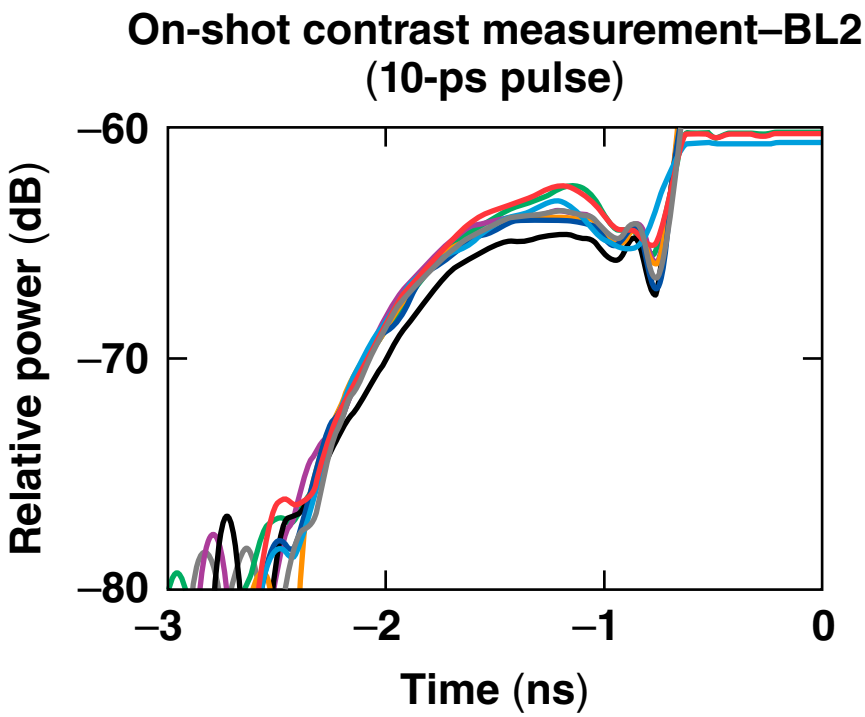
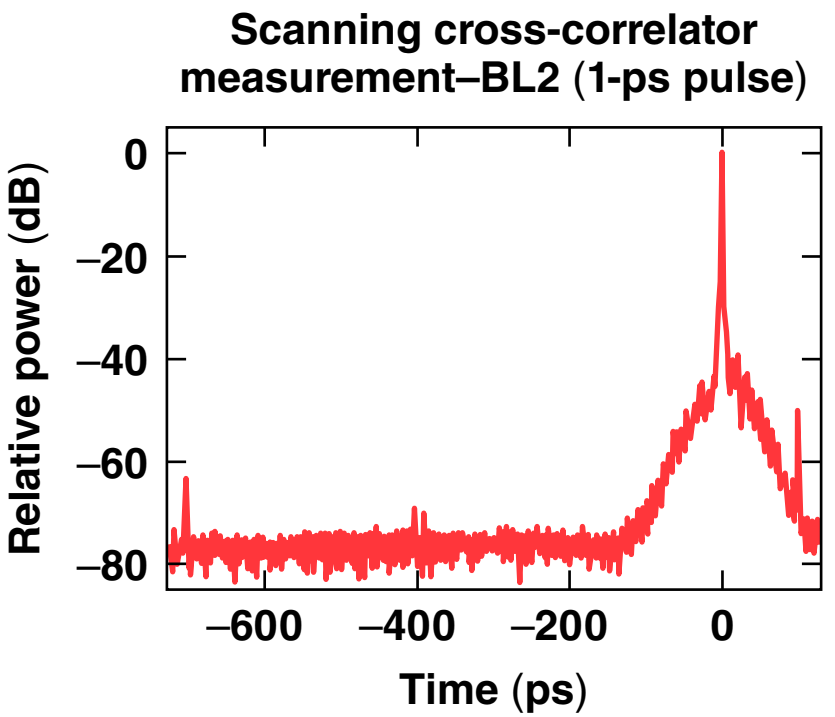
OMEGA EP Temporal Contrast Measurements





