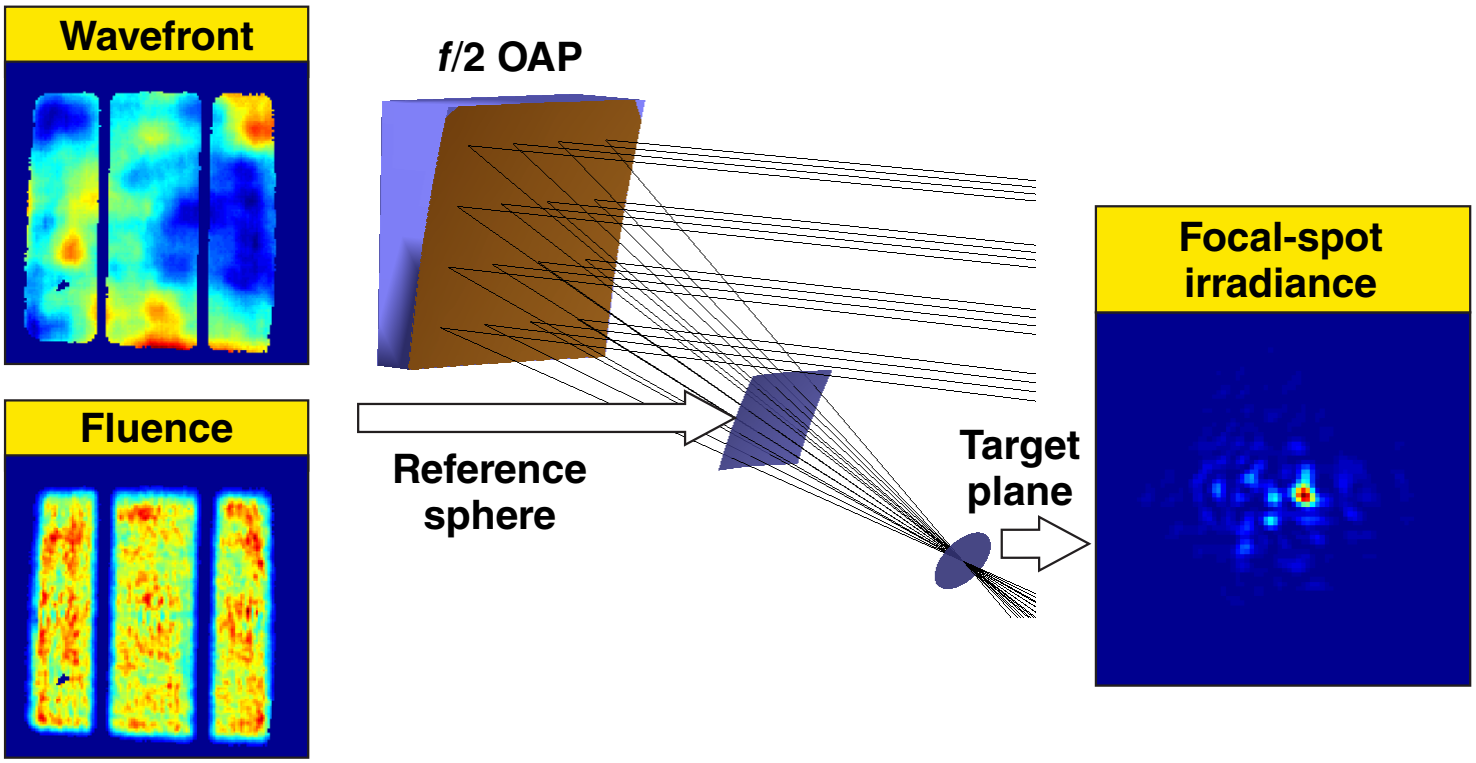
A Focal-Spot Diagnostic for On-Shot Characterization of OMEGA EP



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Summary

A focal-spot diagnostic for on-shot characterization has been successfully deployed on OMEGA EP

