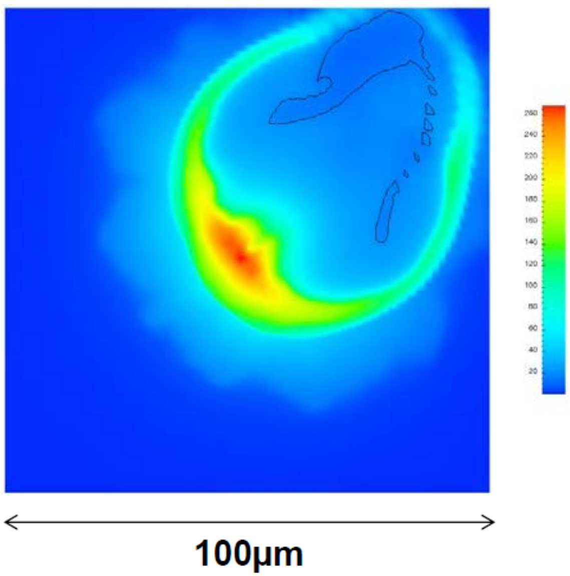
# A Consolidated Picture of the Stagnated Fuel in Cryogenic Direct-Drive Implosions on OMEGA

UR LLE

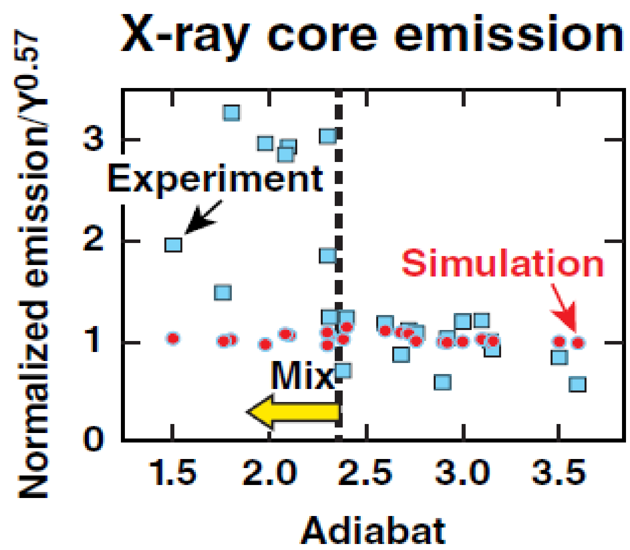
**High adiabat ($\alpha > 3.5$)**

**Long wavelength modes**




**Low adiabat ($\alpha < 3.5$)**

**Long wavelength modes and short-scale mix**




**P. B. Radha**
**Laboratory for Laser Energetics**
**University of Rochester**

**National Implosion Stagnation Physics Group**
**March 8-9, 2016**
**Lawrence Livermore National Labs CA**

# 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
- 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**

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

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

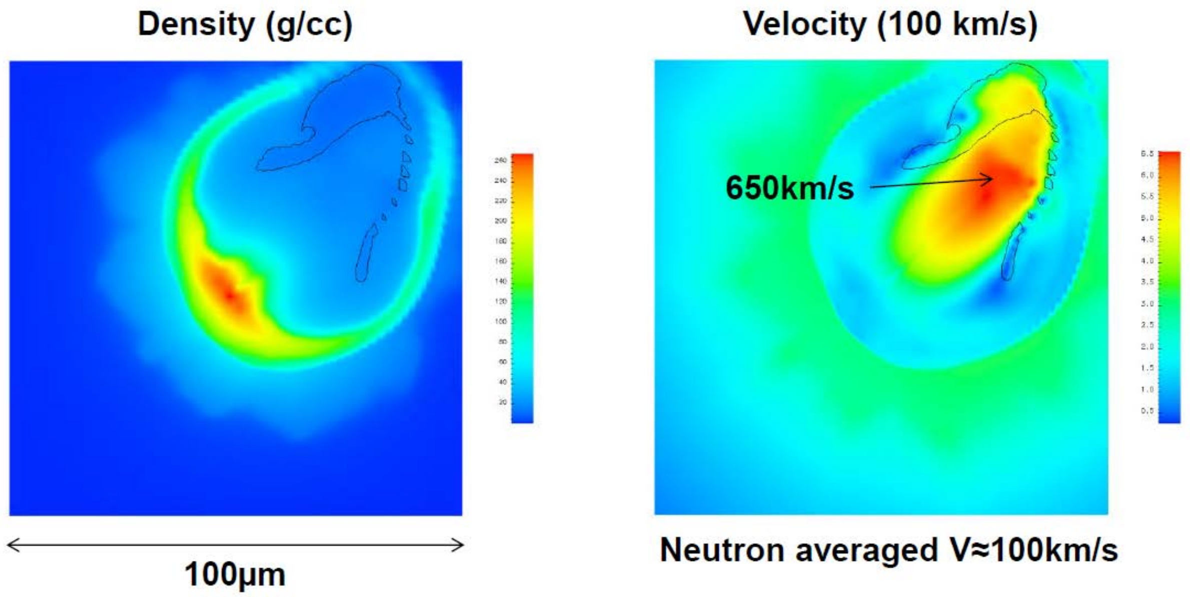
Measured yield | $p_{hs}^2$ | Depends on measured $T_i$ and $V_{hs}$ | Measured burnwidth

