Imperial College London

ND-GAr timing (discussion)

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- Meeting: ND-GAr weekly
- Date: 19-Sep-2023

Overview

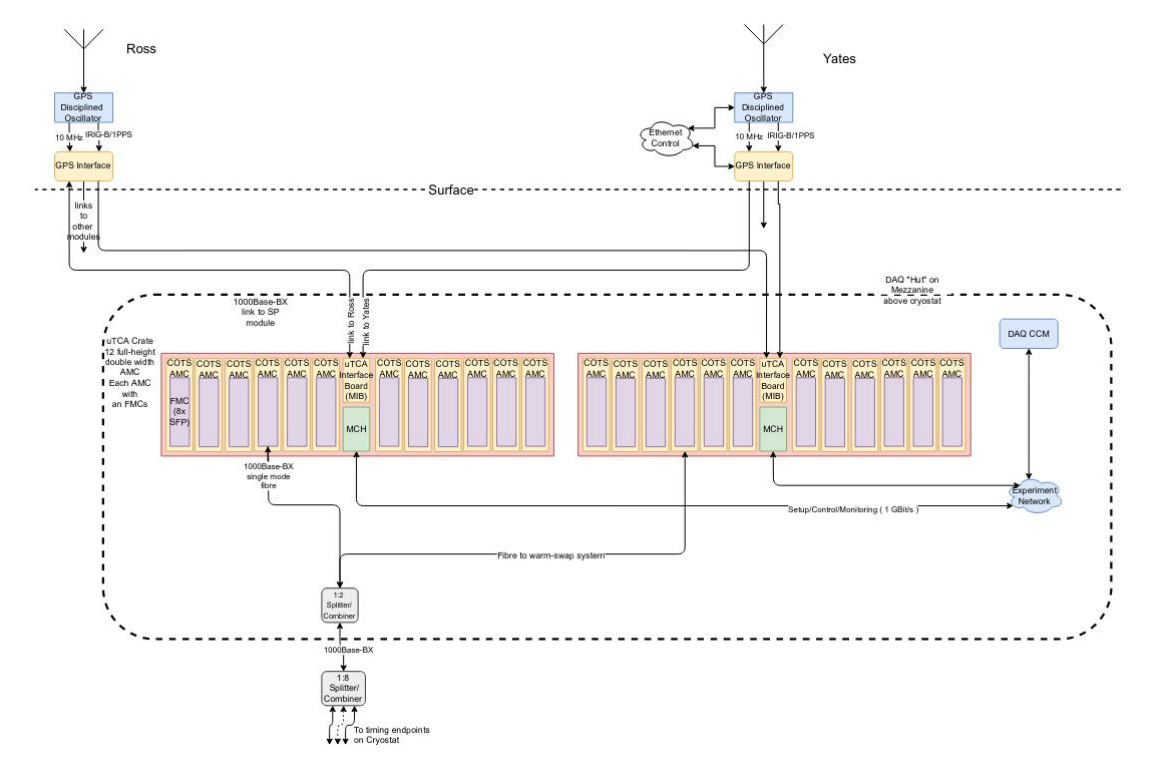
- Scope of discussion
- DUNE Timing system summary
- Experience from TOAD
- Scaling to ND-GAr
- Summary

Scope of the discussion

- Contacted by ND-DAQ coordinator (A. Kaboth) to have an ND-Timing discussion during the CM (Thursday)
- Following questions addressed to all ND sub-detectors:
  - How many and which electronics do you expect to be connected to the timing system? (Endpoint count)
  - What clock/timestamp alignment do you require within the detector
  - What clock/timestamp alignment do you require with respect to the neutrino spill start
  - Will you need to be able to identify bunches within the spill
  - What clock jitter (pref. expressed in phase noise spectrum) can you tolarate at each timing endpoint)
  - What clock/timestamp alignment do you require to any other ND detector (e.g. ND-LAr)

