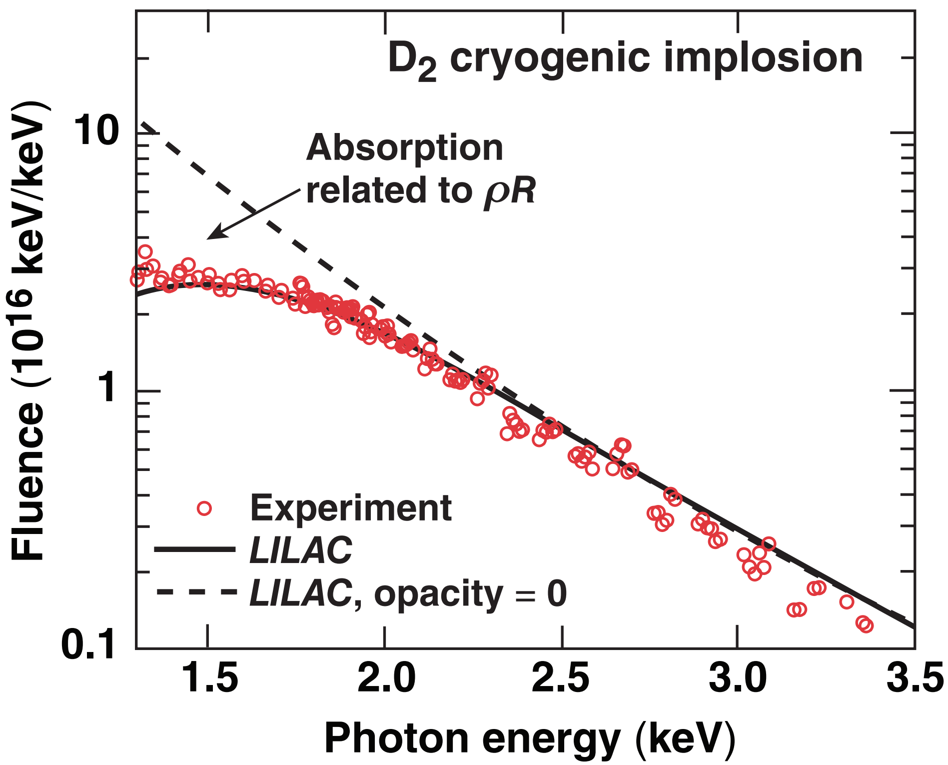
Studies of Adiabat-Shaped Direct-Drive, Cryogenic-Target Implosions on OMEGA



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Summary

High fuel areal densities are observed in implosions on OMEGA that are energy-scaled from NIF ignition designs

- Cryogenic target layering has produced ice smoothness that meets NIF specifications:
  - $<$1-μm rms in all modes in β-layered DT capsules,
  - $<$2-μm rms in all modes in D_2 capsules with auxiliary heating.
- Areal densities in excess of 100 mg/cm^2 are observed from x-ray and nuclear diagnostics.
- The Lawson criterion for these dense plasmas is $>7 \times 10^{20}$ s/m^3 and the fusion parameter is in excess of 10^{20} s-keV/m^3.

Collaborators

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High-contrast pulse shapes are used to place the target on a low adiabat for high compression

