Mars Lander Lidar for Profiling Winds, Water Vapor, and Aerosols

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Abstract 7014

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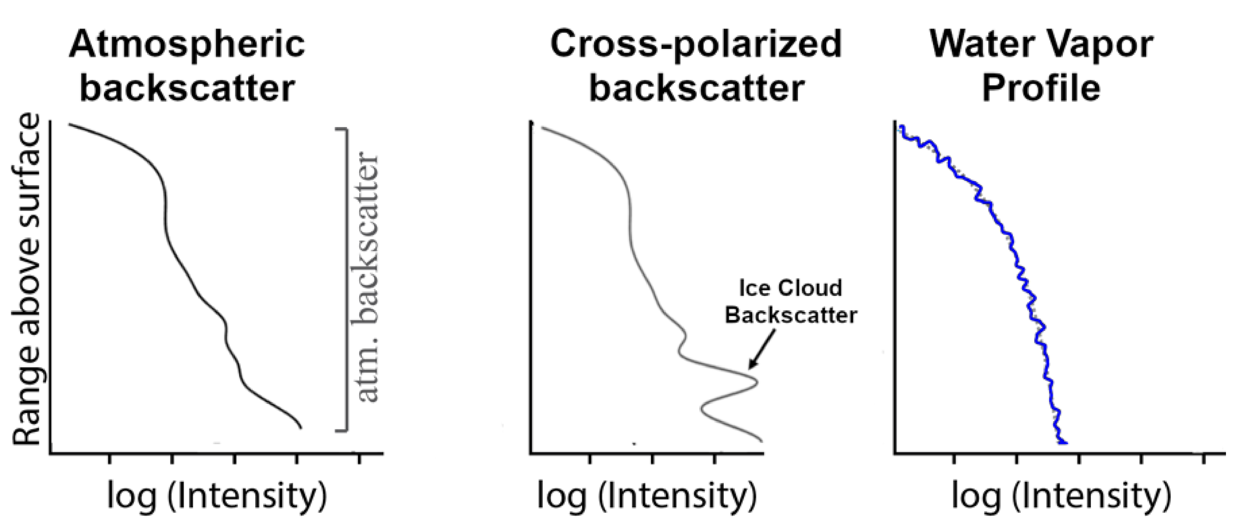
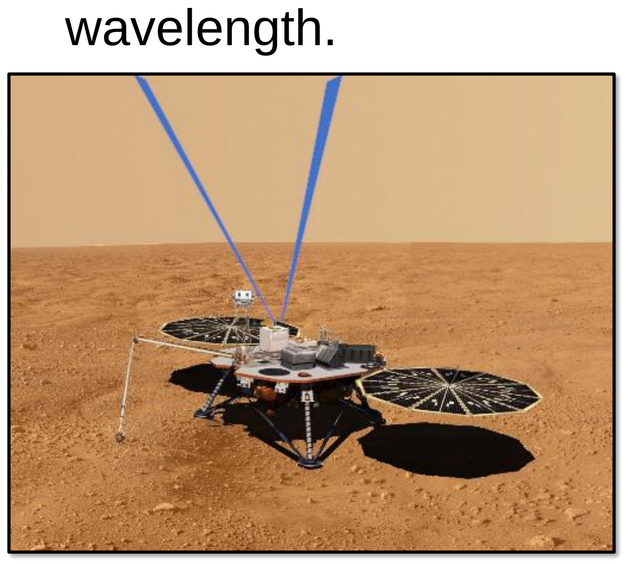
Motivation

