PXD Status

–

DAQ, ONSEN (ROI and HLT Feedback), SlowControl (RC, HVC) & Monitoring

Content

- Setup
- EB Interface
  - Load Balancing
- HLT Interface
  - Event selection
- ROI selection
- (Data-)rates
- ~~Gated Mode~~
- Slow Control
  - RC
  - HVC – Issues
- DQM

Reminder: PXD System Layout

Total of 0.2% of X_0

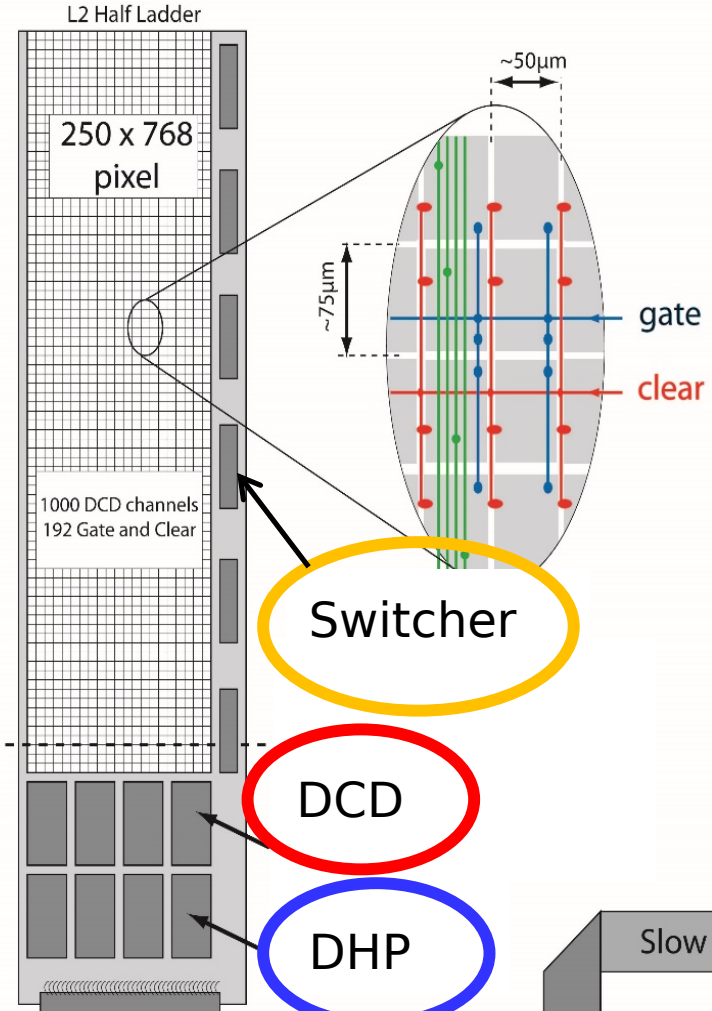
2 layers: @1.4(2.2) cm

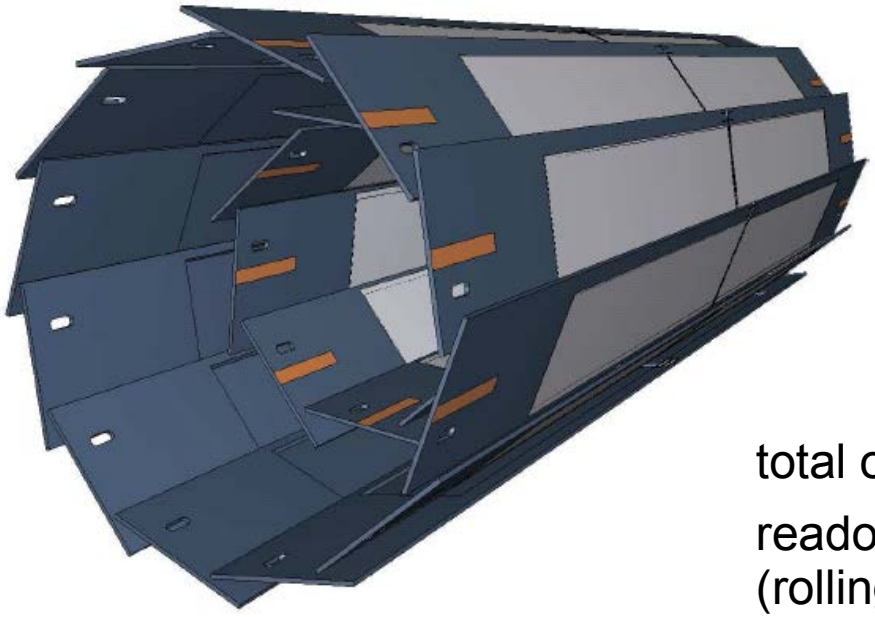
Pixels: 50 x 60(75) µm

half ladder: 768 rows

250 cols

15 x 70 (85) mm

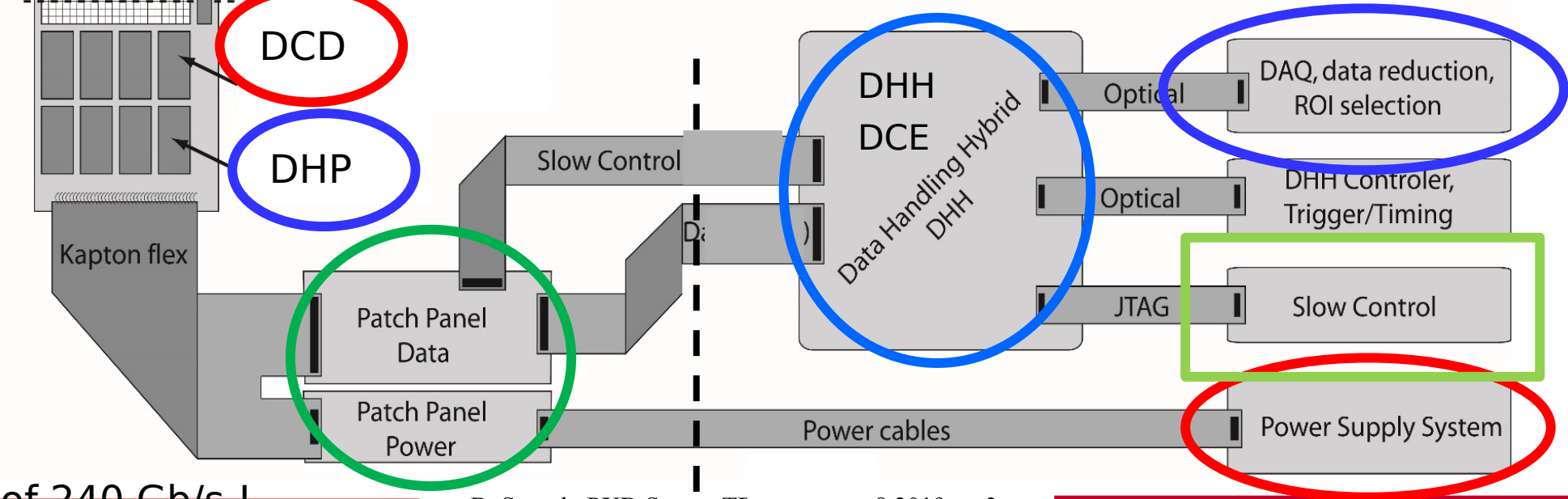




Thickness: 75 µm

total of 8 Mpx

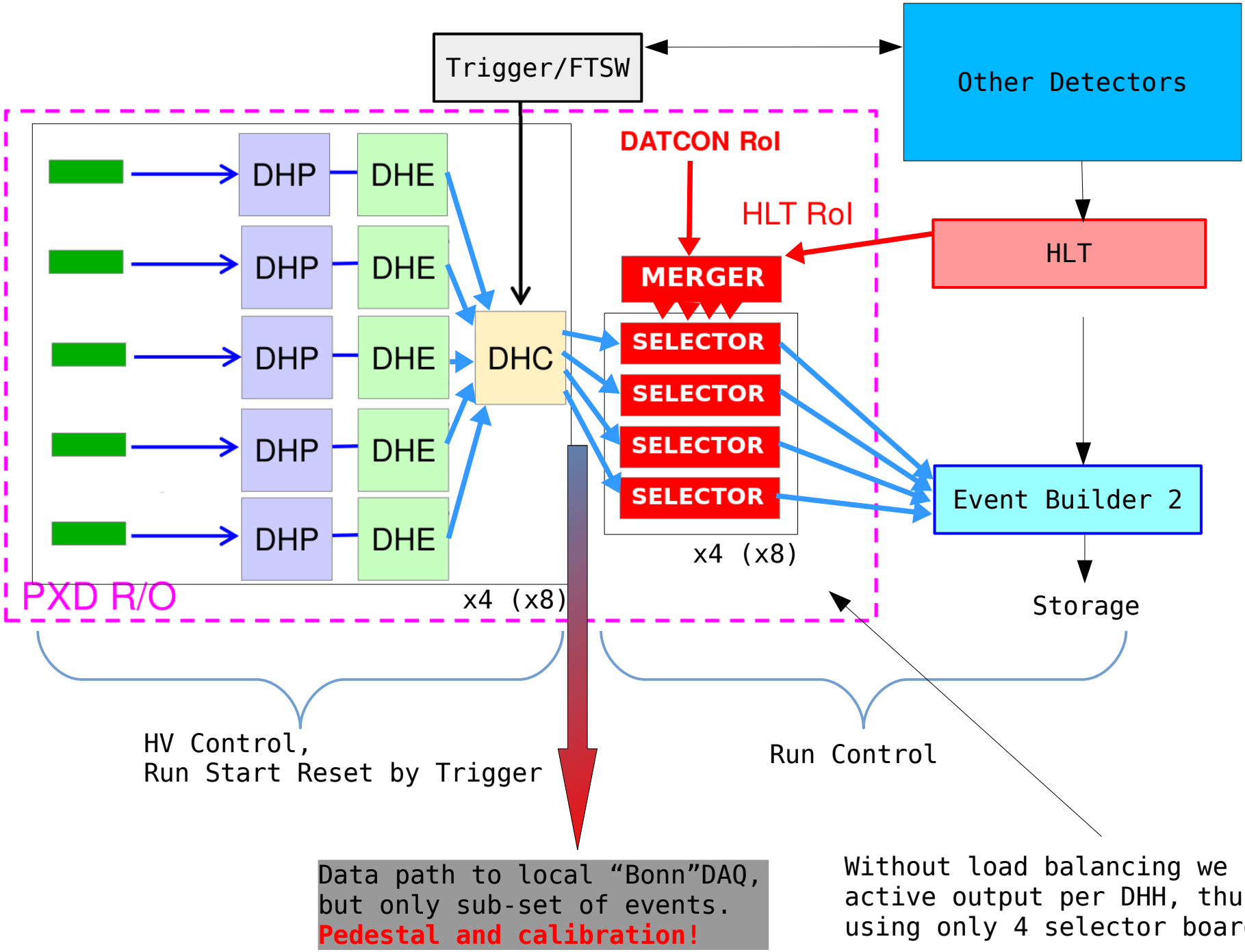
readout: 20 µs (rolling shutter)



total of 240 Gb/s !

