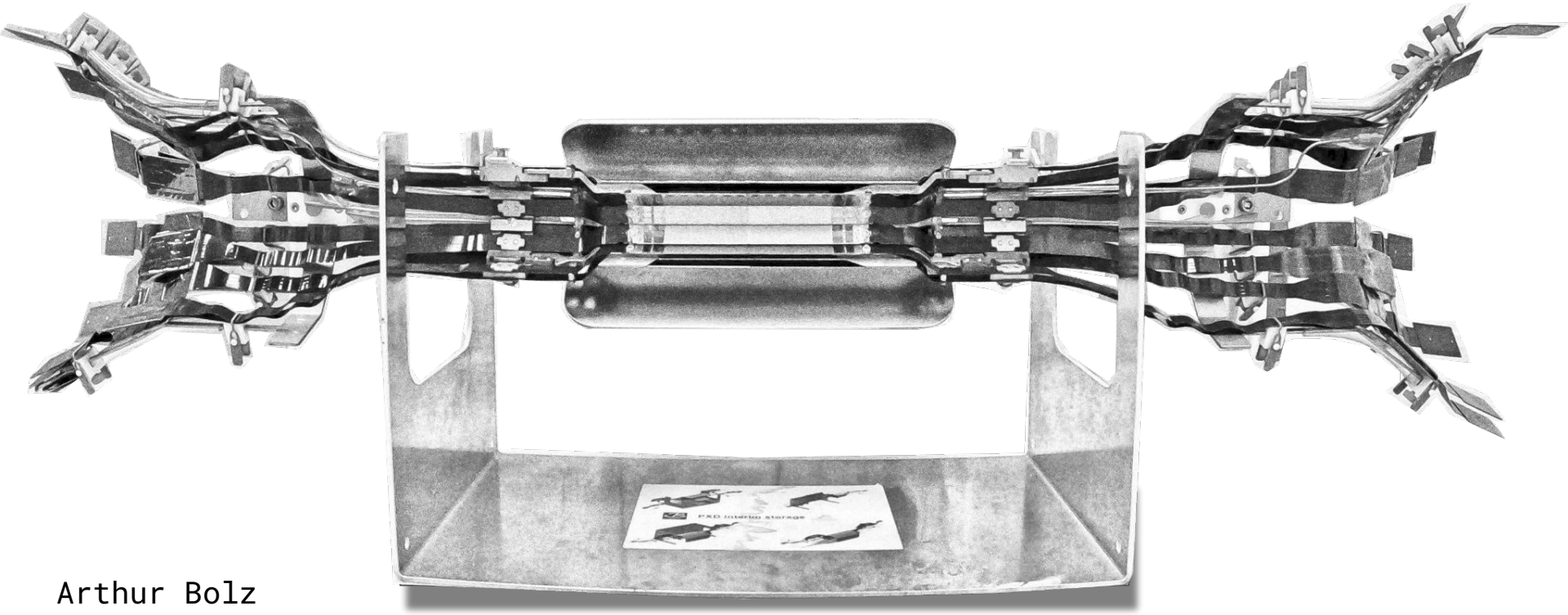
PXD Commissioning

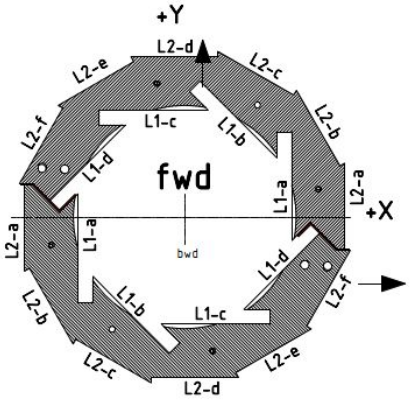
22.05.2023

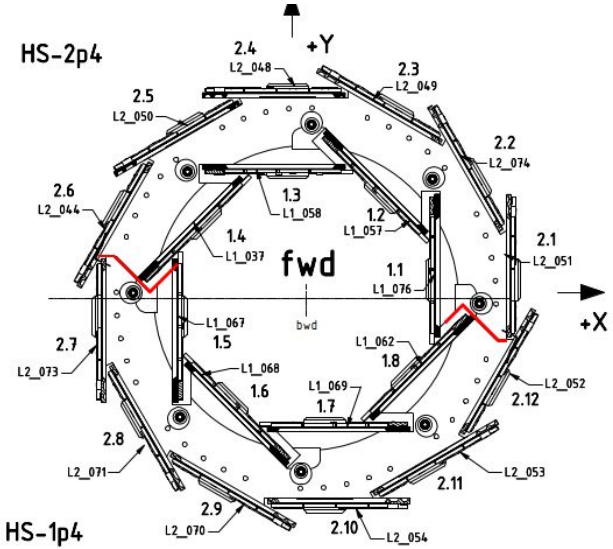


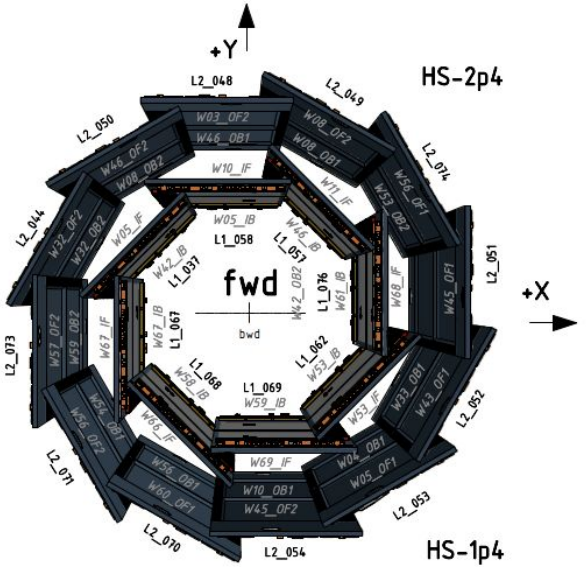
Arthur Bolz

All Hail The Awesome PXD2 Commissioning Crew

The PXD2







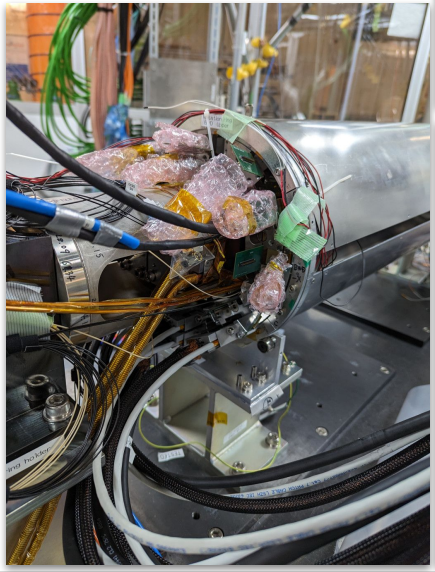
https://confluence.desy.de/display/BI/PXD2+Modules

PXD Services Connection And Testing

- Procedure:
  1. set up outer services 🪄
  2. connect outer cables to PSU/DHH and DB PCBs
  3. test connections: Load and OVP-board and fiber noise
  4. connect PPs to PXD Kaptons
  5. connect PPs to DB PCBs + module by module warm DHP test
  6. cool down and module by module power up

- Details in dedicated talks:
  - PXD installation
  - Power supply commissioning
  - DHH commissioning

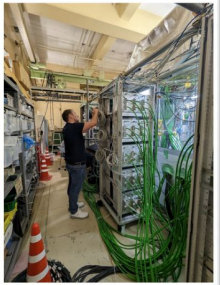
- This talk: skip ahead and discuss PXD standalone testing in B4



PXD Services Preparations: Power Supply System

- last week: pushed service teams (power supply, DHH, env monitoring, …) to get things working minimally for mechanical HS_2p4 tests
  → approach safe and fast but incomplete
- this week: make everything perfect and prepare and test full PXD services system

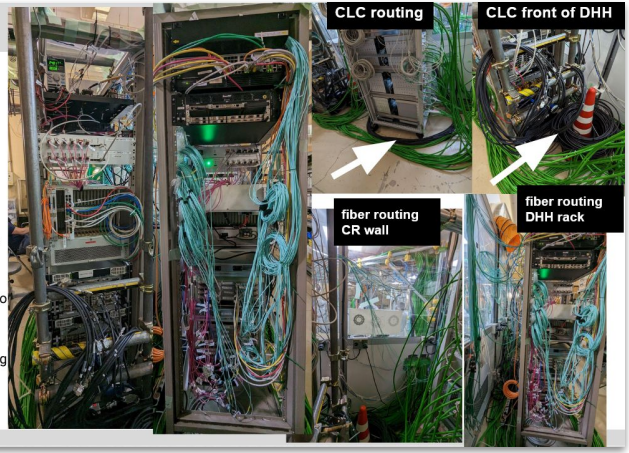



- All cabling done + cleaned up (Confluence B4 Rack Configuration
- Equipped all dockboxes
- OVP tests for all PSs completed
- PSs full-power tests still 48/50 completed (probably 50/50 by meeting)
- some debugging (individual weird DB PCB, PSUs, or cables …) still ongoing

DHH Rack

- 40 CLC routed to DHH rack
- All dockbox fibers routed to DHH rack
- Cleaned up all DHH rack Connections
- Fiber to optical switch tests completed
- optical switch to DHH tests pending (need modules)
- Debugging ongoing (config, single cards not fully behaving yet)



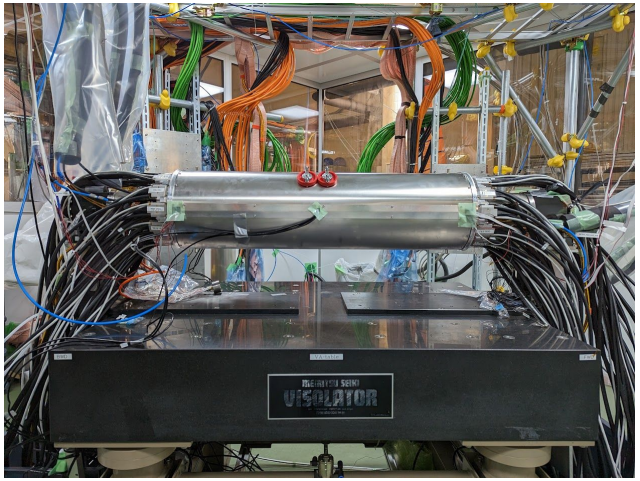
Dry Volume and IBBelle Operation

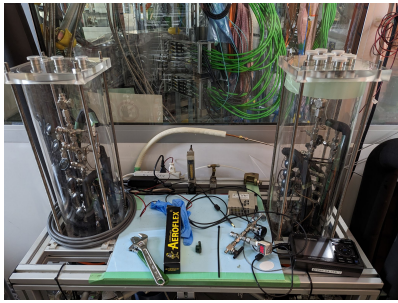
Two stage dry volume:

