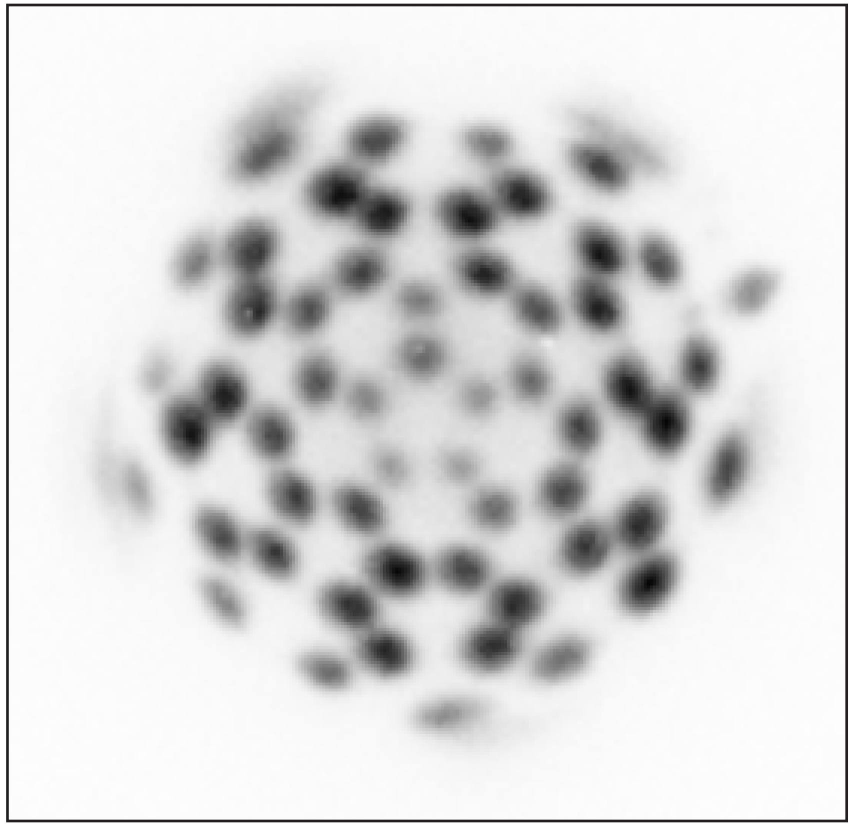
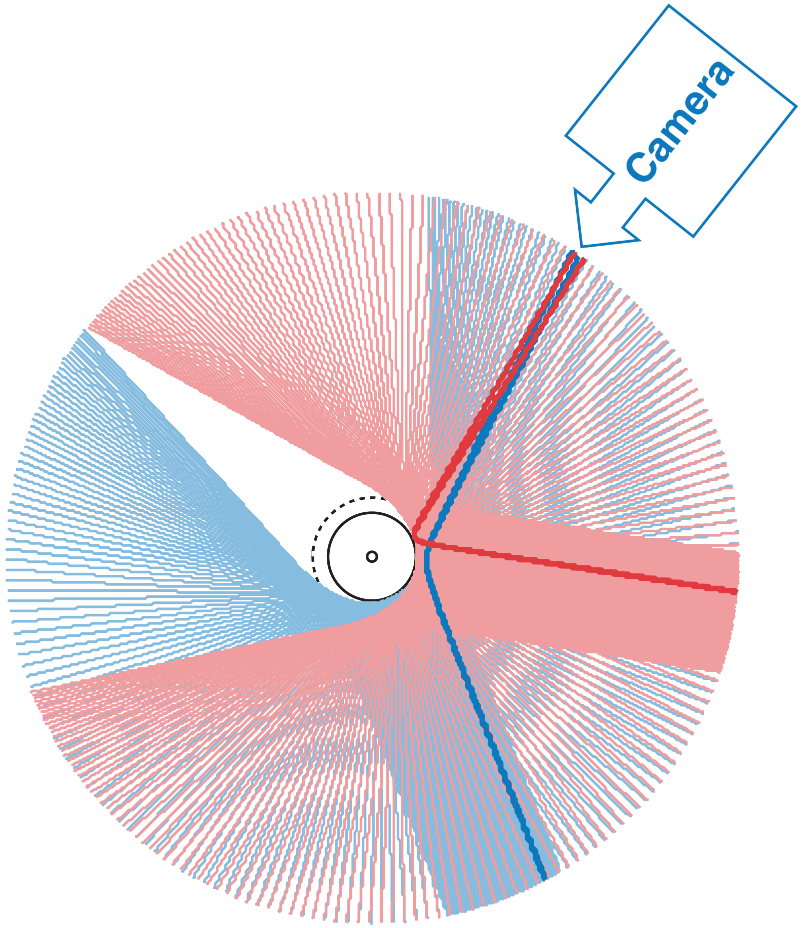
Diagnosing Cross-Beam Energy Transfer Using Beamlets of Unabsorbed Light from Direct-Drive Implosions

Image of 351-nm light from OMEGA implosions





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Summary

The unabsorbed light from individual beamlets is a powerful tool to diagnose implosions

- Images of 351-nm light from OMEGA implosions show a unique and distinct "spot" corresponding to each drive beam
- Each spot is a record of the unabsorbed light from a single "beamlet" originating from a particular location (impact parameter, polar angle) in the beam profile
- The OMEGA Thompson-scattering system (TSS) provides both time-integrated images of all the beamlet spots and time-varying, spectrally resolved streaks of the light from individual beamlets
- This can be used to diagnose how cross-beam energy transfer (CBET) affects different parts of the beam profile and provide benchmarking for hydrodynamics codes

Collaborators

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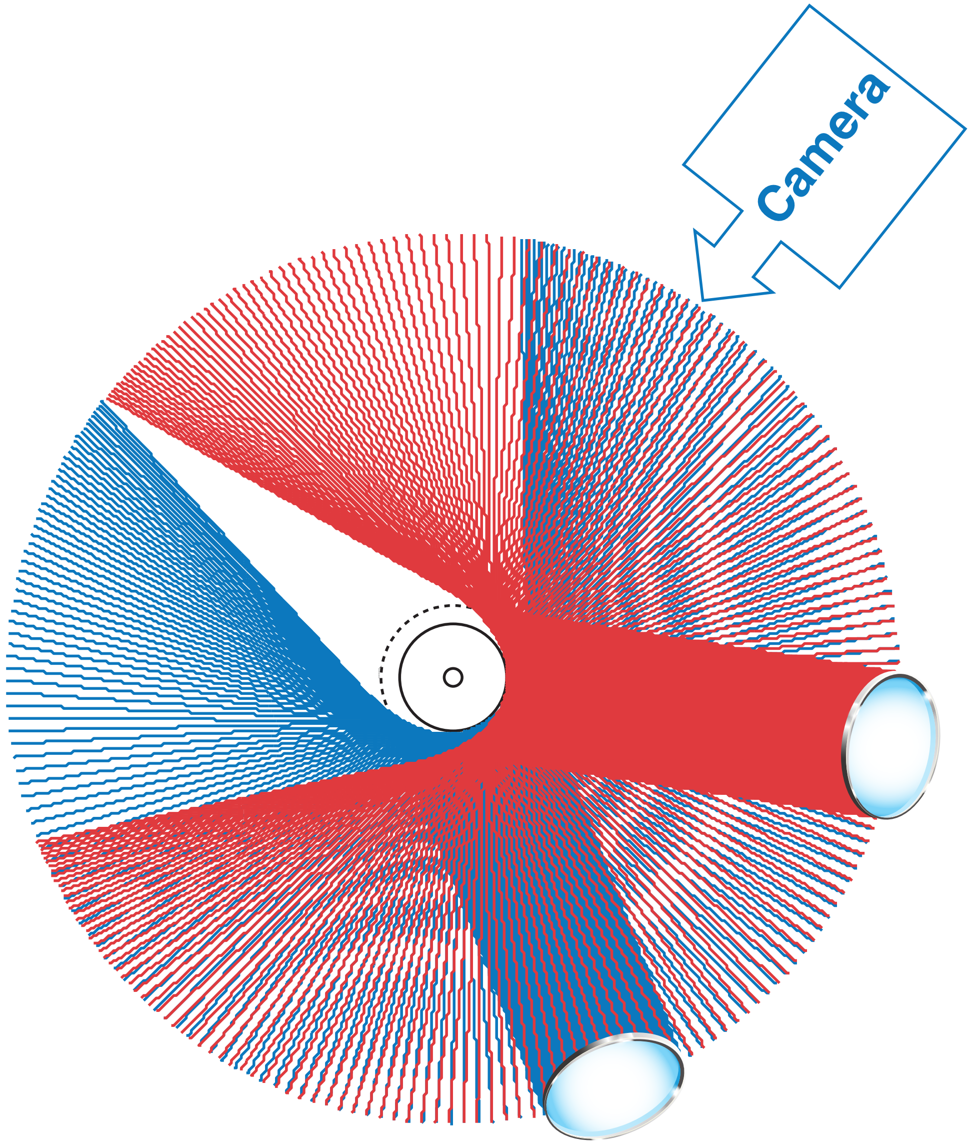
A 351-nm camera records the unabsorbed light of a beamlet from each OMEGA beam

