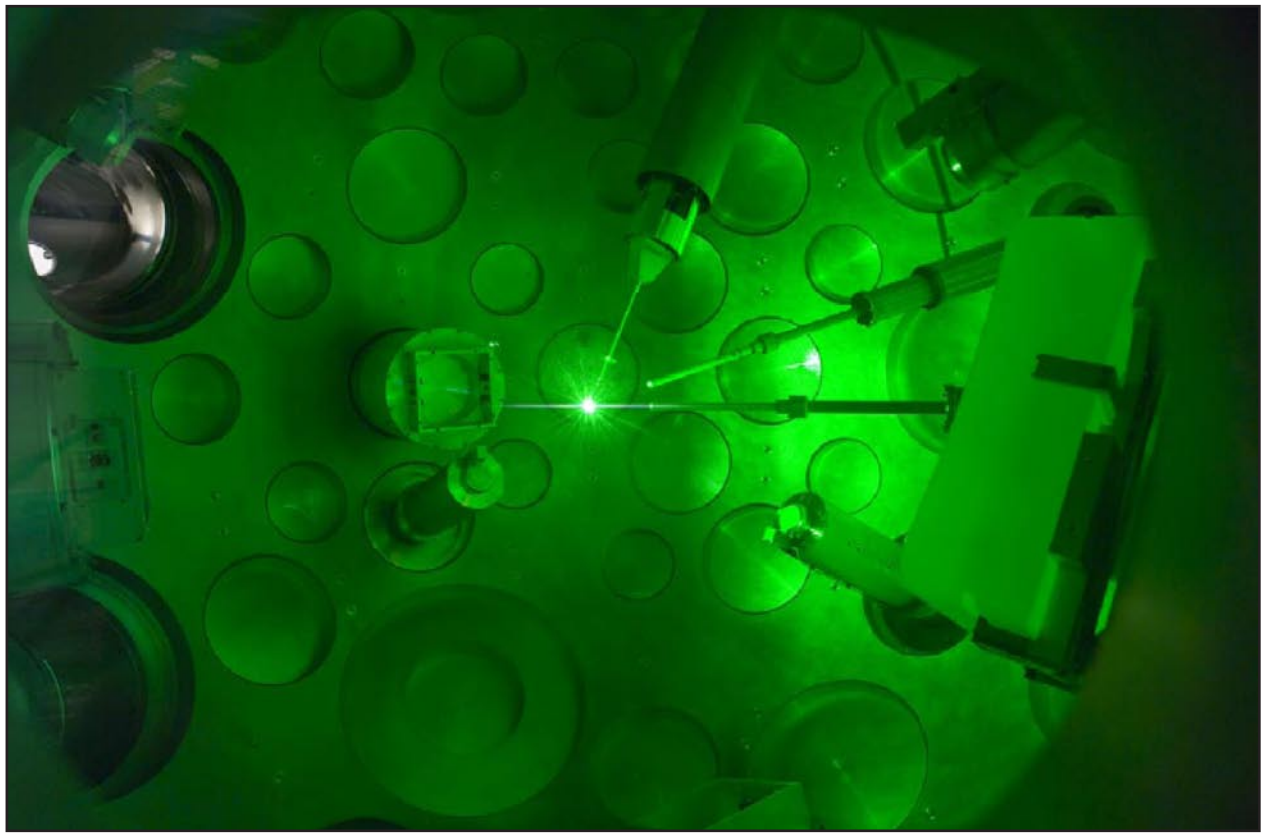
Status of the OMEGA EP Laser System



T. C. Sangster
University of Rochester
Laboratory for Laser Energetics

38th Annual Anomalous
Absorption Conference
Williamsburg, VA
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Summary

