# $^3$He Target: EPR Status

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A1n/d2n Collaboration Meeting

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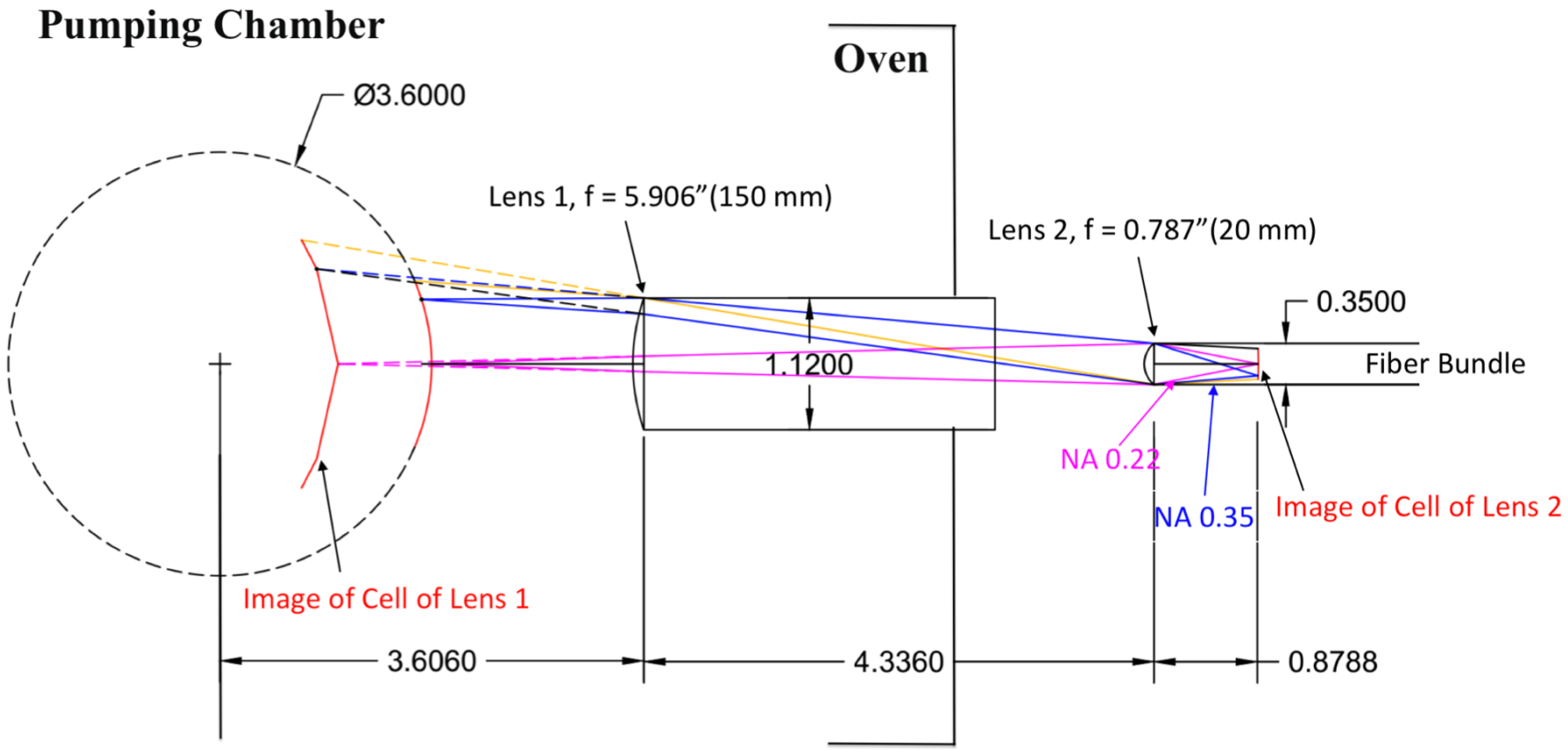
## Outline