- inner DV by cylindrical aluminum cover and heavy metal end flanges
  → PXD N2 flow varied 20 l/min … 34 l/min
- outer DV by frame + plastic foil including PP-Kapton Connectors and CO2 pipes
  → dry air flooded ~ 140 l/min

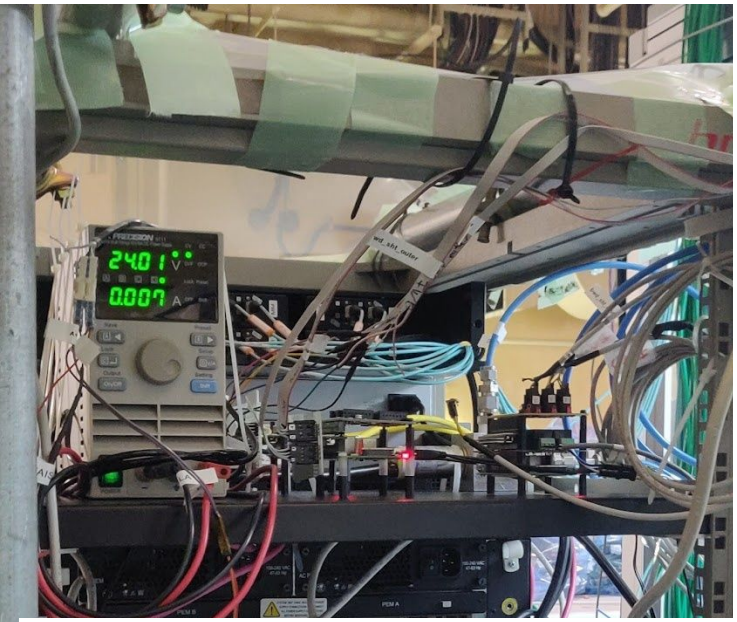
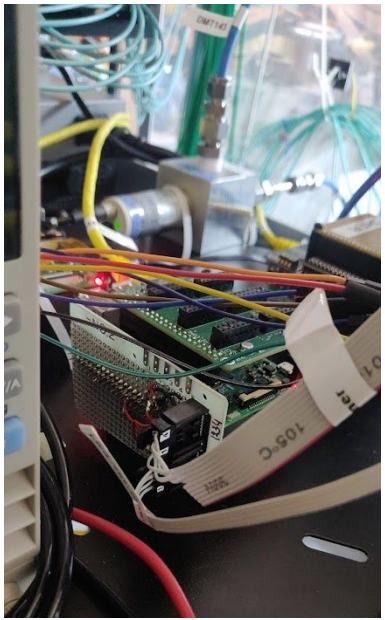
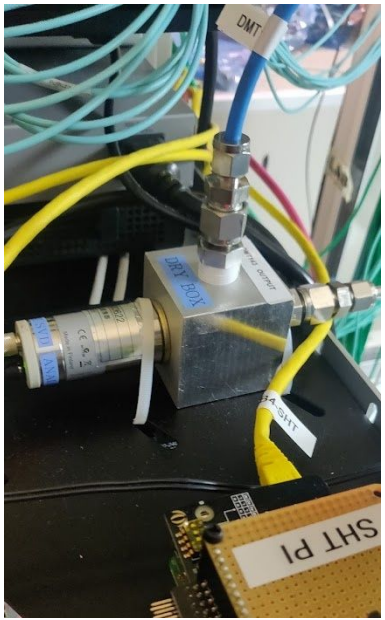
IBBelle

- operated with 4 PXD + 8 shorted SVD lines
- CO2 -20/-25 C

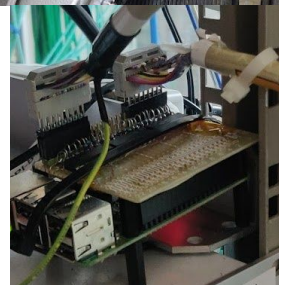




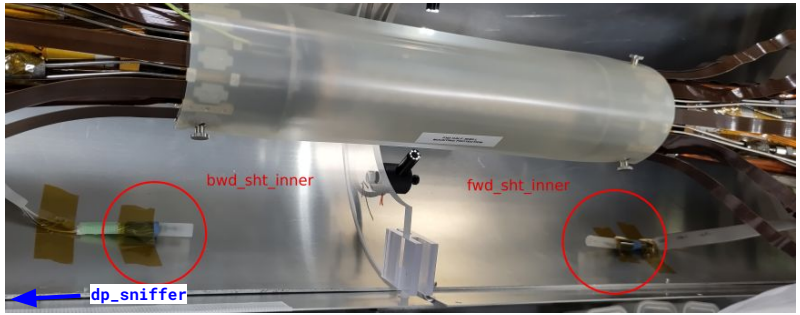
Environmental Monitoring and Interlock

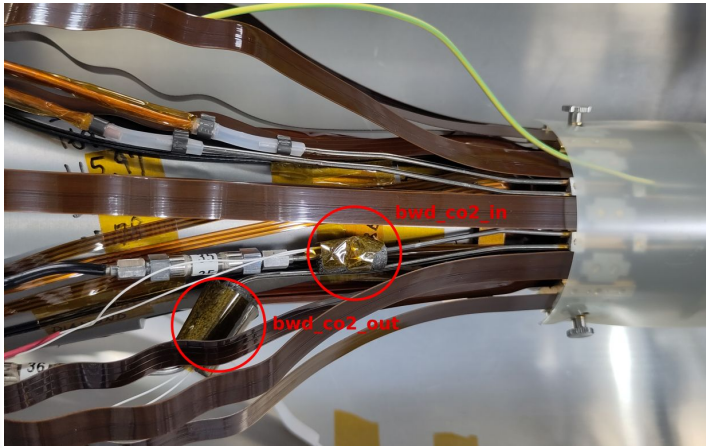




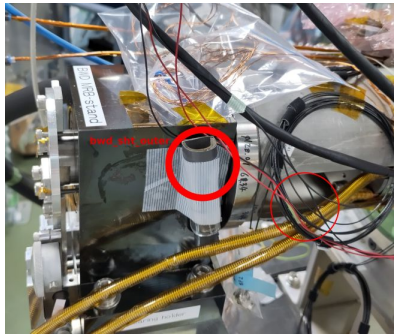

- [Raspberry Pi based system for environmental monitoring and interlock]
- (More or less) set up ad-hoc on cite building up on 2018 system by Hua
- Sensors et al:
  dewpoint: SHT85 for T and RH, DMT143 direct dewpoint sniffer
  (CO2) temperatures: NTCs
  hardware interlock: seeed relay board w/ outputs to IBBelle and PXD PSU system