C. Dorrer
University of Rochester
Laboratory for Laser Energetics

Omega Laser Facility
Users' Group Workshop
Rochester, NY
28–30 April 2010

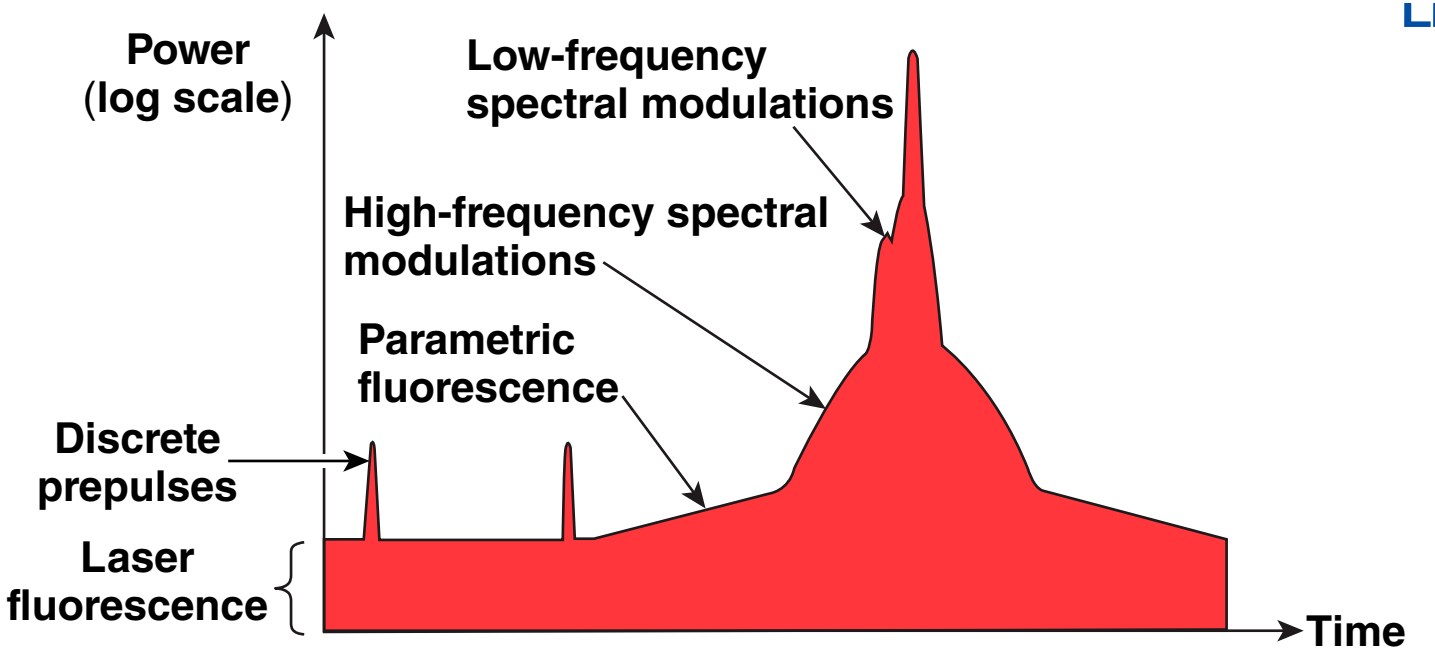
Summary

Temporal contrast diagnostics are deployed on OMEGA EP

UR LLE

- The temporal contrast of OMEGA EP is an important parameter for users
- A suite of three diagnostics is being deployed to fully characterize the temporal contrast over a large temporal range
- Current and future contrast-improvement campaigns are described

The temporal contrast of a short optical pulse can impact its interaction with a target



- Features identified on OMEGA EP (as of March 2010)
  - nanosecond pedestal caused by parametric fluorescence from OPCPA front-end
  - no significant prepulse
  - pedestal caused by OPCPA pump and/or stretcher spectral modulation

On-shot temporal-contrast measurements are crucial for understanding laser–target interaction.