off detector

PXD DAQ Scheme Phase 3 minimal (full) Setup



PXD Status – Short Overview

- Only ½ of PXD (20/40) modules installed
  - Two broken, damages on others
  - Only half of readout used (only ½ DHH and ½ of ONSEN powered off)
- Mostly stable data taking
  - 5kHz real data, 10kHz DAQ test, 35kHz with dedicated tests
  - Event selection on HLT (and ONSEN!) turned on now (event reduction to ~10%)
  - ROI selection tested in few runs (for half the modules → DHE order)
- Overlapping trigger firmware deployed during phase 3
- Only Belle 2 trigger veto for continuous injections, no gated mode (yet)

Overview of Main Issues

- Long HLT startup time, long buffering and processing times for some events (up to 2 minutes!), challenge for ONSEN buffering → full → trigger busy at each run start
- HLT does not clear buffers and/or worker nodes crash → for some events we never get triggers → still in memory at run stop
- NSM timeout EB/HLT → PXD seen as excluded (seems to be solved)
- "HLT before DHH" ← no data sent anymore from DHH (in most cases)
  - Firmware and/or ASIC issue
- Not all problem come from PXD even if PXD notices an error
- DHH firmware was updated/changed several times
  - PXD Busy and data corrupting happen with some versions
  - Different reasons → fixed with latest versions
- Lost 25% of data because of wrong trigger delay setting in early phase 3
- One optical link (of 80) went dead in June

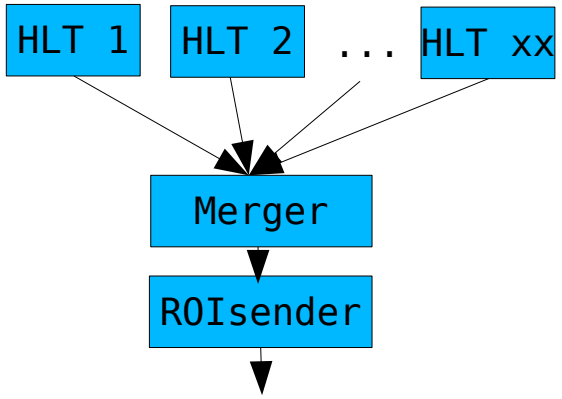
PXD-EB Interface

- Stable
- Few unexplained crashes on EB side
- Changes for ½ PXD and Load Balancing, different distributions schemes
  - Number of links from PXD to EB
  - Order in which events are distributed on the links
  - → configurable, tested and implemented from 2018 on (Simon, Yamagata, BS)
  - Verified again this summer
- NSM timeout issue (“PXD not included”)
- If some events are not coming from HLT→ ROISENDER → ONSEN, we will run out of sync at EB immediately.

DHH Load Balancing

- Needed for full bandwidth!
  - Scheme on DHH, ONSEN and Event Builder need to be configured identical
- Changes
  - 1 → 4 outputs per DHC
  - 4 → 16 ONSEN selectors used
  - 4 → 16 EB inputs used
    - Each 4th event goes to one EB input
- (still ½ of the full system)
- ONSEN and EB scheme prepared and tested already in 2018
  - Worked out of the box, no surprises
- Recently tested without modules and w/o ROI selection

HLT → PXD Interface



- "ROISENDER" and "MERGER"
- Stable
  - Lot of bug fixes and improvements before phase 3
  - Changes ahead: get away from mqueue
- NSM timeout issue ("PXD not included")
- If some events are not coming from HLT→ ROISENDER → ONSEN, we will run out of sync at EB immediately.

- HLT:
  - Events still got lost (not only dying workers)
  - Events still take too much time (>2min!)
  - Main impact: high trigger rate tests
  - Stale events from last run → now: better buffer flush before HLT STOP
    - (more a problem for EB, not so much for ONSEN)

Event Selection on HLT

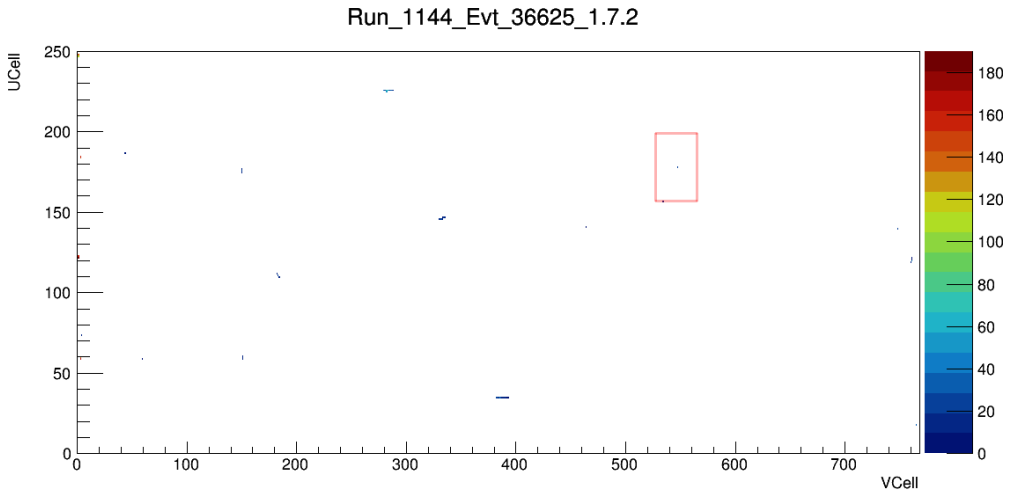
- Real High Level Trigger decision
- Decision is encoded into packet for ONSEN
    - ONSEN rejects data payload and send only header
- No problem found on PXD side
- Remark: we still have to send empty packets, they account for small additional fraction of bandwidth

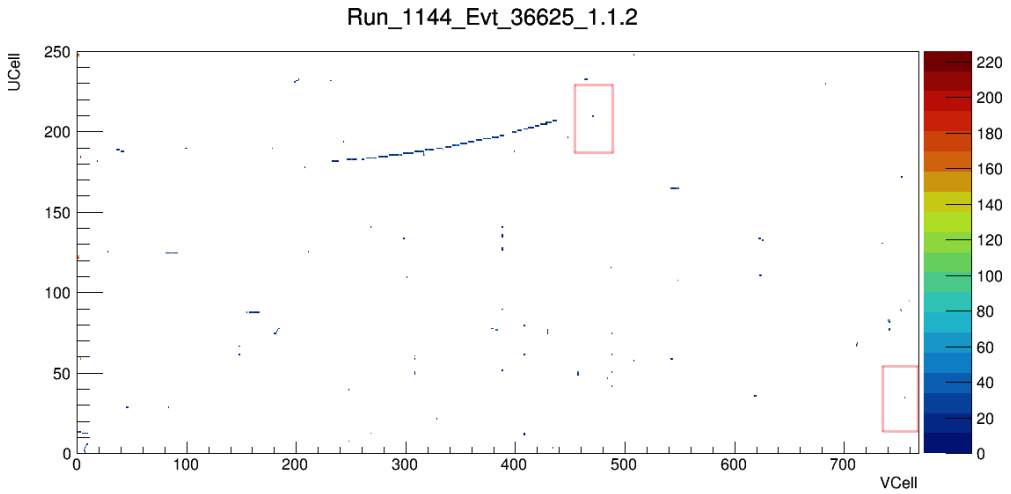
ROI Selection

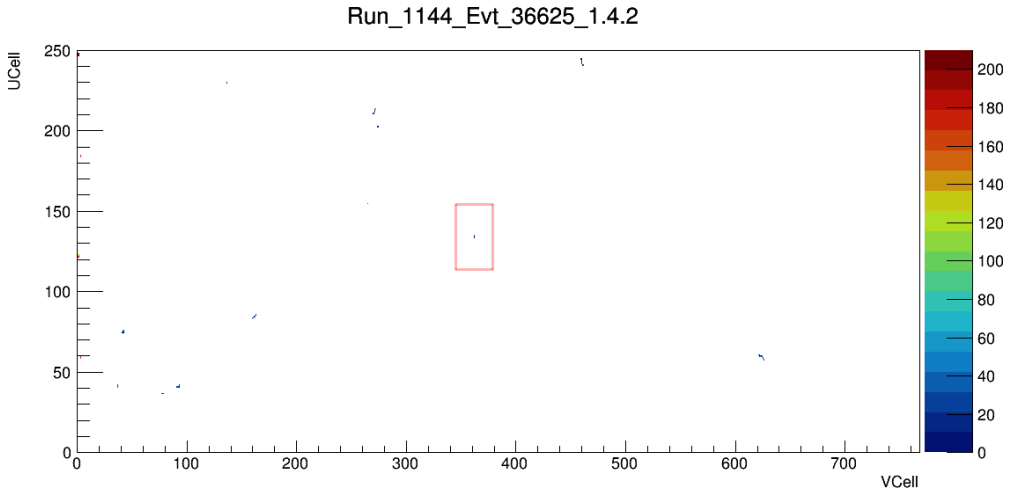
- ROIs are calculated on HLT and send to ONSEN
  - **Always enabled**. Even if ROI selection is disabled (in ONSEN slow control)
  - (DATCON as additional source, was not used until now.)
- ONSEN filters PXD hits based on these ROIs

