Mercury Technical Project Review

Camille Bibeau
Project Leader
Laser Science and Technology

High Average Power Laser
Technical Workshop
Pleasanton, California
November 13 & 14, 2001

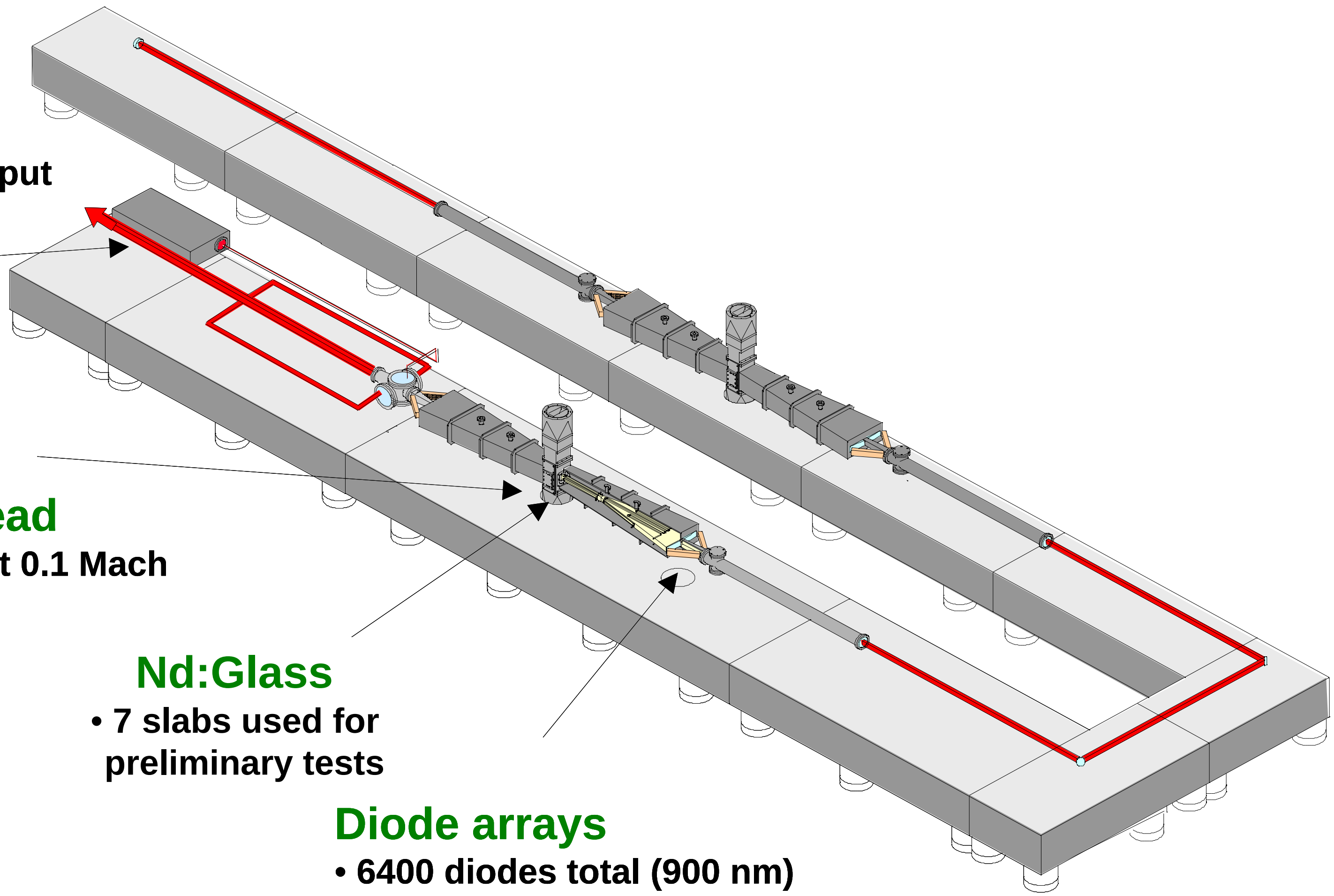
The goals this year are to build and characterize Mercury laser system with one amplifier and two pump modules

This will be accomplished through 6 objectives:

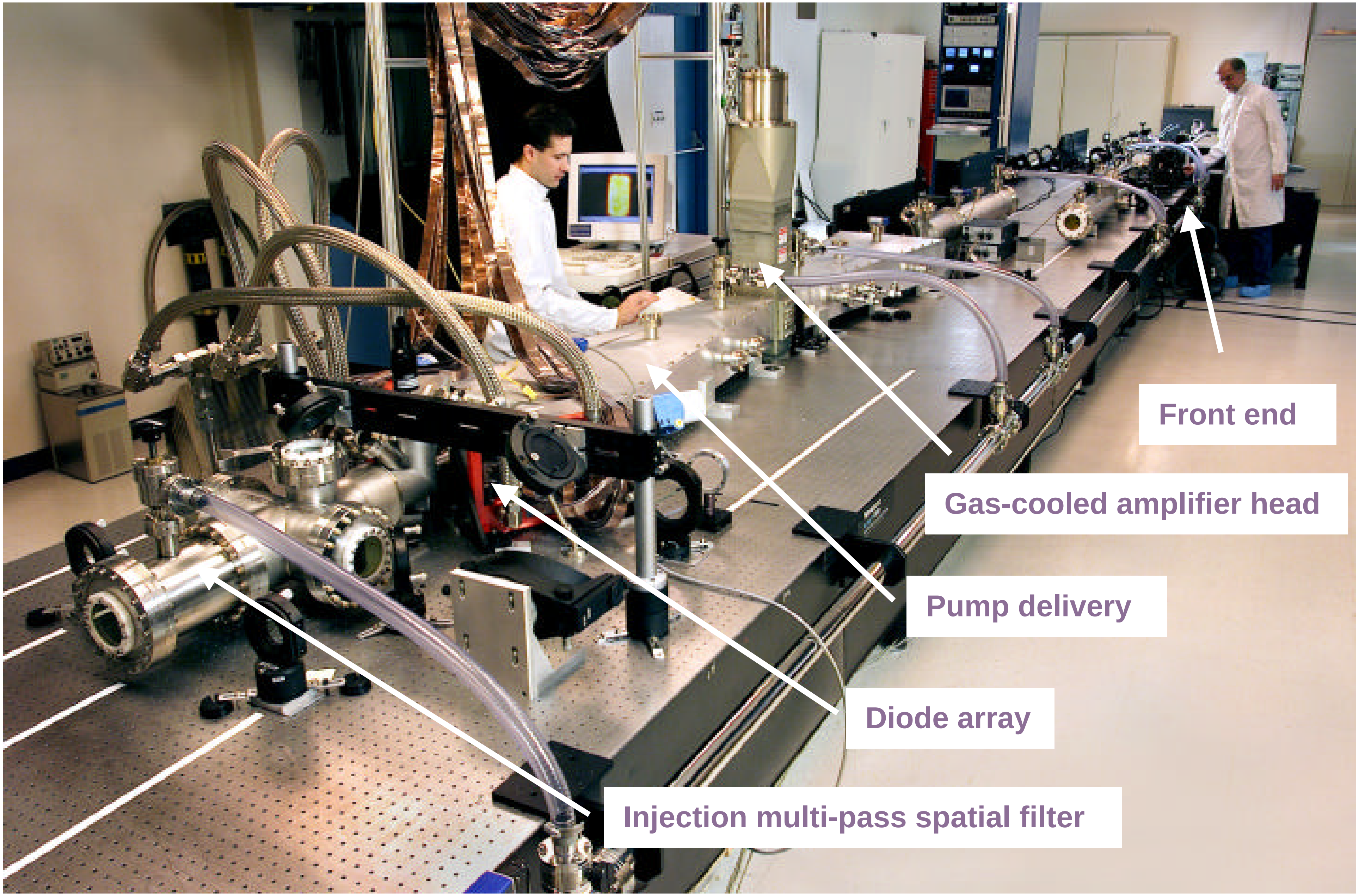
- **Build two pump delivery systems**
- **Fabricate Yb:S-FAP crystals**
- **Design and build wedged amplifier head**
- **Build injection and reverser hardware**
- **Perform integrated tests and code benchmarking**
- **Explore advanced Yb:S-FAP growth**

We are planning to deliver 320 kW of diode peak power to the gas cooled amplifier head and conduct extraction experiments by the end of the year

The full system activation will occur in stages



We are conducting experiments in the Mercury laser



Objective 1: Build two pump delivery systems

Diode tiles
on backplanes

beam

The V-BASiS package requires precision layered metallic coatings

After assembly tile is "burned-in"

V-Contacts
Top: Au
Bottom: In

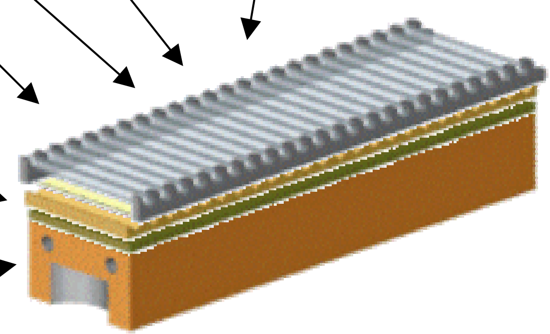
Microlenses
AR coated

Diodes

Etched silicon v-groove substrate
Top: Ti/Ag/Ni/Au
Bottom: Ti/Ni/Au

Indium
reflow & dep

Aluminum Nitride electrical isolation
Top: Ti/Ni/Au/In
Bottom: Ti/Ni/Au

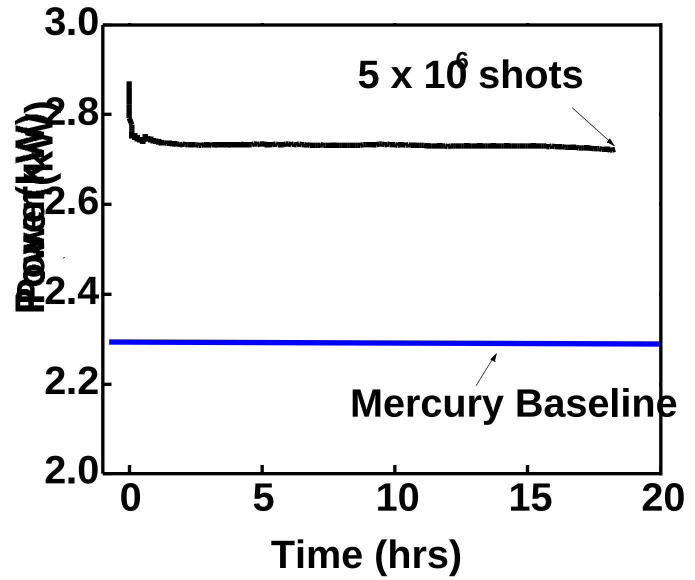


Molybdenum Support Block
Top: Ti/Ni/Au/In

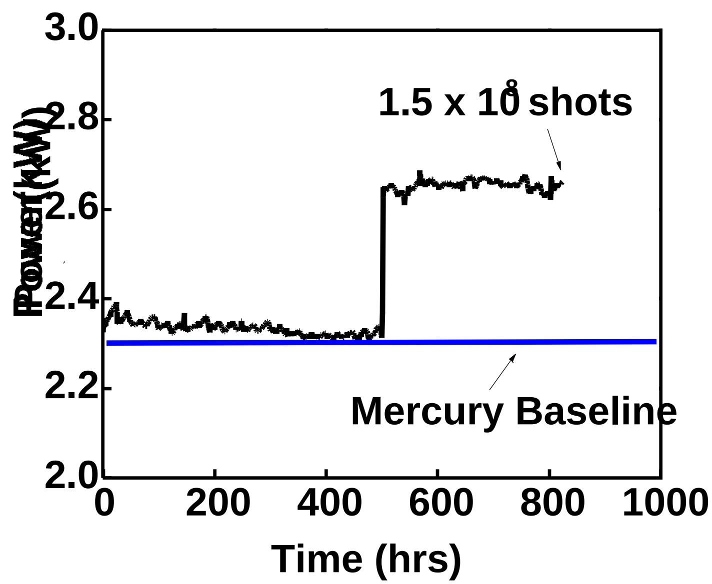
Tiles are operated (burned-in) at ~20% above nominal operating powers for 10^6 shots before assembling in the Mercury system

