ACIGA LASER TECHNOLOGY

10W AND 100W

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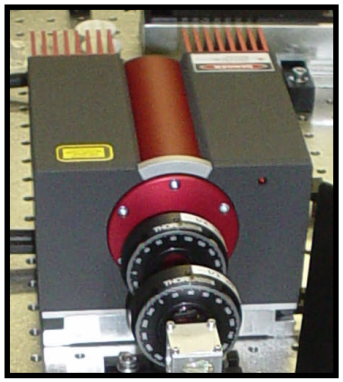
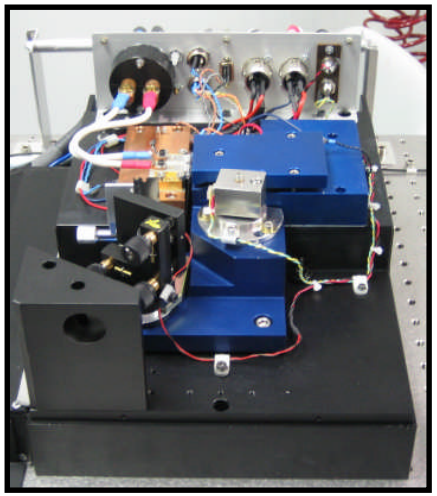
Adelaide High Power Laser Approach for GWI's

Strategy to achieve GWI high power laser requirements:

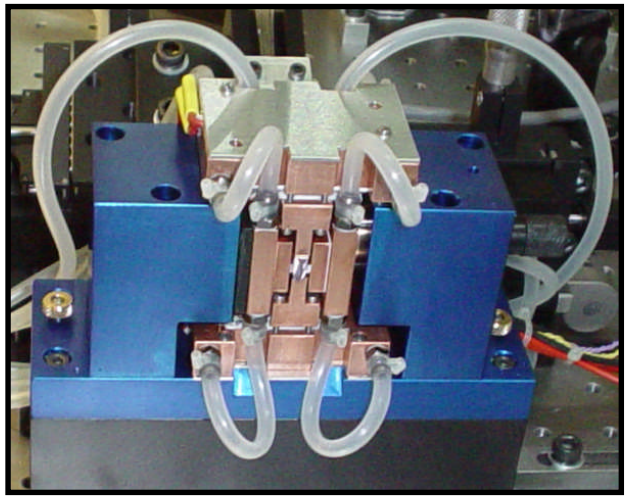
→ Injection-locked chain of lasers



0.5W (NPRO)



10W laser



100W laser

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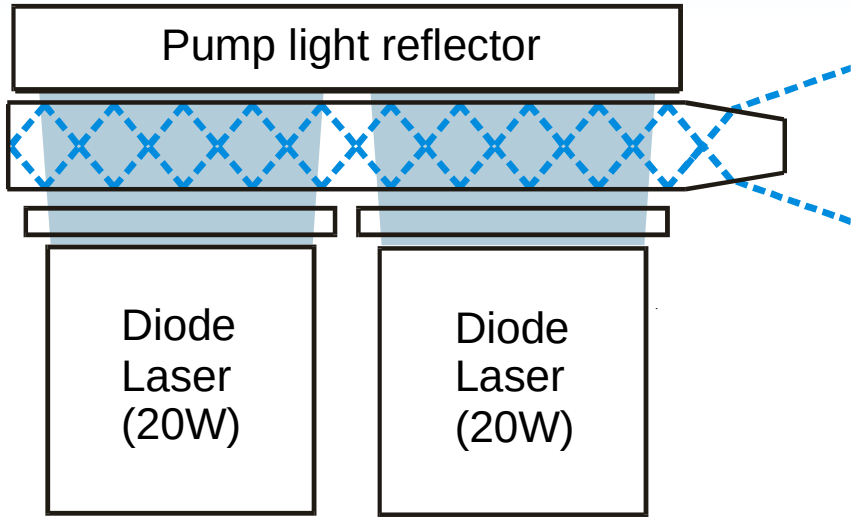
Gain Medium for 10W Slave Laser

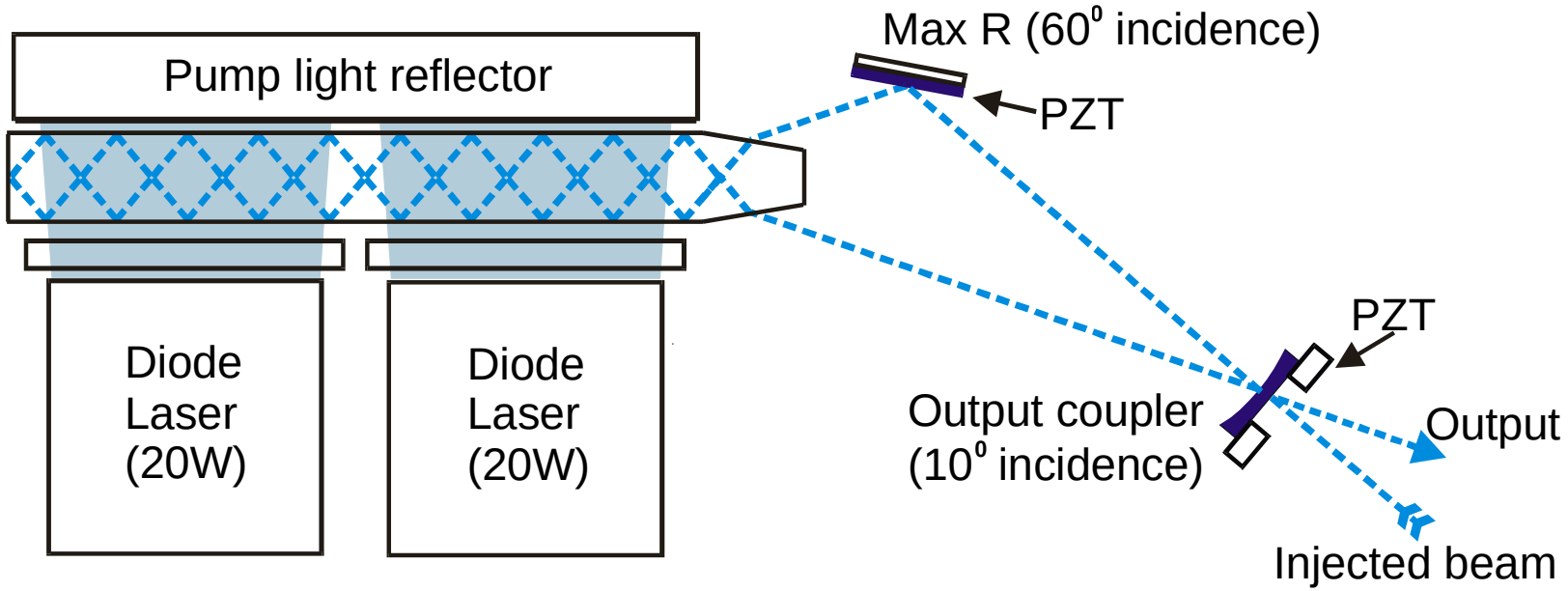


(Diode power derated for increased lifetime)

- Coplanar folded zigzag slab (CPFS) *
- Top and bottom cooled
- Side pumped using fast-axis collimated diode bars

*J. Richards and A. McInnes, *Opt. Lett.* **20**, (1995), 371.

