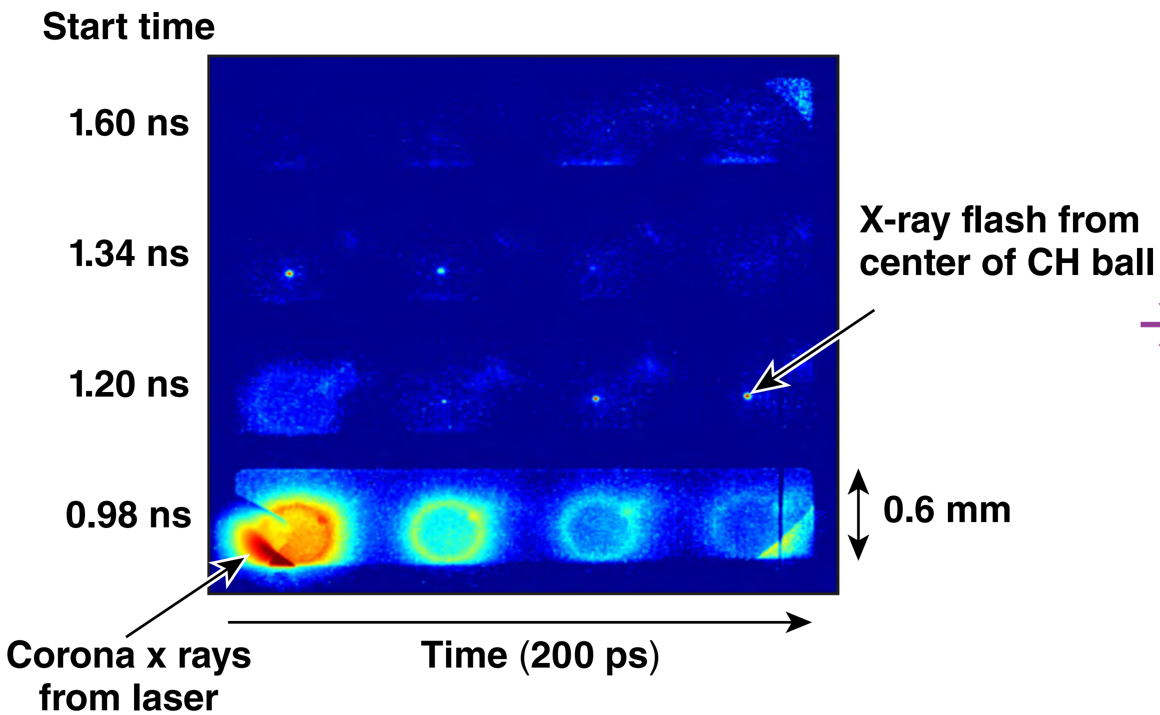
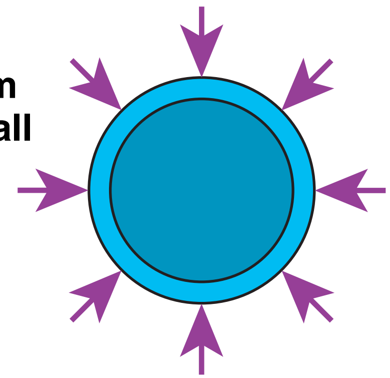
# Demonstration of 200-Mbar Ablation Pressure for Shock Ignition

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Summary

# Shock-ignition–relevant ablation pressures close to 200 Mbar were obtained in spherical targets at ~$3 \times 10^{15}$ W/cm$^2$

- A strong spherical shock wave converges in the center of the solid target and creates a short x-ray flash of Ti He$_\alpha$ line emission
- The x-ray flash was emitted from the target center from a volume of ~$10^3$ $\mu$m$^3$ in less than 50 ps
- A few percent of the laser energy was converted into hot electrons with temperatures ~100 keV

