THE OPTICAL CHALLENGE OF DESIGNING A MINIATURIZED LIDAR FOR MARS ATMOSPHERIC RESEARCH (MILI)

Instituto Nacional de Técnica Aeroespacial

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On behalf of Space Optics Department

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Instituto Nacional de Técnica Aeroespacial

MiLi Instrument

WHAT

Miniaturized LIDAR for Mars Advanced Atmospheric Research

WHERE

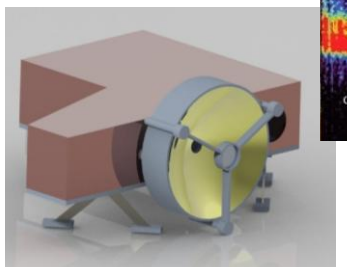
Granted by the European Commission under the Horizon Europe programme

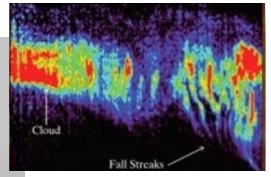
WHO

Asphericon, Integrated Optics, CINN, Politecnico Milano, Universidad York, INTA

TARGET

TRL4: lightweight and low power consumption aimed at providing the most precise characterization of the suspended dust and clouds of the Mars atmosphere through measuring the backscattered signal when they are illuminated by a train of laser pulses





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MiLI REQUIREMENTS

TRL4: lightweight and low power consumption aimed at providing the most precise characterization of the suspended dust and clouds of the Mars atmosphere

Scientific & technological Requirements

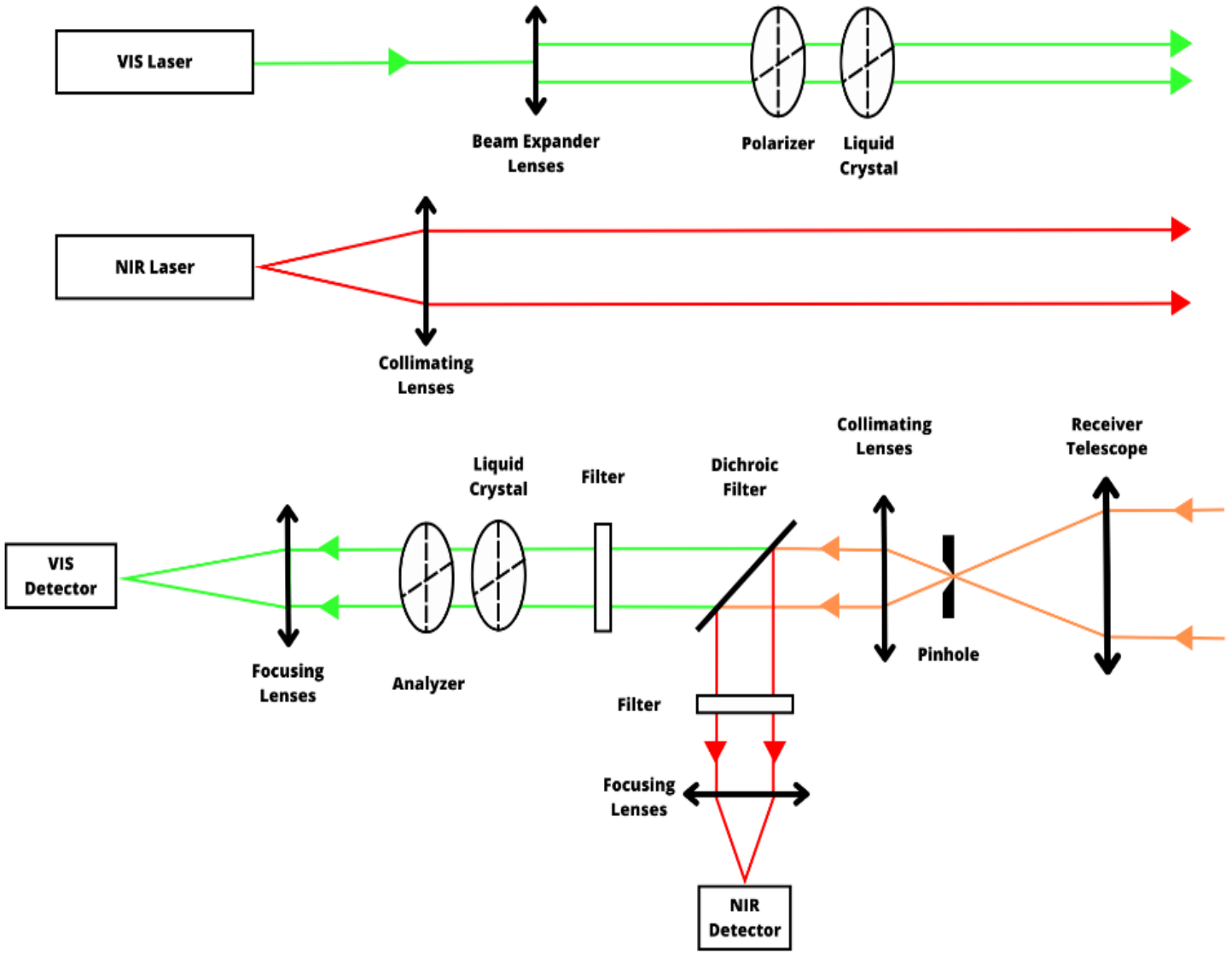
- **Compact instrument (6kg & 30W)**
- **Ability to measure the Particle Backscatter Coefficient (PBC) at two wavelengths (VIS & NIR)**
- **Ability to determine the depolarization ratio at one wavelength (VIS)**
- **To characterize two types of aerosols (dust and particles): maximizing the height range and minimizing the vertical resolution**
- **Working in both day and night operations**

