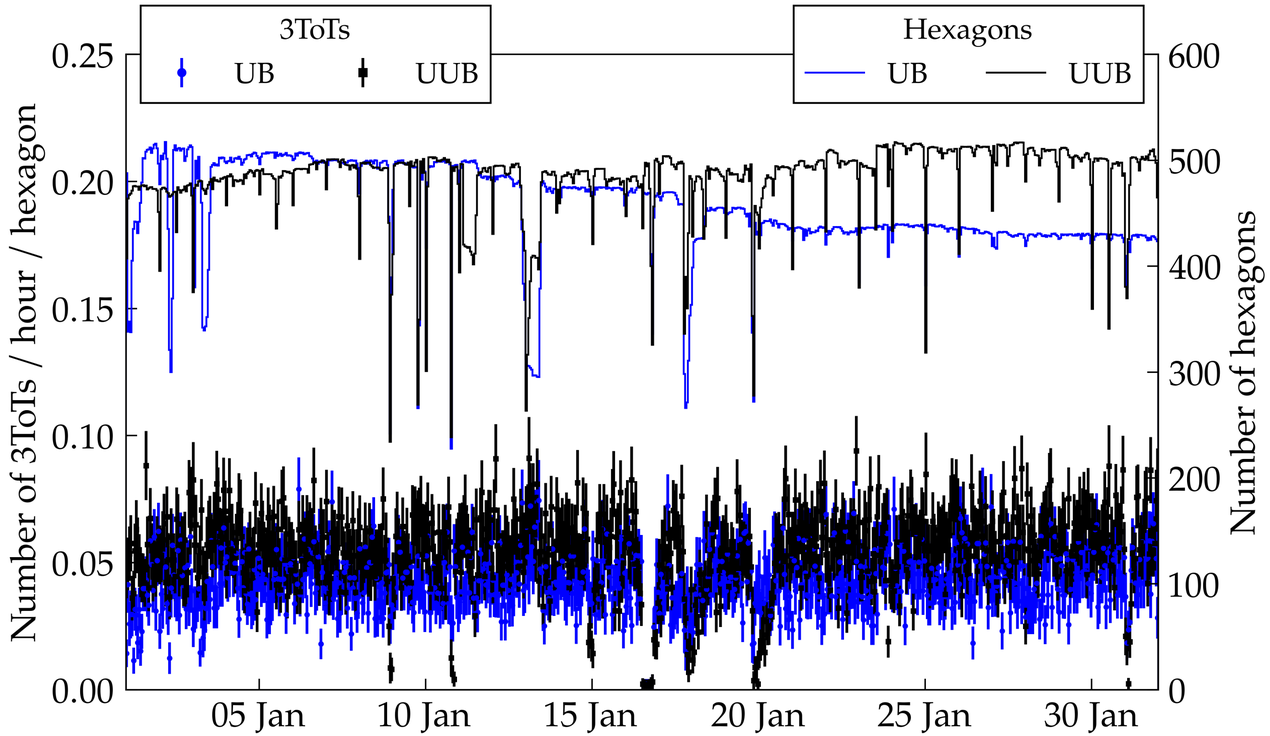
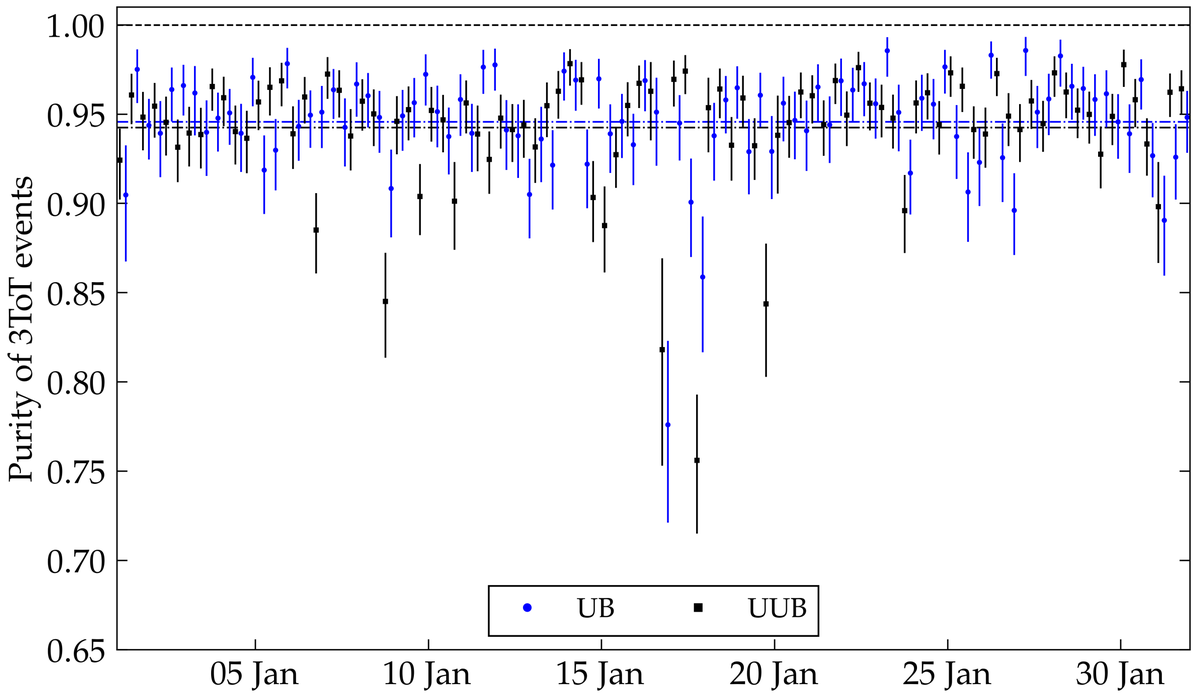
CDAS

