Polarized ^{3}He Target Status

On Behalf of the JLab Polarized ^{3}He Target Group

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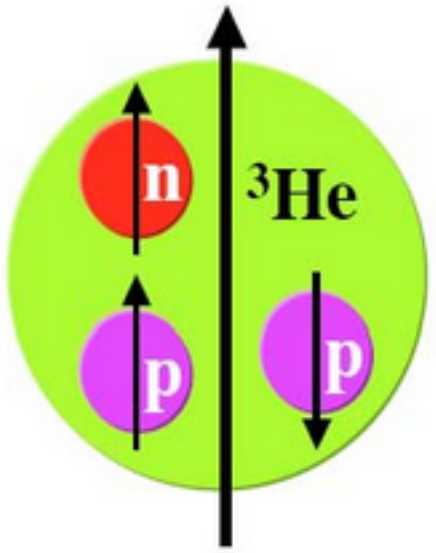
Why Polarized ^{3}He

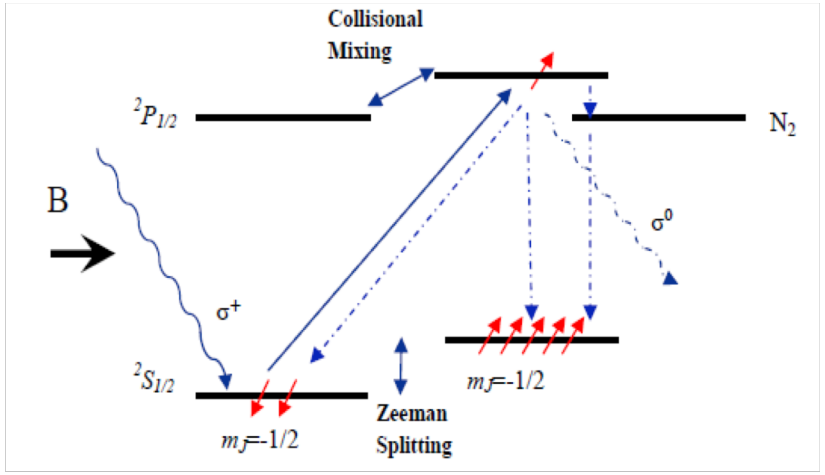
- No free neutron target: life time too short ~ 880.2 s
- Pol. ^{3}He is an effective polarized neutron target:

  neutron carries the majority of the ^{3}He nucleus polarization

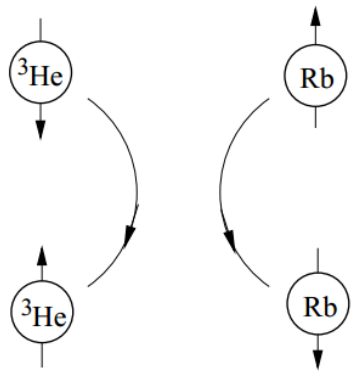


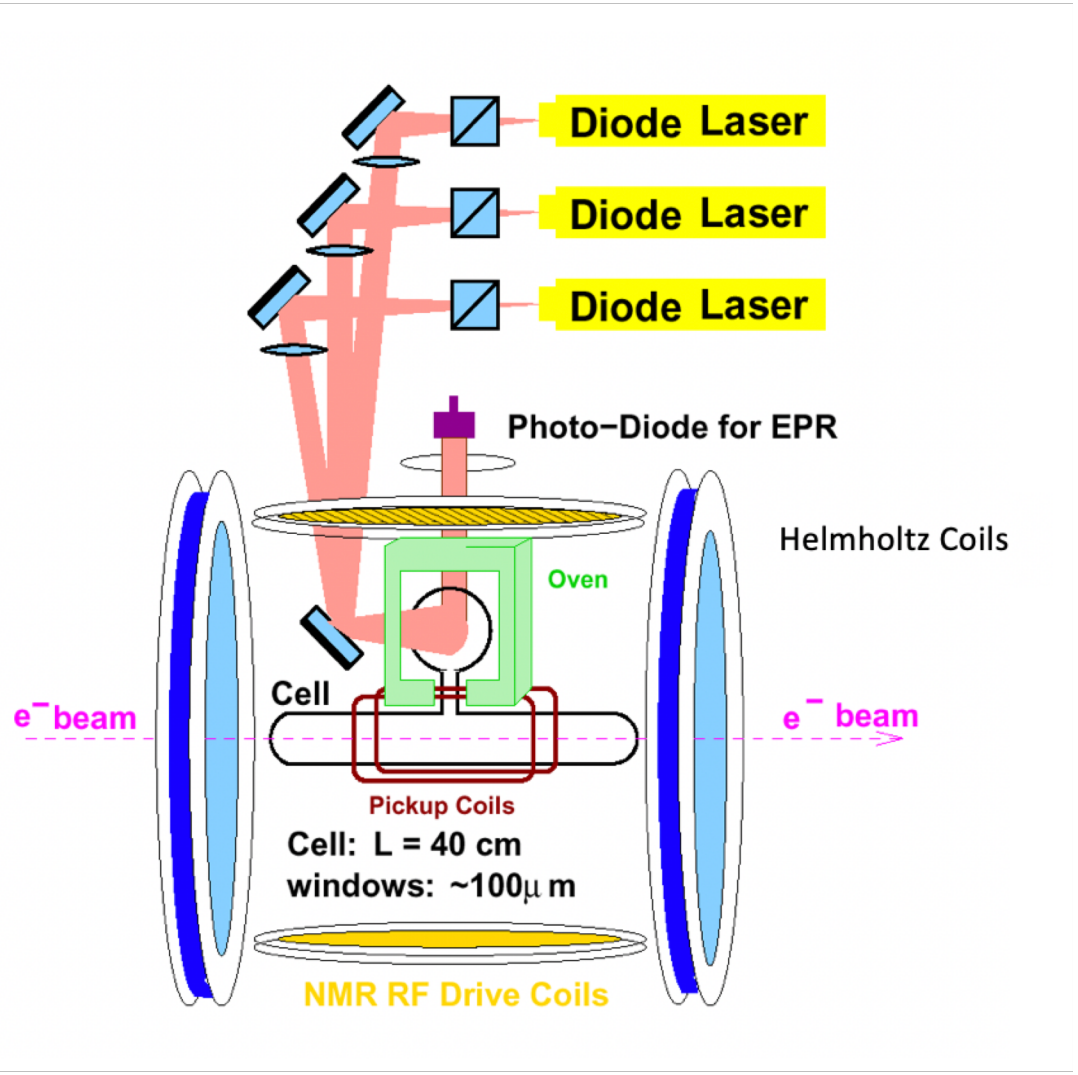
Polarization Method: SEOP (Spin Exchange Optical Pumping)

