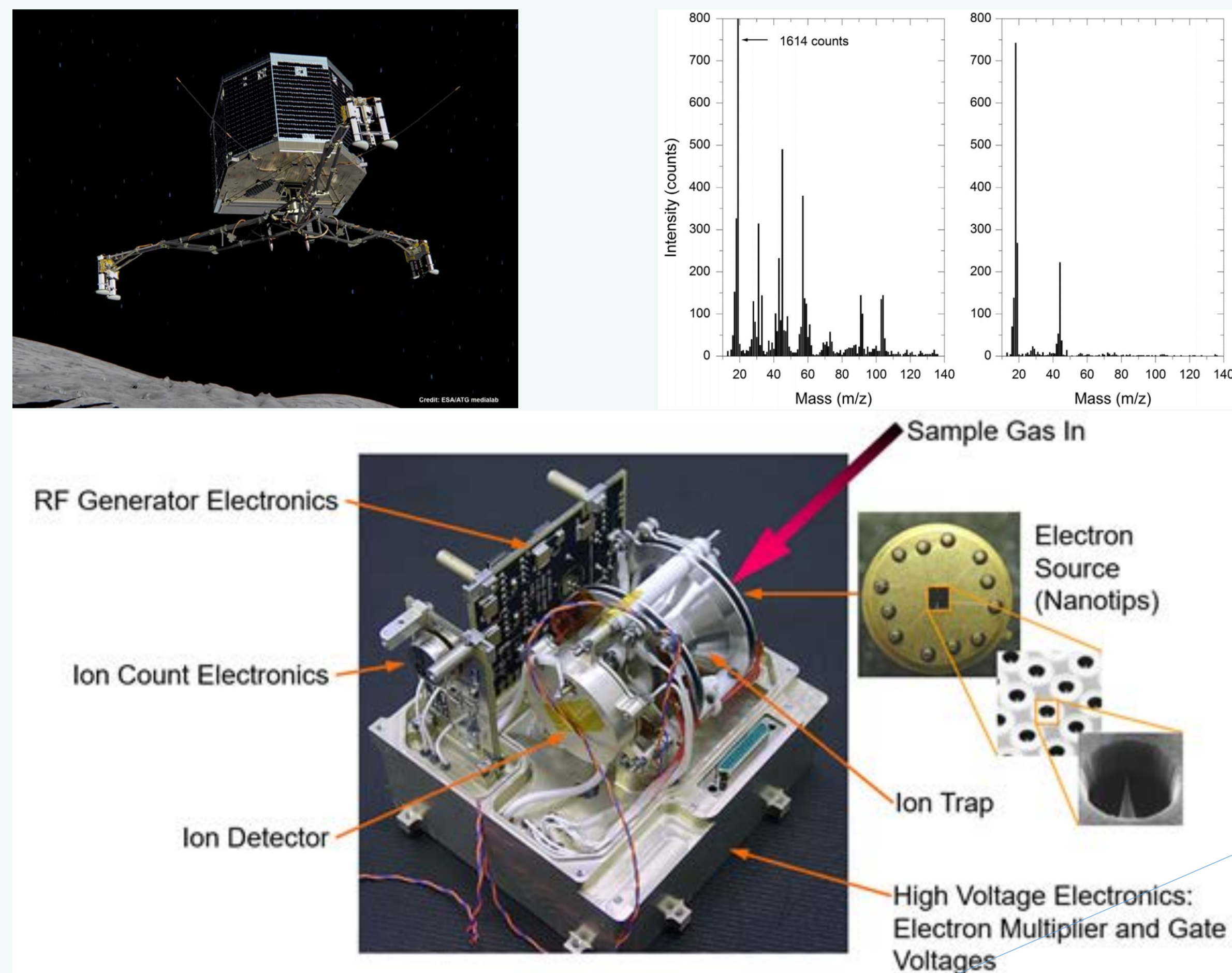


Ion Trap Mass Spectrometers for identity, abundance and behavior of volatiles on the Moon

