Advancement in 2-micron Laser Transmitter at NASA LaRC for Coherent Doppler Wind Lidar

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Objectives & Technical Approach

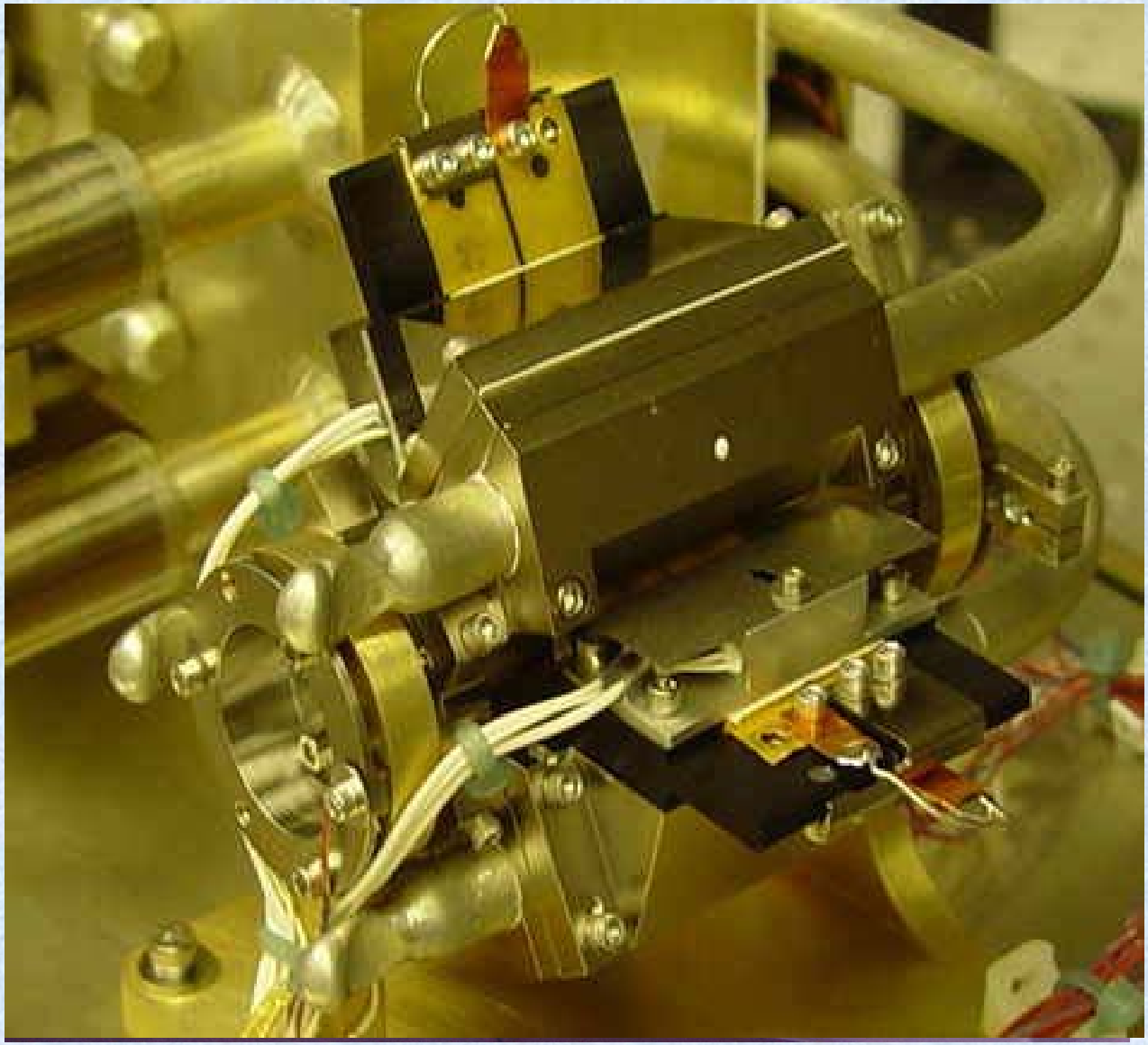
Objectives

Develop related laser technologies leading to a conductively cooled, diode-pumped high-energy and high-efficiency 2-micron pulsed laser suitable for space-based remote sensing Lidar applications to support science and exploration missions.

Technical Approach

"Systematically conduct theoretical and experimental research to develop related laser technologies included but not limited to new laser materials, innovative cavity designs, pump module designs, diode configurations, advanced thermal management systems, creative mechanical design and fabrication technologies."

Laser Head Design Advancement



10 Diode Arrays

Conductively Cooled

2 Water Channels

2004-2006

10 Diode Arrays

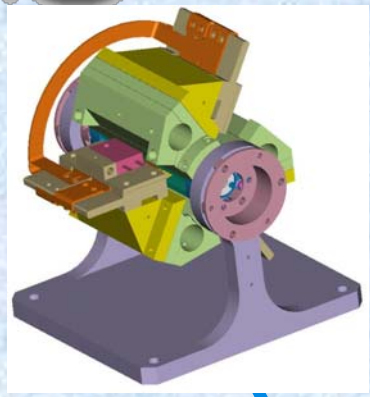
4 Water Channels

2002-2003

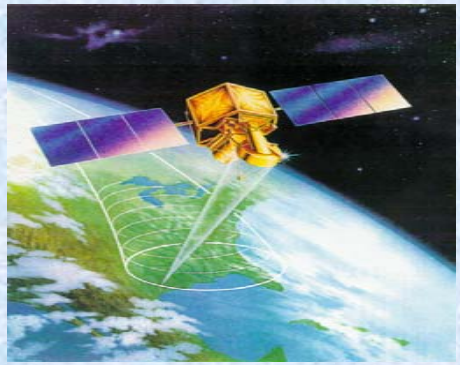
10 Diode Arrays

2001-02

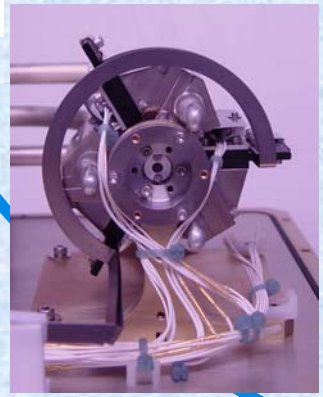
Technology Maturation Example



A fully conductively cooled 2-micron solid-state pulsed laser has been demonstrated to enable 3-D Winds and/or global CO_2 from a space platform

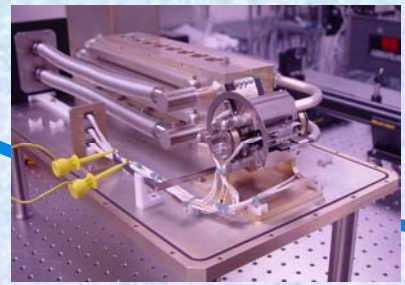


Analysis & Design



Fabrication

Quantum Mechanical Modeling



System Integration

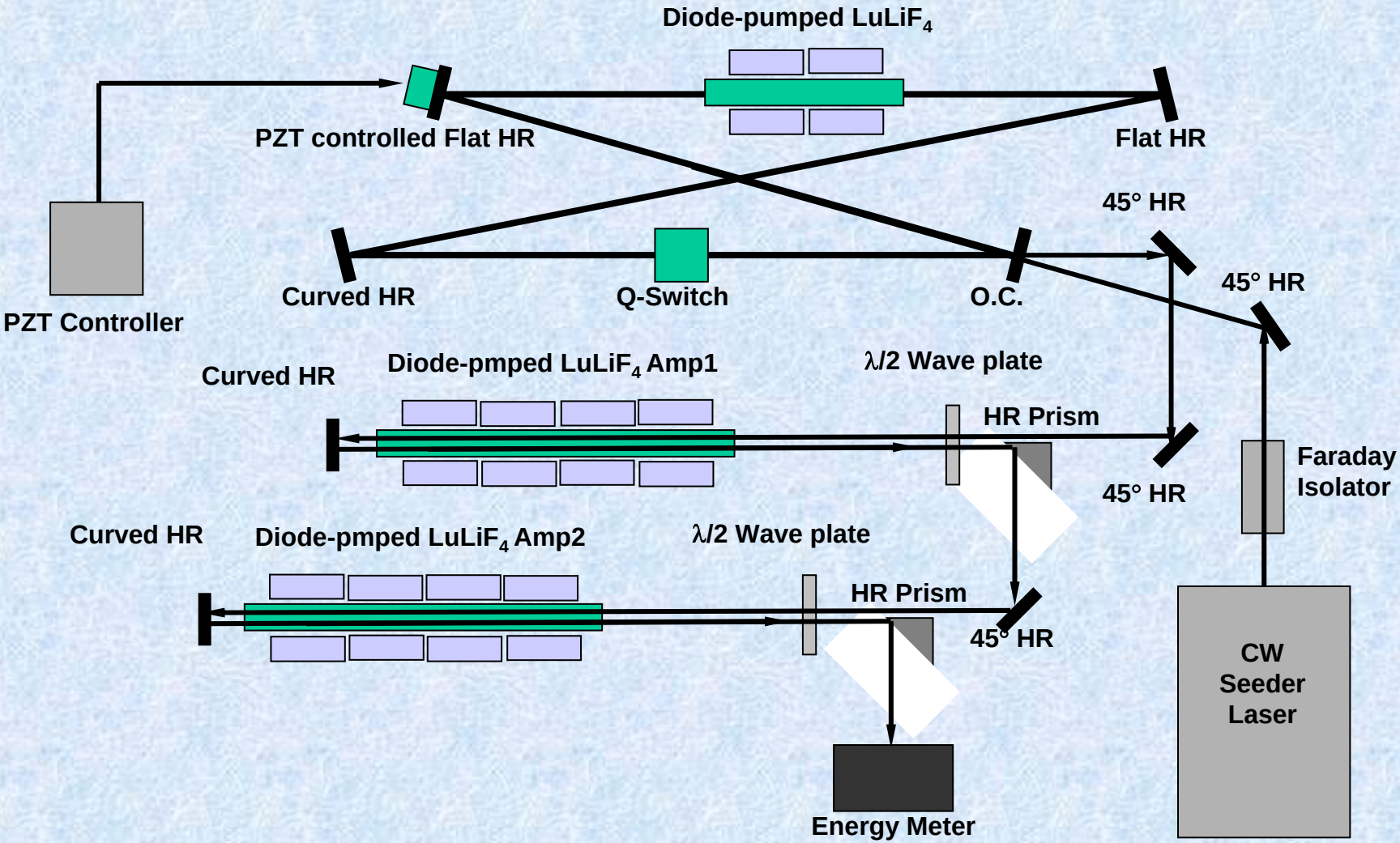
Space Qualifiable Design

Testing and Model Verification

Outline

- 1.2 Joule/pulse energy demonstration
- Compact 2-micron wind lidar transceiver
- Conductive cooled 2-micron amplifier

