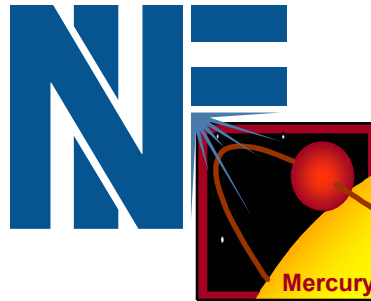


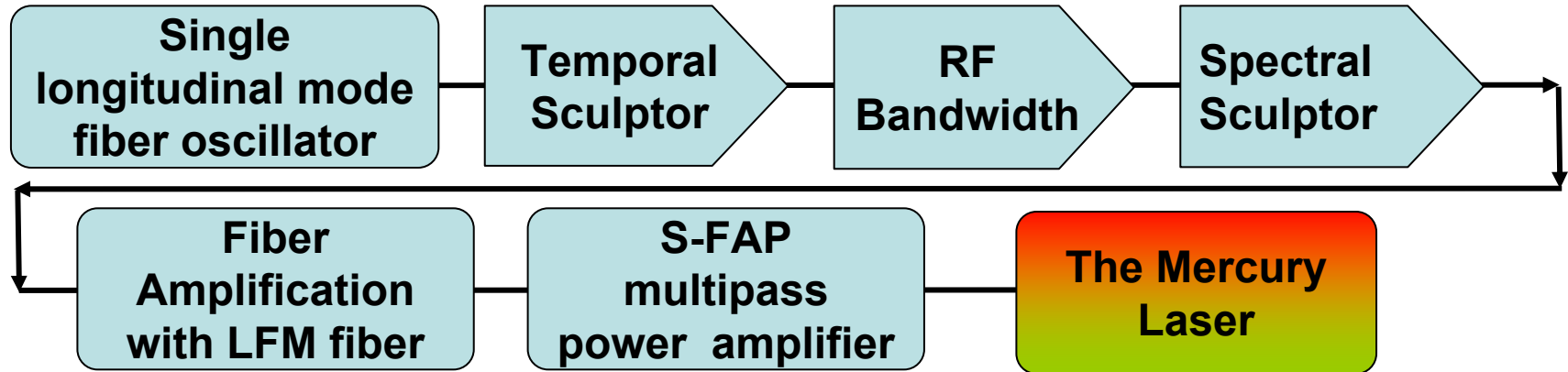
# Temporal and spectrally sculpted front end for the Mercury Laser



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- The front end design for the Mercury laser is based on fiber amplifier technology to provide a stable and robust system



## Front end specifications:

### Energy

- 500 +/- 2.5 mJ @ 10 Hz
- 10,000:1 1047 nm signal to noise
- Beam quality:  $M^2 < 1.1$

### Temporal

- Lower than 5% amplitude fluctuations
- Better than 250 ps jitter
- 20:1 contrast

