APA Design and Interfaces

Lee Greenler

DUNE APA Design Review

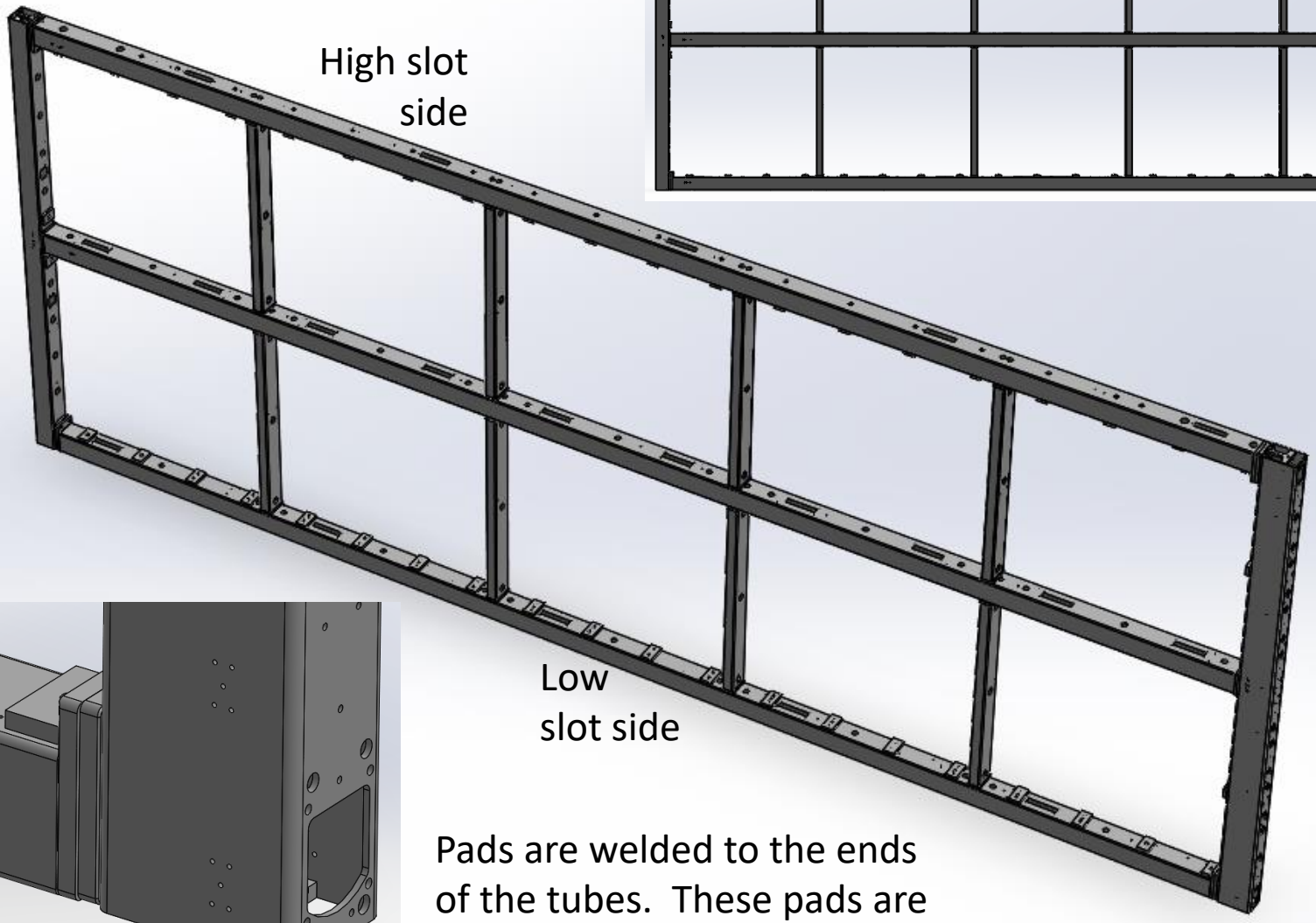
March 27, 2019

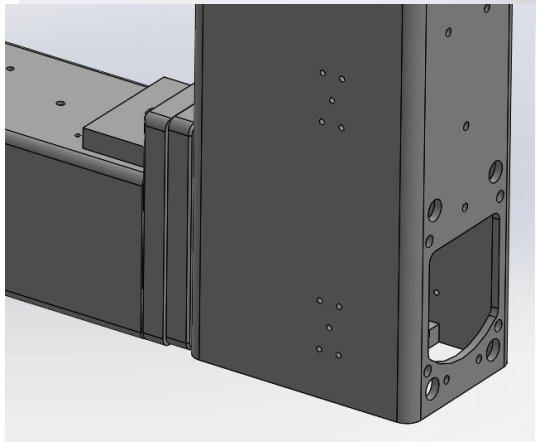
Charge:

2. Are the specifications and drawings for standard and custom components substantially complete and available in EDMS? Are they of sufficient maturity to proceed to final design?
3. Have interfaces with other detector components been addressed and documented? Do risks of design changes in other systems have appropriate mitigation strategies?

