# 2.5-W single-frequency Tm,Ho:YLF ring laser

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***RESEARCH DIVISION***

## Summary of Talk

- Potential uses of multiwatt 2-um SLM laser light
- Specifications of system under development
- System design
  - Thermal management
  - Cavity layout
  - Performance as a function of crystal geometry
- System ruggedization
- Conclusions

## Funding

- Advanced Research Projects Agency
  - SBIR Phase II
  - Contract #DAAH01-94-C-R012
- NASA Marshall
- Lockheed Martin
  - Subcontract ST30G4120M

## Factors limiting Tm,Ho:YLF laser performnace

- Ground State Absorption
  - Bleachable loss: proportional to laser mode volume in crystal and Holmium ion density.
  - Affects threshold of laser
- Up-conversion
  - Rate proportional to inversion density
  - Reduces effective upper-state lifetime
  - Affects threshold and slope
  - Limits maximum pumping level per unit volume
- Tm - Ho transfer rate/ inversion partition function
- Thermal lensing/ fracture

ALL ARE TEMPERATURE DEPENDENT!

# Potential uses of multiwatt 2-um SLM laser light

- **CW Coherent lidar**
  - **Range out to 500 m**
  - **Wake vortex detection, wind mapping**
  - **Vibration monitoring (bridges)**
- **Coherent Imaging**

## Specifications of system under development

- **>1 W single frequency laser**
- **<50 kHz linewidth (over 50 us)**
- **No mode hops over I hour of operation**
- **Low amplitude noise**
- **Operable on a Naval ship board environment**

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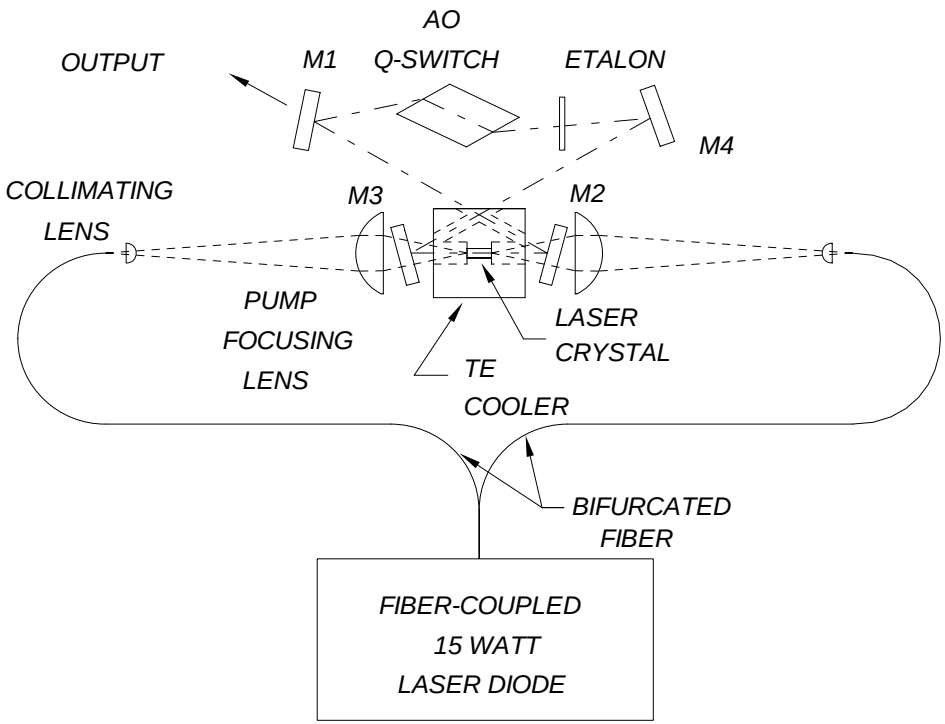
# Schematic of Tm,Ho:YLF Ring Cavity



