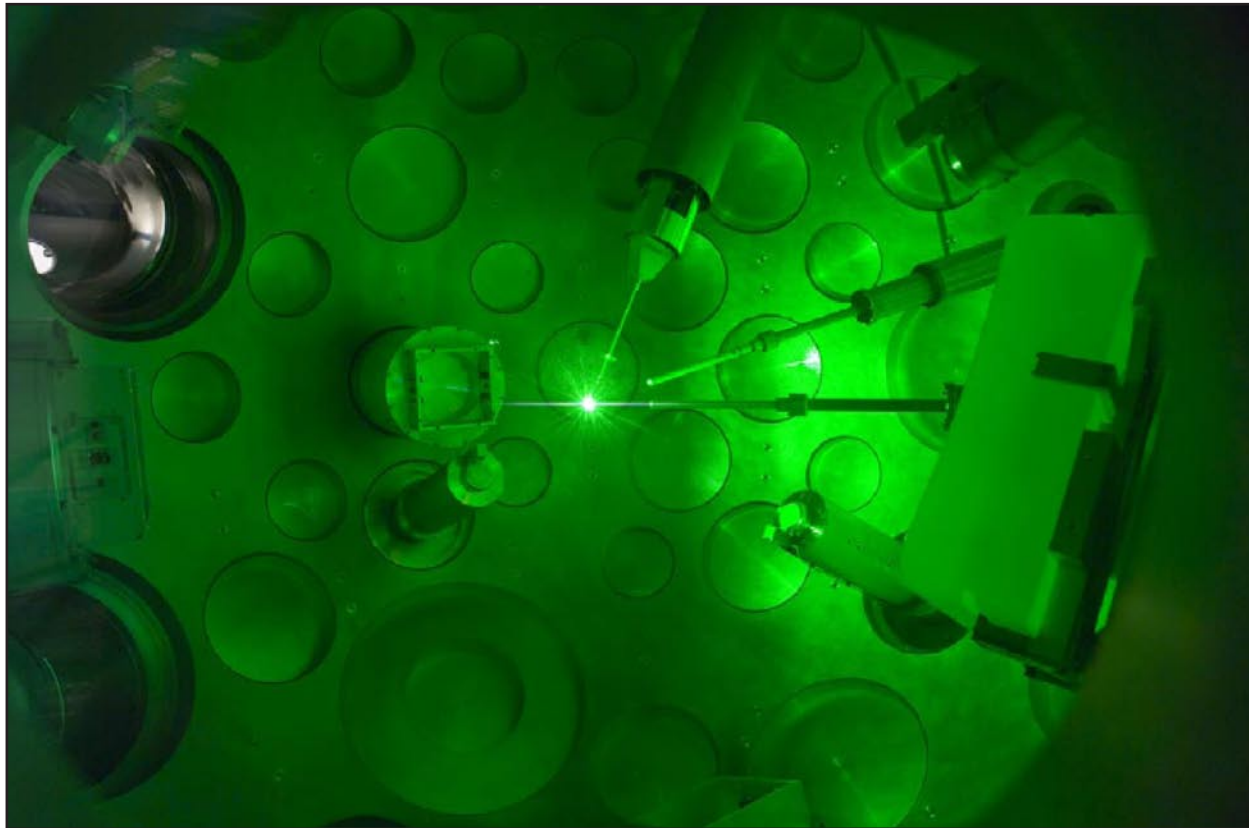


# Status of the OMEGA EP Laser System



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

**38th Annual Anomalous  
Absorption Conference**  
**Williamsburg, VA**  
**1–6 June 2008**

## Summary

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

---



- 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.

