High-Power, Short-Pulse Microlaser - Power Amplifier System

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Technical Objectives

Phase II Goals:

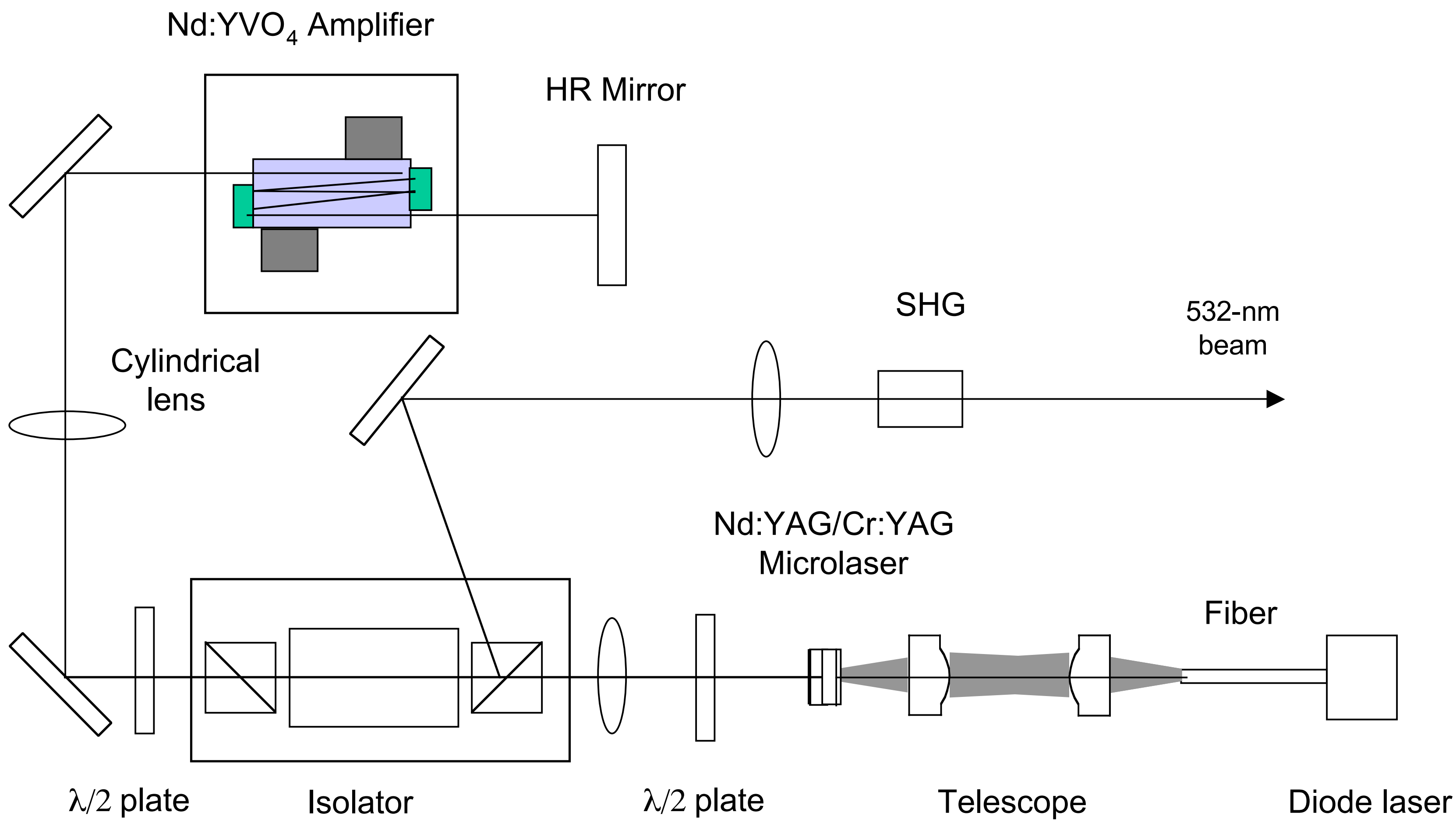
Develop a Subnanosecond-Pulse MOPA System Including diode-laser-pumped, passively Q-switched, 1064-nm Nd-doped microlaser, multipass amplifier and SHG to generate pulses with

- Pulse energy: 150 μJ @ 532 nm (200 μJ achieved- 60% eff.)
- Pulse rate: 2 kHz (achieved)
- Pulsewidth ≤ 200 ps (370 ps achieved)