The high-contrast-diagnostics (HCD) project is a suite of three complementary diagnostics for OMEGA EP

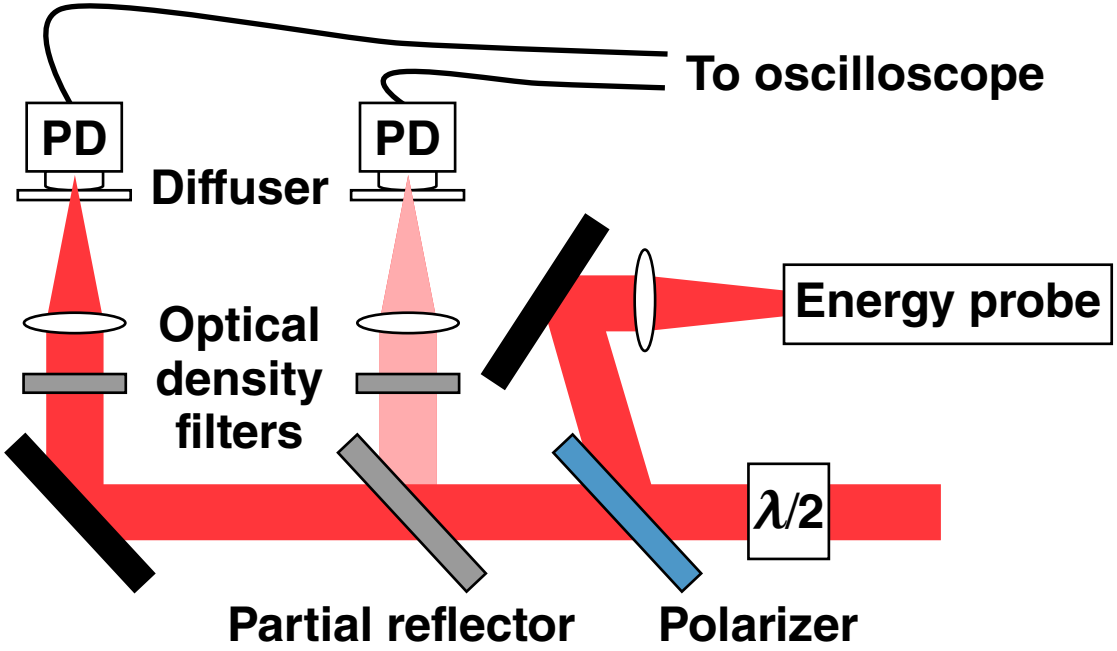
UR LLE

Diagnostic	Range	Status
Nonlinear scanning cross-correlator	(–720 ps, 130 ps)	Operated on BL1/2 (front end only, not on shot)
Photodiode + oscilloscope	(–1 μs, –500 ps)	• Temporary setup operated on BL1/2 (~200 high-energy shots) • Permanent setup being deployed (April 2010)
Nonlinear single-shot cross-correlator	(–600 ps, –30 ps)	• Demonstrated on front-end prototype • Permanent setup being deployed in OMEGA EP (May 2010)

HCD will ensure accurate on-shot contrast measurements for users and will facilitate contrast-improvement campaigns.

