Trigger infrastructure update

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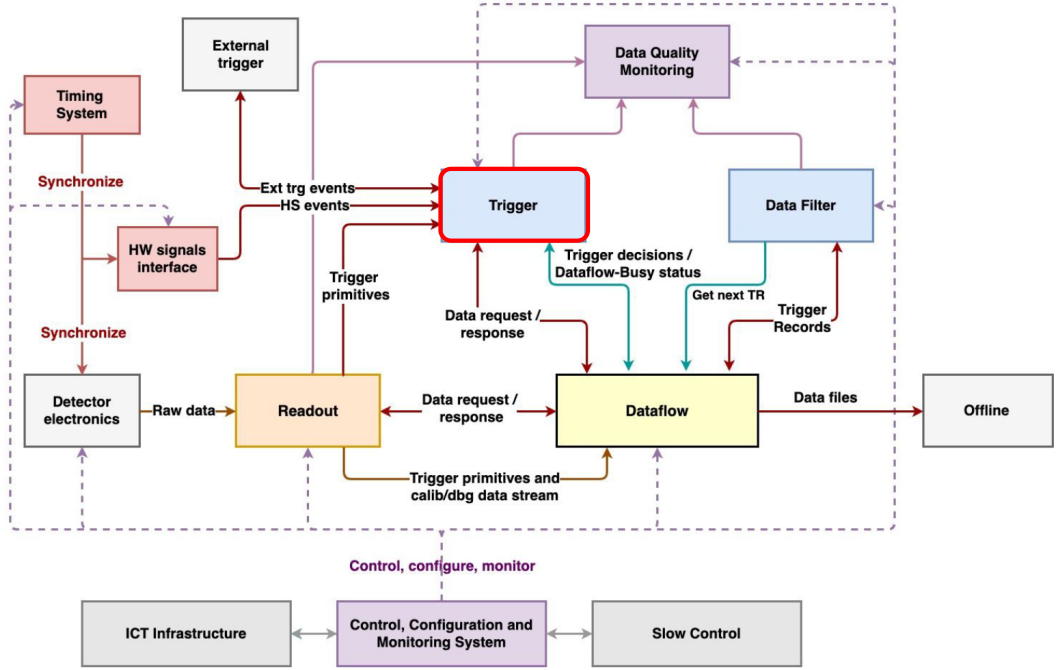
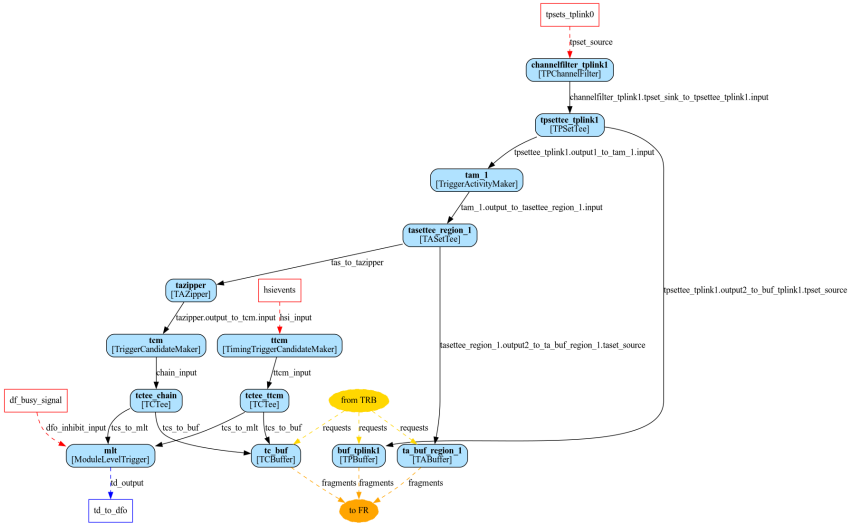
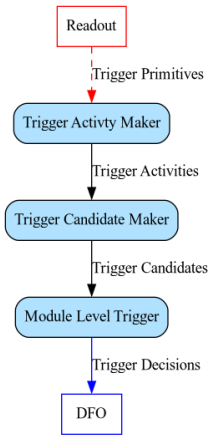
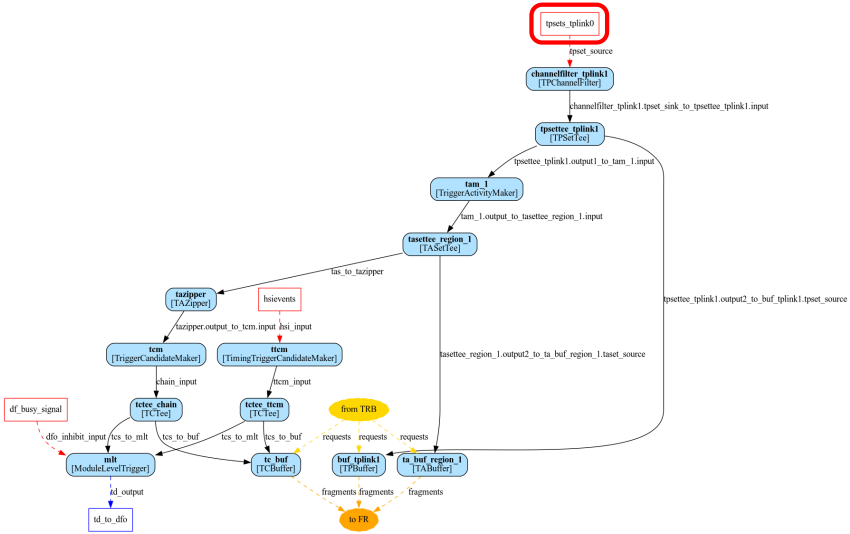
DEEP UNDERGROUND
NEUTRINO EXPERIMENT