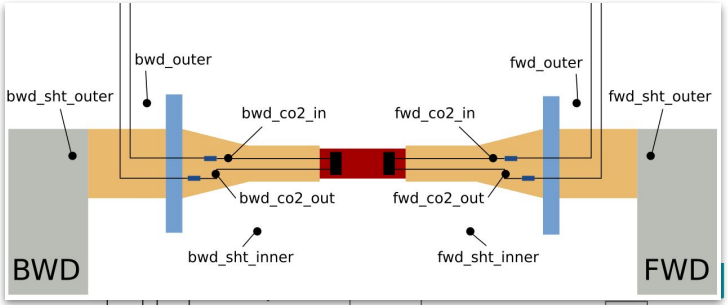


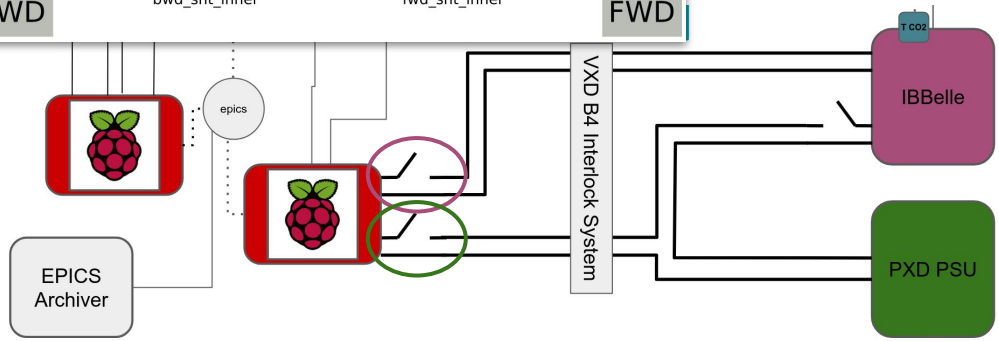
Sensor Positioning and Interlock Logic







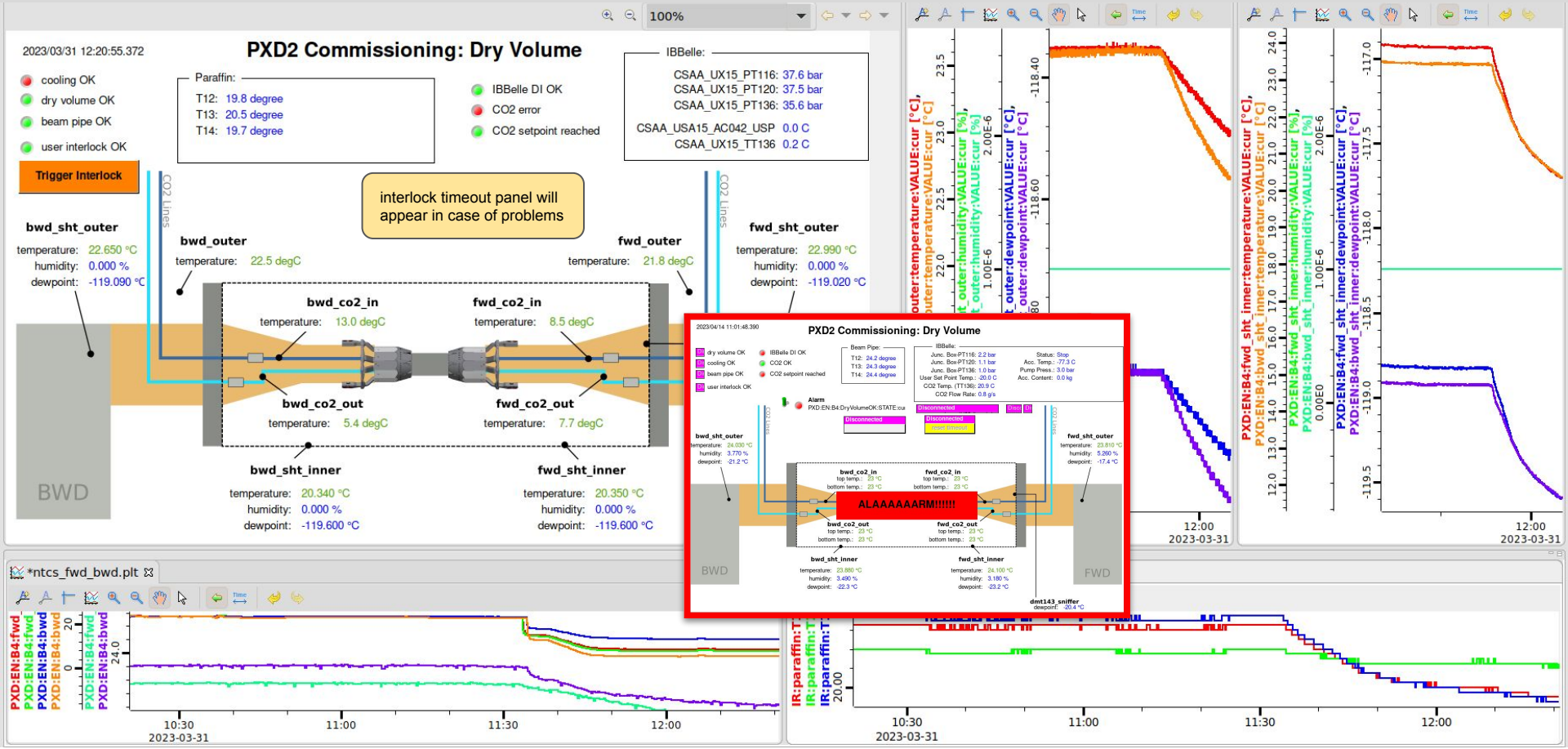




DryVolumeOK to IBBelle
→ if min temp > DP + offset

CoolingOK to PXD PSU system
→ if IBBelle SP reached and
→ if PXD CO2 temps < threshold

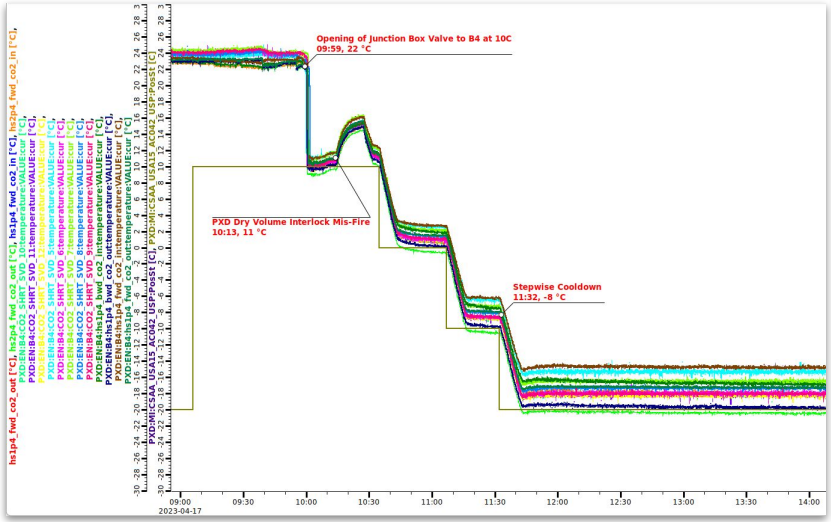
Environmental Monitoring and Alarm Panel

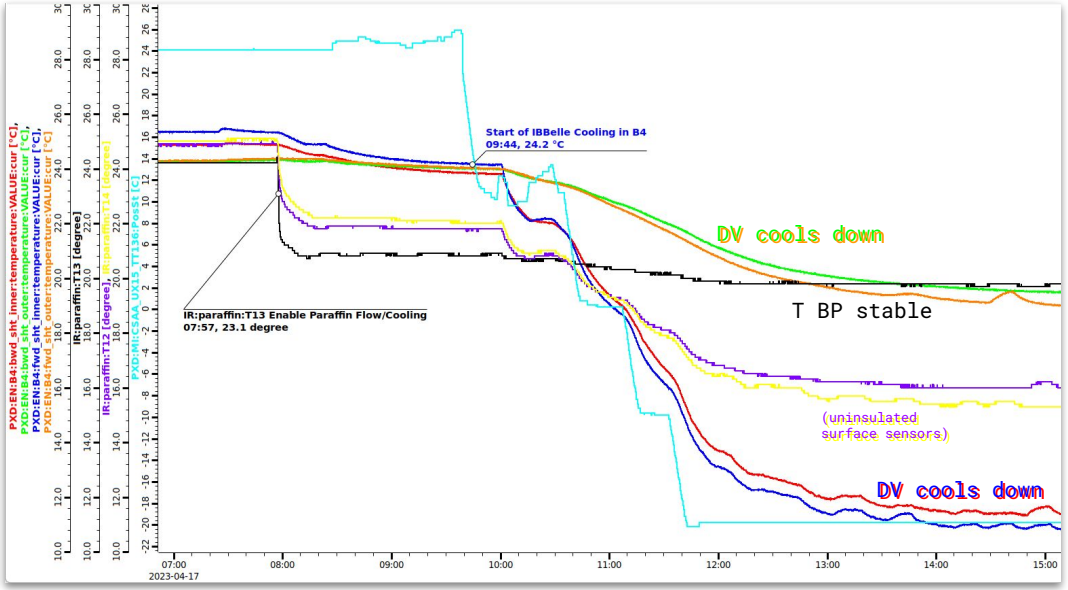


IBBelle Operation Cool-Down

- Operating with all 12 VXD lines in B4 cleanroom → 8 shorted SVD lines (first cooling run only 7)
  - → First cooling runs: stepwise cooling from RT to -20 C, later direct cooldown.
  - → Also tested -25 C operation w/o issues
  - → Overall stable operation with some smaller hiccups (fake interlock, accidental IBBelle stops, … quickly recovered)
  - → very good support by KEK cryo group and MPP

- Beam-Pipe temperature stabilized to 20 +/- 1 C (water cooling)
  - → rather stable, no excessive BP cooling by IBBelle or warming by PXD
  - → largest mechanical stress from turning on/off cooling (~5C temperature change)





First Module Power Up

Test Procedure / Checklist:

- [x] Follow module order in testing spreadsheet (powering L2 before L1 because we can monitor those, powering fwd before bwd because there sliding may work better, powering DHH by DHH because easier)
- [x] elogs:
  - [x] There should be a global elog entry in https://elog.belle2.org/elog/VXD+commissioning/ for every shift
  - [x] There should be an "Oversevation" elog entry for every powered module in https://elog.belle2.org/elog/PXD-Commissioning-KEK (ideally linked in the above global shift elog)
- [x] Power Crate Controller for PS
- [x] Uncheck all boxes in DHE Widget (keep skipping pedestal upload, we do not need it)

skip pedestal upload

- [x] check that steps 4-5 of PS Ramping sequence are checked
- [x] "Enable" PS
- [x] check voltages/currents (screenshot!)
- [x] "disable" PS
- [x] In sequence: follow only module and its associated DHC/DHI
- [x] Start camera recording and take screenshot (suggested naming: screenshot <date> <time> <module-name> <state>)
- [x] Normal power up to STANDBY
  - [x] observe currents
  - [x] document (screenshot) STANDBY power status and DHP status (best combined PSU values and DHE opi screenshot)

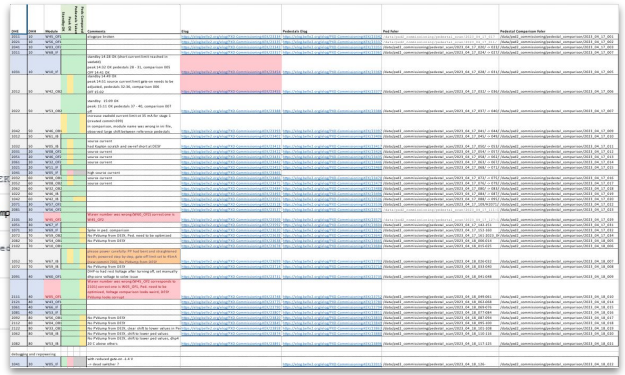
  - [x] any currents in limit? → problem or just adjustment in configDB needed?
- [x] Normal power up to PEAK
  - [x] observe currents ramping up
  - [x] document (screenshot) PEAK power status and DHP status (best combined PSU values and DHE opi screenshot)
  - [x] any currents in limit? → problem or just adjustment in configDB needed?
- [x] In DHC Opi: Adjust `DHE Mask` and `DHC Reset`
- [x] Take pedestals with calibration opi (then no manual adjustment in `[global+measure].ini` needed) for 5 minutes
  - [x] check pedestals OPI. "updated data for all DHHs?" (wtf does this mean???), "Look ok"
  - [x] check PV dump was taken successfully and document path in spreadsheet
  - [x] check elog was taken successfully and document link in spreadsheet
- [x] Quantitative pedestals comparison
  - [x] create soft link to pedestal path in `pxdbonndaq3:/data/pxd2_commissioning/first_pup_ped_comparison/KEK`

```
$ ln -s /data/pxd2_commissioning/pedestal_scan/2023_04_XX_XXX/ /data/pxd2_commissioning/first_pup_ped_comp
```

