

MANCHESTER
1824



DWA Updates

Anyssa Navrer-Agasson

For the DWA team

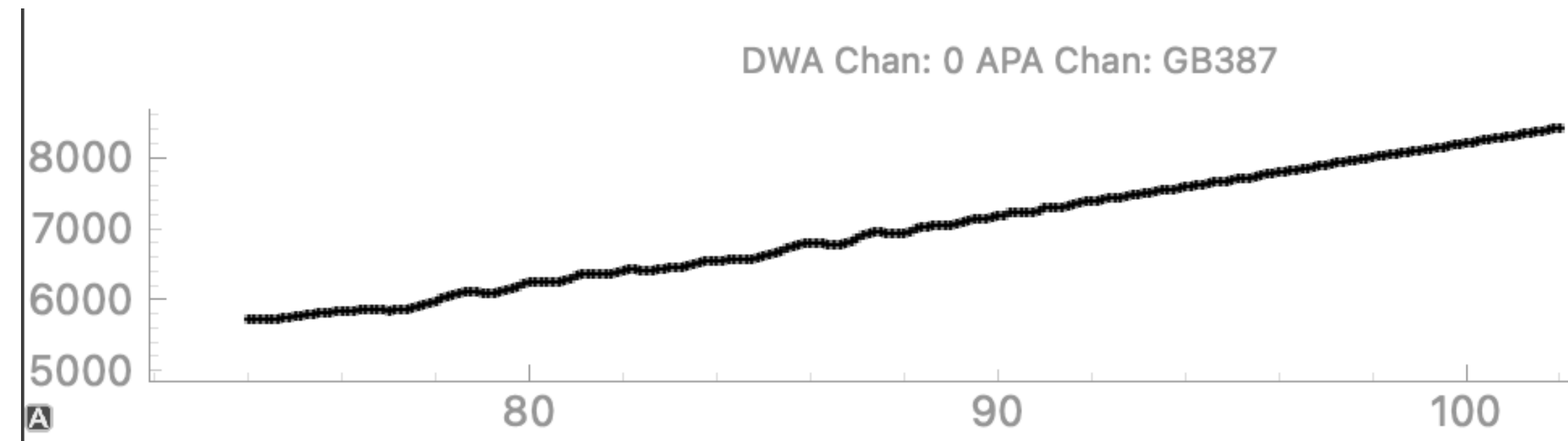
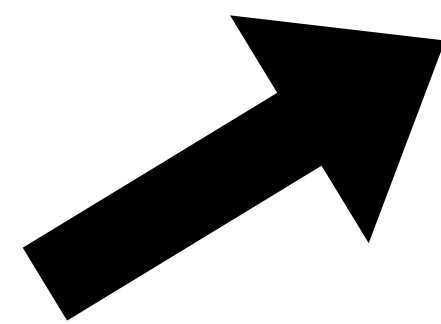
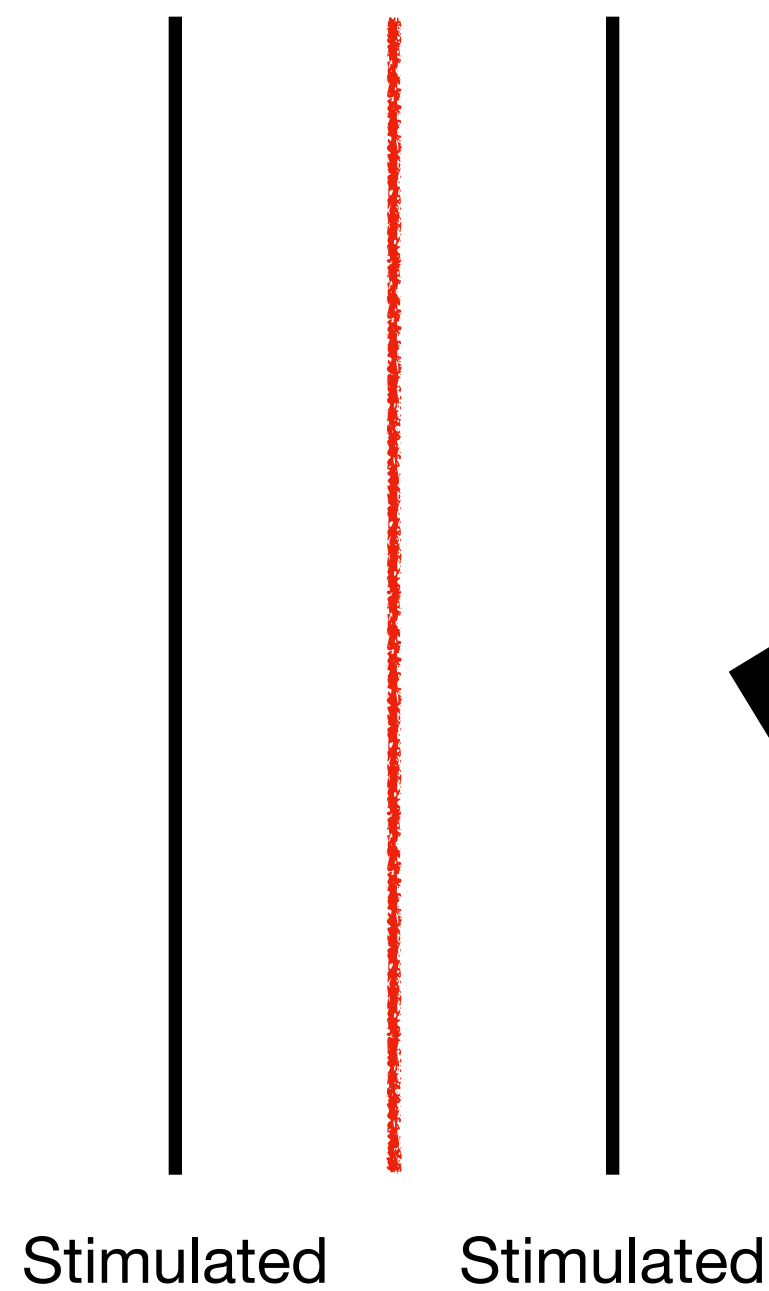
LBNF/DUNE-UK Project Meeting - 4 July 2023

How to measure a tension?

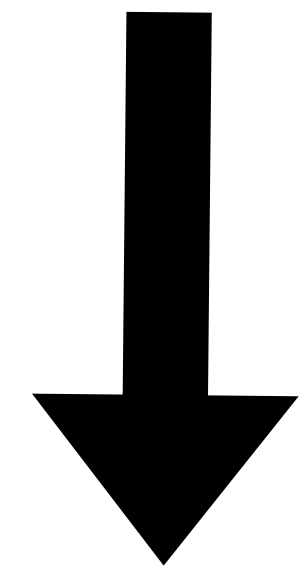
Tension is extracted by measuring the fundamental frequency of the wire:

$$T = 4\lambda L^2 f_0^2$$

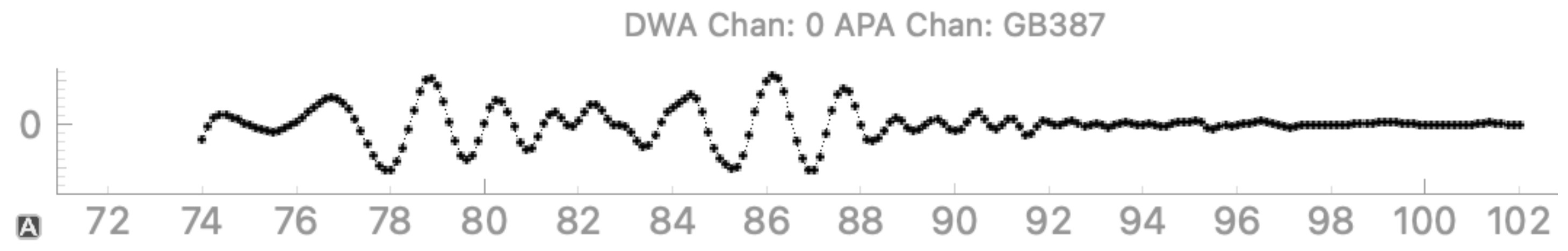
Measured



2. Read out middle wire while sweeping frequency of AC current



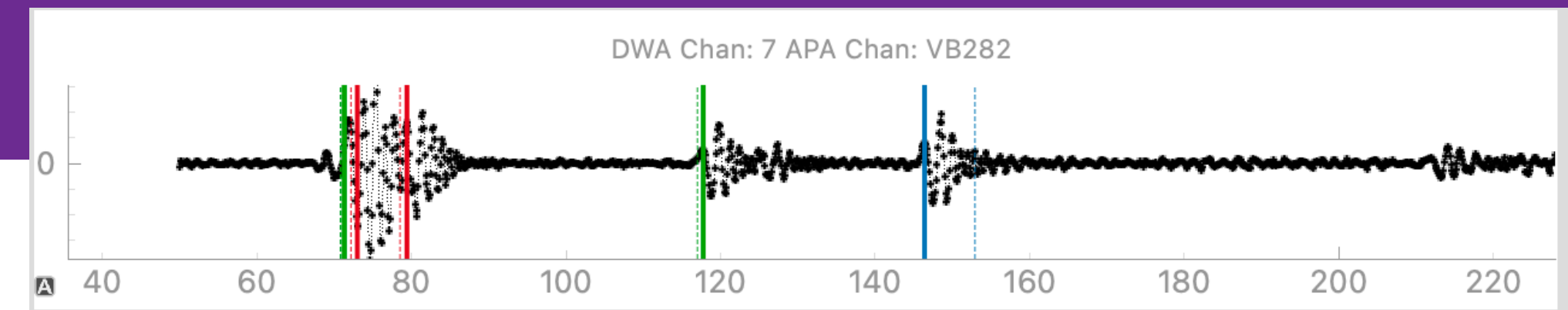
3. Smooth and subtract the baseline



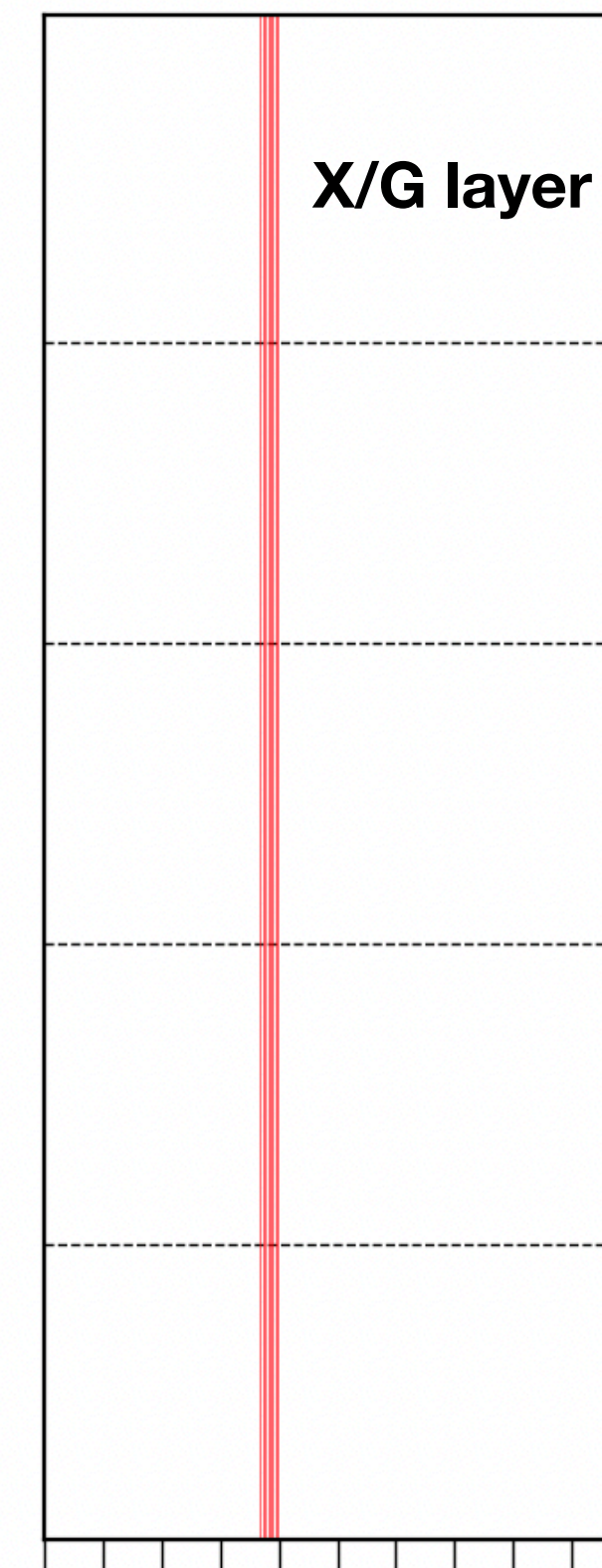
1. The two neighbouring wires are stimulated with a mix of AC and DC current.

