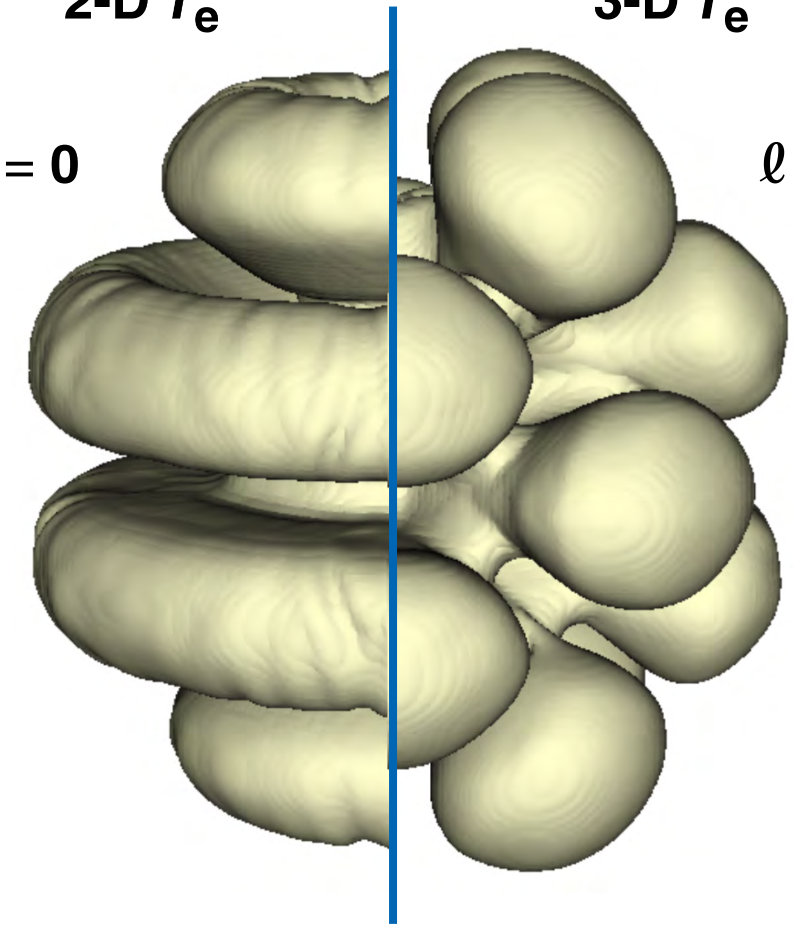
Three-Dimensional Simulations of the Deceleration Phase of Inertial Fusion Implosions Using *DEC3D*



T_e = 1-keV contour surface at stagnation

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Summary

The radiation-hydrocode *DEC3D* was developed to study the deceleration-phase Rayleigh–Taylor instability

UR LLE

- **The 3-D code uses a second-order Riemann solver on a moving mesh and is fully parallelized by domain decomposition**
- **The yield degradation in 3-D versus 2-D single-mode simulations is compared and a reduction by about 10% in neutron yield is observed in 3-D single-mode simulations**

TC12439

Collaborators

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DEC3D is a fully parallelized 3-D radiation hydrocode used to study the deceleration phase of implosions

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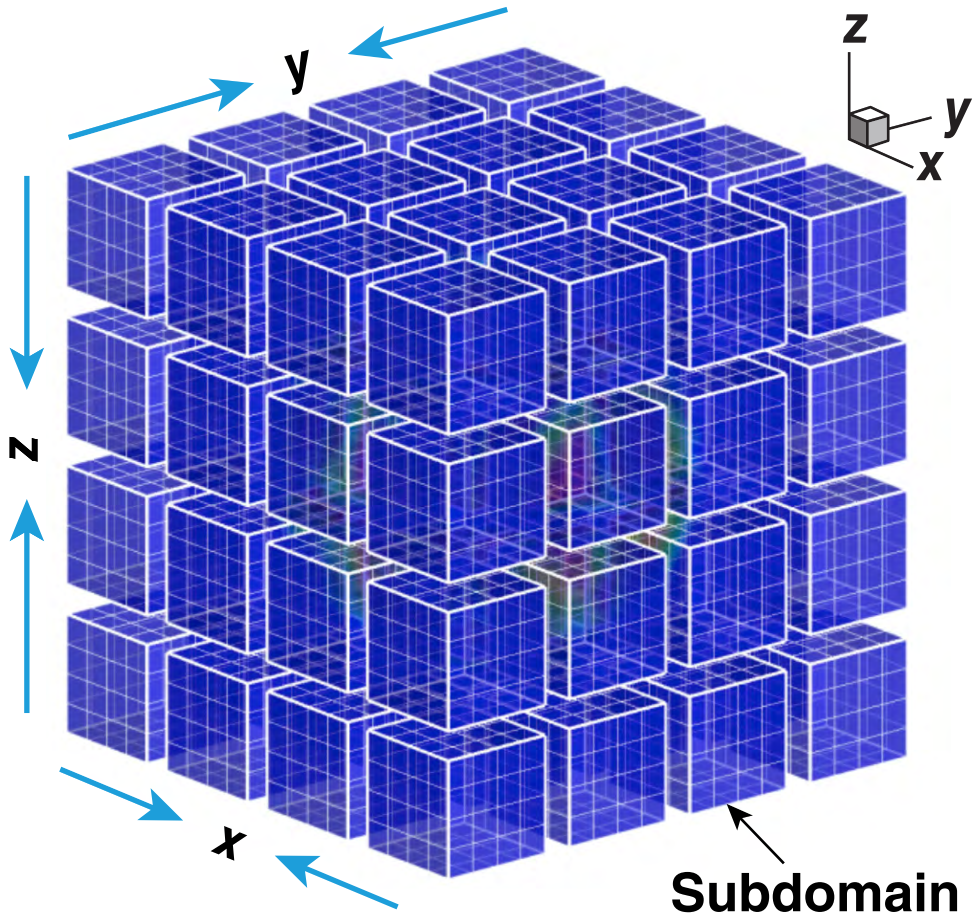
Mesh
- Shrinking Cartesian mesh
- Parallelized by domain decomposition

