Beam Power Matching on the OMEGA Laser

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High-performance, laser-driven inertial confinement implosions require that the drive beams be power matched to 5% rms. The OMEGA laser is equipped with a high-accuracy energy-measurement system, which is used to photometrically calibrate six, ten-channel streak cameras. These confirm that the required level of power balance for square and low-contrast pulse-shapes has been achieved. We infer from the measurements and modeling that we should be able to obtain the requisite power balance required for the higher-contrast shapes of ultimate interest for direct-drive ICF. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460.

Summary

OMEGA has nearly met its ultimate power-balance goal

UR LLE

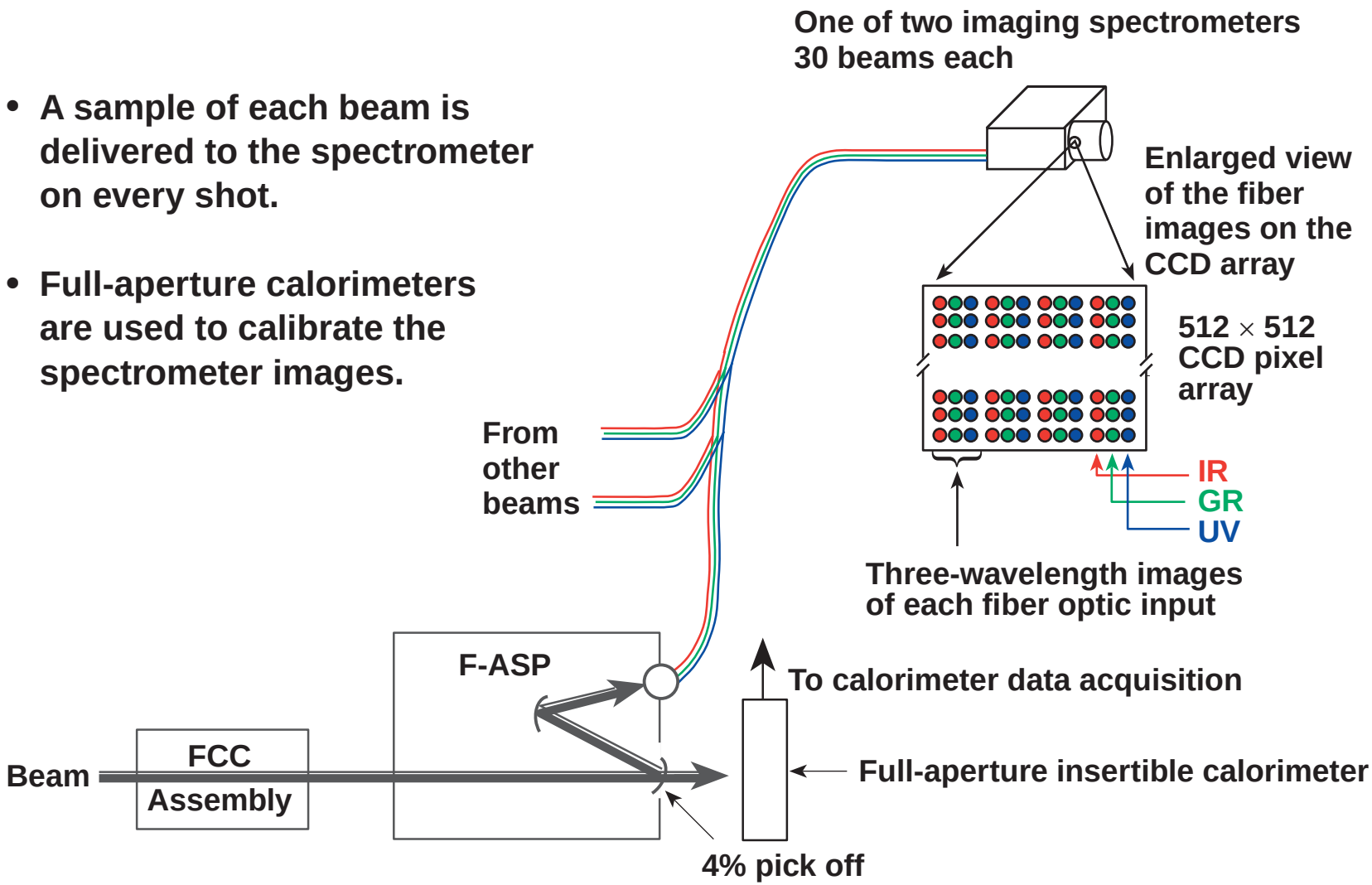
- Meeting the goal of ~1% irradiation uniformity requires beam energy and power balance of 5% or better.
- Energy balance better than 3% has already been obtained.
- Power balance of 5% or better is currently being obtained throughout most of a square pulse.
- We expect to be able to achieve 5% power balance for an "$\alpha = 3$" pulse.
- The power balance levels now being attained are challenging to measure.

