Parametric Study of Direct-Drive Fuel-Assembly Simulations of Fast-Ignition Cone-in-Shell Targets

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The performance of cone-in-shell fuel-assembly implosions is sensitive to cone geometry

- The temporal difference between cone-tip shock-breakout time ($t_{sb}$) and the time of 90% peak $\rho R$ ($t_{90}$) provides a good figure-of-merit for system performance ($\Delta t = t_{90} - t_{sb}$)
  - insensitive to cone opening angle ($\pm 20$ ps)
  - sensitive to cone-tip offset ($\pm 50$ ps)
  - very sensitive to cone-tip thickness ($\pm 100$ ps)

- Optimal cone geometry will be determined by integrated DRACO-LSP* simulations

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Collaborators

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Multiparameter studies characterized the performance of OMEGA CD implosions for various cone-tip geometries.

- Parameters
  - cone angle (12° to 35° half angle)
  - cone-tip offset from target center (40 to 70 μm)
  - cone-tip thickness (5 to 25 μm)
The temporal difference ($\Delta t$) between the shock breakout on the inside of the cone tip ($t_{sb}$) and the time of 90% peak $\rho R$ ($t_{90}$) provides a good figure-of-merit for system performance ($\Delta t = t_{90} - t_{sb}$).

- Fast-electron beam should be injected before $t_{sb}$
- Variations in $\Delta t$ in the parameter space show the effect of cone geometry on timing
Studies examine warm mass-equivalent targets emulating ignition-scaled OMEGA cryogenic cone-in-shell capsules.

\[ E_L = 19.7 \text{ kJ} \]

\[ \text{Adiabat, } \alpha = 1.2 \]
The shock-breakout time inside the cone tip has been measured experimentally.
Target performance is evaluated by measuring the delay between the shock-breakout time in the cone tip and the time of 90% of peak $\rho R$

$t = t_{sb}$ represents the time the cone interior begins filling with plasma.
The shock-breakout time ($t_{sb}$) depends highly on cone-tip thickness, but only moderately on tip offset.
The shock-breakout time ($t_{sb}$) depends highly on cone-tip thickness; moderately on tip offset.

\[ \Delta t = t_{90} - t_{sb} \]

- Cone-tip thickness (\(\mu m\))
- Cone-tip offset (\(\mu m\))
- Cone angle (\(^\circ\))

Graph showing the relationship between shock-breakout time and cone-tip offset and angle.
Integrated *DRACO-LSP* simulations indicate significant coupling of hot-electron energy to the fuel assembly.

Snapshots at $t = 6$ ps after the beginning of the e-beam

- **Plasma density (g/cm$^3$)**
- **Electron-beam density ($\times 10^{21}$ cm$^{-3}$)**
- **Max. plasma temperature increase (keV)**
- **Azimuthal magnetic field (MG)**

55% of hot-electron energy couples to fuel assembly at density greater than 80 g/cc.

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  - insensitive to cone opening angle \( \pm 20 \text { ps} \)
  - sensitive to cone-tip offset \( \pm 50 \text { ps} \)
  - very sensitive to cone-tip thickness \( \pm 100 \text { ps} \)

- Optimal cone geometry will be determined by integrated \textit{DRACO-LSP} \(^* \) simulations

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Future Work

- Optimization of beam configuration with 3-D ray trace (in progress)

- Optimization of yield with integrated fast-electron transport on integrated LSP-DRACO simulations

- Cryogenic and ignition design studies
Target performance is highly dependent on the cone-tip thickness

\[ \rho R_{sb} = \text{areal density at time of shock breakout in cone tip} \]
\[ \rho R_{\text{max}} = \text{maximum areal density} \]

\[ \rho R_{sb}/\rho R_{\text{peak}} \]