SMiLE
Space Missions through Laboratory Experiments

Riccardo Giovanni Urso

Experimental studies of the effects of energetic processing on astrophysical relevant materials

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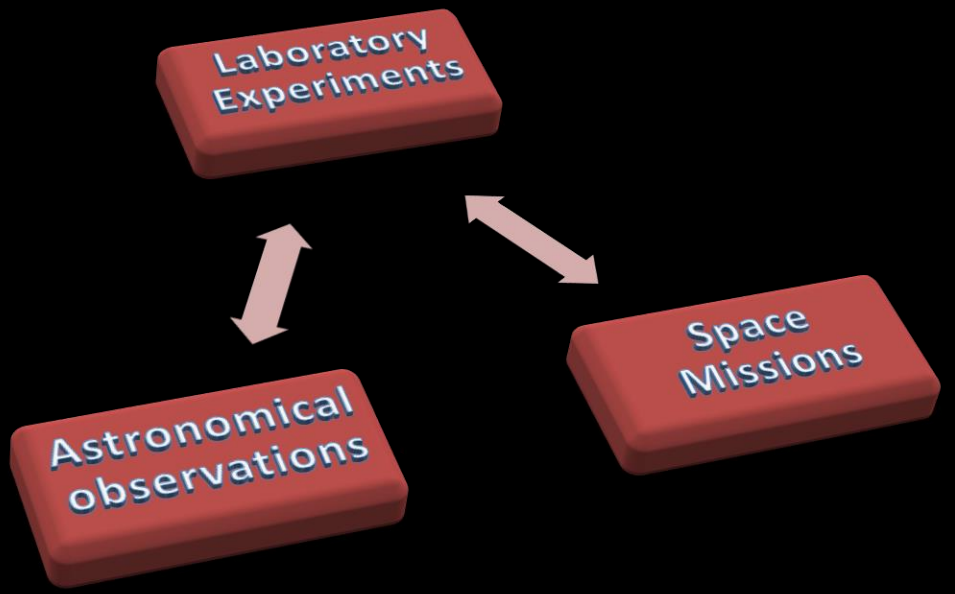
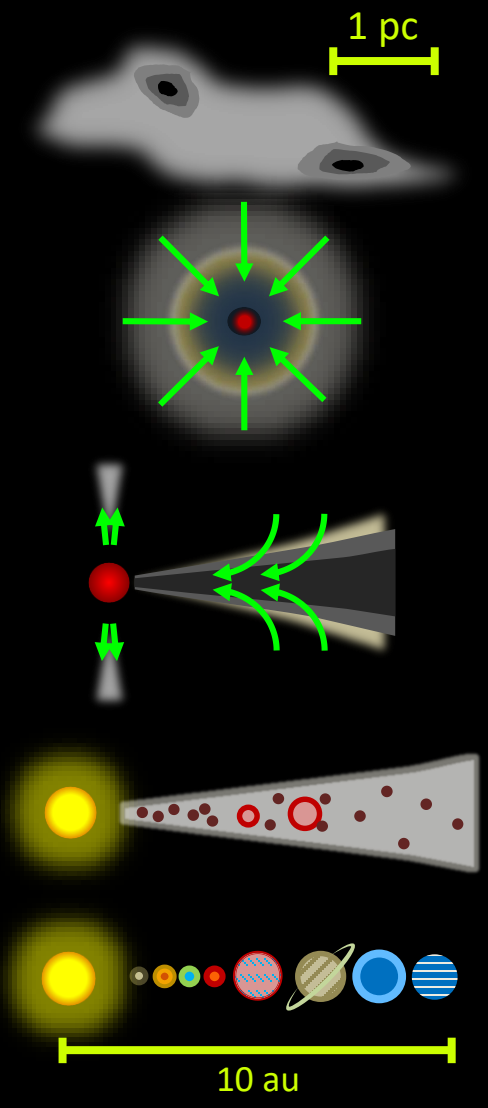
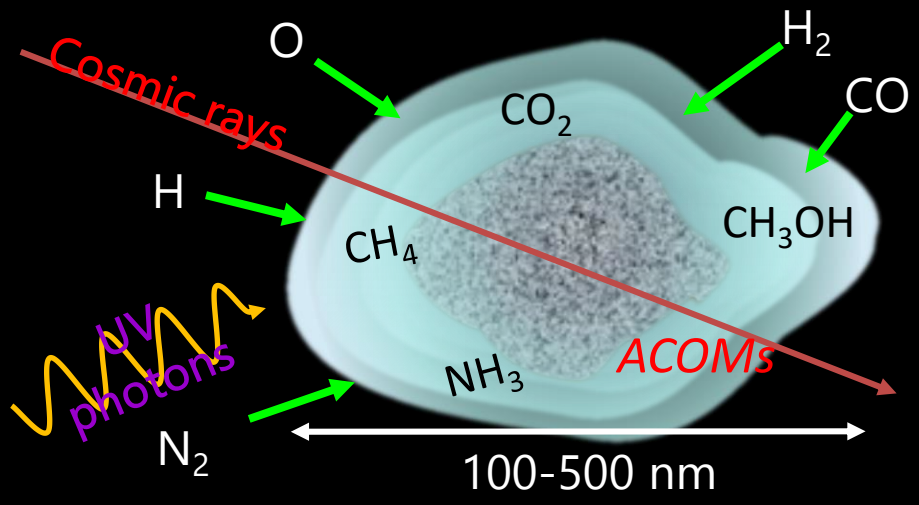
- Structural and phase changes
- Synthesis of new molecular species
- Contribution in increasing the chemical complexity



