Quantum Defects in Diamond:
Identifying Nitrogen Isotopes of Nitrogen-Vacancy Centers in Diamond

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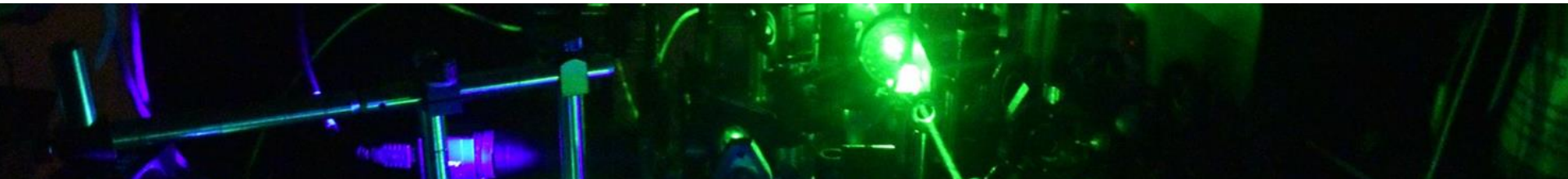
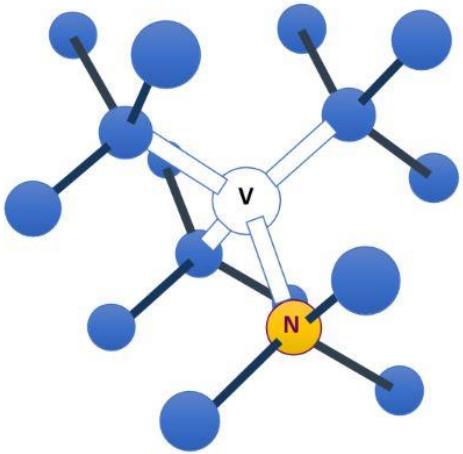
Overview

- Background
  - NV Centers
  - Ion Implantation
- Three tests:
  - Continuous wave optically detected magnetic resonance (CW ODMR)
  - Rabi oscillations
  - Pulsed optically detected magnetic resonance (Pulsed ODMR)
- Next Steps:
  - Run tests for single NV samples implanted with ^{15}N
  - Compare with photoluminescence excitation spectra for each NV center



Defects in Diamond: Nitrogen-Vacancy Centers

A nitrogen-vacancy (NV) center is a point defect in diamond



- Preserves quantum coherence at room temperature

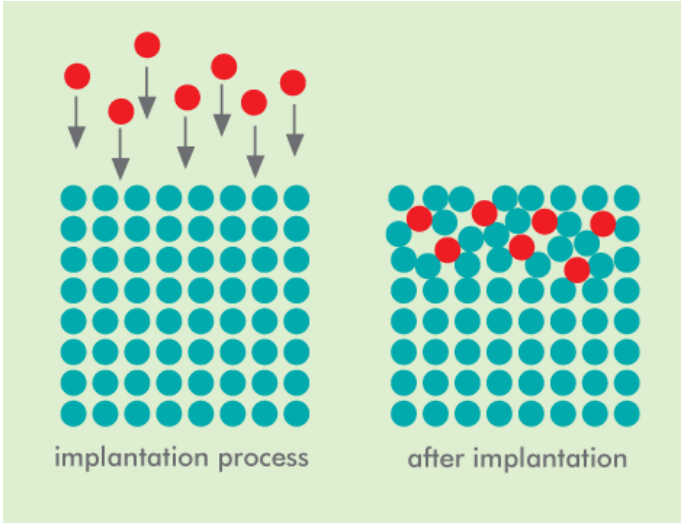
- Ability to resolve the spin state of a single NV using optical pumping and microwave absorption [1]
  - Study the hyperfine interaction
  - Match the number of nuclear interactions with the isotopes' respective spins

[1] J. Applied Physics 123, 161101 (2018)

Ion Implantation

Ion implantation: Method of bombarding the diamond sample [with ^{15}N] to form NV centers