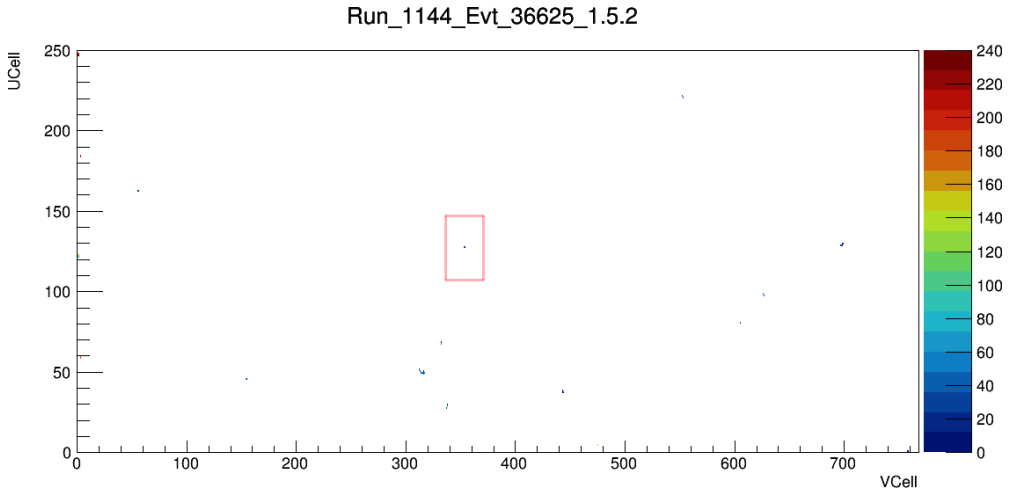
ROI Selection OFF, HLT ROIs Overlayed

Randomly chosen good event





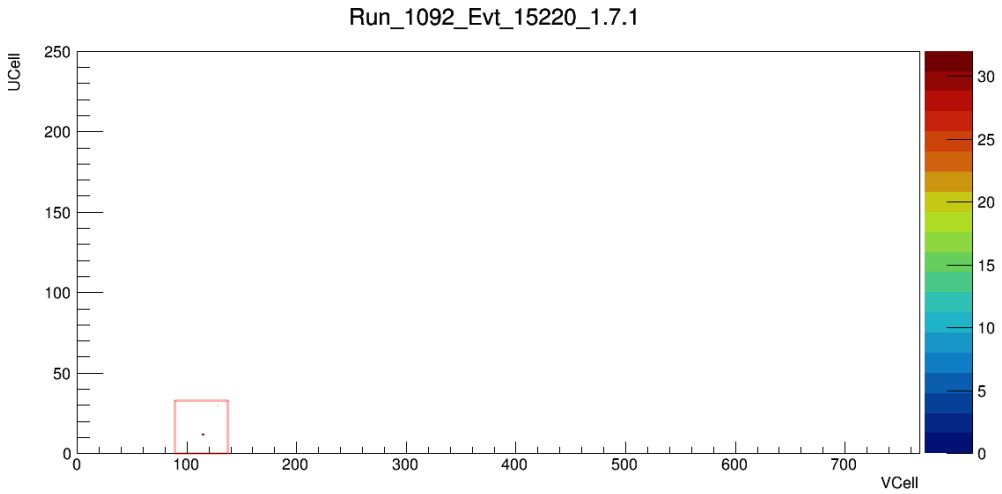


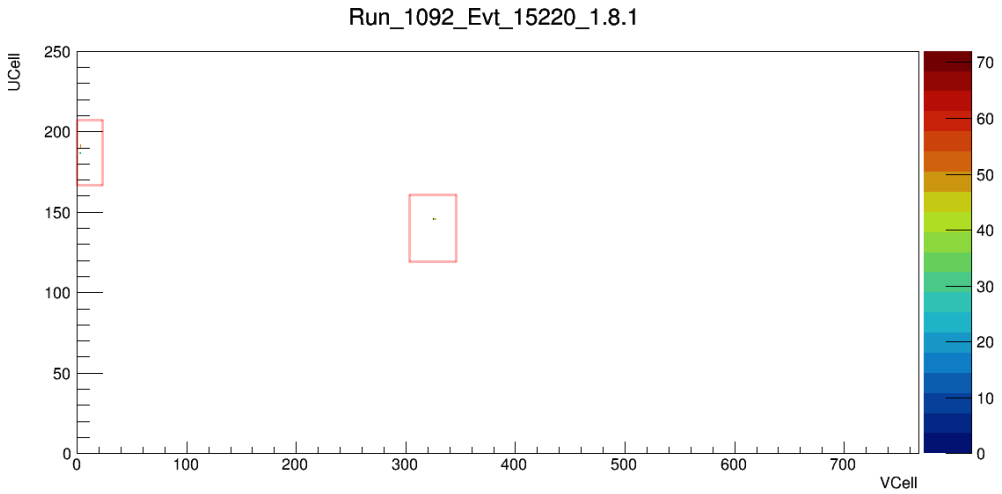


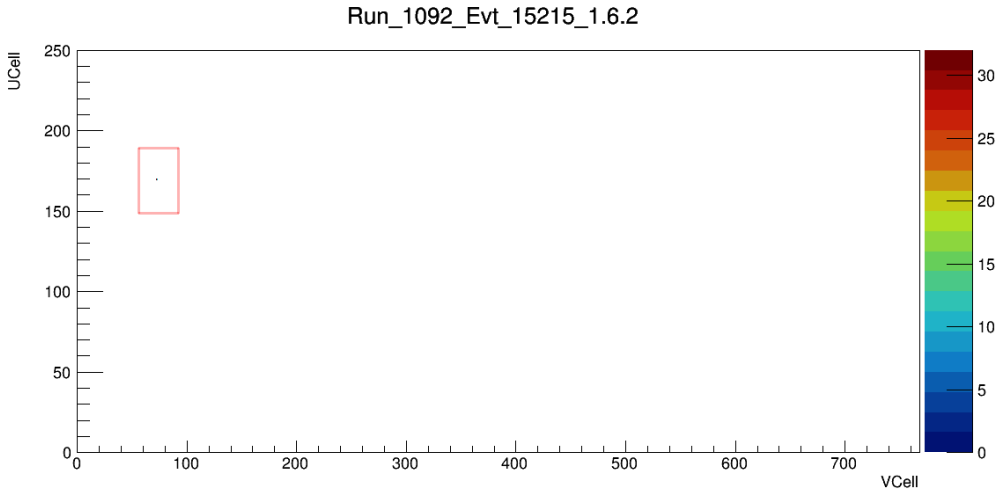
Cluster seem to be centered in ROI → extrapolation on HLT seem to have good quality

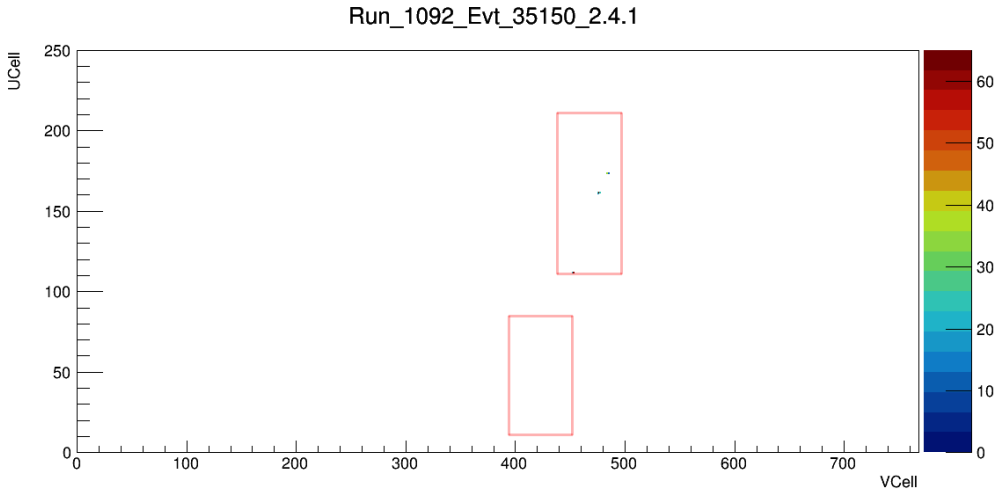
ROI Selection ON, HLT ROIs Overlayed

Randomly chosen good events









Cluster seem to be centered in ROI → extrapolation on HLT seem to have good quality
But: DHE Order problem, half of the modules have not data after selection
Selection worked as expected → verified in pixel-by-pixel check against BonnDAQ data

ROI Selection

- ROI processing was turned on as a test for several runs. As expected, data for modules which were out-of-order is empty (→ no ROIs)
  - Offline check against BonnDAQ data for other modules:
    - → **everything is selected as it should**
- ROI selection needs ascending module ID in data and trigger for matching
  - Not fulfilled in beginning of phase 3
  - Cables within connectors in dock box and on DHH RTM could not be swapped.
  - ROI selection could only be verified for half of the modules (→ B2GM talk)
- Reordering of inputs from PXD Module → DHE → DHC
  - Optical switch has been installed in summer shutdown
  - Full ROI scheme still need testing
- Quality of ROIs (=Tracking Quality & Size) t.b.d.
  - Efficiency for low pT

Problems – High Occupancy During Injection

- High occupancies together with triggers following shortly after each other → "link dropped" (actually the link is still there, but no data is coming for the current event)
  - DHP fifo full (CM=63)
  - Mainly during HER injection, 'dirty bunch'
- This won't stop the DAQ → manual SALS
- DHP ASIC limit
- Workarounds
  - 1: Increase the trigger veto length thus we should not get triggers when we have highest occupancy
  - 2: Gated Mode (todo)
  - 3: Reset DHP during injection veto time thus the dropped links would be limited to a time span between two injections.

(Trigger) Rate Tests

- Without DHH → 40kHz and more have been tested (already last year)
- Two explicit tests June 21st and June 25-26th
- Occupancy (0.052%=112 pixels); not saturate the link to EB (4*100MB/s max)
- Without event selection and ROI selection, the data rate at the output to EB is factor 30-50 higher than realistic case.
- run in global: null, poisson, HLT: passthrough & beam_reco
- 2us holdoff, 10kHz, 20kHz, 30kHz, 50kHz input trigger rate

(Trigger) Rate Test

- Main problem: Missing (trigger) events from HLT, memory is filling up by "forgottten" events
- Summary (after some fix was applied on HLT)
  - 30 kHz worked fine for DHH and ONSEN. HLT script passthrough (no processing at all)
  - 50 kHz is limited by DHH (most likely) to 35 kHz at 0.052% occupancy

  This run was performed with beam_reco_filter. Since HLT threads die and sometimes take > 200s for processing, PXD data in ONSEN memory get stuck. I think, 50 kHz and passthrough was not performed. But since we observe different causes of limiting factor, it's clear that this works as well up to 35 kHz. Hopefully HLT processes will not die such frequently after switch HLT handling to ZMQ. While running with PXD only, HLT load was quite low and not limiting factor of performance.

