Cryogenic DT targets

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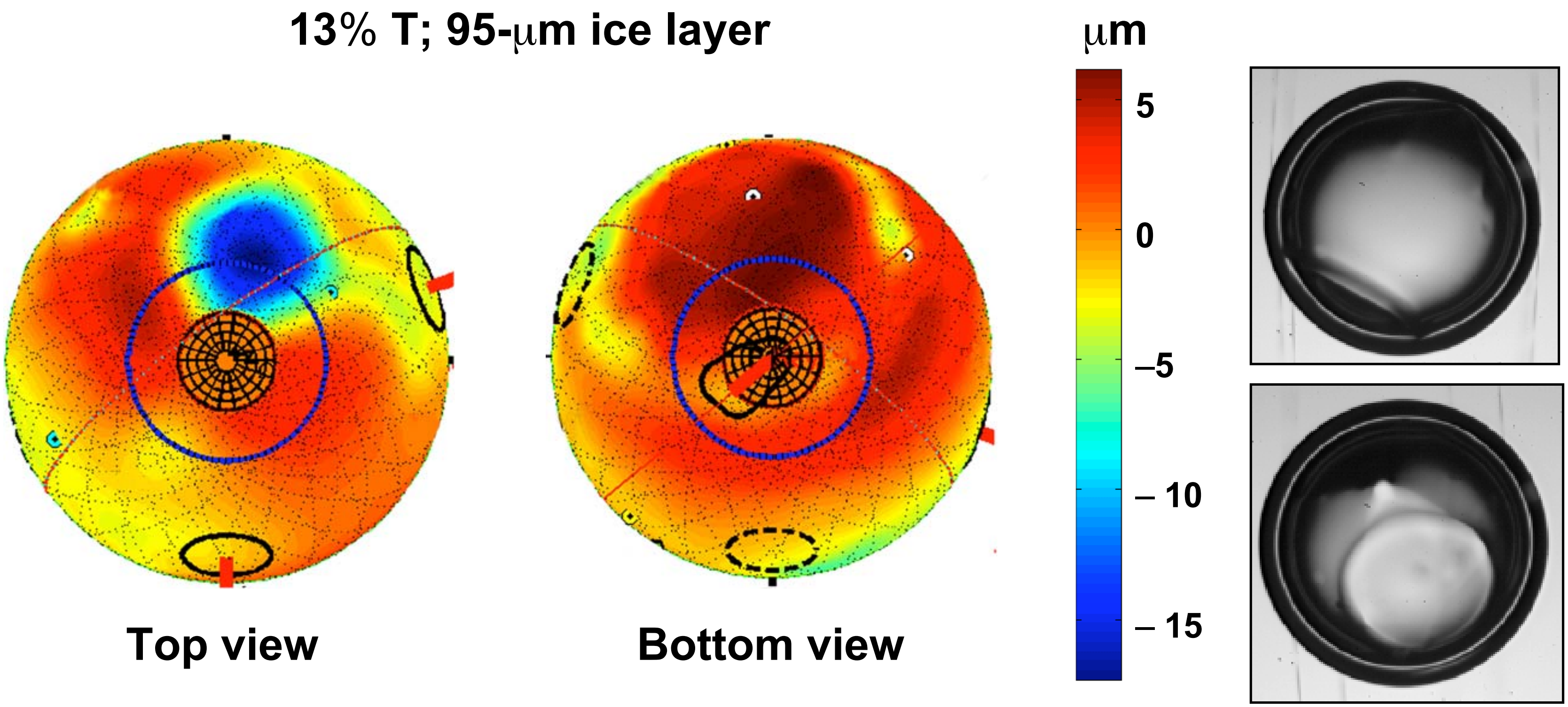
Summary

