

High Power Extremely Narrow Linewidth Diode Laser for Polarizing ^3He Target

RAYTUM PHOTONICS

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DOE SBIR Phase II
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2020 DOE-NP SBIR/STTR Exchange Meeting

Outline

- ❖ Company Introduction
- ❖ Motivations
- ❖ SBIR Project Task Details and Progress
- ❖ Summary of Test

Raytum Photonics *Started in 2014 as a Diode Laser Company*



Headquarter in Sterling, VA with another branch in Columbia, MD

Total size of 5,500 sqf, including 5 optical labs, class 10,000 clean room, chemical lab and fiber components assembly lab.

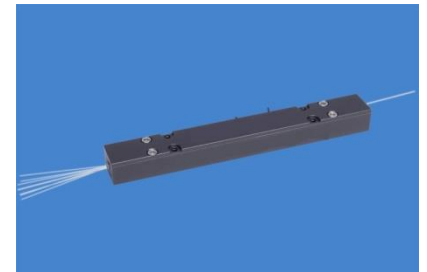
Core Capabilities:



Laser R&D: High Power Diode Laser, High Power/High Energy Fiber laser/amplifier, and novel optical parametric oscillator for Quantum Network.



Optical Coating: provide customer-designed optical coating for application of fiber laser, mid-IR laser beam delivery, etc.



Fiber Optics Components and Services

DOE/NP Motivation

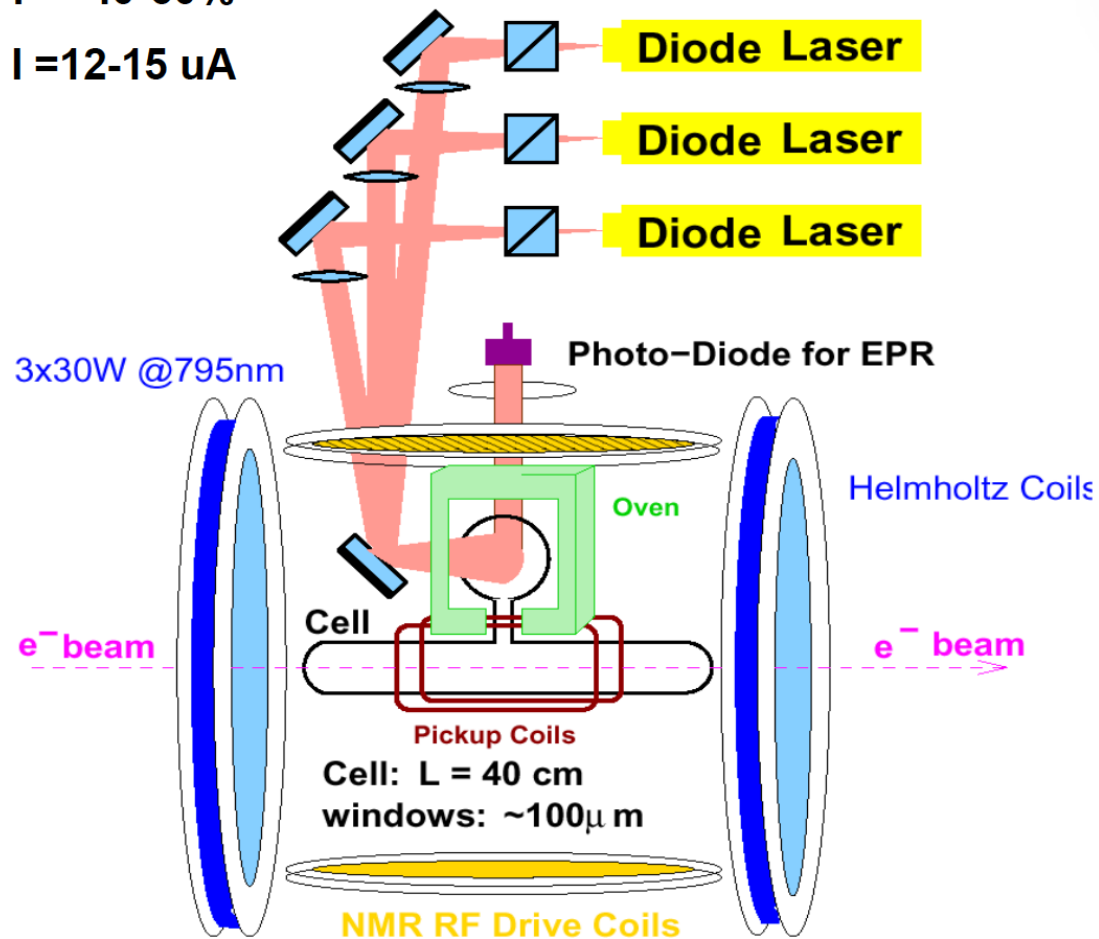
JLab physics program requires a factor of 6-8 improvement in luminosity (FOM) 2-stage upgrades for polarized ^3He target, as a result, improvement and upgrade on pump laser system in several aspects are needed:

- ❖ **Higher power**
- ❖ **Better beam profile**
 - Power scaling is realized in JLab through traditional fiber bundles, which also leads to undesired output beam profile.
- ❖ **High wavelength stability**
 - Long term running of diode laser would cause the output power drop and lasing wavelength shift inevitably.
- ❖ **Remote control and data recording**
- ❖ **Easy maintenance and low cost replacement/repair**