Optical Design CHALLENGES

- **Design for two different wavelengths in a wide spectral range: VIS (515m) and NIR (905nm)**
- **Collimate extended source from diode laser (NIR)**
- **Incorporation of liquid crystal in the optical design to control de polarization (emission and reception)**
- **To detect low backscattered signal (10E-17 W/cm^2) versus the high background signal (10E-9 W/cm^2): control of the stray-light**
- **Volume and mass limited**

OPTICAL CONFIGURATION

OPTICAL CONFUIGURATION



VIS emitter unit of high power:

- ❑ Laser 515 nm
- ❑ Collimator/beam Expander
- ❑ Polarization modulators: Liquid Crystal Variable Retarder (LCVR)

NIR emitter unit of high power:

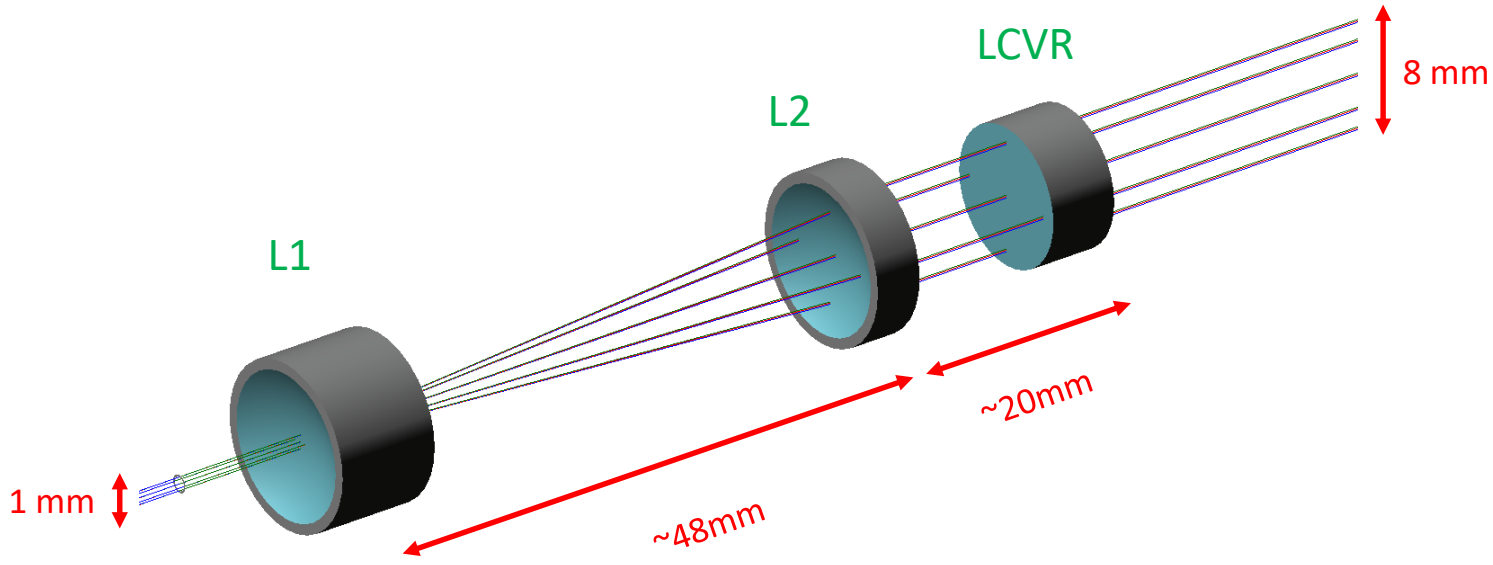
- ❑ Laser 905nm
- ❑ Collimator

