Raman Laser Spectrometer, a very demanding instrument for planetary exploration

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The Raman Laser Spectrometer (RLS) is one of the Pasteur Payload instruments within the ESA/Roscosmos “ExoMars” 2020 mission. The RLS Instrument is part of the Analytical Laboratory Drawer (ALD), a suite of instruments (together with MicrOmega and MOMA) dedicated to exobiology and geochemistry research, which are accommodated inside of the rover and with the scientific objective of “Searching for evidence of past and present life on Mars". The RLS is a very demanding instrument [1] for searching exobiology in the next planetary missions because its scientific goal consists of perform in-situ Raman spectroscopy over different organic and mineral powder samples of the Mars subsoil after crushing the cores obtained by the rover’s drill system. RLS [2] pretends to characterize the mineral phases produced by water-related processes and to characterize water/geochemical environment as a function of depth in the shallow subsurface. Also RLS will attempt to identify the mineral products, indicators of biologic activities; to detect organic compounds and search for signs of life. The RLS instrument consists of three main units:

1) The internal Optical Head (iOH) focuses the excitation laser on the samples (via excitation path), and collects the Raman emission from the sample through the collection path, composed by collimation and filtering systems;

2) The Spectrometer Unit (SPU) collimates the emitted Raman-light entering this unit through the reception fiber of iOH and focuses that light onto a CCD; and

3) the Instrument Control and Excitation Unit (ICEU), which contains the 532nm laser source, the power converter and also the data processing unit.

iOH, SPU and ICEU are connected with optical (OH) and electrical harnesses (EH). Other instrument units are the Calibration Target (CT) and RLS Application SW onboard.

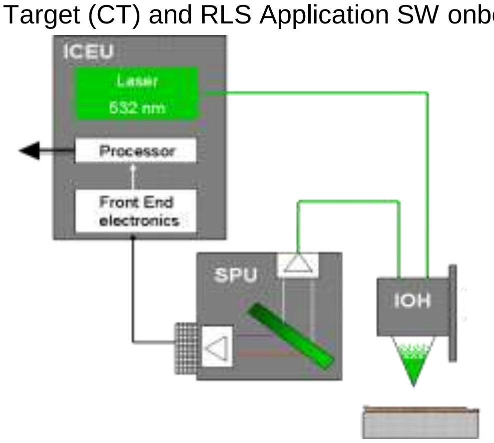

Figure 1. RLS functional Flow.

One of the most critical Units of the RLS instrument is the SPU that performs spectroscopy technique and operates in a very demanding Martian environment (radiation, temperature, dust, etc.) with very restrictive design constraints of schedule, Size, Weight and Power (SWaP). It is a small optical instrument capable to cope with 0.12–0.15nm/pixel of spectral resolution and withstand with the Martian environment (operative temperature conditions: from -40ºC to 6.3ºC). The design selected is based on a single transmissive holographic diffraction grating especially designed to actuate as the dispersion element.

The main goal of the design of the SPU is not only to reach the scientific requirements as spectral resolution and SNR; but also to reach them in a reduced lightweight and maintaining performances in the operative thermal range with low power consumption.

RLS is a very demanding and challenge Instrument which has been successfully qualified for ExoMars2020 under tight environmental conditions (ambient, cruise phase and operation in Mars). After the EQM campaign at Unit level and at Instrument level results have been used as feedback for enhancement of RLS Flight Model (FM) with minor changes of the design. So the FM has been re-designed, manufactured, tested and delivered to ESA to achieving a final TRL 9.

Although these plans have been developed for a mission to Mars, the protocol and procedure applied are valid for any future planetary exploration mission.

It should be also remarked that this instrument has demonstrated to be as flexible as needed due to several changes in the mission along the last years.

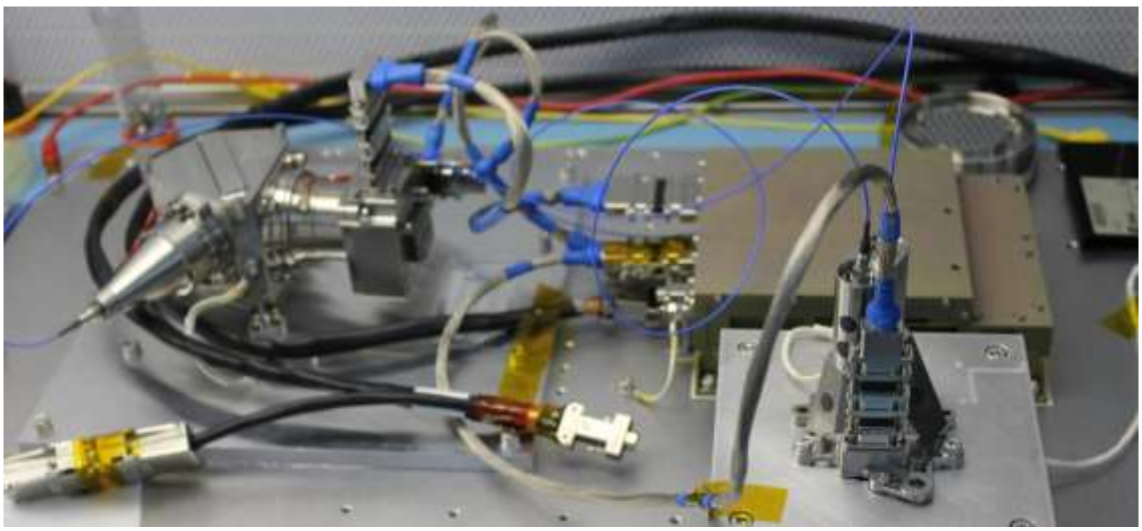

Figure 2. RLS full Instrument.

[1] T. Belenguer, et al. "A very demanding spectrometer optical design for ExoMars Mission", Proc. SPIE 10565, International Conference on Space Optics — ICSO 2010, 105651E (20 November 2017); doi: 10.1117/12.2309128; https://doi.org/10.1117/12.2309128

[2] F. Rull, et al, "The Raman Laser Spectrometer for the ExoMars Rover Mission to Mars," ASTROBIOLOGYVolume 17, Numbers 6 and 7, (2017) https://doi.org/10.1089/ast.2016.1567