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

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A spherical crystal imager (SCI) will be used to backlight cryogenic DT implosions on OMEGA

- An SCI system is well suited for cryo backlighting because of its narrow spectral width, high throughput, and potential for high spatial resolution
- The backlighter is driven by an OMEGA EP short-pulse beam to provide high brightness and a high time resolution
- The first experiments with room-temperature CH targets showed encouraging images with an astigmatism-limited resolution of ~20 µm
- Two major improvements are planned for the Si-SCI on OMEGA
  - an aspheric crystal will be used to reduce the astigmatism
  - a fast target insertion system will make the SCI compatible with cryogenic operation
Collaborators


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A high backlighter spectral brightness at 2 keV is required to image the compressed core of cryogenic targets.

- Simulations predict a self-emission of 8 $\mu$J/eV/ps/Sr in the 2-keV range.
- The simulation assumes, for the backlighter, a 3-keV Planckian spectrum filtered in the 2- to 2.2-keV spectral range ($\sim 60$ $\mu$J/eV/ps/Sr).
Backlighting the compressed core of a cryogenic target implosion is challenging

- The low opacity of DT requires a soft x-ray backlighter
  - the spherical crystal imager uses the Si-He$_\alpha$ line at 1865 eV
- A bright backlighter is required to overcome the self emission
  - the high energy ($\sim$1500 J at 10 ps) of OMEGA EP makes it possible to illuminate a large target area at intensities of $\sim 10^{18}$ W/cm$^2$
- The cryo implosion evolves at high speed
  - the short-pulse duration of OMEGA EP provides a time resolution of the order of 10 ps
- The small size of the core requires a high resolution ($<10 \mu$m)
  - a crystal on an aspheric substrate has a calculated resolution of close to 1 $\mu$m
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
The OMEGA spherical crystal imager* is based on the OMEGA EP** design

- The crystal is located in TIM-6, 267 mm from the target
- The detector in TIM-4 is placed 3.6 m from the crystal for a magnification of ~15

First tests of the Si He\textsubscript{\alpha} SCI system were performed with room-temperature, gas-filled CH target implosions.

- Plastic is completely opaque to Si He\textsubscript{\alpha} near peak compression.
Reasonable agreement is achieved between the experimental image and Spect3D

• Higher-order reflections must be included in Spect3D simulations to reproduce experimental images

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 inserter (FASTPOS) is available to insert the backlighter 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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