Development of an experimental setup to investigate the lunar water cycle in the VOLARIS project.

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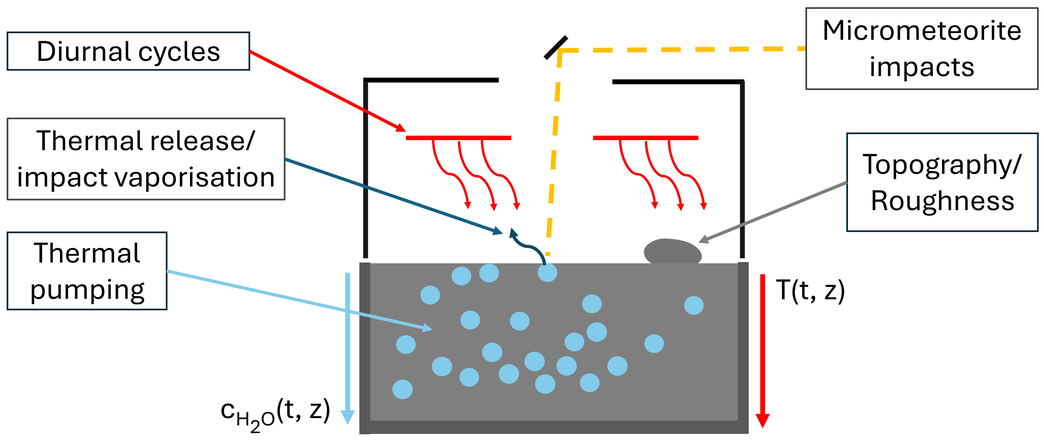
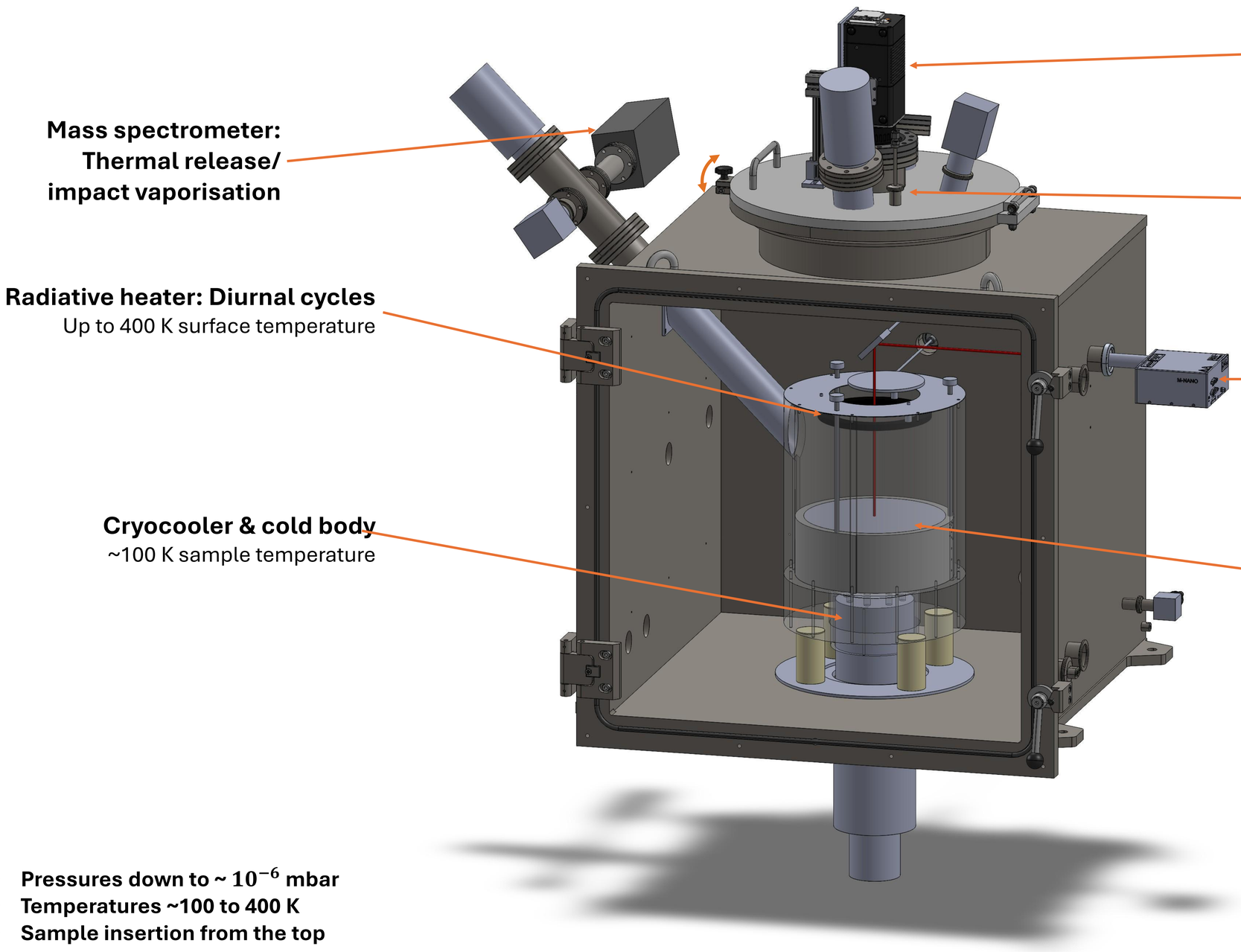
The ERC project **VOLARIS**, funded by the European Union, aims to improve our understanding of the lunar water cycle processes and to assess whether near-surface lunar water reservoirs are more abundant than currently estimated [1]. Therefore, an experimental setup is being built at the Technical University of Munich (TUM) and a numerical model will be correlated to extrapolate to lunar timescales.