T3 formation

TOT2C1&3C2 with SD-1500





From AugerPrime review report

Inclined T3 mode unexamined for SD-1500 and both modes unexamined for infill arrays

Some prominent issues

1) Silent stop in communication between two CDAS processes (Xb and IkServer): loss of all events

Ricardo Sato
April 2024 Collaboration Meeting

Downtime ~3%

- Related to handling of messages between process during periods with high T3 rate
- Likely ***mitigated*** (although not solved) **in undeployed (but tested) CDAS DAQ version**:
  (Xb identifies issue, stops, and is restarted)

2) Rejection of late-arriving event data from stations (Pm/Eb T3 timeout): data loss

Ricardo Sato
April 2024 Collaboration Meeting

Extent unclear (would show up in bad periods)

- Occurs with backlog of event data in station to send to CDAS (periods with high T3 rates)
- After T3 timeout reached, event data arriving at CDAS discarded
- Ideas for treatment:
  - Priority scheme for transfer of data from stations to CDAS with tiny event summary packet sent first
  - Store late arriving data and merge it later during data production
  - Increase wait time before timeout

Some prominent issues

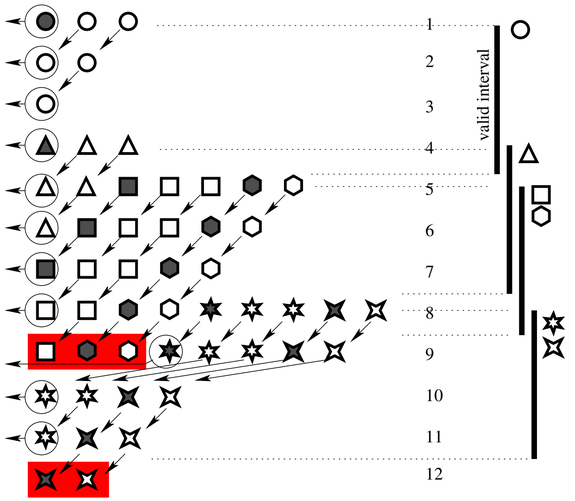
3) Massive backlogs in T3 emission due to T3 bursts during lightning: event loss Downtime ~5%

Mitigation by discarding T3s where emission would be futile (due to elapsed time) implemented **in undeployed (but tested) CDAS version**

Handling of backlogs in T3 emission and T3 priority machinery *Dr. Ricardo SATO*

Centro de Convenciones 13:00 - 13:18

Ricardo Sato
November 2023 Collaboration Meeting



4) VEM coincidence histograms not written to event data by CDAS

Implementation in undeployed (but tested) CDAS version

- Multiple important mitigations/implementation in CDAS DAQ code tested but not in deployed version
- Coupled with upgrade to Debian 11/12, where testing not yet complete
  - Multiple trials… latest on array administered by Ricardo in May, no issues immediately obvious
  - Close look at output planned (but delayed due to conflicting demands on time, person-power)

Until complete: Significant event loss during periods with high T3 rates lightning

No VEM coincidence histograms in event data

Support for new triggers

T2 Format

- New triggers are currently being developed and there will (hopefully) be more proposals (making use of the UUB, SSD, RD, and UMD)
- Our bandwidth from stations to CDAS is limited (to ~140 Bytes per second)
  - Currently, we have a rate of ~20 Hz for T2s
  - Uses ~50% of available bandwidth (station → CDAS) (keeping in mind, we also need to transfer monitoring and event data)
  - ~90% of T2s are T2 Thr triggers with ~10% purity
- Do we envision additional triggers (beyond RD) requiring unique identification when forming T3s?
  → additional T2 bits?
- Do we need to monitor SSD, RD, and UMD uptime in real time (e.g. for exposure with new triggers)?
  → additional T2 bits?