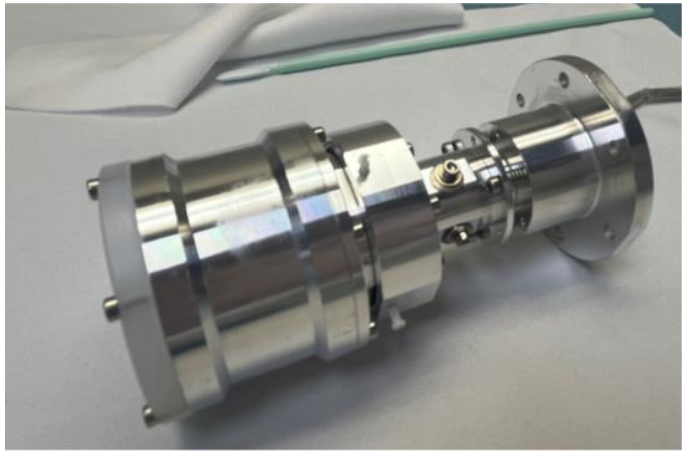
Receiver Unit:

- ❑ Telescope+ collimator+dichroic
- ❑ VIS Channel
  - Filter
  - LCVR
  - Focuser
  - Detector high gain and wide dynamic range
- ❑ NIR cannel
  - Filter
  - Focuser
  - Detector high gain and wide dynamic range

VIS EMITTER UNIT: COLLIMATOR/BEAM EXPANDER

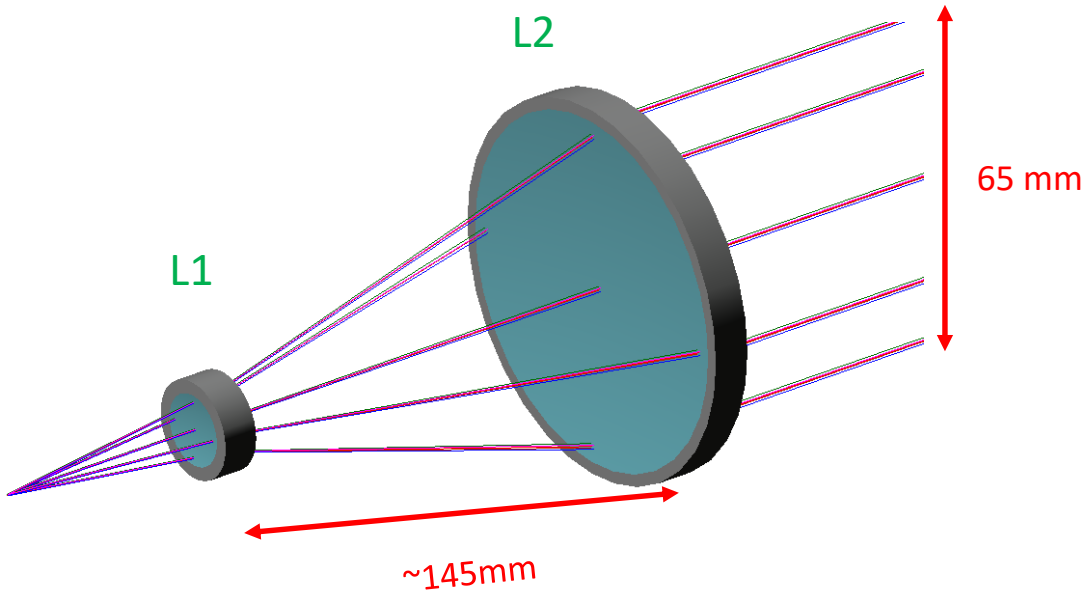
- **To provide the maximum collimation degree (<0,025°) to the laser light (515 nm) and to provide the polarize capability without exceeding the weight and volume restrictions**
  - **Lens barrel composed of two lenses: spherical (L1) and conic (L2)**
  - **Optical quality diffraction-limited (<λ/14; SR 0,99)**
  - **Achieved divergence ~0,01°**
  - **To expand the beam from 1mm of diameter to 8 mm adjusted to LCVR size**

