

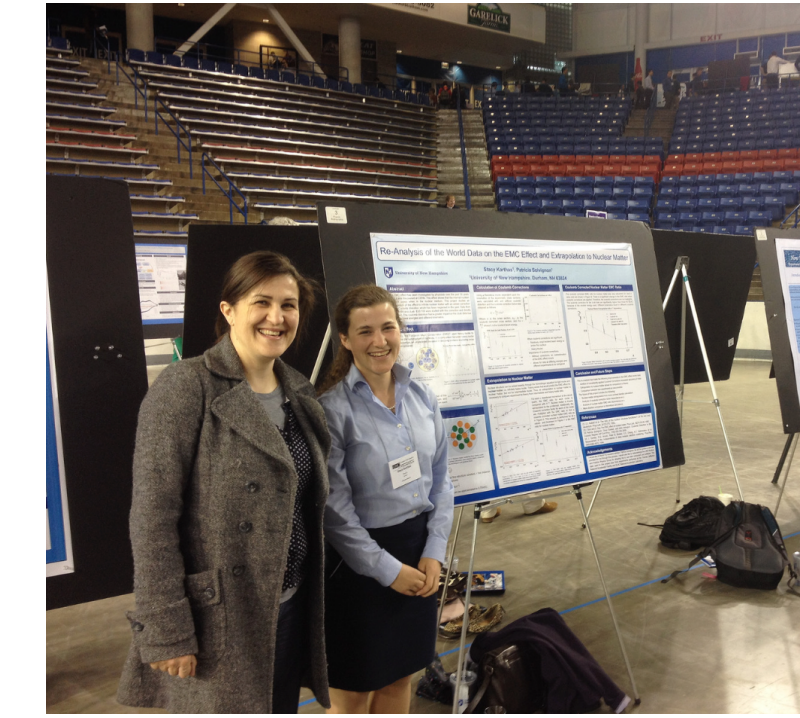
DYNAMIC NUCLEAR POLARIZATION AT UNH



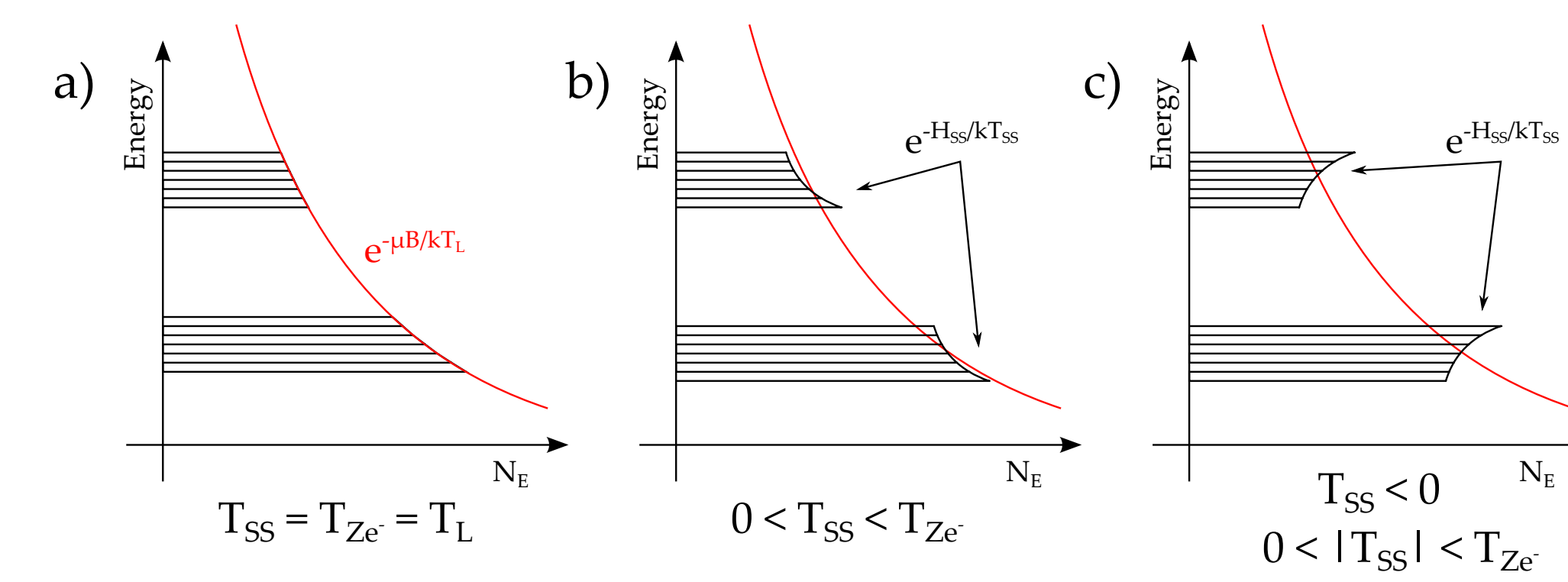
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Abstract

The University of New Hampshire (UNH) is developing a Dynamic Nuclear Polarization (DNP) system in order to produce polarized targets. Currently, the subsystems that compound the DNP system are as follows, i) the magnet subsystem is able to achieve up to 7 Tesla with the superconducting magnet; ii) the helium refrigerator subsystem is able to cool down to 1 K a horizontal fridge. Furthermore, the construction process of a vertical fridge for the superconducting magnet has started; iii) the Nuclear Magnetic Resonance (NMR) subsystem is able to read the crystal oscillator signal; and iv) the microwave subsystem will be the next stage of the construction process. Therefore, the status of the subsystems that compound the DNP system at UNH is presented.



