CRP6 ColdBox testing update

11/28/2023

Roger, Cheng-Ju, Volodya

Timeline

- CRP6 moved from Faraday Cage to ColdBox on
- 34 kHz noise peak is not present in the ColdBox
- ColdBox purging over the weekend of Nov 25-26, 2023.
- Problems with FEMB #10 (WIB 603 FEMB slot 2): Normal on Sat Nov 25, observed high noise and abnormal traces (wrong baseline) on some channels on Sun Nov 26. Debugging on Sun Nov. 26 (power cycling, reconfiguring). Eventually, cannot communicate due to I2c errors. Swapping the WIB (on Mon Nov 27) did not help. Cable connection is the suspect.
- Cooldown started on Monday Nov. 27 at 1pm.
- New problems in cold (Nov 28, night/early morning):
  - FEMB 2 (WIB 601 FEMB slot 2)
  - FEMB 12 (WIB 604 FEMB slot 2)
- FEMBs 2,10,12 are disabled in DAQ since 7:40 am on Nov. 28.

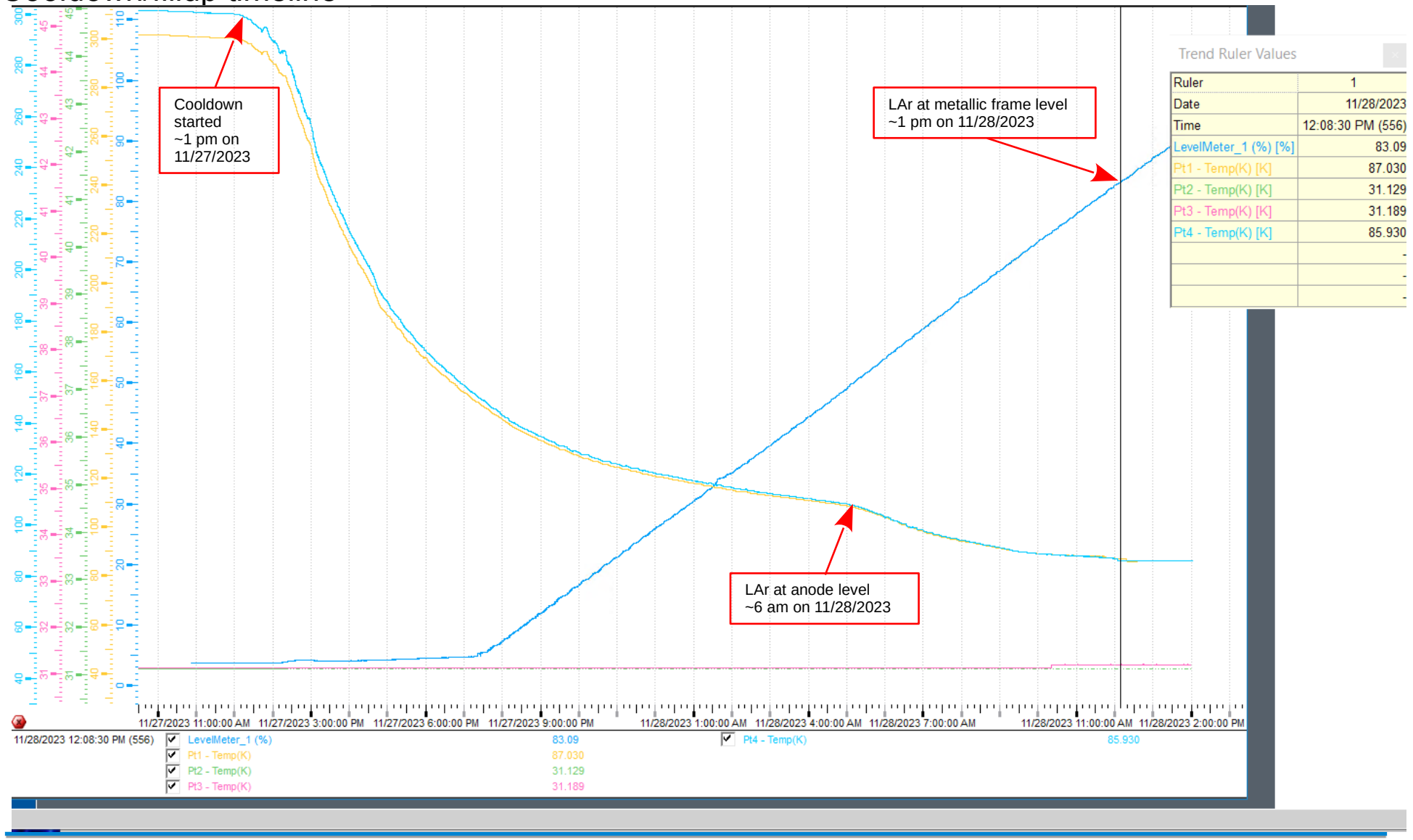
WIBs: 601, 602, 603, 604, 605, 606
FEMB slots: 0,1,2,3

CRP6 configuration

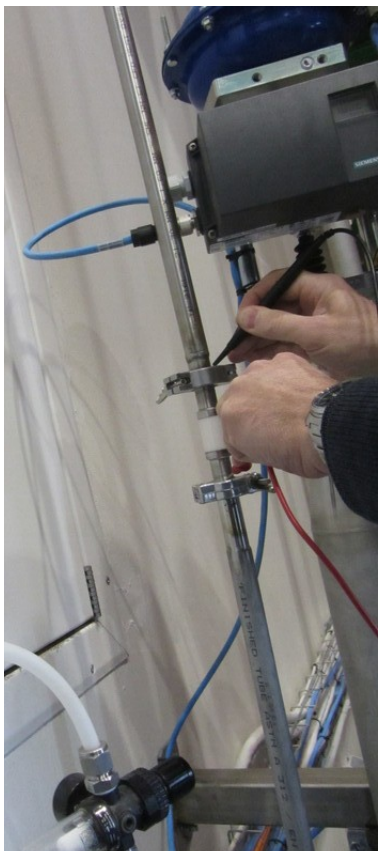
WIB	601				602				603				604				605				606			
IP	10.73.137.50				10.73.137.51				10.73.137.52				10.73.137.53				10.73.137.54				10.73.137.122			
FEMB	6	5	2	1	8	7	4	3	14	13	10	9	16	15	12	11	22	21	18	17	24	23	20	19
FEMB slot	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3	0	1	2	3

Red == malfunctioning

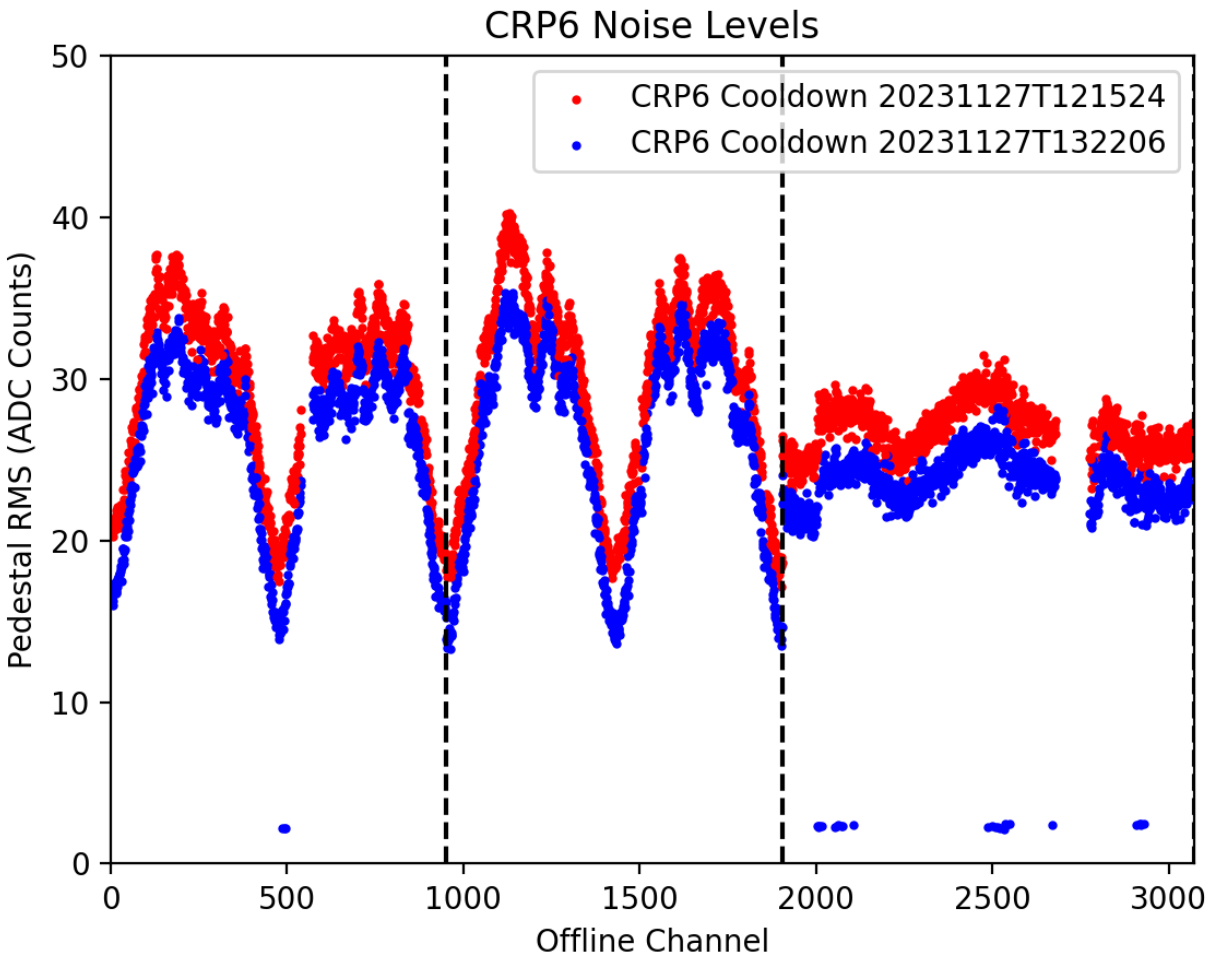
Cooldown/fillup timeline



Measured 15 kOhm between ColdBox and Building Ground



CRP6 noise evolution during cooldown/filling



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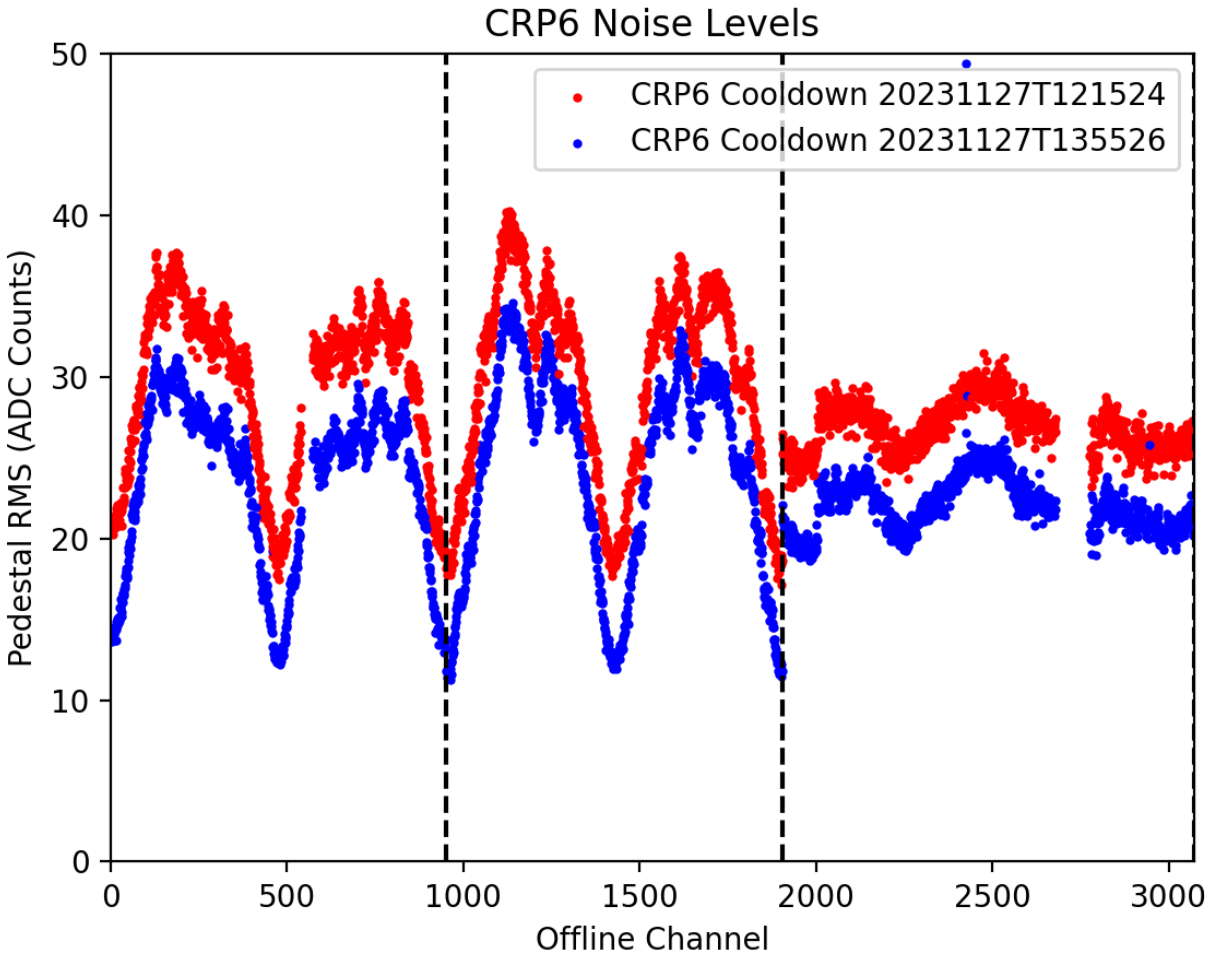

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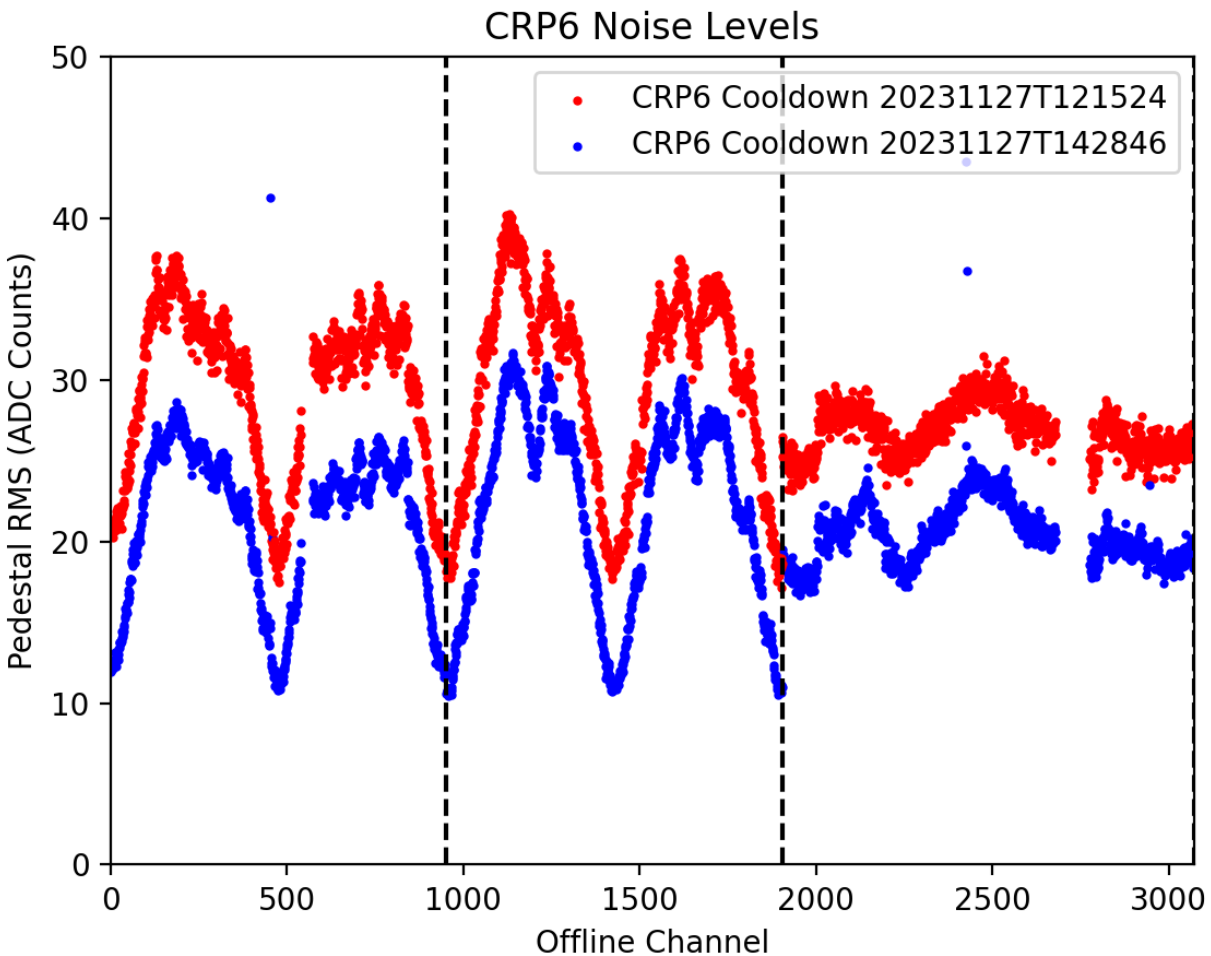

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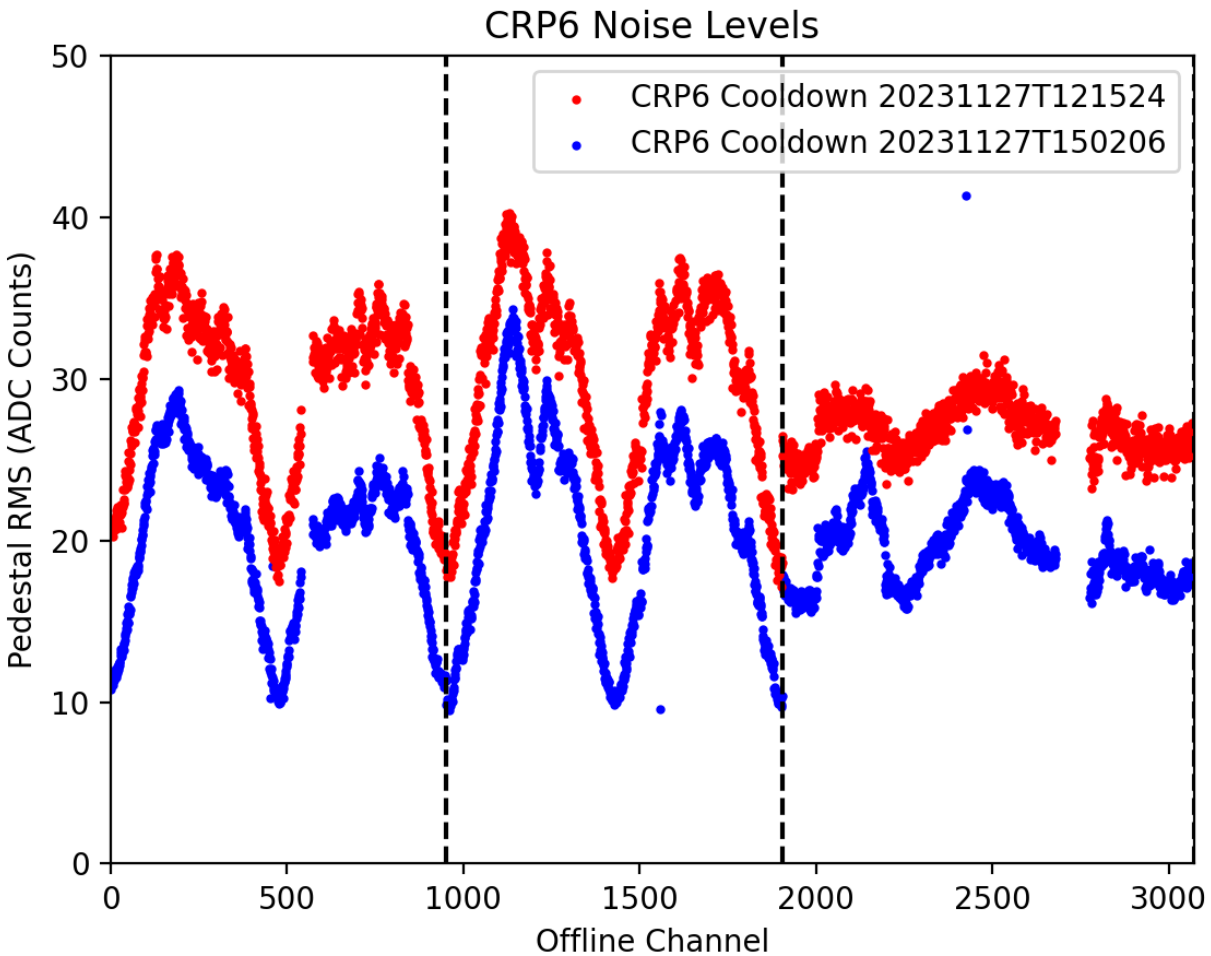

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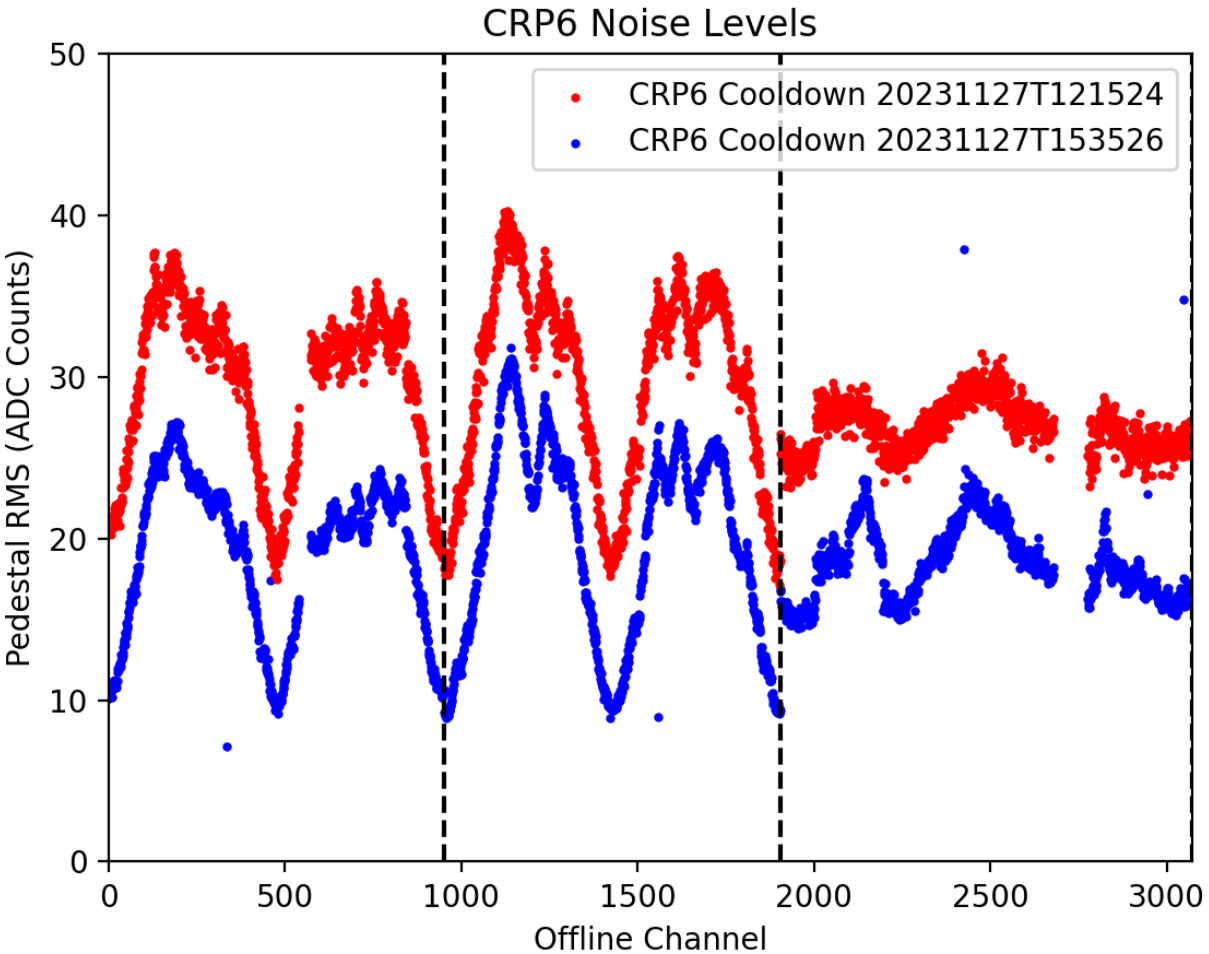

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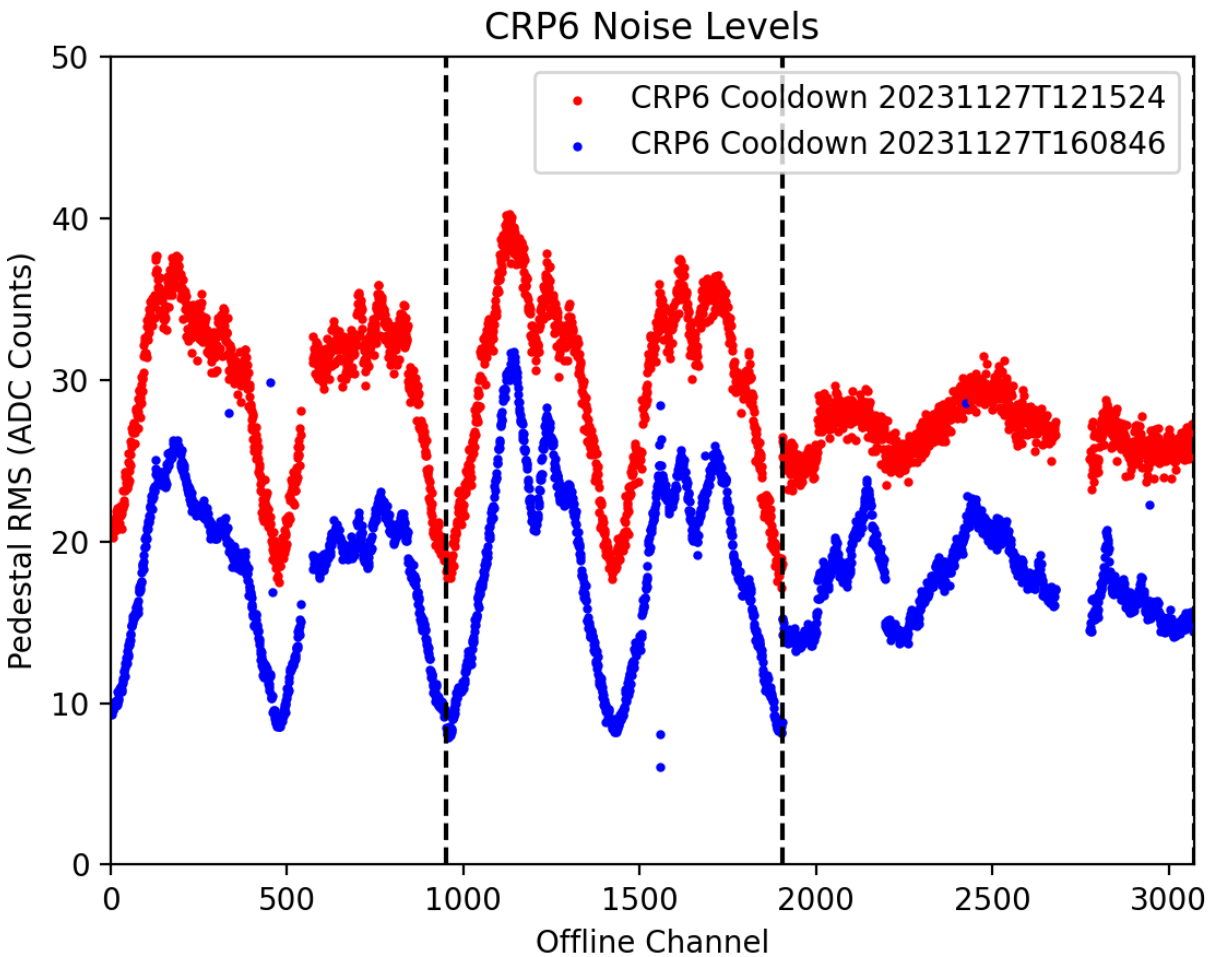

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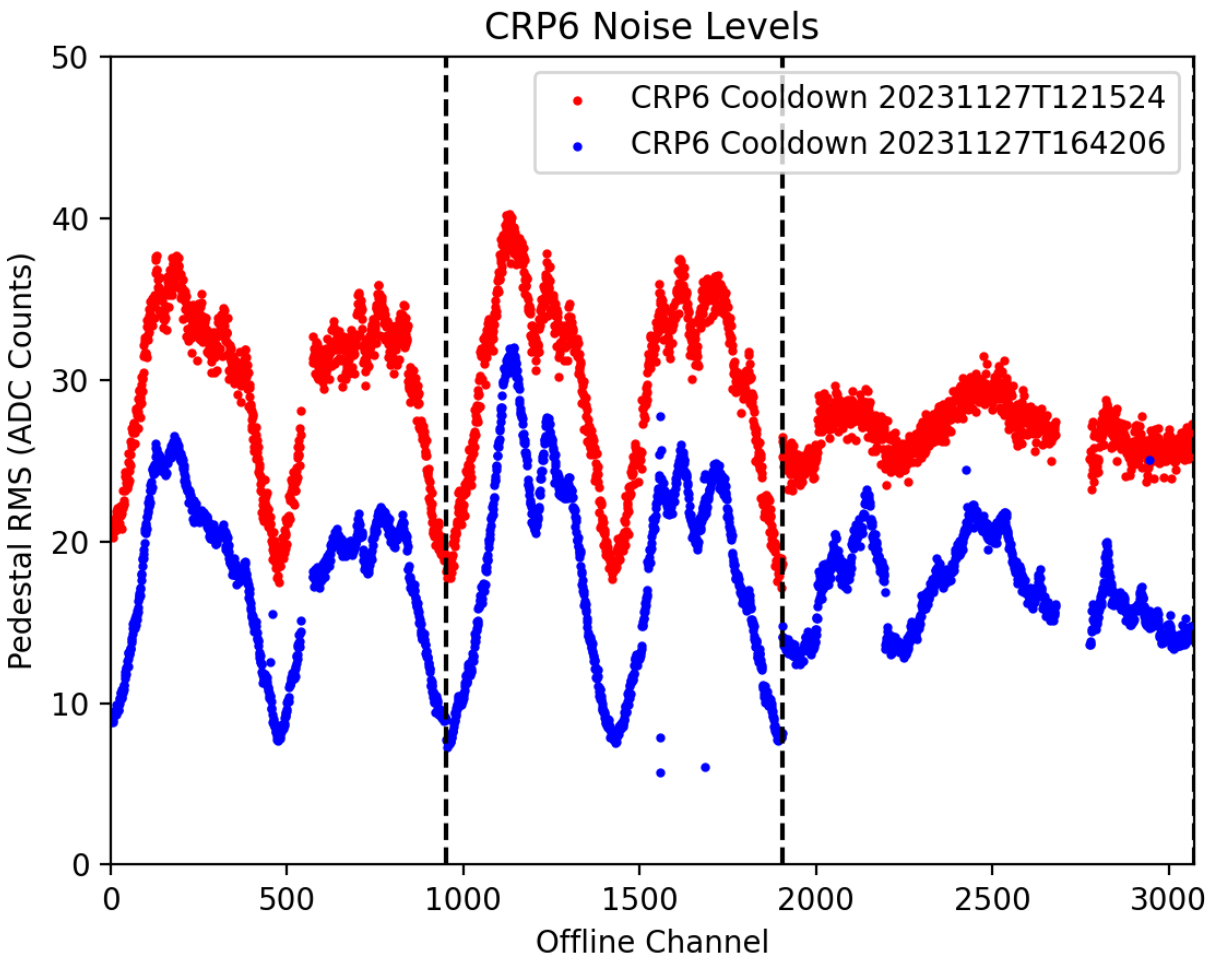

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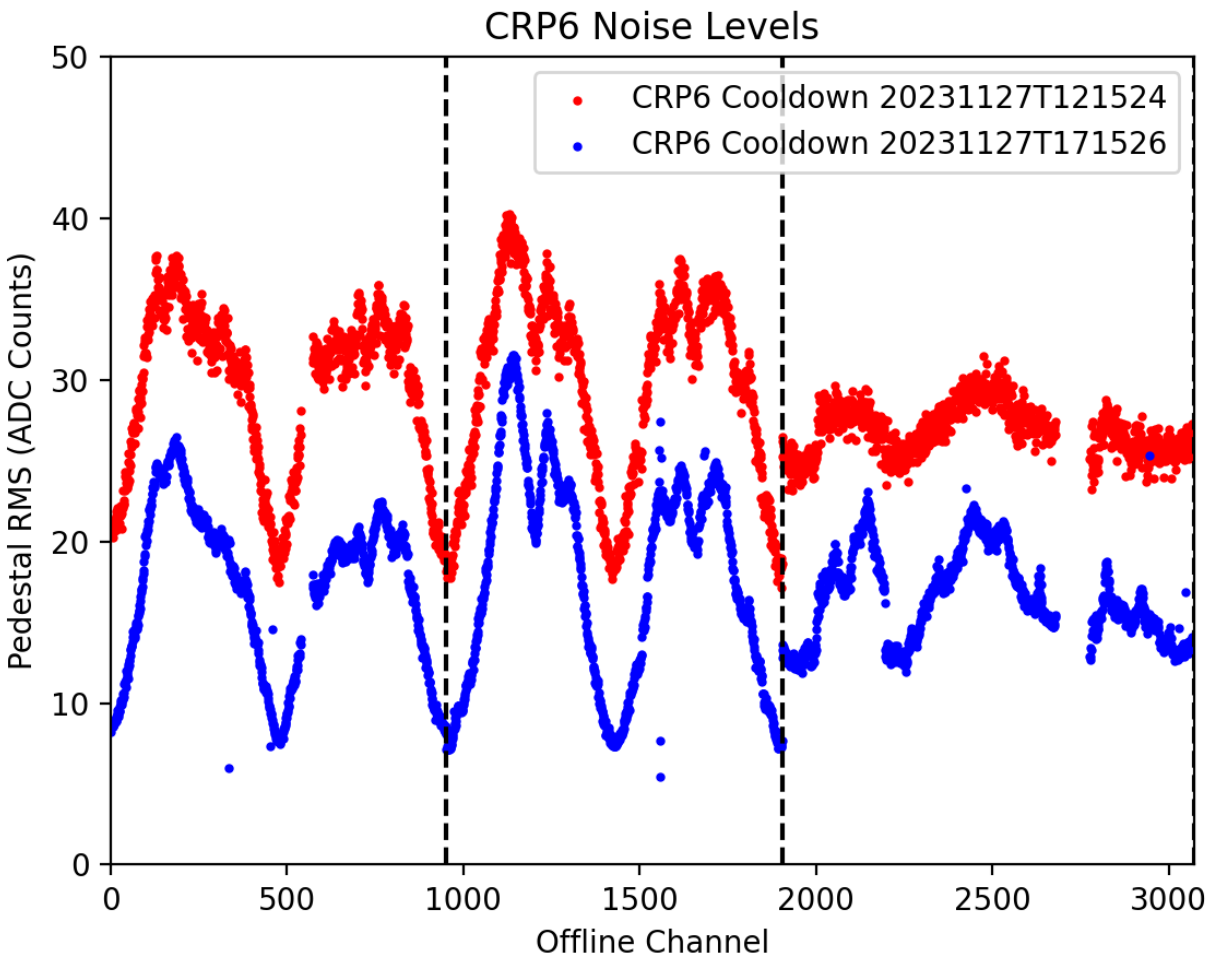

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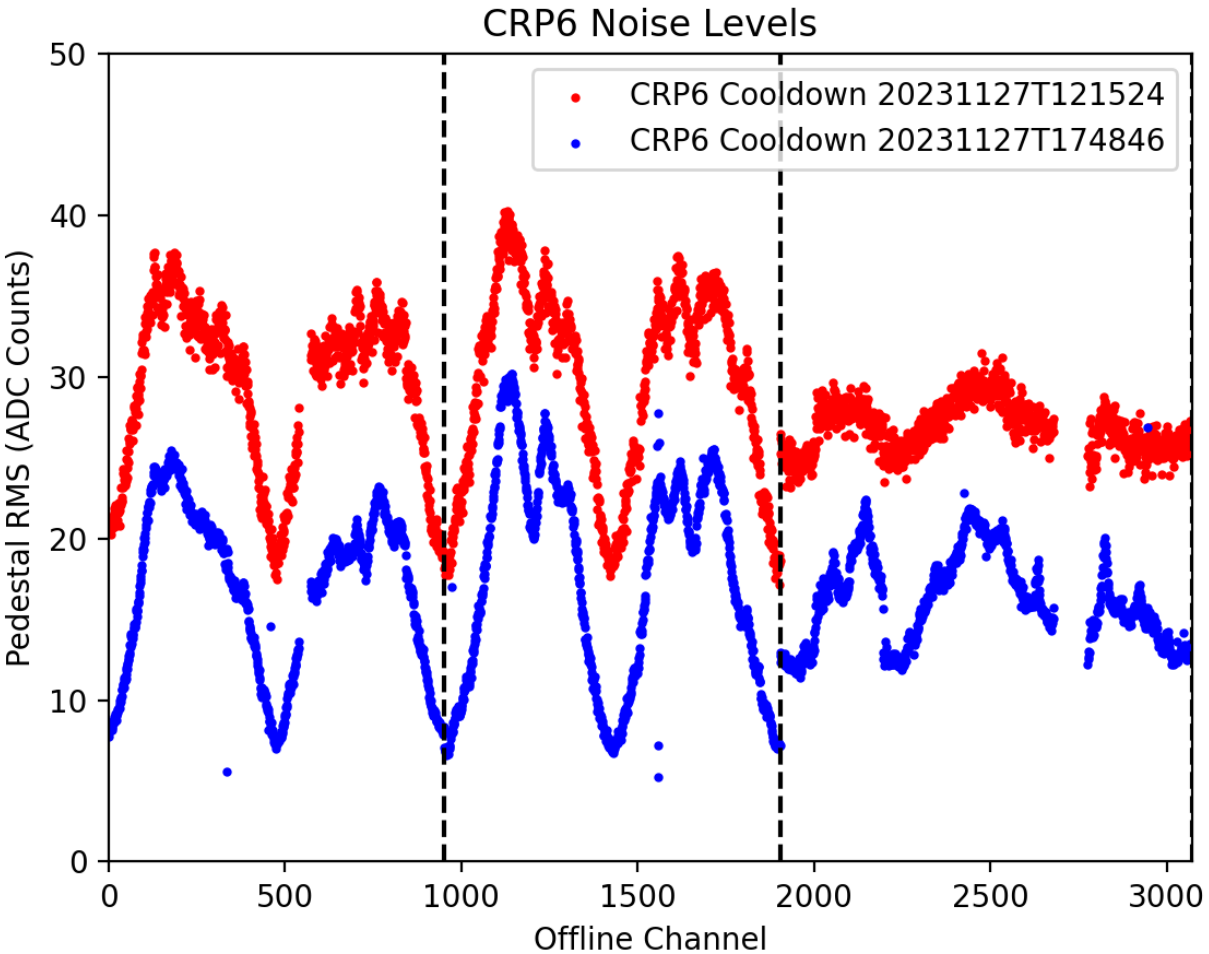

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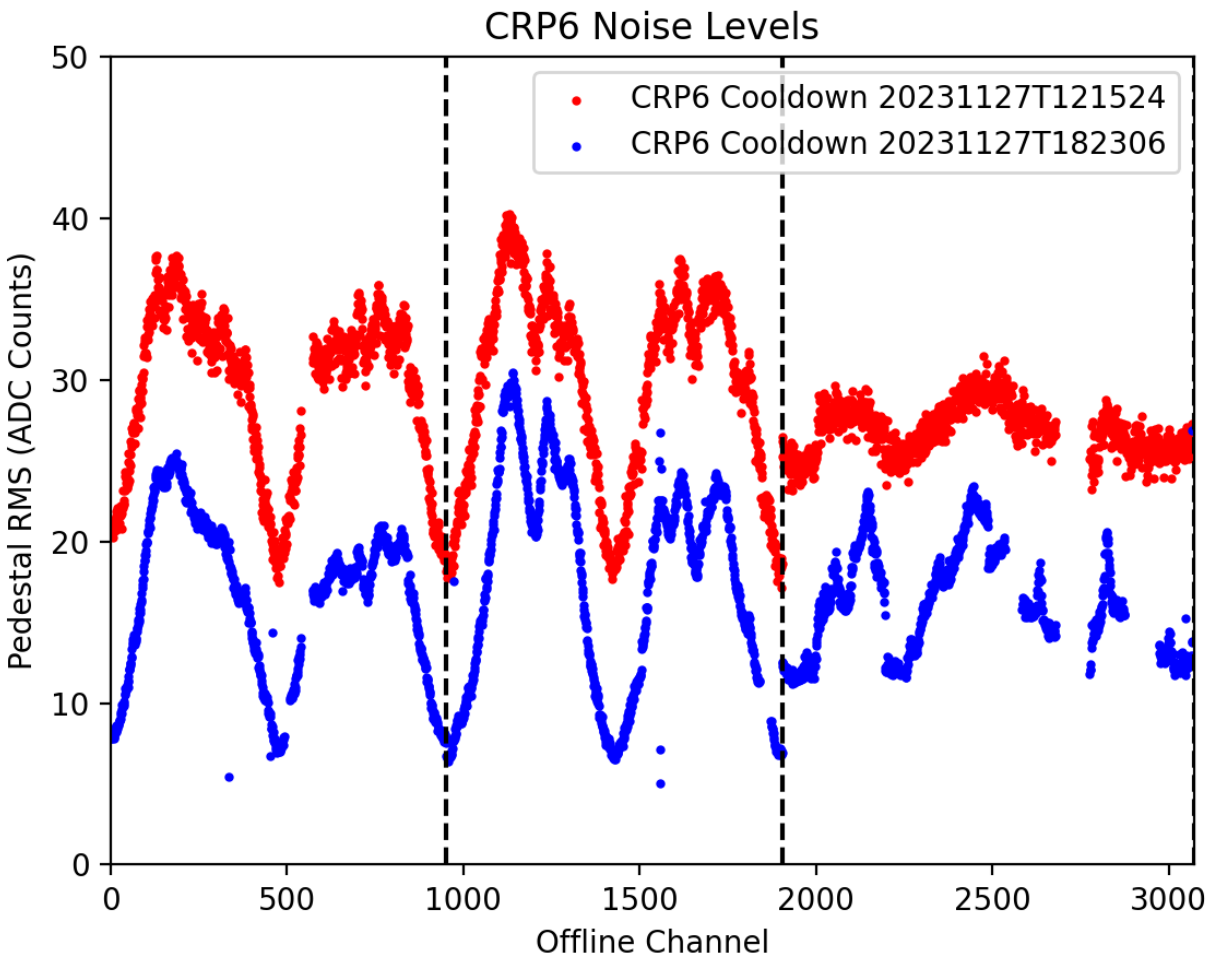

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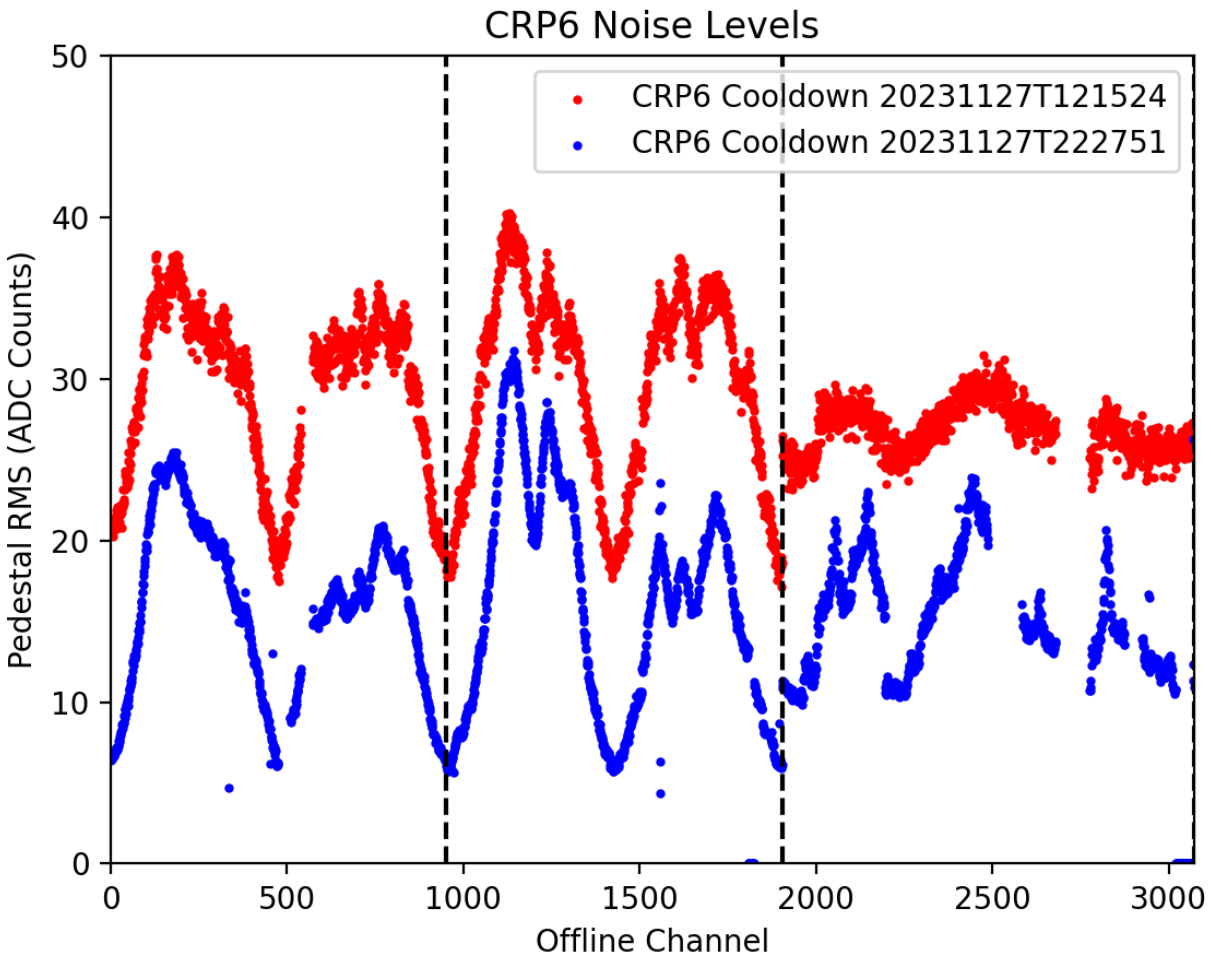

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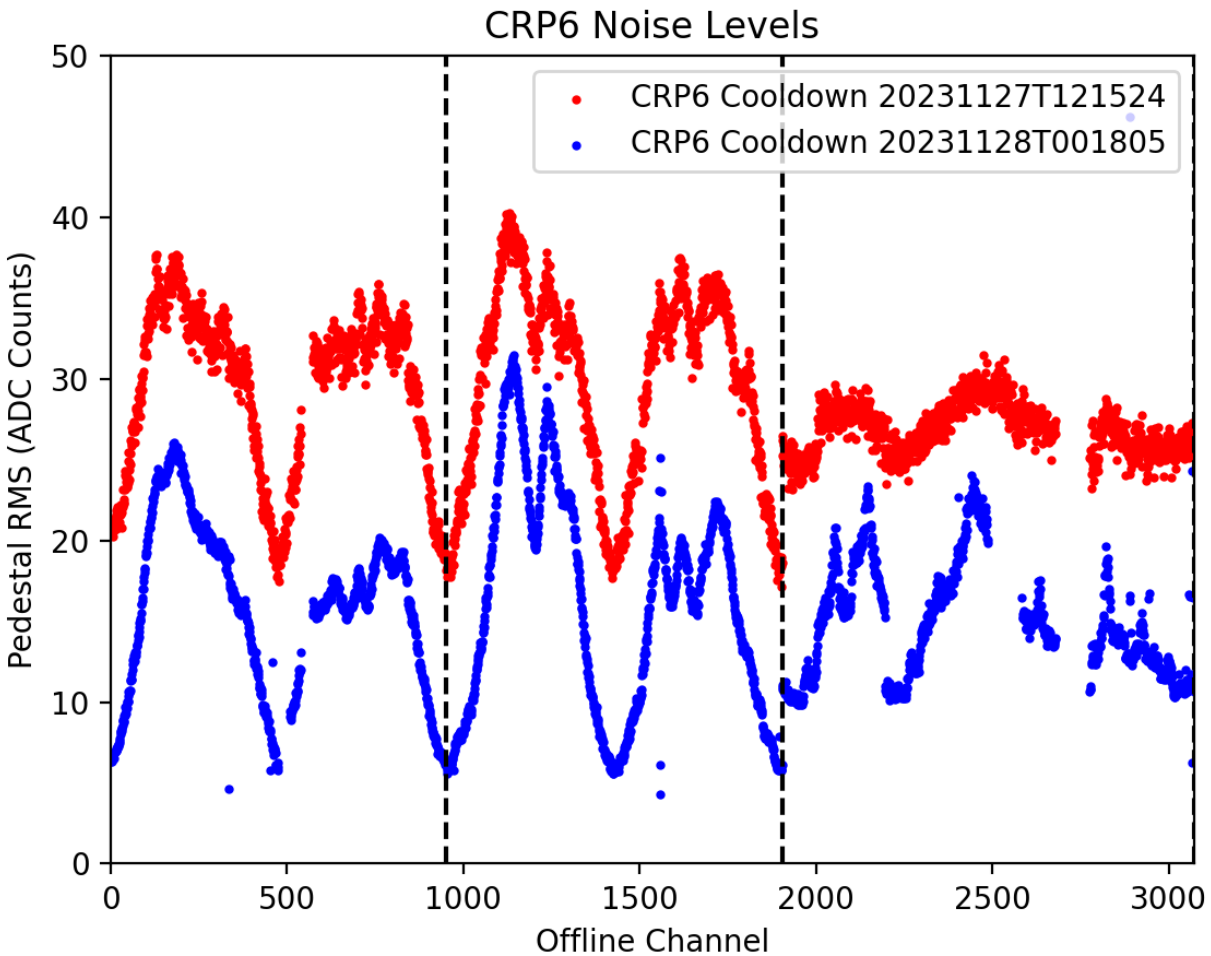

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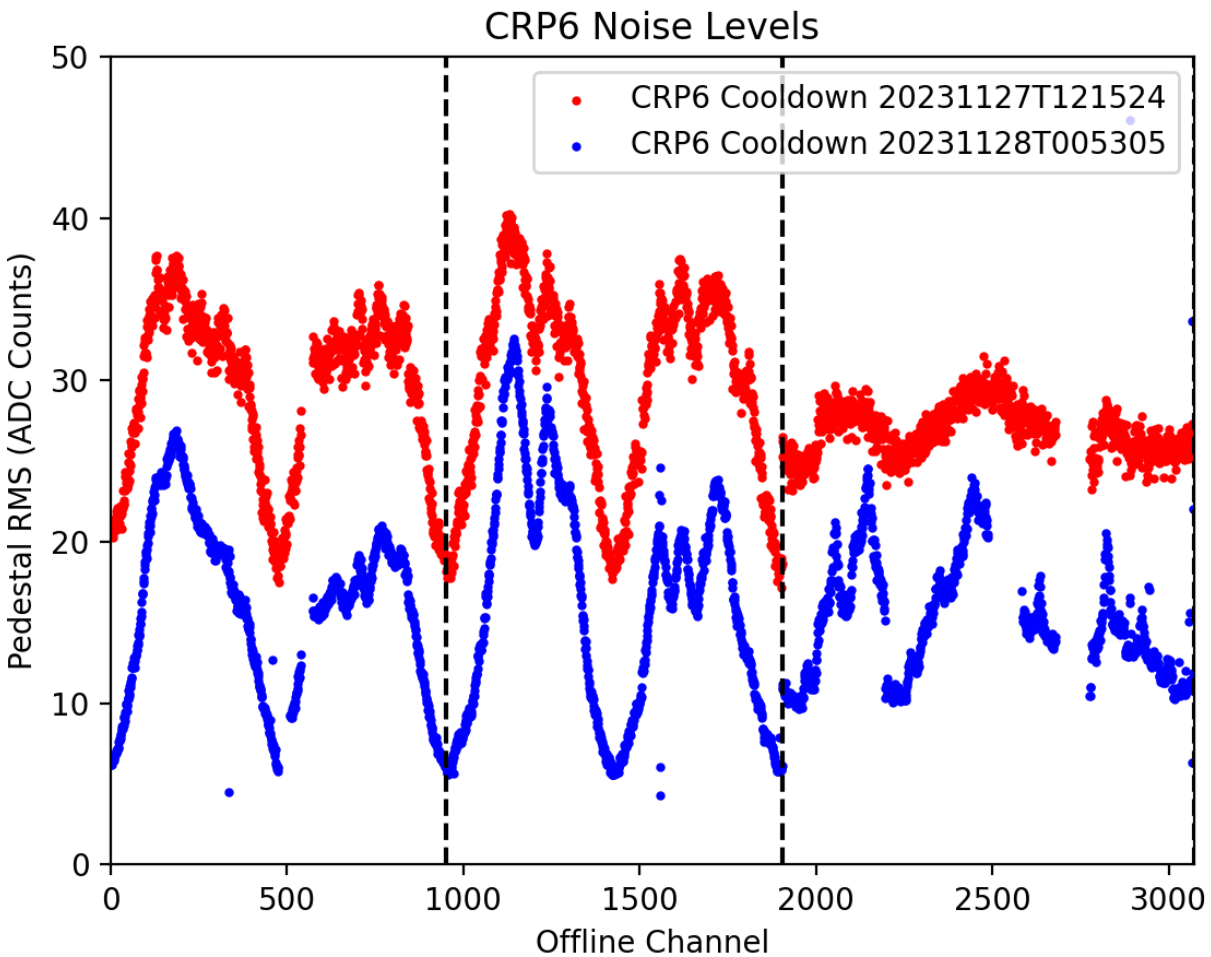

