CubeSat project for sounding the atmosphere of Mars

Laboratory of Applied Infrared Spectroscopy (AIRS)

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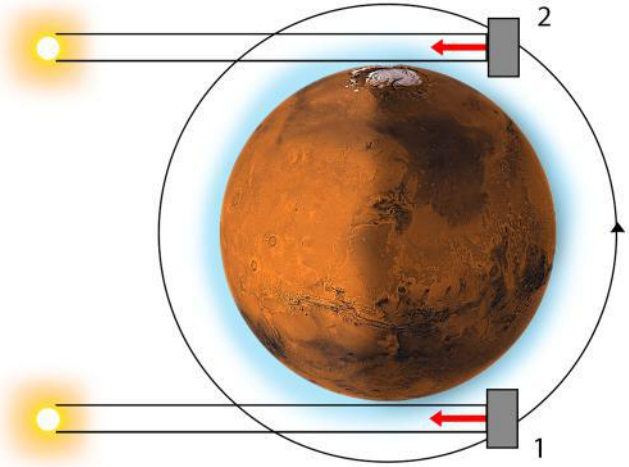
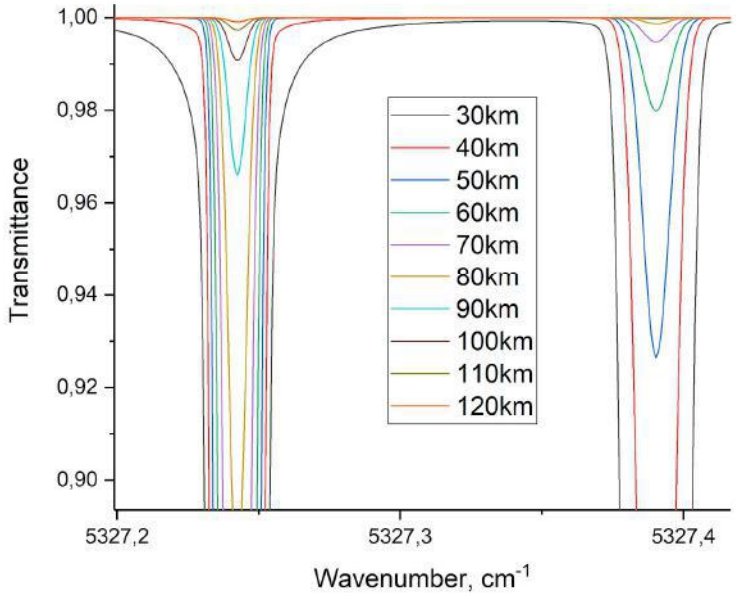
5th IAA Conference
CubeSat on Mars perspectives
2020, Rome

Mission overview



Observation method

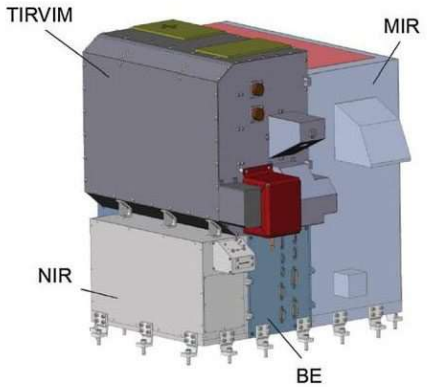


Synthetic spectra

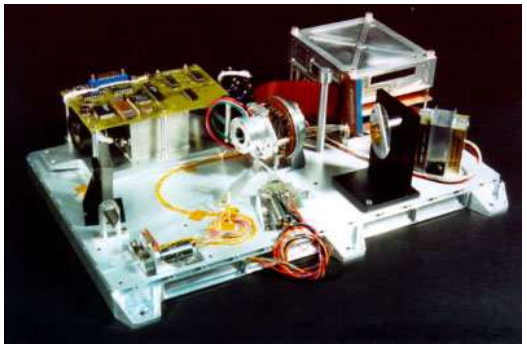
MLHS instrument configuration for 6U CubeSat

Motivation

	Bandwidth, nm	Weight, kg	Resolution, cm^{-1}
ACS NIR on TGO	900	3.2	0.35
SPICAM IR on Mars Express	700	4	3.5
MLHS on CubeSat	**0.2**	**3**	**~ 0.0003**