1. Investigate **thermal profiles** in a cm-sized regolith sample
2. Investigate **subsurface water migration and thermal pumping** by measuring its dielectric properties/ sampling
3. **Laser-induced mass spectrometry** to simulate micrometeorite impacts and constrain thermal release processes

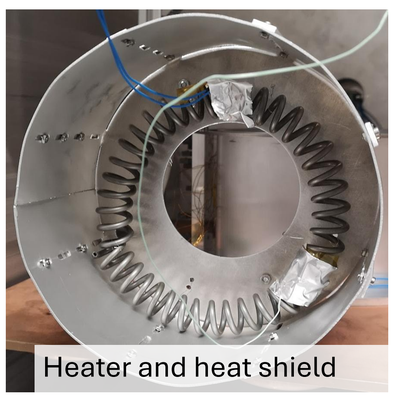
- Long-term experiments on a days-scale
- Optional: manipulate the surface with a rock or similar

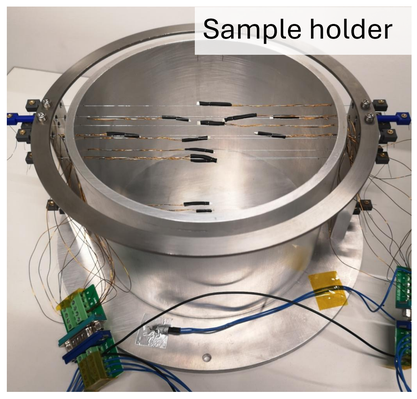
For all experiments, the sample properties, e.g. by using different icy (see poster no. 7 by F. Achorner) and dry simulants, can be varied.



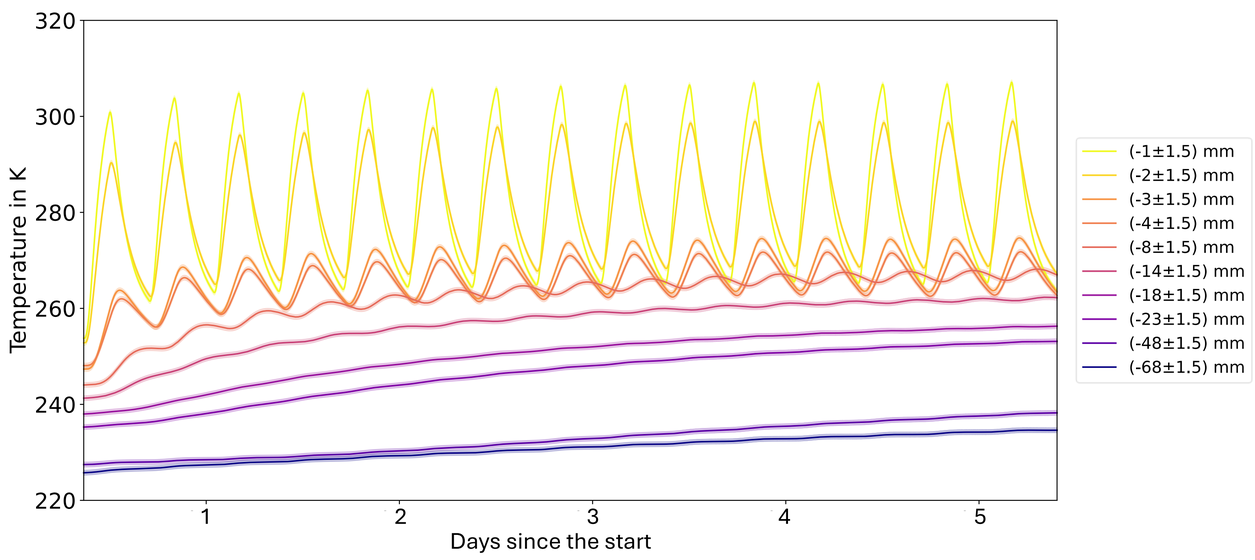
- **Pressures down to ~ 10^{-6} mbar**
- **Temperatures ~100 to 400 K**
- **Sample insertion from the top**

