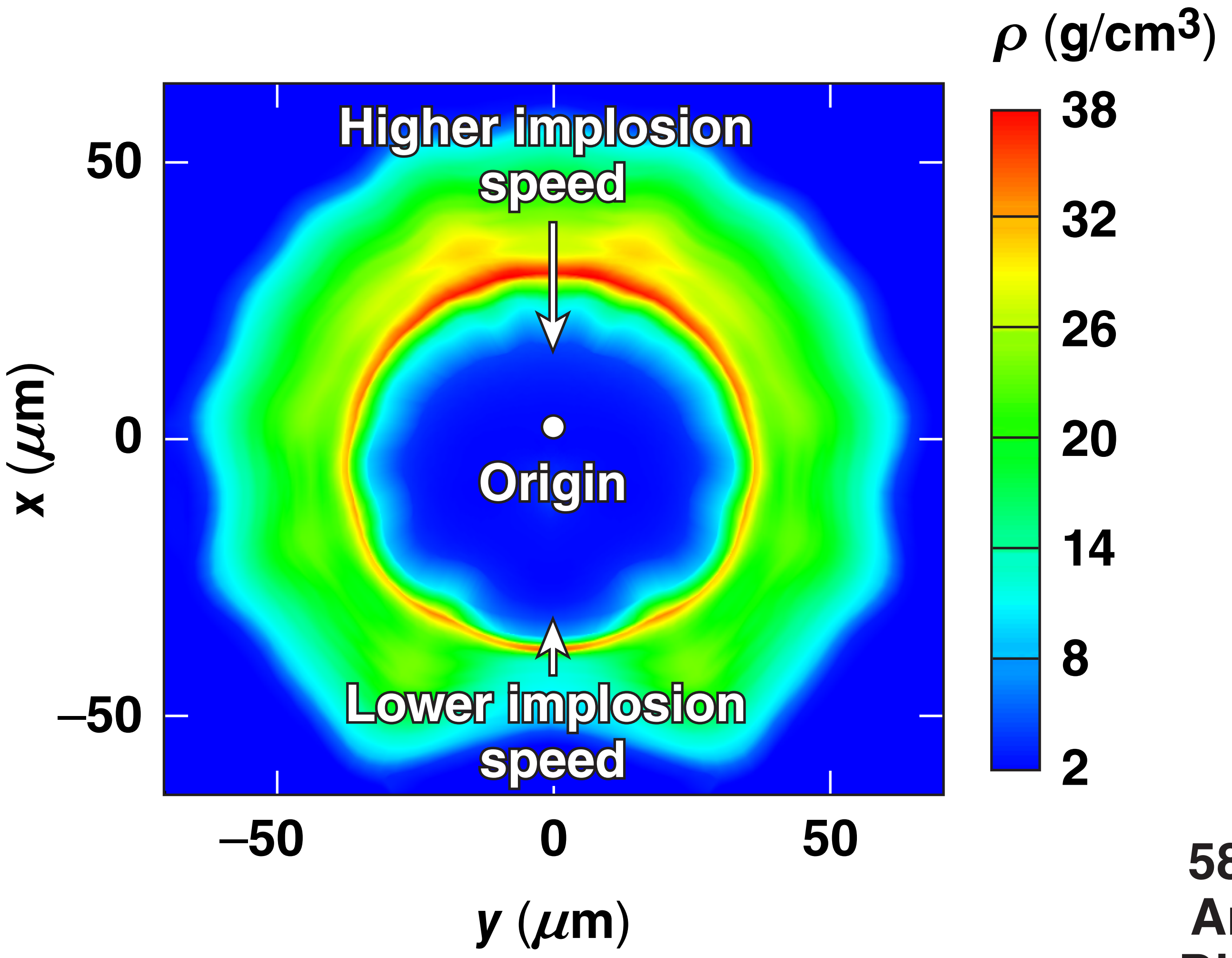
Investigation of Acquired Fuel Motion Caused by Ice Roughness in OMEGA Cryogenic Experiments



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Summary

Ice thickening near the target stalk is hypothesized to give rise to hot-spot velocities in OMEGA cryo targets

- Systemic hot-spot velocity is seen in cryo shots on OMEGA, not in room-temperature implosions
- We hypothesize that this is from a strong $\ell = 1$ mode (along the *z* axis) in the ice–gas interface
- *DRACO* simulations using measured ice-roughness parameters are able to replicate hot-spot velocity values seen in neutron time-of-flight (nTOF) diagnostics
- *DRACO* simulations predict increased performance by moving the target along the *z* axis to compensate for the ice-roughness $\ell = 1$ mode
  - this will be tested on OMEGA in February

