

APA Low Tension Wires

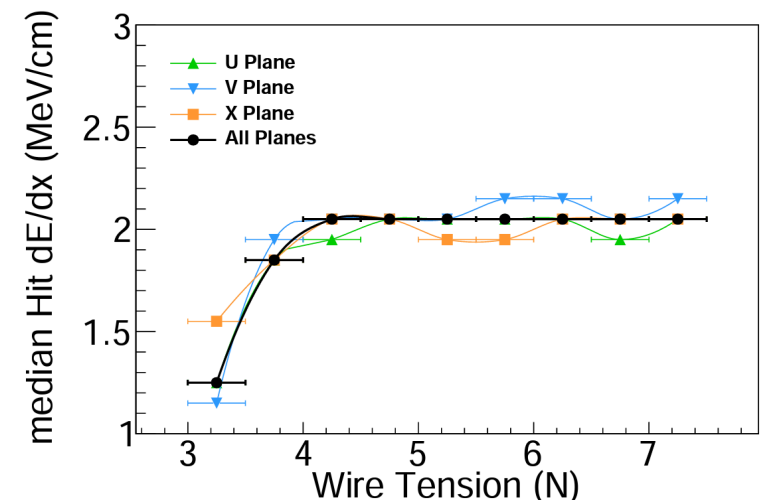
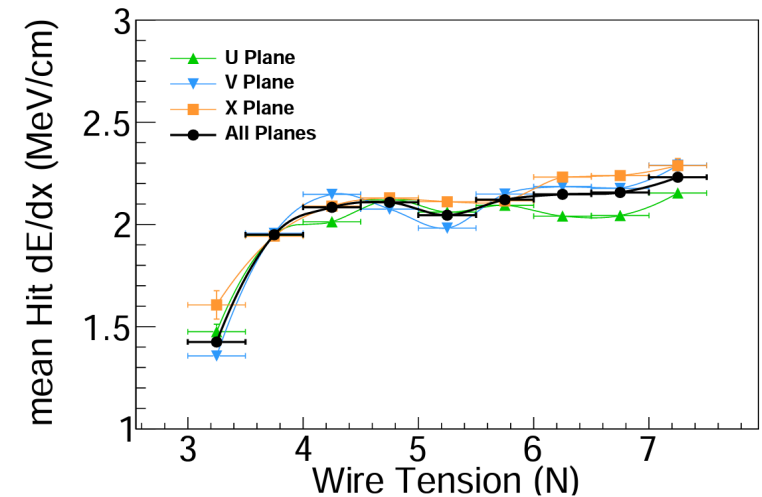
Brian Rebel
October 30, 2023