  - [x] adjust pedestals comparison script `/data/pxd2_commissioning/first_pup_ped_comparison/PXD2_KEKDESYPed`
  - [x] run pedestal comparison, check output and document folder in spreadsheet

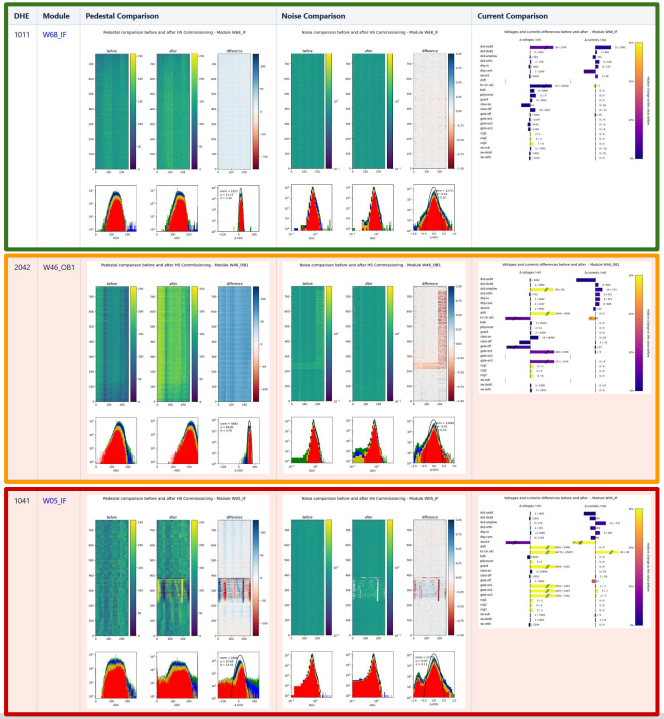
```
$cd /home/b2pxd/lab_framework/basics/pedestal_comparison
$./analysis.py -c /data/pxd2_commissioning/first_pup_ped_comparison/PXD2_KEKDESYPedComp.ini
```

  - [x] screenshot pedestal and current comparison images and add to pedestal comparison slides
- [x] Take camera screenshot
  - [x] compare with "OFF" screenshot → any significant movement → consult expert (@ Fabian Becherer)
- [x] Power to OFF
- [x] Stop camera recording and rename video file in (add module name)
- [x] Power off primary PSU power

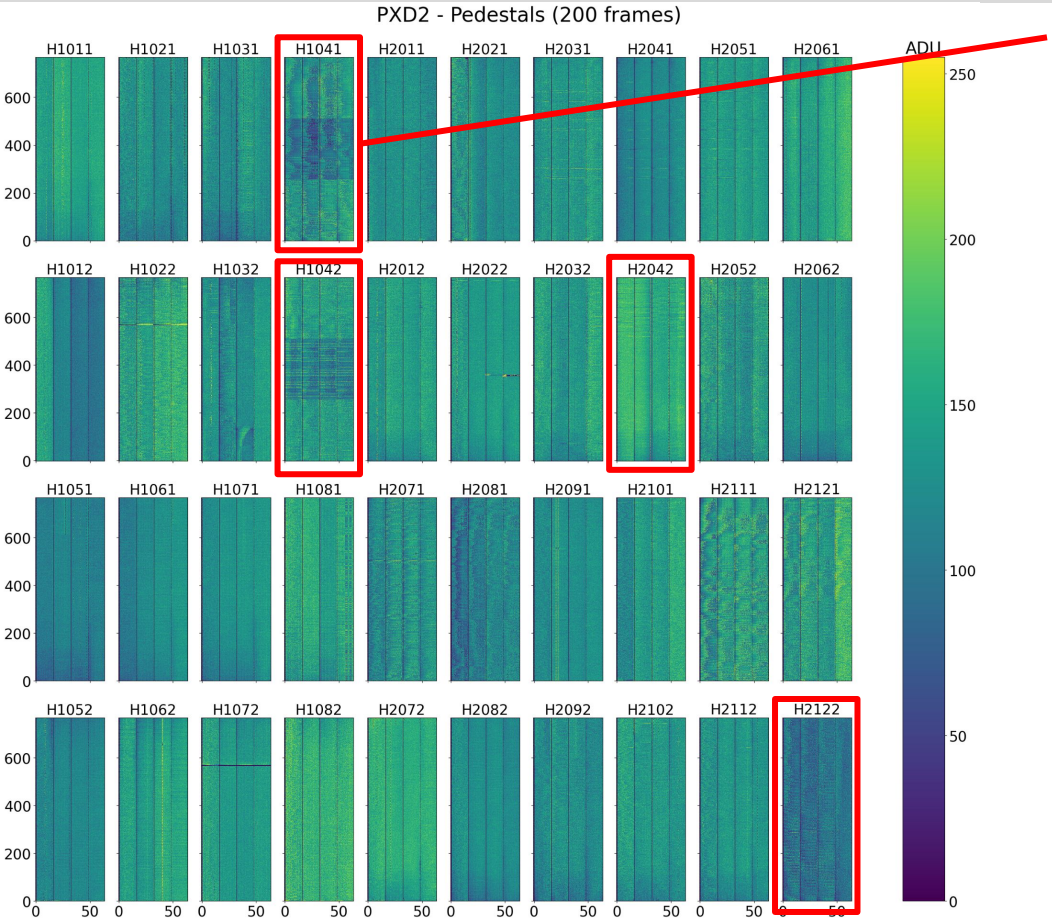


- 38/40 powered w/o issues (more or less)
- 1041/1042 stuck w/ high source current
- most modules have consistent pedestals, ped noise and power consumption to DESY
- 2 modules w/ significant "pedestal glitches" (at least)

[Pedestal Comparisons to DESY:](https://confluence.desy.de/display/BI/Pedestal+Comparison+DESY+-+KEK)
https://confluence.desy.de/display/BI/Pedestal+Comparison+DESY+-+KEK



Pedestals Status and Special Needs Modules

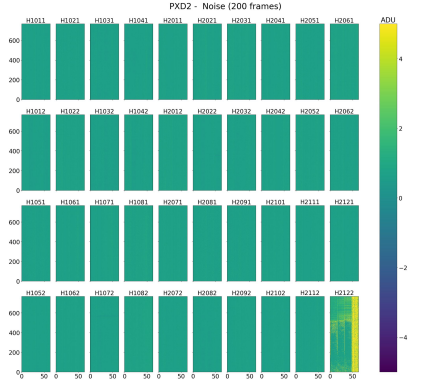


H1041 & H1042

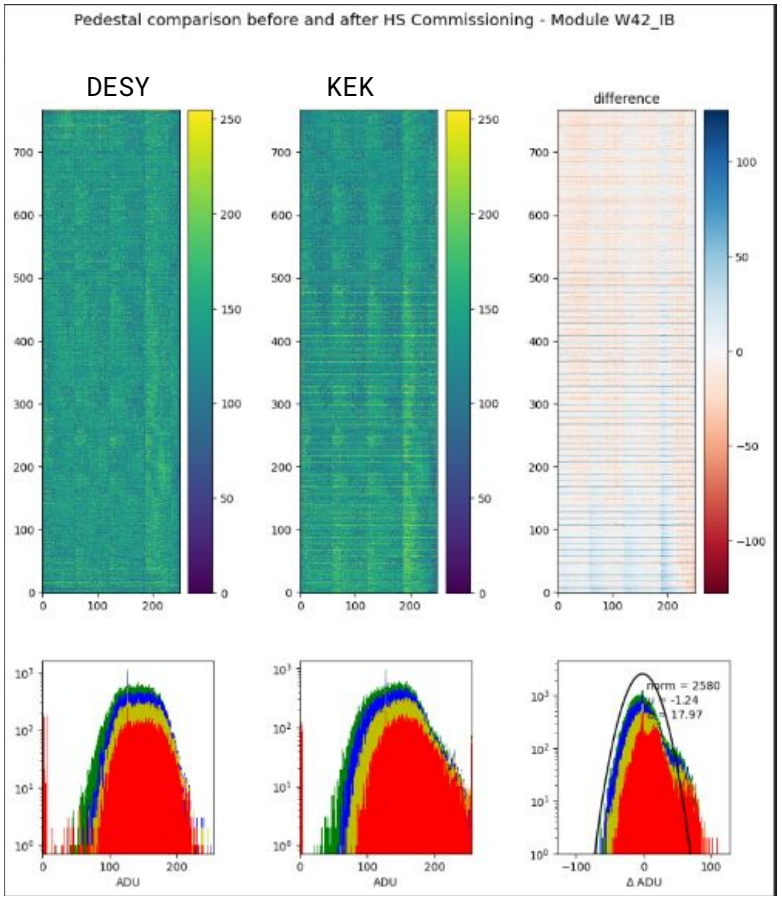
- occasionally ramp/switch to state with problematic switcher (channel)
- gate_on2 region w/ much reduced voltage for now to keep source current in limit when this happens
- need some work, ideally only mask problem sw channel