Equal spin temperature theory



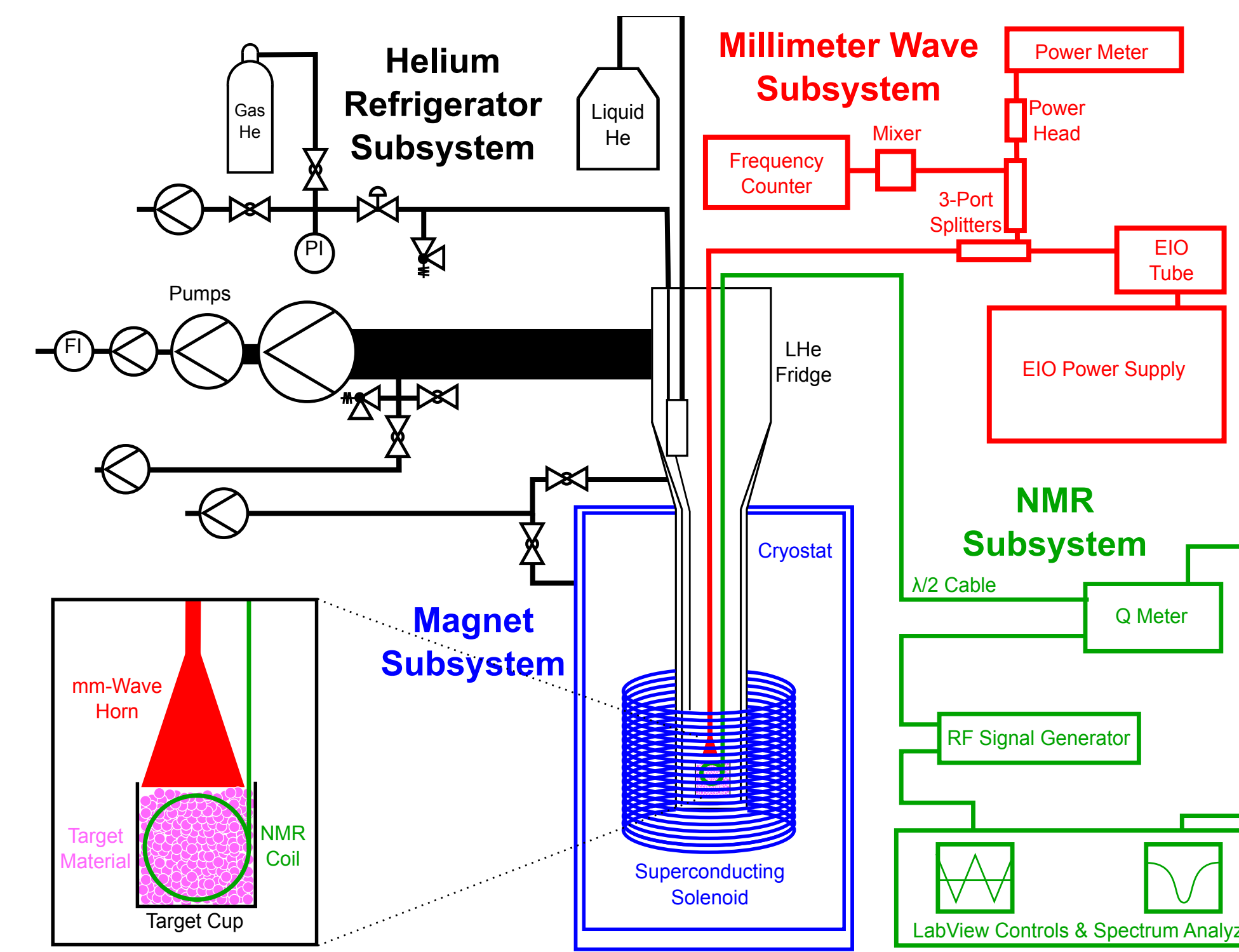
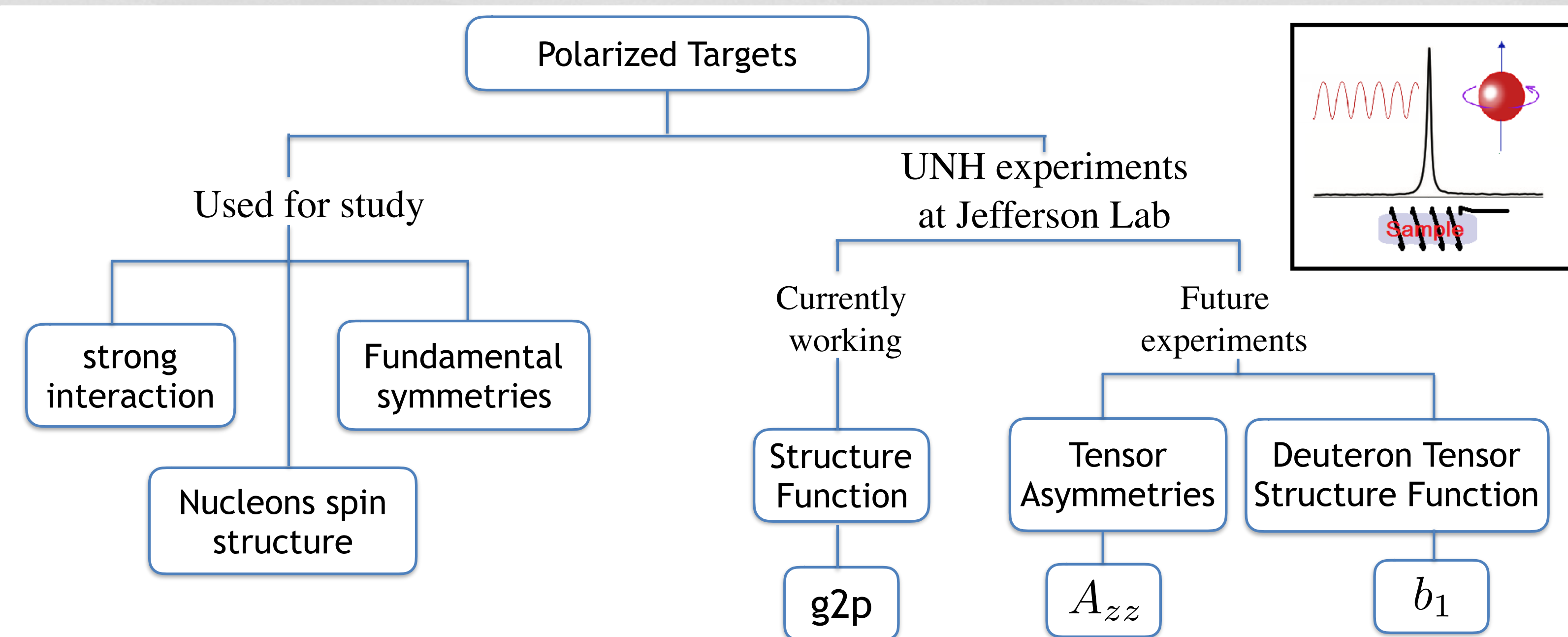
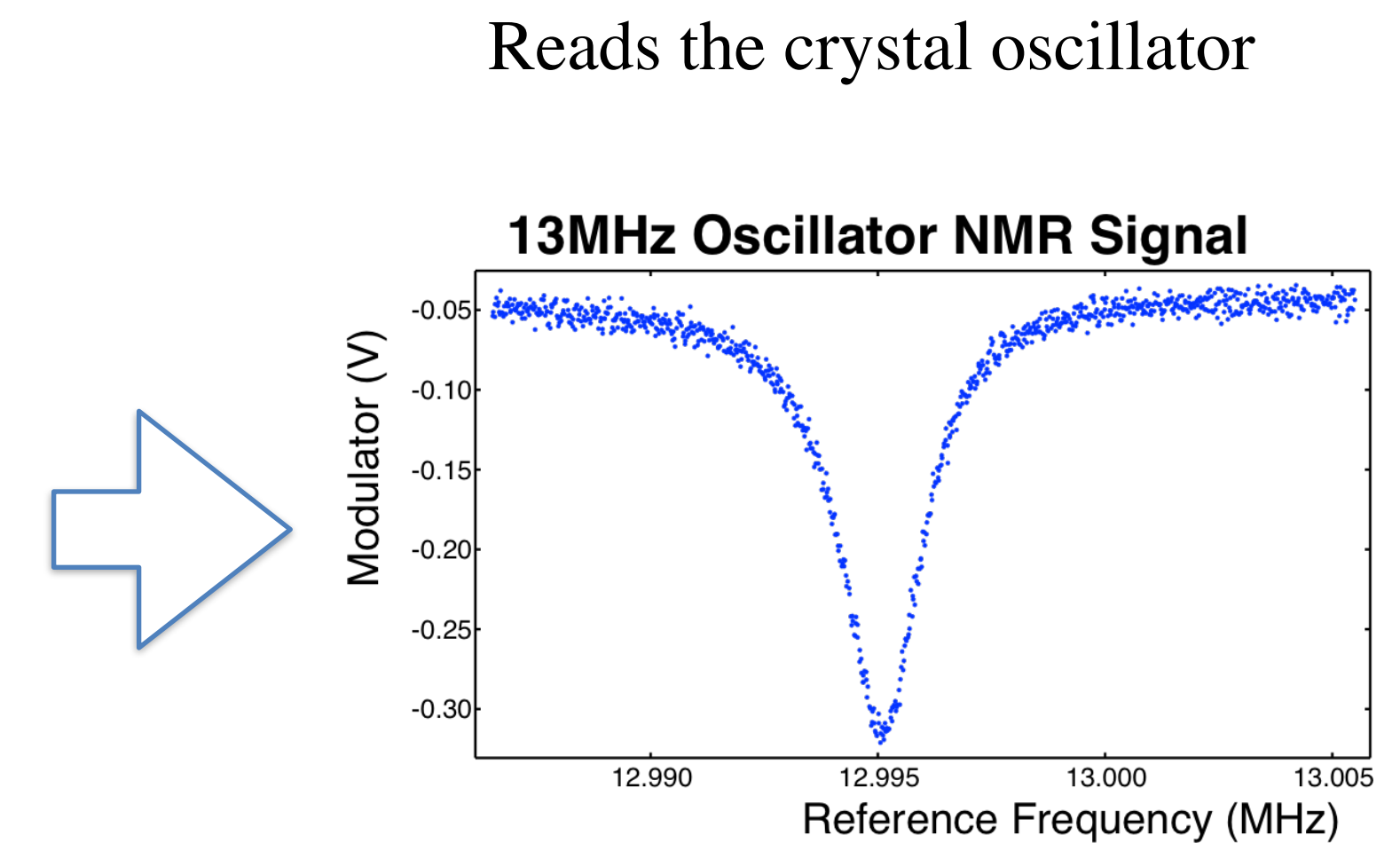
