Noise filter revisit summary

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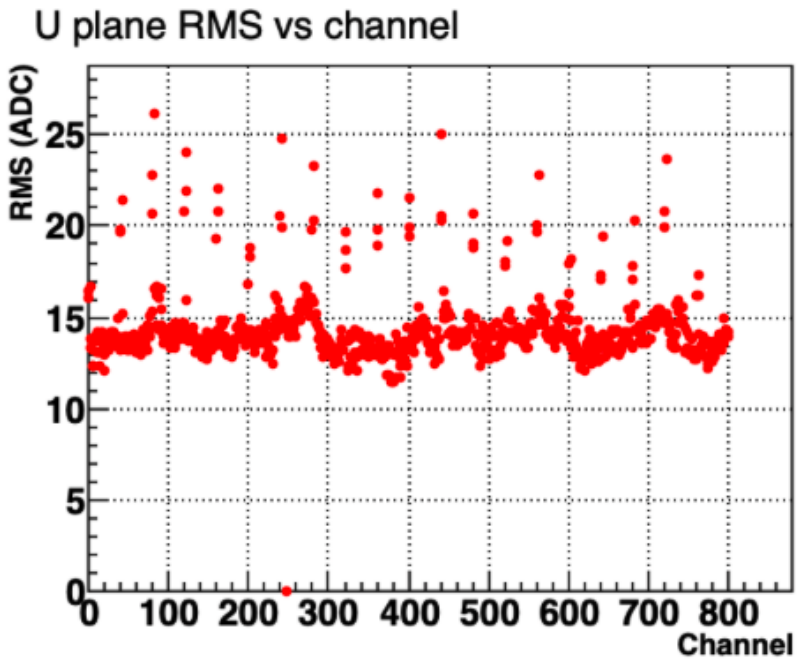
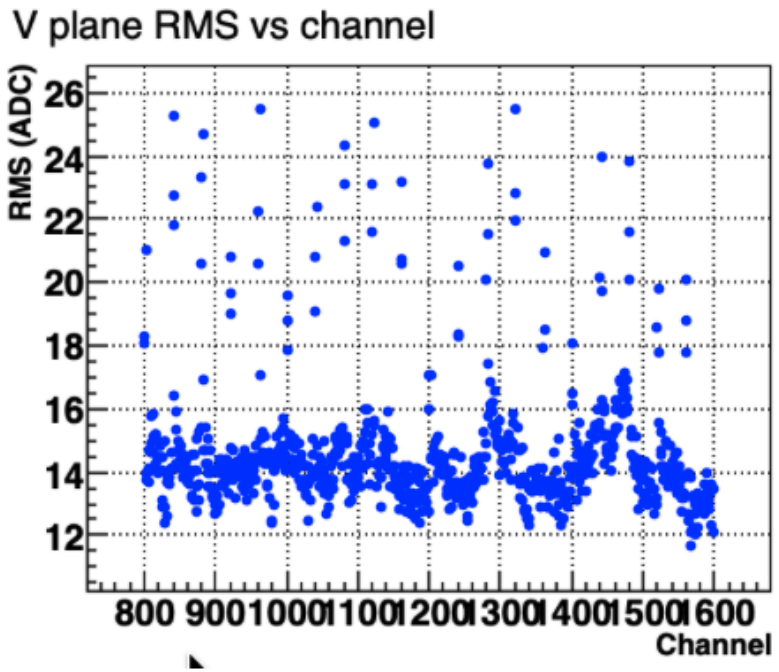
Coherent noise removal: +3 shift

- PDHD issue: 3 channel shift is observed in coherent noise grouping.

After the CNR

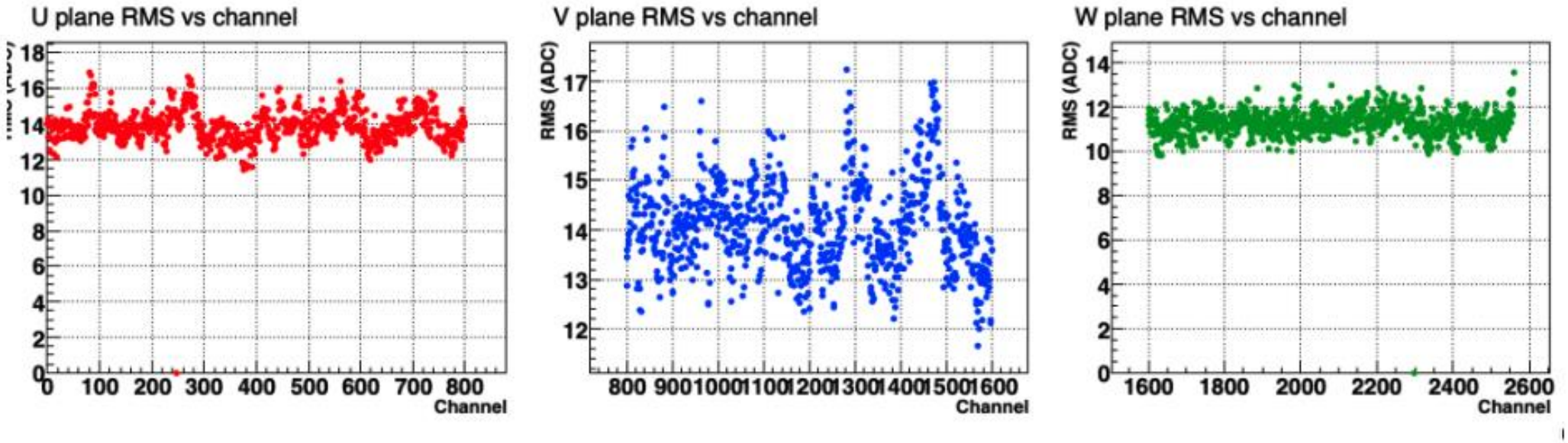




- CNR group matches CE FEMB hardware group mapping.
- **Data shows group boundaries are misaligned by 3 channels.**