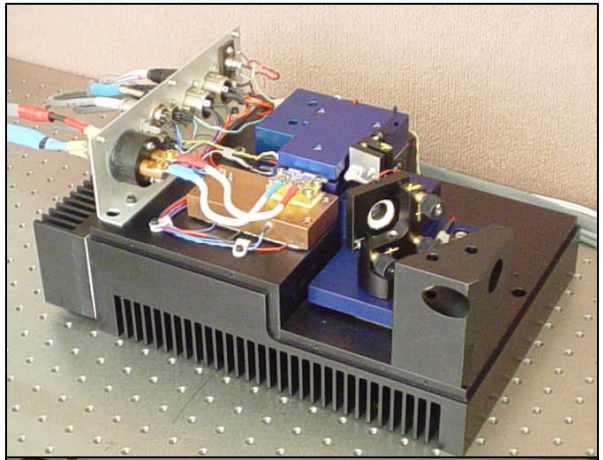
Travelling-Wave Resonator

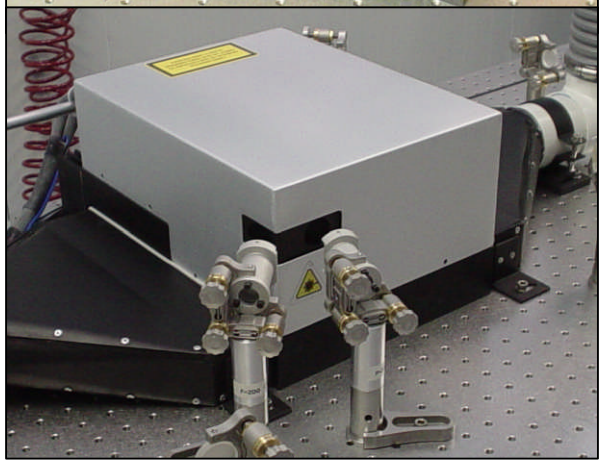


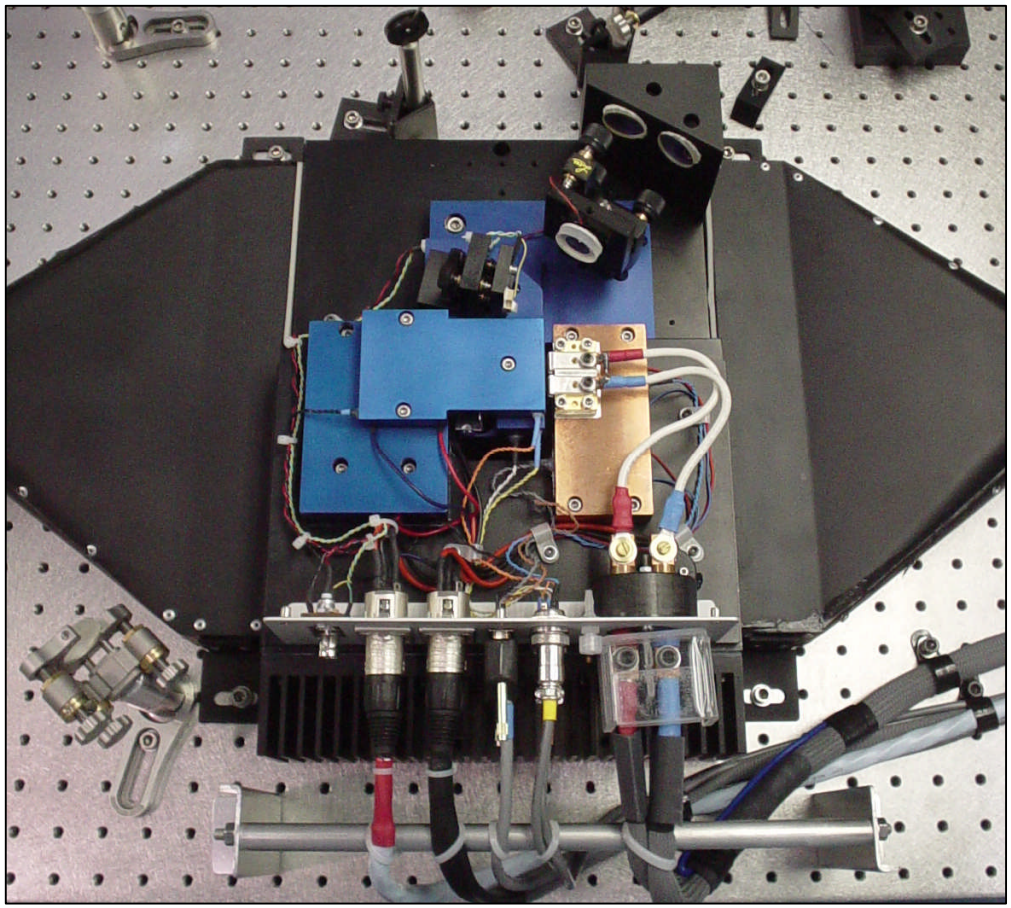
Injection locking servo control system:

Low bandwidth, high dynamic range PZT high bandwidth, low dynamic range PZT together provide sufficient bandwidth and dynamic range.

10W Slave Laser







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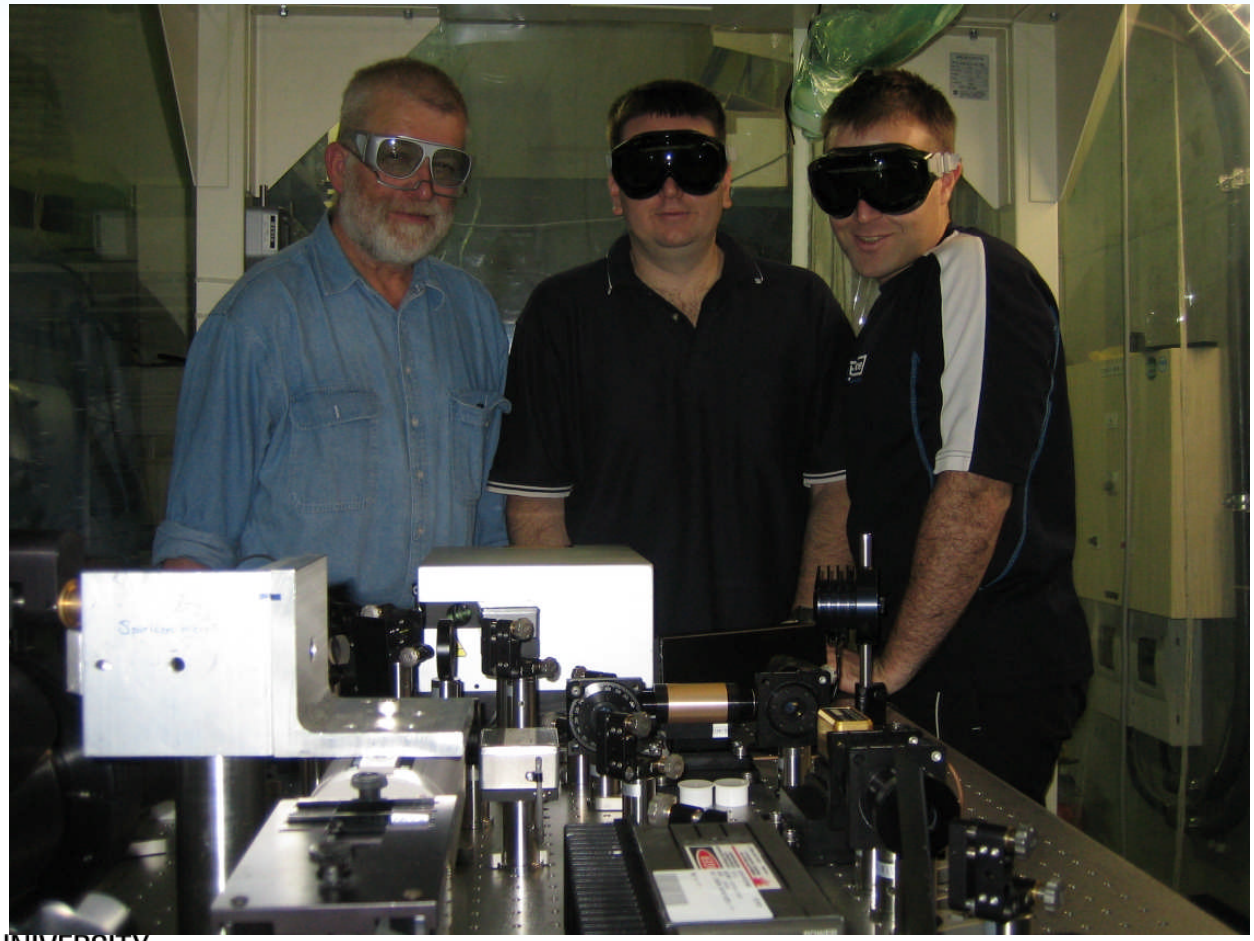
10W Slave Laser at TAMA



