

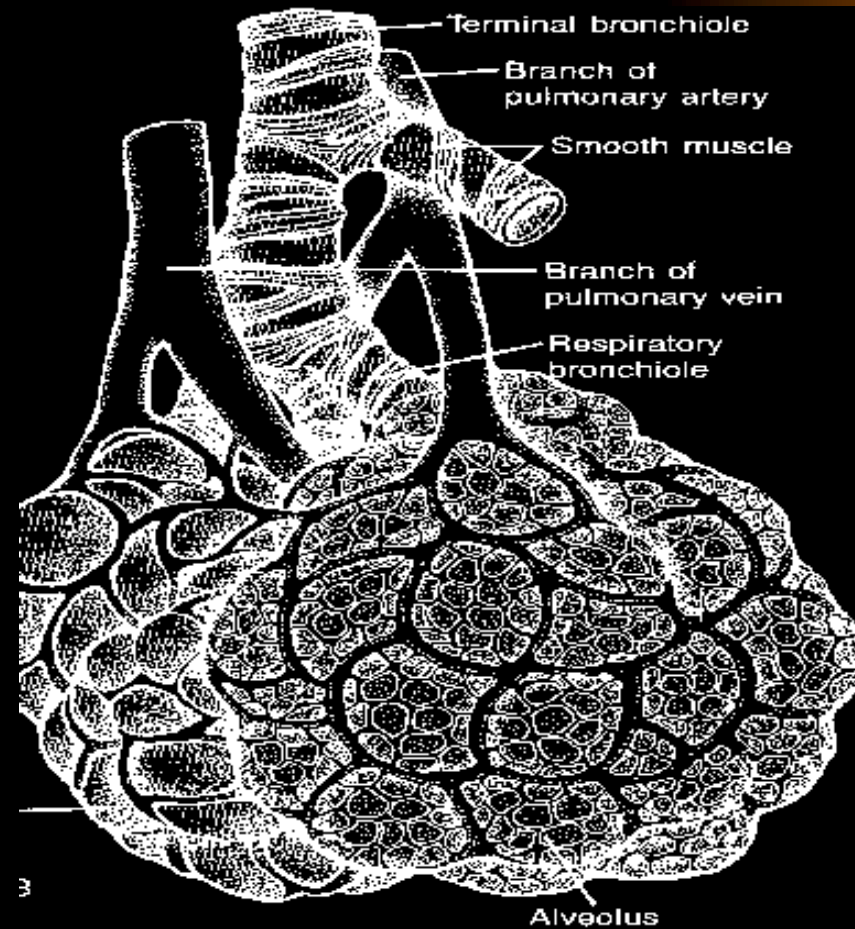


Lung Imaging

報 告 人：黃奕琿

指 導 教 授：鍾孝文

Structure of Lung



Problems of Lung Imaging in MRI



- Low water density (20~30%)
- Air in alveoli
- Respiratory motion
- Cardiac pulsation

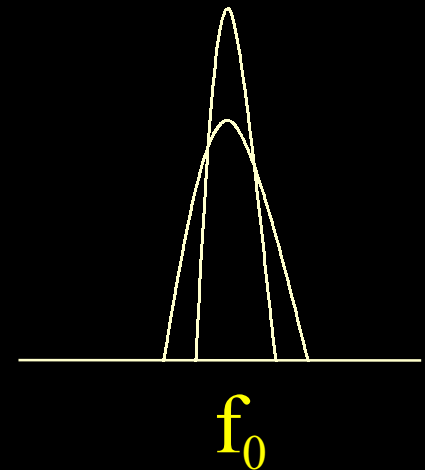
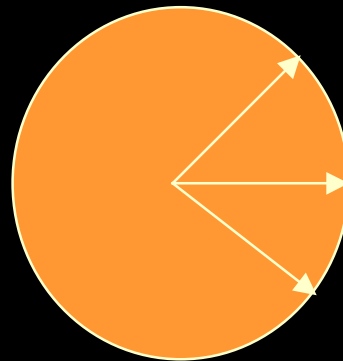
Lung Parenchyma: Magnetic Susceptibility in MRI(1)

