Omega Facility Update: Progress on OLUG Recommendations

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Summary

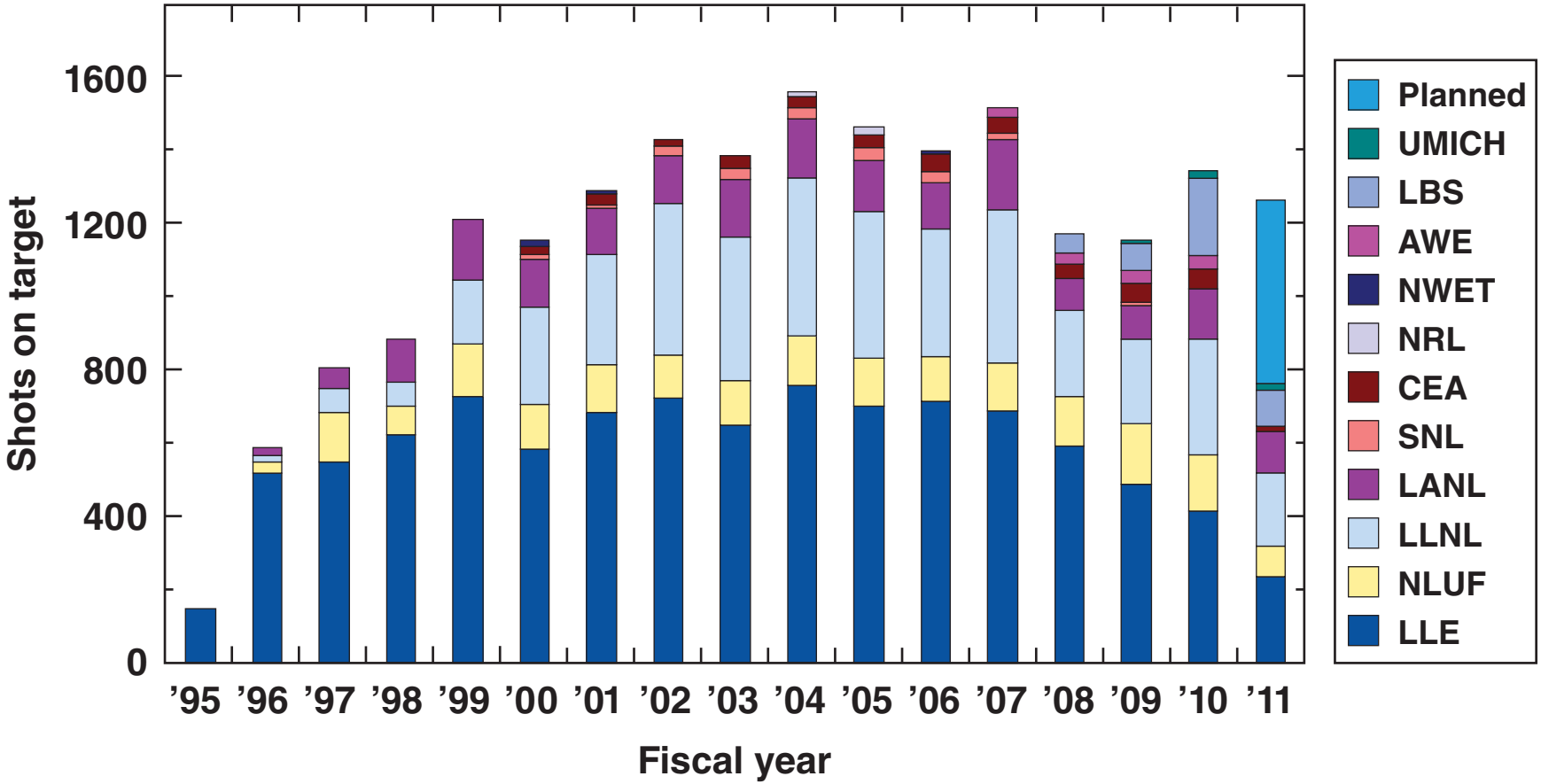
Experiments are conducted at the Omega Laser Facility across a variety of platforms and the Facility continues to evolve

UR LLE

- OMEGA and OMEGA EP are operating reliably at high Availability and Effectiveness
- LLE is making progress on 2010 OLUG recommendations
- Features of OMEGA and OMEGA EP evolve to meet user requirements
- Progress is being made in bringing OMEGA EP up to full performance
- A variety of projects are in progress; status and plans are summarized

OLUG input and support makes the Omega Laser Facility more effective for Users.

OMEGA target shot production reflects strong demand



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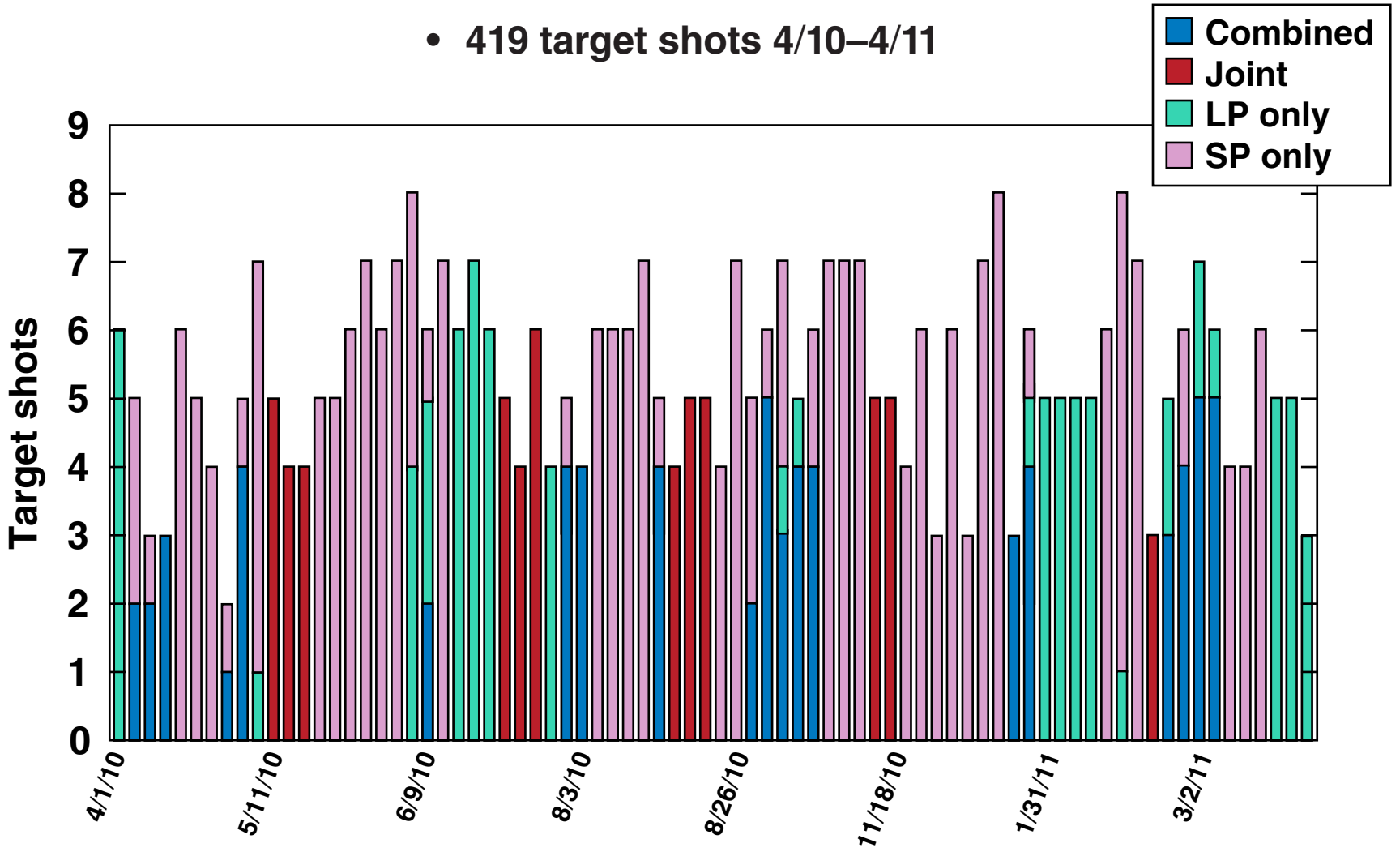
OMEGA EP averaged 5.4 shots per day over the past year

UR LLE

- 419 target shots 4/10–4/11



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FY12 OMEGA provisional shot allocations based on funding

Category	Subdivision	FY12 Notional Allocation		
		%*	OMEGA days	OMEGA EP days
National Ignition Campaign		40	39	25
HED	LLNL and LANL	25	24	15
Basic Science	NLUF Laboratory	15 15	14 14	9 9
Contingency		5	5	3
Total		100	97	62

NOTE

- 1 day (12 h) of system time nominally produces 10 shots on OMEGA (7 on Cryo days) and 5 shots on OMEGA EP.
- The shot allocations assume that 1 week/quarter will be Joint operations (OMEGA + OMEGA EP)

*Allocation recommended by FSAC in June 2010 and approved by LLE Director and NNSA.

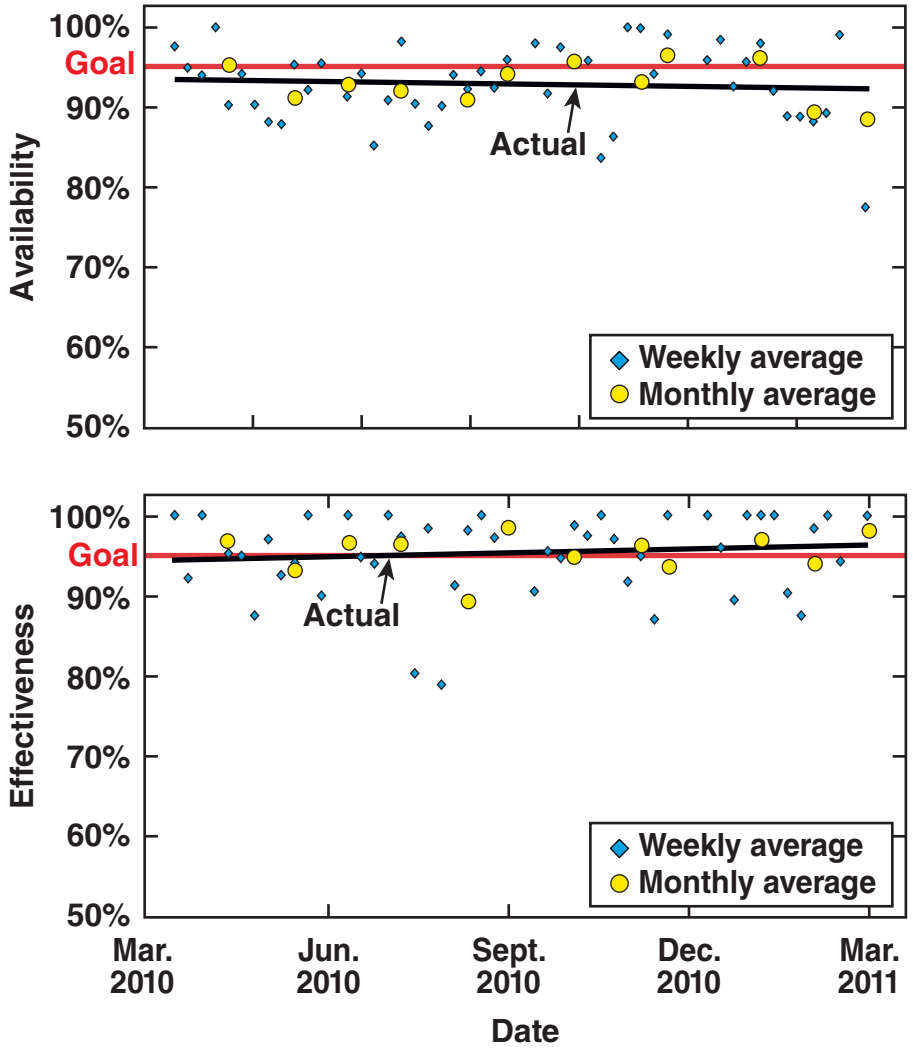
The 60-beam OMEGA Laser System achieves high Availability and Effectiveness