Polarized ^3He Target Setup at JLAB

$P = 40\text{-}60\%$

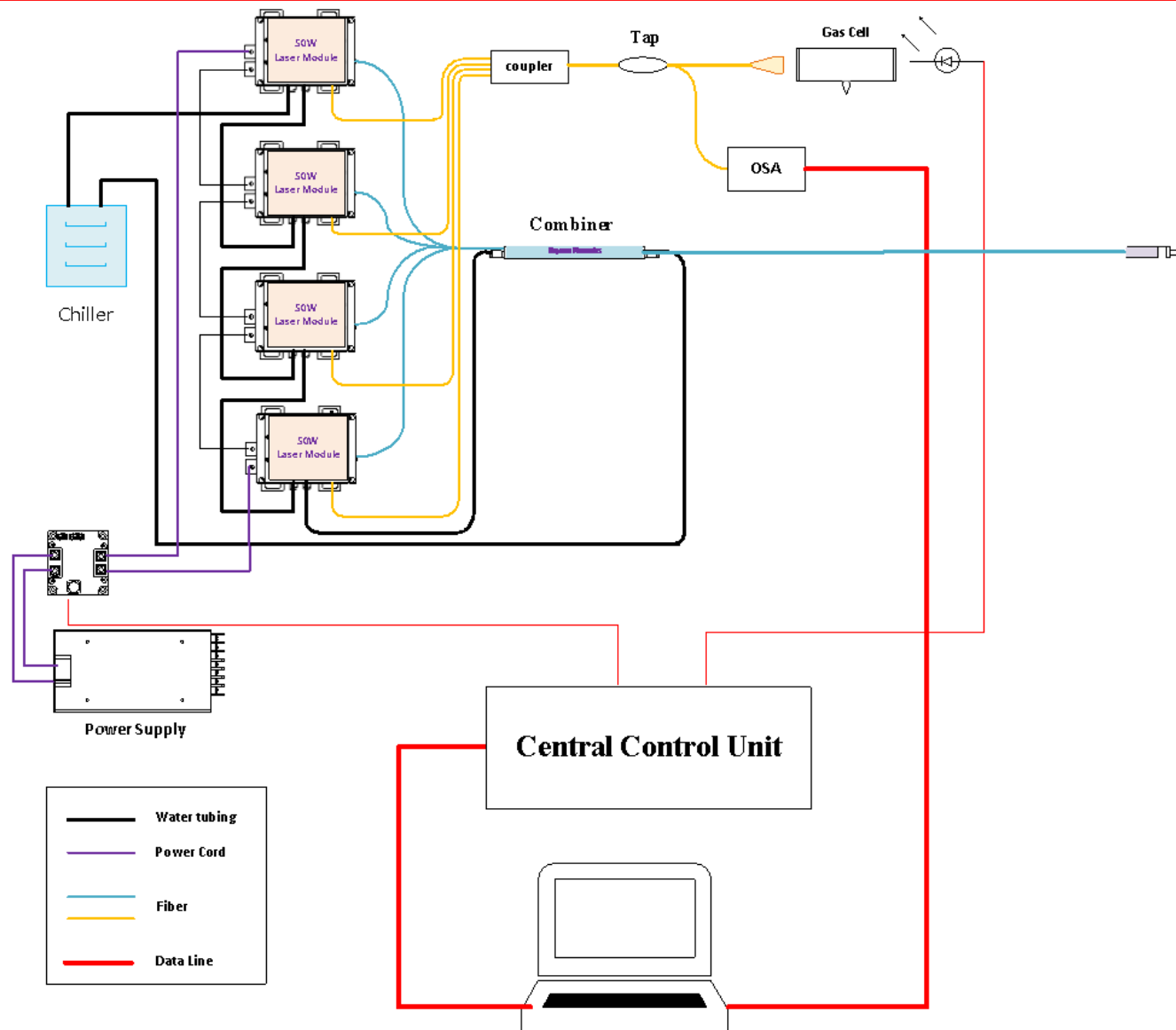
$I = 12\text{-}15\text{ }\mu\text{A}$



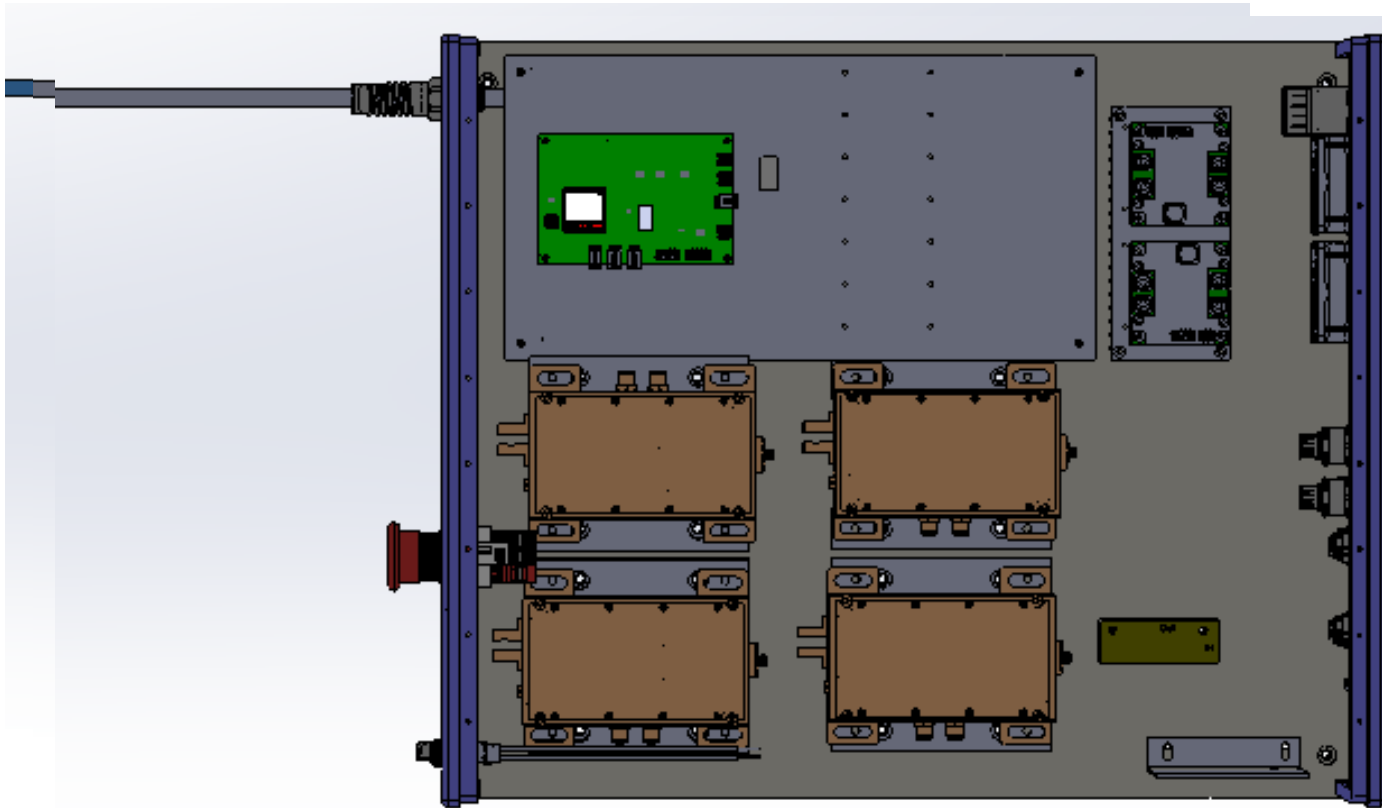
Our Solutions

- **Module design using state-of-art fiber beam combiner**
 - *High power output with power scalable by more modules or/and higher individual module power.*
 - *Uniform output beam profile compared with traditional fiber bundling individual lasers.*
 - *The modular design provides the solution for hybrid pumping the mixed vapor of Potassium (K) (770nm) and Rb (794.7nm) which shows advantage in polarization of ^3He .*
- **Thermal tuning laser modules makes automatic lasing wavelength locking possible.**
- **On system level, integrate the laser modules, current driver, data acquisition, and central control unit.**
- **Target specs are >200 W output power, < 0.1 nm linewidth and center wavelength locked to the designated value.**

