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#02-115 Gamma-ray Detection and Localization at high angular resolution

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The recent association of gamma-ray bursts with neutron star mergers highlighted the need for sensitive gamma-ray detectors with high localization accuracy. Identification of the host galaxy of the gravitational wave event GW170817 and the gamma-ray burst GRB170817A was only achieved 11 hours after initial detection, due to difficulties in surveying the uncertainty region of the gravitational wave event. Gamma-ray bursts are transient events with a rapidly diminishing afterglow at longer wavelengths. A delay in the precise localization means crucial data were lost until observations at longer wavelengths could begin. This problem can only be mitigated using detector systems with large viewing angles, preferably the entire sky, and far improved angular resolution of a few degrees, which is required for prompt follow-up.
We present a novel gamma-ray detector concept aimed at improved angular localization with respect to the current state of the art. The presented detector system relies on a non-uniform pattern of small scintillators coupled to silicon photomultipliers. The pattern utilizes the mutual occultation between detectors to reconstruct the gamma-ray burst's direction in the sky with good angular accuracy. Our simulations show that the achievable localization accuracy for such a configuration is considerably better than those obtained by larger scintillator assemblies while maintaining a field-of-view of the entire sky. We show that even when the total effective area is decreased, our detector system still shows better angular sensitivity compared to designs based on the current state of the art. We present laboratory experiments on various configurations of 90 small detectors. We show the effects of changing the configuration and of changing the scintillator type. The systems are also experimentally compared with a larger detector system built with a traditional approach. Both simulations and experiments clearly show our novel concept can achieve a considerable improvement in angular sensitivity, without compromising sensitivity or field-of-view. The proposed concept can be easily scaled to fit into small satellites, as well as larger missions.

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