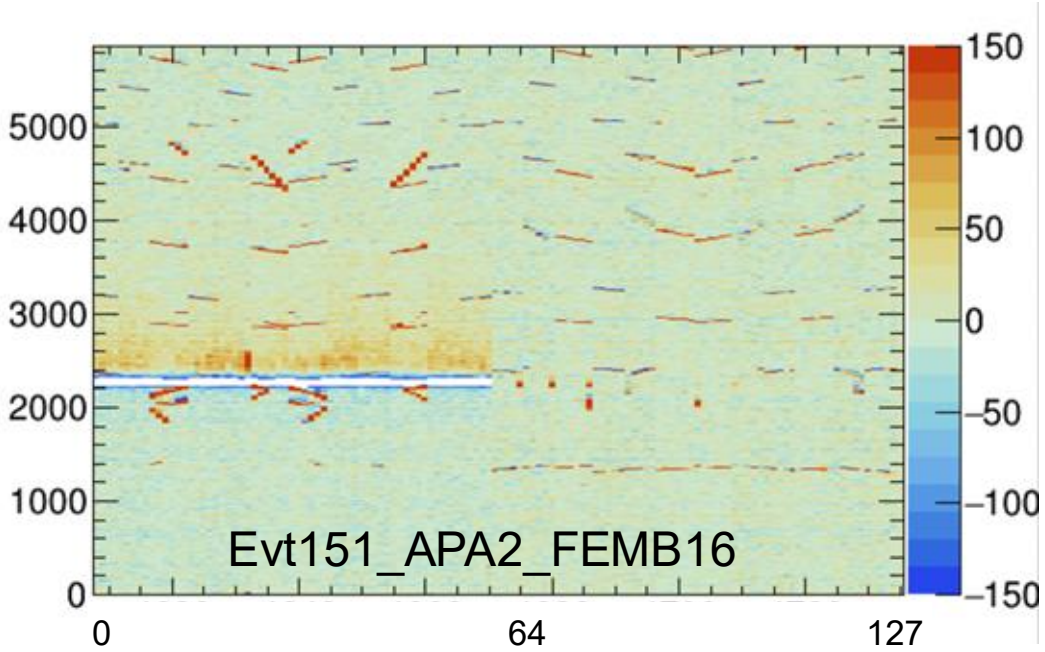
Coherent noise removal: +3 shift

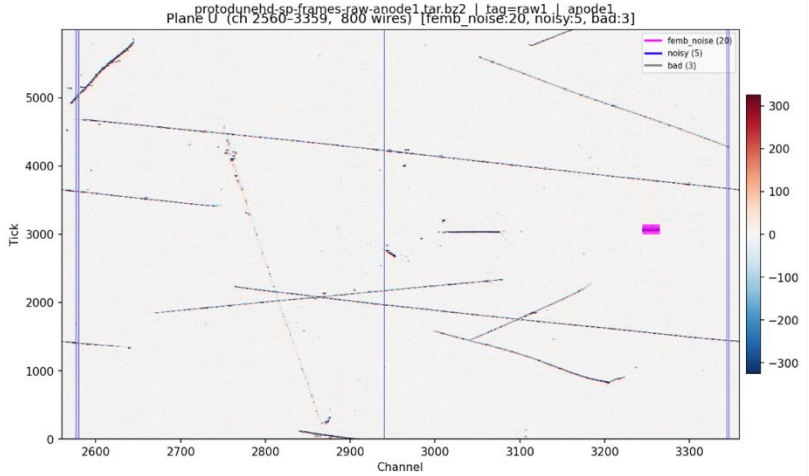
After fix: shift +3.

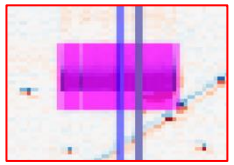


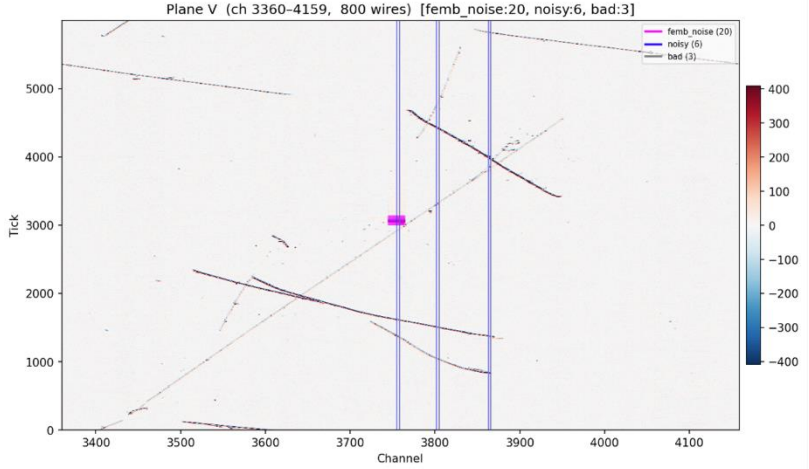
- After +3 cycle shift: coherent noise is properly contained within each group.

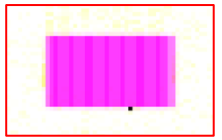
PDHD; FEMB saturation noise

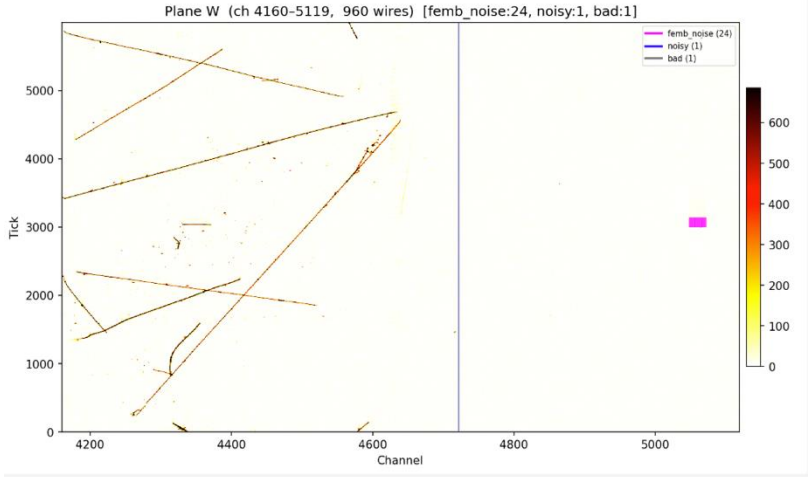












- Affects half-FEMB units; spans all 3 planes.
- Flags only, downstream masking handles the flagged samples.
- now included in the HD noise filter chain

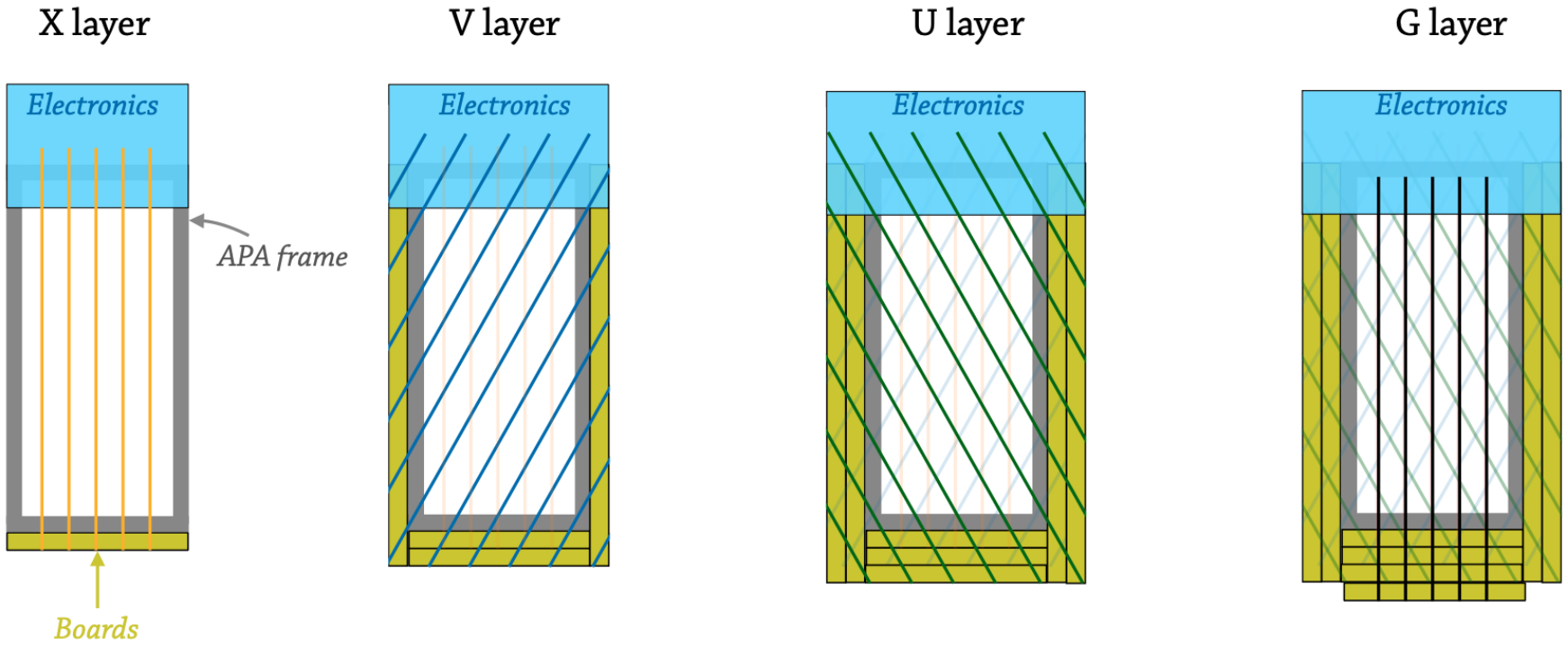
- **FEMB negpulse group should apply −3 cycle shift, net 6-channel discrepancy compared to coherent noise removal.**

