Feasibility of Cold Gas Testing: CRP8

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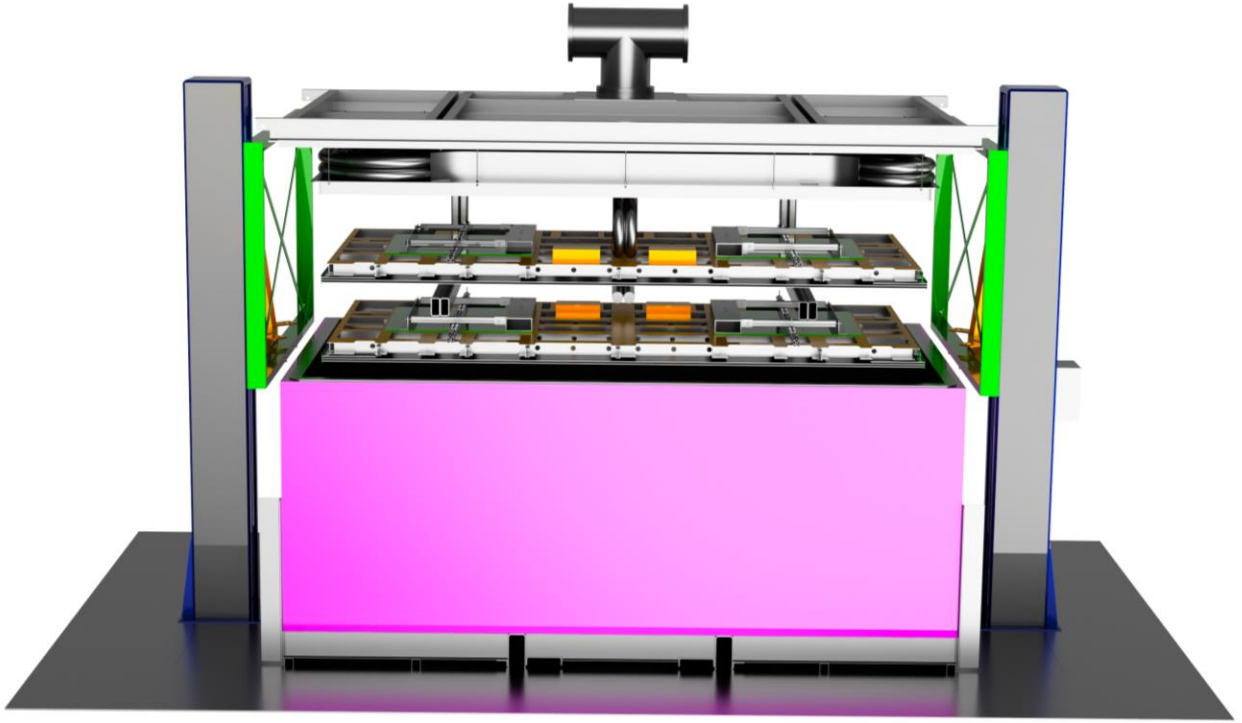
October 15, 2025

Motivation

- May 20, 2025:
  - Yale and BNL teams proposed a cold box design for use at the US CRP Assembly sites
- This design would test 2 CRUs at a time in a single cold box in liquid nitrogen (~9,300L per test)



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- One way to reduce costs is to utilize cold gas for CRU testing (~2,400L per test)

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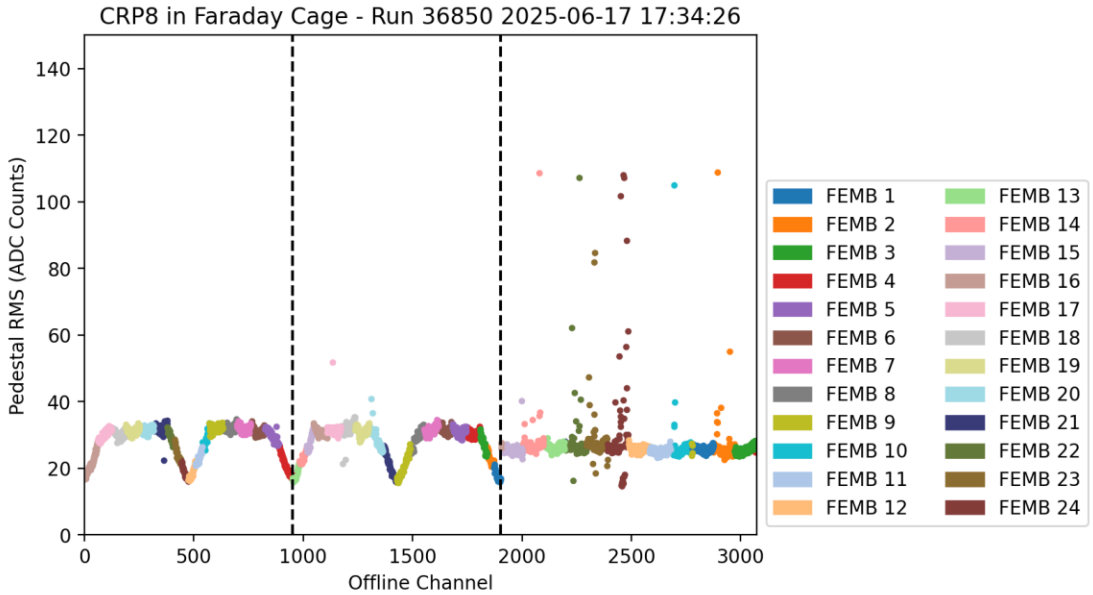
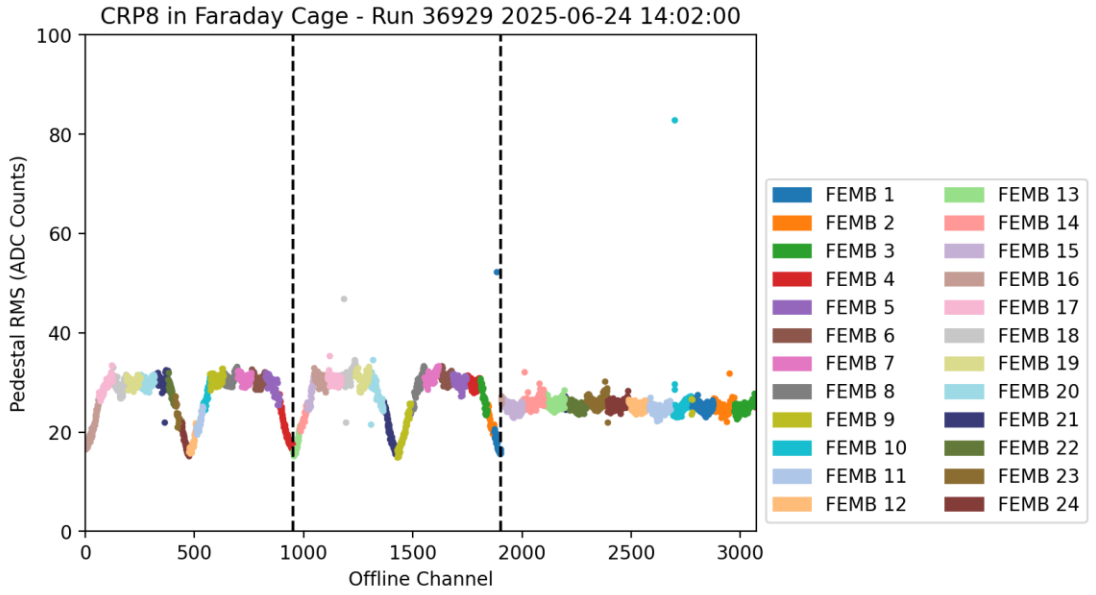
Can we use cold gas for cold box testing at US CRP Assembly sites?

