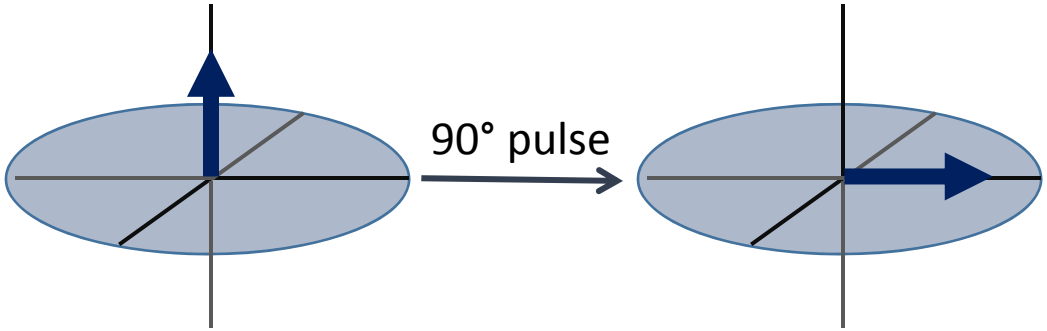
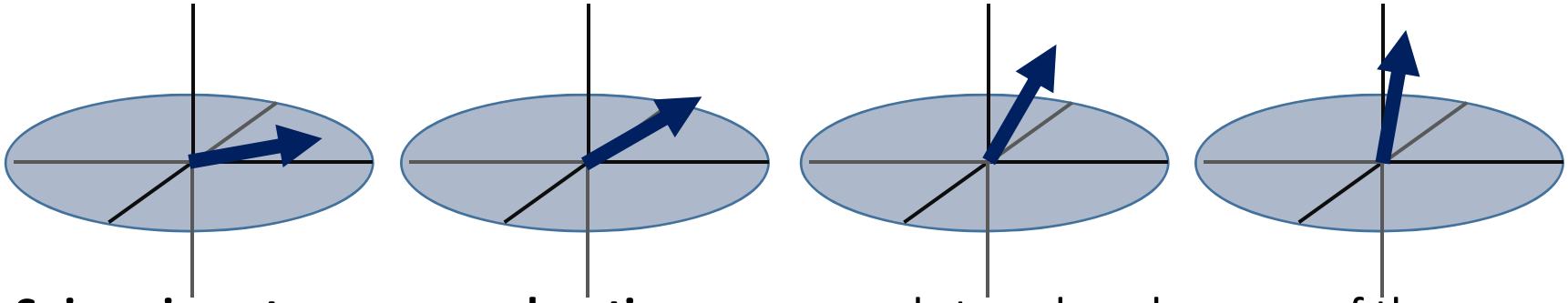
Relaxation Measurements

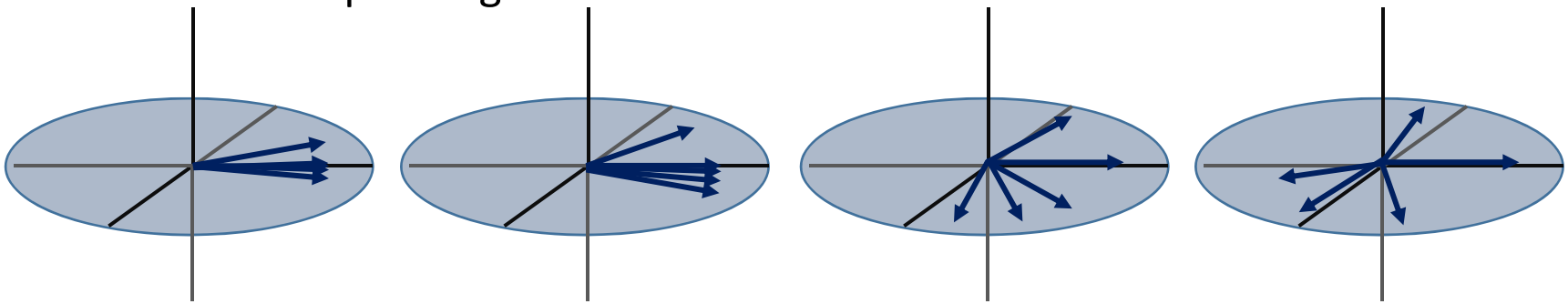
Two Relaxation Mechanisms



T_1: **Spin-lattice** or **longitudinal relaxation** is the average lifetime of the nuclei in the higher spin state



