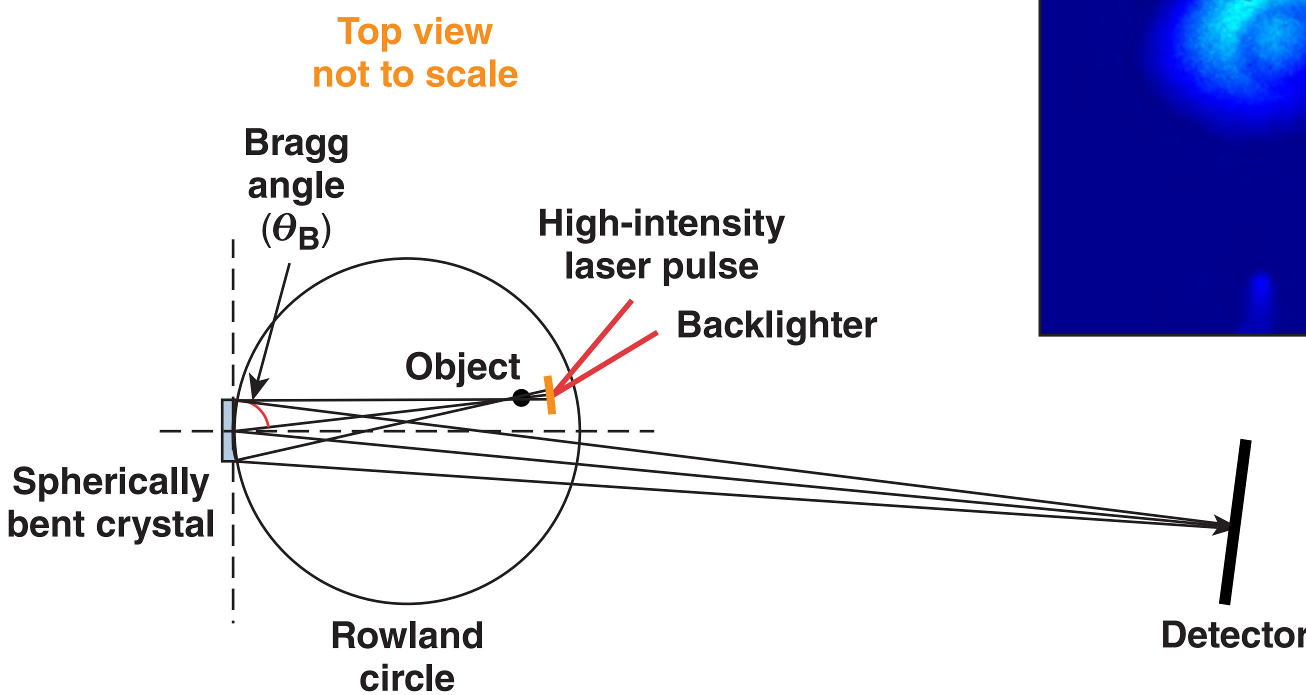
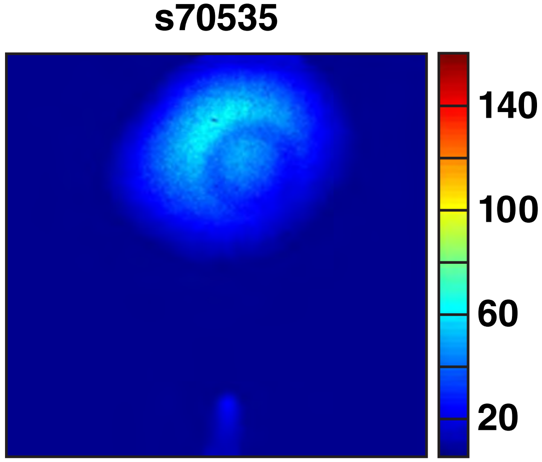
Soft X-Ray Backlighting of Cryogenic Implosions Using a Narrowband Crystal Imaging System





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Summary

First radiographs of cryogenic DT implosions have been recorded with a crystal imager on OMEGA