Hydrodynamics
- HLLC (Harten-Lax-van Leer-contact) second-order approximate Riemann solver

Thermal
- Red–black SOR (successive over relaxation) iteration for implicit thermal diffusion

Radiation
- Multigroup radiation transport*
- Tabular opacities

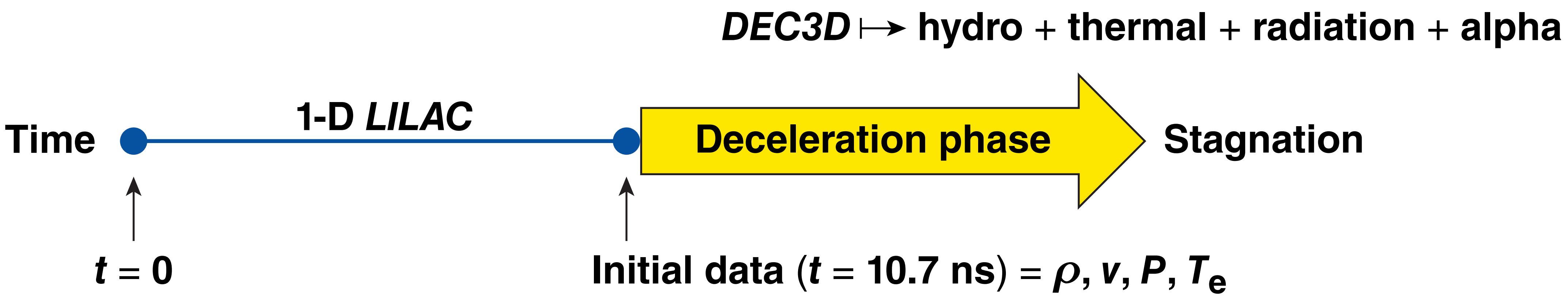
Alpha
- One-group alpha transport**



*K. M. Woo *et al*., Bull. Am. Phys. Soc. 59, 354 (2014).
**K. Anderson, R. Betti, and T. A. Gardiner, Bull. Am. Phys. Soc. 46, 280 (2001).

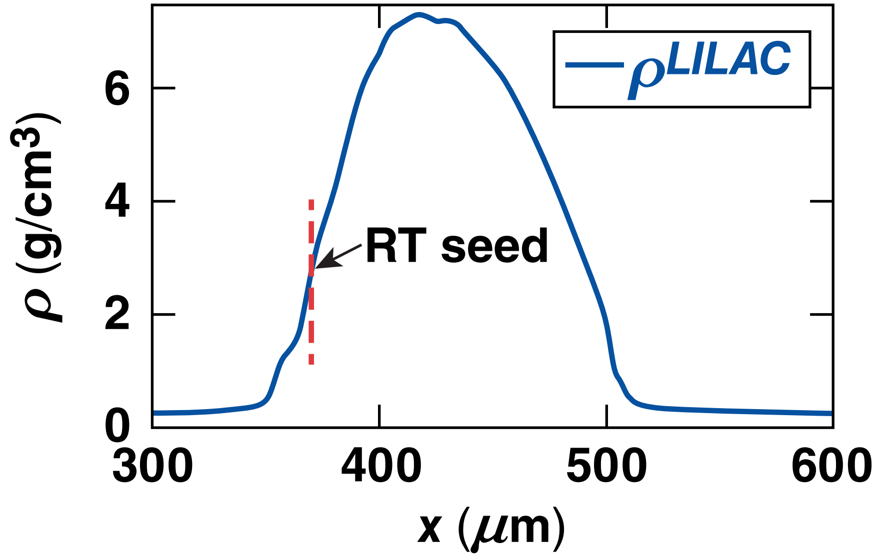
TC12441

Velocity perturbation is applied at the beginning of the deceleration phase to study the Rayleigh–Taylor (RT) instability



