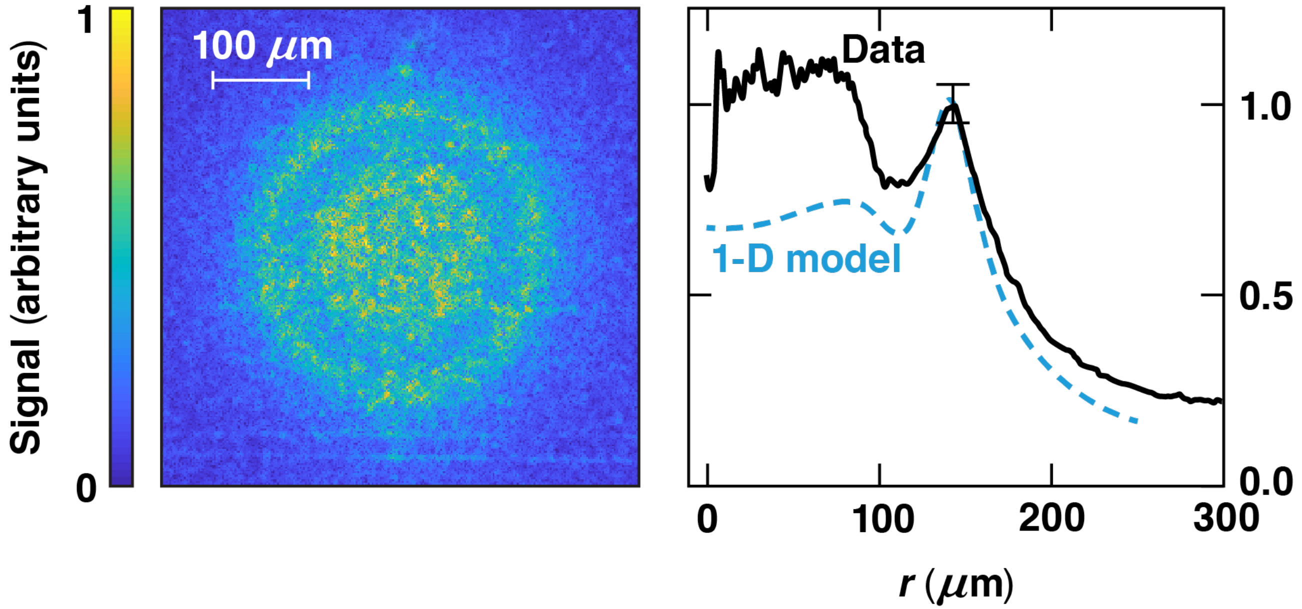
In-Flight Shell Breakup in Direct-Drive DT Cryogenic Implosions



Framed, soft x-ray self-emission from DT cryogenic implosion at onset of hot-spot emission

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Summary

The onset of hot-spot x-ray emission in directly driven DT cryogenic implosions is used to diagnose hot-spot assembly*

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- The onset of hot-spot emission is observed at a larger radius than calculated by a 1-D models over a range of varying DT cryogenic implosions
- The discrepancy in the emission onset increases with an instability parameter** S = IFAR/$\alpha^{1.1}$, where α is adiabat and IFAR is in-flight aspect ratio
- For the least-stable implosion (highest S), modeling that includes laser imprint recovers the advance in emission; however, imprint does not explain the more-stable implosions

The results suggest a gap in our understanding specific to decompression at the start of deceleration.

* R. C. Shah *et al.*, "Probing In-Flight Shell Decompression in Cryogenic Implosions on OMEGA," submitted to Physical Review Letters.
** V. N. Goncharov *et al.*, Phys. Plasmas 21, 056315 (2014).