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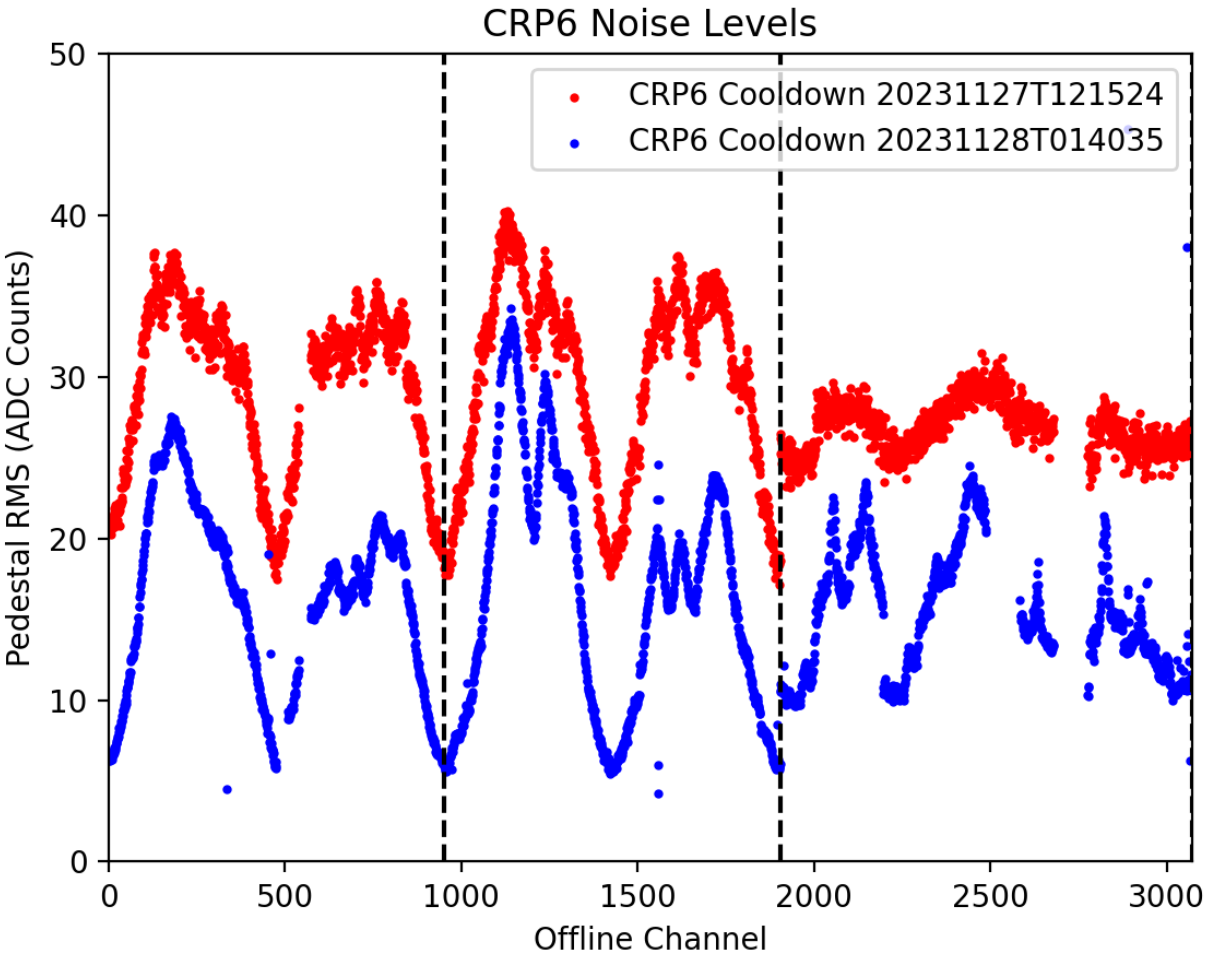

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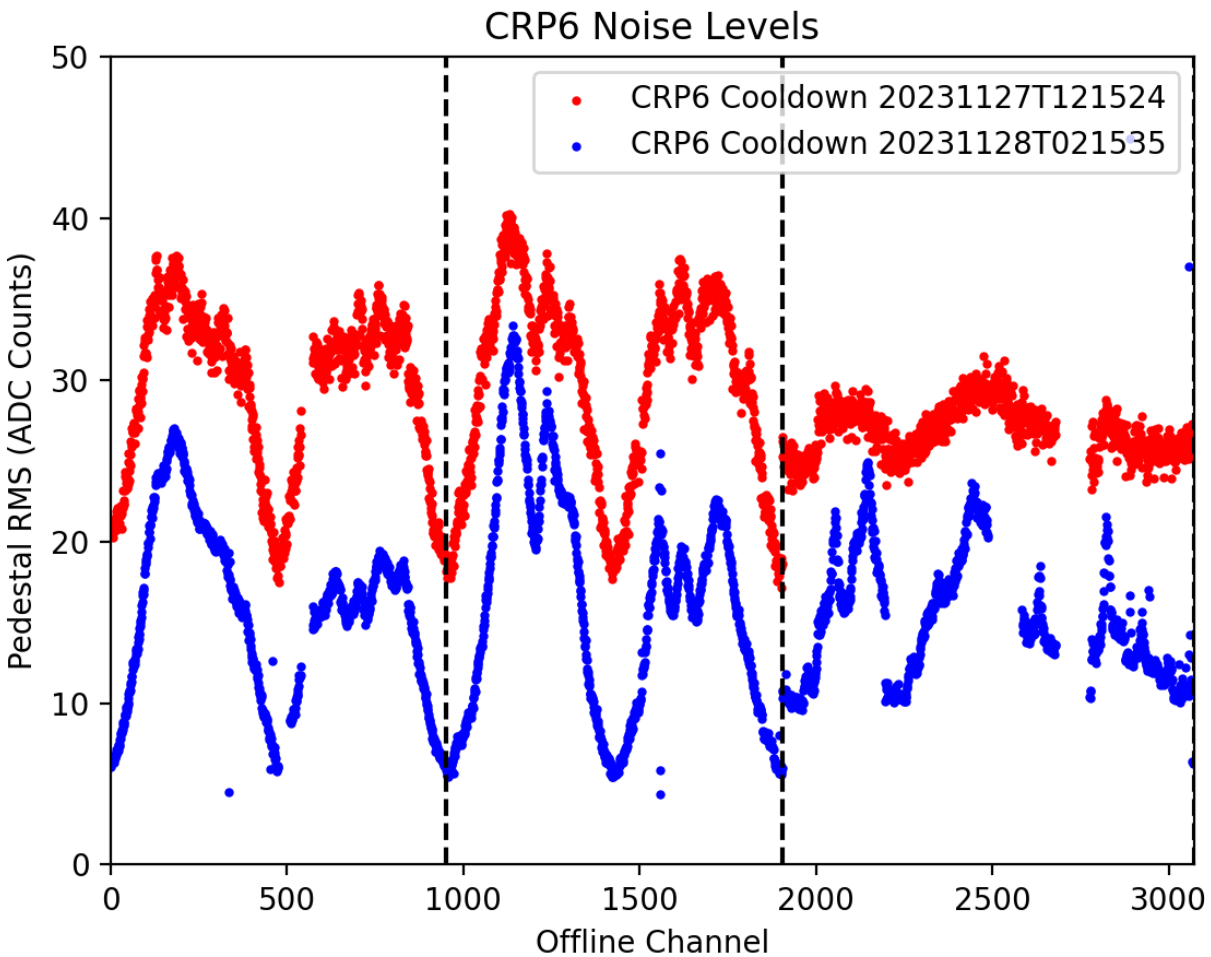

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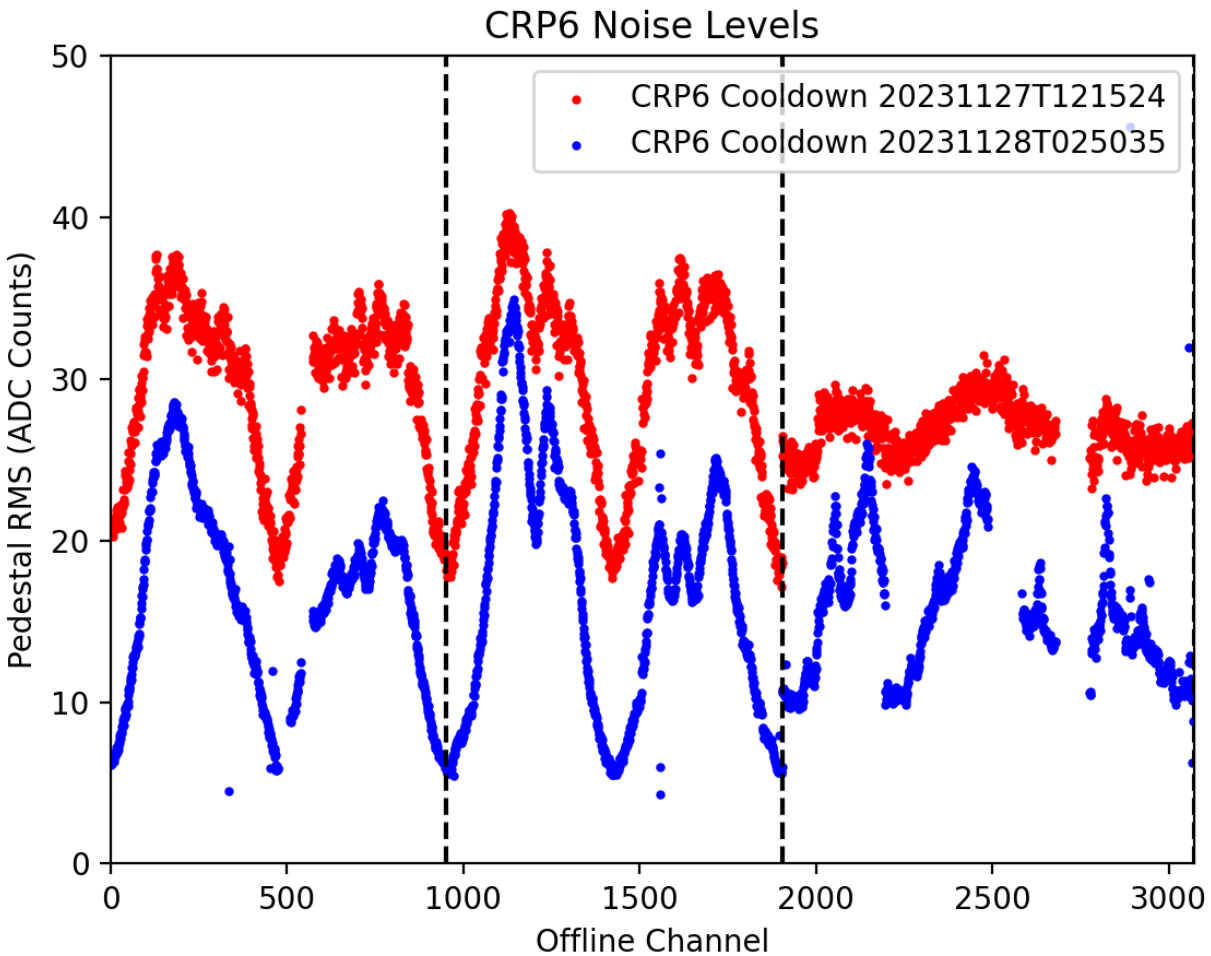

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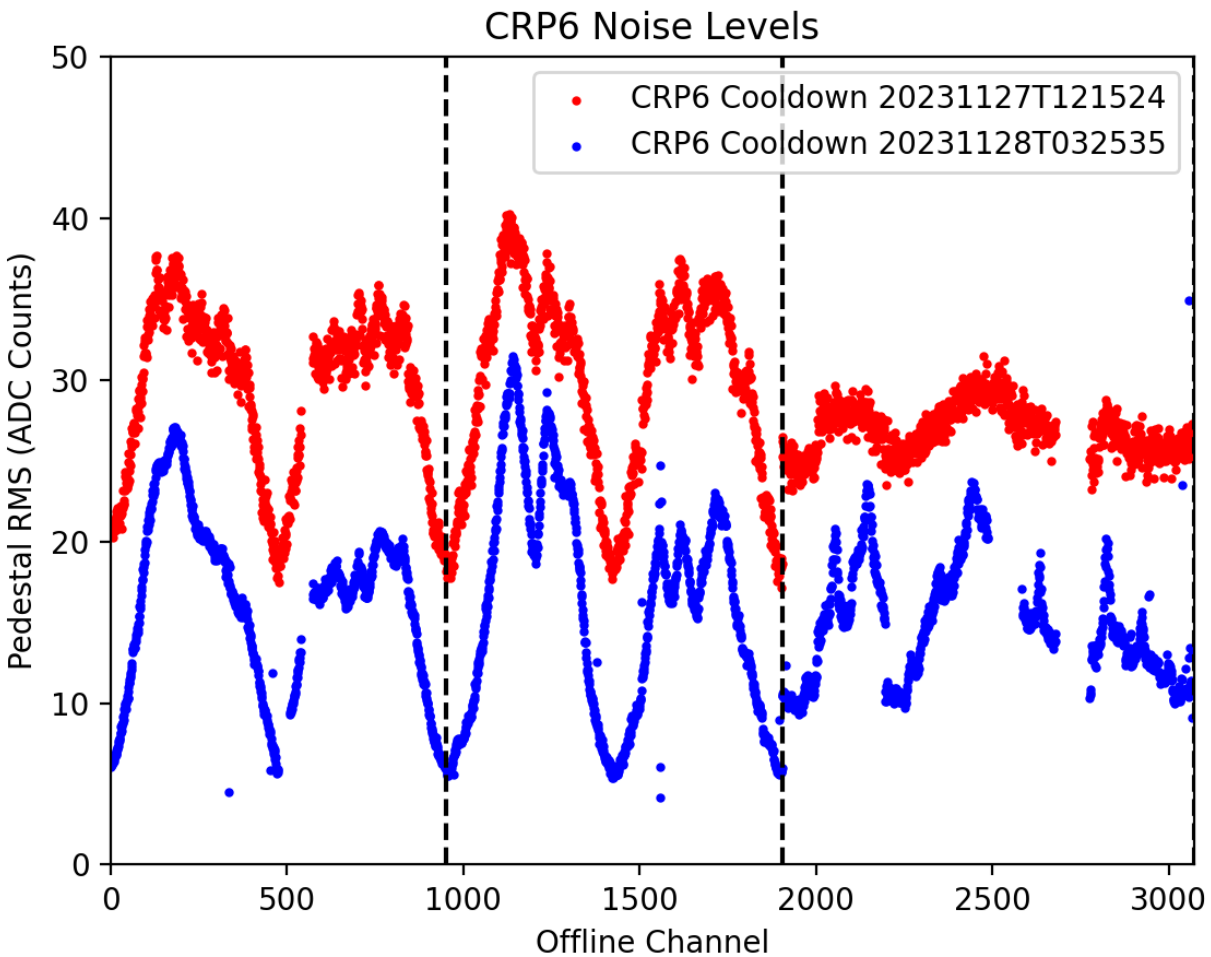

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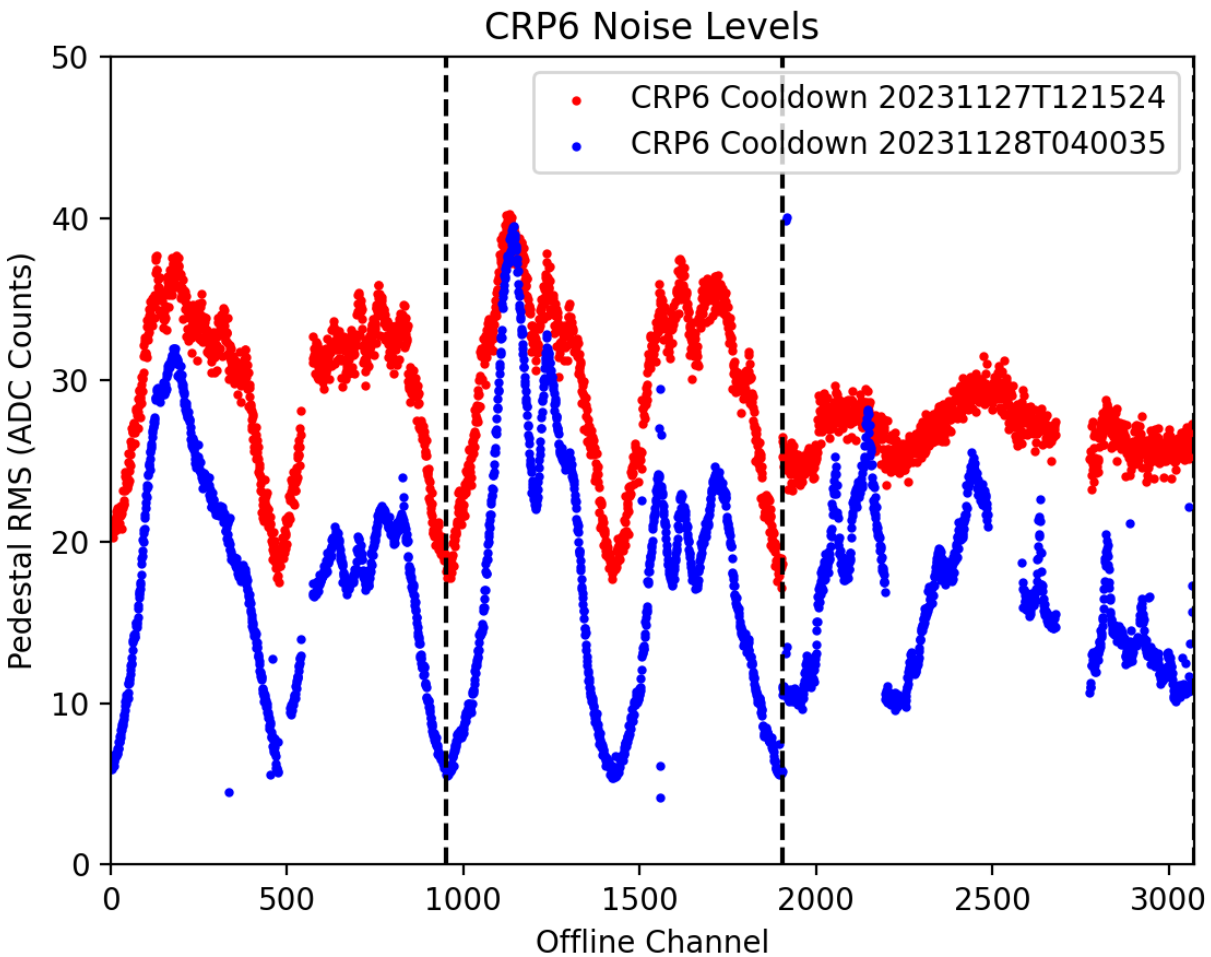

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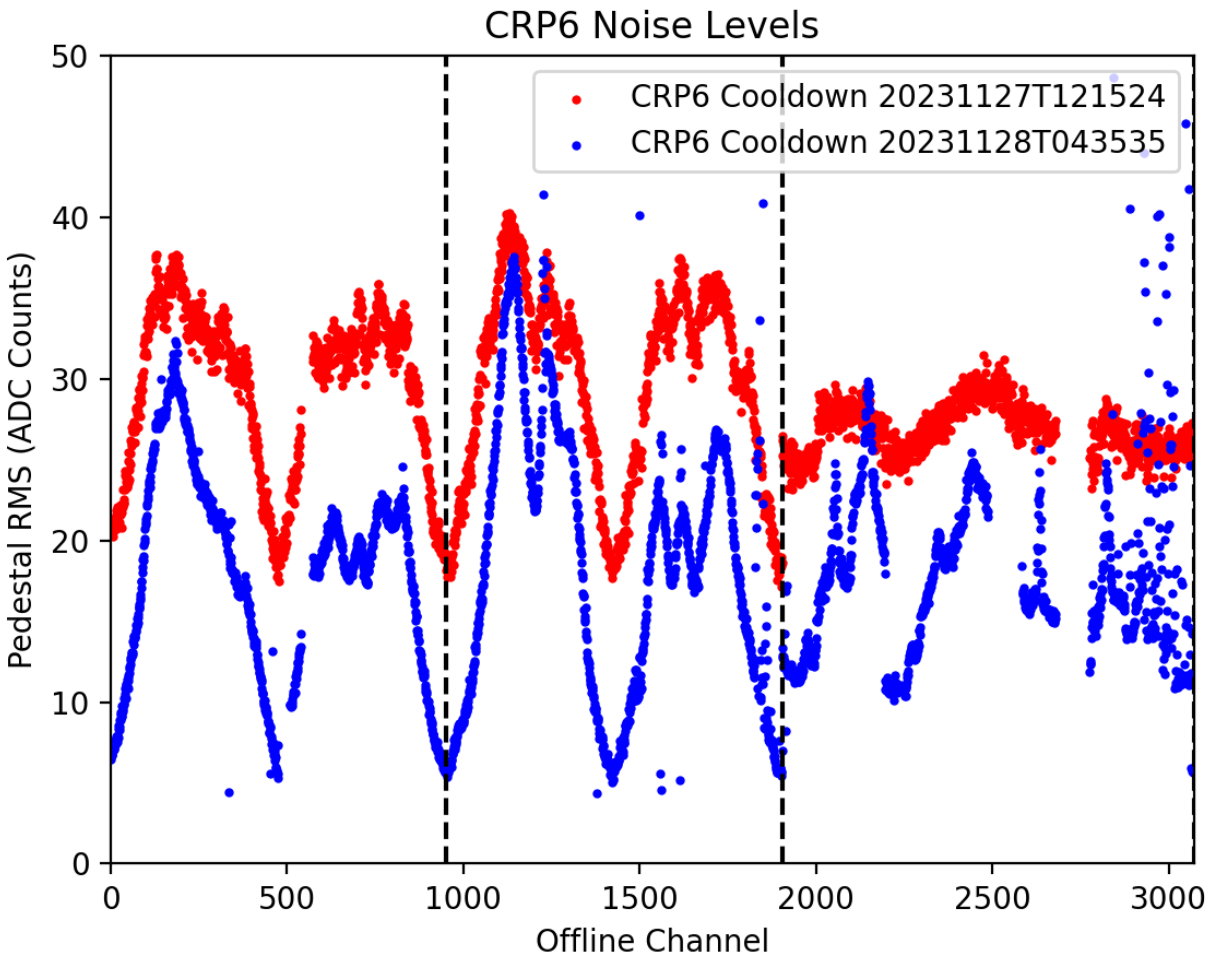

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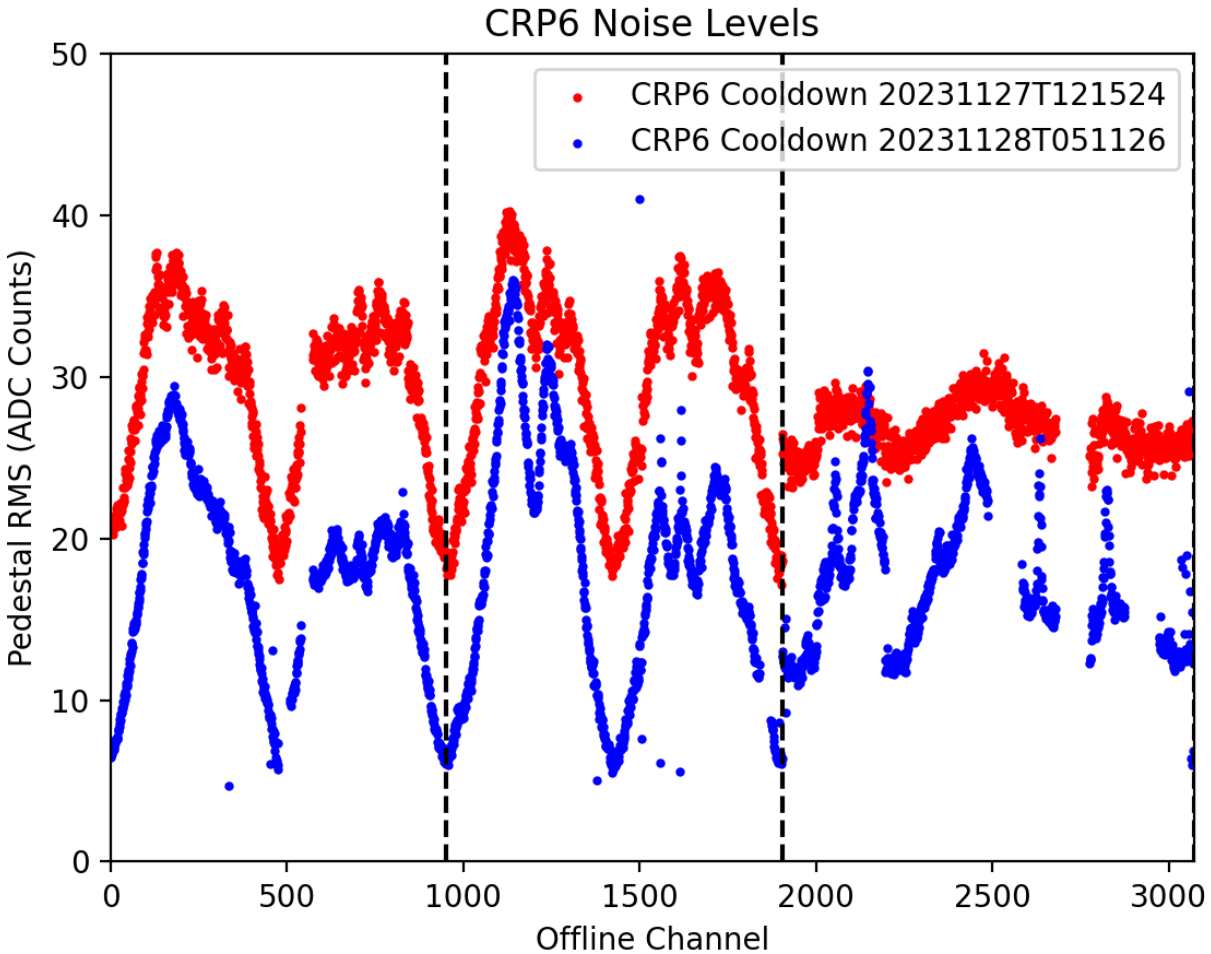

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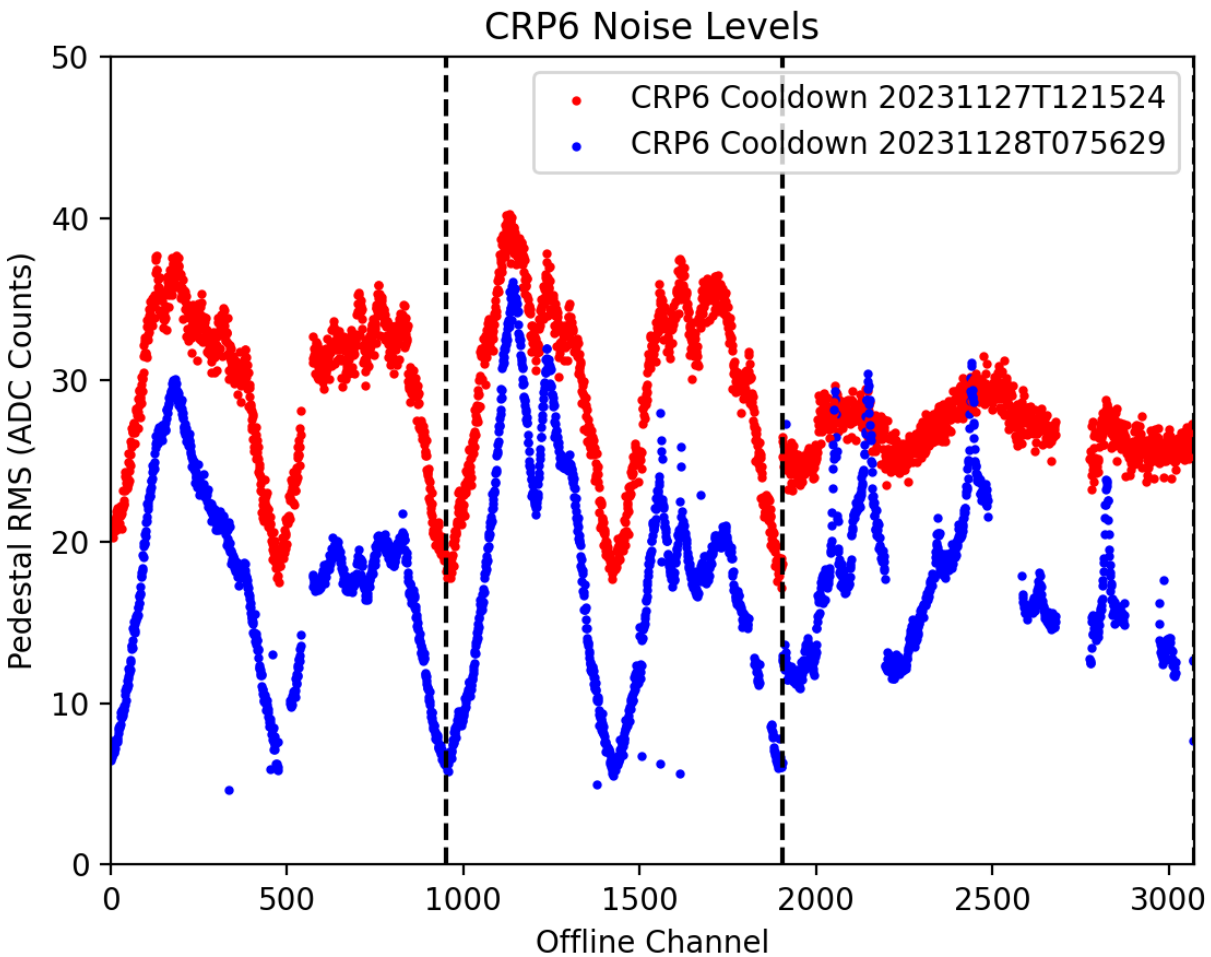

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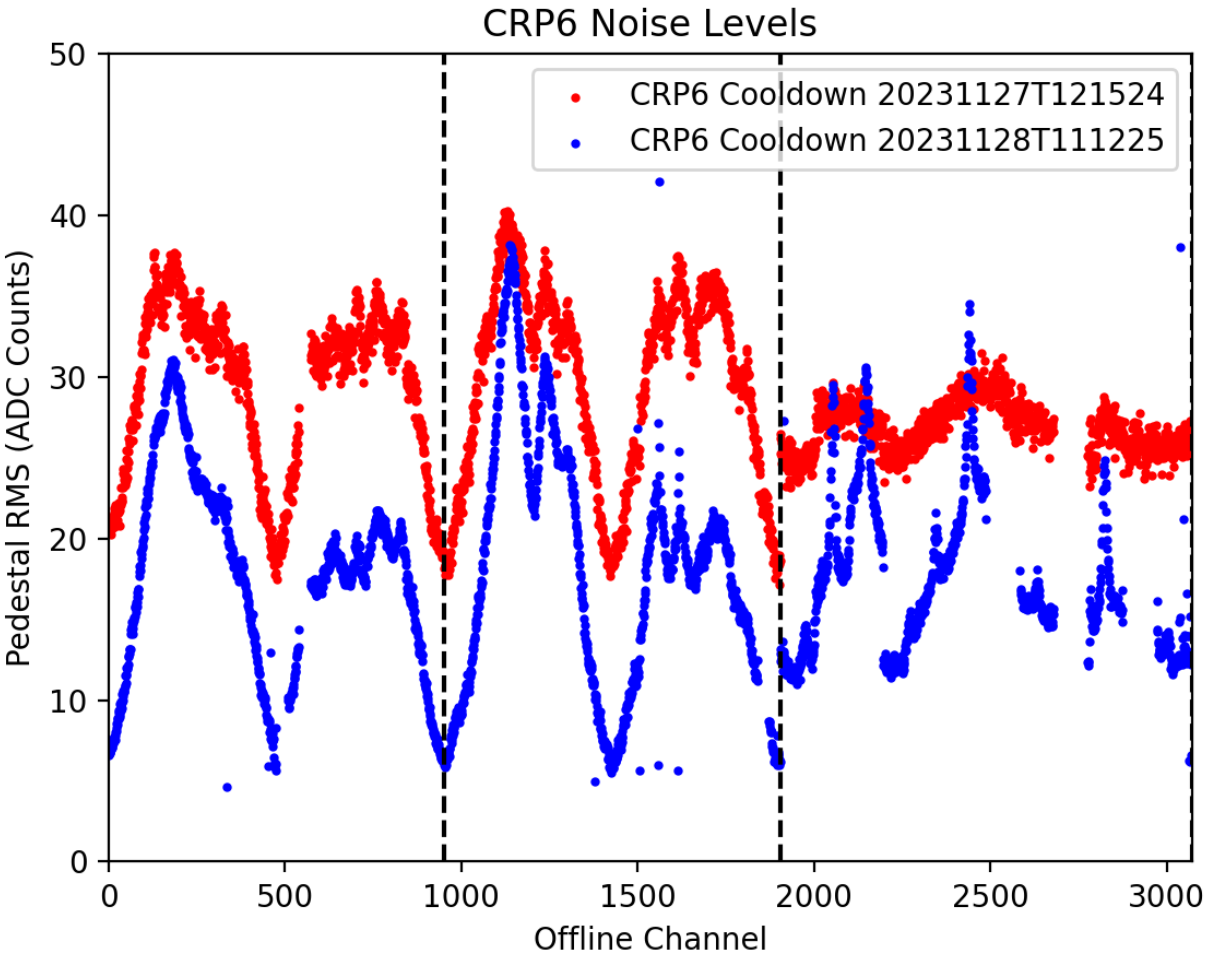
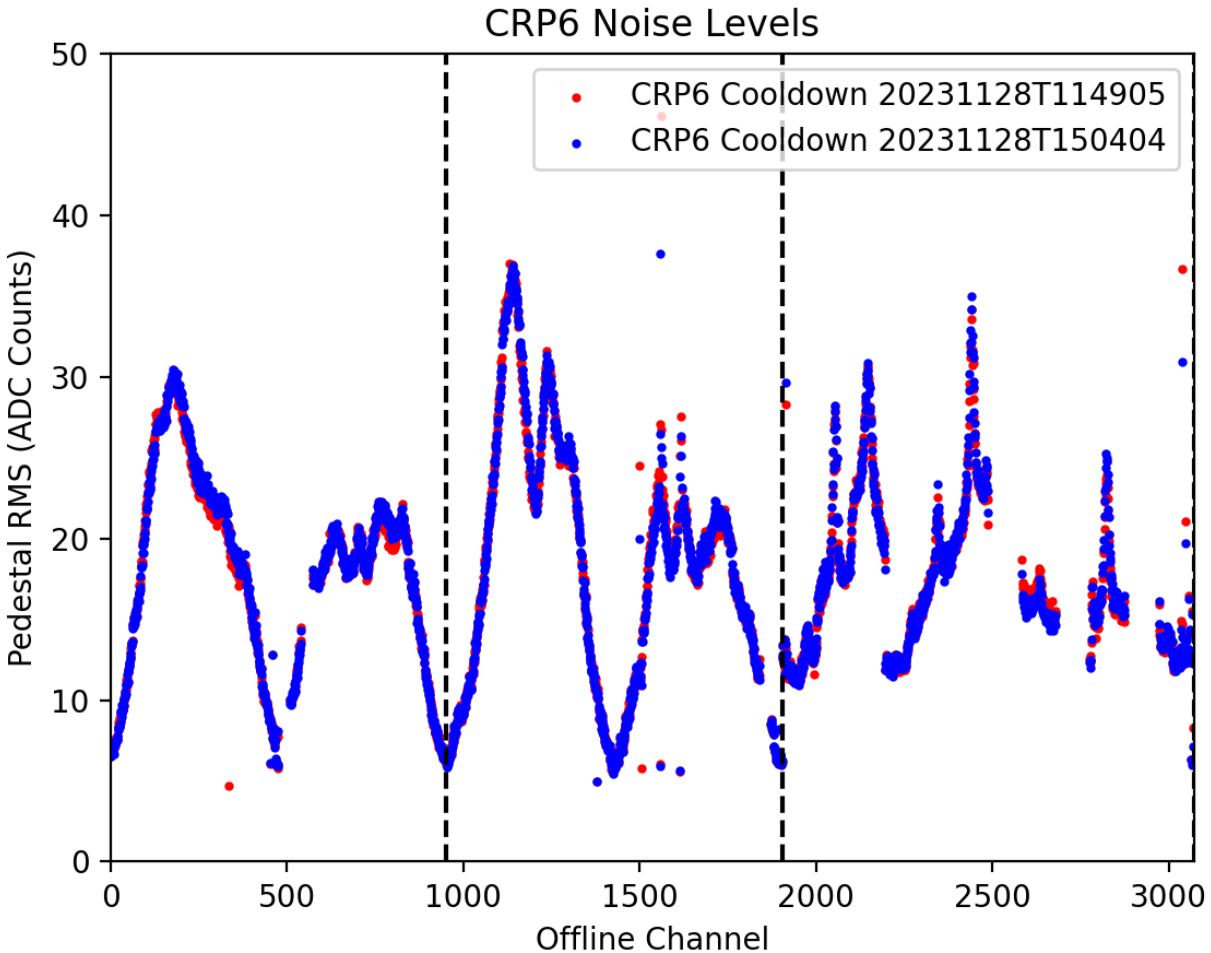


CRP6 noise before and after several tweaks of grounding on top of ColdBox (see next slide)

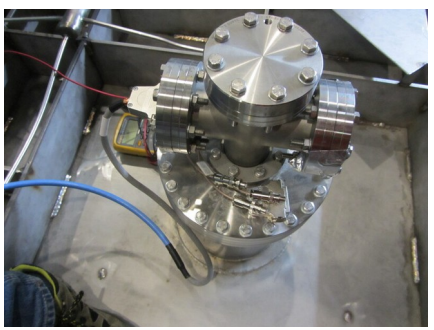


… not much difference

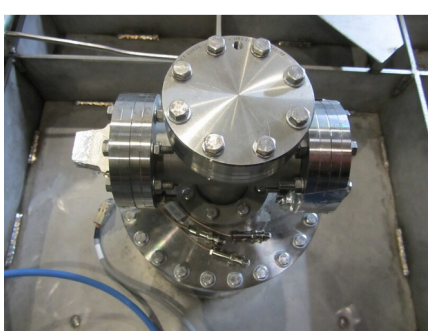
Changes made on the top of ColdBox to improve noise conditions (for the previous slide)

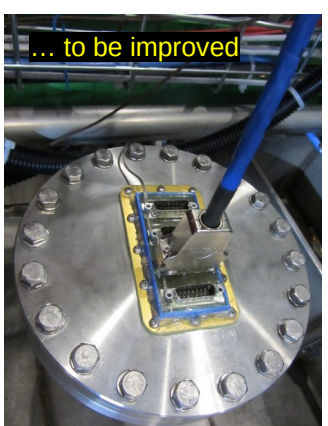
1) Heaters disconnected and related PTs; flange covered.
2) Disconnected CRP metallic frame temperature probes at the flange and terminated
3) Connected Cathode HV cable at the Power Supply
4) Sealed remaining gaps around the lid with Al foil
5) Tightened ground plugs on camera flange.

before

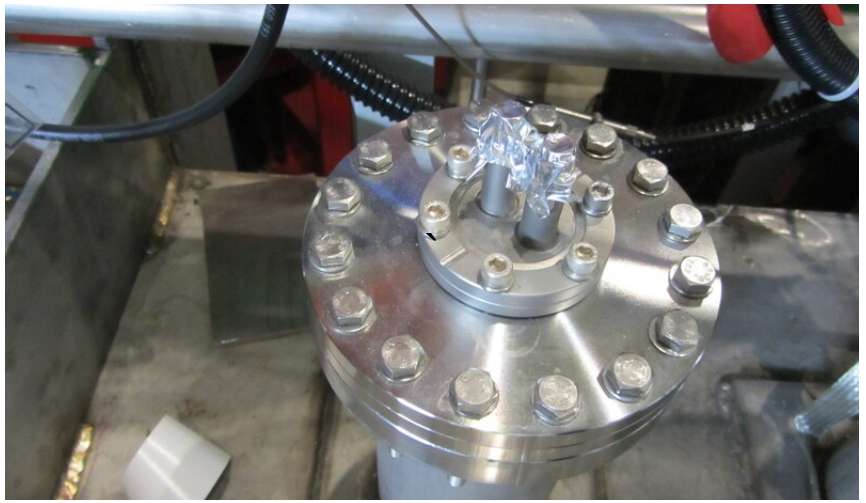


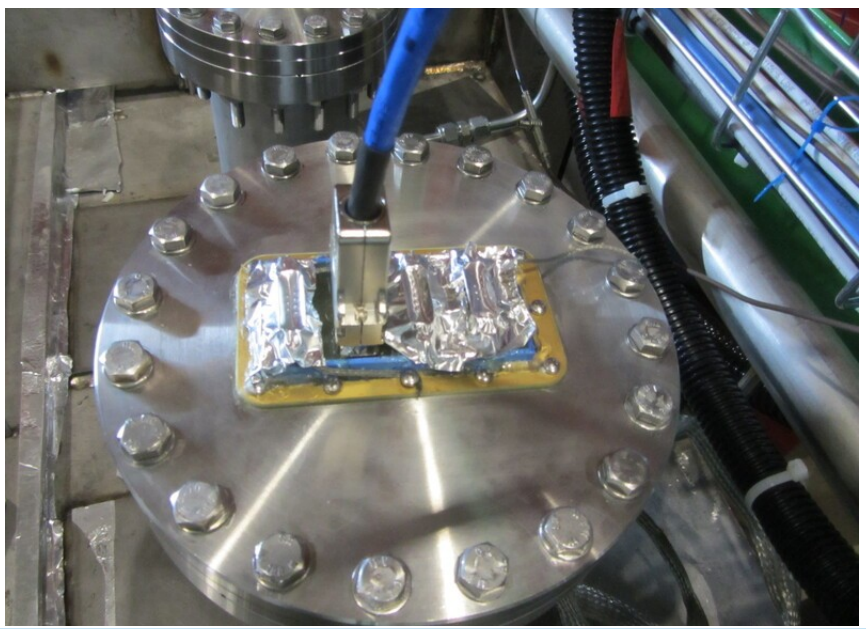
after



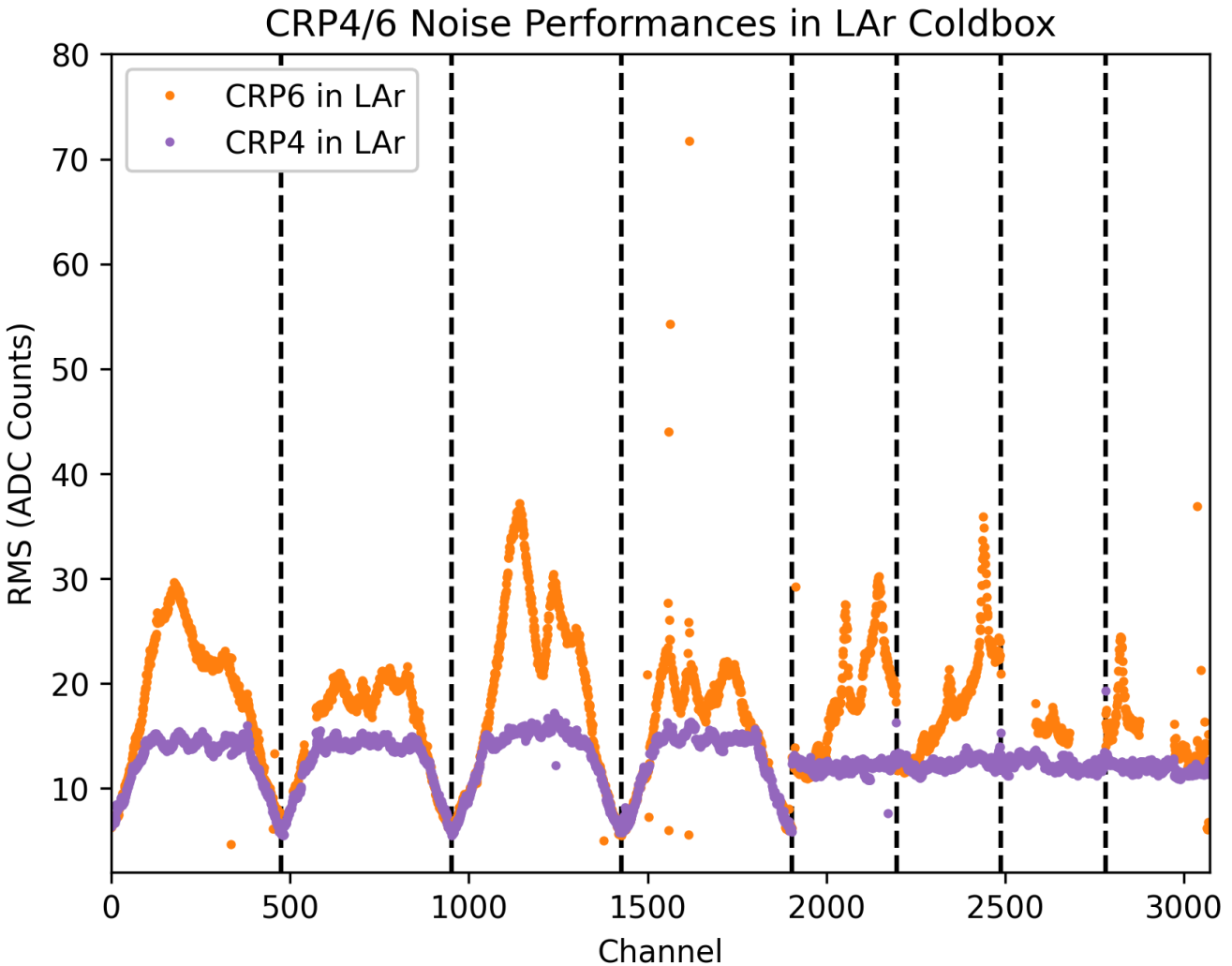


Additional changes made later on, no noticeable change in noise level.



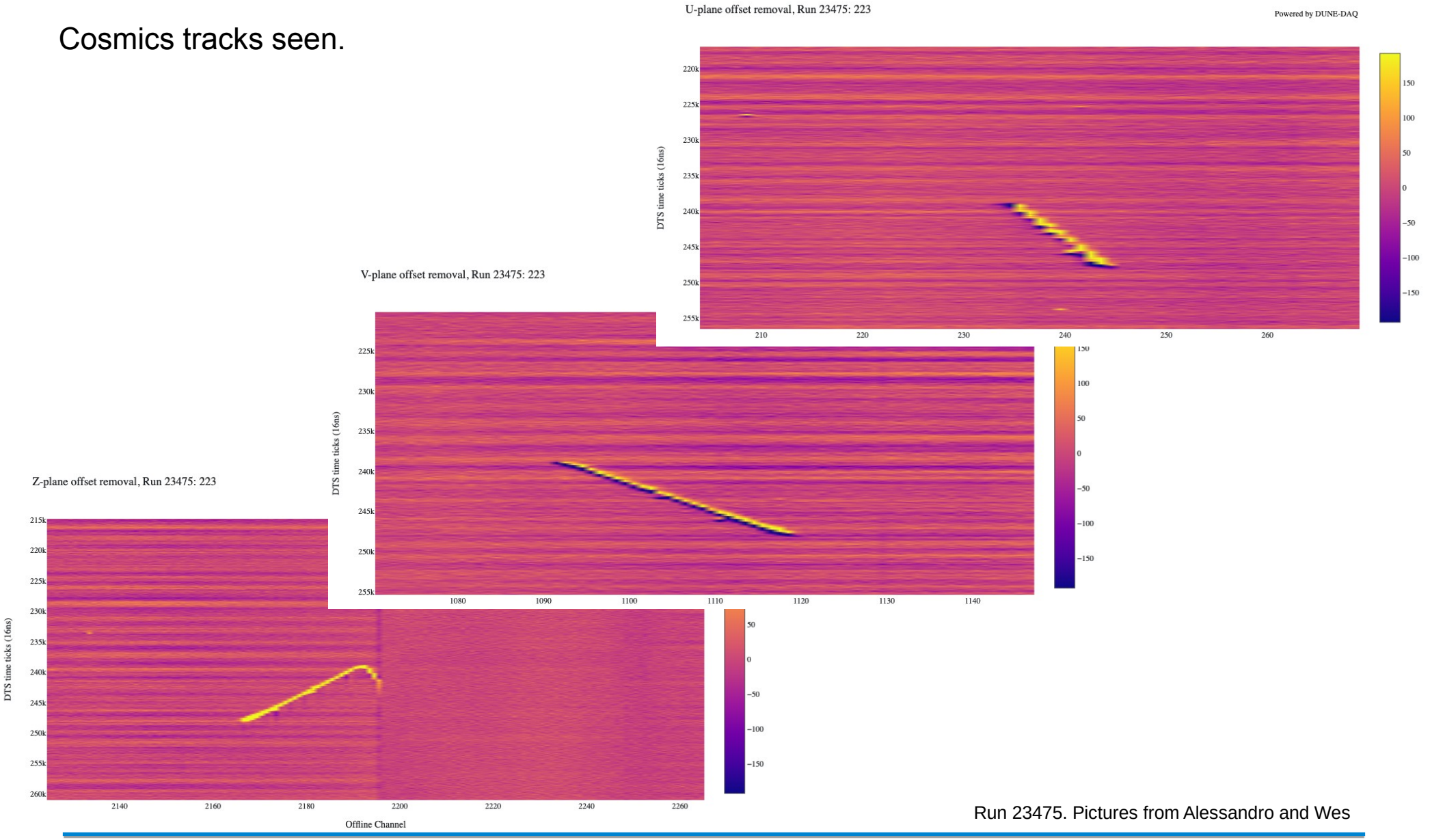


Comparison with CRP4



From Roger

Cosmics tracks seen.



Run 23475. Pictures from Alessandro and Wes

Issues with FEMB 10

i2c_write_verify failed FEMB:2 COLDATA:0 chip:0x2 page:0x0 reg:0x03 :: 0x3C != 0xFF
read is 0xFF
complimentary read is 0x00
i2c_write_verify failed FEMB:2 COLDATA:0 chip:0x2 page:0x0 reg:0x11 :: 0x07 != 0xFF
read is 0xFF
complimentary read is 0x00
i2c_write_verify failed FEMB:2 COLDATA:0 chip:0x2 page:0x0 reg:0x20 :: 0x05 != 0xFF
read is 0xFF
complimentary read is 0x00
i2c_write_verify failed FEMB:2 COLDATA:0 chip:0x2 page:0x0 reg:0x25 :: 0x40 != 0xFF
read is 0xFF
complimentary read is 0x00
i2c_write_verify failed FEMB:2 COLDATA:0 chip:0x2 page:0x0 reg:0x27 :: 0x1F != 0xFF
read is 0xFF

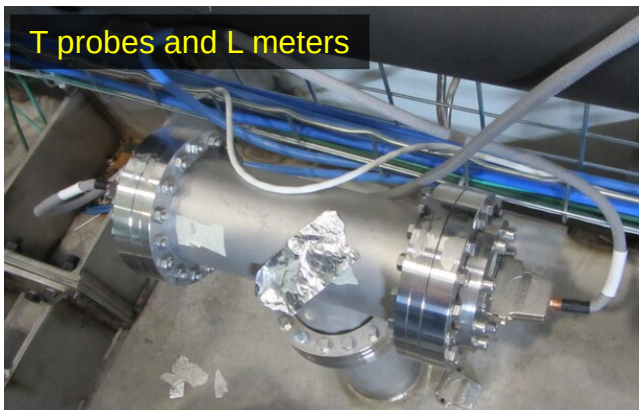
…

complimentary read is 0x00
i2c_write_verify failed FEMB:2 COLDATA:0 chip:0x3 page:0x0 reg:0x01 :: 0x01 != 0xFF
read is 0xFF
complimentary read is 0x00
i2c_write_verify failed FEMB:2 COLDATA:0 chip:0x3 page:0x0 reg:0x03 :: 0x3C != 0xFF
read is 0xFF

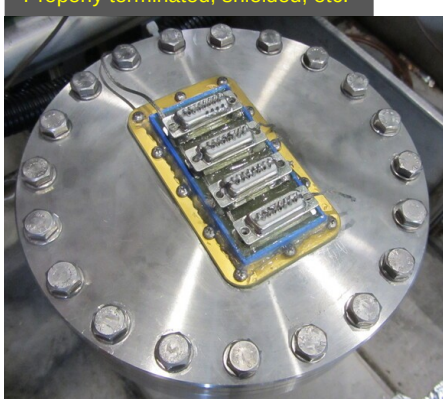
Run plan

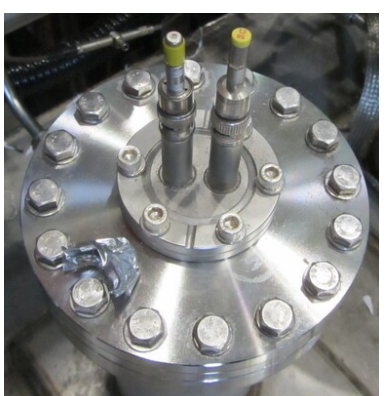
- Tonight (11/28 to 11/29): Cosmics run, 1Hz triggers
- We (11/30) + night: Regeneration will be turned ON; noise studies
  - Overnight noise studies by Roger
- Th (11/31) + night: DAQ software cosmics triggers development and data taking
  - Overnight DAQ cosmics runs
- Fri (12/01) – Photon Detector work
- Sa (12/02) – TBD
- Su (12/03) – TBD

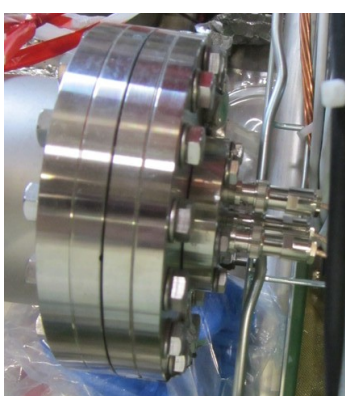
- Cryogenic level meters and temperature probes disconnected (and connectors properly terminated); the O2 meter turned off.



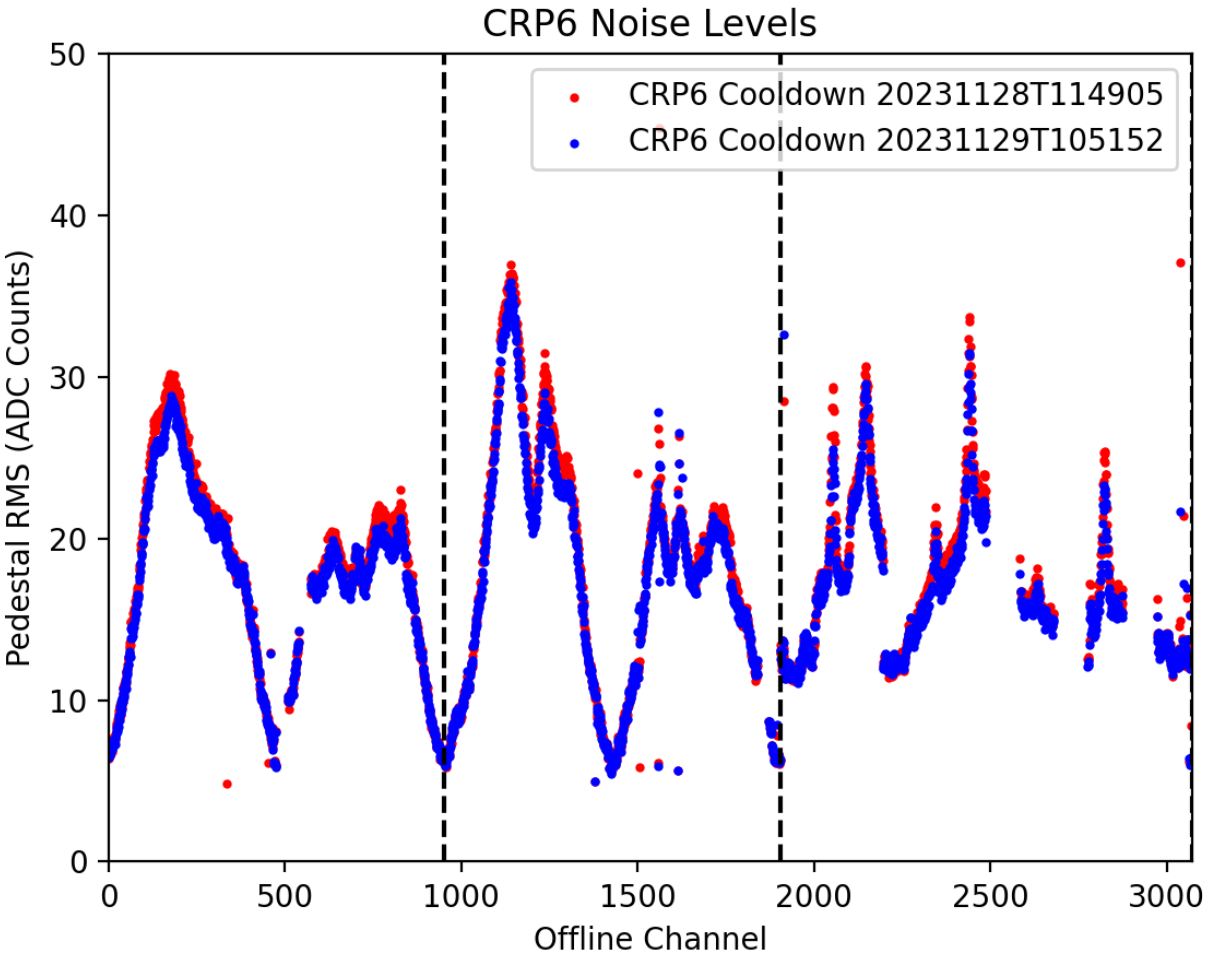
Properly terminated, shielded, etc.