# Collaborators


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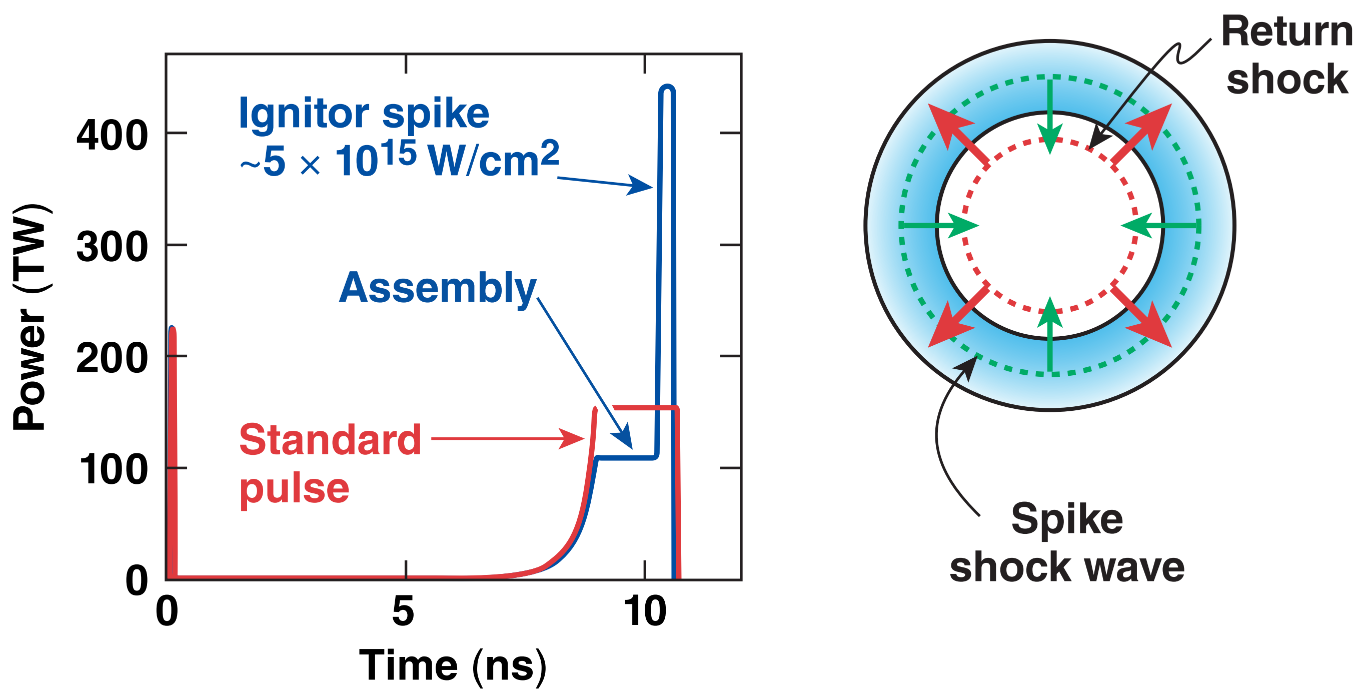
# Shock ignition uses a non-isobaric fuel assembly and promises lower laser energy to achieve ignition*

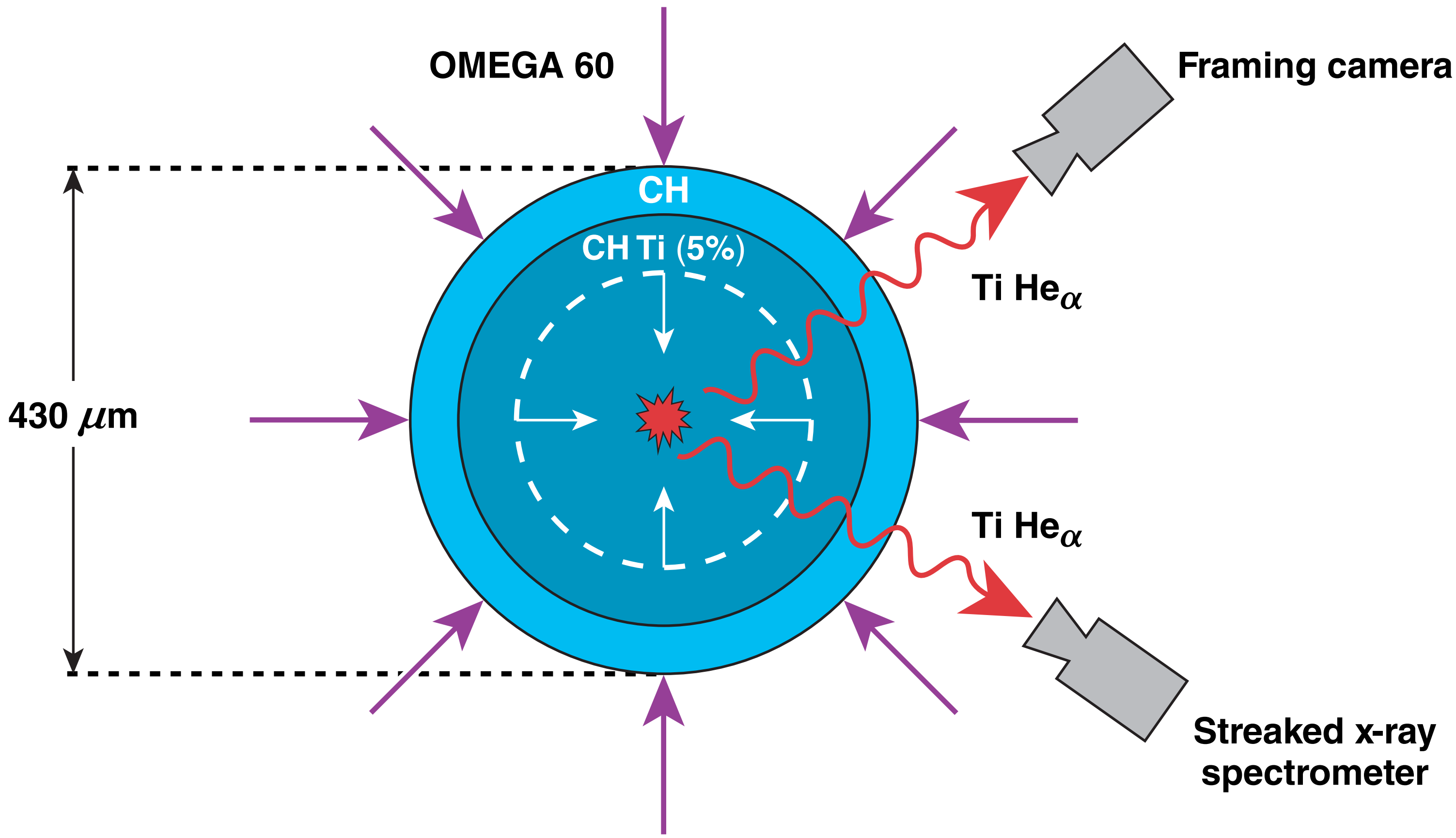



- Critical issues for shock ignition
  - demonstrate ~300- to 400-Mbar spike-generated ablation pressure
  - demonstrate hot-electron temperatures of ≤150 keV generated by spike