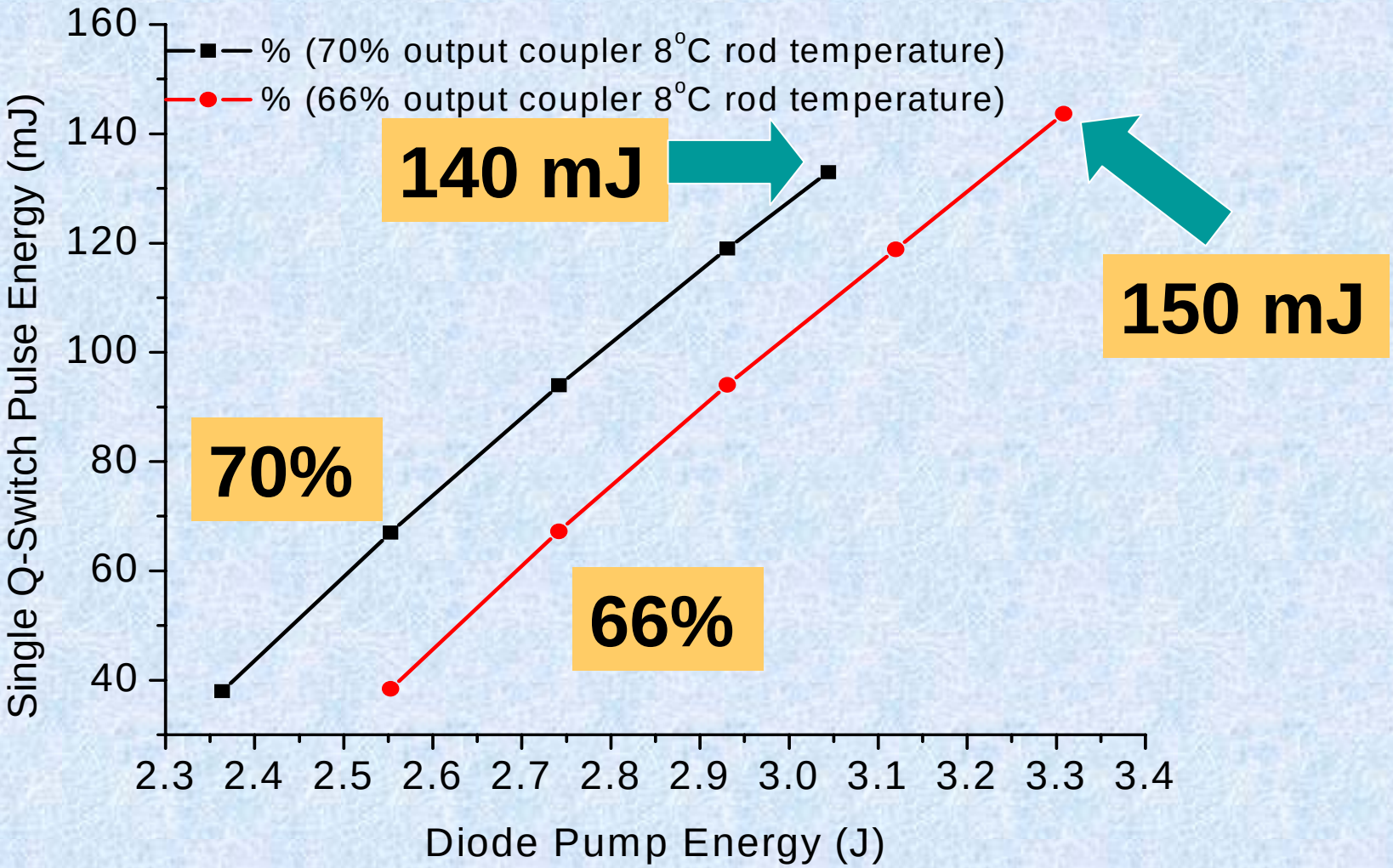
MOPA Schematic



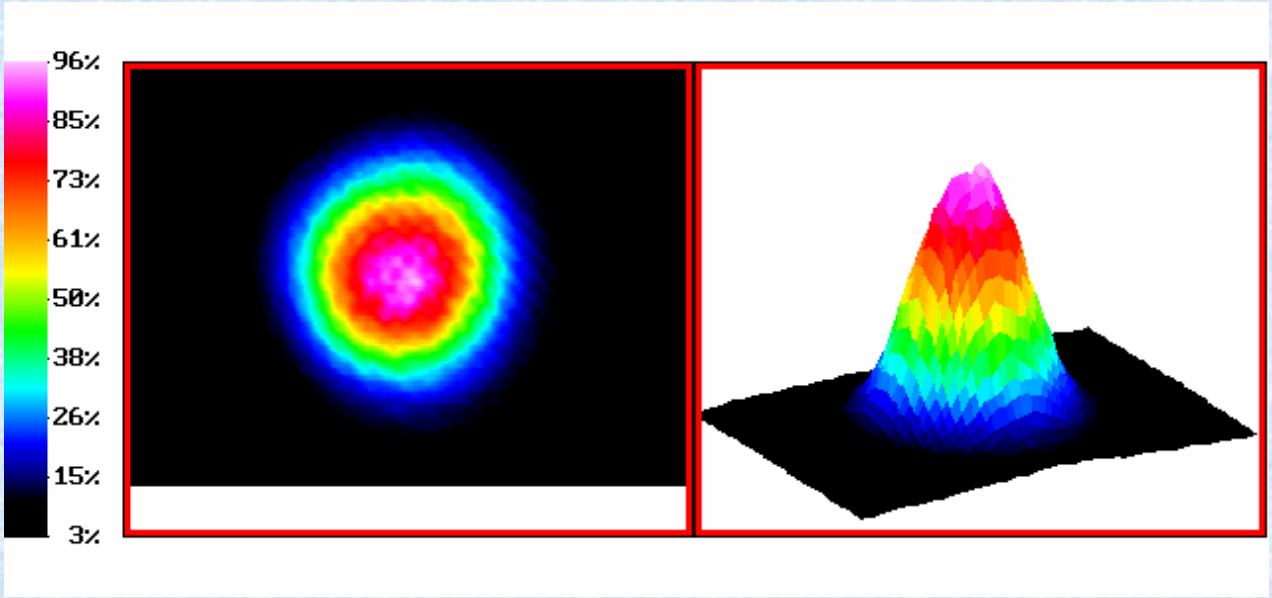
Oscillator Features

Cavity Length	>2m Ring
Output Coupler Reflectivity	~70%
Diode Pump Lasers:	36 bars 100W/bar Conductively Cooled
Crystal Doped Length	21mm
Undoped LuLiF Length	15 mm
Laser Crystal Cooling	Water Cooled
Tube Size	6mm OD 5mm ID AR Coated for 792nm
Laser Rod Ends	Wedged 0.5° along c-axis AR Coated for 2.053μm