How to measure a tension?

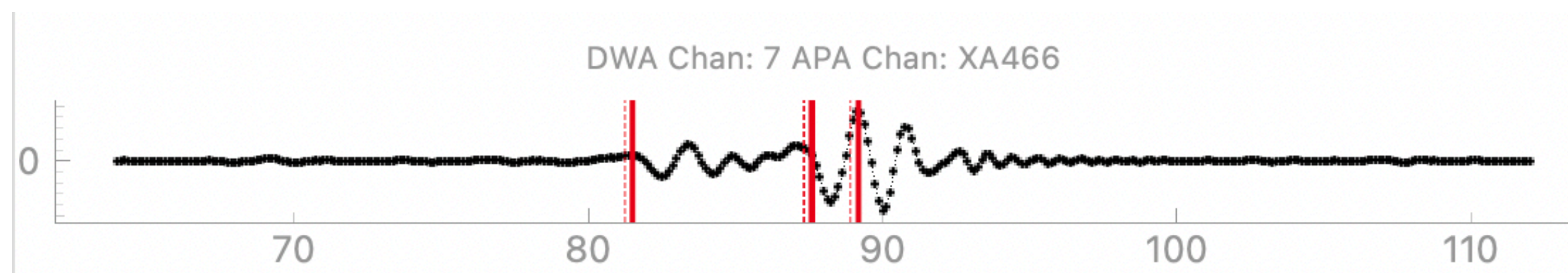
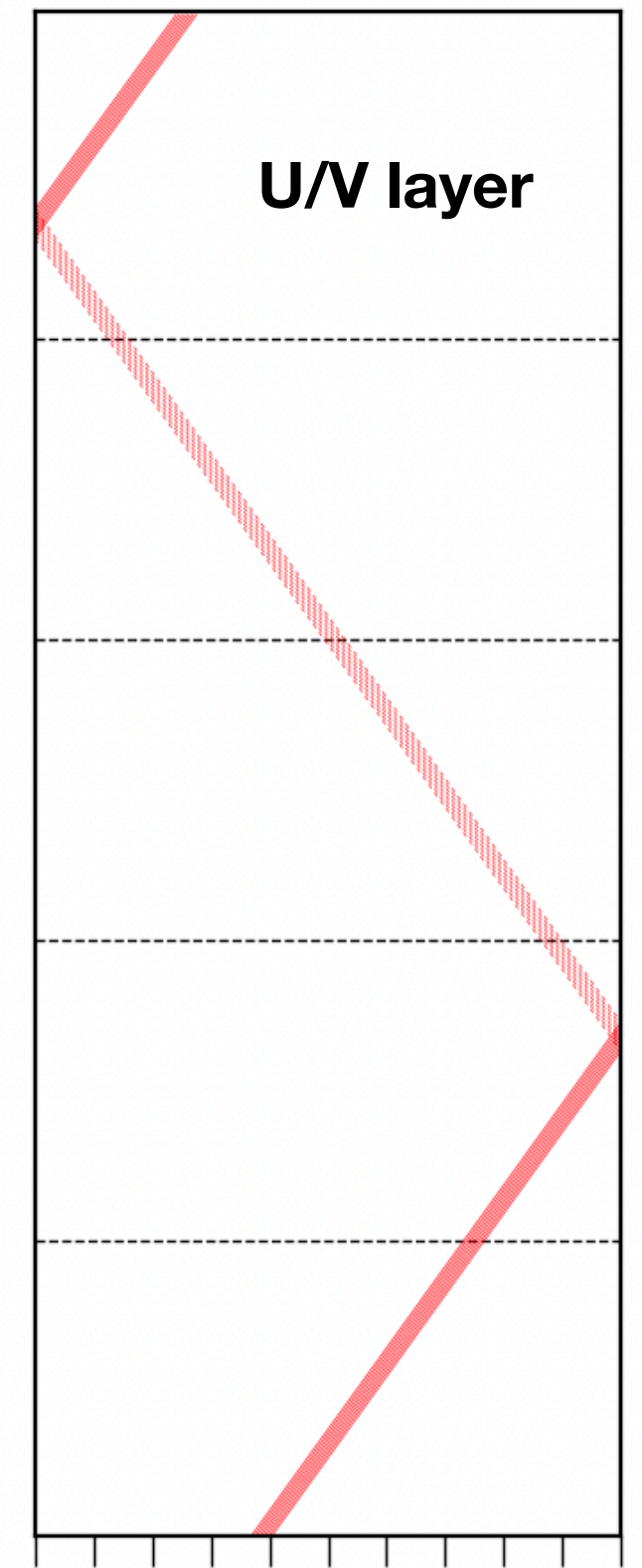
- Algorithm looks for resonance peaks in the baseline subtracted scan
- First peak is used to compute the tension
- Different peaks for different wire segments
 - Peak position depends on wire segment length



----- Comb ——— Wire side A



----- Comb ——— Wire side A
----- Wire side B



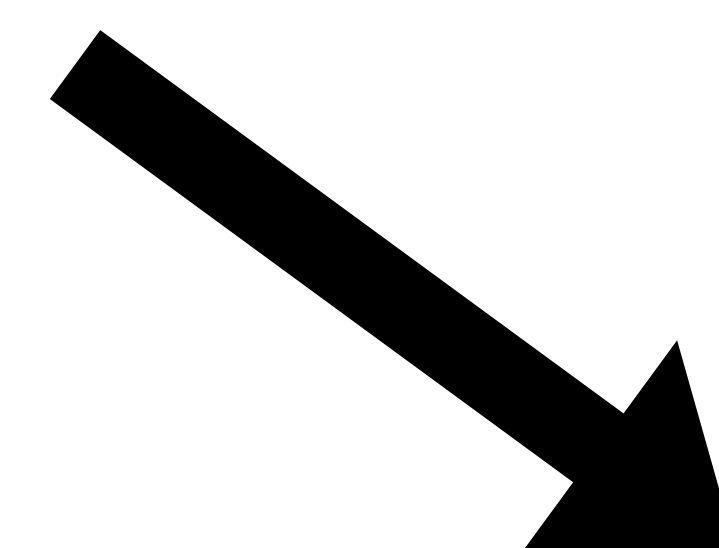
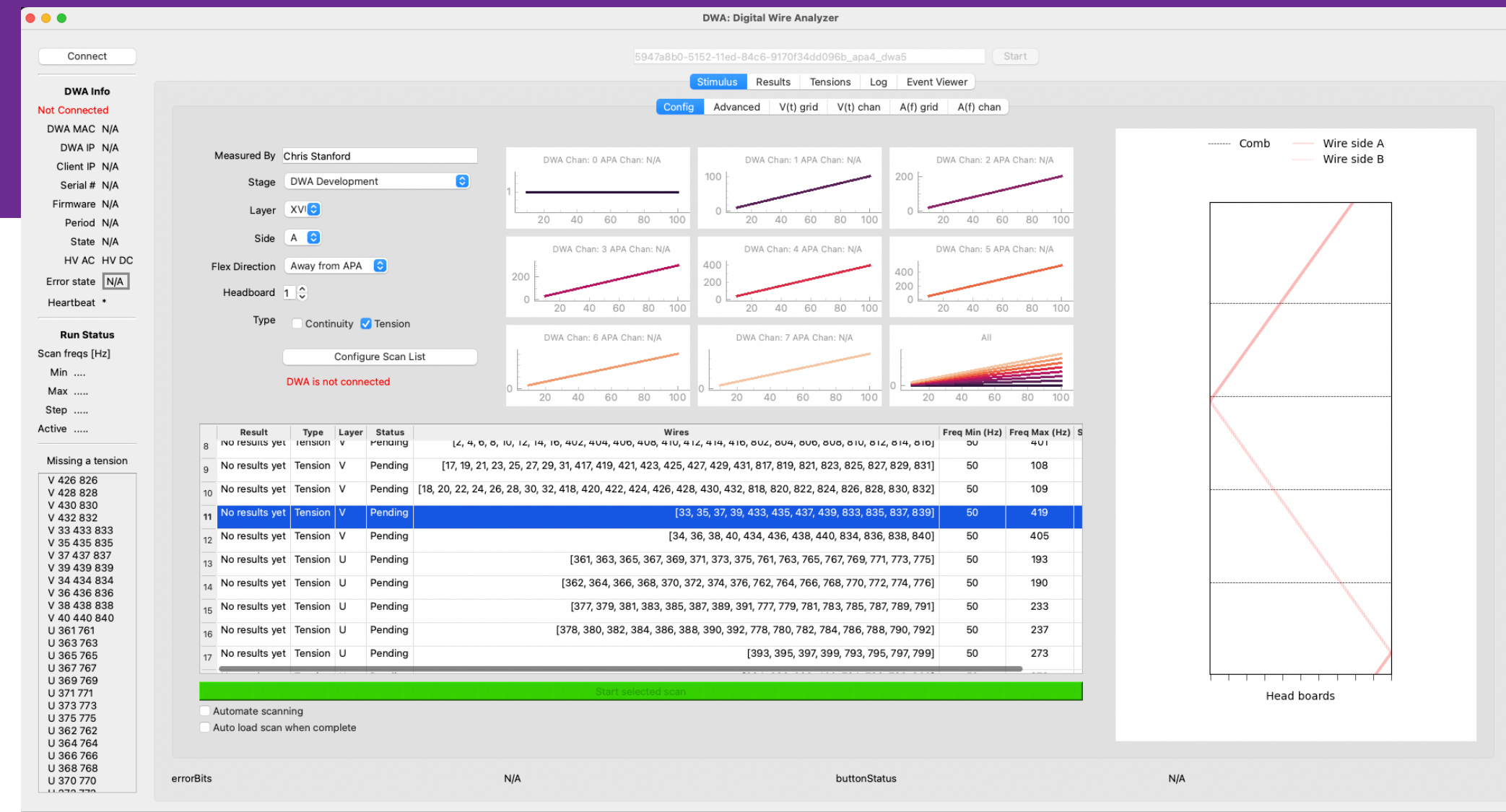
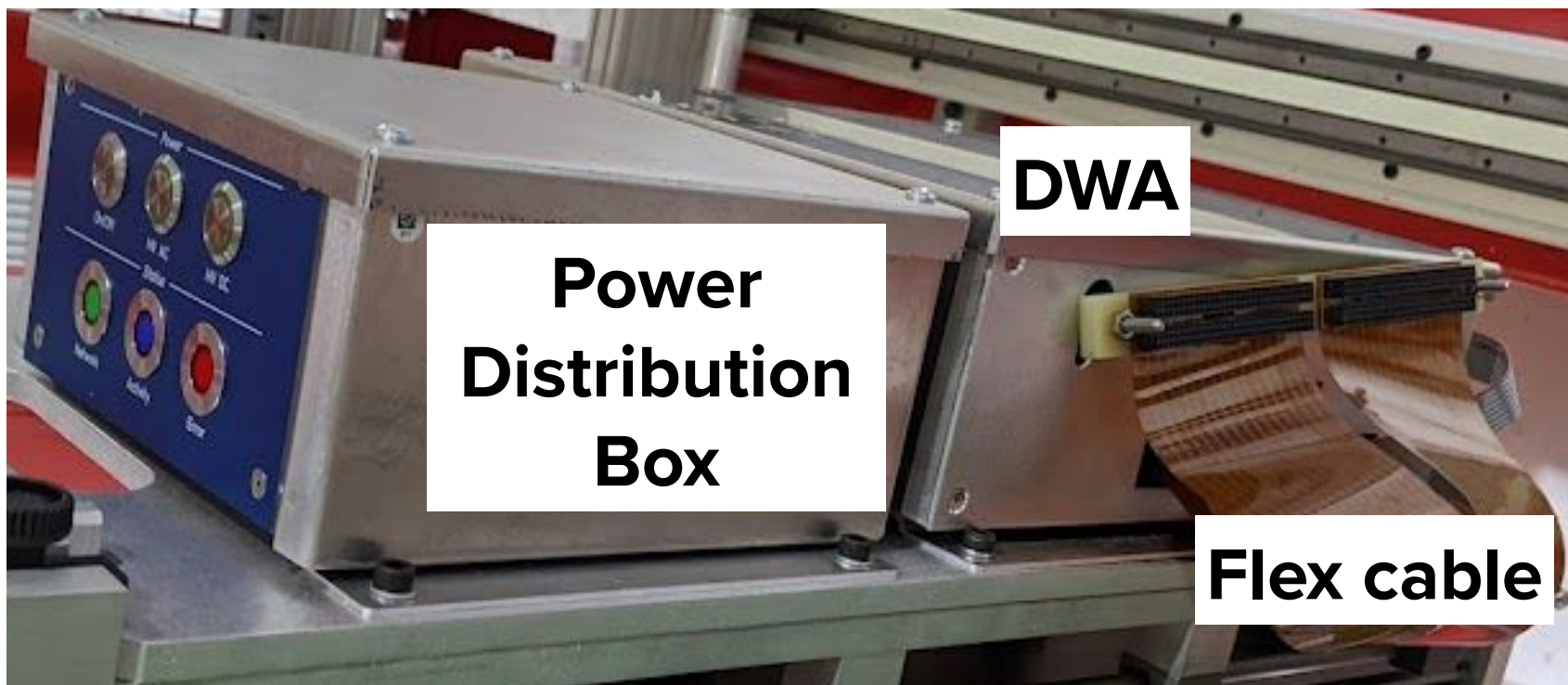
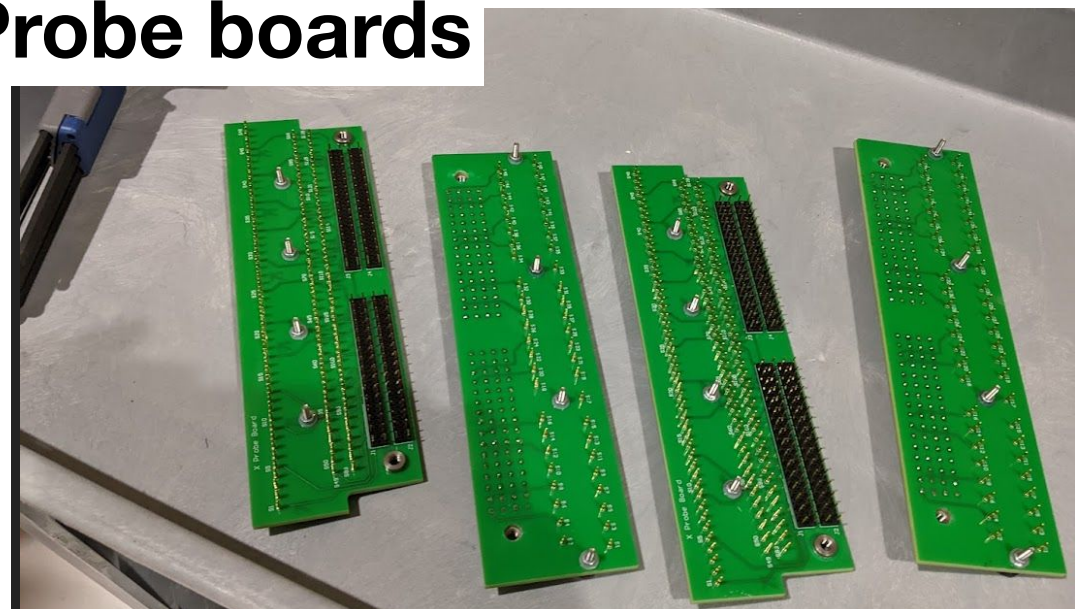
Head boards