A test of this has been conducted at the NP02 cold box with CRP8

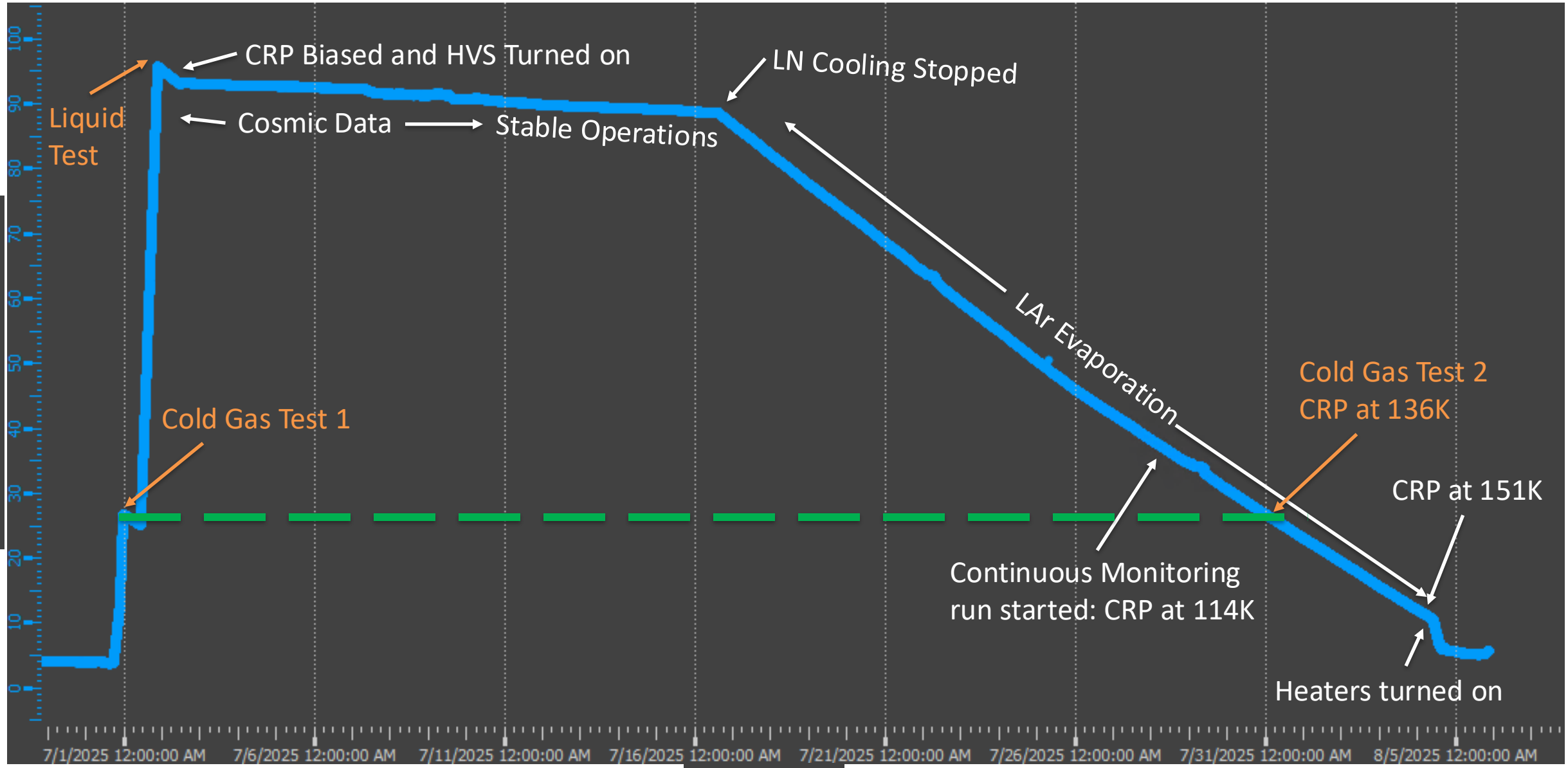
CRP8 Background

- CRP8 is composed of CRU6a and CRU8b
- CRU6a was built in 2023/2024 and sat in a cleanroom for >1 year
- CRU8b was built in March 2025 in Grenoble utilizing new anodes
- In late June we conducted extensive studies of CRP8 in the Faraday cage to understand noise





