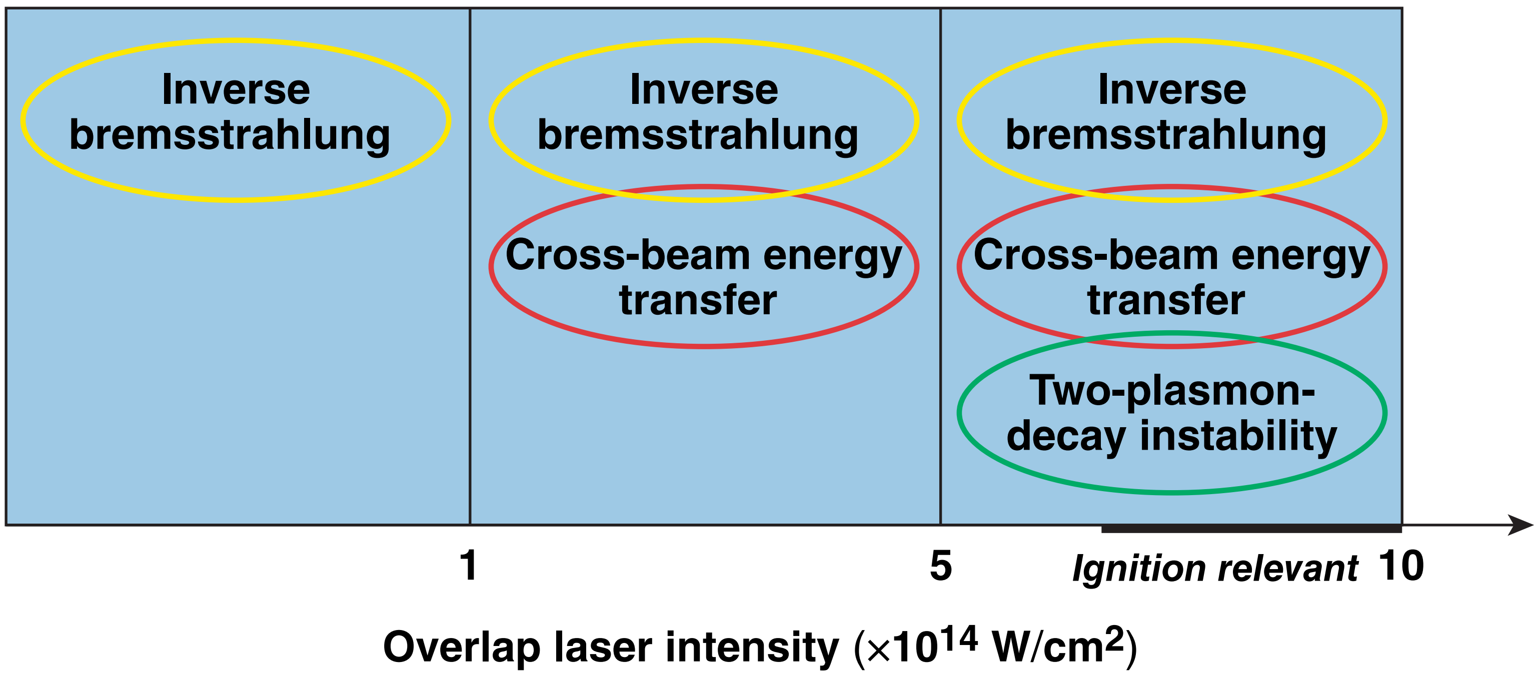
Tuning Laser-Coupling Models Using Cryogenic and Warm Implosions on OMEGA

Main mechanisms determining laser–plasma coupling



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Summary

Studying the interplay between different laser-absorption and laser-scattering mechanisms is an important goal of implosions on OMEGA

- To resolve discrepancies between observation and the predictions for implosions driven at moderate intensities $<5 \times 10^{14}$ W/cm^2, a cross-beam energy transfer mechanism must be included in the modeling

- At higher drive intensities, electron-plasma wave excitation caused by the two-plasmon-decay instability contributes to the laser-energy coupling and target drive

- Since laser–plasma interaction is sensitive to plasma scale length, it is crucial to validate laser-coupling models at NIF-relevant scales using experiments on OMEGA EP and the NIF

