The CAPSULA Project 2.0

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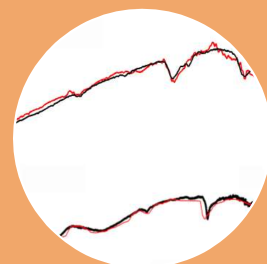
Workshop Raggruppamento Scientifico Nazionale 3 – Napoli OAC – 18/10/2022

Intro and Scientific Rationale (i)

* Lander/orbiter space missions observations of Solar System planetary surfaces

* Rocky / icy bodies / asteroids / satellites



* Spectral data interpretation support

* Spectral modeling

* Retrieving of optical constants / physical parameters (T, g.s., …)

Need for:

* dedicated laboratory measurements

* Reproduce as much as possible surface planetary conditions

Intro and Scientific Rationale (ii)

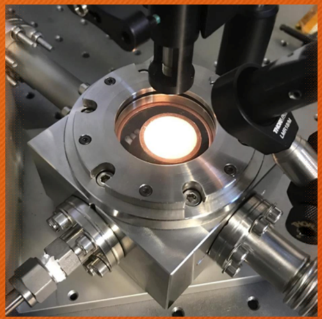
- VIS-to-MIR spectral studies of planetary analogues / meteorites
- Investigate spectral evolution at cryogenic temperatures (icy satellites + outer solar System)
- Investigate spectral evolution at high temperatures (thermal processing on inner planets / asteroids)
- Thermal+vacuum evolution of volatiles species (H_2O, NH_4^+, C-O-H,…) in salts, phyllosilicates, hydrated minerals, meteorites

Intro and Scientific Rationale (iii)

- De-hydration / de-hydroxylation of minerals
- Control of volatilized species by mass spectrometry
- e- irradiation experiments (@low / RT / high temps) on analogues (NEA+MB asteroids, icy bodies) /meteorites
- Study of thermal vs e- induced desorption

The Experimental Setup (i)

Chamber for Analogues of Planetary SUrfaces LAboratory



Ø int = 30 mm
→ **1 sample (HEAT)**

- **Miniaturized custom Cell**
  S. De Angelis et al., Rev.Sc.Instr. 2018
- **Large UHV Chamber**
  CAPSULA project
  IAPS (PI) + INGV + Uni.Fi + Uni.Bari
  ASI-INAF grant n.2018-16-HH.0 (AO 2018) [200k€]
- **Updating Chamber**
  CAPSULA 2.0
  IAPS (PI)
  INAF-AO 2022 funding
  [100k€]

Ø int = 500 mm
→ **10 samples (HEAT)**
+ 10 samples (COOL)

The Experimental Setup (ii)

FTIR Spectrometer	Invenio-X Bruker
	MCT + DLaTGS detectors [<1 – 20 μm]
	KBr beamsplitter
	Optical Fiber Module (SMA905)
Fiber Coupling	2x InF_3 fiber bundles (0.3 – 6 μm)
	Each with 19x fibers (200/260-μm core/cladding)
UHV Chamber	Ø 50 cm + H 60 cm
	Optical feedthrough for fiber bundles (without loss)

