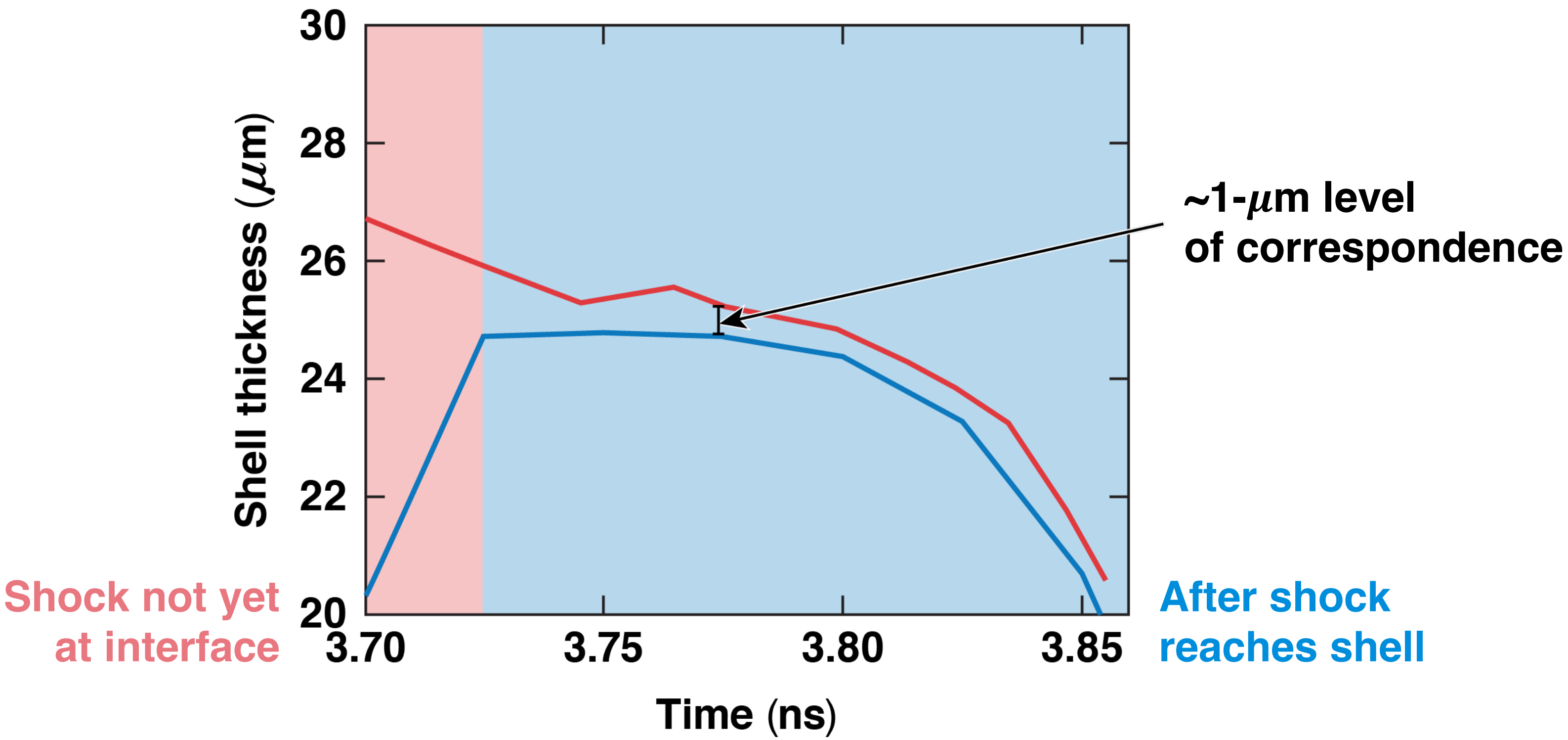
Feasibility Study of Measuring In-Flight Shell Thickness for a Laser-Direct-Drive DT Cryogenic Implosion

Comparison of inferred shell thickness with 1-D prediction



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62nd Annual Meeting of the
American Physical Society
Division of Plasma Physics
9–13 November 2020

Summary

Simulations indicate shell decompression can be inferred in DT cryogenic implosions using the x-ray self-emission technique

- The hydrodynamic instabilities in implosions seeded by laser imprint can increase the in-flight shell thickness during the implosion
- This study explored how the thickness could be extracted in the absence of the material interface present in previous warm studies*
- Using synthetic images from 1-D and 3-D simulations, we find signatures of decompression (shell thickness) can be determined for the DT cryogenic implosions

* D. T. Michel *et al.*, Rev. Sci. Instrum. 83, 10E530 (2012);
S. X. Hu *et al.*, Phys. Plasmas 23, 102701 (2016);
D. T. Michel *et al.*, Phys. Rev. E 95, 051202(R) (2017).