- Intravoxel phase dispersion

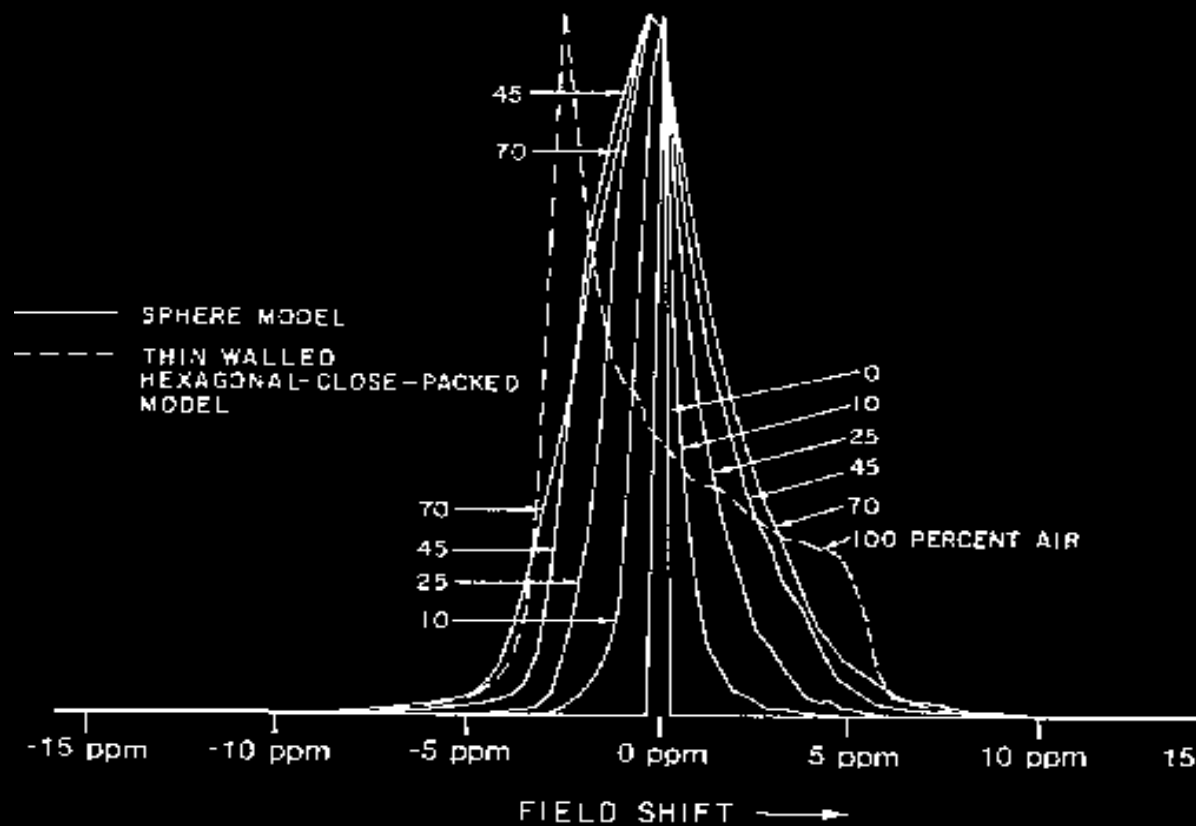
$$1/T2^* = 1/T2' + 1/T2$$

$T2'$: effective susceptibility dephasing
time

$$T2^* \approx 1 \sim 2 \text{ ms}$$



Lung Parenchyma: Magnetic Susceptibility in MRI(2)



Lung Parenchyma: Magnetic Susceptibility in MRI(3)

