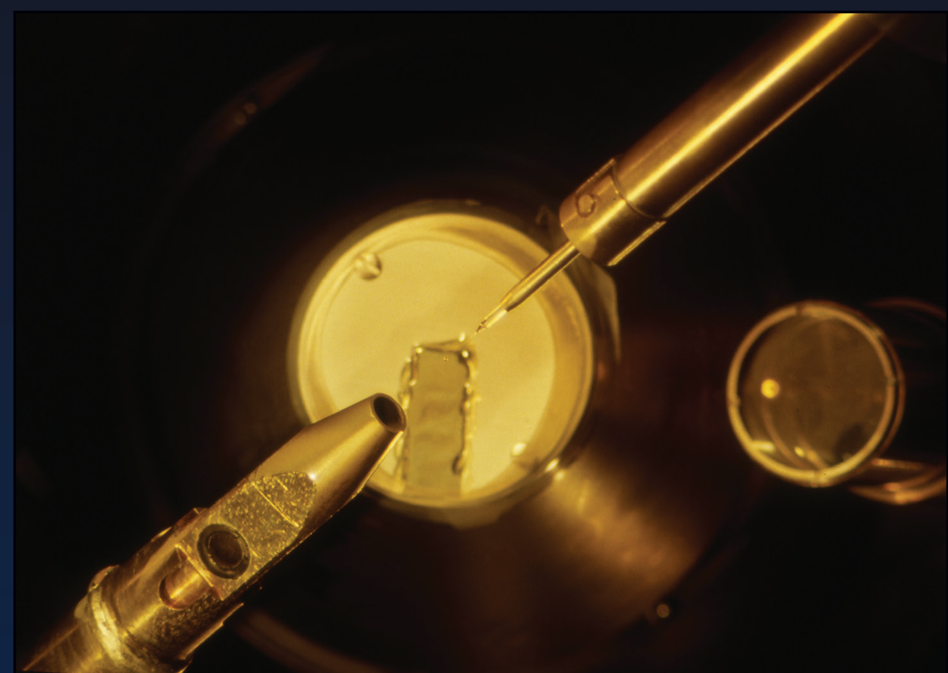
1987

High-Density Compression



Cryogenic target shroud for 24-beam OMEGA

The first cryogenic target system was installed on the OMEGA chamber in support of achieving the Department of Energy (DOE) goal of compressing a cryogenic direct-drive target to a density of 100 to 200× liquid DT density. Many laser shots were taken during the summer and early fall before it was decided to suspend shots in order to carry out several system redesigns. Among the principal problems faced at that time were target vibration, unpredictable cryogenic shroud retraction, and poor DT-layer quality. The lessons learned on this first OMEGA cryogenic system helped in the future design of the much more challenging cryogenic system that was developed a decade later for LLE experiments.