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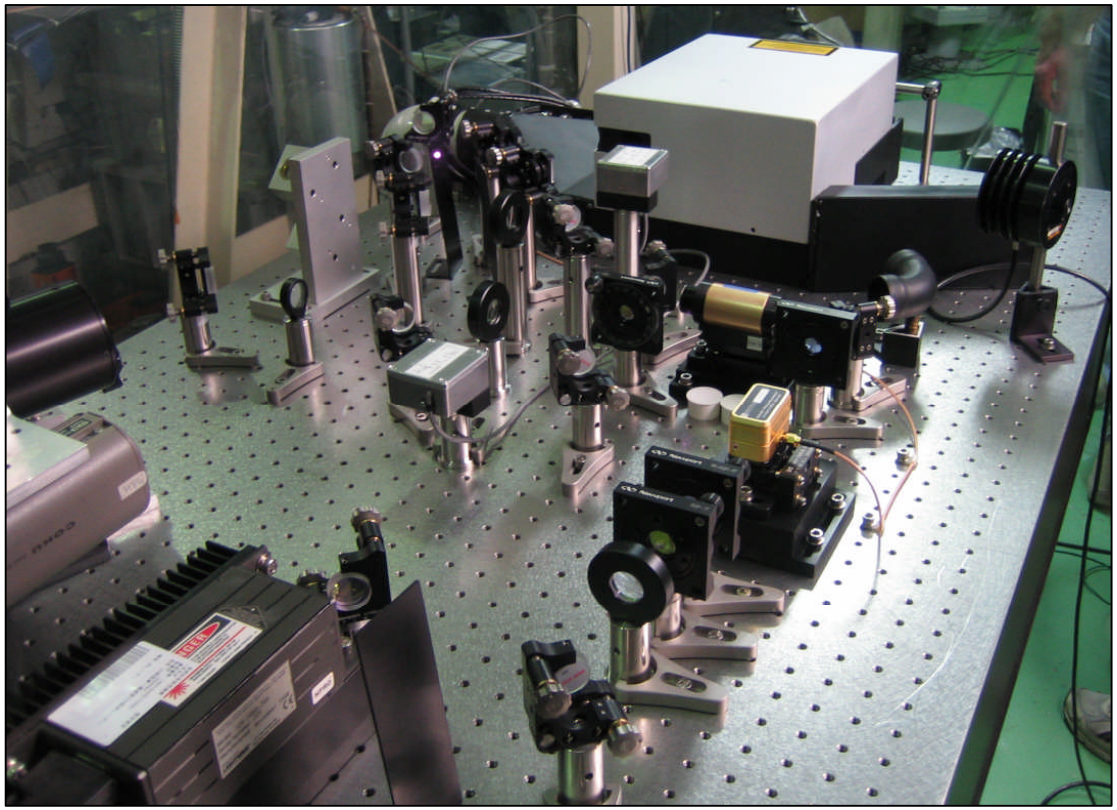
10W Slave Laser



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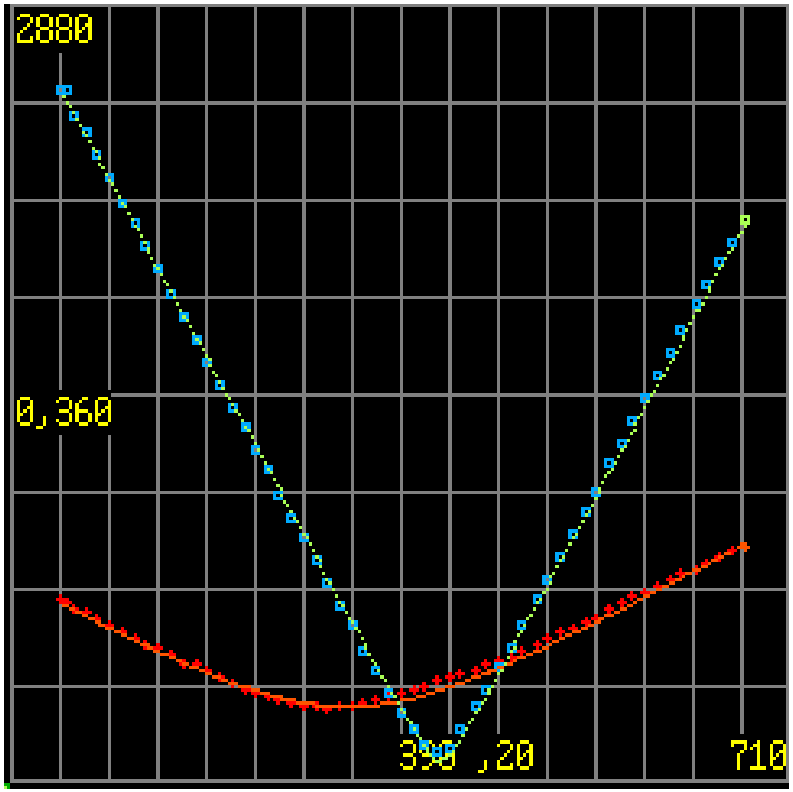
Travelling-Wave Results

Using 90% reflective, 5.00m concave output coupler

- **$M^2_{horizontal}$ = 1.08**
- **$M^2_{vertical}$ = 1.1**
- **Output power = 10.1 W (32W pump power)**