Our primary strategy for achieving power balance is to find and correct laser problems

- Gain saturation, radial-gain variation, and the frequency-conversion process require that gains and losses be reasonably matched to achieve power balance.
- Attempting to compensate for sub-par components in an *ad hoc* fashion, while it may improve energy balance, can degrade power balance.
  - The small-signal-gain measurement allows us to easily find and correct amplifier problems.
- After problems are corrected, amplifier gains are matched by offsetting charge voltages.
- The splits are adjusted based on data obtained by firing subsets of the amplifiers.

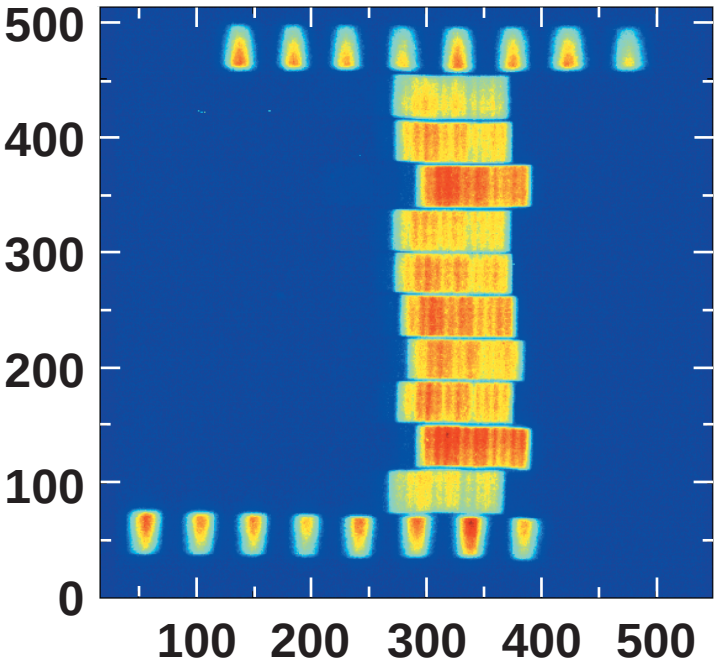
The Harmonic Energy Diagnostic (HED) is used for several power balance–related measurements

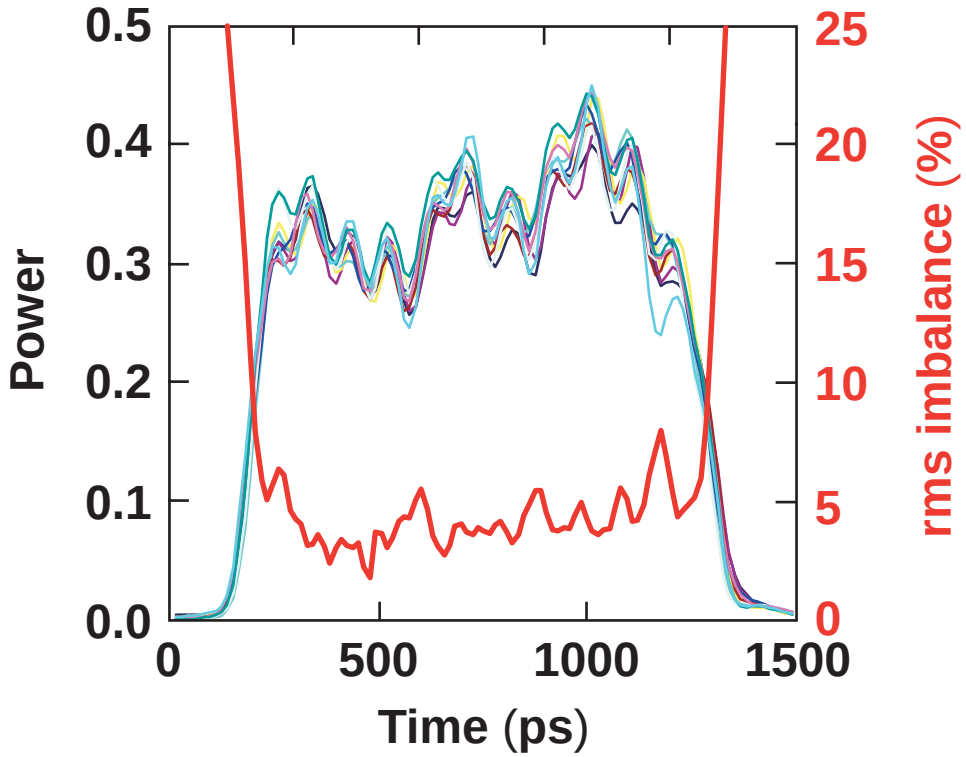
- A sample of each beam is delivered to the spectrometer on every shot.
- Full-aperture calorimeters are used to calibrate the spectrometer images.



