Performance of Spherical Target Implosions on the OMEGA Laser System

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The performance of spherical, gas-filled, plastic capsules imploded with the 60-beam, 30-kJ OMEGA laser system will be presented. The targets had several combinations of wall thickness and material (CH and CD), fill pressure, and gas mixtures. The pulse shapes included a 1-ns square pulse and three different shaped pulses with contrast ratios of up to 40:1. The primary neutron yield from the gas fill and/or shell, normalized to 1-D prediction, varied from ~25% to 0.1%, depending on the target and irradiation conditions. Target performance will be presented as a function of the "distortion fraction" of the implosion,[1] which takes into account the imprinting efficiency of different pulse shapes, the Rayleigh–Taylor (RT) growth during the acceleration phase, feed-through, and deceleration phase. The relevance of these experiments to upcoming cryogenic experiments will be discussed. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460, UR, and NYSERDA.

1. P. W. McKenty *et al*., Bull. Am. Phys. Soc. **41**, 1562 (1996).

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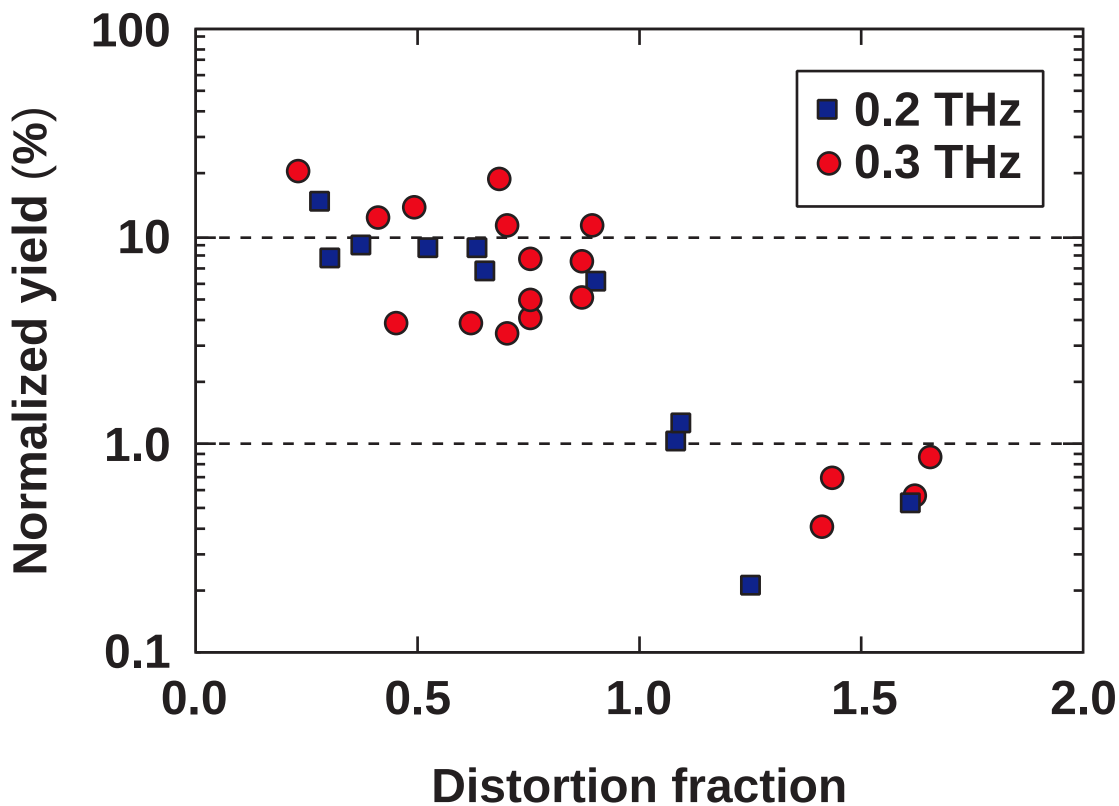

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Summary

The fuel performance in OMEGA spherical implosions improves with increasing shell stability

- CH shells with D_2 fills have been imploded on OMEGA with different pulse shapes, fill pressures, and SSD smoothing levels.
- The fuel performance measured the by yield and areal density is compared to 1-D predictions.
- A calculated distortion fraction of the compressed shell provides a measure of the target stability.
- The distortion fraction predicted for OMEGA cryogenic targets is small.

