Scintillation-Based Gamma Imaging with SPAD Camera

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Abstract:

Imaging high energy particles requires a large detector mass or volume to increase the probability of a particle interacting with the detector. The location, energy deposition, and timing of an interaction are used for determining the particle trajectory.

Scintillator detectors measure signals from visible light with visible light cameras or silicon photomultipliers. The estimated interaction locations and energy depositions may then be used to image the radiation source. We propose using a single photon avalanche diode (SPAD) camera in our scintillation-based gamma ray imager. I will talk about how we measure interactions in a scintillator with a SPAD camera.

SPAD cameras with the ability to detect individual photons at high speed are increasingly used in consumer markets, driving the emergence of sophisticated high resolution SPAD cameras at low cost. We use a SPAD camera to image the visible light emitted from interactions in a large, monolithic scintillator volume. Conventional scintillator-based gamma imagers, known as Compton Cameras, use two thin scintillator planes. The main advantage of using one large scintillator is that interactions are more likely to occur in a thick volume than a thin one. Therefore, our prototype will observe more interactions in a shorter amount of time and locate the radiation source faster.

We determine an interaction's location in the scintillator using defocus blur and perspective projection. Its energy deposition is determined by counting photons. These measurements are used to backproject cones representing where the gamma ray could have originated, as in conventional Compton cameras for gamma imaging. This process is repeated for many gammas, and a heatmap of the direction to the radiation source is generated.

The scintillator and camera optics are simulated with Geant4. Heatmaps from 100,000 incident gamma rays show that our method can determine the direction to the radiation source.