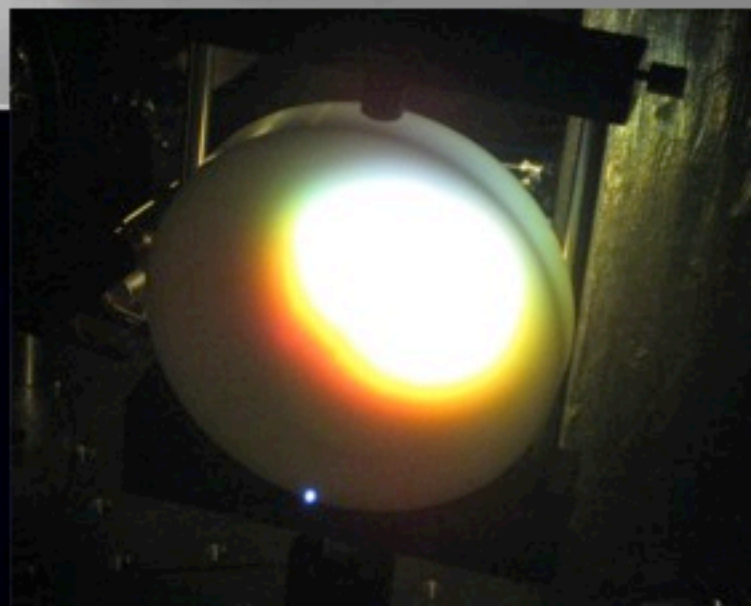
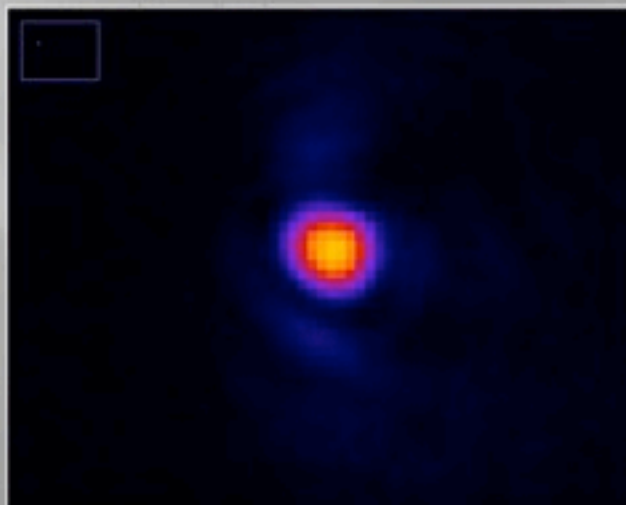




DEVELOPMENT OF PETAWATT CLASS LASER EXPERIMENTAL SYSTEM

Petawatt external review

Enam Chowdhury





Outline

- ◆ Goal
- ◆ Facility Layout
- ◆ People
- ◆ System Architecture
- ◆ Laser System Schematics
- ◆ Path to Upgrade
- ◆ Laser Diagnostics

Goal

▣ Laser

- 1 shot/min, 800 nm, 10+J/shot on target
- Pulse duration 30-60 fs
- Focal spot 50% of energy in 10 micron diameter

▣ Laser Diagnostics:

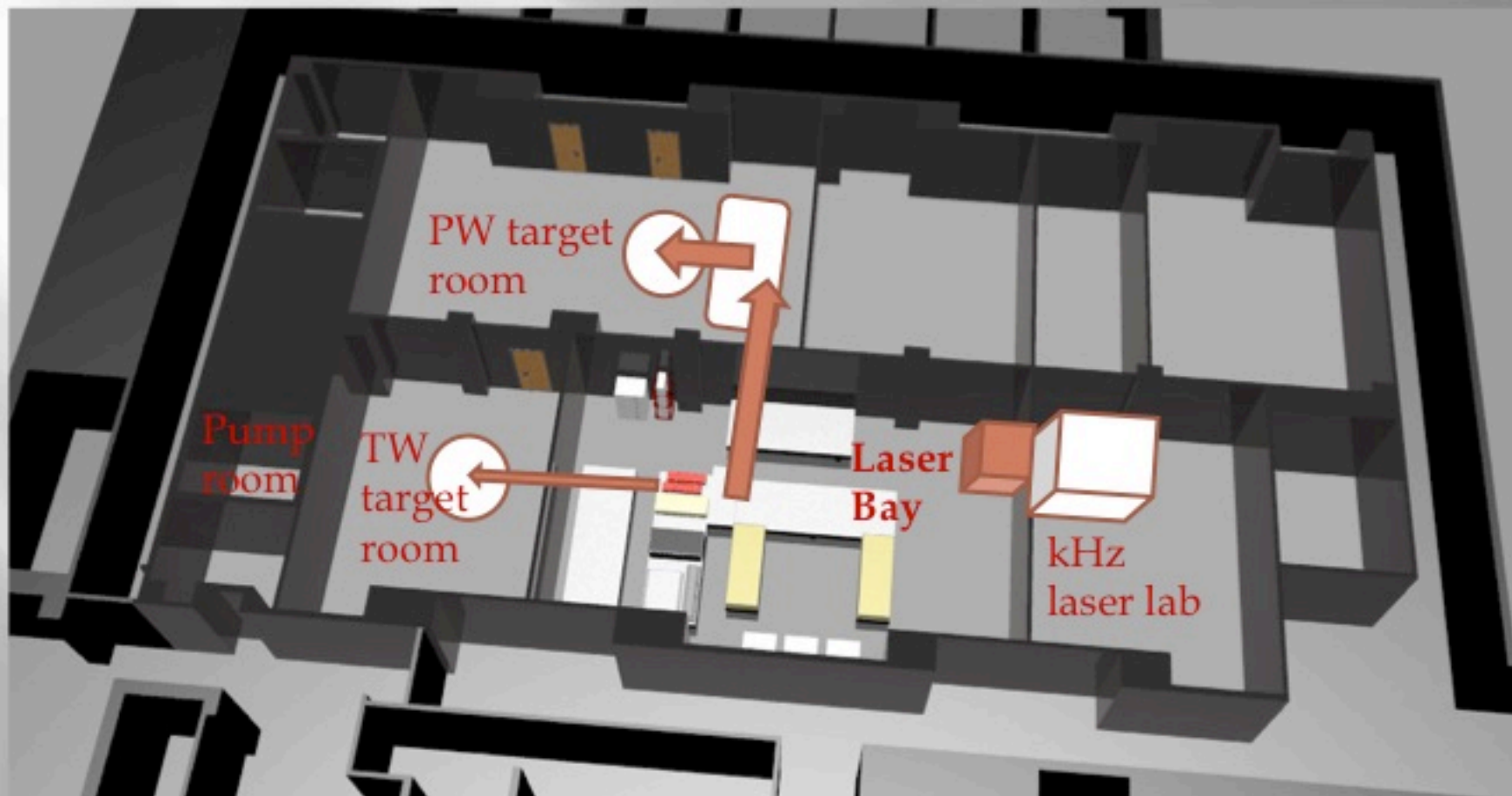
- On shot pulse energy
- On shot pulse spectrum pre and post compressed
- Amplified beam spatial profile
- On shot focal spot diagnostic
- Pulse width measurement
- Pulse contrast measurement