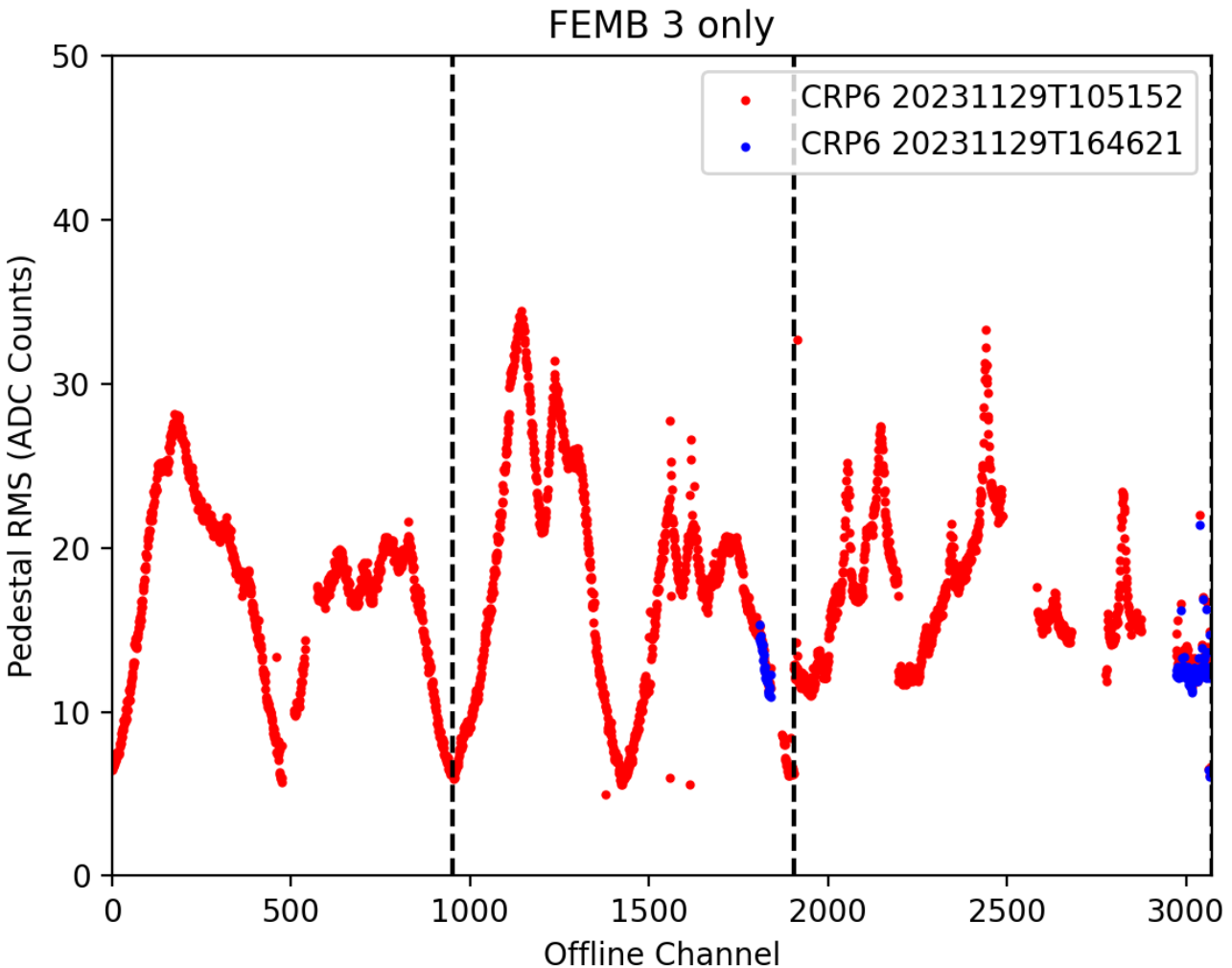




… noticeable but small effect



One FEMB powered ON at a time



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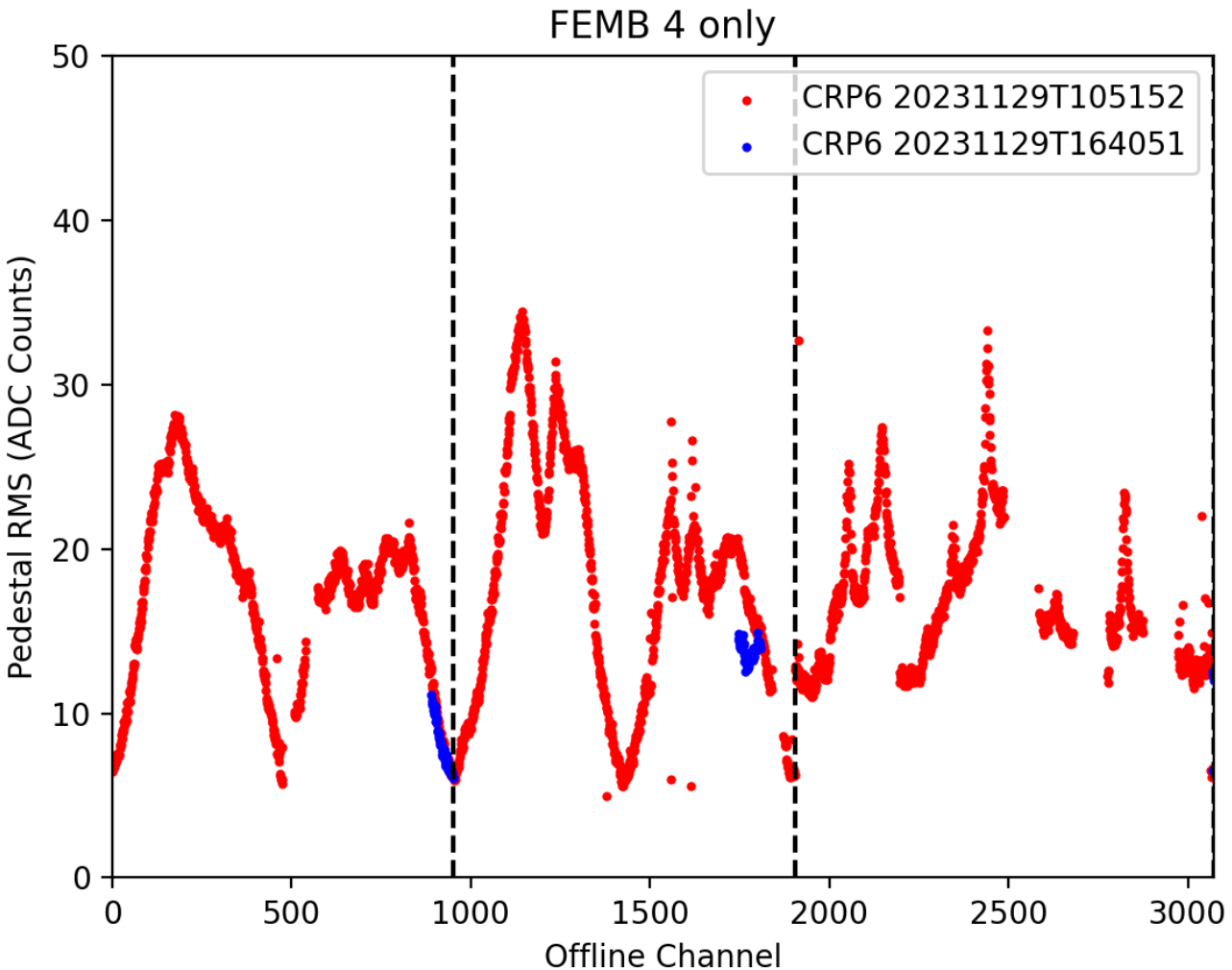

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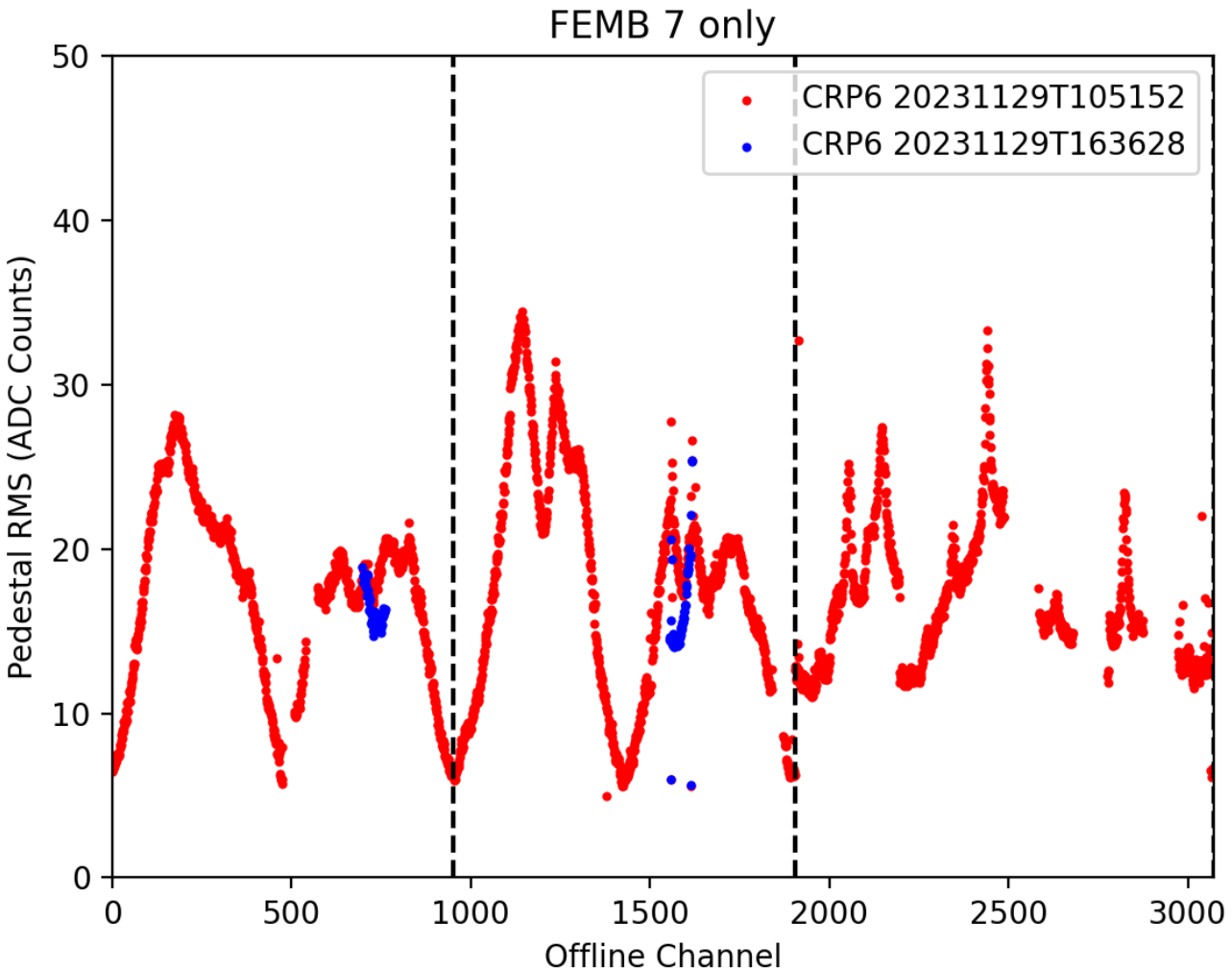

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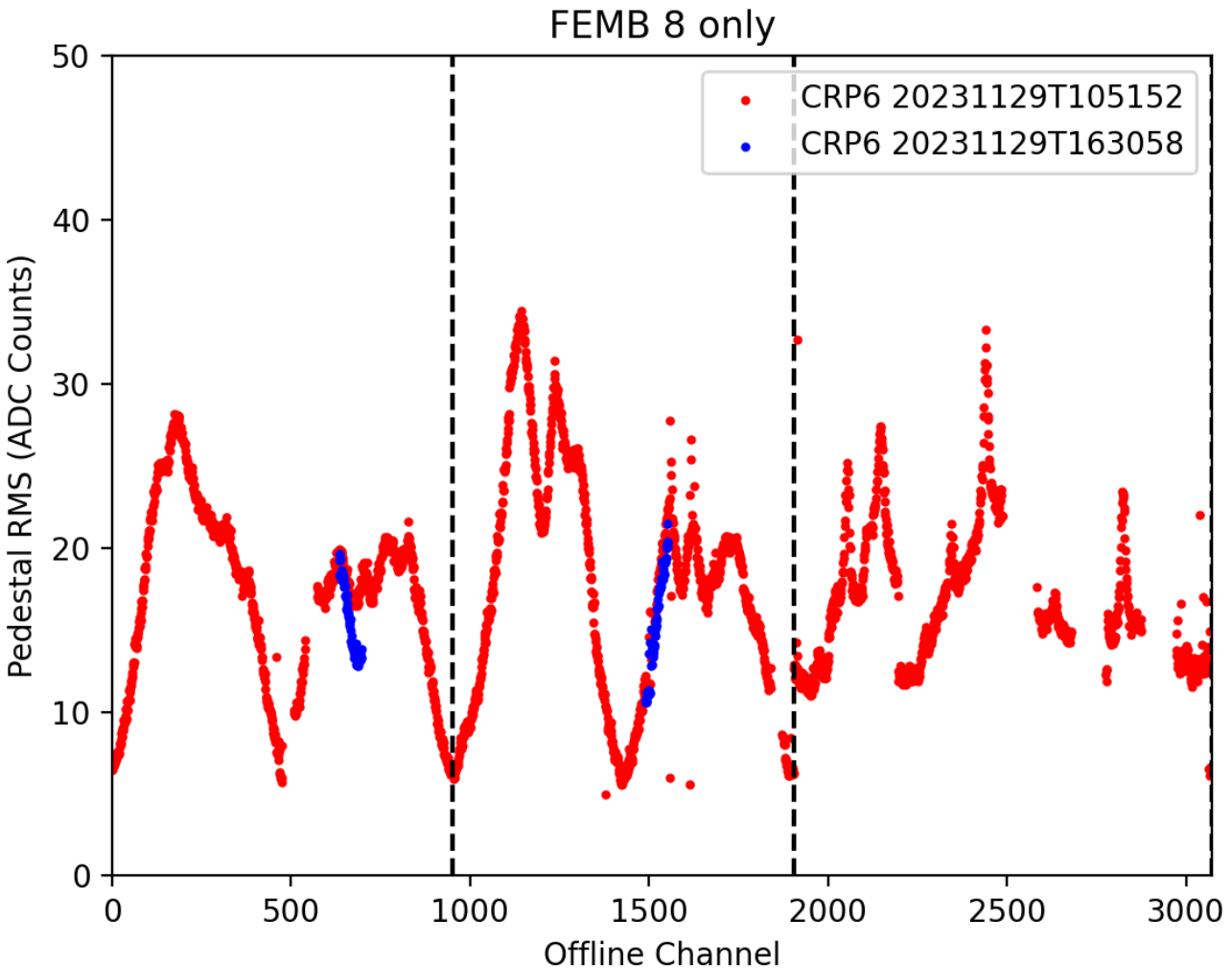

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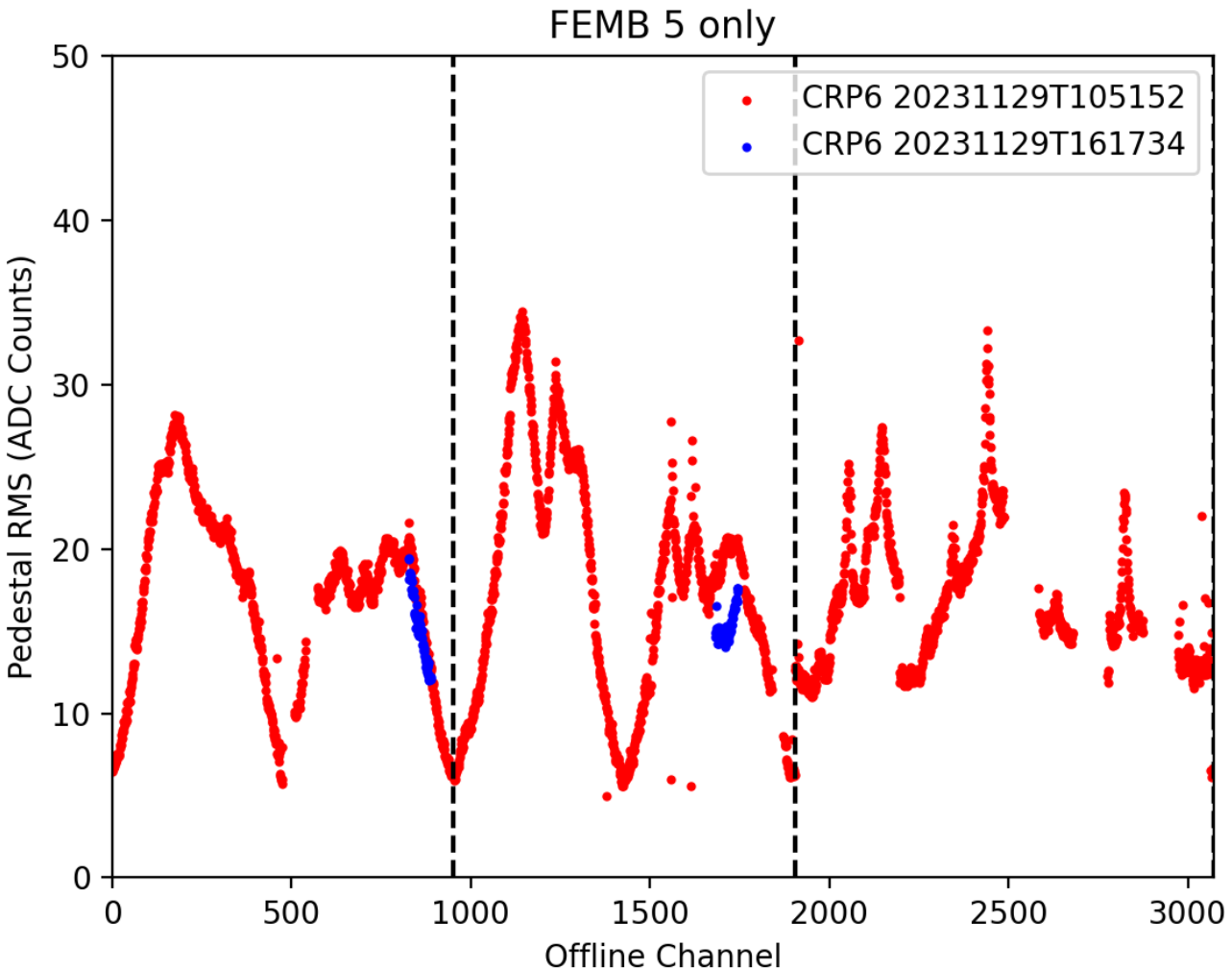

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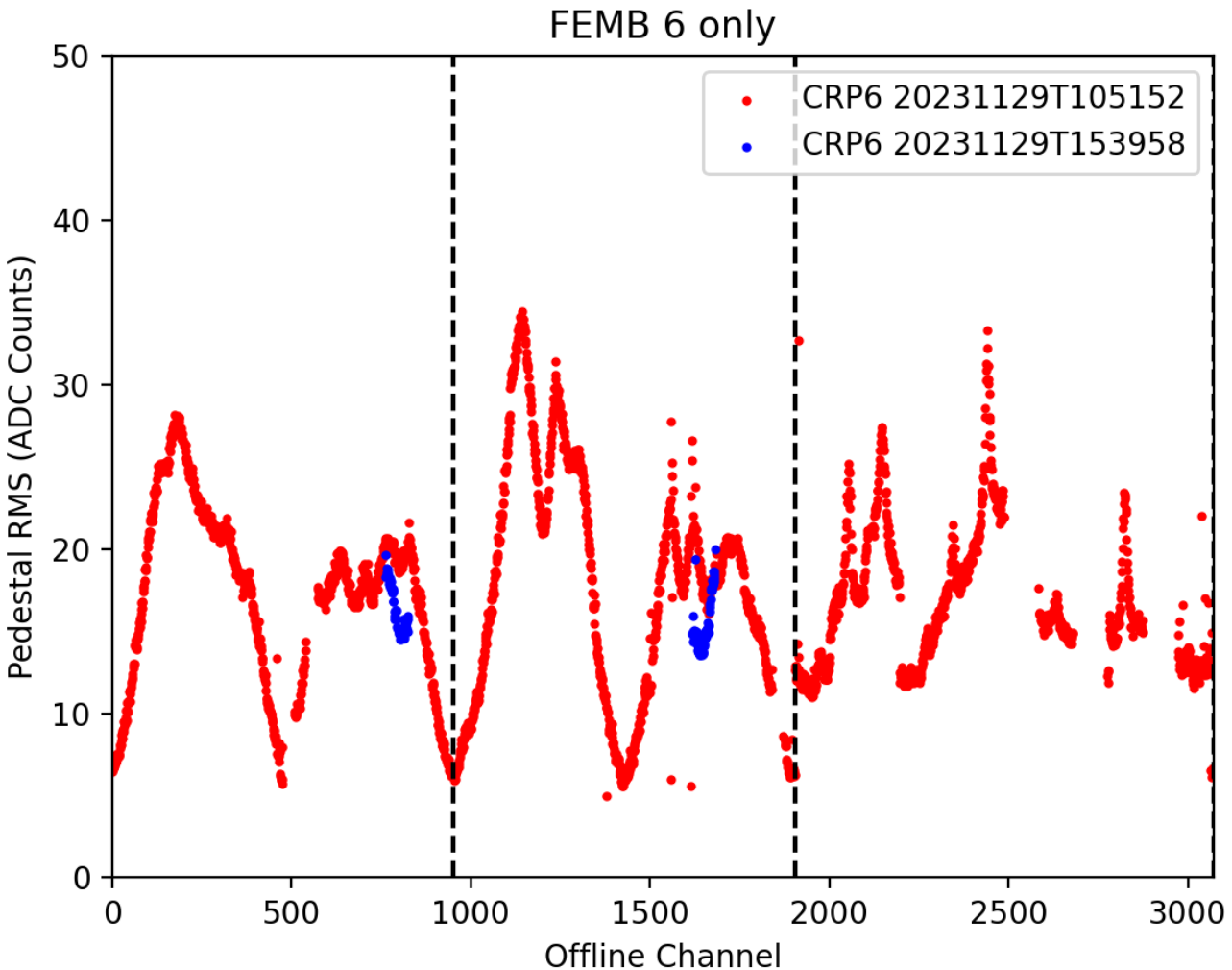
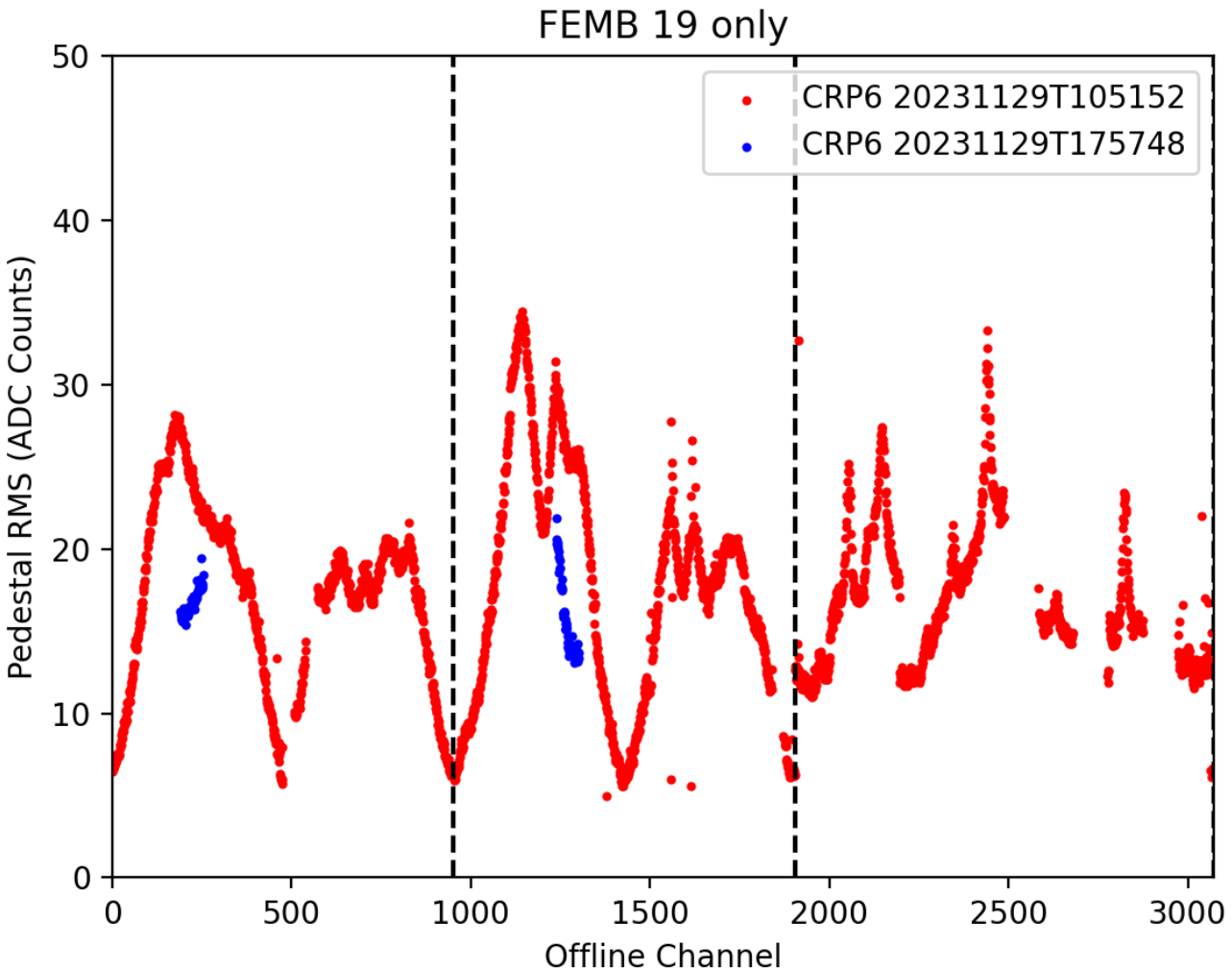


One FEMB powered ON at a time



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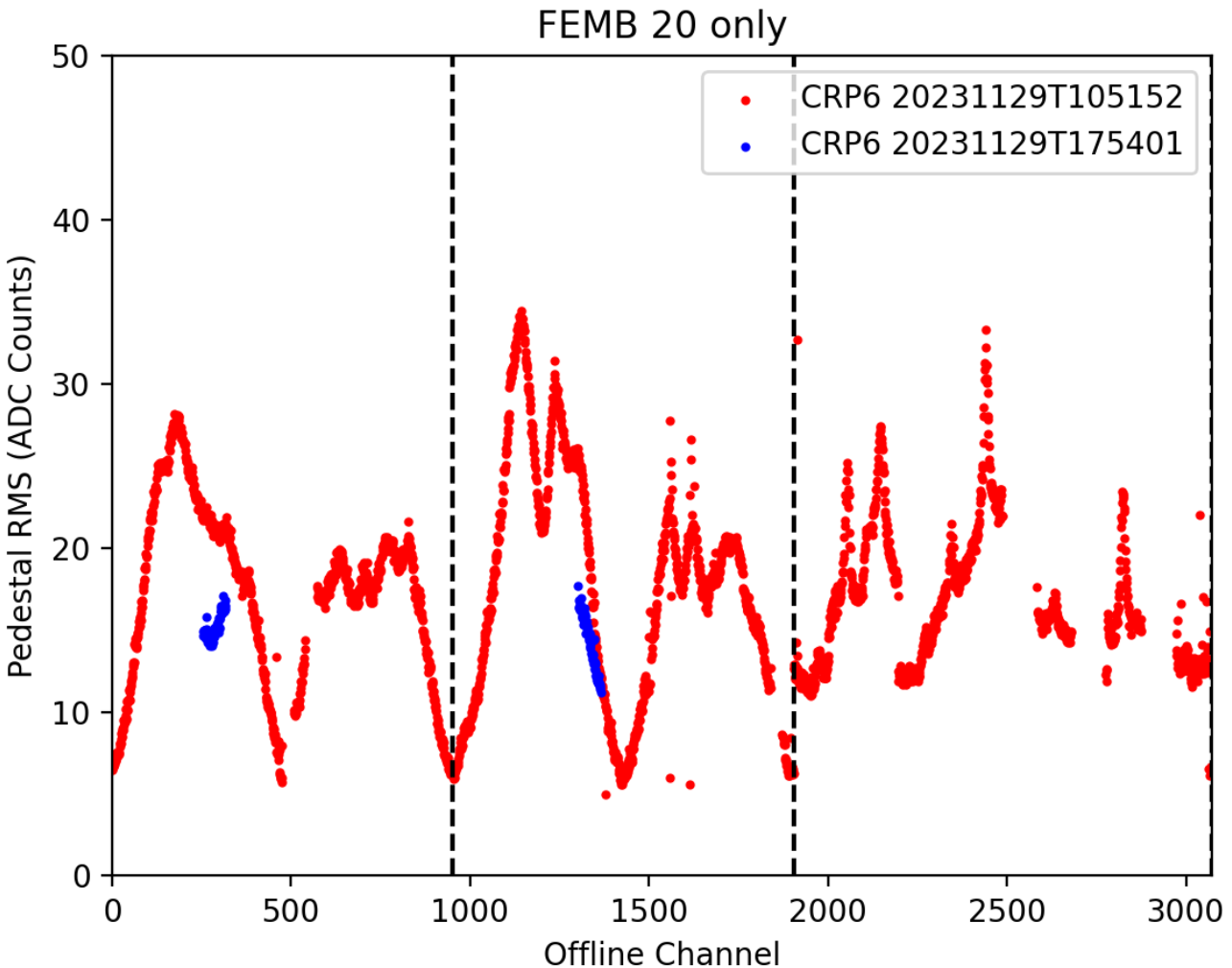

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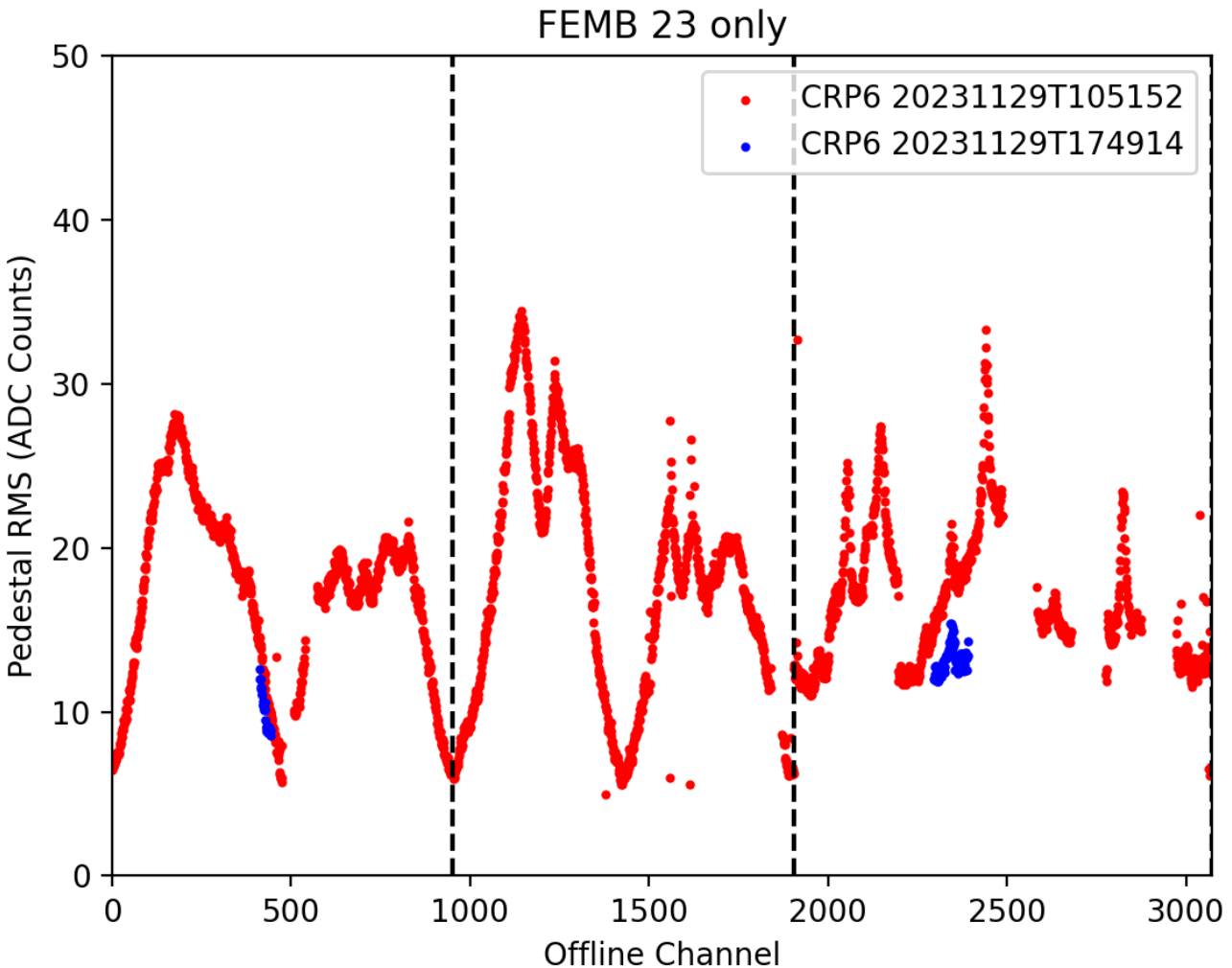

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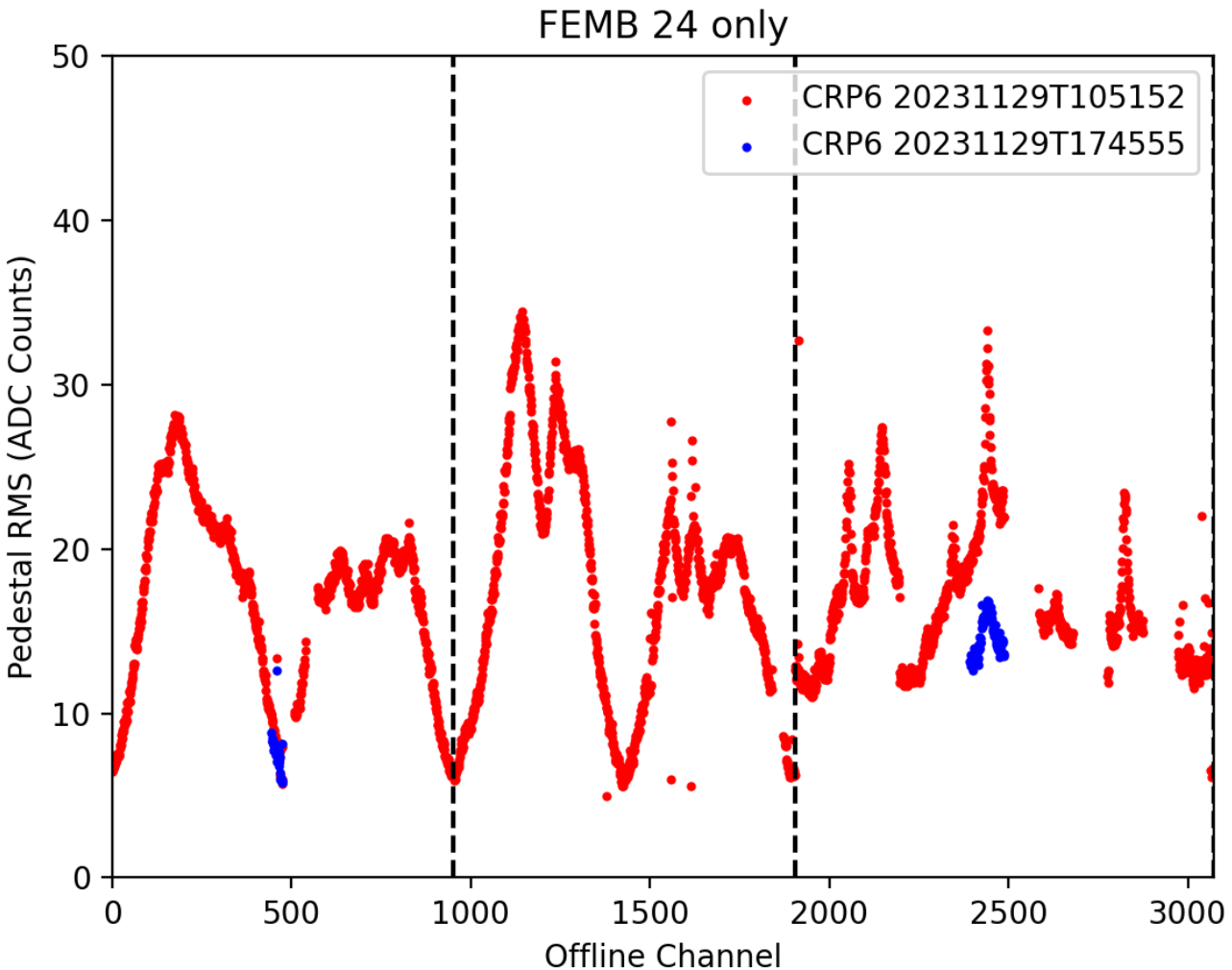

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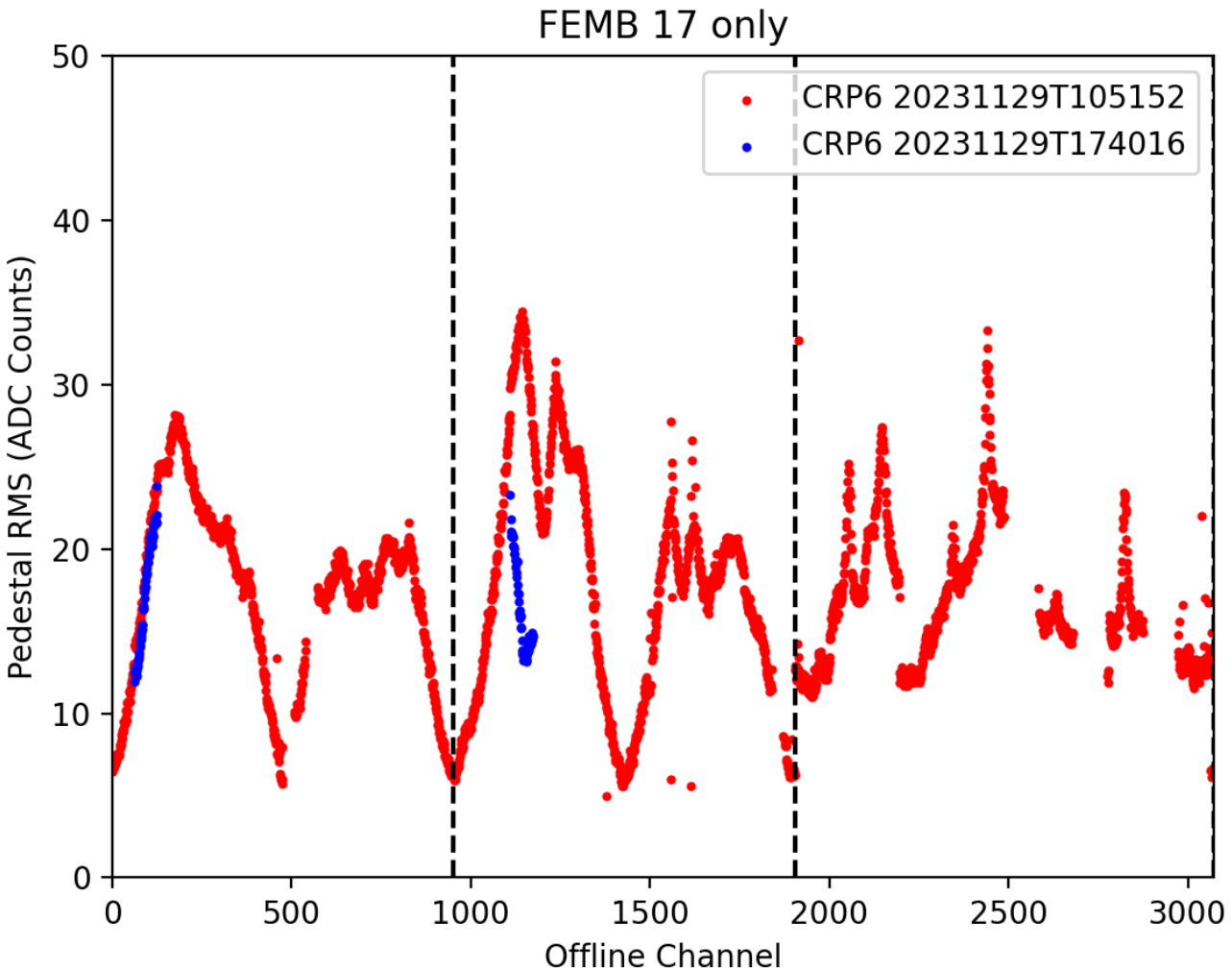

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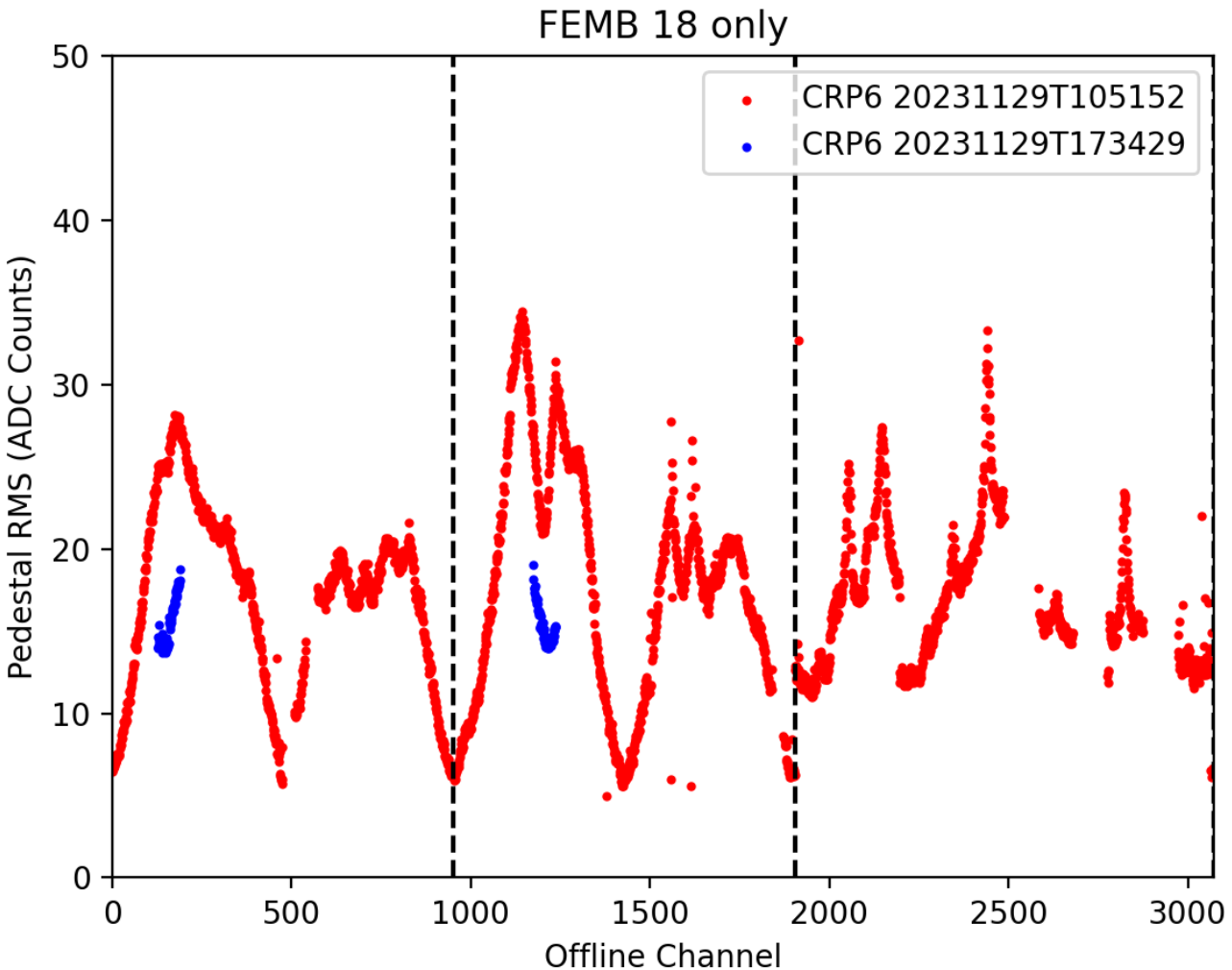
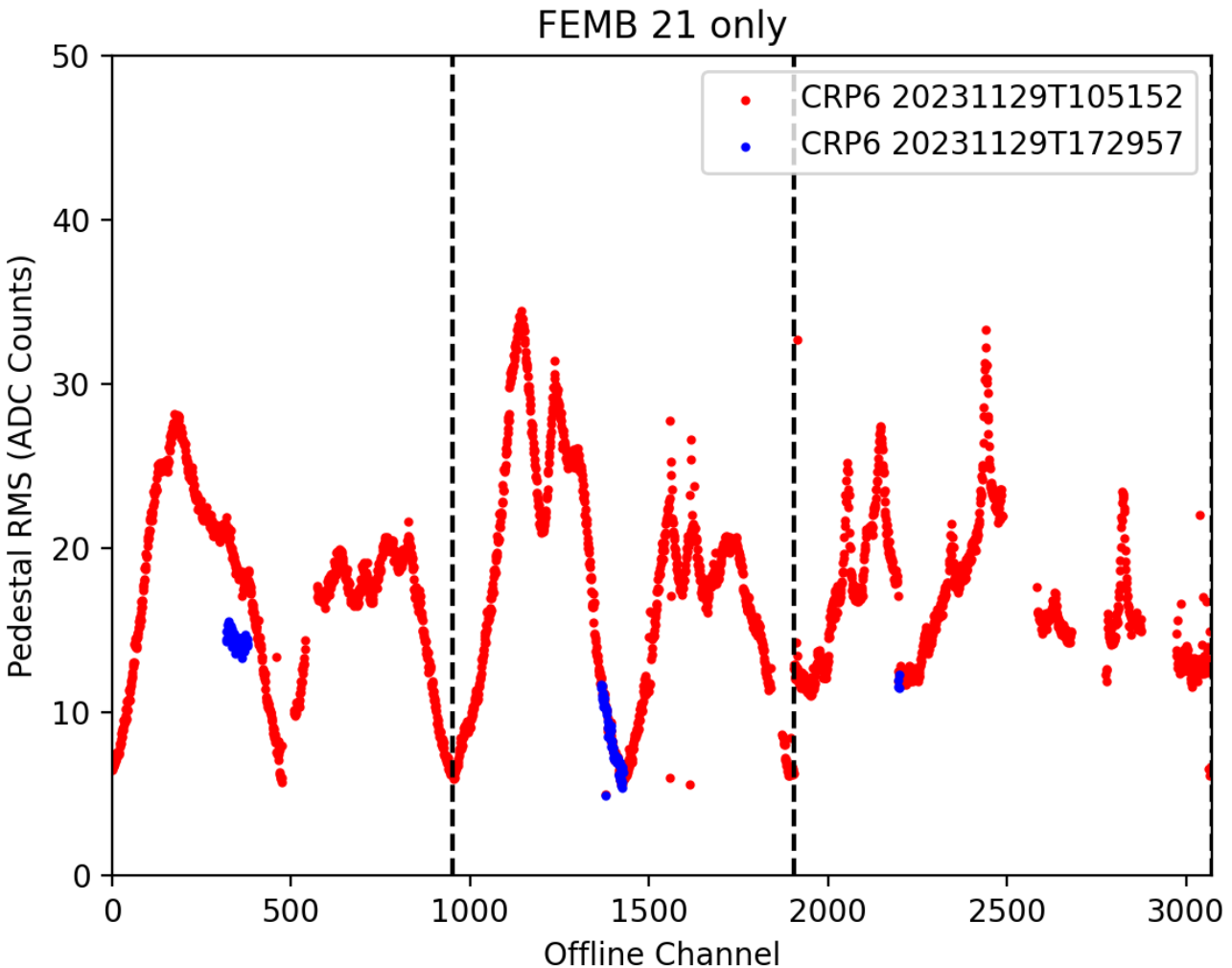
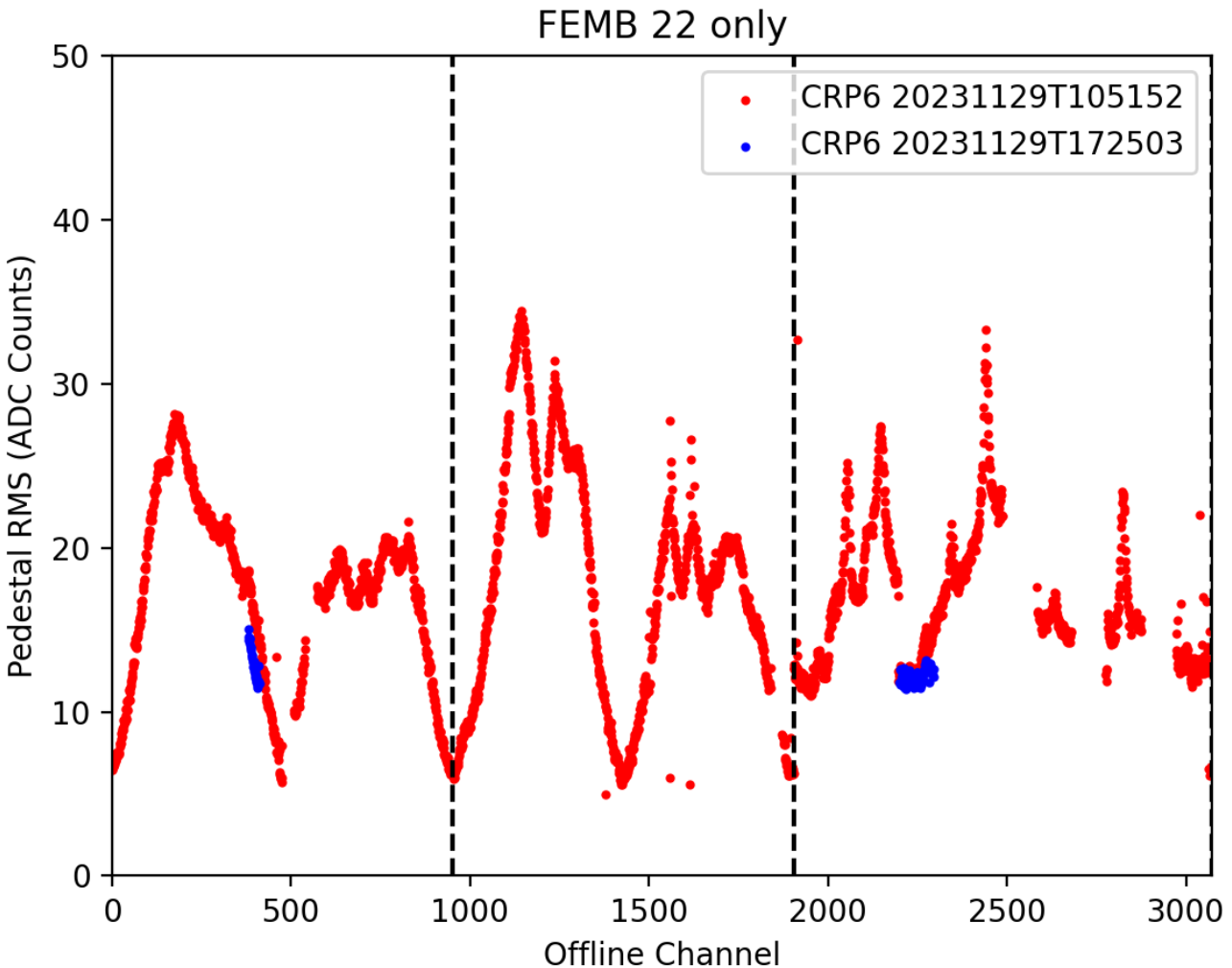