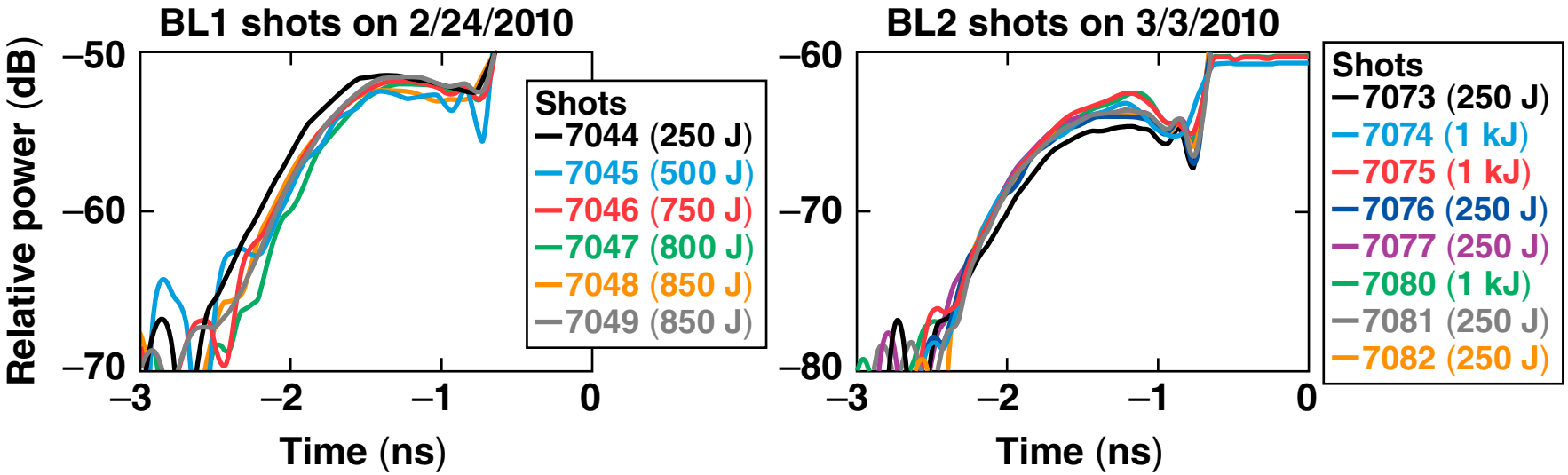
E18847

The on-shot OMEGA EP nanosecond contrast is measured with calibrated fast photodetection



- Consistent contrast measurements obtained using precalibration and knowledge of on-shot filtration and reference energy
- Final deployment: 2 simultaneous measurements per beamline
- Diagnostic performance
  - temporal resolution: ~200 ps
  - dynamic range: 10^9
  - temporal range: >1 μs
  - contrast measured in near field

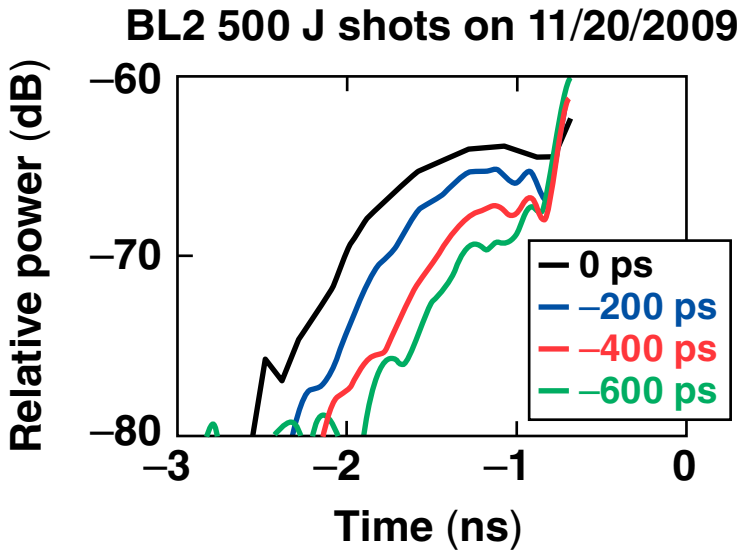
The nanosecond temporal contrast has been measured and is consistent shot-to-shot

