

Title: The NOvA Timing System: A system for synchronizing a Long Baseline Neutrino Experiment.  
Authors: Andrew Norman for the NOvA Collaboration

The NOvA experiment at Fermi National Accelerator Lab, uses a sophisticated timing distribution system to perform synchronization of more than 12,000 front end readout and data acquisition systems on both the near detector and accelerator complex at Fermilab and the far detector 810km away at Ash River, MN. This global synchronization is performed to an absolute clock time with a system wide variation of less than 16ns, which allows for the direct comparisons of detector data with the accelerator beam spills. The system accomplishes this through the use of high precision GPS receivers, which are decoded by custom hardware to both determine the absolute wall clock times and propagate them to the readout systems. This custom hardware is able to perform detector wide calibrations for the paths to each frontend readout system that take into account the signal propagation and retransmission delays. The resulting system ensure that the electronics clock registers tick in perfect unison regardless of their position on the faces of the 220ft long, five story tall far detector. The paper will cover the details of the timing system, its characteristic and performance as demonstrated on the NOvA detectors. The role of high precision timing and the prospects for performing specific measurements related to the properties of the neutrino will be discussed.