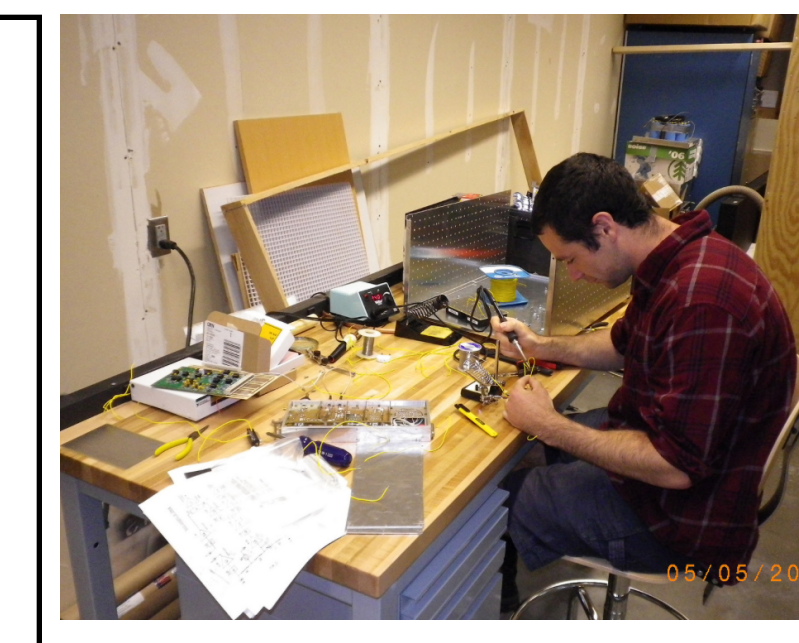
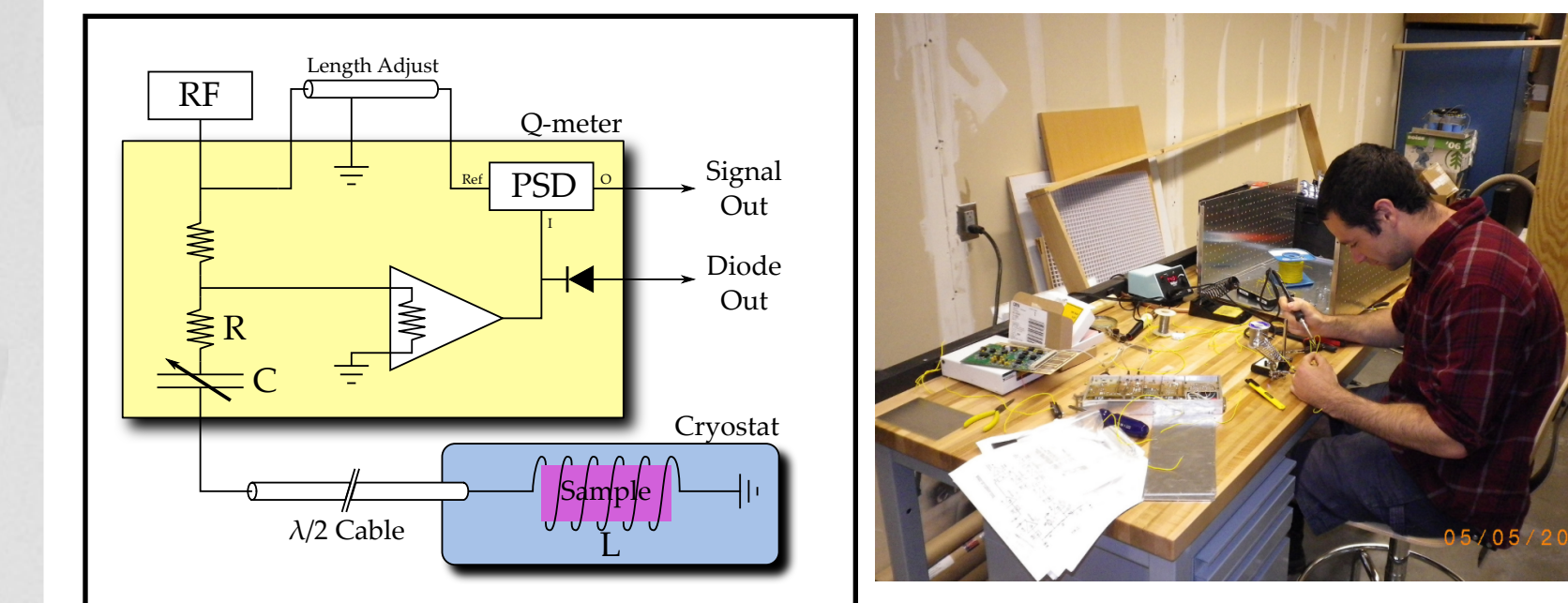
a) thermal equilibrium, b) and c) cooling and heating the system with microwaves [1], [2].

