

# APA QC @ CERN



M.Soderberg, A.Szelc, S. Tufanli, R. Paulos

# Charge

From Rob: “we would like to have a talk focusing on QA/QC and test procedures performed at CERN (with details like which fraction of the wires you are planning to test, which are the criteria to establish whether an APA passes the tests or not, etc), realistic schedule for APA delivery, shipping plans, manpower are you planning to send to CERN if any, help you may need,etc.”

# Constraints

Time in schedule for QC:

APA 1: 4 weeks

Other APAs: 2 weeks

This includes: Unpack, Put on rail, Acceptance Test, PD & CE Install & Test.

This also includes: Raising the APA (0.5 - 1 day?)

This leaves 3-5 days per APA for acceptance test. (optimistic).

# QA/QC at CERN

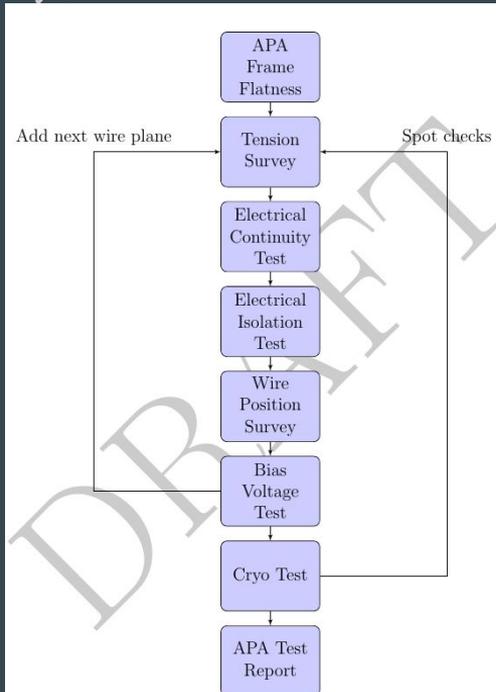
The tests at the factory sites during the APA production will be by definition more thorough than what we can do (and want to do) at CERN.

Necessarily QA/QC at CERN will be a subset of those tests.

We will mostly focus on checking the state of the APAs after transport and controlling potential problem areas/wires (TBD in next slides).

# QC @ PSL and UK

See Docdb#1439 and talk by J. Asaadi at APA review.



## Overview of APA Tests

Test	Requirement	Testing Technique
APA Dimensions and Planarity	Various (See subsequent slides)	Metrology Survey during construction
Wire Tension	5 Newtons +/- 1 Newton per wire	Laser-PhotoDiode Tension Measurement
Wire Position	Design Location per wire +/- 500 $\mu\text{m}$	Made using Cognex Camera on winding machine
Wire Electrical Continuity	< 500 $\Omega$ resistance per channel	Resistance measured between top and bottom of the wire
Wire Electrical Isolation	> 10 M $\Omega$ between adjacent channels	Resistance between adjacent channels where they will mate with the cold electronics
Wire Plane Bias	>100 % nominal voltage	
Cryogenic Performance	Various (See subsequent slides)	Cool with N <sub>2</sub> gas to verify APA function

# Tests we thought we should do/could do at CERN

See Docdb#1439 and talk by J. Asaadi at APA review

## APA Requirement

Requirement	Value	Notes	Verification Scheme
APA Planarity	5 mm	Frame flatness tolerance. Mechanically achievable.	Measure during construction.
APA planarity error	500 microns	uncertainty in the frame flatness measurement	Test at PSL. Recheck at CERN
Wire plane-to-plane position tolerance	500 microns	Frame distortions shift the wire positions. This is the max deviation of the relative wire positions.	Impact of wire misalignments on fields are simulated. The impact on HV to preserve charge transparency are determined.
Wire position tolerance	500 microns	The wire position accuracy is determined by the guide placement precision and wire sag variation. Measured relative to the frame.	Test at PSL. Recheck 10% at CERN pre-ProtoDUNE installation.
Wire guide positioning uncertainty	100 microns	Edge board placement and fabrication tolerance. Measured with a flat frame.	Measure during construction. Provides the start of calibration.
APA Frame Bow / Twist	5 mm	Contribution to the APA flatness	Measure during construction. Provides the start of calibration.
APA fiducial mark location	5 mm	Must be able to locate x,y,z at all fiducial marks	Survey at CERN

# Are APAs tested in cold at factory site?

If “yes”: Catastrophic failure due to cooling excluded.

