NMR Studies of Spin Decoherence in Phosphorus-doped Silicon

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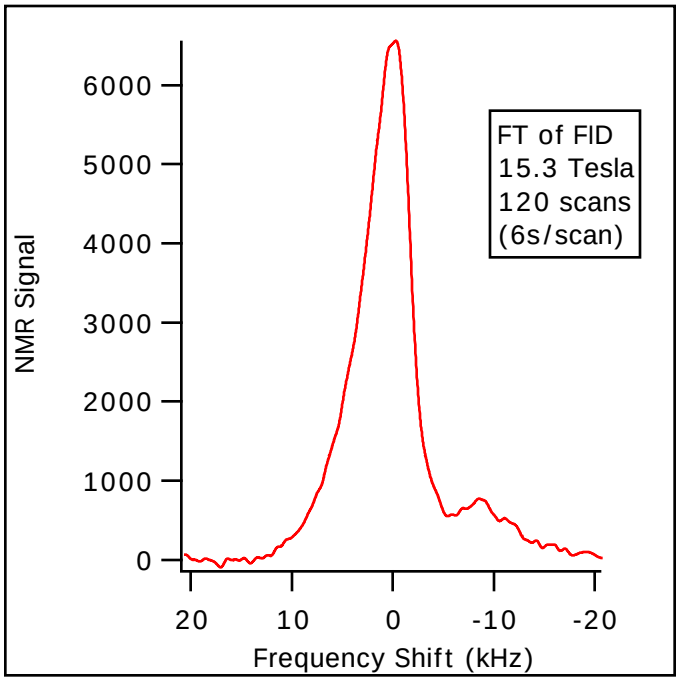
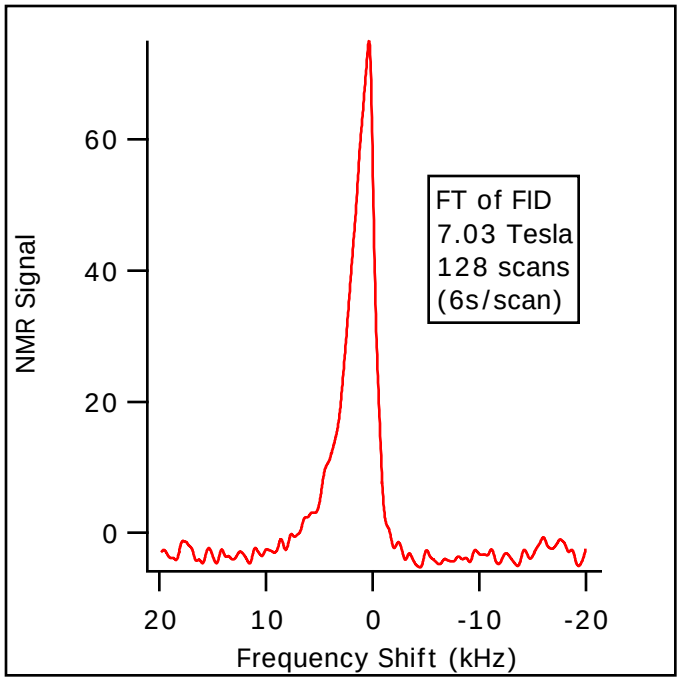
Supported by NSA and ARDA under ARO grant #DAAD19-01-1-0507
and by NSF Grant #OIA-99776546
SEB acknowledges the support of the Alfred P. Sloan Foundation