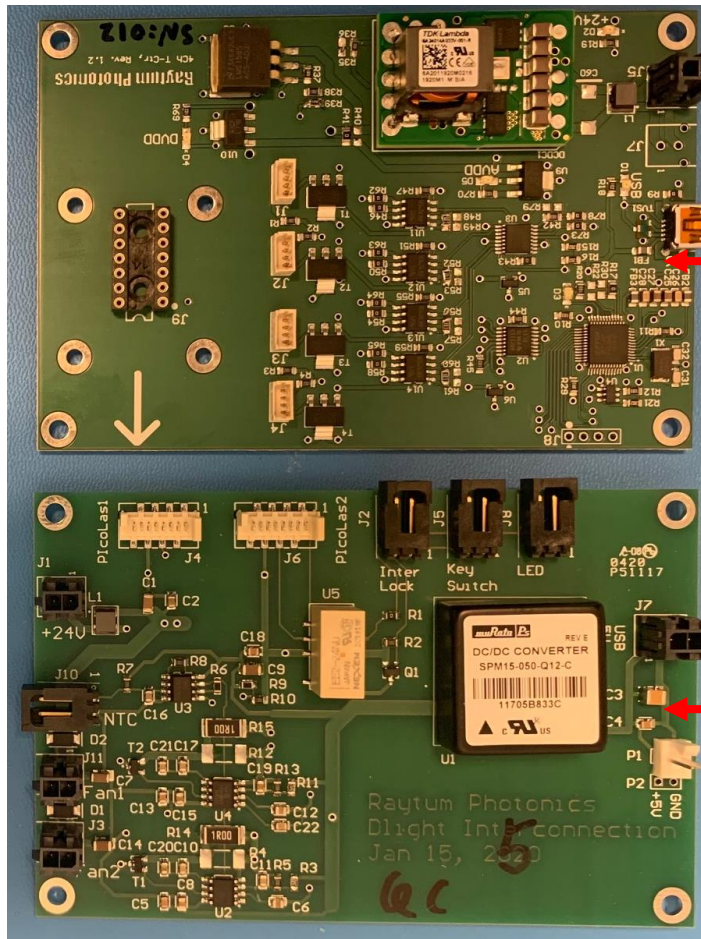
System Schematic



Laser Development



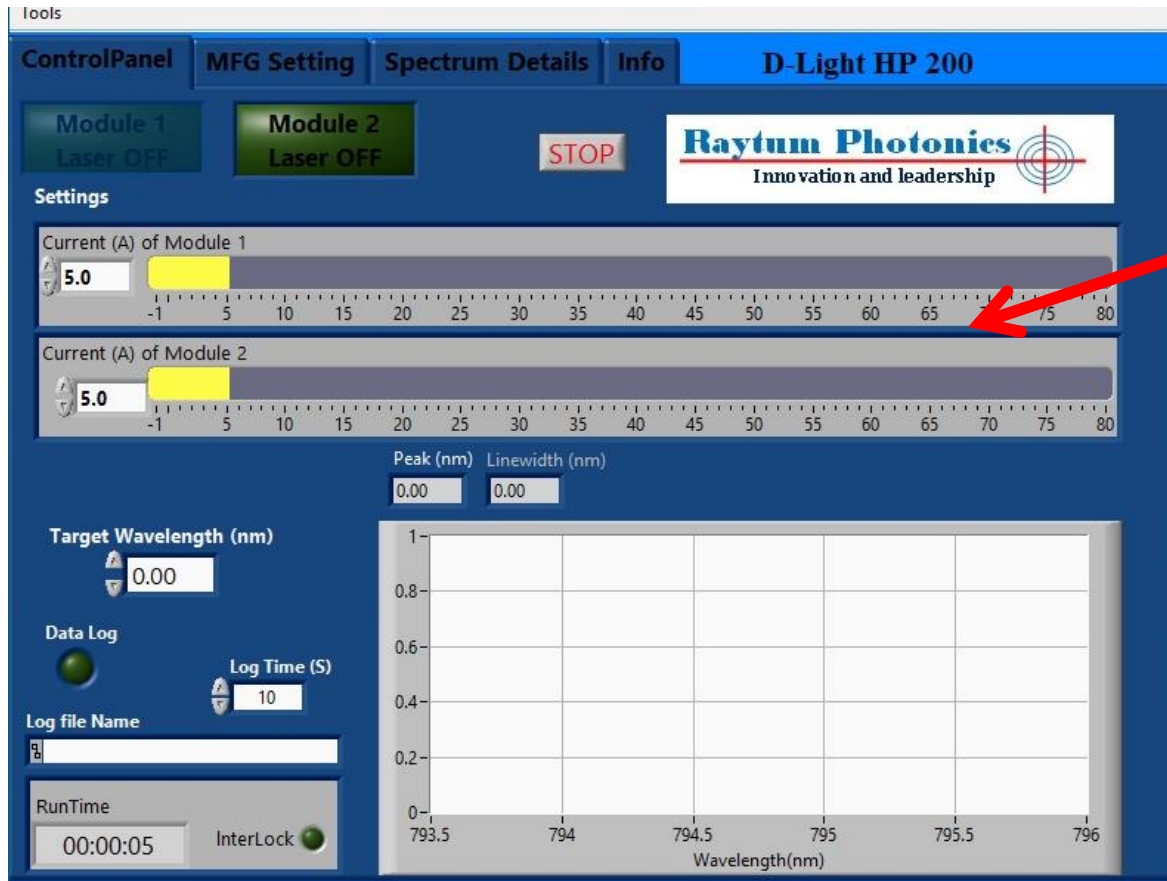
Control Hardware Development



4 Channel Wavelength Control

System Control

Control Software



What to control:

Laser Module

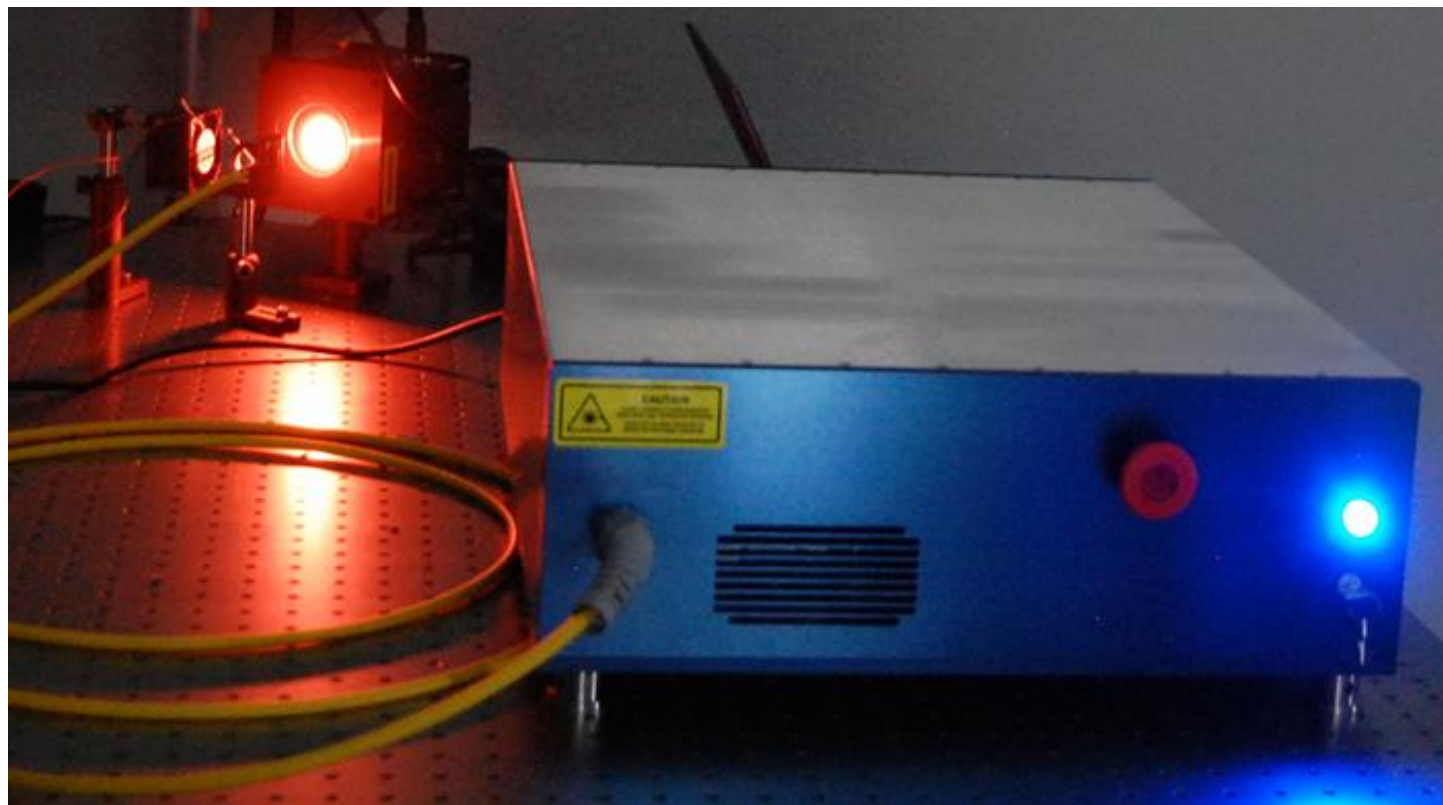
Current

Target Wavelength