But, first, some terminology…

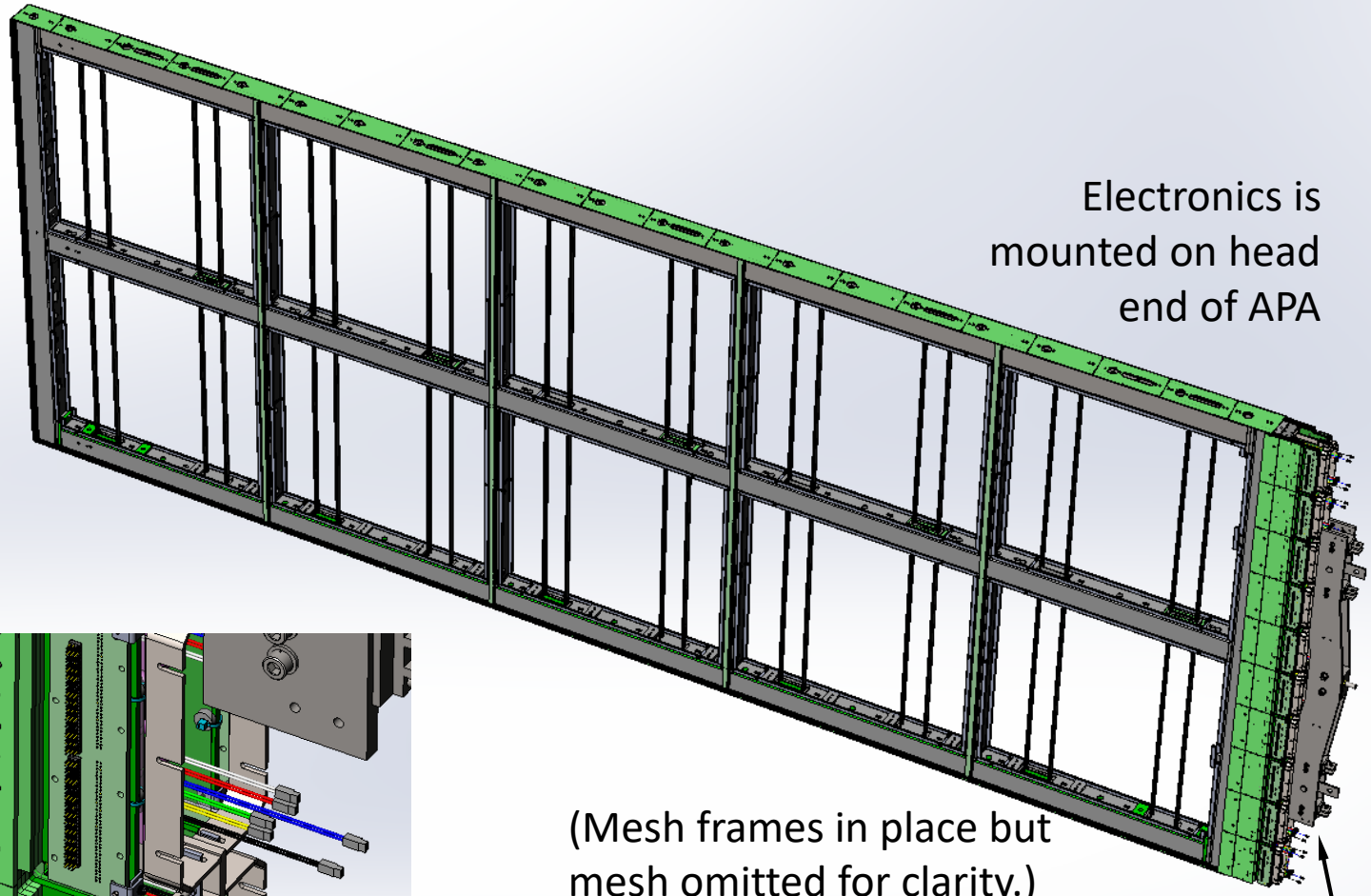
APA Stainless Steel Frame





Pads are welded to the ends of the tubes. These pads are joined with machine screws.

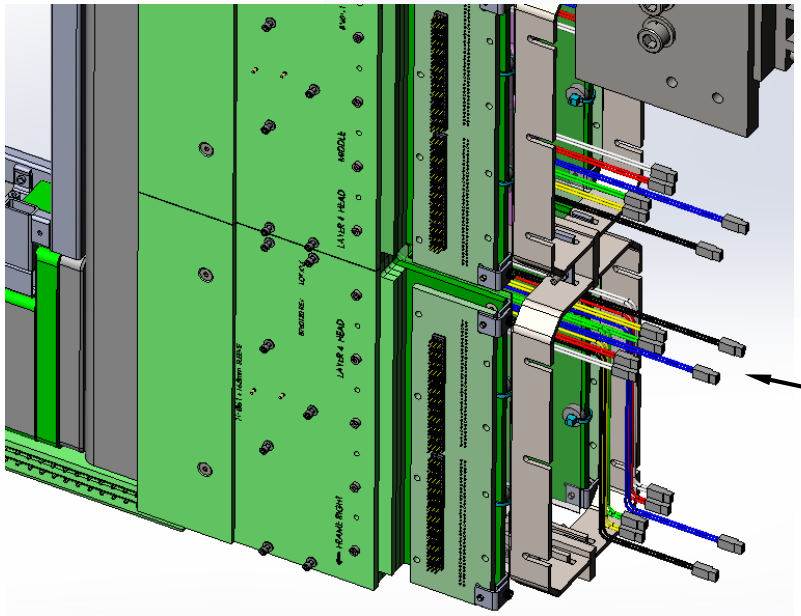
Factory Complete APA



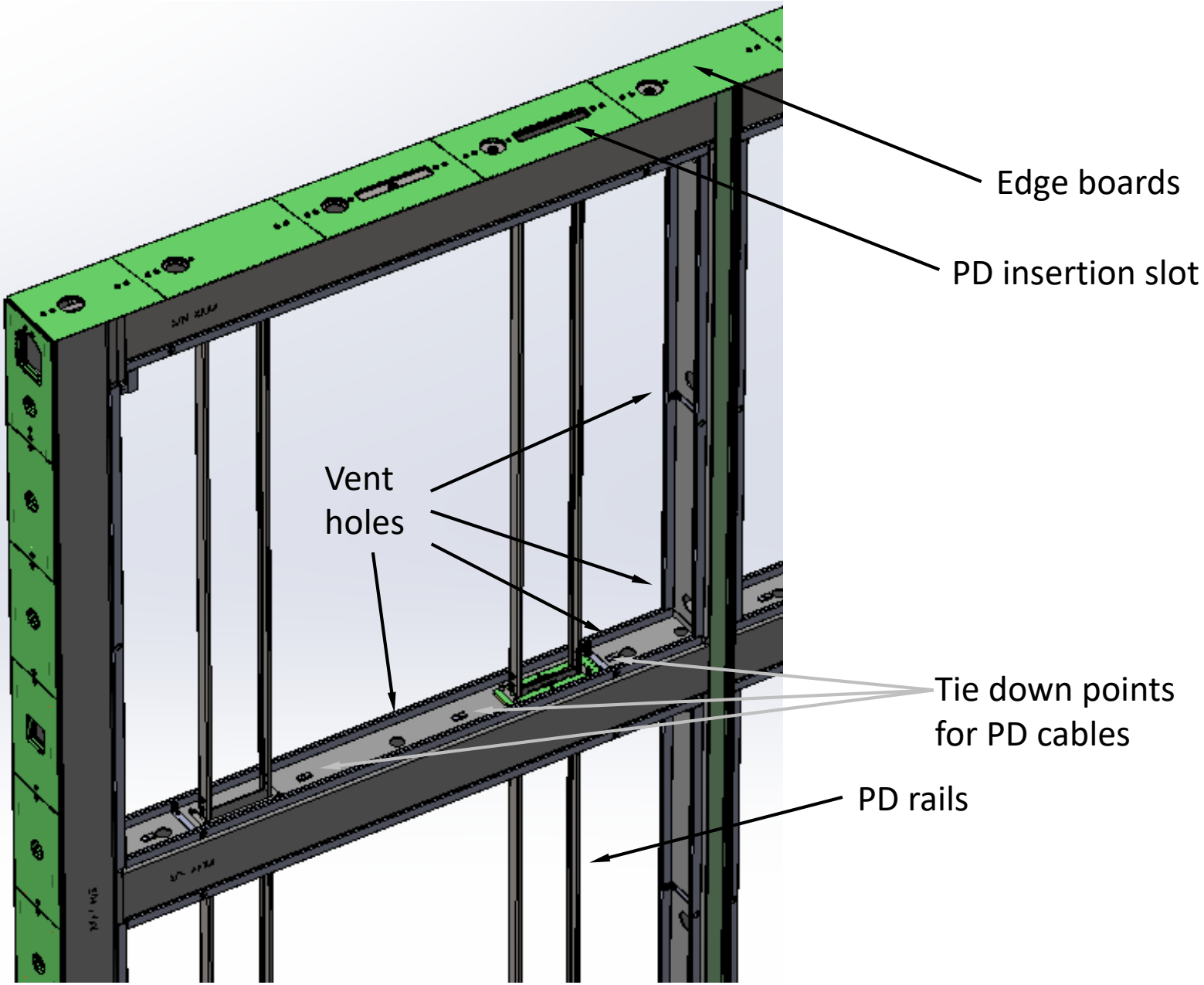
Electronics is mounted on head end of APA

(Mesh frames in place but mesh omitted for clarity.)