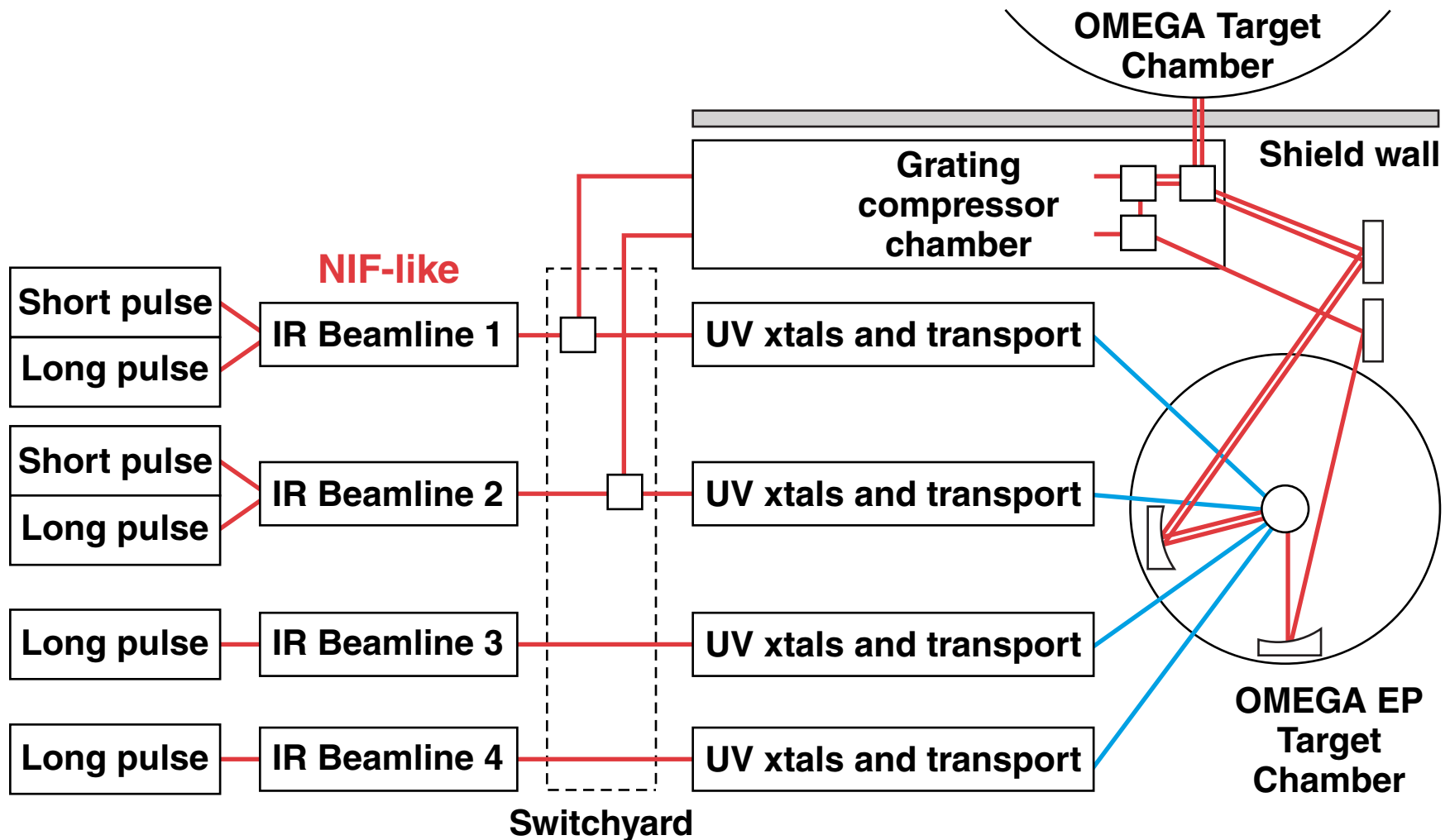
# The combined OMEGA/OMEGA EP Laser System will allow a wider variety of high-energy-density physics experiments