Burn-in fixturing

Burn-in data

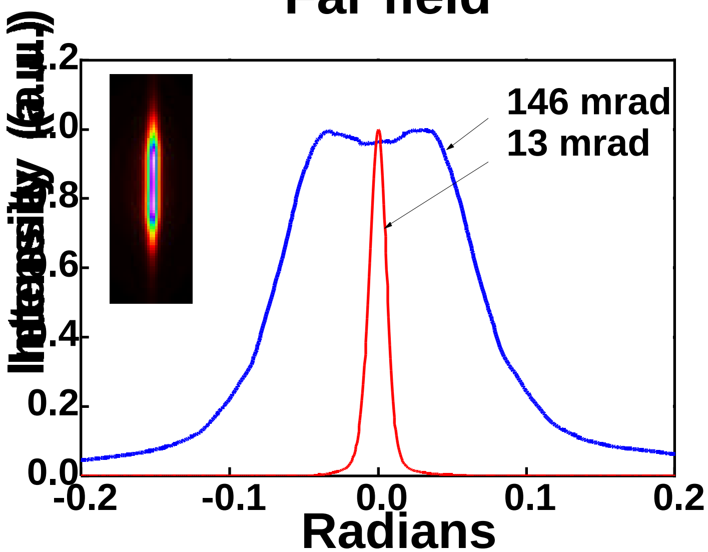


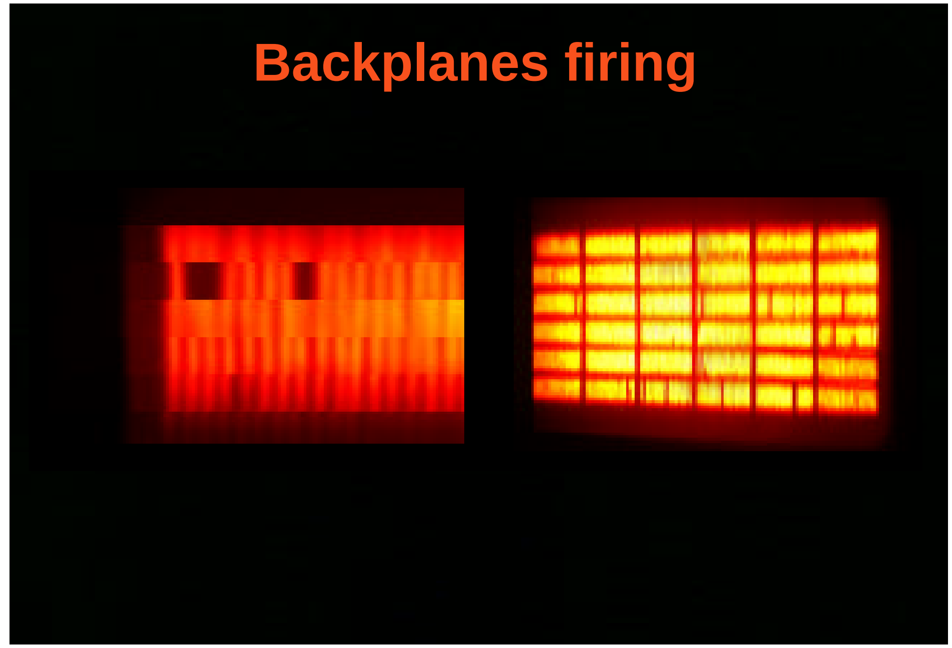
Lifetime data



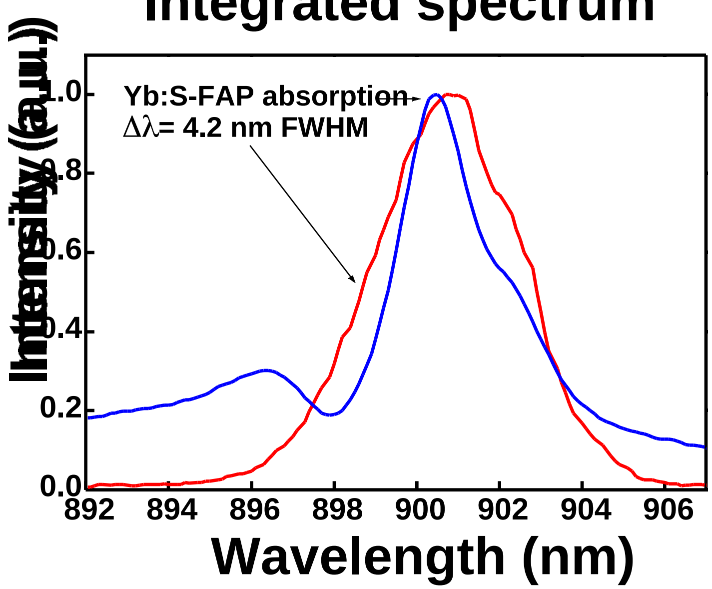
Four 80 kW diode backplanes have been built