  Measured using Spiricon M^2 Beam Analyser



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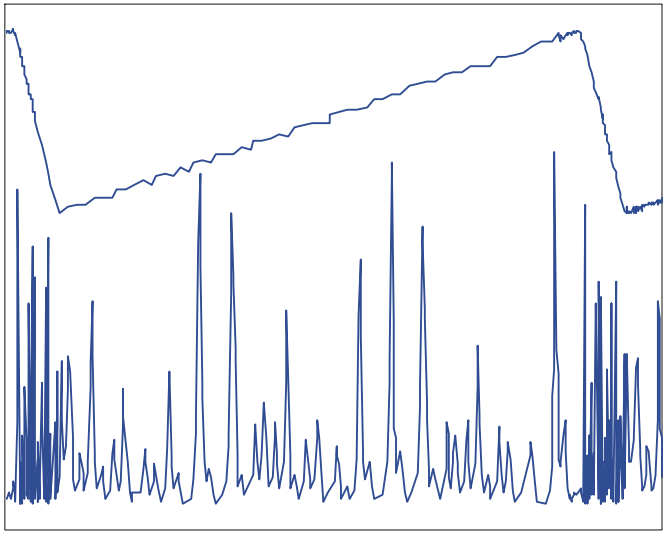
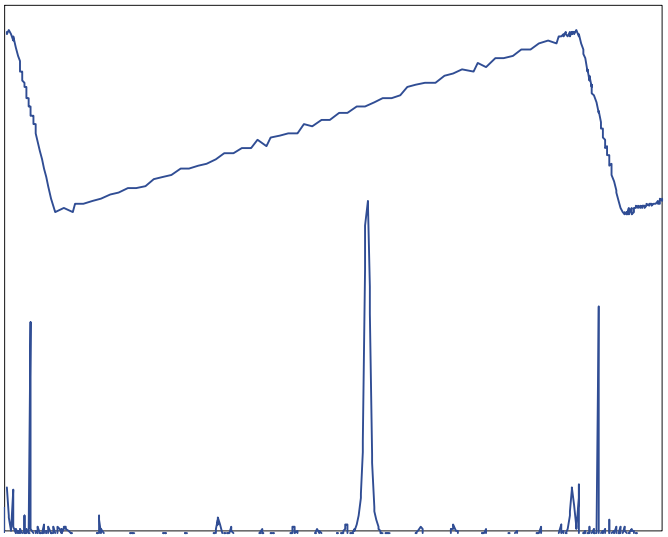
Laser Injection-Locked for Hours



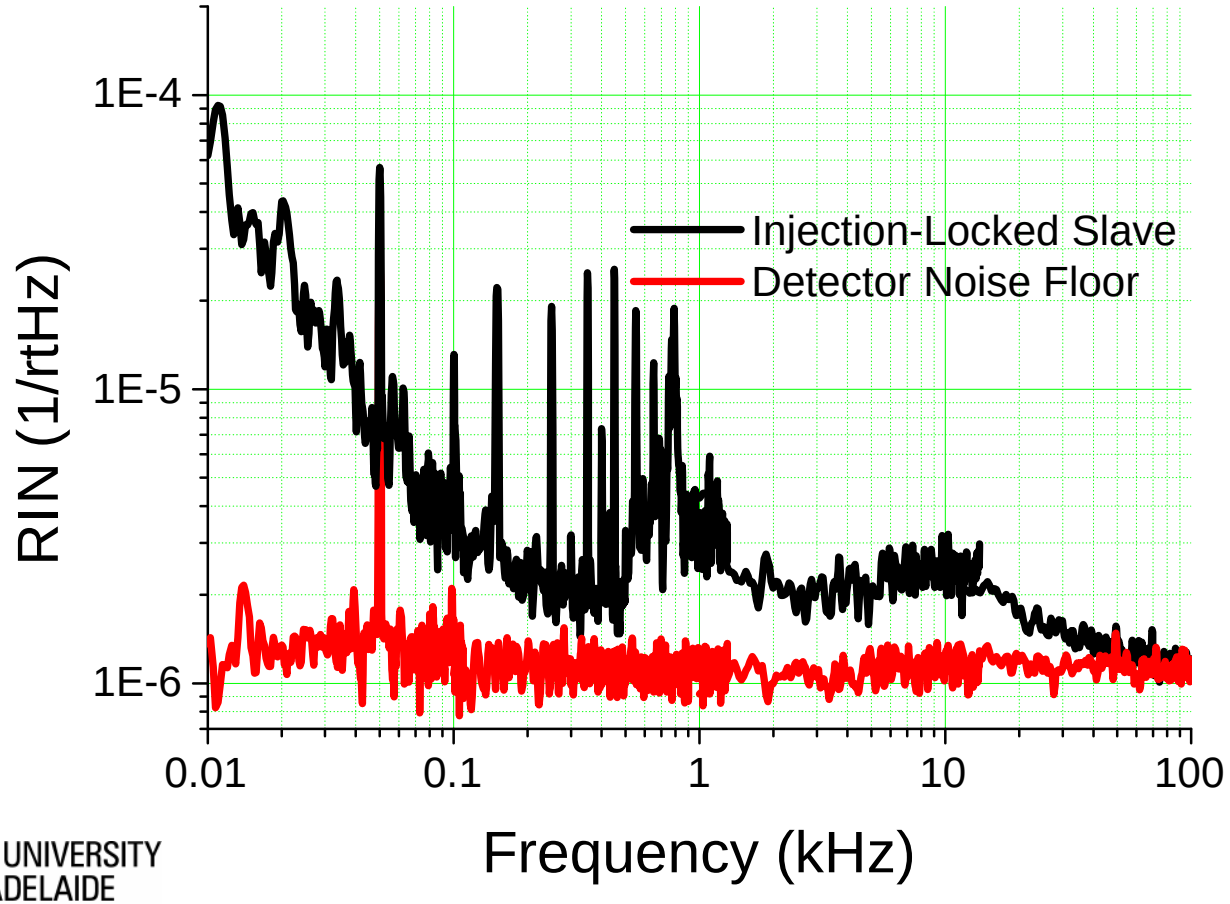
Multi- longitudinal mode operation of free-running slave laser



Injection-locked slave with 100% reverse-wave suppression

(Traces measured using a scanning Fabry-Perot cavity (10GHz FSR))

