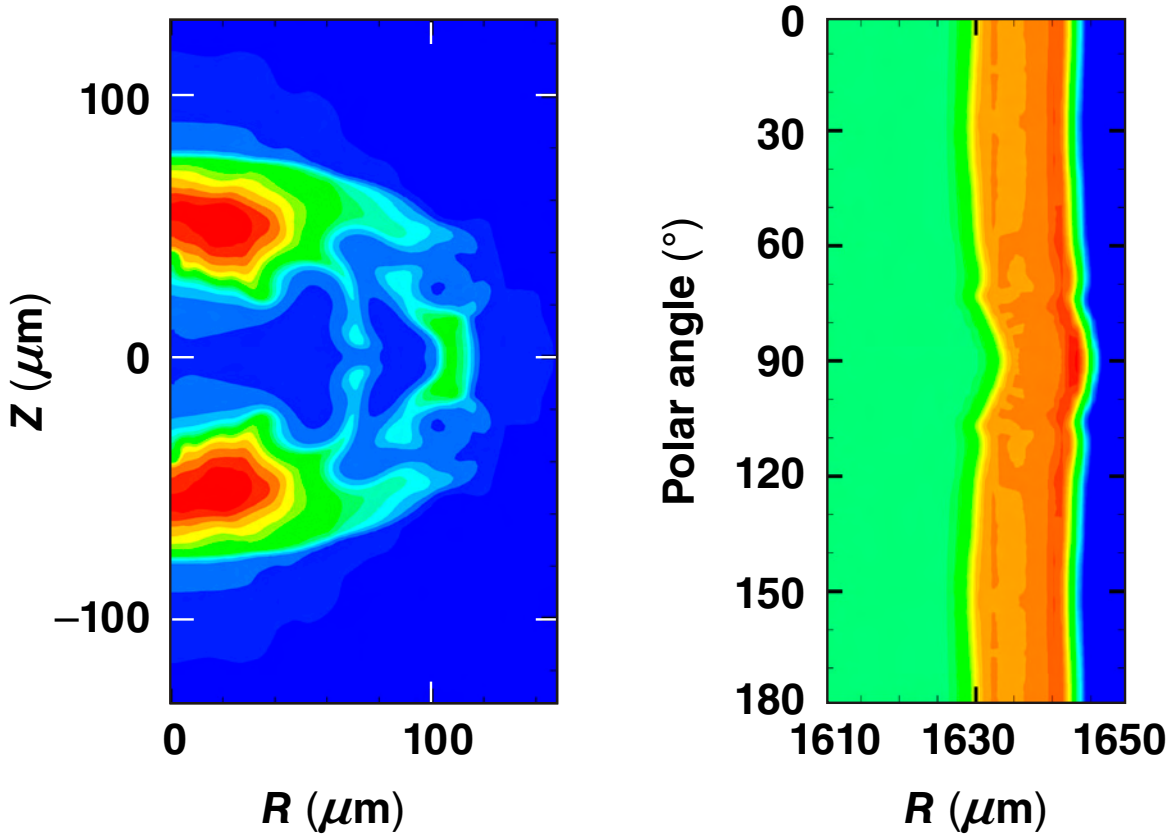
Multidimensional Numerical Investigation of NIF Saturn PDD Designs with 3-D Laser Ray Tracing



P. W. McKenty *et al.*
University of Rochester
Laboratory for Laser Energetics

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American Physical Society
Division of Plasma Physics
Orlando, FL
12–16 November 2007

Summary

DRACO simulations of Saturn ignition designs with CH ablators indicate localized early-time imprint

UR LLE

- Previous work involving DT ablator designs indicated very little deviation from 1-D target performance.
- Precision ablator conditioning may mitigate the effects of the early-time imprint.
- Modeling of ring plasma is critical for proper distribution of laser energy onto the target
- Work is underway to continue Saturn modeling using *HYDRA* with two- and three-dimensional simulations.

