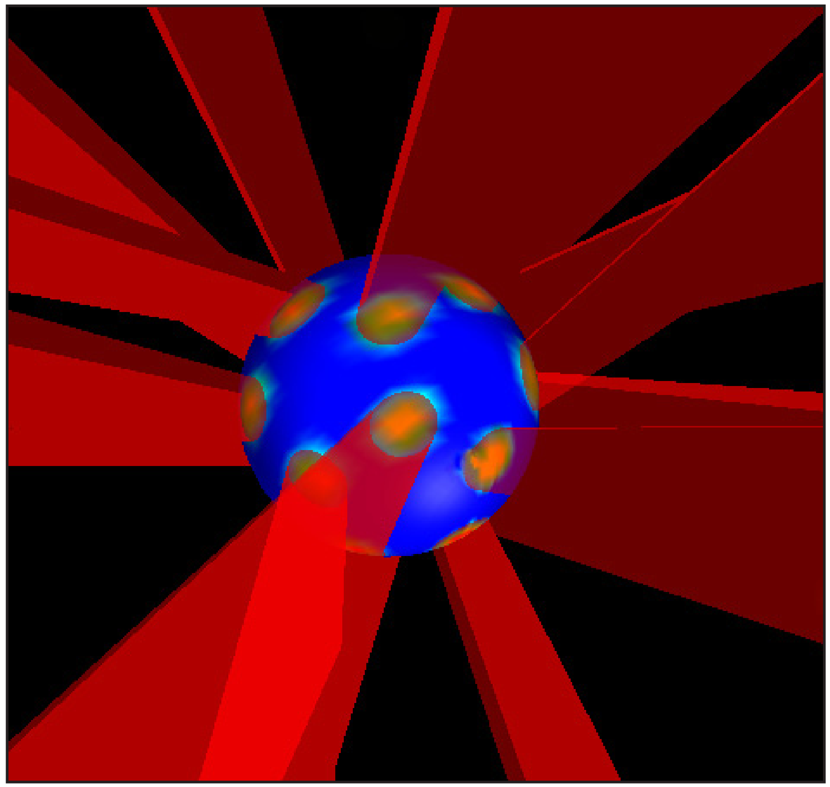
Shock-Ignition Experiments on OMEGA at NIF-Relevant Intensities



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Summary

A new setup enables studies of shock-ignition at intensities of up to 1×10^{16} W/cm^2 on OMEGA

UR LLE

- Shock ignition uses a highly shaped laser pulse with a trailing high intensity (~5×10^{15} W/cm^2) spike
- Good coupling of the shock-beam energy was observed, leading to an ~20× increase in neutron yield.
- A significant Raman backscattering signal was observed with no indication of the two-plasmon-decay instability
- Up to 16% of the energy of the high intensity beams was converted into hot electrons of ~45 keV temperature

Collaborators

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Shock ignition requires ~3.5× less energy to achieve marginal ignition than a conventional hot-spot isobaric target