- **Availability = 92%**

  Quantitative schedule performance metric for Laser and Experimental operations

- **Effectiveness = 96%**

  Initial response of the PI to whether the shot produced good data quality

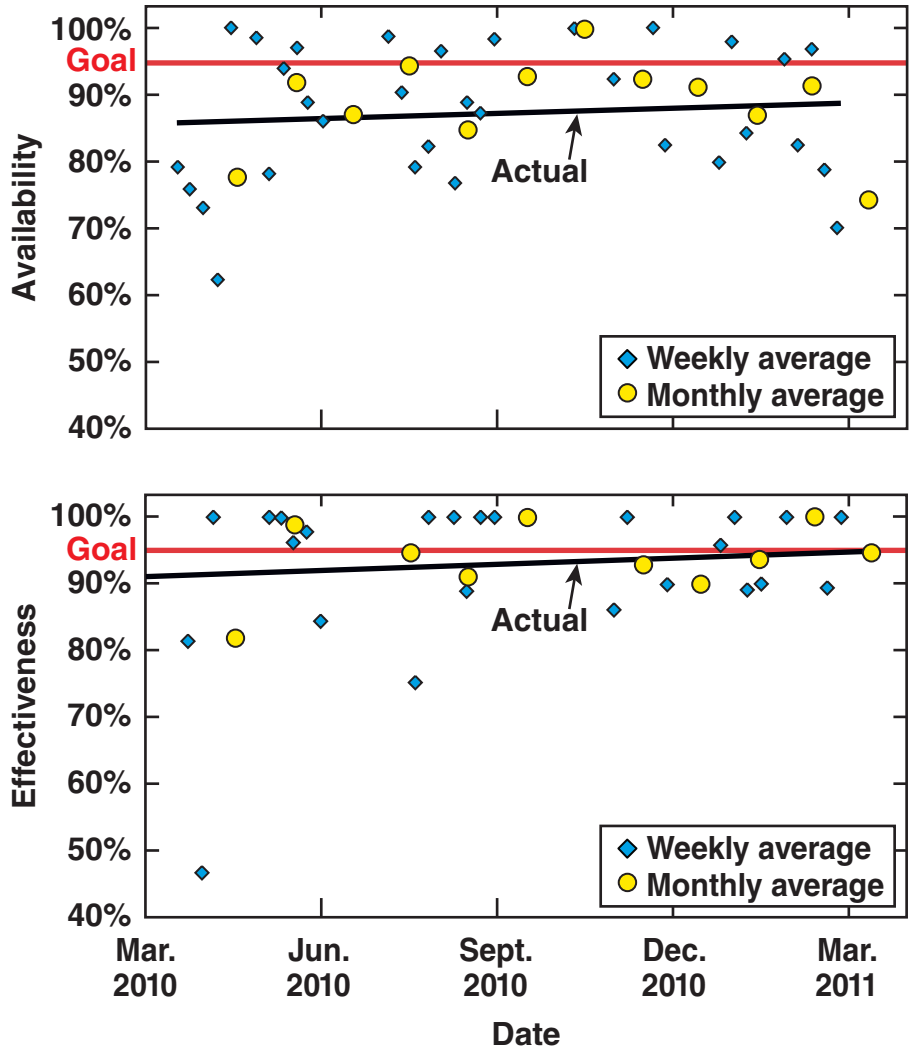


OMEGA EP Availability and Effectiveness have improved over the past year

UR LLE

- **Availability:**
  Overall Availability = 87%

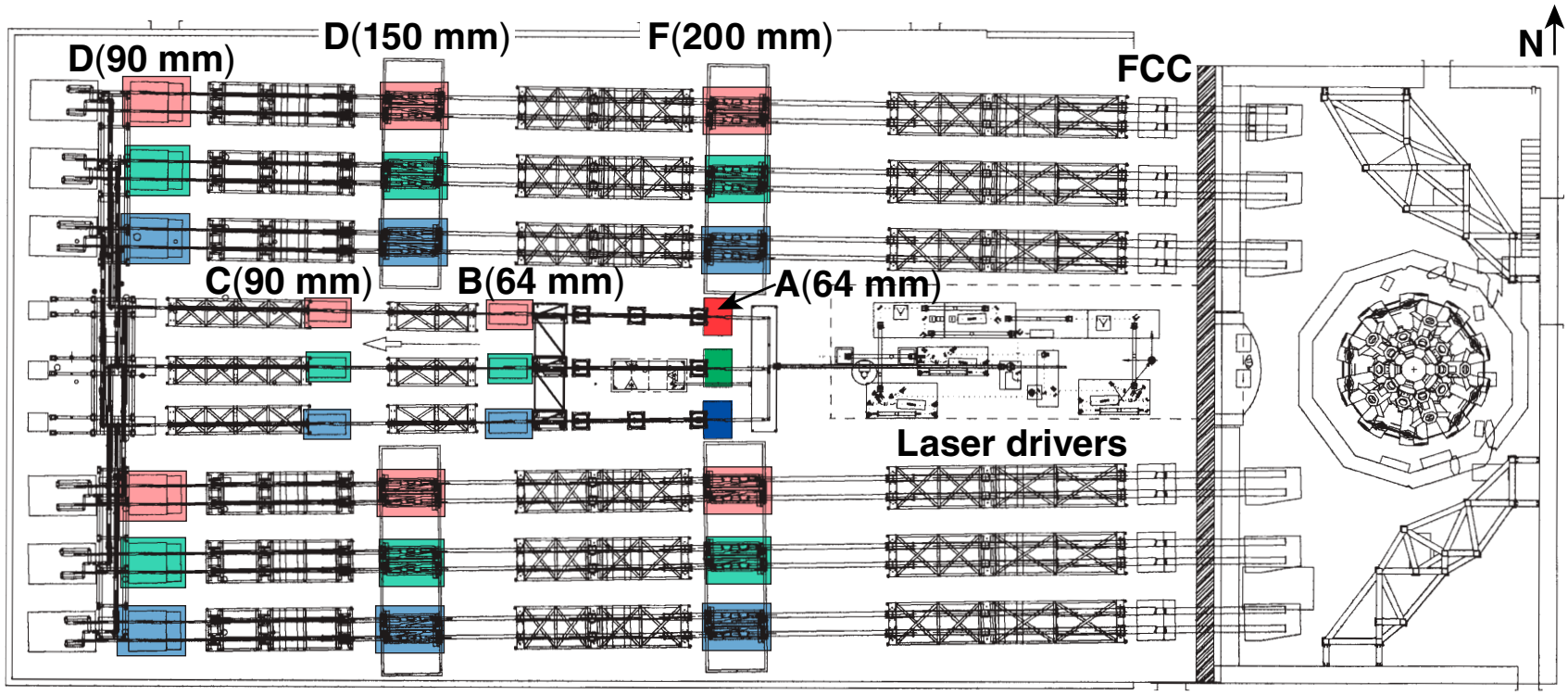
- **Effectiveness:**
  Overall Effectiveness = 94%



OLUG recommendations for the OMEGA Laser System

- Driving multiple legs with independent drivers
- OMEGA spherical crystal imaging
- 8 SG8 DPP's are on order, FY12 delivery
- Dual focusing of OMEGA EP
- Laser-timing-measurement accuracy
- Internal users have requested improved understanding of UV transport

OMEGA has three laser drivers and a three-way split at the start of "beamlines" (stage A)



Each stage-A beam is split to 20 beamlines.

LLE requires feedback from OLUG on FY12 plans for independent drivers

- Driving three legs independently would be very difficult and perhaps impossible
- An updated solution would
  - retain current capability—SSD in two legs, backlighter in one leg
  - add the capability to drive two legs with backlighter and SSD in one leg
- Adds 64-mm amplifer to backlighter path to solve the energy issue

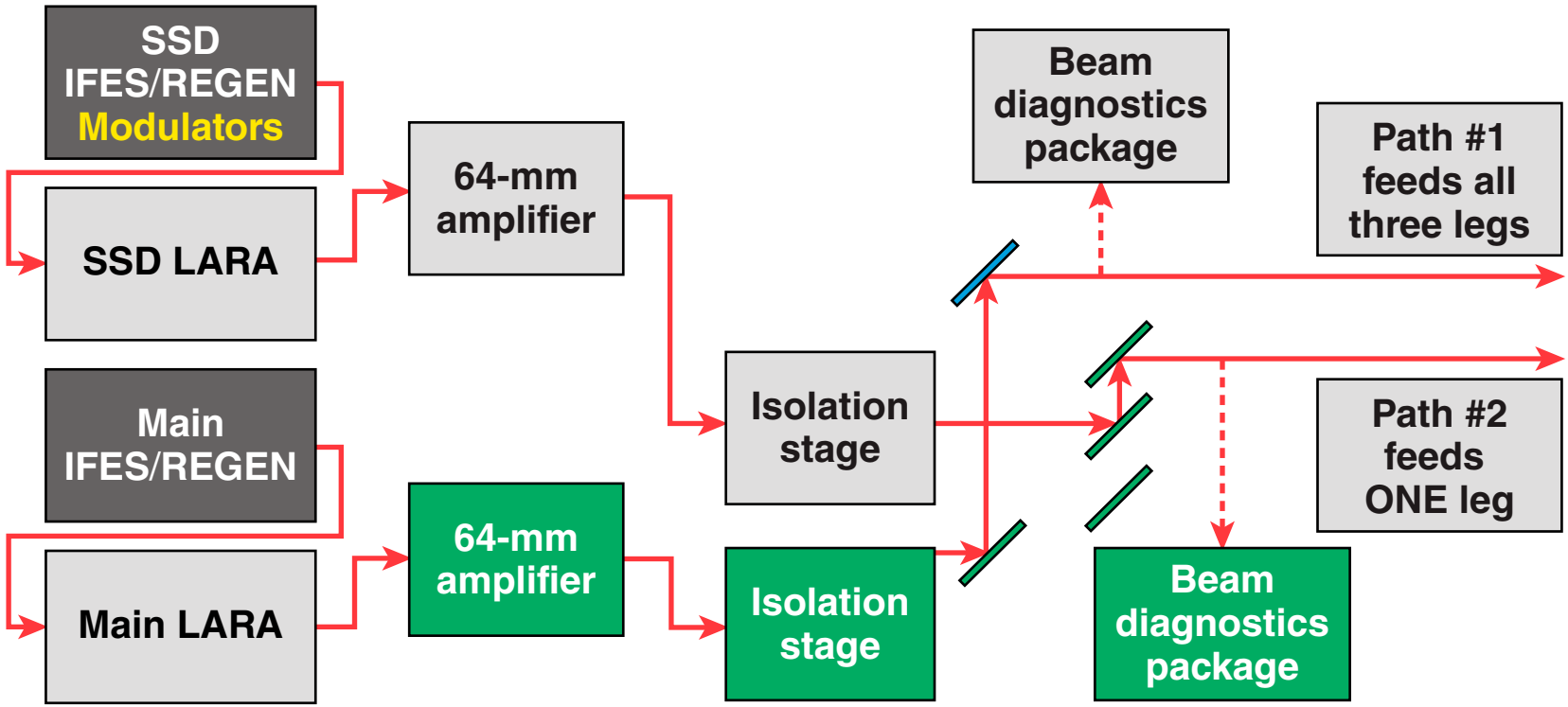
A discussion of this topic is planned for the OLUG general session.

