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| **Fiscal Year:** | FY 2007 | **Task Last Updated:** | FY 11/08/2007 |
| **PI Name:** | Pisacane, Vincent L. Ph.D. | | |
| **Project Title:** | Lunar EVA Dosimetry: MIcroDosimeter iNstrument (MIDN) System Suitable for Space Flight | | |
| **Division Name:** | Human Research | | |
| **Program/Discipline:** | NSBRI Teams | | |
| **Program/Discipline--Element/Subdiscipline:** | NSBRI Teams--Technology Development Team | | |
| **Joint Agency Name:** | | **TechPort:** | Yes |
| **Human Research Program Elements:** | (1) **SR**:Space Radiation | | |
| **Human Research Program Risks:** | (1) **ARS**:Risk of Acute Radiation Syndromes Due to Solar Particle Events (SPEs) | | |
| **Space Biology Element:** | None | | |
| **Space Biology Cross-Element Discipline:** | None | | |
| **Space Biology Special Category:** | None | | |
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| **Zip Code:** | 21402-1314 | **Congressional District:** | 3 |
| **Comments:** | PI retired October 2011 (Ed., 2/29/2012; information from NSBRI) | | |
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| **No. of Post Docs:** | 2 | **No. of PhD Degrees:** | 0 |
| **No. of PhD Candidates:** | 1 | **No. of Master' Degrees:** | 0 |
| **No. of Master's Candidates:** | 0 | **No. of Bachelor's Degrees:** | 8 |
| **No. of Bachelor's Candidates:** | 9 | **Monitoring Center:** | NSBRI |
| **Contact Monitor:** | | **Contact Phone:** | |
| **Contact Email:** | | | |
| **Flight Program:** | | | |
| **Flight Assignment:** | Note: title changed per NSBRI info (12/08)<br>NOTE: End date changed to 12/31/2008 per NSBRI (5/2008) | | |
| **Key Personnel Changes/Previous PI:** | | | |
| **COI Name (Institution):** | Cucinotta, Francis ( NASA JSC )<br>Rozenfeld, Anatoly ( University of Wollongong )<br>Ziegler, James ( USNA )<br>Nelson, Martin ( USNA )<br>Zaider, Marco ( Memorial Sloan-Kettering Cancer Institute )<br>Dicello, John ( USNA ) | | |
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**Task Description:**

A microdosimeter is perhaps the only active detector capable of directly determining the mean radiation quality of a mixed or unknown radiation field, and, therefore, the dose equivalent and effective dose from which the radiation risk can be assessed in real time. Objectives of this research project are to develop a rugged, portable, low power, low mass, solid-state microdosimeter suitable for an area sensor, as a spacecraft or habitat, and as a personnel monitor, such as a spacesuit, and to verify its performance through radiation source and beam tests. The original objectives were expanded to include a student-developed instrument for the MidSTAR-I spacecraft launched in February 2006 although only a short time was available for its design and production by the students. The a priori third-year objectives of the research plan extracted from last year's submittal were:
1. Support the launch of the MIDN-MidSTAR instrument. We caution that this experiment is a student built instrument and is consequently a high risk opportunity.

2. Support data acquisition and reduction of the MIDN-MidSTAR data.

3. Carry out additional radiation beam tests at Brookhaven National Laboratory.

4. Reconcile the radiation beam tests with digital simulations

During the year as experimental data was becoming available with the present system we added an additional task of identifying and initiating development of improved solid-state microdosimeter sensors. We have satisfied several but not all of our second year objectives. Recall that the MIDN-I instrument for the MidSTAR-I mission consisted of three sensor systems (one exterior to the spacecraft, the second internal to the spacecraft, and the third internal to the spacecraft in a polyethylene absorber) connected to a custom multi-channel analyzer with storage and command capability. The instrument was integrated into the spacecraft on an accelerated schedule as the spacecraft was behind schedule. We originally requested a voltage of +/-9V which late in the program were told that the spacecraft could not supply and agreed to +/-6V. During initial integration of the instrument we found that only +5V was available. The spacecraft power system was changed to also provide +/- 5V which was marginal for our instrument. Integration with the spacecraft communication system was successful and sample pulser data was retrieved prior to and subsequent to spacecraft vibration and thermal tests. However, the noise on the +/-5 V power lines had a significant ripple well outside of specifications that directly affected the MIDN lower energy cutoff. Because of the delays that had already occurred in designing and producing the spacecraft, the team decided to proceed with the described problems. We added filters to suppress this noise but they were only marginally effective. Introducing a battery powered interface to the spacecraft power system was not an option because of the late date at which we has access to the spacecraft for testing. As a result, we were forced to set our lower energy threshold significantly higher than originally planned and much above the performance level of the system itself.