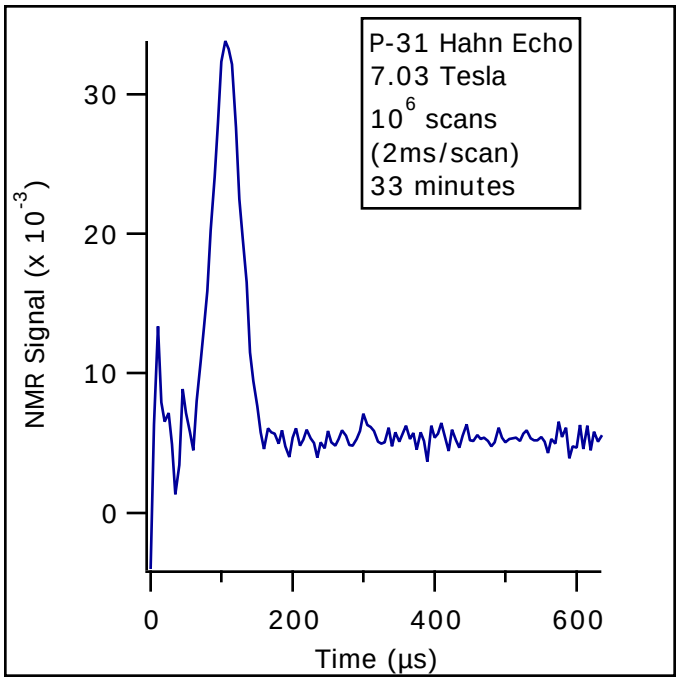
Si:P NMR

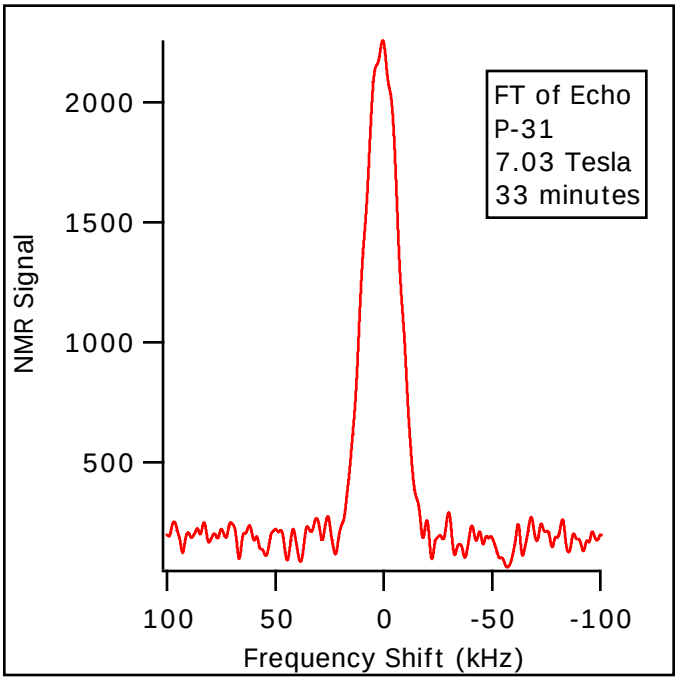
10^{21} Si-29 nuclei at Room T





10^{19} P-31 nuclei at Room T





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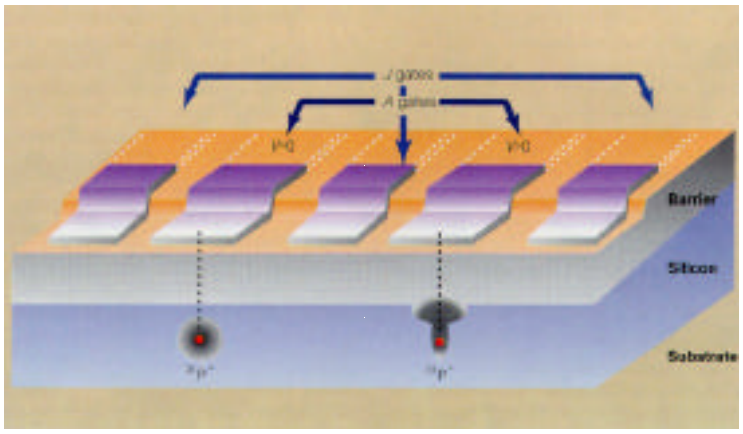


B.E. Kane, *Nature* **393** 133 (1998).

- Why do this?

  - Proposals for Scalable Solid-state Qubits based on spin require "long" nuclear spin decoherence times

