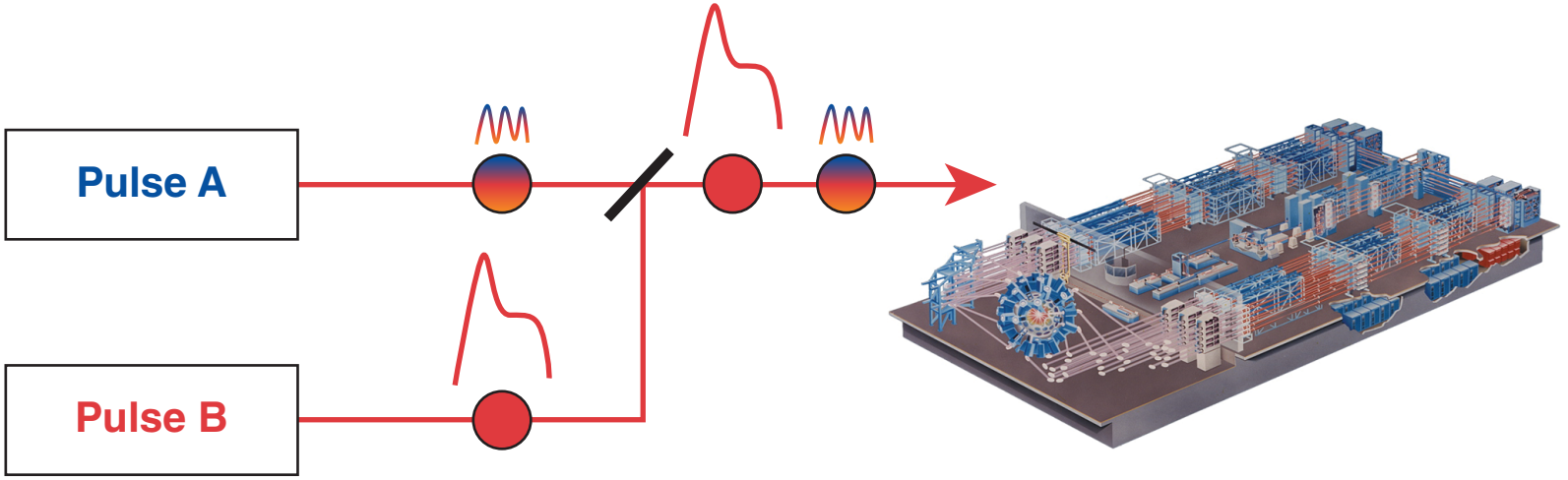
OLUG 2015 Update: Progress on Recommendations and Items of General Interest



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

Omega Laser Facility
Users Group Workshop
Rochester, NY
22–24 April 2015

Summary

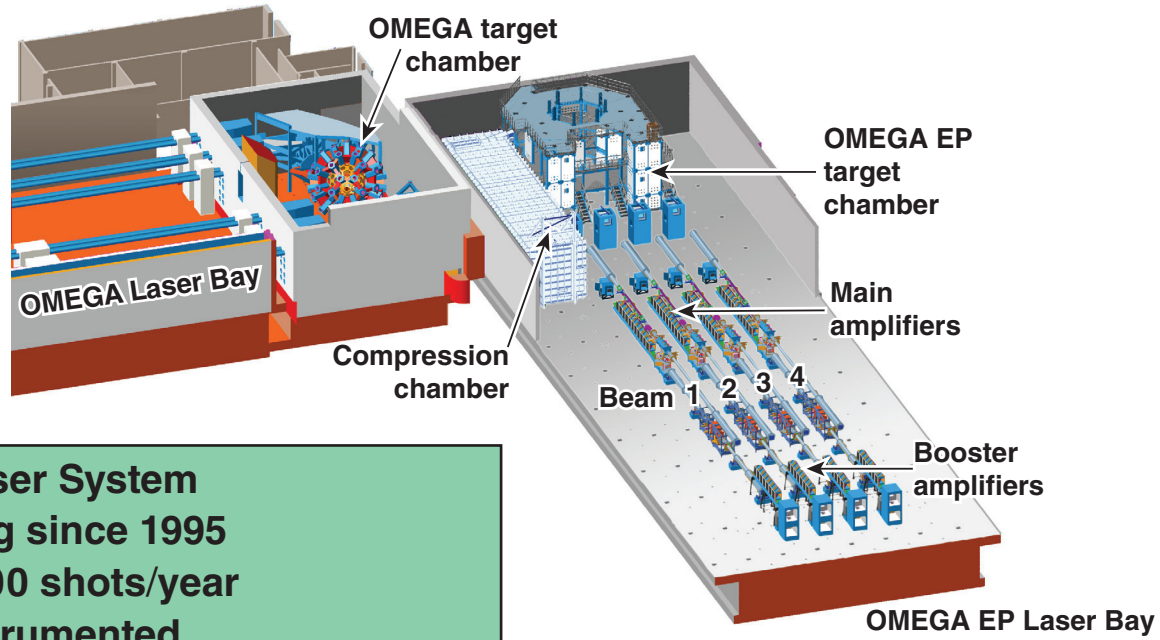
OMEGA is an effective and efficient facility and continues to evolve to meet user requirements

UR LLE

- OMEGA, 20 years post commissioning, continues to thrive as an National Nuclear Security Administration (NNSA) workhorse
  - 24,667 target shots on OMEGA; 3,098 on OMEGA EP
- Operational statistics show continued high performance
- OMEGA improvements in pulse shaping and dynamic bandwidth reduction were completed in January 2015
- Improvements to energy on target, beam timing, distributed phase plates (DPP's), and diagnostics for the hot-spot pressure measurement benefit all users conducting implosions
- Work continues on meeting the OMEGA EP operational specifications

LLE provides 80% of shots for the National Inertial Confinement Fusion (ICF) and Stockpile Stewardship Programs.

OMEGA and OMEGA EP continue to be very effective and productive user facilities



OMEGA Laser System

- Operating since 1995
- Up to 1500 shots/year
- Fully instrumented
- 60 beams
- >30-kJ UV on target
- 1% to 2% irradiation nonuniformity
- Flexible pulse shaping
- Short shot cycle (1 h)

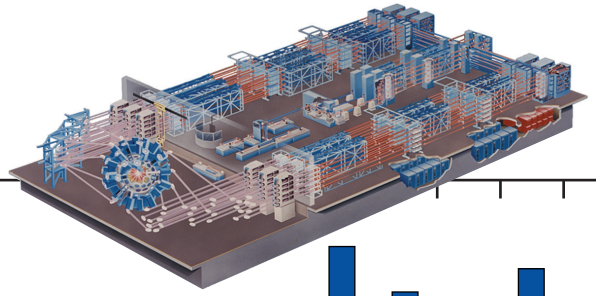
More than half of OMEGA's shots are for external users.

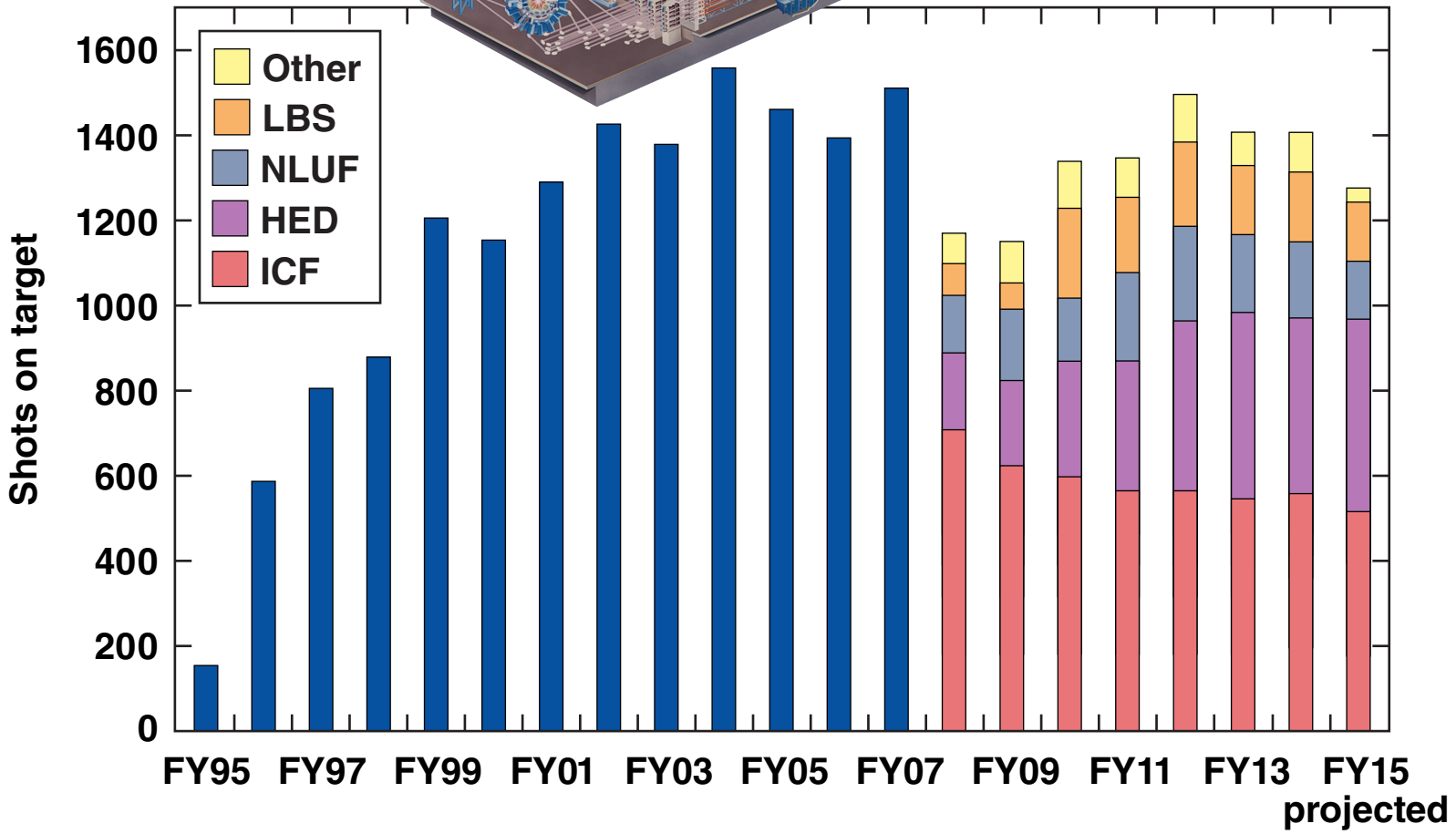
OMEGA EP Laser System

- Operating since 2008
- Adds four NIF-like beamlines; 6.5-kJ UV (10 ns)
- Two beams can be high-energy petawatt
  - 2.6-kJ IR in 10 ps
  - Can propagate to the OMEGA or OMEGA EP target chamber