Collaborators

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Laser coupling determines hydrodynamic efficiency and the shell implosion velocity

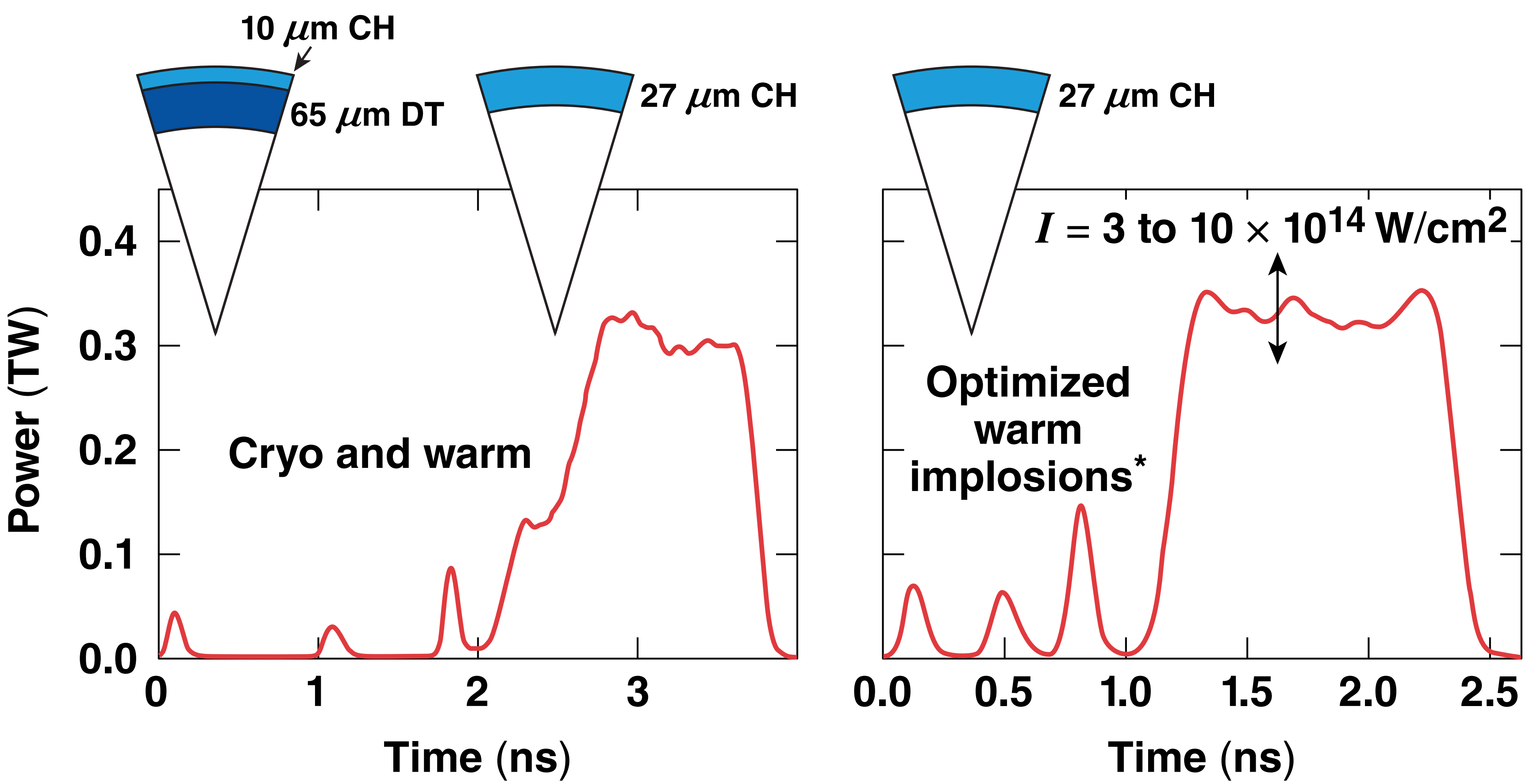
- Shell kinetic energy in an ignition design must exceed a threshold value[1]

$$E_{min}\,(\mathrm{kJ}) = 50\,\alpha^{1.9}\left(\frac{V_{imp}}{3\times 10^7}\right)^{-5.9}\left(\frac{P_{Mbar}}{100}\right)^{-0.8}$$

- E_{min} has a strong dependence on the shell implosion velocity V_{imp}
- Shell implosion velocity is inferred by measuring
  - shell trajectory (backlighting, self-emission)
  - timing and history of neutron production (NTD)

[1]M. C. Hermann, M. Tabak, and J. D. Lindl. Phys. Plasmas 8, 2296 (2001).