▣ Experiment

- Manipulate, align and shoot simple targets
- HOPG diagnostic

Facility Layout

3,700+ sq. ft. modern Laboratory Space
1600 sq. ft class 1000 clean room space



People

Rick Freeman Group Leader: SCARLET

Jim Krygier Chief of Operations

Enam Chowdhury, PW team Leader

John Marketon, Senior Design Engineer

Rebecca Daskalova, Laser Operations, LSO, Web Master

Grad Students: P. Poole, C. Willis, S. Jiang, D. Wertepny, K. George, S. Feister

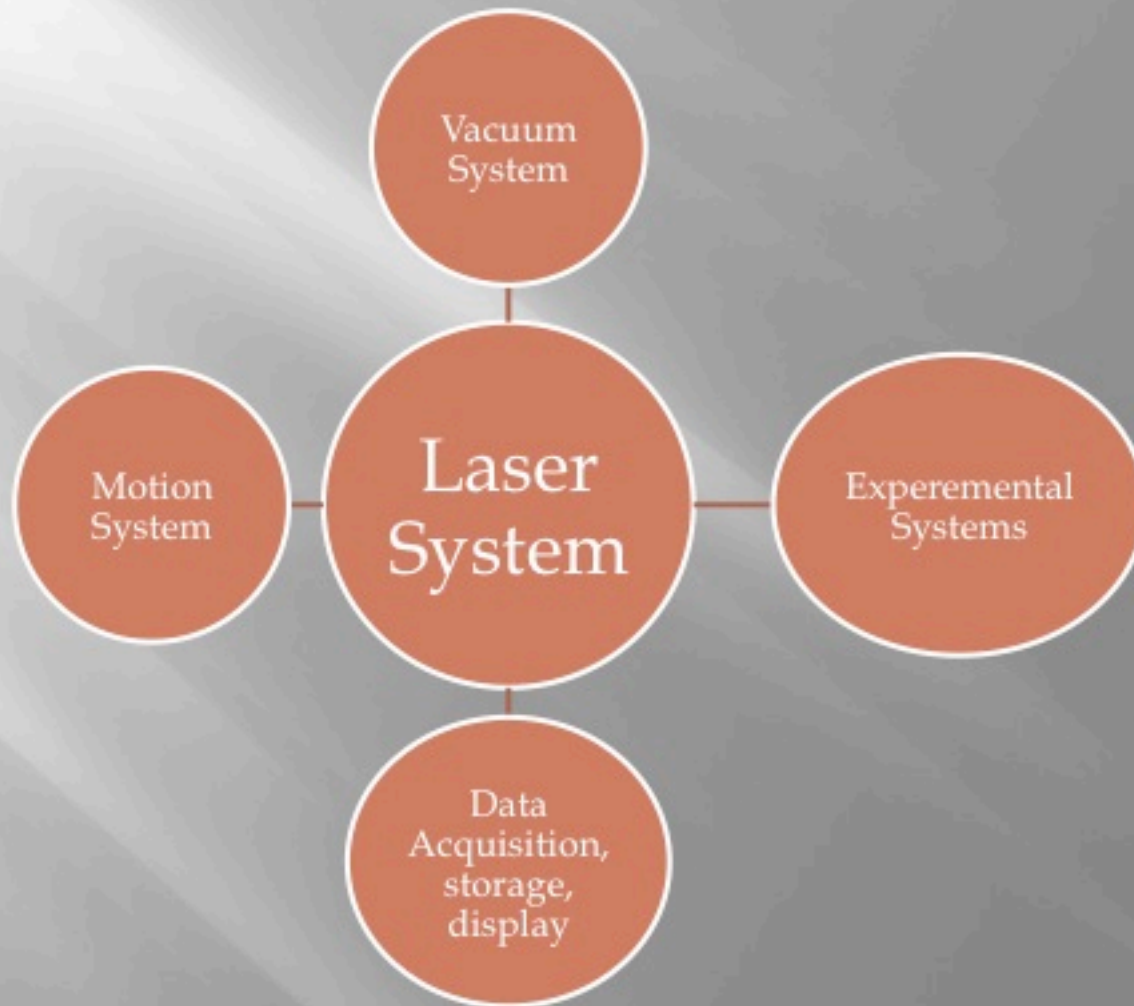
Undergraduates: Aakash Patel, Taryn Kaufman

Experimental:

Kramer Akli, Senior Research Scientist

Mike Storm, Research Scientist

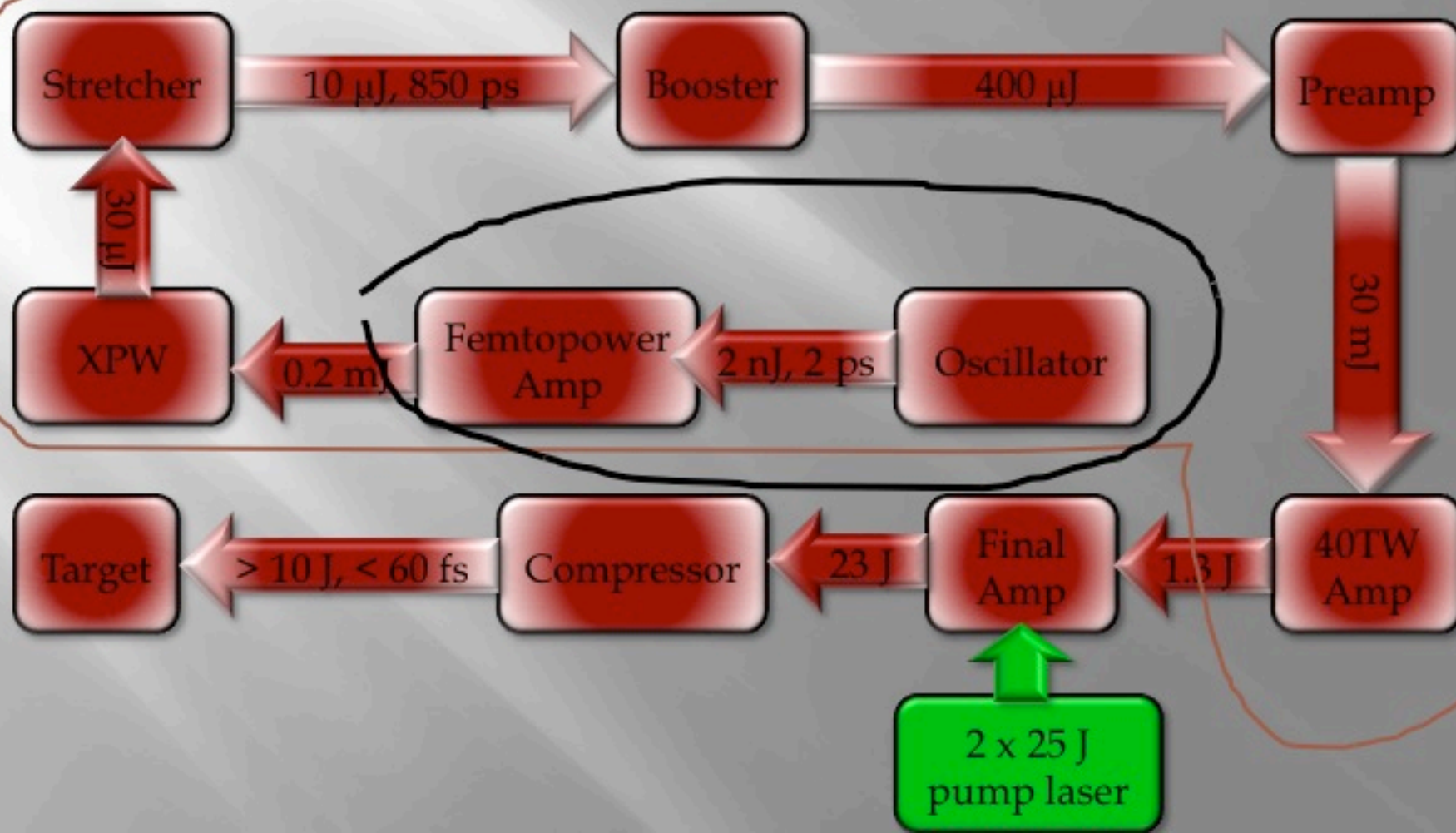
System Architecture





Laser System Schematics

Modified 40 TW system

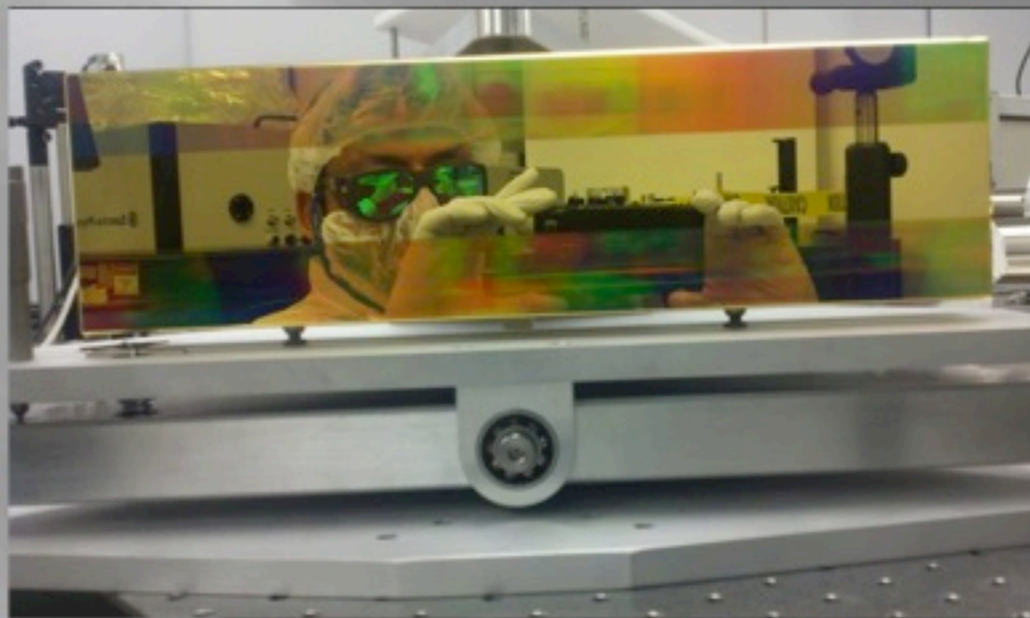
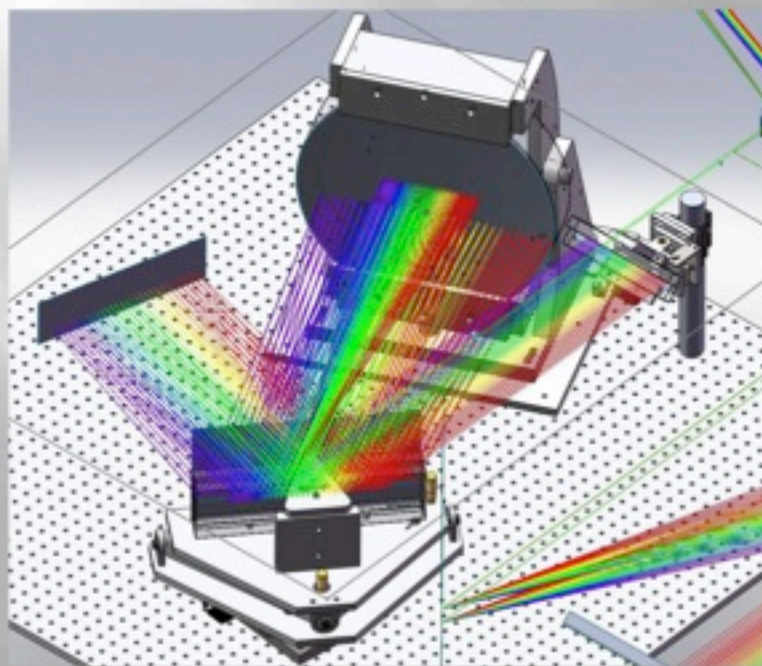


