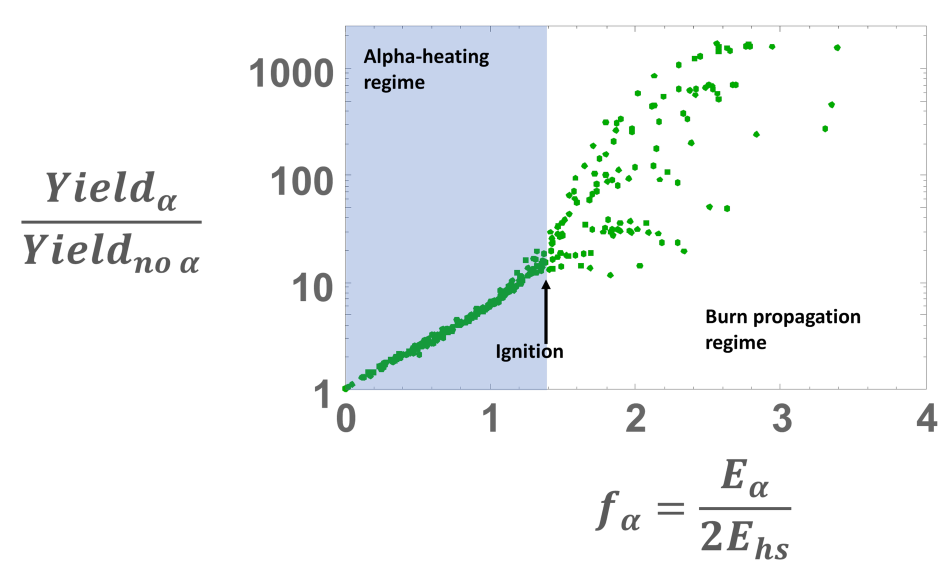
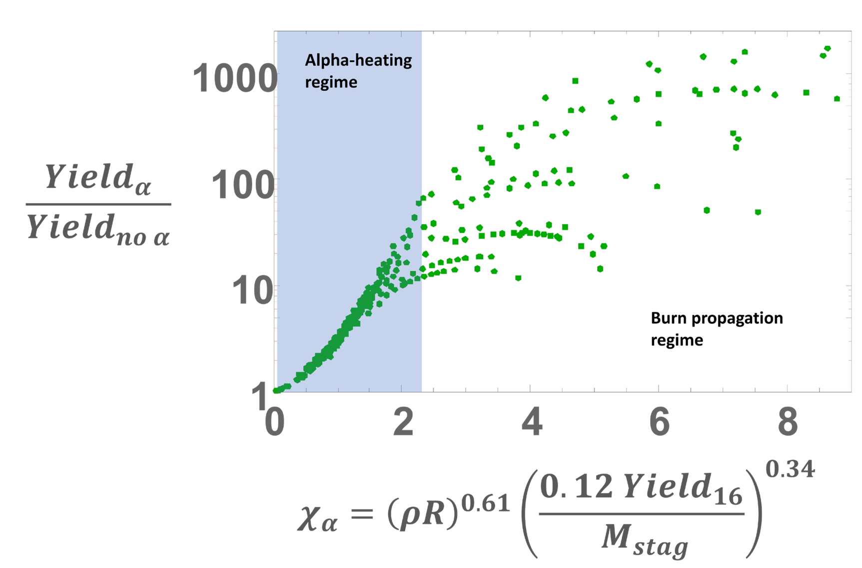
Theory of ignition and burn propagation in inertially confined plasmas

A. R. Christopherson, R. Betti, S. Miller, V. Gopalaswamy, D. Cao, O. Mannion

University of Rochester, Laboratory for Laser Energetics

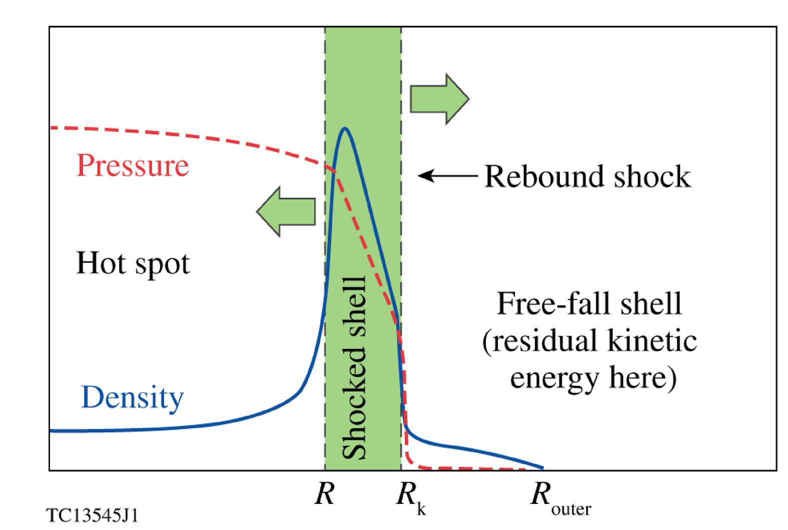
Ignition occurs when the hot spot transitions out of the alpha heating regime and into the burn propagation regime