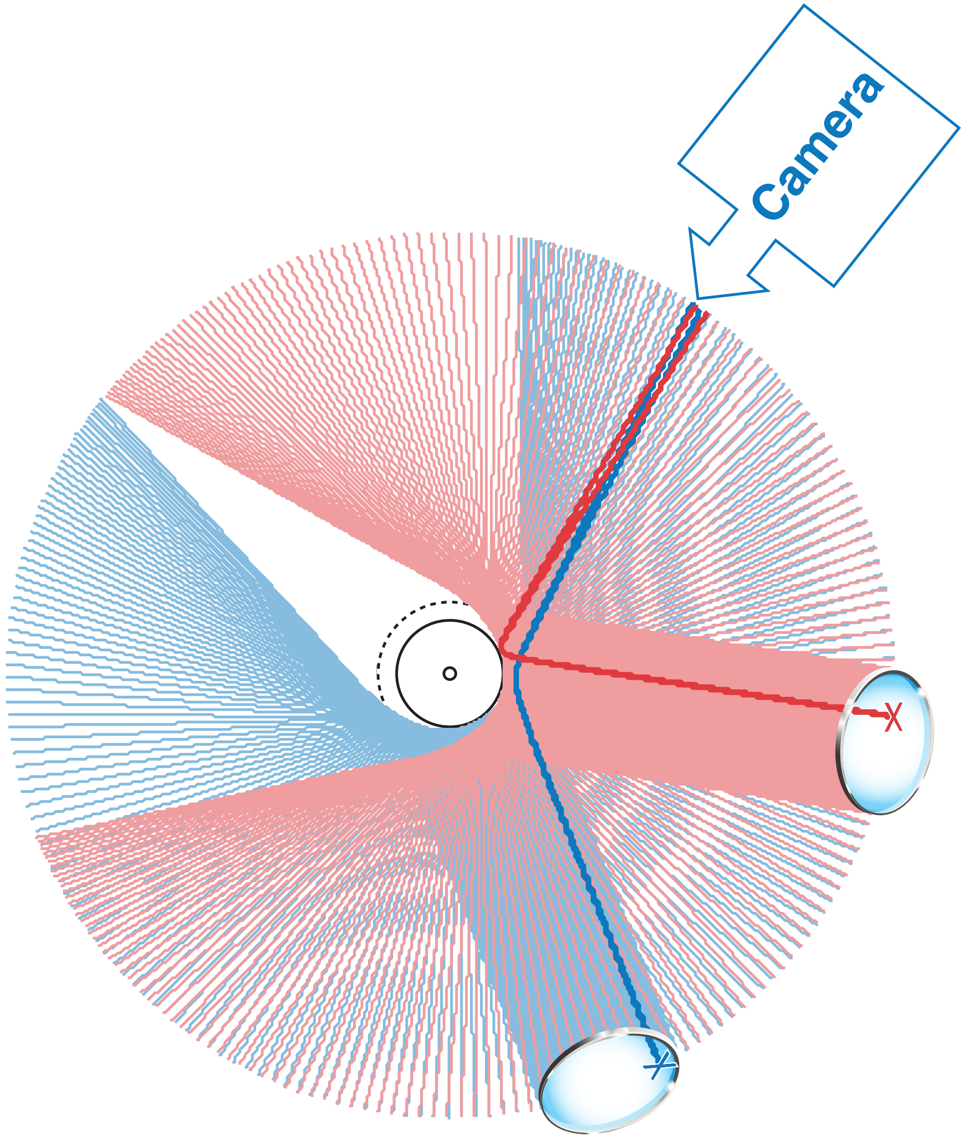
- **Light reaching a scattered-light detector originates from each beam**



E24108

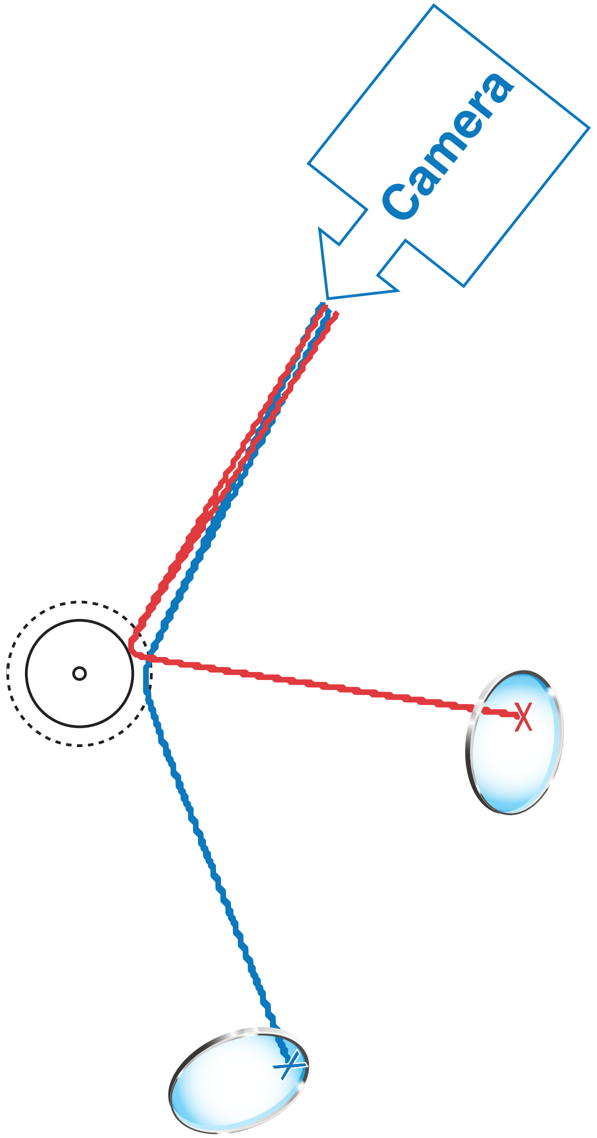
A 351-nm camera records the unabsorbed light of a beamlet from each OMEGA beam

- Light reaching a scattered-light detector from each beam
- Recorded light originates from a determinable point in a beam profile
  - impact parameter
  - polar angle



A 351-nm camera records the unabsorbed light of a beamlet from each OMEGA beam

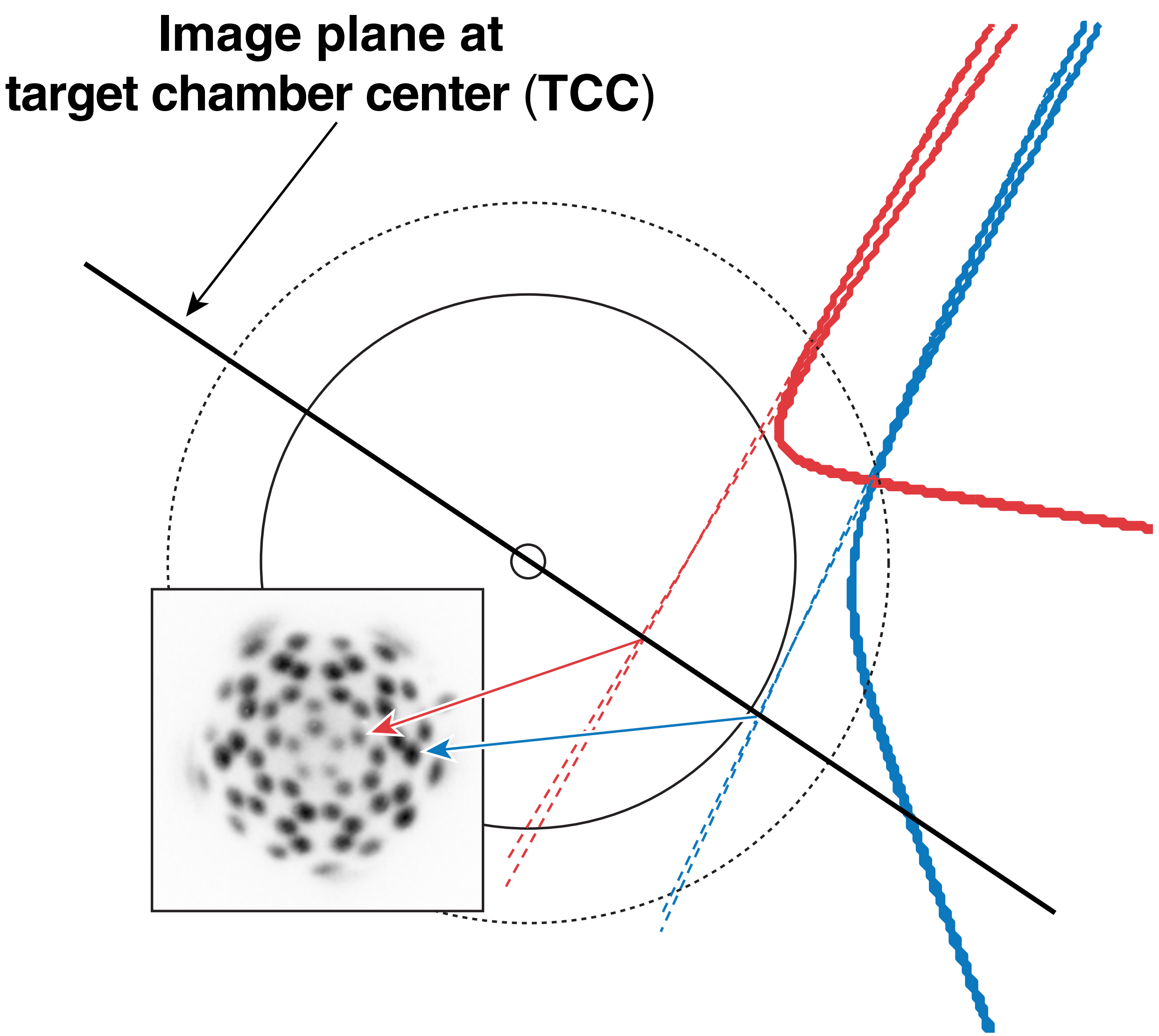
- Light reaching a scattered-light detector from each beam
- Recorded light originates from a determinable point in a beam profile
  - impact parameter
  - polar angle
- This light can be considered as sampled from a small component of the incident beam
  - a “beamlet”



