Adelaide High Power Laser Development

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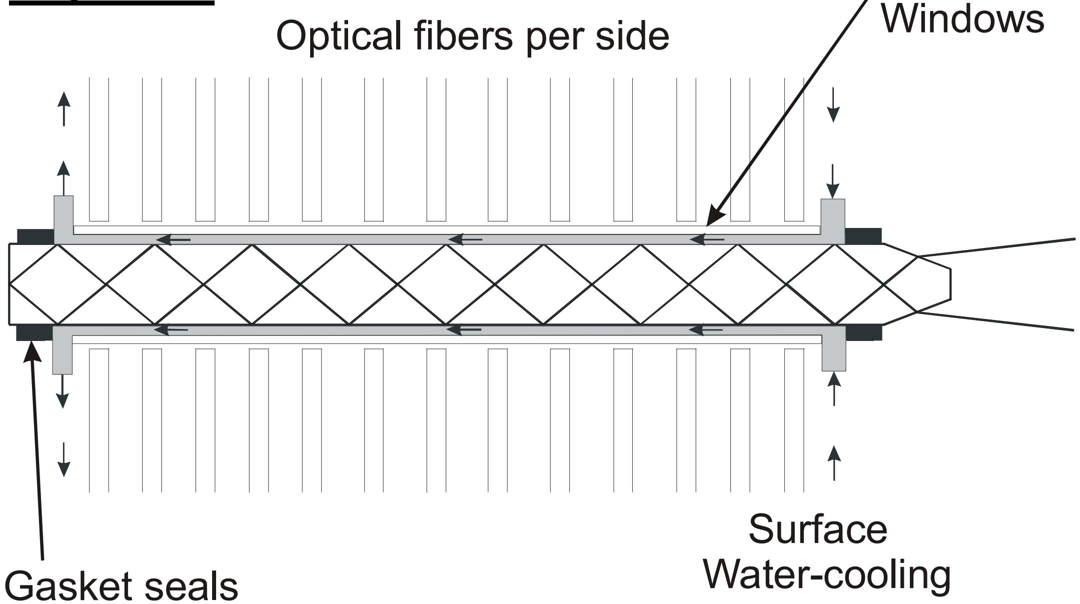
Contents

- Re-cap demonstrated technology
  - Unstable resonator
  - Injection locking
  - Discussion of pump profile & inhomogeneity
- Improved folded TIR slab design
  - Design overview
  - Pumping scheme
  - Characterization
  - Conclusions

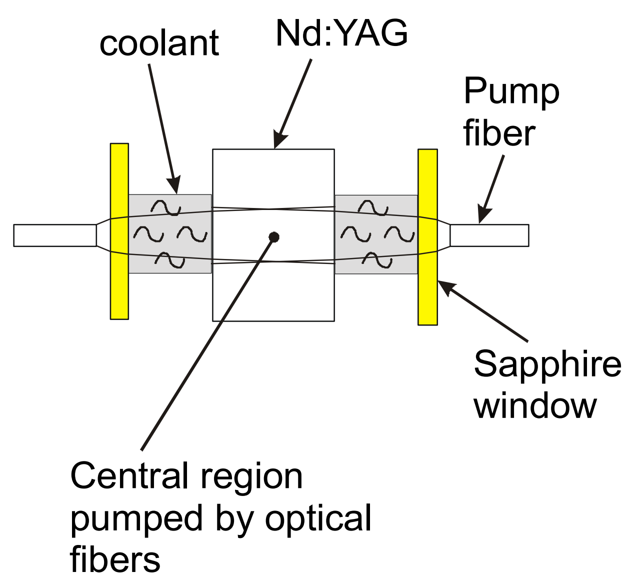
Original side-pumped, side-cooled design

- Side-pumped, side-cooled folded TIR laser head used to demonstrate injection locking of CW stable-unstable resonator

