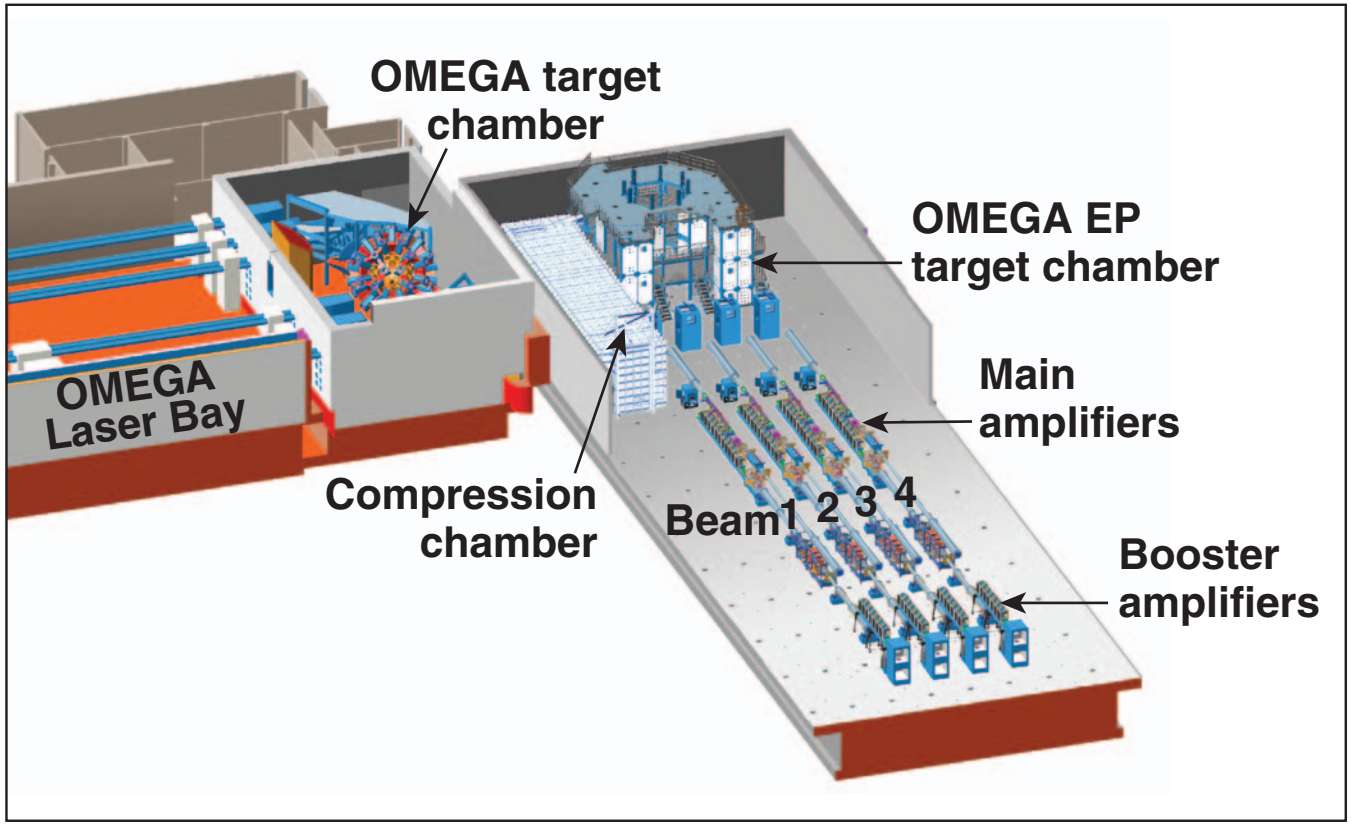
Omega Facility Update: Progress on OLUG Recommendations



S. F. B. Morse
Omega Facility Division Director
University of Rochester
Laboratory for Laser Energetics

Omega Laser Facility
Users' Group Workshop
Rochester, NY
25–27 April 2012

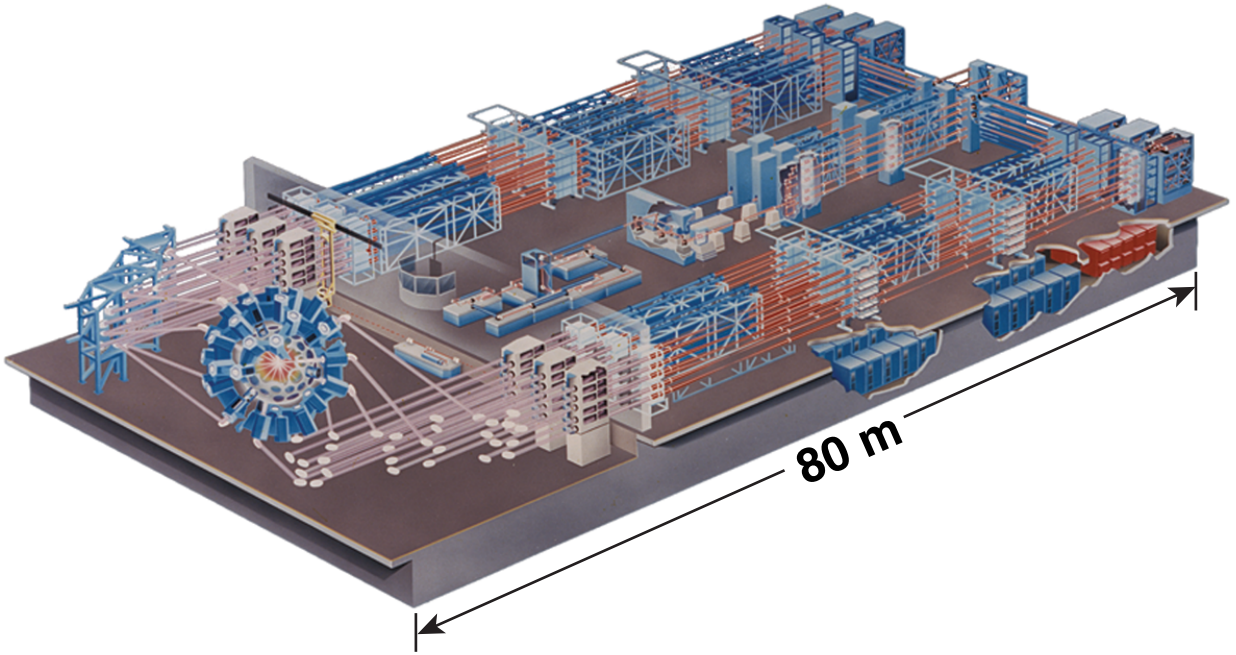
Summary

OLUG findings, recommendations, and endorsements influence priorities for facility improvements

- LLE is making progress on many OLUG initiatives
- Highlights of facility enhancements this year include
  - OMEGA spherical crystal imaging
  - Thomson-scattering spectrometer upgrade
  - magnetic-field platform development
  - OMEGA EP fourth-harmonic probe laser and diagnostics
  - OMEGA EP focal-spot improvements
  - OMEGA EP UV performance improvements

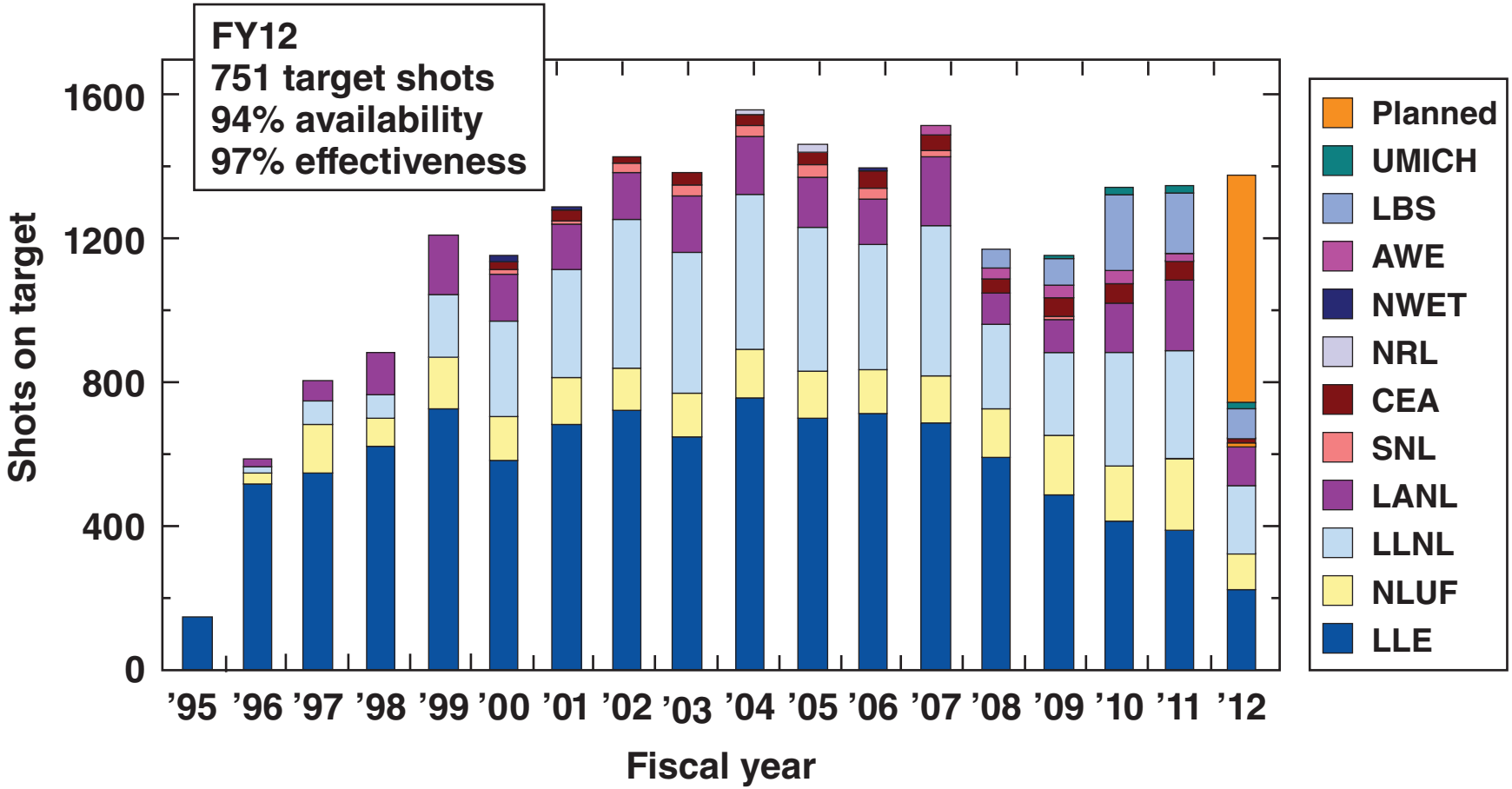
Omega Facility scientific productivity stems from liaisons with users.

