# Towards A Distributed Scalable Water Cherenkov Detector


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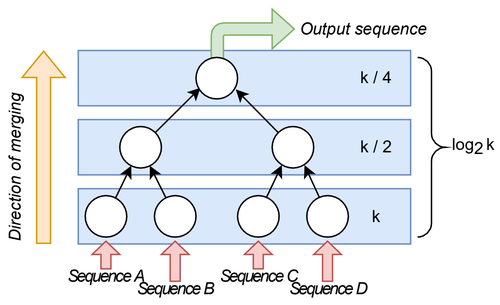
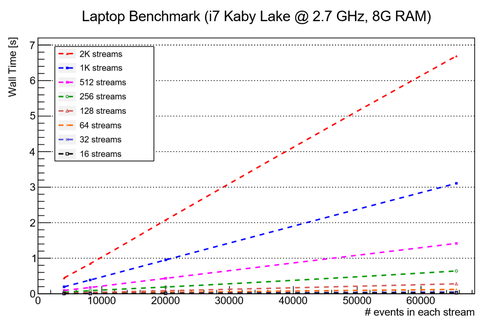
## CHIPS R&D Project

- Affordable water Cherenkov detectors for large-scale underwater applications.
- Deployed by sinking flexible water tanks in deep bodies of water, providing support through buoyancy and natural overburden from cosmic rays.
- Photo-sensitivity achieved via detector planes – modular photomultiplier arrays.
- Costs further reduced by use of commercially available components.
- Prototypes deployed in northern Minnesota (USA) in 2014, 2019.

## Online Hit Sorting

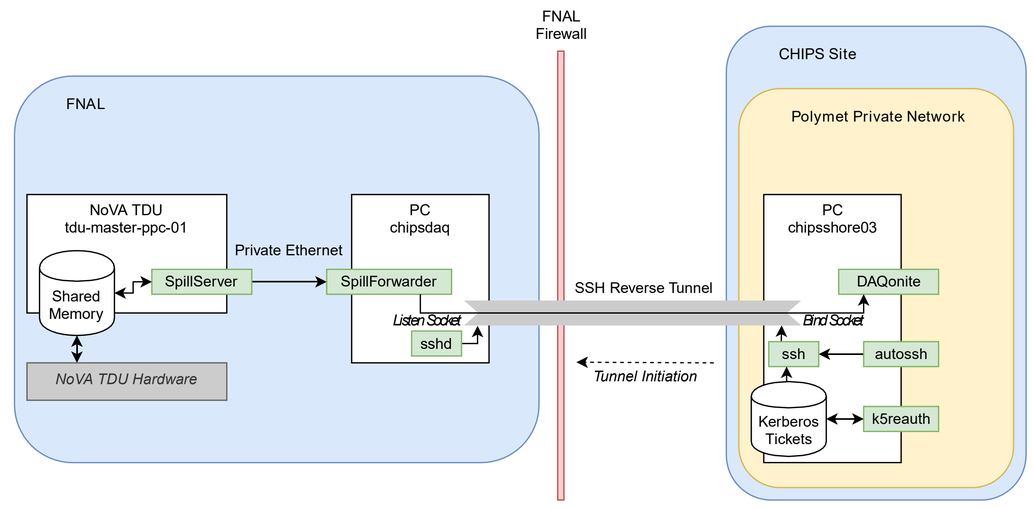
- CHIPS DAQ processes photomultiplier hits.
- Since detector planes are distributed, measured data must be consolidated following each run.
- To accelerate computation, a real-time algorithm was developed to consolidate hits during data acquisition.
- Benchmark shows that algorithm's performance permits application under realistic conditions.