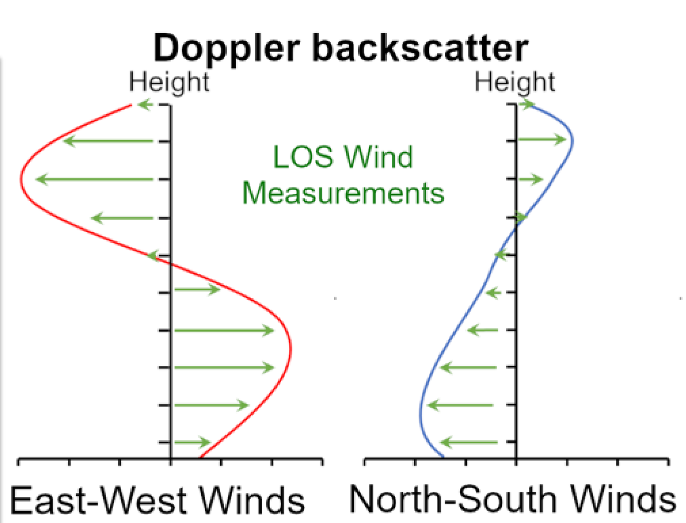
- Processes within the Mars PBL control the transfer of heat, momentum, dust, water, and other constituents between surface and atmospheric reservoirs.
- The **lack of PBL observations** has led to significant gaps of understanding in several key areas. These include **diurnal variations of aerosols and water vapor, and direct measurements of wind velocity**, the combination of which provides information on the horizontal and vertical transport of water, dust, and other trace species and their exchange with the surface.
- Because these quantities are interrelated and they partially drive the wind fields, **it is important to measure the water vapor, aerosols, and winds simultaneously,** ideally using a single instrument.