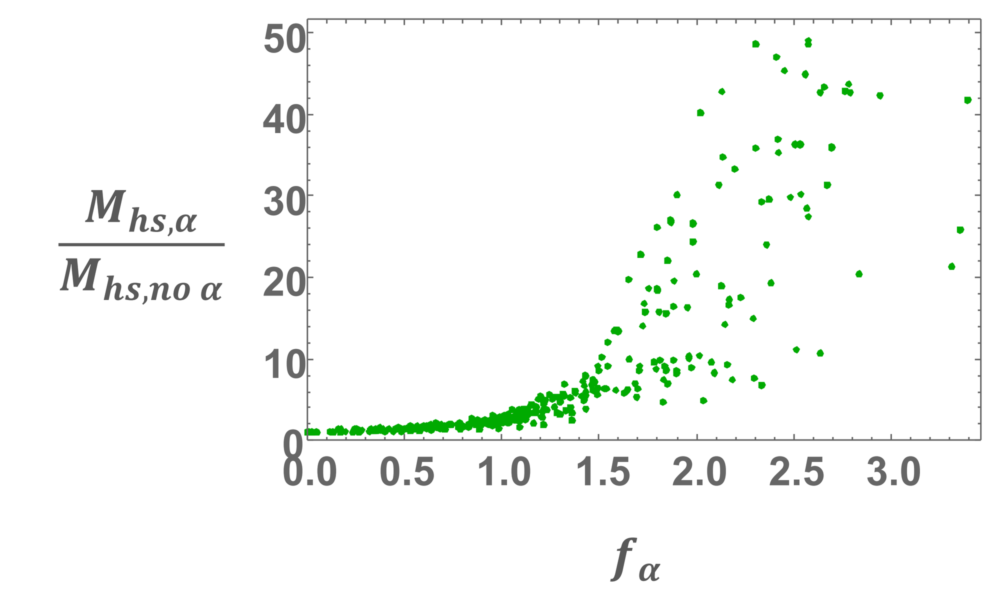


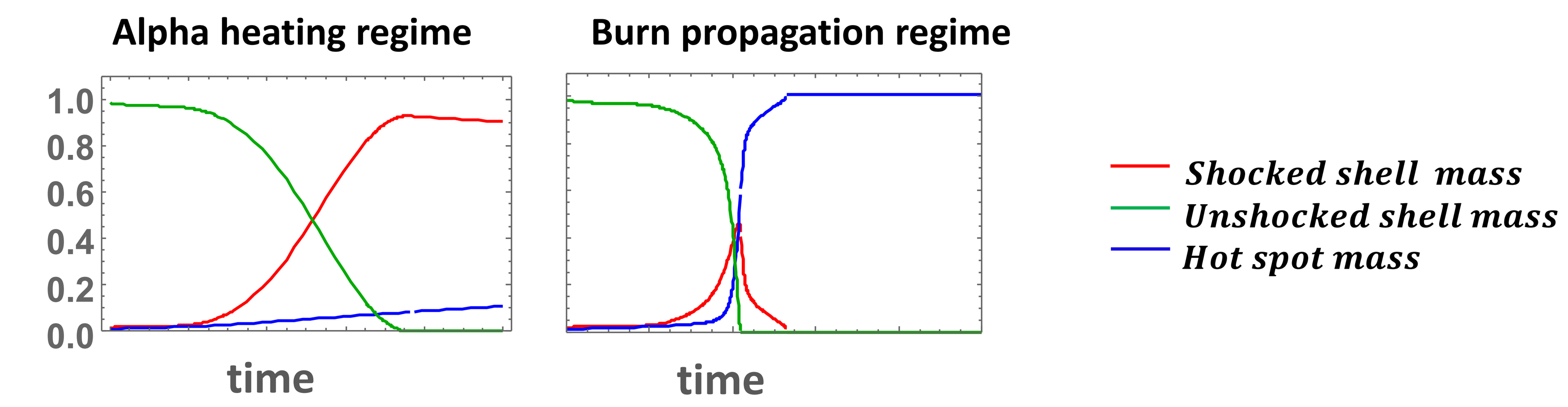


- $Y_{amp} = \frac{Yield_\alpha}{Yield_{no\ \alpha}}$ is the yield enhancement due to alpha heating
- $Yield_\alpha$ = neutron yield from simulation including alpha transport
- $Yield_{no\ \alpha}$ = neutron yield from simulation with alpha transport off
- ρR = neutron averaged shell areal density
- M_{stag} = stagnated mass at bang time
- $E_\alpha = \varepsilon_\alpha \cdot Yield_\alpha$ = total alpha energy produced in implosion
- E_{hs} = hot spot internal energy at bang time

Burn propagation causes a rapid accumulation of mass into the hot spot (M_{hs})