Collaborators

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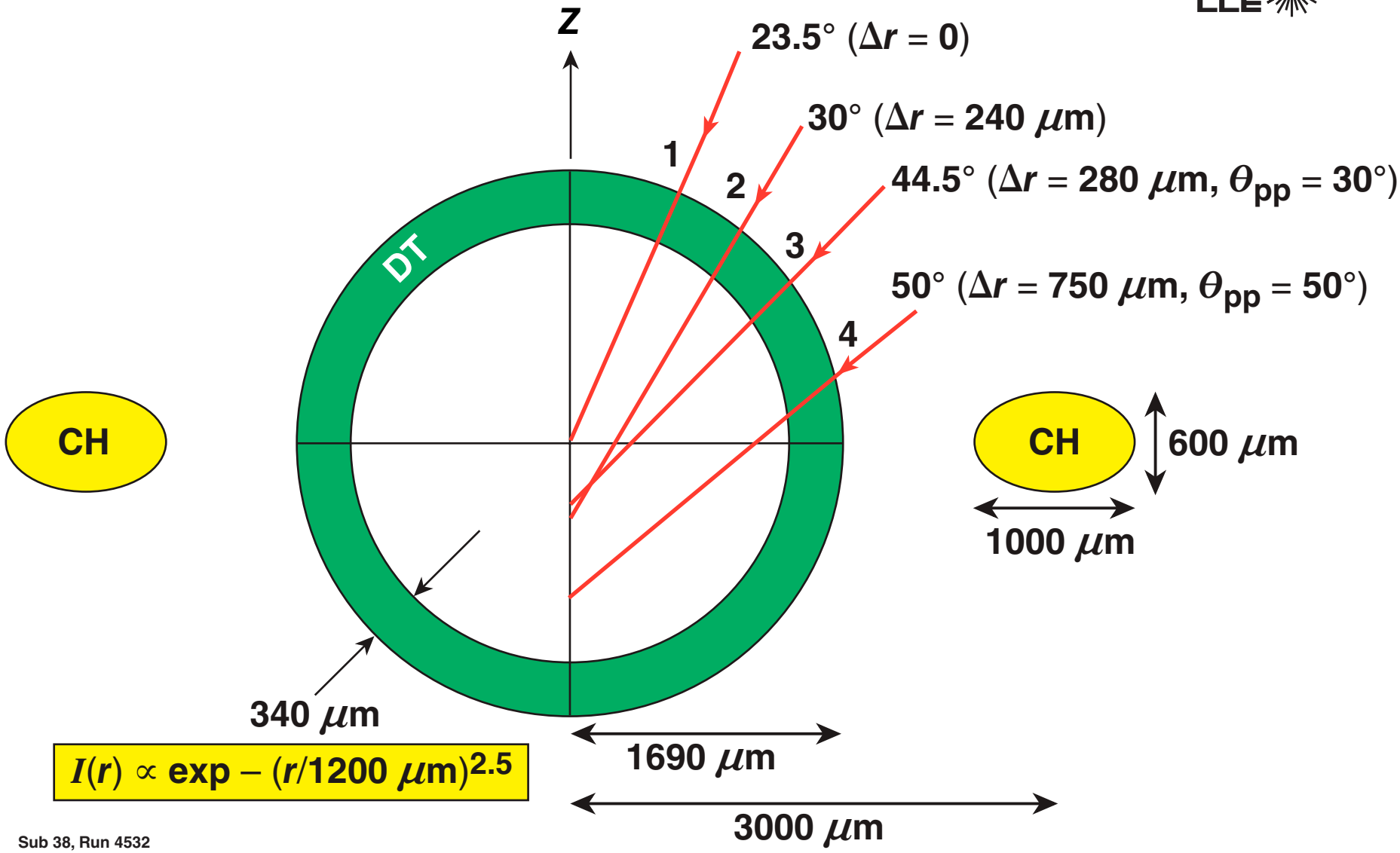
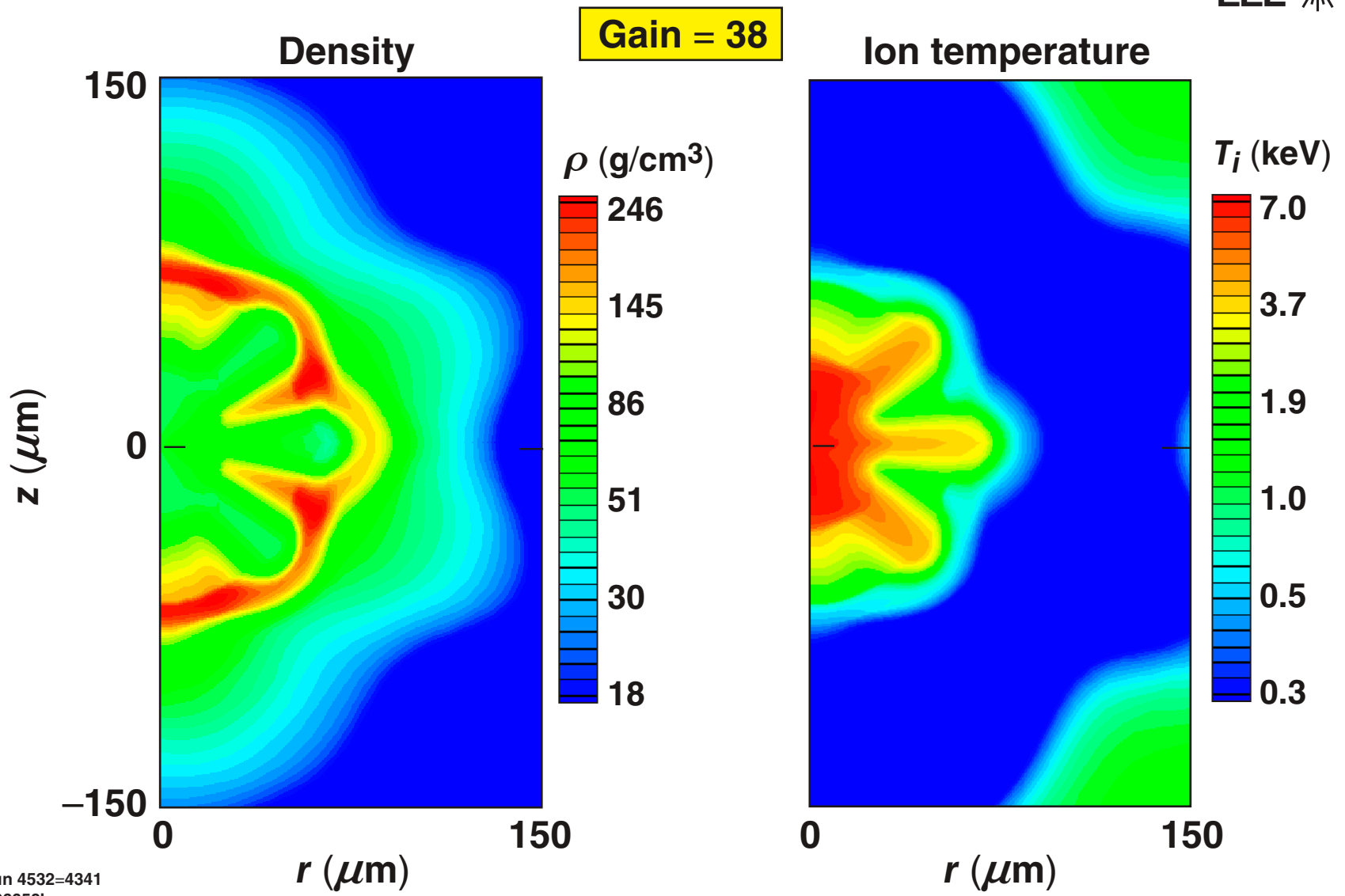
The Saturn design results from an optimization over many parameters*



Sub 38, Run 4532
TC6654

*R. S. Craxton *et al.*, Phys Plasmas 12, 056304 (2005).

Hybrid *SAGE*/*DRACO* runs indicated little deviation from 1-D target performance



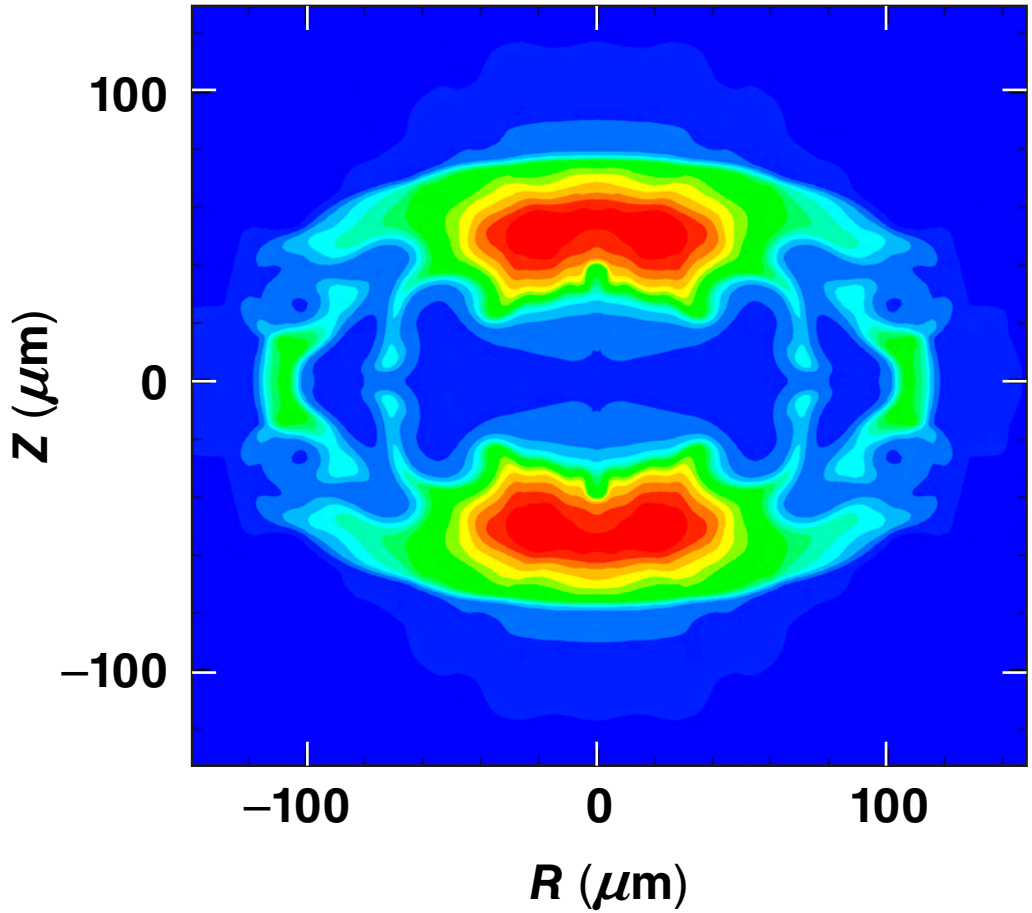
Run 4532=4341
TC6658b

Further validation of the Saturn Polar Drive concept required adaptation of the *DRACO* 2-D code and the eventual implementation of the *HYDRA* 3-D code