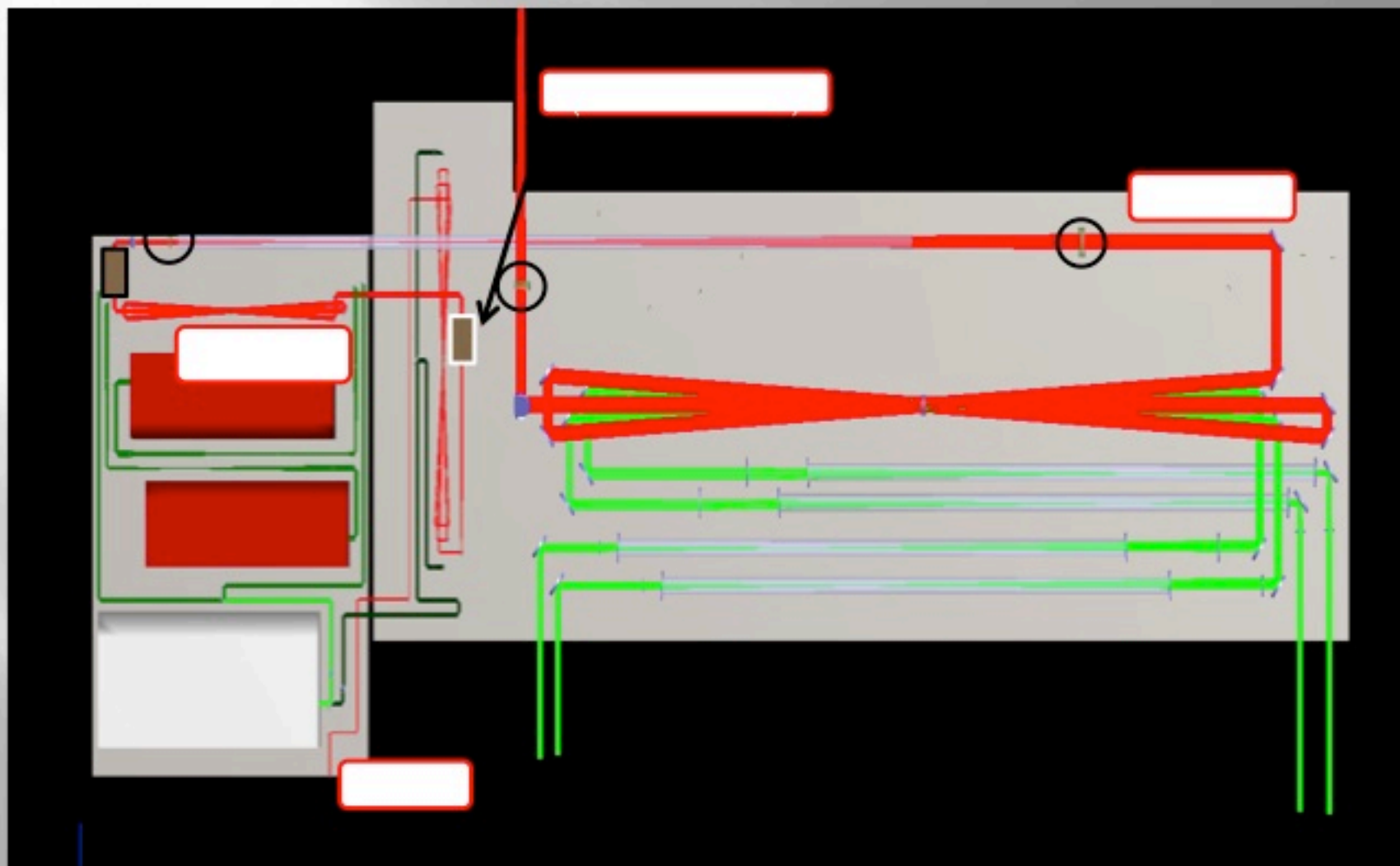
Path to Upgrade



Stretcher Design

- ◆ Pulse stretched to $\sim 850\text{ps}$
- ◆ Large Bandwidth: $730\text{nm} \rightarrow 860\text{nm}$
- ◆ Compact Striped Grating design

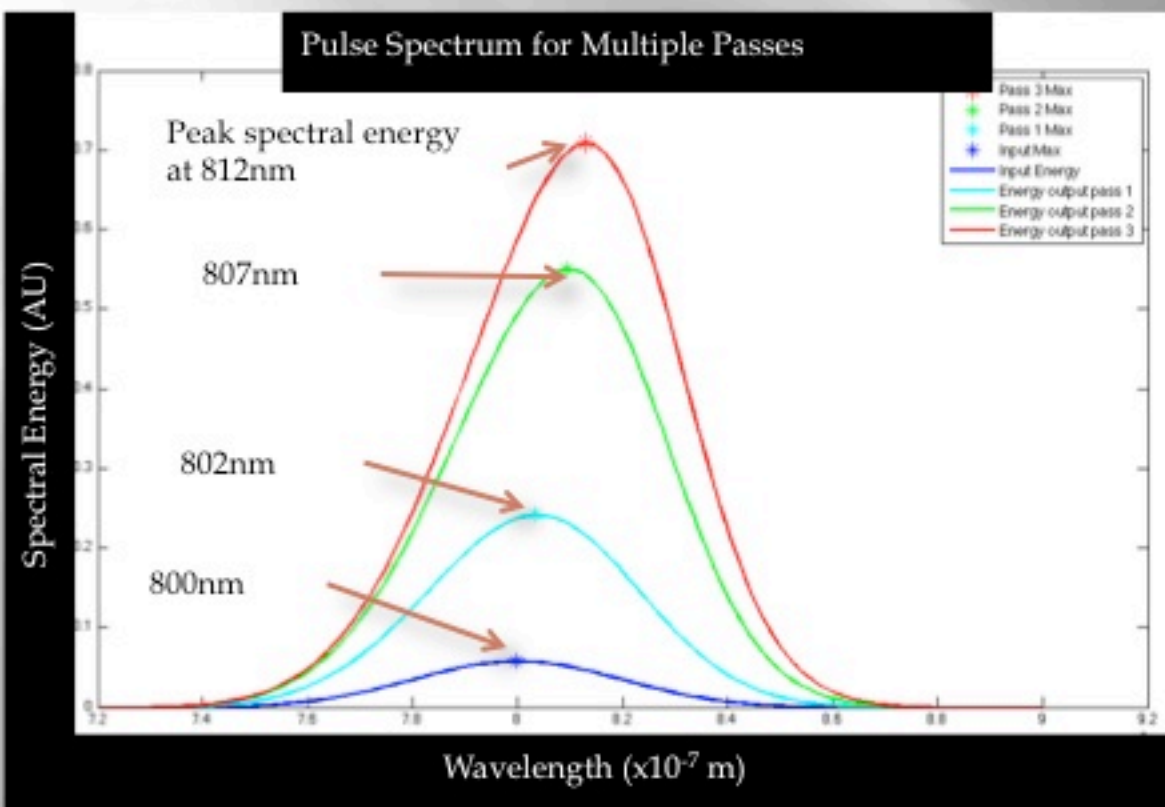






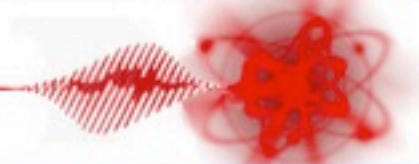
Gain Modeling

- ▣ Assumptions
 - 3 passes
 - 2% loss in pump delivery
 - $\alpha \sim 0.95 \text{ cm}^{-1}$, *non-absorbed pump energy, 3J*
 - Pump efficiency, 95%
 - 5% loss from pass to pass