Outline

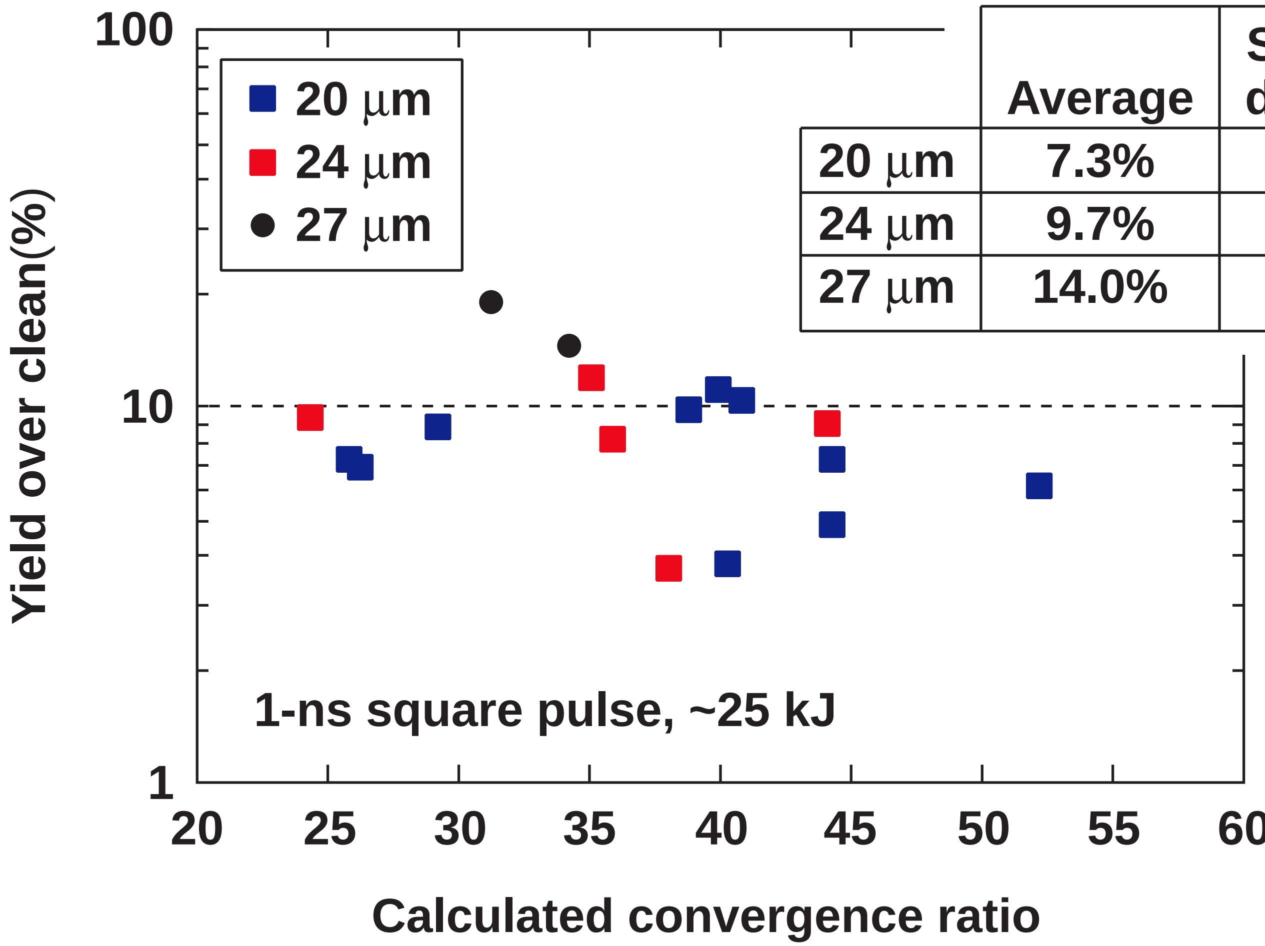
- **Target stability and distortion fraction**
- **OMEGA experimental results**
- **OMEGA cryo predictions**