TC12985

Collaborators

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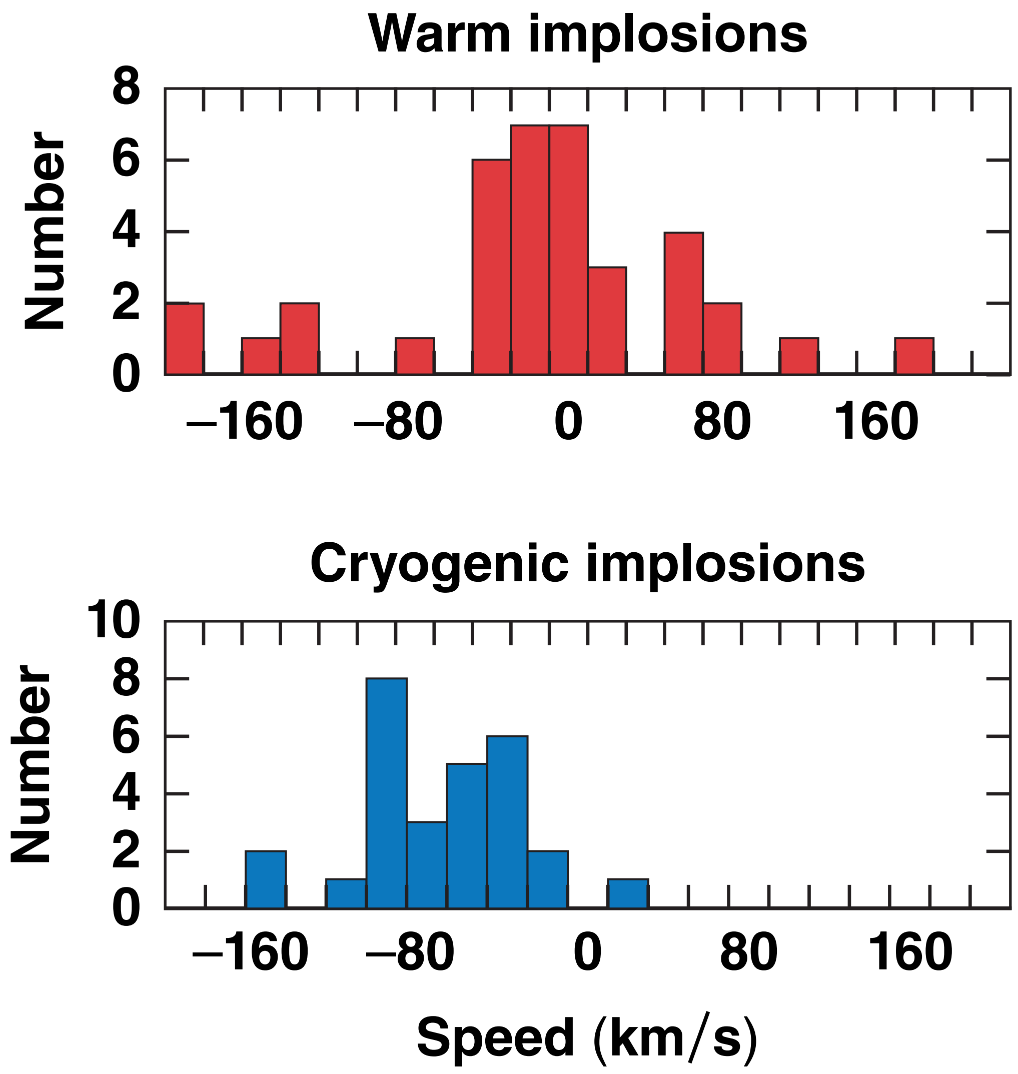
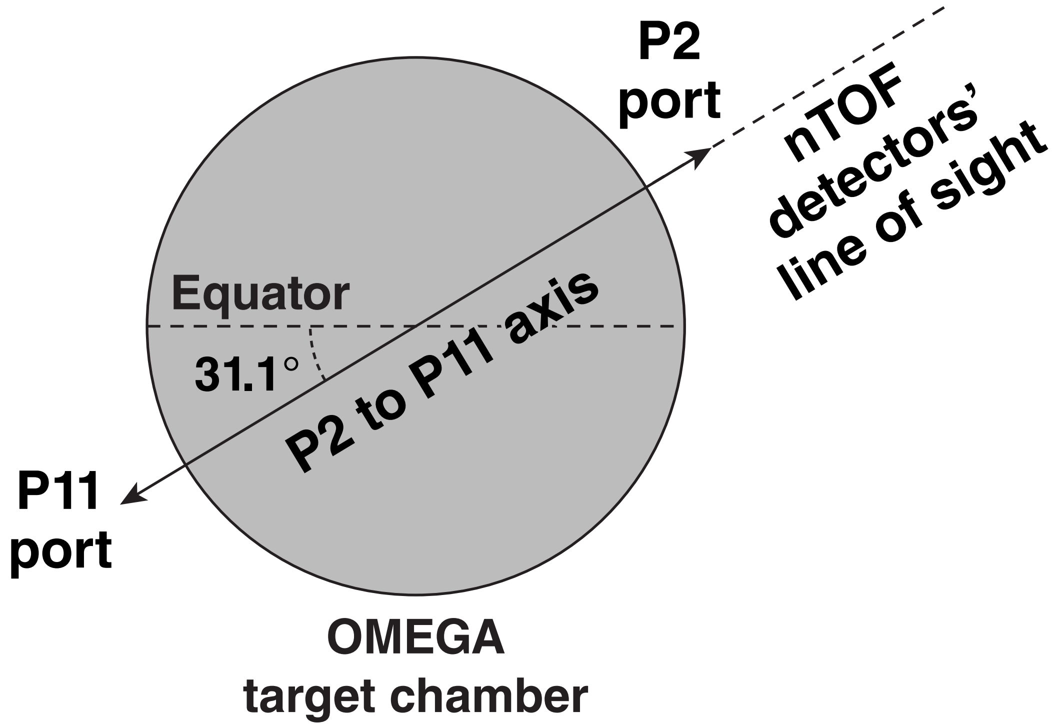
Histograms of speed along the P2 to P11 axis shows cryogenic implosions have a mean hot-spot velocity around –84 km/s



