Wire tension measurements after constuction

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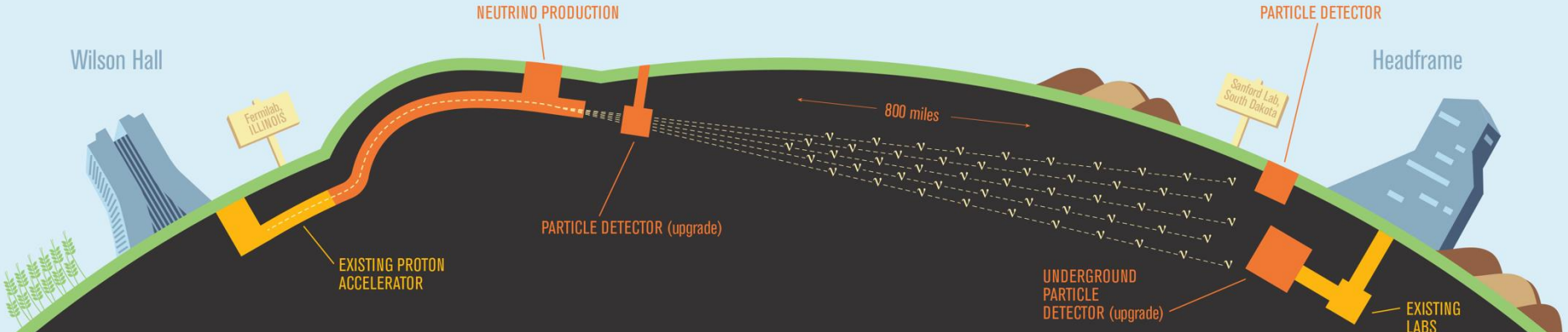
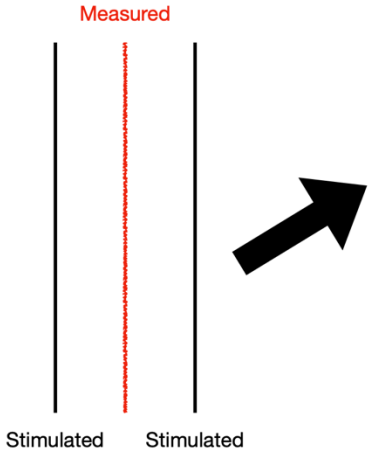
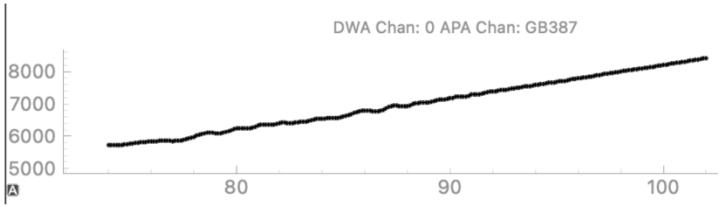


How the DWA measures tension

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

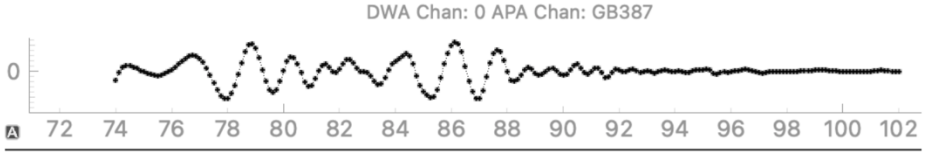


1. The two neighbouring wires are stimulated with a mix of AC and DC current.



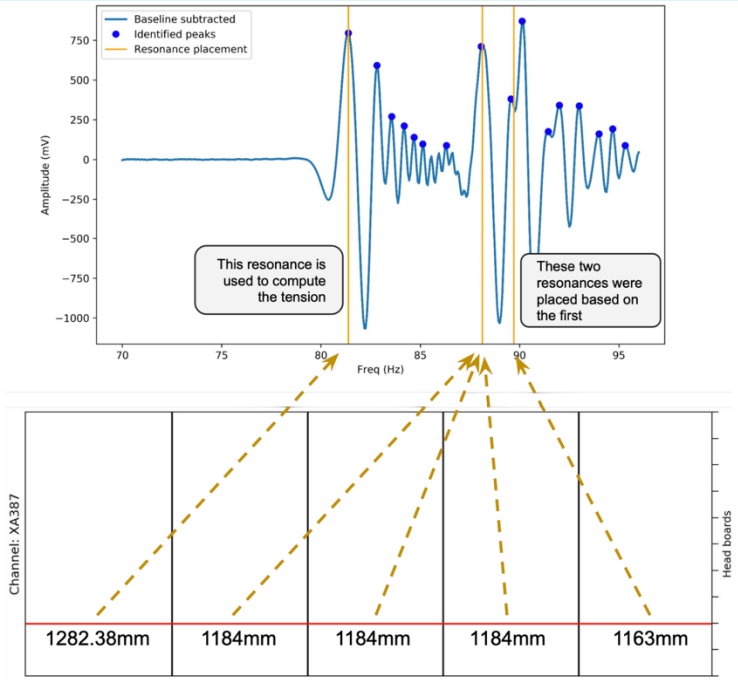
2. Read out middle wire while sweeping frequency of AC current