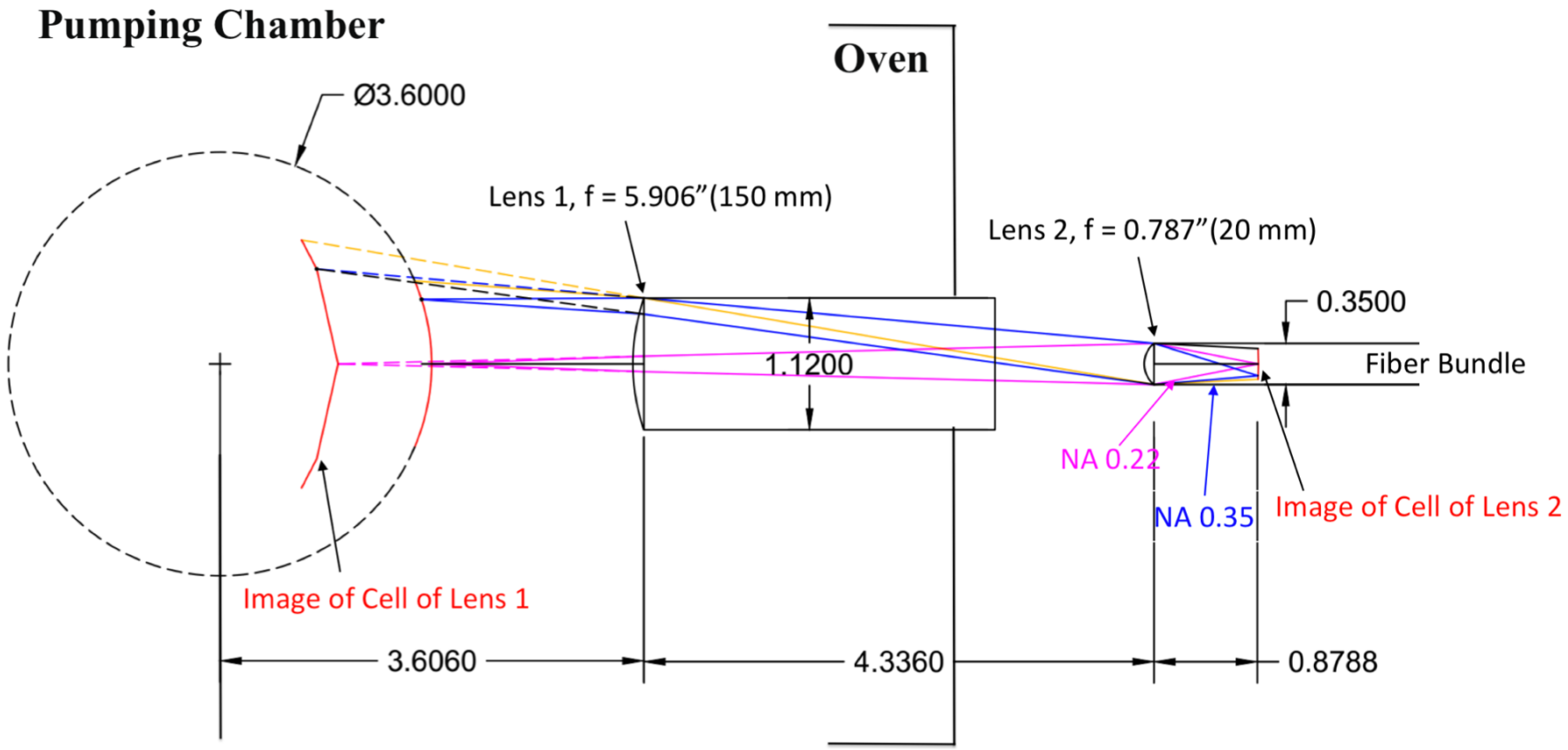
- D2 Light Collection Design
- New EPR Coil Mount for Larger Oven
- EPR Coil Optimization
- To-Do

