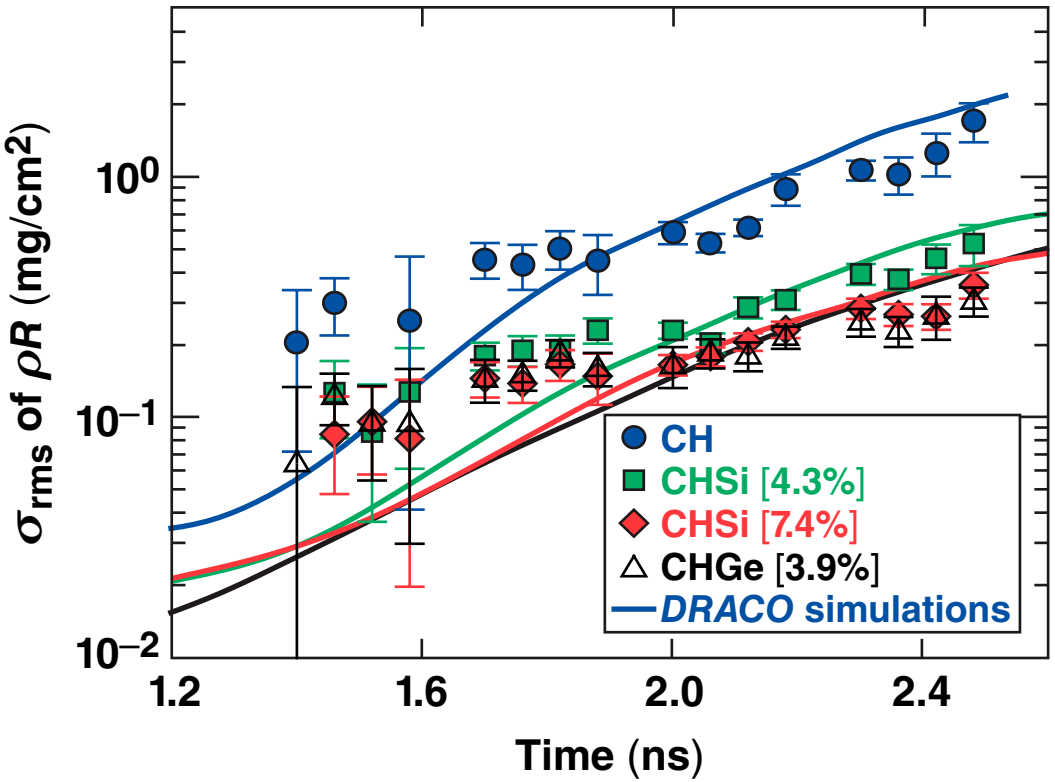
Analysis of Laser-Imprinting Reduction in Spherical-RT Experiments with Si-/Ge-Doped Plastic Targets



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53rd Annual Meeting of the
American Physical Society
Division of Plasma Physics
Salt Lake City, UT
14–18 November 2011

Summary

A few percent of Si-/Ge-doping into plastic ablators can reduce the σ_{rms} of shell-ρR perturbations by a factor of 3 to 5

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- Mitigating laser imprint with high-*Z* doping has been explored in both spherical Rayleigh–Taylor (RT) experiments and 2-D *DRACO* simulations
- Experimental results show
  - a factor of 2 to 3 reduction in the laser imprinting efficiency
  - reduced RT growth rate by ~50% when high-*Z*-doped targets are used
- The experimental observations are reproduced by radiation–hydrodynamics simulations using 2-D *DRACO*

Collaborators

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Hydro-simulations predicted that high-*Z* doping can mitigate laser-imprinting effects* on target implosions

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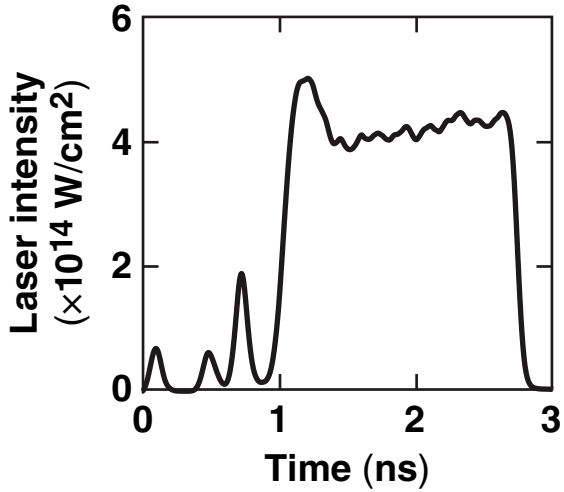
- High-*Z* doping can increase the standoff distance between the ablation surface and the laser-deposition regions, thereby reducing the imprint
- Radiation preheat from high-*Z* doping increase the ablation velocity, leading to enhanced ablative stabilization of the RT growth
- Implosions with Si-/Ge-doped plastic targets** have shown a yield increase by a factor of >2, which have been attributed to improved target stability
- Thin-layer (<1000 Å) high-*Z* coatings*** have also shown yield improvements in target implosions