Measurement Approach

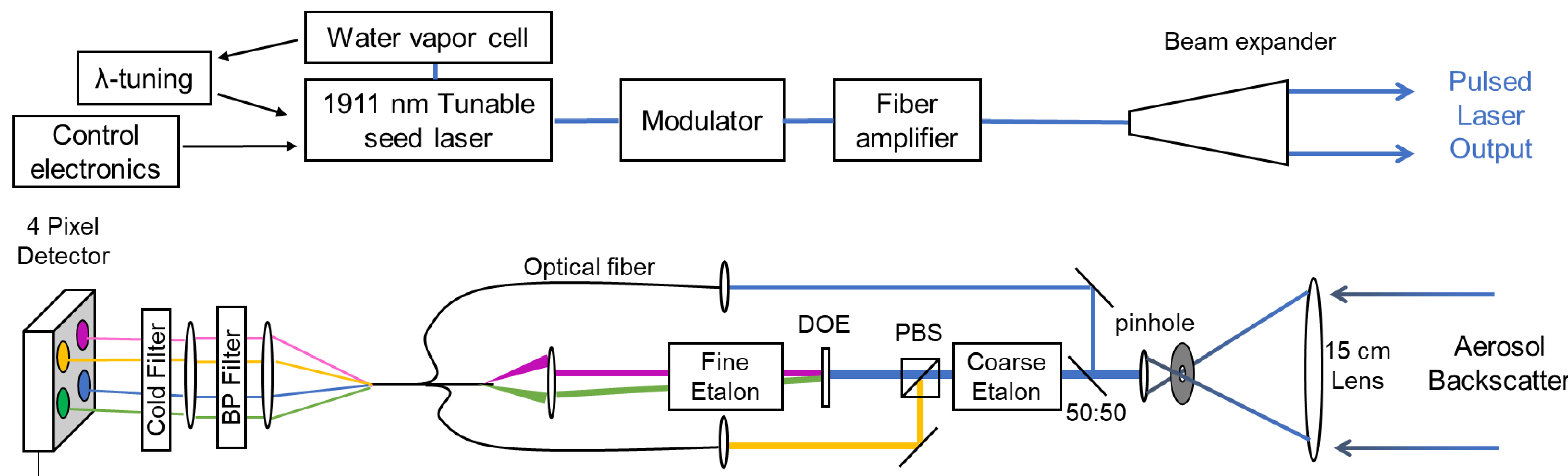


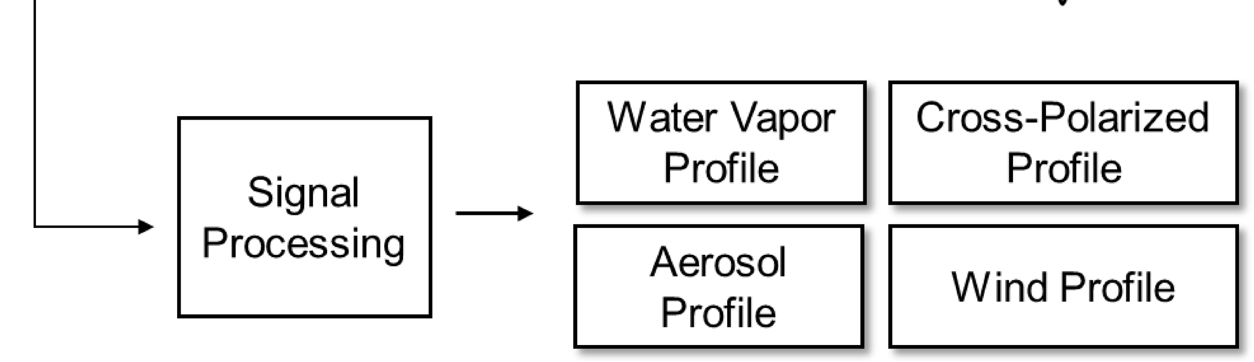
- Our approach is to measure **laser backscatter** from aerosols at **several key wavelengths near 1911 nm.**
- Water vapor profiles are measured using **the differential absorption lidar technique.** Here, we use backscattered profiles both on and off an isolated water absorption line at 1911.35 nm. The Doppler wind measurements are made at the off-line wavelength.



