FY24 Strategic Initiatives Research and Technology Development (SRTD)

# Enceladus Habitability and Life Science Mission Sampling

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**Strategic Focus Area:** Enceladus Habitability and Life Science Mission **| Strategic Initiative Leader:** Valerie Scott

## Objectives:

The objective was to develop a sample collection and transfer system applicable to an Enceladus plume fly-through mission as well as complete development of a plume testbed where the sampling system was to be validated to TRL 5.

## Background:

A sampling system is being developed that could collect a sufficient quantity of ice particle-based sample from an Enceladus plume and transfer it to in situ instruments on the spacecraft for an Enceladus plume fly-through mission. The unique Enceladus environment conditions provide challenges for the development of the plume testbed and sampling system. A plume at 10-25km altitude would have very low-flux 10µm-scale ice particles travelling at 250-800m/s relative to the spacecraft. The lead role Enceladus is expected to play in the search for life is highlighted in the priorities laid out in the current NASA Decadal Survey. A non-landed Enceladus plume sampler could provide the lowest cost mission that allows for direct sampling and analysis of material containing evidence of life on another planetary body

## Significance/Benefits to JPL and NASA:

The plume testbed is expected to be the most realistic testbed in NASA representing an Enceladus plume. This capability is critical for generation of convincing sampling system validation results for a mission proposal. Determining that life exists elsewhere in our solar system would be one of the most important discoveries in human history. This task will develop and validate a system for direct sample collection from an Enceladus plume and transfer of the sample into an in situ life detection instrument, enabling JPL to submit a compelling New Frontiers proposal. The Enceladus plume fly-through mission spacecraft would orbit Enceladus and pass through the southern region plumes. Sample collection would accumulate sample from multiple fly-throughs until sufficient sample has been collected.

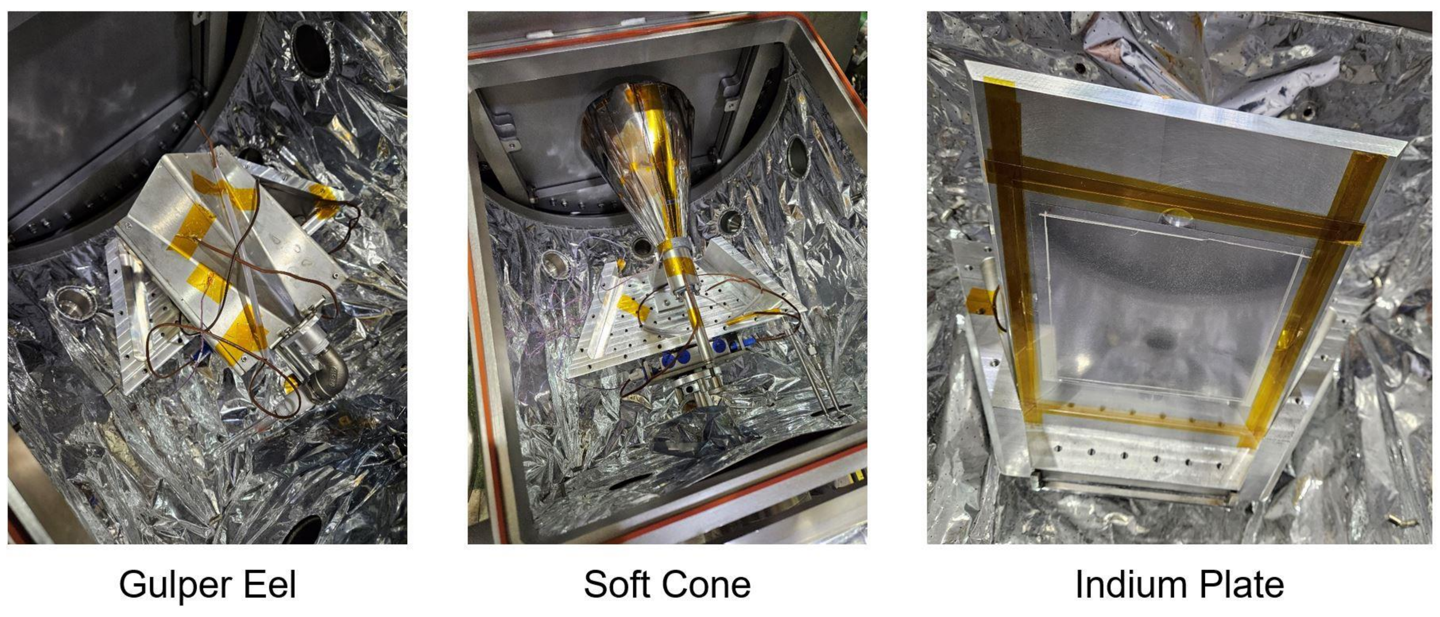


*Figure 3. Collector prototypes mounted in a load lock of the CITADEL thermal-vacuum chamber testbed.*