- Remember: the selected the occupancy depending on what you want to test → if we are dominated by back pressure from EB, we cannot go to higher rates. Realistic test would need load balancing and data reduction by 1/5 event and 1/10 ROI selection

Run Control

- No big problems since January, no big changes
- Restart procedure, environment for EPICS have been improved
- RC Status of HLT, EB connection to PXD improved, but I think it is not always showing error if the connection was dropped (crash?)
- NSM timeout EB/HLT → PXD seen as excluded (seems to be solved)

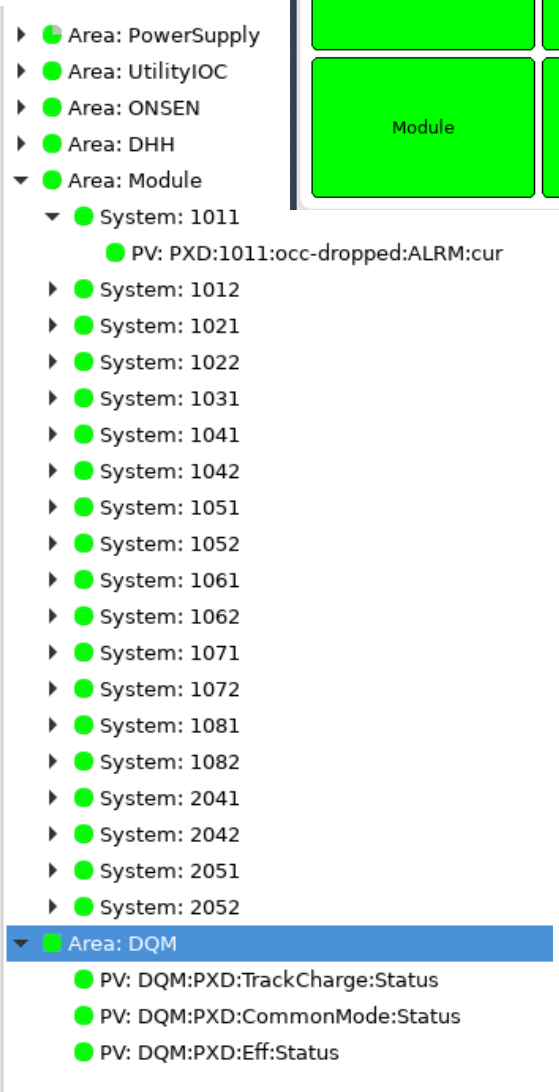
HV Control

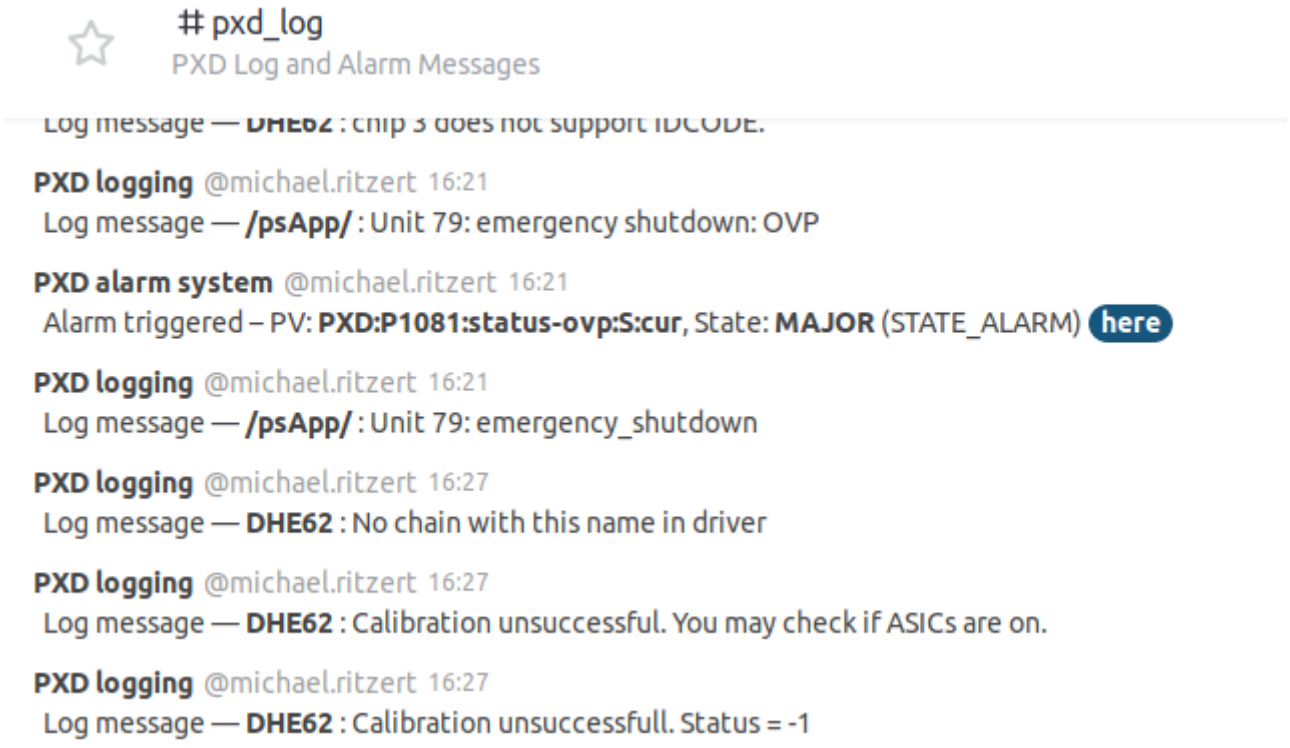
- Working as designed, but maybe not what is wanted
  - Injection inhibited while HV is in error (after over voltage protection shutdown) turning on/off or interlocked (cooling)
  - Removed TURN ON/OFF from state machine response (this is not what is intended…)
  - Automatic transition from ERROR to OFF
- Ongoing discussion …

- Observed several OVP in phase 3. → PXD shifter need to intervene as error state is blocking injections. Not clear yet how we can fit some (partly) automatic recovery in the current HVC scheme.

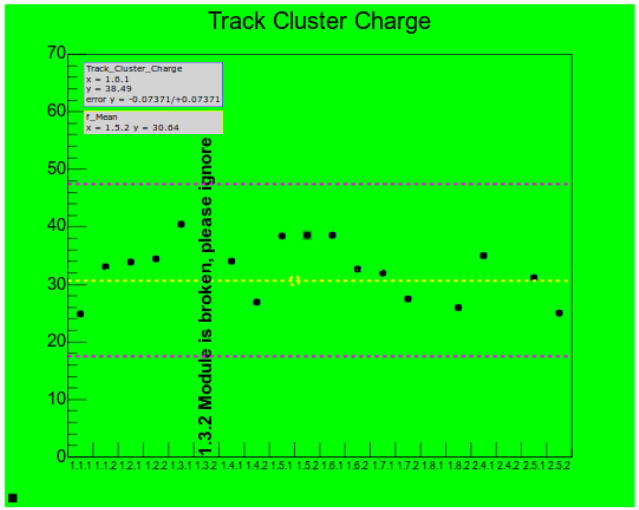
Slow Control & PXD Alarm System

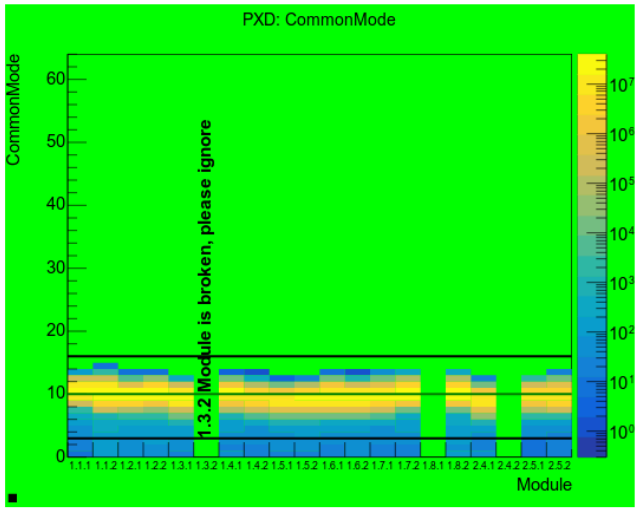
- PXD SC: no major issues, hardware was upgraded
  - IOCs, GW, archiver, monitoring…
- Alarms system & alarm tree
  - DHP temp measurement, occ. Drops, links …
  - New: Interface to RocketChat
  - (independent development from the one which is now used for DAQ/Zabbix)

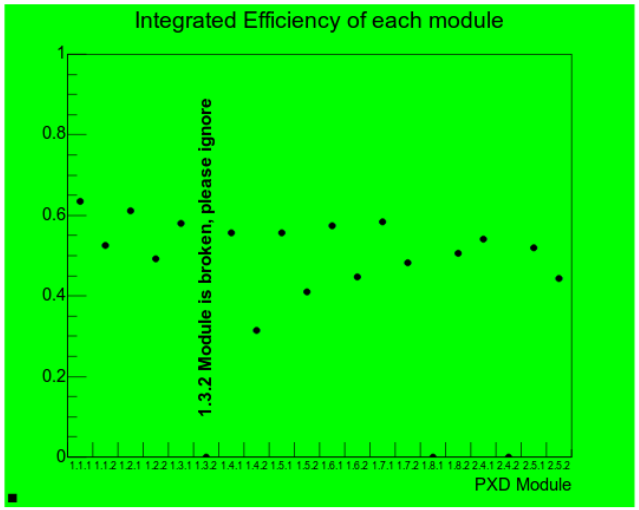




DQM "flags" in Alarm System







Histogram Status exported to EPICS & archived

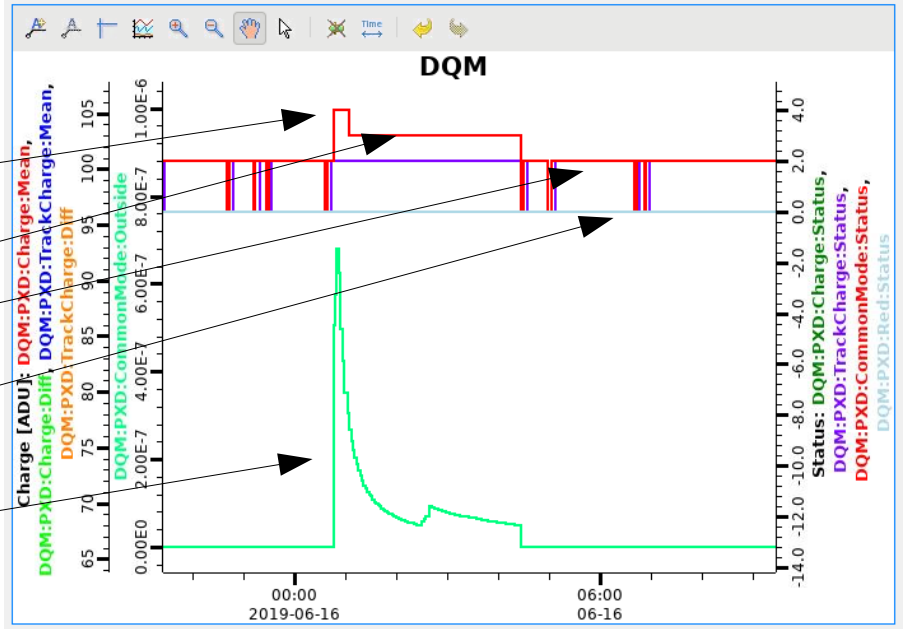
RED = CHECK!!!