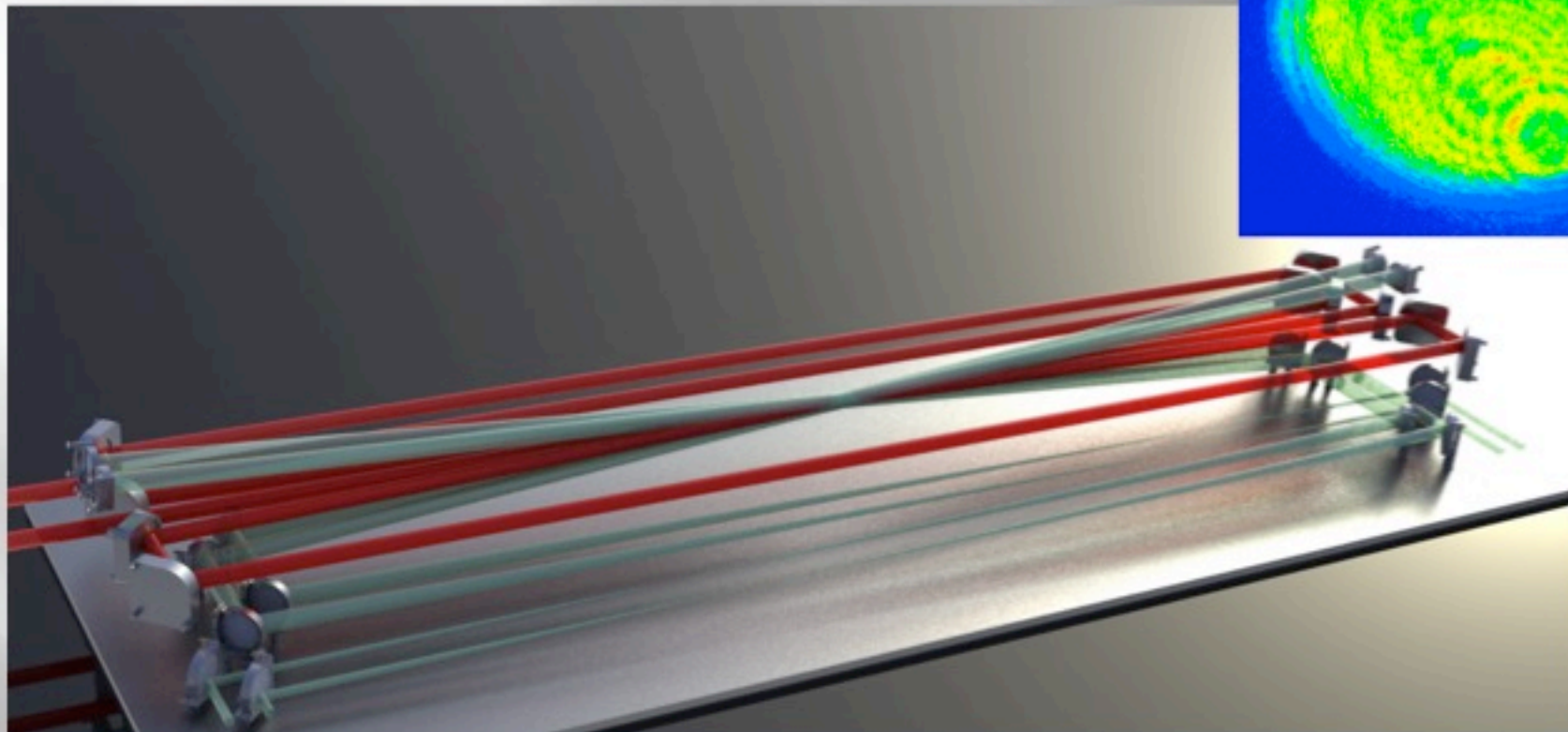
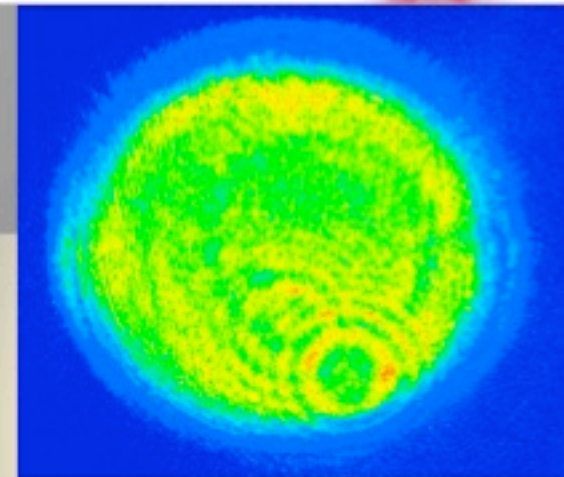


Amplifier design Consideration

- ▣ 50 J pump with four 12.5 J beams pumped from both sides
- ▣ Repetition rate 1 shot/min
- ▣ 1.3 J, 800 ps short pulse input
- ▣ Target output 23 J
 - B integral < 0.5 rad
 - Flat top profile
 - Energy fluctuation $< 5\%$ rms
 - Strehl ratio > 0.7

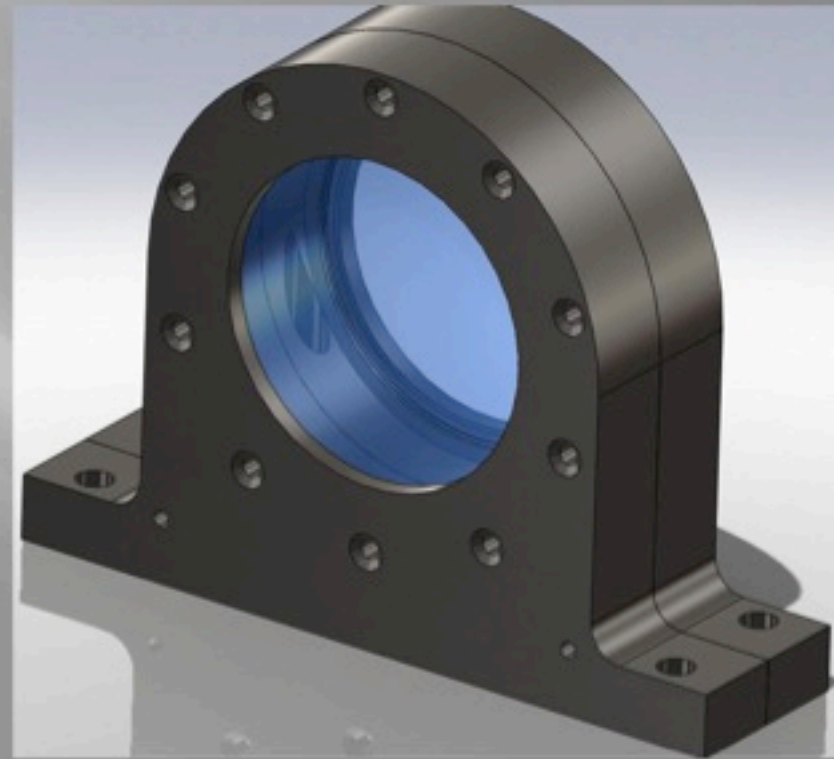


Design of Final Amp



Parasitic Lasing Suppression

- ▣ Crystal holder design allowing fluid contact over whole cylindrical surface
- ▣ Index matching fluid with appropriate absorbing die/paint for suppression of transverse gain of $\sim 10^3$