Currently active Setup

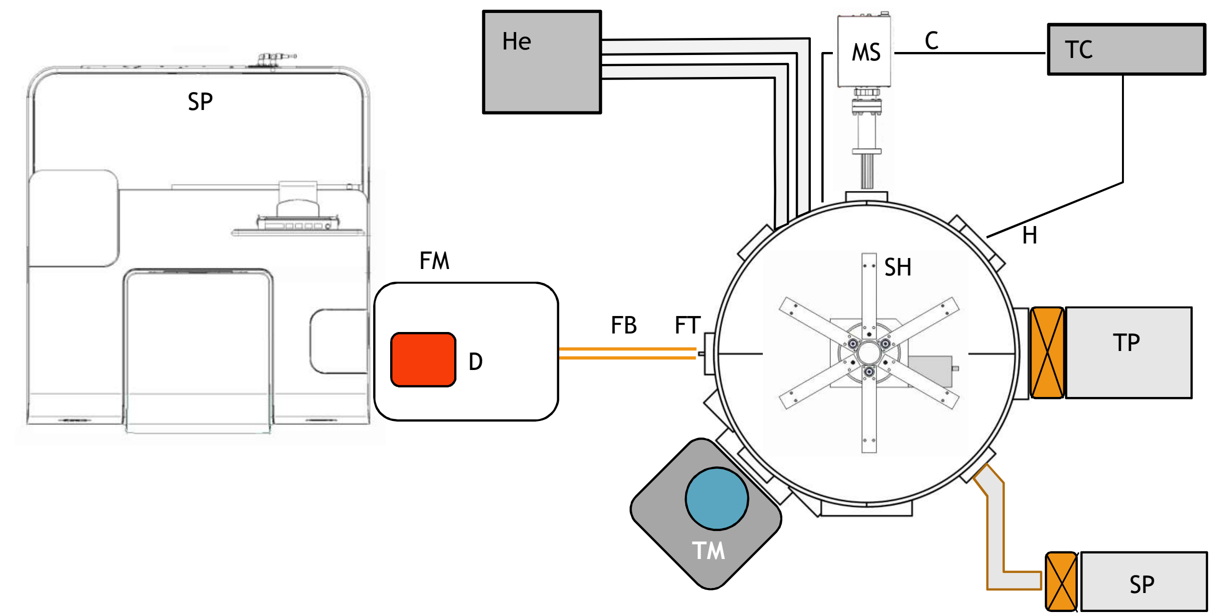
The Experimental Setup (ii)

Setup under construction

Heating System	5x Si_3N_4 heaters
	Each 20x70 mm to heat up to 10 samples
	T_{max} ~ 1073K in vacuum
Cooling System	Liquid 4He closed-loop compressor
	2-stages cold head to cool samples down to cryo T
	T control via Lakeshore module
Mass Spectrometer	PrismaPro QMG 250 M2
	Mass range 1-200 amu

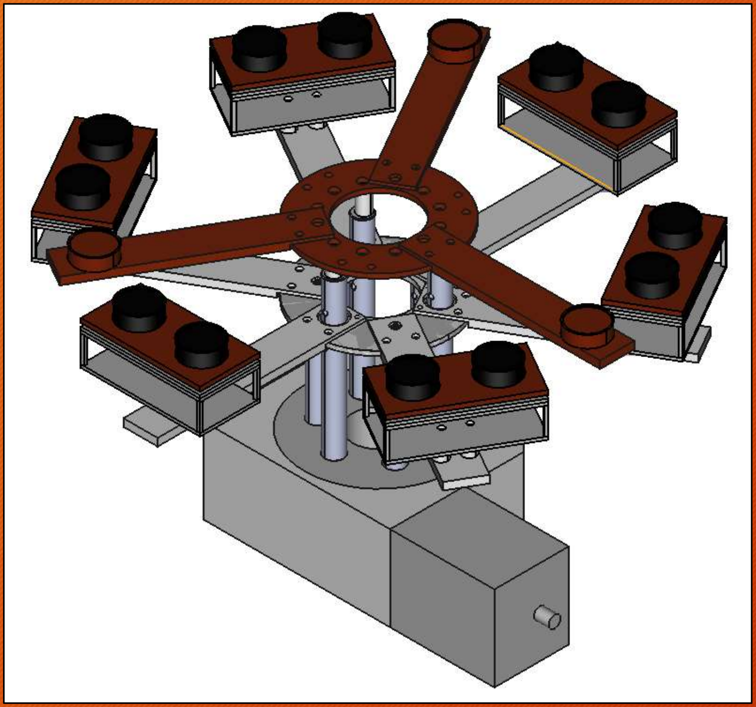
The Experimental Setup (iii)