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- A crystal imager is well suited for cryo backlighting because of its narrow spectral width, high throughput, and high spatial resolution
- The backlighter is driven by the OMEGA EP short-pulse beam to provide high brightness and a high time resolution
- Three major improvements have been implemented
  - an aspheric crystal is used to reduce the astigmatism
  - a time-resolved recording system reduces the background
  - a fast backlighter target insertion system makes the crystal imager compatible with cryogenic operation
- There are indications of carbon mixing into the DT shell

Collaborators

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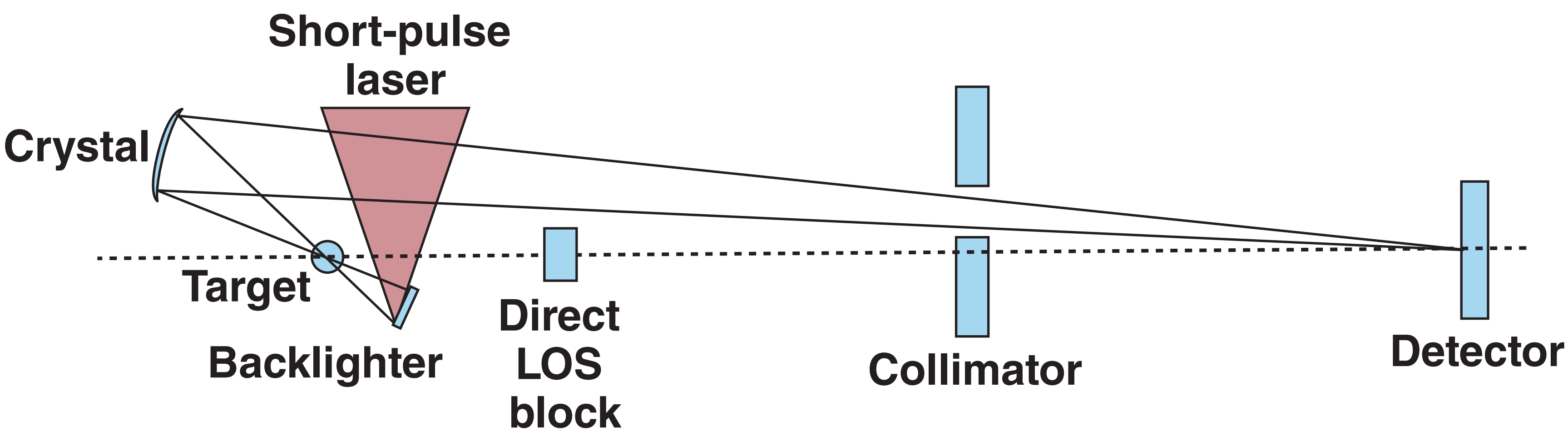
High-quality backlit images of implosions can be obtained with a crystal imaging system

