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Space Environment Effects: Payoffs of UNSGC Research Infrastructure Awards

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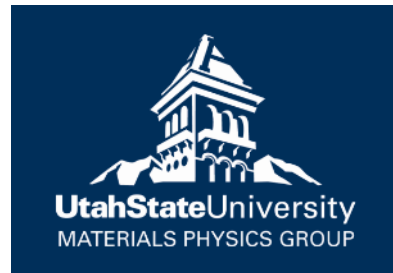


Space Environment Effects: Payoffs of UNSGC Research Infrastructure Awards

J.R. Dennison¹ and Elizabeth Vargis²

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²Biological Engineering, Utah State University



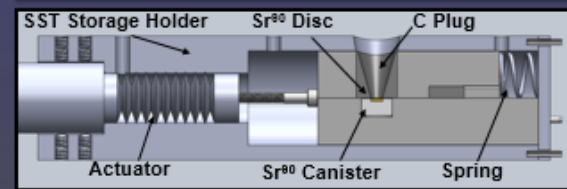
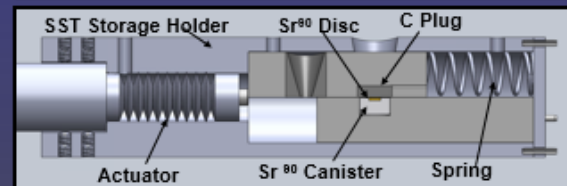
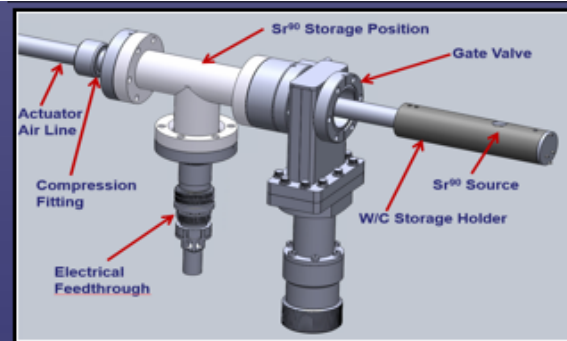
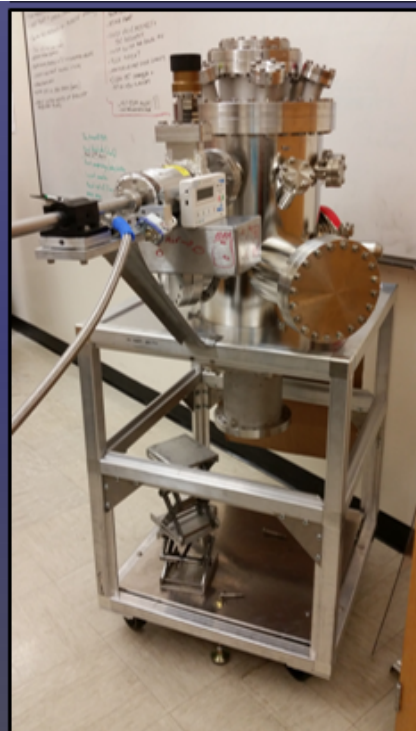
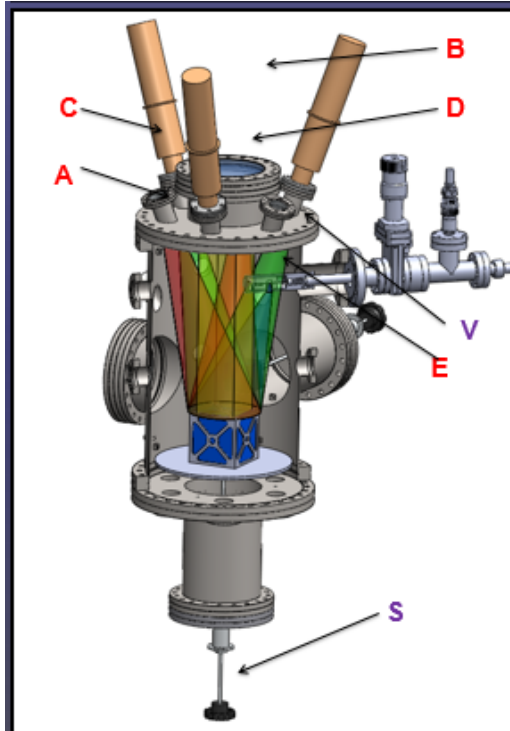
Utah NASA Space Grant Consortium Annual Meeting
Weber State University
May 7, 2018



USU Space Survivability Test Chamber

UNSGC 2016 Infrastructure Grant

Utah NASA Space Grant Consortium Faculty Research Infrastructure Award Program, "Space Survivability Test Facility for CubeSats, Components and Spacecraft Materials," JR Dennison, (April 2016 to April 2017).



Radiation Sources

- A High Energy Electron Gun
- A' Low Energy Electron Gun
- B UV/NIS/NIR Solar Simulator
- C FUV Kapton Discharge Lamps
- D Air Mass Zero Filter Set
- E Flux Mask
- E' Sr⁹⁰ Radiation Source

Analysis Components

- F UV/VIS/NIR Reflectivity Spectrometers
- G IR Emissivity Probe
- H Integrating Sphere
- I Photodiode UV/VIS/NIR Flux Monitor
- J Faraday Cup Electron Flux Monitor
- K Platinum Resistance Temperature Probe

Sample Carousel

- L Samples
- M Rotating Sample Carousel
- N Reflectivity/Emissivity Calib. Standards
- O Resistance Heaters
- P Cryogen Reservoir

