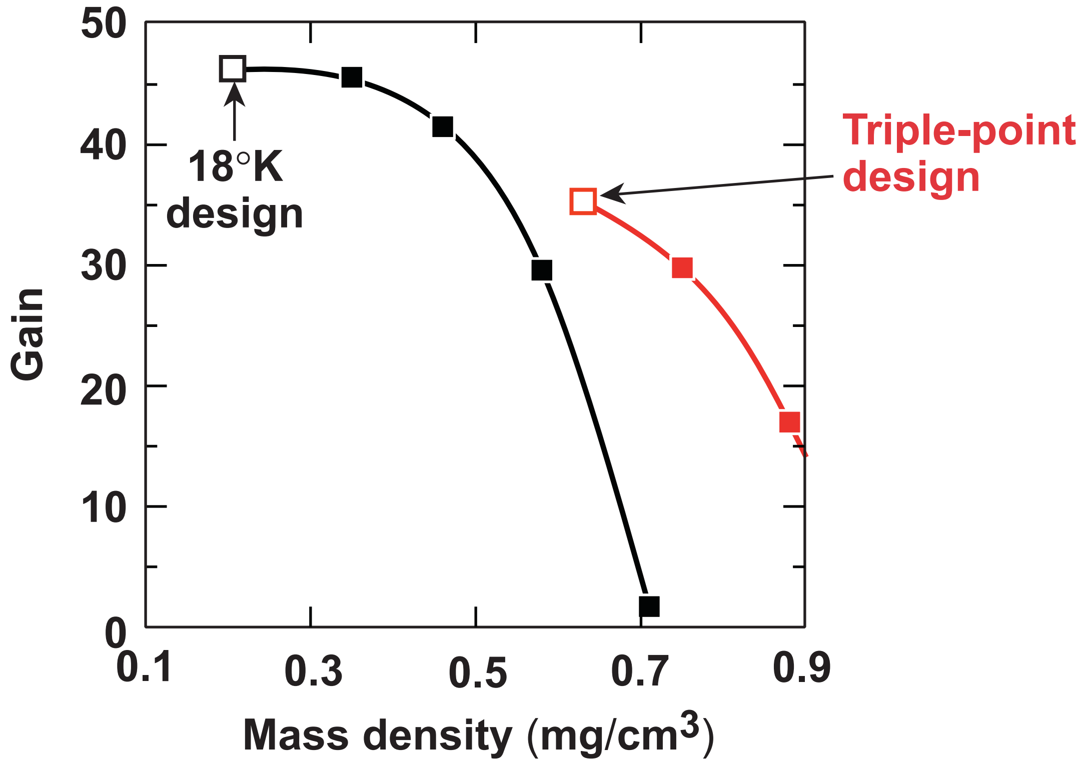
The Effect of Elevated Internal Gas Pressure on Direct-drive Cryogenic Target Performance



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Direct-drive cryogenic target designs consist of a thin polymer ablator surrounding a thick DT-ice shell that acts as the abalator and fuel. Initially, a low-pressure residual DT gas is contained within the DT-ice shell; however, the storage and temperature of the cryogenic target can elevate this pressure. For optimal layering of the inner ice surface, the cryogenic target should be maintain at the triple point. The residual gas pressure at this temperature, however, is almost a factor of 3 greater than LLE's base-line design, which operates at 18.5K. During the filling and cooling of the capsule, tritium within the shell decays to produce He^3, which migrates to the central region and also causes an increase in the residual gas pressure. This paper studies the effect on target performance from the increased residual gas pressure caused by operating at the triple point and from the expected He^3 build-up. This work was supported by the U.S. Department of Energy Office of Inertial Confinement Fusion under Cooperative Agreement No. DE-FC03-92SF19460.