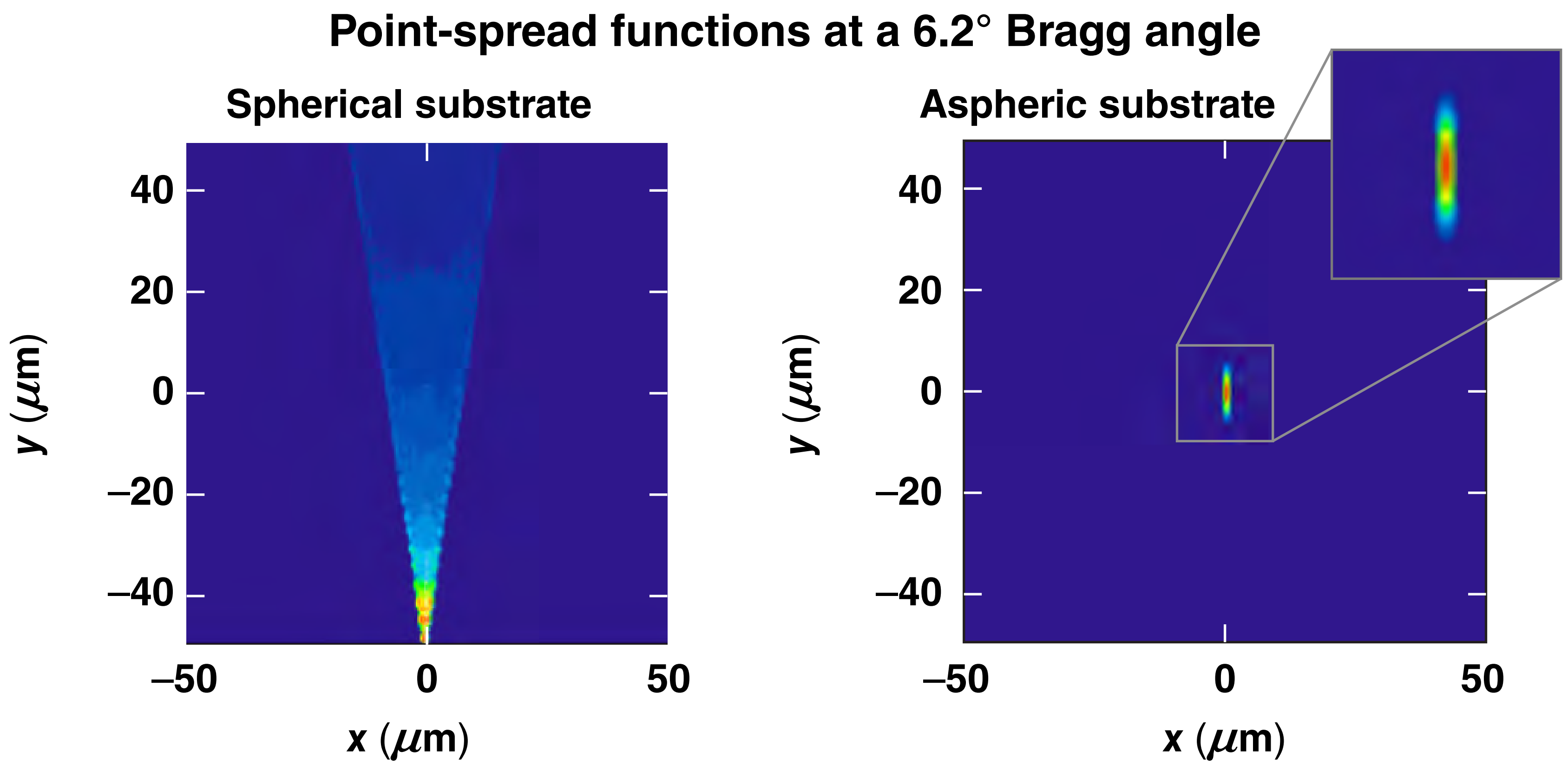


- The backlighter foil is not in the focus of the imaging system, so the backlighter uniformity does not depend on the laser-intensity distribution
- A collimator blocks the line of sight (LOS) to the backlighter, minimizing the background from the short-pulse laser
- A direct LOS block shields the detector from background produced by the implosion target

