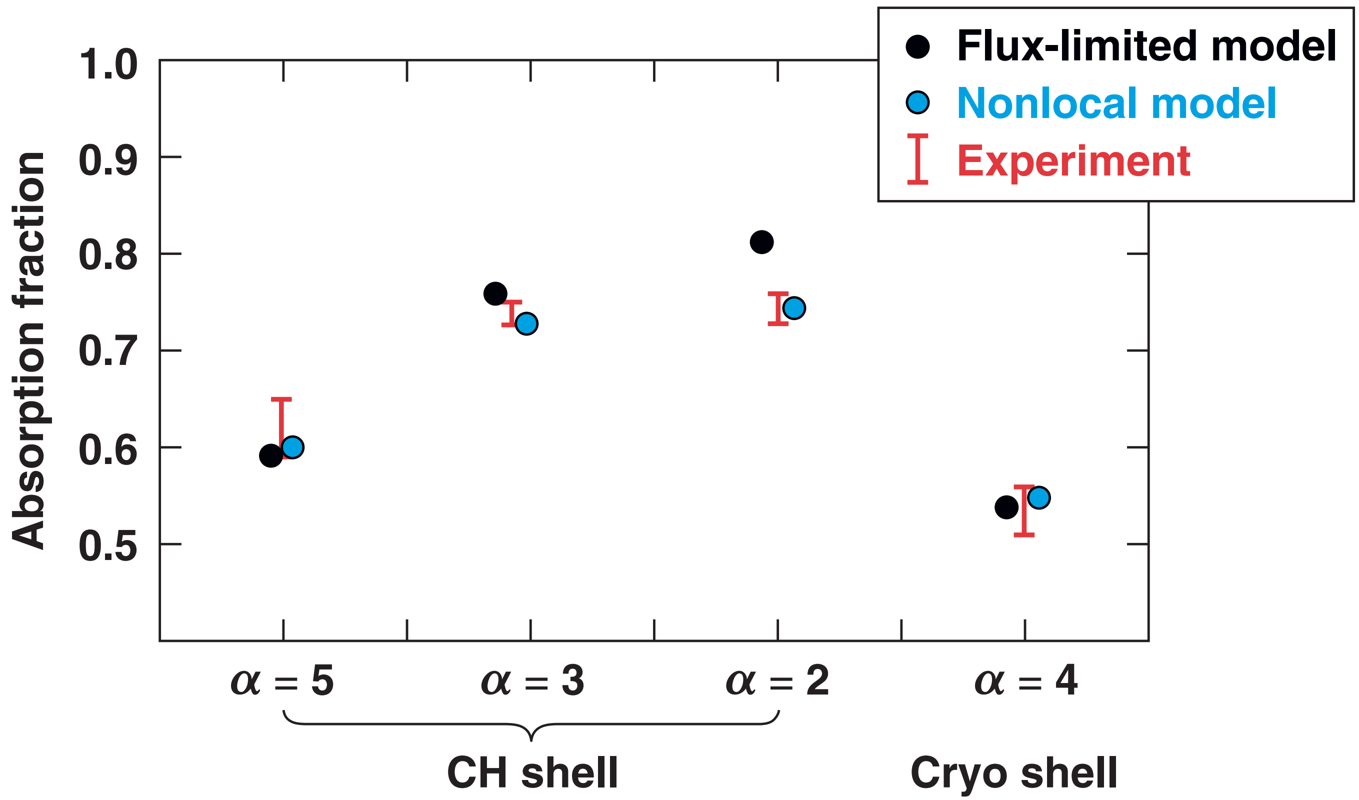
# Electron Transport Modeling for Inertial Confinement Fusion Experiments