Top view

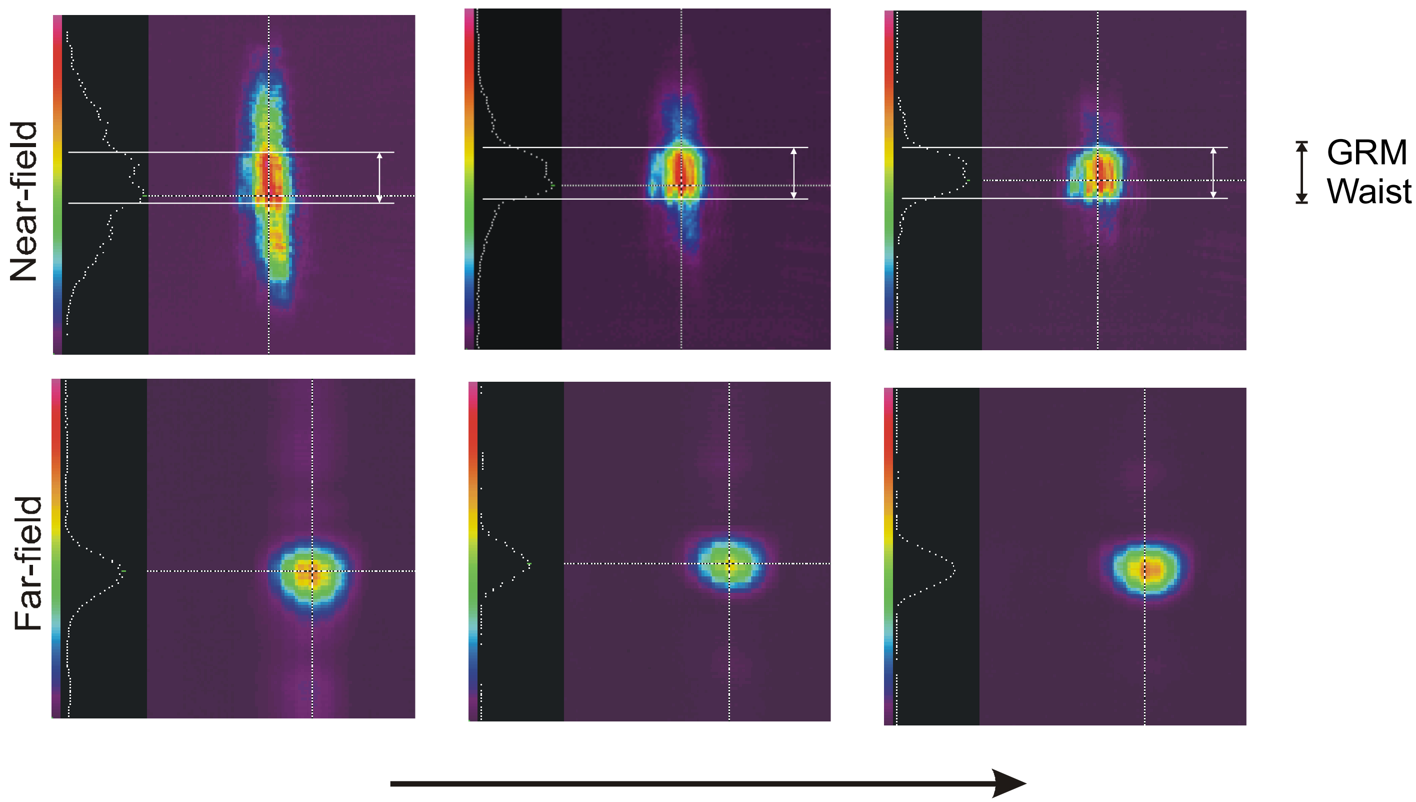


End view



CW Stable-Unstable Resonator

Mode patterns produced by standing-wave resonator using a Graded Reflectivity Mirror (GRM) output coupler



Pump power

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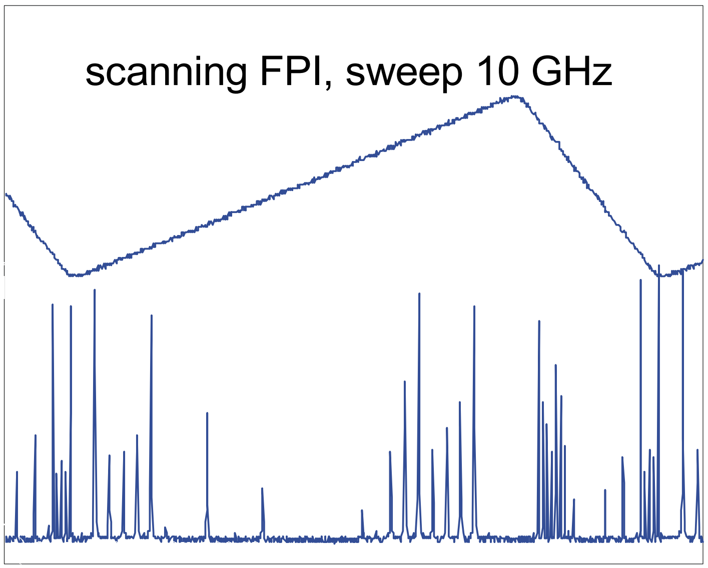
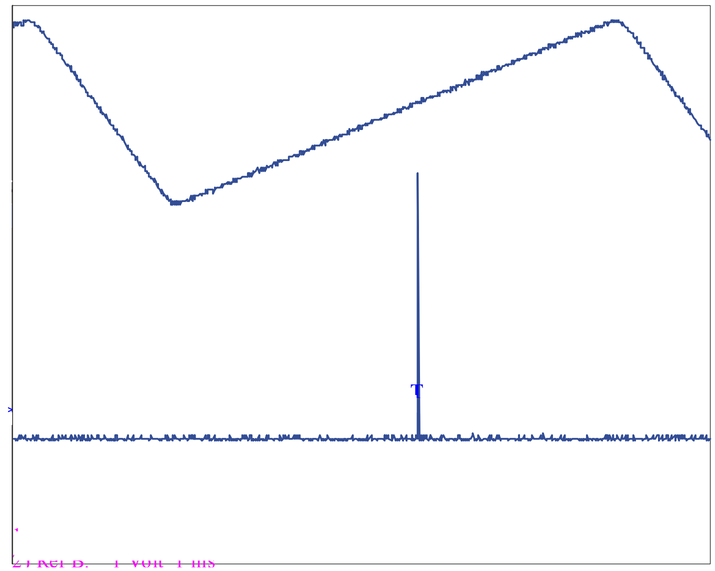
Stable-Unstable Resonator Injection-locked