Head boards

DWA Setup

Hardware

Probe boards

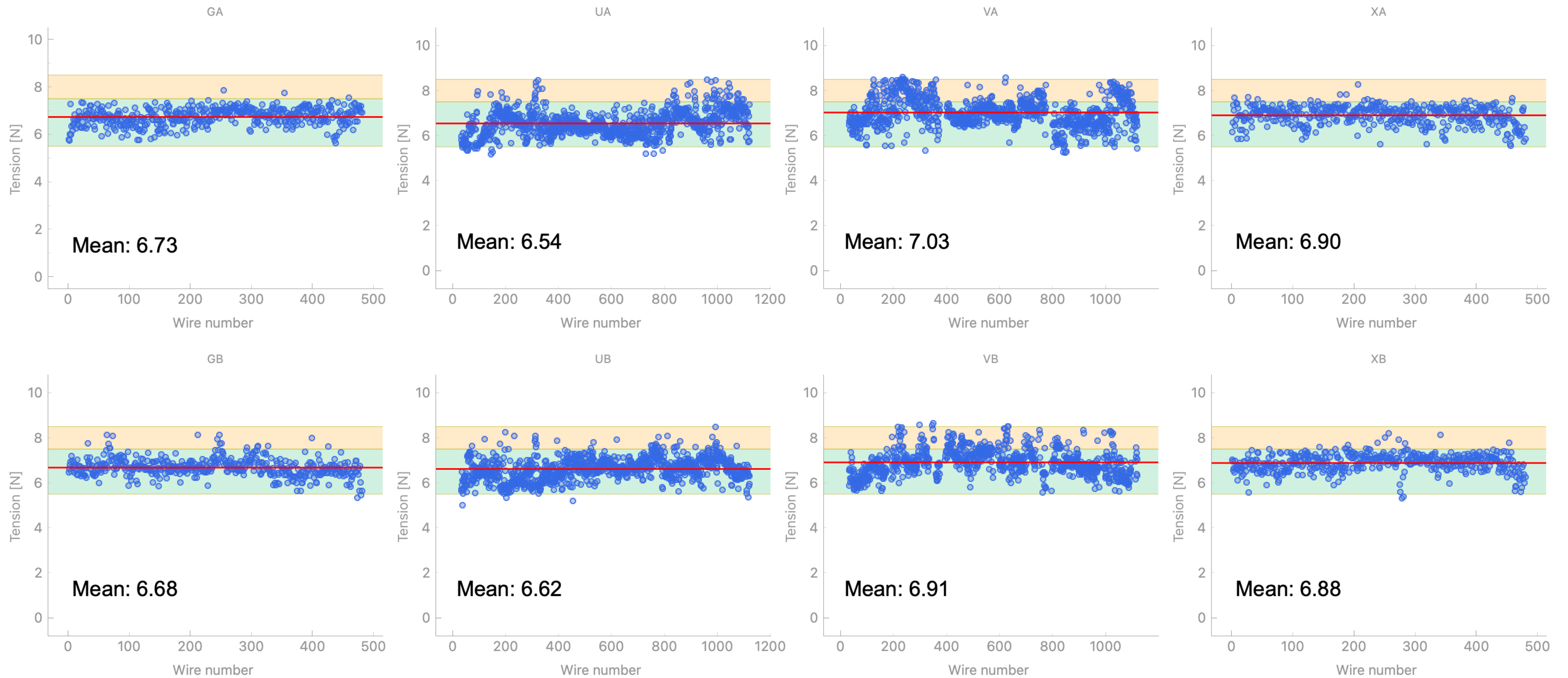


DWA DAQ

Wire Analysis Code



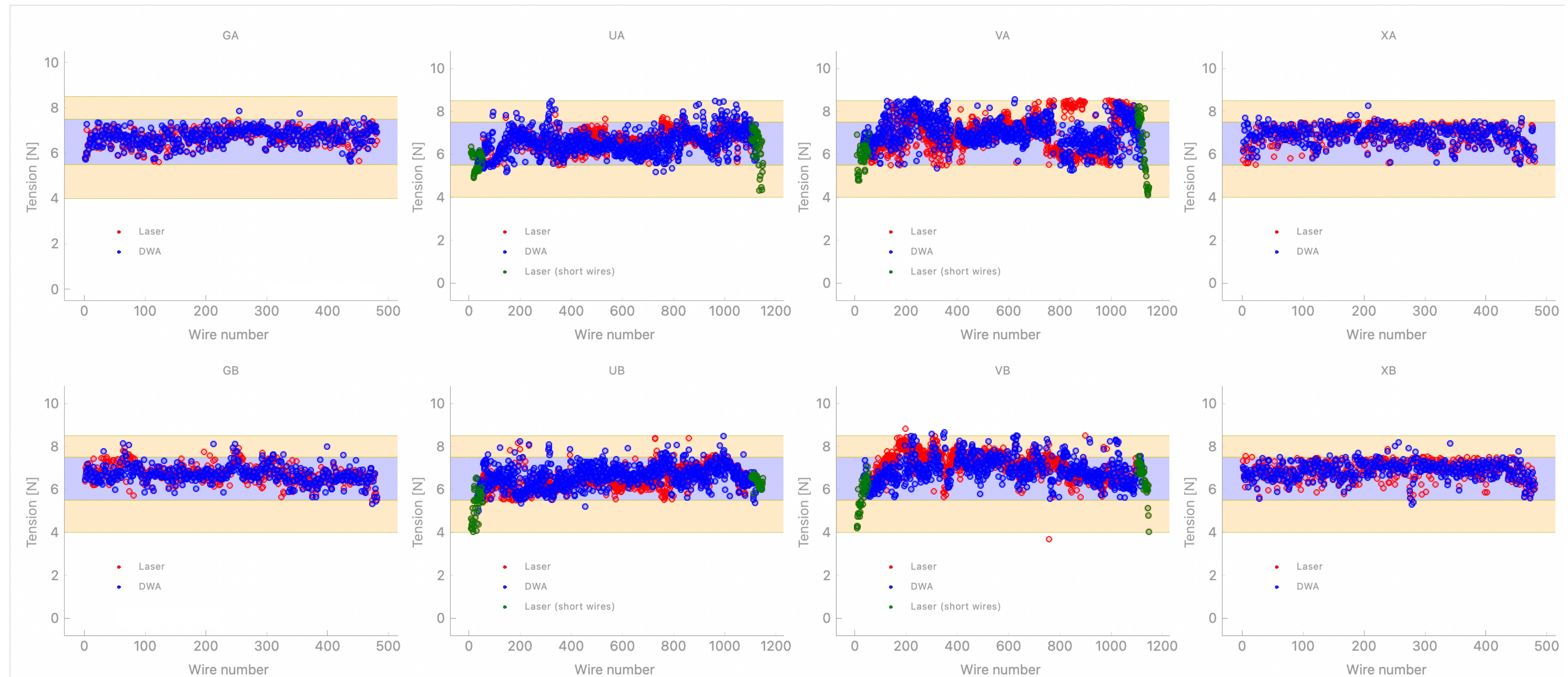
Wire tensions (APA 4)