Collaborators

S. X. Hu, I. V. Igumenshchev, J. Baltazar, D. Cao, C. J. Forrest, V. N. Goncharov,
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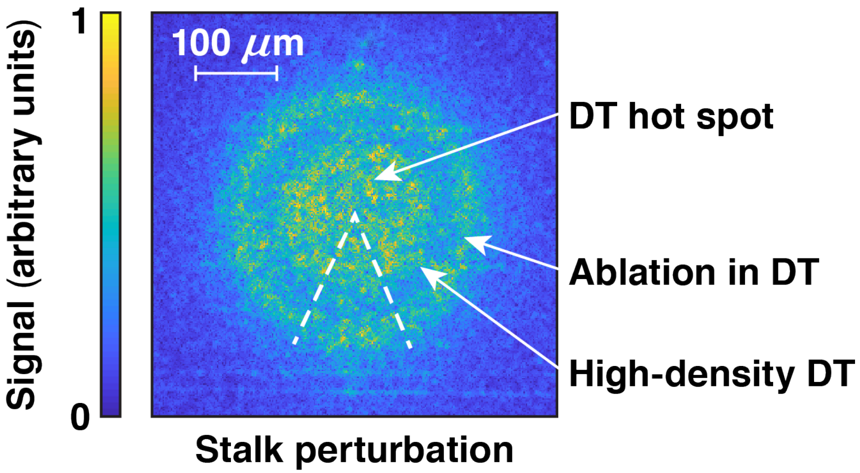
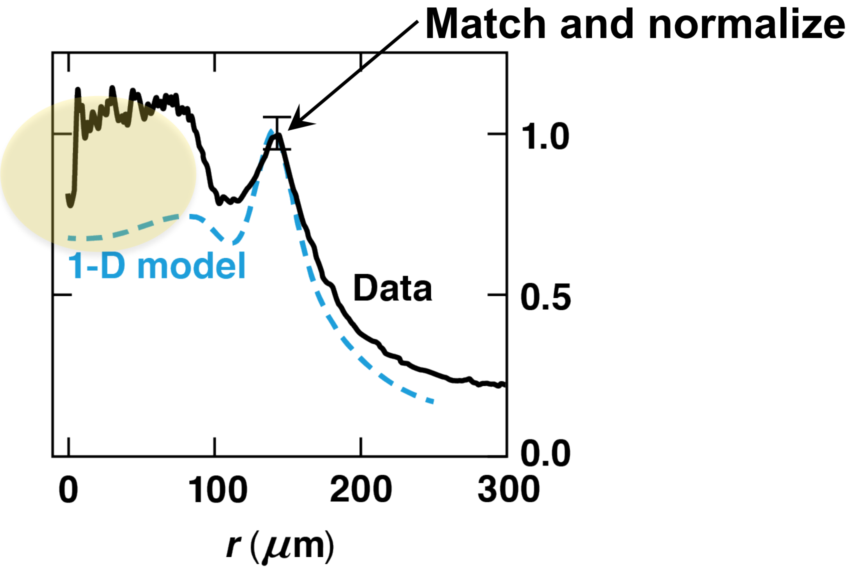
CEA

An observed discrepancy in the onset of hot-spot x-ray self-emission motivated its use to diagnose early-stage hot-spot formation





