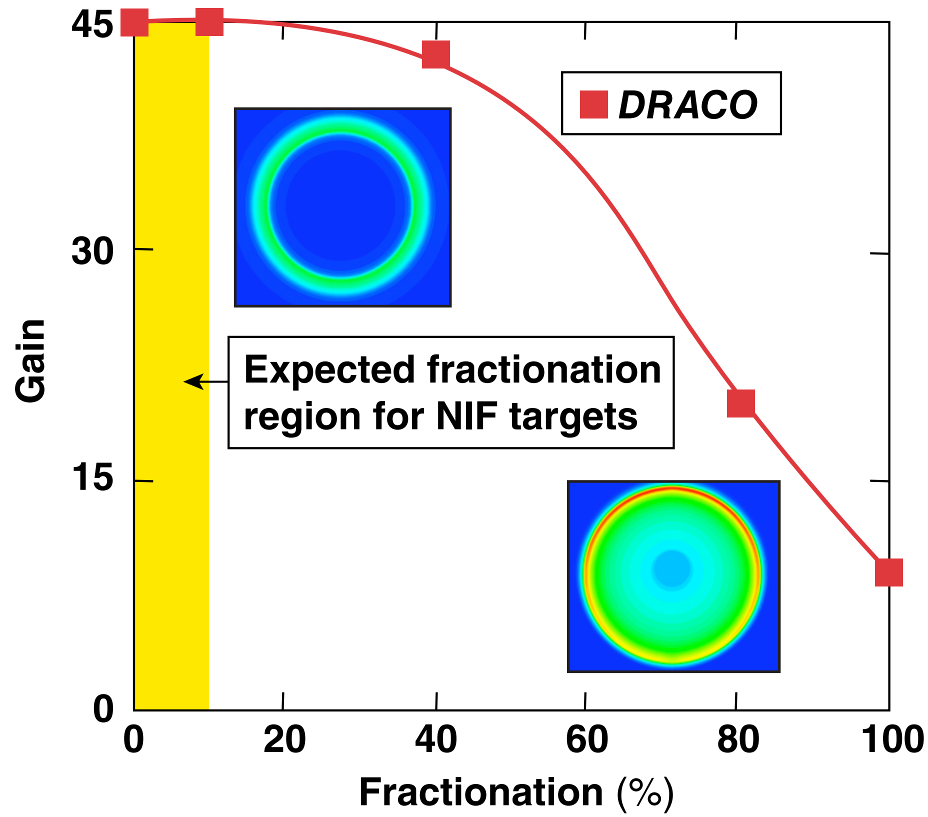
Role of Hydrogen Fractionation in ICF Ignition Target Designs



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Summary

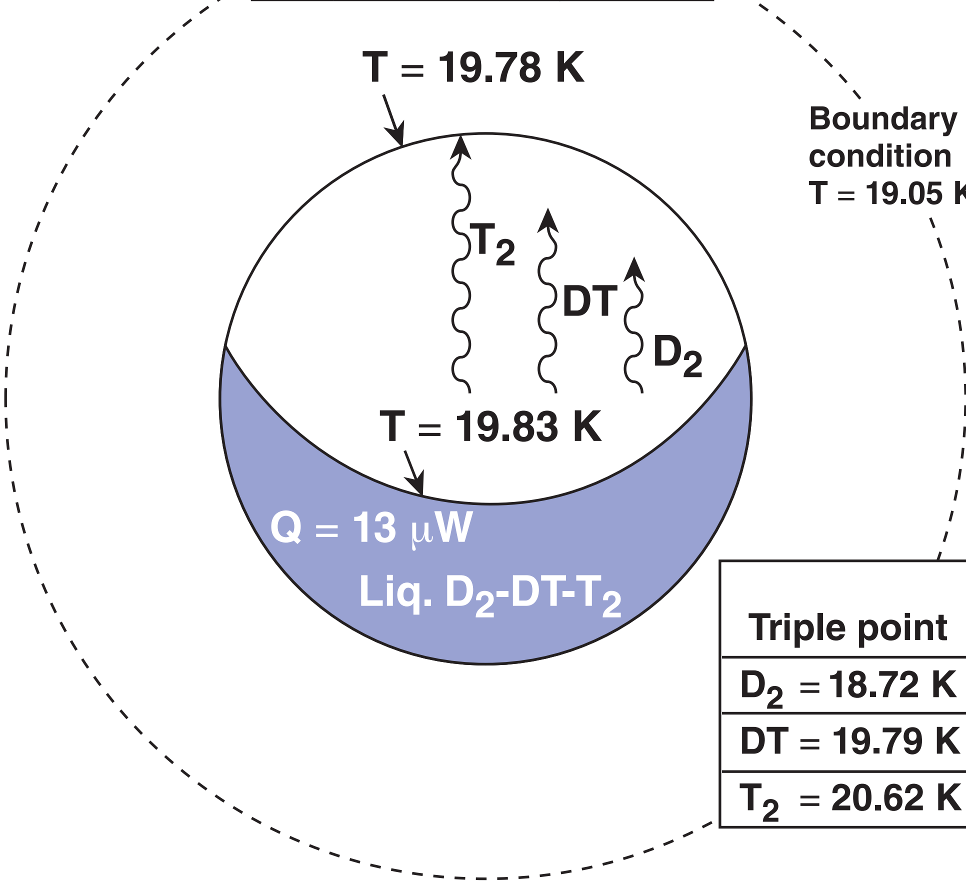
Isotopic hydrogen (H/HD/D) fractionation has been observed in the laboratory but at levels that do not impact ignition target performance