Collaborators

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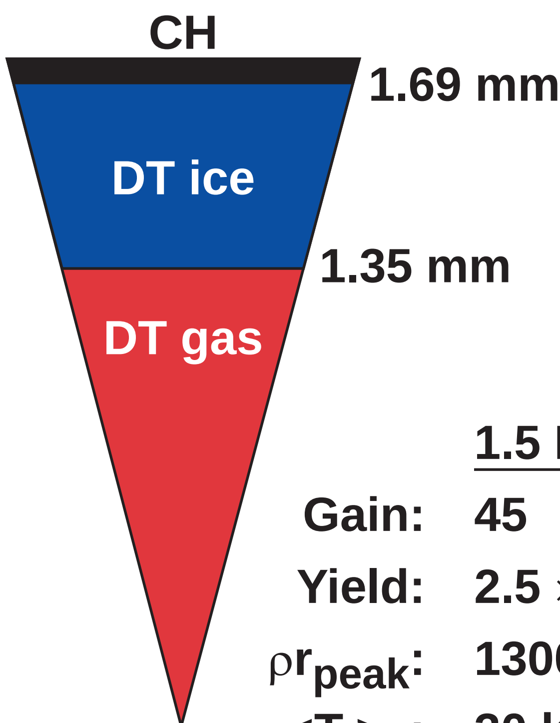
Summary

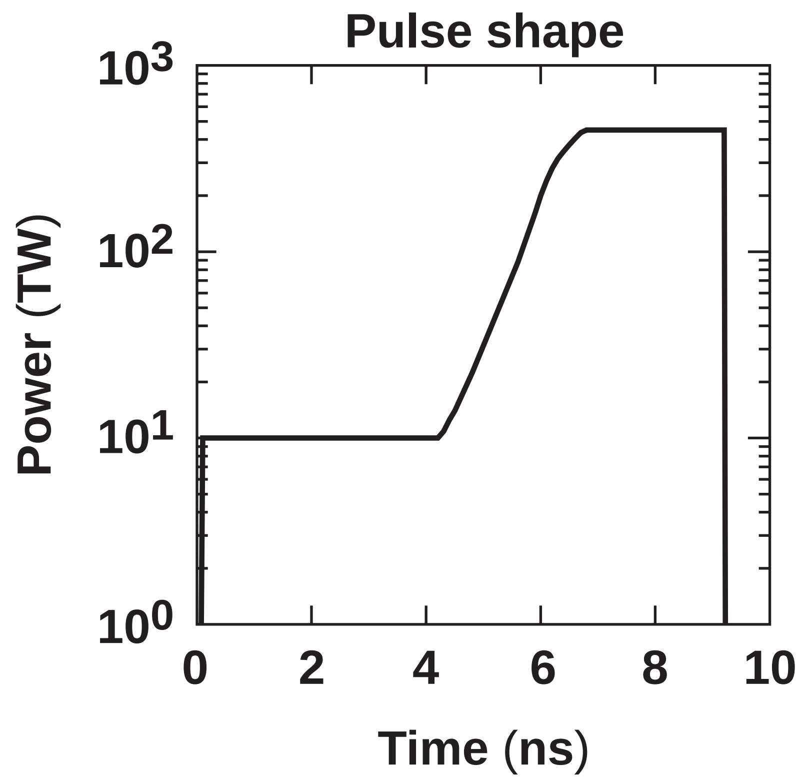
Higher gas fill reduces direct-drive cryogenic target performance

- Higher gas-fill pressures occur
  - at higher operating temperatures and
  - after longer storage.
- 1-D simulations show reduced performance at higher gas fills.
- Higher gas-fill pressures lead to a delay in ignition, making the target more susceptible to the deceleration-phase Rayleigh–Taylor instability

The “all-DT” direct-drive target is a thick DT-ice layer enclosed by a thin CH shell