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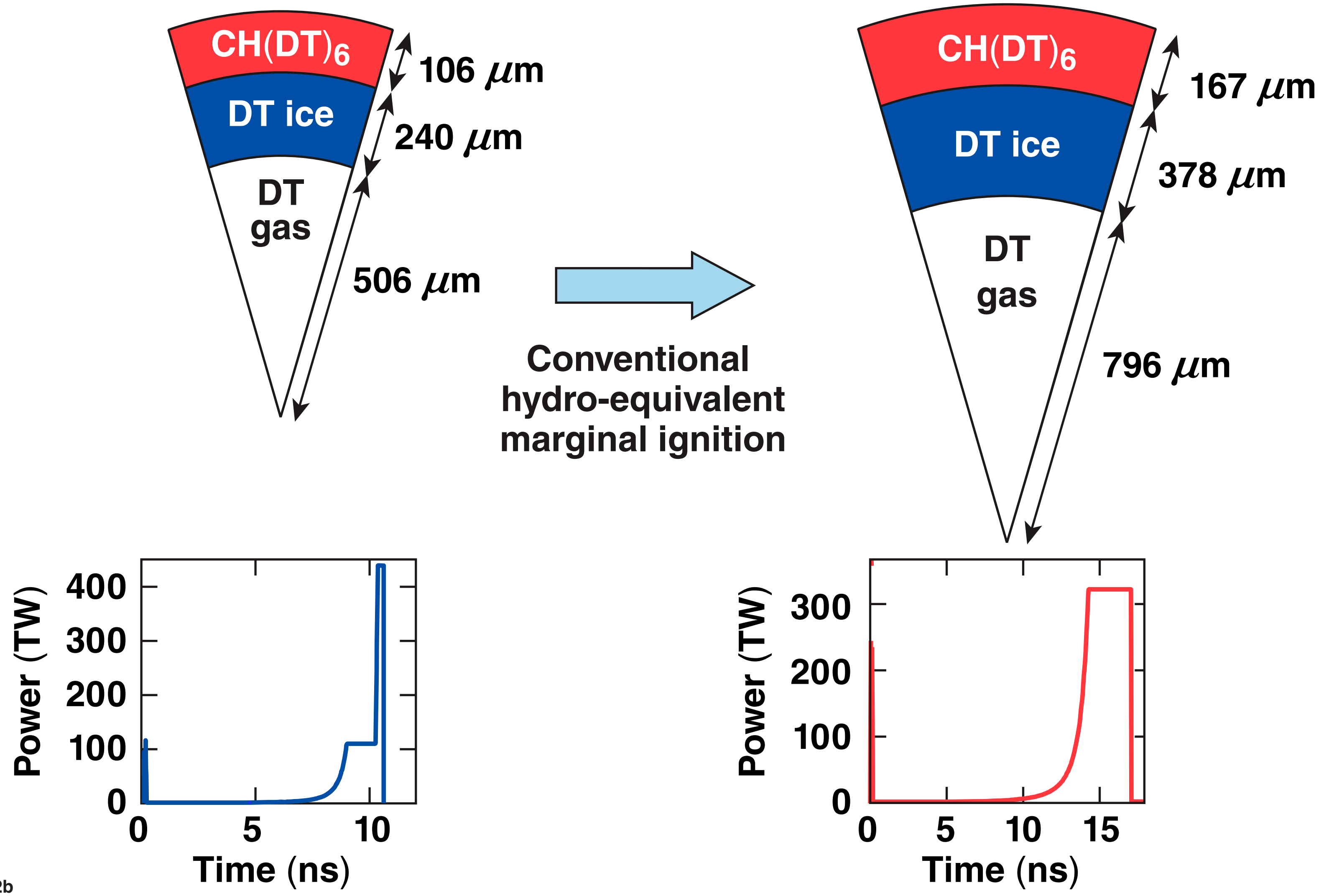
Marginal shock ignition (350 kJ) | **Marginal conventional ignition (1.2 MJ)**



E16312b

*R. Betti *et al.*, Phys. Rev. Lett. 98, 155001 (2007).

Laser–plasma interaction during the spike pulse and hot-electron generation are important issues for shock ignition

