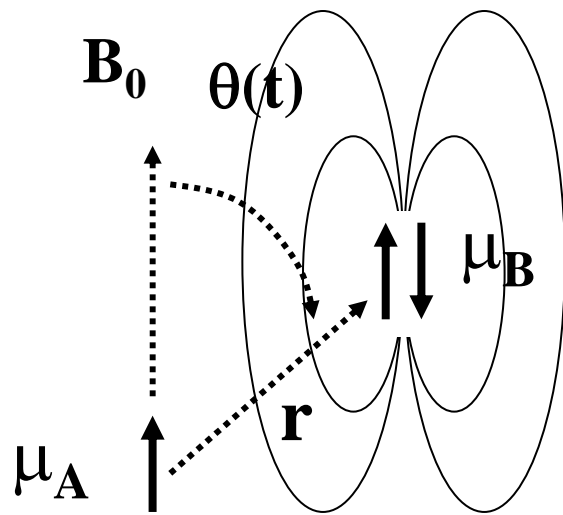


NOESY – Applications to Proteins

BCMB/CHEM 8190

The Dipole-Dipole Interaction



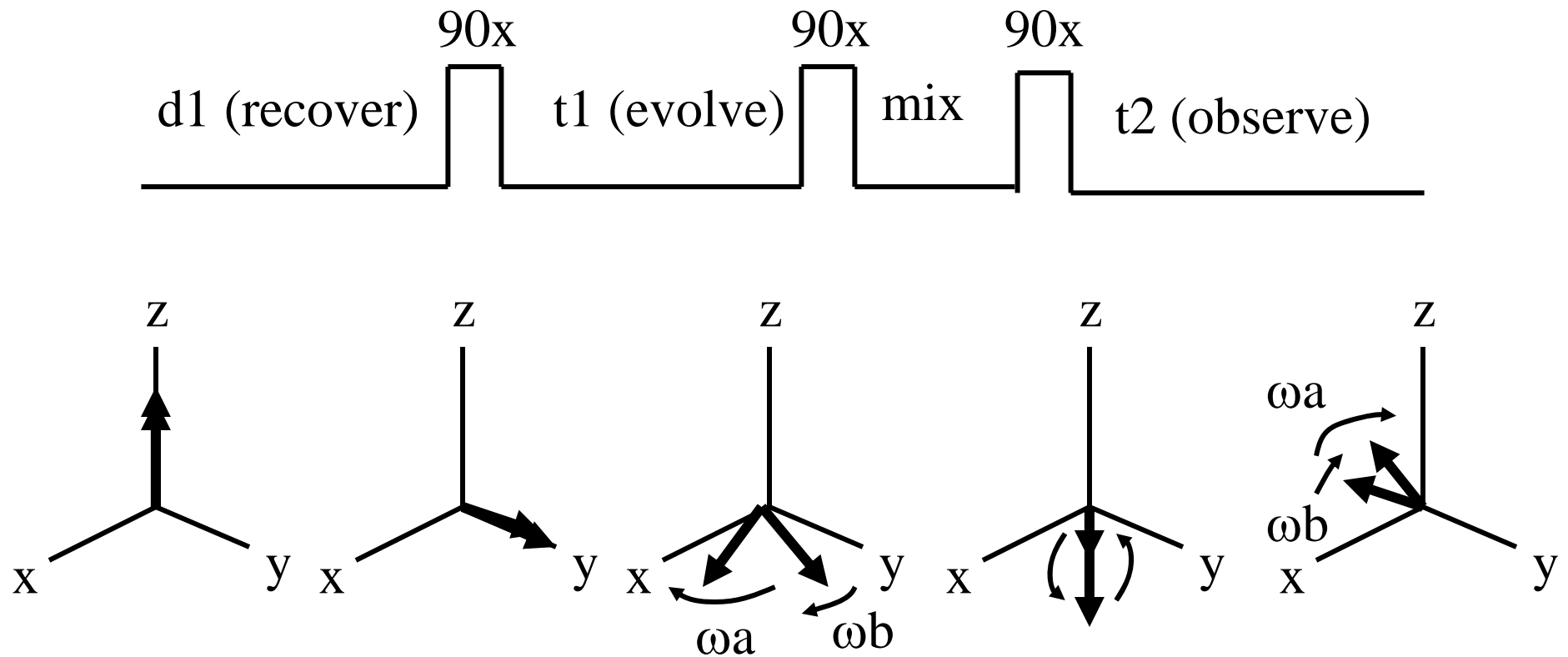
The field seen at nucleus A fluctuates as a molecule tumbles and θ changes.