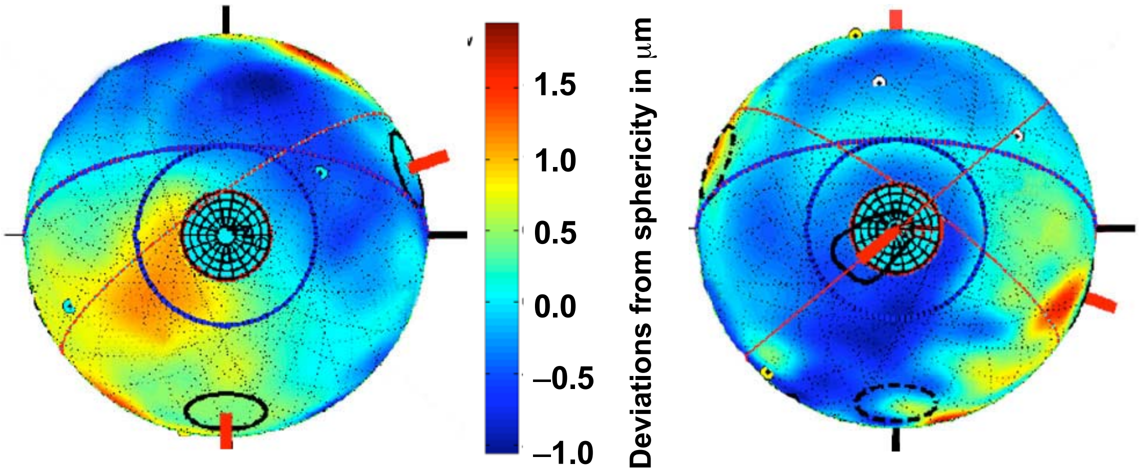
- Commissioned the OMEGA Cryogenic Target Handling System with tritium (0.05%, 1%, 13%, 55% T)
- Quantified tritium migration through various handling processes
- Demonstrated a very smooth DT ice layer (0.73-μm rms) on all Legendre modes and over the entire surface
- Quality of the ice layer is determined by the ability to form a single ice crystal—range is 0.7- to 1.5-μm rms for the best quality crystals
- It is necessary to freeze DT over a greater temperature range than it is for D_2, presumably due to the difference in the freezing temperature for the isotopes.
- The performance of DT layers confirms suspicion of the cause of the ice-thickness variation in D_2 targets

Low amounts of tritium can effectively layer a target, albeit not to the required smoothness

13% T; 95-µm ice layer

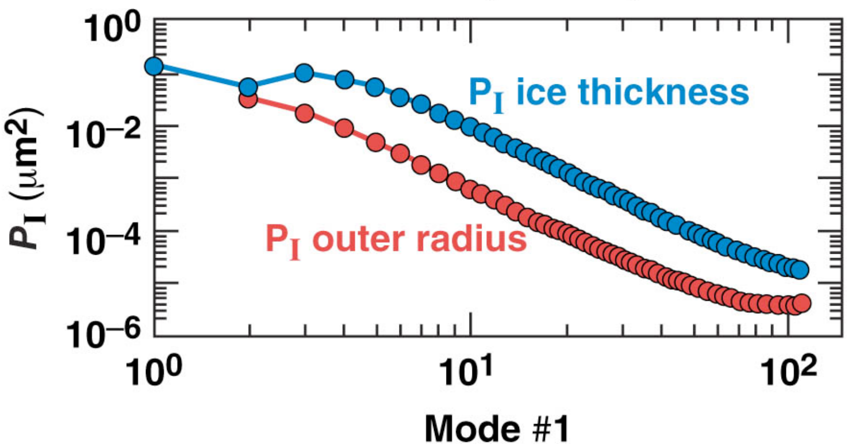


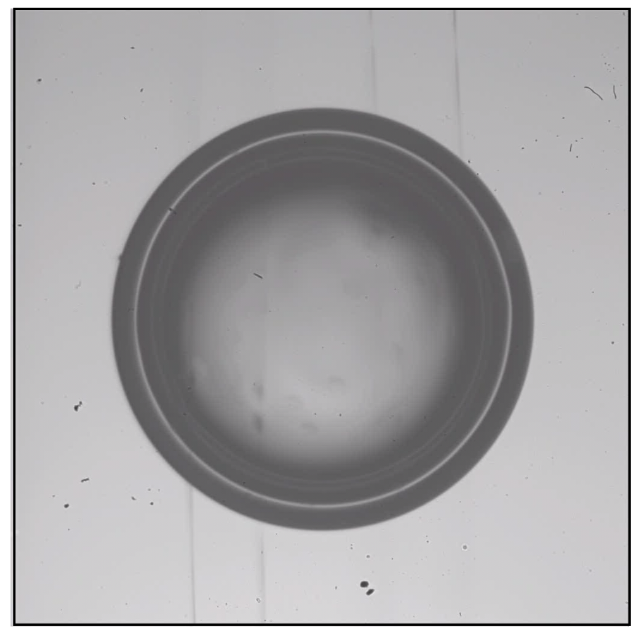
We have demonstrated a DT (45:55) target with an ice roughness of 0.73-μm rms for all modes



