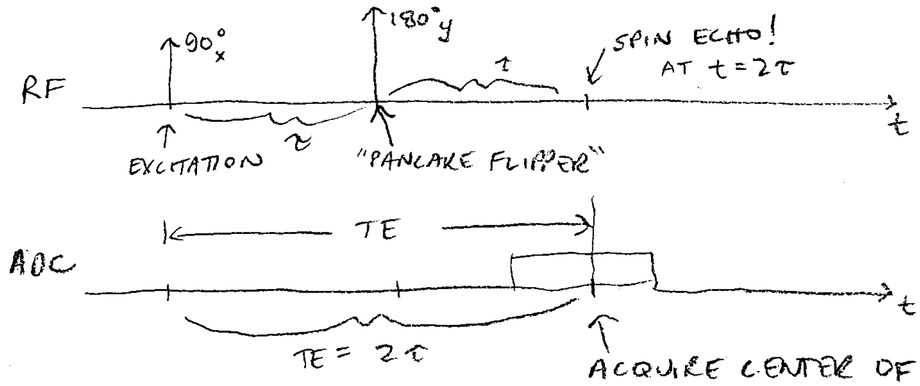
SPIN ECHOES IN IMAGING:

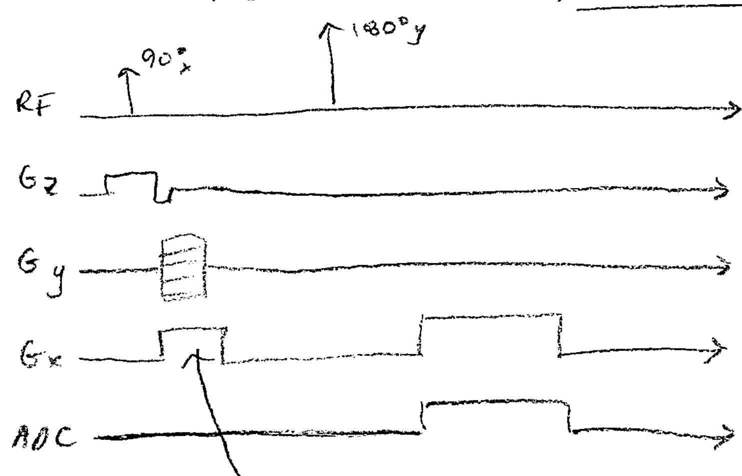
– LAST TIME WE LEARNED ABOUT INDUCING A "SPIN ECHO", AND HOW IT LETS US UNDO THE EXTRINSIC FACTORS THAT CAUSE THE MR SIGNAL TO DEPHASE AND DECAY MORE RAPIDLY (T_2^* DECAY).

HOW CAN WE USE A SPIN ECHO IN A PULSE SEQUENCE?



ACQUIRE CENTER OF K-SPACE (GRADIENT ECHO) AT THE SAME TIME AS THE SPIN ECHO.

– NOTICE THAT I HAVEN'T DRAWN THE GRADIENTS. YOU CAN USE THE SPIN ECHO TECHNIQUE WITH A VARIETY OF K-SPACE TRAJECTORIES! FOR EXAMPLE, 2DFT SPIN ECHO:

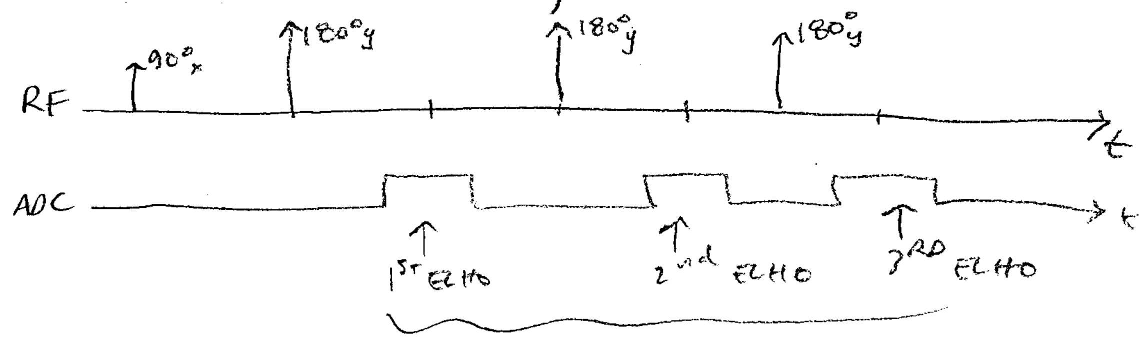


WHY IS THIS POSITIVE!?