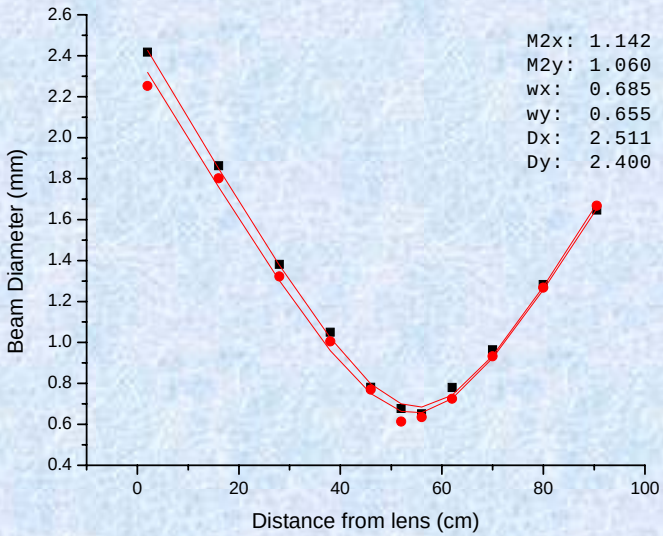
Oscillator Output Energy



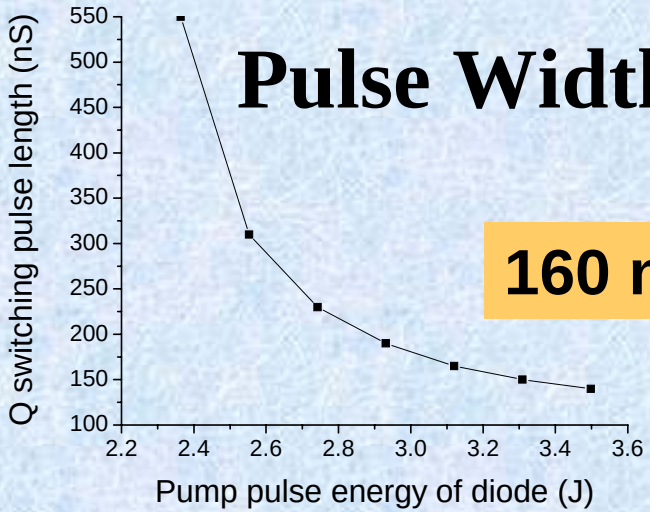
Laser beam profile



$M^2 \sim 1.2$



Pulse Width



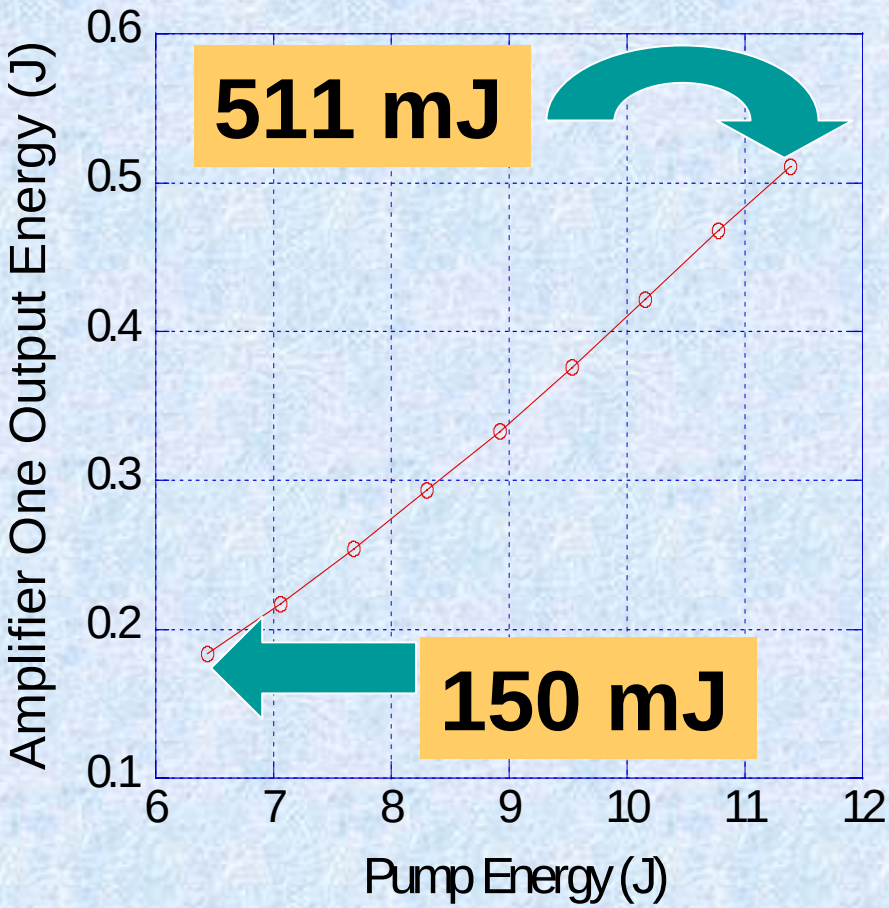
160 ns

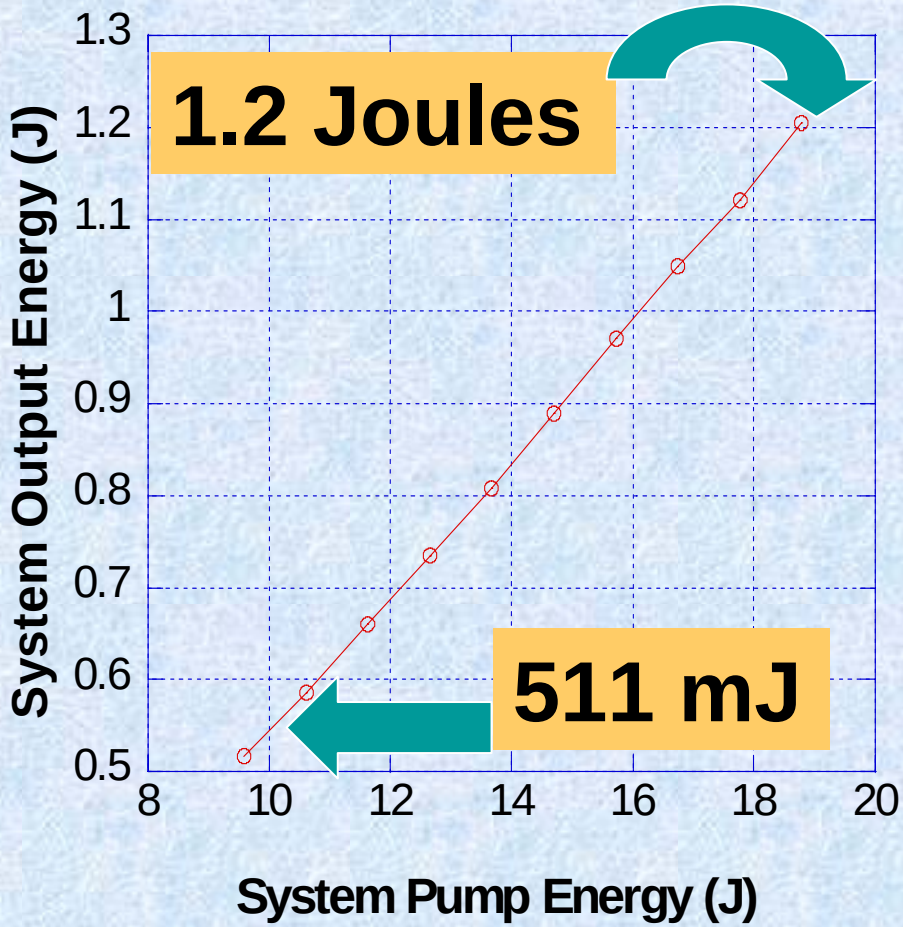
Amplifier features

Pump Energy	7.2 Joules, 12x6 bar Arrays 100w/bar
Diode Laser	Conductively Cooled ‘A’Pkg
Laser Crystal	Ho:Tm:LuLF 0.5% Ho 6%Tm
Doped Crystal Length	42.5mm
Ends Diffusion Bonded	15 mm Undoped LuLiF Crystals
Laser Crystal Cooling	H_2O
Flow Tube Size	7mm OD 6mm ID AR Coated
Rod Ends	AR Coated for 2.053µm Flat
Configuration	Double Pass

Amplifier Performance

(First and Second)





Results

Developed a 2 μm solid state Ho:Tm:LuLF laser oscillator and two amplifiers (MOPA)