Far field

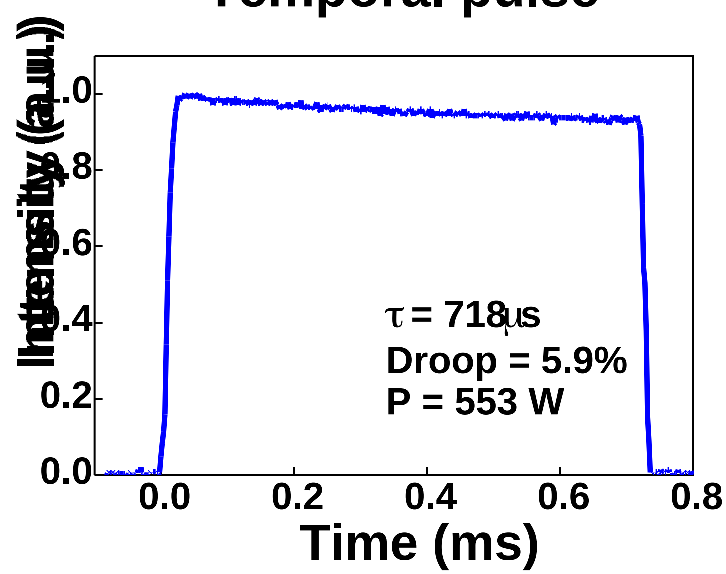




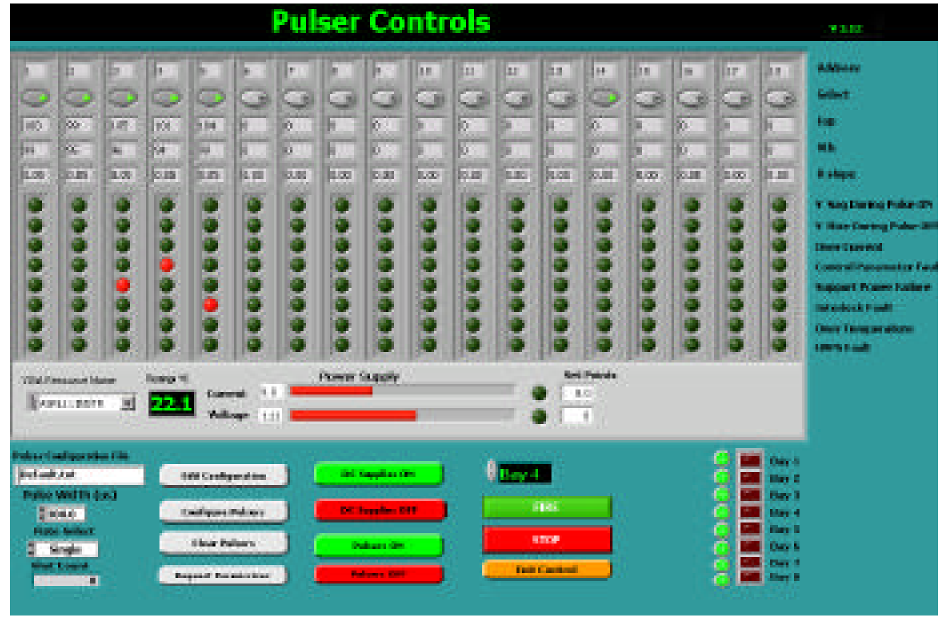
Integrated spectrum



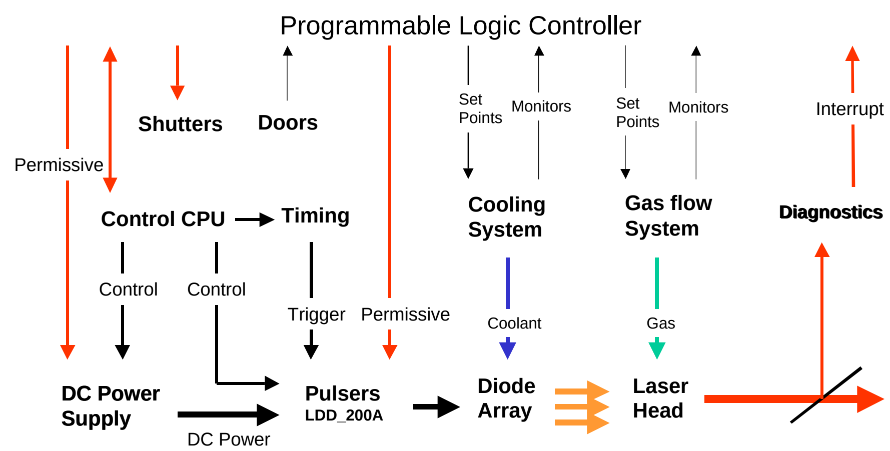
Temporal pulse



The Control System has been upgraded to include real-time error flagging

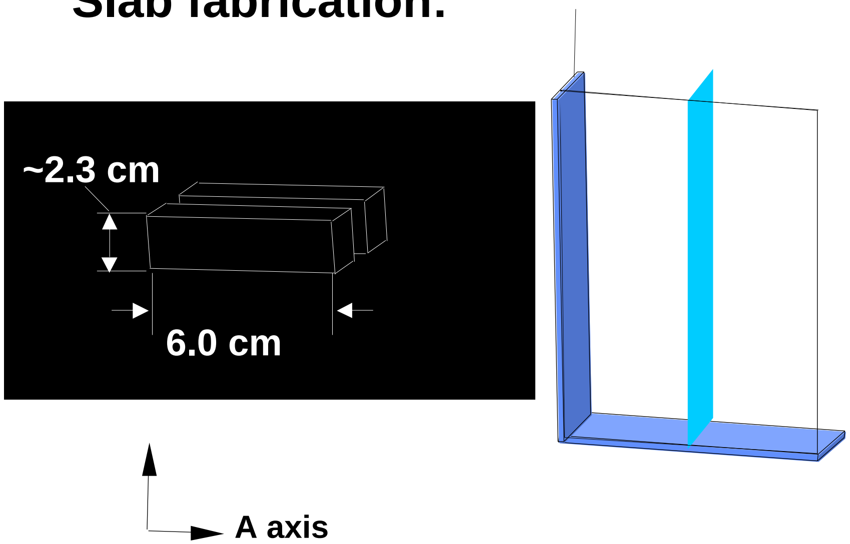


Controls – Hardware Diagram



Objective 2: Fabricate Yb:S-FAP crystals

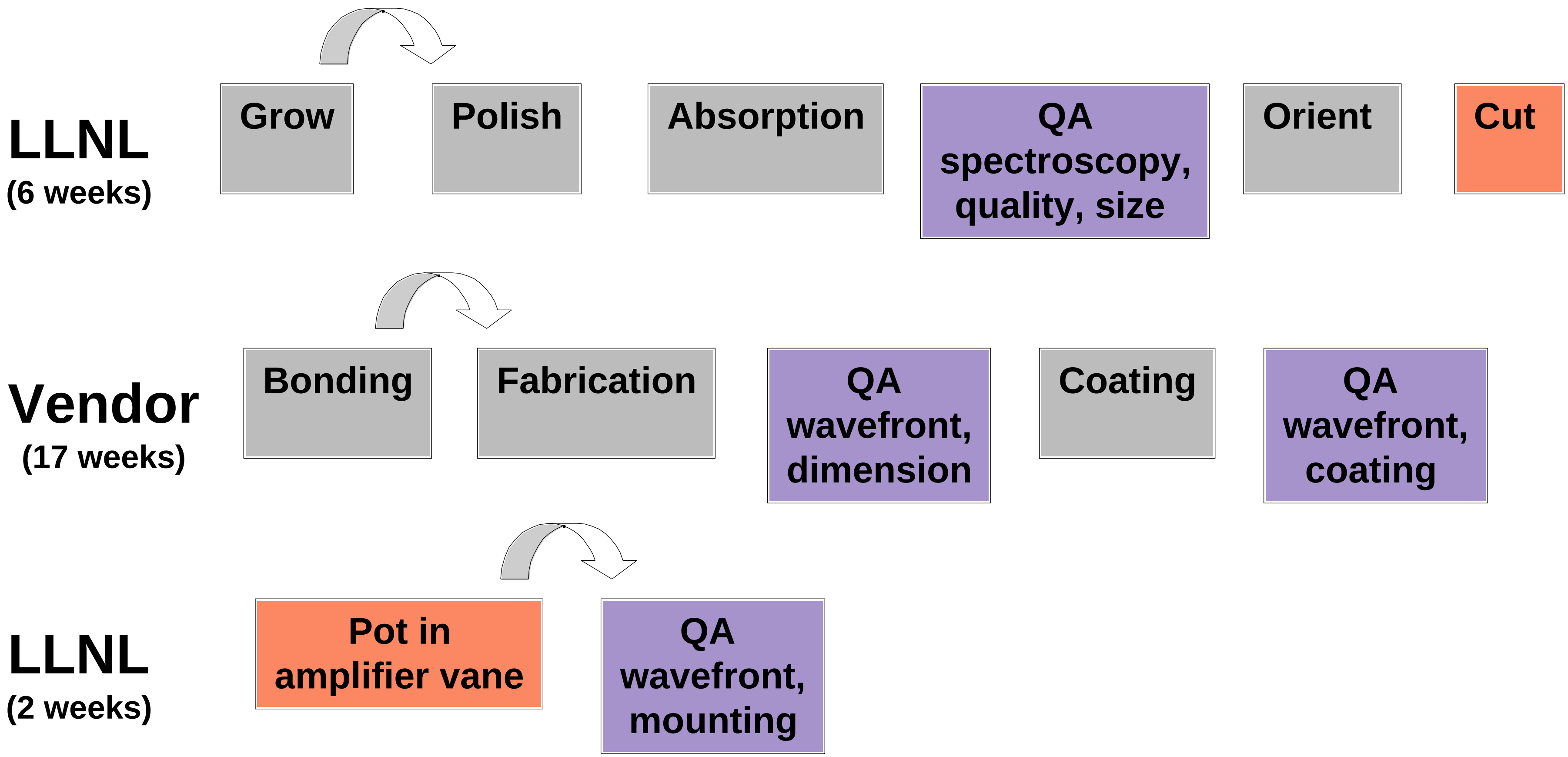
Slab fabrication:



Status

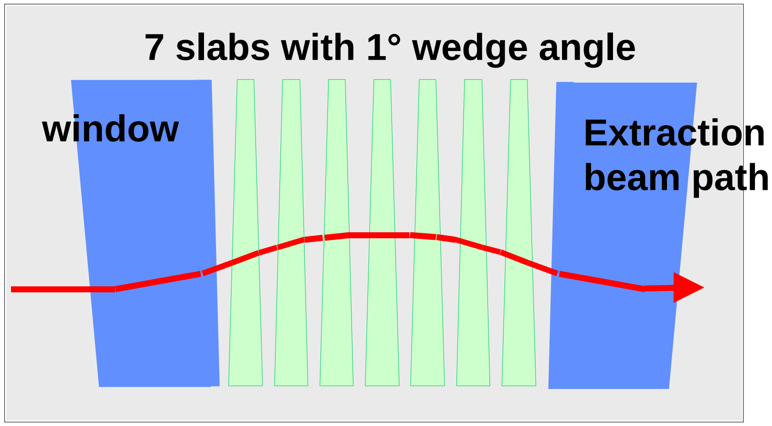
- Four 4x6 cm slabs were diffusion bonded and are being finished (3 LLNL, 1 Northrup)

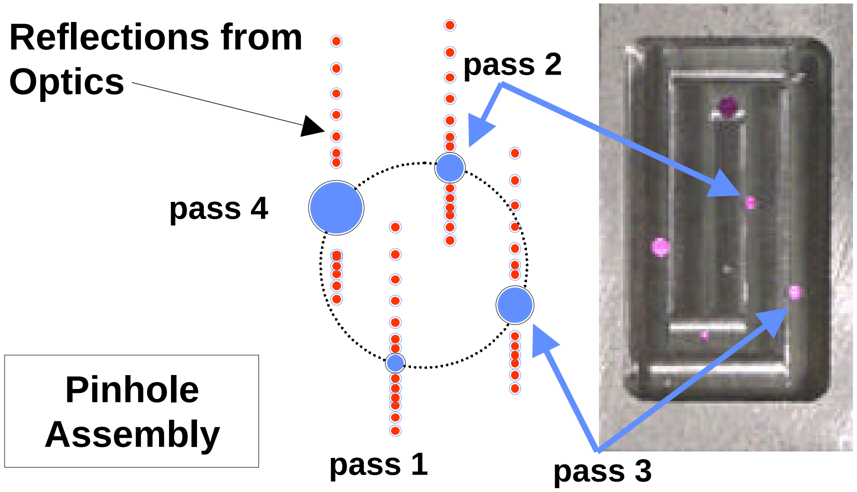
We incorporate QA at several points during the fabrication process

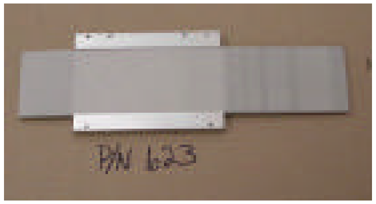


Objective 3: Design and build wedged amplifier head

Schematic:

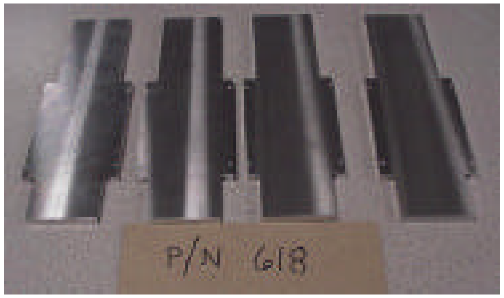




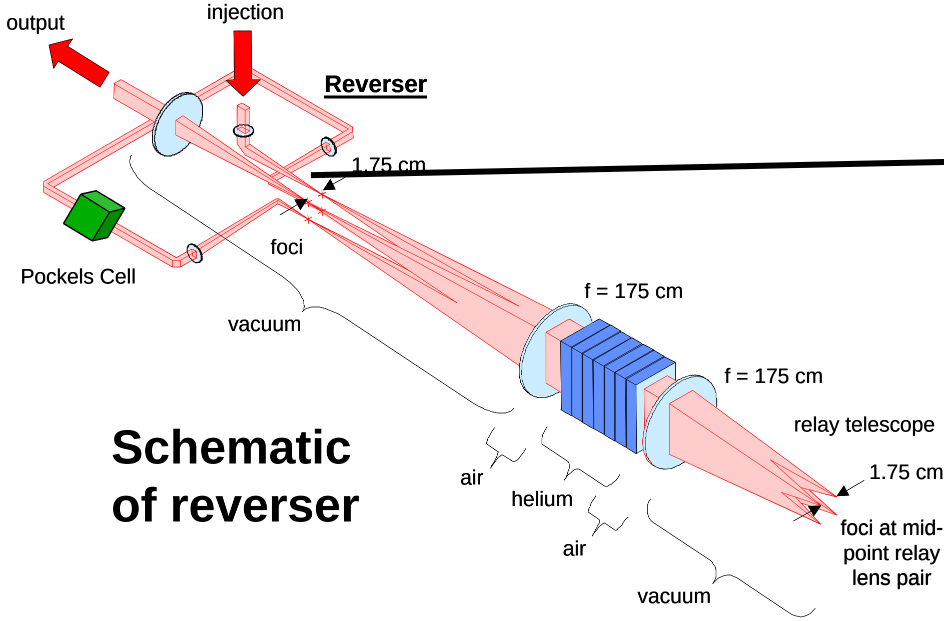


Status

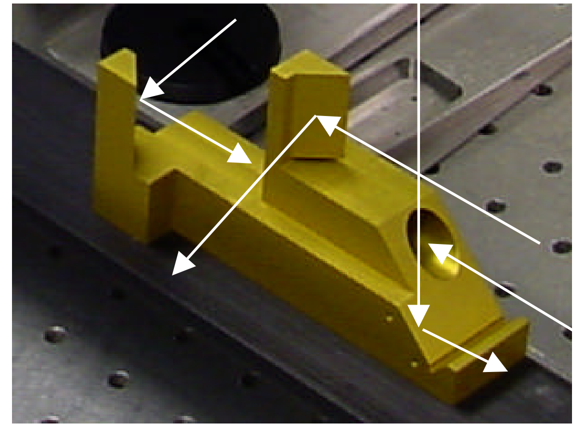
- Solid vanes will start arriving on 11/9
  - vibration tests will validate design
- Vanes with holes for slabs will arrive in December

