Miniaturized LIDAR for MARS Atmospheric Research: Front-End Electronic for Miniaturized LIDAR Signal Conditioning

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1. PROJECT SUMMARY

1.1 - PROMOTER

This project falls within the **European Union** funding program **Horizon Europe.**

HORIZON-CL4-2022-SPACE-01

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Funded by the European Union

1.2 - SCIENTIFIC OBJETIVES

1 - To build a tiny, power-efficient LIDAR to explore the Martian atmosphere

2 - Increasing the Technology Readiness Levels (TRL)

- Semiconductors and miniaturized high energy lasers
- Si-PMTs as detectors
- Low coefficient of thermal expansion (CTE) structures
- Complex "Free form" alike solutions in the optical design

1.3 - FUTURE STEPS

Terra Novae 2030+

- ESA identifies the climate monitoring through networks as a key element in the roadmap for exploration of Mars. A deeper knowledge of the **Martian atmosphere** and the **airborne dust** is considered a prerequisite for future human missons.
- **FAHRENHEIT** mission for "*High-resolution Regional Environmental Monitoring Network for Human Exploration*".

TERRAE NOVAE 2030+ Continuing the European heritage esa

2. DESIGN

2.1 – INSTRUMENT BASICS

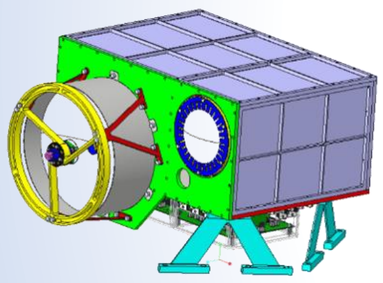
Through the present design several aspects on the airbone dust particles and water ice clouds can be determined. For instance, the **type of aerosol** (dust or cloud), the **aerosol shape and particle size,** together with the **dust opacity**, **cloud ice content** and **dust-cloud interaction issues**.

LIDAR Configuration proposed is **2β + 1δ** in order to obtain the Particle Backscatter Coefficient (PCB) at two wavelengths **(2β)** , and the depolarization ratio at one of them **(1δ)** . Two wavelengths are: **VIS - 515 nm** and **NIR – 905 nm**

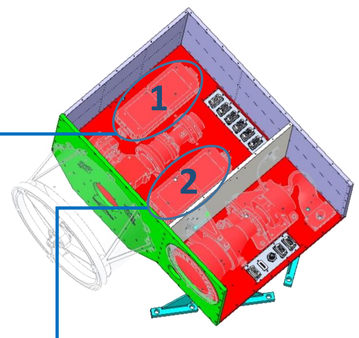
All the information will be obtained with **vertical resolution** altough it can be used for horizontal pointing and perpendicular to the predominat wind direction.

2.3 FRONT END ELECTRONIC PLACEMENT

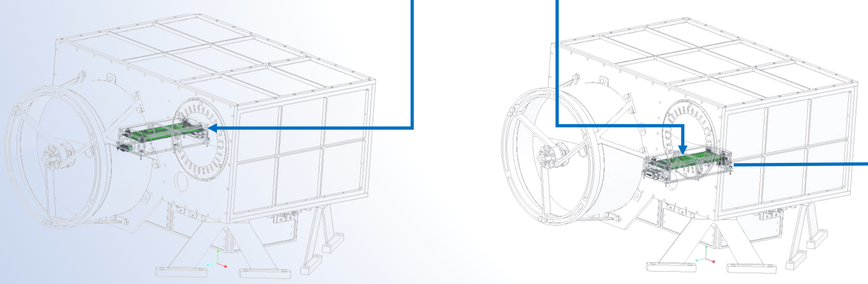
The instrument has two identical Front End Electronic for the acquisitision and conditioning of each of the lasers used.



General Assembly



Internal view



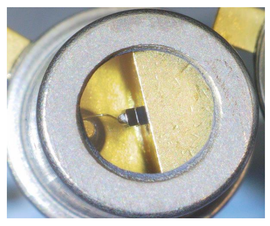
Front End Electronic integrated. Assembly view

2.2 - MINIATURIZED LIDAR vs PREDECESSOR

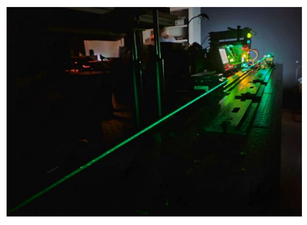
Only one LIDAR, on board the Phoenix mission has been used for Mars exploration, which was landed in the North Pole of Mars in 2008. It used a two wavelengths configuration (532 and 1064 nm) and had a vertical resolution but **wihtout depolarization**.

Main differences are:

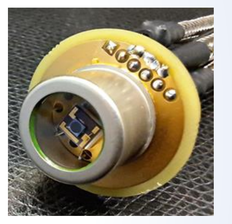
PHOENIX LIDAR	MiLi LIDAR
• Weight (Kg) – 6	• Weight (Kg) – 6
• Consume (W) – 30	• Consume (W) – 15
• Pulse Repetition (Hz) – 100	• Pulse Repetition (Hz) – 1000 / 10000
• Telescope Diameter Aperture (cm) – 10	• Telescope Diameter Aperture (cm) – 15
• Emiter Technology – Diode Pumped	• Emiter Tecnology – Semiconductor Laser (VIS) / Diode Pumped (NIR)
• Receiver technology – PMT / APD	• Receiver technology – Si-PMT
• Depolarization – No	• Depolarization - Yes