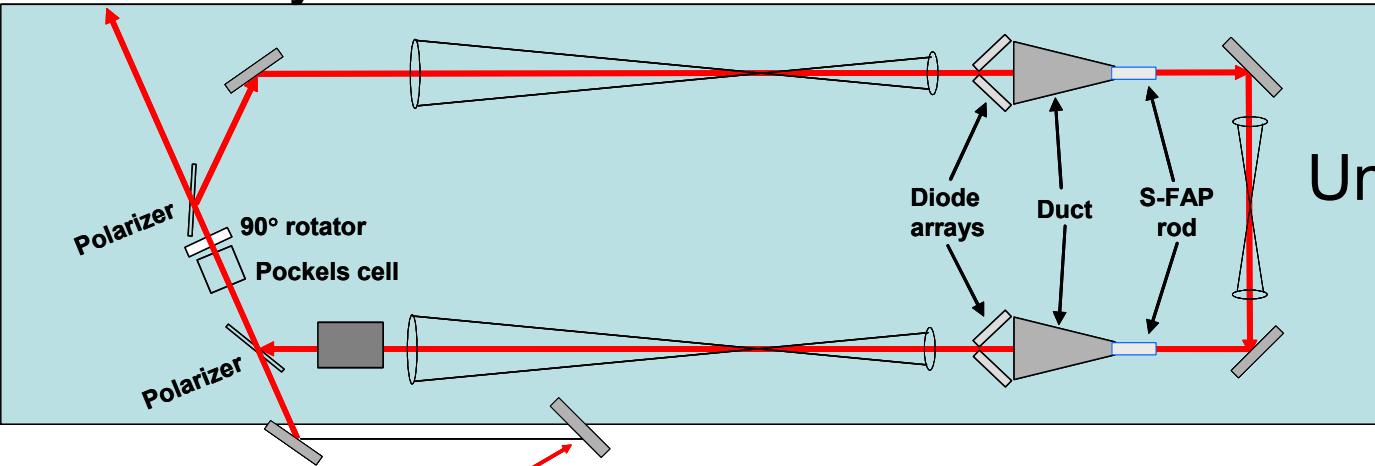
### Spectral

- 3 GHz stability
- 300 GHz bandwidth
- 100:1 contrast

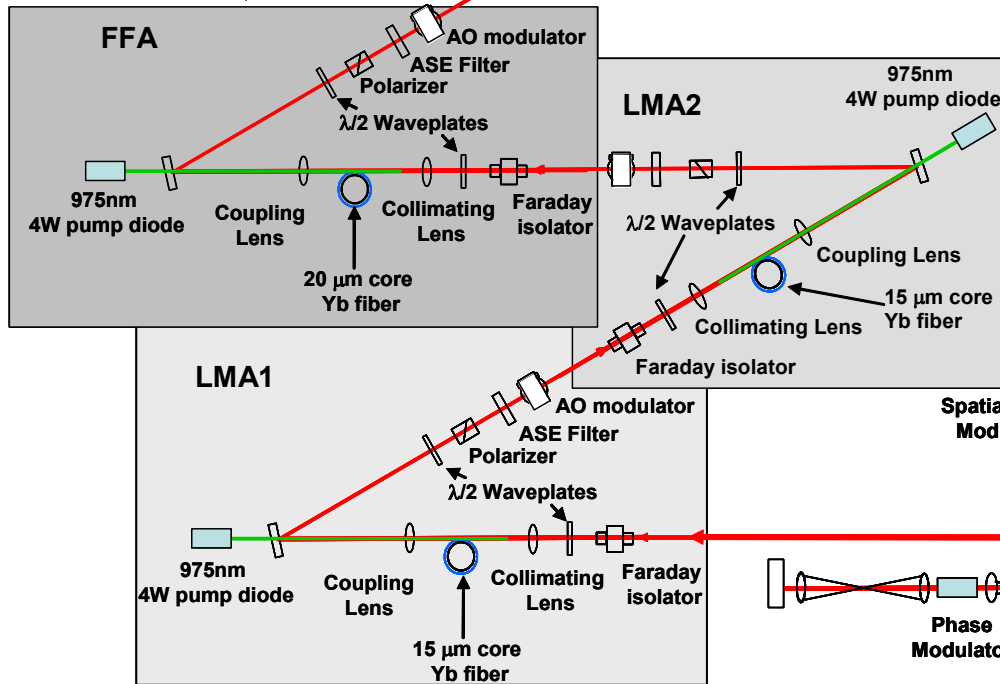
# System layout



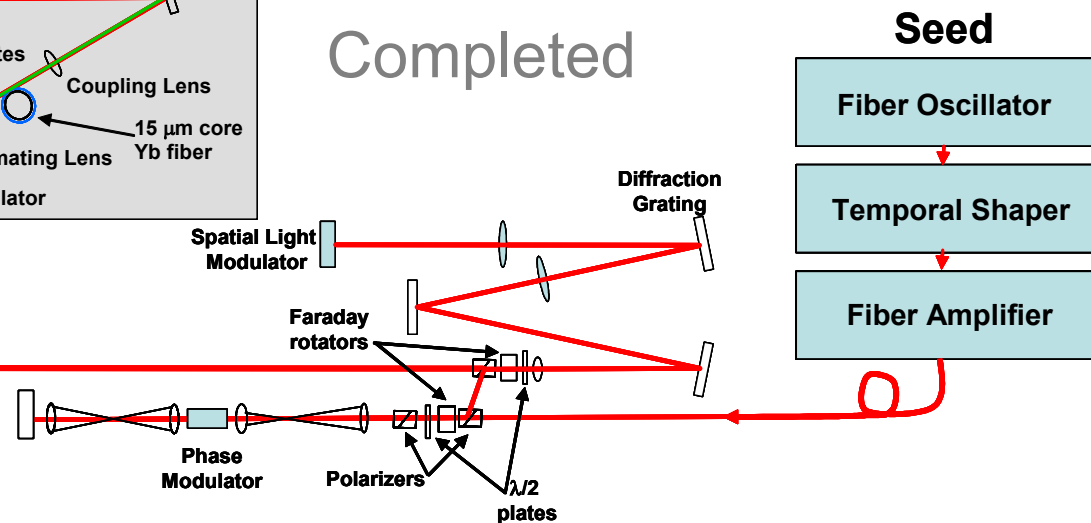
## Out to Mercury



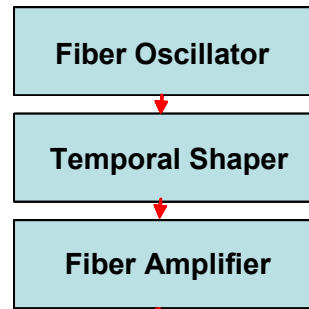
Under Construction



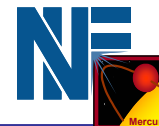
Completed



Seed