ACS

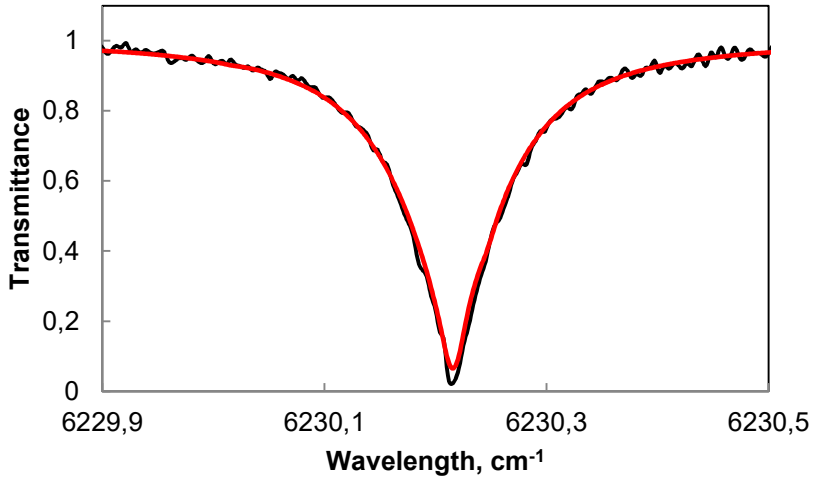


SPICAM IR

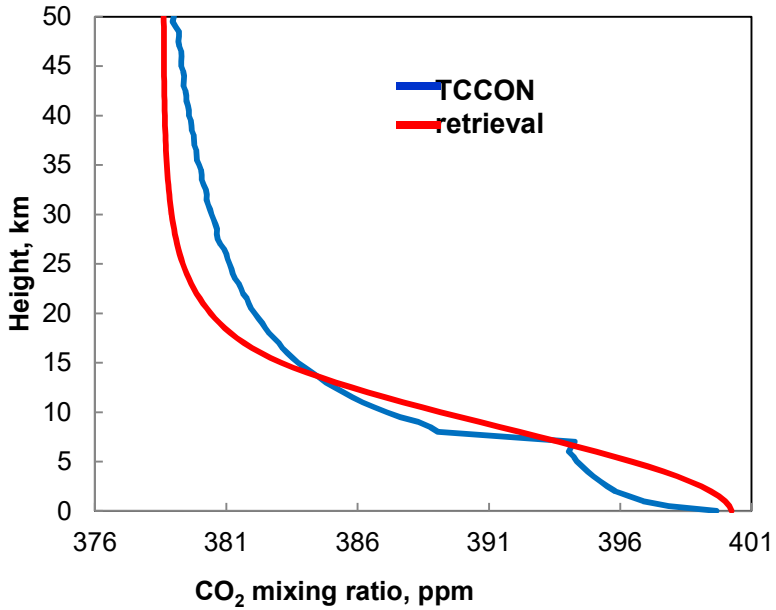
MLHS

CO_2 retrievals

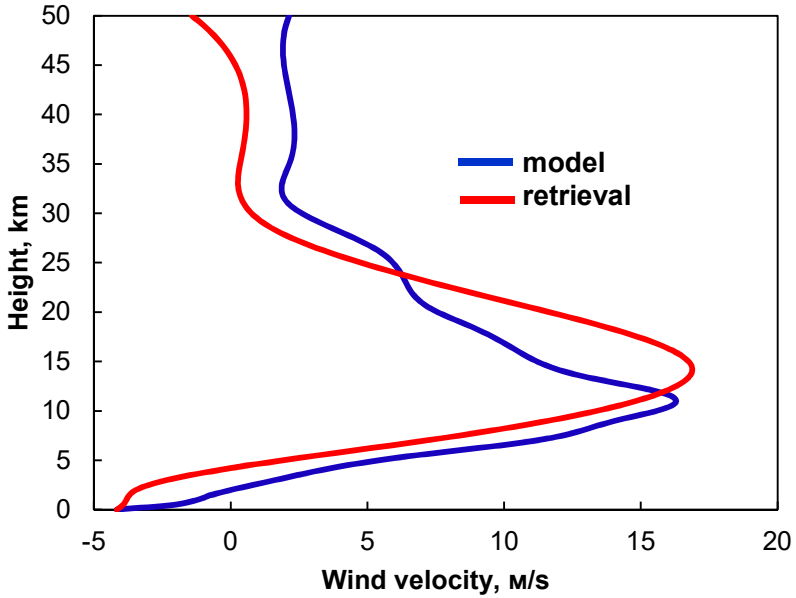
Earth atmospheric measurements by MLHS



Observed CO_2 absorption line and model fit