AN FY12 project enables the driver line to feed OMEGA from two front ends

- Front end #1 will be an SSD-capable driver
  - modulation may be "on" or "off" as determined by the PI
  - independent pulse shaping
  - able to feed A-split through driver-line standard path or backlighter path with proper beam size/polarization/energetics
- Front end #2 will not be SSD capable
  - independent pulse shaping
  - able to feed A-split through standard path or backlighter path with proper beam size/polarization/energetics
- Driver-line path #1, standard 1:3 path
  - current SSD path
  - able to feed all three legs simultaneously
  - one leg is blocked when propagating a front end down path #2
- Driver-line path #2, current backlighter path
  - able to feed any ONE of the three legs at any given time
  - must include proper beam rotation for dispersion of SSD

A kinematic switchyard will allow either driver to be injected into either A-split path

- Image planes and beam sizes must be matched at the switchyard area
- Current SSD layout will require minimal changes for this project
  - this will enable the upgrades to be simultaneous to the shot operations to minimize OMEGA down time
- All kinematic mirrors are aligned during a maintenance day change



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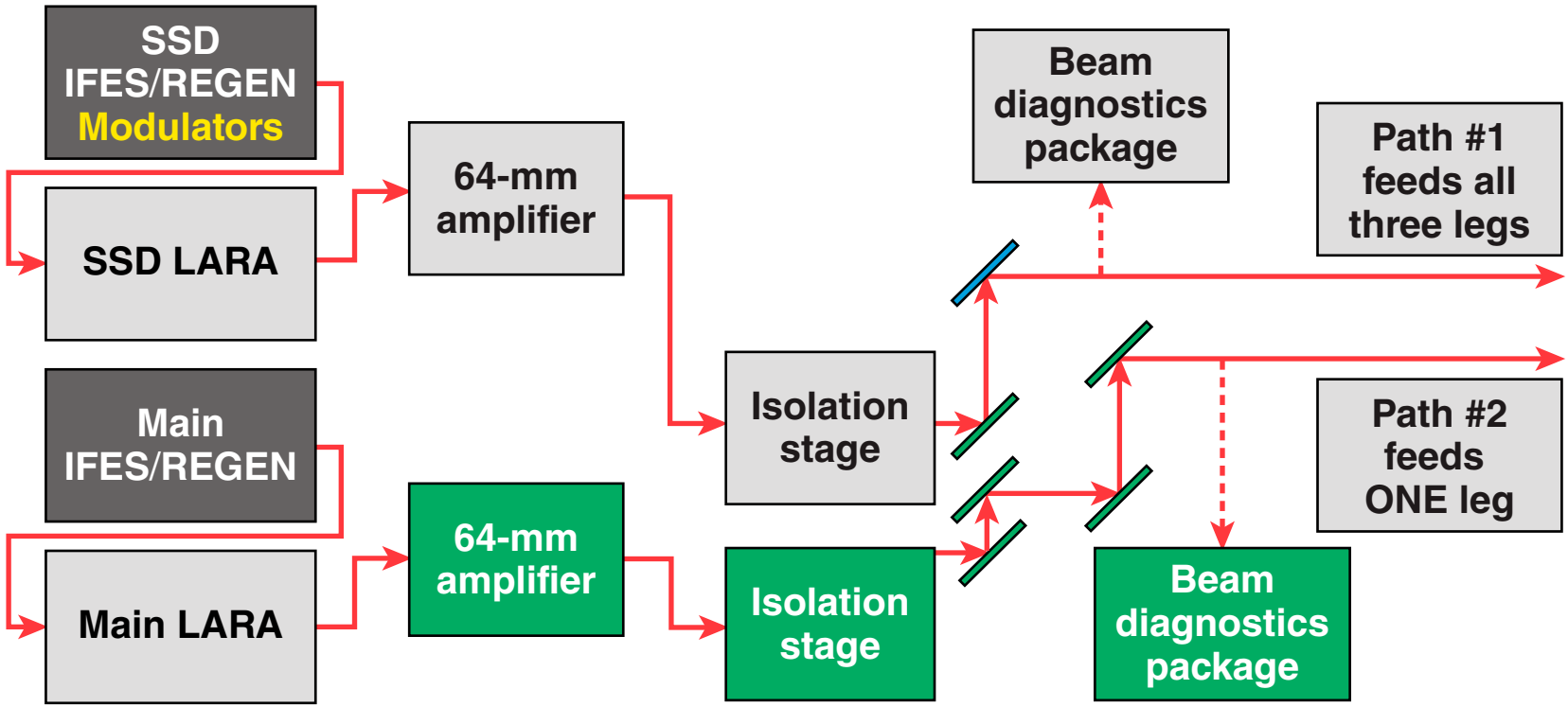

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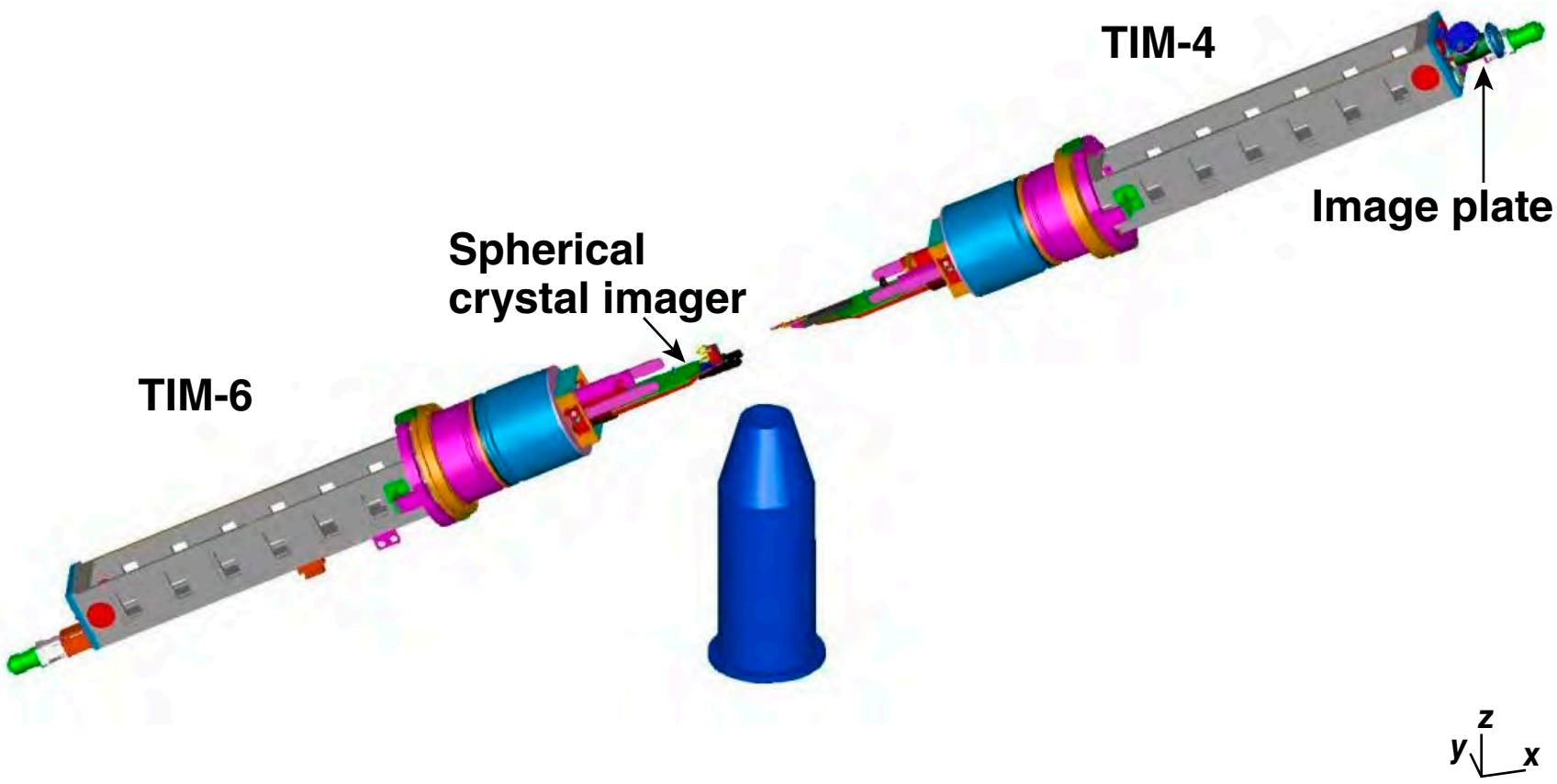
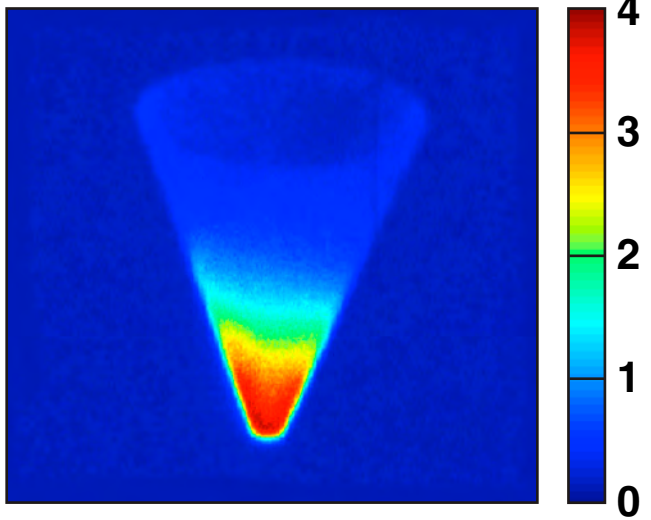
OMEGA spherical crystal imager requires the use of two opposing TIM's



