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# Timing and Synchronization of the DUNE Neutrino Experiment

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Synchronizing the different parts of a Particle Physics detector is an essential part of its operation. In the DUNE liquid argon neutrino detector timing information is transmitted to the readout systems and time-stamped data is sent to the DAQ.

We describe the DUNE timing system, which uses Duty Cycle Shift Keying with 8b10b encoding and a simple message protocol. The system is designed to allow simple implementation in the readout system timing endpoints.

## Summary (500 words)

Synchronizing the different parts of a Particle Physics detector is an essential part of its operation. We describe the system being planned for the DUNE liquid argon neutrino detector and experience from the single phase protoDUNE detector currently operating at CERN.

DUNE is will have four caverns, each of which can house a detector with 10kT fiducial mass. The first caverns is planned to house a single phase module and the second a dual phase module. In both systems the time-stamps are locked to timing provided by GPS/GLONASS antennae.

The timing system uses Duty Cycle Shift Keying with 8b10 encoding and a simple message protocol to give a system designed to be easy to implement in the readout systems.

For one of the readout systems DUNE timing system is used as a master syncronization source for a IEEE1588 (White Rabbit) network distributing timing information within that readout system.

The timing distribution system for the single phase detectors can use passive optical fan-outs which reduces cost and allows for the use of redundant timing masters.

Measurements in the lab and at the on the single phase protoDUNE system indicate that the timing distribution system adds ˜ 15ps RMS per hop, with a total jitter of < 100ps (Sigma) from a GPS disciplined oscillator (which would be on the surface) to a timing endpoint (which would be in the cavern)

We describe the measures taken to reduce the risk of "silent failures"where synchronisation is lost with GPS without being detected. This is achieved using separate, spatially separated, antennae together with independent GPS receivers.

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