Laser-coupling models are tuned using both cryogenic and warm implosions



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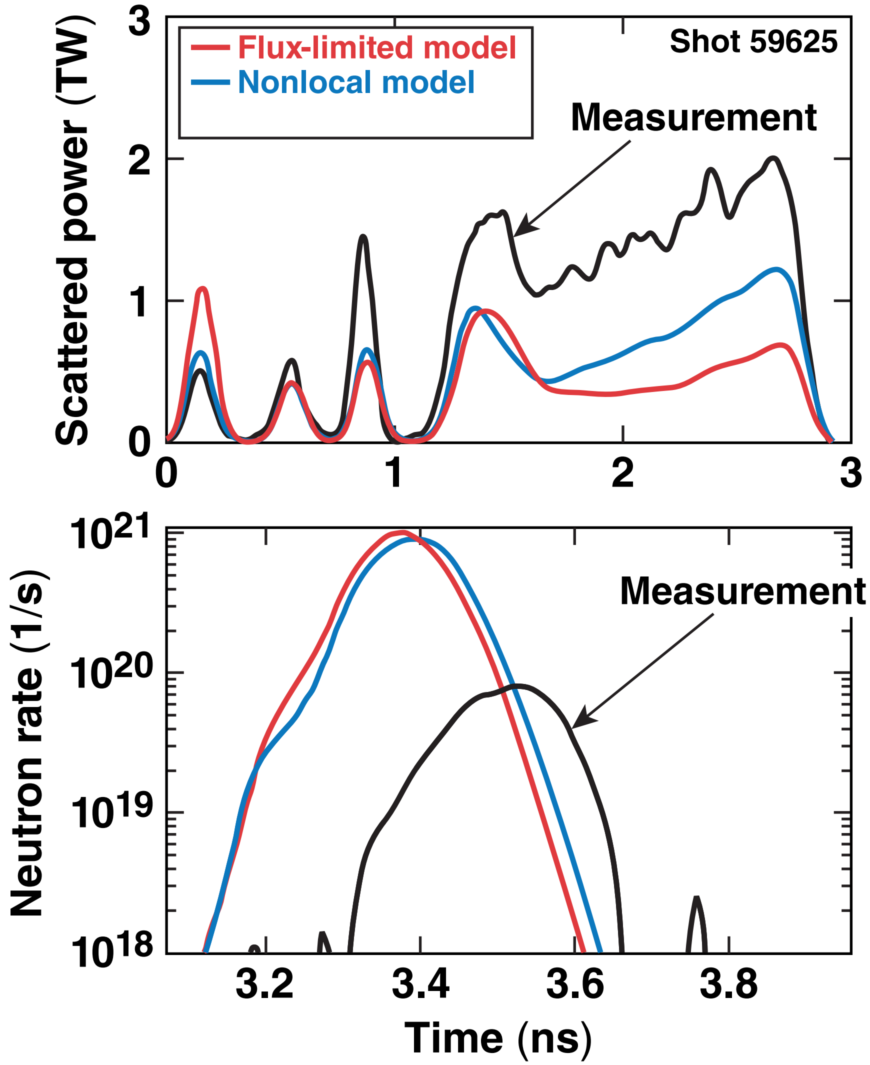
*P. B. Radha *et al.*, Phys. Plasmas 18, 012705 (2011).
C. Stoeckl, PO8.00004

At moderate drive intensities <5 × 10^{14} W/cm^2, cross-beam energy transfer (CBET) limits laser coupling