UR LLE

- *DRACO* 2-D
  - noise-free, high-resolution 3-D ray trace
  - sliding grid, Eulerian hydrodynamics
  - accurate modeling of refraction off of the Saturn ring
- *HYDRA* 3-D
  - advanced logical grids
  - estimation of *m*-mode contributions to target performance

Initial *DRACO* modeling of Saturn designs with 3-D ray trace resulted in large damaging trenches developing during the implosion

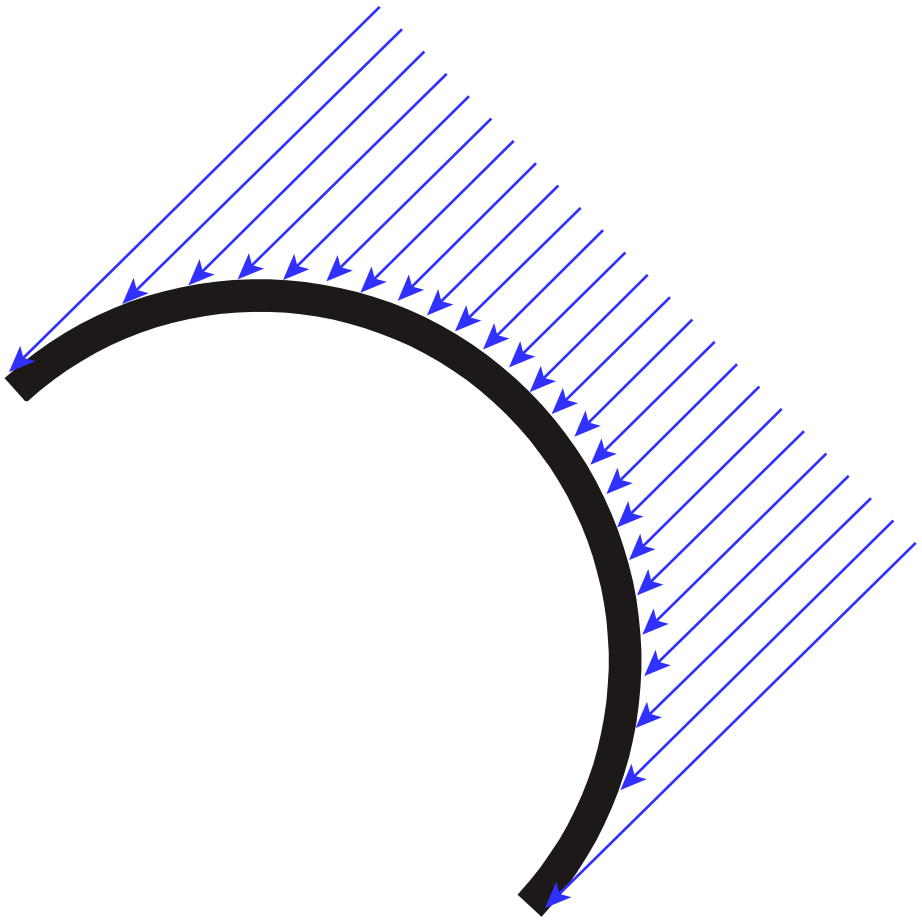


TC7967

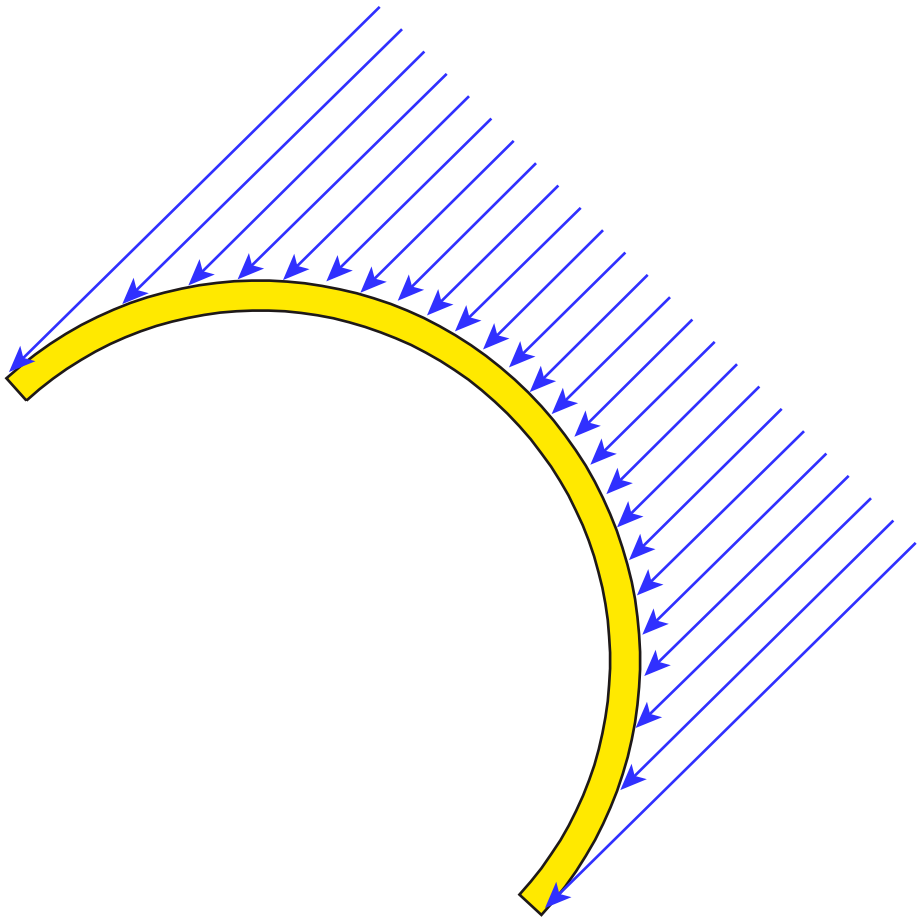
Perturbation trenches develop due to early-time imprint from refraction through emerging ring plasma

Perturbation trenches develop due to early-time imprint from refraction through emerging ring plasma

UR LLE



Perturbation trenches develop due to early-time imprint from refraction through emerging ring plasma