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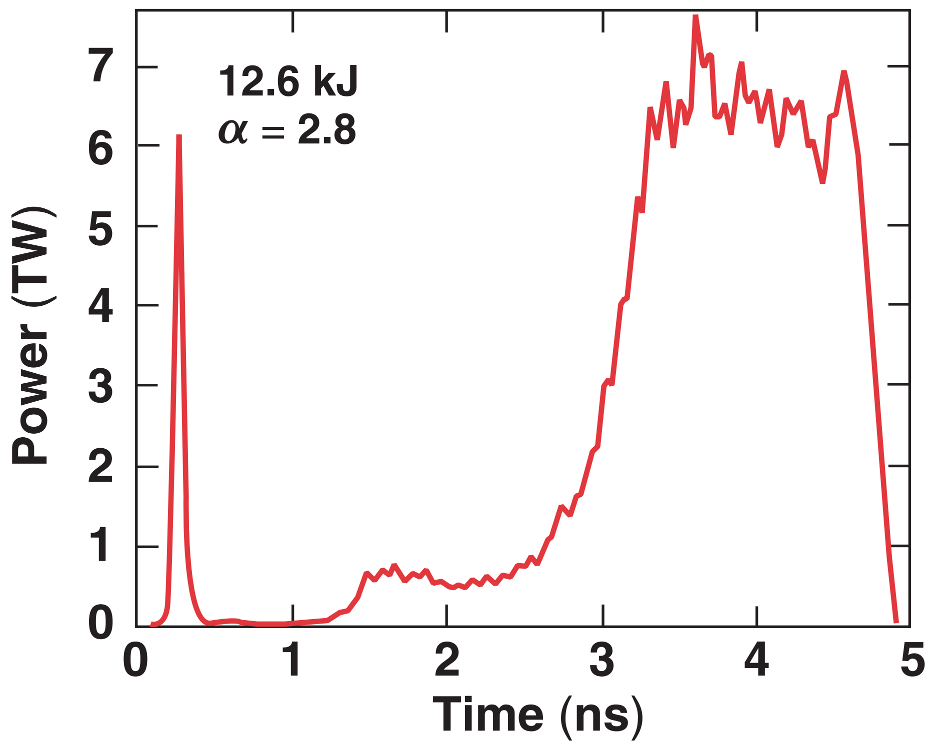
- Cryogenic ice-layer smoothness is routinely below 2-μm rms.[1]
- The picket shapes the target adiabat[2]
- The peak intensity limits the core temperature for continuum measurements.

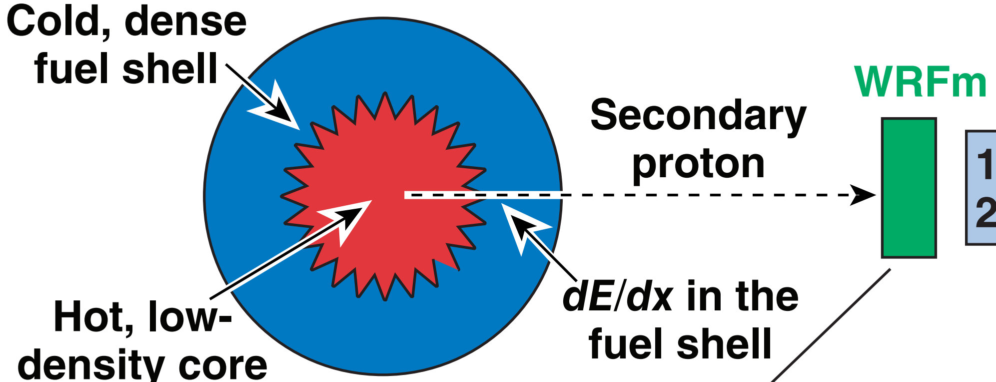


[1]See T. C. Sangster QT1.00001

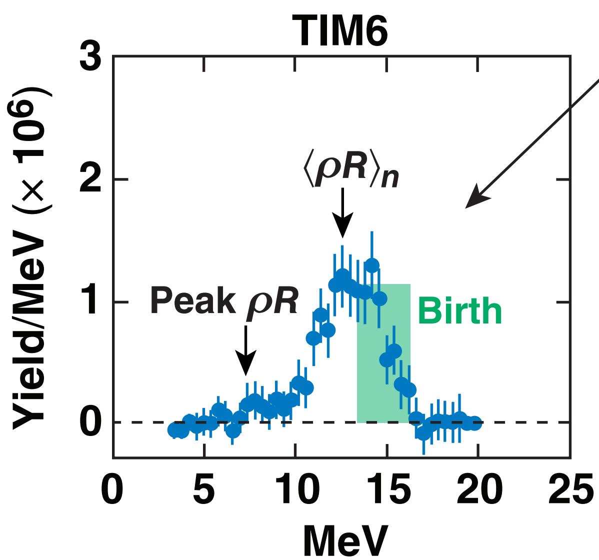
[2]K. Anderson and R. Betti, Phys. Plasmas 10, 4448 (2003).