I ~ 3.3 × 10^{14} W/cm^2, warm implosion



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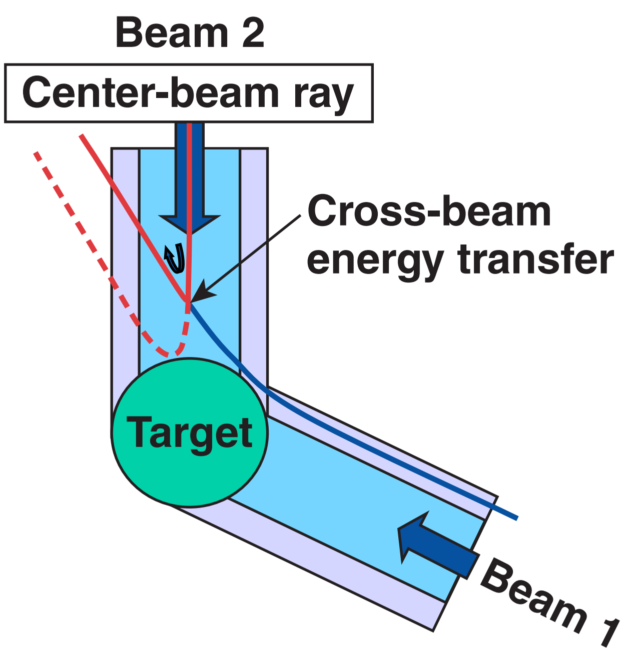
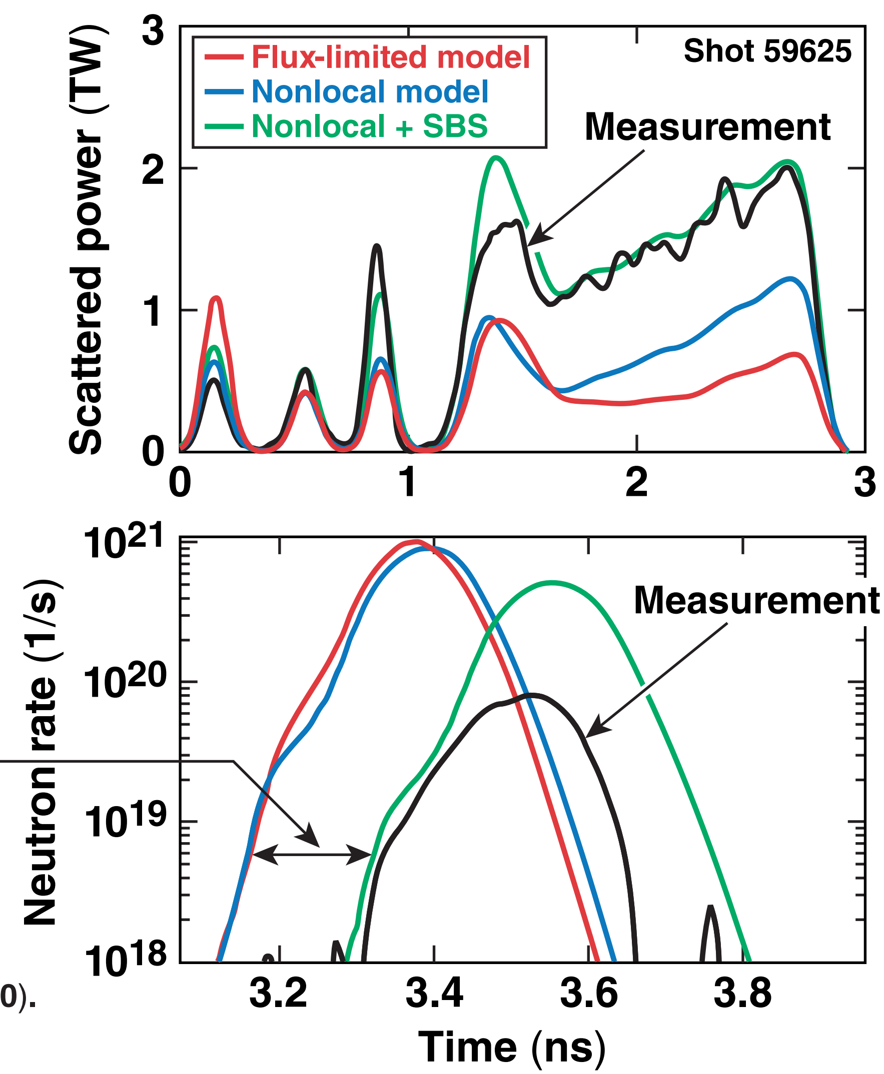