Backlighting the compressed core of a cryogenic target implosion is challenging

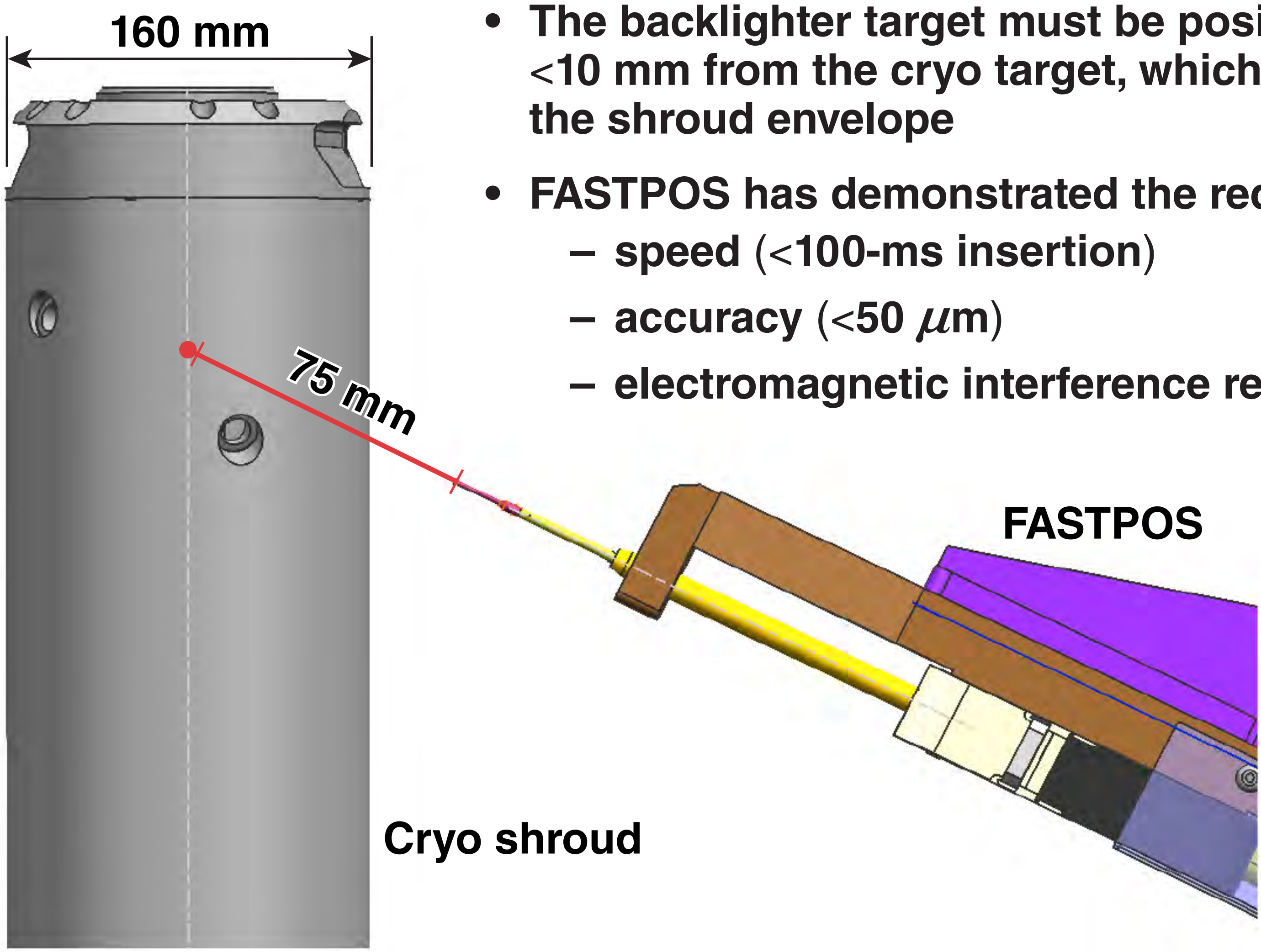
- The low opacity of DT requires a soft x-ray backlighter
  - the crystal imager uses the Si-He$_\alpha$ line at 1865 eV
- A bright backlighter is required to overcome the self-emission
  - the high energy of the OMEGA EP laser at 10 ps allows for the illumination of a large target area
- The cryo implosion evolves at high speed (>3×10^7 cm/s)
  - the short pulse duration of OMEGA EP provides a time resolution of ~10 ps
- The small size of the core requires a high resolution (<10 μm)
  - a crystal on an aspheric substrate has a calculated resolution close to 1 μm

An aspheric crystal substrate has been designed to reduce the aberrations of the crystal imager



- The design of the aspheric substrate uses five aspheric terms to reduce the astigmatism, coma, and fourth-order horizontal aberrations

A fast target positioner (FASTPOS) inserts the backligher target once the cryo shroud is removed