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# Collaborators


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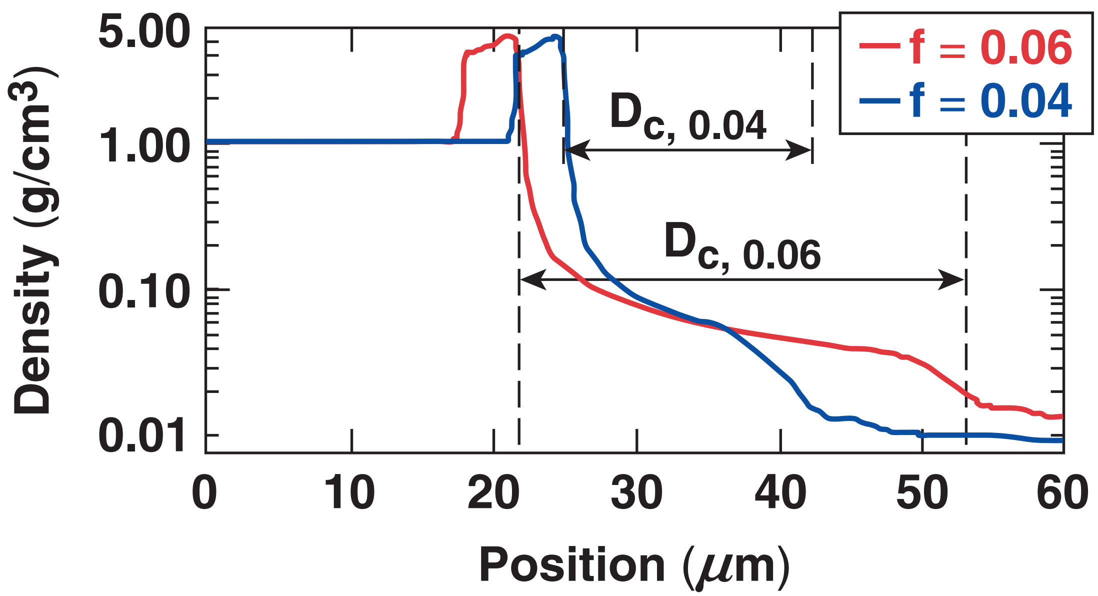
Summary

# The new nonlocal thermal transport model is consistent with the experimental data

- New nonlocal model for electron thermal transport has been developed and implemented in the 1-D hydrocode *LILAC*.
- Applied to the shock timing and RM measurements in planar geometry, the model is in good agreement with the experimental data.
- The model prediction for laser absorption is in excellent agreement with the measurements. The bang time is within the experimental error bar when 2-D effects are included in the analysis.

# A flux-limited thermal transport model* has traditionally been used in hydrodynamic simulations

- $q_{SH} = -\kappa \nabla T$ $q_{FS} = nTV_T$
- Sharp cutoff $q_{eff} = \min(q_{SH}, fq_{FS})$
- $0.04 < f < 0.1$

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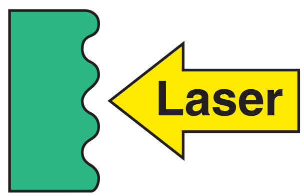
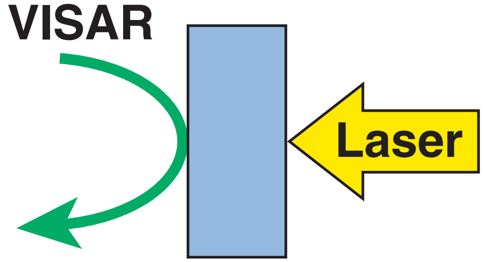
*R. C. Malone, R. L. McCrory, and R. L. Morse, Phys. Rev. Lett. 34, 721 (1975).