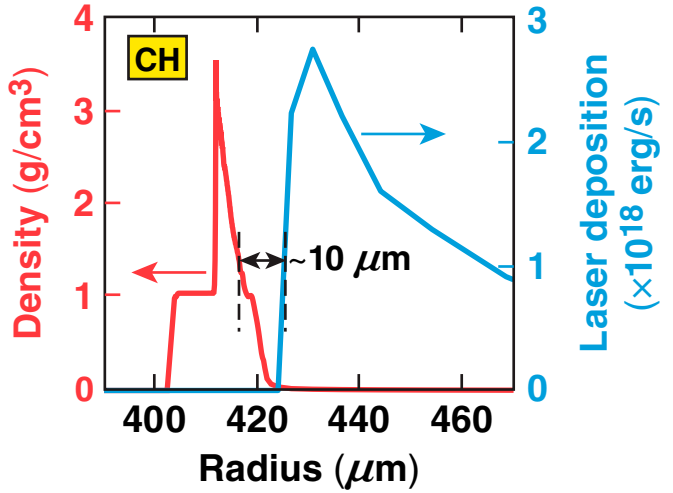
* S. X. Hu *et al*., "Mitigating Laser Imprints in Direct-Drive ICF Implosions with High-Z Dopants," submitted to Physical Review Letters.

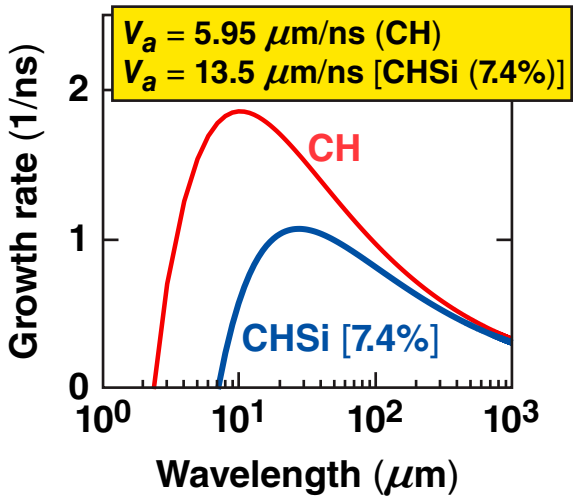
** V. N. Goncharov *et al*., Phys. Plasmas, 15, 056310 (2008); J. P. Knauer *et al*., Bull. Am. Phys. Soc. 52, 233 (2007); P. B. Radha *et al*., Bull. Am. Phys. Soc. 52, 143 (2007).

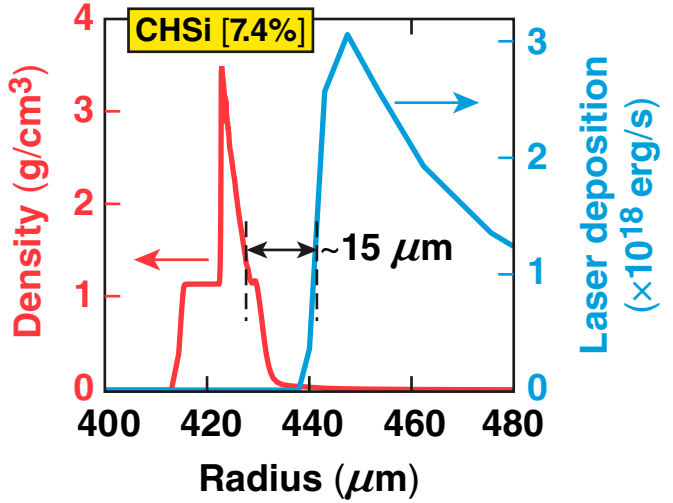
*** S. P. Obenschain *et al*., Phys. Plasmas 9, 2234 (2002); A. N. Mostovych *et al*., Phys. Rev. Lett. 100, 075002 (2008).

