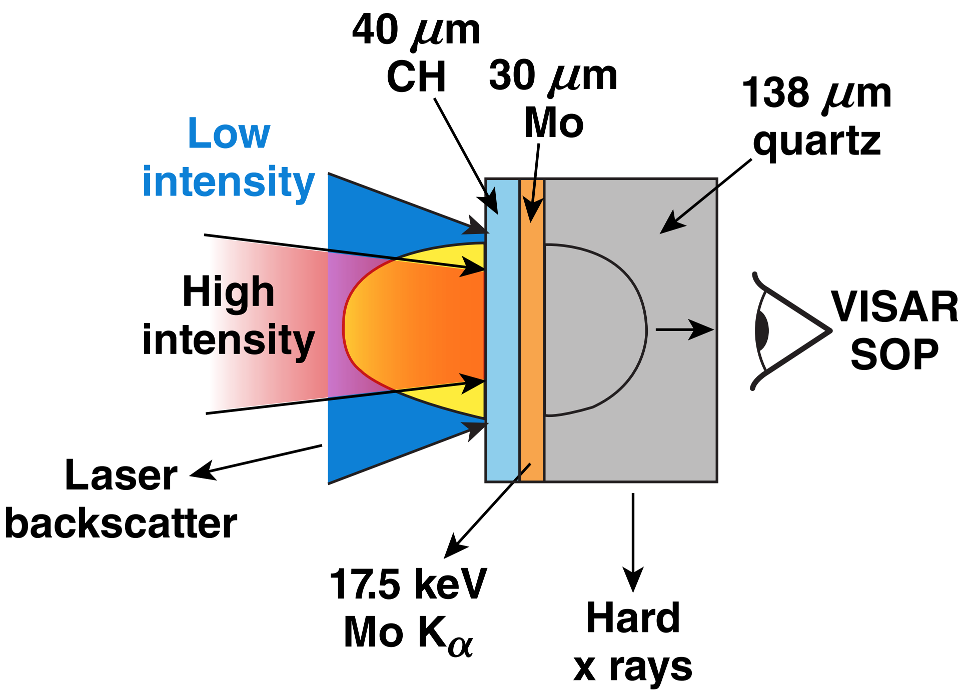
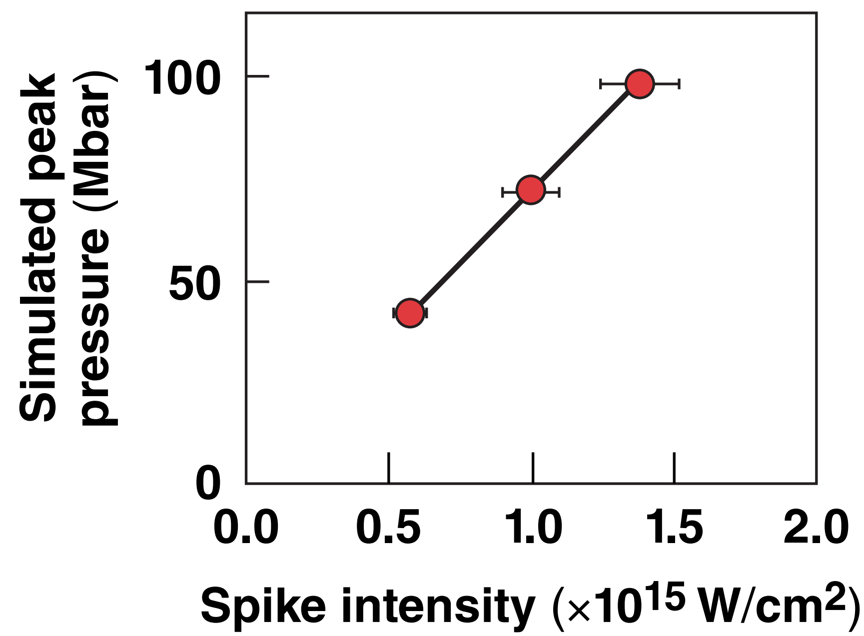
High-Intensity Shock-Ignition Experiments in Planar Geometry





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Summary

100-Mbar shocks are generated by an ~1.5×10^{15} W/cm^2 spike pulse in a long-scale-length plasma

- Shock ignition requires ~100's of Mbar of pressure and hot-electron temperature $\lesssim$150 keV
- Hot-electron temperatures up to 70 keV were measured at 1.5×10^{15} W/cm^2
- ~2% of the spike beam energy is converted into hot electrons and up to ~7% of the laser energy is backscattered
- 2-D *DRACO* simulations reproduce the shock dynamics well over a range of spike intensities

First demonstration of a 100-Mbar laser-driven shock at shock-ignition–relevant conditions.

