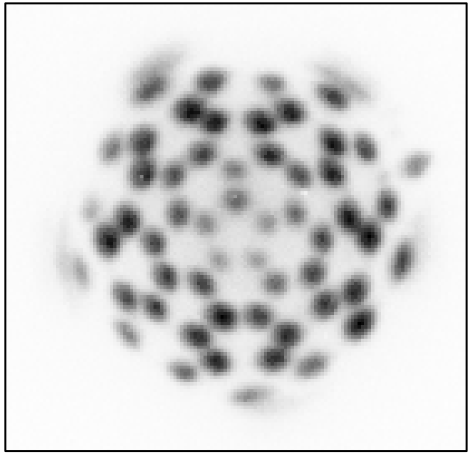
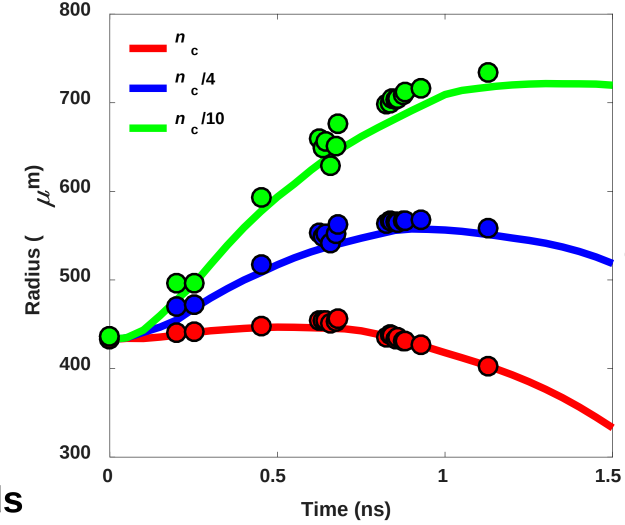
Density Profile Measurements on OMEGA using the CBET Beamlets Diagnostic

CBET beamlets image



Radial position of spots depends on plasma density profile

Critical radius versus time



Lines: code predictions
Circles: fits to data

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Laboratory for Laser Energetics

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Measured beamlet spot radial positions are very consistent with hydrodynamics code predictions

- **“CBET beamlets” is a gated optical imager (GOI) diagnostic that records scattered-light intensities as discrete spots from each OMEGA beam**
- **Beamlet spot locations are predicted by ray tracing light from each beam through the coronal plasma predicted by the 1-D hydrodynamics code *LILAC***
- **Best match between measurements and predictions of beamlet spot radii is achieved when nonlocal heat transport and cross-beam energy transfer (CBET) models are used in the hydrodynamics code**

Collaborators

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University of Rochester
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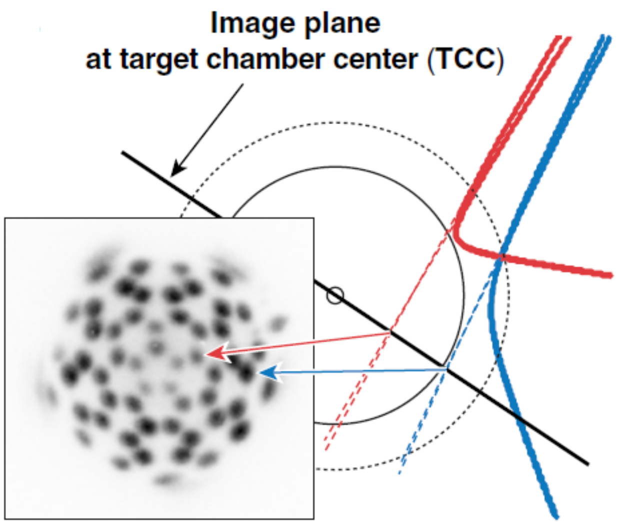
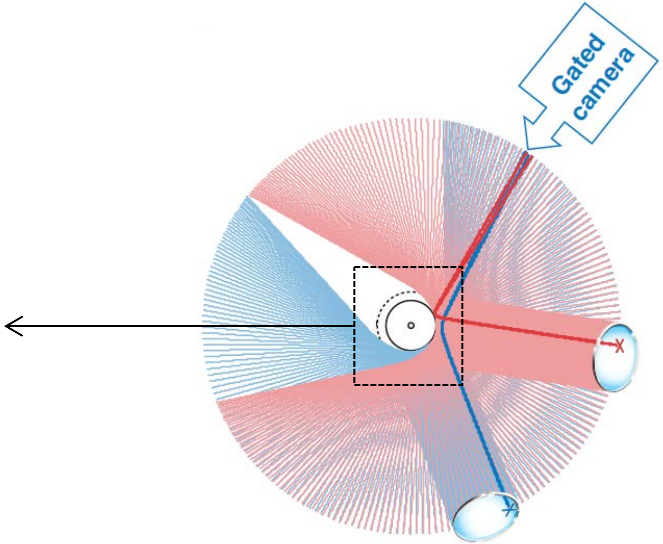
CBET beamlets is a GOI diagnostic that records scattered-light intensities separately for each OMEGA beam[1]

