Prompt, Accurate Localization of Gamma-Ray Bursts in the Advanced Particle-astrophysics Telescope

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The Advanced Particle-astrophysics Telescope (APT) is a mission concept aimed at providing all-sky sensitivity, a very large effective area, and prompt localization of MeV transients such as GRBs. ADAPT (the Antarctic Demonstrator for APT) is under construction and scheduled to fly from Antarctica in 2024. The prompt reconstruction and integration of evidence from multiple Compton scatters raises significant computational challenges. A burst is localized in real time onboard the instrument by reconstructing the Compton angles of incoming photons, resulting in a ring of possible source directions for each photon; intersecting these rings yields the common source direction. We are developing a computational pipeline to perform reconstruction and localization rapidly and accurately enough to direct follow-up observations of even short-duration (subsecond) bursts by instruments with narrow fields of view (around one degree) while operating under strict size, weight, and power constraints imposed by both ADAPT and APT.

This poster describes our recent work to improve the speed and accuracy of our pipeline. For APT, algorithmic improvements to reconstruction of each gamma ray's Compton ring reduced error in the inferred source direction for a representative simulated GRB from 2.53 to 1.74 degrees (68% containment error) at a fluence of 0.03 MeV/cm^2. Improvements to our localization algorithms reduced running time by more than half for even high-fluence (1 MeV/cm^2) GRBs without impacting accuracy, producing results in under 70 ms even on a low-power four-core ARM processor. Augmenting the wavelength-shifting fiber readout of the instrument's CsI:Na scintillators with SiPMs covering the edges of the crystal enabled sub-degree accuracy for our representative burst at fluences down to 0.02 MeV/cm^2.