National Ignition Facility (NIF)-size target

ρ^{LILAC} at 10.7 ns



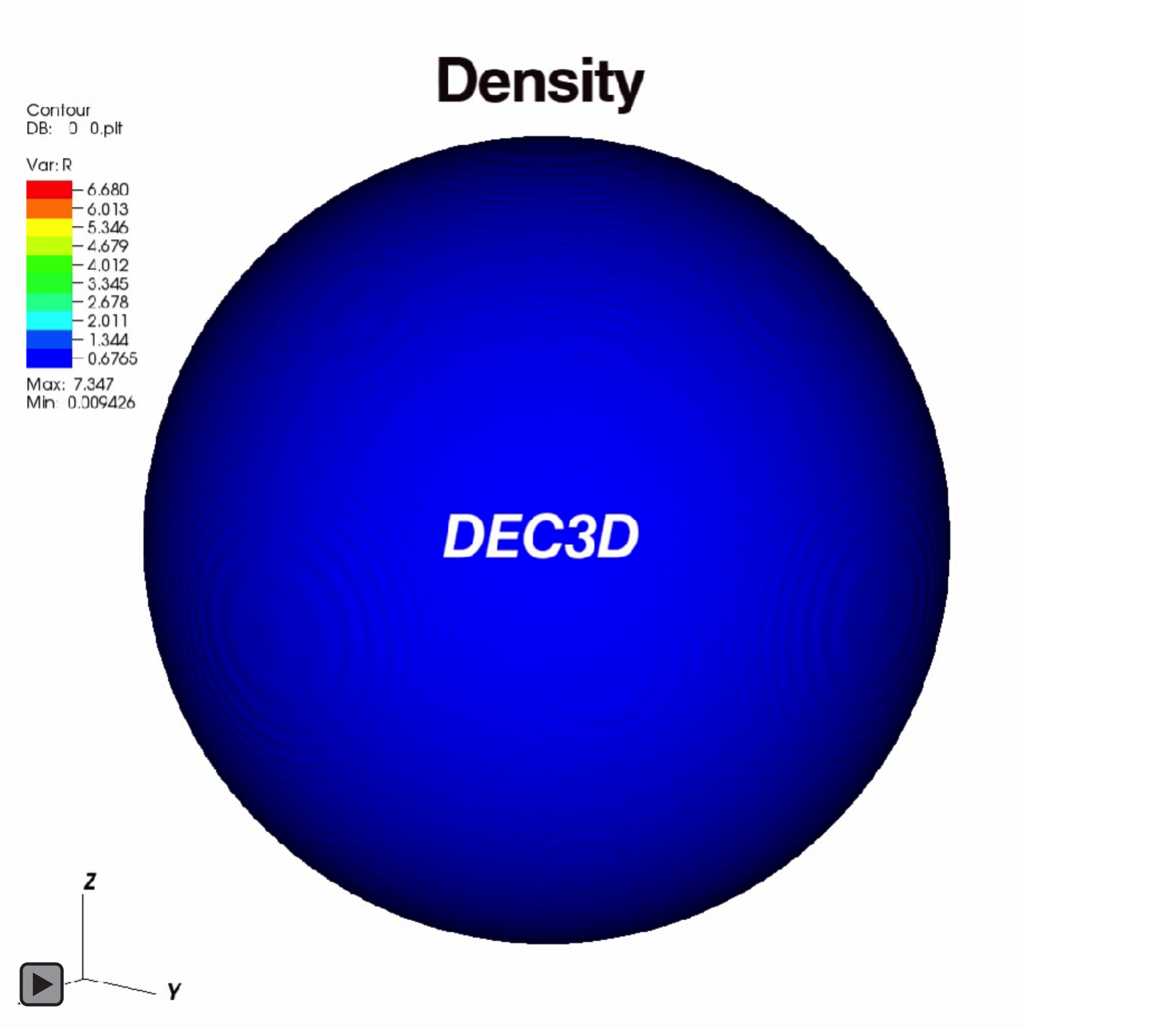
<u>Initial velocity perturbations</u>

$U_{3\text{-D}} = U_{1\text{-D}} + \Delta U\, Y_\ell^m(\theta, \varphi)$ ... single mode

$U_{3\text{-D}} = U_{1\text{-D}} + \sum_{\ell, m} \Delta U_{\ell m}\, Y_\ell^m\,(\theta + \theta_\ell, \varphi + \varphi_m)$ ... multimode