	Master Oscillator	MOPA
Output Energy	150 mJ	1.2 J
Optical Efficiency	4.5 %	6.5 %

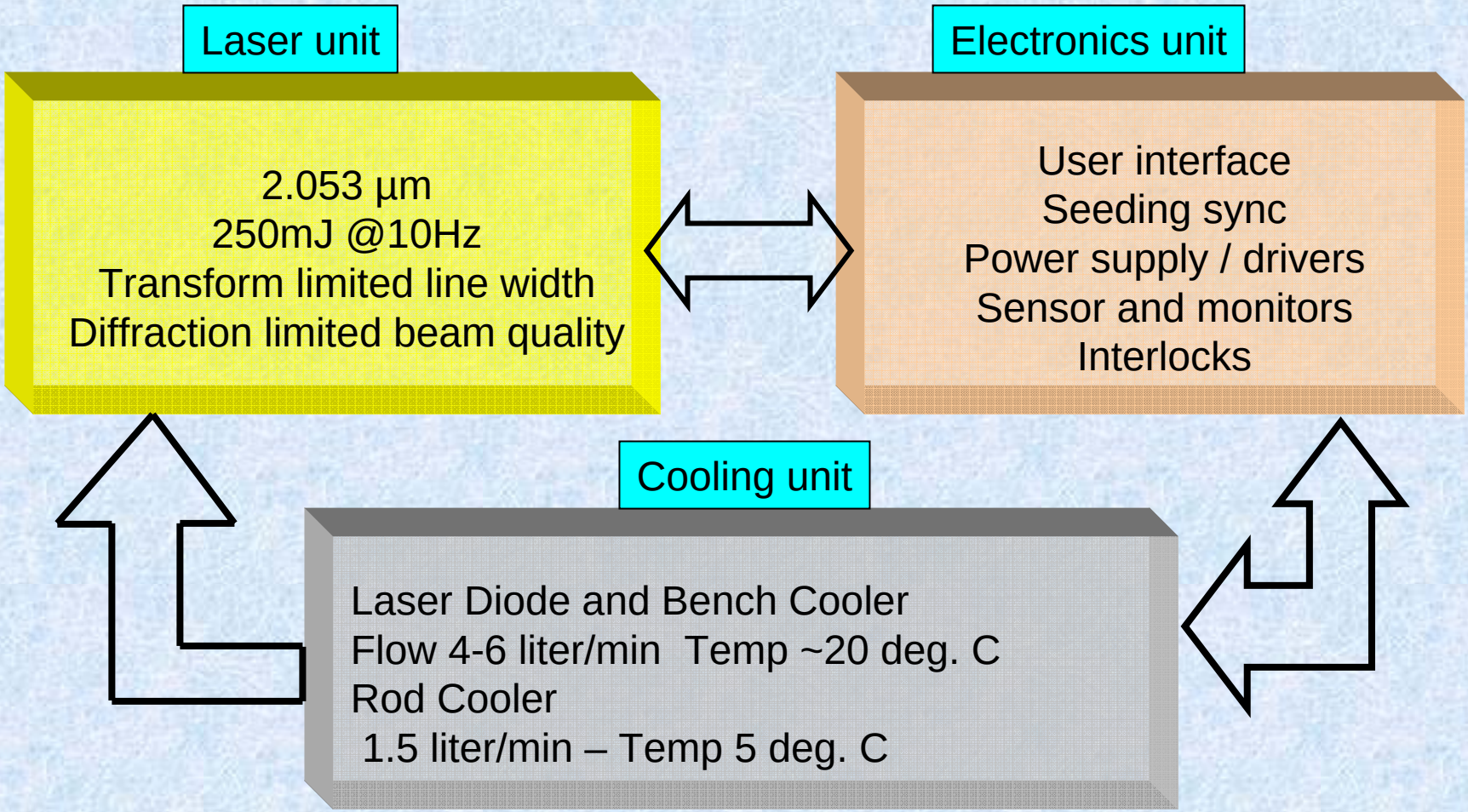
Outline

- 1.2 Joule/pulse energy demonstration
- Compact 2-micron wind lidar transceiver
- Conductive cooled 2-micron amplifier

Objective

- Convert the bench top laser in to a compact, hardened, field deployable lidar transmitter
- Reduce risks associated with Doppler Lidar transmitter
- Identify lifetime sensitive components and initiate early testing

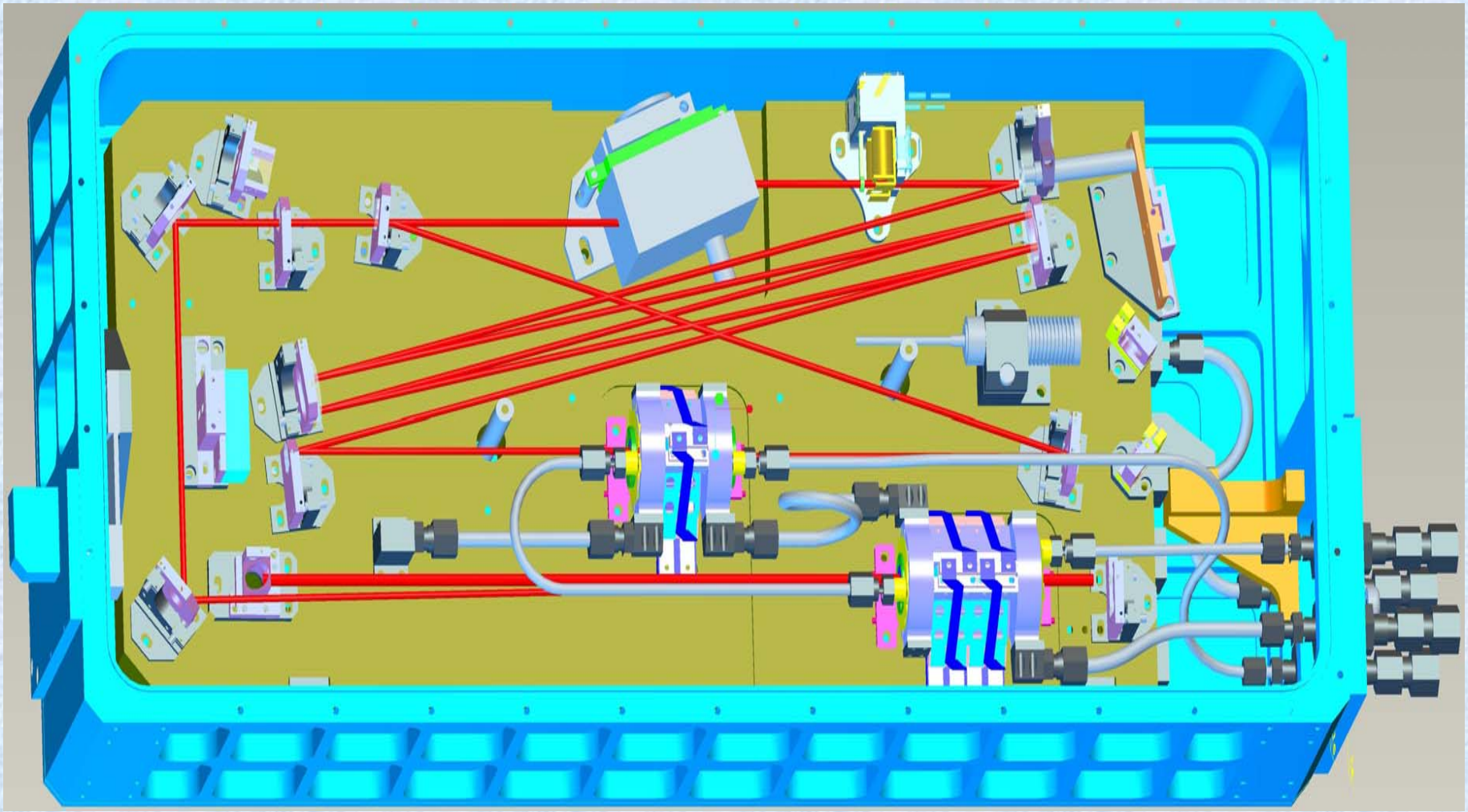
System Block Diagram



Oscillator Features

- Injection seeded 3m Ring resonator
- Pump energy up to 3.6 joules
- Lasers Diode pump “AA” Package LDA conductive cool
- Laser crystal material Ho:Tm:LuLF 0.5% Ho 6%Tm
- 4mm diameter by 21mm long Doped Crystal
- Rod ends diffusion bonded with 15mm undoped LuLF
- 6mm OD 5mm flow Tube ID AR coated for 792nm
- Laser rod ends are wedged 0.5° along c-axis and AR coated for 2.053μm