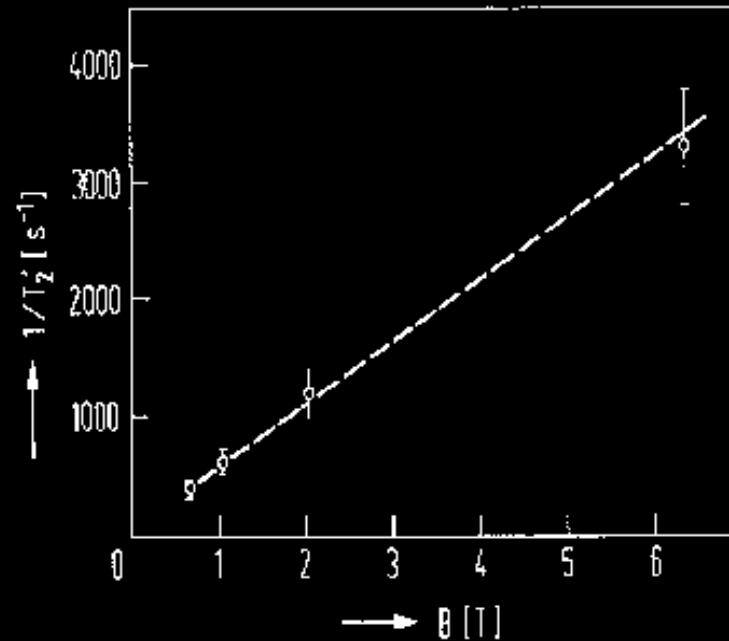
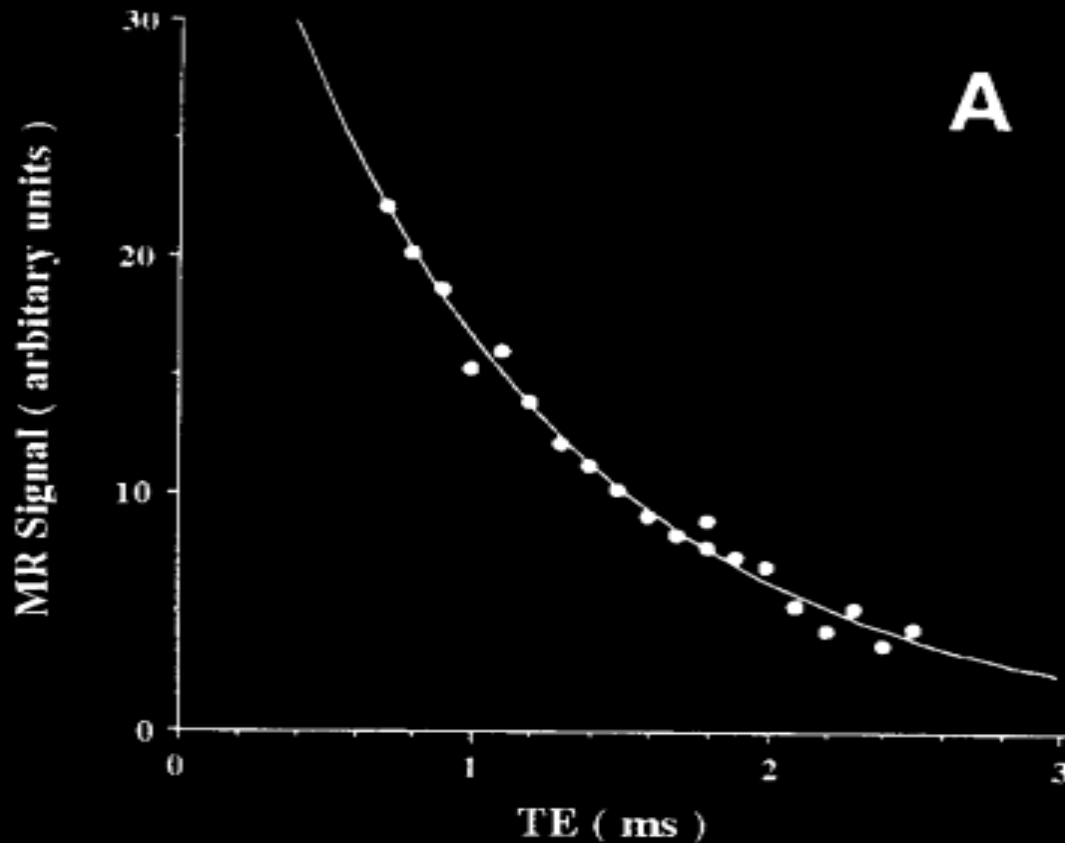


FIG. 1. Magnetic field dependence of the tissue-induced water proton free induction decay rate $(T_2')^{-1}$ lung tissue at room temperature.