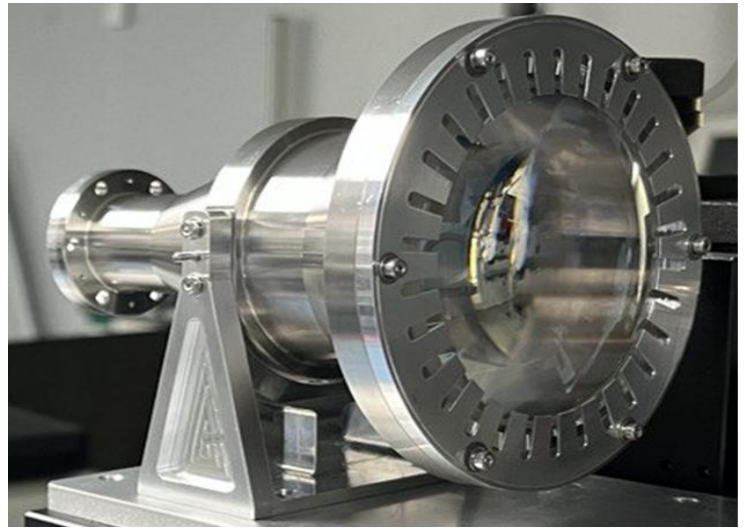




NIR EMITTER UNIT: COLLIMATOR

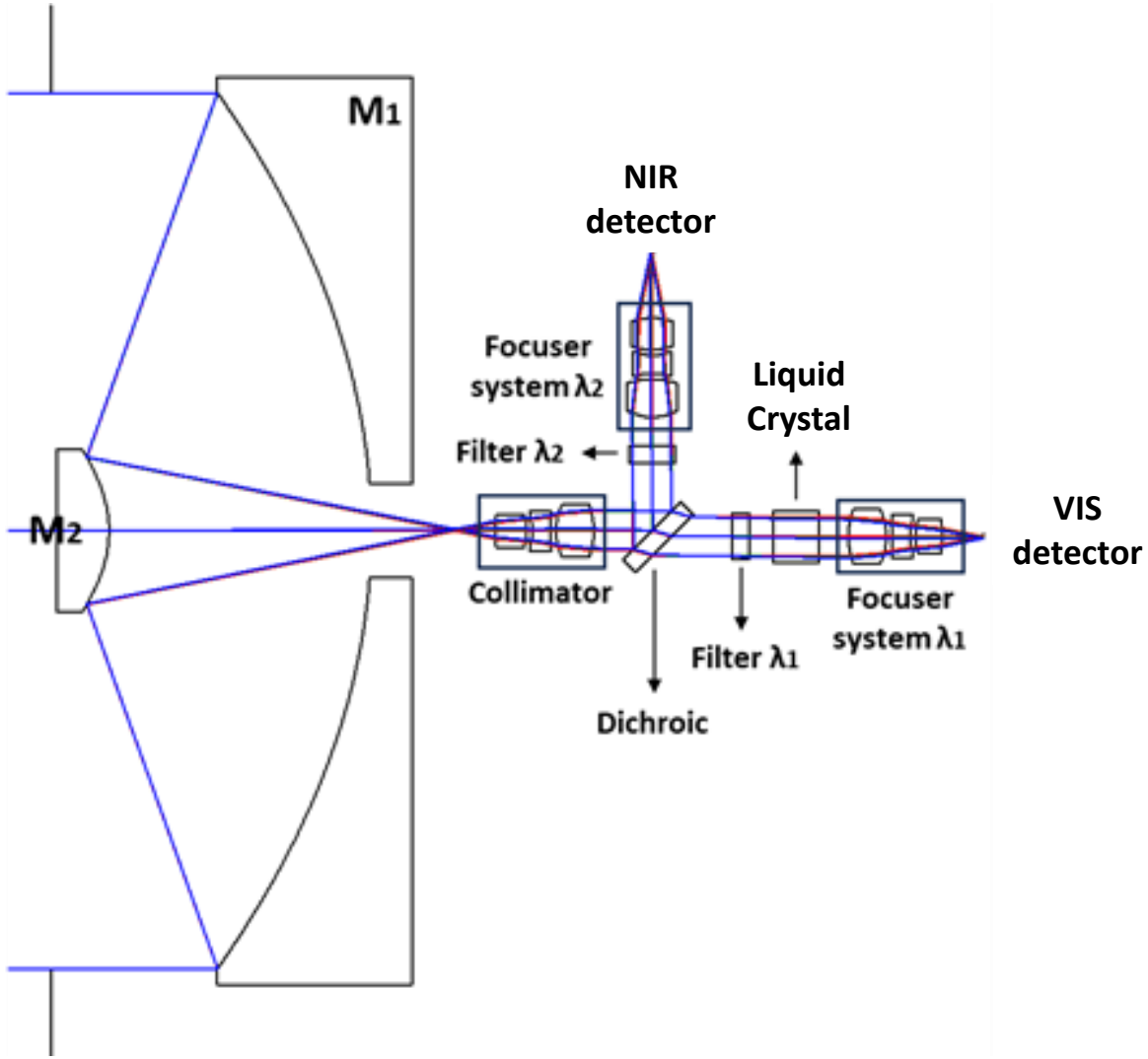
- **To provide the maximum collimation degree (0,075°) to a rectangular and extended laser (905nm) of 212µm X 232µm area and a beam spread of 15° x 40° without exceeding the weight and volume restrictions**
  - **Lens barrel composed of two lenses: spherical (L1) and conic (L2)**
  - **Optical quality diffraction-limited (<λ/14; SR 0,99)**
  - **Collimated beam spread of 15° x 15° (reduced mass an volume)**
    - **Shielding aperture: relation between spread and aperture (divergence)**
    - **Acceptable loss of energy around ~50%**
  - **Achieved divergence ~0,075°**