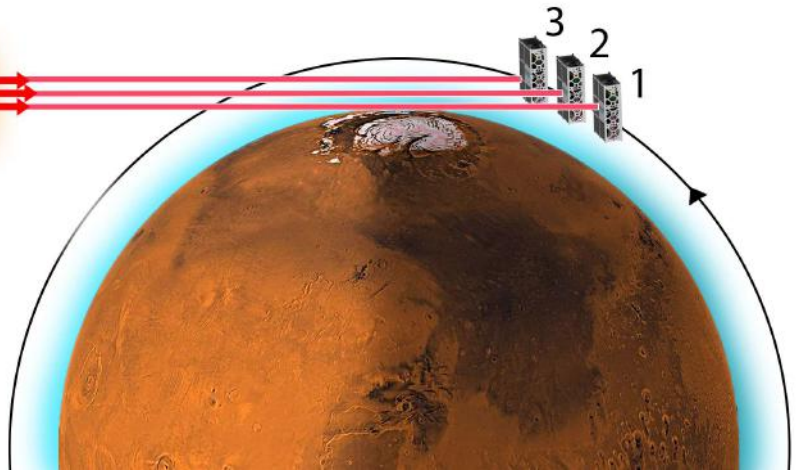


Retrieved CO_2 concentration profile

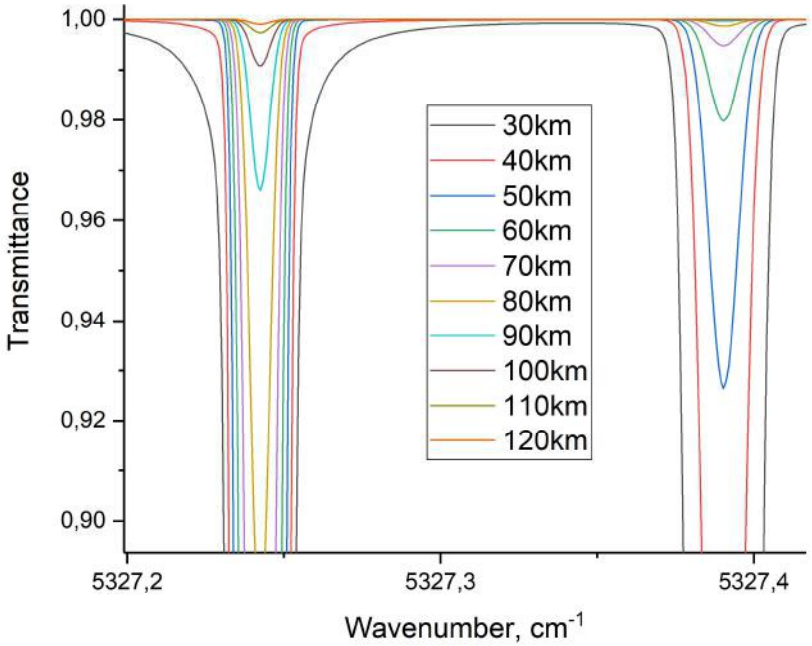


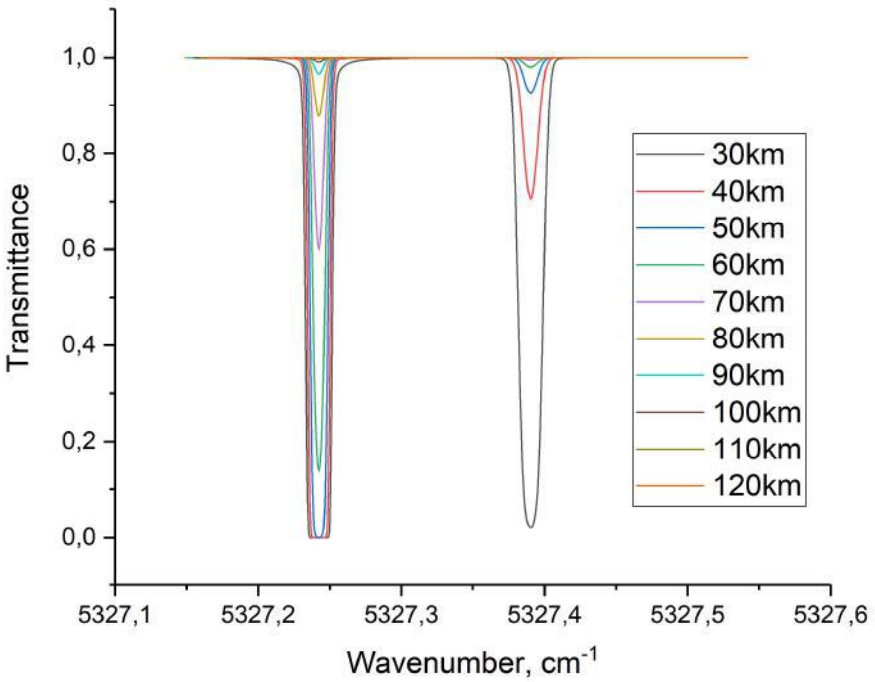
Wind profile retrieved from CO_2 absorption line