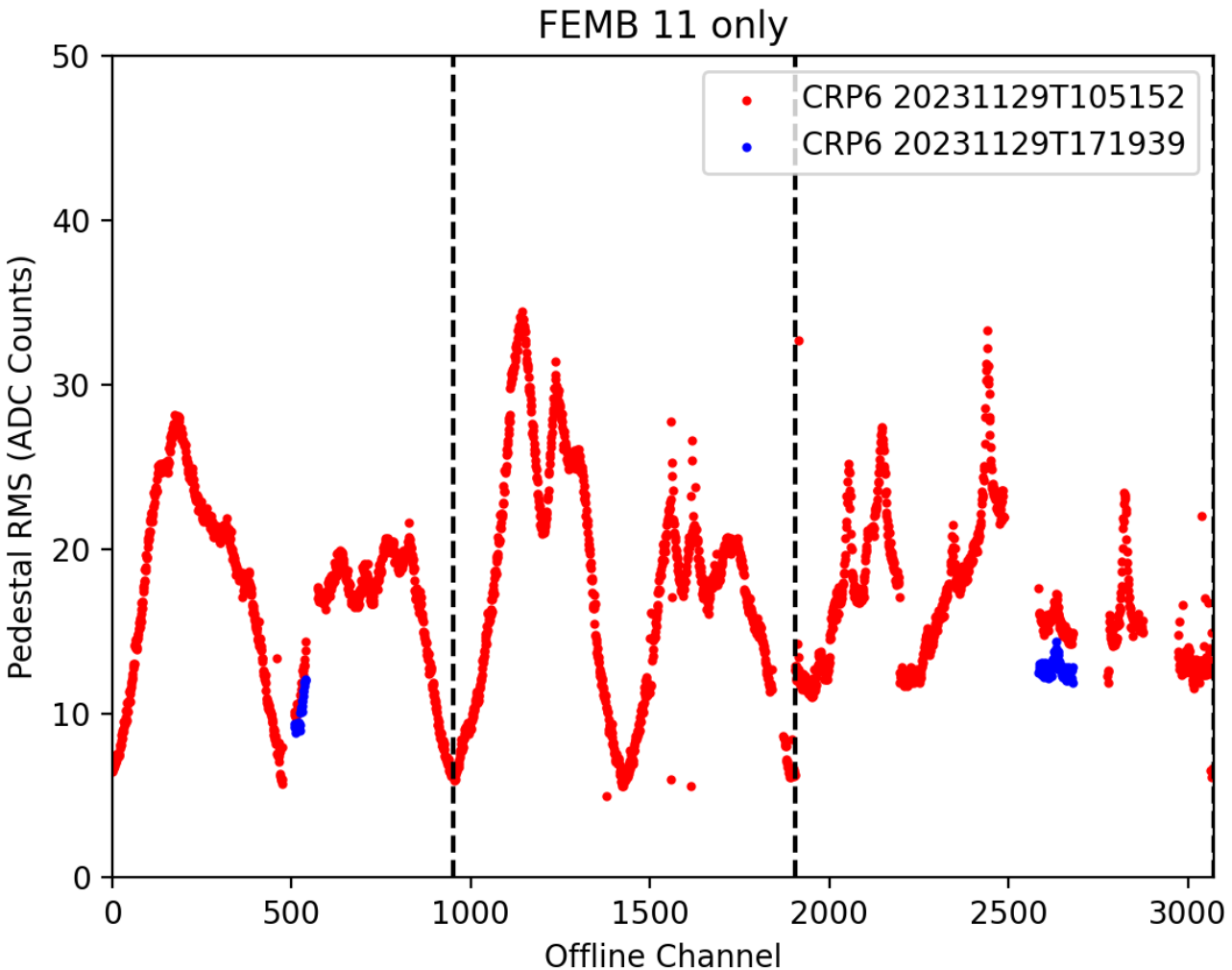
One FEMB powered ON at a time



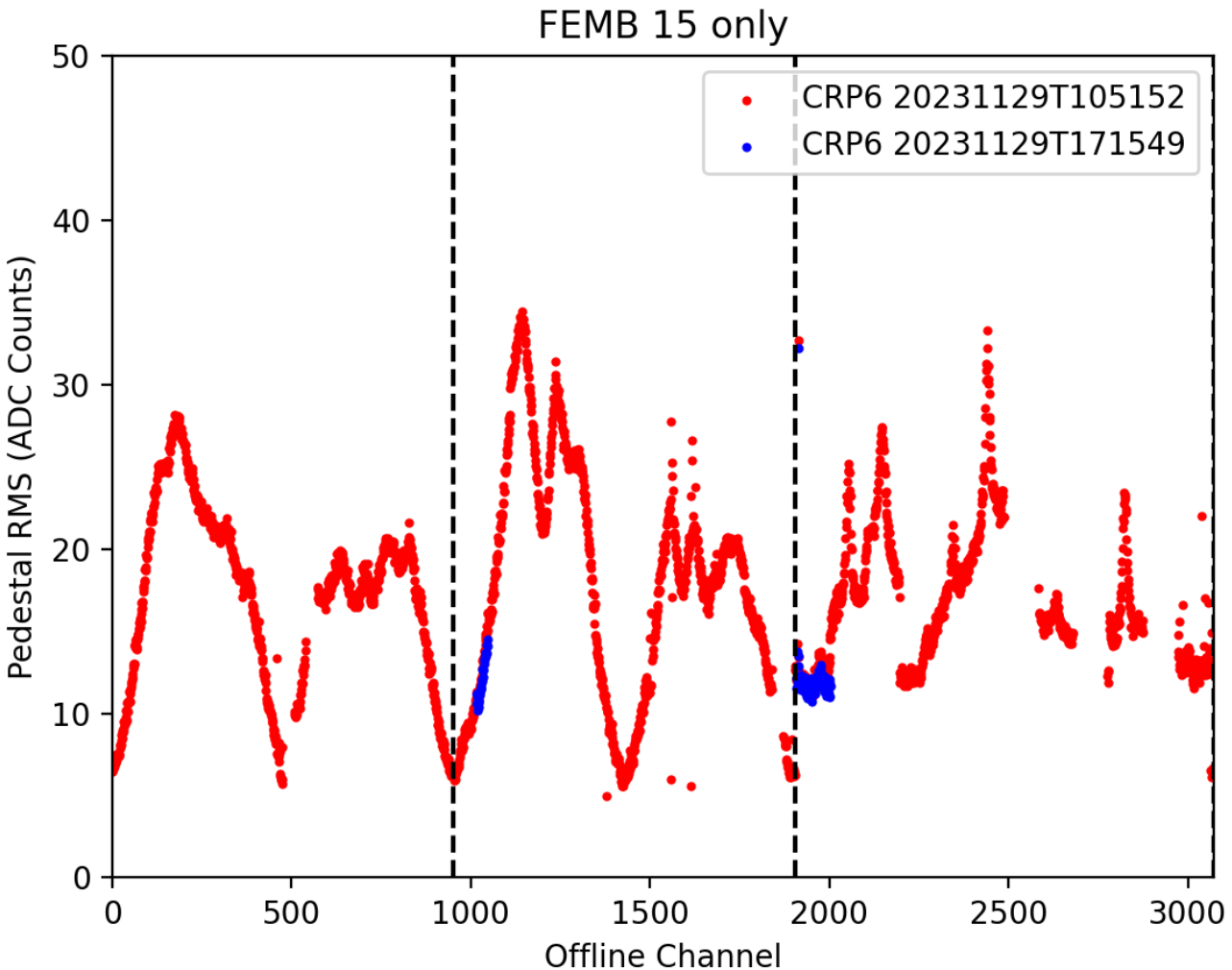
One FEMB powered ON at a time



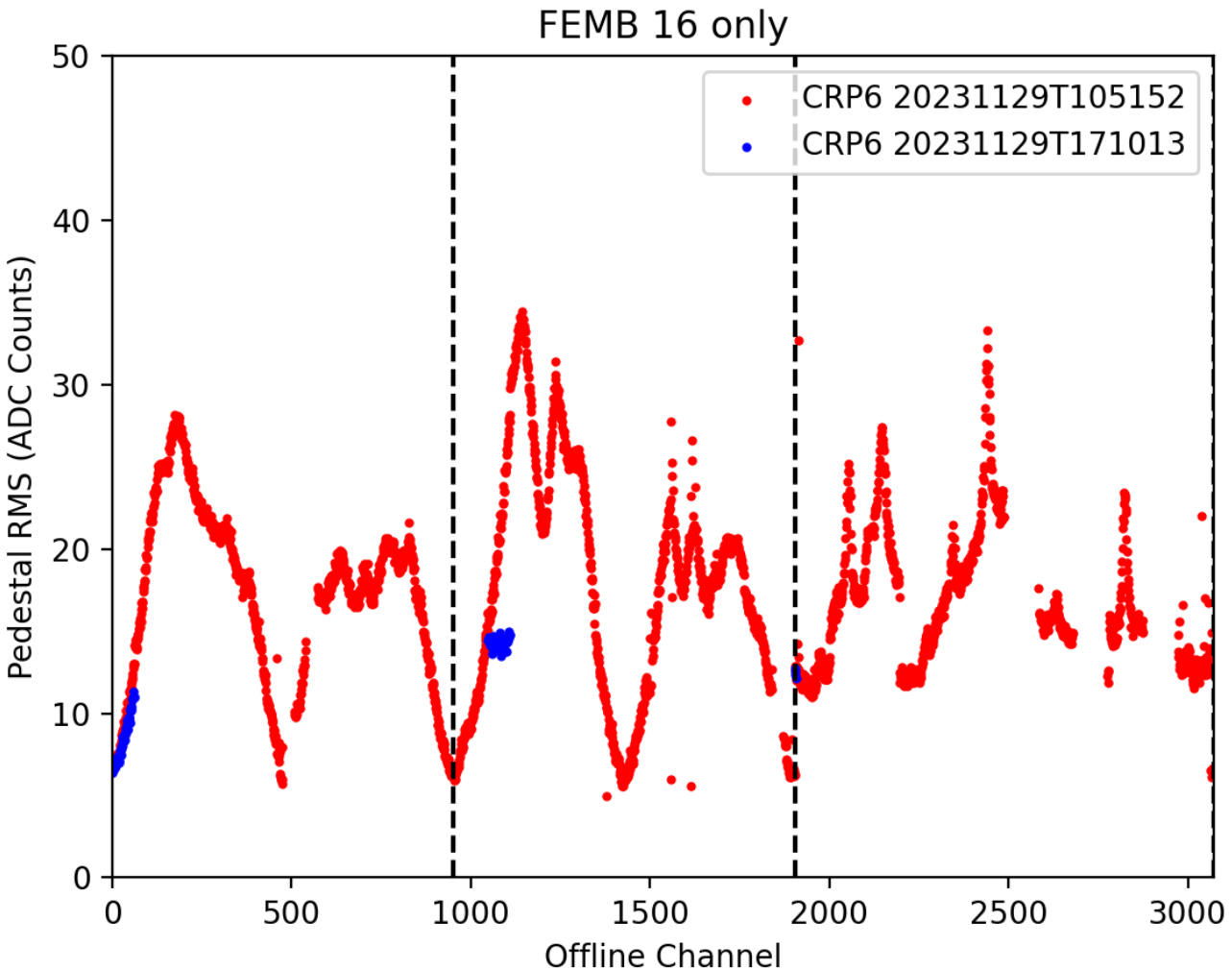
One FEMB powered ON at a time



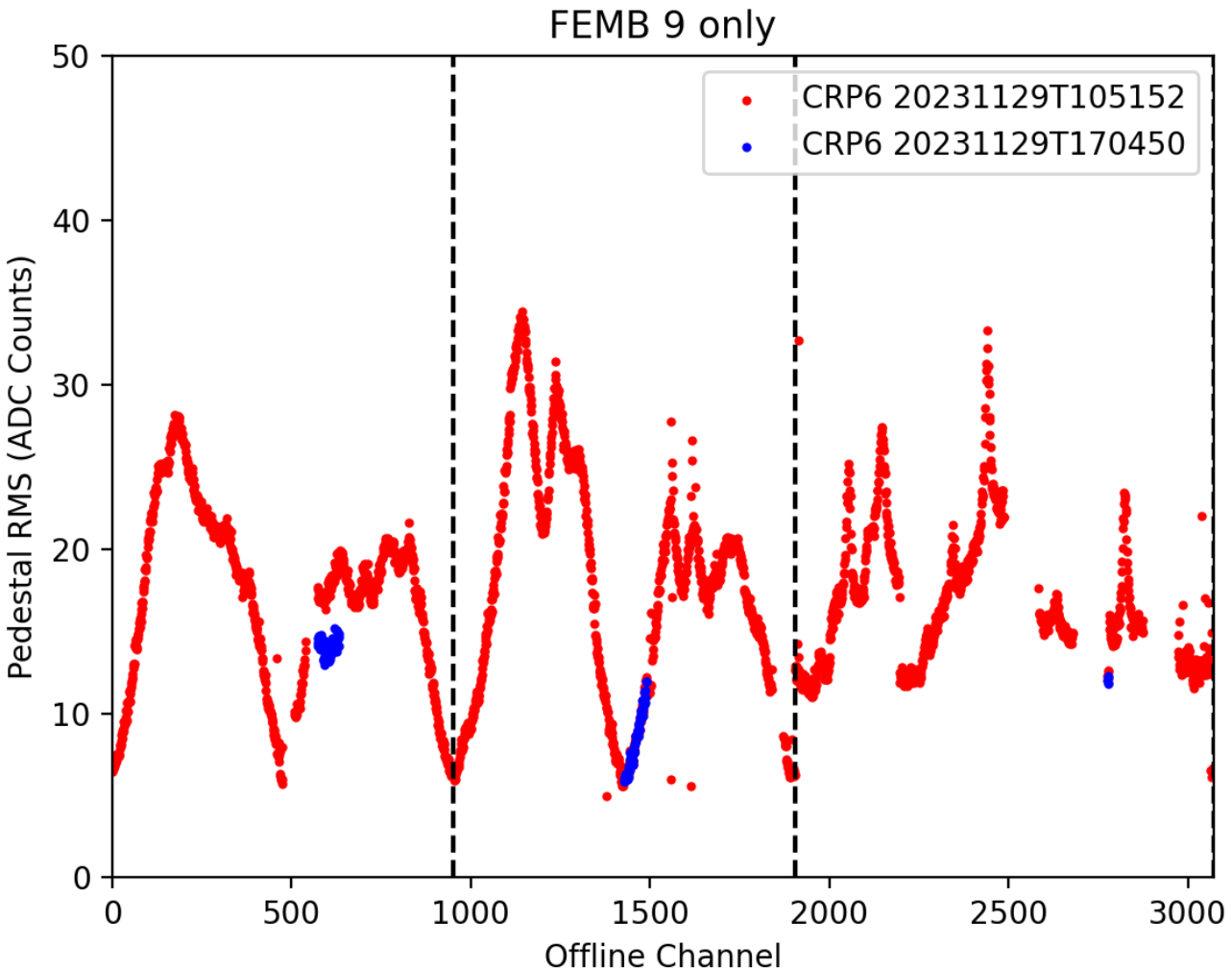
One FEMB powered ON at a time



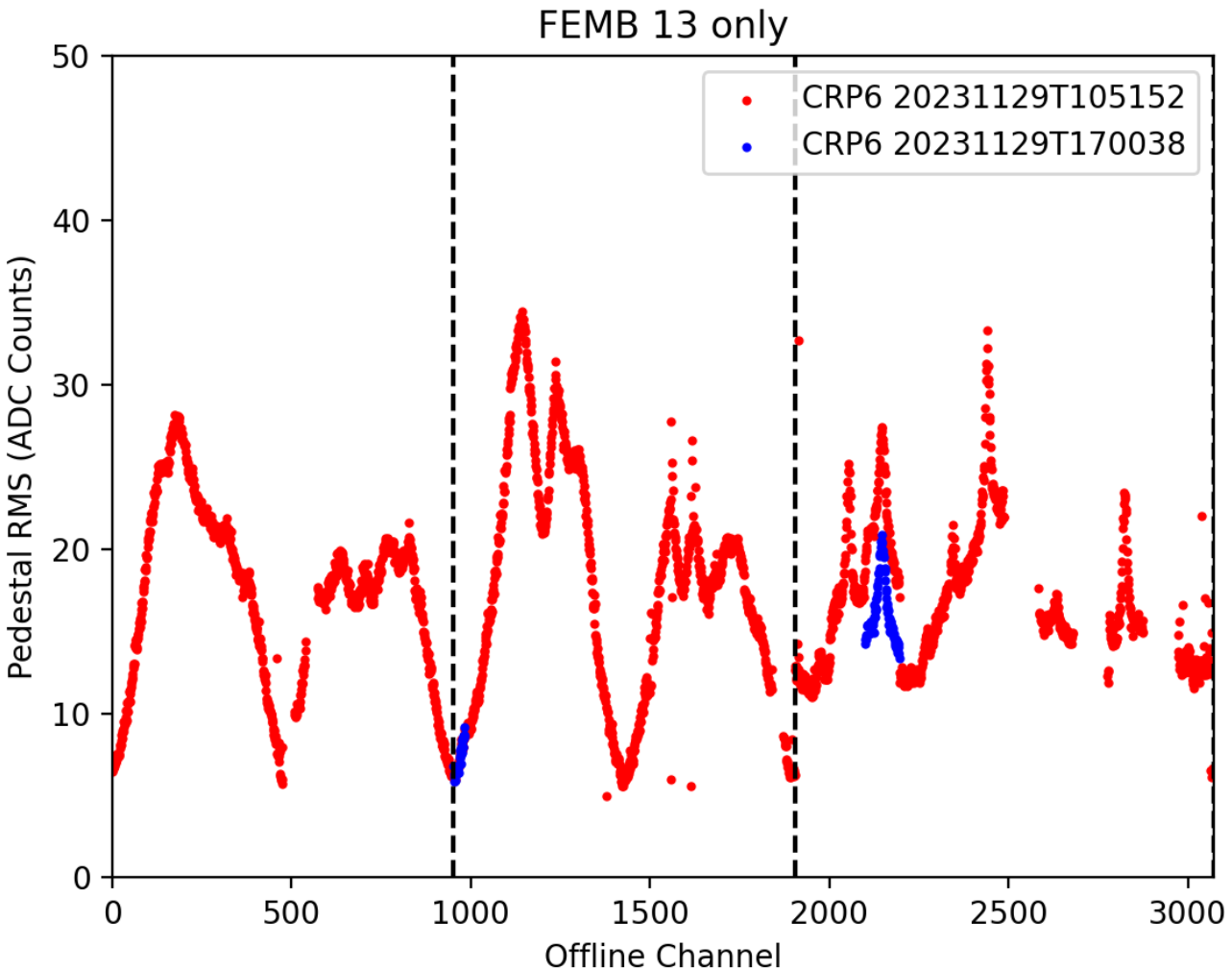
One FEMB powered ON at a time



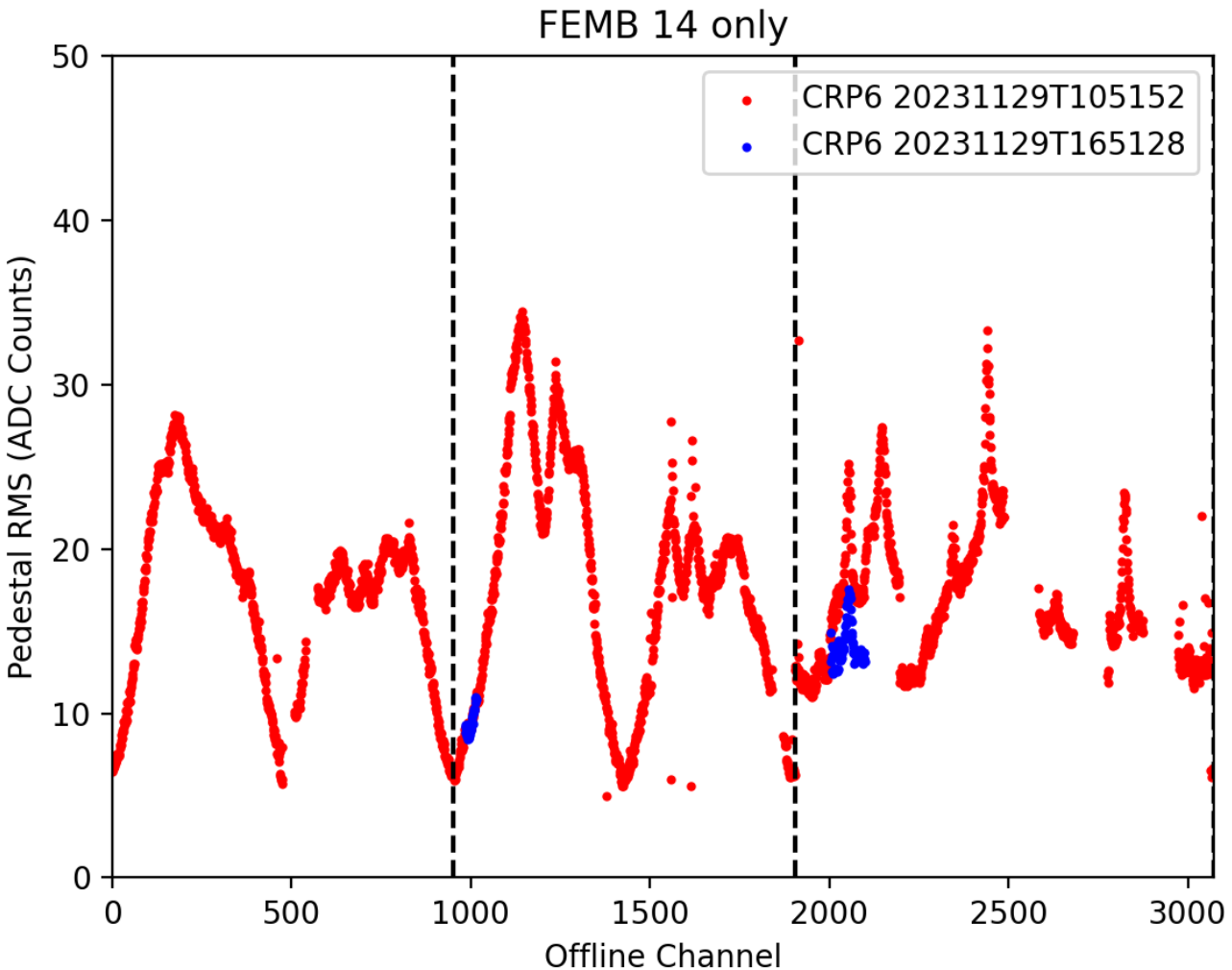
One FEMB powered ON at a time



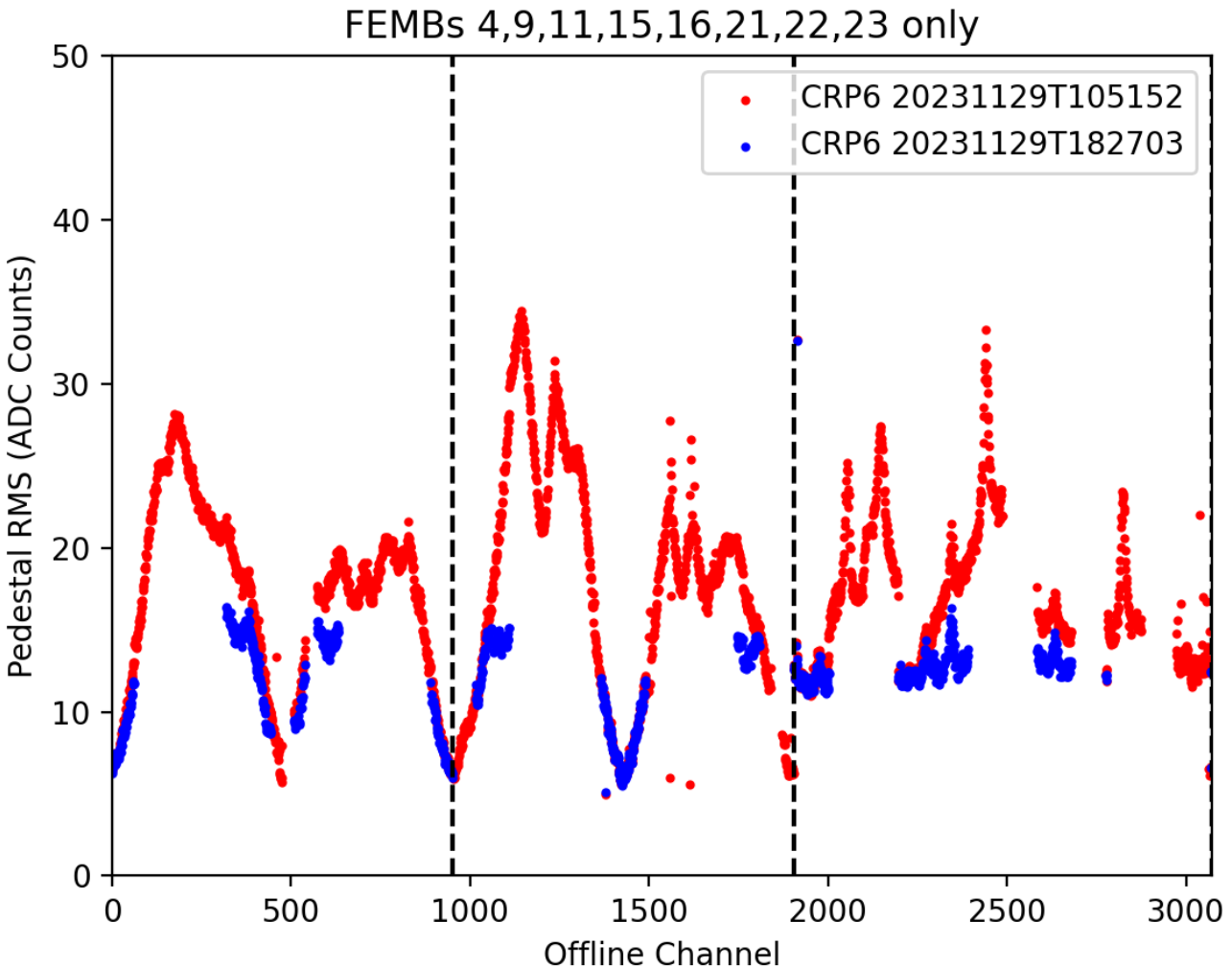
One FEMB powered ON at a time



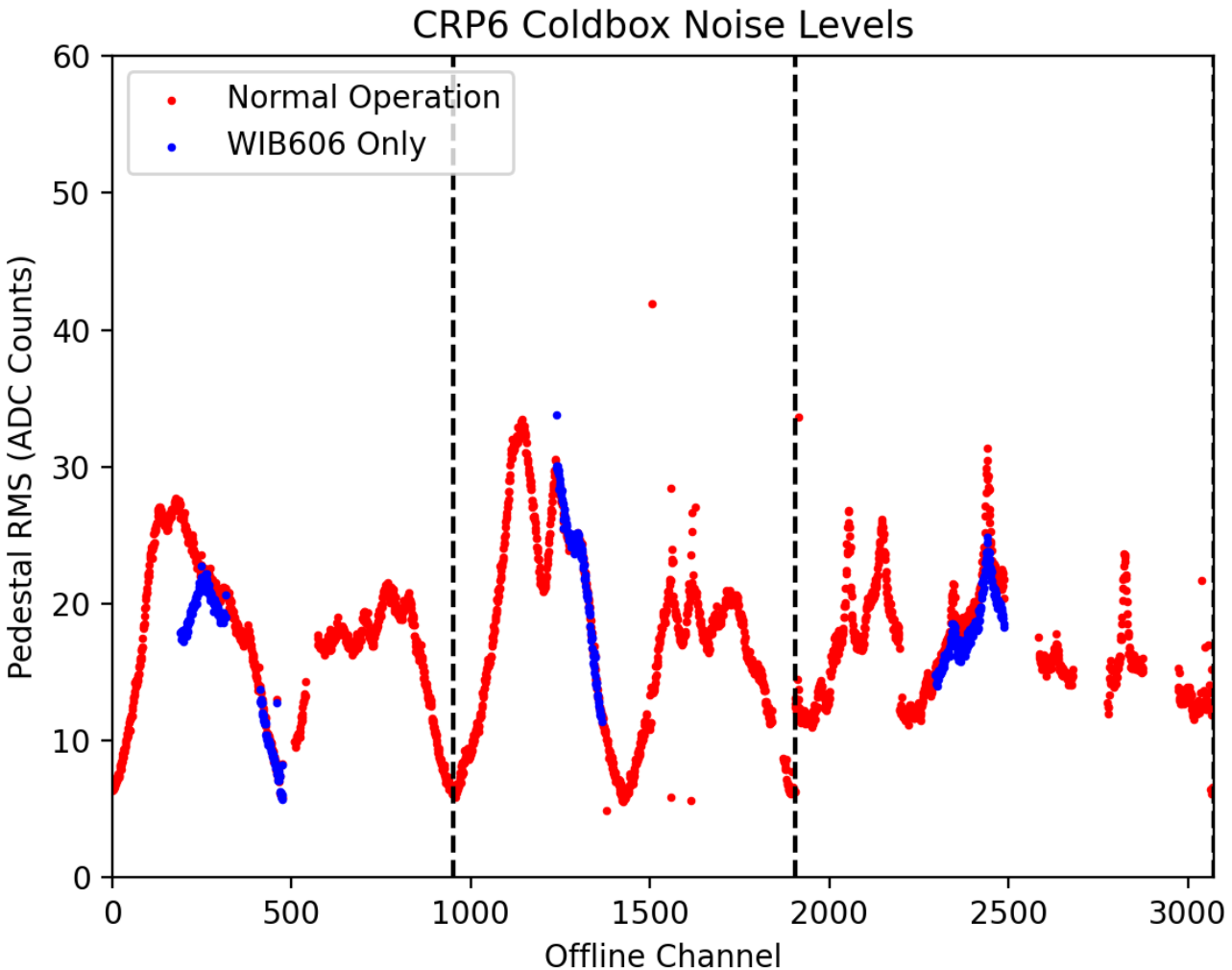
One FEMB powered ON at a time



Several FEMBs with low individual noise turned ON – no/small interference

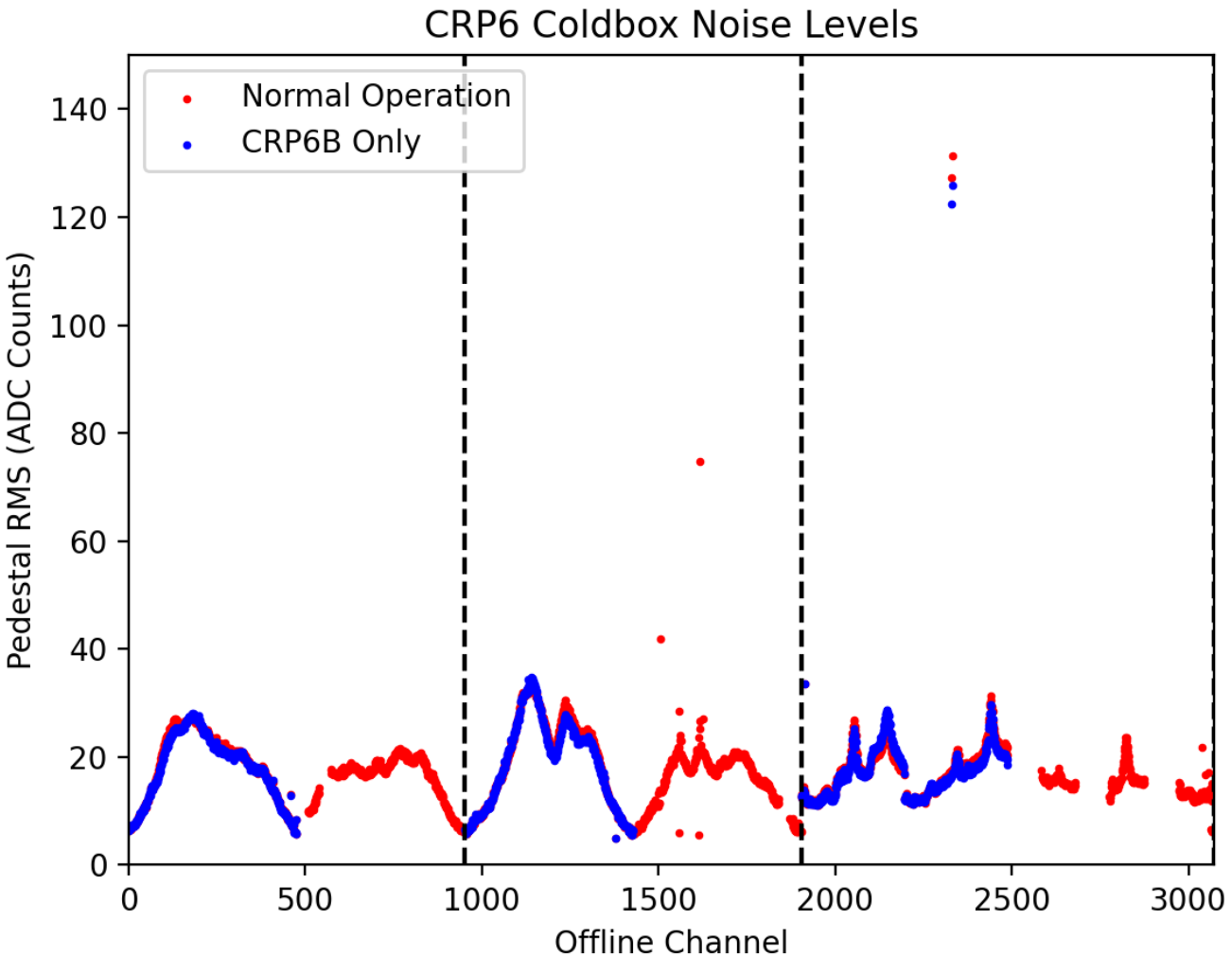


WIB 606 only



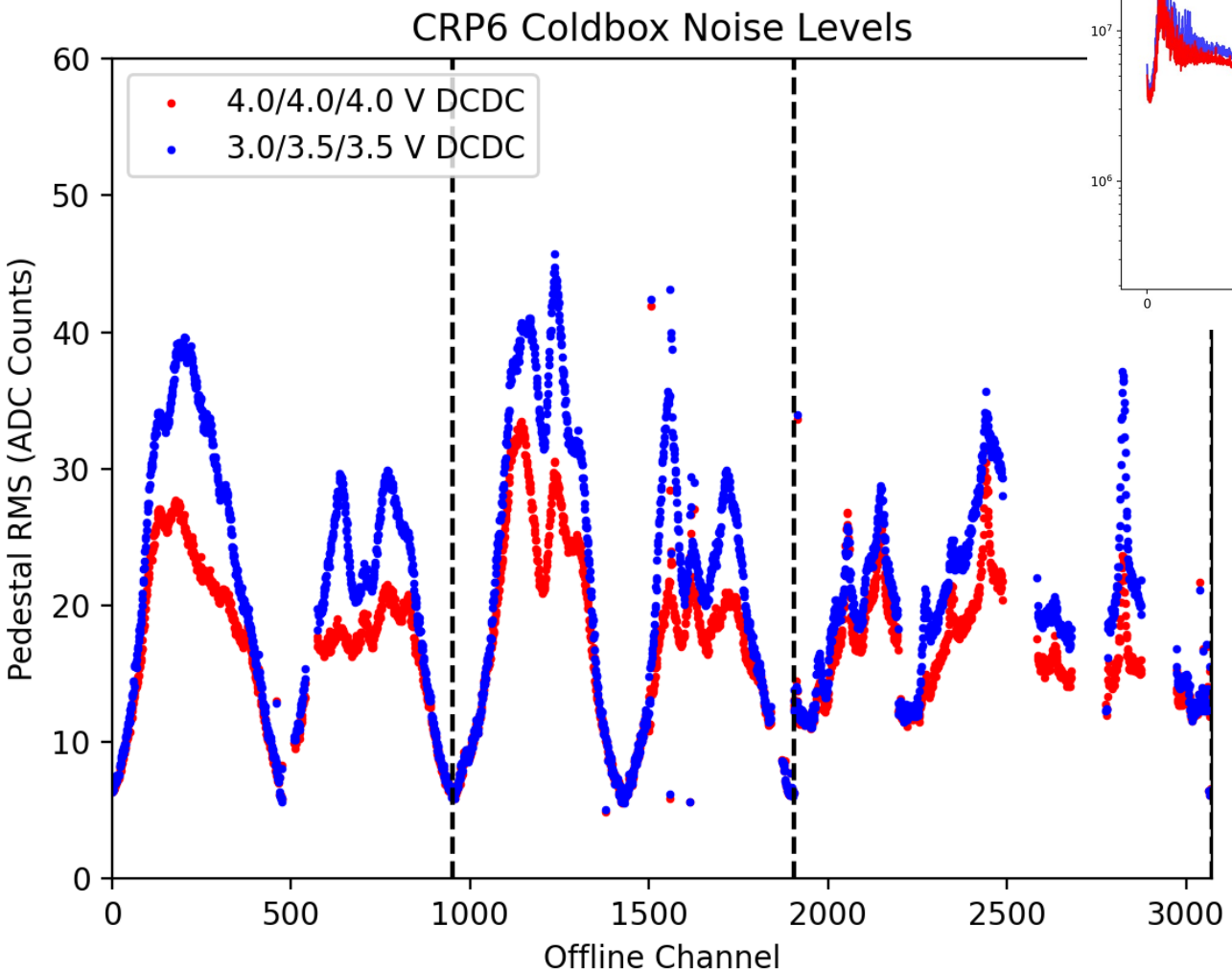
From Roger

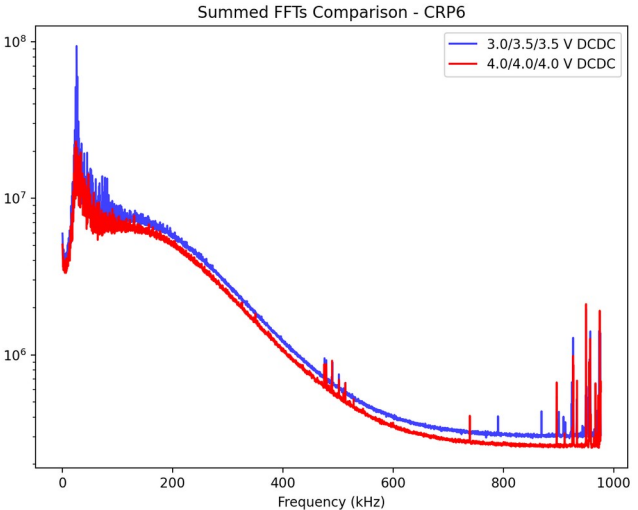
CRP 6B only



From Roger

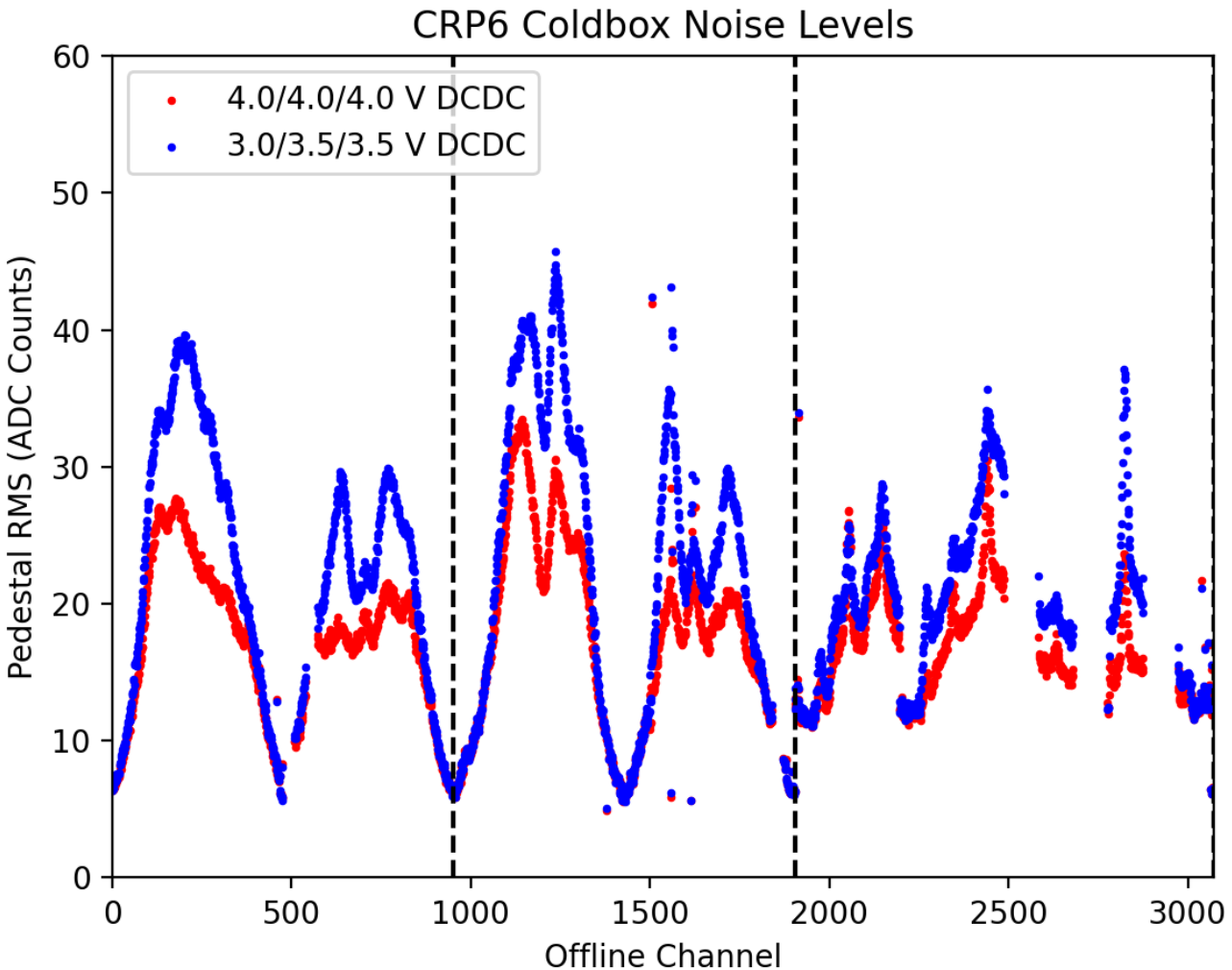
Lower DCDC power settings – noise gets worse





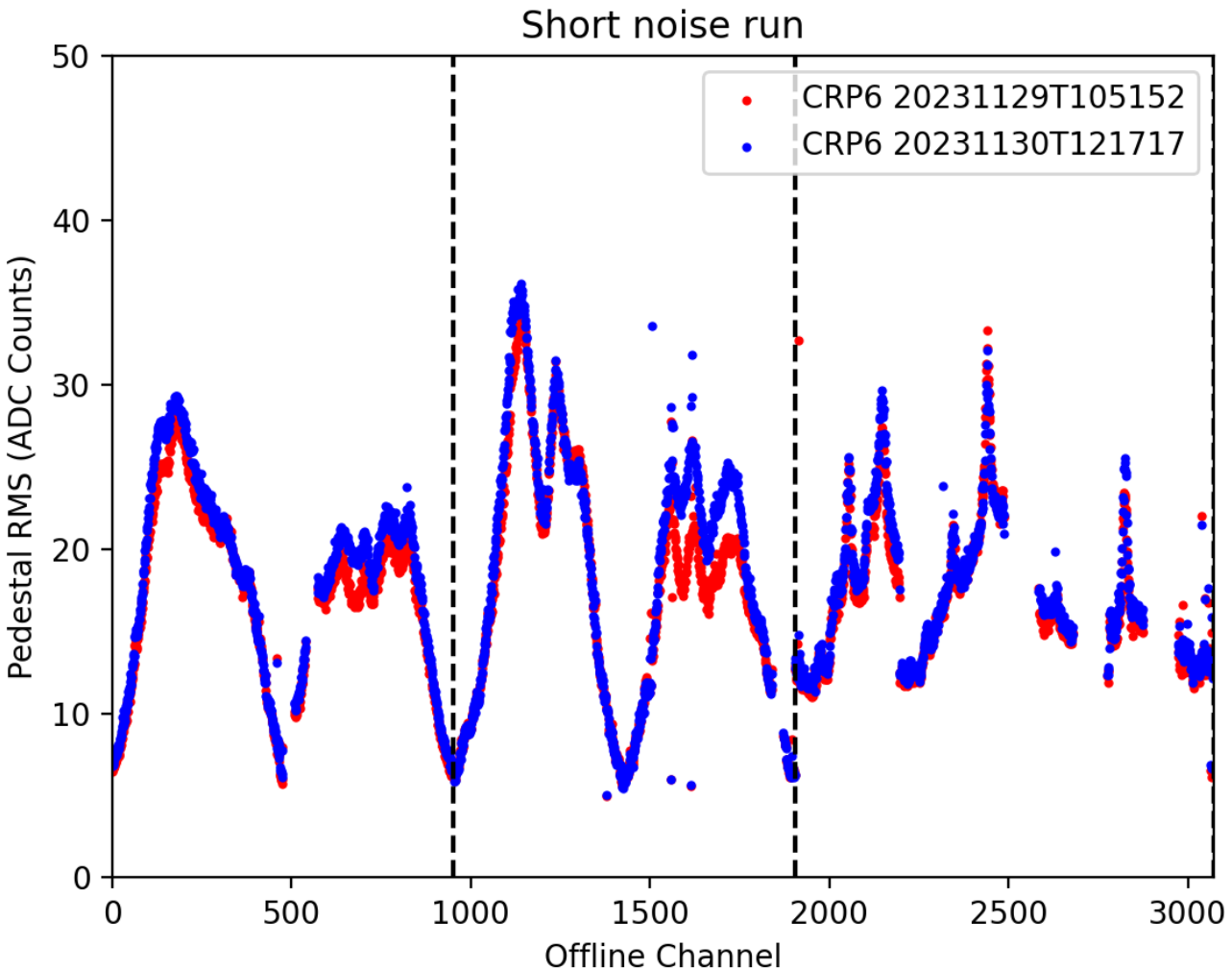
From Roger

Lower DCDC power settings – noise gets worse



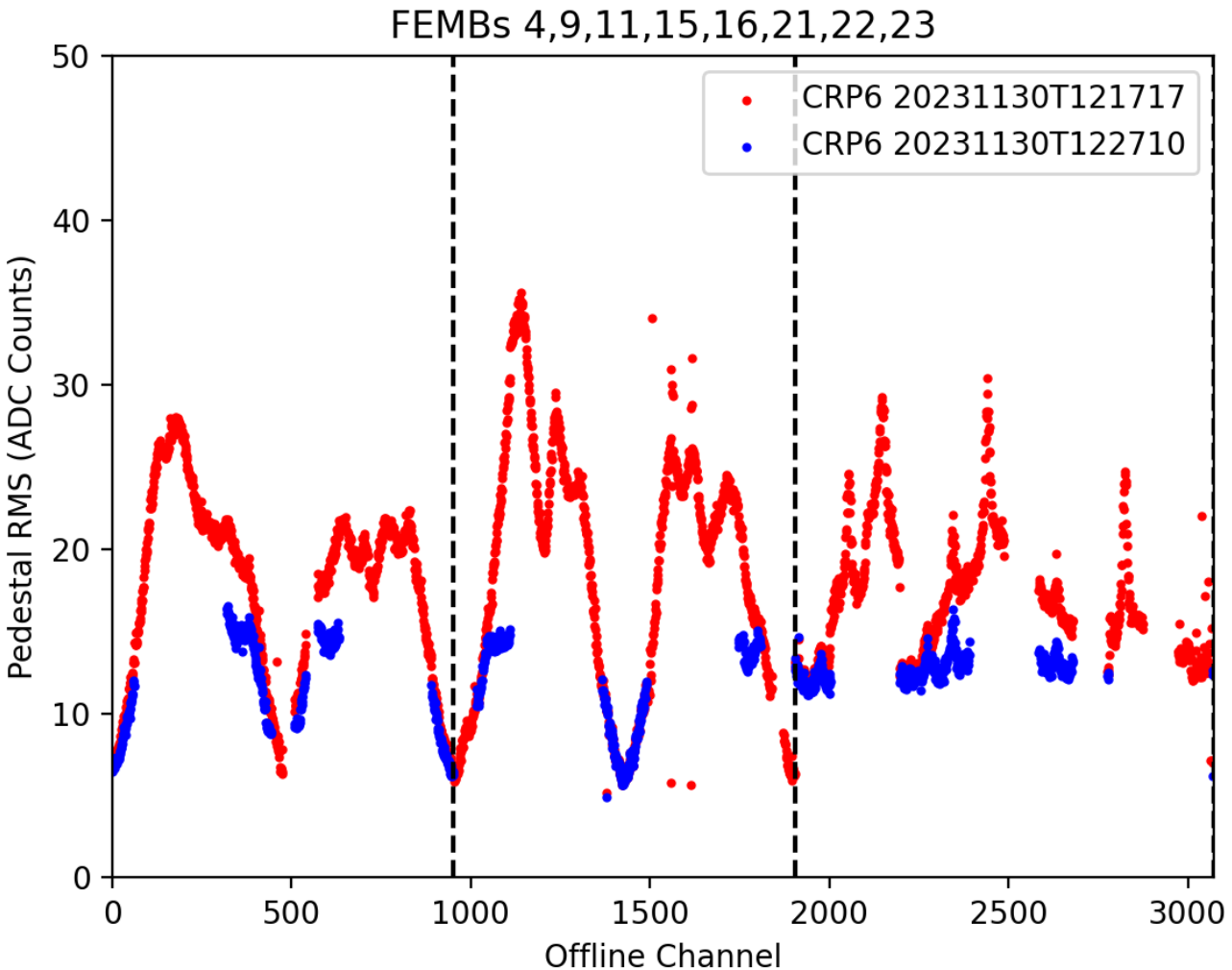
From Roger

11/30/2023 – continue noise studies

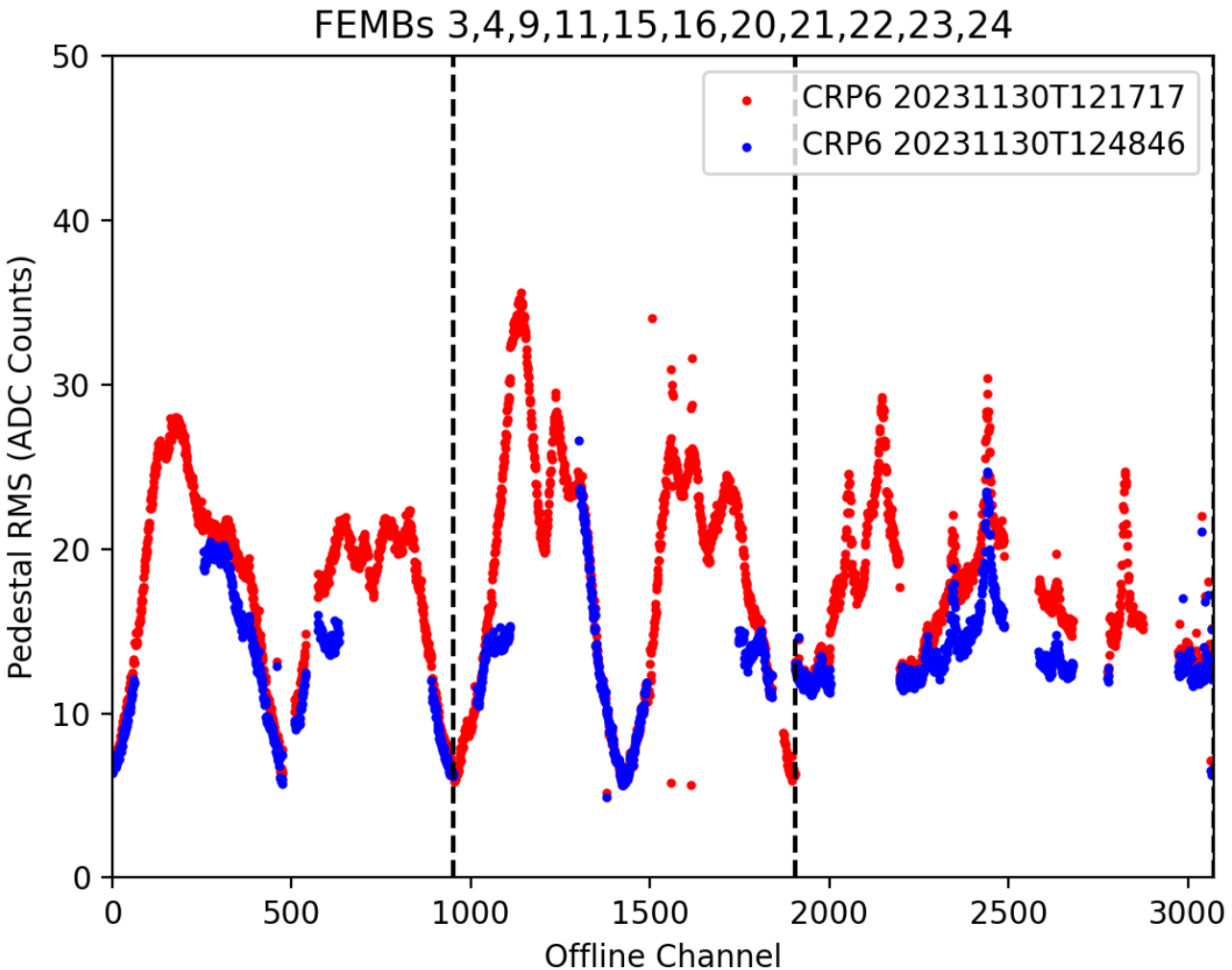


Today the noise level is slightly higher.
Can be due to level meters that were connected yesterday night.
Serhan says they are on Jura side, which is consistent with the location of increased noise in CRP.

