



Mission

# SELPHIE

Surface, Exosphere, and Lunar Polar Hydration with Impact Experiments

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The SELMA proposal team, the SELPHIE proposal team,  
and the Bifrost team

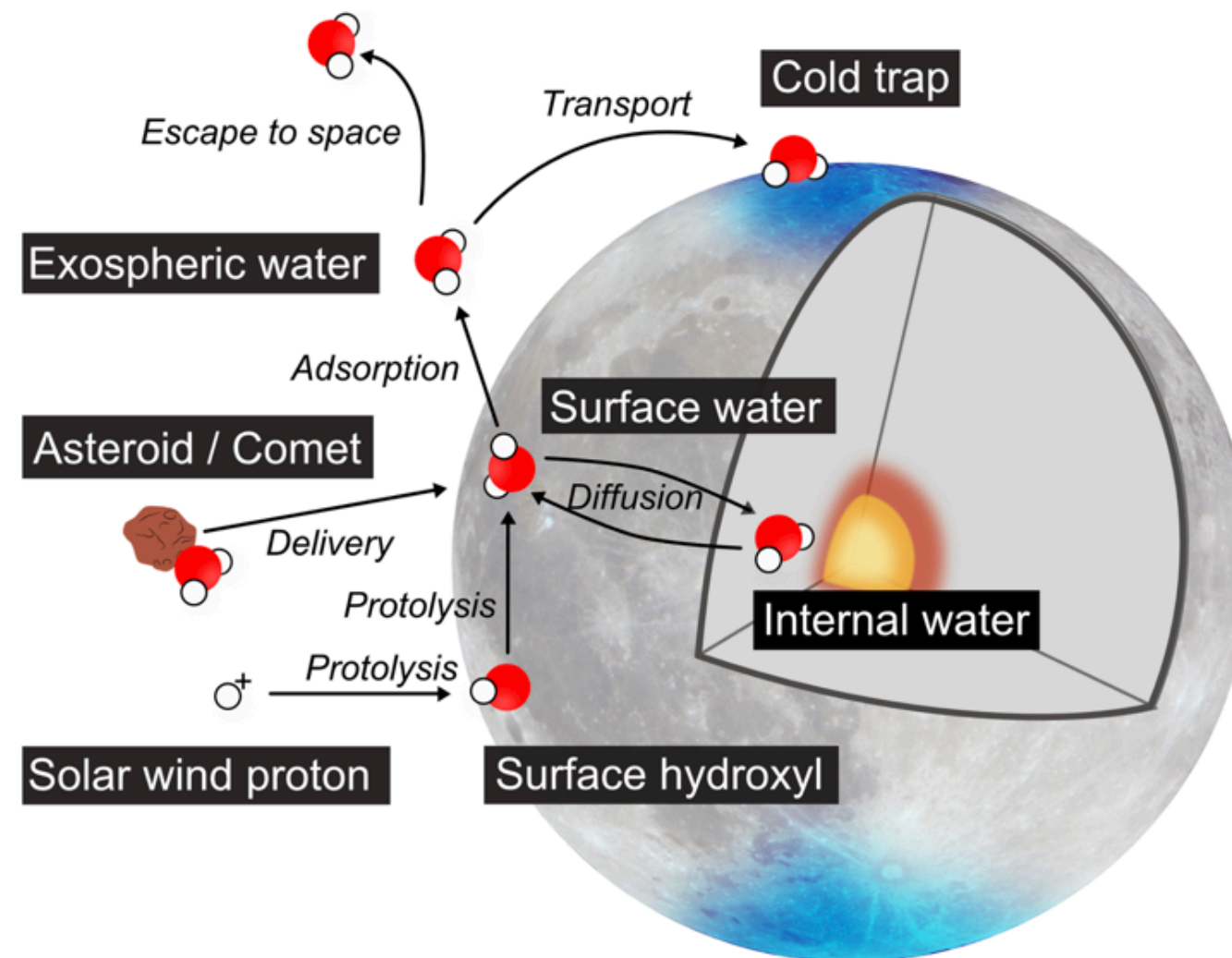
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# The mission SELPHIE