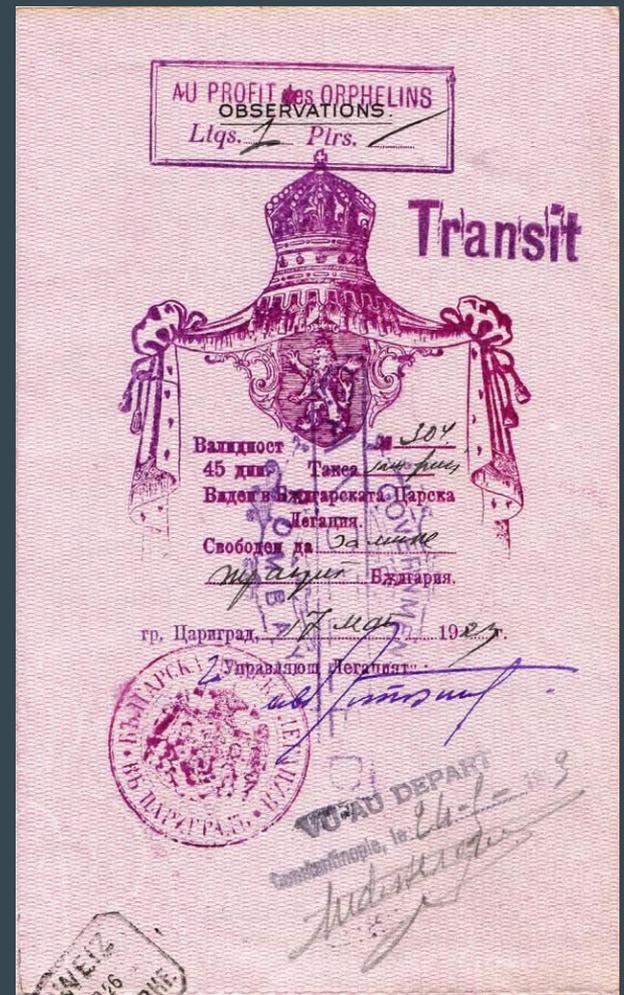
If “no”: Arriving APA has never been cooled down. Tests at CERN should be more thorough - recheck after coldbox?

# APA traveller document

APAs will have documents that specify results of tension, connectivity of wires, planarity of APA, etc...

This will provide the first focus points for places we will want test after transport.

Would like to test o(100) wires (~3%) starting with wires that are at the extremes of tension measurements. First definition of “To Be Tested” pool.



# Tests to do:

## Visual inspection.

Inspect APA while horizontal (in box).

Take pictures of all wire/APA intersections, starting from top and going clockwise.

Take pictures of wire-comb connections. (this is mostly to catalogue and enforce the visual inspection). Compare to pictures from factory site.

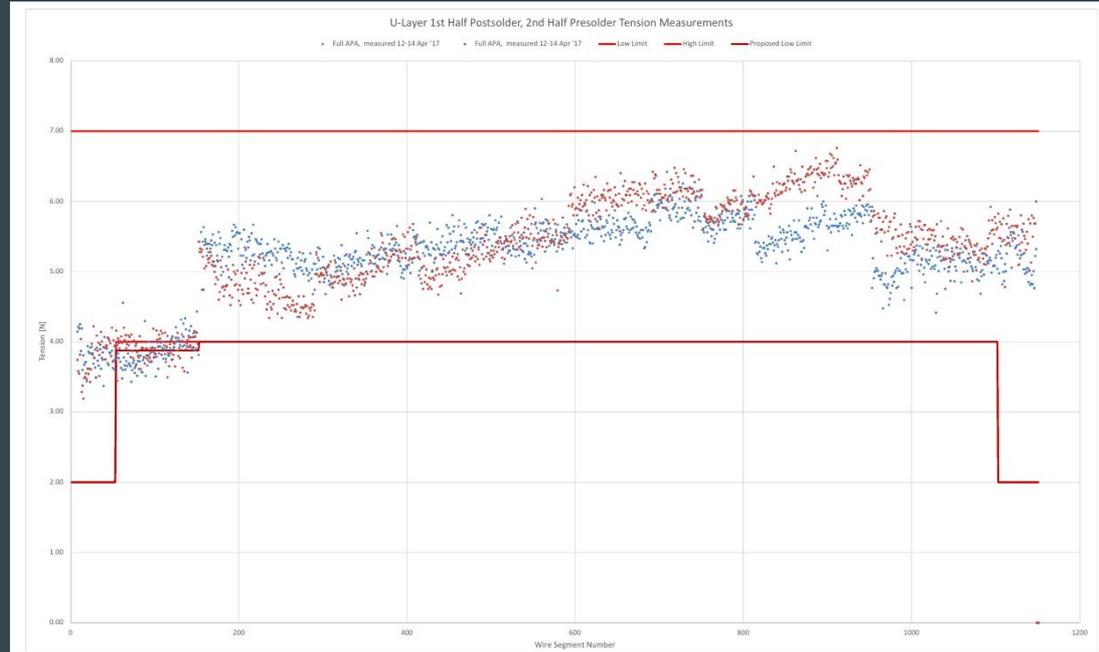
Inspect for sagging wires: Visual + light & slow strum of wires (look for vibrations blatantly different than adjacent wires). Outliers added to the “To Be Tested” pool.