UR LLE

- Experimental data has demonstrated that fractionated fusion fuels do not exhibit complete solidification.
- Levels of fractionation are not affected by the duration of the layering procedure.
- Current experimental estimates place the degree of fractionation at no more than 10%. Two-dimensional simulations indicate that target performance is unaffected by levels of fractionation less than ~30%.

Slow solidification produces the smoothest deuterium ice layers but increases the possibility of fractionation in D_2-DT-T_2 mixtures

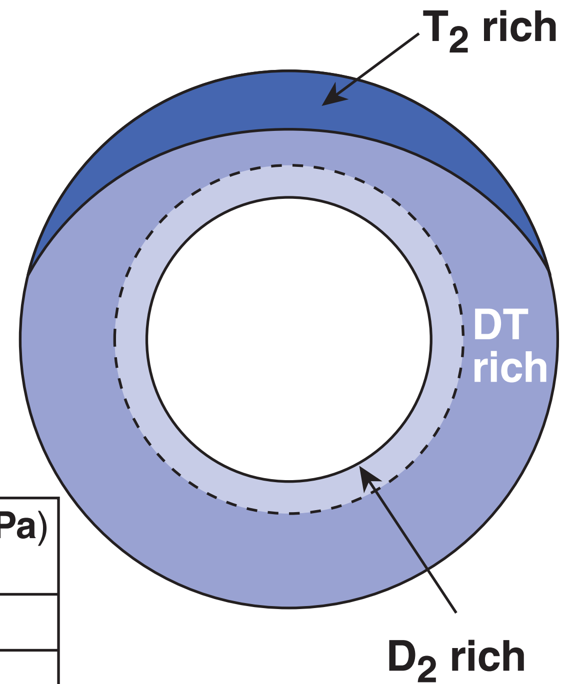
During solidification



Triple point	Vap. press. (Pa) at 19.79 K
D_2 = 18.72 K	2930
DT = 19.79 K	2200
T_2 = 20.62 K	1580

