The OMEGA Cryogenic Target--Handling System

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The OMEGA cryogenic target–handling system is designed to provide cryogenic targets for direct-drive ICF experiments on the OMEGA laser facility. The equipment is currently being assembled and tested and is expected to be operational in the fall of 1999. This presentation will describe the features and capability of the cryogenic system. Briefly, four direct-drive targets (1-mm diam, 1-μm wall) are filled to 1500 atm (equivalent to a 100-μm ice layer) with D_2 (or DT), cooled to 20 K, and individually transferred to a cryogenic "shuttle." The shuttle is portable and is used to insert the cold, filled targets into the target chamber. The ice is "layered" (made symmetric within the capsule) and smoothed using IR light; the smoothness of the ice is determined by phase-shifted interferometry. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, the University of Rochester, and the New York State Energy Research and Development Authority.

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Summary

Direct-drive cryogenic experiments will begin shortly on OMEGA

- The OMEGA Cryogenic Target-Handling System is assembled and is being integrated into the OMEGA facility.
- The critical engineering components have been tested to validate the design.
  - Targets have been filled with sufficient D_2 to provide a 100-μm ice layer.
  - Filled targets have been moved at 20K.
  - The moving cryostat (cryogenic-target positioner) has placed a target at the chamber center.
  - The shroud-retraction system has removed and replaced the shrouds and has demonstrated a maximum velocity of 4.8 $m.s^{-1}$.
- Direct-drive capsules with the desired wall thickness and known mechanical properties are available for use (1-mm-diam, 1-μm wall).
- Initial experiments will use D_2/He gas.
- Issues to be studied in the future are
  - identify the processing conditions needed to fill and cool thin-wall (fragile) targets, and
  - study the ice-layering mechanism.

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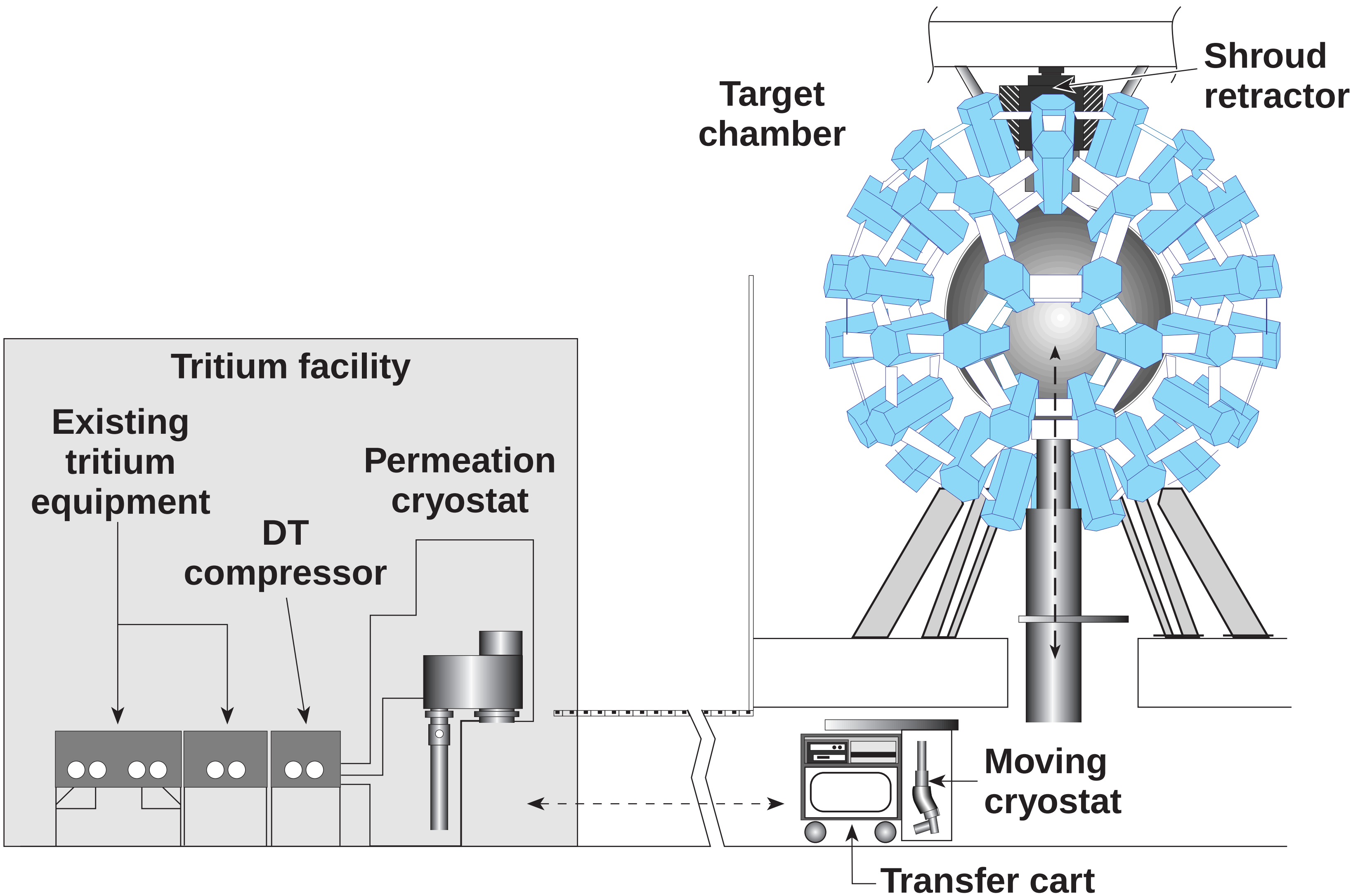
The OMEGA cryogenic target–handling system