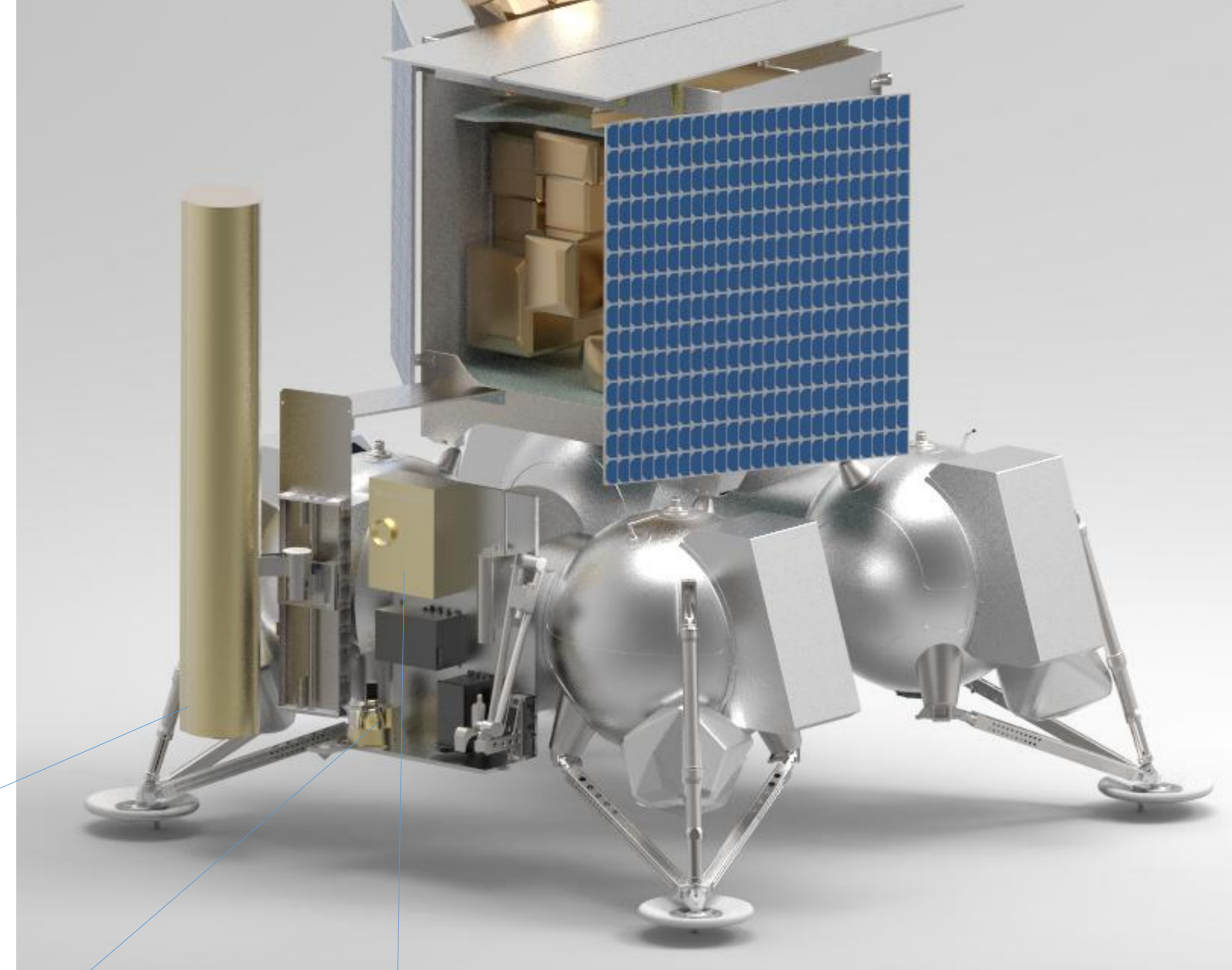
S. J. Barber¹, A. D. Morse¹, S. Sheridan¹, B. A. Cohen², W. M. Farrell², I. P. Wright³, C. Howe³, T. Morse³, R. Trautner⁴
¹The Open University, UK, ²NASA Goddard Space Flight Center, Maryland, USA, ³RAL Space, UK, ⁴ESA ESTEC, Netherlands

NASA GSFC and The Open University (UK) are collaborating to deploy an Ion Trap Mass Spectrometer on the Moon to investigate the lunar water cycle. The ITMS is flight-proven through the Rosetta Philae comet lander mission. It is also being developed under ESA funding to analyse samples drilled from beneath the lunar surface on the Roscosmos Luna-27 lander (2025). Now, GSFC and OU will now develop a compact ITMS instrument to study the near-surface lunar exosphere on board a CLPS Astrobotic lander at Lacus Mortis in 2021.

ITMS on Rosetta lander made first in-situ analyses of comet organics



PROSPECT on Luna-27 lander utilises Ptolemy-type ITMS



PROSPECT: Science to enable Exploration

PROSPECT combines sample drilling (ProSEED) & analysis (ProSPA) :

ProSEED drill:

- To demonstrate extraction of 25 samples up to 1.2 m deep
- Cryogenic processing to reduce volatile losses
- Distribution to Russian and ESA payloads