Thermal Cycling


Heater and heat shield

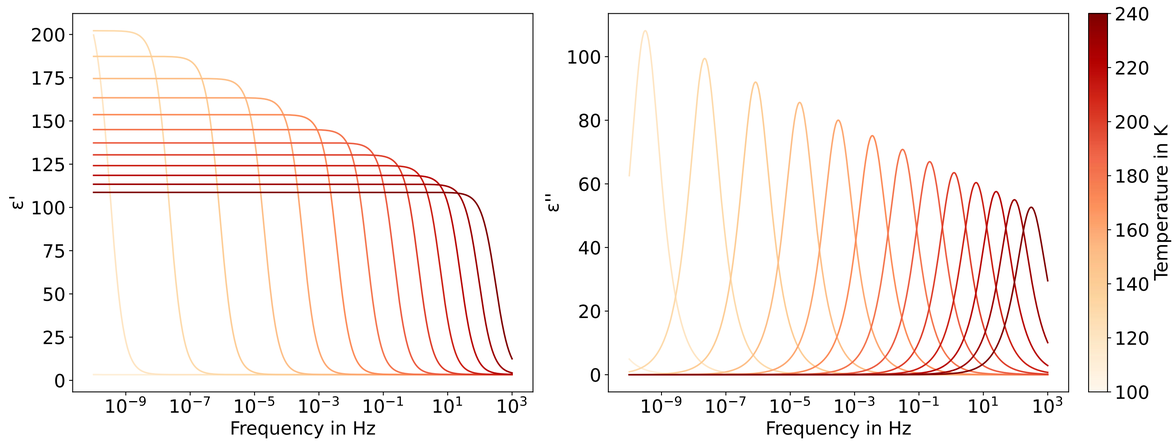

Sample holder

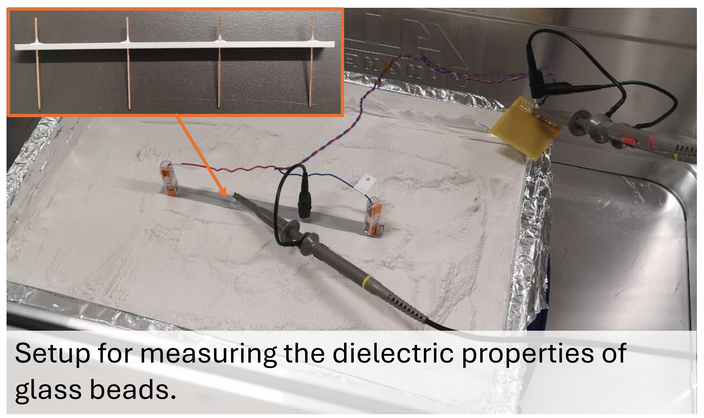
A preliminary setup is placed inside a thermal vacuum chamber reaching pressures down to ~10^{-3} mbar and temperatures around 200 K. A heater is mounted above the sample to investigate the thermal cycling of samples. The figure below shows exemplary measurement data.



Ice Content Measurement

Water ice and lunar regolith show different dielectric behaviour as a function of frequency and temperature. Lunar regolith's relative permittivity depends only slightly on temperature and density, ranging from ~ 2 to 3, but not on frequency [2]. In contrast, water ice shows a strong dependence due to Debye relaxation with permittivities ranging from ~3 to 100:




Setup for measuring the dielectric properties of glass beads.

An experimental setup for dielectric spectroscopy to determine the water ice content inside a sample is built and tested. Similar measurement techniques, such as those employed, e.g., for SEMSAME and PROSPECT [3, 4], have already been successfully applied.

References:
[1] Reiss, P. et al. (2025), doi: 10.54050/PRJ2423610.
[2] Gscheidle, C. (2025), doi: 10.14459/2025md1776775.
[3] Seidensticker, K. J. et al. (2007), doi: 10.1007/s11214-006-9118-6.
[4] Gscheidle, C. and Reiss, P. (2024), doi: 10.5194/epsc2024-559.

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