Collaborators

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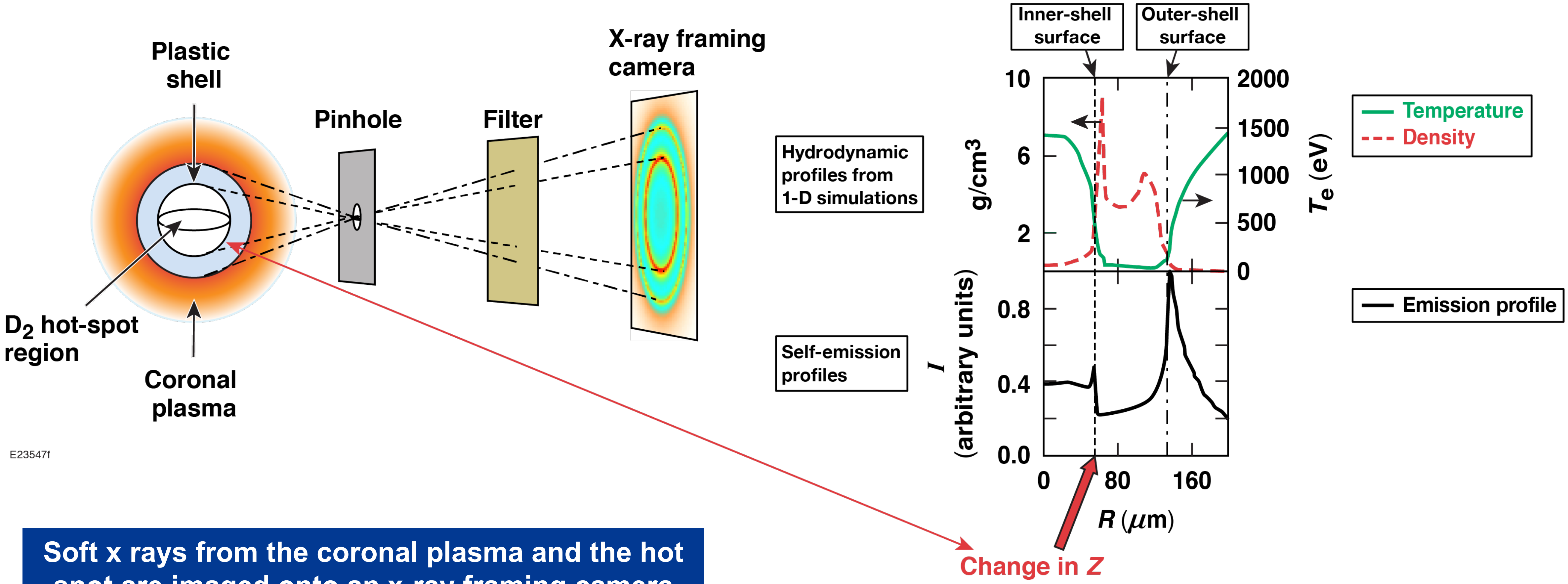
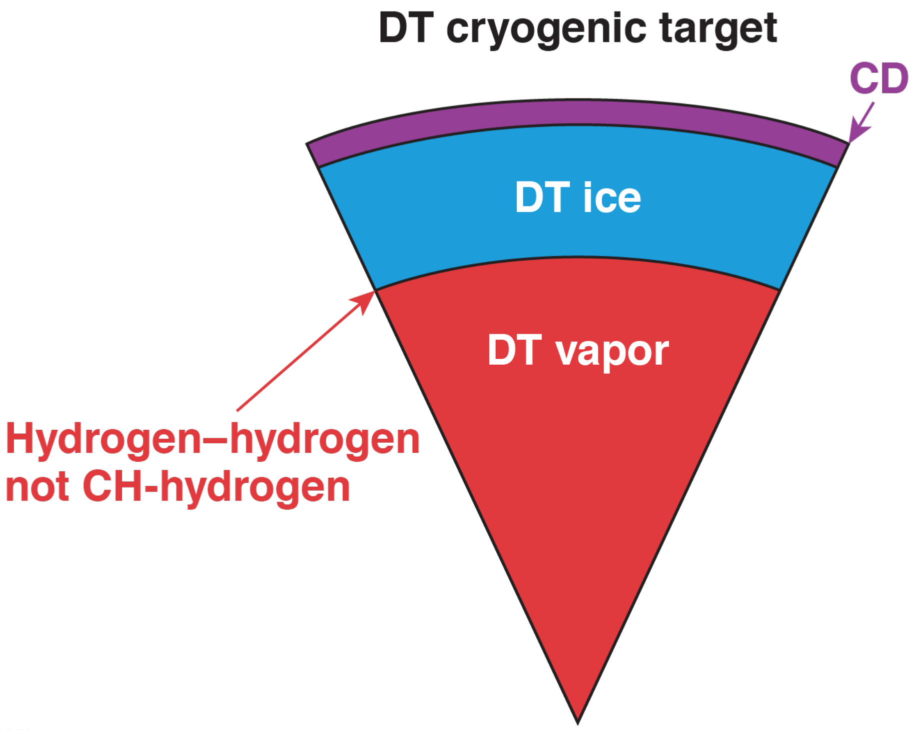
In previous experiments of warm targets* with material interface, shell thickness was inferred from x-ray self-emission signatures



