DUNE APA Board Tests at CERN

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LBNF/DUNE-UK Project Meeting

The University Of Sheffield.

Outline

- DUNE-HD module-0 detector component validation tests at CERN.

- APA Warm Tests at CERN.

- APA Cold Box Tests at CERN.
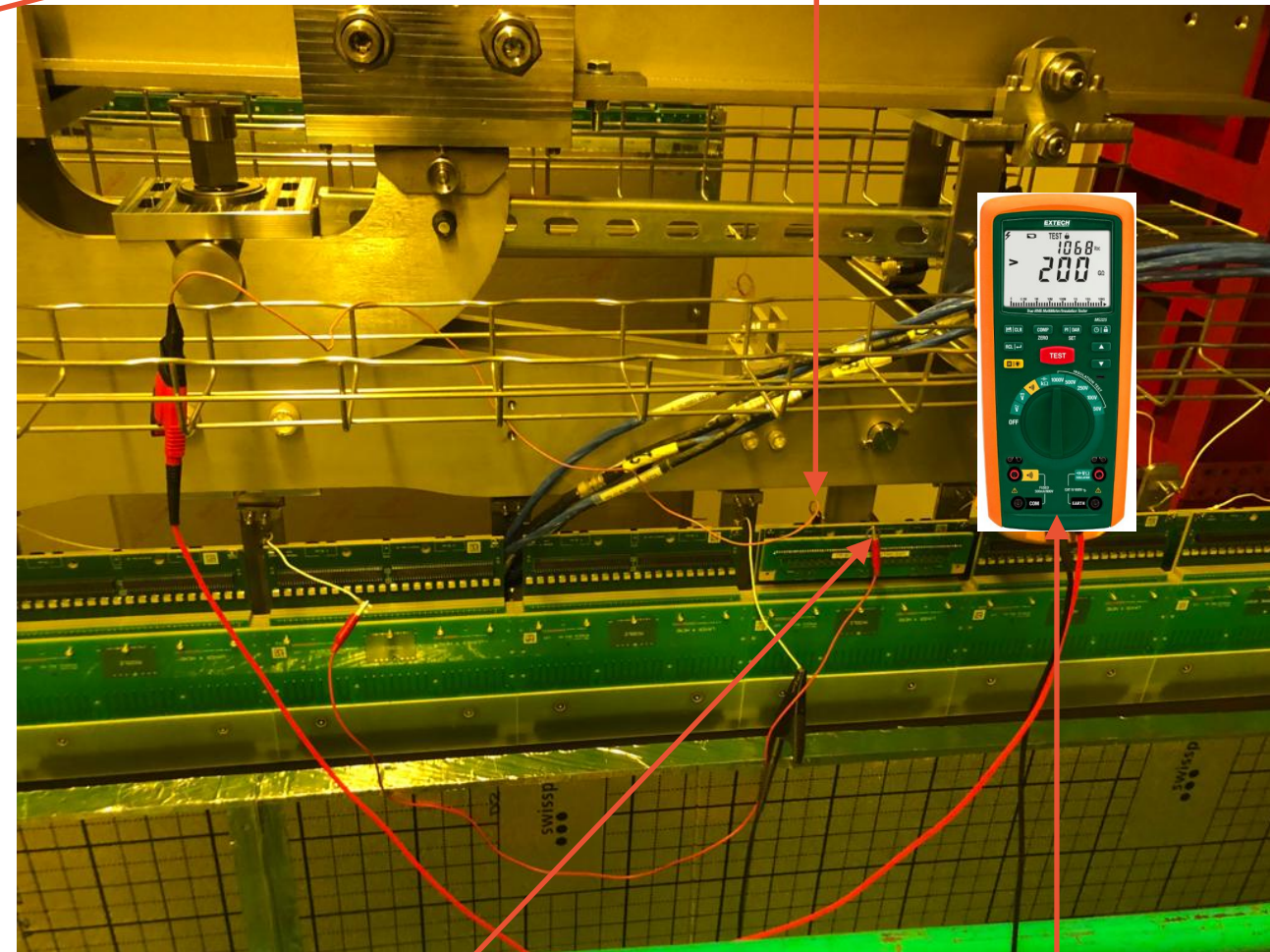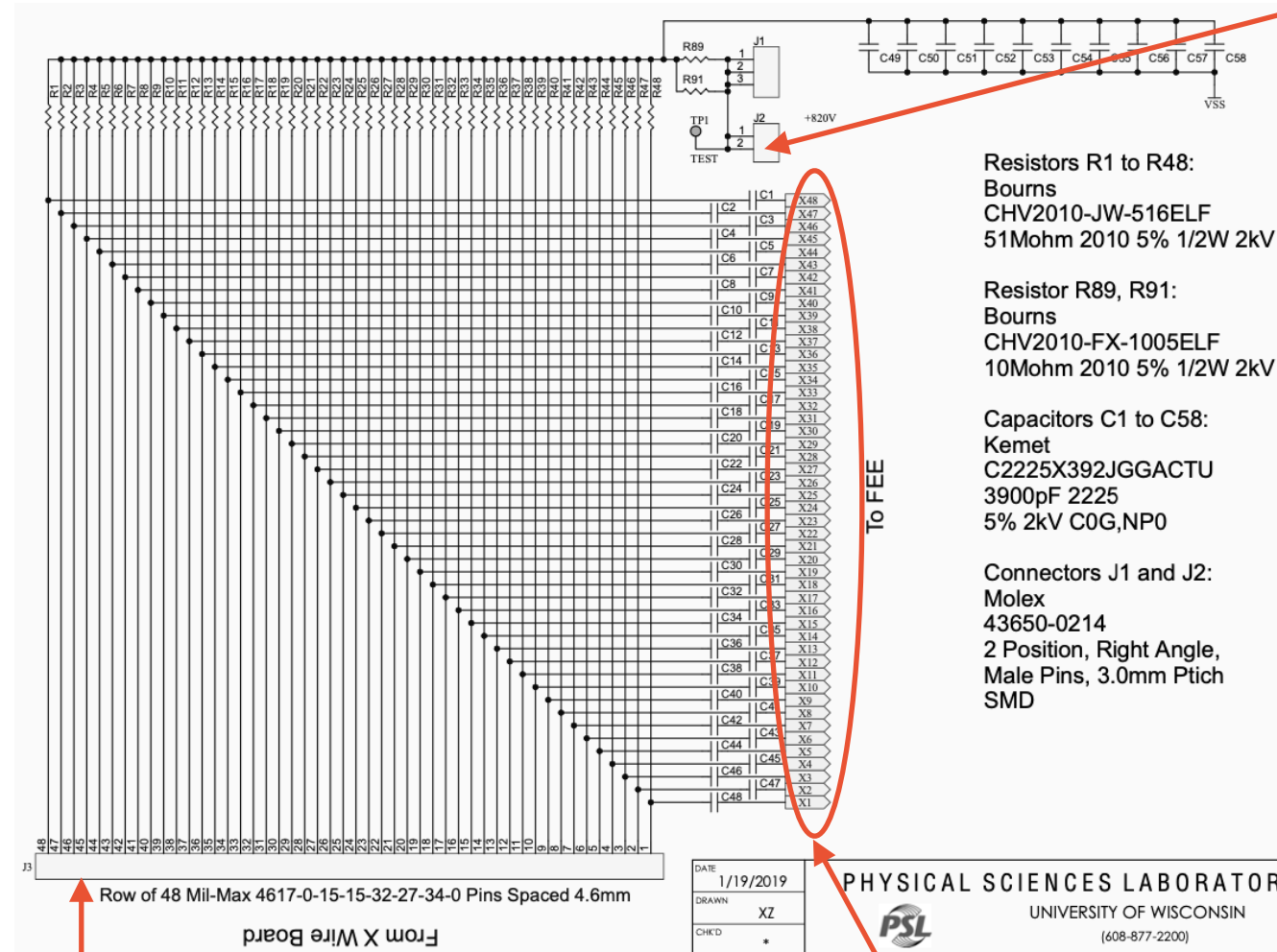
- Summary.