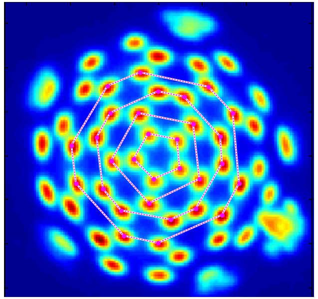




The radial position of each beamlet spot depends only the incident beam direction (fixed for OMEGA geometry) and on refraction through the density profile

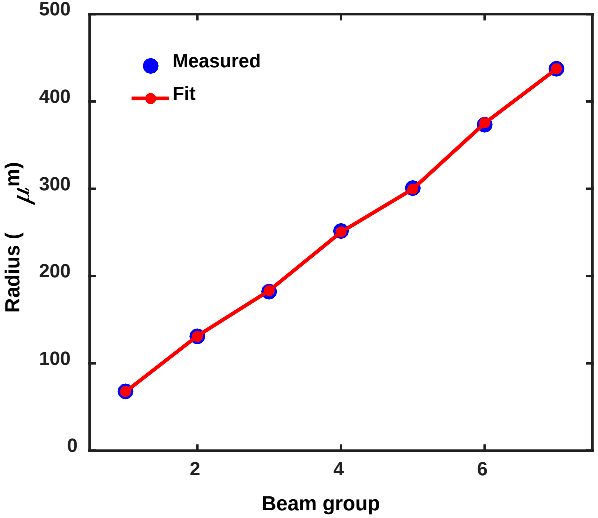
1. D.H. Edgell et al, Rev. Sci. Instrum. **89**, 10E101 (2018).

A density profile is fit to the measured radial position of the beamlet spots using ray tracing

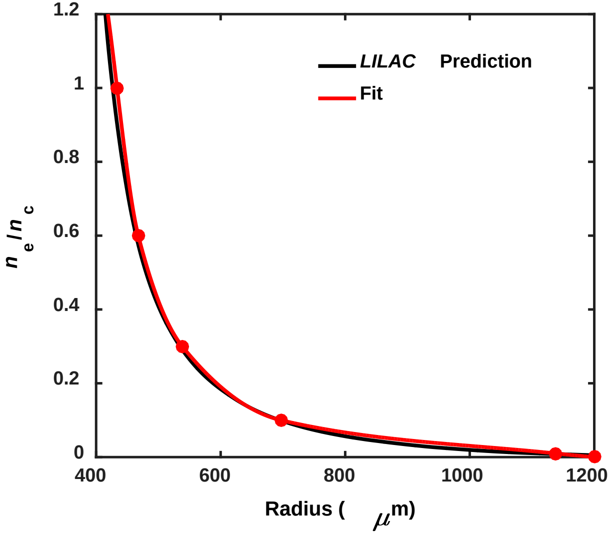


Beams are grouped according to their radial position, e.g., Beam Group 1 is the innermost five spots