  - In real samples we don't know how long "long" is

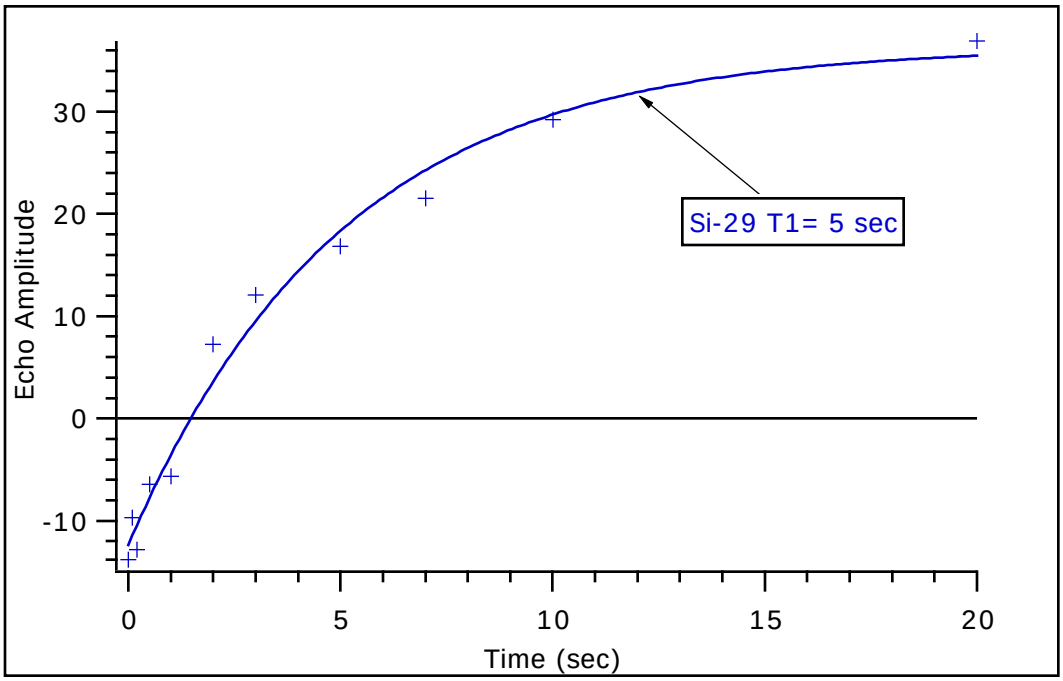
- Time scales to be measured

  - T_1, T_2^*, T_2, . . .etc.