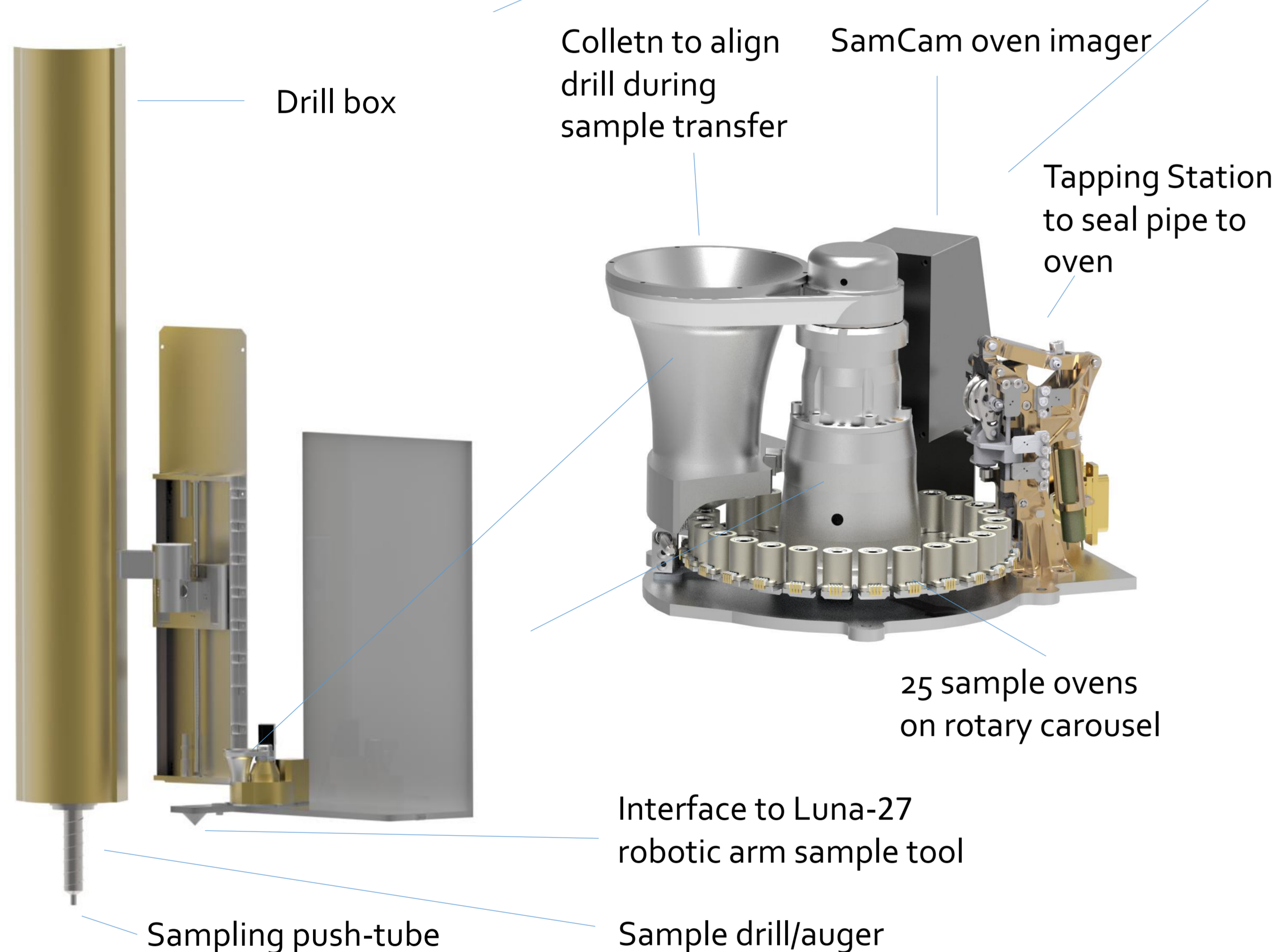
ProSPA Science Lab:

- To determine inventory & distribution of lunar volatiles
- To determine key isotopic ratios (δD , $\delta^{13}C$, $\delta^{15}N$, $\delta^{18}O$)
- To assess resource potential of the Moon (ISRU)