E7576a

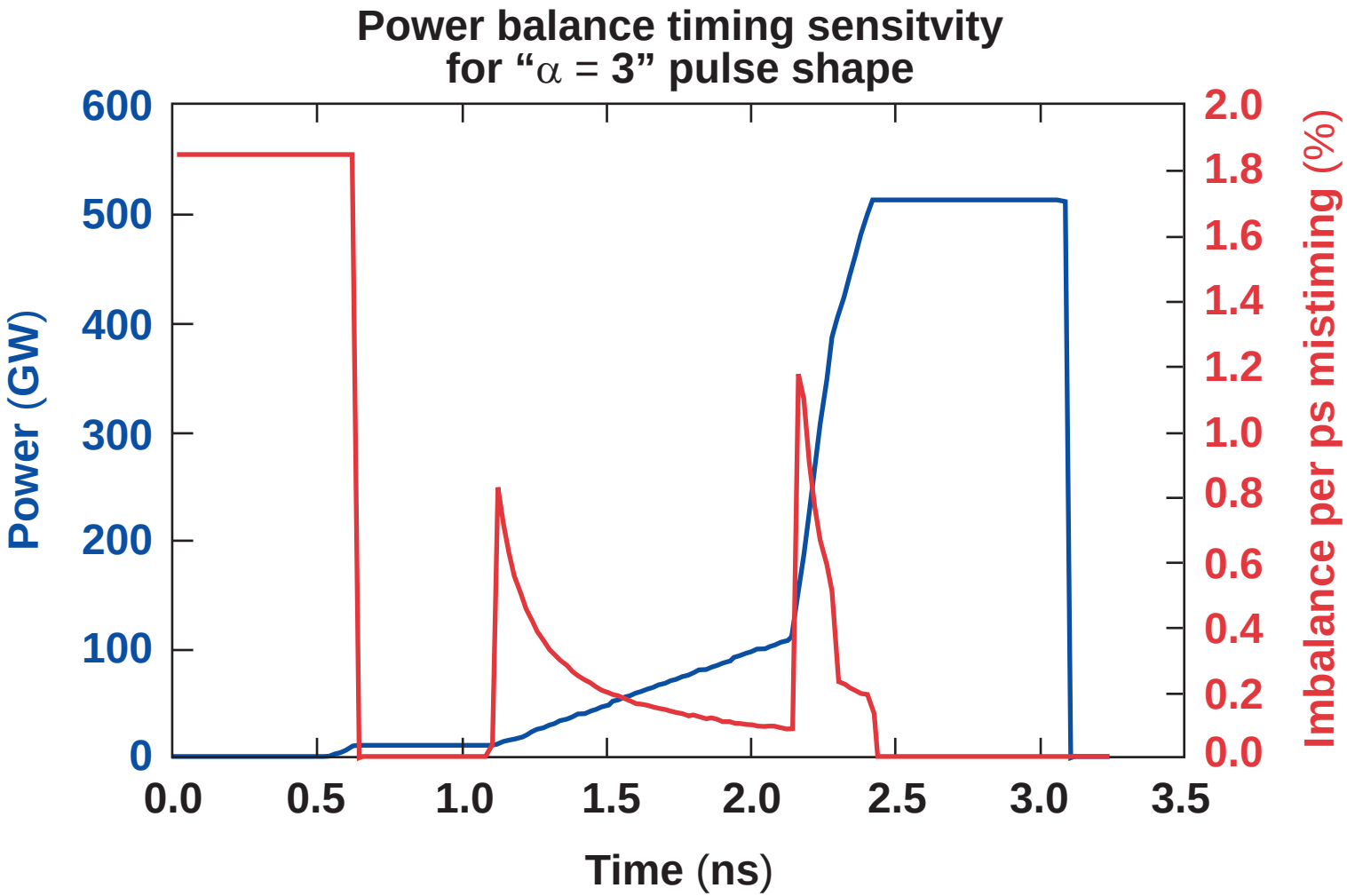
Five LLE “P510” ten-channel streak cameras provide power measurements on 50 beams of OMEGA