NP02 Coldbox: Liquid Level

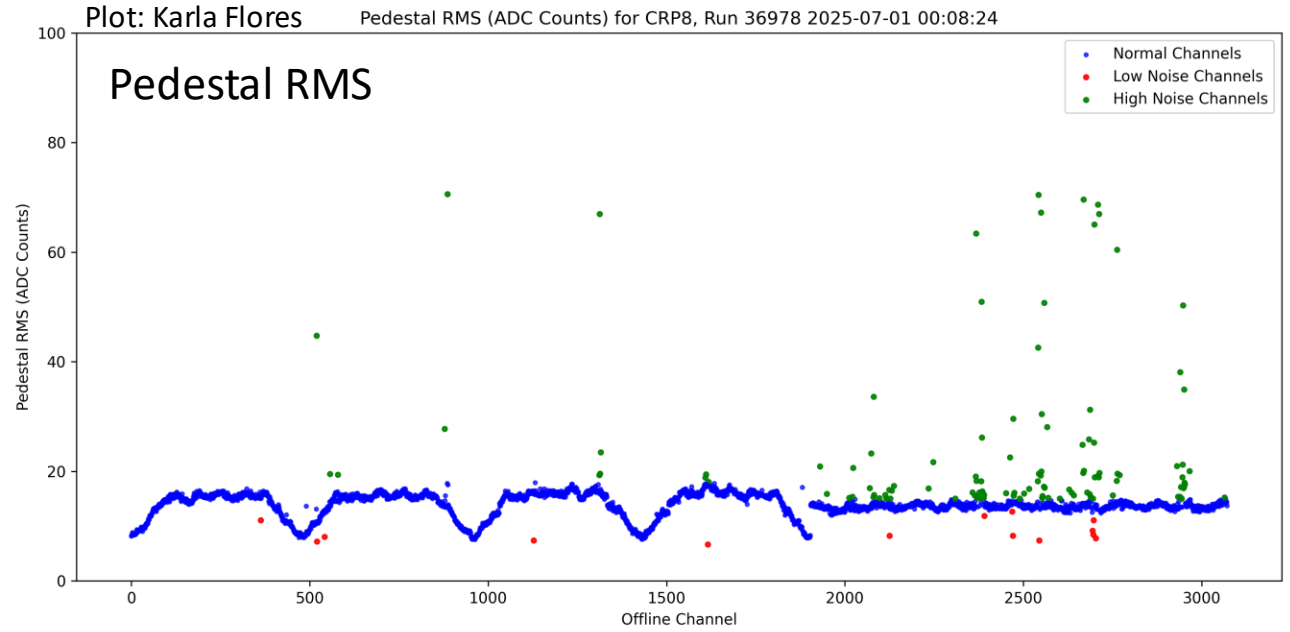


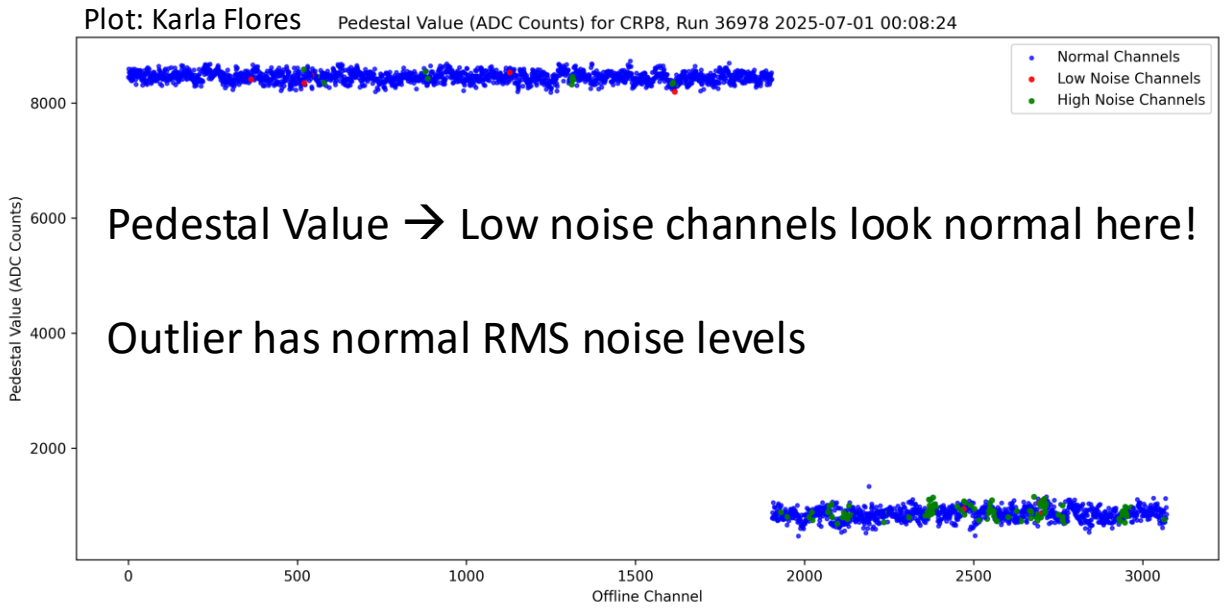
Cold Gas Test 1 (140K)

- In Cold Gas Test 1 we had the following **low noise channels**:

  CRU6a: 520, 541, 1616, 2544, 2694, 2696, 2703 → 7 low noise channels

  CRU8b: 363, 1128, 2125, 2471 → 4 low noise channels





- No pulser runs were taking during the first cold gas phase

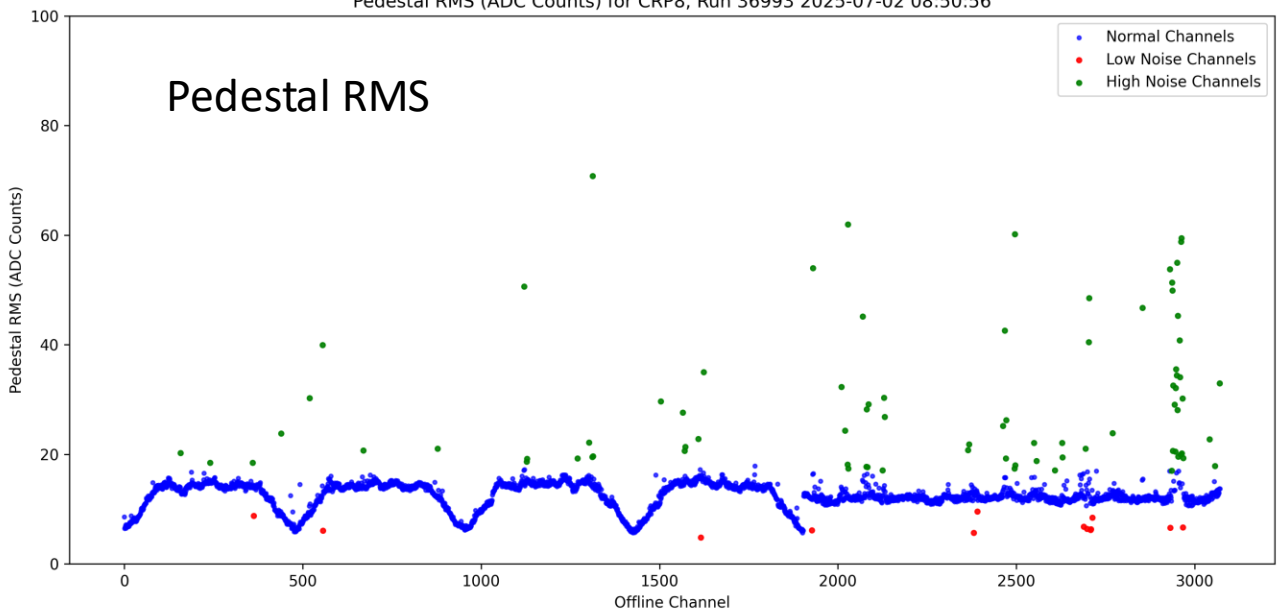
Liquid Test (86K)

- In Liquid Test test we had the following **low noise channels**:

  CRU6a: 557, 1616, 2689, 2698, 2708, 2709, 2713, 2931, 2967 → 9 low noise channels