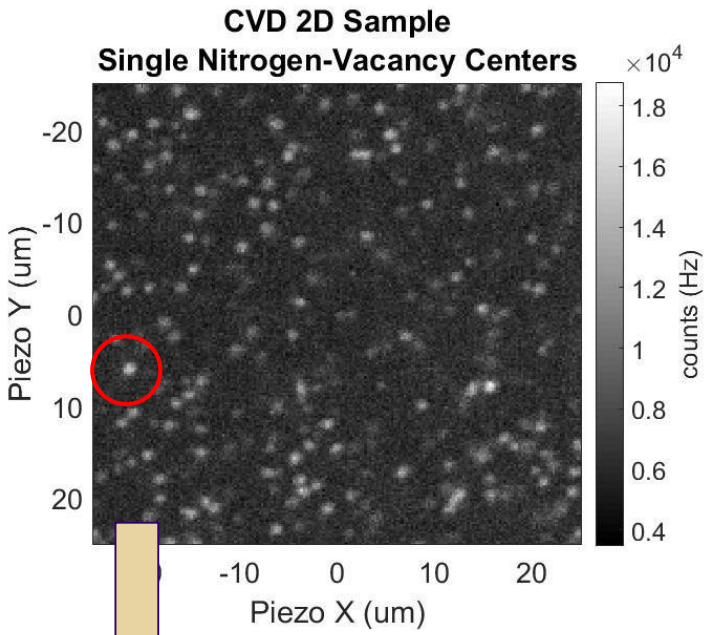
- Pros: Precise control over location of NV centers
- Cons: May damage diamond lattice [2]

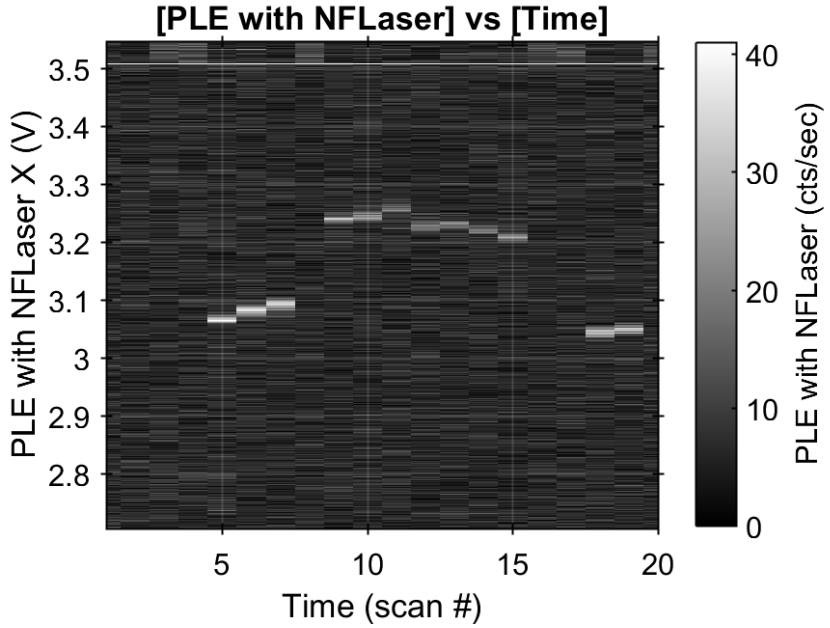


Our project aims to find whether there is a distinct correlation between the NV's method of growth and their amount of spectral diffusion.

[1] S.B. van Dam, et. al. Physical Review B 99,161203 (2019)

Find desired single NV center





Is this NV center ^{15}N or ^{14}N?

Is it a good NV?

Motivation: To identify single nitrogen-vacancy (NV) centers in diamond and determine whether they are naturally grown ^{14}N NV centers or if they are a product of ^{15}N ion implantation. Compare results with photoluminescence excitation (PLE) spectra of each NV center to study if ion implanted NV centers display greater spectral diffusion.