3. Smooth and subtract the baseline



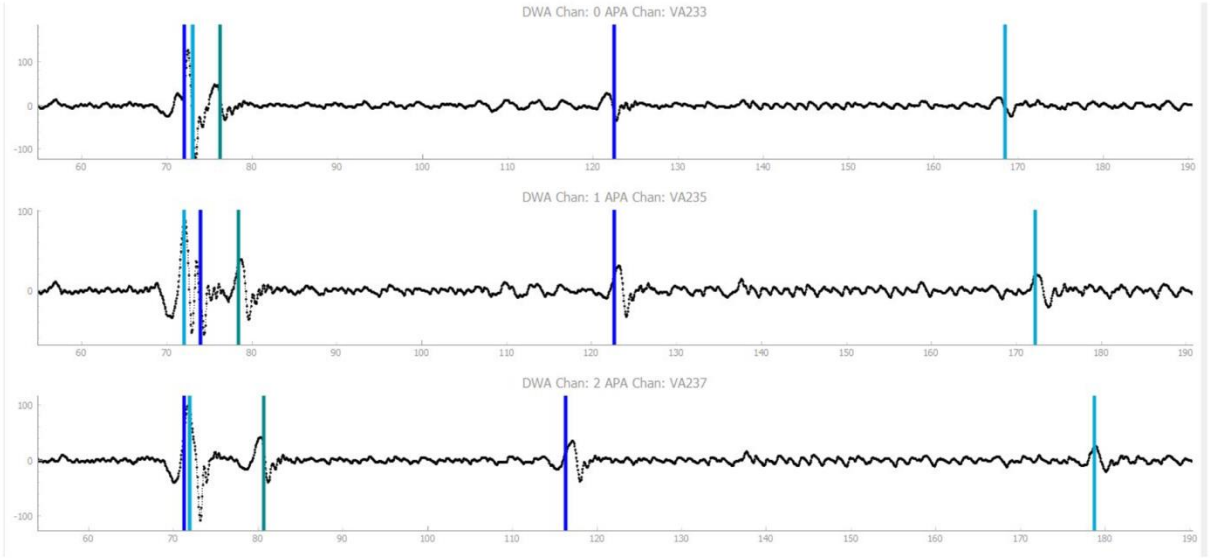
How the DWA measures tension

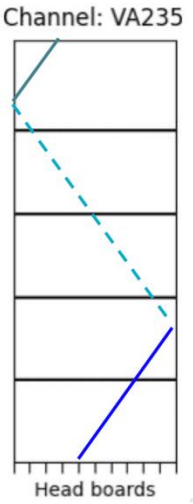
- Algorithm looks for resonance peaks in the baseline subtracted scan
- First peak is used to compute the tension
- Different peaks for different wire segments
    - Peak position depends on wire segment length



How the DWA measures tension

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





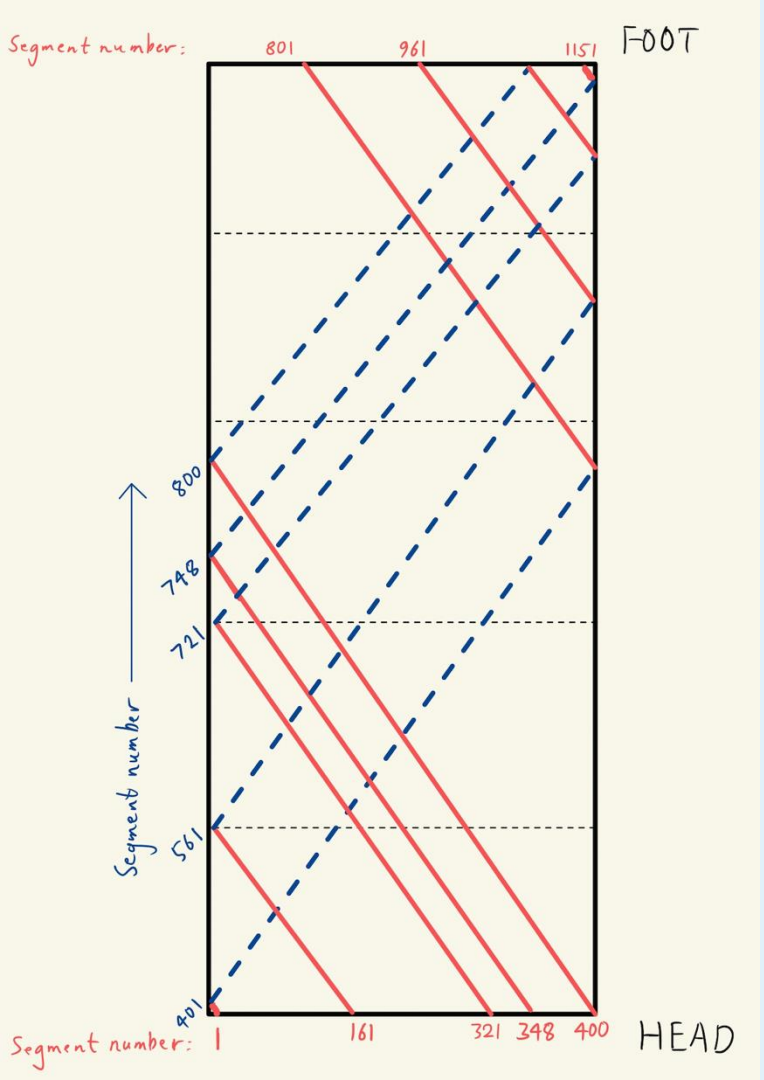
Reading DWA graphs

When reading DWA plots, remember that the x-axis ‘wire number’ refers to a ‘wire segment’

- Every time a wire wraps around the APA frame, we treat it as a new ‘wire’
- So a U or V layer, whilst having 800 readout channels, has 1151 ‘wire segments’
- Some wires have two segments, some wires have 3 segments
- And every time a wire segment passes through a comb, we assume this is a node at which the wire does not oscillate

We only take DWA measurements for wire segments longer than 30 cm

- We measure wire segments 33—1122
- Note that this choice was tuned when using the old operating voltage of 1600 V d.c. between adjacent wires. We now use 500 V d.c. between wires so will need to re-optimize this.



