BIO-INDICATOR LIDAR INSTRUMENT FOR NASA PLANETARY MISSIONS

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Introduction: We propose a novel planetary Astrobiology instrument based on a real-time technique of remote detection and discrimination of any bio-signatures dispersed in the ground-level planetary atmosphere, with or without the presence of solar optical background radiation, leveraging the fluorescence lidar technology transferred from DoD's Joint Biological Standoff Detection System to NASA. Capabilities of the first planetary atmospheric bio-indicator survey instrument will dramatically increase the probability of finding the signatures of extraterrestrial life by performing atmospheric volume scans of hundreds of meters in a radial direction around the rover or lander.

The Bio-Indicator Lidar (BIL) technology employs real-time aerosol particle detection and discrimination based on two physical variables: particle fluorescence and particle size in the bio-discrimination space (BD). The bio-indicator lidar laser transmitter has at least 2 low pulse operated lasers (266 nm, (optional 355 nm) and 905 nm). The instrument detection channels correspond to the laser emission wavelengths (elastic channels) and the backscattered fluorescence band (fluorescence channels). The BD space is a mathematical space constructed to discriminate different types of aerosol particles by data clustering. The real technology of Bio-Indicator Lidar is in developing the calibration approach and algorithm as applied to planetary bio-signature detection, while leveraging the existing knowledge from Earth-based R&D.

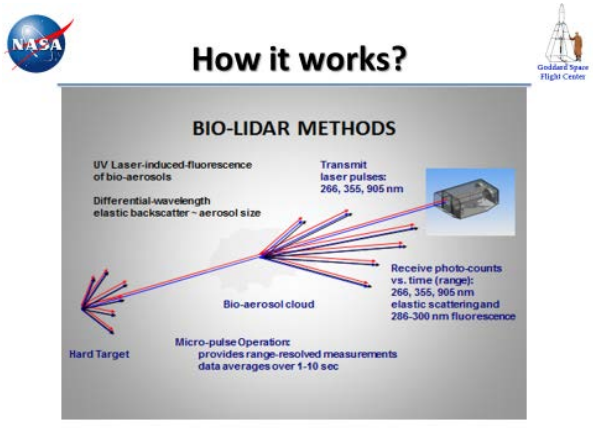

Figure 1. The Bio-Lidar concept: Staring and scanning operational modes.

From many BILI field trials, it is shown that the BIL technology is capable of simultaneously detecting and discriminating inorganic from life produced organic carbon-containing particulates. Terrestrial bio aerosols have been shown to cluster into specific, reduced subspaces of the instrument defined BD space. We believe that this technique can be applied similarly on planetary surfaces as a powerful survey instrument to remotely identify organic species and therefore possible bio-signatures. This technology utilizes the inherent property of biologically relevant organic molecules, such as amino acids, to fluoresce following UV irradiation. While the BILI does not directly detect or confirm the presence of life, current exploration goals for several major Solar System targets including Mars involve simply the identification of organic chemistry. With the BIL technique, a scan of the environment around a rover or other exploration platform could direct an Astrobiology-focused payload towards promising target sites.

Figure 2. The Bio-Indicator Lidar prototype (2008).

Further development is required to modify the instrument for planetary environments. The proposed Bio-Indicator Lidar Instrument (BILI) could be employed in various missions − as a stand-alone instrument or as a channel on a larger instrument − such as a planetary rover, lander, balloon, or in a fly-by mission.

The Bio-Indicator Lidar is a maturing technology. In the near future it will be enhanced with new component technology products such as the next generation of

UV lasers and SiC-based solid state UV detectors. From this perspective, the BIL technology roadmap is focused to two steps: 1. Instrument prototype development and calibration vs. mission targeted bio-signature materials, 2. Development of the instrument flight unit for future mission opportunity. This roadmap is likely to be enhanced and accelerated without the supplemental funding through NASA Advanced Component Technology (ACT) program, by a new generation of UV lasers coming from 2014 DARPA Compact Mid-Ultraviolet Technology (CMUVT) program next 2 years.

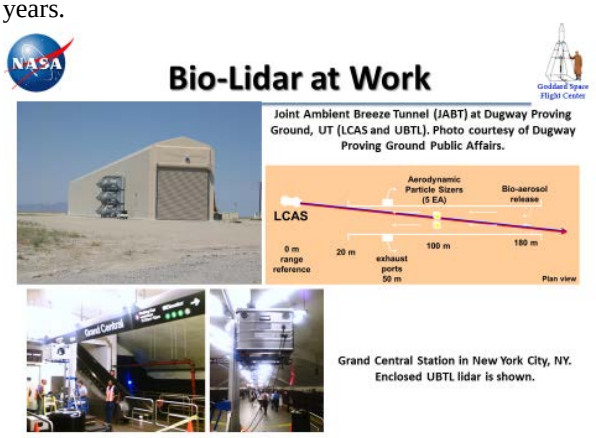

Figure 3. The Bio-Indicator Lidar Instrument calibration in the Joint Ambient Breeze Tunnel (JABT) at Dugway Proving Ground, UT, and operation in the Grand Central Station, New York City, NY.

Future opportunities and funding sources are Planetary and Astrobiology instrument development funding lines such as PICASSO. The types of mission opportunities to which this instrument could ultimately be proposed following appropriate maturation include (from the latest Planetary Decadal Survey): Enceladus water tail with Enceladus Flyby Sample Return, LIFE (Life Investigation For Enceladus), Water plumes on Europa with Europa Lander & Carrier Orbiter, Astrobiology Research Priorities for Primitive Asteroids, Icebreaker Life Mars lander mission, or a follow on to Mars 2020 rover.