LILAC simulations for pure-CH targets and 7.4% Si-doped CH targets indicate the expected laser-imprinting reduction effects









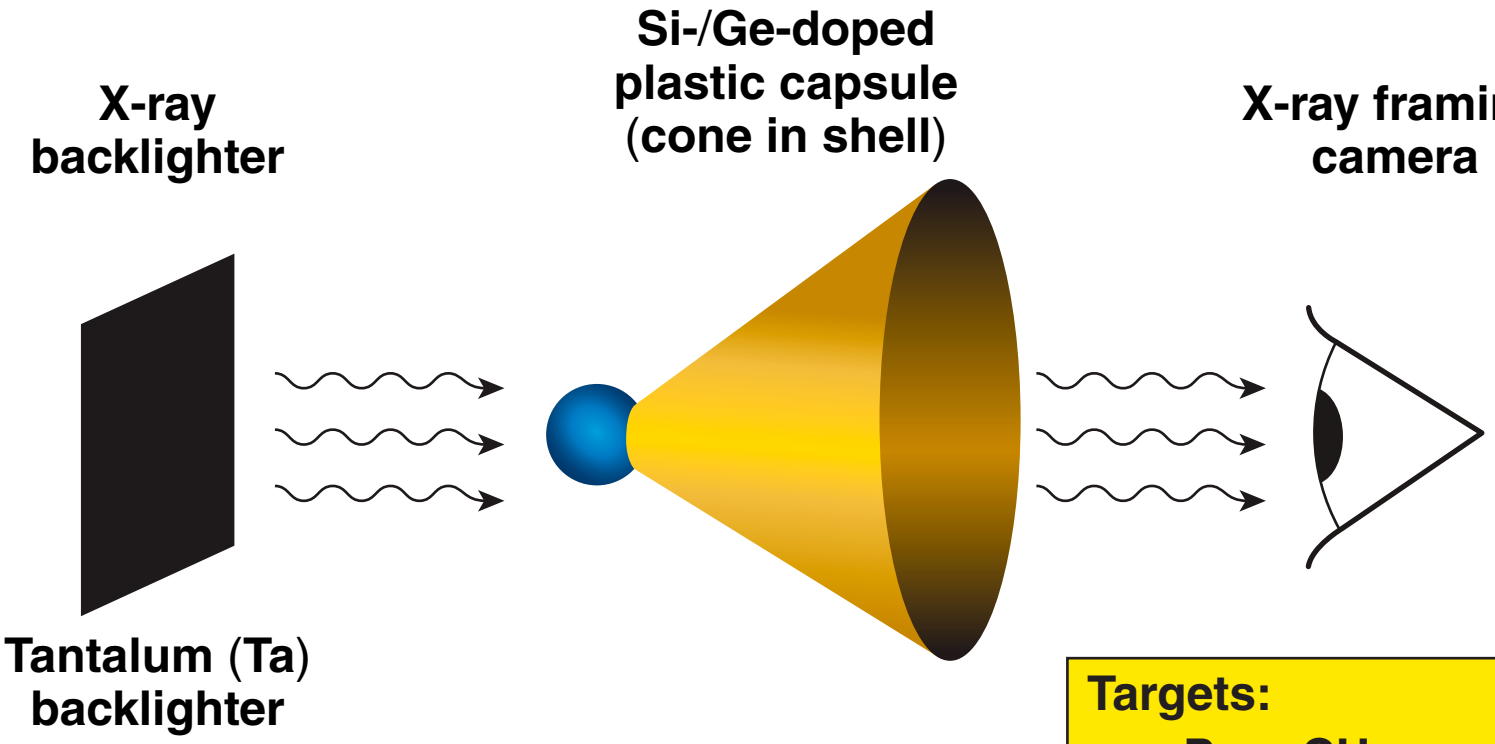
The RT growth rate*

$$\Gamma_k = 0.94\sqrt{kg/\left(1+kL_n\right)} - 1.5\,kV_a$$

TC9751

*R. Betti *et al.*, Phys. Plasmas 5, 1446 (1998).