Re-define T2 structure?
- Requires changes at every level of DAQ chain
- Timescale (with testing): 1 year+

Noisy T2 / T3 types

- How to avoid communications being overwhelmed though T3 types prone to noise bursts (e.g. radio trigger)
- Proposals & test implementations (all veto based) at UUB DAQ and CDAS level
  - How to safely and efficiently test them?

DAQ testing environment

- Proper testing incredibly time consuming (since no standardized tools) but necessary when testing on (stations operating in) main CDAS instance
- Separate CDAS instance with one BSU would minimally impact aperture (<10%) while allowing for aggressive testing and development of new triggers (and other DAQ implementations) without risk to operation of main CDAS instance

Towards standardized testing tools…

Checklists for testing UUB and CDAS DAQ output on AugerWiki
(and space to document results)

Simulation of full CDAS pipeline in development by Ricardo

(testers?)

DAQ Testing

1. DAQ Testing
    1. List of past events / tests / updates
    2. Checklists

List of past events / tests / updates

Completeness is not guaranteed. Event data can largely be used to determine the software and configuration applicable to individual stations at a given point in time.

DAQ Software	Start	Stop (if applicable)	Details/Validation	Brief Description
UUB DAQ	March/April 2024			Tests of UUB DAQ V128R0B0P22 on test hexagon
CDAS	Jan 11 and 23, 2024			Handful of BSUs rerouted to test CDAS DAQ instance during lightning period
UUB/RD	Jan 2024			RD-T2 Tests in Tromen and Hilda
UUB	July 7-10, 2023		Link	UUB DAQ updated in most UUBs to V128R0B0P20.
UUB	March 2, 2023			Command to disable ToTD triggers sent to all UUBs to confirm ToTD as dominant cause of transient spikes in trigger rates at 0 and 12 UTC.
UUB	Dec. 5, 2022		Link	UUB DAQ updated to V128R0B0P15. Includes downsampling in VEM peak calculation for triggers, machinery for tracking GPS 1s issue and comparisons with CDAS time, and fix to offset w.r.t. UB in T2 timestamp
CDAS	Oct. 1, 2022	Oct. 1, 2022	Link	New version of CDAS DAQ compiled using root 6.26/06 (requiring C++14) on test OS, Debian 11, with full support for WCD-SSD VEM coincidence histograms.
UUB	Sep. 2, 2022		Link	DAQ updated on all UUB stations to V128R0B0P12
CDAS, UUB	August 10, 11		Link	UUB DAQ updated on a few test stations to V128R0B0P12. Includes T2 trigger flag disambiguation and GPS configuration protocol with respect to integer second offsets. CDAS DAQ update with bug fix.
CDAS, UUB	June 24, 2022	June 27, 2022		Array shut down due to battery levels
UUB	May 25, 2022			Command to reenable ToTD and MoPS triggers sent to all UUBs

Checklists

Following tests of the CDAS DAQ and/or UUB DAQ, the contents of the T2, event data, and monitoring files should be inspected. The following questions should either be answered or deemed very low-risk.

Status Legend
Confirmed OK
Seems OK
Deemed low risk
Problems found
Not checked

CDAS DAQ

Event data:

Status	Test Description	Plots/Slides/Comments
	Are sd_*.root and merged ad_*.root readable with standard software (either cdas-user or Offline)?	
	Do the contents appear reasonable? Check distributions of reconstructed energy and zenith angle compared to reference spectra.	
	Was the rate of T3s (for both UB and UUB events) different during the testing period?	
	Was the rate of reconstructed events (for both UB and UUB events) different during the testing period?	
	Does the distribution of core positions match expectations?	
	Are sd_*.root and merged ad_*.root readable with standard software (either cdas-user or Offline)?	
	Are T2 and monitoring related files produced by the CDAS DAQ?	
	Future: Scripts testing existence of all relevant data in sd_*.root files.	

Monitoring files:

Placeholder.

T2 files:

Placeholder

UUB DAQ

One or few test stations

Status	Test Description	Plots/Slides/Comments
	Were the stations' trigger rates (T1/T2 threshold, ToT, MoPS, TOTd) different during the testing period?	
	Do the stations form and respond to T3 requests with event data at the expected rate?	
	Are the signals and timing reconstructed from the event data for these stations compatible with associated T3 event?	
	Is monitoring data sent and does it look reasonable?	
	Do the stations appear synchronized (i.e. no GPS integer-second offset)?	