- The backlighter target must be positioned <10 mm from the cryo target, which is inside the shroud envelope
- FASTPOS has demonstrated the required
  - speed (<100-ms insertion)
  - accuracy (<50 μm)
  - electromagnetic interference resilience

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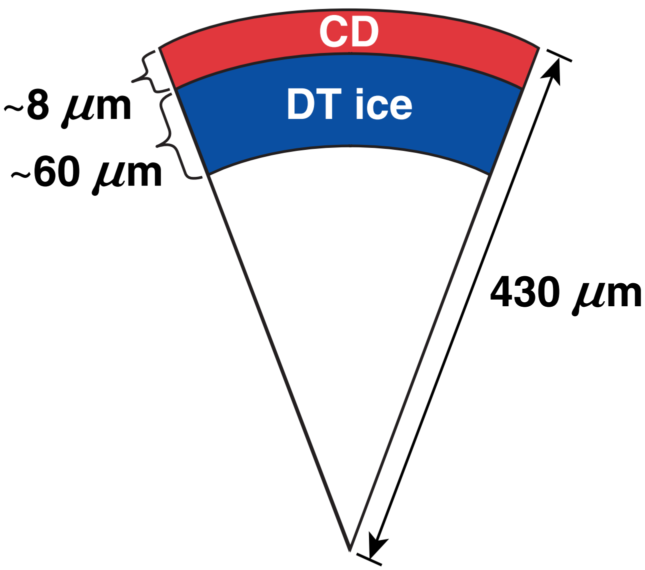
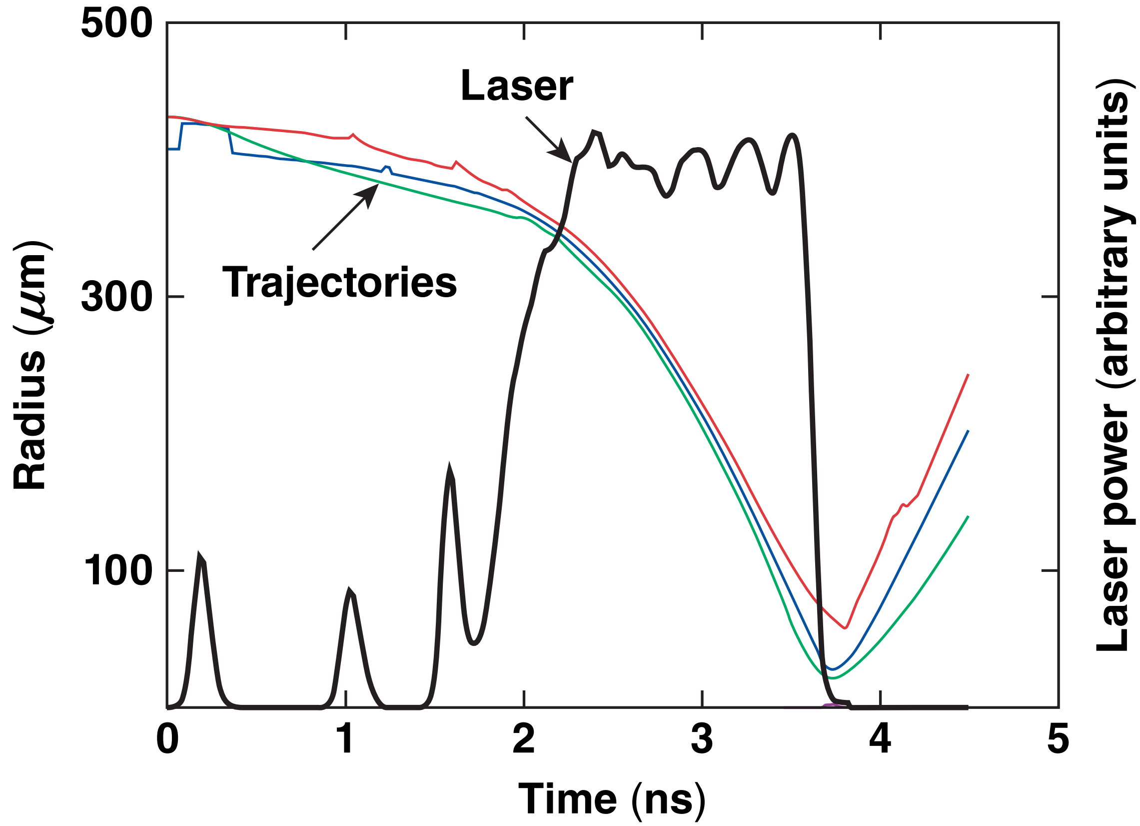
A low-adiabat, triple-picket pulse was used for the cryogenic target experiments*