E24236

A 351-nm camera records the unabsorbed light of a beamlet from each OMEGA beam

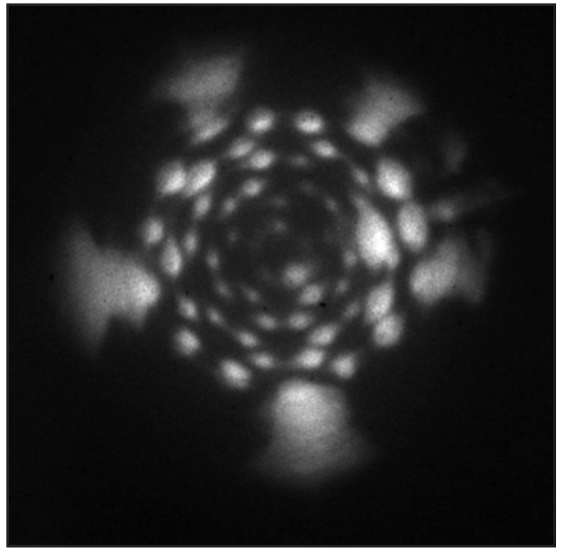
- Light reaching a scattered-light detector from each beam
- Recorded light originates from a determinable point in a beam profile
  - impact parameter
  - polar angle
- This light can be considered as sampled from a small component of the incident beam
  - a “beamlet”
- Unabsorbed light from this beam appears as a spot in the image plane



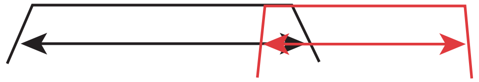
E24237

The position of each beamlet spot varies dynamically as the coronal plasma changes in time