Can measure individual layer or full APA

Wire Tolerances

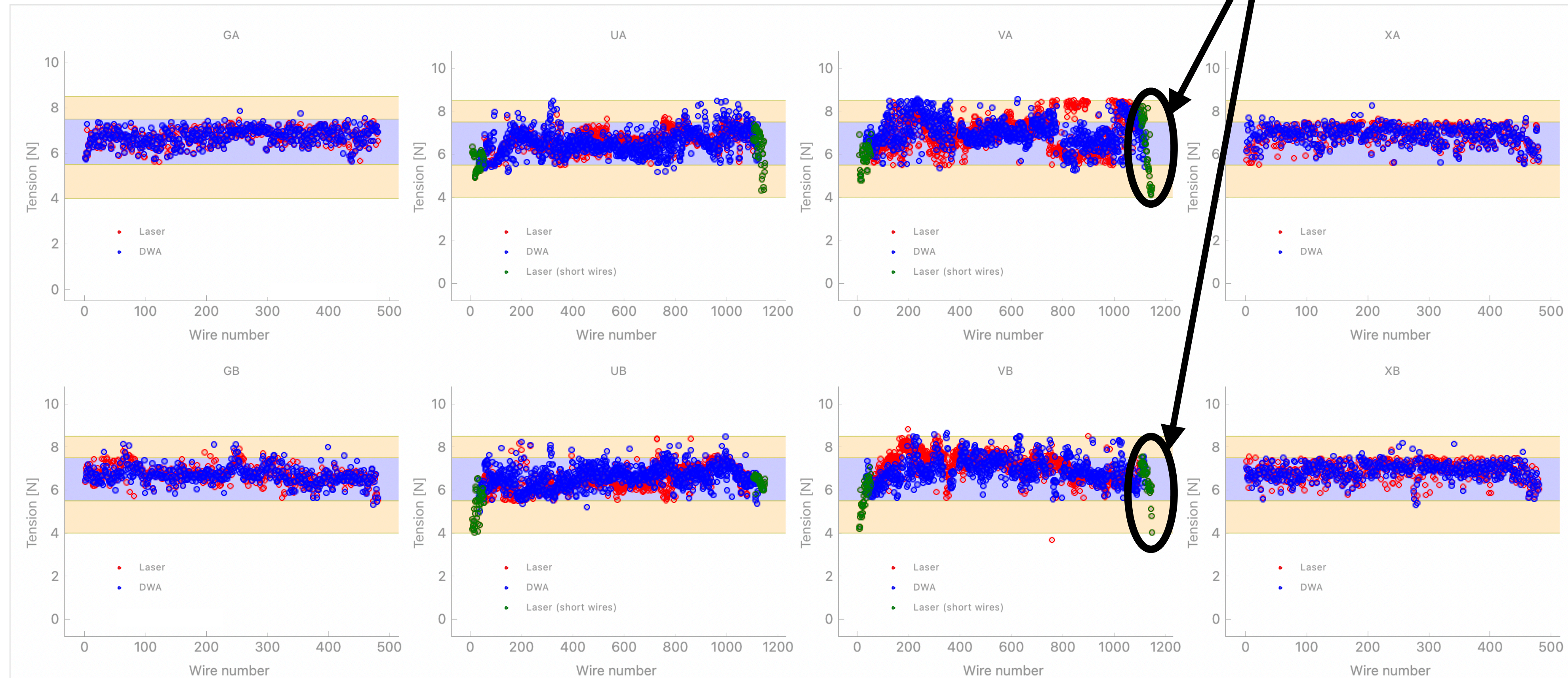
- Average tension < 7.5 N: $5.5 \text{ N} < T < 8.5 \text{ N}$
- Average tension > 7.5 N: $5.5 \text{ N} < T < 7.5 \text{ N}$



Wire Tolerances

- Average tension < 7.5 N: $5.5 \text{ N} < T < 8.5 \text{ N}$
- Average tension > 7.5 N: $5.5 \text{ N} < T < 7.5 \text{ N}$

If wire length < 50 cm, tension down to 4 N are accepted



Wire tensions report

- Report including all data obtained until now in preparation
 - Review all data to go from “preliminary” results to final results
 - Check mapping to offline channels
- Will include:

Data

APA #	Layers
4	XVUG
5	XVUG
7	XV

Studies

- Tensions vs. wire number
- Comparison with laser
- Orientation
- Time evolution
- Short wires

DWA Team

UK

- 2 experts (Manchester)
 - 3 more in training starting this summer
- 3 users (Manchester)

CERN

- 1 expert to be trained
- User(s) to be trained

US

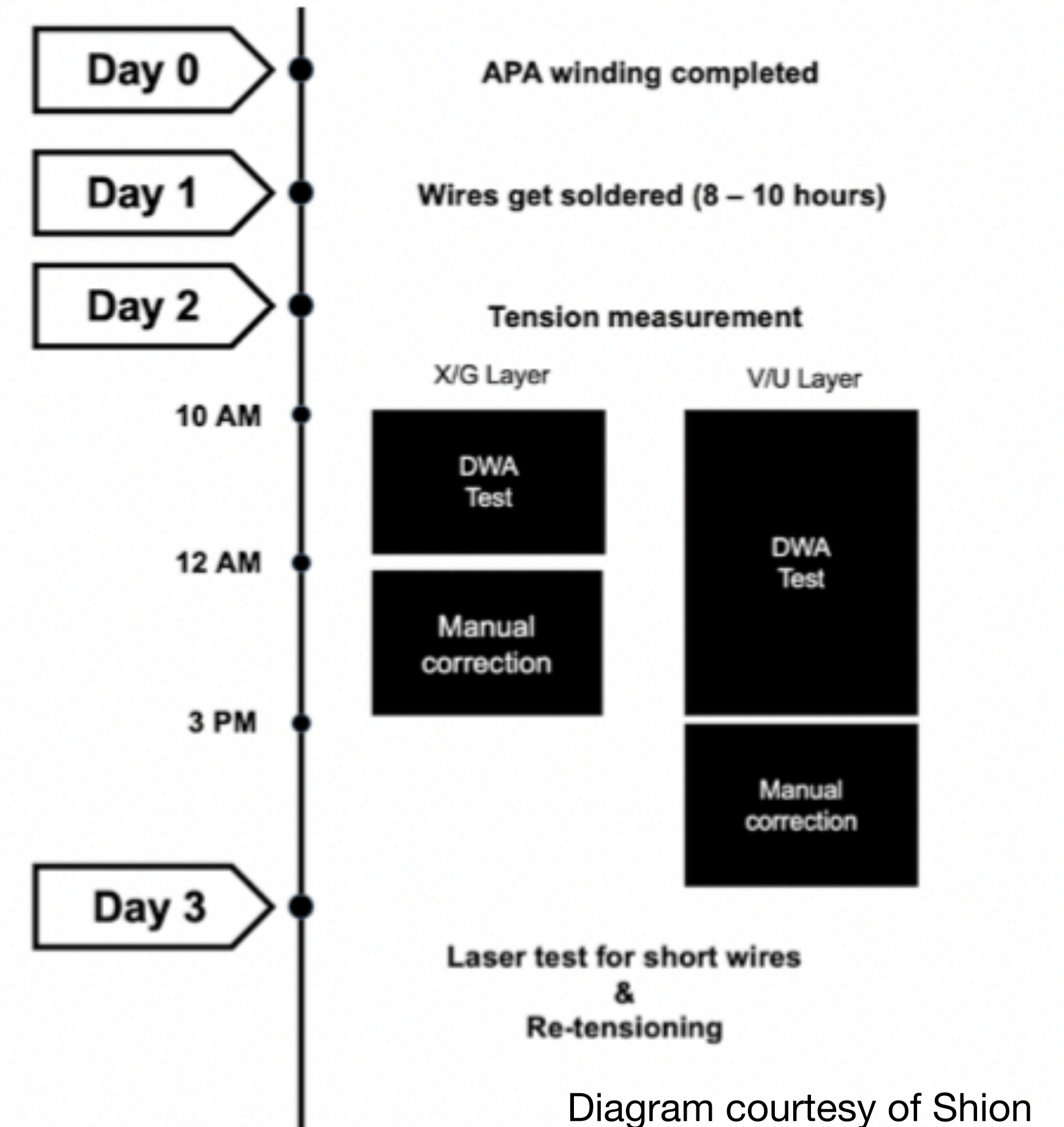
- 1 expert to be trained
- 2 users (Fermilab)

Tutorial and user guide being updated to reflect recent hardware/software upgrades

DWA testing at Daresbury

Wire Tensions Measurement Plan

1. Measure layer with DWA right after its finished
2. Extract list of wires to re-tension
3. Laser measurement of short wires
4. Take laser measurement for subset of wires ($O(100)$, transition period only)
5. Re-tension
6. Re-take tension measurement for re-tensioned wires (< 150: laser, > 150: DWA)



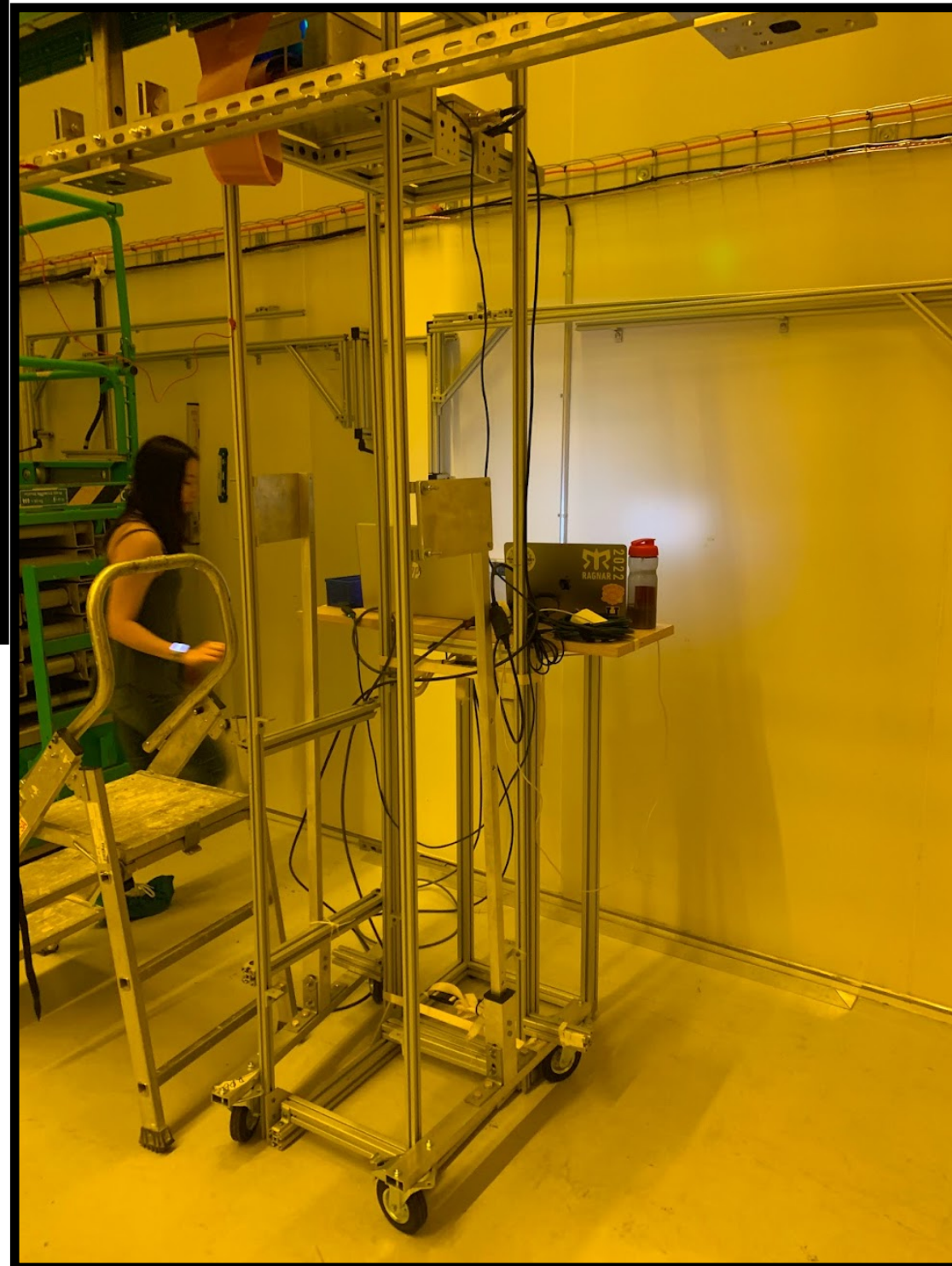
Total DWA-related time for one APA: ~15h

One-layer measurement time:

~2h (X/G)

~5h (U/V)