  CRU8b: 363, 1927, 2391, 2381 → 4 low noise channels

Plot: Karla Flores



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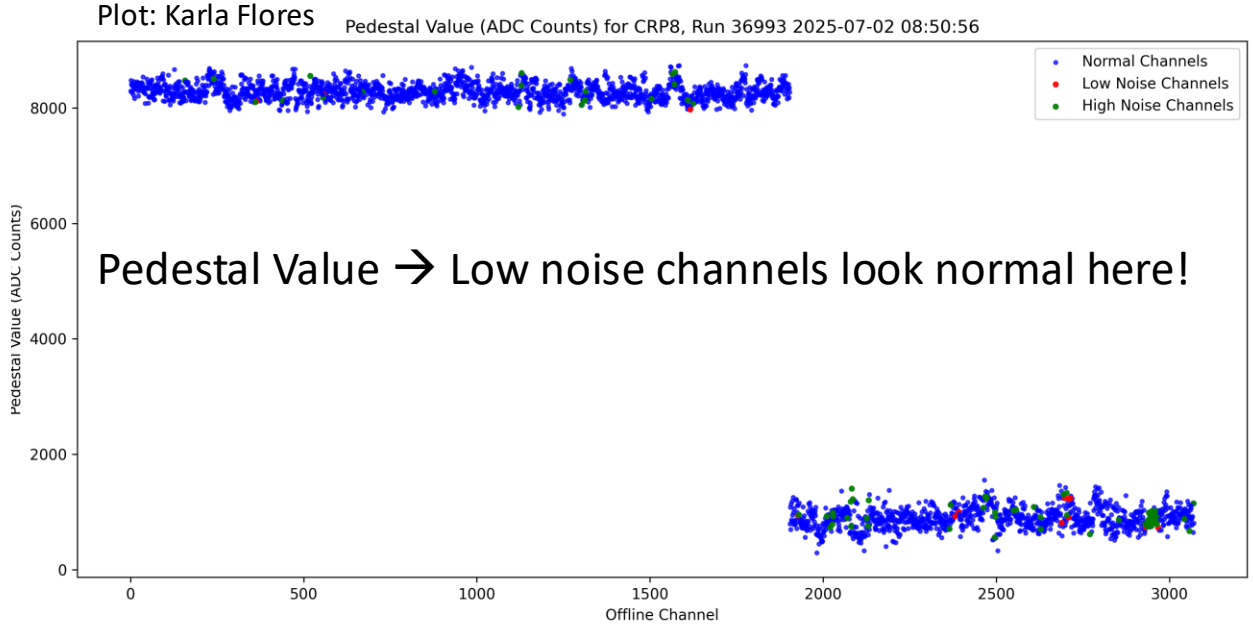
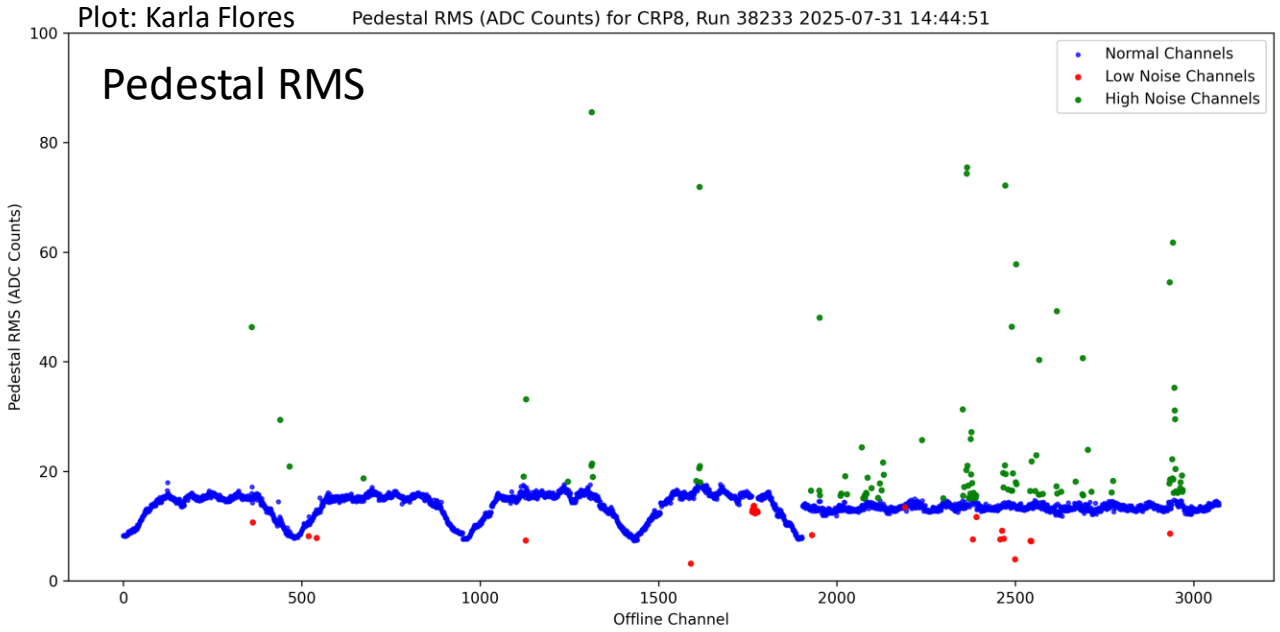
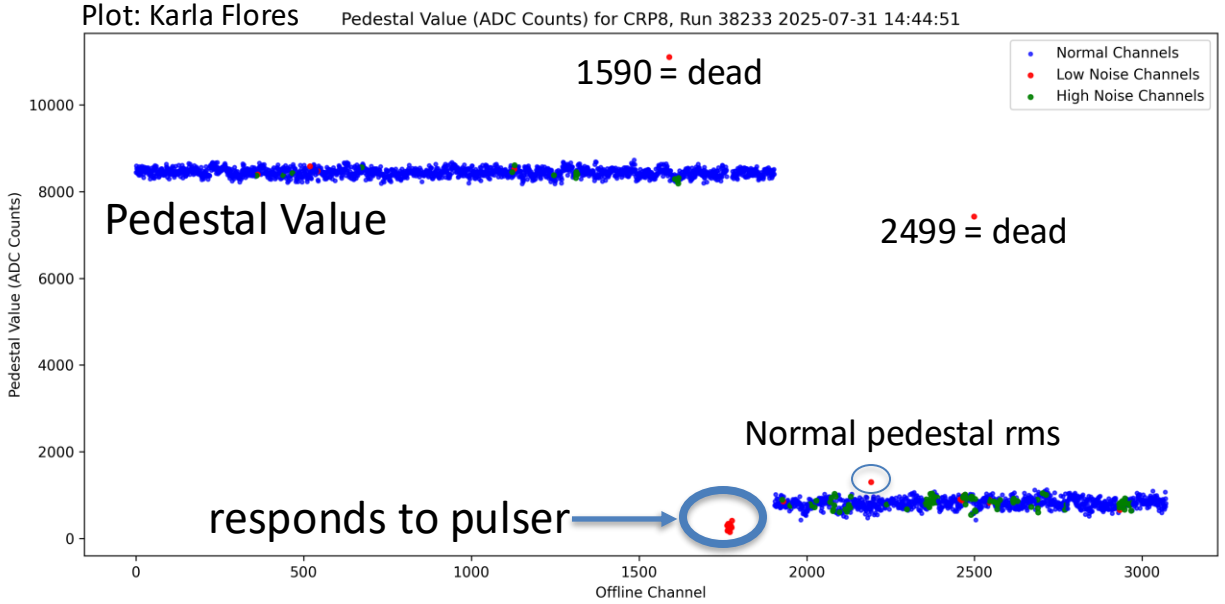


Gas Test 2 (140K)

Black bold = dead
Purple = WIB configuration failure
Green = consistent from Gas Test 1

- In Cold Gas Test 2 we had the following **low noise channels**:
  - CRU6a: 519, 541, **1590**, **1762-1777**, **2499**, 2542, **2544**, 2933 → 7 low noise channels (ignoring FEMB 4)
  - CRU8b: 363, 1128, 1930, 2457, 2463, 2468, 2381, 2391→ 8 low noise channels

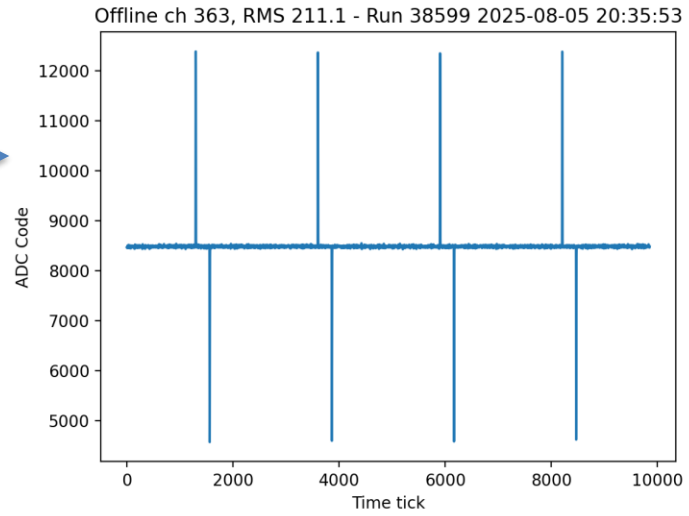


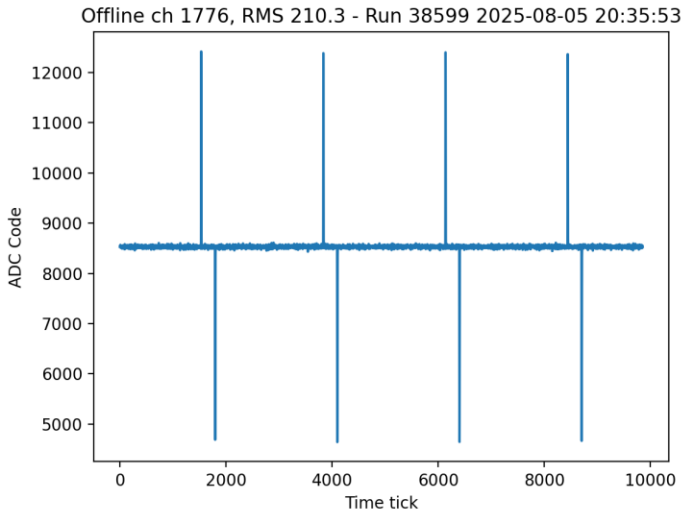


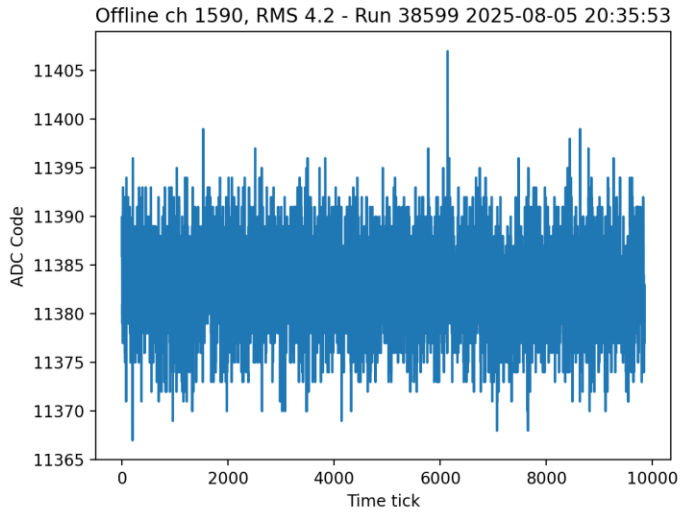
- A Wib configuration failure was responsible for the large grouping of low noise channels (Roger)
- 1590 and 2499 channels died when switching biases during cosmic runs (run 37042)