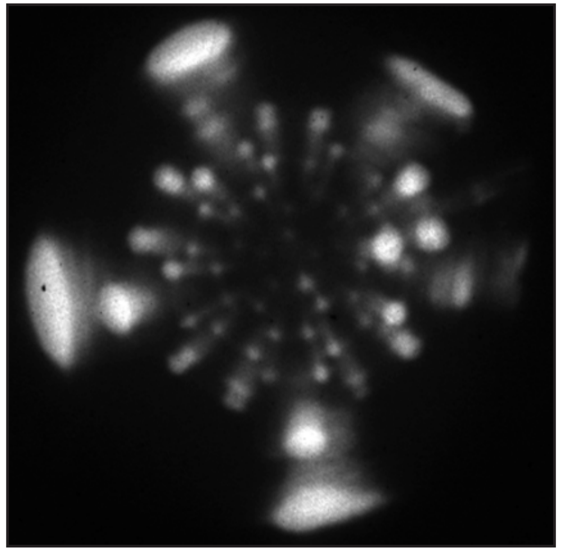
Shot 74080



Camera gate 3 ns | Laser pulse 2 ns

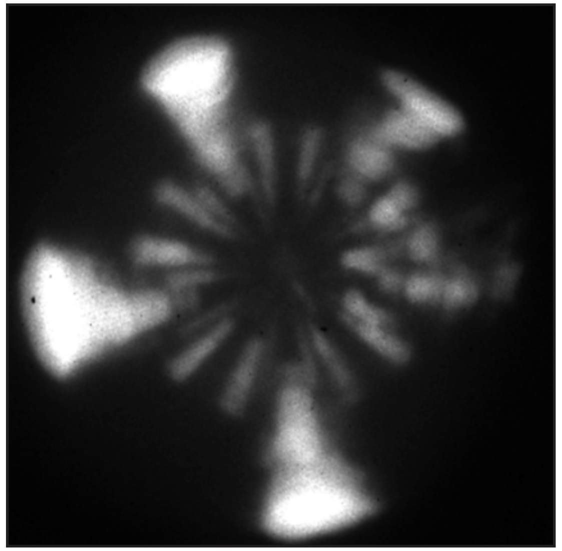


Shot 74074

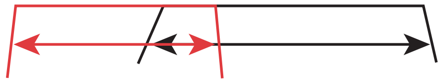


Camera gate 3 ns | Laser pulse 2 ns

Shot 74082



Laser pulse 2 ns | Camera gate 3 ns

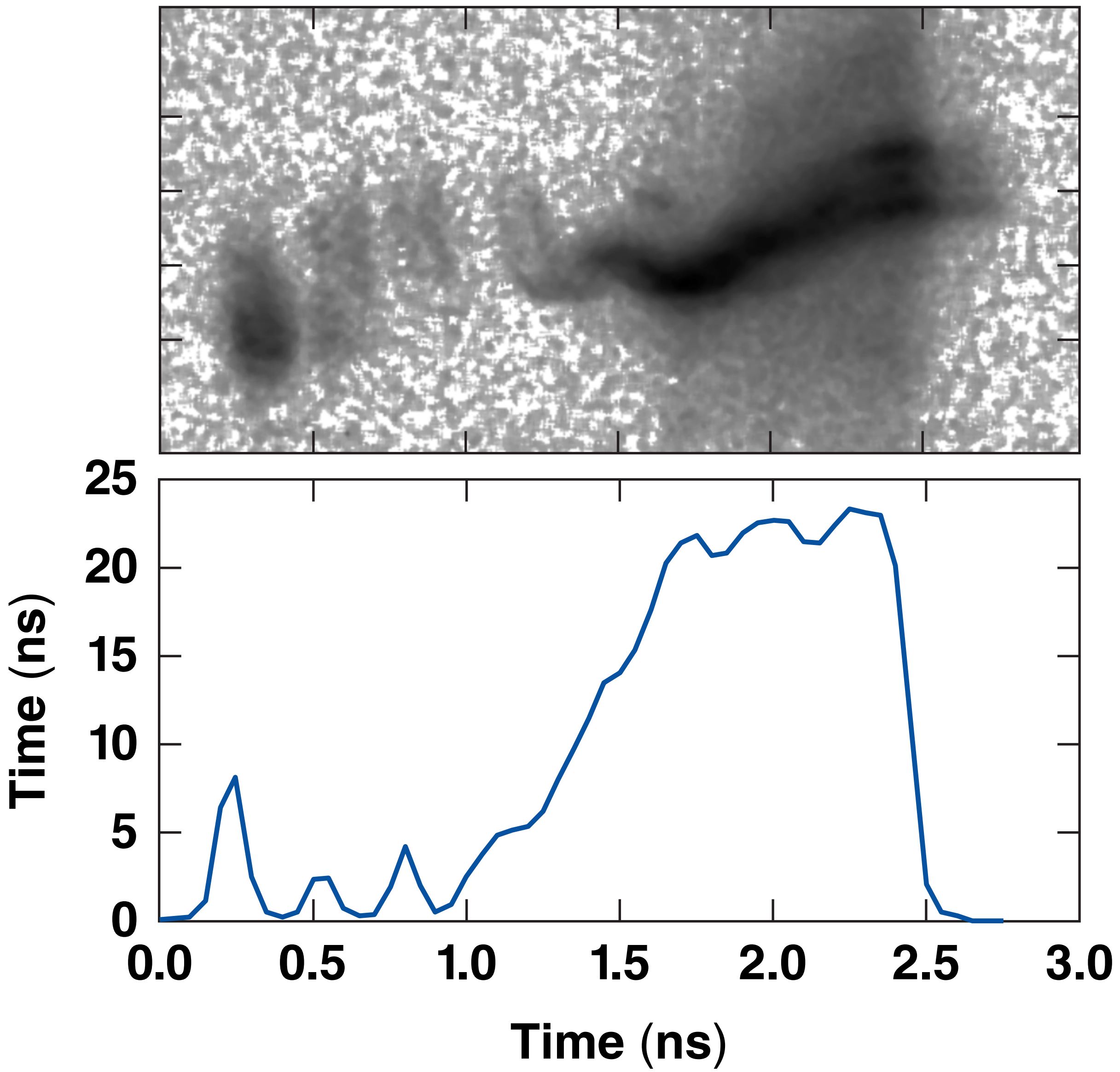


We will use solid plastic targets to minimize the spot motion during implosion experiments.

E24113

Streaking the light from a single spot gives the time-varying, spectrally resolved intensity from a beamlet

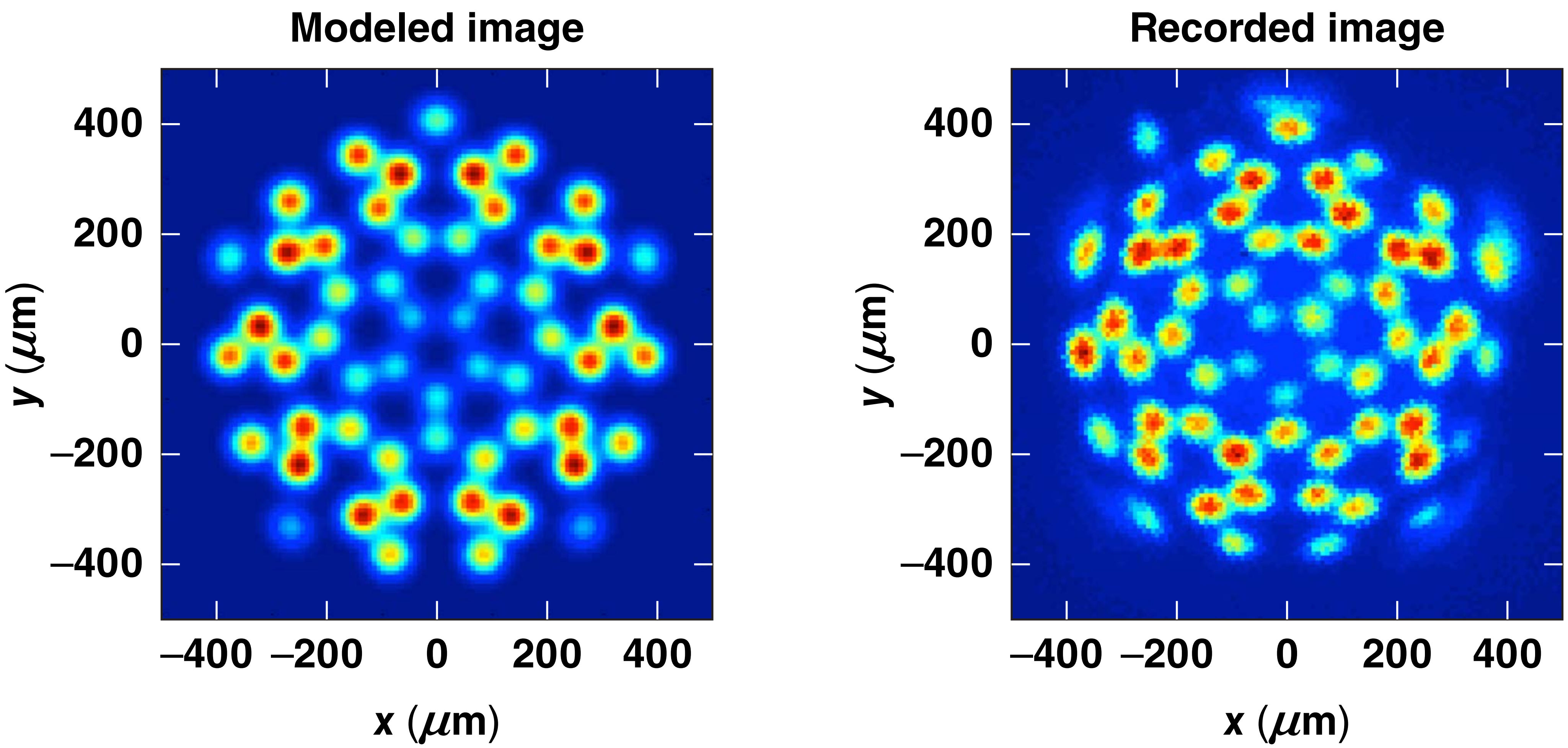
- A pinhole is placed at the position of a single spot and the light is directed onto a streak camera
- This makes it possible to study time-varying CBET effects on upcoming experiments



E24239

Unabsorbed light predictions correlate well with the images in both spot position and intensity

