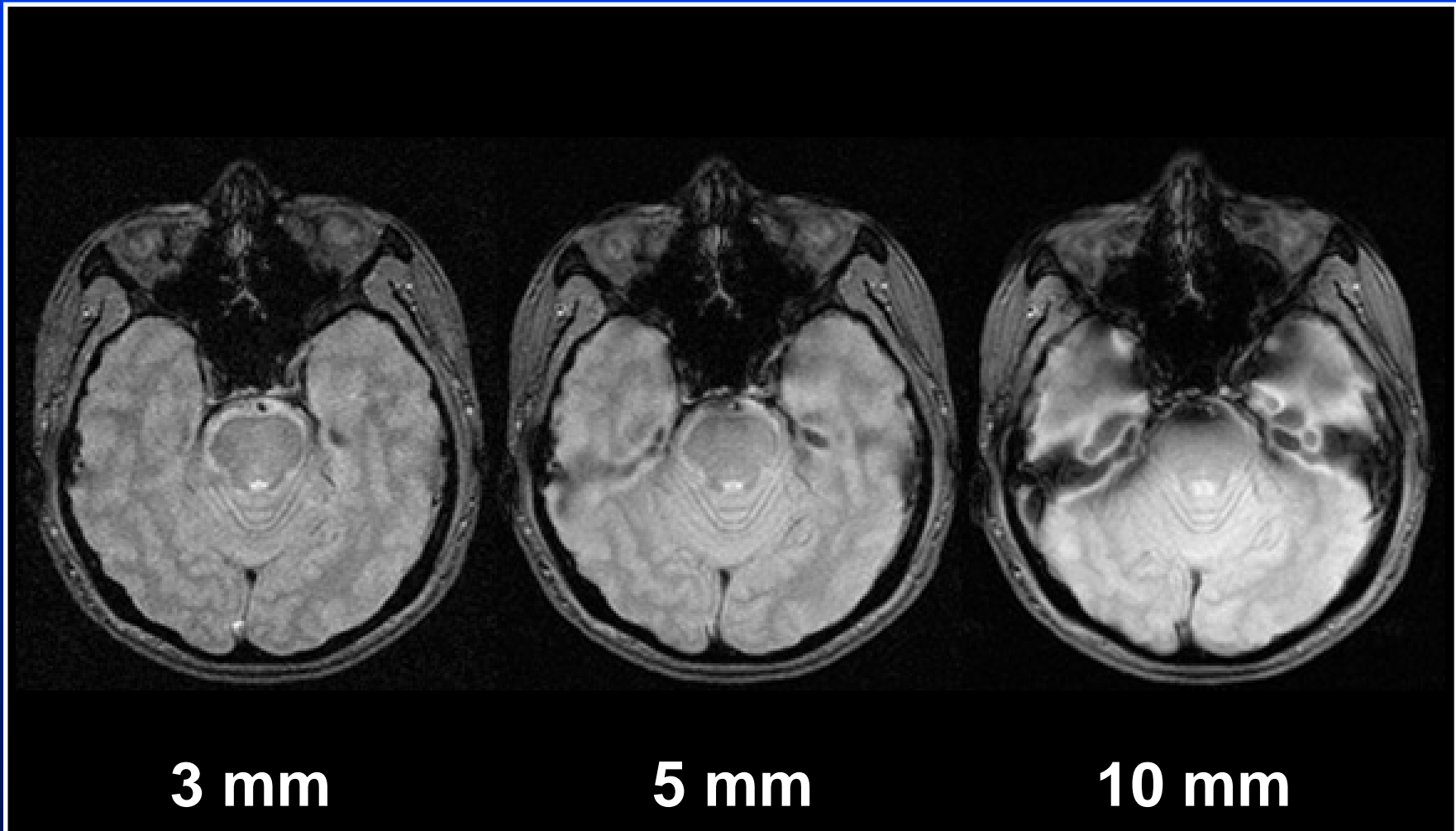
- **Number of signal averages (NEX)**
- **Usage of RF coil**
- **Sampling frequency (i.e., readout bandwidth)**

# # of Protons (Volume)

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- **As slice thickness gets larger :**
  - **Voxel volume is larger, hence containing more protons**
  - **SNR becomes higher**
  - **Lowered resolution !**

# Effects of Slice Thickness



# TR & TE (T1 & T2)

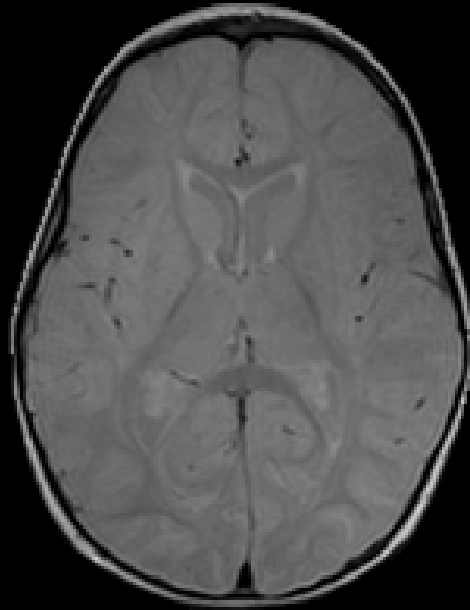
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- **Longer TR → T1 recovery → higher SNR**
  - **Reduced T1 weighting; Longer scan**
- **Shorter TE → T2 decaying → higher SNR**
  - **Reduced T2 weighting**