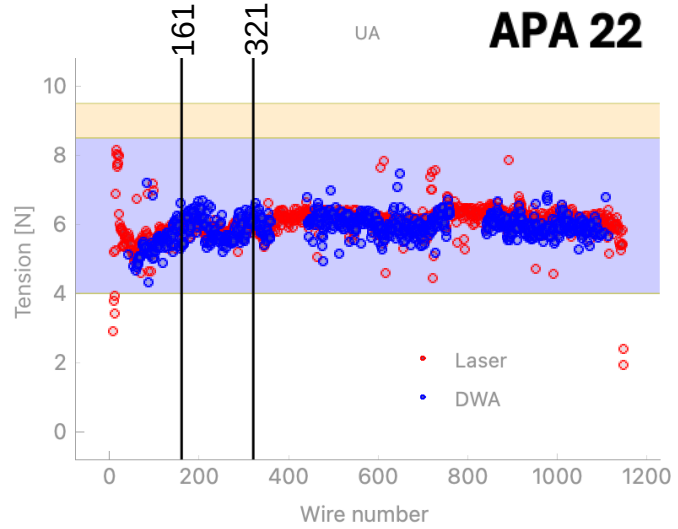
Reading DWA graphs

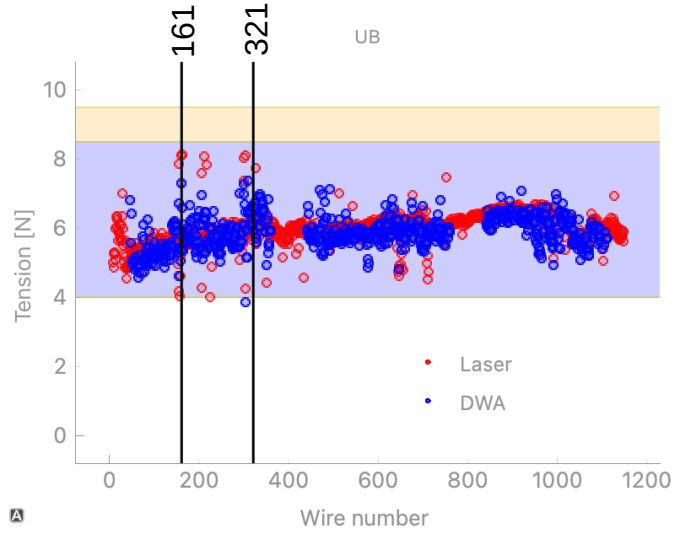
The segment numbers shown in the figure are the x-axis of the DWA tension graphs

- Segments 1—400 connect to the head end
- 401—800 go from side to side
- 801—1151 connect to the foot end (though the last three wires ‘don’t exist’)

Wire segment 161 is the first to pass through a comb

Wire segment 321 is the first to pass through two combs





Direct DWA-laser comparison

On APA 22, on 28th November, we were able to do a DWA measurement of a U layer immediately after it had been wound

- This gives us the most direct comparison possible between laser and DWA

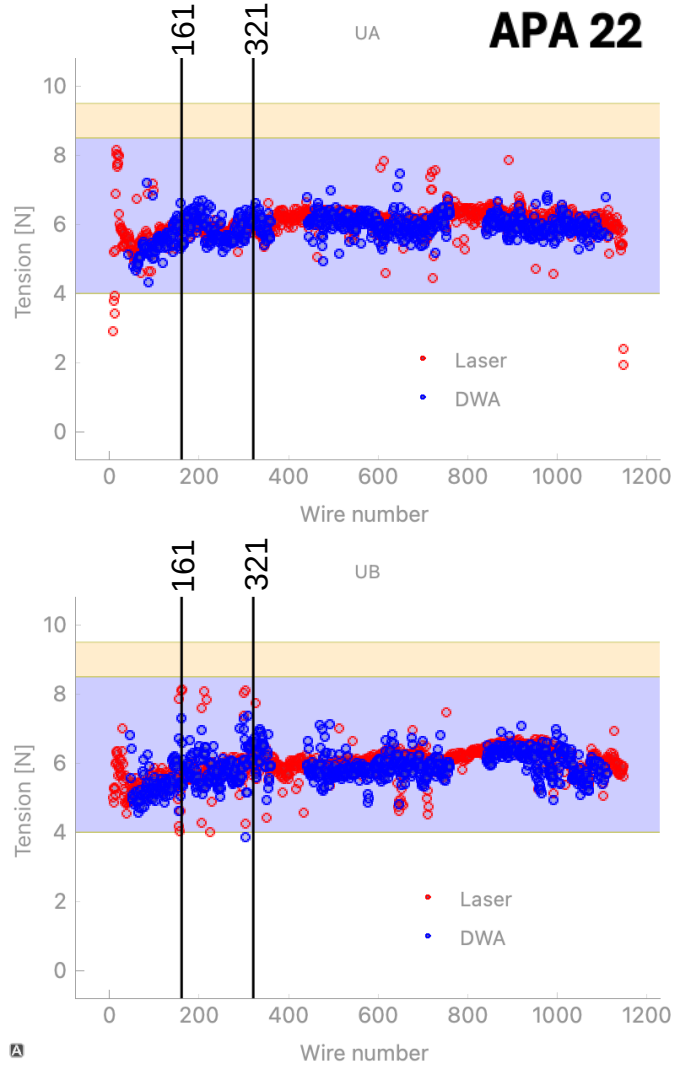
The two gaps are because there were transition boards in the way so we could not attach the probe boards

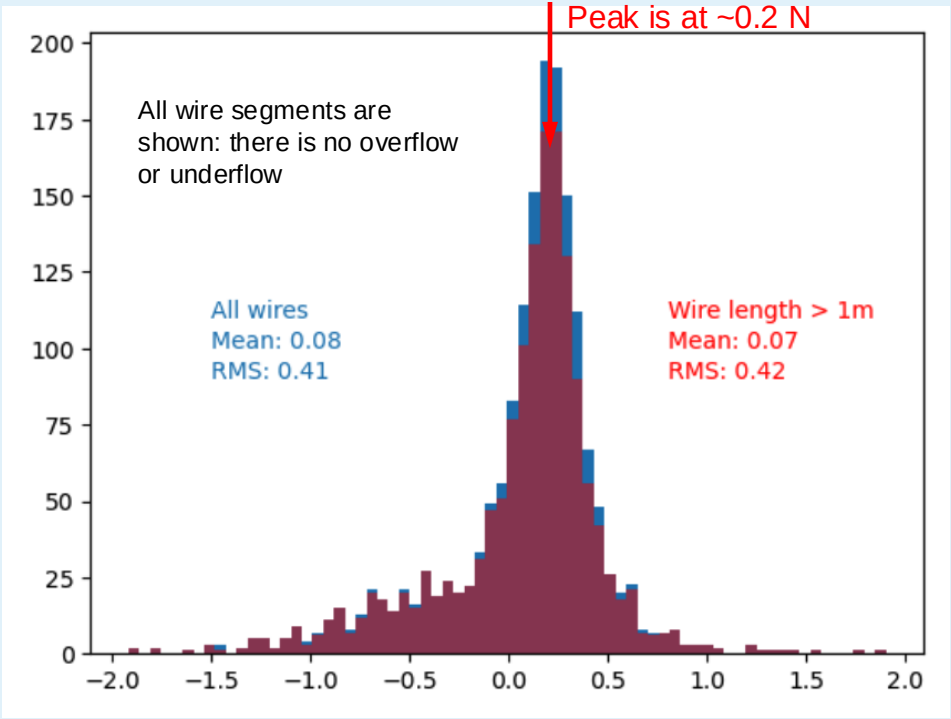
DWA measurements are shown for segments 33—1122