	μm	rms
Outer surface	428.15	0.24
Bright ring	379.17	0.73
Ice surface	338.61	0.73
Ice layer	89.55	0.74

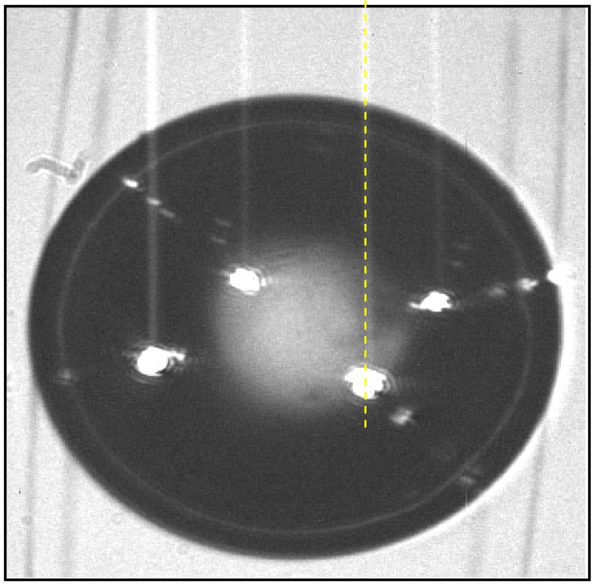
Pollaine mode-power spectrum

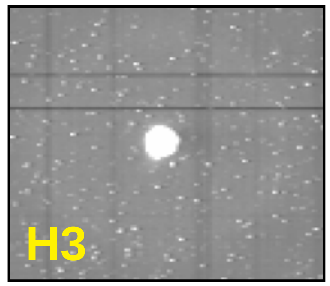


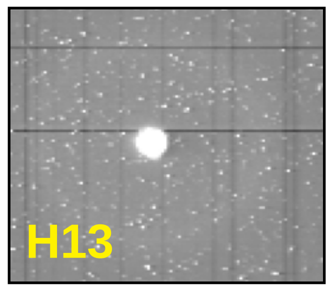


T2255

A 1-μm ice layer was successfully imploded within 10-μm of the desired position







- ~1-μm-rms layer appears intact at T_0 (ie, no Q-DT melting)
- Pulse-shape metrics achieved (note high-predicted ρR)
- Little vibration; small TCC offset
- Lost two beams

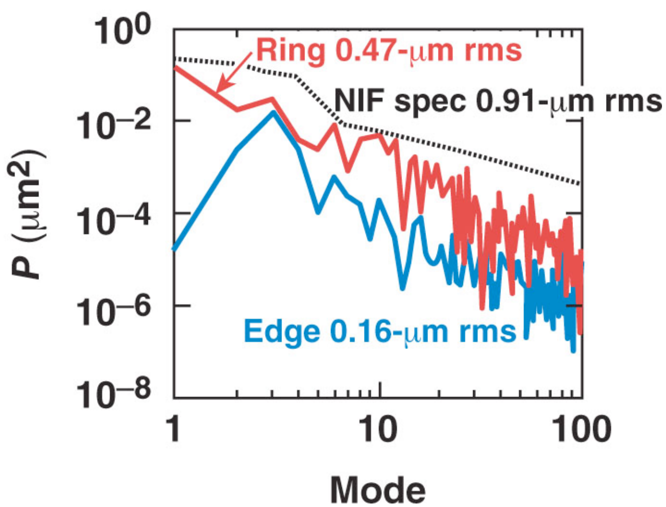
Shot 44240 (20 July 06)