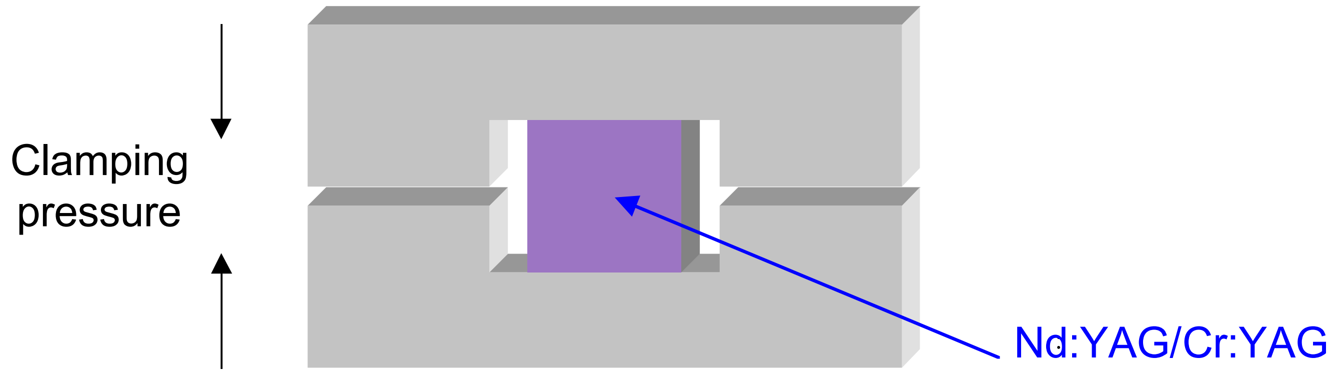
Phase III Goals:

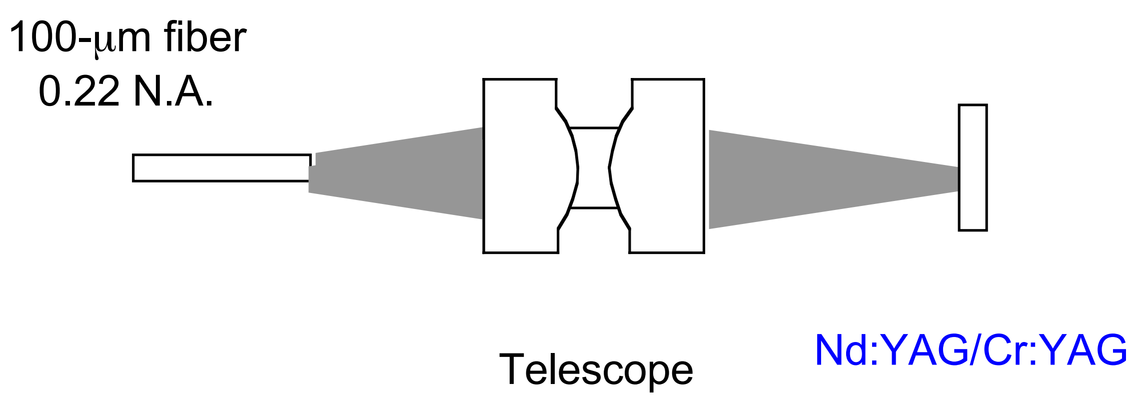
Reduce laser footprint to about 50 x 25 cm
Eliminate all water cooling
Increase pulse energy to 270 -300 μJ @532 nm
Further reduce laser pulsewidth
Provide additional computer control and monitoring interfaces
Delivery expected January 2003

Optical layout



Pumping and mounting the microchip

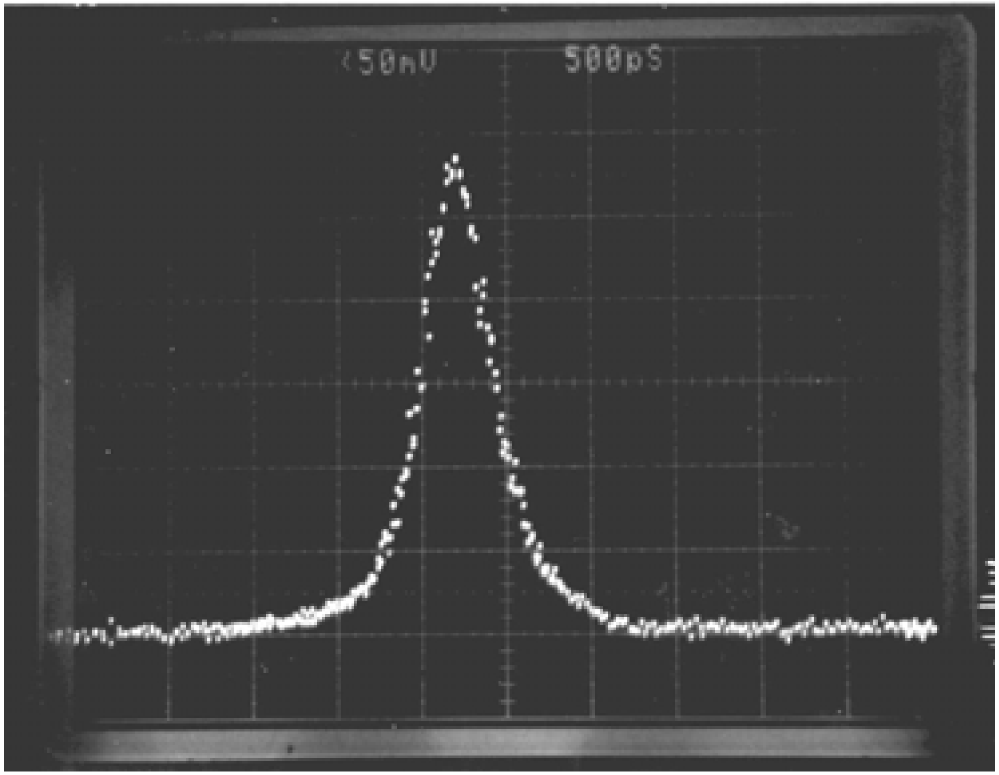




Microchip designs

Microchip design	**Q-Peak-1**	**Q-Peak-2**	**Synoptics**
Nd:YAG doping *t* (mm)	2.8% 0.5	2.8% 0.5	1.9% 1.25
Cr:YAG *t* (mm)	0.25	0.5	0.25
Cr:YAG α (cm^{-1})	5.7	5.7	6.0
R_{oc} (%)	80	80	80
$T_{p\ calcls}$ (ps)	304	204	200
$T_{p\ measur}$ (ps)	700	440	440