G10425a

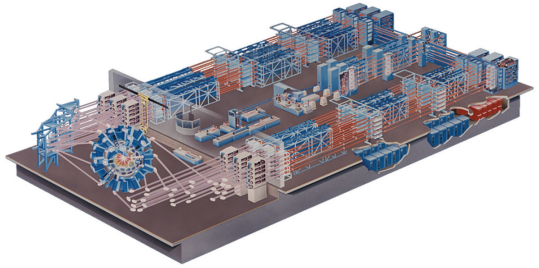
OMEGA has performed 24,667 shots in the 20 years since the May 1995 commissioning



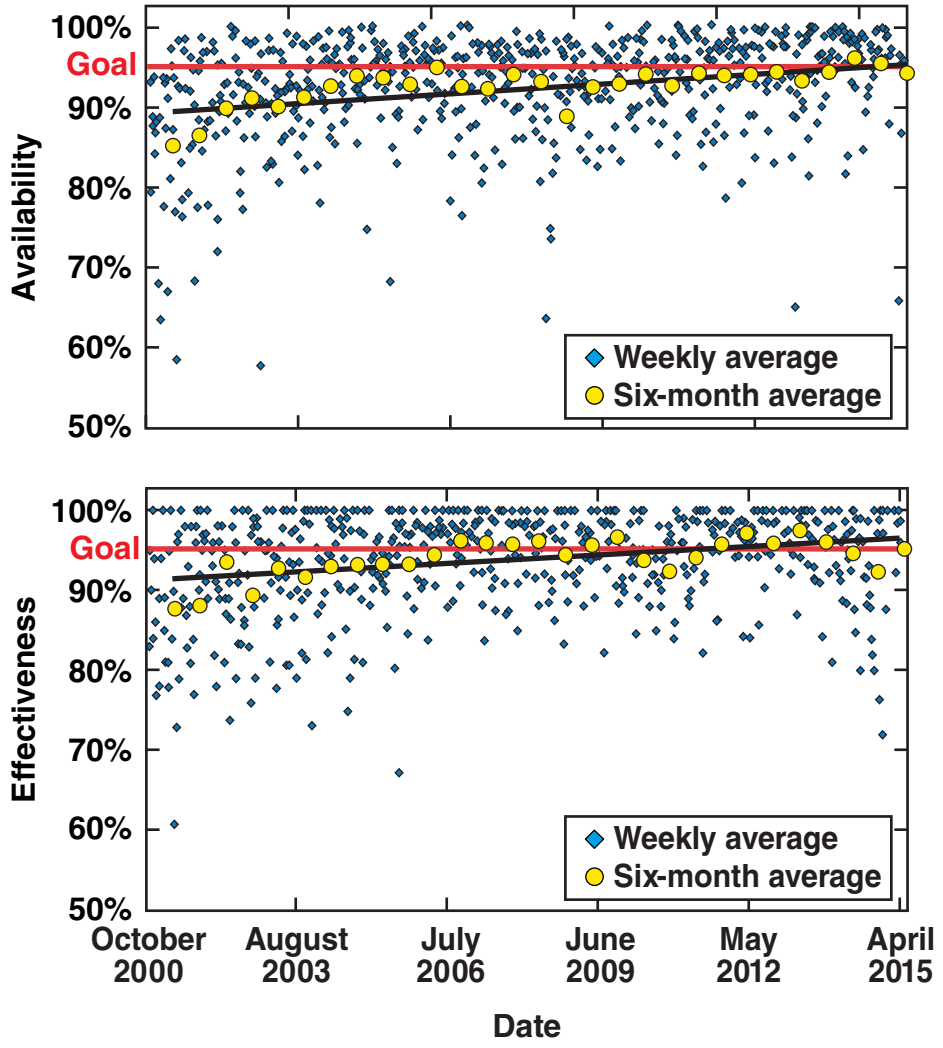


G10046a

OMEGA operational statistics have been recorded since FY00 and remain high

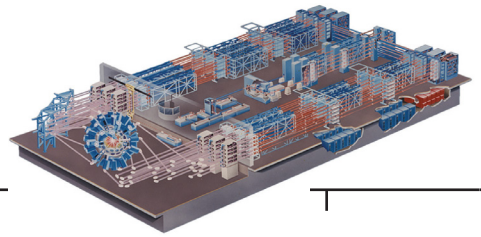


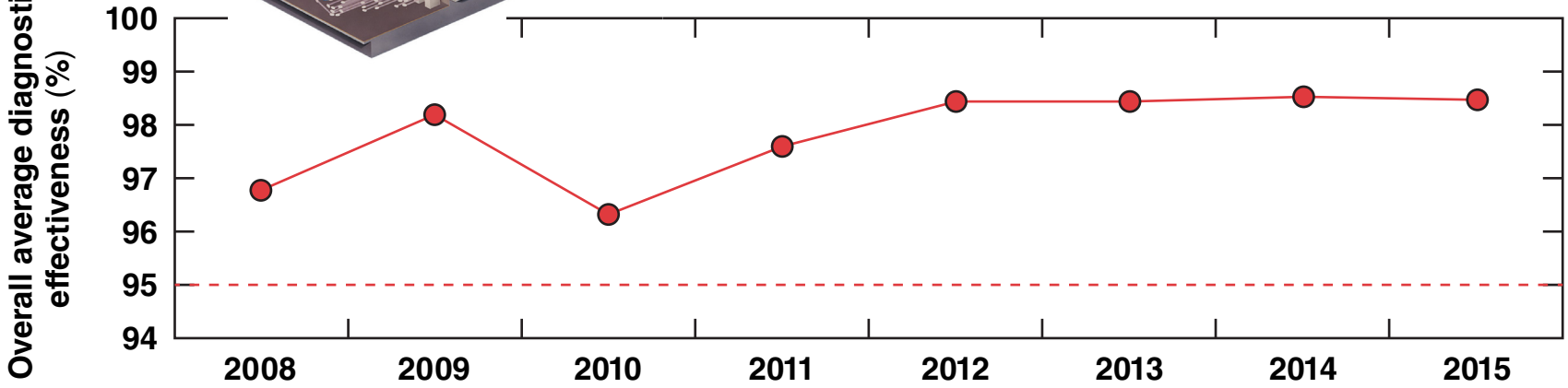
- **Availability: quantitative schedule performance metric**
  - **first shot by 0900**
  - **60-min shot interval**
- **Effectiveness: initial response of the Principal Investigator (PI) as to whether or not the shot produced good data**
  - **laser performance**
  - **target/diagnostic**
  - **experiment design**

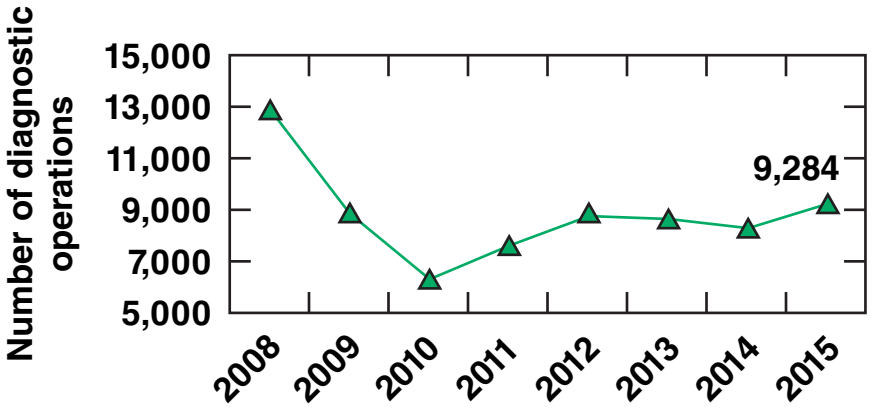


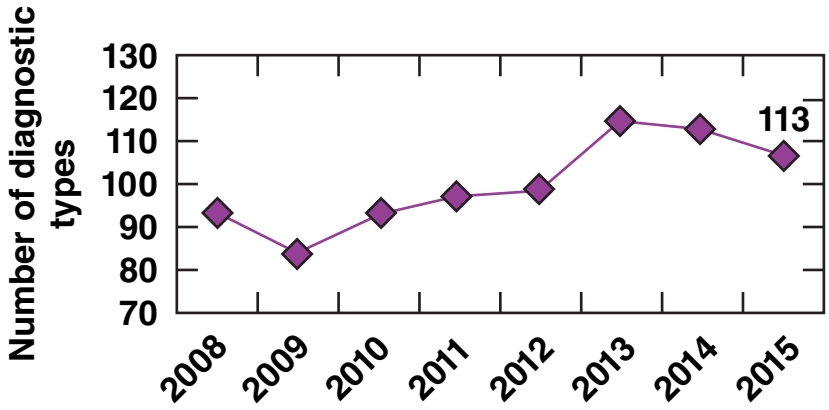
G10426

Primary diagnostic experimental effectiveness on OMEGA-60 is consistently above the 95% goal



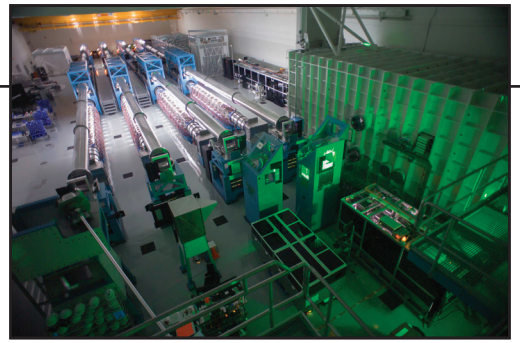






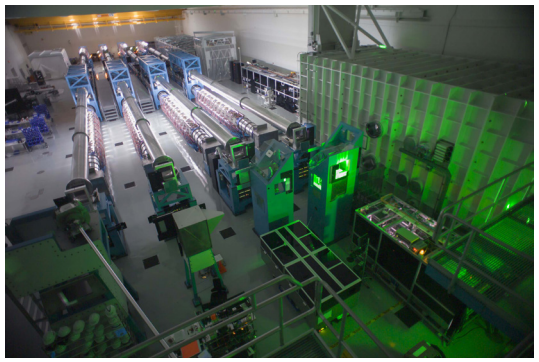
G10499

OMEGA EP has performed 3098 shots in the seven years since commissioning in May 2008