Radial Positions of the beamlet spots in image

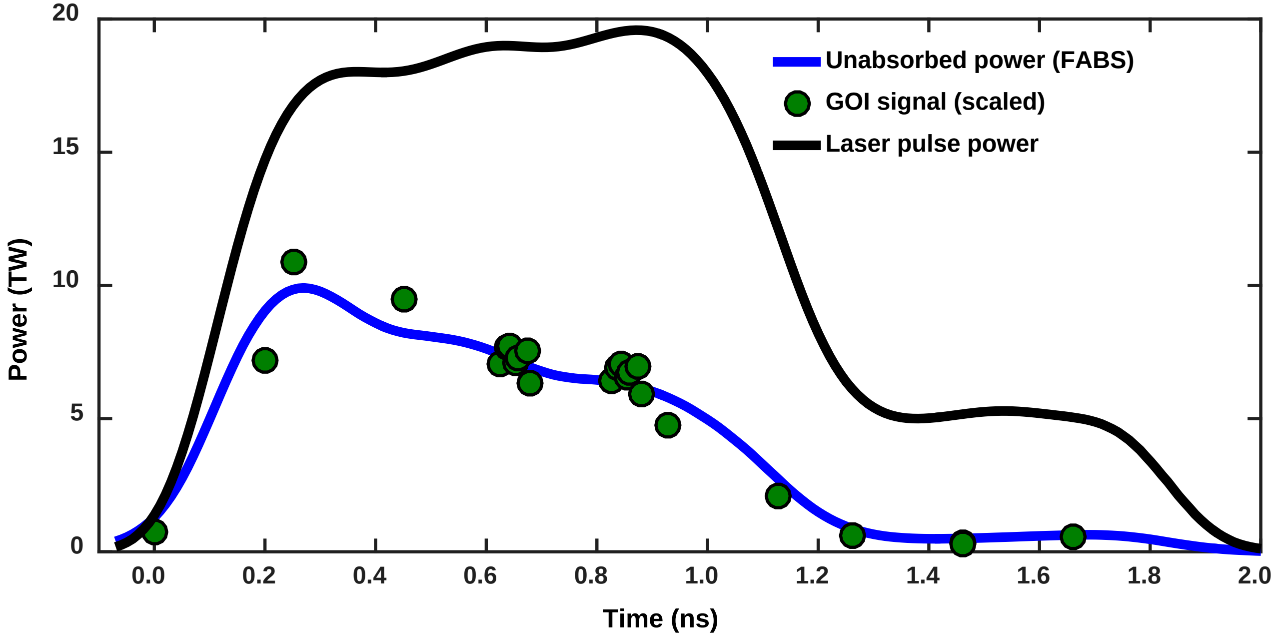


Plasma density profile



- 1-D *LILAC* hydrodynamics code coronal density predictions are used as an initial guess for the fit

Timing of the beamlet images is verified by comparison with the scattered-light time history measured by FABS*



- Each data point is from a different image
  - two images(times) per shot
- A single scale factor for all shots/images is estimated from the sum of all the beamlet spots with the FABS measurement
- Measurements at similar times have consistent total intensities

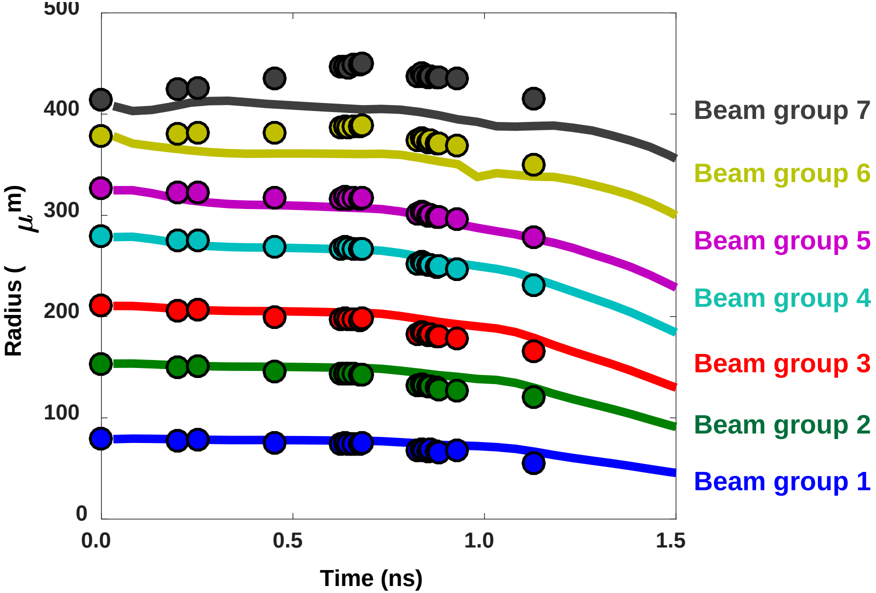
*FABS: full aperture backscatter station