Soft x rays from the coronal plasma and the hot spot are imaged onto an x-ray framing camera - hydrogen–CH interface in warm targets

* S. X. Hu *et al.*, Phys. Plasmas 23, 102701 (2016);
D. T. Michel *et al.*, Phys. Rev. E 95, 051202(R) (2017);
A. K. Davis, Ph.D. thesis, University of Rochester, 2017.

Simulations of DT cryogenic implosions are used to study the x-ray signatures of the compressed DT shell



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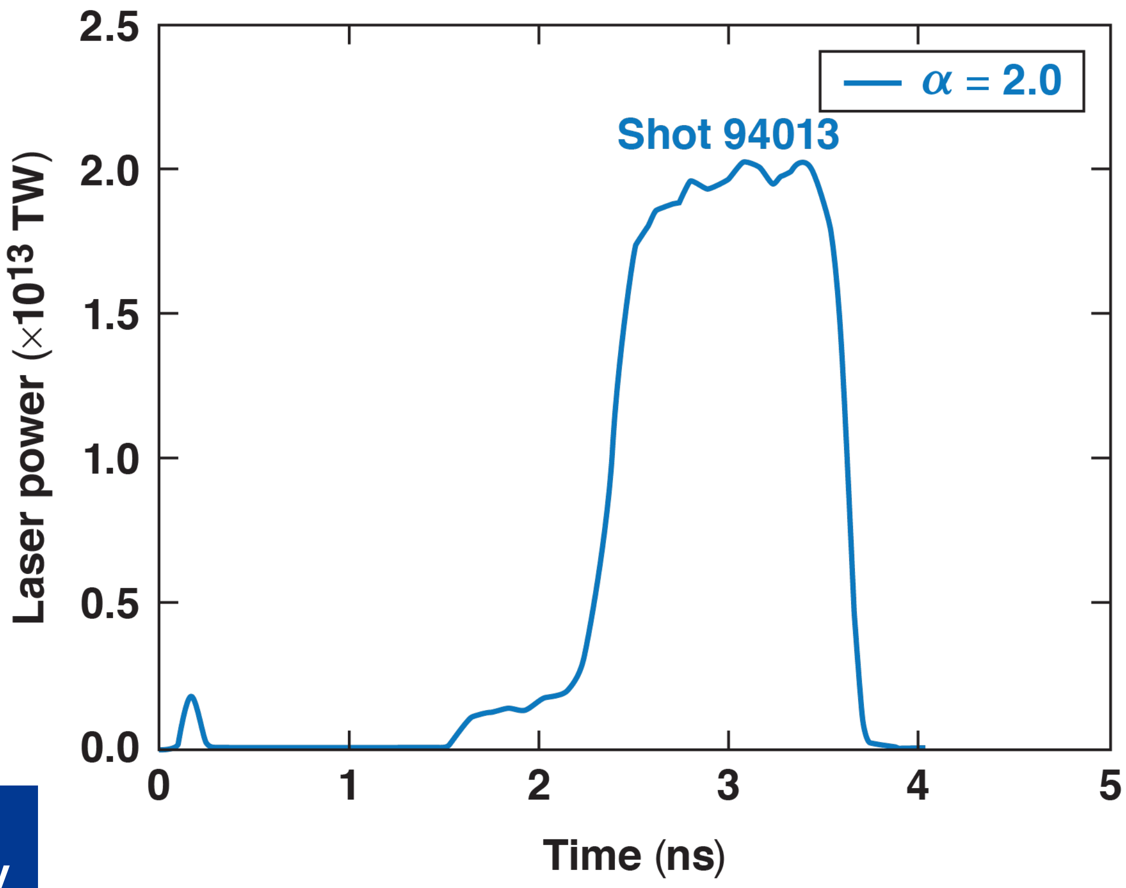
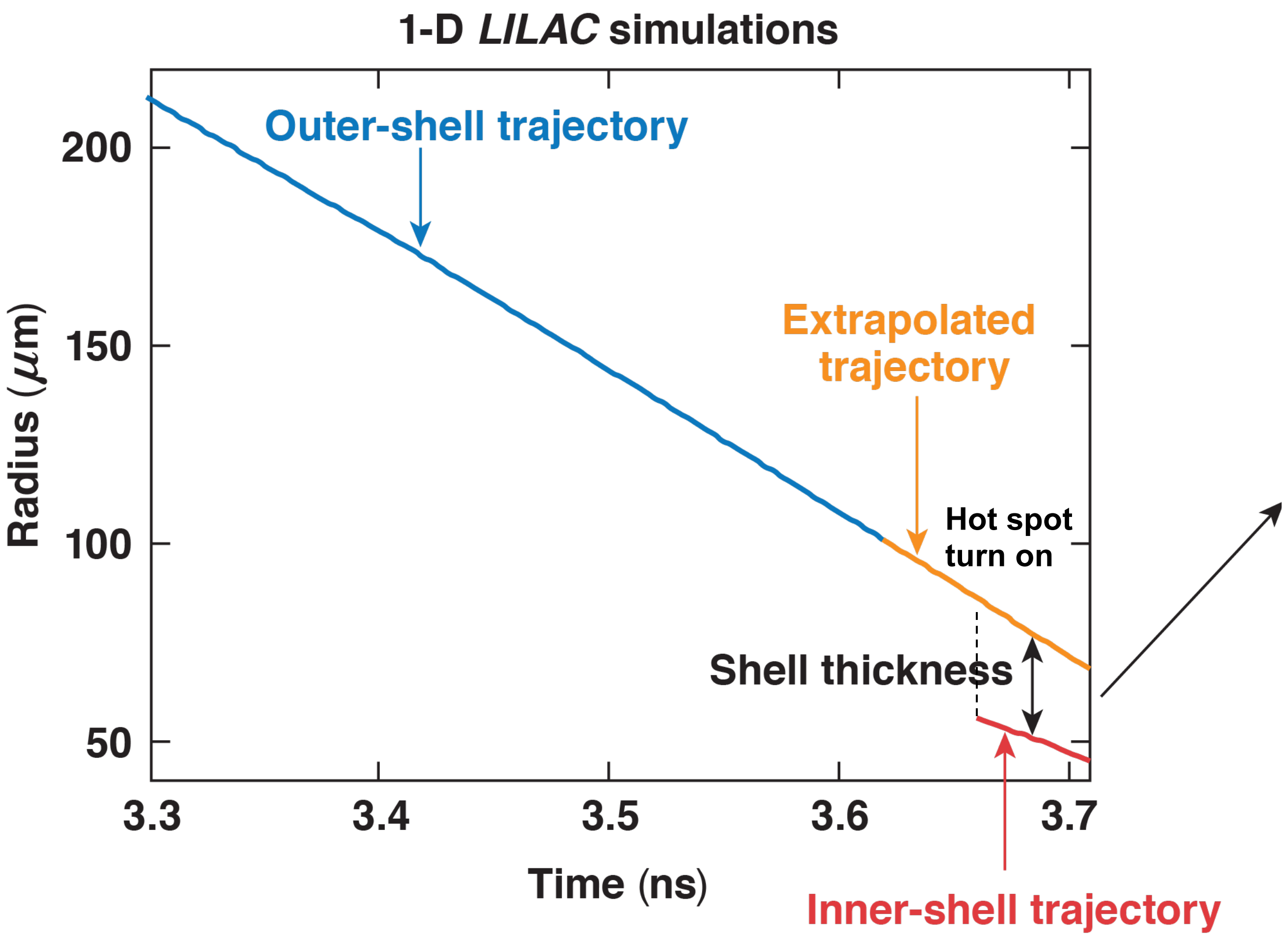
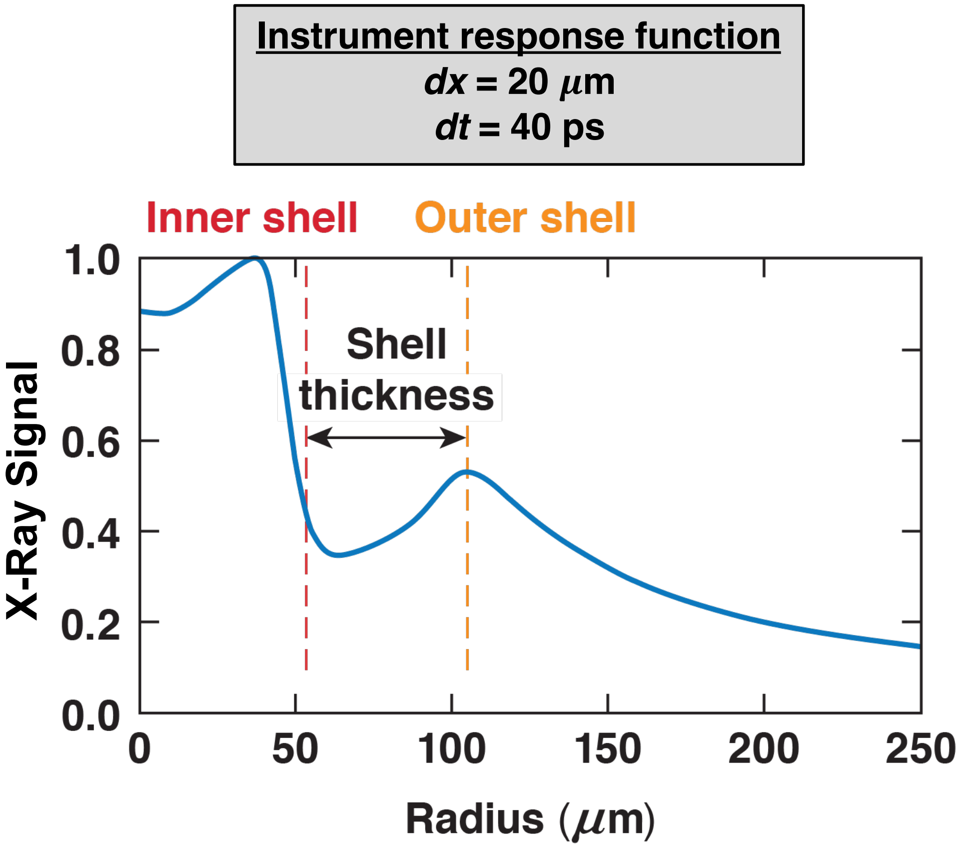