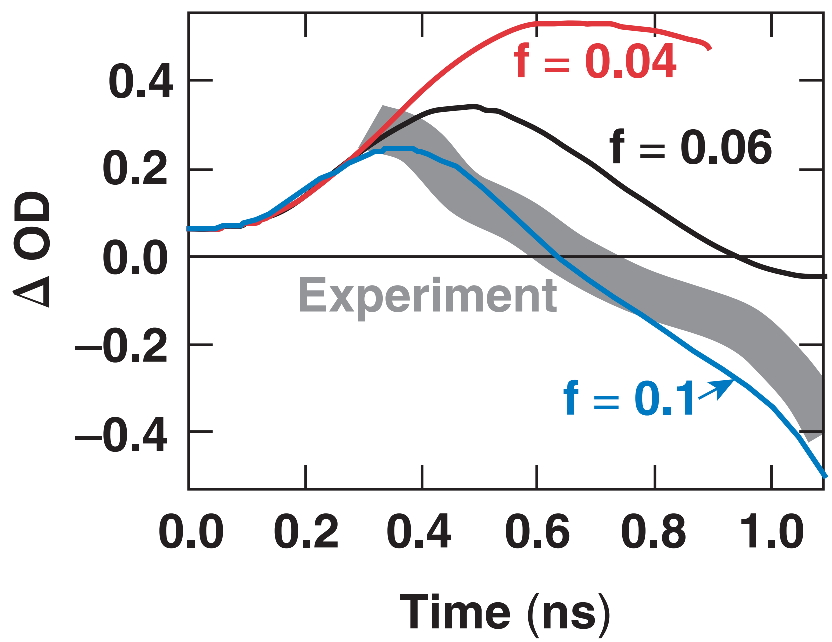
# A single-valued flux limiter is not consistent with shock-breakout and RM growth planar experiments

## RM Experiment*

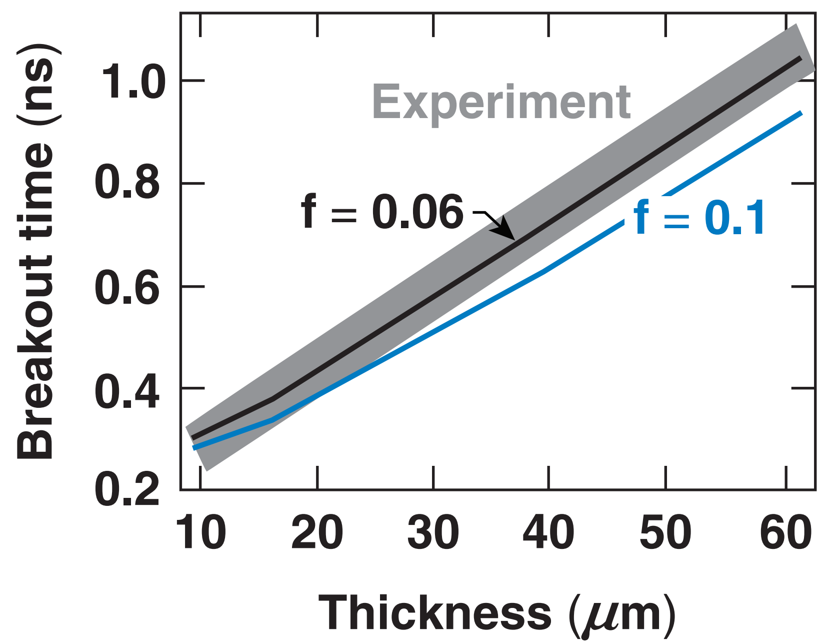



- 2-ns square pulse, $I = 4 \times 10^{14}$ W/cm$^2$
- CH foil d = 40 $\mu$m, $\lambda$ = 20 $\mu$m




Shock-breakout measurements

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*O. Gotchev, Ph.D. thesis, University of Rochester, 2004.

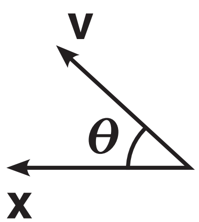
# A new nonlocal transport model has been developed to test the results of flux-limited approximation

UR LLE

- Simplified Boltzmann equation (Krook model)