LRRP Pulsed, 2-Micron Laser Transmitter

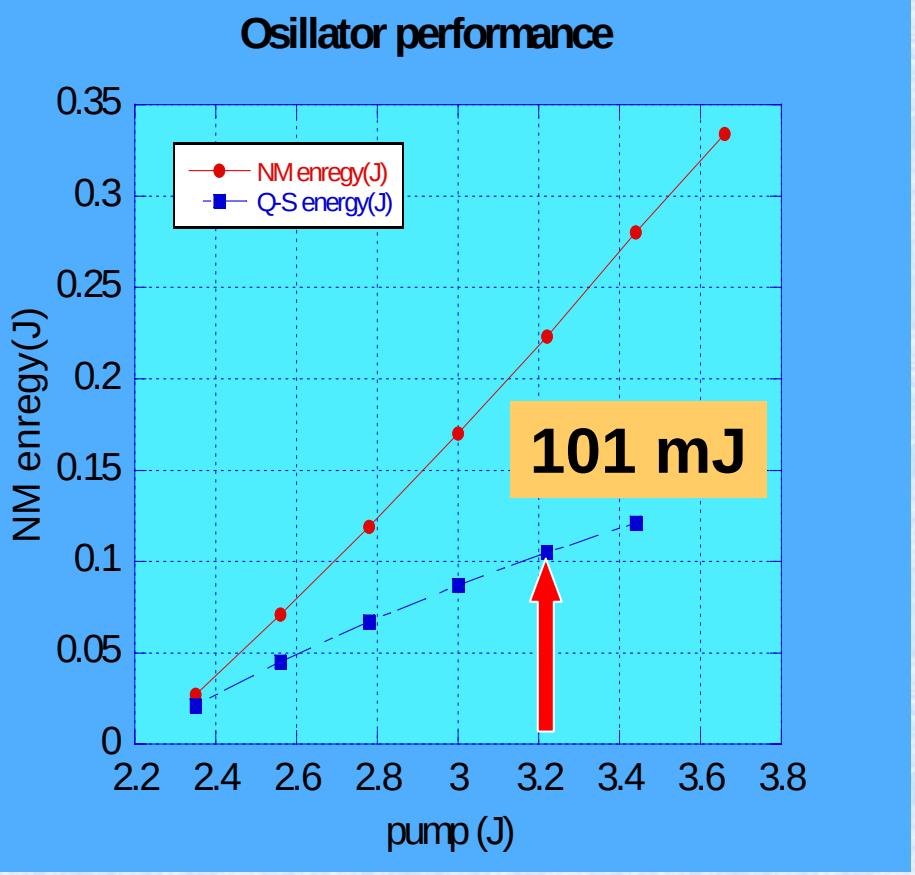


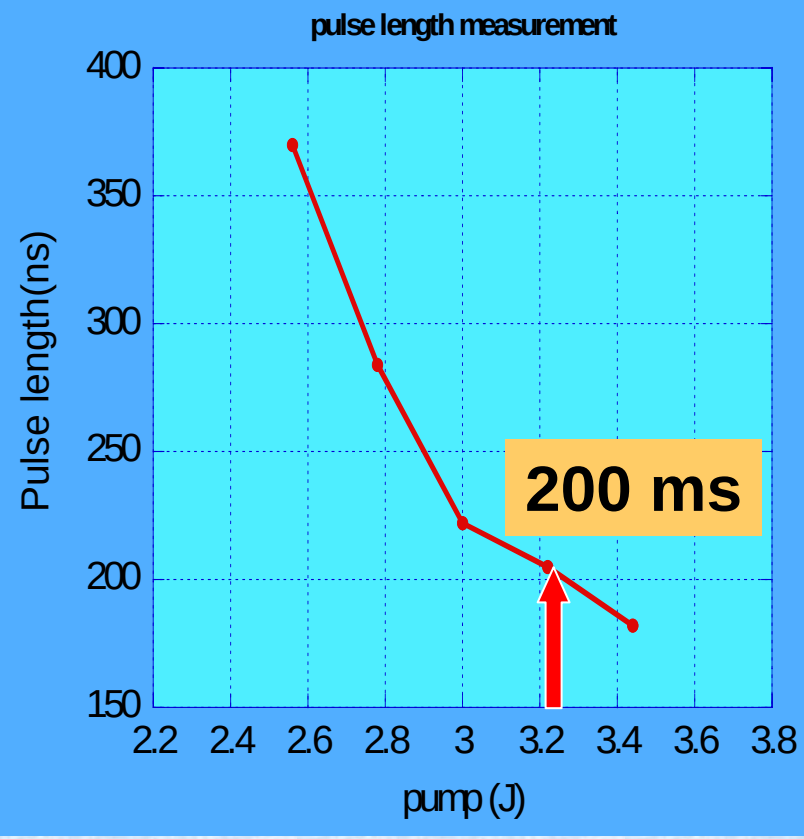
Compact Laser Transmitter

Compact Laser Transmitter

Enclosure Box

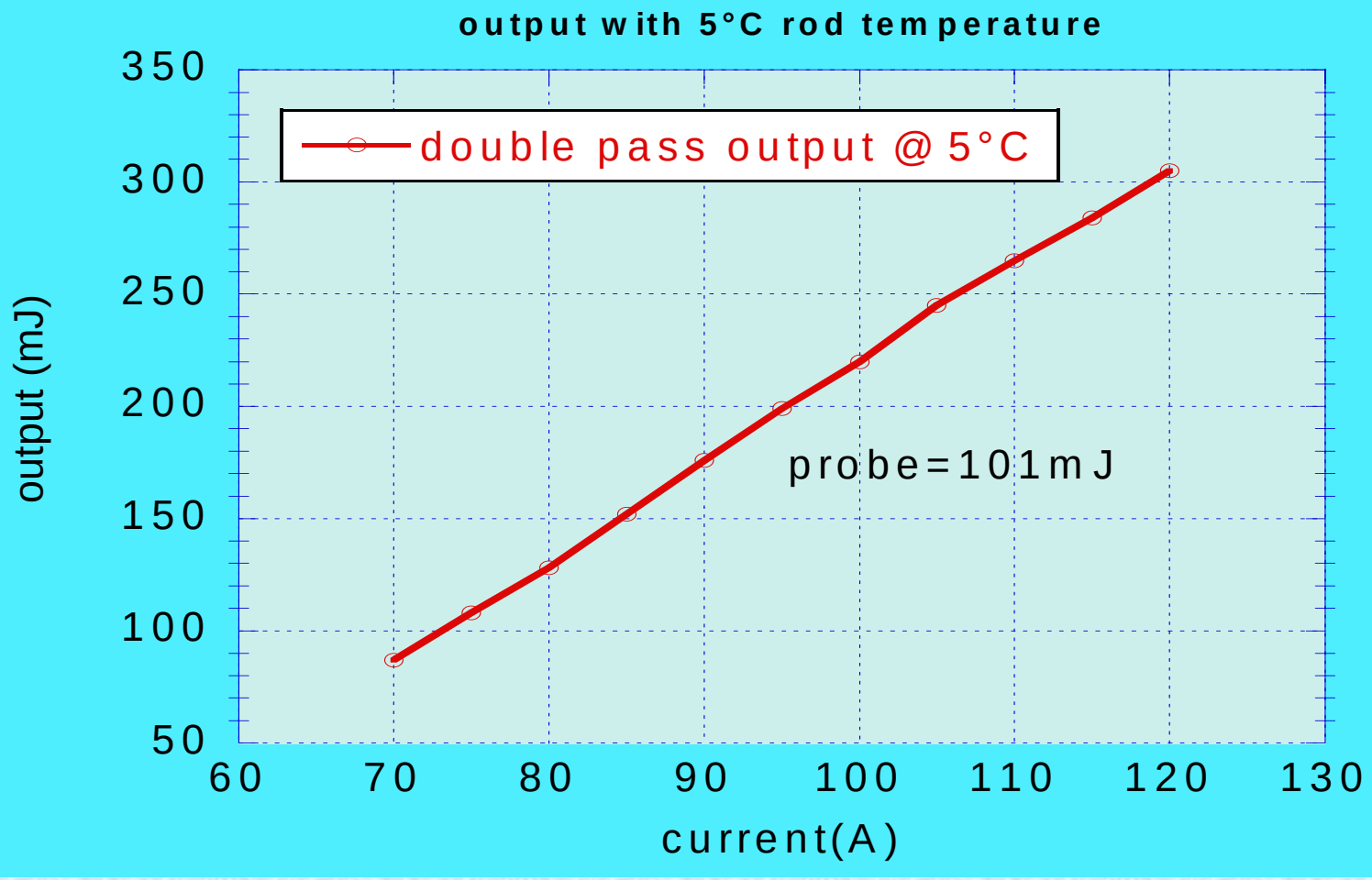
Oscillator Performance





3.2 Joule is selected as the operating point

Double Pass Amplifier Performance



Summary

- A compact wind lidar transceiver has been designed and manufactured.
- Oscillator produced ~100mJ at pump energy of 3.2J
- A MOPA system output of 300mJ at 10 Hz demonstrated.

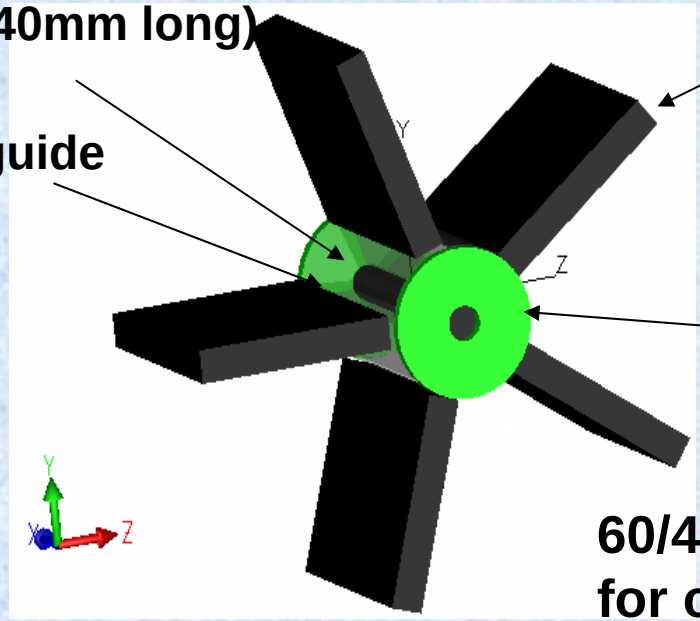
Outline

- 1.2 Joule/pulse energy demonstration
- Compact 2-micron wind lidar transceiver
- Conductive cooled 2-micron amplifier

5-sided Amplifier Head Concept

Laser Rod (5mmX40mm long)

Light wave guide



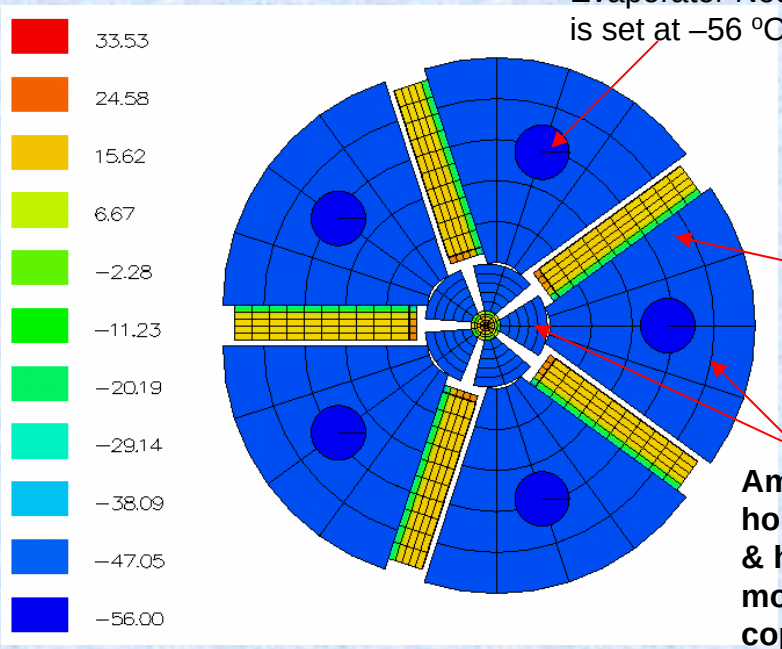
Pump-diode modules, 5x

Laser Rod Housing

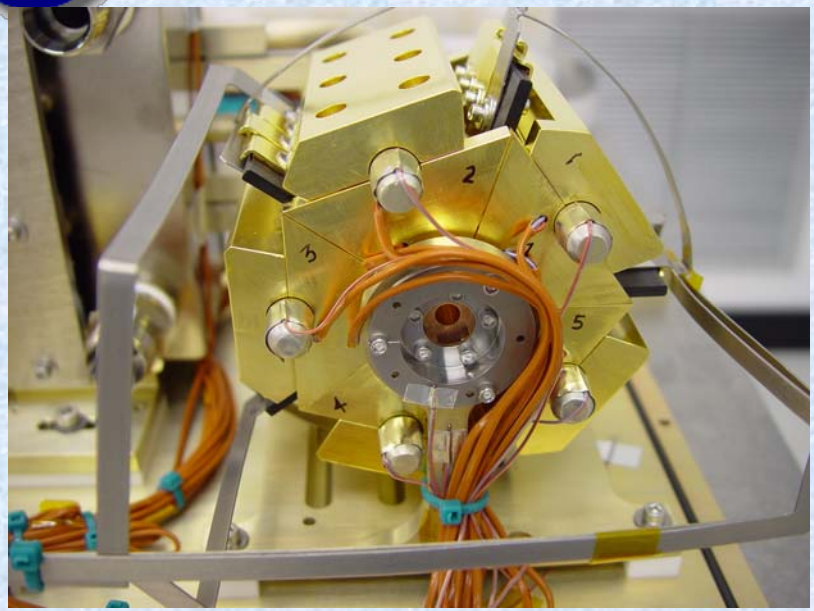
60/40 of arc-length is allocated for conductive cooling

