LIDAR ON THE PHOENIX MARS MISSION

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ABSTRACT

The design of the lidar for the Phoenix Mars mission will be described and the current state of development will be reported. Results will be presented from the associated field campaigns involving a model of the Phoenix Lidar. This will include airborne lidar and in situ measurements in tropical cirrus and ground based measurements of desert dust. Results will also be presented from simulations of the lidar performance in the varying Martian climate.

1. INTRODUCTION

In June 2008, the Phoenix spacecraft will land on the northern plains of Mars and it will operate as shown in Fig. 1 for at least 90 sols. The primary goals of the mission are to investigate the history of water on Mars in all of its phases, to search for evidence of a habitable zone, and to assess the biological potential of the ice-soil boundary. The location of the landing site will be chosen to follow on the discovery of near surface ice by the Mars Odyssey mission. A Robotic Arm will dig trenches, scoop up soil and water ice samples, and deliver these samples to the TEGA and MECA instruments for detailed chemical and geological analysis; the Thermal and Evolved Gas Analyzer (TEGA) will combine a high-temperature furnace and a mass spectrometer to analyze the composition of Martian ice and soil samples; the Microscopy, Electrochemistry, and Conductivity Analyzer (MECA) will combine a wet chemistry laboratory, optical and atomic force microscopes, and a thermal and electrical conductivity probe; the Mars Descent Imager (MARDI) will record images while the spacecraft descends; the Surface Stereoscopic Imager (SSI) will provide high-resolution, panoramic images of the Martian arctic and it will also view the Martian atmosphere at a variety of wavelengths to derive properties of dust and clouds; and the Meteorological Station (MET) will provide measurements of the present day Martian climate.

Simulations of the Martian climate have demonstrated how the day-to-day variability in temperature and wind is influenced primarily by the absorption and scattering of sunlight by dust in the atmosphere [1,2]. The Mars Orbiting Lidar Altimeter (MOLA) has detected the presence of water ice clouds throughout the Martian atmosphere [3]. The meteorological component of the Phoenix mission will include a lidar to provide measurements of atmospheric processes that determine the climate and the transport of water. The Phoenix Lidar will measure the height distribution of both dust and clouds within the Martian atmosphere.

2. THE PHOENIX LIDAR INSTRUMENT

The lidar is based on a diode pumped Nd:YAG laser emitting pulses at the wavelengths of 1064 nm and 532 nm. The backscatter is collected by a 10 cm diameter telescope and detected with an APD for the 1064 nm and with a PMT for the 532 nm. A 14 bit analog to digital converter is used to record the signals at both wavelengths, while photon counting is also used for the 532 nm wavelength. The basic technical specifications of the *Phoenix Lidar* are given in Table 1, and a schematic diagram along with a three dimensional drawing of the system design is shown in Fig. 2.

3. FIELD CAMPAIGNS FOR LIDAR CHARACTERIZATION

Field measurement campaigns are being carried out with a lidar that is essentially equivalent to the Phoenix Lidar. The measurement campaigns focus on scenarios within the Earth's atmosphere that are similar to what we expect to observe with the Phoenix lidar from the surface of Mars: ice clouds and airborne desert dust. The first campaign has involved airborne lidar and in situ measurements of very cold ice clouds (cirrus) in the tropical tropopause region above Darwin Australia. This was completed in February 2006. The second campaign will involve ground based measurements of airborne desert dust at Eloy, Arizona during May 2006. The third campaign will combine lidar and airborne in situ measurements of desert dust within the Australian interior. A forth campaign will involve conducting measurements with the Flight Model of the Phoenix lidar, while the Field Lidar will be operating simultaneously at the same location. The goal is to transfer the characterization of the Field Lidar to the Phoenix Flight Model Lidar in order to aid in interpreting the measurement data from Mars, and also to identify any peculiarities in the characteristics of the Flight Model.