Observed delay in bang time indicates 10% reduction in implosion velocity



[1] I. V. Igumenshchev, YI3.00001
I. V. Igumenshchev, Phys. Plasmas 17, 122708 (2010).
D. H. Froula, UO6.00005
J. A. Marozas, PO8.00003

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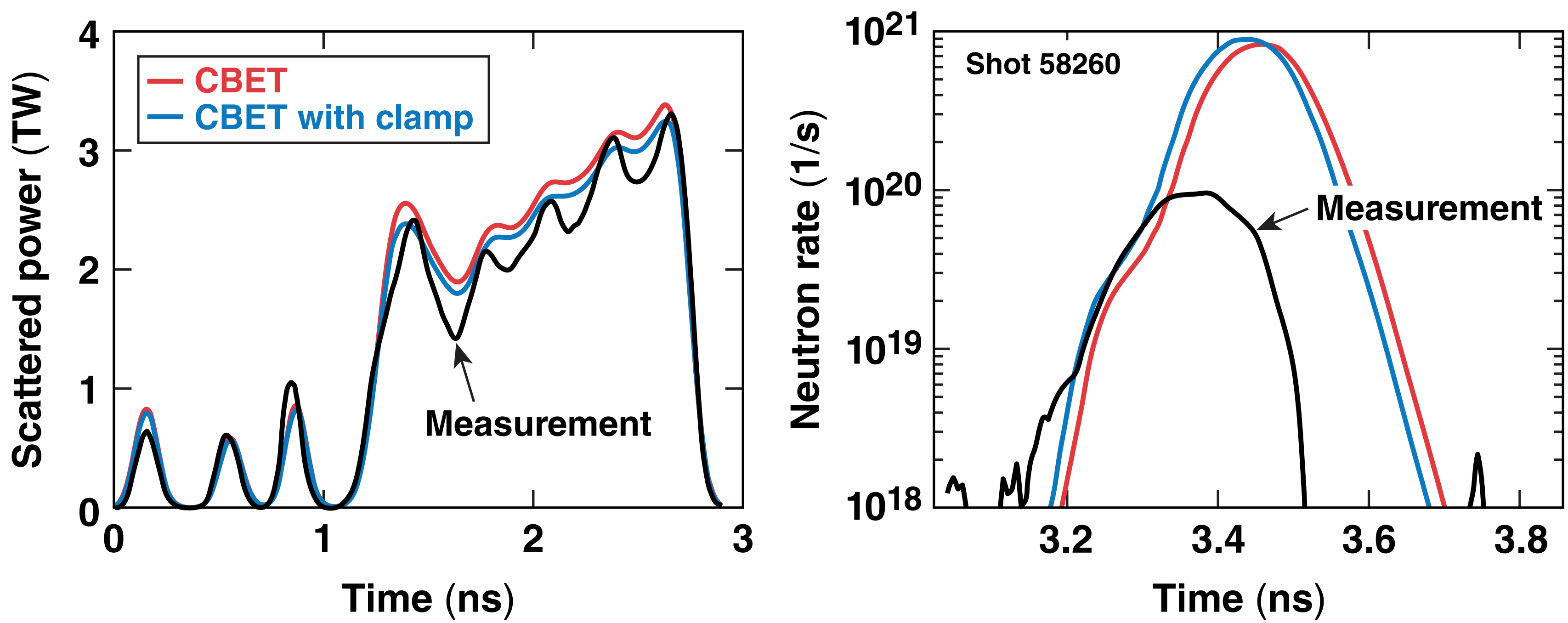
As drive intensity approaches 5×10^{14} W/cm^2, predictions using CBET start to deviate from the data

$I \sim 4.5 \times 10^{14}$ W/cm^2, warm implosion



- Clamping the ion wave amplitude in the CBET model[1,2] to $\delta n/n \sim 10^{-3}$ brings predictions in closer agreement with the data
- Adhoc clamp value indicates presence of an additional absorption mechanism

[1] P. Michel *et al*., Phys. Rev. Lett. 102, 025004 (2009).
[2] I. V. Igumenshchev, YI3.00001