Microlaser output pulse profile



0.7 W pump power at 809.0 nm
440 ps pulse duration

Microlaser characteristics

Microlaser parameters	Microlaser 1, 4:3 telescope	Microlaser 2, 2:1 telescope	Microlaser 3, 4:3 telescope
Average power, mW	4.4	3.1	6.4
Pulse energy, μJ	2.2	1.55	3.2
Pulse width, FWHM, psec	700	400-440	400-440
Delay, μsec	90	40	70
Pump pulse width, μsec	120	60	120
Jitter, ns	± 100	± 100	± 100
Drift, 5 min, ns	± 300	± 200	± 200

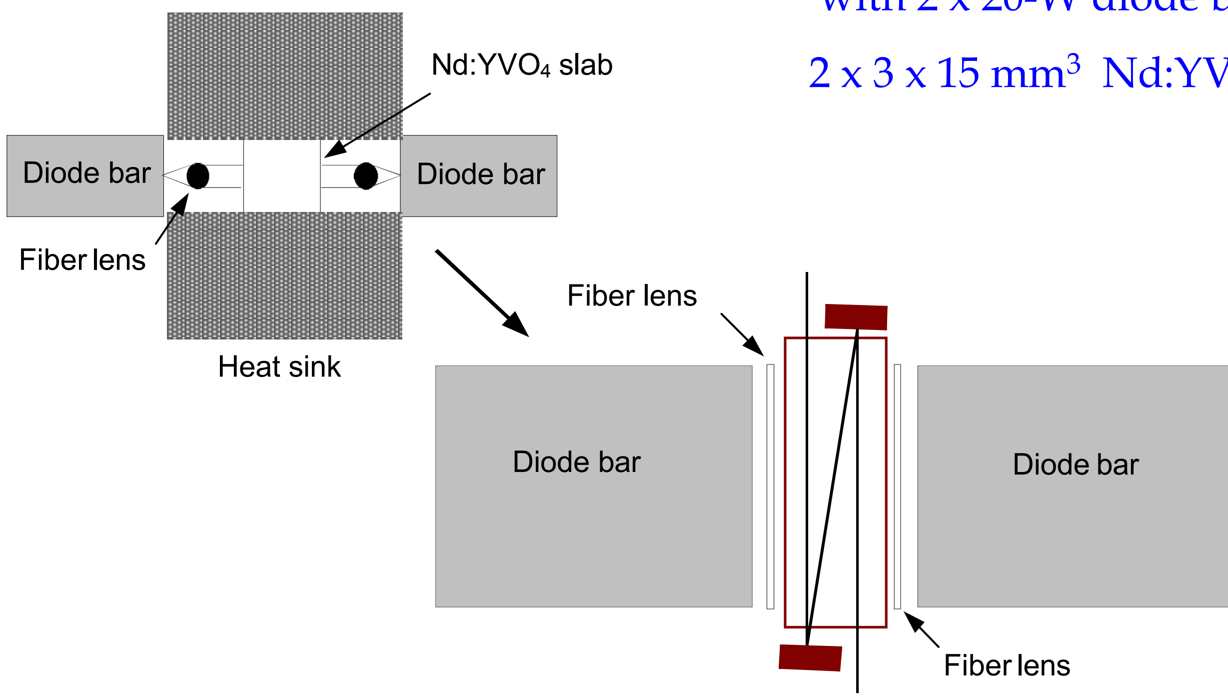
Optical layout of a multi-pass Nd:YVO4 slab amplifier