# D2 Light Collection Design (Raytum Photonics)



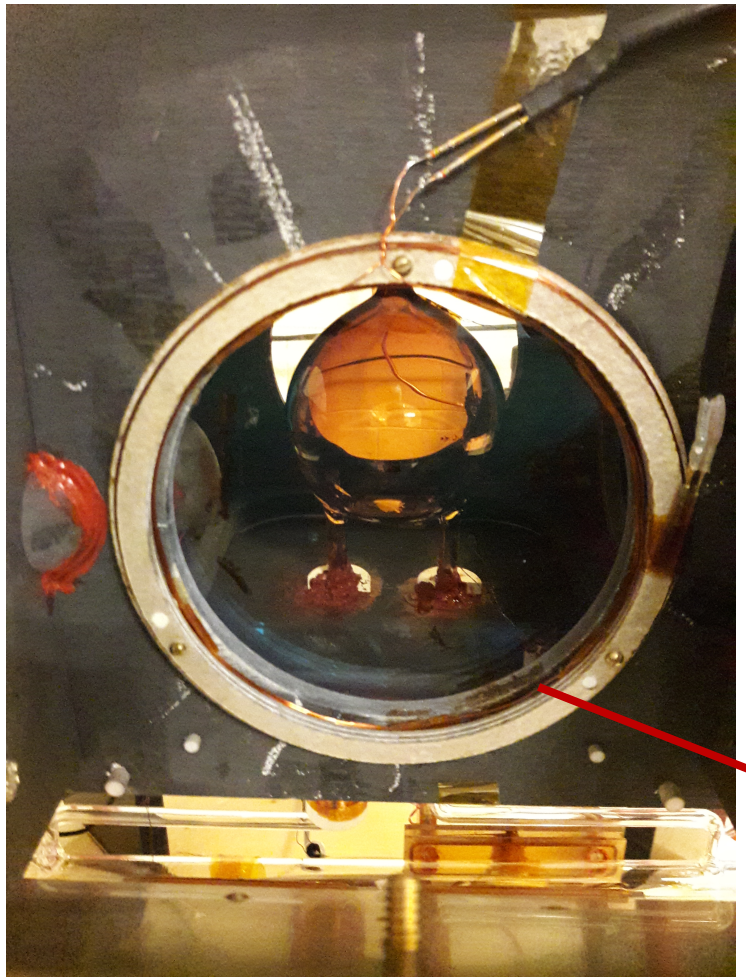

- Current EPR tests have been done with the Photodiode (PD) sitting close to the oven
  - During the actual experiments, the PD will be placed away from the target area ( ~ 4 m) to avoid radiation damage
- The lens system is developed to **maximize fluorescence detection**

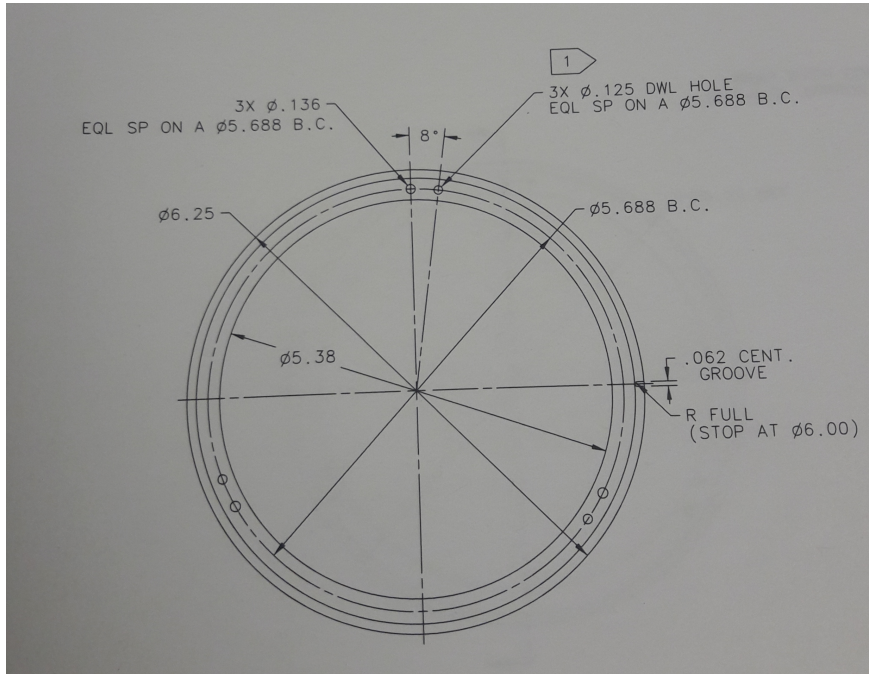
# D2 Light Collection Design (Raytum Photonics)




- Current Pin Photodiode (Newport) has large active area (~ 11mm) but poor responsivity near D2 line (780 nm)
- **Avalanche Photodiode** (Thorlabs) has smaller active area (~ 1 mm), but would **increase responsivity ~ 40x**
  - Another lens will be fabricated at the exit end of the fiber link to focus it onto the APD

# EPR Coil Mount on ~ 5” Oven






- Mount will be modified to include EPR RF coil underneath NMR RF coil (~ 5.38”)