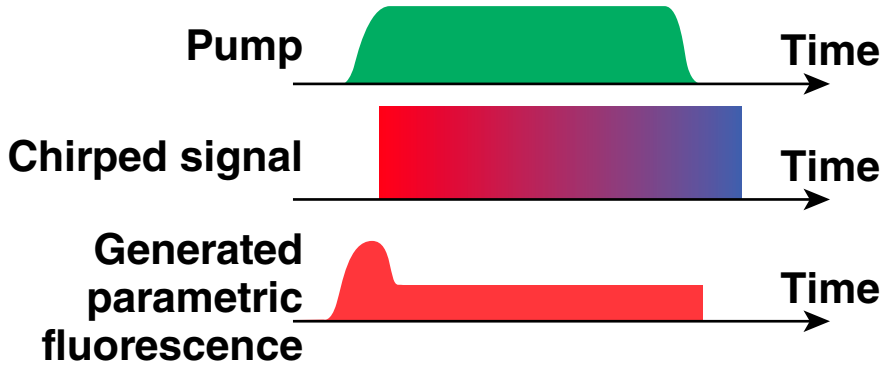


	BL1 (February 2010)	BL2 (March 2010)
Intensity contrast (10-ps pulse)	$1.6 \times 10^5 \pm 9\%$	$2 \times 10^6 \pm 15\%$
Energy contrast for nanosecond pedestal	$1.6 \times 10^3 \pm 11\%$	$2 \times 10^4 \pm 11\%$

- The contrast varies by ~10% over a large variety of on-shot energies
- Day-to-day contrast varies by ~50%
- BL1's contrast is worse than BL2's by a factor of ~10

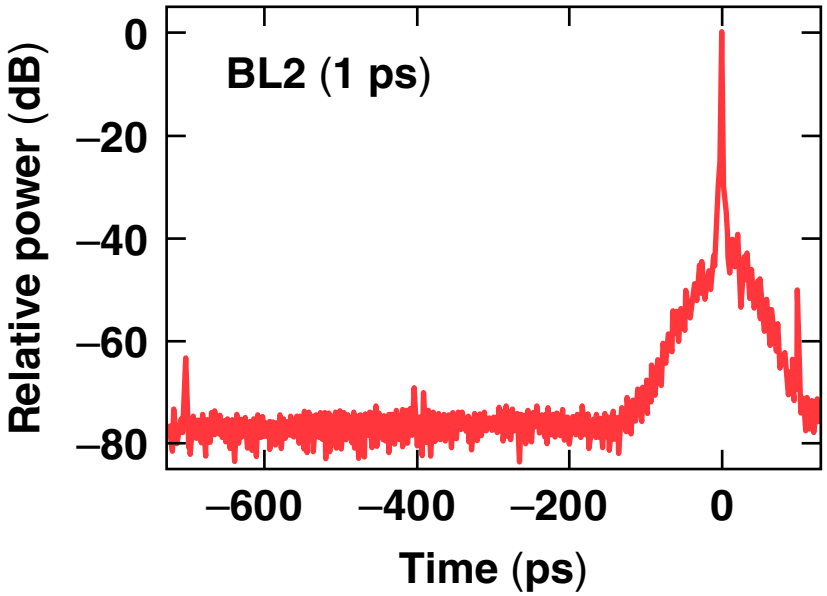
The nanosecond contrast diagnostic has been used for a first contrast-improvement campaign

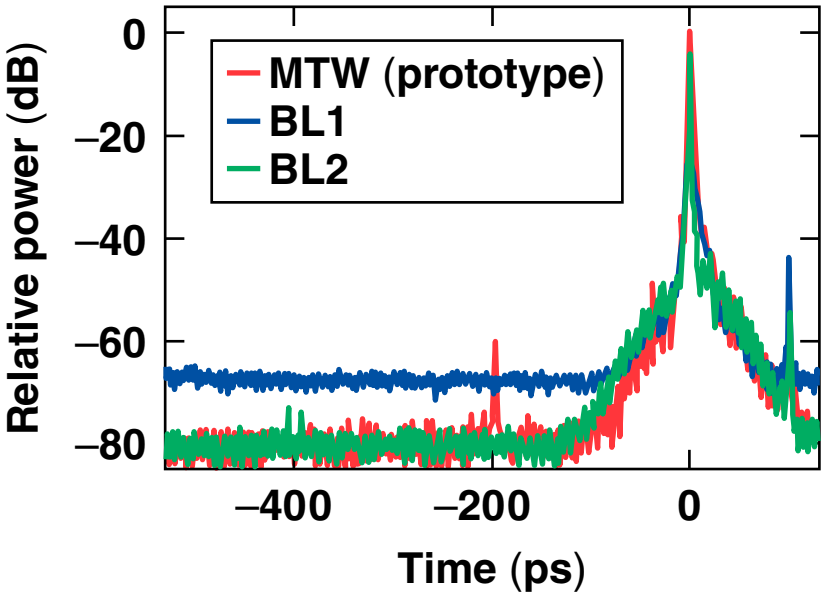




- Temporal contrast has been increased by adjusting the pump-signal relative delay in the OPCPA front end
  - improvement of energy contrast by a factor of 4 was demonstrated
  - energy contrast as high as 10^5 was obtained
- Daily variation in pump-pulse timing and configuration explains the observed variation in contrast