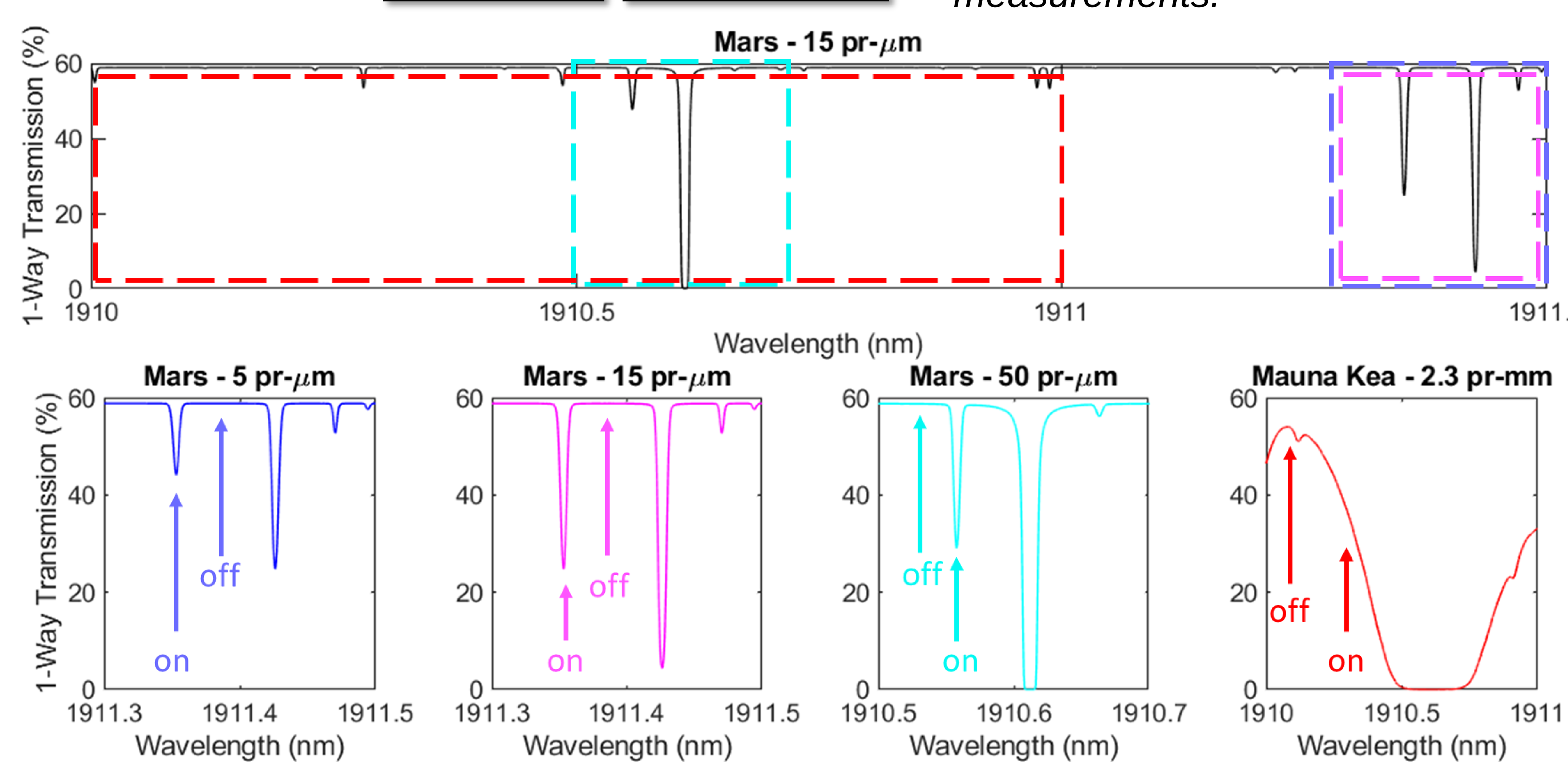


- Wind measurements are performed using the double-edge Fabry-Perot (DEFP) etalon technique in which an edge filter is used **to Doppler-resolve the backscattered laser light**. Two identical receivers offset 30 degrees from zenith and 90 degrees from each other in azimuth enable vector wind measurements.
- Finally, **polarized aerosols backscatter** is measured by splitting the parallel and perpendicular polarization components of the backscattered light in our lidar receiver.