The OMEGA laser achieves high uniformity with flexible pulse shaping and irradiation conditions



- 60-beam laser completed in 1995
- Up to 30-kJ UV on target
- 1% to 2% irradiation nonuniformity for spherical targets
- A project is underway to increase flexibility in the coupling of laser drivers to the A-split

OMEGA has performed 20,568 target shots to date and continues to serve high demand with ~1300 shots/year



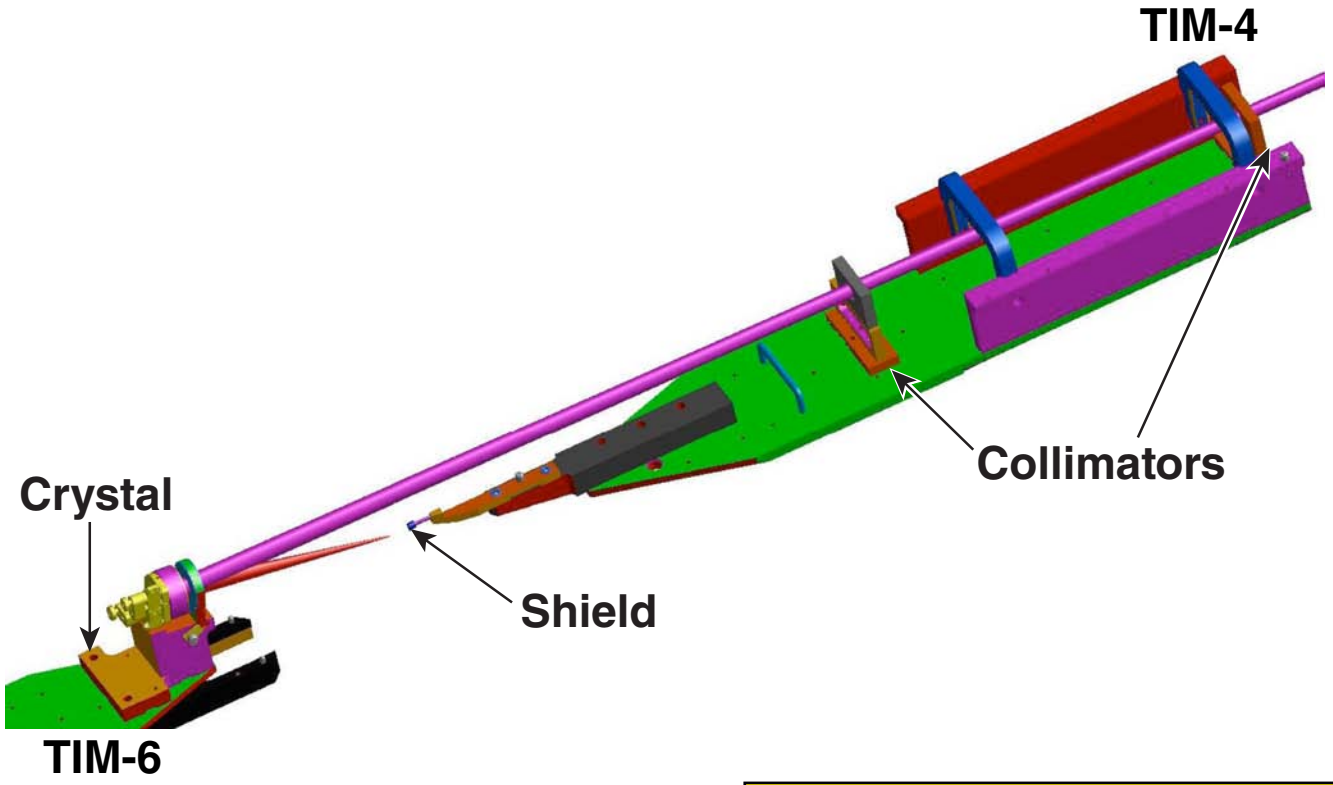
G9528

The OMEGA laser driver flexibility enhancement project is underway

- The OLUG user request for greater flexibility of laser-driver-to-beamline coupling is a large multi-year undertaking
- Smoothing by spectral dispersion (SSD) is desired in one of three legs, narrowband into the other two legs
- The reconfiguration project will allow the PI to select either laser source for each leg of OMEGA
- The pulse-generation room portion of the project is currently underway and will provide the first phase of improved backlighter performance in Q4 of FY12

A spherical crystal x-ray imaging diagnostic has successfully been migrated to OMEGA

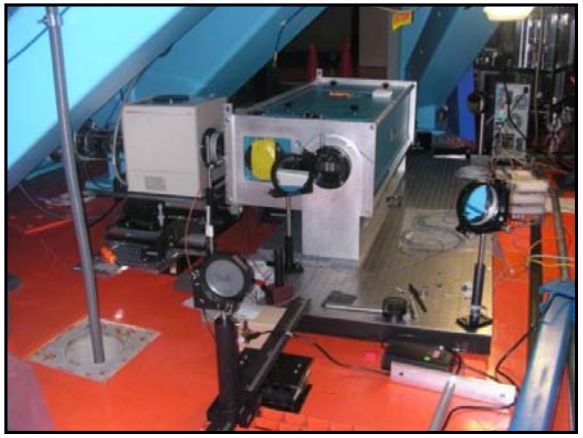
- Monochromatic at Cu K_α (~8 kev)
- Recently modified for Si He_α backlighting capability



See C. Stoeckl poster for details

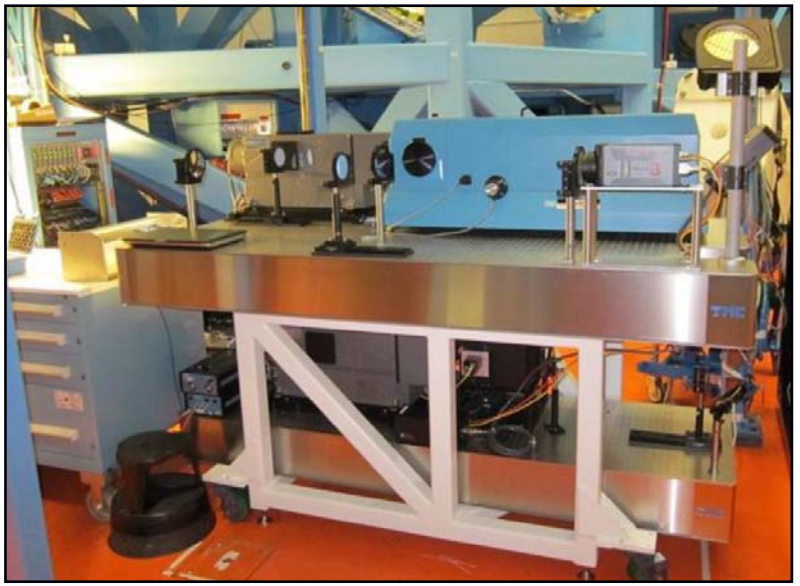
Thomson-scattering spectroscopy has been rebuilt by LLE as a facility diagnostic