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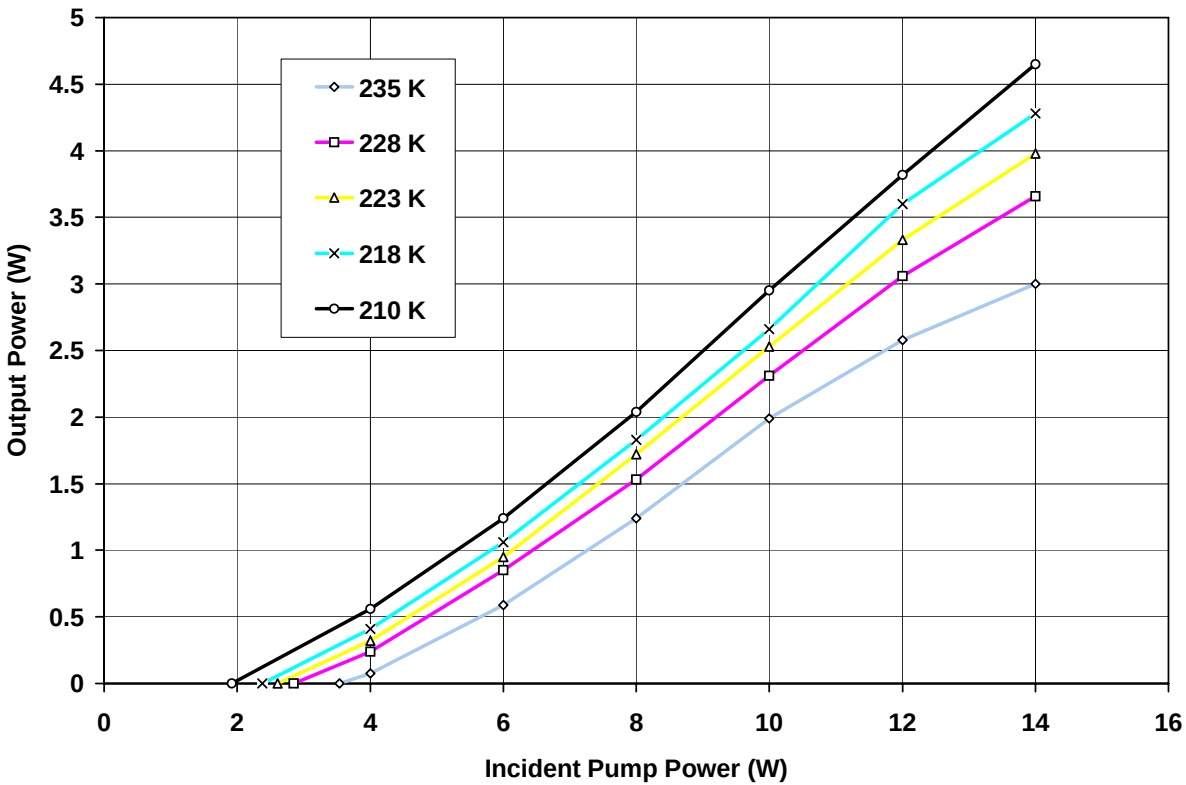
# Multi longitudinal mode CW performance of Ho,Tm:YLF ring laser vs temperature



# Acousto-optic modulator as a unidirectional device

- **Previous work in Nd: Laser:**
  *W.A. Clarkson, A.B. Nielson, and D.C. Hanna, Opt. Lett. 17 601 (1992).*
  *M. K. Reed, W. K. Bischel, Opt. Lett. 17 691 (1992).*

- **Basic concept**
  - **Operate modulator slightly away from Bragg angle to generate a differential loss between forward and reverse directions**
  - **Apply sufficient RF power to suppress one direction**

- **Draw back:**
  - **RF introduces effective insertion loss in the unsuppressed direction which is typically higher than Faraday based optical diodes**

- **Advantages:**
  - **Adjustable differential loss to accommodate feed back effects**