From diffuse clouds to planets





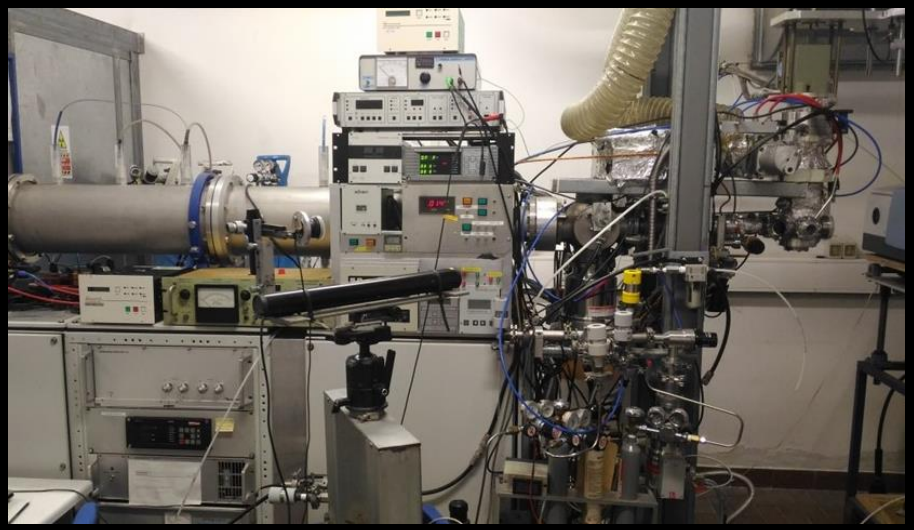
Laboratorio di Astrofisica Sperimentale LASp – OACt

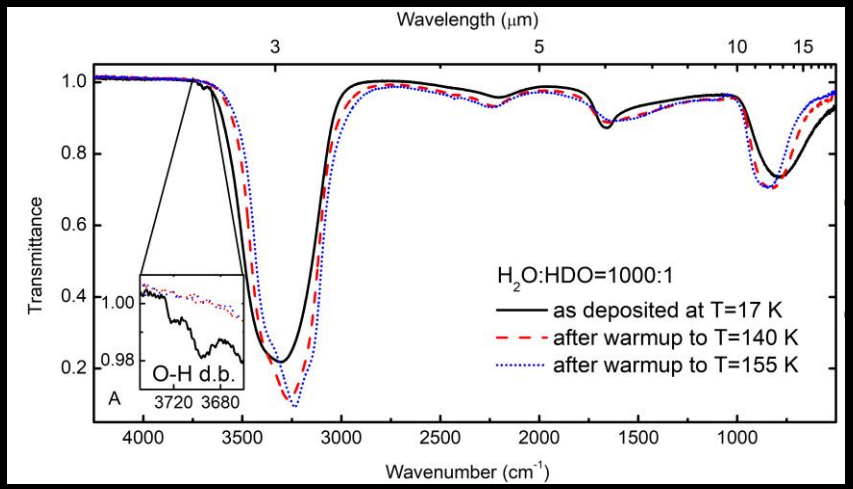
UHV (P=10^{-9} mbar)