# Fiber Oscillator

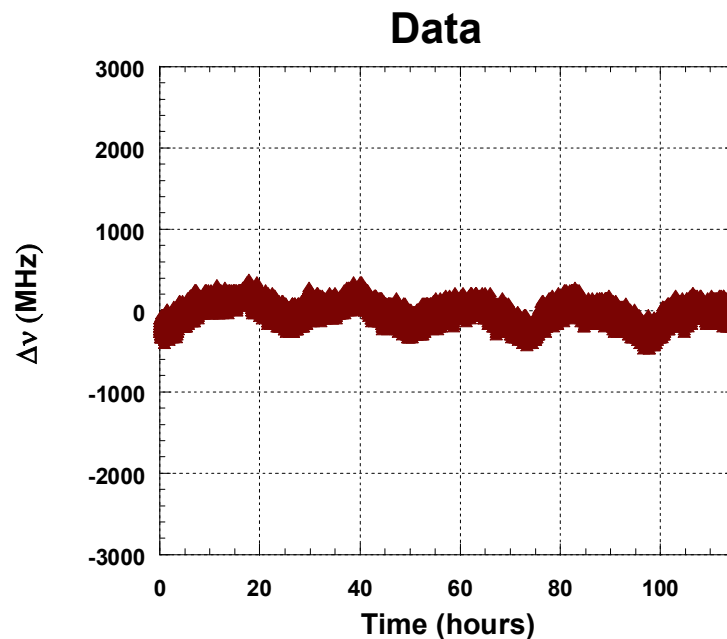
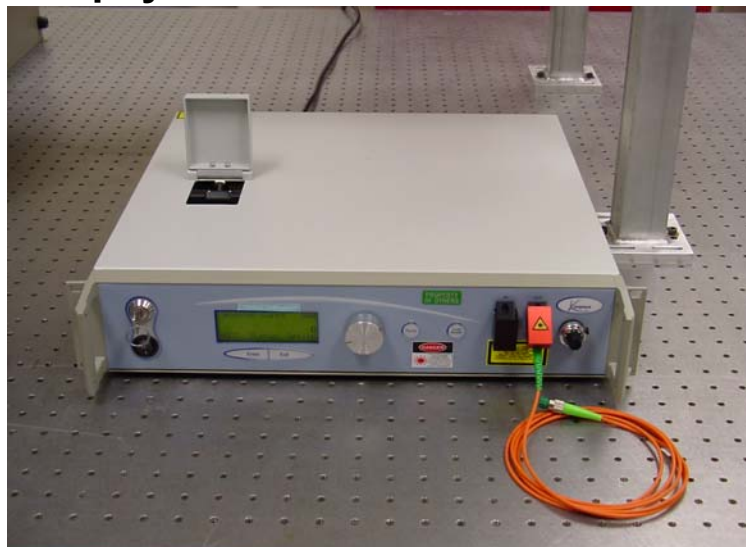


➤ A commercial fiber oscillator provides the wavelength stability and required linewidth

Specifications:

- 1047.7 nm with 1nm tuning
- SLM with  $\Delta\nu < 100$  kHz ( $t < 1$   $\mu$ s)
- Long term drift  $\Delta\nu < 3000$  MHz ( $t < 1$  hour)
- Power output  $> 10$ mW
- 50:1 linearly polarized