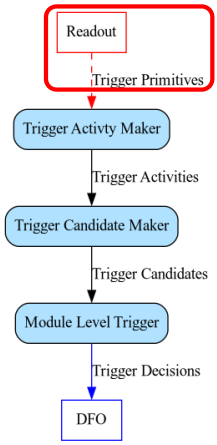
- Introduction/Trigger overview
- Coldbox runs
- Concurrent triggering algorithms & APAs
- Module Level Trigger logic
- Other


External trigger
Data Quality Monitoring
Timing System
Synchronize
Ext trg events
HS events
Trigger
Data Filter
HW signals interface
Trigger decisions / Dataflow-Busy status
Trigger primitives
Get next TR
Trigger Records
Data request / response
Synchronize
Detector electronics
Raw data
Readout
Data request / response
Dataflow
Data files
Offline
Trigger primitives and calib/dbg data stream
Control, configure, monitor
ICT Infrastructure
Control, Configuration and Monitoring System
Slow Control


tpsets_tplink0
tpset_source
channelfilter_tplink1
[TPChannelFilter]
channelfilter_tplink1.tpset_sink_to_tpsettee_tplink1.input
tpsettee_tplink1
[TPSetTee]
tpsettee_tplink1.output1_to_tam_1.input
tam_1
[TriggerActivityMaker]
tam_1.output_to_tasettee_region_1.input
tasettee_region_1
[TASetTee]
tas_to_tazipper
tpsettee_tplink1.output2_to_buf_tplink1.tpset_source
tazipper
[TAZipper]
hsievents
tazipper.output_to_tcm.input
hsi_input
tcm
[TriggerCandidateMaker]
ttcm
[TimingTriggerCandidateMaker]
tasettee_region_1.output2_to_ta_buf_region_1.taset_source
chain_input
ttcm_input
df_busy_signal
tctee_chain
[TCTee]
tctee_ttcm
[TCTee]
from TRB
dfo_inhibit_input
tcs_to_mlt
tcs_to_buf
tcs_to_mlt
tcs_to_buf
requests
requests
requests
mlt
[ModuleLevelTrigger]
tc_buf
[TCBuffer]
buf_tplink1
[TPBuffer]
ta_buf_region_1
[TABuffer]
td_output
td_to_dfo
fragments
fragments
to FR