Observations

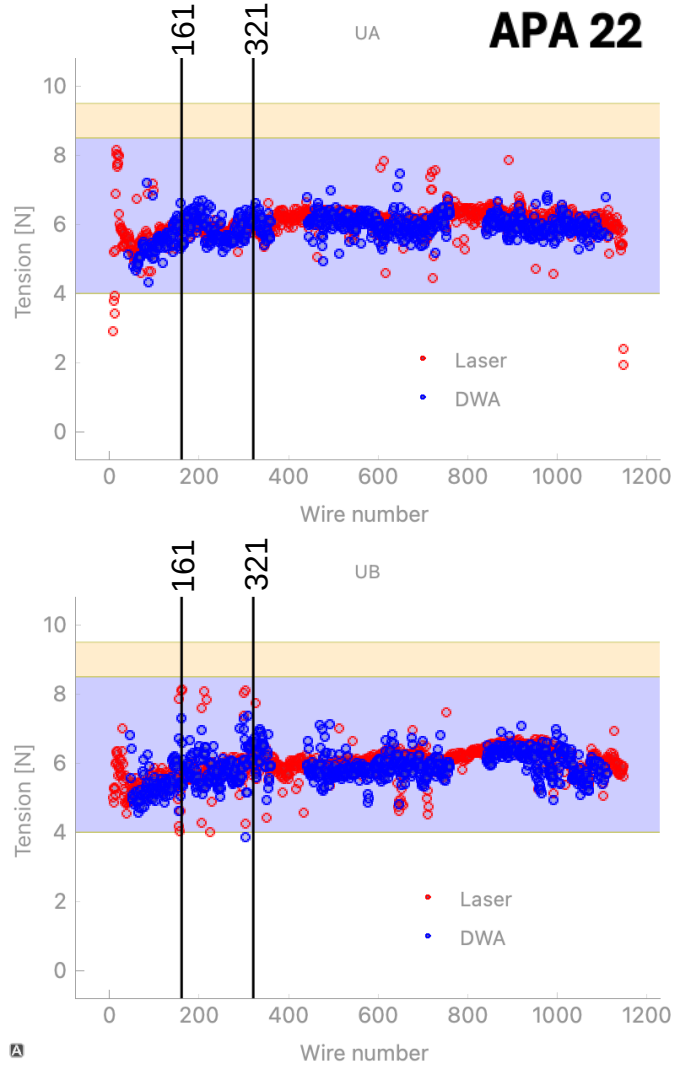
- The majority of wire segments have good agreement between laser and DWA, with some evidence of tension relaxation
- There are two clusters of high DWA measurements around segments 200 and 300
- There are a handful of outliers in both the DWA data and the laser data

