Project Synopsis

An Array of Silicon-Based Detectors for Imaging the Gamma-Ray Background

In general, sources of background radiation can be divided between solid sources, airborne sources, and cosmic radiation. Our research is concerned with the imaging of solid sources (or the lack thereof), but airborne sources and most particularly, cosmic radiation, can dominate the gamma-ray response. Thus, it is helpful to determine not only the spectrum but also the angular distribution of the gamma-rays incident on the detector. Then one can identify the gamma-ray products of cosmic ray interactions through a diffuse distribution, and isolate the concentrated potassium-40 (^{40}K) due to the random cinder block, for instance. Furthermore, temporal variations in the background rate can be due to alterations in the airborne activity (in the form of ^{222}Rn), which would reveal itself in roughly uniform variations in the air volume surrounding the detector array. Thus, any detector solution should be able to distinguish both the energy and the direction of the incident gamma rays, so that one may identify both the isotopic composition of the source material and map its geometrical arrangement.

The most important isotopes from solid sources are found in common building materials and the soil in the form of uranium, thorium and its decay daughters, as well as potassium. Furthermore, the interaction of cosmic ray neutrons with hydrogenous materials, such as wood-frame housing, can result in the 2.22 MeV capture gamma from hydrogen, although typically at low levels. The highest flux of gammas for the expected materials of interest occurs at energies between 50 and 150 keV, as pointed out in the original solicitation, although the ^{40}K line at 1.46 MeV can also be prominent. These low gamma energies limit the detection range because, of course, the gamma ray flux from distance background sources is attenuated in the air and other intervening materials. Furthermore, low energies impact the detector design because the preferred gamma ray interaction *mode* depends on energy, as well as the material composition.

The characterization, attenuation and imaging of the background are the subjects of Section 3 using a general detector, and the impact of various detector design choices will be addressed in Section 4. That is, for many of the presented results the count rate will be evaluated per *square meter* of subtended detector area so that interaction rates for smaller and larger areas can be easily inferred. Furthermore, the intrinsic efficiency will, in general, be assumed to be unity although our proposed Phase II design will have an overall intrinsic efficiency of 50 %, for the optimization reasons discussed in Section 4. Finally, the angular resolution will be assumed to be 10, which we will show in Section 4 to be larger than that can be achieved using either semiconductor of scintillation-based systems, but which is sufficient for background imaging to reasonable standoff distances.