Collaborators

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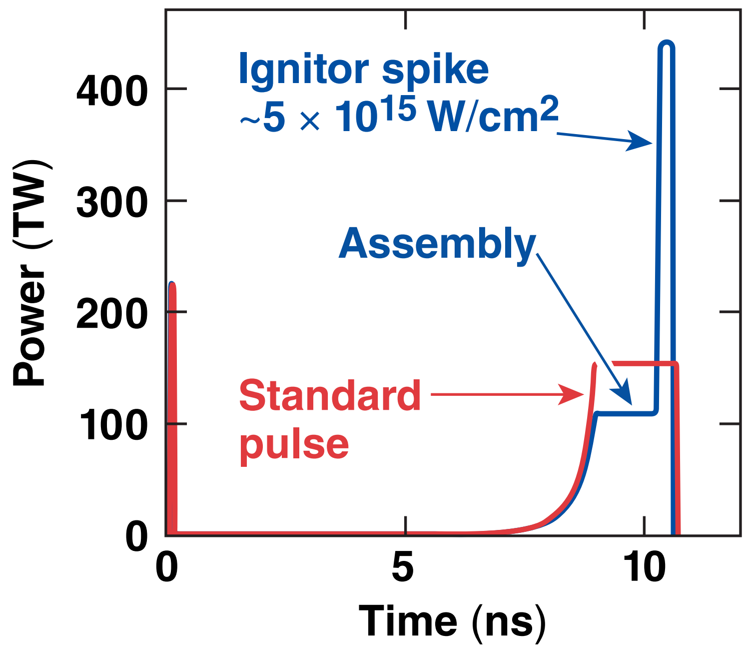
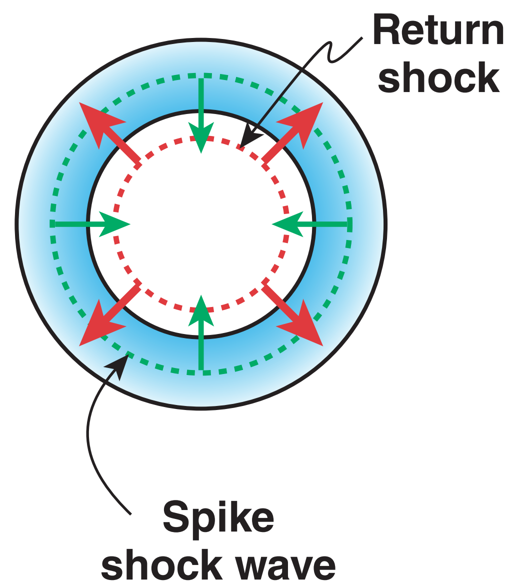
Shock ignition uses a non-isobaric fuel assembly and promises lower laser energy for achieving ignition*



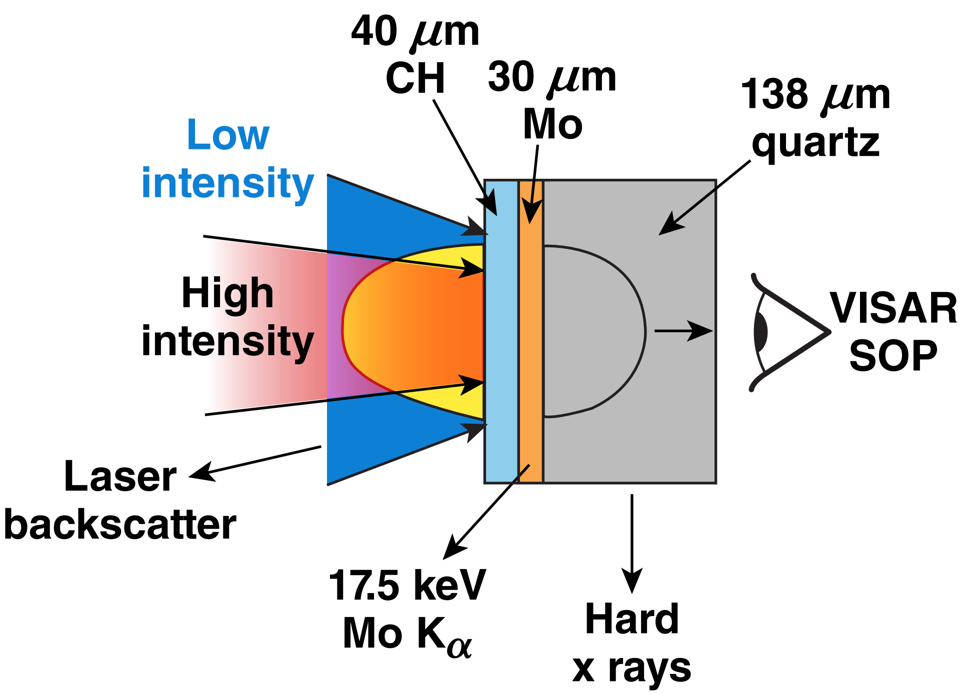


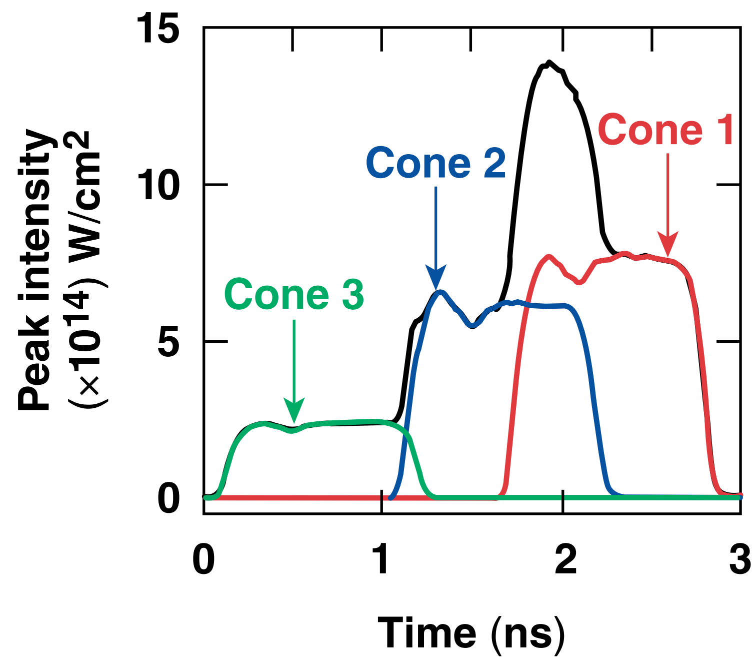
- Critical issues for shock ignition
  - demonstrate hot-electron temperatures of ≤150 keV generated by spike
  - demonstrate ~300- to 400-Mbar spike-generated pressure