1. Optical Pumping



2. Spin Exchange

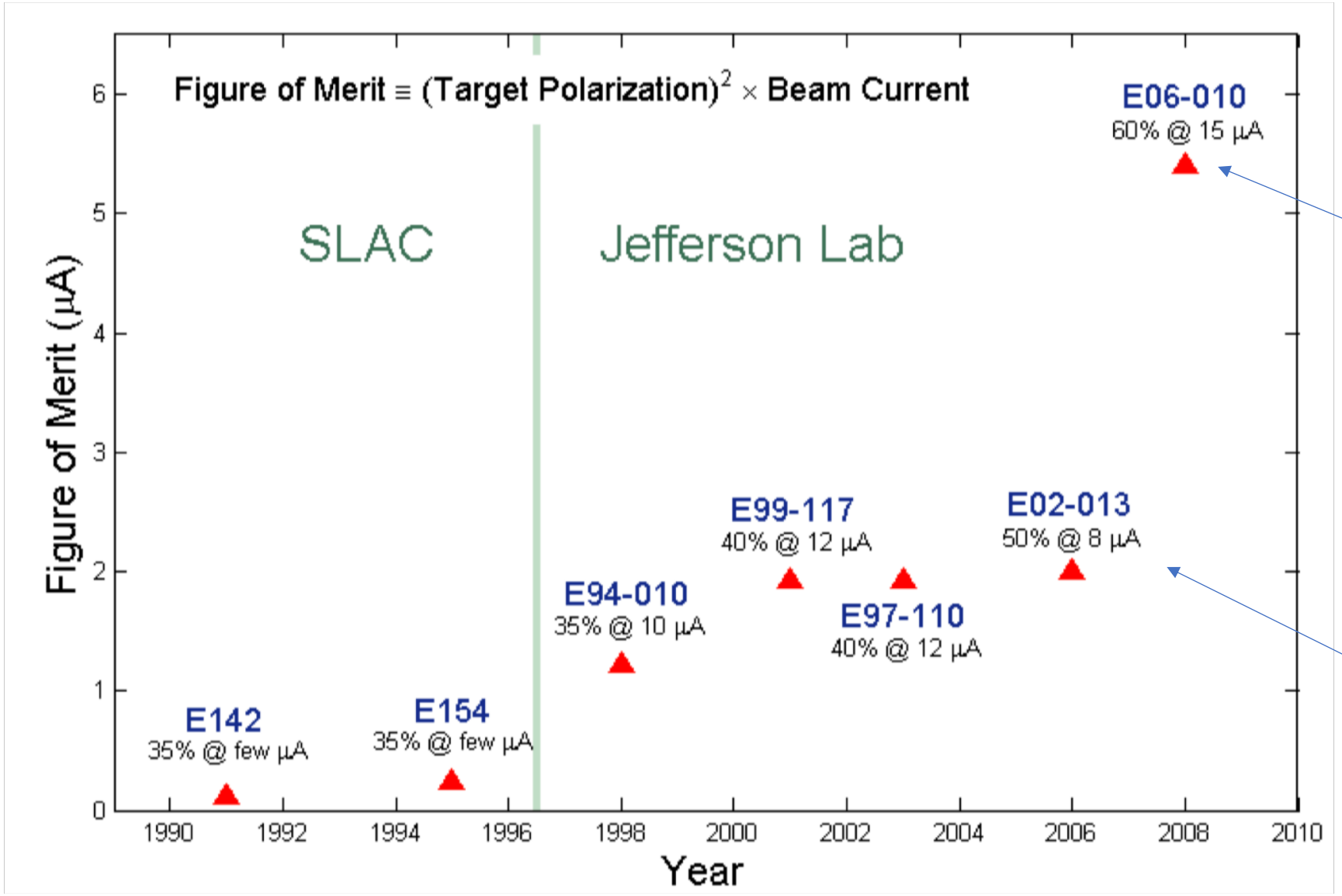




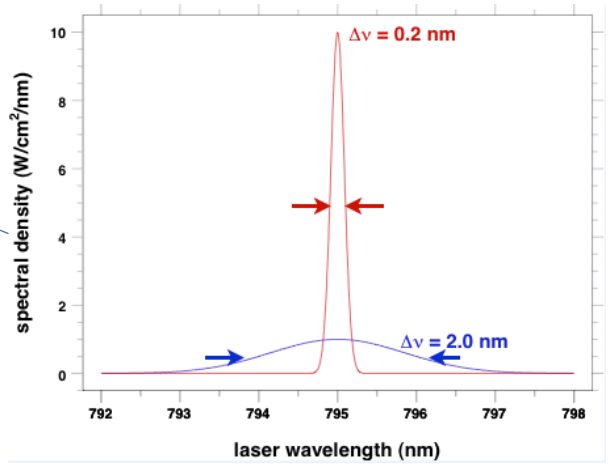
^{3}He Polarimetry Methods

- Adiabatic Fast Passage Nuclear Magnetic Resonance (AFP NMR)
  - Magnetic resonance of ^{3}He nucleus
  - AFP: flip the nucleus spin direction with minimum loss
- Pulse NMR
  - Instead of flipping the spin direction, tilts the nucleus spin to a certain angle
- Electron Paramagnetic Resonance (EPR)
  - Magnetic resonance of the alkali atoms in external field
  - Resonance frequency shifted due to polarized ^{3}He, get ^{3}He polarization through the frequency shift

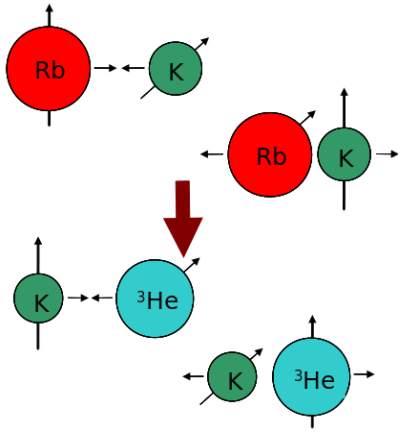
Polarized ^{3}He Performance for 6 GeV Experiments