interactions of the electron spins cannot be ignored.

Zeeman and dipole-dipole interactions are reservoirs with different temperatures.

- T_{SS} electron spin-spin interaction reservoir.
- T_{Ze} electron Zeeman reservoir.
- T_{Zp} proton Zeeman reservoir.
- T_L Lattice temperature.

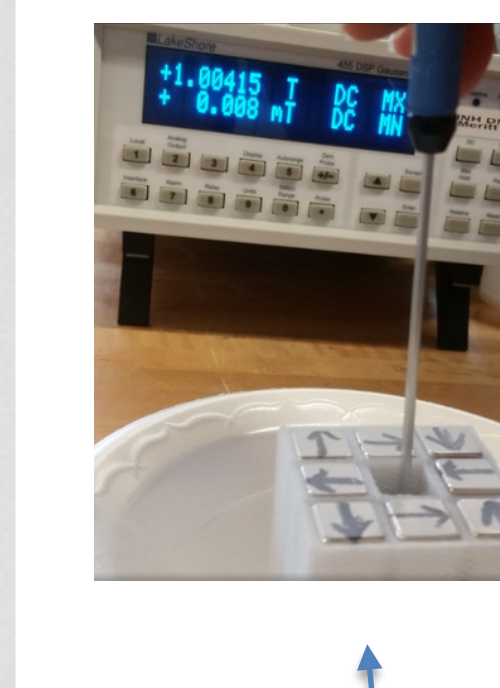
NMR



Subsystems required for DNP

- Helium Refrigerator ~ Low T
- Superconducting Magnet ~ High B
- Microwaves
- Nuclear Magnetic Resonance (NMR) ~ Measure the polarization
- Suitable target material

