LAST TIME WE TALKED ABOUT THE BASICS OF AN MRI MACHINE

- MAIN POLARIZING SUPERCONDUCTING MAGNET $\Rightarrow B_0$
- RADIO FREQUENCY COIL FOR EXCITATION/RECEPTION $\Rightarrow B_1$
- GRADIENT MAGNETS (CHANGE B_z LINEARLY W/ POSITION)

3 OF THEM: G_x, G_y, G_z

MAGNETIC FIELDS W/ GRADIENTS ON

$$B_z(x,y,z) = B_0 + G_x x + G_y y + G_z z$$

So

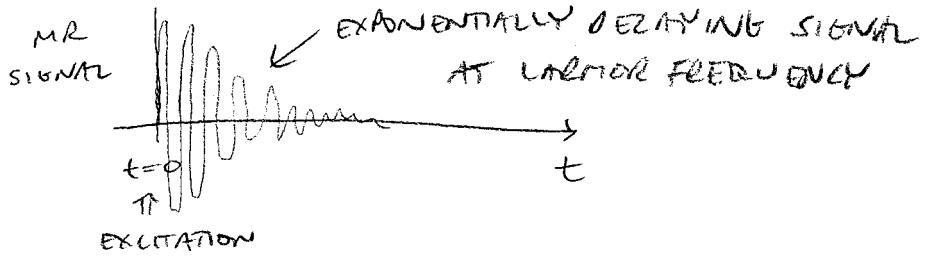
$$\omega(x,y,z) = \gamma B_0 + \gamma G_x x + \gamma G_y y + \gamma G_z z$$

FREQUENCY W/ GRADIENTS ON!

G_x, G_y, G_z ARE USUALLY GIVEN IN G/cm OR mT/m.

FREE INDUCTION DECAY (FID)

- WHEN WE EXCITE A SPIN, THE SIGNAL WE PICK UP AFTERWARDS IS CALLED A FREE INDUCTION DECAY (FID)



- THE BODY CAN BE VIEWED AS AN ENSEMBLE OF TINY SPINS (OR RESONATORS) INDUCING RF SIGNALS (FIDS) IN OUR RECEIVE COIL.
- WE WANT TO MAP THE SPATIAL DISTRIBUTION OF THE AMPLITUDES OF THESE FIDS.
- IN MRI, WE RECORD A SET OF FIDS FROM WHICH WE TRY TO RECONSTRUCT AN IMAGE.

ANALOGY:

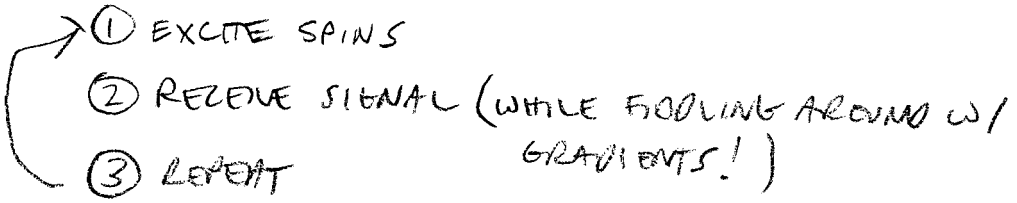
- IMAGINE A ROOM FULL OF SINGERS, WHO ALL SING AT THE LARMOR FREQUENCY WHEN NO GRADIENTS ARE ON.
- LISTENING TO SINGERS, WE HEAR 1 SINGLE PITCH => NO SPATIAL VARIATIONS. WE CAN'T TELL WHERE THE SINGERS ARE (OR HOW LOUD IT IS AT DIFFERENT LOCATIONS) (ASSUME WE ONLY HAVE ONE MIC...)
- WE CAN "CONDUCT" THE SINGERS (MAKE THEM SING AT DIFFERENT FREQUENCIES BASED ON POSITION) W/ OUR GRADIENTS.
- THEN WE CAN TRY TO FIGURE OUT WHAT THE CHARACTERISTICS ARE OF SINGERS AT DIFFERENT LOCATIONS IN THE ROOM:
  - HOW LOUD ARE THEY? (PROTON DENSITY)
  - HOW LONG CAN THEY HOLD A NOTE? (T_2)
  - HOW QUICK CAN THE REFILL THEIR LUNGS? (T_1)
  - ARE THEY ON KEY? (CHEMICAL SHIFT)
  - ARE THEY WIGGLING IN THEIR SEATS? (DIFFUSION)

  ...AND MANY MORE ATTRIBUTES!

PULSE SEQUENCES:

- THE WAY WE MEASURE A SERIES OF FIDS TO GET DATA FOR AN IMAGE IS CALLED A "PULSE SEQUENCE"

PULSE SEQUENCE:



EACH TIME WE RECEIVE OUR SIGNAL IN ② WE GET A TIME SIGNAL FID (FOR MAYBE 10 MS).

SELECTIVE EXCITATION:

- WHAT HAPPENS IF WE EXCITE OUR COLLECTION OF SPINS WITH RF AT THE LARMOR FREQUENCY WHILE WE HAVE A Z-GRADIENT (G_z) TURNED ON??

  - WITH NO GRADIENT, THE WHOLE VOLUME WOULD BE EXCITED.
  - WITH A G_z GRADIENT, ONLY A SLICE IN THE XY PLANE WILL RESONATE AT THE RIGHT FREQUENCY AND BE EXCITED! => **SELECTIVE EXCITATION**

SLICE WIDTH IS CONTROLLED BY:

- MAGNITUDE OF G_z
- BANDWIDTH OF B, (THE RF SIGNAL FOR EXCITATION)

2D IMAGING

- IN 2D IMAGING, WE ALWAYS APPLY A GRADIENT WHILE PLAYING OUR RF EXCITATION PULSE, SO ONLY A SINGLE 2D SLICE IS "SINGING" TO US.