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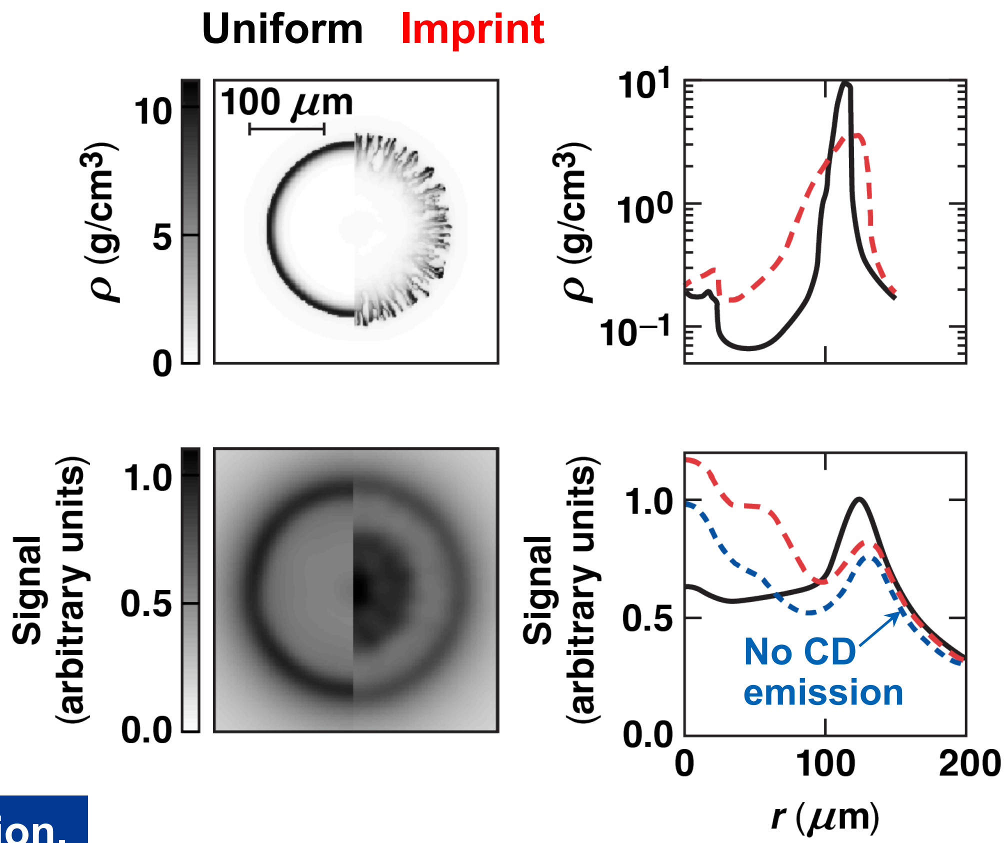
- An emission advance was shown in simulations of plastic implosions to accompany shell thickening due to imprint*
- An analysis that extracts shell thickness is also being considered for the DT system (earlier talk, J. Baltazar *et al.*, BO09.00006)

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

Three-dimensional modeling shows imprint *can* cause early hot-spot emission

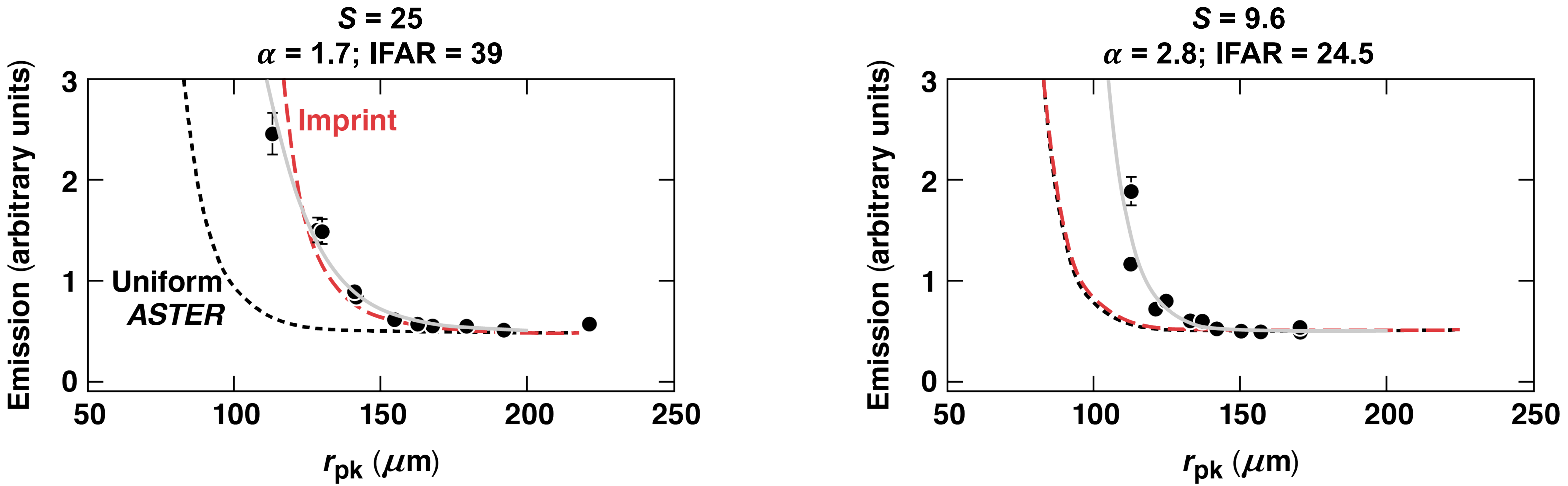
- ***ASTER****
  - resolves $\ell < 200$
  - speckle-based model for laser imprint
- ***S = 25***
  - α = 1.7, IFAR = 39
  - 90% yield reduction due to imprint