The interaction operator, V , is distance dependent ($1/r^3$) and contains several types of operators: I_z , I_+ , I_- , I_{+-} , I_{++} , etc. (I_+ , I_- , etc are linear combinations of I_x , I_y)

These operators can cause several types of transitions: one quantum, W_1 , two quantum, W_2 , zero quantum, W_0

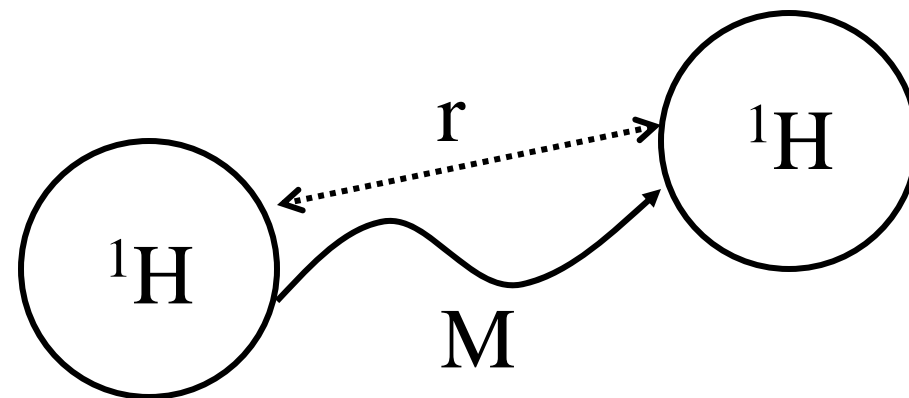
The magnitude of μ_B is important – an unpaired electron is $(2000)^2$ more efficient than a proton at the same distance

2D NOE Spectroscopy (NOESY)

