Fiscal Year:	FY 2006	**Task Last Updated:**	FY 01/08/2007
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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Organization Name:	United States Naval Academy		
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City:	Annapolis	**State:**	MD
Zip Code:	21402-1314	**Congressional District:**	3
Comments:	PI retired October 2011 (Ed., 2/29/2012; information from NSBRI)		
Project Type:	Ground	**Solicitation / Funding Source:**	2003 Biomedical Research & Countermeasures 03-OBPR-04
Start Date:	08/01/2004	**End Date:**	07/31/2008
No. of Post Docs:	2	**No. of PhD Degrees:**	1
No. of PhD Candidates:	1	**No. of Master' Degrees:**	0
No. of Master's Candidates:	0	**No. of Bachelor's Degrees:**	20
No. of Bachelor's Candidates:	11	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	Note: title changed per NSBRI info (12/08)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Cucinotta, Francis (NASA JSC) Rozenfeld, Anatoly (University of Wollongong) Ziegler, James (USNA) Nelson, Martin (USNA) Zaider, Marco (Memorial Sloan-Kettering Cancer Institute) Dicello, John (USNA)		
Grant/Contract No.:	NCC 9-58-TD00407		
Performance Goal No.:			
Performance Goal Text:			

Task Description:	A microdosimeter is perhaps the only active detector capable of directly determining the 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. The objectives of this research project are to develop a rugged, portable, low power, low mass, solid-state microdosimeter suitable for spaceflight and verify its performance through radiation source and beam tests. The original objectives were expanded to include development of an instrument for the MidSTAR-I spacecraft to be launched in October 2006. This flight will provide evaluation of a preliminary student built version of the instrument in the space environment. The a priori second-year objectives of the research plan were: 1. Complete qualification of the MIDN-MidSTAR instrument through vibration and thermal vacuum testing and integrate it into the MidSTAR spacecraft supporting efforts at the launch site, Cape Canaveral. 2. Continue development of the engineering and bench-top models to explore reductions in noise, power, and mass and increase sensitivity. 3. Develop the first version of the MIDN instrument to be used for beam tests in year 2. 4. Carry out preliminary testing at the Naval Academy with radiation sources and simulated pulses and carry out two trips to Brookhaven National Laboratory for additional beam tests. 5. Finalize implementation of the GEANT4 and MCNPX radiation transport codes and use the codes to help interpret the radiation test data. We have satisfied our second year objectives. The MIDN-MidSTAR instrument has been completed. Electrical tests, alpha source calibration tests have been carried out, the instrument has been vibration testes at the Naval Research Laboratory, and preliminary integration tests with the spacecraft are ongoing governed by the spacecraft development schedule. Integration with the spacecraft communication system was successful and sample pulser data was retrieved. The bench-top engineering model has been improved and used to carry out alpha calibration tests of the sensors at the Naval academy and in March at Brookhaven National Laboratory where we were assigned 24 hours of beam time of Fe. The bench-top system was also used in June for 32 hours of beam timeat Brookhaven of Fe, Ti, O, and protons. Because of schedule considerations and beam intensities of the Fe beam, we were did not test the MIDN-MidSTAR instrument at Brookhaven. Instead we carried out calibration tests with radioactive sources at the Academy and used the identical MIDN-MidSTAR sensor electronics during the beam tests at Brookhaven to assure its performance. The GEANT4 and MCNPX codes are operational and have been used to help interpret the experimental data. The space radiation transport code HZETRN was updated to more accurately represent the energy and charge spectra data measured by the Advanced Composition Explorer (ACE) for the last two solar cycles. The description of the energy and isotopic spectra of target fragment produced locally in a small detectors such as MIDN by high-energy protons and neutrons was improved using the quantum multiple scattering model of fragmentation (QMSFRG). QMSFRG has been extended to include a 190-isotopic grid and to add the contributions of nuclear coalescence for the production of 2-H, 3-H, 3-He, and 4-He fragments in nucleon and heavy ion induced reactions. In addition we were selected for potential of a flight on the Space Station by the Department of Defense Space experiments Review Board. In addition, we may have a flight opportunity on another small satellite that the Academy may build. Our plan for next year is to: 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.
Rationale for HRP Directed Research:	
Research Impact/Earth Benefits:	Experimental microdosimetric techniques are perhaps the only experimental methods for actively determining the radiation quality of mixed or unknown radiation fields and their dose equivalent. The radiation quality and the corresponding dose equivalent and/or effective doses form the basis of regulatory dose limits both in the U.S. and internationally as well as the basis for the evaluation of potential overexposures. Generally, in radiation fields with average quality factors greater than one, those radiation components with the highest quality may represent a component of the dose comparable to the dose uncertainty. For example, as the energy of x-ray therapy machines increases to accommodate intensity modulated radiotherapy and other new techniques, the contributions of secondary neutrons produced in the shielding materials to the whole-body exposure of the clinical personnel as well as the patients themselves increase. With a quality factor as high as twenty, a one or two percent neutron component can contribute as much as twenty to thirty percent of the dose equivalent. Likewise, in radiation storage and clean-up, it is the dose equivalent or effective dose, not the physical absorbed dose, that determines the need and level of clean up, yet it is the physical dose that is usually measured because of the difficulty in measuring dose equivalent in the field by personnel who are not experts in microdosimetry. Finally, the detection of radiation emitted by nuclear materials that may be used in terrorist activities requires cheap, reliable, and rugged microdosimeters that can determine small changes in the radiation environment and issue reliable alerts in real time. The use of prior methods is limited in part because of the complexity, sensitivity, and lack of reliability of the most commonly used instruments, gas proportional counters. The compact system that we have developed for space applications would likewise be applicable for the situations and measurements described in the previous paragraph.