First-generation LLNL diagnostic ~2003–2008 under the mirror structure



Second-generation LLNL diagnostic 2008–2011

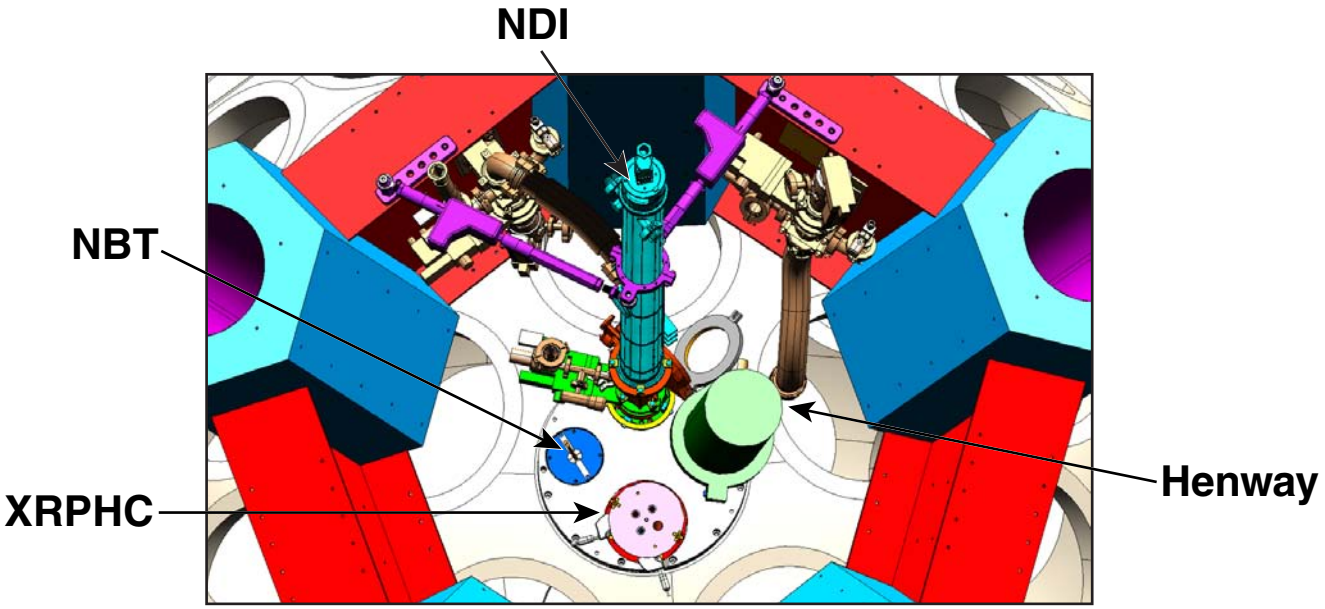
LLE Thompson-scattering diagnostic 2012



See J. Katz poster for details

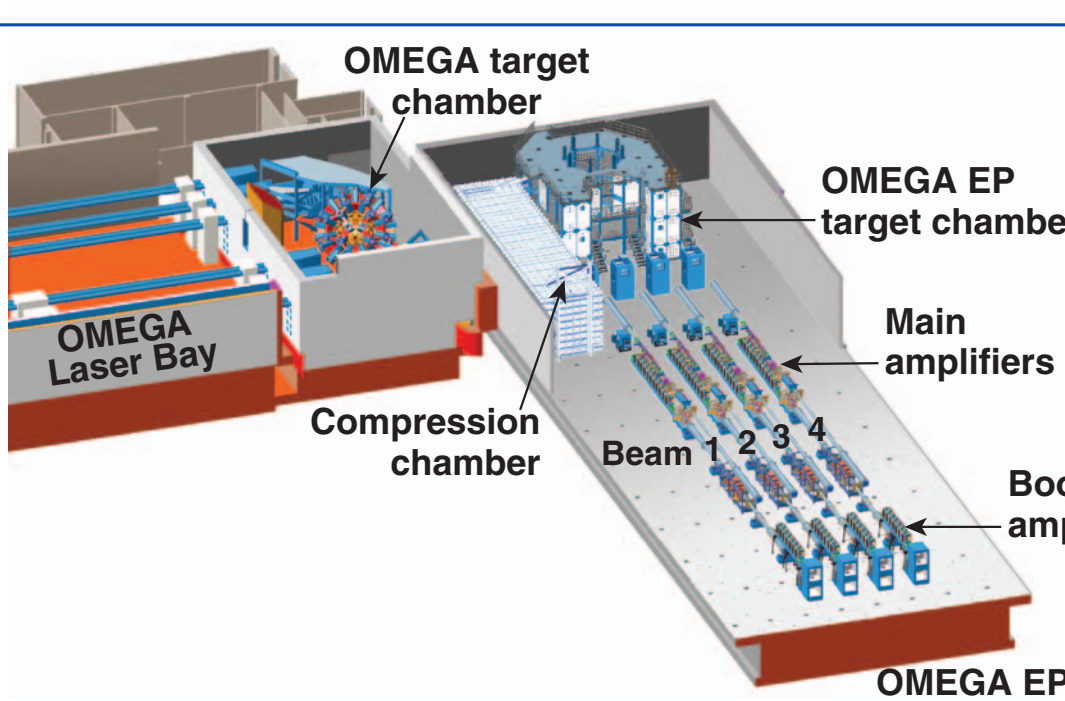
The OMEGA target chamber infrastructure continues to evolve with other new diagnostics and capabilities

- The latest chamber reconfiguration removed 14 diagnostics for new projects and vacuum performance improvement
- Port P2 is being reconfigured in Q3 FY12 to add another fixed x-ray pinhole camera (XRPHC), improve the Henway vacuum system, and add a nuclear diagnostic inserter (NDI) and bang-time detector (NBT)



See J. Puth poster for details.

OMEGA EP beamlines can be operated as short-pulse, high-energy petawatt at 1.0 μm or long-pulse at 0.35 μm



Design capabilities	Short-pulse Beam 2	Short-pulse Beam 1	Long pulse (any beam)	
Wavelength	Infrared (1.0 μm)	Infrared (1.0 μm)	UV (0.35 μm)	
Pulse width	1 to 100 ps	1 to 100 ps	1 ns	10 ns
Energy on target (kJ)	2.6 kJ, 10 to 100 ps grating limited <10 ps	2.6 kJ, 80 to 100 ps beam combiner limited <80 ps	2.5	6.5
Intensity (W/cm^2)	3×10^{20}	~2×10^{18}	3×10^{16}	8×10^{15}
Focusing (radius)	>80% in 20 μm	>80% in 40 μm	>80% in 100 μm	

Short-pulse beams can be directed to either OMEGA or the OMEGA EP target chamber.

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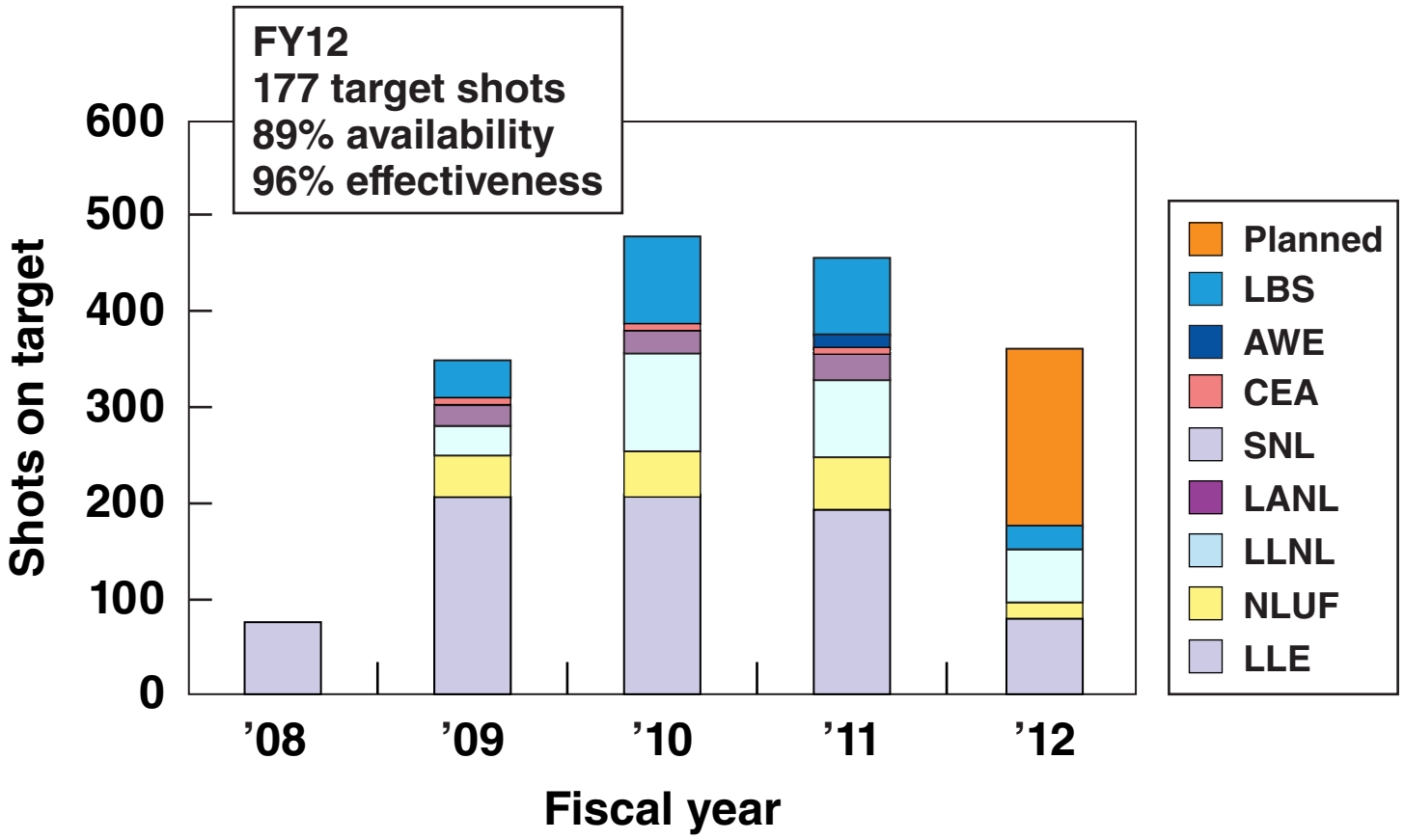
OMEGA EP has completed 1538 target shots and is also being used to test SSD for polar-drive ignition on the NIF