Chamber Components

- Q Cryogen Vacuum Feedthrough
- R Electrical Vacuum Feedthrough
- S Sample Rotational Vacuum Feedthrough
- T Probe Translational Vacuum Feedthrough
- U Sapphire UV/VIS Viewport
- V MgF₂ UV Viewport
- W Turbomolecular/Mech. Vacuum Pump
- X Ion Vacuum Pump
- Y Ion/Convectron Pressure Gauges
- Z Residual Gas Analyzer

Chamber Components

- α CubeSat
- β CubeSat Test Fixture
- Γ Radiation Shielding
- Δ COTS Electronics
- ε Rad Hard Breadboard
- η COTS Text Fixture
- ⊙ Electron Gun

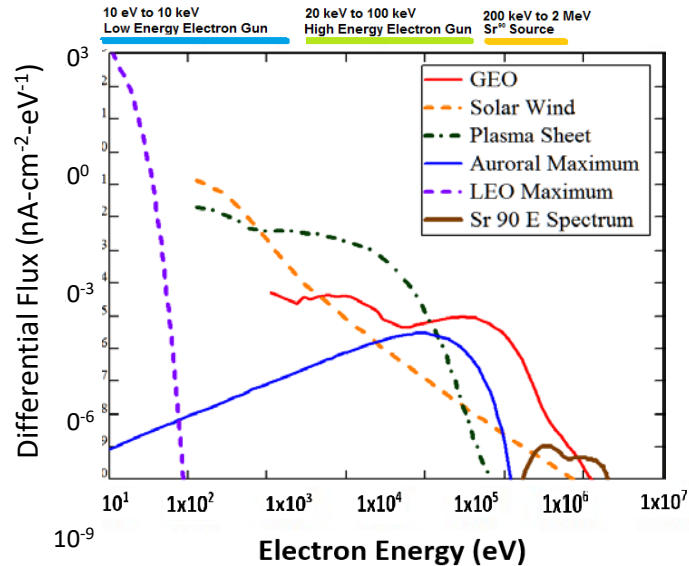
Instrumentation (Not Shown)

- Data Acquisition System
- Temperature Controller
- Electron Gun Controller
- UV/VIS/NIR Solar Simulator Controller
- FUV Kr Resonance Lamp Controller
- Spectrometers and Reflectivity Source



UNSGC 2016 Infrastructure Grant

Simulated Space Environment Fluxes



Electron Radiation

A high energy (~10-80 keV) and three lower energy (~10 eV to 5 keV) electron guns provide high electron fluxes.

Ionizing Radiation

A 100 mCi encapsulated Sr⁹⁰ β-radiation source (~200 keV to >2.5 MeV) mimics high energy (~500 keV to 2.5 MeV) geostationary electron flux [2].

Infrared/Visible/Ultraviolet Flux

A commercial Class AAA solar simulator provides NIR/Vis/UVA/UVB electromagnetic radiation (from 200 nm to 1700 nm) at up to 4 times sun equivalent intensity.

Far Ultraviolet Flux

Kr resonance lamps provide FUV radiation flux (ranging from 10 to 200 nm) at 4X sun equivalent intensity. Kr bulbs have ~3 month lifetimes for long duration studies.

Temperature Control

Temperature range from 60 K [4] to 450 K is maintained to ±2 K [3]. This is achieved through cartridge heaters, and chilled fluid pumped through a cold plate.

Controlled Atmosphere and Vacuum

Ultrahigh vacuum chamber allows for pressures <10⁻⁷ Pa to simulate LEO.

Video Discharge Monitoring

Using custom developed software, live video capture and processing of electrostatic discharge events allows for visual identification of discharge location and frequency.

Flexible Sample Mounting

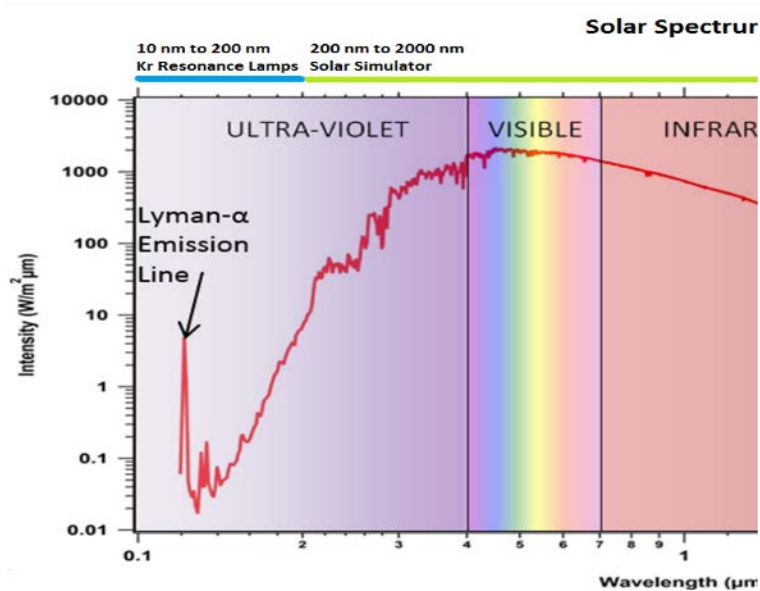
A rotating graphite carousel, ensures uniform irradiation and allows for custom mounting of samples. Or a flange mounted fixture allows for electrostatic discharge testing. Radiation source to sample distance is adjustable.

Biological Testing

Biological samples, which are vacuum incompatible, can use a custom designed chamber with controlled atmosphere and temperature.