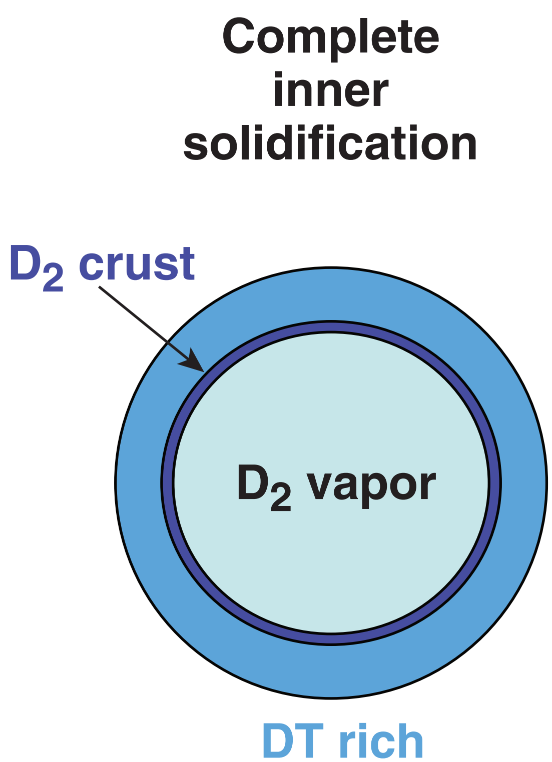
Resulting ice layer

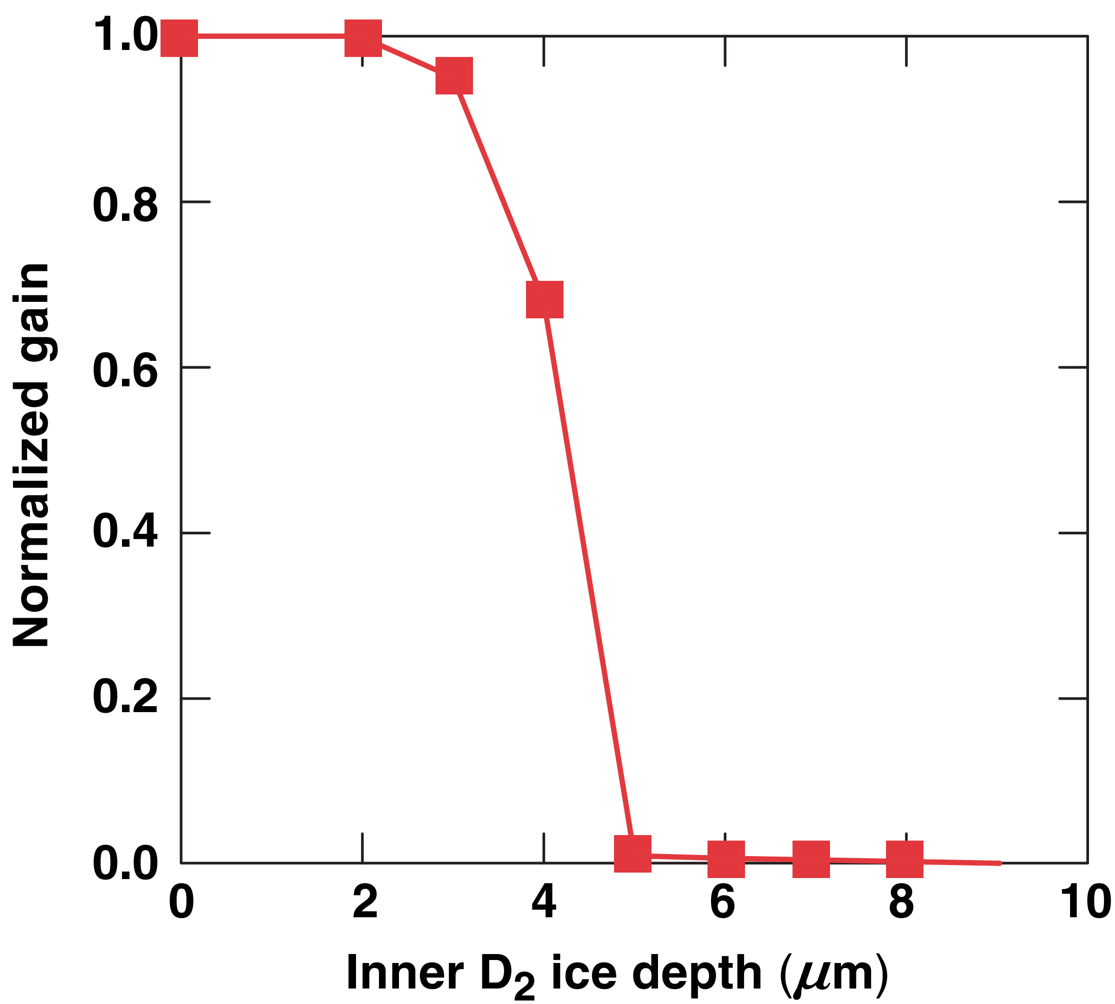
(if fractionation occurs)



T1876a

An inner crust of solid deuterium denies the hot spot of the necessary tritium, which, in absentia, can preclude ignition





TC7086

A polar cap fractionation scenario exempts the DT-poor poles from the ignited burn wave