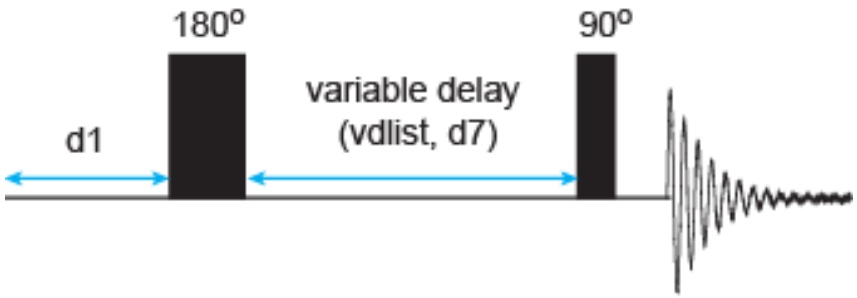
T_2: **Spin-spin** or **transverse relaxation** corresponds to a de-coherence of the transverse nuclear spin magnetization



Spin-Lattice Relaxation Time or T_1

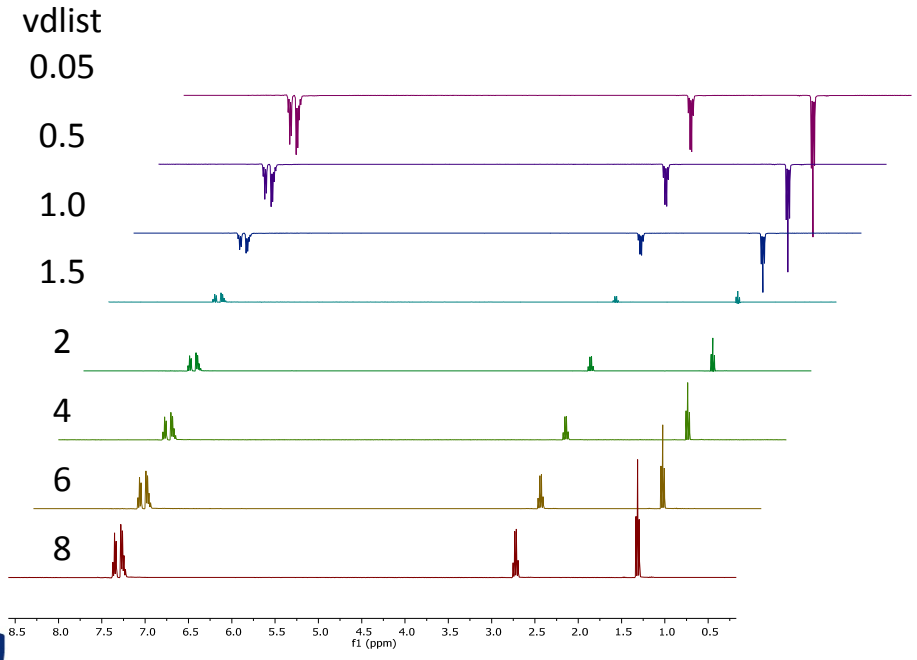
- Any factor which slows molecular motion (e.g. increasing solution viscosity, aggregation, or rigidifying the molecule) shortens the spin-lattice relaxation time
- A short T_1 favors sensitivity but too short can result in line broadening and degradation of resolution since T_2 cannot be longer than T_1
- 3 principal magnetic interactions that contribute to T_1 relaxation of spin ½ nuclei:
  - Dipole-dipole interaction - the nucleus experiences a fluctuating field due to the motions of neighboring dipoles, unpaired electrons, or other nuclei
  - Chemical shift anisotropy - chemical shielding of the nucleus is a function of molecular orientation with respect to B_0 field direction
  - Spin rotation interaction – small magnetic fields are induced at the nucleus as a molecule reorients; this field fluctuates because the motions are not uniform but proceed by a series of small jumps
- Small amounts of paramagnetic substances speed up relaxation
- Inversion recovery experiment measures T_1