A spherical crystal imager will complement the existing x-ray diagnostics

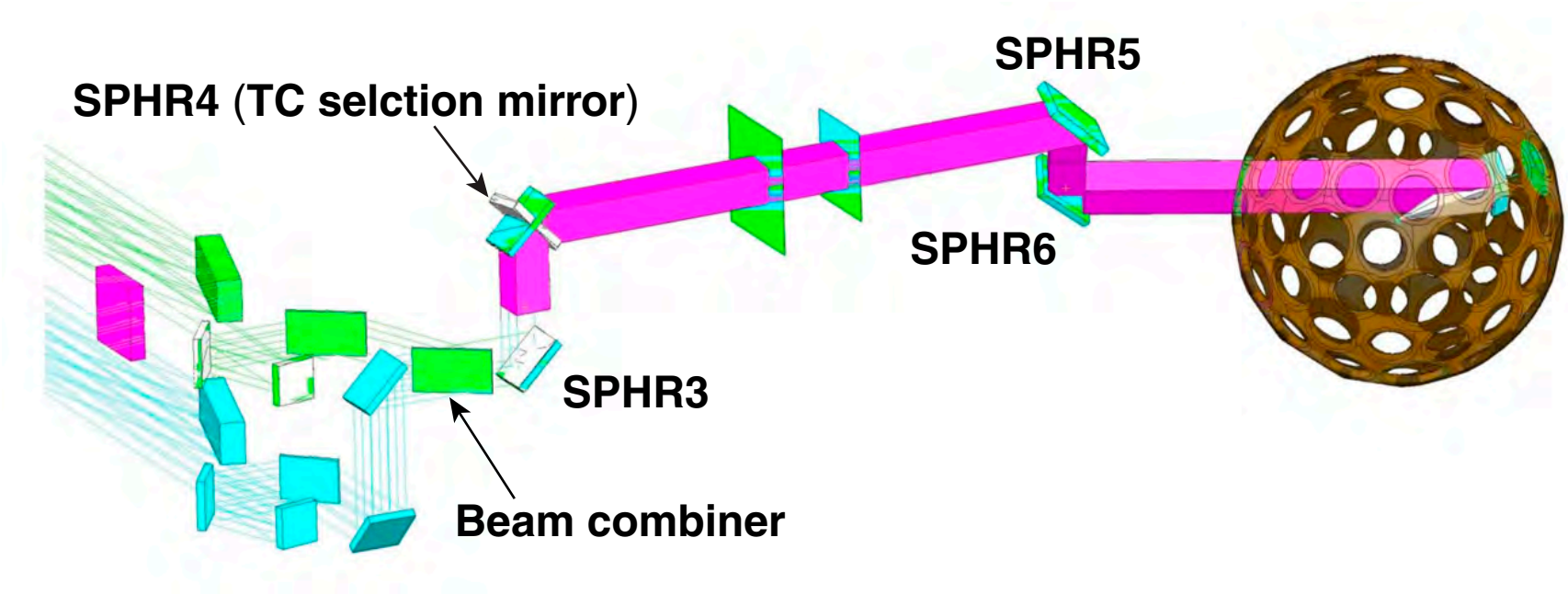
- There is a broad range of applications including
  - self-emission and backlighting imaging of fusion targets
  - fast-electron dynamics in fast-ignition experiments
  - hydrodynamics instabilities
- The key features are
  - high spatial resolution ≤10 μm
  - large light collection area ~f/10

8-keV x-ray image of Cu cone

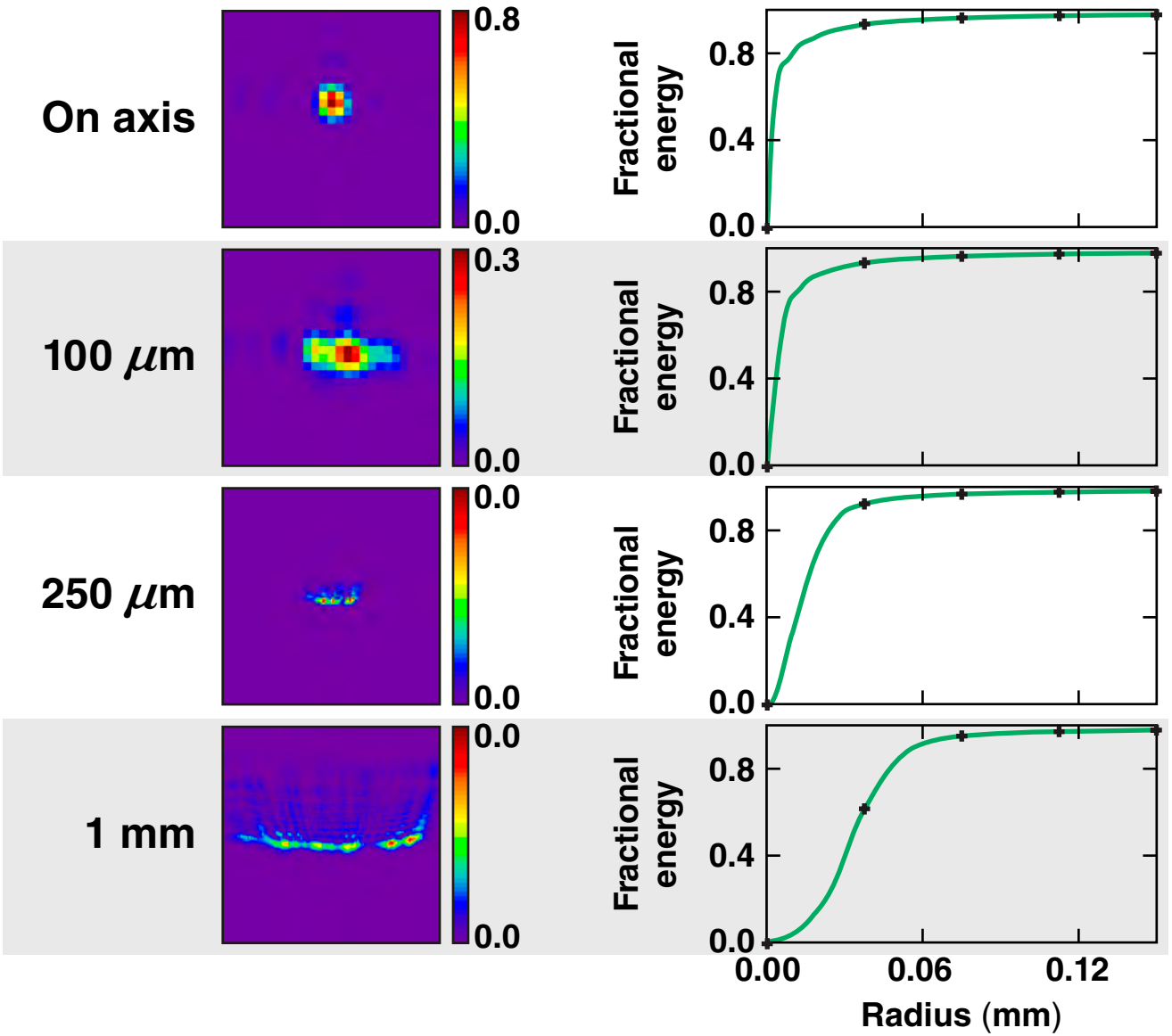


Courtesy of H. Sawada and F. N. Beg, University of California, San Diego

Dual focus on OMEGA requires the beam combiner to be installed in the grating compressor chamber



As foci are split at the target plane, one or both beams pick up significant aberrations



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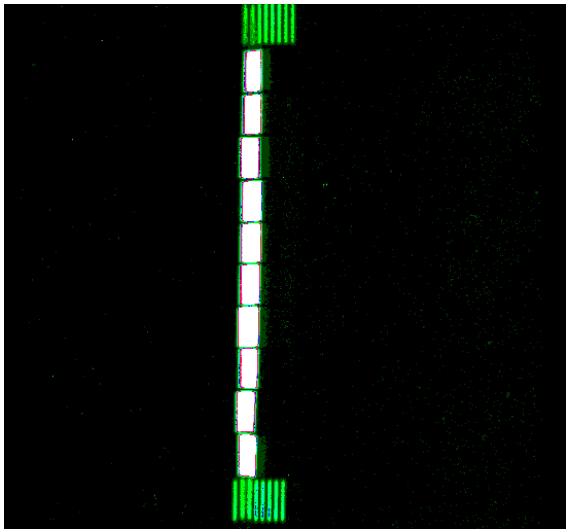
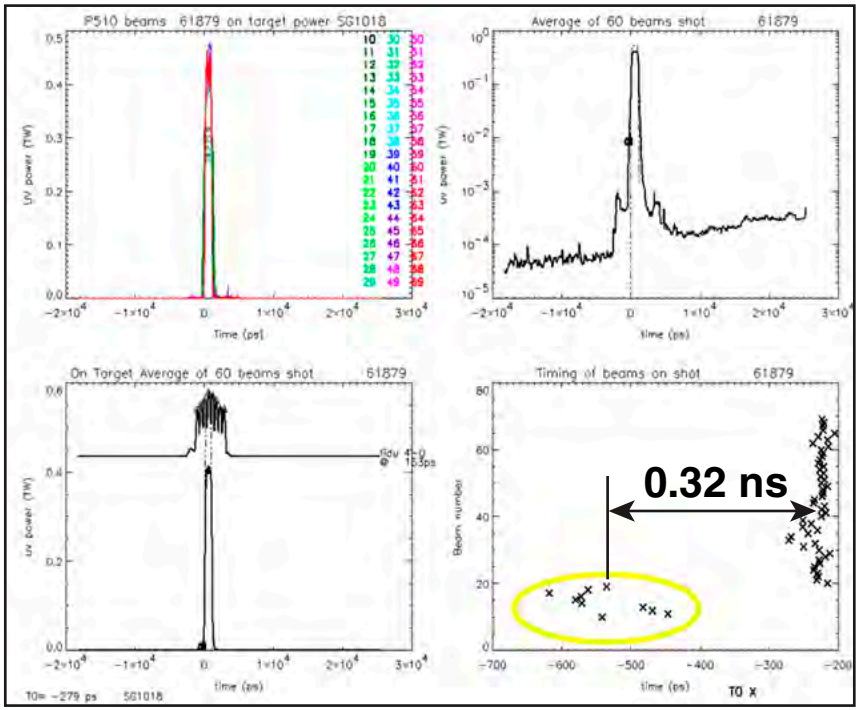
The P510 45-ns sweep resolution currently provides 300- to 500-ps timing accuracy



Shot 61879

- 90- to 100-ps/px resolution
- 2.5-px line spread function

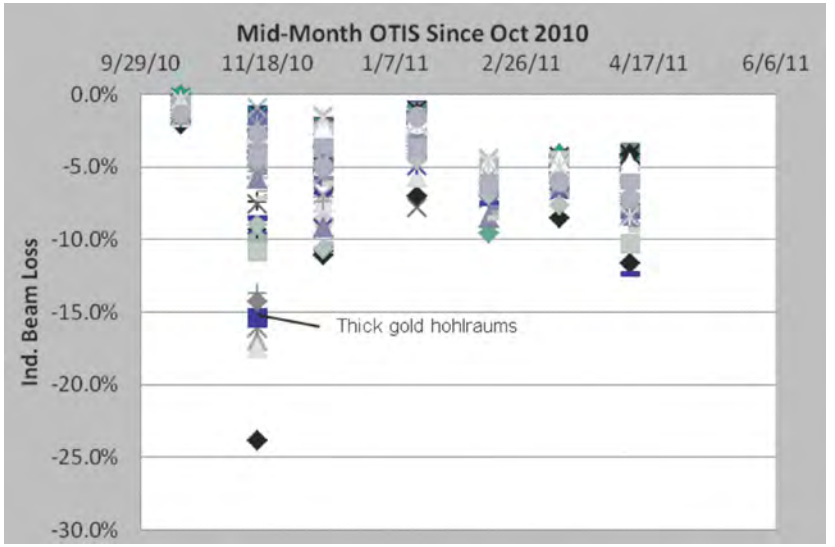
Accuracy may be improved with additional effort.