Micro-gravity Simulation Testing

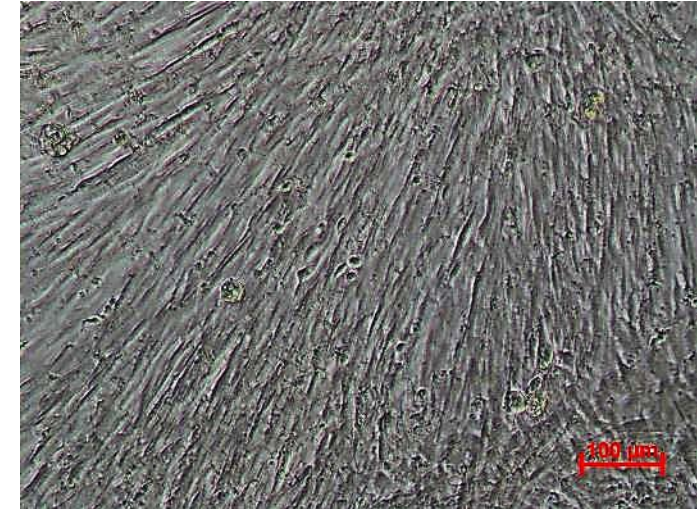
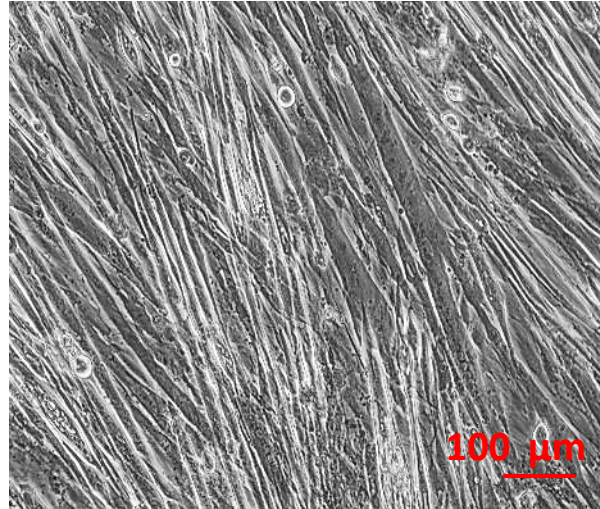
Biological sample cell for simulated micro-gravity



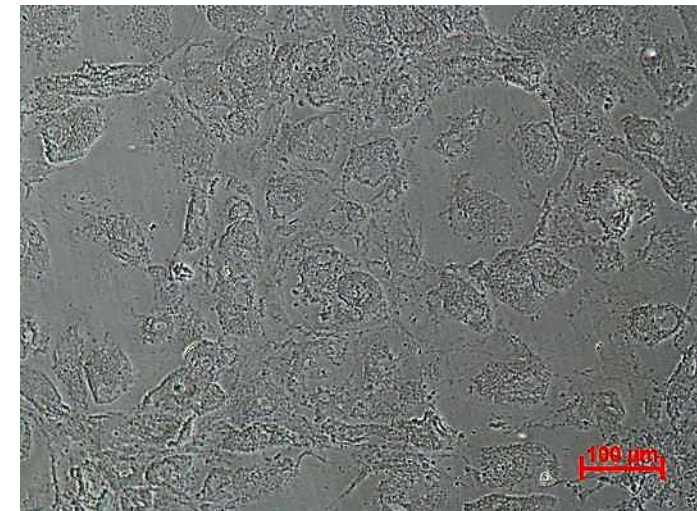
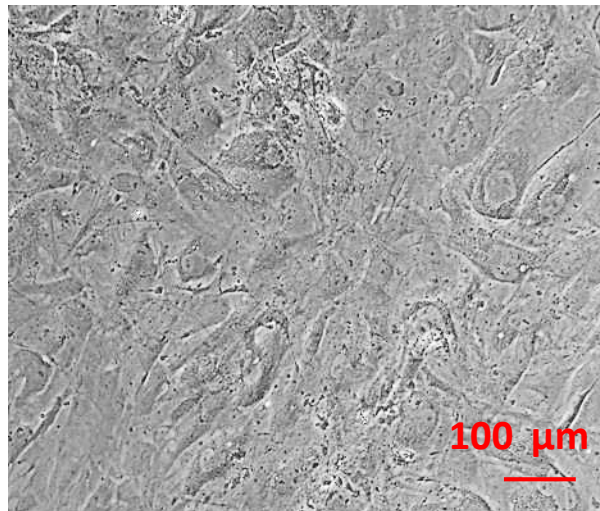
Space Environment Effects on Muscle and Skeletal Cells

- ***In-Vitro*** tests of muscles cells irradiated in the SST and biological test chamber have quantified space ionizing radiation effects.
- Studies of the effects of radiation on muscle cells will progress work in cardiovascular disease and degenerative tissue risks from space radiation and from microgravity.

C2C12
Skeletal
Muscle



CRL-1999
aortic
smooth
muscle



Control

2 Gy Radiation Exposure

UNSGC 2017 Infrastructure Grant

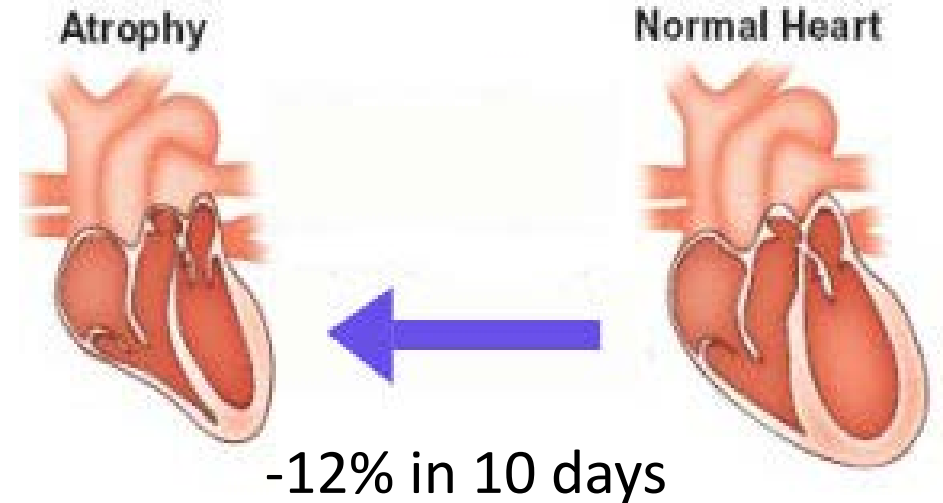
Effects of Simulated Space Environment on Biological Samples

