NP04 DAQ Performance and Testing Plans

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Reminder on DUNE DAQ

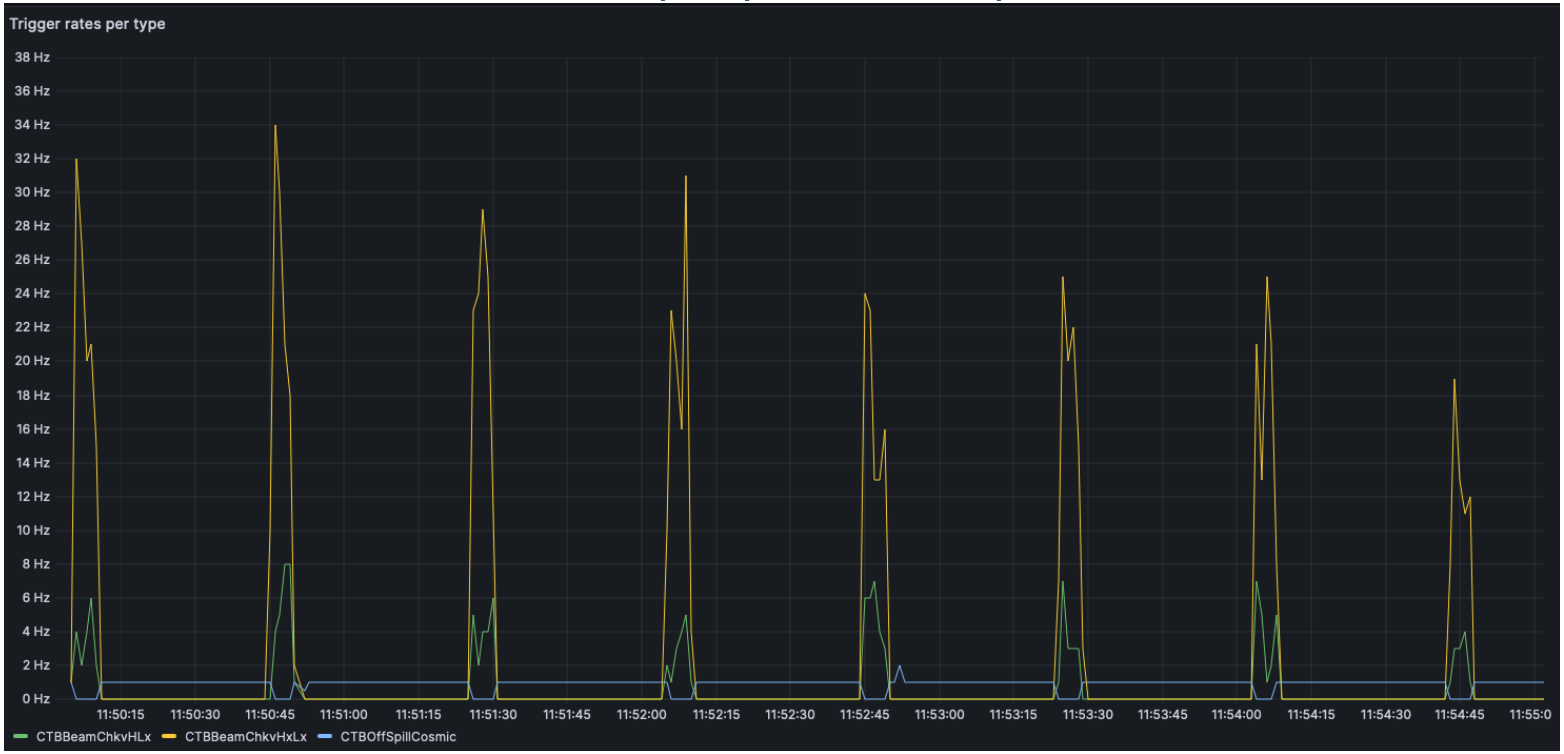
- DUNE DAQ is ***substantially*** overhauled from the previous NP04 run
  - Completely new, DUNE-specific DAQ application framework
  - New interfaces to detector electronics, including ethernet-based readout for TPC
  - New configuration, control, and monitoring systems
  - Software-based trigger primitive (TP) generation from TPC waveforms
- All of these changes bring us closer to the final design and implementation for DUNE
  - And especially in some cases, re-adapting them to run for a beam run in a surface detector has been challenging!