Transverse pumping @808 nm

with 2 x 20-W diode bars

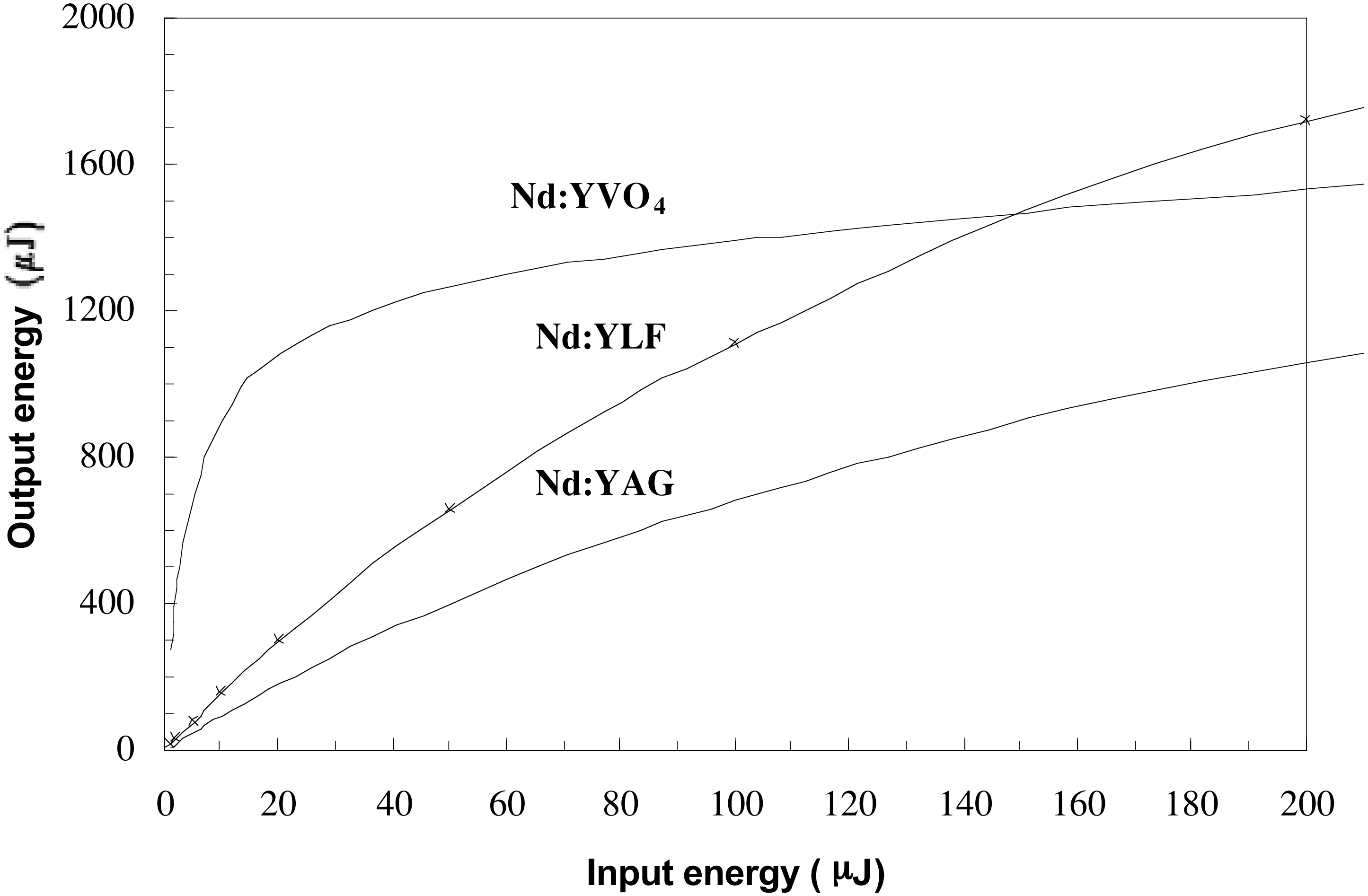
2 x 3 x 15 mm^3 Nd:YVO4 slab

Side view

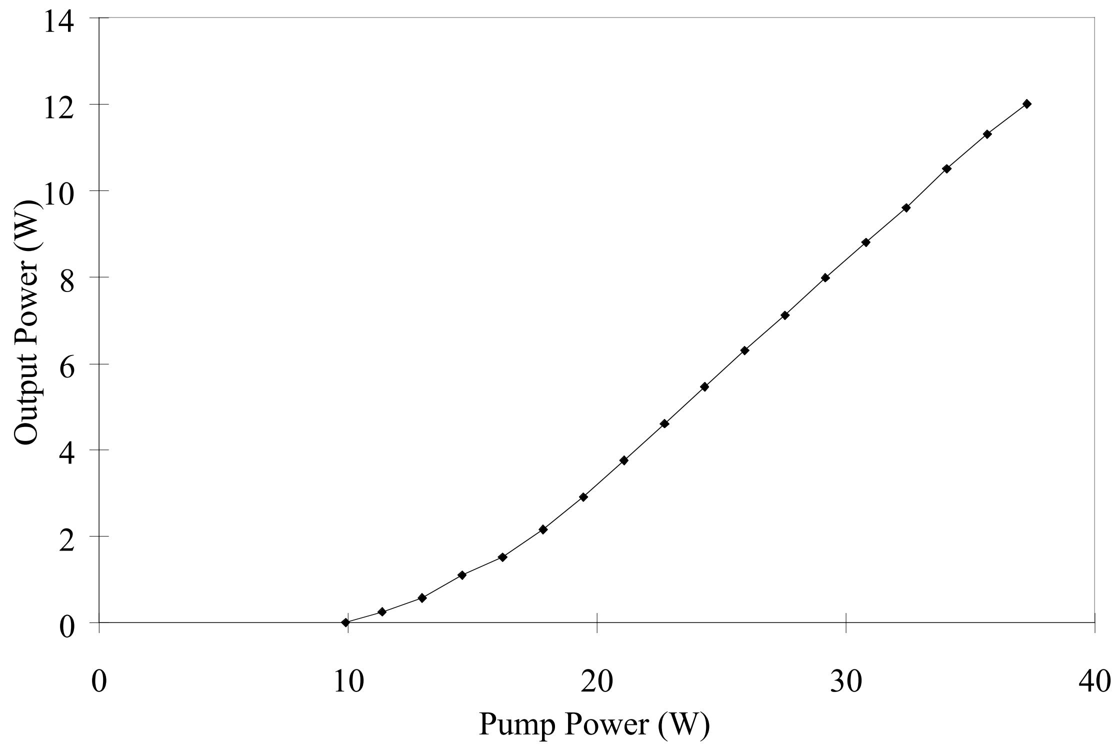


Top view

Theoretical double-pass gain curves for cw-pumped Nd-doped multi-pass slab amplifiers