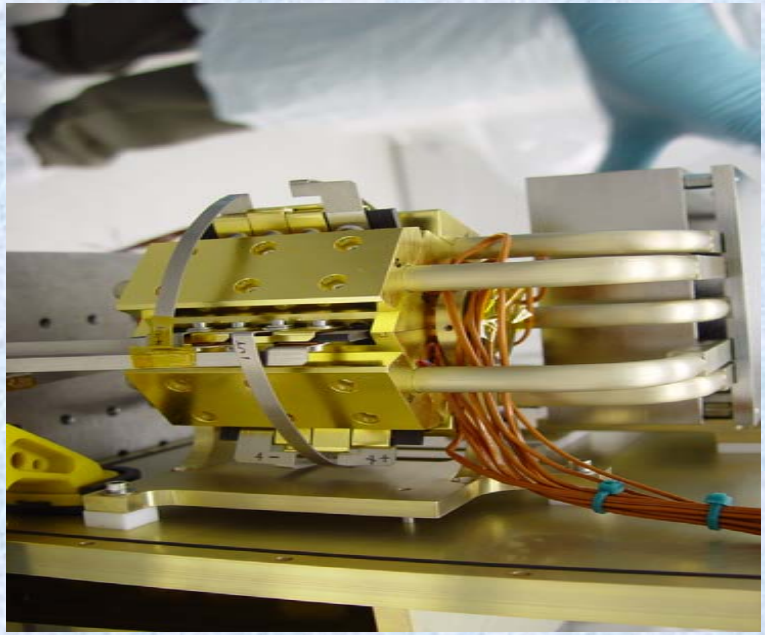
Amplifier Head Thermal Map

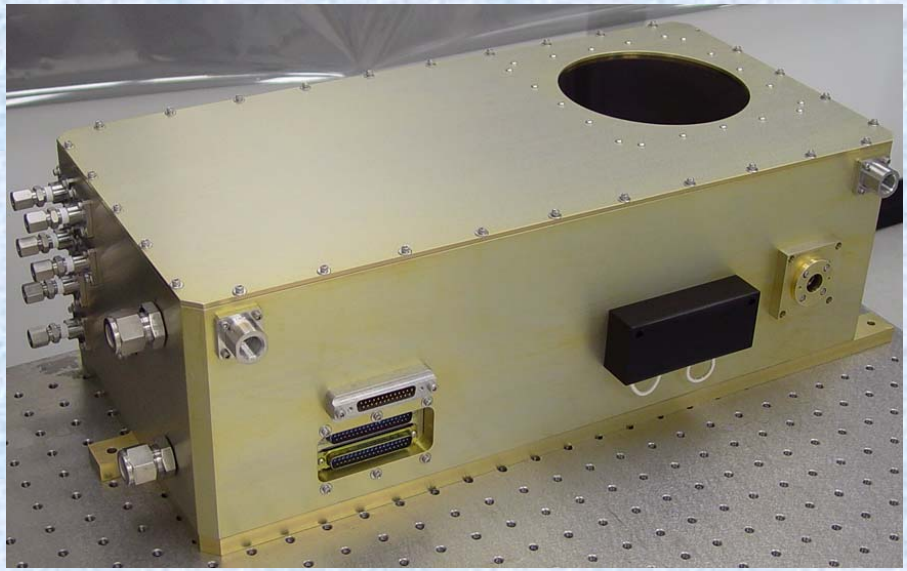
- **Tradeoff studies were performed to optimize amplifier housing for minimum thermal gradient**
- **Optimization parameters included: physical geometry and material selection.**
- **Optimized solution is to combine crystal cartridge with heat pipe saddled into a single piece amplifier head housing made of copper**