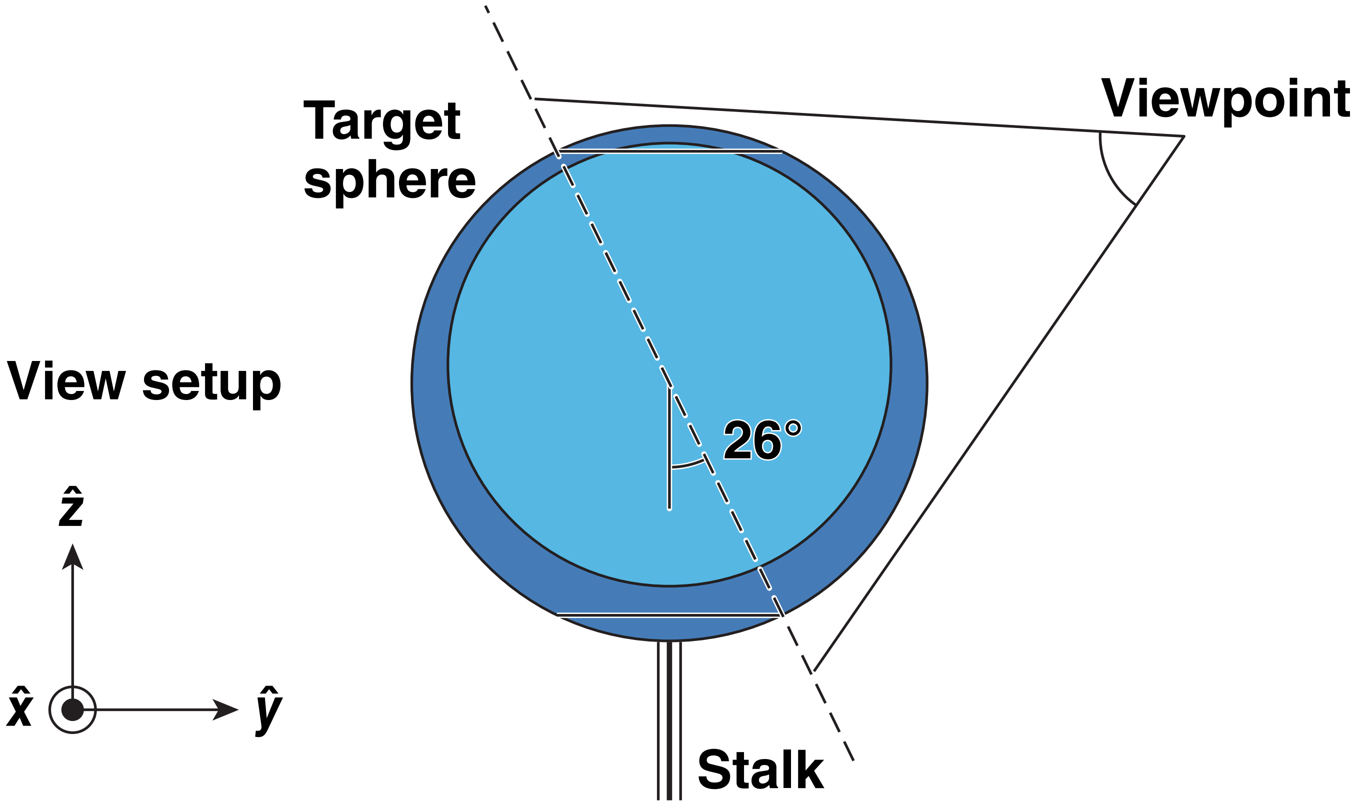


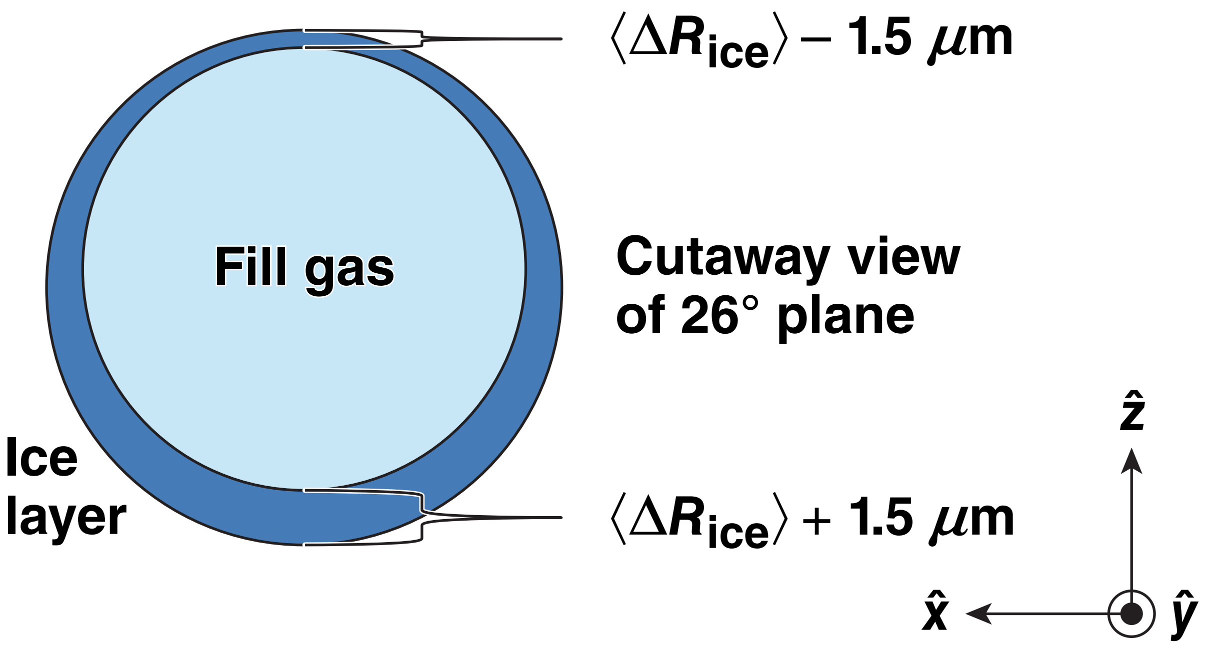
- Negative speed toward P11
- Red distribution for warm implosions
  – 37 total; mean = –26 km/s ±27 km/s
- Blue distribution for cryogenic implosions
  – 28 total; mean = –84 km/s ±27 km/s

TC12988

Ice roughness on the Laboratory for Laser Energetics (LLE's) layered targets have an apparent $\ell = 1$ mode as seen by the characterization stations from the 26° view plane

- Overall, ice thickness varies from –1.5 μm at ±26° from the north pole to +1.5 μm at ±54°
  - data obtained from the view plane that is 26° off-axis
  - it is unknown if ice roughness worsens or improves closer to the poles