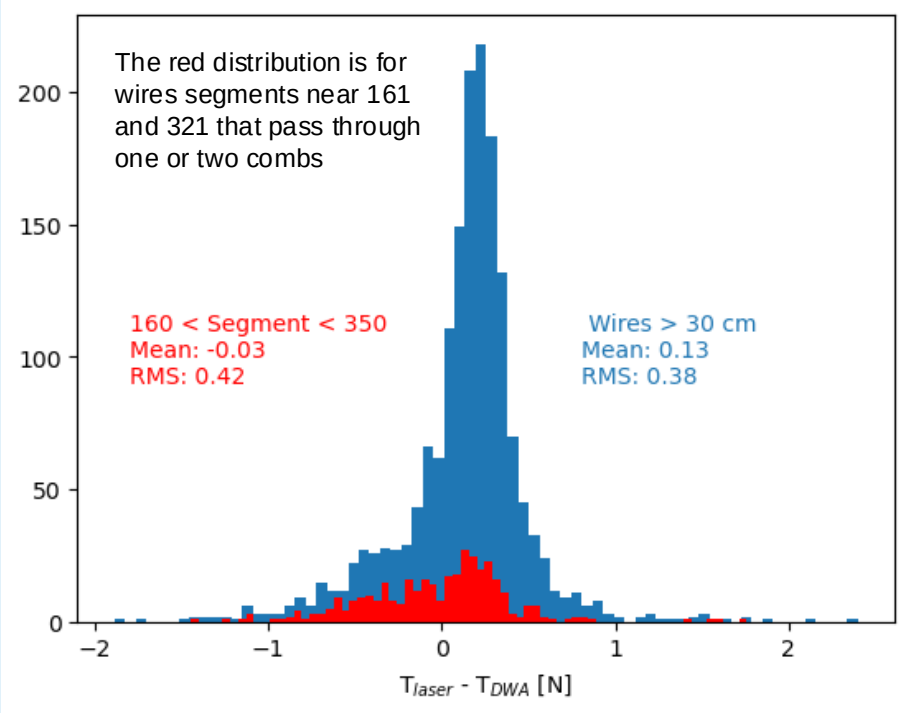
Direct DWA-laser comparison





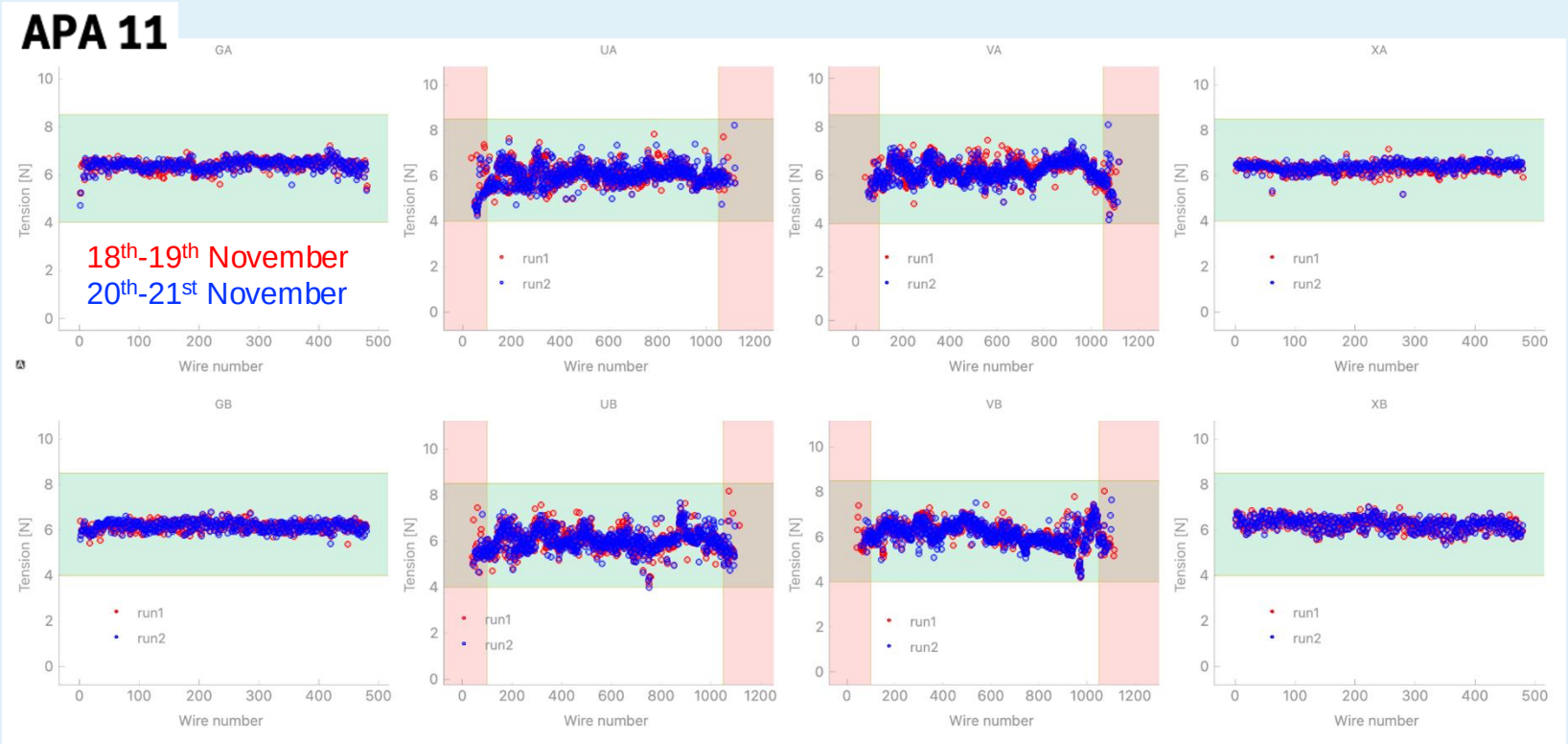
Direct DWA-laser comparison





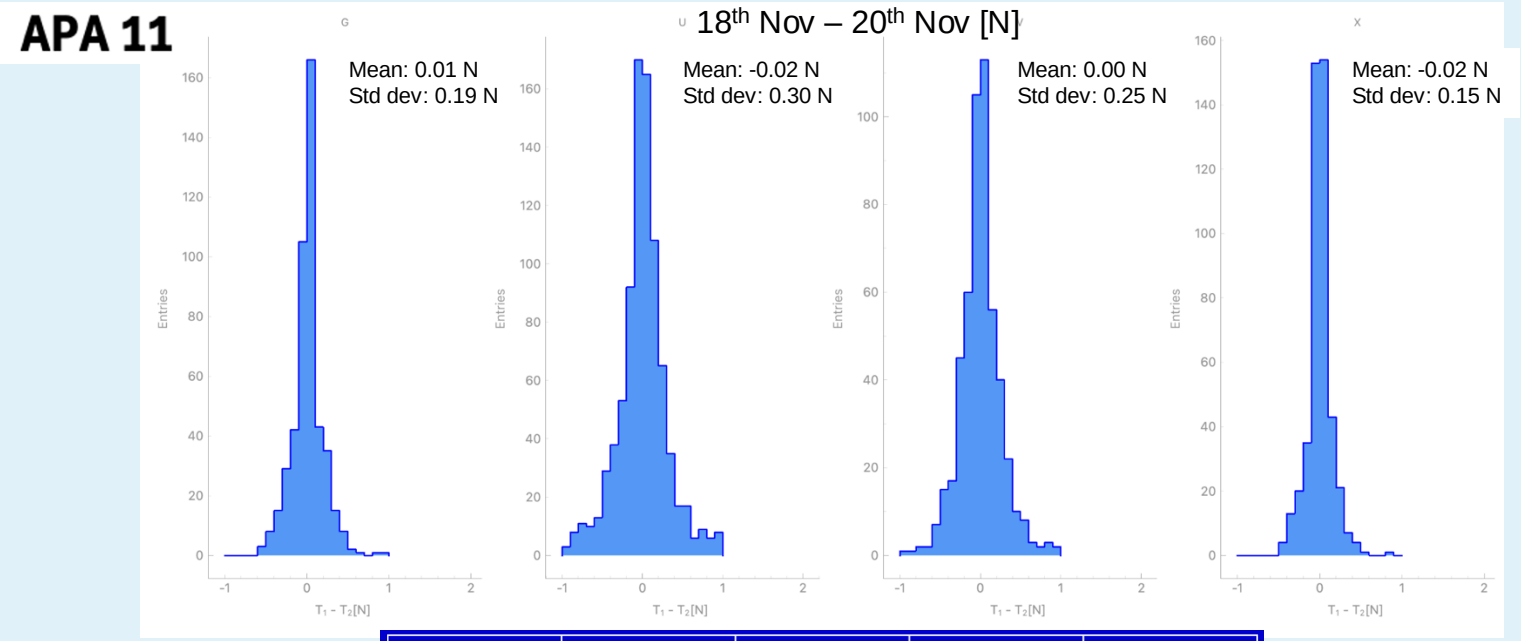
Laser – DWA (N)