Finding the Proton signal

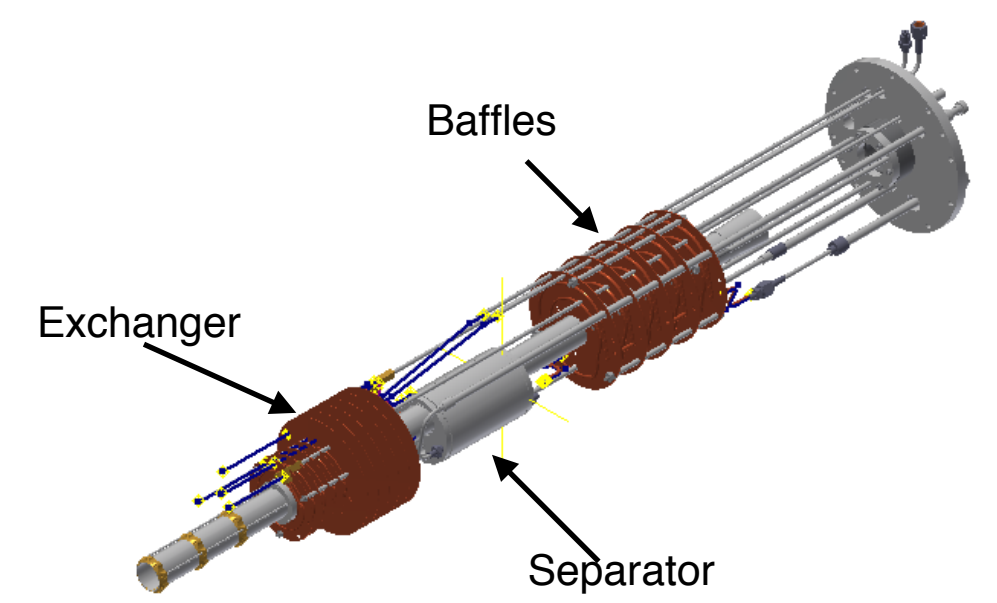


Yale card

Lock in amplifier

In progress

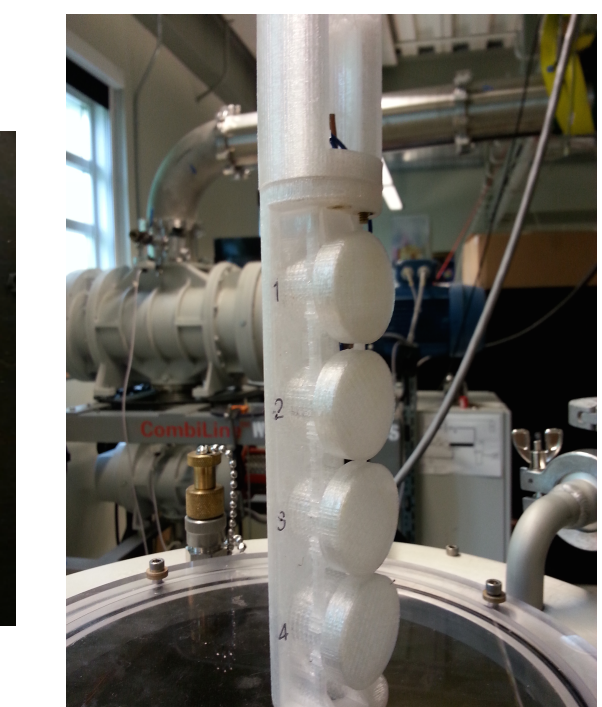
New vertical fridge for the superconducting magnet



Original design Chris Keith and Dave Meekins from Jefferson Lab.

3D printing lab equipment

Magnets in a Halbach array



Target insert

Thermal Equilibrium Polarization

B constant
T constant

Starting with...

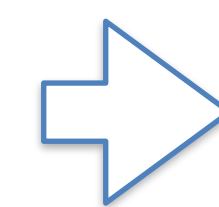
Spin 1/2 Proton
$$P(1/2) = \tanh\left(\frac{g\mu_p B}{2k_B T}\right)$$

B Magnetic Field
T Temperature
 μ Magnetic Moment
 k_B Boltzmann Constant
g factor

Deuteron Spin 1
$$P(1) = \frac{4 \tanh\left(\frac{g_d \mu_d B}{2k_B T}\right)}{3 + \tanh^2\left(\frac{g_d \mu_d B}{2k_B T}\right)}$$