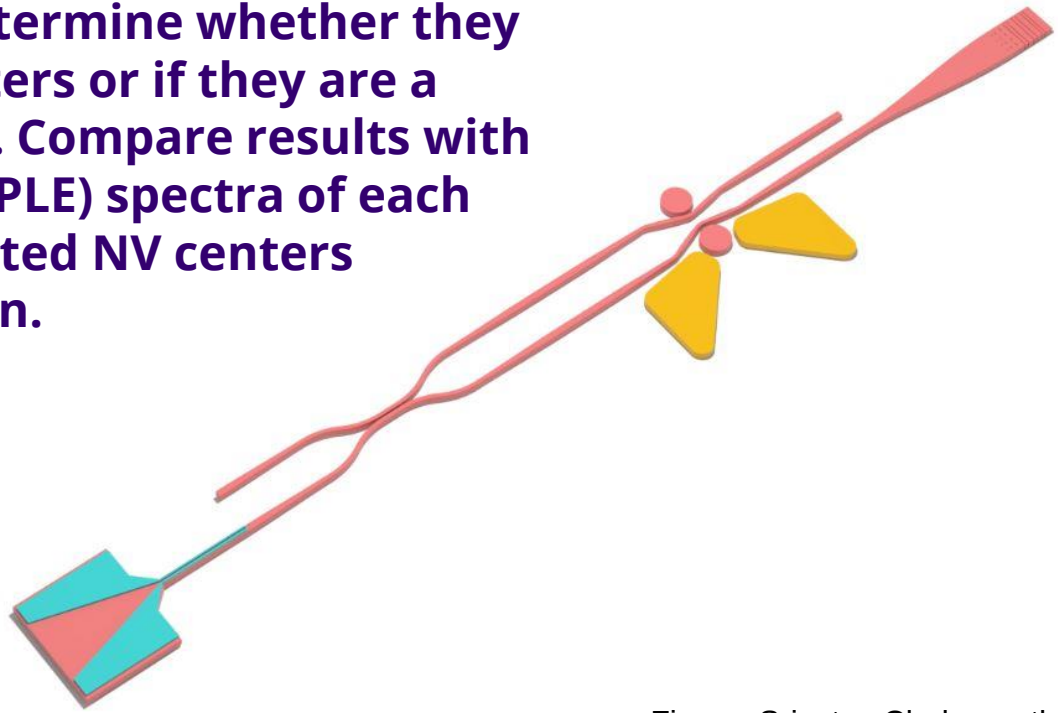
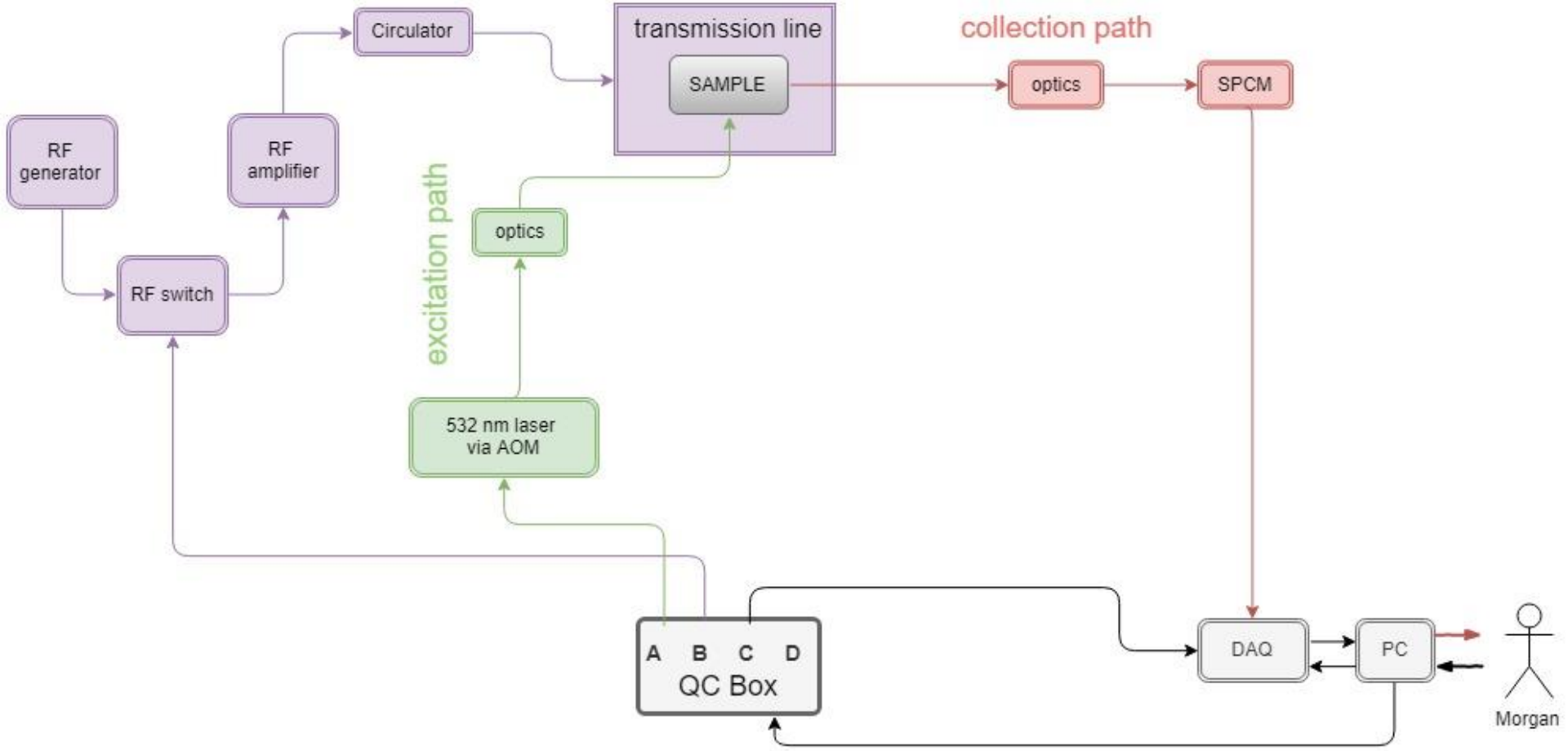