E15269

The neutron averaged areal density $\langle \rho R \rangle_n$ is greater than 100 mg/cm^2 for cryogenic D_2 implosions



1. $D + D \rightarrow {}^3He$ (0.7 MeV) + p
2. ${}^3He + D \rightarrow p$ (12.5–17.4 MeV) + ${}^4He$



- *dE*/*dx* corresponds to $\langle \rho R \rangle_n$ ~ 100 to 110 mg/cm^2 over several lines-of-sight
- Low-energy tail suggests peak ρR approaches 200 mg/cm^2

Further analysis is underway to infer a $\rho R(t)$ by convolving the neutron emission rate with the measured proton spectrum*

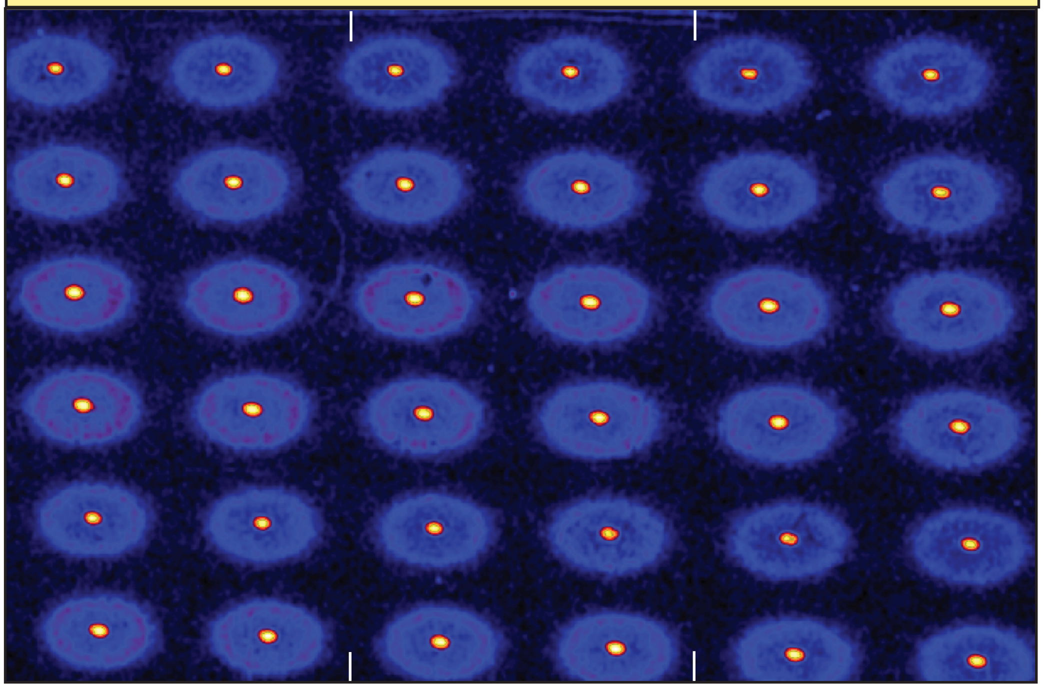
E15270

*V. A. Smalyuk *et al.*, Phys. Rev. Lett. 90, 135002 (2003).