Unabsorbed light modeled using a 3-D CBET postprocessor for hydrodynamics codes

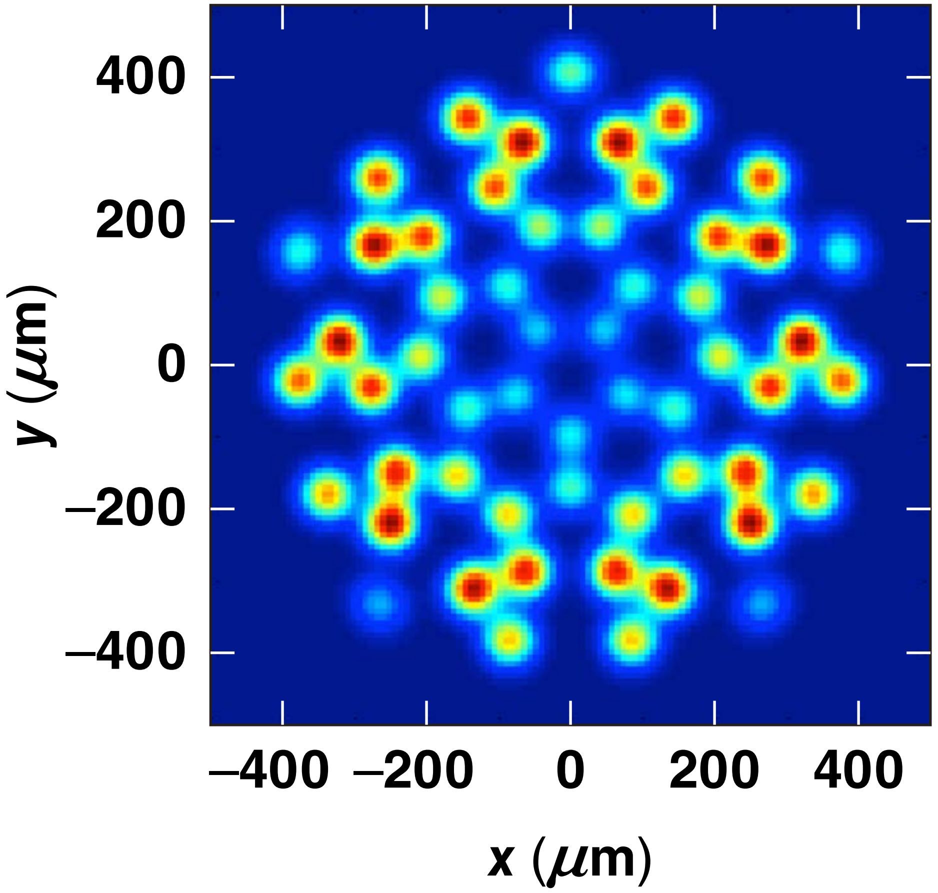


E24238

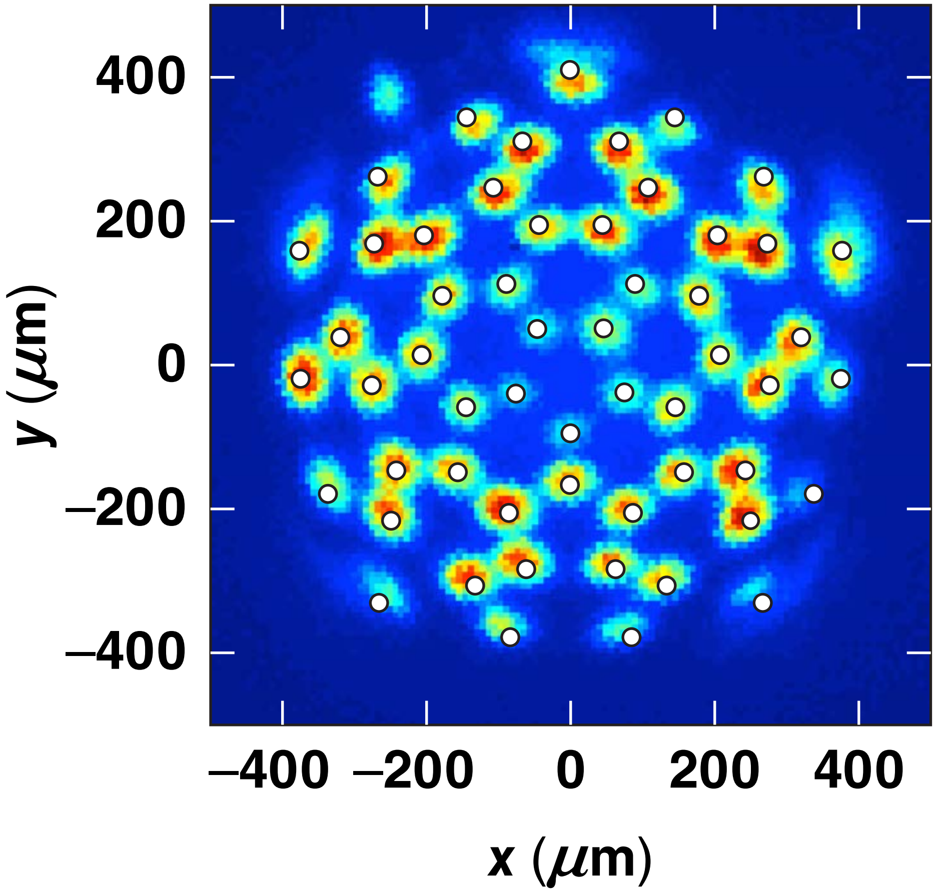
Unabsorbed light predictions correlate well with the images in both spot position and intensity

Unabsorbed light modeled using a 3-D CBET postprocessor for hydrodynamics codes

Modeled image

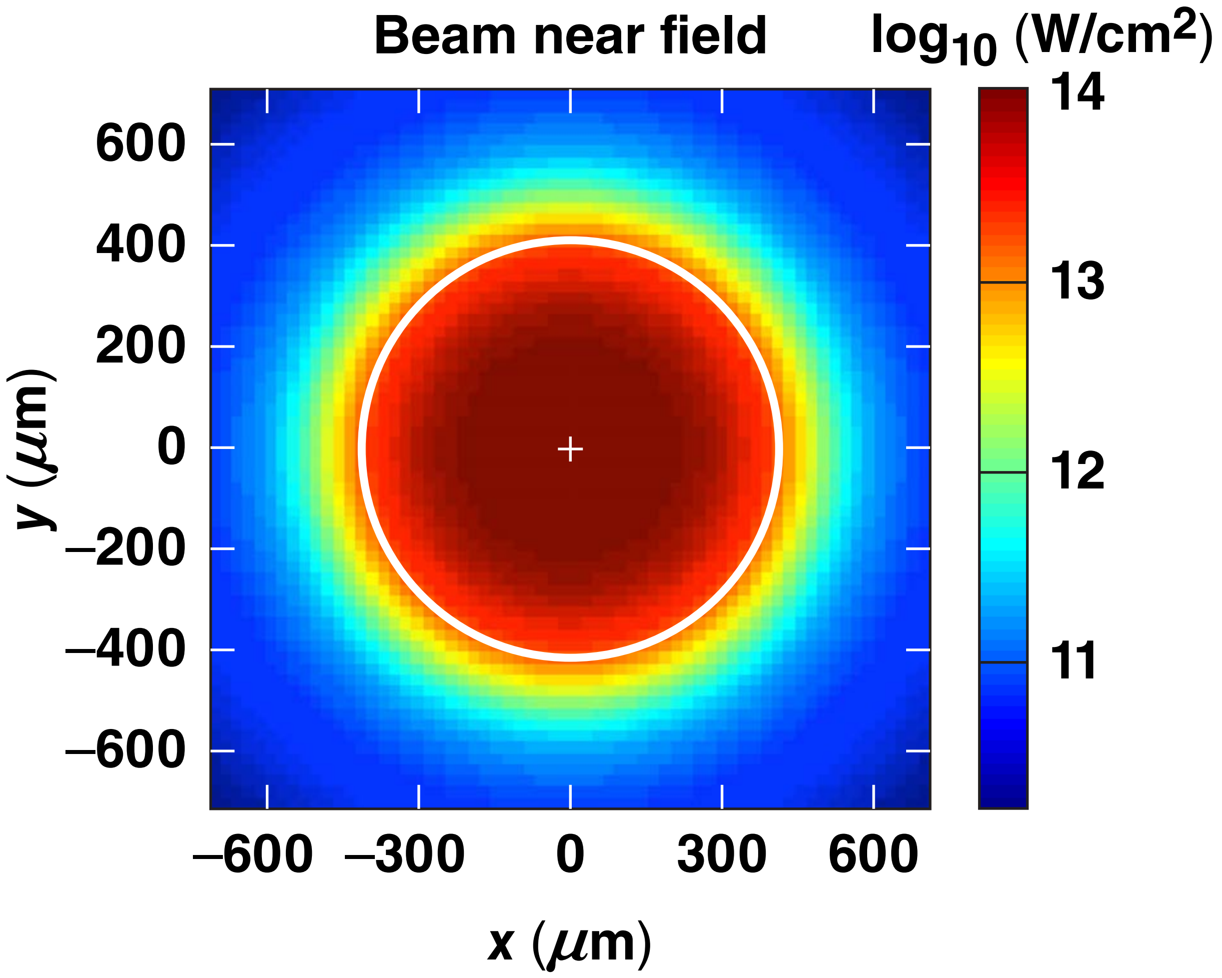


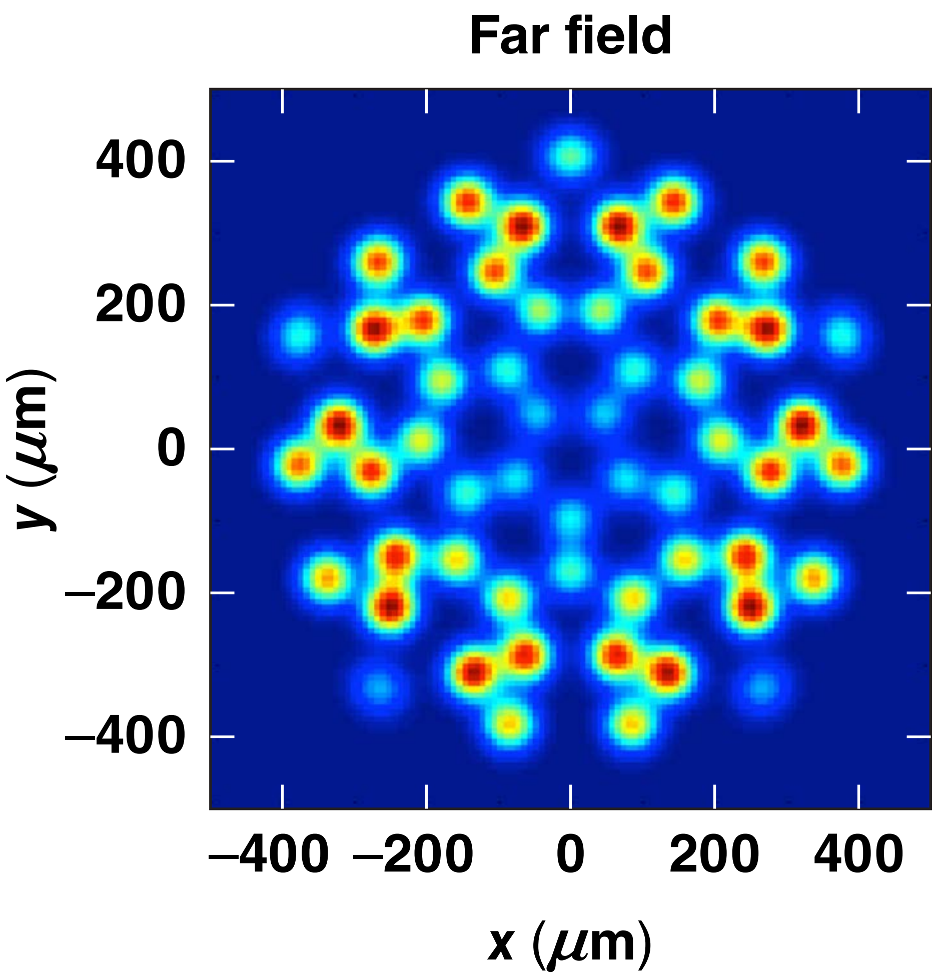
Recorded image
with predicted spot locations