At higher drive intensities >5 × 10^{14} W/cm^2, an additional absorption mechanism is required to match predictions with the data

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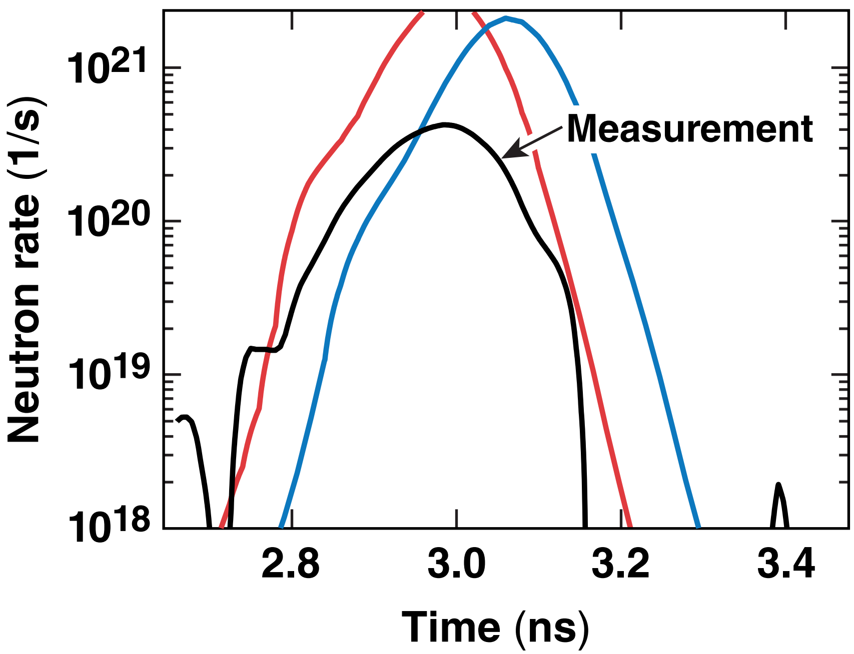
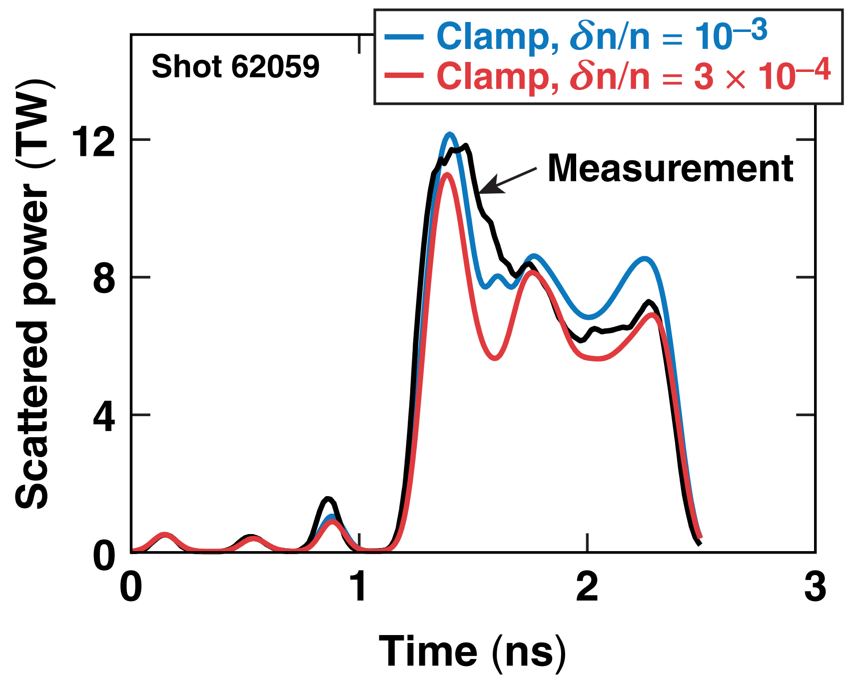
I ~ 10^{15} W/cm^2, warm implosion