The OMEGA/OMEGA EP Laser System is a unique HED research platform

UR LLE

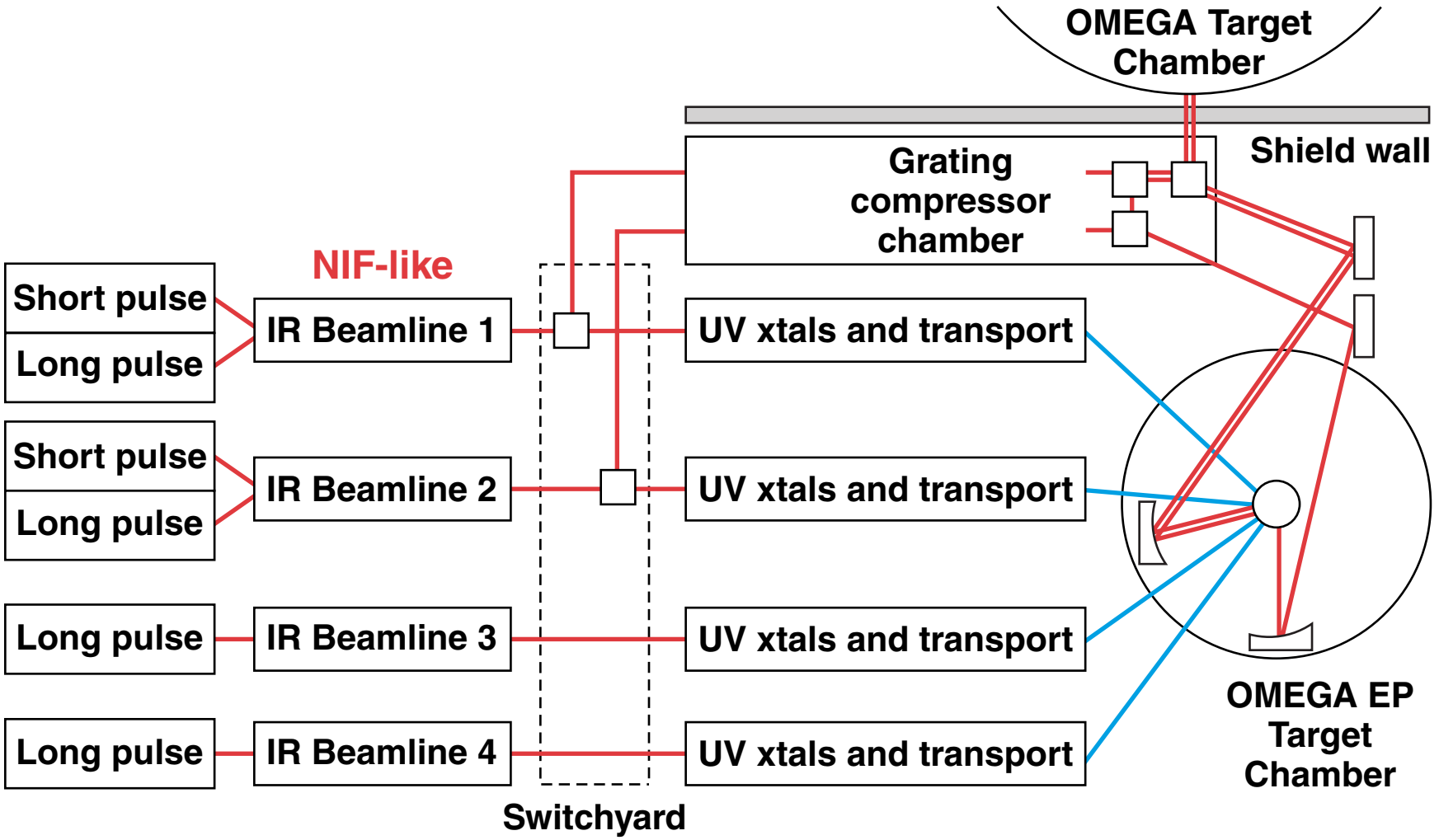
- The OMEGA EP project was completed in April 2008.
- Many of the essential diagnostics identified during a series of OMEGA EP users workshops will be available by the start of operations in October.
- A set of near-term experiments is planned during the summer as the facility performance continues to ramp to design goals.
- Approximately 25% of the shot time available for basic science.

The combined OMEGA/OMEGA EP Laser System will allow a wider variety of high-energy-density physics experiments

UR LLE

- Significant advances in radiographic capabilities for HED experiments
- Development of diagnostics and diagnostic techniques for the NIF
- Studies of the fast-ignition concepts
- Additional precision HED physics experiments
- Studies of ultrahigh-intensity laser–matter interactions
- Optimizing the use of the NIF through platform development