+-3 wires: HD geometry

How wires are wrapped

Thanks Roger and Laura for lots of help

There are boards around the APA frame for wrapping (side boards) and holding the wires (foot boards). The wire are read by the electronics at the top

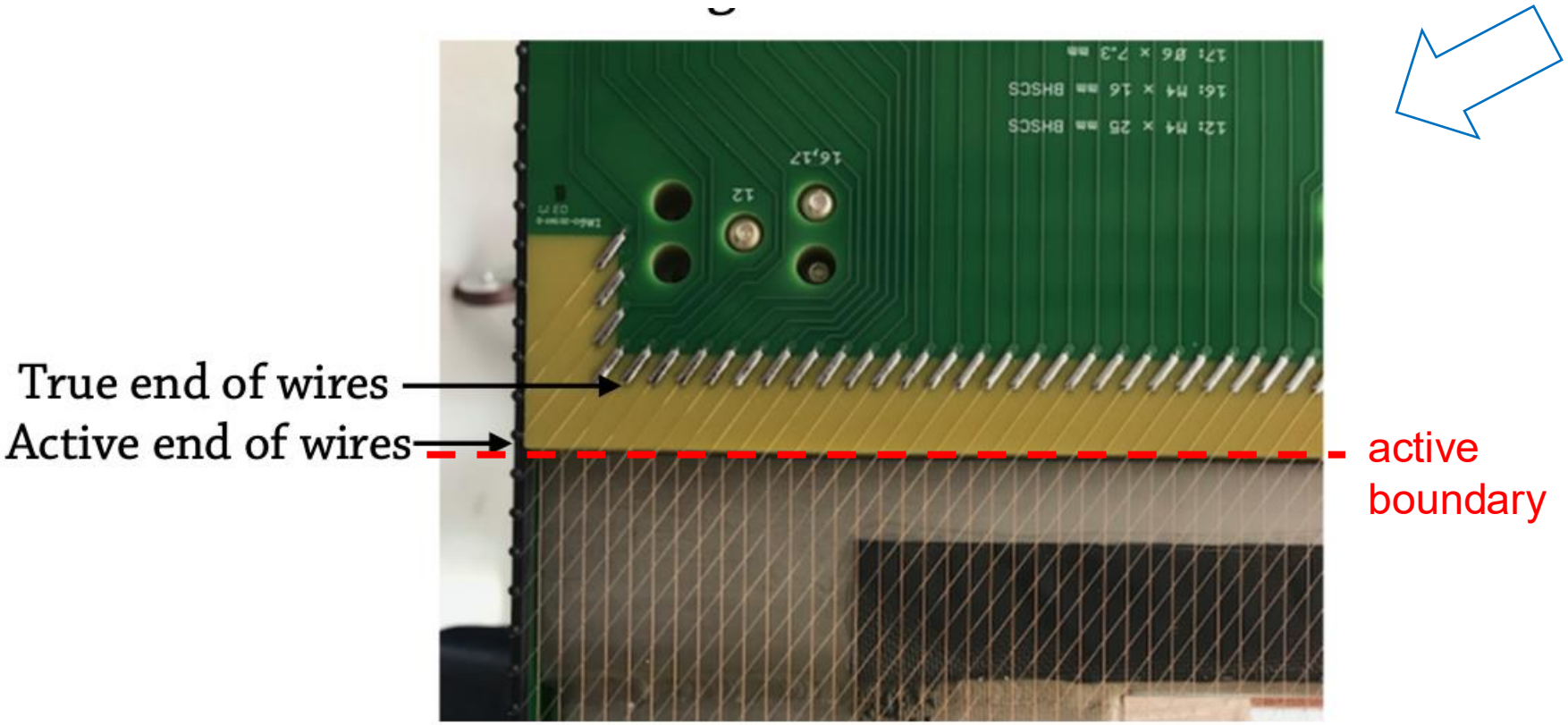


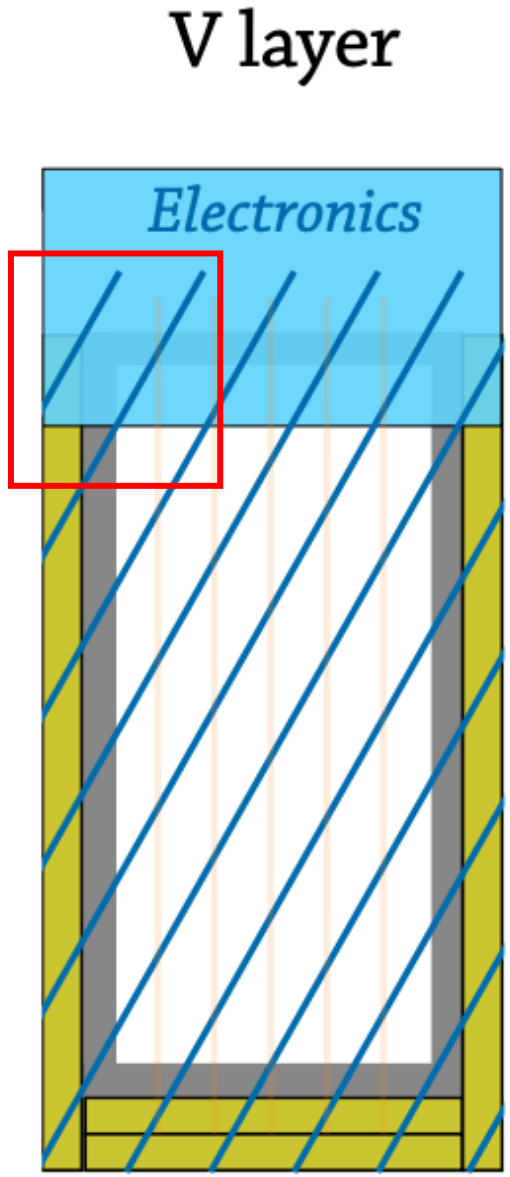
There are 2 boards for holding / wrapping the wires on 3 sides of an APA

From Laura; DRA - July 2nd 2025

How wires are read

At the top of the APA, the wires are soldered to an electronic card (head board). The head board thickness in 4.7 mm (matching the distance between layers)
The wires are soldered 2.3 cm away from the board ends, but this part of the wires is completely inactive as other boards are glued above them.