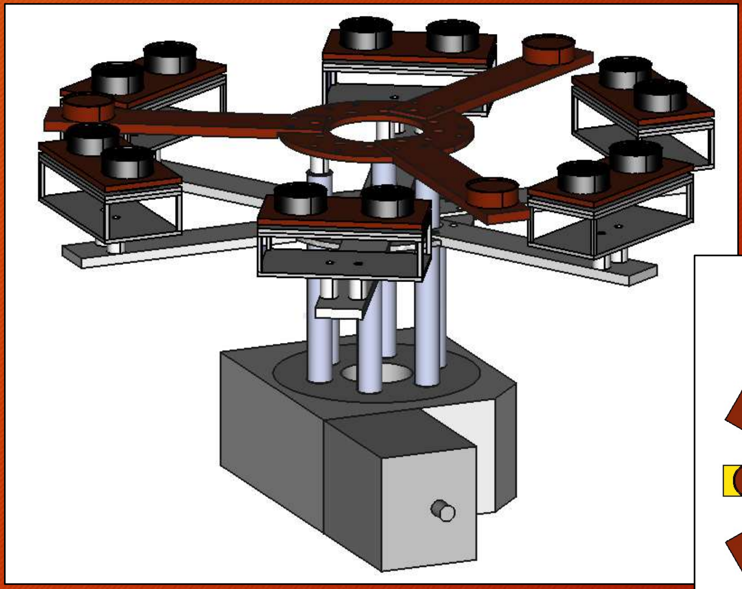
- SP: FTIR spectr.
- FM: Optical Fiber Module
- D: MCT Detector
- FB: Fiber Bundles I/C
- FT: Optical Feedthrough
- TM: Transmission Module
- SH: Rotating Sampleholder
- He: Liquid 4He compressor
- TC: Temperature Control
- C: Cold line
- H: Heating line
- MS: Mass Spectrometer
- TP: Turbo-molecular pump
- SP: Scroll pump

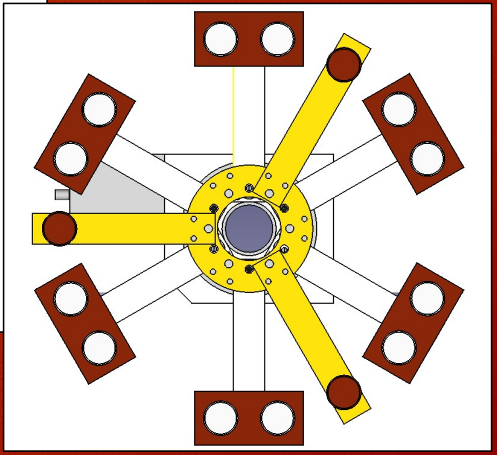


Under development…

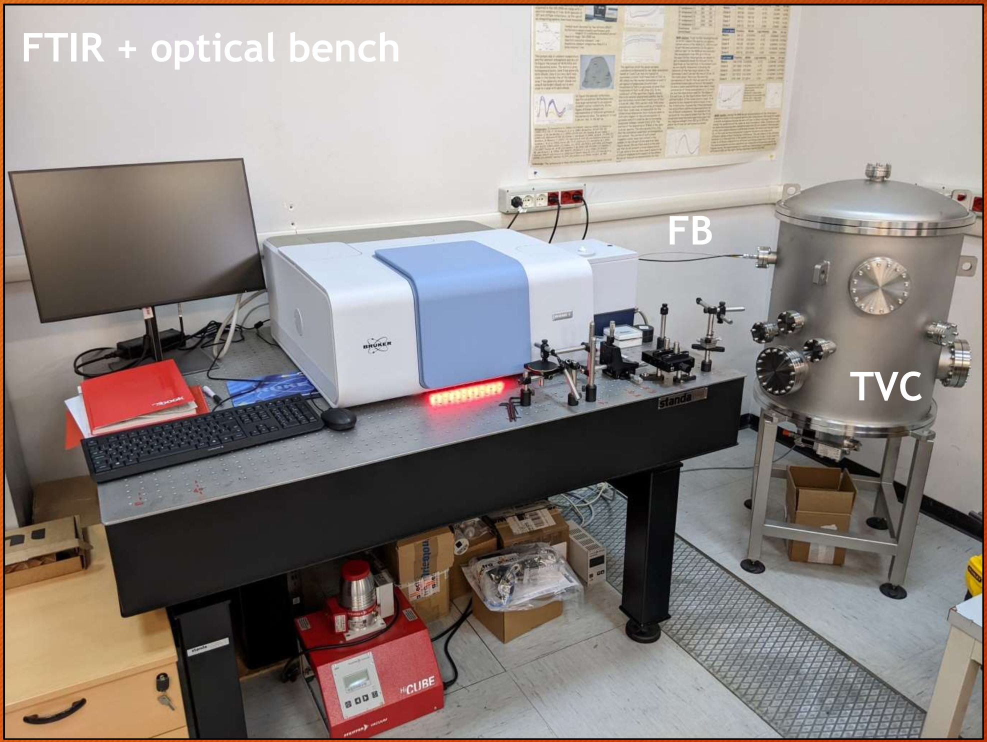
The Experimental Setup (iv)