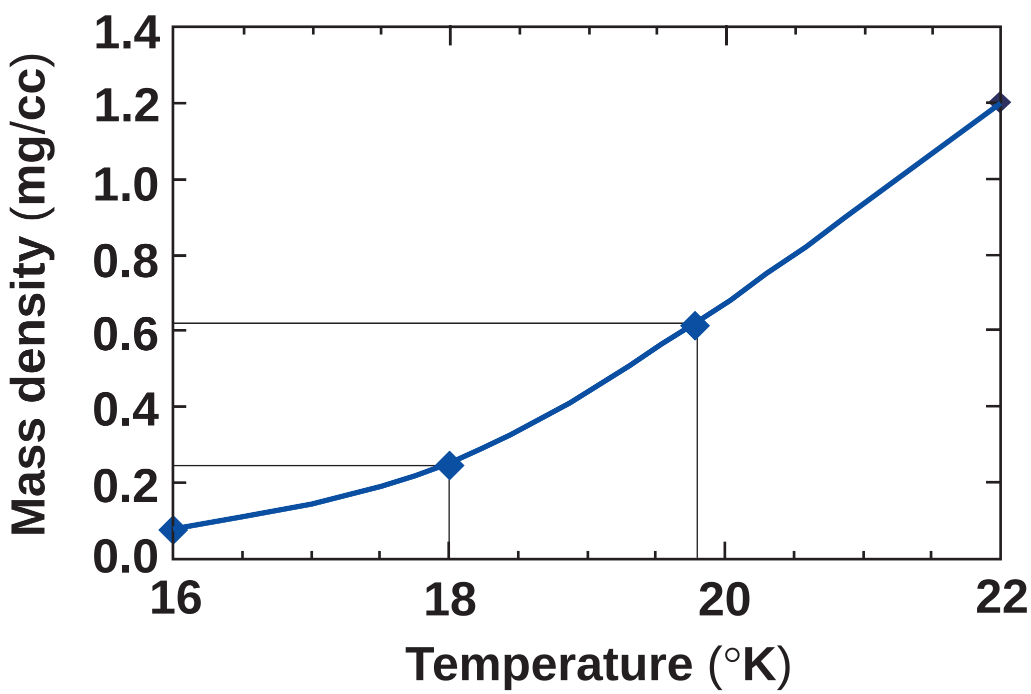


	1.5 MJ, α = 3
Gain:	45
Yield:	2.5×10^{19}
ρr_{peak}:	1300 mg/cm^2
$\langle T_i \rangle_n$:	30 keV
Hot spot CR:	29
Peak IFAR:	60



Operating at higher temperatures increases the mass density of the residual gas

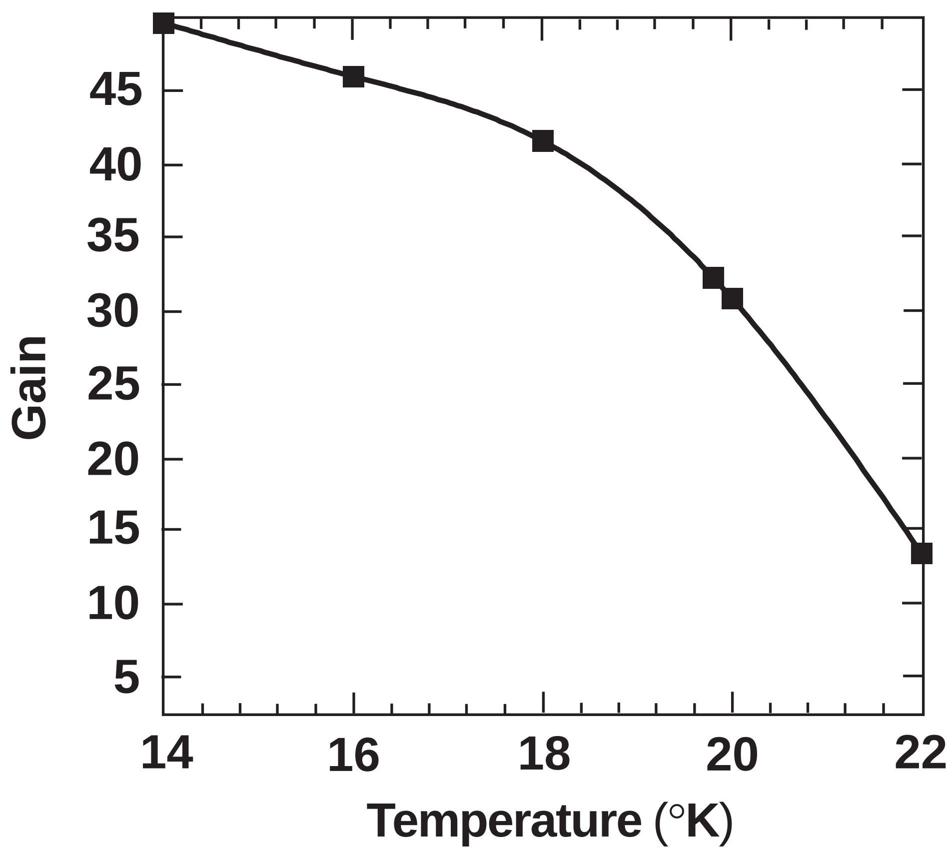
- The base-line direct-drive ignition design operates at 17.8°K.
- Smoother ice layers are obtained at the triple point (19.8°K).



Operating at the triple point almost triples the mass density of the gas.