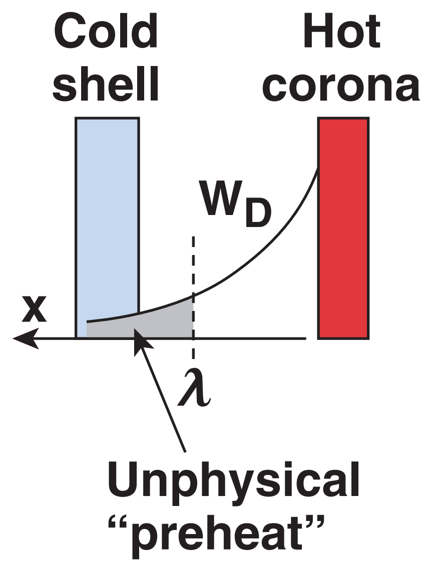
Electric field    Collisional frequency

$$v\frac{\partial f}{\partial x}+\frac{eE}{m}\frac{\partial f_0}{\partial v_x}=-\nu\left(f-f_0\right)$$




$$f=\int^{x}\left(f_0-\frac{eE}{m\nu}\frac{\partial f_0}{\partial v_x}\right)W_D\,(x')\frac{dx'}{\lambda\cos\theta},$$

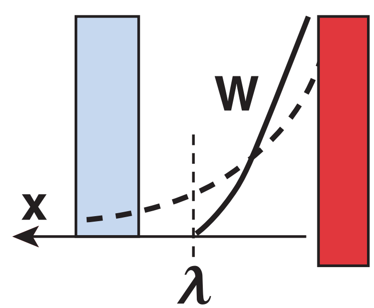
$$W_D=e^{-\xi},\ \xi=\int_{x'}^{x}\frac{dx''}{\lambda\cos\theta},\ \lambda=\frac{v}{\nu}.$$




- To limit delocalization length
  - electron slow-down range
  
  $\lambda_K \sim$ (kinetic energy)$^2$

$$\frac{dK}{ds}=-\frac{K}{\lambda_K}\Rightarrow W=\frac{3}{2}\sqrt{1-\xi}$$

Electron path

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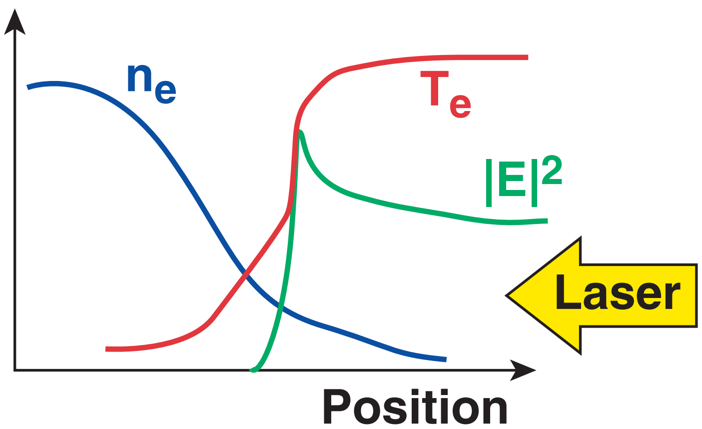
# Ponderomotive terms in heat conduction are included by modifying the symmetric part in the distribution function $f_0$




- Limit at large velocity*
(main contribution to heat flux)