The time-varying radial positions of the spots are compared to predictions from the 1-D hydrodynamics code *LILAC*

- **Circles: Measured radial positions of beamlet spots from images recorded at different times (from multiple shots)**

- **Lines: Predicted radial positions of beamlet spots using …**
  - **flux-limited (f = 0.06) electron heat transport model**
  - **No CBET model**

Radial positions of the beamlet spots in image



The time-varying radial positions of the spots are compared to predictions from the 1-D hydrodynamics code *LILAC*

- **Circles: Measured radial positions of beamlet spots from images recorded at different times (from multiple shots)**
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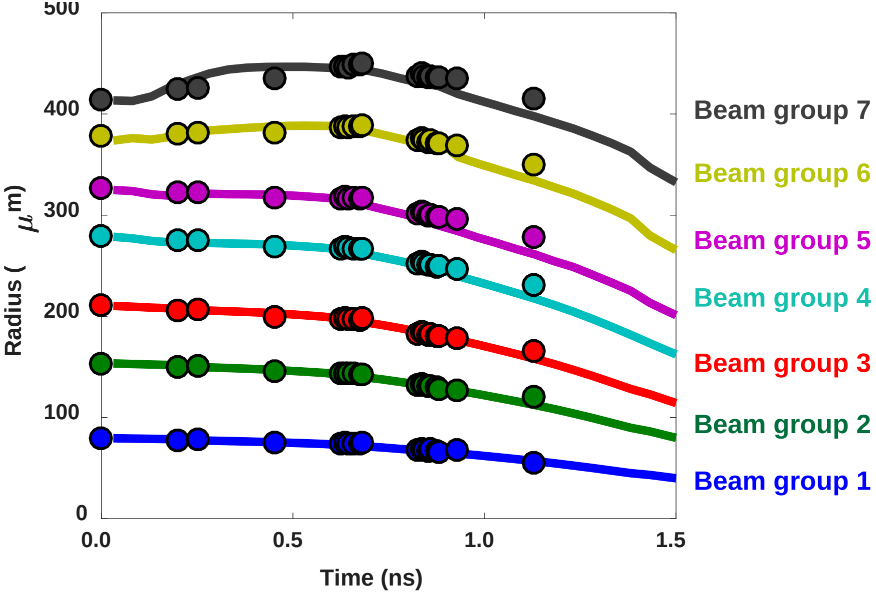
  - Goncharov nonlocal electron heat transport model
  - No CBET model

Radial positions of the beamlet spots in image



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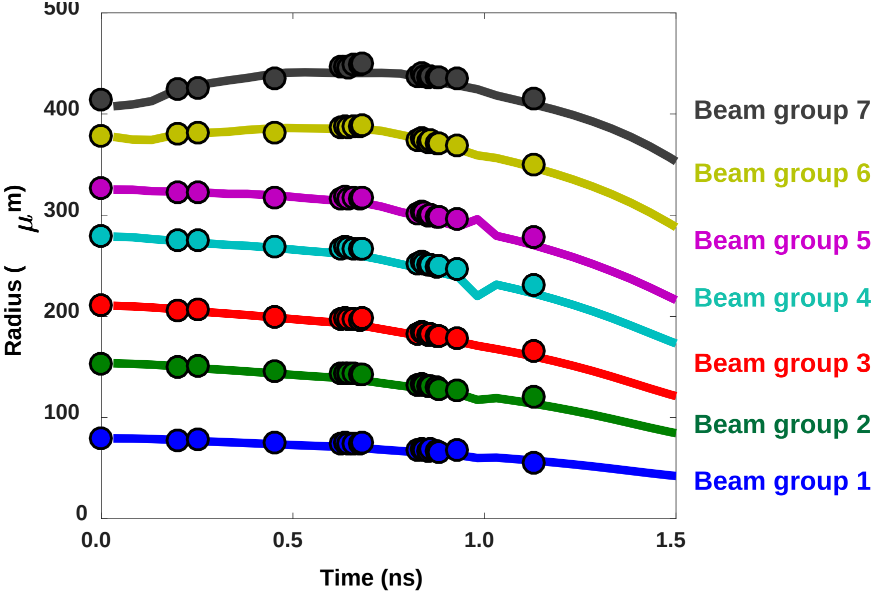
  - **Goncharov nonlocal electron heat transport model**
  - **with CBET model**