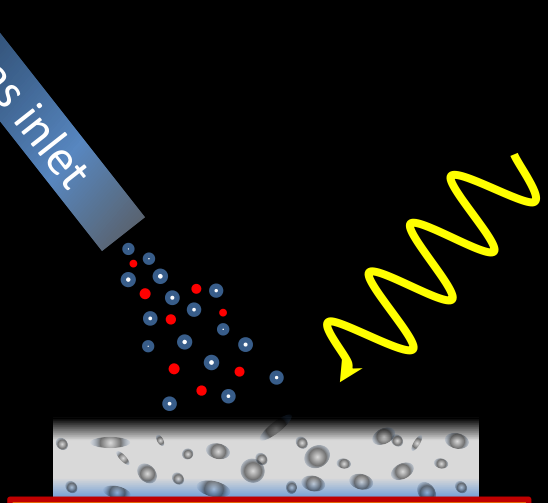
$15 \leq T \leq 300$ K

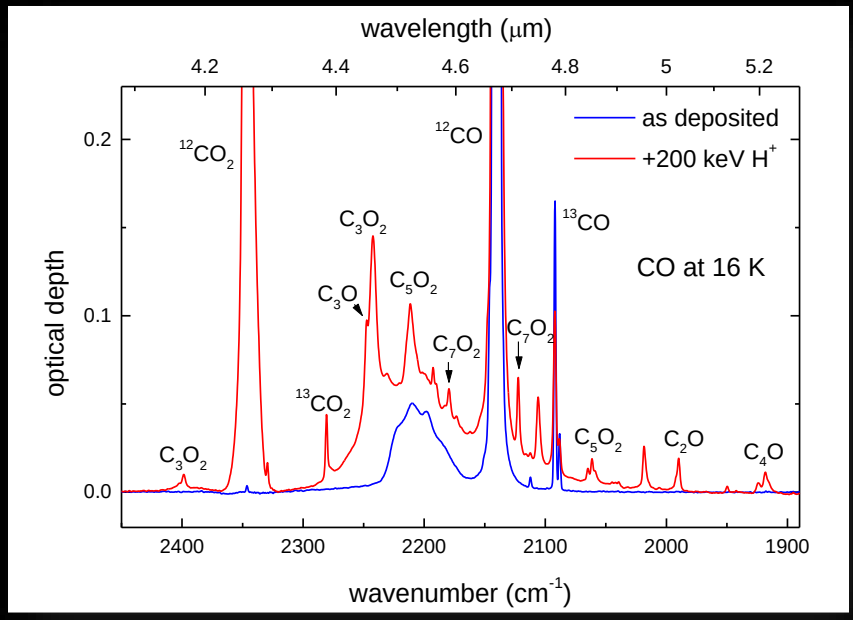
Energetic processing of frozen volatile species

200 keV ions (H^+, He^+)







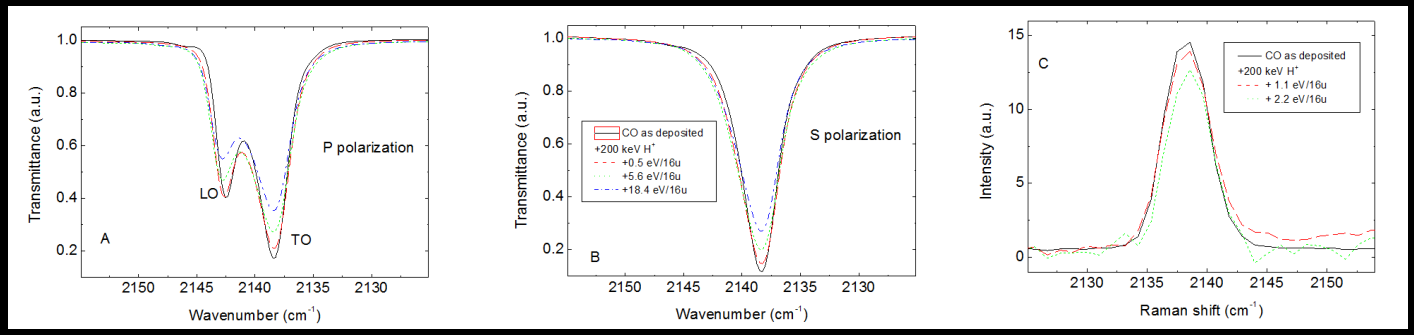


e.g., Palumbo et al. 2008 and Sicilia et al. 2012, Urso et al. in prep.