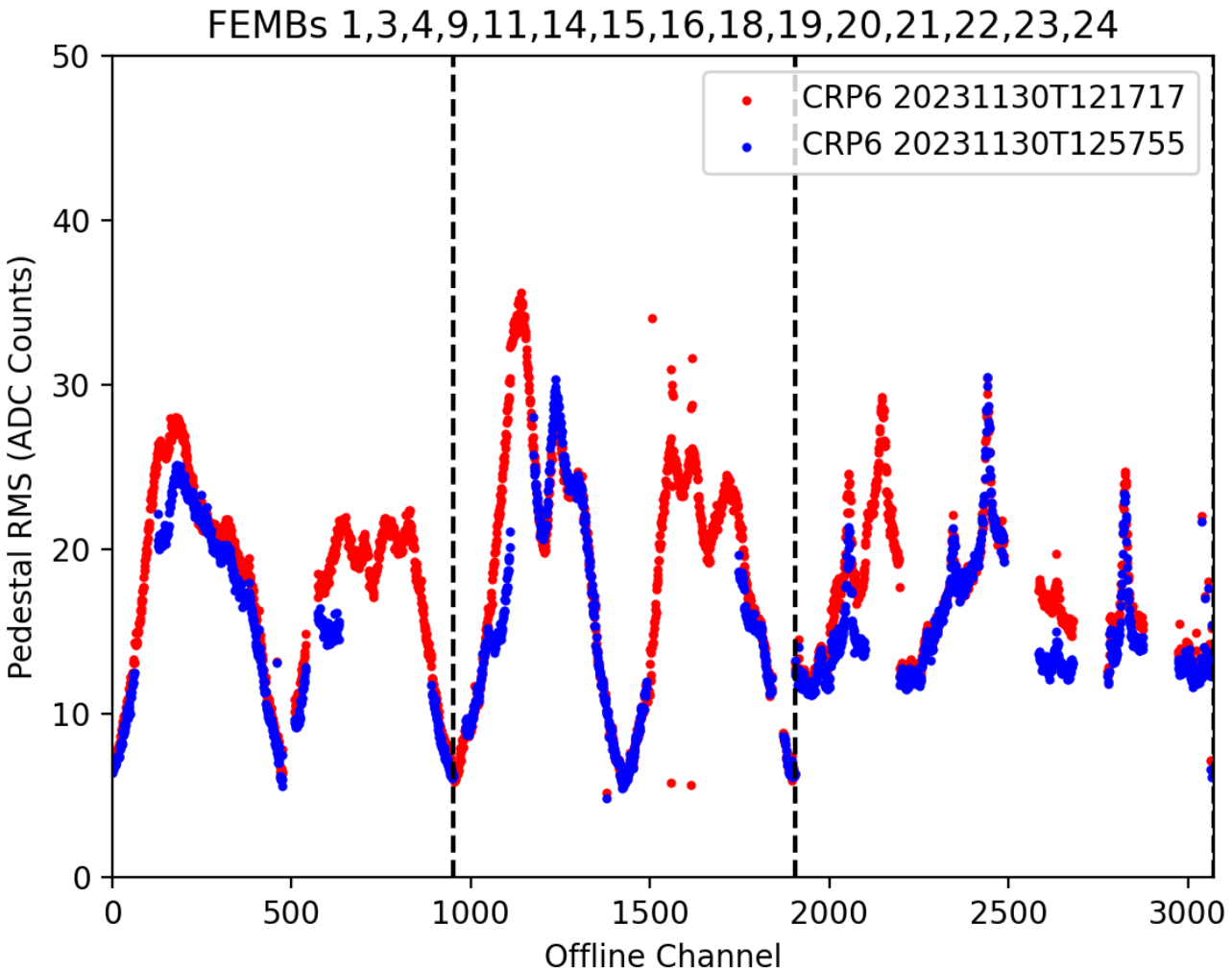
FEMBs 4,9,11,15,16,21,22,23 only



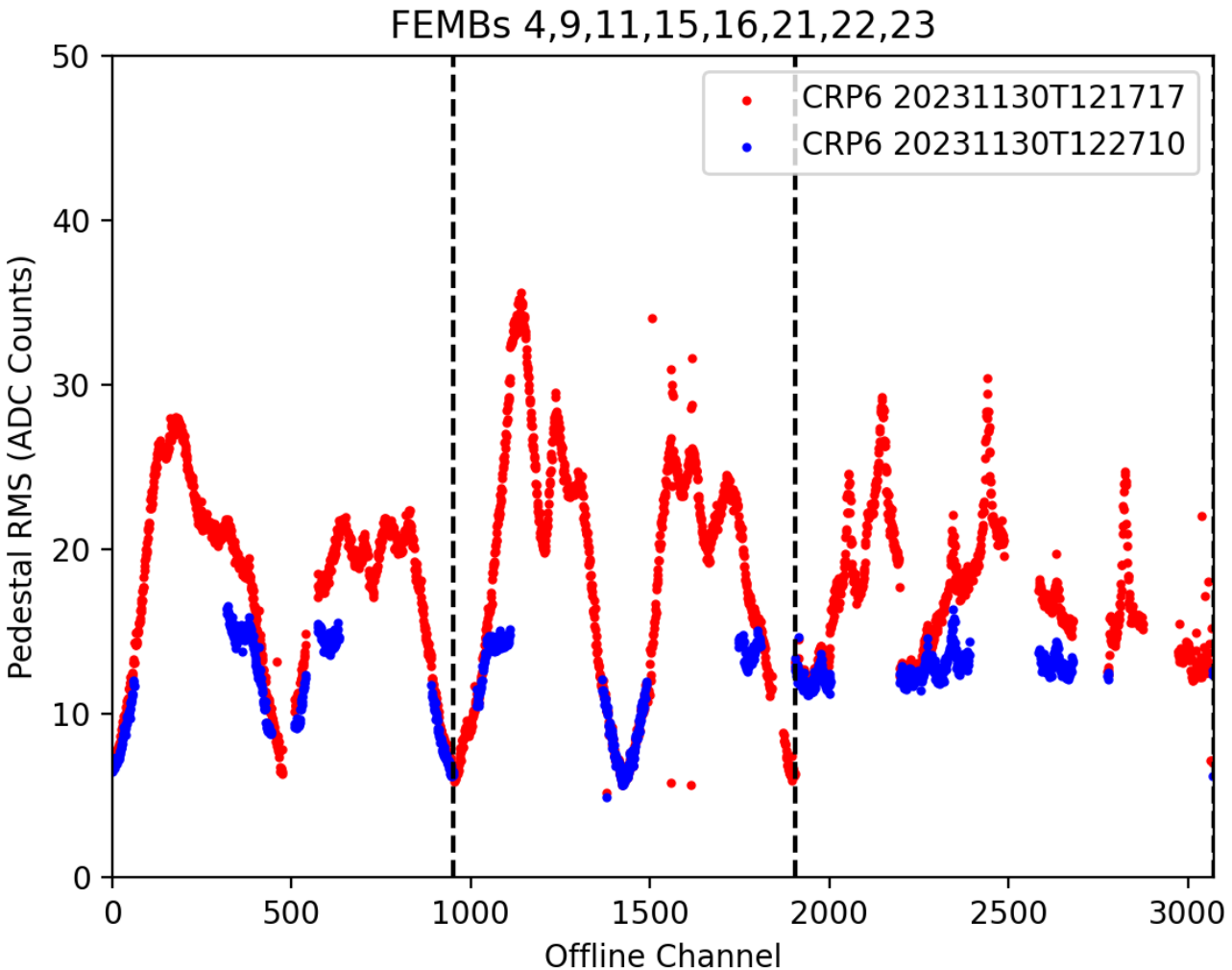
FEMBs 3,4,9,11,15,16,20,21,22,23,24 only (added FEMBs 3,20,24)



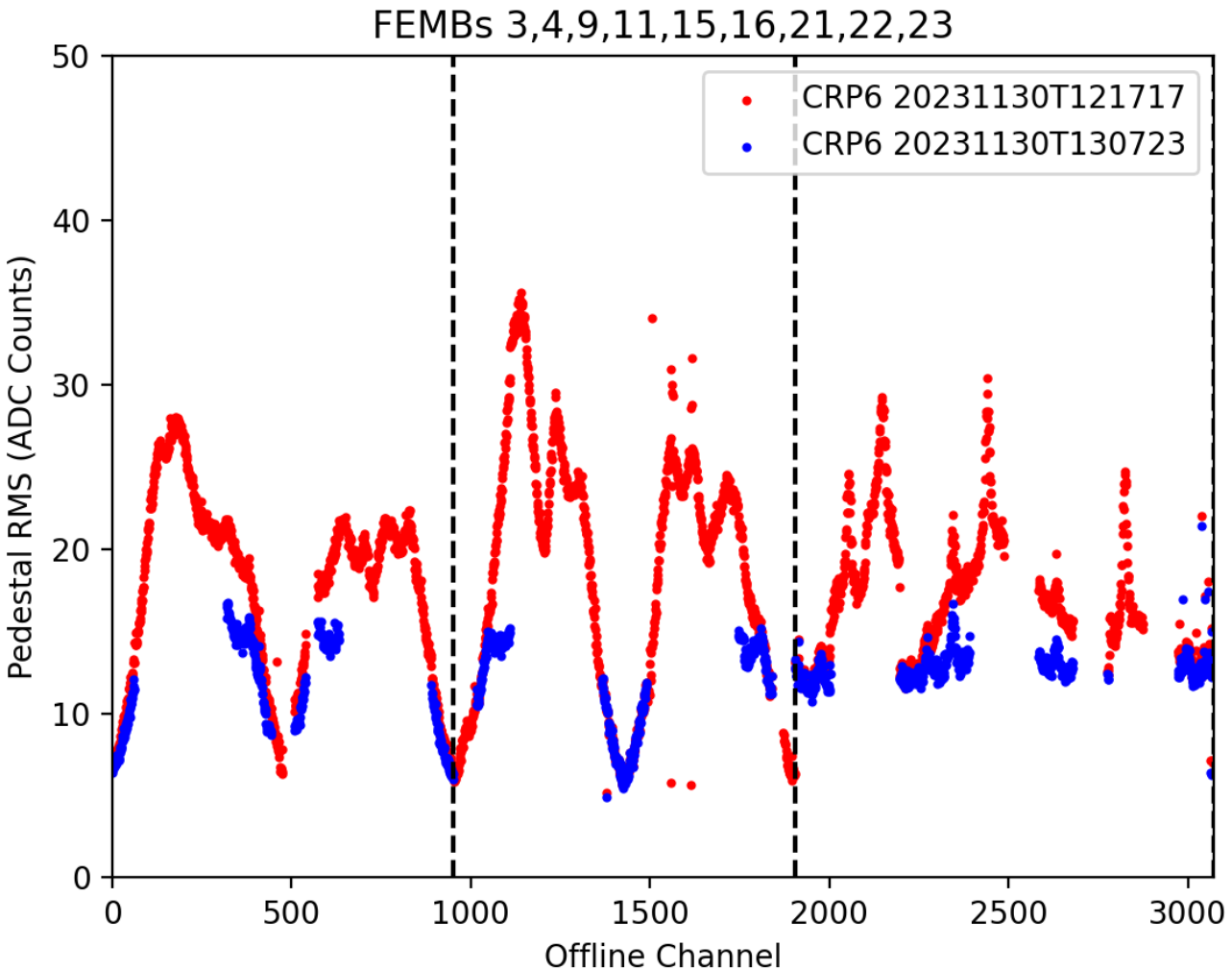
FEMBs 1,3,4,9,11,14,15,16,18,19,20,21,22,23,24 only (added FEMBs 1,14,18,19)



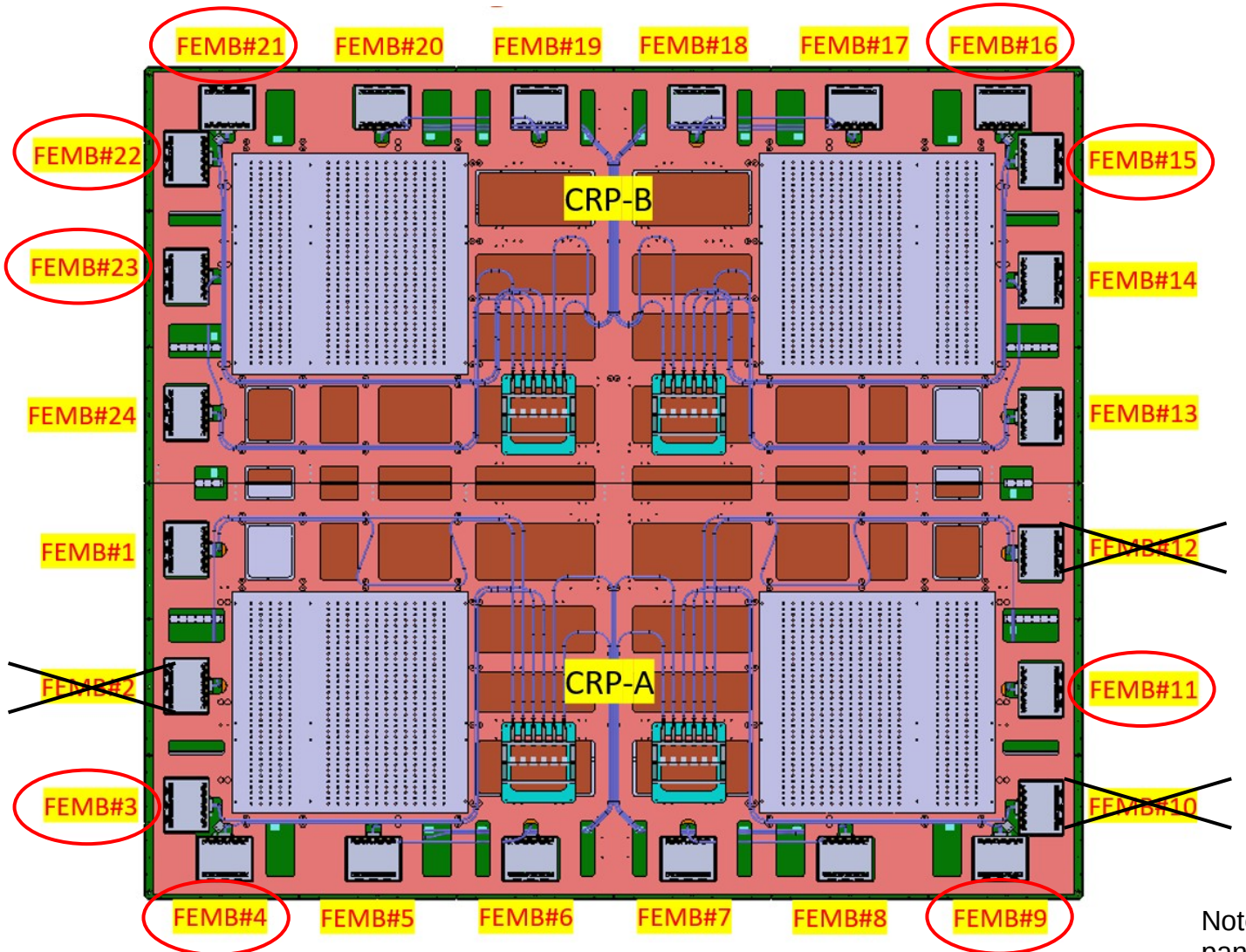
FEMBs 4,9,11,15,16,21,22,23 only (for reference)



FEMBs 4,9,11,15,16,21,22,23 only + FEMB 3

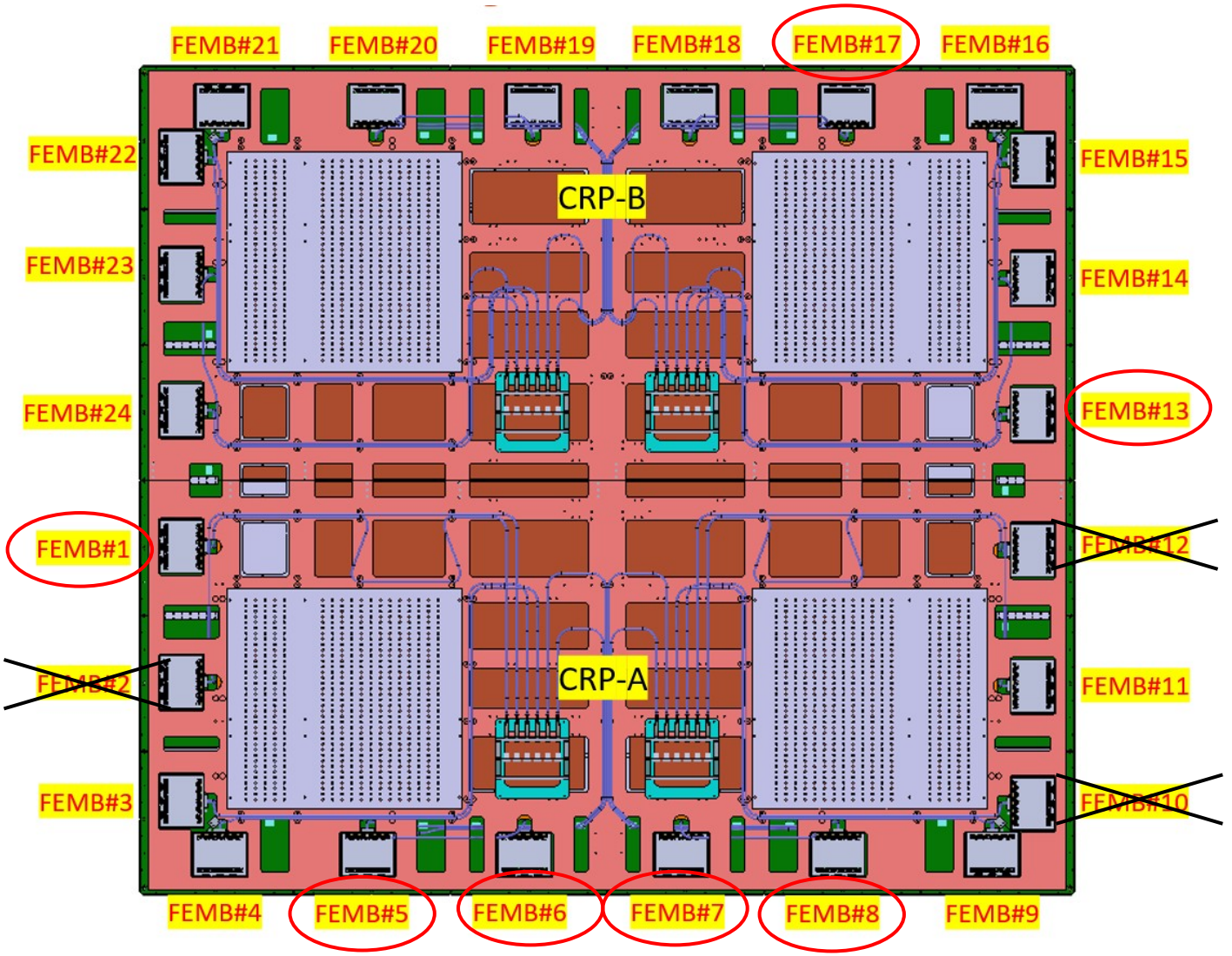


FEMBs with relatively low noise circled (3,4,9,11,15,16,21,22,23)

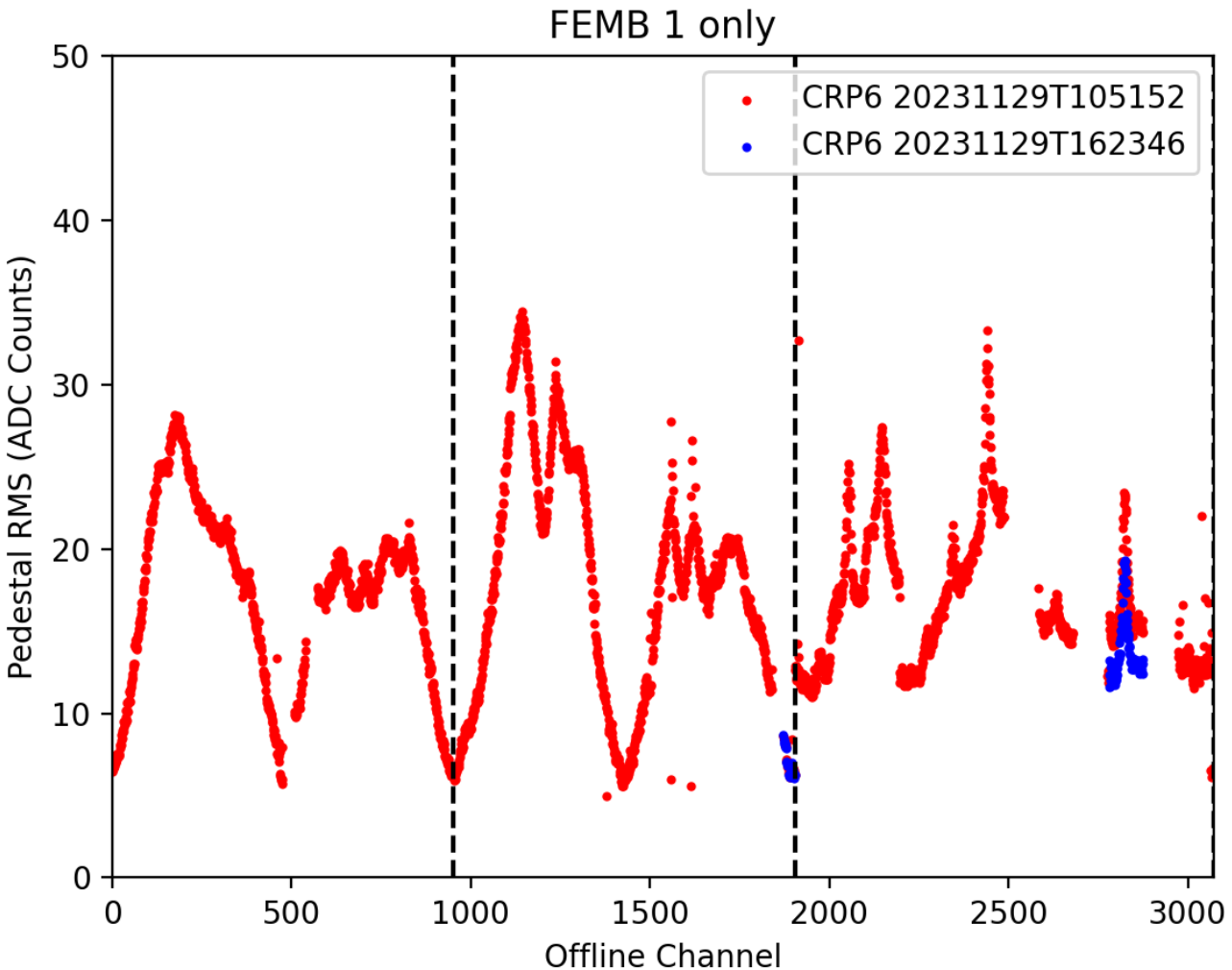


Note: position of patch panels is not accurate

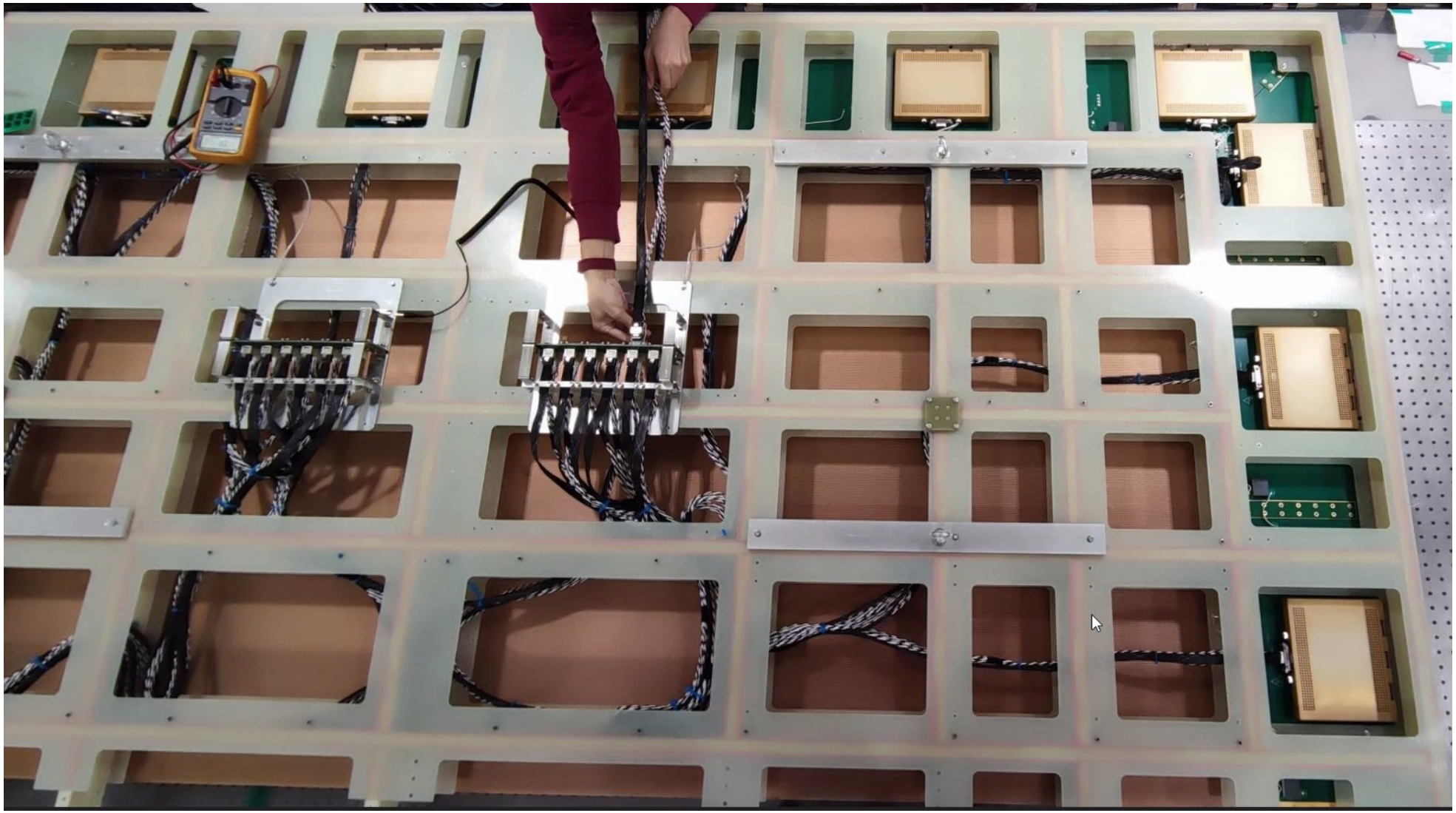
FEMBs with relatively high noise circled



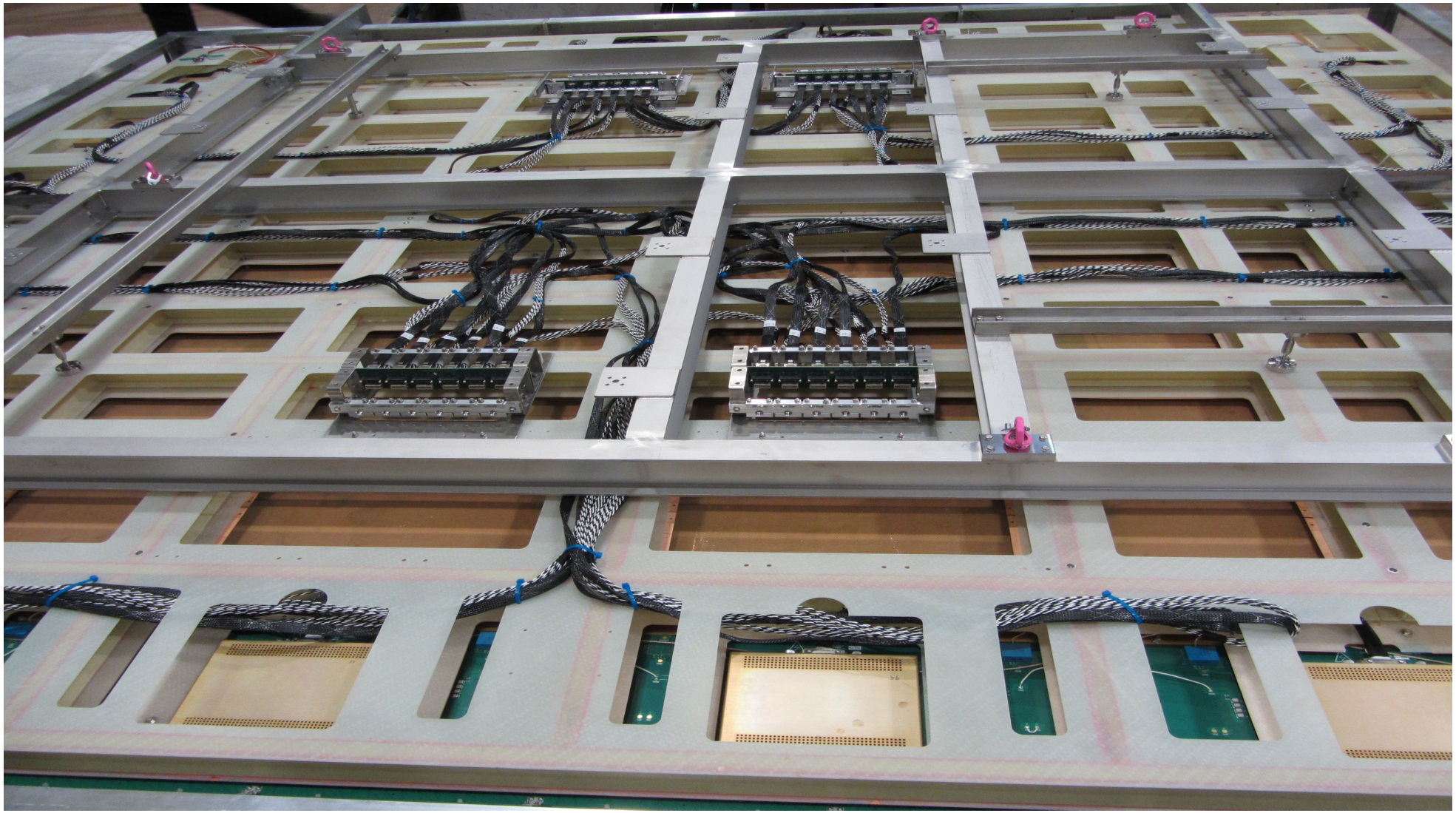
One FEMB powered ON at a time



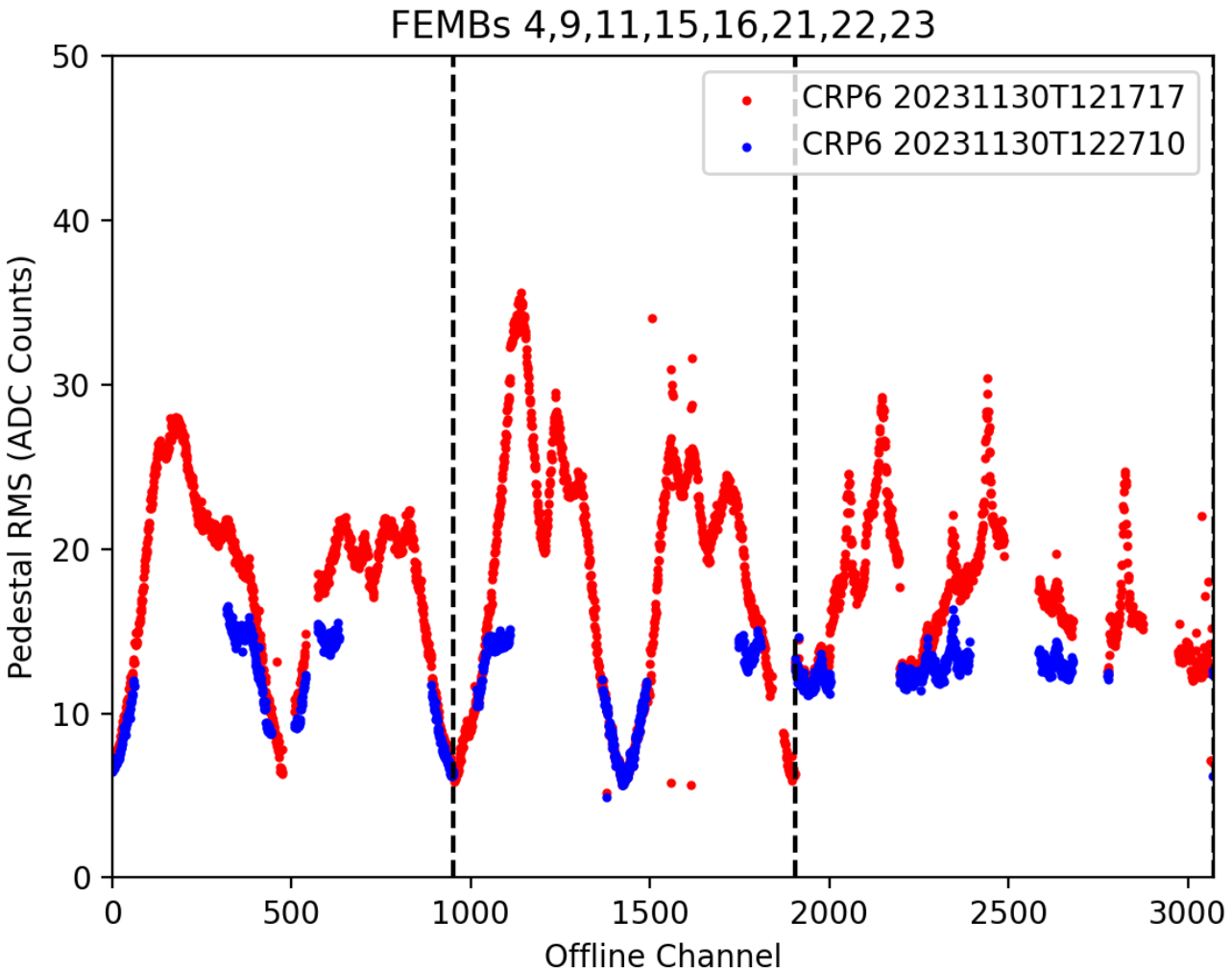
Picture showing the cable routing on CRP6



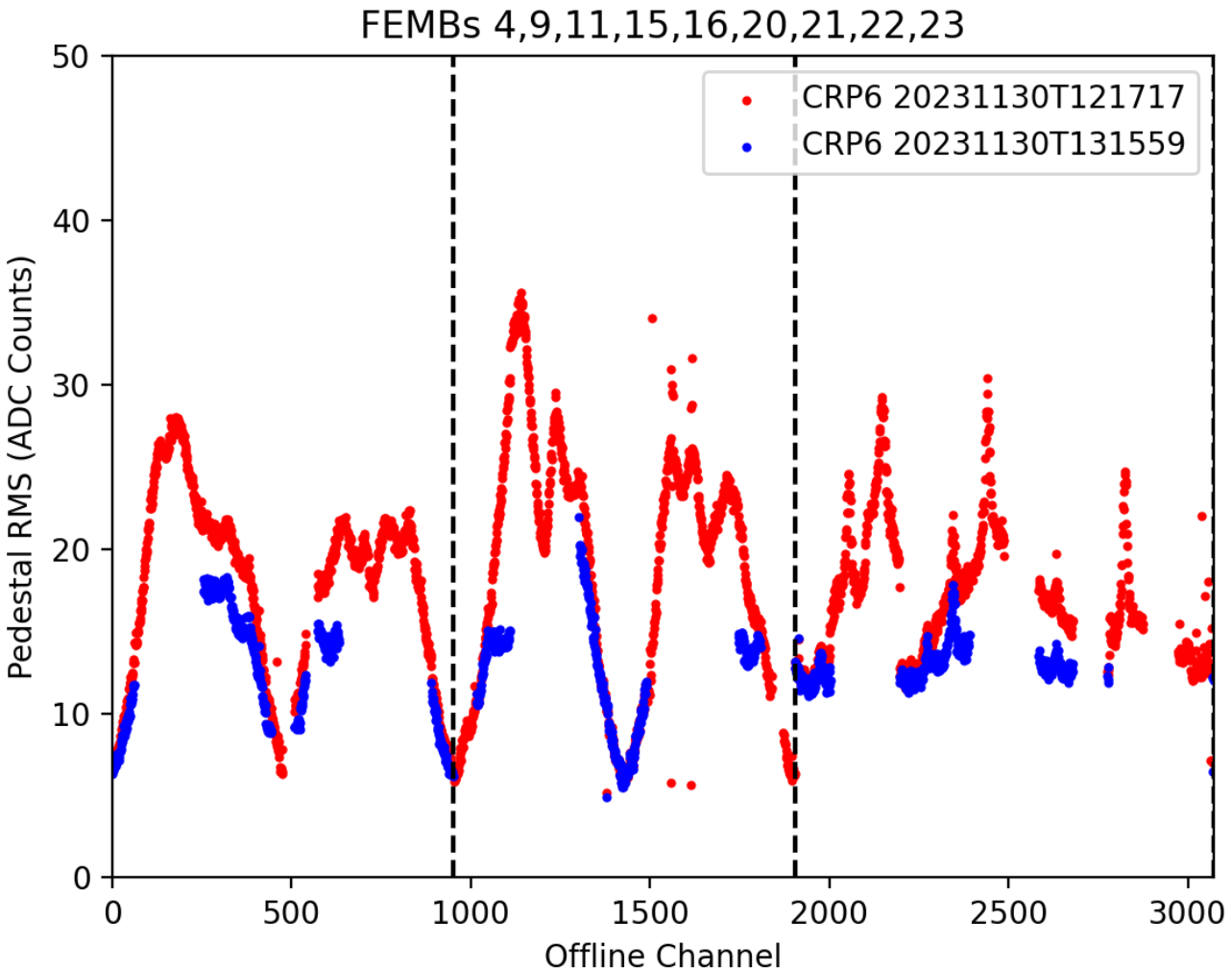
Cabling of CRP5 for comparison



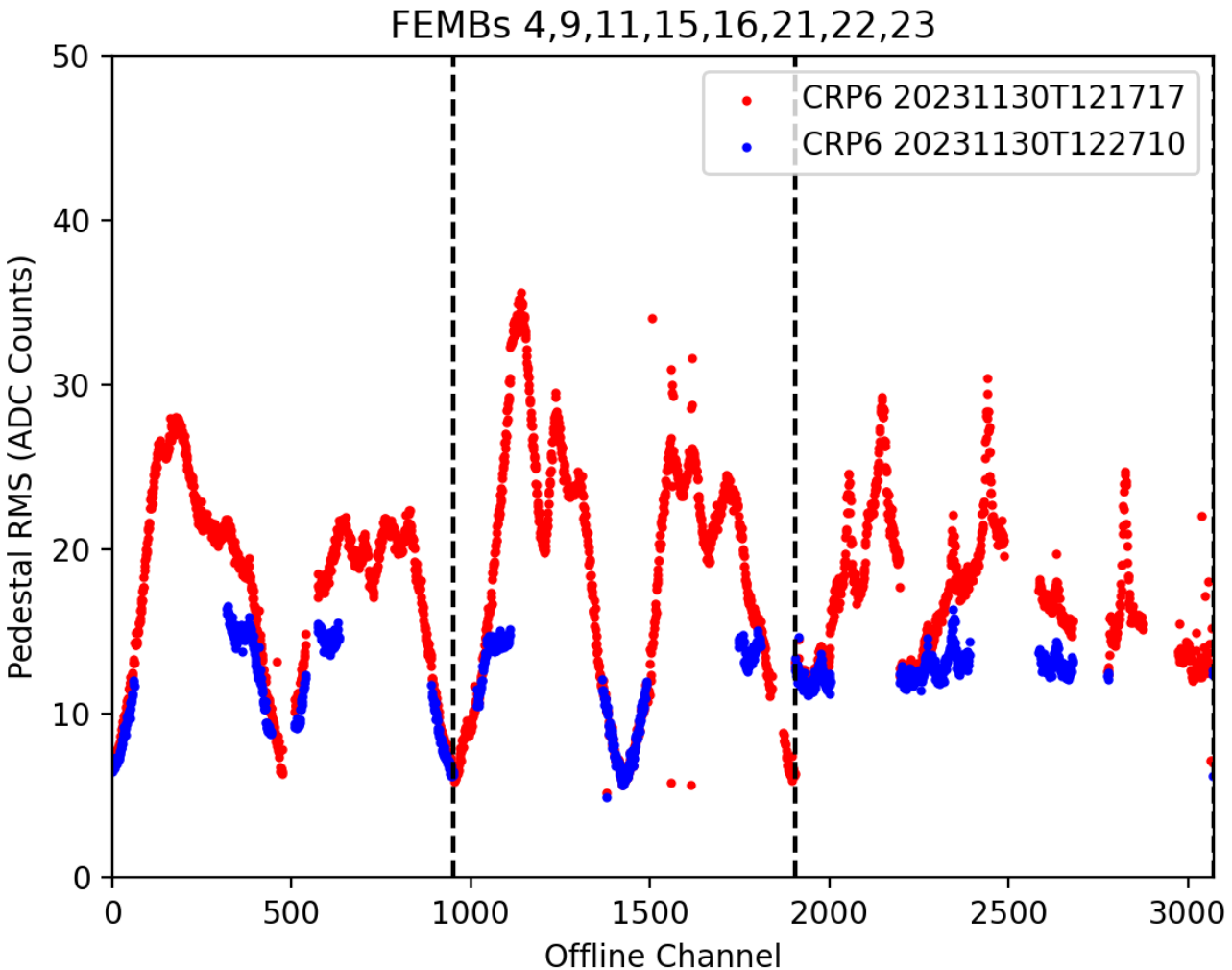
FEMBs 4,9,11,15,16,21,22,23 only (for reference)



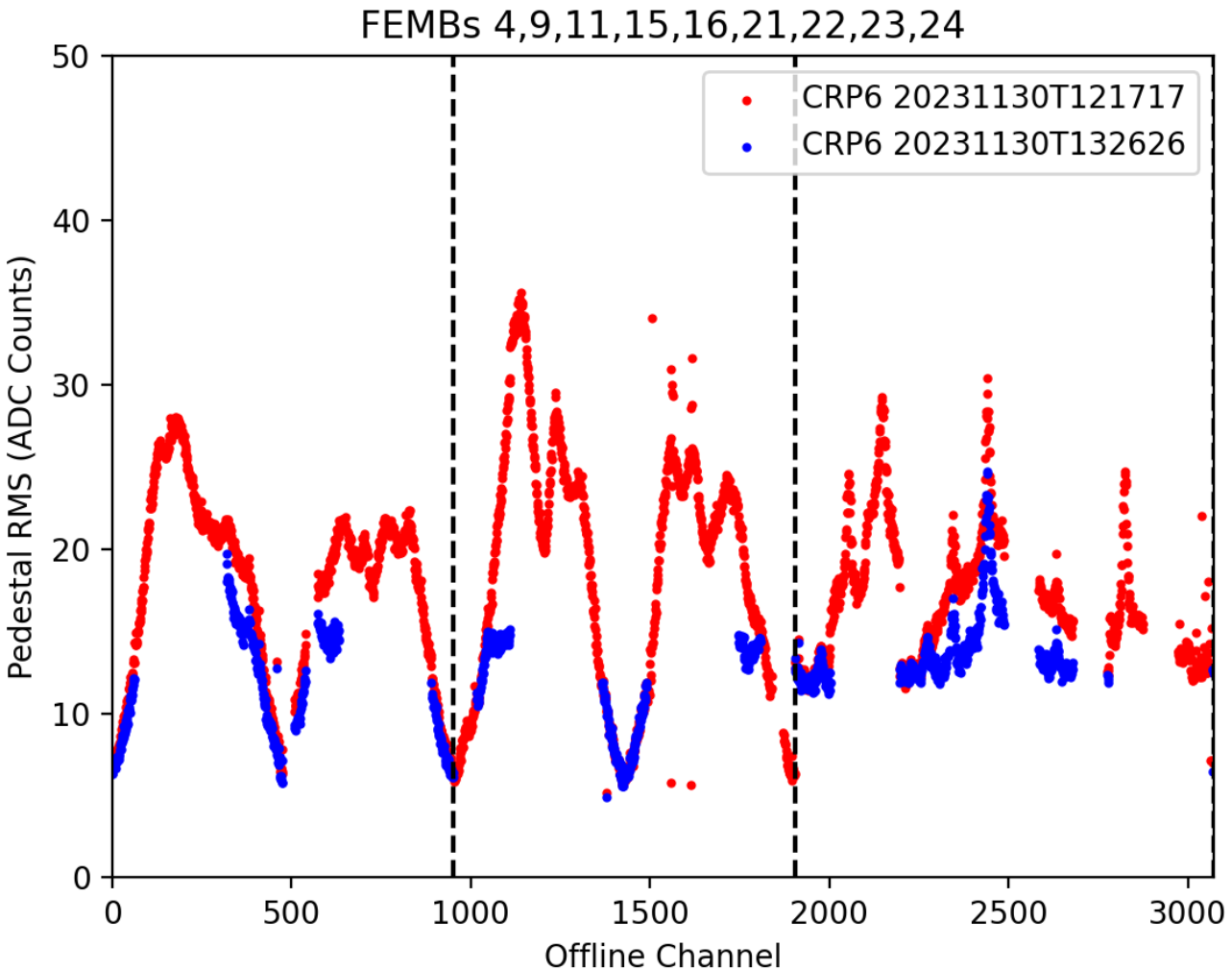
FEMBs 4,9,11,15,16,21,22,23 only + FEMB 20



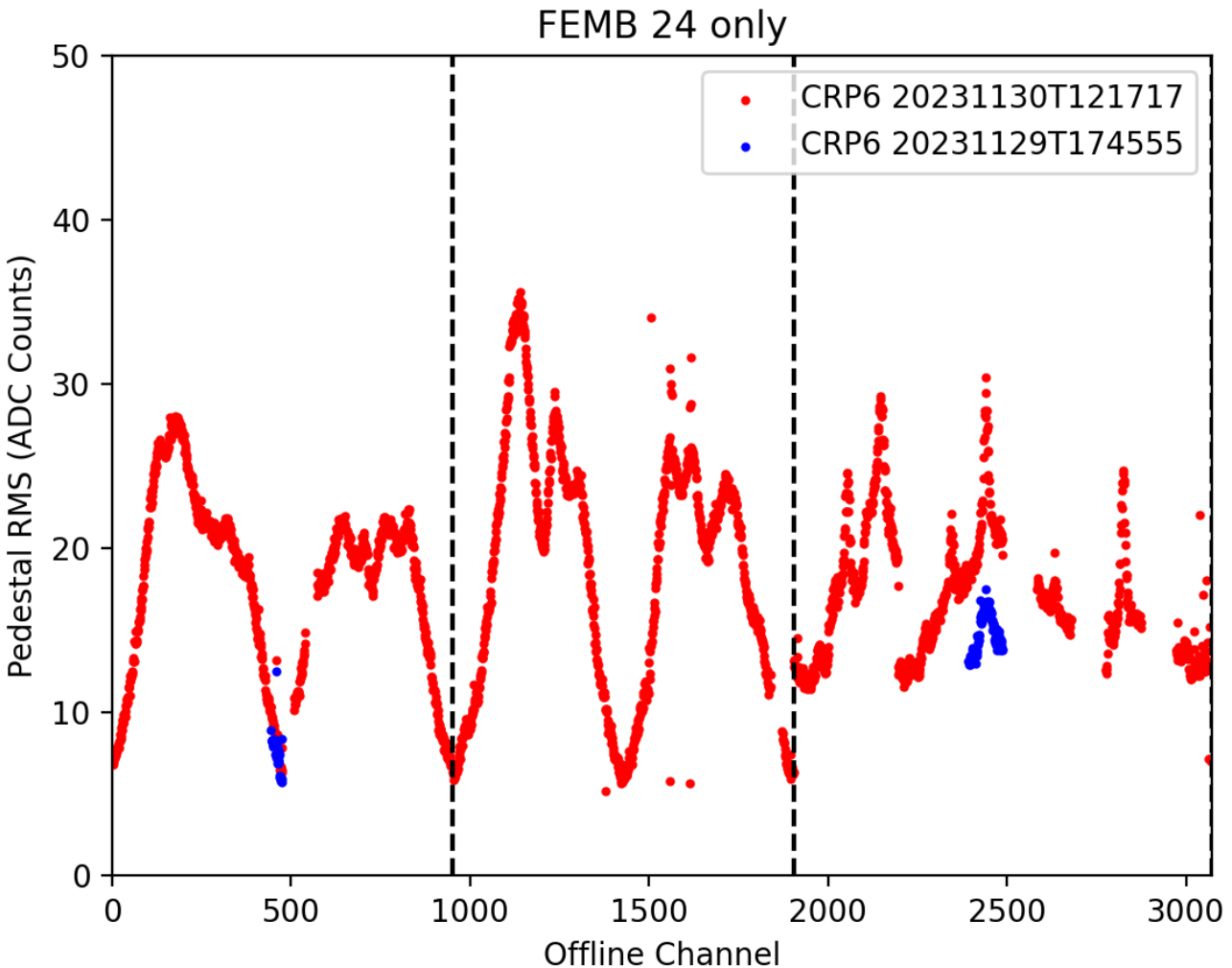
FEMBs 4,9,11,15,16,21,22,23 only (for reference)



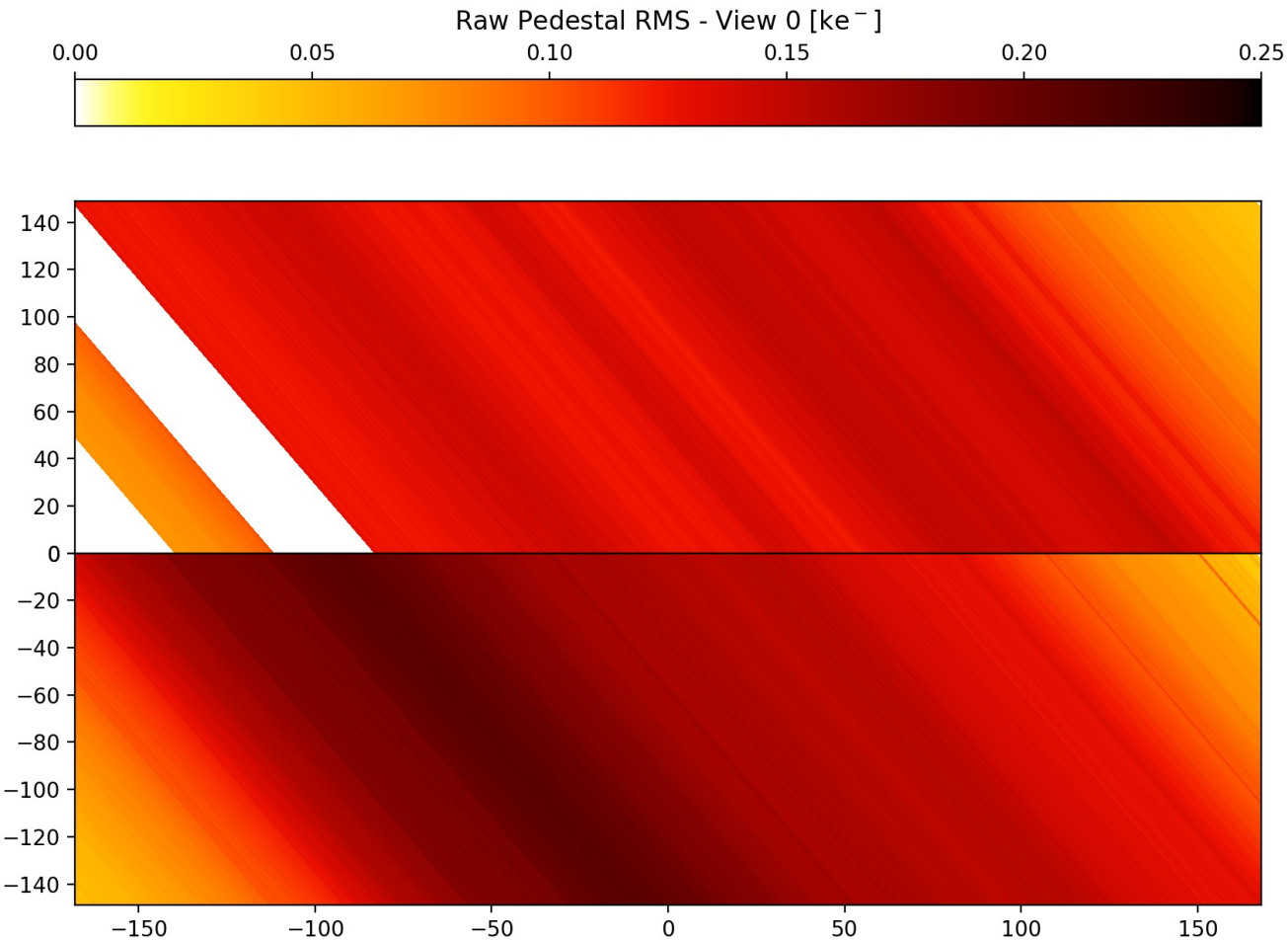
FEMBs 4,9,11,15,16,21,22,23 only + FEMB 24