TC8918b

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

A laser–plasma interaction experiment was performed in planar geometry with overlapping beams



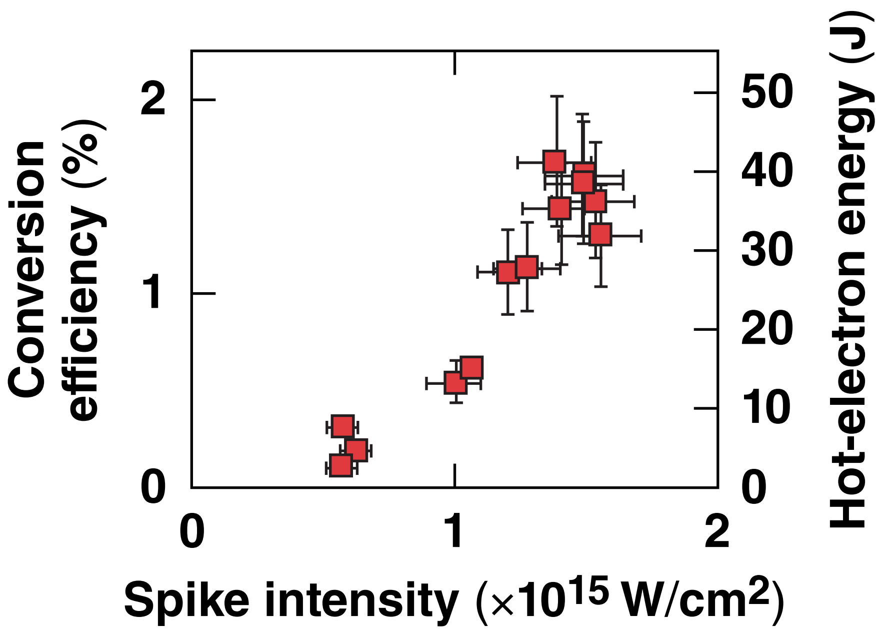


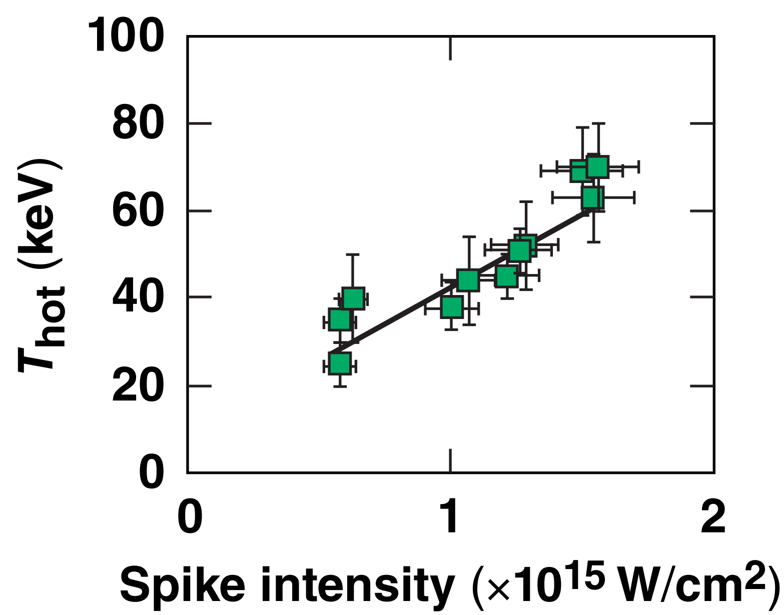
- Phase plates and DPR's with ~900 μm focal spots were used in plasma-generating beams (cone 2 and cone 3)
- Phase plates with an ~600-μm focal spot were used in six high-intensity beams (cone 1)

E20455

The number of hot electrons and T_{hot} increase with spike laser intensity

- E_{hot} from measured Mo K_{α} yield and Monte Carlo simulations of electron stopping[1]
- T_{hot} from measurement with time-resolved four-channel hard x-ray detector[2]