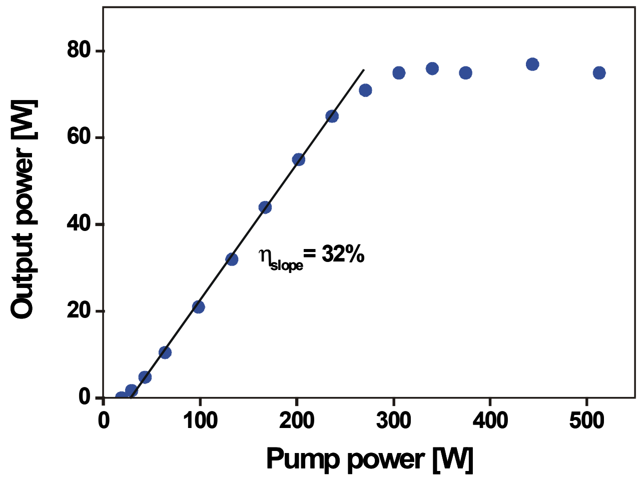
free-running slave

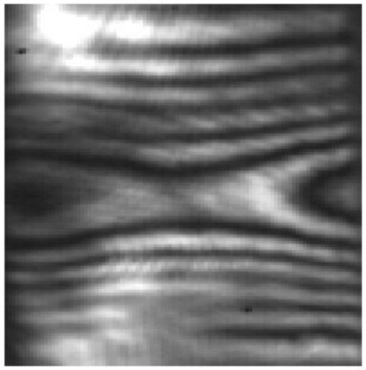
master laser on

Inhomogeneous pumping leads to output power saturation

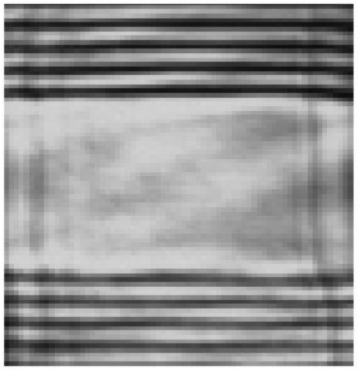
Output power saturation at 80W due to
• thermally induced birefringence
• loss of thermal lens control (pump power dependent horizontal negative thermal lens)

→<u>Both</u> effects due to inhomogeneous pump profile





Inhomogeneous pumping



Homogeneous pumping

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Design Objectives for Laser Head

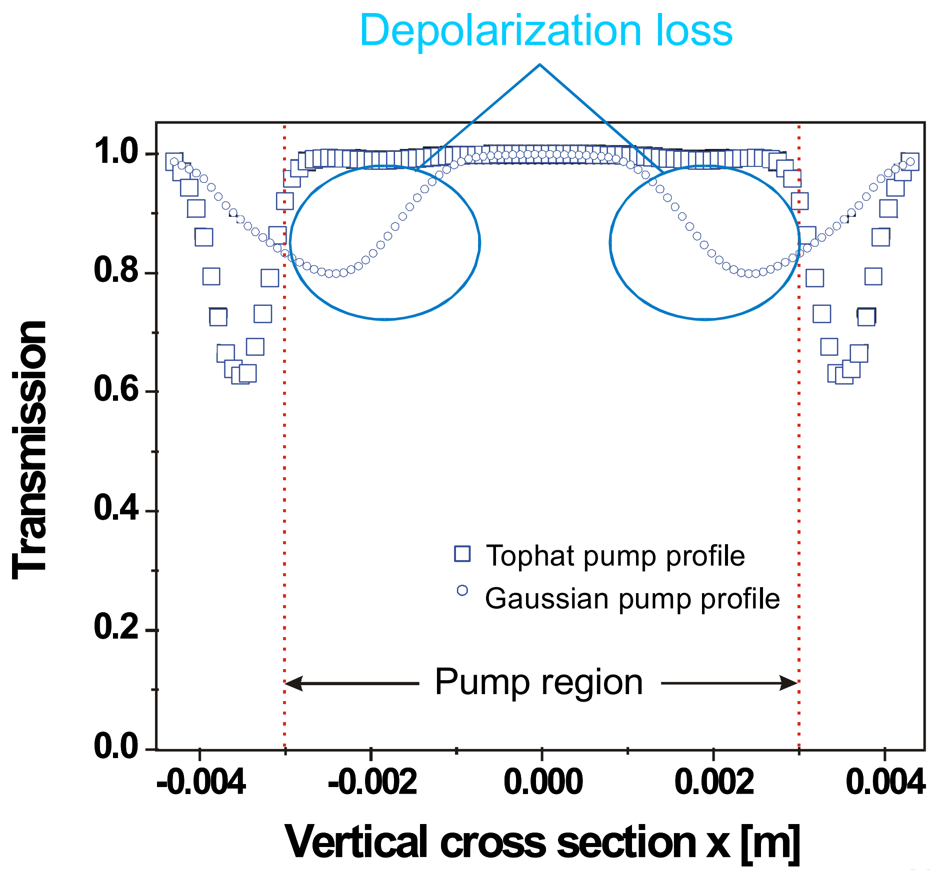
Required:

- Uniform pumping along zigzag mode-path
- Uniform power loading of slab
- Pump profile to minimize birefringence
- More robust coatings (more reliable than Teflon)

While maintaining:

- Injection-locked of stable-unstable resonator
- Good efficiency & high gain folded TIR crystal geometry
- Thermal lens control orthogonal to zigzag mode plane
  (ie: top & bottom heating/cooling)
- Scalability

Pump profile determines depolarization loss distribution



Modeling: M. Ostemeyer

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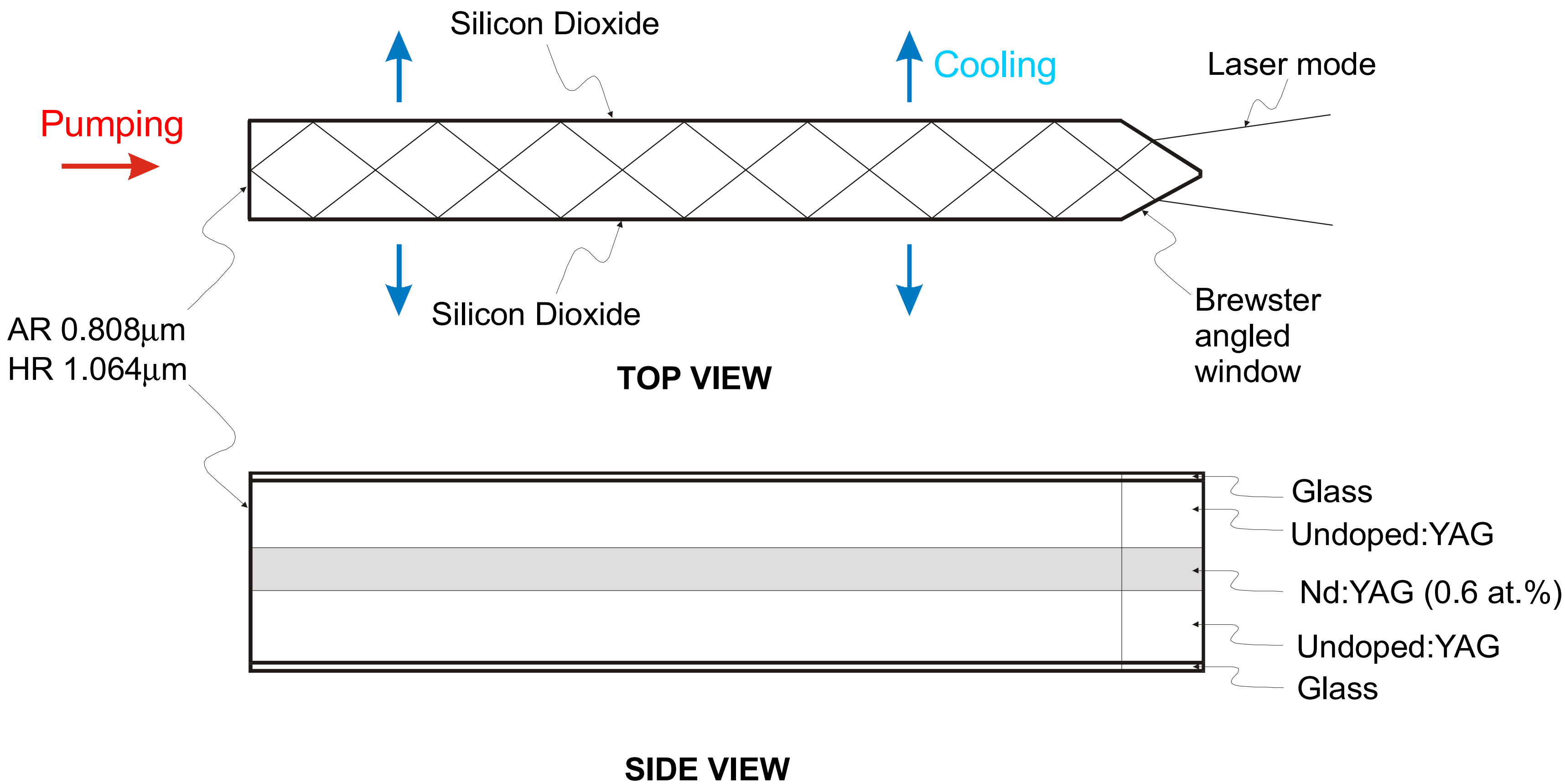
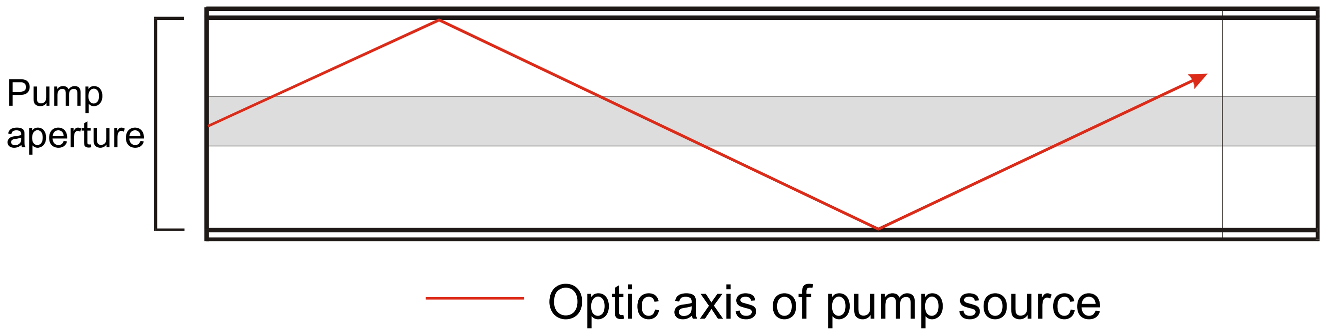
New Design Concept: Composite end-pumped, side-cooled folded zigzag slab