Picosecond contrast measurements of the front-end are indicative of the on-shot contrast

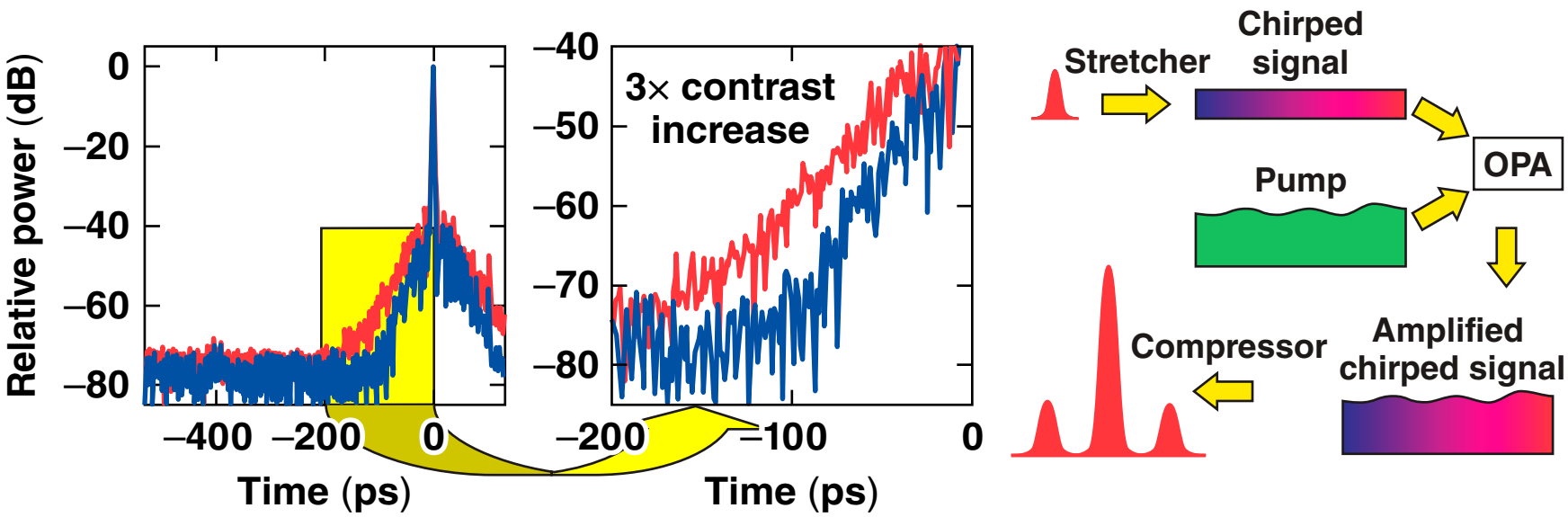




- Picosecond contrast measured with a commercial scanning cross-correlator (Sequoia, Amplitude Technologies) on the 5-Hz front end (February 2010)
  - best compression (subpicosecond) for best resolution
  - propagation through the entire laser system (identical to on-shot beam path)
- Findings are indicative of on-shot performance
  - no significant prepulse before the main pulse
  - BL1 contrast is approximately 10× worse than BL2 contrast