Spherical-RT experiments with high-Z-doped targets (entire shell doping) were performed on OMEGA using the cone-in-shell configuration*



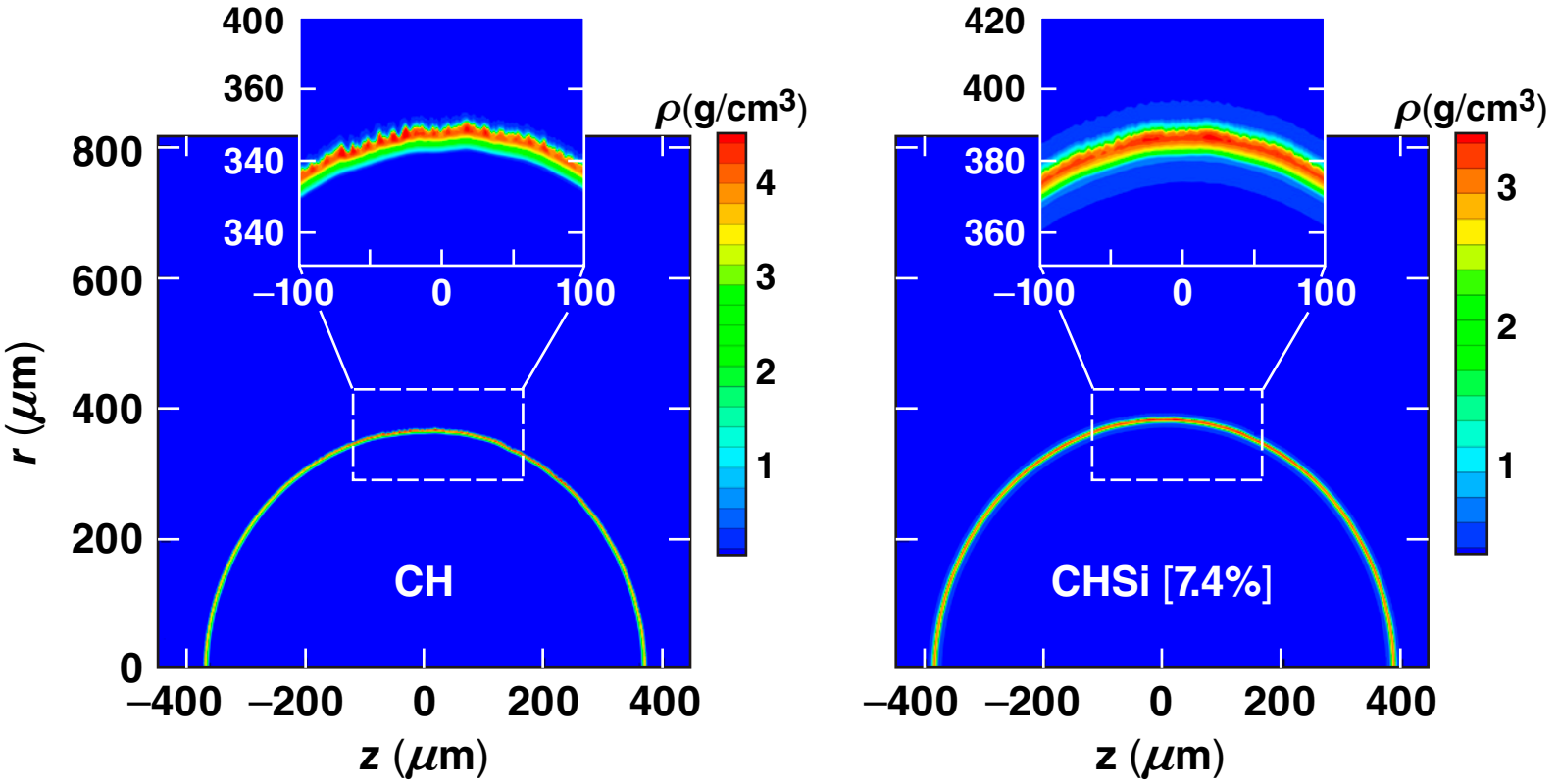
48 OMEGA beams were used to drive target implosions, with laser imprints of broadband DPP modes (SSD off).

Targets:
- Pure CH
- CHSi [4.3%]
- CHSi [7.4%]
- CHGe [3.9%]

*V. A. Smalyuk *et al.*, Phys. Rev. Lett. 103, 105001 (2009).