ProtoDUNE-II HD Test Plans

- As part of the final sign off for the DUNE HD module 0 APA production, there is plan to:

  - Install and operate all the module 0 APA components as ProtoDUNE-II at CERN.

  - Validate the detector components and their installation/assembly processes.

- The ProtoDUNE-II detector will have 10,240 signal channels (4 APAs x 2560 Channels per APA).

- The required 4 x APAs (i.e. 2 x top APAs & 2 x bottom APAs) have been delivered and being tested at CERN.

- CE are installed on the top-end of a top-APA and on the bottom-end of a bottom-APA.

- These include 3 x UK-APAs and 1 x US-APA.

Arrow point to an APA

CPA

Arrow point to an APA

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DUNE
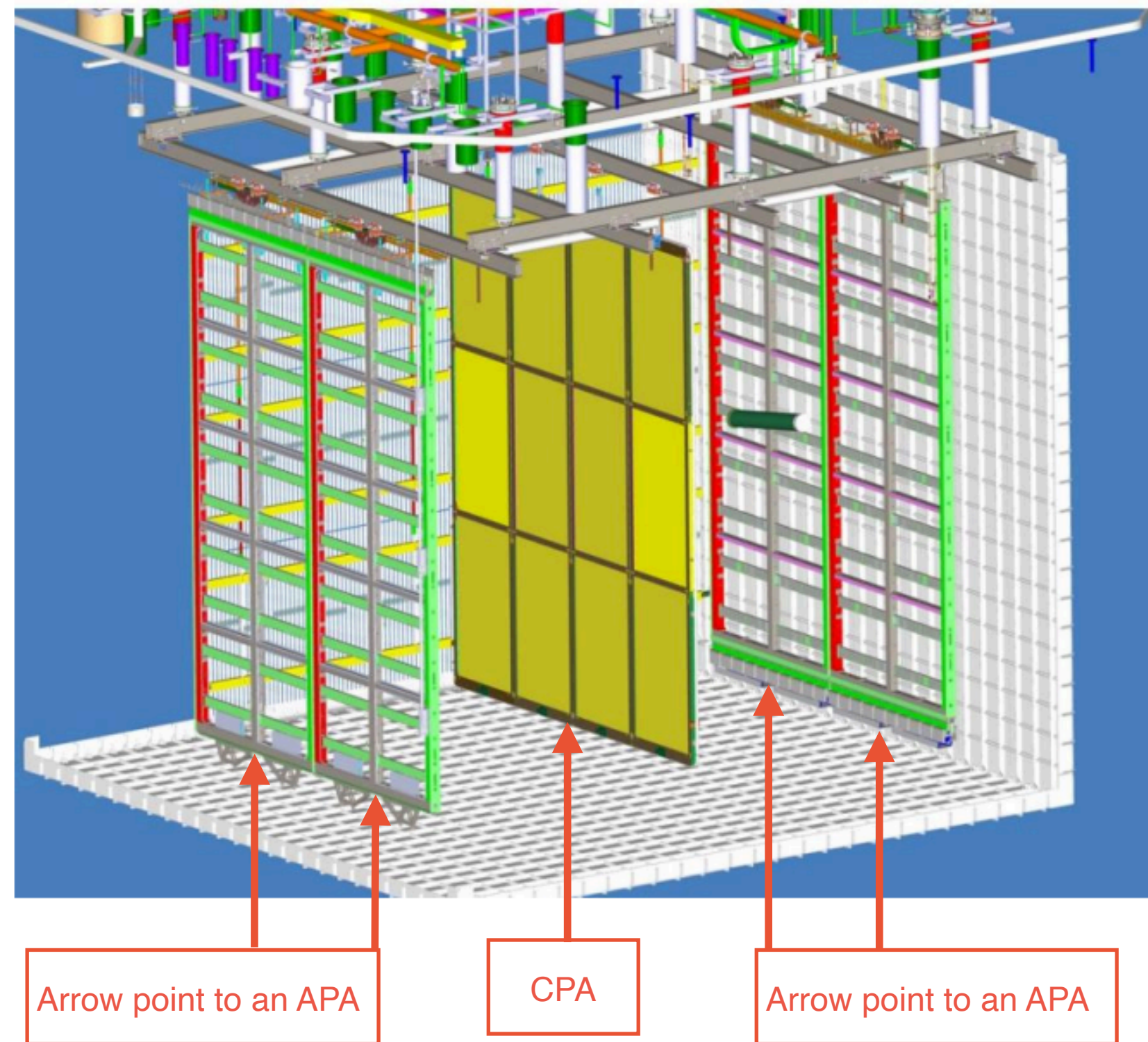
APA Warm Test Setup

- Voltage tests are required to ensure that there are no short paths on the given APA before any cold box/FEMB installations.

Voltage Bias Point

Resistors R1 to R48:
Bourns
CHV2010-JW-516ELF
51Mohm 2010 5% 1/2W 2kV

Resistor R89, R91:
Bourns
CHV2010-FX-1005ELF
10Mohm 2010 5% 1/2W 2kV

Capacitors C1 to C58:
Kemet
C2225X392JGGACTU
3900pF 2225
5% 2kV C0G,NP0

Connectors J1 and J2:
Molex
43650-0214
2 Position, Right Angle,
Male Pins, 3.0mm Ptich
SMD

Row of 48 Mil-Max 4617-0-15-15-32-27-34-0 Pins Spaced 4.6mm

From X Wire Board

DATE 1/19/2019
DRAWN XZ
CHK'D *

PHYSICAL SCIENCES LABORATORY
UNIVERSITY OF WISCONSIN
(608-877-2200)

Connected to X-Layer Head Board

Decoupling capacitors grounded

EXTECH MG325 Insulation Tester.