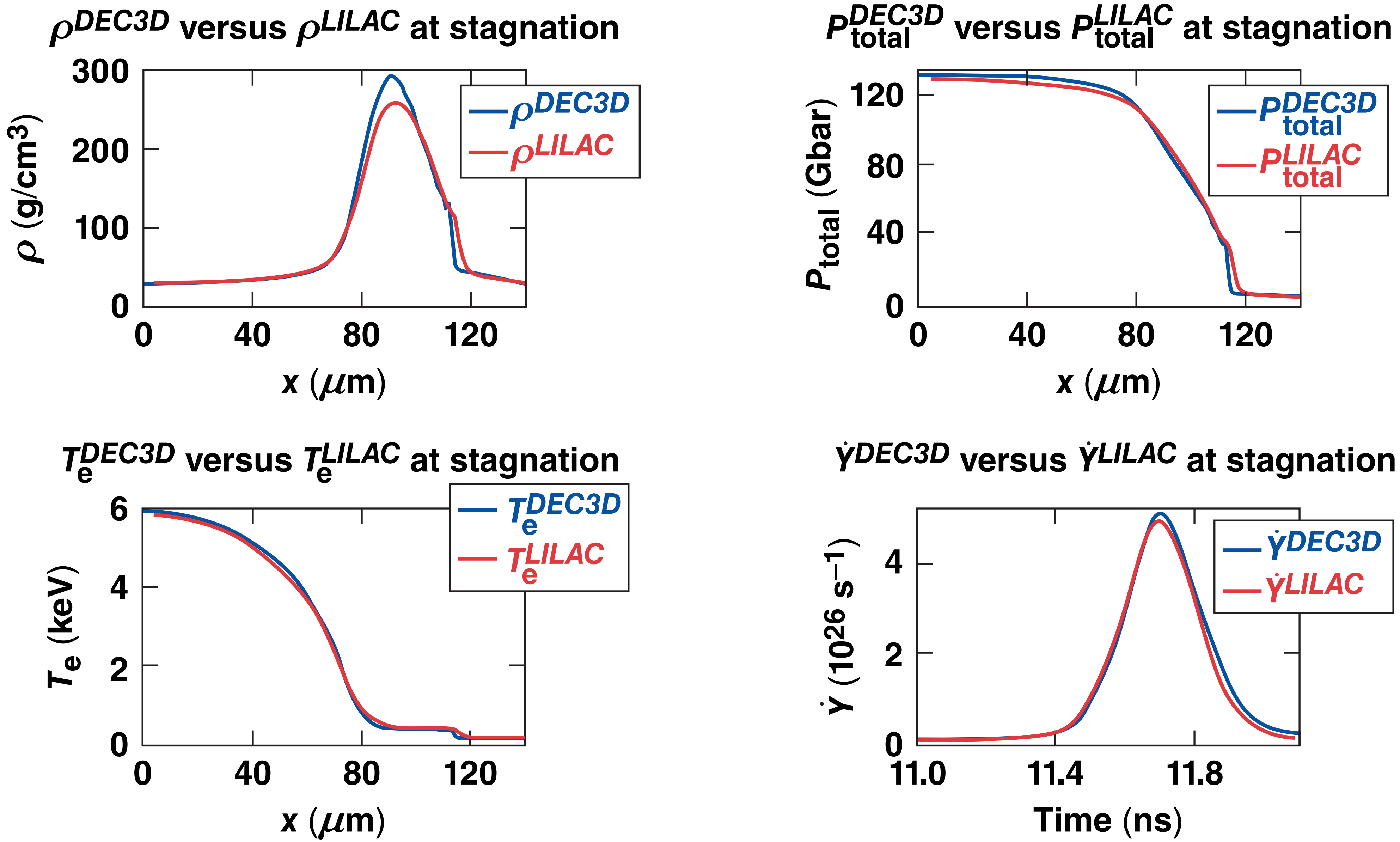
TC12608

The Rayleigh–Taylor instability during the deceleration phase is modeled by *DEC3D*