## Keopsys Inc. fiber oscillator



**Long term wavelength drift ( $t < 1$  hr) is less than 300 MHz**

# Temporal Shaping

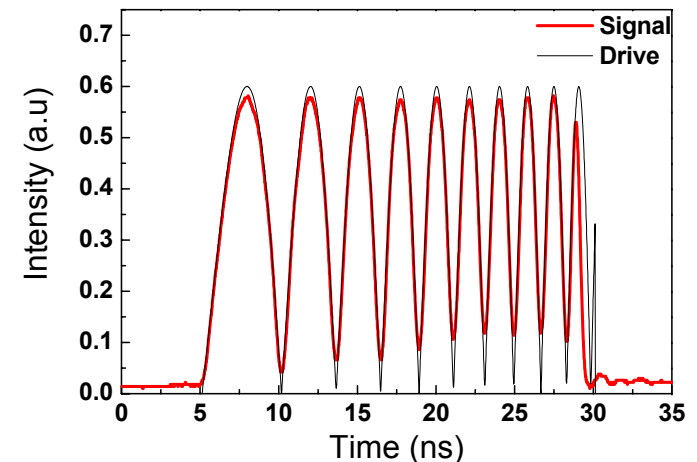
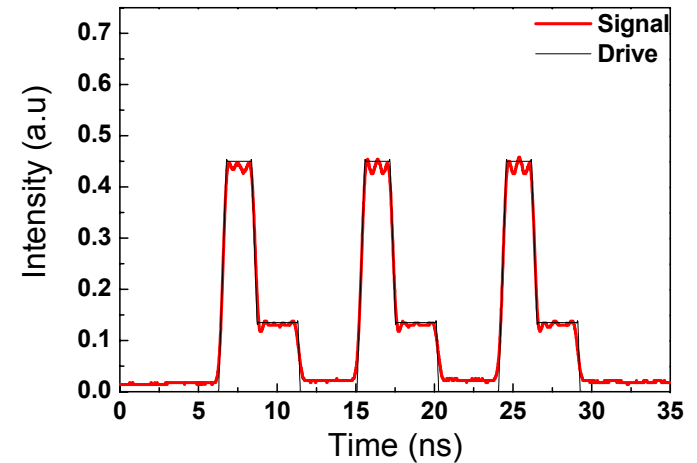


➤ Temporal shaping is controlled by the Highland Technology arbitrary waveform generator (AWG)

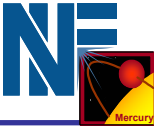
Specifications:

- Dual-stage EO modulator
- 27 dB single-stage extinction
- 6 dB insertion loss
- 96 temporal adjustment points over 24 ns (250 ps resolution)

Highland Technologies temporal shaper (NIF design)



# Fiber Amplifier



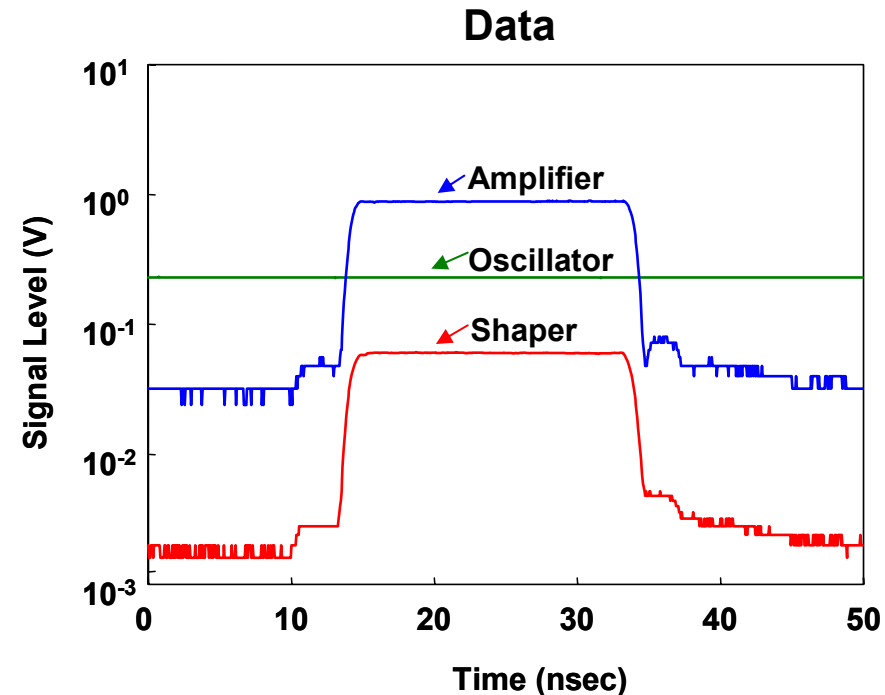
➤ A commercial fiber amplifier provides the gain for the first stage fiber amplifier.