H2042 & H2122

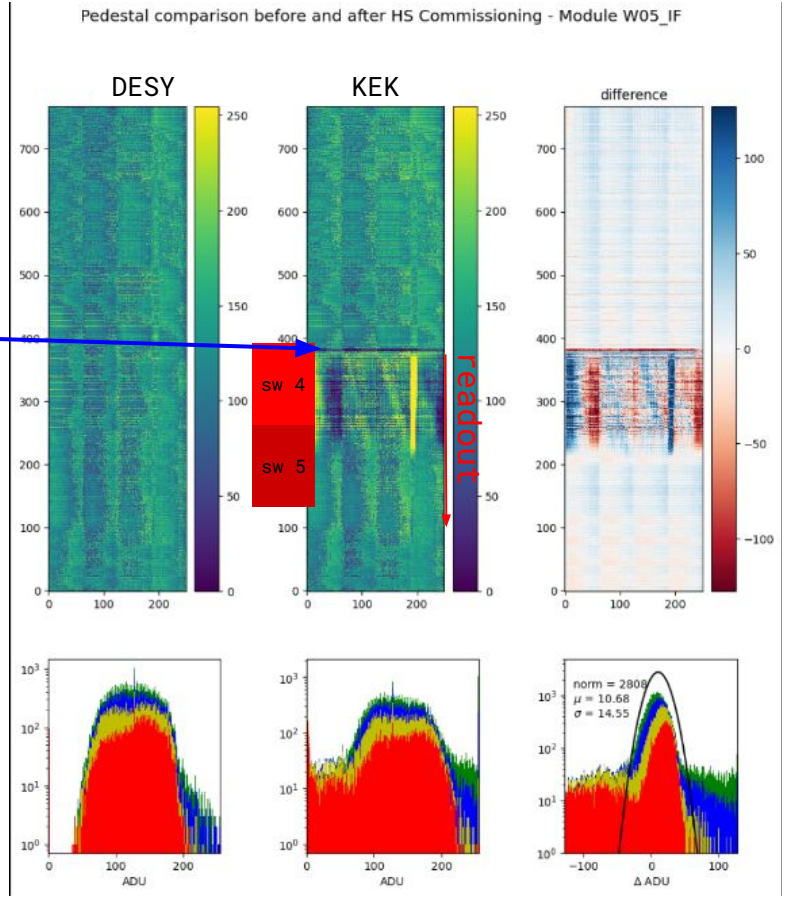
- have “glitchy” frames where all pedestals jump to very different values
- reason not understood
- observed at DESY already
- impact on data taking not understood



104X / L1_037 / W42_IB and W05_IF



broken sw 4 or possible problem gate affecting gates downstream of the switcher sequence / rolling shutter readout
full sw 4 but overlapping into sw 5 region



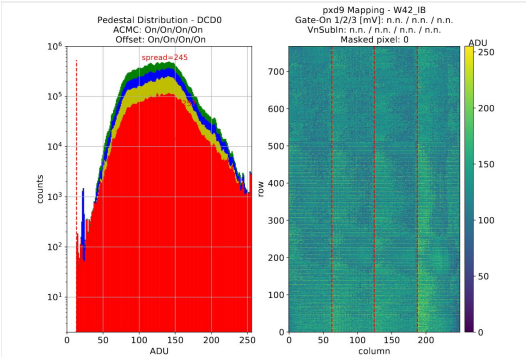
1042 and 1041

- Both modules can be powered into “good” and bad state.
  (Stable or switch during operation also?)
- Bad state is qualitatively similar: one dead switcher (channel).
- Introduces pedestal shifts and noise. Doubled source current.
- Temporary mitigation: reduced gate-on voltages. Better if switcher (channel) could be individually masked.
- details 1042 and 1041

W42_IB:

good:

https://elog.belle2.org/elog/PXD-Commissioning-KEK/24164



bad:

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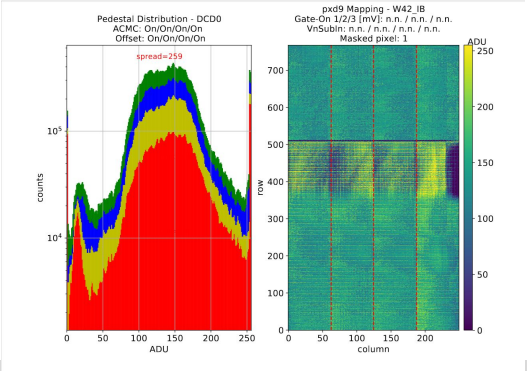
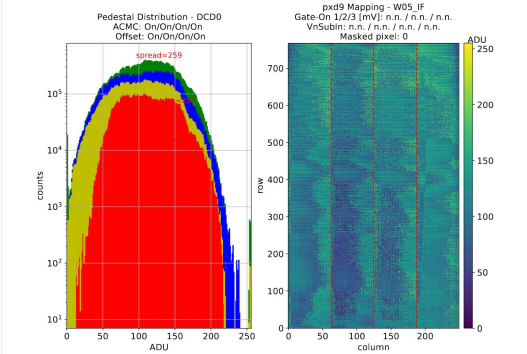


W05_IF:

good:

https://elog.belle2.org/elog/PXD-Commissioning-KEK/24119



bad:

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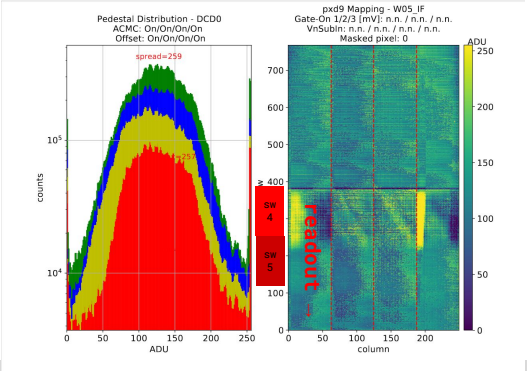
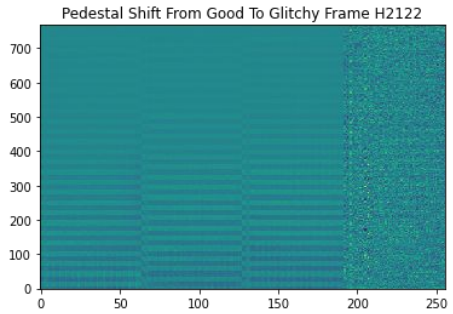
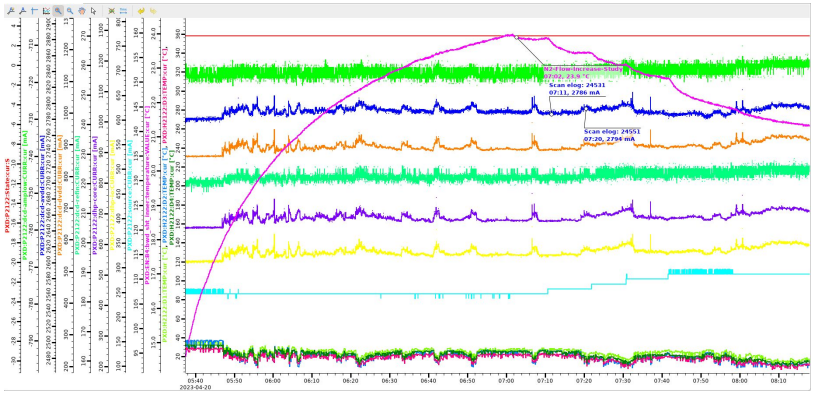
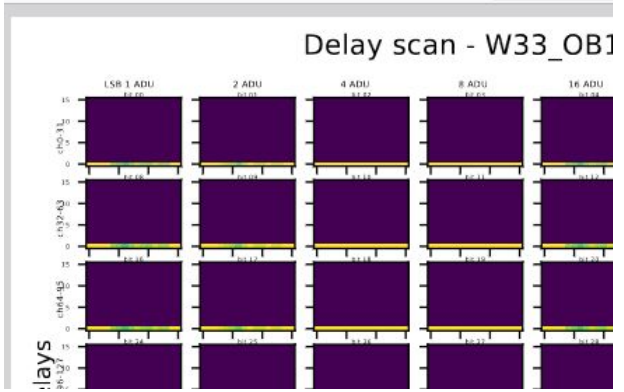


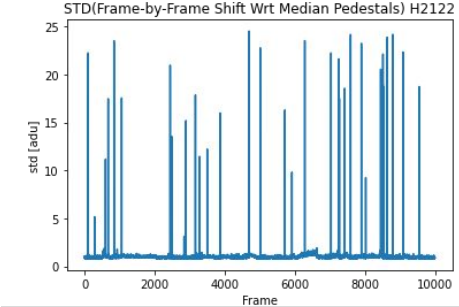
2042/2122 Pedestal Glitches

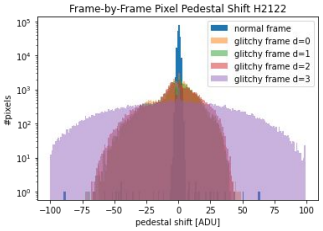
- Already observed at DESY. More details: https://gitlab.desy.de/belle2/detector/pxd/commissioning/-/issues/221
- Significant pedestal shifts in individual frames.
  → qualitatively different for different DCDs. Single DCD origin of issue?
- Reason/origin not really known. At DESY services might have had a contribution.
  → not further investigated at KEK
- 2122 exhibits very bad/unstable asic currents that might be related
- Bad delay scan results → could not be improved at DESY











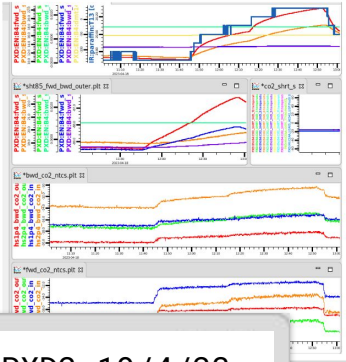
- 2122 plots
- 2042 qualitatively similar
  but better currents and lower glitch “rate”

Approaching Full PXD2 Operation

Stepwise approaching full PXD2 Operation

1. module-by-module
2. ladder-by-ladder
   → observe L2 ladder bending
3. FWD modules only (both HS)
   → observe L2 ladder bending
   → study thermal behaviour
4. BWD modules only (both HS)
5. Full PXD
   → slowed down by significant ladder bending
   → slowed down by uncertainty about having sufficient cooling

First All FWD to PEAK: IBBelle and DV Response



Dry Volume:
- N2 at ~24 l/min
- inner: OFF ~10 C → ~19 C
- outer: OFF ~19 C → ~21 C