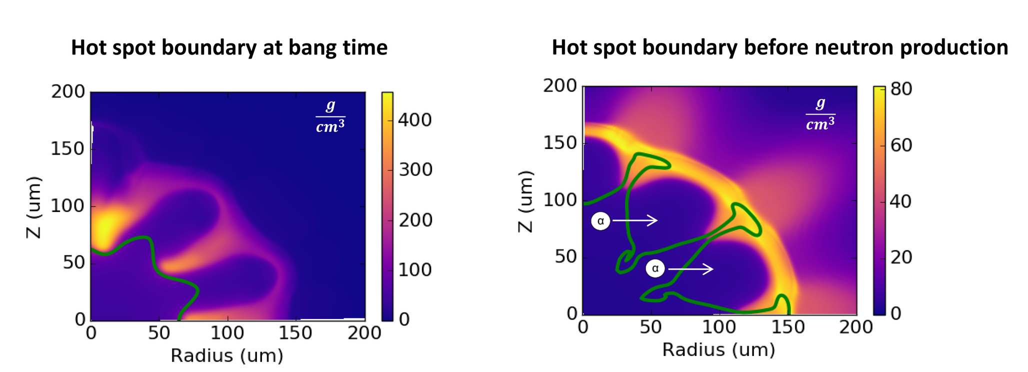


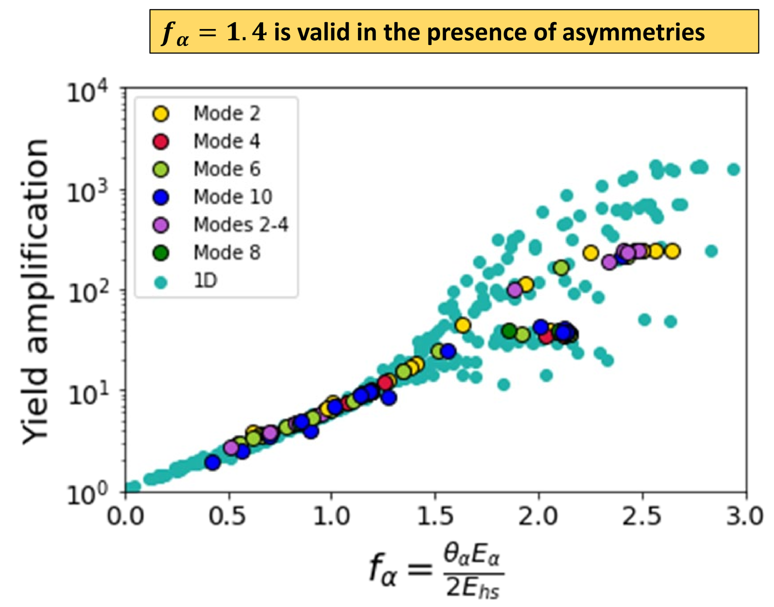


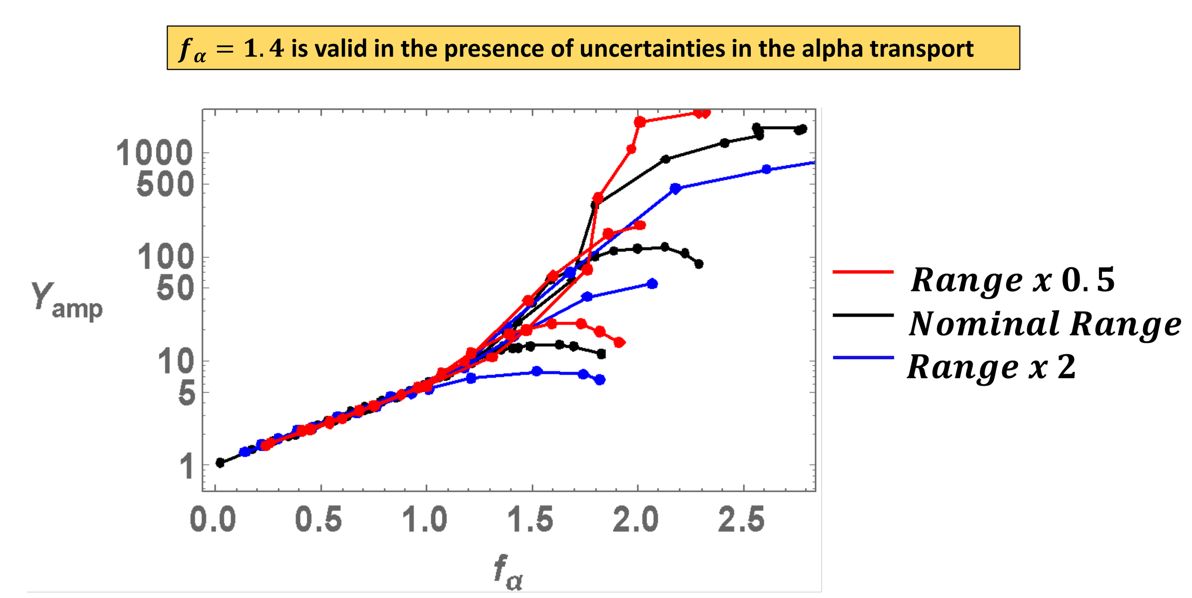


The definition of ignition at $f_\alpha \sim 1.4$ is valid provided that the fraction of absorbed alpha particles is correctly accounted for

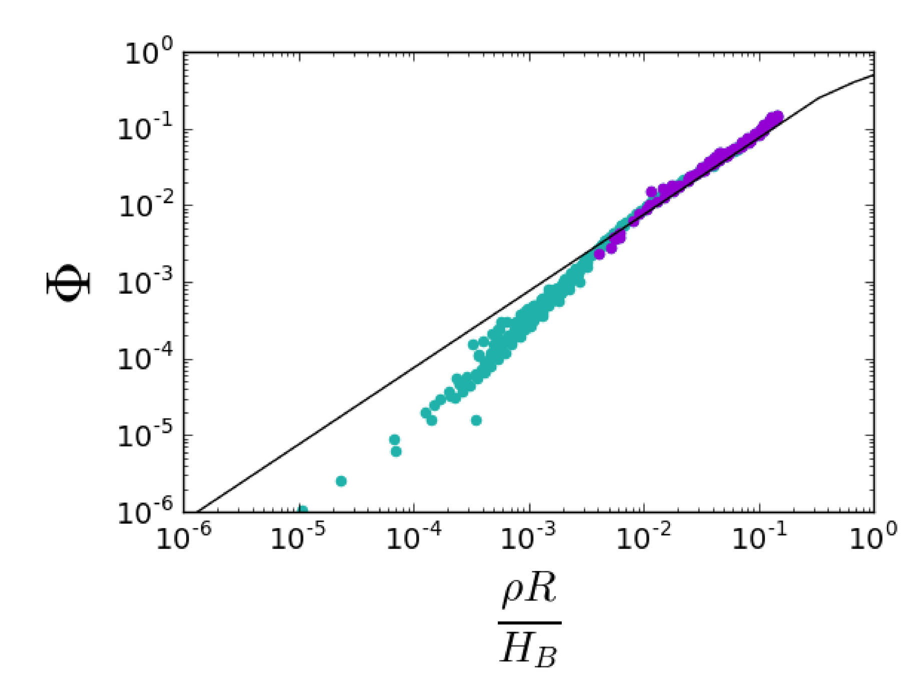
Absorbed fraction of alpha particles θ_α= alpha energy deposited into hot spot/ total alpha deposition in the domain before bang time. It is determined by calculating the Lagrangian trajectories of hot spot points back in time







In the burn propagation regime, the fuel burnup scales as expected with the hot spot temperature and areal density



$$\Phi = \frac{Yield}{N_{DT}(0)} = \frac{\rho R}{\rho R + H_B}$$

$$H_B \sim \sqrt{T}/\langle\sigma v\rangle$$