The trigger and data acquisition system for the TRIDENT phase-1 detector

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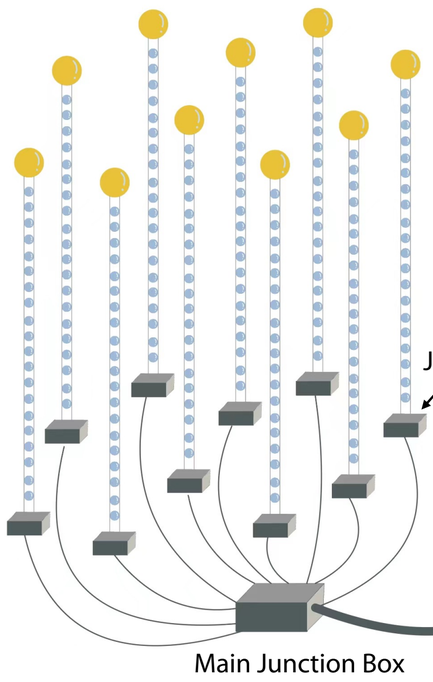
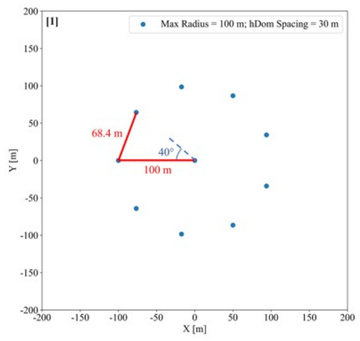


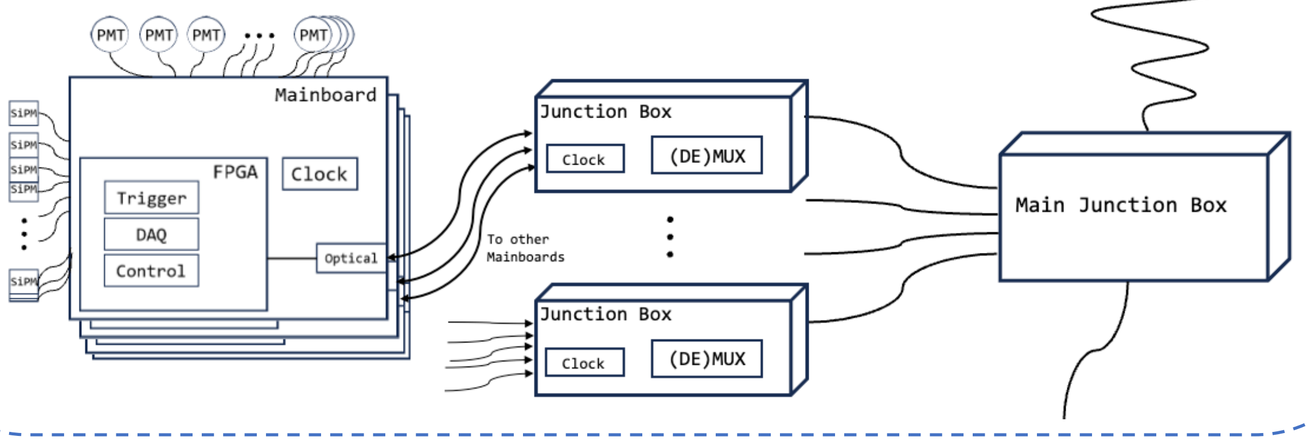
TRIDENT Phase-I layout

- 10 strings, 200 hDOMs
- hDOM: hybrid Digital Optical Module [1] [2] [3]



DAQ system schematic

- Digitization of PMT/SiPM signals
- Data transportation, filtering, storage
- Detector control, monitoring, clock distribution



TRIDENT Preliminary

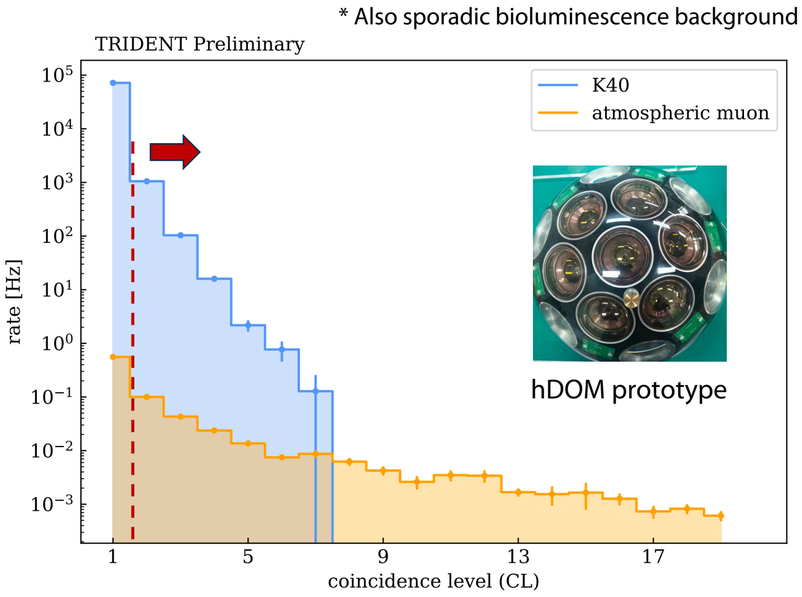
Main background (*)	Rate/Flux
Potassium-40 (K40)	O(10^5) Hz per hDOM
Atmospheric muon	O(100) Hz over whole phase-1 array