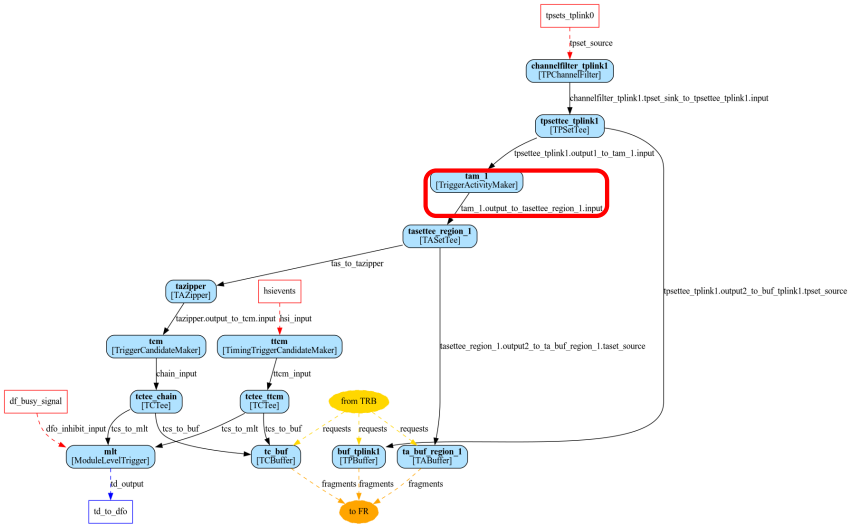

Readout
Trigger Primitives
Trigger Activty Maker
Trigger Activities
Trigger Candidate Maker
Trigger Candidates
Module Level Trigger
Trigger Decisions
DFO