Keopsys Inc. fiber amplifier

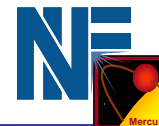


Specifications:

- Polarization maintaining
- 30 dB small-signal gain



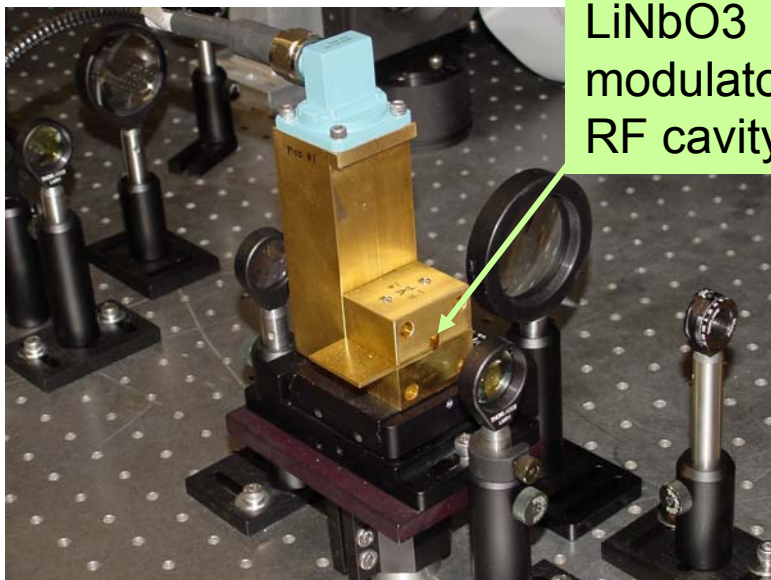
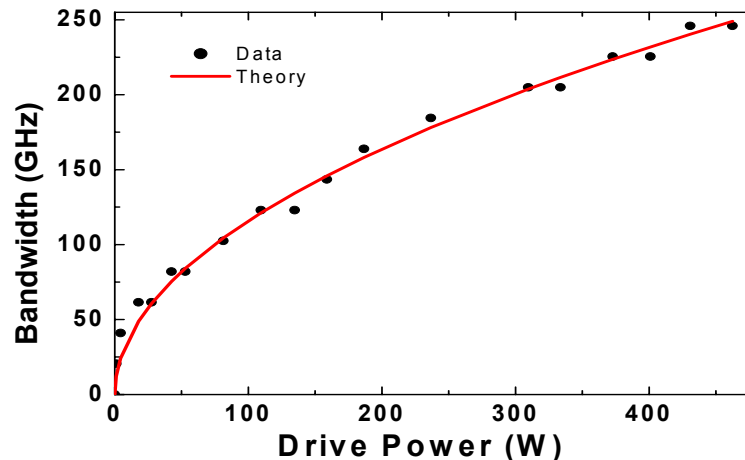
# RF Bandwidth



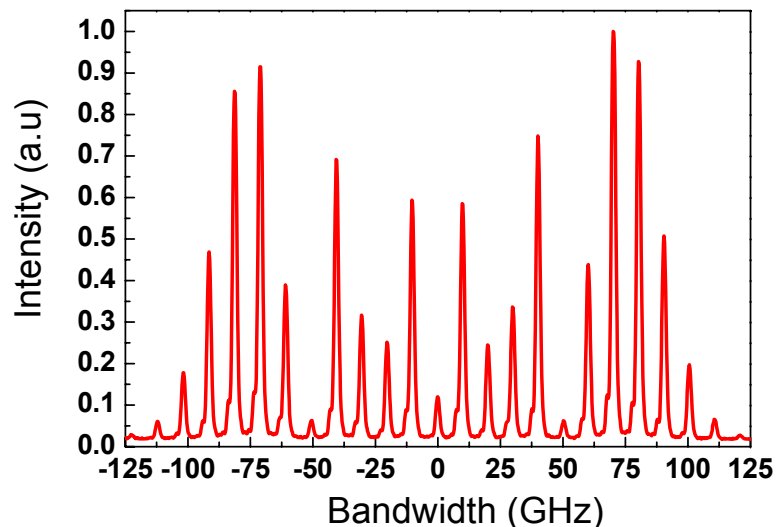
➤ The bulk phase modulator broadens the spectral output of the single mode fiber

## Specifications:

- Bulk LiNbO<sub>3</sub> modulator with 5 x 5 mm aperture
- Designed for RF modulation up to 300 GHz (double pass)
- Low optical loss (< 1%)



