National Aeronautics and Space Administration

Enceladus and Mars Sample Handling System for SCHAN Life Detection Instrument

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Program: FY22 R&TD Strategic Initiative
Strategic Focus Area: In-Situ Extant Life Detection Technology - Strategic Initiative Leader: Victor S Abrahamsson

Objectives:

There were two primary objectives of the FY22 task.

1) Develop and validate a TRL 4 sample handling system for the Supercritical CO_2 and Subcritical H_2O Analysis (SCHAN) instrument for ice particle samples of an Enceladus mission.
2) Develop a conceptual design of a TRL 4 sample handling system for the SCHAN instrument for a Mars surface mission application.

Background:

The recent NASA Decadal Survey identified an Enceladus mission which collects and analyzes plume material as a high priority both as a flagship mission and for a New Frontiers program mission. Plumes in the southern region of Enceladus continuously eject material from the subsurface ocean. A primary objective of an Enceladus mission would be to analyze plume material to detect evidence of life in the subsurface ocean if it exists there. The Decadal Survey also prioritized the Mars Life Explorer mission. The SCHAN instrument could perform the life detection analysis for an Enceladus or Mars mission. This task is developing the sample handling system for the SCHAN instrument for Enceladus and Mars mission applications. It is assumed that pneumatic sample transfer is used to deliver samples to the sample handling system.

Significance/Benefits to JPL and NASA:

The SCHAN instrument (including QITMS mass spectrometer) provides unique capability of detecting ppb-level chemical biosignatures from as few as ~10^4 cell/g of live or dormant organisms. The instrument suite will be able to detect microbes and hardy bacterial spores in Martian soil simulants as well as from ice or liquid samples from targets such as Enceladus, Europa, or Ceres. Different sample handling systems are needed for the mixed ice-regolith samples of Mars and ice samples of Ocean Worlds.

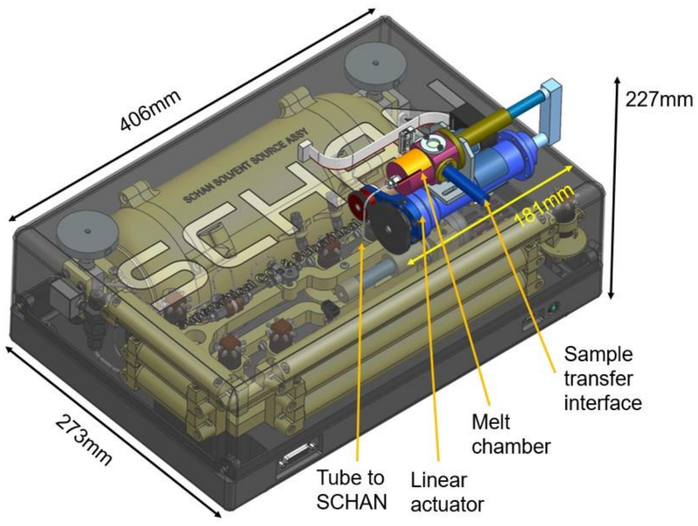

Figure 1. Sample handling system design integrated with SCHAN instrument for an Enceladus application.

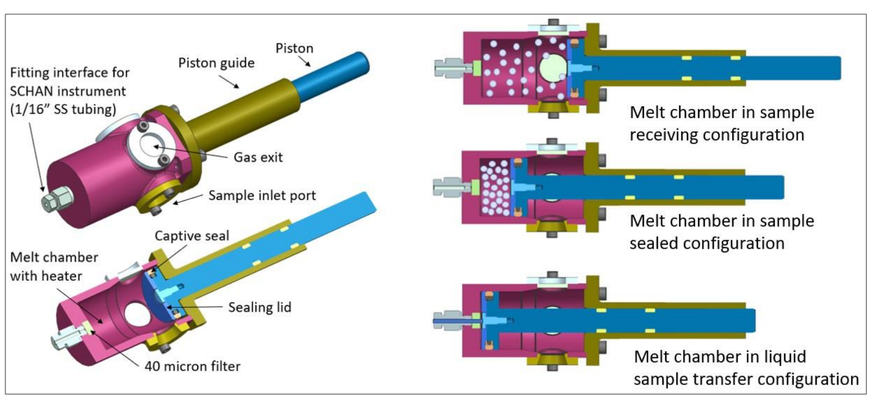

Figure 2. Components and process of the sample handling system for an Enceladus application.