The OMEGA EP architecture is based on multi-configurable beam paths



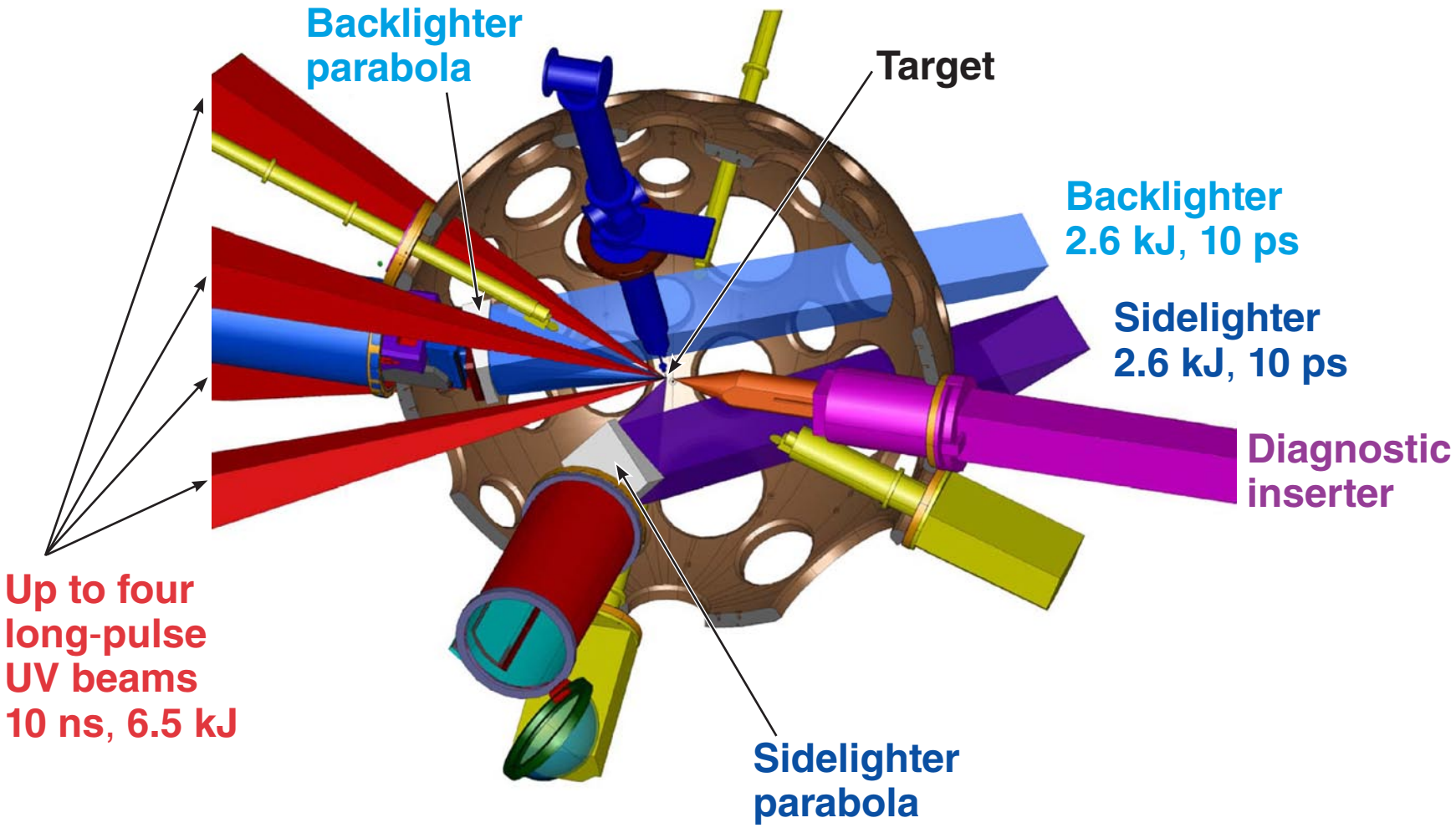
G7791

OMEGA EP will achieve its missions using a variety of on-target intensities and pulse durations

Performance capabilities	Short-pulse beam 1		Short-pulse beam 2		Long-pulse beams 1–4	
Target chamber	Ω or EP		Ω or EP		EP	
Pulse width	1–10 ps	10–100 ps	1–80 ps	80–100 ps	1 ns	10 ns
Energy on target (kJ)	1–2.6 (grating limited)	2.6	0.03–2.6 (combiner limited)	2.6	2.5	6.5
Intensity (W/cm^2)	3×10^{20}	8×10^{19}	2×10^{18}		3×10^{16}	8×10^{15}
Focusing (diam)	>80% in 20 μm		>80% in 40 μm		>80% in 100 μm	
Wavelength (nm)	1053		1053		351	

G5546bb

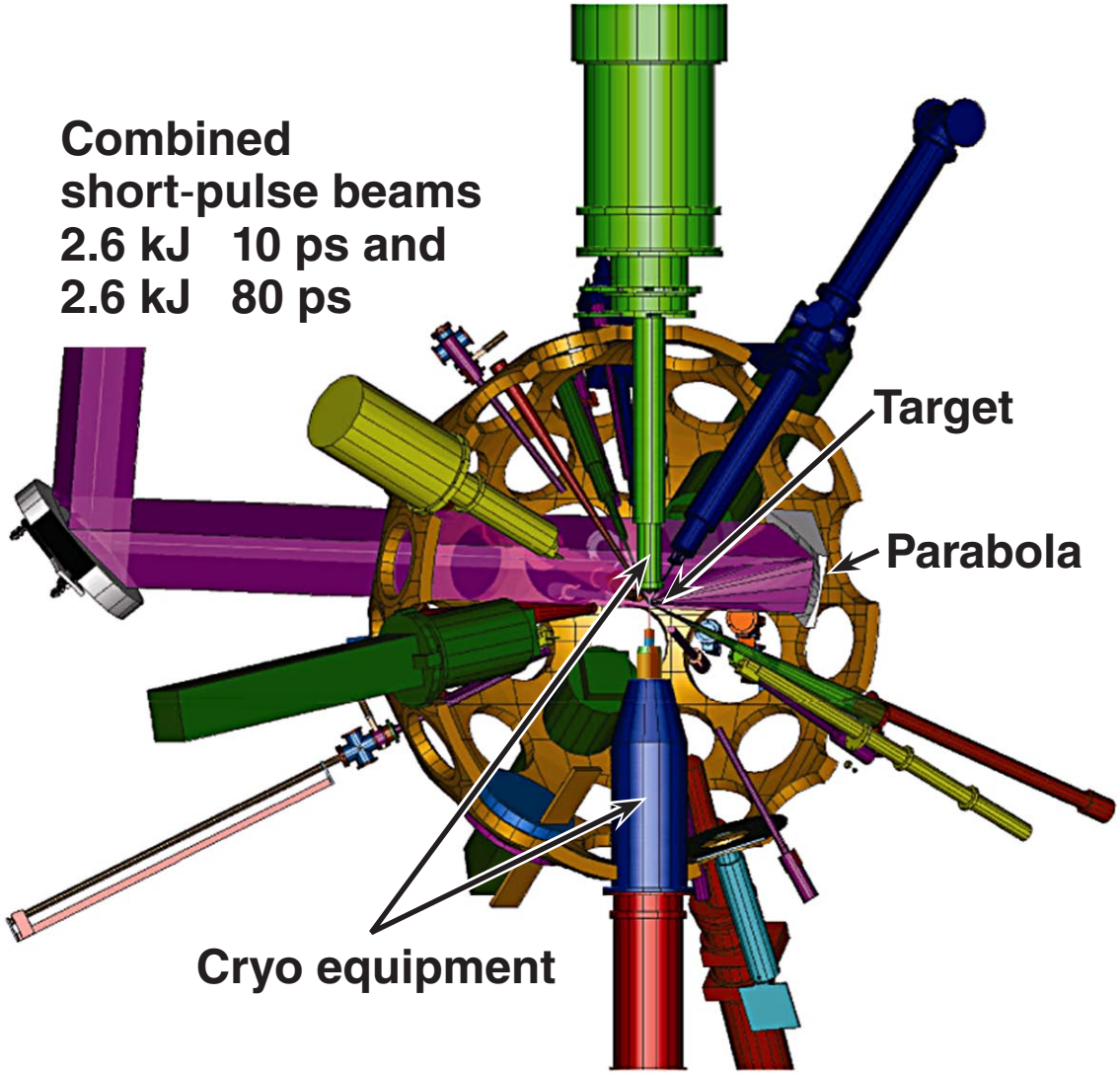
Simultaneous sidelighting and backlighting will be possible in the new OMEGA EP target chamber