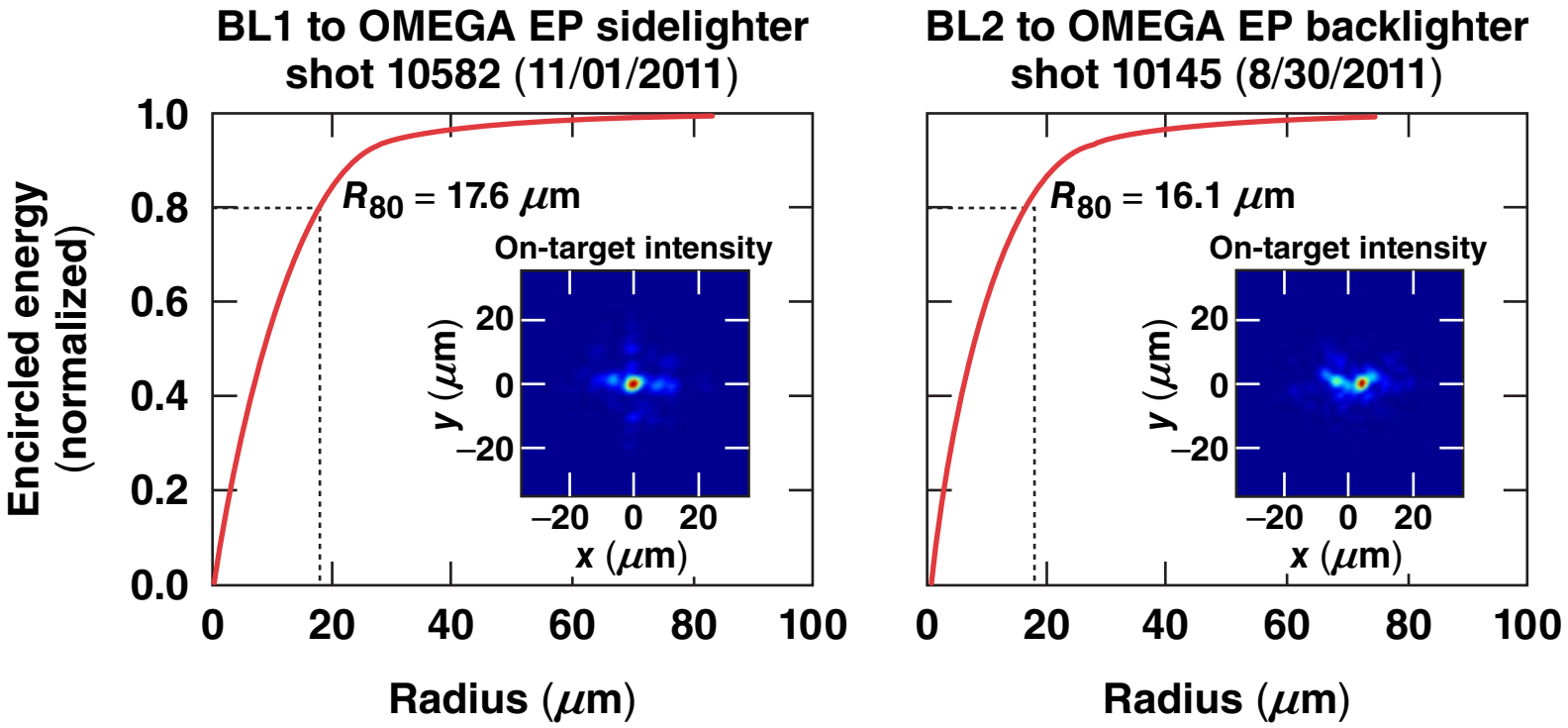


The first quarter of FY12 was used to deploy and demonstrate Multi-FM SSD beam smoothing.

OMEGA EP is a platform where many OLUG and LLE priorities are being advanced

- Short-pulse capability
  - focal-spot improvements
  - energy on target
  - prepulse contrast
  - beam combination
- Polar-drive ignition
  - Multi-FM beam smoothing
  - equivalent-target-plane diagnostic
- Fourth-harmonic probe laser and diagnostics
- Ultraviolet performance

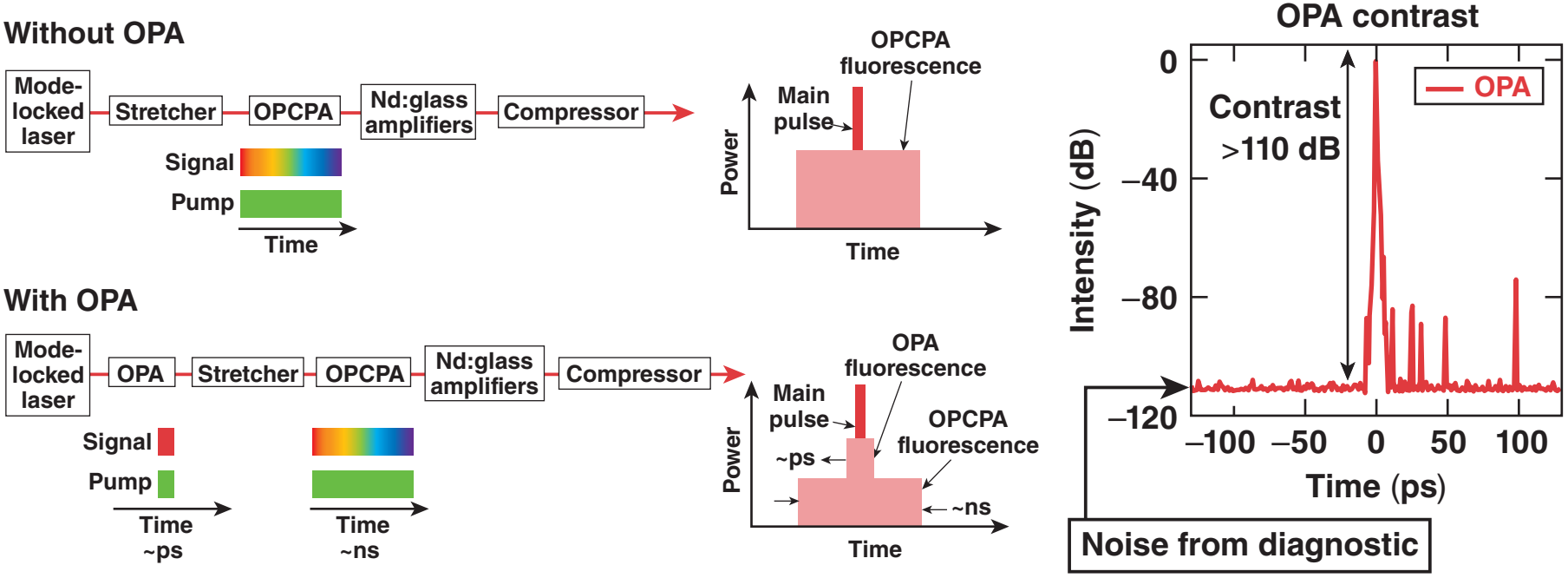
The OMEGA EP short-pulse focal spot has met the specification $R_{80} < 20\ \mu m$ with recent improvements



Future work will improve repeatability through wavefront correction right up to shot time.

See D. Canning poster for details.

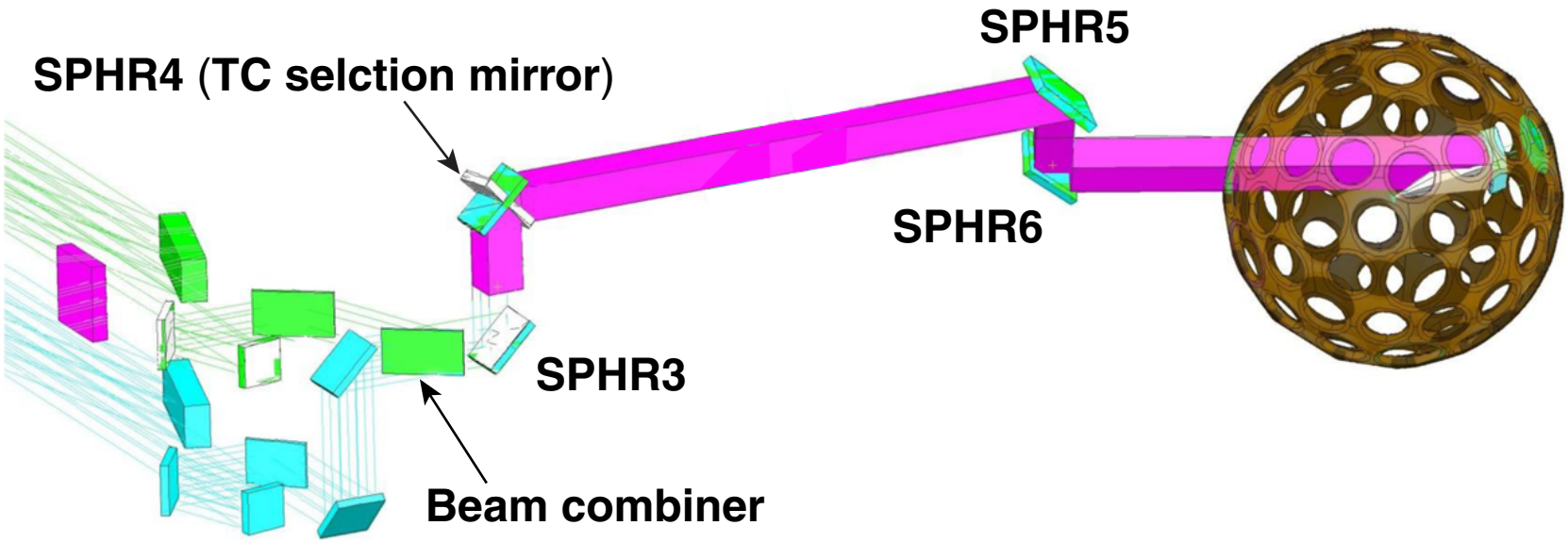
Parametric gain provided by a short pulse OPA will generate a clean high-energy seed for OMEGA EP



- A high-contrast, high-energy seed reduces the required gain in the nanosecond OPCPA stages
  - nanosecond fluorescence is reduced
  - picosecond fluorescence remains only on the time scale of the gain of the short-pulse OPA
- Will be installed in FY12