TC8918d

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

# A new platform has been developed to study the generation of strong shocks at shock-ignition–relevant laser intensities

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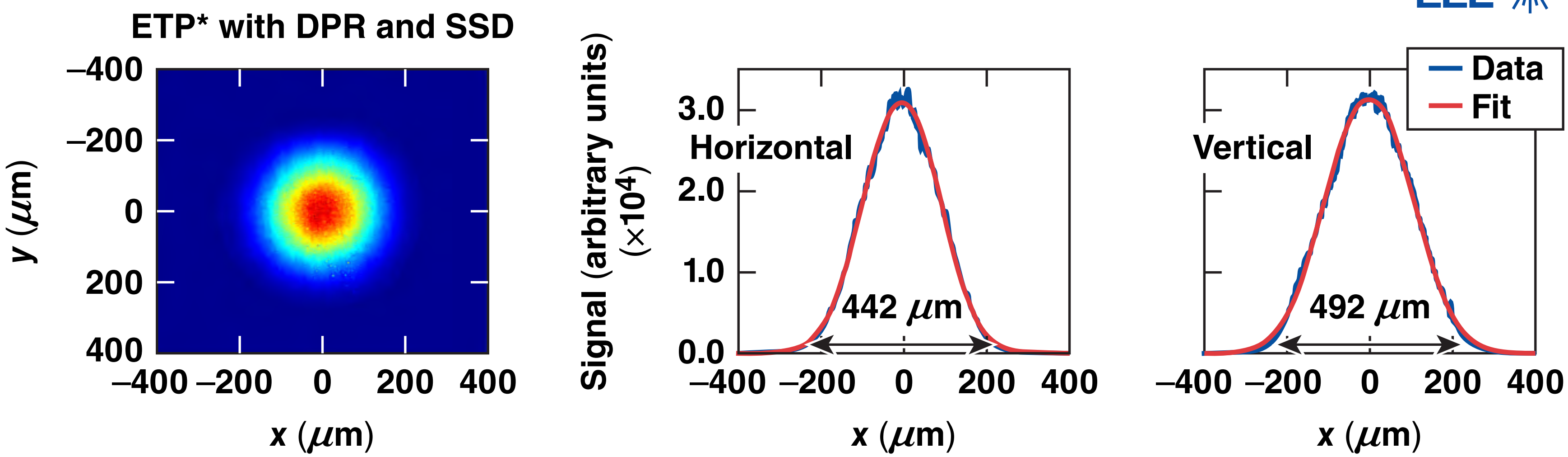
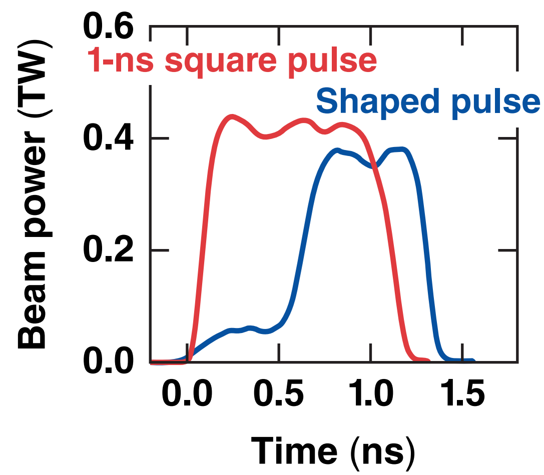
# The small solid target was irradiated by 60 high-intensity beams equipped with distributed phase plates