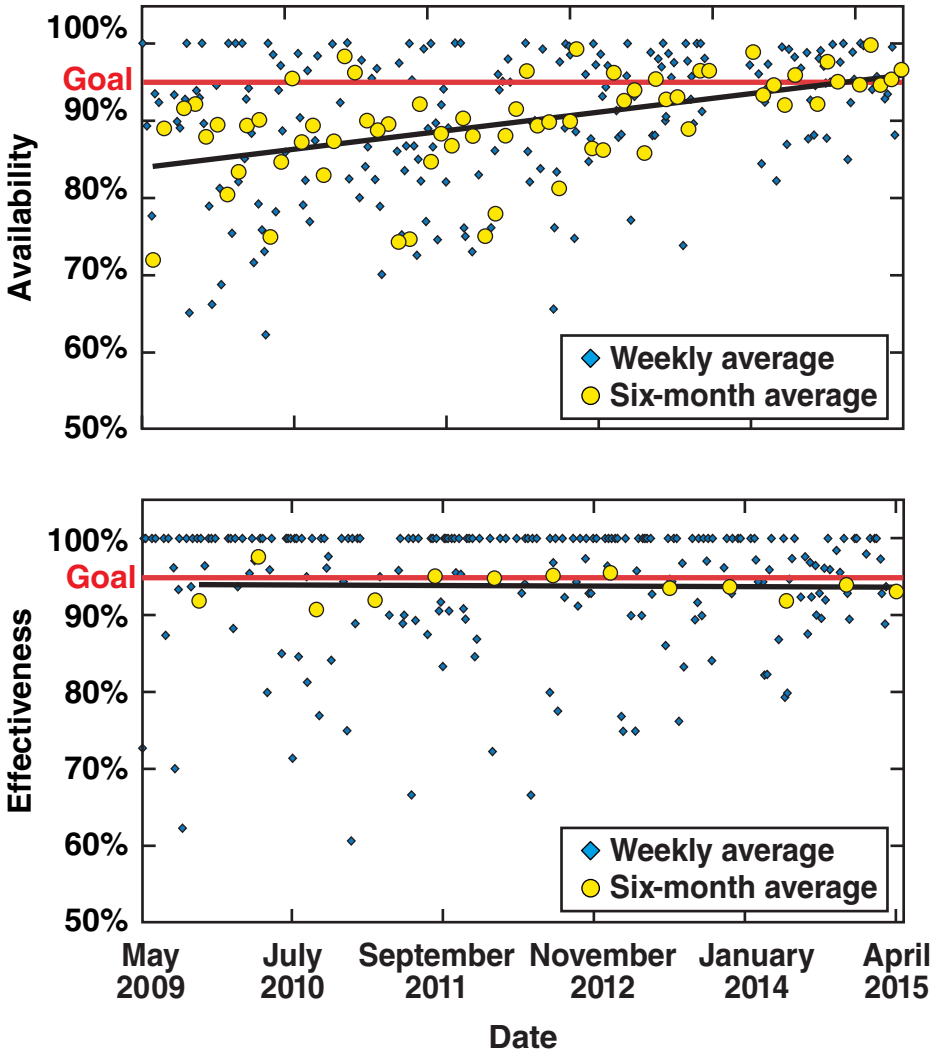


G9532d

OMEGA EP operational statistics have been tracked since FY09 and show improvement

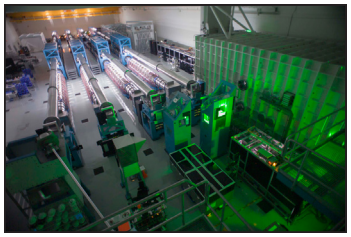


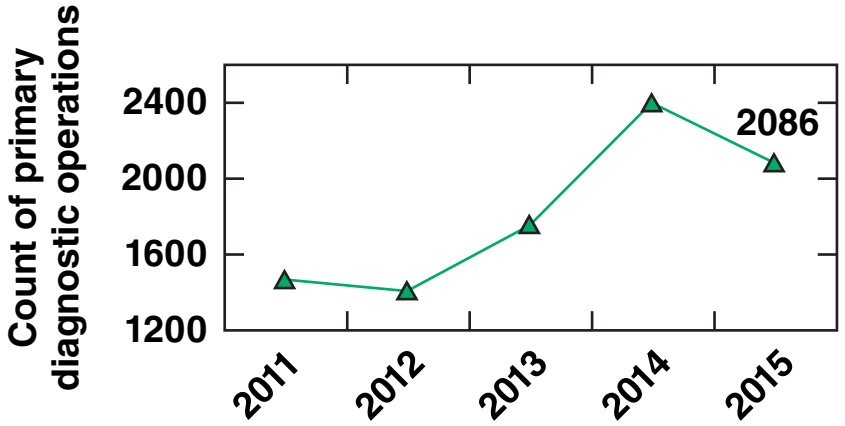
- **Availability: quantitative schedule performance metric**
  - **first shot goal varies by configuration**
  - **105-min shot interval**
- **Effectiveness: initial response of the PI as to whether the shot produced good data**

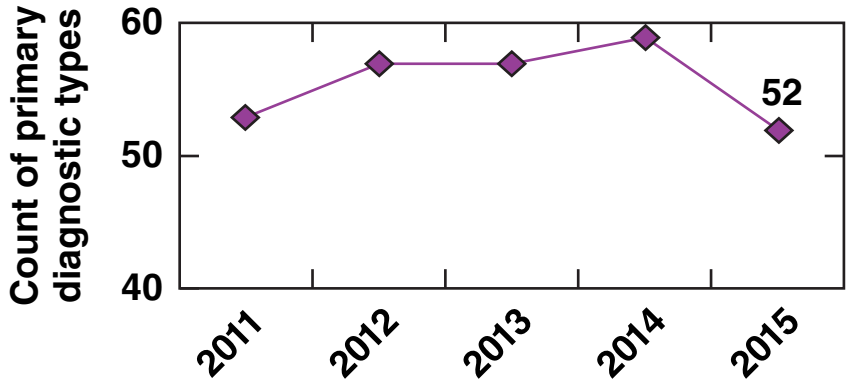


G10427a

Primary diagnostic experimental effectiveness on OMEGA EP is consistently above the 95% goal

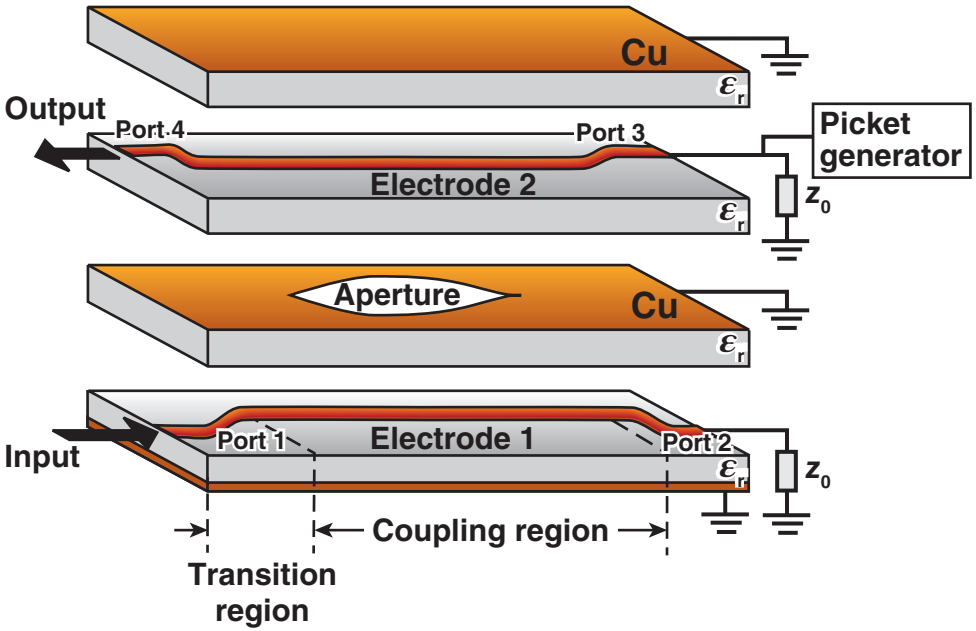


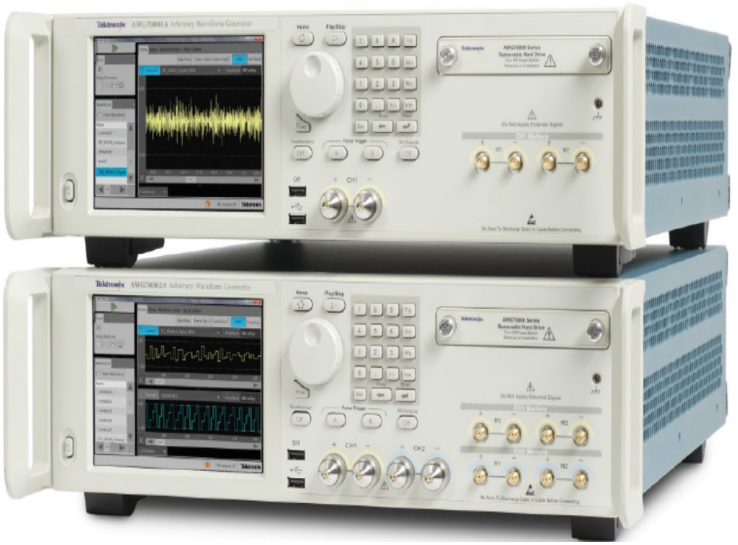




G10500

OMEGA pulse-shaping migration is complete for the backlighter driver as of March 2015