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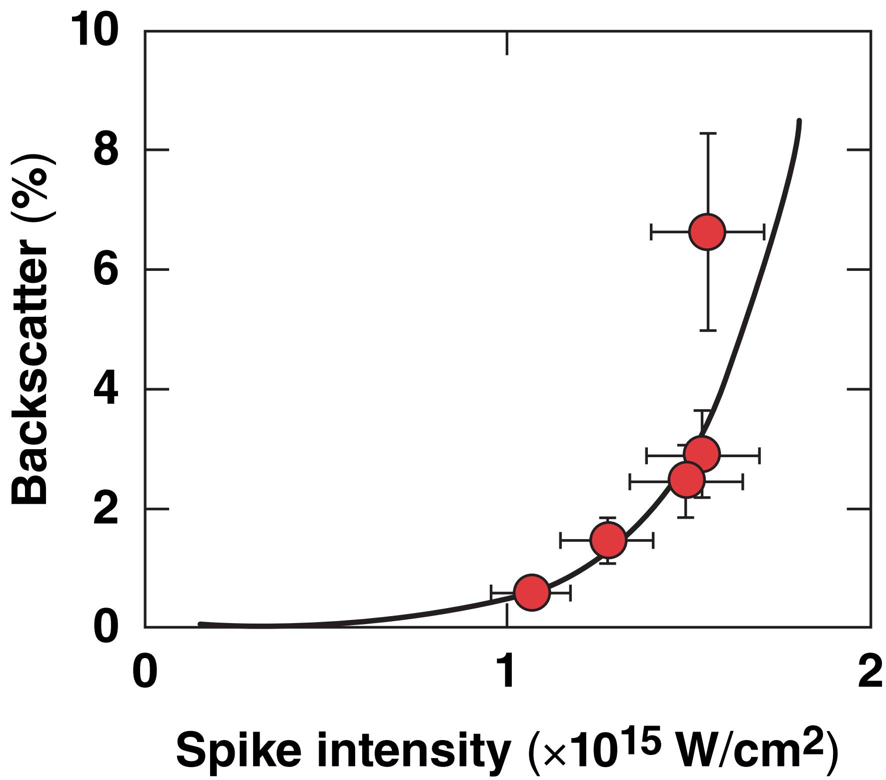
[1] B. Yaakobi *et al*., Phys. Plasmas 16, 102703 (2009).
[2] C. Stoeckl *et al*., Rev. Sci. Instrum. 72, 1197 (2001).

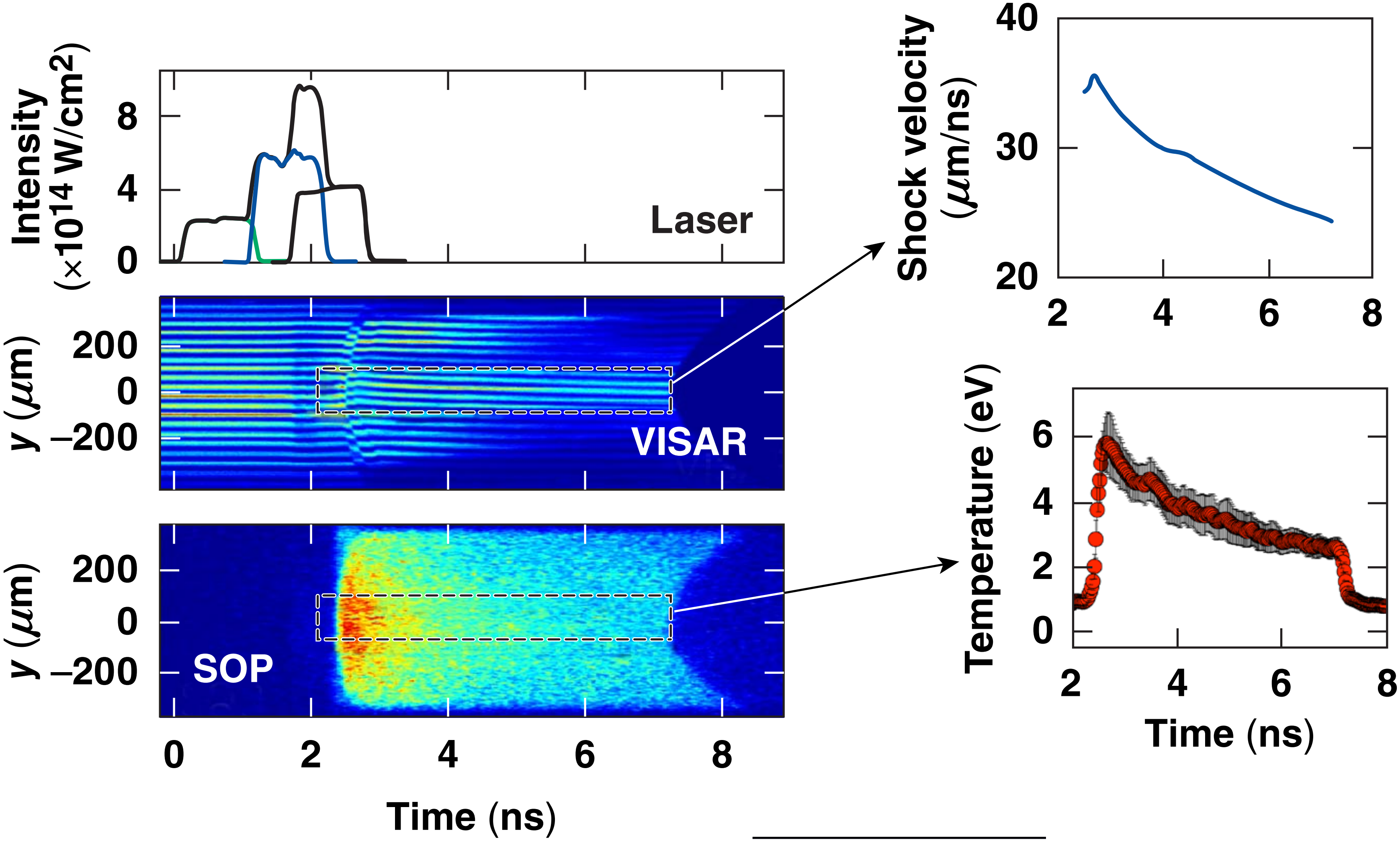
The backscattered laser energy increases with spike laser intensity



