**Technical Goal**

Preserve an ice sample at cryogenic temperatures during return (about 7 years) and Earth re-entry for three classes of missions:

An integrated cryogenic chamber includes three types of technologies: Phase Change Materials (PCM); multistage shield and heat switch; and mechanical cryocooler.

- **Class 1:** Sample kept between 100K – 150K
  - Adapt current PCM (e.g. Argon), cryocooler, shield, and heat switch tech. for larger heat sink caused by sample size. Develop baseline integrated Cryogenic Chamber.

- **Class 2:** Sample kept between 65K - 100K
  - Improve from class 1, heat switch reliability & multistage switch.

- **Class 3:** Sample kept 55K - 65K
  - Improve from class 2; Adapt N2 PCM
  - Improve heat switch reliability & improve efficiency of passive radiator cooling;
  - Develop battery powered 2nd stage cryocooler for earth entry vehicle

- Perform trade studies between use of passive thermal radiators (PTR), size of cryocoolers, and number of cryocoolers for different mission classes and Understand location of cryocoolers: internal or external to the earth entry vehicle.

- Challenges: If batteries power a cryocooler in earth return vehicle, then battery life could be a concern. The ICC needs a hermetic seal to maintain the vacuum in the ICC needed to minimize heat transfer.

**Mission Applications**

**What science is enabled if we achieve the goal?**

1. Return of ice samples that contain evidence of habitability and/or potential life, e.g. from Europa or Enceladus.
2. Subsurface comet nucleus sample that contains information about the formation of the solar system.

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<th>Class</th>
<th>Europa, Enceladus, Comet</th>
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| 1     | • Minimize chemical processes of non-volatile organics;  
| 1<150K| • Maintain complex organics;  
|       | • Maintain crystalline ice  
|       | • Maintain evidence of potential life (non-comet) |
| 2     | • Stop chemical processes of non-volatile organics;  
| 2<100K| • Maintain volatile organics.  
|       | • Maintain amorphous ice (comet) |
| 3     | • Maintain native state (temp ≤ original environment)  
| 3<65K | • Retain CO2, ammonia |