This is a simulation-based scoping study that complements the current analysis of experimentally observed hot-spot x-ray emission signatures.*

* R. Shah *et al.*, BO09.00006, this conference.

Shell thickness measurements are obtained by taking the difference between the extrapolated trajectory and the inner-shell trajectory





The DT shell thickness can be diagnosed after the onset of hot-spot x-ray emission.

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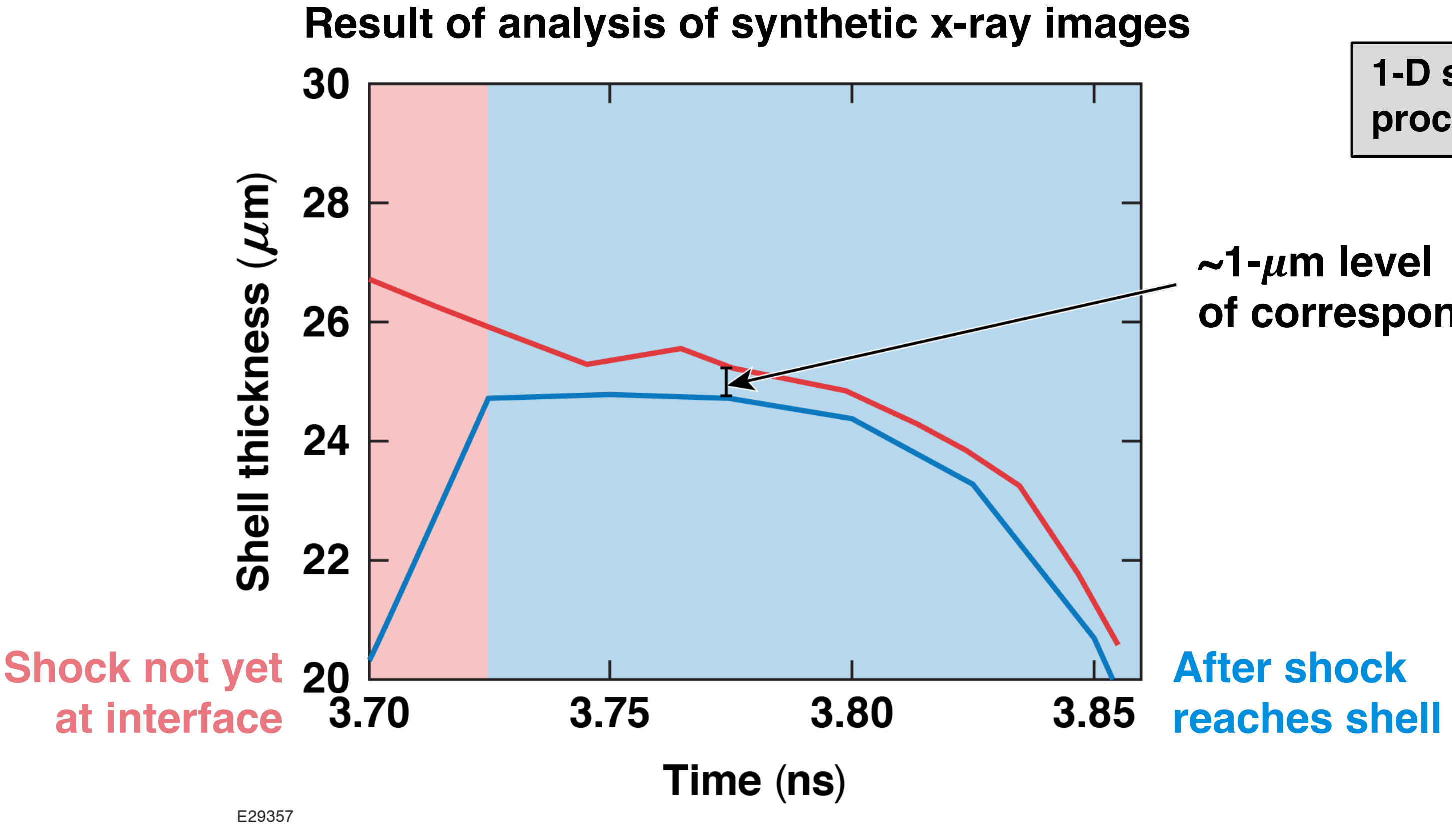
X-ray inferred shell thickness shows a correspondence with the 1-D hydrodynamic profile of the cryogenic implosion