Tested at: 50V, 100V, 250V, 500V & 1000V.
Measures IR to >200 GΩ

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Results: UK-APA-1 Warm Tests

Board Ref		X-Bias	X-Bias		U-Bias	U-Bias
Side-B	at 1000 V	R (GOhm)	I (nA)	at 1000 V	R (GOhm)	I (nA)
X100	1065	10.4	102.4038462	1065	10.65	100
X107	1065	10.9	97.70642202	1065	10.9	97.70642202
X105	1065	13.2	80.68181818	1065	12.2	87.29508197
X101	1065	11.9	89.49579832	1065	11.9	89.49579832
X114	1065	16.2	65.74074074	1065	12.6	84.52380952
X104	1065	13.3	80.07518797	1065	53	20.09433962
X121	1065	16.7	63.77245509	1065	67	15.89552239
X118	1064	19.5	54.56410256	1065	15.9	66.98113208
X106	1064	12.3	86.50406504	1065	20	53.25
X120	1064	19.4	54.84536082	1065	10.8	98.61111111
Side-A						
X110	1065	38	28.02631579	1065	11.1	95.94594595
X113	1065	38	28.02631579	1065	12.7	83.85826772
X111	1065	7.8	136.5384615	1065	33	32.27272727
X117	1064	43	24.74418605	1065	21.5	49.53488372
X103	1064	13.7	77.66423358	1065	10.3	103.3980583
X109	1065	10.6	100.4716981	1065	11.3	94.24778761
X116	1065	16.9	63.01775148	1065	18.7	56.95187166
X102	1065	9.9	107.5757576	1065	10.2	104.4117647
X112	1065	7.6	140.1315789	1065	11.5	92.60869565
X108	1065	18.9	56.34920635	1065	9.8	108.6734694
Total_I			1538.335302			1535.756689

- Insulation resistance observed from the **UK-APA-1** CR-board bias channels **"passed"** the required >2 GΩ criterion.

- Observed maximum current from the X-layer of **UK-APA-1** at the operational voltage of +820 V is **<1.2 μA**

- Observed maximum current from the U-layer of **UK-APA-1** at the operational voltage of -370 V is **<0.6 μA**

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Results: UK-APA-2 Warm Tests