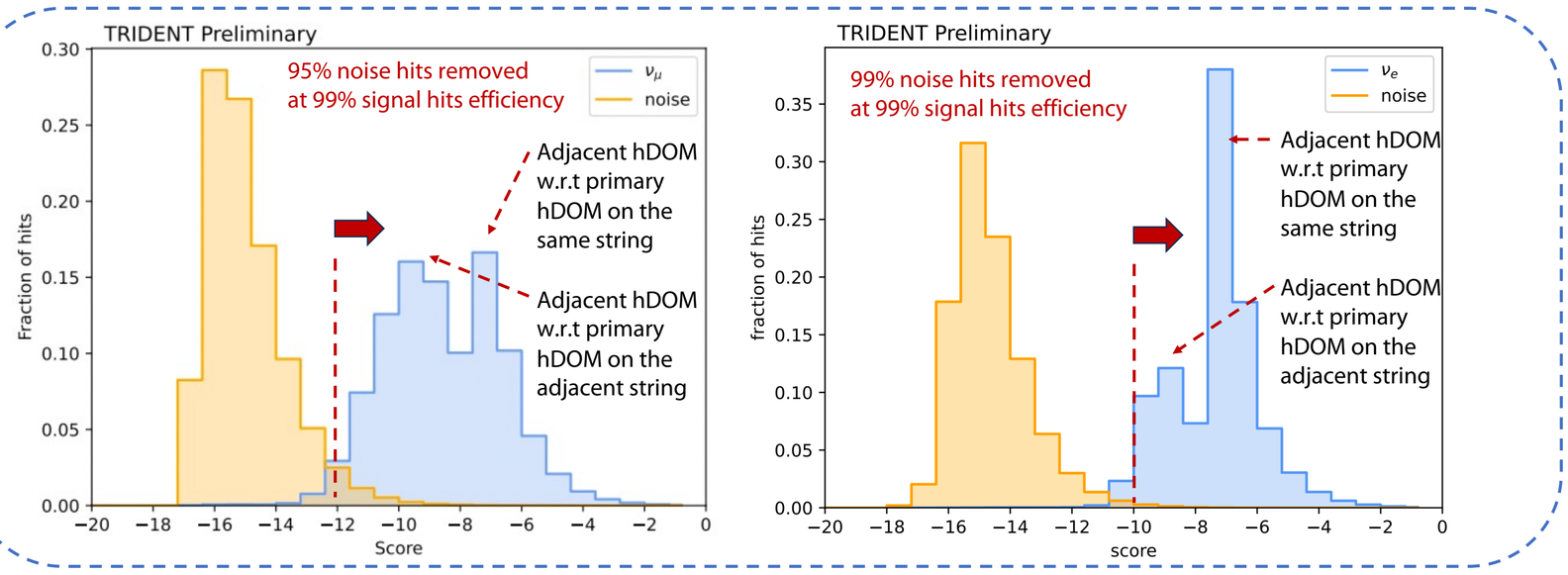
* Also sporadic bioluminescence background

PMT waveform readout → **O(100)Mb/s per hDOM**

Purpose of trigger system:

1. Reduce data throughput without losing interesting physics events
2. Open up opportunities for new physics search (e.g. slow monopole)