$$f_0 \approx f_M \exp\left(-0.01Z \frac{v_E^2}{v_T^7} v^5\right)$$

$$v_E = eE/m\omega_L, \; v_T = \sqrt{T/m}$$

- Obtained distribution function f determines heat flux

$$j_x = e \int d^3 v v_x f, \; j_x = 0 \Rightarrow E$$

$$q_x = \frac{m}{2} \int d^3 v v^2 v_x f$$

*V.N. Goncharov and G. Li, Phys. Plasmas 11, 5680 (2004);
G. Li BO1 0003

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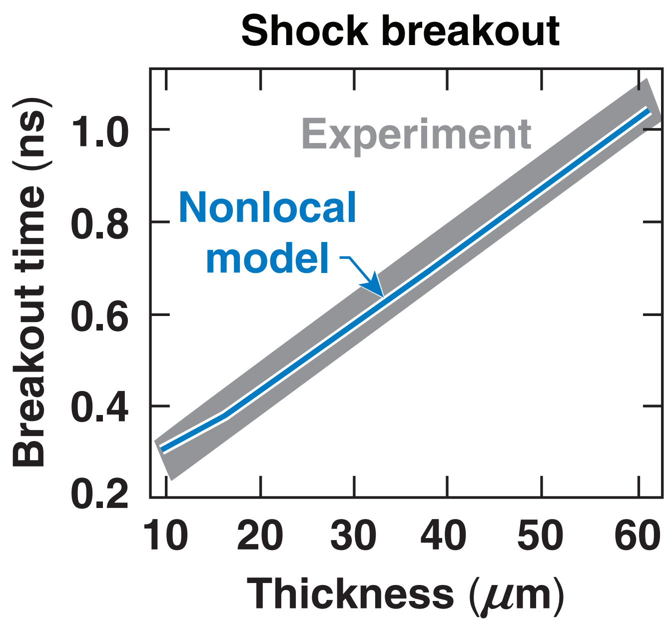
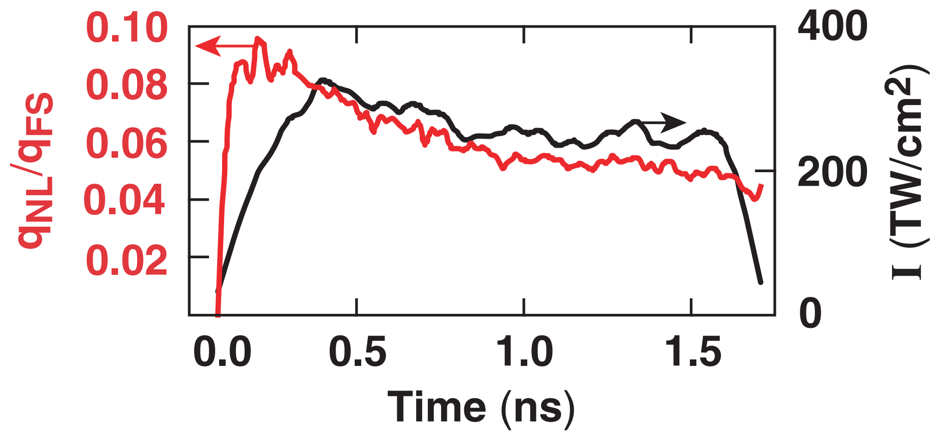
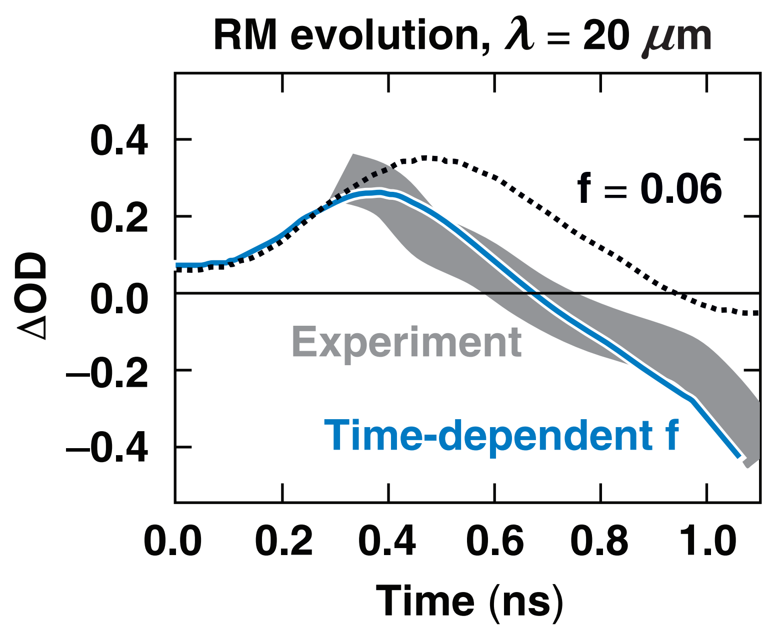
# The nonlocal transport model is consistent with shock timing and RM growth measurements