Many (T3 forming) stations

Other

Tasks/Issues

CDAS

- **Delayed messages from Ik**
  Delay can be on order of 20 seconds resulting in loss of almost all events (data gone by the time T3 reaches stations). Problem persists until CDAS processes restarted (manually). Source not understood.
- **Upgrade of OS on which CDAS runs**
  Currently, this is Debian 9, which has lost official support. Work on-going for update to Debian 11.
- **Xb / IkServer communication issues during high T3 rates**
  Connection closed by IkServer but Xb keeps operating as normal.
- **T2 raw files indicating station offline but triggers visible in T2 dumps**
  Needs troubleshooting.
- **Pm sometimes gets stuck**
  Thought to be related to the connection of the BSU or some BSU emulator. Additional issue with IkServer disconnection. Details to come.
- **Include version of CDAS running into event data**
  Currently, it is not possible to precisely identify the version of the CDAS DAQ that was running at the time a given event was measured.
- **Merging of CDAS DAQ and cdas-user IO classes**
  Currently near-duplicate copies of IO classes exist (one in CDAS DAQ and one in cdas-user). This is inefficient and error prone.
- **Pre-deployment testing of changes to CDAS applications**
  Testing of compilation, unit tests, and functionality. Could test that by feeding in old input (e.g. T2s), applications produce same output (e.g. T3s). Could use simulated input as well.
- **Testing of CDAS output**
  Programs testing T2 data, event data, monitoring data should be placed in common repository with scripts to easily produce output checking integrity of file contents, etc.

UUB

- **Repeated traces in event data**
  16 out of 160 stations exhibit multiple instances of identical RD traces in event data. A similar issue appears in SD data in the case where two T2s exist for a single station in a single T3. Station 1101, PMT-3 can appear in searches for this effect due absence of baseline fluctuations.
- **Issues in online VEM charge estimate**
  Version of UUB DAQ with possible fix (relating to filtering and downsampling) requires further testing.
- **3 vs. 1 fold trigger for construction of WCD calibration histograms**
  Unintended switch when moving from UB to UUB. Impact requires investigation.
- **ToTd bursts at sunrise/sunet**
  Transient bursts in rate of ToTDs resulting in stations being switched off by CDAS. Can down significant fraction of array for a number of hours in some seasons. Source of noise not confirmed (appears to be linked to TPCB for at least ~12 UTC noise). Source of noise also linked to loops in cables inside station.
- **ToTd and MoPS rates exceptionally low in UUB**
  ... in nominal conditions. Possible differences in algorithms compared to UB, especially in integral conditions.
- **Oscillations in SSD baseline**
  Observable in many traces. Amplitude of oscillations well exceeds level of noise in baseline. Source unknown.
- **Two populations in ToT rates**
  Second population is of rates multiple times higher than nominal rate. Significant number of stations affected (>5%). Individual stations have been observed to operate in both modes at different points in time.

Other

- **Differences in output between running and repository code for creation of T2 uptime files**
  t2* and t2raw* files created from second_* files produced by CDAS DAQ at runtime. Historically only processed t2* and t2raw* files have been sent to Lyon. Differences need to be understood and it needs to be verified that there is no significant impact on exposure calculations.
- **SD Observer software needs update for info to identify and fix broken station hardware**
  Update needed to cdas-user Event Display to properly search for events with desired UUB stations to view traces, calibration data, etc. for use by the SD Observer in diagnosing problematic hardware to send teams to field to fix.

Pending Software Implementations

CDAS

- **CDAS monitoring of GPS 1s offset**
  Regular comparison of the GPS second of CDAS with that of stations is required for monitoring for 1s GPS offset issue. This check is implemented in the UUB DAQ, but the CDAS implementation is still missing.
- **SD Ring Trigger**
  Prioritization (and perhaps expedited emission) of T3 requests for lightning ring/disk events. Identification of such events would be performed using long signals flag in T2s.

UUB+CDAS

- **Status of SSD/SPMT/UMD/RD in T2 messages**
  If these detectors are to participate in future trigger algorithms, it must be reported whether the detectors are functioning or not for a given second to be able to accurately calculate exposure.

UUB

- **Online estimate of MIP peak**
  Peak estimate required for development of future triggers and for tube mask (deciding if PMT is functioning properly and if it should participate in triggers). Online, rate-based estimate of MIP charge would be helpful as fall back / cross check to histograms as well.
- **Both compatibility and full bandwidth VEM peak/charge to be included in event data**
- **Check status of ADC initialization**
  ADC unit appears to get stuck on occasion, always reporting the same one or two values. Details: details example

Documentation of Commissioning Bugs / Features

Observed features/bugs should be documented in a report within the corresponding repository on the Auger gitlab:
https://gitlab.com/auger-observatory/cdas/daq-fmea

Please feel free to create new items and add information/analysis on existing ones.