Waveform generator FY00–FY14

- ~350 production shapes over 14 years

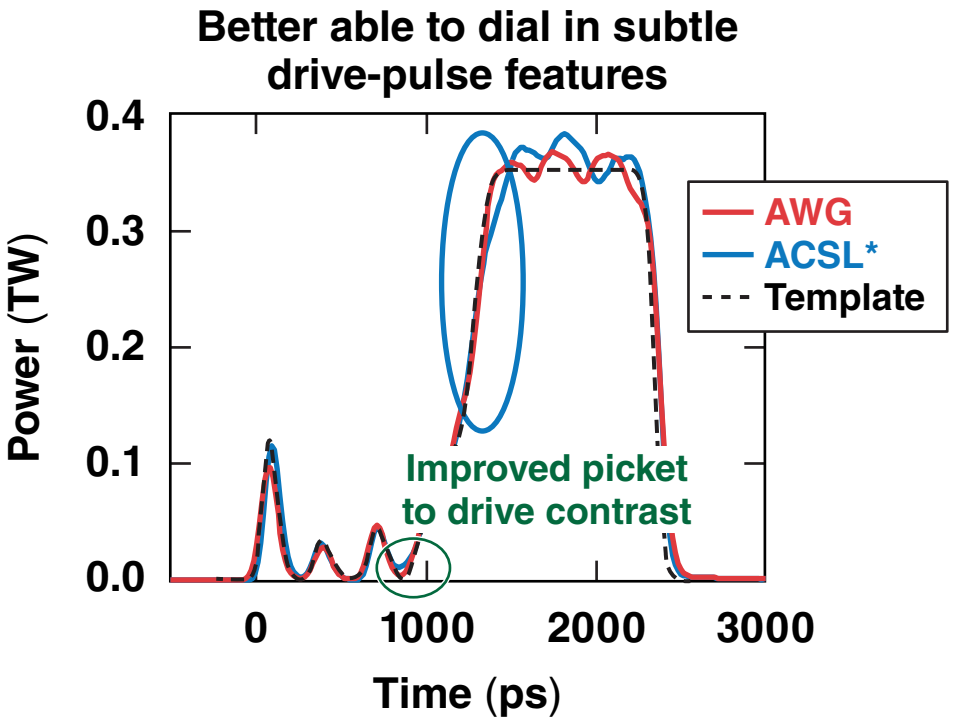
Waveform generator 2014 forward

- Waveforms uploaded to 50-G sample generator
- ~200 production shapes over 14 months

G9889e

The arbitrary-waveform-generator (AWG) pulse-shaping system has significantly improved pulse-shape accuracy

- In FY14 the OMEGA SSD front end was upgraded to use a high-bandwidth AWG
  - this greatly improved the facility's ability to design and produce pulse shapes that better met users' requirements
- As part of the multiple-pulse driver-line project, a low-jitter, time-multiplexed pulse-shaping system (TMPS) was added to the OMEGA front end
  - this has facilitated the feeding of multiple front ends with a single AWG



Complex shape effectiveness improved from 96.4% to 98.2%.

*ACSL: aperture-coupled stripline

G10315a

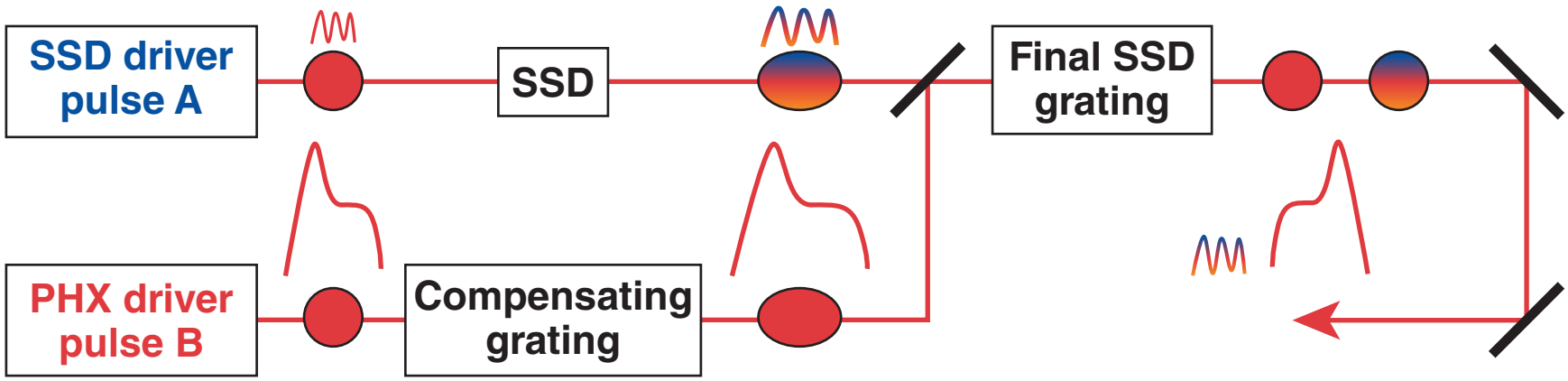
The OMEGA multiple-pulse driver line (MPD) provides co-propagation of two separate pulses in all 60 beams

- MPD is key to improve target-implosion performance by providing dynamic bandwidth reduction
- A single pulse-shaping system generates both pulse shapes to minimize the interpulse jitter of two co-propagated drivers
- A driver-line diagnostic upgrade was implemented to characterize the combined pulse shape
- MPD activation in January 2015 has resulted in improved cryo target performance

S. P. Regan *et al.*, this conference.

The OMEGA driver line was reconfigured to increase on-target energy and allow development of focal zooming

- The picket pulse (A) is generated using the smoothing by spectral dispersion (SSD) regenerative amplifier and bandwidth is added in the SSD arm
- The drive pulse (B) is produced with a new regenerative amplifier, Phoenix (PHX); a compensating grating is used to introduce temporal shear
- Both pulses are combined using a beam combiner

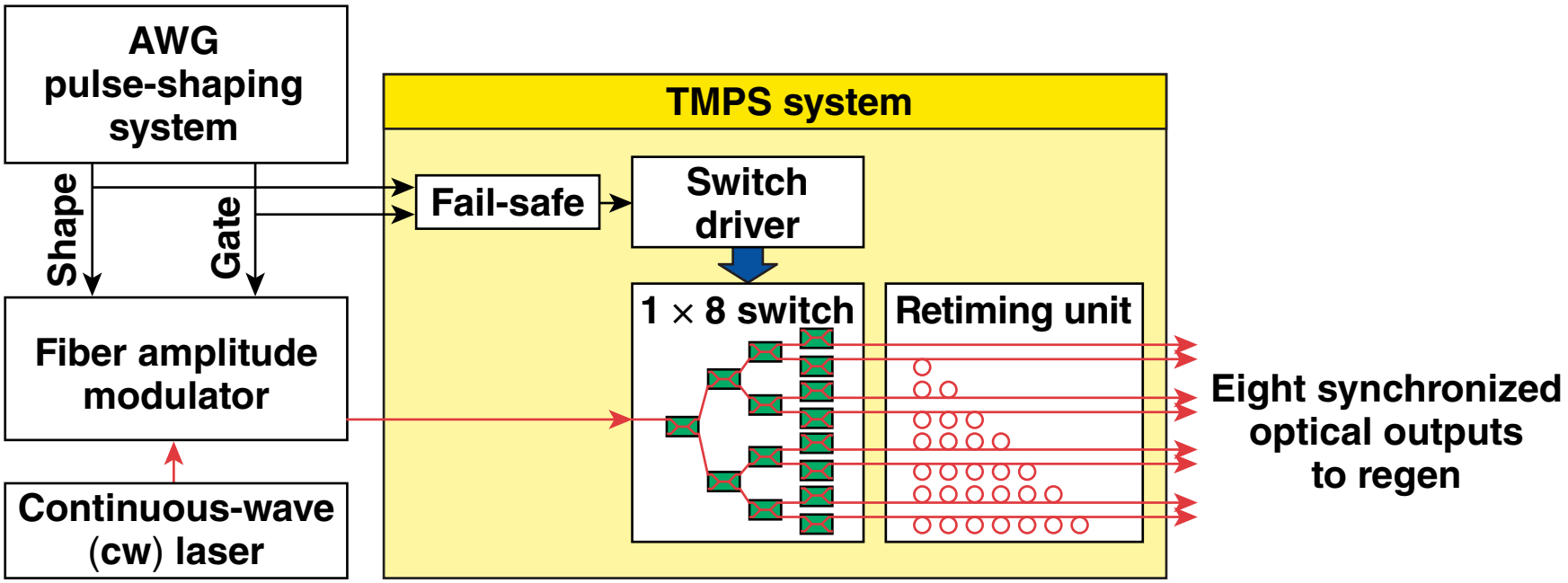


SSD bandwidth is only applied to one pulse to generate dynamic bandwidth reduction.

G10285b

A single pulse-shaping system generates both pulses to provide synchronized optical waveforms to multiple laser front ends

- The TMPS system is an add-on to an existing AWG-based pulse-shaping system



TMPS minimizes interpulse jitter for two co-propagating drivers.