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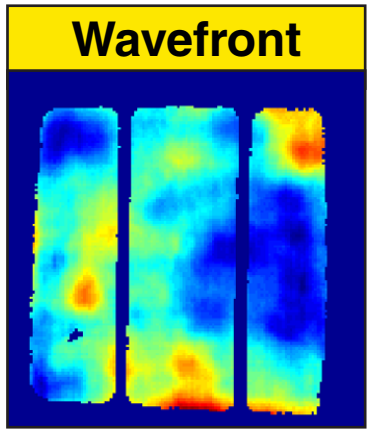
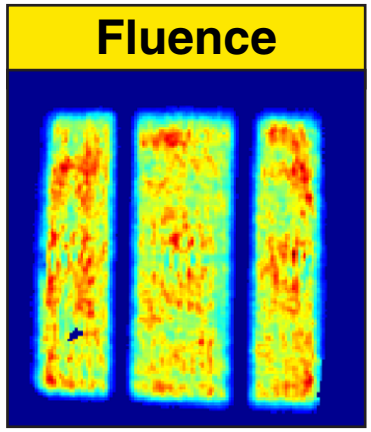
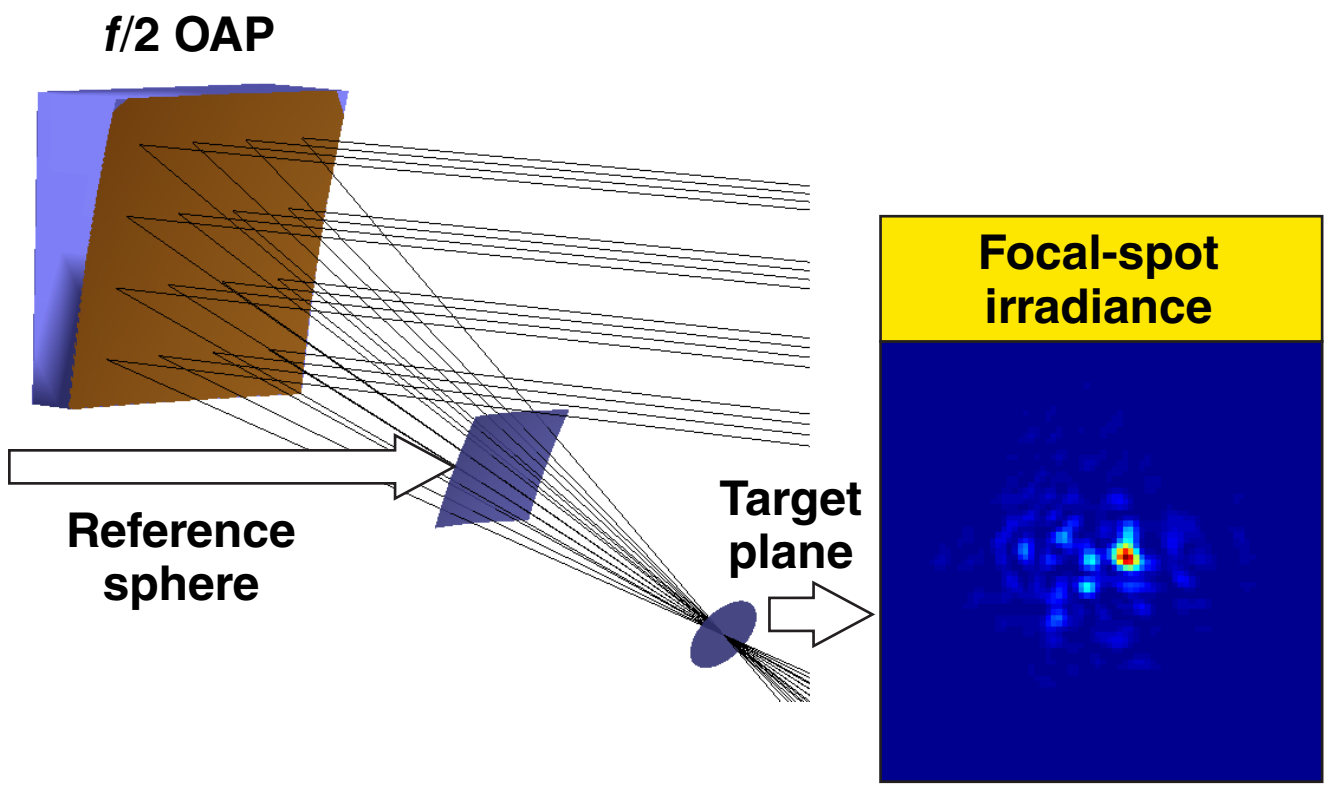
- Focal-spot diagnostics (FSD's) are critical for target experiments and system optimization.
- Direct measurement at full energy is impractical.
- FSD's have been deployed on both of OMEGA EP's short-pulse beamlines
  - based on calibrated measurements of sample beam near field
  - use high-resolution wavefront sensors (133×133)
  - focal profile may be calculated at any plane relevant to the target experiment
- The FSD was qualified using a TIM-based focal-spot microscope (FSM) for direct measurement at low energy.

A focal-spot measurement is presented for a 290-J, short-pulse target shot.

FSD calculates the on-target irradiance from near-field measurements of the on-shot fluence and wavefront