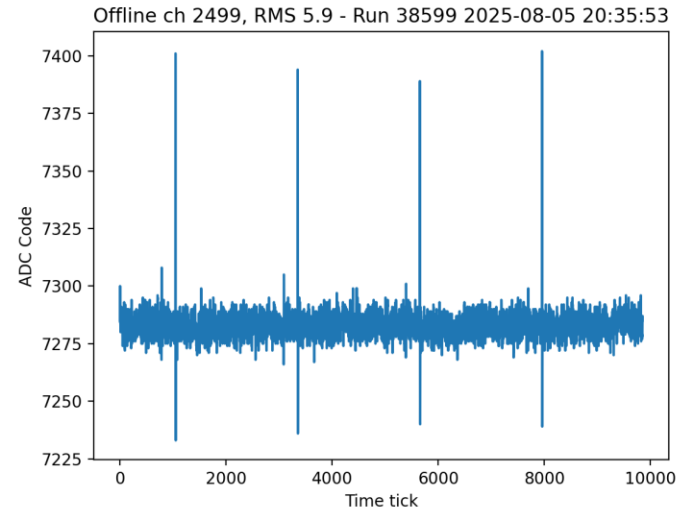
Pulser Tests: Cold Gas Test 2

- Pulser runs confirm 1590 and 2499 are dead and the rest of the low noise channels are alive
- Sends an injected pulse to channels
- If they are alive, they respond like →

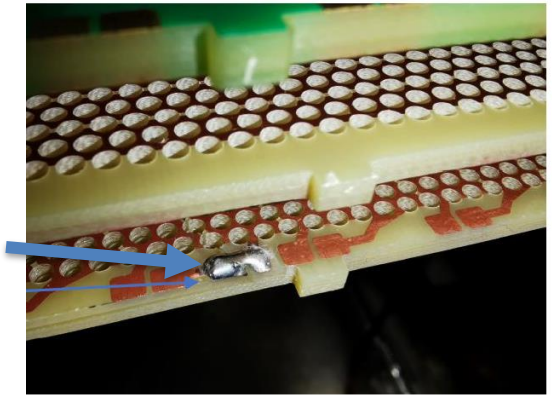








Takeaway from comparison



- **Gas testing reliably flags known issues**
  - Channel 363 consistently showed low noise! (correlates with large solder bump)
  - 2 BDE channels died during cosmics → appeared in later liquid and gas tests!
- **Quantity of low noise channels is within specifications (1%)**
  - CRU8b: 0.26% to 0.39% low-noise channels
- Ongoing Studies:
  - Select low noise channels appear unique to each test!
    - Efforts are ongoing to address this from the CRP side through better connections (see I&I EC Talk)
    - New tests will be performed in November at the NP02 coldbox

Low Noise Channels		
	CRU6a	CRU8b
Gas Test 1	7 channels	4 channels [0.26%]
Liquid Test	9 channels	4 channels [0.26%]
Gas Test 2	7 channels	8 channels (2 new dead channels) [0.39%]

Extra Slides

Takeaway from comparison

- Across all 3 tests the low noise performance was not consistent
- If a channel is dead, we can identify it in cold gas
  - low rms noise, outlier on pedestal, and not responsive to pulser
- If a channel has connection issues, cold gas **may not** alert us of it
  - 64% of low noise in CRU8b and 84% of low noise in CRU6a only occurred in 1 test

Low Noise Channels		
	CRU6a	CRU8b
Occurs in at least 1 test	19 channels	11 channels
Occurs in **only** 1 test	16 channels (84%)	7 channels (64%)
Occurs in both Gas tests	2 channels (11%)	2 channel (18%)
Occurs in at least 1 Gas test and liquid	1 channel (5%)	3 channels (27%)

What have we seen historically?

- Roger presented a summary talk on this in February 2024: [Roger's BDE Talk]

How many of the issues we've seen in CRP coldbox tests so far would have been caught in only a cold gas test, and how many only appeared in LAr?

CRP issues (e.g. connectors)
FEMB/Cable issues
Grounding issues

Summary of CRP Cold Issues

	1st CRP5 Test	CRP4 Test	2nd CRP5 Test	1st CRP6 Test	2nd CRP6 Test
Issues appearing in Cold Gas	Random channel disconnects and noise	None	Random channel disconnects and noise	1 FEMB lost during pre-cooldown warm purge 2 FEMBs lost in mid-100s K cold gas	Random channel disconnects and noise
Issues appearing only in LAr	1 FEMB inoperable due to loss of clock signal More excess noise	None	More excess noise	More random channel disconnects and noise	None

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His Conclusion in 2024:
We cannot say everything gets caught in gas

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Conclusion

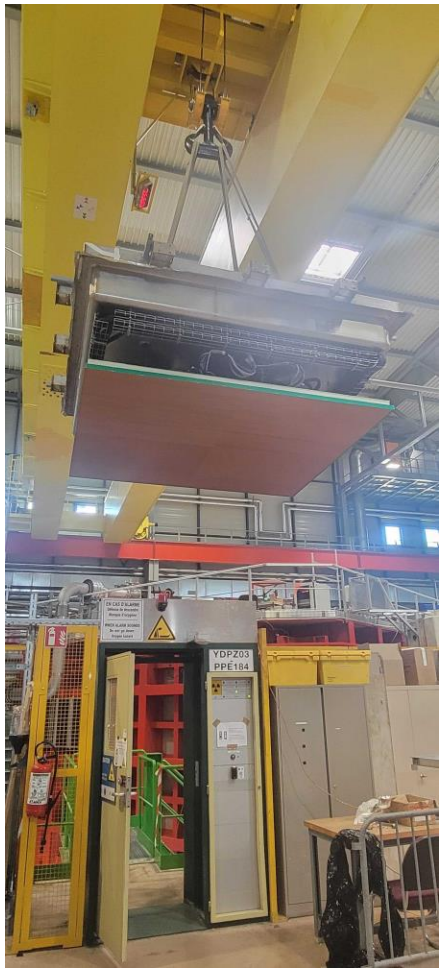
- If the goal is to identify **no-broken** channels: Cold gas (140K) will be sufficient
- If the goal is to identify **bad connections**: Cold gas (140K) **introduces risk**
  - Historically cold gas has shown random channels disconnecting
  - This behavior is not as prevalent in liquid testing