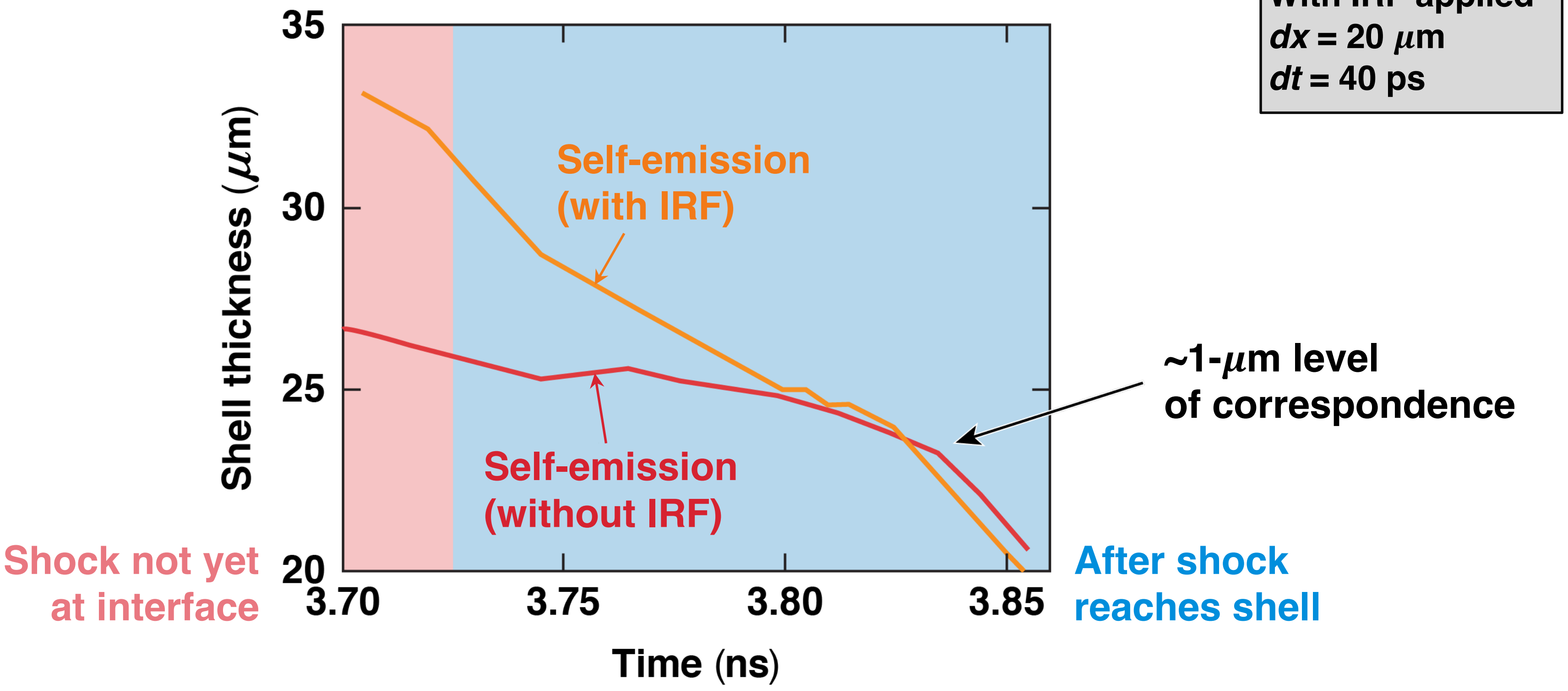
1-D simulation is post processed with Spect3D*

No instrument response function is applied to the synthetic images (best-case scenario).