Figure: Srivatsa Chakravarthi

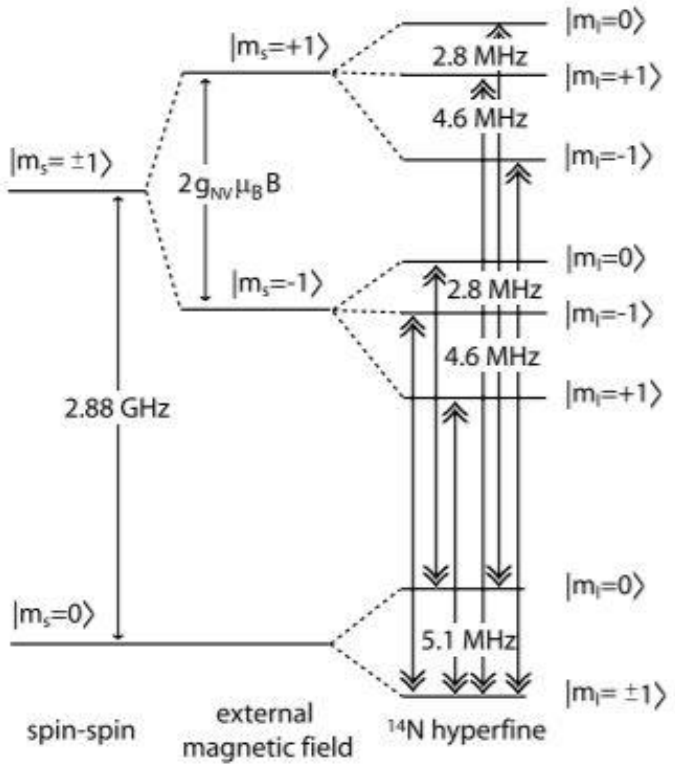
Experimental Setup



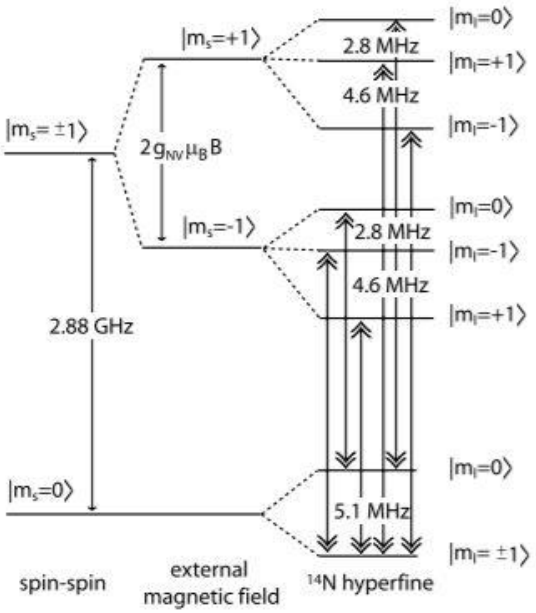
Continuous Wave Optically Detected Magnetic Resonance (CW ODMR)