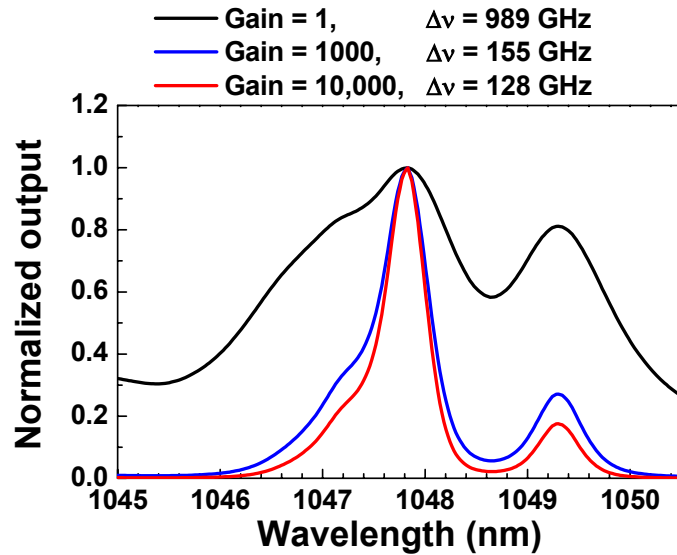
## Demonstration of 250 GHz RF



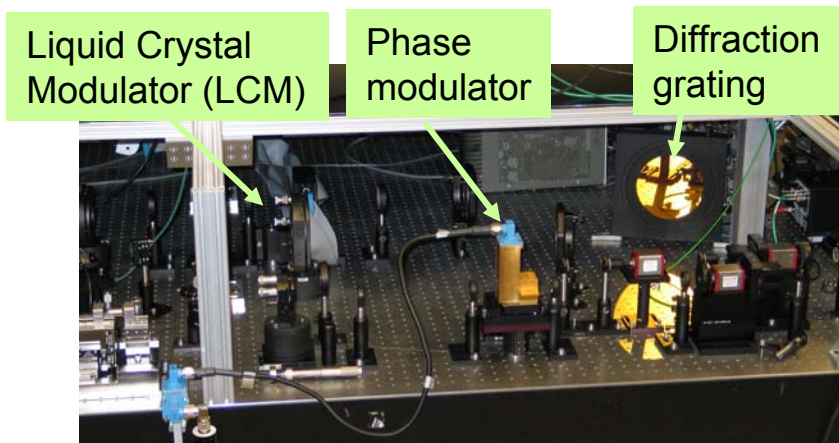
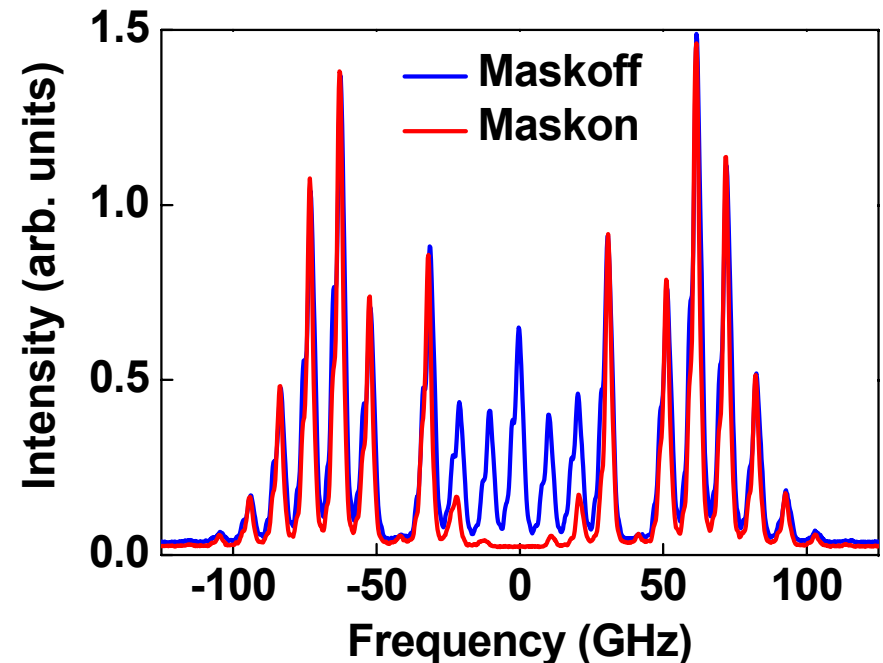
# Spectral Sculpting



➤ Spectral sculpting is accomplished through the use of spatial liquid crystal modulator to mitigate the effects of gain narrowing (FM to AM modulation)