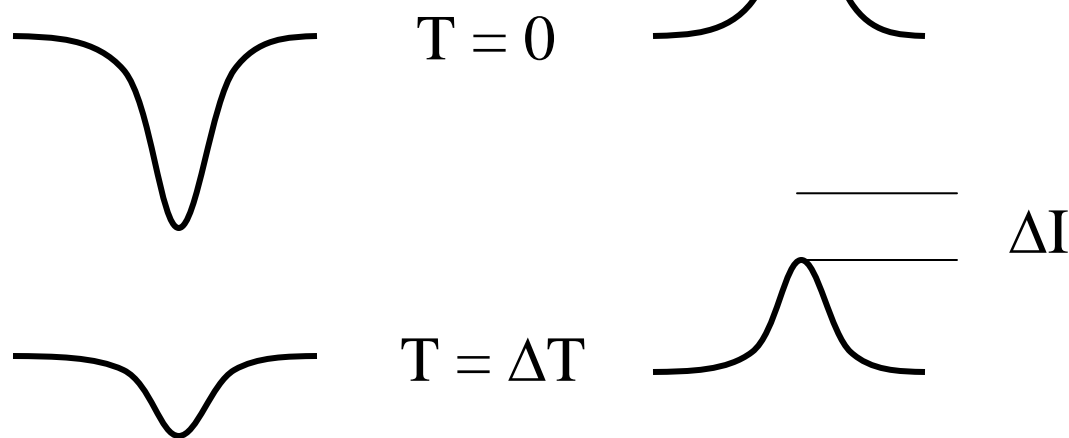


Some magnetization precessing at ω_a in $t1$ can precess at ω_b in $t2$

Periodic Inversion Sets Stage for Magnetization Transfer During Mixing Time

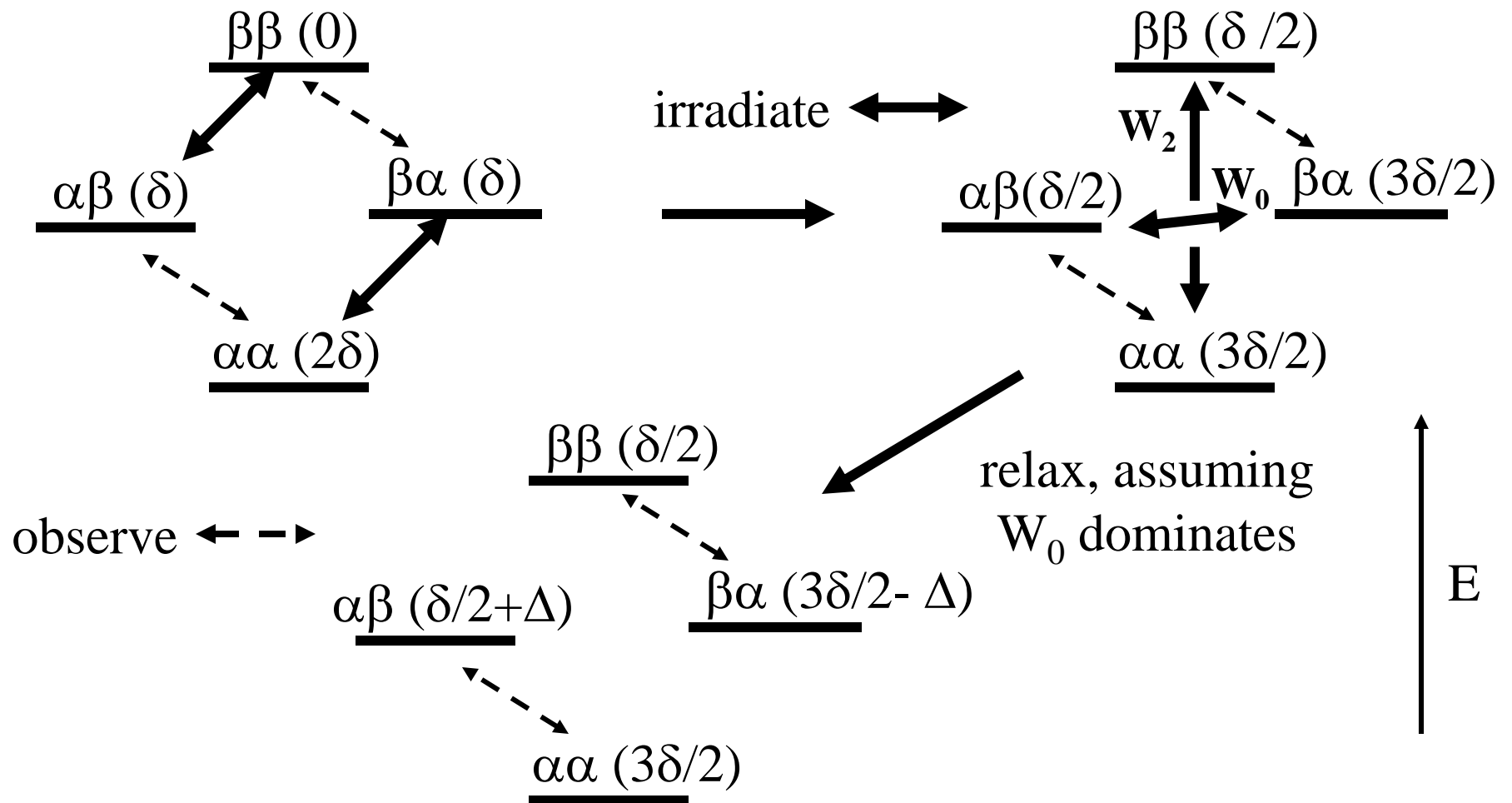


For short T ,
Large τ_c ,
 $\Delta I \propto 1/r^6$



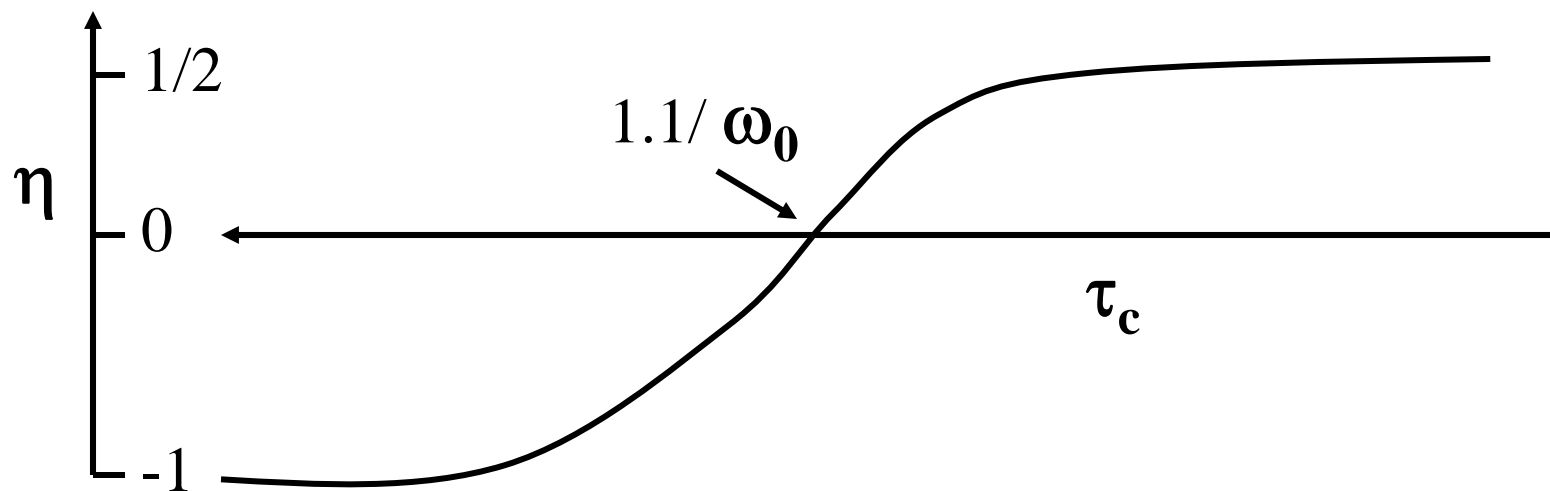