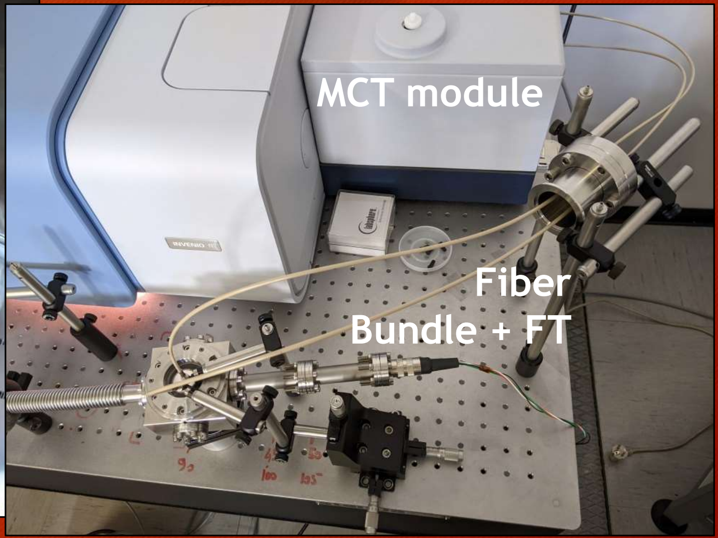






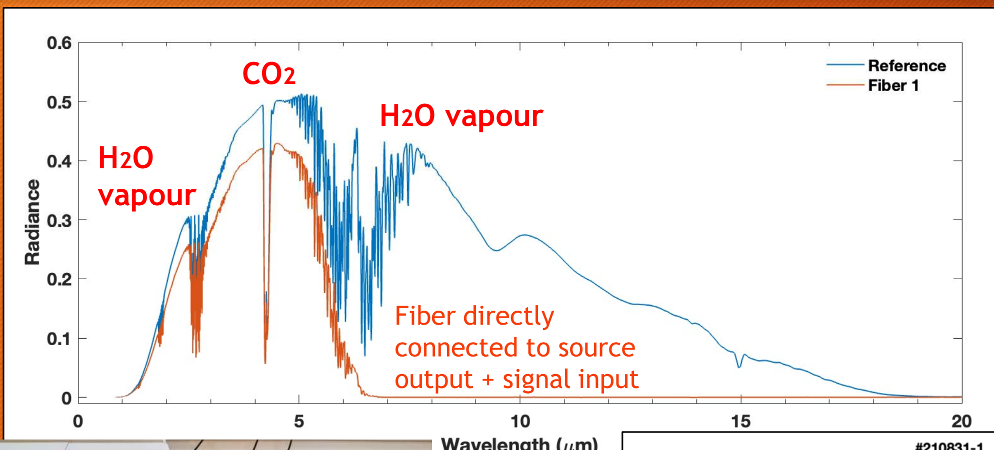
The Experimental Setup (v)