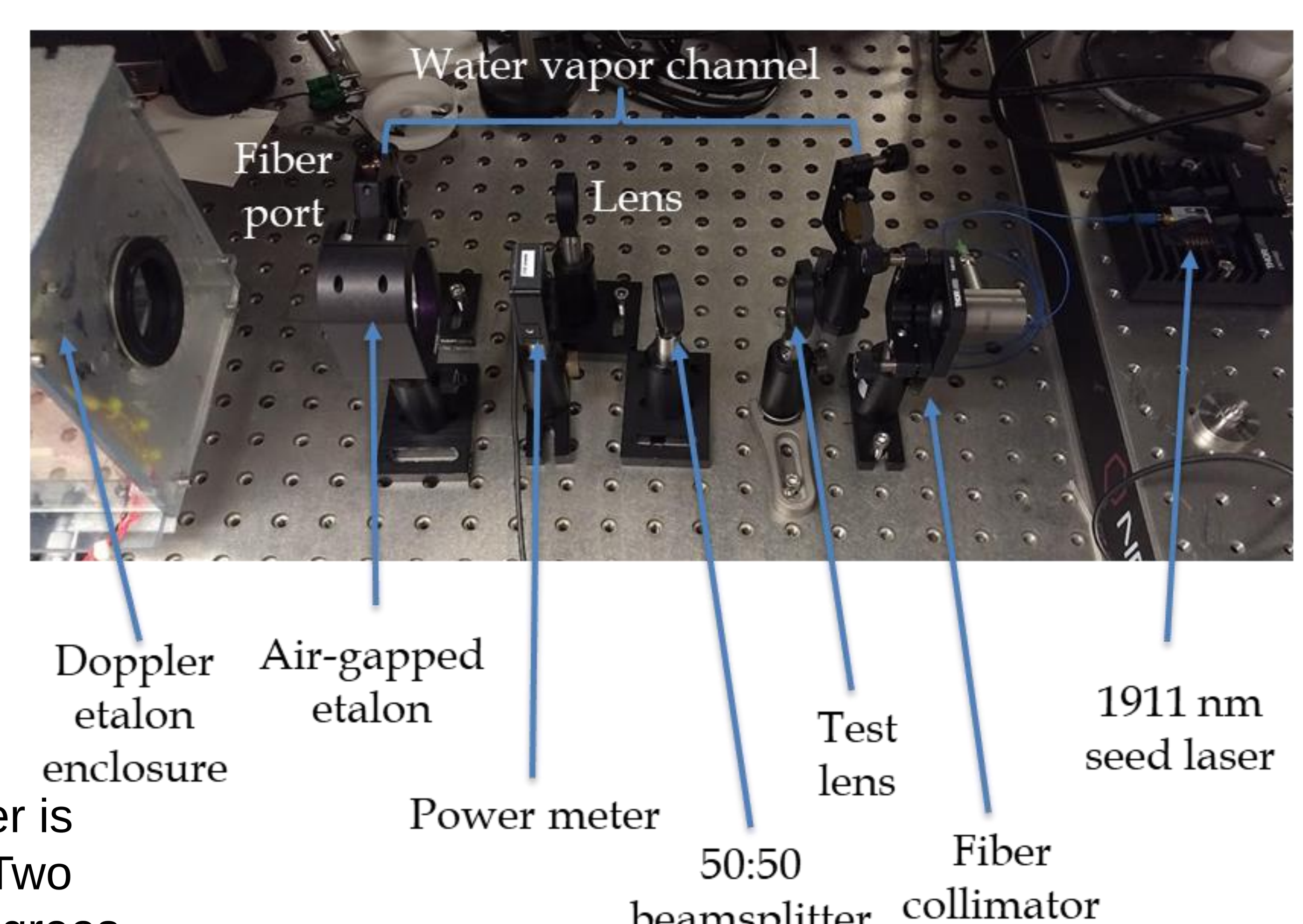




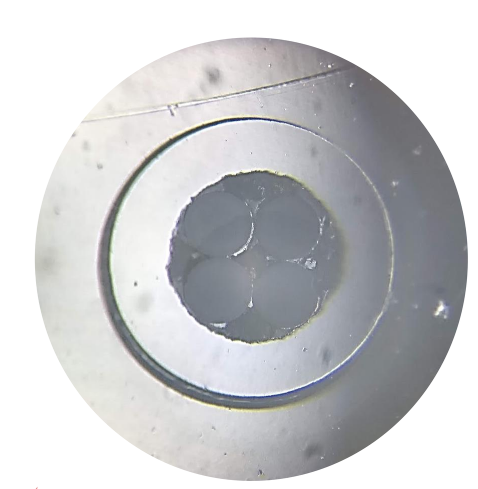
(above) Lidar instrument diagram. A single laser is used for both water vapor and wind measurements. The receiver shown is duplicated for the vector wind measurements.