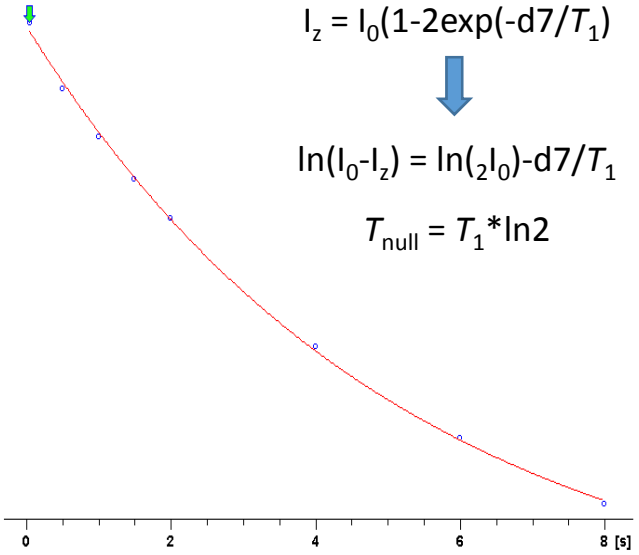
T_1 Measurement: Inversion Recovery



Parameters to note & Optimize

- To change the value of the delay, **d7**, a variable delay list must be created.
- In the acquisition parameters a VDLIST can be generated which contains values that typically cover a time range which extends past the expected T_1 value.