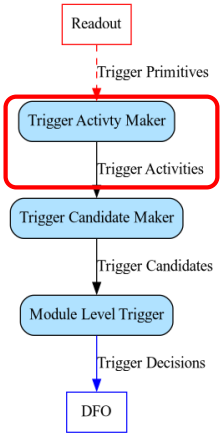




Trigger Primitive

Simplest signal waveform representation. I.e. wire hit



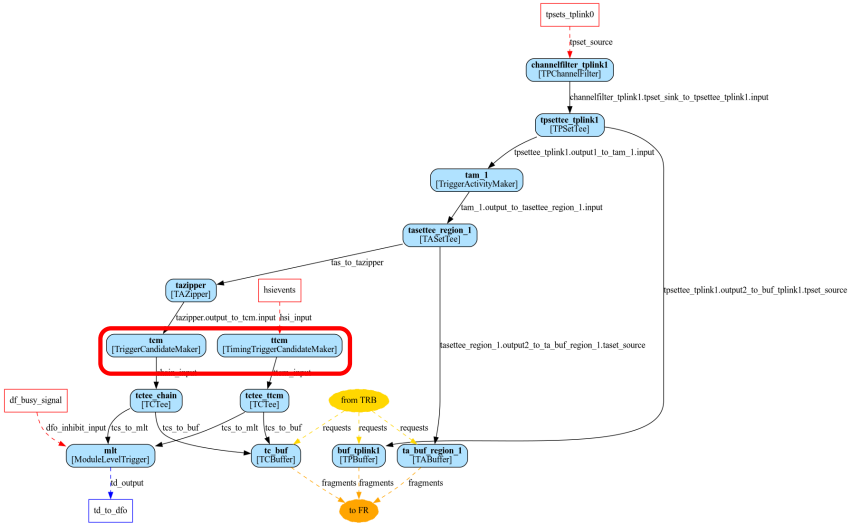


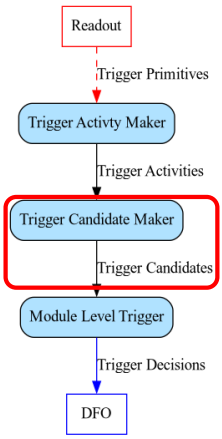
Trigger Primitive

Simplest signal waveform representation. I.e. wire hit

Trigger Activity

Cluster of TPs in sub-detector

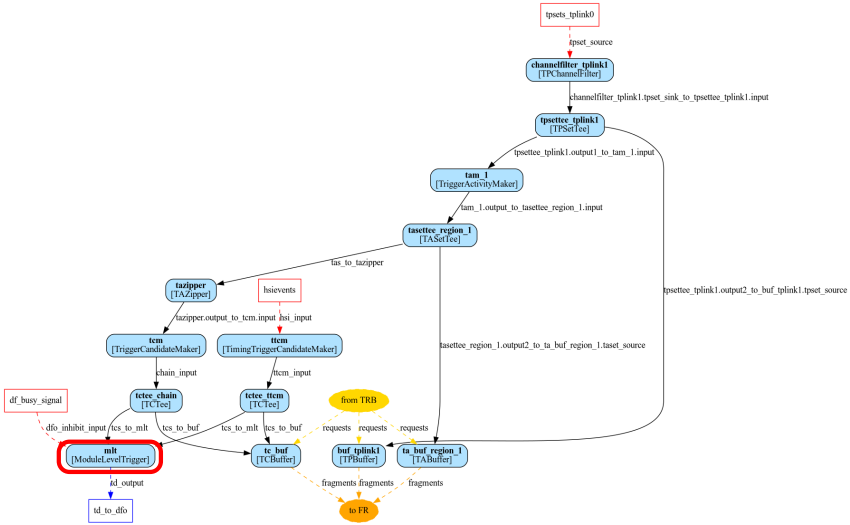


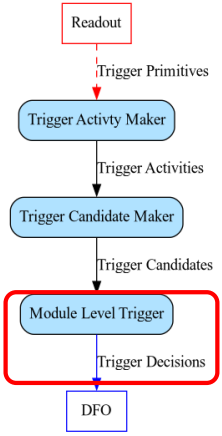


Trigger Primitive
Simplest signal waveform representation. I.e. wire hit

Trigger Activity
Cluster of TPs in sub-detector

Trigger Candidate
Cluster of TAs across all sub-detectors





Trigger Primitive
Simplest signal waveform representation. I.e. wire hit

Trigger Activity
Cluster of TPs in sub-detector

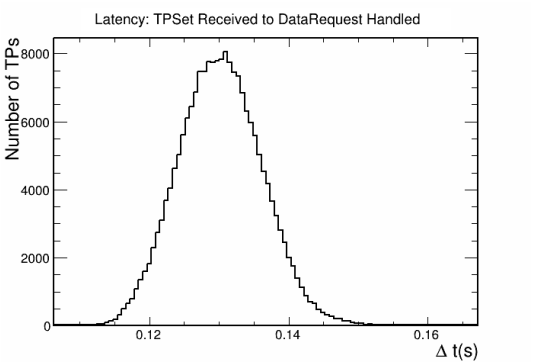
Trigger Candidate
Cluster of TAs across all sub-detectors

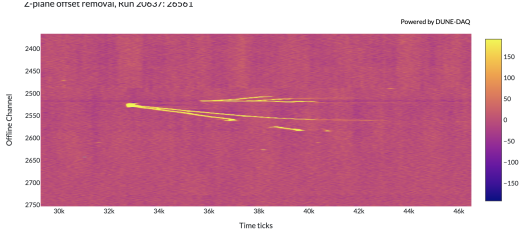
Trigger Decision
Issues trigger request based on some logic

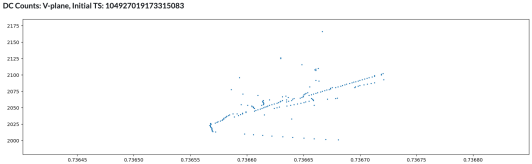
Multiple trigger tests with the Vertical Drift Cold Box at CERN.

- February:
  - Mostly not good! Issues outside of the trigger: very high TP rates, unphysical time over threshold.
  - Likely Software TPG implementation & detector noise issues.
- March:
  - Good! Recovered stable Software TPG once the detector was stable.
  - Trigger rate tests, trigger algorithm tests, latencies.
- May:
  - MLT tests, multiple algorithms, trigger rate scans, stable-running.
  - Concurrent triggering algorithms setup tested for the first time – did not work correctly.

- Confirmed various bugfixes work.
- Collected data with various triggering algorithms.
  - Horizontal muon, Prescale, Michel electron, low energy event
  - We can use that data offline with trigger replay app.
- Measured latencies between different parts of the trigger graph.
  - Mostly satisfying, but need to streamline the process & include in diagnostic graphs/Grafana.
- Trigger rates before crash: $\sim$25 Hz with 1 TRB, $\sim$80 Hz with 6 TRBs.

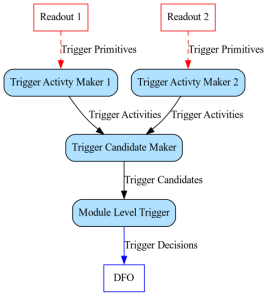






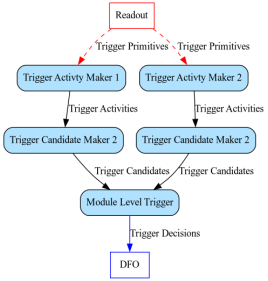
Concurrent sub-detectors (e.g. APAs) setup

- Tested on warm-box APAs.
- Runs without issues, but lower TP frequency thresholds tolerated before crashing.
- Will need to test performance scaling with number of APAs.