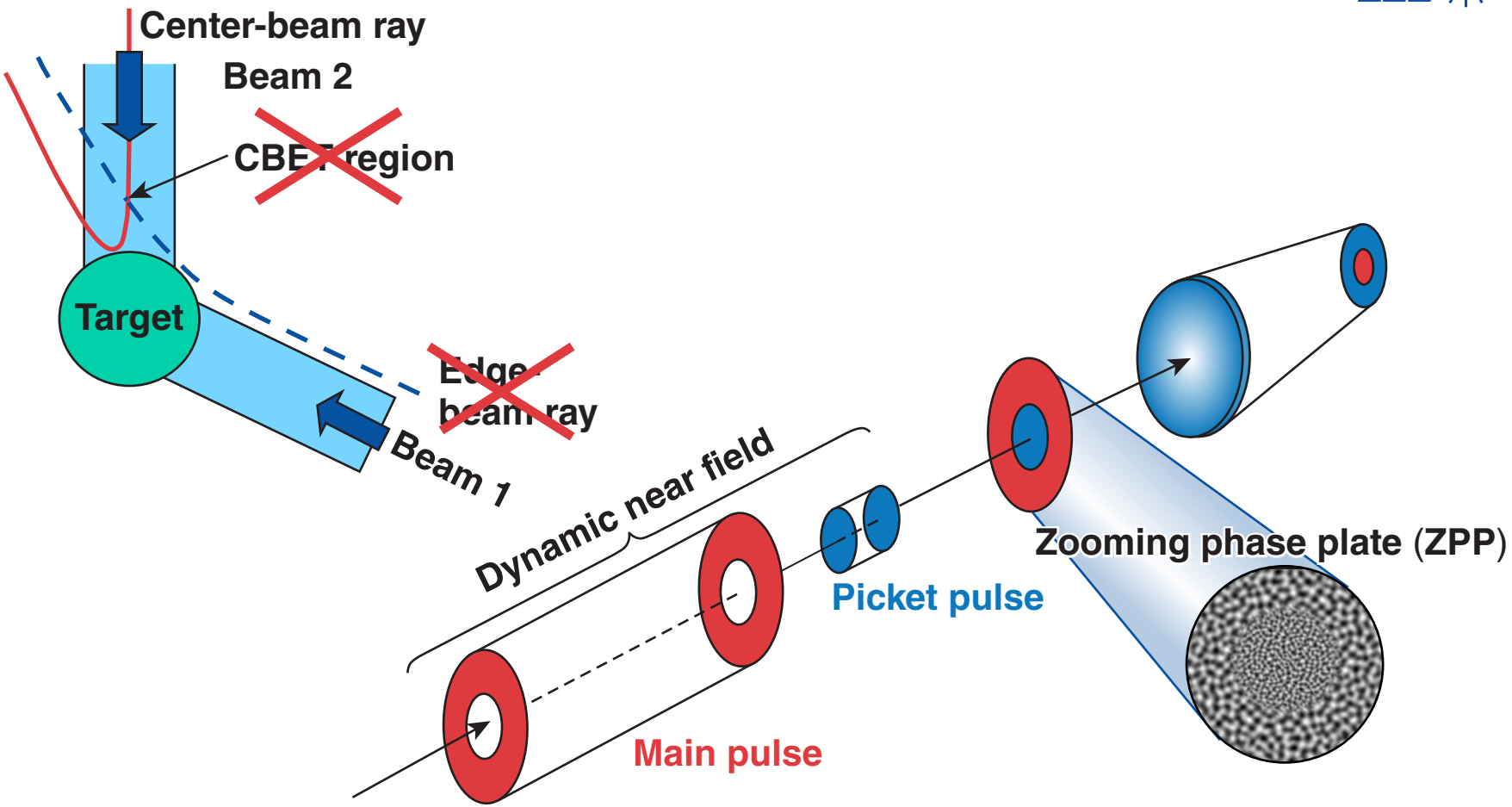
G10294a

Significant shot delays may be incurred when switching between dynamic bandwidth reduction (DBR) configurations

- Switching from no bandwidth to either full SSD or DBR involves minimal reconfiguration
- There is a significant reconfiguration when switching from SSD to DBR or DBR to SSD
- Shots are grouped such that significant reconfigurations do not occur during a shot day

Careful coordination with the Laser Facility Manager prior to shot day is required to minimize reconfiguration delays.

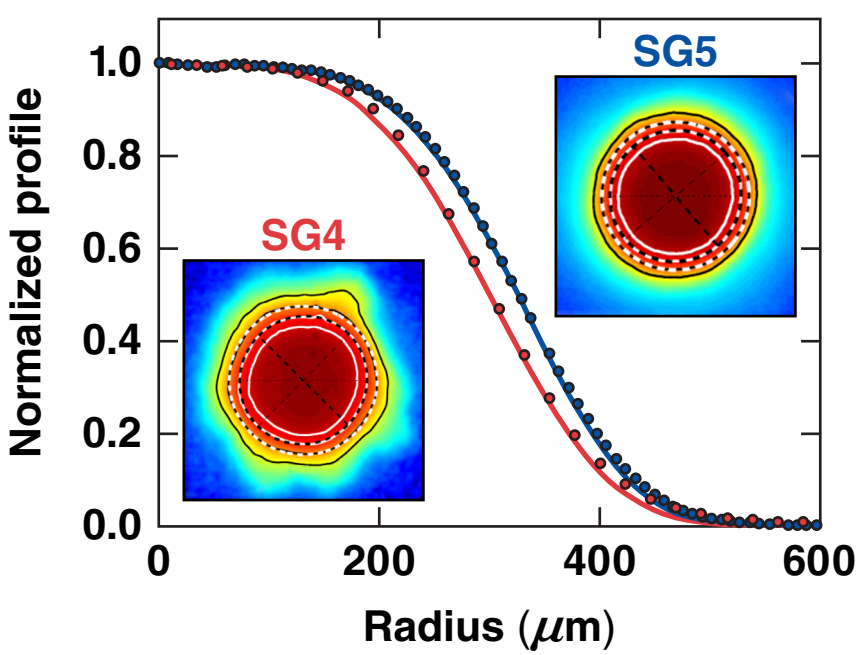
Zooming can be implemented on OMEGA using a radially varying phase plate and a dynamic near field

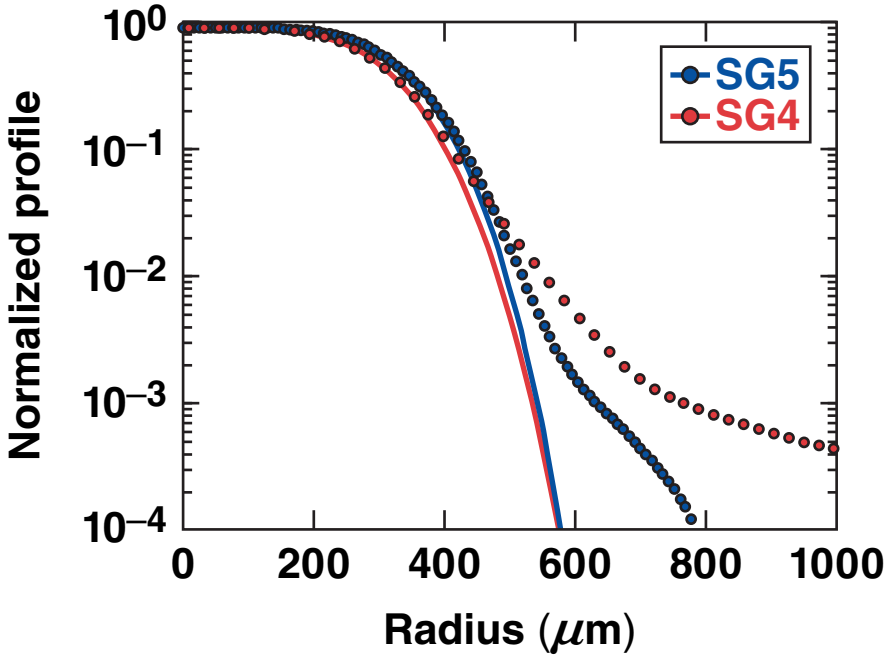


Zooming is predicted to recover the ablation pressure lost to CBET.

D. H. Froula *et al.*, Phys. Plasmas 20, 082704 (2013).

SG5 DPP's in use since February 2015 have improved uniformity and reduced wings



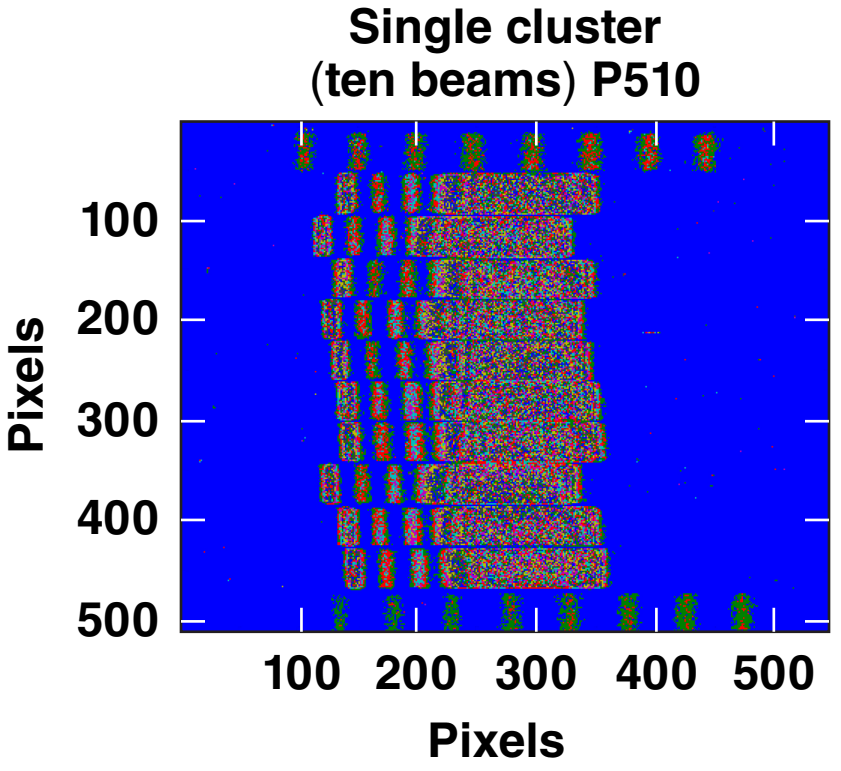


The intent is to retire SG4's when PI's gain experience with SG5's.

G10491

OMEGA beam timing and UV pulse shapes are measured with six 10-channel, UV streak cameras (P510's)

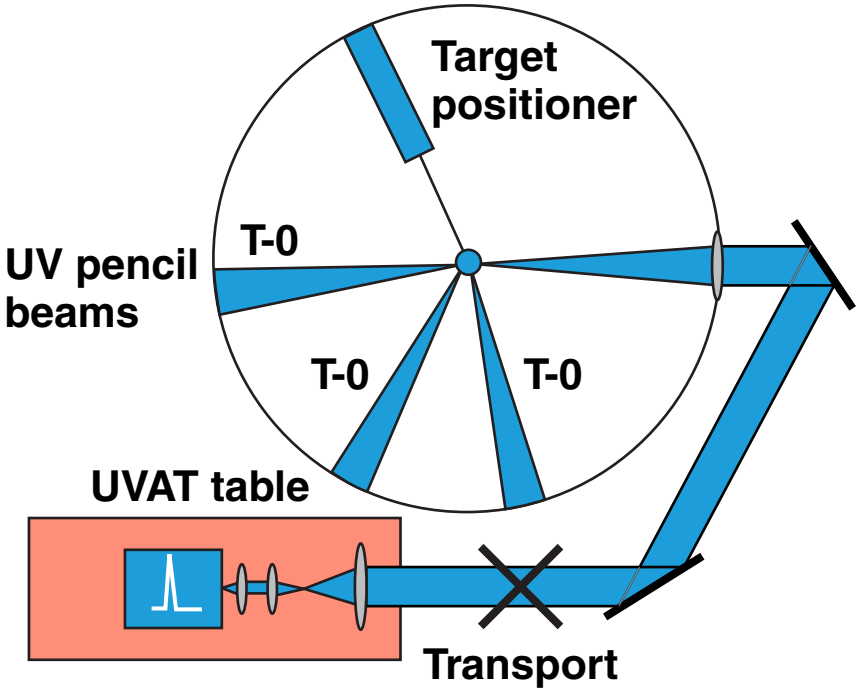
- Each of the 60 beams has a diagnostic pickoff just after the frequency-conversion crystals that feed a P510 channel
  - the cameras are grouped by cluster
- The P510's include an internal optical calibration module
  - geometric, flat-field, and sweep-speed calibrations are completed monthly
- Timing on OMEGA is referenced to the OMEGA fiducial