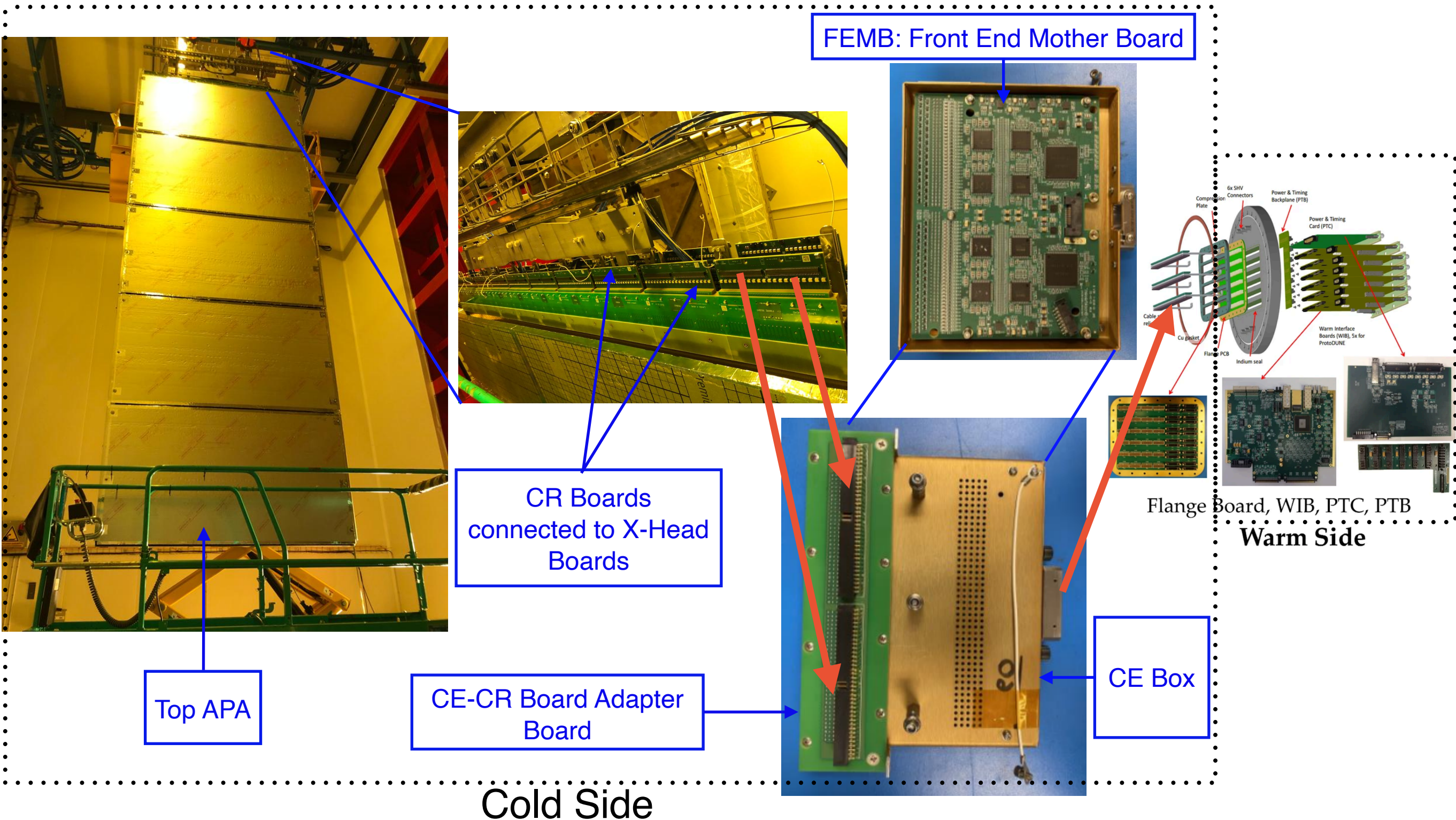| Board Ref		X-Bias	X-Bias		U-Bias	U-Bias
Side-A	at 1000 V	R (GOhm)	I (nA)	at 1000 V	R (GOhm)	I (nA)
x143	1065	12.7	83.85826772	1065	17.3	61.56069364
x132	1065	17.4	61.20689655	1065	12.3	86.58536585
x129	1065	17.1	62.28070175	1065	22.3	47.75784753
x127	1065	18.2	58.51648352	1065	15.2	70.06578947
x130	1065	17.2	61.91860465	1065	13.1	81.29770992
X119	1065	17.2	61.91860465	1065	19.3	55.18134715
X134	1065	19.1	55.7591623	1065	11.9	89.49579832
X122	1065	20	53.25	1065	13.6	78.30882353
X137	1065	14.8	71.95945946	1065	14	76.07142857
X123	1065	19.7	54.06091371	1065	12.3	86.58536585
Side-B						
X141	1065	17.1	62.28070175	1065	16	66.5625
X125	1065	20.1	52.98507463	1065	18	59.16666667
X138	1065	19.5	54.61538462	1065	15.1	70.52980132
X142	1065	16.3	65.33742331	1065	19.4	54.89690722
X126	1065	14.1	75.53191489	1065	19.2	55.46875
X124	1065	8.8	121.0227273	1065	16.2	65.74074074
X131	1065	15.3	69.60784314	1065	18.7	56.95187166
X135	1065	17.2	61.91860465	1065	17.1	62.28070175
X130	1065	16.6	64.15662651	1065	17.5	60.85714286
X133	1065	14.3	74.47552448	1065	10.6	100.4716981
Total_I			1326.66092			1385.83695

- Initially, there was a stray mesh wire that shorted 2 of the CR board channels to ground. This was found and removed so all the CR boards bias channel on **UK-APA-2** now *"passed"* the required >2 GΩ criterion.

- Observed maximum current from the X-layer of **UK-APA-2** at the operational voltage of +820 V is **<1.1 μA**

- Observed maximum current from the U-layer of **UK-APA-2** at the operational voltage of -370 V is **<0.5 μA**

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Results: US-PSL-APA-4 Warm Tests

Board Ref		X-Bias	X-Bias		U-Bias	U-Bias
Side-A	at 1000 V	R (GOhm)	I (nA)	at 1000 V	R (GOhm)	I (nA)
x154	1065	19.8	53.78787879	1065	17.9	59.4972067
x159	1065	13.7	77.73722628	1065	15.6	68.26923077
x158	1065	21.4	49.76635514	1065	14.5	73.44827586
x146	1065	14.4	73.95833333	1065	12.3	86.58536585
x139	1065	16.8	63.39285714	1065	6.5	163.8461538
x145	1065	14.4	73.95833333	1065	5.7	186.8421053
x157	1065	11.6	91.81034483	1065	9.5	112.1052632
x153	1065	21.2	50.23584906	1065	10.4	102.4038462
x156	1065	16.4	64.93902439	1065	13.6	78.30882353
x147	1065	19.2	55.46875	1065	11.2	95.08928571
Side-B						
x163	1065	13.8	77.17391304	1065	18.3	58.19672131
x149	1065	16.1	66.14906832	1065	17	62.64705882
x162	1065	15.4	69.15584416	1065	12.2	87.29508197
x155	1065	15.7	67.8343949	1065	14.4	73.95833333
x164	1065	16.1	66.14906832	1065	21.2	50.23584906
x151	1065	13.9	76.61870504	1065	16	66.5625
x161	1065	17.8	59.83146067	1065	11	96.81818182
x152	1065	19	56.05263158	1065	20.3	52.46305419
x148	1065	16.9	63.01775148	1065	20	53.25
x150	1065	21.6	49.30555556	1065	10.7	99.53271028
Total_I			1306.343345			1727.355048

- Insulation resistance observed from the **US-PSL-APA-1** also **_"passed"_** the required >2 GΩ criterion, however, the U-layer bias of this APA were found to be most sensitive to relative humidity.