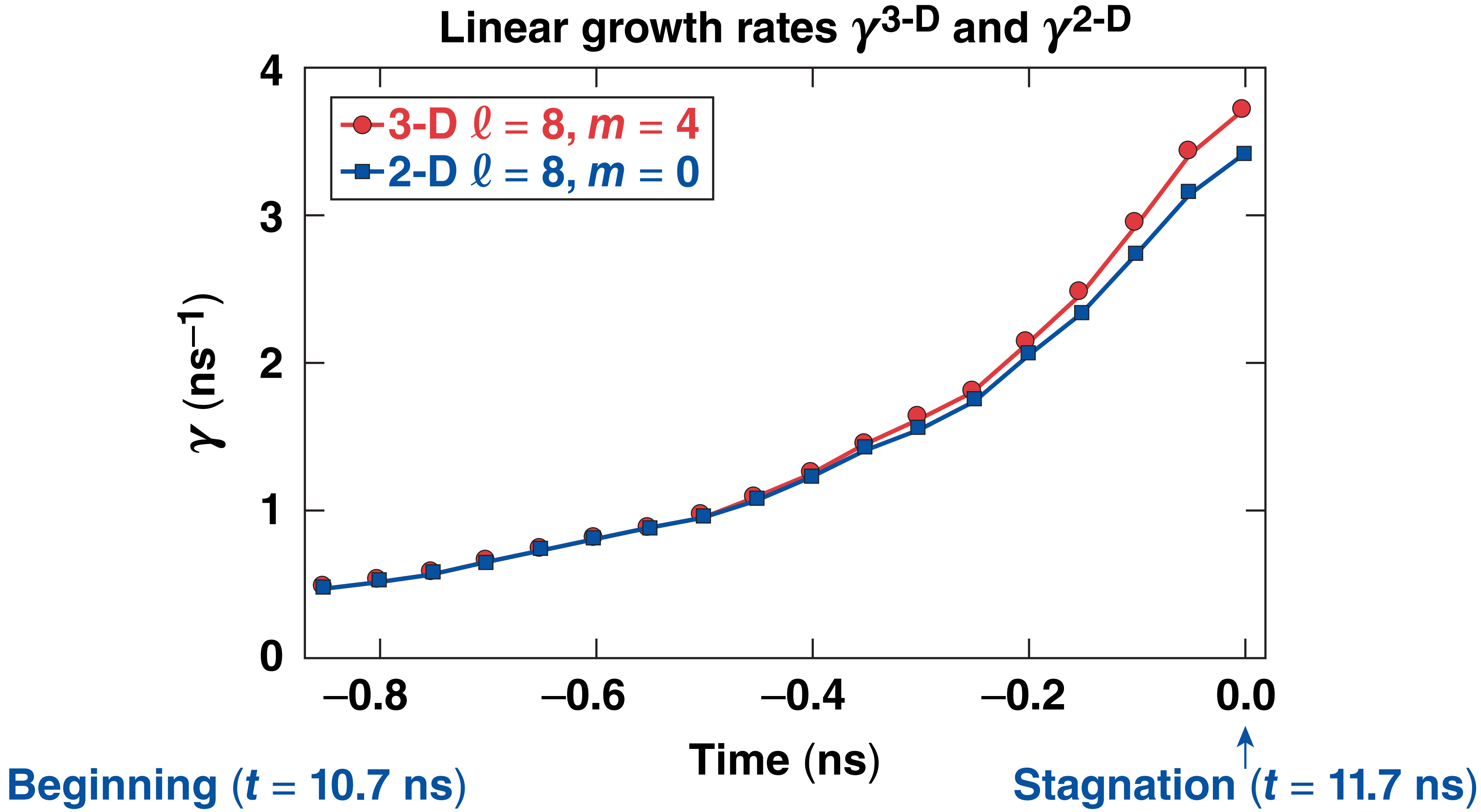
TC12609

Hydrodynamics, thermal conduction, and radiation transport have been validated against 1-D *LILAC*



TC12442

Single-mode Rayleigh–Taylor perturbation growth rates are compared to benchmark 3-D with 2-D simulations

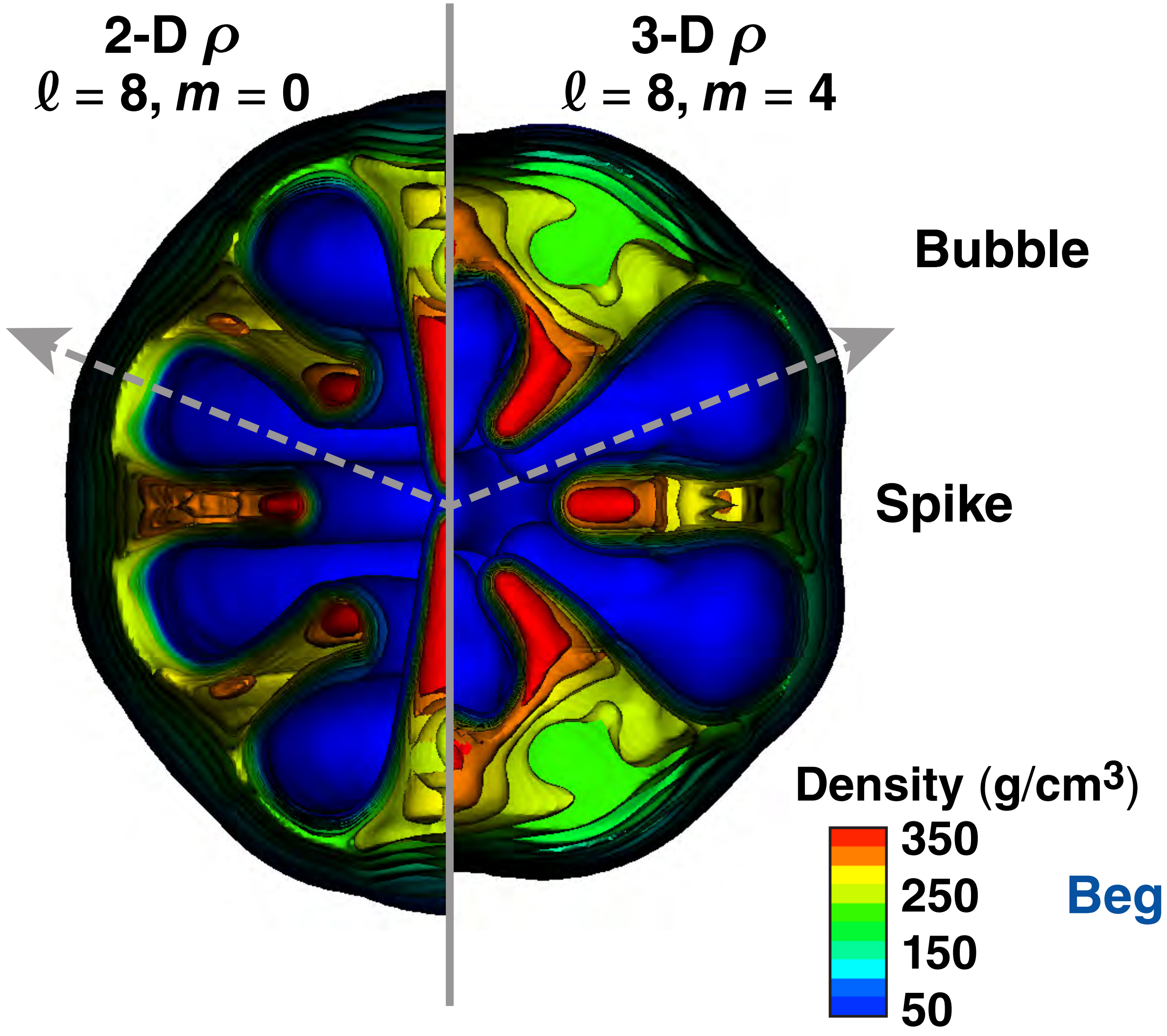


- Simulated linear growth rates are consistent with theories* for converging targets in the deceleration phase