The compressed fuel performance of spherically imploded CH shells is measured

- Targets
  - ~925-μm-diameter CH shells (some with CHTi layers)
  - 15- to 27-μm wall thickness
  - stalk mounted
- Fills
  - 3 to 15 atm of D_2, H_2-D_2, or D_2-^3He
- Pulse shapes
  - 1-ns square, up to 30 kJ
  - 2.4-ns, 8:1 contrast, up to 24 kJ
- Nonuniformity
  - SSD bandwidth 0.2 THz and 0.3 THz (3 color cycle)
  - power balance
- Diagnostics
  - primary neutron yield (up to 10^{11})
  - secondary neutron yield (MEDUSA)
  - ρR deduced from central source; no slowing down model

Fuel performance is not a strong function of convergence ratio

- The primary yield normalized to 1-D predictions is primarily a function of shell thickness.



	Average	Standard deviation
20 μm	7.3%	2.5%
24 μm	9.7%	1.7%
27 μm	14.0%	4.6%

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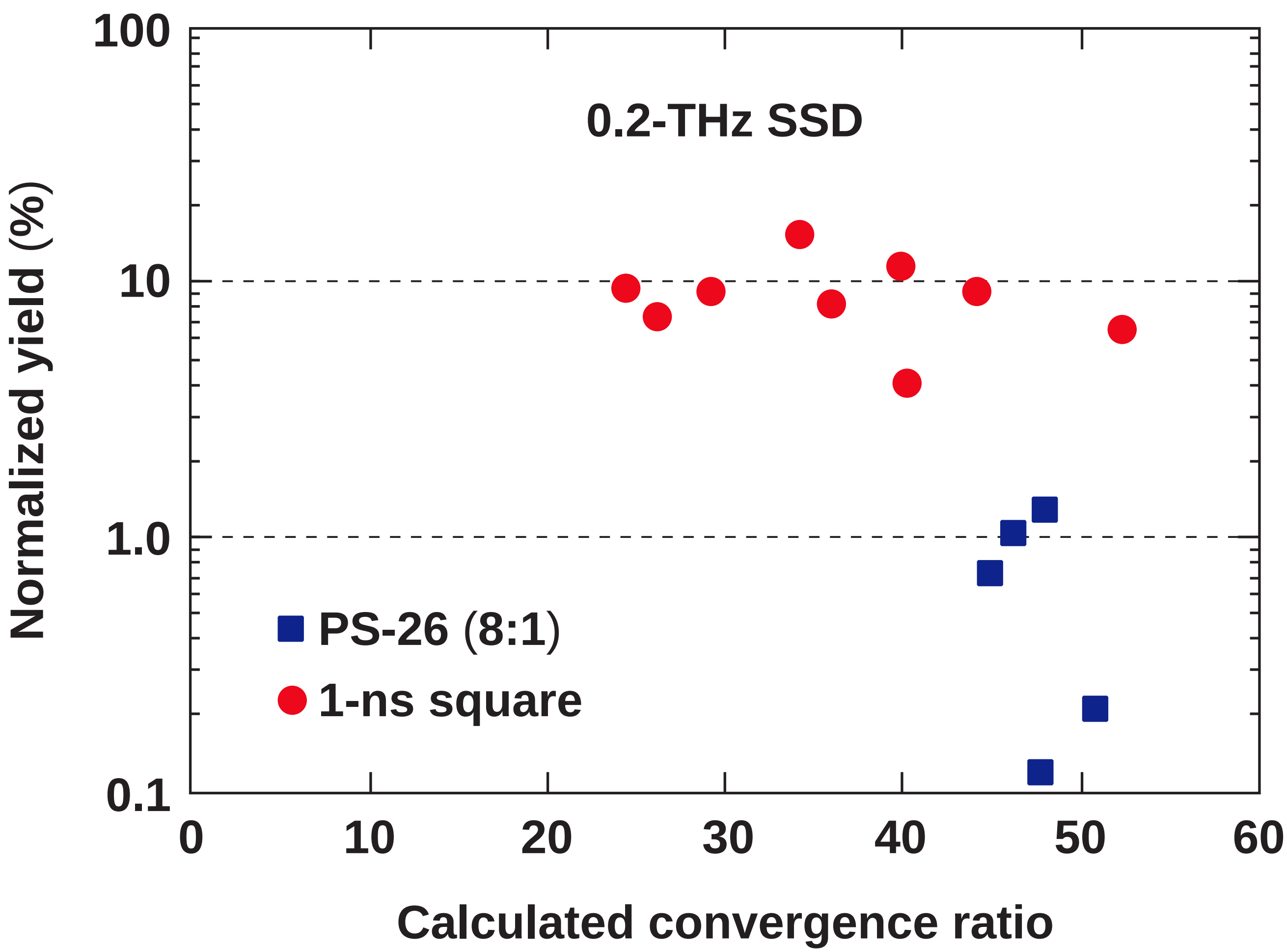
The normalized yield depends on temporal pulse shape