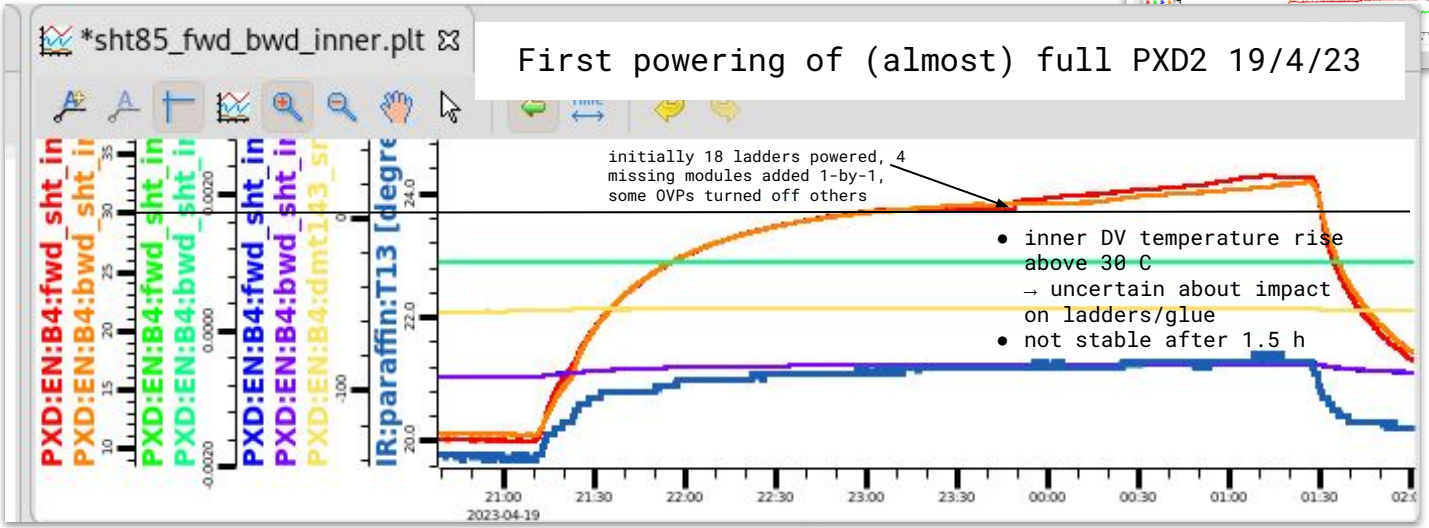
Beampipe:
- paraffin: OFF 19.7 C → PEAK 20.3 C

IBBelle:
- CO2 temperature ~20 C
- PXD CO2: OFF → PEAK ~+2 C (surface pipe NTCs!)
- shorted lines CO2 not affected
- junction box etc CO2 not affected

Stable state not reached after 1h

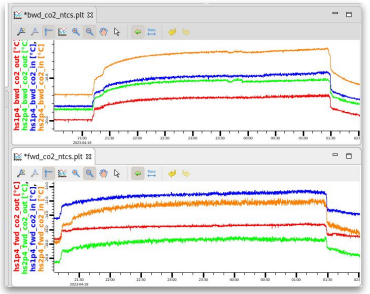
18

First powering of (almost) full PXD2 19/4/23



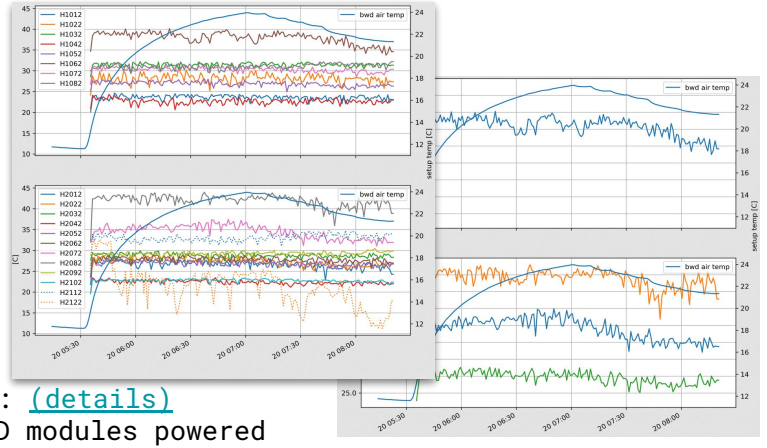
- inner DV temperature rise above 30 C
  → uncertain about impact on ladders/glue
- not stable after 1.5 h

elog: https://elog.belle2.org/elog/VXD+commissioning/141



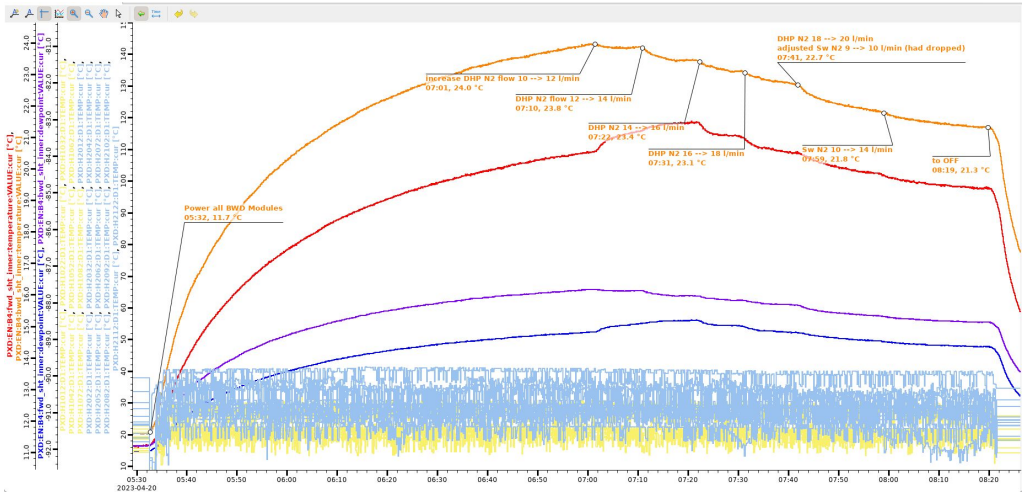
Improving on PXD Cooling

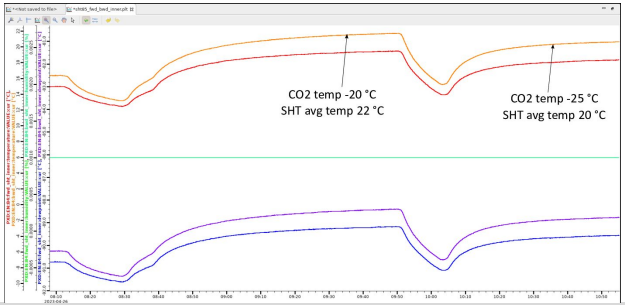
- Only measures for cooling:
  → DHP temperatures: dominated by CO2 temperature
  → DV air temperature: determined by N2 flow and CO2 temperature
  → no direct knowledge on sensor temperature (but relevant for ladder bending, glue joint, …)
- Gut feeling target: DV air temperature stable < 30 C
  → lower limit for sensor temperature
- Not achievable with PXD1 settings
  → N2 at 28 l/min (only max ~24 l/min in B4) at -20 C CO2
- Adjusted settings “that work ok”:
  → CO2 at -25 C
  → DHP N2 flow 18 l/min, Switcher N2 flow 16 l/min



Study: (details)

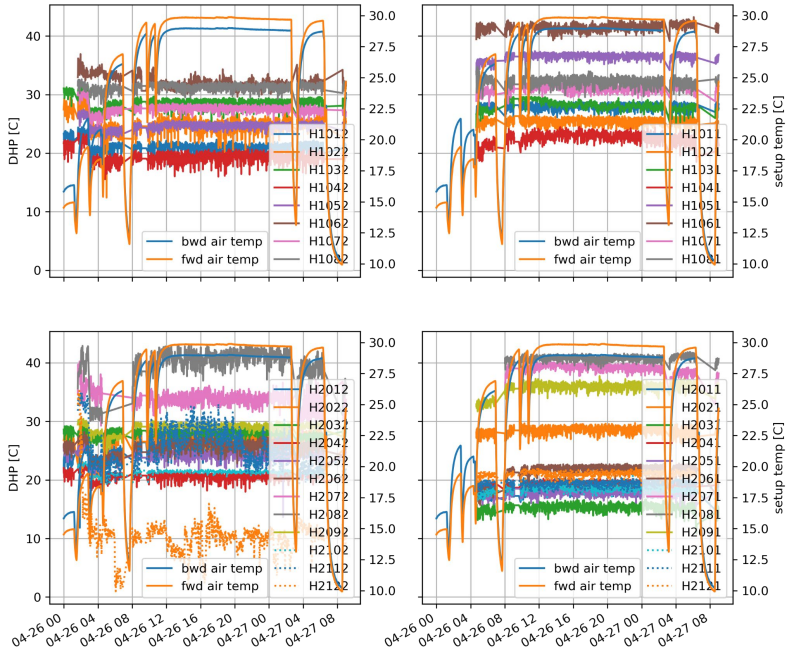
- FWD modules powered
- increasing N2 flow 20 → 34 l/min
  → DV air from 24 → 21.3 C
  → impact only on some DHP temps
- lowering CO2 temperature -20 → -25 C
  → DV air from 22 → 20 C

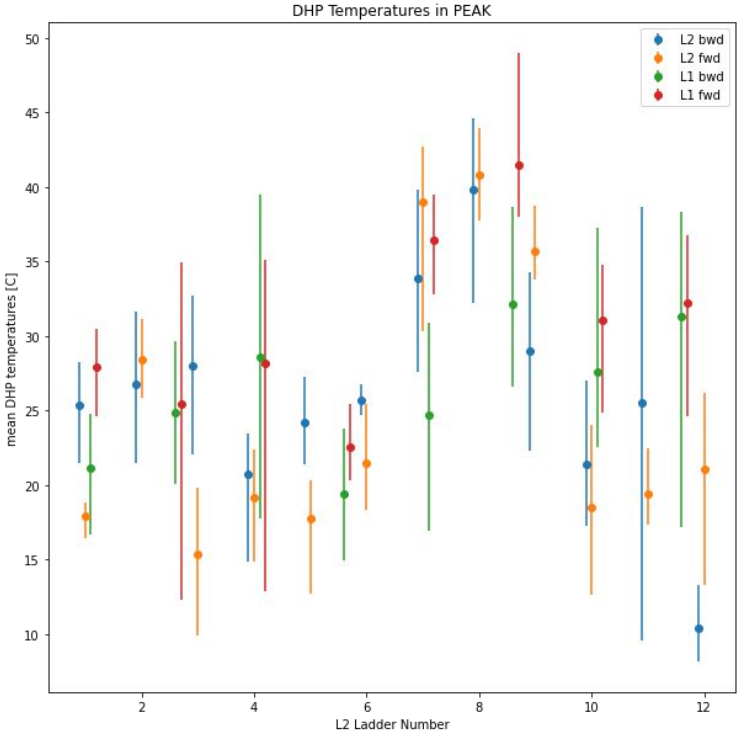




DHP Temperatures (Full PXD PEAK)