Profile relaxation drives the early emission.

* I. V. Igumenshchev *et al.*, Phys. Plasmas 23, 052702 (2016).; I. V. Igumenshchev *et al.*, Phys. Rev. Lett. 123, 065001 (2019).

Two companion shots contrast the role of imprint in creating the emission discrepancy



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- Imprint is modifying hot-spot <u>formation</u> (as compared to less specific signatures such as Y_{DT}, ρr)
- There is a modeling gap regarding hot-spot formation for the more-stable implosion

Results

The emission onset for implosions of differing stabilities is compared to 1-D modeling (*LILAC*)

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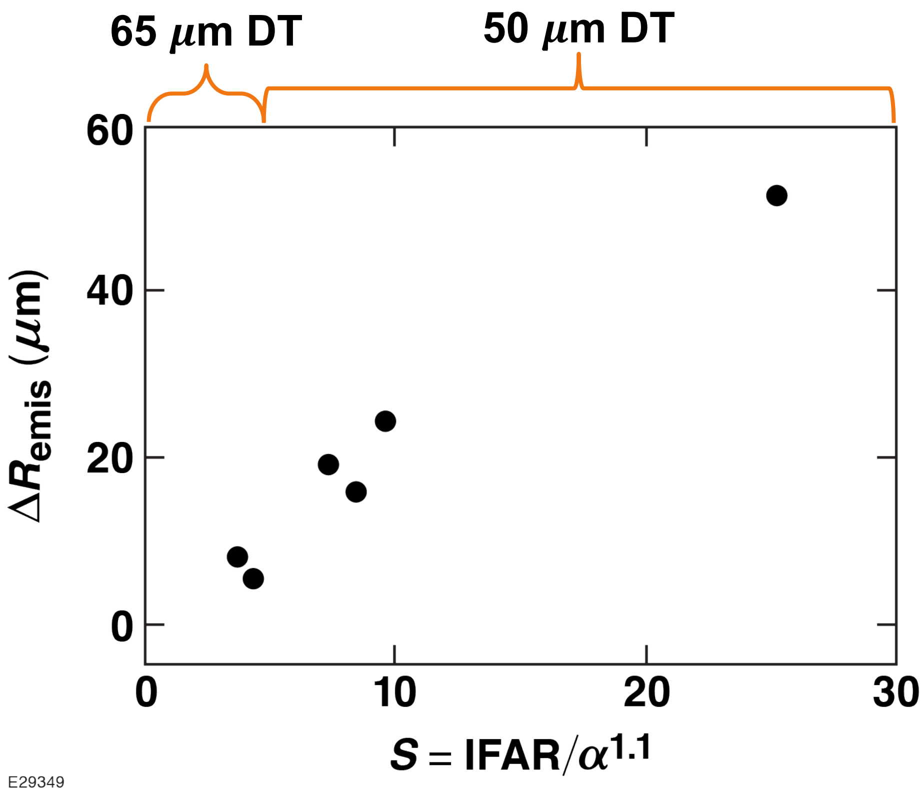

- ΔR_{emis} is the shift in onset determined from the emission versus limb-position curves of each analyzed shot
- The 3-D model suggests $S \leq 10$ are not explained by imprint

The discrepancy is reduced for more-stable implosions.