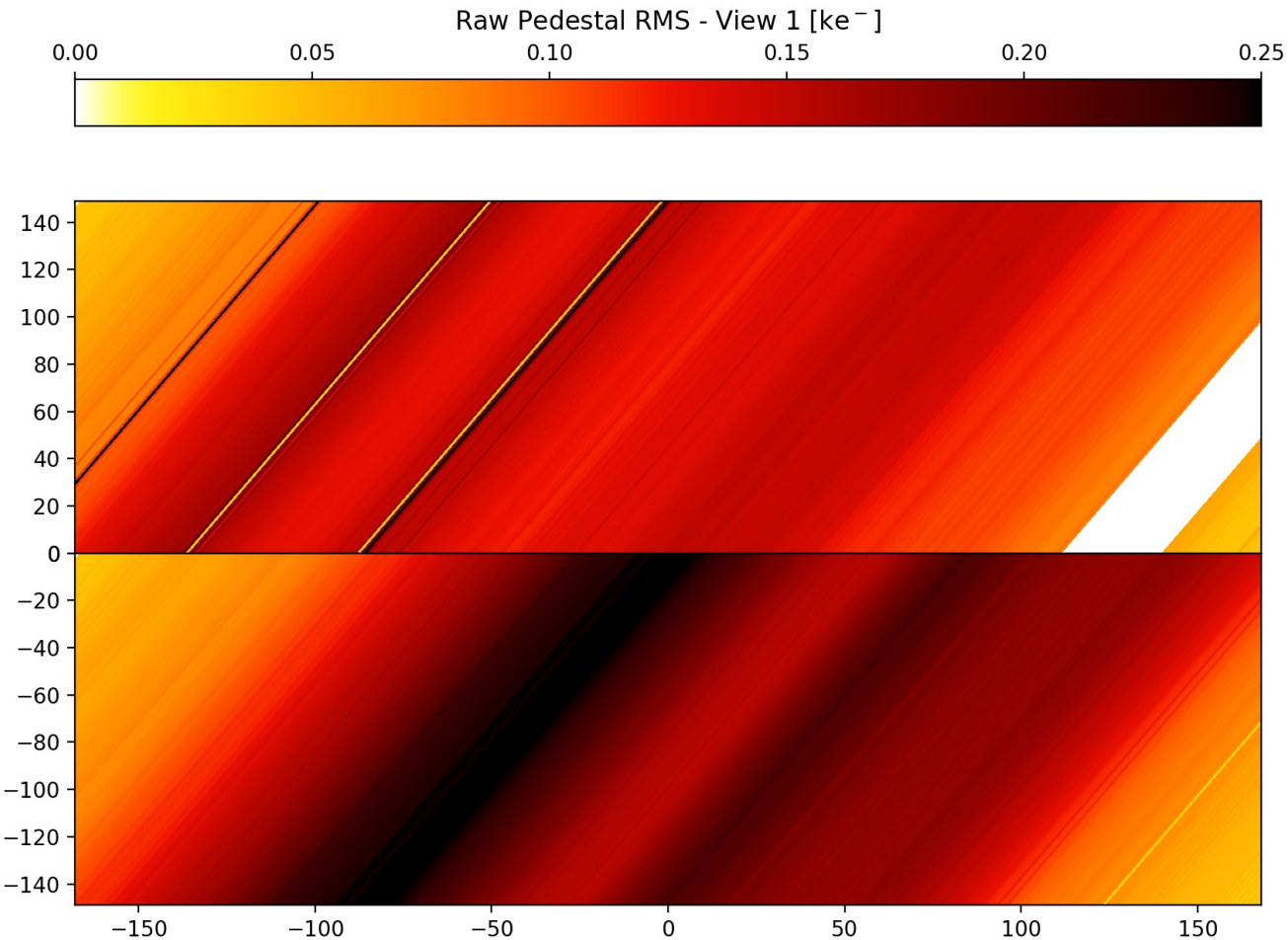
FEMB 24 alone for comparison



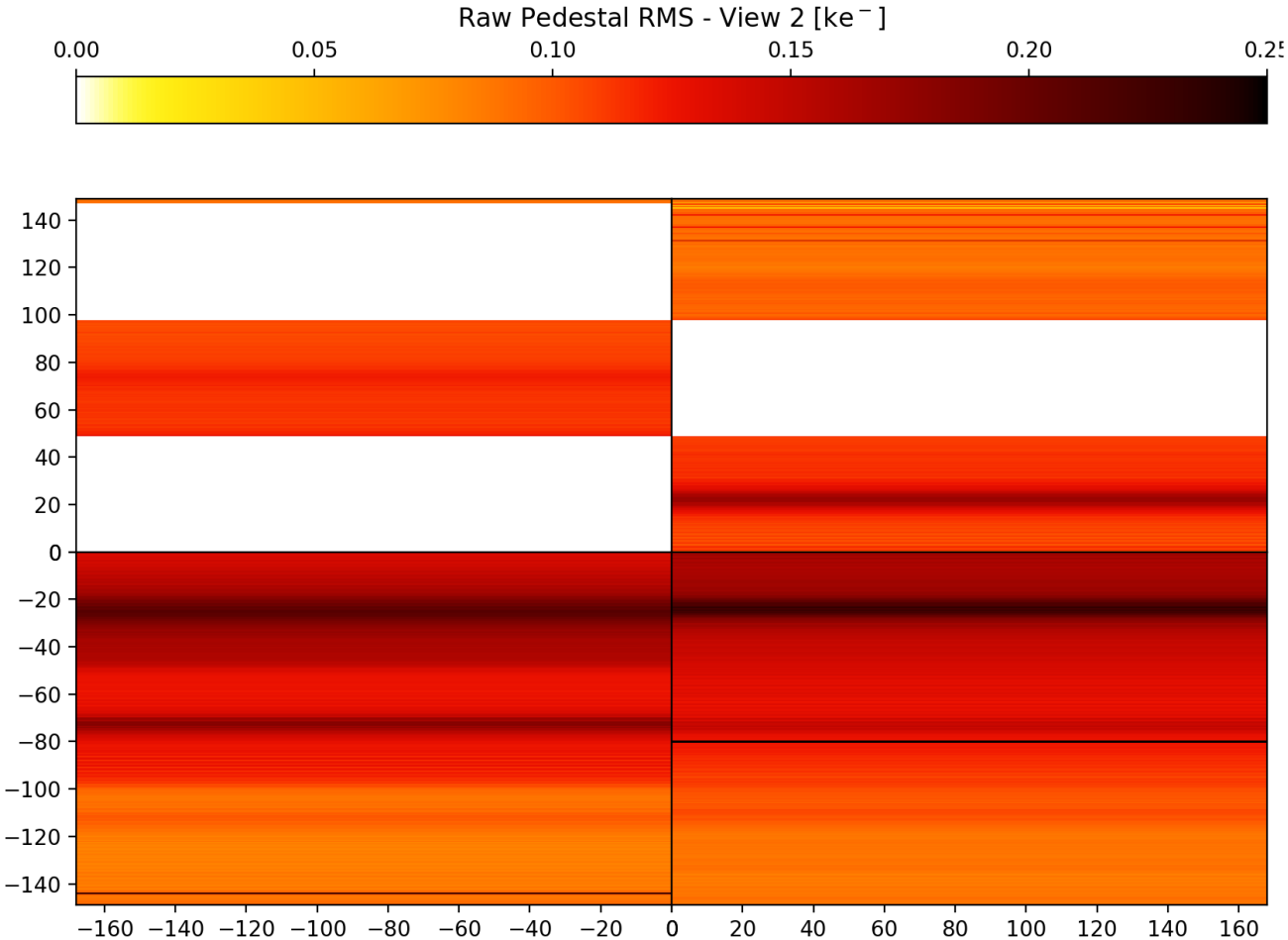
Plots from Laura

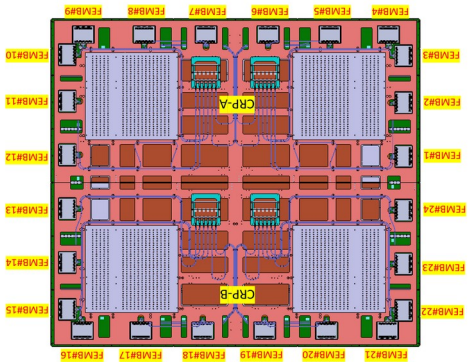


Plots from Laura

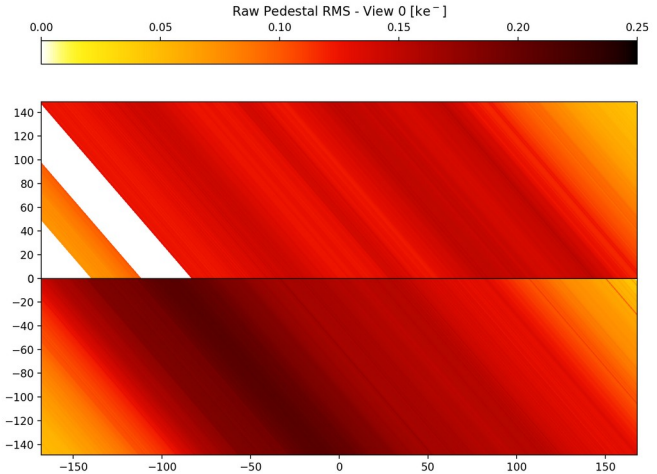


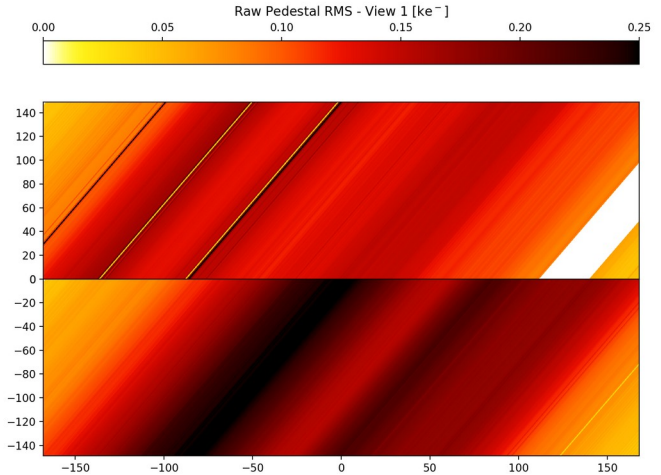
Plots from Laura

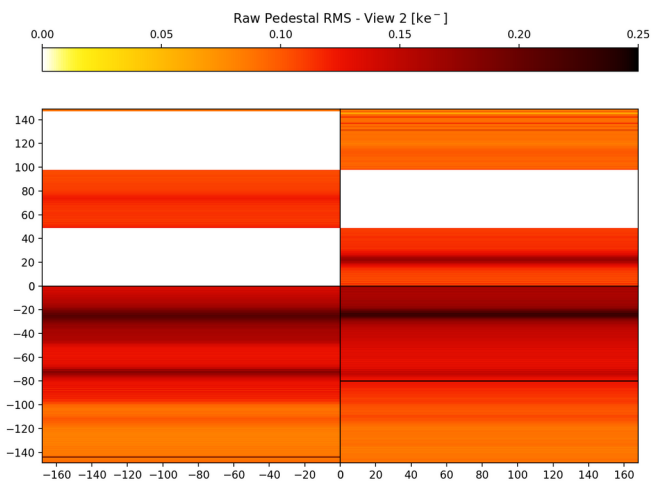


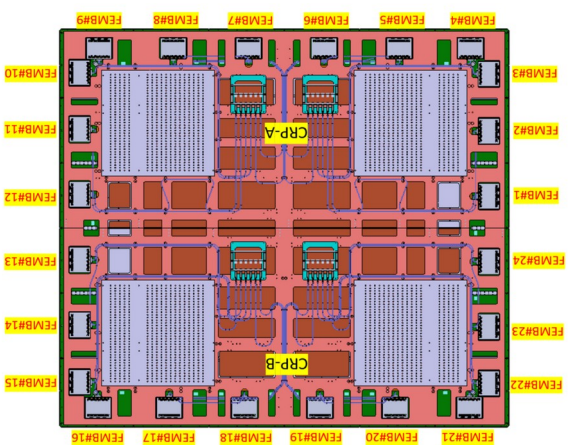


Plots from Laura

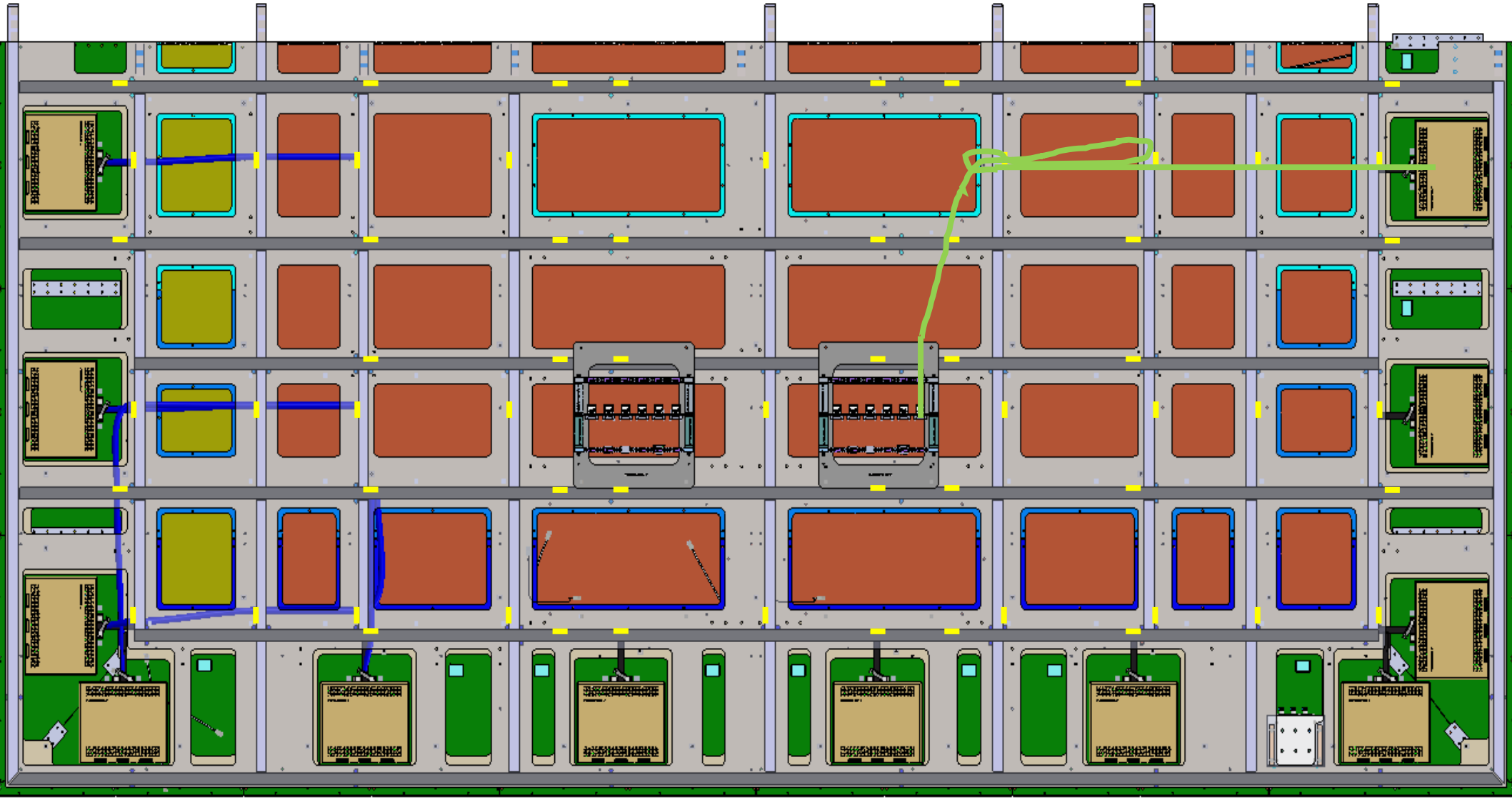


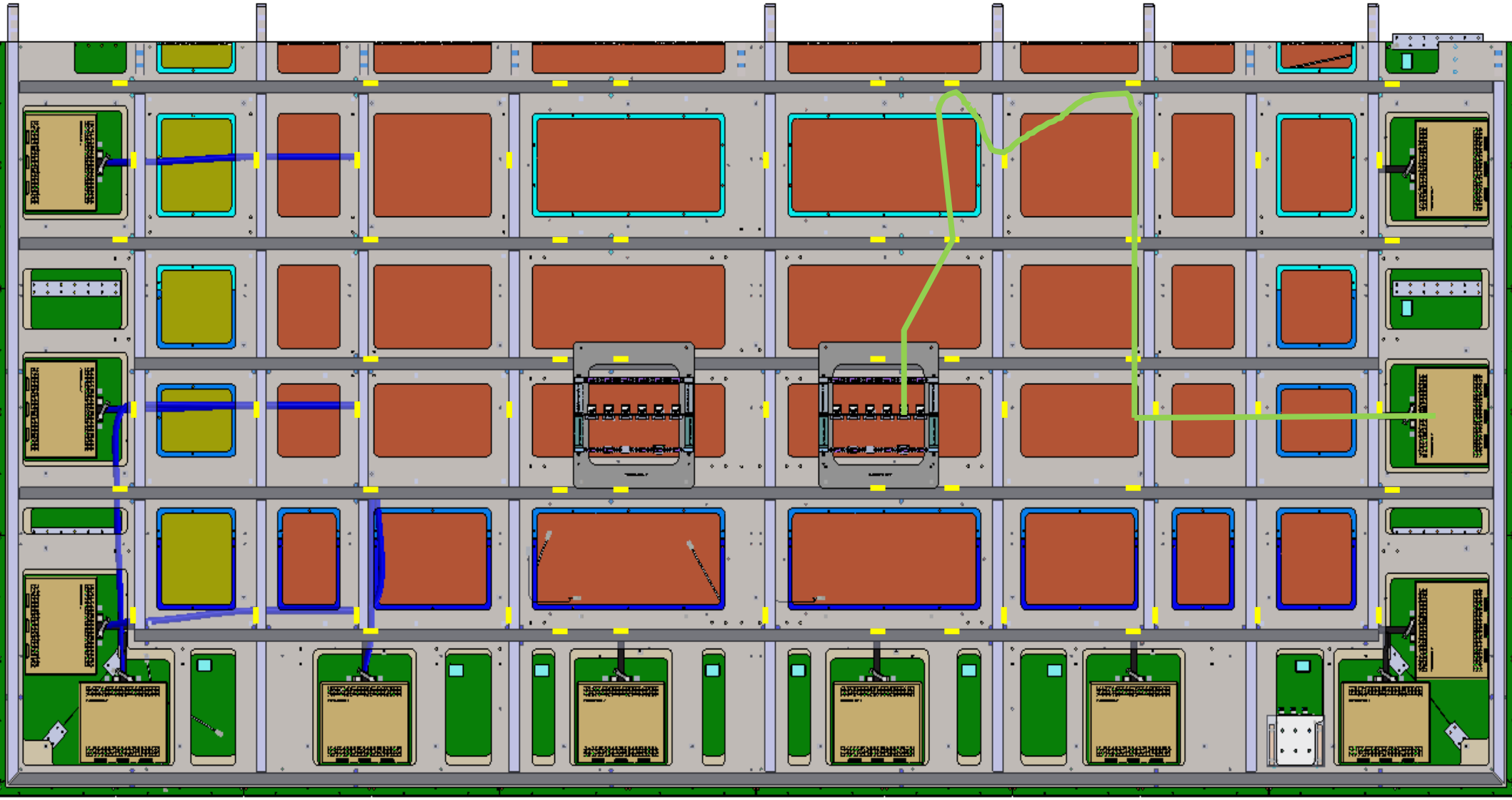


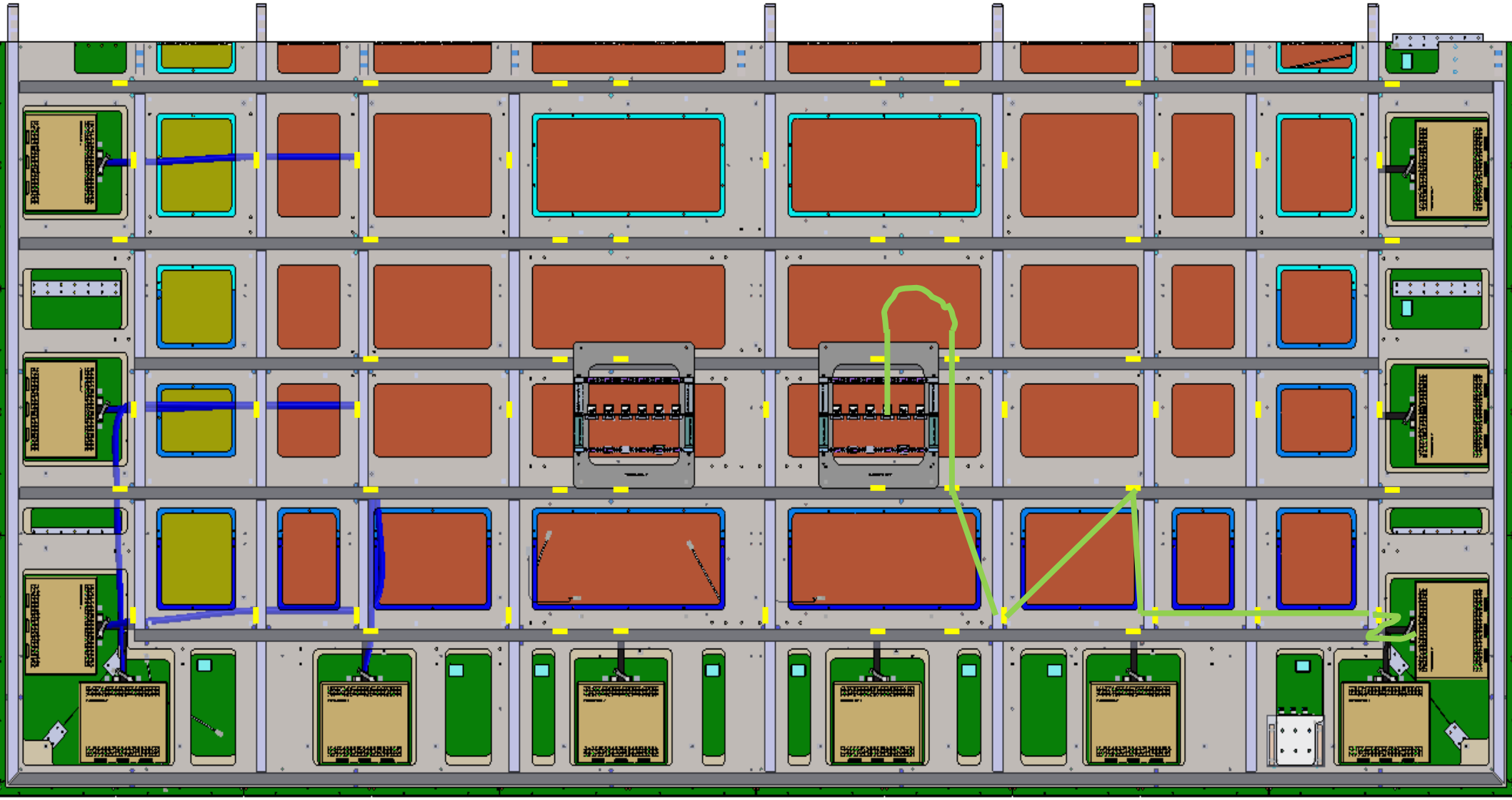


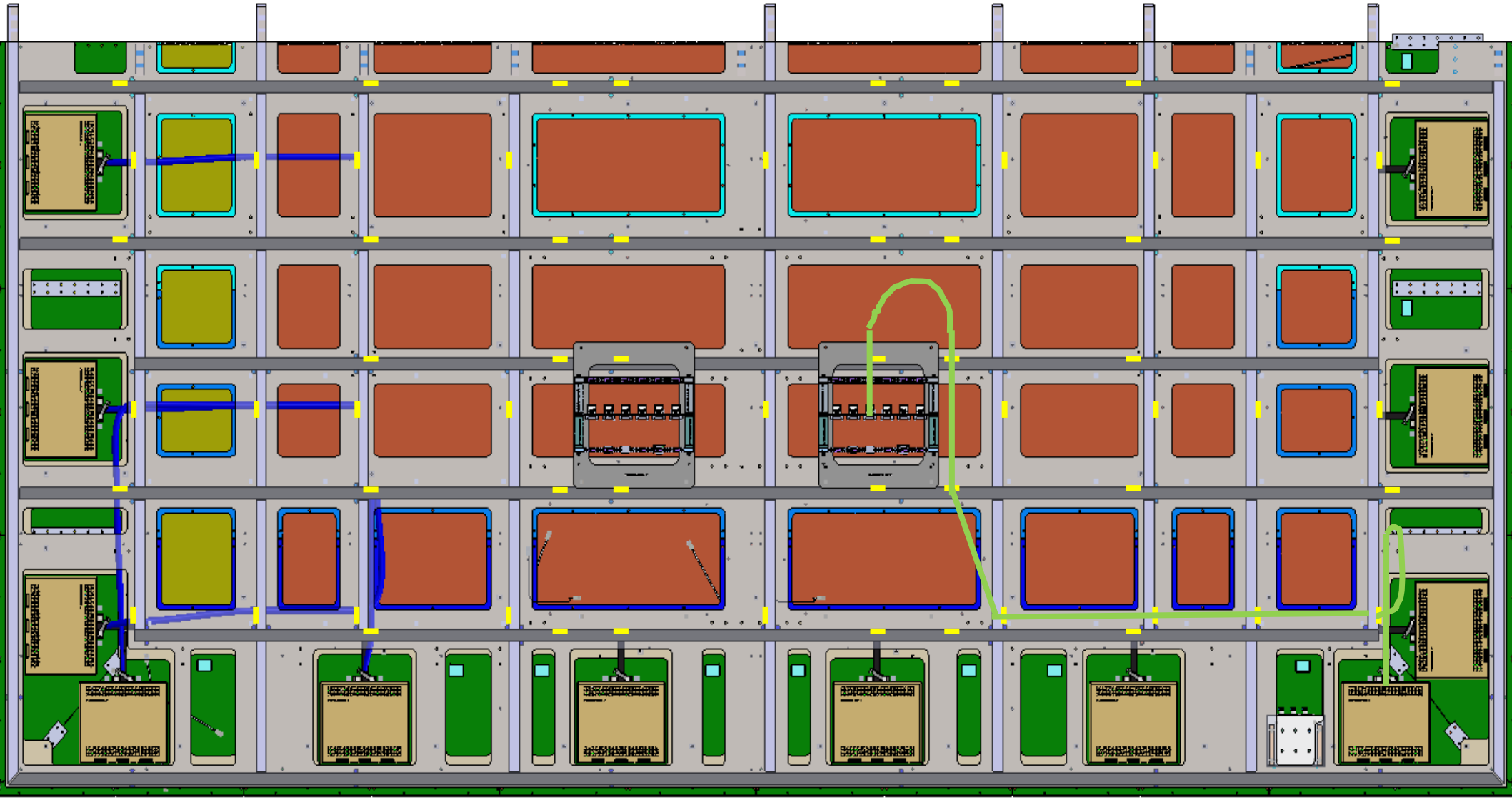


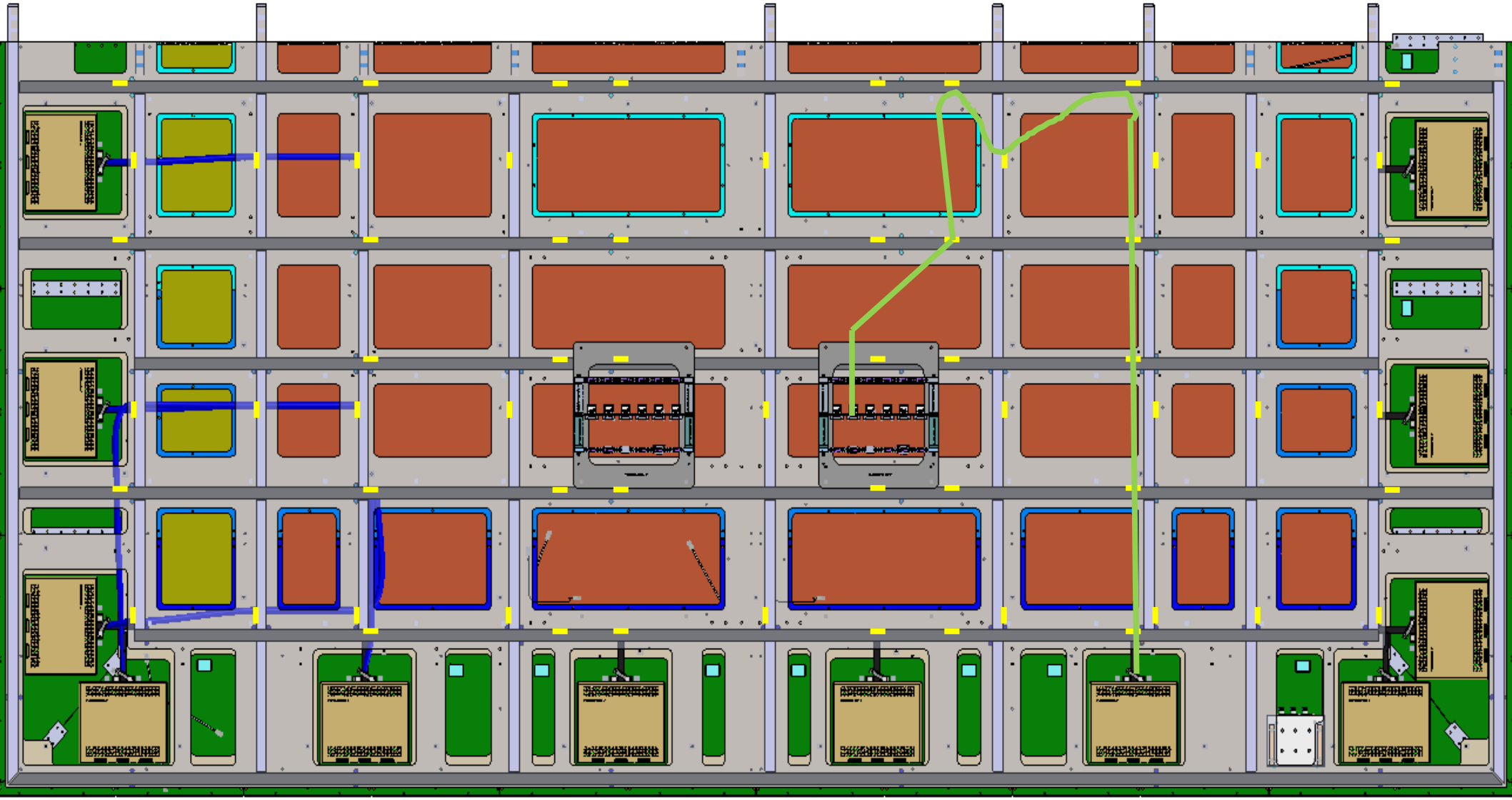
Layout of CE cables on CRP6 – from Manhong

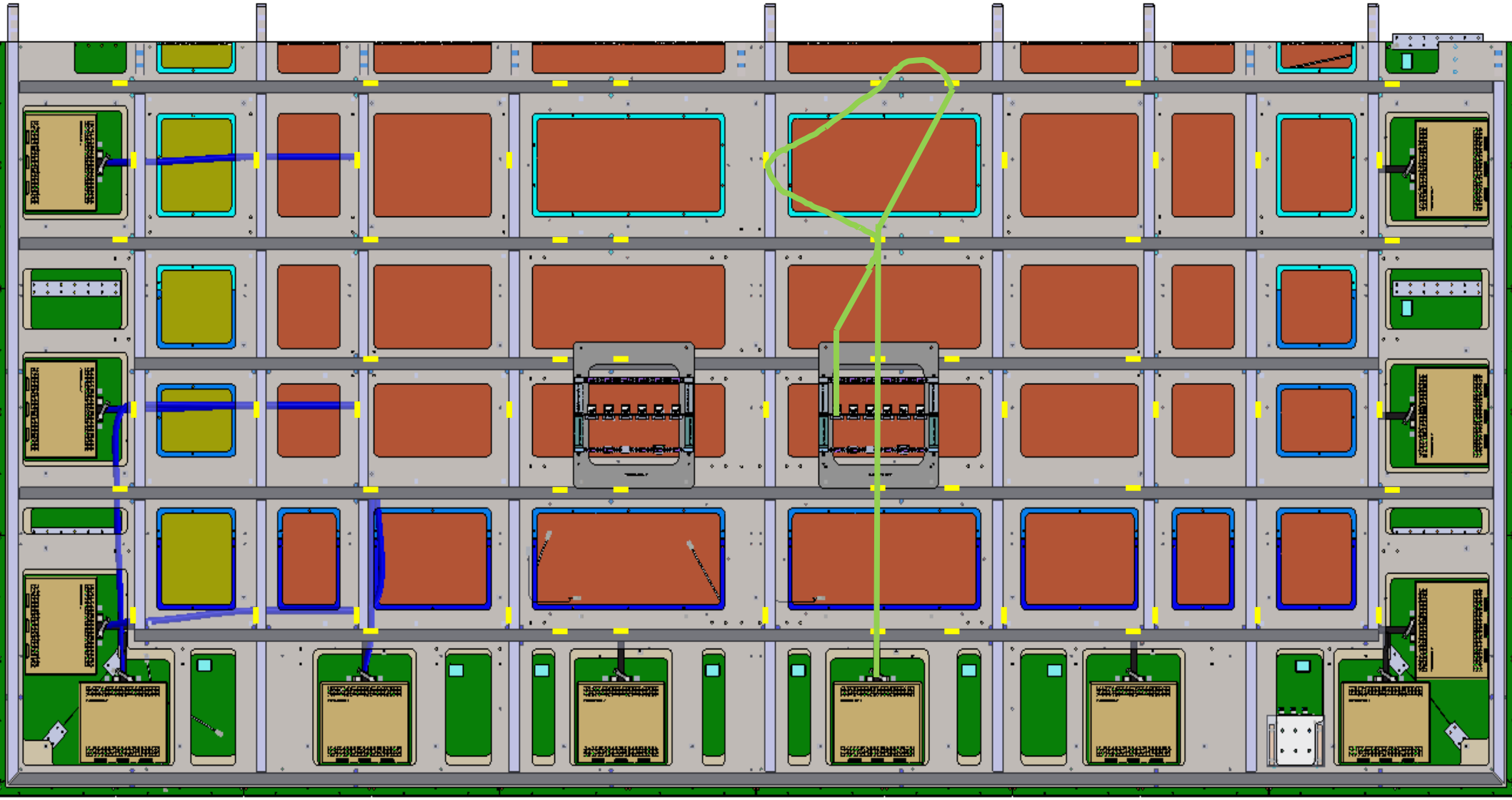




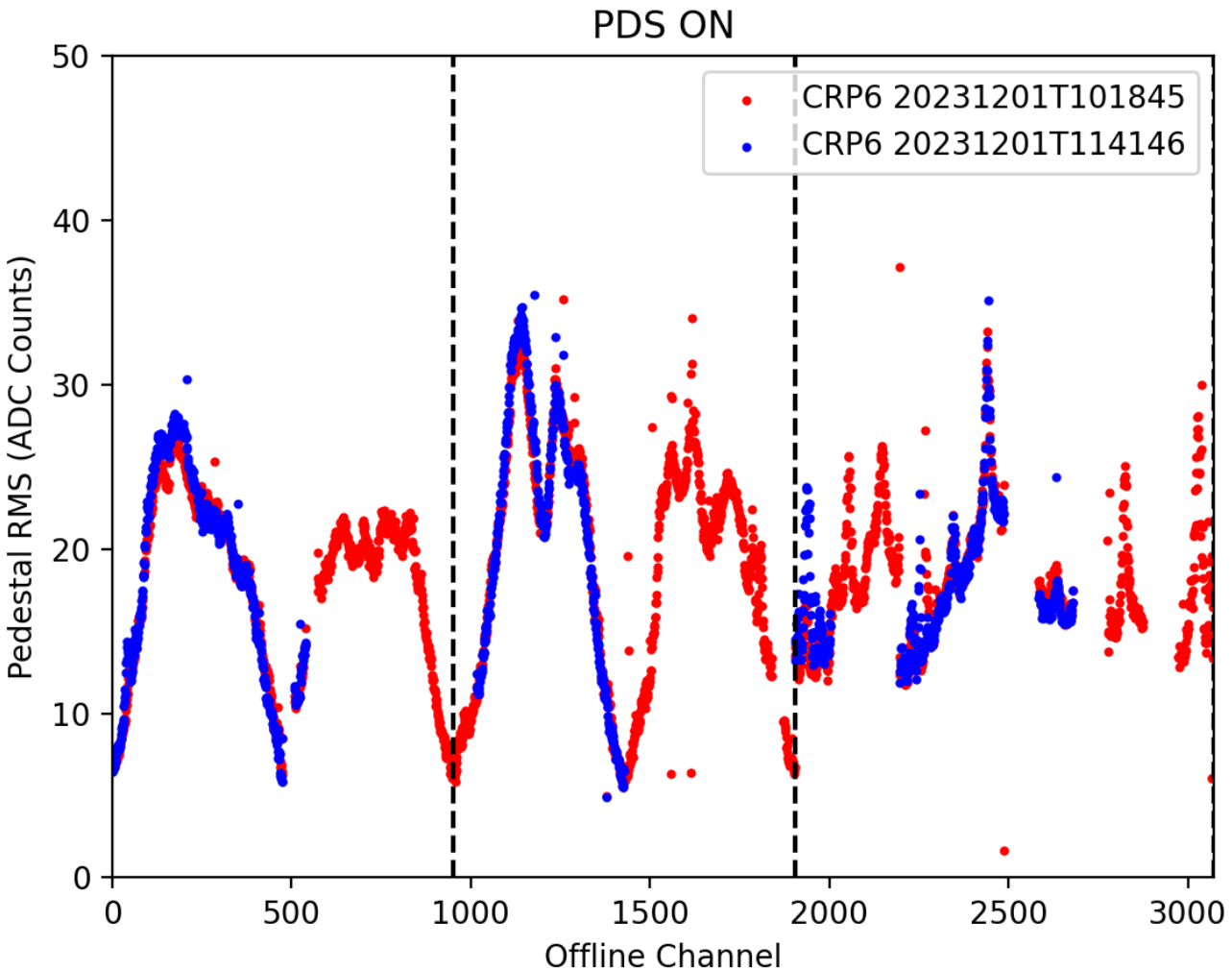








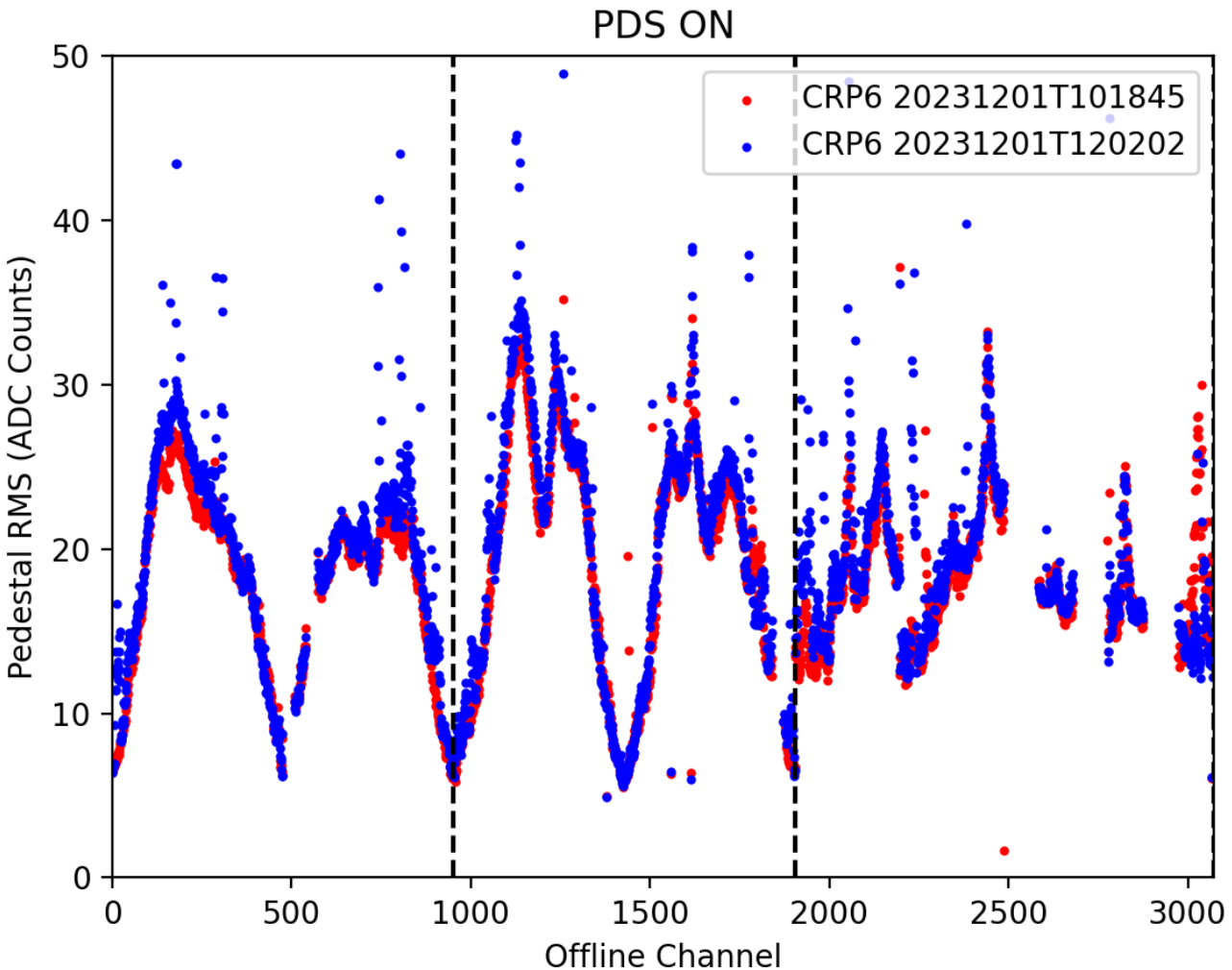
PDS ON (blue) vs OFF (red)



We don't know why some FEMBs are missing – the DAQ said there were no error messages during the run.

No noticeable effect due to PDS.

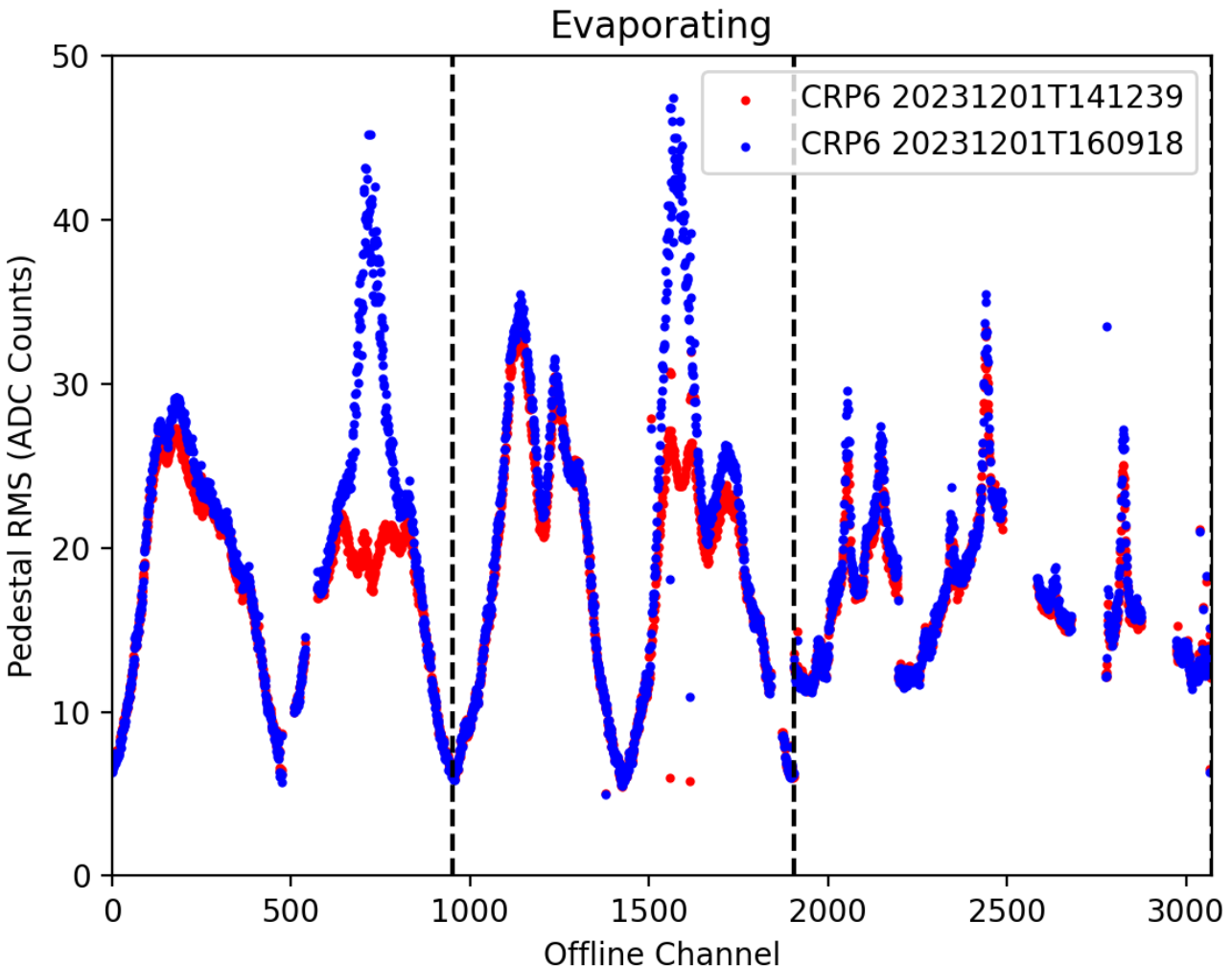
PDS ON Cathode ON (blue) vs PDS OFF Cathode OFF (red)



The extra “noise” is due to charge collection (HV is on).

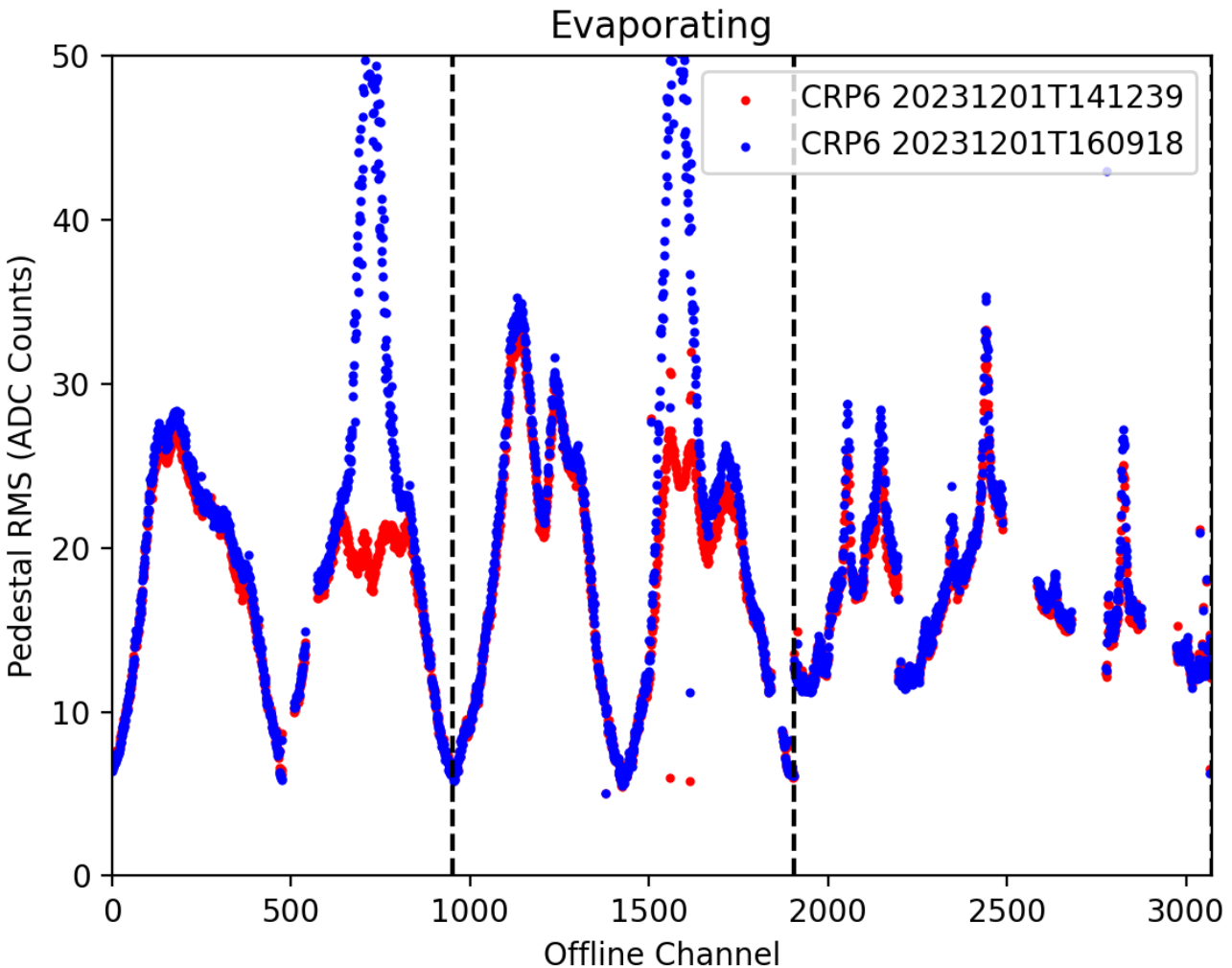
No noticeable effect due to PDS.

12/01/2023 ColdBox emptying



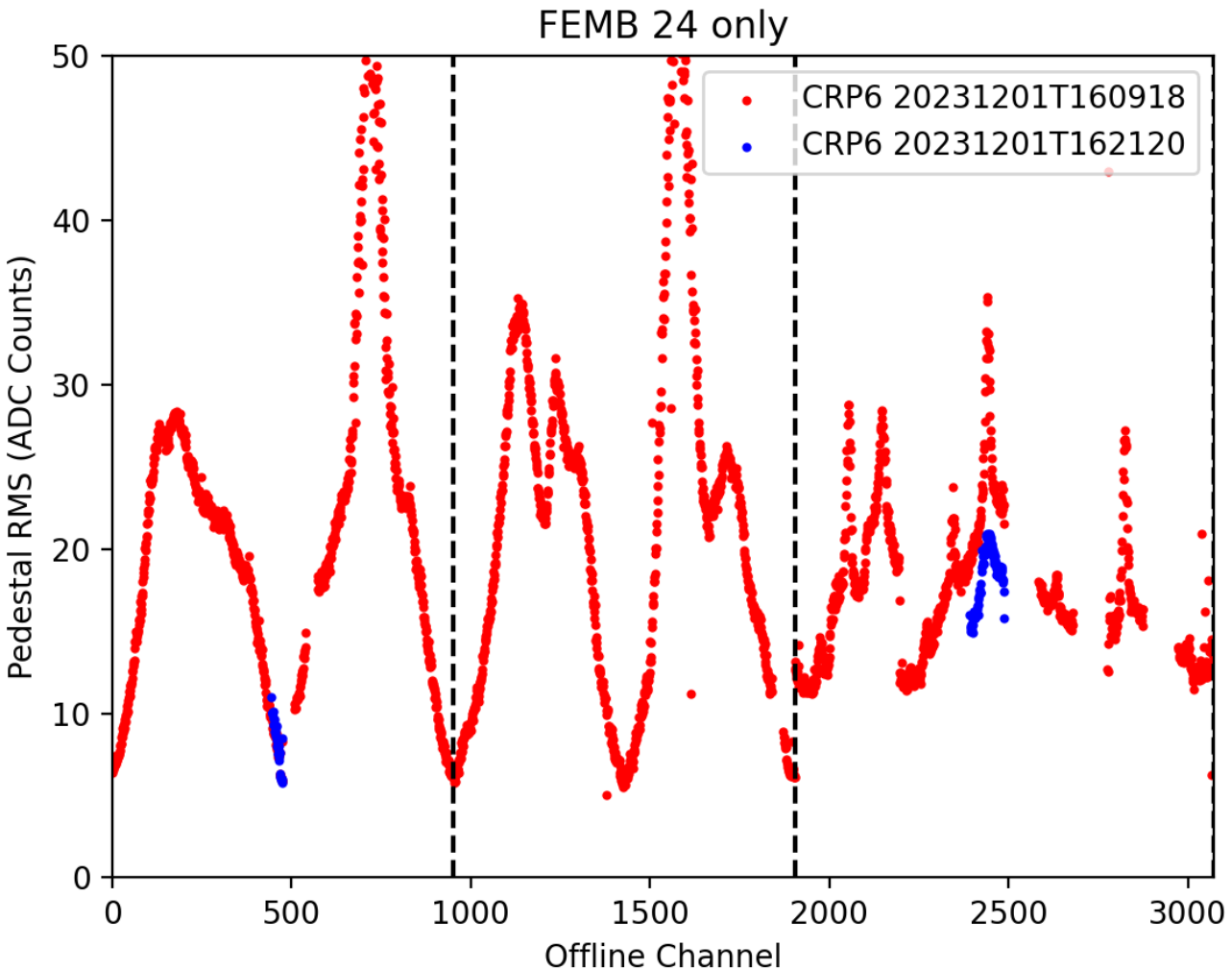
Noise due to Cryo instrumentation?

12/01/2023 ColdBox emptying



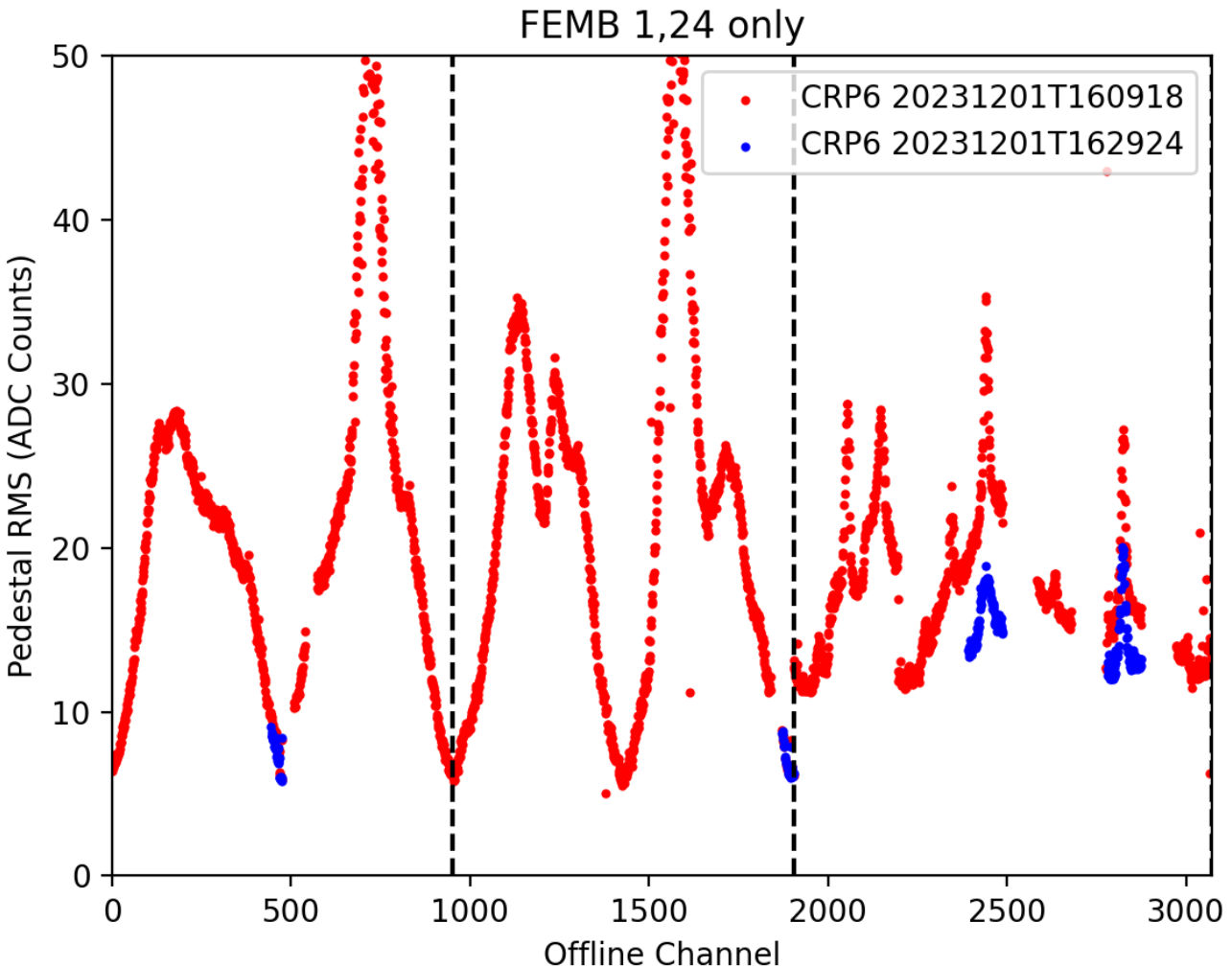
Same day, but different time, noise conditions vary, which makes it difficult to perform noise studies – results can be inconclusive.
Will use blue points here as red points on the following slides for reference.

12/01/2023 ColdBox emptying. FEMB 24 only



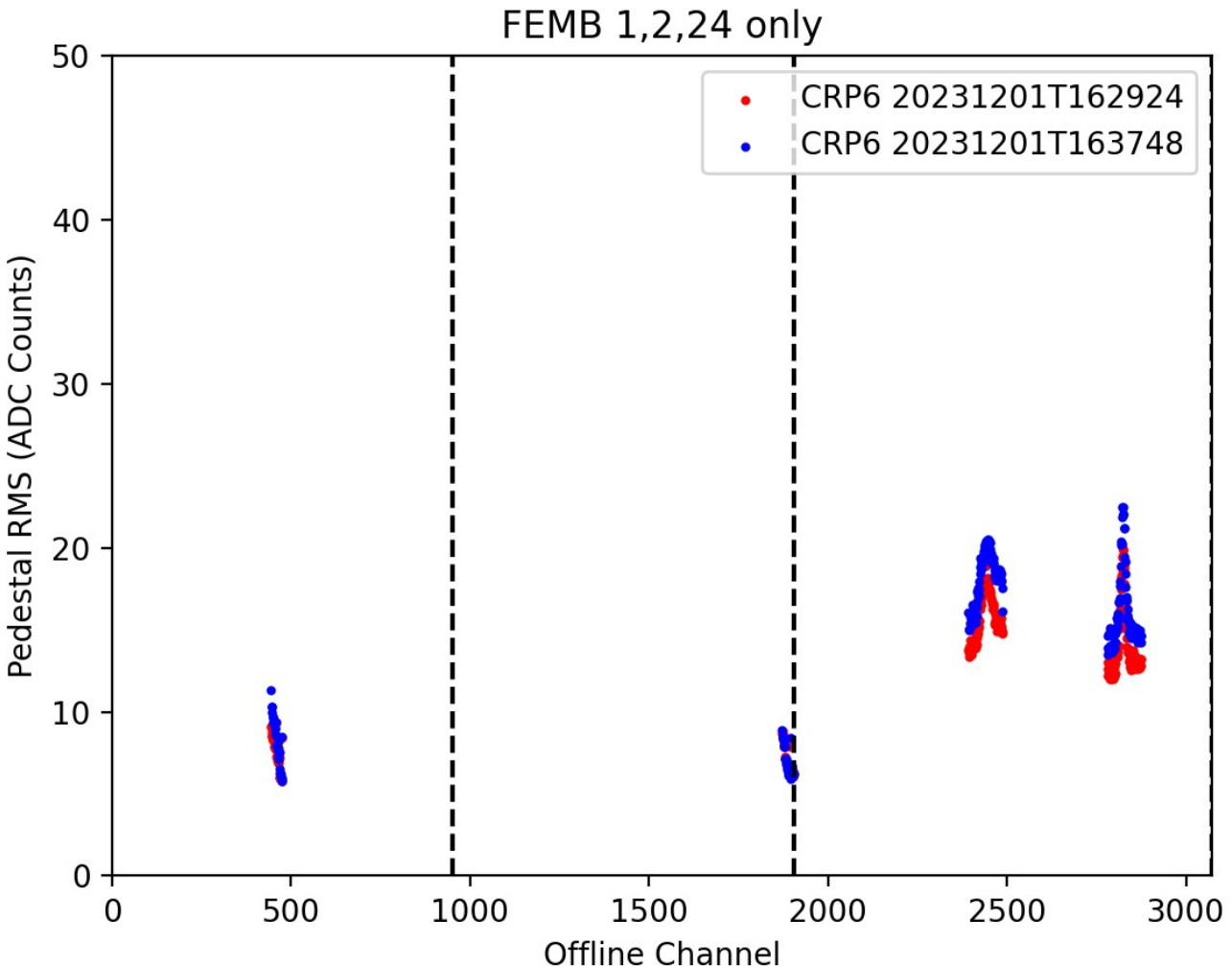
With FEMB 24 powered ON alone the noise is lower, but the peak structure persists.