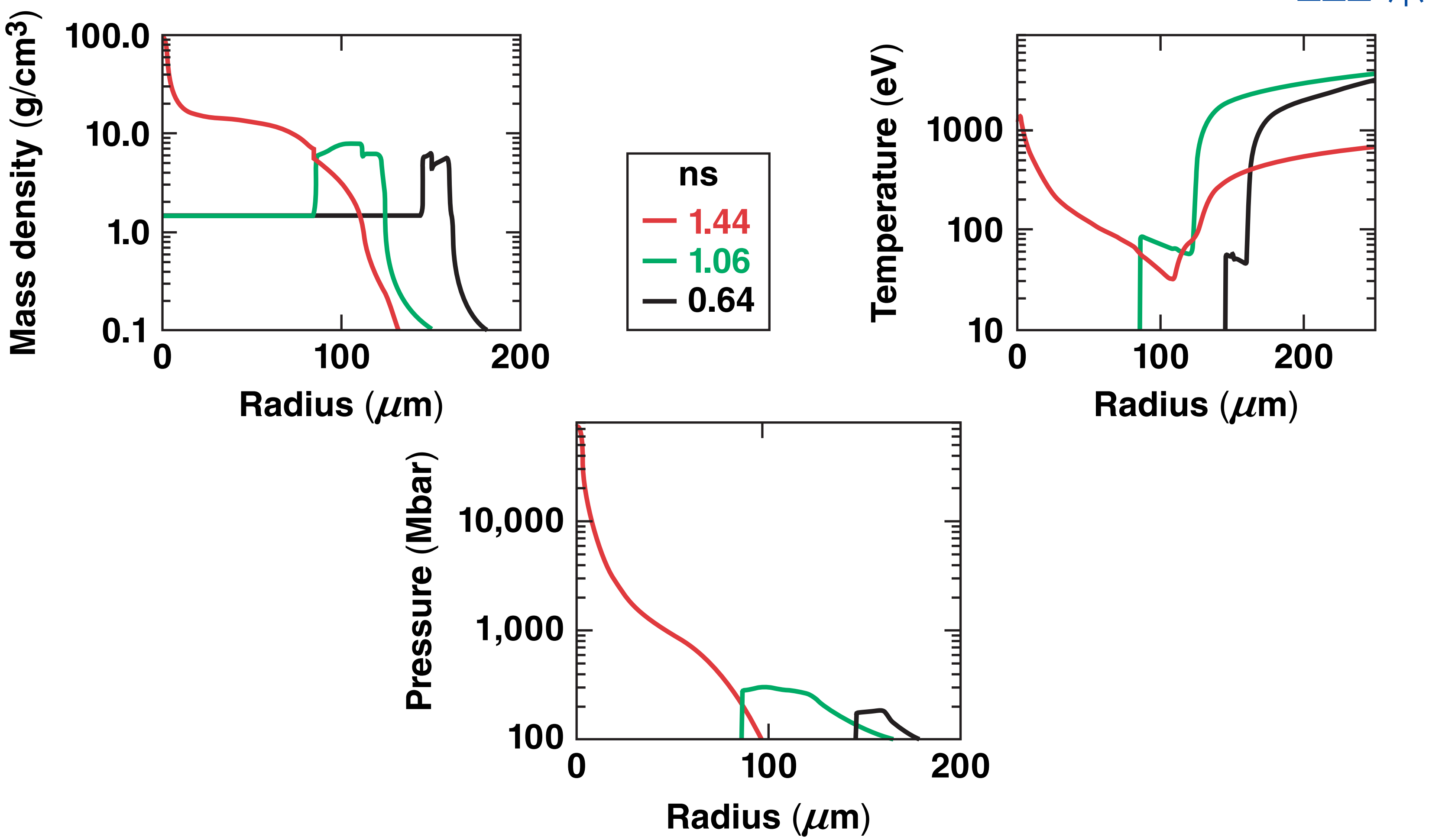



- Small-spot phase plates
- Distributed polarization rotators (DPR's)
- Smoothing by spectral dispersion (SSD)
- $\langle I \rangle \sim 3 \times 10^{15}$ W/cm$^2$
- Density scale length $L_{n_c/4}$ ~120 $\mu$m




*Equivalent target plane

# One-dimensional *LILAC** simulations predict a strong spherical shock wave that converges in the center of the solid target




*J. Delettrez and E. B. Goldman, Laboratory for Laser Energetics, University of Rochester, Rochester, NY, LLE Report No. 36 (1976).