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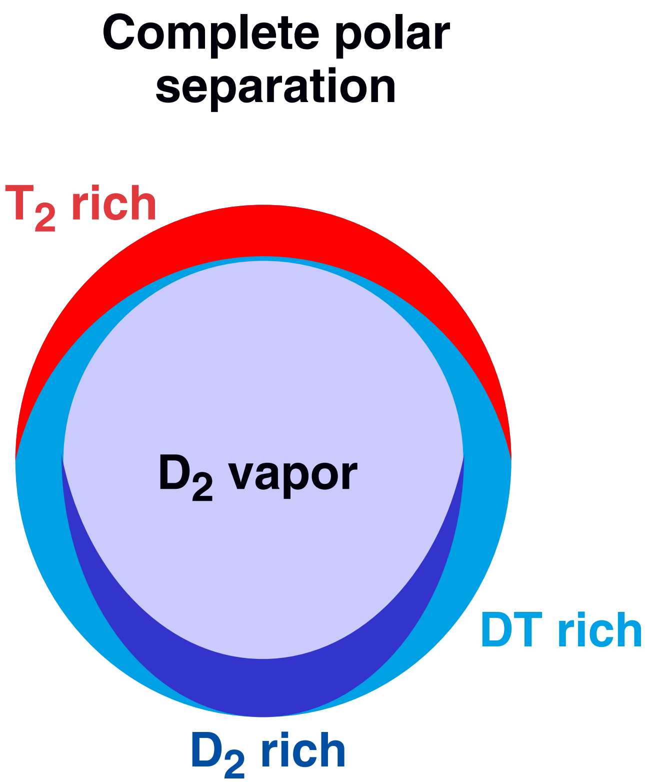