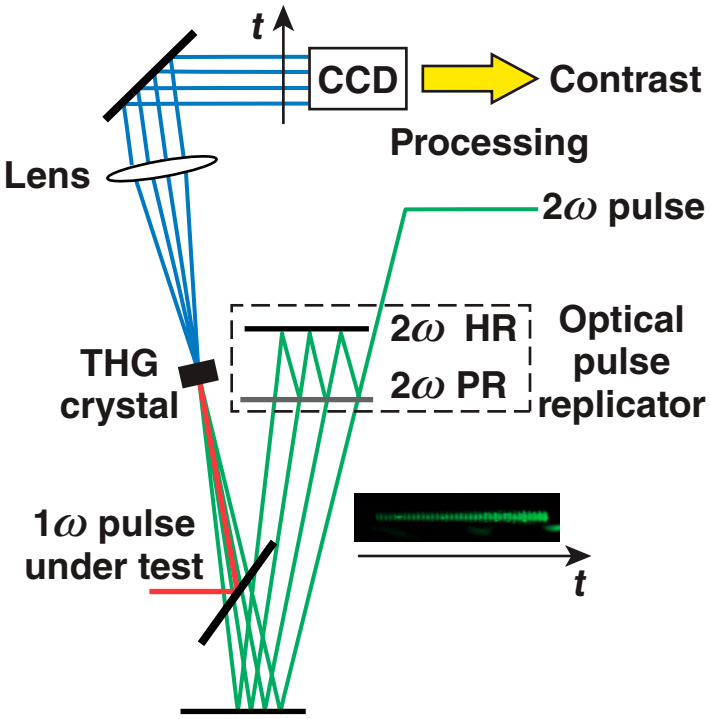
E18851

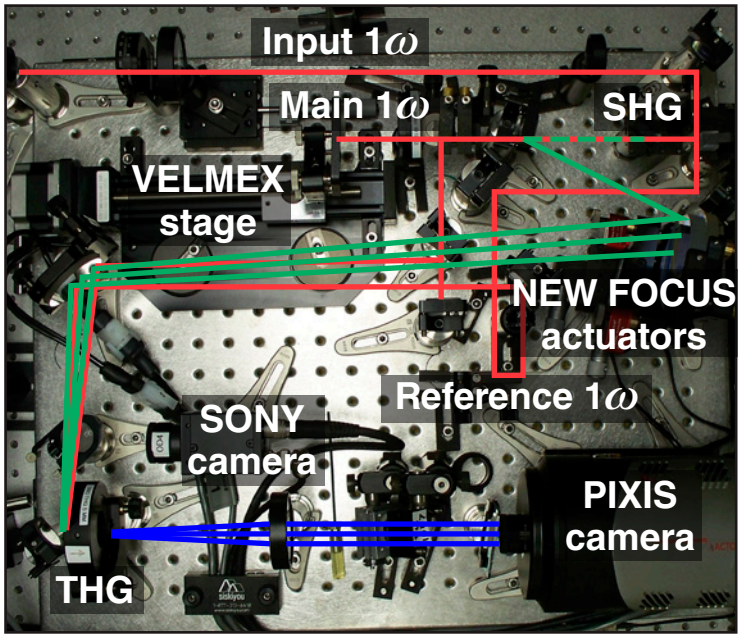
The BL2 contrast was improved by a factor of 3 in the 100-ps window before the main pulse



- Wavelength tuning of the seed-pulse laser used to generate the OPCPA pump pulse
  - better match with the pump amplifier wavelength
  - lower noise on the pump pulse
  - decreases high-frequency spectral modulations on the amplified signal
- A 3× improvement in this temporal range translates to on-shot pedestal energy reduced from 2 J to 0.6 J for a 1-kJ shot