Project goal is to evaluate the effects of simulated space environment and pharmaceutical countermeasures by studying the effect of space radiation and microgravity on cardiac and skeletal muscle cells *in vitro*.

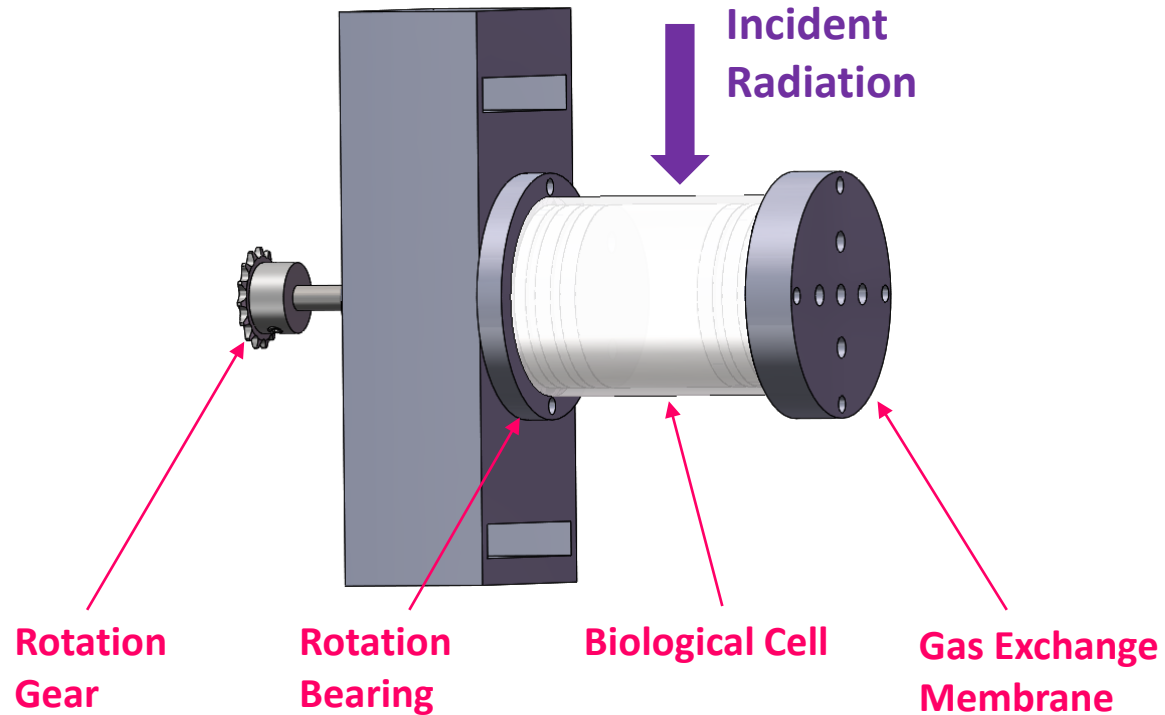
We propose:

- (i) Upgrade USU Space Survivability Test (SST) facility to accommodate biological samples
- (ii) Develop microgravity simulation cells for biological samples
- (iii) Test new and unique capabilities on biological samples.

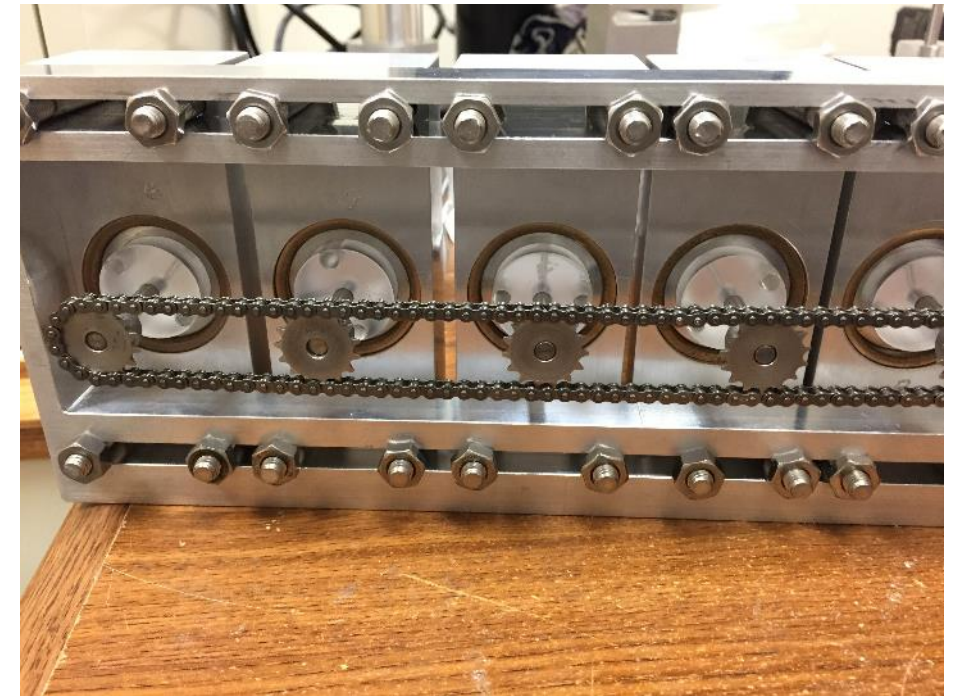
Utah NASA Space Grant Consortium Faculty Research Infrastructure Award Program, “Simulating the Space Radiation Environment on Human Cardiac and Skeletal Muscle,” Elizabeth Vargis, (April 2017 to April 2018).