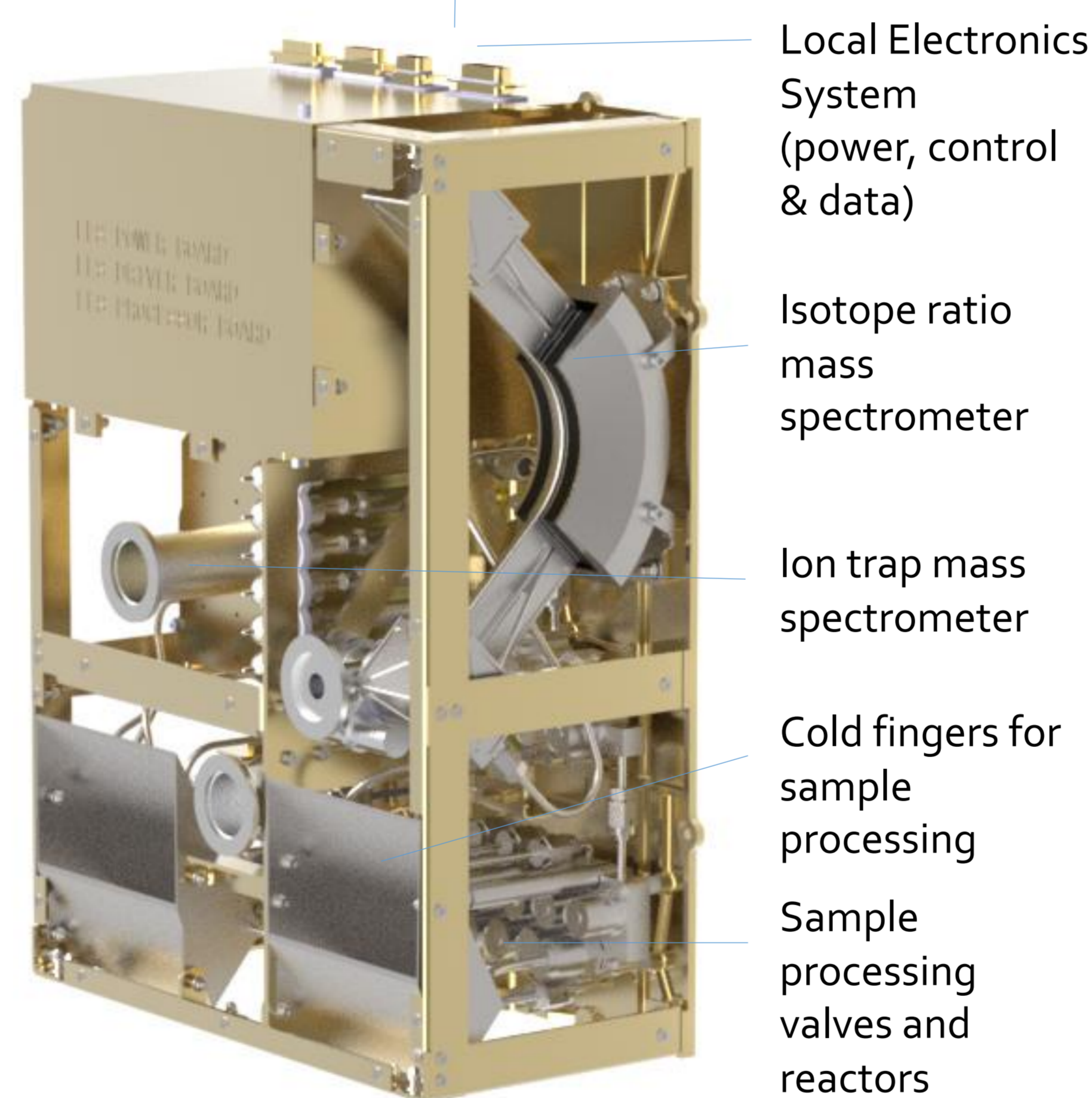
PROSPECT will fly as part of Roscosmos Luna-27 mission:

- Launch 2025
- Precision landing at south polar region
- 12 month surface operations

ProSEED Drill and ProSPA Solids Inlet System

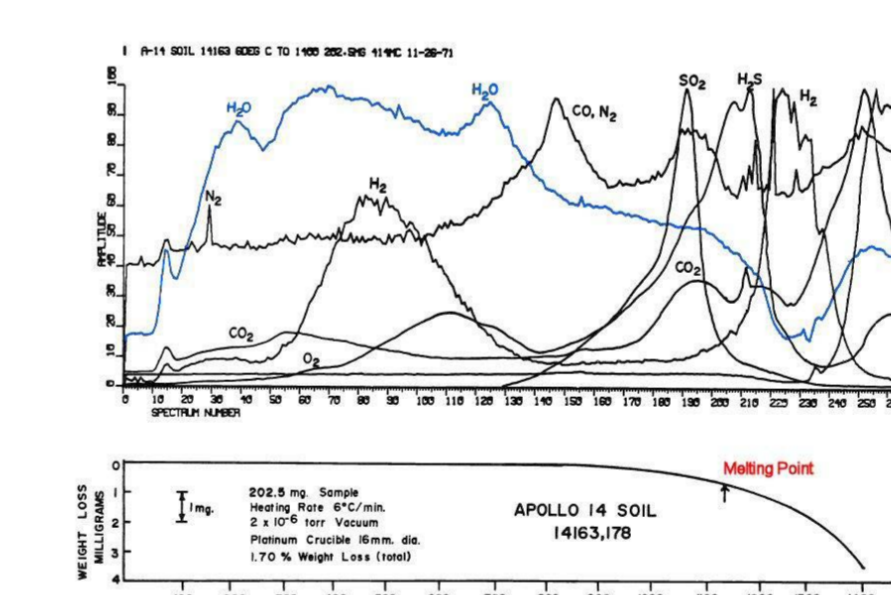
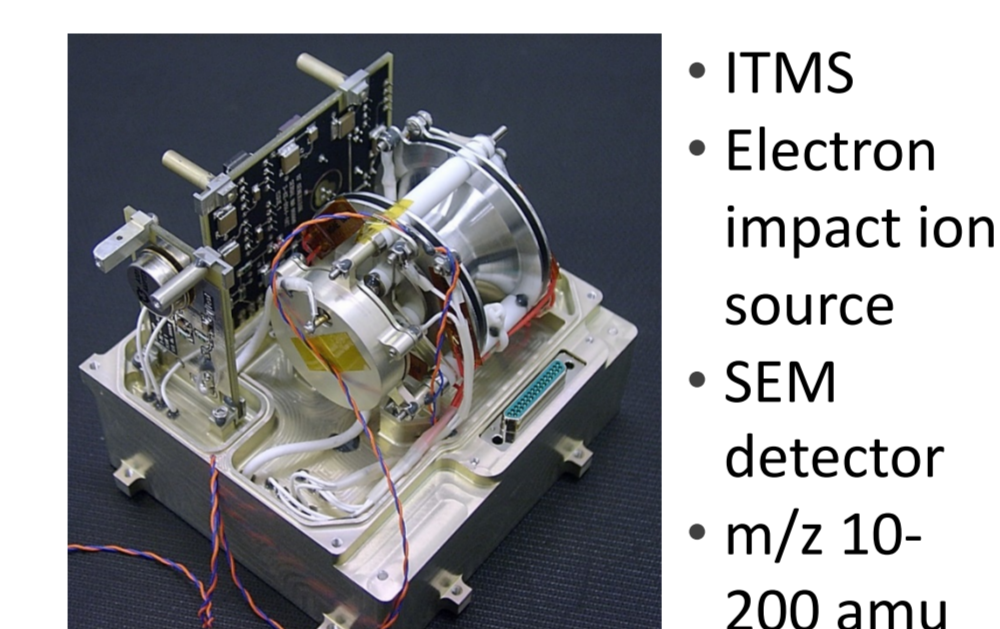