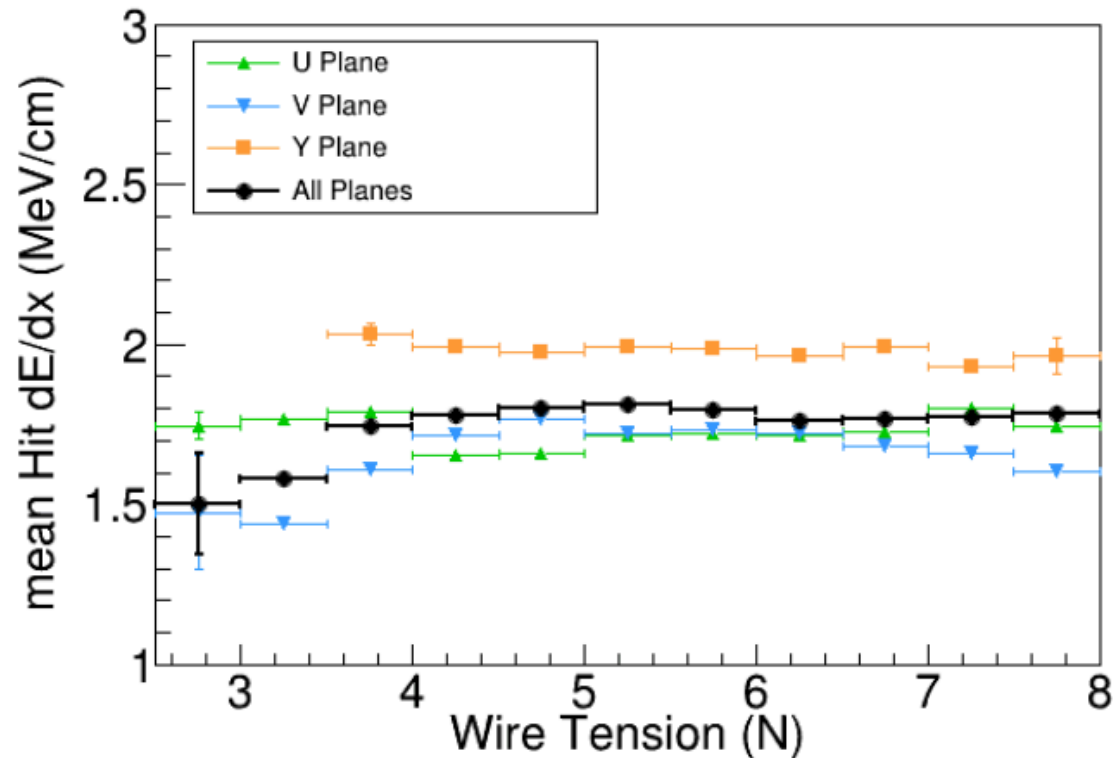


- TDR tension requirements based on ProtoDUNE I studies
 - ProtoDUNE I dE/dx measurements, pre-calibrations
 - ProtoDUNE I dE/dx measurements, post-calibrations
- ProtoDUNE II example tension measurements
- Summary

SP-APA-3	Wire tension	$6\text{ N} \pm 1\text{ N}$	Prevent contact between wires and minimize break risk	ProtoDUNE-SP
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- The TDR specified the tension to be $6\text{ N} \pm 1\text{ N}$
- Adam Lister (UW) used the ProtoDUNE I data to calculate the dE/dx of the hits for each layer as a function of tension (see [docdb](#))
- These profiled results were with pre-calibrated data
- dE/dx per hit is pretty stable when wire tensions are greater than 4 N, but we set the minimum to be 4.5 N to avoid that edge
- Partially based on these results we increased the target tension to be $6.5\text{ N} \pm 1\text{ N}$



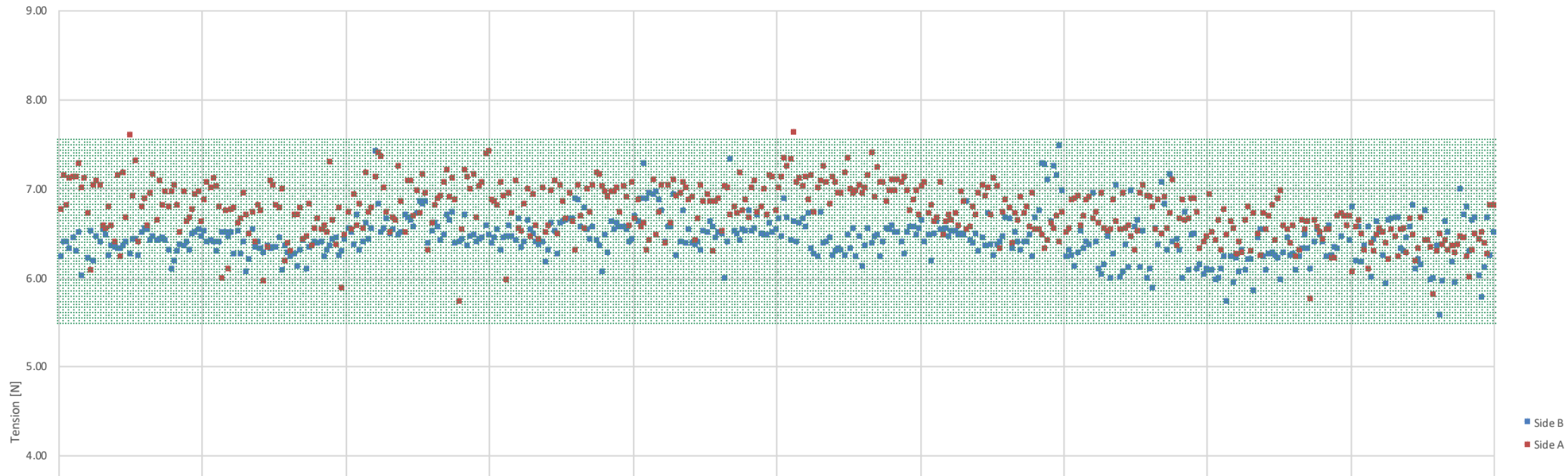


- Once calibrations were available Adam attempted to redo the studies
- He found the dE/dx value when using hits from all layers to be stable from ~ 3.5 N and above
- However, there is more layer to layer variation when the calibrations are applied and the V layer seemed to fall some at both low and high tensions
- We were unable to track down the cause of this behavior and Adam had to pivot to other work