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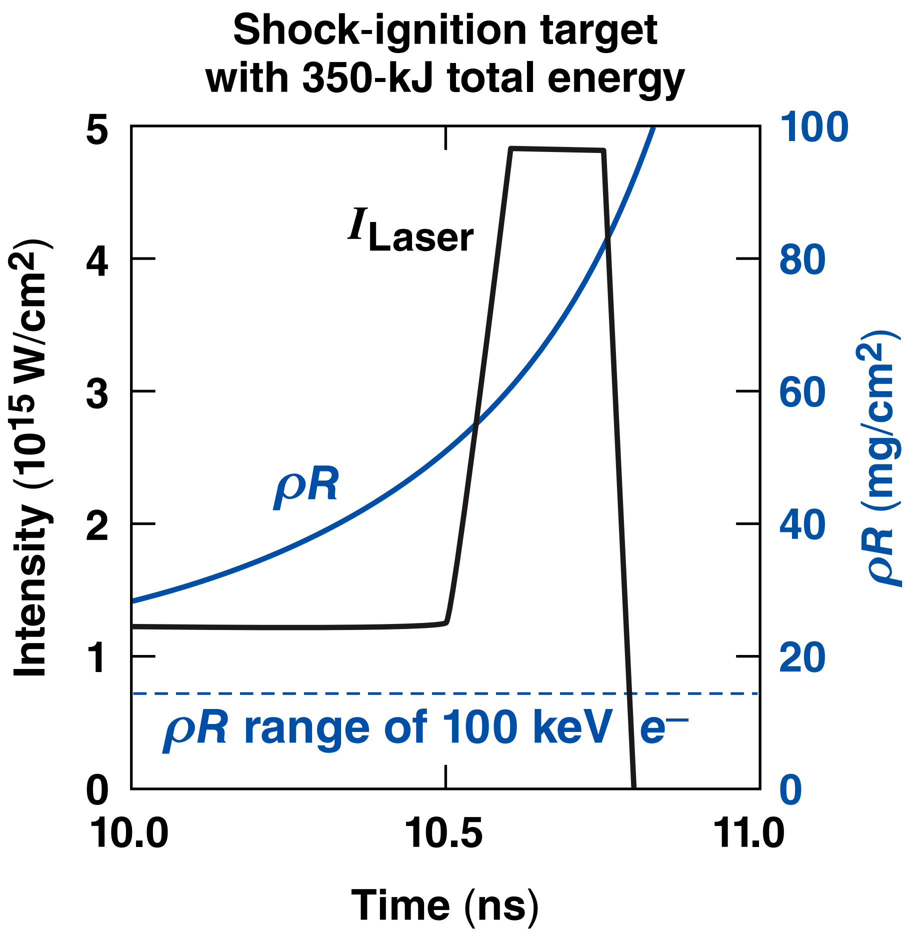
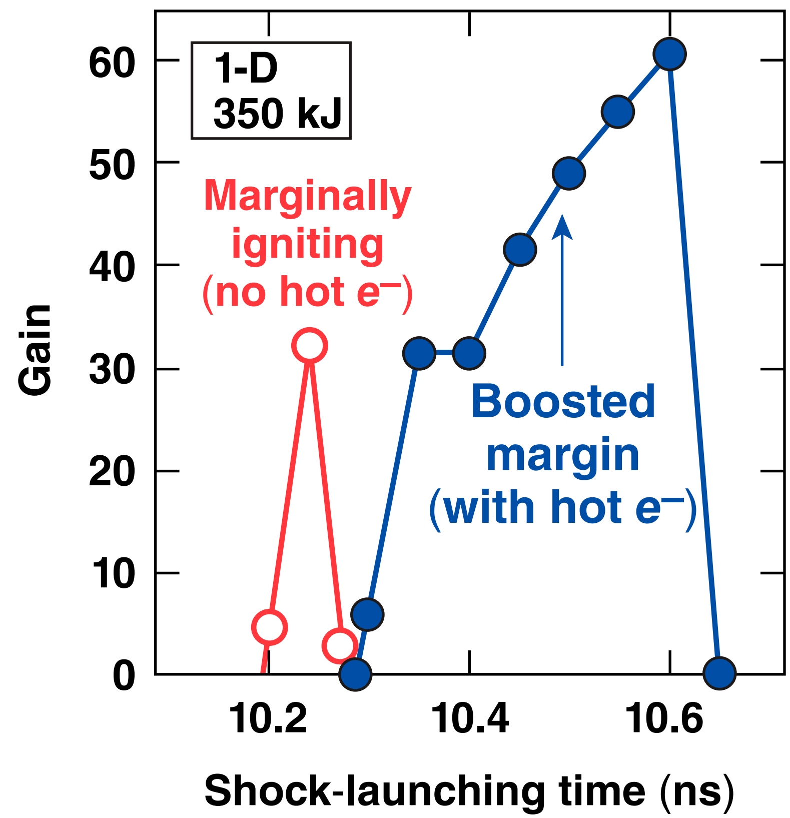