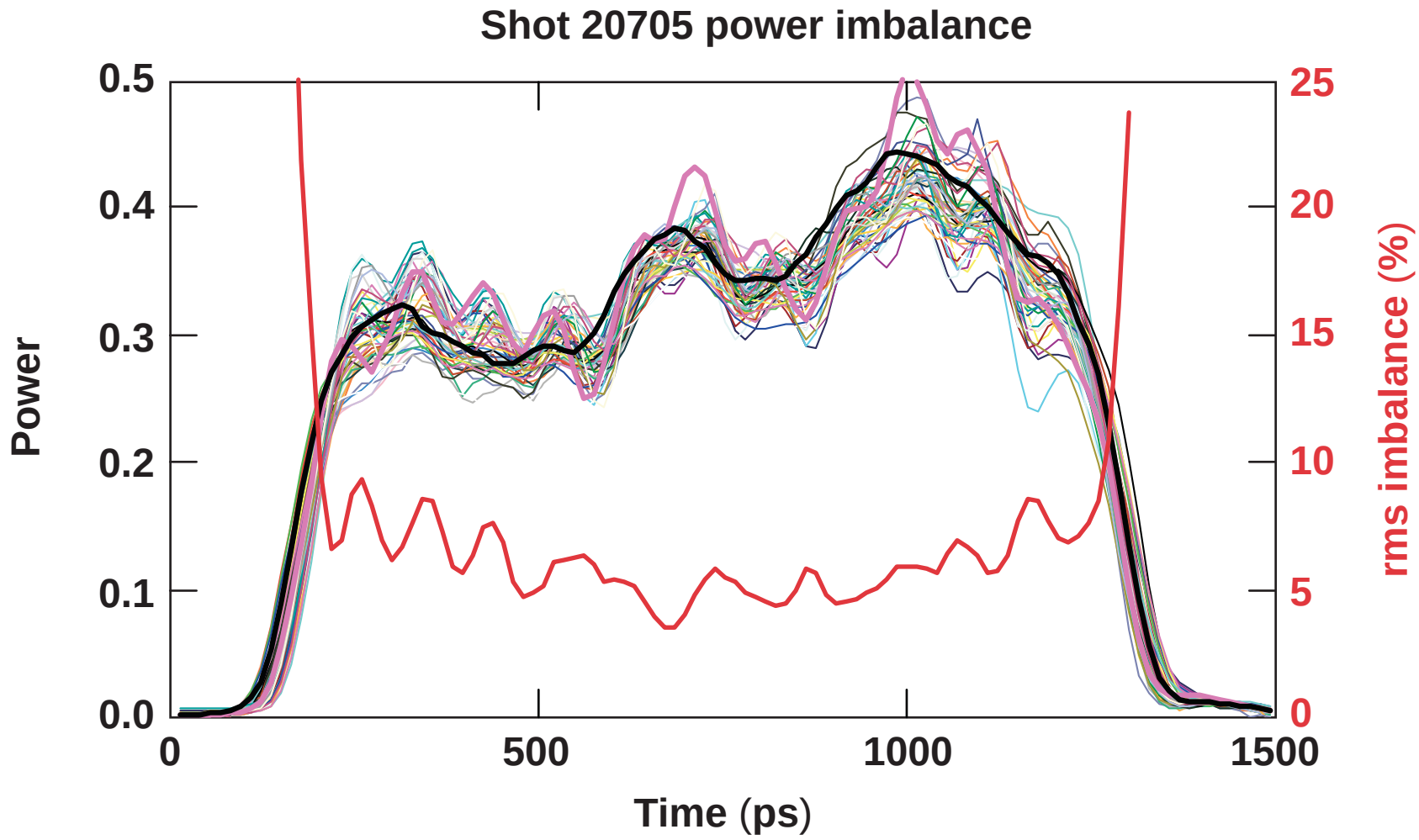
E10609

Power balance requires that the beams be accurately timed