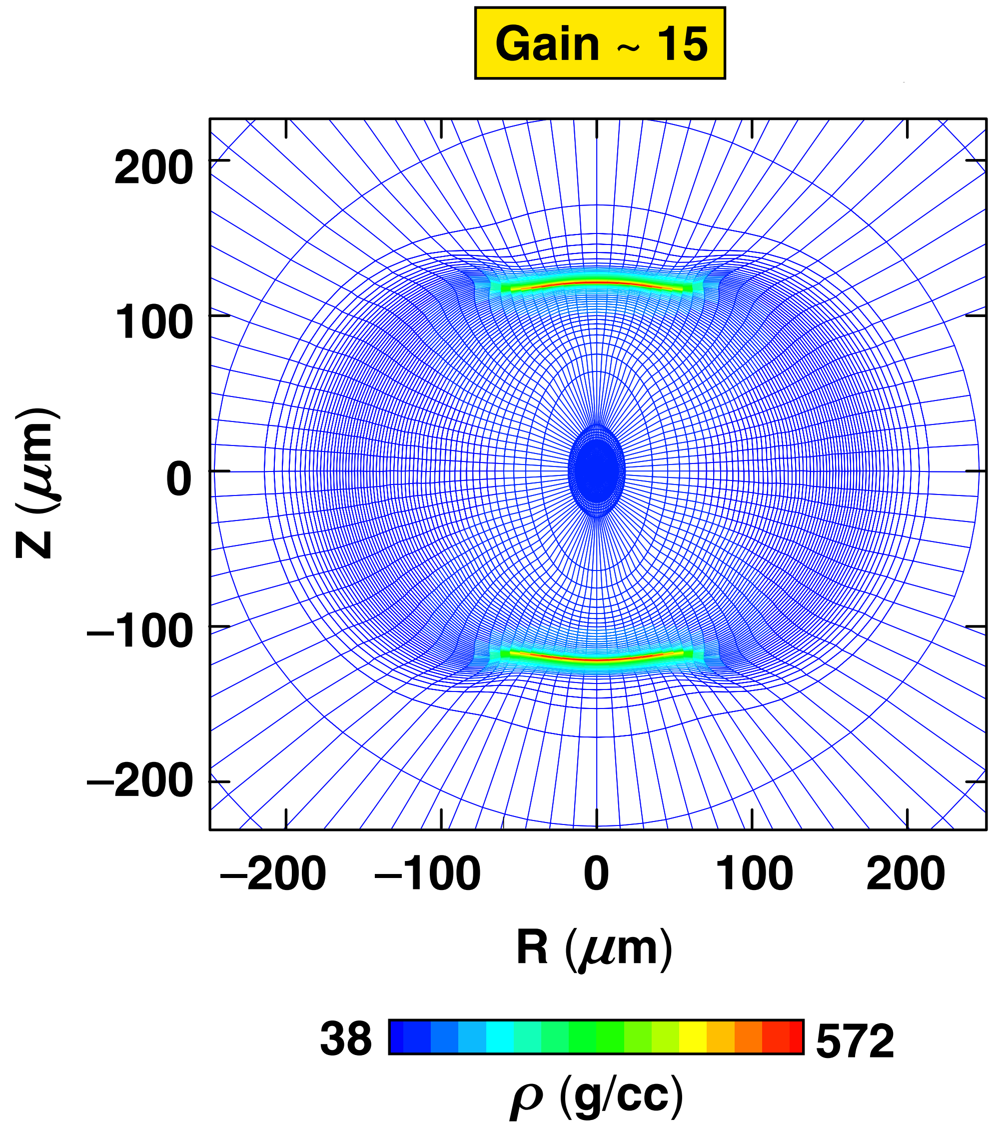
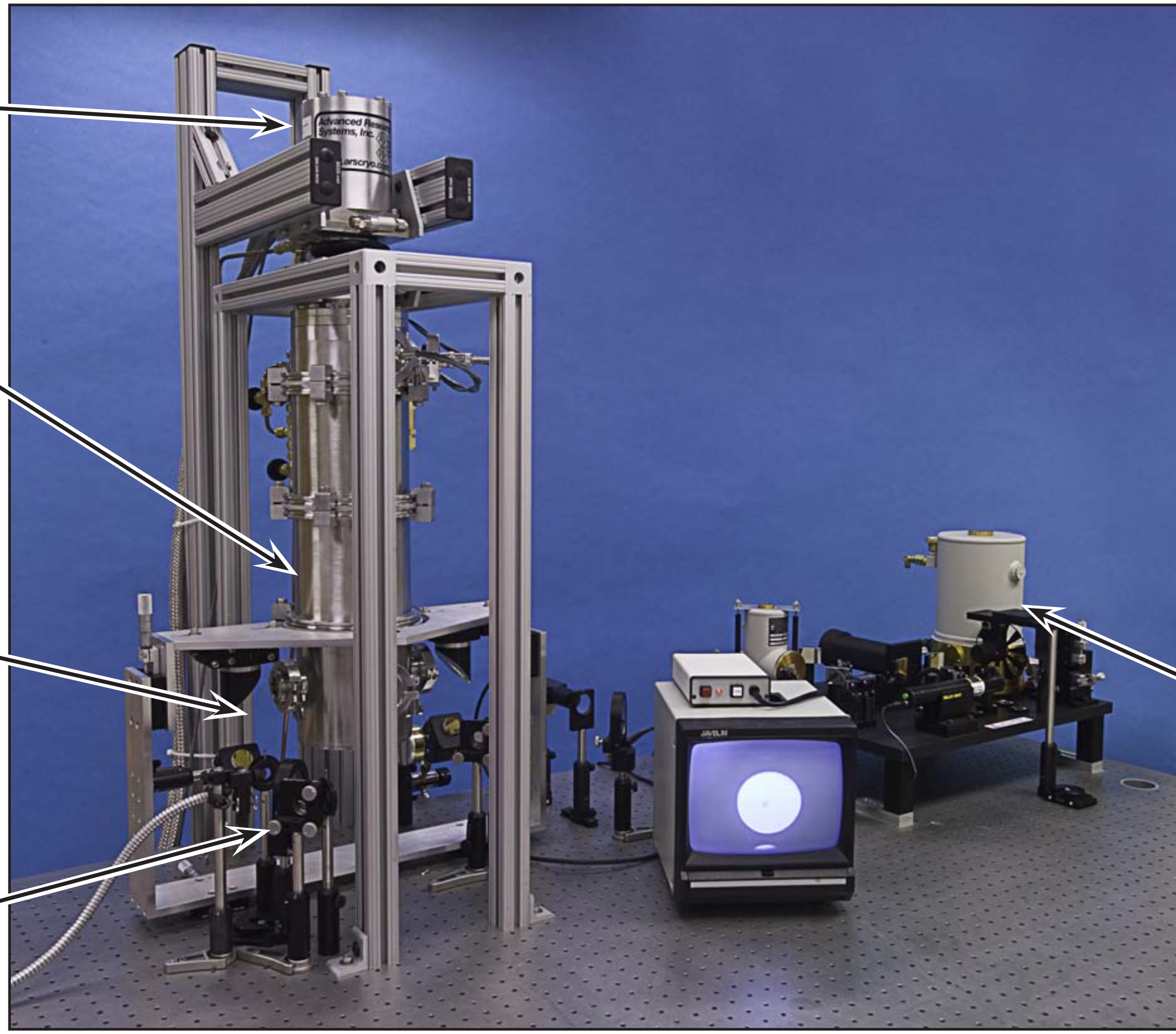