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

Three steps required by FSD

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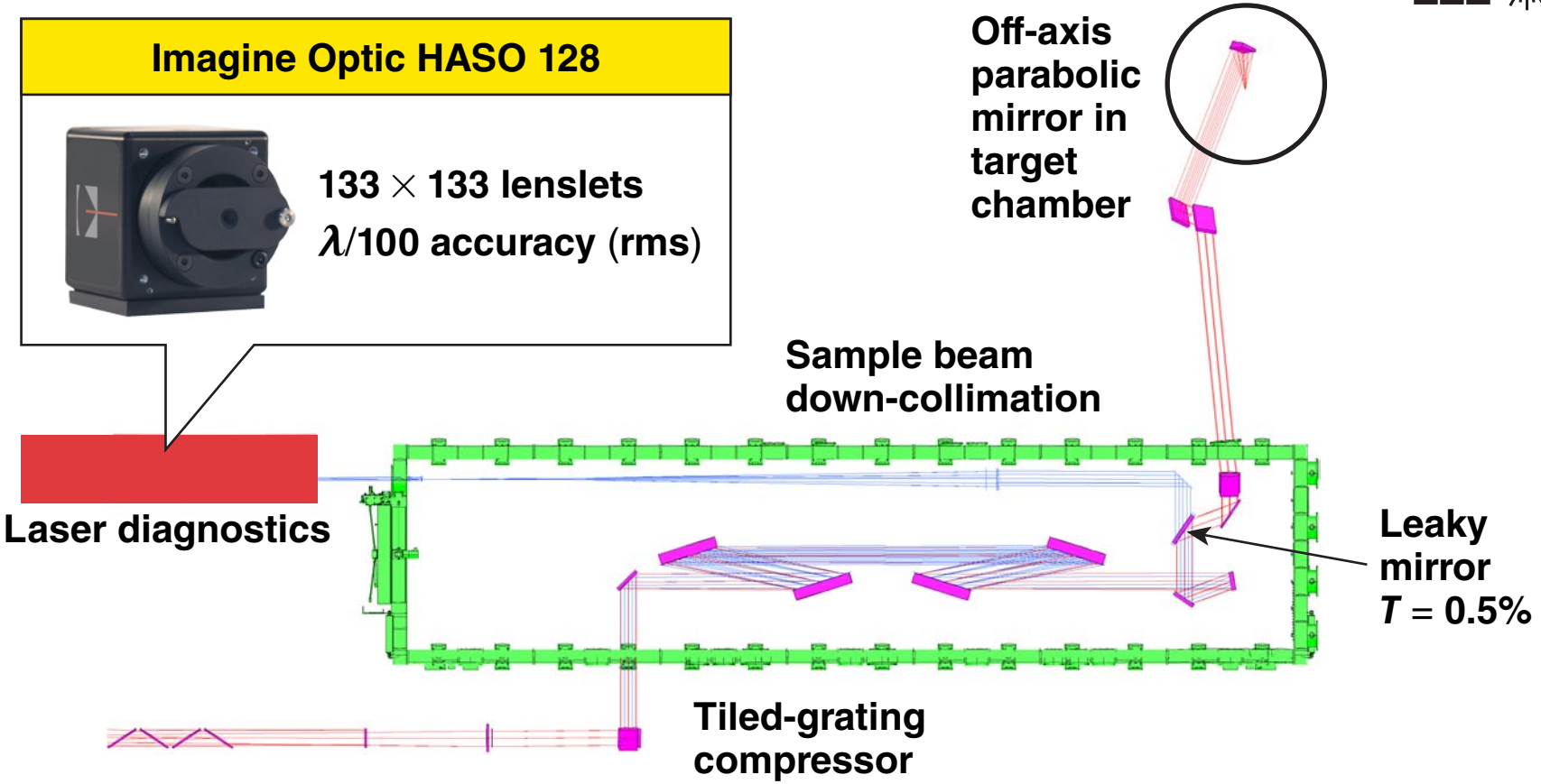
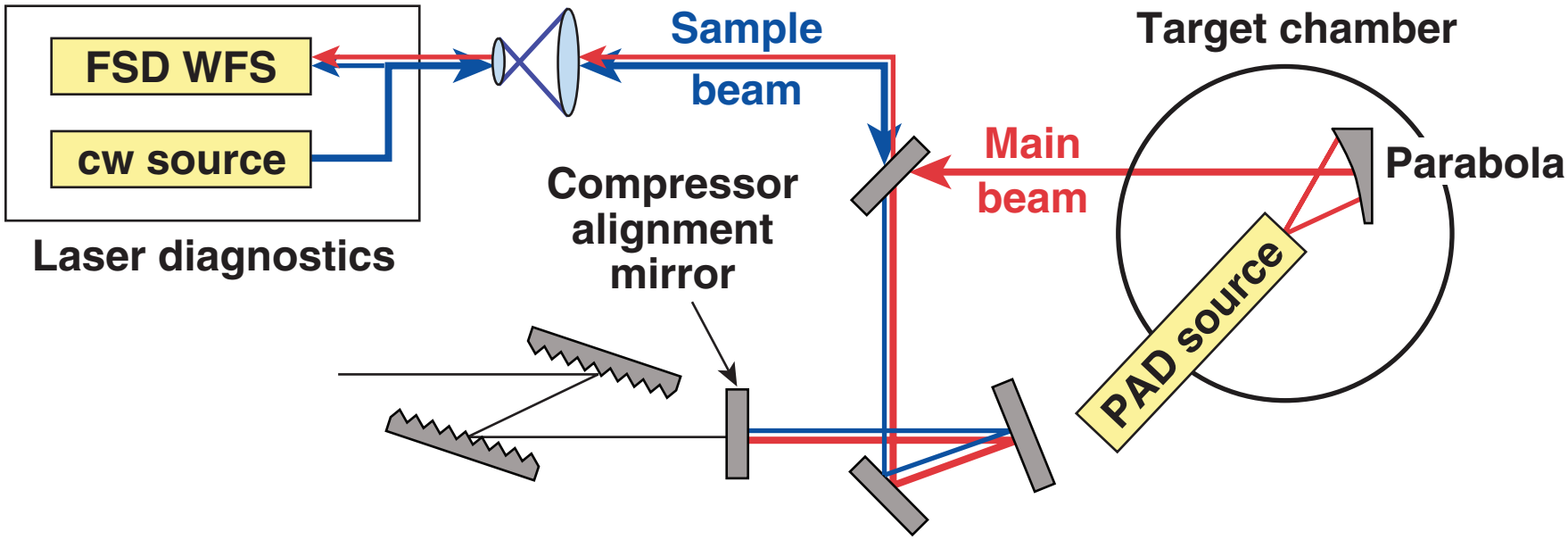
A high-resolution Shack–Hartmann wavefront sensor measures the sample beam feeding the laser diagnostics



- Not sensitive to chromatic effects such as angular dispersion from compressor misalignment.
- Such effects, once separately quantified during alignment, can be included in the post-shot calculation.*

*S.-W. Bahk *et al.*, Appl. Opt. 47, 4589 (2008).

The FSD is calibrated using two cw beams to probe the difference between main and sample beam paths



- Measure wavefront from PAD source: W_1
- Measure wavefront from diagnostics source: W_2
- Obtain transfer wavefront from difference: ΔW