---



- 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

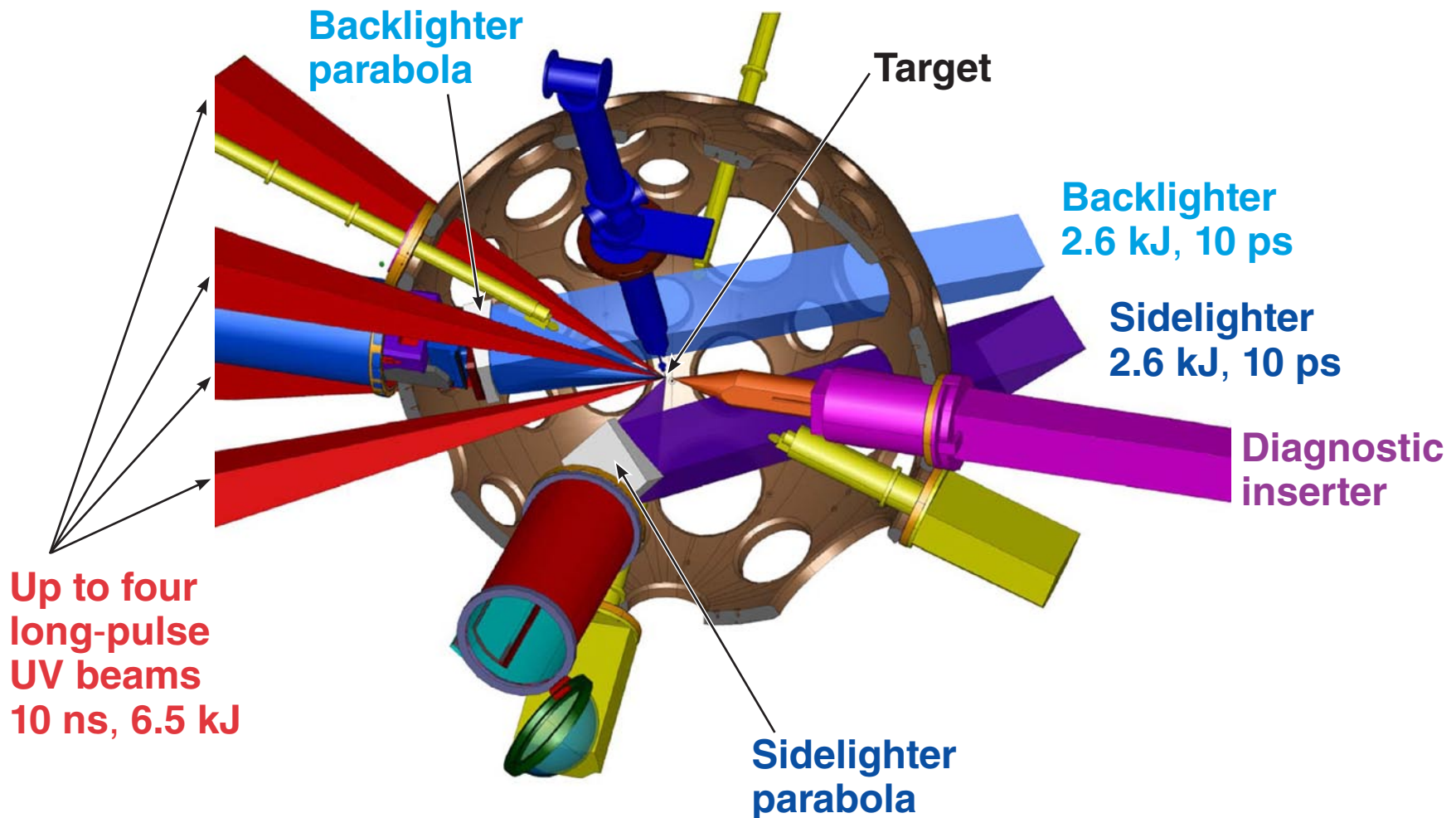


# OMEGA EP will achieve its missions using a variety of on-target intensities and pulse durations



Performance capabilities	Short-pulse beam 1		Short-pulse beam 2		Long-pulse beams 1–4	
Target chamber	$\Omega$ or EP		$\Omega$ 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 <sup>2</sup> )	$3 \times 10^{20}$	$8 \times 10^{19}$	$2 \times 10^{18}$		$3 \times 10^{16}$	$8 \times 10^{15}$
Focusing (diam)	>80% in 20 $\mu\text{m}$		>80% in 40 $\mu\text{m}$		>80% in 100 $\mu\text{m}$	
Wavelength (nm)	1053		1053		351	