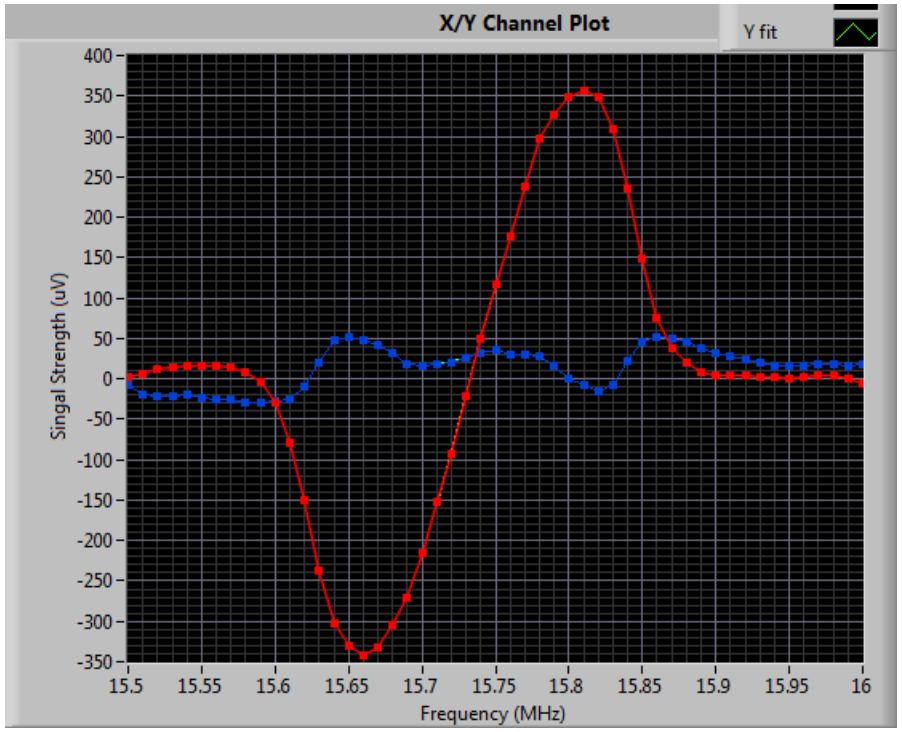
# EPR RF Coil Optimization Studies: Current (mA)

- **Goal**: optimize coil impedance to reach maximum RF signal at the pumping chamber
- Coil diameters vary from 5.125” to 5.375”, made with 24 AWG wire, -5 dBm RF power @ 15.730 MHz

| N (# of turns) | R(Ω) | L(μH) | Current (mA) at RF Gain | | | |
|---|---|---|---|---|---|---|
| | | | 20% | 40% | 60% | 80% |
| **2** | **0.16** | **10.2** | **88** | **152** | **230** | **310** |
| 3 | 0.18 | 12.1 | 86 | 146 | 220 | 300 |
| 4 | 0.23 | 14.4 | 84 | 144 | 216 | 292 |
| 5 | 0.28 | 18.2 | 78 | 140 | 212 | 288 |
| 6 | 0.32 | 22 | 84 | 140 | 208 | 286 |
| 7 | 0.38 | 25.8 | 76 | 130 | 194 | 264 |
| 9 | 0.47 | 36.4 | 78 | 134 | 198 | 272 |
| 12 | 0.77 | 54.4 | 78 | 132 | 198 | 268 |
| 18 | 1.04 | 110.4 | 78 | 130 | 194 | 264 |
| 30 | 1.13 | 264 | 84 | 138 | 206 | 276 |