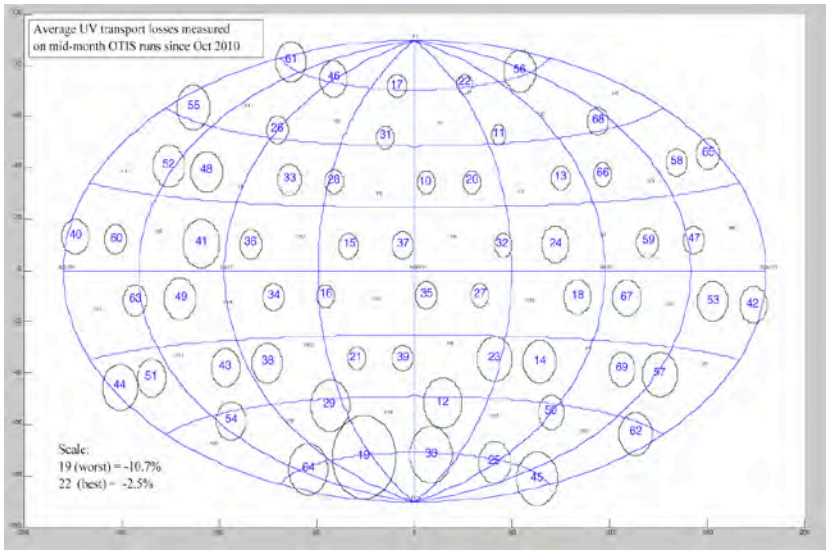


- Only cluster 1 set to 45-ns sweep
- Reduced resolution compared to 6-ns P510's

"Mid-month" measurements quantify the UV transport degradation due to debris-shield contamination

- Overall system as well as beam-to-beam transmission varies
- Several factors contribute to magnitude and distribution of losses
  - target type and quantity
  - which beams are fired (i.e., "self-cleaning")
  - experiment geometry
  - beam location on target chamber
- Measurements will continue to be acquired to better understand transport
- Current HED report specifies UV on-target energy based on "clean" debris shield transmission





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LLE is developing an HED report that estimates UV on-target energy

- **Frequent measurements of two witness beam-pairs will be used to estimate average system transmission**
- **Historical correlation between system average and individual beam transmissions then used to estimate all 60 beams**

UV On-Target / BWA Degradation Report

Log Number: 61380 4/7/2011 20:03

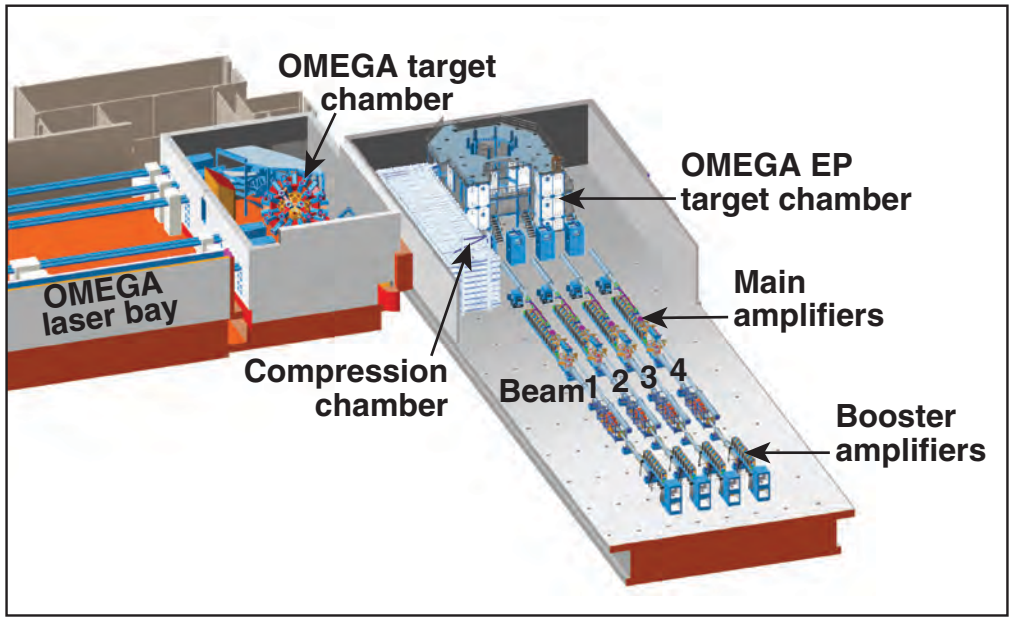
Last OTIS measurement 3/28/2011 Last BWA swap: 3/27/2011
Last Witness Beams Measured: 4/12/2011 # target shots since last BWA swap: 25

Beam	HED On-Target UV Energy	Estimated Loss %	Adj. On-Target UV Energy
10	423.4	-4.4%	404.8
11	444.9	-5.7%	419.8
12	422.0	-5.2%	400.3
13	430.0	-5.0%	408.6
14	455.9	-4.8%	434.0
15	425.1	-4.7%	405.0
.	.	.	.
.	.	.	.
.	.	.	.
65	420.7	-5.6%	397.2
66	428.6	-4.6%	408.7
67	434.6	-6.3%	407.1
68	433.4	-5.0%	411.6
69	425.8	-6.0%	400.1
Mean	431.3	-5.2%	408.8
RMS	10.7	0.6%	10.4
P/V	35.2	1.9%	36.8

This adjusted on-target UV energy should be used for simulations

Recommendations for the OMEGA EP Laser System

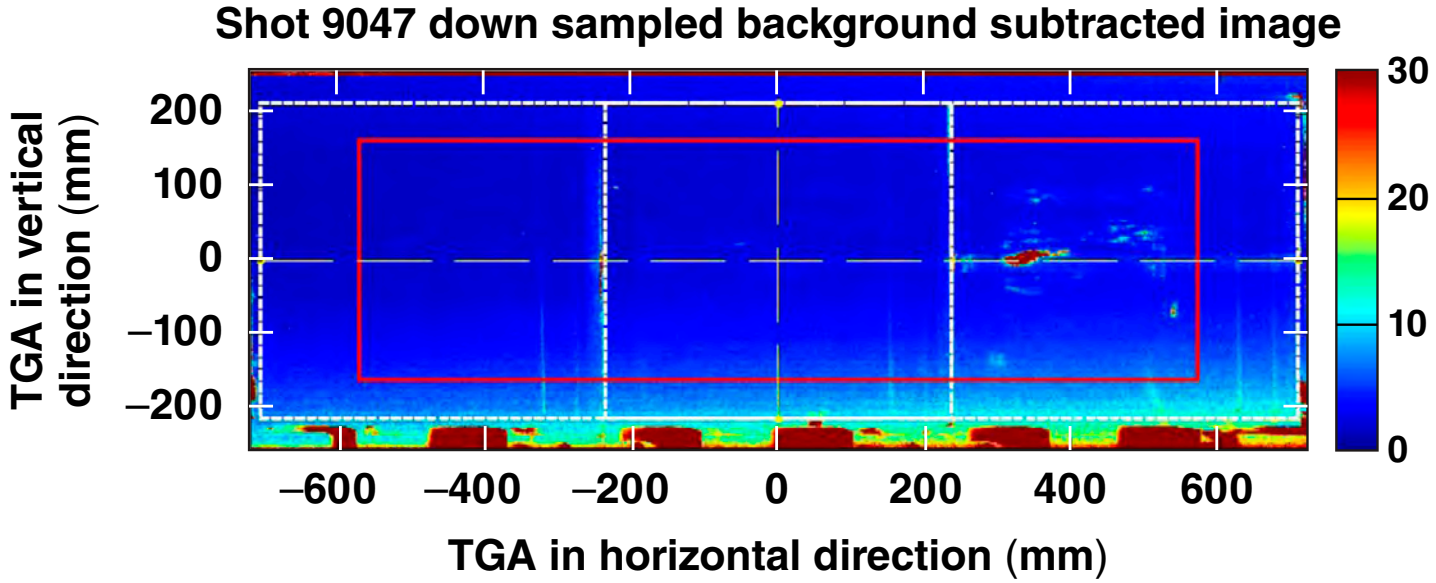
- OMEGA EP performance improvements
  - energy and wavefront
  - contrast
- Fourth-harmonic probe beam
- Other



G9346

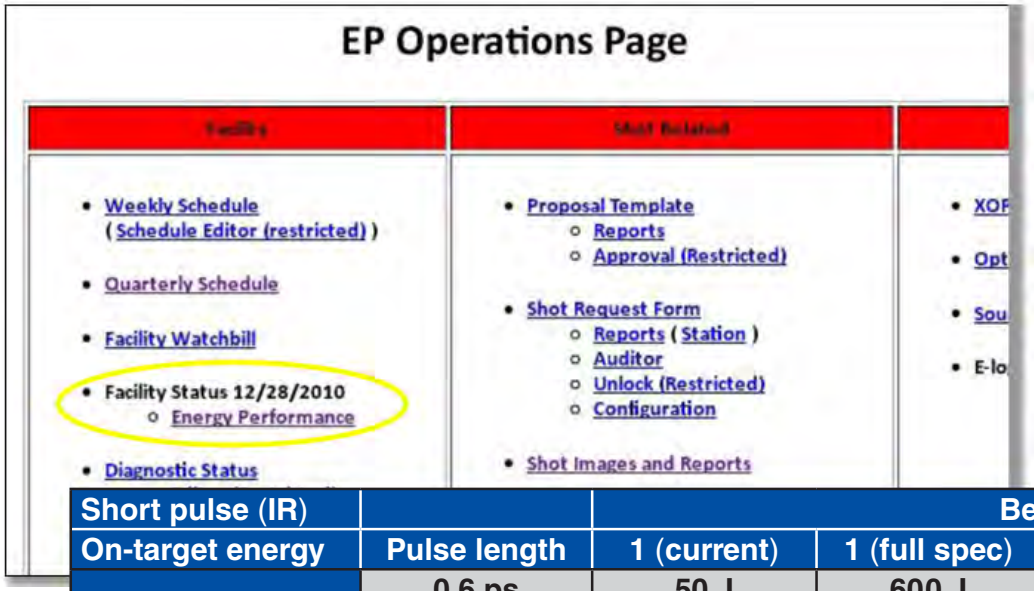
OMEGA EP tested new PGL gratings at 1.25 kJ and 1.5 kJ on target during the week of 28 February 2011

- Increase to 1.5 kJ at 10 ps led to changes in the grating inspection system images collected after each shot
- The changes were primarily located on a single tile of TGA4
- The grating tile has been replaced
- The grating tile with increased scatter is being studied; there is correlation between damage threshold and initial diffraction efficiency



OMEGA EP backlighter beam will be operated at 1.5 kJ in May 2011.