- Only the backscattered energy (SRS + SBS) in the lens was quantified
- Sidescattering was observed, but not quantified

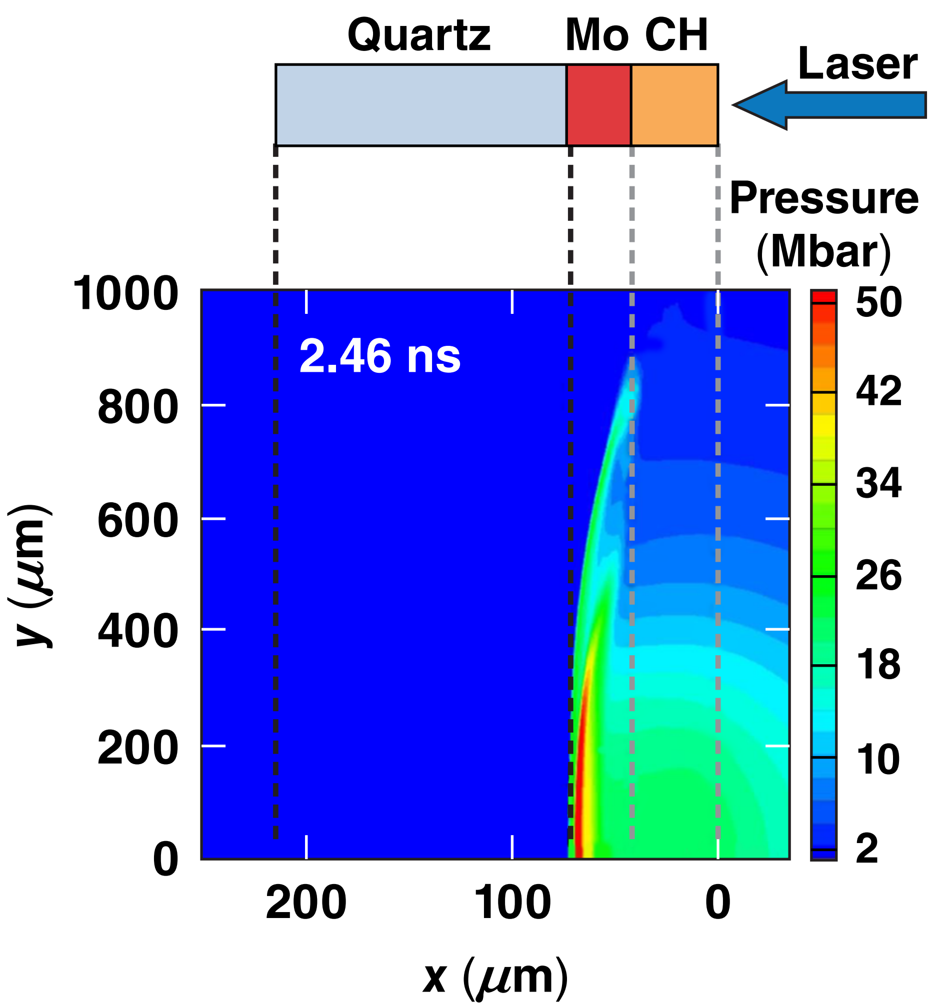
E20450

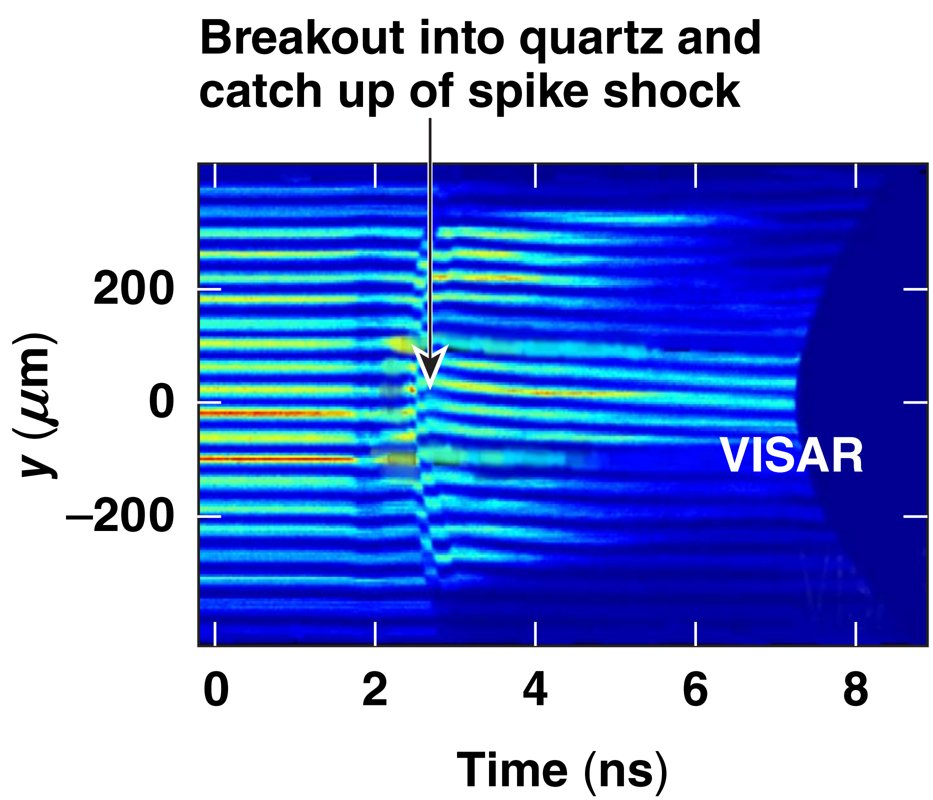
The shock propagation in quartz was observed with streaked optical pyrometry and VISAR*



*J. E. Miller *et al*., Rev. Sci. Instrum. 78, 034903 (2007).
P. M. Celliers *et al*., Rev. Sci. Instrum. 75, 4916 (2004).