Ice = ~0.8-μm rms
(~250 mK below TP)
Y_{DD} = n/a
Y_{DT} = 2.43×10^{12}
(YOC = 5.7%)
T_{ion} = 2.0 keV (1-D:keV)
Bang = tbd ns (1-D:ns)
Burn = tbd ps
Energy = 23.9 kJ
(HE307101P, SSD on)
Offset = 10 μm
($\theta = 71°$, $\phi = 329°$)
$\langle \rho R \rangle_n$ = n/a mg/cm^2
(1-D:281 mg/cm^2)
α (1-D) = Absorption
(1-D) = 47%

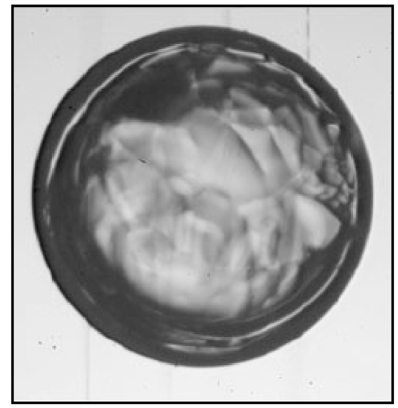
T2256

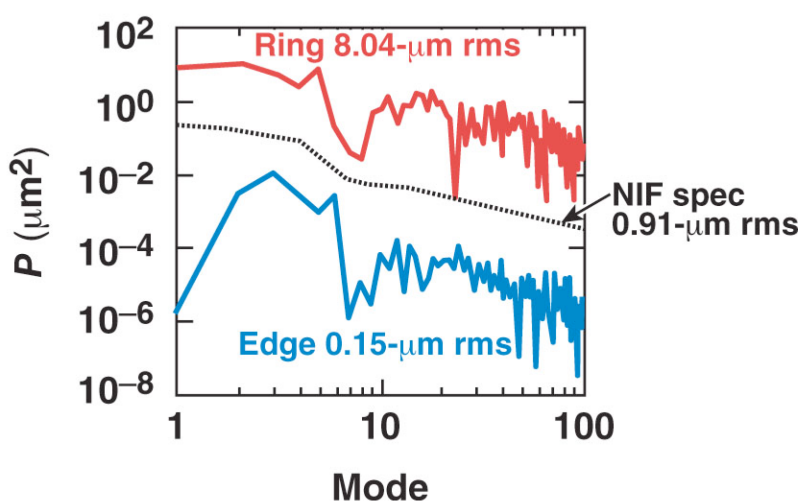
Growing an ice layer from a single seed crystal is essential to forming a smooth layer