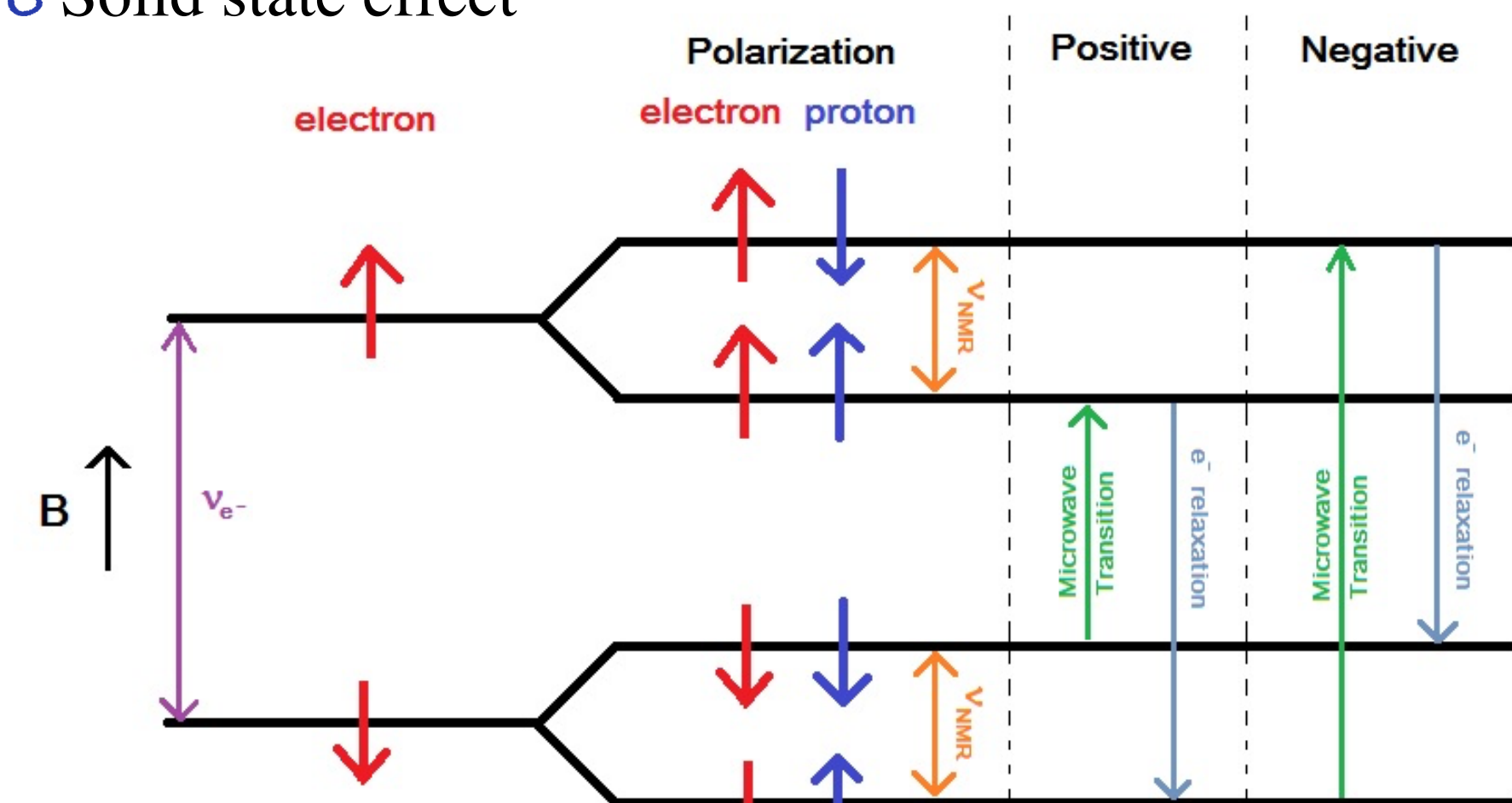
$\mu_p = 1.410606743(33) \times 10^{-26} \text{ JT}^{-1}$
 $\mu_d = 0.430735040 \times 10^{-26} \text{ JT}^{-1}$

Very low polarization due to low magnetic moment



Solid state effect

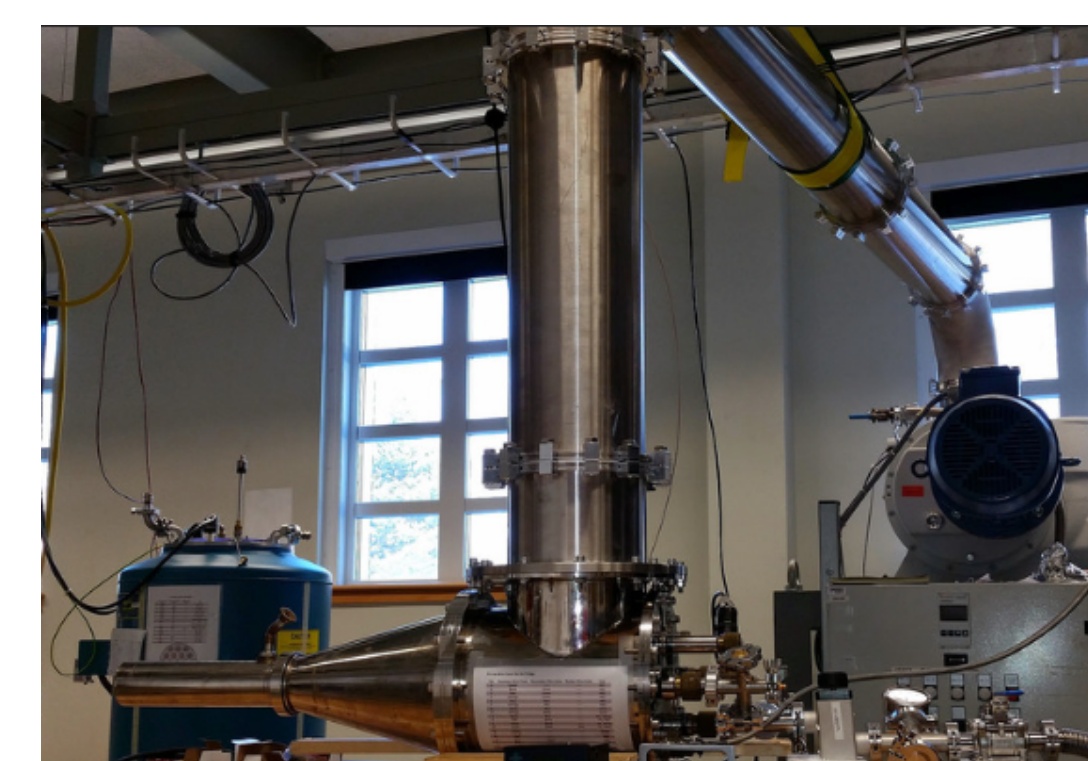
Adding microwaves...