E24258

Each beamlet originates from a specific location in its beam's profile

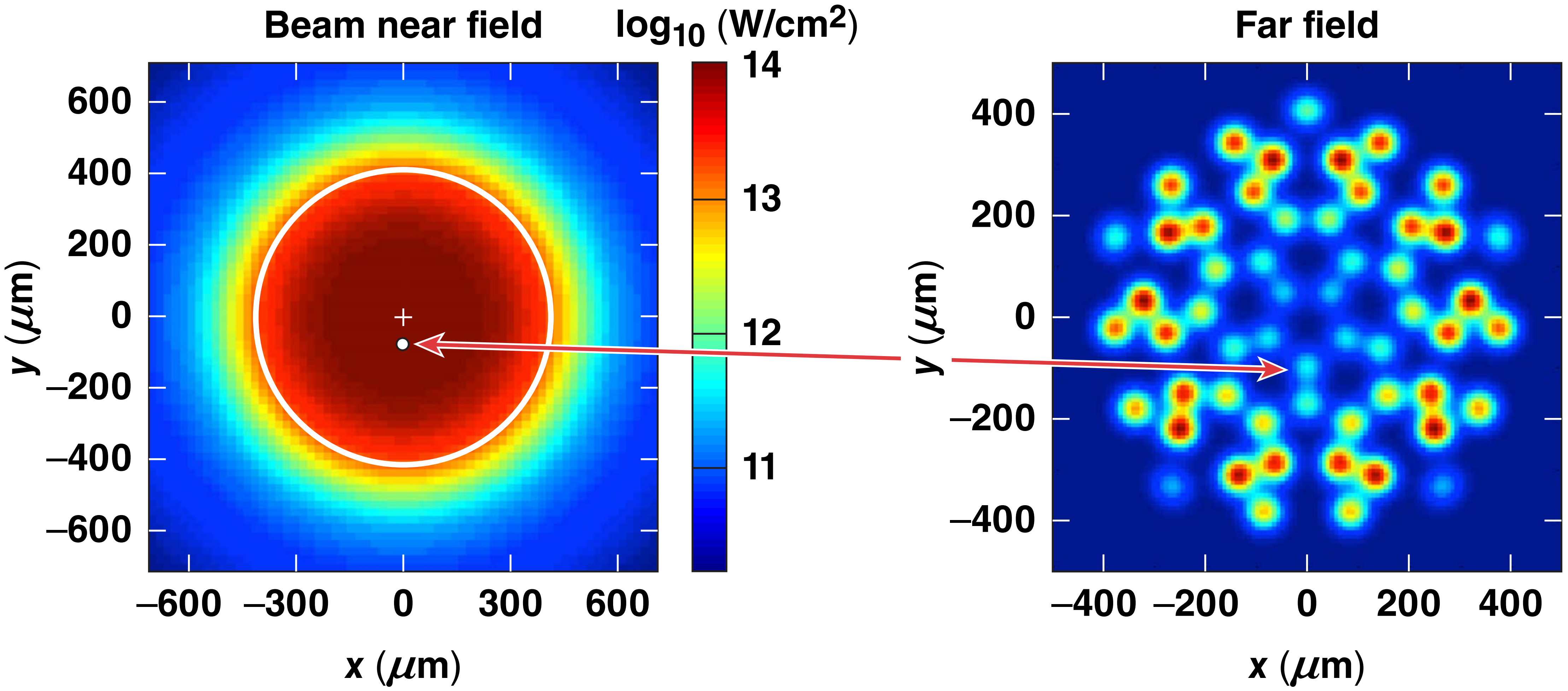




E24259

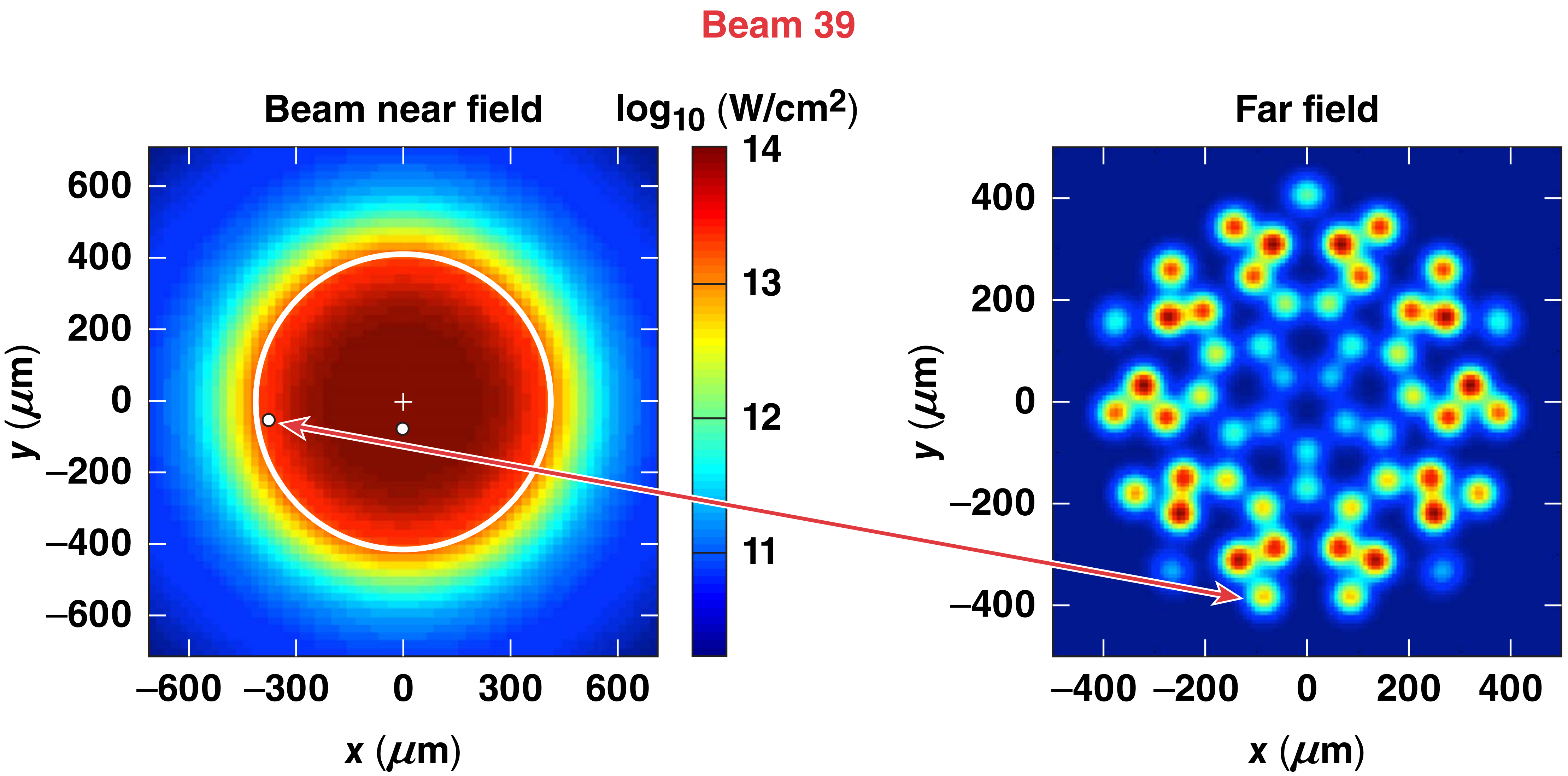
Each beamlet originates from a specific location in its beam's profile