Best Match

Radial positions of the beamlet spots in image

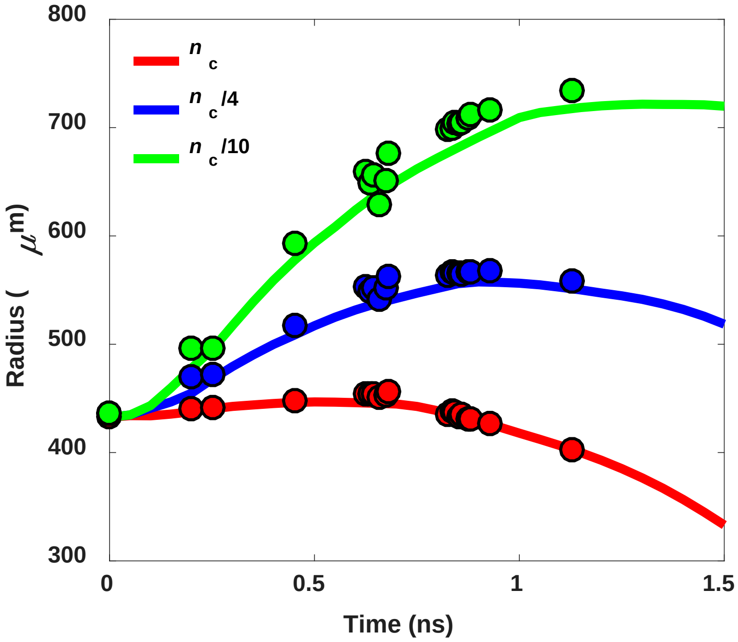


Least-square fitting a density profile to the measured radial position of the beamlet spots using ray tracing gives a time history of the coronal plasma evolution

- **Circles: Radius of critical density surface, etc. from the profile best fit to the measured beamlet spot positions in images**

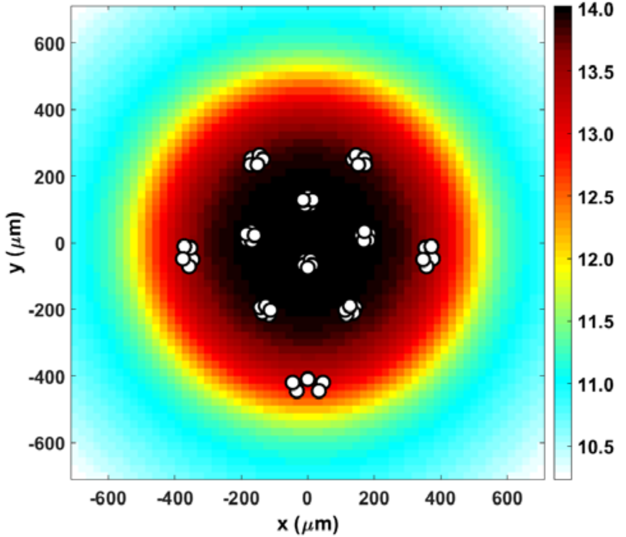
- **Lines: Predicted radius of critical density surface, etc. from the 1-D hydrodynamics code *LILAC* using**
  - **Goncharov nonlocal electron heat transport model**
  - **with CBET model**

Plasma profile changes in time



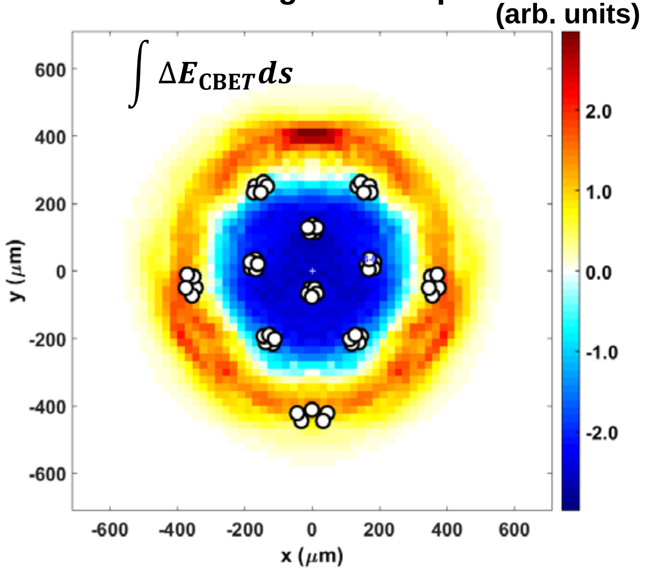
The intensity of each beamlet spot depends on its initial intensity and absorption/CBET along its path