Repeatability measurements



- APA 11, measured ~2 days apart, both times with the DWA

Repeatability measurements



	X	V	U	G
T_1-T_2 > 0.5 N	0.33%	9.97%	14.04%	1.39%
T_1-T_2 > 1 N	0%	1.21%	3.63%	0%

APA 11, measured two days apart, both times with the DWA

- We only consider segments >1 m in length in these comparisons

Tension extraction efficiency

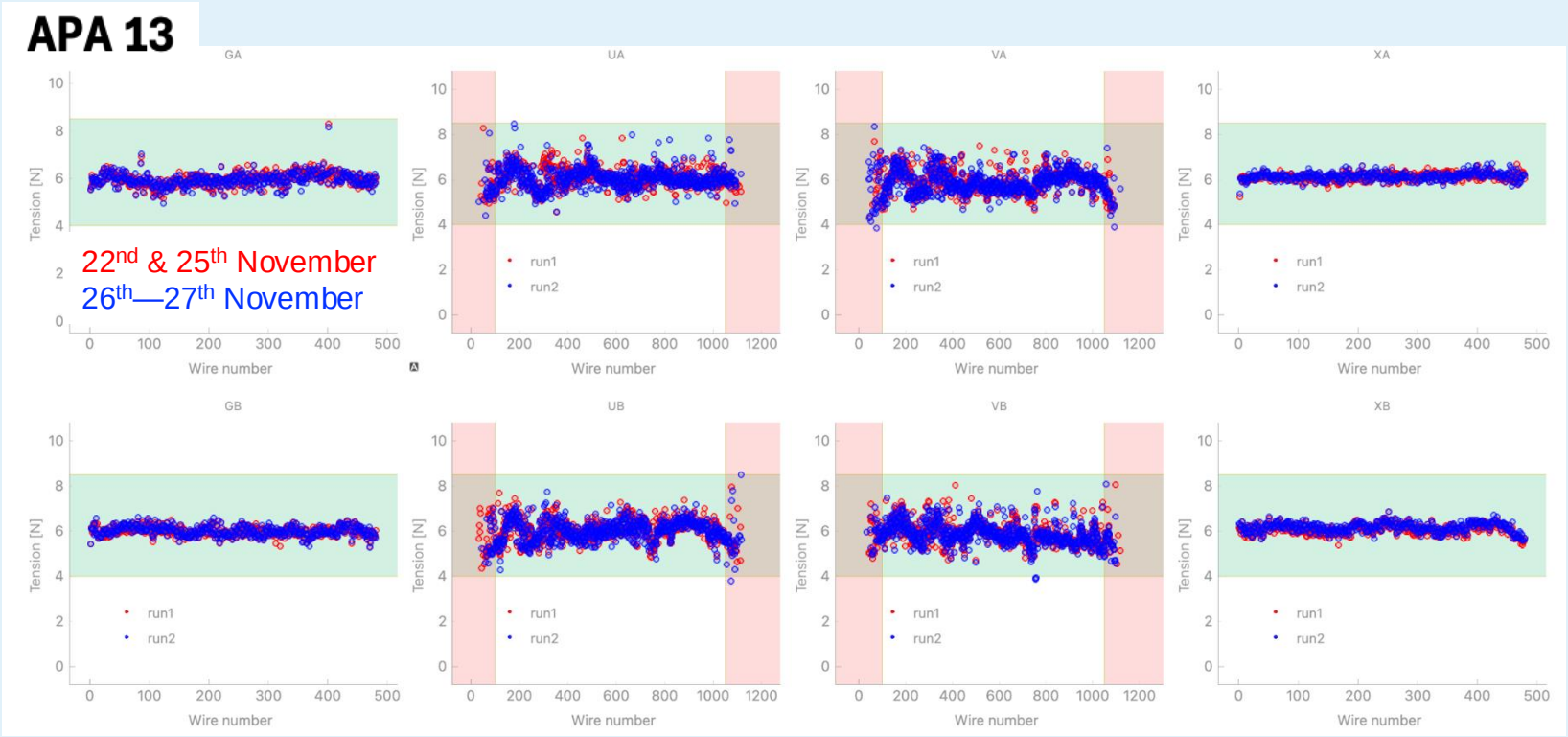
APA 11		
Run 1, wires > 1 m Failures of tension extraction		
Layer	Side A	Side B
X	15/480	8/480
V	29/950	38/950
U	34/950	35/950
G	14/481	3/481

APA 11		
Run 1, wires > 30 cm Failures of tension extraction		
Layer	Side A	Side B
X	15/480	8/480
V	103/1089	99/1089
U	119/1089	97/1089
G	14/481	3/481

APA 11		
Run 2, wires > 30 cm Failures of tension extraction		
Layer	Side A	Side B
X	8/480	3/480
V	85/1089	97/1089
U	106/1089	100/1089
G	12/481	2/481

- For wires longer than 1 m, the efficiency is 97%
- For wires longer than 30 cm. the efficiency is 86%