12/01/2023 ColdBox emptying. FEMBs 1 and 24 only



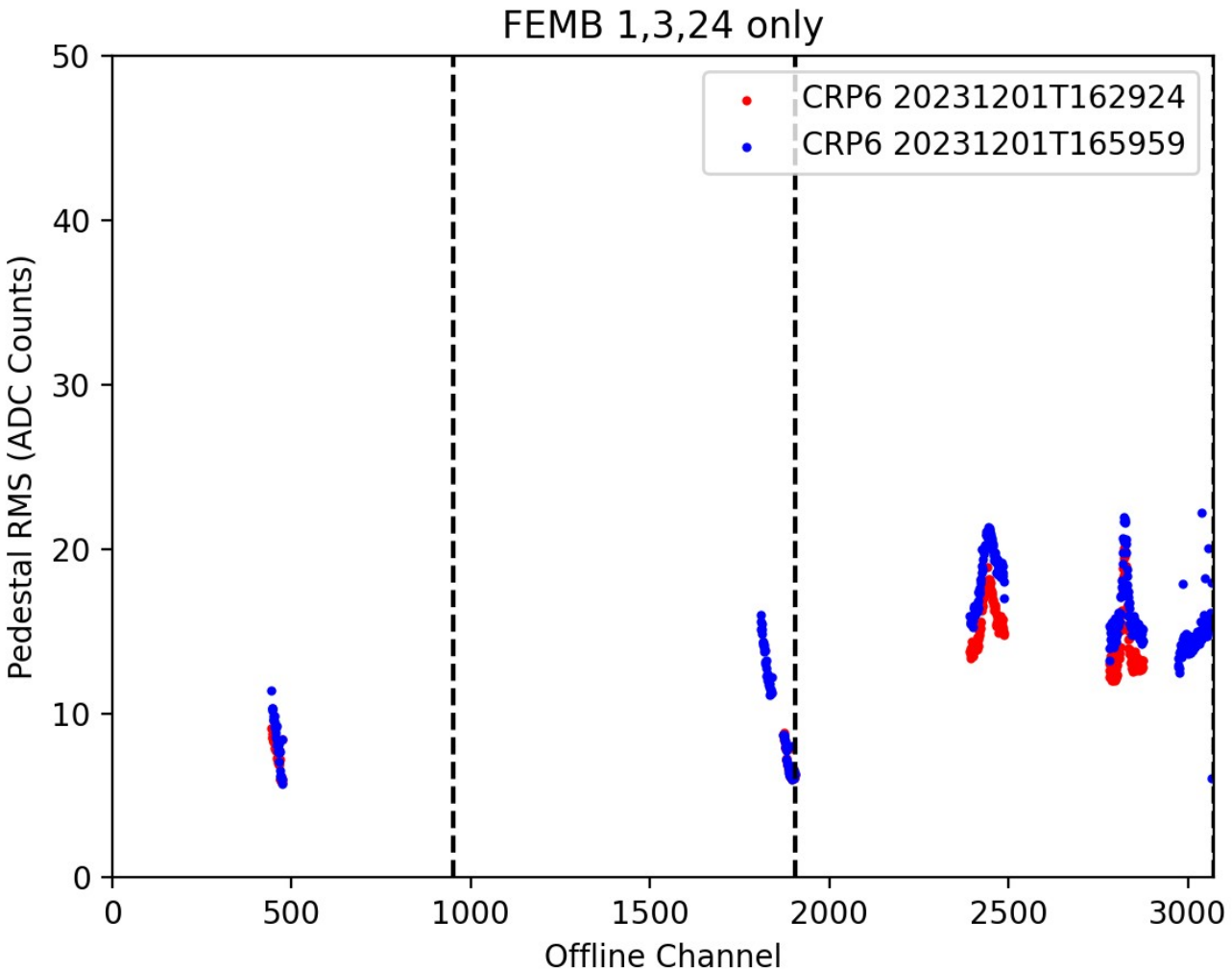
The noise on FEMB 24 went down. Is this due to interference between FEMBs 1 and 24, or the noise conditions in the ColdBox are changing?

12/01/2023 ColdBox emptying. FEMBs 1,2,24 only



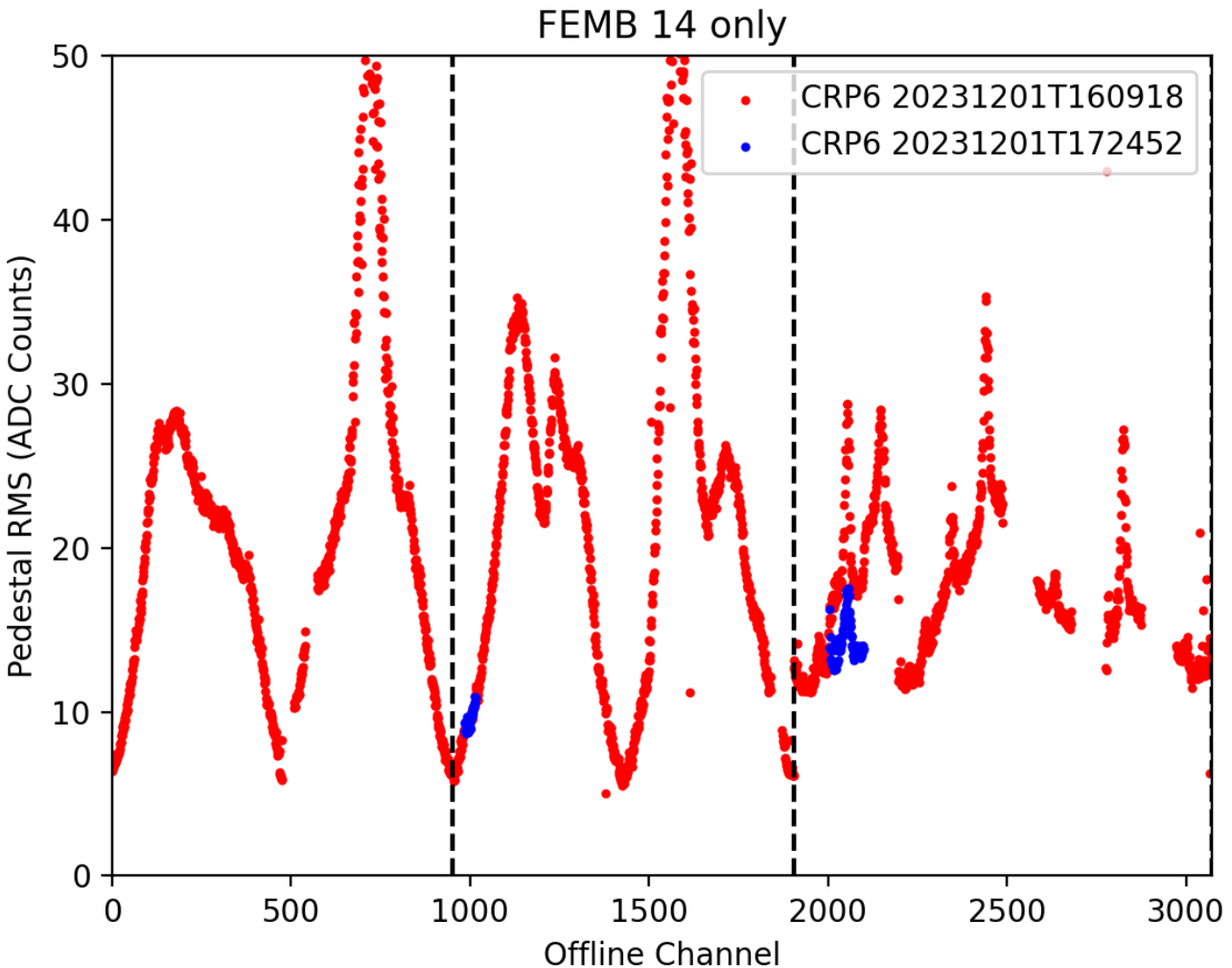
Powering ON the FEMB 2 increases the noise. Note that we do not receive data from FEMB 2.

12/01/2023 ColdBox emptying. FEMBs 1,2,3,24 only



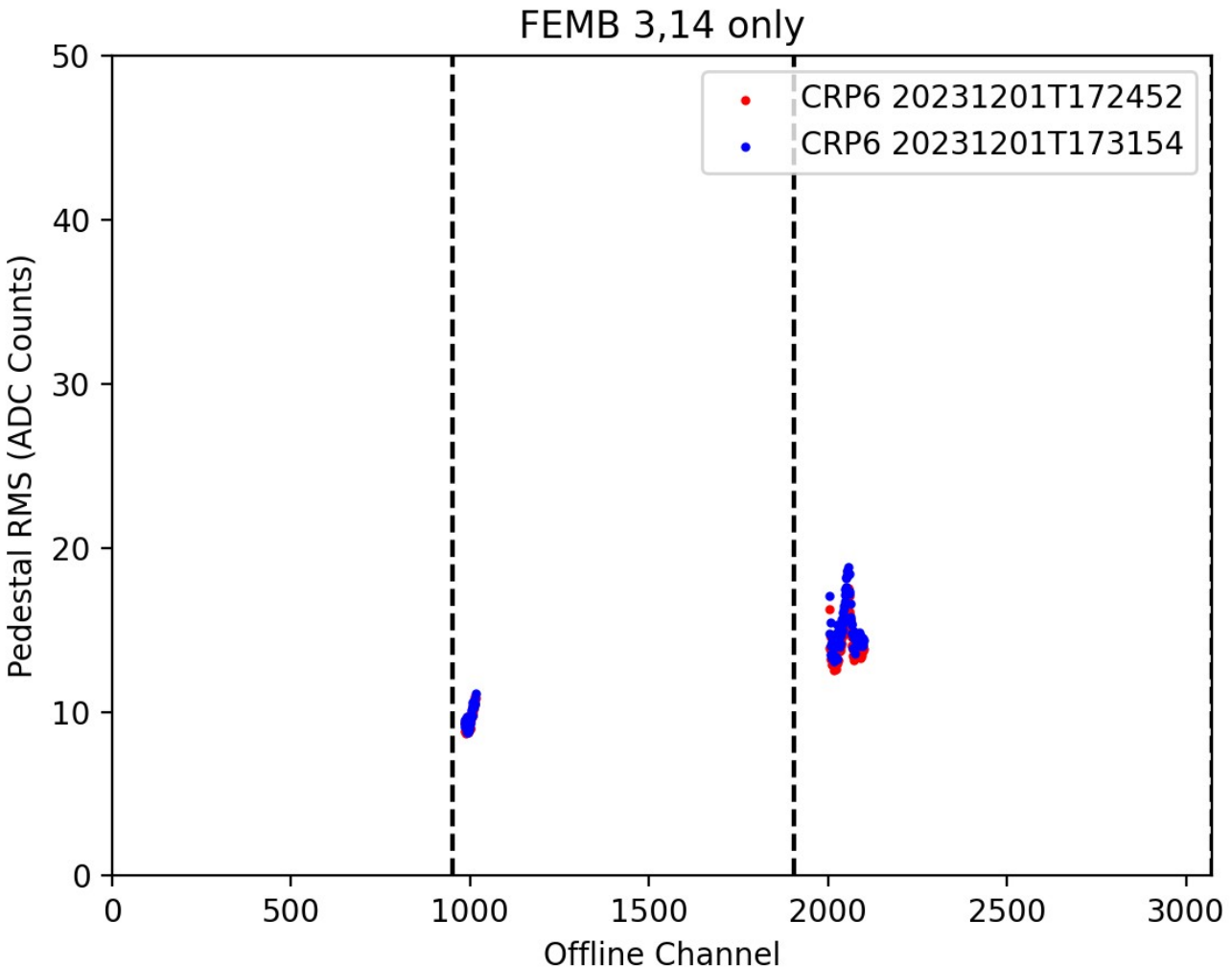
Looks like the noise goes up a bit with powering ON the FEMB 3 in addition.

12/01/2023 ColdBox emptying. FEMB 14 only



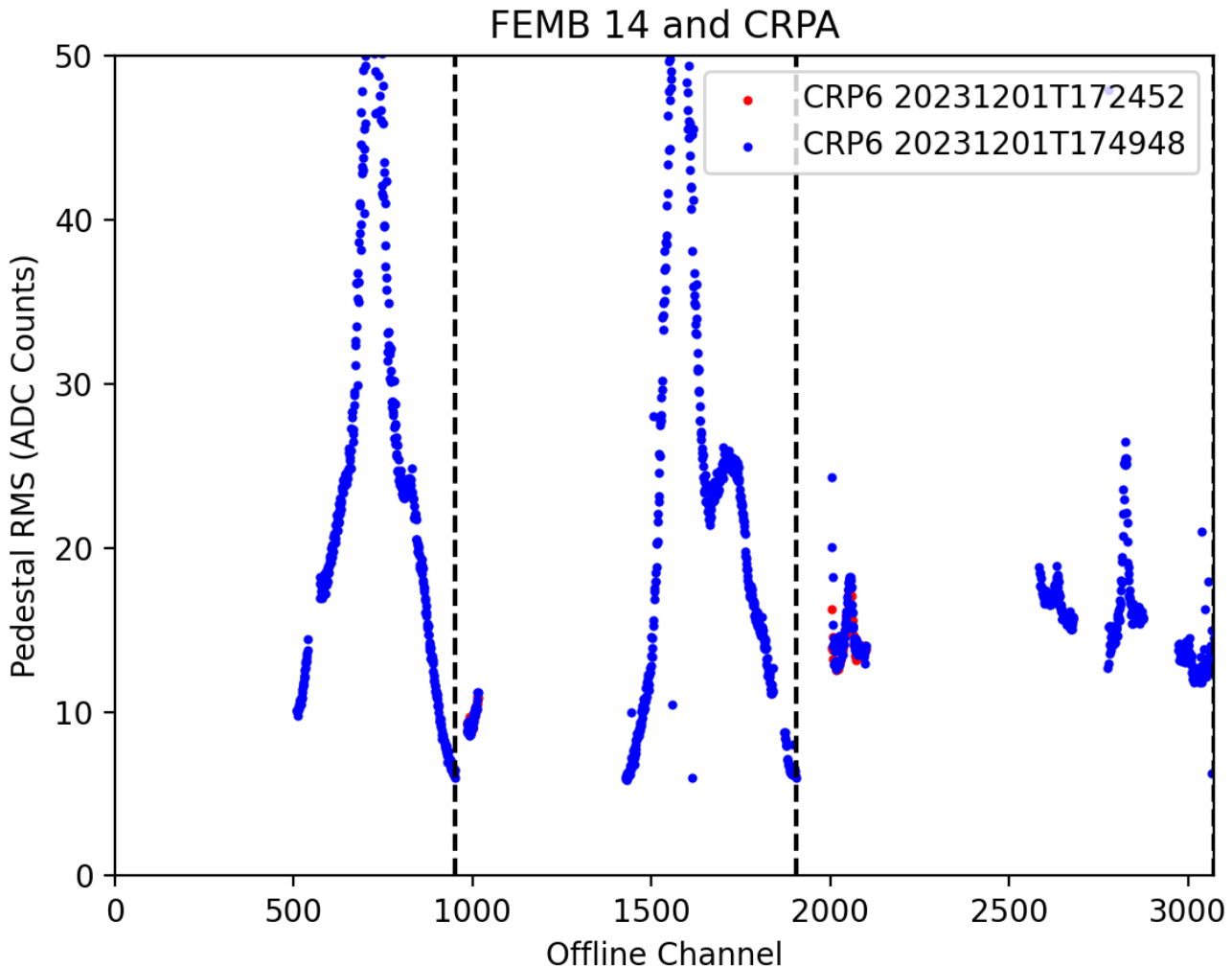
Like in the case of FEMB 24, the noise is lower, but the peak structure is there.

12/01/2023 ColdBox emptying. FEMBs 3,14 only



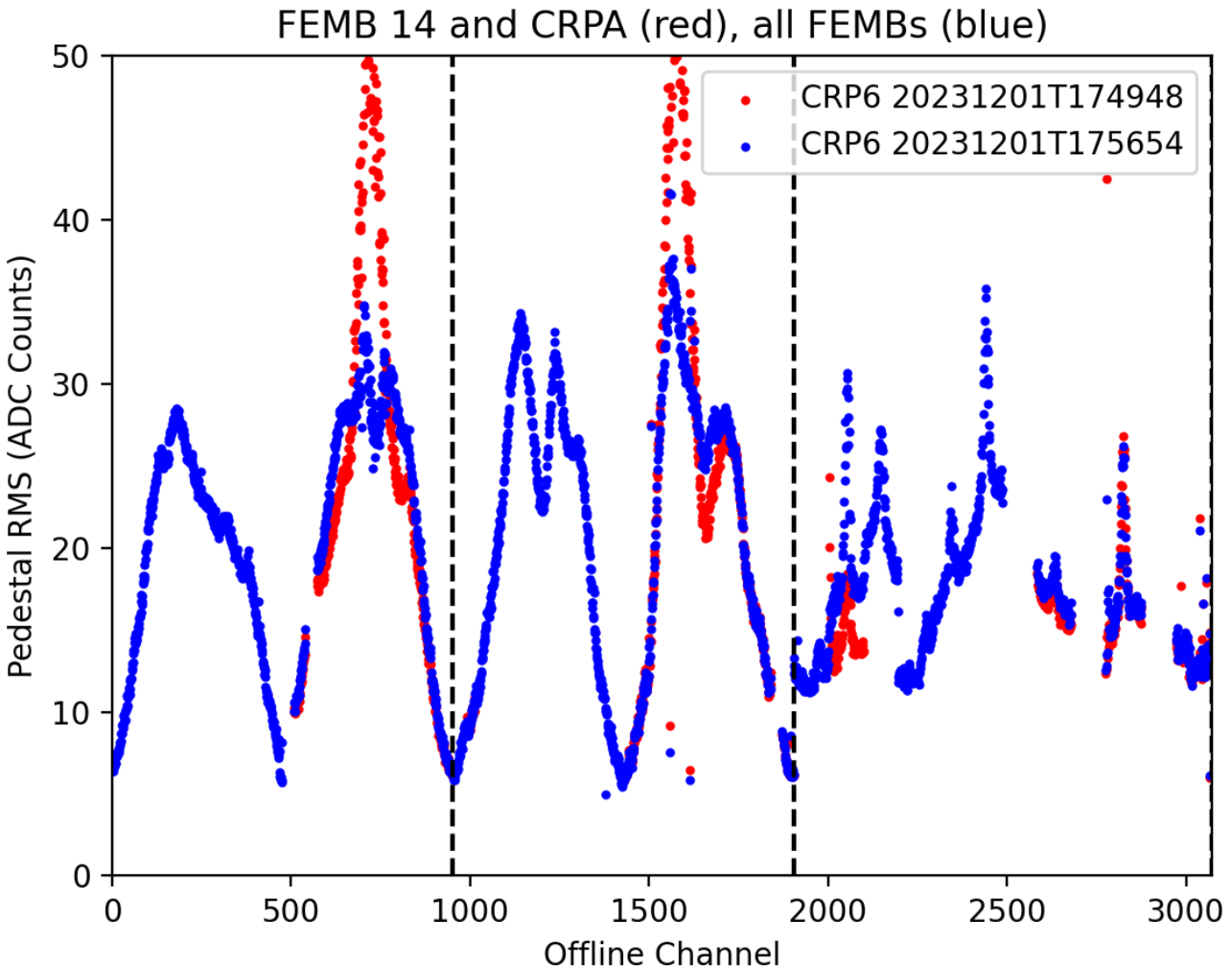
FEMB 3 was powered on, but disabled in DAQ (to save time).

12/01/2023 ColdBox emptying. FEMB 14 and CRP-A



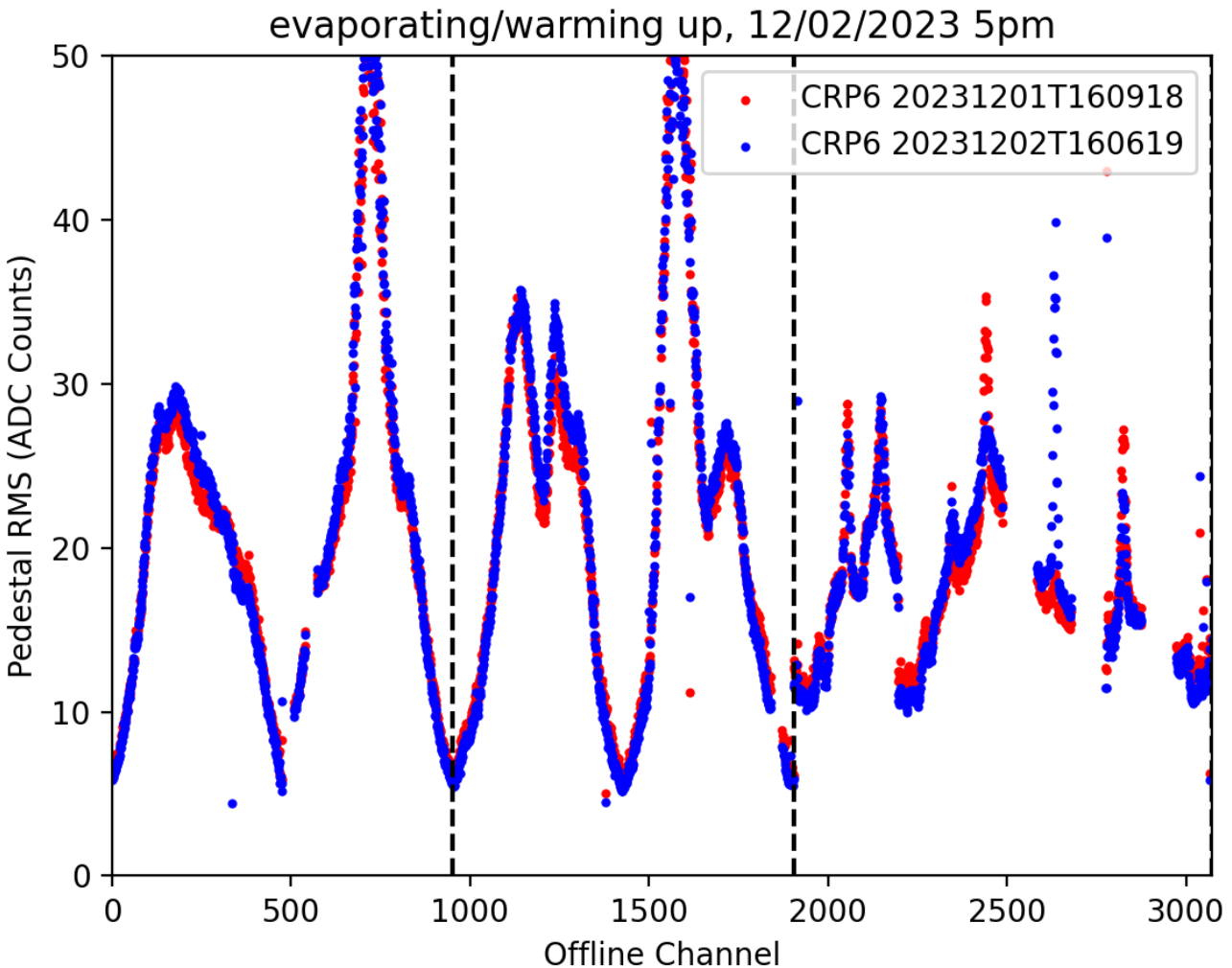
Turning ON and OFF the CRP-A has small effect on the noise level of FEMB 14.

12/01/2023 ColdBox emptying. FEMB 14 and CRP-A (red) vs all FEMBs (blue)



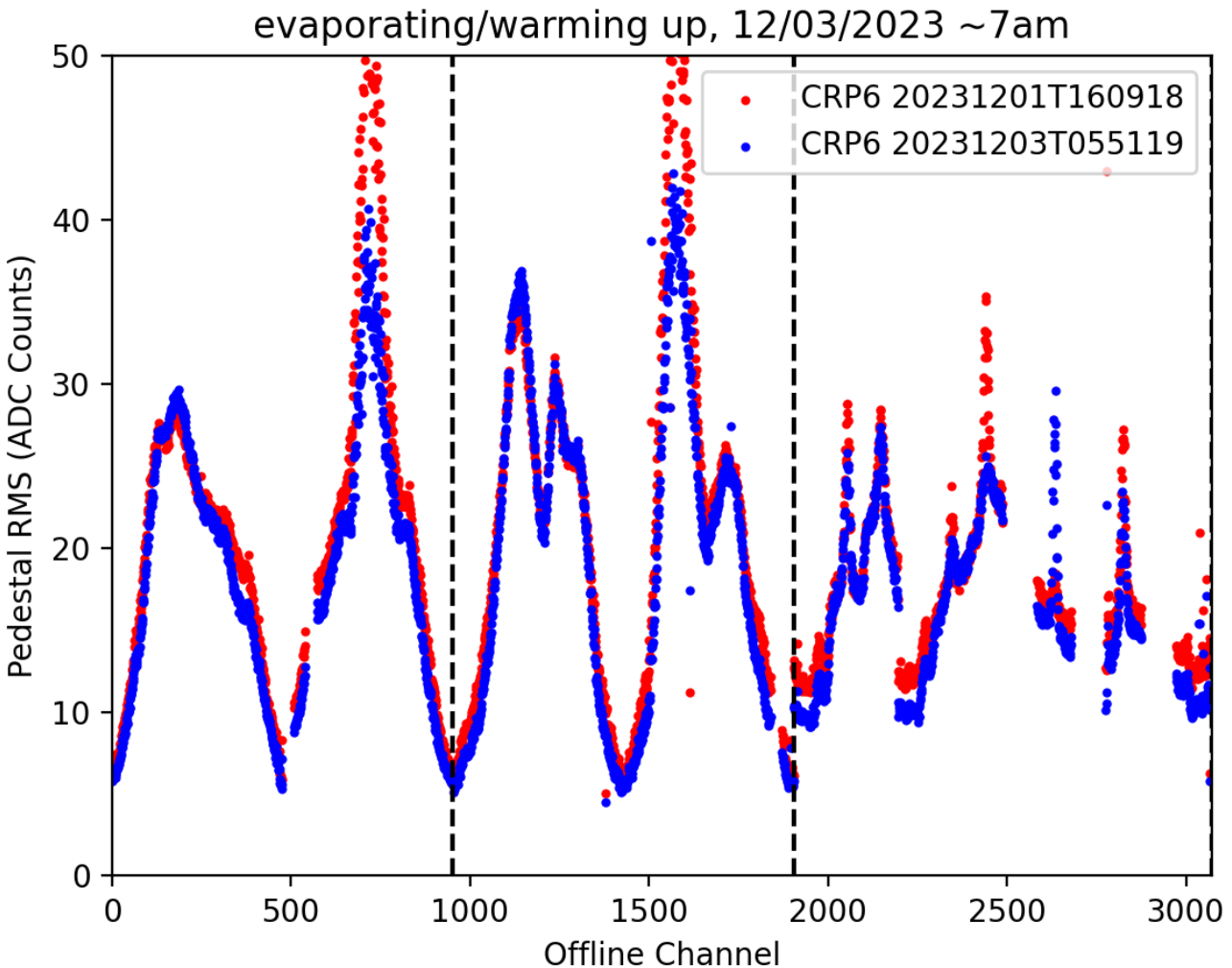
Turning ON CRP-B increases the noise level of FEMB 14.

12/02/2023 – 2nd day of ColdBox emptying.



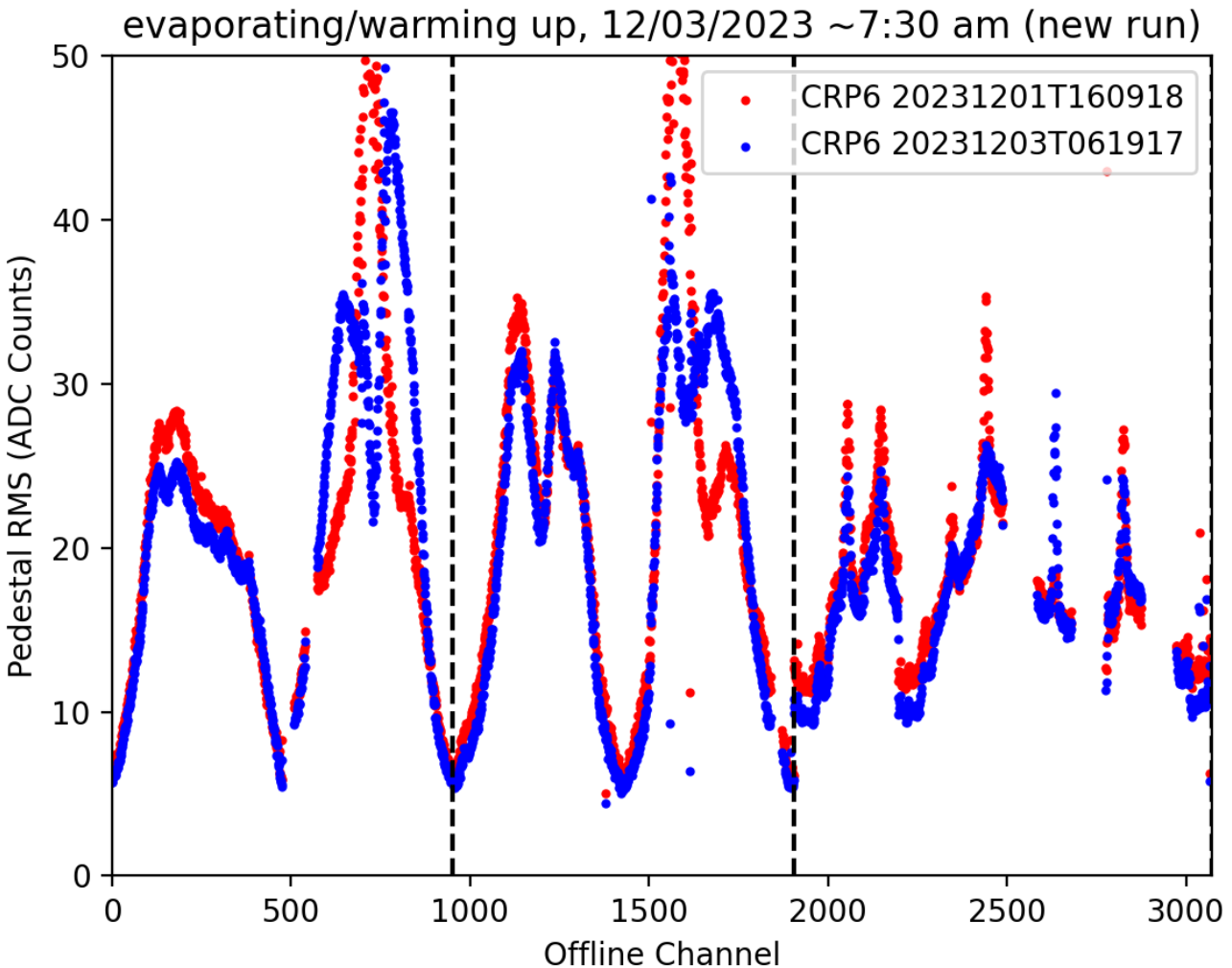
Significant noise increase at the peak of FEMB 11.

12/03/2023 – 3rd day of ColdBox emptying, early morning, ~ 7 am.



Significant noise increase at the peak of FEMB 11.

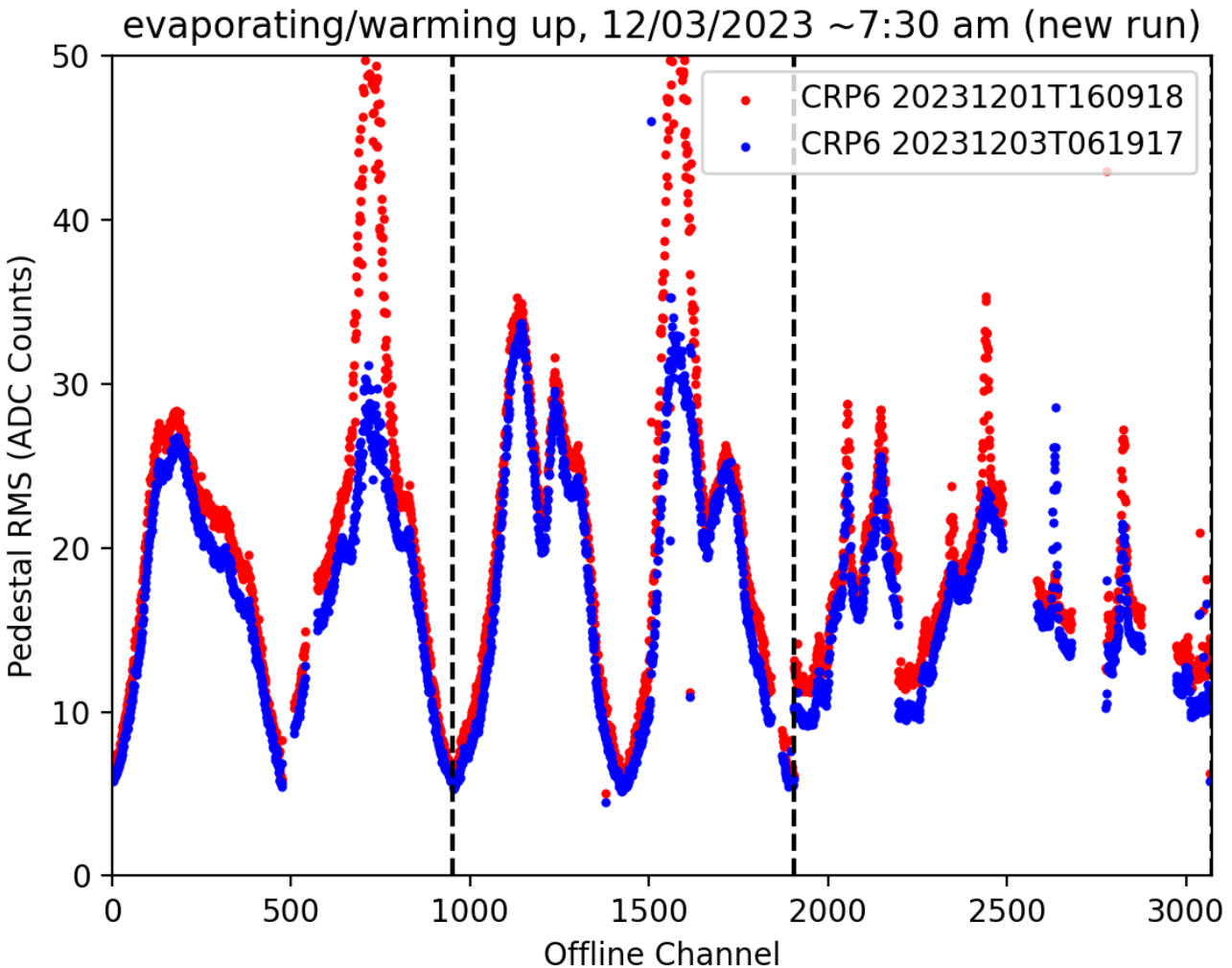
12/03/2023 – 3rd day of ColdBox emptying, ~ 7:20 am, new run.



Change in noise conditions on CRP-A. Induction 2 is affected the most.

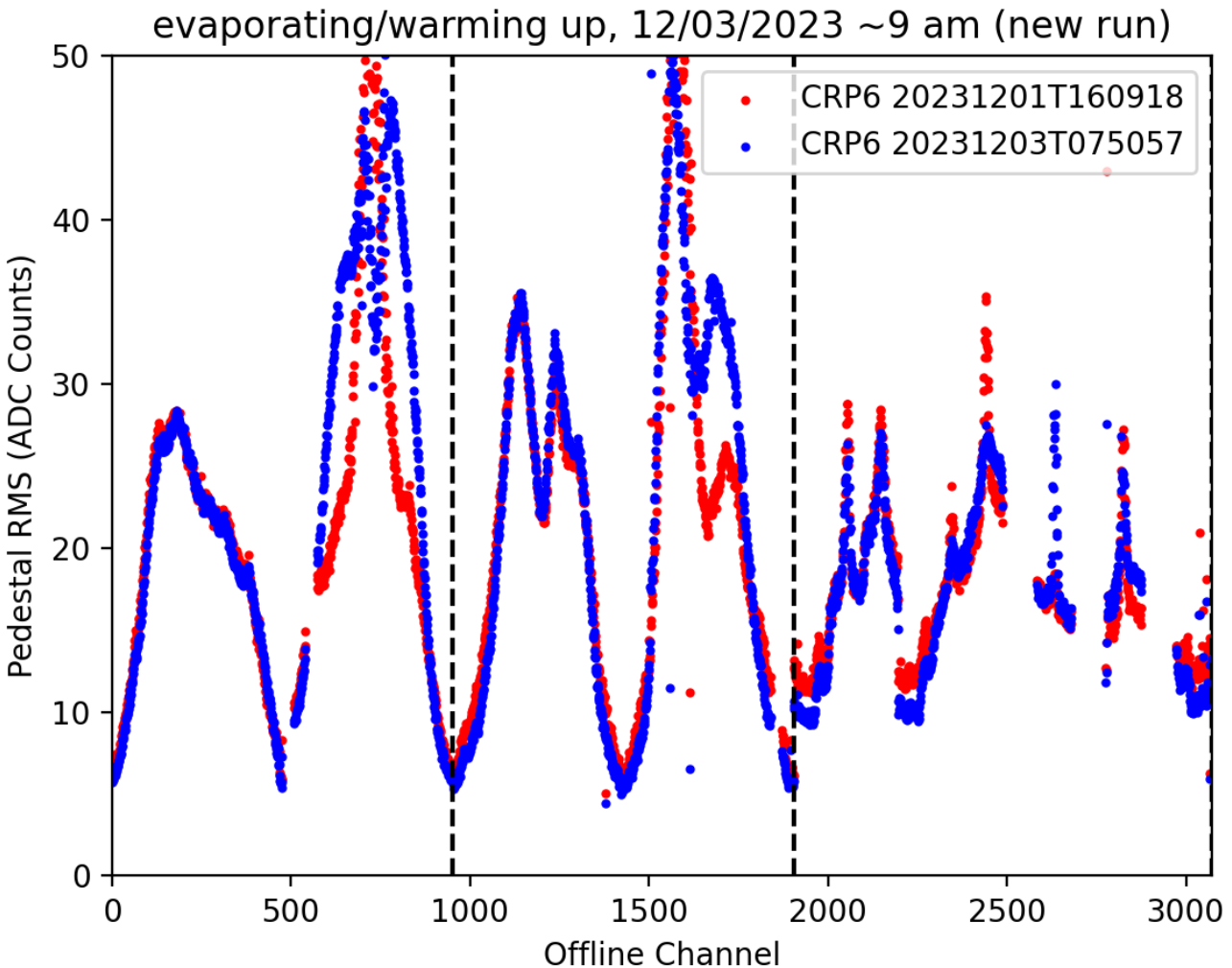
Q:
* Why CRP-A is affected the most? Is it close to cryo instrumentation?

12/03/2023 – 3rd day of ColdBox emptying, ~ 7:40 am.



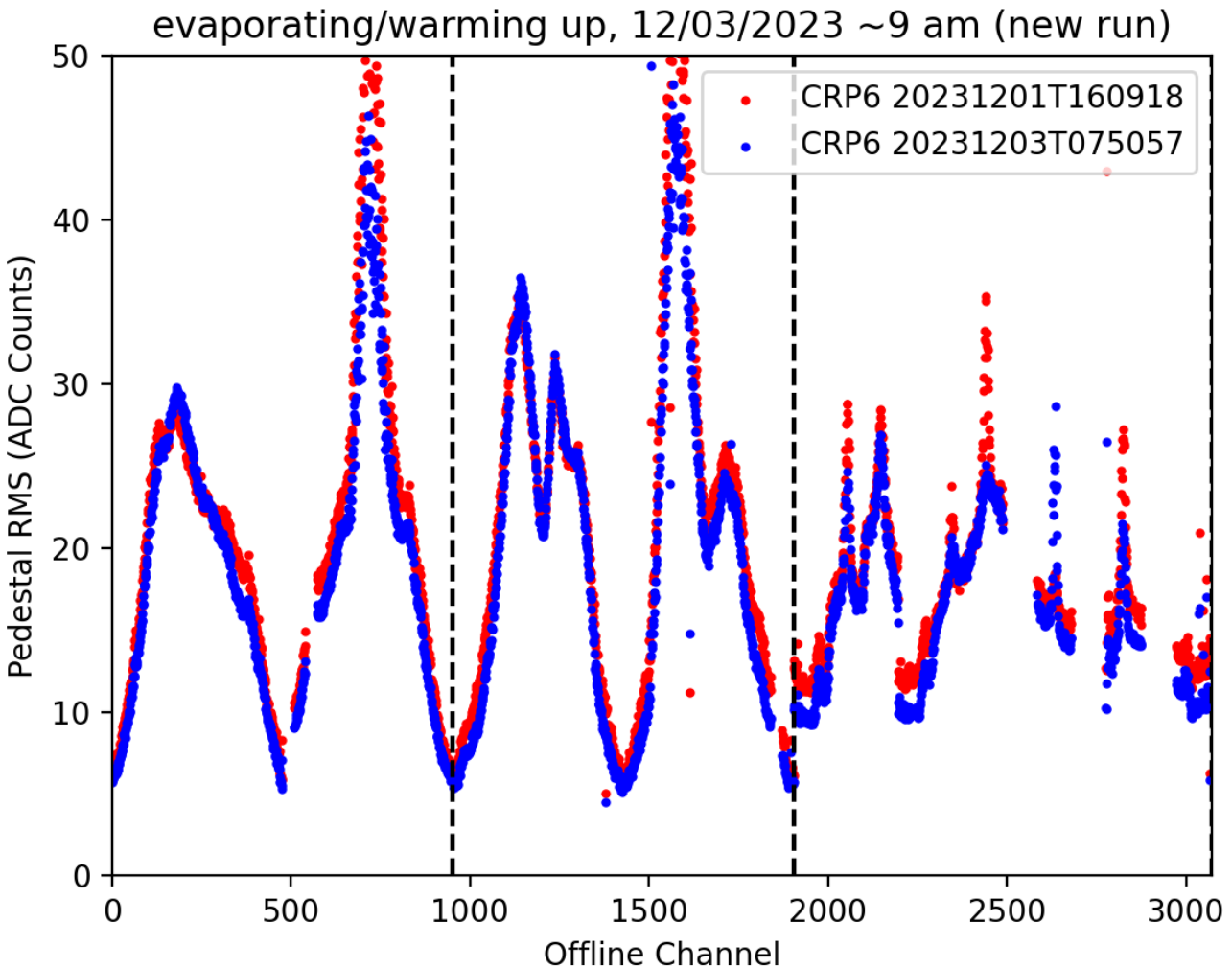
Cryo instrumentation is off?

12/03/2023 – 3rd day of ColdBox emptying, ~ 8:50 am.



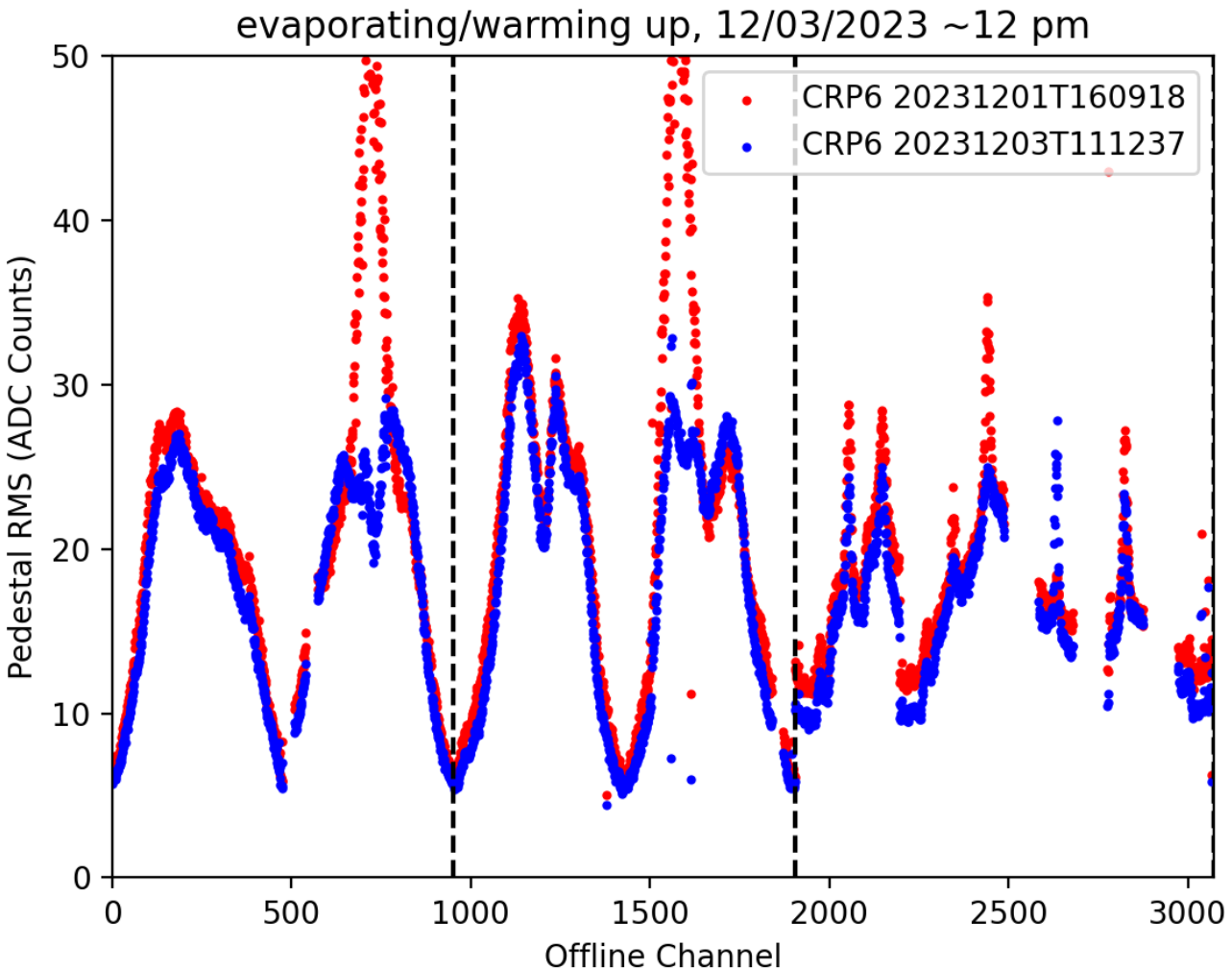
Cryo instrumentation is ON again?

12/03/2023 – 3rd day of ColdBox emptying, ~ 9:05 am.



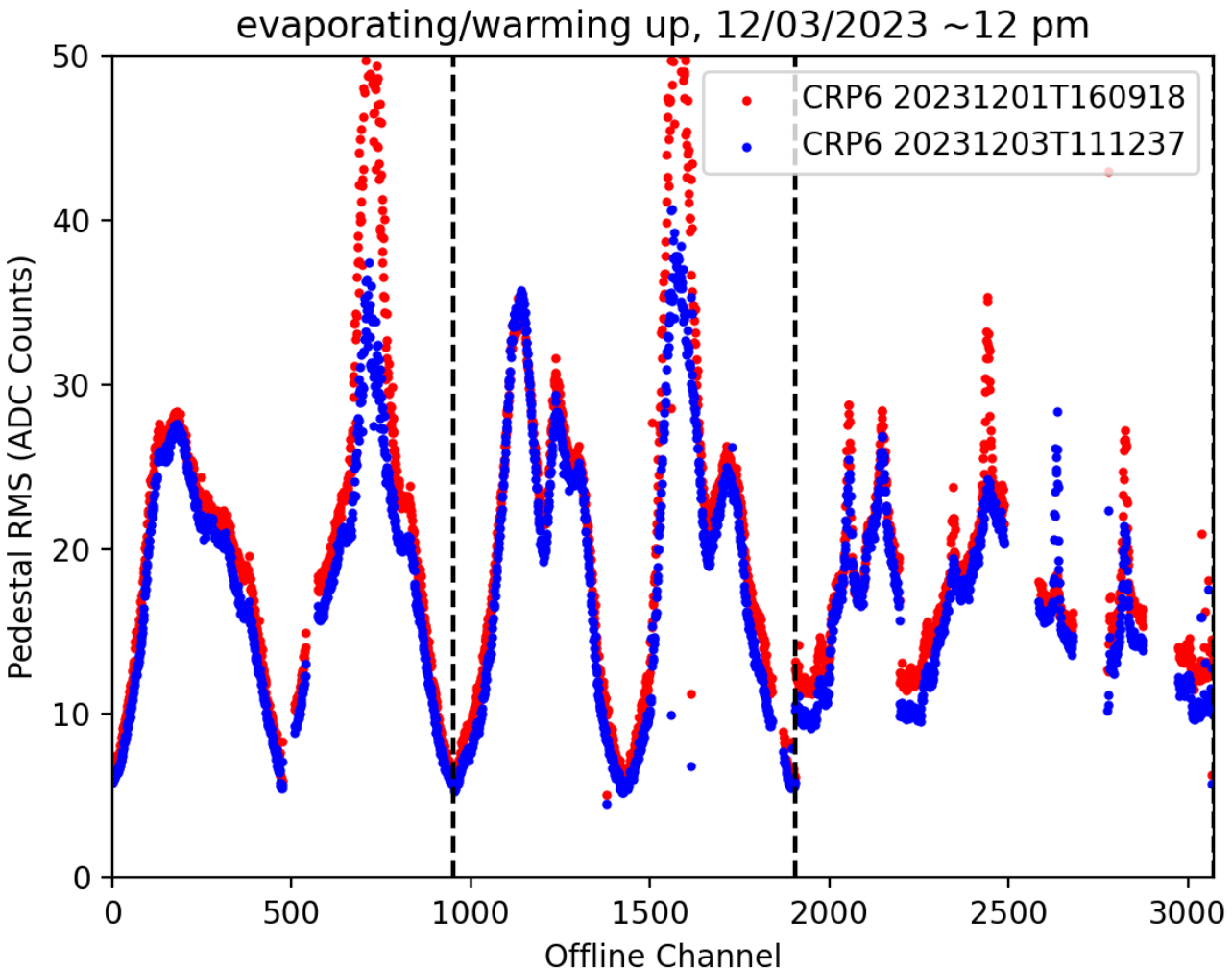
Cryo instrumentation is ON again?

12/03/2023 – 3rd day of ColdBox emptying, ~ 12 pm.



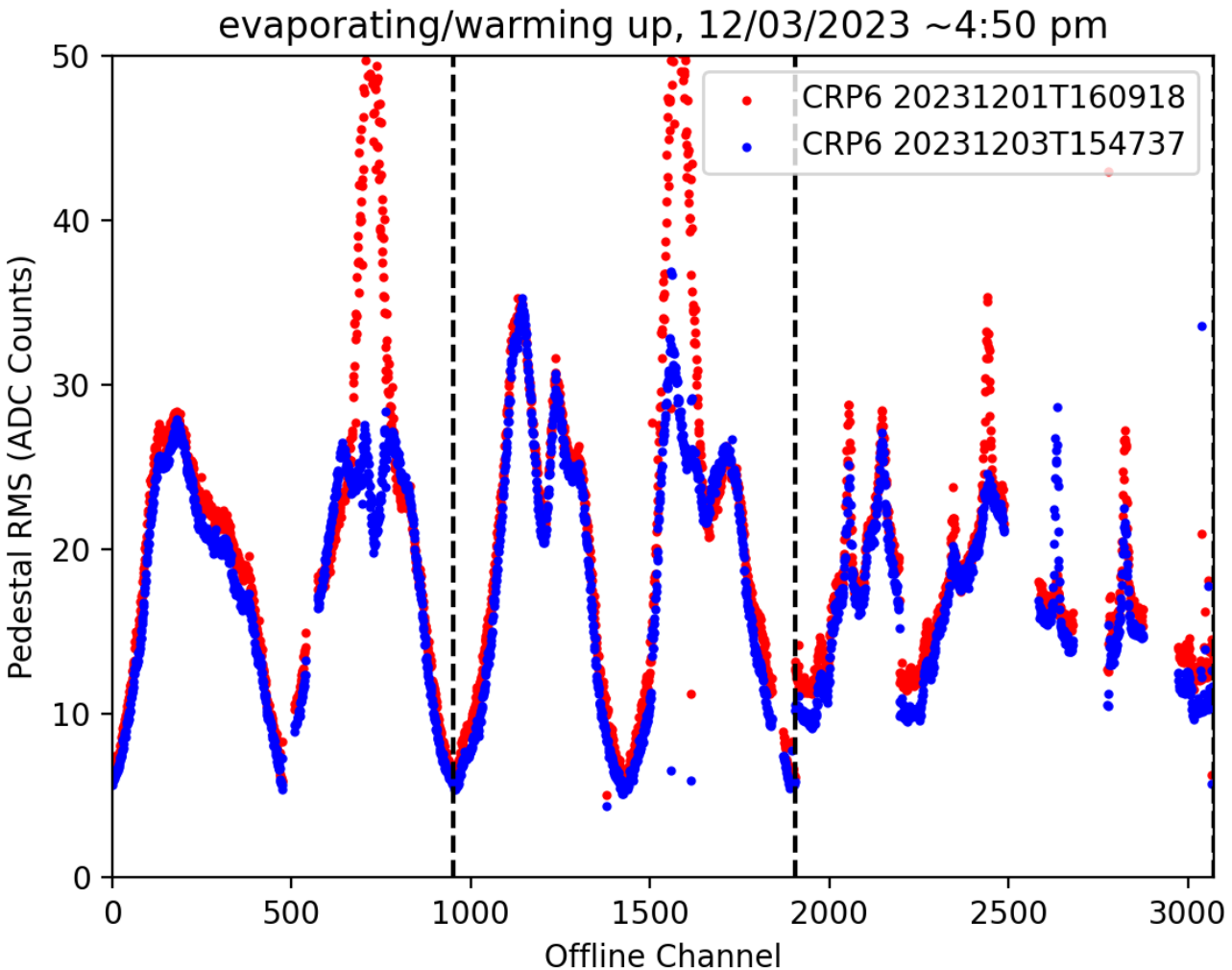
How is it possible that the noise on some channels goes up and down on others?

12/03/2023 – 3rd day of ColdBox emptying, ~ 12:03 pm.