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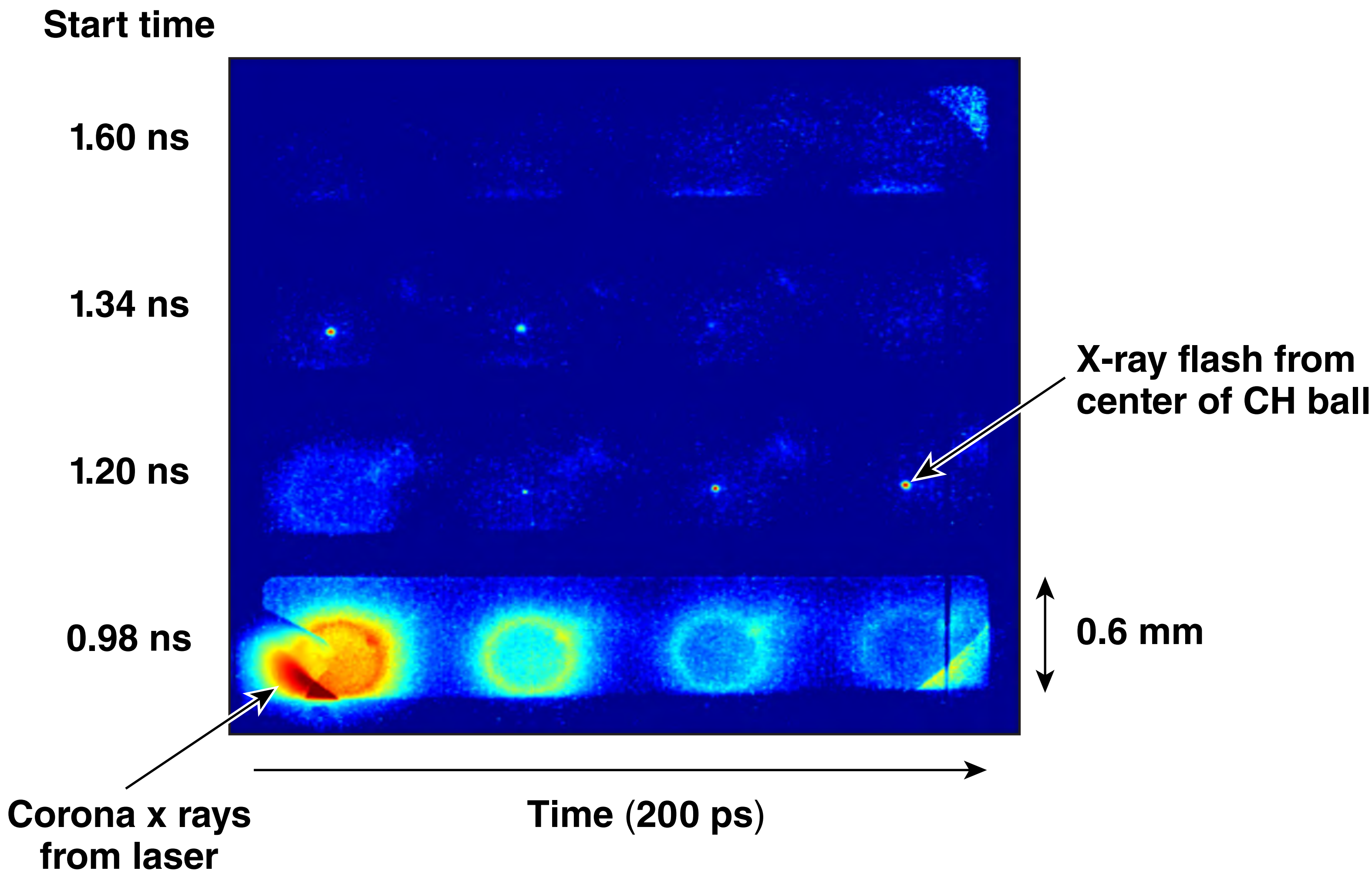
# An x-ray framing camera captured a short x-ray flash at the time when the shock converged in the center

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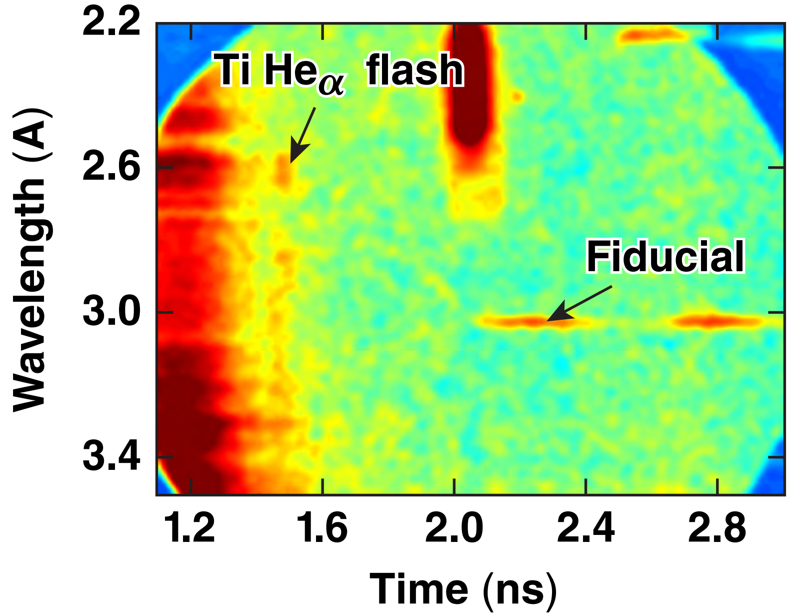
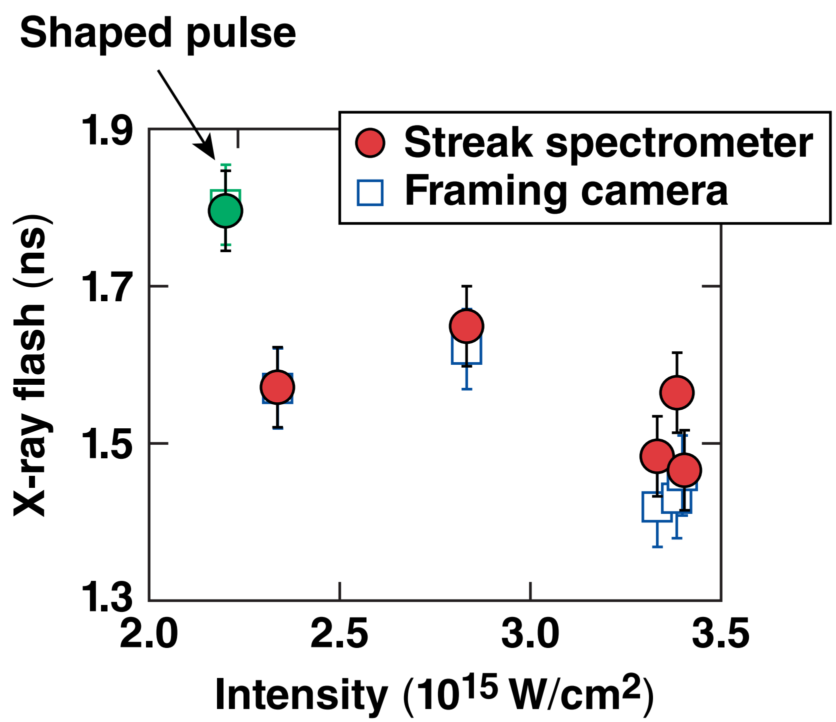
# The x-ray flash was measured with a streaked x-ray spectrometer