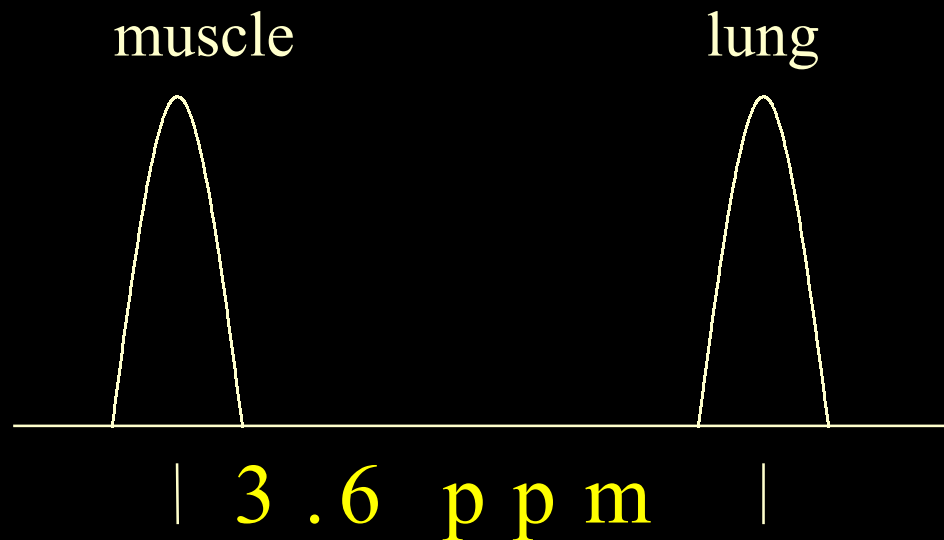
Lung Parenchyma: Magnetic Susceptibility in MRI(4)



Lung Parenchyma: Magnetic Susceptibility in MRI(5)

- Shift in the macroscopic resonant frequency

$$\omega = \gamma B, \quad B = \mu H, \quad \mu_{\text{water}} = 0.9999991 \mu_{\text{air}}$$



Problems in Conventional Technique

- Conventional spin-echo sequence
TE: 15~30ms
 - Conventional gradient echo sequence
TE: 5~10ms, lack of a refocusing pulse
-
- Lung parenchyma:
T2': 5~10ms, T2: 25~35ms

Lung Imaging Methods

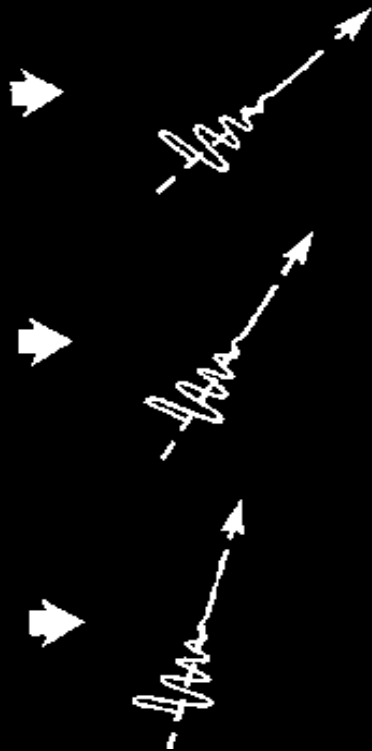
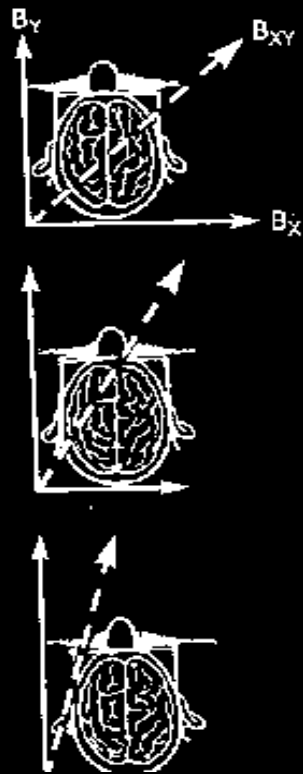


- Projection reconstruction method
(Bergin CJ et. al., 1991)
- Short TE spin-echo pulse sequence
(John R. Mayo et. al., 1992)
- Short TE gradient echo pulse sequence
(David C. Alsop et. al. 1995)