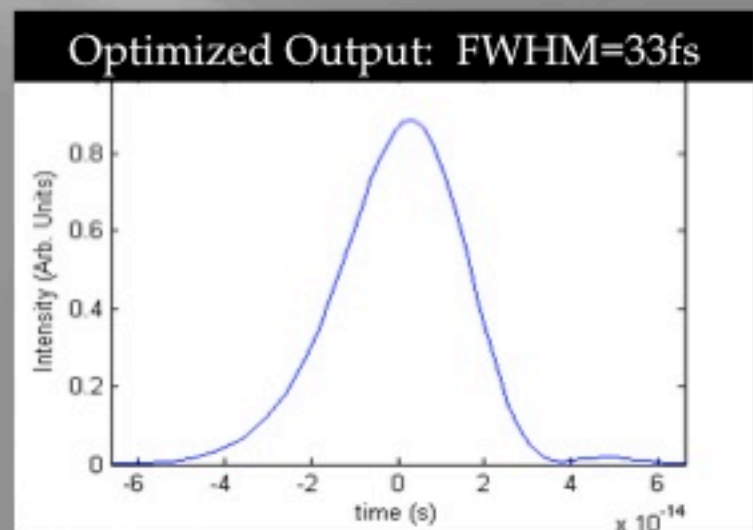
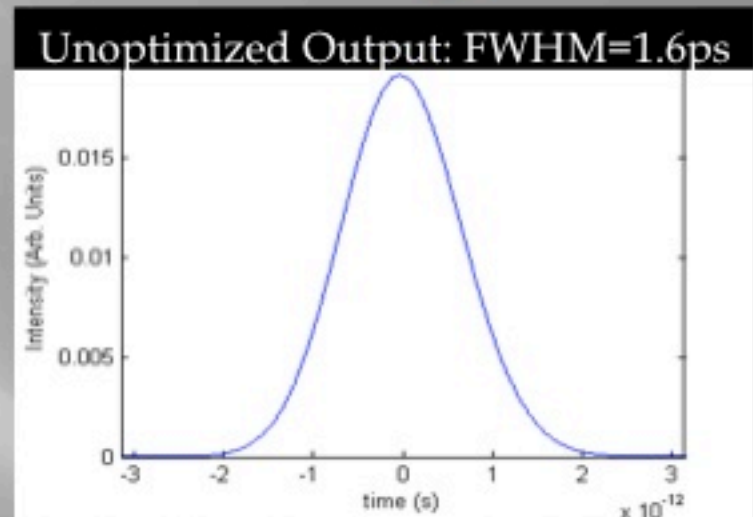
Isolation of Amplifier Stages

- ▣ XPW + ~ 20 m pathlengths acts as isolator between booster and femtopower
- ▣ Active isolation thru Pockel's cell + polarizers between Power amp and Final Amp (gain ~ 20)
- ▣ Passive isolation thru spatial filter between Power Amp and Final Amp
- ▣ Added passive isolation between amplifiers
 - Booster (gain ~ 60) $\ggggg$ Preamp (gain ~ 70)
 - Preamp $\ggggggg$ Power Amp (gain ~ 45)



Dispersion Modeling

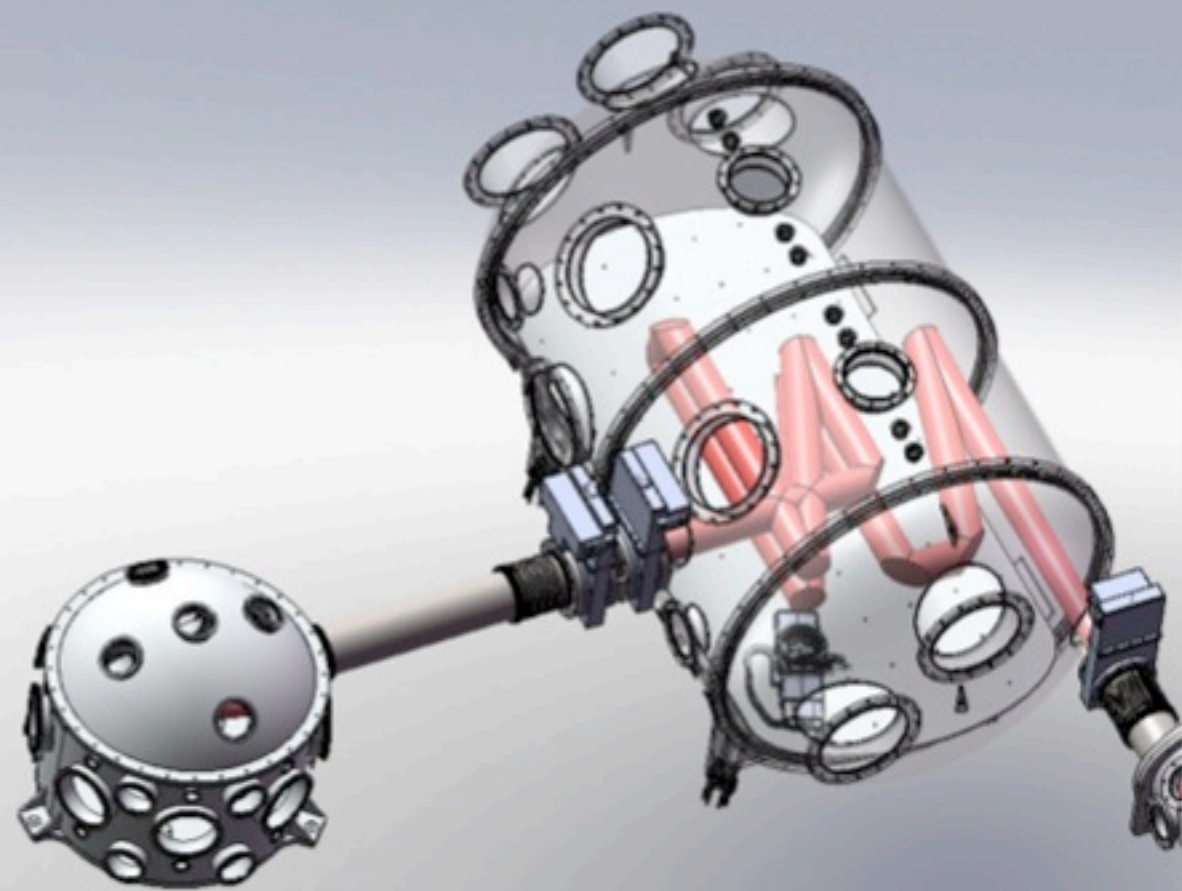
- ◆ Genetic algorithm calculates RMS phase error for many compressor configurations
- ◆ Compressor optimized for a given stretcher and amplifier design