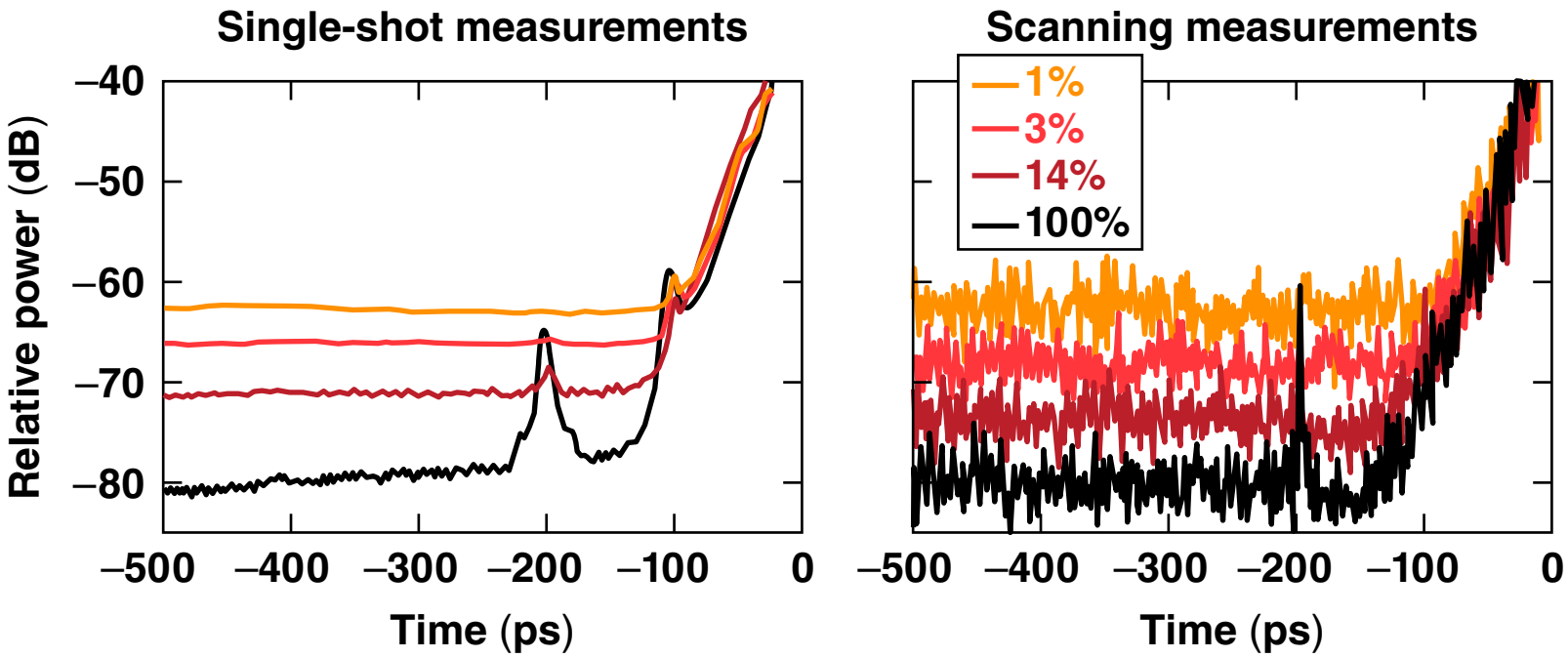
An on-shot single-shot picosecond contrast diagnostic is ready to be deployed





- Single-shot third-order cross-correlator
  - single 2ω sampling pulse generated from 1ω test pulse
  - sequence of ~100 sampling pulses generated with an optical pulse replicator
  - THG of 1ω and 2ω pulses for background-free measurements
- Various calibrations ensure accurate measurements

Testing of a single-shot cross-correlator on the prototype front-end has demonstrated accurate results



- Single-shot cross-correlator for OMEGA EP
  - 550-ps window selectable in (–860 ps, 0 ps) range
- Measurement of discrete prepulses, parametric fluorescence, and pedestal close to main pulse
- Diagnostic will first be deployed on BL2 in May 2010

Measuring and improving temporal contrast is an on-going effort at LLE

- The focal spot of parametric fluorescence will be measured in May 2010 to provide the on-shot intensity contrast
- Deployment of additional amplification stage based on parametric amplification with a short pump pulse (demonstrated by LLE in 2007)
  - expected 10^4 increase in nanosecond contrast
- Deployment of OPCPA pump filtering, as demonstrated by LLE in 2007
  - expected contrast increase in the 100-ps window before the main pulse

Summary/Conclusions

Temporal contrast diagnostics are deployed on OMEGA EP

UR LLE

- The temporal contrast of OMEGA EP is an important parameter for users
- A suite of three diagnostics is being deployed to fully characterize the temporal contrast over a large temporal range
- Current and future contrast-improvement campaigns are described