*V. N. Goncharov, GI3.00001, this conference (invited)
T. C. Sangster *et al.*, NO4.00009, this conference.

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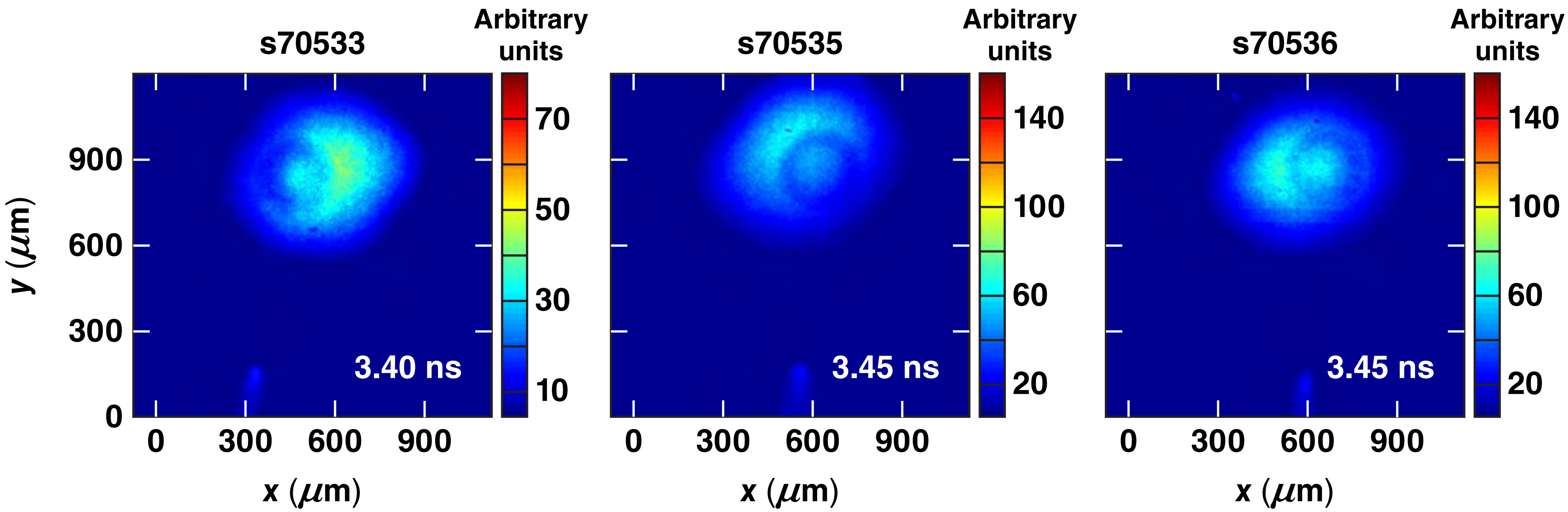
Framed backlit images of DT cryo implosions were obtained on every shot



- **The focal spot size of the OMEGA EP beam was reduced from 400 μm (s70533) to 300 μm (s70533 and 70536), leading to an ~2× increase in backlighter intensity**

Simulations assuming mixing of carbon into the DT shell can reproduce the measured absorption