Beam 62



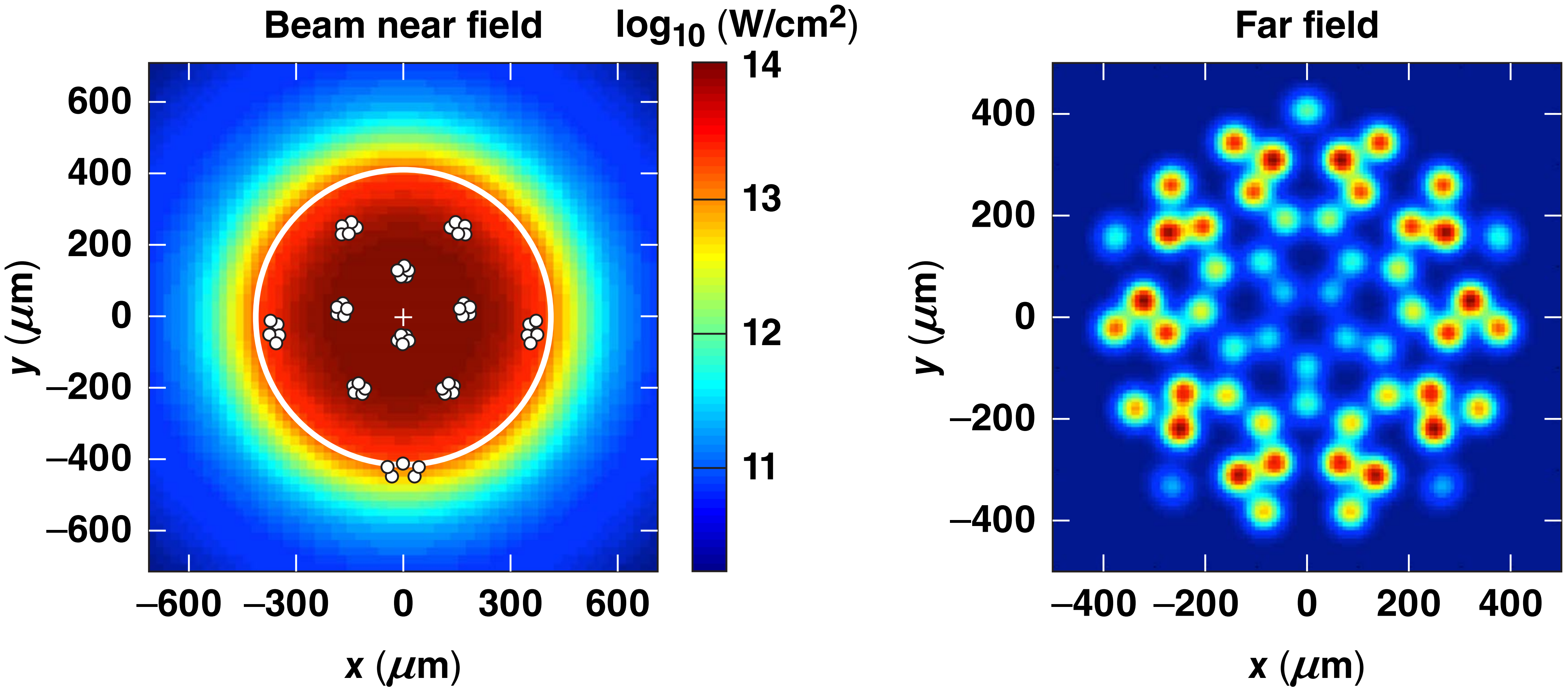
E24260

Each beamlet originates from a specific location in its beam's profile



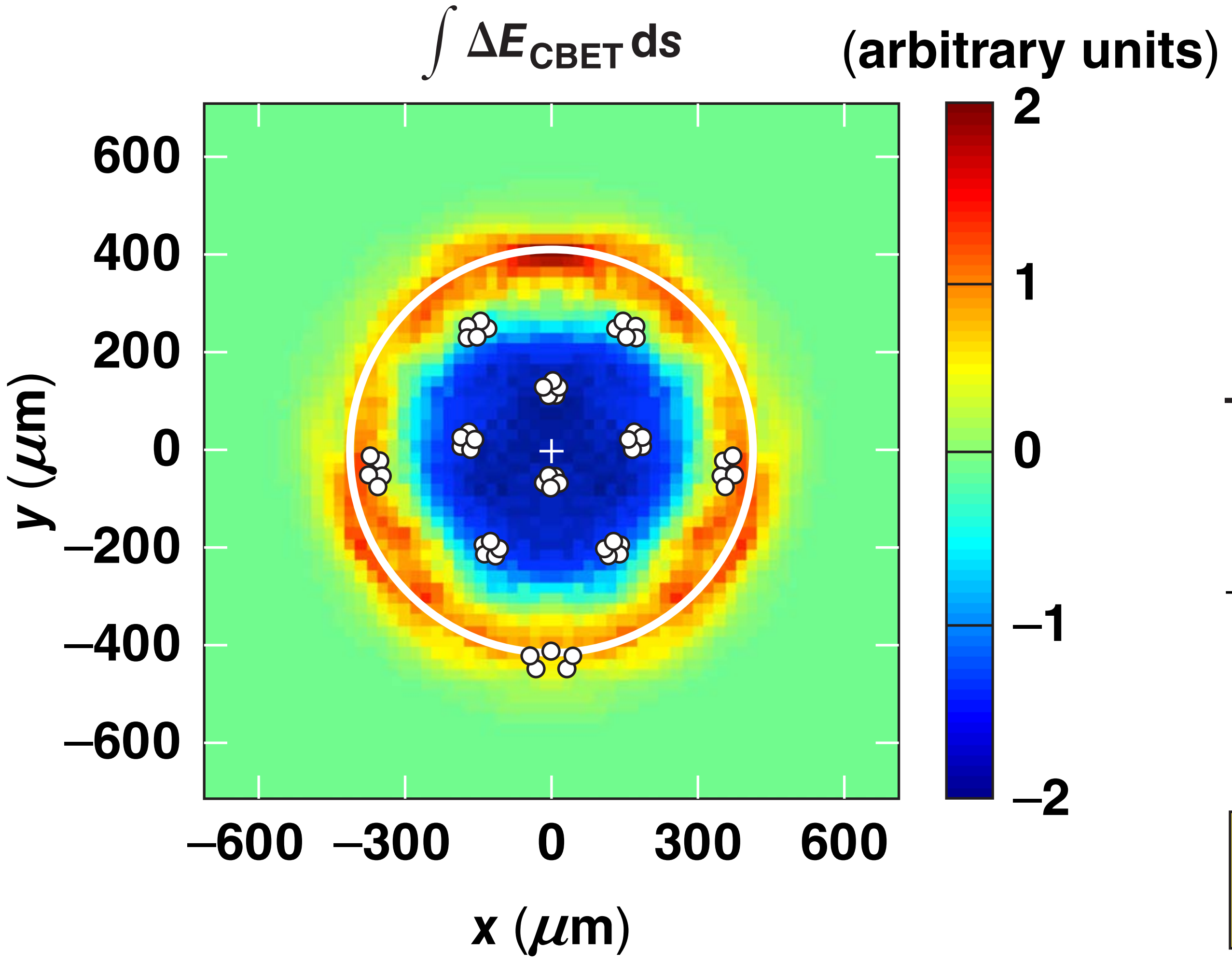
E24261

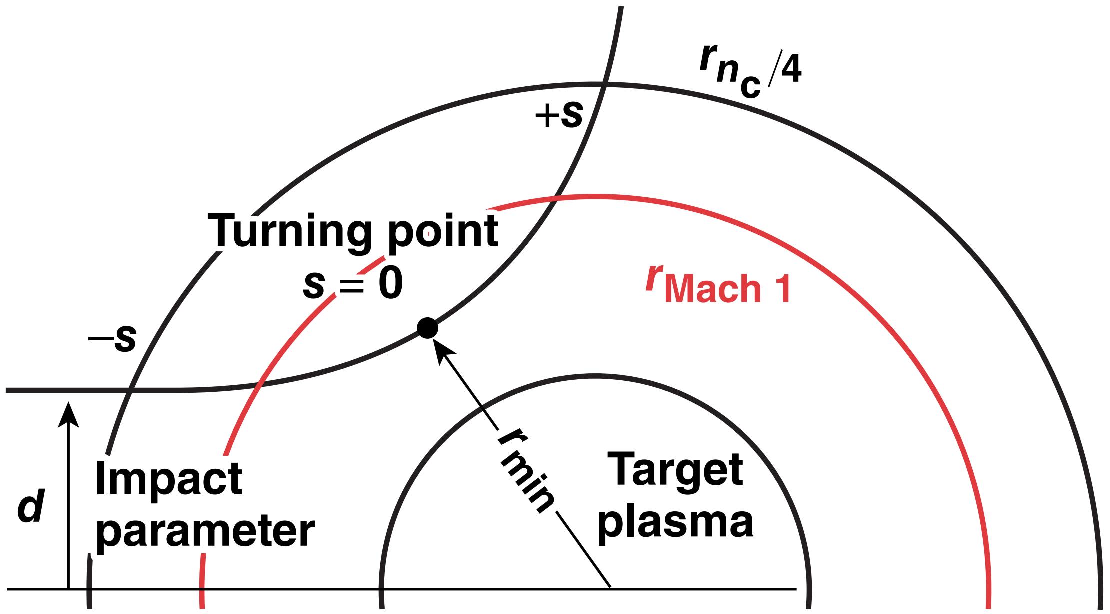
Each beamlet originates from a specific location in its beam's profile