1. Use narrow band laser



2. Use Rb/K hybrid alkali cell



Polarized ^{3}He Upgrade

6 GeV Era Performance

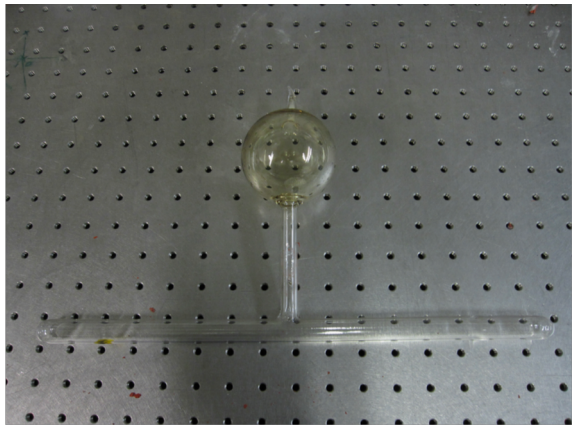
- Beam Current: 15 uA
- Luminosity: 10^{36} $cm^{-2}s^{-1}$
- Polarimetry: 3% for Rb only
  5% for hybrid

12 GeV (A1nd2n) requirements

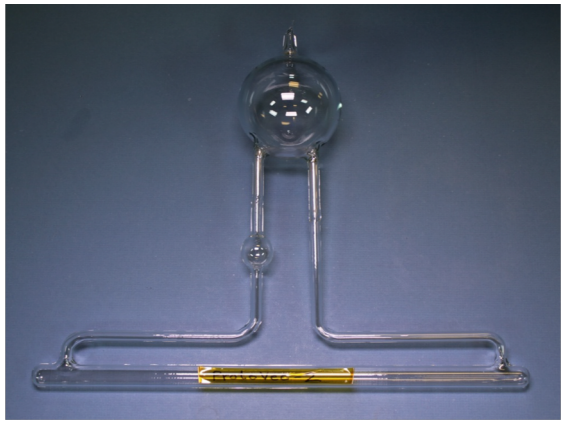
- Beam Current: 30 uA
- Luminosity: ~ $2x10^{36}$ $cm^{-2}s^{-1}$
- Polarimetry: 3% for hybrid

Approaches

- Diffusion Cell
- 3” pumping chamber
- 50-80 W laser power



- Convection Cell
- Larger (3.5”) pumping chamber
- More (~ 100 W) laser power



Target Upgrade Activities at JLab

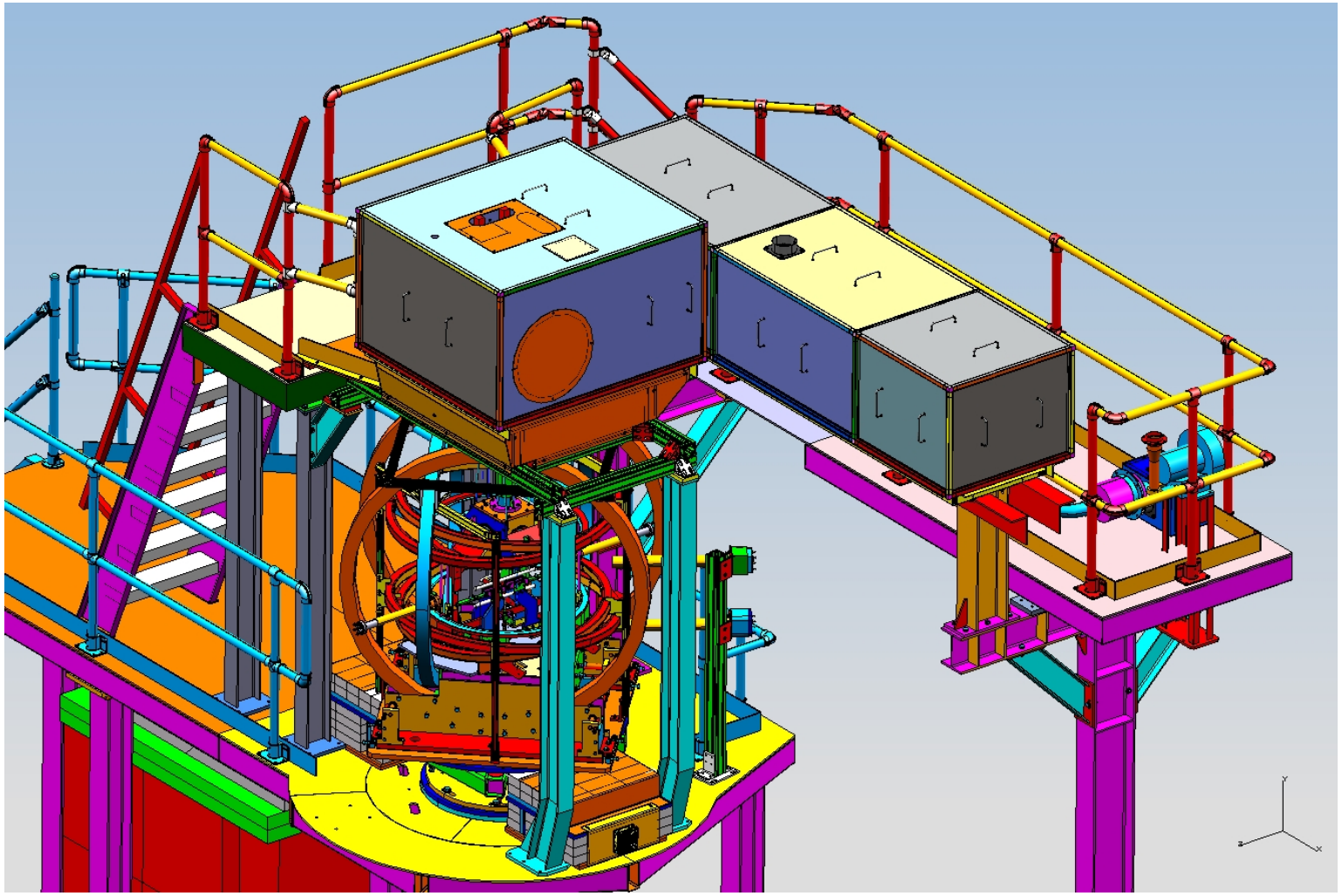
Manpower at JLab:

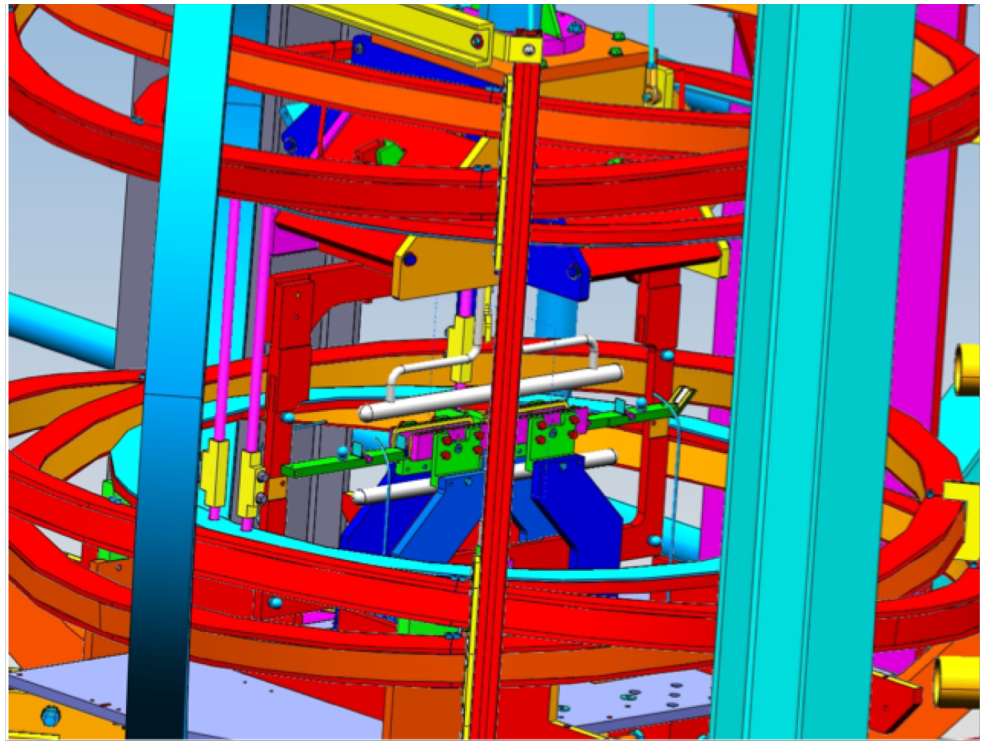
- PhD students: Junhao Chen (W&M, Todd Averett), Mingyu Chen (UVa, Xiaochao Zheng), Melanie Rehfuss (Temple, Zein-Eddine Meziani)
- Engineers/Designer (Bert Metzger)
- Supervisor/coordinator (Jian-ping Chen)

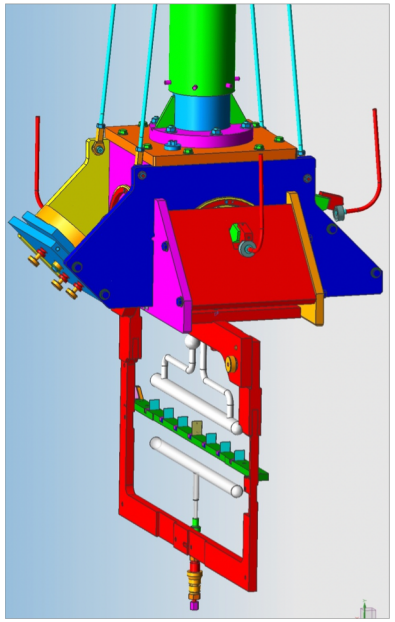
Overview of Activities:

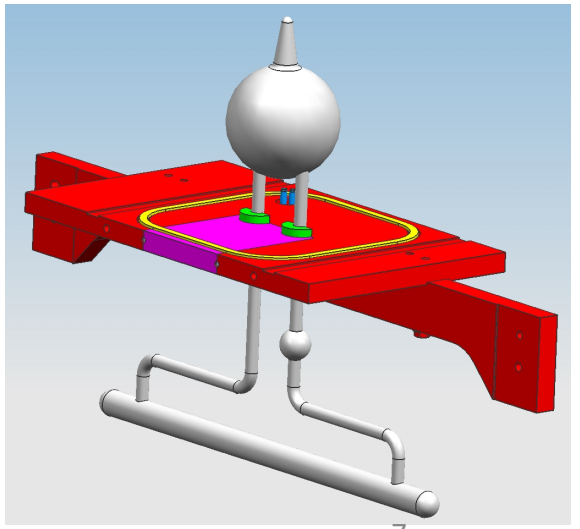
- Design to fit the polarized ^{3}He into Hall C (first time), construction (Bert)
- Develop pulse NMR (Mingyu)
- Upgrade EPR (Melanie)
- Fully characterize cells (Junhao)
- Testing components and prepare for installation (all)

Updated Design and Installation Design Fit into Hall C (Bert Metzger)