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The Cryogenic Target-Handling System consists of four major components

1. High-Pressure System

Smoothly increases the gas pressure from vacuum to 1500 atm.

- **$\Delta P = 8.6 \times 10^{-5}$ atm/step (65 mtorr/step) (allowable pressure increment is 50 torr).**
- **System uses D_2/He or DT (1-g license).**
- **Triple containment where pressure > 1 atm.**

2. Fill/Transfer Cryostat

Location where targets are filled, cooled, and transferred to the moving cryostat.

- **Maintains the target below 20°K throughout the transfer.**
- **Targets have been successfully filled to 1000 atm, cooled to 19.5°K (at 2°K/min), and transferred to the moving cryostat's target support stalk.**

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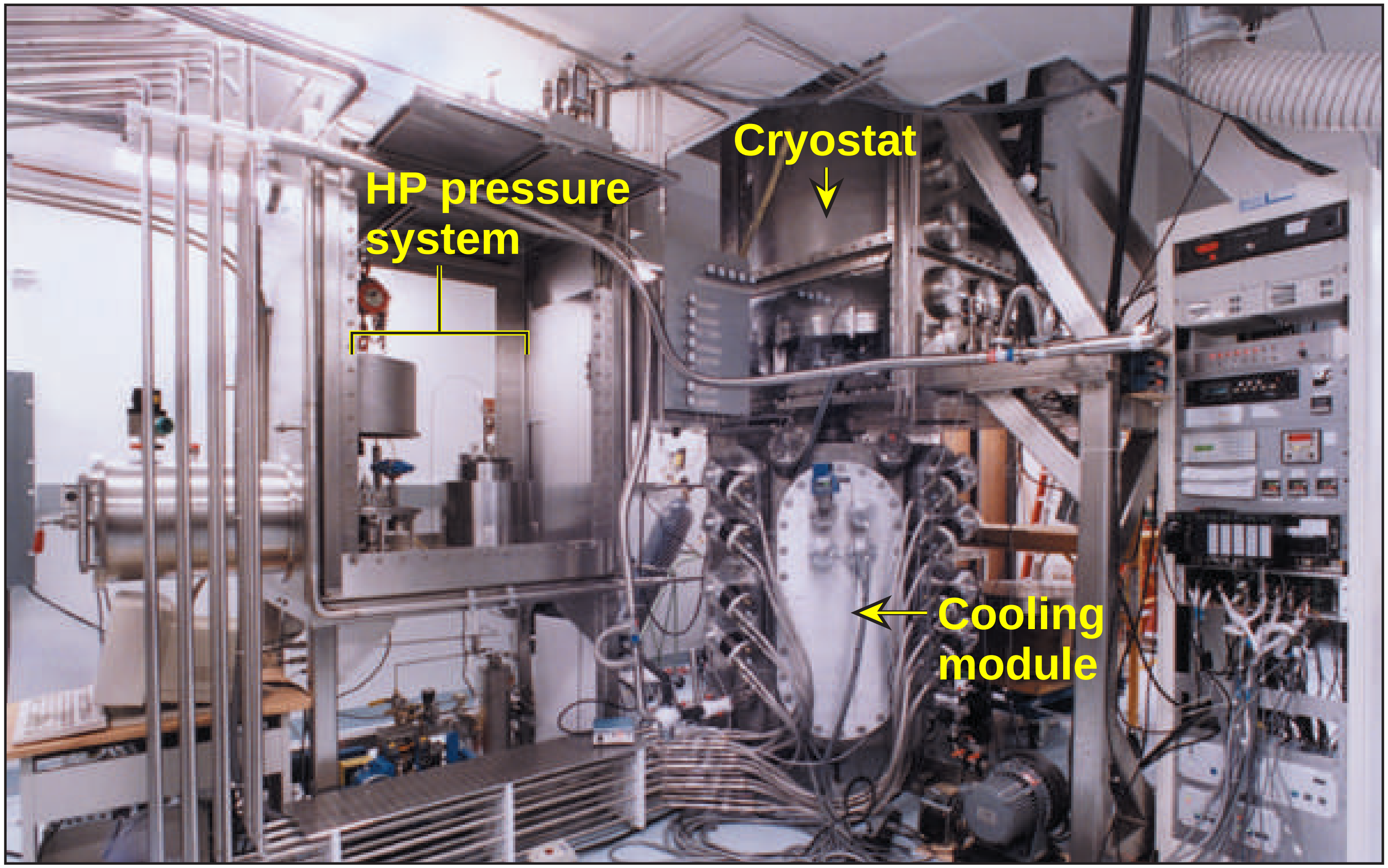
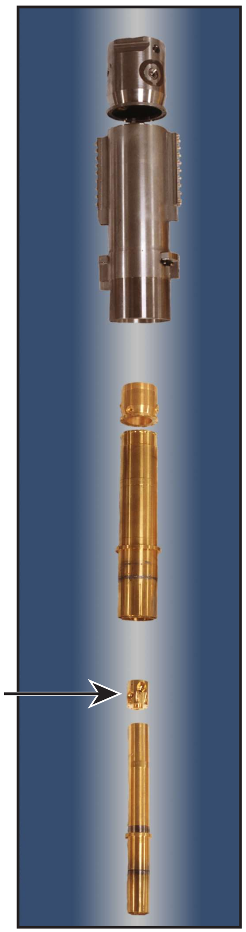
Target-filling and transfer equipment