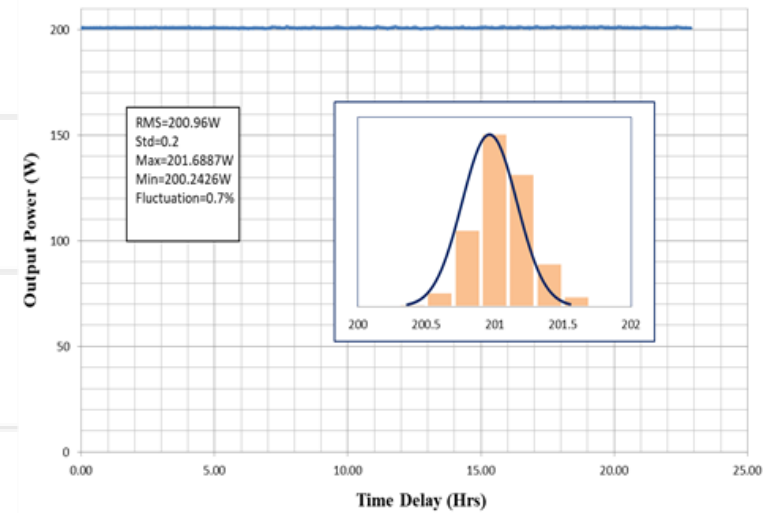
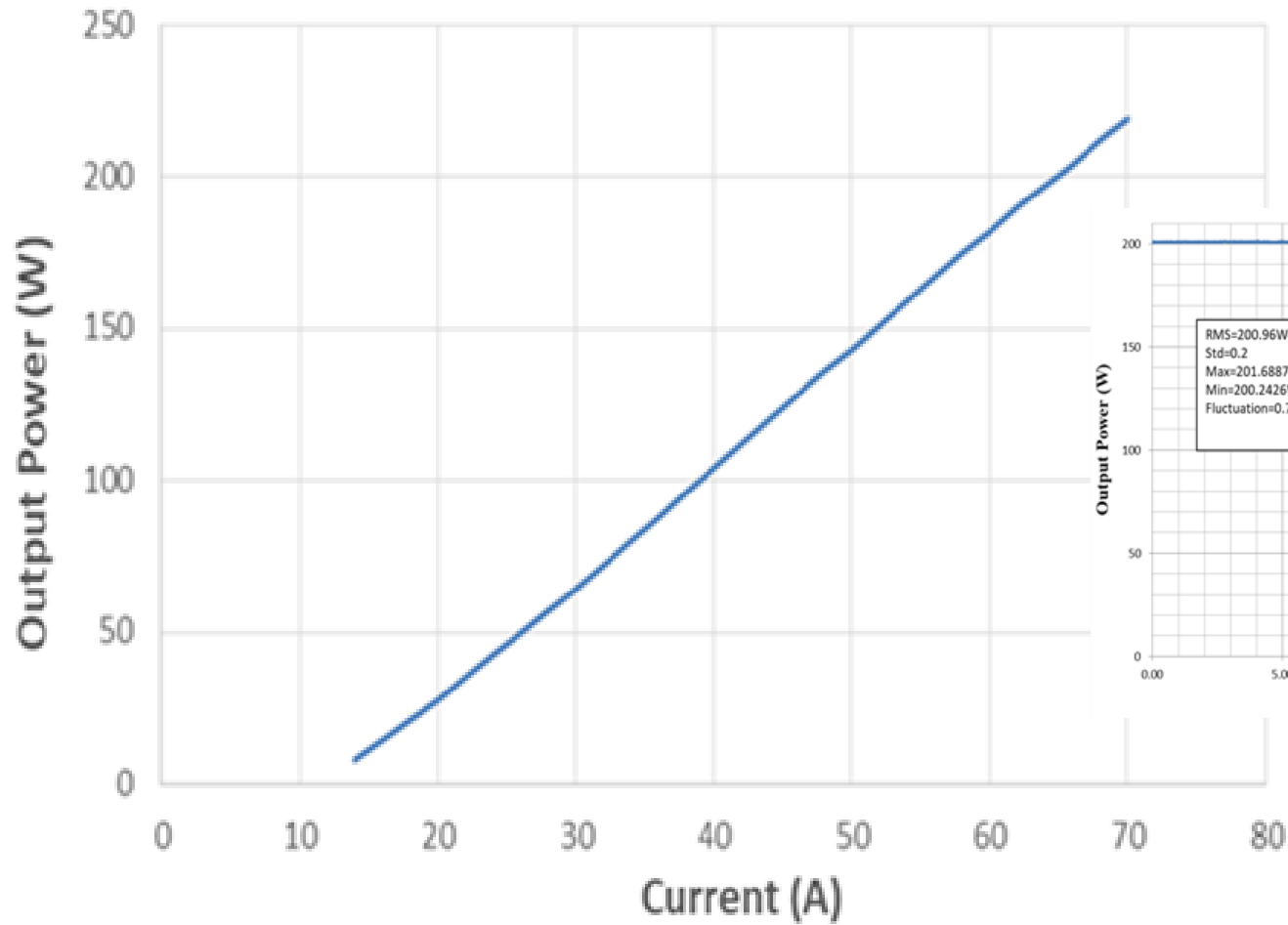
Data Log