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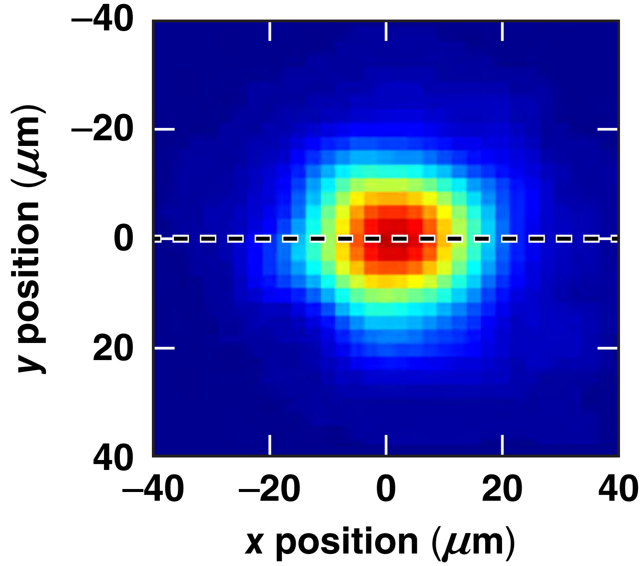
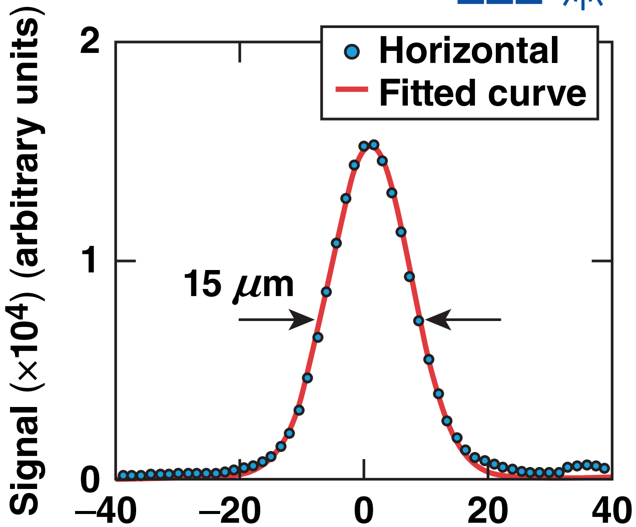
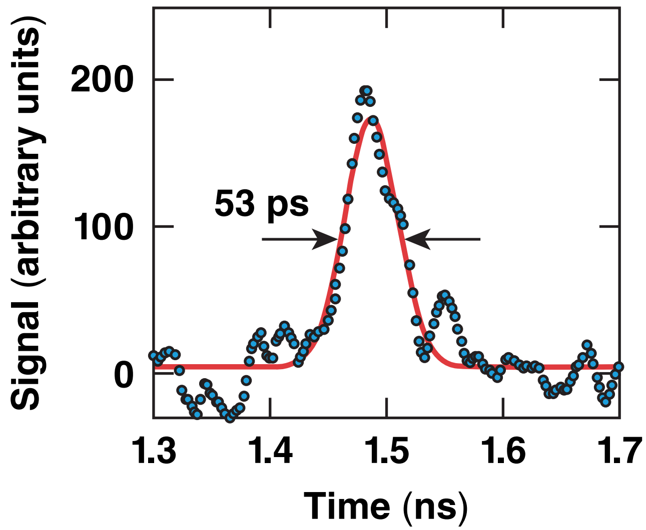
# The x-ray flash was emitted from a small volume of ~$10^3$ $\mu m^3$ in less than 50 ps