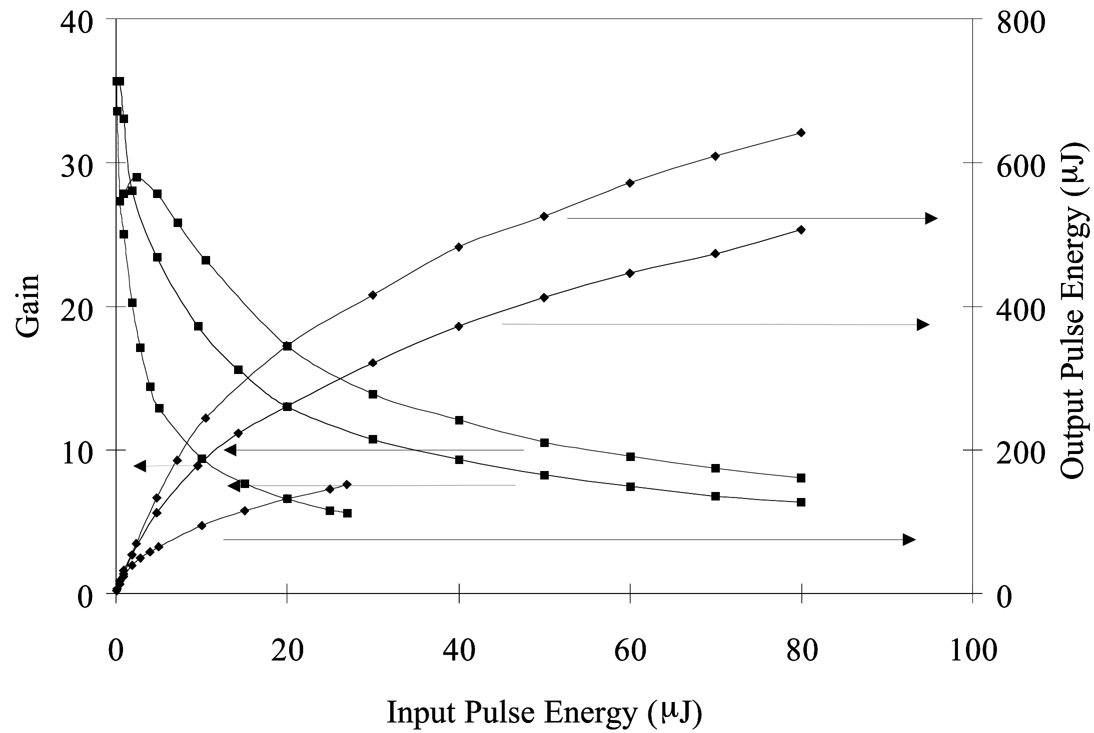


CW Nd:YVO_4 oscillator output power versus pump power

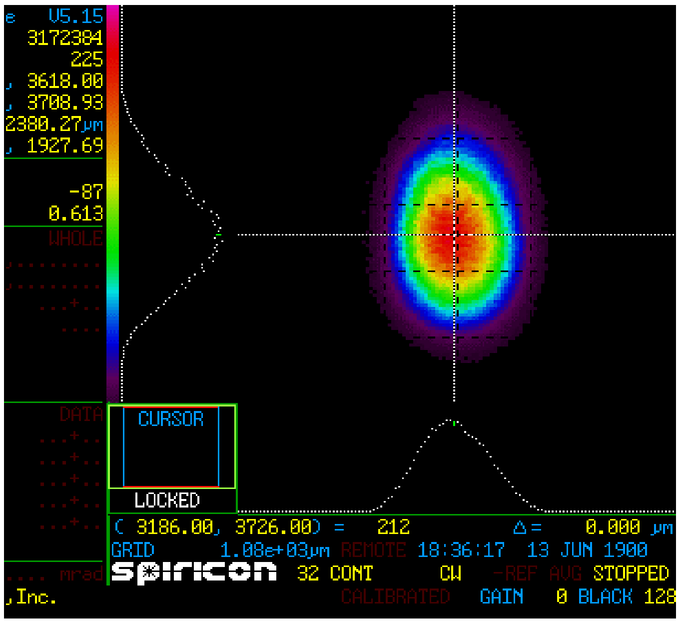


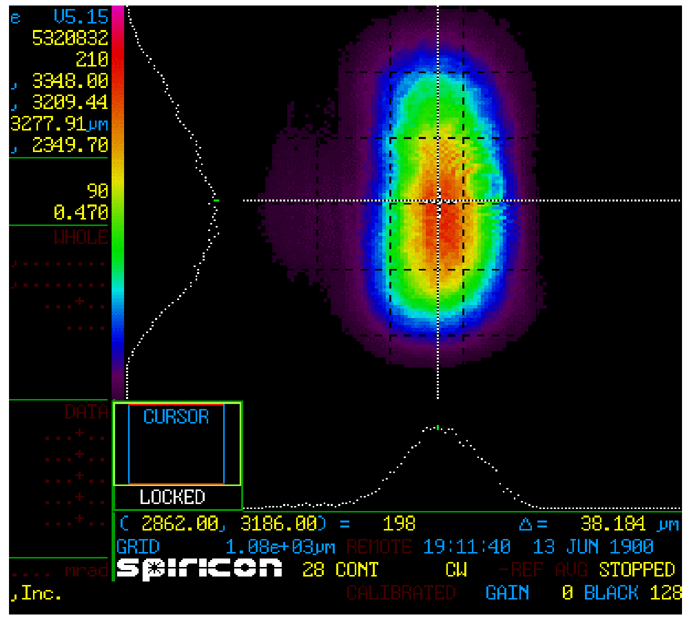
Single-pass amplifier performance at different repetition rates