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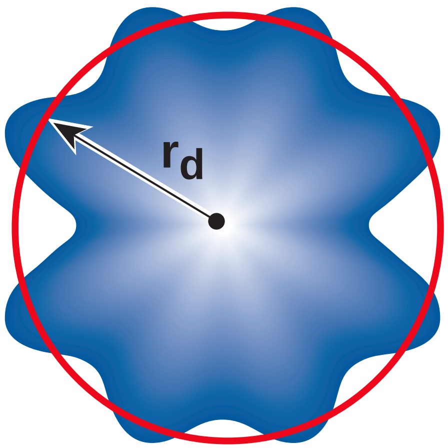
Spherical implosions are Rayleigh–Taylor unstable during both the acceleration and deceleration phases

- **Target stability depends on**
  - **the growth of laser nonuniformities in both the acceleration and the deceleration phases**
  - **the amplitude of the perturbations relative to**
    - **shell thickness—acceleration phase**
    - **compressed core size—deceleration phase**
- **A distortion fraction* is calculated from**
  - **the initial nonuniformity (including generic power balance),**
  - **the Rayleigh–Taylor growth in the acceleration phase,**
  - **the feedthrough to the inner surface, and**
  - **the Rayleigh–Taylor growth in the deceleration phase.**

***P. W. McKenty *et al*., BAPS 41, 1562 (1996).**

Analysis of target performance (yield-over-clean) is now drawn as a function of the calculated distortion fraction $\langle\delta_s\rangle / r_s$



Start of deceleration phase

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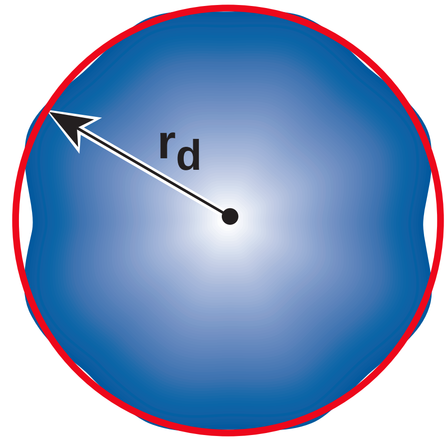
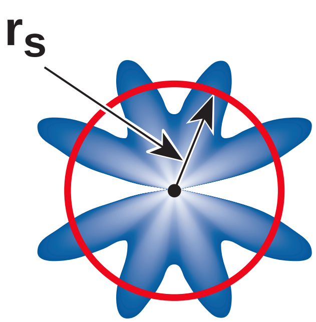
Perturbation amplitude

$$\langle\delta_d\rangle = \langle\delta_i\rangle\langle GF\rangle_a\langle \text{feedthrough}\rangle$$