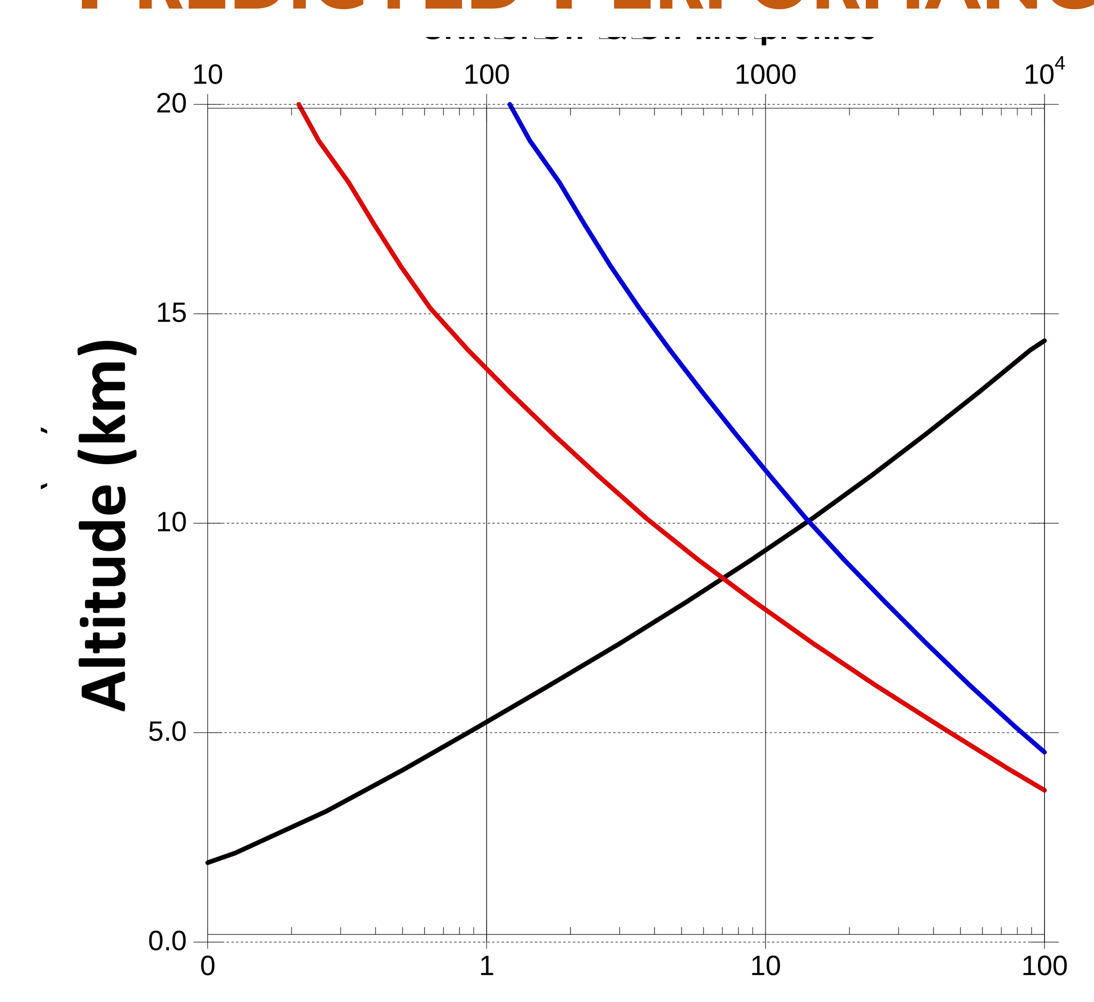
(above) Plots of the Mars atmospheric transmission from the surface to 20 km in the 1911 nm region targeted for the water vapor measurements. amount of Mars water vapor, which ranges from 5 to 50 pr-μm. The rightmost plot also shows the 1910 nm wavelength region also may be used for the open-path DIAL lidar demonstration at the Mauna Kea Observatory to ~ 1-km altitude.



(left) Current status of lidar receiver assembly and test. The Doppler and water vapor channels are assembled, and component testing has been completed. (below) Custom four-core fiber optic bundle to illuminate 4-pixel HgCdTe APD.