E15300

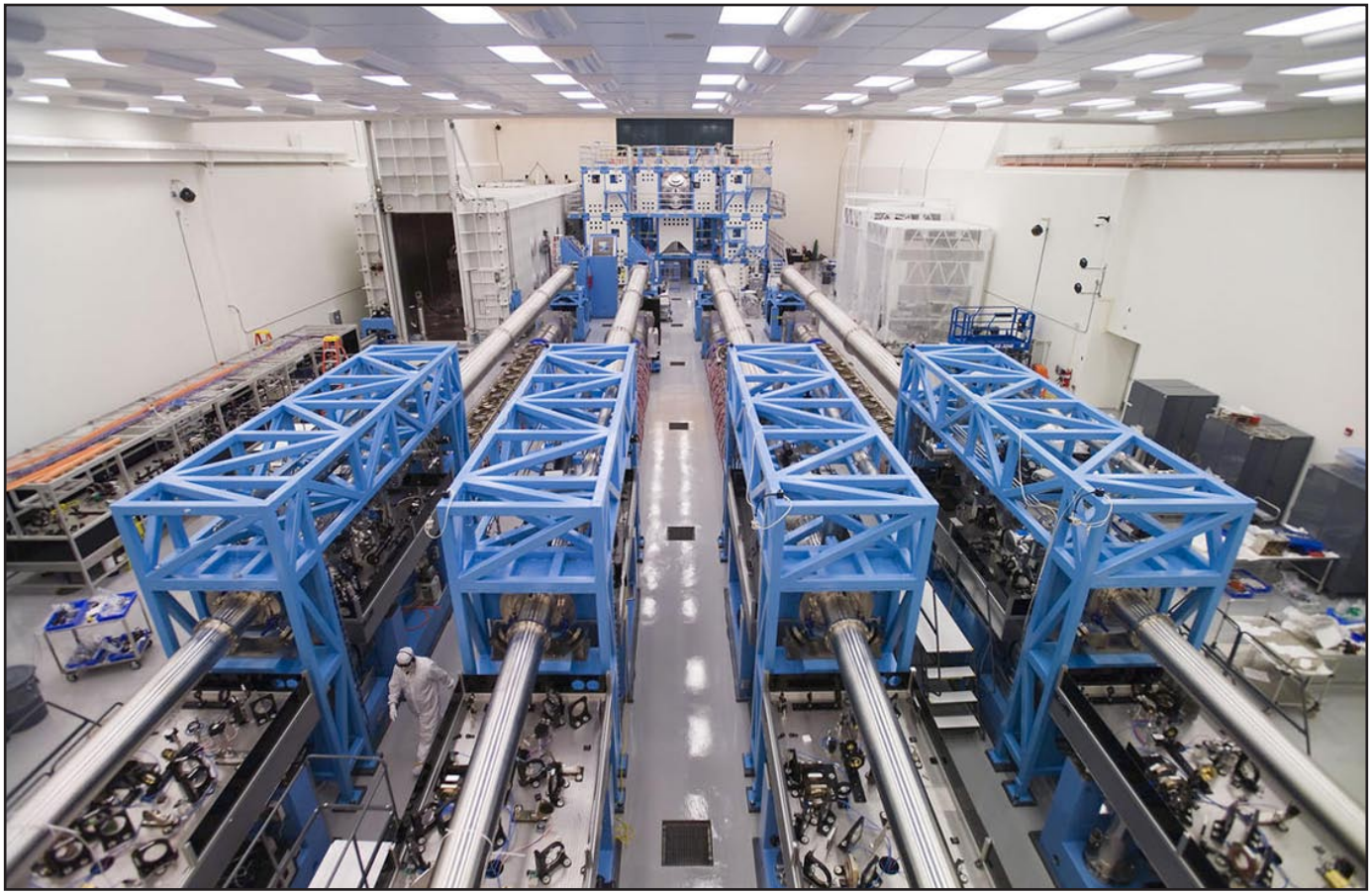
The beams from OMEGA EP will be focused with a 23° *f*/2 off-axis parabola inside the OMEGA target chamber

- A fast-focusing optic is necessary to meet the 20-μm-diam focal-spot requirement
- Pointing requirement in OMEGA: 20-μm rms
- 2-h shot cycle (in either chamber)



E13316d

OMEGA EP was completed on 25 April 2008—on schedule and on budget



OMEGA EP significantly advances NNSA's User Facility capabilities.