From Laura; DRA - July 2nd 2025

3 wire problem

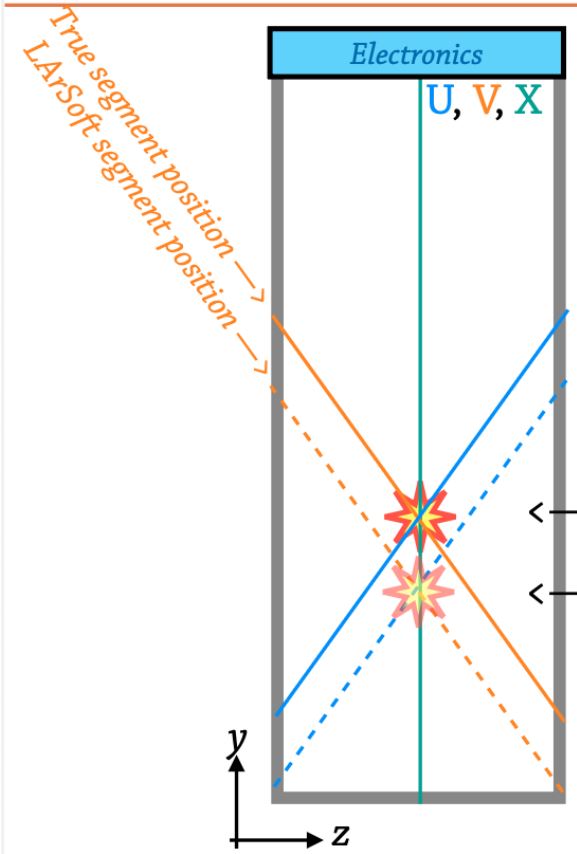
Let's focus on the top side of the APA, where the wires are soldered to the electronics (i.e APA 1&2 for ProtoDUNE-HD, we'll discuss APA3&4 later)

U (\)	399	<—	0
V (/)	0	—>	399
X (|)	0	—>	479
	APA seen from above		
X (|)	480	—>	959
V (\)	799	<—	400
U (/)	400	—>	799

In LArSoft, the wire segment are defined up to the active boundary at the board end : there is a mismatch between the real location of these wires and where it is defined in the reconstruction

From Laura; DRA - July 2nd 2025

Does it matters ?

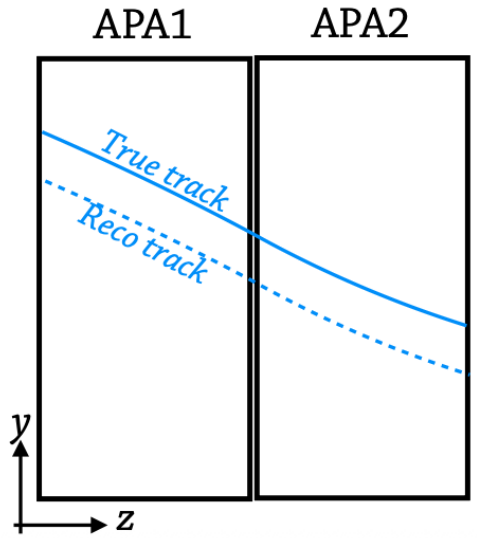


—> Yes and No

For a true deposition at (x, y, z) seen by U, V, X wires, if we don't fix the 3-wires problem, the hit will be reconstructed at (x, y', z) where
$\Delta y = y' - y = 2.4$ cm

<— True deposition

<— Reconstructed deposition



If all APAs have the same offset (like in ProtoDUNE-SP), then one can just move the active volume definition by -2.4cm along y.

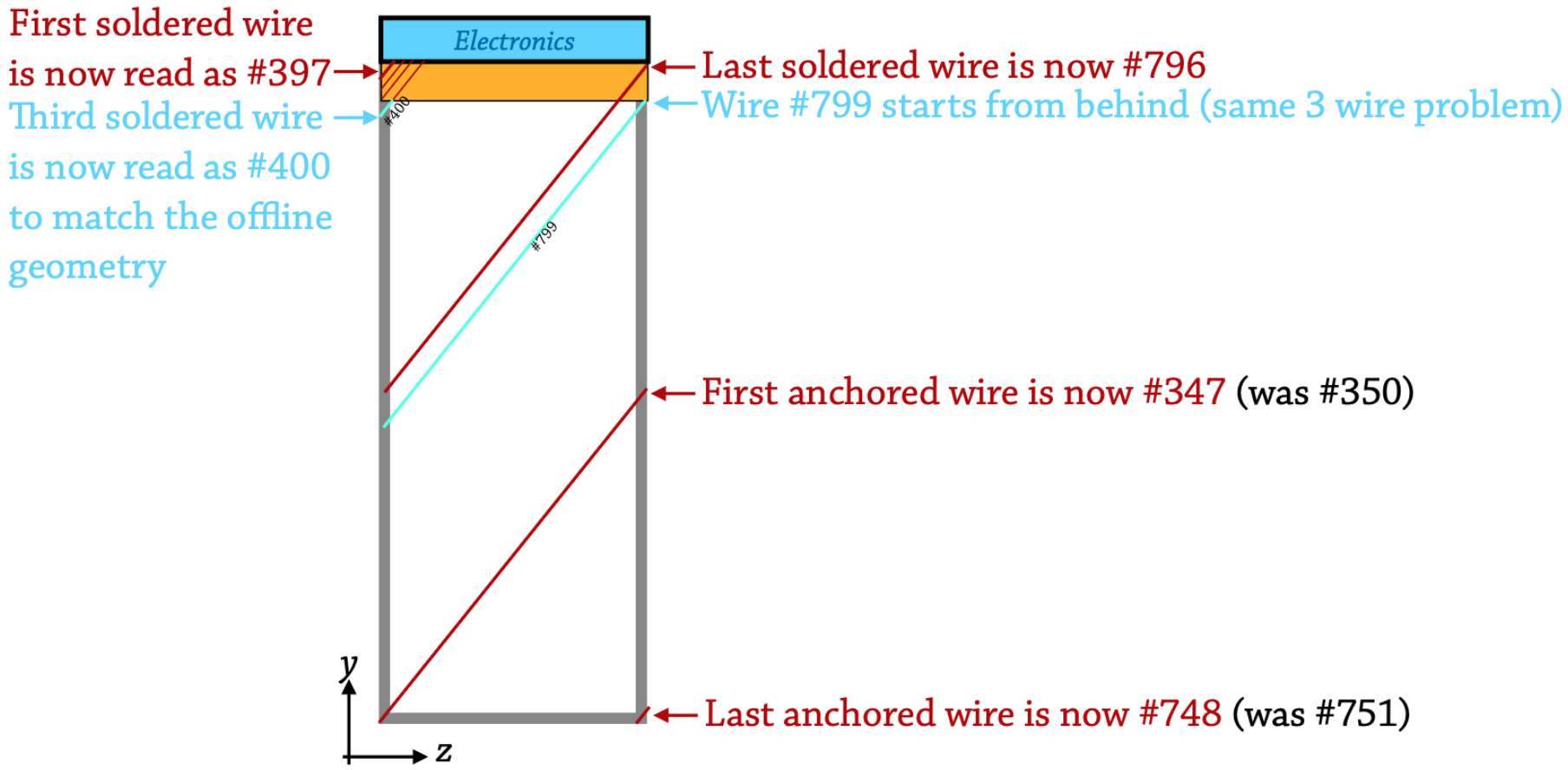
In ProtoDUNE-HD, we have to fix the problem as the offset has different consequences for APA1&2 (electronics at the top) and APA 3&4 (electronics at the bottom)