Overall DAQ Performance for Beam Running

- DAQ collects data surrounding the trigger time
  - 3 ms total readout window for TPC (0.25 ms before trigger, 2.75 ms after)
  - 5.5 ms total readout window for all other components (2.75 ms before trigger, 2.75 ms after)
- Trigger records are ~142 MB in total size
  - TPC readout (streaming, unbiased): 107 MB
  - “Streaming” (unbiased) PDS readout in APA1: 25 MB
  - “Self-triggered” PDS readout in APAs 2-4: 9 MB
  - Trigger Primitives (from TPC): 1 MB
- DAQ is stable collecting data at ~15 Hz average rate, 40-45 Hz instantaneous rate
  - Using 8 datawriter applications writing to SSD storage volumes
  - Limitation overall data rate is bandwidth from readout servers to data storage servers
- Getting to that state has been a long effort, especially in PDS readout
  - Still seeing occasional losses (sub %) of data from self-triggered PDS, and continuing to fine-tune/debug this
  - Offline analysis of data needed to better inform overall data completeness / quality

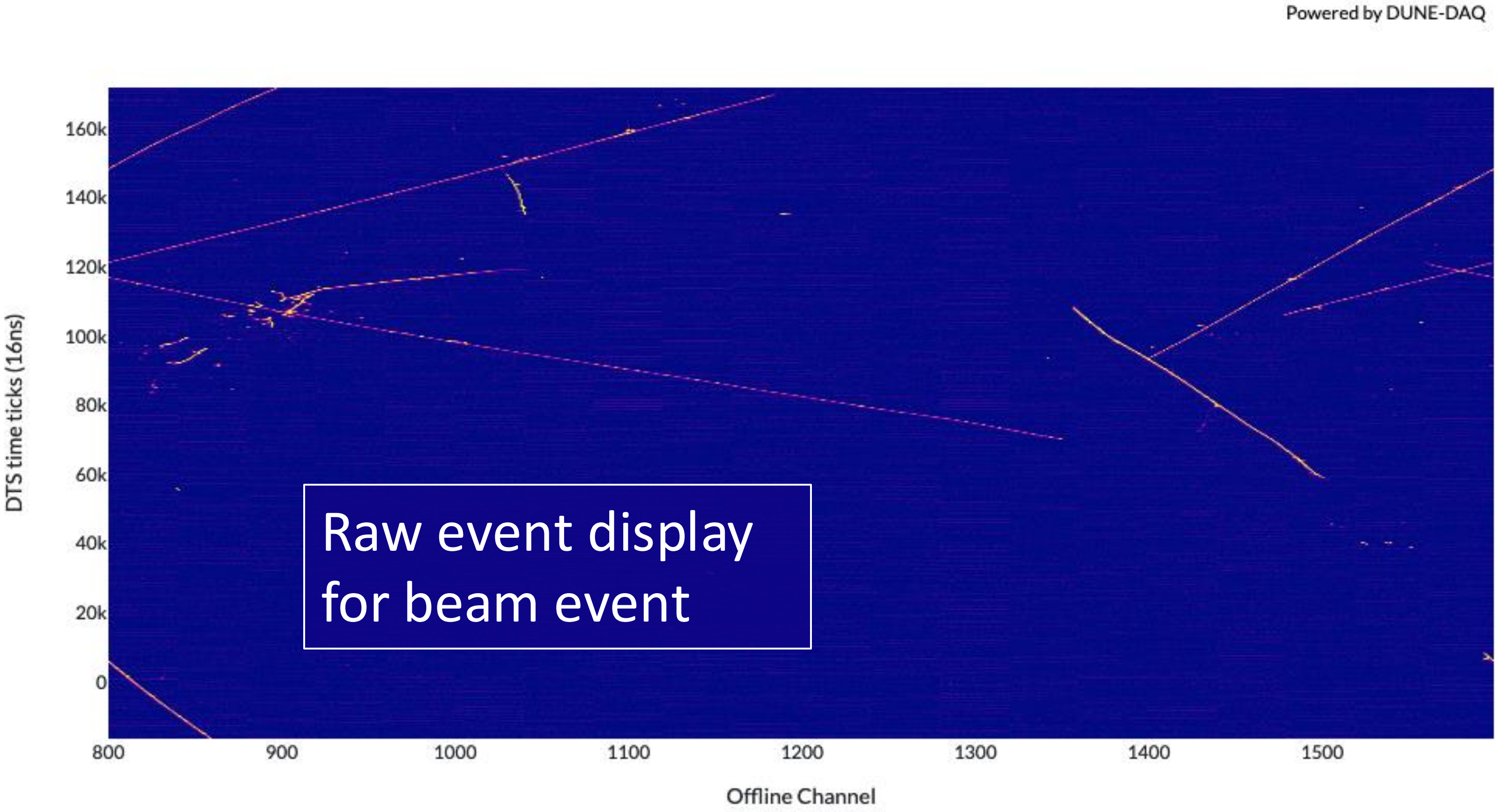
Trigger

- DAQ central trigger board (CTB) records external signals (beam instrumentation, cosmic-ray-tagger hits) and performs trigger logic
  - Typical configuration uses beam TOF counters in coincidence or anti-coincidence with Cherenkov counters (yellow and green below), with cosmics collected outside of spill (blue below)



TPC Trigger Primitives

- Performing realtime processing of collection wire signals to identify interactions and construct trigger primitives