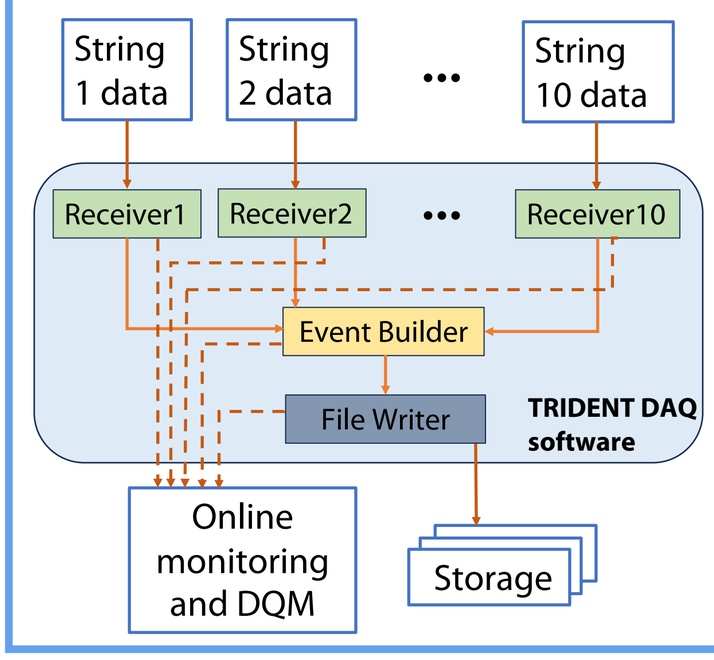


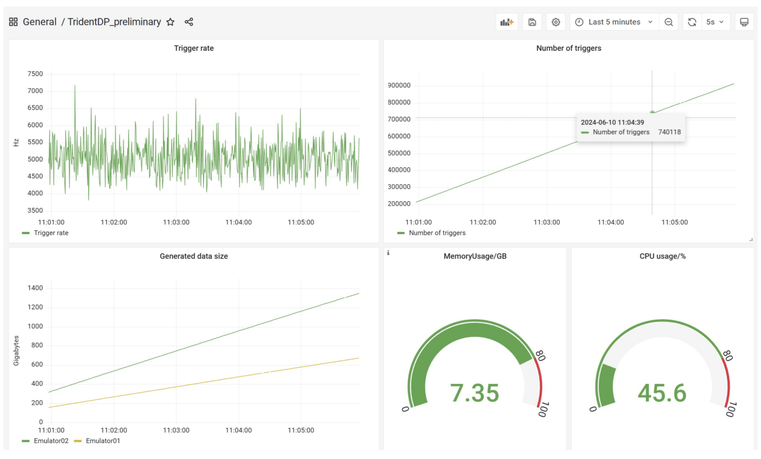
Level 1: Local coincidence trigger (CL ≥ 2)

- Use information from individual hDOM
- Perform at hDOM main board's FPGA off-shore
- Number of PMTs having over-threshold signals within 20 ns, mostly removing K40 background

Level 2: Global trigger

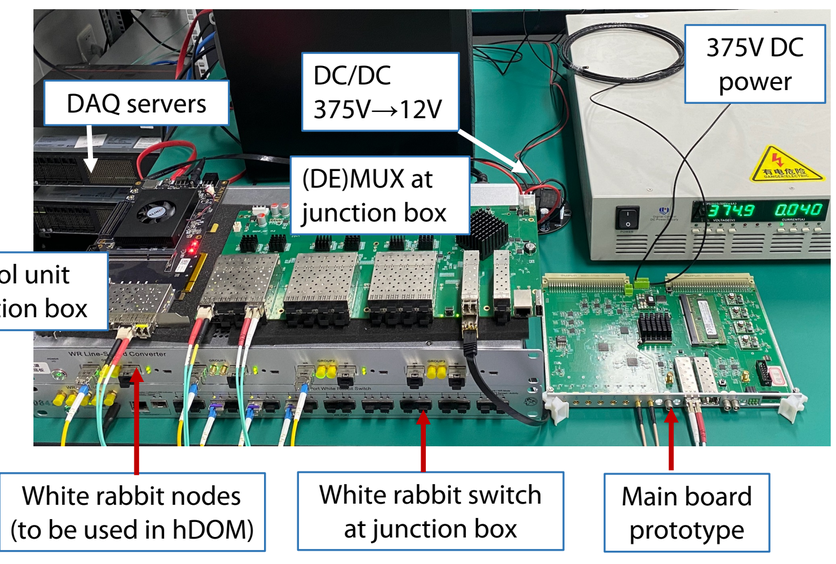
- Based on information from the whole detector volume (e.g. total NPE, space-time correlation)
- Perform at computing cluster on-shore, filter data and further classification (track, cascade, BSM …)
- Example above (assuming 3KHz random noise per PMT from K40/dark noise):
  - Define primary hDOM (most hits: t^0, x^0) → Calculate $dR^2 = (t_0\text{-}t)^2\text{-}(x_0\text{-}x)^2$ → Score = -log(1+|dR^2|)





- Software built on open-source DAQling framework [4]
- Prototype works with multiple receivers at 5kHz rate
- Able to emulate electronics output and data format

DAQ testbench in the lab



[1] A multi-cubic-kilometer neutrino telescope in the western Pacific Ocean, Nature Astronomy volume 7, pages 1497–1505 (2023)
[2] Fan Hu, Zhuo Li, Donglian Xu, Exploring a PMT+SiPM hybrid optical module for next generation neutrino telescopes, PoS (ICRC 2021), 1043
[3] Qichao Chang, Fan Hu, Iwan Morton-Blake*c*, Donglian Xu, Optimizing the optical array geometry for TRIDENT, PoS (ICRC 2023)1203
[4] https://daqling.docs.cern.ch/

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