Task Progress:	Accomplishments in year two of the project include: 1. MIDN-MidSTAR. a. Fabrication of the MIDN-MidSTAR instrument was completed. b. Electrical testing was completed. c. Calibration testing using an alpha source was completed. d. Vibration testing of instrument at the Naval Research Laboratory was completed. e. Initial integration of the instrument with the spacecraft communication system was initiated and will be carried out over the summer. f. The spacecraft was able to turn the instrument on, initiate the built-in pulser, instruct the instrument to collect and store data, and then transmit the data to the spacecraft memory which was recovered and compared exactly with what was expected. These intial tests demonstrated that the spacecraft power system had a major problem, now being addressed through a redesign. g. Continued testing will restart when the spacecraft power system is redesigned and the spacecraft flight harness completed. h. MIDN requires 1.1 Watt of power. 2. The bench-top system was completed and issues of variations in noise from chip to chip were successfully addressed. Calibration of the sensors with the bench-top system established the calibration and dynamic range of the MIDN-MidSTAR instrument. 3. Two proposals were written to solicit radiation beam time at the Brookhaven NASA Space Radiation Laboratory. Awarded were 24 hours in the Spring 2006, 32 hours Summer 2006, and 32 hours Fall 2006; the total amount of time requested in the proposal. 4. The bench-top system was used in the radiation beam tests at Brookhaven National Laboratory that included Spring and Summer campaigns: 24 hours of Iron at 1 GeV/nucleon; 8 hours of Iron at 0.6 GeV/nucleon; 8 hours of Oxygen at 1 GeV/nucleon; 8 hours of Titanium at 1 GeV/nucleon; 8 hours of protons at 1 GeV/nucleon 4. Radiation Transport Codes. Calculations were made using Geant4 and SRIM to compare the experimental data with the simulations. The Academy has been designated a beta site for the MCNPX radiation transport code. The space radiation transport code HZETRN was updated to accurately represent the energy and charge spectra data measured by the Advanced Composition Explorer (ACE) for the last two solar cycles. The description of the energy and isotopic spectra of target fragment produced locally in a small detectors such as MIDN by high-energy protons and neutrons was improved using the quantum multiple scattering model of fragmentation (QMSFRG). 5. The Navy and DoD Space Experiments Review Boards have each approved a version of the microdosimeter for a potential flight on the International Space Station for a shielding experiment. Funding must be secured. 6. Preliminary discussions have been held for inclusion of the MIDN instrument in a spacecraft called ParkinsonSat which the Academy may build. Again funds must be secured.
Bibliography Type:	Description: (Last Updated: 07/24/2015)
Articles in Peer-reviewed Journals	Wroe AJ, Cornelius IM, Rosenfeld AB, Pisacane VL, Ziegler JF, Nelson ME, Cucinotta F, Zaider M, Dicello JF. "Microdosimetry simulations of solar protons within a spacecraft." IEEE Transactions on Nuclear Science. 2005 Dec;52(6, Pt 1):2591-6. http://dx.doi.org/10.1109/TNS.2005.860706 , Dec-2005
Articles in Peer-reviewed Journals	Pisacane VL, Ziegler JF, Nelson ME, Caylor M, Flake D, Heyen L, Youngborg E, Rosenfeld AB, Cucinotta F, Zaider M, Dicello JF. "MIDN: a spacecraft microdosimeter mission." Radiat Prot Dosimetry, in press, Mar 2006. , Mar-2006
Awards	"Fulbright Fellowship and IEEE NSREC (Nuclear and Space Radiation Effects) Phelps Award for PhD students." Jan-2006
Awards	Pisacane V, MIDN project group. "Visit by Dr M. Griffin, NASA Administrator, to review MIDN project, March 2006." Mar-2006
Papers from Meeting Proceedings	Reinhard MI, Cornelius I, Prokopovich DA, Wroe A, Rosenfeld AB, Pisacane V, Ziegler JF, Nelson ME, Cucinotta F, Zaider M, Dicello JF. "Response of a SOI Microdosimeter to a 238 PuBe Neutron Source." 2005 IEEE NUCLEAR SCIENCE SYMPOSIUM AND MEDICAL IMAGING CONFERENCE (NSS/MIC), Puerto Rico, October 23 – 29, 2005. 2005 IEEE Nuclear Science Symposium Conference Record. volume 1, p. 68-72. http://dx.doi.org/10.1109/NSSMIC.2005.1596209 , Oct-2005