Mission Implementation Constraints on Planetary Muon Radiography

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Transitioning an instrument from a configuration used for laboratory-based or terrestrial field experiments to that suitable for extraterrestrial planetary studies is a difficult endeavor, requiring modifications to meet numerous mission requirements that are often at odds with optimal instrument design for science return. In the end, the instrument delivered to another planet often bears little resemblance to its terrestrial cousin. The challenge for the scientists and engineers is to maximize the science return while optimizing the design to meet the constraints imposed by the requirements to transport the instrument through interplanetary space and successfully operate it in the new environment. Here we discuss design considerations for a muon detector to do near-surface geological exploration on Mars. The cosmic ray muon generation mechanism requires that the detector be placed directly on the surface, so the additional constraints for lander or rover based operation will also be addressed.

The two overarching limitations on planetary instruments are mass and power. For planetary muon radiography the detector size, or footprint, is also limited by the size of the platform (lander or rover) and the area already devoted to primary mission instruments. Allowable detector size and mass are the constraints with the most straightforward impact on the science return. Although muon detectors already have low power requirements, meeting the practical goal of ~3-4 Watts for the entire instrument is a challenge that will require innovative design. At the same time, myriad additional constraints placed by the need to transport the detector from Earth to the surface of Mars will limit the choice of electronics and packaging. Here we focus on the most practical near-term scenario for using muon radiography to study geologically interesting features on another planet, in which muon radiography is a secondary capability added to a NASA Discovery Mars lander mission. A discussion of the issues and the possible trade-offs between various options will be presented.