- mostly stable DHP temperatures, large spread between DHPs and mean DHP temperature per modules
- interestingly: strongly bent ladders 207X/208X are also hottest
- HS1 vs H2 difference?
  → origin not known, uneven N2 flow?
  → all N2 lines measured independently at roughly ⅛ of flow but varying
  → not an issue in Belle2 anymore with 1 flow meter per channel
- SCB left / right difference?1



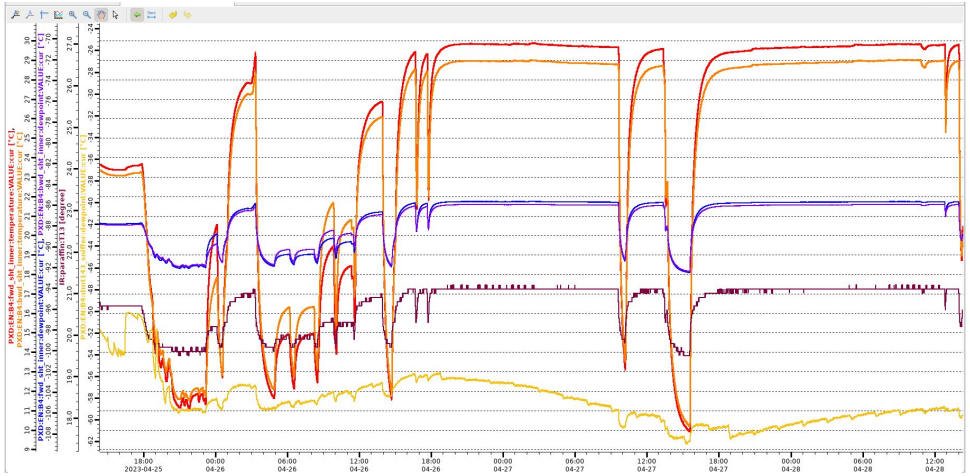


Status PXD Commissioning

- **Full PXD** running stably for few days (continuously with multiple power cycles in between)
- 36 modules look good as expected so far
  → 4 have issues but are functional
  → impacts on Belle 2 performance to be further understood

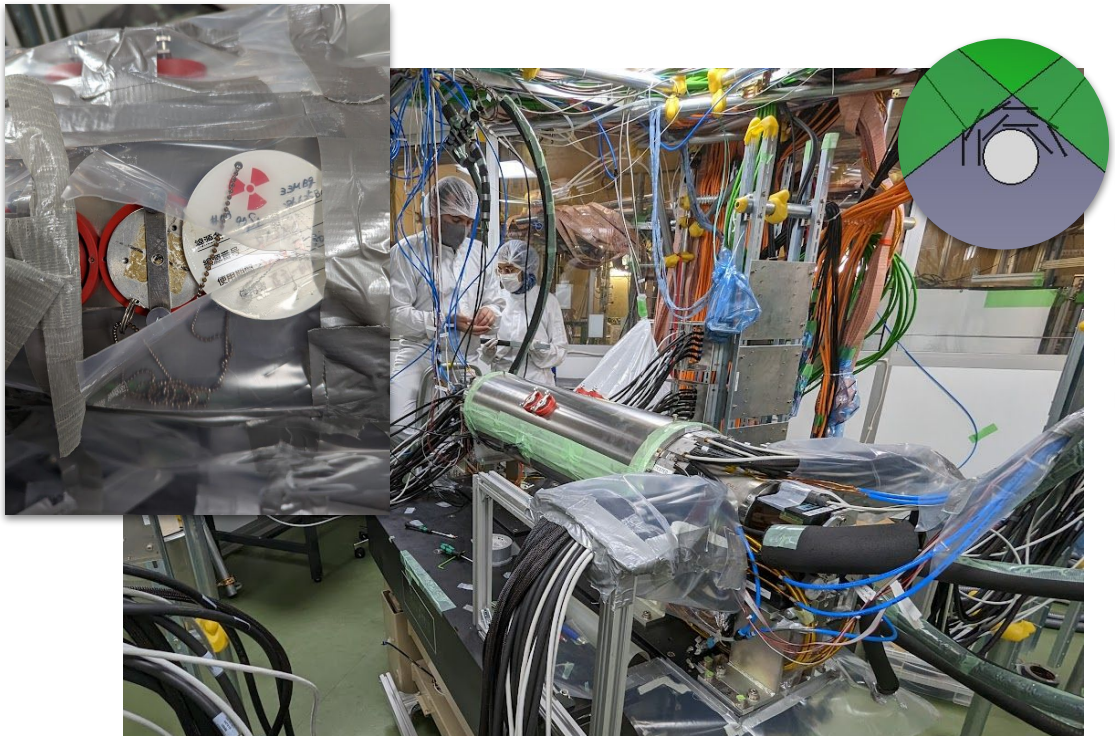
- Cooling stable at -25 C CO2 + 34 l/min N2 flow (16 sw, 18 dhp channels)
  → inner dry volume air temperature stable at safe 30 C
  → CO2 colder than Belle II VXD, N2 higher than PXD1
  → increasing N2 flow leads to increased ladder vibration amplitudes
  (thermal mockup study, < 0.1 um amplitude at 200 Hz)

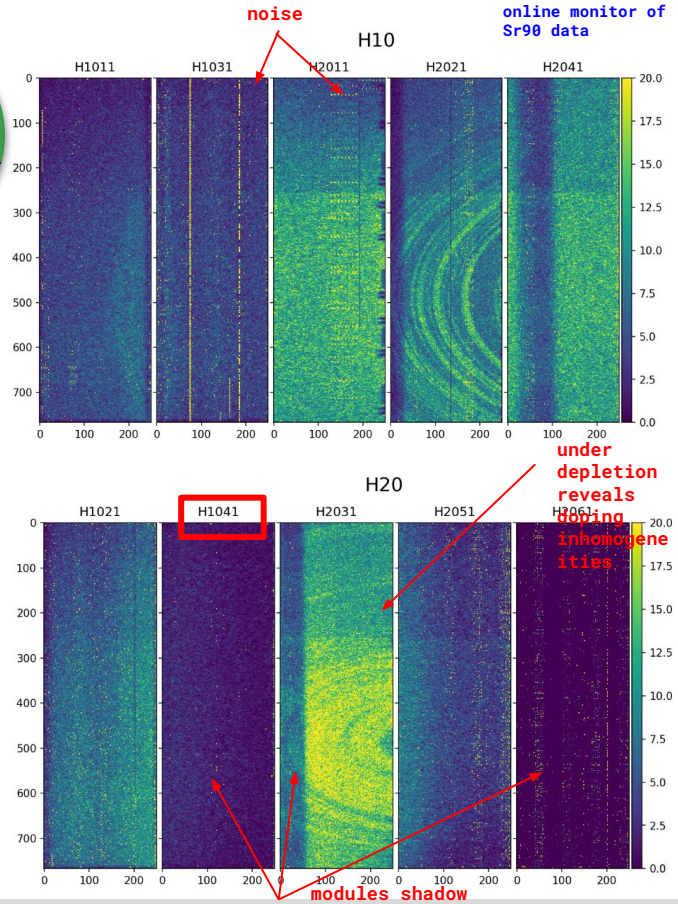
- SVD not comfortable with -25 C
  → uncertain if PXD cooling sufficient at -20 C, not sufficiently studied yet
  → will have to re-evaluate situation during combined VXD commissioning



- air temperature inner DV ~30C
- dewpoint SHT 85 below sensitivity
- beampipe temperature ~21C
- dewpoint humidity sniffer ~ -60C

Extended Run Full PXD: Source Scan HS_2p4



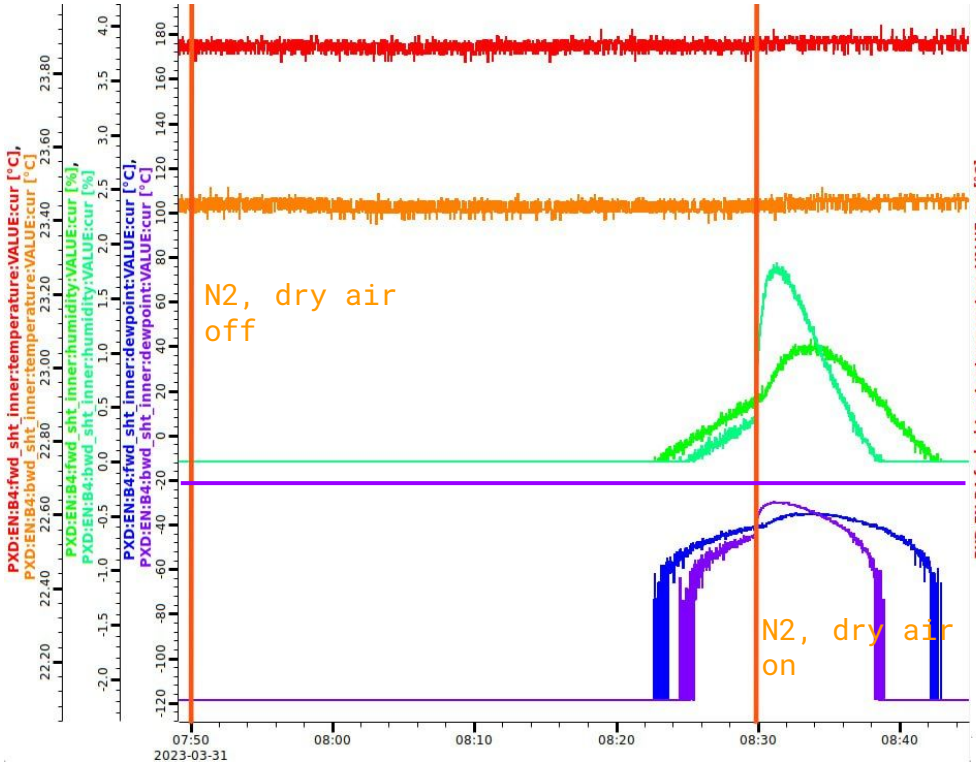


- Performed detailed Sr90 source scans for HS_2p4_v1 and HS_1p4 at DESY
- No data for replaced HS_2p4_v2 modules
- Took data scanning HV during extended PXD operation
  → dedicated talk (?)