Microgravity Simulation Cell for Biological Samples



- Radiation penetrates fully through biological vessel
 - Beta radiation (~200 keV to 2.5 MeV)
 - IR-Visible-UV radiation (~2000 nm to 120 nm)
- Temperature controlled environment
- Gas exchange membrane for controlled gas/vacuum environment
- Cells suspended in viscous biological medium
- Microgravity simulated using continuous rotation of vessel maintaining cells at their terminal settling velocity



Related Funding

RESEARCH FUNDING

Pending Funding

SpaceX, “UV Degradation of SpaceX Thermal Control Materials,” JR Dennison, (\$20,863, April 2018 to February 2019).

SpaceX, “Electron Emission Studies of SpaceX Coating Materials,” JR Dennison, (\$9,481, July 2018 to February 2019).

SpaceX, “Electron Transport Studies of Space X Coating Materials,” JR Dennison, (\$14,261, June 2018 to December 2018).

Times Microwave Systems, “Deep charging effects of GEOS environment on coaxial cable: Phase II,” JR Dennison, (\$25,000, March 2018 to September 2018).

American Heart Association, “Modeling the Long-Term Risk of Cardiovascular Disease following Radiation Treatments,” Elizabeth Vargis and JR Dennison, (\$200,000, June 2018 to May 2020).

NASA and the Human Research Program, NASA Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions, “Investigating the effects of combined microgravity and radiation on myocyte differentiation and morphology,” Elizabeth Vargis and JR Dennison, (\$300,000, June 2018 to June 2021).

Current and Recent Funding

Utah NASA Space Grant Consortium Faculty Research Infrastructure Award Program, “Effects of Space Ionizing Radiation on Cell Viability,” Elizabeth Vargas with JR Dennison, (\$20,000, April 2017 to April 2018).

Air Force Office of Scientific Research, Defense University Research Instrumentation Program (DURIP), “Enhanced Test Facility for Survivability and Characterization of Evolving Multiscale Materials in Extreme Plasma Environments,” JR Dennison, (\$498,869, January 2017-to December 2019).

Space Dynamics Laboratory IR&D, “Radiation Modification of Space Flight CCD Array,” JR Dennison, (\$8,450, July 2016 to March 2017).

Varex Imaging, “Electron Emission Studies of Low Electron Yield Layered Materials,” JR Dennison, (\$16,000, October 2017 to June 2018).

SpaceX, “Measurements of Electron Induced Arcing of SpaceX AIP Components,” JR Dennison, (\$35,481, August 2017 to February 2018).

SpaceX, “Studies of Electric Charging Properties of SpaceX Dielectric Coating Material,” JR Dennison, (\$34,444, January 2018 to August 2018).

Space Dynamics Laboratory, “Beta Radiation of Optical Materials,” JR Dennison, (\$5,500, February 2018 to August 2018).

Space Dynamics Laboratory, “UV Degradation of Optical Materials,” JR Dennison, (\$3,500, February 2018 to August 2018).

Past Funding

Space Dynamics Laboratory, “SteelHead GPS LNA and active components test,” JR Dennison, (\$3,479, July 2017 to December 2017).

Space Dynamics Laboratory IR&D, “Radiation Modification of Space Flight CCD Array,” JR Dennison, (\$8,450, July 2016 to March 2017).

ViaSat, “Simulated Space Radiation Effects on Spacecraft Components: Phase I and II,” JR Dennison, (\$76,191, May 2016 to December 2016); Phase III,” JR Dennison, (\$38,403, October 2016 to February 2017).

Lockheed Martin, “Electron Emission Studies of Orion Backshell Materials,” JR Dennison, (\$24,000, May 2016 to April 2017).

Utah NASA Space Grant Consortium Faculty Research Infrastructure Award Program, “Space Survivability Test Facility for CubeSats, Components and Spacecraft Materials,” JR Dennison, (\$20,931, April 2016 to April 2017).

Times Microwave Systems, “Deep charging effects of GEOS environment on coaxial cable,” JR Dennison, (\$35,593, May 2016 to December 2017).

Vanguard Space Technologies, “Evaluation of Space Radiation Environment Degradation of Solar Array Panels,” JR Dennison, (\$2,000, July 2015 to June 2016).

Declined Funding

NASA and the Human Research Program, NASA Research and Technology Development to Support Crew Health and Performance in Space Exploration Missions, “Optimized Cardiac Tissue Models to Evaluate Countermeasures to Weightlessness and Spaceflight Radiation,” Elizabeth Vargis and JR Dennison, (\$300,000, June 2018 to June 2021).

National Science Foundation (NSF) Biological and Environmental Interactions of Nanoscale Materials Program, Chemical, Bioengineering, Environmental and Transport Systems (CBET) Engineering Directorate, “Building a Muscle Atrophy Model to Develop and Test Medical Interventions,” Elizabeth Vargis, Jon Y. Takemoto, and JR Dennison, (\$300,000, June 2018 to June 2021).

STUDENT FUNDING:

Current Funding

NASA Utah Space Grant Consortium Graduate Student Fellowship, “Multilayer Models of Electron Emission and Charge Transport with Spacecraft Charging Applications.” (\$40,000, September 2015 to August 2019) [for Greg Wilson with J.R. Dennison].