- Observed maximum current from the X-layer of **US-PSL-APA-1** at the operational voltage of +820 V is **<1.0 μA**

- Observed maximum current from the U-layer of **US-PSL-APA-1** at the operational voltage of -370 V is **<0.6 μA**

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APA Integration with FE Electronics

FEMB: Front End Mother Board

CR Boards connected to X-Head Boards

Top APA

CE-CR Board Adapter Board

CE Box

Flange Board, WIB, PTC, PTB

Warm Side

Cold Side

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APA Cold Box Tests

Signal Feed-through

CERN NP04 Cold Box

APA

- Samples of geometry, filter boards and charge readout front end electronics to be used on the DUNE-HD module-0 detector are being tested on ProtoDUNE-II APAs.

- The plan is to test ProtoDUNE-II APAs at their respective operational voltages in the CERN NP04 cold box before the APAs are moved into the cryostat.

- Next slides will discuss test results from the cold box test of the first 2 x UK ProtoDUNE-II APAs.
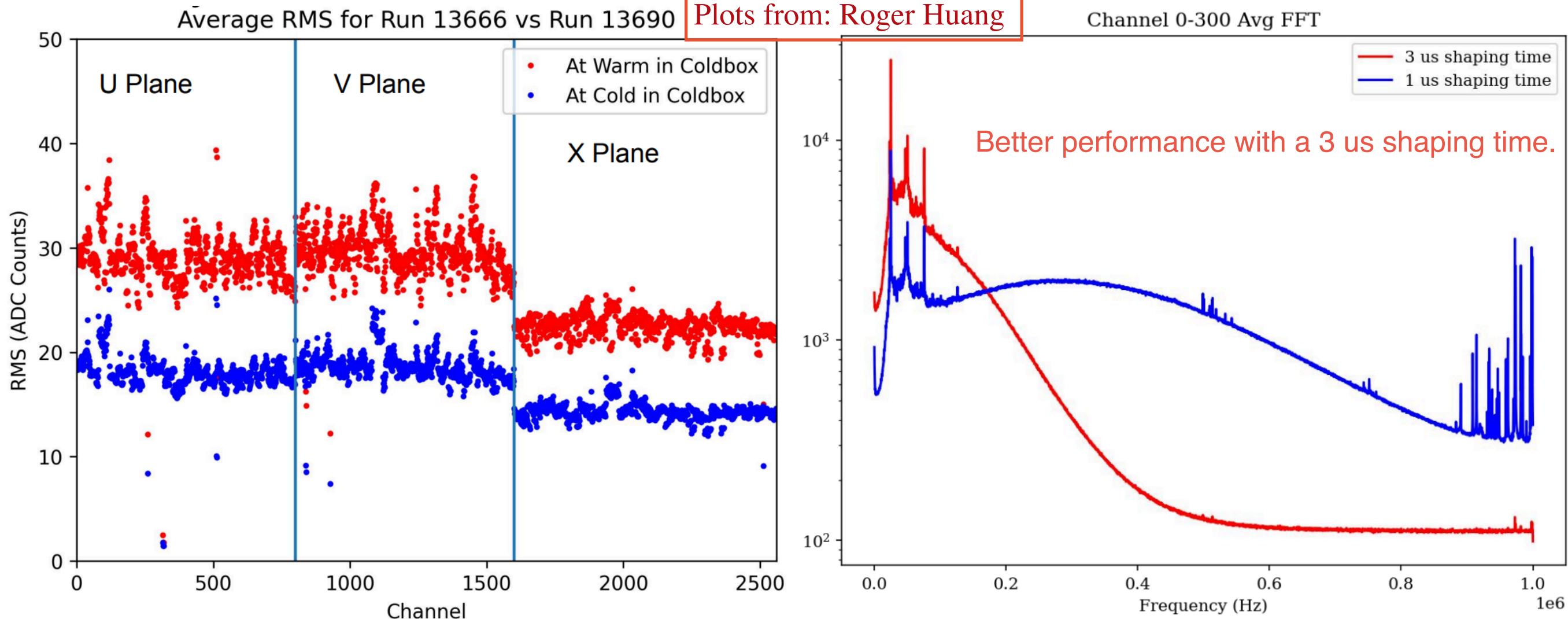
Results: UK-APA -1 Cold Box Tests