Framing camera images from target center




Ti He$_\alpha$ flash from streak camera

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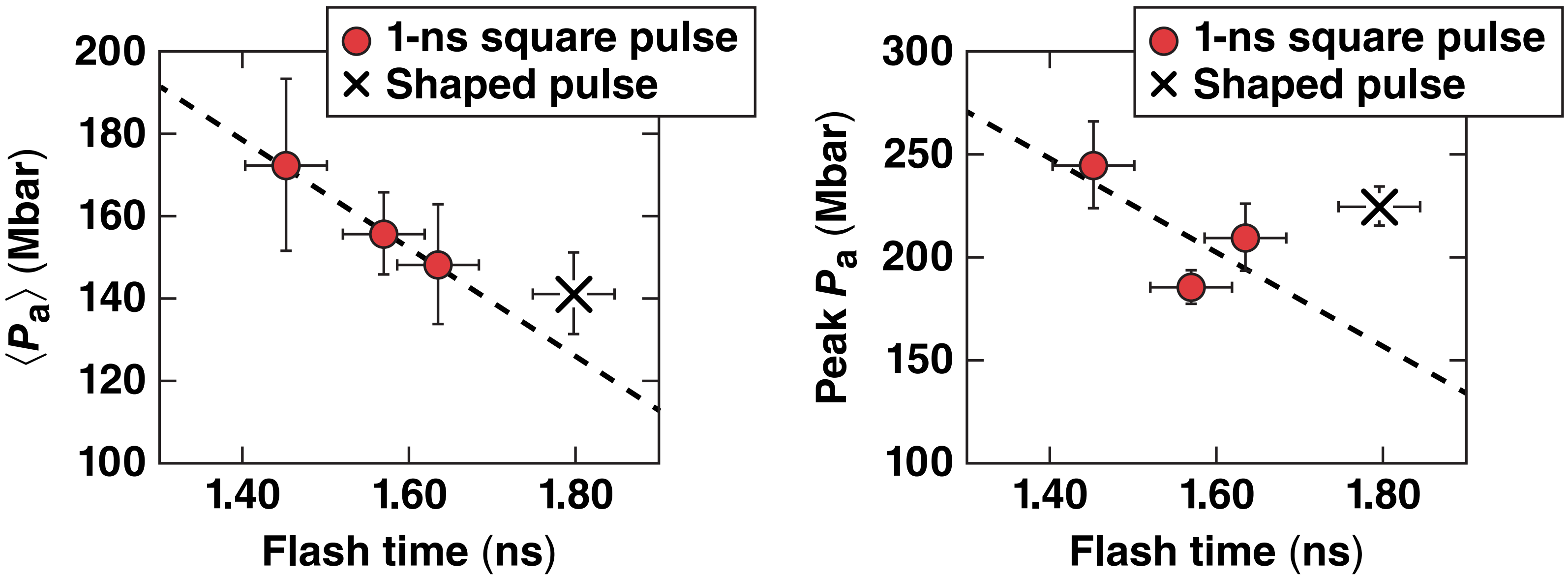
# Average ablation pressures of up to 170 Mbar are inferred from hydrodynamic *LILAC* simulations* including hot electrons

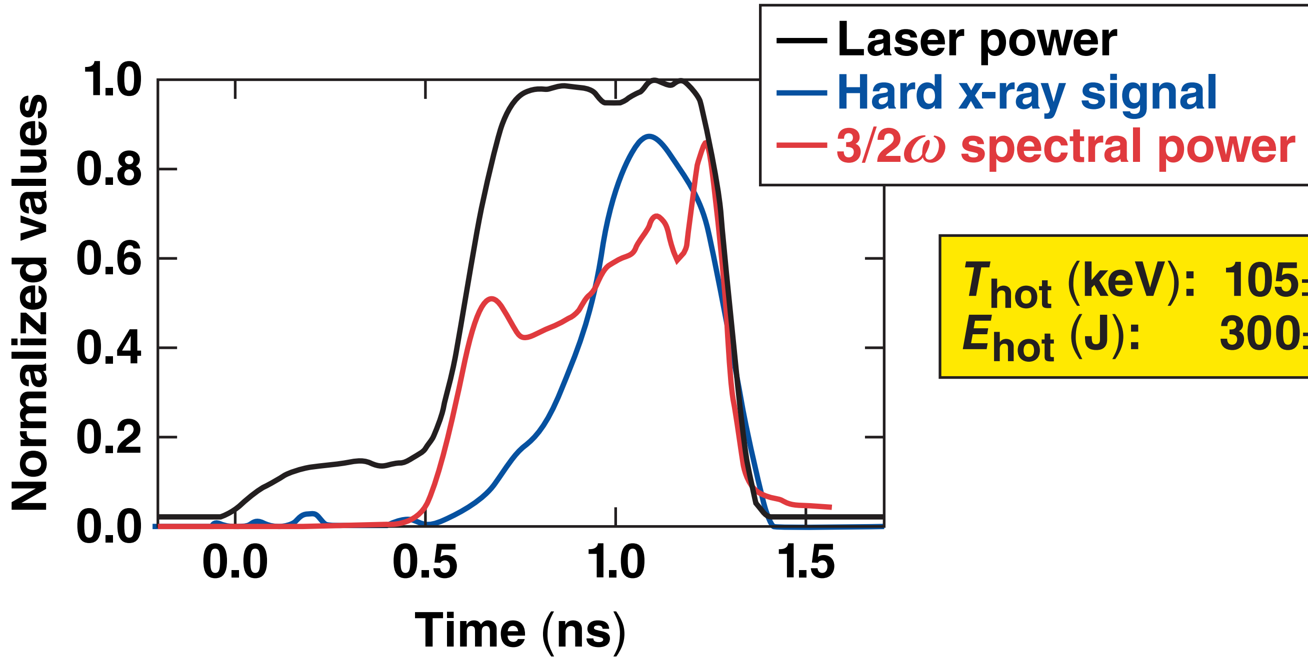



- **Hydrodynamic simulations match the measured flash time and the measured time-resolved absorption**

*J. Delettrez and E. B. Goldman, Laboratory for Laser Energetics, University of Rochester, Rochester, NY, LLE Report No. 36 (1976).