# Effects of TR on T1 Contrast



**TR = 600**

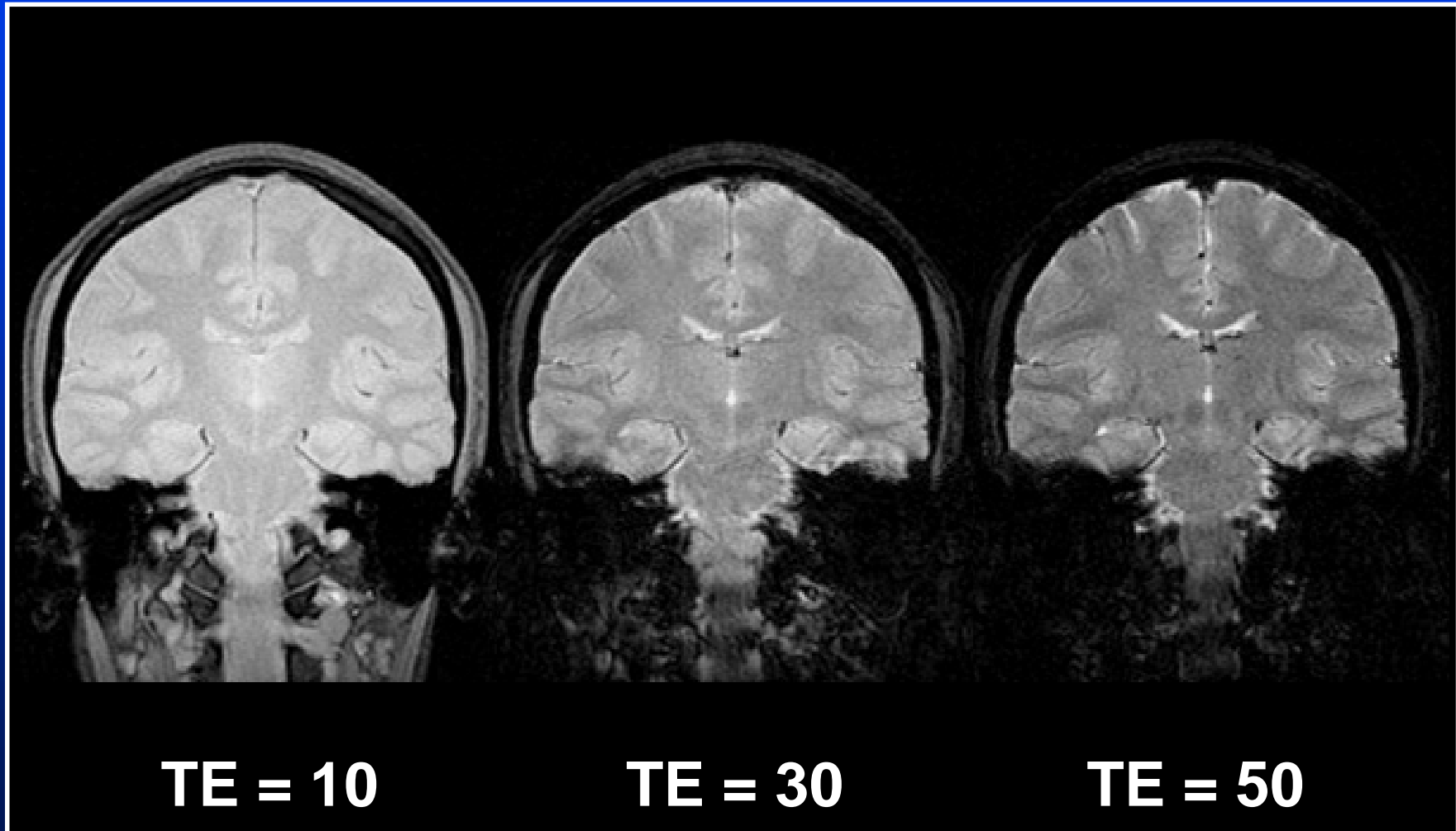


**TR = 2400**



**TR = 4200**

# Effects of TE on SNR & T2\* Contrast



# What Is a Good Image ?

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- Fine details -- high resolution
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- Be practical -- short scan time