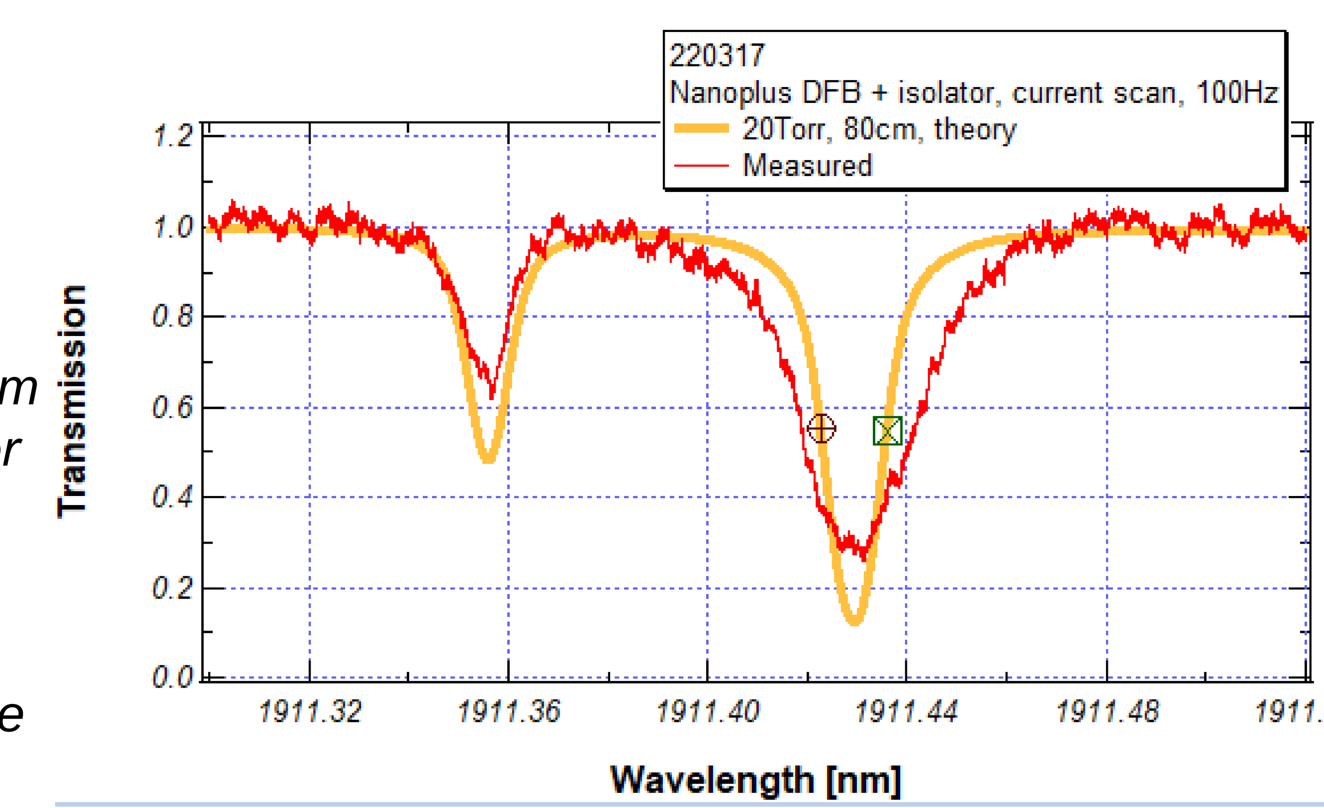
Predicted Performance



This case is based on an average from Southern Hemisphere spring (L_s = 150° to 230°) of Mars Year 33 mid-latitudes from Mars Climate Sounder. The model assumes random error only, 250-s integration time, 1-km vertical bins and 0.5 W laser power.

Parameter	1 km	5 km	15 km
Water vapor rel. error (%)	<0.2	1	110
Aerosol rel. error (%)	<0.02	0.05	1
Wind speed error (m/s)	<0.02	0.1	2

Instrument Status



(above) Laboratory data showing laser tuning across chosen water vapor lines using an 80 cm path water vapor cell and comparison with theoretical cell transmission.

The lidar transmitter and receiver subsystems are being assembled and tested. System integration and test will be **followed by field experiments at Mauna Kea, HI** to measure wind and water vapor profiles to 1 km range (limited by water vapor absorption).

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