Sculpting demonstration with a gaussian amplitude mask

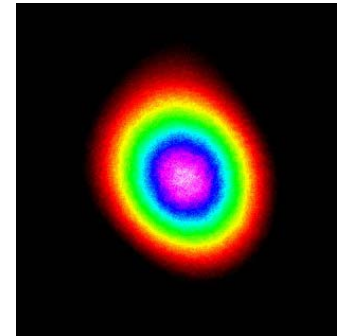
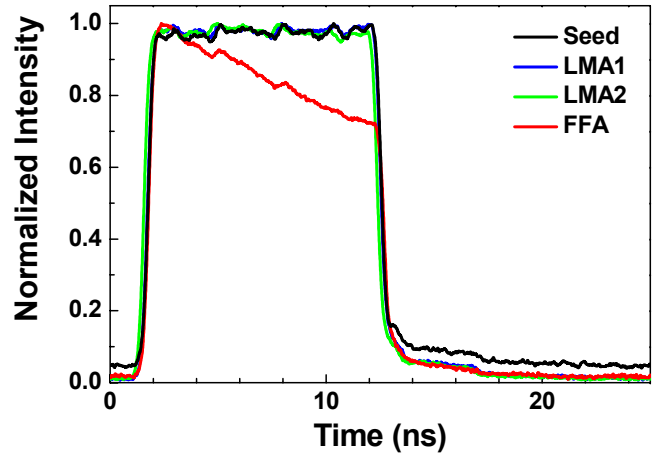
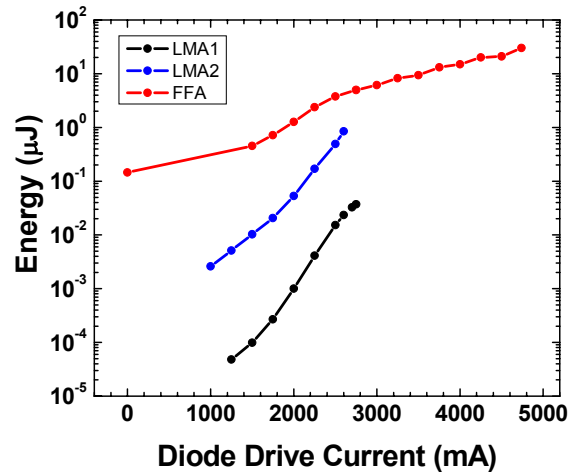




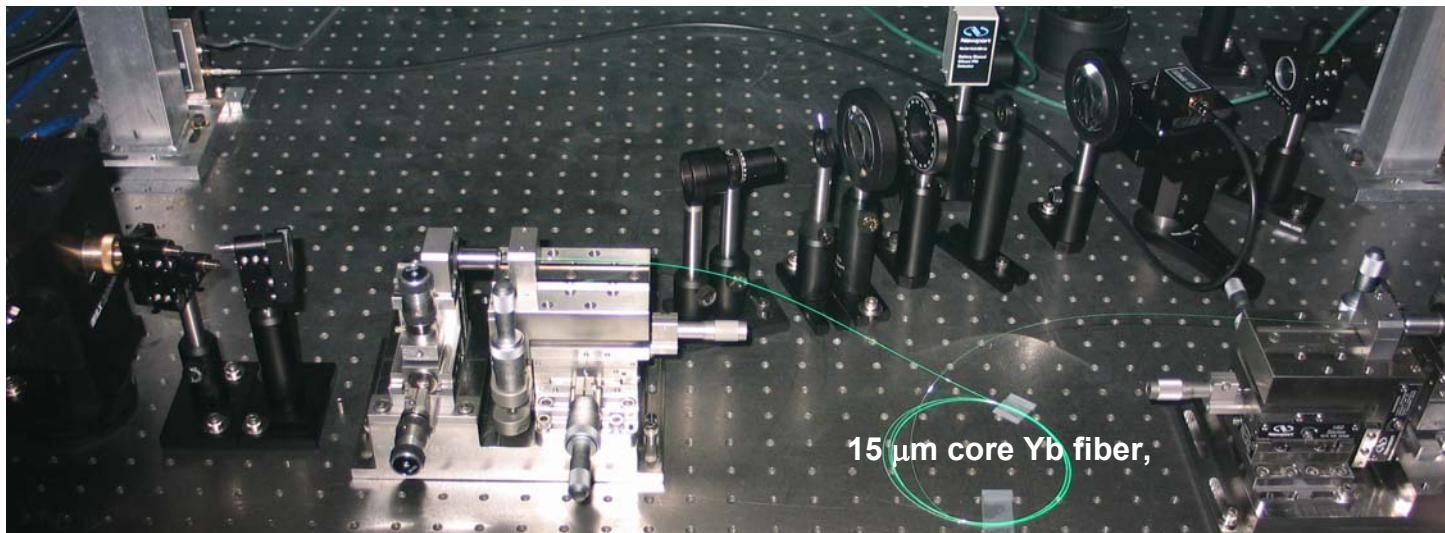
# Fiber Large Mode Area Amplifier



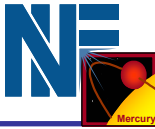
➤ Using a 15  $\mu\text{m}$  core large-mode-area fiber, we have demonstrated the 30  $\mu\text{J}$  of energy required for injection into the power amplifier.