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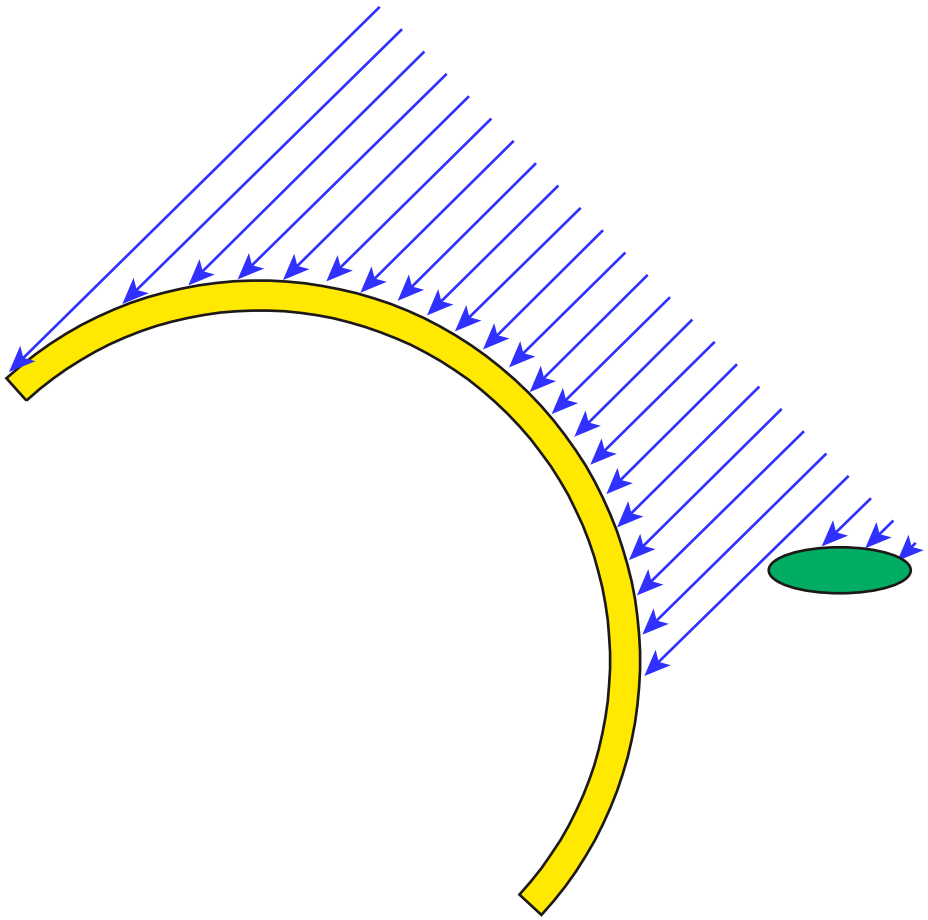

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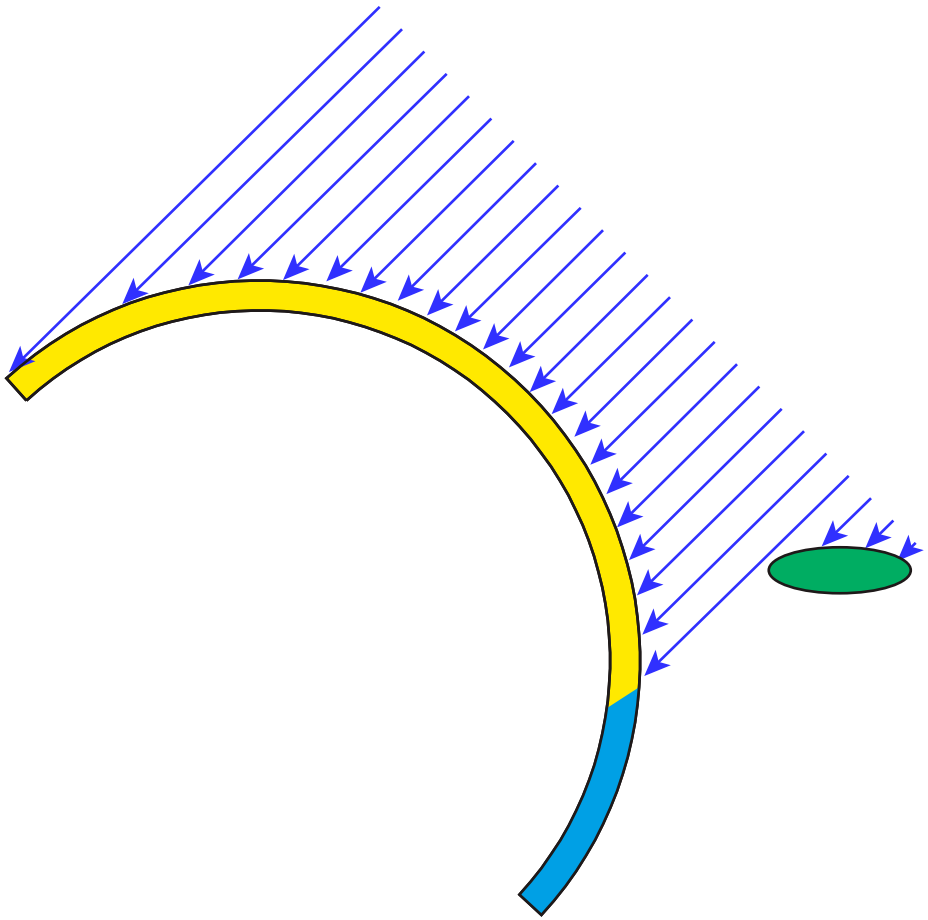

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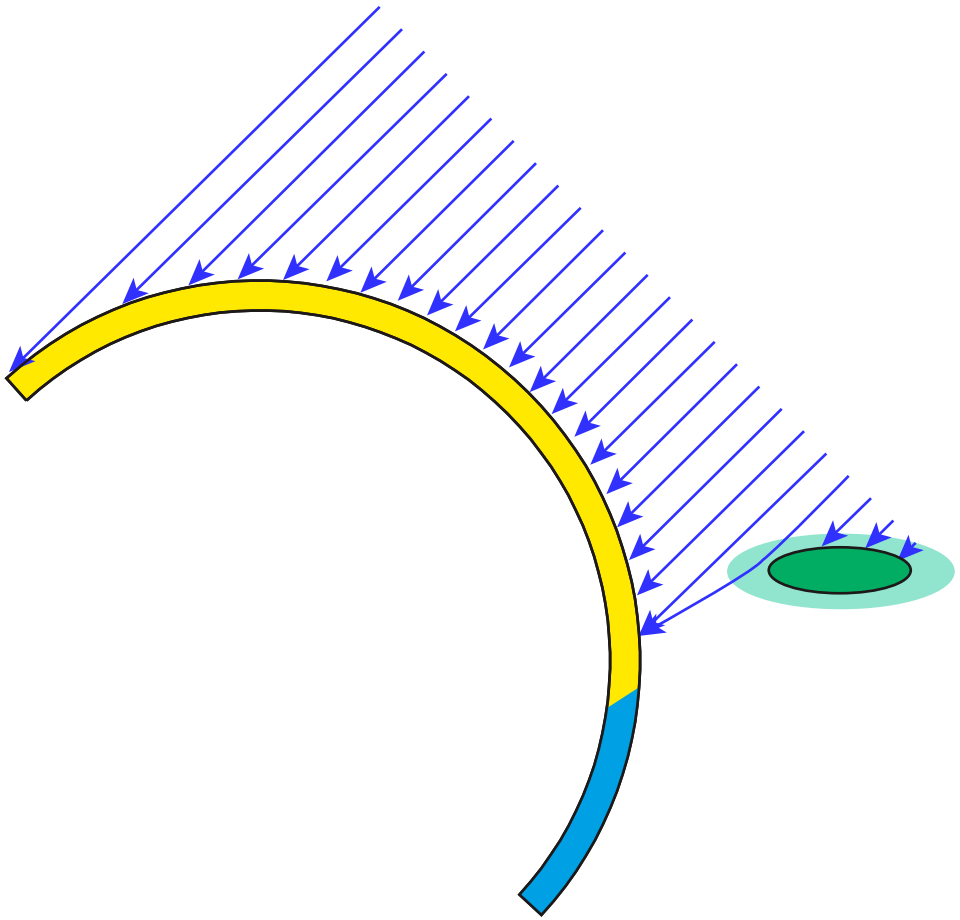