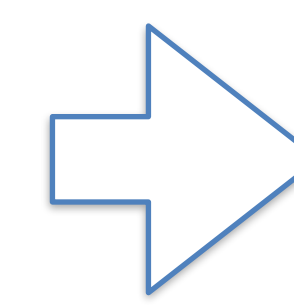
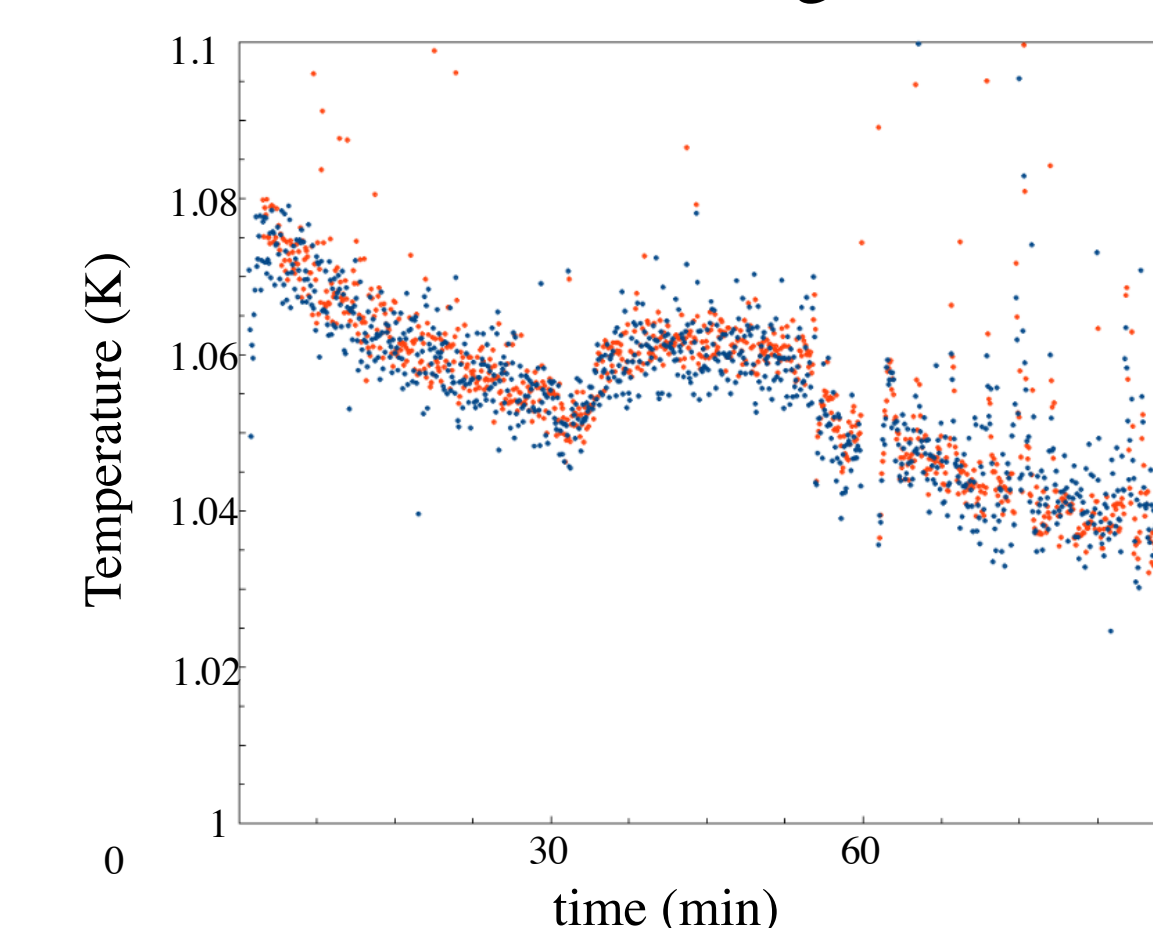
Microwaves drive electron-proton transitions [2]. Electrons relax faster than the protons to the lower energy state. They can be used to polarize other protons. This approximation neglect spin-spin interaction of the electrons.