NOE (Nuclear Overhauser Effect)

depends on competition between W_0 and W_2 processes



NOEs are Positive for Small Molecules, Negative for Large

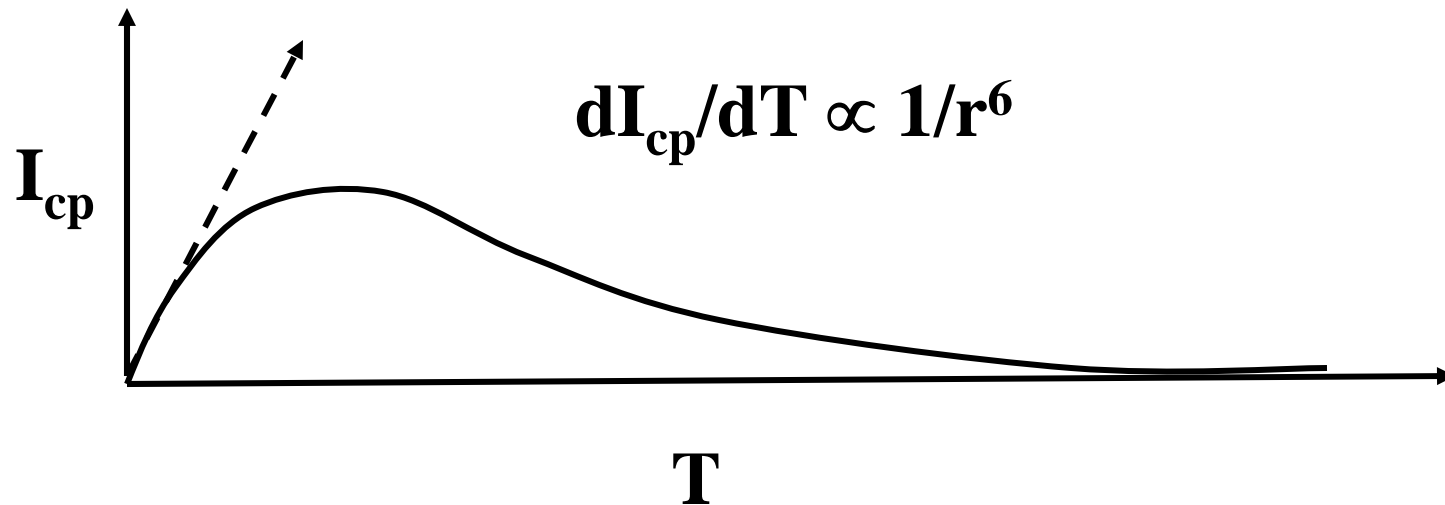
$$\eta = (-1 + 6/(1+4\omega_0^2\tau_c^2))/(1 + 3/(1+\omega_0^2\tau_c^2) + 6/(1+4\omega_0^2\tau_c^2))$$



