CITADEL Europa Simulation Testbed

(Cryogenic Ice Transfer, Acquisition Development, and Excavation Laboratory)

Europa Sampling

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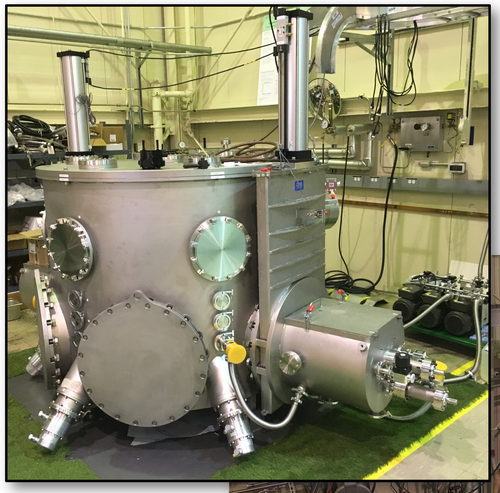
Objective:

Provide a high-fidelity Europan surface environment for full-scale sampling and surface interaction development with high testing throughput.

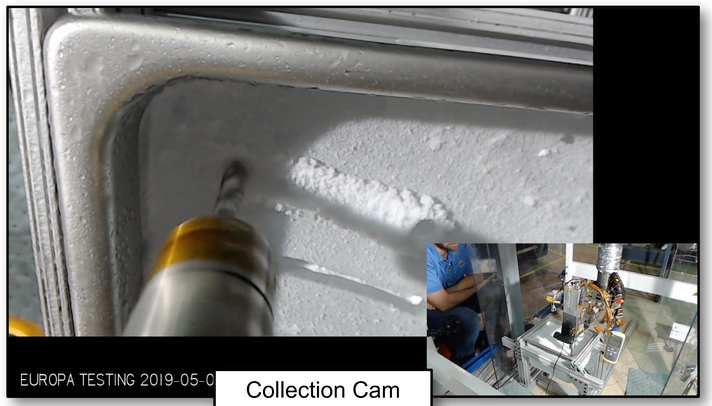
Testbed Capabilities:

Demonstrated Capability	Motivation
Able to cool inserted samples to ~50K, maintain environmental pressure <10^{-6} Torr	Replicate ocean worlds surface environments
Can withstand reaction loads > 500 N, and measure 6DOF tool loads	Broadly envelope proposed Europa Lander reaction load limits
Allow high throughput of surface simulants without cycling chamber	Evaluate wide range of potential ocean world surface composition and material properties
Capture high rate data and video	Characterize simulant chip/shaving dynamics
Future Capability	**Motivation**
Sample collection and transport	Demonstrate end-to-end sample integrity
Non-contact temperature sensing, LIDAR sample volume assessment	Characterize additional simulant chip/shavings behavior in cryo-vac environment



The CITADEL Chamber

Chamber Interior and Lid Installation



Collection Cam Cutting View

Collection Tool Concept

Planned Investigations: What This Chamber Will Enable

Motivation: Testing in a relevant environment is *required* to fully understand the interactions between tools and surface simulants.

Cutting/Excavation:

Determine energy efficiency of various tools and how efficiency relates to other parameters such as reaction forces and simulant properties

- Mechanical properties of ice change with temperature and composition, increasing the energy required to excavate a trench

Sample Collection:

Characterize environment-specific challenges for acquiring sample from excavated terrain

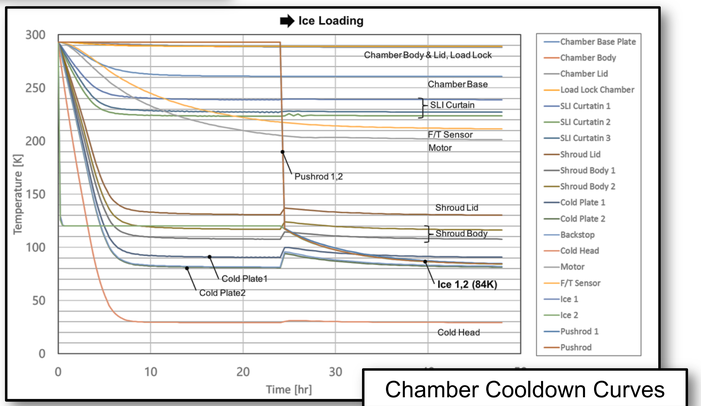
- Collection mechanism must minimize heat transfer into the sample to meet goal of keeping sample < 150 K
- Dynamic behavior of chips/shavings will change in the absence of atmosphere, and will not melt and refreeze (as is typical on earth). These factors will affect debris pile-up and tool function.

Sample Transport:

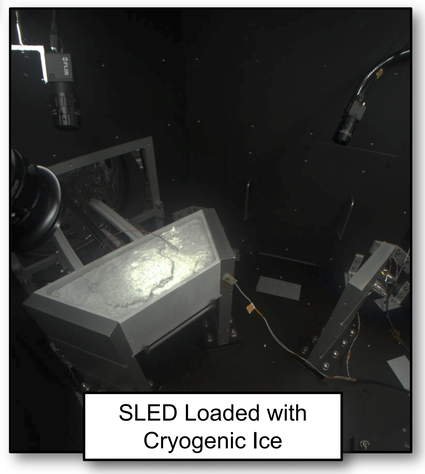
Investigate functionality and performance of proven ambient sample transport concepts in a relevant environment

- Sublimation rates drastically increase above 150K, along with potential reaction of volatiles
- No free moisture (from low pressure and low temperature) could change clumping behavior
- Compare with ambient results to develop ambient simulants

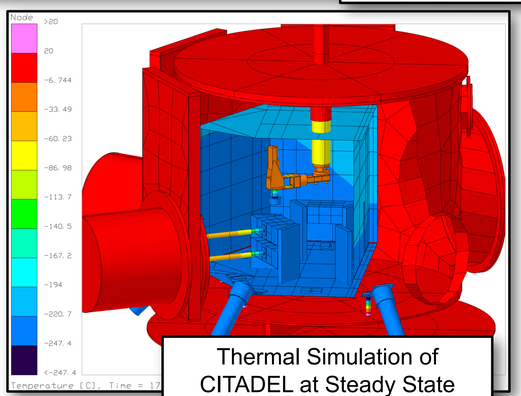
The impact of these phenomenon **must** be understood to design effective sample acquisition and handling tools



Chamber Cooldown Curves



SLED Loaded with Cryogenic Ice



Thermal Simulation of CITADEL at Steady State

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