THE 180° PANCAKE FLIPPER MOVES US TO THE CONJUGATE POSITION IN K-SPACE! (SEE p.140-142 IN NISHIMURA)

- SPIN ECHO SEQUENCES ARE VERY PREVALENT IN IMAGING (OR VARIATIONS LIKE FAST SPIN ECHO). FSE

- IN FAST SPIN ECHO, WE ACQUIRE MULTIPLE LINES IN K-SPACE WITH EACH EXCITATION (THAT IS, WE ACQUIRE MULTIPLE LINES IN K-SPACE PER TR)



OF SPIN ECHOES ACQUIRED PER TR IS CALLED THE "ECHO TRAIN LENGTH"

CAN YOU DESIGN THE G_x AND G_y WAVEFORMS NEEDED FOR FSE?

INCORPORATING T_2 RELAXATION INTO SIGNAL EQUATION:

- WE HAVE IGNORED T_2 RELAXATION IN OUR SIGNAL EQN UP TO THIS POINT:

$$s(t) = \int_x \int_y m(x,y)\, e^{-i2\pi\left(k_x(t)x + k_y(t)y\right)}\, dy\, dx$$

- ADDING IN THE EFFECT OF A SPATIALLY-VARYING T_2 VALUE, WE HAVE:

$$s(t) = \int_x \int_y m(x,y)\, e^{-i2\pi\left(k_x(t)x + k_y(t)y\right)}\, e^{-\frac{t}{T_2(x,y)}}\, dy\, dx$$

SOMETIMES TO GAIN INSIGHT INTO THE T2 BLURRING THAT THIS T_2 DECAY DURING OUR READOUT PRODUCES, WE ASSUME A CONSTANT T_2 OVER THE OBJECT.

WE THEN HAVE:

$$s(t) = e^{-t/T_2} \int_x \int_y m(x,y) e^{-i2\pi(k_x(t)x + k_y(t)y)} \, dy \, dx$$

OR, IN K-SPACE:

$$s(t) = e^{-t/T_2} M(k_x(t), k_y(t))$$

WITH THIS MODEL, IT IS EASY TO SIMULATE THE BLURRING EFFECT FROM THE EXPONENTIAL DECAY ACROSS OUR TRAJECTORIES IN K-SPACE.

YOU DID THIS IN H.W. #1!

RF FIELD (OR B_1) INHOMOGENEITIES:

- OUR RF COILS OFTEN HAVE VARIATIONS IN SENSITIVITY (AMPLITUDE AND PHASE) ACROSS OUR IMAGING VOLUME
  - DURING EXCITATION, THIS CAUSES VARIATIONS IN FLIP ANGLE ACROSS OUR OBJECT AND VARIATIONS IN SIGNAL PHASE ACROSS OUR OBJECT (ON TOP OF PHASE VARIATIONS WE INDUCE W/ GRADIENTS!).
  - DURING SIGNAL RECEPTION, THIS SIMPLY ATTENUATES THE SIGNAL IN A POSITION-DEPENDENT FASHION (MAGNITUDE VARIATIONS) AND INDUCES ADDITIONAL POSITION-DEPENDENT PHASE IN THE DETECTED SIGNAL.

TRANSMIT OR EXCITATION VARIATIONS HAVE A SEQUENCE DEPENDENT EFFECT!

HARDER TO MODEL!

WE CAN MODEL RECEIVE COIL SENSITIVITY (MAGNITUDE & PHASE) IN THE SIGNAL EQN. AS:

$$s(t) = \int_x \int_y c(x,y)\, m(x,y)\, e^{-i2\pi(k_x(t)x + k_y(t)y)} e^{-\frac{t}{T_2(x,y)}} \, dy \, dx$$

COMPLEX-VALUED (MAG. + PHASE) COIL SENSITIVITY

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