Intensity Noise Meets Requirements



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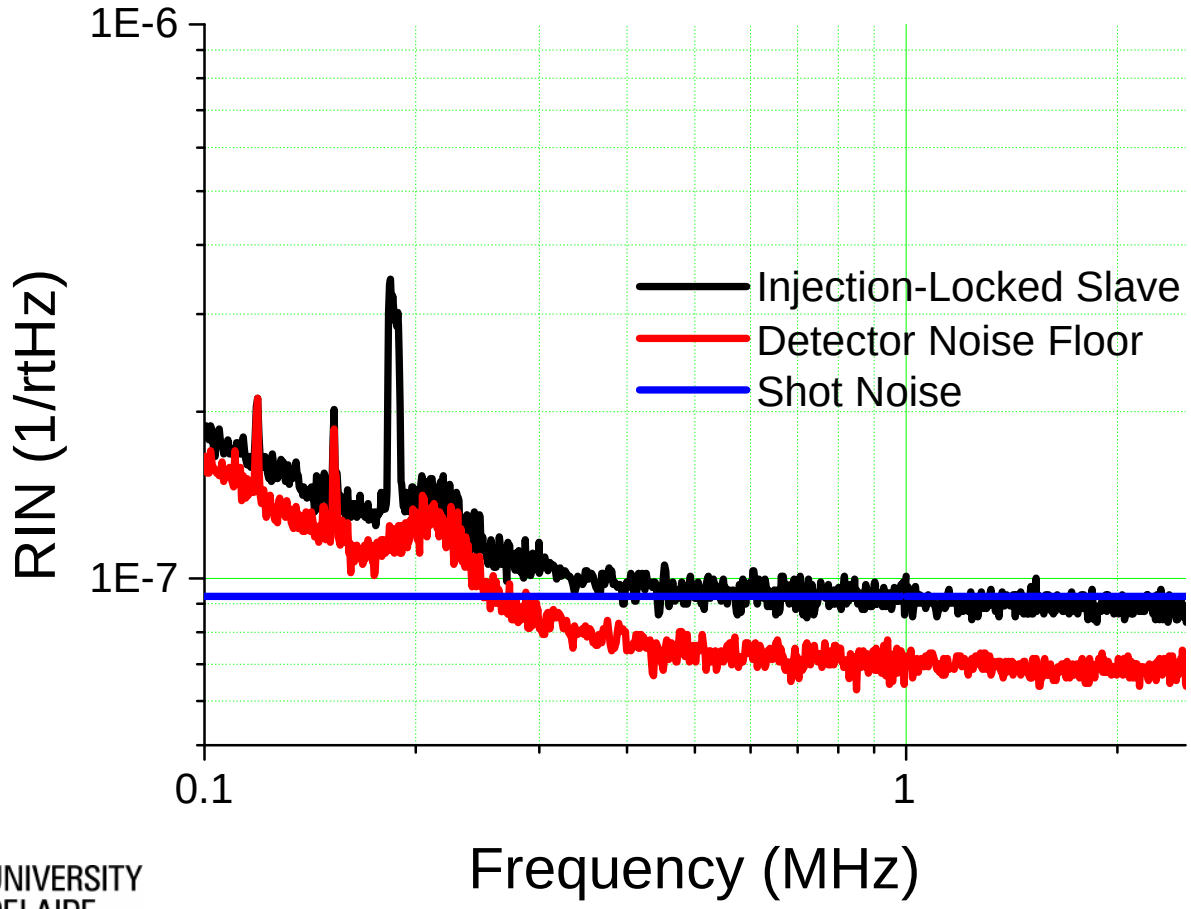
RF Intensity Noise Meets Requirements



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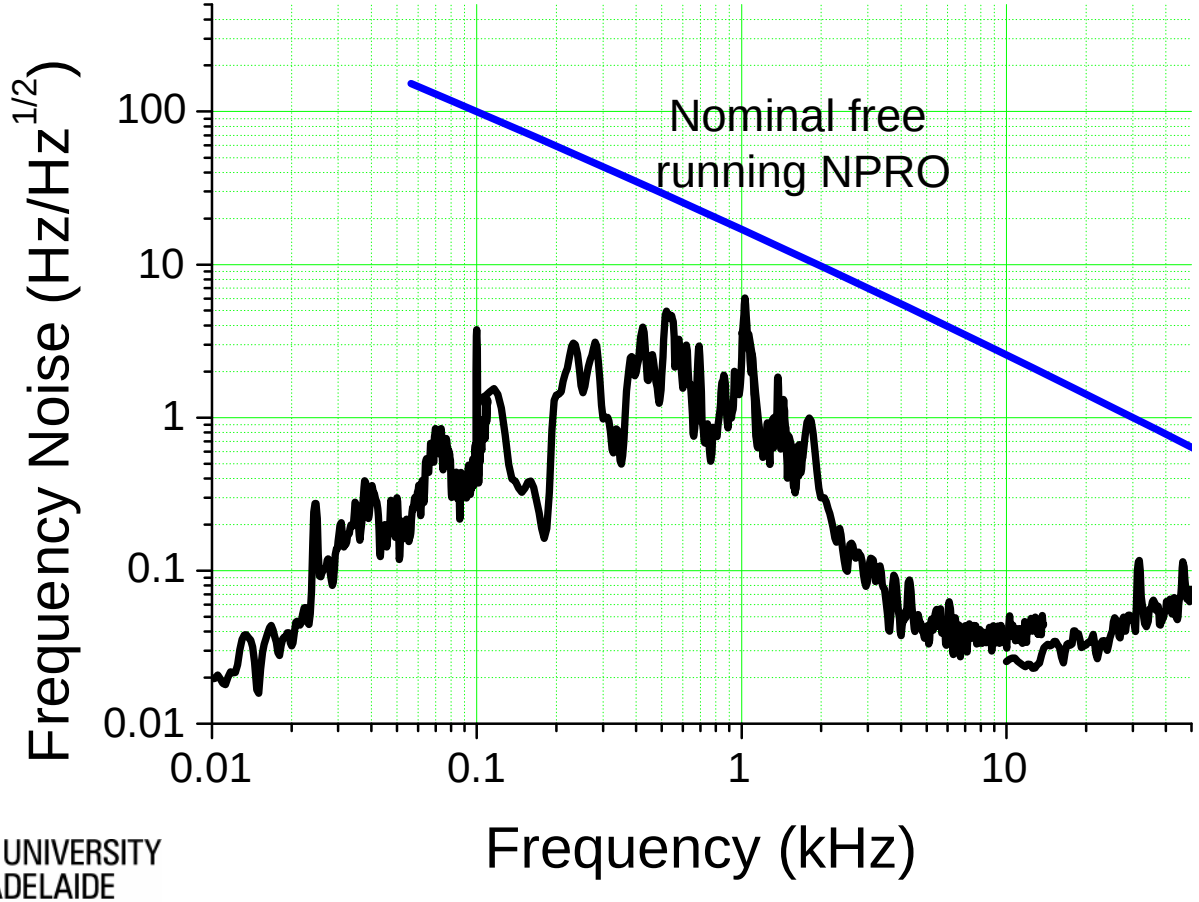
Very little added Frequency Noise when going to 10W

(Meets current requirements)