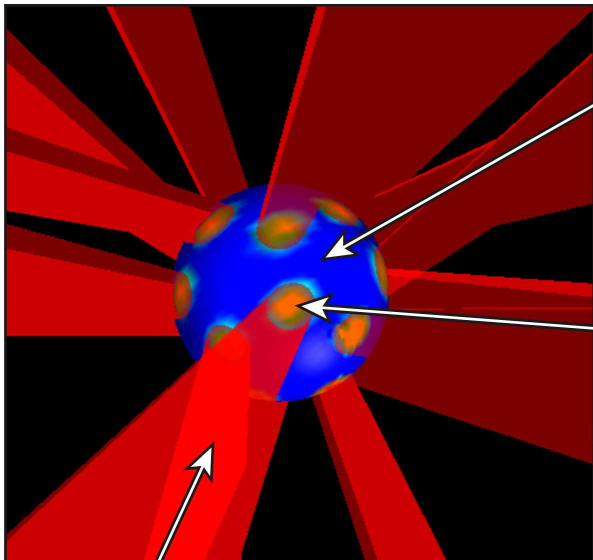


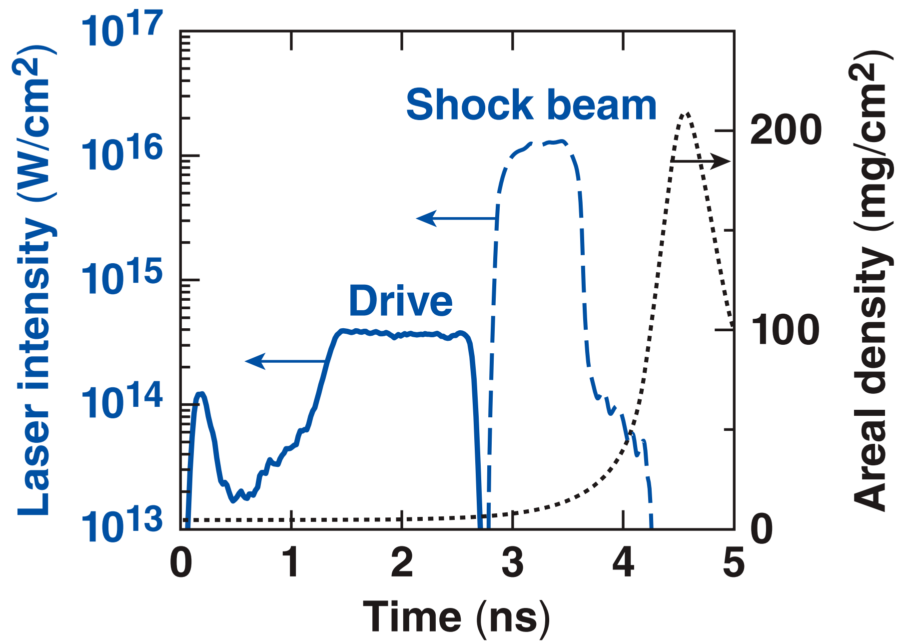
Hot e$^-$ with Maxwellian T_{hot} = 150 keV, E_{hot} = 17% of spike energy, treated using a multigroup diffusion model*