YELLOW = check

GREEN = OK

GREY = empty

Value the decision is taken from



Summary

- PXD DAQ basically running stable (towards the end of data taking period)
  - Big troubles at the beginning and before phase 3
- ROI and events selection proved
  - ROI selection for all modules should be working by now
- RC/HVC, SlowControl, monitoring, DQM etc fine
  - Still continuous improvements
- High occupancy burst need some workarounds
- Investigate why we lost one optical link (like in phase 2)
- Improve on the time we need for pedestal taking (esp after some emergency off)

- Not discussed here:
  - Fast emergency off in case of “beam dust” events (change in PSU)

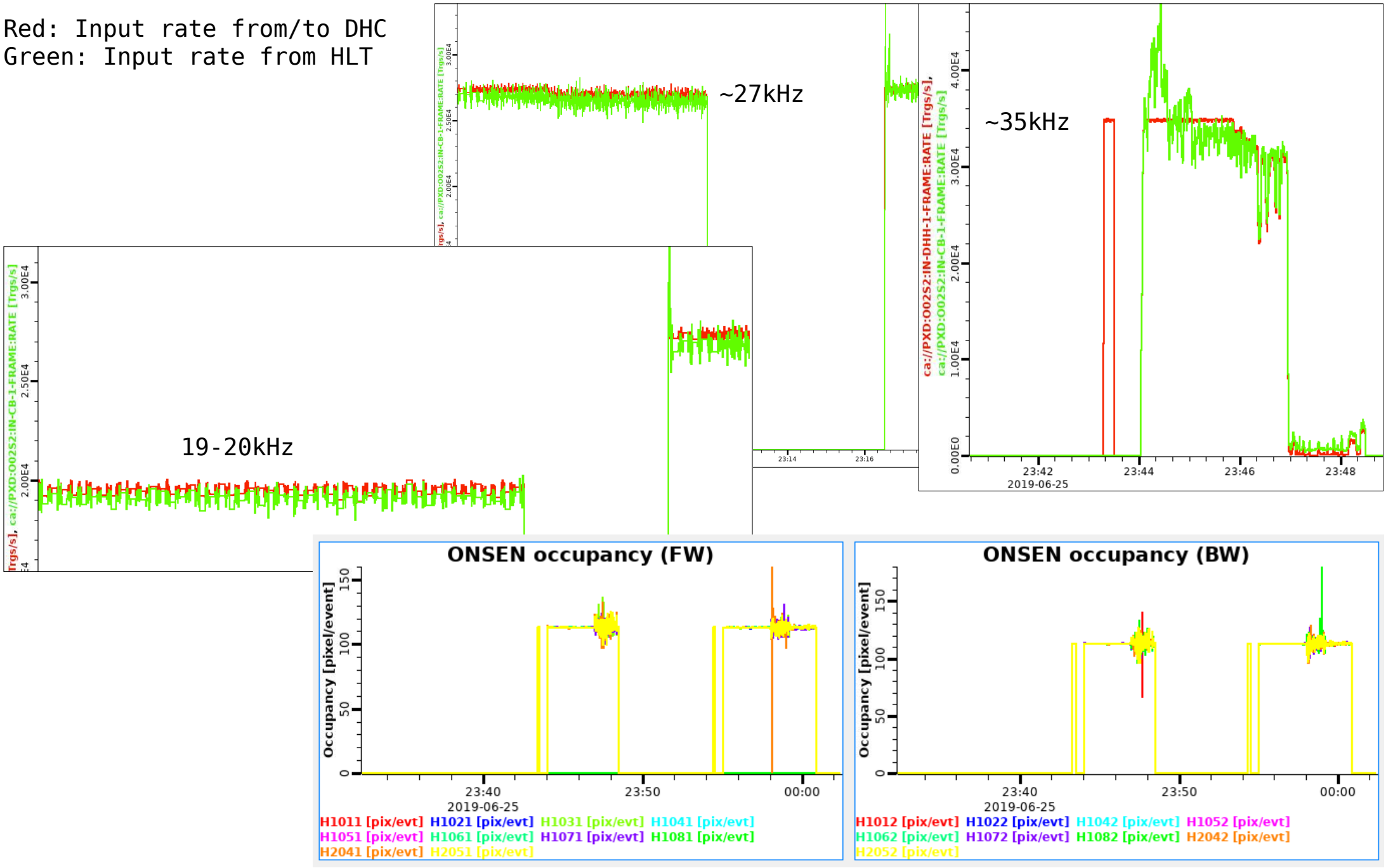
Backups

Open Questions

- Observed some “coincident” errors with other detectors
  - e.g. CDC error just before PXD got busy.
  - Reason still unclear.

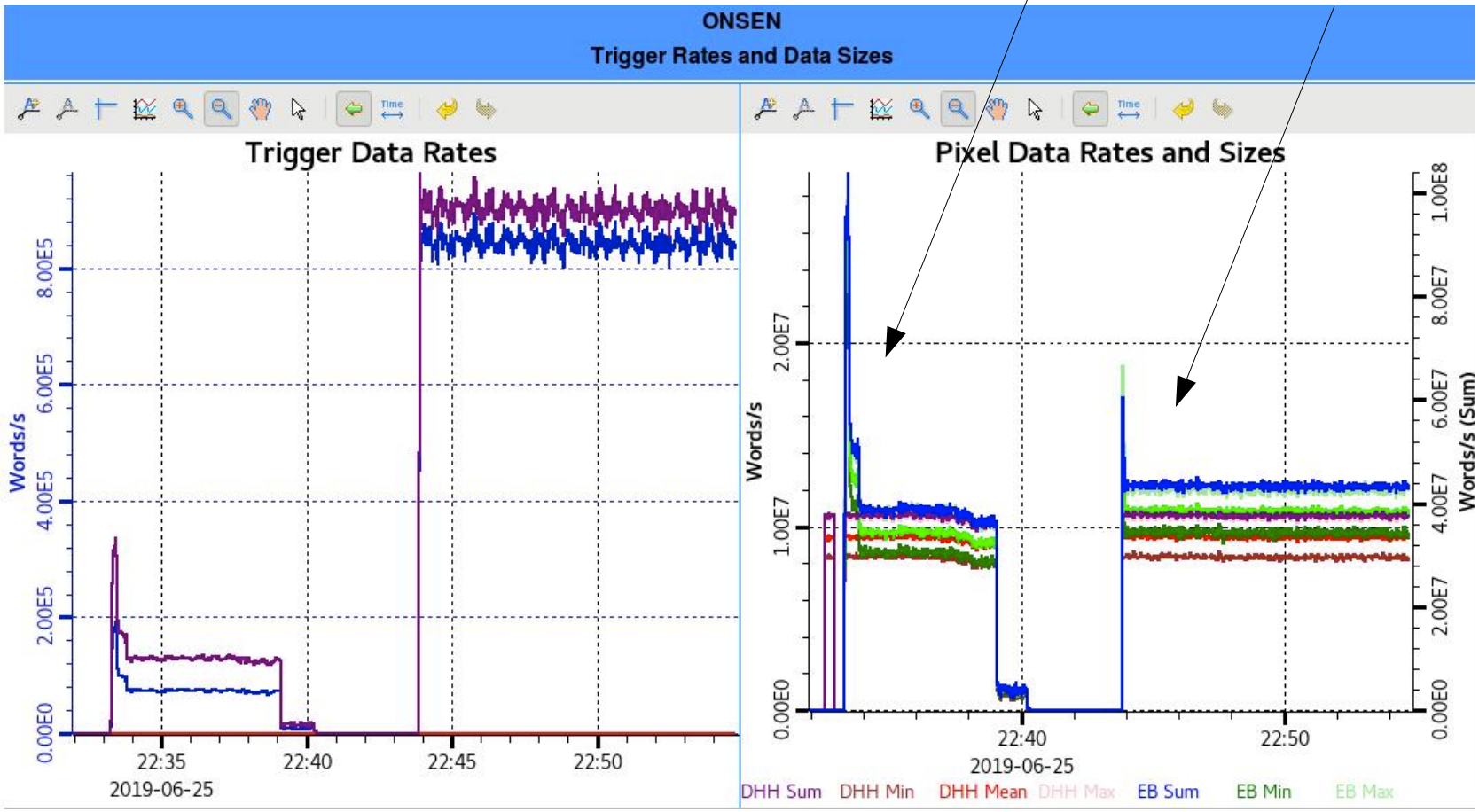
Trigger Rate Plots

Red: Input rate from/to DHC
Green: Input rate from HLT



HLT: beam_reco_monitor

HLT: passthrough



Over Voltage Protection (OVP) Emergency Off

→ See Talk by M. Ritzert

- Triggered OVP in Nov 2018:
  current limits for clear-off to close => increased current limits
- Triggered OVP in April 2019:
  frequently: 1072, unit 80, but also other ones less frequent
  After update of DHI firmware / JTAG libraries
  reason still unclear
  => switched back to old version
- Still under investigation? (DESY long term test)
  https://agira.desy.de/browse/BIIPXDH-289
- How to handle PS when OVP happens:
  bring it into a save state, ramp up (recover)
  https://agira.desy.de/browse/BIIPXDH-259
- Retuning of gate-on voltages
  - Actual currents as current limit (1 week)

2019-04-26 22:53:55, H1012 ovp
2019-04-24 23:13:11, H1082 ovp
2019-04-26 18:10:33, H1082 ovp
2019-04-29 18:47:30, H1082 ovp
2019-03-29 04:31:56, H1032 ovp
2019-04-08 10:01:30, H1062 ovp
2019-04-24 11:13:48, H1072 ovp
2019-04-24 16:45:01, H1072 ovp
2019-04-27 17:37:56, H1072 ovp
2019-04-28 22:25:31, H1072 ovp
2019-04-29 09:38:33, H1072 ovp
2019-04-29 22:06:42, H1072 ovp
2019-04-30 17:58:45, H1072 ovp

- Module emergency shutdown w/o reason due to OVP
  - Not observed for quiet some time (solved?), Reason not completely understood
- Re-evalute logic now because we want a faster emergency off

Solved Problems

- Trigger delay, DHP latency
  - **We lost 25% efficiency in early phase 3**
  - need physics trigger and knowledge of first gate
- Occupancy calculation (was data rate on DHH → now real pixels on ONSEN)
- Parallel ramp-up (CPU limited, Log message flood)
- JTAG, pedestal upload & verify
- Workaround for “DHP last gate bug” (was done wrongly for some time)
  - Now fire 2 pixels permanent in second last row in each DHP
- Lot of H1051 (DHI50) data drop fixed by FW update on DHI