# A few percent of the laser energy was converted into hot electrons with temperatures of ~100 keV

UR LLE




| | |
|---|---|
| $T_{hot}$ (keV): | 105±30 |
| $E_{hot}$ (J): | 300±80 |

- A strong 3/2$\omega$ signal was measured, showing that hot electrons were generated by the two-plasmon–decay (TPD) instability
- TPD is not observed in single-beam interactions (40 + 20) at similar laser intensities*

*W. Theobald *et al*., Phys. Plasmas 19, 102706 (2012).

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Summary/Conclusions

# Shock-ignition–relevant ablation pressures close to 200 Mbar were obtained in spherical targets at ~$3 \times 10^{15}$ W/cm$^2$

UR LLE

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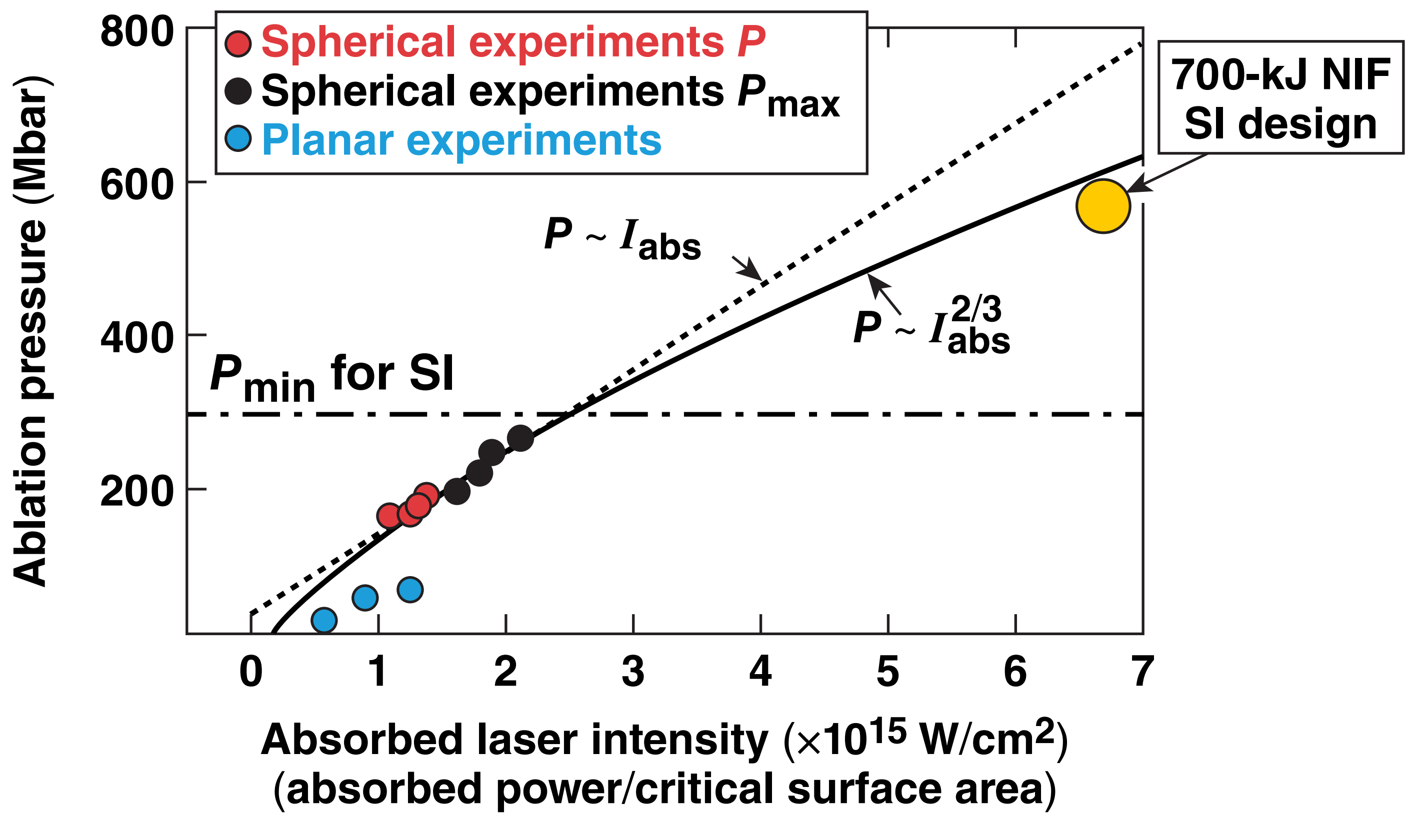
# A plot of the ablation pressure versus the absorbed intensity shows the extrapolation required for the shock-ignition (SI) 700-kJ NIF point design






The ablation pressure in the OMEGA experiments approaches the minimum requirements for SI of 300 Mbar. Demonstration of ~600 Mbar for the SI NIF design may require experiments on the NIF.

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