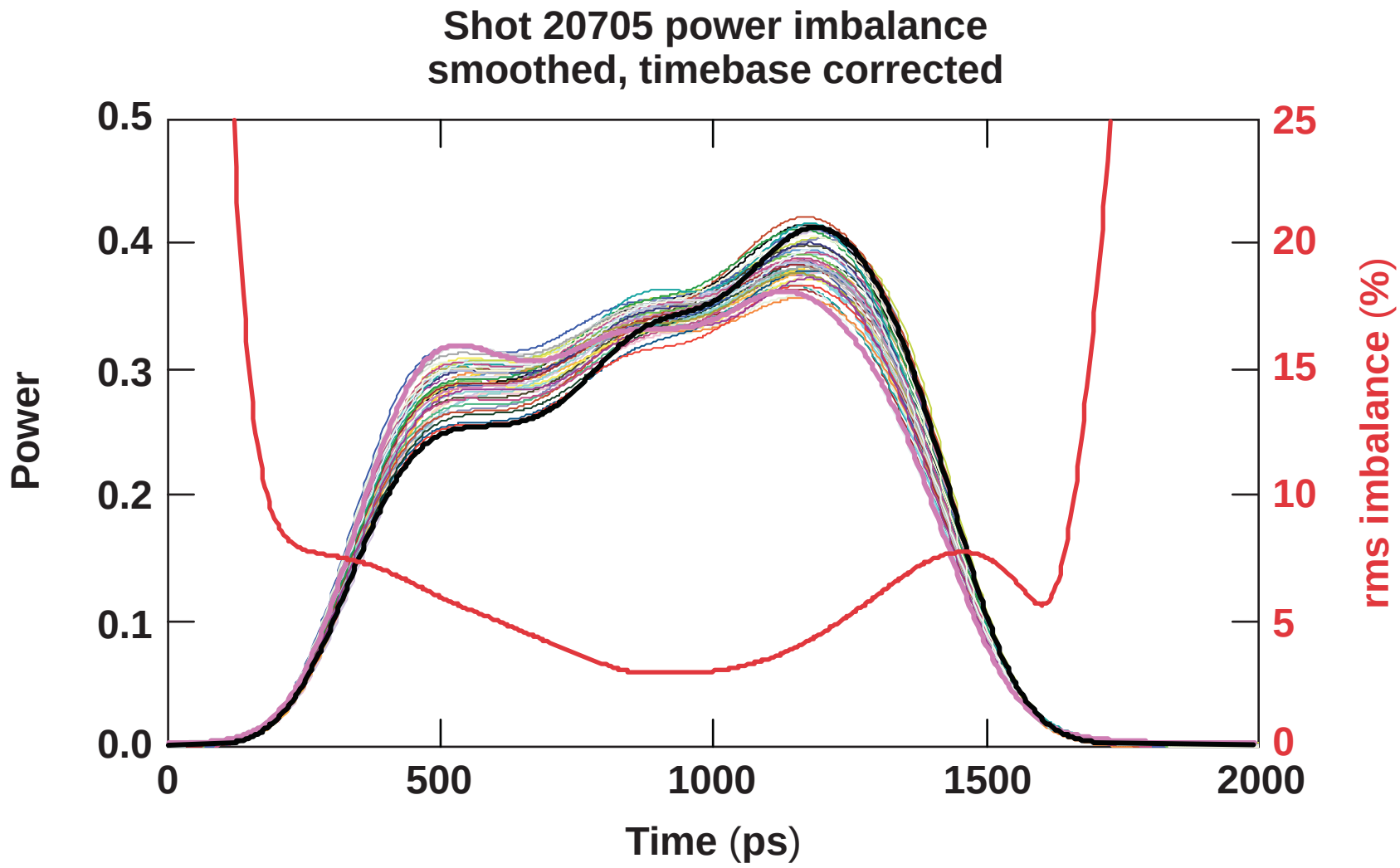
E9485

Bandwidth differences and timing errors lead the P510 raw data to overestimate the beam imbalance