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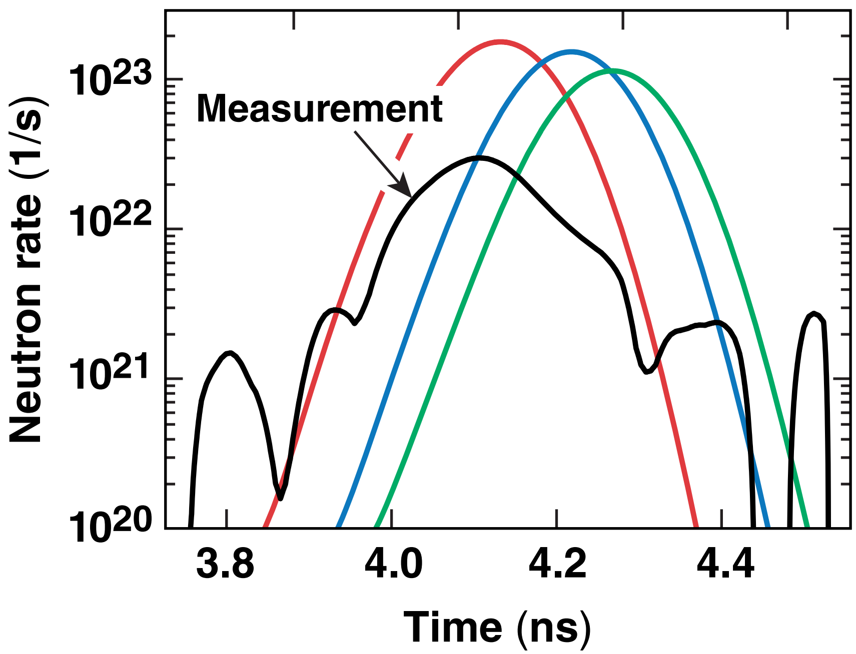
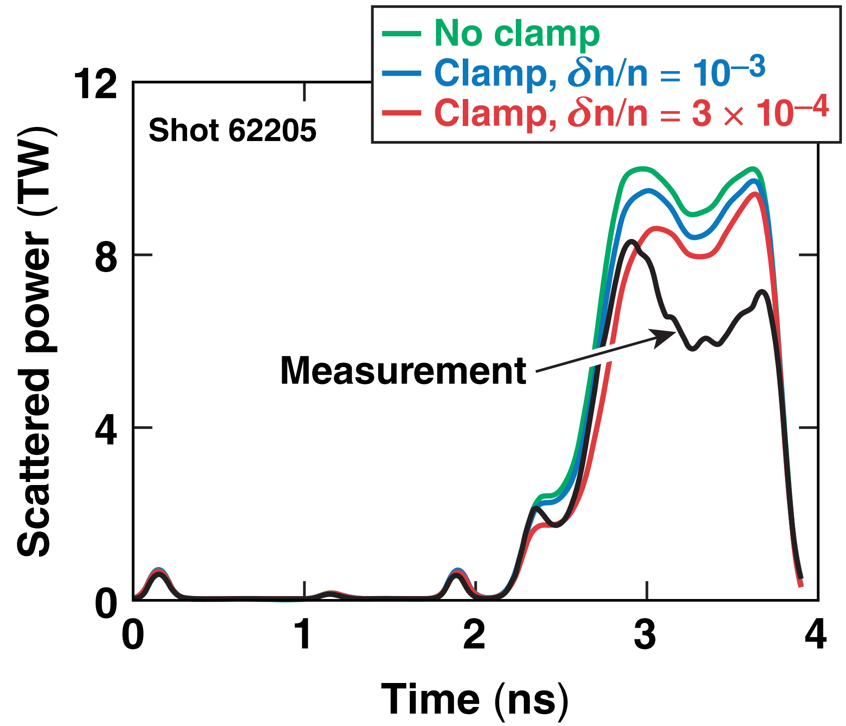
Results of cryogenic implosions also indicate presence of an additional absorption mechanism at higher drive intensities