USU Undergraduate Research and Creative Opportunities (URCO), “Relaxation of Radiation Effects in Polymer,” (\$2,000, May 2018 to December 2018) [for Alex Hughlett Nelson with Brian Wood and J.R. Dennison].

USU Undergraduate Research and Creative Opportunities (URCO), “Testing of Microcontrollers Radiation Damage Threshold to Determine Their Stability for Satellite Use,” (\$2,000, January 2018 to August 2018) [for Jonh Decana with Brian Wood and J.R. Dennison].

NASA Utah Space Grant Consortium Graduate Student Fellowship, “Effects of Space Ionizing Radiation on Cell Viability,” (\$20,000, September 2015 to August 2017) [for D. Harding with J.R. Dennison].

Past Funding

NASA Utah Space Grant Consortium Graduate Student Fellowship, “Electron Yield Measurements of High-Yield Low Conductivity Dielectric Materials.” (\$15,000, September 2015 to August 2016) [for Justin Christensen with J.R. Dennison].

USU Physics Department Undergraduate Student Summer Research Internship, “Development and Applications for the Space Survivability Test Chamber.” (\$2,000, May 2015 to August 2015) [for Heather Tippetts with J.R. Dennison].

USU Undergraduate Research and Creative Opportunities (URCO), “Temperature Dependence of Electrostatic Breakdown in Highly Disordered Polymers.” (\$2,000, January 2017 to June 2017) [for Trevor Kippen with Allen Andersen and J.R. Dennison].

USU Undergraduate Research and Creative Opportunities (URCO), “Degradation Effects of Ionizing Radiation on Commercially Available Spacecraft Components,” (\$2,350, June 2016 to December 2016) [for Alex Souvall with Greg Wilson and J.R. Dennison].

Related Publications

RELATED PUBLICATIONS

Submitted

Gregory Wilson and JR Dennison, "Electron Range Computational Tool for Arbitrary Materials over a Wide Energy Range," *15th Spacecraft Charging Technology Conference*, Kobe University, (Kobe, Japan, June 25-29, 2018).

Jacob Kleiman, Z. Iskanderova, L. Kirshtein, Brian Wood, JR Dennison, and Carl. Best, "Long-term Stability in GEO-simulated Environment of Space Polymers Treated by Ion-beam Techniques," *Proceedings of 12th International Conference on Protection of Materials from Space Environment (ICPMSE)*, Biarritz, France, October, 2018.

Brian Wood, Justin Christiansen, Greg Wilson, T.C. Shen, and JR Dennison "Secondary Electron Yield Measurements of Carbon Nanotube Forests: Dependence on Morphology and Substrate," *15th Spacecraft Charging Technology Conference*, Kobe University, (Kobe, Japan, June 25-29, 2018).

Published

Greg Wilson and JR Dennison, "Electron Range Model," *Proceedings of the Utah NASA Space Grant Consortium Research Symposium*, May 5, 2018, Orbital ATK Conference Center, Ogden, UT, 9 pp.

Greg Wilson and JR Dennison, "Hemispherical Grid Retarding Field Analyzer Redesign for Secondary Electron Emission Studies," *Proceedings of the Utah NASA Space Grant Consortium Research Symposium*, May 8, 2017, Weber State University, Ogden, UT, 9 pp.

Robert H. Johnson, Lisa D. Montierth, JR Dennison, James S. Dyer, and Ethan Lindstrom, "Small Scale Simulation Chamber for Space Environment Survivability Testing," *IEEE Trans. on Plasma Sci.*, **41**(12), 2013, 3453-3458.

JR Dennison, Kent Hartley, Lisa Montierth Phillipps, Justin Dekany, James S. Dyer, and Robert H. Johnson, "Small Satellite Space Environments Effects Test Facility," *Proceedings of the 28th Annual AIAA/USU Conference on Small Satellites*, (Logan, UT, August 2-7, 2014), 7pp.

Robert H. Johnson, Lisa D. Montierth, JR Dennison, James S. Dyer, and Ethan Lindstrom, "Small Scale Simulation Chamber for Space Environment Survivability Testing," *Proceedings of the 12th Spacecraft Charging Technology Conference*, (Kitakyushu, Japan, May 14-18, 2012), 6 pp.

JR Dennison, John Prebola, Amberly Evans, Danielle Fullmer, Joshua L. Hodges, Dustin H. Crider and Daniel S. Crews, "Comparison of Flight and Ground Tests of Environmental Degradation of MISSE-6 SUSpECS Materials," *Proceedings of the 11th Spacecraft Charging Technology Conference*, (Albuquerque, NM, September 20-24, 2010), 12 pp.

Amberly Evans and JR Dennison, "The Effects of Surface Modification on Spacecraft Charging Parameters," *Proceedings of the 11th Spacecraft Charging Technology Conference*, (Albuquerque, NM, September 20-24, 2010), 5 pp.

Related Presentations

Accepted

Jacob Kleiman, Z. Iskanderova, L. Kirshtein, Brian Wood, JR Dennison, and Carl. Best, “Long-term Stability in GEO-simulated Environment of Space Polymers Treated by Ion-beam Techniques,” *12th International Conference on Protection of Materials from Space Environment* (ICPMSE), Biarritz, France, October, 2018.

Gregory Wilson and JR Dennison, “Electron Range Computational Tool for Arbitrary Materials over a Wide Energy Range,” *15th Spacecraft Charging Technology Conference*, Kobe University, (Kobe, Japan, June 25-29, 2018).

