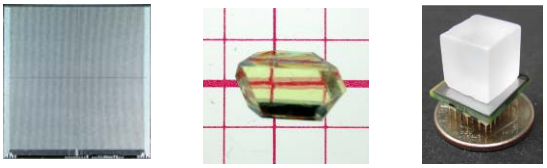
Project Summary

Model calculations and risk assessment estimates indicate that secondary neutrons, with energies ranging between 0.5 to >150 MeV, make a significant contribution to the total absorbed dose received by space crews during long duration space missions [1-3]. Advanced scintillation materials, which exhibit radiation type and mass dependent emission times, coupled to SSPM detectors provide the optimum volume to payload performance and the ability to easily discriminate between the fraction of dose which results from secondary neutrons and that which results from exposure to energetic charged particles and background gamma-rays.

The Phase-1 effort successfully characterized the critical components of the proposed dosimeter, specifically, the response of the scintillation material to irradiation by gamma-rays, protons, and neutrons, as well as the performance of the SSPM detector. The Phase-1 modeling studies provide a critical foundation for assessing the anticipated signals in the space radiation environment. The proposed dosimeter would overcome many of the limitations in the current generation of neutron dosimeters and would provide baseline information on the physics, needed with the information from biological studies, to assess risk in future human-space-exploration missions to the moon and Mars.

Summary of Phase-I Feasibility Demonstration:

Goal: Fabricate critical detector components that support the following performance criteria: DPA scintillation detector and SSPM-based detector successfully fabricated.



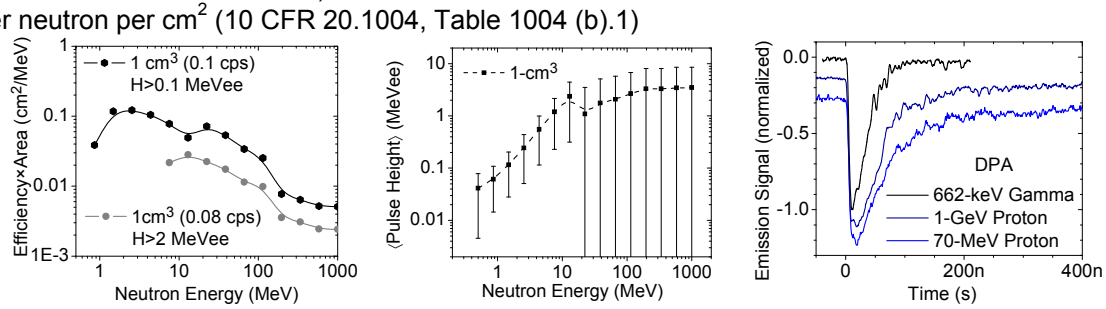
Photograph of the following critical components: SSPM detector, left, DPA crystal, middle, and 1-cubic-cm plastic scintillation cube on packaged SSPM.

Criteria: Show acceptable detection efficiency for neutrons over the targeted energy range:

- The sensitivity of a 1-cubic-cm detector segment is ~0.08 detected-neutrons per second (20 neutrons/s incident rate) for neutrons from background cosmic rays, which corresponds to a dose of ~7 nSv per event for GCR. The expected background from GCR is ~4 events/s. The expected background from secondary gammas is also ~4 detected events per second (~50 events/s incident)
- The noise threshold needed to achieve this efficiency is 2-MeVee: 1-square-cm SSPMs exhibit a room-temperature noise threshold of <0.2 MeVee for DPA.
- The selected scintillation material is DPA, diphenyl-anthracene: Shows emission-time distinction between gamma-rays and protons. Spectrally matched to SSPM detector. Preliminary results suggest emission-time distinction for different energy protons, which may provide a correlation to mass.

Criteria: Demonstrate the correlation between the amplitude of the scintillation pulses and the energy deposited, or dose.

- Below 20 MeV, the mean pulse height shows a correlation to the incident neutron energy, as shown in figure below. Above 20 MeV, the neutron-flux-to-dose conversion varies from 5×10^{-8} to 7.1×10^{-8} rem per neutron per cm^2 (10 CFR 20.1004, Table 1004 (b).1)



Plots of the simulated sensitivity (left), simulated correlation between scintillation pulse-height spectra and incident neutron energy (center), and preliminary measurement of scintillation emission time showing distinction between gamma events, 1-Gev protons and 70-MeV protons (right).