Firmware

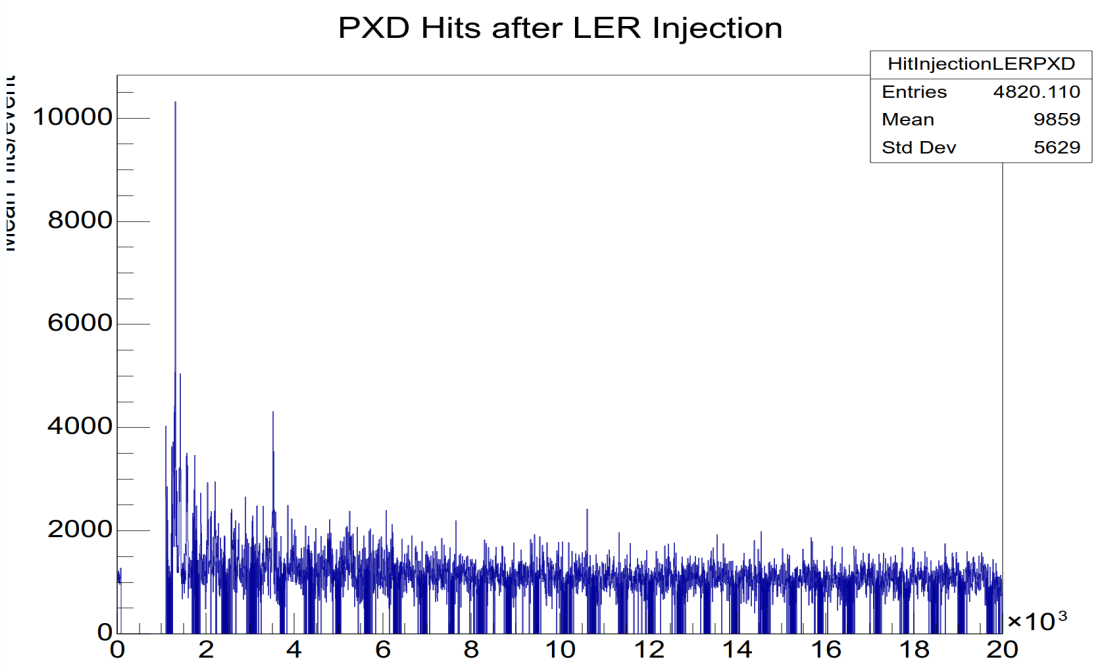
- Overlapping triggers FW deployed in early phase 3, basically work
- DHH → DHC+DHE+DHI firmware.
  - Updating led to problems, often unclear which update was responsible
  - Lost time & lumi
  - Test setup at DESY is not a 1:1 copy, agreed to test changes there first
- Current situation is reasonable stable
  - But: Occupancy drops → DHP/DHE interface
- Gated Mode, Signal from FTSW and parameters
  - Test at DESY and KEK

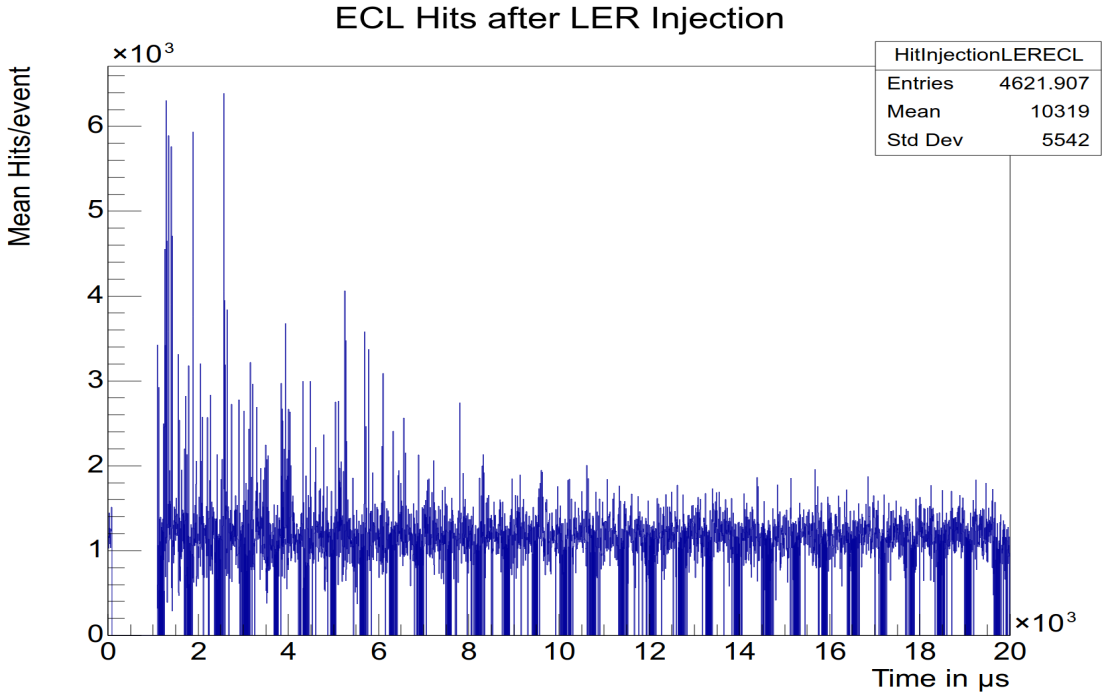
→ See Talk by F. J. Müller

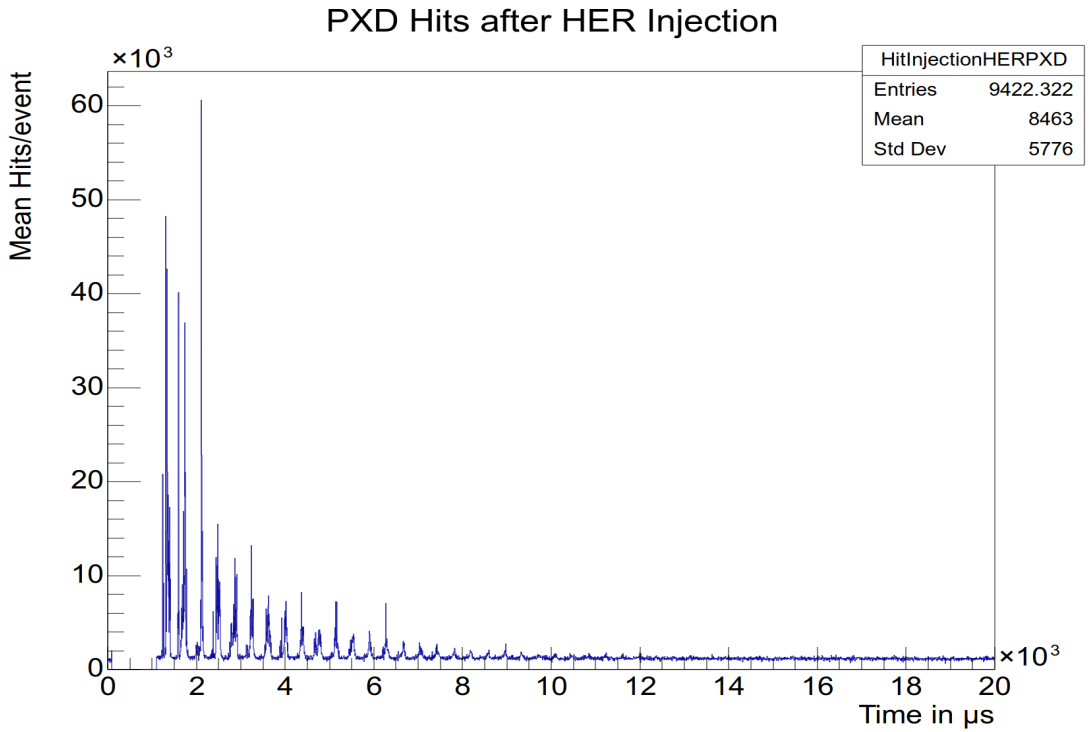
- Few other features no deployed

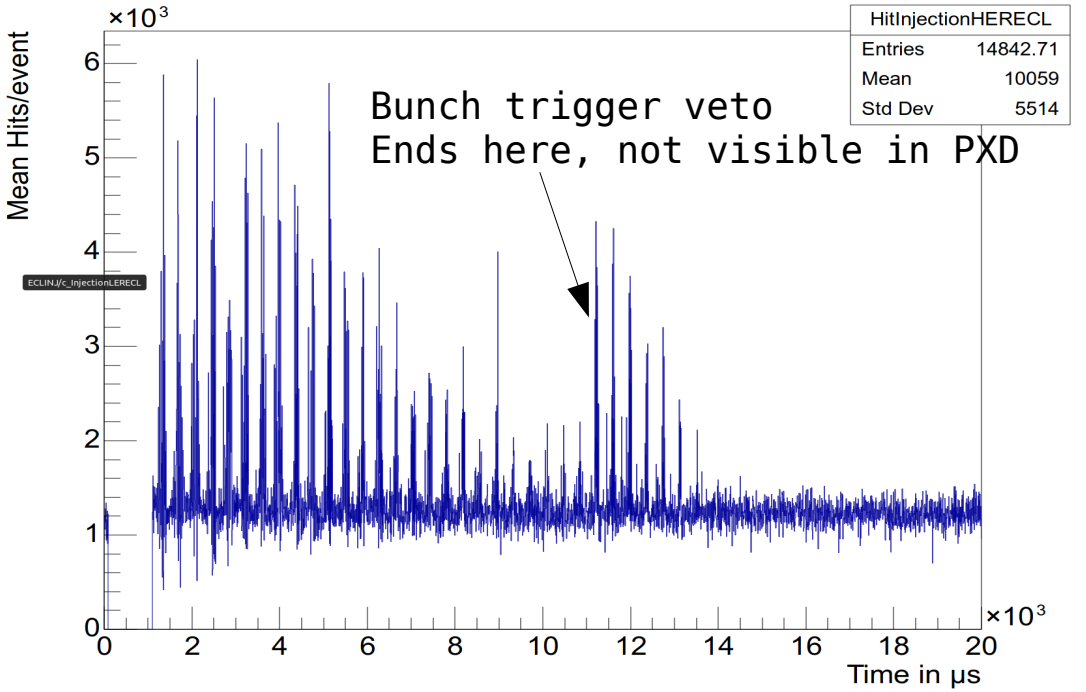
Occupancy after Injection

Not the current setting!