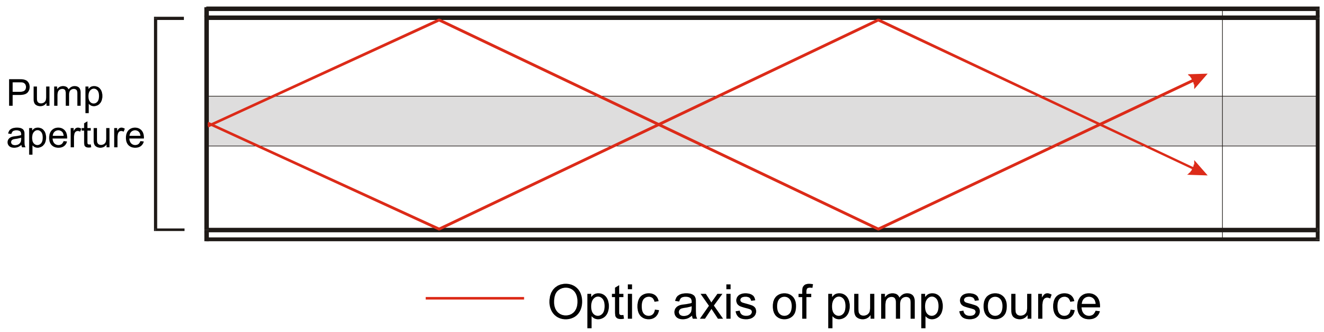


Off-axis, zigzag end-pumping



- Clad design results in ideal tophat pump distribution – min. birefringence
- Good absorption efficiency due to quasi end-pumping
- Zigzag and undoped YAG transports pump light along the slab before absorption, leads to more uniform power loading within slab
- Absence of hard-edged apertures in vertical direction
- Large pump input aperture, with thinner, higher central gain region