The spacecraft was launched on 9 March 2007 from the Cape Canaveral Air Force Station on an Atlas-V Centaur launch vehicle as part of a 6 military spacecraft mission. Midstar's orbit is an altitude of 492 km at an inclination of 46 degrees. MIDN has two modes of operation. The first mode is with the electronic pulser activated, to evaluate overall instrument performance. The second mode is with the pulser off so that observations can be made. The instrument with the pulser turned on is working as anticipated but the data collection mode has not obtained useful data due to the high energy cutoff.

Analysis subsequent to launch based upon the spectra measured at the Brookhaven facility and our transport codes indicates that given the anticipated low proton fluxes at the spacecraft altitude, the expectation of collecting data is remote. The instrument continues to operate and so far has accumulated 39 days of observations. On occasion in the pulser mode, the instrument does provide spurious data that we attribute to the magnitude of the minus voltage being less than 5 V. Improvements continue to be made to the bench-top engineering model used for developmental testing at the Naval Academy and at the NSRL facility at Brookhaven National Laboratory. Our runs at the NSRL in March 2007 were with carbon at 290 MeV/n and protons at 1 GeV/n. As a result of the improvement that we had made in our instrumentation, we reduced our low energy cutoff to < 1 keV/micron; a significant accomplishment. In addition, we compare favorably with that published data on tissue samples. We have prepared a presentation for the Navy and DoD Space Experiments Review Boards (SERB) proposing a MIDN-II instrument for a spacecraft or Space Station Mission that is planned to be presented in July and November 2007.

Our plan for next year is to:

1. Continue to support data collection of the MIDN-I instrument on the MidSTAR-I spacecraft.

2. Petition the NAVY and DOD SERB for a flight on the Space Station or a spacecraft of opportunity.

3. Evaluate the new potential microdosimeter sensors developed by the Electrical Engineering Department at Johns Hopkins.

4. Complete design a MIDN-II that is battery powered with characteristics such as the lower-energy threshold and amplifier gain that can be monitored and changed by remote command along with a total end-to-end calibration that includes a light-source that can be turned on or off to directly test the functionality of the entire instrument.

5. Carry out additional radiation beam tests at Brookhaven National Laboratory and reconcile data with the radiation transport code Geant-4.

**Rationale for HRP Directed Research:**

**Research Impact/Earth Benefits:** A low powered, low mass, relatively inexpensive solid-state microdosimeter has medical applications in radiation oncology and protection from terrorism incidents involving radiation.

**Task Progress:**

MIDN-I on MidSTAR-I

1. The MIDN-I instrument was launched on the MidSTAR-I spacecraft.

2. Prior to launch and subsequent to vibration and thermal testing the instrument performed as anticipated but the low energy threshold had to be increased to reduce pile up due to noise much higher than we specified on the power lines from the spacecraft.

3. Filters added to reduce the noise were only partially effective.

4. Pulser data was consistent with pre-installation data and non-pulser data showed no counts.

5. In orbit the pulser, for the most part, has essentially reproduced the prelaunch observations but the non-pulser data has produced no observations.

6. We continue to collect observations and troubleshoot the performance of the instrument.

7. Ground based tests in which the ƒ{5 V supply has its magnitude reduced tend to reproduce many of the observed phenomenon.

8. Lessons learned: Need to insolate MIDN from the power supply by using batteries and utilize an LED in place of a pulser to obtain an end to end system test.

MIDN-II

1. Based on our experience with the MIDN-I development, we are designing an advanced version of the MIDN instrument called MIDN-II.

2. Requirements include: a. gain changed by remote command, b. lower-energy threshold changed by remote command, c. power supplied by dual sets of batteries with one charging while other provides power, d. exploring increased use of digital components to reduce low energy cutoff, e. use of a LED to excite the sensor to provide and end to end system test, and f. utilization of radiation hardened parts.

BENCHTOP DEVELOPMENT SYSTEM

1. By redesigning the Faraday cage that houses the sensor and preamplifier circuit and changing the cabling, we were able to reduce the inherent noise level.

2. We measured the energy deposited in a microdosimeter with radiation beams of Carbon at 290 MeV/n and degraded protons initially at 1 GeV/n at the NSRL facility at the BNL and achieved a lower energy cutoff of < 1keV/micron.


| Bibliography Type: | Description: (Last Updated: 07/24/2015) |
|---|---|
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