Compressor Consideration

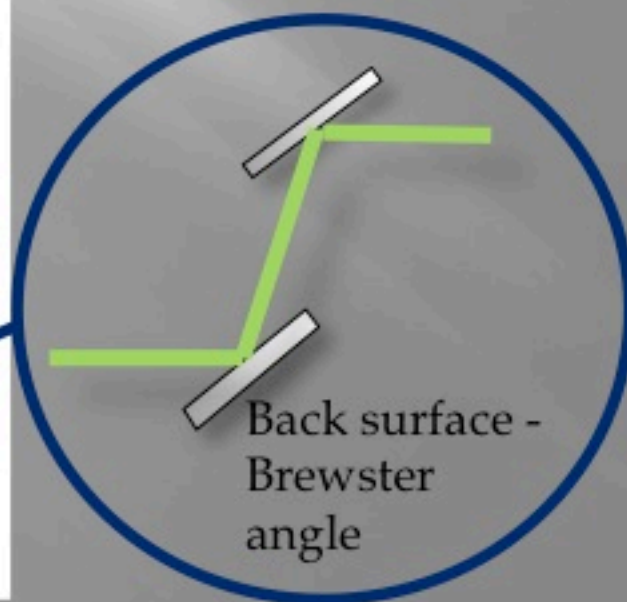
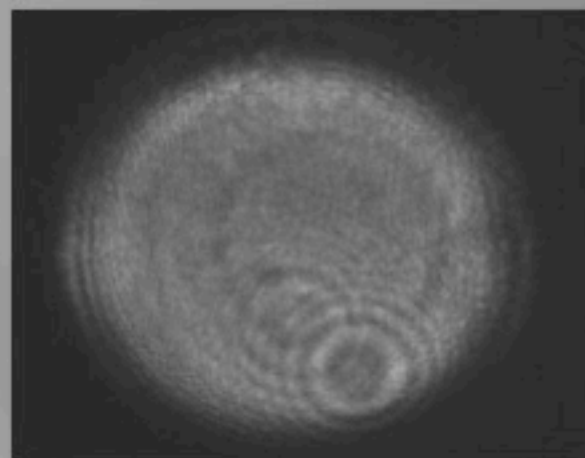
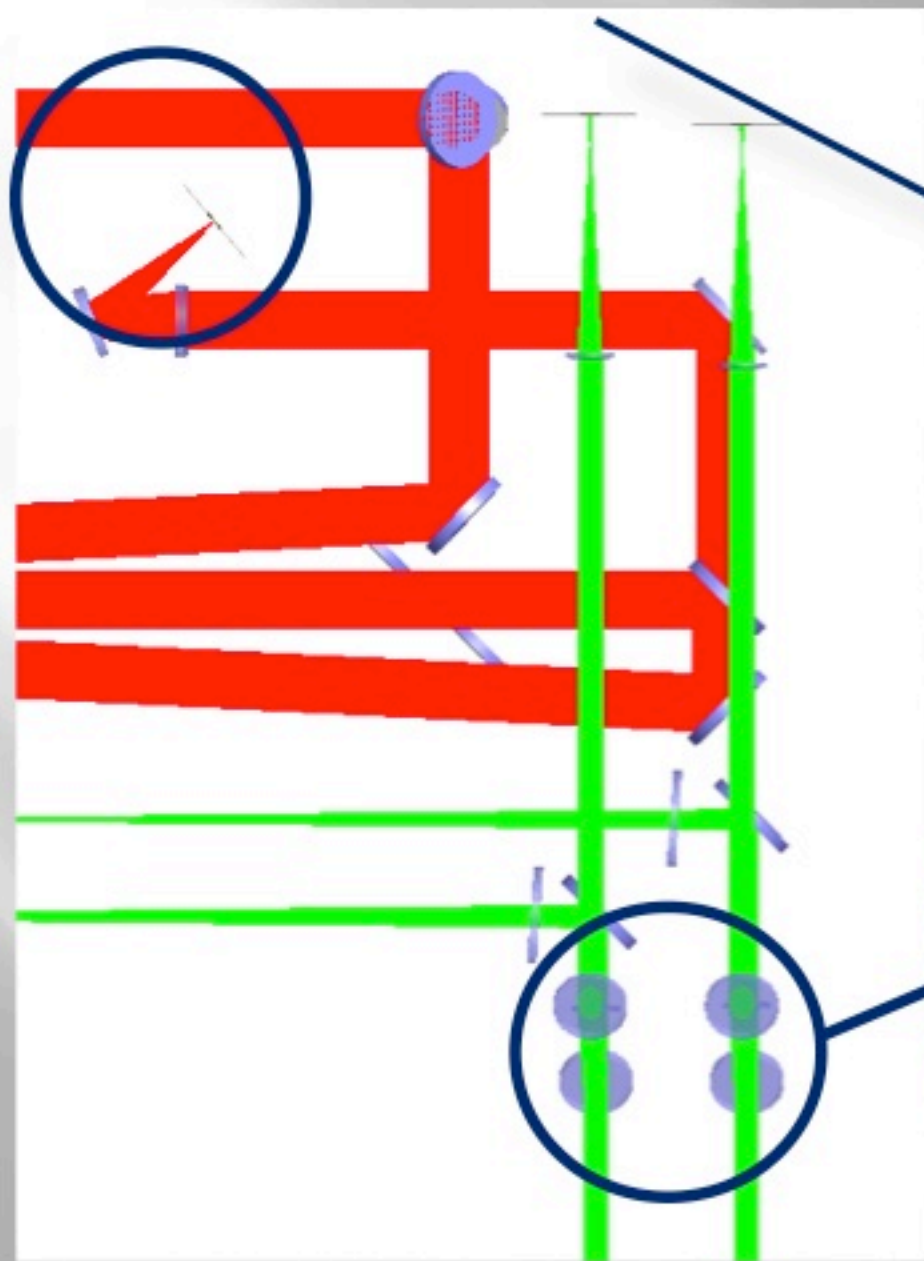
- ▣ Vacuum Chamber pressure below 10^{-6} torr, ultraclean
- ▣ 6" (150 mm) beam diameter
- ▣ Max fluence: 23 J on grating at $\sim 49^\circ$ incidence, 75 mJ/cm²
- ▣ Grating sizes: 350 x 420 x 78 mm, 560 x 420 x 78 mm
- ▣ Large mirrors TLMB from CVI, 8" x 14" largest
- ▣ Grating blackening:
 - Move to etched substrate gratings
 - Complete isolation from target chamber via pellicle chamber
- ▣ Grating damage testing performed
- ▣ Grating Mounts being designed in house with help from PGL