OMEGA EP performance envelope detailed data is now posted on the OMEGA EP Operations web page



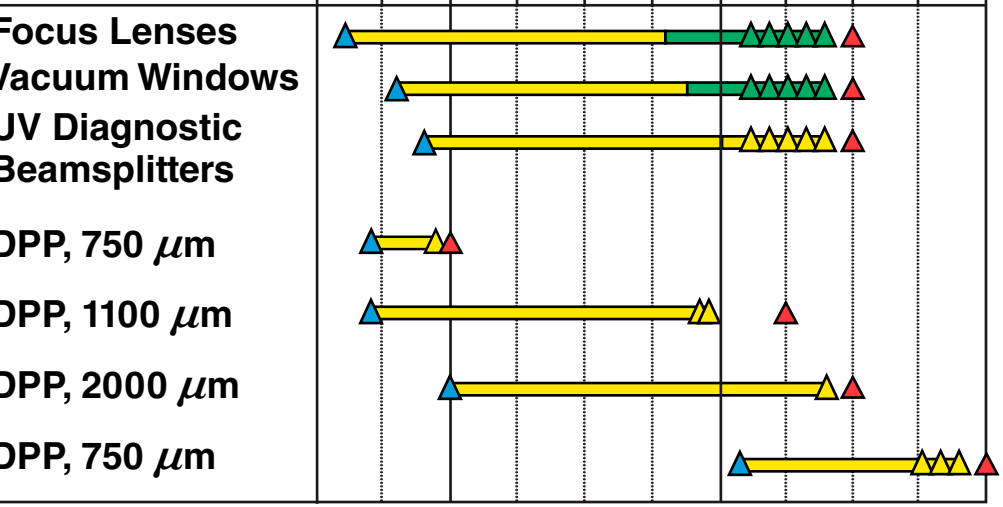
Short pulse (IR)		Beam			
On-target energy	Pulse length	1 (current)	1 (full spec)	2 (current)	2 (full spec)
No disposable debris shield	0.6 ps	50 J	600 J	300 J	600 J
	10 ps	850 J	2600 J	1250 J	2600 J
	100 ps	950 J	2600 J	1250 J	2600 J
With disposable debris shield	0.6 ps	50 J	50 J	50 J	50 J
	10 ps	850 J	850 J	850 J	850 J
	100 ps	950 J	2600 J	1250 J	2600 J

Procurement of optics with higher LDT's should allow OMEGA EP to meet UV design goals

UR LLE

UV Optics Acquisition

ITEM	FY09		FY10				FY11			
	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
5 – Focus Lenses										
5 – Vacuum Windows										
5 – UV Diagnostic Beamsplitters										
2 – DPP, 750 μm										
2 – DPP, 1100 μm										
1 – DPP, 2000 μm										
4 – DPP, 750 μm										



▲ Contract placed with vendor
▭ Vendor production and shipment (▲)
▭ LLNL UV optic processing and shipment (▲)
▲ Installed and ready for high-power use

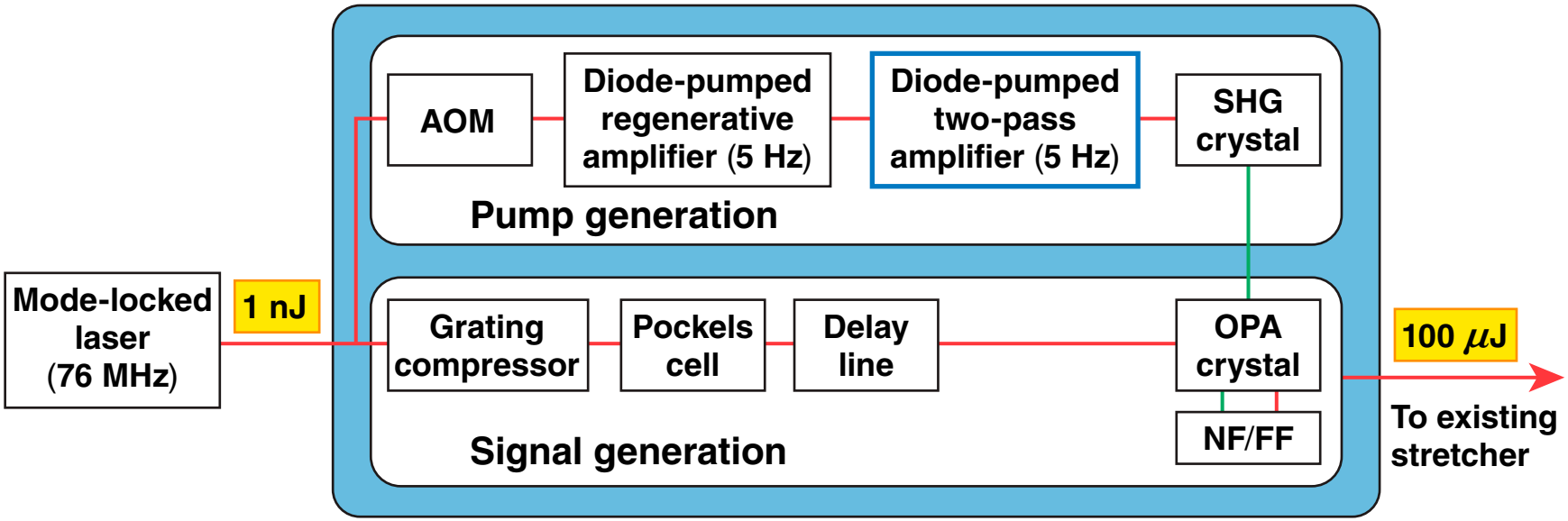
- LLNL managed the procurement of replacement optics for OMEGA EP
- A full set of 750-μm DPP's were ordered as a result of the OLUG request

OMEGA EP also tested the UV operational envelope during the week of 28 February 2011

- New UV optics were acquired with LLNL AMP-2 process in January 2011
- Purpose of the test was to experimentally damage test existing optics on the system to provide a baseline fluence limit for operation with the new optics
- The UV-damage test shots resulted in damage to the UV HR mirrors, vacuum window, and focus lens
- Based on the results of these damage tests, the UV system can be operated with a peak fluence of 7.5 J/cm^2 in a 6-ns square pulse

Long-pulse UV		Beam				
On-target energy	Pulse length	1 (current)	2 (current)	3 (current)	4 (current)	Any beam (full spec)
Square-pulse shape values	100 ps	Not currently available				100 J
	1 ns	950 J	950 J	1250 J	1250 J	2000 J
	2 ns	1350 J	1350 J	1800 J	1800 J	2900 J
	4 ns	1900 J	1900 J	2500 J	2500 J	4100 J
	6 ns	2300 J	2300 J	3100 J	310 0 J	5000 J
	10 ns	3000 J	3000 J	4000 J	4000 J	6500 J

An ultrafast optical parametric amplifier will be added to OMEGA EP short pulse front ends in 2011



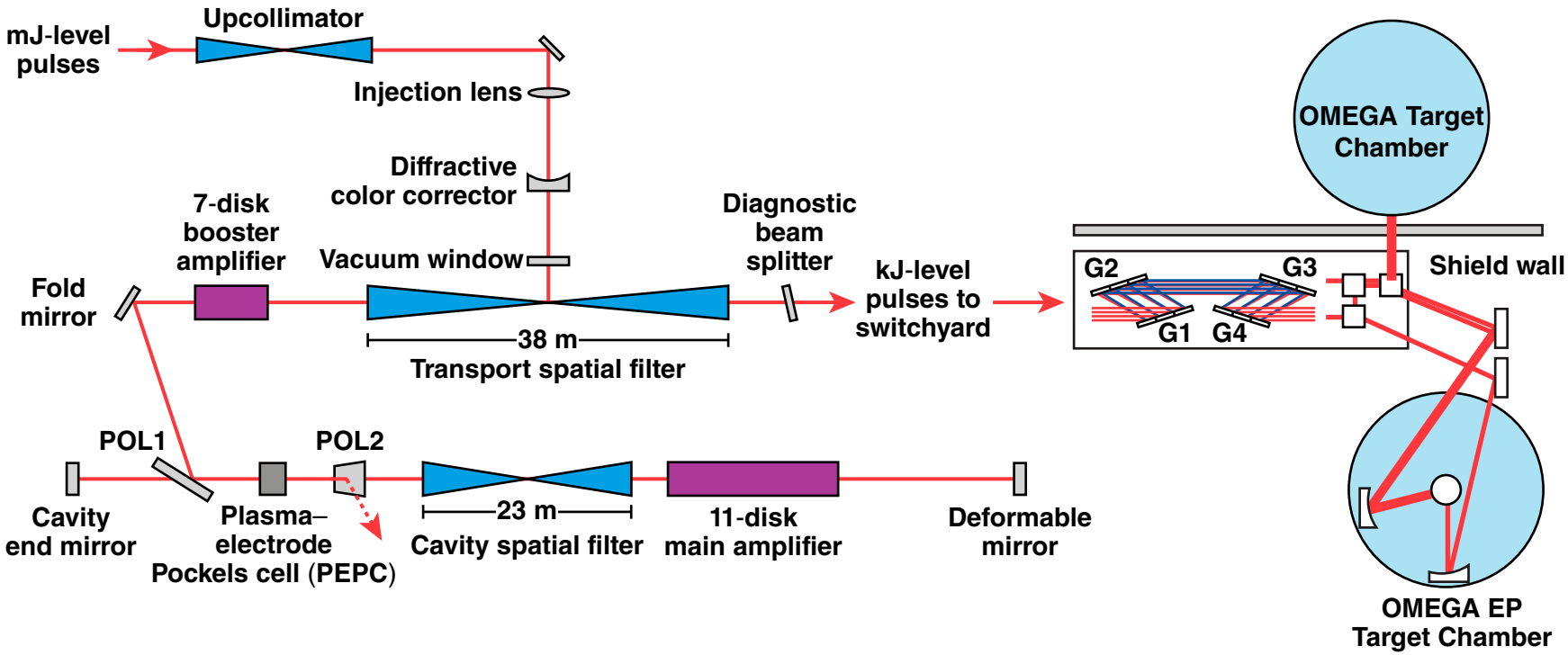
This project is expected to reduce nanosecond pedestal from parametric fluorescence by >100×.

Significant work is devoted to measuring and improving the OMEGA EP temporal contrast

- On-shot diagnostics to measure the contrast to the 100-dB level have been developed and are being implemented
  - the contrast up to 500 ps before the pulse is measured by photodiodes
  - a single-shot cross-correlator is being installed to measure the contrast in the final 500 ps
- Laser technologies to improve the contrast are being developed
  - an ultrafast optical parametric amplifier will increase the nanosecond contrast by a factor of ~300
  - the contrast in the final 200 ps will be improved through the use of a narrowband filter in the pump laser

The current on-target intensity contrast is of the order of ~80 dB (10^8).

The focal spot is a function of the residual phase errors from the beamline and the compressor-to-target



The residual phase error of the beamline has a "fixable" (repeatable) component.