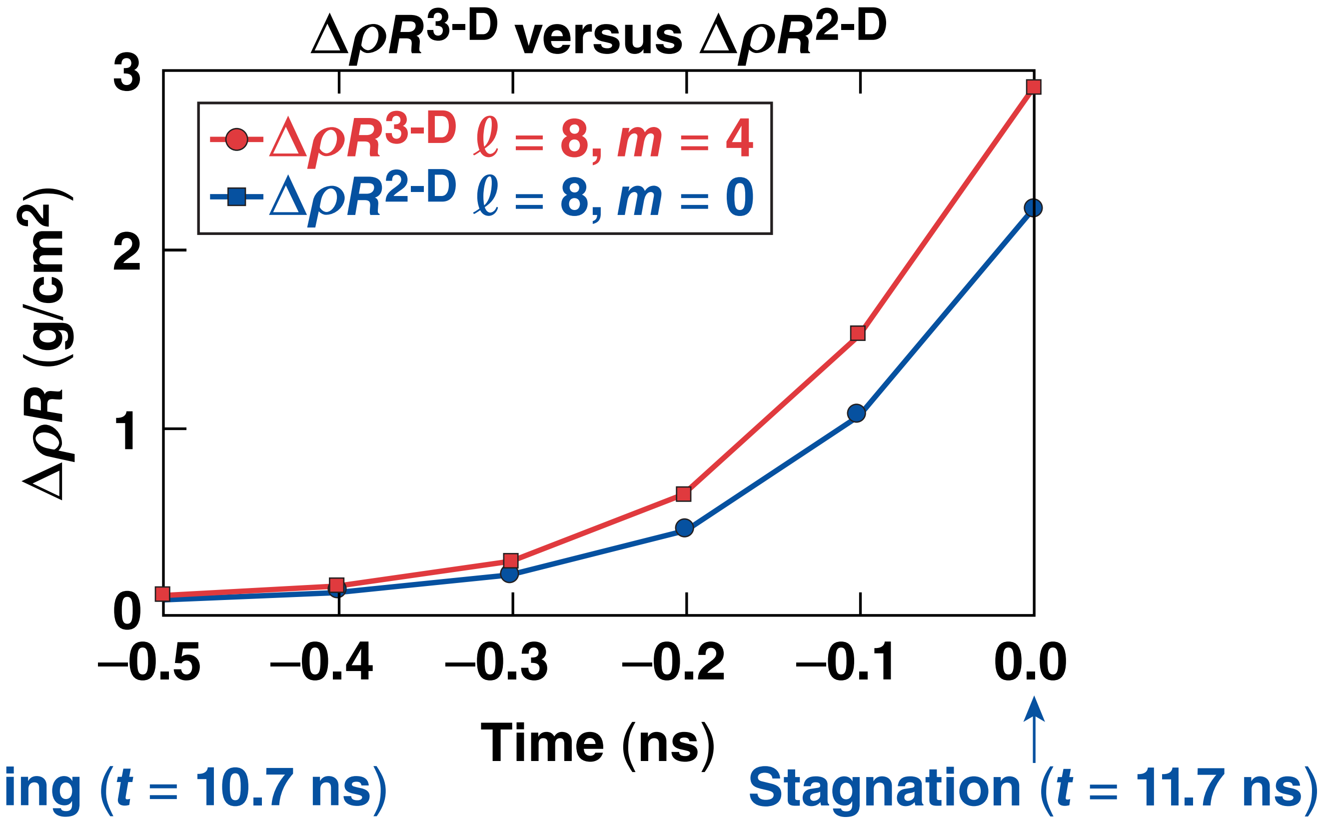
*R. Epstein, Phys. Plasmas 11, 5114 (2004).

TC12610

Nonlinear Rayleigh-Taylor growth leads to a thinner shell wall in 3-D than 2-D



Areal-density profile



An ~10% reduction in neutron yield is observed in 3-D versus 2-D single-mode simulations