Stagnation

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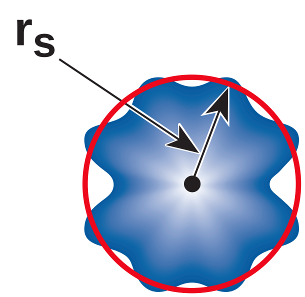
Perturbation amplitude

$$\langle\delta_s\rangle = \langle\delta_d\rangle\langle GF\rangle_d$$



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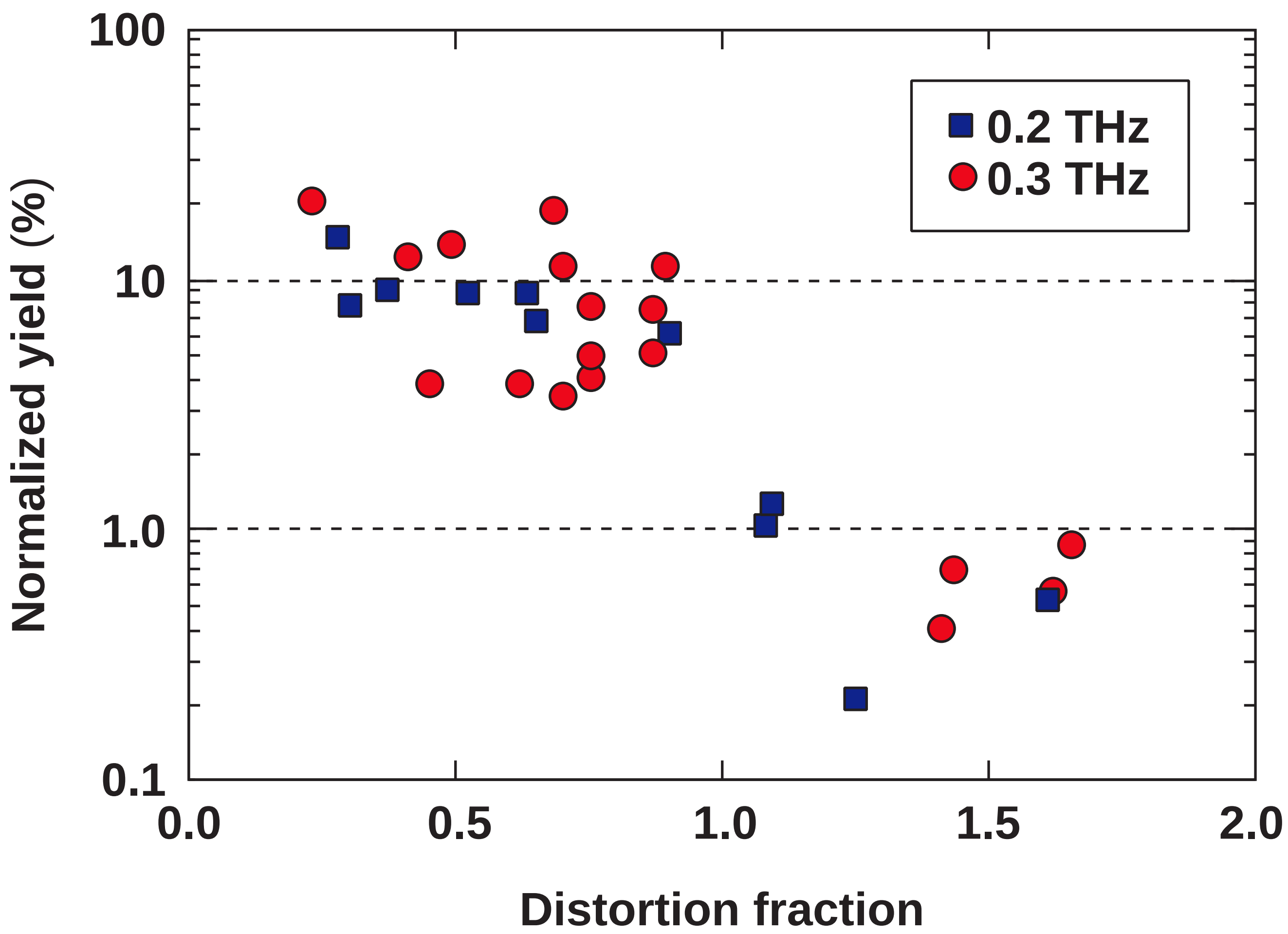
The normalized neutron yield is a function of the distortion fraction