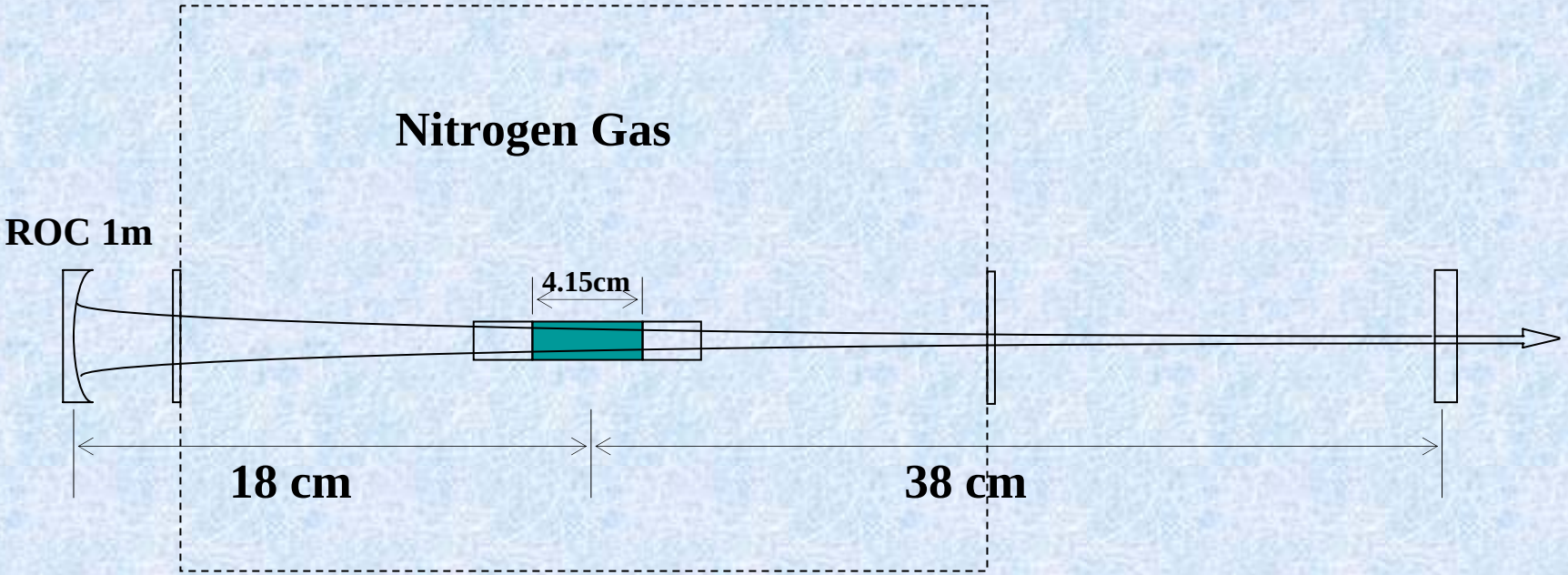
Amplifier Head and Housing



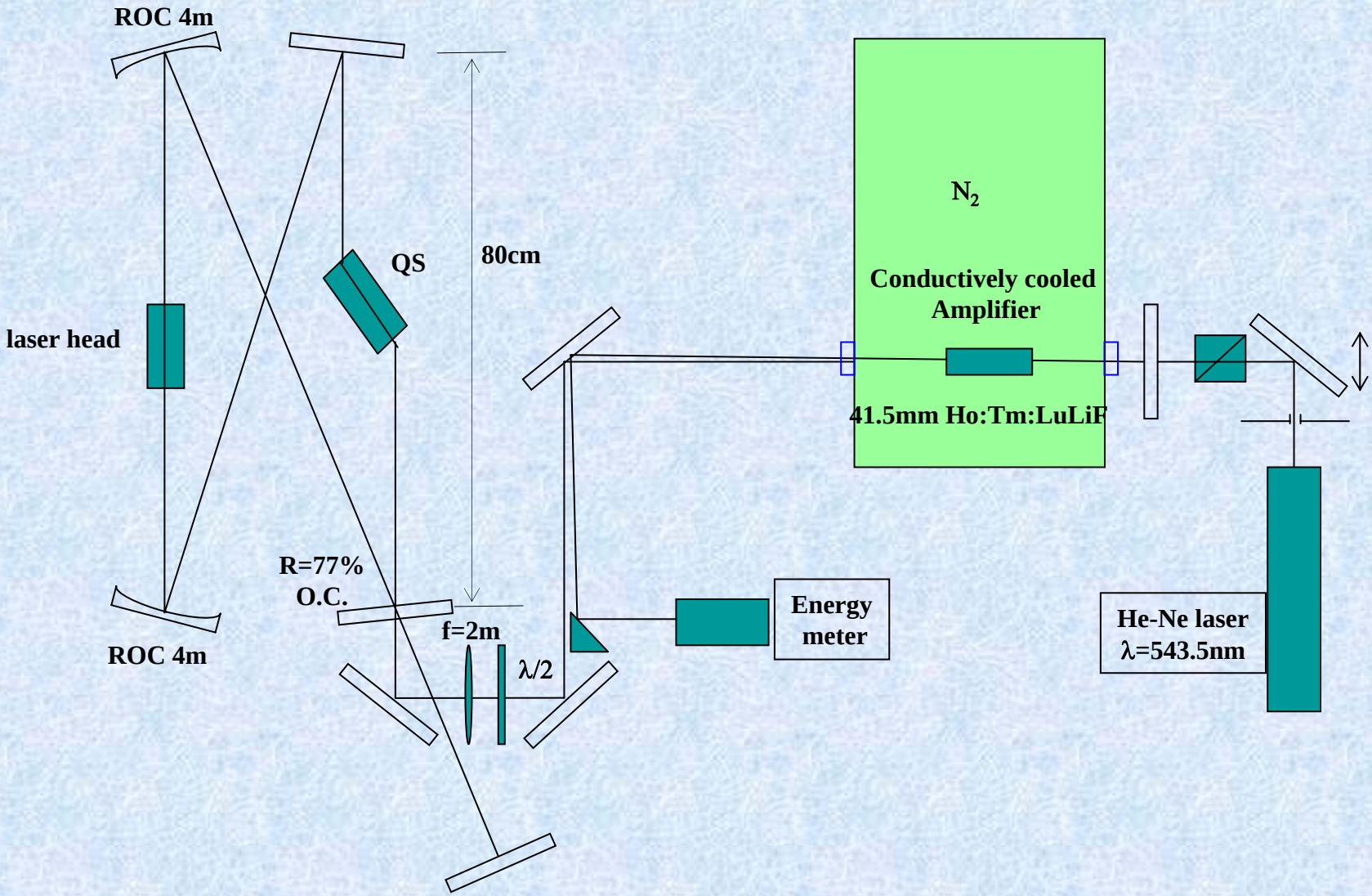




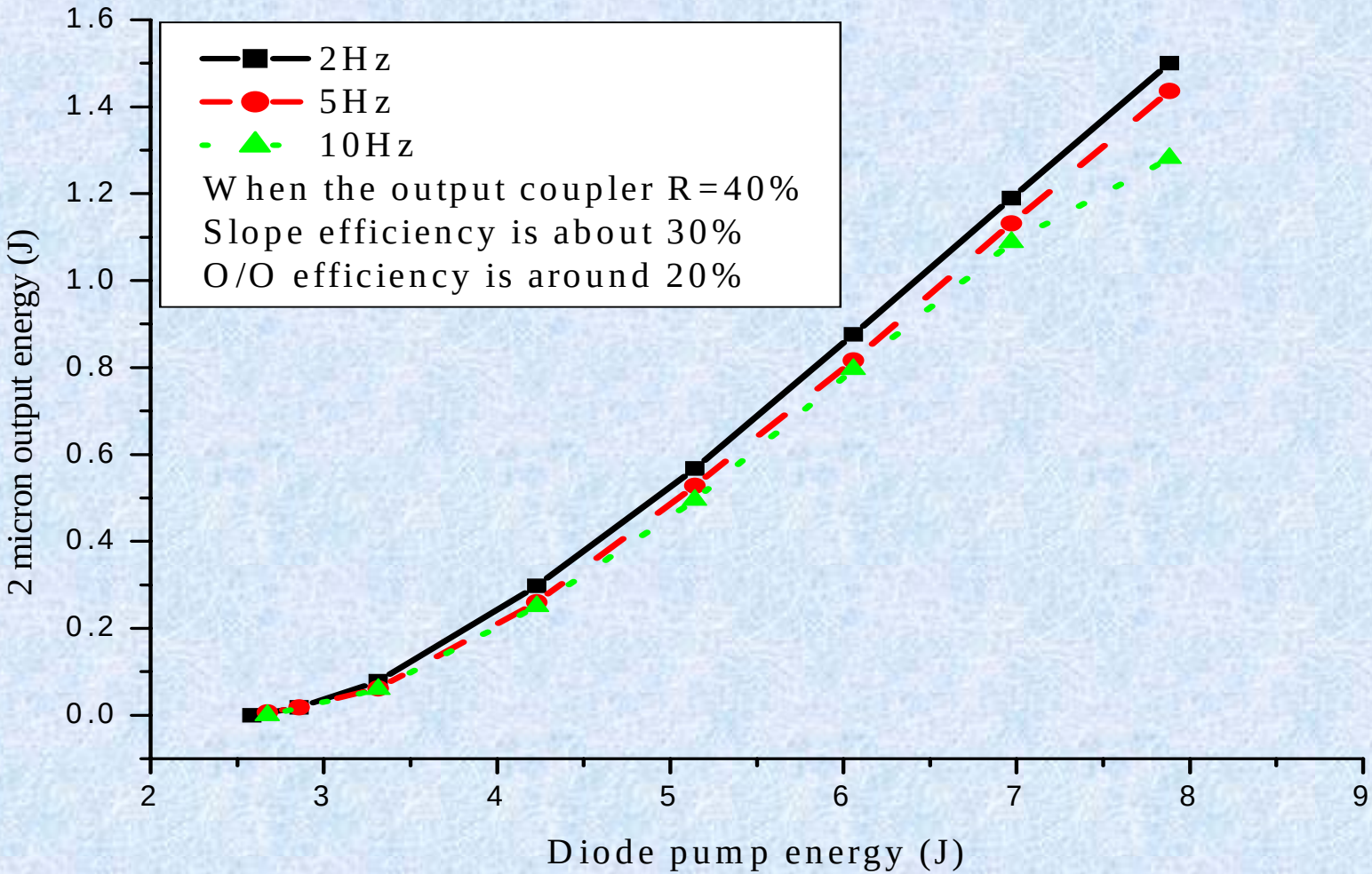
Conductively Cooled Laser



Experimental Setup

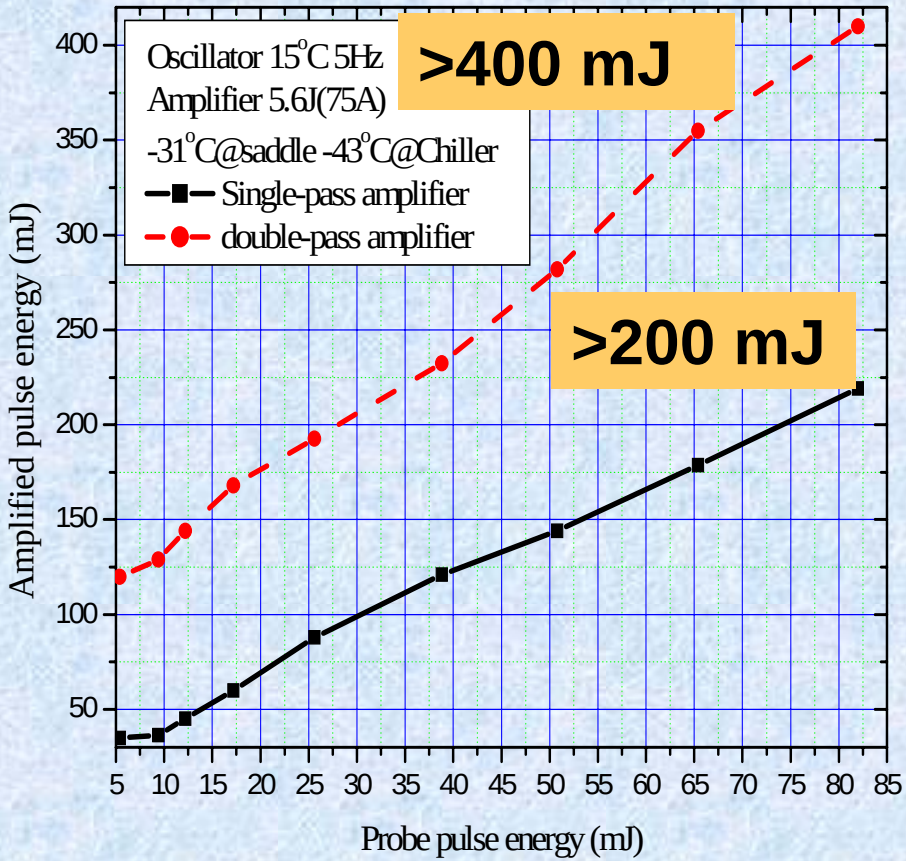


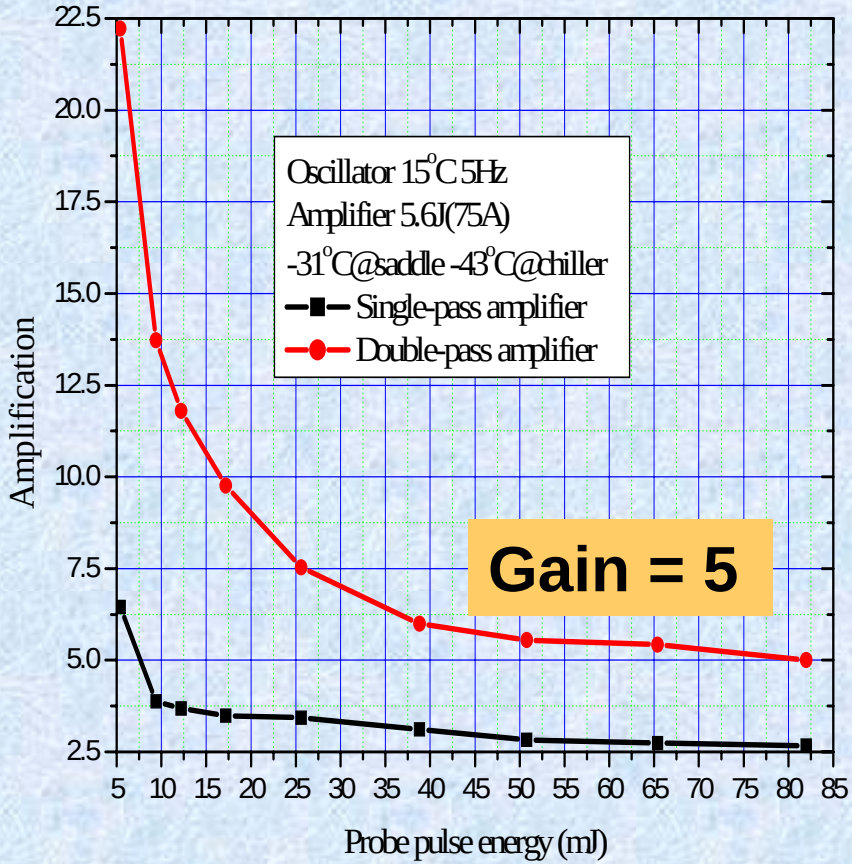
Conductively Cooled Laser Normal Mode



Single/Double - Pass Amplification

Amplification of 5Hz/80mJ/334ns Pulse



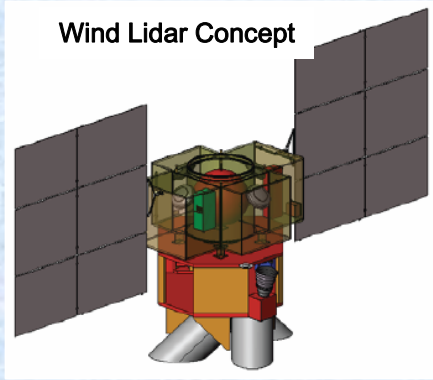


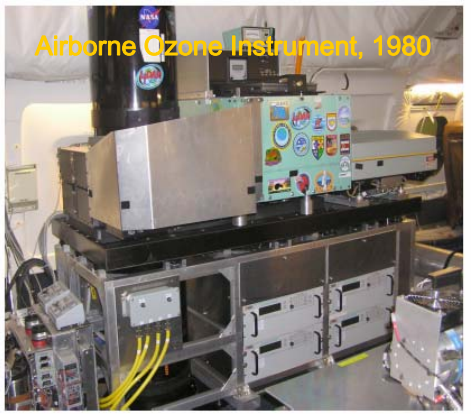
Summary (Real One!)

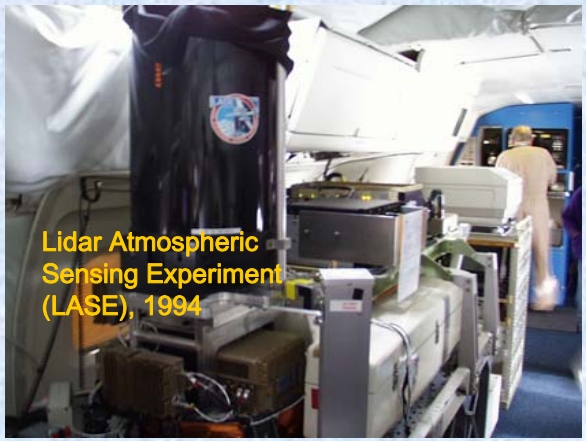
- Developed conductively cooled master oscillator and power amplifier (MOPA) system.
- Through better thermal management, demonstrated 200% improvement in amplifier gain