DWA testing at CERN



In the hall

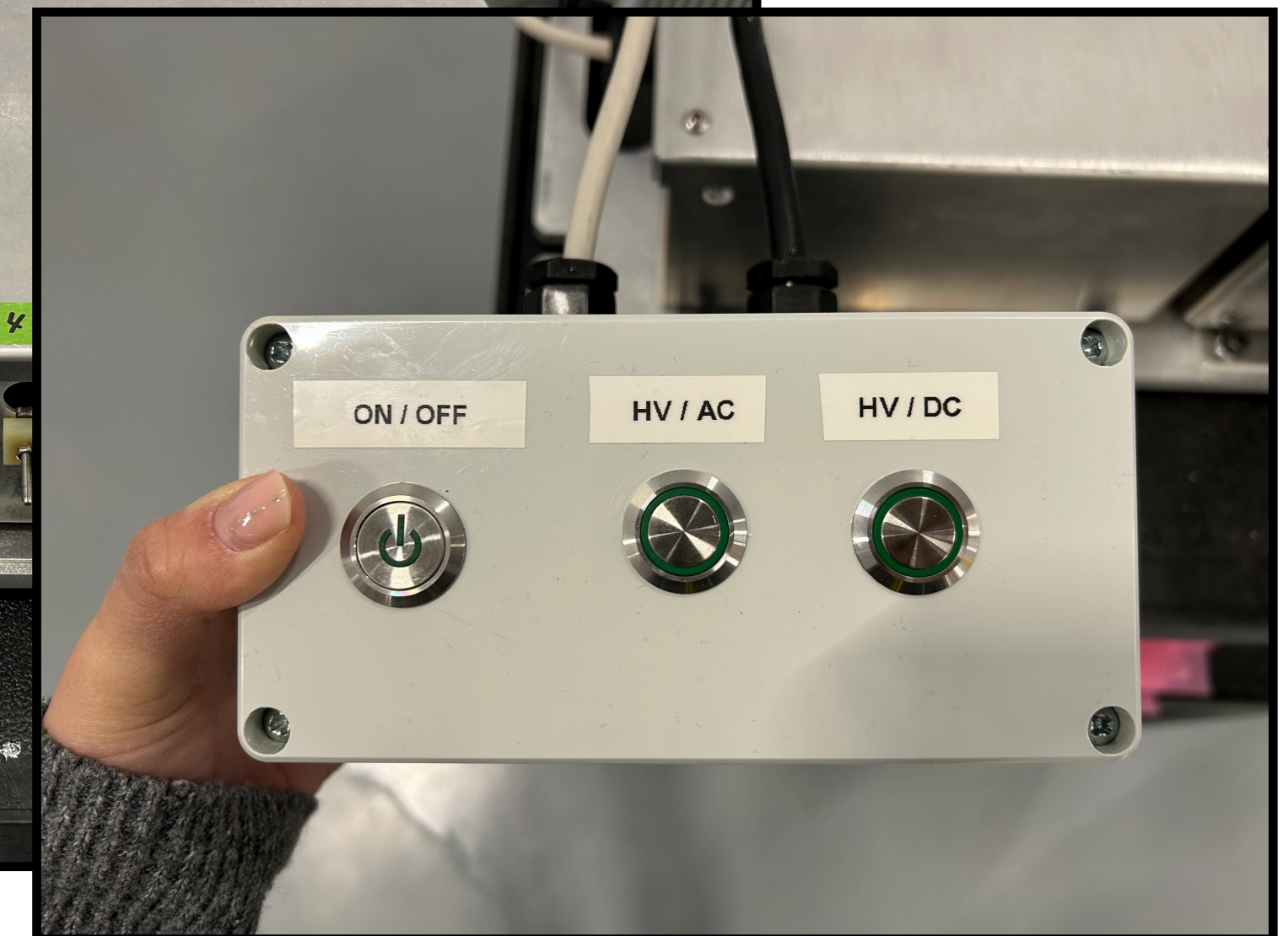
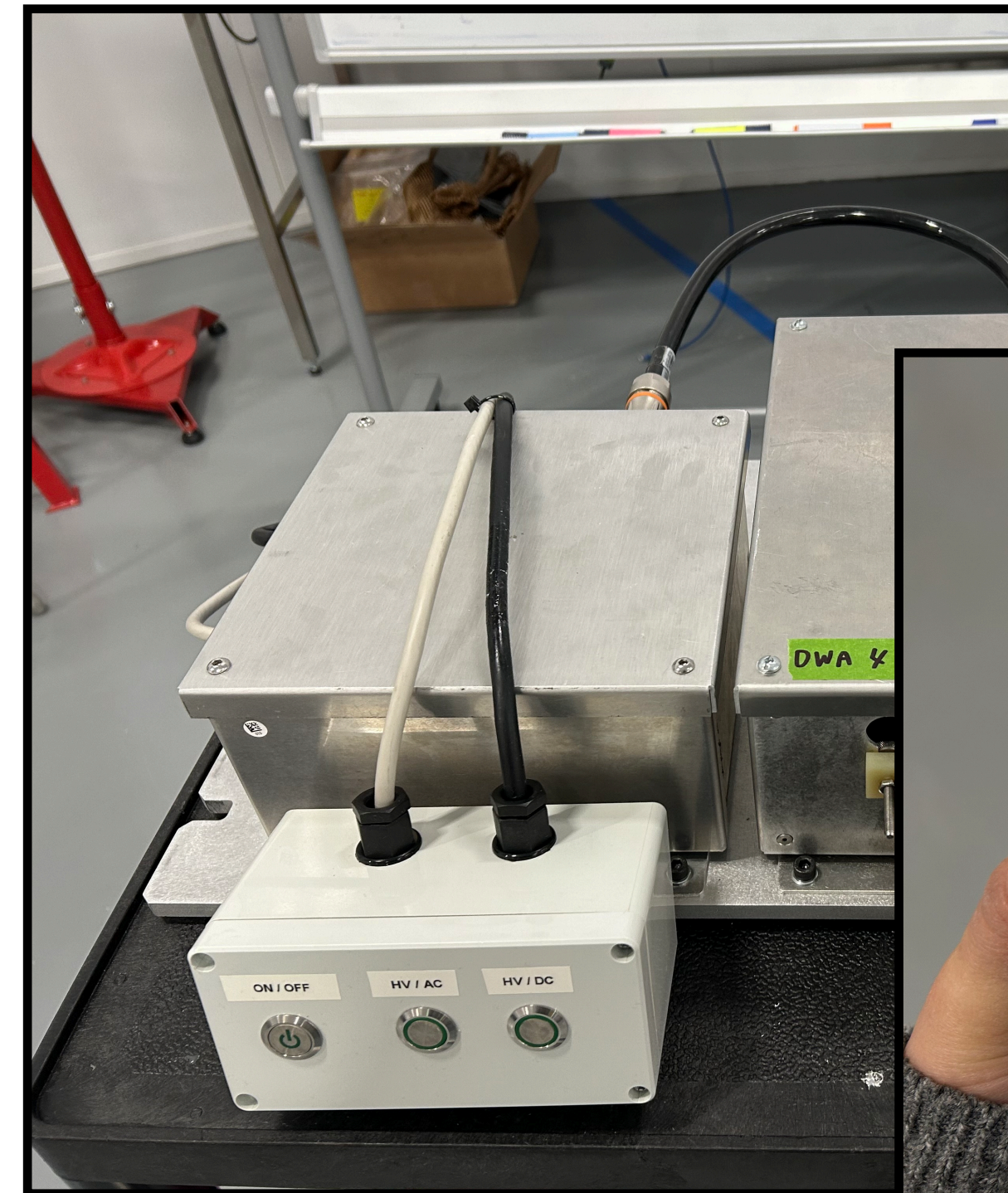
- APA protection panels need to be removed to access the headboards
 - Proved challenging
 - Having them in two parts would help

In the clean room

- Top APA: use the small stand in the lift
- Bottom APA: use the tall stand on the ground
 - Lift can be used but requires a trained driver

Health & Safety at Daresbury

- General risk assessment written
- Three people of the Manchester team completed working at heights training
- Remote control added to PDB to allow switching on/off high voltage without getting close to the APA

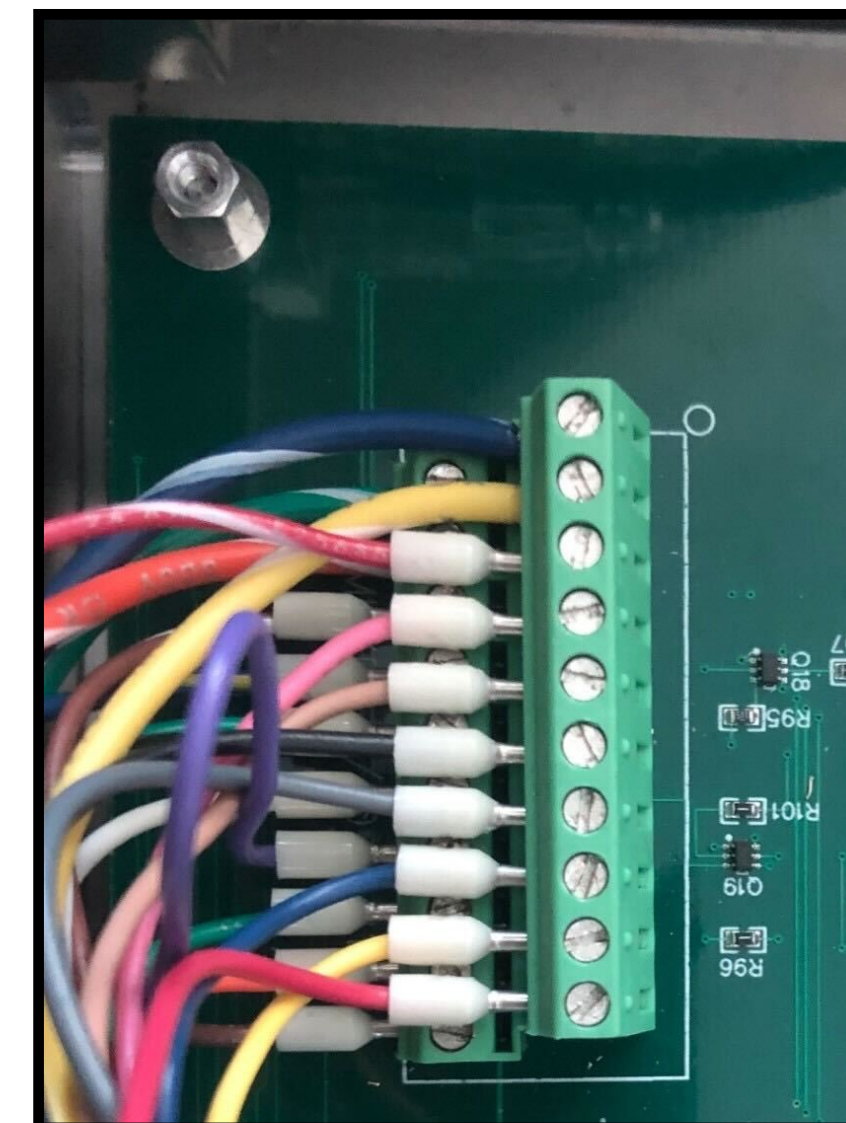
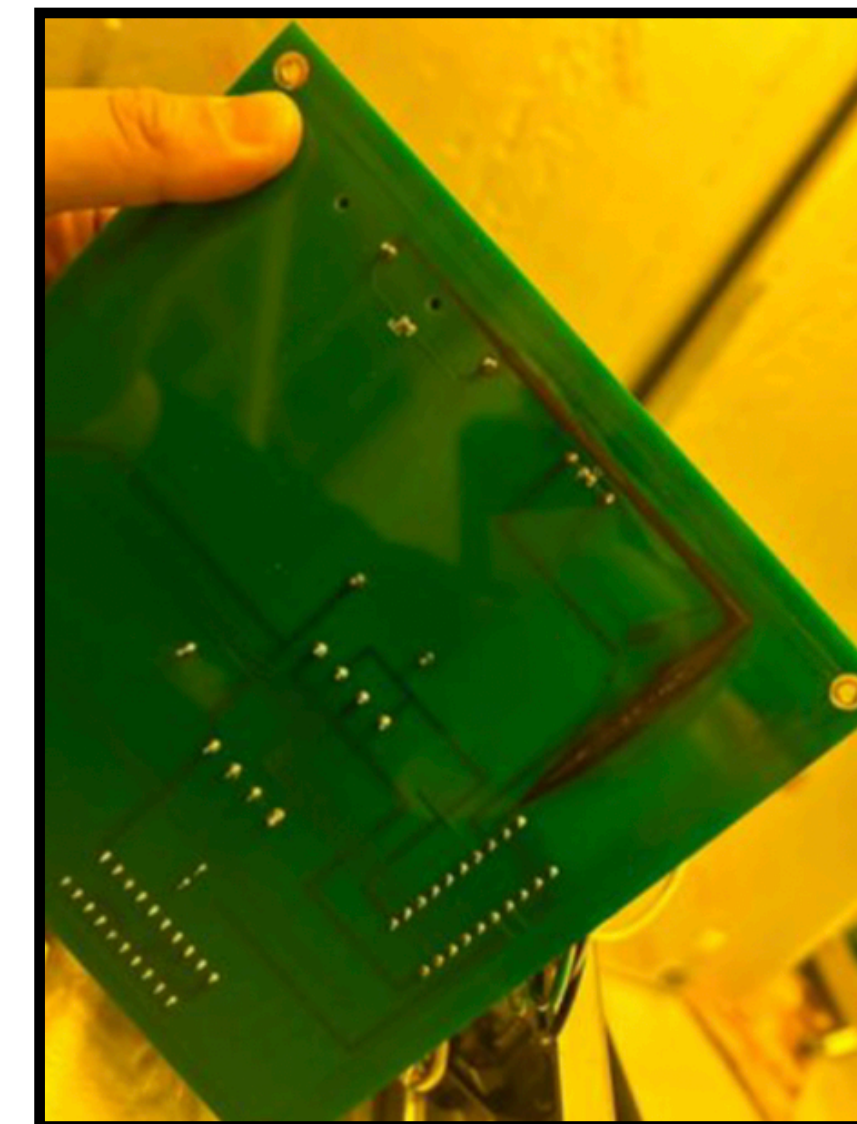
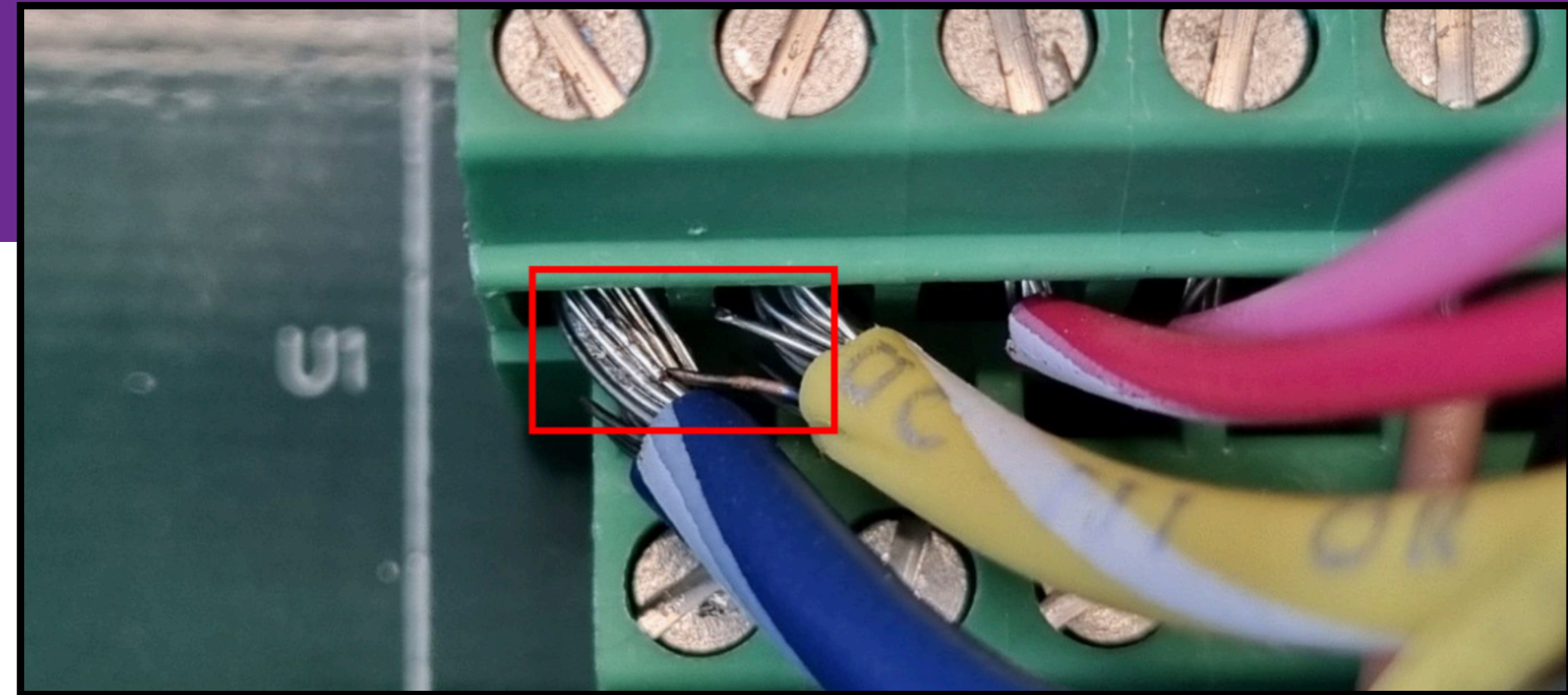