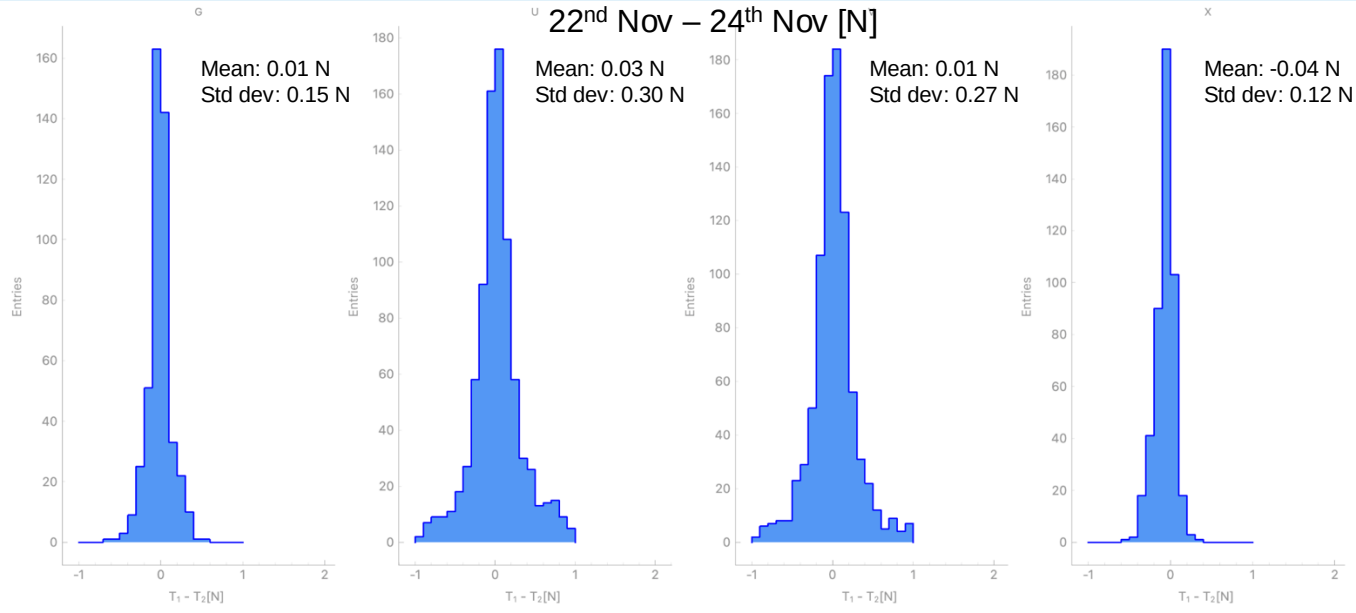
Repeatability measurements



- APA 13, measured ~four days apart, both times with the DWA

Repeatability measurements

APA 13

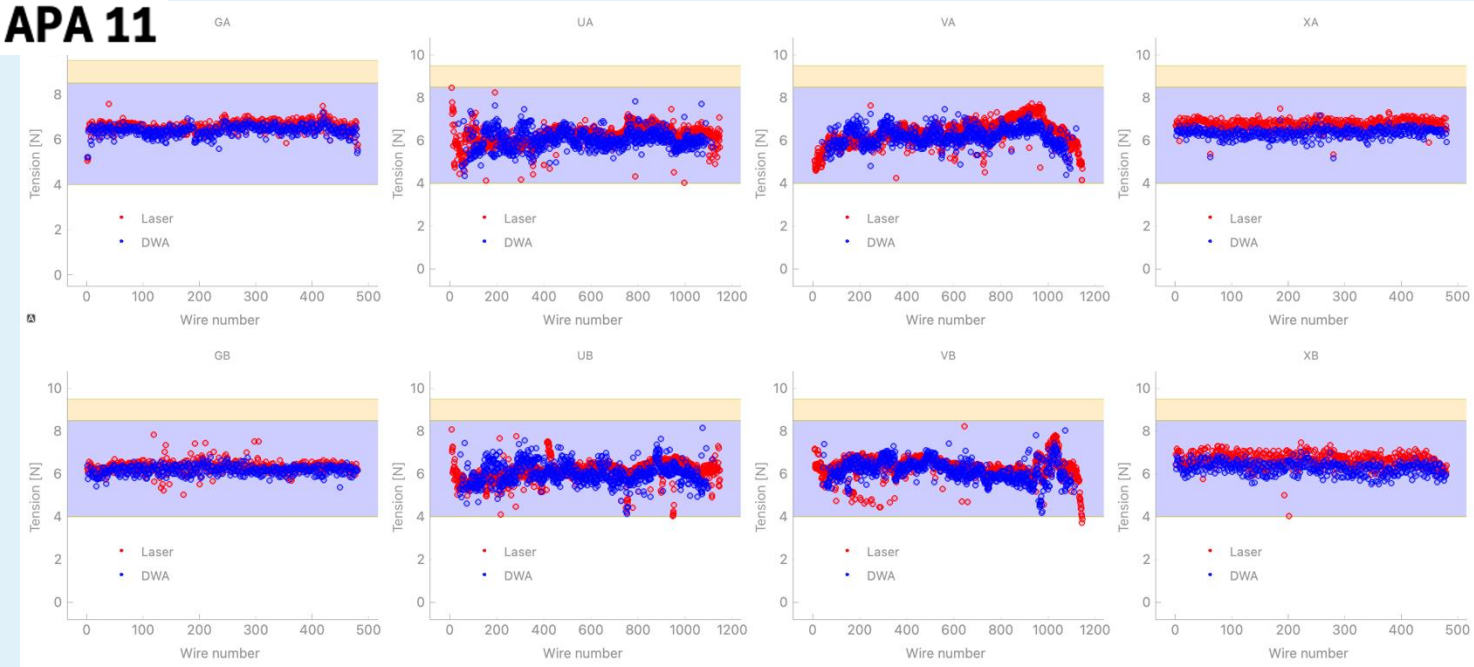


	X	V	U	G
T_1-T_2 > 0.5 N	0.22%	12.09%	14.15%	1.3%
T_1-T_2 > 1 N	0%	3.30%	3.83%	0%

APA 13, measured four days apart, both times with the DWA

- We only consider segments >1 m in length in these comparisons

Wire tension relaxation



Laser dates:
X: 25th Jul
V: 22nd Aug
U: 17th Sep
G: 10th Oct

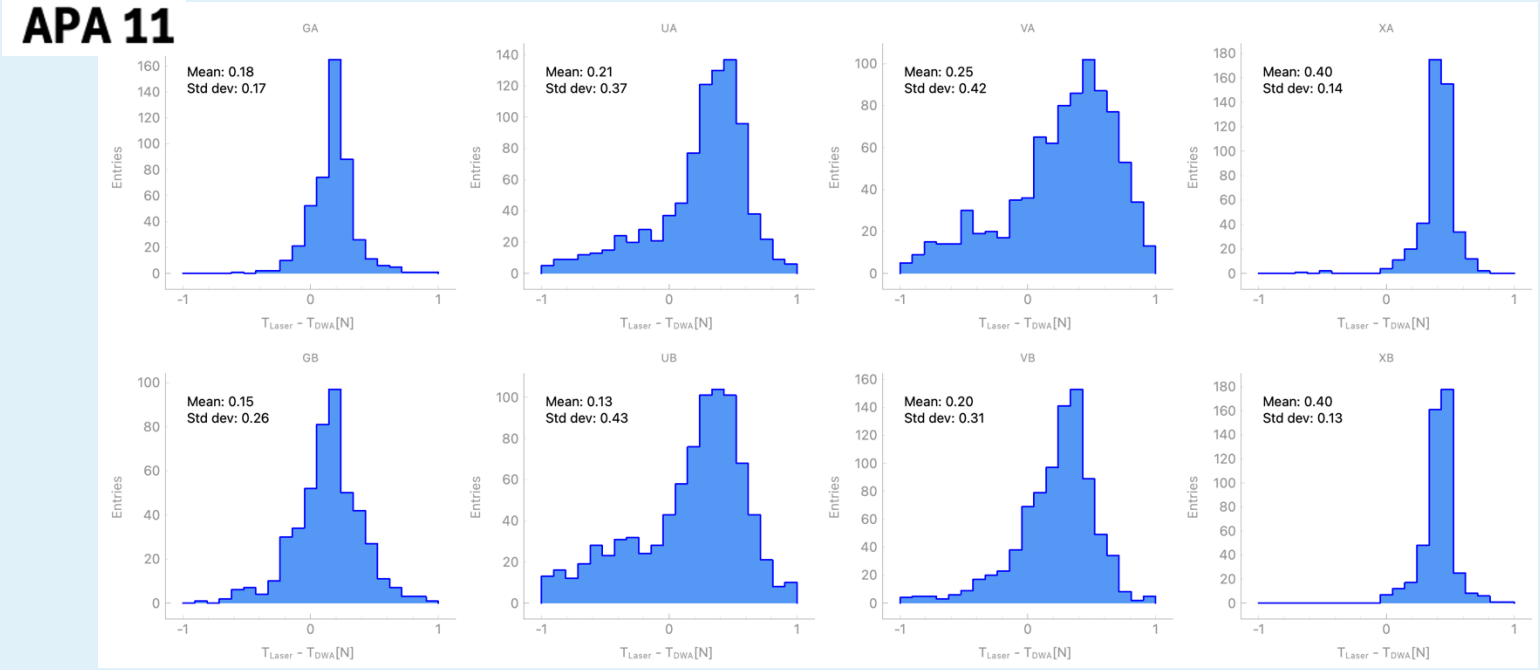
DWA:
18th Nov

APA 11, comparing DWA measurements of a complete APA to the laser measurements during construction

The DWA and laser measurements track well