# Image Matrix Size

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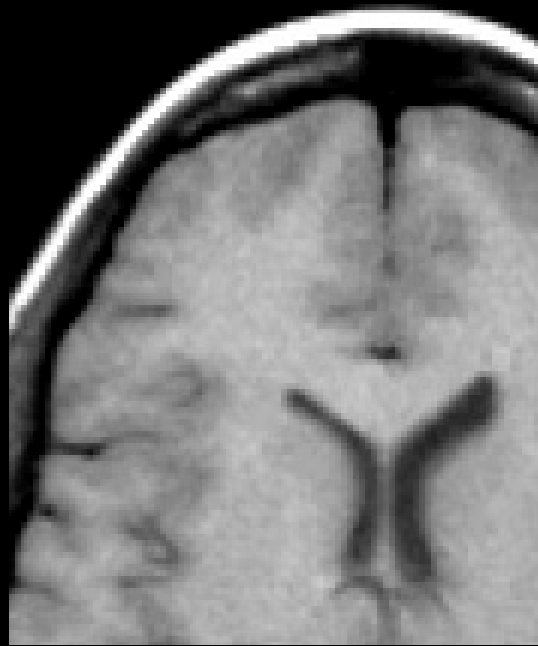
- **The more you sample, the higher SNR**
  - **Also higher resolution if at fixed FOV**
  - **Lowered voxel volume also reduces image SNR !**
- **Needs thorough quanticonsideration**

# Example : FOV = 24 cm

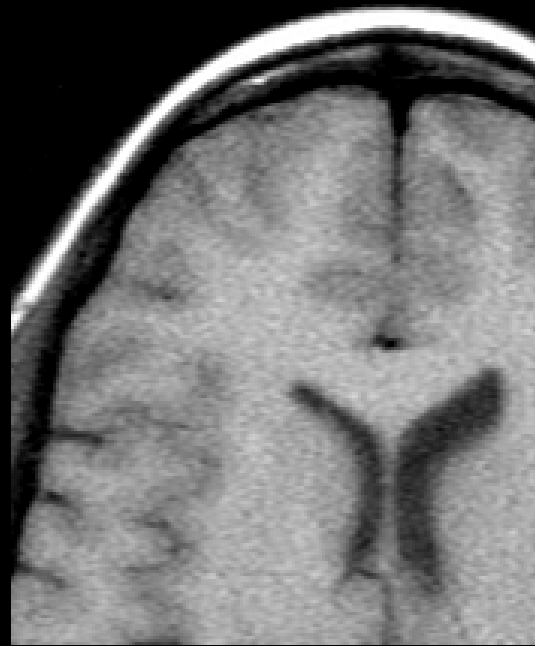
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- **256 x 128 → 256 x 256**
  - **2x sampling points → 40% SNR gain**
  - **Voxel volume reduced to half → 50% SNR loss**
- **Overall SNR reduced to 70% !**

# Effects of Image Matrix Size



**256x256**



**512x256**



**512x512**

# # of Signal Averages

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- **Doing it more times if unsatisfied**
- **More averages give higher SNR**
  - **Square root proportional**
- **Scan time increases proportionately**
- **Completely in vain if patient moves**

# Usage of RF Coil

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- **Smallest coil that can cover the tissue (wire as close to human body as possible)**
- **~ 80% volume filling factor**

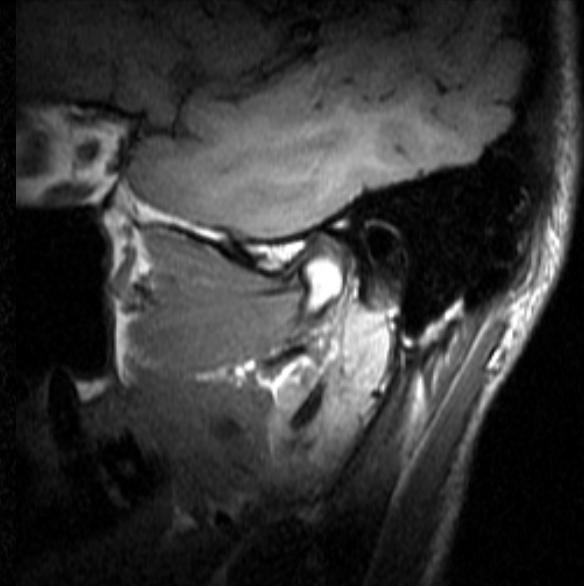
# Effects of Coils on SNR



**Body coil**



**Head coil**



**3-inch surface**

# Sampling Frequency

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- Higher readout bandwidth allows receiving of more noise
- ... in addition to other subtle effects
  - Minimum TE, chemical shift artifacts ...
- Seldom changed by clinical technologists

# In Summary ...

**SNR proportional to :**

**number of protons**

**slice thickness**

**pixel width (2 directions)**

$\sqrt{\text{matrix size (2 directions)}}$

$\sqrt{\text{\# of signal averages}}$

$1 / \sqrt{\text{readout bandwidth}}$

**affected by T1, T2, TR, TE**

**affected by RF coil**

# What Is a Good Image ?

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# Lesion Contrast

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- **Understand the relaxation properties of different lesions**
- **Proper choice of TR and TE**
- **Create other contrast (flow, diffusion ...)**
- **Usage of contrast agents**

# Scan Time Consideration

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- **(TR) x (phase encoding) x (NEX)**
- **Patient comfort**
- **Efficient scanner usage**
- **Motion artifacts**

# Effects of Scan Time (already fast)