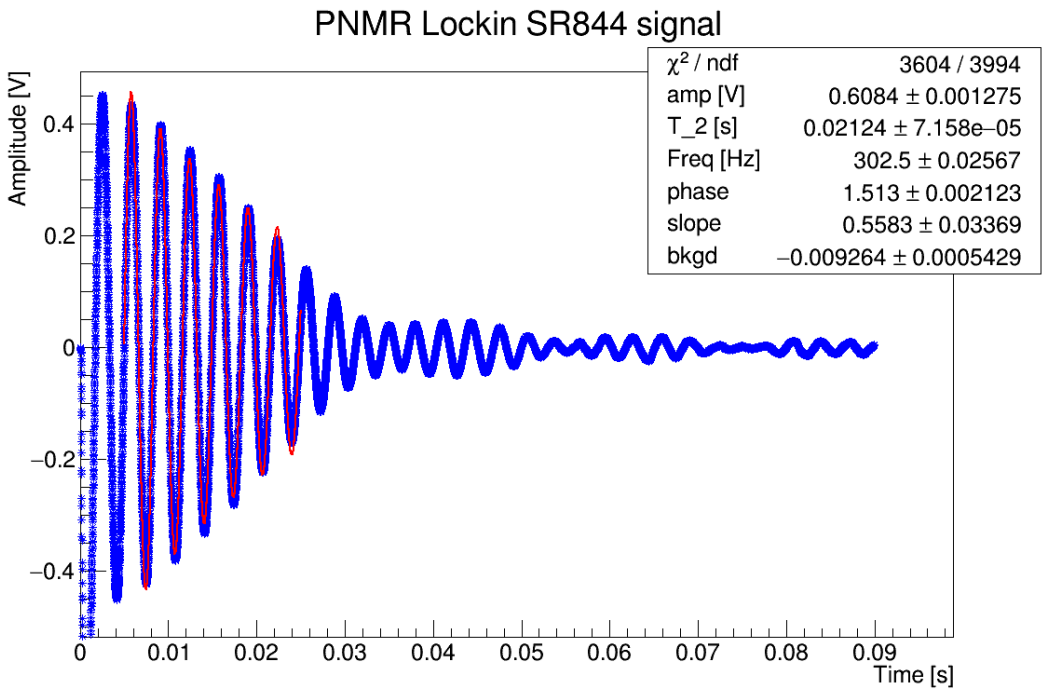


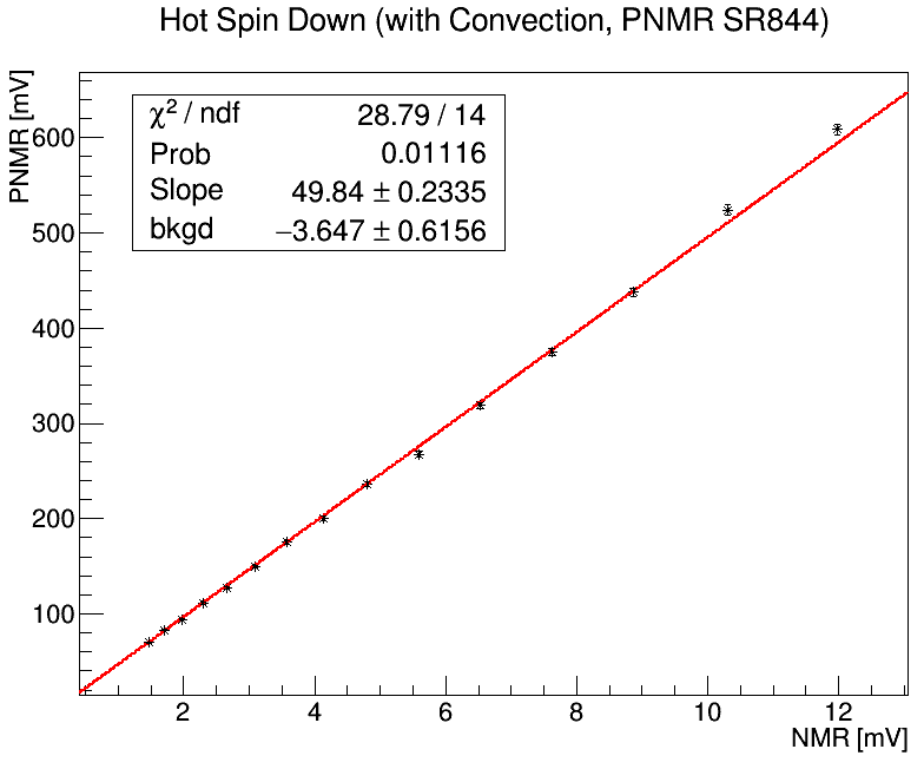




Pulse NMR (Mingyu Chen)

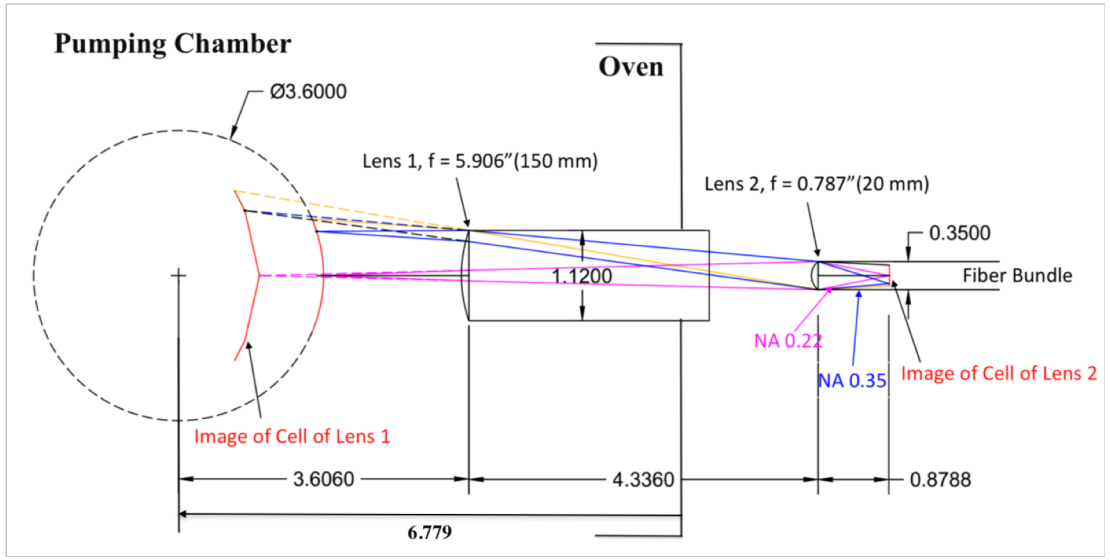
- Correlation between AFP NMR and Pulse NMR signal reached 1% level using Mixer + Oscilliscope (Nguyen Ton)
- Upgrade the system by using Lock-in Amplifier and DAQ system, still need to study the systemic uncertainties.