The core x-ray continuum is measured with a pinhole-array spectrometer

~200 monochromatic images with 50-μm pinholes

Array tilt spreads images along energy axis



1.6 1.7 1.8 1.9

Photon energy (keV)

Core emission is well separated from ablation-region emission and background

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The peak areal density ρR_{peak} may be inferred by using core self emission to backlight the fuel shell

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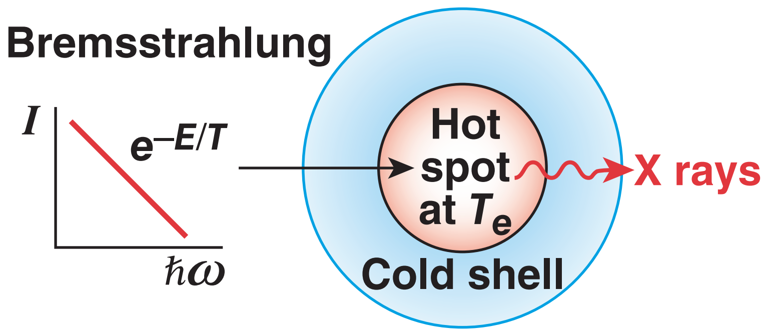
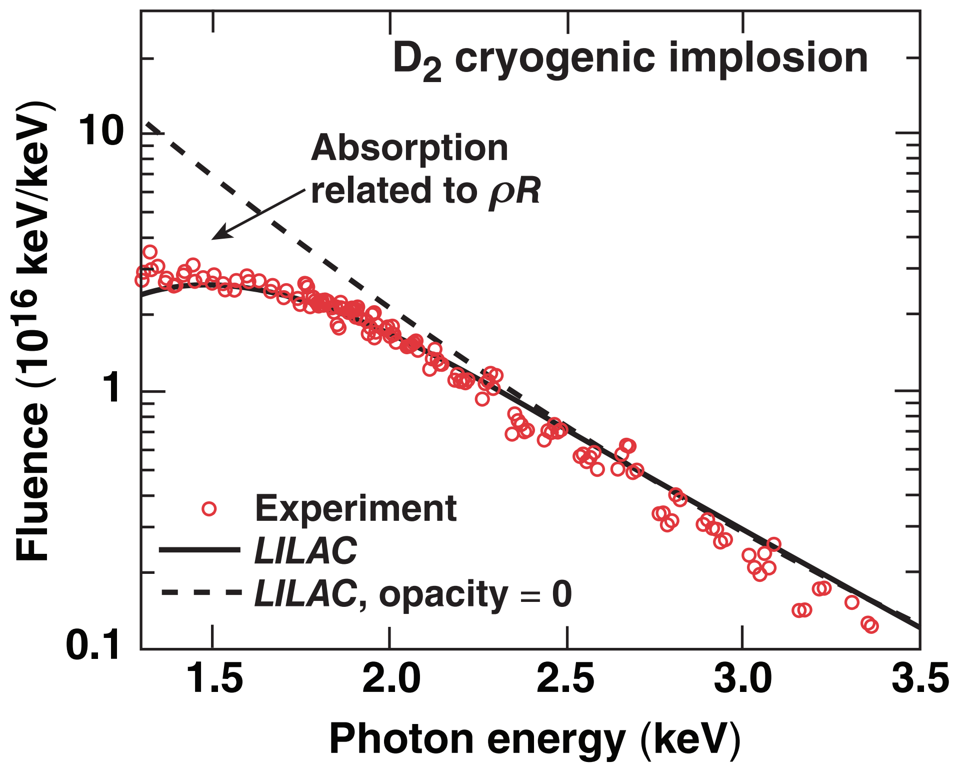
Emitted x-ray spectrum is the product of a source term and an attenuation term



- Spect = $(e^{-E/kT_{hot}}) \times (e^{-\mu\rho R_{shell}})$, where μ is the mass attenuation coefficient and is proportional to ρ

The fuel–shell attenuation is proportional to $\rho^2 R$

1-D simulations can be used to estimate ρ and suggest the ρR_{peak} could be as high as 180 to 190 mg/cm^2