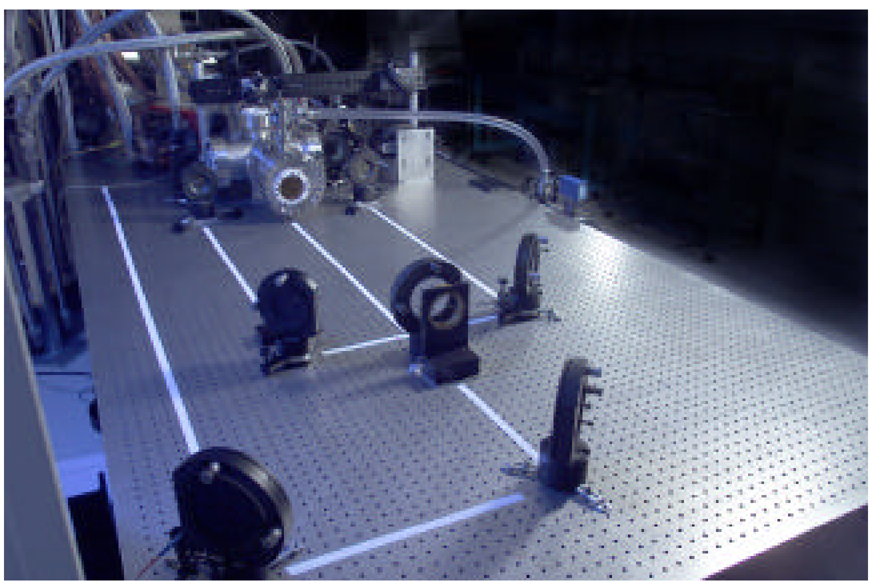


Objective 4: Build reverser and injection hardware



Schematic of reverser





Status

- Injection and reverser hardware installed

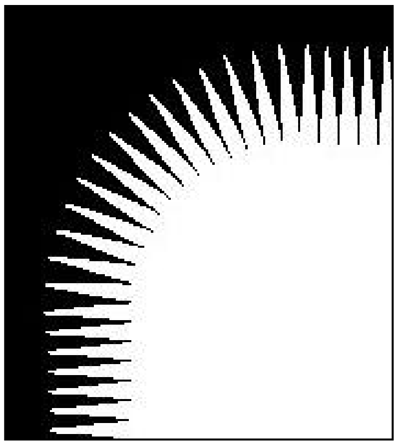
- Vacuum transport telescopes collimated
  - 4 pinhole plate installed

  Front end fully assembled
  - YLF oscillator, two preamps, pc installed
  - serrated aperture installed
  - collimation established

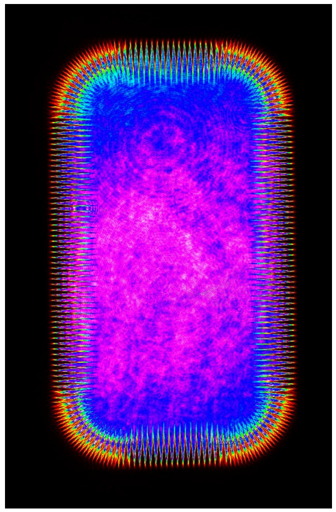
- Half aperture Pockels cell tested and driver built
  - 1.5 x 2.5 cm^2 (< 0.5% depolarization)
  - Full aperture design specified

We have four-passed the beam through the system using the reverser

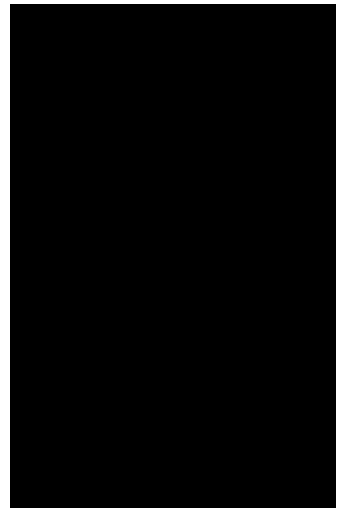
Serrated aperture



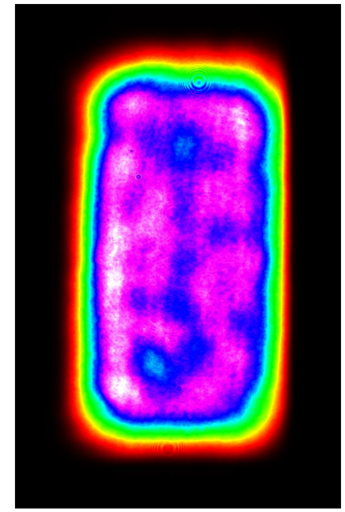
Pass 0

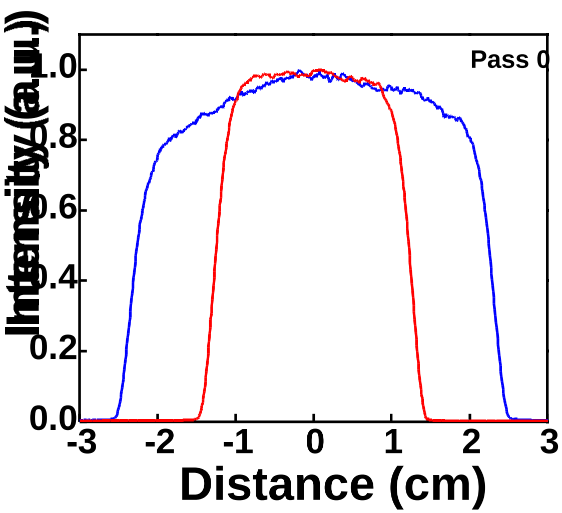


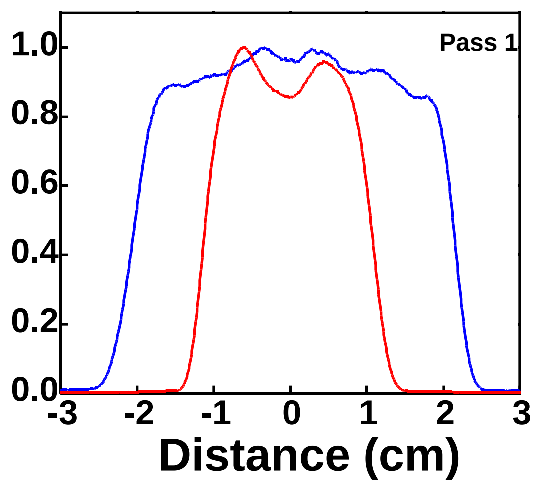
Pass 1

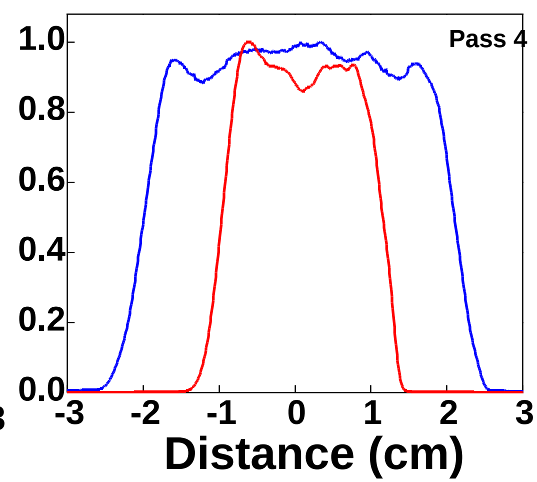


Pass 4

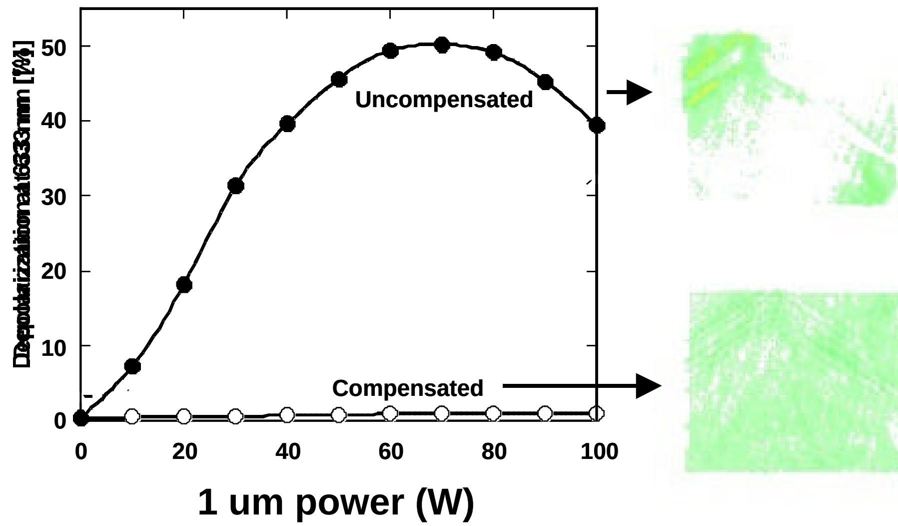


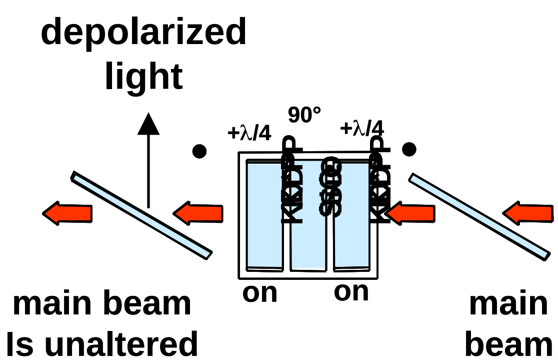


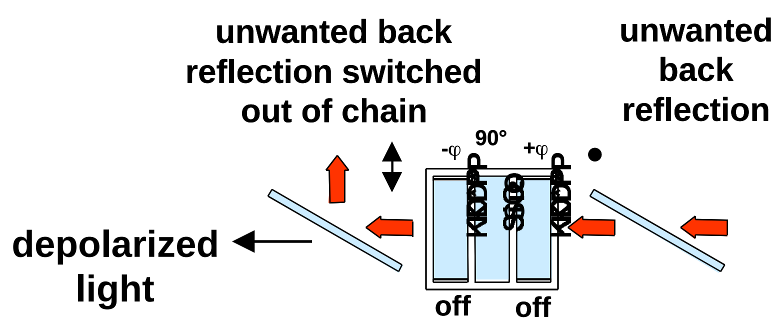




A half aperture (1.5 x 2.5 cm^2) Pockels cell with high average power capability was tested and shown to have depolarization of < 0.5% at 1.047 nm