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

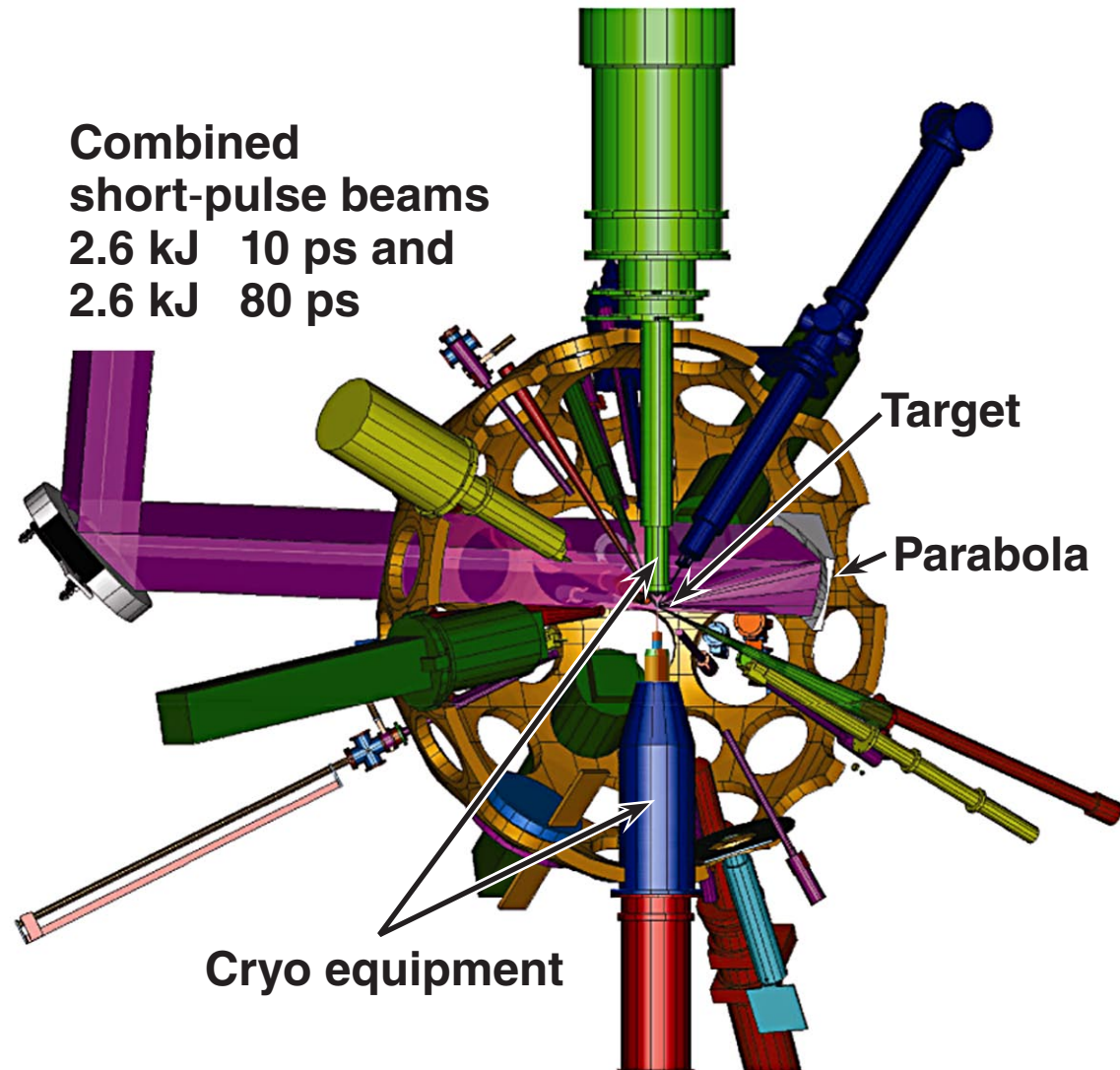


# The beams from OMEGA EP will be focused with a $23^\circ$ $f/2$ off-axis parabola inside the OMEGA target chamber



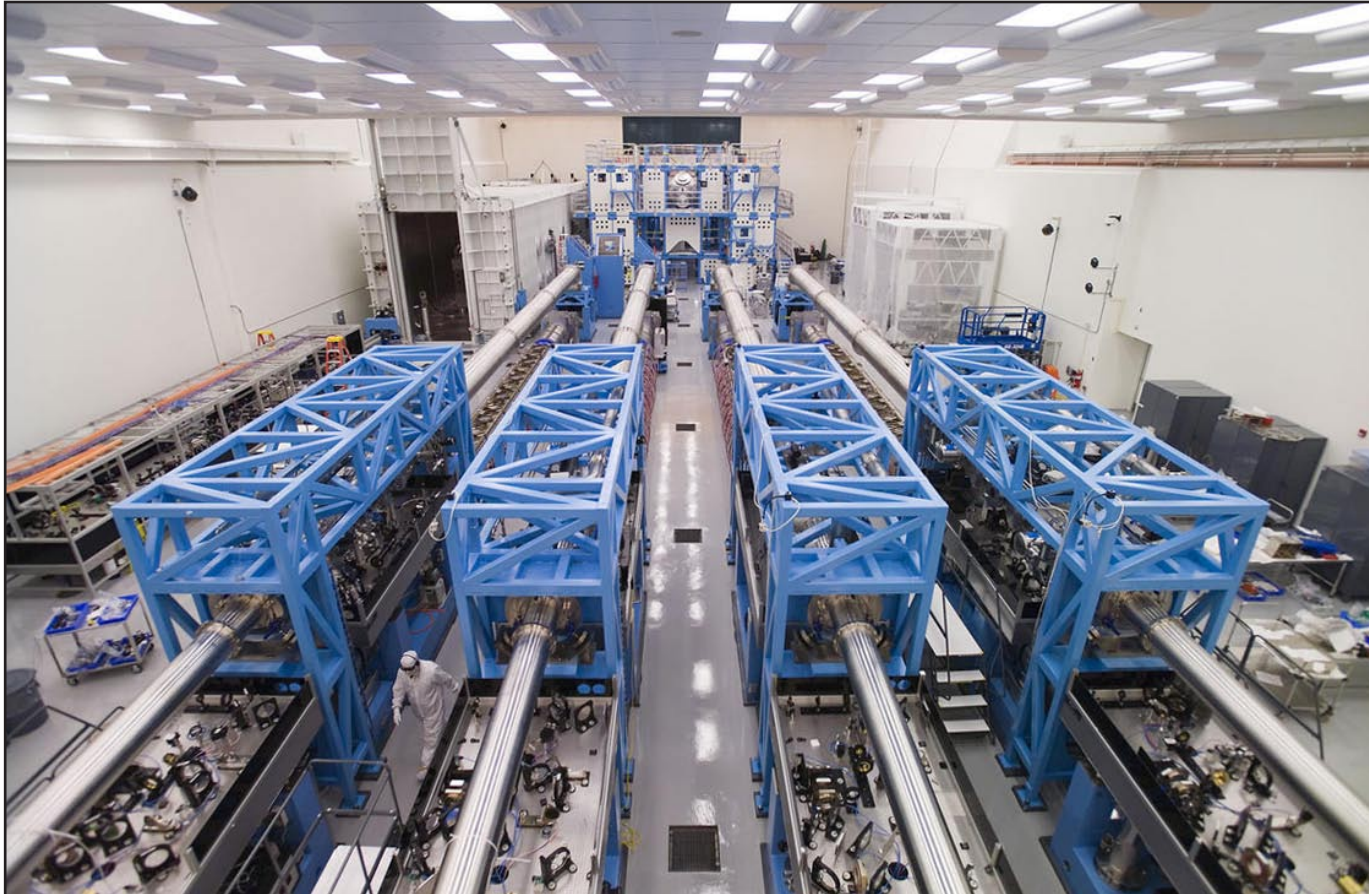
- A fast-focusing optic is necessary to meet the  $20\text{-}\mu\text{m}$ -diam focal-spot requirement
- Pointing requirement in OMEGA:  $20\text{-}\mu\text{m}$  rms
- 2-h shot cycle (in either chamber)