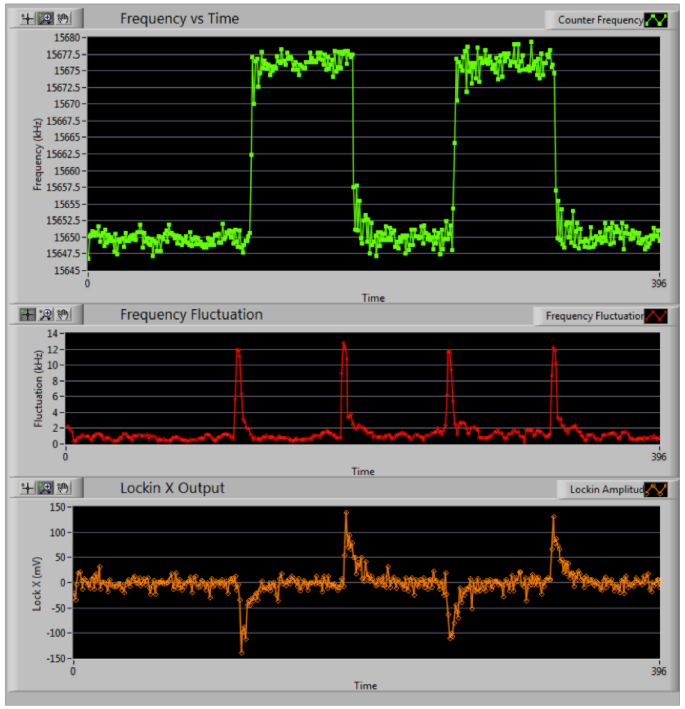


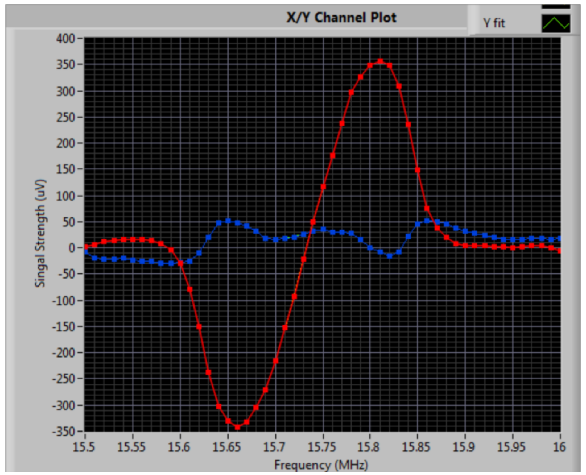


EPR Improvement (Melanie Rehfuss)

- Received D2 Fiber Bundle from Raytum Photonics. Testing underway.
- Upgraded photodiode to avalanche photodiode, which has 40X responsivity in our signal wavelength. Testing underway.

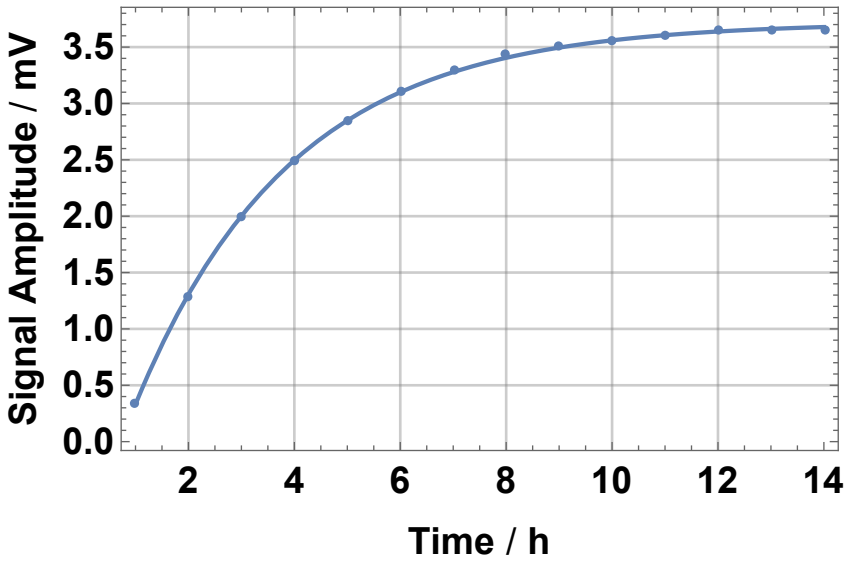




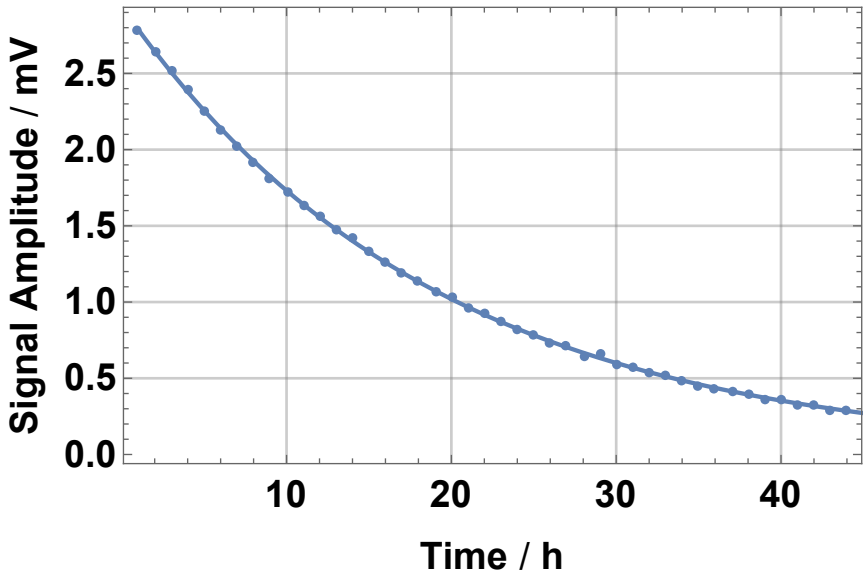


Characterization of Prototyping Cell (Provec-1)