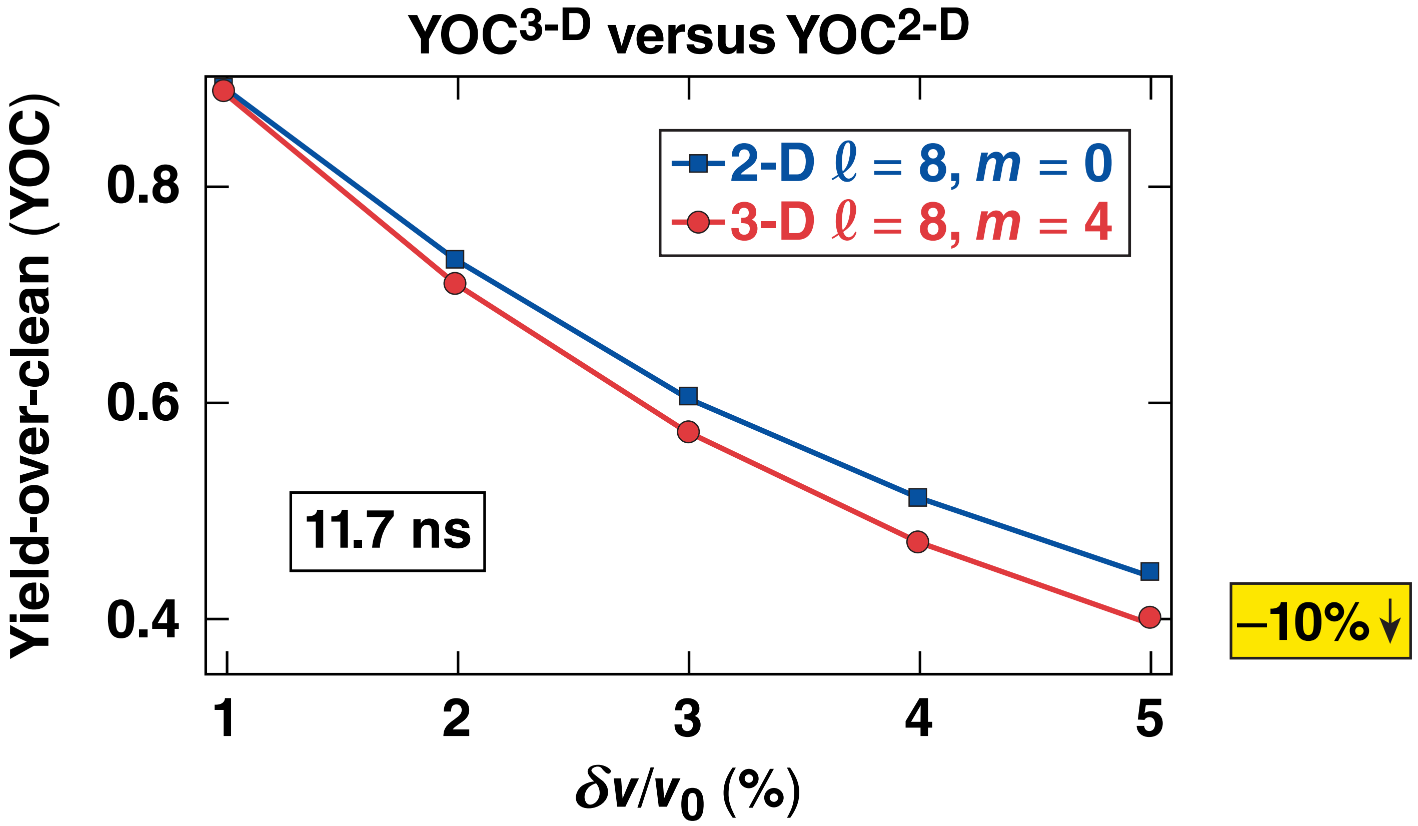
- Two types of 3-D initial perturbations are investigated to eliminate the possibility of design-dependence on the yield degradation

Orthogonal sinusodial modes

$$U_{3\text{-D}} = U_{1\text{-D}} + \Delta U\,[P_{2\text{-D}}(\ell\theta) + \sin m\varphi]$$