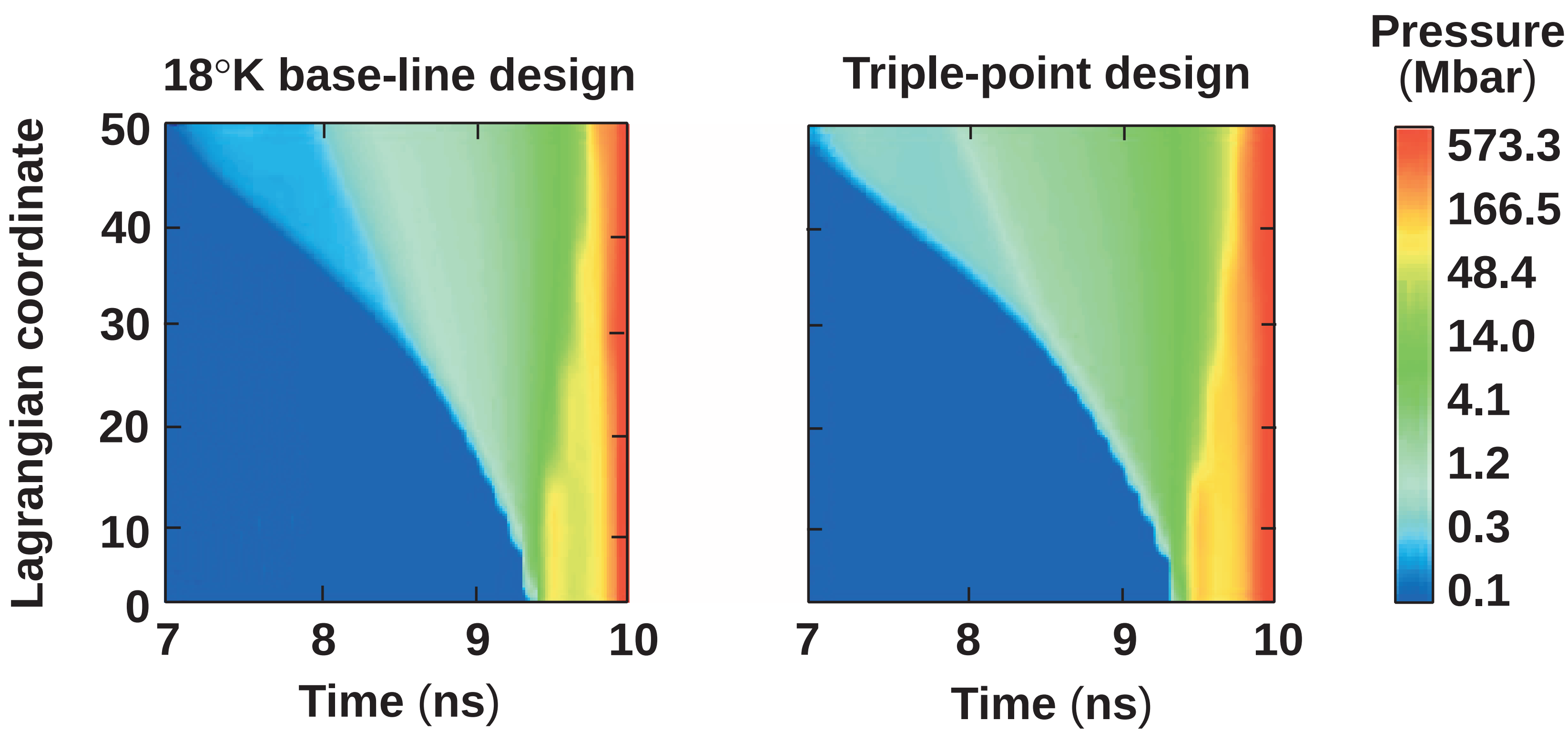
TC5436

Operating at the triple point reduces the target gain to 80% of the base-line 18°K gain