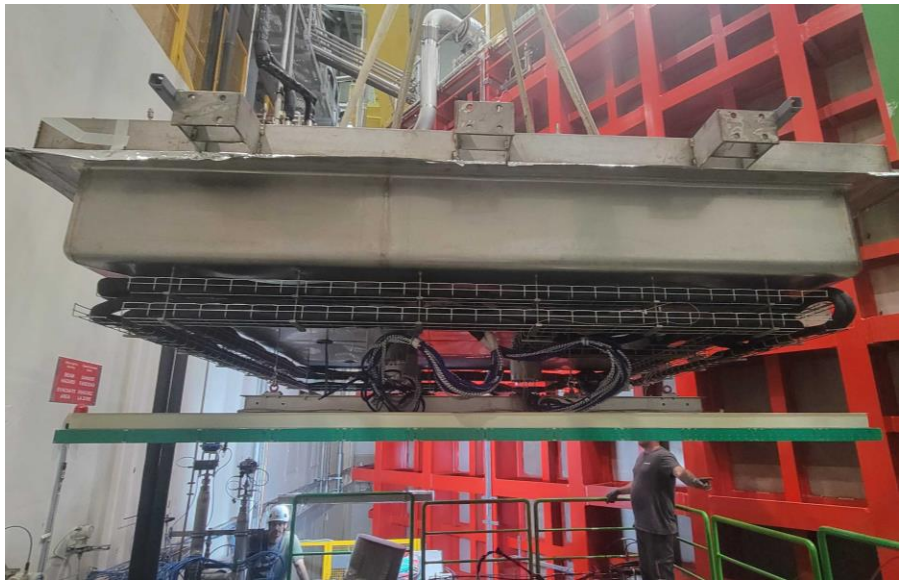
- How much risk we are willing to accept needs to be defined
- Previous cold box studies showed fewer low noise issues
- If we are able to test a CRP in the coldbox with new edge cards, and show fewer low noise channels compared to CRP8, I believe our risk can be reduced
  - Recall: when in the Faraday Cage, we reduced low noise by adjusting the edge cards

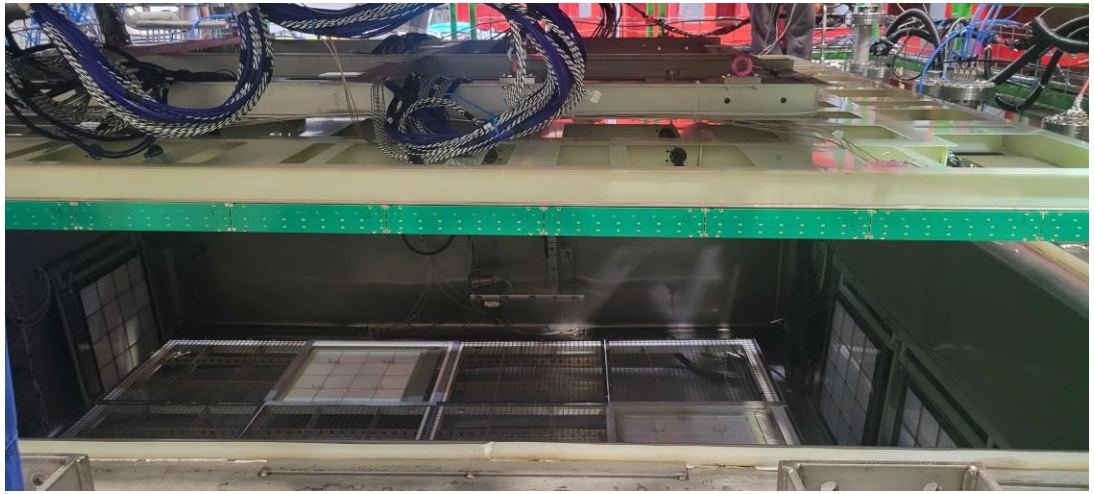
- Next Steps and Milestones:
  - Cold Gas cold box design *review/socialization*: ~last week of September
  - CRP8 will be upgraded in October and cold tested in November → repeat cold gas test

CRP8: Faraday Cage → Coldbox

- June 2025: After we were satisfied with the Faraday Cage tests we moved CRP8 to the Cold Box and installed