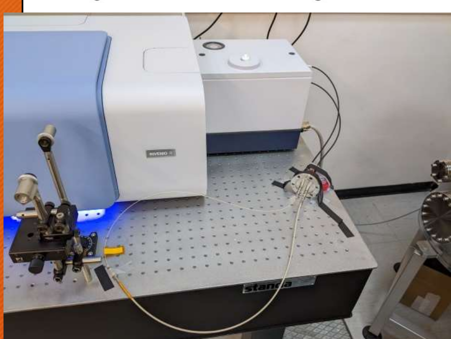


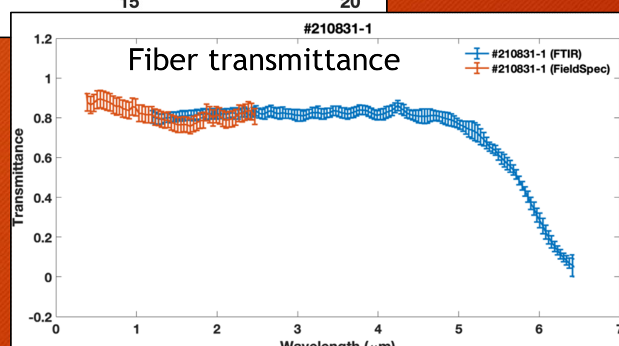


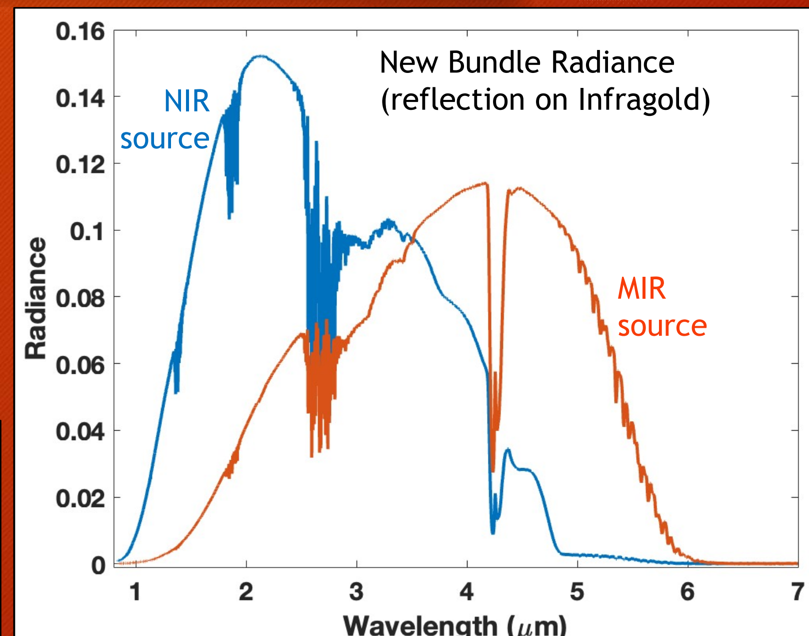
Preliminary Measurements (i)

* fibers characterization *









Preliminary Measurements (ii)

** vacuum evolution of NH_4-montmorillonite **

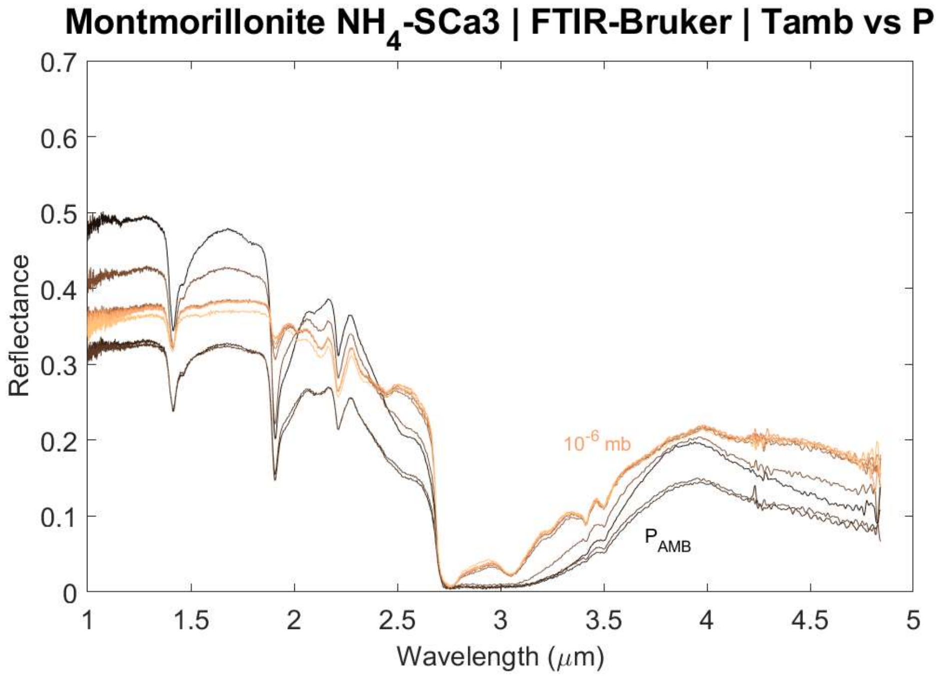


Fig.2. Reflectance spectra of NH4-SCa3 acquired in the range 1-5 μm. Spectra have been acquired at room temperature and different values of pressure, from 10exp3 down to 10exp-6 mbar.