The average power extracted as a function of pulse rate is 10%, 42%, and 67% at 2 kHz, 10 kHz, and 50 kHz



Output beam profile for single-pass and double-pass amplifier

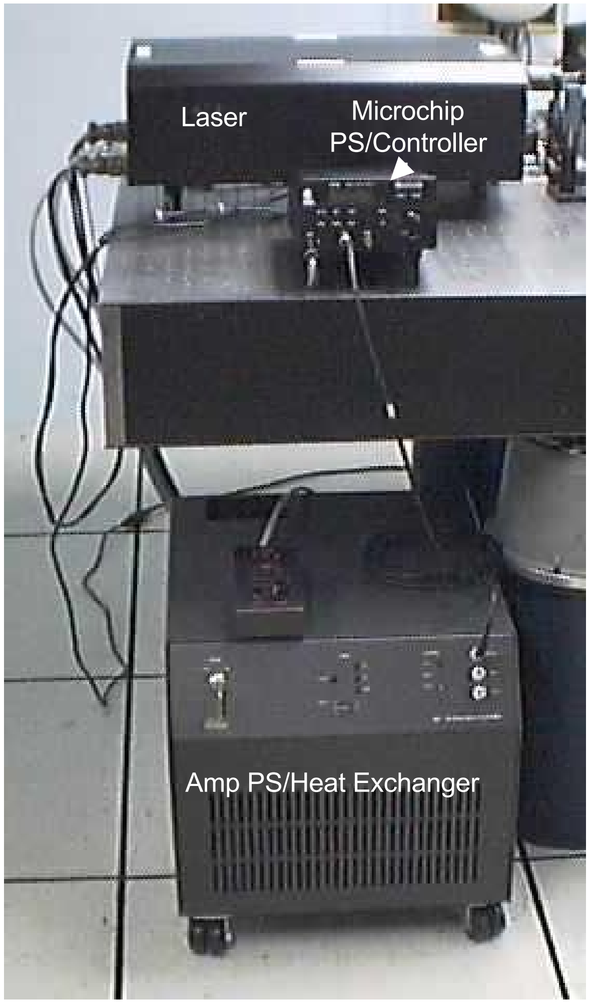


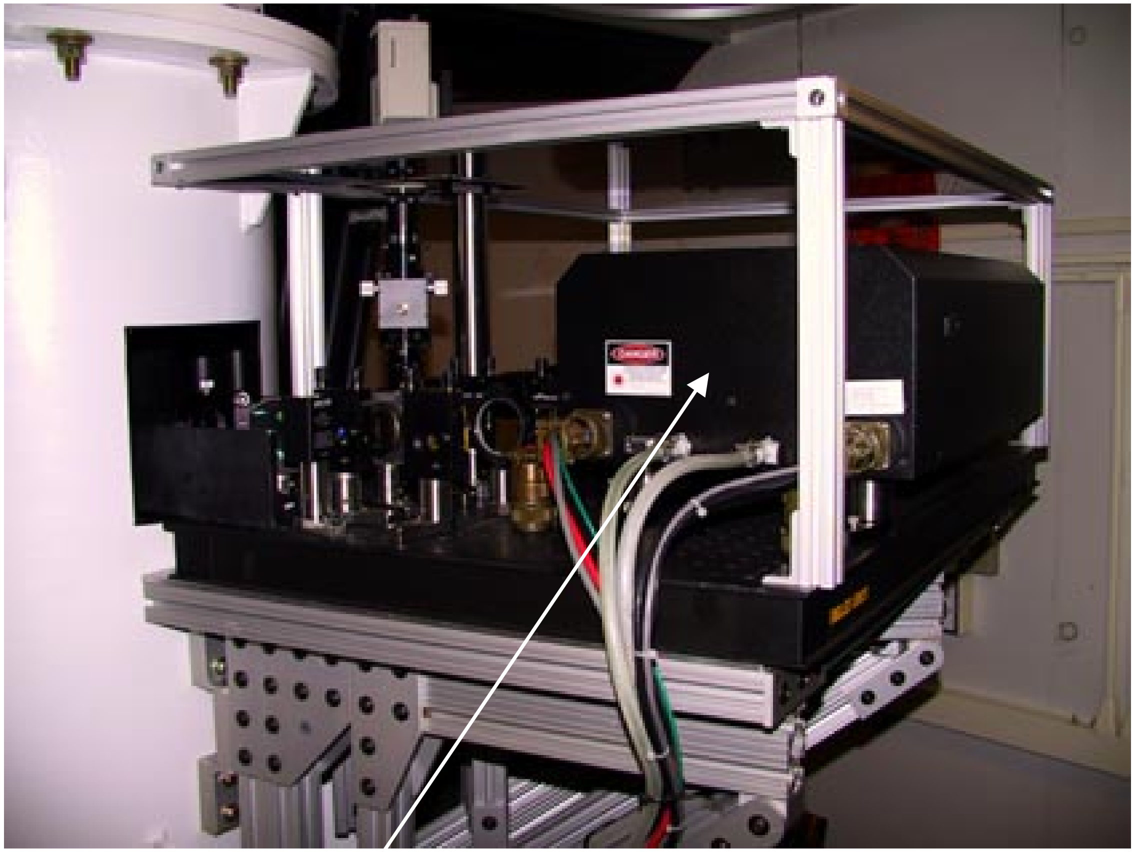


Nonlinear conversion results

Nonlinear conversion	SHG	THG	FHG
Crystal & sizes	LBO 3x3x15 mm	LBO 3x3x12 mm	BBO 3x3x7 mm
Conversion type	Type I, NCPM	Type II, CPM $\theta = 42.7^\circ, \phi = 90^\circ$	Type I, CPM $\theta = 47.6^\circ, \phi = 0^\circ$,
Conversion efficiency	60%	36%	12%

Phase II Transmitter

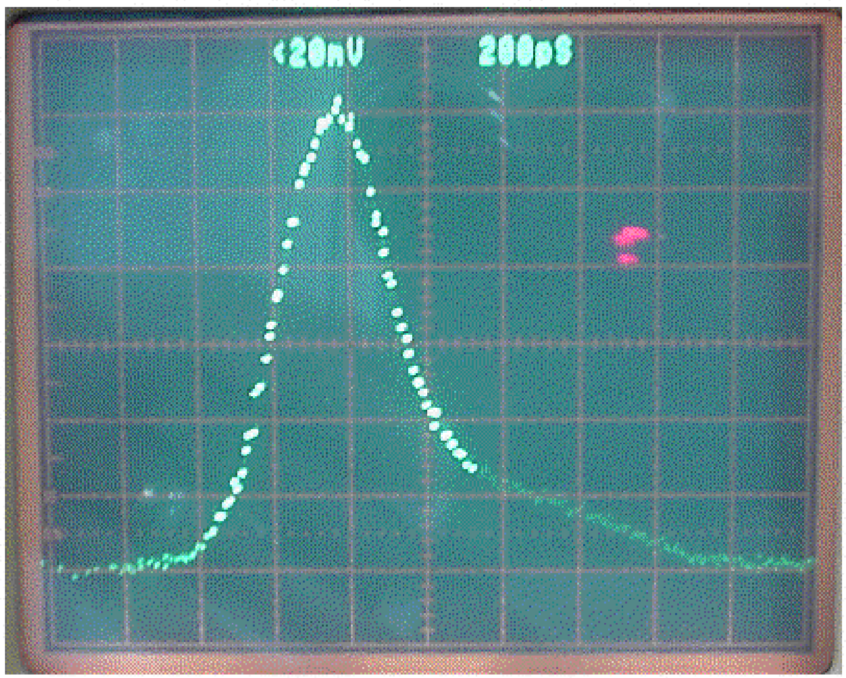