Average RMS for Run 13351 (3 us)

Channel 0-200 Avg FFT - APA1
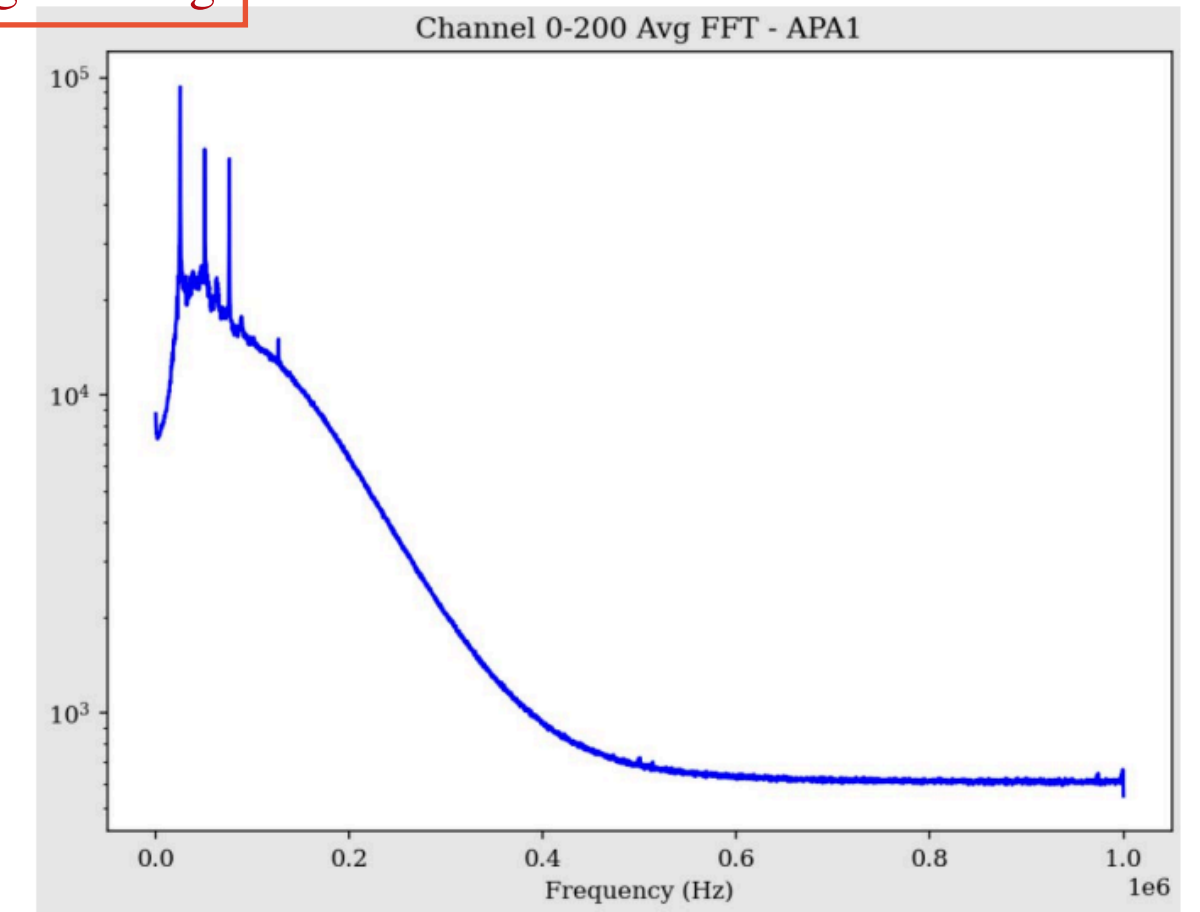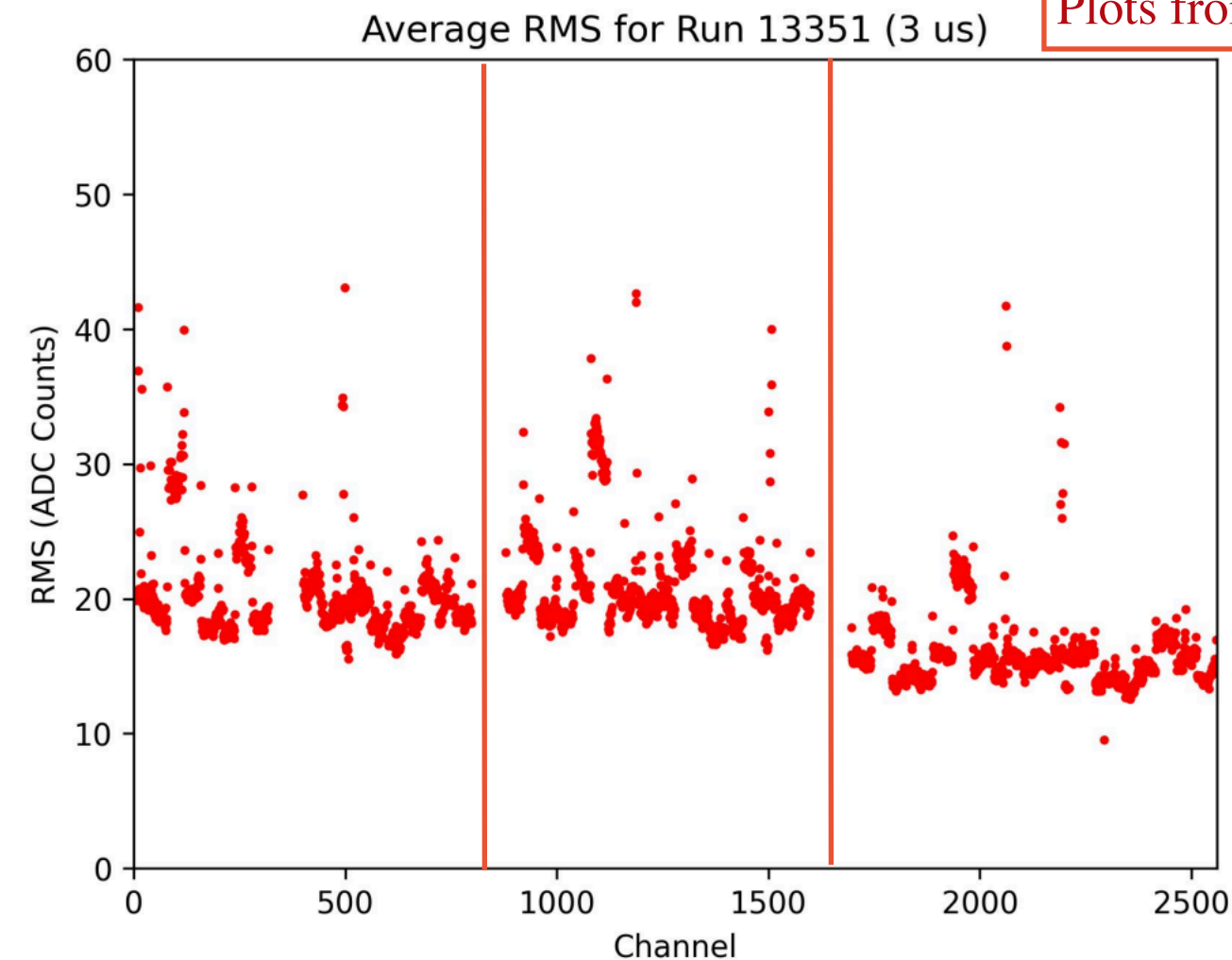
- Noise RMS spread: ~30 ADC.