OMEGA EP met most of its completion criteria

UR LLE

OMEGA EP performance to the OMEGA target chamber

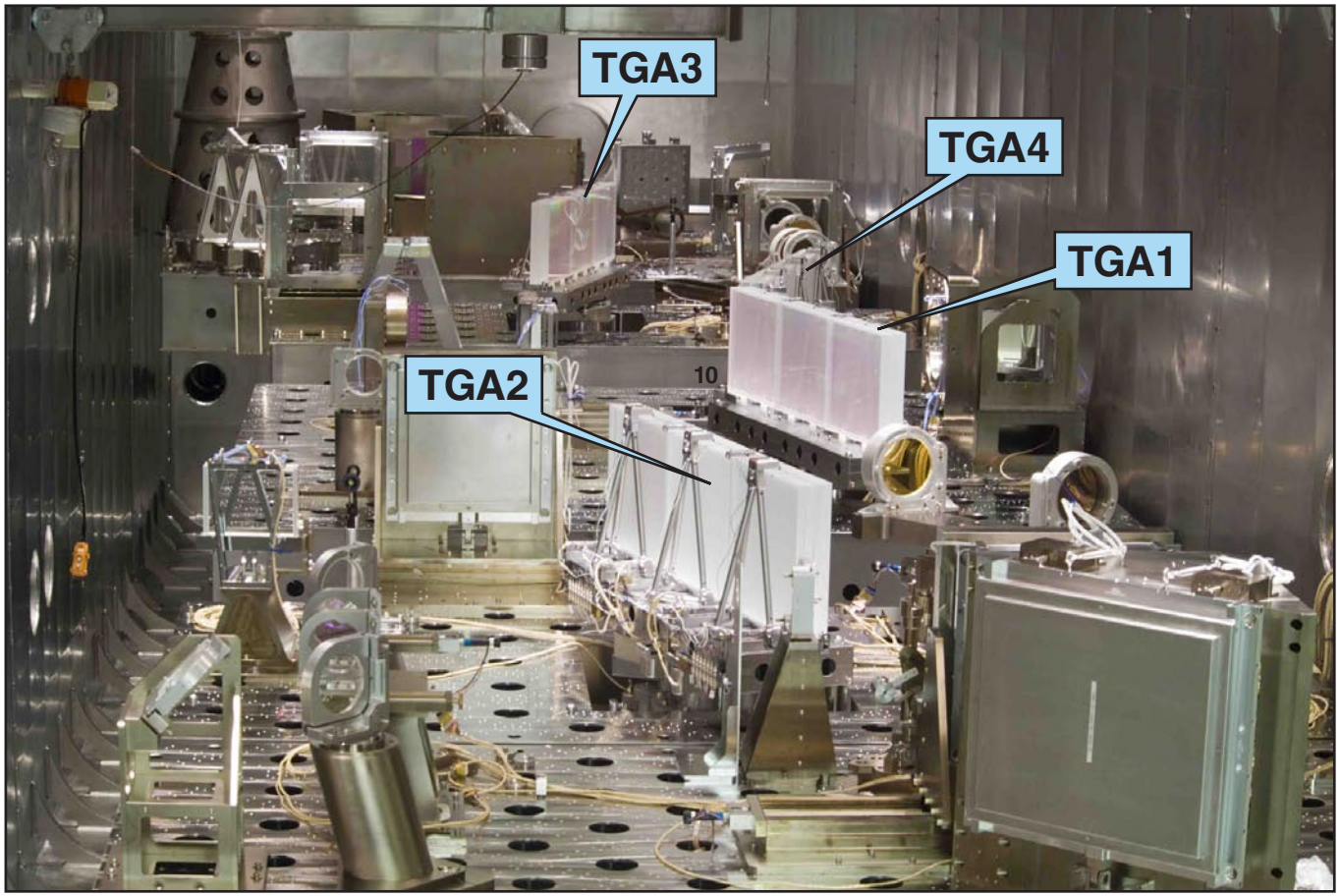
Criteria	Beamline 1	Beamline 2
Co-propagating pulse duration	84 ps	9.5 ps
On target energy	630 J	460 J
Co-timing to OMEGA	6-ps rms	6-ps rms
Focal spot (R_{80})		33 μm
Time between shots	1.7 h	1.7 h
Pointing stability	2.8-μrad rms	3.0-μrad rms

- The measured focal spot exceed the R_{80} = 20 μm requirement
  - operational experience will reduce the focal spot size
- The remainder of FY08 will be used to gain operational experience and perform initial experiments

OMEGA EP fired 22 target shots to the OMEGA chamber in four days.

E16833

The OMEGA EP compressors and diagnostics were the most technically challenging aspect of the project



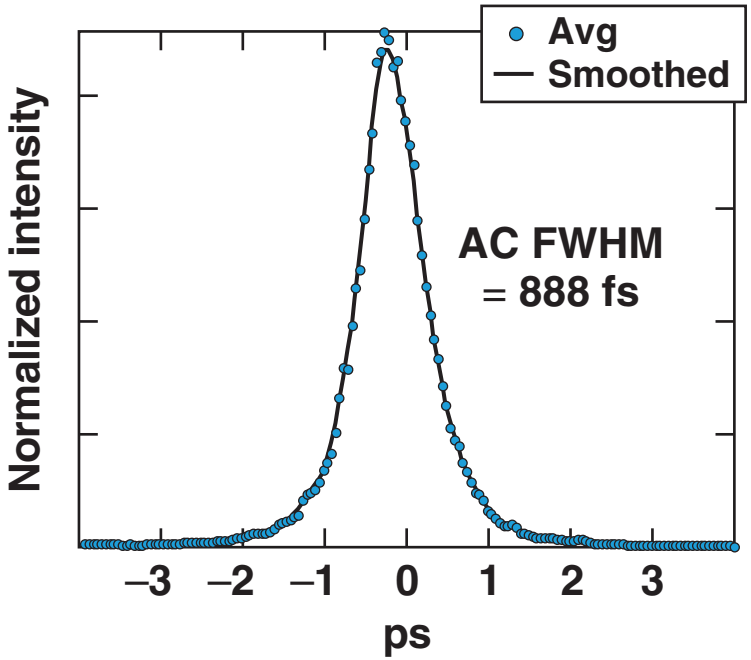
Four tiled-grating assemblies (TGA's) of the upper compressor are shown with ancillary optics for transport and diagnostics.