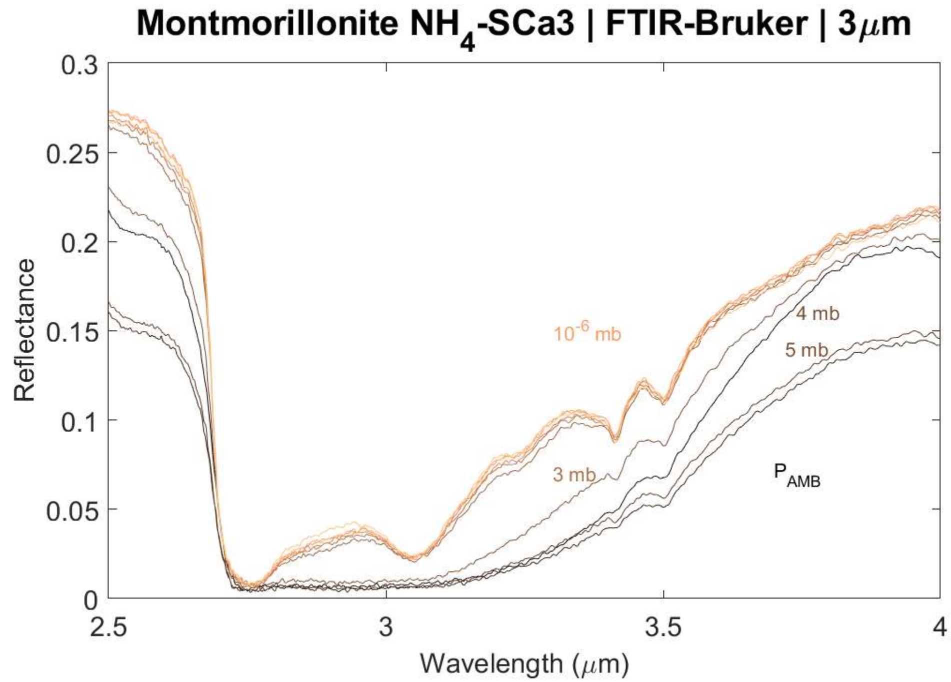
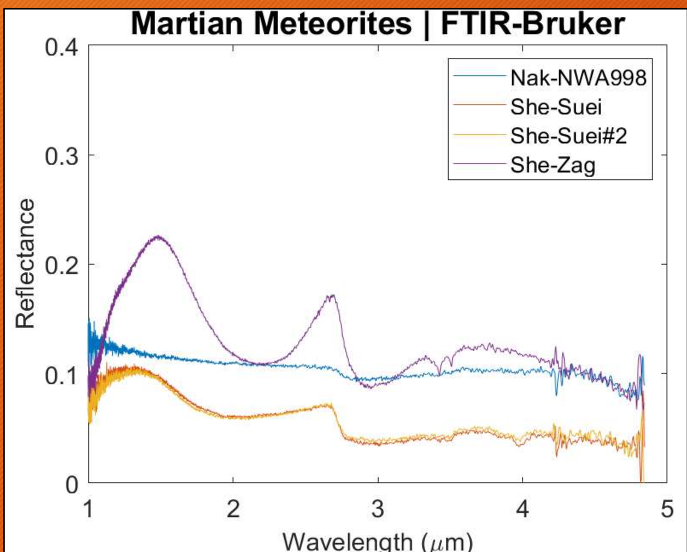