# EPR RF Coil Optimization Studies: Amplitude (μV)

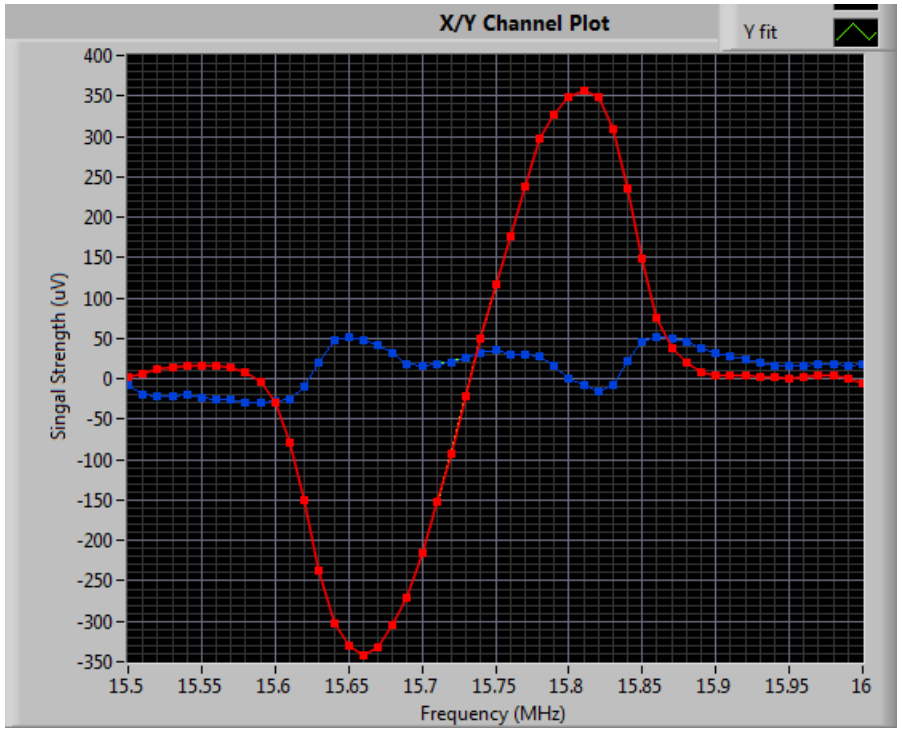
- **Goal**: optimize coil impedance to reach maximum RF signal at the pumping chamber
- Corresponding EPR FM sweeps: -5 dBm RF power, 1 mV lock-in sensitivity (N = 2 below)




| N (# of turns) | R(Ω) | L(μH) | Signal Strength (uV) at RF Gain | | | |
|---|---|---|---|---|---|---|
| | | | 20% | 40% | 60% | 80% |
| 1 | 0.13 | 9 | 74 | 225 | 300 | 354 |
| **2** | 0.16 | 10.2 | **90** | **240** | **330** | **350** |
| 3 | 0.18 | 12.1 | 50 | 140 | 250 | 300 |
| 4 | 0.23 | 14.4 | 40 | 68 | 140 | 225 |
| 5 | 0.28 | 18.2 | 18 | 23 | 60 | 110 |
| 6 | 0.32 | 22 | 25 | 30 | 64 | 115 |

# EPR RF Coil Optimization Studies: Slope (μV/kHz)

- **Goal**: optimize coil impedance to reach maximum RF signal at the pumping chamber
- Corresponding EPR FM sweeps: -5 dBm RF power, 1 mV lock-in sensitivity (N = 2 below)