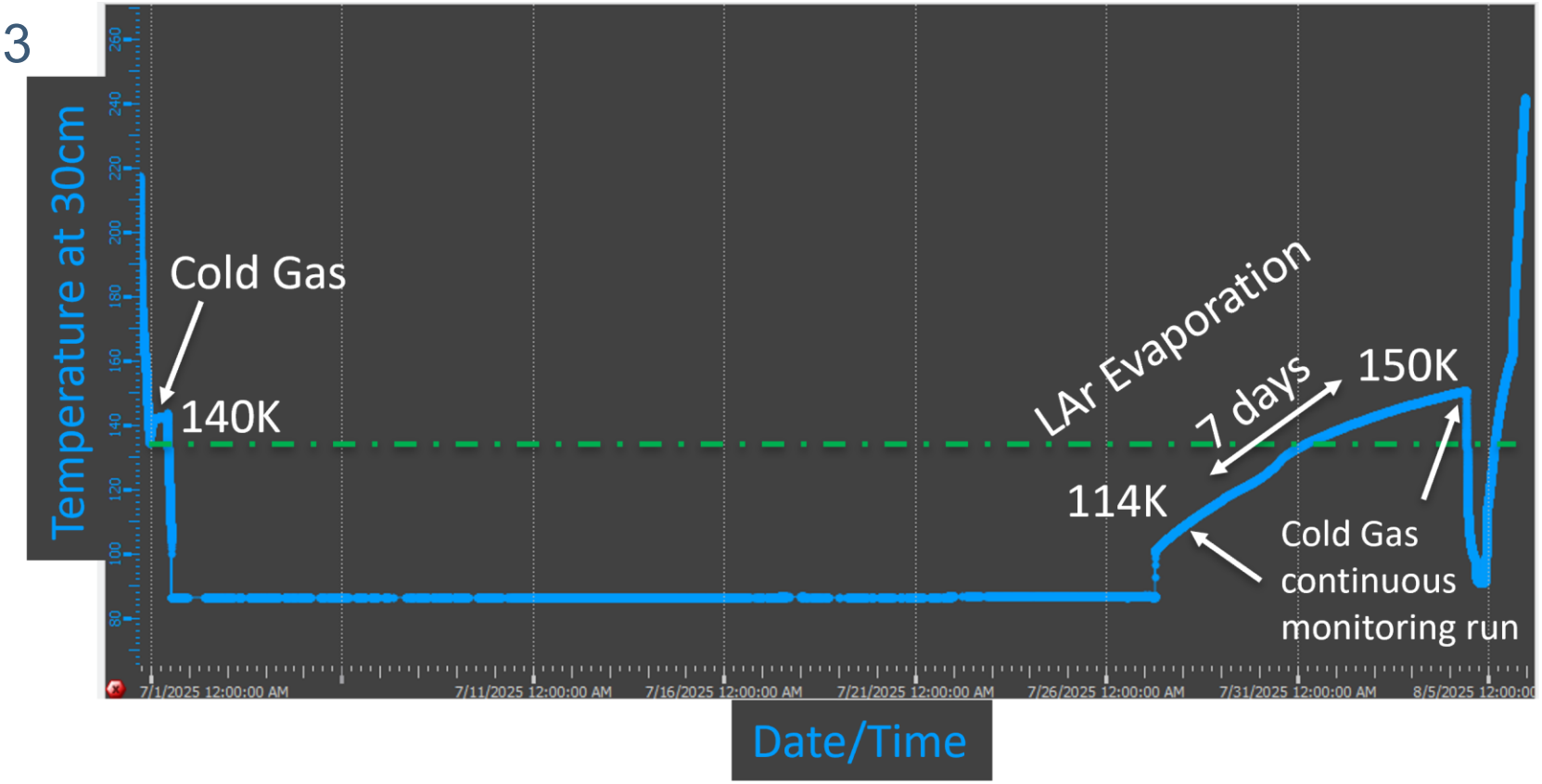






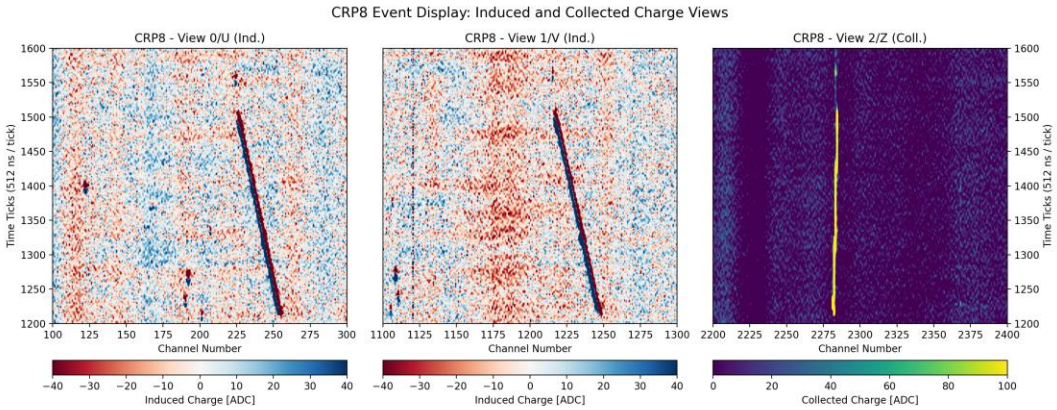
NP02 Coldbox Testing Overview

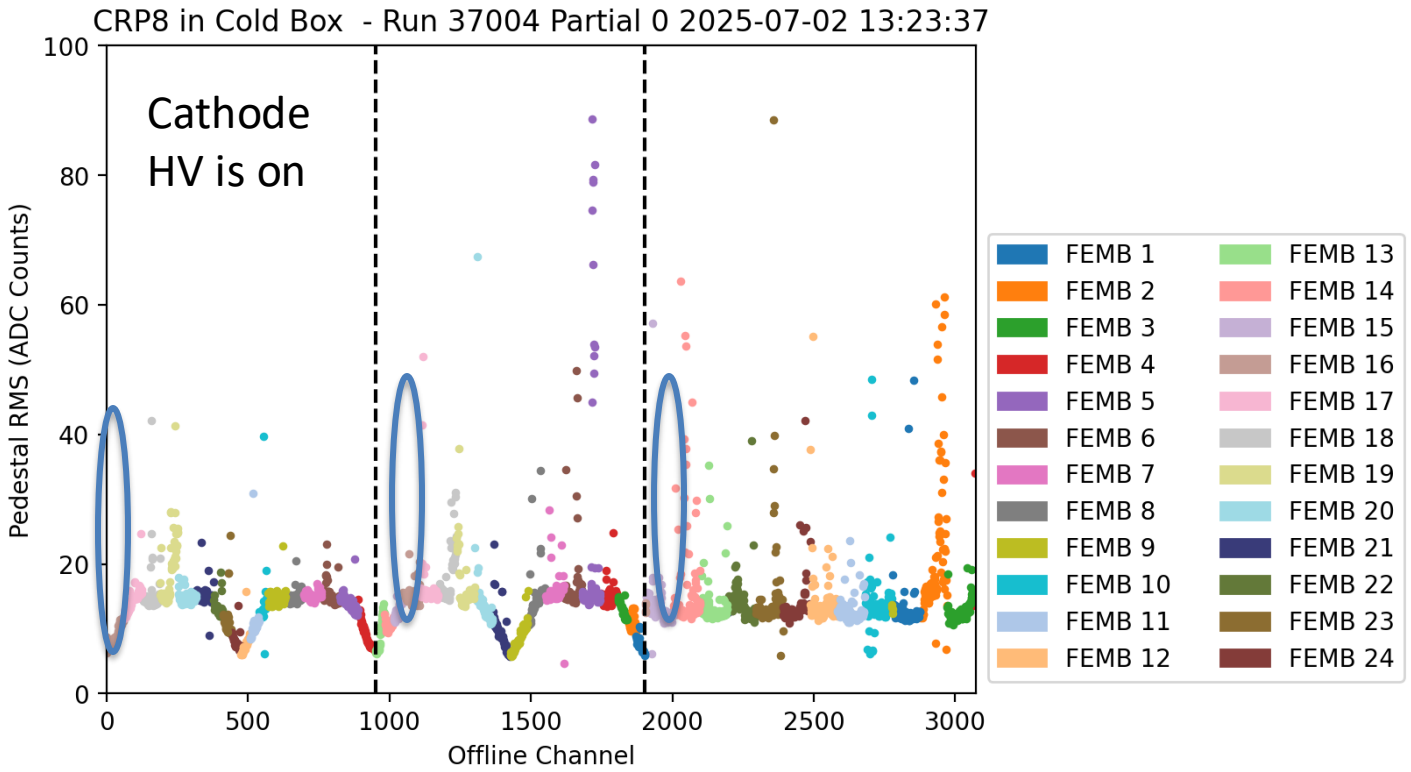
- Cold gas noise test 1: Run 36978 (8 hours)
- Liquid noise test: Run 36993 (13 hours)
- Liquid HV Bias Test: Run 36997
- Cold gas noise test 2: Run 38233
  - LAr evaporation over 7 days
    - CRP from 114k to 150K
    - >3 TB of noise monitoring data

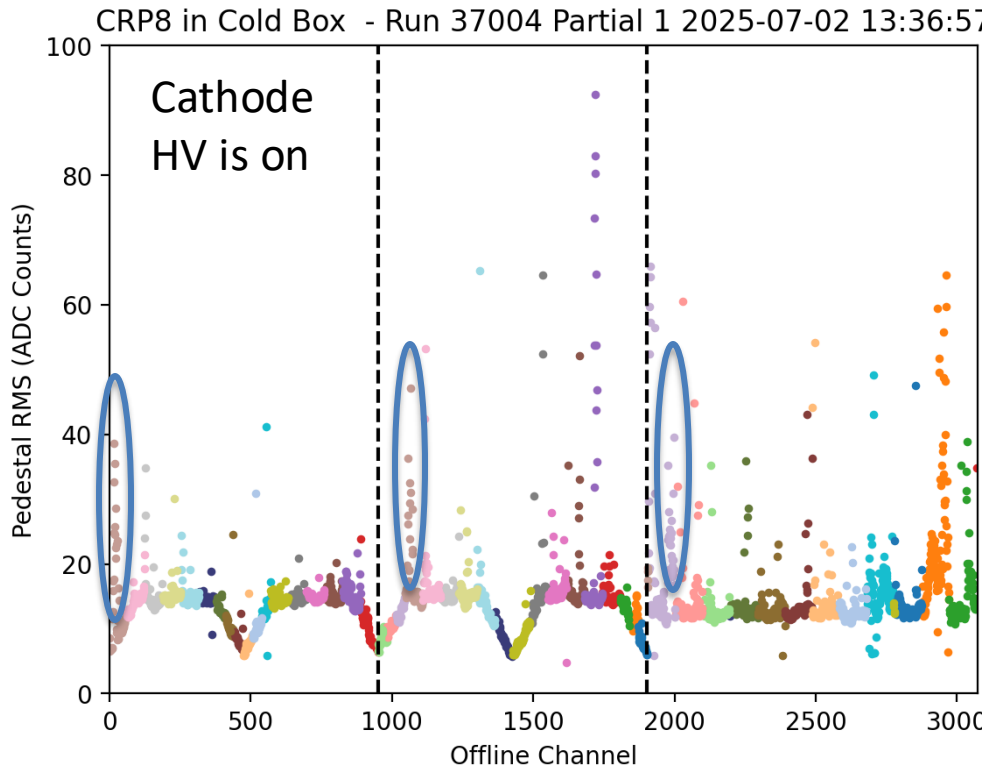


Cosmics

- Numerous runs with cosmics were taken at different bias voltage settings to study CRP transparency
  - See Joshua Pinchault talk about this at the May CM
- Cosmic ray tracks can be seen in the noise plots!