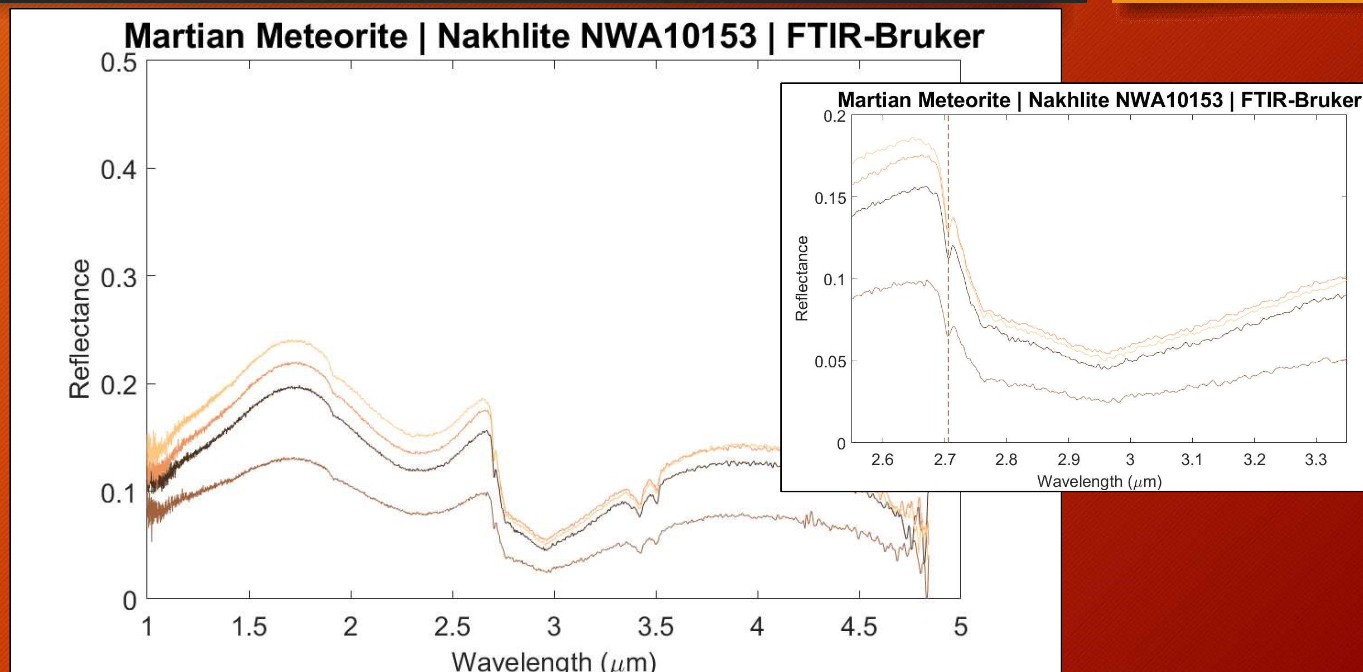