- A few FEMBs were "noisier" than others.

- Observed ~25 kHz noise peaks from the FFT spectrum.

- The observed noise features respond to changes in the FEMB bias voltages.

Results: UK-APA -2 Cold Box Tests

Average RMS for Run 13666 vs Run 13690

- At Warm in Coldbox
- At Cold in Coldbox

U Plane   V Plane   X Plane

Channel 0-300 Avg FFT

— 3 us shaping time
— 1 us shaping time

Better performance with a 3 us shaping time.

- Noise RMS spread: ~30 ADC. The cold electronics group are developing a coherent noise filter which is expected to improve this baseline noise.

- The ~25 kHz noise peaks were also observed from the UK-APA-2 FFT results.

- Initially, 3 channels were dead, the affected FEMBs were replaced which solved this issue. However, 7 other channels were reported to look open. These potential open channels are being investigated.

- During the APA warn up, FEMB 10 and 11 showed ~180 ADC continuous noise spikes. This is being investigated.

Summary

- All the 4 x APAs required to build ProtoDUNE-II HD at CERN have been delivered and are currently undergoing pre-installation tests at the CERN NP04 clean room area in preparation for their installation in the cryostat.

- 3 x APAs out of the required 4 x ProtoDUNE-II APAs were produced and shipped to CERN from the UK-APA factory at Daresbury.

- Warm and cold box tests of the first 2 x UK-APAs were successful. Noise issues observed during the tests are being investigated.

Thanks for listening!