Adaptive Real-Time Computation for Prompt Localization of Transients

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The Advanced Particle-astrophysics Telescope (APT) is a planned space-based observatory designed to detect and localize MeV transients such as gamma-ray bursts (GRBs) in real time. The goal is to enable concurrent, multi-messenger observation of transient GRBs from any direction with minimal delay. To this end, we have designed a parallel computational pipeline for real-time multi-Compton reconstruction and GRB localization. To keep latency low, this will execute fully onboard the instrument, which imposes significant size, weight, and power constraints.

Due to the dynamic and uncertain nature of GRBs, the localization task's computational workload is not known prior to detection. Neither is its deadline, which may be informed by the collection of available follow-up instruments and how much time they need to make worthwhile secondary observations. Using theory from real-time systems scheduling, we have developed new techniques to enable adaptive computation under dynamic workloads and deadlines. Through extensive offline characterization of how result utility (in this case, GRB localization accuracy) is affected by tunable algorithmic parameters, and by analyzing the worst-case response times associated with them, we generate a surface that can be efficiently searched online to select Pareto-optimal execution parameters. We modified the computational pipeline to perform this search and adjust its execution mode when a GRB is detected, allowing it to maximize localization accuracy while maintaining hard latency guarantees. In simulation, this approach enables APT to perform subdegree GRB localization within 100 ms of detection. This poster details our approach, presents its results, and suggests its applicability to other instruments and transient phenomena.