Combined  
short-pulse beams  
 $2.6\text{ kJ}$   $10\text{ ps}$  and  
 $2.6\text{ kJ}$   $80\text{ ps}$





# 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



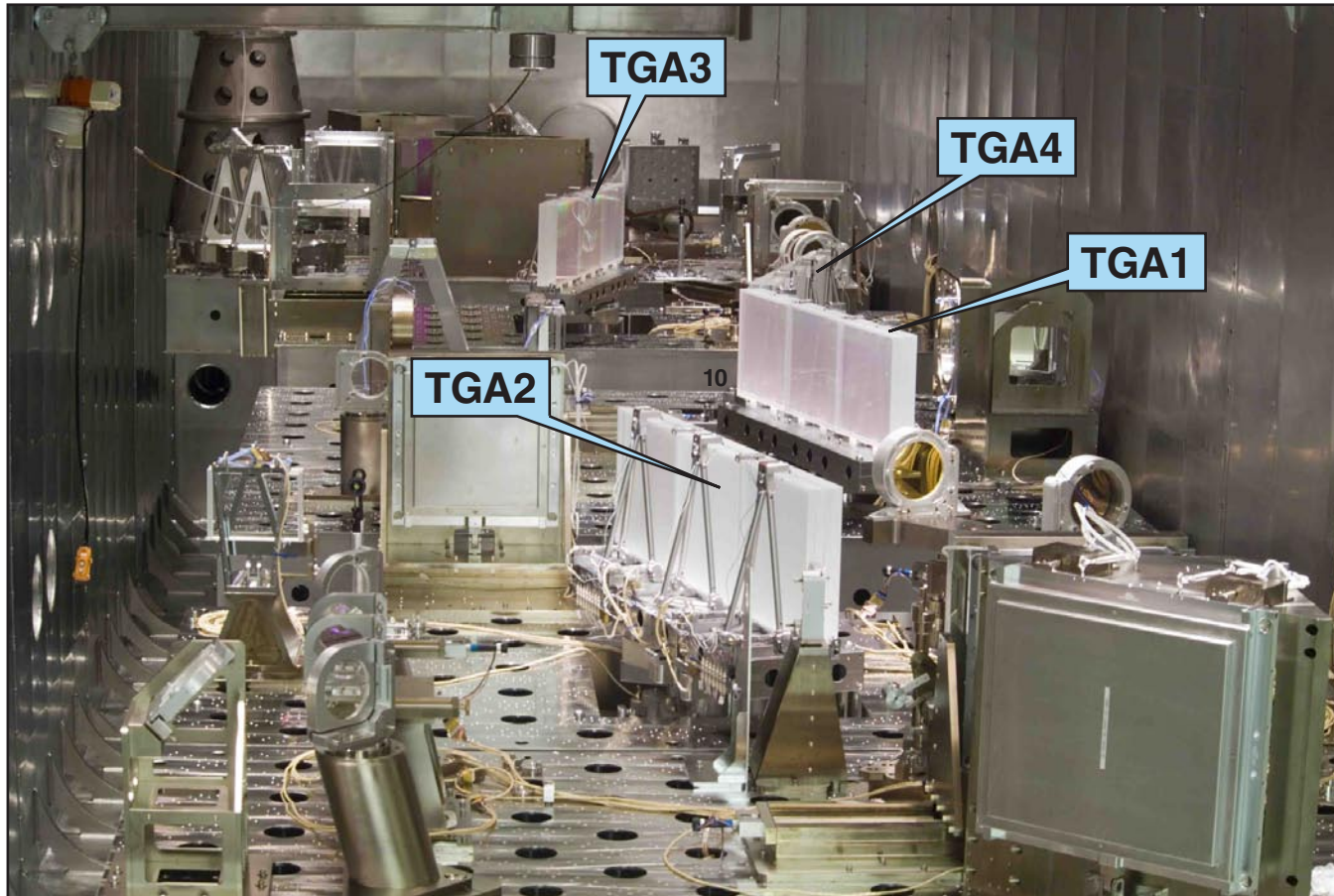
## OMEGA EP performance to the OMEGA target chamber

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 $\mu\text{m}$
Time between shots	1.7 h	1.7 h
Pointing stability	2.8- $\mu\text{rad}$ rms	3.0- $\mu\text{rad}$ rms