E24262

The beamlet spots can be used to diagnose the variation in CBET over a beam profile

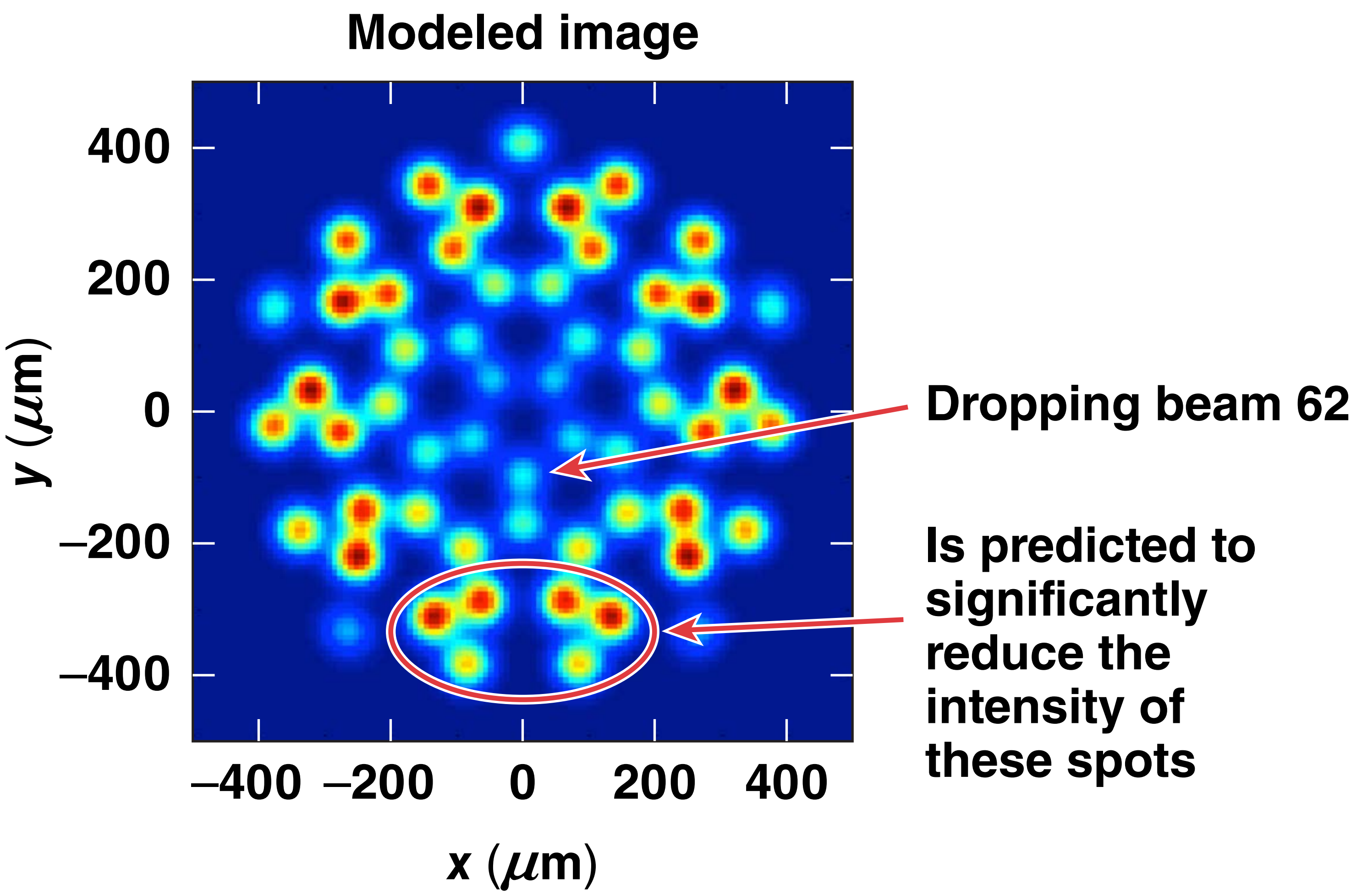


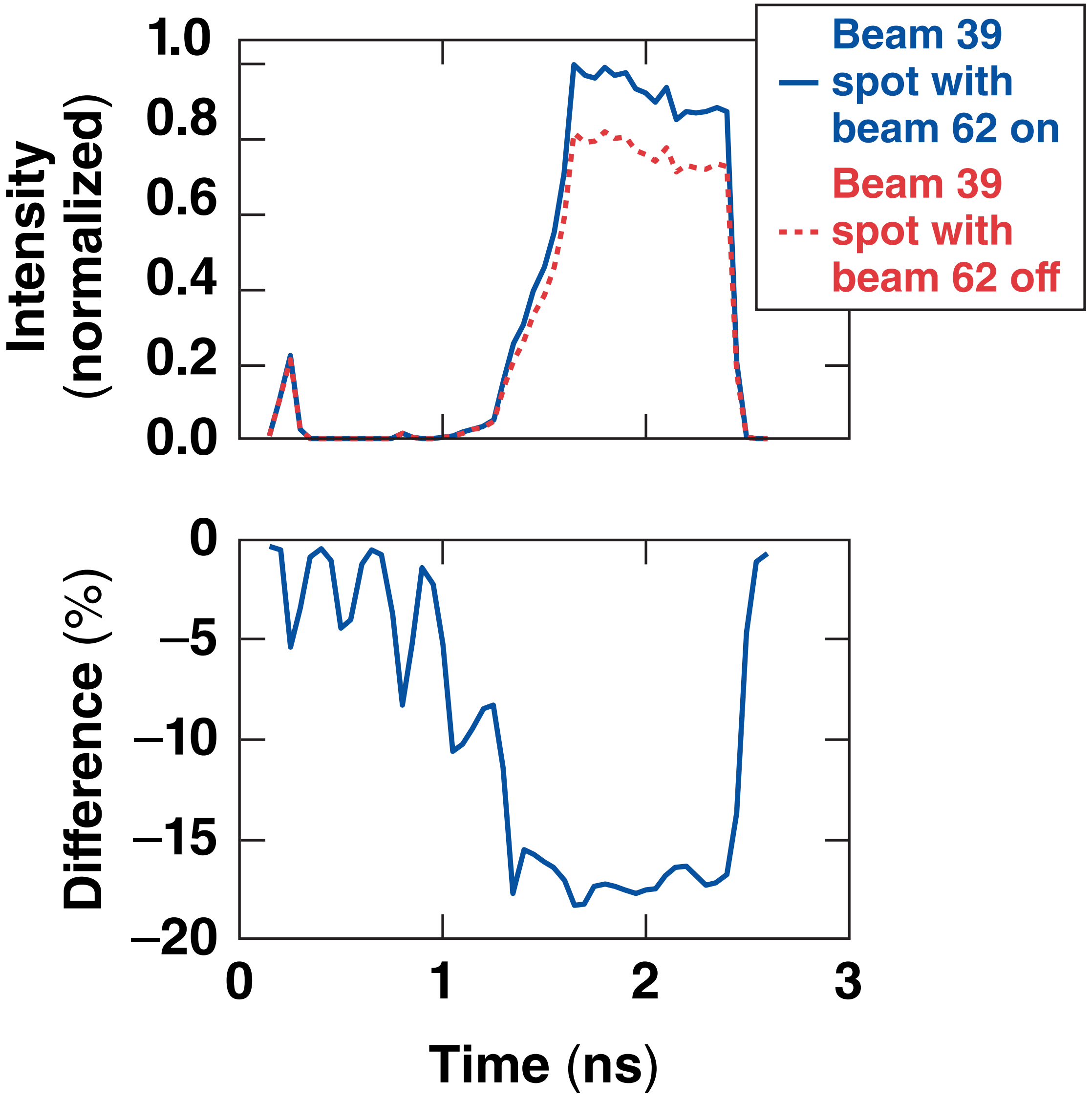


Some of the recorded beamlets experience net loss because of CBET while others gain.

E17999b

Three-dimensional CBET modeling predicts that turning off one beam can reduce the intensity of some other spots by over 15%





E24263

There are other possible measurements that could be made using beamlet spots in the future

- In polar-direct-drive implosions, CBET is stronger and more concentrated in certain beams that cross near the equator
  - up to 20% to 30% change in some spot intensities are predicted when a different beam is dropped
- It may also be possible to diagnose CBET by using a Wollaston prism to separate the polarization of beamlets into orthogonal components*
- The time-varying position of the beam spots as the capsule implodes could provide an implosion-trajectory diagnostic

* D. Turnbull *et al.*, Rev. Sci. Instrum. 85, 11E603 (2014).

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