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 different from forms of radiation encountered on Earth. Radiation in space consists of high-energy protons, heavy ions and secondary products created when the protons and heavy ions pass through spacecraft shielding and human tissue. The Space Radiation Program Element uses the NASA Research Announcement as a primary means of soliciting research to understand the health risks and reduce the uncertainties in risk projections. Reliable radiation monitoring for manned and unmanned spaceflight is a specific area where the SBIR technologies can potentially contribute to NASA's overall goal. Three particular areas of interest are: Small Personal Dosimetry; Charged Particle Spectroscopy; Neutron Spectroscopy.

**Subtopics**

**X14.01 Small Personal Dosimetry**

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

**Background:**

As astronauts return to the Moon, and this time, work for extended periods, there will be a critical need for crew personnel radiation monitoring as they perform a myriad of extravehicular activities (EVAs). Increased ISS crew size and mission duration are also driving the need for during-mission evaluation of crew specific radiation exposures.

The components of the radiation field, both primary and secondary particles, can vary significantly in charge, energy, and intensity between galactic cosmic rays and solar particle events (SPEs). This dynamic and complex radiation environment requires the development of suitable detection systems that can meet the requirements of each component of the field.

Of particular concern is the need for active monitoring capabilities that provide relevant radiation personal dosimetry information for long term galactic cosmic ray exposure (including neutron secondary radiation) and for
short term high dose rate SPEs. In addition to a complex Lunar radiation environment, which must be detected while electronics are protected by radiation hardening, there are restrictions on size, weight, power availability, and data transmission, as well as challenges presented by the Lunar surface environment, such as dust, temperature, and UV radiation. If mounted on or in the EVA suit, suit constraints must be addressed and crew safety ensured. For daily mission use, the requirements on size, data storage, and battery life/operation are particularly challenging.

Requirements/Needs:

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. New software needs to be fault tolerant and compatible with current operating systems, new hardware and software must be fully documented (schematics, etc.).

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.

For EVA and Mission Needs

- The dosimeter should be an omnidirectional detector system that can continuously measure and record the absorbed dose from charged particles with linear energy transfer 0.2 to 300 keV/micrometer, as a function of time, at two shielding depths: 0.5 g/cm$^2$ and 3 g/cm$^2$.

- The dosimeter should measure cumulative absorbed dose and dose equivalent once per minute and report data with latency less than five minutes.

- The dosimeter should produce and alarm whenever the absorbed dose rate exceeds a programmable threshold in the range 0.05 mGy/min to 10 mGy/min for 3 consecutive 1 minute readings.

- The dosimeter dimensions should be no larger than 8.5 cm x 4.5 cm x 2 cm.

- The dosimeter should weigh no more than 150 g.

Additional Mission Only Needs

- The dosimeter should be able to be battery (re-chargeable) powered and operate for 14 days without recharge.

- The dosimeter shall be able to measure dose rates in the range 0.005 mGy/hour (0.0075 mSv/hour) to 1 cGy/hour (1.5 cSv/hour).

- The dosimeter should able to measure neutron exposure (personal dose equivalent) in the energy rage 0.5 MeV to 10 MeV, with dose equivalent sensitivity of 0.2 mSv to 0.1 Sv in a 1 hour measurement, delivered at 0.02 mSv/hour to 1 mSv/hour.
Additional EVA Only Needs

- For suit based versions, the dosimeter would interface to the EVA suit with TBR power available. No battery is allowed for suit versions.
- The dosimeter shall be able to measure dose rates in the range 0.005 mGy/hour (0.0075 mGy-Eq/hour for proton fields in the energy 10 MeV to 300 MeV) to 70 cGy/hour (105 cGy-Eq/hour for proton fields in the energy range 10 MeV to 300 MeV).
- Software and algorithms must interface with the suit data system, but do not necessarily need to be integrated into suit control algorithms.

X14.02 Charged Particle Spectroscopy

Lead Center: ARC

Participating Center(s): GSFC, JSC

Charged particles (protons and heavy ions) contribute most of the dose-equivalent received by astronauts. Current instruments at NASA, and those under development, can provide the total (combined) dose and dose-equivalent for protons, heavy ions, gamma rays, and neutrons. At present NASA has active detectors for ISS that measure energy fluence of charged particles; however, more compact detection systems that measures energy fluence and spectrum for Exploration class missions are needed. Advanced technologies (up to technology readiness level (TRL) level 4) are requested.

Subtopic Requirements/Needs:

Of particular interest are compact real-time detection systems that can measure energy fluence and spectrum of protons and other ions ($Z = 2$ to 26) and be sensitive to charged particles with LET of 0.2 to 1000 keV/µm. For $Z$ less than 3, the spectrometer should detect energies in the range 20 MeV/n to 400 MeV/n. For $Z = 3$ to 26, the spectrometer should detect energies in the range 50 MeV/n to 1 GeV/n.

The monitor should be able to measure charged particles at both ambient conditions in space (0.005 mGy/hr) and during a large solar particle event (1000 mGy/hr).

The time resolution should be less than or equal to 1 minute.

The dosimeter shall be able to perform data reduction internally and provide processed data out to ISS, CEV, and future lunar outpost data systems. New software needs to be fault tolerant and updated to current operating
systems, new hardware and software must be fully documented (schematics, etc.).

X14.03 Neutron Spectroscopy

Lead Center: ARC
Participating Center(s): GSFC, JSC

Neutrons can contribute a significant fraction to the total dose-equivalent received by astronauts. Current instruments at NASA, and those under development, can provide the total (combined) dose and dose-equivalent for protons, heavy ions, gamma rays, and neutrons. At present, neutrons are included as integral measurements of NASA space flights; however compact active detection systems that can measure neutrons only are needed. Advanced technologies (up to technology readiness level (TRL) level 4) are requested.

Subtopic Requirements/Needs:

Systems are needed specifically to measure the neutron component of the dose and provide the neutron dose-equivalent in real time. Of interest also would be compact active monitoring devices that could measure neutron energy spectra.

The principal energies of interest are neutrons from 0.5 MeV to 150 MeV.

The monitor should be able to measure neutrons at ambient conditions such that proton/ion veto capability should be approaching 100% at solar minimum GCR rates.

During solar particle events, neutrons will be present at increased levels and should also be measured.

The device should be able to measure ambient dose equivalent of 0.02 mSv in a 1 hour measurement period, using ICRP 74 (1997) conversion factors.

The instrument shall be able to perform data reduction internally and provide processed data out to ISS, CEV, and or future lunar outpost data systems. New software needs to be fault tolerant and updated to current operating systems, new hardware and software must be fully documented (schematics, etc.).