* J. J. MacFarlane et al., High Energy Density Phys. 3, 181 (2007).

When the instrument response function (IRF) is applied to the simulated brightness profiles, the inferred shell thickness is affected

Result of analysis of synthetic x-ray Images

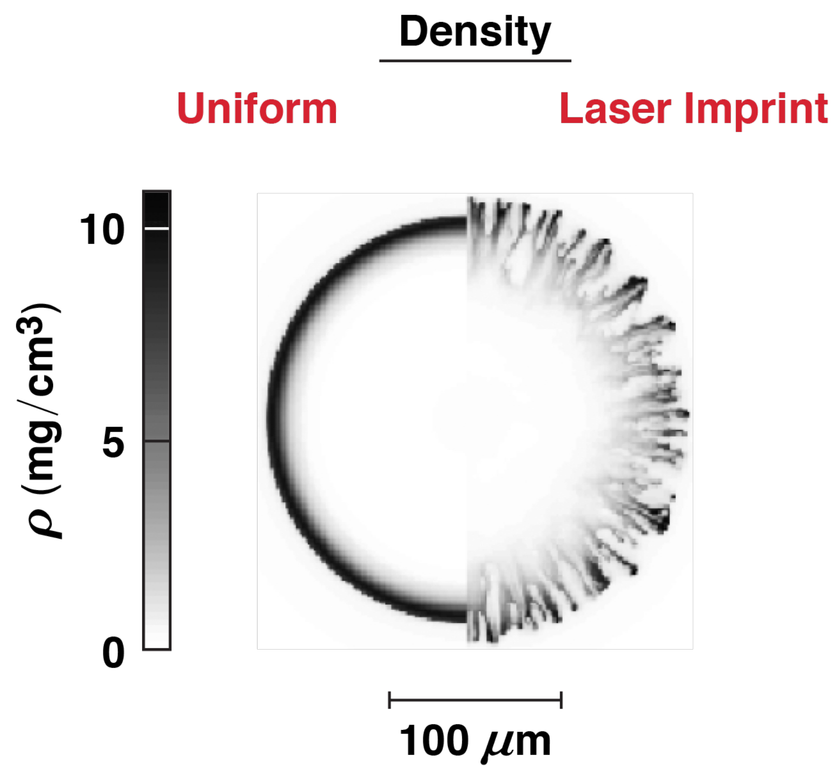


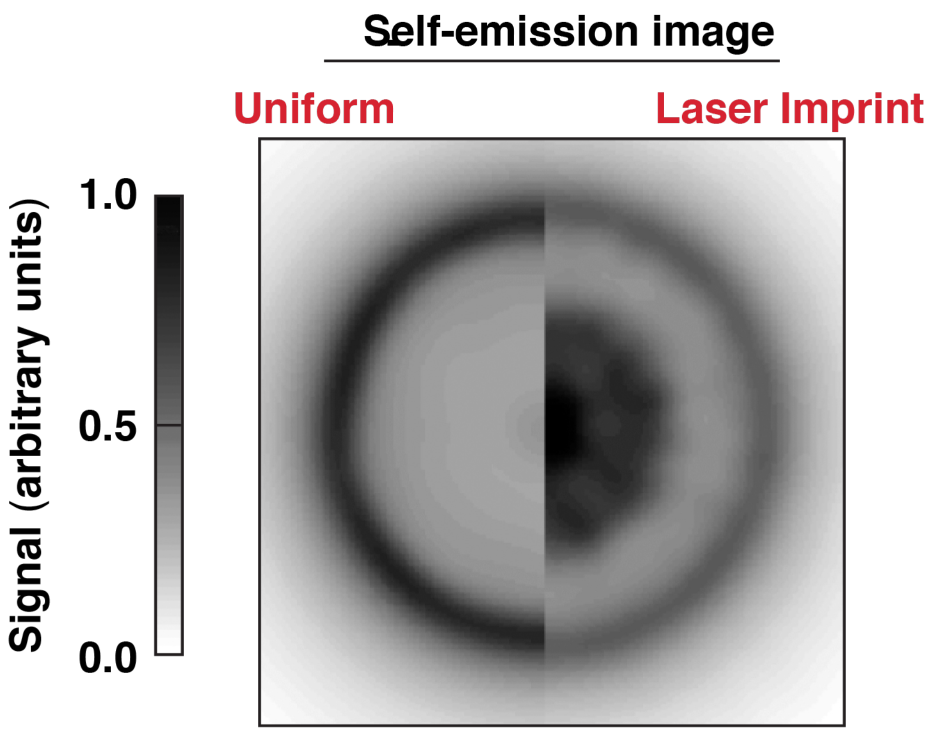
Measurements* should be directly compared with simulations including the IRF; further optimization of the diagnostic (e.g., filtering and spatial resolution) is underway to address the early time discrepancy.**

* R. Shah *et al.*, BO09.00006, this conference.

