FY23 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 GN&C and Sampling **| 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. This includes both the sampling system and a plume testbed for testing the sampling system. The unique environment conditions provide challenges for development of the plume testbed and sampling system. A plume at 10-25km would have very low-flux and 10µm-scale ice particles travelling at 250-800m/s relative to the spacecraft.

Background:

The lead role Enceladus is expected to play in the search for life independent of Earth is highlighted in the priorities laid out in NASA's 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:

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 instrument. An 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. The Enceladus plume analog chamber will provide a relevant environment for validating Enceladus plume sampling systems.

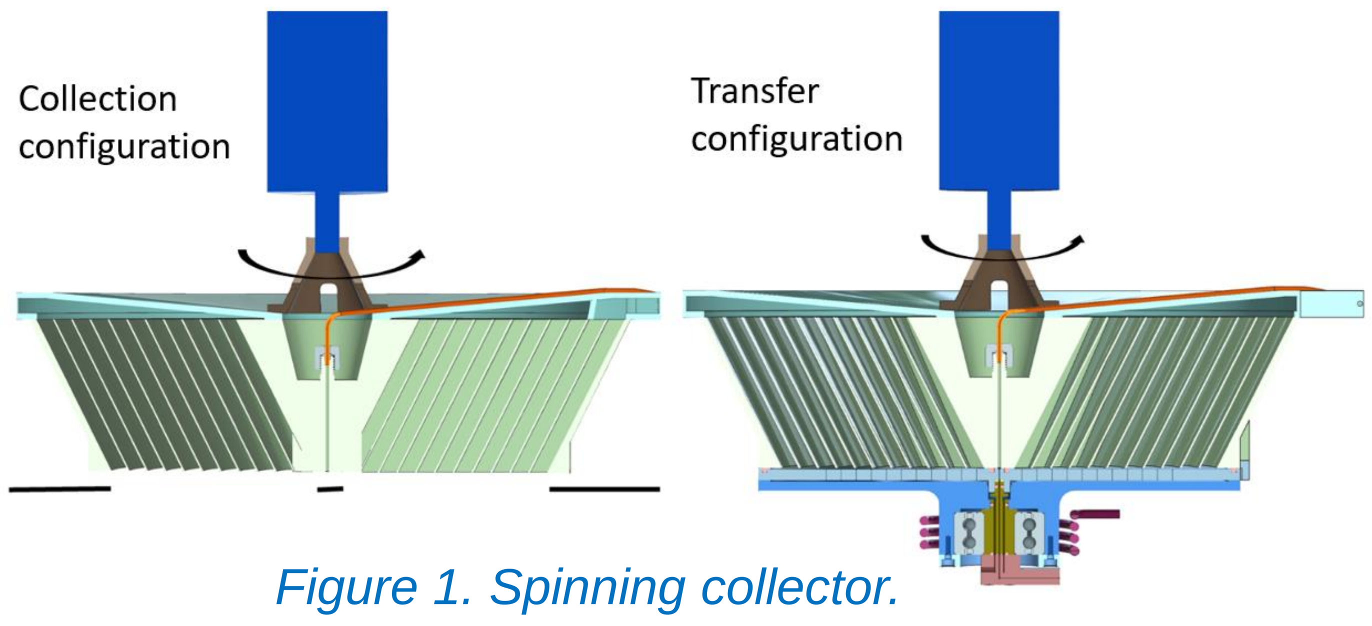

Figure 1. Spinning collector.

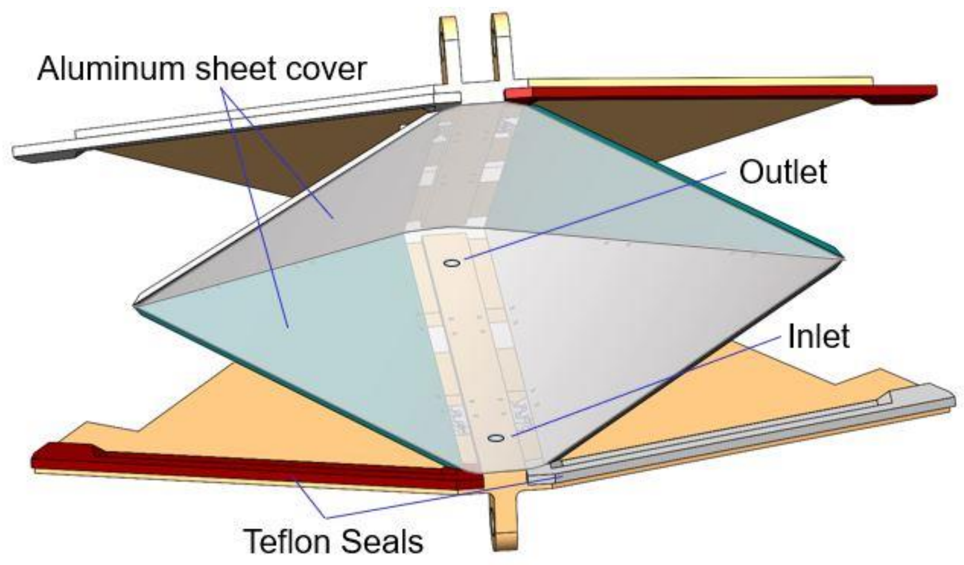

Figure 2. Gulper-Eel sampler in collection configuration.