Currently working

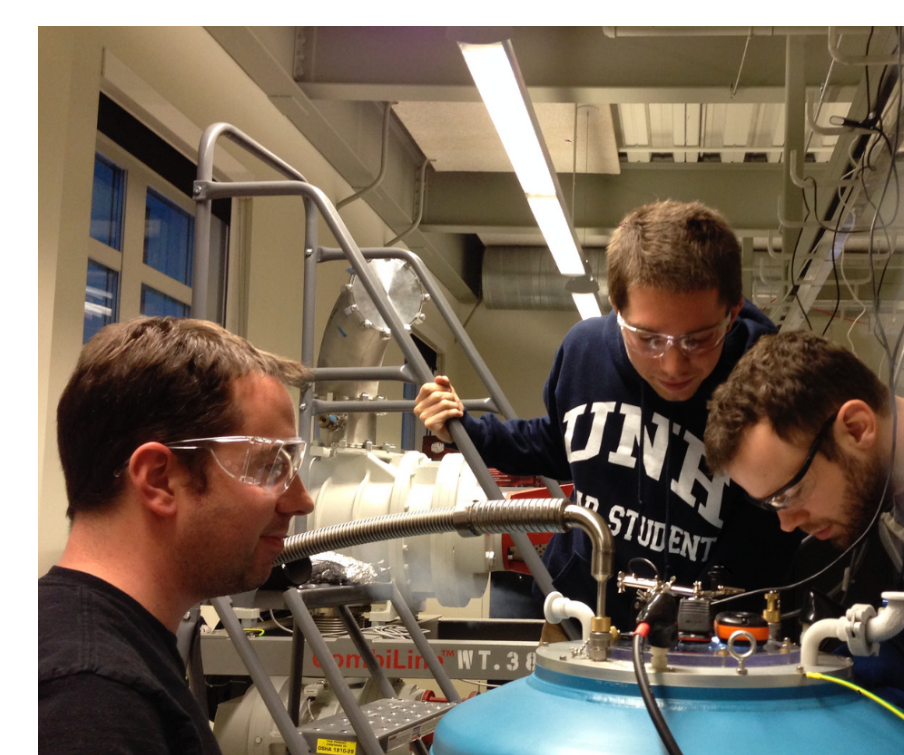
Helium Refrigerator



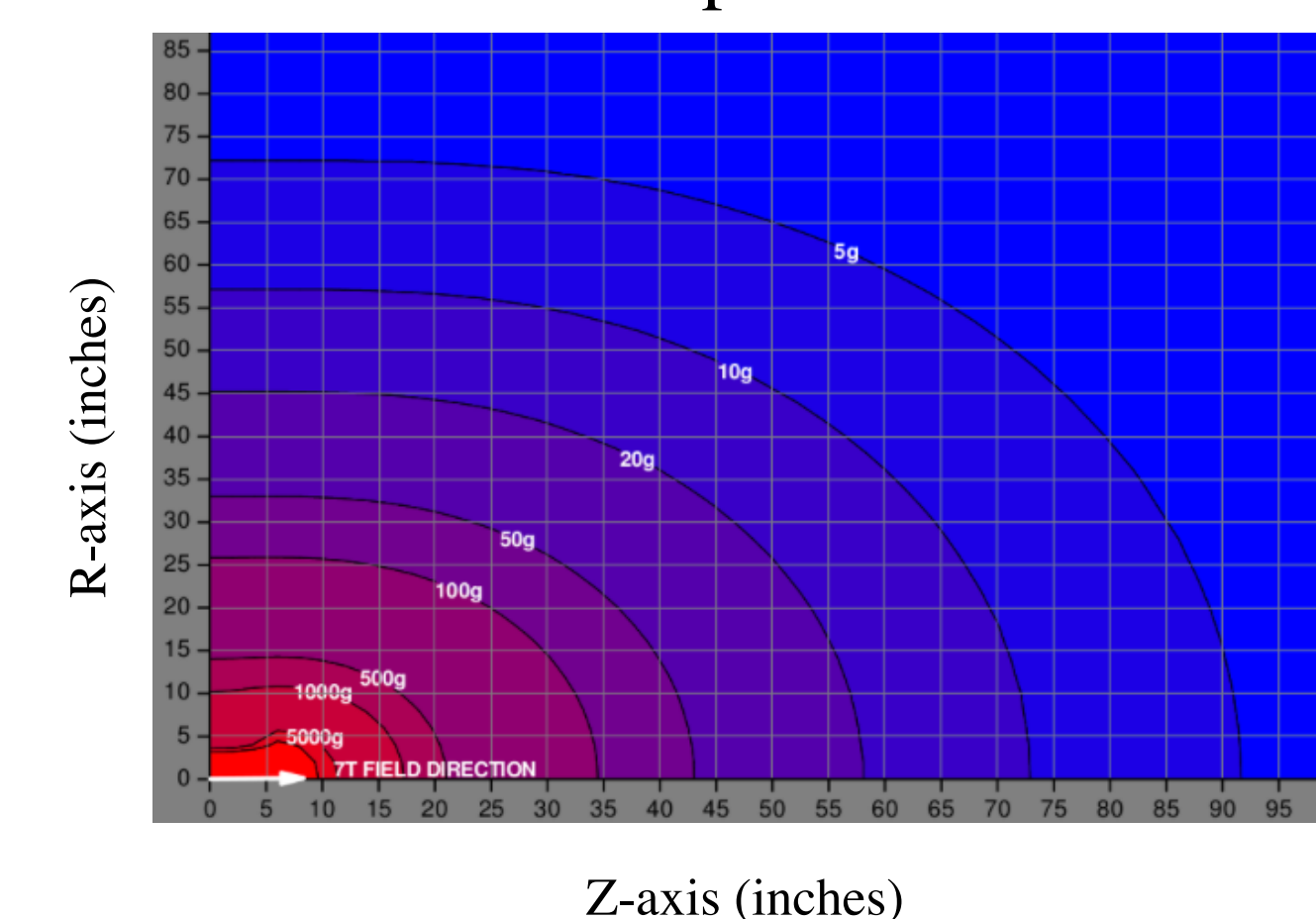
Horizontal Fridge at ~ 1 K



Superconducting magnet



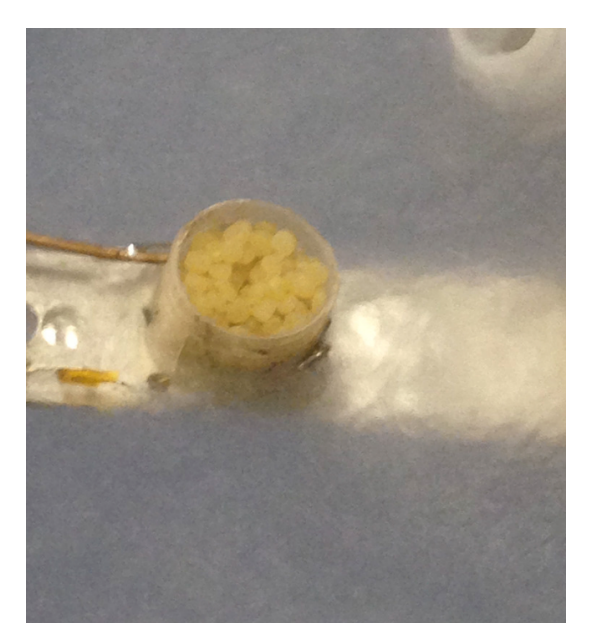
up to 7 T



Microwaves



Target Material



Future Plans

References

[1] D. G. Crabb and W. Meyer. *Solid polarized targets for nuclear and particle physics experiments*. Annual Review of Nuclear and Particle Science, 47(1):67-109, 1997.
[2] J. Maxwell. *Probing Proton Spin Structure: A measurement of g2 at four momentum transfer of 2 to 6 GeV*. PhD thesis, UVA, 2010.
[3] P. McKee, "The Spin Structure Function of the Proton From SLAC Experiment E155," PhD thesis, University of Virginia, Charlottesville, PhD thesis, UVA, 2010.
[4] M. Borghini, et al. *Nucl. Instr. & Meth.* 49:248 (1967); 49:259 (1967).



In collaboration with