Output mode quality



# Multi-Pass Ring Amplifier

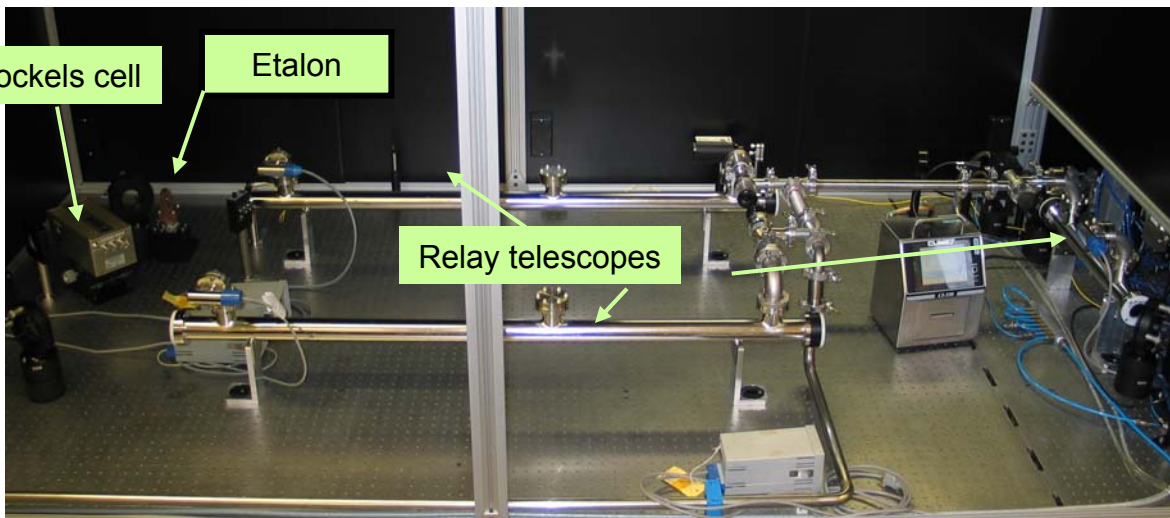
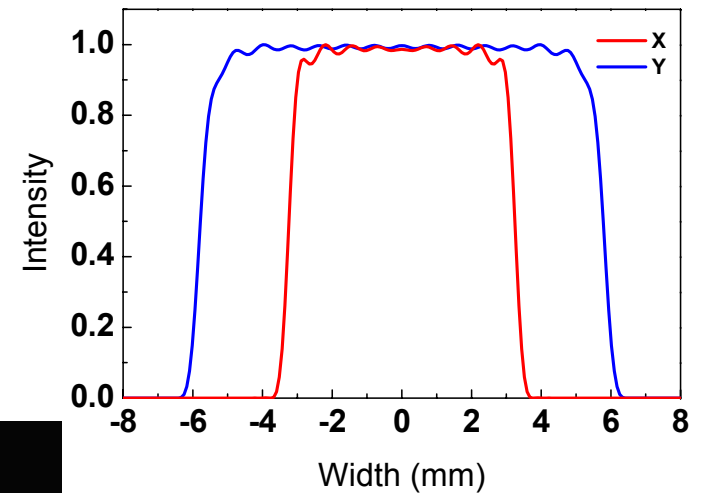


➤ We have modeled the expected performance of the power amplifier – currently under construction.

## Requirements

- 500 mJ @ 10 Hz
- Beam spatial profile = Supergaussian w/ 1.67:1 aspect ratio
- Polarization: Linear, S-polarized 100:1
- Supported pulsewidths: 2-10 ns
- Supported bandwidths:  $\geq 300$  GHz RF
- Output pulse maintains 20:1 temporal shaping for Mercury

Lineouts of output profile



We have successfully demonstrated nearly all of the component technologies of a high energy – spectrally and temporally sculpted front end for the Mercury laser:

- Oscillator – stability better than 1 GHz
- Temporal modulator – pulse shaping with 100:1 contrast
- RF modulator – 250 GHz bandwidth
- Sculptor – 100:1 spectral modulation demonstrated
- Fiber amplifiers – 30  $\mu$ J output
- Ring amplifier – Hardware assembled, amplifier characterization started

## Future work

- Complete activation of ring amplifier
- Amplify narrowband signal to 500 mJ
- Broadband spectral sculpting test
- Complete system activation – monitor system stability
- Install on Mercury laser – Fall 2005