Transfer wavefront: $\Delta W = W_1 - W_2$

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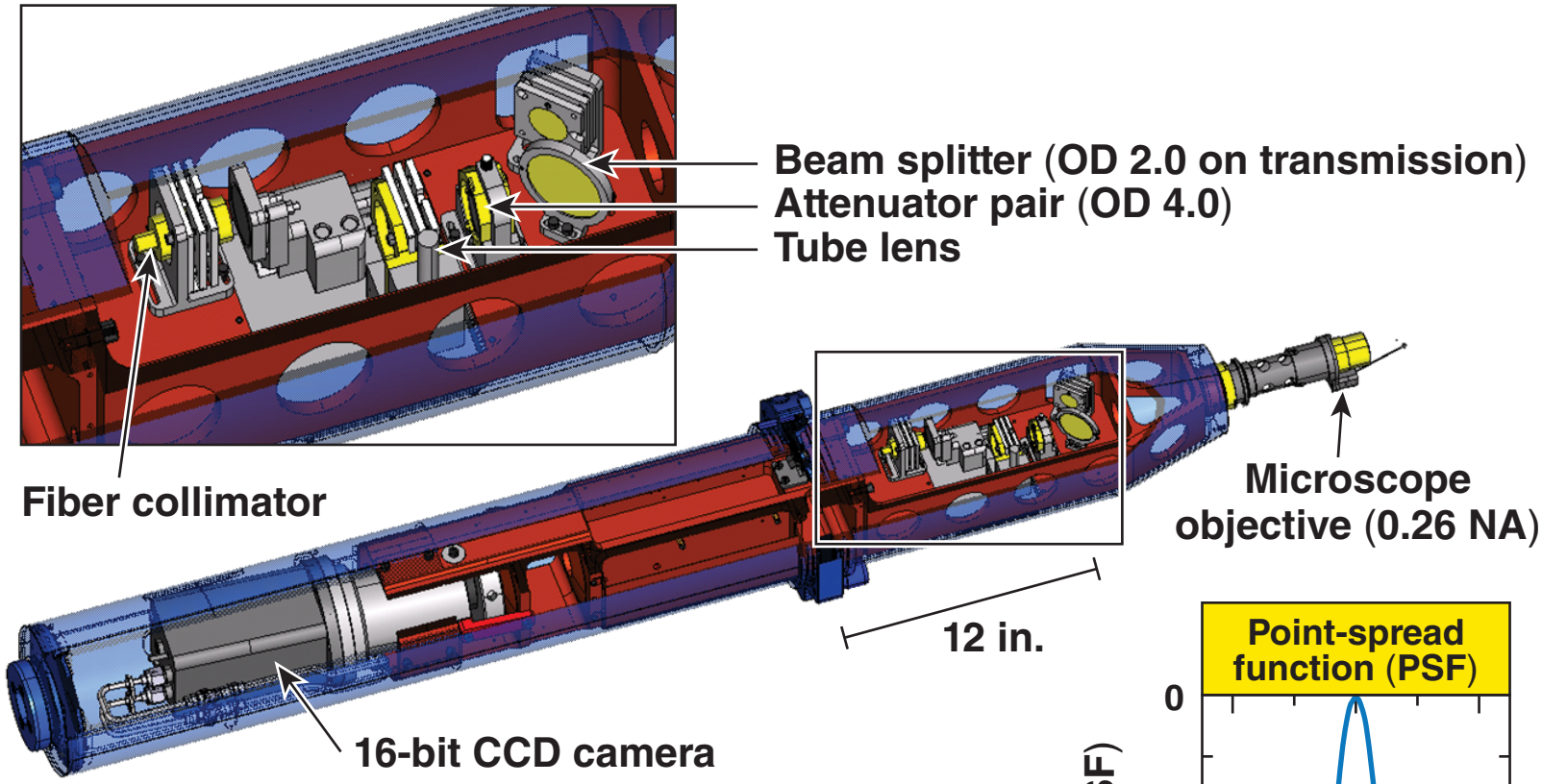
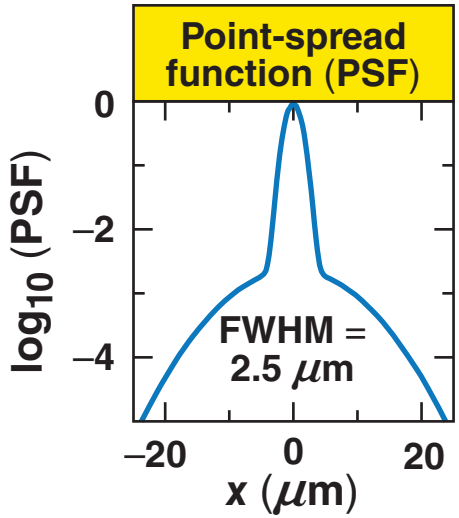
A focal-spot microscope (FSM) for direct measurement in the target chamber was used to qualify FSD





- Dynamic range = 45 dB (CCD noise floor)
- Point spread = 2.5-μm FWHM
- Field-of-view = 360 μm

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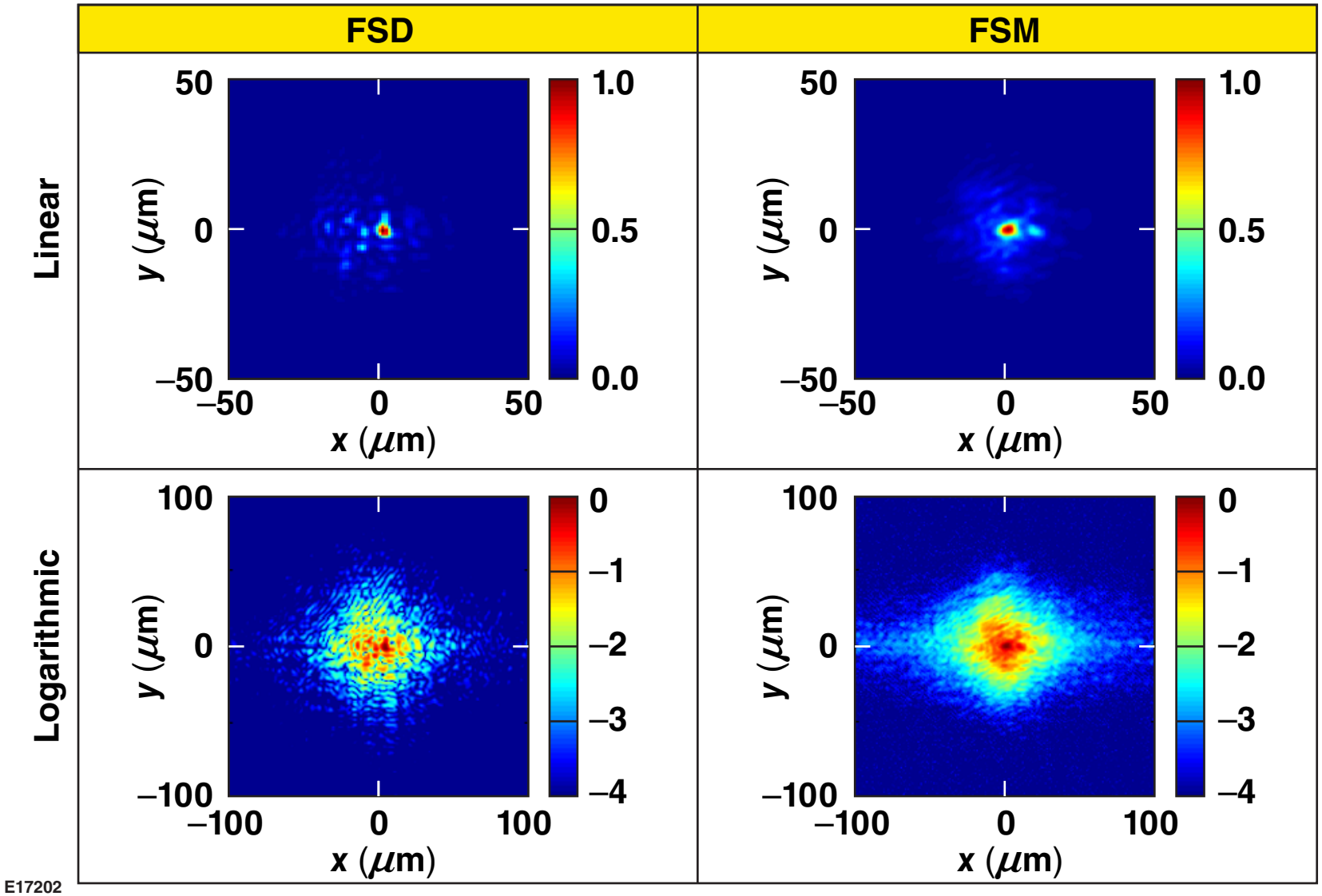
The FSD and FSM measurements agree well on both linear and logarithmic scales