TC7089

Experimental Setup

The H_2/HD/D_2 fractionation test bed is used to measure the IR absorption coefficient in the solidified mixture



T2068

A mixture does not have a specific triple point but exhibits a first-freezing temperature and solidifies over a range

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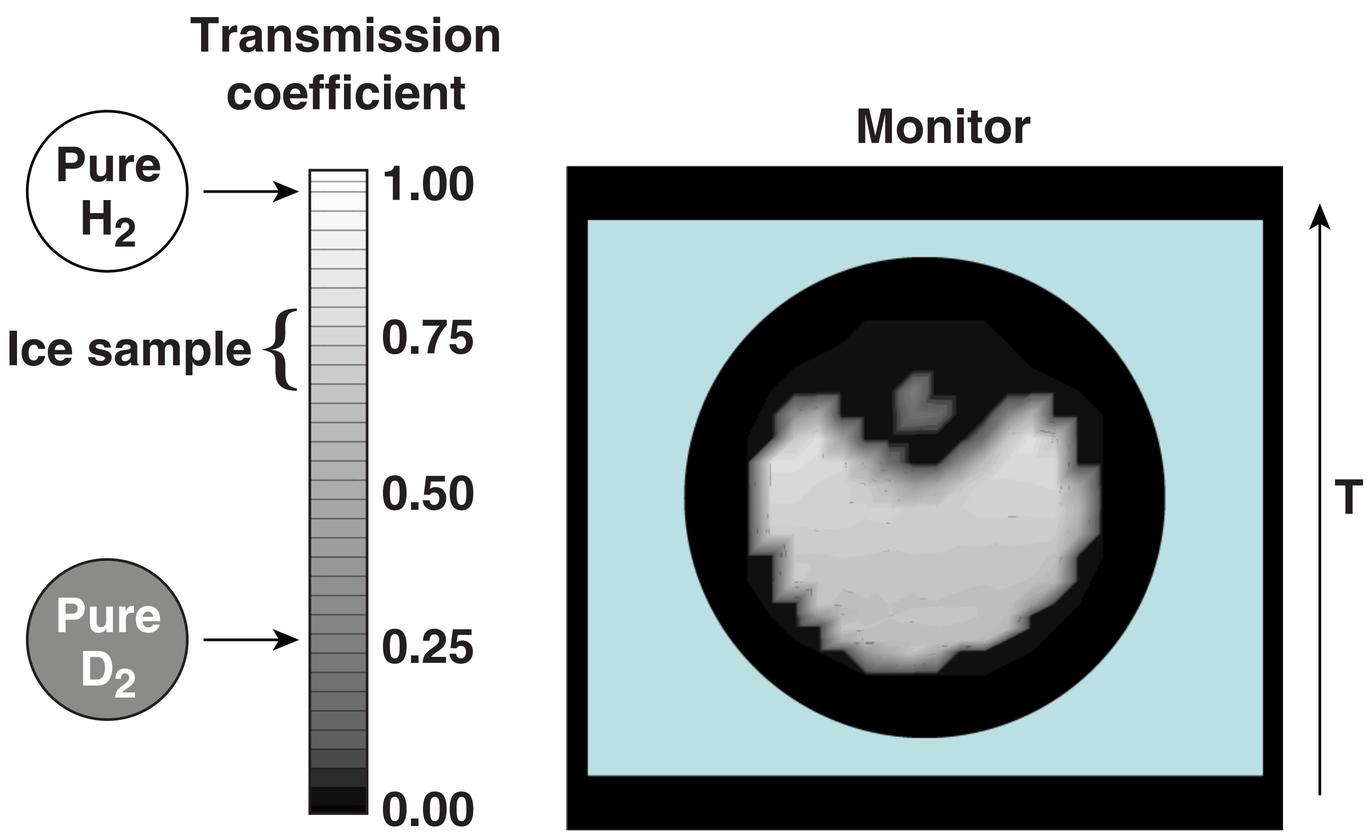
$$\theta = \sum_i \mathbf{mf}_i \times \mathbf{T}_{\mathbf{tp},i}$$

Molecule	Triple point (K)	Mass fraction from pressure	Mass fraction from mass spec.	Mass fraction with frozen D_2
H_2	13.96	0.24	0.26	1/3
HD	16.60	0.49	0.50	2/3
D_2	18.73	0.25	0.24	0
	First-freezing temperature (K)	16.49	16.42	15.72