- The mission SELPHIE
  - Surface, Exosphere, and Lunar Polar Hydration with Impact Experiments
- The mission SELPHIE is a proposed lunar mission, with focused science objectives derived from its precursor mission, SELMA (Futaana et al., 2018)
- The mission SELPHIE will reveal actively ongoing water circulation processes on the Moon
- The mission SELPHIE was proposed for
  - F-class mission call (ESA, science programme), 2018
  - Lunar RFI (request for information) (ESA, Exploration Campaign Science and Technology Payloads), 2018
- A new small-scale mission study, Bifrost, is undertaken

# Science question and objectives

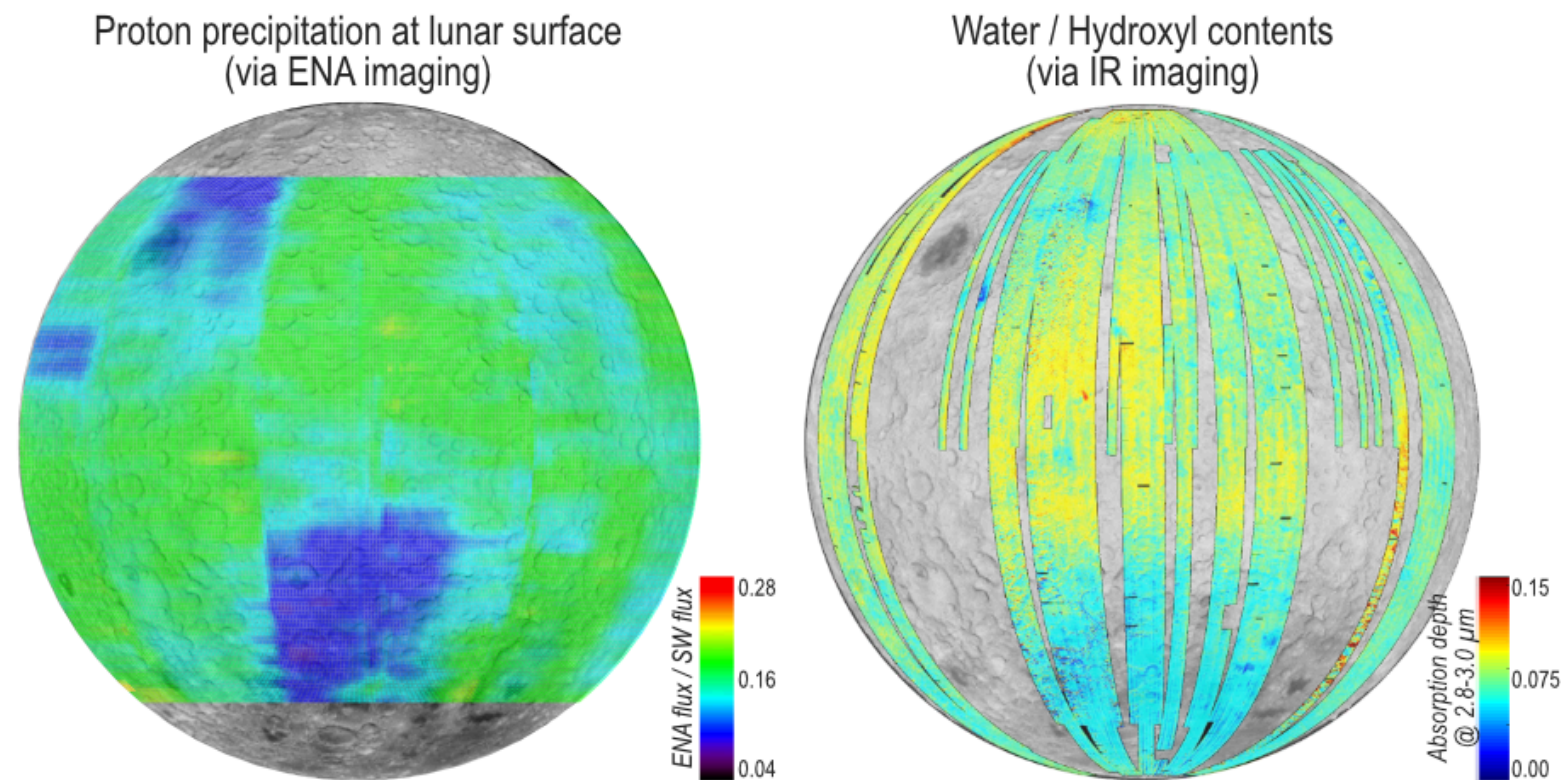
- How is the lunar surface water delivered or produced, transported, and accumulated in cold traps?
  - What is the origin of the surface water?
  - What is the origin of the water in cold traps?
  - What is the role of exosphere for transporting surface water to cold traps?