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End Pumped 100W Laser

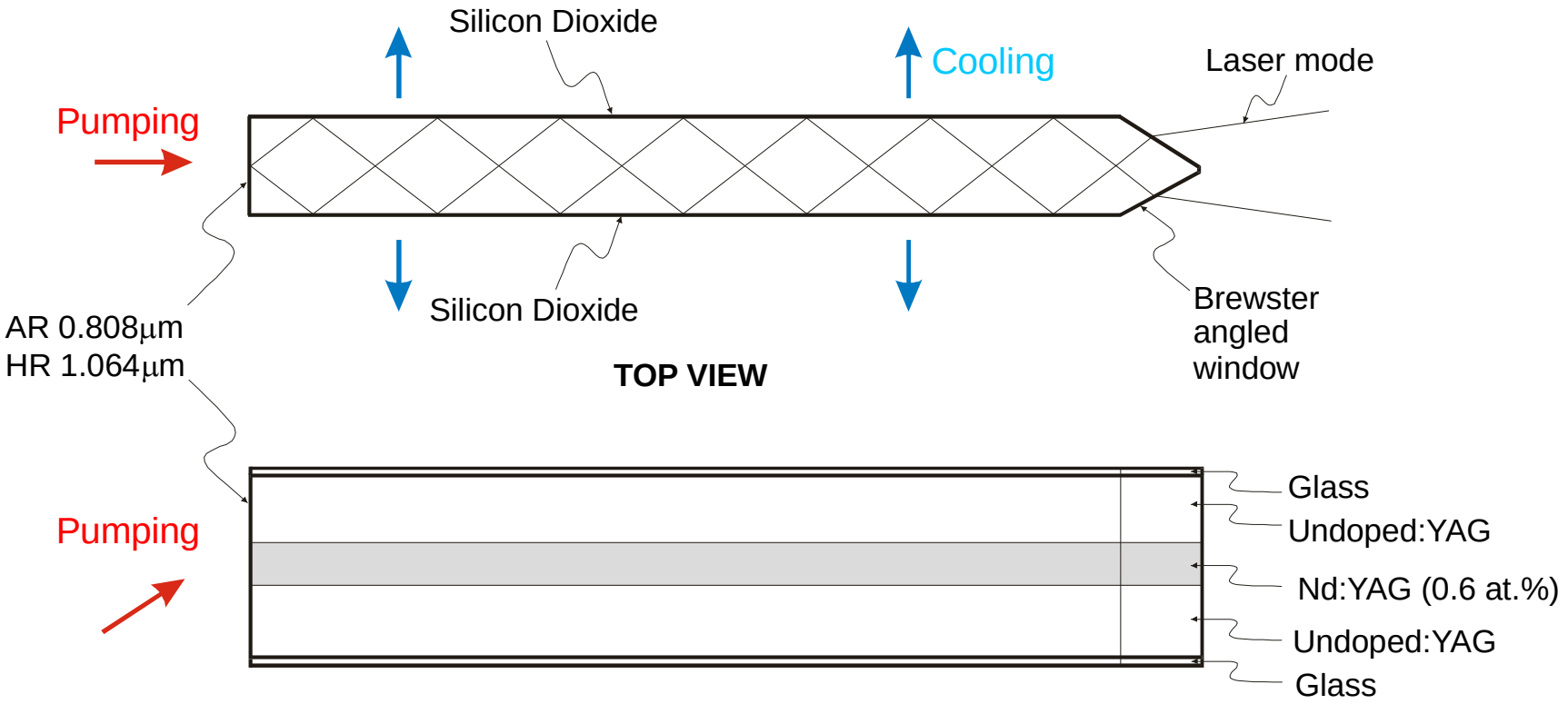
Extension of previous approach:

- Zigzag slab
- Unstable Resonator
- Injection locked oscillator

New Features:

- End pumping
- Birefringence control by defined pump profile within gain medium
- Improved pump uniformity across wavefront
- Robust
- Scalable to very high power (kW)

Composite end-pumped, side-cooled folded zigzag slab



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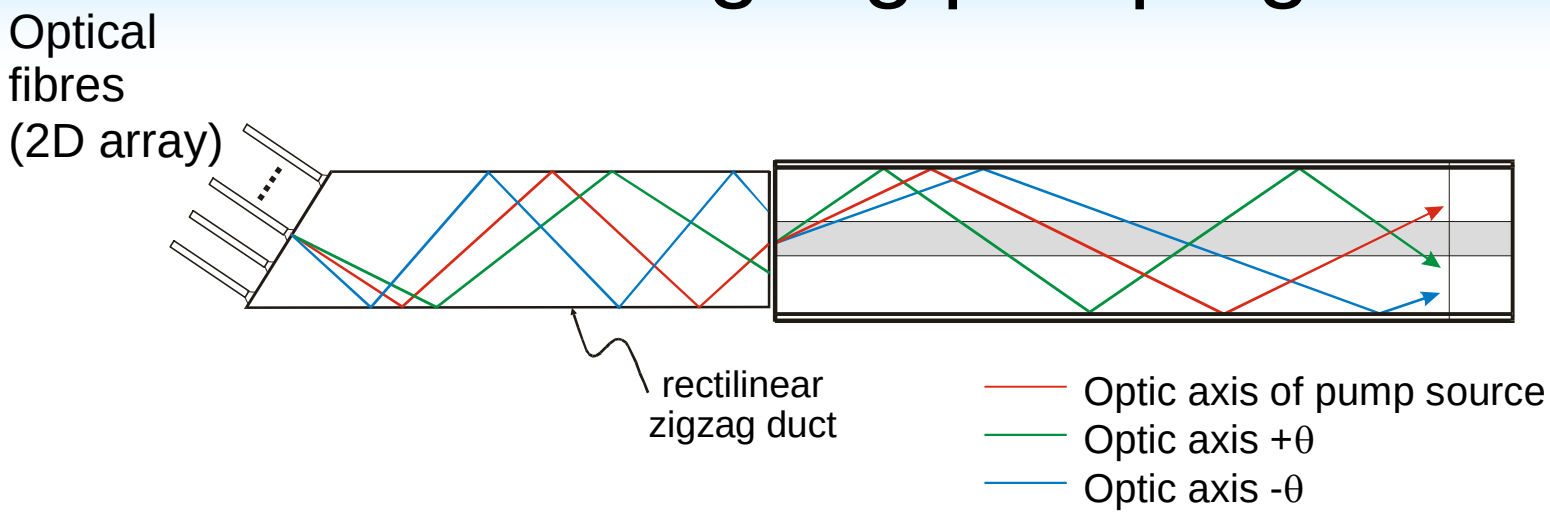
Off-axis zigzag pumping

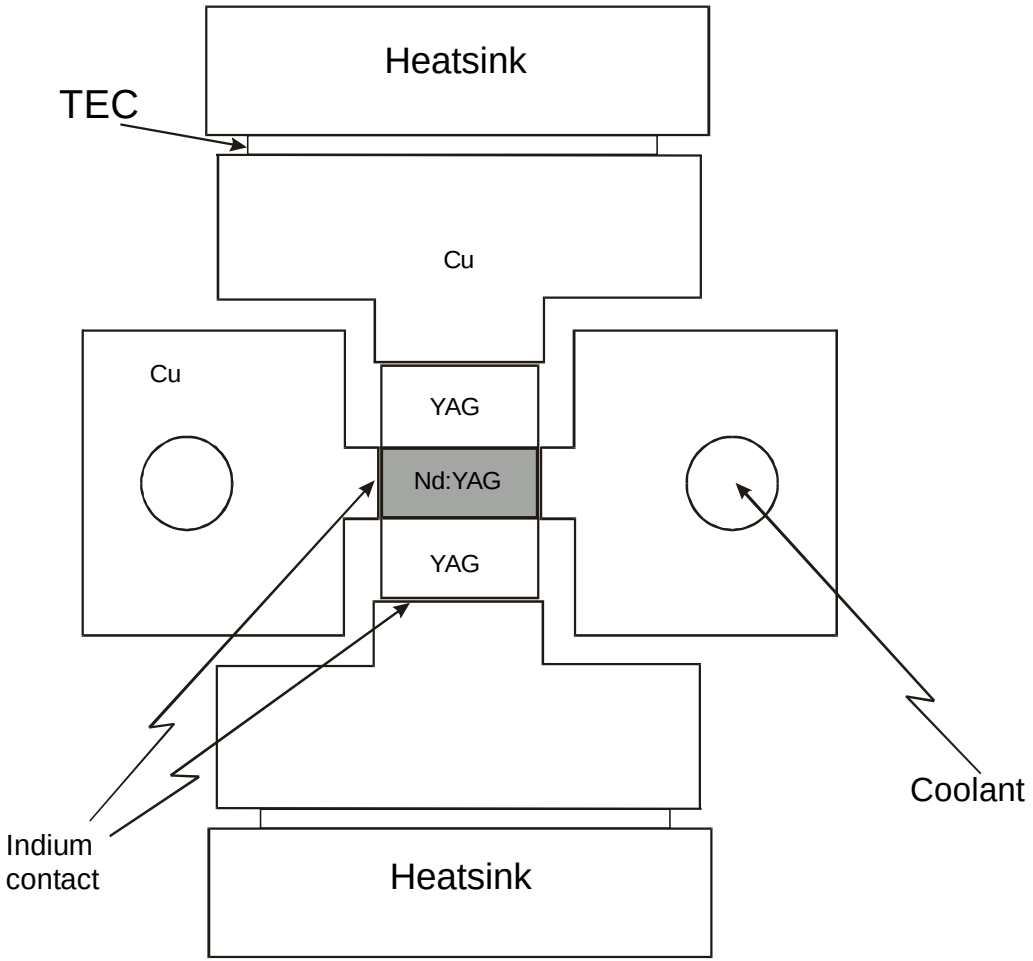


- Rectilinear zigzag duct allows pumping at normal incidence and homogenizes pump light prior to slab entry
- Can replace pump fibers by collimated bar-stack-array and use non-imaging lens duct
- Scalable by increasing pump power, height of doped and undoped region (scaling direction is orthogonal to cooling/laser zigzag mode plane)