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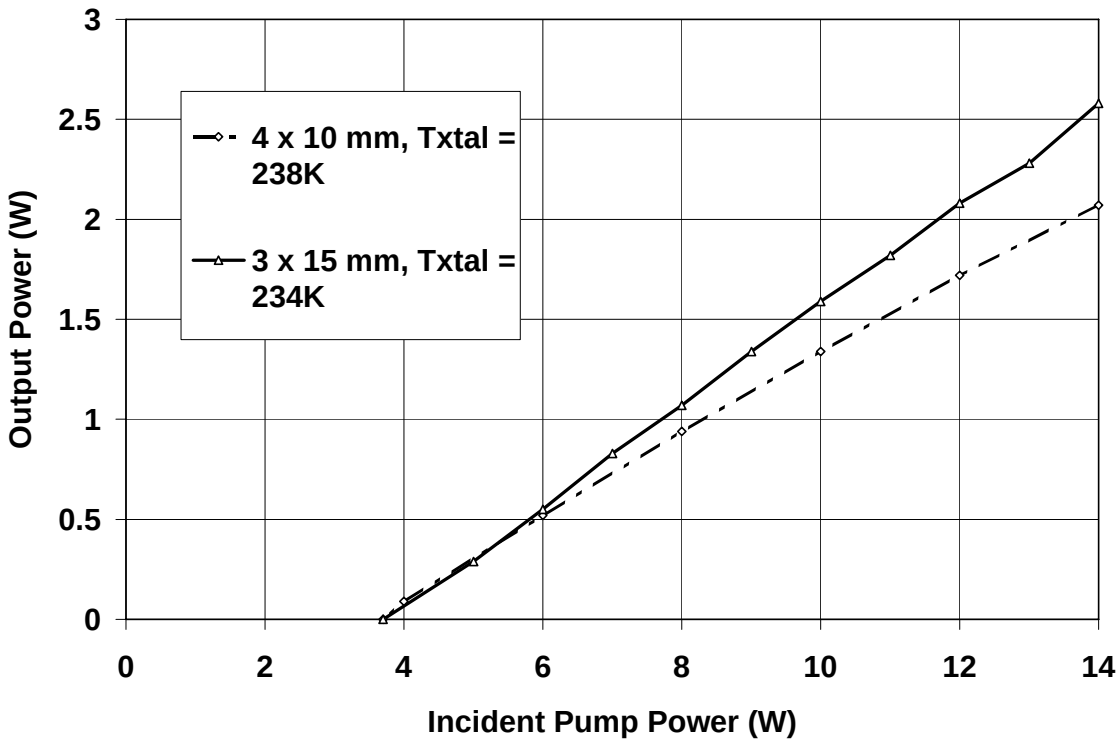
# SLM CW performance as a function of crystal geometry



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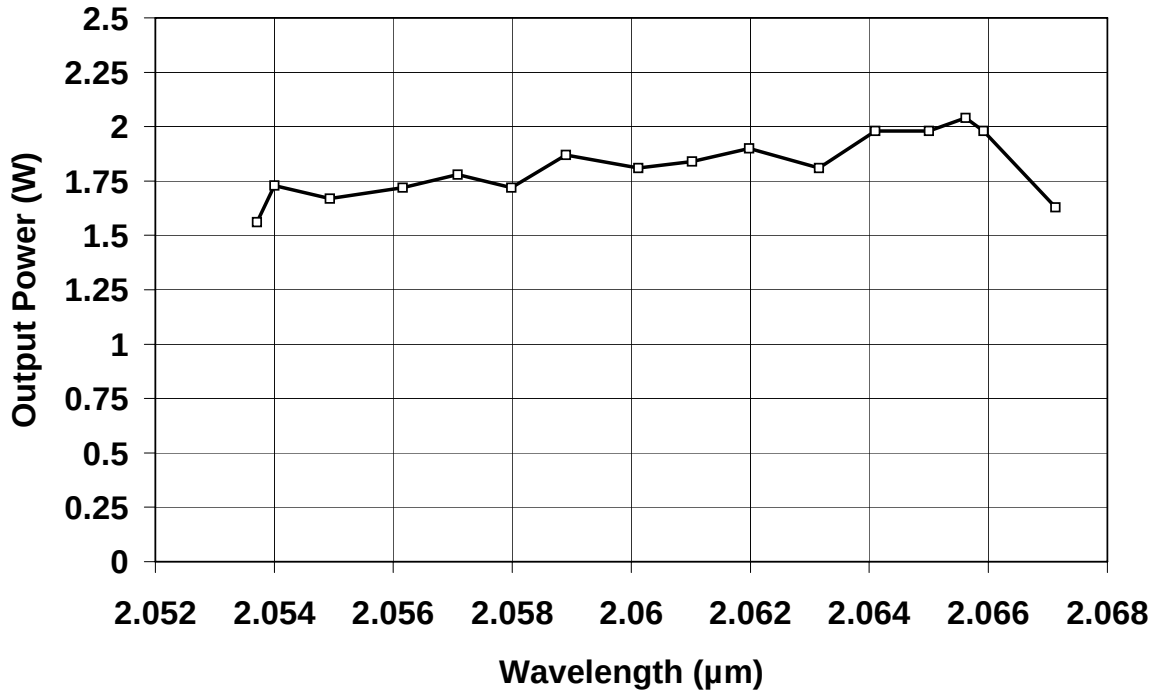
## Tuning curve of Tm,Ho:YLF ring laser