# What is the source?

- Solar wind protons or comets, asteroids, or meteoroids
  - Correlation among magnetic field strength, local solar wind flux, and IR absorption depth imply the solar wind protons as the source of surface water
- What is the origin of the surface water?
  - SELPHIE answers this question by coordinated measurements of solar wind precipitation, meteoroid flux, and HO/H<sub>2</sub>O contents with various time scales

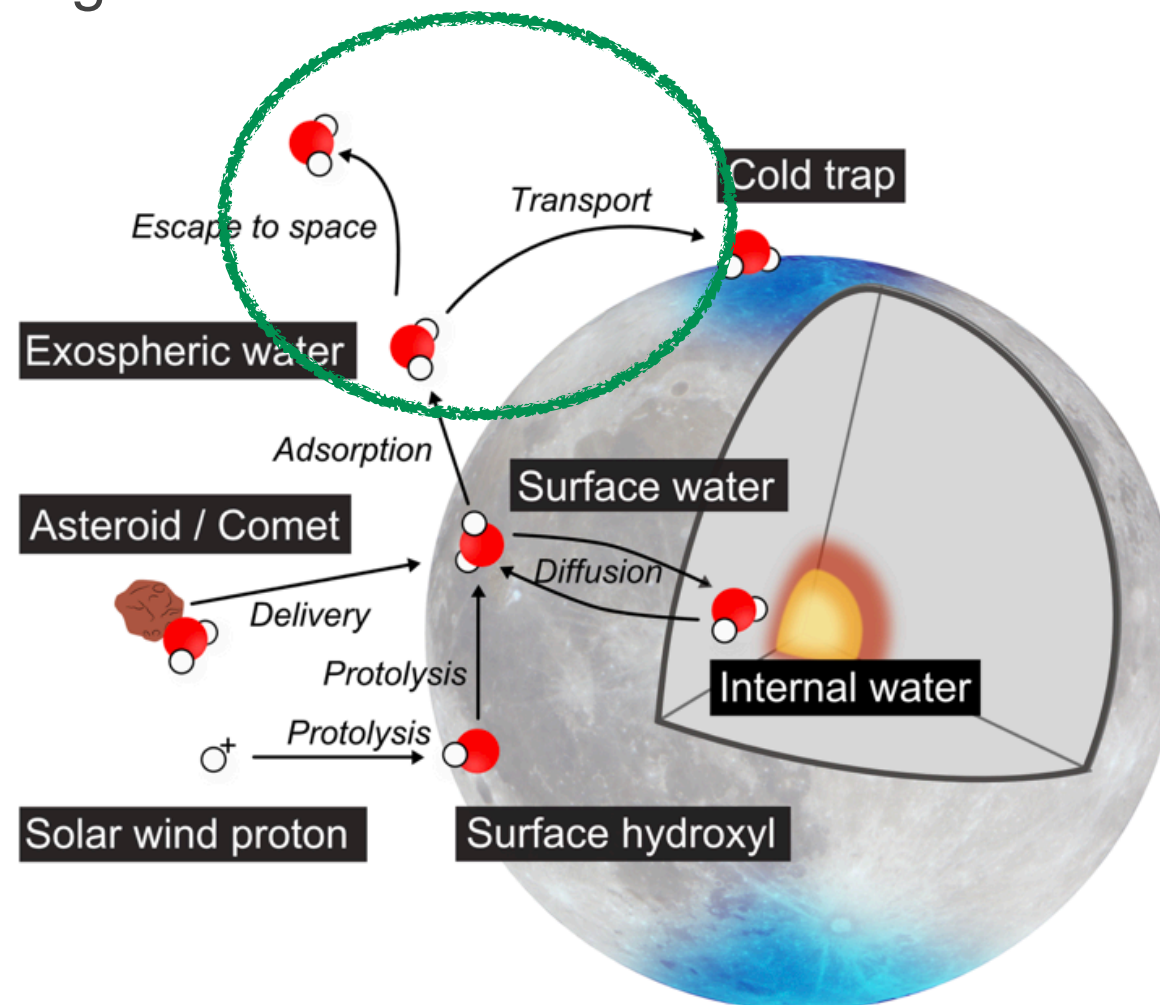


Vorburger et al., 2014

Adopted from Wöhler et al., 2017

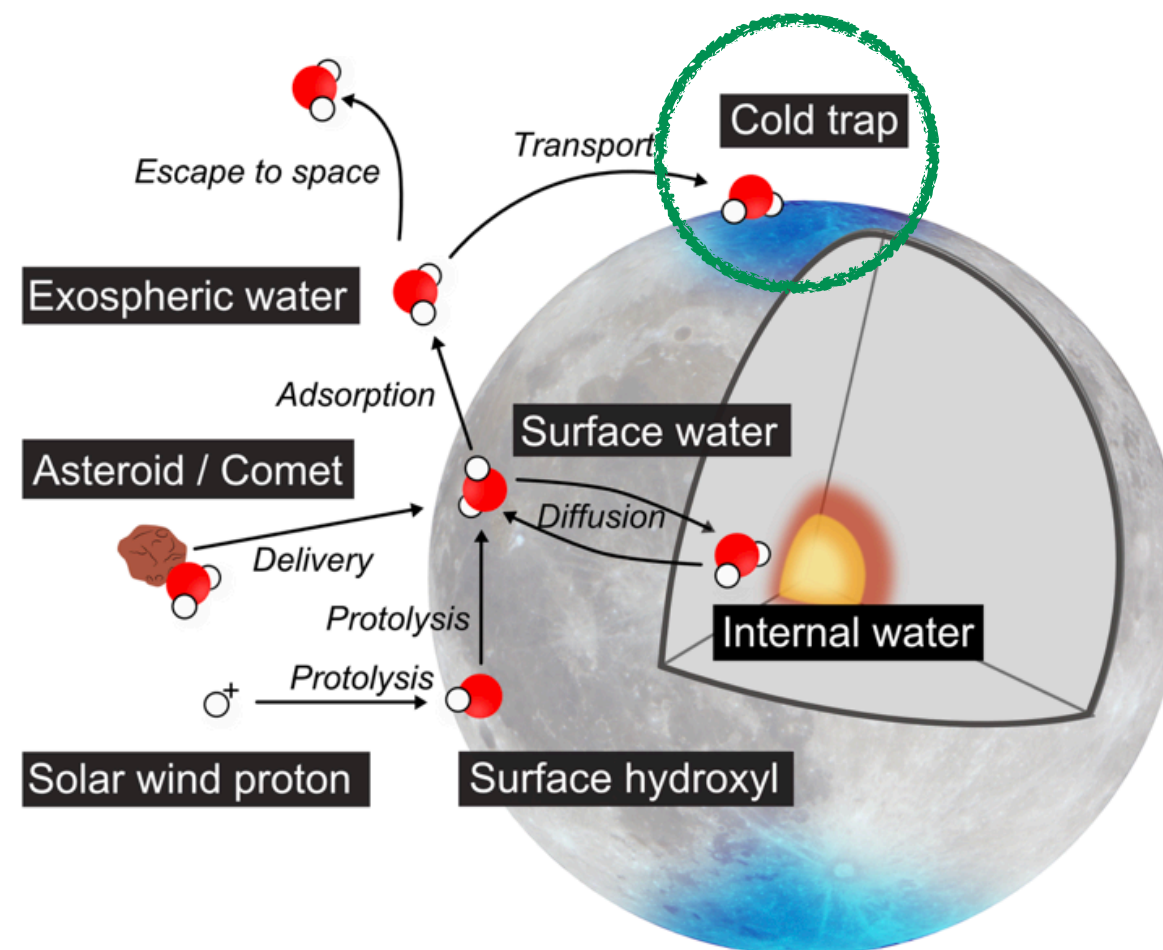
# How is water transported?