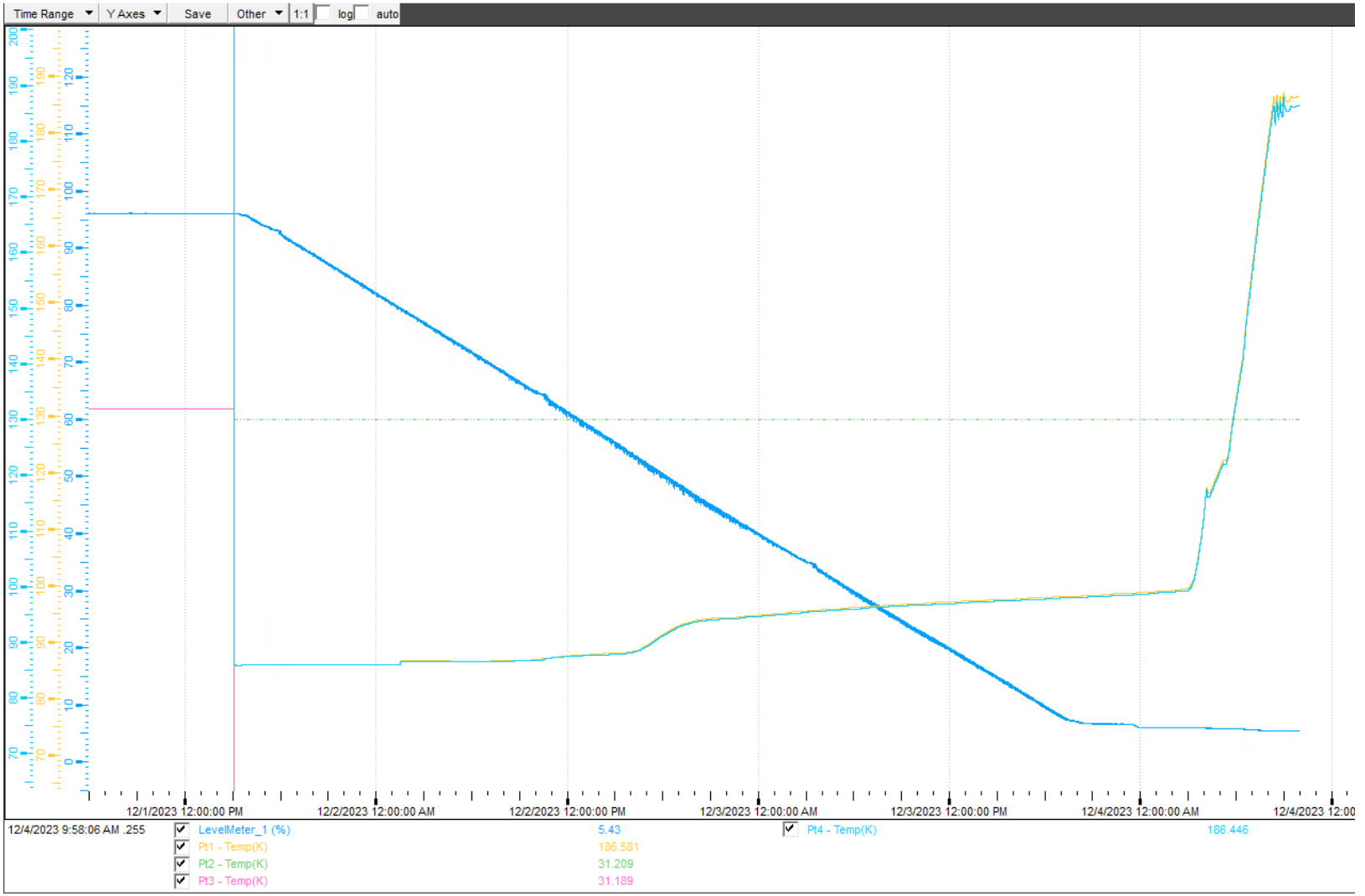


How is it possible that the noise on some channels goes up and down on others?

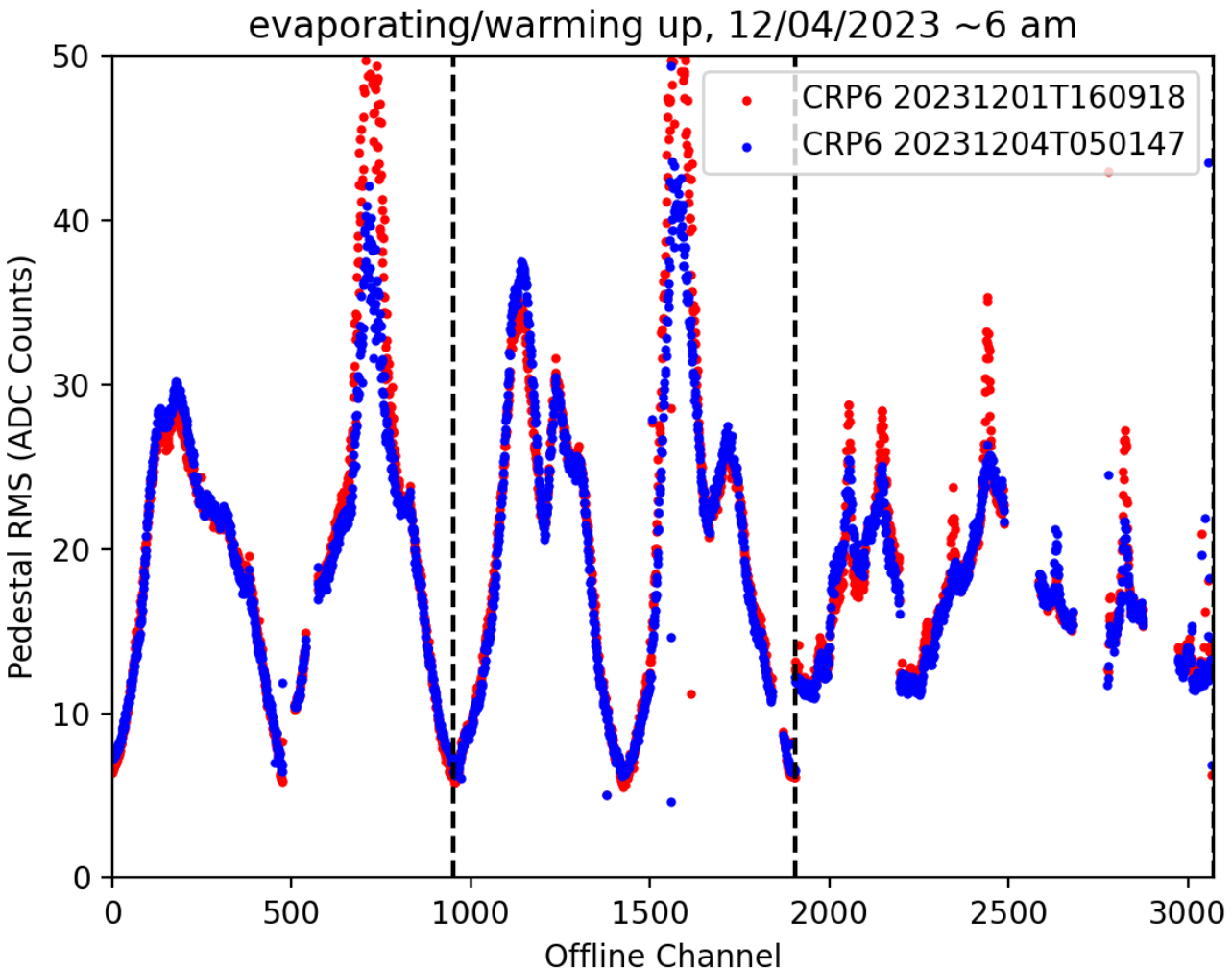
12/03/2023 – 3rd day of ColdBox emptying, ~ 4:50 pm.



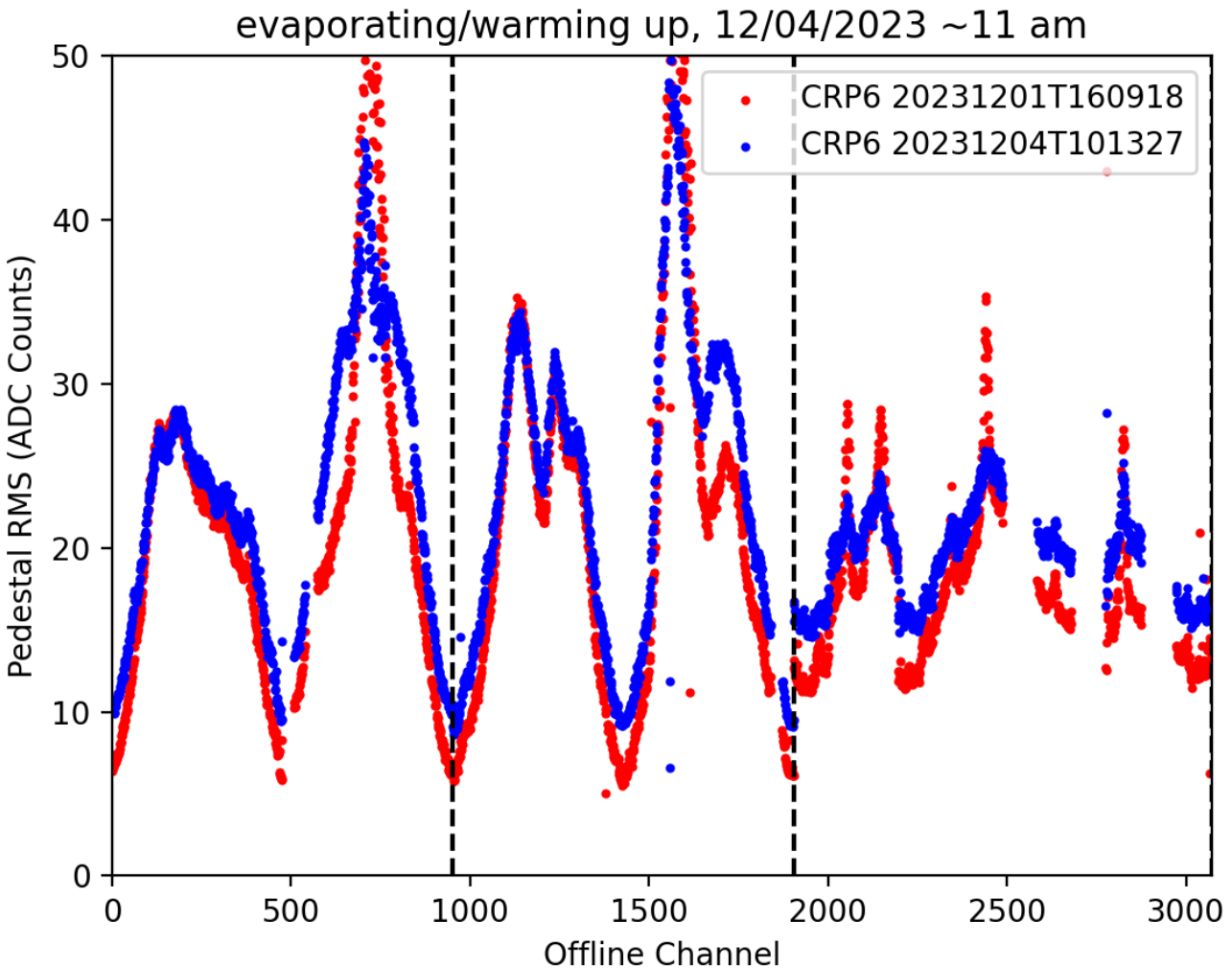
CRP6 emptying / warmup history plot



12/04/2023 – 4th day of ColdBox emptying, ~ 6 am

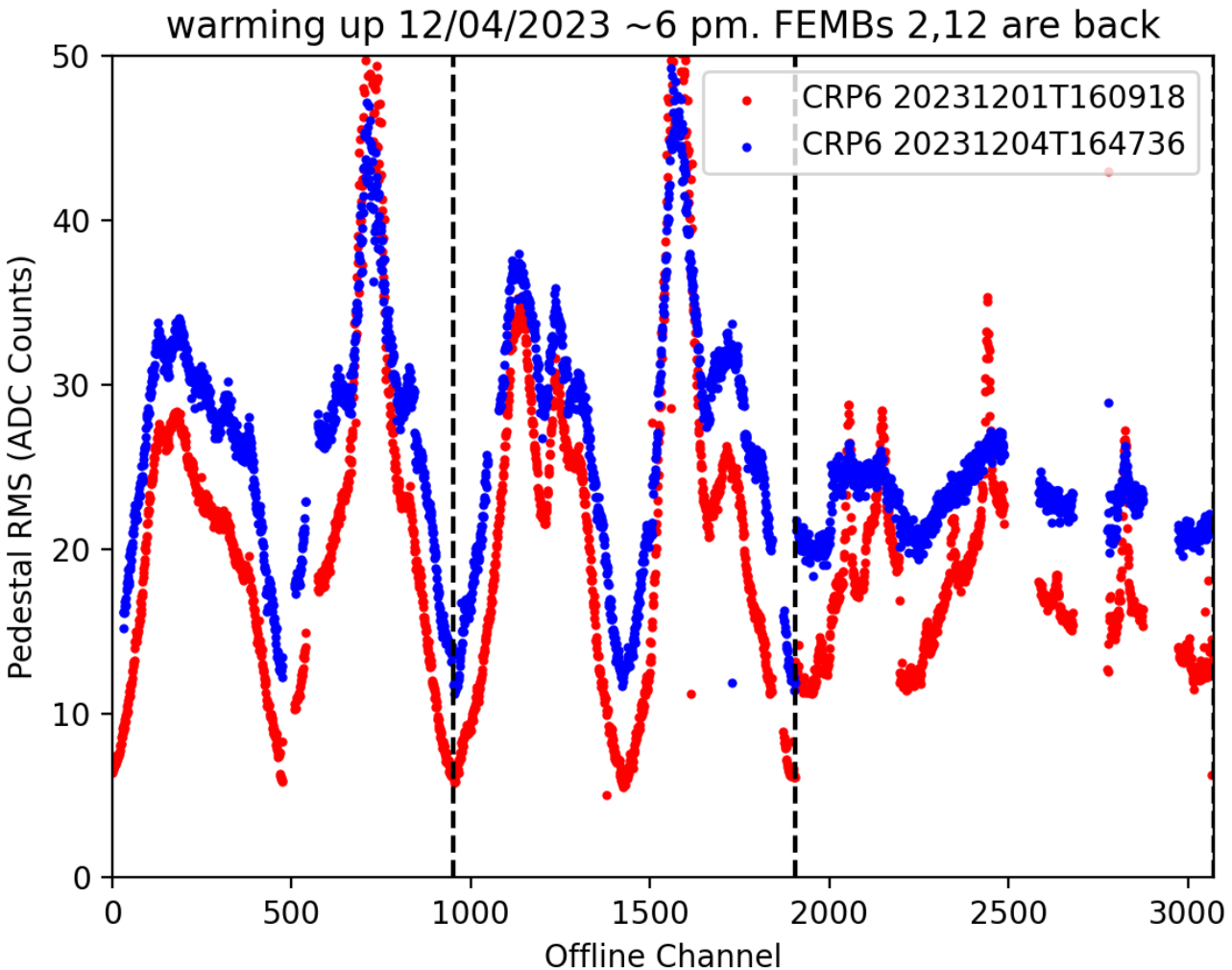


12/04/2023 – 4th day of ColdBox emptying, ~ 11 am, T~190 K.



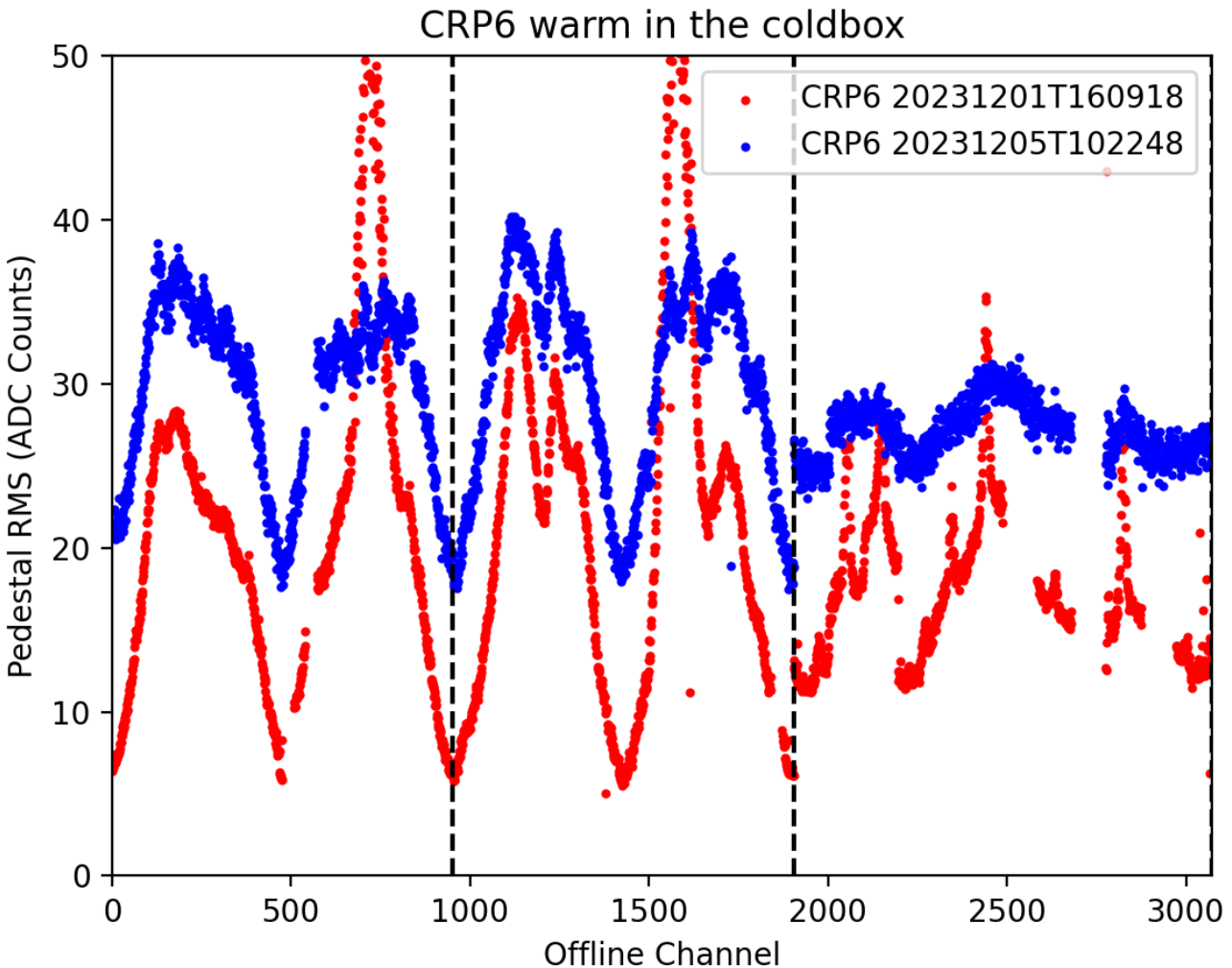
LArASIC noise went up with temperature, as expected.

12/04/2023 – 4th day of ColdBox warmup, ~ 6pm, T~? K.



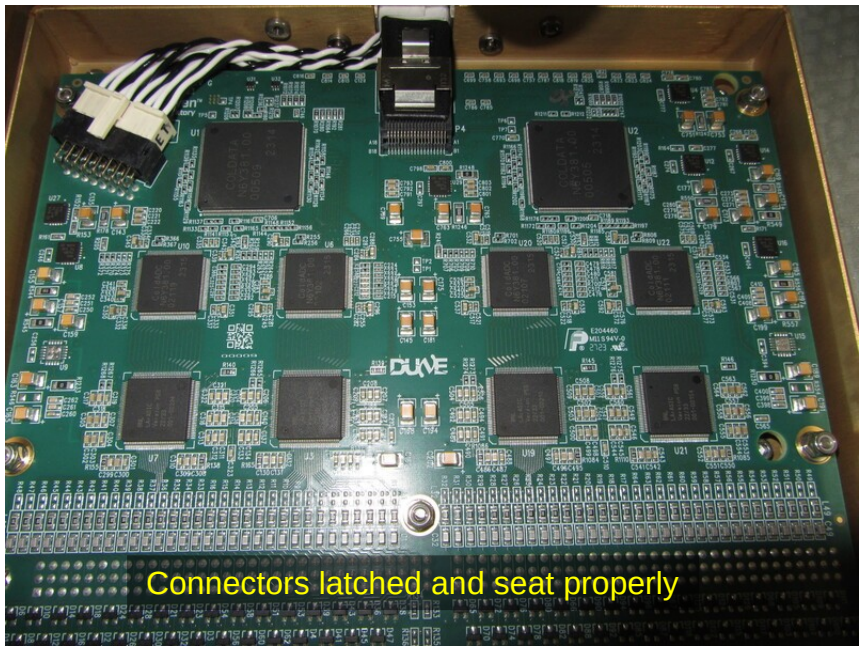
FEMBs 2 and 12 are up and running, but still masked in DAQ, so we don't see data from them.

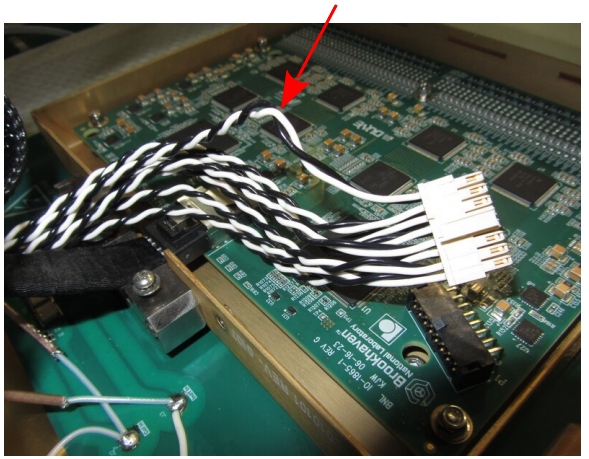
12/05/2023 – CRP6 warm in ColdBox, before shutdown, ~11:30 am.

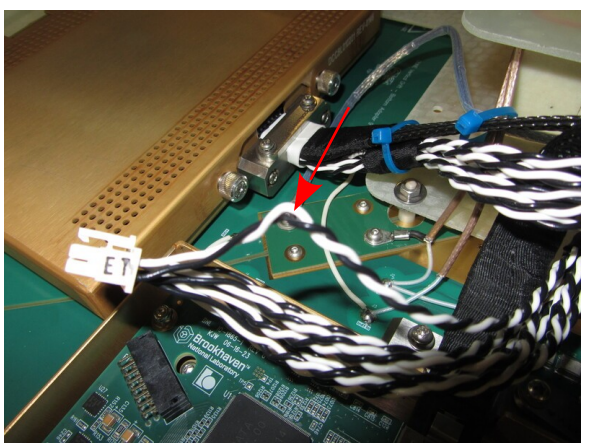


FEMBs 2 and 12 are back.

12/06/2023 FEMB-10 investigations





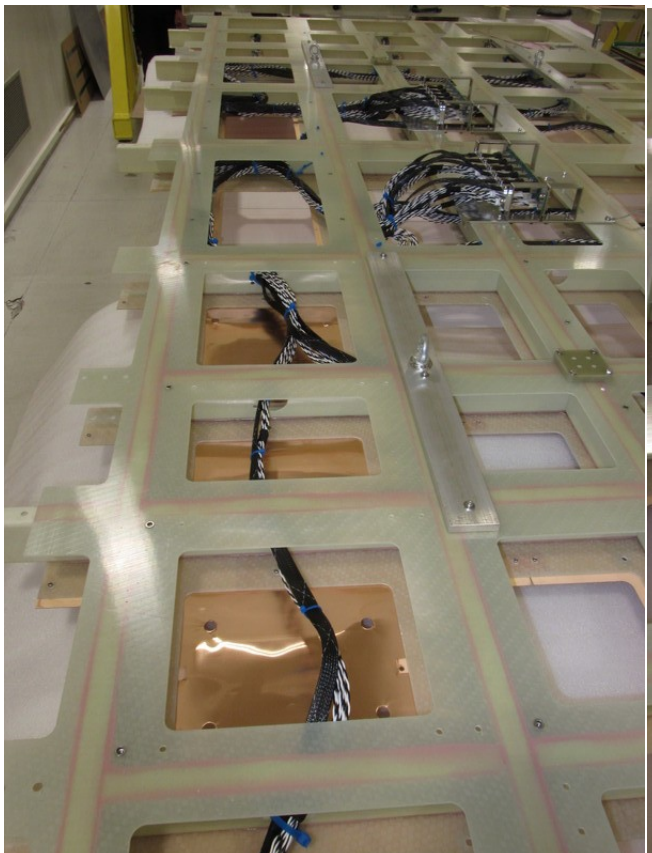


Activities:
1. Dominique and Serhan lowered CRP6
2. Confirmed low current in FEMB10 (expected ~2.4 A, measured 2.09 A at PS)
3. Opened FEMB 10 for visual inspection. No obvious problems observed.
4. Unplugged power and signal cables from FEMB 10 and plugged into a spare FEMB. Observed 2.39 A at PS with the spare FEMB – good.
   Conclusion: ~~Problem with FEMB 10~~?
5. Plugged power and signal cables back to FEMB 10. Observed 2.44 A at PS – back to normal.
6. Conclusion: The problem must be with cable of connector at FEMB side, or with FEMB 10 itself. We did not disturb cables at the patch panel nor at the CE flange. The good news is that those connections most likely are Ok. The only potential problem we see is a suspicious kink and “week when wiggle at the kink” on the one white cable as indicated by red arrows.
7. We tried to wiggle the cables, but could not reproduce the low current situation anymore.

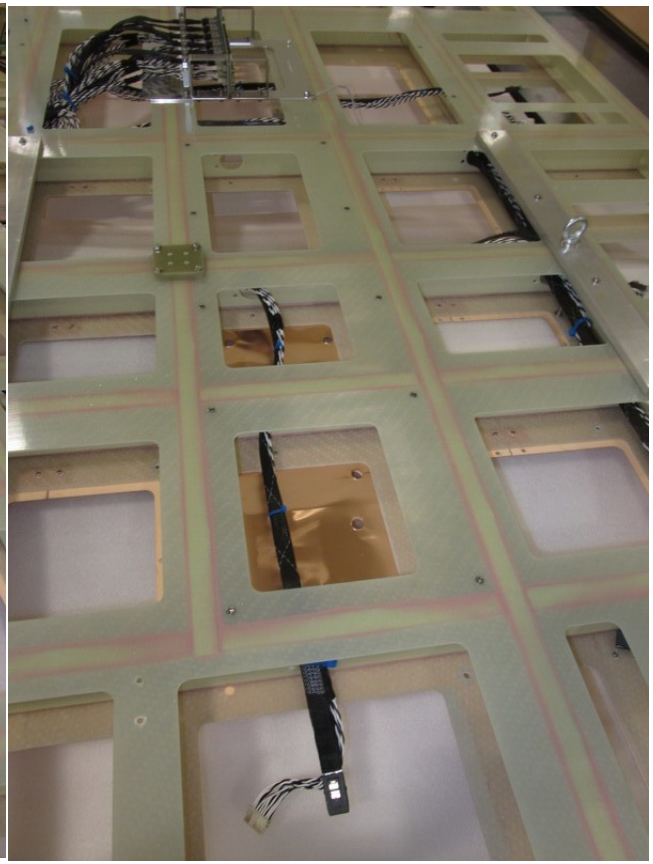
Recommendation:
* Replace both FEMB10 and short cables for FEMB10 / (only the power cable?).

- Power cable for FEMB 10 replaced
- FEMBs 2 and 12 replaced:
  - CE box 35 installed as FEMB 12
  - CE box 10 installed as FEMB 2
- Copper ground plane installed
- Copper sheets added to shield CRP6 collection strips from CE cables
- Washers and spring-washers added to mini-PCBs connecting adapter boards for at least four screws; remaining points populated with screws with flat washers.
- Manhong will
  - replace FEMB 10
  - connect all CE cables to FEMBs
  - install ground braids between adapter boards and copper plane
  - reconnect ground braids to patch panels
  - what about extra ground braids to FEMBs? (has not been discussed with others)
- Chris will test all FEMBs in CRP6 after installation
- FEMB 18 brought to BNL. Shanshan tested it but could not reproduce problems encountered at CERN.
- No washers on FEMB for ground connections?
- Would be good to have independent strain relief systems for power and signal cables on FEMBs.

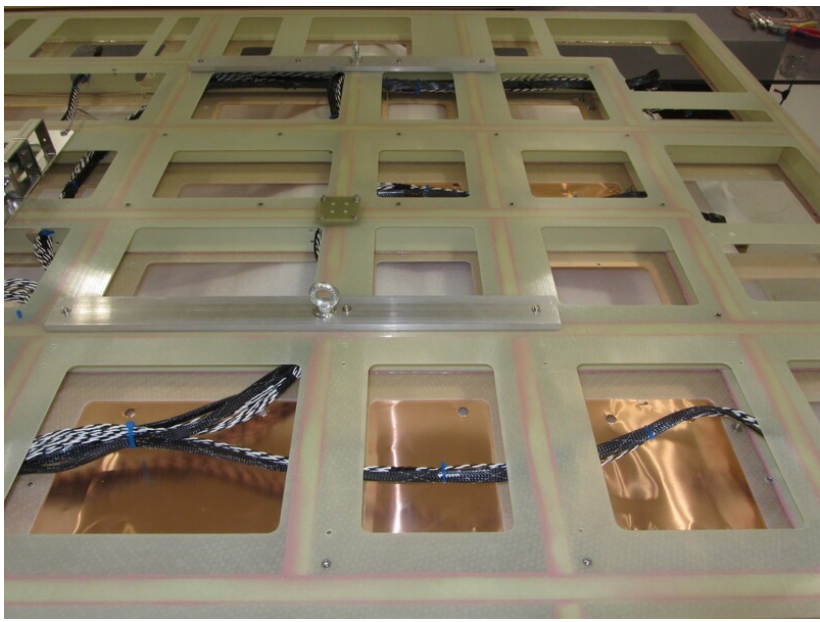
12/08/2023 – CRP6 modifications – copper sheets installed



FEMB 13

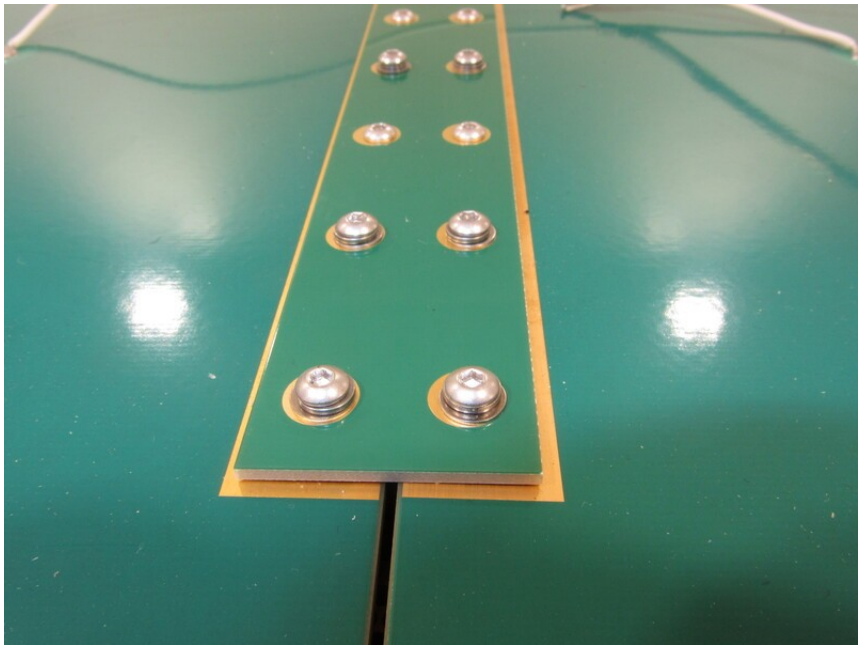


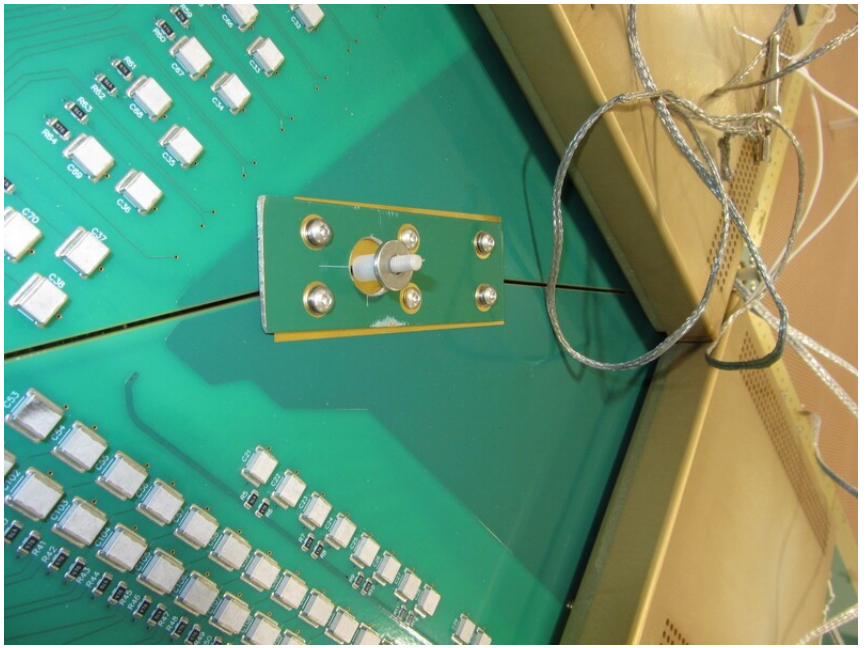
FEMB 14

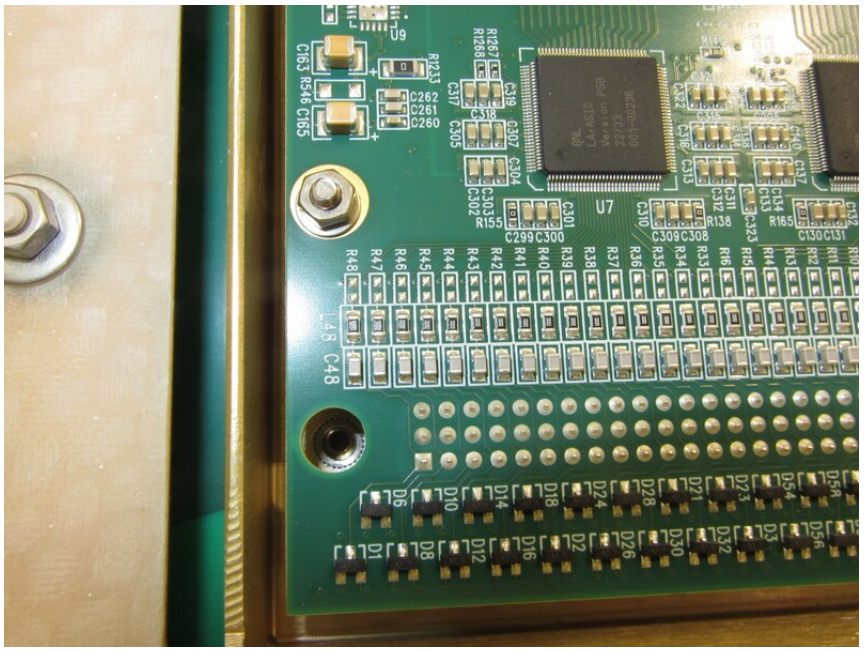


+ FEMB 23, 24

12/08/2023 – CRP6 modifications – mini-PCBs with flat and spring-washers

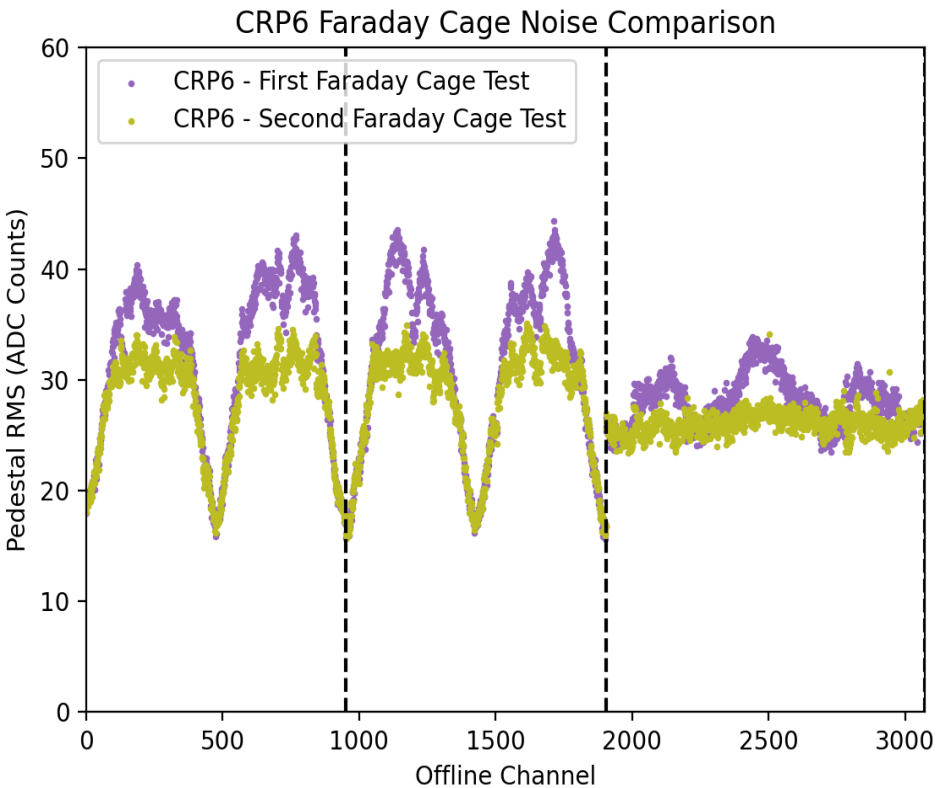


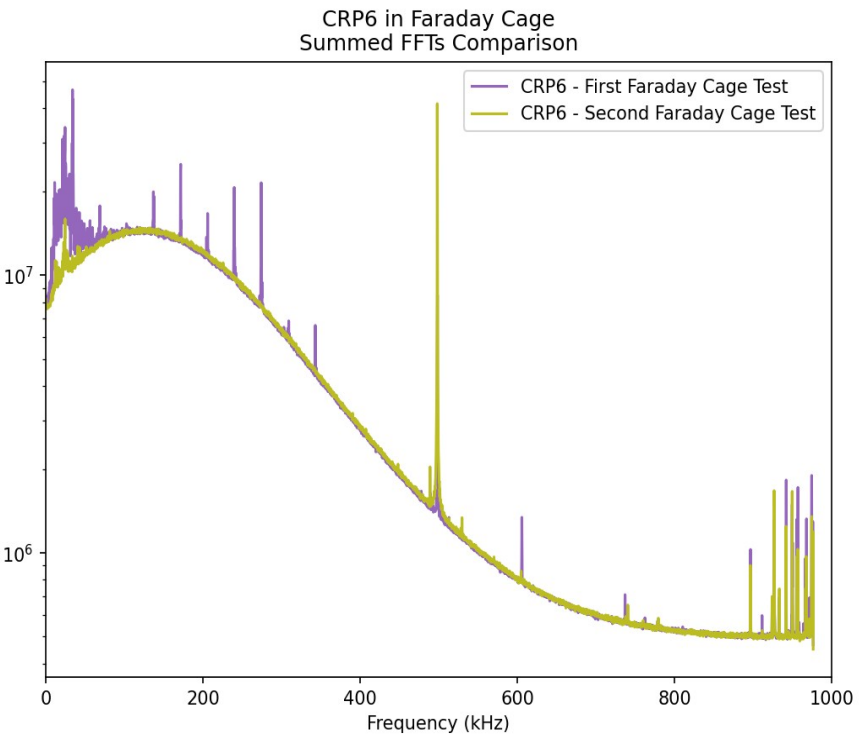




It is not possible to know if the spring washer sits well on the screw or was lost. It will hard to get out the spring washer if dropped.

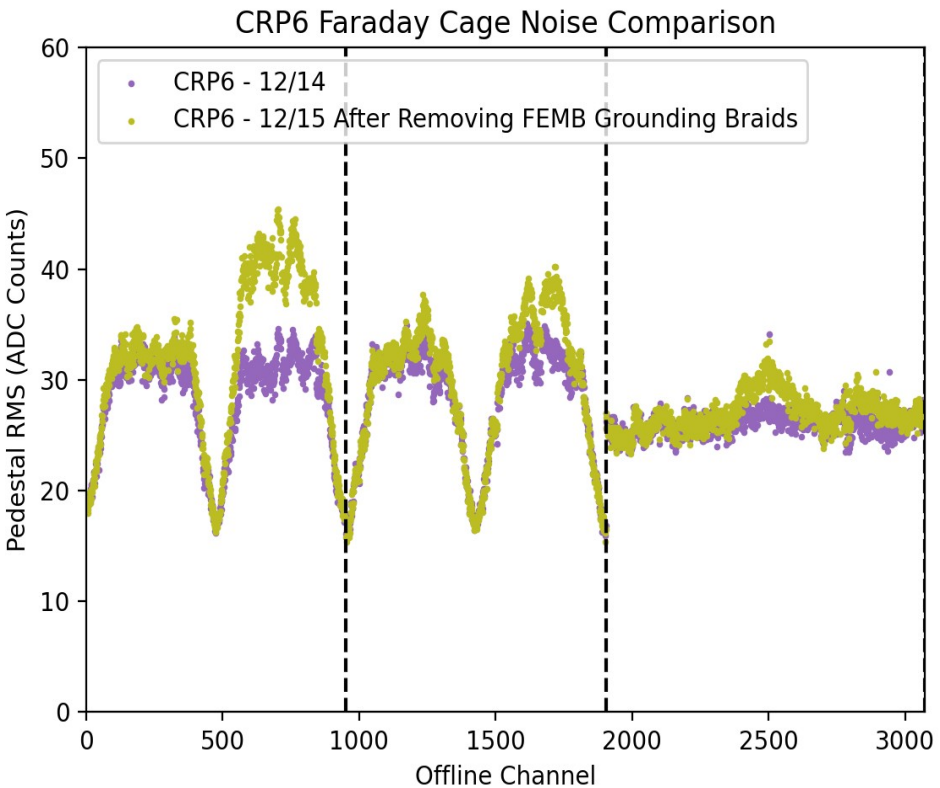
12/15/2023 – CRP6 in Faraday cage

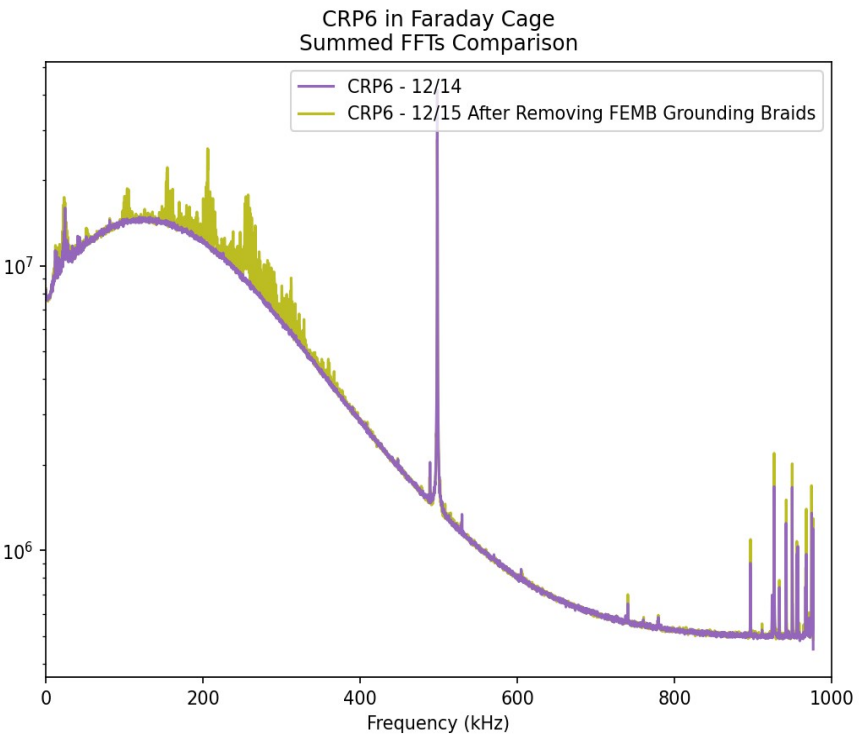




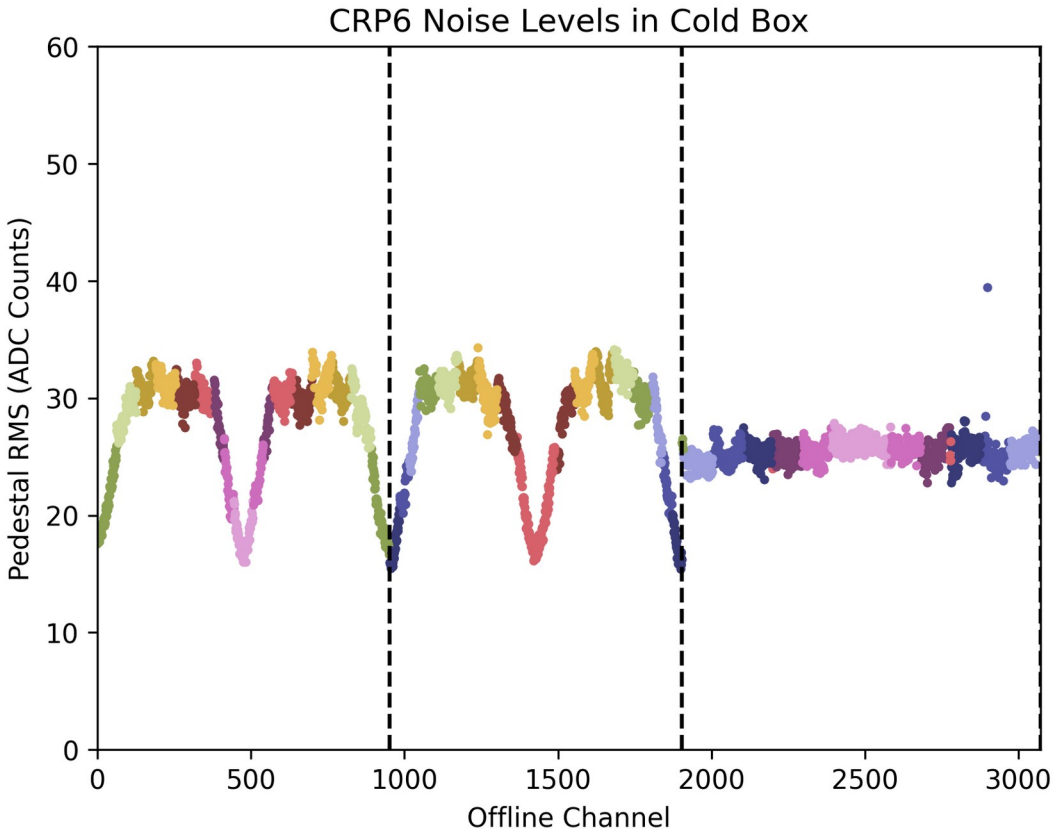
It is not possible to know if the spring washer sits well on the screw or was lost. It will hard to get out the spring washer if dropped.

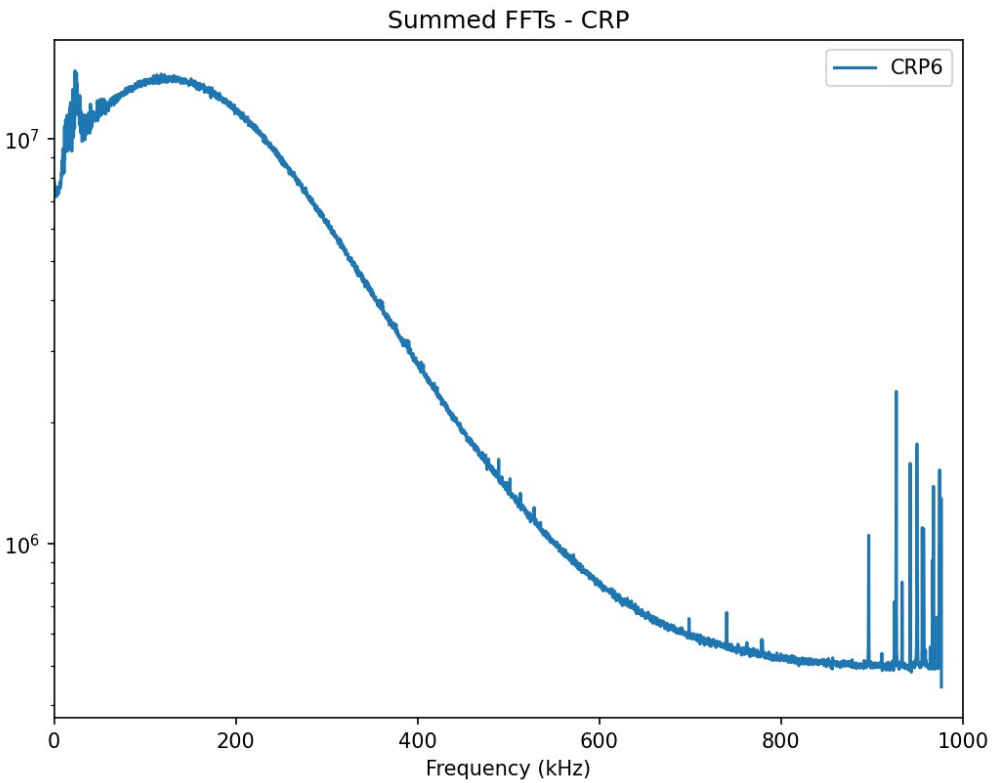
12/15/2023 – CRP6 in Faraday cage – w/ and w/o FEMB grounding braids





12/21/2023 – CRP6 in ColdBox





CRP6 pictures, FEMB test data from Chris:

https://drive.google.com/drive/folders/1y_D7E2zXh7GmUKDb3JxemvBAWVv-D24p

Analysis by Lingyun Ke of test data from FEMBs on CRP6 taken in Bldg. 185:

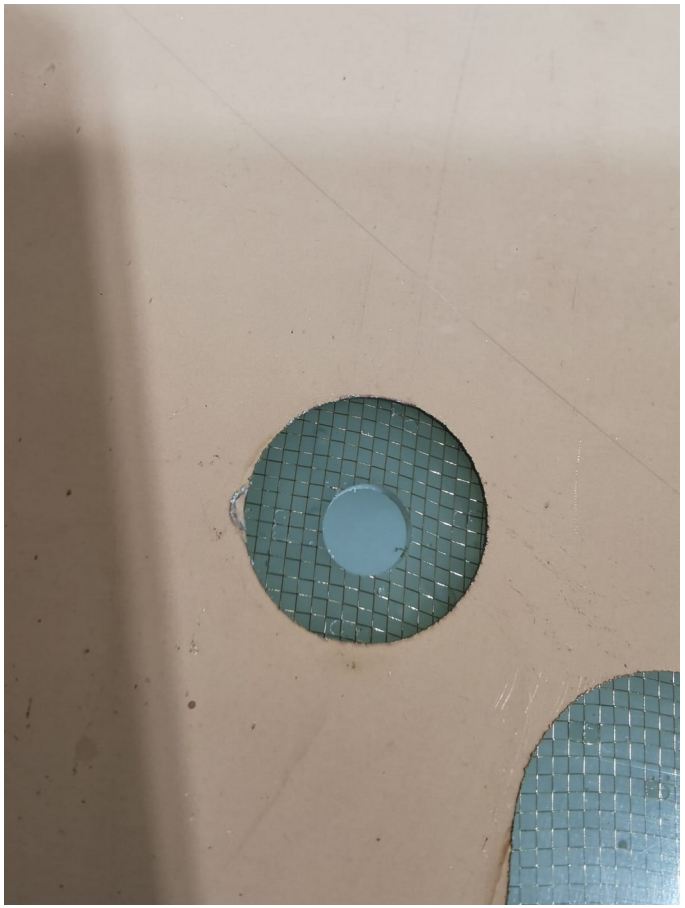
https://docs.google.com/document/d/1-SPGC4taXr_NPdEdpjsIN-CLfUsm-LqDkfHYL8DtVHQ/edit#heading=h.xd6pfk3e6eur

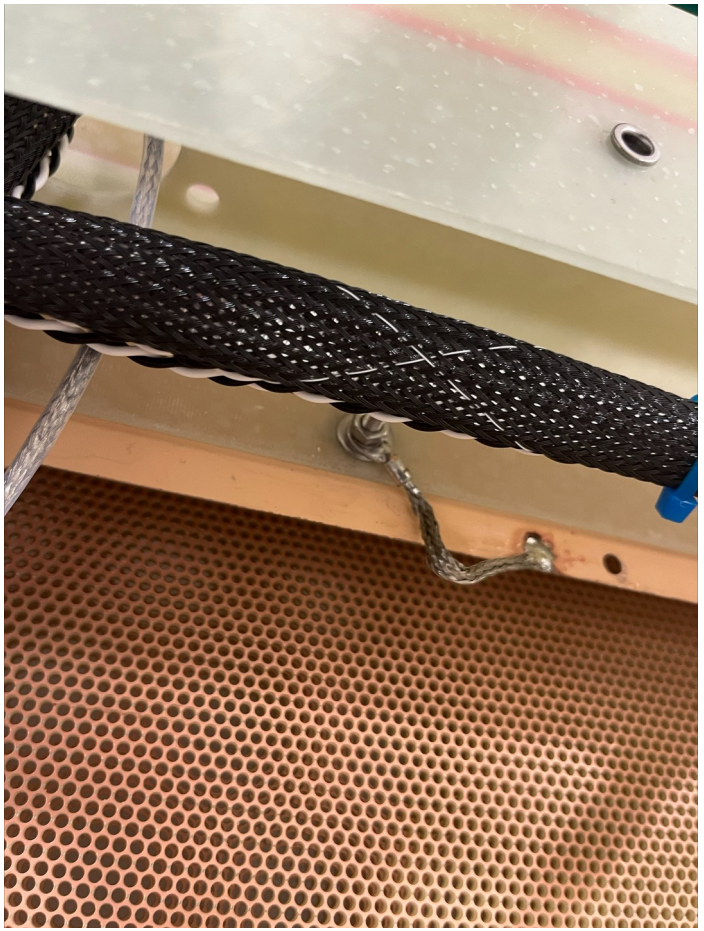
Summary slides from Roger
https://indico.fnal.gov/event/62347/contributions/280508/attachments/173316/234567/CRP6_Coldbox12_5.pdf

Summary of FEMB problems during CRP 6 testing

FEMB #	CE box #	CB test	Description
2	10	1	Stopped working in LAr during 1st ColdBox test. Recovered at RT. Replaced by VT with a spare at CERN. Brought back to BNL by Hucheng. Tested at RT by Lingyun, no problems found.
10	9	1	Stopped working in Cold during 1st ColdBox test. Did not recover at RT. Was replaced by Manhong with a spare brought from BNL (CE Box #12). Brought back to BNL by Manhong. Tested at RT by Lingyun, but no problems found.
12	35	1	Stopped working in LAr during 1st ColdBox test. Recovered at RT. Replaced by VT with a spare at CERN. Brought back to BNL by Hucheng. Tested at RT by Lingyun, no problems found.
18	?	pre-1	Removed from CRP6 by Cheng-Ju before 1st ColdBox test. It came with a paper describing the problem. Shanshan tested it at BNL both at RT and LN, but could not reproduce the problem. Suspecting poor miniSAS cable installation at FEMB.
18*	?	pre-2	One power was bent during preparation for the 2nd ColdBox run. The pin was repaired and the CE box was installed as FEMB 20 for the 2nd ColdBox run.
20	?	pre-2	Replaced by Chris with FEMB 18 (see above) during preparation for the 2nd CB test. Brought to BNL by Manhong. Tested at RT by Lingyun, no problems observed.
17	?	pre-2	Replaced by Chris before 2nd CB run with a spare brought from BNL by Manhong. Brought back to BNL by Manhong, tested at RT by Lingyun, no problems observed.

December 13, 2023: Ground mesh is grounded to Copper Plane for the 2nd CB test – from Chris.





CRP-6 2nd CB run

Slides from Roger:

https://indico.fnal.gov/event/63336/contributions/284650/attachments/175110/237518/CEConsortium_CRPColdIssuesRecap_2_13.pdf