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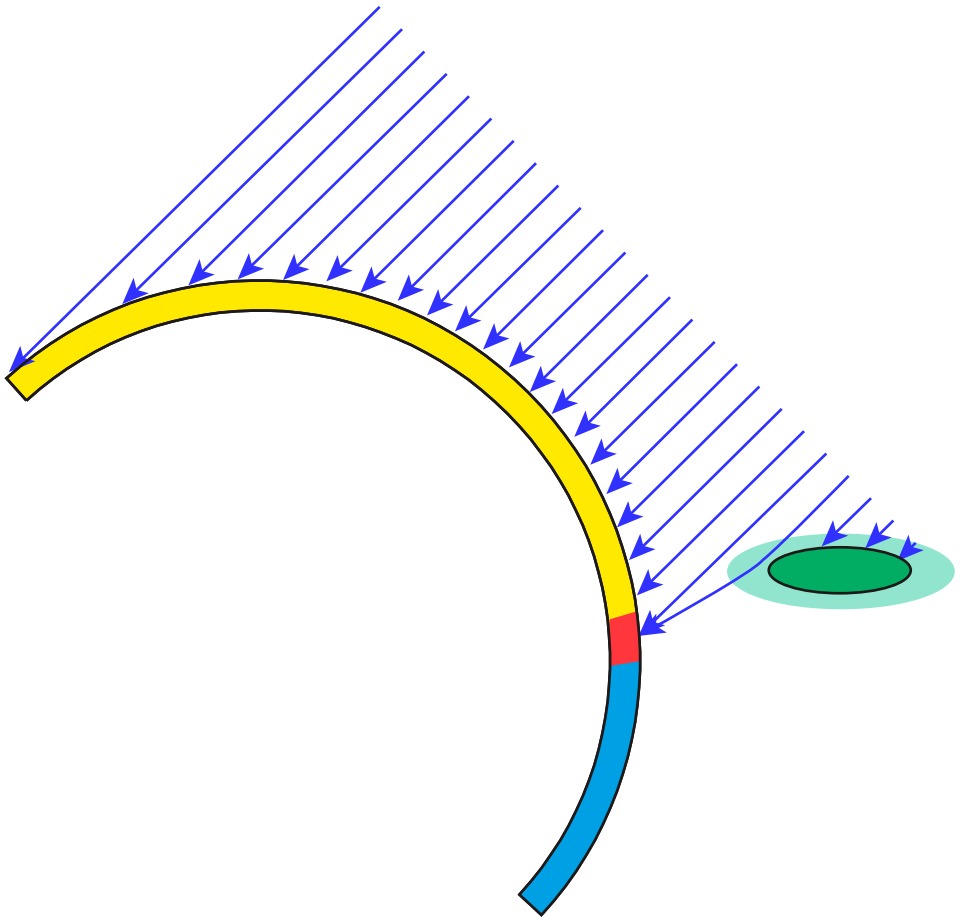
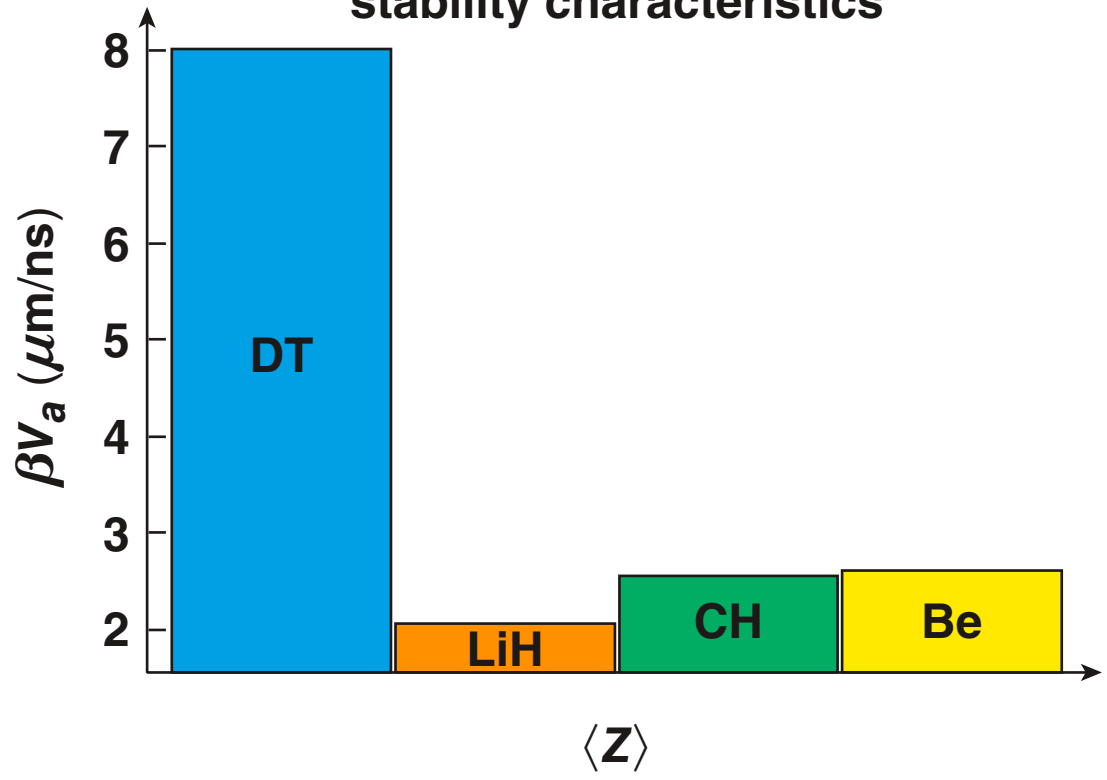
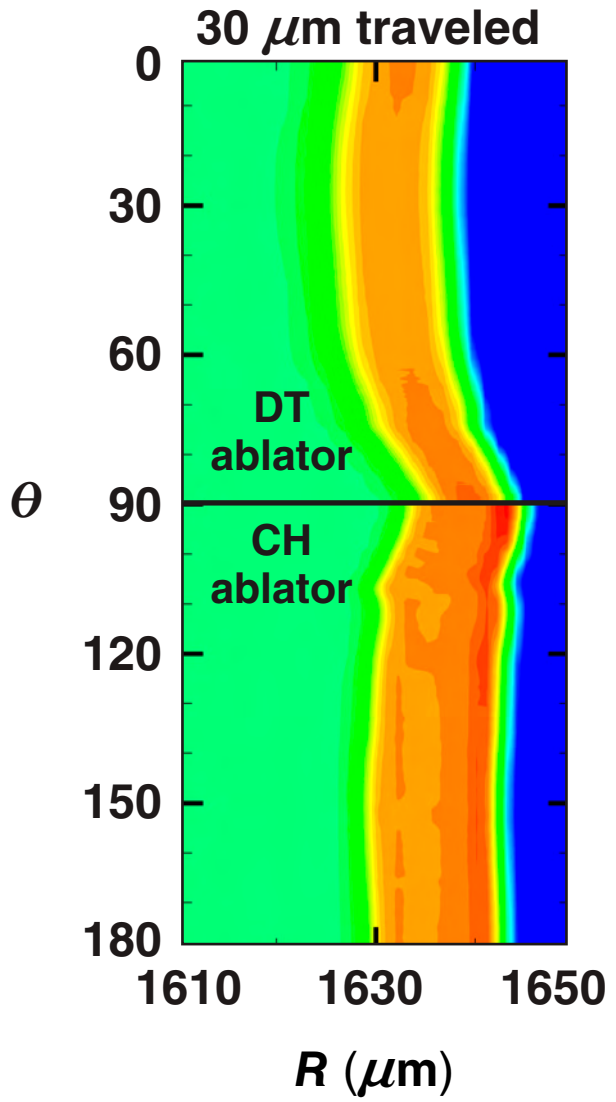