G8204a

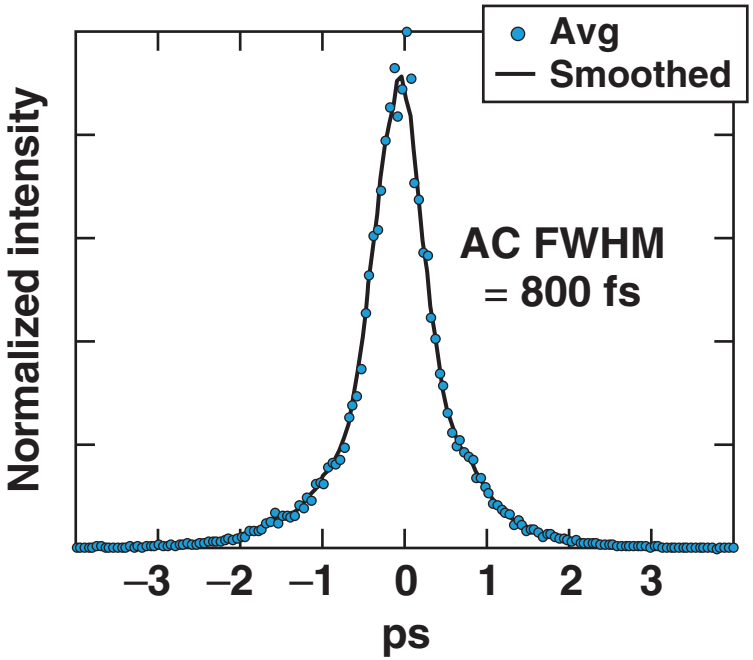
"Subpicosecond compression" was achieved at vacuum for 5-Hz OPCPA beams

UR LLE

Autocorrelator trace for lower compressor



Autocorrelator trace for upper compressor

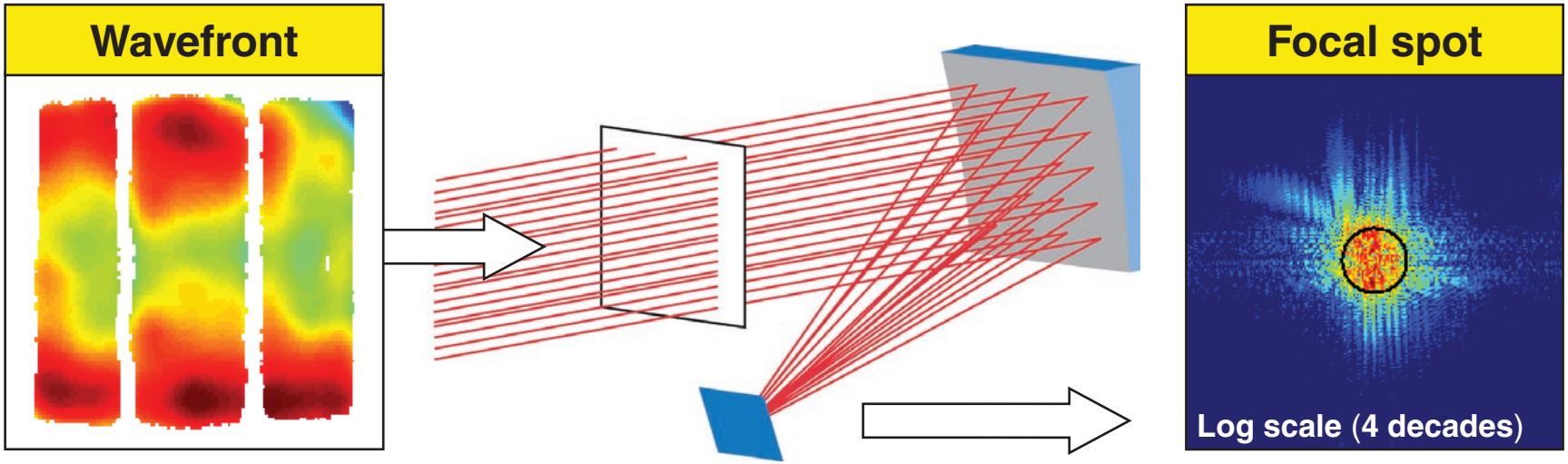


Less than 1-ps pulse width achieved on both compressors for tiled gratings in vacuum.

G8205

The focal-spot diagnostic (FSD) is a novel system capable of on-shot spot characterization

- The FSD concept
  - calculate the on-target focal spot from measurements that give the on-shot amplitude and wavefront at the OAP