3. The Moving Cryostat

Maintains the target at a constant temperature to layer the DT (D_2) ice and transports the target to the center of the target chamber

Upper shrouds (exploded view)



Outer shroud

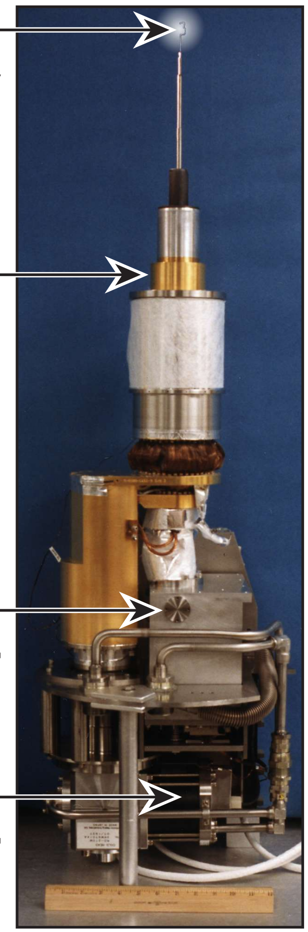
Middle shroud

Layering sphere

Inner shroud

Target assembly

Cryostat base



Lower shrouds

4-axis positioner

Cryo-cooler

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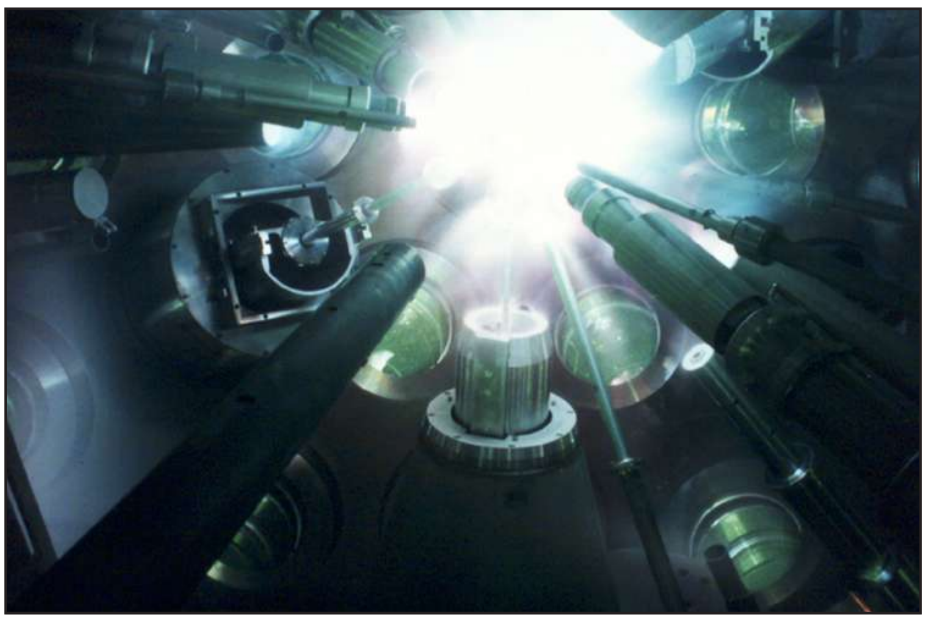