Electrical Safety

- Incident with Power Distribution Box at CERN
 - Due to a short in the DWA connection
 - Fix being implemented on all DWAs/PDBs
 - Upgraded DWAs will be tested on APAs

Electrical Safety Review

- Met with CERN & FNAL electrical safety experts
- Documentation in preparation
 - Internal DUNE review: ~1 month
 - CERN/FNAL review



DWA hardware status

DWAs

DWA #	Location	Status
1	Manchester	Functional - Awaiting test
2	Fermilab	Functional - Awaiting upgrade
3	Fermilab	Functional - Awaiting upgrade
4	Manchester	Functional - Awaiting test
5	Manchester	Functional - Awaiting test

- Ordered parts for 7 more DWAs
 - Assemble 4 and keep spare parts
- ETA 6-9 months

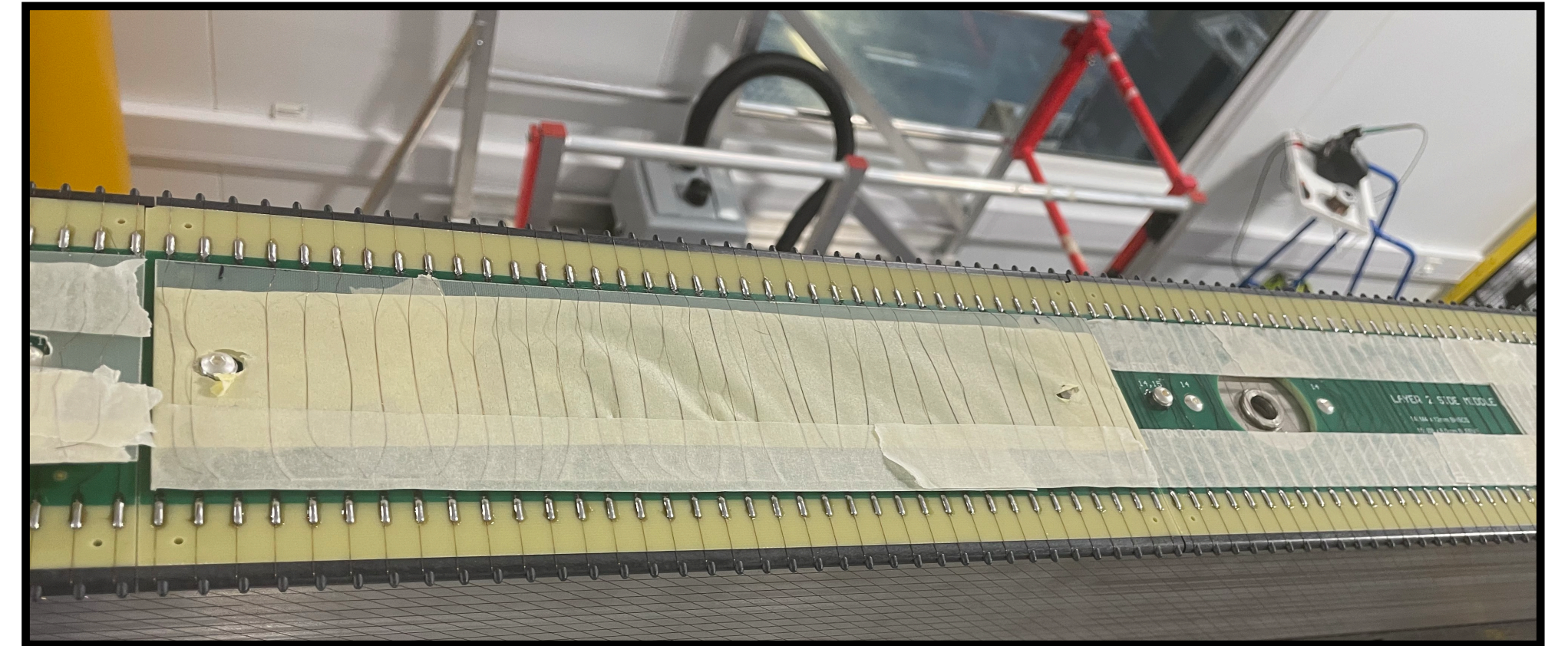
Power supplies

Power Supply #	Location	Status
1	—	Broken
2	Fermilab	Functional - Awaiting upgrade
3	Manchester	Functional - Awaiting test
4	—	Broken
5	Manchester	Functional - Awaiting test

- Expedite assembly of 3 more power supplies this summer
- ETA September

DWA production integration to-dos

- Test DWAs after upgrade
- Electrical safety review
- Check DWA-offline channel mapping
- Database communication
- U/V layer wires need to be isolated from sideboards for the DWA measurement to be possible
 - Solution: layer of FR4 on the side boards to separate wires from traces
 - APA 6 will be used as a validation of this procedure
 - Awaiting V layer winding



Summary

Production integration

- DWA being upgraded to improve electrical safety
 - Review ongoing
 - DWAs to be tested after upgrade
- X/G layer ready to be measured with DWA as part of production procedure
- U/V layer isolation procedure needs to be validated
 - Will be done using APA 6
 - Full measurement already possible on finished APAs

Wires Tensions

- Data available for APAs 4, 5, 7
- Full report on wire tensions in preparation

Backup

DAQ Software

DWA: Digital Wire Analyzer

5947a8b0-5152-11ed-84c6-9170f34dd096b_apa4_dwa5 Start

Stimulus Results Tensions Log Event Viewer

Config Advanced V(t) grid V(t) chan A(f) grid A(f) chan

DWA Info

Not Connected

DWA MAC N/A

DWA IP N/A

Client IP N/A

Serial # N/A

Firmware N/A

Period N/A

State N/A

HV AC HV DC

Error state N/A

Heartbeat *

Run Status

Scan freqs [Hz]

Min

Max

Step

Active

Missing a tension

- V 426 826
- V 428 828
- V 430 830
- V 432 832
- V 33 433 833
- V 35 435 835
- V 37 437 837
- V 39 439 839
- V 34 434 834
- V 36 436 836
- V 38 438 838
- V 40 440 840
- U 361 761
- U 363 763
- U 365 765
- U 367 767
- U 369 769
- U 371 771
- U 373 773
- U 375 775
- U 362 762
- U 364 764
- U 366 766
- U 368 768
- U 370 770
- U 372 772

Measured By Chris Stanford

Stage DWA Development

Layer XVI

Side A

Flex Direction Away from APA

Headboard 1

Type Continuity Tension

Configure Scan List

DWA is not connected

	Result	Type	Layer	Status	Wires	Freq Min (Hz)	Freq Max (Hz)	S
8	No results yet	Tension	V	Pending	[2, 4, 6, 8, 10, 12, 14, 16, 402, 404, 406, 408, 410, 412, 414, 416, 802, 804, 806, 808, 810, 812, 814, 816]	50	401	
9	No results yet	Tension	V	Pending	[17, 19, 21, 23, 25, 27, 29, 31, 417, 419, 421, 423, 425, 427, 429, 431, 817, 819, 821, 823, 825, 827, 829, 831]	50	108	
11	No results yet	Tension	V	Pending	[33, 35, 37, 39, 433, 435, 437, 439, 833, 835, 837, 839]	50	419	
12	No results yet	Tension	V	Pending	[34, 36, 38, 40, 434, 436, 438, 440, 834, 836, 838, 840]	50	405	
13	No results yet	Tension	U	Pending	[361, 363, 365, 367, 369, 371, 373, 375, 761, 763, 765, 767, 769, 771, 773, 775]	50	193	
14	No results yet	Tension	U	Pending	[362, 364, 366, 368, 370, 372, 374, 376, 762, 764, 766, 768, 770, 772, 774, 776]	50	190	
15	No results yet	Tension	U	Pending	[377, 379, 381, 383, 385, 387, 389, 391, 777, 779, 781, 783, 785, 787, 789, 791]	50	233	
16	No results yet	Tension	U	Pending	[378, 380, 382, 384, 386, 388, 390, 392, 778, 780, 782, 784, 786, 788, 790, 792]	50	237	
17	No results yet	Tension	U	Pending	[393, 395, 397, 399, 793, 795, 797, 799]	50	273	