TC7870d

*LILAC simulations by C. D. Zhou and R. Betti

60 OMEGA beams are split into 40 low-intensity drive beams and 20 tightly focused, delayed beams





- The delay and intensity of the tightly focused beams are varied

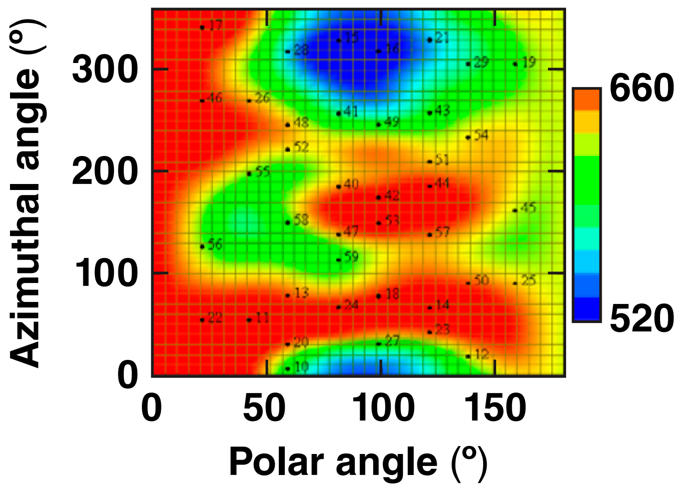
Hydrodynamic performance, energy coupling, laser backscattering, and hot-electron generation are studied.

E17863d

A significant amount of energy is coupled into the capsule by the high-intensity beams

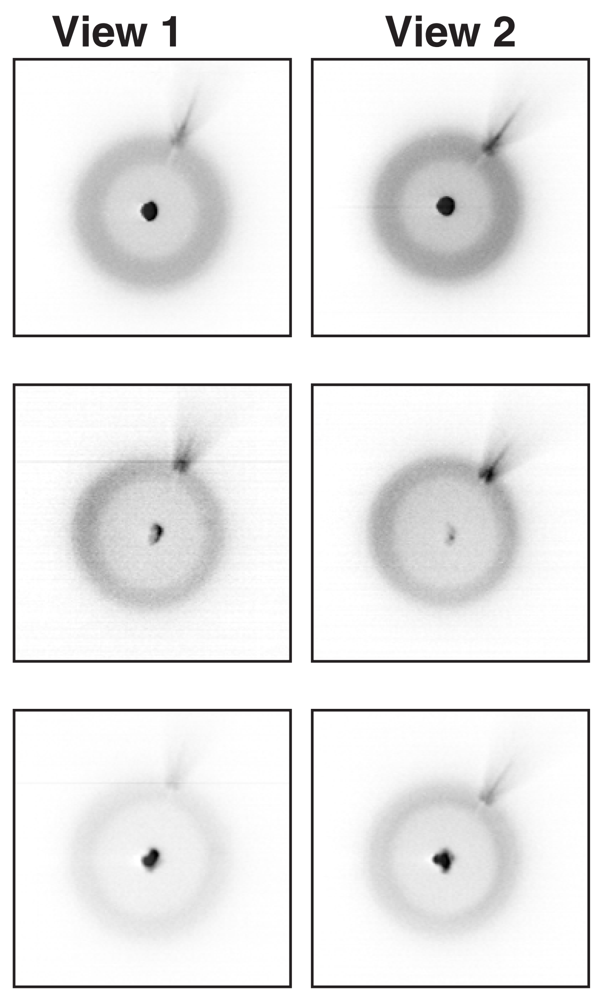
Calculated 40-beam drive power

Direct laser power deposited (TW/cm^2)