TC5437

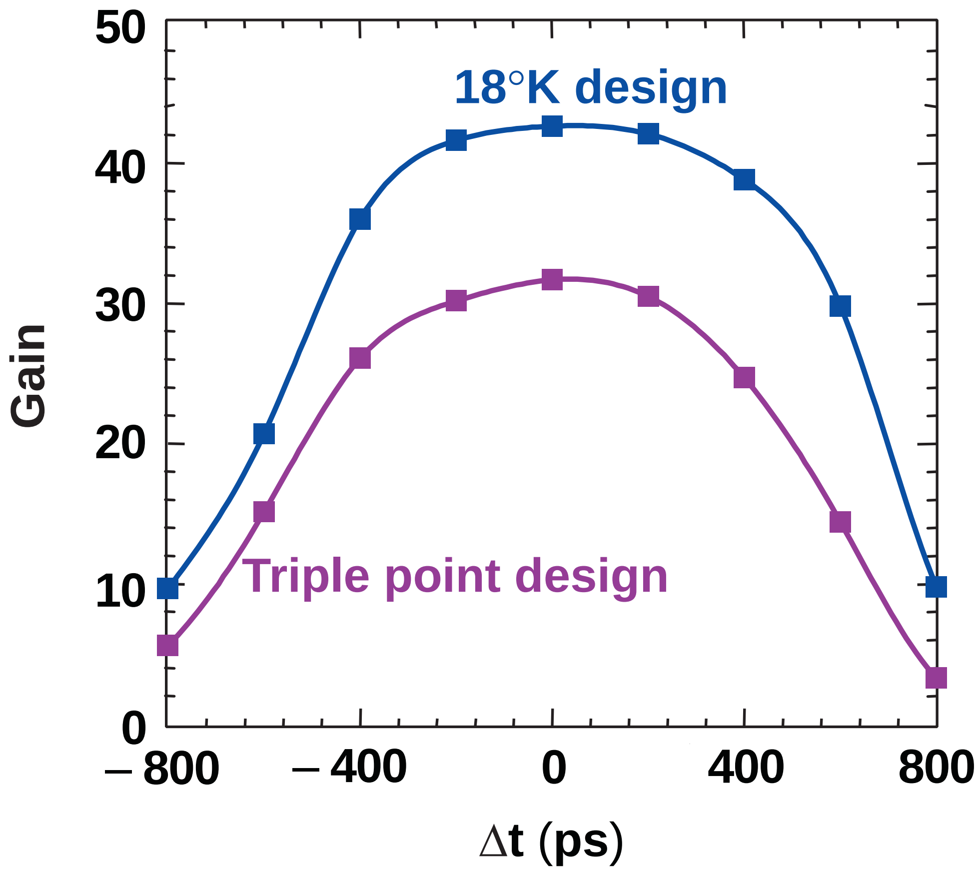
The triple point design generates a stronger stagnation shock pressure than the base-line design



- This higher pressure causes
  - lower convergence ratio,
  - lower areal density, and
  - lower target gain.

TC5438

Tuning can be performed in the same manner as the base-line design at higher gas-fill densities



TC5439

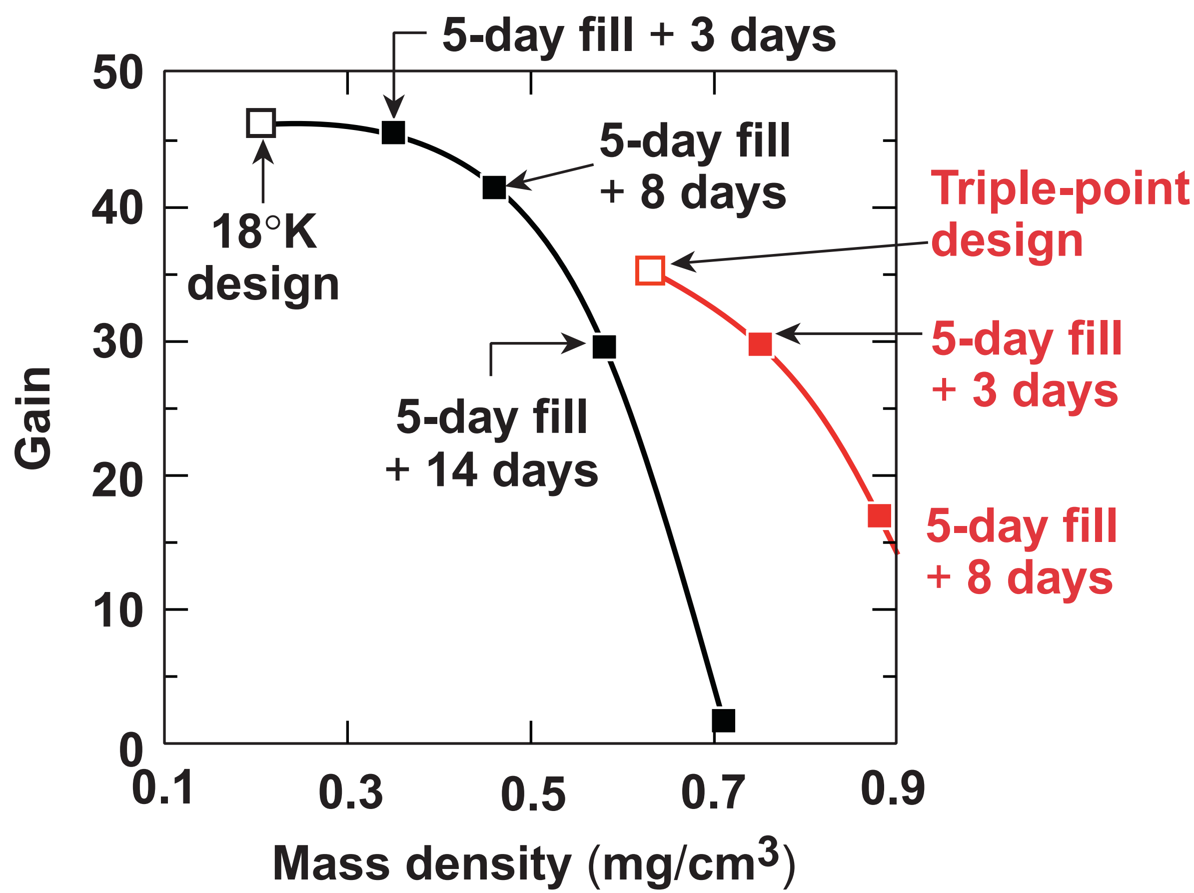
The decay of tritium leads to the buildup of ^{3}He in the central gas