Initial PoP studies of the Saturn polar drive-ignition design did not examine the use of CH ablators

$$\gamma = \alpha\sqrt{kg} - k\beta V_a$$



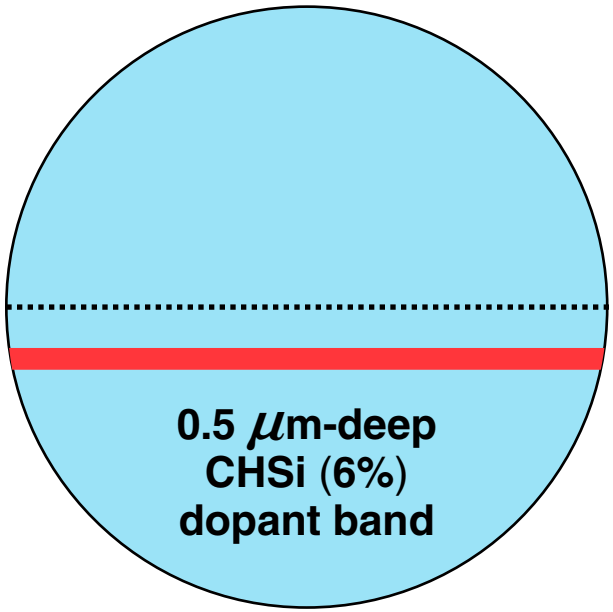


TC8047

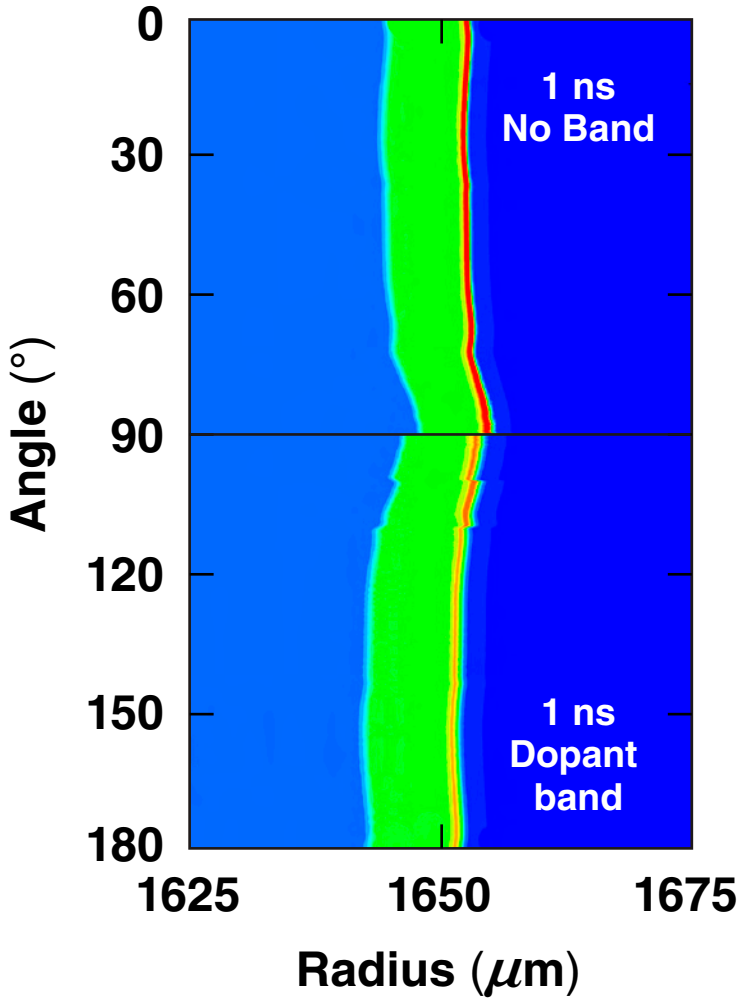
Precision ablator conditioning* may hold the key to smoothing the early-time ring imprint

UR LLE

Saturn Capsule



DRACO simulations



TC8035

*S. A. Slutz *et al.*, Phys. Rev. Lett. 99, 175001 (2007).

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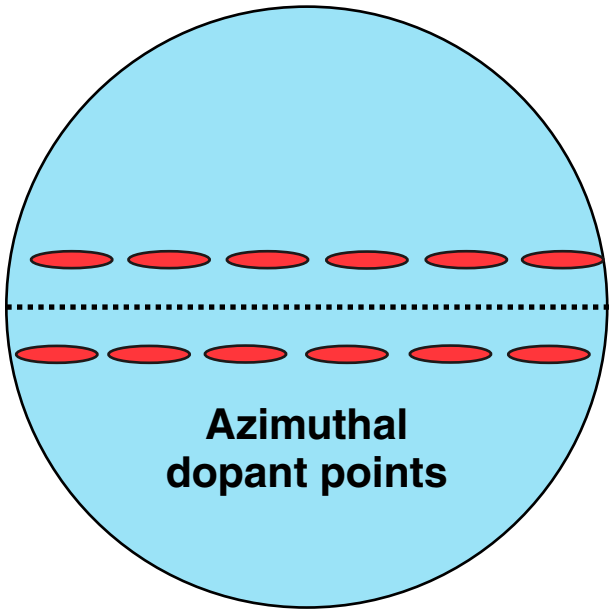
UR LLE