Showing output spectrum

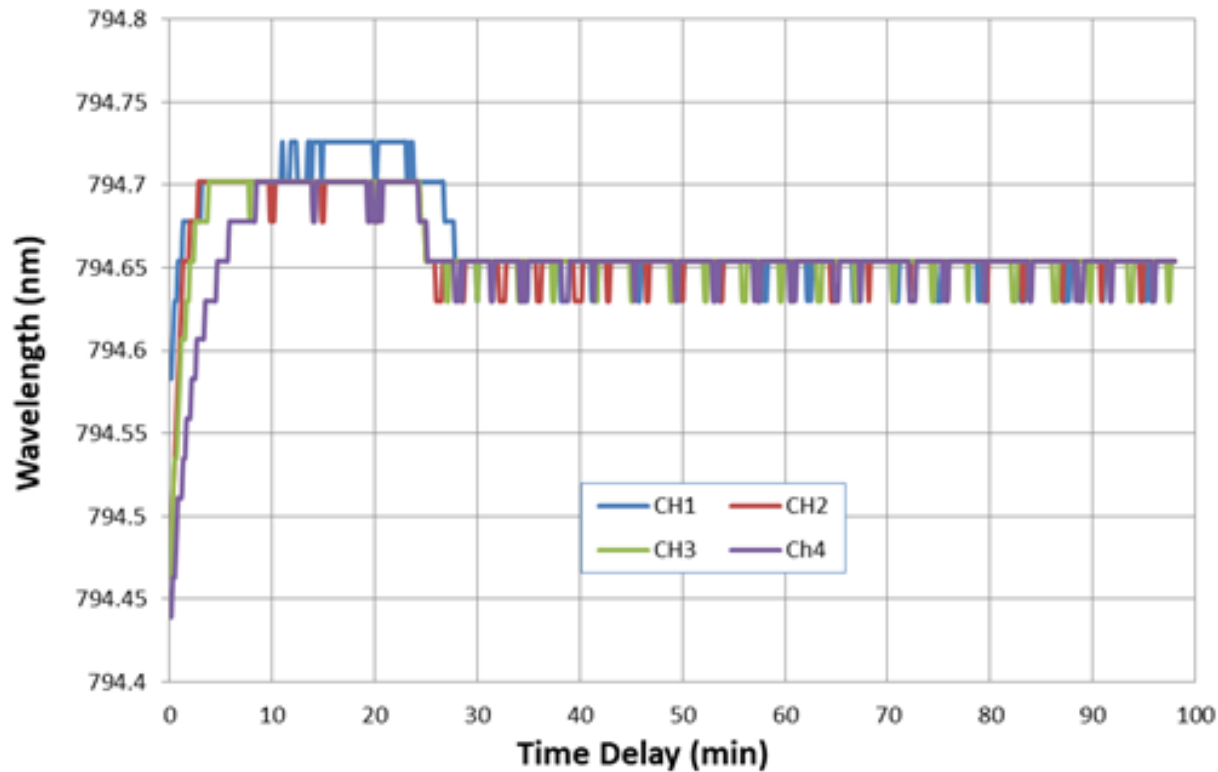
Prototype of 200W Laser



Laser Performance



Wavelength Stability



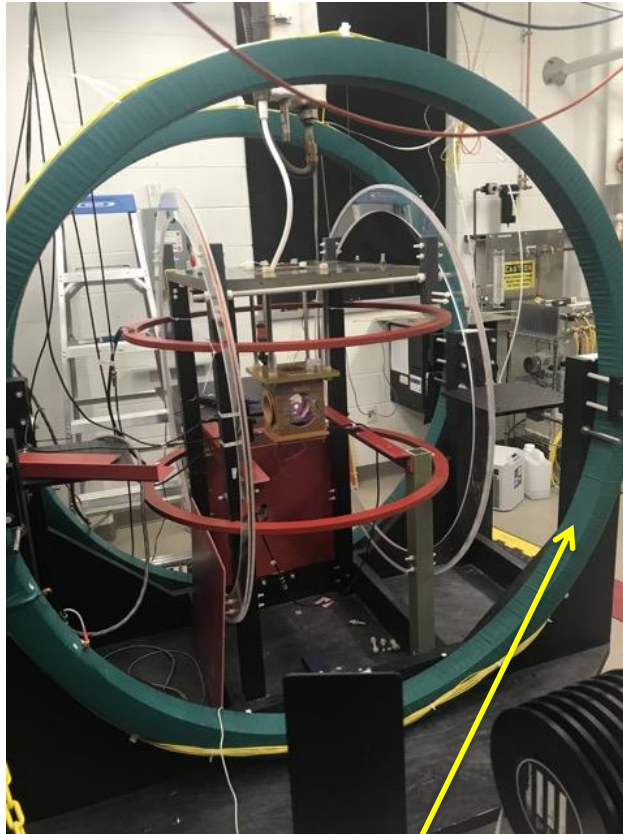
**Beam profiles
over time**

Conclusions

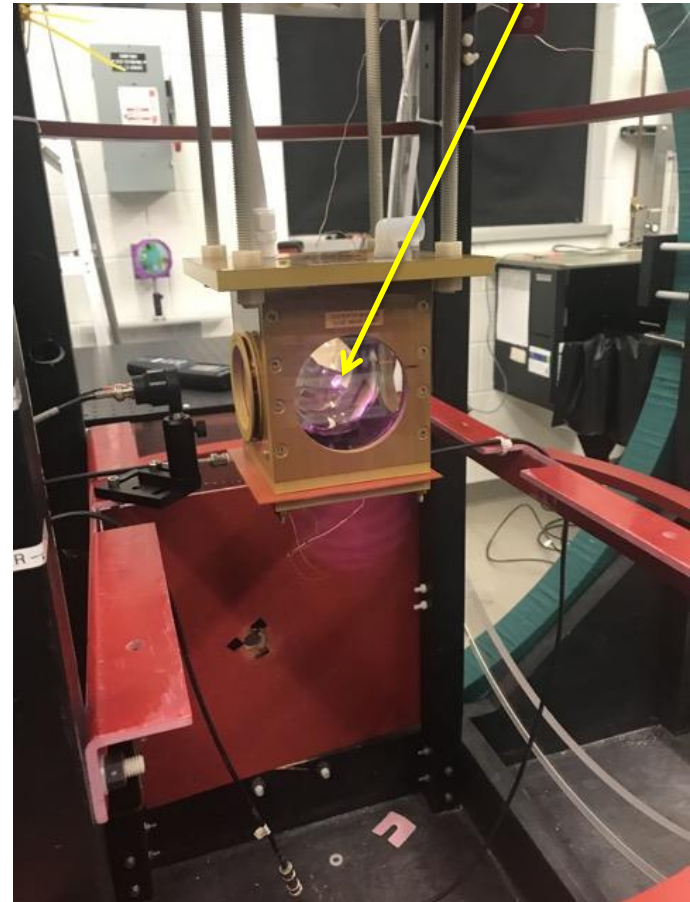
- Integrated, turn-key, fiber-coupled diode laser with power of more than 200 was developed with lasing linewidth close to 0.1nm.
- The laser has extraordinary stable output with stability of 0.7% over 24hours.
- Lasing wavelength is automatically locked to desired wavelength. (794.7nm or any other value been set within +/-0.2 nm)
- Homogenous output beam profile.
- Modularized system design to lower the cost and make maintenance easier.