$$T \rightarrow {}^3He + e^- + \bar{\nu}_e \text{ (12.3 years)}$$

- **General Atomics has refined the capsule fabrication process to increase both the permeability and strength of OMEGA-scale thin-wall capsules.**
- **Scaling the measured performance to NIF:**

	Time required to fill target (days)	^{3}He density after fill (mg/cc)	^{3}He accumulation per day (mg/cc)
Standard capsule	18.7	0.25	0.023
Improved CH capsule	5.2	0.07	0.023

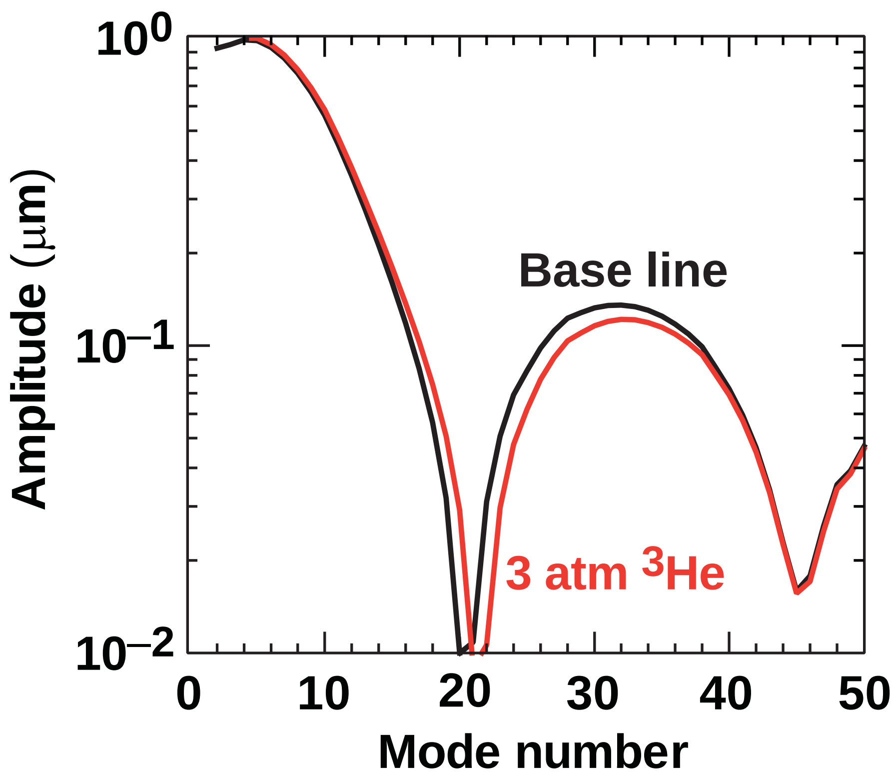
Rapid filling and shooting of cryogenic targets will be required