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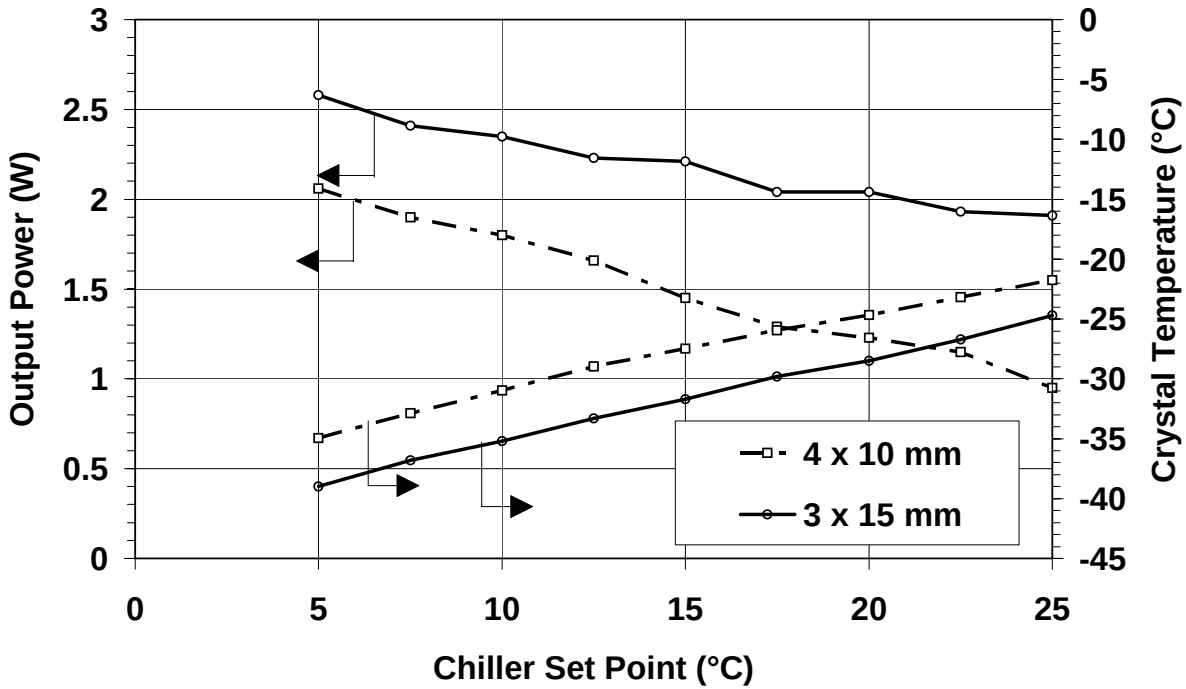
## SLM performance and crystal barrel temperature as a function of chiller set point



## Cavity ruggedization

- System to be mounted on a user supplied cold plate maintained at 20 ± 5°C
- Build whole cavity from Super Invar for temperature stability
- Hard mounted cavity optics
- Control laser crystal and Etalon temperature to better than 0.1 degrees

## Conclusions

- AO modulator proved very reliable unidirectional device for 2-um applications
- Demonstrated >2.5 W SLM output from Tm,Ho:YLF laser
- Higher powers should be available by enhanced wing pumping
- Ring cavity design is a generic Lidar transmitter design which can operate as multi - mJ Q-switched or multi-Watt CW Single-frequency source