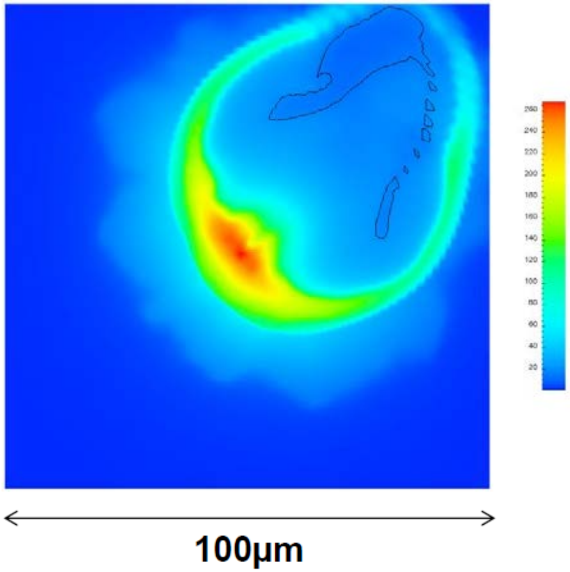
A Consolidated Picture of the Stagnated Fuel in Cryogenic Direct-Drive Implosions on OMEGA

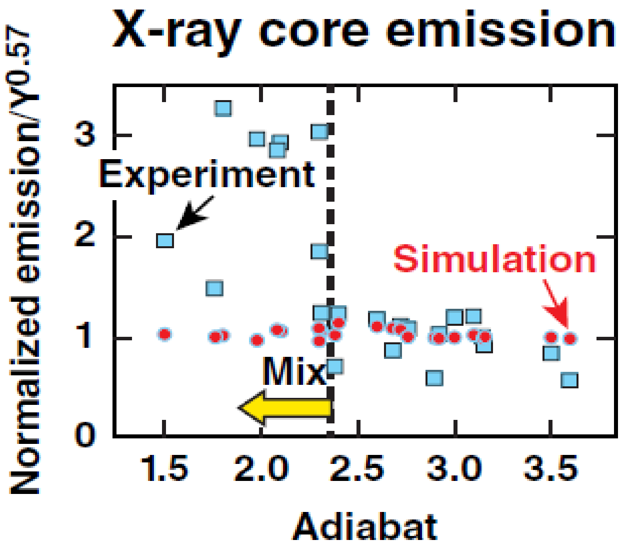
High adiabat ($\alpha > 3.5$)

Long wavelength modes



Low adiabat ($\alpha < 3.5$)

Long wavelength modes and short-scale mix



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Inferred hot spot pressure is lower than simulated for low-adiabat implosions ($\alpha < 3.5$)

- **Absolute pressures decrease with increasing calculated convergence or decreasing calculated adiabat**
  - **Hot spot radius is larger than simulated for low adiabat implosions (Marshall)**
  - **Significant T_{ion} variations are measured for all implosions (Knauer)**
  - **Experimental neutron rate is truncated relative to simulation for all implosions**
  - **Normalized emission from the core increases with decreasing calculated adiabat**
- **A number of hypotheses have been proposed**
  - **long wavelength asymmetries [laser beam imbalances] - high and low adiabat**
  - **Too much mass in the hot spot prior to deceleration [short scale mix due to imprint/jets; relaxation at inner boundary due to secondary shocks, EOS errors] – high and low adiabat**
  - **Incoming shell density is too low (ineffective piston) [imprint growth at ablation front] – low adiabat**
- **Measurements addressing each hypothesis are in progress**

Hotspot pressure is the primary metric of OMEGA direct-drive cryogenic target performance

- **Hotspot pressure is derived from observations**

$$\text{Yield}= \int_{\Delta t_{\mathrm{burn}}} dt \int_{V_{hs}} n_D n_T < \sigma v > dV$$