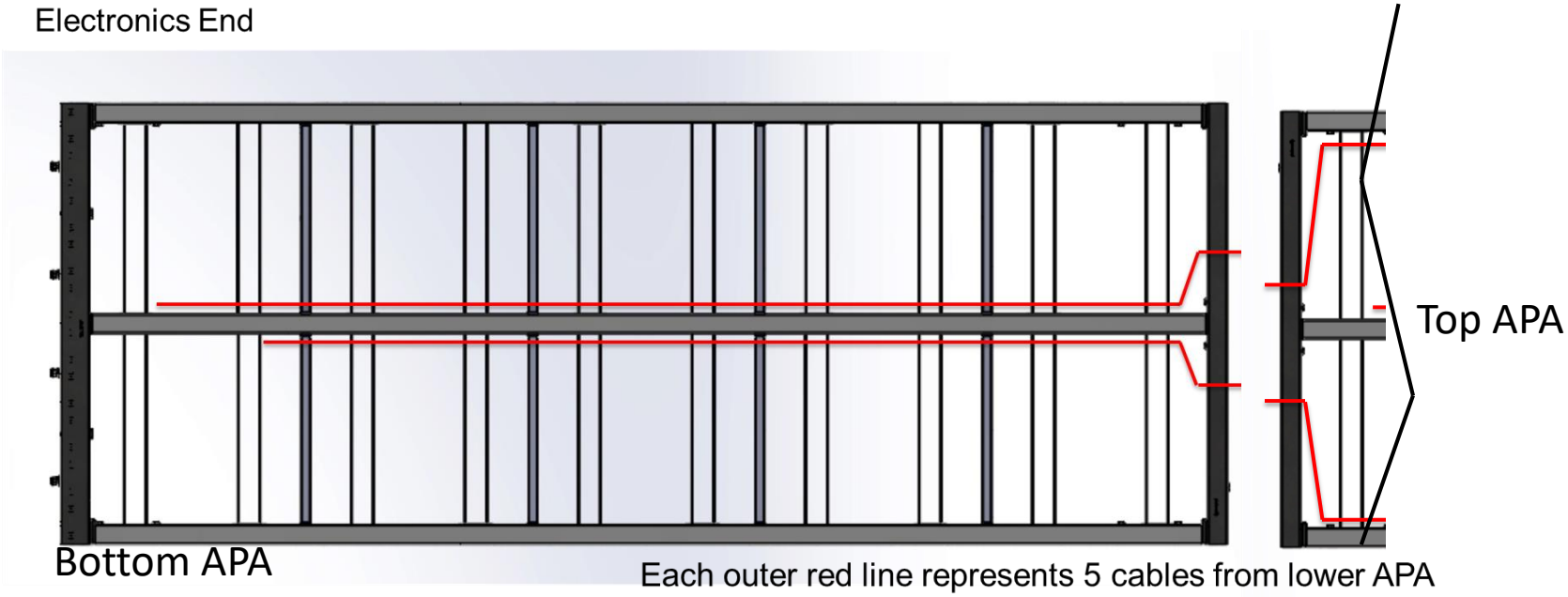
Yoke

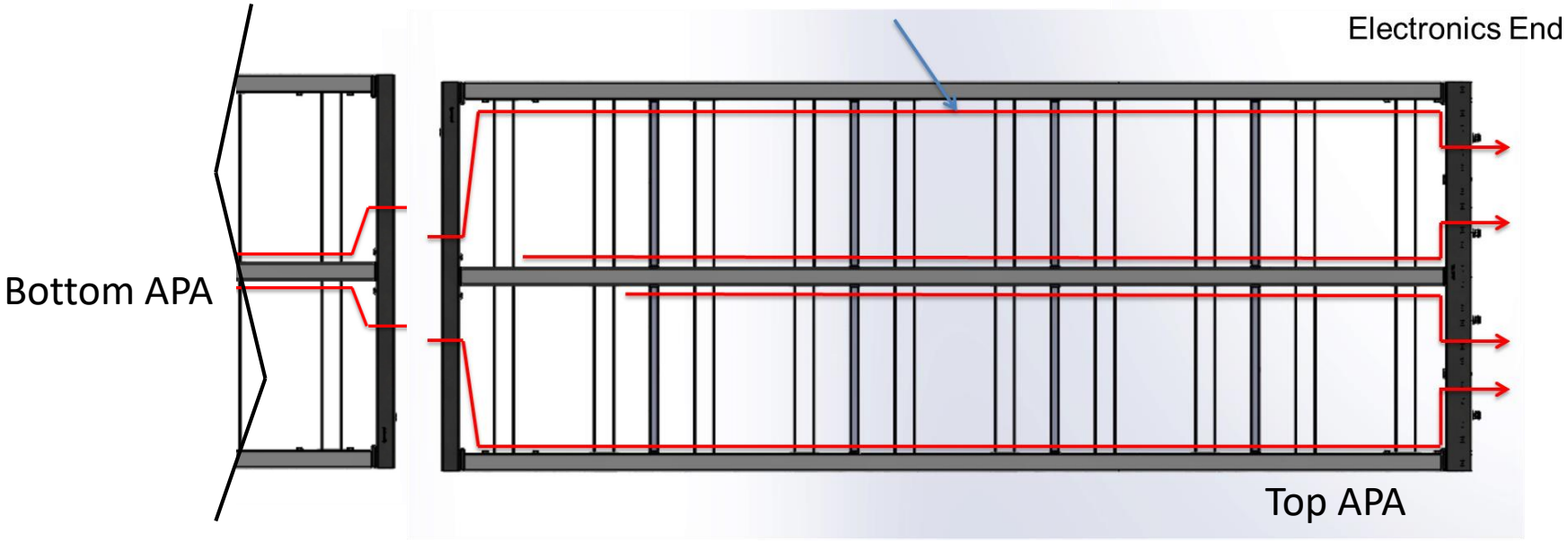


Power to CE boxes


Edge boards
PD insertion slot
Vent holes