100W design advantages

- **Tophat pump distribution** – minimum birefringence
- **Good absorption efficiency** due to quasi end-pumping
- **More uniform power loading** within slab due to double-clad structure transporting pump light along slab before absorption
- **No hard-edged apertures** in vertical direction
- **Large pump input aperture and acceptance angle** accommodates real divergent pump sources
- **Insensitive to pump beam-quality** due to mixing of pump light in slab
- Undoped YAG layers produce **reduced thermally induced stress**
- **Conduction-cooled**

End pumped, conduction-cooled laser head



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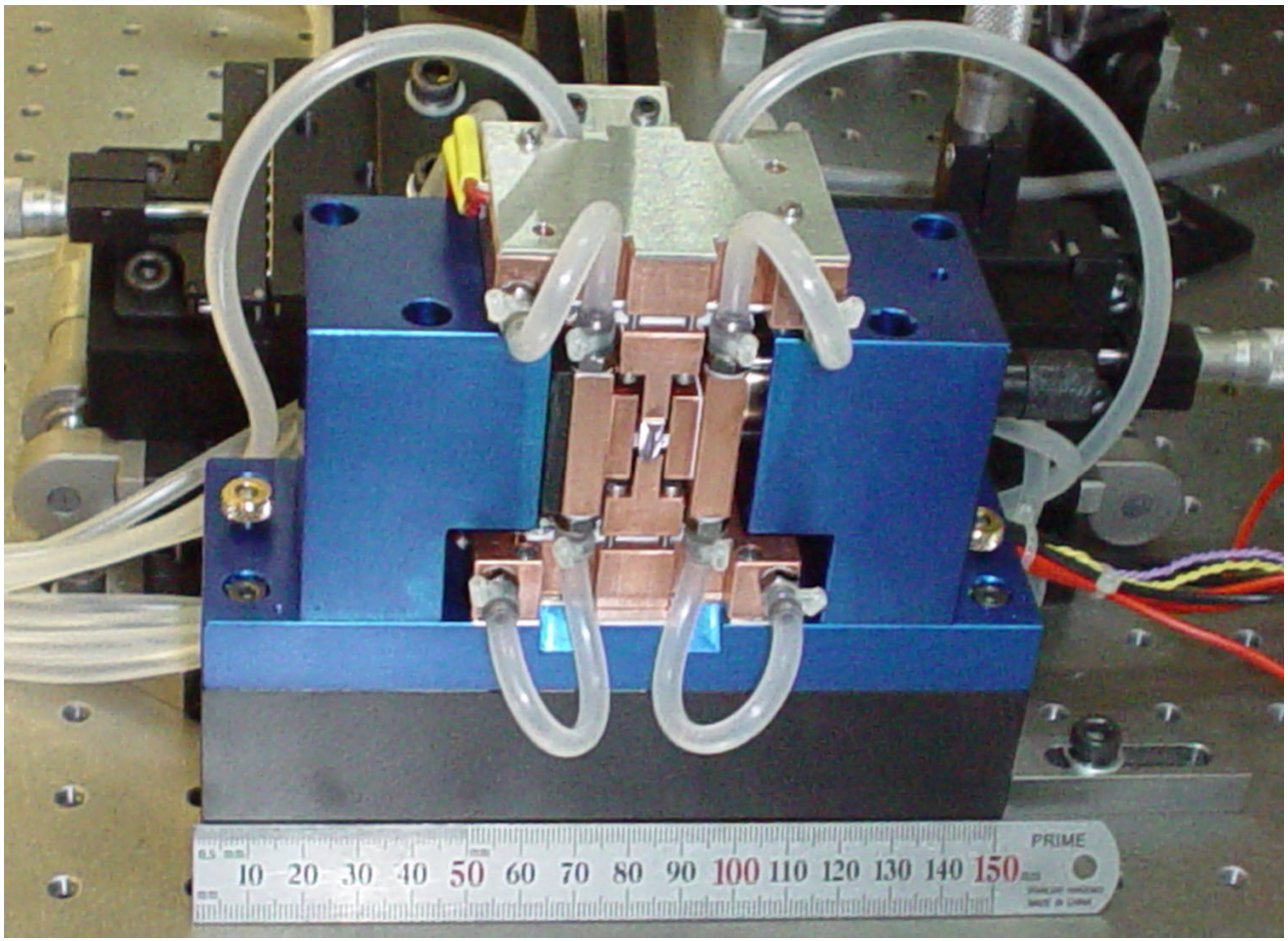
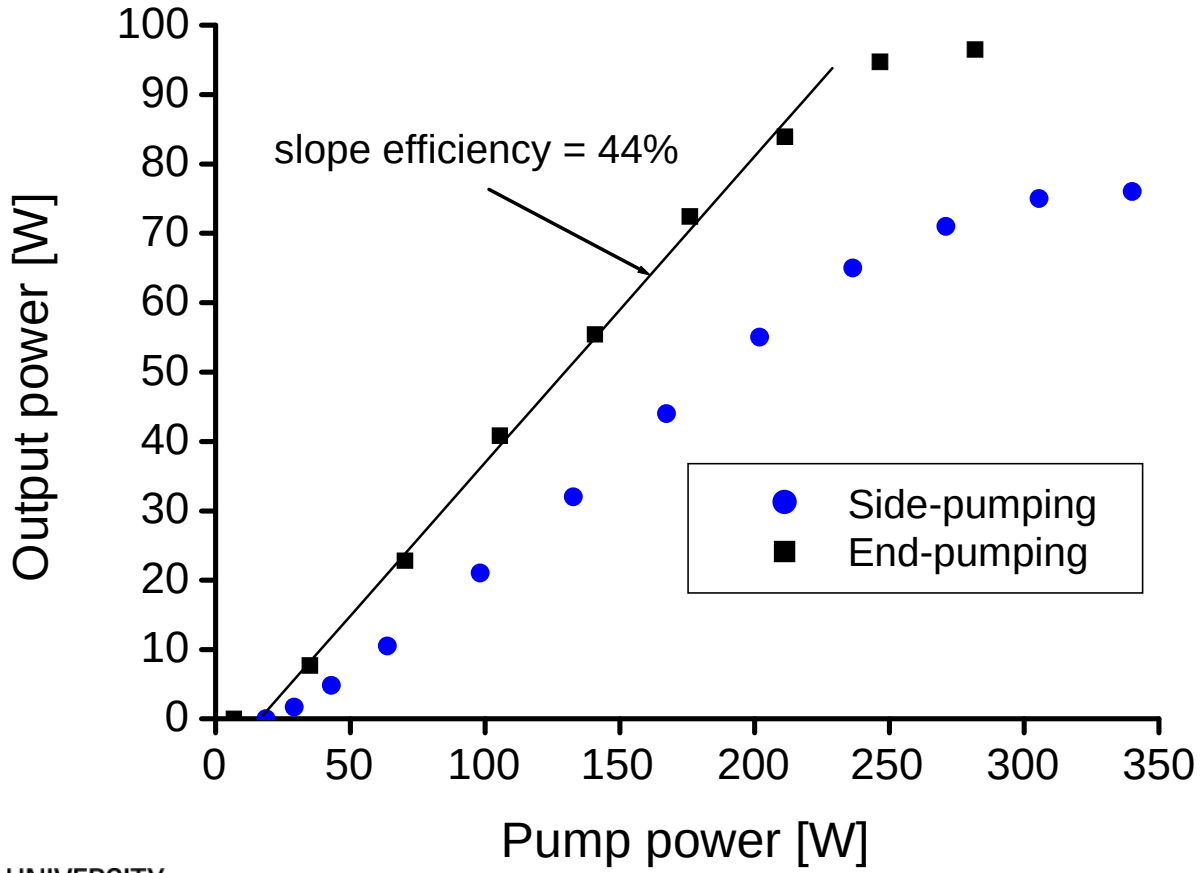
100W laser head