- **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 $\alpha$ > 3.5 proceed close to 1-D.**

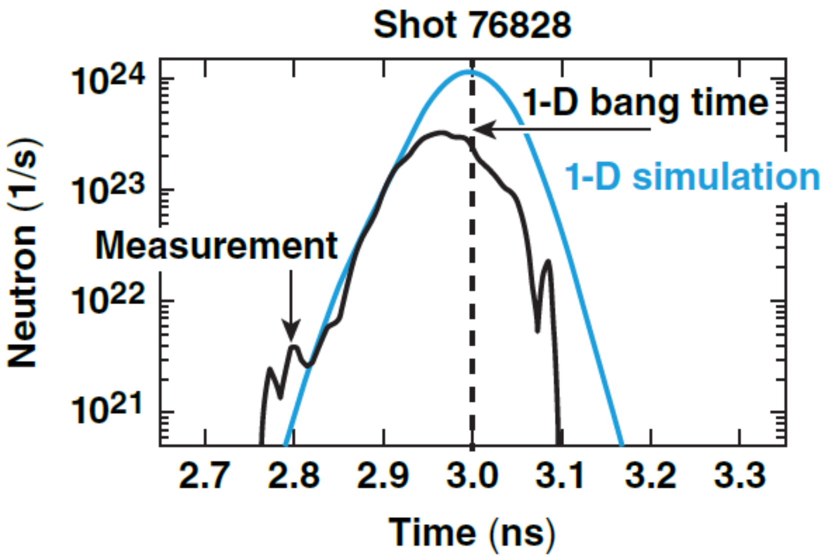
- **DD requires $P_{hs}$ > 120 Gbar; $C_r$ > 22; $\alpha$ =1.5-3**

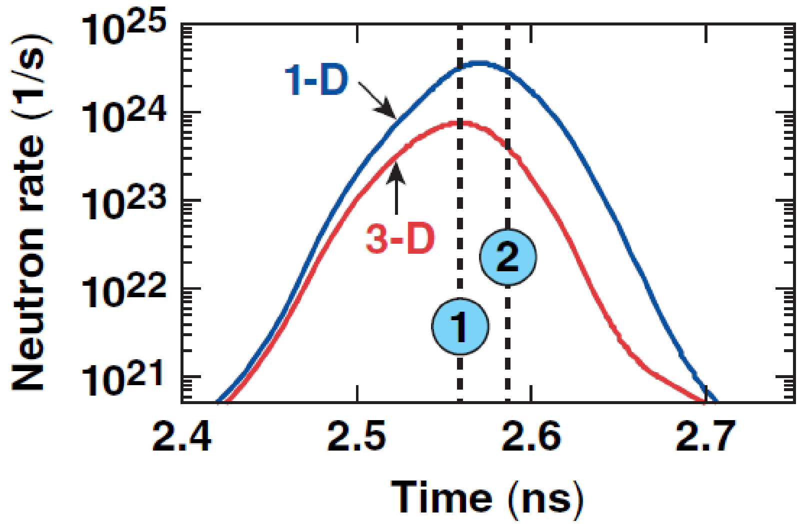
# Multidimensional effects are believed to be primarily responsible for pressure degradation in high adiabat implosions