Tie down points for PD cables
PD rails

Photon Detector Cabling





PD Cables Along Side Tubes

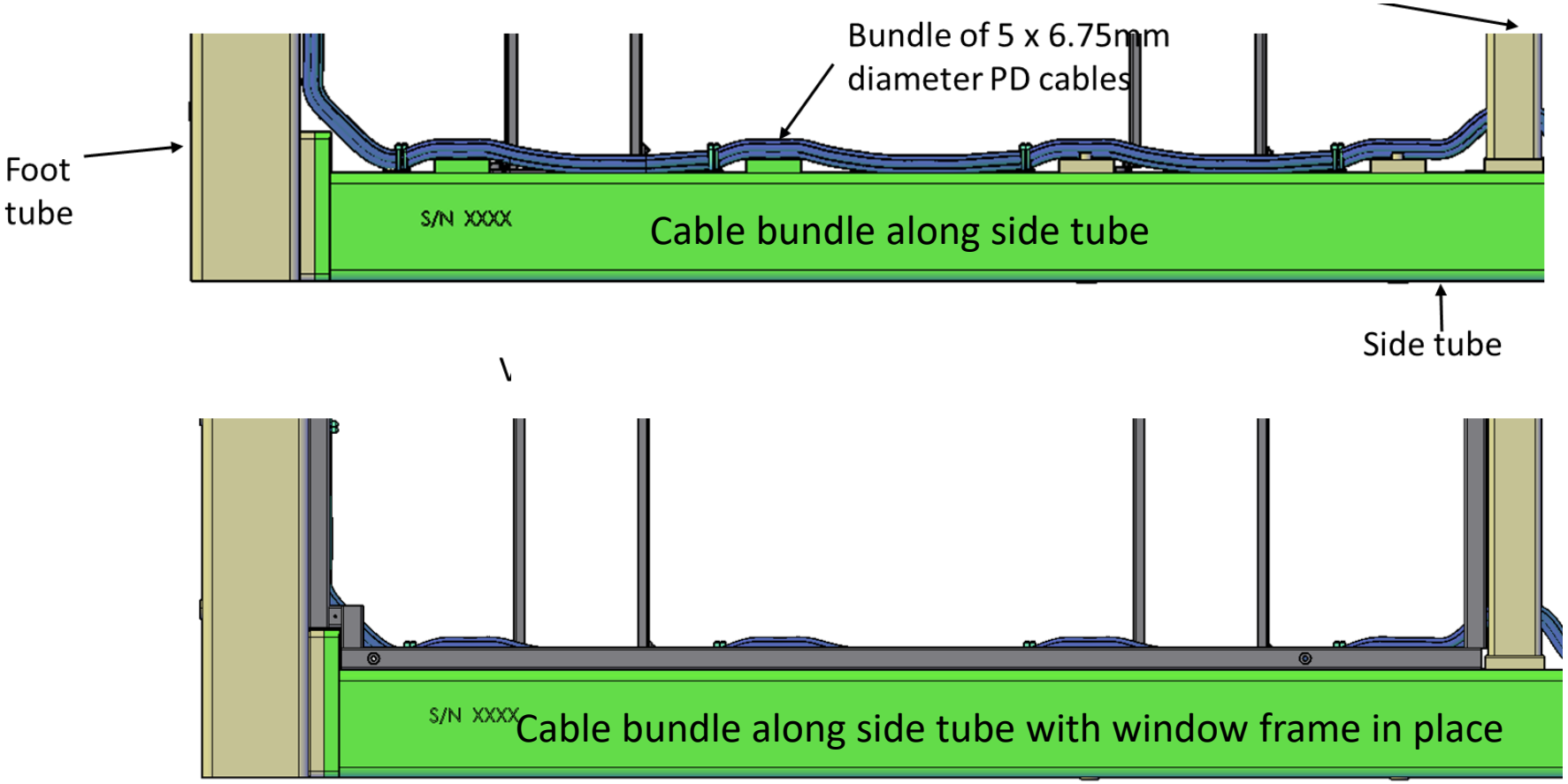
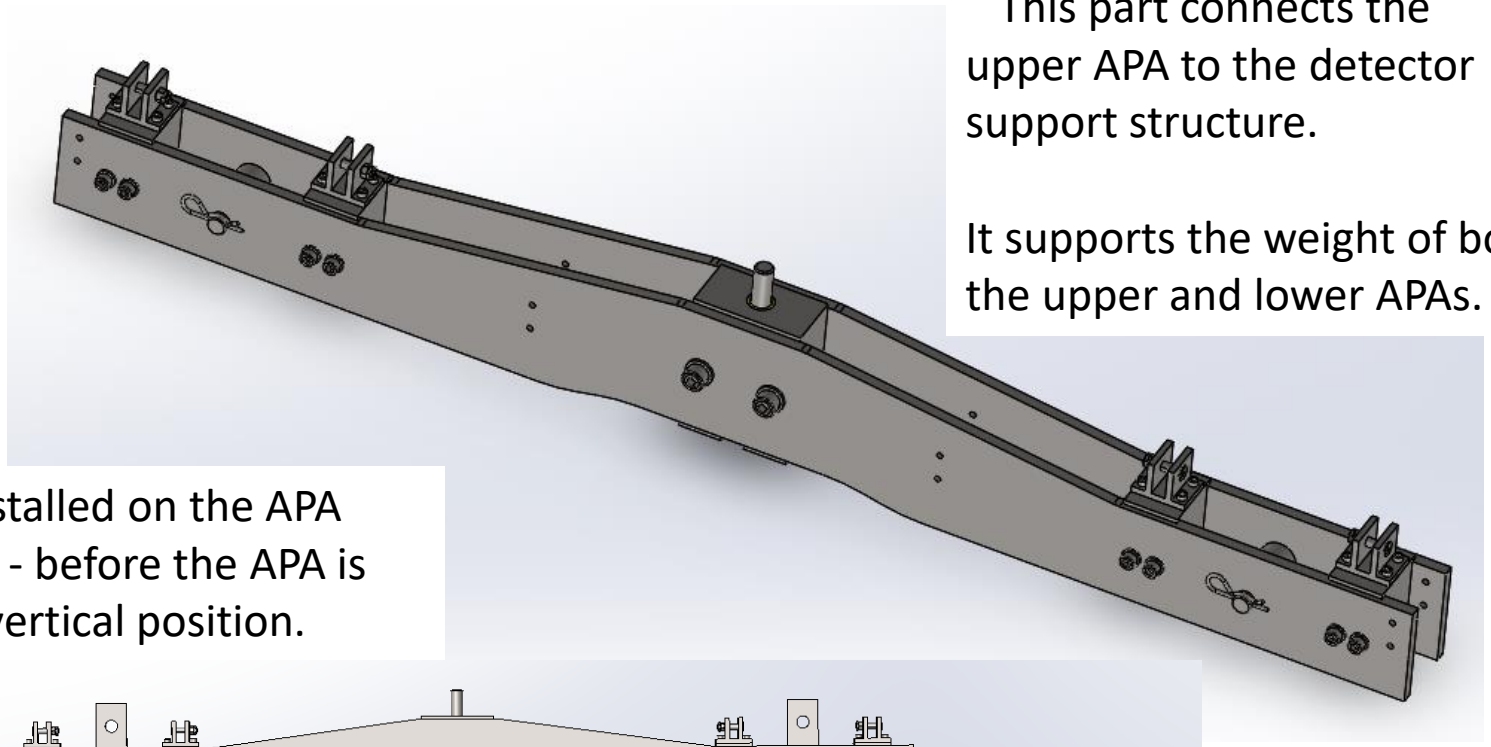