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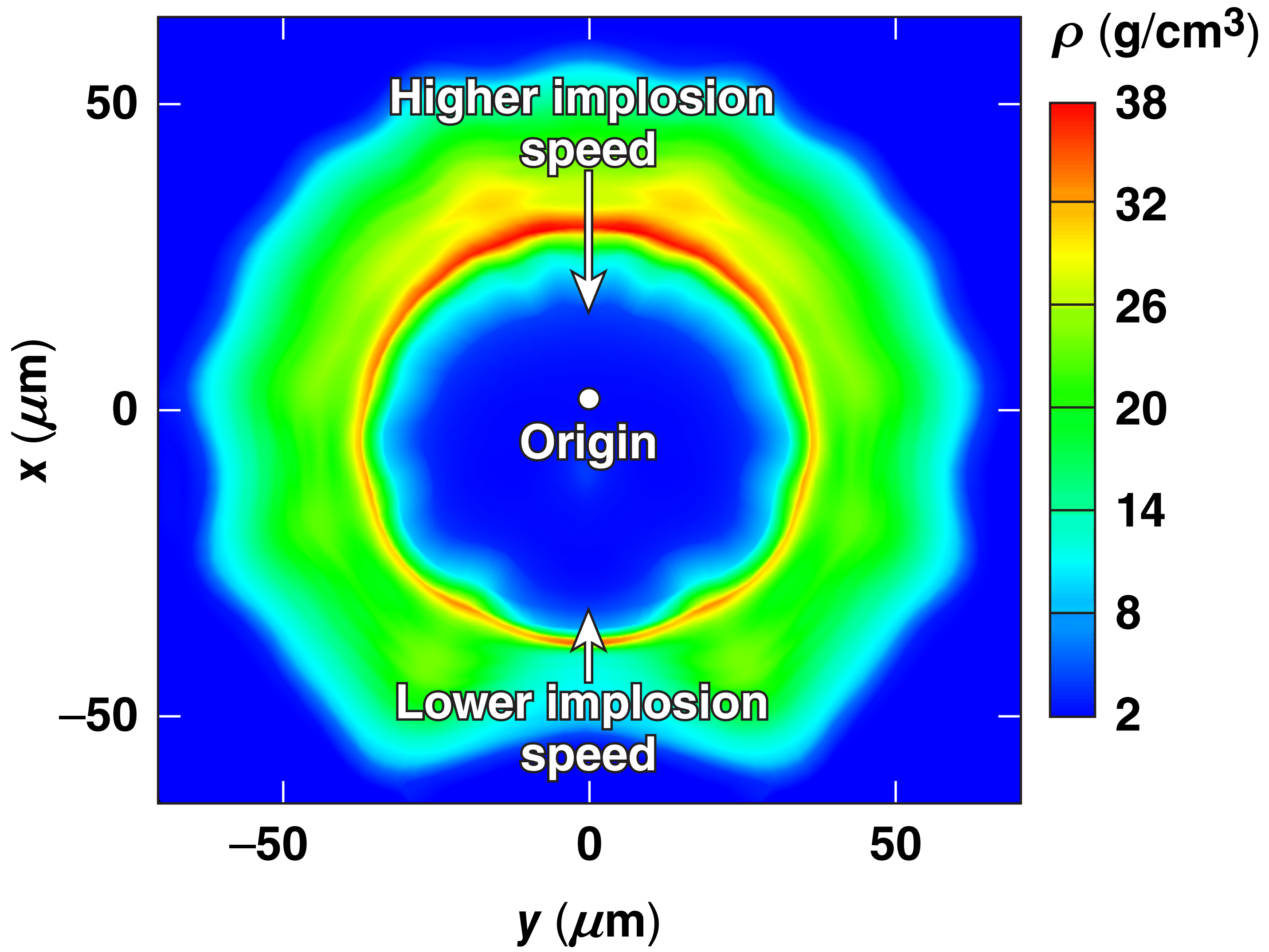
North–south ice-thickness asymmetry can cause performance degradation because of nonuniform convergence

- Thicker ice on the south pole compared to the north pole
  - causes the northern thinner shell portion to have higher implosion speed
- Asymmetric convergence will cause an overall velocity to be imposed on the hot spot
  - effect would be systematic for cryo shots
  - hot-spot velocity measureable with nTOF diagonostics