G10311a

The 3ω beam-timing system references the P510 calibration to target chamber center (TCC)

- A refined method has been developed to measure the timing with 100-ps UV pulses
  - the front end is configured to produce a 5-Hz pencil beam
  - the pencil beam is injected down one beam at a time
- A diffuse sphere placed at TCC is used to measure timing at the ultraviolet alignment table (UVAT)

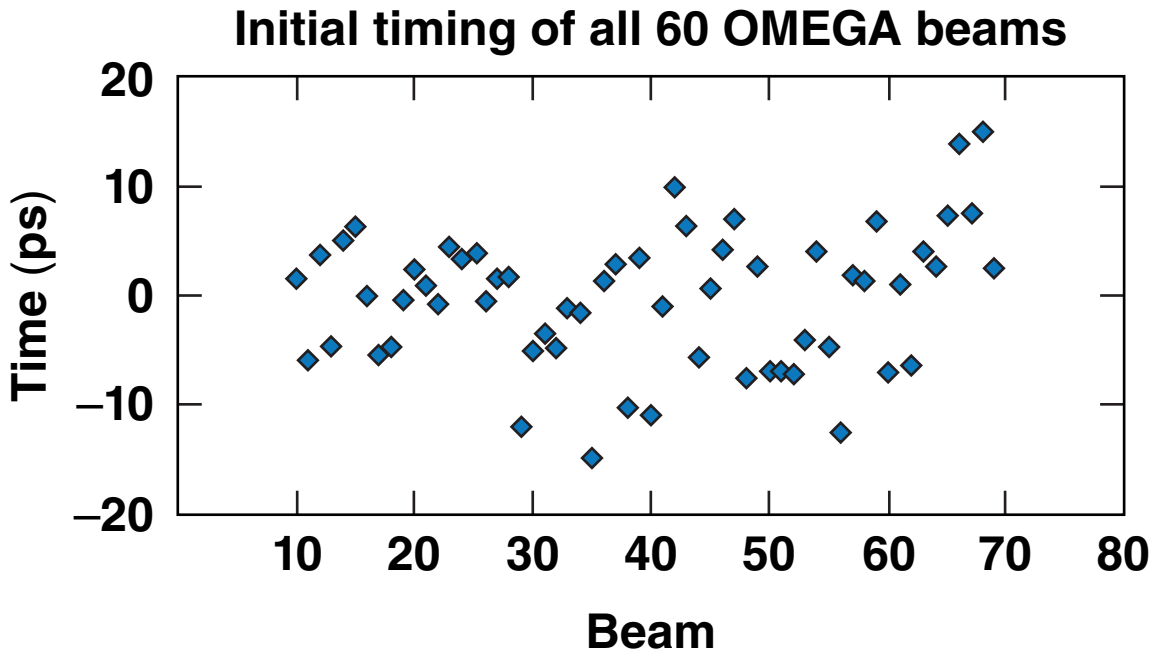


Beam timing can be accomplished on all 60 beams in less than 2 h.

G10312

The new 3ω beam-timing system has demonstrated the ability to co-time all 60 beams to better than 5-ps rms

- Beam-timing runs are accomplished on a maintenance day
- Beam-to-beam timing is then corrected to better than 5-ps rms

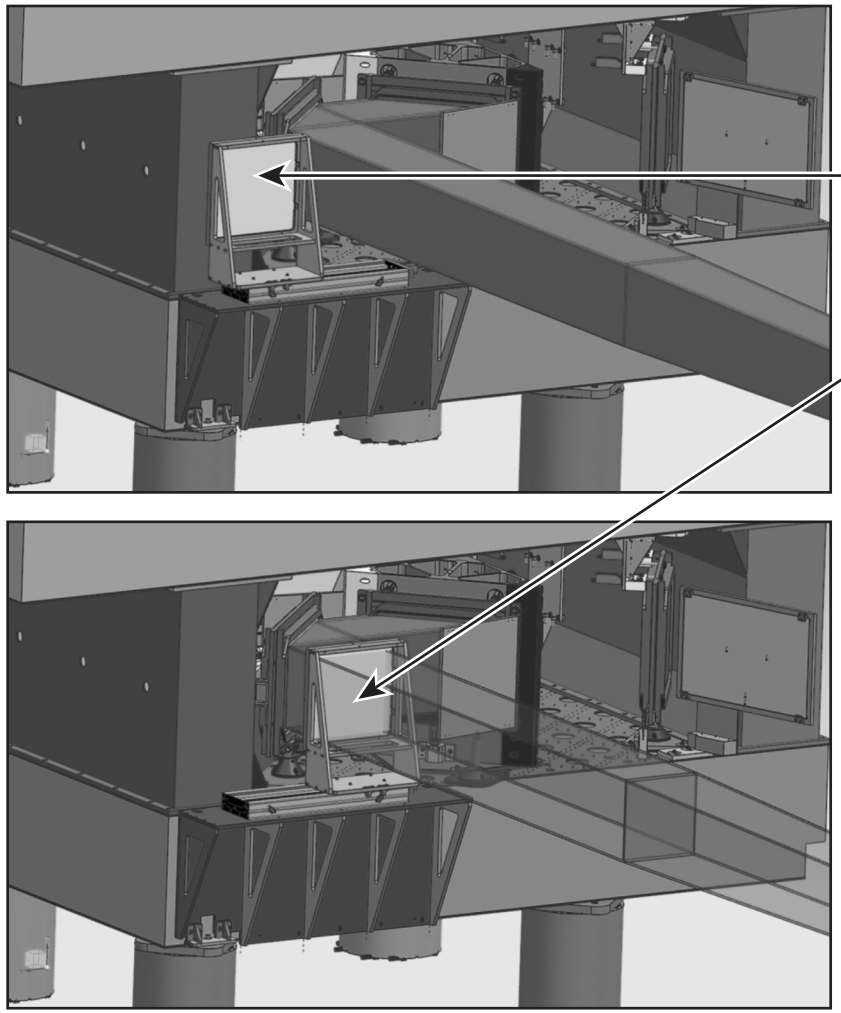


G10313a

LLE continues to work to advance OMEGA EP to full specifications

- The Beam 1 short-pulse energy will be increased for 0.7 ps to 10 ps for sidelighter (non-co-propagated) operation in FY16 through the use of a lower-compressor diagnostic filter
- UV beam energy has been restored by changing the UVHR2 (UV high reflector) location
- Diagnostics, optics reconfiguration, and beam shaping improvements are in development to increase short pulse energy

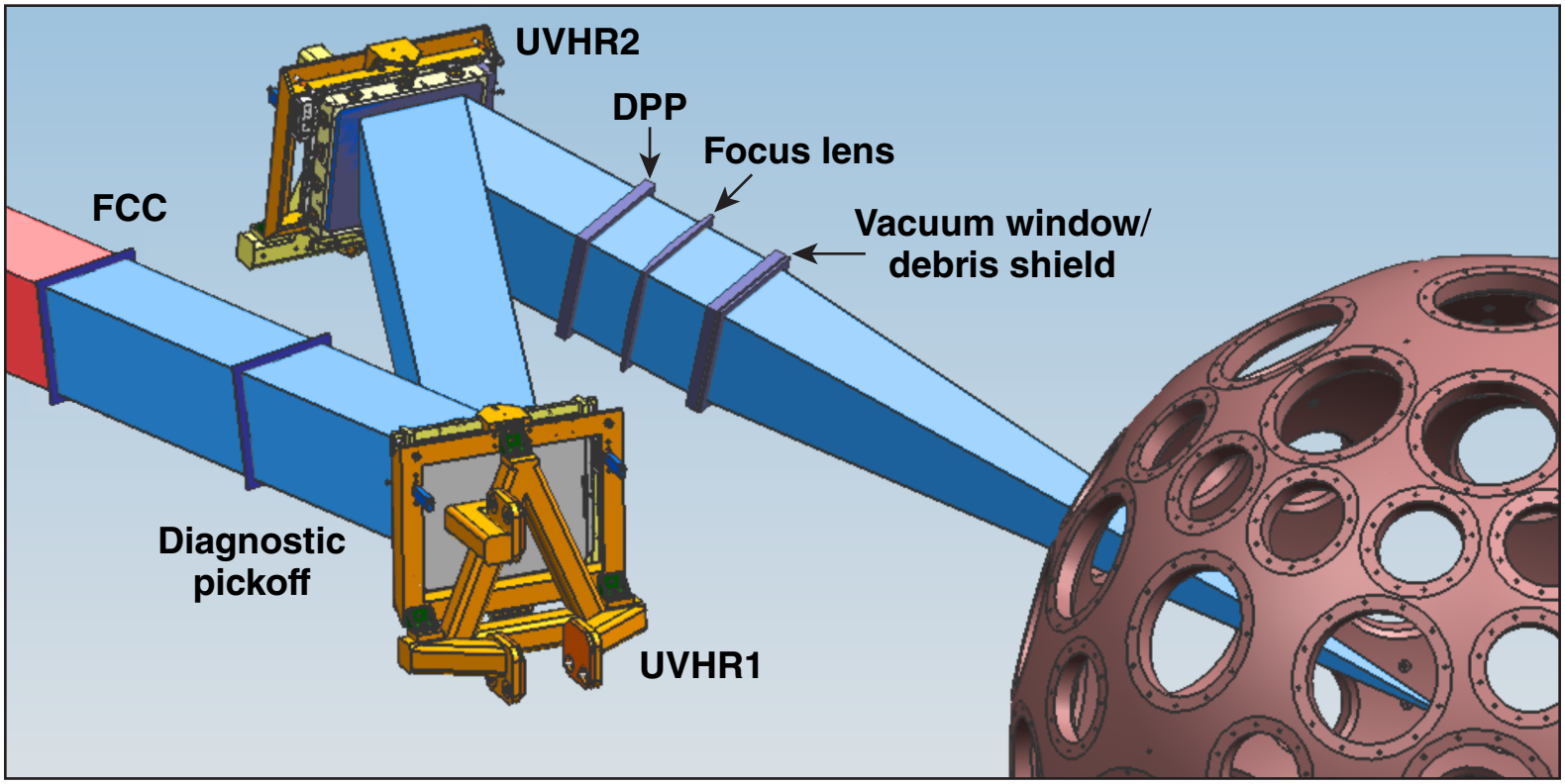
Lower-compressor short-pulse energy will be increased when operating to the sidelighter path by the installation of a filter