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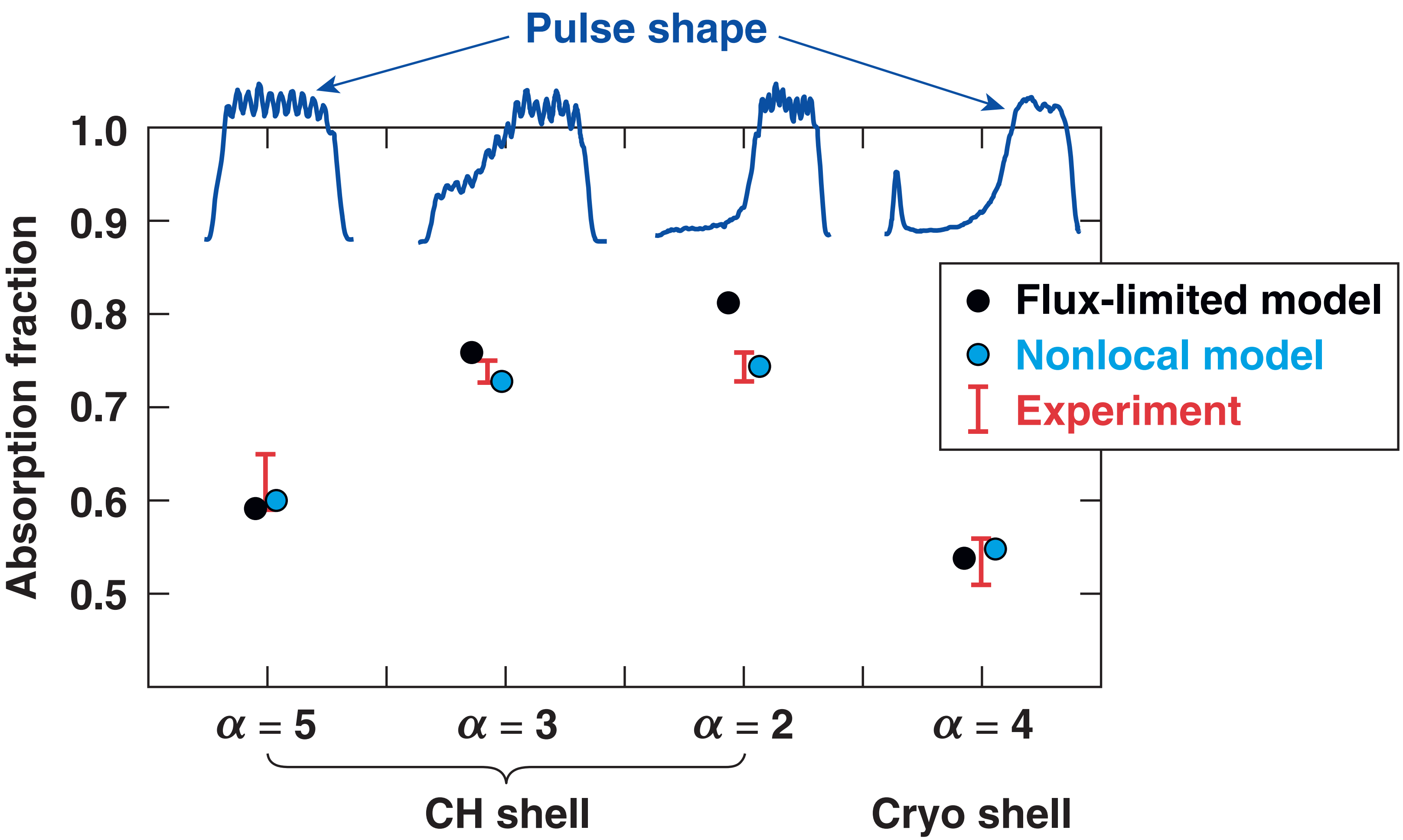
# The nonlocal model is also in agreement with absorption measurements of CH and cryogenic shell implosions

