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Achieving Picosecond-Scale Time Synchronization in Distributed Optical and Cherenkov Telescopes with White Rabbit

Cherenkov telescopes (IACTs) require synchronization at the nanosecond scale for real-time event tagging and common triggering, enabling coincidence detection across multiple telescopes. Even more stringent timing is required for intensity interferometry, where the light intensity fluctuations of a source are sampled at multiple telescopes and correlated to reveal a source size-dependent correlation peak, offering unique insights into the structure of astronomical objects. We explore the integration of White Rabbit (WR), a fiber-based Ethernet timing technology developed at CERN, into the clock distribution network for intensity interferometry across telescopes separated by kilometer-scale baselines. WR, built upon the Precision Time Protocol (PTP), natively offers sub-nanosecond synchronization with deterministic latency. We demonstrate that a WR network can be efficiently shared between optical and IACT observatories for joint intensity interferometry observations. We investigate and address key challenges, including the effects of fiber temperature fluctuations and dispersion, which can impact long-distance timing stability. Through experimental validation, we achieve 5 ps RMS time synchronization over a 5 km fiber link, demonstrating the feasibility of WR for high-precision astronomical applications. Furthermore, we analyze how WR clock phase coherence affects intensity interferometry sensitivity and discuss the implications for long-baseline and large-scale deployments.

Collaboration(s)

QUASAR Project

Author: Dr SLIUSAR, Vitalii (University of Geneva)

Co-author: Dr PRODUIT, Nicolas (Universite de Geneve (CH))

Presenter: Dr PRODUIT, Nicolas (Universite de Geneve (CH))

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