C. Dorrer, PI

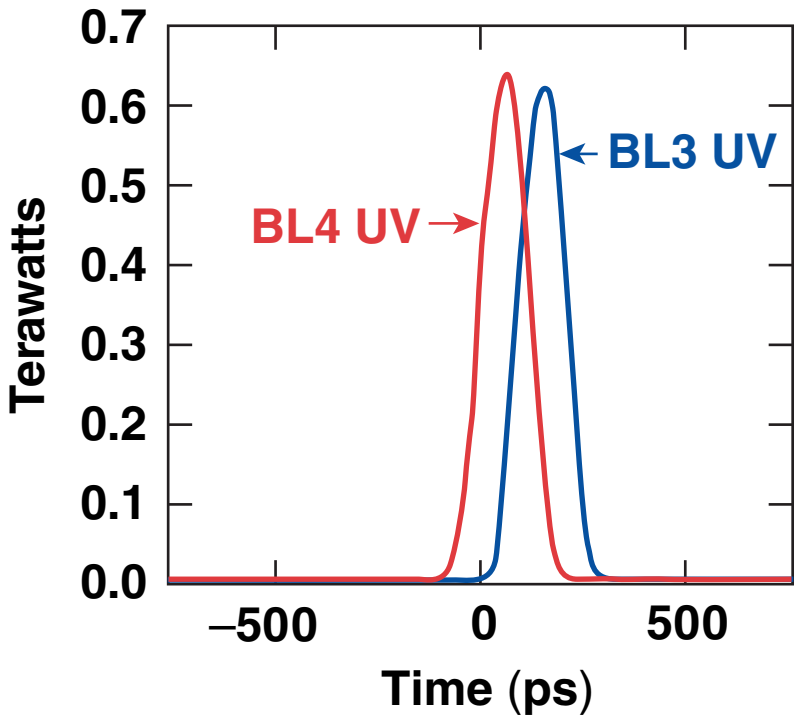
The beam-combiner optic was installed in FY11; procedures and characterization are in development



- The beam-combiner optic was installed in September 2011
- Alignment techniques, focal-spot characterization, and operational details preceding use of the capability will be completed in FY12

In FY11, OMEGA EP added 100-ps UV pulse-shape capability

- This capability was developed on the UV beams in May 2011
- 100-ps UV pulses produce short-duration x-ray pulses
- X-ray diagnostics are used to deterministically co-time the beams
- The UV ROSS streak camera is the reference for timing for all UV shots



An updated energy table is available on the OMEGA EP Operations website

UR LLE

OMEGA EP Performance Envelope descriptive values*

Revision date: 02/21/12

Short Pulse (IR)		Beam				
On target energy	Pulselength	1 (current)	1 (full spec)	2 (current)	2 (full spec)	Notes
No Disposable Debris Shield	0.7 ps	50 J	700 J	400 J	700 J	
	10 ps	850 J	2600 J	1500 J	2600 J	
	100 ps	1000 J	2600 J	2000 J	2600 J	

Note: Beam 1 is also known as the "Sidelighter" or alternatively the "Lower Compressor"
Beam 2 is the "Backlighter" (OMEGA EP or OMEGA) or the "Upper Compressor"

Short Pulse (IR)		Beam				
On target energy	Pulselength	1 (current)	1 (full spec)	2 (current)	2 (full spec)	Notes
With Disposable Debris Shield	0.7 ps	50 J	50 J	50 J	50 J	
	10 ps	810 J	850 J	850 J	850 J	
	100 ps	1000 J	2600J	1500 J	2600 J	

Long Pulse UV		Beam				
On target energy	Pulselength	1 (current)	2 (current)	3 (current)	4 (current)	Any Beam (full spec)
Square pulse shape values	100 ps	100 J	100 J	100 J	100 J	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	3100 J	5000 J
	10 ns	3000 J	3000 J	4000 J	4000 J	6500 J

*** DISCLAIMERS:**

The values represented in this chart are most recent estimates for near term (current) energy maximum values and are subject to change without advance notice.

Long pulse values shown are for nominal "square" pulse shapes, other pulse shapes require system modeling.

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Many LLE-driven system improvements stem from plans to explore polar-drive ignition (PD) on the NIF

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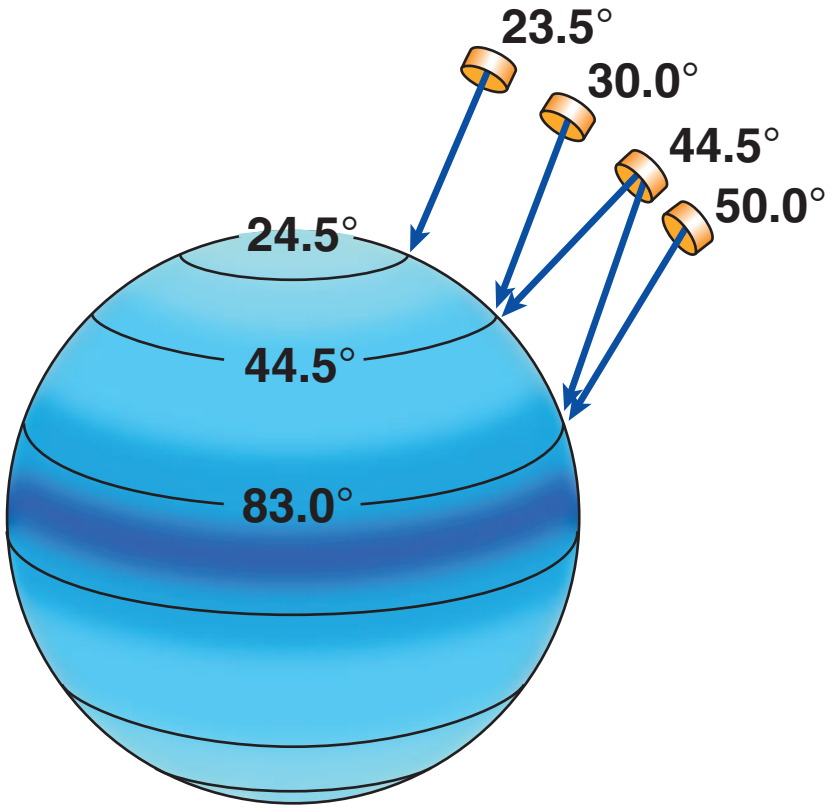
Repointing for PD on the NIF



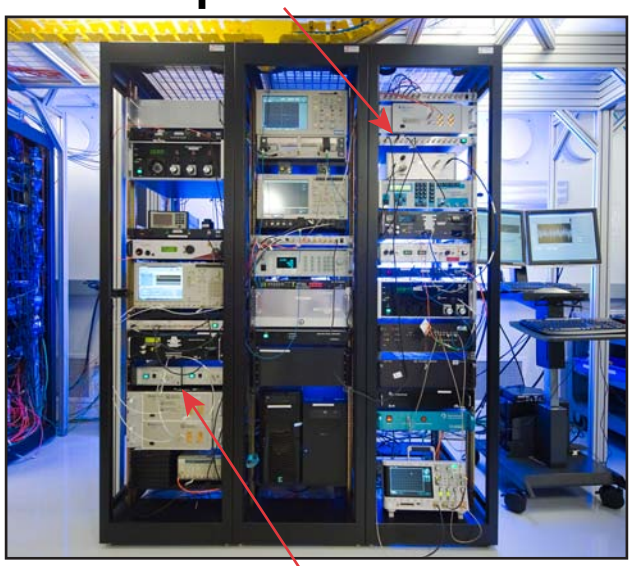
- ~300 shots have been taken on OMEGA in the polar-drive configuration
  - symmetry studies
  - validation simulations
- New phase plates are on order to improve polar-drive uniformity
- Multi-FM SSD beam smoothing is being tested on OMEGA EP and is proposed for the NIF

Uniform target drive with PD irradiation requires increased intensity at the equator and high-performance beam smoothing.

TC9532g

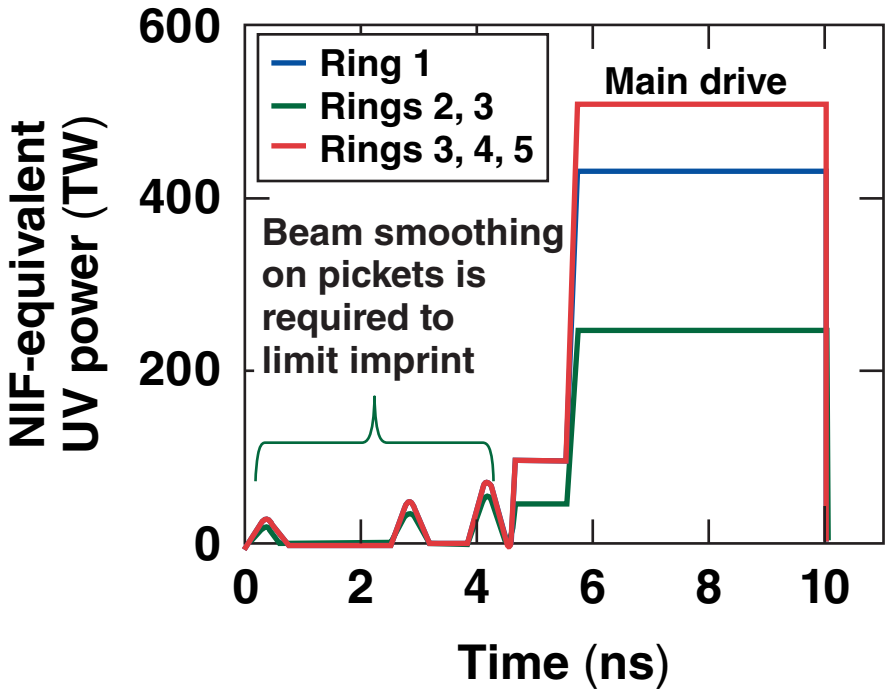
The Multi-FM system has been installed on OMEGA EP and used to demonstrate picket smoothing