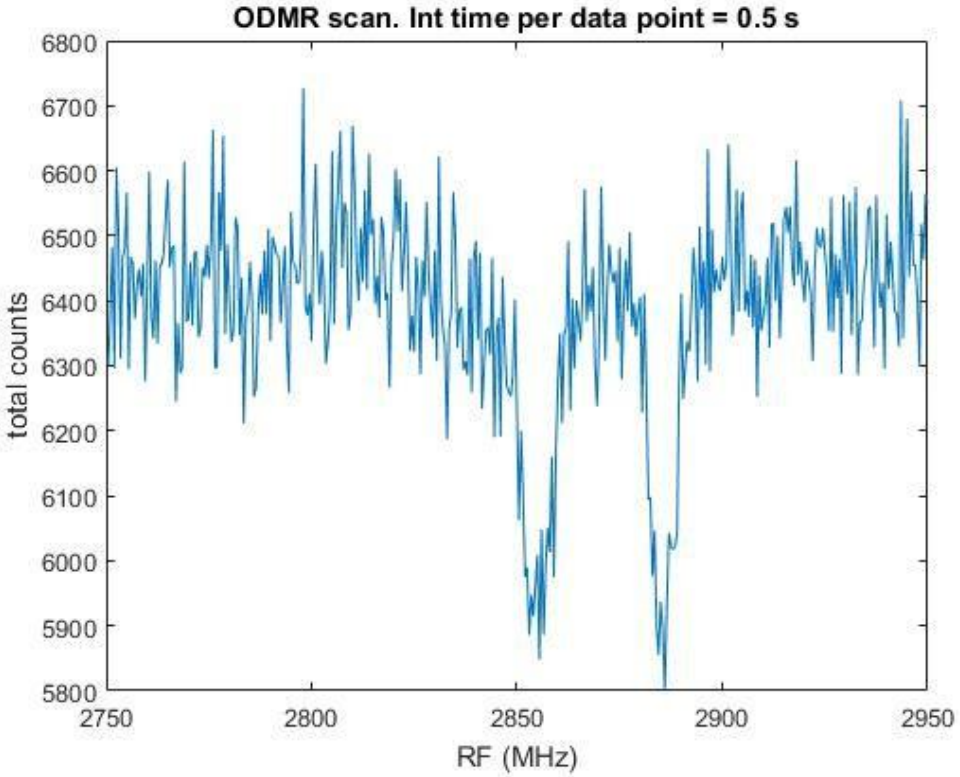
Purpose: Allows us to determine the spin state of the NV center by studying the emitted optical photons.

This it utilized in order to determine the resonant frequency needed to rotate the spin state from the ms = 0 ground state to the excited ms = ± 1 state.

