



S&T Campaign: Materials Research
Photonics
Quantum Information Science

Elizabeth Goldschmidt
(301) 394-3434
elizabeth.a.goldschmidt2.civ@mail.mil



Objective: Quantum information with rare-earth atoms in solids

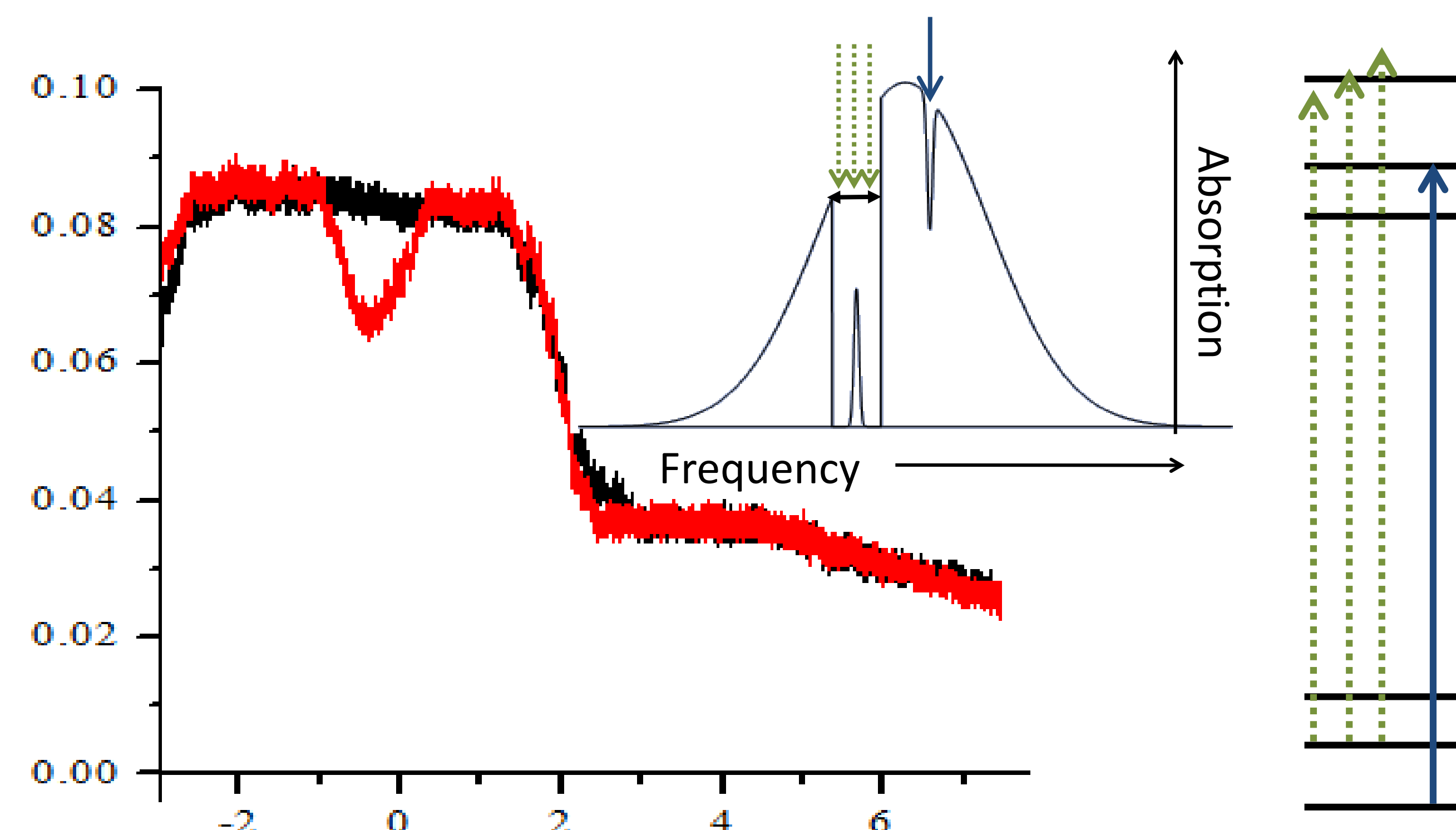
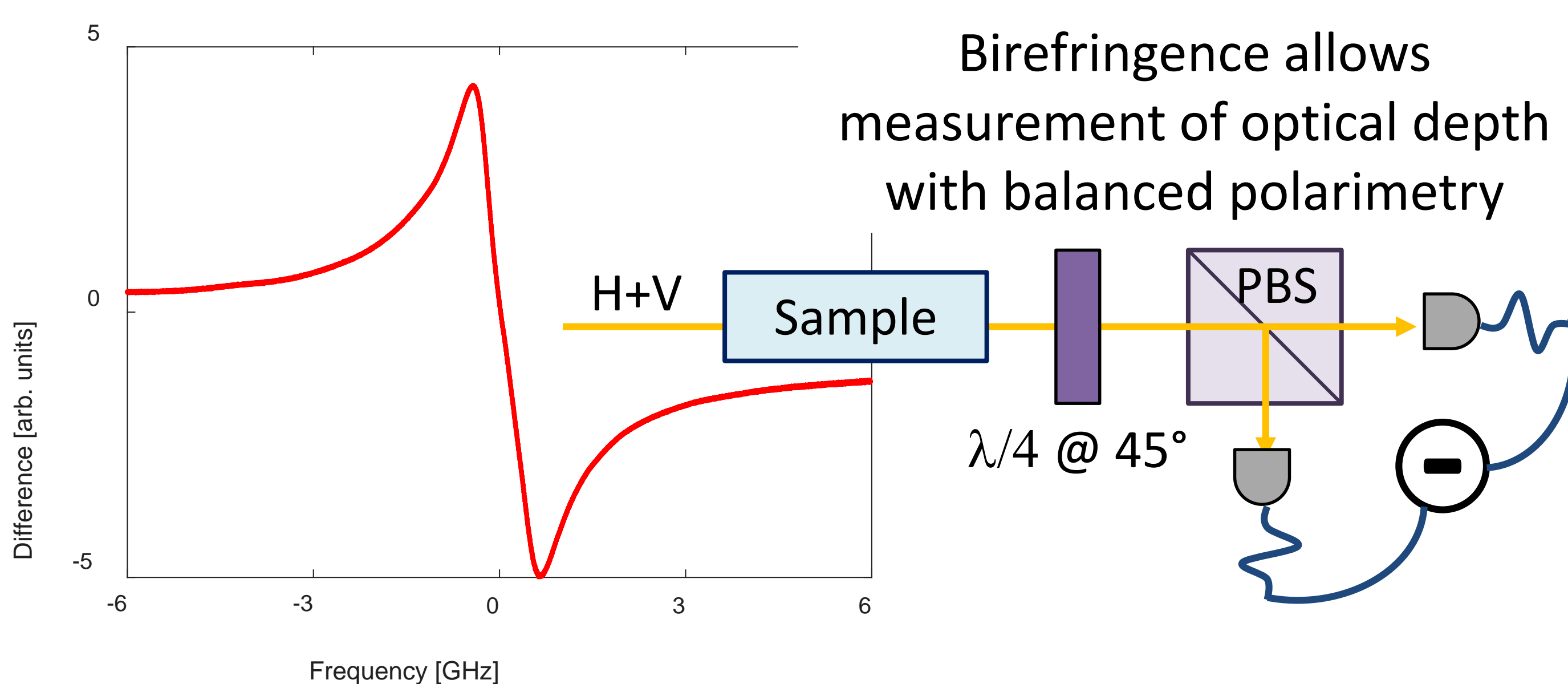
- Promising platform for photonic quantum networks and quantum information processing.
- “Frozen gas” of atoms at 4 K.
- Long-lived qubits/memory – long optical (~ms) and spin (up to hours) T_2 , no motional dephasing.
- Efficient and broadband memory – high optical depth over a large bandwidth.
- Atom-atom interactions – electric and magnetic dipole
- Inhomogeneous broadening limits protocols in doped samples.