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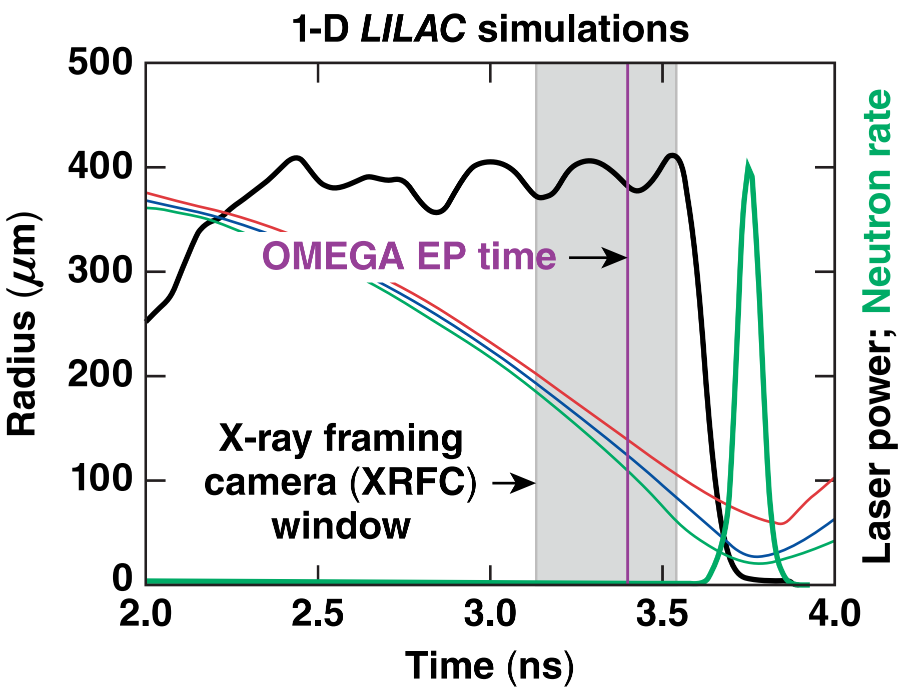
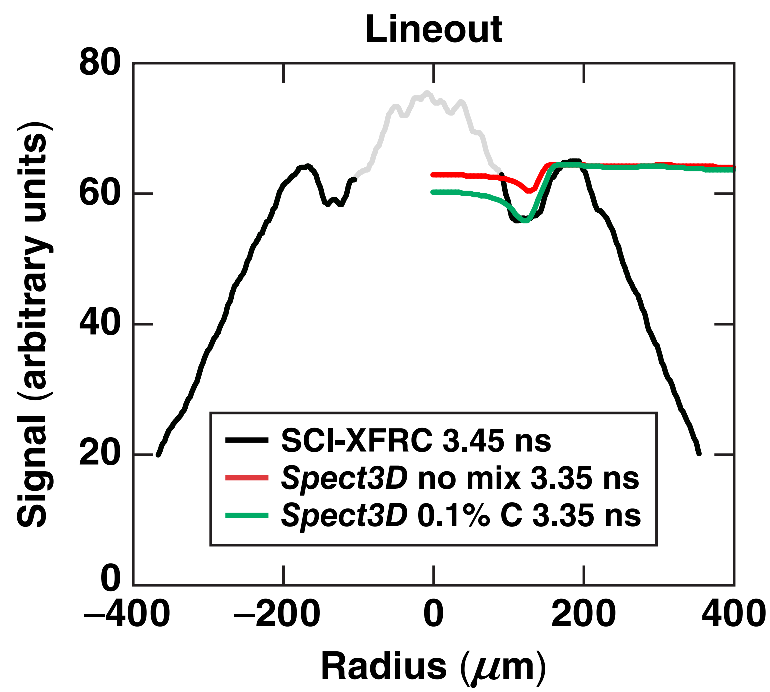
s70535 cryo target





- The experimental bang time is ~30 ps later than in *LILAC*
- The measured radius implies a 100-ps delayed trajectory
- The observed opacity increases relative to s70533 (OMEGA EP fired 50 ps later)

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Summary/Conclusions

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