Beamline Layout



Laser Diagnostics

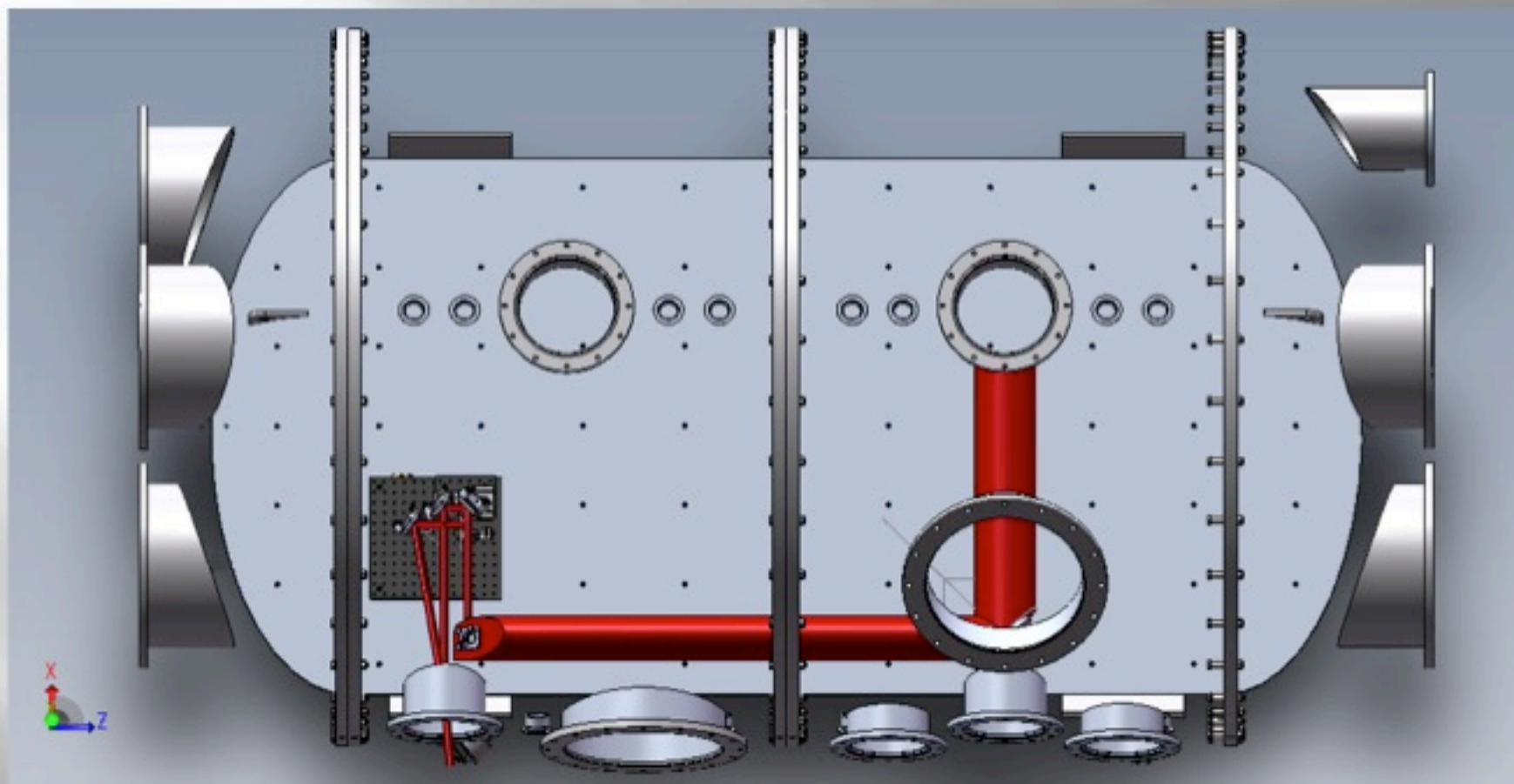
Beam Spatial Profile Diagnostics



Focal Spot Diagnosis Setup

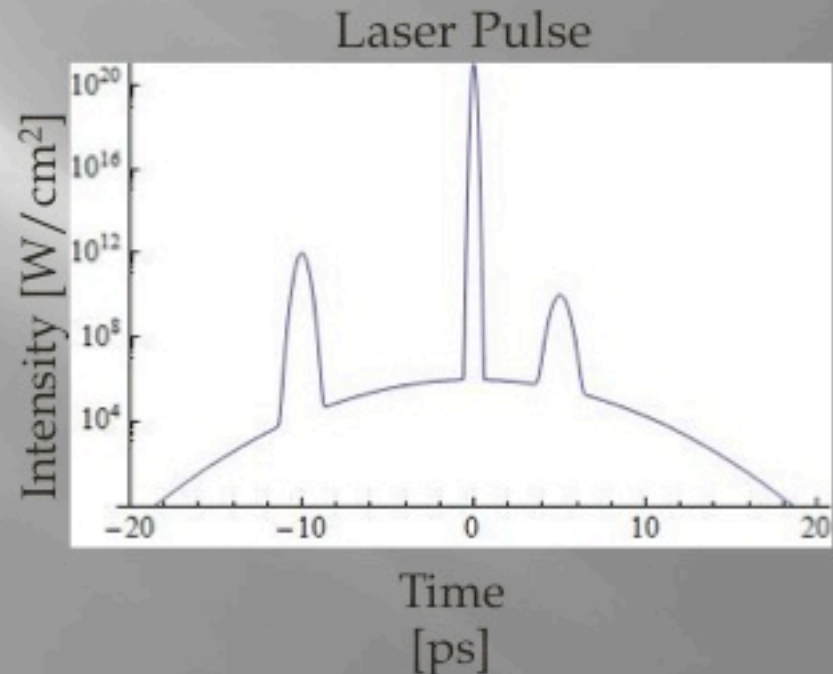


Autocorrelator Design



Contrast Measurement

- ▣ Important laser characteristic
- ▣ Single-shot third order cross-correlator
- ▣ Allows differentiation of pre and post pulse
- ▣ Repetition rate too low for scanning measurement
- ▣ Detection Range: 10^9
 - Al coated UG5 Filter Mask
- ▣ Temporal Range: ~ 40 ps



Other Considerations

- ▣ Alignment cross hairs
- ▣ Mount designs
- ▣ Various Relays to shut off the laser
- ▣ PW pump laser diagnostics IR beam
- ▣ Grating alignments/compressor
- ▣ Timeline

Thank You