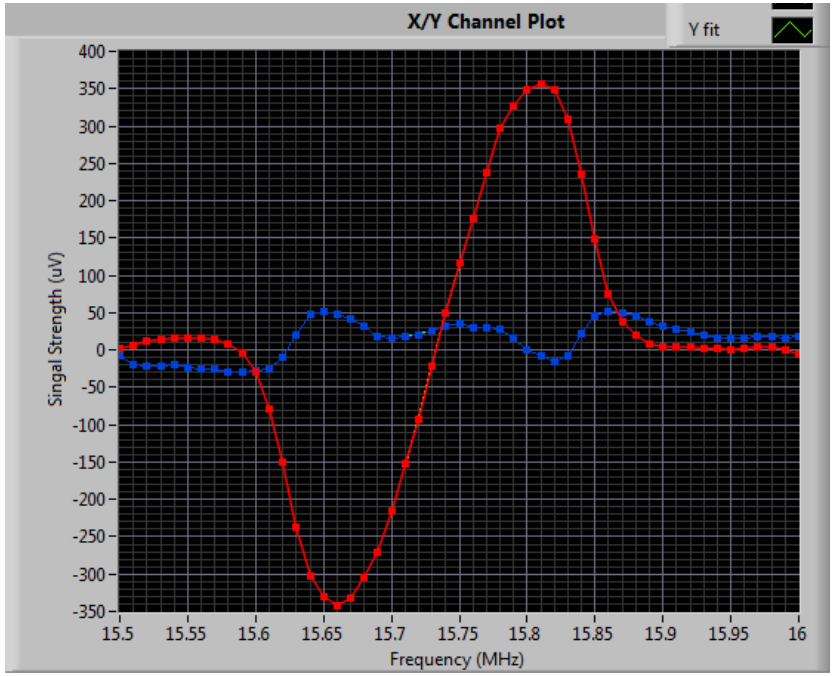

| N (# of turns) | R(Ω) | L(μH) | Slope (μV/kHz) at RF Gain | | | |
|---|---|---|---|---|---|---|
| | | | 20% | 40% | 60% | 80% |
| 1 | 0.13 | 0.46 | 0.94 | 3.64 | 5.96 | 7.4 |
| **2** | **0.16** | **1.84** | **1.08** | **4.18** | **6.06** | **6.84** |
| 3 | 0.18 | 3.9 | 1.04 | 1.96 | 4.62 | 5.97 |
| 4 | 0.23 | 6.6 | 0.36 | 0.64 | 1.66 | 3.76 |
| 5 | 0.28 | 9.8 | 0.31 | 0.25 | 0.69 | 1.33 |
| 6 | 0.32 | 13.6 | 0.41 | 0.48 | 0.65 | 1.63 |

# EPR RF Coil Optimization Studies

- Corresponding EPR FM sweeps: -5 dBm RF power, 1 mV lock-in sensitivity

✗ Greater-turn coils produce poor FM spectra (N = 30 right)

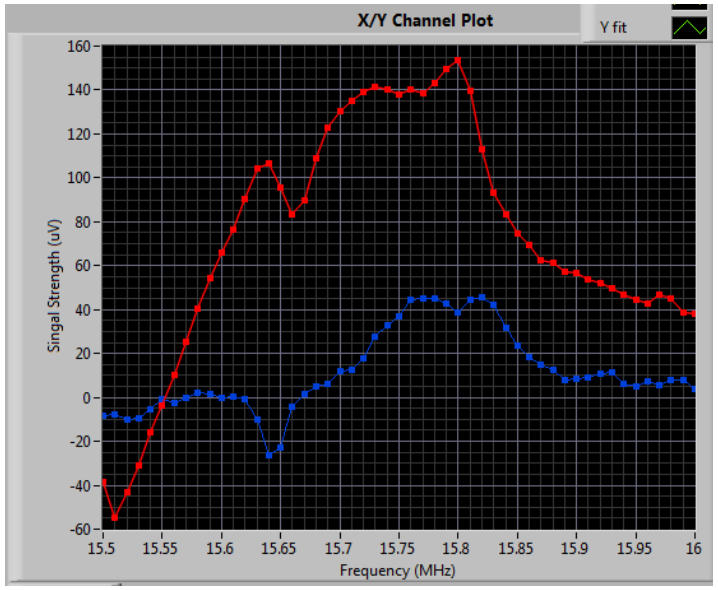
✓ Fewer-turn coils (N=2 in this study, N = 4 found by Kai) confirmed to perform best



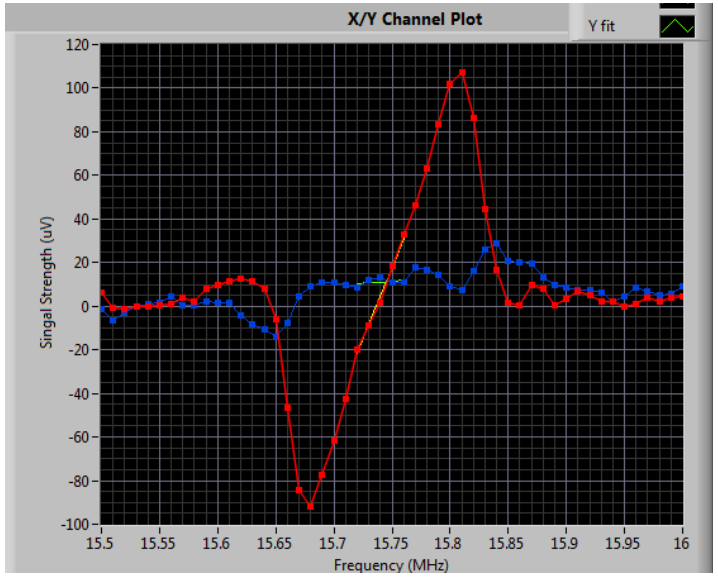

✓ Greatest **current**

✓ Greatest **amplitude**

✓ Greatest **slope** (vs. background)