- The OMEGA EP lower compressor is currently limited by the peak power in the diagnostic arm
- An insertable filter is being added to attenuate the power in the diagnostic path before down-collimation
- This will enable increase the available sidelighter energy at 0.7 ps to 10 ps

G10493

UV beam energy has been restored by changing the UVHR2 relocation

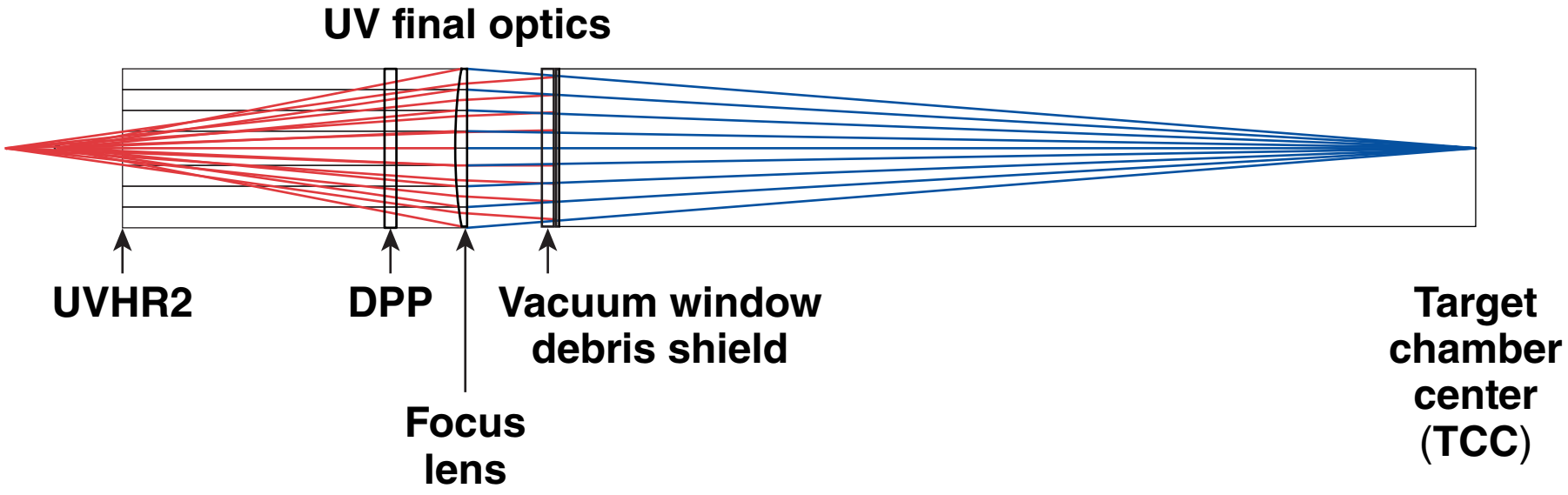


- The final UV transport mirror UVHR2 showed the most damage
- The onset of damage was not correlated to increases in shot energy

DPP: distributed phase plate
FCC: frequency-conversion crystal

G10328a

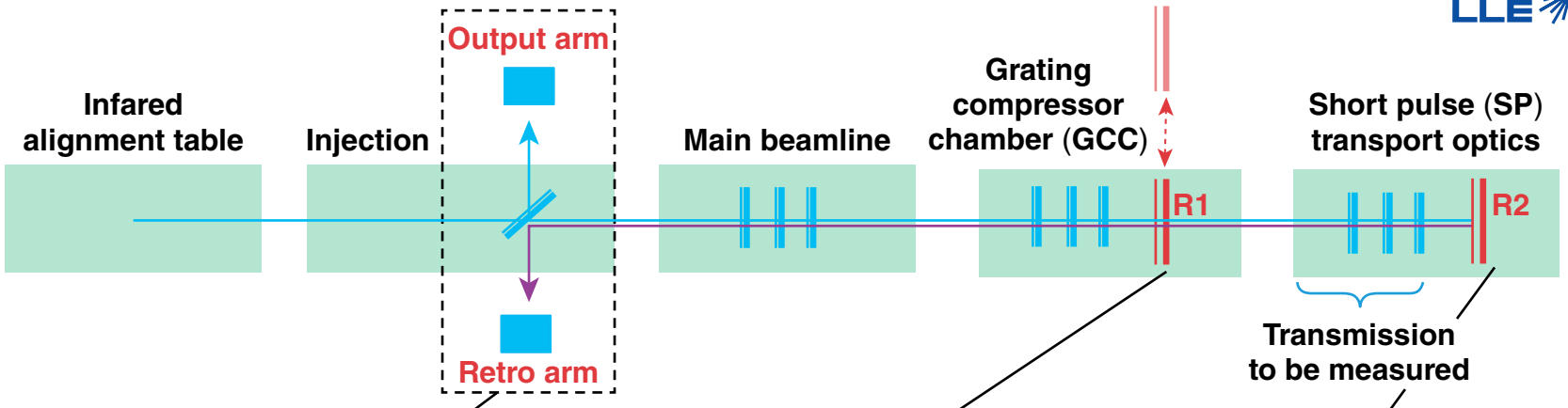
Damage was caused by counter-propagating ghosts

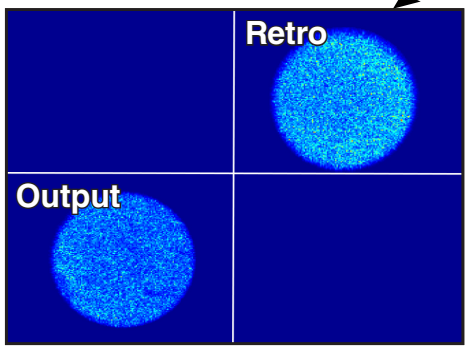


- The damage region was traced to match the area illuminated by converging ghosts from surfaces in the focus lens, vacuum window, and debris shields
- The expected ghost intensity was well below that of the forward-going beam
- Anti-reflection coating performance combined with DPP modulation caused damaging ghost

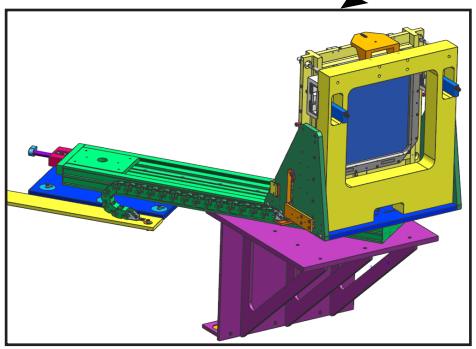
G10329a

A ratiometer has been implemented to characterize transmission through the final OMEGA EP short-pulse optics

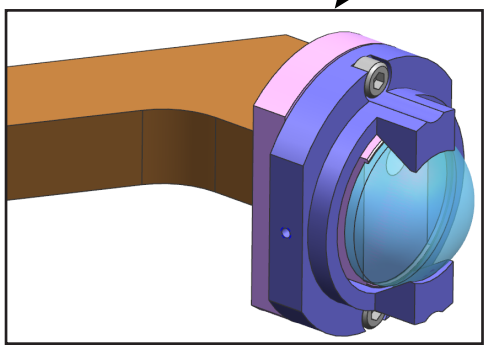




Ratiometer diagnostic



CAM3 reflector in GCC



Spherical reflector at TCC

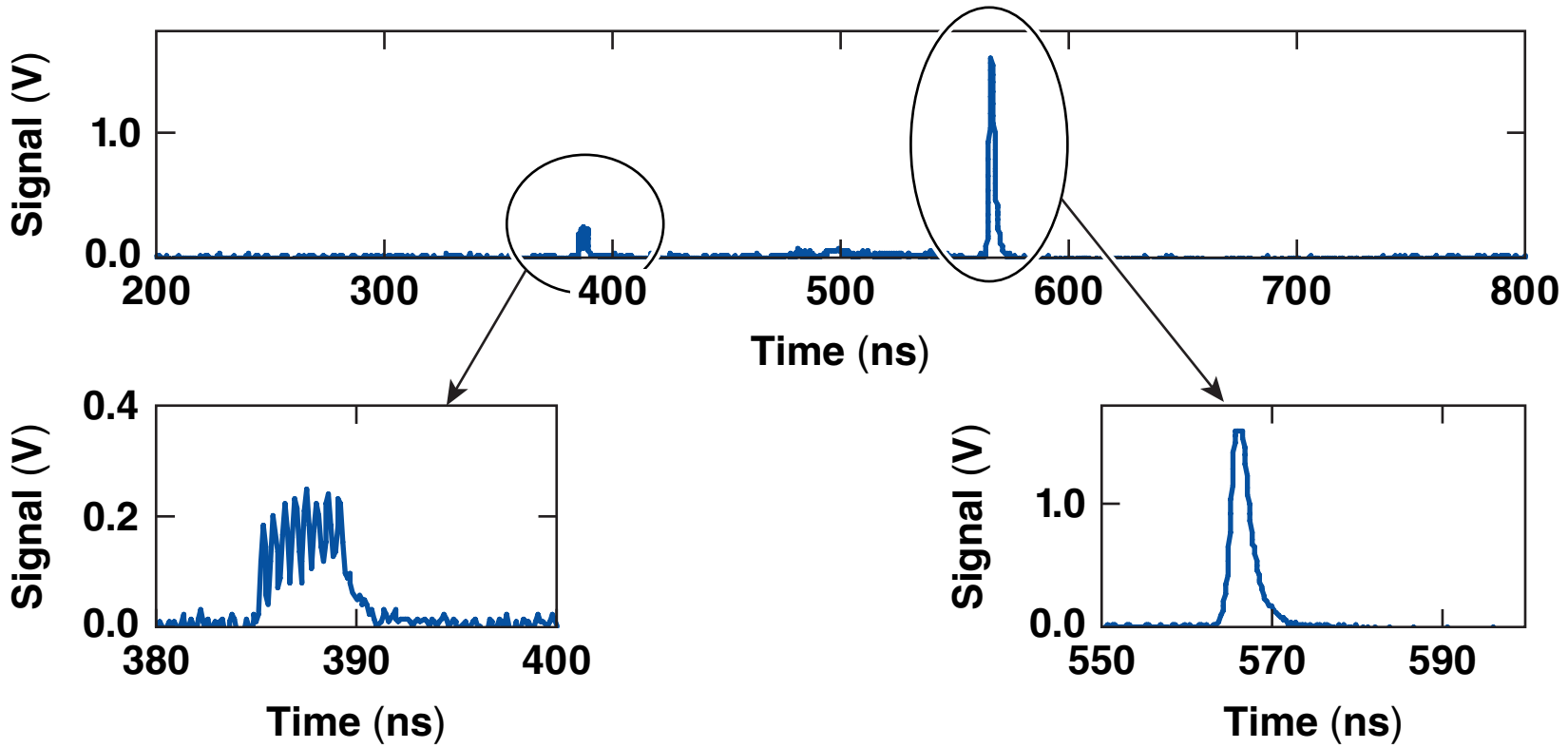
(Uncoated optics with Fresnel reflection)

$$\text{Transmission}_{R_1 \rightarrow R_2} = \sqrt{\frac{\text{Retro}R_2 / \text{Output}R_2}{\text{Retro}R_1 / \text{Output}R_1}}$$

*J. Kwiatkowski et al., this conference.