Fig.3. Zoom on the 3-μm spectral region. The ab-sorption features due to NH4+ become clearly visible (3.1 and 3.25 μm) as dehydration proceeds.

Preliminary Measurements (iii)

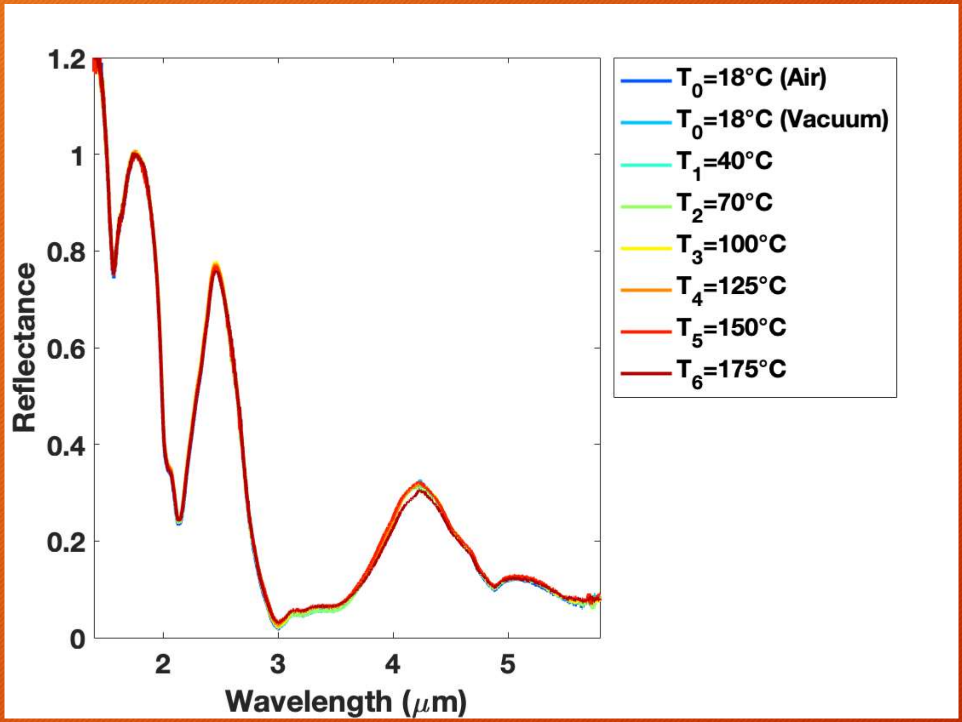
*** Martian meteorites ***

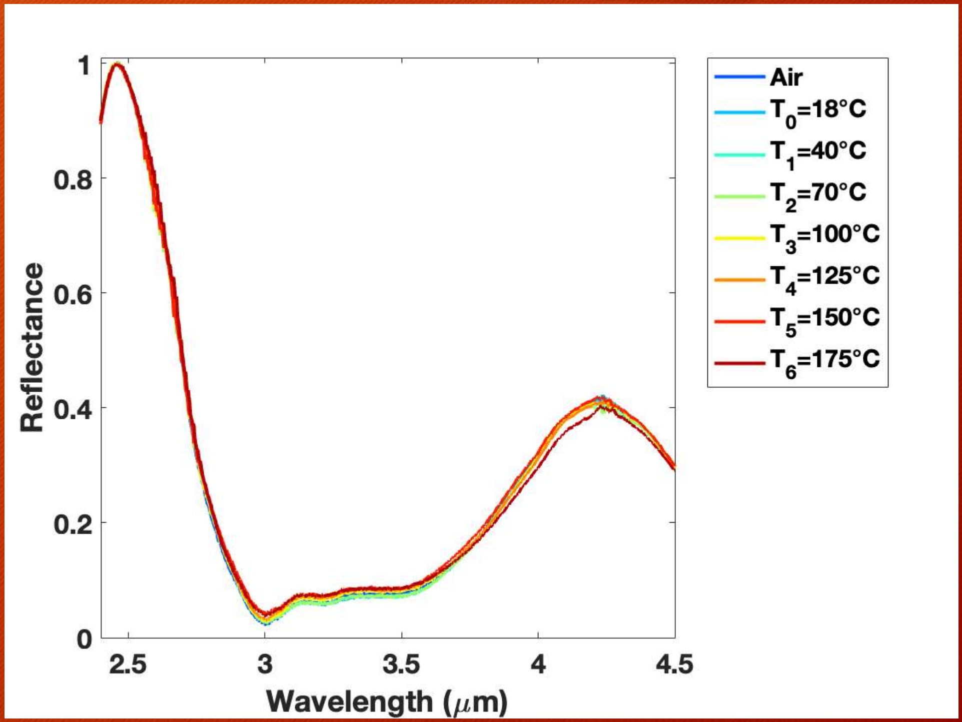




Preliminary Measurements (iv)

**** vacuum evolution of NH_4-sulfate ****





Updates & Future Work

HW

- Cooling system
  - implement cooling line
  - test T_{MIN}, T ramps and error
- Heating system
  - Heaters connections
  - Testing T_{MAX}, ramps and error
- e- irradiation system
  - Identify and procure e- gun
  - implementation
- Ext Spectral range
  - Extension towards VIS and midIR
  - Fibers → Au Mirrors

Sci

- Continue exp…
  - IR vacuum+high T study of NH_4-salts
- Start new exp…
  - Meteorites in vacuum vs T
  - Mineral mixtures for Mars, Ceres, …
- Define new exp…