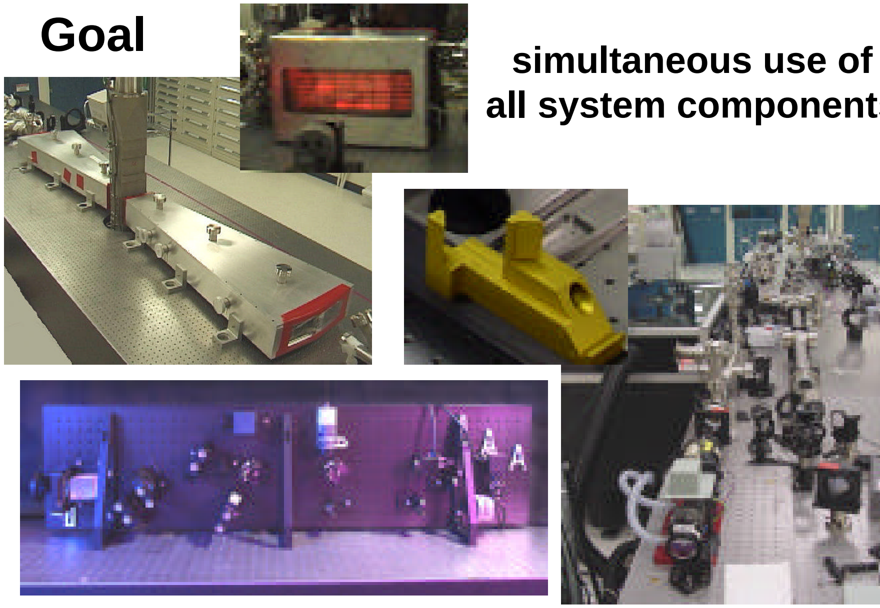




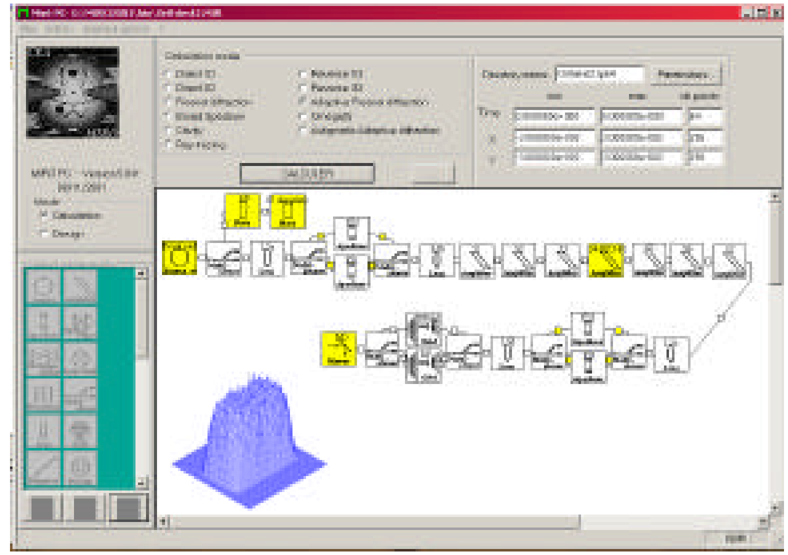
Objective 5: Integrated tests and benchmarking

Goal

simultaneous use of all system components



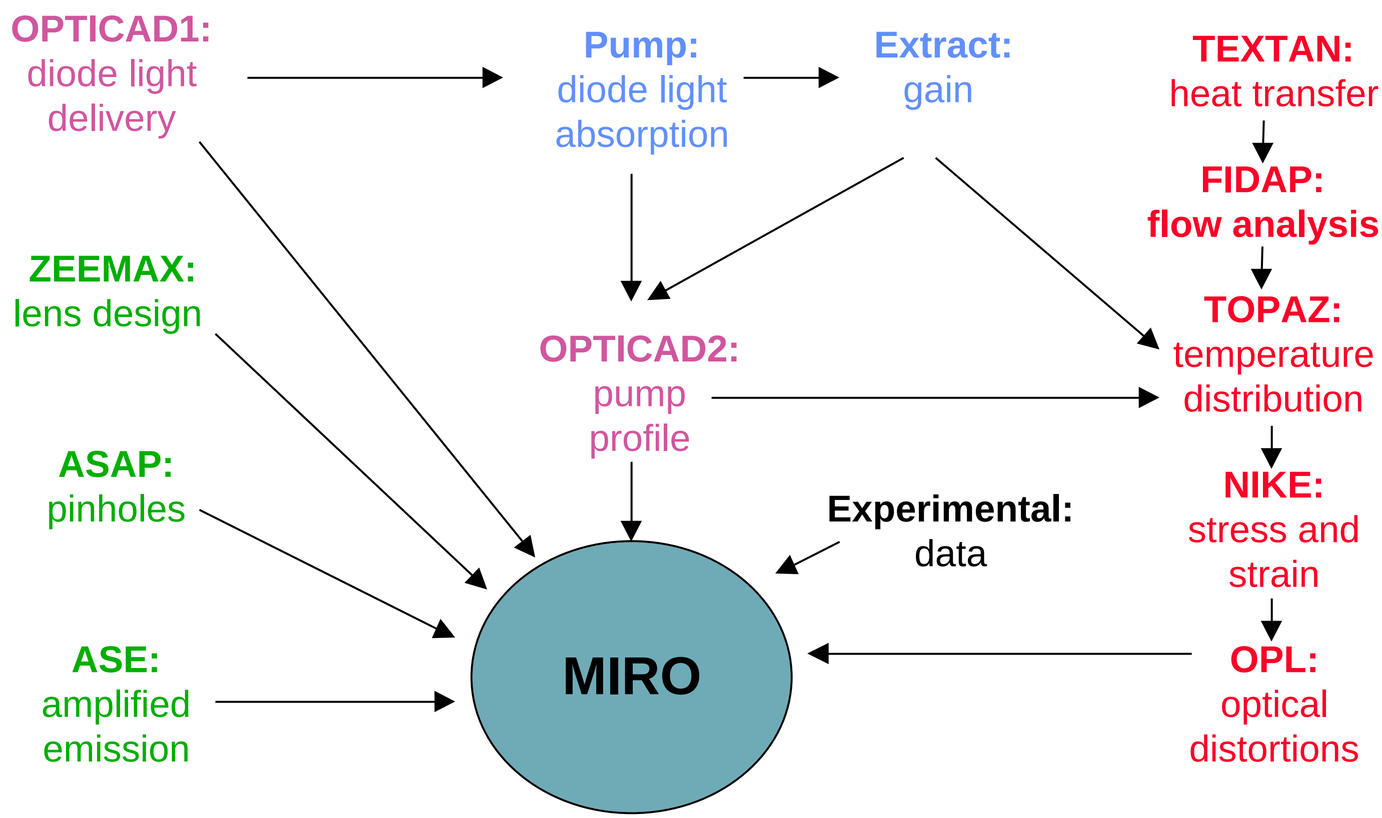
Mercury layout with MIRO propagation code



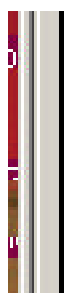
Status

- Beam was successfully 4-passed through system
- Several measurements with glass performed
  - imaging
  - pointing stability
  - gain
- Four diagnostics packages built
  - 3 activated
- MIRO propagation code written to model full and half Mercury

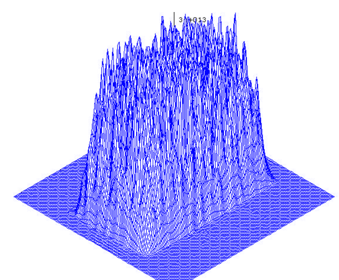
MIRO is used to predict energy, wavefront B-integral, etc



τ = 5 ns



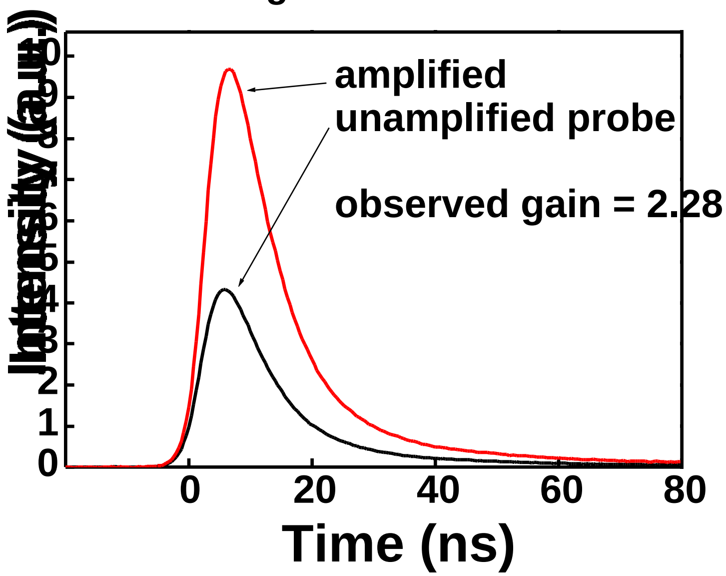
τ = 1 ns



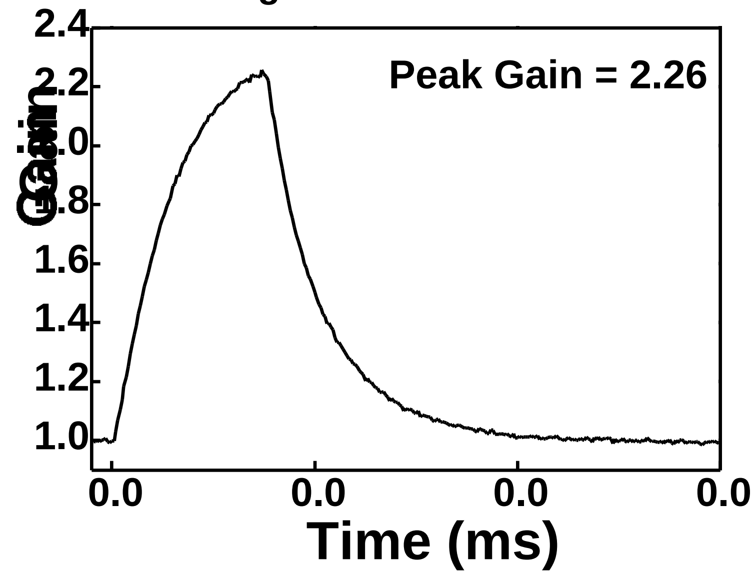
τ = 0.5 ns

Four-pass gain measurements were performed with Nd:glass slabs as surrogate amplifier material