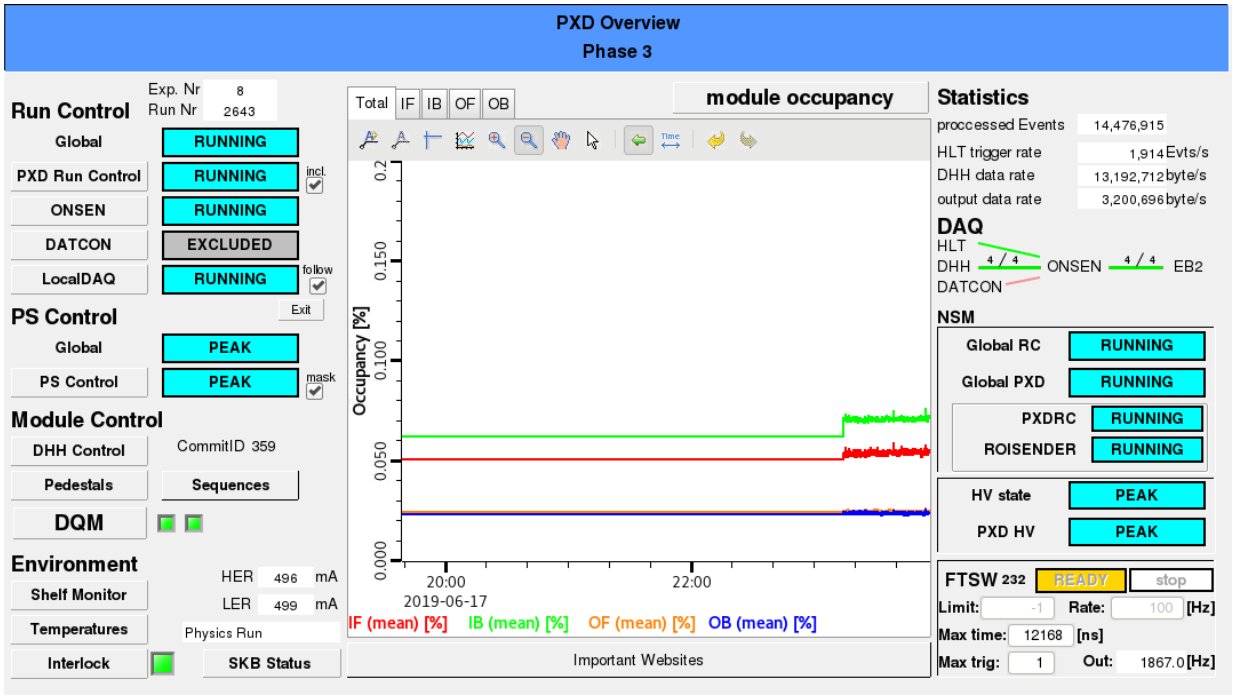


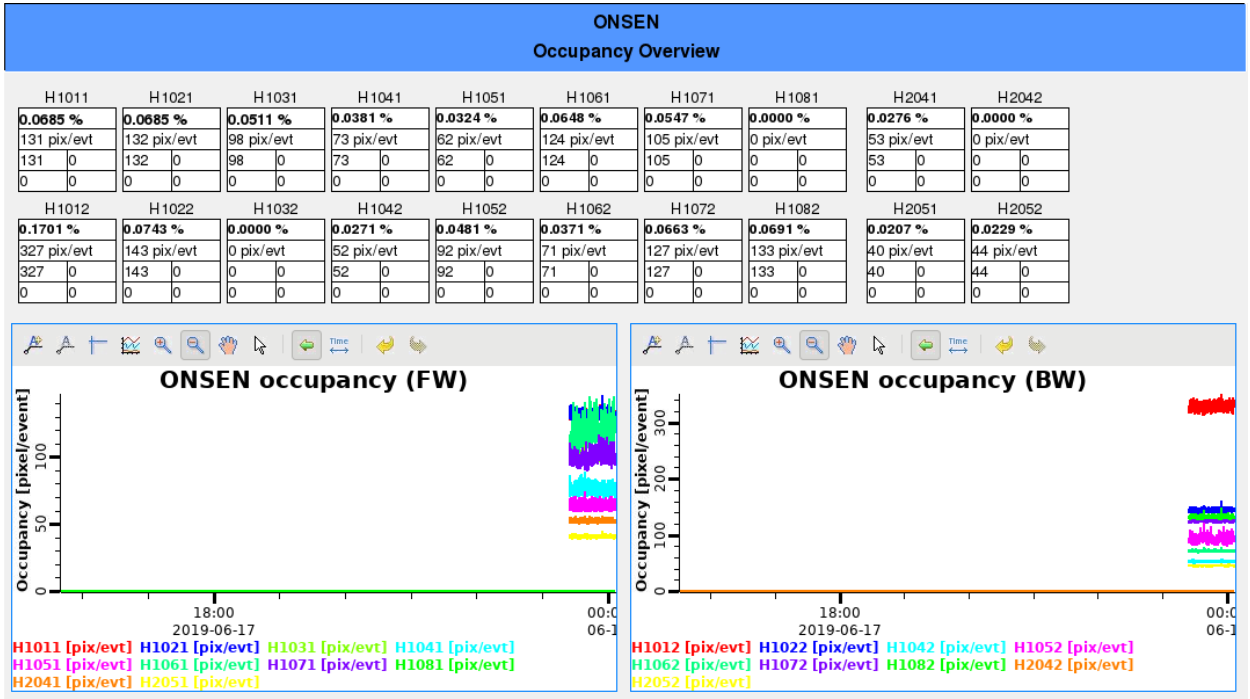






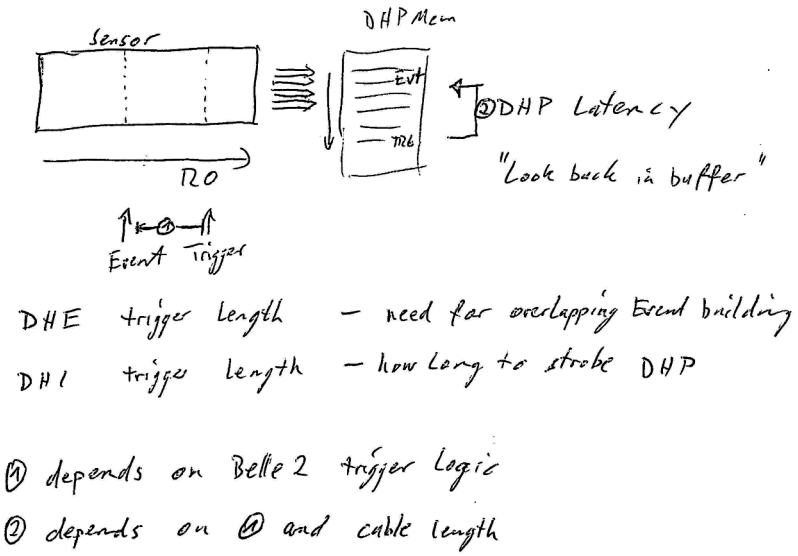
PXD Shifter CSS





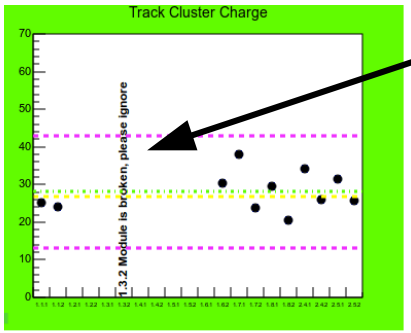
PXD Trigger "delay"

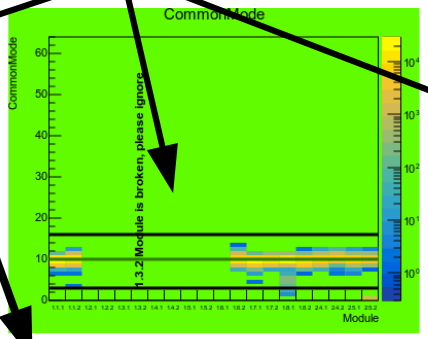
- PXD trigger consists mainly on one parameter:
  - DHP latency (look back in time in DHP memory)
  - 1 gate ≙ ~100ns
- Readout length depends on two parameters
  - DHI trigger length (strobe length to DHP)
  - DHE trigger length (used by the FW to build event)
- Latency depends on the trigger latency and timing of Belle2
  - DHP latency was ~50 in Phase2
  - Was set to 5 in early Phase3?
    - 45 gates off → ~23% (=45/192) loss of efficiency!
- Finding correct timing only possible with "real" physic triggers (but low stat with cosmics)
  - Need correct trigger gate (timing pixels) → can tune "Start Gate emulator" on DHE, x-check
  - Need to know the readout frame the pixel is firing in (timing pixels), determine when next readout frame starts (per DHP!). Information is lost in overlapping firmware due to event building

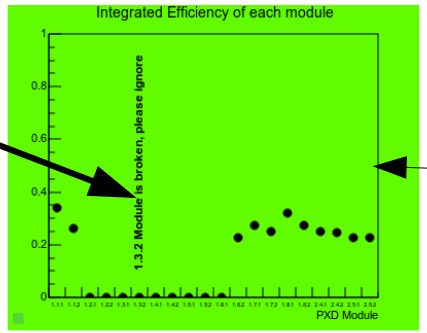


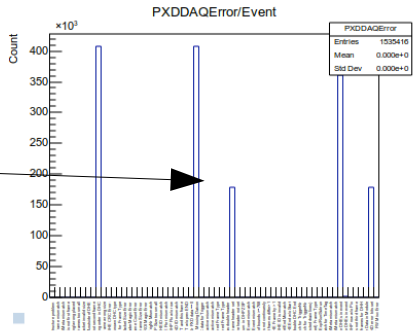
- Data reduction at work!
- Effect of wrong DHE order

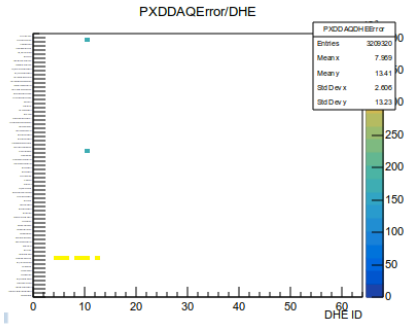
Event with errors show up as missing Efficiency for all modules (not only the one affected by the error

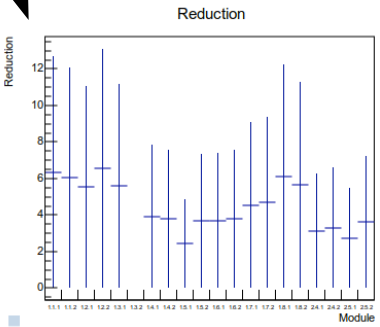


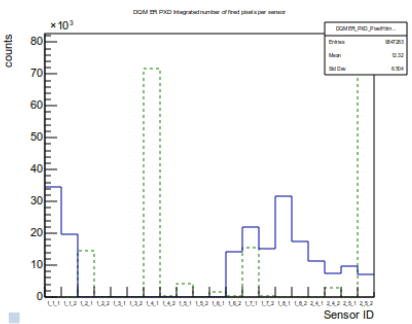


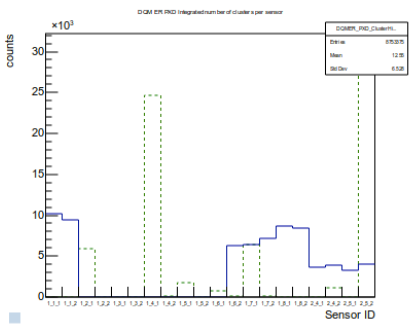












- PXD stopped run for two main reasons:
  - DHH did not send data anymore (finally BUSY)
  - DHH send too many corrupted data
  - HLT did not send Triggers* (anymore)
  - HLT did not send Triggers for too many events at the beginning of a run (overwrite)
    - → memory occupancy at end of run
  - Misconfiguration or -operation (after pedestal taking, ioc crash, operator error)
- * this could happened if the HLT did not notice that PXD was included into run (NSM SC timeout!)
  - NSM timeout of EB (have observed that before…)
- EB2 crash → link to ONSEN drop → PXD ERROR

Event Selection on HLT

- Real High Level Trigger decision
- Decision is encoded into packet for ONSEN
    - ONSEN rejects data payload and send only header
- Only in few runs for testing this morning.
- Event selection != ROI selection
    - ROI selection was OFF!
    - Any data reduction is only by event selection
- Seem to work without problem from our side.