From Laura; DRA - July 2nd 2025

How to fix it (top electronics: APA 1&2)

The solution to fix the problem is to make an offset of **-3** to the wire number when reading them (i.e. at the channel mapping level)

e.g. for the U layer on the active side of APA1&2



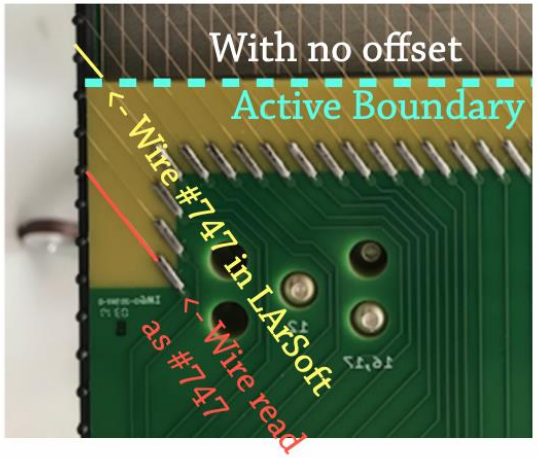
From Laura; DRA - July 2nd 2025

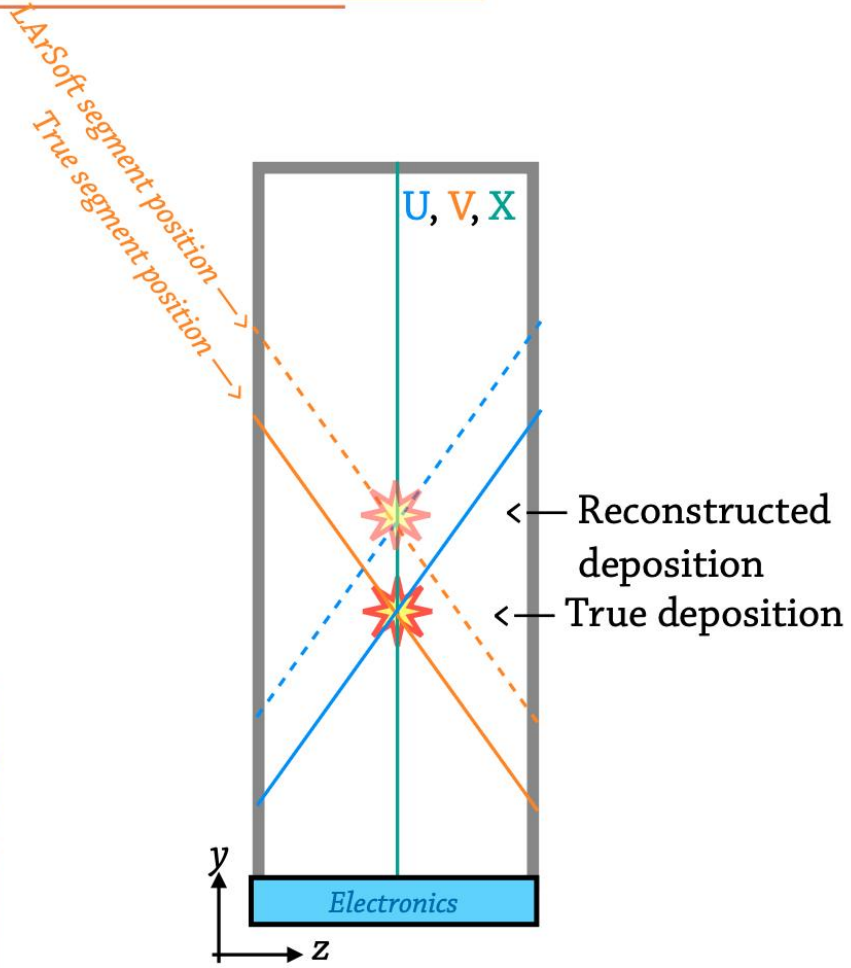
Inverted APAs (APA 3&4)

At the bottom of the APA

Channel ordering at active boundary
-> Used for reconstruction

U (\)	347	<—	0, 799...,748
V (/)	748 ... 799, 0	—>	347
X (|)	0	—>	479
	APA seen from above		
X (|)	480	—>	959
V (\)	747	<—	348
U (/)	348	—>	747





If you don't correct for the 3-wire offset, the deposition will be reconstructed 2.4cm higher than where it actually is

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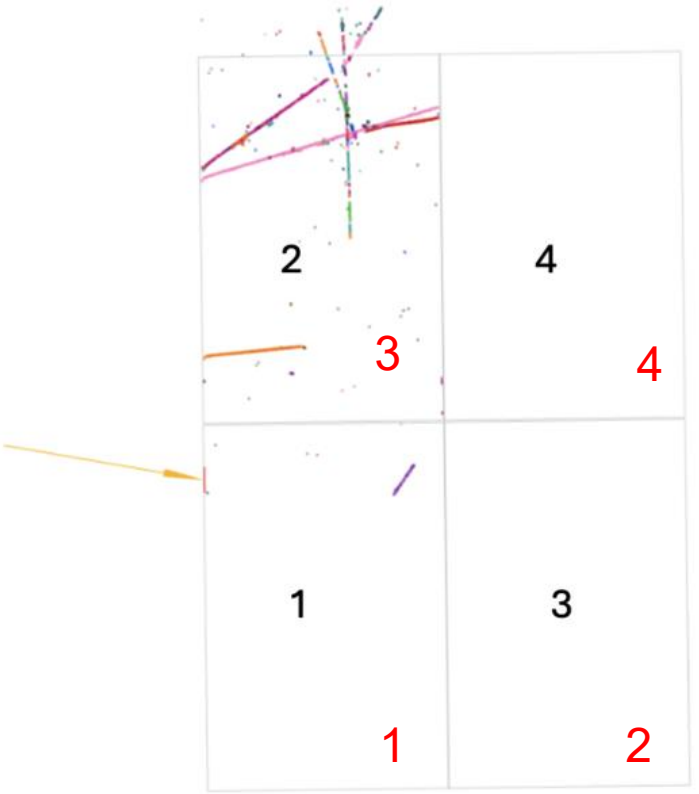
From Laura; DRA - July 2nd 2025

Consistent with our observation:

- In coherent noise group, APA 1 and 3 (labeled 1 and 2 in HD) exhibit a +3 channel shift.
  - For APA 2 and 4 ((labeled 3 and 4 in HD)), the shift is less clear, but we assume a similar +3 channel shift. (which is not right)
- In FEMB saturation noise group, all observed examples I have occur in APA 2 and 4 (labeled 3 and 4 in HD), with a −3 channel shift.
- These observations are consistent with the mapping shift behavior.
- Update channel groupings accordingly based on this convention.