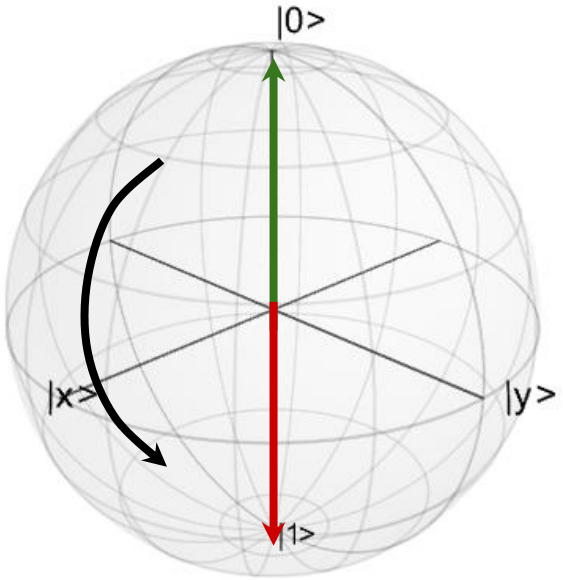


CW ODMR

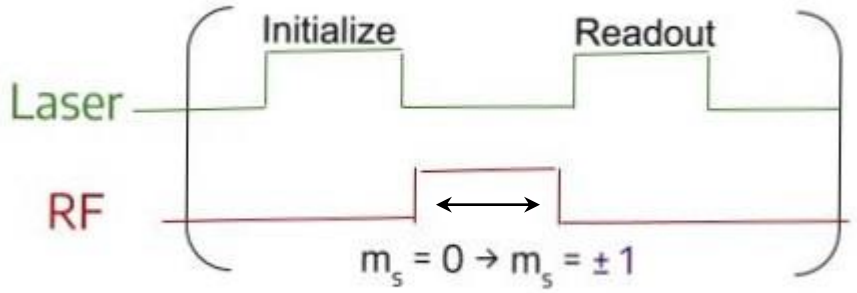




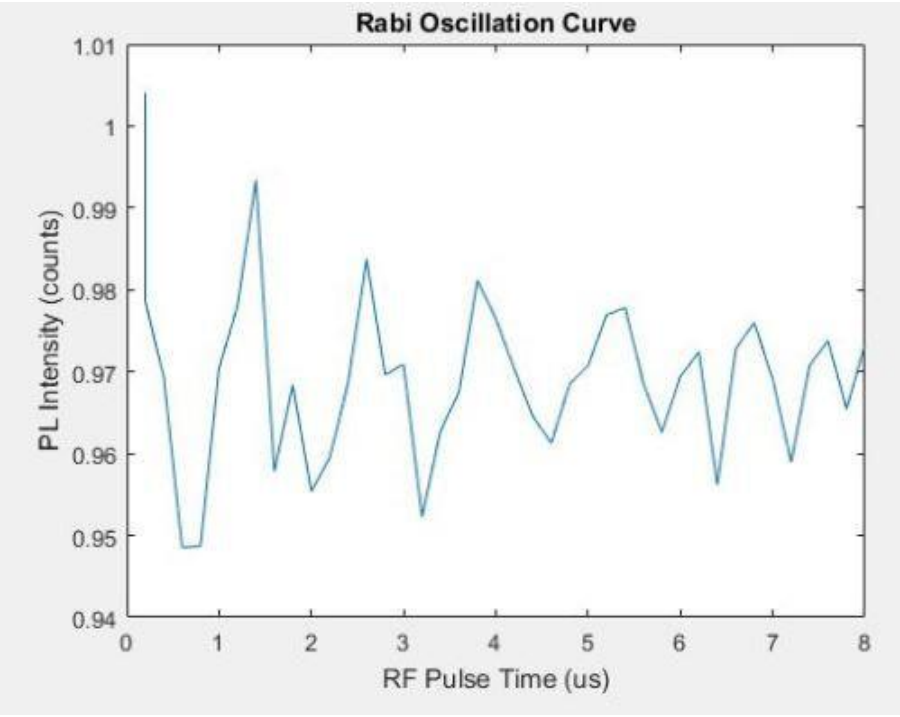
Rabi Oscillations

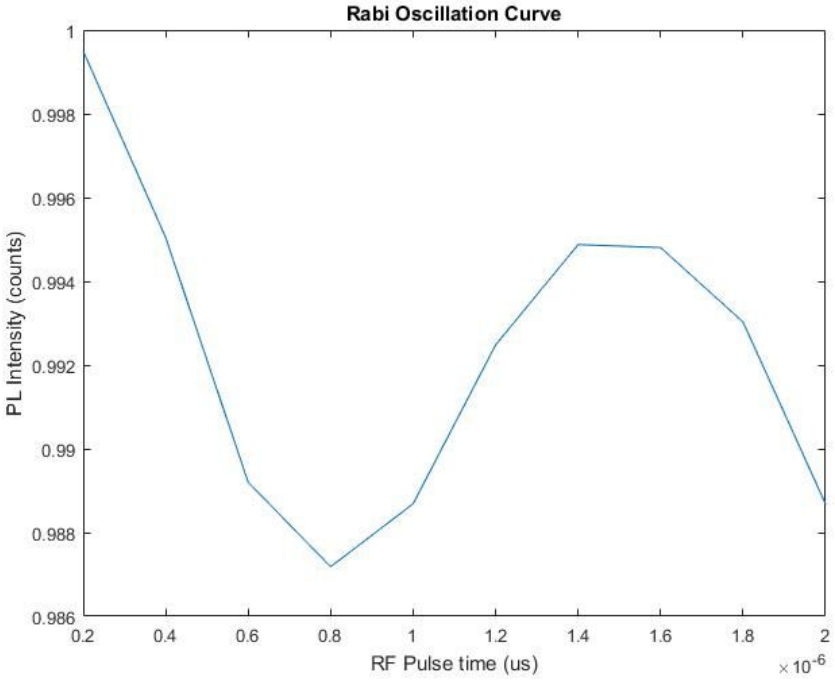


Pulse Sequence