# Tension Measurements

Measure tensions after APA is Vertical

APA 1: spot-check tensions both While APA horizontal and while Vertical (gives idea of what change To expect).

Start with extreme cases: factory tension measurement, suspicious wires from visual inspection. Some baseline wires to make sure still ok. (“To Be Tested” pool)



## Tests to do (2):

Use laser measuring technique a'la MicroBooNE.

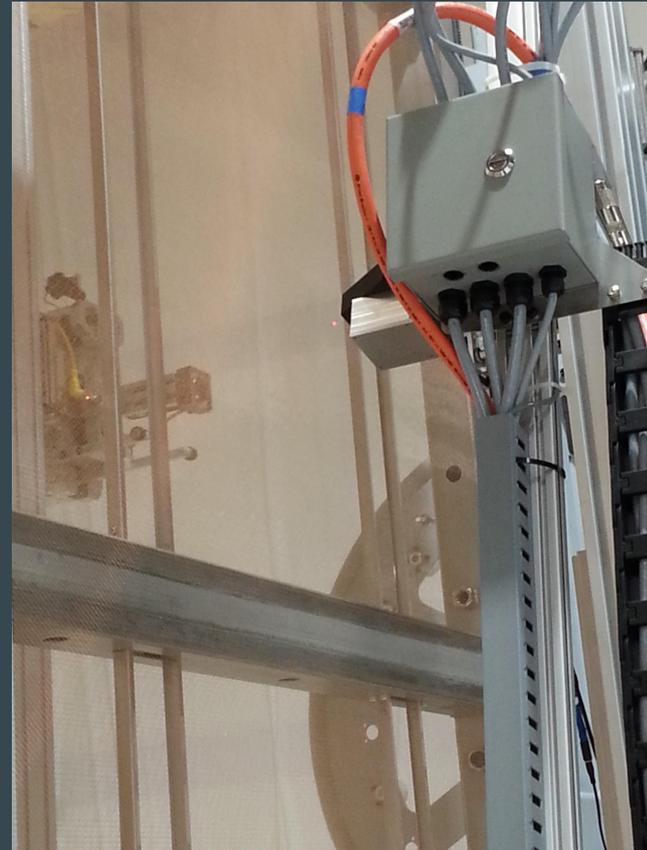
Need laser head + mounting setup.

Estimate we can measure  $\mathcal{O}(100)$

Wires in a (long) day.

We can use the uB/LArIAT device

Or a new one.



# Tests to do (2b):

Alternative method to check wire tension:

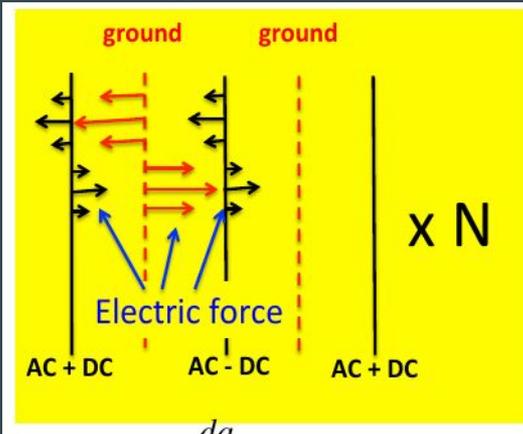
Need voltages of ~400V (AC+DC).

