The space radiation environment is very different from the terrestrial radiation environment. It includes high-energy protons from solar activity as well as energetic heavy ions from galactic cosmic sources and their secondaries generated in vehicle structures. The success of future human exploration missions, especially future missions beyond low Earth orbit will depend on technologies that will allow astronauts to safely live and work in the space radiation environment. Technologies that will allow NASA to measure the biological effects of the unique types of radiation in the space environment are necessary to elucidate the types of countermeasures that are required and their efficacy. Subtopic X13.01, Radiation Health, seeks innovative technologies for increasing the throughput and capabilities in heavy ion beam experiments for radiobiology at the Brookhaven National Laboratory, automated and high-throughput techniques for identifying small scale cellular radiation damage from protons or heavy ions, and radiation dosimeters for manned and unmanned spaceflight.

**Subtopics**

**X13.01 Space Radiation Health Research Technology**

**Lead Center:** JSC  
**Participating Center(s):** ARC, LaRC

The goal of the NASA Space Radiation Research Program is to assure that we can safely live and work in the space radiation environment, anywhere, any time. Space radiation is distinct from terrestrial forms of radiation, being comprised of high-energy protons and heavy ions and their secondaries produced in shielding and tissue. The Radiation Program Element uses the NASA Research Announcement as a primary means of soliciting research to reduce the uncertainties in risk projections, however, there are specific areas where the SBIR technologies can potentially contribute to NASA's overall goal:

**Ground-based Heavy Ion Accelerator Research Support Equipment**

NASA utilizes Facilities at Brookhaven National Laboratory (BNL) (for more information see [www.bnl.gov/medical/NASA/NSRL_description.asp](http://www.bnl.gov/medical/NASA/NSRL_description.asp)) to conduct fundamental radiobiology and physics experiments. However the Facilities at BNL were not developed with NASA's high number of investigators in mind, thus there are areas where technology developments can improve efficiency and throughput. Technologies of specific interest include, but are not limited to, the following:
• Advanced animal support equipment, sample holders, live imaging of samples on the beam line during heavy ion irradiation, or specimen transport systems that allow remote transport into and out of the target areas and precise positioning of specimens in the beam line with minimal human interaction in the target areas;

• Environmental control for cell studies while in the beam line, and automated fixation capabilities to perfuse small cell and tissue samples directly after exposure to the ion beam;

• Advanced detector systems to provide rapid assessments of elemental fluence spectra and neutron fluence spectra following heavy ion irradiation of biological or shielding samples.

**High Throughput Genomic Analysis Techniques**

Following low dose irradiation of cells by protons and heavy ions, damage is localized to only a very few cells. The ability to separate cells with or without genetic changes in an automated manner is of interest. Current technologies are inefficient in identifying small-scale genetic changes (less than several thousand base-pairs (Mbp)) under these conditions. Technologies of interest are:

• Complementary technologies to the fluorescence in situ hybridization (FISH) method used to score large scale (>1 Mbp) genetic changes to chromosomes following low dose irradiation in order to rapidly score small-scale genetic changes;

• Imaging techniques to rapidly identify with high accuracy undamaged cells from a cell population irradiated at low doses.

**Reliable Radiation Dosimeters for Manned and Unmanned Spaceflight**

Current environment dosimeters have exceeded their designed lifetimes and should be replaced. These include small active dosimeters to monitor individual astronauts’ exposure, Tissue Equivalent Proportional Counters (TEPC), Charged Particle Directional Spectrometer (CPDS) capable of internal and external deployment, and externally deployed electron and neutron detectors. New software needs to be fault tolerant and updated to current operating systems, new hardware and software must be fully documented (schematics, etc.). Areas of interest are:

• Advanced spaceflight detector systems to provide reliable environment data for a specific spectrum of energies, including real time dosimetry providing dose and particle types, and energies and cumulative dosimeters, for characterizing space environments for use onboard spacecraft and planetary surfaces, as well as alarm systems for Solar Particle Events. Dosimeters should provide time resolved linear energy transfer (LET) data and have embedded LET-based quality factor algorithms for determining dose equivalent. The expected radiation environment includes protons from 10 Mev to 1 GeV, electrons from .5 Mev to 7 Mev, primary and secondary HZEs (He to Fe) from 10 Mev/amu to 1 Gev/amu and secondary neutrons from 1 Mev to 200 Mev. NASA acknowledges the difficulty in measuring secondary neutrons from interactions of protons and heavy ions with spacecraft structures and has particular interest in this area.