PSL - FR - 003

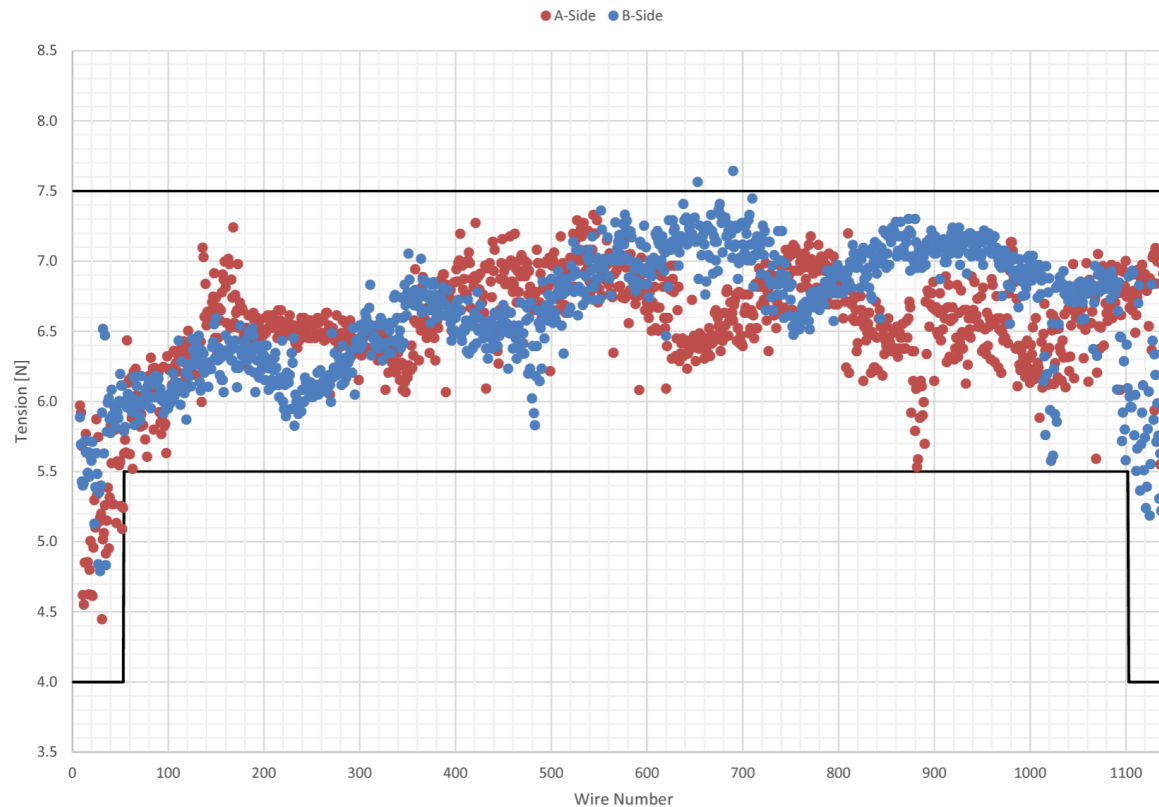
5.5 N \leq Tension \leq 7.5 N



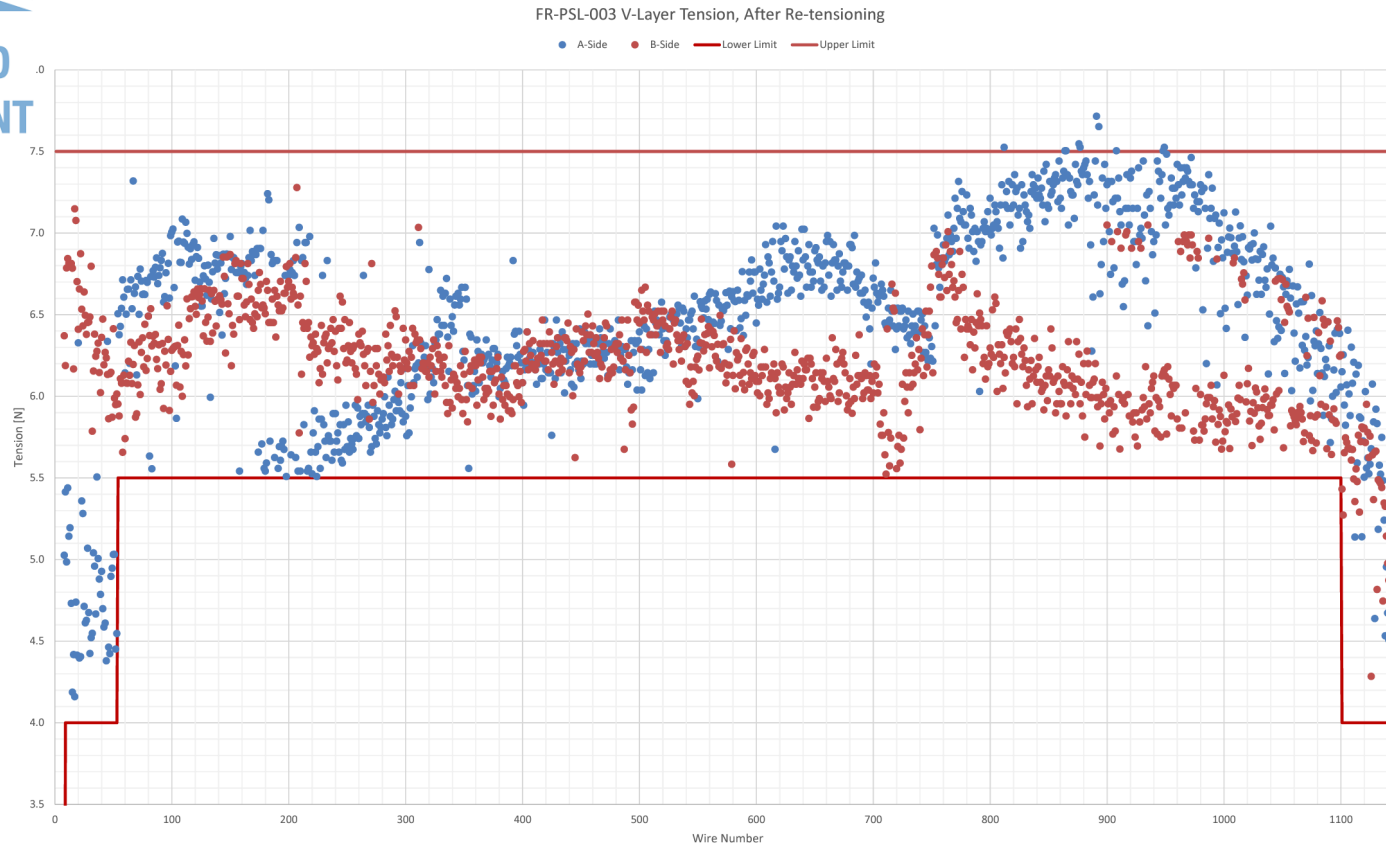
- These are the tensions from the X layer of the UW built APA for ProtoDUNE II
- The shaded band is from 5.5 N to 7.5 N
- The tensions on each wire segment are within the expected tolerance, modulo a couple that are slightly high