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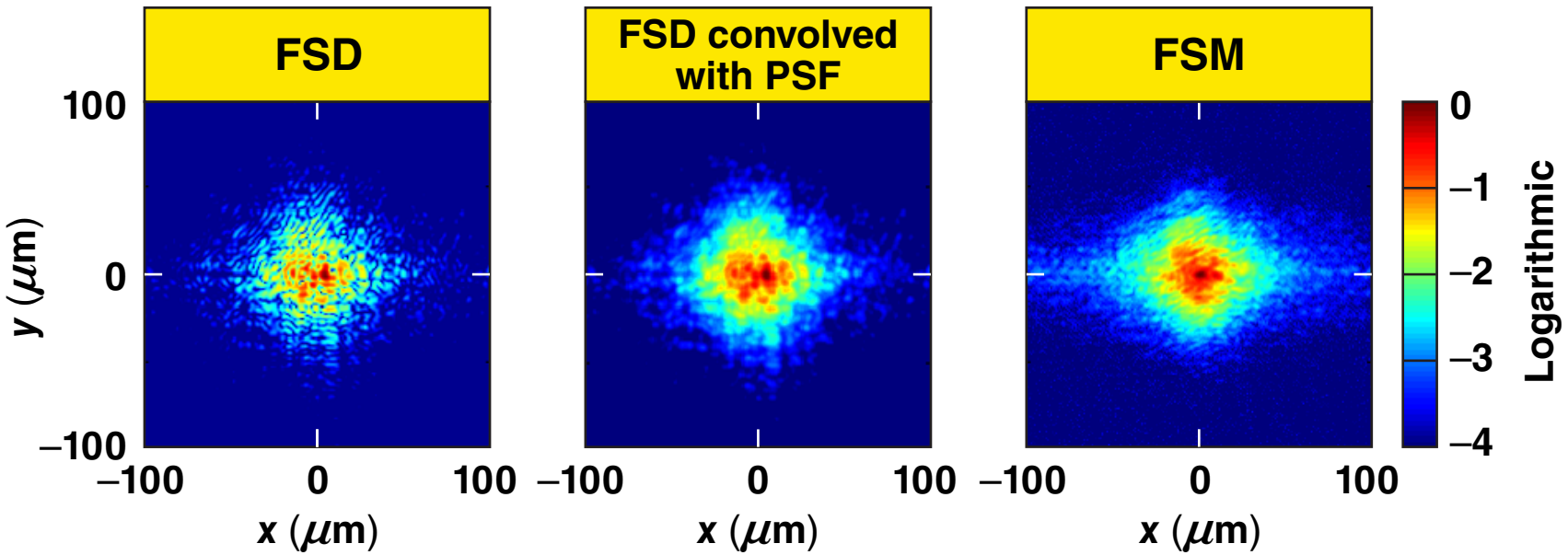
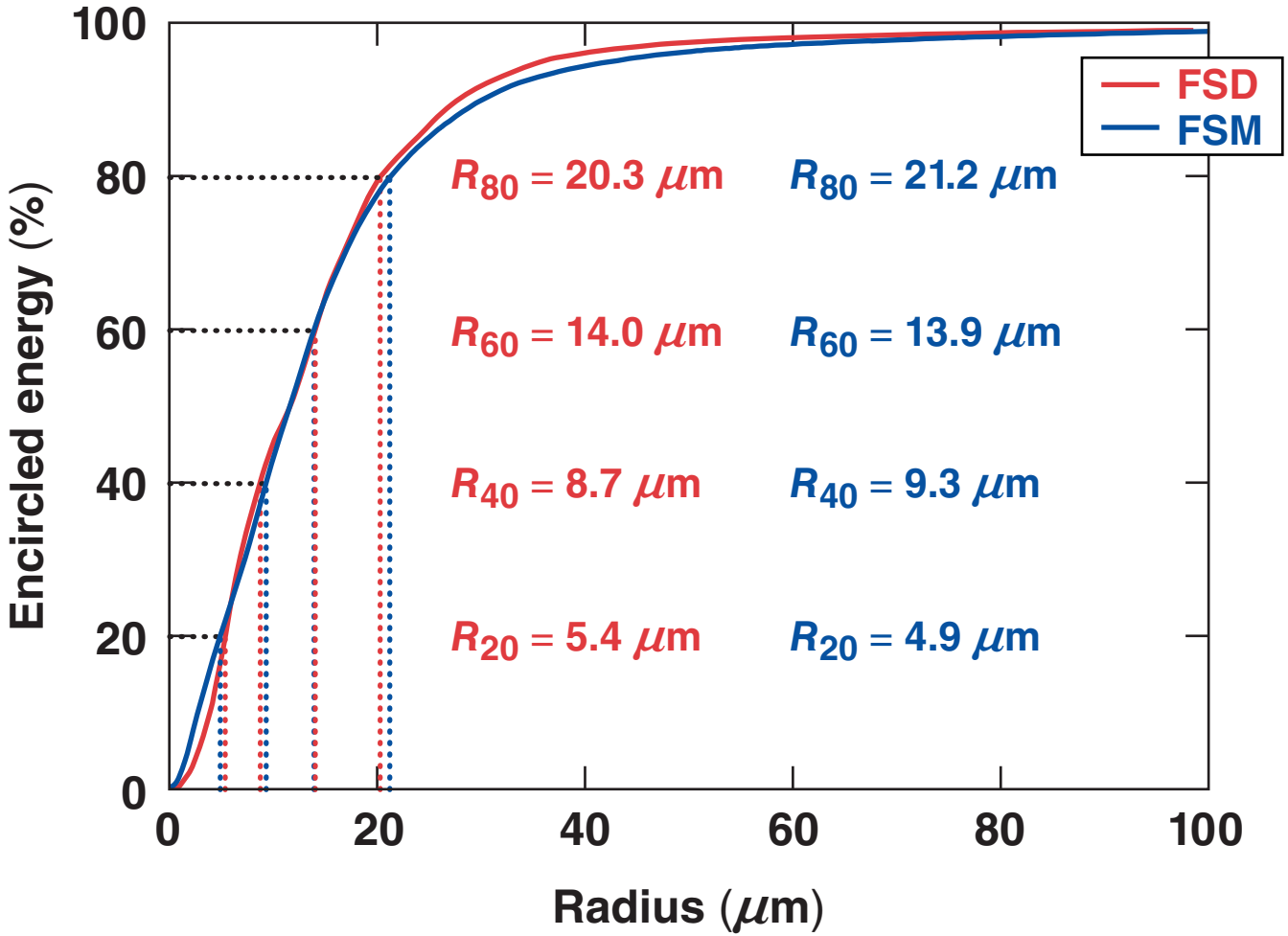
The difference in high contrast structure is likely due to the point-spread function of the FSM



