New Day

Fast Fourier Transform:

- requires that the number of complex data values be an integer power of 2

N-complex data values covering k-space ⇒ N_x, N_y, N_z, all 2^p.

→ N_{REAL} and $N_{imaginary}$

$N = 2^p = 2n$

—

Nyquist Theorem:

(A) the detection bandwidth = inverse of complex data sampling interval

$BDW = (\text{dwell time})^{-1}$

Ex: Dwell time $= 20\mu s$
$BDW = (20\mu s)^{-1} = 50\,kHz$

Aside: If we use quadrature detection, (M_x, iM_y), we can place zero frequency in the center of the bandwidth

(Distinguish + and - frequencies)

Ⓑ Must sample at least 2 data values per cycle at the highest frequency you wish to detect.

$20\mu s = 50{,}000$ complex points/second $\cdot 2$ (real & imaginary)

$= 100{,}000$ total data values/second.

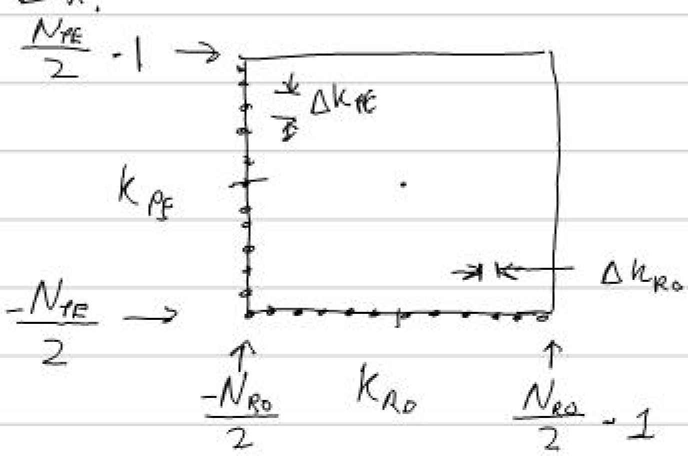
Imaging: BDW → field of view

Dwell time → Δk

So, $(\Delta k)^{-1} = FOV$, $(\Delta k_{RO})^{-1} = FOV_{RO}$, &c.

So, small Δk leads to a large field of view, and vice versa.

Ex:



$$\Delta k_{RO} = \gamma(^1H) \cdot G_{RO} \cdot \underbrace{\Delta t_{RO}}_{\text{dwell time of the analog to digital converter}}$$

Say we want a FOV of 5cm, dwell time of 20 μs

$$\gamma(^1H) = 4 \cdot 10^3 \ Hz/gauss$$

Then $G_{RO} = \frac{5\ cm^{-1}}{4 \cdot 10^3\ Hz/gauss \cdot 2 \cdot 10^{-5} s} = 2.5 \ \frac{gauss}{cm}$

How long to collect?

Suppose $N_{RO} = 256$ ~~collect~~ complex data values

This will take $(256-1) \cdot 20 \mu s = 5.1 \ ms$

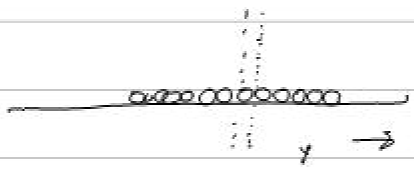
Example:

Suppose we also want $FOV_{PE} = 5cm$. Say $t_{PE} = 2ms$. What is ΔG_{PE}?

$\Delta k_{PE} = \gamma(^1H) \cdot \Delta G_{PE} \cdot t_{PE}$, $\Delta G_{PE} = 0.025 \ \frac{gauss}{cm}$

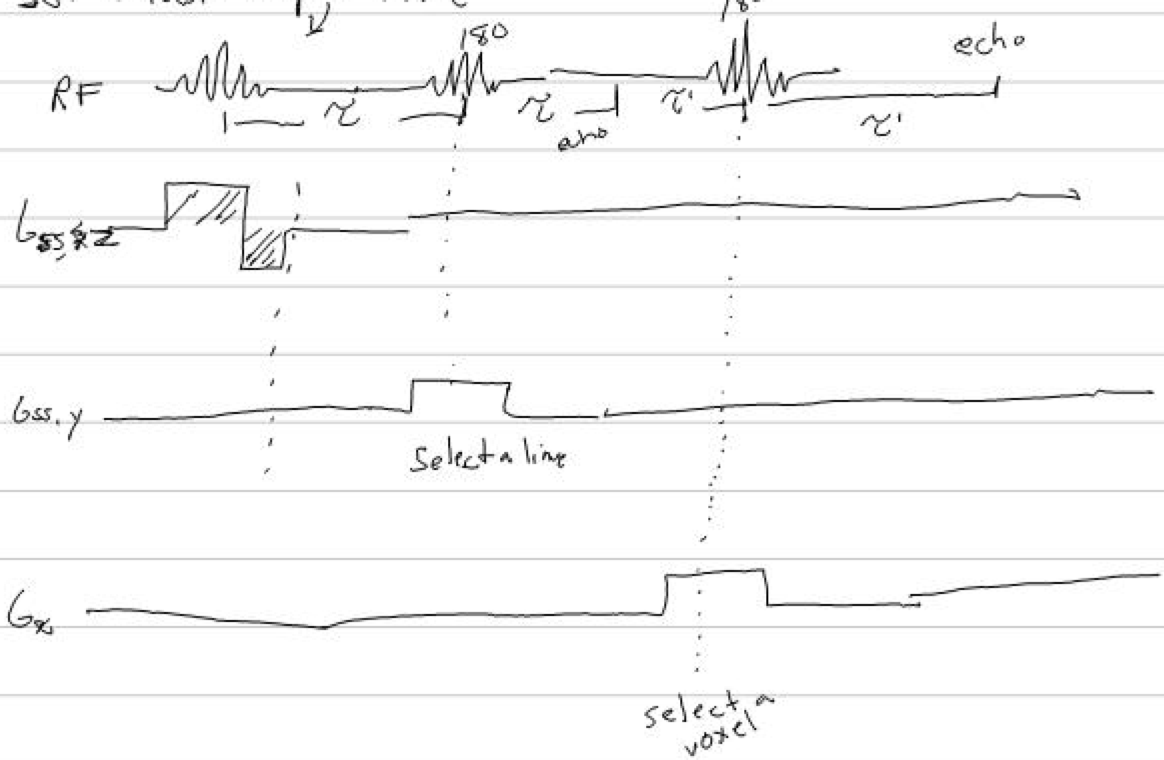
Assume 256 PE steps, start at $-128 \cdot .025 \frac{gauss}{cm} = -3.2 \ \frac{gauss}{cm}$

Single Voxel Spectroscopy (Reduced Field of View)



$G_{ss}(x)$ slice select pulse

1st Select Proper Plane



Problems re MRS in imaging mode

1. H_2O is 110 molar in equivalent ^1H,
   metabolites are $\approx$ 1-10 mM.

   We could start our experiment with a water suppressive pulse.

2. lipid → large broad signal
   ↳ short T_2. (100-200ms)

3. Dynamic range suppression problem
   - outer volume suppression around field of view of interest

4. Chemical Shift artifacts

   Say $\Delta x = 1\,mm$, $G_{RO} = \frac{1\ gauss}{cm}$

   $\Delta \nu_{voxel} = \gamma G_{RO} \Delta x = 400\,Hz$ across a voxel