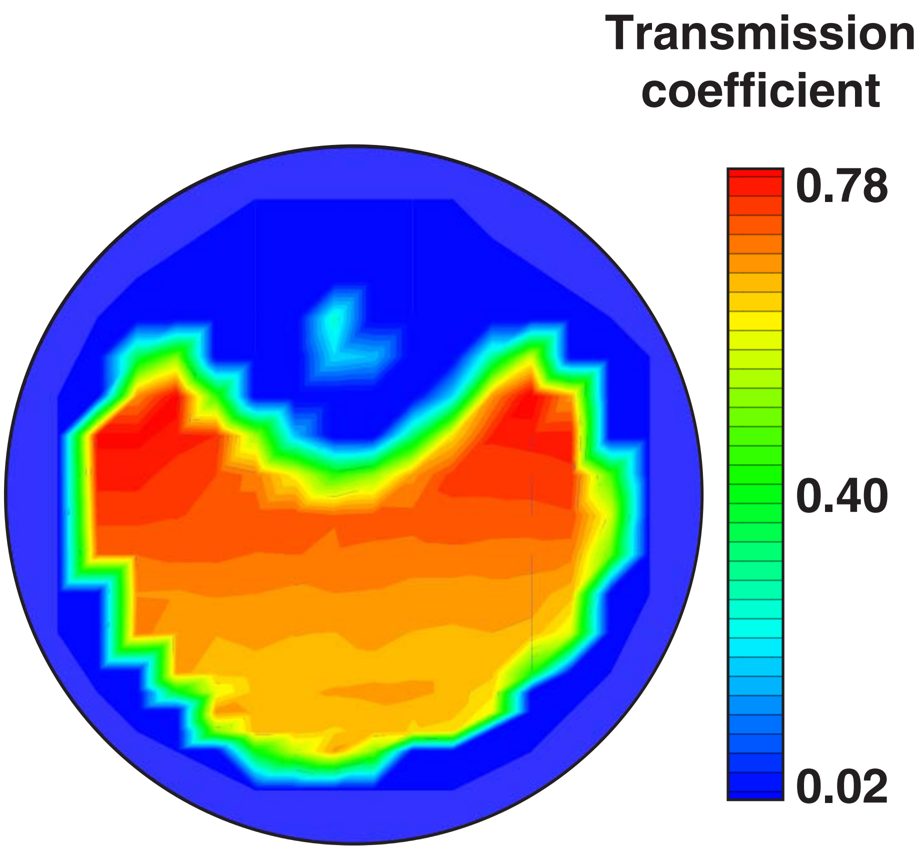
- Experimentally, the first-freezing temperature for the mixture was 16.53 K and the mixture had completely frozen at ~16.10 K.
- This implies that complete fractionation does not occur in the mixture.

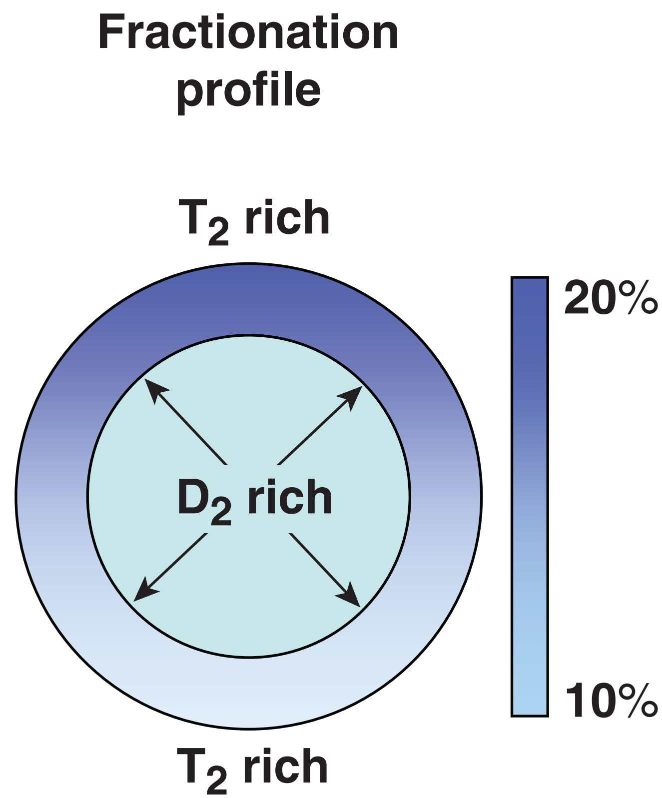
T2074

The absorption coefficient of the H_2 in the H/D mixture is less than 1/20th of that for pure D_2