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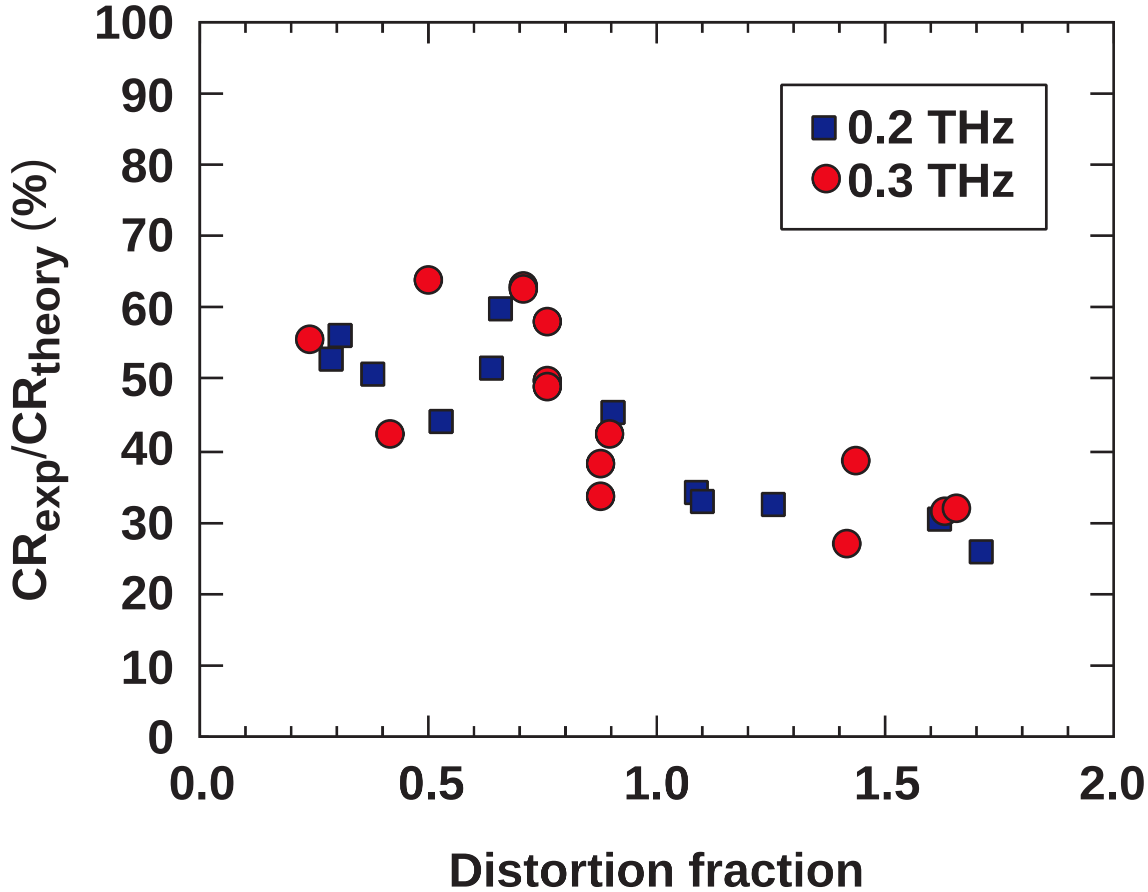
The ratio of experimental to predicted convergence ratio is a function of the distortion fraction



- The experimental convergence ratio is obtained from the measured fuel ρR to its initial value.