4. Target insertion and shroud retraction

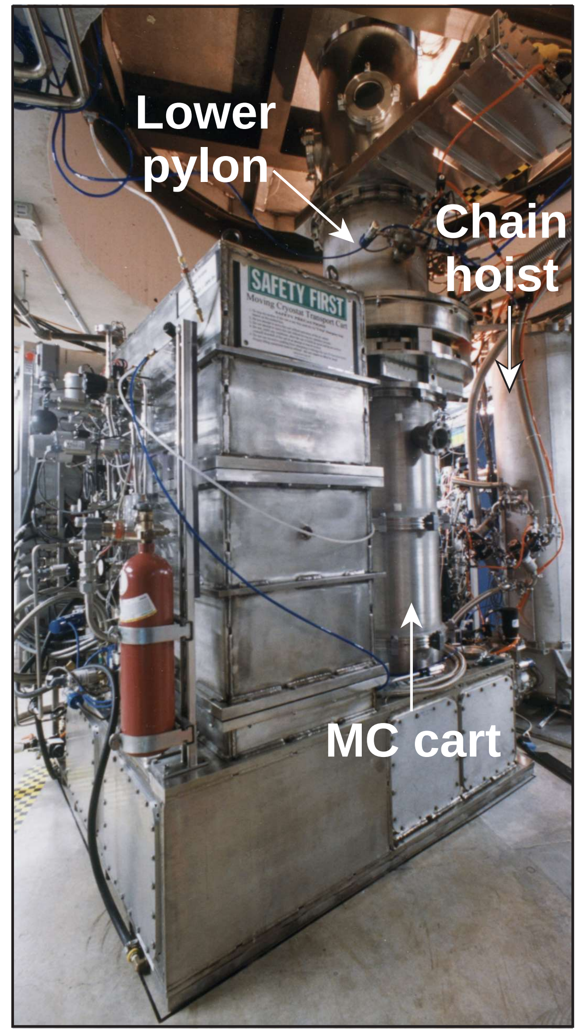
- The moving cryostat is transported in a vacuum vessel.
- Shroud retraction is provided by a linear motor attached to a bridge over the target chamber.

  a = 2.5 g (constant)

  $v_{max} = 4.8\ ms^{-1}$

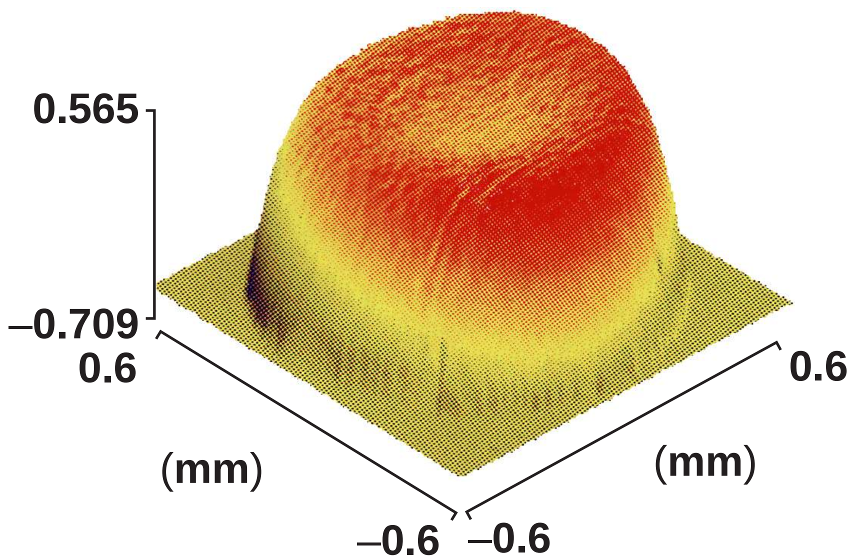
  target exposure time < 50 ms





D_2 ice layering and characterization are in development and will be tested later this year

