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

RAYTUM PHOTONICS

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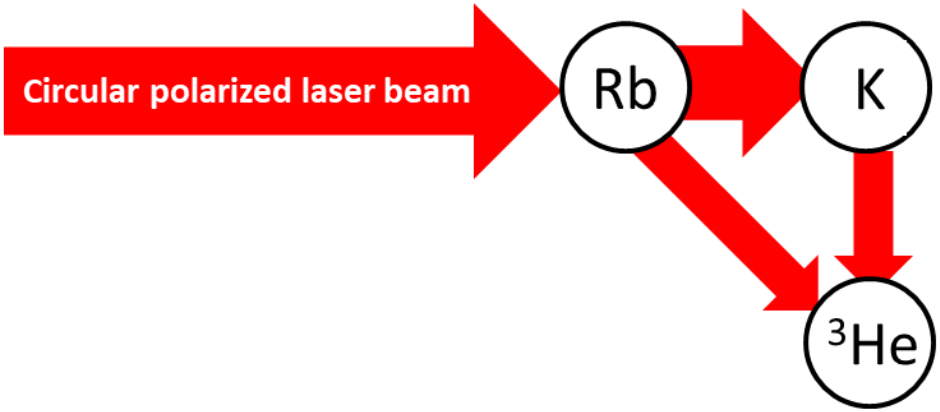
DOE SBIR Phase 2
8/14/2019

How to Get Polarized ^{3}He Gas and Applications



Spin-Exchange Optical Pumping (SEOP)

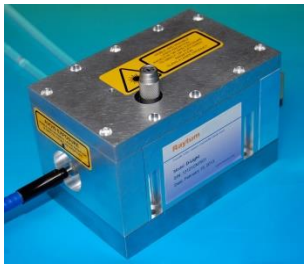
- Gas target in CEBAF, JLab
- Neutron filter in SNS, ORNL
- Gas MRI medical imaging diagnosing lung disease

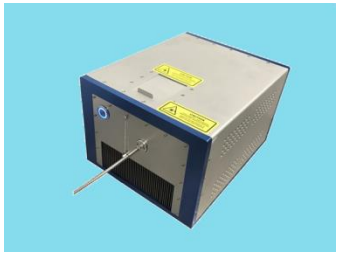
Outline

- Company introduction
- Summary and progress of SBIR program
- Briefly introduction of next generation laser source for polarizing ^{3}He target

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

Evolution of High Power Fiber Coupled Diode Laser for Polarizing ^{3}He



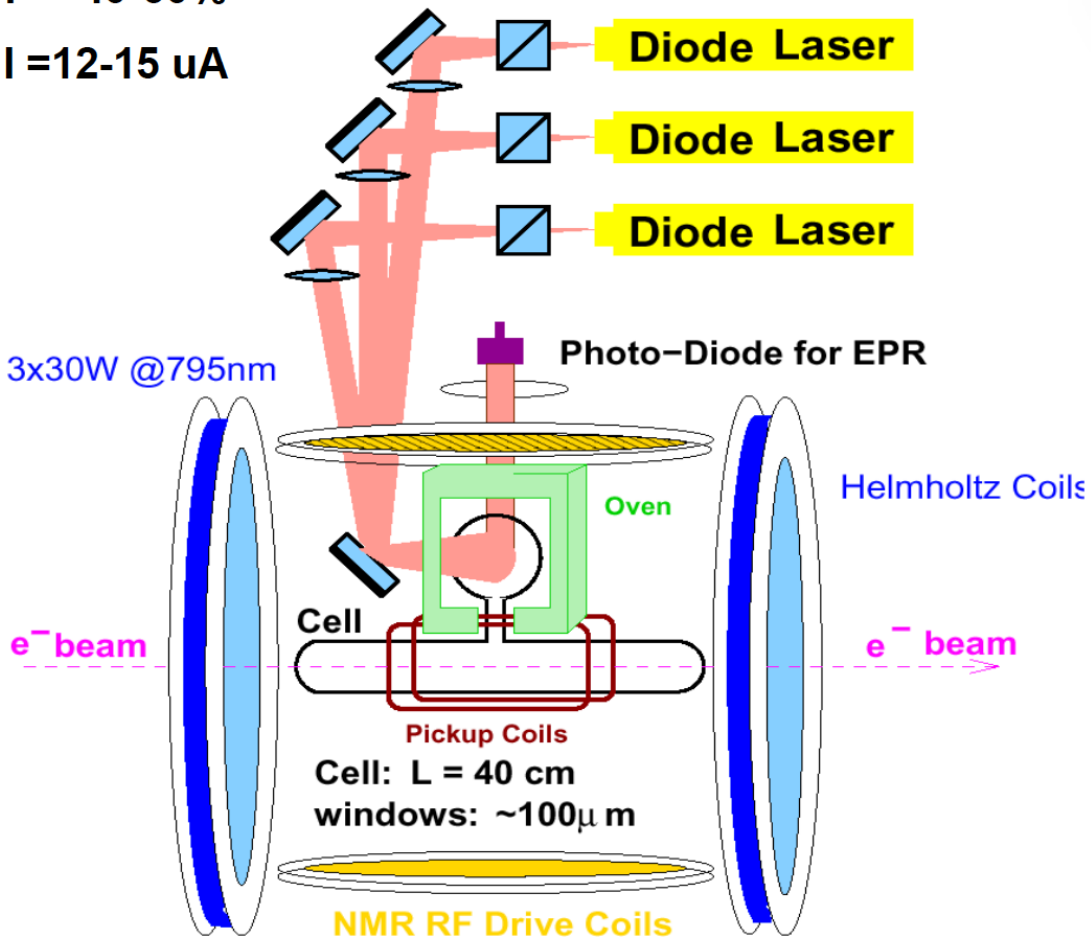



- From individual module to integrated system
- Output Power is higher
- Linewidth is narrower
- More control features
- Smaller size