Spin Up



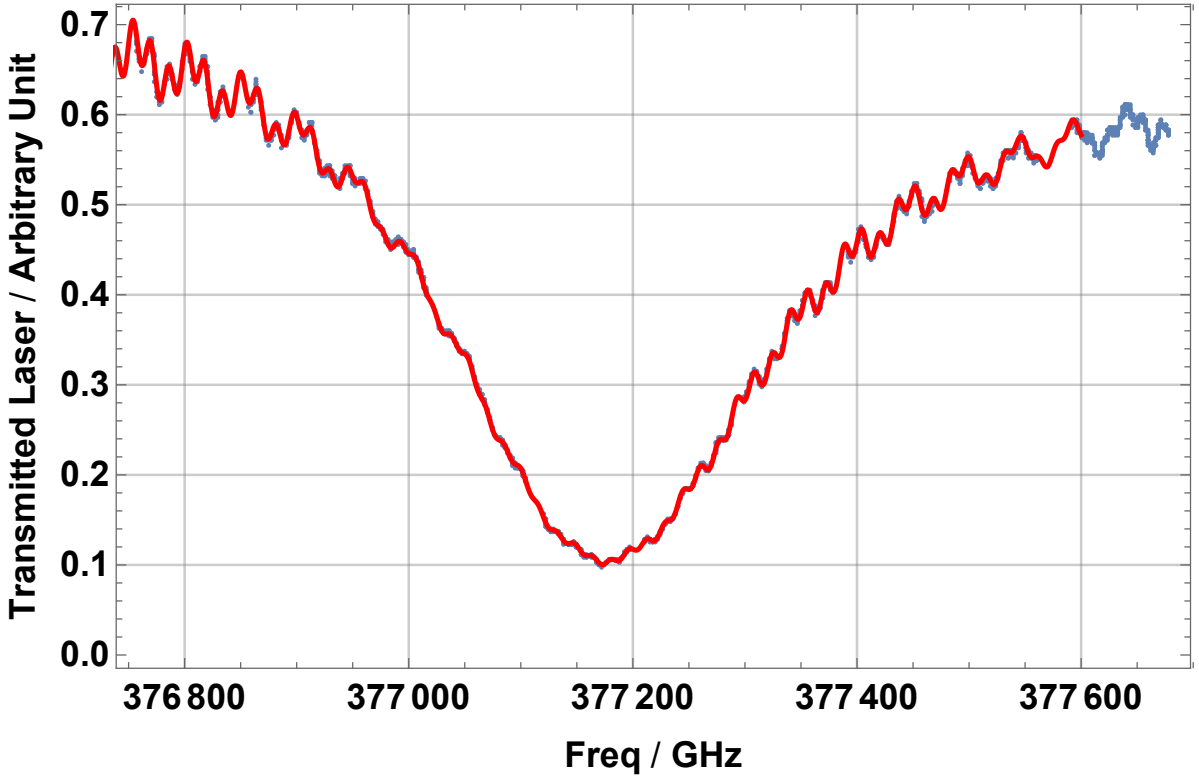
Spin Down

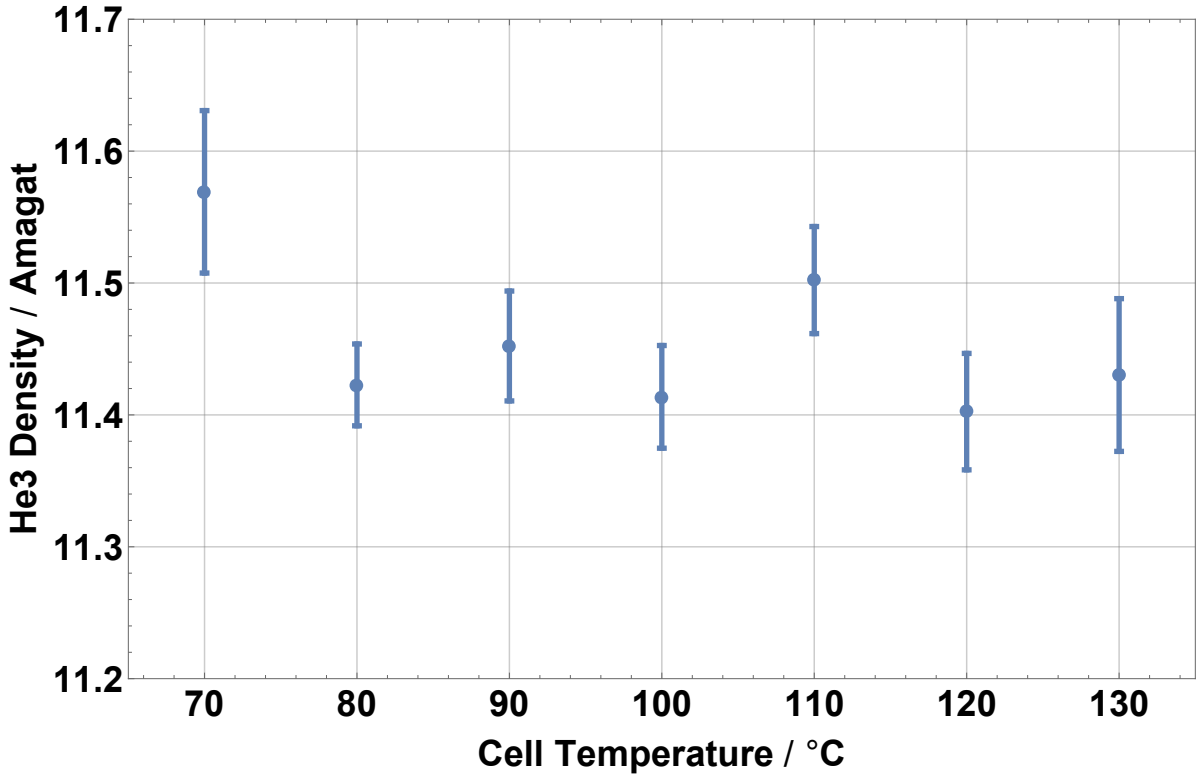


Cell Condition		Spin Up / h	Spin Down / h	AFP Loss per Sweep / %
Hot with Convection	P.C.	5.98 ± 0.06	9.36 ± 0.05	0.27 ± 0.01
	T.C.	6.11 ± 0.09	9.44 ± 0.04	0.28 ± 0.01
Cold without Convection	P.C.		19.5 ± 0.4	0.25 ± 0.02
	T.C.		22.6 ± 0.2	0.17 ± 0.01