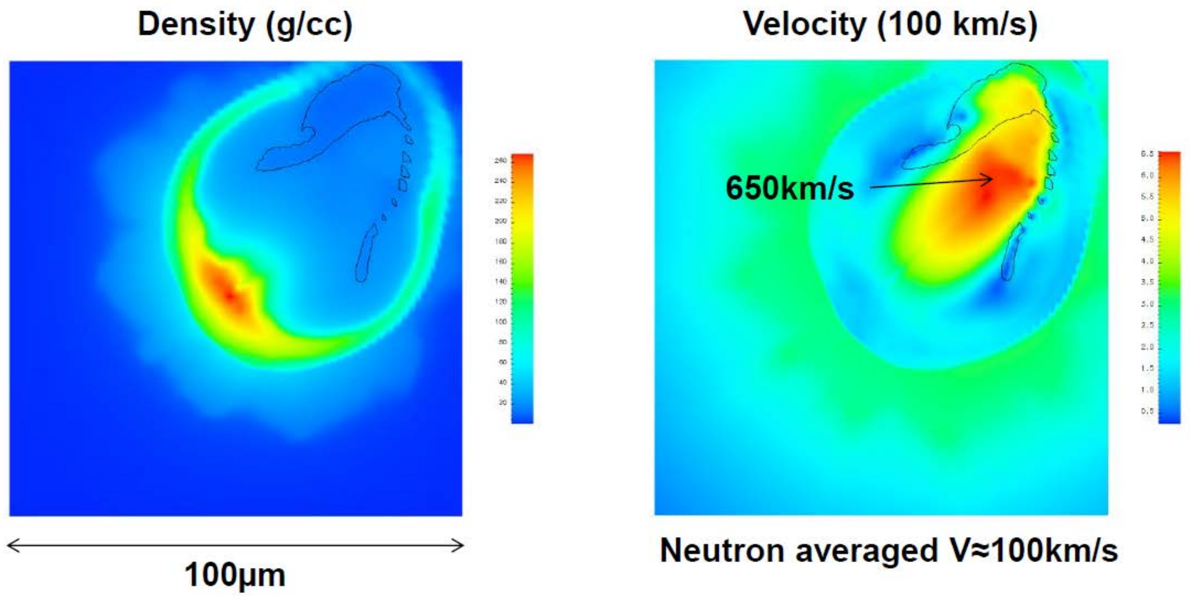
$$\underbrace{\text{Yield}}_{\text{Measured yield}} \sim \underbrace{n_D n_T T^2}_{p_{hs}^2} \underbrace{\left(\int_{V_{hs}} \frac{<\sigma v>}{T^2} dV\right)}_{\text{Depends on measured } T_i \text{ and } V_{hs}} \underbrace{\Delta t_{\mathrm{burn}}}_{\text{Measured burnwidth}}$$

- **The highest pressure to date is P_{hs}=56±7 Gbar to be compared to the simulated value of 80 Gbar. C_r < 17 and α > 3.5 proceed close to 1-D.**

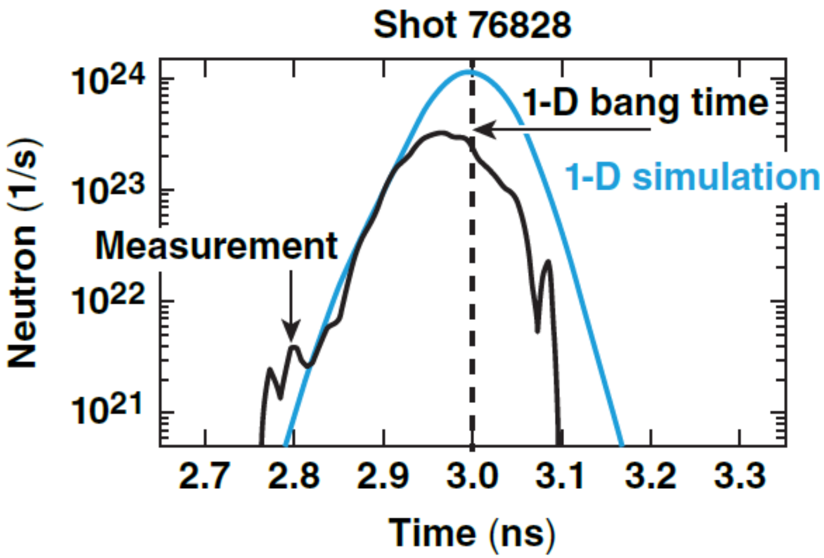
- **DD requires P_{hs} > 120 Gbar; C_r > 22; α =1.5-3**