- The surface water is released to the exosphere, but what's the fate?
  - The daily variation of surface water contents implies stable water circulation
  - Meteostream events release surface water to the exosphere
- What is the role of the exosphere for transporting surface water to cold traps?
  - SELPHIE answers this question by understanding the responses of water in the exosphere against the micrometeoroid flux and the solar wind



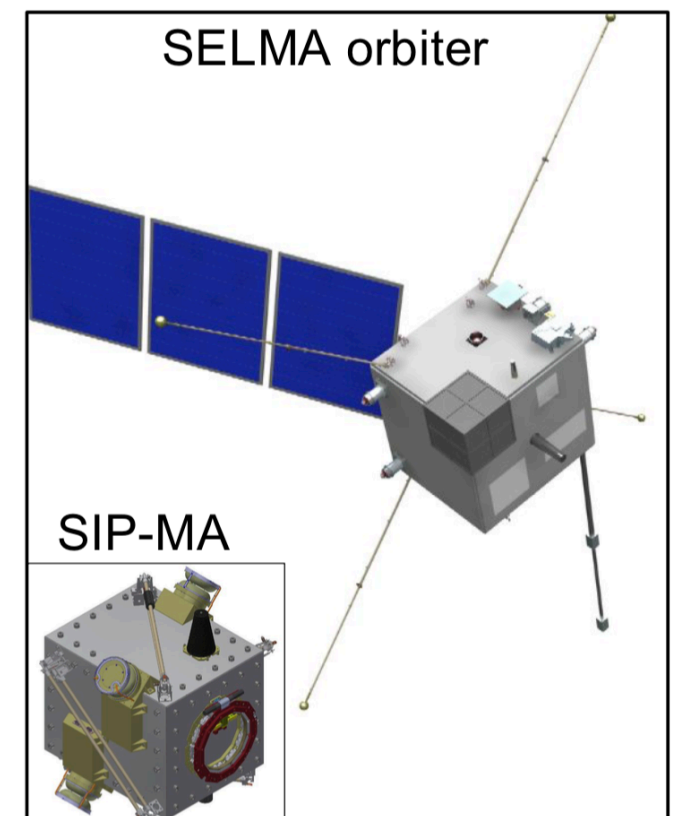
# What are the sink? The cold traps?

- The cold traps are the potential water reservoir
- What are the origin of the cold trap water? Solar wind protons or endogenic water?
  - SELPHIE answers this question by identifying the isotope ratio of the water in cold traps



# The SELMA/SELPHIE missions

- SELMA mission design study in 2016
  - 627 kg dry mass with 111 kg payload
  - In addition to water science, SELMA studies the mini-magnetosphere and global dust environment
  - Additional impactor for magnetic anomaly is also planned
  - SELMA orbiter in 30x200 km elliptical polar orbit
- SELPHIE mission design study in 2018
  - Based on SELMA mission design
  - <600 kg wet mass with 61 kg payload



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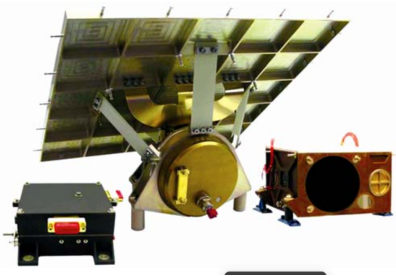


- Orbiter is 3-axis stabilized platform, hosting six payloads
  - 30x200 km, polar orbit
  - >8 months operations
  - Simultaneous observation with coordinate

## Orbiter

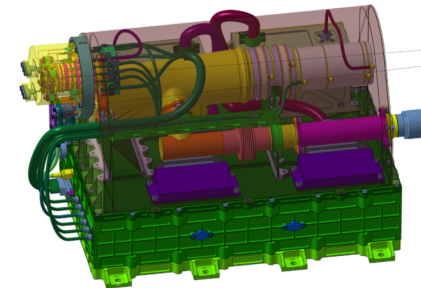
**LuIS:** Lunar Infrared Spectrometer

*Surface hydration*



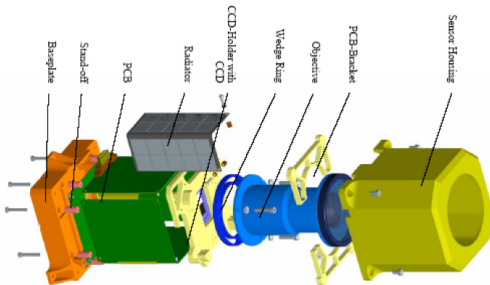
**LEMS:** Lunar Exosphere Mass Spectrometer