- ~11% power imbalance

X-ray pinhole images



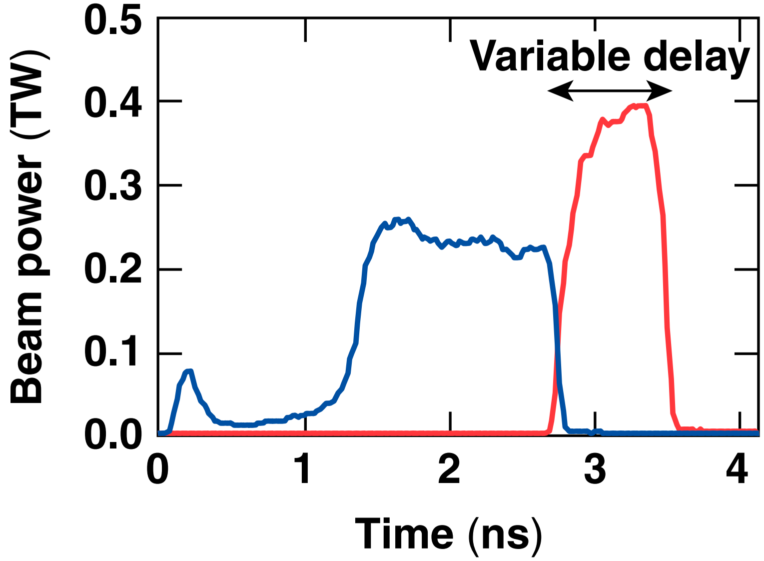
60 beam, 20.8 kJ
uniform illum.
N yield: 1.3×10^{10}

40 beam, 13.7 kJ
nonuniform illum.
N yield: $\sim 2 \times 10^{8}$

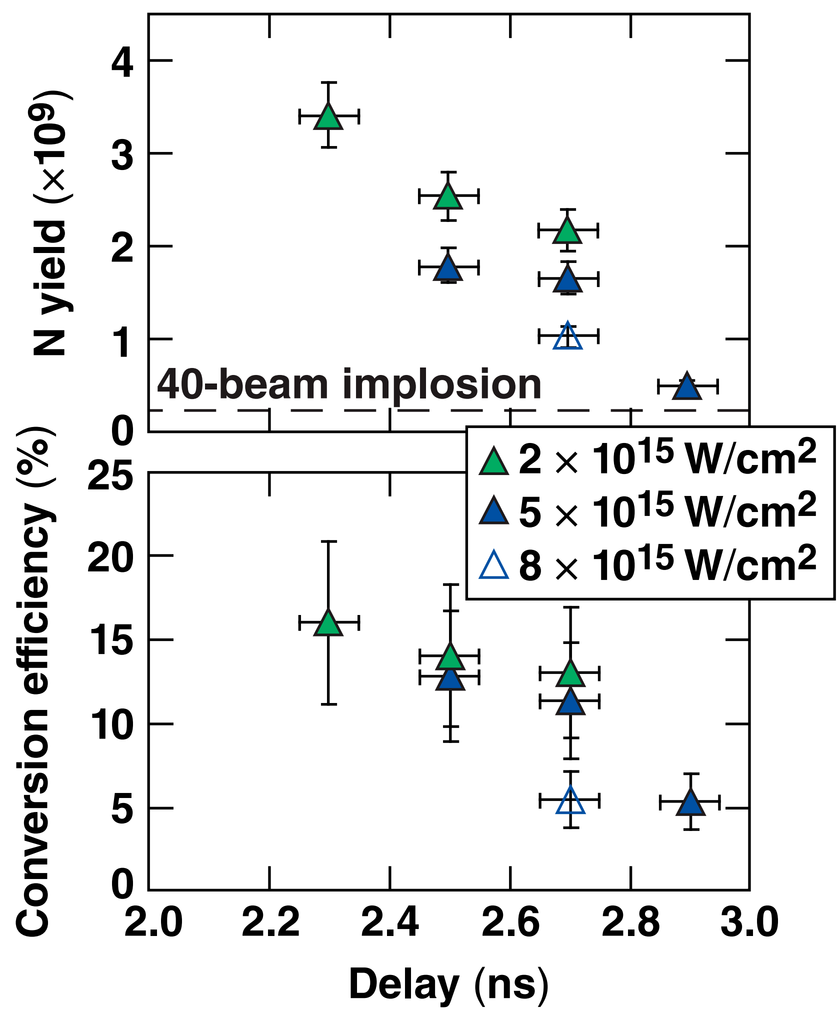
40 + 20 beam,
13.6 + 4.8 kJ = 18.4 kJ
nonuniform illum.
N yield: 3.7×10^{9}

E17749c

Up to 16% of the shock-beam energy is converted into hot electrons of 45-keV temperature



- The neutron yield enhancement is most sensitive to shock-beam timing.