Density Measurement
Pressure Broadening

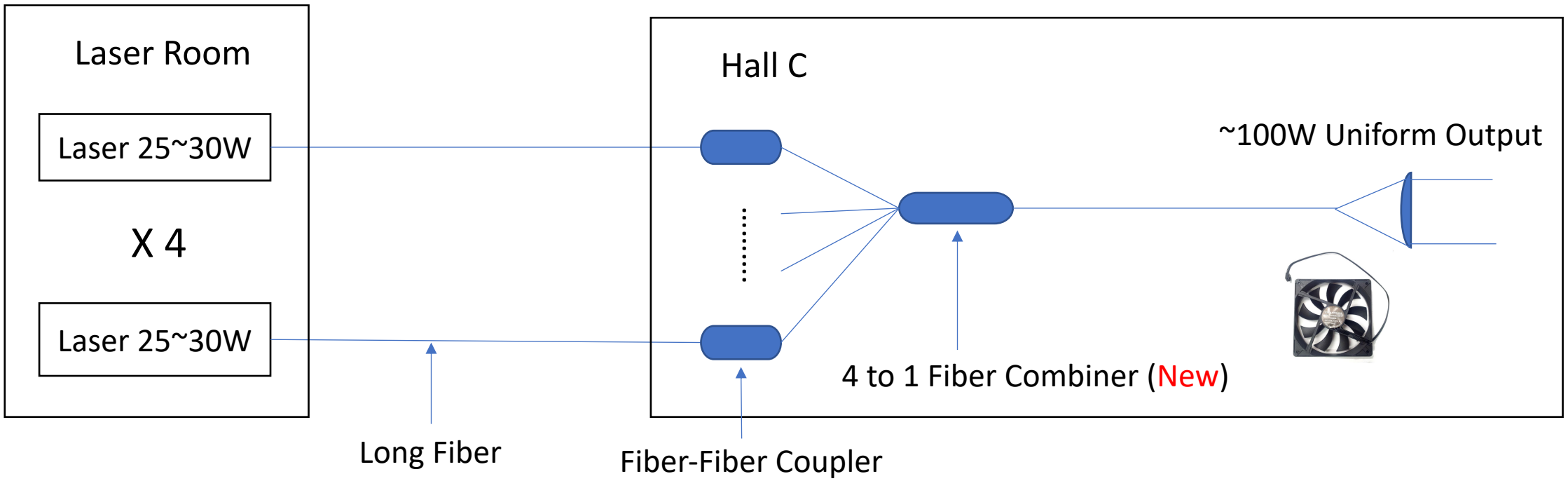
Rb D1 absorption profile at 100 ℃





Averaged Density: 11.45 ± 0.02 (Stat.) ± 0.18 (Sys.) amg

Laser Power Delivery to Hall C

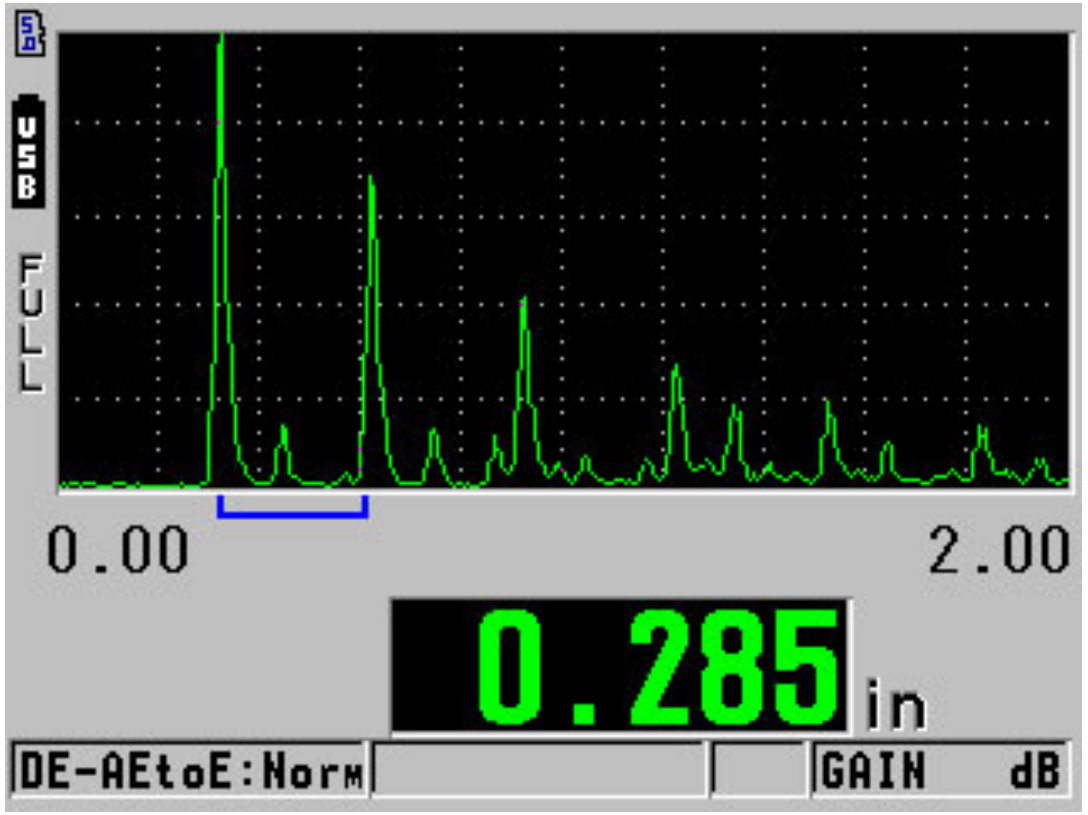


- ✓ Need: 10 long fiber, 8 fiber-fiber coupler, 2 4-1 combiner
- ✓ 4-1 output end need cooling with fans
- ✓ 4-1 tested, steadily works 20 h with 100 W output power

4-1 Specification
Input: 600 um, 0.22 NA
Output: 1320 um, 0.22 NA

Ultrasonic Thickness Measurement

- ✓ Instruments: 45MG Thickness Gauge, M208 Delay Line Transducer from Olympus
- ✓ How: Time difference between the reflected ultrasonic pulses on material's surfaces
- ✓ Tested on the GE180 Fragments, agrees well with micrometer



Target Activities at User Institutions

- Cell fabrication and testing: UVa (Gordon Cates)
- κ_0 measurement: W&M (Todd Averett), UVa
- Reference cell system/cooling jets: W&M
- Field direction measurement: Kentucky (Wolfgang Korsch)

Plan:

- Polarimetry
  - EPR: finalize D2 light collection optics setup
    study systematics
  - Calibrate pulse NMR signal with AFP NMR
    minimize systematics
  - Calibrate AFP NMR with water NMR
- Characterize new cells
- Working with supporting groups
  - EPICs
  - Interlock system
- We will be ready for installation which starts in July
- Instruments locations and cables have been checked