Image compliments of Dave Warner

Photon Detector Cables vs. Cold Electronics Cables

Note: The PD cables run up the *outside* of the long tubes as just shown. The cables between the lower APA cold electronics and the top of the cryostat run *inside* the side tubes.

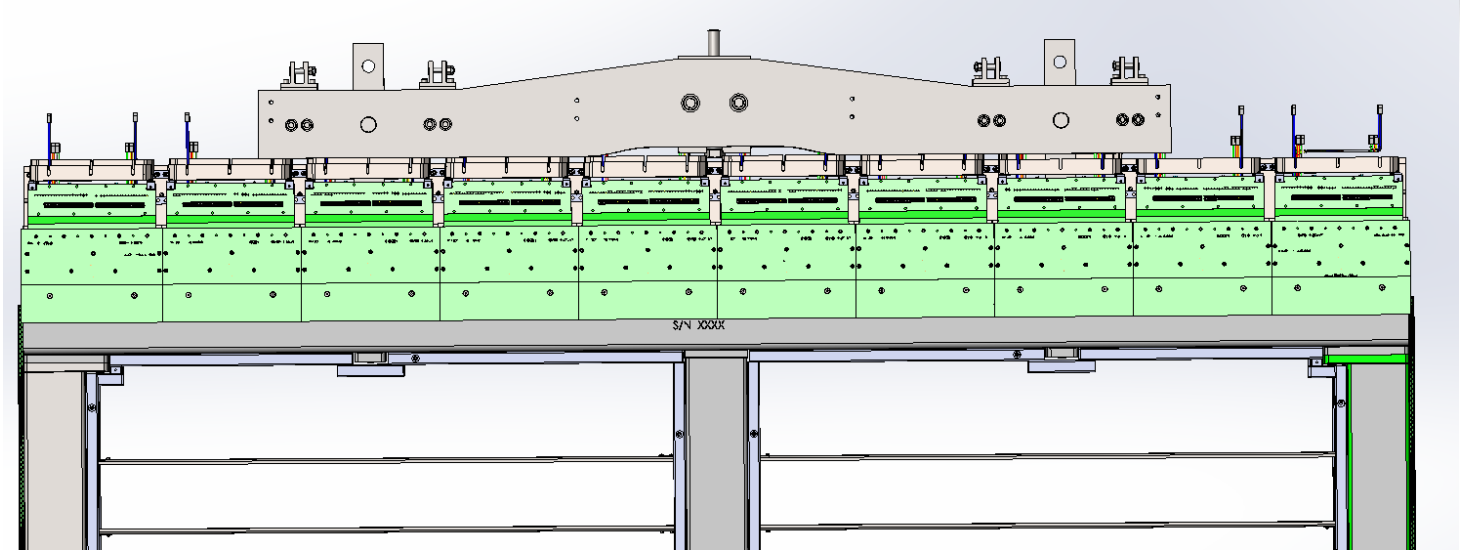
Upper Yoke



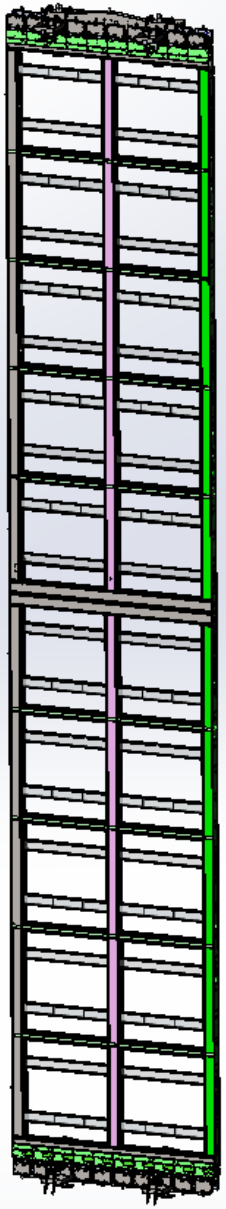
This part connects the upper APA to the detector support structure.

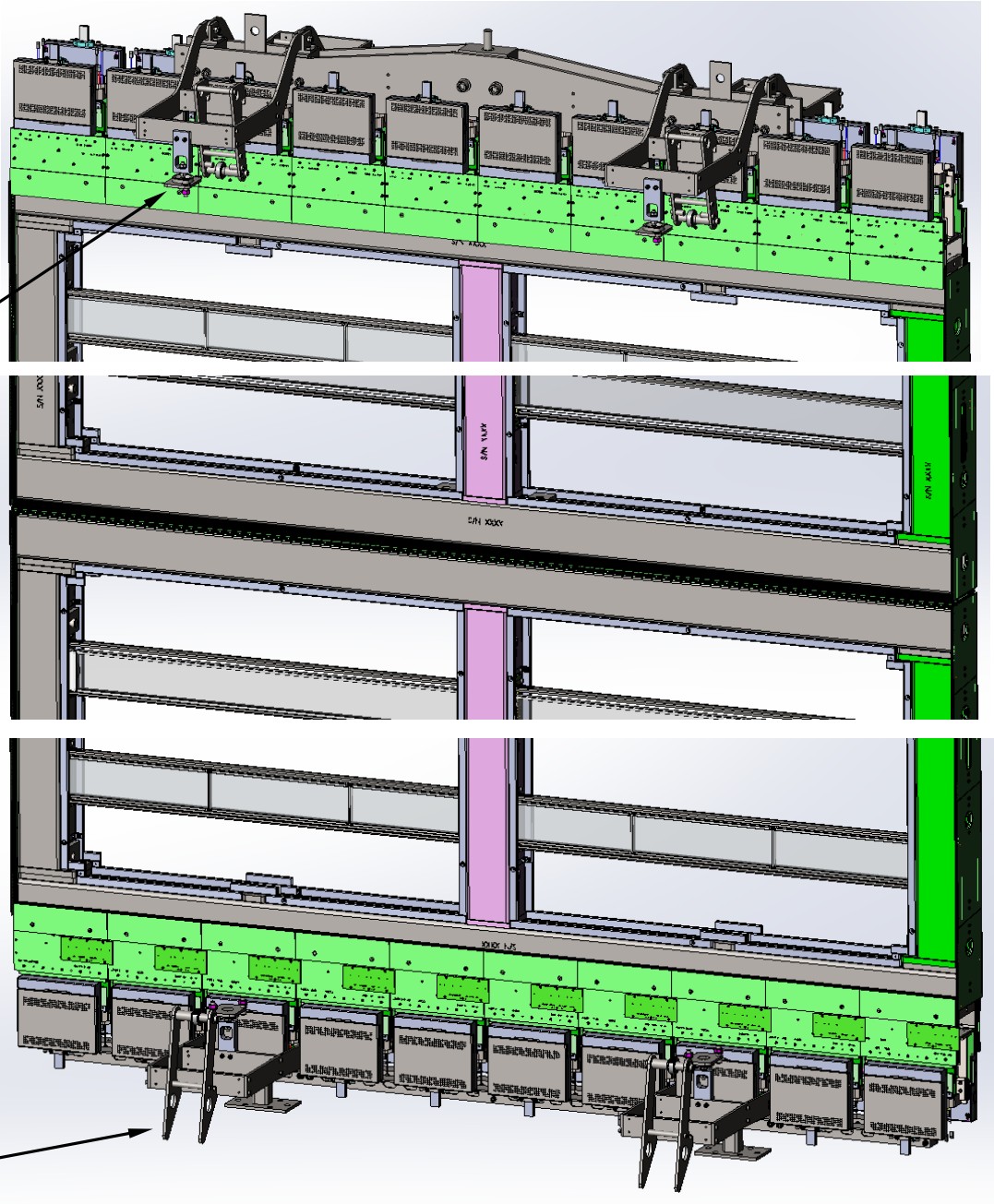
It supports the weight of both the upper and lower APAs.