Measurements



Observation method





ƛ = 1.87 μm

Synthetic transmission spectra for CO_2 and H_2O in solar occultation observation for different tangent heights in the range 30-120 km

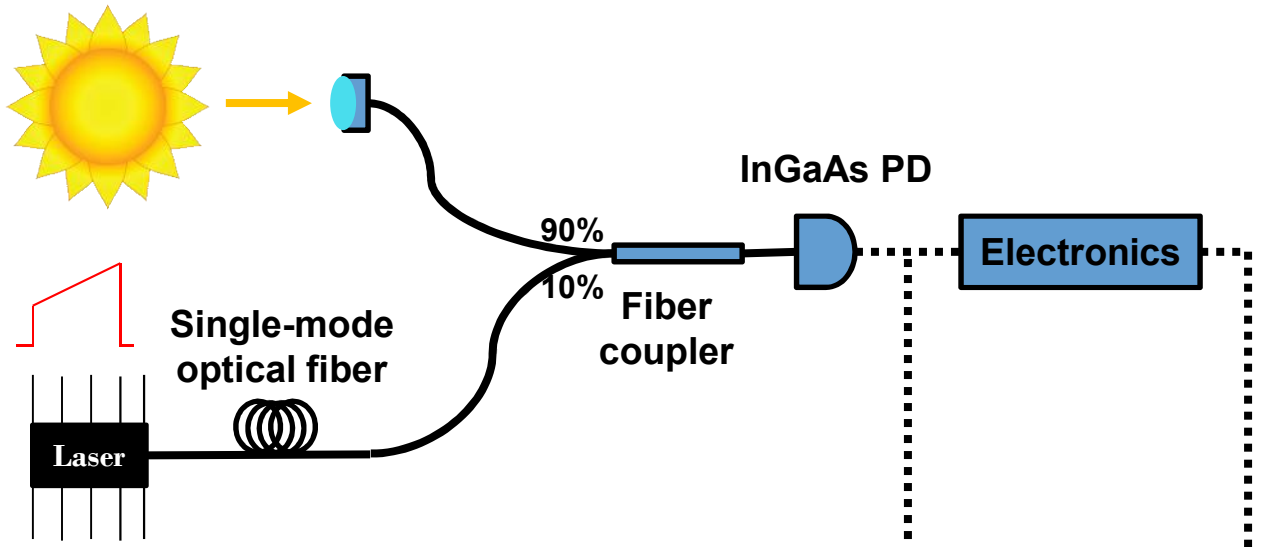
Heterodyne detection in the NIR

Signal

$$E_s = \int_0^\infty E_\omega e^{(-i\omega t)}\, d\omega$$

LO

$$E_{LO} = E_{LO} e^{(-i\omega_{LO} t)}$$



Photodiode output

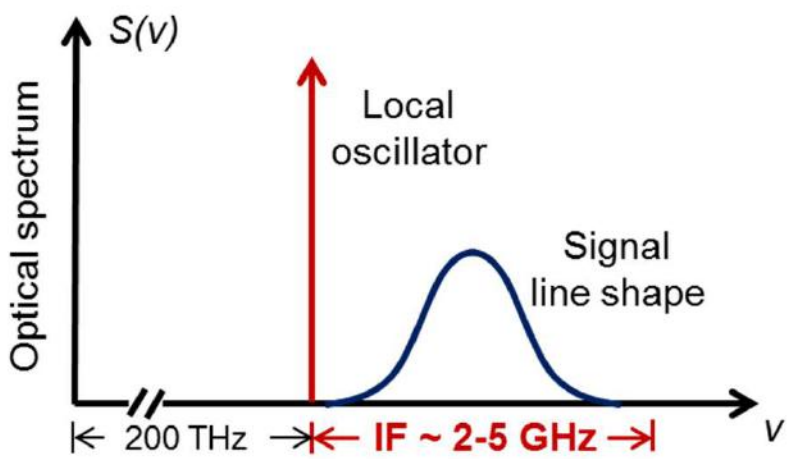
$$i = K|\vec{E}_{LO} + \vec{E}_s|^2 = K\left[|\vec{E}_{LO}|^2 + \left[\vec{E}_{LO}\vec{E}_s^{\,*} + \vec{E}_{LO}^{\,*}\vec{E}_s\right] + |\vec{E}_s|^2\right]$$