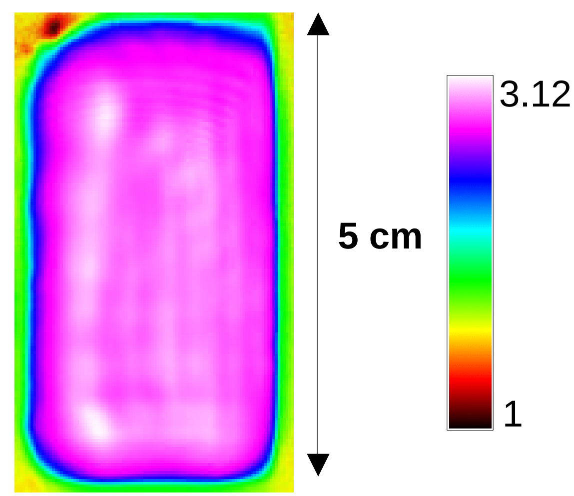
Pulsed gain measurements



CW gain measurements

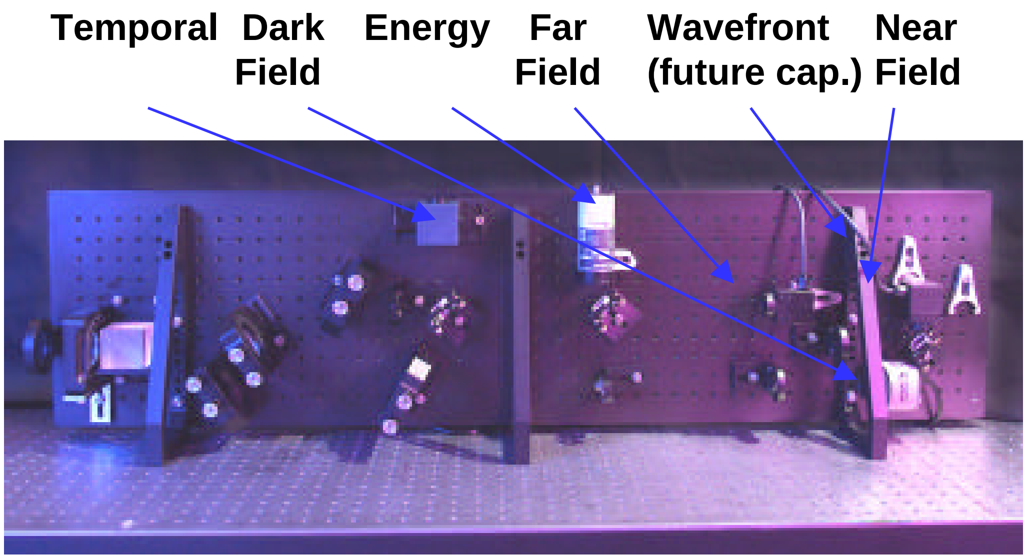


Spatially resolved gain profile where total gain = 2.36 in 3x5 cm area

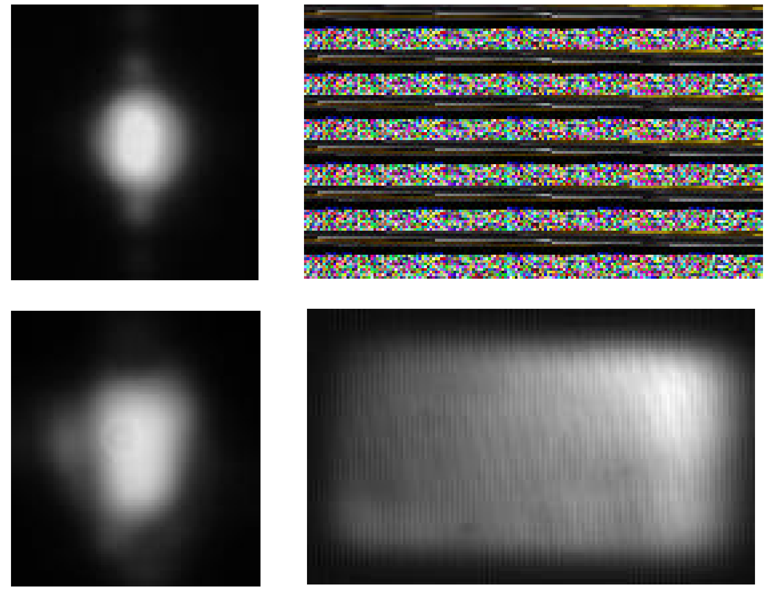


The theoretically expected gain is 2.8

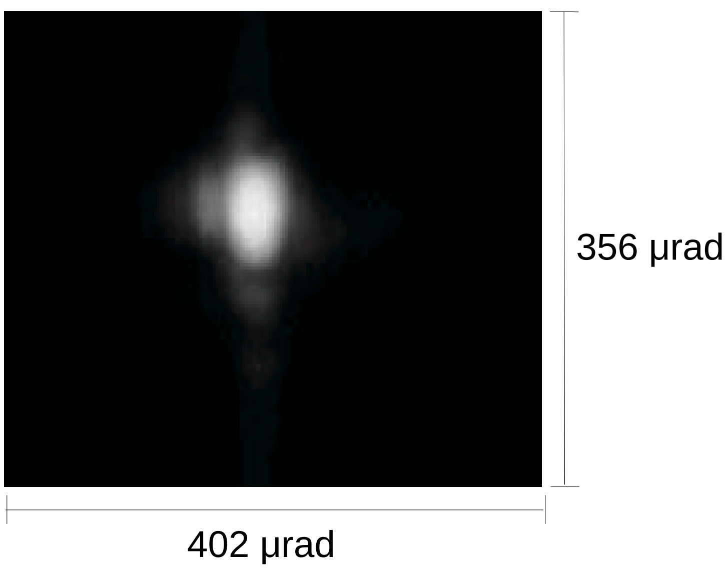
Four diagnostic stations have been built



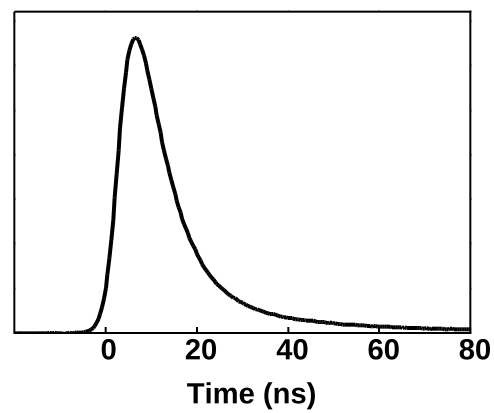
Far field **Near field**



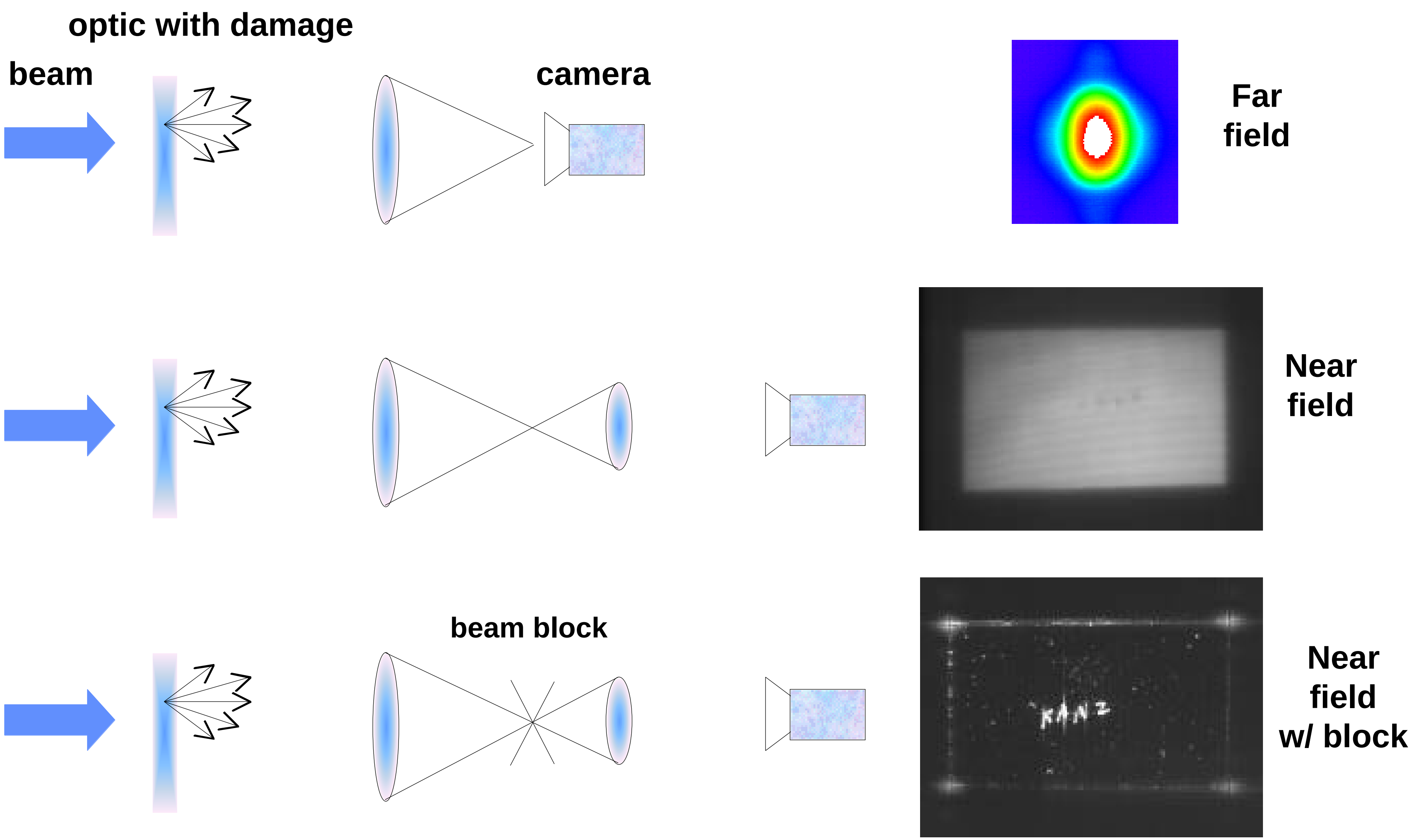
Pointing stability < 34 µrad



Temporal

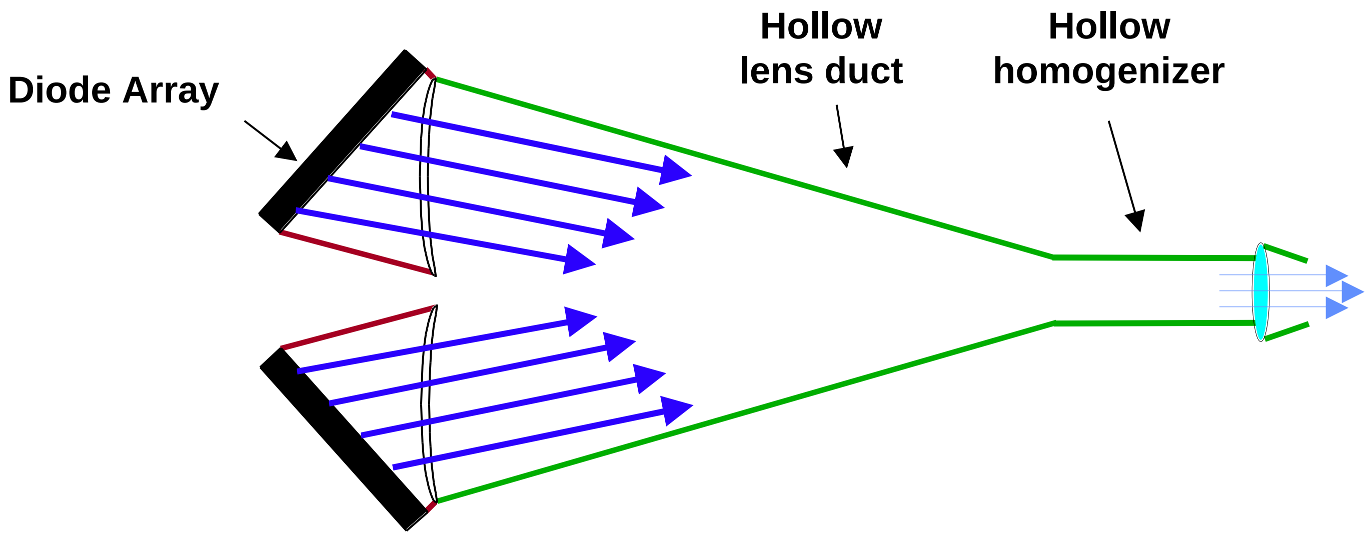


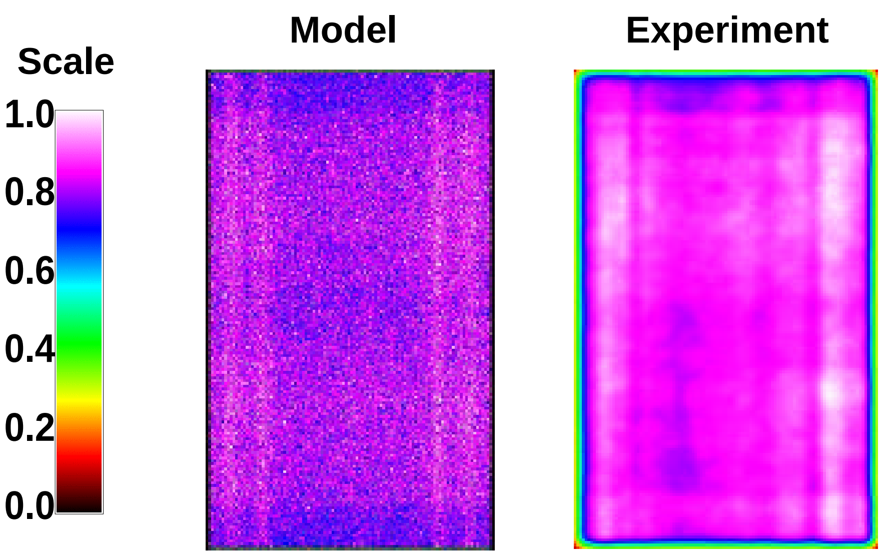
We are using a dark field image to track the onset of damage