*Exospheric neutral particles*



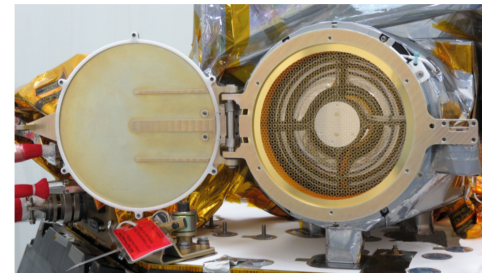
**SPOSH:** Smart Panoramic Optical Sensor Head

*Meteoroid impact monitor*



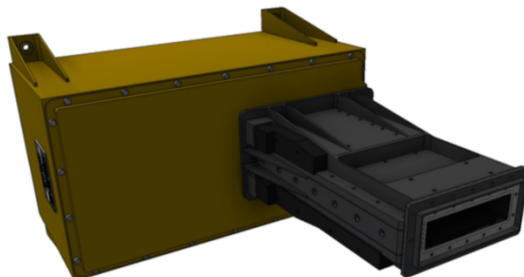
**LDD:** Lunar Dust Detector

*Dust impact monitor*



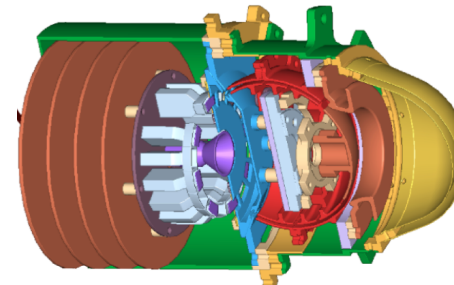
**ENAT:** Energetic Neutral Atom Telescope