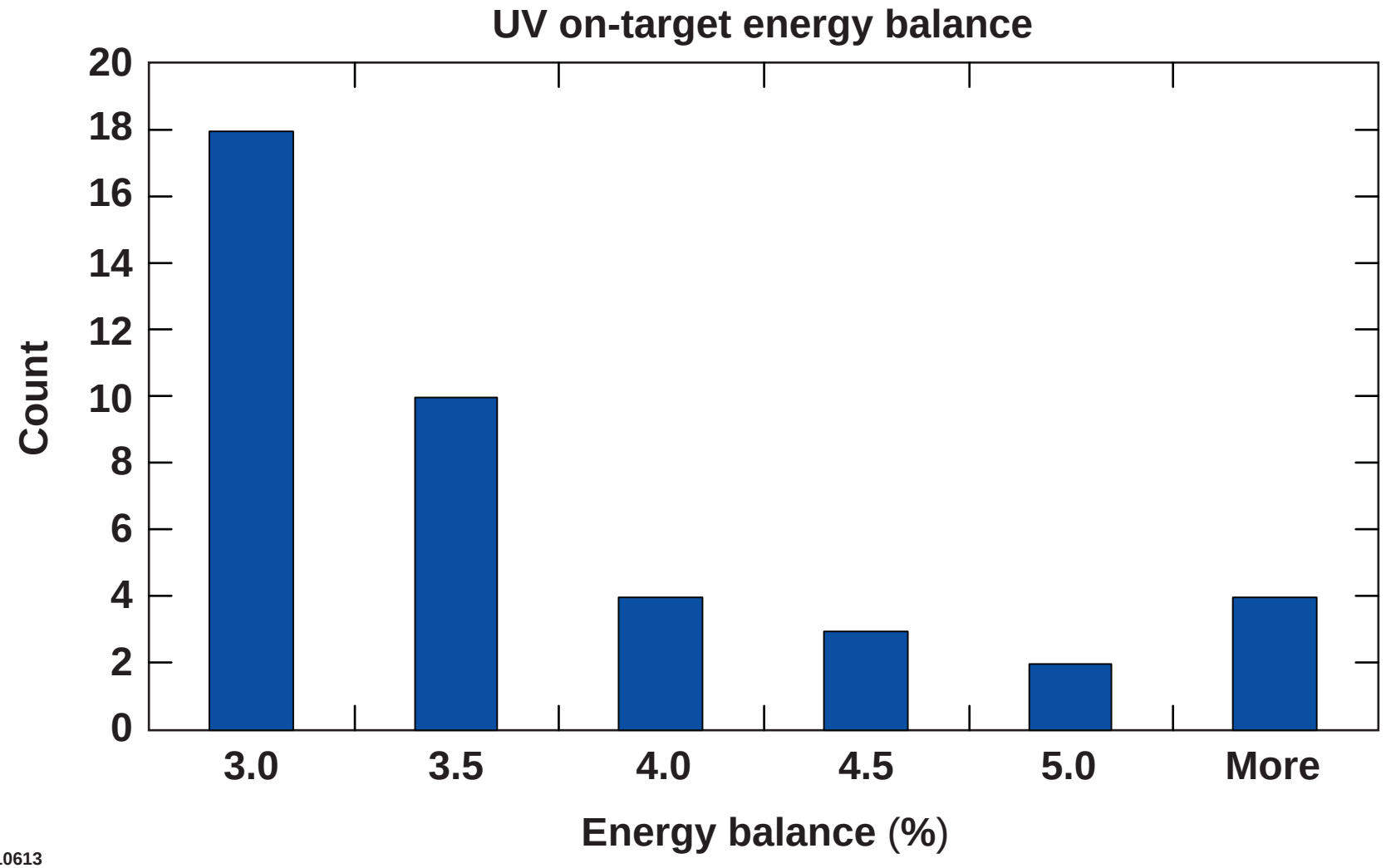
E10610

Even with averaging, the streak-camera data is probably overestimating OMEGA's power imbalance



E10611

Over a two-week period, the majority of the shots met the on-target-uniformity requirement



E10613

We are improving and expanding existing diagnostics to ensure the required power balance is achieved

- We are implementing a new beam-timing diagnostic to improve beam-timing accuracy.
- We are improving the UV-transport measurement for better accuracy and ease of use.
- We are upgrading two first-generation P510 streak cameras to the current design and adding one additional camera to obtain 60-beam coverage.
- We are refining our calibration of the P510 streak cameras to obtain the required measurement accuracy.

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