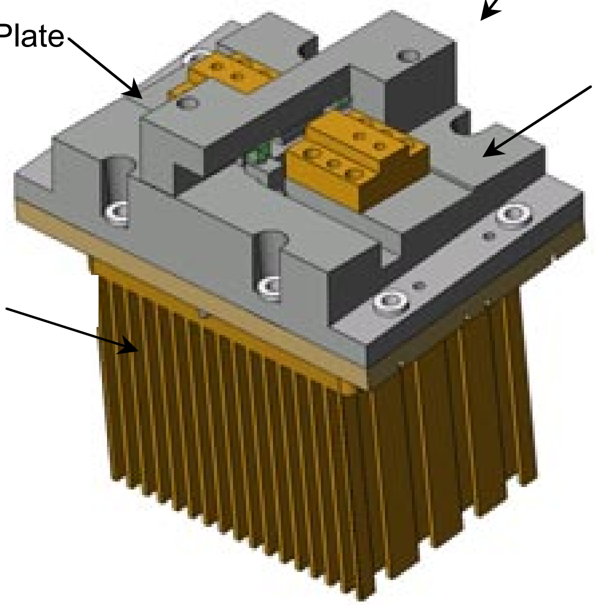
Phase II XMTR Installed on SLR2000 Transceiver Bench

Phase III Microchip System Development

Using the Unique Mode diode laser as a pump source, we were able to achieve lasing with the new microchips. Using a 4:3 telescope, and pumping with 2.0 W, we measured a 350-ps pulsewidth and an energy per pulse of ~15 ìJ. The pulsewidth measurement was made with the system that had a measured pulse response of 40 – 50 ps. Measurements of M^2 resulted in values of ~1.4 for each axis. Frequency doubling a small fraction of the light to 532-nm using a KTP crystal resulted in pulses with widths of ~270 ps.