Additional experiments and data will test the leading candidate hypotheses for the discrepancy in the onset of the x-ray self-emission from the hot spot

- Hydrodynamic origin
  - Condensate, debris and damage maybe accumulated during cryogenic processing
  - a new cryo microscope will inspect for ~micron features after DT diffusion fill*

- Shock-related processes such shock timing or shock release (studied in plastic ablator to date**, †)
  - implosions are being planned in which shock parameters will be maintained while stability is increased with thicker cryogenic layers

MD: molecular dynamics
* R. T. Janezic, D. Bredesen, and M. D. Wittman, Laboratory for Laser Energetics, private communication (2020).
** D. Haberberger *et al.*, Phys. Rev. Lett. 123, 235001 (2019).
† S. Zhang and S. X Hu, Phys. Rev. Lett. 125, 105001 (2020).

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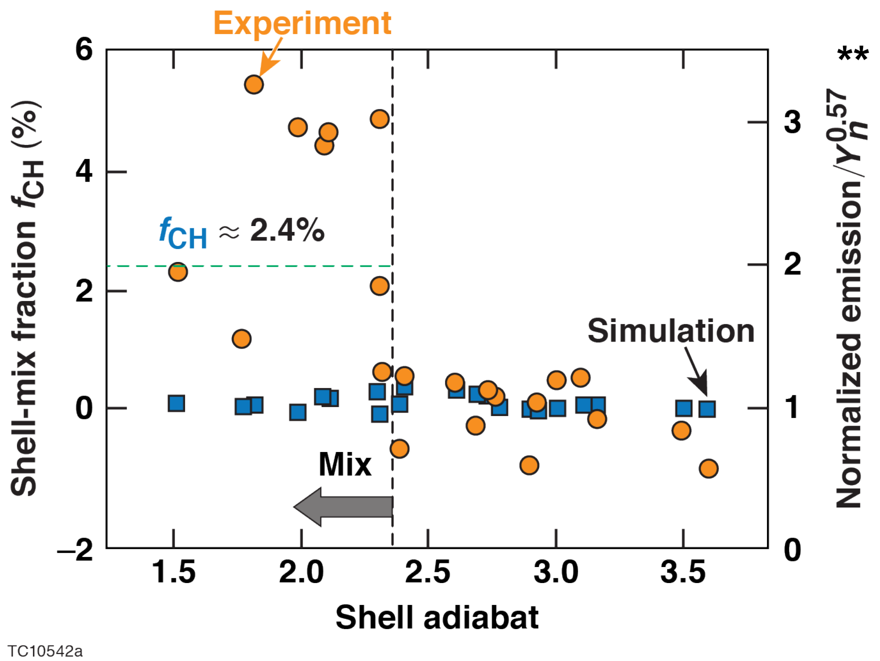
Backup

Enhanced emission due to mix is not considered a primary candidate for the observation

- Unless imprint is *OVER-predicted* and fortuitously in agreement, good agreement in the low-stability case is contrary to C mixing in higher-stability implosions
- Broad emission in the core is observed rather than localized features such as associated with fill tube at the NIF
- Mix is not indicated for implosions of stabilities in question based on previous analysis of x-ray emission* (see also D. Cao *et al.*, BO10.00006, this conference)



* T. C. Sangster *et al.*, Phys. Plasmas 20, 056317 (2013).
** R. Epstein *et al.*, Phys. Plasmas 22, 022707 (2015).