Structural and phase changes

Ion irradiation of pure CO

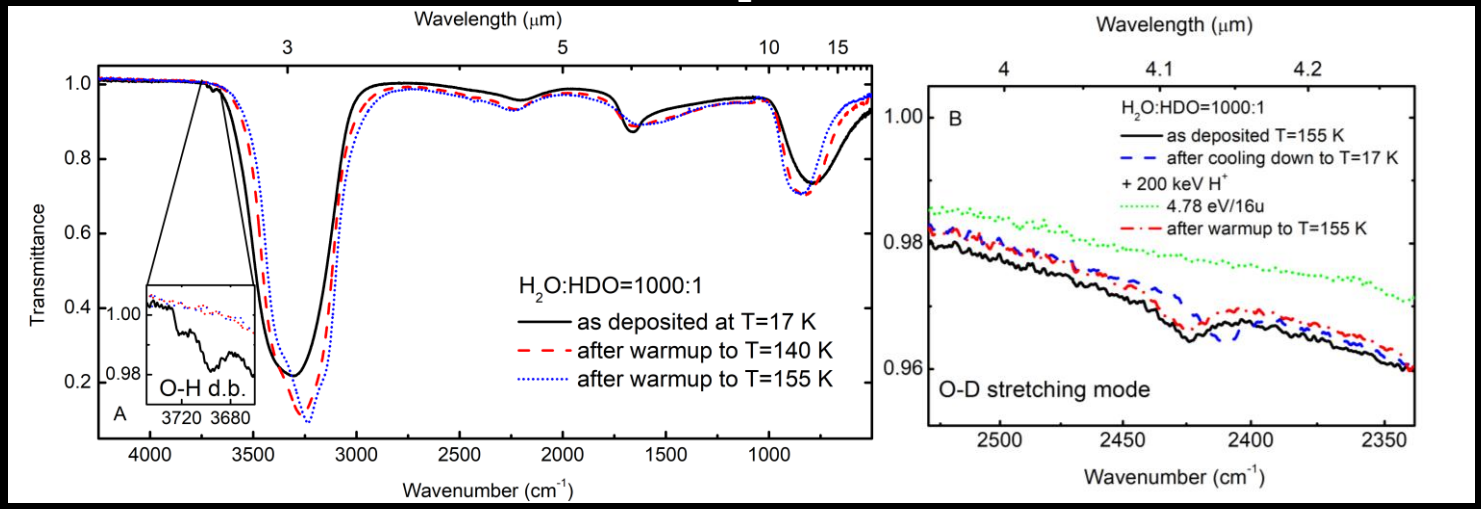
Carbon monoxide



Urso et al. 2017, Combined infrared and Raman Spectroscopy on solid CO, A&A, 594, A80