2-D *DRACO* simulations show a spherical, decaying shock generated by the high-intensity spike





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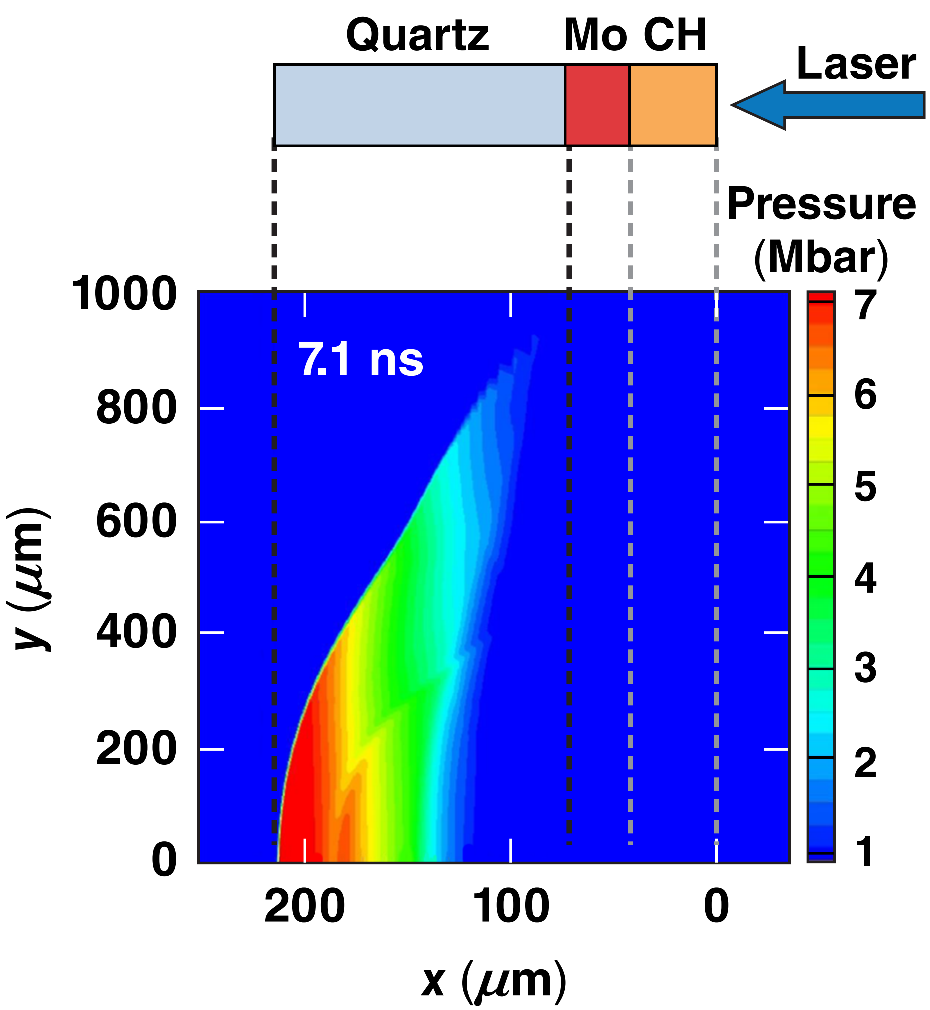
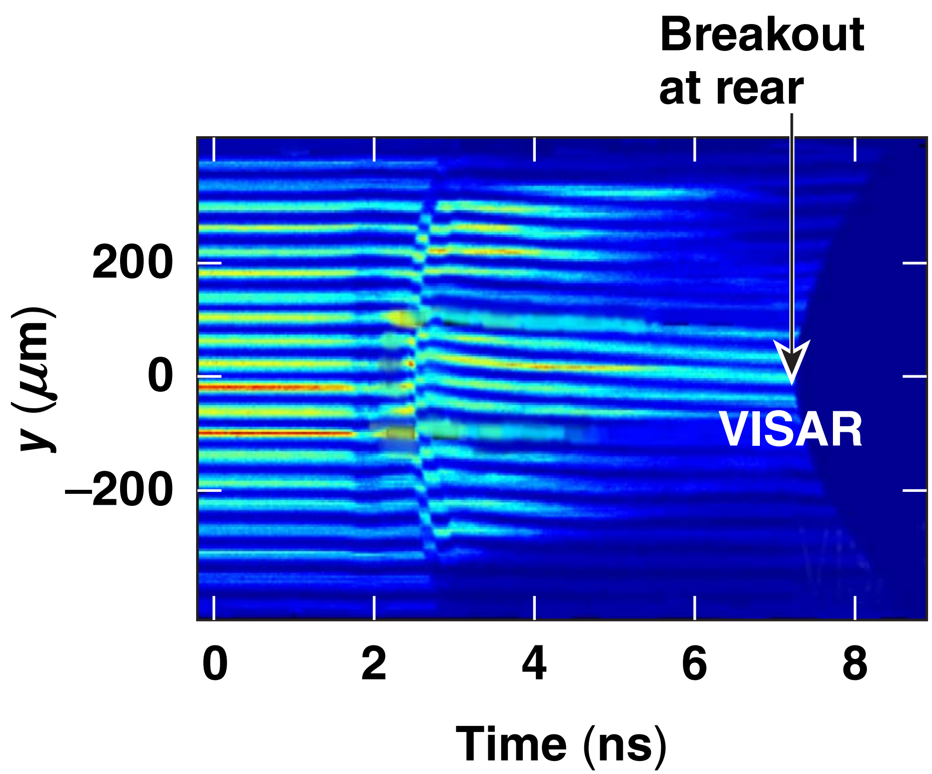
Both the shock breakout into the quartz layer and the rear are reproduced well in the simulations