Possible to test multiple wires at the same time (up to 32).

Time of measurement is: o(1 minute) + reconnecting.

In principle easier to setup.

In process of making sure this is ok.



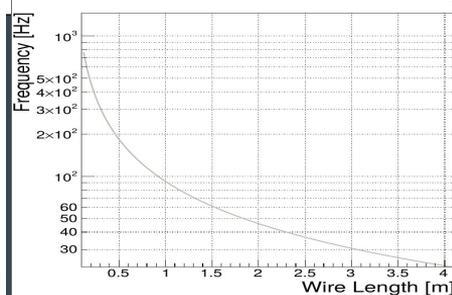
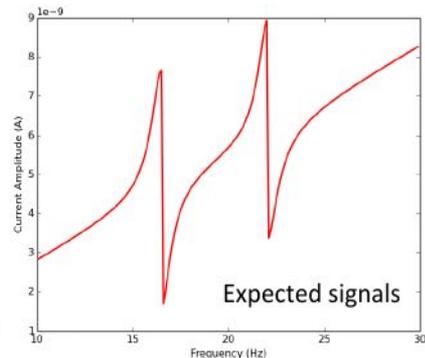
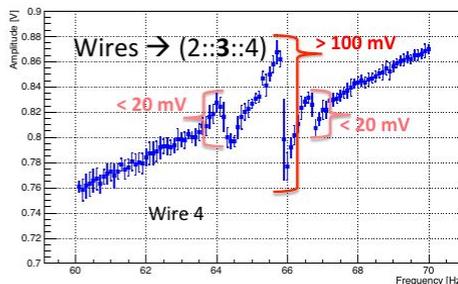
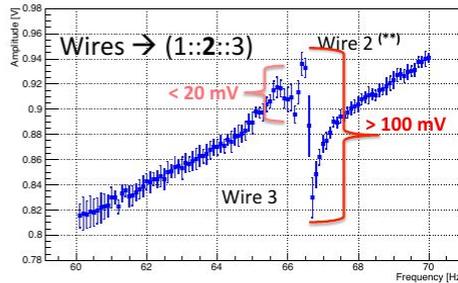
Uses two wires adjacent to each other for applying AC and DC electric fields, and can easily detect a weak current signal at the resonance frequency corresponding to the wire tension.

## Preliminary Results:

Tension wire 1: 5.0 N  
 Tension wire 2: 5.0 N  
 Tension wire 3: 4.8 N  
 Tension wire 4: 4.6 N

Wire length 1.3 m  
 AC: 40 V; DC: 350 V

(\*\*) Wire 1 tension hidden in the signal of wire 2, the enhanced wire, so the one we are measuring



# Other Tests (not?) to do:

Connectivity - not much sense to do, given it will be easier after connecting CE.

Planarity; survey of APA positions in the detector (after final installation)  
- see discussion this morning.

# Raising the APA

Need crane/hoist operator.

Repeat visual inspection.

Tension measurements happen only after raising the APA (except for APA 1).

Planarity measurements for APA1

# What we need

Help raising the APAs

Laser tension measurement equipment (a'la uBooNE)?

PC + 2 custom boards + HV power supply + Function generator for electric tension measurements?

- safety advice: everyone comfortable with  $\sim 400\text{V}$  on wires?
- need to test at PSL first.

CERN Survey teams (?)

# Timelines/Personpower

Serhan: @CERN from the beginning of June (+ Yale graduate student from June to August)

Andrzej: @CERN from September, here for arrival of first APA (mid June-ish?)

UK PDRA's: Nicola McConkey (Sheffield), Dom Brailsford (Lancaster), Andy Furmanski (Manchester) - times being defined.

# Schedule for APA delivery and shipping plans

First APA ~ June 20 but we will have better estimate in 3 weeks.

< 10 days shipping time

UK estimates: UK 1: 27th September (sent, working to speed up)

UK 2: 6th December (sent)

UK 3: 21st February (sent)