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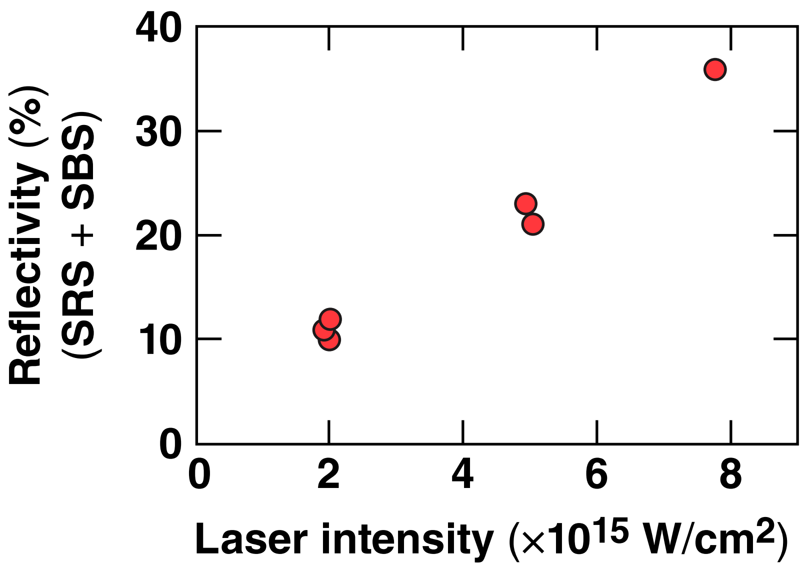
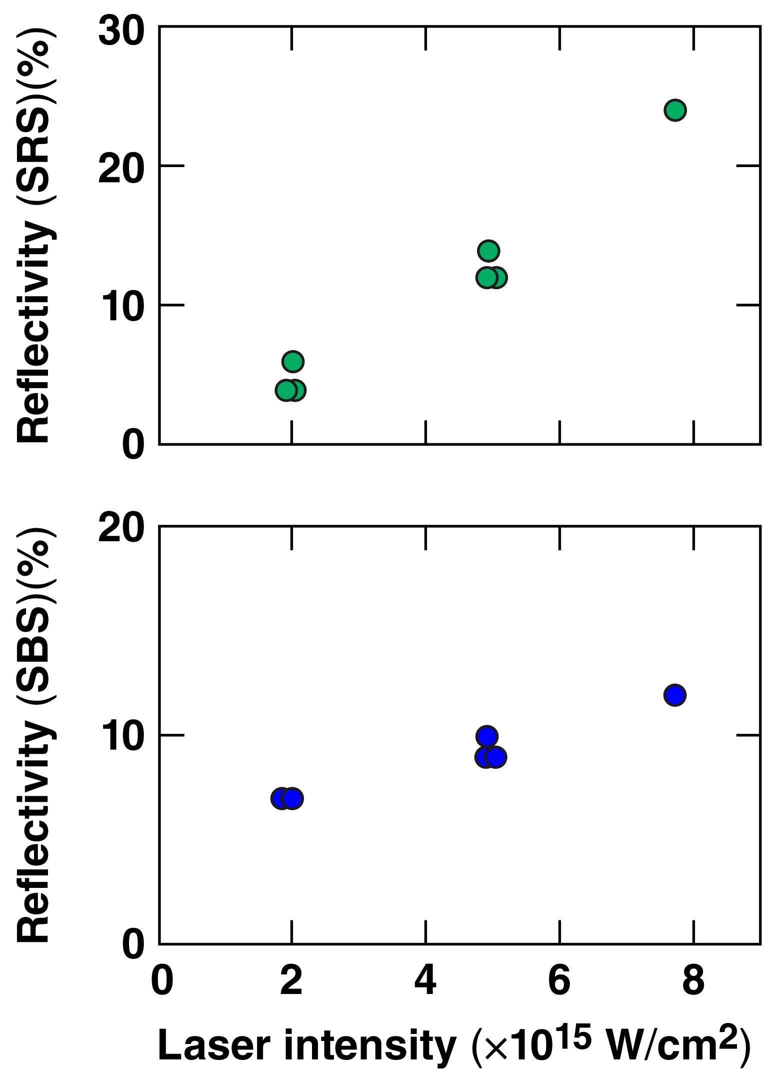
Up to 35% of the shock-beam laser energy is lost due to backscatter