Start selected scan

Automate scanning

Auto load scan when complete

Wire map

Head boards

errorBits

buttonStatus

N/A

List of wires that remain to be scanned/ don't have a tension

Live visualisation of the scans

Number of bad channels in the scan

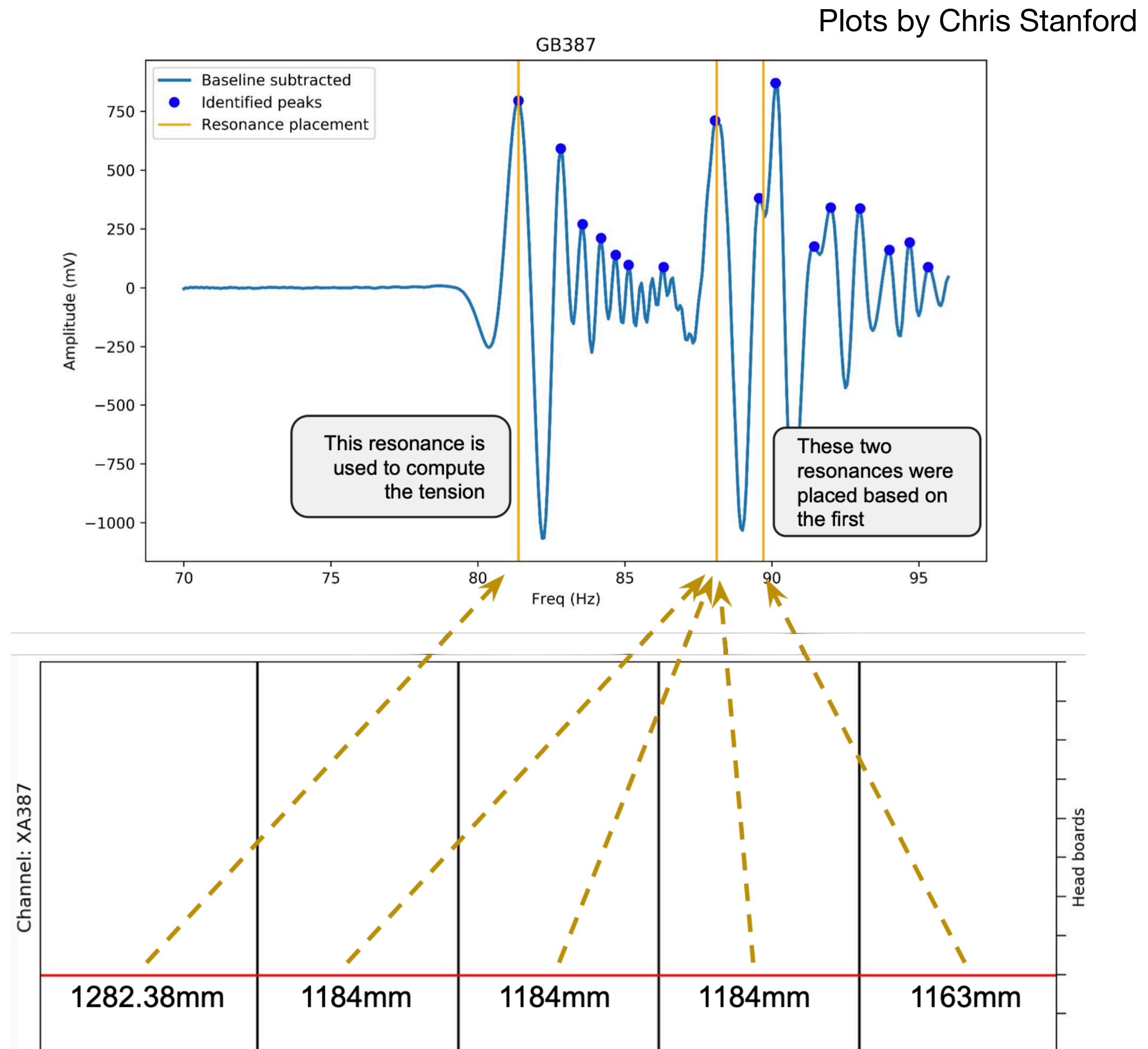
Wire Analysis Code

- Developed an interface to speed up offline tension analysis
 - Makes all standard plots automatically
- Currently has:
 - Tension vs wire number
 - Failures (wires out of spec)
 - Comparison with laser tension
- Communication with the database will be added



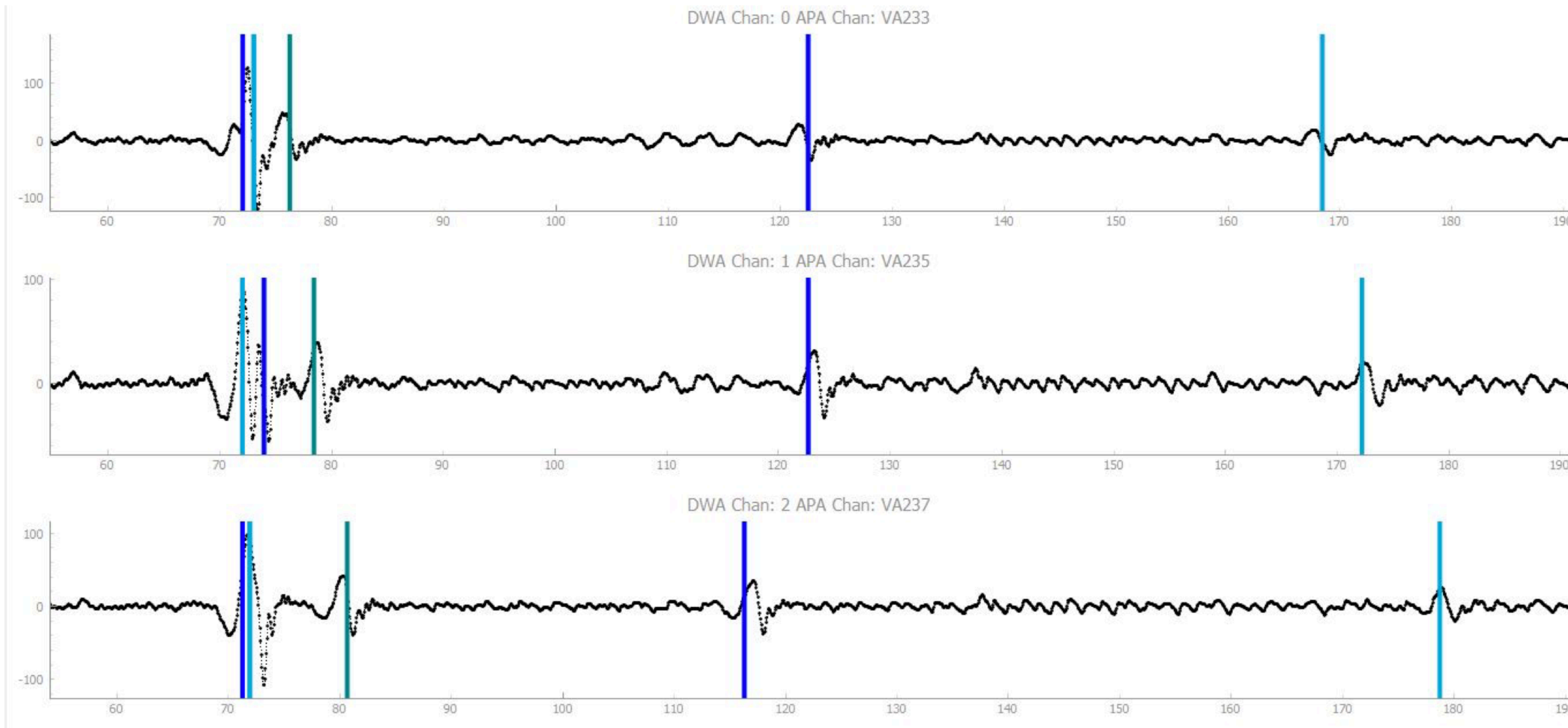
How to measure a tension?

- Algorithm looks for resonance peaks in the baseline subtracted scan
- First peak is used to compute the tension
- Different peaks for different wire segments
 - Peak position depends on wire segment length

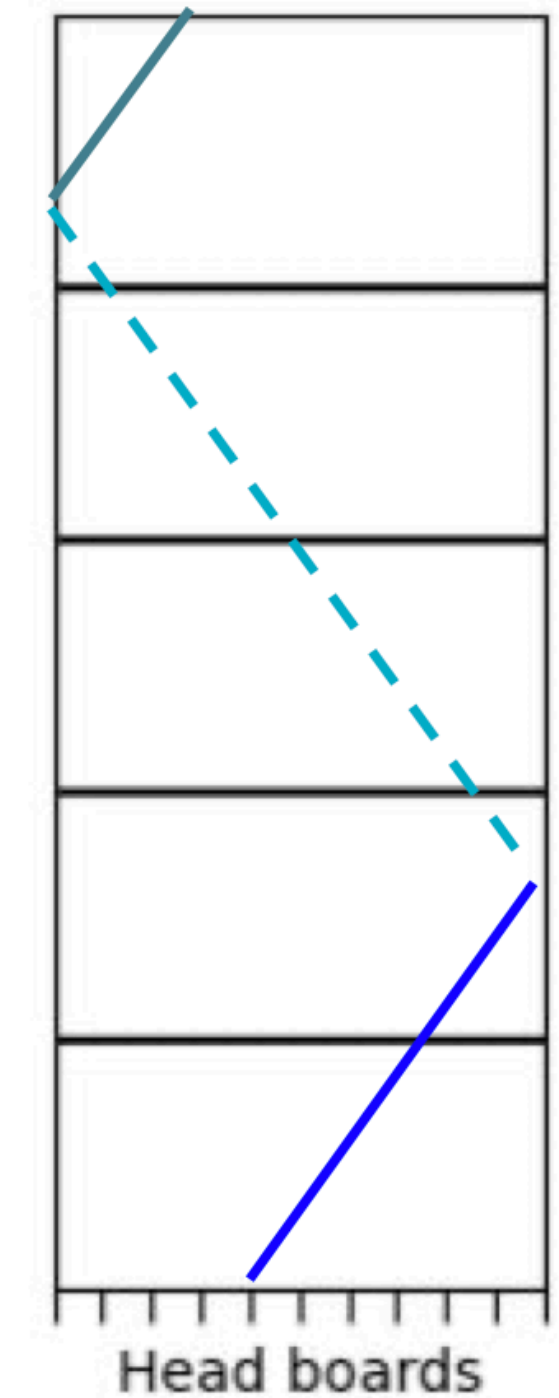


Mapping the wires

The DWA uses an algorithm to identify resonances and assign them to different wire segments



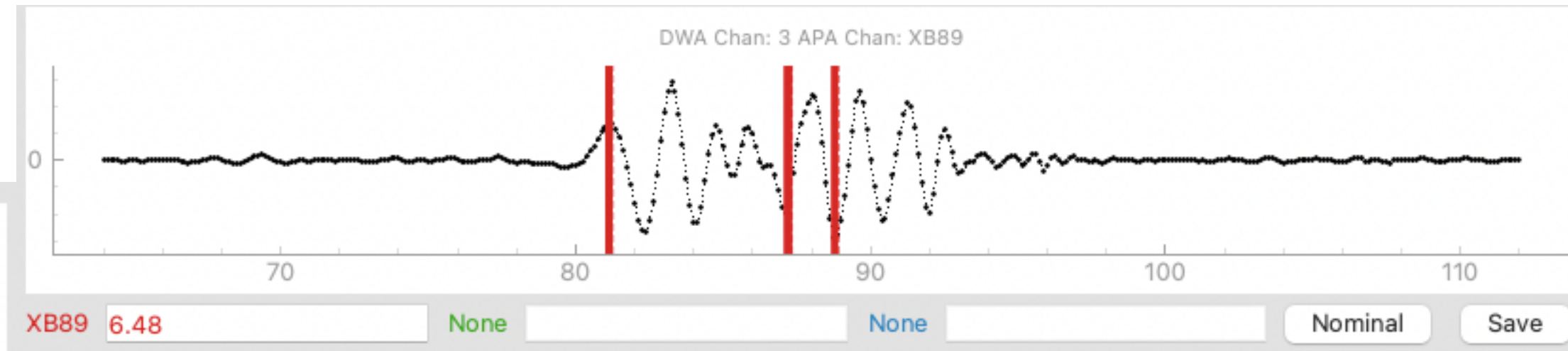
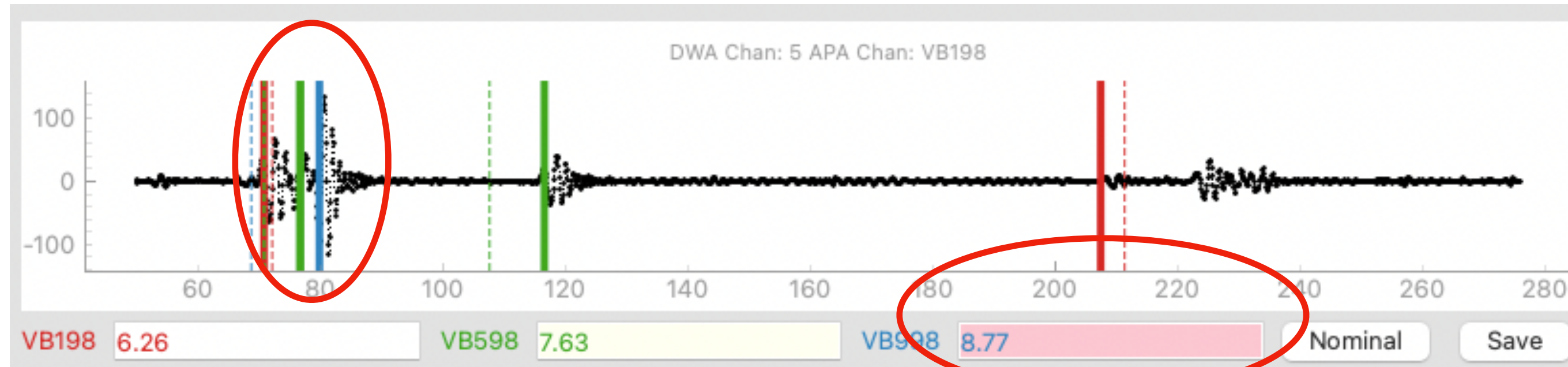
Channel: VA235