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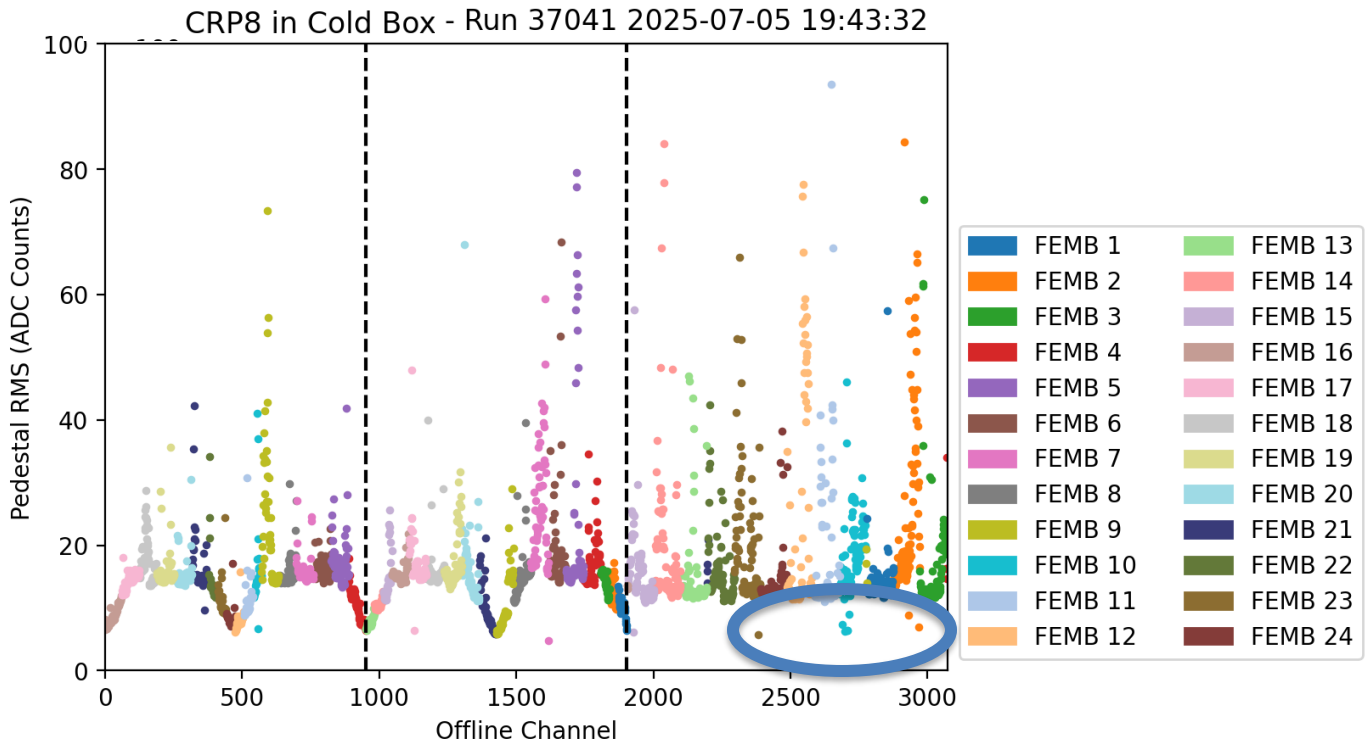
Cosmics + low noise shift

- When switching biases for run 37042 2 channels died
  - 2590 and 2499
- The low noise also shifted in CRU6a at this point



Run	REMARKS	
37004	CRP bias -1.5/-0.5/+1.0 kV	
37024	CRP bias -1.5/-0.5/+1.0 kV	
37029	CRP bias -1.45/-0.45/+1.0 kV	
37031	CRP bias -1.4/-0.4/+1.0 kV	
37032	CRP bias -1.35/-0.35/+1.0 kV	
37034	CRP bias -1.3/-0.3/+1.0 kV	
37035	CRP bias -1.45/-0.5/+1.0 kV	
37036	CRP bias -1.4/-0.5/+1.0 kV	
37039	CRP bias -1.35/-0.5/+1.0 kV	
37040	CRP bias -1.30/-0.5/+1.0 kV	
37041	CRP bias -1.5/-0.5/+0.95kV	When switching biases for run 37042 2 channels died
37042	CRP bias -1.5/-0.5/+0.9kV	
37043	CRP bias -1.4/-0.45/+1.0 kV	
37046	CRP bias -1.5/-0.5/+1.0 kV	
37081	CRP bias -1.35/-0.45/+1.0 kV	

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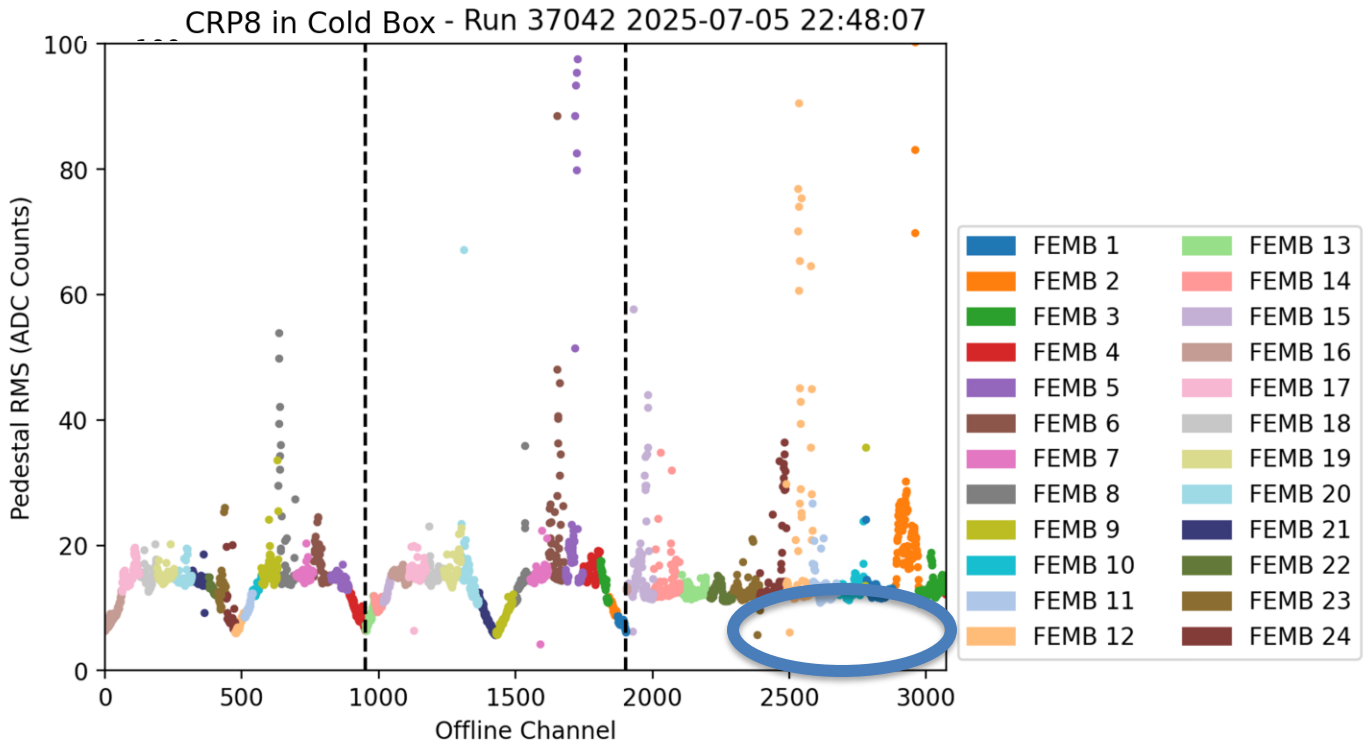

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