Encircled energy curves for FSD and FSM are in good agreement



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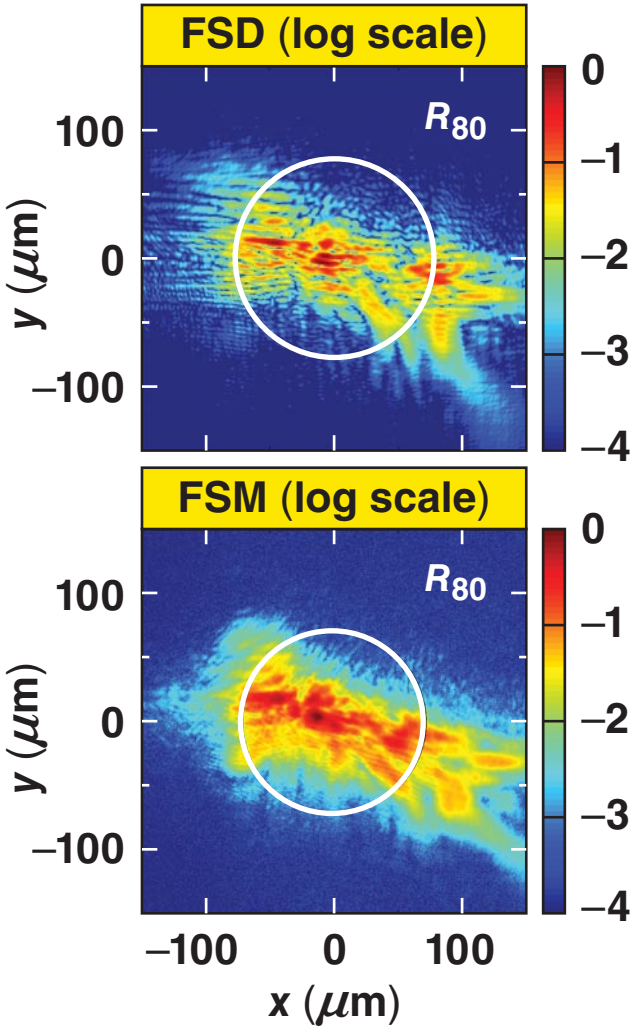
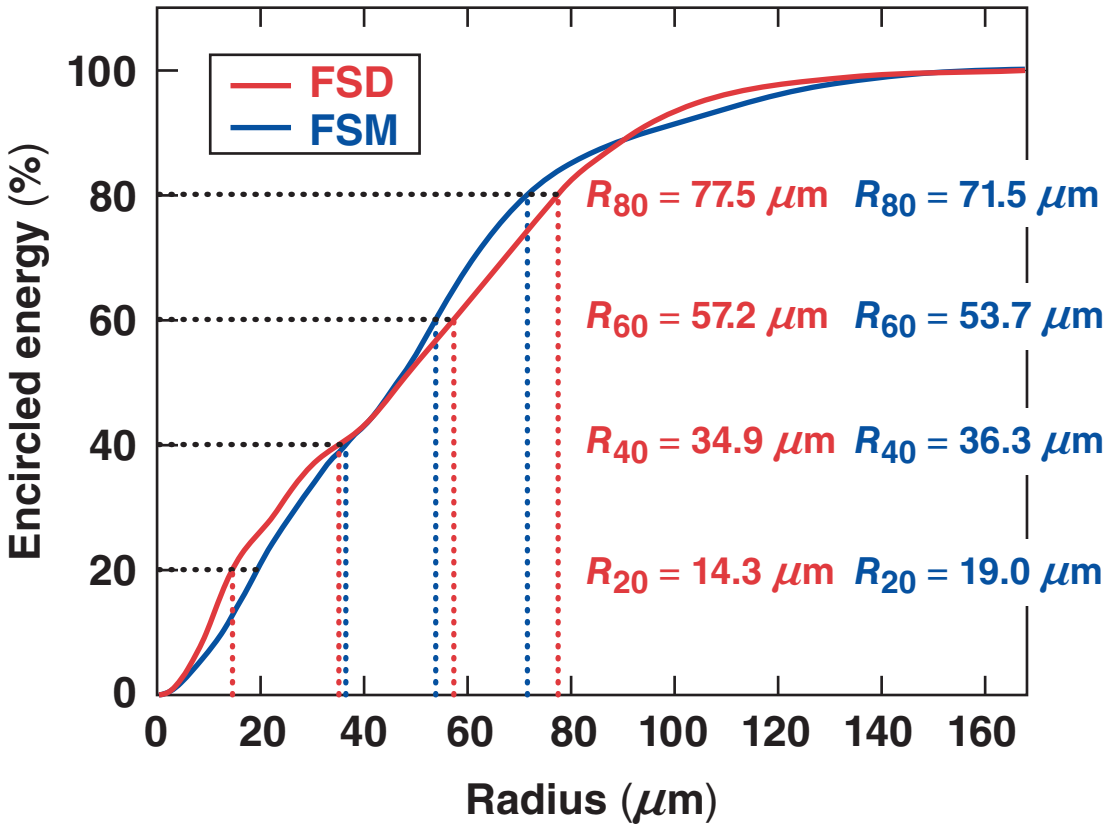
FSD and FSM agree for highly aberrated spots, created by adjusting the deformable mirror