$I \sim 8 \times 10^{14}$ W/cm^2, cryogenic implosion





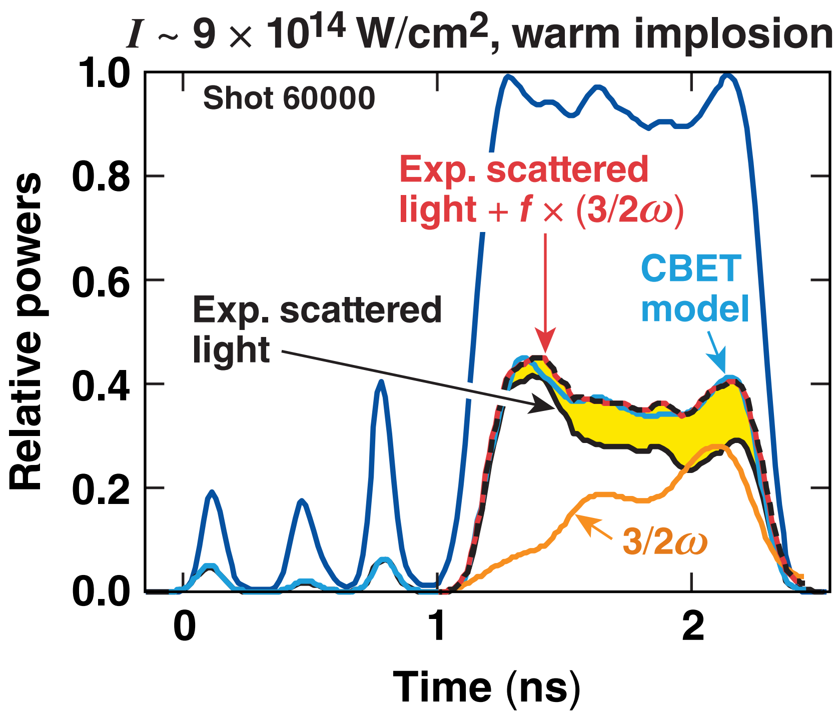
A single clamp model is not consistent with all observations.

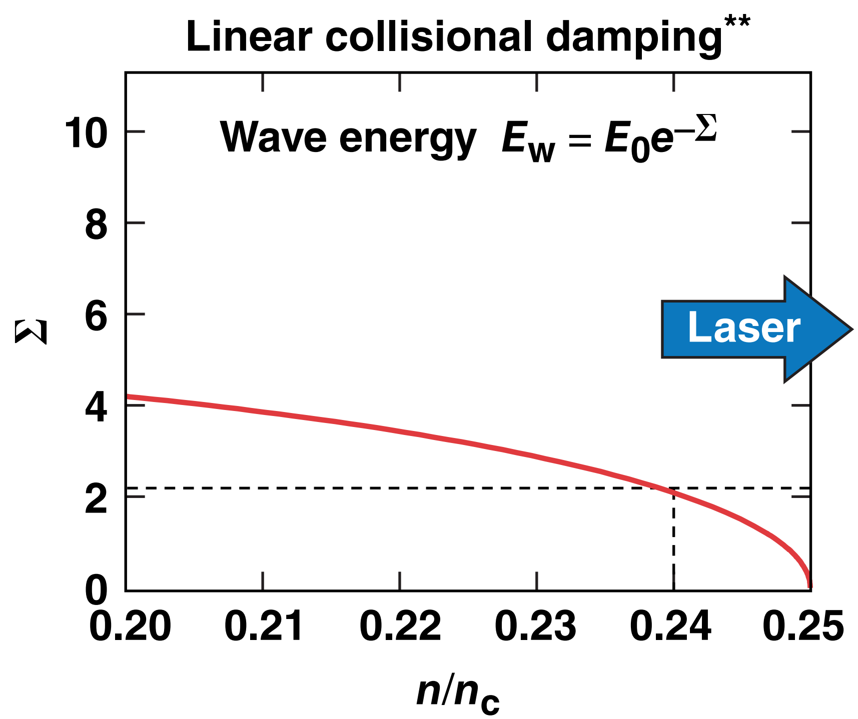
TC9782

Effect of laser hot spots on SBS reflectivity is discussed by A. V. Maximov, UO6.00007.

Discrepancy between the CBET model predictions and the data is reduced by including energy deposition into electron-plasma waves* (EPW)

- Collisional damping of EPW is high enough to deposit the majority of wave energy into thermal electrons





A laser deposition model caused by TPD instability is currently being implemented in hydrocodes.

* W. Seka, UO6.00005

** TPD model including nonlinear effects is presented by J. Myatt, UO6.00008.

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Summary/Conclusions

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