Main pulse rack



Picket pulse rack

Triple-picket PD pulse shapes



- Improved beam smoothing over what is currently available on the NIF is required for the picket portion of the polar-drive pulse shapes
- The system is constrained to Beam-4 through the OMEGA EP preamplifier module (PAM) and is not used for routine operations at this time

G9536

A demonstration on OMEGA EP has validated Multi-FM beam smoothing concepts for polar-drive NIF experiments

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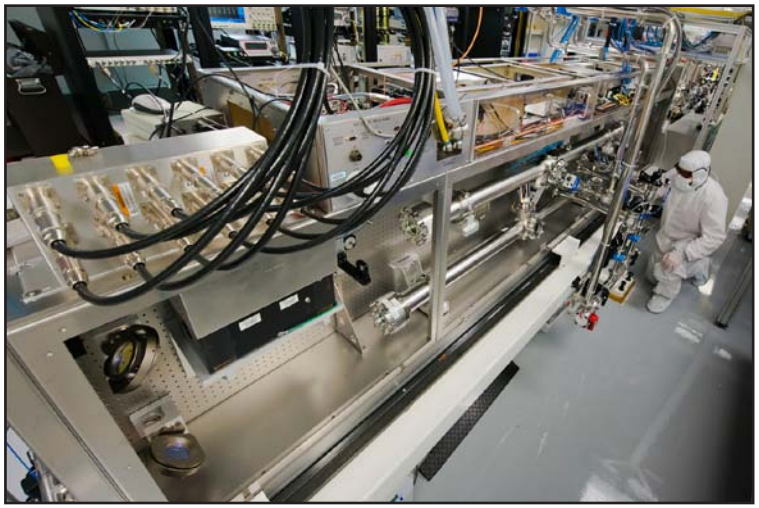
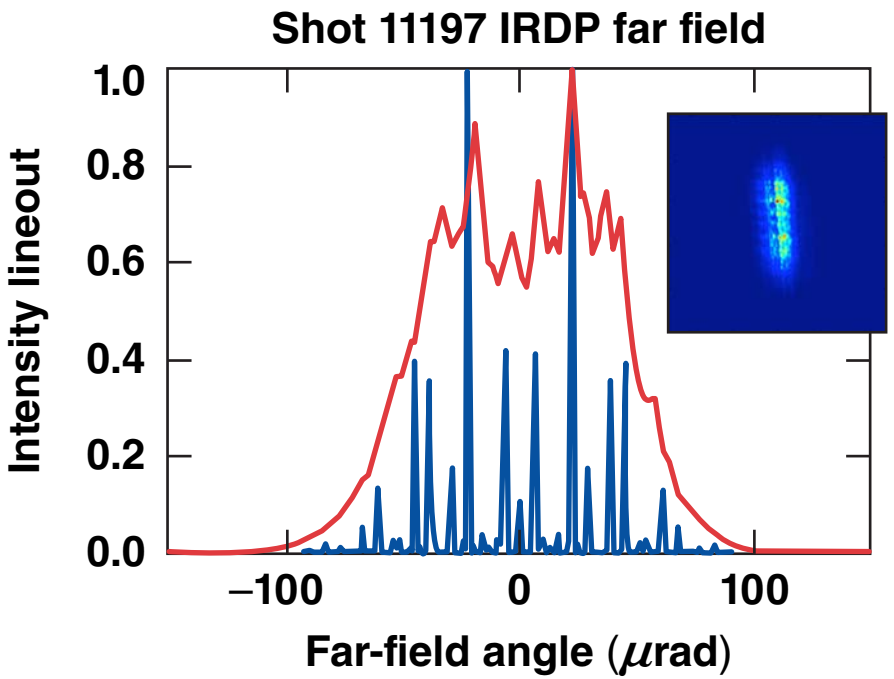
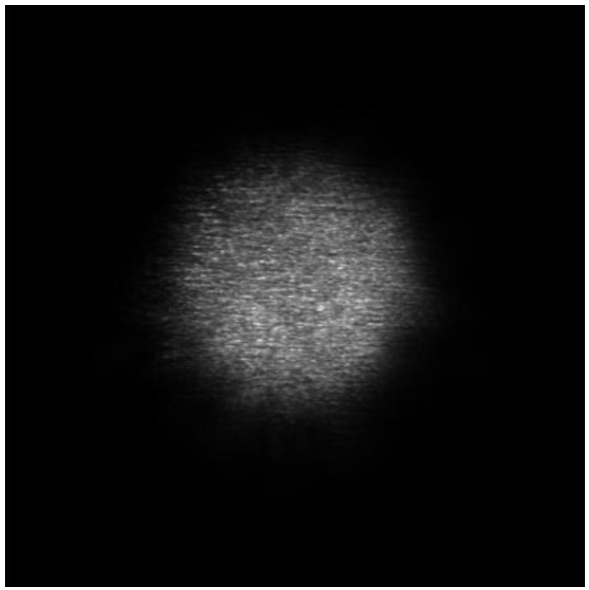
- A NIF PAM has been integrated into the OMEGA EP Beam-4 front end



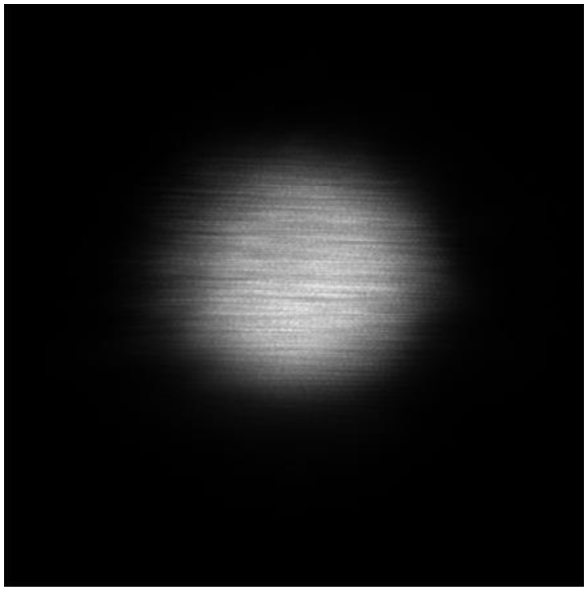
- Multi-FM seed-source spectrum meets requirements



Equivalent-target-plane images were acquired on OMEGA EP with Multi-FM and a 1.1-mm distributed phase plate (DPP) on 26 January