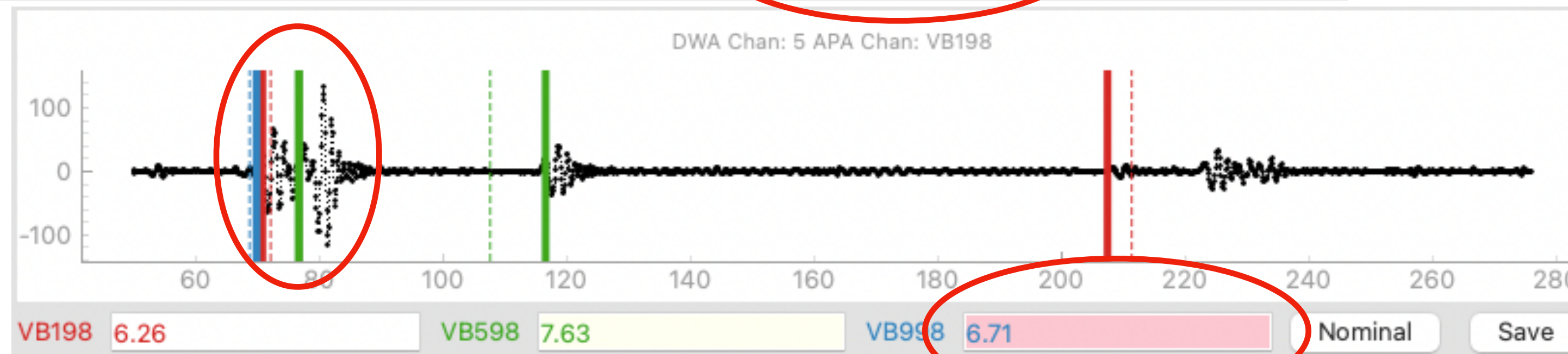
Slide by Chris Stanford

Peak corrections

U/V layer has a complicated pattern



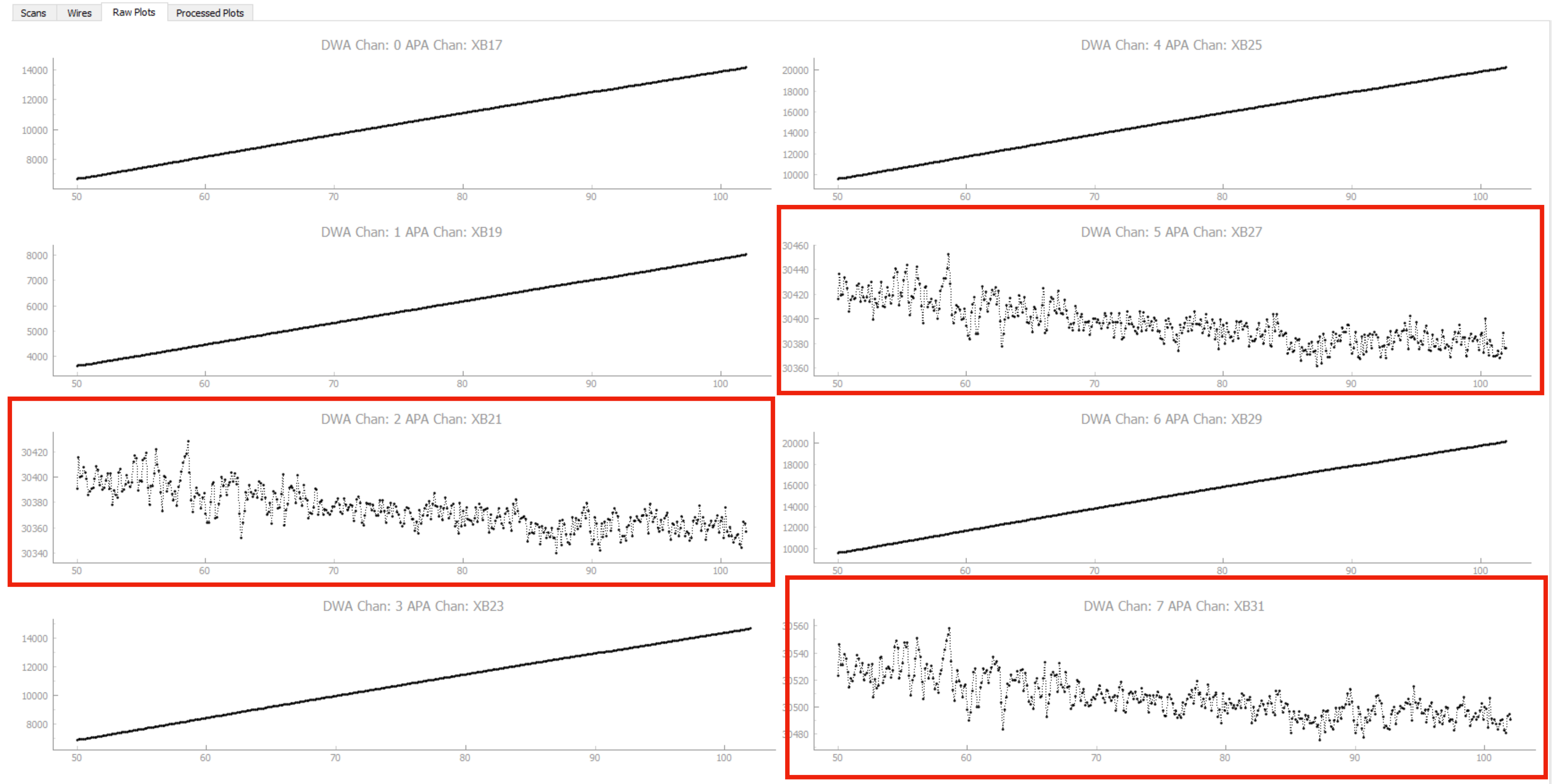
X/G layer is much simpler



“Human accuracy” factor in the correction.

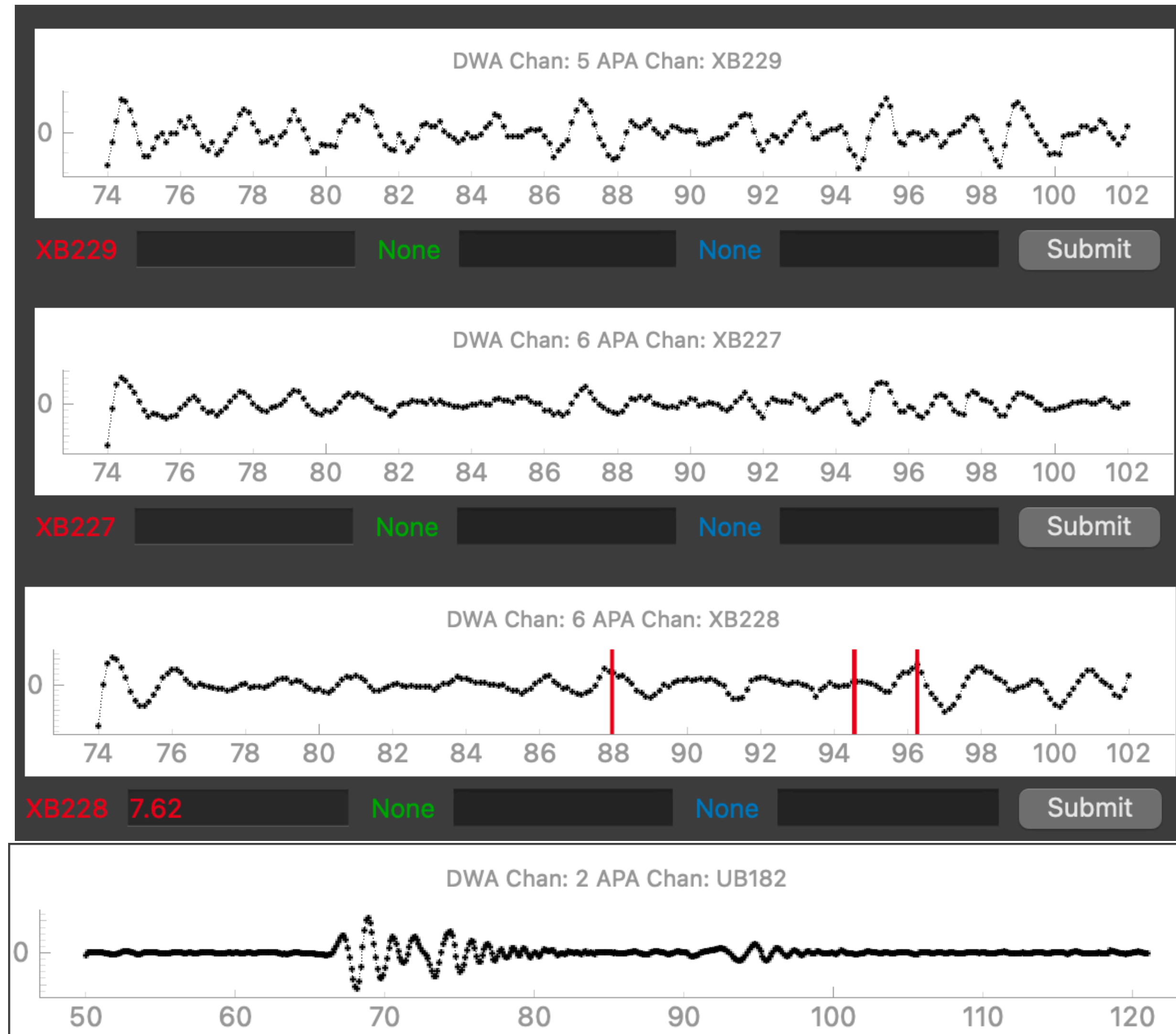
Offline tension analysis

- **Broken wires**
(when shorting others) are easy to spot



Offline tension analysis

- **Broken wires** (when shorting others) are easy to spot
- **Missing wires** are harder to identify for sure



Easy to address live

Need to understand how many times the algorithm is failing this

How about using two DWAs at a time?

- Tried using two DWAs at the same time on APA 5
 - Would speed up the process if only one APA is awaiting measurement
- However, we saw interference on the U/V layer
- Resonances cannot be extracted



Only one DWA can be active on an APA at a given time

How to measure tensions the right way?

1. Install the probe boards. (1h)
 - ➔ Must happen before the APA is in the winder.
 - ➔ They stay on during the whole winding process.
2. Install the tees on the APA frame (10 mins)
 - ➔ Stay on during the whole winding process.
3. Install the rail (5 mins)
4. Set up the DWA (10 mins)
5. Take measurements on one side (including live scan correction)
 1. X/G layer (1h)
 2. U/V layer (2.5h)
6. Disconnect the DWA and remove the rail
7. Repeat 3-6 on the other side

Total DWA-related time for one APA: ~15h

One-layer measurement time:

~2h (X/G)

~5h (U/V)

User manual on EDMS