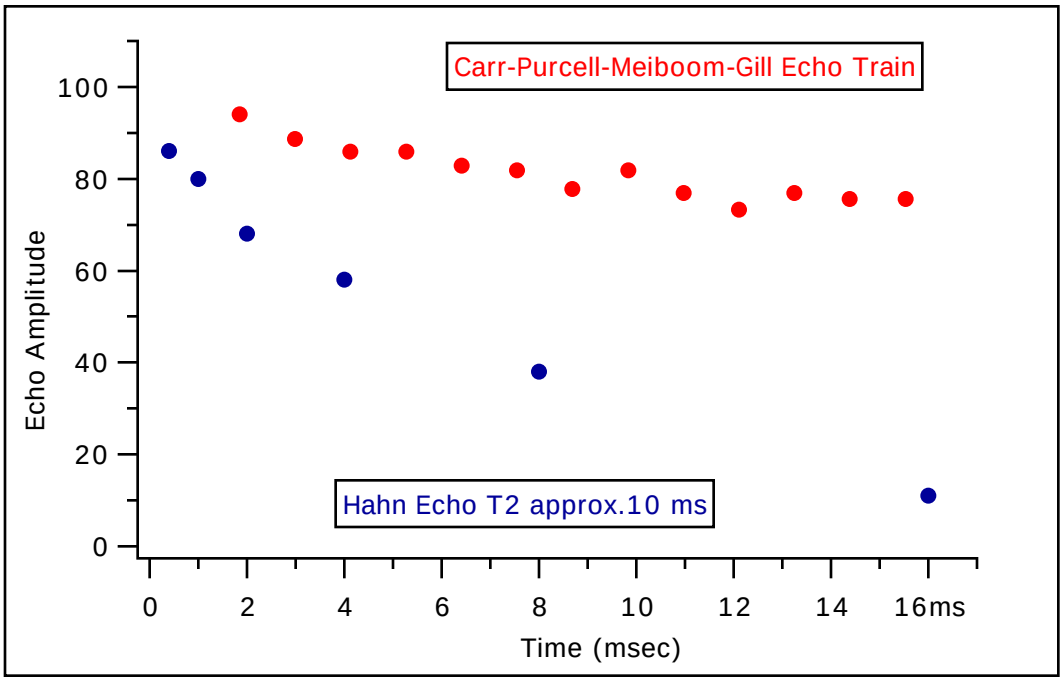
Si:P NMR

Measuring Spin Dynamics of Si-29

T_1



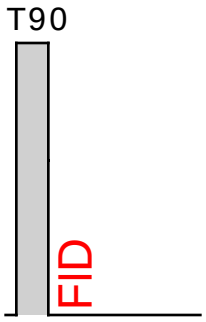
T_2

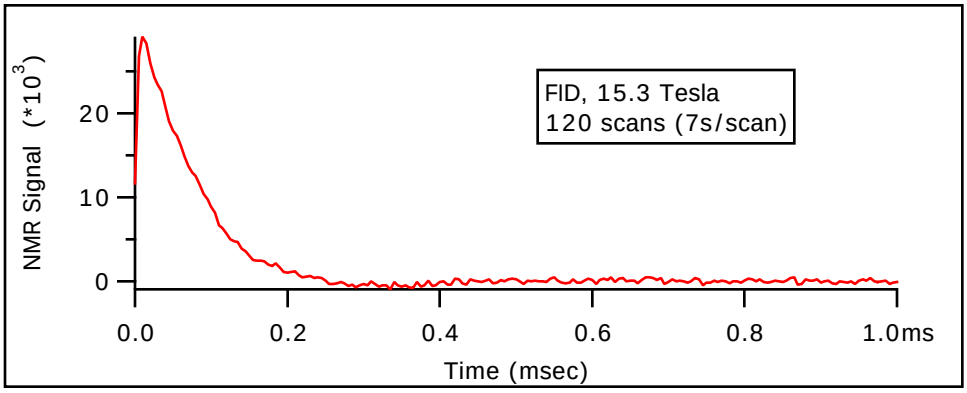


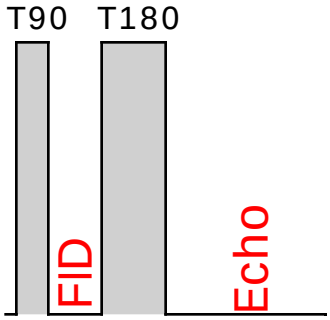
10^{21} Si-29 nuclei at Room T

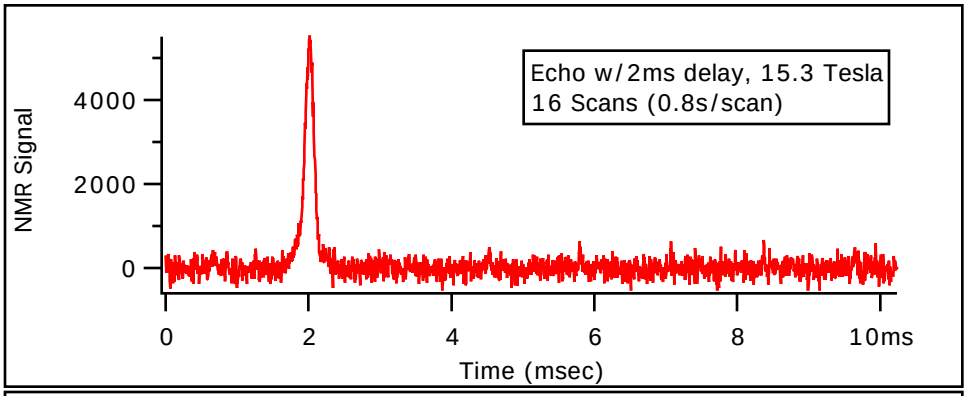
Si:P NMR

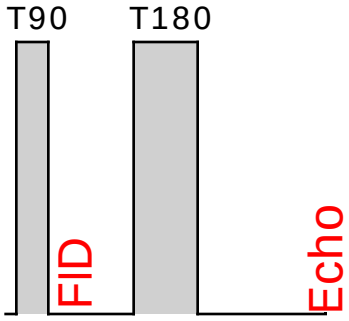
10^{21} Si-29 nuclei at Room T

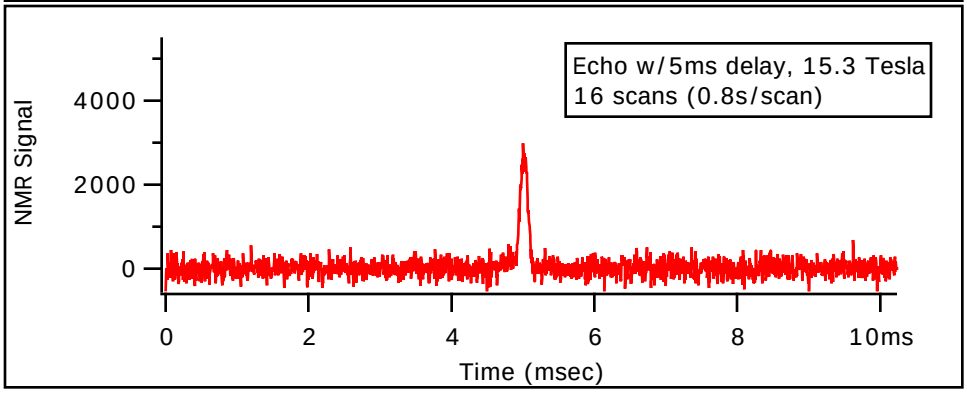


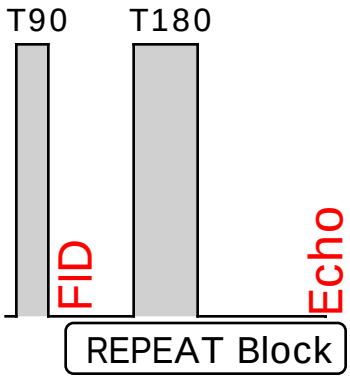


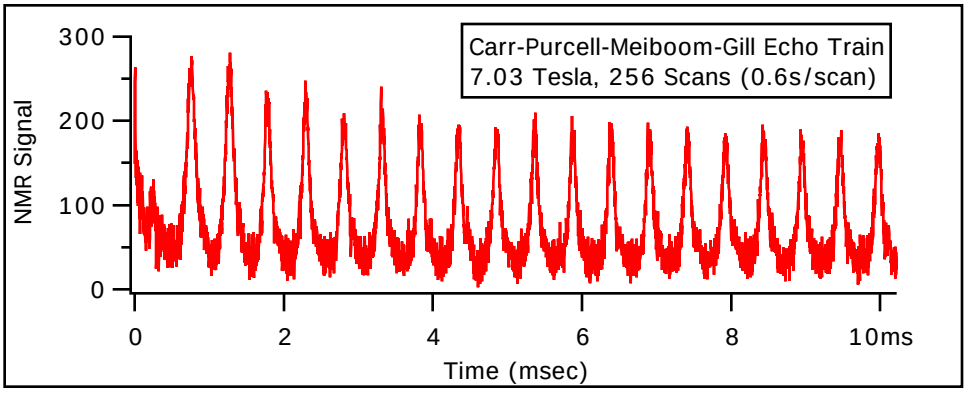