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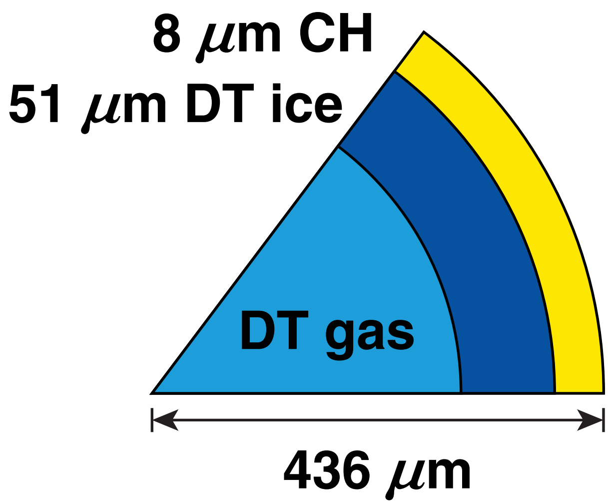
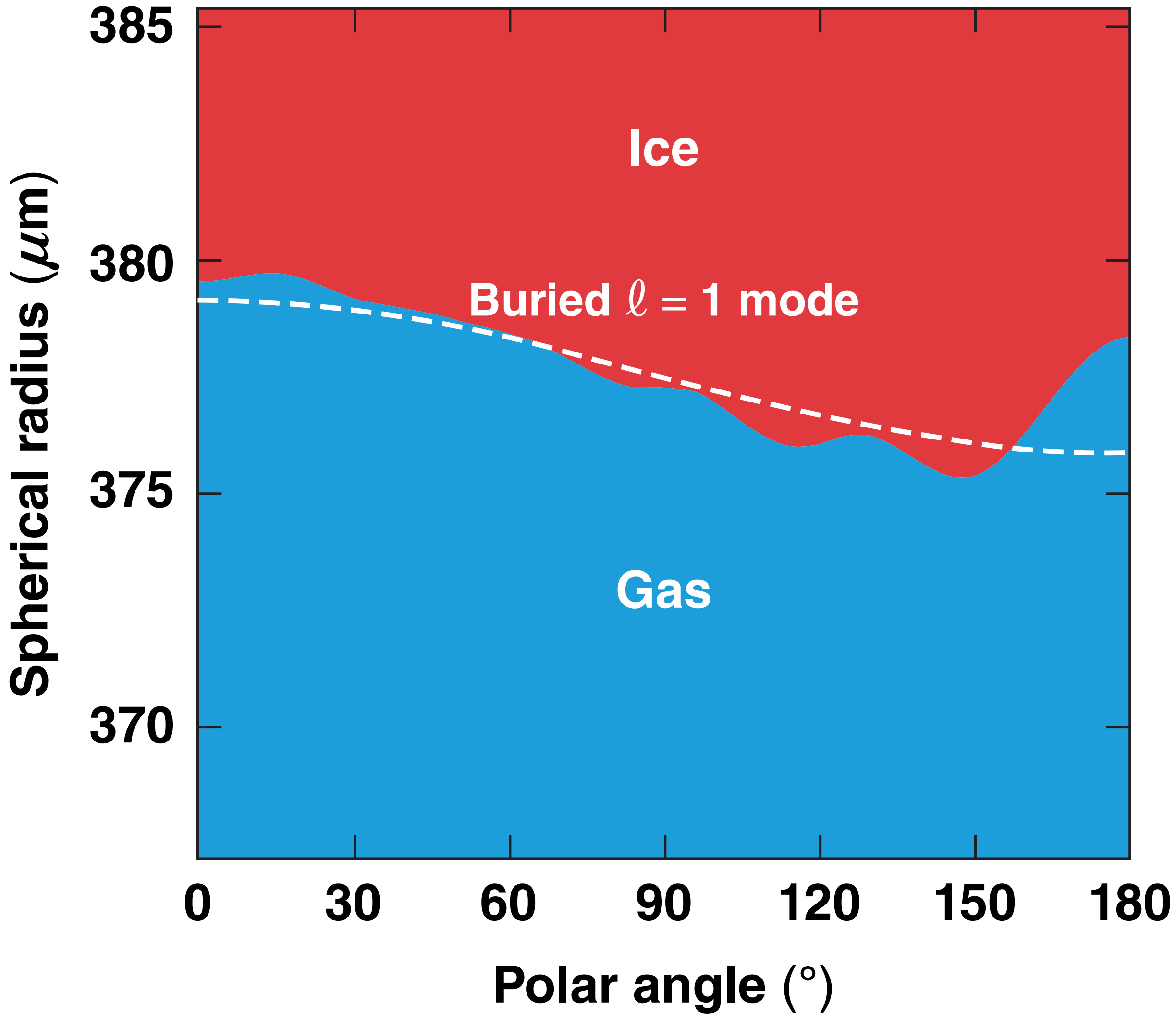
To simulate the effect of ice thickening near the stalk, the $\ell = 1$ mode of a 0.83-rms ice-roughness spectrum was modified