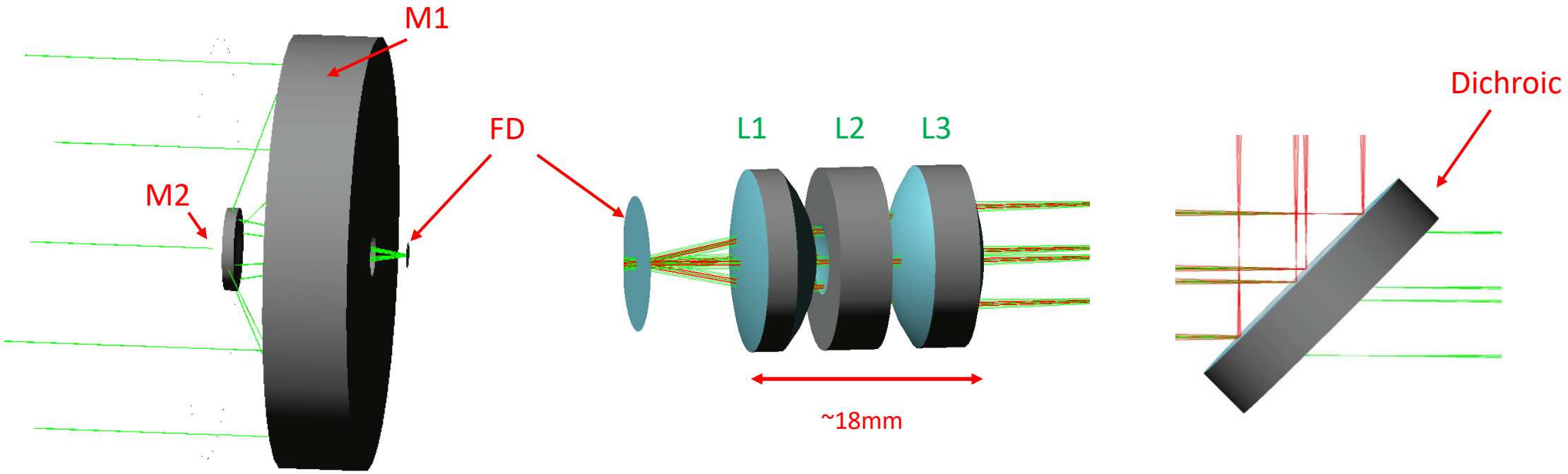
RECEIVER UNIT

- **To collect the faint signal inside the complete field of view of both channels which are in a wide spectral range: VIS FoV = 0,04º and NIR FoV = 0,1º (day operation)**



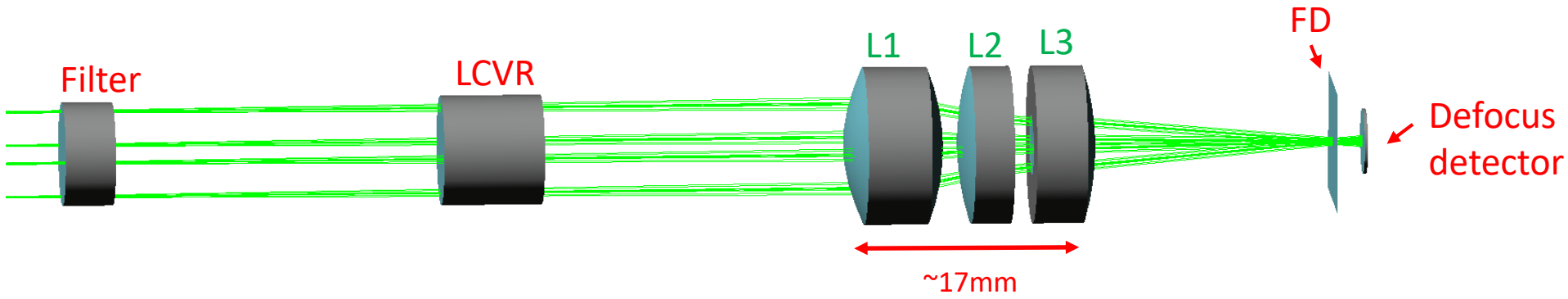
RECEIVER UNIT: TELESCOPE + COLLIMATOR

- **To collect the faint signal inside the complete field of view of both channels which are in a wide spectral range: VIS FoV = 0,04º and NIR FoV = 0,1º**
  - **Telescope: based on a Cassegrain configuration with 150mm of aperture and image intermediate where is placed the field diaphragm to fix the NIR FoV and to minimize stray-light**
  - **Collimator: two spherical (L1 & L2) and one aspheric (L3)**
  - **Dichroic filter: split in both channel, VIS & NIR**