Laser Semiconductor



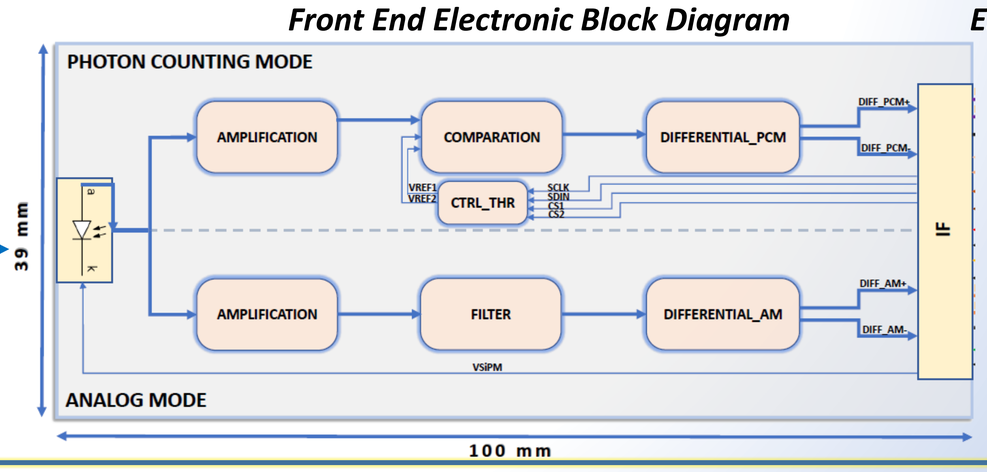
Diode Pump



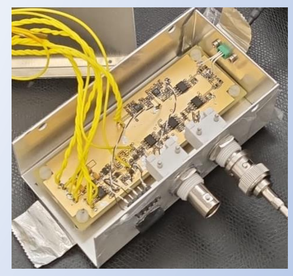
Si-PMT

2.4 - FRONT END ELECTRONIC STRUCTURE

Front End Electronic Block Diagram



Engineering model used for validation tests



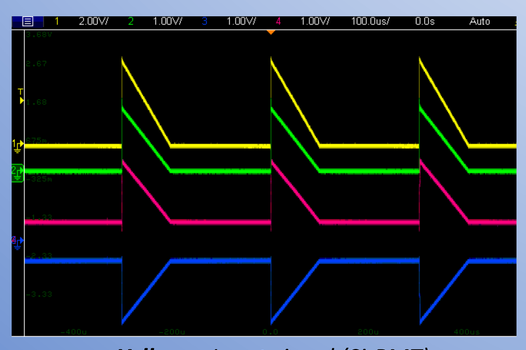
3. OPERATING MODES

Due to the miniaturization objective. It is proposed an unique conditioning Printed Board Circuit for analog and photon counting mode. Both are operating at the same time so that a parallel signal treatment is possible.

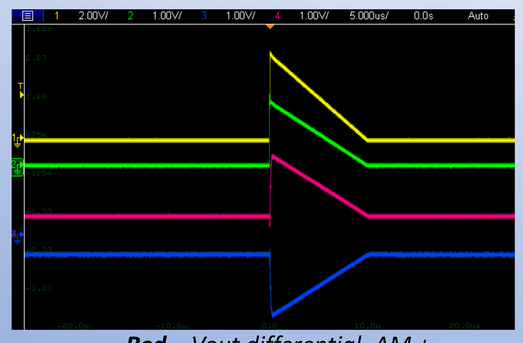
3.1 – ANALOG

This mode is used to condition the signal received at the detector (Si-PTM) produced by the backscattering effect.

Maintaining the integrity of the signal received is considered key so that the signal sent to the processing stage (ADC) is a faithful representation of the original.



Yellow *– Input signal (Si-PMT)*
Green *– Vout filter stage*

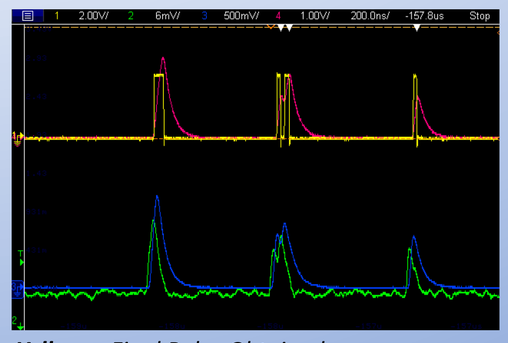


Red *– Vout differential_AM +*
Blue *– Vout differential_AM -*

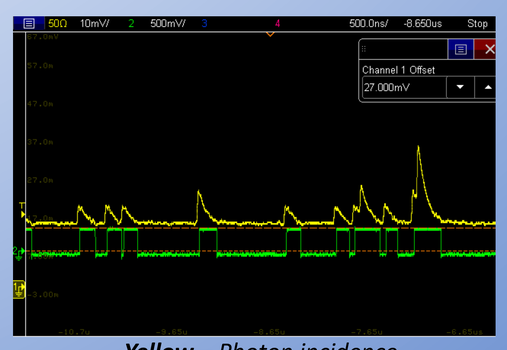
3.2 – PHOTON COUNTING

This mode allows to characterise the environmental conditions in which the measurement has been carried out.

It is used once the analogue signal received due to the backscattering effect has been completly extinguished, until the next laser pulse is emited.



Yellow *– Final Pulse Obtained*
Other Colors *– Photon incidence through different conditioning stages*



Yellow *– Photon incidence*
Green *– Final pulse obtained*

Representative pictures taken during validation tests, using the engineering model show the difference in the signals processed when operating in analog mode (dust and ice cloud detection) or in photon counting mode.

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