Brian Wood, Justin Christiansen, Greg Wilson, T.C. Shen, and JR Dennison “Secondary Electron Yield Measurements of Carbon Nanotube Forests: Dependence on Morphology and Substrate,” *15th Spacecraft Charging Technology Conference*, Kobe University, (Kobe, Japan, June 25-29, 2018).

Presented

Greg Wilson and JR Dennison, “Electron Range Model,” *Utah NASA Space Grant Consortium Research Symposium*, May 5, 2018, Orbital ATK Conference Center, Ogden, UT.

Lori Caldwell , Charles Harding, Eryn Hanson, A Nelson, JR Dennison, E Vargis. “Characterizing the Effects of Radiation on Muscle Cells,” Institute of Biological Engineering. April 2018

Lori Caldwell , Charles Harding, Eryn Hanson, A Nelson, JR Dennison, E Vargis. “Characterizing the Effects of Radiation on Muscle Cells,” *USU Student Research Symposium*, Logan, UT, April 12, 2018.

Jonh Carlos Mojica Decana, Brian Wood, Ryan Martineau, Michael Taylor, and JR Dennison, “Tests of Radiation Damage Threshold of Raspberry Pi Zero in LEO Environment for OPAL CubeSat Project,” *Space Weather Workshop*, Westminster, CO, April 16-20, 2018.

Jonh Carlos Mojica Decana, Brian Wood, Ryan Martineau, Michael Taylor, and JR Dennison, “Radiation Damage Threshold of Satellite COTS Components: Raspberry Pi Zero for OPAL CubeSat,” *USU Student Research Symposium*, Logan, UT, April 12, 2018.

Tyler Kippen, Allen Andersen and JR Dennison, “The Effects of the Beta Transition on Dielectric Breakdown in LDPE,” *USU Student Research Symposium*, Logan, UT, April 12, 2018.

Lori Caldwell, Charles Harding, JR Dennison, Elizabeth Vargis, “Characterizing the Effects of Radiation on Muscle Cells,” Biomedical Engineering Society (BMES) Annual Meeting, Phoenix, AZ, October 11-14, 2017.

Lori Caldwell, Elizabeth Vargis, Charles Harding, and JR Dennison, “Characterizing the Effects of Radiation on Muscle Cells,” 33rd Annual Meeting of the American Society for Gravitational and Space Research, Seattle, WA, October 25-28, 2017

Tyler Kippen, Allen Andersen and JR Dennison, “Temperature Dependence of Electrostatic Discharge in Highly Disordered Polymers,” American Physical Society Four Corner Section Meeting, Colorado State University, Fort Collins, CO, October 20-12, 2017.

Brian Wood, JR Dennison, Justin Christensen, and Greg Wilson, “Electron Yield Measurements of Vertically Aligned Multi-Walled Carbon Nanotubes,” *American Physical Society Four Corners Meeting*, Colorado State University, Fort Collins, CO, October 20-21, 2017.

JR Dennison, “Enhanced Test Facility for Survivability and Characterization of Evolving Multiscale Materials in Extreme Plasma Environments,” 2017 Aerospace Materials for Extreme Environments Program Review, Air Force Office of Scientific Research, Kirtland Air Force Base, Albuquerque, NM, May 15, 2017.

Alex Souvall, Ben Russon, Greg Wilson, Brian Wood and JR Dennison, “Myriad Investigations Using the USU Space Survivability Tests Facility,” *Utah NASA Space Grant Consortium Research Symposium*, May 8, 2017, Weber State University, Ogden, UT.

Windy Olsen and JR Dennison, “Microcontroller and Memory Card Survivability in Space Conditions,” *USU Student Research Symposium*, April 13, 2017, Logan, UT.

David King and JR Dennison. “Temperature Dependent Conductivity of Polymers,” *USU Student Research Symposium*, April 13, 2017, Logan, UT.

Alexandra Hughlett and JR Dennison, “Reduction of Radiation Effects in Polymers,” *USU Student Research Symposium*, April 13, 2017, Logan, UT.

JR Dennison, “Satellite Survivability in a Harsh Space Environment: A Materials Perspective,” *Invited Talk*, SDL-USU Technical Lecture Series, Logan, UT, February 28, 2017.

Tyler Kippen, Allen Andersen, and JR Dennison, “Temperature Dependency of Electrostatic Breakdown in LDPE and PEEK,” *Utah Conference on Undergraduate Research (UCUR) Meeting*, Brigham Young University, Provo, UT, February, 28, 2017.

Alexander Souvall, Takuyuki Sakai, Takahiro Shimizu, Yuta Takahashi, Midori Morikawa, Shusuke Okita, Akihiro Nagata, Toshihiro Kameda, Shaunda Wenger and JR Dennison, “Space Environment Effects of Ionizing Radiation on Seed Germination and Growth,” Utah Research on Capitol Hill, Salt Lake City, UT, January 26, 2017.

Gareema Dhiman, Michelle Jung, Andre Nguyen, Shaunda Wenger, Alexander Souvall, JR Dennison, Takuyuki Sakai, Takahiro Shimizu, Yuta Takahashi, Midori Morikawa, Shusuke Okita, Akihiro Nagata, and Toshihiro Kameda, “Effects of Space Travel on Seed Germination and Viability,” *Logan School Board Forum*, Logan High School, Logan, UT, January 10, 2016.

Alexandra Hughlett, Tyler Kippen, and JR Dennison, “Relaxation of Radiation Effects on the Optical Transmission of Polymers,” *American Physical Society Four Corner Section Meeting*, New Mexico State University, Las Cruces, NM, October 21-22, 2016.