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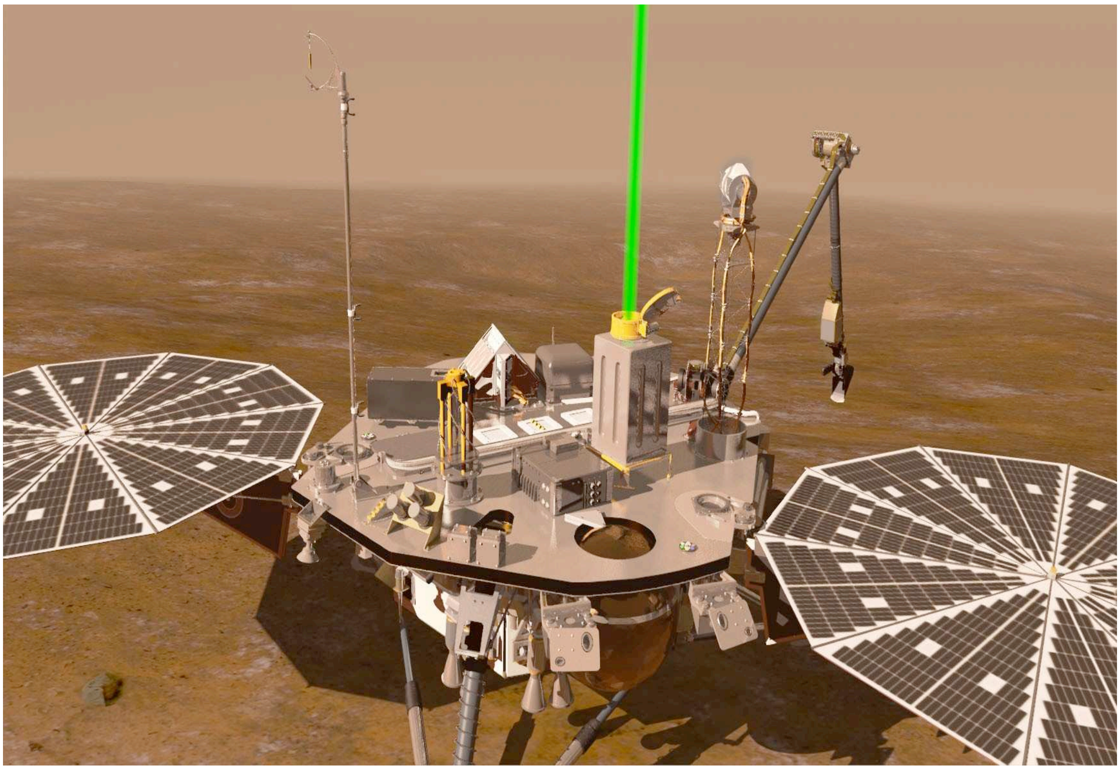

Fig. 1. Drawing of the Phoenix Mars Lander.

Table 1. Basic characteristics of the Phoenix Lidar.

Transmitter		
Laser	Nd: YAG Diode pumped	
Wavelengths	1064 nm	532 nm
Pulse repetition rate	100 Hz	100 Hz
Pulse energy	0.4 mJ	0.5 mJ
Divergence	0.25 mrad	0.25 mrad
Emitted line width	0.25 nm	0.25 nm
Receiver		
Telescope	10 cm diameter	
Field of View	2 mrad	1 mrad
Spectral width	2 nm	1.5 nm
Detector	Silicon APD (Perkin Elmer)	PMT (Hammamatsu R7400P)
Acquisition	Analog: 12 bit ADC	Analog: 12 bit ADC + Photon Counting
Bandwidth	100Hz to 20 MHz	Analog: 100Hz to 20 MHz Max count rate 100 MHz
Sampling frequency	15 MHz (10 m)	15 MHz (10 m)

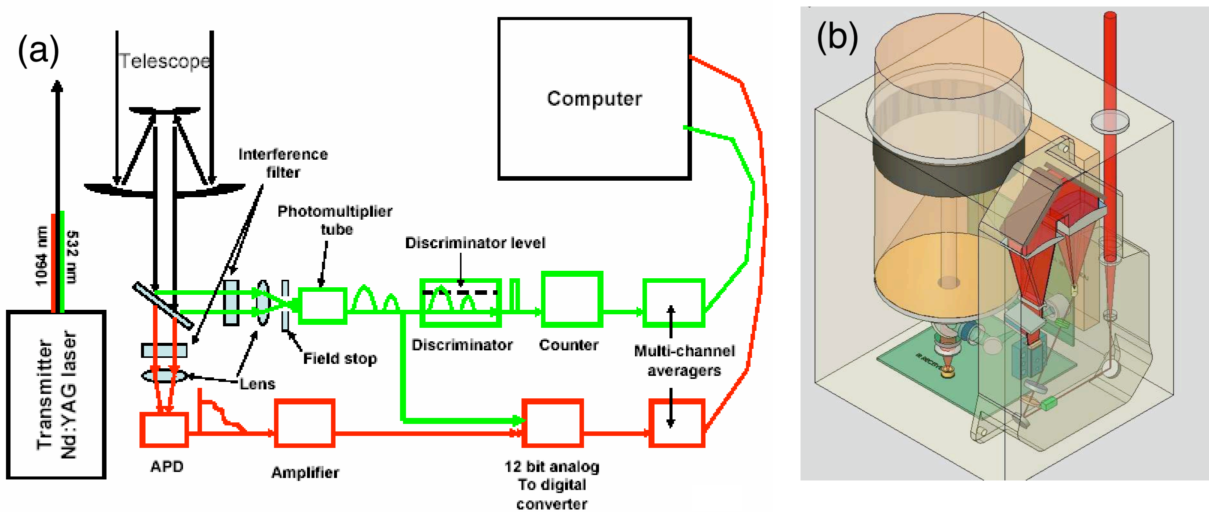

Fig. 2. (a) Schematic diagram for the Phoenix lidar system. (b) Drawing of the Phoenix lidar design.