** F. J. Marshall *et al.*, "High-Resolution X-Ray Radiography with Fresnel Zone Plates on the University of Rochester's OMEGA Laser Systems," submitted to Review of Scientific Instruments.

Three dimensional (*ASTER*) simulations* show laser imprint can degrade the target shell and advance the hot-spot emission





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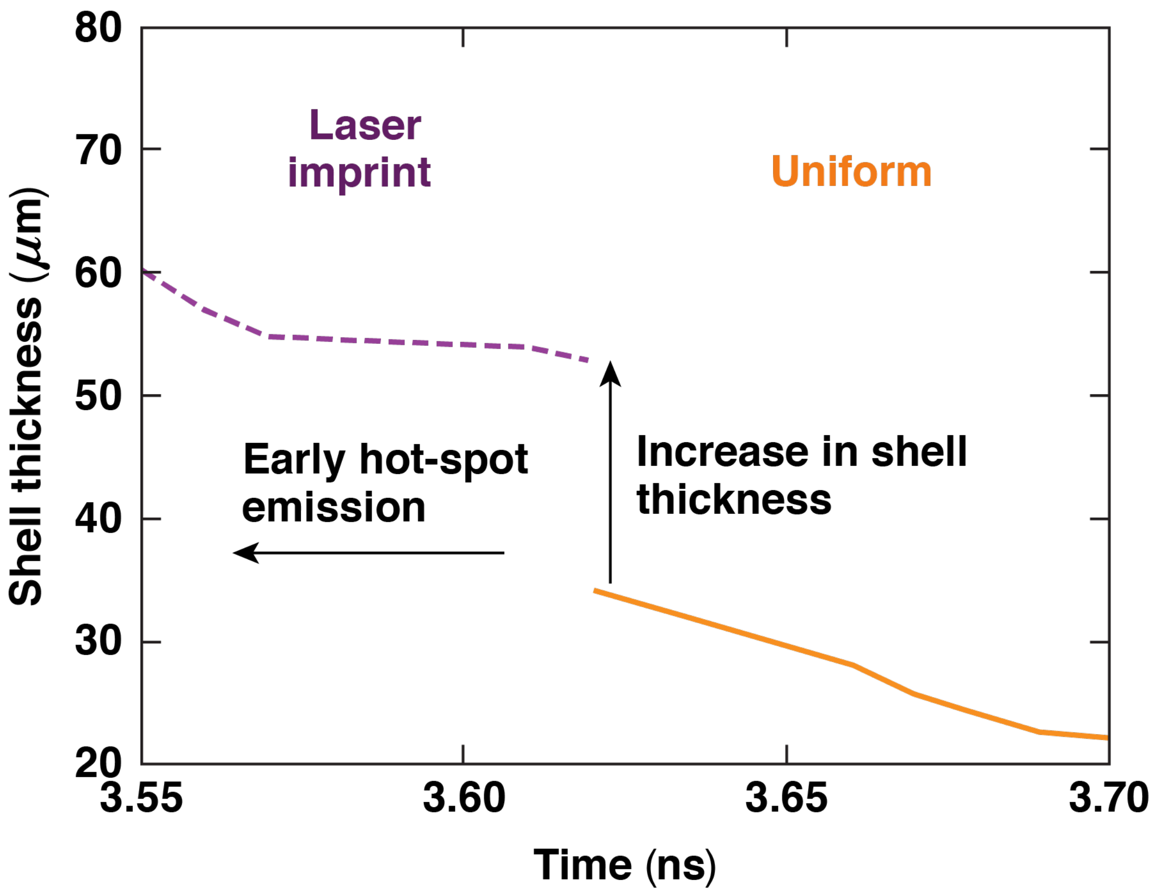
This simulation accounts for the current beam smoothing applied in experiments

* R. C. Shah *et al.*, "Probing In-Flight Shell Decompression in Cryogenic Implosions on OMEGA," submitted to Physical Review Letters; I. V. Igumenshchev *et al.*, Phys. Rev. Lett. 123, 065001 (2019).

Using synthetic images from 1-D and 3-D (*ASTER*) simulations,* we find signatures of decompression (i.e., increase in shell thickness) can be determined for the cryogenic implosions



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* R. C. Shah *et al.*, "Probing In-Flight Shell Decompression in Cryogenic Implosions on OMEGA," submitted to Physical Review Letters; I. V. Igumenshchev *et al.*, Phys. Rev. Lett. 123, 065001 (2019).

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Application of the ideas from this scoping study will be applied to experimental data and diagnostic development to improve spatial resolution is underway†.**

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