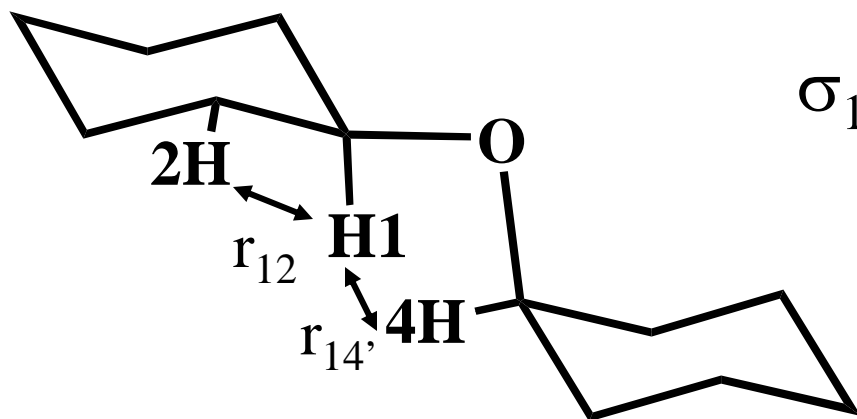
In Practice Data May be Collected for Cross Peaks at a Series of Mixing Times

$$I_{cp} = C\{\exp(-\rho T) \cdot (1 - \exp(-2\sigma T))\}$$

$$\rho = 2W_1 + W_2 + W_0, \quad \sigma = (W_2 - W_0)$$

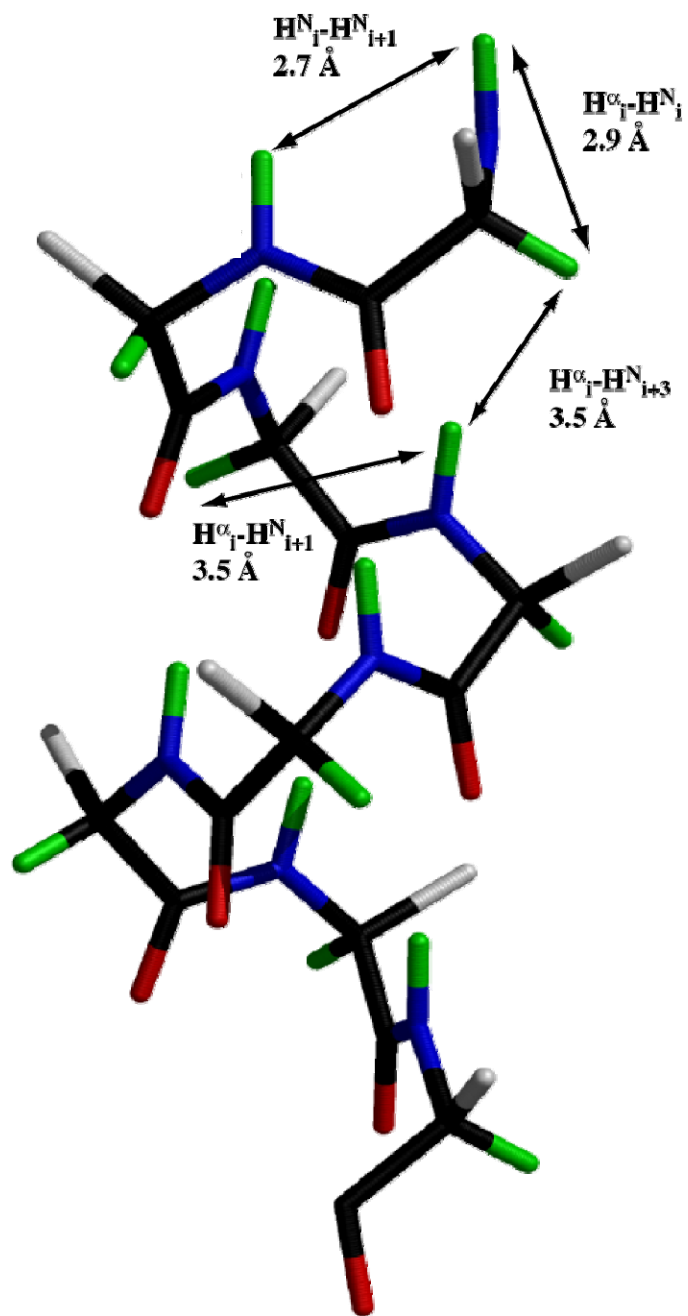


NOEs Give Structural Information



$$\sigma_{14'} / \sigma_{12} = r_{12}^6 / r_{14'}^6$$

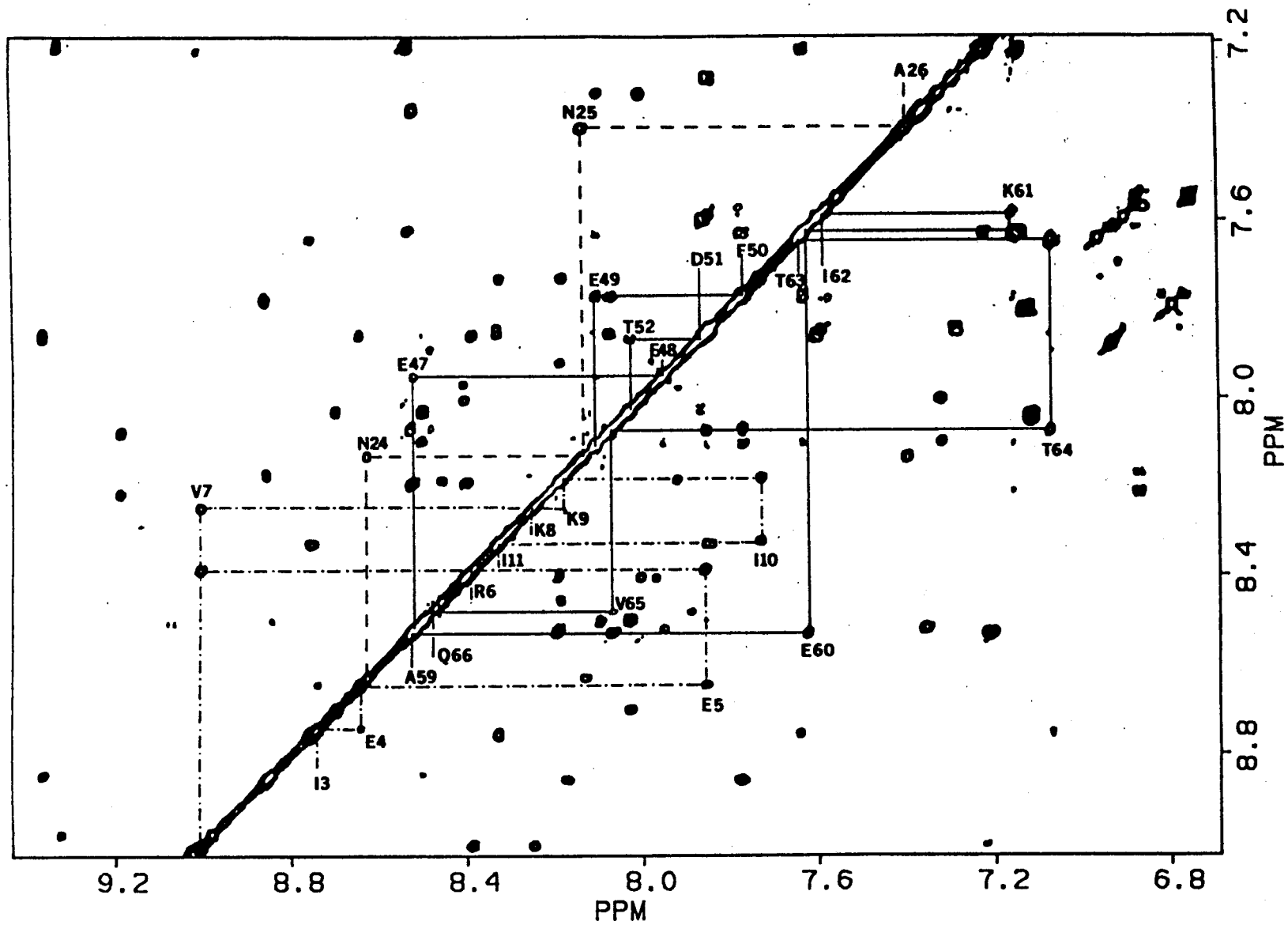
$$r_{12} = 2.5 \text{ \AA}, \quad \sigma_{14'} / \sigma_{12} = 4.0, \quad \text{implies: } r_{14'} = 3.15 \text{ \AA}$$



Potential NOE Interactions

In an Idealized α -Helix

NOESY Spectrum of ACP



NOEs for Intermediate Sized Molecules: ROESY

- Short peptides and oligosaccharides often have tumbling times near $1/\omega_0$, and NOEs near zero.
- ROESY – Rotating Frame Overhauser Effect Spectroscopy – offers a solution – cross-relaxation in the low effective field of a “spin-lock”.
- Cross-peaks and auto-peaks are always of opposite sign. Still $1/r^6$ dependent. $1/2$ the intensity for a large molecule.