Off-axis, zigzag end-pumping



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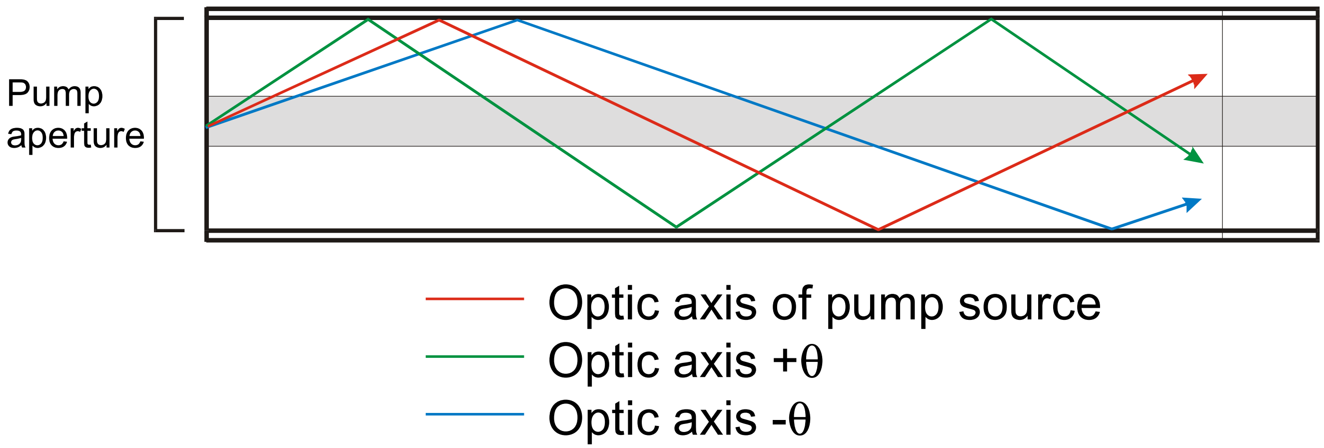
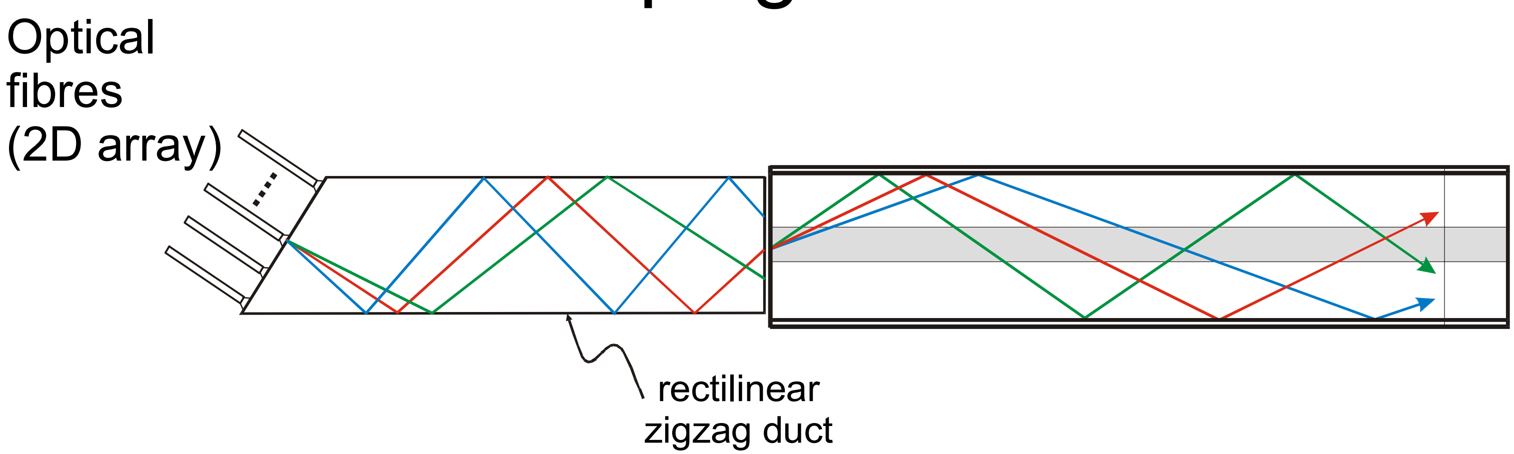


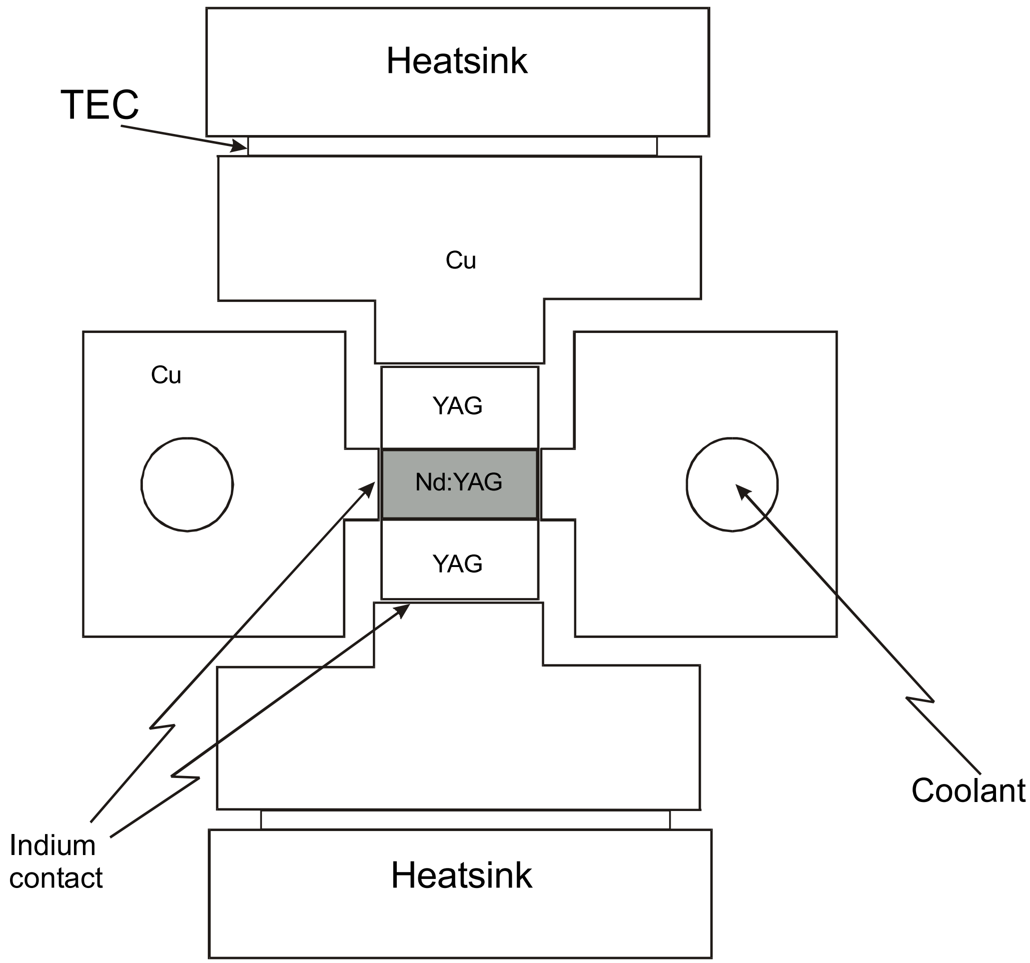
- Accommodate real divergent pump sources
- In general, all pump rays have same total pathlength within doped YAG
- Insensitive to pump beam-quality due to mixing of pump light in slab
- Undoped YAG layers increase aspect ratio of slab which reduces thermally induced stress
- Glass bottom/top for TIR of pump light and thermal insulation
- Not waveguide laser as heat is removed via sides not through clad layers