Projection reconstruction method(1)

- employs projection reconstruction acquisition gradients and a section-selective excitation pulse
- Echo time $\sim 50 \mu\text{s}$ (due to receiver dead time, Signa, GE)
- proton-density-weighted image

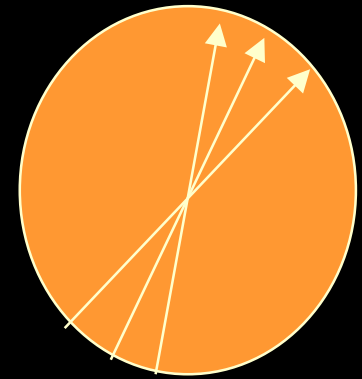
Projection reconstruction method(2)



Projection no. 1

Projection no. 2

Projection ...etc.



Projection reconstruction method(3)

- T2* decay during excitation
→reduce section sharpness (line boarding)
- T2* decay during the readout
→reduce image resolution
- images show a rotational blur that increase with distance from center

Projection reconstruction method(4)

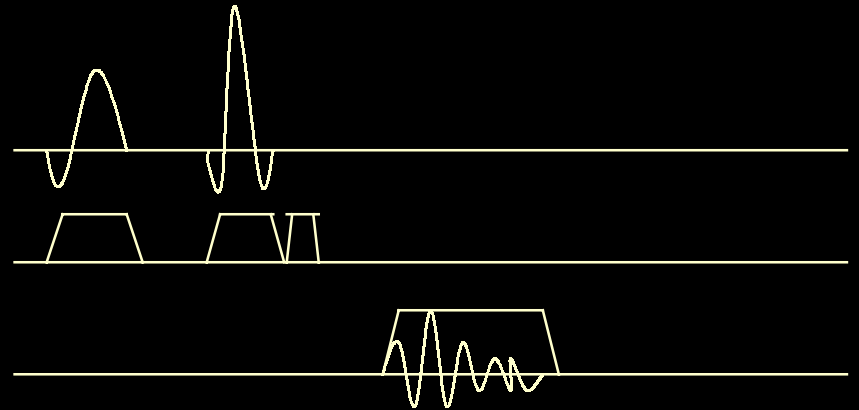
- With PR acquisition, off resonance structures produce *blurring* rather than *shift* → use very short readout ($\sim 1.5\text{ms}$) to minimize the effect
- Over sampling of the low frequencies in k space
→the same effect as multiple averaging,
reduce motion artifact

Projection reconstruction method(5)

- PR images motion causes diffuse, streak like artifact as in CT images
- With long TR, short TE
→proton density weighted image, limited soft tissue contrast
- image time about 2 min for non-gated images, 10~12 min for gated images

Short TE spin-echo pulse sequence (1)

- Slice selective 90° pulse (2.4ms) truncated at the first zero crossing after the peak
- Slice selective 180° pulse (1.6ms)
- TE=7ms
- RW: 6.36ms
- Cardiac-gated
- T1-weighted image