$$CR_{exp} = \sqrt{\frac{\langle \rho R_f \rangle}{\langle \rho R_i \rangle}}$$

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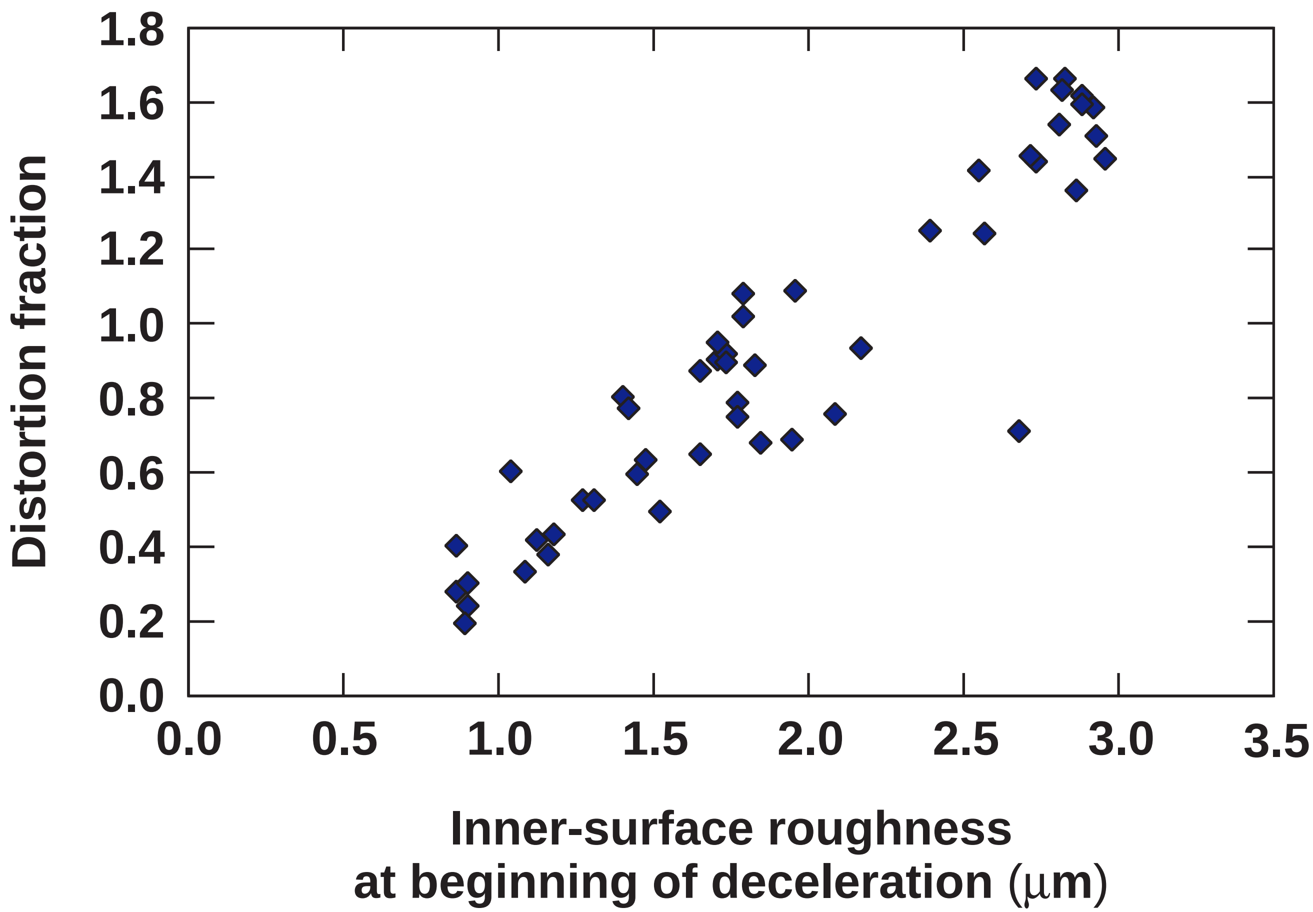
The distortion fraction is a strong function of the inner-surface perturbation at the beginning of the deceleration phase

- The inner-surface roughness depends on pulse shape, shell thickness, and initial nonuniformity.
- The distortion fraction is a better predictor of normalized yield.