JLAB Polarized ^{3}He Target Setup

P = 40-60%

I =12-15 uA



Customers


JL


Argonne
NATIONAL LABORATORY


OAK RIDGE
National Laboratory

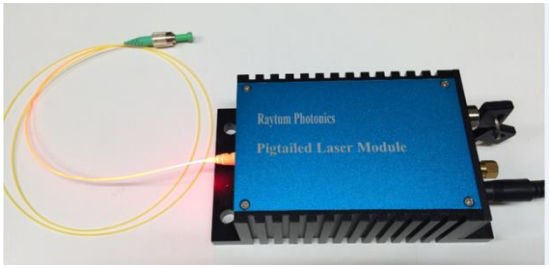

NIST
National Institute of Standards and Technology
U.S. Department of Commerce


UNIVERSITY of VIRGINIA


TEMPLE
UNIVERSITY

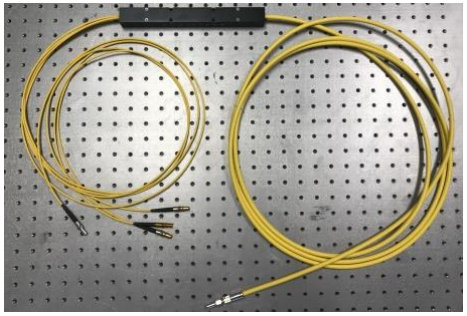

JG|U
JOHANNES GUTENBERG
UNIVERSITÄT MAINZ

Other products

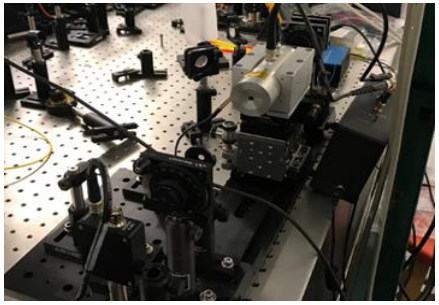


Low power turn-key fiber pigtailed laser, covering wavelength range from 400nm-2000 nm

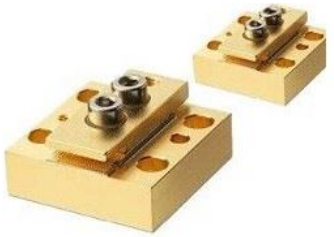
Components and Services



High Power Fiber Combiner



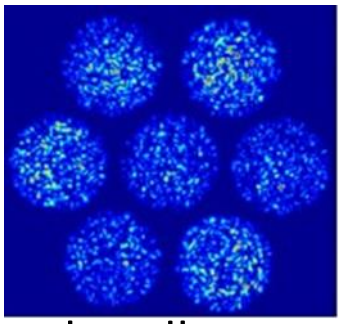
Transverse driven Pockels-Cell is being evaluated in UVA



Any services related to the diode bar like installing the FAC, SAC or BTC

DOE/NP Motivation

JLab physics program requires a factor of 6-8 improvement in luminosity (FOM) 2-stage upgrades for polarized ^{3}He target. The improvement and upgrade on pump laser system are needed to have:

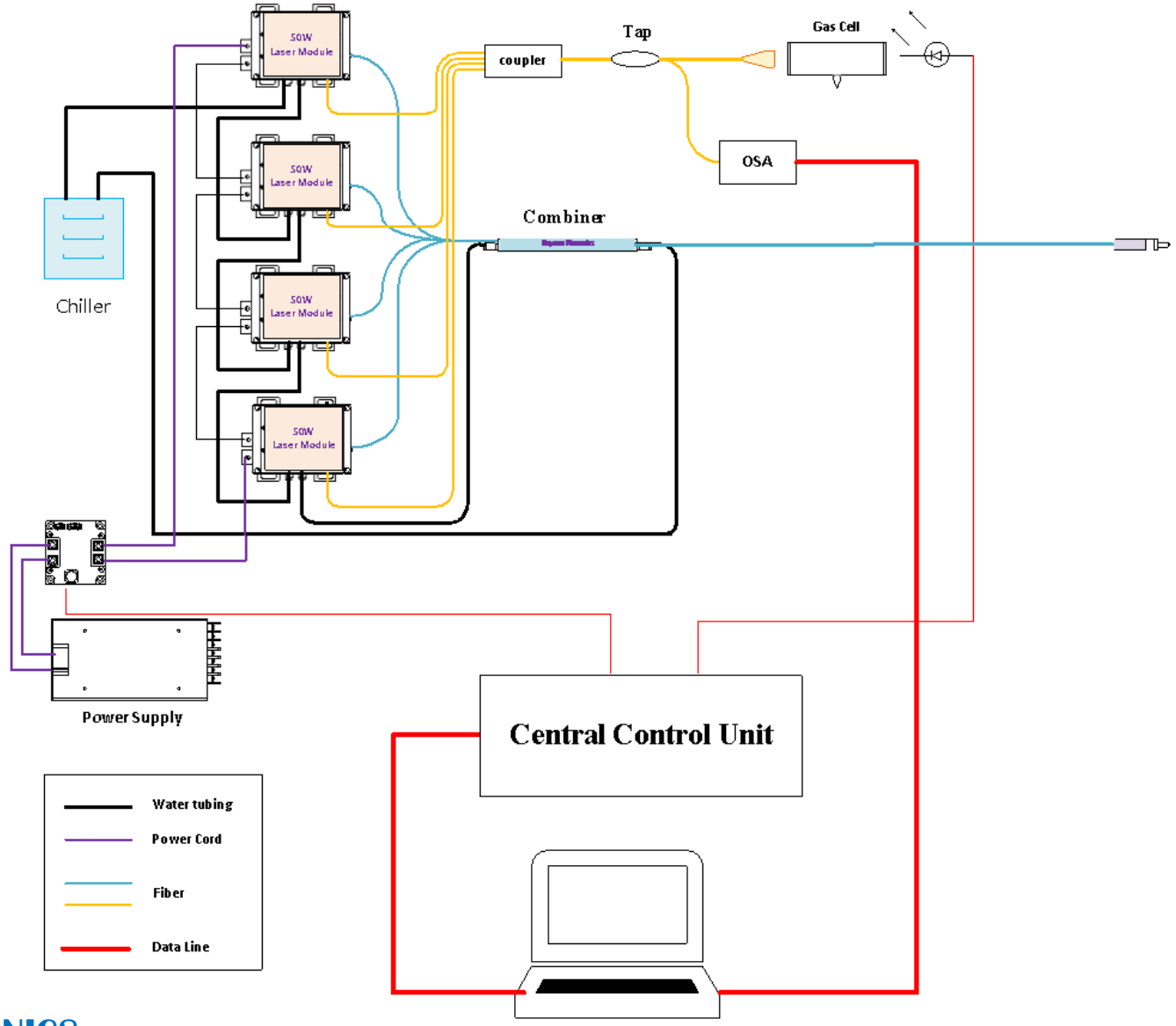


- **Higher power**
- **Better beam profile**
  - Power scaling is realized in JLab through traditional fiber bundle, which leads to terrible output beam profile.
- **Stable lasing wavelength**
  - Long term running of diode laser would cause the output power drop and lasing wavelength shift inevitably.
- **System level remote control and data recording.**
- **Easy maintenance and low cost replacement/repair.**