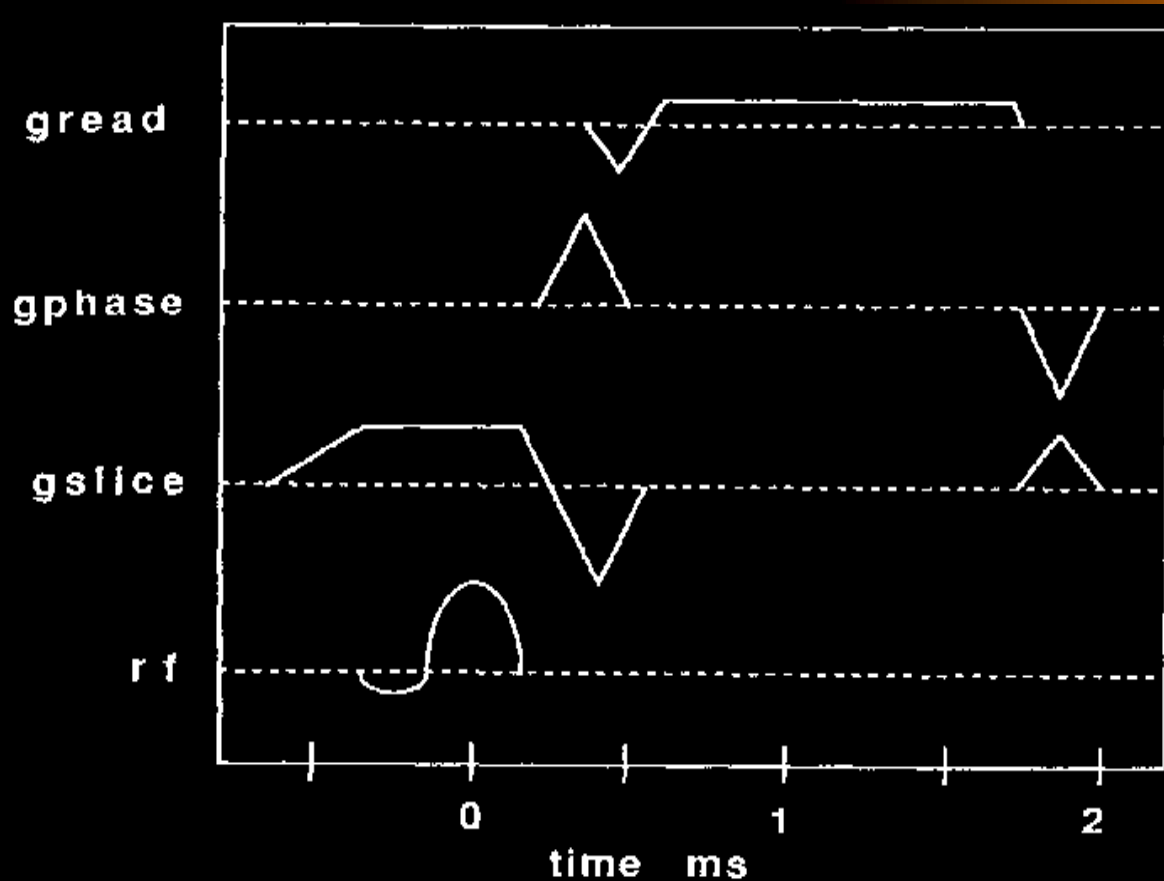
Short TE spin-echo pulse sequence (2)

- SNR is 3.5 times greater than that on images with 20-msec TE
- Respiratory artifact was equivalent
- Cardiac motion artifact was decreased
- Motion of the lung water molecules due to diffusion and perfusion causing dephasing
- decreased in vascular contrast

Submillisecond echo times pulse sequence (1)

- Equipment: GE SIGNA, 1.5T
- Max gradient: 23mT/m, 150 μ s switching time
- A 480- μ s-width truncated RF pulse is used
- Sampling rate= 125kHz
- TR= 100ms, TE= 0.71ms
- Imaging in a single 16-s breath-hold

Submillisecond echo times pulse sequence (2)