Formed from a single crystal—0.47-μm rms



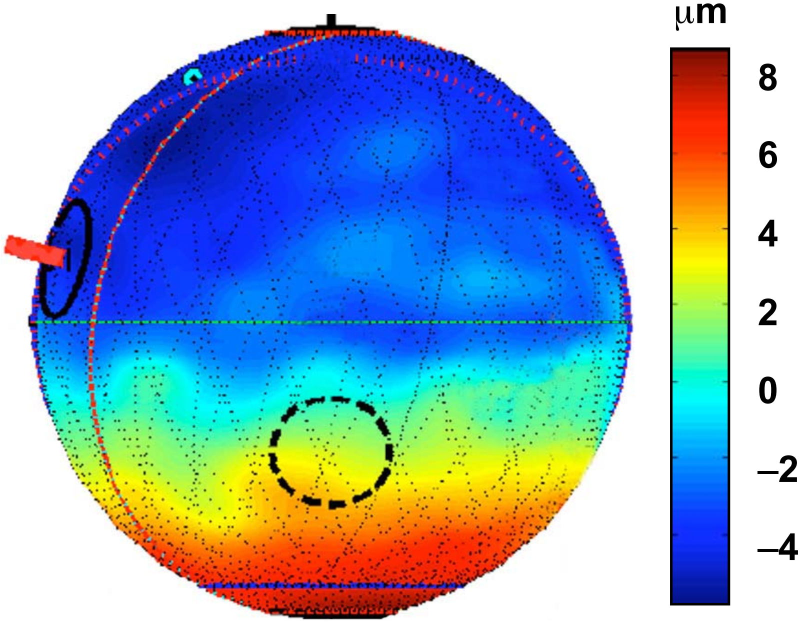
Flash frozen—8.4-μm rms



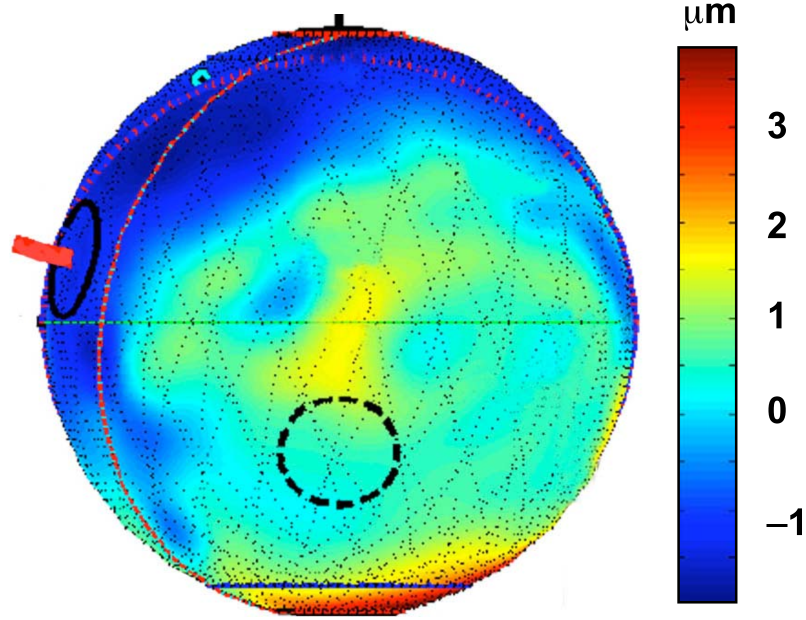


T2257

Need to freeze DT over a temperature range of 50 to 70 mK to form the layer; this is different from D_2 targets and is presumed due to the different freezing points of D_2, DT, and T_2 isotopes



T = 19.476 K
4.7-μm rms

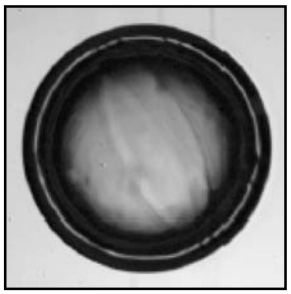


T = 19.455 K
1.4-μm rms

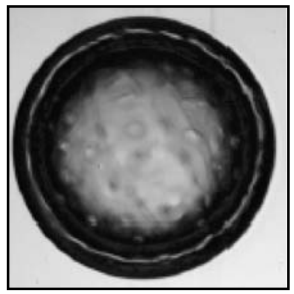
Side view

T2258

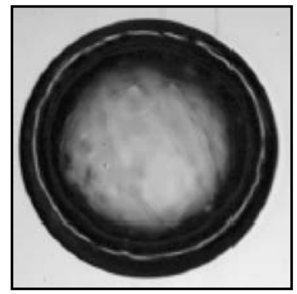
The sequence of melting and reforming the ice layer is critical for achieving the desired smoothness