- Modes modeled go up to $\ell = 13$
- The $\ell = 1$ mode was modified so that the overall ice roughness would meet the measured parameters
  - $R_{\text{interface}} = \langle R_{\text{gas}} \rangle - 1.5\ \mu\text{m}$ at $\theta = \pm 26°$
  - $R_{\text{interface}} = \langle R_{\text{gas}} \rangle + 1.5\ \mu\text{m}$ at $\theta = \pm 154°$
  - this results in a ~3× increase of the original $\ell = 1$ mode amplitude





rms: root mean square

TC12989

Observed hot-spot speed toward P11 can be reproduced with *DRACO* flux-limited, cryo simulations that include the $\ell = 1$ mode shown previously

- Hot-spot velocity along the *z* axis was obtained using the formula

$$\langle v_{n,z} \rangle = \frac{\iiint_0^\infty v_z \mathring{Y}_n r\,dr\,dz\,dt}{\iiint_0^\infty \mathring{Y}_n r\,dr\,dz\,dt}$$

- nTOF measurements show a systematic 84-km/s average hot-spot velocity toward P11 for cryogenic shots
- A prediction of 74 km/s toward P11 is obtained with *DRACO* flux-limited simulations that include the $\ell = 1$ mode shown previously
- In general, an implosion speed is obtained if the ice roughness is dominantly low mode and uniformly illuminated

TC12990

These perturbations can be corrected with the nTOF measurements serving as a litmus test

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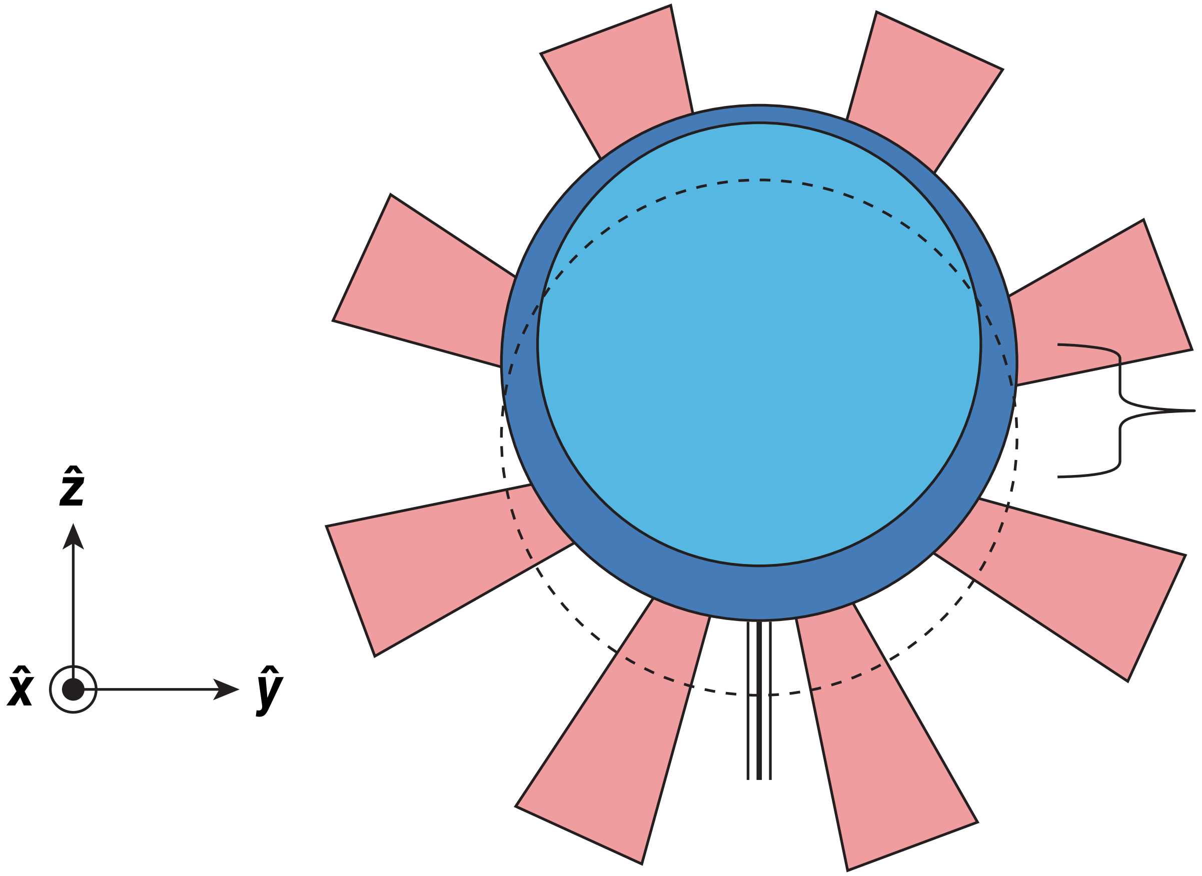
- **Repositioning the target in z (z_{comp}) can redistribute laser energy from the thinner to the thicker ice layer to compensate for developing asymmetries**
  - **this will cause the nTOF measured hot-spot velocity to decrease**