## Approach and Results:

An Enceladus plume analog testbed system was updated to provide the relevant conditions needed for comparison testing of the sampling concepts (Figure 1). The testbed, including the Plume Ice Creator (PIC) and plume in the CITADEL chamber, was completed and characterized as needed for collector testing. A prototype PIC developed in FY23 validated the concept for micron-scale ice particle generation but a new PIC was developed in FY24 to provide the repeatable and tunable capability needed for collector testing and validation. Ice particles with a narrow band on order 10µm diameter were produced. A nebulizer produced small water droplets that were frozen as they fell inside a coil with LN2 running through it. Cold helium gas flowed through PIC to entrain the ice particles and the entrained ice particle flow was merged with a high-pressure helium gas flow to produce the plume as it exited an ejector into the CITADEL thermal-vacuum chamber. Ice particle sizes were measured in PIC and particle speeds were measured in CITADEL using a laser Doppler velocimeter (LDV). The LDV was also used to characterize the plume cross section and flux. Tuning the PIC and plume gas flows enabled control of the particle speed and flux in the plume.

Prototype Gulper-Eel and Soft-Cone collectors (concepts in Figure 2) were tested in the testbed chamber and a series of coupon collection tests was conducted to determine the dependence of ice particle sticking on material type and incident angle (Figure 3). Coupon tests were conducted with Indium to evaluate sampling with the Space Sciences Laboratory PICO sampler. Test results generally showed a reduction in material captured on the coupons with reducing incident angle (Figure 4). Unexpected results of Aluminum having more material captured than Indium suggest additional causes for material sticking such as surface texture.