TPC Trigger Primitives

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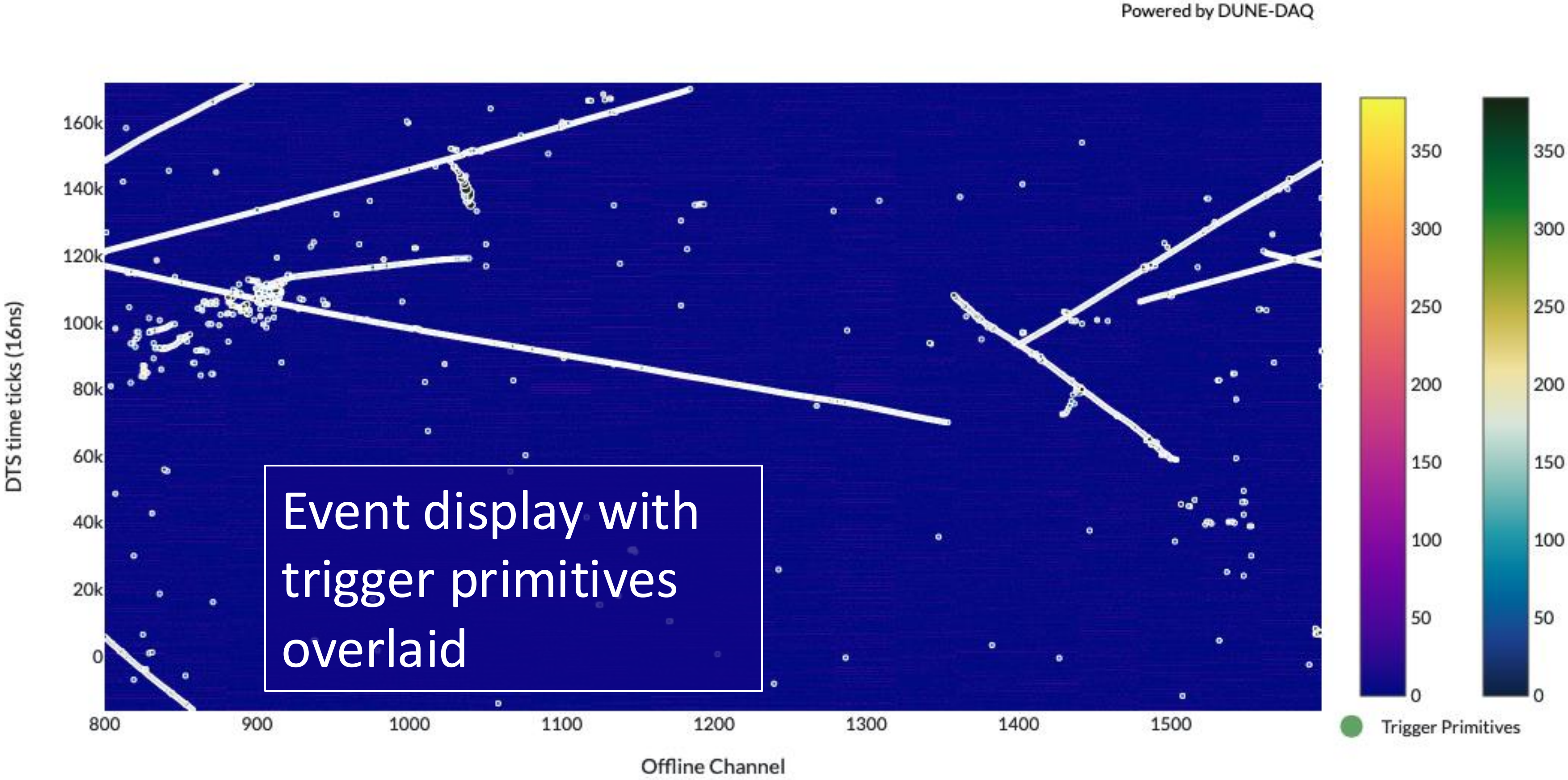
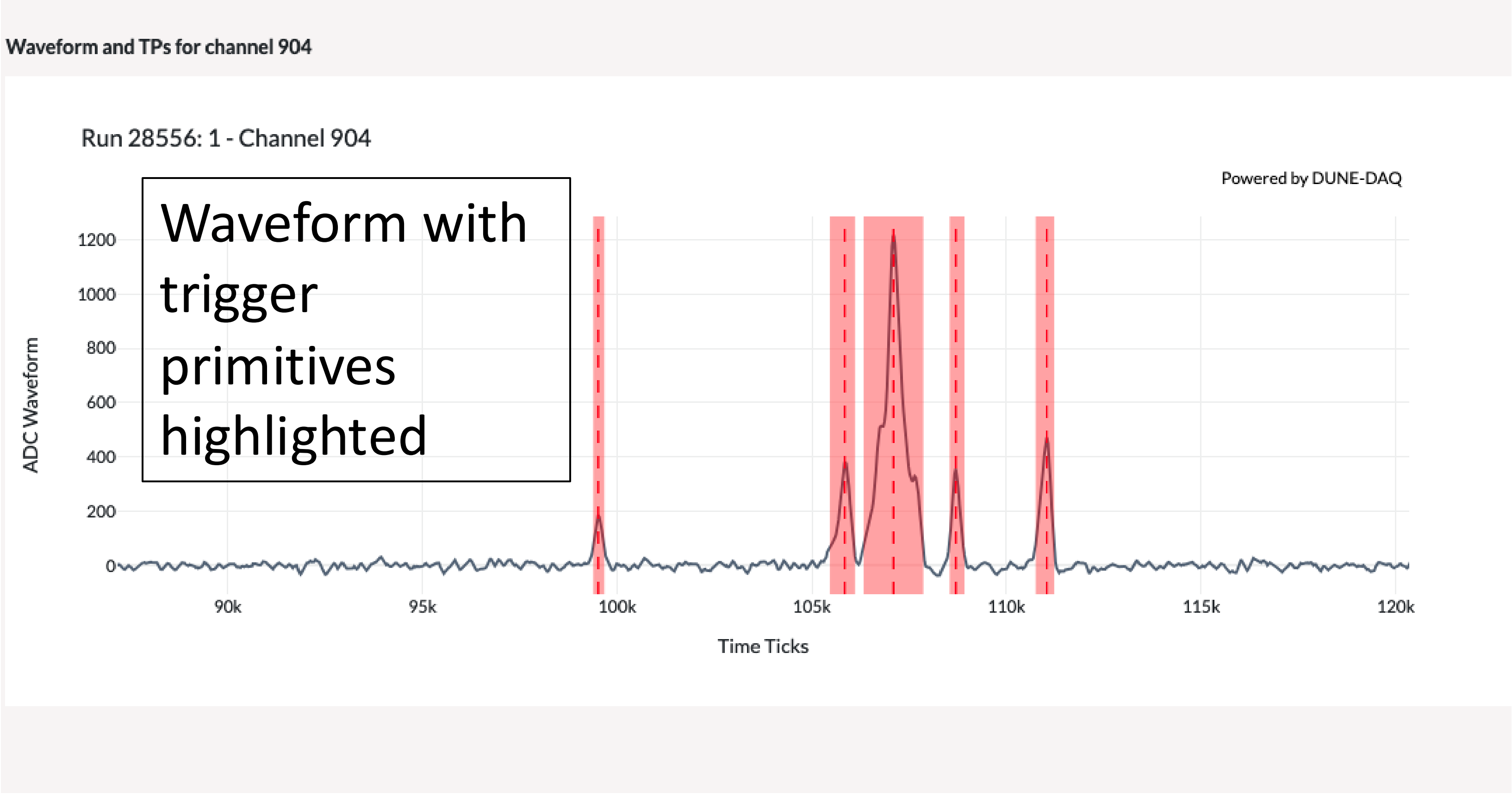