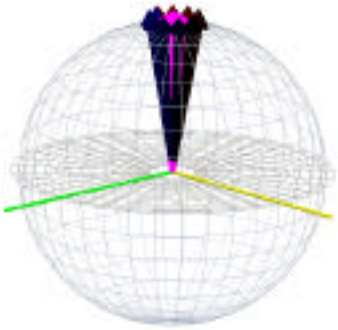




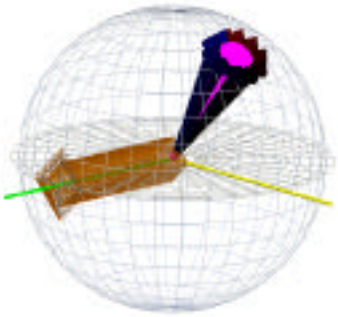




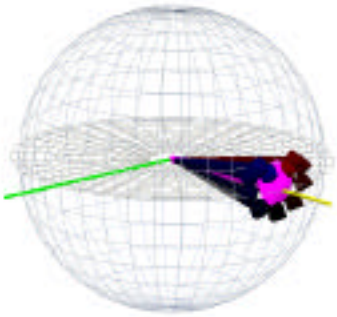
Hahn Echo Formation in the Rotating Coordinate System



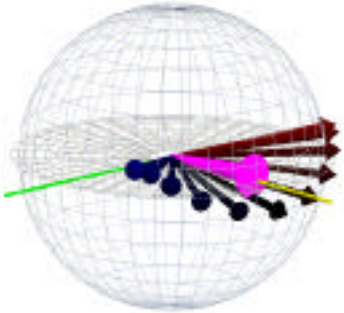
Spins initially
polarized along Z-axis



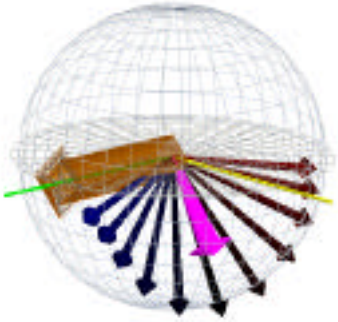
"∏/2-Pulse"
H1 applied along X-axis
Spins begin to precess



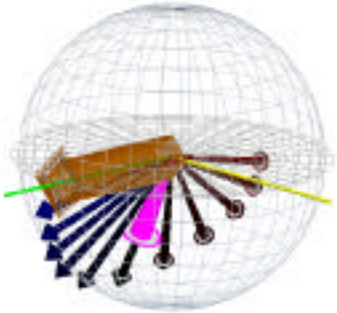
Free Precession begins (no H1)
fully polarized along Y-axis