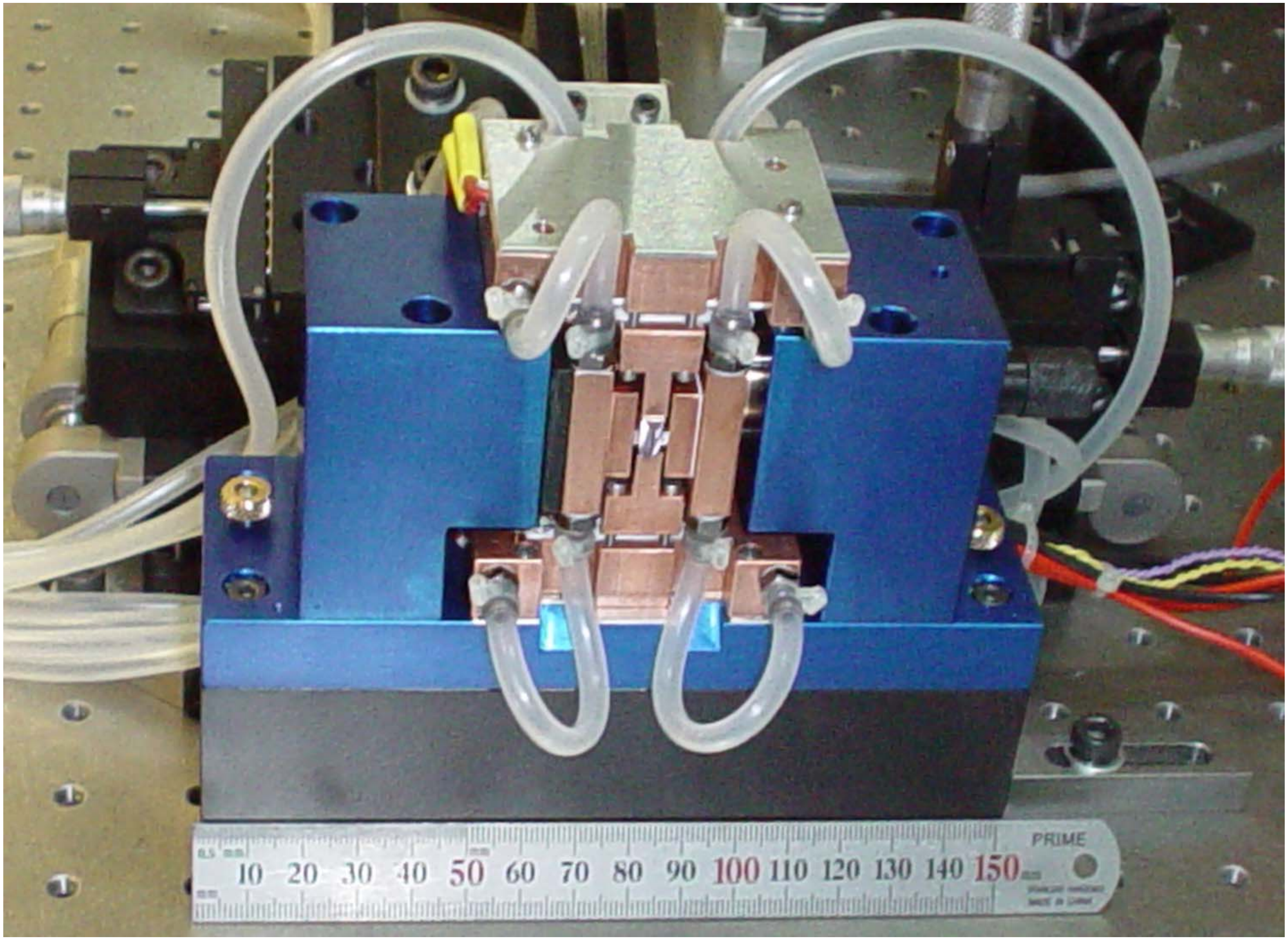
Pumping scheme



- Rectilinear zigzag duct allows pumping at normal incidence
- Homogenizes pump light prior to slab entry, facilitates diode-laser change while injection-locked
- 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)