This is how our define APA 1-4



This is how hardware people always define APA 1-4;

official chain update timeline

When the flip from `electronics_v1` → `visiblewires_v1` happened

Upstream commit: `3f70ab5d2d` — *"change default channel map for PDHD to the visible wires from the electronics map."*

- **Author:** Thomas Junk (`trj@fnal.gov`)
- **Date authored:** 2025-03-18 23:30 UTC
- **File touched:** `fcl/protodunehd/reco/standard_reco_protodunehd_keepup.fcl` (+1/-1, just the FileName line)

First release containing it: `dunesw v10_04_07d00`, published to cvmfs on **2025-03-24 09:14 PDT** (6 days after the commit).

cvmfs publish timeline around the flip:

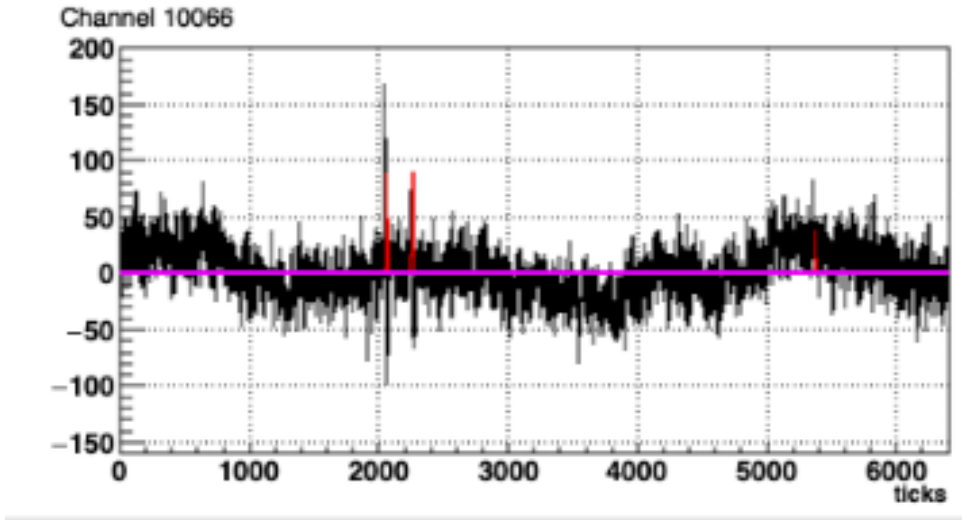
Version	Published to cvmfs	FileName
`v10_04_06d00`	2025-03-14 13:59 PDT	`electronics_v1` (last release before the flip)
`v10_04_07d00`	**2025-03-24 09:14 PDT**	**`visiblewires_v1` (first release after the flip)**
`v10_04_07d01`	2025-03-28 12:09 PDT	`visiblewires_v1`
`v10_05_00d00`	2025-04-18 11:37 PDT	`visiblewires_v1`

For reference, the actual fcl change in `v10_04_07d00`:

```
PD2HDChannelMapService:
 {
   FileName: "PD2HDChannelMap_WIBEth_visiblewires_v1.txt"   # was: ..._electronics_v1.txt
 }
```

https://github.com/DUNE/duneprototypes/blob/c8f43809881be9636bac9abcc2dea6df6f12711c/duneprototypes/Protodune/hd/ChannelMap/PD2HDChannelMap_WIBEth_visiblewires_v1.txt

Finalize RMS cut



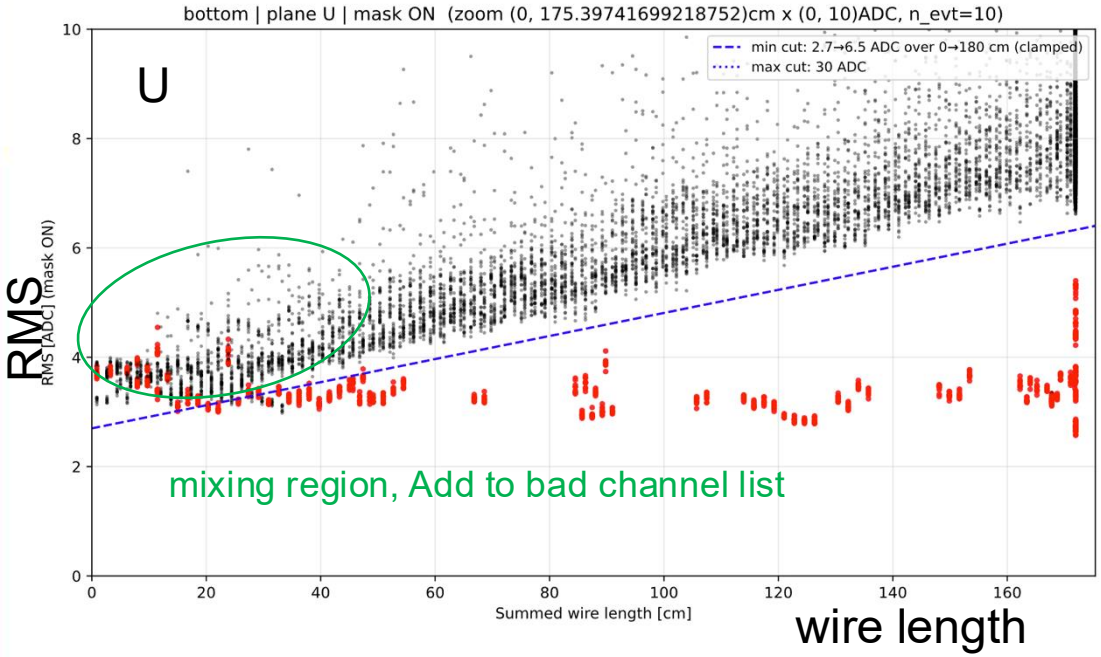
- PDHD Updates
  - Apply gain-dependent flat cut (7.8 or 14 mV/fC).
  - 10 < RMS < 50. @ 14 mV/fC
  - Remove frequency mask.

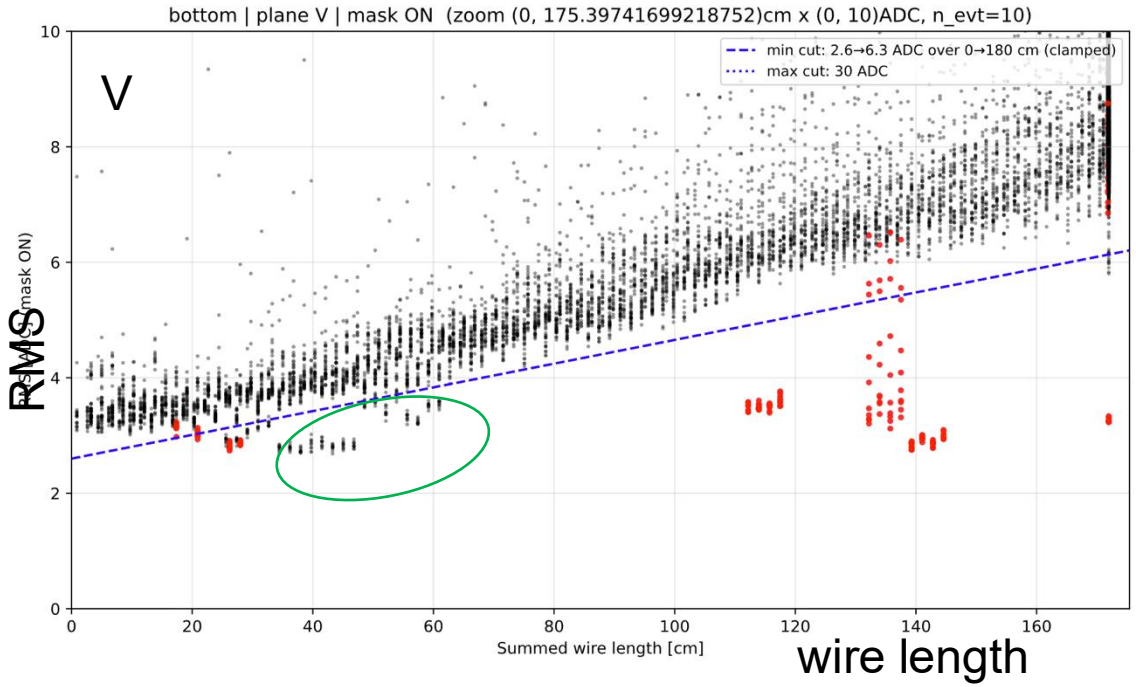
- PDVD Updates
  - Re-scan all channels and label only absolutely dead channels.
  - Definition of a dead channel:
    - Within a track, a channel shows no signal, while its ±1 neighboring channels do.
    - Some TDE channels exhibit abnormal baseline behavior, and will cause problem in signal processing