E23894a

A timing fiducial has been installed on the P2 3-D nTOF detectors and on the 8 × 4 nTOF



- The 3-D nTOF instrument PI is J. Knauer and is useful at DT yields > 10^{13}
- The 8 × 4 nTOF instrument PI is C. Forrest and is useful for DD and DT shots with yields from 10^{7} to 10^{14}

G10495

An Isotope Separation System was commissioned in Q4 FY14 and LLE DT fuel has been purified

- Before: T:D:H was 34%:60%: 5% (estimated)
- After: T:D:H is 60%:40%: <0.1% (estimated)
- 8500 Ci processed in September 2014

The 60:40 T:D ratio was chosen to provide a 50:50 mixture in the gas phase (fractionation) of a layered capsule.

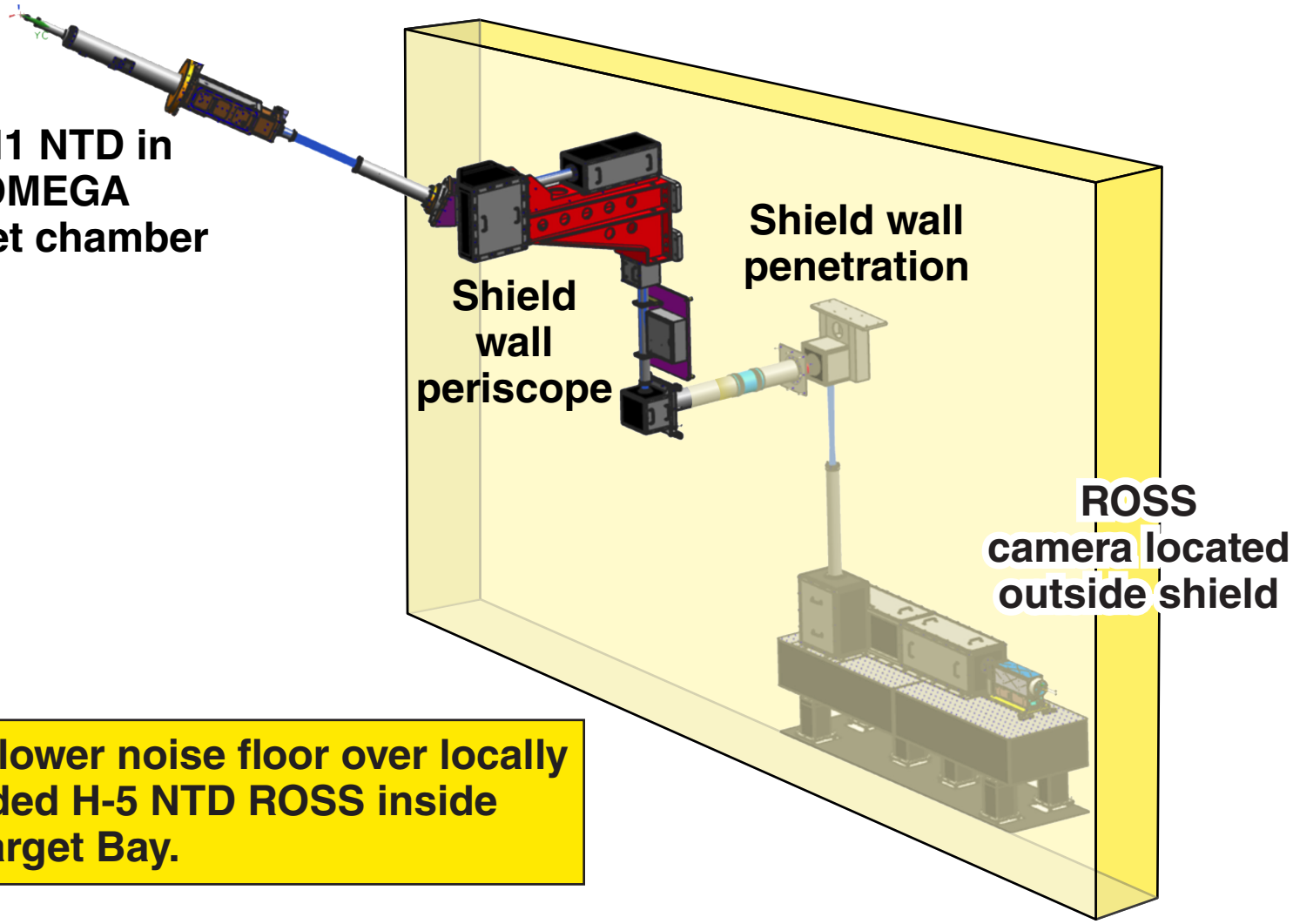
*Developed jointly with Savannah River National Laboratory.

E23693b

Imaging Thomson scattering on OMEGA EP is being considered for implementation in FY16

- The diagnostic will use the existing 4ω probe modified to provide 100-ps pulses at 200 mJ
- The diagnostic will use port 4, which is 90° from the 4ω probe
- A final requirements document will be completed this summer
- Contact Dustin Froula if you are interested in this diagnostic

The OMEGA neutron temporal diagnostic (NTD) was relocated to a shielded location in Q2 FY15



200× lower noise floor over locally shielded H-5 NTD ROSS inside the Target Bay.

*See J. Katz poster, this conference.

G10429a

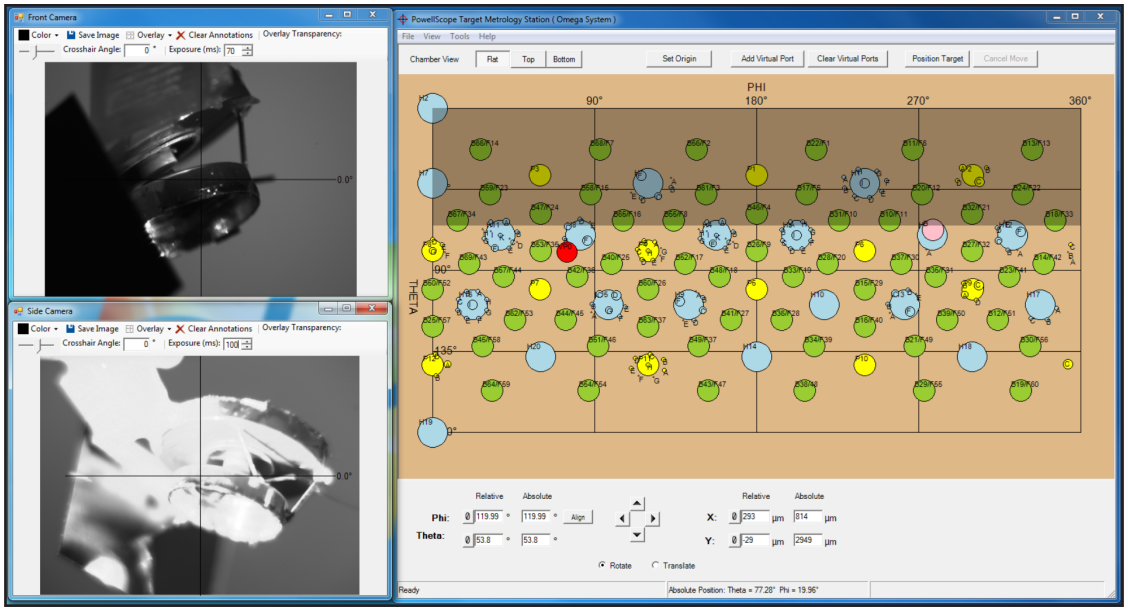
Improvements are being made to gas-filled targets on OMEGA and OMEGA EP

- Phase I:* Gas target manifold
  - OMEGA EP operations underway
  - higher pressure accessible (currently 10 atm)
  - hardware capable of 20 atmospheres
- Phase II: Planar cryo platform
  - will be able to perform D_2 fill *in-situ*
  - one gas only
  - testing required, approximately end of FY15 to prove concept
- Phase III: TIM based version of phase II capability envisioned, ~FY17
  - impact to high-voltage diagnostics may cause restrictions
  - multiple gasses not easily supported

*See D. Mastrosimone poster, this conference.

The Target Metrology Station "Powell Scope" cameras and software have been upgraded

- New cameras were installed providing increased field of view and pixel density
- Software enables reticle rotation to measure angles directly, simultaneous camera views, and save images
- An additional upgrade is planned for in FY16 to improve the quality of mechanical stages and achieve higher precision and faster motion



See Mark Bonino to get an introduction to the new software.

G10498

Summary/Conclusions

OMEGA is an effective and efficient facility and continues to evolve to meet user requirements

UR LLE

- OMEGA, 20 years post commissioning, continues to thrive as an National Nuclear Security Administration (NNSA) workhorse
  - 24,667 target shots on OMEGA; 3,098 on OMEGA EP
- Operational statistics show continued high performance
- OMEGA improvements in pulse shaping and dynamic bandwidth reduction were completed in January 2015
- Improvements to energy on target, beam timing, distributed phase plates (DPP's), and diagnostics for the hot-spot pressure measurement benefit all users conducting implosions
- Work continues on meeting the OMEGA EP operational specifications

LLE provides 80% of shots for the National Inertial Confinement Fusion (ICF) and Stockpile Stewardship Programs.