Approach: Stoichiometric crystals

- Collaborators at the Australian National University demonstrated small inhomogeneity in-house grown stoichiometric europium [PRL 117, 250504 (2016)].
- Extremely high optical depth (10^{22} cm⁻³ Eu density).
- Small inhomogeneity due to low disorder.

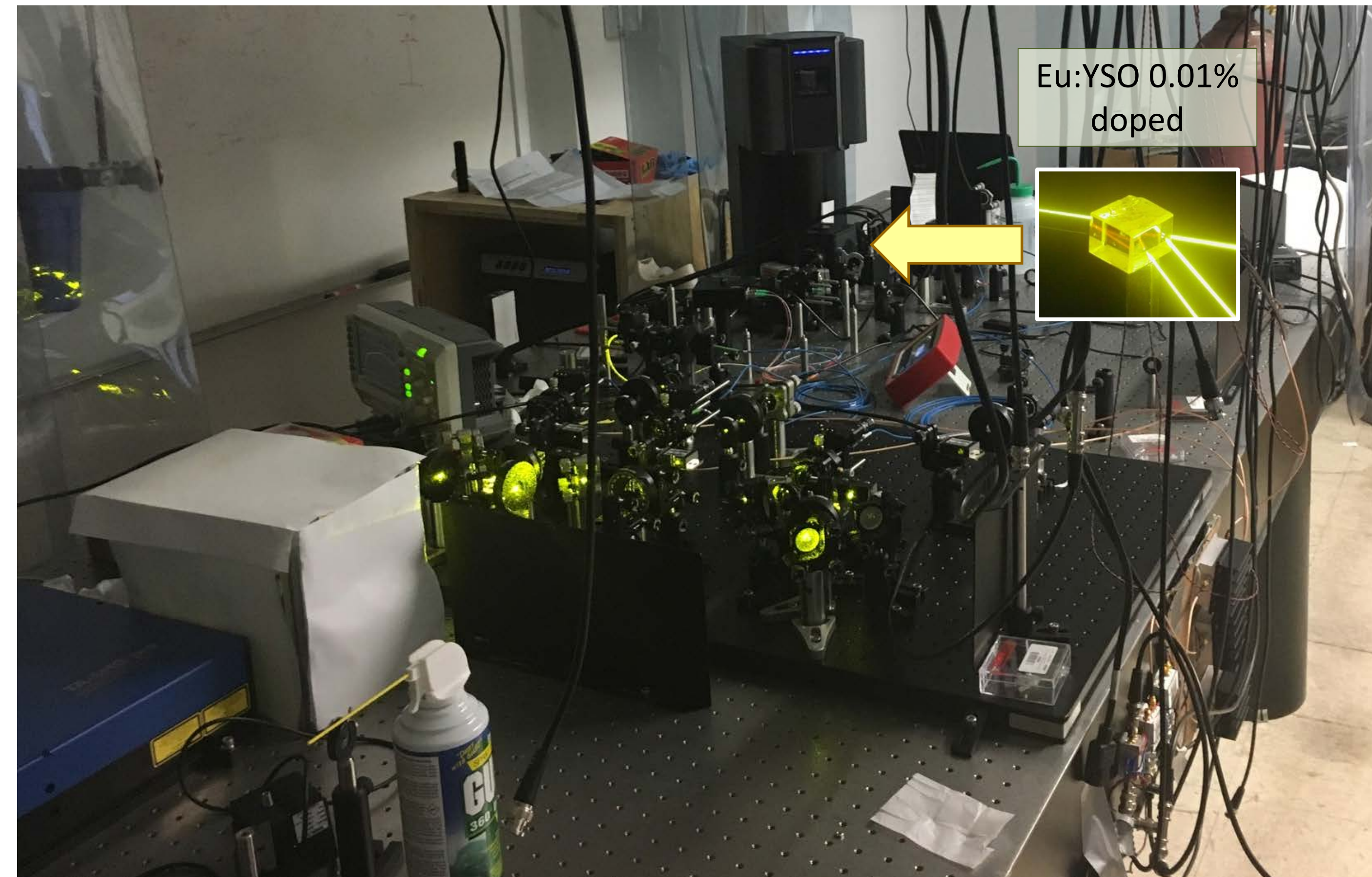
Initial results: Optical pumping/spectral hole-burning

- Optical pumping to initialize spin state population will be difficult in high optical depth sample – initial studies in “low” optical depth doped sample.