Polarization Test with ^3He target (JLab and W&M)

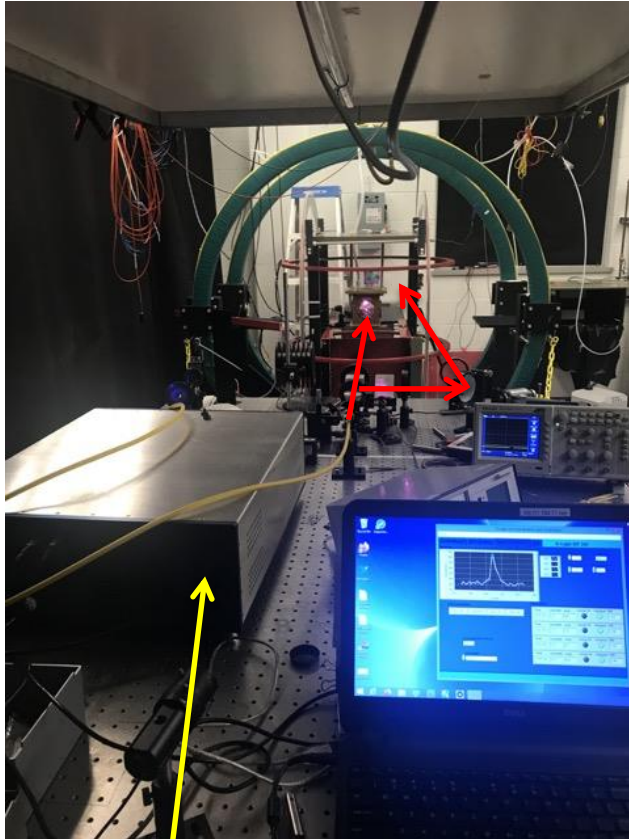
Target Cell in Oven



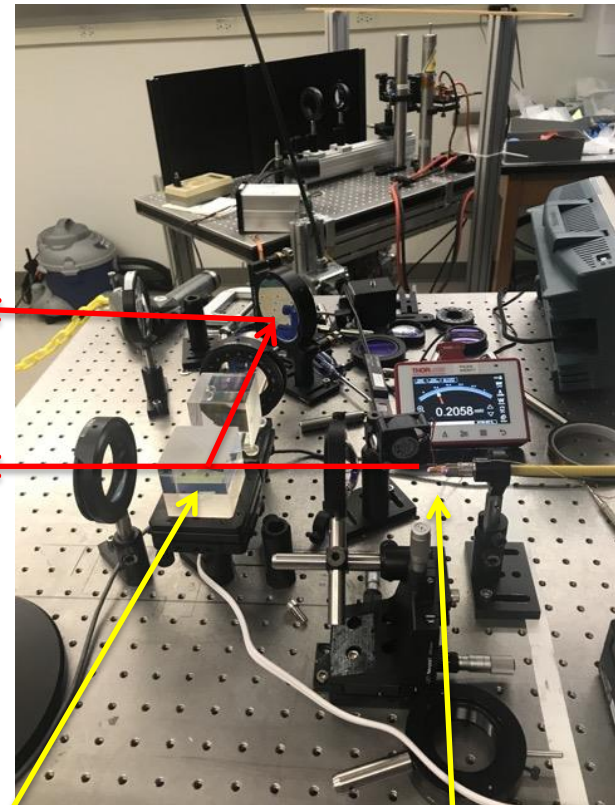
Helmholtz Coils for Magnetic Field



Single Optics System for Bi-directional Pumping



Raytum Photonics Laser



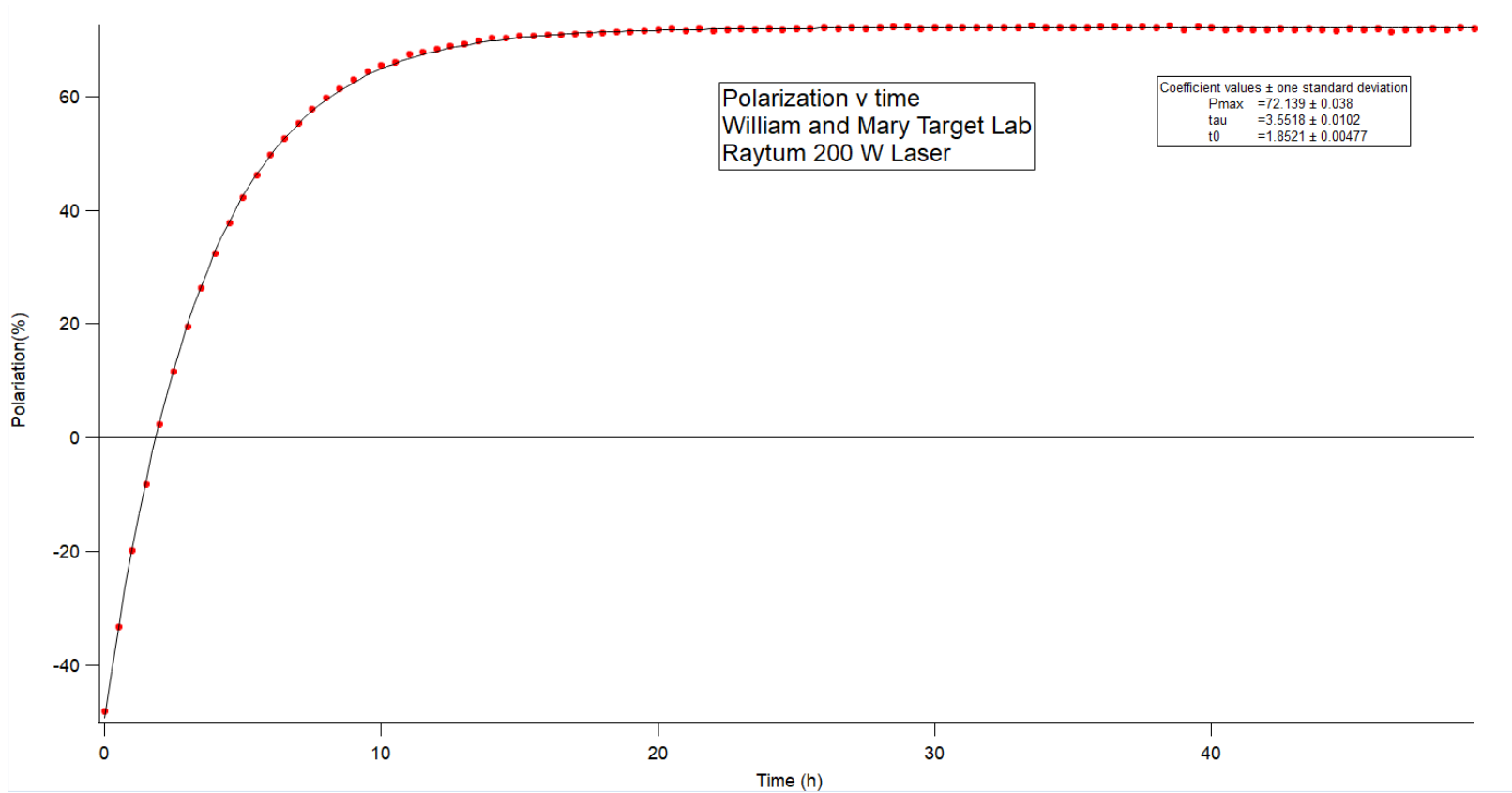
To rear of cell

To front of cell

single fiber output

Red beam path shows
200 W light thru a splitter and going to both front
and rear of target system

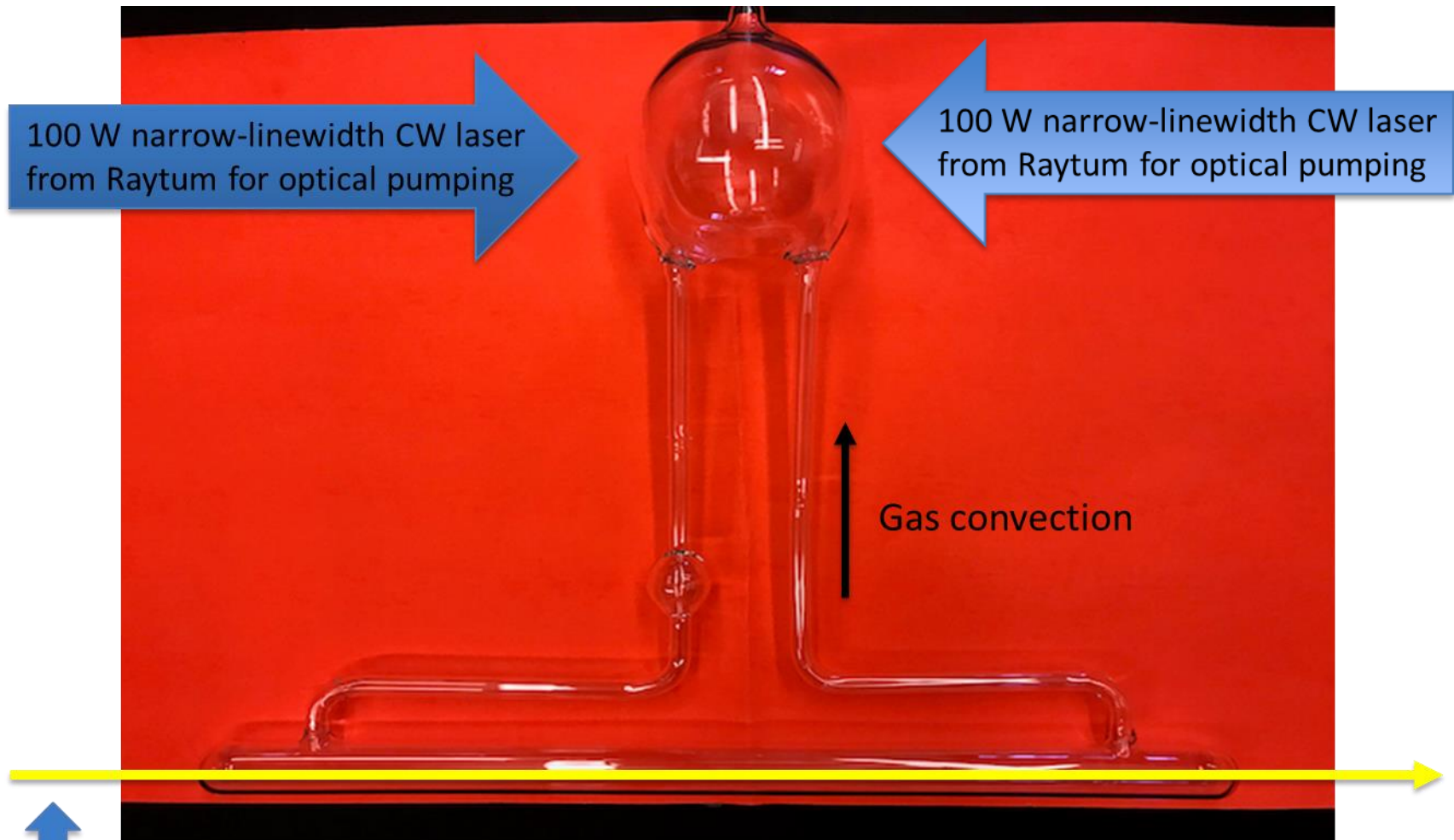
Preliminary Polarization Result



Conclusions of testing

- Initial tests on spherical target cell using setup with no changes reached polarization of 60% using 50 W pumping from one directions. Never before done with single laser.
- Now pumping from both directions. Never before done. AND using single laser.
- Currently pumping at 100W reached 72% polarization. A record!
- Next: Steadily increase laser power up to 200 W with corresponding Rb density increases. Expect even larger polarization.
- Then: Install cell with complicated Jefferson Lab geometry currently in use. Expect significant improvement in polarization which would be huge advantage.
- Finally: Optimize system for use with larger next generation target cells. Require full 200 W laser power. Allows high polarization of larger gas volume and density. Huge advantage.
- None of this possible without new Raytum laser. All can be done with single laser! Huge advantage. Huge cost savings and simplification of optics.

New Target Cell Design for Jlab Physics Experiment



8/13/2020