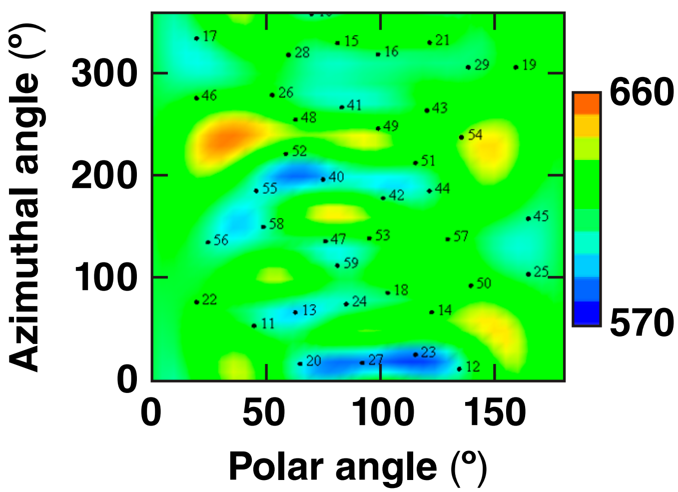
- No measurable signal of the 3/2 harmonic
- SRS dominates back reflection at highest intensity
- SBS reflection is relatively stable at ~10%

E18435

Experiments with repointed beams show reduced illumination nonuniformities and improved performance

Calculated 40-beam drive power

Direct laser power deposited (TW/cm^2)



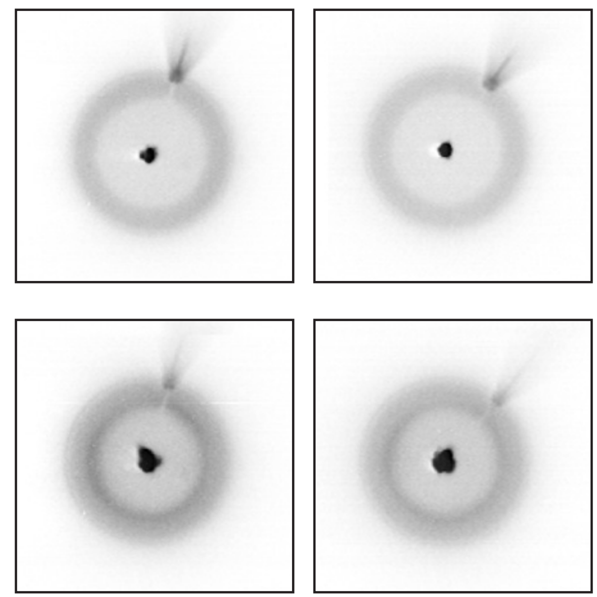
- ~2.6% power imbalance with repointed beams

40 beam, 13.5 kJ
improved illum.
N yield: 1.6×10^9

40 + 20 beam,
13.9 + 5.6 kJ = 19.5 kJ
improved illum.
N yield: 3.3×10^9

X-ray pinhole images

View 1 | View 2



Summary/Conclusions

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