*Surface proton monitor*



**LSoW:** Lunar Solar Wind

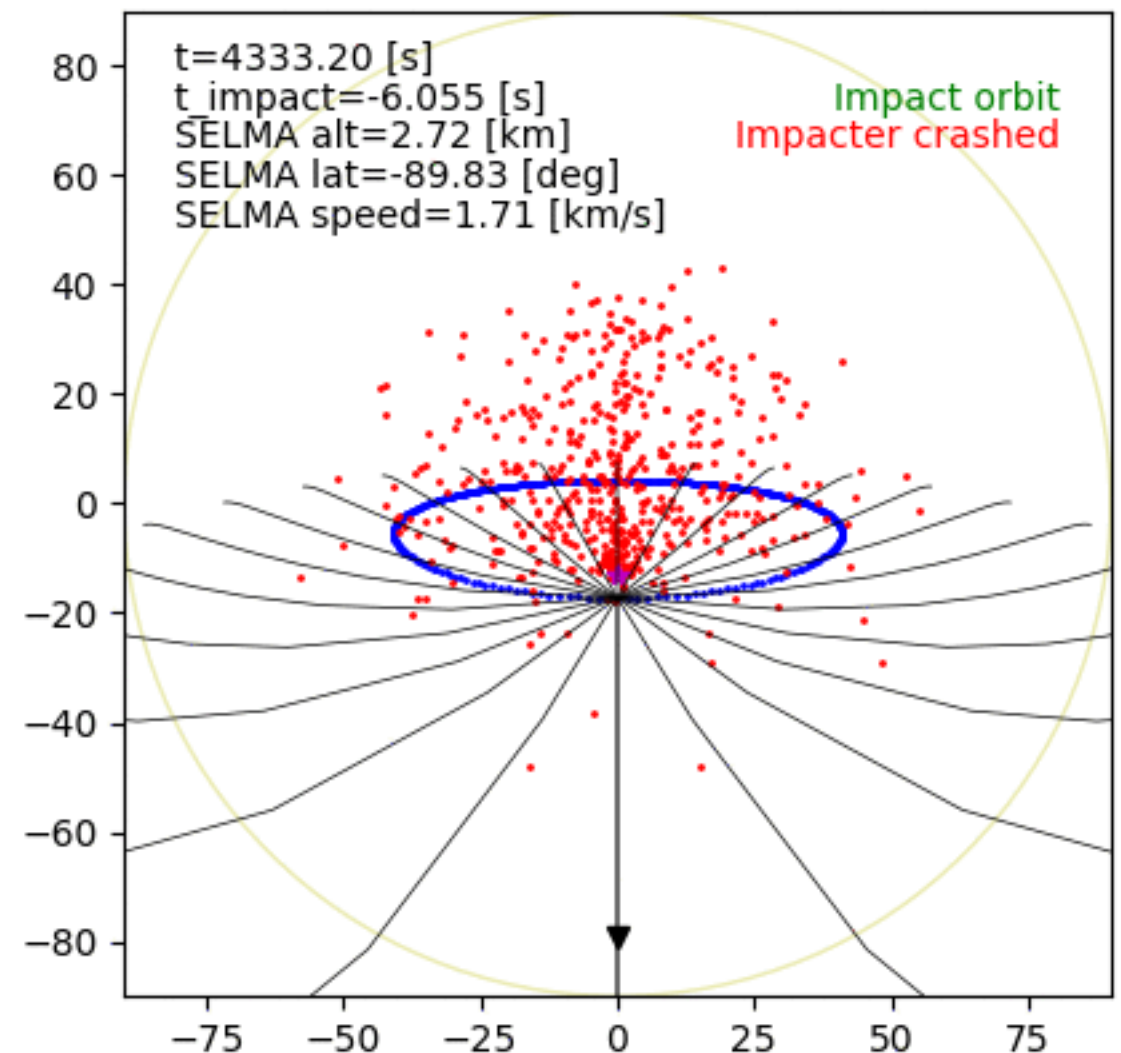
*Solar wind monitor*



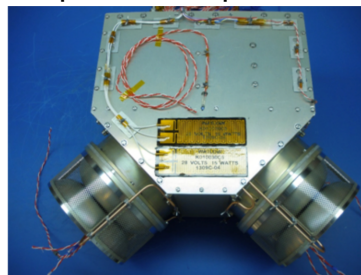


# Impact experiment

- Impact experiments
  - Impact of Tungsten ball (4 kg) to a cold trap
  - Two identical system for two independent experiments
    - Shackleton crater
    - Haworth crater
  - Measurements will be done by cubesat (>5s)