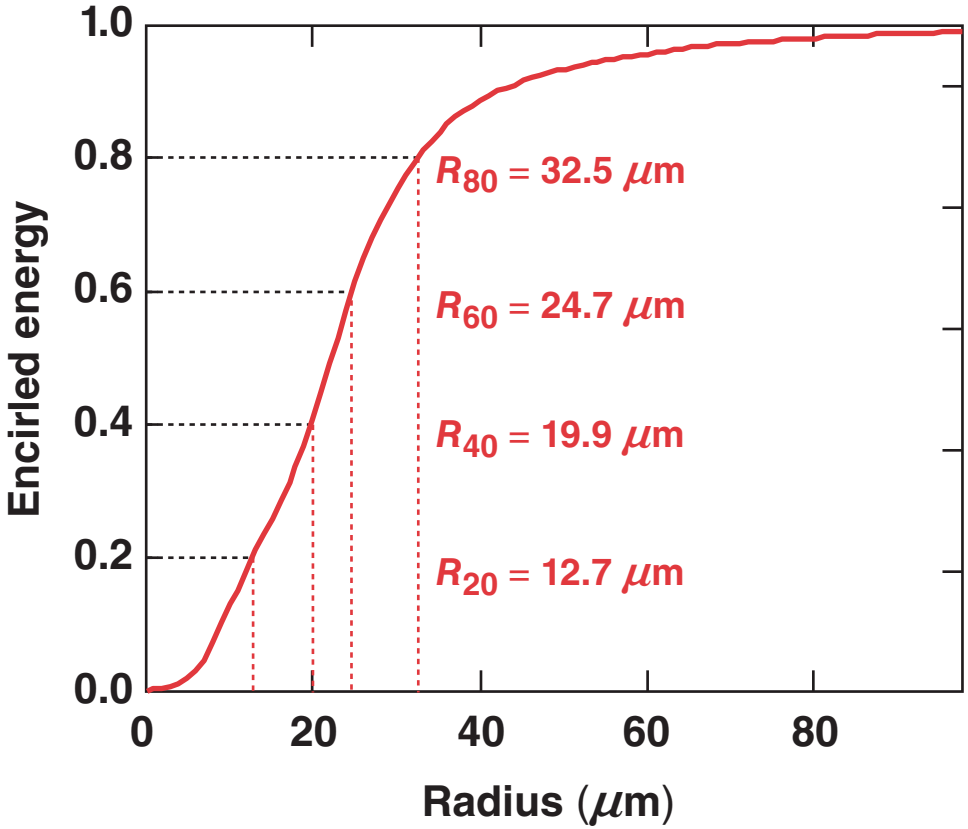


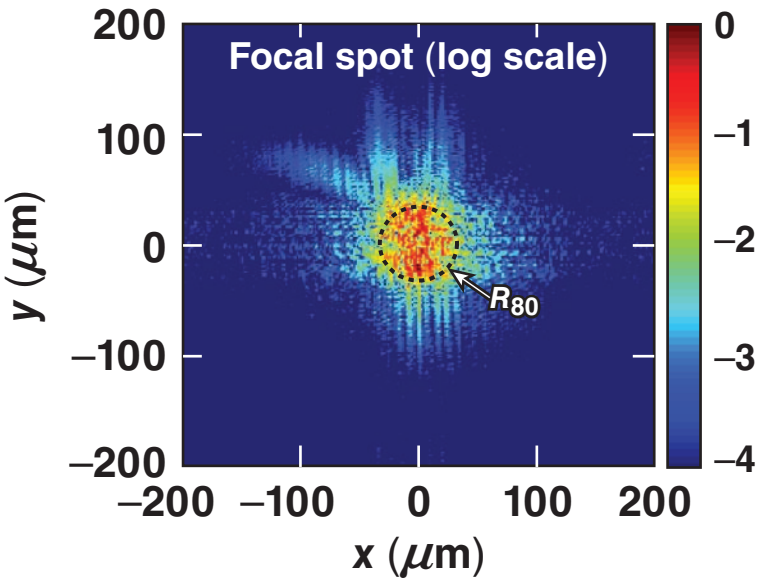
1. Pre-shot calibration
2. On-shot measurement
3. Post-shot calculation