Approach and Results:

The Enceladus application sample handling system (Fig. 1) would utilize a reusable sample chamber which would receive ice particle samples via pneumatic sample transfer. A piston driven by a linear actuator would push and seal the sample in the melt chamber where it would be transitioned to liquid with a heater. The piston would then push the liquid out to the SCHAN instrument (Fig. 2). The sample handling system was fabricated and then validated to TRL 4 in a thermal-vacuum chamber (Fig. 3). Atomized ice particles were placed in the sample chamber, sealed in the melt chamber, melted, and the liquid was pushed out through a stainless steel tube, through a thermal-vac chamber feedthrough port, and then through SCHAN instrument extraction cell and trap filters. A manual linear actuator was used through a feedthrough port of the thermal-vac chamber. A load cell measured the force necessary to push the piston.

The Mars application sample handling system (Fig. 4) would receive mixed ice-regolith samples, perhaps acquired using a drill sampling tool. Multiple single-use sample chambers are provided on a carousel, with 30 sample chambers assumed for this initial design. An inlet port receives the sample via pneumatic sample transfer and guides the sample into a sample chamber at the sample transfer station. The carousel would rotate to place the sample chamber at the extraction station. A linear actuator would seal the sample chamber between a solvent inlet port and an outlet port to the SCHAN instrument. Supercritical CO_2 would flow into the sealed chamber and the chamber would be heated to 200°C to extract organics and then a valve would open in the SCHAN instrument to allow the fluid to flow out of the extraction chamber and into the SCHAN instrument. This process would be repeated for H_2O solvent.

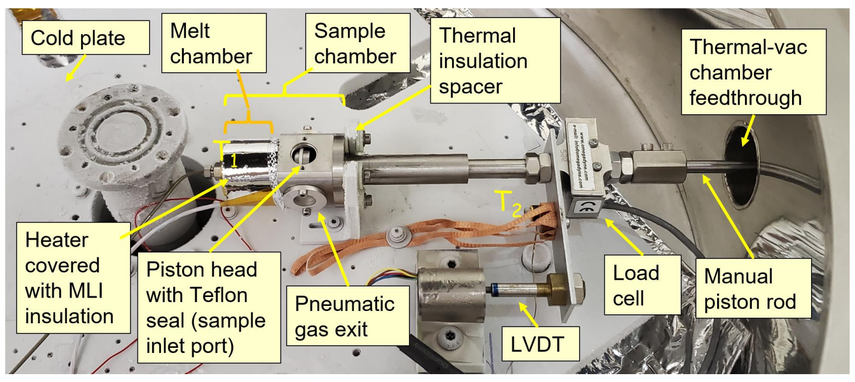

Figure 3. Thermal-vacuum chamber validation setup. Atomized ice particles were melted and pushed out with the piston through SCHAN extraction cell and trap filters.

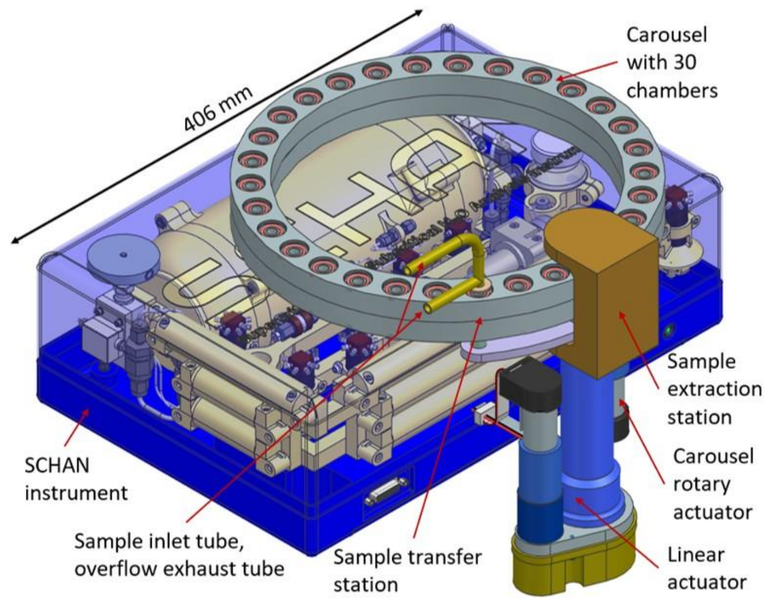

Figure 4. Sample handling system design integrated with SCHAN instrument for a Mars surface application.

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Publications:

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