Direct-Drive Fast-Ignition Research at LLE:
The LLE direct-drive research program includes
the investigation of the direct-drive fast-ignition
(FI) concept.1 FI involves the assembly of a
dense fuel core using a conventional high-
energy-density system and the subsequent heat-
ing of the core to ignition conditions by the
rapid deposition of energy from an ultrahigh-
power, short-pulse, 1-μm laser. In collaboration
with General Atomics, Lawrence Livermore
National Laboratory, and the Institute of Laser
Engineering of the University of Osaka, Japan,
LLE has initiated experiments to study direct-
drive fuel core assembly for FI using the “cone-in-shell” concept2 with the specific objective of validating this approach for ultimate implementation on the NIF. Recent OMEGA experiments used the target shown in Fig. 1 to demonstrate that cone-in-shell targets could be imploded in a direct-drive mode on OMEGA (see Fig. 2). In future experiments, gas-filled capsules will be
imploded, and ultimately the experiments will be extended to cryogenic targets and to the heating of the compressed core using ultrahigh-intensity laser beams from the OMEGA EP system currently in design.

2-D Performance of a Low-Adiabat Cryogenic Implosion: A new low-adiabat drive
pulse (α ~ 4) has been developed specifically for the 5-μm-CH, 100-μm-thick
cryogenic D2 capsules routinely imploded on OMEGA. The shell stability3 with this
pulse is considerably improved compared to the nominal α ~ 3 design that is, in
turn, scaled from the baseline direct-drive-ignition pulse shape for the NIF.
Therefore, these implosions are less sensitive to the current levels of laser system
nonuniformity on OMEGA. Shot 28969 was the first cryogenic implosion with little
or no target alignment offset using this new pulse shape. A shadowgraph of the capsule (Fig. 3) shows a relatively large / = 1 mode on the ice layer (/ = 1 amplitude ~8 μm).
The measured neutron yield was only 11% of the 1-D prediction but very close to the calculated 2-D DRACO
yield (Table I). Although the low-mode, D2-ice nonuniformity most likely dominated the implosion performance,
the 2-D DRACO simulation was able to correctly account for the degradation in performance; the 2-D predictions agree well with the experimental quantities listed in Table I.

OMEGA Operations Summary: A total of 107 target shots were taken on OMEGA during November. The LLE cam-
paigns (34 shots) included stockpile stewardship and Rayleigh–Taylor (RT) instability experiments. LLNL campaigns (69 target shots) included RT, NIF hohlraum symmetry, x-ray Thomson scattering, gas-bag long-scale-length plasma physics, and x-ray conversion experiments. Four target shots were taken for long-scale-length plasma physics experiments by Commissariat à l’Énergie Atomique. In addition, 16 laser development
shots were taken on OMEGA to explore the system energy performance limits with low-adiabat pulses.

Table I: A comparison of the 1-D LILAC and 2-D DRACO predictions for shot 28969 shows that the 2-D simulation agrees well with the experimental measurement of primary (Y1n) and secondary neutron yield (Y2n), average areal density (ρR m/g cm2), and ion temperature (Tion in keV).

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<th>1-D Simulation</th>
<th>2-D Simulation</th>
<th>Experiment</th>
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<tr>
<td>Y1n</td>
<td>5.60 × 1010</td>
<td>5.32 × 109</td>
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<td>Y2n</td>
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<td>&lt;pR&gt;</td>
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