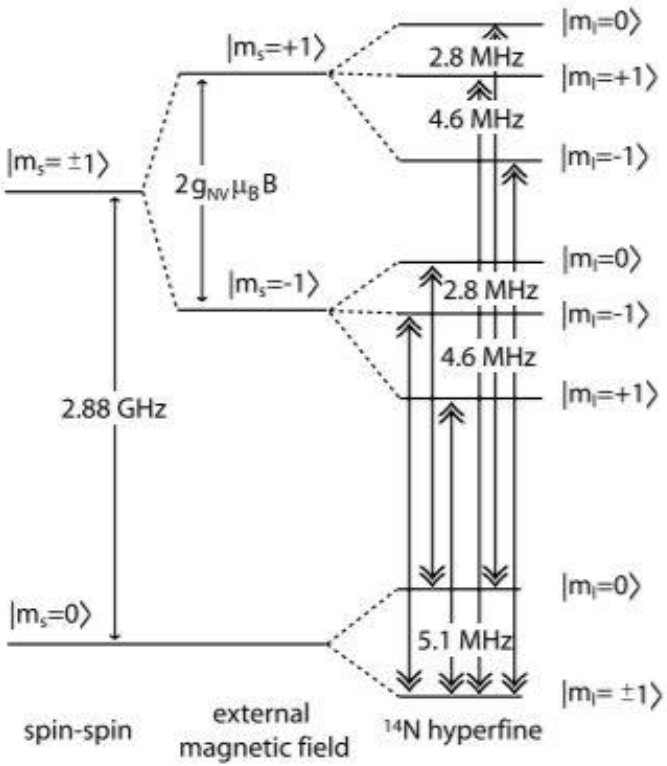


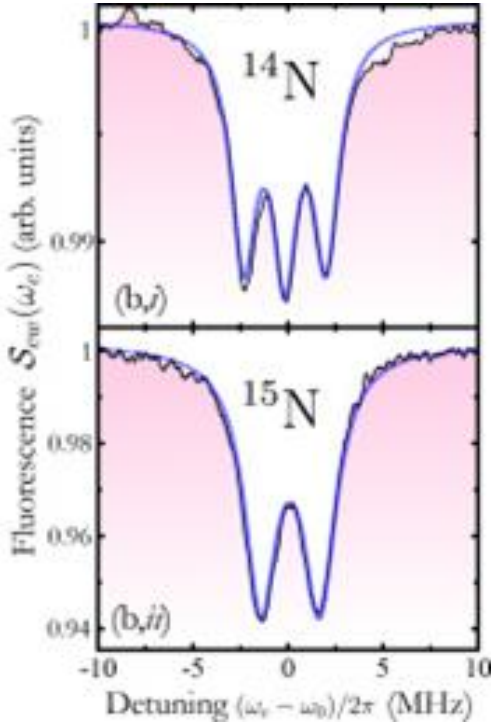
Rabi Oscillation





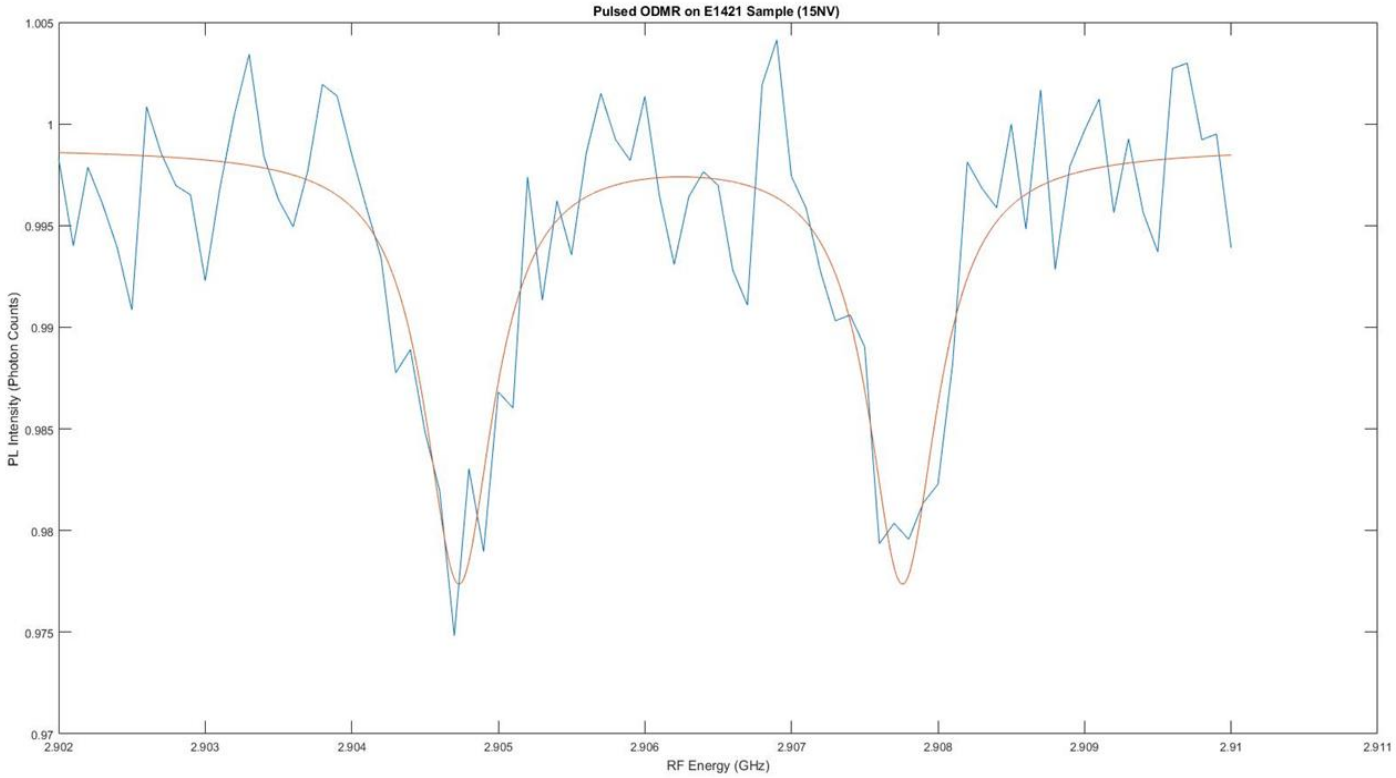
Pulsed Optically Detected Magnetic Resonance (Pulsed ODMR)