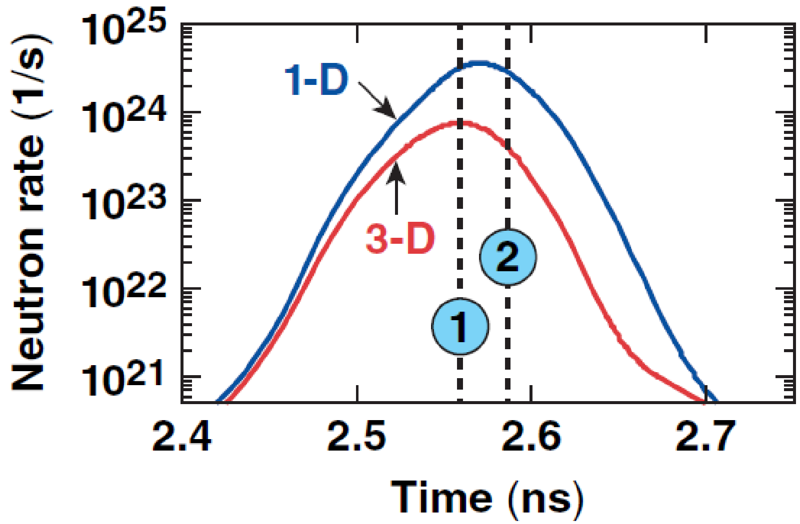
Multidimensional effects are believed to be primarily responsible for pressure degradation in high adiabat implosions

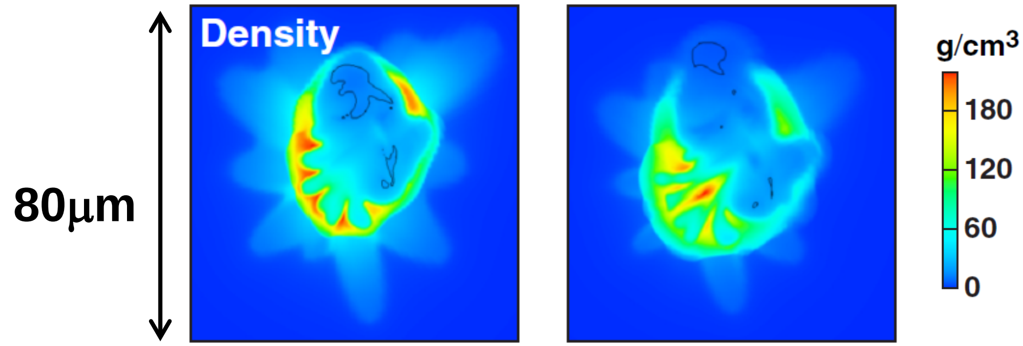
- **Multidimensional effects (result in RKE in addition to 1D)**
  - **- Beam-to-beam variations – T_{ion} variations, burn truncation**
  - **- Target offset – T_{ion} variations**
  - **- Isolated defects, stalk/glue etc. – burn truncation**



Measurements show earlier peak burn and burn truncation







Additional performance degradation in low-adiabat implosions is from short-scale mix