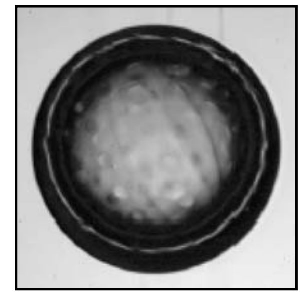
t_0 = 1.9-μm rms



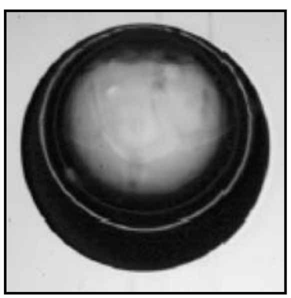
+10 mK +8 min
5.4-μm rms



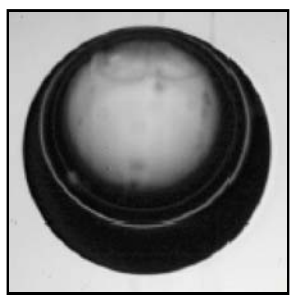
+25 min
7.4-μm rms



+20 mK
+50 min

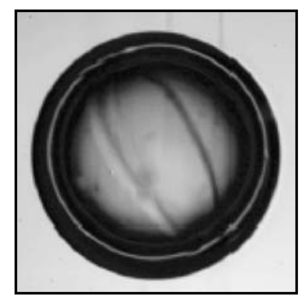


+20 mK
+170 min



–20 mK
+200 min

–15 mK
+202 min

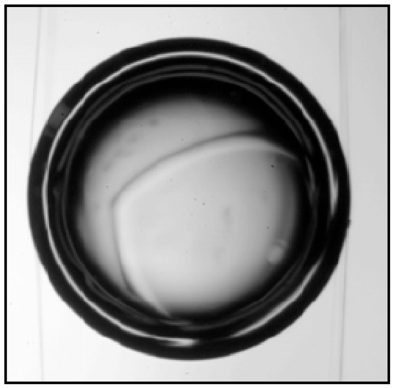


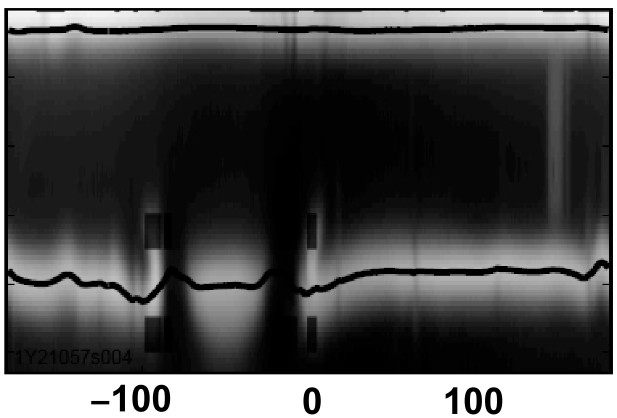
–5 mK, +332 min
7-μm rms

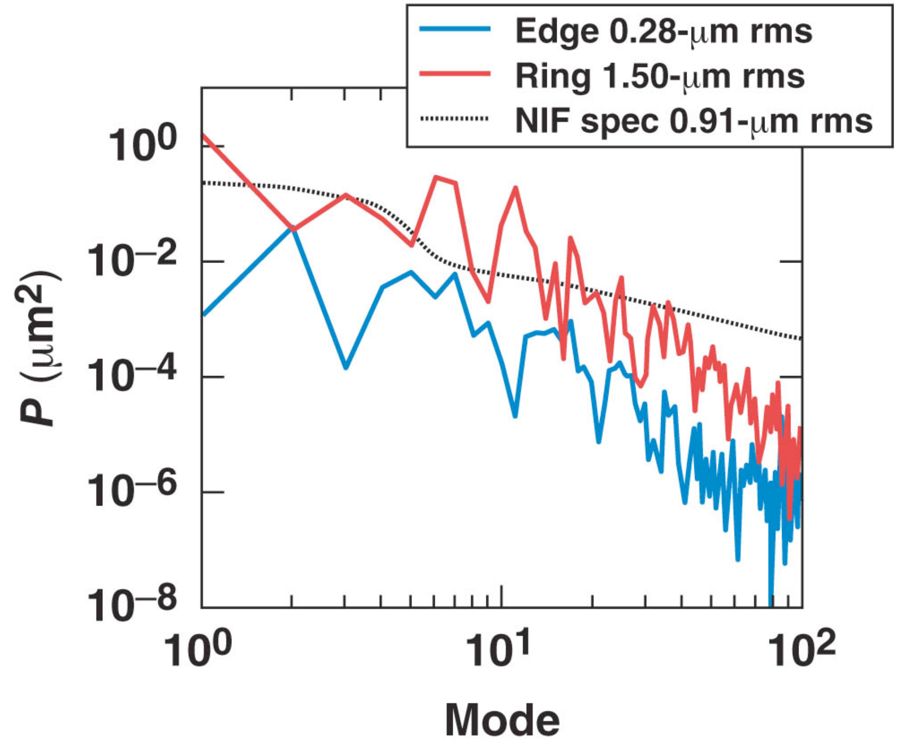
Temperature changes of 50 mK and times in excess of 5 hrs were required.