- The measured focal spot exceed the  $R_{80} = 20 \mu\text{m}$  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.**

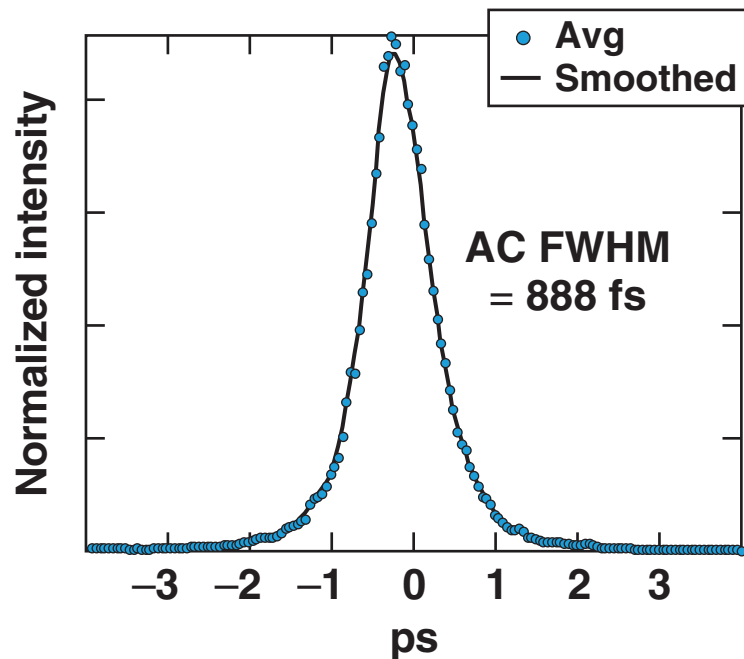
# The OMEGA EP compressors and diagnostics were the most technically challenging aspect of the project



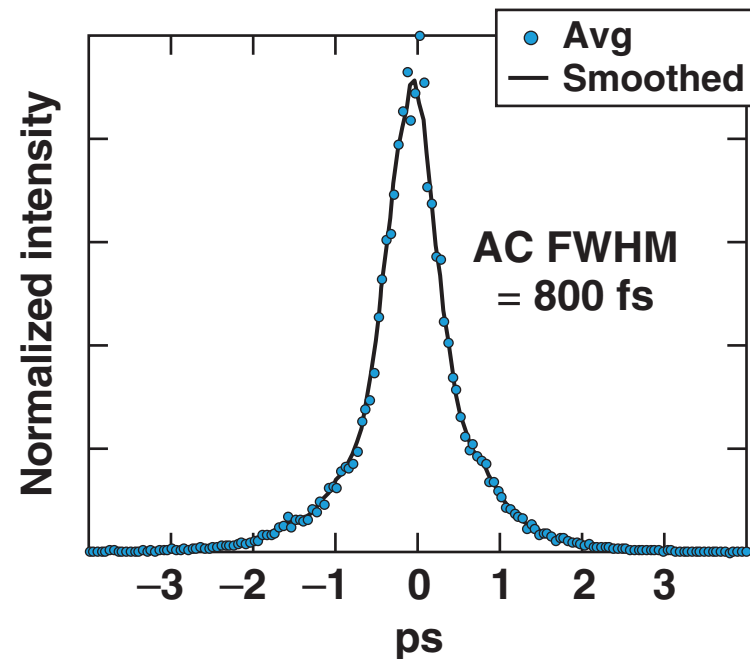
**Four tiled-grating assemblies (TGA's) of the upper compressor are shown with ancillary optics for transport and diagnostics.**

# “Subpicosecond compression” was achieved at vacuum for 5-Hz OPCPA beams

Autocorrelator trace for lower compressor



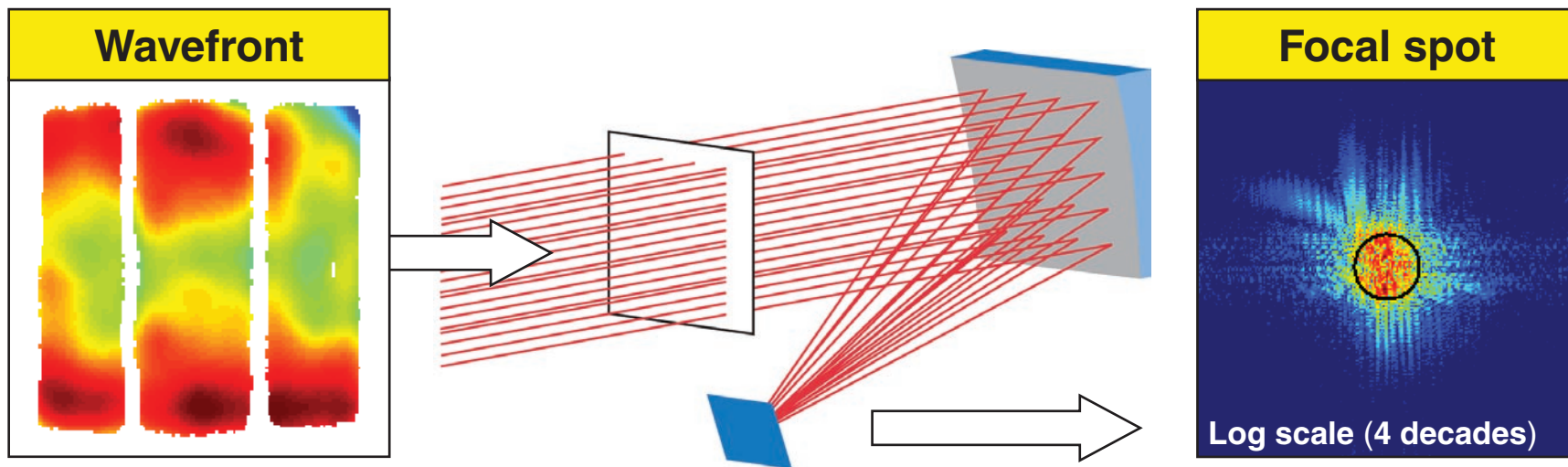
Autocorrelator trace for upper compressor



