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Timing Synchronization and Data Analysis for Gamma-Ray Telescope Arrays

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Ground-based gamma-ray telescope arrays can be used to view Cherenkov light created when a high-energy photon interacts with a massive particle in the atmosphere, creating a cascade of photons and particles of very high energy called an electromagnetic shower. The sources of these gamma-rays are not thermal sources (e.g. stars), but energetic non-thermal sources (supernovae, black holes) capable of accelerating particles up to very high energies. The spectrum, angular distribution, and time variability of the VHE gamma-rays from these sources can be used to infer information about what created them, giving astrophysicists useful information about some of the most extreme events in the universe. This project aims to exploit the characteristics of the next-generation atmospheric Cherenkov telescope arrays to improve angular reconstruction of the gamma-rays near the instruments’ threshold energy. The idea is to supplement the standard analysis with information of the relative arrival time of the Cherenkov photon wavefront. This might be accomplished by adding hardware to implement a more accurate timing system among the telescopes relative to one another. Various methods for timing synchronization were considered and the White Rabbit project looked promising. In addition to identifying the timing limitations of such hardware approaches, algorithms to combine time measurements from an array of telescopes to reconstruct both the shower direction and mean height of shower development in the atmosphere are being developed and tested on Monte Carlo simulations of photon arrival times for simulated events. Since the computations need to be completed at a high rate, algorithms that use the discrete spacing of telescopes to pre-compute costly aspects of the analysis are explored. Algorithms for this do exist but with the advent of more detailed simulations and larger telescope arrays, there is potential for improvement.