1988

OMEGA Experiments Show 200× Liquid-DT Density

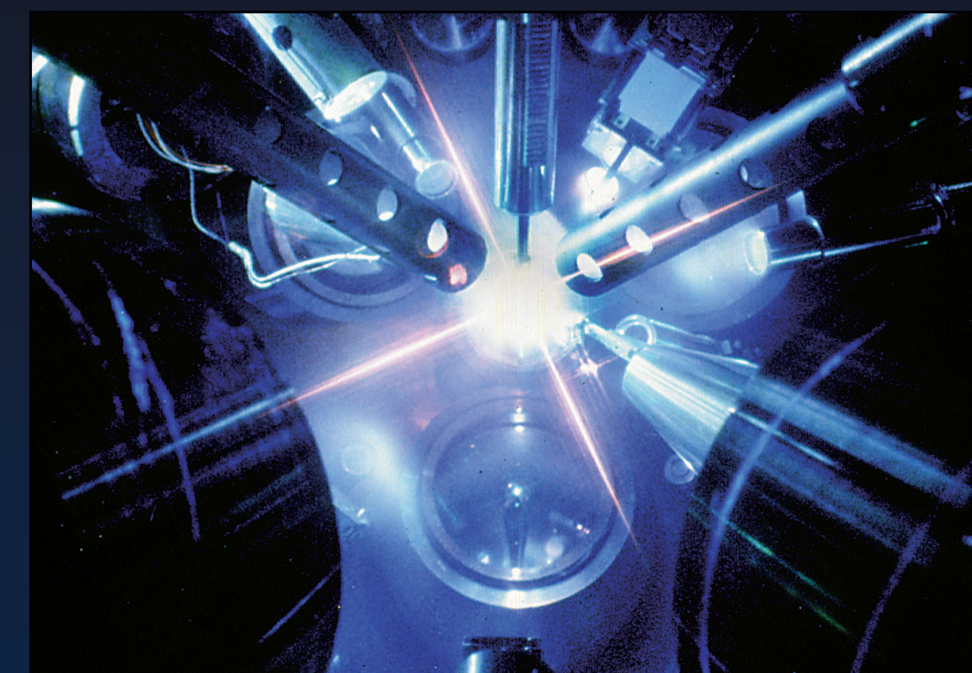


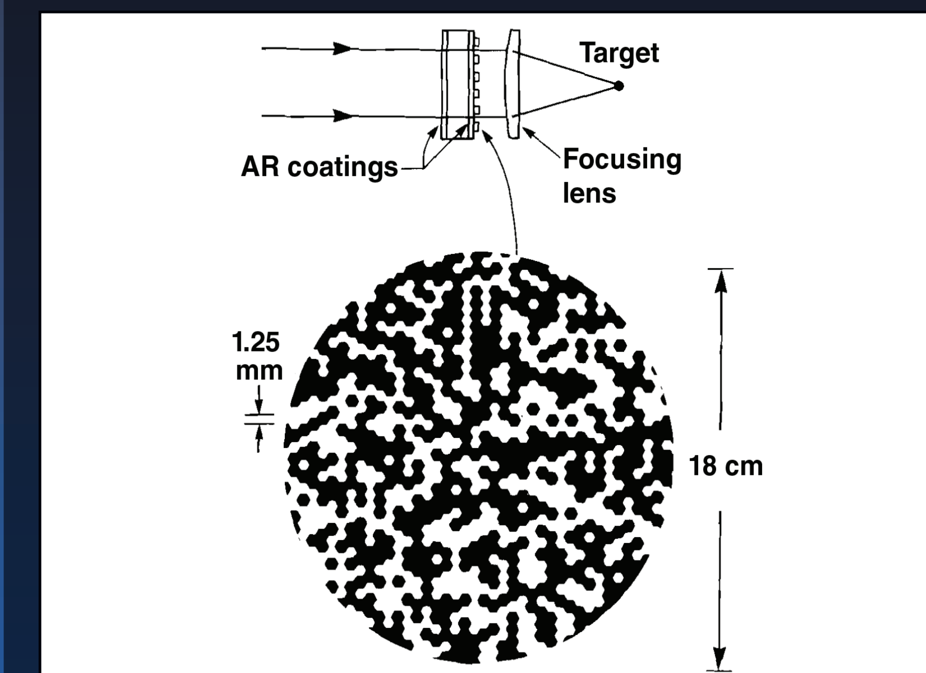
Image from Nature *article*

In 1988, with an adapted cryogenic system and newly developed beam smoothing, LLE demonstrated 100 to 200× liquid-DT density implosions on OMEGA. An extensive array of experimental diagnostics was employed to carry out these experiments including absorption and fractional conversion of the absorbed energy into x rays; time- and space-resolved measurements of x-ray emissions; neutron yield and energy spectrum; and fuel-areal-density measurements using knock-on diagnostics. The knock-on diagnostics technique conceived and developed at LLE, in particular, gave unequivocal evidence of high density. It was the only diagnostic that could measure density in a temperature-independent way. The experimental results were validated by an independent DOE panel in March 1988. This was the highest compressed-fuel density record in ICF experiments using either the direct or indirect approach at that time and made a strong case for the direct-drive approach.

"Laser Driven Implosion of Thermonuclear Fuel to 20 to 40 g cm^{-3}" by R. L. McCrory *et al*. published in the September 1988 issue of Nature, highlighted this achievement.