End view of laser head





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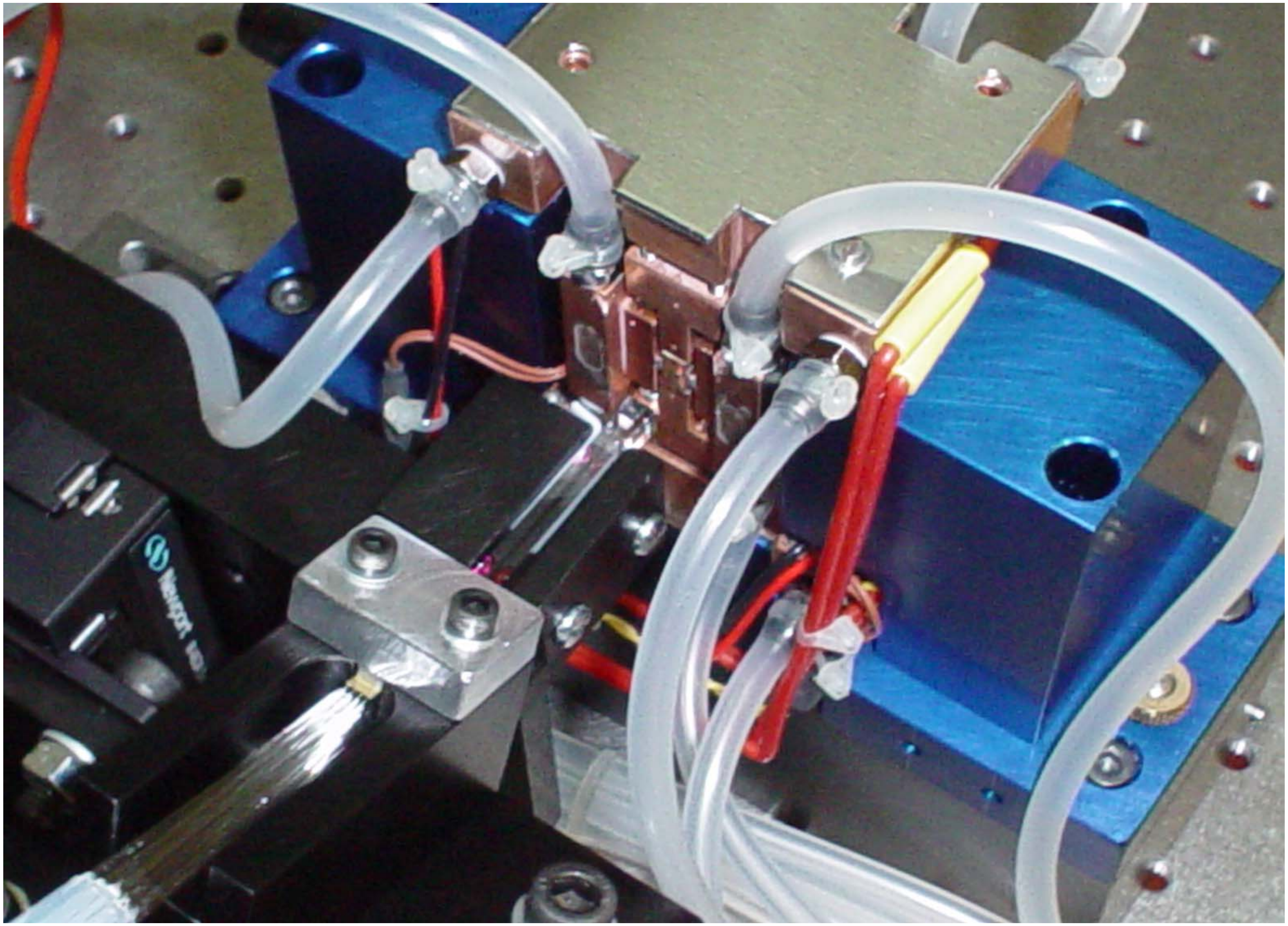
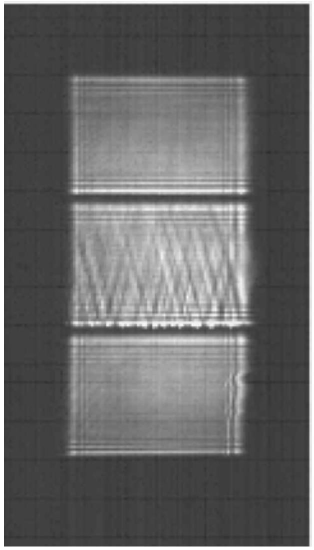


Gain medium characterization

Initial testing

- Bonding of Nd:YAG/undoped YAG/glass successful
- Efficient transmission through rectilinear zigzag duct
- Successful design of laser head & slab mounting
- Approx. 10% leakage of pump light from end of slab (efficient end-pumping)



Problem: Manufacturing error by crystal/bonding vendor, growth striations visible to laser mode within Nd:doped region!

Conclusions

- New off-axis zigzag cladding-pumped slab geometry designed and assembled
- Design verification testing has commenced, future testing will include interferometric evaluation of the thermal behavior within the slab and optimization of the pump geometry, the laser head assembly and the control instrumentation
- Revised Plan
  - Order replacement crystals
  - Assemble previous 80W laser design for Gingin
  - Assess and develop new high power laser design