T2259

Apparent ice smoothness is affected by the connectivity of the “bright band” and, therefore, the ability to form a single ice crystal



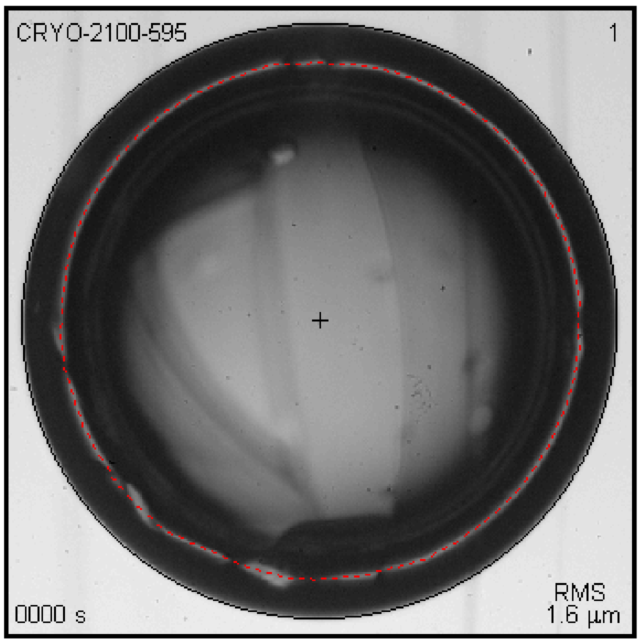


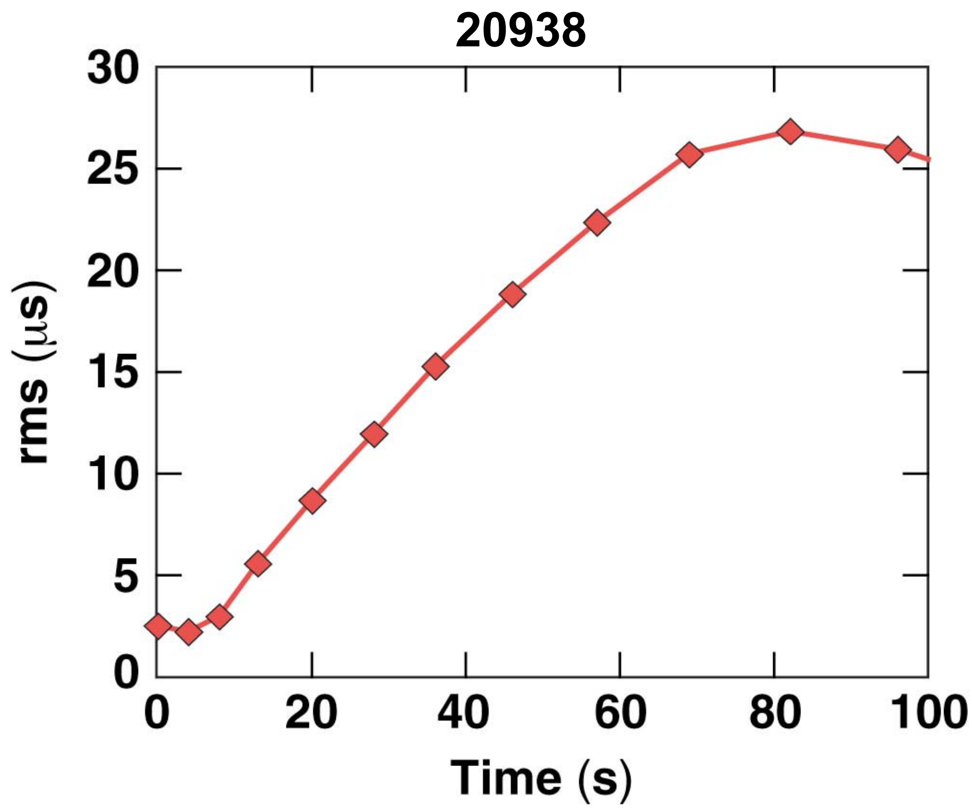


- Are we approaching the sensitivity limit of shadowgraphy?
- Are small, high-frequency deviations in the bright band due to effects on the ice surface OR effects within the ice layer OR on the plastic ablator?