Gates Mode

- Test on June 19th → 20th
- 1.5 hour during normal data taking, normal physics trigger
  - File is ‘beam’ on BCG request, but beside PXD and veto it is usable as physics
- Cont Injection in both rings
- Trigger Veto for HER reduced from 200 to 20 turns
- 10 settings of offset for HER scanned, each ~5 HER fills.
- > 1TB of raw data in three runs (2731, 2732, 2733)
  - Most setting changes in 2732
- 18 sensors on, only two were gated (1.03.1, 1.04.1), but all had DHP-trigger-”inhibit”
- No effect of setting sweep was seen online (rates)
  - But the rate went up a lot during GM (noise!, ped oszillations) but also because we now trigger on events near HER injection!

Gated Mode (Analysis and Discussion) Results

- No effect between different setting was seen offline
  - → offset was not set/changed in hardware!
- Effect of injected bunch clearly visible (in-sync between gates and bunch)
- HER/LER flag not set correctly (FTSW/DHC), thus we were gating with HER setting on LER, too
- Wrong unit of offset (turns instead of 127MHz ticks), but it was not set anyway
- Large noise even when doing a charge cut.

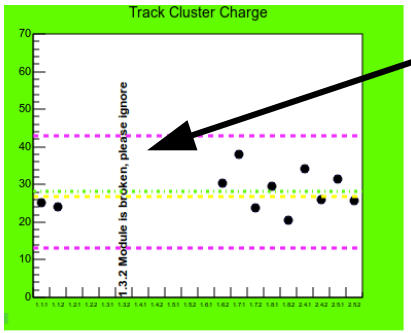
- TODO:
  - No hits expected in DHP-trigger-inhibit times → but I see (tbc)
  - Units of SC parameters compared to Trigger group (done)
  - Fix SC parameter writes to DHC hardware
  - Prepare another test → be ready if we get the opportunity

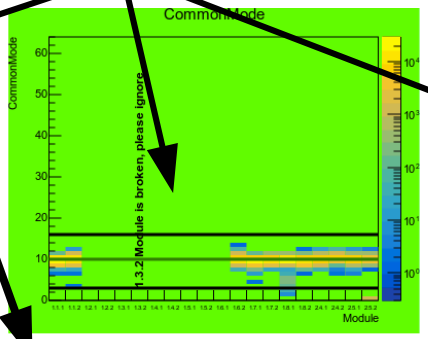
ROI Selection

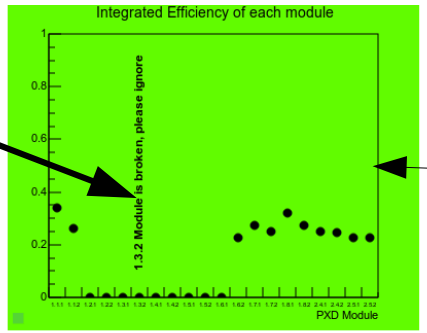
ROI Selection ON (e8 r01092)

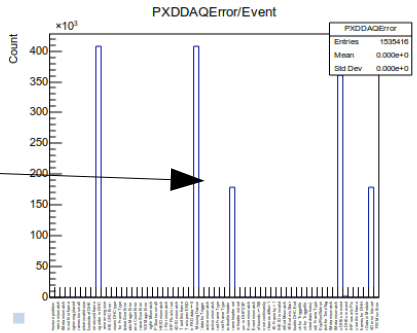
- Data reduction at work!
- Effect of wrong DHE order

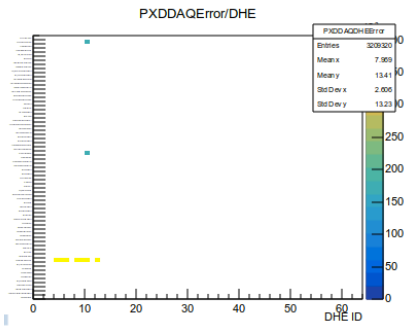
Event with errors show up as missing Efficiency for all modules (not only the one affected by the error

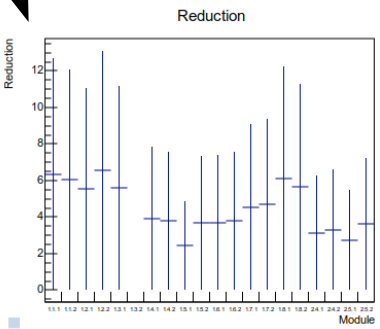




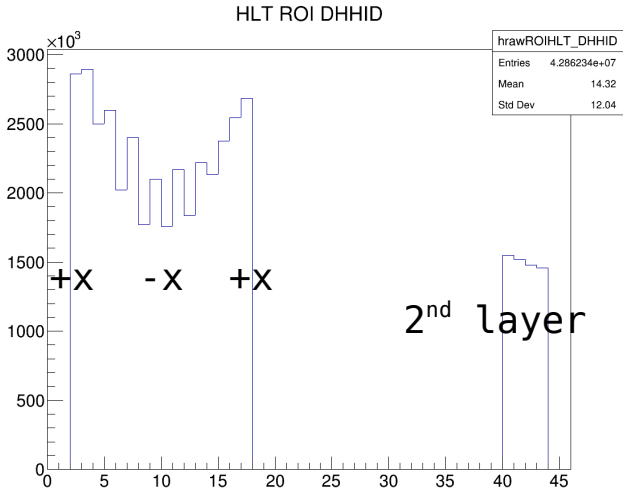


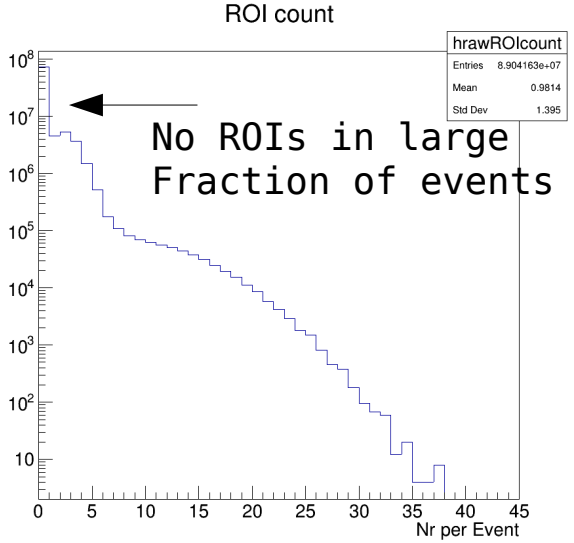






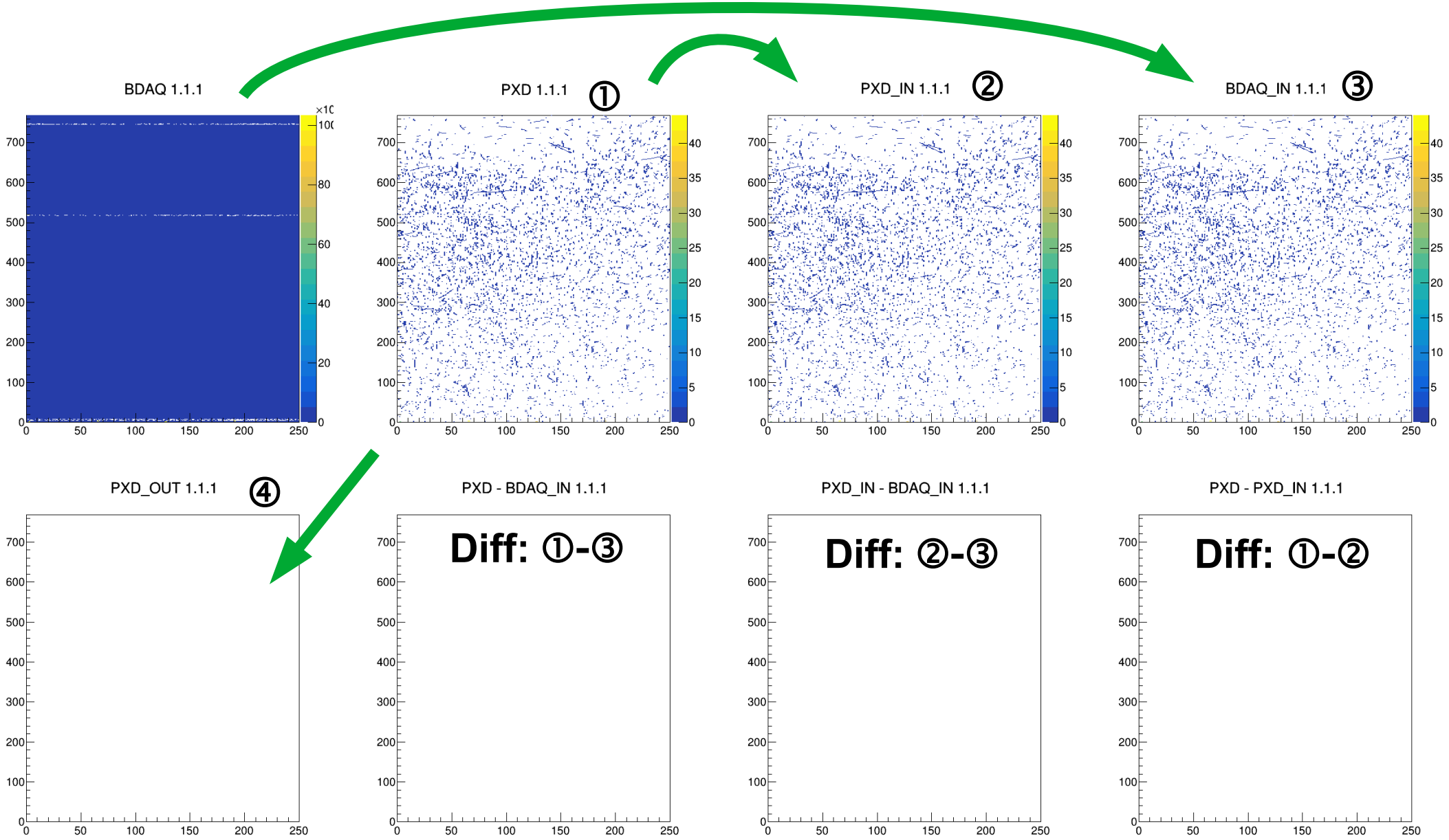
Reasonable number of ROIs and Distribution on the modules





Emulate ROI Selection & Cross-Check

→ software emulation of ROI selection (on BonnDAQ and basf2 selected data)



①②③ should be identical, ④ and all the differences should be empty

Results

- … and so for all other modules (see backup slides)
- No hits OUTSIDE of ROIs
- No extra hits inside ROIs
- No hit is missing inside ROI
- → **everything is selected as it should**
- (but only few events 91244 within one run checked)