Interrogating the Martian Subsurface using Muon Radiography. C. Naudet[1], H. Tanaka[2], S. Kedar[1], J. Plaut[1], C. E. Jones[1], and F. H. Webb[1], [1]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Dr., Pasadena, CA, [2]Earthquake Research Institute, University of Tokyo, ht@eri.u-tokyo.ac.jp

Introduction: Muon radiography is a technique that uses naturally occurring showers of muons, generated by cosmic rays, to image the interior of geological structures in much the same way as standard X-ray radiography. Unlike gamma rays and neutrons that penetrate only a few meters of rock, muons can traverse through up to several kilometers of a geological target. Recent developments [1] and applications [2] of the technique to terrestrial volcanoes, caves, and mines have demonstrated that a low-power, passive muon detector can image deep into kilometer-scale geological structures and provide unprecedentedly crisp density profile images of their interior. Preliminary estimates of muon production on Mars [3] indicate that the near-horizontal Martian muon flux, which is used for muon radiography of surface features, is close to that seen on Earth, making the technique suitable for geological exploration of Mars.

The muon telescope represents an entirely new class of instruments for planetary exploration [4], providing a wholly new type of measurement for delineation of potentially habitable subsurface environments through detection of caves, sub-surface ice, and water, and for the interpretation of composition and evolutionary state of the Martian surface. Muon radiography is a proven, simple, low cost, and efficient technology that could detect subsurface radiation-shielded habitable environments that would not be detectable by any other technique available today. Thanks to its low power and low data rate demands, it could be integrated as a secondary instrument on future missions with minimal impact on primary mission operations. A mission that includes a muon detector could set the stage for a future mission to directly explore subsurface habitable environments on Mars. Developing the technology now would position it favorably for a surface mission in the next decade to explore Martian regions with previously-identified potential trace gas sources, especially if they are associated with caverns, lava tubes, or hydrothermal vents.

References: [1] Tanaka, H., et. al. (2008) Am. Jour. Sci., V. 308, 843-850. [2] Tanaka, H., et. al. (2009) Geophys. Res. Lett., V 36 L01304. [3] Tanaka, H., et. al. (2007) Icarus 191 603-615 [4] Kedar, S., Tanaka, H. K. M., Naudet, C. J., Jones, C. E., Plaut, J. P., and Webb, F. H., Muon radiography for exploration of Mars geology, Geosci. Instrum. Method. Data Syst. Discuss., 2, 829–853, 2012