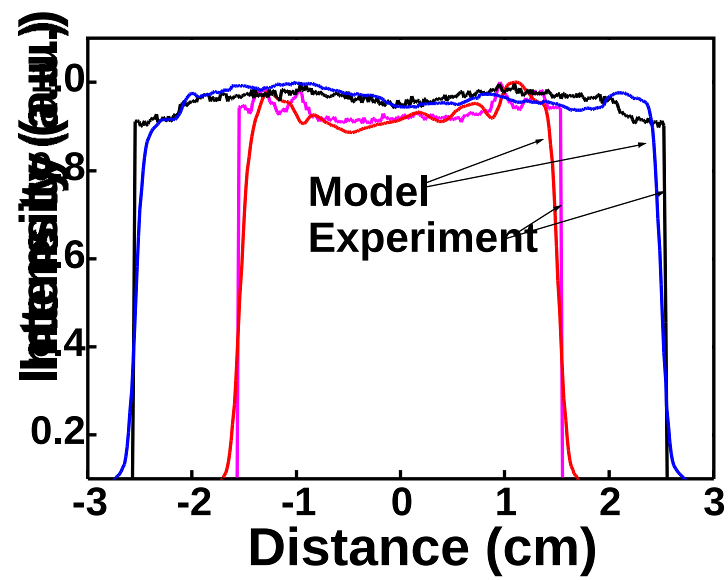


“Dark field" image

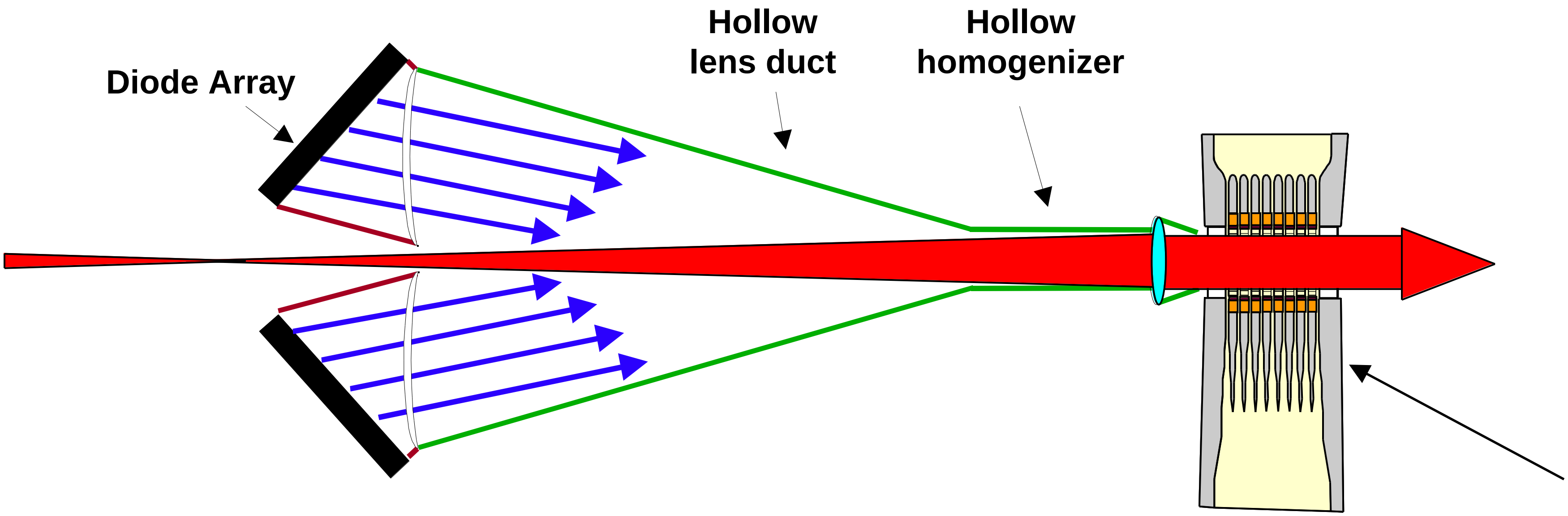
Ray trace code is used to design pump delivery system