Multimode Lasing Performance



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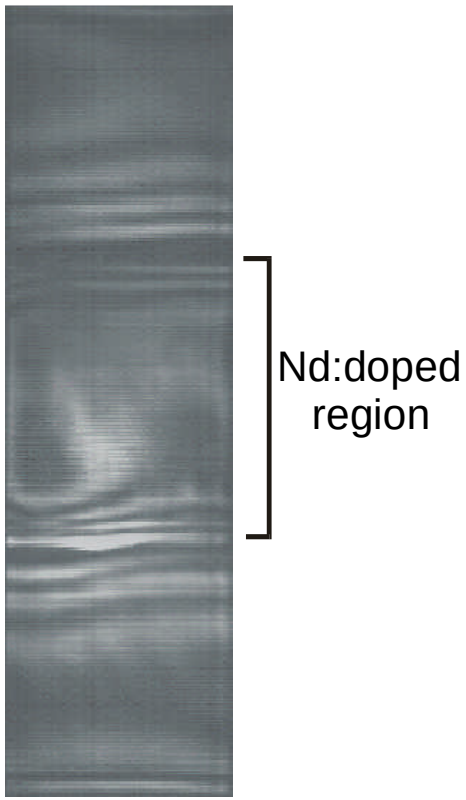
Low thermal lensing and distortion

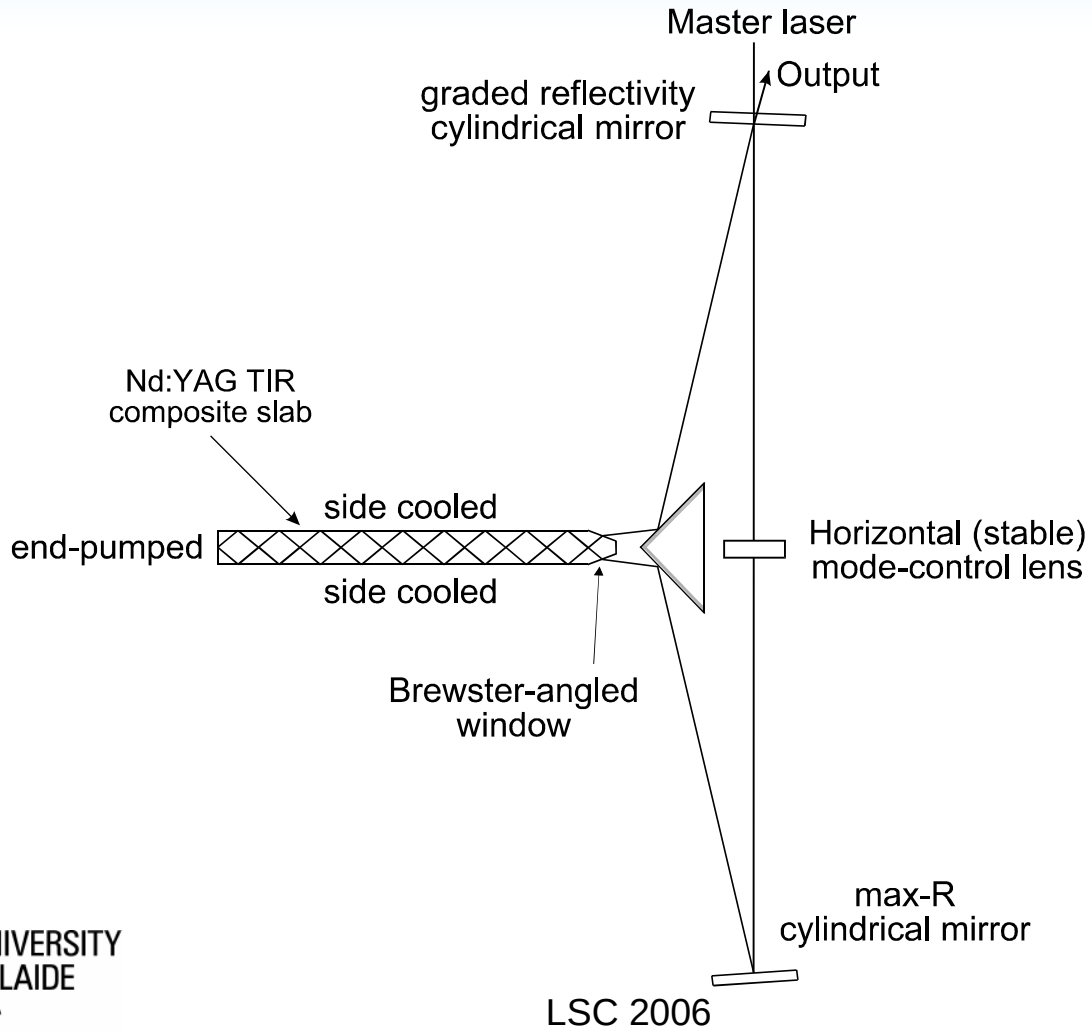
- Typical interferogram at 200W pump power
- Low distortion - only approx. 1 wave of distortion within the pump region
- Efficient heat removal
- Low thermal lensing



100W laser progress

- 100W extracted, multimode, standing wave
- Excellent efficiency: slope efficiency 44%
- Low threshold power
- Efficient contact cooling, ensures low Nd:YAG crystal centre temperature for efficient injection-locking
- End-pumping efficiency far exceeded side-pumped slab efficiency (greater than 45% improvement in efficiency)
- Pump scheme works well:
  - Off-axis pumping unaffected by thermal gradients
  - Insensitive to waveguide positioning on end face aperture
- Robust: No water contact with gain medium.

Compact unstable resonator



Conclusions

- Slab laser oscillator architectures work well, are robust, compact and scalable to high power
- 10 W lasers delivered and operational
- 100W end pumped laser meeting or exceeding all design performance specifications, so far
- Expect to have >100W single mode injection locked by mid to late 2006.