Fiscal Year:	FY 2010	**Task Last Updated:**	FY 12/09/2009
PI Name:	Borak, Thomas B. Ph.D.		
Project Title:	Lunar EVA Dosimetry: Design of a Radiation Dosimeter for Astronauts During Lunar Extravehicular Activities		
Division Name:	Human Research		
Program/Discipline:	NSBRI		
Program/Discipline--Element/Subdiscipline:	NSBRI--Radiation Effects 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		
PI Email:	tborak@colostate.edu	**Fax:**	FY 970 491 0623
PI Organization Type:	UNIVERSITY	**Phone:**	970-491-6450
Organization Name:	Colorado State University		
PI Address 1:	Environmental & Radiological Health Sciences		
PI Address 2:	1618 Campus Delivery		
PI Web Page:			
City:	Fort Collins	**State:**	CO
Zip Code:	80523-1618	**Congressional District:**	4
Comments:			
Project Type:	GROUND	**Solicitation / Funding Source:**	2006 Radiation Biology NNJ06ZSA001N
Start Date:	11/01/2007	**End Date:**	10/31/2011
No. of Post Docs:	0	**No. of PhD Degrees:**	0
No. of PhD Candidates:	1	**No. of Master' Degrees:**	1
No. of Master's Candidates:	2	**No. of Bachelor's Degrees:**	0
No. of Bachelor's Candidates:	0	**Monitoring Center:**	NSBRI
Contact Monitor:		**Contact Phone:**	
Contact Email:			
Flight Program:			
Flight Assignment:	NOTE: title changed per NSBRI (12/08)		
Key Personnel Changes/Previous PI:			
COI Name (Institution):	Braby, Leslie (Texas Engineering Experiment Station) Zeitlin, Cary (Lawrence Berkeley National Laboratory) Benton, Eric (Eril Research, Inc.) Miller, Jack (Lawrence Livermore National Laboratory) Heilbronn, Lawrence (Lawrence Livermore National Laboratory)		
Grant/Contract No.:	NCC 9-58-RE01301		
Performance Goal No.:			
Performance Goal Text:			

Task Description:

Task 1: Design, Fabrication and Testing Mod1 prototype detector
The purpose of this task was to design, build and assemble a prototype Tissue Equivalent Proportional Counter (TEPC) that would satisfy the basic specifications outlined by NASA for a dosimeter for astronauts during lunar EVAs.

The spherical TEPC is based on a single-wire anode with recessed guard ring insulators to shape the electric field near the poles. The diameter of the gas cavity is 18mm and the wall thickness is 3mm for a total diameter of 24mm (~ 1 inch). A stainless steel vacuum chamber designed to accommodate the TEPC and pre amplifier has been fabricated and leak tested. The hemispherical dome surrounding the TEPC has a wall thickness of 1 mm. This is welded to a cylindrical sleeve with a vacuum tight flange that can be easily removed whenever modifications to the components are necessary.

The unit has been assembled and leak tested using a He vacuum leak test system.

Initial signals were observed using neutrons from a PuBe source. The vacuum was stable for periods of several days. The gain of the proportional counter was reproducible after many repeated gas filling operations.

The detector was exposed to high energy charged particle beams at the HIMAC synchrotron in Chiba Japan. This included the following ions and energies: 14N (180 MeV/amu), 20Ne (180 MeV/amu), 28Si (600 MeV/amu), and 56Fe (500 MeV/amu). Measurements were taken at several angles of incidence to determine the angular response of the detector. These results were compared with similar measurements using a commercial TEPC that has a helical grid surrounding the anode to provide a uniform angular response. Analysis is continuing to evaluate how to reduce variations in response as a function of incidence angle.

We have begun the design of Mod 2 system based on the results of the experimental investigations with Mod 1. A new vacuum chamber has been successfully machined using Al with a wall thickness of 0.5mm. Mechanical parts for Mod 2 are being fabricated and assembly of the system is in progress.

Task 2: Modeling Detector Response

The objective of this task is to determine the response of the TEPC under ambient conditions and during SPE events on the lunar surface. Computations using the Monte Carlo Code PHITS have been made to determine the energy deposition in the TEPC using protons with an energy spectrum from a SPE in October 2003. These data were compared with the dose that would be delivered to the skin beneath a space suit with an areal density of 0.4 g/cm2. It is clear that a stainless steel vacuum chamber in Mod 1 needs to be replaced with lighter and thinner materials. These results will be important in determining what additional modifications will be necessary to achieve the design goal for real time measurements to the skin and BFO.