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

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

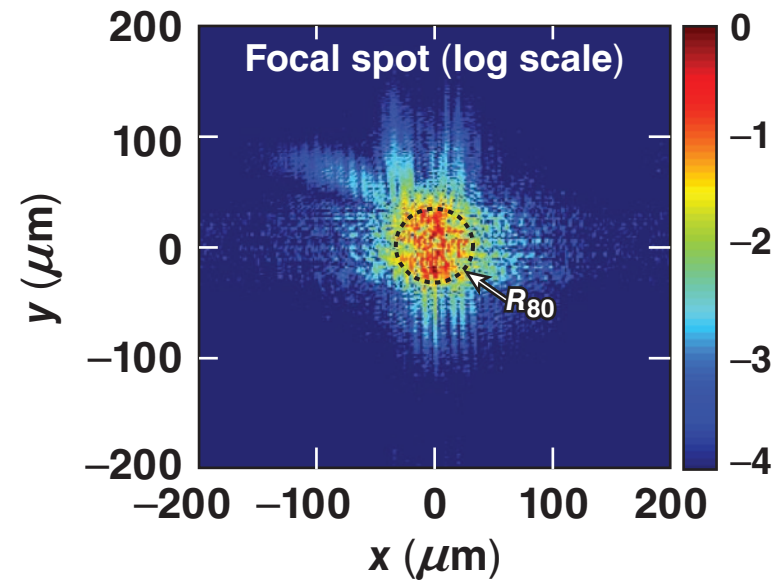
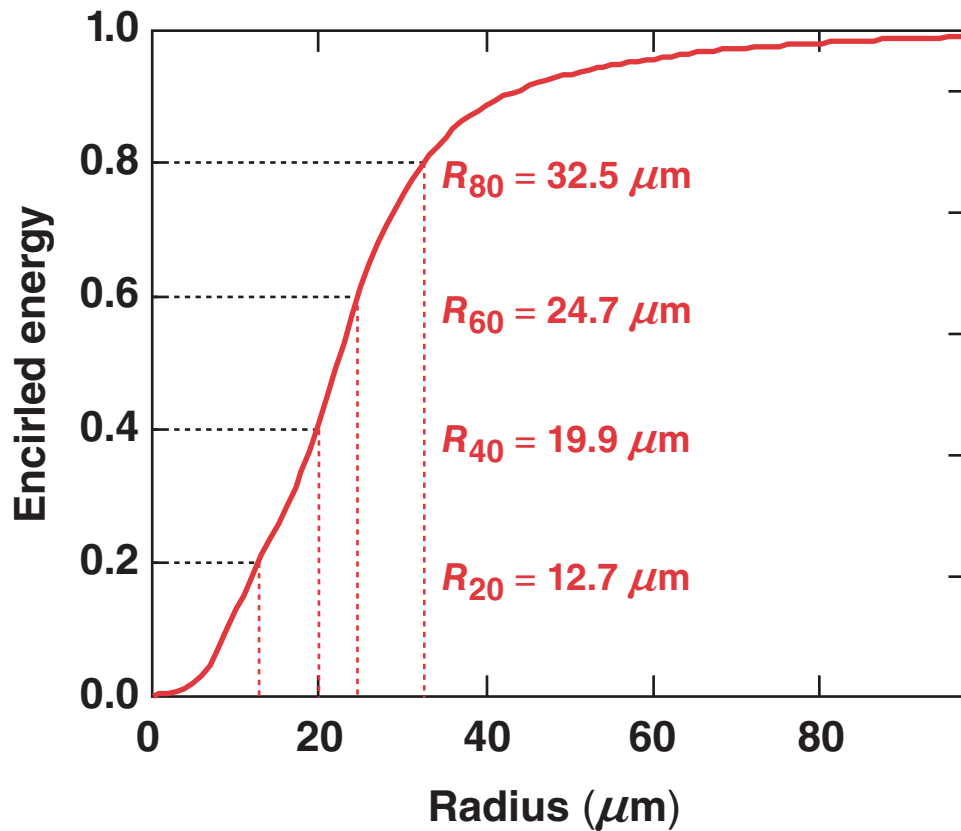
- The FSD concept
  - calculate the on-target focal spot from measurements that give the on-shot amplitude and wavefront at the OAP