TC5295b

The acceleration phase is independent of the gas-fill pressure

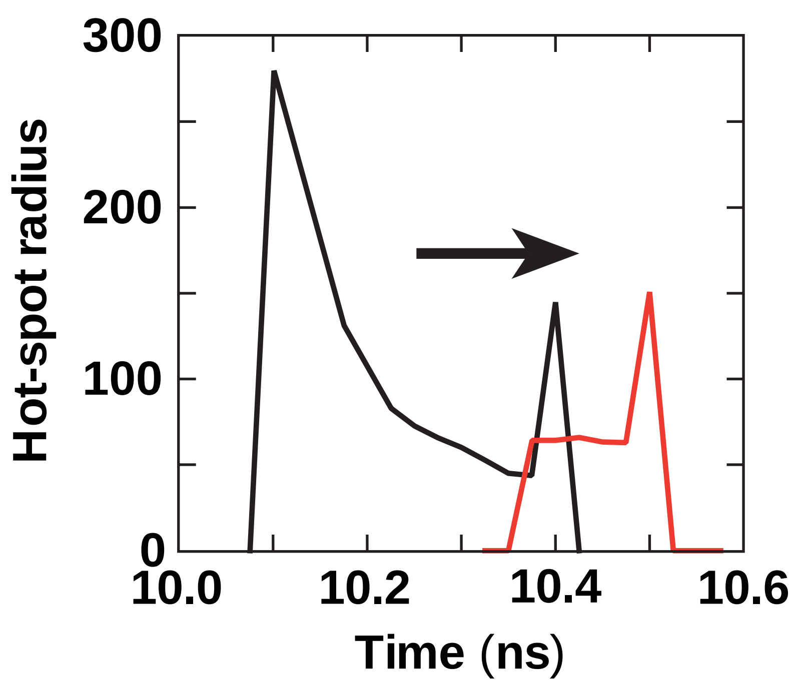
- The base-line design and higher-pressure cases experience similar amounts of Rayleigh–Taylor growth during the acceleration phase.
- The mode spectrum on the inner ice surface at the start of the deceleration phase is identical.

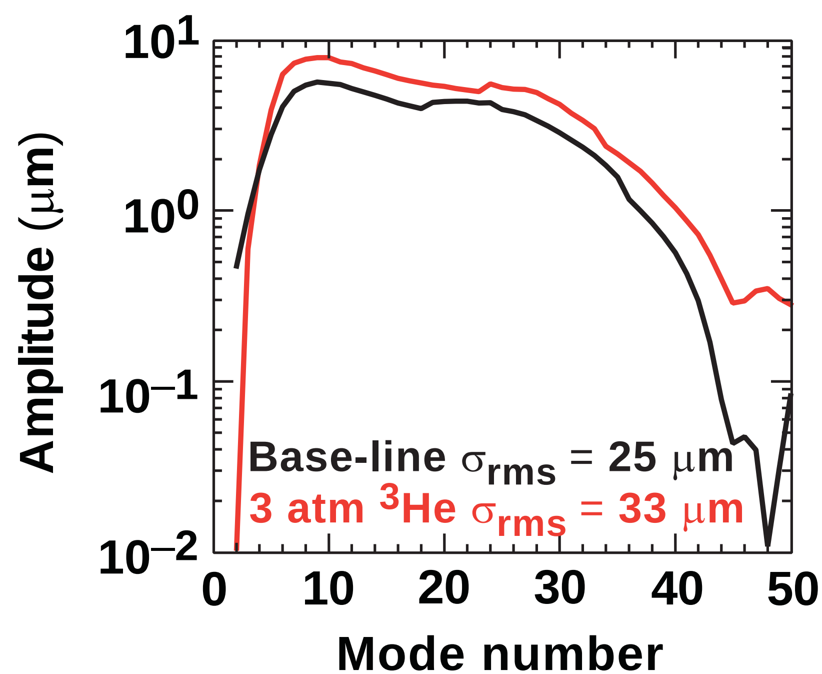


TC5441

The addition of ^{3}He delays ignition, leading to larger Rayleigh–Taylor growth during the deceleration phase

- **Adding ^{3}He to the residual gas delays the formation of the hot spot.**
- **The mode spectrum on the inner ice surface at the time of hot-spot formation is larger for ^{3}He-filled targets.**





Summary/Conclusion

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