Saturn Capsule



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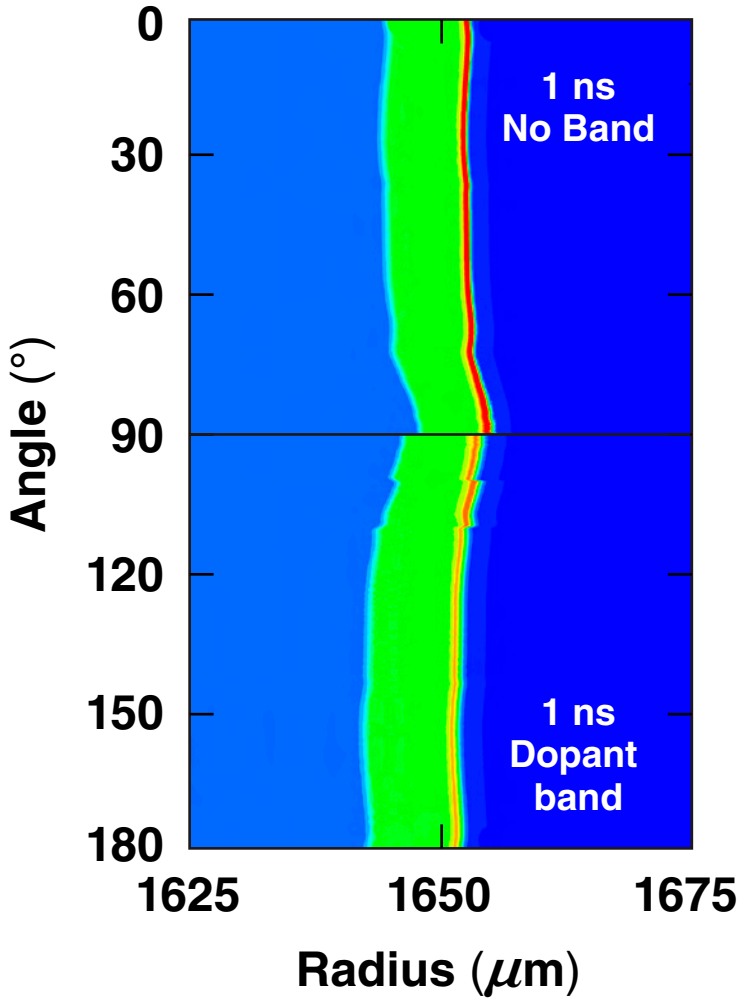

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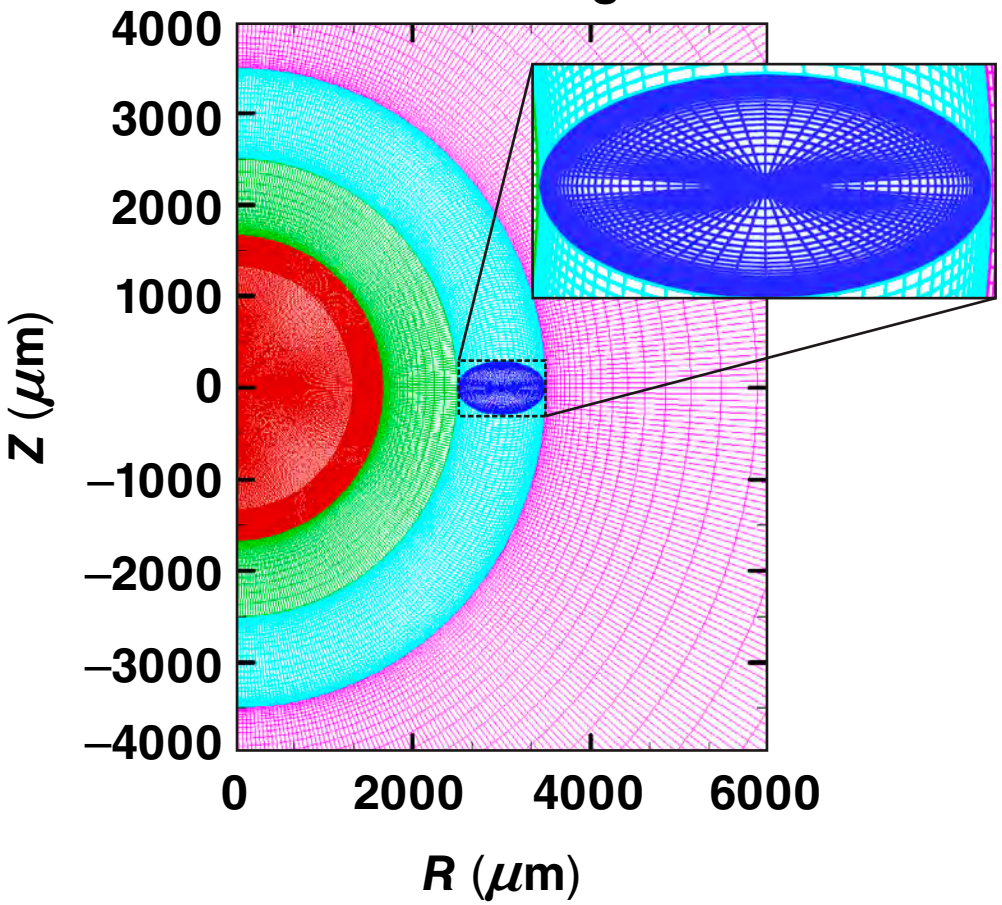
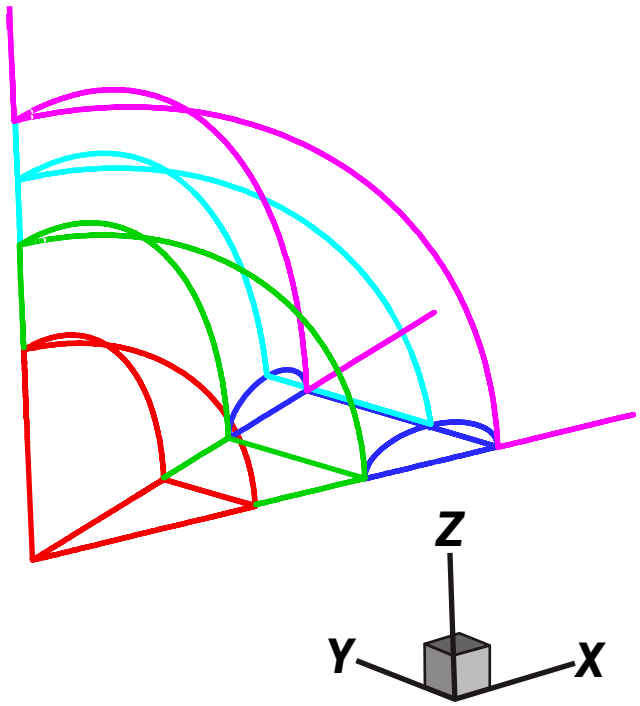
Upcoming Saturn simulations will employ the LLNL code *HYDRA* with its flexible use of logical grids

UR LLE

HYDRA 2-D grid



HYDRA 3-D interface plot



TC8032

Summary/Conclusions

DRACO simulations of Saturn ignition designs with CH ablators indicate localized early-time imprint