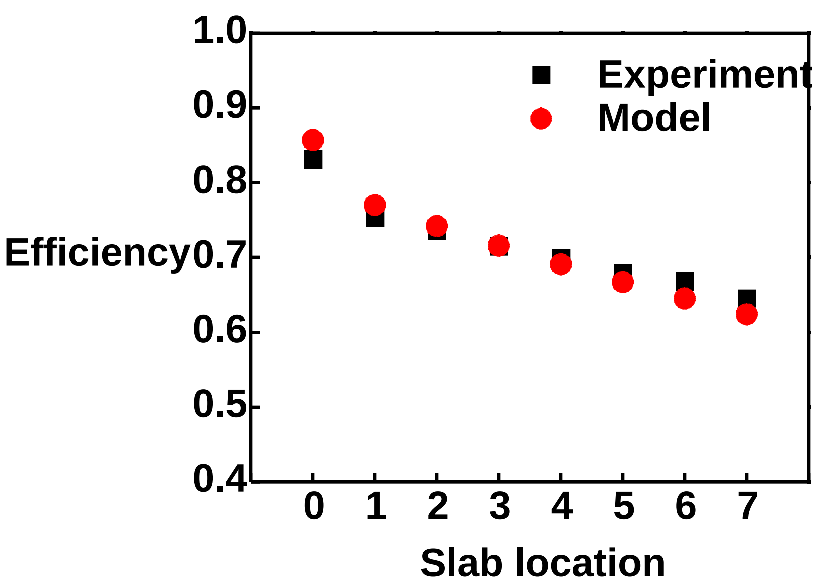


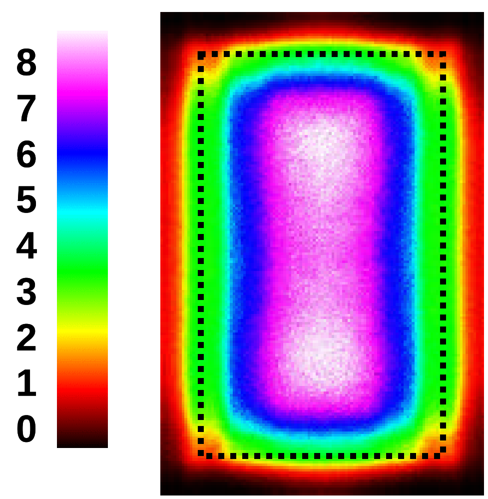


Pump light distribution at output agrees with model



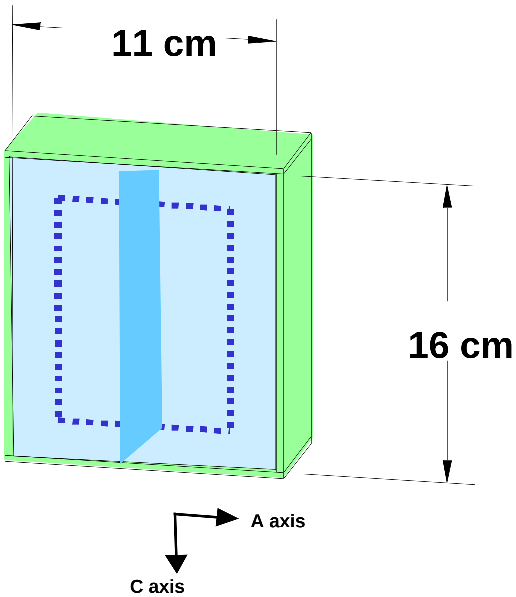
Modeled gain profile



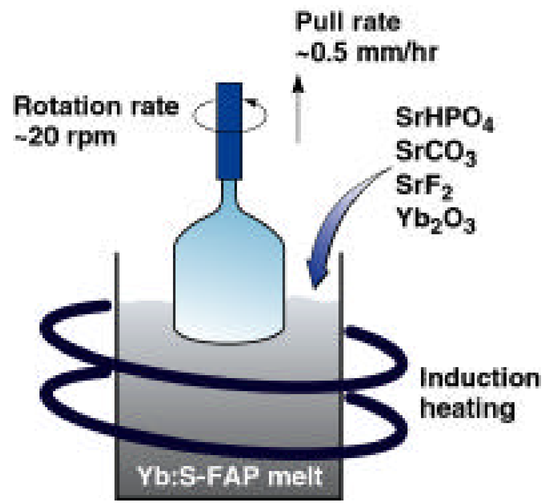


Objective 6: Advanced S-FAP growth

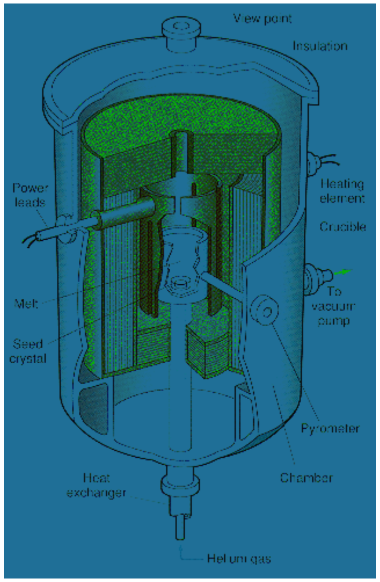
Goal

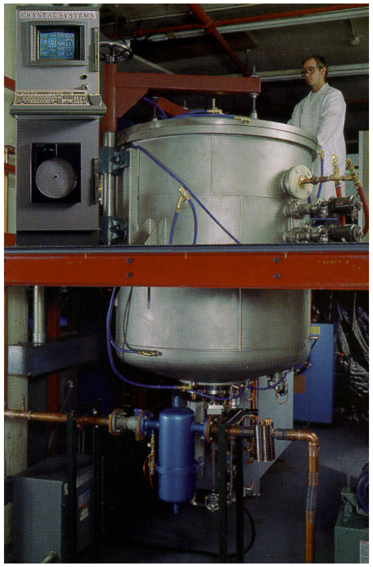


Czochralski: LLNL/Northrup



HEM: Crystal Systems

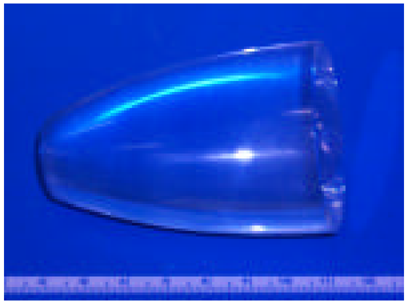




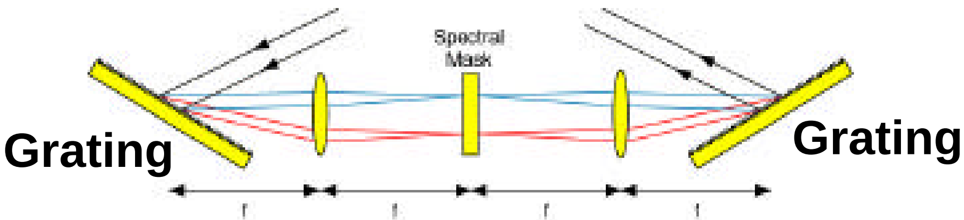
Status

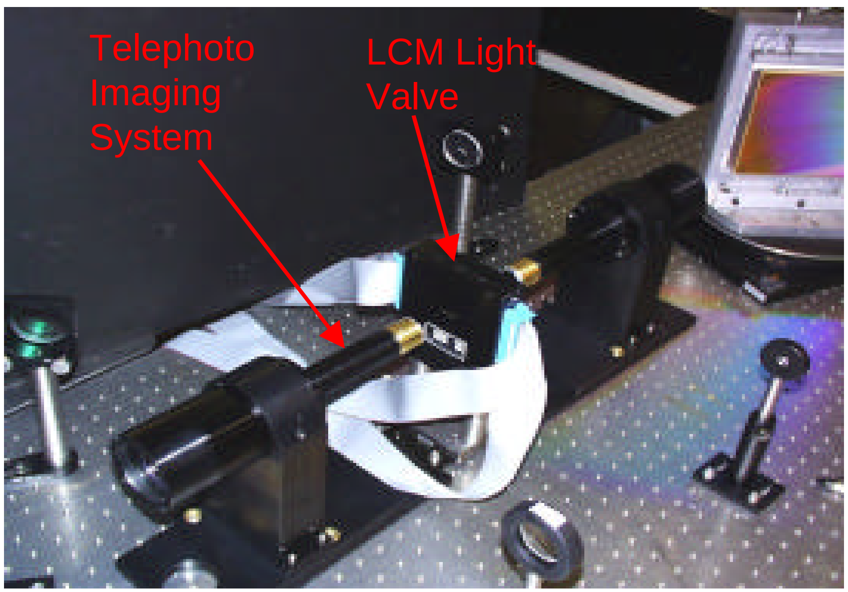
- Feasibility study with HEM
  - 11 crystal growth experiments
  - 2 cm cube crystals grown, but have brownish color from color centers
  - annealing appears to remove color centers

- LLNL growth yielded a 5 cm diameter boule

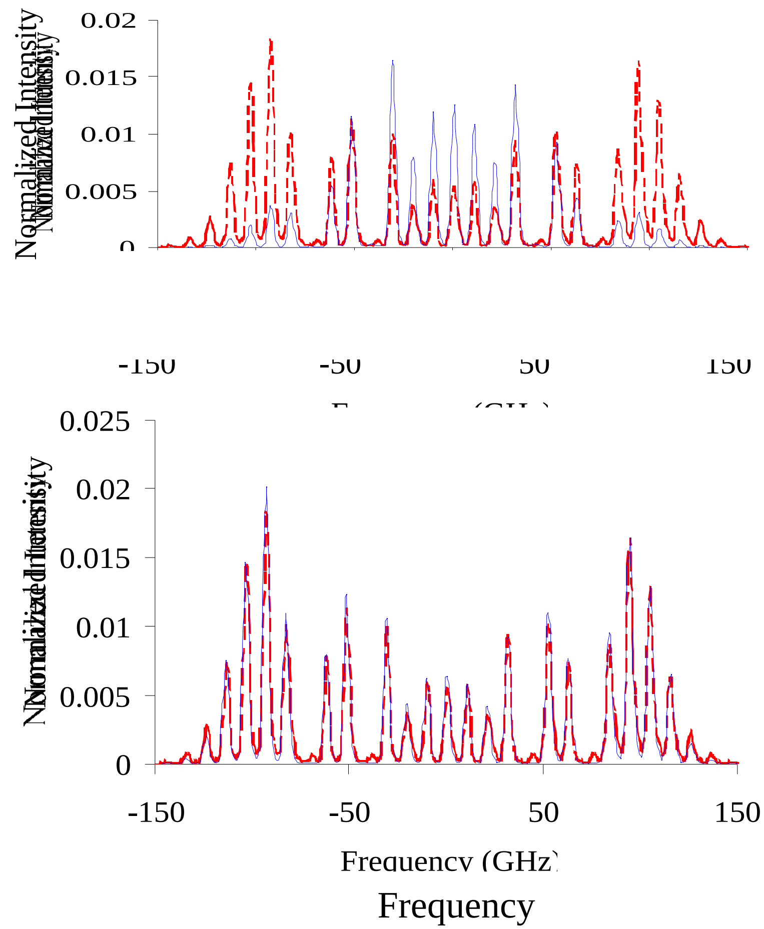


A compact spectral sculptor using a liquid-crystal modulator light valve has been demonstrated





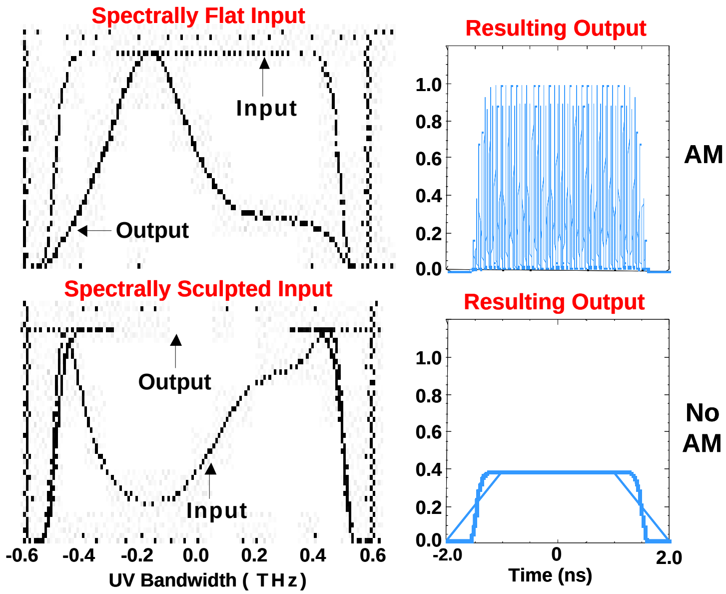
- **Sculptor was achieved with ~ 100:1 dynamic range**

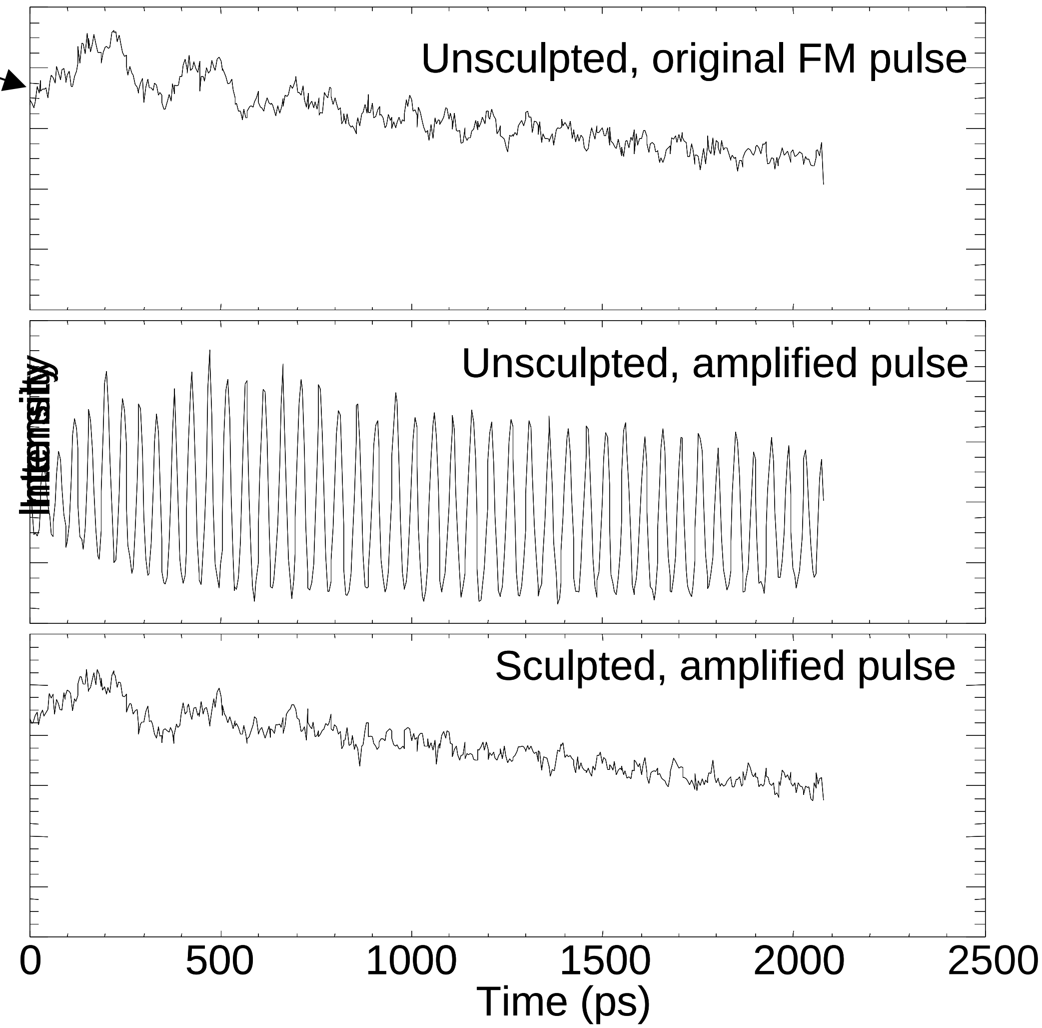


Spectral sculpting has been demonstrated

Experimental Setup

Gain media:	Nd:YLF
Total gain:	9200
YLF bandwidth:	13 Å
FM bandwidth:	8.3 Å





Our goal is to fully activate the system by the end of the 2001 calendar year

Month	1	2	3	4	5	6	7	8	9	10	11	12
1. Build two pump delivery systems					✓ array 1		✓ array 2			✓ array 3		✓ array 4
2. Fabricate Yb:S-FAP crystals (min. 1, goal of 7)					✓ bond 1				✓ 2,3,4			✓ fab
3. Design and build wedged amplifier head								✓ design			✓ solid	✓ hollow
4. Build injection and reverser hardware											✓	
5. Integrated tests and code benchmarking											✓	
6. Advanced crystal growth										✓		
7. Spectral sculpting (University of Rochester)										✓		

We are planning for first light in mid 2002

- Build remaining two pump delivery systems (3 & 4)
- Install 7 Yb:S-FAP crystals in amplifier and grow 7 more for 2nd amplifier
- Build and install second amplifier head and utilities
- Build full aperture Pockel cell and install in reverser
- Perform experiments with one amplifier fully populated with Yb:S-FAP crystals
- Continue advanced Yb:S-FAP growth
- Install spectral sculptor in front end and
  develop code for average-power frequency conversion