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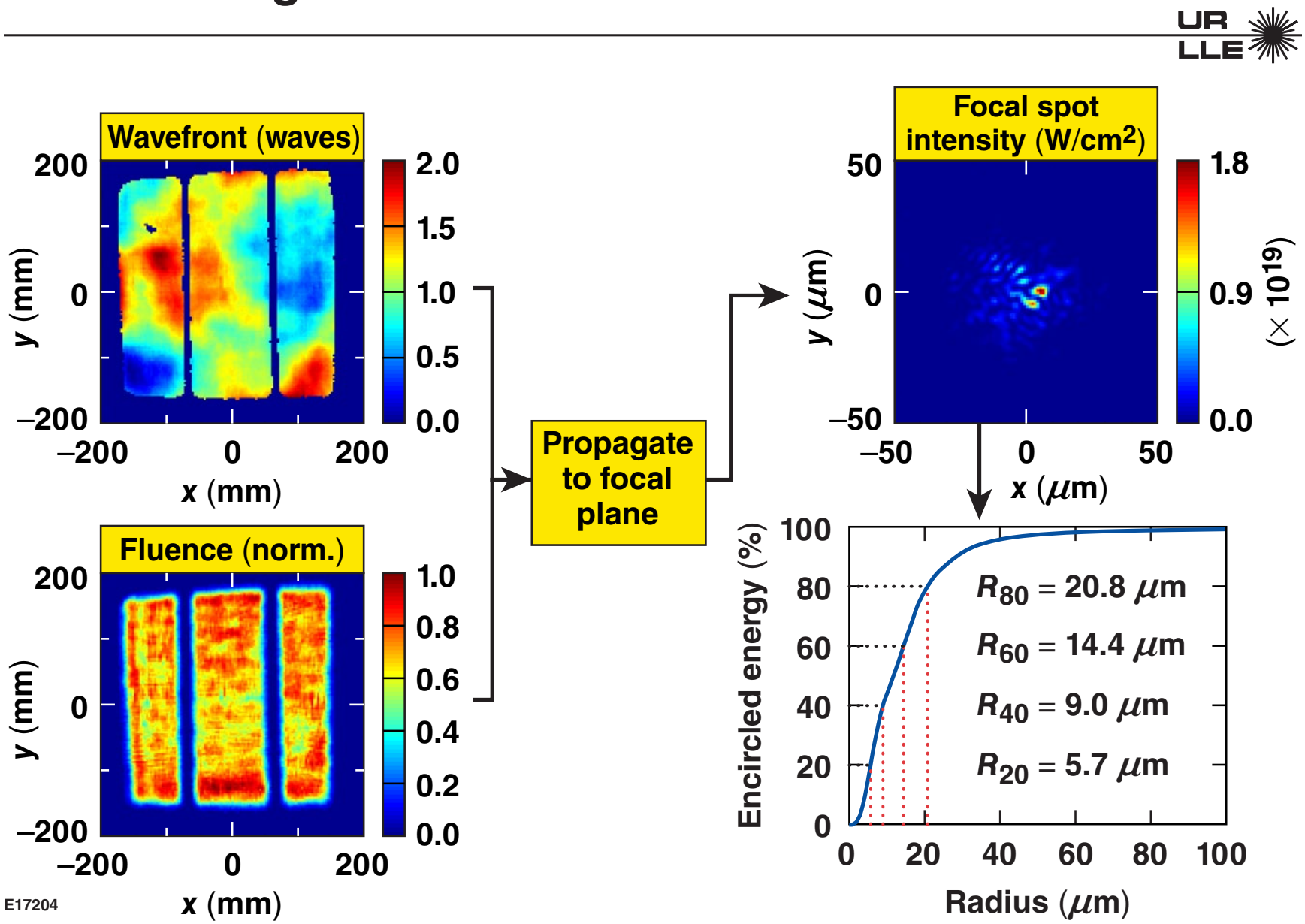
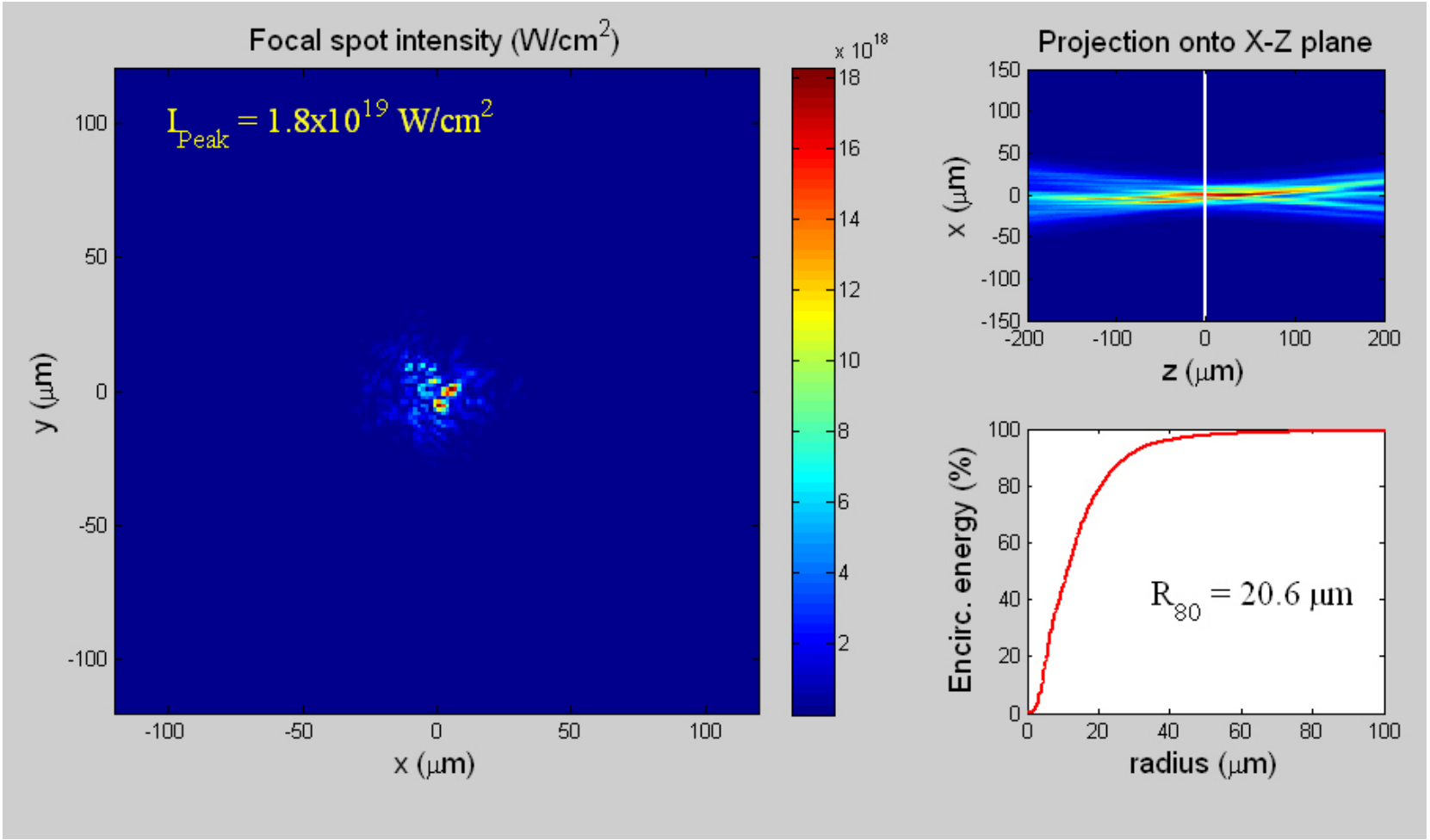
Example of FSD data from 11-ps shot that produced 290 J on target