Compression and transport errors are mitigated by vacuum DM

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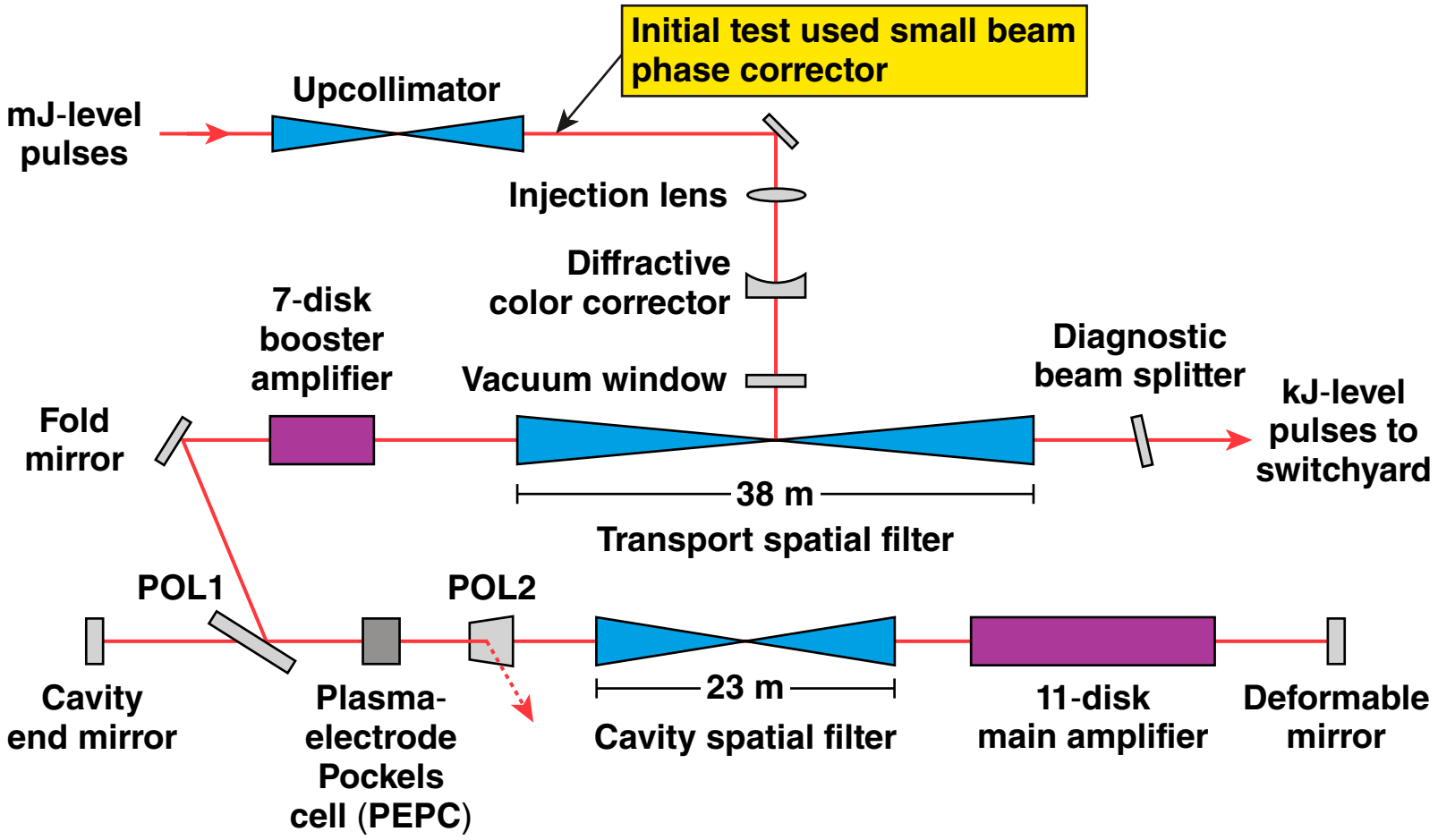
A static phase-correction technique was tested on one beam in Q1 FY11



Initial tests have shown that the static phase corrector improves wavefront performance.

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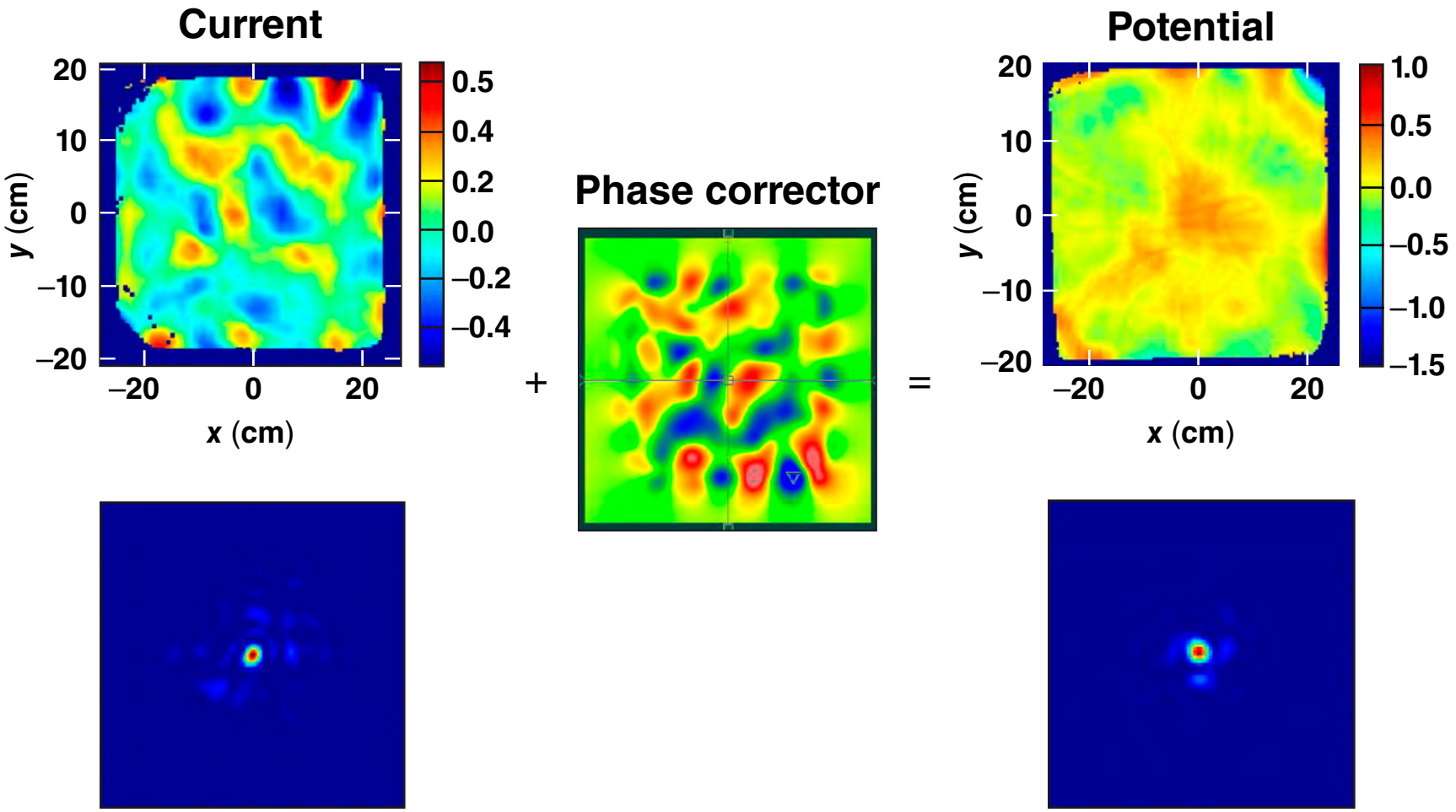
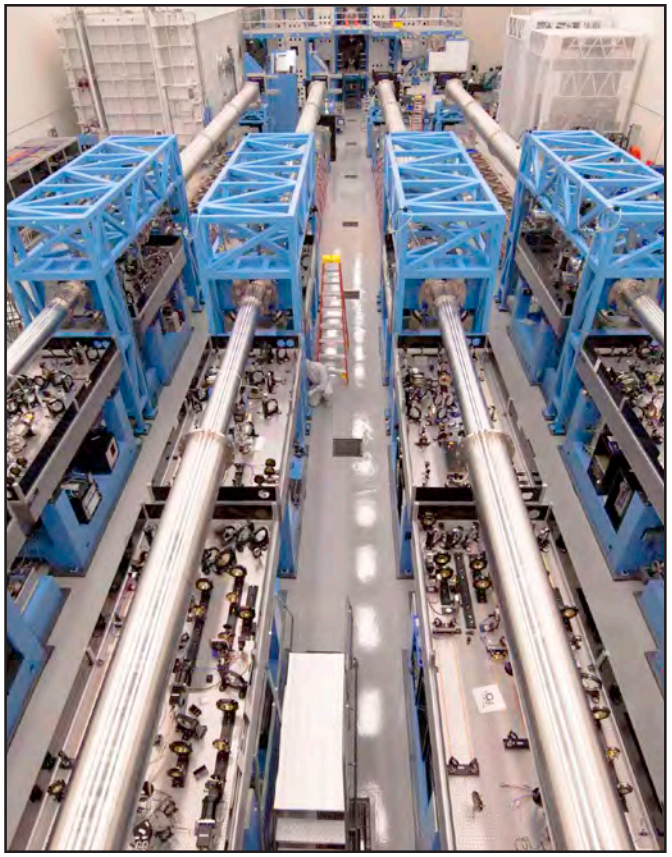
The spot size on target is expected to improve from $R_{80} \cong 25\ \mu m$ to $R_{80} < 20\ \mu m$



OMEGA EP System Science will report on details of this work.

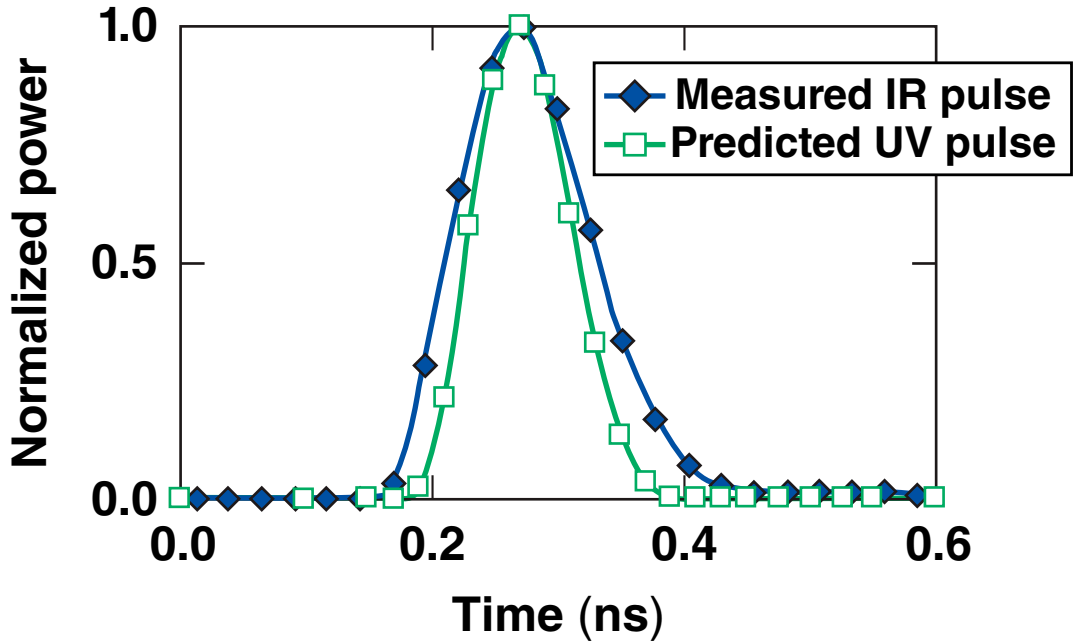
OMEGA EP beamline alignment and injection improvements have increased system performance and availability

- Spatial profile improvements allow for increased energy
  - improved imaging between the laser sources and beamlines
  - upgraded and additional diagnostics
- Short-pulse focus improvements will improve focus repeatability and on-target spot size
  - continue wavefront control system operation until closer to shot time
  - the static phase corrector is located in the new injection system
- Simultaneous laser sources and beamline alignment operations will further improve availability when implemented



OMEGA EP will offer subnanosecond UV pulses beginning in Q4 of FY11

- Initially, ~90-ps pulses will be offered with 100 J of UV energy on target
- 100-ps shots have been taken to the IR switchyard
- 100-ps UV tests will be conducted this quarter
- Variable pulse widths will be available in the future