Alexander Souvall, Takuyuki Sakai, Takahiro Shimizu, Yuta Takahashi, Midori Morikawa, Shusuke Okita, Akihiro Nagata, Toshihiro Kameda, Shaunda Wenger and JR Dennison, “Space Environment Effects of Ionizing Radiation on Seed Germination and Growth,” *American Physical Society Four Corner Section Meeting*, New Mexico State University, Las Cruces, NM, October 21-22, 2016. *Presentation received award for outstanding Undergraduate Talk.*

Harding C* and E Vargis. *In Vitro* Modeling of Microgravity-Induced Muscle Atrophy and Spaceflight Radiation. *American Society for Gravitational and Space Research Annual Meeting (ASGSR) Annual Meeting*. October 2016

Alex Souvall, Gregory Wilson, Ben Russon, Katie Gamaunt, and JR Dennison, “CubeSat Space Environments Effects Studied in the Space Survivability Test Chamber,” USU Fall Undergraduate Research Orientation, Logan, UT, September 9, 2016.

JR Dennison, Gregory Wilson, Alex Souvall, Ben Russon, and Katie Gamaunt, “CubeSat Space Environments Effects Studied in the Space Survivability Test Chamber,” Paper Number SSC16-P-, 30th Annual AIAA/USU Conference on Small Satellites, (Logan, UT, August 6-11, 2016).

Katie Gamaunt, Krysta Moser, Alex Souvall and JR Dennison. “UV Degradation Effects: Surface vs. Space Environment,” *USU Student Research*

L. H. Pearson, J. R. Dennison, E. W. Griffiths and A. C. Pearson, “Pulsed Electroacoustic System Modeling an dSignal Processing for Volume Charge Distribution Measurement in Thin Dielectric Films,” *14th Spacecraft Charging Technology Conference*, Space Research and Technology Centre of the European Space Agency (ESA/ESTEC), (Noordwijk, Netherlands, April 4-8, 2016).

Heather Tippets with JR Dennison, “Developing a Safe Test System for High-energy Electron Flux Environments Testing,” Research and Creative Works Conference, Brigham Young University-Idaho, Rexburg, ID, March 30, 2016.

JR Dennison, “The Role of Space Materials Research in Spacecraft Charging and Satellite Survivability,” Keynote address, *JAXA 12th Space Environment Symposium*, Laboratory of Spacecraft Environment Interaction Engineering, Kitakyushu, Japan, November 16, 2015.

Harding C*, Takemoto J, and E Vargis. Prevention of Oxidative Stress and Microgravity-Induced Muscular Atrophy with Mesobiliverdin-IXa. *American Society for Gravitational and Space Research Annual Meeting*. November 2015 – *3rd Place Winner*

Harding C*, Takemoto J, and E Vargis. Prevention of Microgravity-Induced Muscular Atrophy with Mesobiliverdin-IXa. *Hansen Life Sciences Retreat*. September 2015 - *Poster Award Winner*

Alex Souvall, Greg Wilson, Katie Gamaunt, Ben Russon, Heather Tippets and JR Dennison, “Properties of Spacecraft Materials Exposed to Ionizing Radiation,” *American Physical Society Four Corner Section Meeting*, Arizona State University, Tempe, AZ, October 16-17, 2015.

Ben Russon, Heather Tippets, Greg Wilson, Katie Gamaunt, Alex Souvall and JR Dennison, “Measurement of Effects of Long Term Ionizing Radiation on High Efficiency Solar Arrays,” *American Physical Society Four Corner Section Meeting*, Arizona State University, Tempe, AZ, October 16-17, 2015.

Katie Gamaunt, Heather Tippets, Alex Souvall, Ben Russon and JR Dennison, “The Space Survivability Test Chamber,” *American Physical Society Four Corner Section Meeting*, Arizona State University, Tempe, AZ, October 16-17, 2015. *Presentation received award for outstanding Undergraduate Poster.*

JR Dennison, Crystal Frazier, Erik Stromberg, Ben Russon, Heather Tippets, Lisa Phillipps, Alex Souvall, and James S. Dyer, “Small Satellite Verification and Assessment Test Facility with Space Environments Effects Ground-testing Capabilities,” Paper Number SSC15-P-2, *29th Annual AIAA/USU Conference on Small Satellites*, (Logan, UT, August 8-13, 2015).

Lisa Phillipps, JR Dennison, Kent Hartley, Robert H. Johnson, Justin Dekany and James S. Dyer, “Space Effects Survivability Testing,” American Physical Society Four Corner Section Meeting, Utah Valley University, Orem, UT, October 17-18, 2014.

USU Materials Physics Group

(Back row Left to Right) **Ben Russon**, Heather Zollinger, Zack Gibson, Matthew Robertson, Jordan Lee, David King

(Front row Left to Right) **Justin Christensen**, **Alexandra Hughlett Nelson**, **Alex Souvall**, **Greg Wilson**, Allen Andersen, JR Dennison, Windy Olsen

(Not pictured) Brian Wood, Vladimir Zavyalov, Jodie Gillespie, **Jonh Mojica Decena**, **Katie Gamaunt**, **Davis Muhwezi**, **Tyler Kippen**

USU Bioengineering Vargis Group

(Back row Left to Right) Matt, Farhad, **Charles**, Connor, **Eryn**

(Front row Left to Right) Anna, **Lori**, Cindy, Gareema, EV, Chase

UNSGC Student Support

Charles Harding, MS BioEng student in Dr. Vargis' lab.

Lori Caldwell, BS/MS BioEng student in Dr. Vargis' lab.

Greg Wilson, PhD Physics student in Materials Physics Group

Eryn Hanson, BS/MS BioEng student in Dr. Vargis' lab.

Alex Nelson, BS Physics/MAE student in Materials Physics Group

Alex Souvall, BS Physics/MAE student in Materials Physics Group

(UNSGC Supported)



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