- Layering uses an optical parametric oscillator tuned to the S(0) D_2 transition.
- Inner-surface roughness is measured using a phase-shifting convergent-wave interferometer (5-nm height resolution; 3-μm spatial resolution).
- Interferograms of multiple views of the targets are averaged to provide the power spectrum.



A 3-D phase map of the entire capsule.

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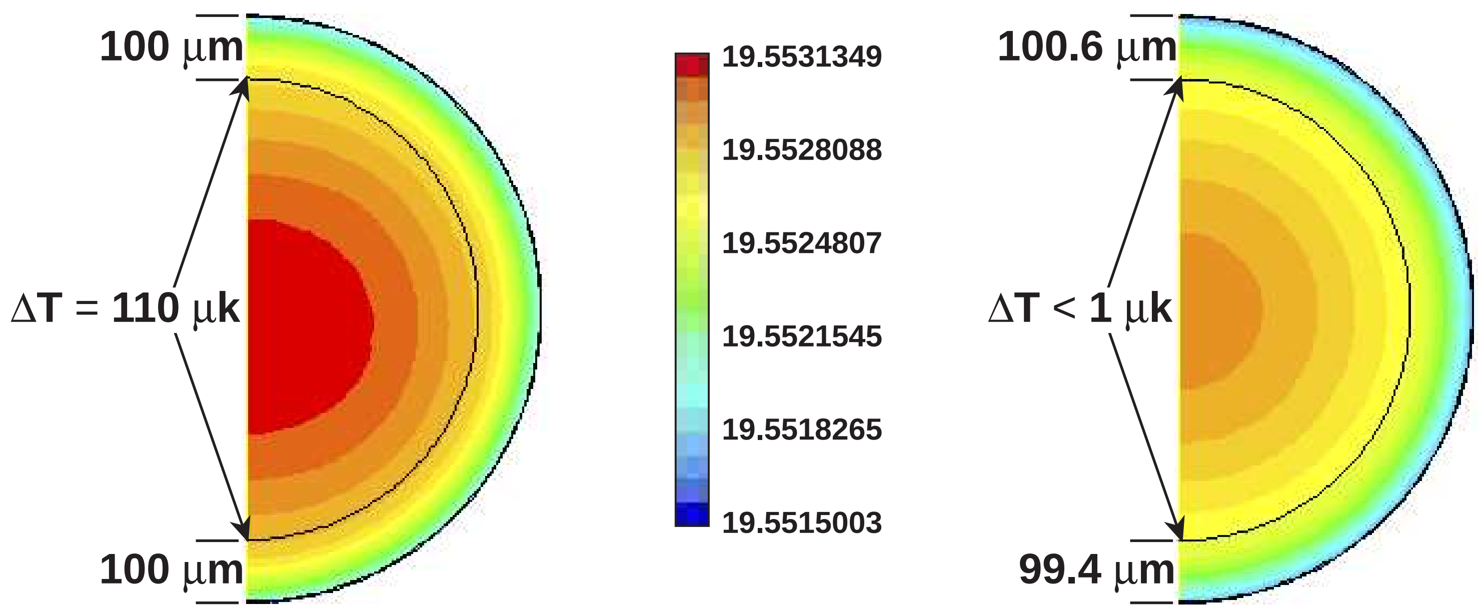
CFD modeling is used to calculate the sensitivity of the ice layering process to temperature gradients

Example: A layered target is moved one target diameter (1 mm) up from the center of an isothermal layering sphere (25 mm inside diameter).

$T_{\text{layering sphere}}$ = 19.2 K



Steady-state temperature distribution before the layering occurs

Steady-state temperature distribution once the ice has relayered: 1.2-μm amplitude develops in the l = 1 mode.

- Axisymmetric 2-D temperature profile across a 1-mm polyimide capsule with a 2-μm wall

T1468