ProtoDUNE II Layer Tensions

PSL-FR-003 U-Layer Tension - Post-solder All Final Measurements



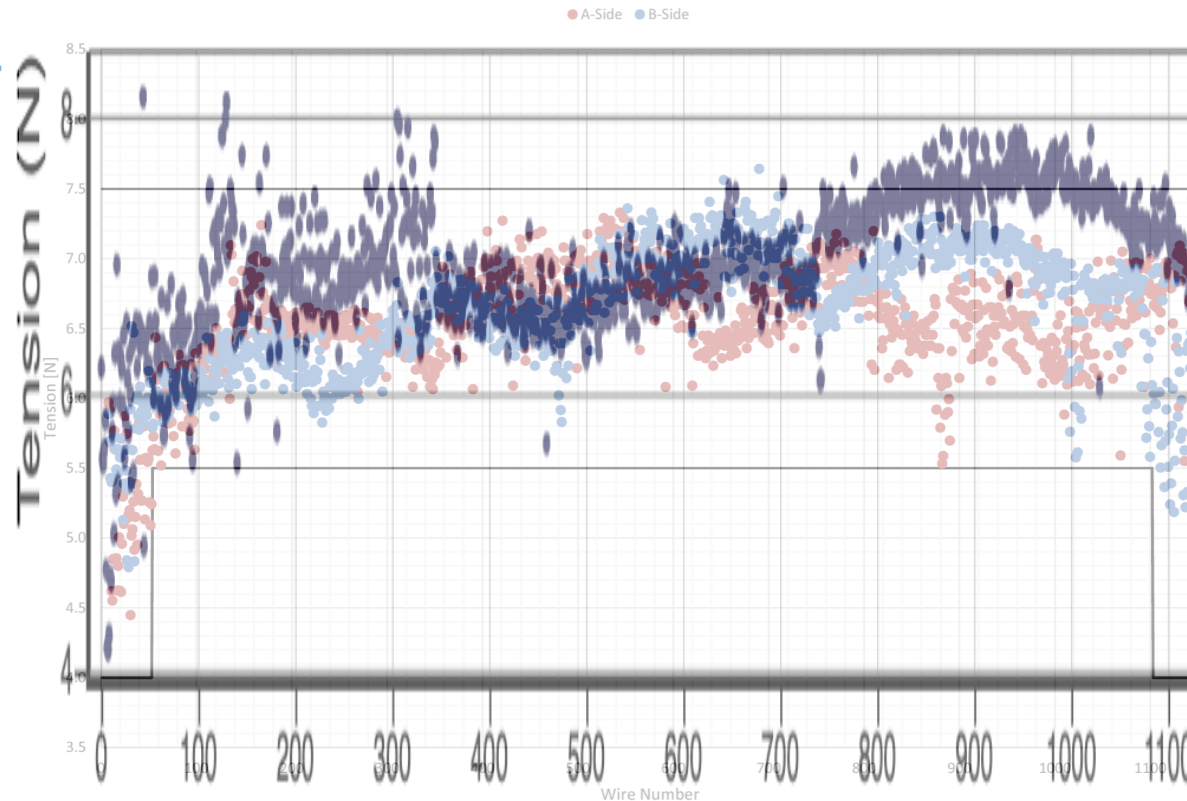
- These are the tensions for the U layer of the same UW made APA
- Notice the black lines indicating the bounds of what was accepted
- The ~50 shortest segments closest to one end are shorter than ~50 cm and are hard to get tensions at the specification
- I believe the stiffener was intended to help somewhat with this issue, but the short wires remain challenging to get to the minimum tension



- The V layer shows similar behavior
- The tensions across the APA for the U and V layers shows some structure, which is different on the A and B sides (V layer colors flipped compared to U layer)
- Found broken short wires in the corners when removing the ProtoDUNE I APAs, attributed to increased tension during the warm up

Recent U Layer Tensions

PSL-FR-003 U-Layer Tension - Post-solder All Final Measurements



- The U layer tensions from UK APA 8 side B are overlaid on the ProtoDUNE II APA from UW
- Compare the blue points from both plots
- Similar structure seen in both APAs, but APA 8 has no low tension wires on the high segment numbers
- UK APA 8 aimed 7 N on each wire; the shortest wires still around 4 N



- The conservatively chosen minimum tension requirement of 4.5 N was based on dE/dx studies from ProtoDUNE I
- Calibrated hits from ProtoDUNE I showed some interesting behavior and may suggest the minimum tension could go lower, but we would want to resolve the origin of the interesting behavior before making such a change
- It is challenging to get tensions above 4.5 N for short wires in the corners of the U and V layers
- Given the dead space between neighboring APAs (~ 22 cm due to frames and geometry boards), we may want to exclude those short wire regions from the fiducial volume
- The short wire length in those areas could also mean that any vibration of the lower tension wires would not inject much noise compared to the signal detected
- Defining a separate tension tolerance (and maybe specification) for short U and V layer wires may be our best option