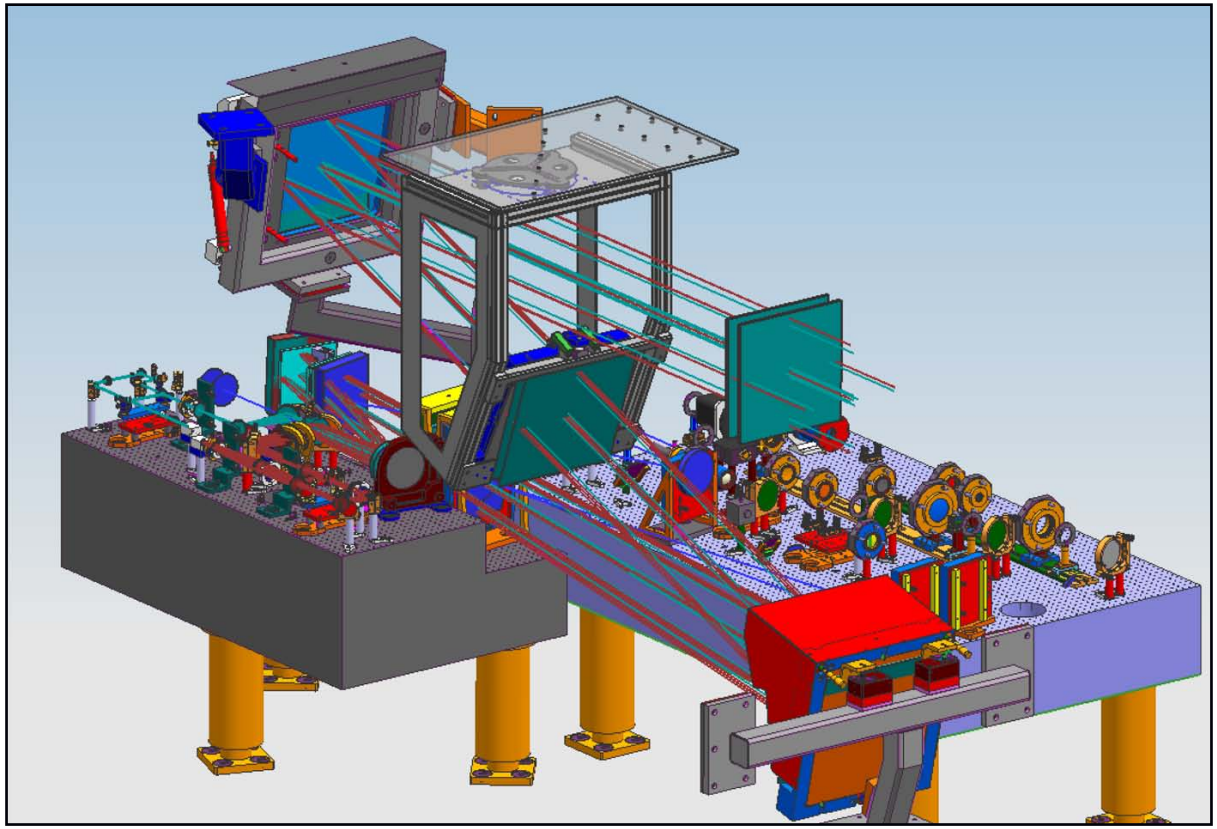


Shot 11212 without Multi-FM



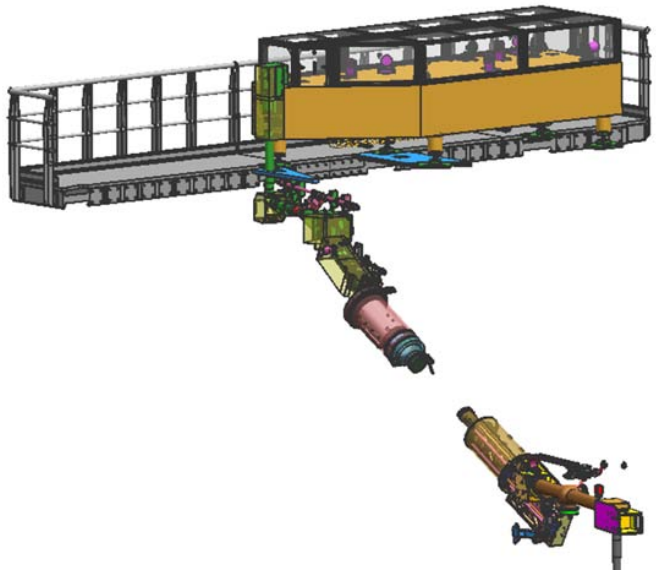
Shot 11214 with Multi-FM

A phase-plate holder in the UV diagnostic table beam path allows equivalent-target-plane (ETP) image acquisition



ETP images are being collected and will be available soon.

The fourth-harmonic probe laser and instrument package is a major effort on OMEGA EP

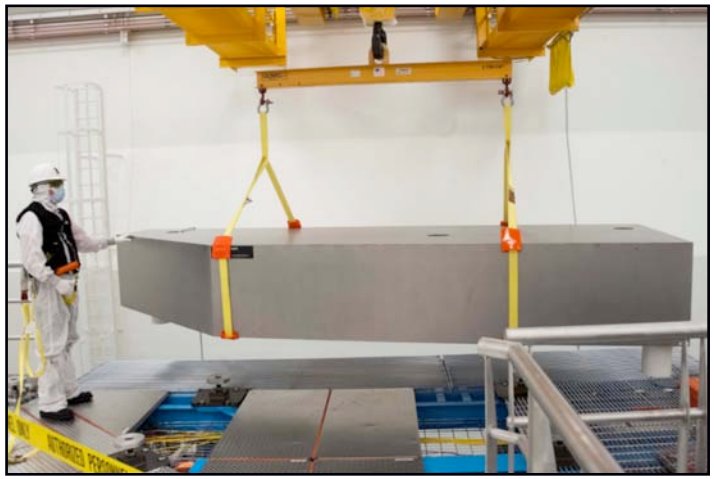


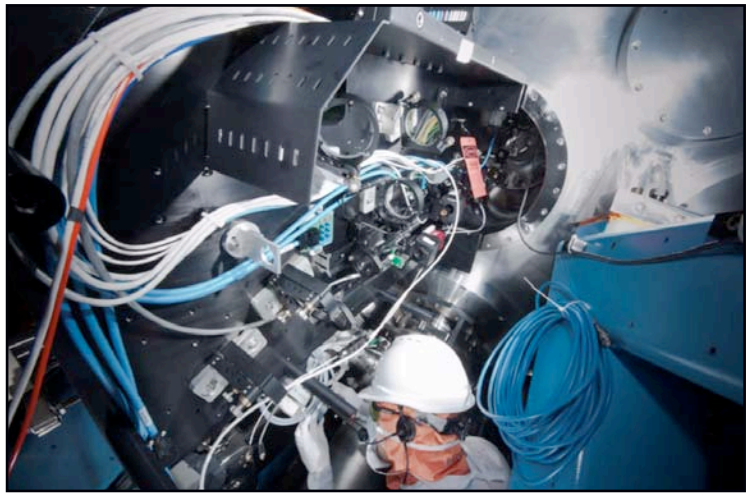
See D. Froula poster for details.

	05/01/2012	06/01/2012	07/01/2012	08/01/2012	09/01/2012	10/01/2012	11/01/2012	12/01/2012	01/01/2013
Fourth-harmonic beam to frequency conversion table	★								
Diagnostic alignment and optimization		———	———	———	★				
Fourth-harmonic probe system initial readiness initial activation and calibration target shots					★	———	———	★	
Fourth-harmonic probe online as facility diagnostic									★

G9540

Fourth-harmonic probe beam hardware is installed on the OMEGA EP target chamber

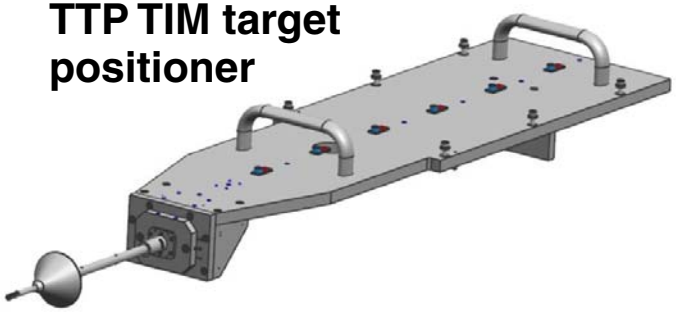




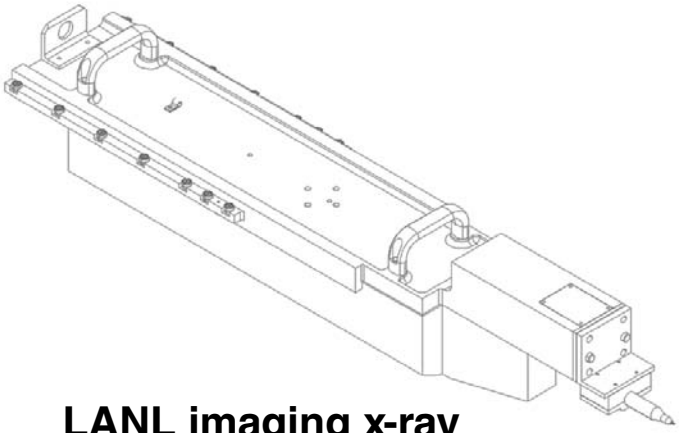
G9541

The OMEGA and OMEGA EP diagnostic inventory growth continues

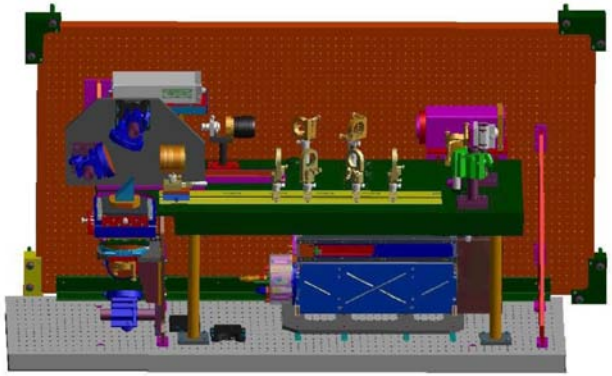
TTP TIM target positioner



Streaked x-ray spectrometer



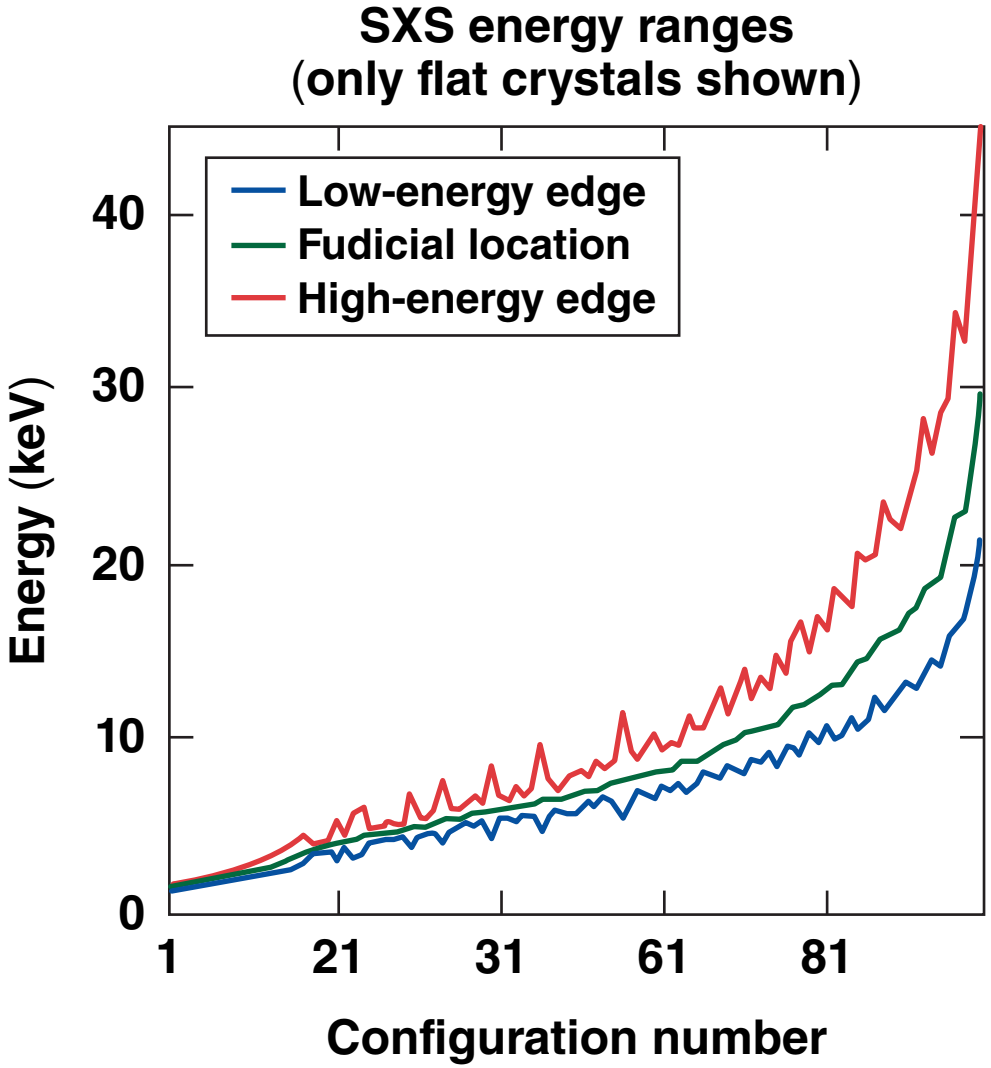
LANL imaging x-ray Thomson spectrometer (IXRTS)