2-D *DRACO* simulations predict ~3× lower laser imprinting amplitude for the CHSi [7.4%] target

DPP modes up to , ℓ = 400 were included



The shell ρR-modulation comparison at the beginning of acceleration (t = 1.5 ns)

$\sigma_{rms}(\rho R)$ = 0.080 mg/cm^2 (CH)

$\sigma_{rms}(\rho R)$ = 0.026 mg/cm^2 (CHSi [7.4%])

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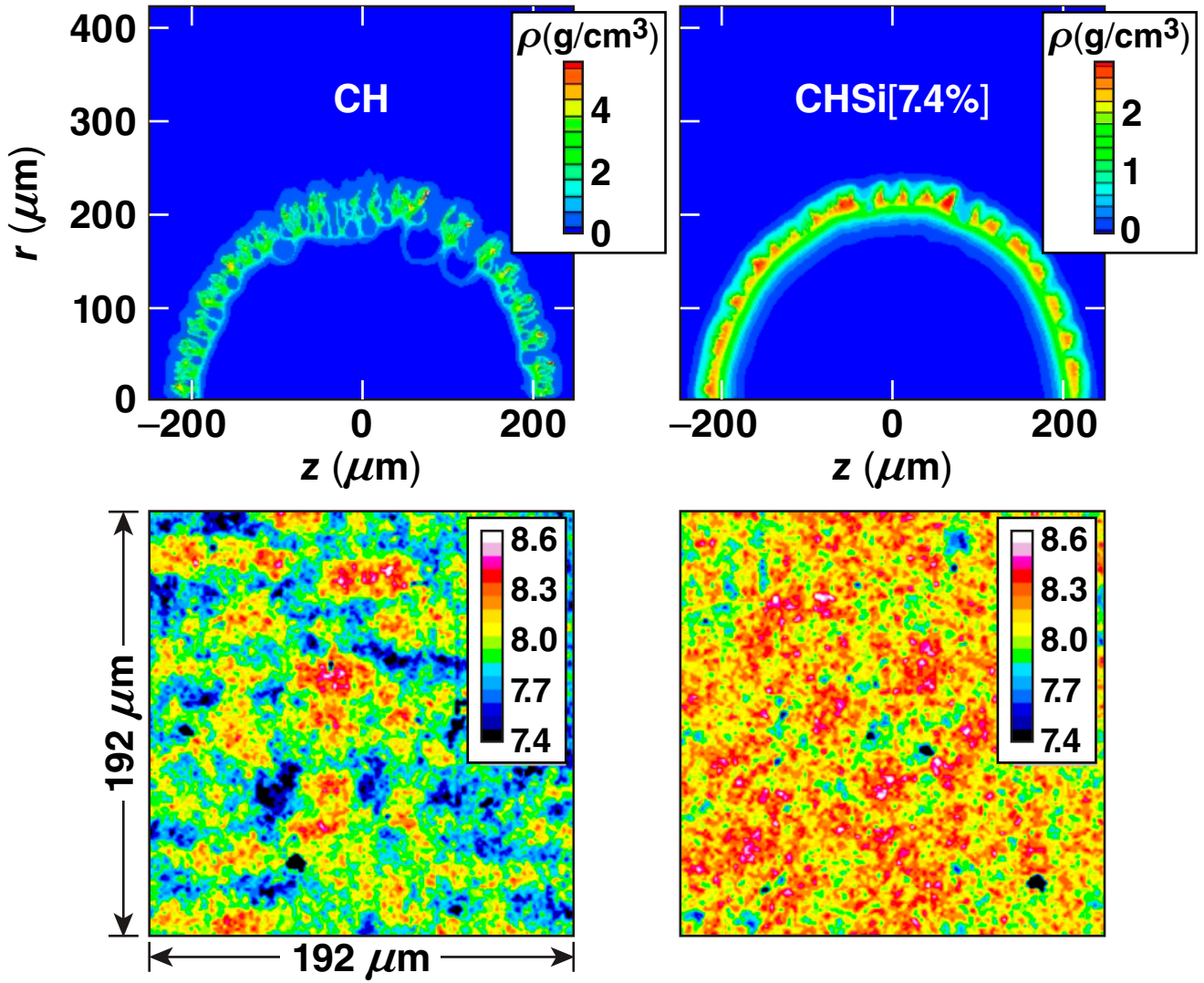
Both simulations and experiments show significant improvements of shell integrity with high-Z doping



Near the end of shell acceleration

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Significant imprinting reduction in ρR modulation by 3 to 5 times has been observed for high-Z-doped targets