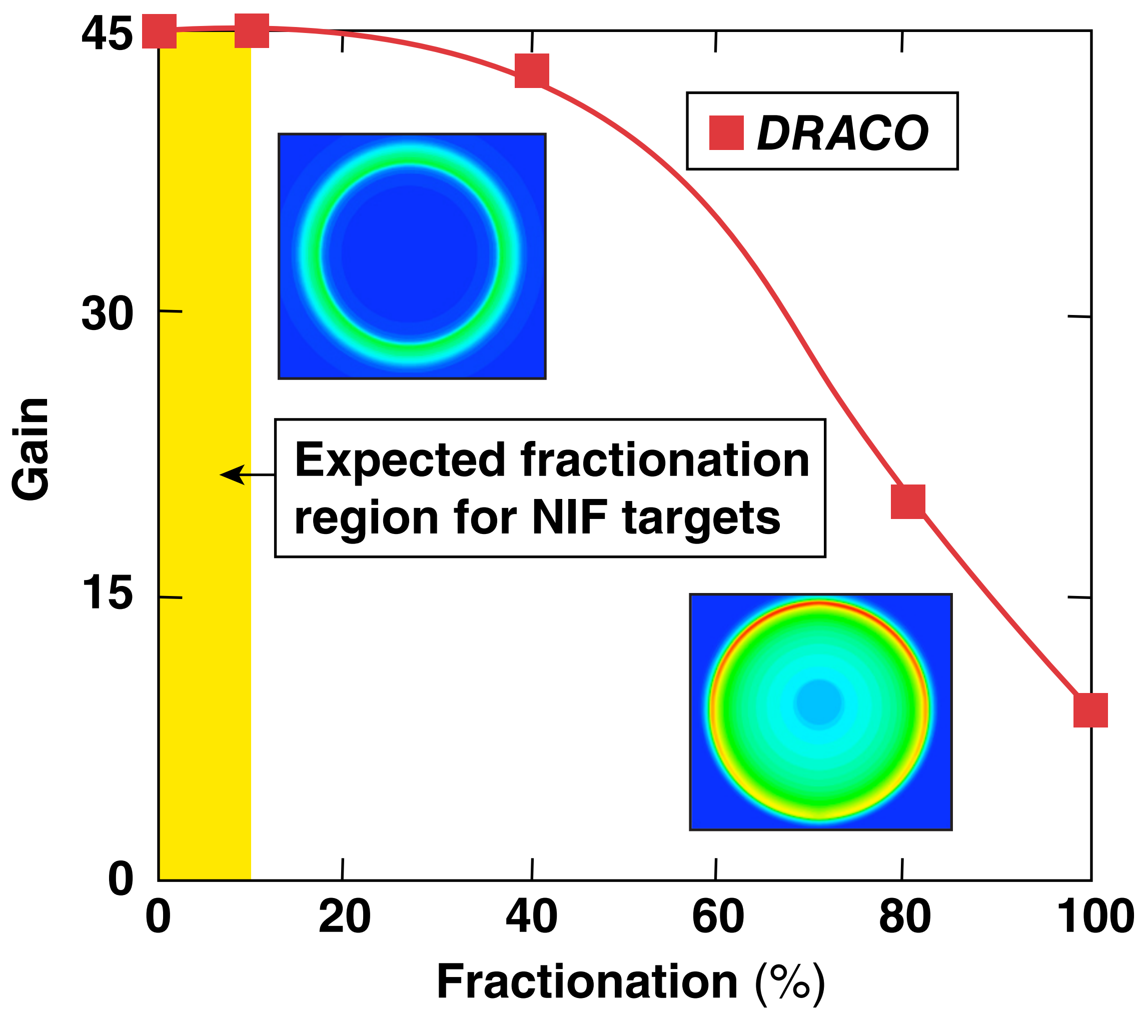
Isotopic hydrogen (H/HD/D) fractionization in solution has been observed in the laboratory at levels approaching 10%





TC7090

Fractionization levels in excess of ~30% are required before ignition target performance is affected



Summary/Conclusions

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