

The MERLIN Phobos Ionizing Radiation Experiment (MPIRE) S. S. Smith¹, H. E. Spence¹, C. Zeitlin², N. A. Schwadron¹, ¹Space Science Center, University of New Hampshire, Durham, NH (sonya.s@unh.edu), ²Southwest Research Institute, Boulder, CO.

Introduction: The MERLIN Phobos Ionizing Radiation Experiment (MPIRE) closes a Strategic Knowledge Gap (SKG) for Mars' moons and the circum-Mars environment not addressed by other instruments on the proposed MERLIN mission. MPIRE measurement requirements and flight spare hardware both derive from the Cosmic Ray Telescope for the Effects of Radiation (CRaTER) instrument onboard the Lunar Reconnaissance Orbiter (LRO). CRaTER is *characterizing the global lunar radiation environment and its biological impacts*; MPIRE will accomplish the same objectives but in the Mars environment with the CRaTER flight spare unit, made available for MERLIN.

Goals: MPIRE will investigate the effects of galactic cosmic rays (GCR), solar energetic protons (SEP), and any secondary radiation produced by interactions between GCRs and SEPs at Phobos' surface using tissue equivalent plastic (TEP) to simulate shielding as in an astronaut's body or inside a moderately thick spacecraft hull. MPIRE accomplishes this by measuring linear energy transfer (LET) spectra over a wide dynamic range behind different areal densities of TEP and under different levels of solar activity and GCR flux.

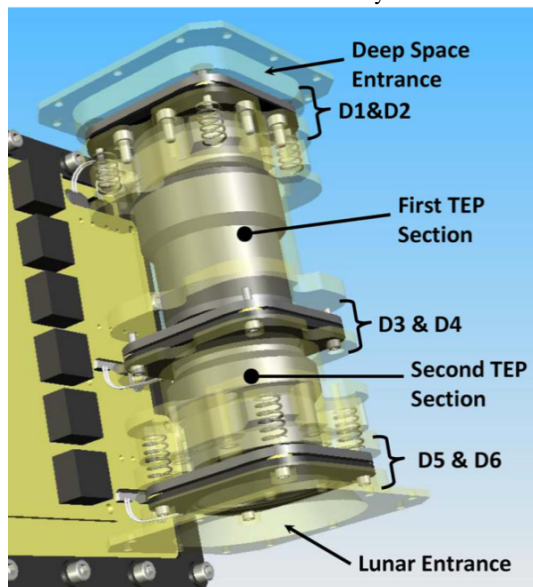


Figure 1. Transparent view of MPIRE telescope, showing pairs of thin (D1,D3,D5) and thick (D2,D4,D6) detectors sandwiching TEP volumes, and the associated electronics.

Design: Functionally, MPIRE consists of a stack of circular silicon semiconductor detectors and cylindrical sections of TEP arranged so the ends of the stack have unobscured views (see Figure 1). Radiation passing through the stack, including ions and electrons, and to a lesser extent neutrons

and gamma-rays, loses energy while passing through the silicon detectors. When ionizing radiation passes through a detector a signal is produced that is proportional to the total energy ΔE lost in the detector. Combined with the thickness Δx of the detector, an approximate LET is determined for the single particle where $LET = \Delta E/\Delta x$. Detectors are in pairs, with a thin detector connected to a low gain amplifier and a thick detector connected to a high gain amplifier. Together, the detector pairs and associated amplifiers provide sensitivity to a broad range of LET from approximately 0.1 keV/ μm to 2.2 MeV/ μm . A list of MPIRE accommodation and design parameters are found in Figure 2.

Parameter	Value
Low LET range (D2, D4, D6)	0.09 keV/ μm to 85 keV/ μm
High LET range (D1, D3, D5)	2.2 keV/ μm to 2.2 MeV/ μm
LET resolution	<0.3% of maximum in each range
Temperature Range	-25C to +50C operational -35C to +60C survival
Telemetry rate	High rate: 89.1 kbps Normal for Mars orbit: 200 bps Low for cruise: 20 bps
Max. event detection rate	1200/sec
Zenith full angle FOV	31.4°
Nadir full angle FOV	65.9°
Mass	5.53 kg
Power	6.66 W
Volume	24.1 X 23.0 X 15.9 cm
Alignment	On side deck, canted to align "nadir" with Phobos at 45° phase angle

Figure 2. MPIRE accommodation and design parameters

Science Products and Deliverables: By combining signals from different detectors to identify the path of individual particles, MPIRE will be used to understand how radiation loss evolves in human tissue and how dose rates change during periods of heightened solar activity and ultimately over the course of the solar cycle in the Mars' environment, not only filling a SKG but also complementing identical contemporary measurements at Earth's Moon. Key unique capabilities of MPIRE are the inclusion of the TEP to make biologically relevant radiation measurements and a telemetry rate sufficient to capture high resolution LET values for up to 1,200 events per second. Whereas previous instruments were hampered by the need to reduce LET resolution or the number of events recorded owing to telemetry constraints, MPIRE will be able to produce spectra with unprecedented high resolution in both LET and time enroute to and while in Mars' planetary system.

Spence et al. [1] derived level 2 and 3 instrument requirements on the LRO CRaTER (and by extension MPIRE)

instrument to meet its level 1 mission goals needed to characterize the deep space and Mars moon radiation environments, and to establish radiation effects on human tissue equivalent for exploration. All of the derived requirements are met by both the LRO flight model as well as more critically the instrument spare to be used for MERLIN. To acquire its measurements, MPIRE will operate continuously during cruise and Mars orbit phases. After landing on Phobos it will operate at times during daylight when power is not being drawn by arm motions for at least 3 hrs. We expect $\sim 150 \geq 3$ -hr radiation measurements over 214 sols of landed operations.

References: [1] Spence et al. (2010), *Space Science Rev.*, 150, 243-284.