ProSPA Science Lab: identify, quantify and isotopically characterise volatiles released by heating drilled samples; perform ISRU demo



1. Evolved gas analysis:

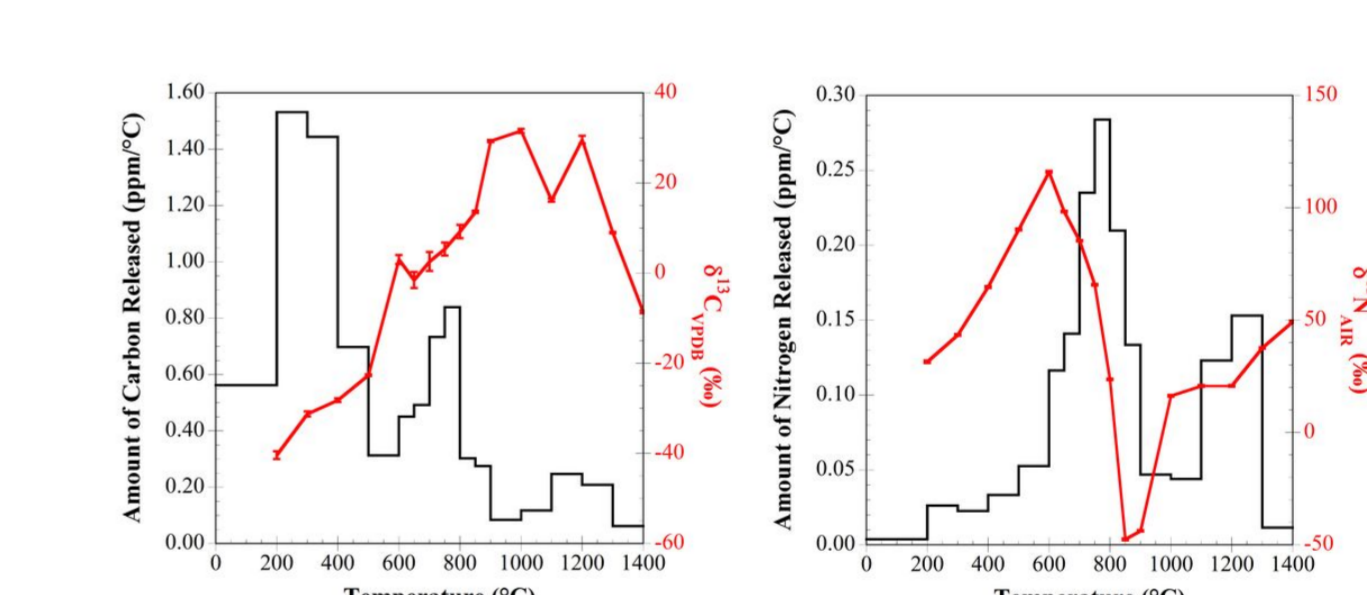
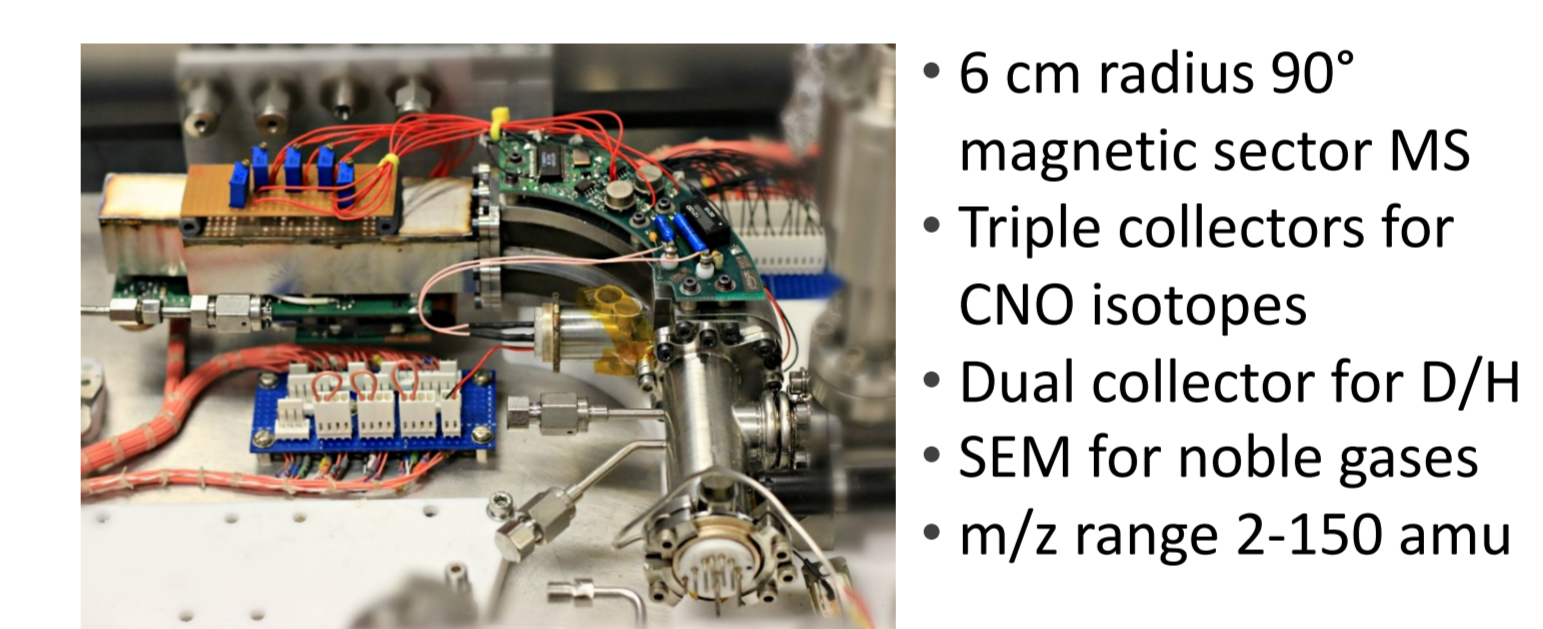
- Oven ramped at 6°C/min
- Evolved gases continuously analysed by ion trap MS