The quality of the ice layer at the time of the shot is determined primarily by the time the target is in a vacuum with insufficient He gas

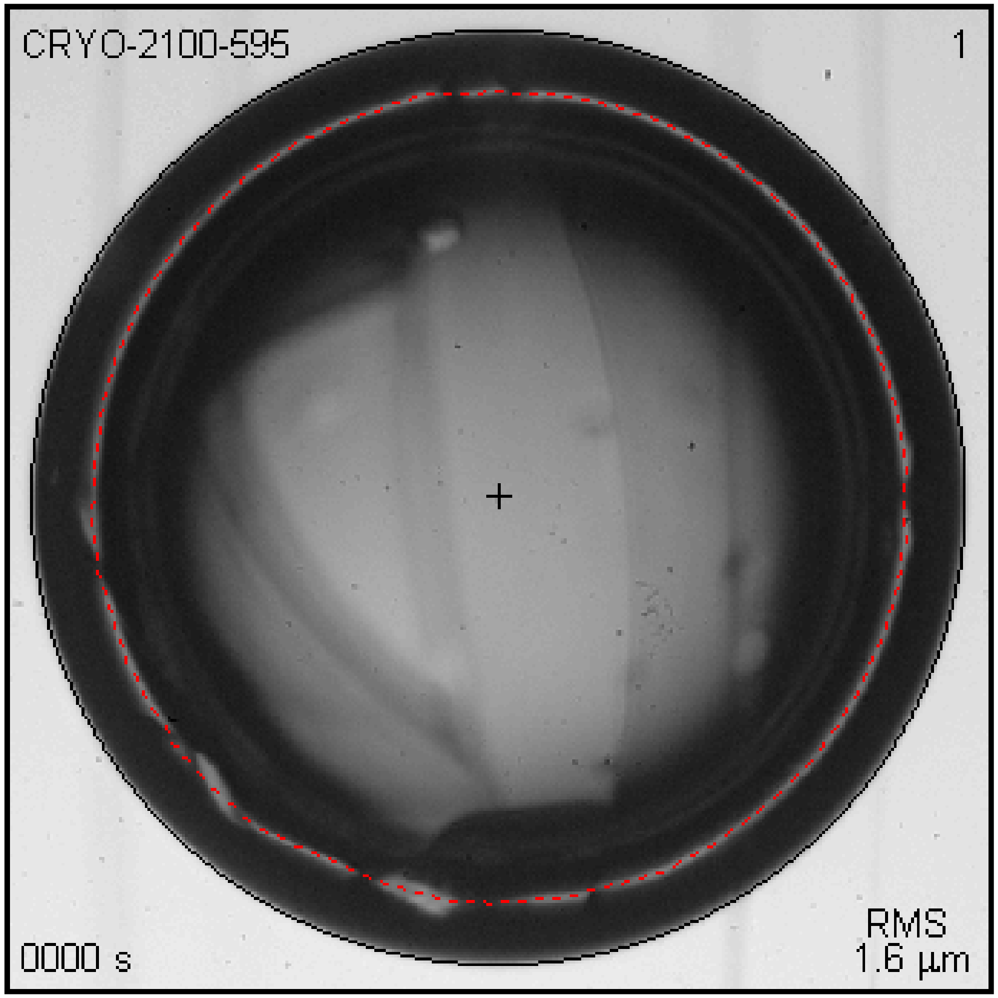
Removing the shrouds to expose the target first removes the helium exchange gas from around the target. This allows the ice to warm at a rate of 1 K/15 s and slump at a rate of ~1 μm/s.





T2261

Evidence of bubble formation occurring in a partially slumped layer as it relayers



T2262

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