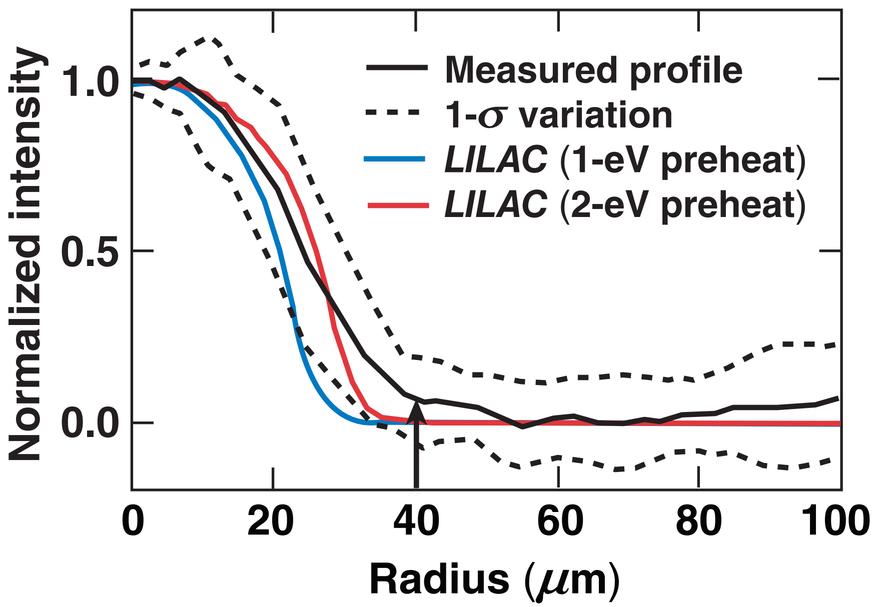


2-D simulations are expected shortly to confirm fuel density estimates

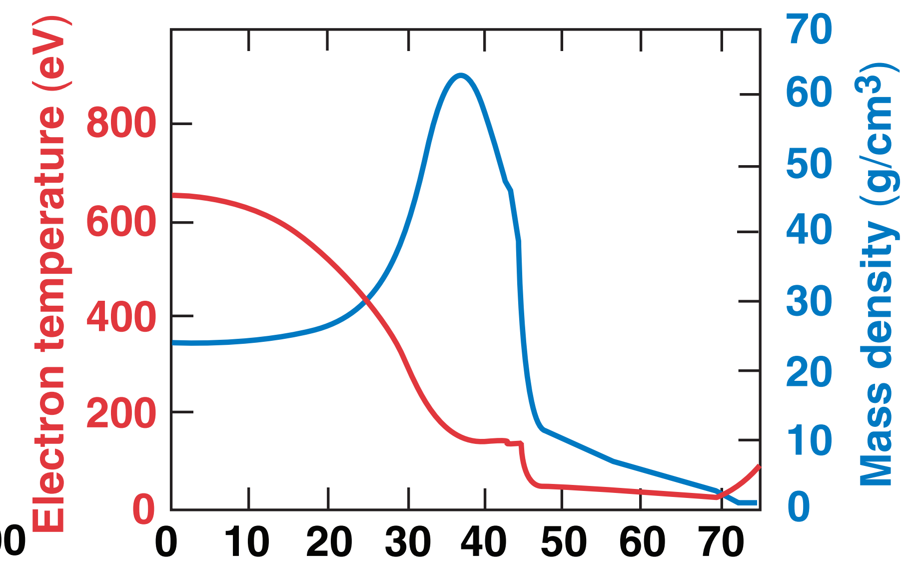
E15271

The Lawson criterion can be estimated from the core size and calculated density

Core size measured using the KB microscope



LILAC simulation of DD cryo shot 44948; time of peak ρR



- The average density is ~30 g/cm^3 → $n_e \sim 7 \times 10^{24}$ cm^{-3}
- The confinement (disassembly) time is greater than 100 ps
- $n_e \tau > 7 \times 10^{20}$ s/m^3
- at 200 eV, $n_e \tau\, T > 10^{20}$ keV-s/m^3

E15273

The fusion-confinement parameter in cryogenic implosions on OMEGA is comparable to those achieved in Tokamak experiments