V. M. Acosta, et. al. Physical Review B 80,115202 (2009)
Opt. Express **25**, 14809-14821 (2017)

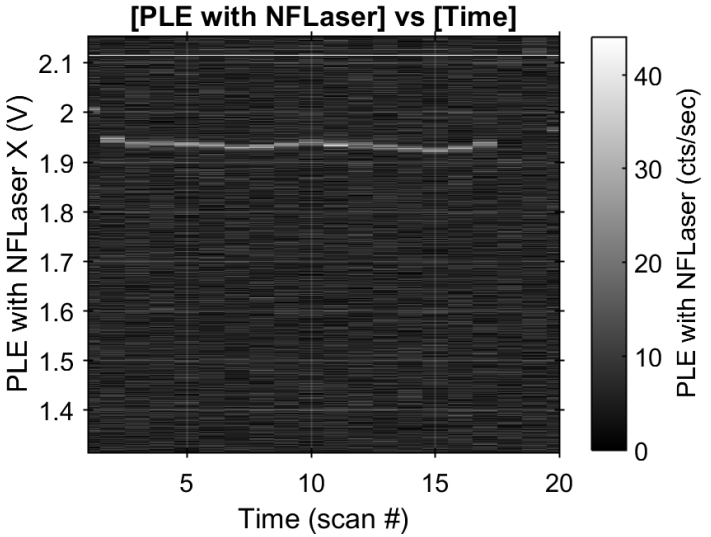
Pulsed ODMR

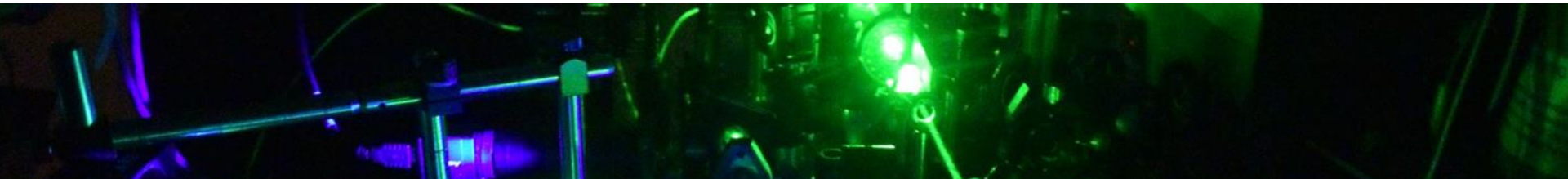

Pulsed ODMR on E1421 Sample (15NV)
PL Intensity (Photon Counts)
RF Energy (GHz)
1.005
1
0.995
0.99
0.985
0.98
0.975
0.97
2.902
2.903
2.904
2.905
2.906
2.907
2.908
2.909
2.91
2.911

Next Steps

Repeat this process for desired single NV samples:

- Locate the desired single NV center on the sample
- Identify isotope using three tests
- Compare with previously taken photoluminescence excitation (PLE) spectra to study the correlation between isotope and amount of spectral diffusion





Acknowledgments

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