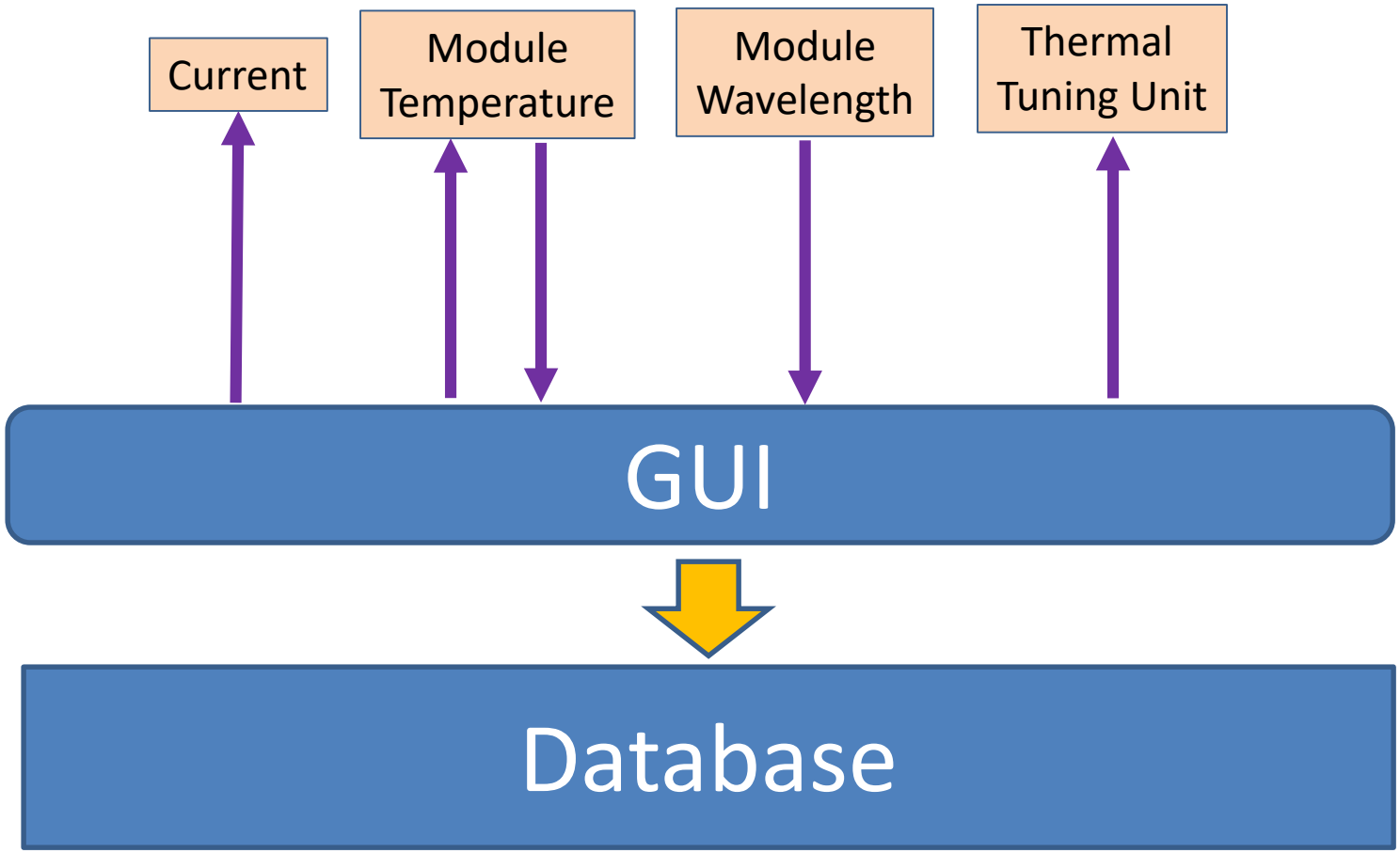
Our Solutions

- **Module design using state-of-art fiber beam combiner**
  - *High power output with power scalable by increasing the module number or/and the power of individual module.*
  - *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 to working wavelength possible.**
- **In the system level, integrate the laser modules, current driver, data acquisition, and central control unit.**
- **The targeting specs are >200 W output, < 0.1 nm linewidth and center wavelength locked to working wavelength.**