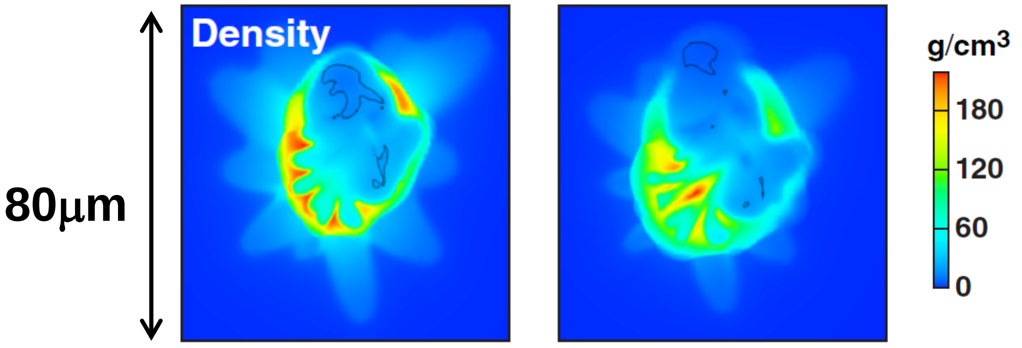
- **Multidimensional effects (result in RKE in addition to 1D)**
  - **- Beam-to-beam variations – $T_{ion}$ variations, burn truncation**
  - **- Target offset – $T_{ion}$ variations**
  - **- Isolated defects, stalk/glue etc. – burn truncation, excess emission from hotspot**



# 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**

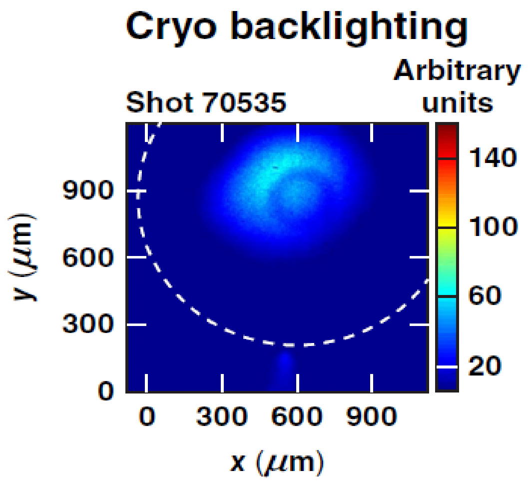
  **- Target offset – $T_{ion}$ variations**

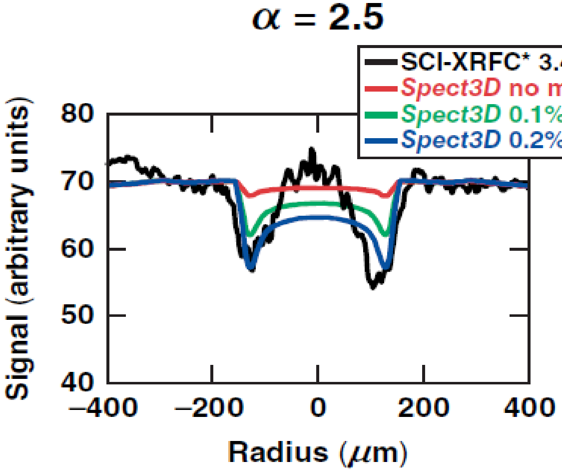
  **- Isolated defects, stalk/glue etc. – burn truncation, excess emission from hotspot**

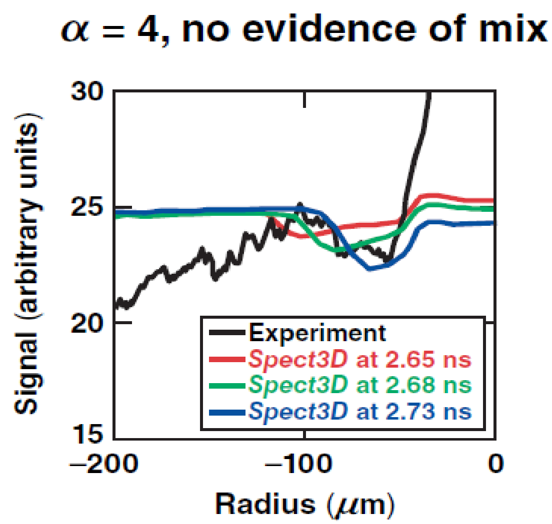
  **- Laser imprint – ineffective piston, more mass in the hotspot – excess emission from hotspot**

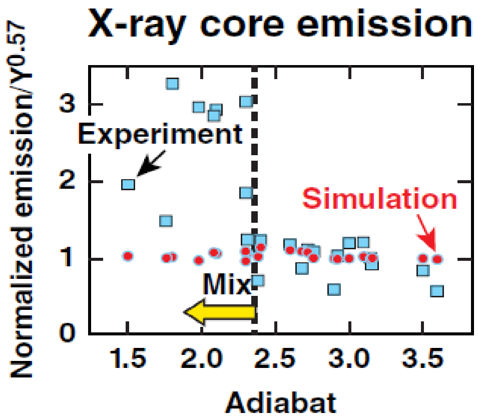
# Additional performance degradation for low-adiabat implosions is caused by short-scale mix at the ablation front

- Observables that give clues on degradation mechanisms: evidence of mix in low-$\alpha$ implosions




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

TC12327