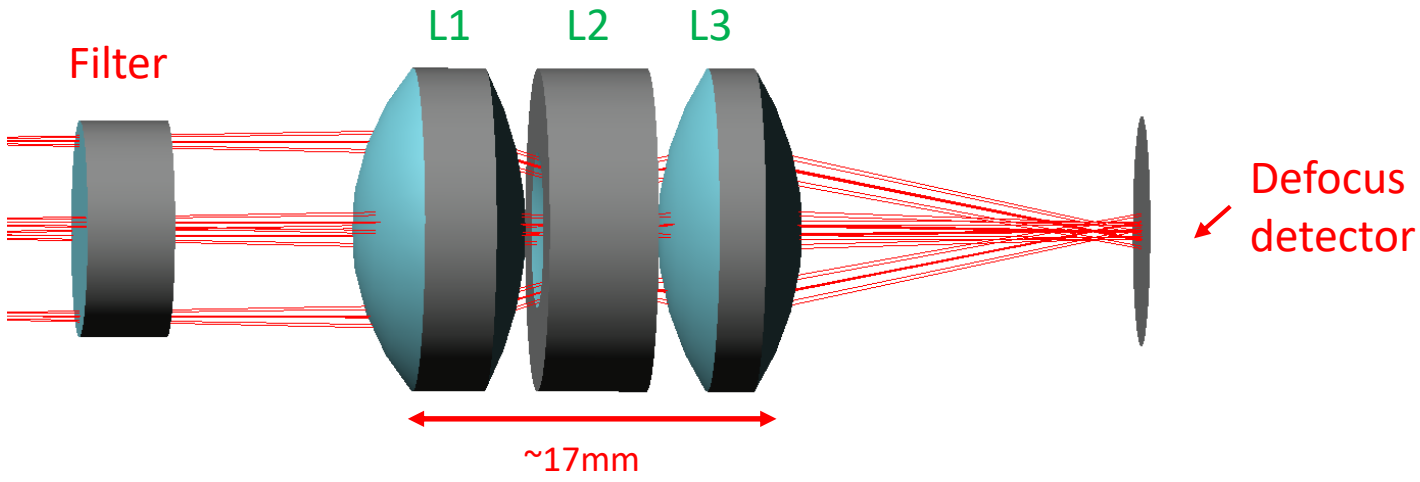
RECEIVER UNIT: VIS CHANNEL

- **To collect the faint signal inside the complete field of view of both channels which are in a wide spectral range: VIS FoV = 0,04º and NIR FoV = 0,1º**
  - **Telescope**
  - **Collimator**
  - **Dichroic filter**
  - **VIS channel:**
    - **Narrow interferential filter (width ~1,5nm)**
    - **Liquid Crystal Variable Retarder**
    - **Focuser: one aspheric (L1) & two spherical (L2 & L3)**
    - **Field diaphragm**
    - **Defocus detector (PMT)**
  - **Optical quality of the whole channel is diffraction-limited (~λ/14; SR 0,98)**