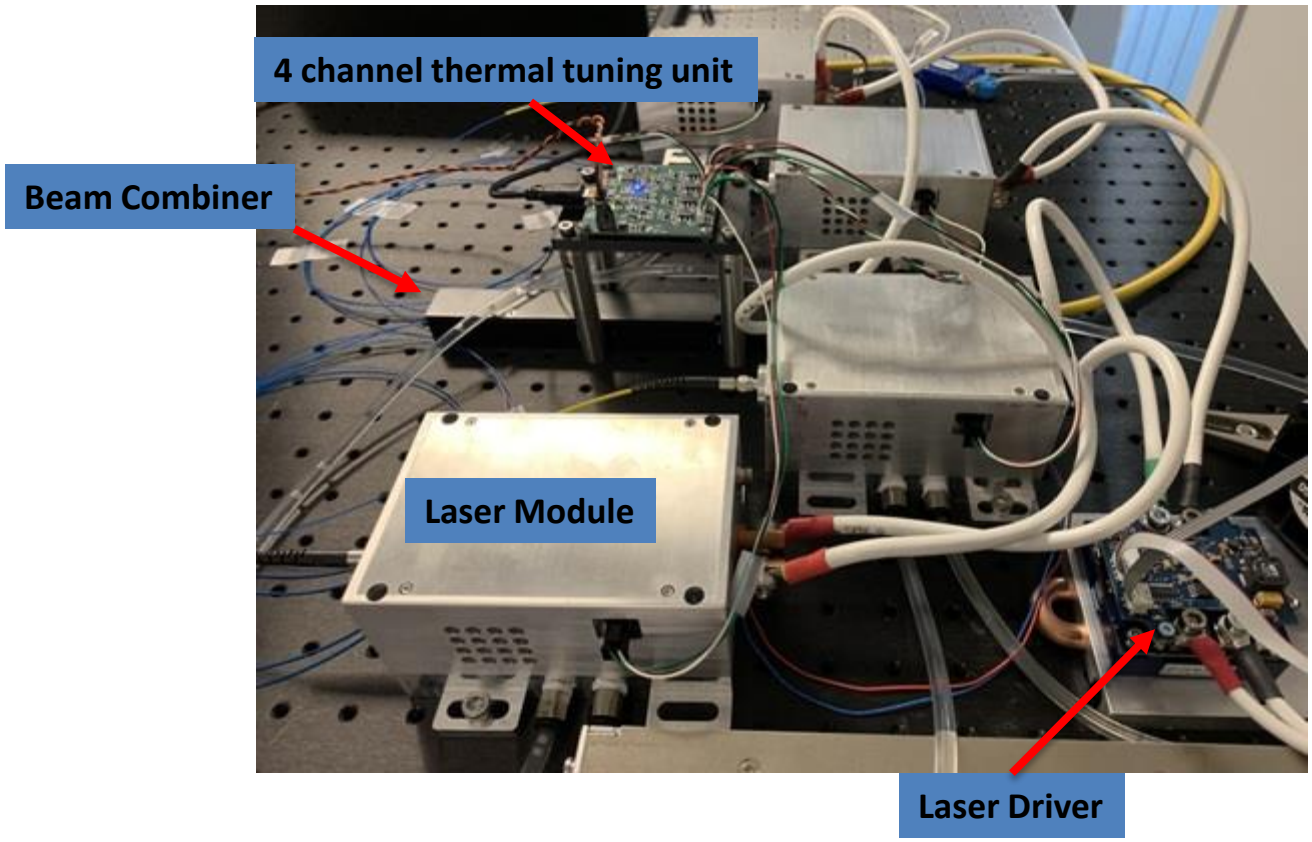
System Schematic



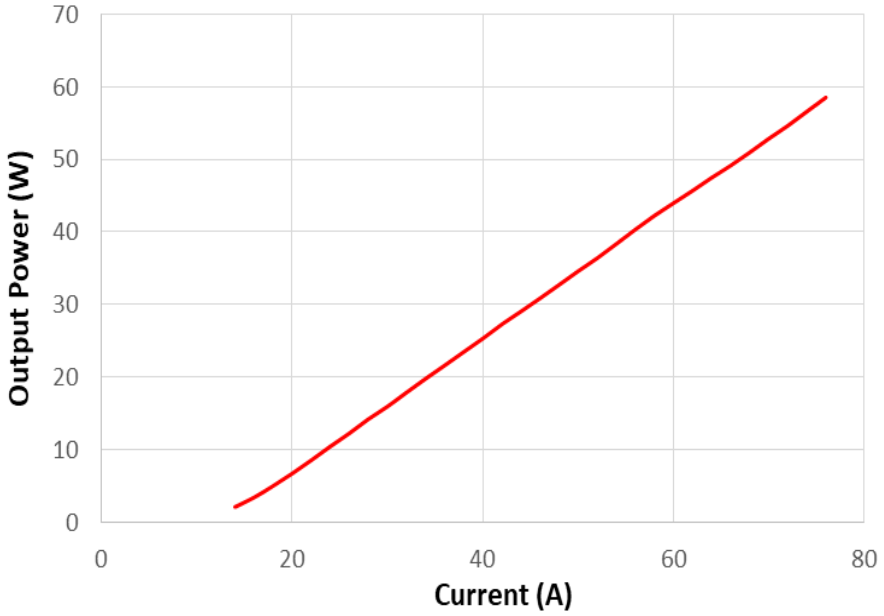
Software Integration

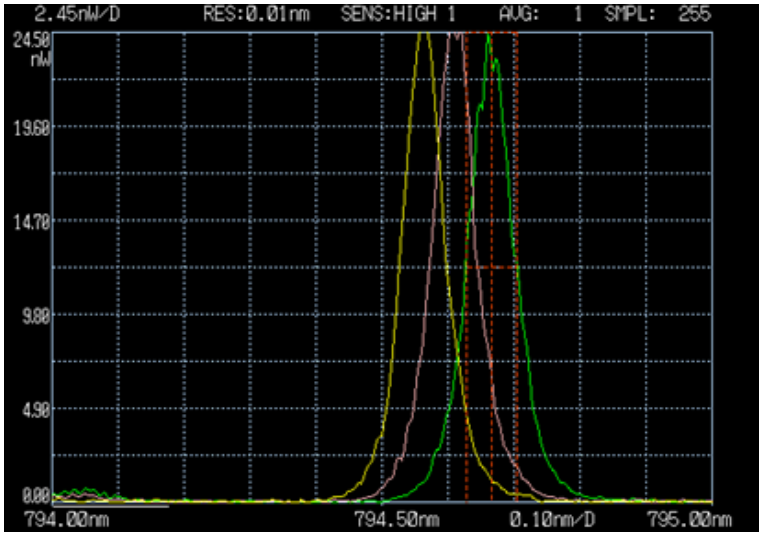


Breadboard Demonstration



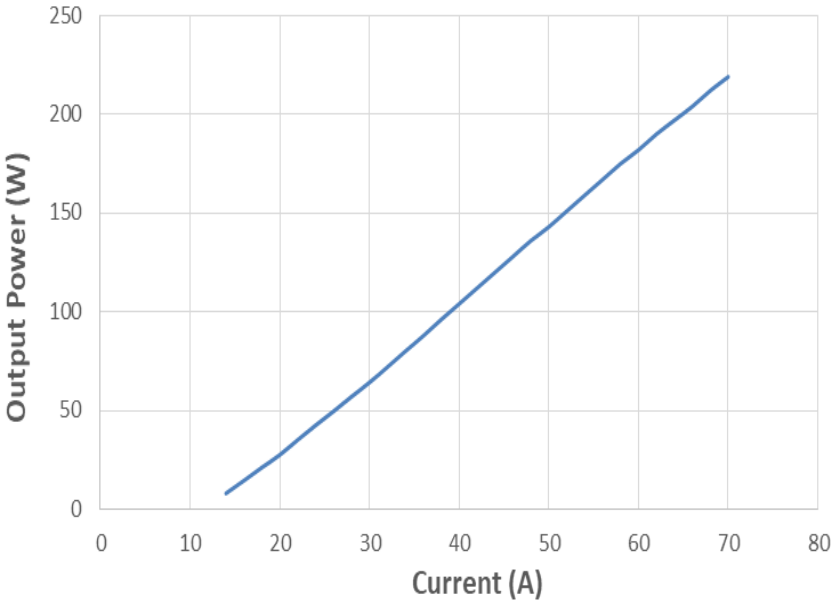
Single Module Performance

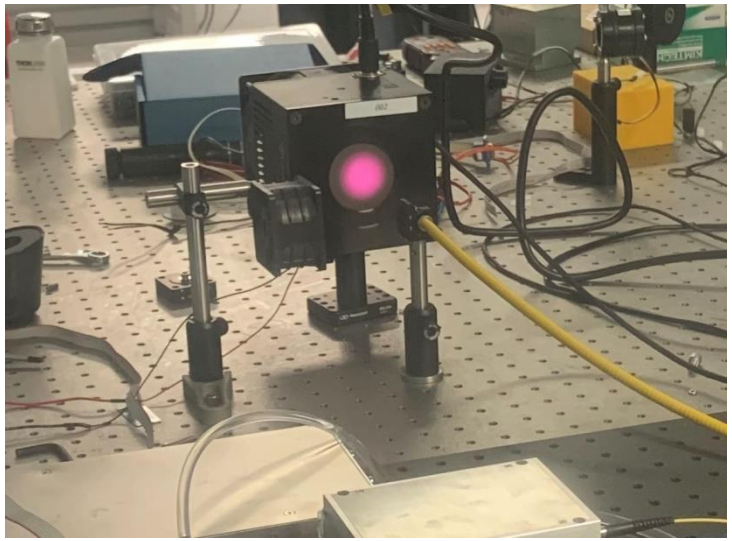




- Output power is close to 60W.
- The lasing wavelength is thermally tunable with a range of +/- 0.2 nm around nominal wavelength of 794.7nm.
- The linewidth is less than 0.1 nm.