Three steps required by FSD

E16387b

Multiple focal-spot measurements indicate an average R_{80} value of 34 μm

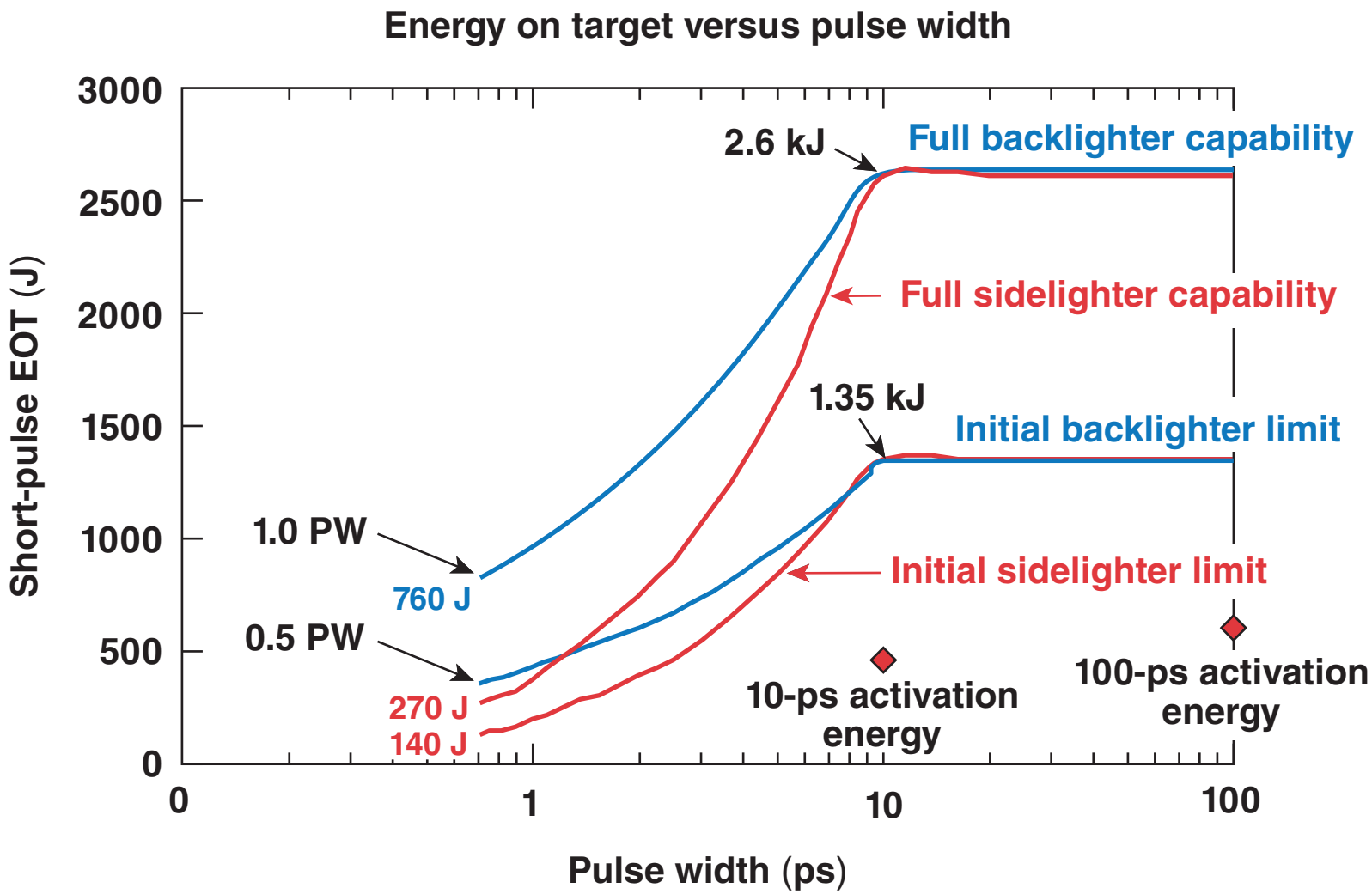




Measured	Criteria
33.0 μm	20.0 μm
35.5 μm	
32.5 μm	

G8290

OMEGA EP short-pulse energies will be ramped to full capability during FY09



G6676c

A number of long- and short-pulse diagnostics will be available on OMEGA EP

UR LLE

- Long-pulse UV diagnostics
  - framing camera, pinhole camera, spectrometer (TIM based)
  - x-ray CCD camera, x-ray streak camera (TIM based)
  - fixed pinhole camera (CID readout, done)
  - HXRD (design started, complete FY08)
  - ASBO/SOP (design started, complete FY09)
- Short-pulse diagnostics
  - single-photon-counting (design started, complete FY08)
  - optical transition radiation diagnostic (planned for FY09)
  - K-shell spectroscopy (planned for FY09)
  - soft x-ray diodes (planned for FY09)
  - neutron detector (done)
  - x-ray monitor (done)
  - EMP monitor (done)
  - radiation monitor (95% done)

E16584a

A series of OMEGA EP Use Planning workshops was held

UR LLE

- January 2006 — Develop priorities for capability development
  - over 50 external user participants (national laboratory, university, and foreign)
  - working groups suggested
    - fast ignition
    - short-pulse, hard x-ray sources and detectors
    - ion sources
    - long-pulse dynamic loading
    - isochoric heating of warm dense matter
    - backlight implosions
- May 2007 — Began detailed experimental planning
  - first 100 shots defined
- April 2008 — Detailed experimental planning
  - target design and laser configuration

Approximately half of the OMEGA EP Users' Shot Plan will be executed in FY08

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Target	Goal	Diagnostics	Number of Shots
Fast Ignition: Sandwich planar targets Al/Cu/Al, Al, free study	Electron/proton production temperature with 10-ps pulses	K_α spectroscopy	15
CH foil with witness layer	Initial channeling	X-ray imaging, transmitted light	5
Hard x-ray, WDM: Ag and Sm foil/flag/wire, resolution grid	Hard x-ray and keV broadband	50~100 mic spots, x-ray spectometers, imagers	15
High-brightness keV sources: F~Si materials, foams, colloidal targets	High brightness for ICF backlighting	keV x-ray spectrometer, x-ray streak camera with spectrometer	10
Long-pulse backlighting: Thick foil (pinhole for PPB)	Develop capability	X-ray streak	5
Low- and high-Z ions: Thin foil	Develop capability	Optical pyrometer, heating source, RCF	5
HED materials: Thin Al/$Si0_2$ foil	Initial shock velocity	ASBO/VISAR	10
Al foil	Direct measure of Al EOS	Hard x-ray source and detector	5
WDM: Planar foil	Double/colliding shock	SOP	5
ICF: Planar foil	Initial scale length	FABS, HXRD 4ω probe	5
Complex Hydro: Washers/foam	Initial episodic jet	X-ray image	5
D^3He proton source: Exploding pusher	Monoenergetic proton source	WRF	2
High-intensity physics: Planar foil, gas jet	Magnetic-field + MeV photon generation	Photon diagnostic, photon beam, nuclear activation	10

E15937b

Nearly 25% of the shot time on OMEGA EP will be devoted to basic science

Category	Subdivision	FY09 Notional Allocation		
		%*	OMEGA Shots**	OMEGA EP Shots**
National Ignition Campaign	IDI DDI	10 40	105 420	45 180
HED	LLNL and LANL	20	210	90
Basic Science	NLUF Laboratory	13 12	136 126	58 54
Contingency		5	53	23
Total		100	1050	450

* Allocation recommended by FSAC in June 2007 and approved by LLE Director.
** Shot availability at full operations funding.

The FY09 schedule will be determined by 1 July 2008.

Summary/Conclusions

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