Approach and Results:

Initially, a **spinning collector** (Figure 1) was developed for collection of sufficient sample from the Enceladus plume. Plume ice particles would enter the spinning collector and be captured by sticking to the surface of one of the concentric cavities or by bouncing through to a perimeter ring. For transfer, the sampler would dock with a transfer station, warm up and add water, and use gas while spinning to push sample through a tube to the science instrument.

Three lower-cost alternative sampling approaches were then developed. The **Gulper-Eel** concept (Figure 2) would store flat and then open with hinges for sample collection. Plume ice particles would either stick to collector surfaces or bounce and be retained at the bottom. After collection, the collector would flatten, be warmed, and water would fill the narrow volume between the two surfaces via Hele-Shaw flow to dissolve sample that stuck to the plates or collected at the bottom, and then flow to the science instrument. The **Soft-Cone** sampler would use a thin 25-75µm material cone deployed from an edge of the spacecraft out of a bio-barrier (Figure 3). Plume ice particles would bounce down the cone to the bottom and into a sample cup. A linear actuator would push a piston head up into the bottom of the cone to provide an annular ring for the particles to enter the sample cup. After collection, the piston head would be pulled back to engage a seal. The sample cup would then be warmed and water would be added to dissolved the sample. The piston would be retracted further to transfer the liquid out of a tube and into the science instrument. An **aerogel** sampler concept has a layer of aerogel on a surface into which plume particles would embed. After collection, a lid would close and water would be added to collapse the sample-containing aerogel and the liquid would be filtered and flowed to the instruments.

An **Enceladus plume analog system** was developed that produces a stream of ice particles of similar size, speed, and temperature as the anticipated Enceladus plume and within a thermal vacuum chamber. A nebulizer generates 6µm-scale water droplets that freeze and enter a helium gas flow (Figure 4) that carries the ice particles into the vacuum chamber. Initial collection tests were performed with the Gulper Eel, Soft-Cone, and aerogel samplers. The Gulper-Eel and the Soft-Cone in the vacuum chamber are shown in Figure 5.

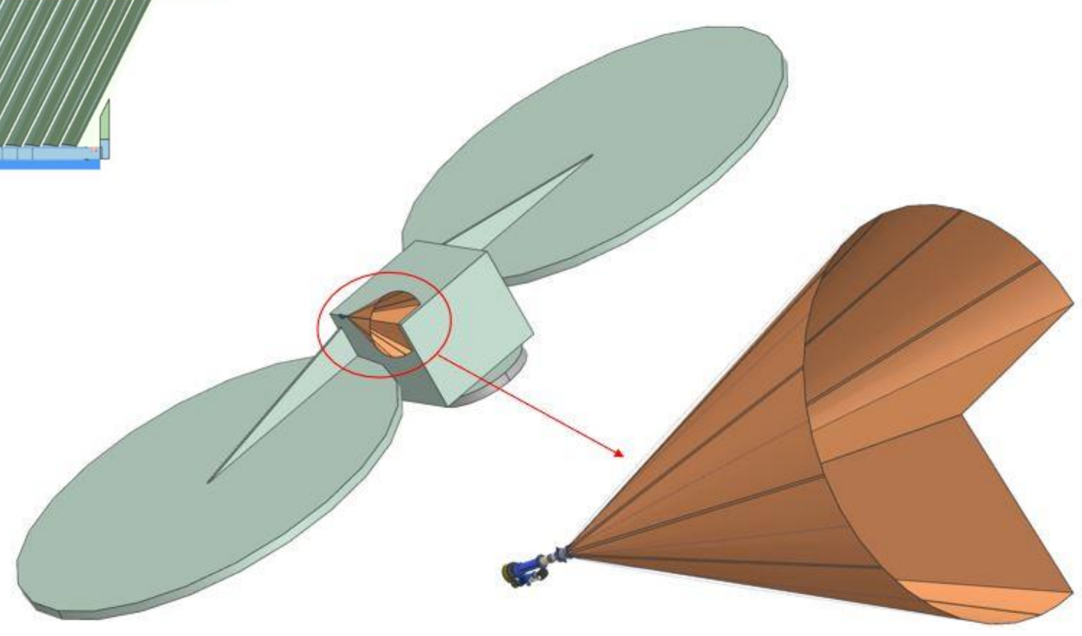

Figure 3. Soft-Cone sampler deployed from the edge of a spacecraft.