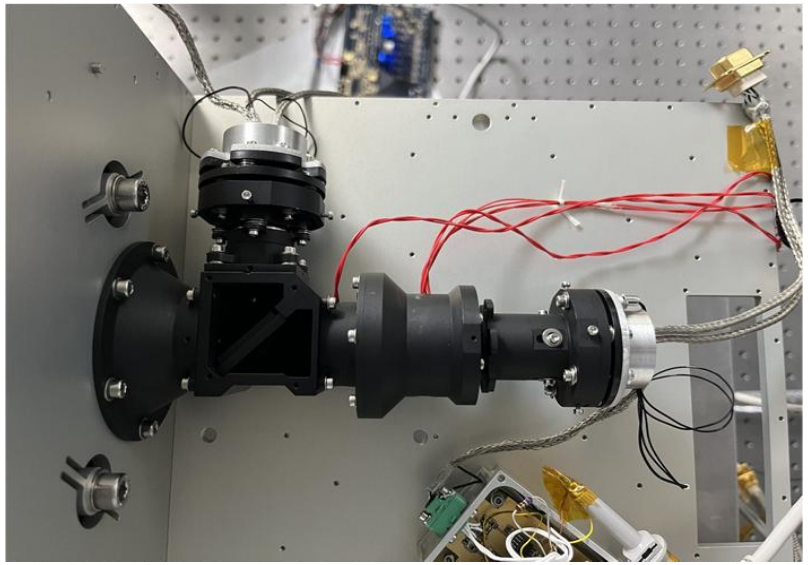


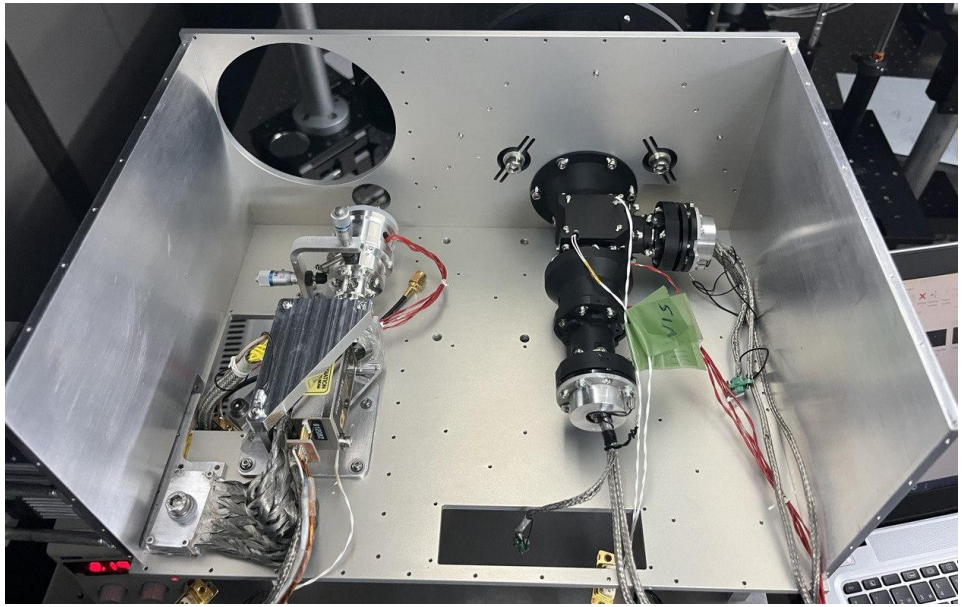
RECEIVER UNIT: NIR CHANNEL

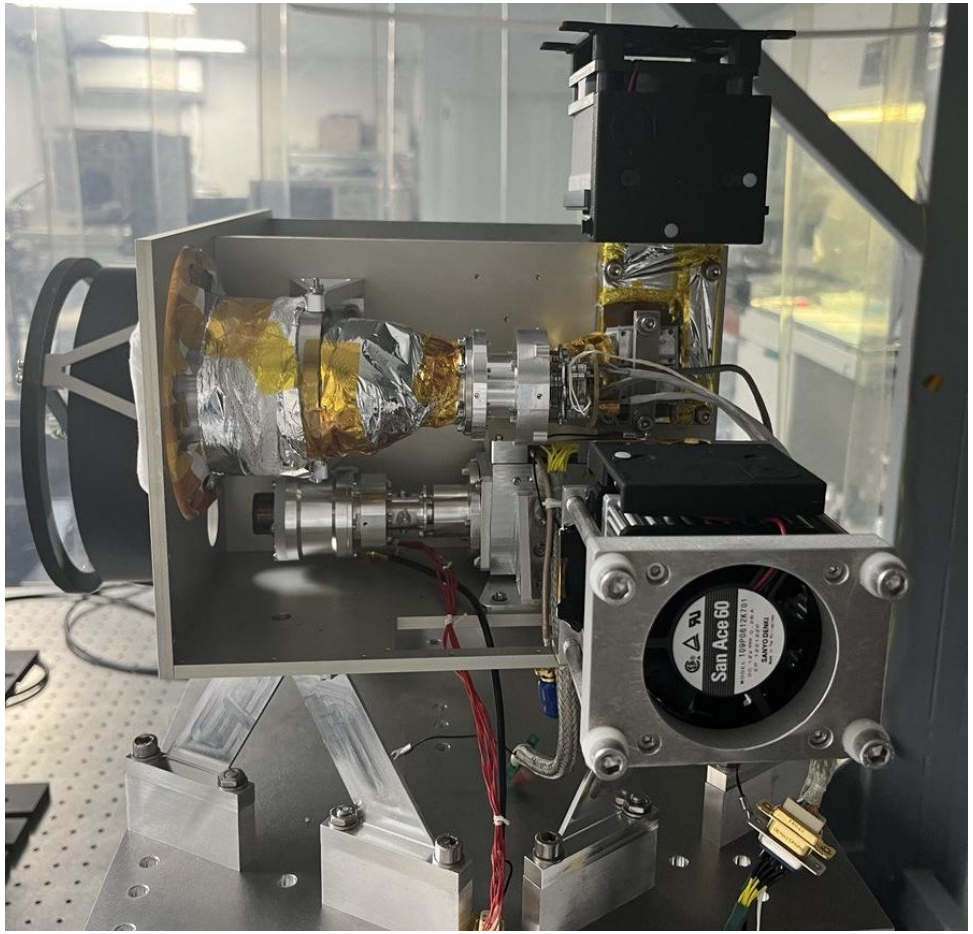
- **To collect the faint signal inside the complete field of view of both channels which are in a wide spectral range: VIS FoV = 0,04º and NIR FoV = 0,1º**
  - **Telescope**
  - **Collimator**
  - **Dichroic filter**
  - **NIR channel:**
    - **Interferential filter (width ~3nm)**
    - **Focuser: two spherical (L1 & L2) & one aspheric (L3)**
    - **Defocus detector (PMT)**
  - **Optical quality of the whole channel is diffraction-limited (<λ/20; SR 0,99)**