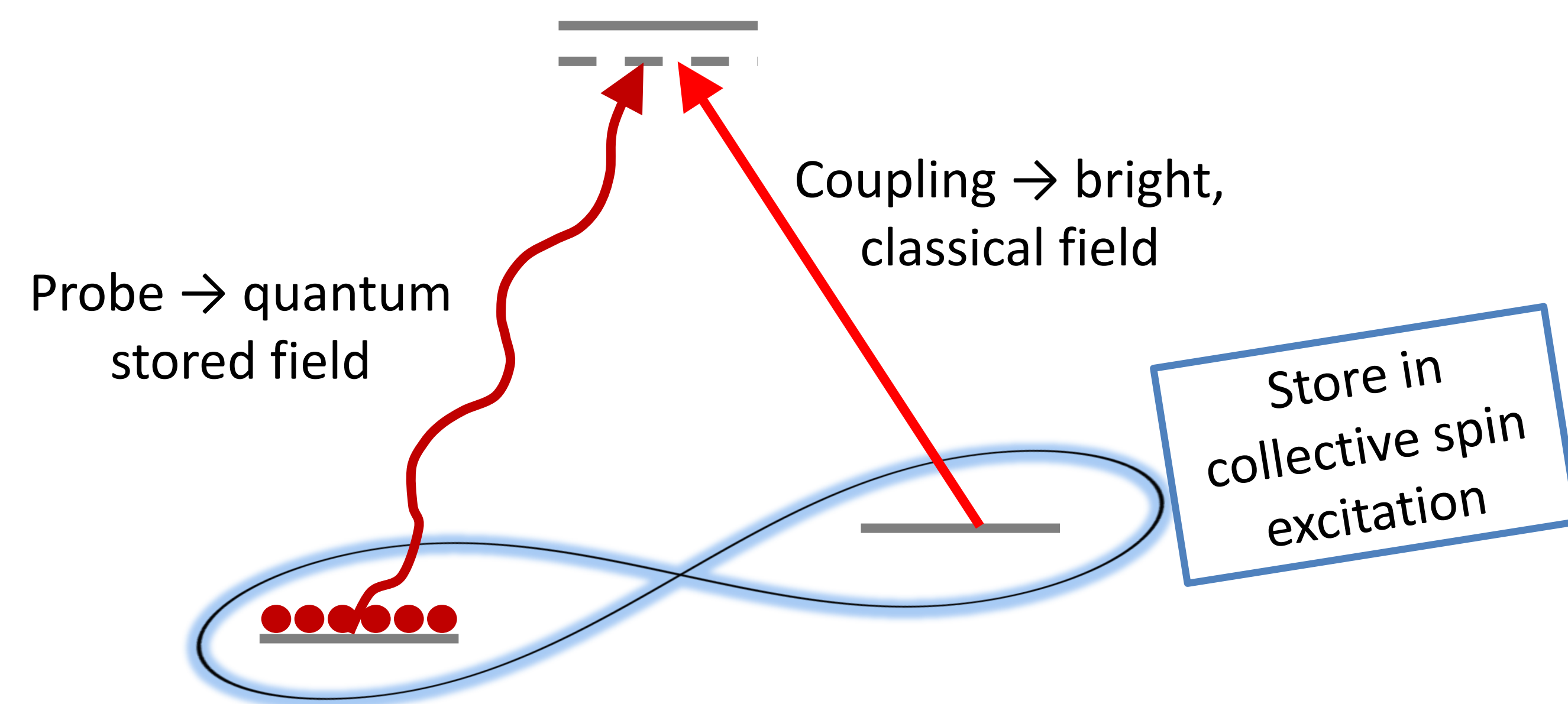
Initial laboratory setup

- Stabilized doubled diode laser to produce 580 nm light, closed-cycle cryostat to achieve 4 K temperatures.
- Doped sample currently under investigation to build and test optical addressing and readout.



Path forward: Experimental plans

- Raman quantum memory: optical spin polarization and high optical depth required for broadband spin state storage should be achievable in stoichiometric sample.



ARL Facilities and Capabilities to Support Collaborative Research

- Expertise in solid-state atomic dopants and quantum memory

Complementary Expertise / Facilities / Capabilities Sought in Collaboration

- Quantum information in rare-earth solids is a rapidly growing field and we are interested in collaboration
- Materials science: many possible hosts for rare-earth atoms that could allow interesting capabilities