Evolved gas analysis of Apollo 14 soil
 Gibson E.K., Jr. et al. (1972) Proc. Lunar Sci. Conf. 2029-2040

2. Stepped pyrolysis or combustion:

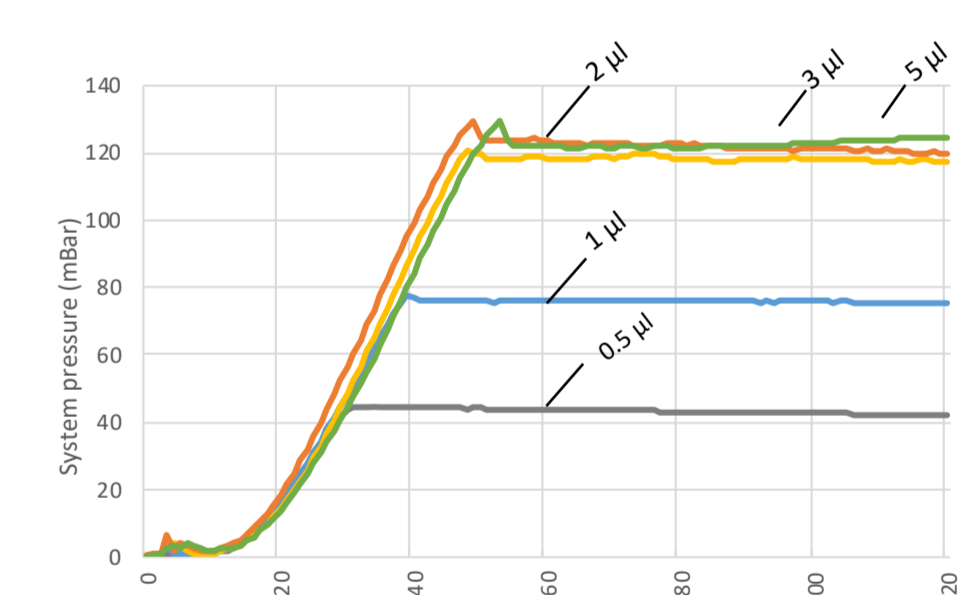
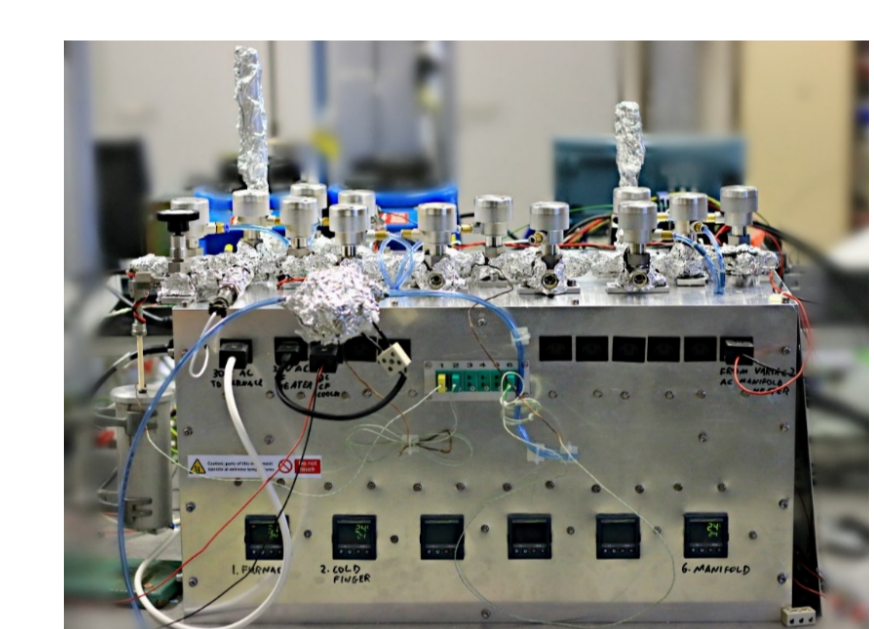
- Stepped extraction with/without oxygen
- Batch thermochemical processing
- Isotopic analysis in magnetic sector MS