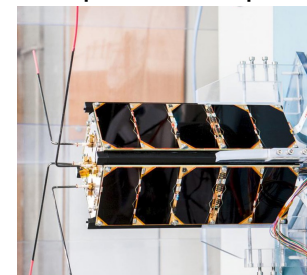


**IEMS:** Impact Experiment Mass Spectrometer



*D-H ratio*

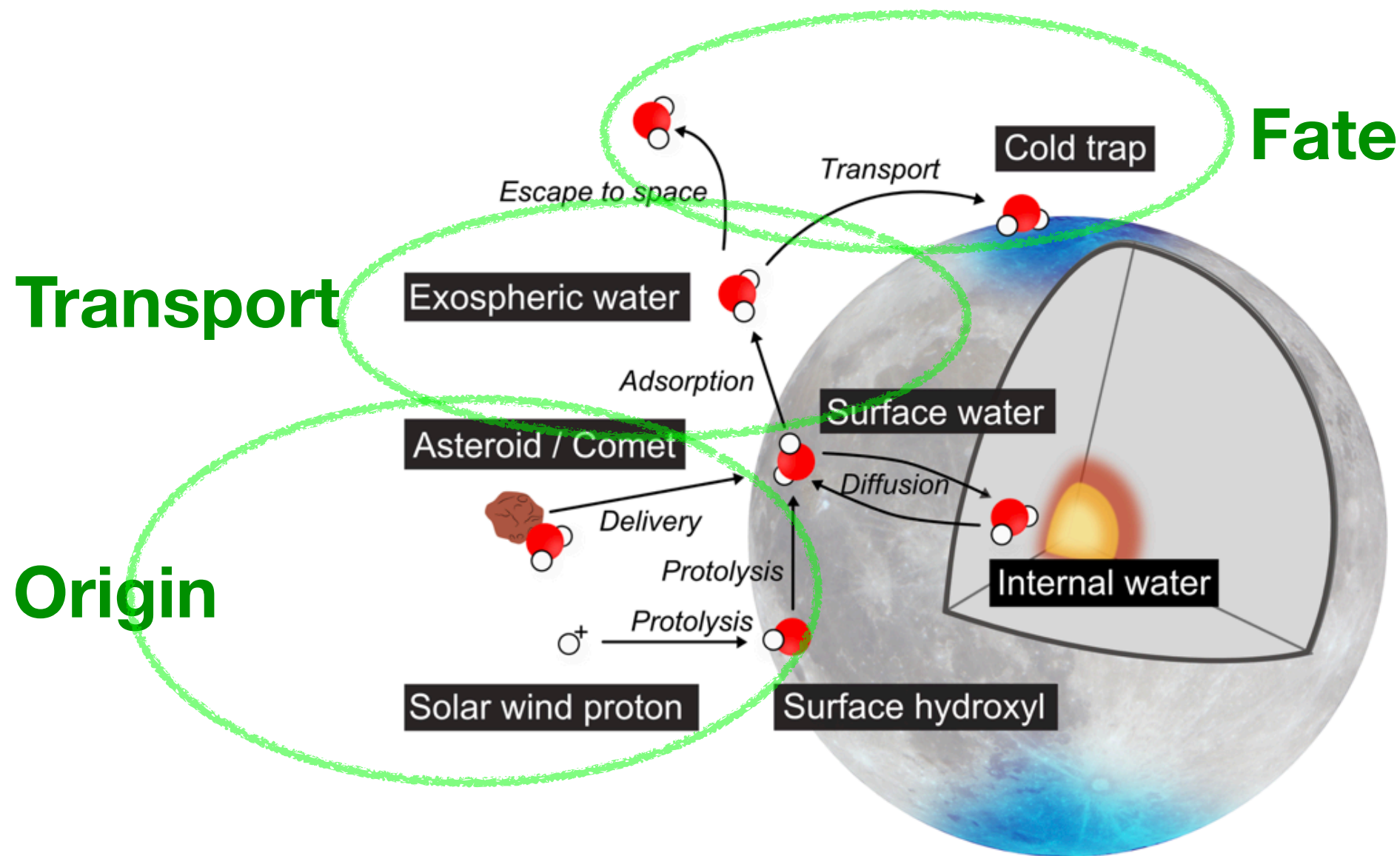
**IECS:** Impact Experiment Cubesat System



*Cubesat and  
impactor ejection*

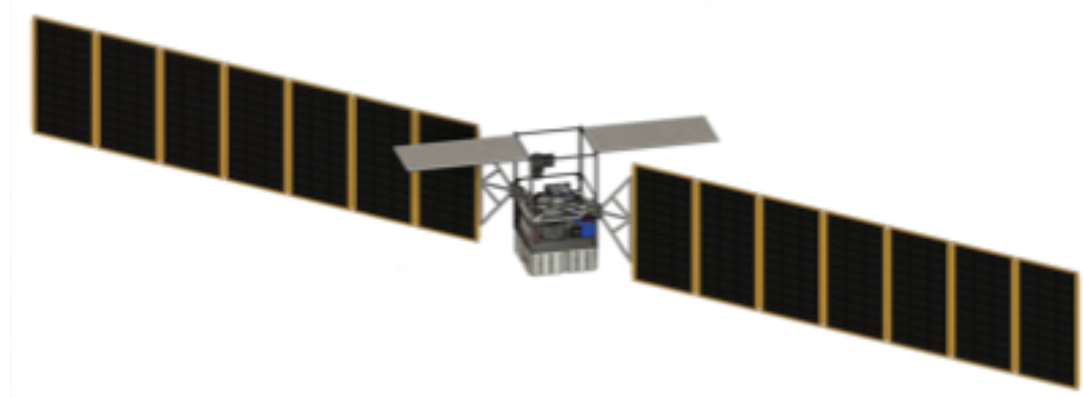
# The mission SELPHIE

- SELPHIE is a concept of the new Lunar mission to reveal actively ongoing water circulation processes on the Moon
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# The mission Bifrost

- The mission Bifrost, under study
  - Science based on SELPHIE
  - With the state-of-the-arts technologies, the spacecraft resources will be significantly reduced, but with scientific ambitions retained
    - Miniatured scientific sensors
    - Electric propulsion system
    - Communication system
  - An innovative mission developed in collaborations between academia and private sectors in Sweden (IRF, Beyond Atlas AB, LTU, KTH)
  - Open a path for new companies to enter the space market



(c) Beyond Atlas AB