It will be installed on the APA underground - before the APA is rotated to a vertical position.

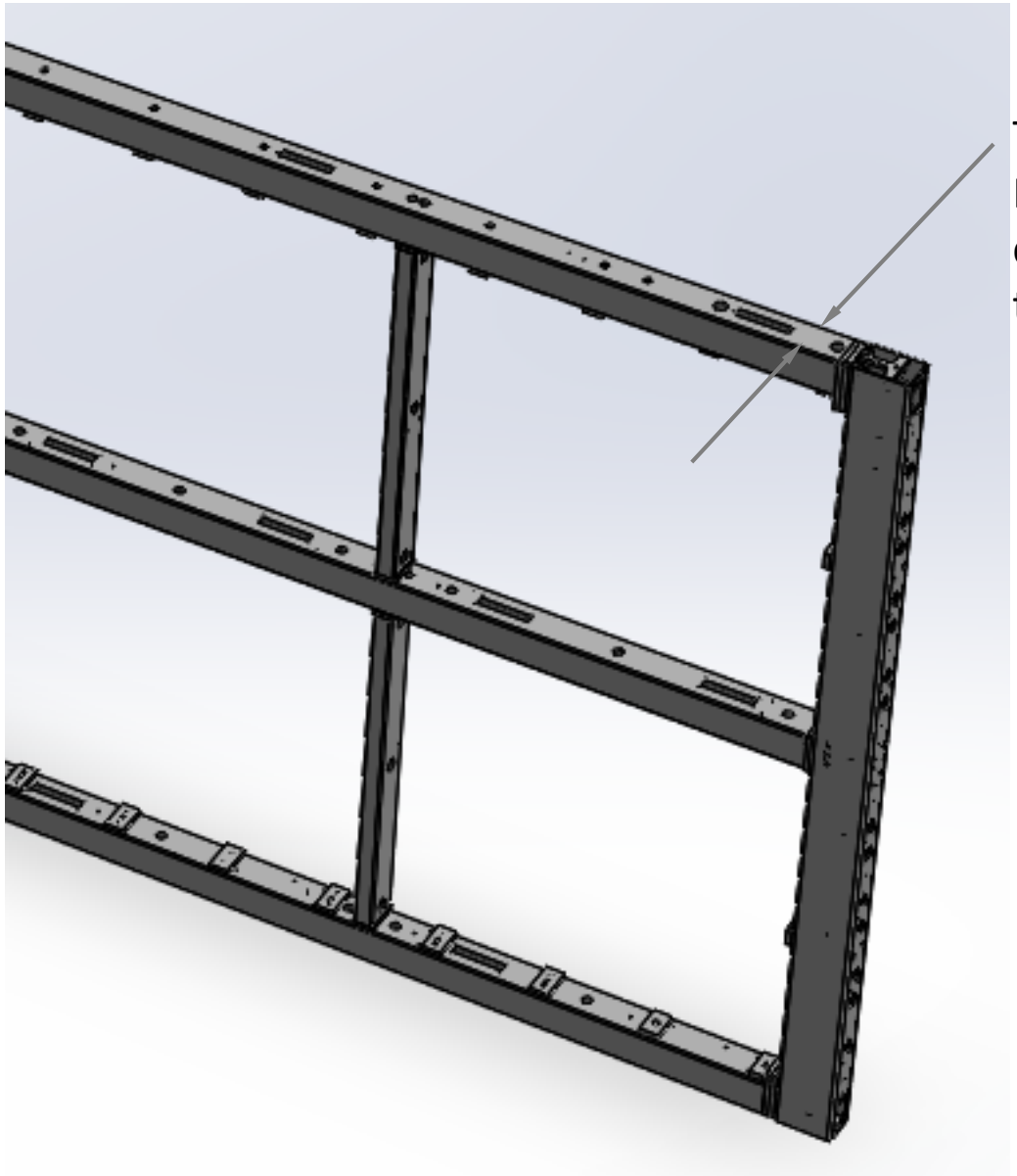


APA Pair




Head of upper APA
Upper field cage latch
Foot-to-foot connection
Head of lower APA
Lower field cage latch