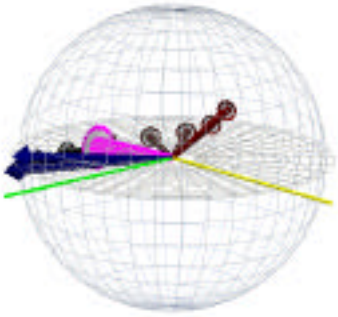
"Pancake" forms in
free precession (no H1)



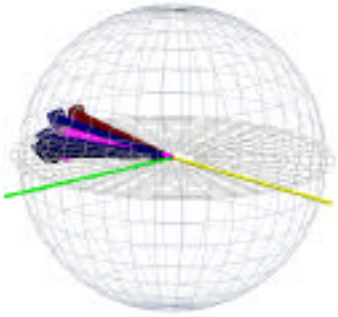
"∏-Pulse"
H1 applied along X-axis



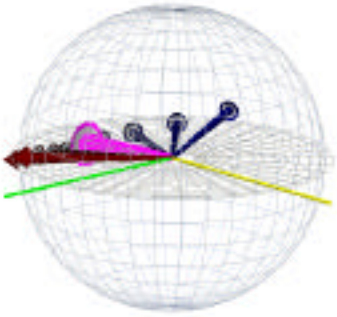
"∏-Pulse" continues



"Inverted Pancake"
Free Precession

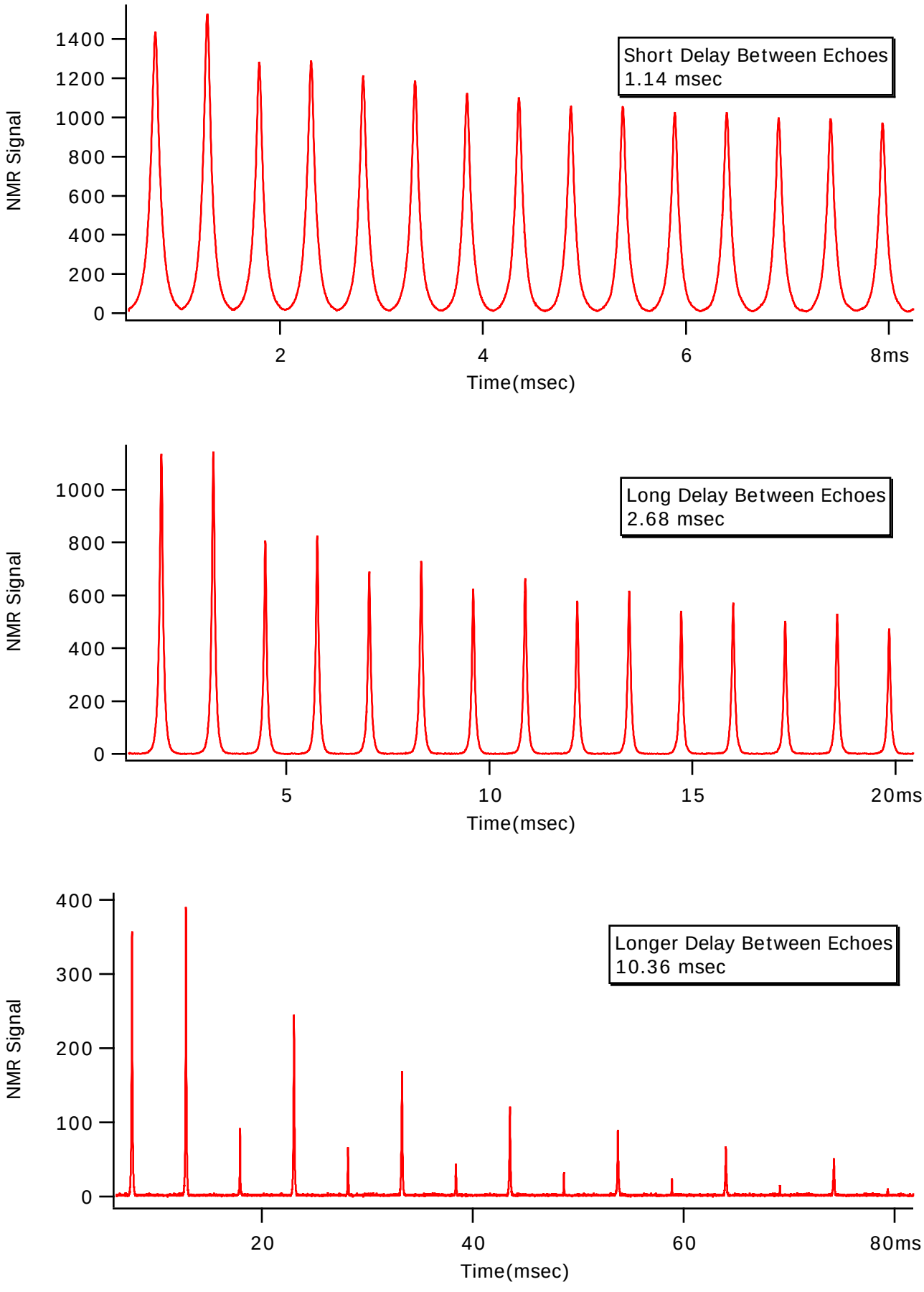


Refocussing