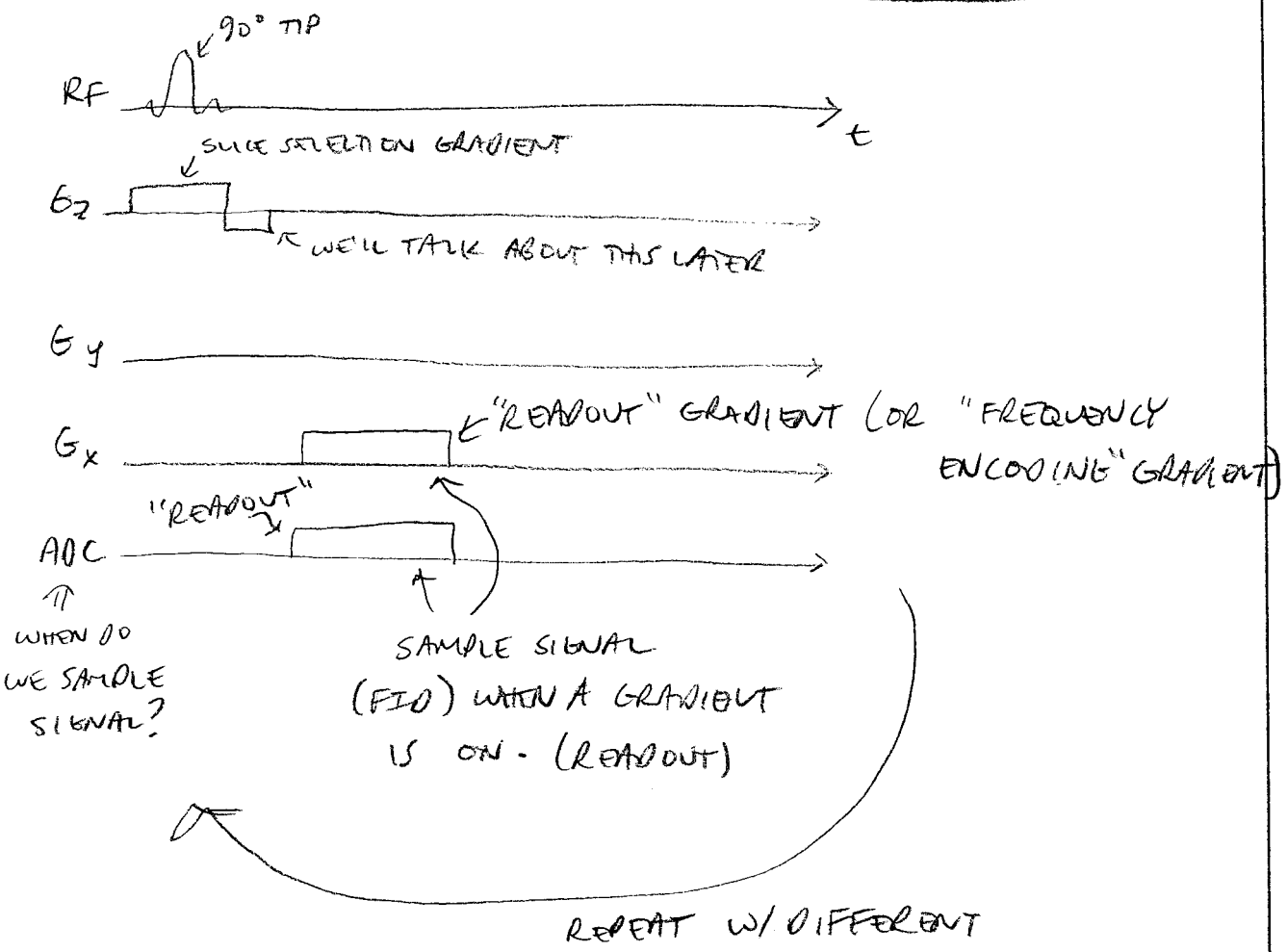
- OUR 2D PULSE SEQUENCE:

  ① APPLIES A SLICE SELECTIVE 90° PULSE

  ② EXCITED SPINS HAVE AN AMPLITUDE $m(x,y)$ IN EXCITED PLANE. WE ① ENCODE SIGNALS W/ GRADIENTS ② RECEIVE FIDs

  ③ LET SPINS RETURN TO EQUILIBRIUM AND REPEAT!

LET'S CONSIDER A SIMPLE PULSE SEQUENCE DIAGRAM:



- THE X-GRADIENT MAKES SPINS AT DIFFERENT X LOCATIONS "SING" AT DIFFERENT FREQUENCIES. WE HAVE ENCODED X POSITION IN FREQUENCY! ("FREQUENCY ENCODING")
- FOURIER TRANSFORM OF OUR SIGNAL GIVES A PROJECTION (1D) OF OUR 2D SLICE (LIKE IN CT!)
- REPEATING WITH DIFFERENT COMBINATIONS OF X AND Y GRADIENTS DURING READOUT GIVES DIFFERENT PROJECTIONS! ⇒ RECONSTRUCT LIKE CT!

THIS 2D PULSE SEQUENCE IS CALLED 2DPR (2D PROJECTION RECONSTRUCTION).

- ALSO REVIEW 2DFT IN BOOK.