MiLi INSTRUMENT







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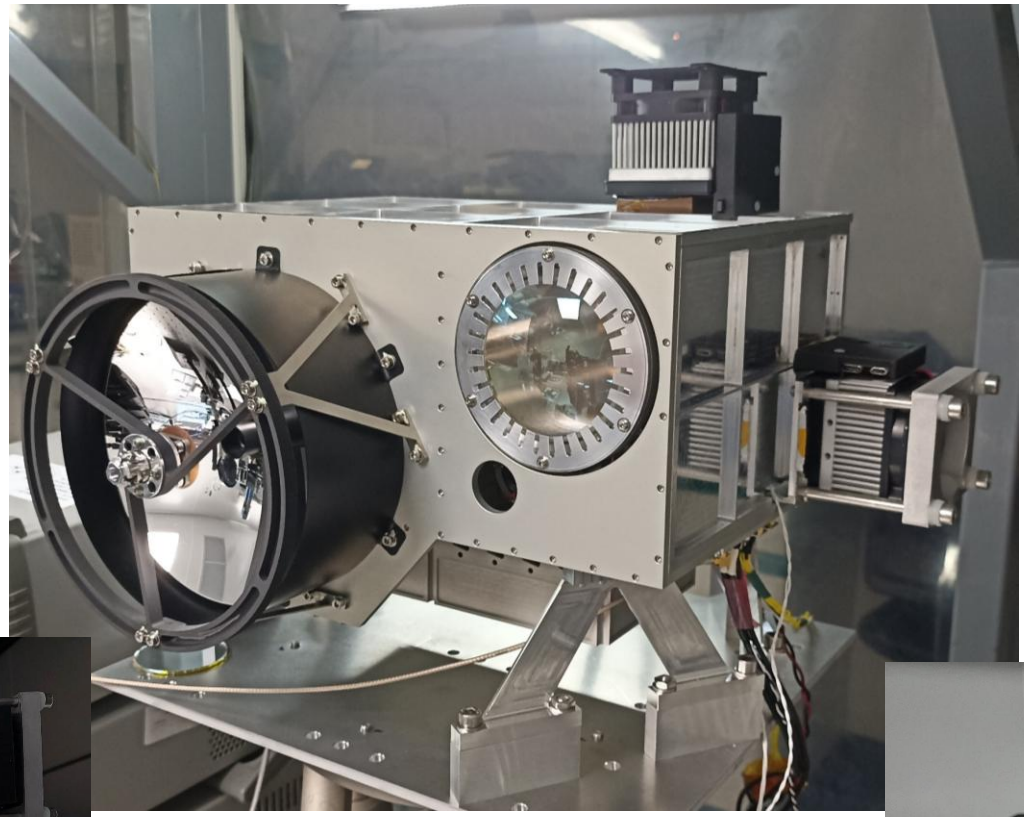

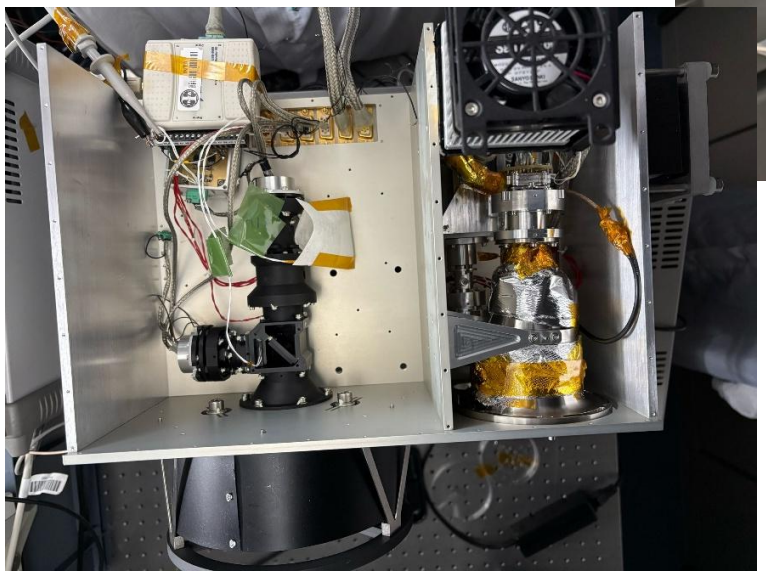

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THANK YOU