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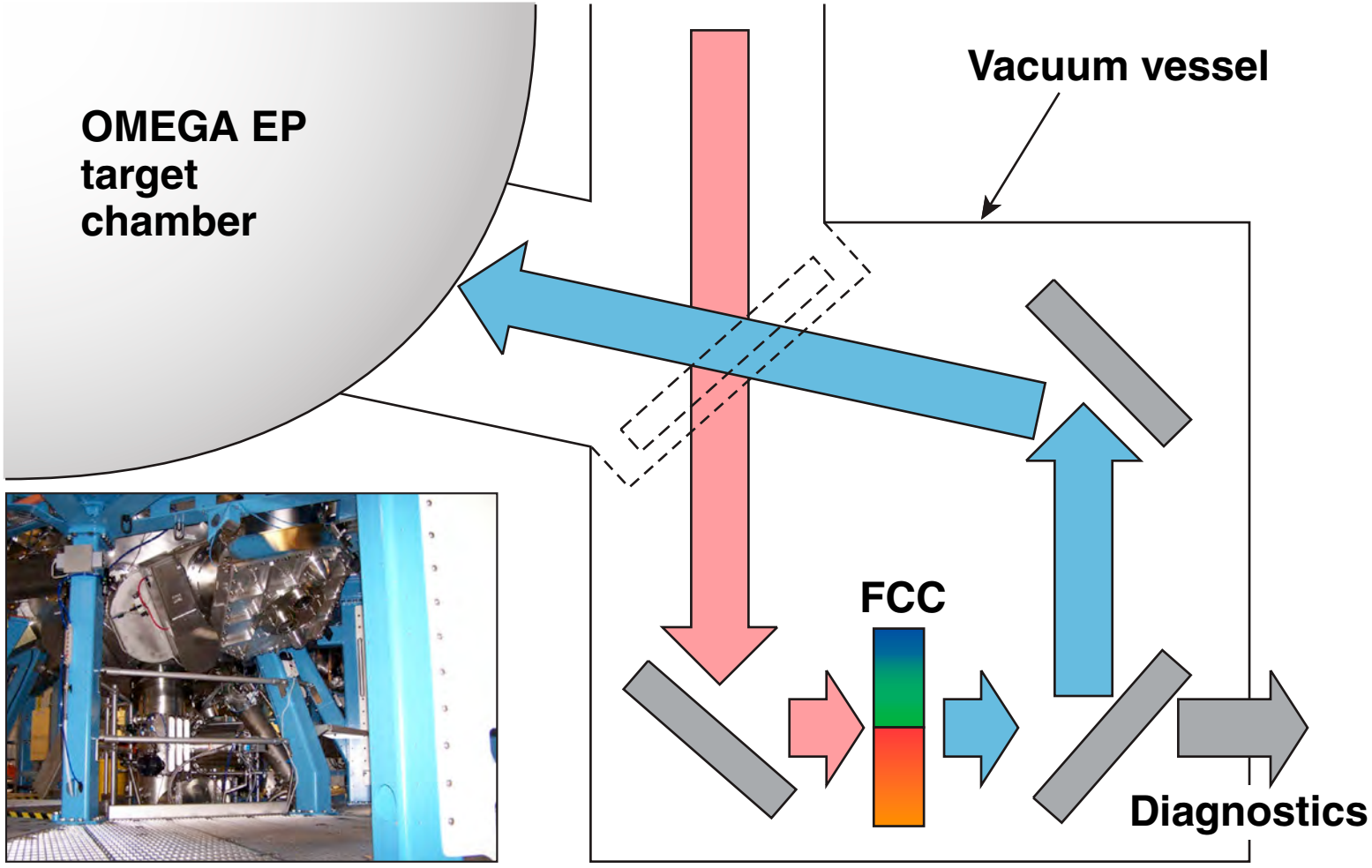
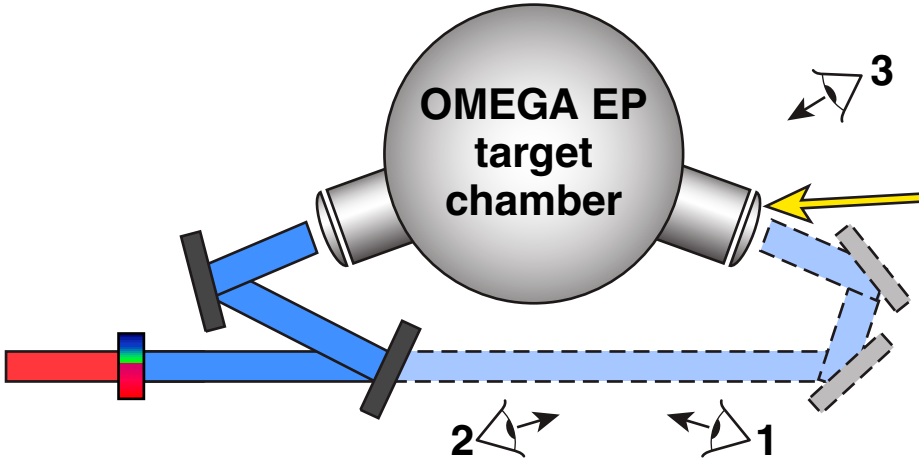
An FY13–FY17 project is being developed to support the OLUG request for short-pulse frequency conversion

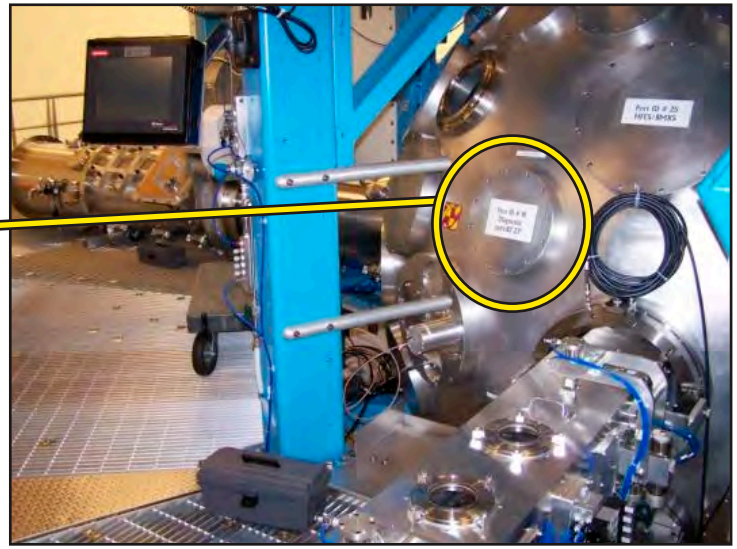


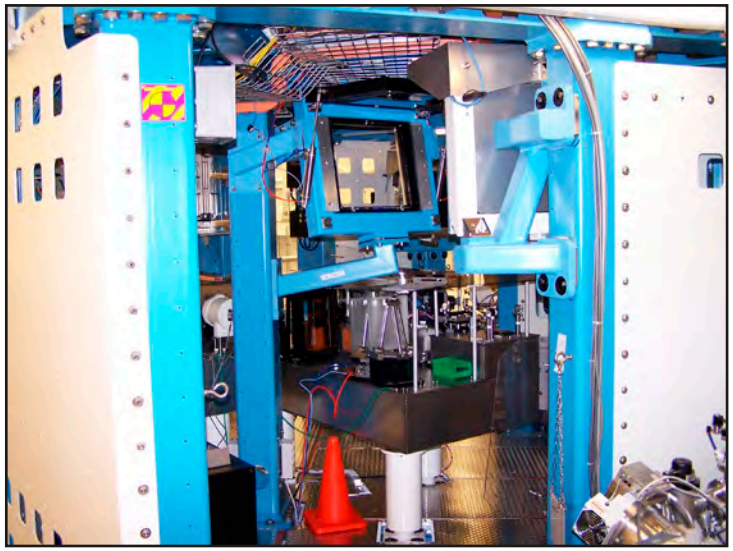
- A vacuum vessel containing frequency-conversion crystals will add $2\omega/3\omega$ capability to the OMEGA EP short pulse

An FY13–FY17 project is being developed to support the OLUG request for OMEGA EP UV configuration flexibility

UR LLE







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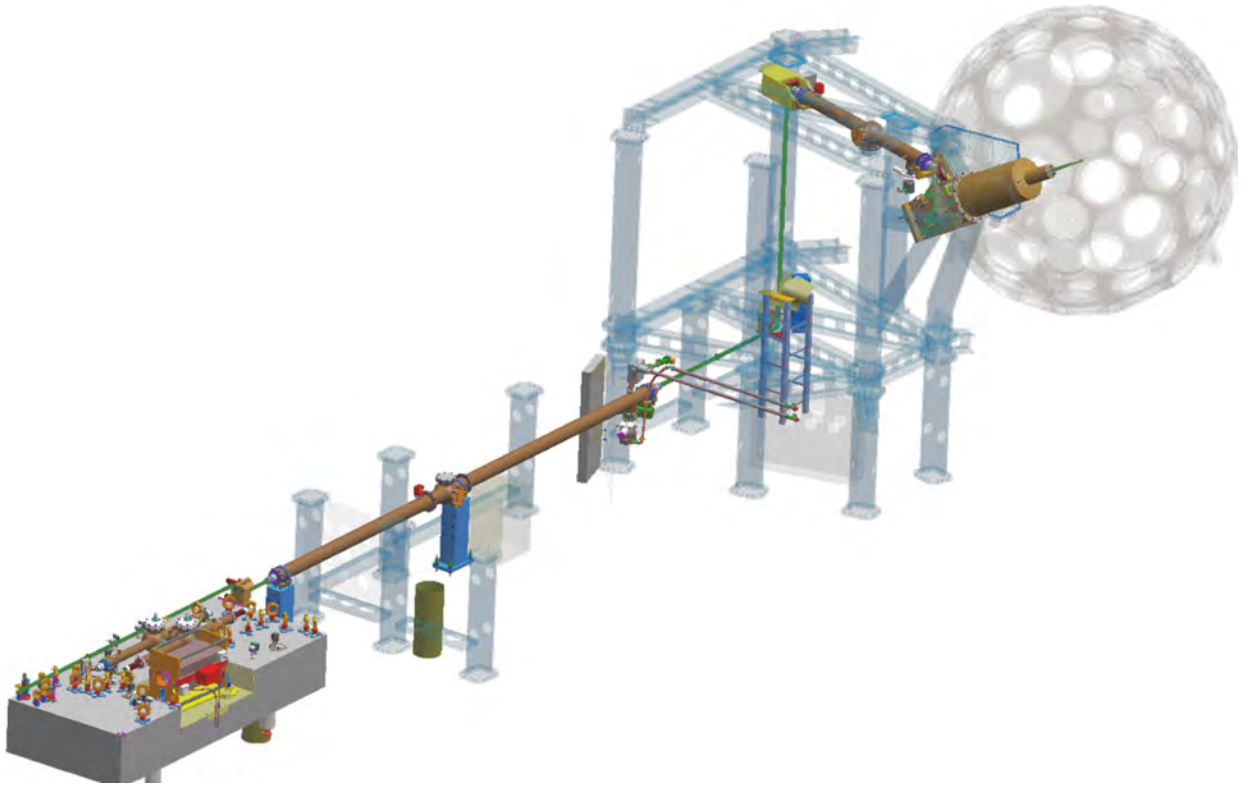
The fourth-harmonic probe laser is currently being activated



Fourth-harmonic probe status will be presented by D. Froula.

A Facility Information Technology (FIT) group was recently established to support improved information flow

- FIT focus is on developing new ways to access system information
- Consolidation of diverse information into a central repository
- Focused on supporting the findings and recommendations identified by the OLUG members and the Student/Postdoctoral Panel
- System status
- Diagnostic availability
- Laser configuration
- Sharing of information
- Ease of use

Summary/Conclusions

LLE management greatly appreciates OLUG's recommendations on priorities for the Omega Laser Facility

UR LLE

- The Omega Laser Facility Users Group (OLUG) is the largest user organization in HEDP – R. Petrasso (MIT) Chair
- The Omega Laser Facility Users Group held its second annual workshop 28–30 April 2010
- The OLUG report provides a number of recommendations
- LLE is actively exploring all of them
  - some need further definition—part of today's discussion

OLUG input and support makes the Omega Laser Facility a more effective User Facility.