Stepped combustion of Apollo 16 soil 69921
 After Mortimer, J. et al. (2016), Geochim. et Cosmochim. Acta 193, pp. 36-53

3. ISRU demonstration:

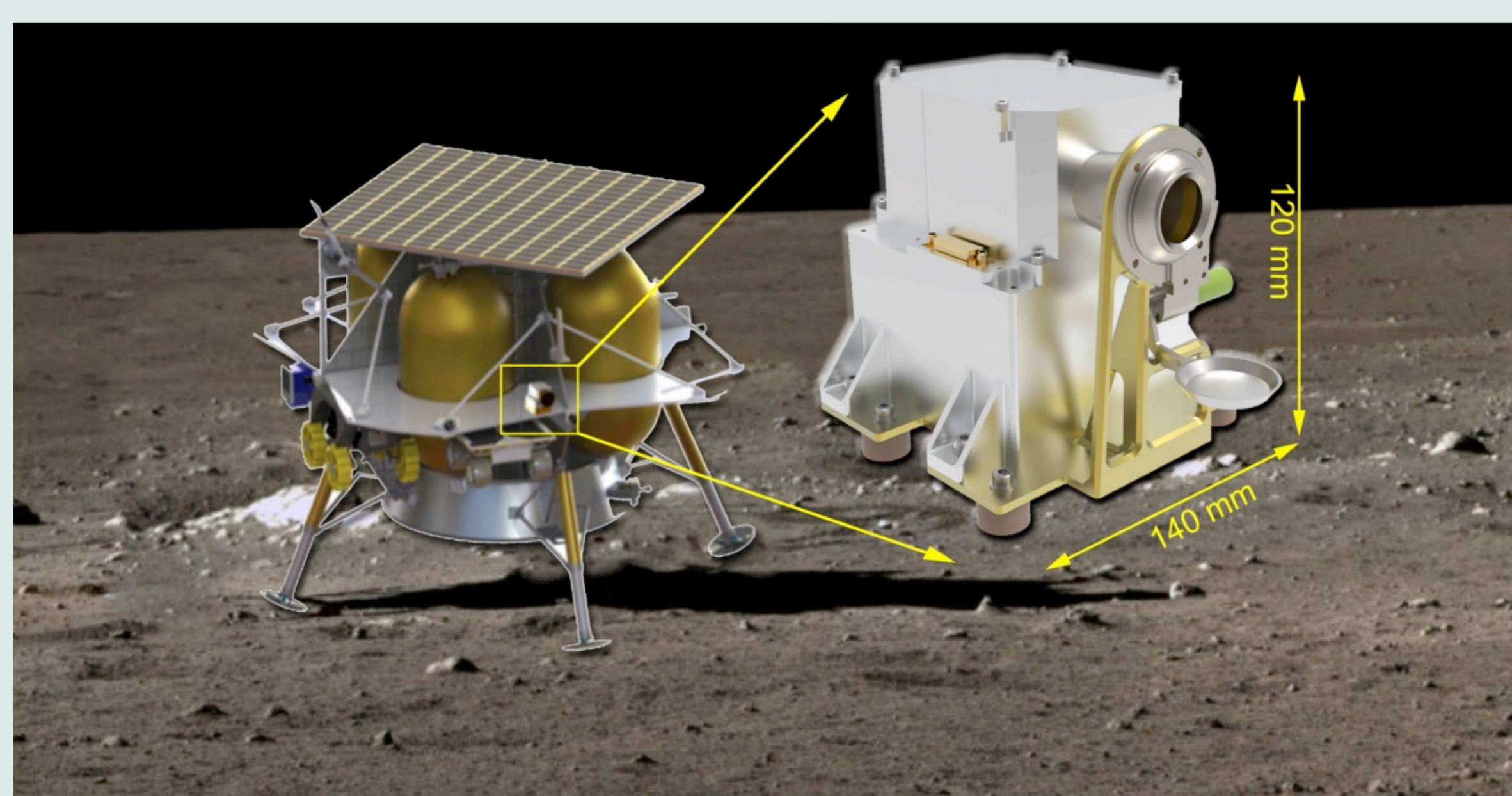
- Reduction of oxides with hydrogen at 900 °C
- Reduction by CH₄ at 1000 °C