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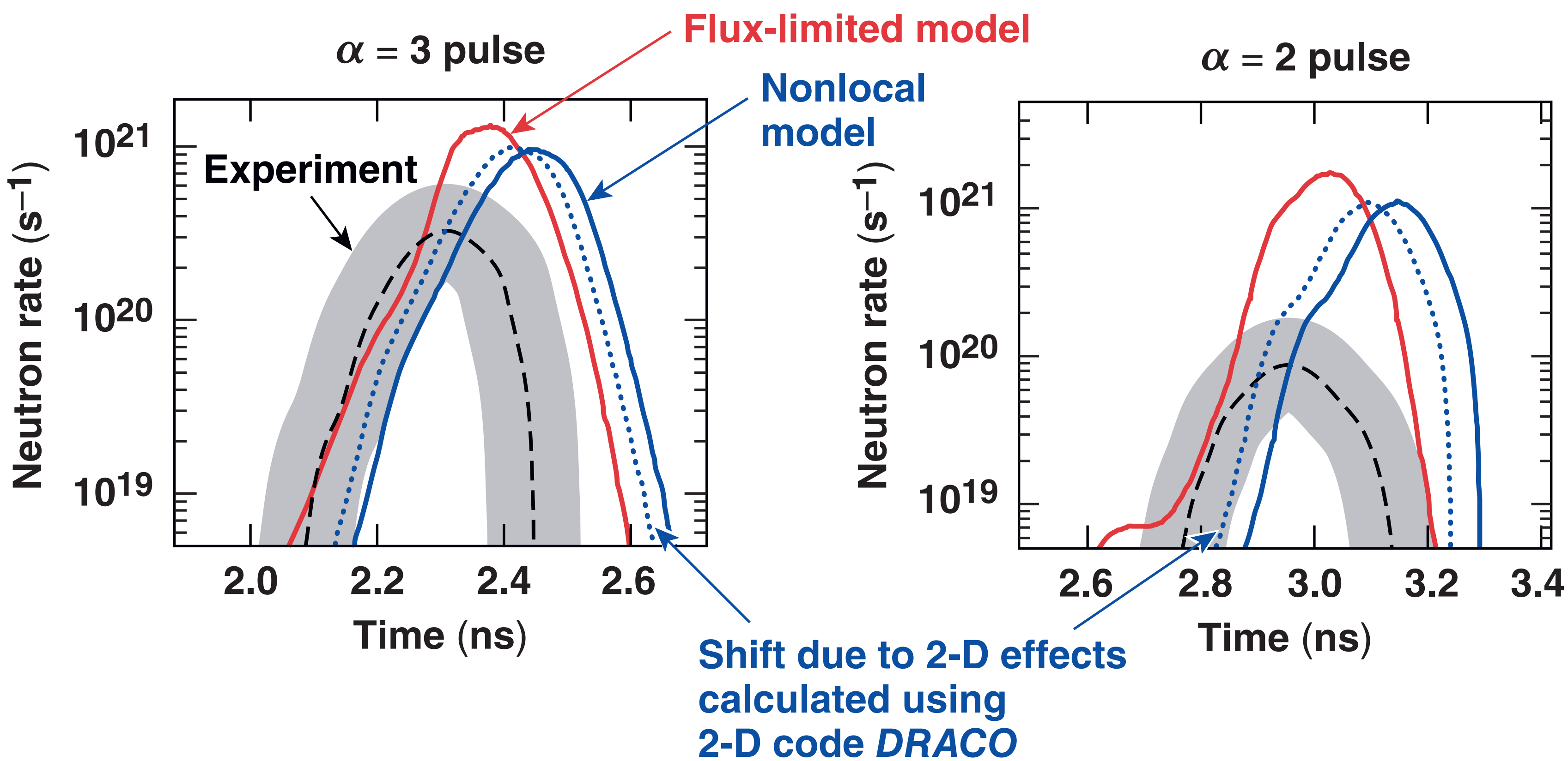
# Neutron production timing calculated using the nonlocal model is within the experimental error bar when two-dimensional effects are included

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Summary/Conclusions

# The new nonlocal thermal transport model is consistent with the experimental data

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