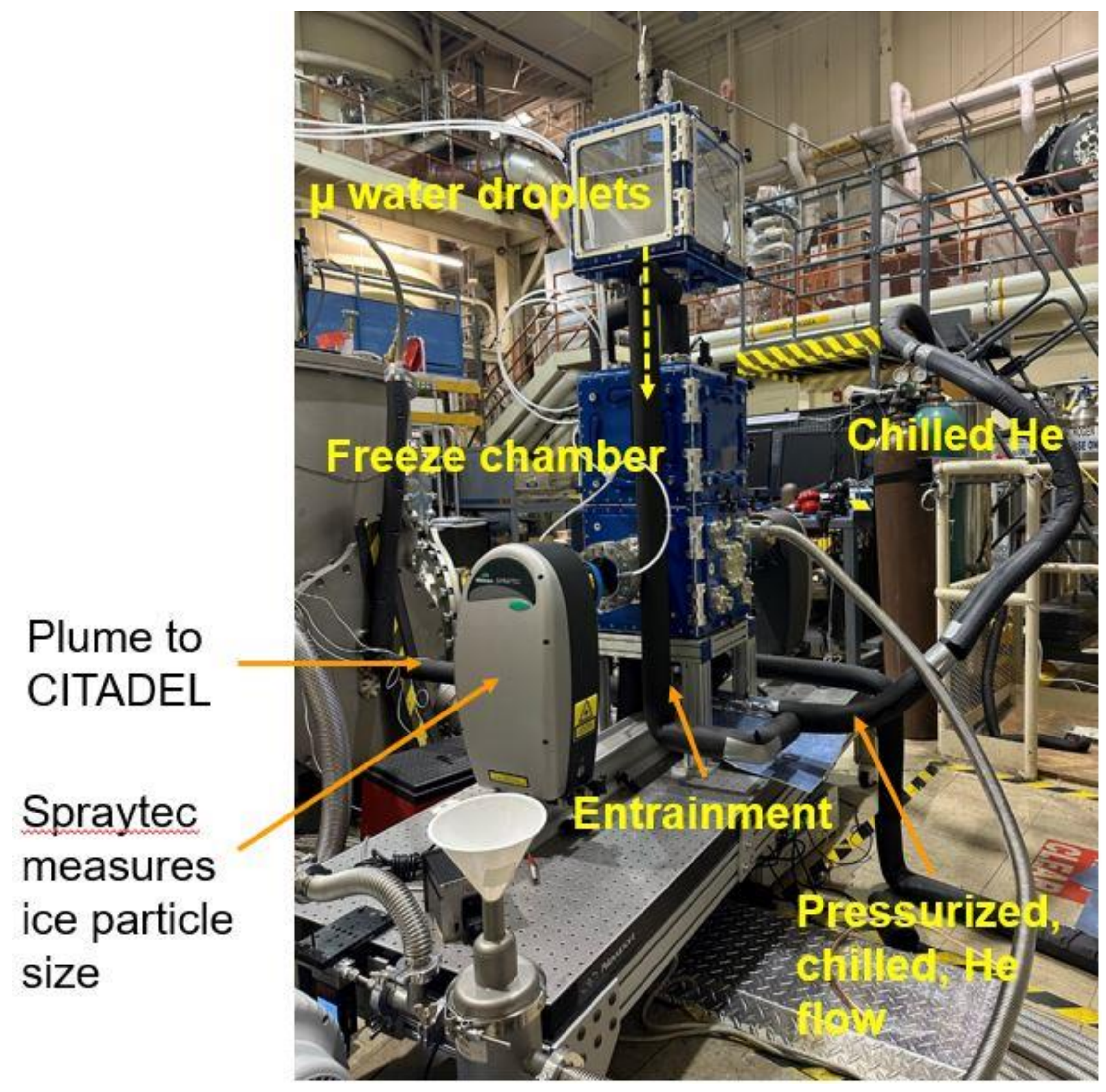


*Figure 1. Enceladus plume analog testbed system.*

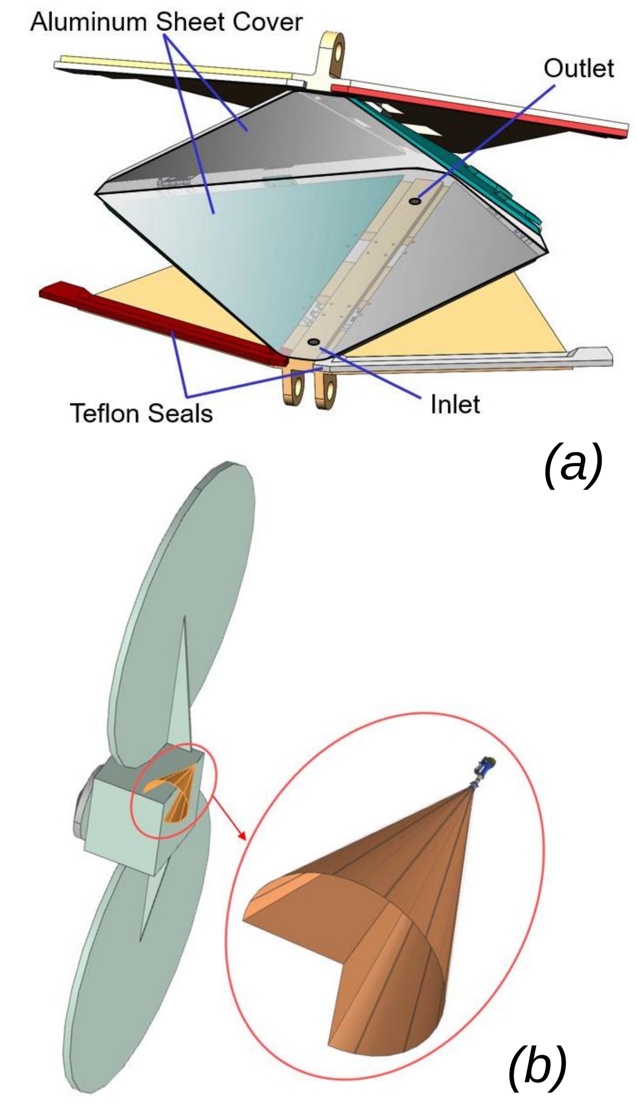


*Figure 2. Gulper-Eel (a) and Soft-Cone (b) collector concepts.*

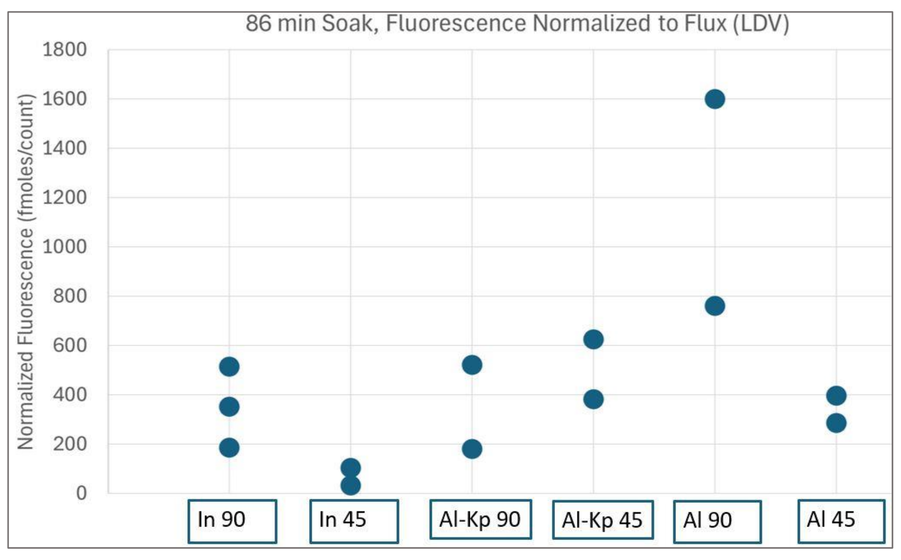


*Figure 4. Coupon test results with Indium (In), Aluminized Kapton (Al-Kp), and Aluminum (Al) coupons at 90 and 45 degree plume ice particle incident angles.*

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