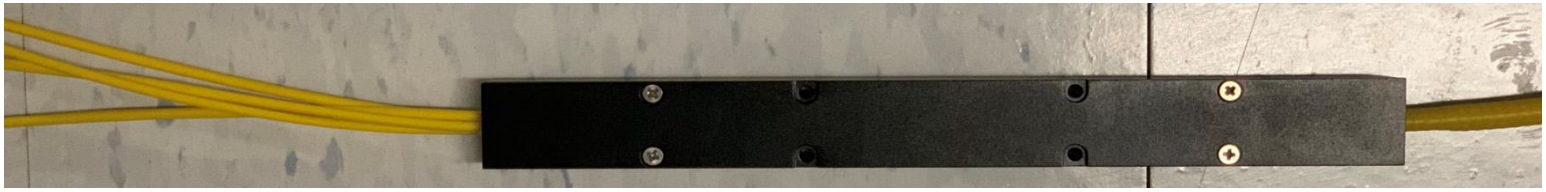
Laser System Performance



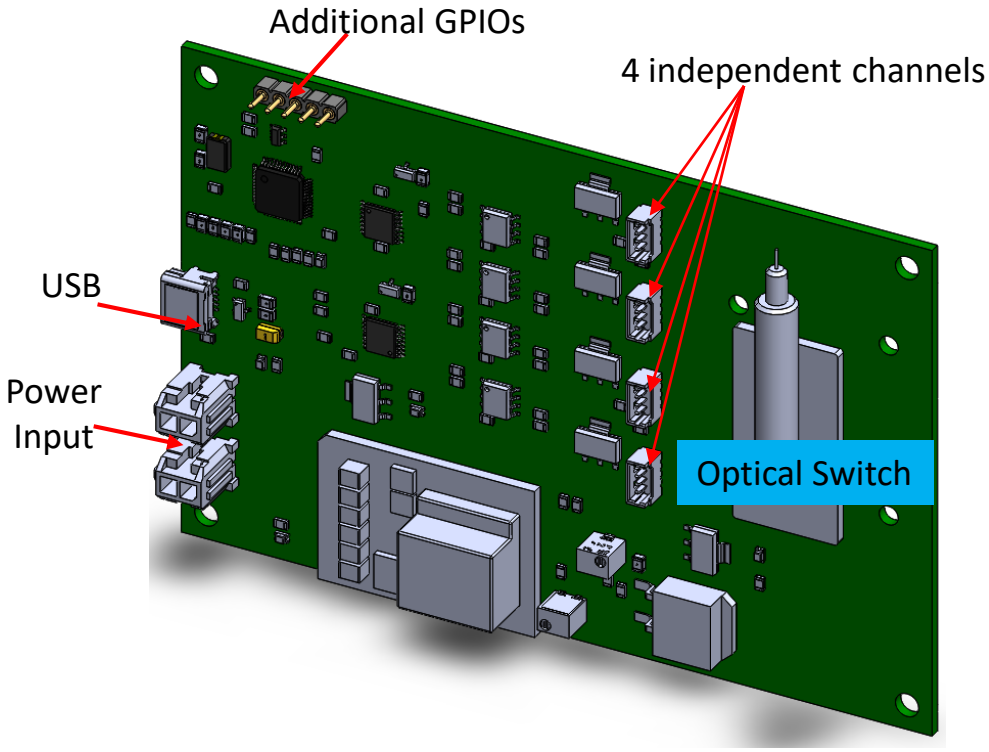


- Output power is more than 200W @70A
- Output beam profile is nice and homogeneous distributed.