Streaked optical pyrometer ROSS

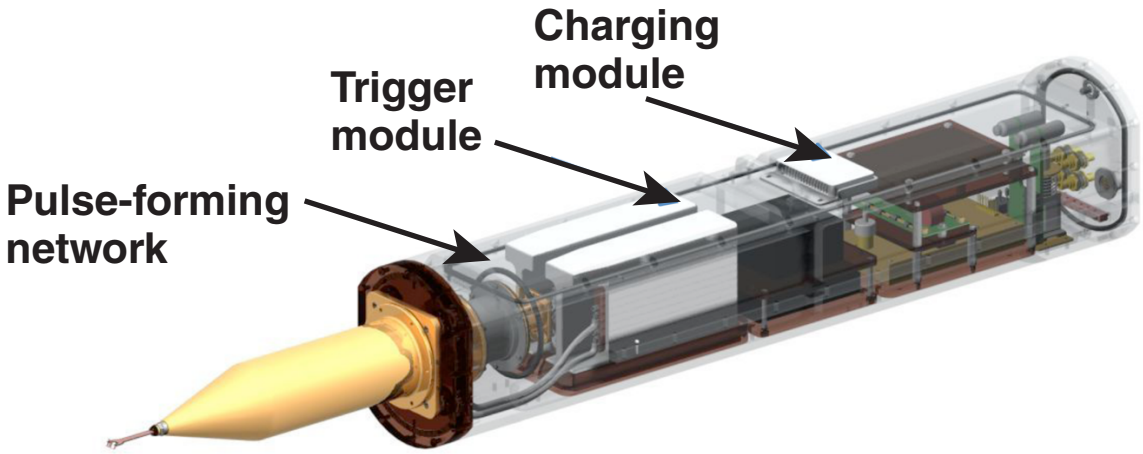
See C. Sorce poster for details.

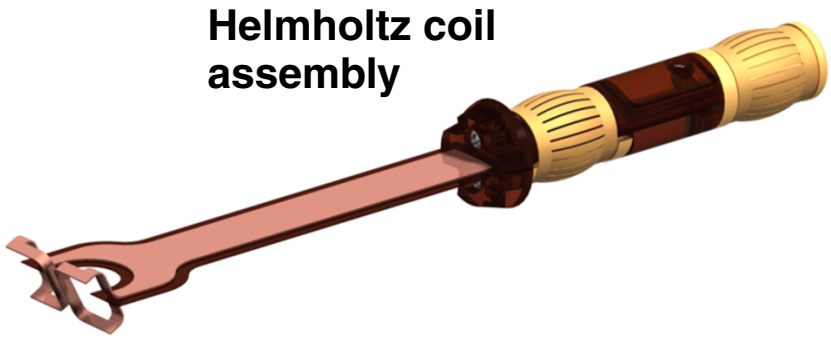
The streaked x-ray spectrometer (SXS) uses four crystals and 25 positions to achieve 100 configurations



G9543

The MIFEDS field generator will be replaced in FY13 with 50-kA peak current capability and reduced jitter





See G. Fiksel poster for details.

LLE organization has evolved to better serve Omega users

- Management team
  - S. Morse, Omega Facility Division Director
  - J. Puth, Omega Operations Manager
  - S. Stagnitto, OMEGA Laser Facility Manager
  - D. Canning, OMEGA EP Laser Facility Manager

- System scientists
  - J. Kelly, OMEGA Lead
  - T. Kosc, OMEGA
  - B. Kruschwitz, OMEGA EP Lead
  - M. Barczys, OMEGA EP
  - M. Guardalben, OMEGA EP
  - L. Waxer, OMEGA EP
  - J. Qiao, OMEGA EP

- Group leaders
  - E. Hill, Laser Driver Ops
  - R. Kidder, Informatics
  - M. Moore, Beamlines
  - G. Pien, Experimental Ops
  - T. Smith, Amplifiers

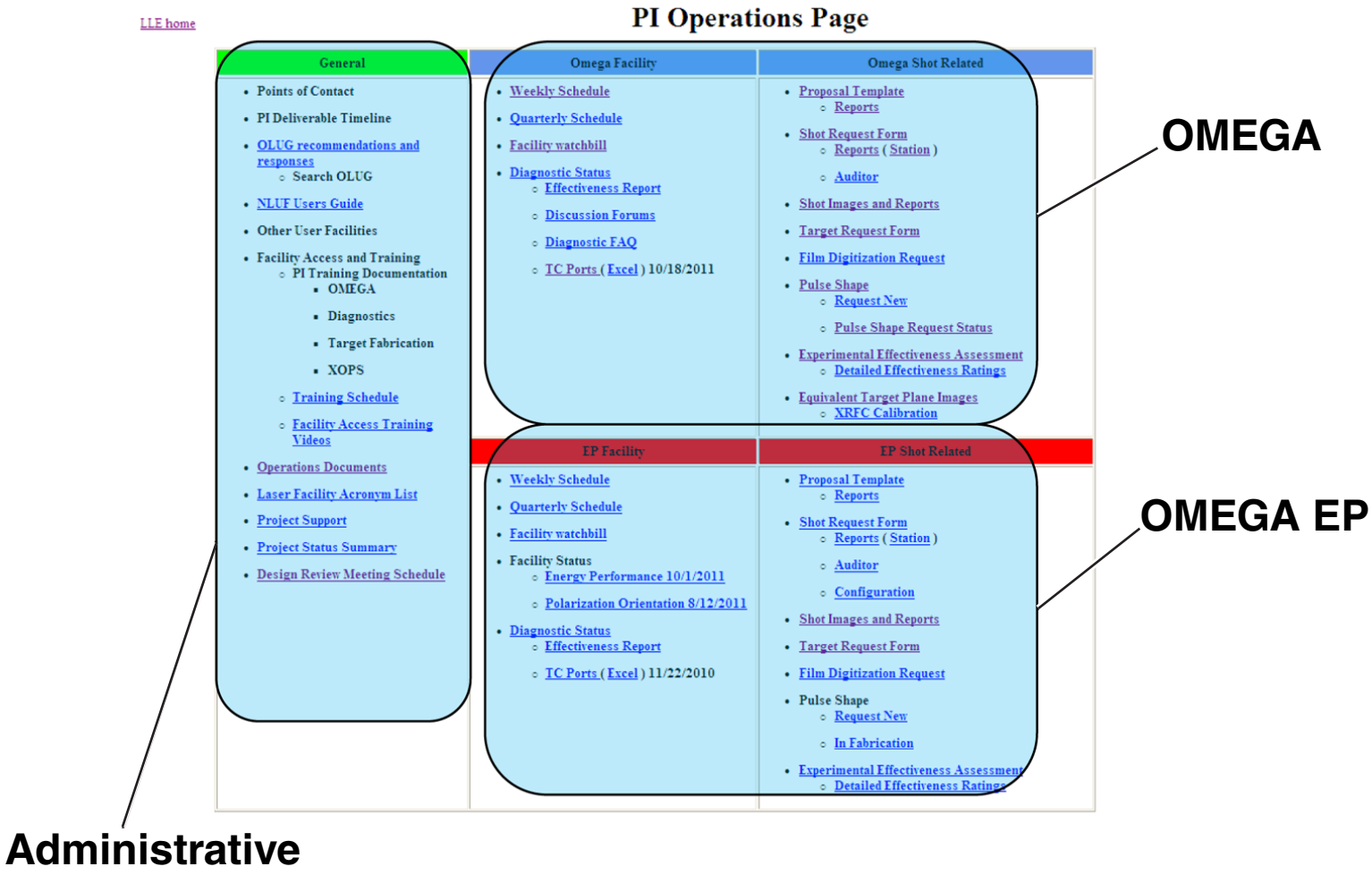
Two groups have grown out of OLUG recommendations to facilitate effective experiments

- Informatics, R. Kidder—addresses information management concerns
  - Principal Investigator interface improvements
  - Laser and diagnostic control system architecture oversight
- April ’09 OLUG request

“The role that Chuck Sorce plays in LLNL experimental campaigns as a link between scientists (PI’s) and facility engineers and technicians has been noted and praised by many users not involved in LLNL campaigns. It was suggested at the workshop that it would be useful to have a similar resource person to perform that task for all experimental campaigns.”

Chuck Sorce now has a staff of eight and heads up the Experimental Support Group.

A PI "portal" that consolidates information access needed to conduct OMEGA shots is nearing completion



Many OLUG information requests are located here.

Summary/Conclusions

OLUG findings, recommendations, and endorsements influence priorities for facility improvements

UR LLE

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- Highlights of facility enhancements this year include
  - OMEGA spherical crystal imaging
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