Changes from ProtoDUNE to DUNE

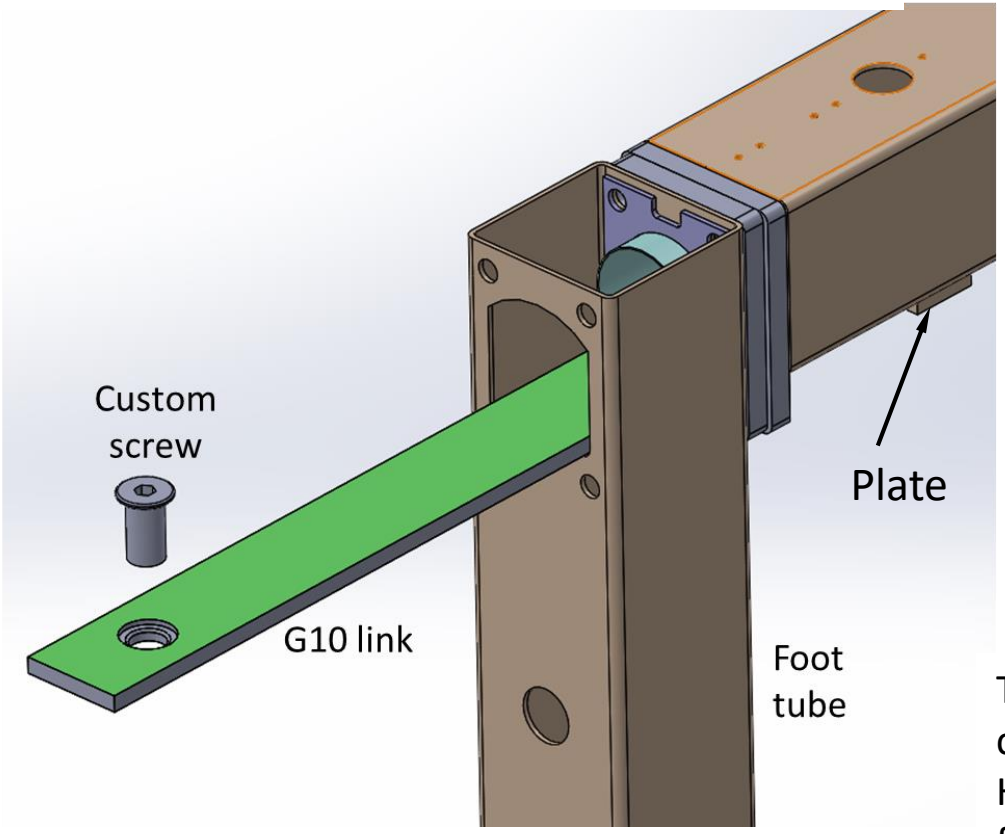


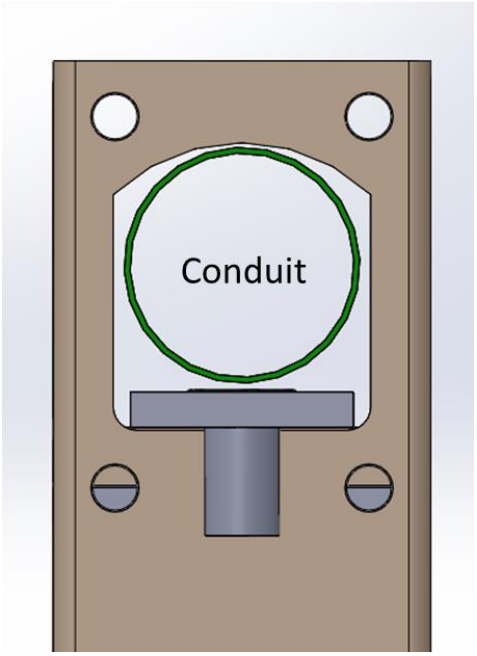
The biggest change between ProtoDUNE and DUNE is the chang from a 3 inch thick frame to a 4 inch thick frame.

- More room for running cables inside the side tubes
- Greater out-of-plane stiffness

Changes from ProtoDUNE to DUNE

The link is new to DUNE because there was no lower APA in ProtoDUNE. The link fits along the inner surface inside the side tube. The screws screw in to heavy plates welded to the outside of the side tube.

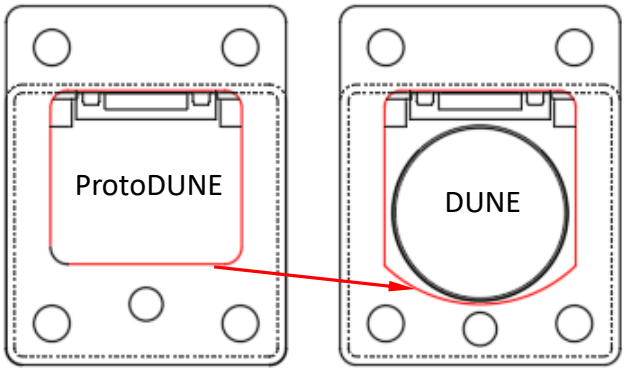




The link has been planned in G10 – and calculations show good safety margin. However, we are considering stainless steel for increased strength, with G10 linings to insulate it from the frame.

Added round conduit tube inside APA side tubes

There is now a 2.5” OD x 0.065” wall round SS tube for running the lower CE cables up through the sides of the APAs. It has cutouts to allow attachment of the M20 bolts used for lifting.



Changed shape of opening

Plate at head end is welded to conduit tube. Plate is screwed to head tube.

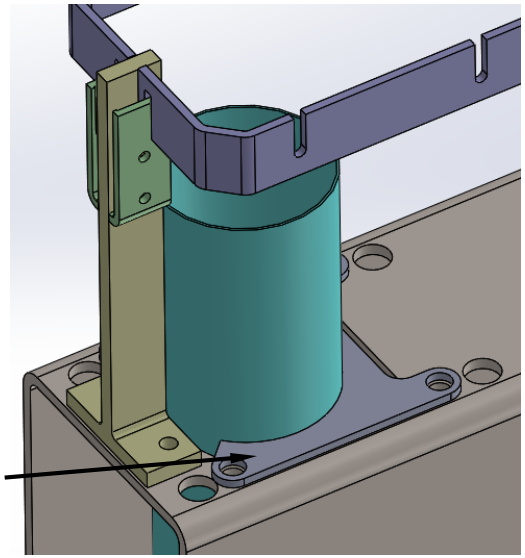
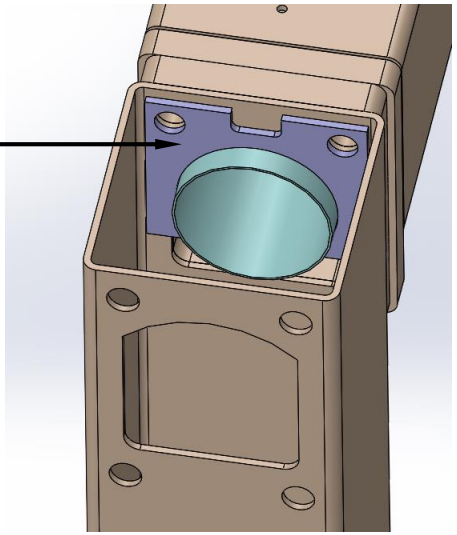
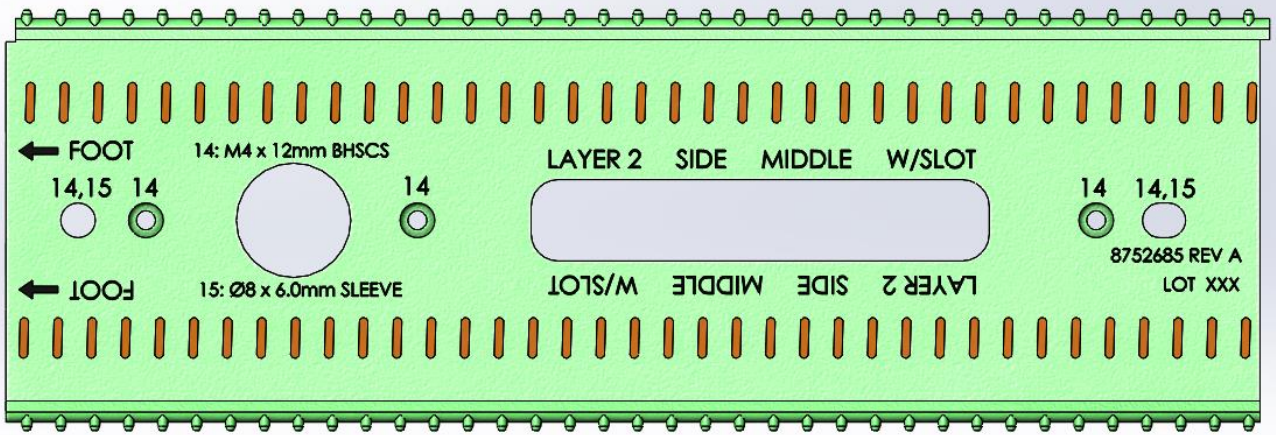