- Current performance indicates that conductively cooled power oscillator can deliver wind quality beam with energy of >250mJ at the repetition rate of 5-10 Hz. Also, in double-pass configuration LaRC developed conductively cooled amplifier can amplify the 250mJ pulses to 1J pulses for 3-D operational mission

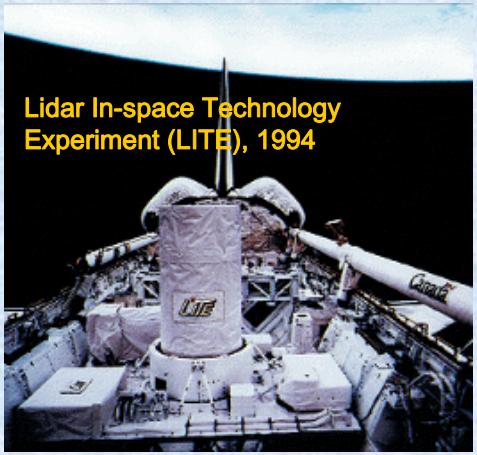
Langley's Lidar Capabilities

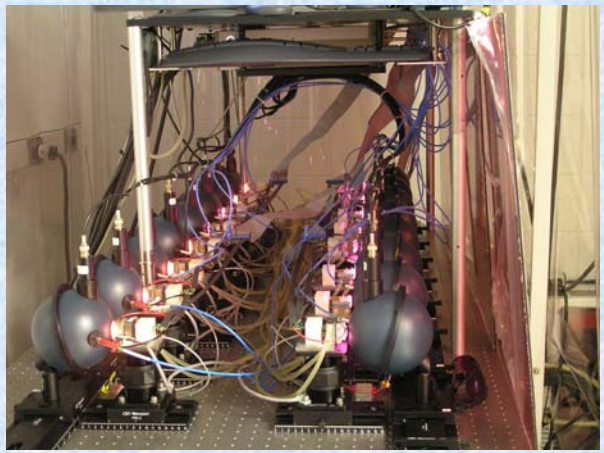
Langley has over three decades experience in fundamental laser research, concept demonstrations, instrument (design, build and testing) of LIDAR instruments for ground, airborne and space.



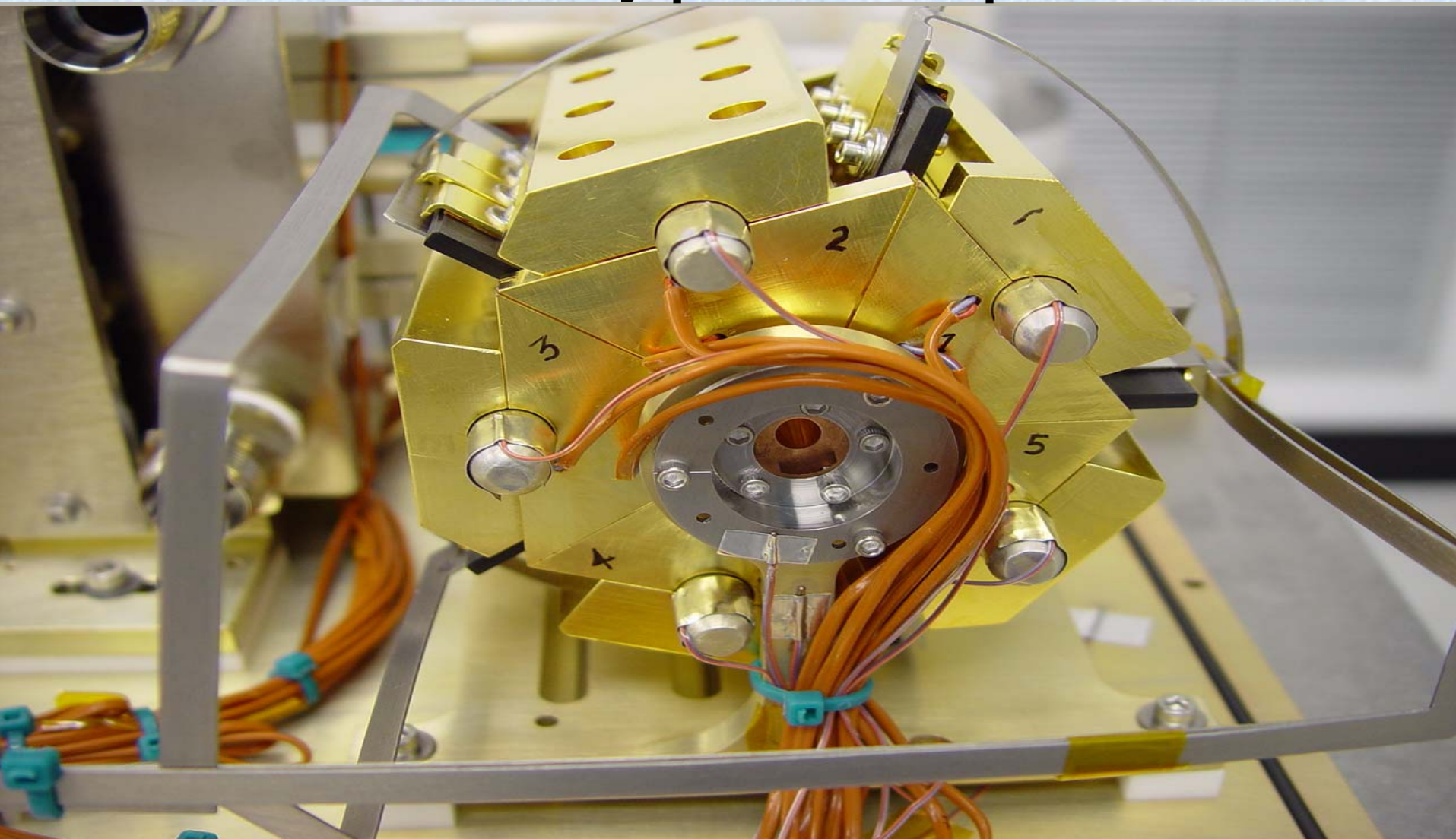








2-Micron Laser Development Enables 3-D Winds DS Mission



Thank you for your attention