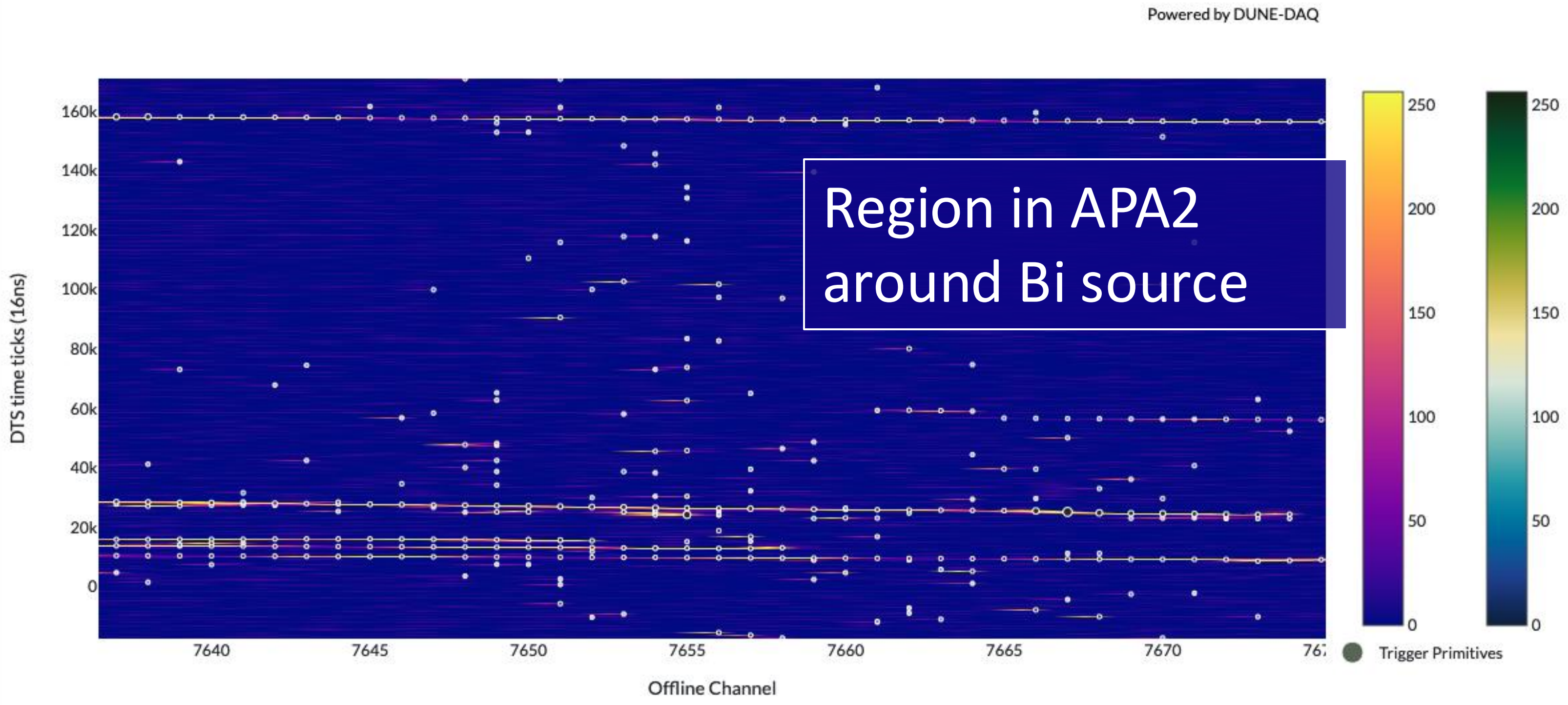
TPC Trigger Primitives

- Performing realtime processing of collection wire signals to identify interactions and construct trigger primitives
  - TP threshold at 60 ADC counts above baseline with 7.8 mV/fC gain setting