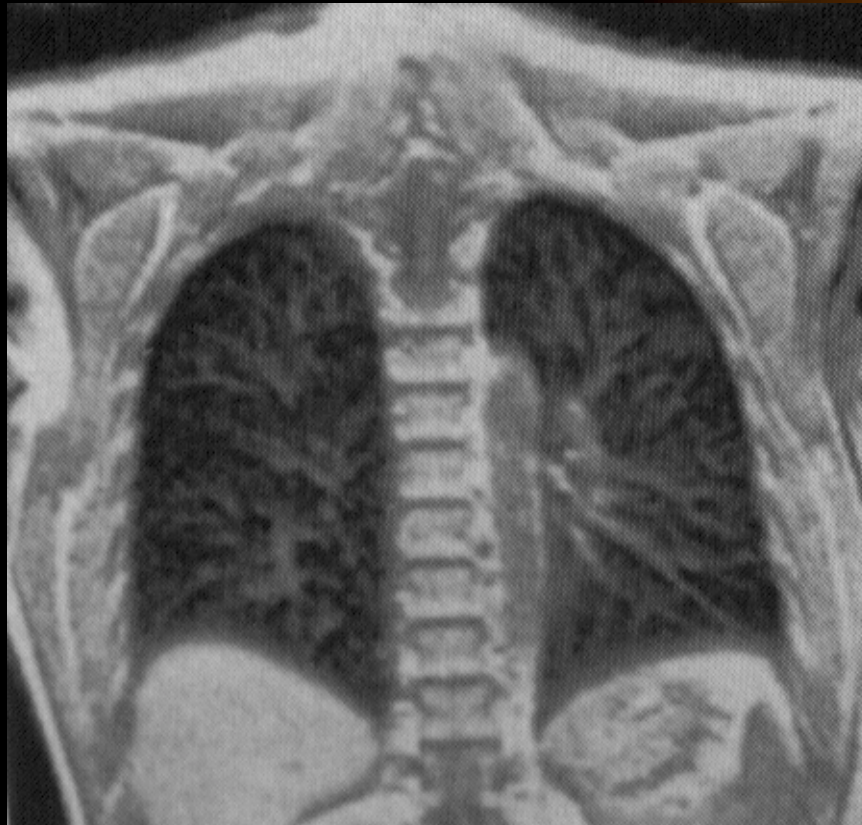
Submillisecond echo times pulse sequence (3)

- SNR=4.6
- phase offset at the echo time causes chemical shift artifact
- This sequence is limited by slice refocus gradient

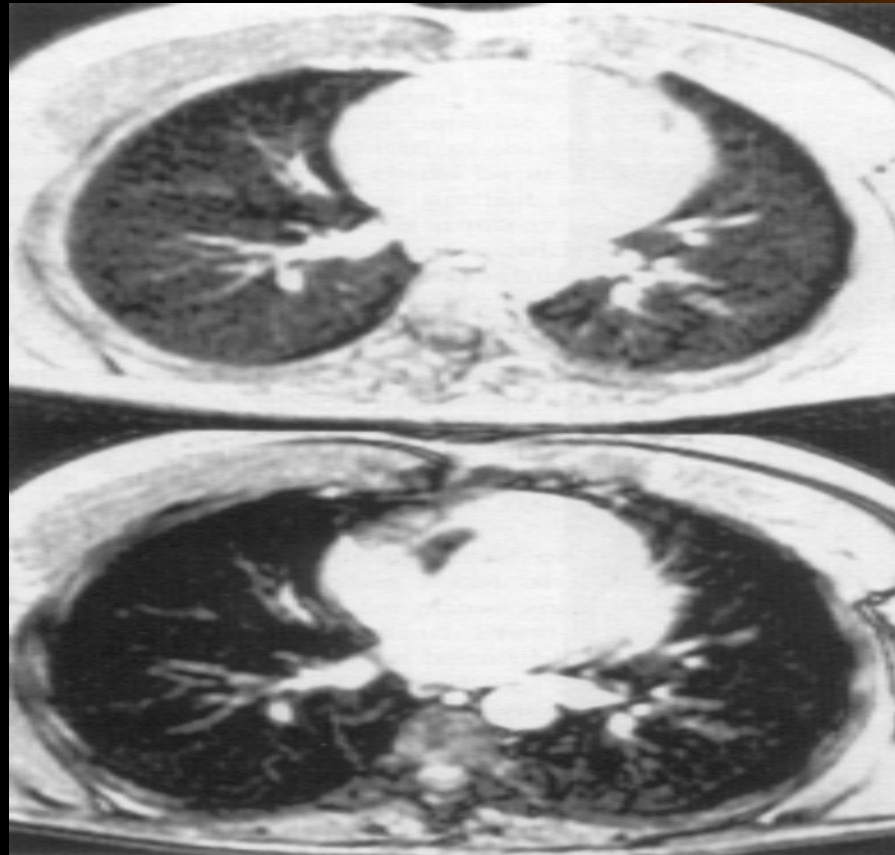
Summary

- Main problem of MRI lung imaging
 - Susceptibility
- Solutions
 - Shorten TE
 - Shorten readout time
 - Increase Field strength, $\text{SNR} \propto \sqrt{B_0}$
(when $\text{TE} < T_2'$)

Examples of lung image (1)



Examples of lung image (2)



Examples of lung image (3)