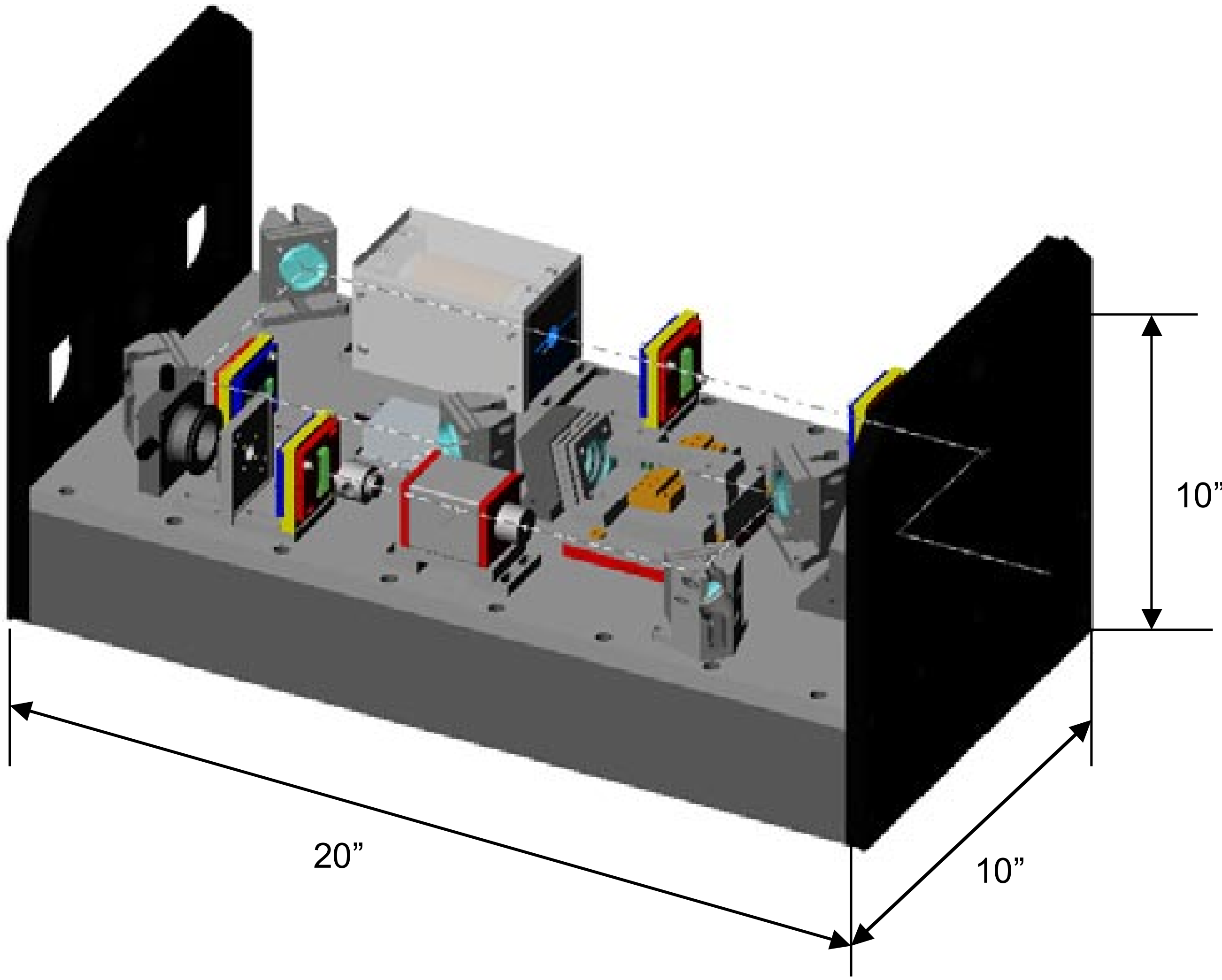


Mechanical design of Phase III Nd:YVO_4 amplifier



- The pump diode lasers and Nd:YVO_4 crystal mount on a solid block of Ni-plated copper
- A Ni-plated copper clamp holds the crystal in place
- The bottom copper plate is cooled by thermo-electric coolers
- The air-cooled fins of the heat sink dissipate the heat from the thermo-electric coolers

Preliminary Design of Phase III Air-Cooled System



Phase II Summary

- *A Cr:YAG passively Q-switched Nd:YAG microchip laser that generated 3.2-μJ, 400-ps pulses at a 2 kHz rate*. The microlaser, quasi-cw end-pumped by a 1-W fiber-coupled laser diode, combines high peak power output, good beam quality, and compactness and reliability.
- *An efficient cw transversely-diode-pumped double-pass Nd :YVO4 amplifier.* The amplifier multipass gain module is based on the design developed by Q-Peak for the MPS commercial series of lasers. It combines high-power output, and freedom from optical distortion of the laser material caused by the pumping process. The amplifier *produced 370-ps output pulses of 335μJ energy at a 2 kHz rate.*
- *A 60-% conversion efficiency second harmonic generator (SHG)* based on a NCPM Type I LBO crystal mounted in a temperature-stabilized oven. The average output power of the 532-nm beam was 400 mW (200 μJ per pulse) that is ~1.3 times the proposed value. The M^2 values characterizing the beam quality were 1.17 and 1.14 in the horizontal and vertical plane, respectively.
- *Third and fourth harmonic nonlinear devices* based on critically-phase-matched LBO and BBO crystals, respectively, operating at room temperature. The output powers at *355 nm and 266 nm were 240mW and 66 mW, respectively.*