Ion irradiation of frozen mixture containing H_2O:HDO=1000:1

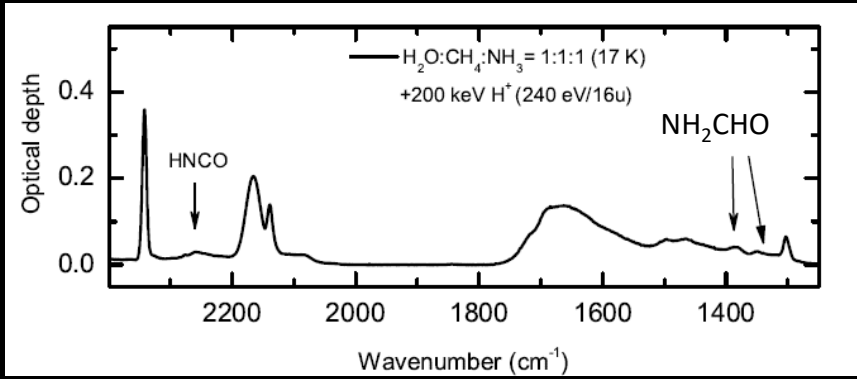
Deuterated water

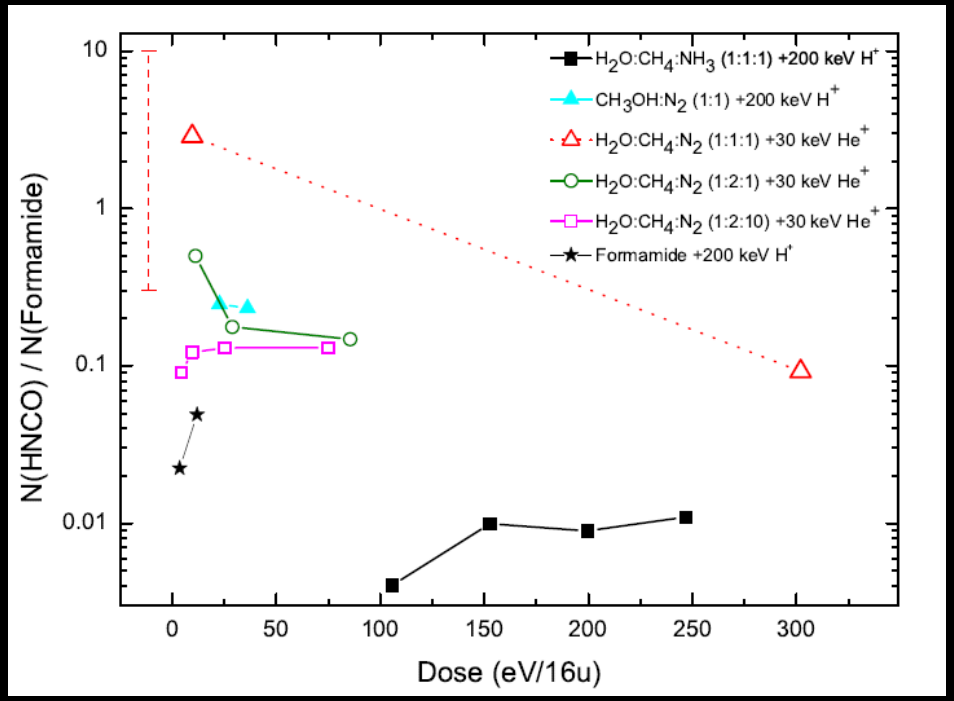


Urso et al. 2018, *Solid deuterated water in space: detection constraints from laboratory experiments*, MNRAS, 479, 130

Contribution in increasing the chemical complexity
Prebiotic species

Synthesis of formamide and isocyanic acid after ion irradiation of frozen gas mixtures

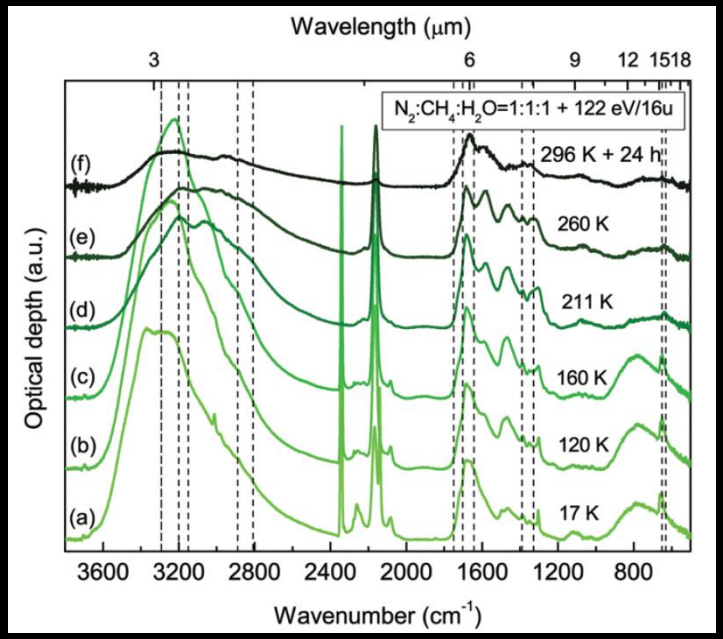




Molecular number ratio HNCO/NH_2CHO obtained after ion bombardment of different frozen ice mixtures vs irradiation dose (eV/16u).

Kaňuchová, Z., **Urso, R.G.** et al. 2016, A&A, 585, A155

Contribution in increasing the chemical complexity
Prebiotic species



N_2:CH_4:H_2O = 1:1:1 + 200 keV H^+

Formamide is trapped within the *organic refractory residue*.