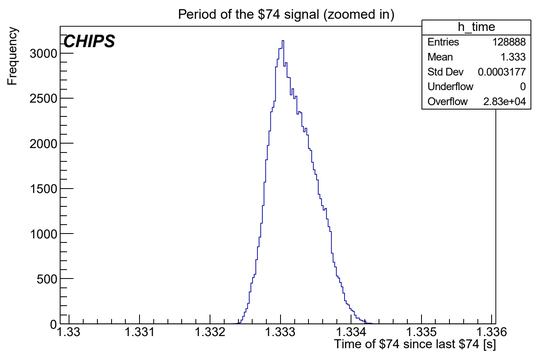



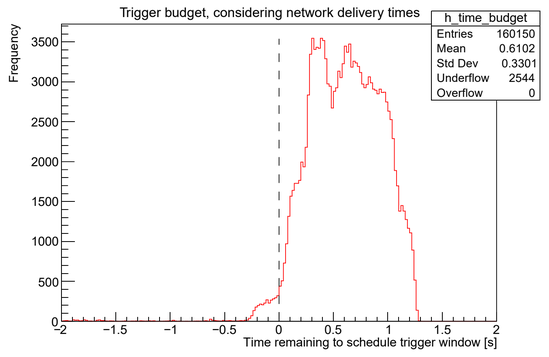

## Low-latency NuMI Trigger

- Main CHIPS signal source is the NuMI neutrino beam, generated 707 km away at Fermilab‡ (7 mrad off-axis).
- Both sites use locally-synchronized UTC clocks.
- Time Distribution System (TDS) was implemented to transmit accelerator hardware signals to the CHIPS detector site for triggering on neutrino spills.




- Available signals were analyzed for latency and reliability over the period of 52 hours.

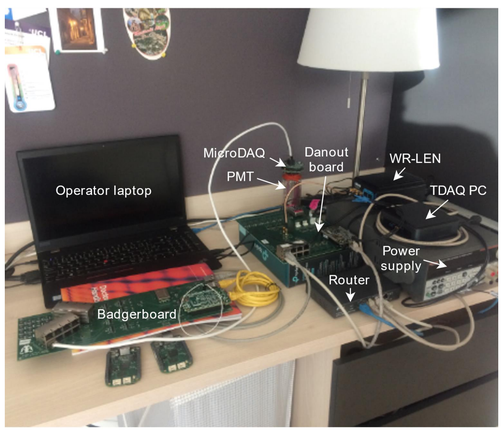


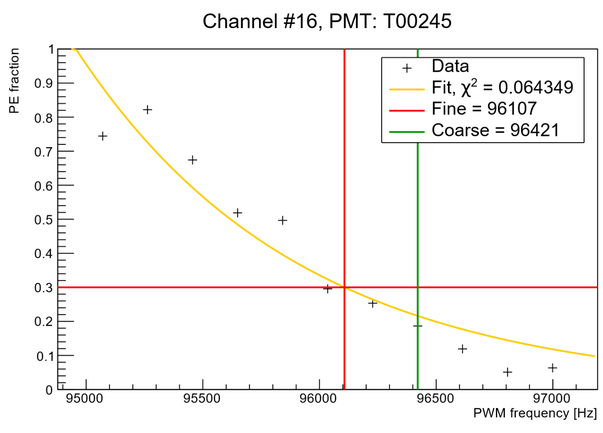




- Selected configuration was found to offer 3.48 µs jitter.
- Considering baseline length, 96% of observed signals reached the detector site before expected spills.
- Novel triggering scheme is developed, where DAQ autonomously initiates data taking following trigger.

## Detector Planes Upgrade

- New detector hardware, developed by CHIPS and WIPAC†, was integrated with existing DAQ system.
- Integration allows per-channel configuration, run control, live data streaming and status checks.
- A dedicated software tool was developed for bulk photomultiplier gain tuning. Relying the MINUIT package, its fits were found to be more robust with noisy data.




- Benchmark indicates that presented software offers a 88x per-channel speedup compared its predecessor.

## References


Mánek, P. Towards A Distributed Scalable Water Cherenkov Detector. Upgrade Report, UCL. Nov 2020.



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