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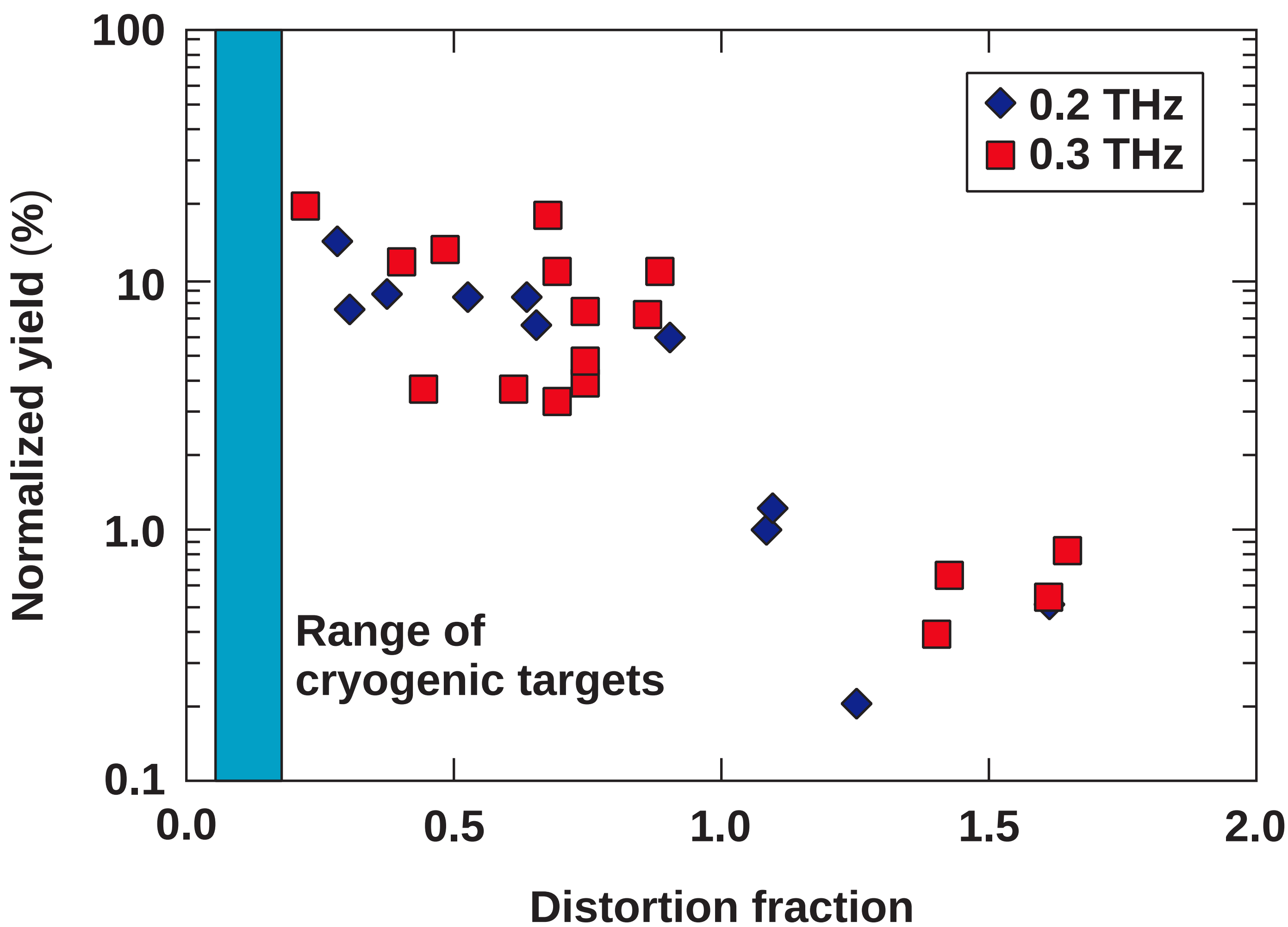
Cryogenic targets are expected to have small distortion fractions



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Summary/Conclusions

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