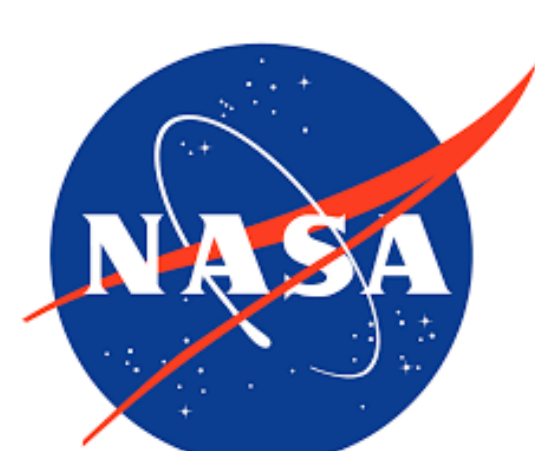
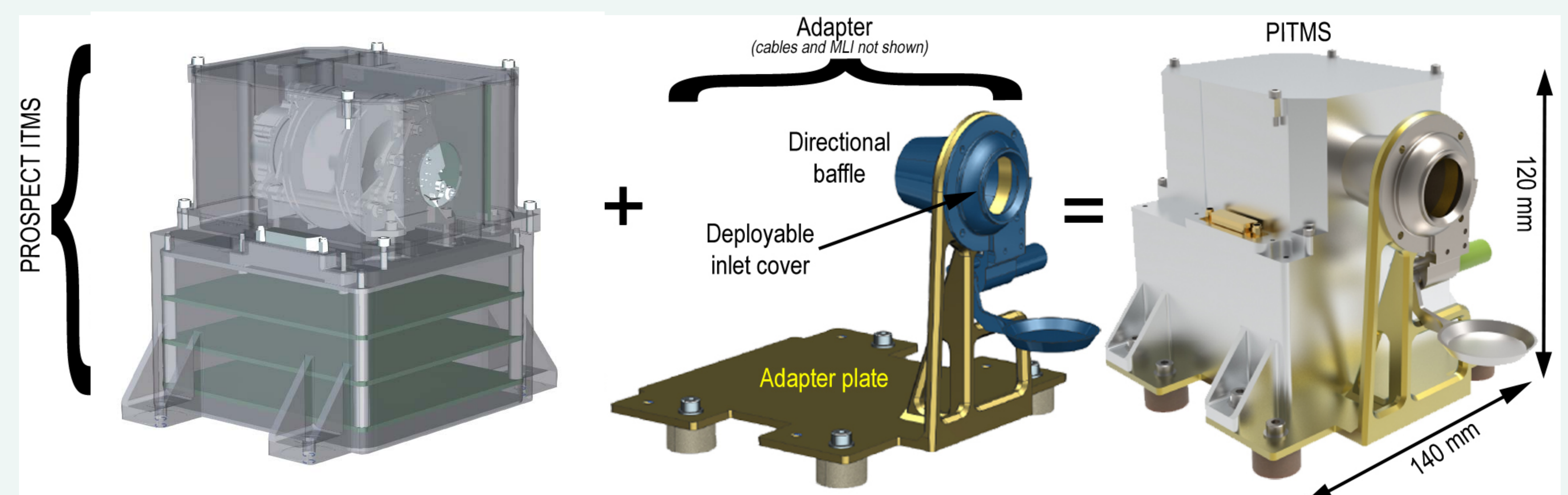
Early stage ISRU testing for ProSPA
 Sargeant et al. (2018) European Lunar Symposium

PITMS*: an ITMS for lunar volatiles studies with CLPS

Characterizes the lunar exosphere after descent and landing, and throughout the lunar day, to understand the nature, release and movement of volatile species of interest to both science and human exploration.
 *working title: watch this space



PITMS (right) comprises the Ion Trap Mass Spectrometer from PROSPECT equipped with modified electronics boards appropriate for a commercial lander (left), together with a NASA GSFC-provided Adapter.



Acknowledgement: ProSPA is being developed by a consortium led by The Open University, UK, under contract to the PROSPECT prime contractor Leonardo S.p.A., Italy, within a program of and funded by the European Space Agency. PITMS is being developed by NASA Goddard Spec Flight Center in collaboration with OU and RAL Space with ESA funding.