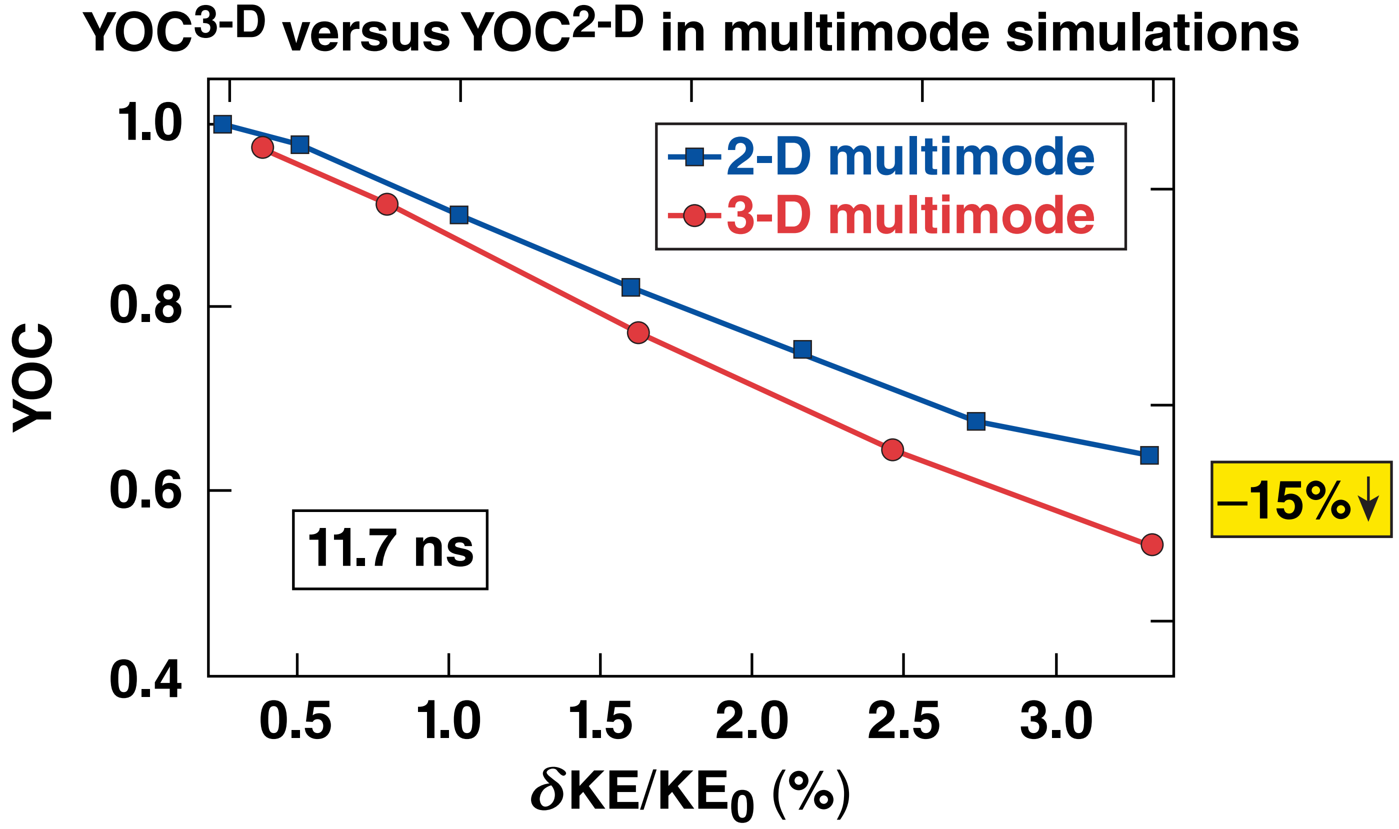
Spherical harmonic eigenmodes

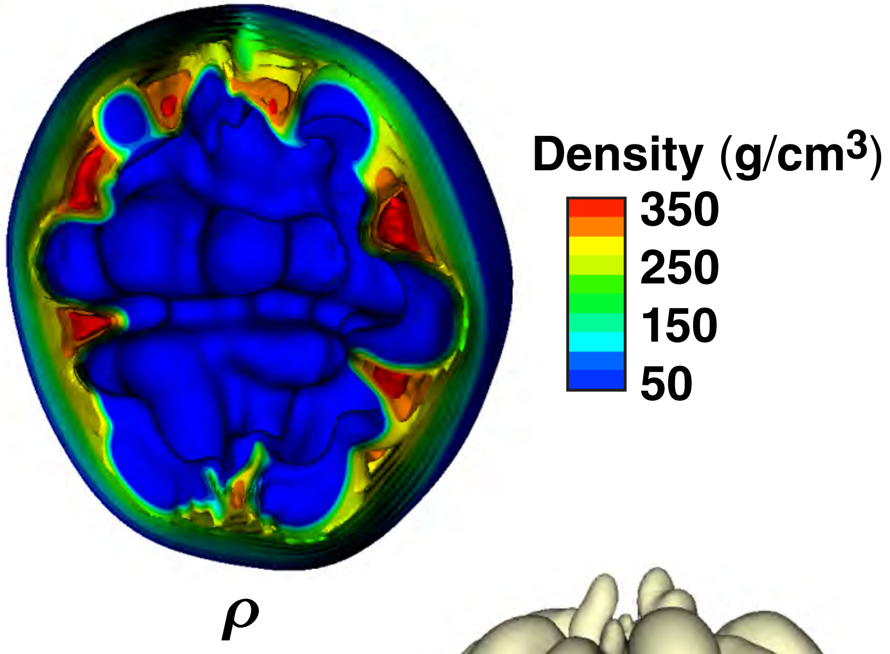
$$U_{3\text{-D}} = U_{1\text{-D}} + \Delta U\, Y_\ell^m(\theta, \varphi)$$

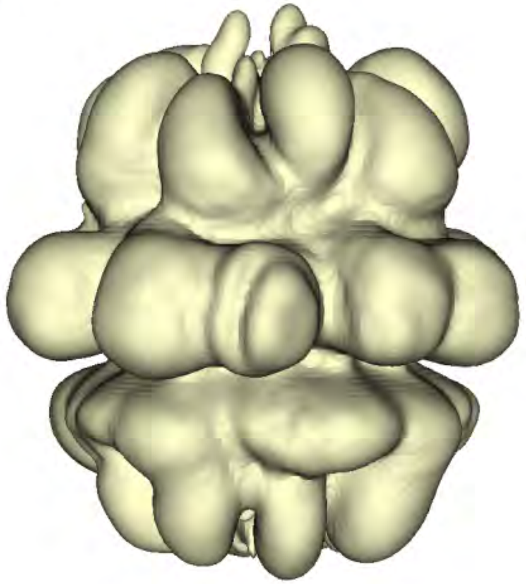


TC12612

An ~15% reduction in neutron yield is observed in 3-D versus 2-D multimode simulations







TC12613

The radiation-hydrocode *DEC3D* was developed to study the deceleration-phase Rayleigh–Taylor instability

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Appendix

DEC3D is a fully parallelized 3-D radiation hydrocode to study the implosions of the deceleration phase