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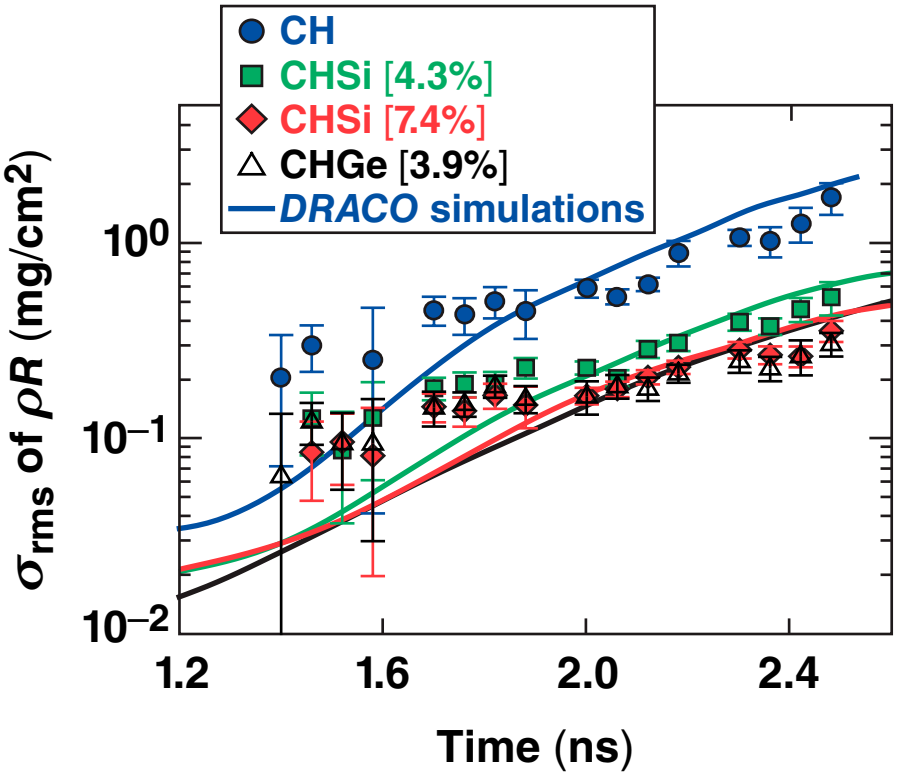
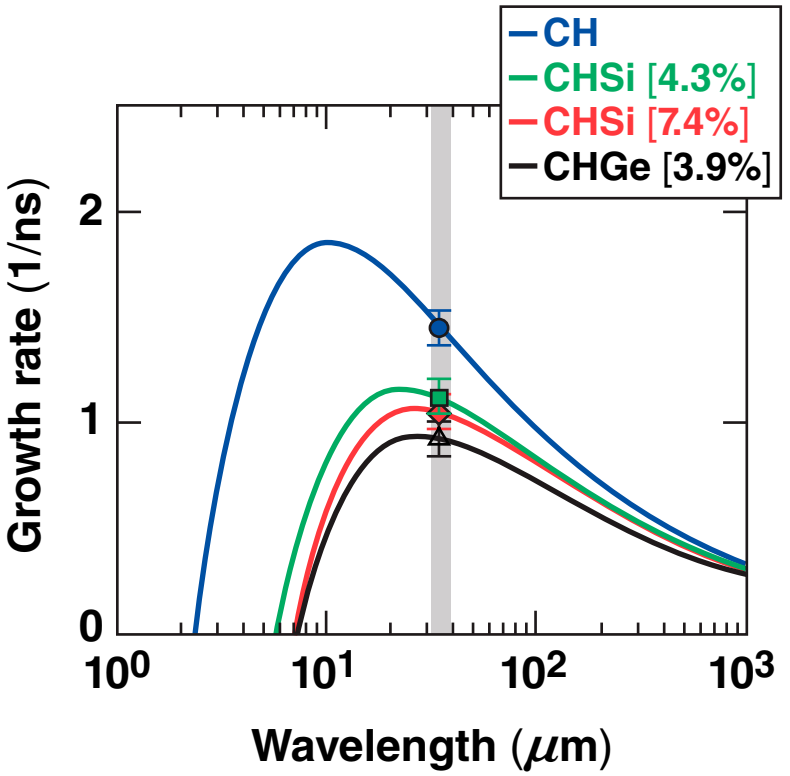
Using the directly measured mass-absorption coefficients (μ) of undriven targets, we can infer the evolution of ρR modulations because of $\Delta_{OD} = \mu\Delta_{\rho R}$.





TC9755

Summary/Conclusions

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NIF ignition designs using a CH ablator with halfway Si doping show no reduction in gain (radiation preheat effects minimized).