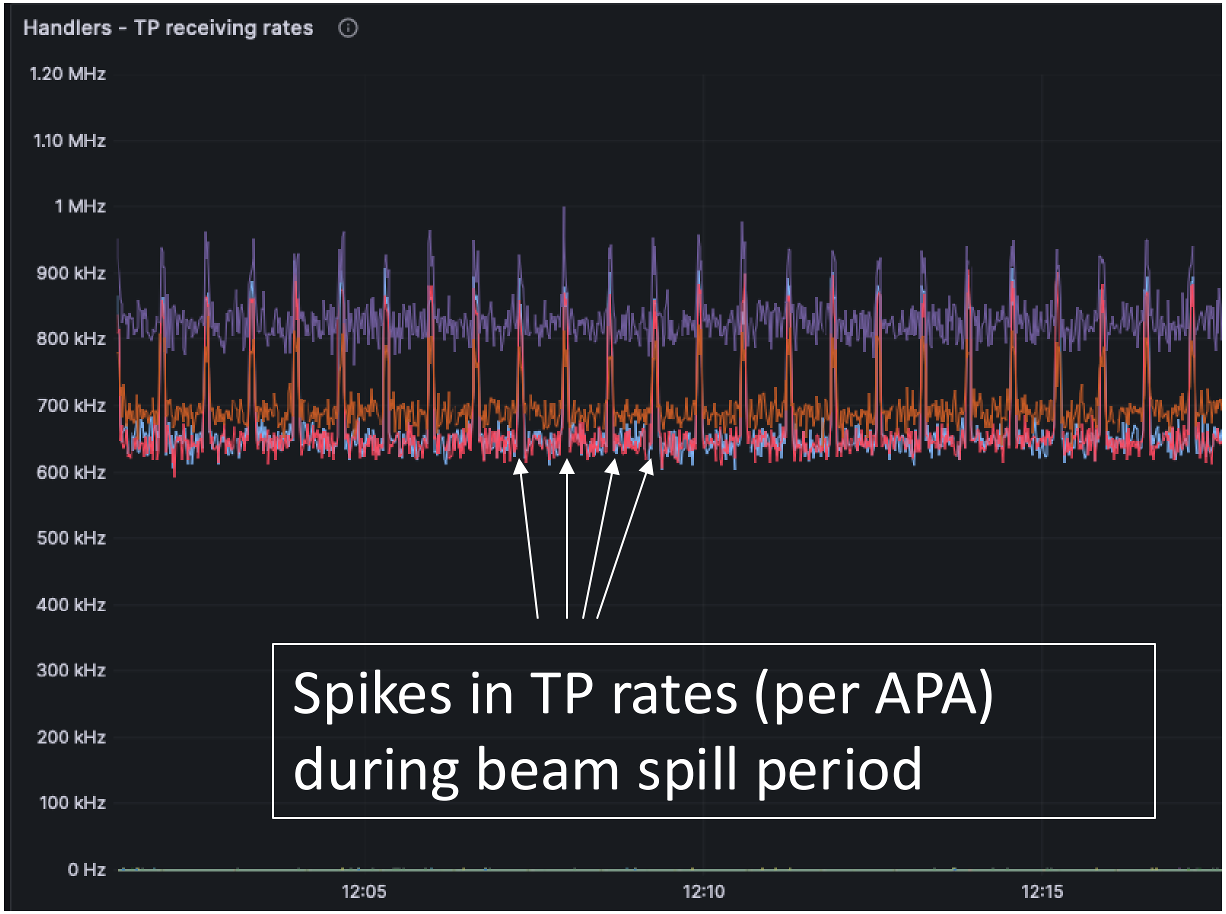
TPC Trigger Primitives

- Performing realtime processing of collection wire signals to identify interactions and construct trigger primitives
  - TP threshold at 60 ADC counts above baseline with 7.8 mV/fC gain setting
  - Still need to complete detailed energy threshold studies, but clearly show sensitivity to sub-MeV signals