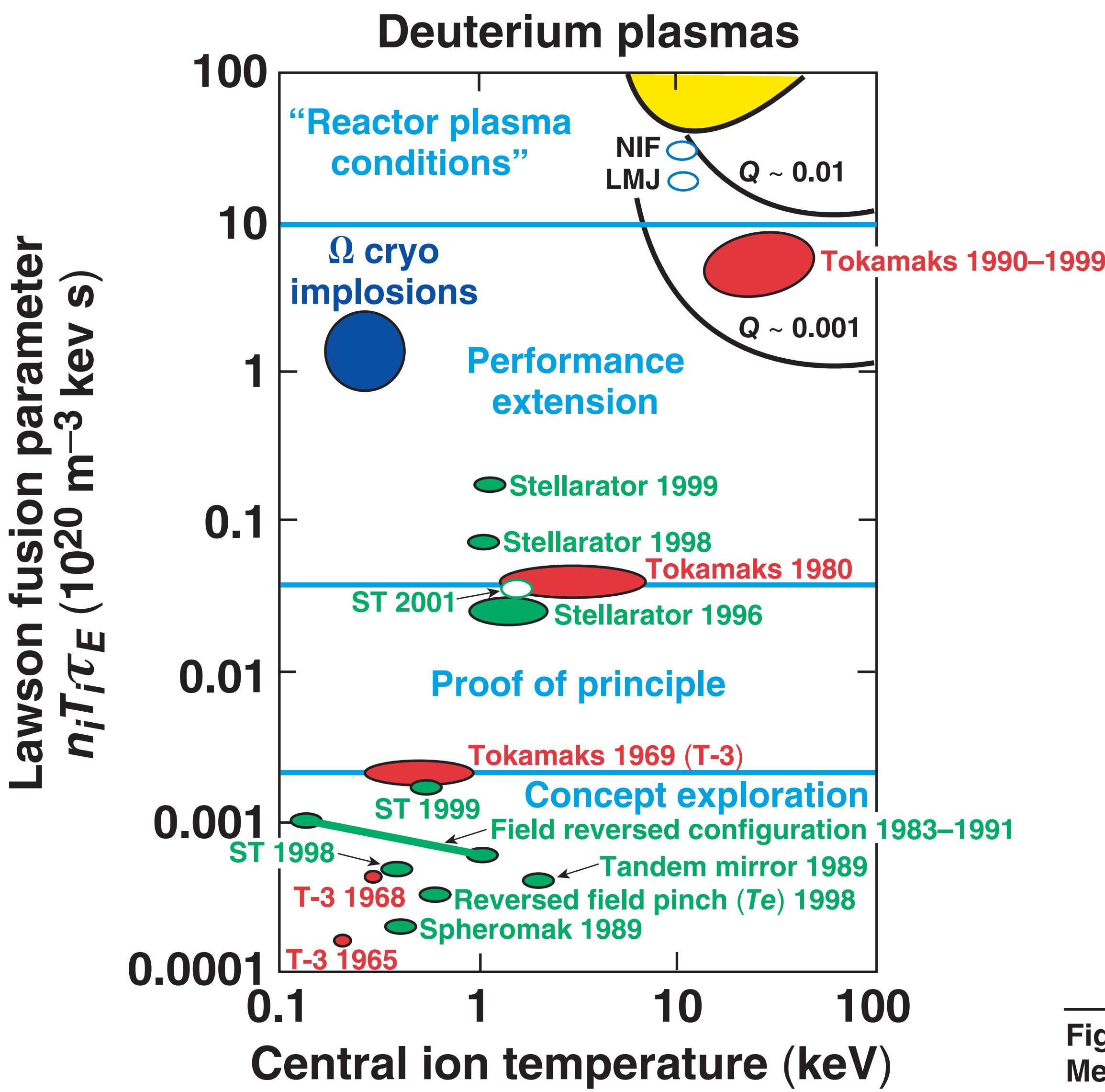


Figure adapted from Meade, AAAS

E15274

High fuel areal densities are observed in implosions on OMEGA that are energy-scaled from NIF ignition designs

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