Process of High Power Fiber Beam Combiner

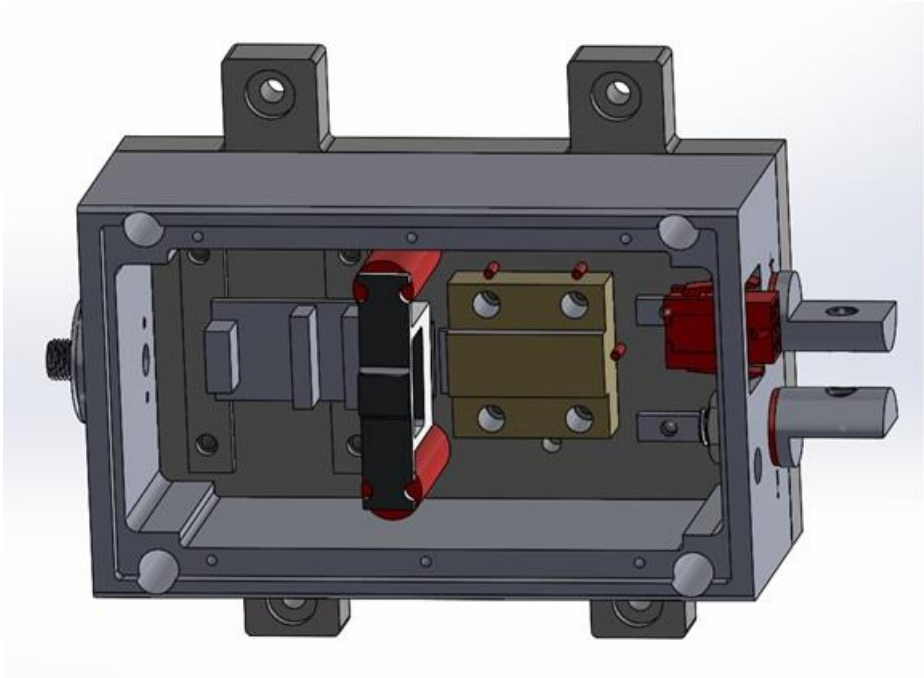


4-Channel Temperature Controller



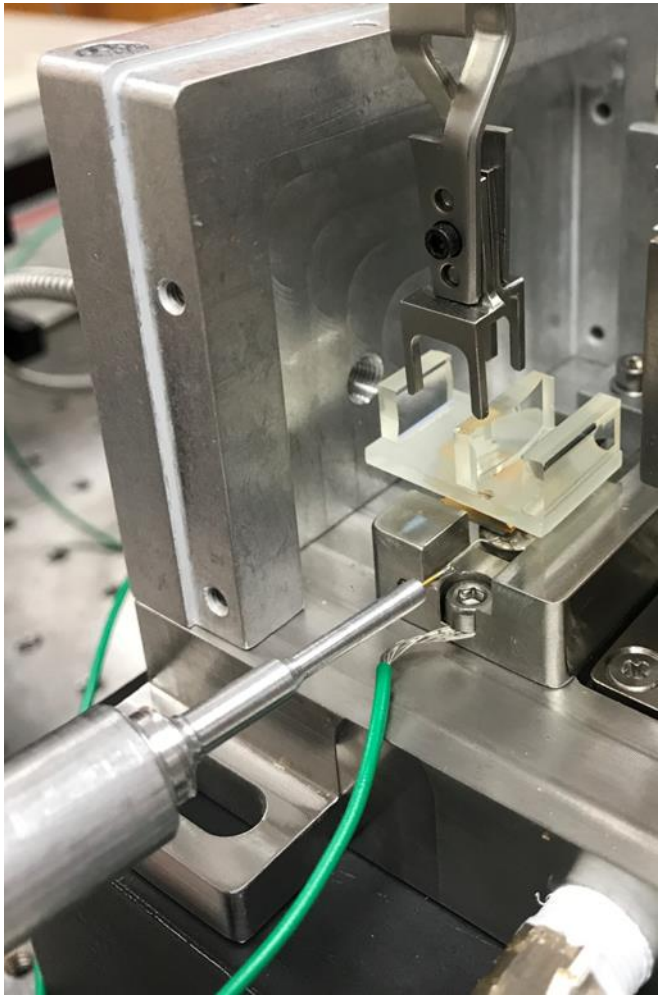
- 4 independent temperature control channels
- Low noise reading and setting with 16-bit resolution
- Easily adjustable heating power to optimize for different thermal loads
- Wide DC power input voltage range (up to 40VDC)
- Compact board design with USB communication
- Integrated on board Optical Switch

3-D Printing in the Laser Module Development



- Perfect for manufacture of tiny components
- Faster turn around time for the product development.

Optics Mechanical Soldering



- Optics soldering provides reliable and robust alternative to the epoxy.
- The whole soldering process finishes in seconds- no worry about the mis-alignment of optics during the long curing time of epoxy.

Works Left

- Brass-board integration of whole system.
- In-house reliability test.
- Wavelength detection and locking. The hardware board is ready and waiting for software integration and debugging.
- Expect to deliver the whole system to Jefferson Lab by the end of this year for the test.

High Power Fiber Laser System for Polarization of ^{3}He Gas

Phase II starts in June 2019

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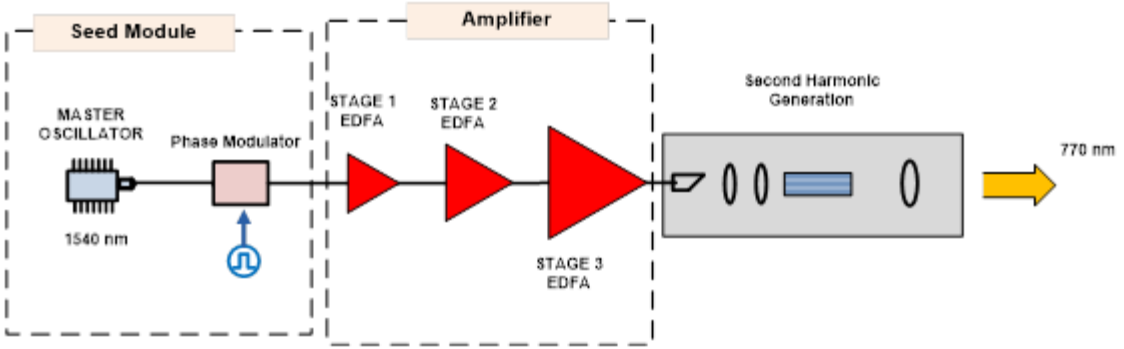
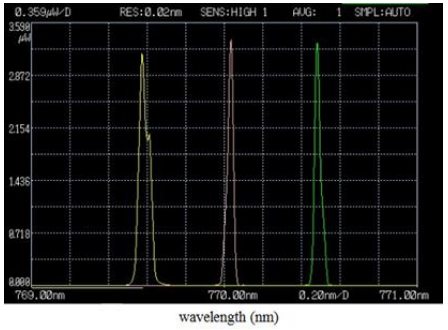
Phase One Achievement