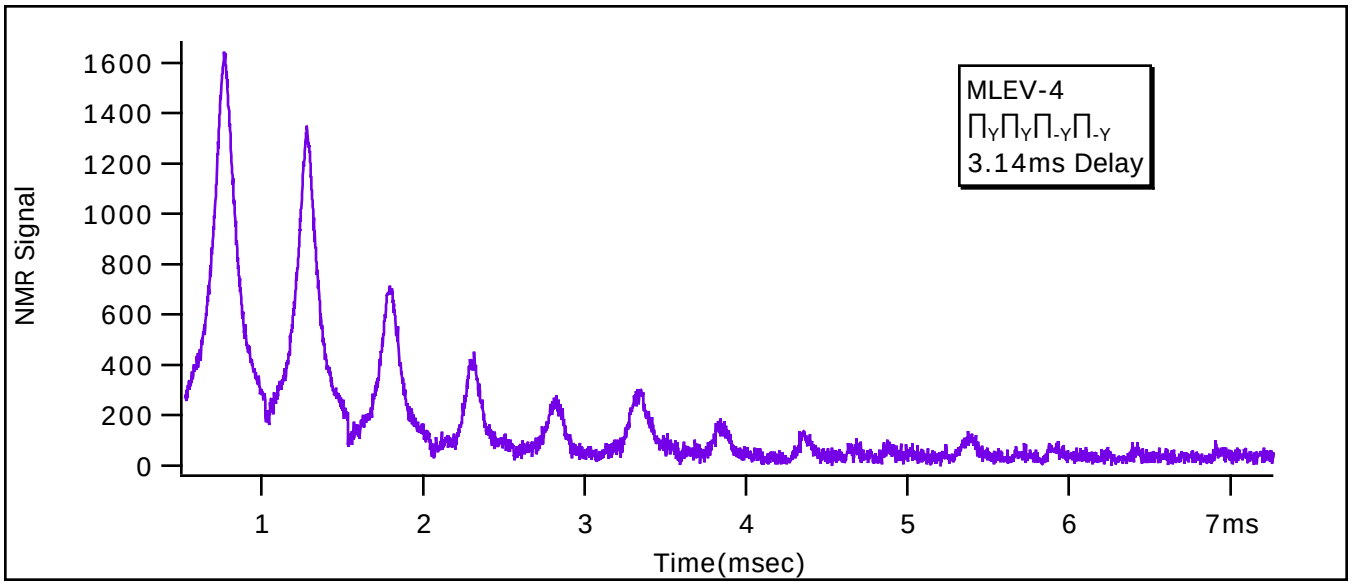


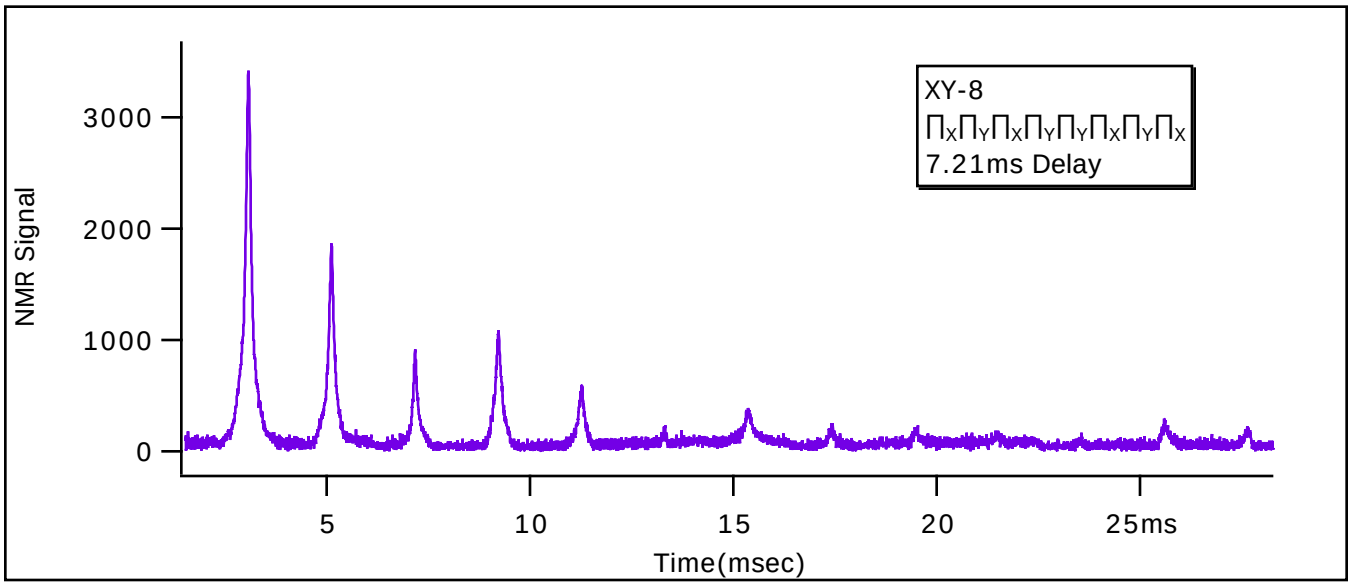
Free Precession continues

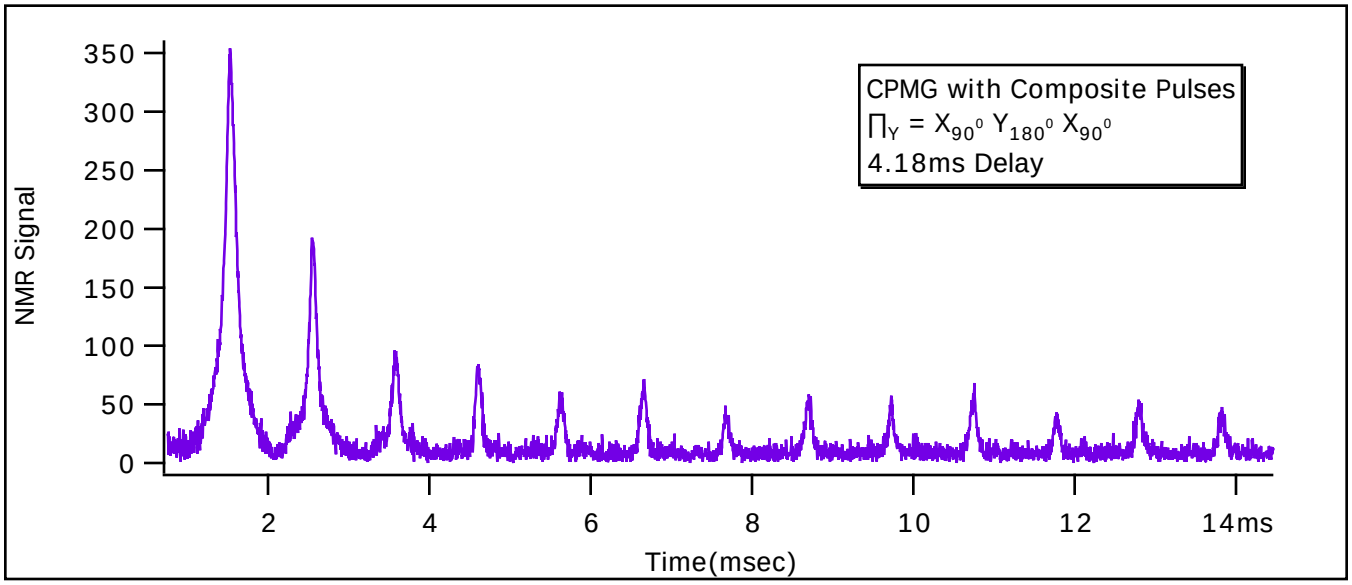
CPMG Echo Sequences on ^{29}Si at 4K



Other Pulse Sequences for ^{29}Si at Room Temperature







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Summary-

- Measurements in samples relevant to scalable, solid-state qubits
  - T_2^* is a lower limit
- Interesting Dynamics to Understand
  - Spin-Spin Coupling for a small number of neighbors
  - Spin Locking Effects in Pulse NMR
- Next Steps
  - Lower Dopant Concentrations
  - Optically Pumped NMR
  - Higher B/T

References-

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