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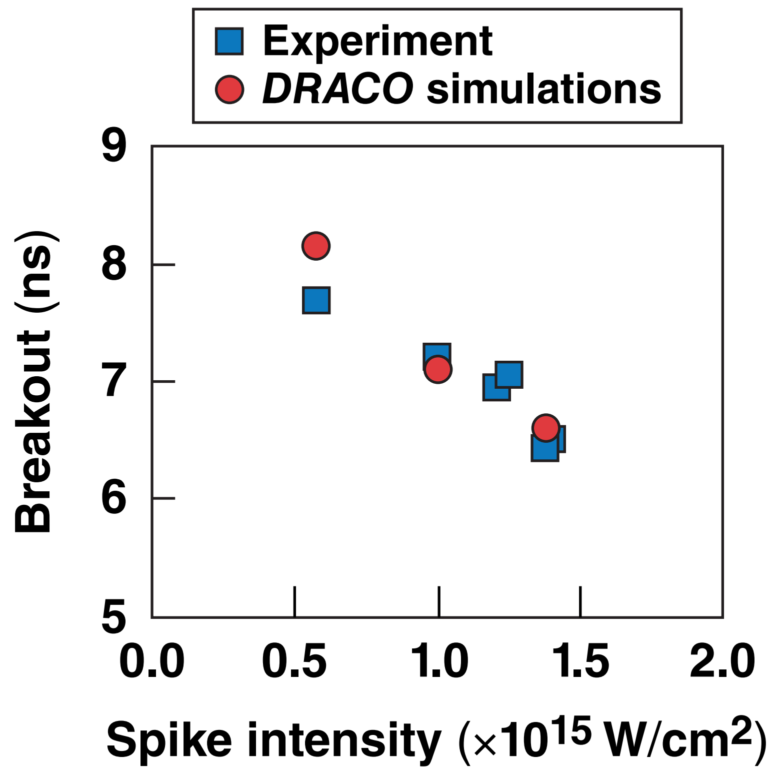
2-D *DRACO* simulations reproduce well the shock dynamics over a range of spike intensities



The agreement of measured and simulated shock-breakout times is better than 6%.