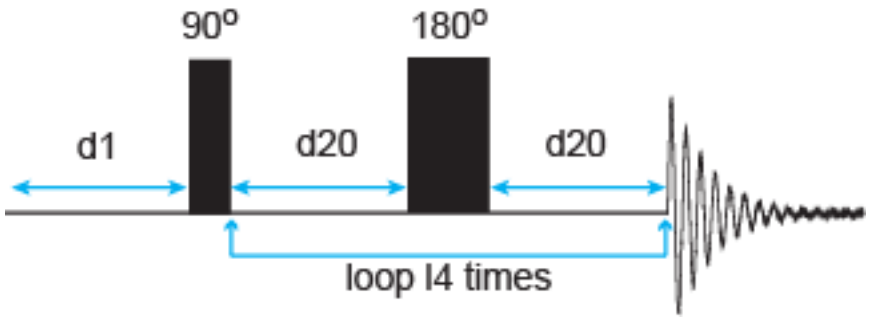


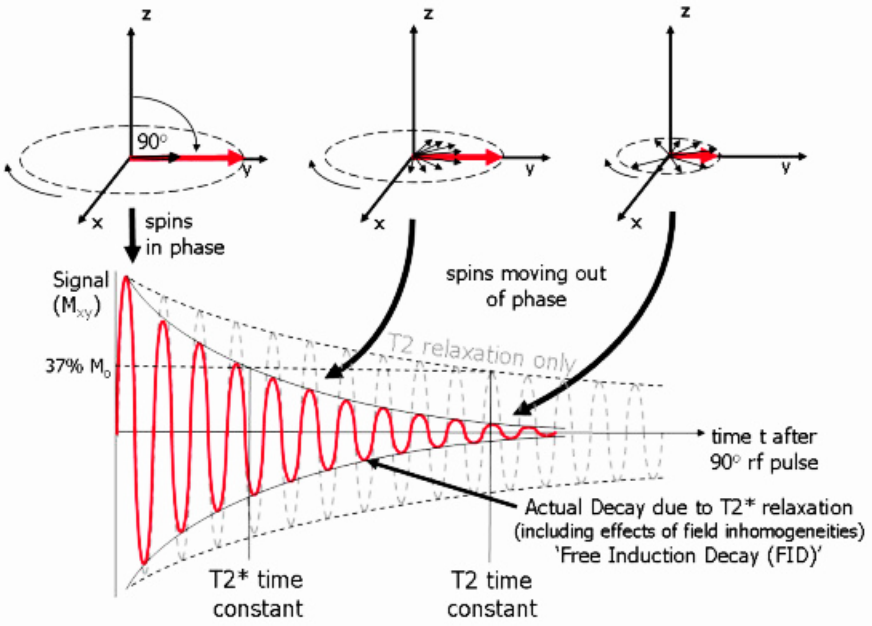


Spin-Spin Relaxation Time or T_2

- $T_1 = T_2$ when molecular tumbling is fast compared with the Larmor frequency; this is the condition for small molecules.
- Mechanisms of spin-spin relaxation:
  - Chemical exchange
  - Scalar spin-spin coupling if modulated at a 'suitable rate'; these are detectable when a ^{1}H is coupled to a quadrupolar nuclei such as ^{14}N, ^{35}Cl, or ^{37}Cl
- In a frozen sample, line broadening increases as the result of static dipole-dipole interactions.
- T^*_2 describes the magnetization (M_Y) decay resulting from B_0 inhomogeneity.

T_2 Measurement: CPMG Experiment

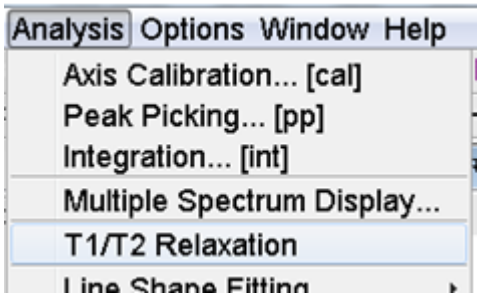


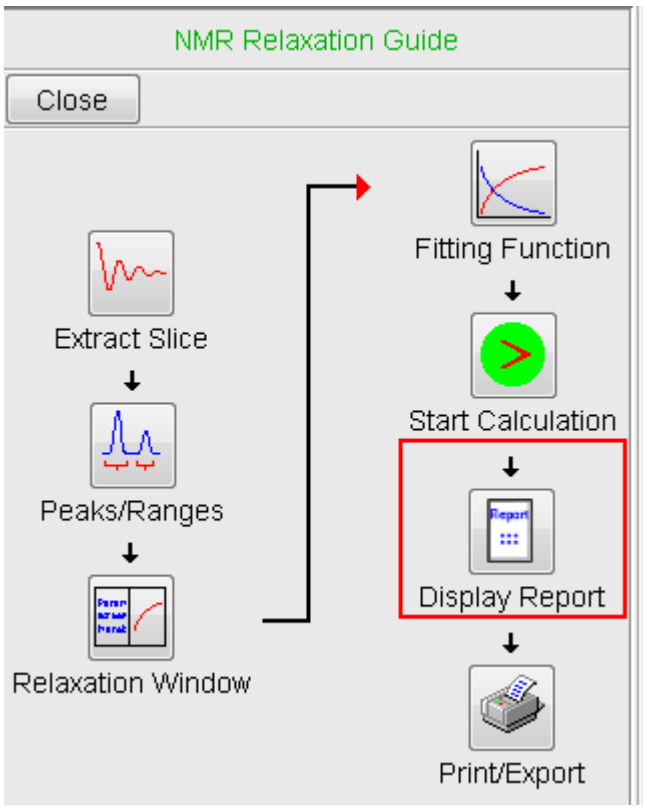



```
;cpmg1d
;1D experiment with T2 filter using Carr-Purcell-
Meiboom-Gill sequence

"p2=p1*2"
"d11=30m"

1 ze
2 30m
  d1
  p1 ph1
3 d20
  p2 ph2
  d20
  lo to 3 times l4
  go=2 ph31
  30m mc #0 to 2 F0(zd)
exit

ph1=0 0 2 2 1 1 3 3
ph2=1 3 1 3 0 2 0 2
ph31=0 0 2 2 1 1 3 3

; d20: fixed echo time to allow elimination of J-mod.
effects
; d20 should be << 1/J ,but > (50 * P2)      [1-2 msec]
;l4: loop for T2 filter                      [4 - 20]
```