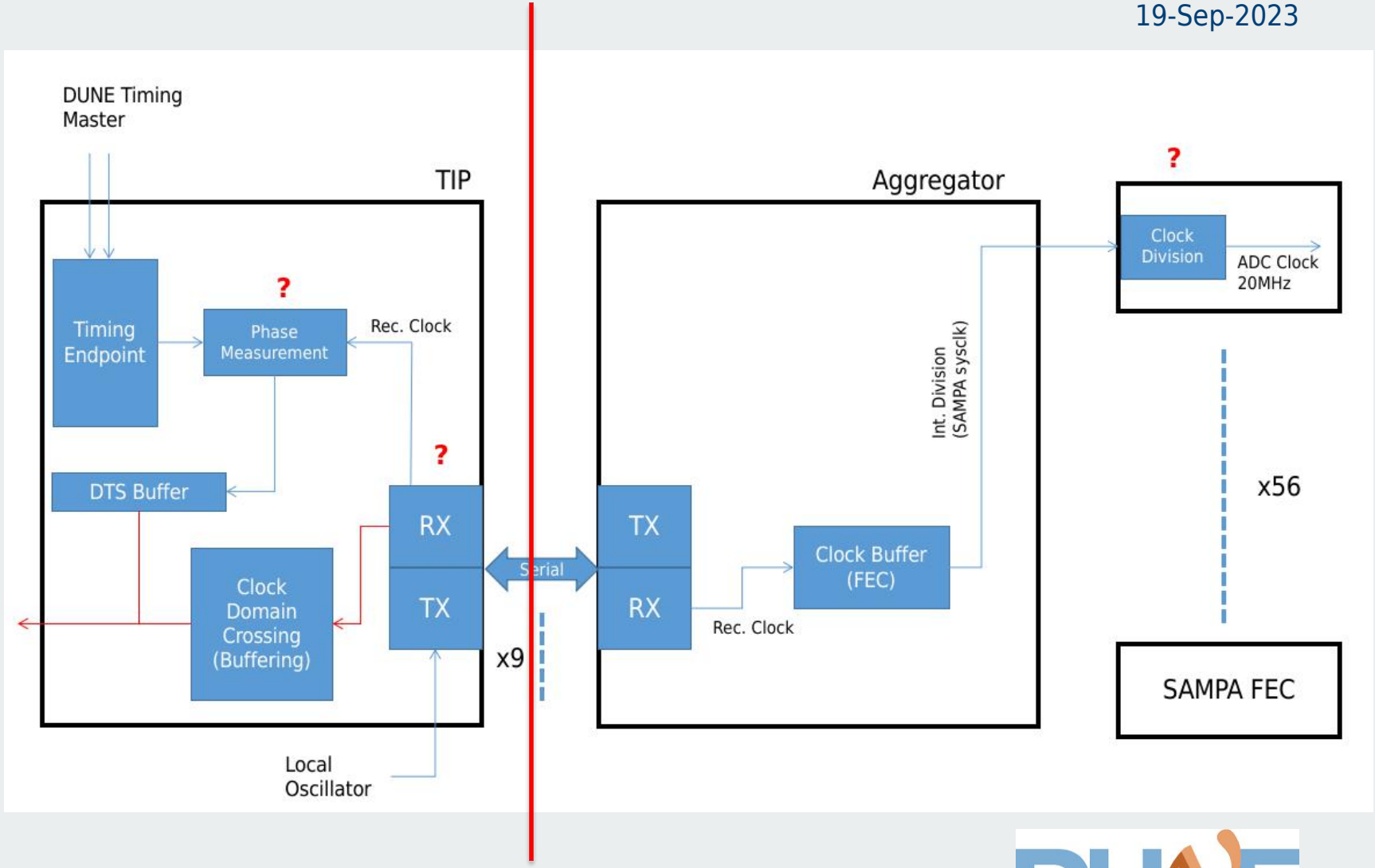
DUNE Timing System summary

- Definitely not an expert on this
- Default clock freq. for DUNE: 62.5MHz
  - Typical: <20ps jitter on clock
- Generation at master
  - Using GPS + Accelerator signals
- Distribution over a 312MHz data stream
  - Over optical fibre
- Clock recovery and synchronisation in Firmware
- Produce: 64-bit timestamp (ns precision)
  - At the end-point



Experience from TOAD

- Clock recovered in FPGA with DUNE endpoint firmware
- Synchronisation of at-pressure electronics via Serial Transceivers
  - O(ns) time differnence with respect to TS
- FEC sampling at 20MHz
  - O(us) resolution
- Local clock compared with DUNE clock to adjust time stamp
  - O(10ns) resolution for phase difference
- Timestamps from start of spill as spill length constant



Scaling to ND-GAr TPC

- O(700k) channels on ND-GAr charge readout:
  - Requires: O(220) TIP cards = O(220) timing endpoints
  - With current design we are looking at micron precision on incoming diffused signals (20MHz from SAMPA)
    - Do we need more?
    - With new electronics design seems like a fractional division for SAMPA clock is needed (worse case a few ns, but always deterministic), can we discuss about a common sampling frequency?
  - Timestamps for TPC should be synchronised with ECAL signal at least
    - What precision does the ECAL have in readout?
    - Do we need to be syncrhonised with ND-LAr?
- In case readout is optical, what are the requirements there in terms of timing?

Summary

- From the TOAD experience we can answer some of the question for ND-GAr:

- How many and which electronics do you expect to be connected to the timing system? (Endpoint count): **Charge readout O(220)**
- What clock/timestamp alignment do you require within the detector: **Integer division from DUNE clock (62.5 isn’t really great) - synch’d timestamps between TPC and ECAL**
- What clock/timestamp alignment do you require with respect to the neutrino spill start: **We want start of beam spill (end as well if not fixed)**
- Will you need to be able to identify bunches within the spill: **?**
- What clock jitter (pref. expressed in phase noise spectrum) can you tolarate at each timing endpoint): **Charge readout requires <100 dBc/Hz for transceivers to work**
- What clock/timestamp alignment do you require to any other ND detector (e.g. ND-LAr): **We will need alignment with ND-LAr/SAND (?)**

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THANKS