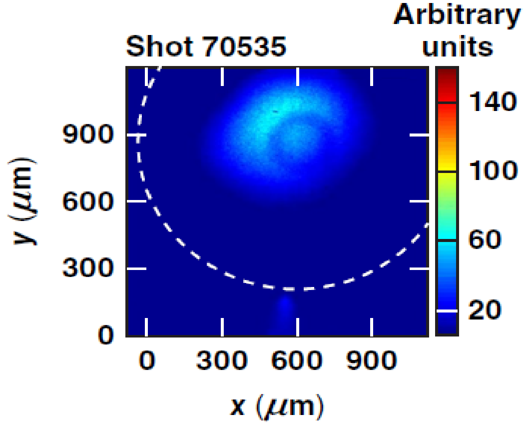
- **1D effects (speculative)**
  - Is the density of the incoming shell low (shock mistiming, preheat?)
  - Is there more mass in the hotspot from 1D effects? (excess emission from hotspot)

- **Multidimensional effects**
  - Beam-to-beam variations – T_{ion} variations, burn truncation
  - Target offset – T_{ion} variations
  - Isolated defects, stalk/glue etc. – burn truncation, excess emission from hotspot
  - Laser imprint – ineffective piston, more mass in the hotspot – excess emission from hotspot

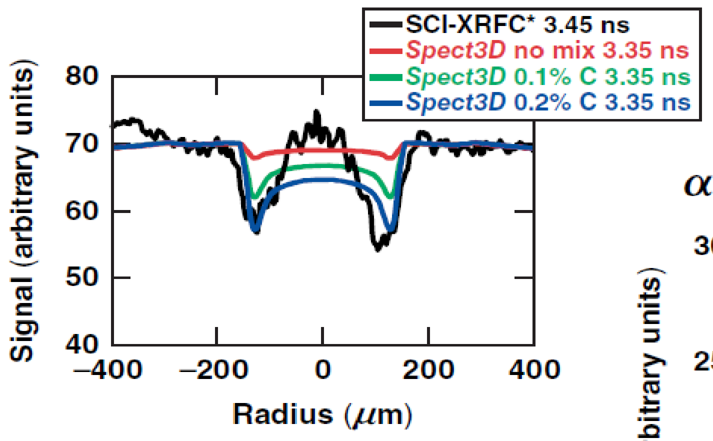
Additional performance degradation for low-adiabat implosions is caused by short-scale mix at the ablation front

- Observables that give clues on degradation mechanisms: evidence of mix in low-α implosions

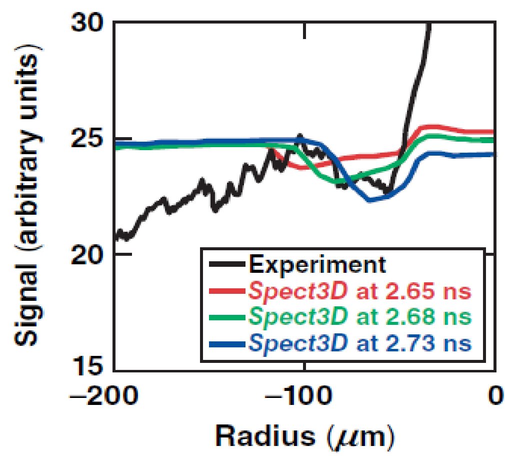
Cryo backlighting



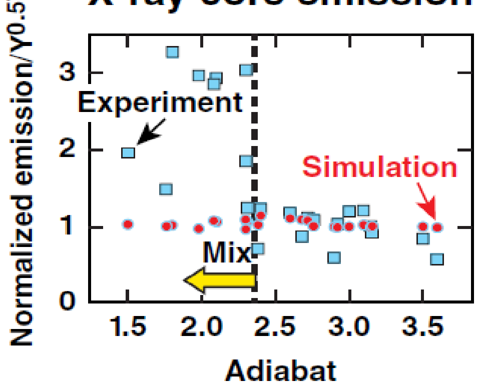
α = 2.5



α = 4, no evidence of mix



X-ray core emission



*SCI-XRFC: spherical crystal imager x-ray framing camera