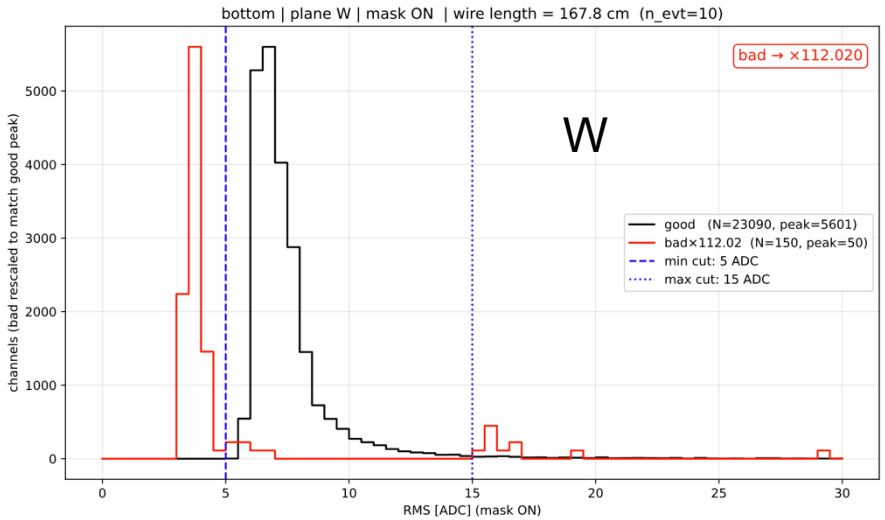
  - Some noisy channels show elevated RMS only at specific frequency peaks, while their signals remain good. These channels will not be labeled as bad in this iteration.