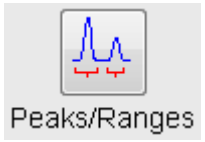
Image from:
Ridgway *Journal of Cardiovascular Magnetic Resonance* 2010 **12**:71

T_1 & T_2 Relaxation Analysis

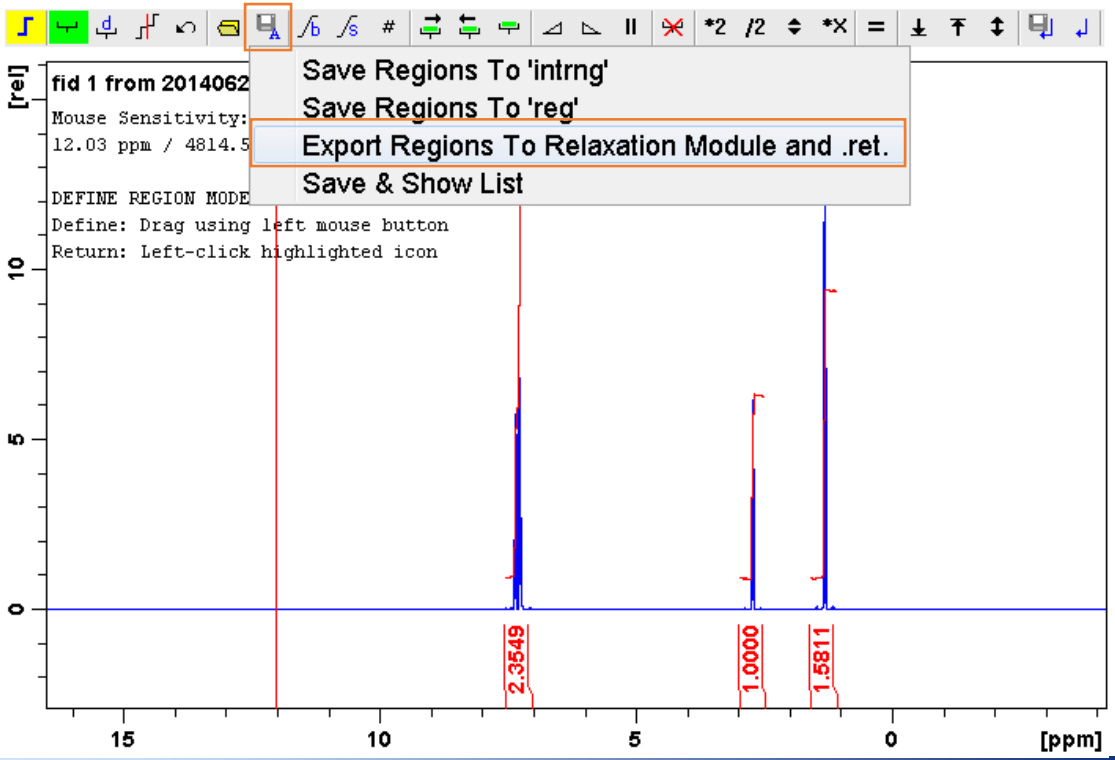




- 1st popup select “FID”, 2nd popup enter a value of “1”
- This will process all slices based on the first slice.

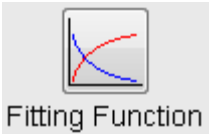


- Select “Manual Integration” and integrate regions of interest.
- Once regions are selected, save integrals to the relaxation module through the “Save Region as…” icon (see below).