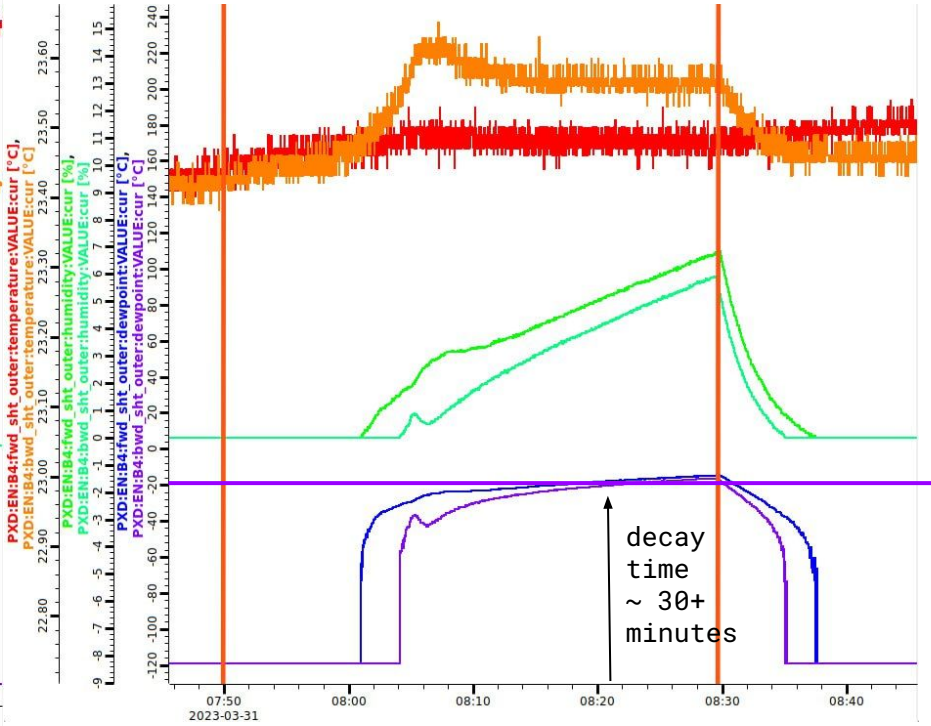
BACKUP

Dry Volume Dry Air Only: Decay and Recovery

inner dry volume SHT85



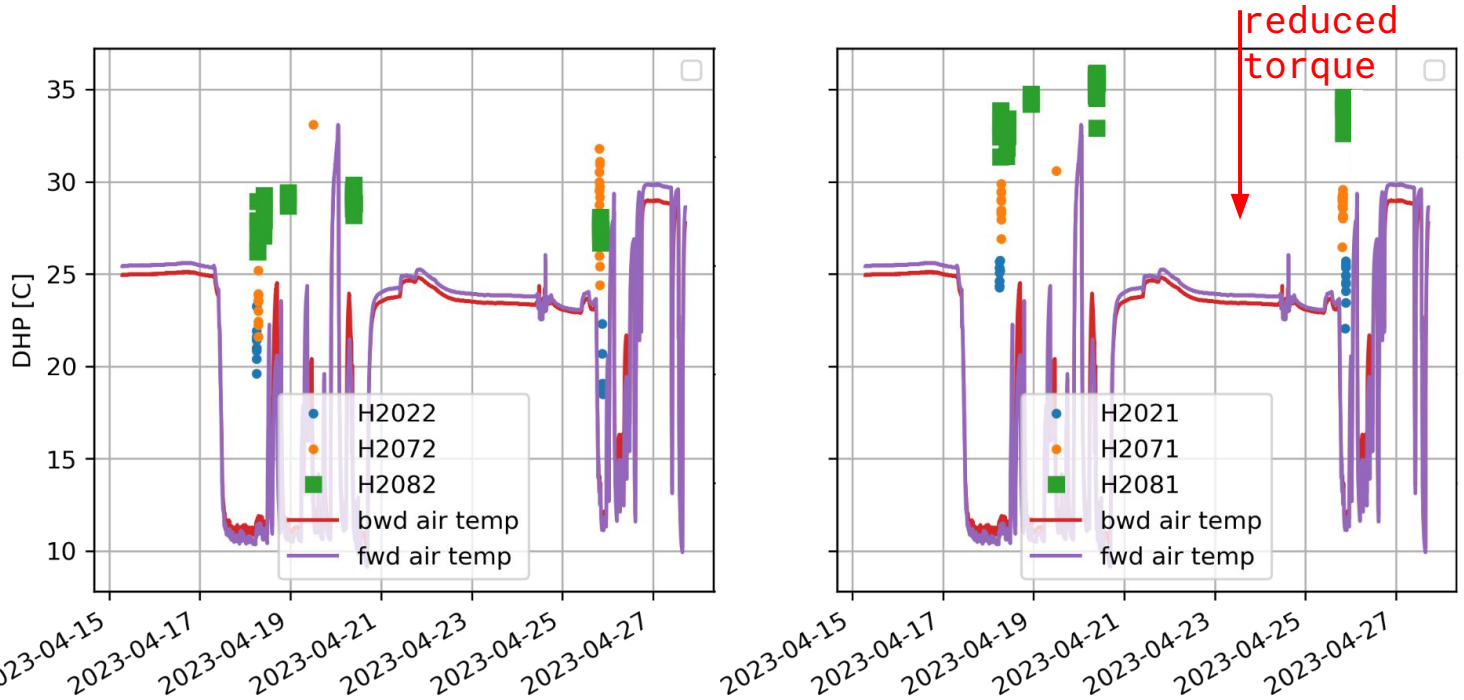
outer dry volume SHT85



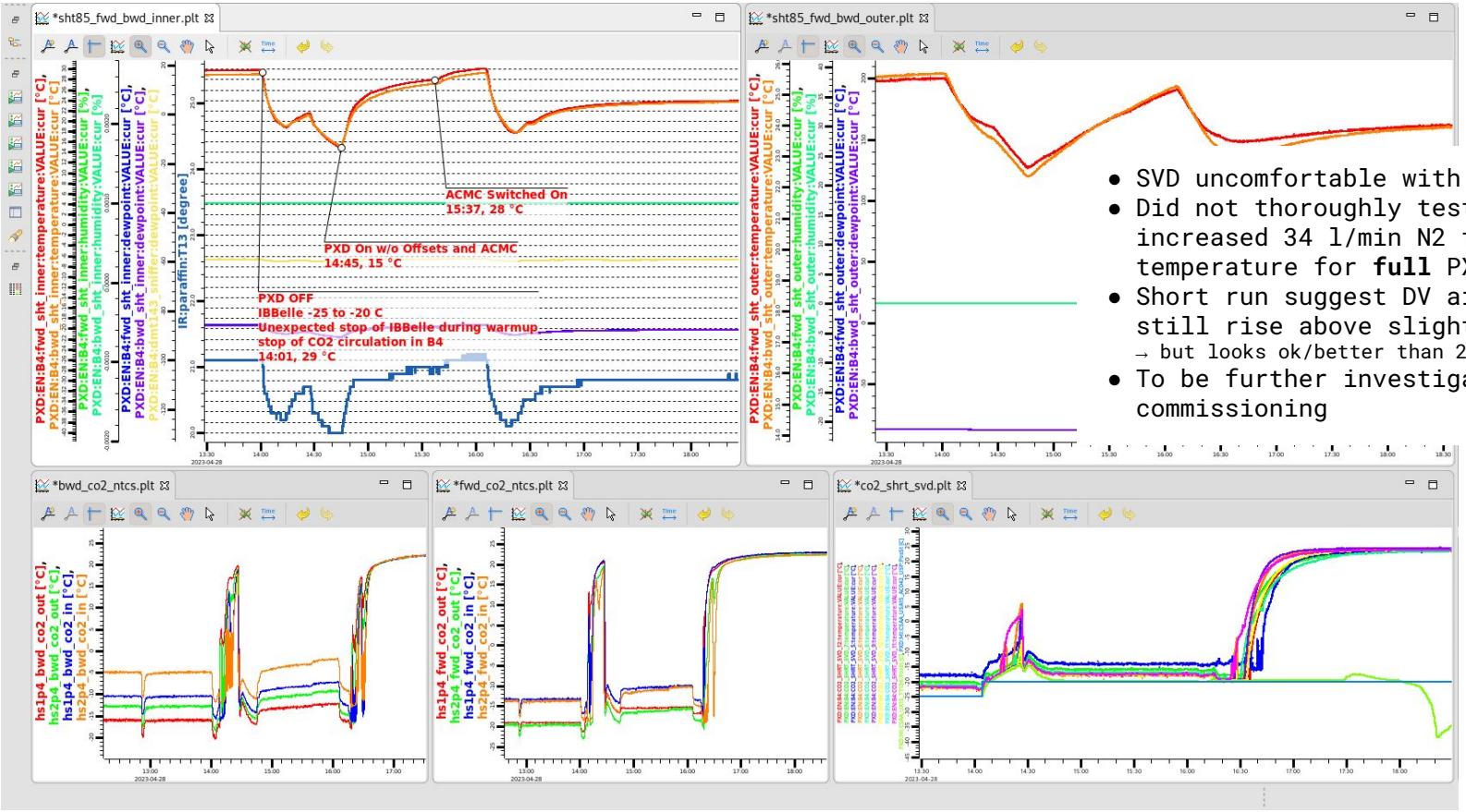
inner dry volume: no decay if N2 flow present

FWD Torque Reduction DHP Temperatures

- mean DHP temperatures for only one ladder powered
- some differences in dry volume temp (eg N2 flow)
- no significant increase in mean DHP temp after reducing torque



Terminal Temperature at -20 C CO2 Full PXD



- SVD uncomfortable with -25 C.
- Did not thoroughly test cooling with increased 34 l/min N2 flow at -20 C CO2 temperature for **full** PXD.
- Short run suggest DV air temperatures still rise above slightly 30 C.
  → but looks ok/better than 24 l/min at -20C
- To be further investigated during VXD commissioning