Organic refractory residue

Alchols, caboxylic acids, amines, nitriles, esters, amides, …
(e.g., Palumbo et al. 2004, Baratta et al. 2015, d'Hendecourt et al. 2014, de Marcellus et al. 2017, Urso et al. 2017)

Trapping in organic refractory residue - formamide on the surface of comet 67P/C-G

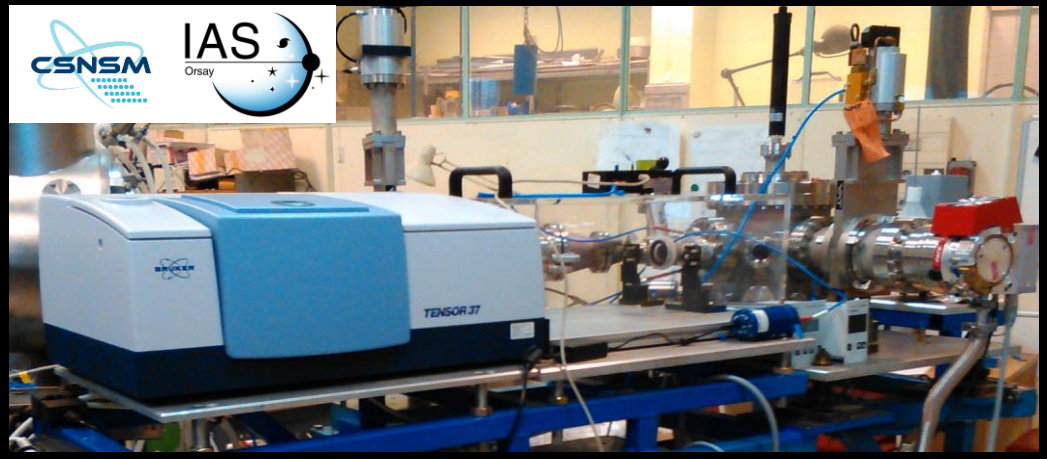
Urso, R. G., et al. **2017**, **PCCP**, 19, 21759

Main results:

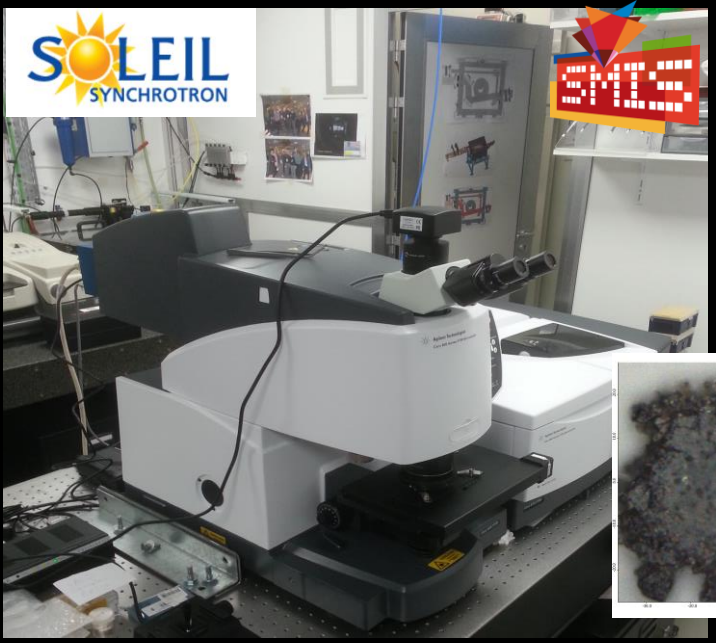
- Interpret astronomical abundances (C_2O, C_3O, formamide)
- Obtain constraints for future observations (CO, HDO)
- Evidences of the role of energetic processing in modifying the physical-chemical structure of ices
- Strengthen the hypothesis of the existence of a link between the composition of star-forming regions matter and comets

What's next

INGMAR at IAS-CSNSM

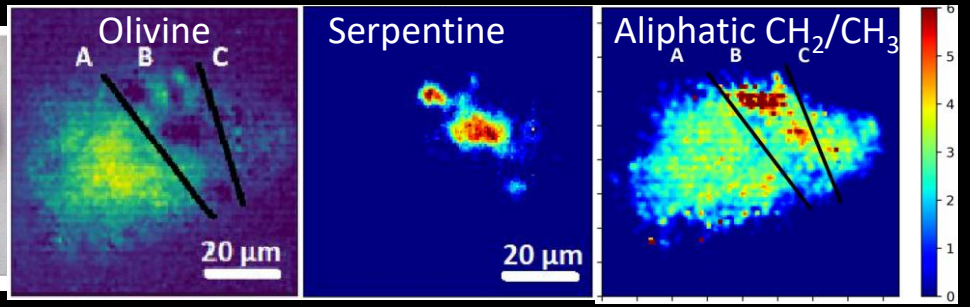


e.g., Brunetto et al. 2014; Lantz et al. 2017



SOLEIL synchrotron-SMIS line facility

Microscopic characterization



Dionnet et al. 2018