- Earlier layers show more evidence of relaxation after the addition of the later layers

Wire tension relaxation



APA 11, comparing DWA measurements of a complete APA to the laser measurements during construction

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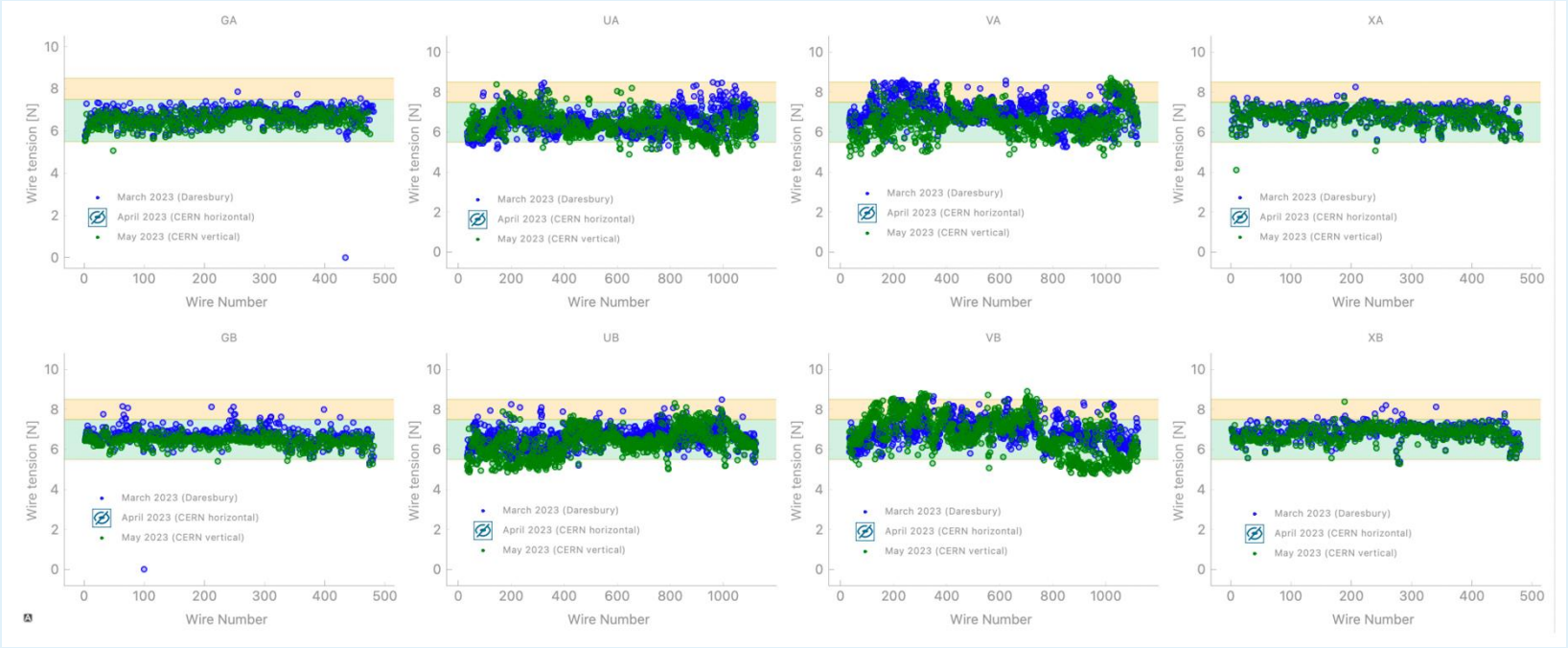
Change in orientation



- We have some data from 2023 on APA 4, measured horizontally at Daresbury and vertically at CERN

How long do things take?

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

One-layer measurement time:
~2h (X/G)
~5h (U/V)

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

- Data analysis for standard plots is instantaneous
- Manual data correction takes ~1 hr for an X or G layer, longer for a U or V layer