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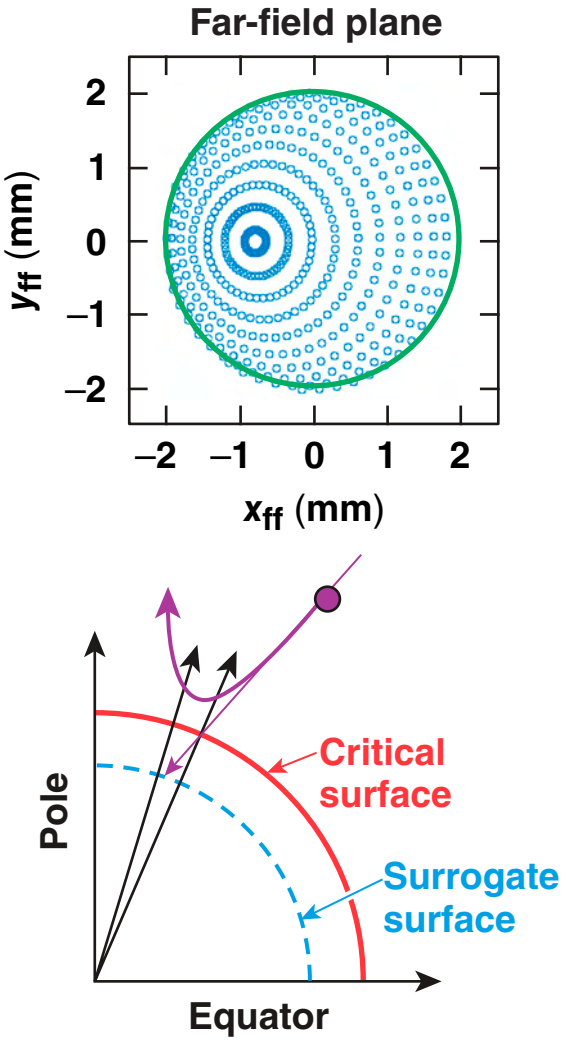
- Work is underway to continue Saturn modeling using *HYDRA* with two- and three-dimensional simulations.

DRACO now incorporates 3-D laser ray-trace routines with enhanced noise reduction

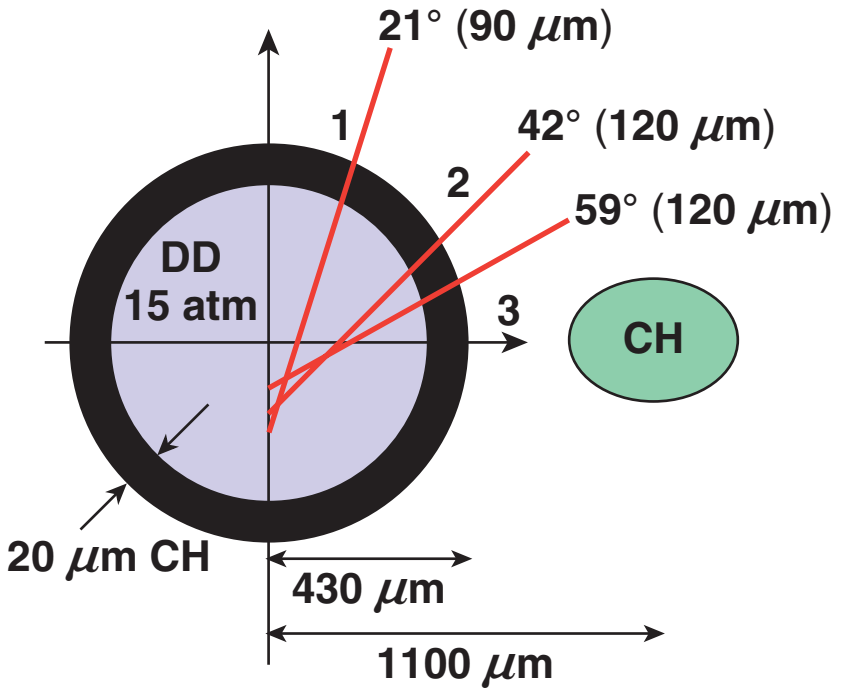
- Ray-trace noise reduction
  - The initial ray-position distribution is defined by an inverse-projection algorithm.
  - Adaptive integrators are employed.
  - Dynamic adjustment of the inverse-projection algorithm attempts to compensate for refraction.



Eulerian hydro is required to simulate plasma flow between ring and target

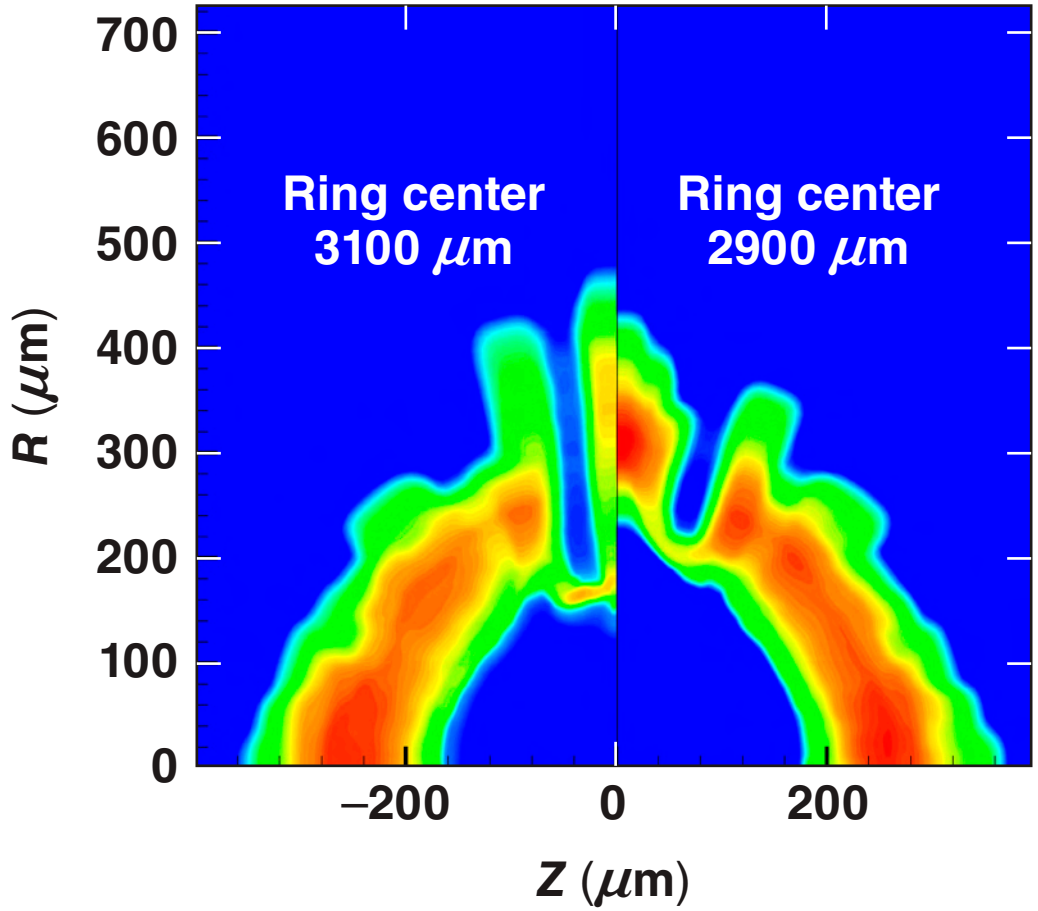
- The complexity of the flow makes it difficult to use ALE hydrodynamics.
- An Eulerian hydro-option has been developed and integrated into *DRACO.*
  - Godunov-type hydro scheme
  - piecewise parabolic interpolation
  - moving spherical numerical grid

OMEGA Saturn design



40-beam 15-kJ drive
1-ns square pulse

DRACO optimization of ring location does not provide relief from the formation of the large equatorial perturbations



TC7968