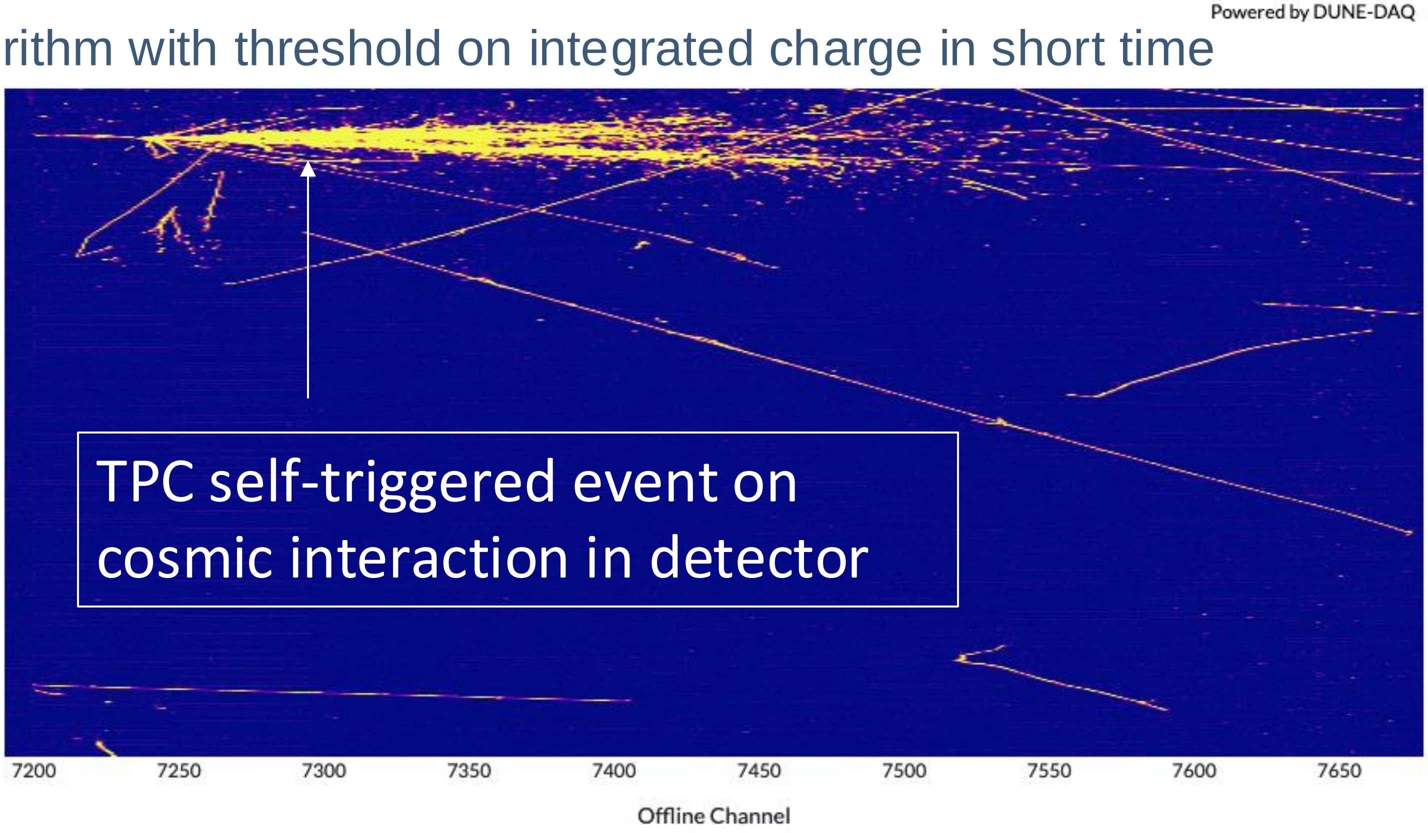
TPC Trigger Primitives

- Trigger primitive rates are sensitive to both beam and detector conditions



TPC Trigger Primitives

- Able to trigger on collected TPs
  - Simple algorithm with threshold on integrated charge in short time window
- ***All TPs recorded in separate data stream***
  - ~3 MHz of TPs from all collection planes, ~160 MB/s



  - Note: estimates for far detector are ~2 MHz of TPs (collection only) per 10 kTmodule

Remaining DAQ work / status

- Integration of CRT into DAQ
  - ~Completing today with deployment of CRT-driven triggers in our configs
  - Limited in readout of CRT due to stability of electronics during day hours → still understanding that
- Integration with laser calibration system
  - Software integration validated last week, with laser producing 10 Hz of trigger candidates, properly handled in same way as all other triggers by the DAQ
  - Still need to fully demonstrated with synchronized laser pulses; in meantime, have taken long (136 ms) readout windows to capture laser tracks
- Debugging / optimization to improve data completeness for self-triggered PDS
- Deploying improved network monitoring
- Further analysis of the data!

Plans for after beam run in NP04

- Main priority is to support other detector work
  - Laser, investigations on ground bounce, etc.
- Second priority is additional running with TPC self-triggers
  - Use simple integrated ADC over time window to trigger on high energy interactions
    - If time allows there are some other algorithms that could be of interest to try, but not a high priority
  - Main technical goal is to ensure stability and gather latency measurements over long period of running (~day)
- Deferring many additional tests / developments to NP02
  - Deploying new version of DAQ there that has substantial differences in CCM