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) to conduct fundamental radiobiology and shielding 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;
- Controlled beam line access that provides safe, but rapid and reliable human access to the beam target areas and lockout during specimen exposure; and
- 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.

**Radiation Shielding and Fabrication**

The NASA Space Radiation Research Program uses the NASA Research Announcement (NRA) as the primary means of soliciting research to conceive and radiation-test new radiation shielding materials concepts. The materials concepts include new and innovative lightweight radiation shielding materials to shield humans in crew exploration vehicles, large space structures such as space stations, orbiters, landers, rovers, habitats, and spacesuits. The materials emphasis is on non-parasitic radiation shielding materials, or multifunctional materials, where one of the functions is the radiation shielding, but also serves as structural and other functional components of flight and/or habitat systems. The specific areas in which SBIR-developed technologies can contribute to NASA's overall mission requirements for advanced radiation shielding materials technologies are:

- Characterization of the physical, chemical and relevant functional properties and the validation and qualification of such multi-functional radiation shielding materials;
- New and innovative manufacturing techniques for producing quality-controlled advanced radiation shielding products and structural components, including innovative scale-up methods for producing quality-controlled viable quantities of advanced radiation shielding materials;
- New and innovative processing methods for producing quality-controlled advanced radiation shielding materials of all forms - resins, fibers, fabrics, composites and fiber-reinforced composite materials;
- New and innovative fabrication techniques for fabricating advanced radiation shielding materials into useful products and structural components; and
- New and innovative commercialization strategies to introduce advanced radiation shielding materials technologies into the marketplace to enable availability of the technologies for use by NASA and the space exploration community.

**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; and

• Microdosimetry for operational and research applications, including implantable dosimeters for biological studies, that translate particle counts into biologically relevant dose or damage.