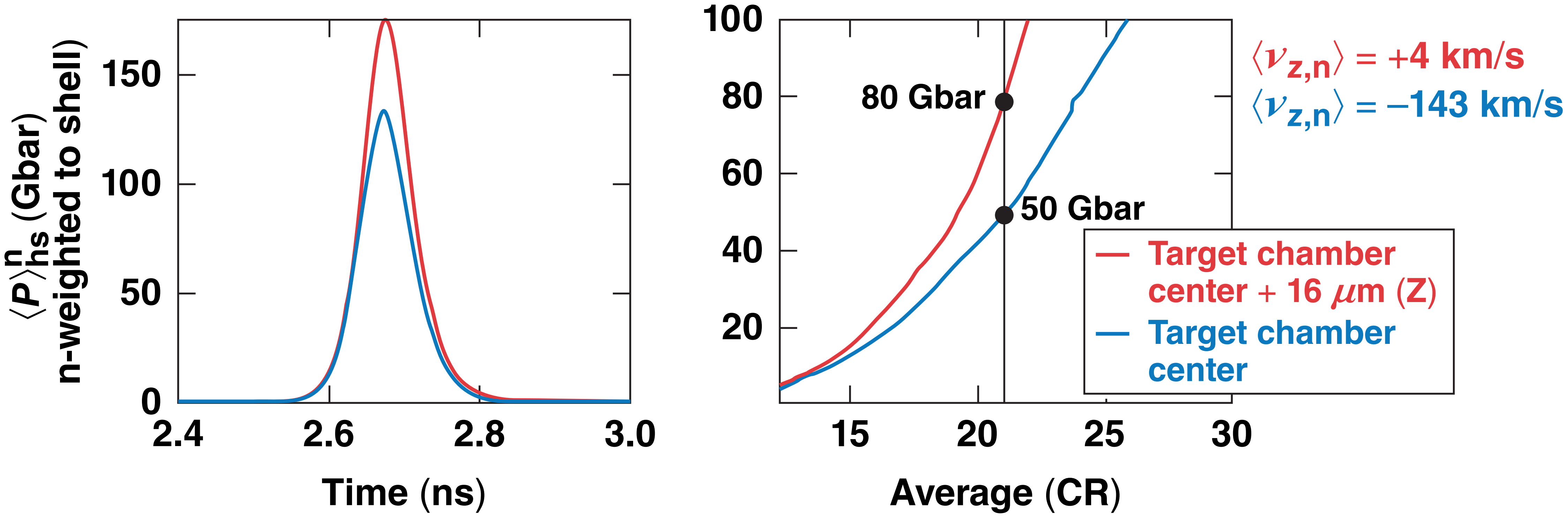
Apply z_{comp} to counteract asymmetric ice roughness and have $\langle \nu_{n,z} \rangle \longrightarrow 0$

TC12991

Target performance is expected to increase given enough z_{comp}

- A decrease in hot-spot velocity implies a rounder implosion
  - this results in increased target performance [e.g., increased hot-spot pressure for the same convergence ratio (CR)]

Hot-spot evolution



Simulations suggest that using a z_{comp} = +16 μm can improve $\langle P \rangle^{n}_{hs}$ from 50 Gbar to 80 Gbar for the same CR.

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