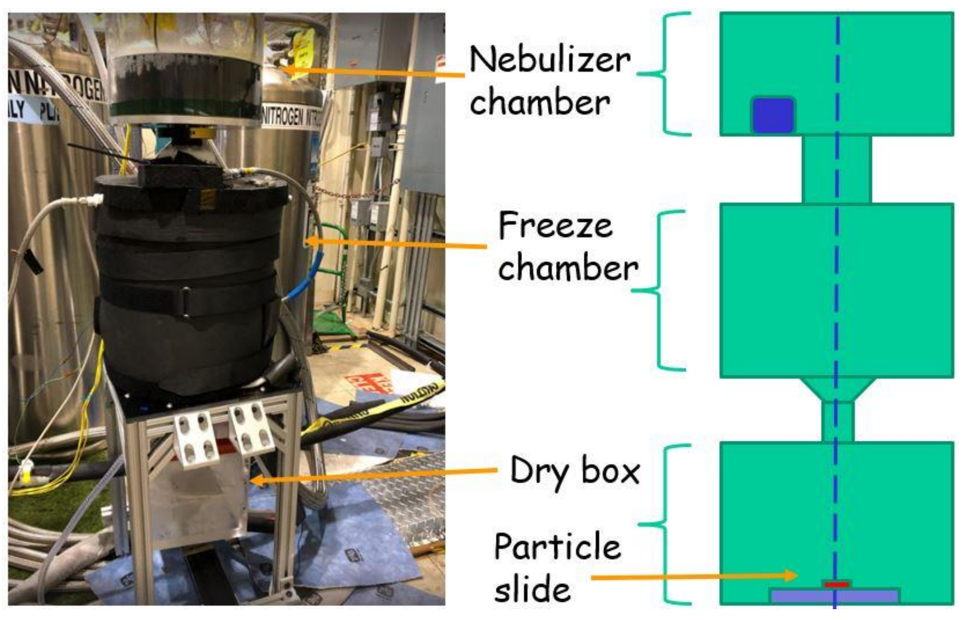

Figure 4. Plume ice creation part of the plume analog generation system.

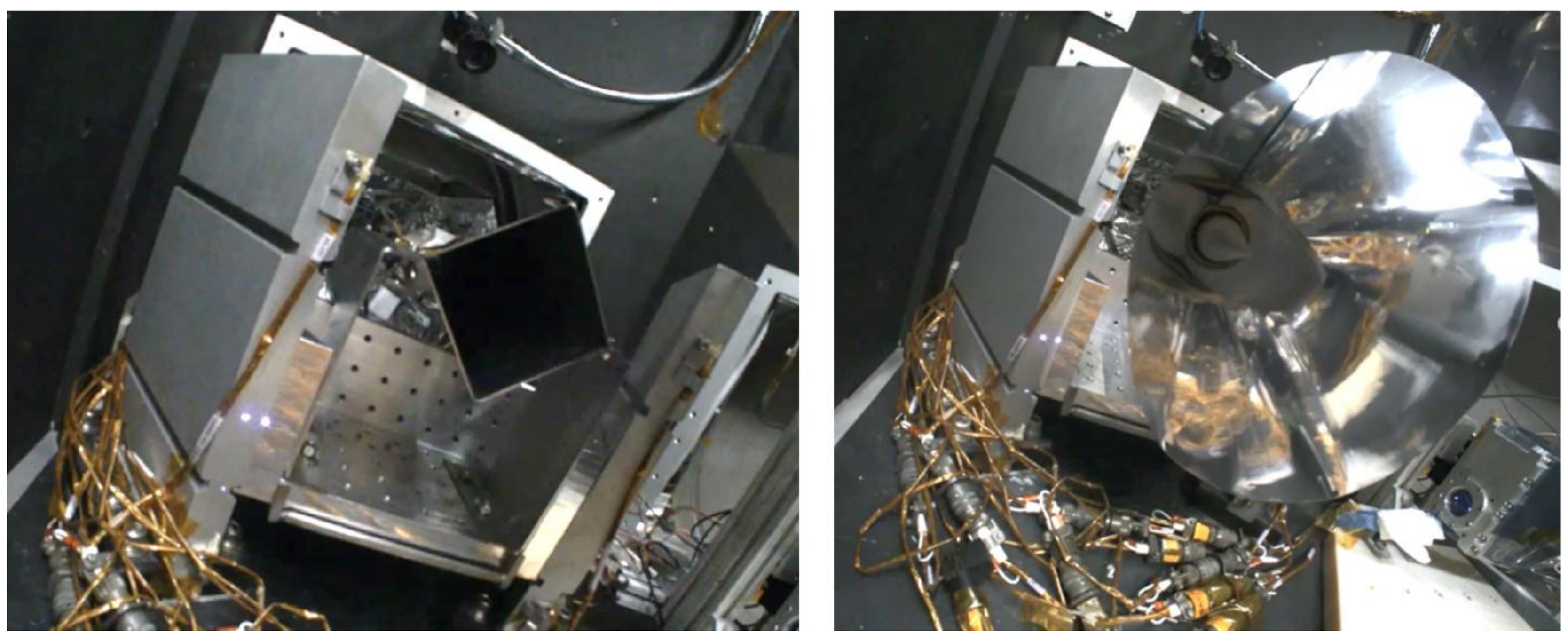

Figure 5. Gulper-Eel (left) and Soft-Cone (right) samplers in the plume analog thermal vacuum chamber.

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