Intermediate frequency signal

$$\left[\vec{E}_{LO}\vec{E}_s^{\,*} + \vec{E}_{LO}^{\,*}\vec{E}_s\right] = 2\int_0^\infty E_\omega E_{LO} e^{-i(\omega_{LO}-\omega)t} d\omega + CC$$

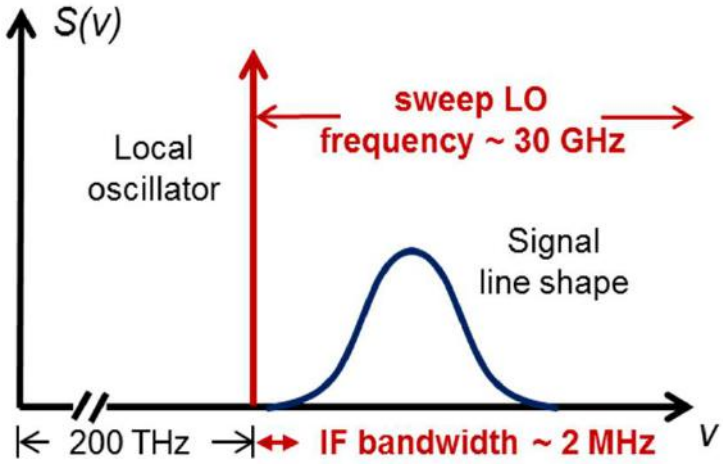
Tunable laser and narrow-band

Standard approach:



- Constant frequency LO
- Wide bandwidth of IF

Our approach:

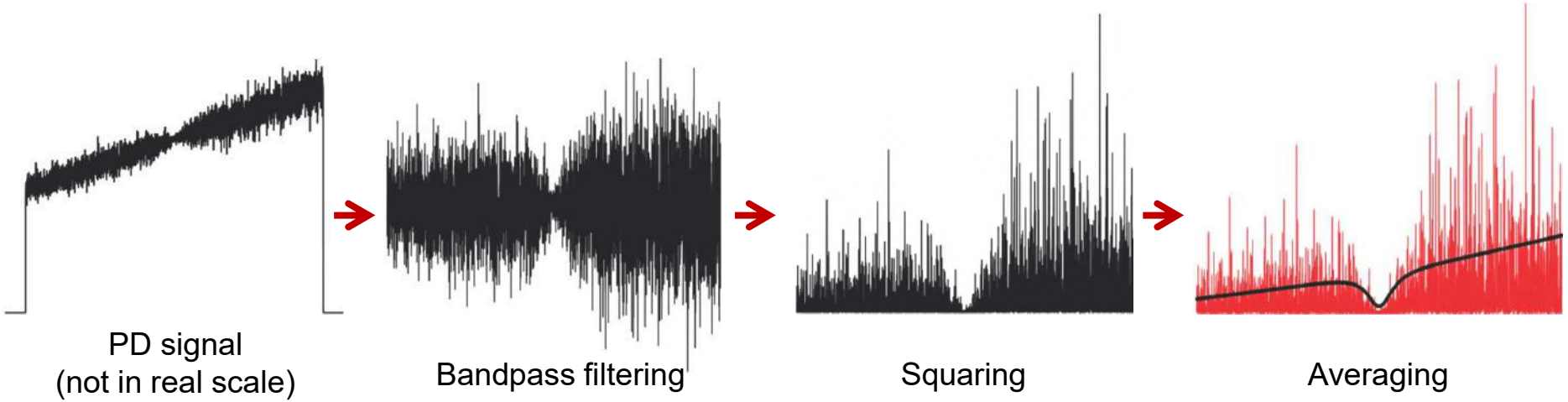


- Sweeping LO frequency
- Narrow bandwidth of IF

Advantages:

- Don’t have to use IF spectrum analyzer
- Compactness
- Advanced frequency locking techniques
- Don’t need special sideband treatment

Payload signal processing

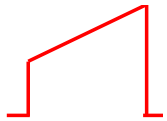


PD signal
(not in real scale)