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

Three steps required by FSD

# Multiple focal-spot measurements indicate an average $R_{80}$ value of $34 \mu\text{m}$

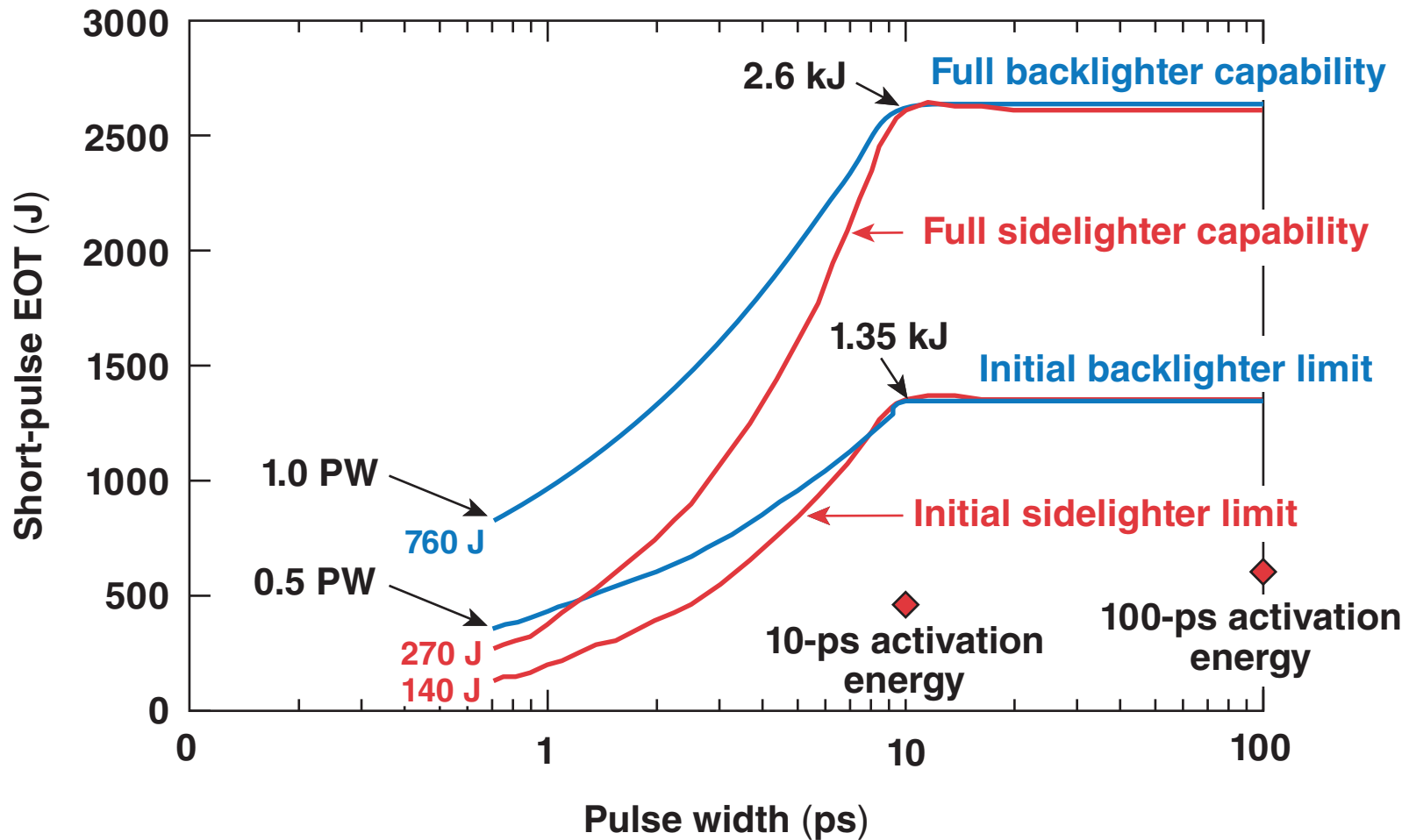


Measured	Criteria
33.0 $\mu\text{m}$	20.0 $\mu\text{m}$
35.5 $\mu\text{m}$	
32.5 $\mu\text{m}$	

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



Energy on target versus pulse width





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

---



- **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)

# **A series of OMEGA EP Use Planning workshops was held**

---



- **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



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

# 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	10	105	45
	DDI	40	420	180
HED	LLNL and LANL	20	210	90
Basic Science	NLUF Laboratory	13	136	58
		12	126	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.**

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

---



- **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.**