Task 3: Modeling the Variance-Covariance Method

The original proposal for the EVA dosimeter was based on the concept of having two independent proportional counters that would be used to obtain estimates of dose, D, and a quality factor, Q, based on estimating using the variance-covariance method. It was recognized that because of size limitations, the proportional counters would have to be located too close to one another to satisfy the condition that a single particle could not intercept both detectors. The additional constraint that one of the detectors must measure the dose at the skin surface and the other at a depth corresponding to the blood forming organs, makes the original variance-covariance method with paired detectors impractical.

We are developing a method based on using one detector in a variance-covariance scheme. The concepts are based on collecting the charge, zi, in a single TEPC for n successive time intervals. The method proposed by Borak at CSU separates the data set into two groups of n/2 entries of values for zi based on odd and even indices. The n/2 pairs of data (odd and even) are used to obtain the covariance and each of the two sets of n/2 values (odd or even) to estimate a variance. Monte Carlo codes have been written to test the algorithms and determine if there are any limitations to this process.

Rationale for HRP Directed Research:

Research Impact/Earth Benefits:

The instrument being proposed here is specifically designed to meet the dosimetry requirements inherent in Lunar EVA. However, the tissue equivalent chamber that forms the core can also be used as the basis for radiation area monitors aboard exploration spacecraft or as a TEPC on a robotic lander to assess the radiation environment on Mars or other planetary bodies. By adopting a single tissue equivalent chamber design, NASA can simplify the interpretation, evaluation, and comparison of dosimetric data collected aboard different spacecraft, since differences in detector operating principles, design, and sensitivity will be largely eliminated. In addition, the process of calibrating the detectors will be greatly simplified, since the all detectors will be of a common design. We view the development of this dosimeter system as being the next logical step in the evolution of space flight instrumentation for the measurement of space radiation.
Modifications to this dosimeter could be applied for in-situ dosimetry of patients undergoing heavy ion radiation therapy or measuring stray radiation near high energy particle accelerators.

Task 1: Design, Fabrication and Testing Mod1 prototype detector
The purpose of this task was to design, build and assemble a prototype Tissue Equivalent Proportional Counter (TEPC) that would satisfy the basic specifications outlined by NASA for a dosimeter for astronauts during lunar EVAs.

Mod 1 of the spherical TEPC is based on a single-wire anode with recessed guard ring insulators to shape the electric field near the poles. The unit was built, assembled and leak tested using a He vacuum leak test system. Initial signals were observed using neutrons from a PuBe source. The vacuum was stable for periods of several days. The gain of the proportional counter was reproducible after many repeated gas filling operations.

The detector was exposed to high energy charged particle beams at the HIMAC synchrotron in Chiba Japan. This included the following ions and energies: 14N (180 MeV/amu), 20Ne (180 MeV/amu), 28Si (600 MeV/amu), and 56Fe (500 MeV/amu). Measurements were taken at several angles of incidence to determine the angular response of the detector. These results were compared with similar measurements using a commercial TEPC that has a helical grid

Task Progress:	surrounding the anode to provide a uniform angular response. Analysis is continuing to evaluate how to reduce variations in response as a function of incidence angle. We have begun the design of Mod 2 system based on the results of the experimental investigations with Mod 1. A new vacuum chamber has been successfully machined using Al with a wall thickness of 0.5mm. Mechanical parts for Mod 2 are being fabricated and assembly of the system is in progress. Task 2: Modeling Detector Response The objective of this task is to determine the response of the TEPC under ambient conditions and during SPE events on the lunar surface. Computations using the Monte Carlo Code PHITS have been made to determine the energy deposition in the TEPC using protons with an energy spectrum from a SPE in October 2003. These data were compared with the dose that would be delivered to the skin beneath a space suit. It is clear that a stainless steel vacuum chamber in Mod 1 needs to be replaced with lighter and thinner materials. These results will be important in determining what additional modifications will be necessary to achieve the design goal for real time measurements to the skin and BFO. Task 3: Modeling the Variance-Covariance Method We are developing a method using a single detector in a variance-covariance scheme to obtain dose, D, and quality factor, Q. The method proposed by Borak at CSU separates the data from successive time intervals into two groups of entries based on odd and even indices. The odd-even pairs of data are used to obtain the covariance and either of the two sets of odd or even data are used to estimate a variance. Monte Carlo codes have been written to test the algorithms to insure that they reproduce the correct values of D and Q.
Bibliography Type:	Description: (Last Updated: 03/20/2019)
Dissertations and Theses	Manglass L, Borak TB. "Omni-directional sensitivity of a tissue equivalent proportional counter for personal dosimetry during EVA on the Moon." Thesis, Colorado State University, August 2009. , Aug-2009