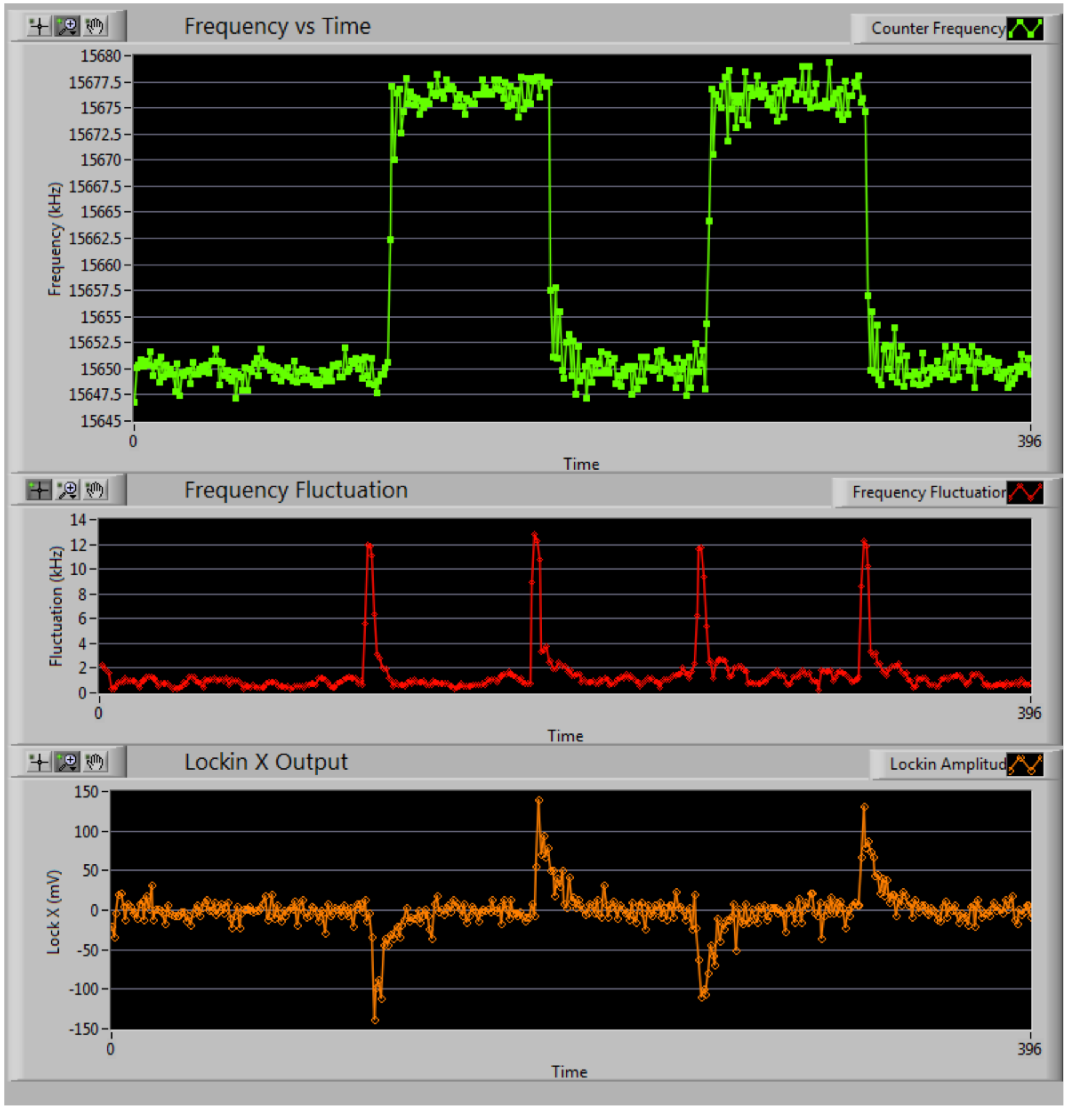



N=30 (above) and N = 5 (below)



# TO-DO

- Test Avalanche Photodiode with current setup
- Test coils with new mount and completed fiber bundle with APD to choose the optimal one
  - Clear FM sweep (lock to resonant frequency)
  - Clear EPR-AFP (at both low and high $^3$He polarization)
- Optimize EPR-AFP
  - EPR coil noise currently at ~ 5 kHz (too high)
  - Study polarization loss
- Goal is to finalize EPR by the end of January, 2019



# Thank you!