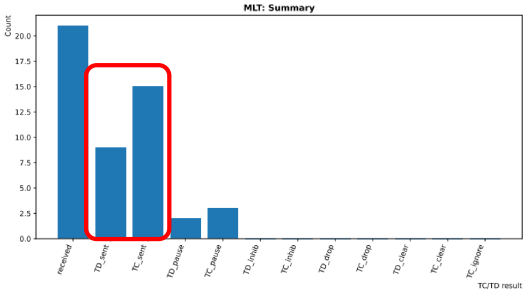


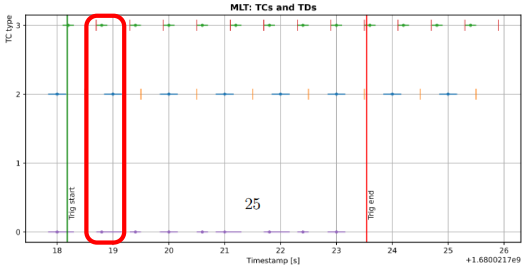
Concurrent triggering algorithms setup

- Initially tested on cold box in May.
  - Not successful: runs, but doesn't produce as many TDs as expected.
- Recently brought to dev & fixed few bugs.
  - Many other changes since then, including how readout links with trigger.
- Now runs successfully on warm box. Will test on cold box.



- New MLT logic: merging time-windows for overlapping TCs.
- TC buffered *timeout* time for another TC with overlapping readout window.



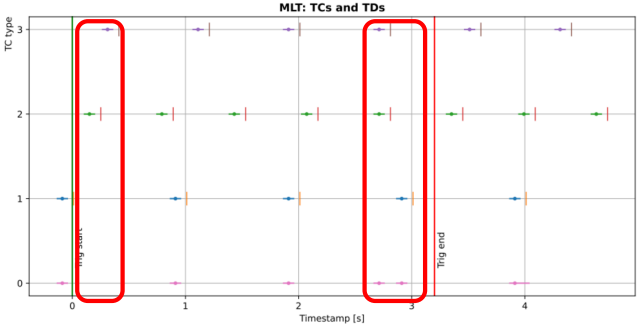


- Number of TCs and TDs don't match.
- TD can contain time-windows of multiple TC!

- TD (row 0) crated from multiple TCs (row 2 & 3)

- **Goal:** To trigger on coincidence of different triggered algorithms.
- E.g. trigger on SN, OR trigger on overlapping PDS TC & TPC.

["kSupernova"], ["kHorizontalMuon"], ["kTPCLowE", "kTiming"]
↓
[3], [7], [2, 1]
↓
0000000000001000, 0000000010000000, 0000000000000110



Can trigger on different "bitwords" – combinations of algorithms.

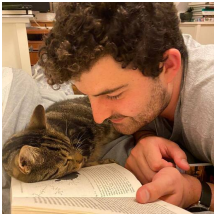
Example: Triggering on [1] or [2,3].

Many other developments on MLT!

- Readout window for TD can be expanded beyond the TC start/end time.
  - Configurable for each triggering algorithm via standard json
- Custom Trigger Candidate Maker
  - A fake TCMaker that can "pretend" to be of any triggering algorithms.
  - Fully configurable: chosen frequency, algorithm type etc.
  - Useful for testing the MLT logic.
- Can ignore TC by algorithm type, but still use it to expand time-window of another algorithm.
- Option to drop timed-out TCs.
- Limit on the maximum length of TD.

- Offline Trigger Simulation (Iker Loïc de Icaza Astiz)
  - Interface TPs from offline physics simulation (larsim) with DUNE DAQ.
  - Store triggered TA/TC/TD in the offline simulated files.
  - Work in progress! LINK
- Lots of bug-fixes: fixes for coldbox running, fixing TZippers, expected queues tolerance, etc.
- Mini trigger infrastructure meeting at UCL in April.
  - Knowledge transfer (Charlie breaking for work placement), running on real hardware.
  - Trigger infrastructure overview/intro document written (with TODOs) DocID: 28497
  - Iker Loïc de Icaza Astiz, Charlie Batchelor, Maria Flavia Cicala, Michal Rigan, Artur Sztuc.
- Trigger deliverables for v4.1: MLT coincidence logic.





Simranjit Singh Chhibra | Iker Loïc de Icaza Astiz | **Charlie Batchelor** | Michal Rigan | Artur Sztuc

- **New member of the group: Simranjit Singh Chhibra!**
- **Charlie on a work placement for the next few months.**
- We work with Data Selection/Physics Performance & Core Software groups.
- UK is leading the trigger development.
- Volunteers very welcome, a lot of work/github issues still ongoing!

- Scratched the surface of the trigger work over the past 6 months.
- Many changes made to the MLT logic by Michal.
- Coldbox allows us testing the trigger performance on a live system.
  - Issues found help us to create more stable & robust system.
  - Performance/latencies/stability tests.
- More changes to the trigger infrastructure before the next test:
  - More multiple-algorithm/MLT logic tests.
  - More fluid data transfer between modules.
  - Latency/stability/performance diagnostics.