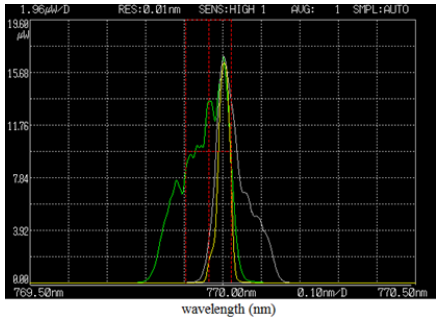
Parameters	Phase I Specification	Phase I Achievement
Wavelength(s)	Funamental: 1540 nm Output: 770nm	The output wavelength is tunable between 769 and 771 nm by adjusting the seed diode temperature
Output Average Power	P_{1540} = 30W, P_{770}=10 W	P_{1540} > 60W, P_{770}>25 W
Optical Linewidth	MHz to GHz	Up to 50GHz was demonstrated
Output Beam Quality	$M^2 < 1.2$	Excellent output beam profile was achieved
Polarization	Circulatr polarized	The output beam is linear polarized with polarization extinction ratio > 20 dB.
Packaging	Low SWaP	Both first stage and second stage amplifiers are packaged in the box. The mechanical design of system integration is finished, as shown in **FigureS. 1**

Phase I Performance

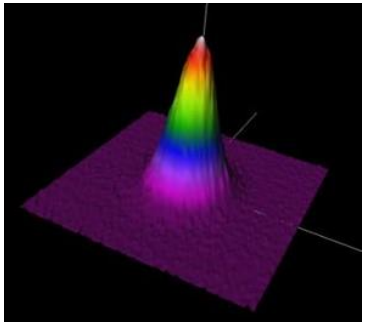




Wavelength tuning

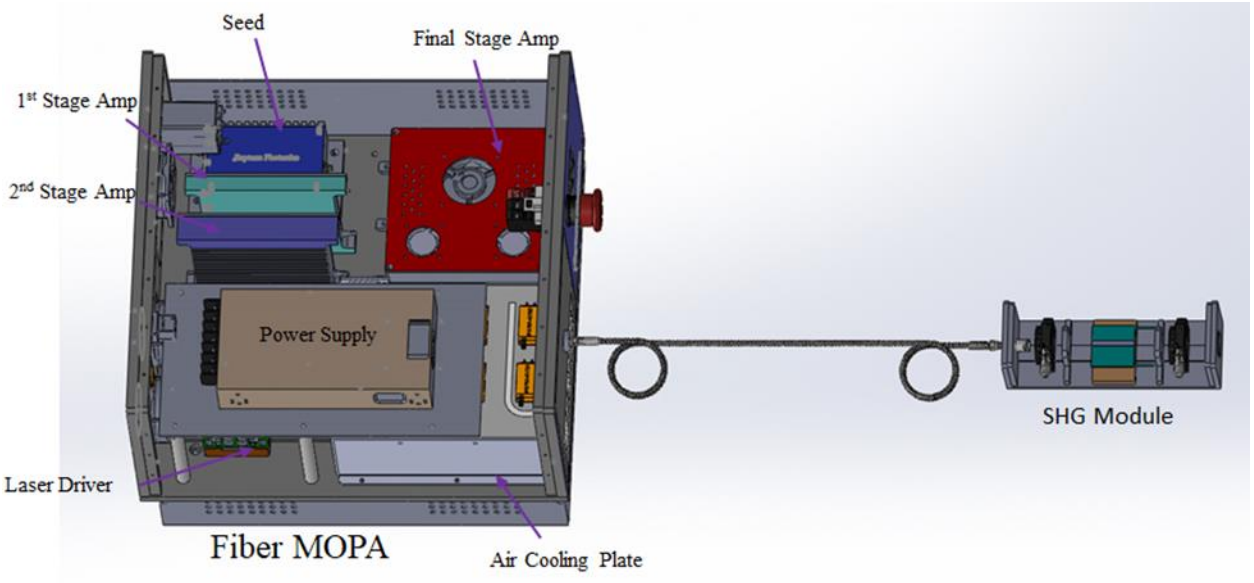


Linewidth tuning



Excellent beam quality

System to deliver



Parameter	Specification	Additional Comments
Output Power	100 W at 1540 nm > 50 W at 770 nm	Output power at 770 nm might be higher if higher efficiency is achieved
Wavelength (nominal)	1540 nm (Fundamental) 770 nm (SHG)	Tunable
Linewidth Tuning	0.01 nm to 0.2 nm	
Wavelength Tuning	> 1 nm	Sufficiant for the K vapor pumping and can be locked to the absorption line
Output Polarization	Circular	
Thermal Management	Air Cooling	
Lifetime	> 8,000 hours	The laser module is hermetically sealed
Package Size	1,300 in^3	This is a rough estimate