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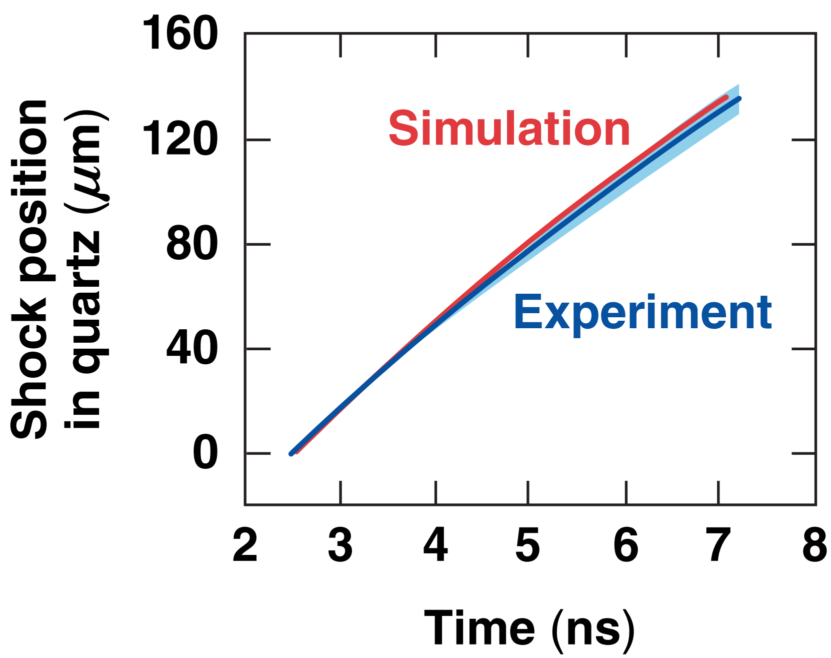
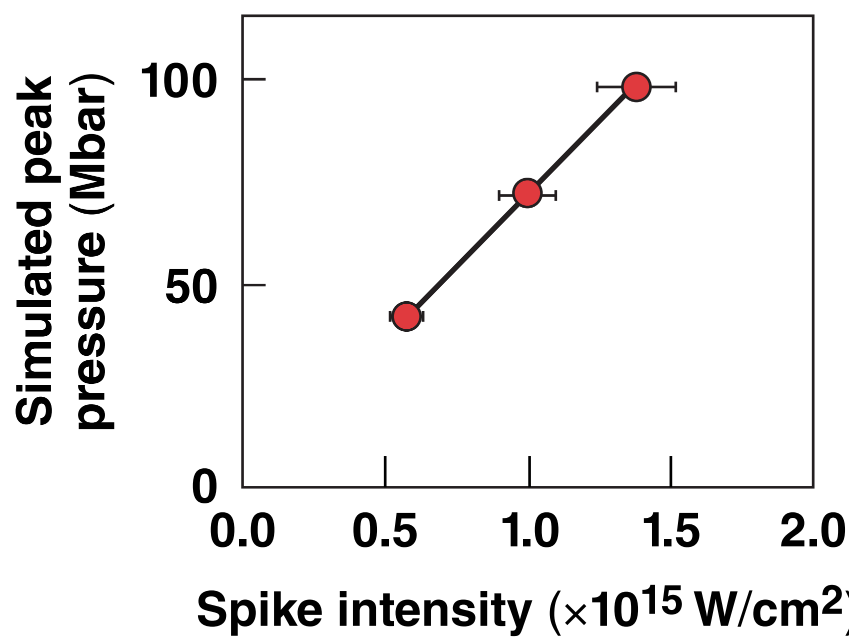
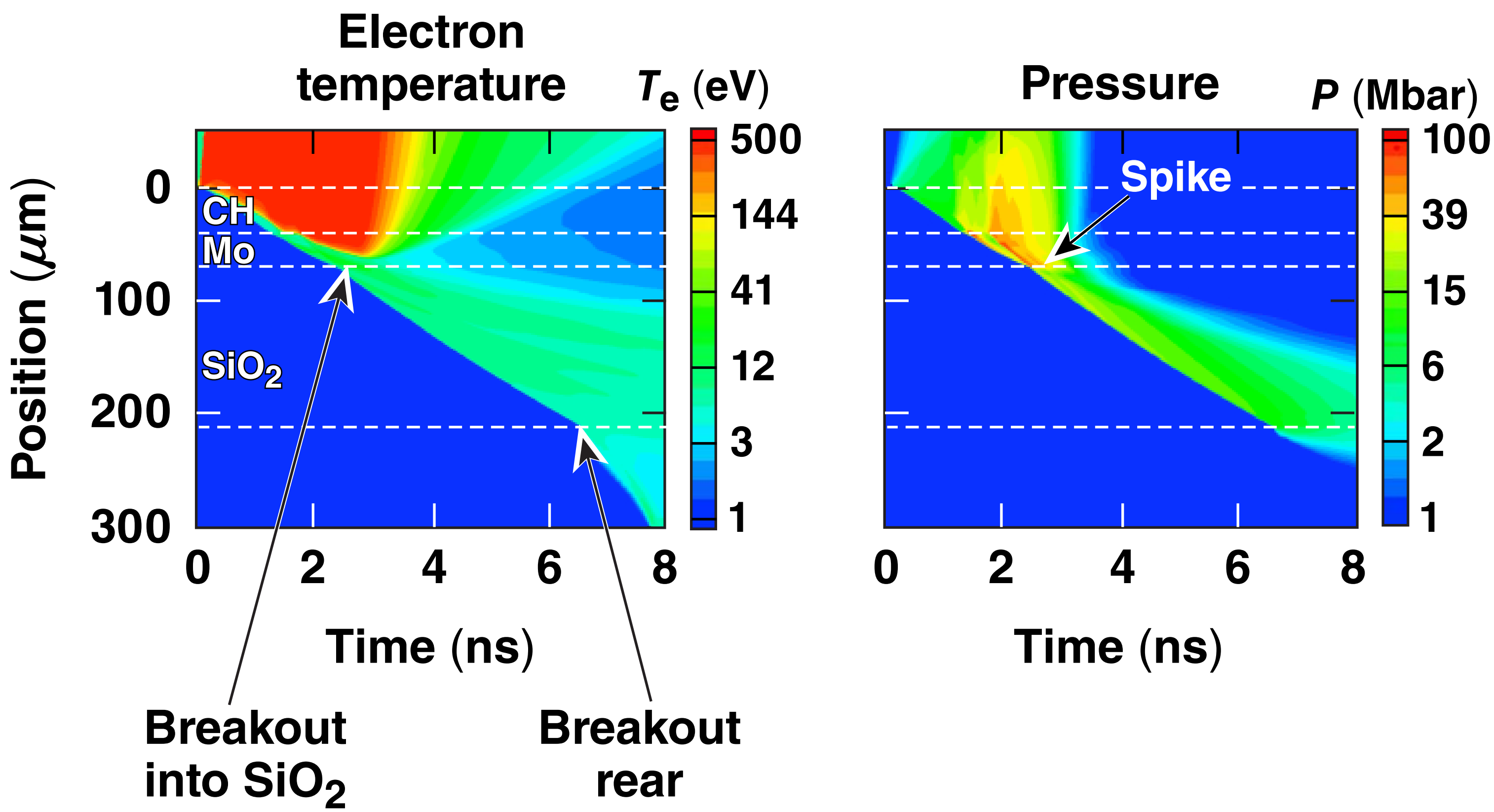
The excellent agreement between experiment and simulations gives confidence in the simulated peak pressure





2-D hydrodynamic *DRACO* simulations predict an initial plasma pressure of 100 Mbar for ~1.5×10^{15} W/cm^2



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100-Mbar shocks are generated by an ~1.5 × 10^{15} W/cm^2 spike pulse in a long-scale-length plasma

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