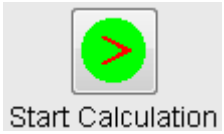


T_1 & T_2 Relaxation Analysis

- Will extract integrals and plot for fitting.

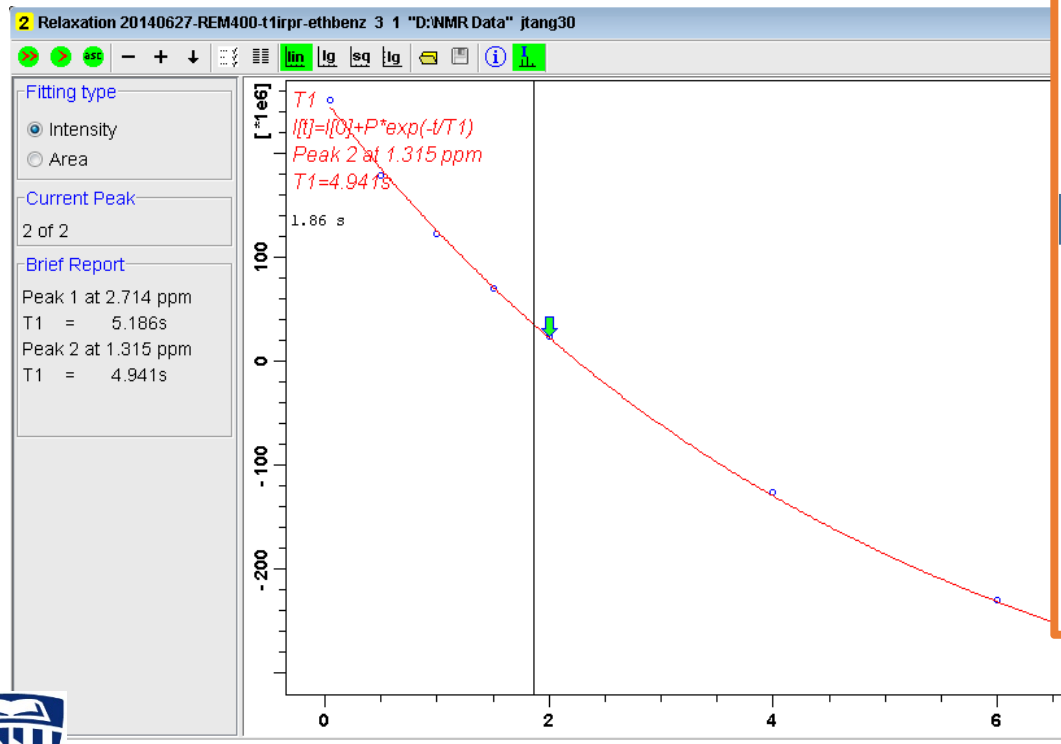


- Select the appropriate function (T_1 or T_2) to use in the fit.



- Calculates relaxation parameter for single site. Click  for all sites.

- Creates a relaxation report.



Relaxation Report

```
I[t]=I[0]+P*exp(-t/T1)

8 points for Peak 1,  Peak Point at 2.714 ppm
Results     Comp. 1

I[0]  =   -1.488e+000
P     =   2.335e+000
T1    =        5.186s
SD    =   1.790e-002

    tau    ppm     integral    intensity

   50.000m     2.714  2.5114e+009  1.0285e+008
  500.000m     2.714  1.7393e+009  7.2504e+007
    1.000s     2.714  1.1713e+009  5.0455e+007
    1.500s     2.714  6.5604e+008  3.0787e+007
    2.000s     2.714  1.8077e+008  1.2362e+007
    4.000s     2.714 -1.3507e+009  -4.725e+007
    6.000s     2.714 -2.4432e+009 -8.9516e+007
    8.000s     2.714 -3.2185e+009 -1.2001e+008
```