R. L. McCrory, J. M. Soures, C. P. Verdon, F. J. Marshall, S. A. Letzring, S. Skupsky, T. J. Kessler, R. L. Kremens, J. P. Knauer, H. Kim, J. Delettrez, R. L. Keck, and D.K. Bradley, "Laser-Driven Implosion of Thermonuclear Fuel to 20 to 40 g cm^{-3}," Nature **335** *(6187), 225–230 (1988).*

Phase Conversion with Distributed Phase Plates

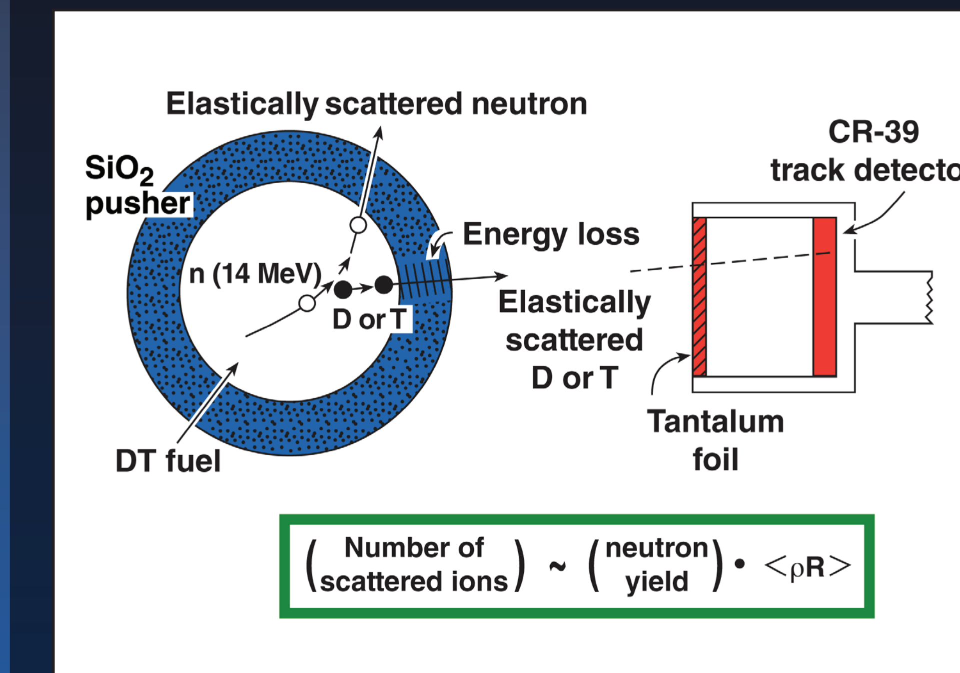


Distributed phase plate

An alternative to phase correcting a wavefront involves modifying the laser beam's coherence properties, thereby changing its focusing characteristics. A phase-conversion technology that incorporates a distribution of near-field phases to perform either static phase correction or induce spatial incoherence offers a degree of flexibility needed at this stage of research. Distributed-phase-plate technology, deployed on the OMEGA Laser System, offers this parallel route toward increasingly higher levels of irradiation uniformity.

The joining of many diverse technologies resulted in the design, fabrication, and testing of high-quality distributed phase plates (DPP's). Computerized image generation, photolithography, chemical vapor deposition, and high-resolution interferometry were combined to make OMEGA the only frequency-tripled and phase-converted laser system. DPP's improved the irradiation uniformity at the target plane by more than a factor of 3. The increased reproducibility of the beam profiles offered by the DPP's made possible the more-critical assessment of shot-to-shot variations in beam energy and beam pointing.

Diagnosing High Density Using Fusion



Schematic of the knock-on diagnostic

The DT fuel density in high-compression experiments at LLE was measured using the "knock-on" diagnostic. Previously, this diagnostic had been used only in low-density experiments where there was a negligible amount of slowing of the knock-on particles within the target. In the experiments, the target density-radius product (ρR) was sufficiently large to significantly moderate the knock-on particles. So a new technique had to be developed to accommodate the distorted spectrum.

A technique was developed to measure fuel ρR with knock-on particles in a model-independent way for experiments where the total target ρR is less than ~50 mg/cm^2. The technique takes into consideration moderation of the knock-on within the target and is independent of the moderation source whether it is in the fuel or shell. Even if there is mixing between the fuel and shell, the diagnostic measures the ρR of the fuel portion. In addition, the $\rho \Delta R$ of the shell can be estimated by demanding consistency among the number of tracks in different foils.