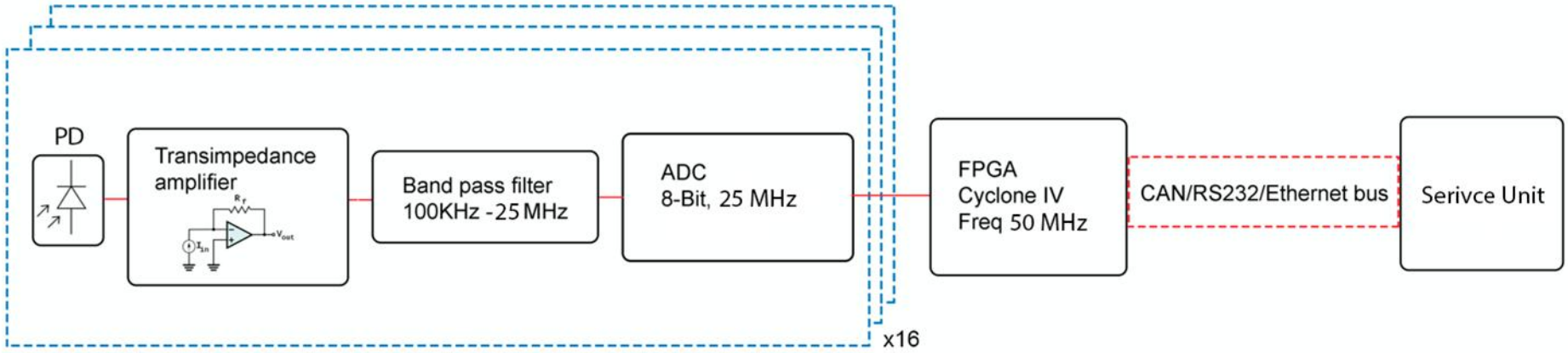
Bandpass filtering

Squaring

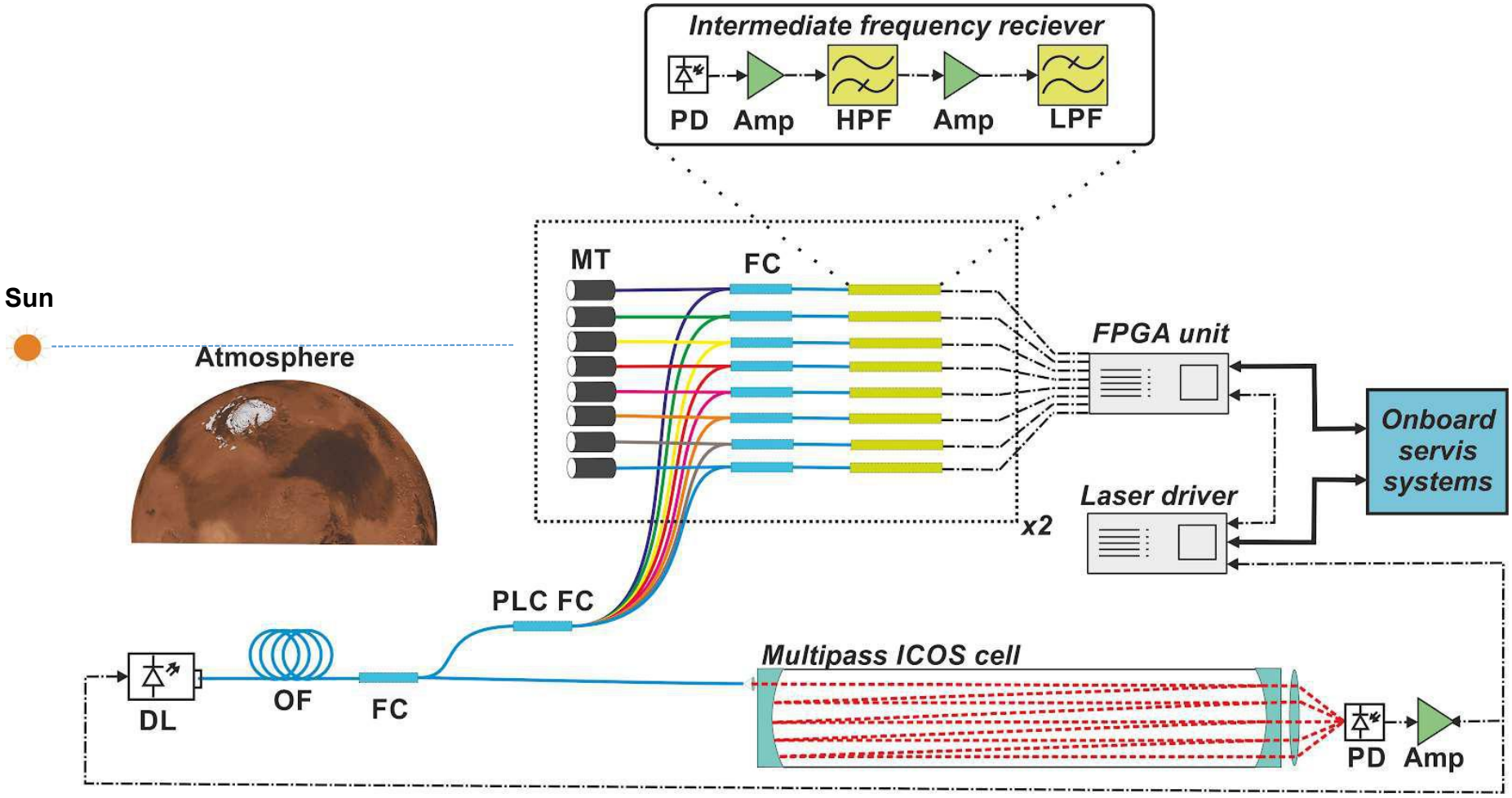
Averaging



Laser current



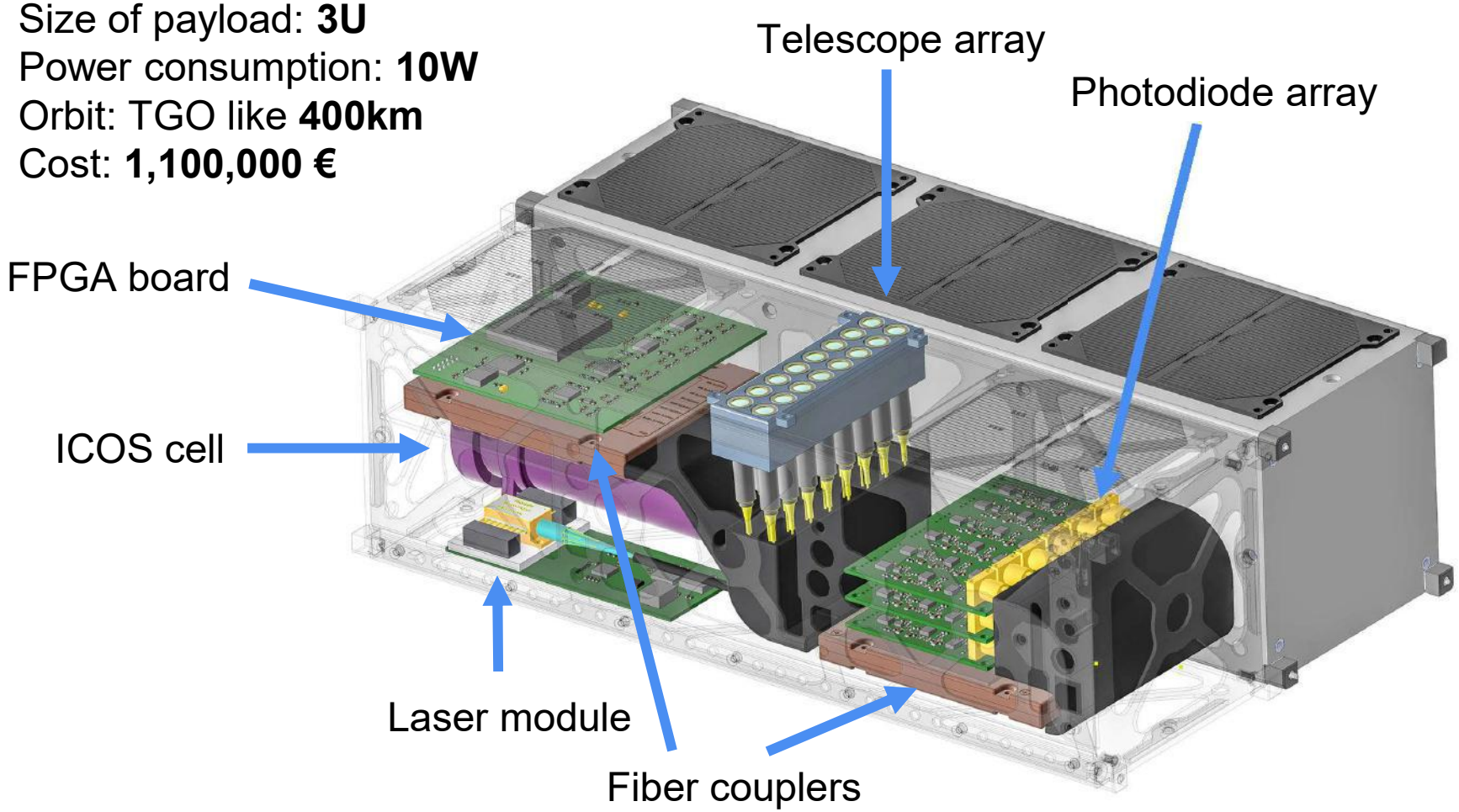
Block diagram



Satellite construction

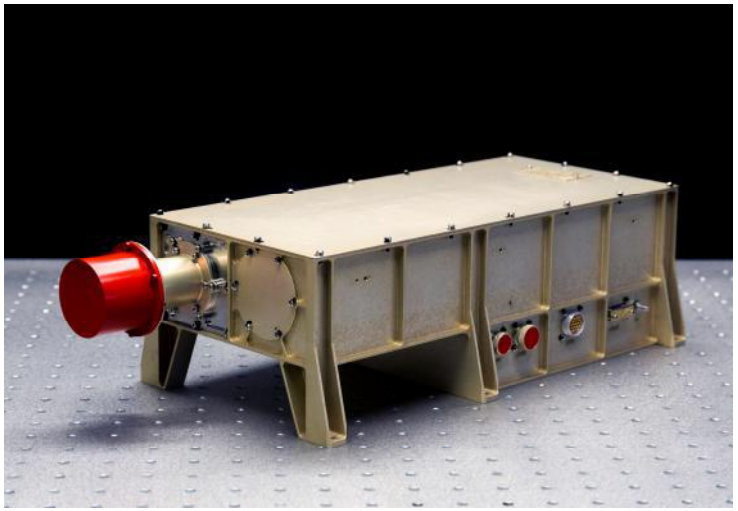