One advantage of this approach is that the focal spot at other surfaces of interest can also be calculated



Summary/Conclusions

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- FSD's have been deployed on both of OMEGA EP's short-pulse beamlines
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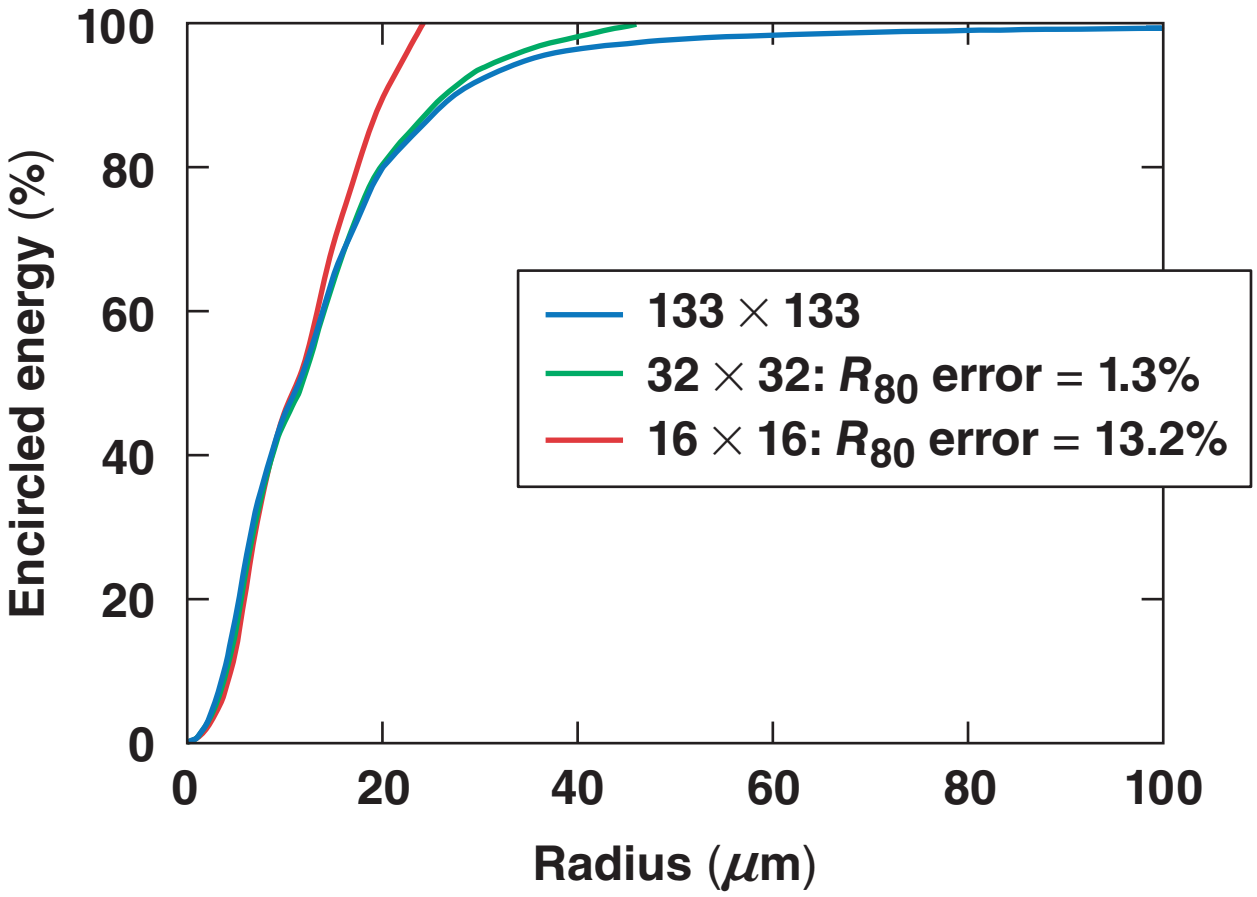
Improving the focal spot is an iterative process…

- We have an unmatched capability for characterizing the on-shot focal spot in the LLE focal-spot diagnostic (FSD)
- We have to date employed this capability on fewer than 64 target shots
  - we are very early in the learning curve
- Using the FSD, we are actively investigating improving the large-scale-length, base-beamline wavefront to reduce the required deformable-mirror correction
- OMEGA EP system time has been allocated in FY09 for further efforts to improve the focal spot

Our initial efforts have produced focal-spot improvement.

Analysis shows the FSD wavefront sensor has a spatial resolution (133 × 133) suitable for OMEGA EP



Simulations based on OMEGA EP data show that lower spatial-resolution wavefront measurements lead to significant errors in encircled energy.

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