PDVD; Bottom

10 events;
Red dots: hand-scan bad channels



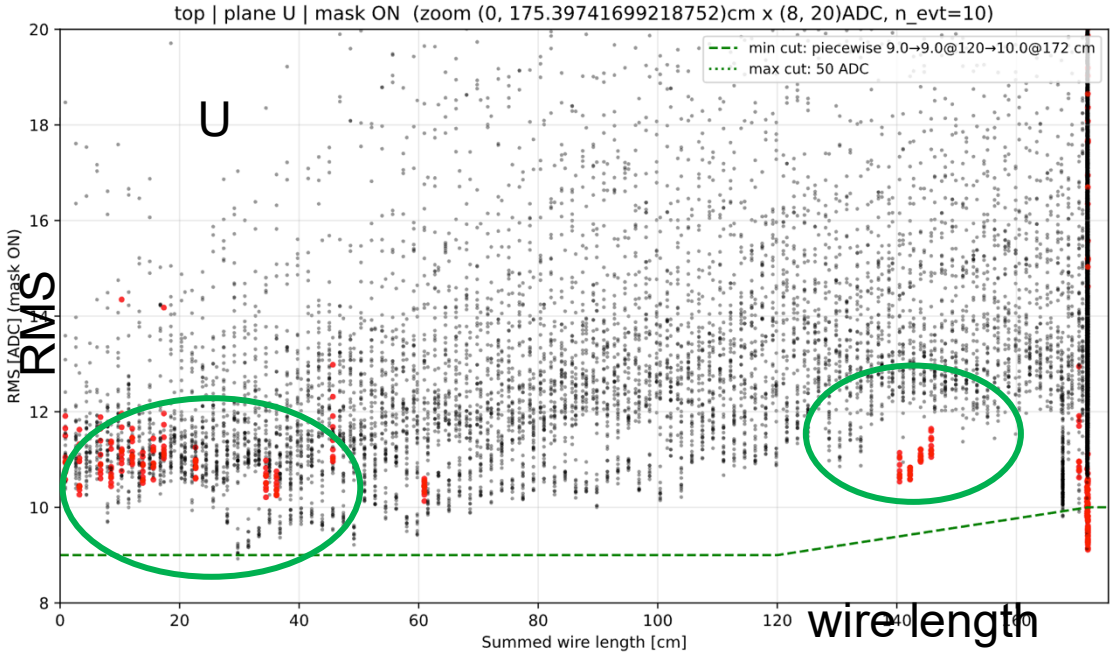


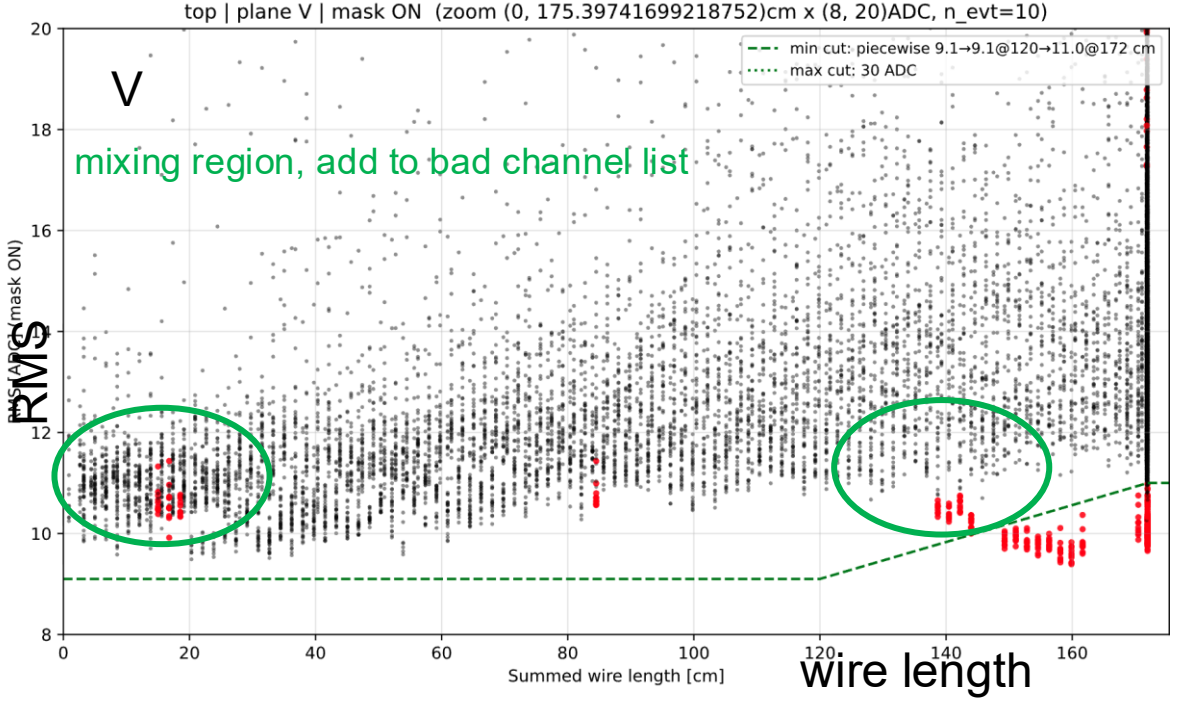


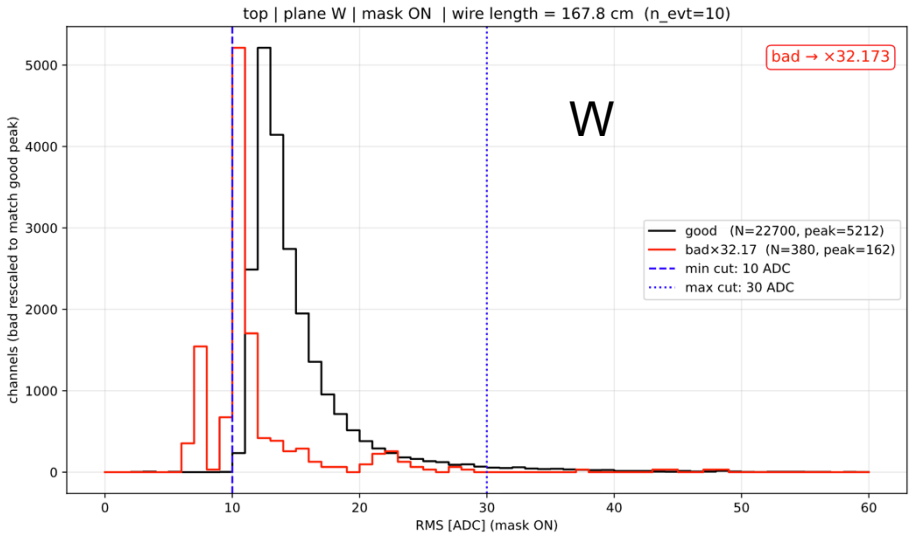
- Channels in this region are **not manually labeled**,
  - Lie at the **detector edge,** No tracks pass through; **no direct evidence** to classify them as bad.
- However, based on **RMS results**, it is **reasonable to consider them as bad channels**.

PDVD;Top

10 events;
Red dots: hand-scan bad channels







Final cuts for PDVD:

Bottom:

```
// Bottom TPCs: W flat; U and V linear-in-wirelength on min
{ channels: w_chans, min_rms_cut: 5.0 * gain_scale, max_rms_cut: 15.0 *
gain_scale },
{ channels: u_chans,
  min_rms_cut: { type: 'linear_in_wirelength', l0: 0.0, v0: 2.7 * gain_scale,
  l1: 180.0, v1: 6.5 * gain_scale },
  max_rms_cut: 30.0 * gain_scale },
{ channels: v_chans,
  min_rms_cut: { type: 'linear_in_wirelength', l0: 0.0, v0: 2.6 * gain_scale,
  l1: 180.0, v1: 6.3 * gain_scale },
  max_rms_cut: 30.0 * gain_scale },
```

Top:

```
// Top TPCs.
// U/V: piecewise-linear-in-wirelength min — flat at short L, then
//   linear up at long L because longer-than-typical induction wires
//   pick up extra capacitive noise. Max stays per-plane flat.
// W: flat per-plane (collection: ~uniform length).
{ channels: u_chans,
  min_rms_cut: { type: 'piecewise_linear_in_wirelength',
                 points: [
                   { l:   0.0, v:  9.0 * gain_scale },
                   { l: 120.0, v:  9.0 * gain_scale },
                   { l: 172.0, v: 10.0 * gain_scale },
                 ] },
  max_rms_cut: 50.0 * gain_scale },
{ channels: v_chans,
  min_rms_cut: { type: 'piecewise_linear_in_wirelength',
                 points: [
                   { l:   0.0, v:  9.1 * gain_scale },
                   { l: 120.0, v:  9.1 * gain_scale },
                   { l: 172.0, v: 11.0 * gain_scale },
                 ] },
  max_rms_cut: 30.0 * gain_scale },
{ channels: w_chans, min_rms_cut: 10.0 * gain_scale, max_rms_cut: 30.0 *
gain_scale },
```

Bad channel list:

```
bad: [
  // top electronics
  293, 955, 1482, 2657, 2705, 2727, 4242, 4243, 5471,
  11701, 11702, 11703, 11893, 11895, 11996,
  // CRP4 U
  188, 422, 423, 432, 433, 434, 435, 452, 453, 454, 455,
  464, 465, 466, 467, 471, 472, 473, 474, 475,
  494, 495, 496, 497, 498, 499, 500, 501, 502, 503,
  // CRP4 V
  528, 529, 530, 531, 544, 545, 546, 547, 548, 549, 550, 551, 665, 666,
  // CRP4 U hand scan (anode 0, run 039324, low-RMS bad signals)
  4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 20, 21, 25,
  // CRP4 V hand scan (anode 0, run 039324)
  962,
  1365, 1366,
  1402, 1403, 1412, 1413, 1416, 1417, 1418, 1419, 1420,
  1421, 1422, 1423, 1424, 1425, 1426, 1427,
  // CRP4 Z
  972, 973, 1143, 1243, 1610, 1799, 1800, 1801, 1802,
  2172, 2197, 2199, 2294, 2370,
  // CRP5 U
  3180, 3181, 3186, 3187, 3197, 3427, 3445,
  3452, 3453, 3454, 3455,
  3520, 3521, 3522, 3523, 3524, 3525, 3526, 3527,
  3535, 3536, 3537, 3538, 3539,
  3552, 3553, 3556, 3557, 3558, 3559,
  3570, 3571, 3582, 3583, 3584,
  3618, 3619, 3620, 3621, 3628, 3629, 3630, 3631,
  3636, 3637, 3640, 3641, 3642, 3643,
  3794, 3919,
  // CRP5 V
  4026, 4027, 4028, 4029, 4030, 4031, 4032, 4033, 4034, 4035,
  4036, 4037, 4038, 4039, 4040, 4041, 4042, 4043, 4044, 4045,
  4046, 4047, 4048, 4049, 4050, 4051, 4052, 4053, 4054, 4055,
  4084, 4085, 4086, 4087,
  4892, 4893, 4894, 4895, 4896, 4897, 4898, 4899,
  // CRP5 Z
  5193, 5239, 5265, 5266, 5267, 5344, 5821, 5824, 5825,
  // anode 4 top U hand scan (run 039324, collection-like bad signals)
  6248, 6406, 6407,
  // anode 4 top W hand scan (run 039324, weird smaller signals)
  8123, 8124, 8414, 8507,
  // that the new RMS cut still misses (mostly dead with normal RMS).
  // Bottom (CRP4/5):
  928, 929, 964, 3072, 3073, 3074, 4001, 4707, 4791,
  // Top (anodes 4–7) — 84 channels:
  6604, 6620, 6621, 6622, 6623, 6624, 6625, 6626, 6628, 6629,
  6724, 6725, 6744, 6771, 6776, 6961, 7094,
  7341, 7346, 7442, 7572, 7573, 7574, 7817,
  7952, 7954, 7955, 7956, 7957, 7958, 7959, 7960, 7961, 7962, 7963,
  8316, 8772, 8899, 8914,
  9081, 9121, 9122, 9132, 9163, 9262,
  9724, 9725, 9784, 9785, 9786, 9787,
  10066, 10705, 10922,
  11044, 11045, 11046, 11047, 11048, 11049, 11050, 11051,
  11054, 11055, 11056, 11057,
  11410, 11411, 11458, 11463, 11464, 11467, 11468,
  11556, 11558, 11652,
  11727, 11730, 11731, 11773, 11848,
  12210, 12216, 12217,
],
```