Far-field beam profile

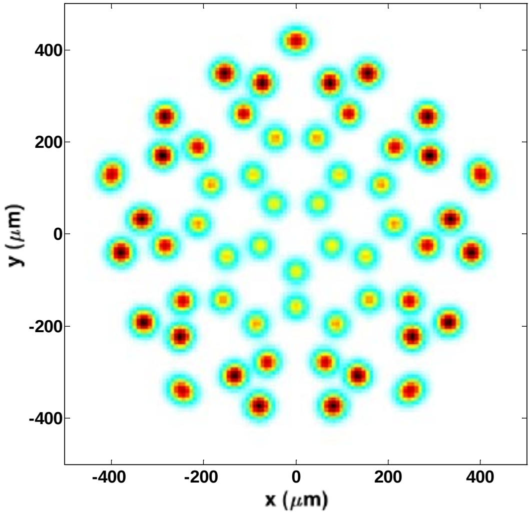


Origin of beamlet

CBET along beamlet path



Simulated beamlet image



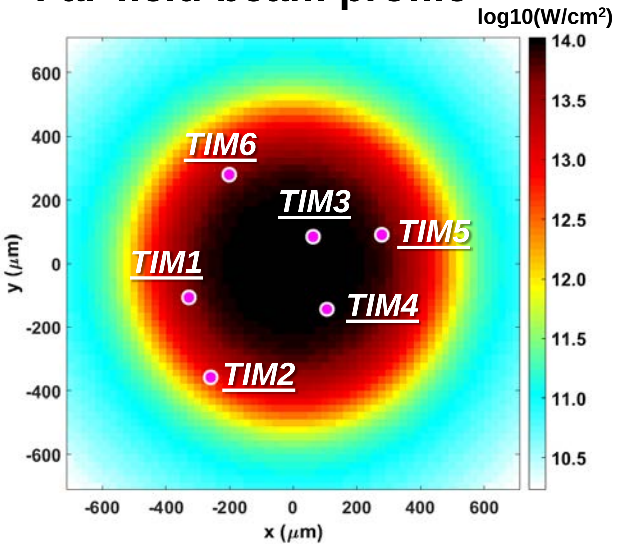
End point of beamlet

A single diagnostic image records light for a single pathway from the beam profile of each beam.

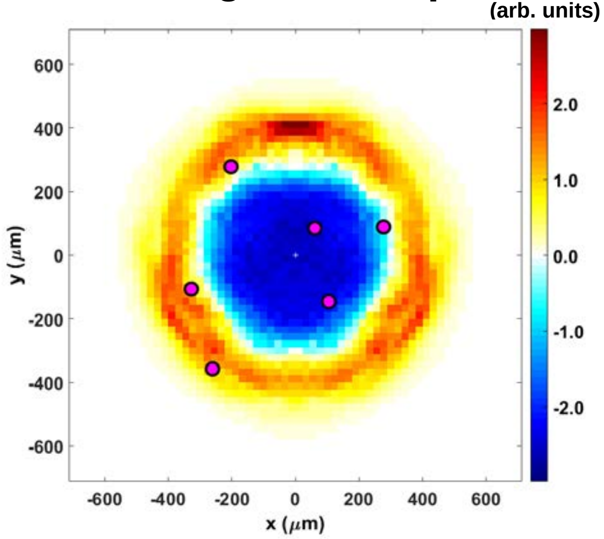
Beamlets from multiple locations in a beam profile could be measured by deploying multiple beamlet diagnostics in the OMEGA diagnostic TIM* ports

- Beamlets sampled from TOP9 beam (originating in OMEGA port P9) for diagnostics located in the different TIM diagnostic ports

Far-field beam profile



CBET along beamlet path



Beamlet spot intensities will be used to verify (CBET) mitigation with the new TOP9 variable wavelength beam.[1]

*TIM: ten-inch manipulator

[1] A. Hansen, CO4.00008

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