CubeSat 6U formfactor

Approximate mass of payload: **3 kg**
Size of payload: **3U**
Power consumption: **10W**
Orbit: TGO like **400km**
Cost: **1,100,000 €**

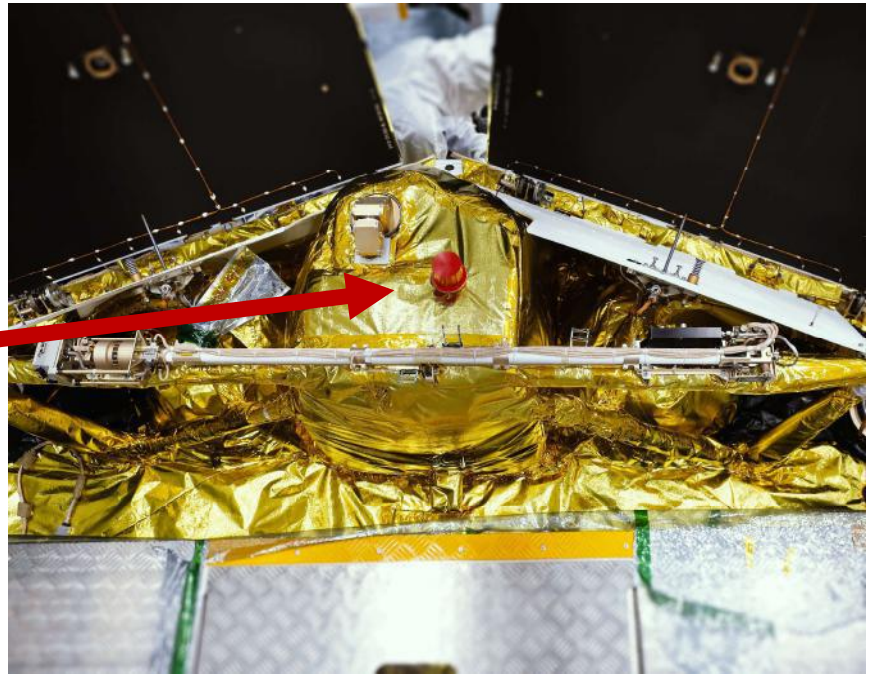


Planetary exploration in our Lab

Now:



M-DLS spectrometer developed by IKI and MIPT



M-DLS integrated with ExoMars2020 landing platform

Future:

IVOLGA: a laser heterodyne NIR spectrometer for studying of structure and dynamics of the Venusian mesosphere.

Thank you for your attention

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