Radiation Dosimetry From a Nanosat Lander System for Mars. Orlando Santos[1], Eric Benton[2], Lawrence Pinsky[3], Antonio Ricco[1], John Hines[1], Elwood Agasid[1], David Blake[1], Chris McKay[1], Pascale Ehrenfreund[4]. [1]Ames Research Center, Moffett Field, CA 94035 MS239-4, orlando.santos@nasa.gov. [2]Oklahoma State University, Dept of Physics, Stillwater, OK 74078, eric.benton@okstate.edu. [3]University of Houston, Physics Department, Houston, Texas 77204, pinsky@uh.edu. [4] George Washington University, 1957 E Street, NW Suite 403, Washington, D.C. 20052, pehren@gwu.edu.

Introduction

We propose to develop and fly in 2018 a nanosat package that can deliver a 2 cubesat sized science payload to the surface of Mars. The nanolander would be deployed from a Mars orbiter. This would be the first technology demonstration of the lander system, and accomplish real science in direct support of human exploration by making surface radiation measurements. Development of the nanolander system would begin (2018-2024) with easier to accomplish requirements (hard impactor-type landings, large landing ellipses), but be designed for steady progress in developing more stringent requirements (2024 and beyond). At first, one lander would be deployed, but one could envision dedicated orbiters with a fleet of nanolanders that could be deployed on command. In addition to radiation dosimetry, a suite of payloads could be developed including biological and chemical sensors, three major potential hazards for human exploration. The developed 2 cubesat-sized instruments could also be hand carried or deployed from small rovers. The flexible, standard cubesat packaging would allow for commercial payloads similar to NanoRacks on ISS.

2018 Radiation Dosimetry Nanolander Payload

Measuring radiation levels at the surface of Mars is necessary to ensure human safety. Subsurface composition significantly affects the generation of secondary particles from cosmic rays, which determine total dose and biological effect. The Mars Science Laboratory Mission will make important radiation measurements on the surface, but ultimately what is required are complete surveys of areas where human exploration will occur, as recommended by the National Research Council (1). We propose to develop a detector system based on the current Medipix2 and Medipix3 technologies (Figures 1 & 2), and their ongoing evolution, to make radiation measurements from a 2 cubesat landed package (2). NASA has identified the Medipix2 radiation detector and associated technology developed by the Medipix consortium at CERN as forming the basis for the next generation of space crew personal dosimeters and area radiation monitors. The Timepix version of this radiation dosimeter has been developed in cooperation with members of our team as the LUCID instrument (Figure 3) in a 1 cubesat package for the UK Tech Demo Satellite (3), and in 2012 NASA will test this version of Medipix2 aboard the International Space Station (ISS) in a Station Detailed Test Objective (SDTO) experiment [4]. The device can characterize radiation in terms of the charge of the incident particles and their energy spectrum. Sensitivity can be optimized for energetic protons and heavy ions ranging in energy from MeV/nucleon to GeV/nucleon. Importantly, this solid-state device can be hardened to survive relatively hard landings. Of course, the package would also be capable of taking measurements en route to Mars, and in Mars orbit.

Figures 1 & 2. Two diagrammatic views of the Medipix2 detector.

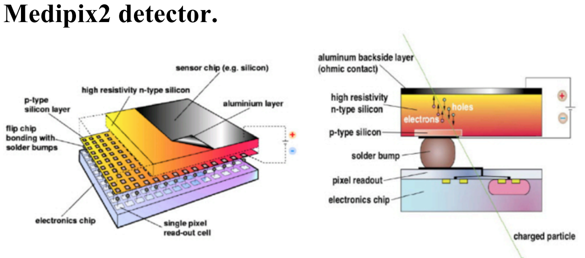

Figure 3: The LUCID instrument (from Pinsky *et al*, 2011).

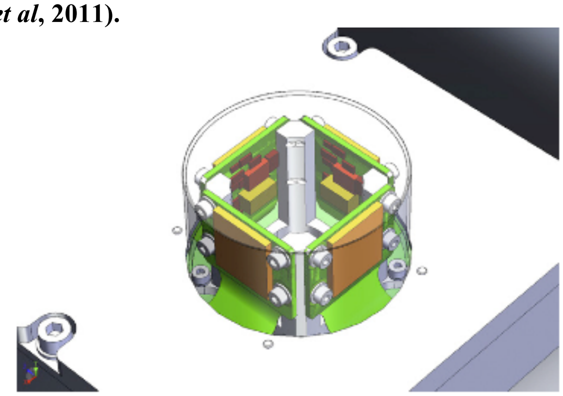

Fig. 3. The detector head of the LUCID instrument to be flown on the UK Tech Demo Sat is shown. There will be 5 TimePix-based detectors with 300 μm thick Si detector layers arrayed as shown on the 4 faces of a cubic lattice with current plans calling for the 5th detector to be placed on the base printed circuit board looking upward.

Phobos/Deimos

The nanolander payload could also be developed as a Phobos or Deimos lander. Alternatively, the radiation dosimeter could be packaged aboard another landed platform. In fact, the technology is ideally suited for all interplanetary missions.

Missions Beyond 2018

After the initial technology demonstration in 2018, we would propose a fleet of these radiation dosimetry nanolanders, in direct support of human exploration. Once a human landing site is selected, this technology would allow for several dosimeters to be landed covering the entire area of proposed human exploration at modest cost. Science packages to monitor other potential human threats such as biological or chemical hazards could also be deployed. Nanolanders could be held in orbit, ready to deploy to areas of initially unplanned sorties as the need arises.

Heritage

Ames Research Center is world renowned for entry, descent, and landing (EDL) systems, as well as nanosatellite development. Recent nanosatellite missions include GeneSat (5), PhamaSat (6), and O/OREOS (7, 8).

Fit with Challenge Areas

We believe we can move this example to the near-term time frame, beginning in 2018.

"Challenge Area 1: Instrumentation and Investigation Approaches —

5. In situ sample analysis for purposes of human health risk reduction to support crewed missions to Mars orbit (e.g., ionizing radiation, materials toxicity, etc). Recommended timing of such measurements is also of interest, as is a potential interaction/encounter with Phobos/Deimos."

We also address these near-term examples.

"Challenge Area 2: Safe and Accurate Landing Capabilities, Mars Ascent, and Innovative Exploration Approaches —

10. Concepts for public-private partnerships to provide infrastructure, services, instruments, or investigation platforms that can lower the cost and/or risk of future Mars exploration.

11. Lightweight, low-cost, probes or platforms (single or multiple), suitable to be carried by larger orbital or landed vehicles ("mother-ships").

12. Systems that enable low cost access to the surface of Mars at or below the current Discovery mission cost cap."

References

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