Plate at foot end is **not** welded to conduit tube.

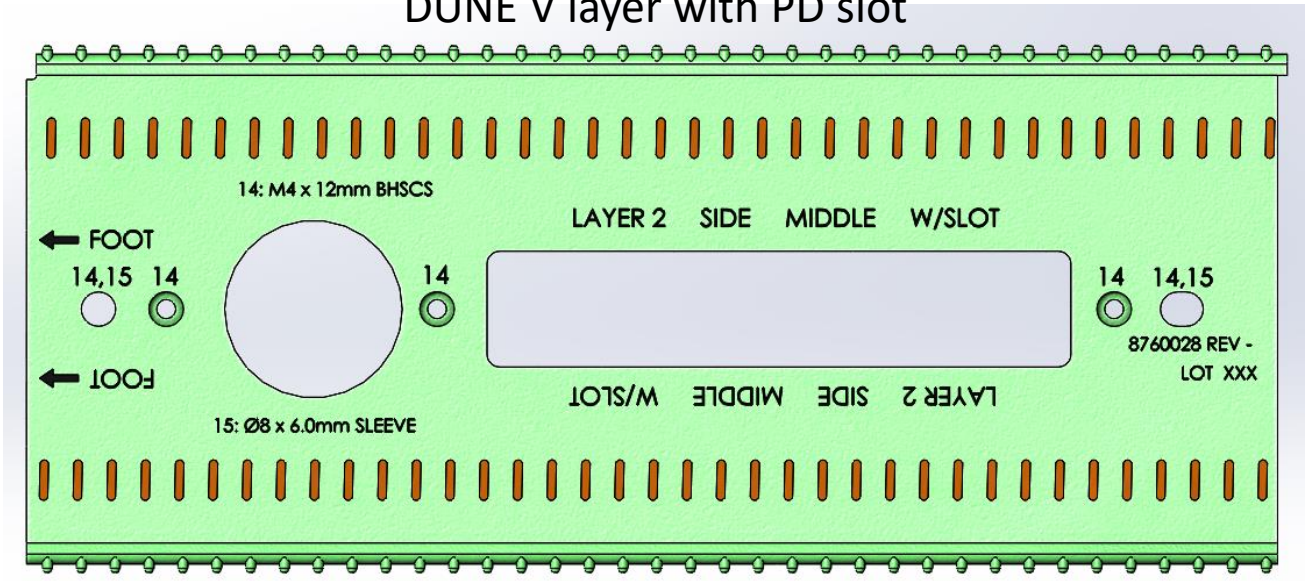


Changes from ProtoDUNE to DUNE

ProtoDUNE V layer with PD slot



DUNE V layer with PD slot



Changes

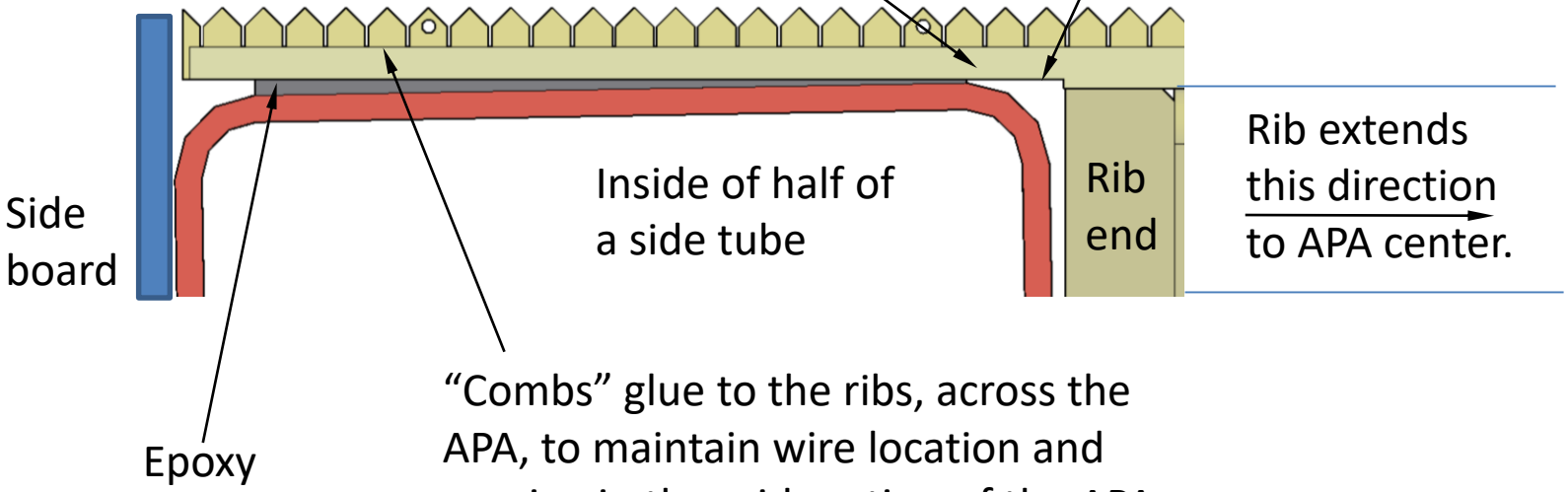
- Board is wider to match thicker frame
- Larger PD slot
- Larger round hole around M20 access and rivnuts

Changes from ProtoDUNE to DUNE

If the side tube is not exactly flush with the rib, as shown here…

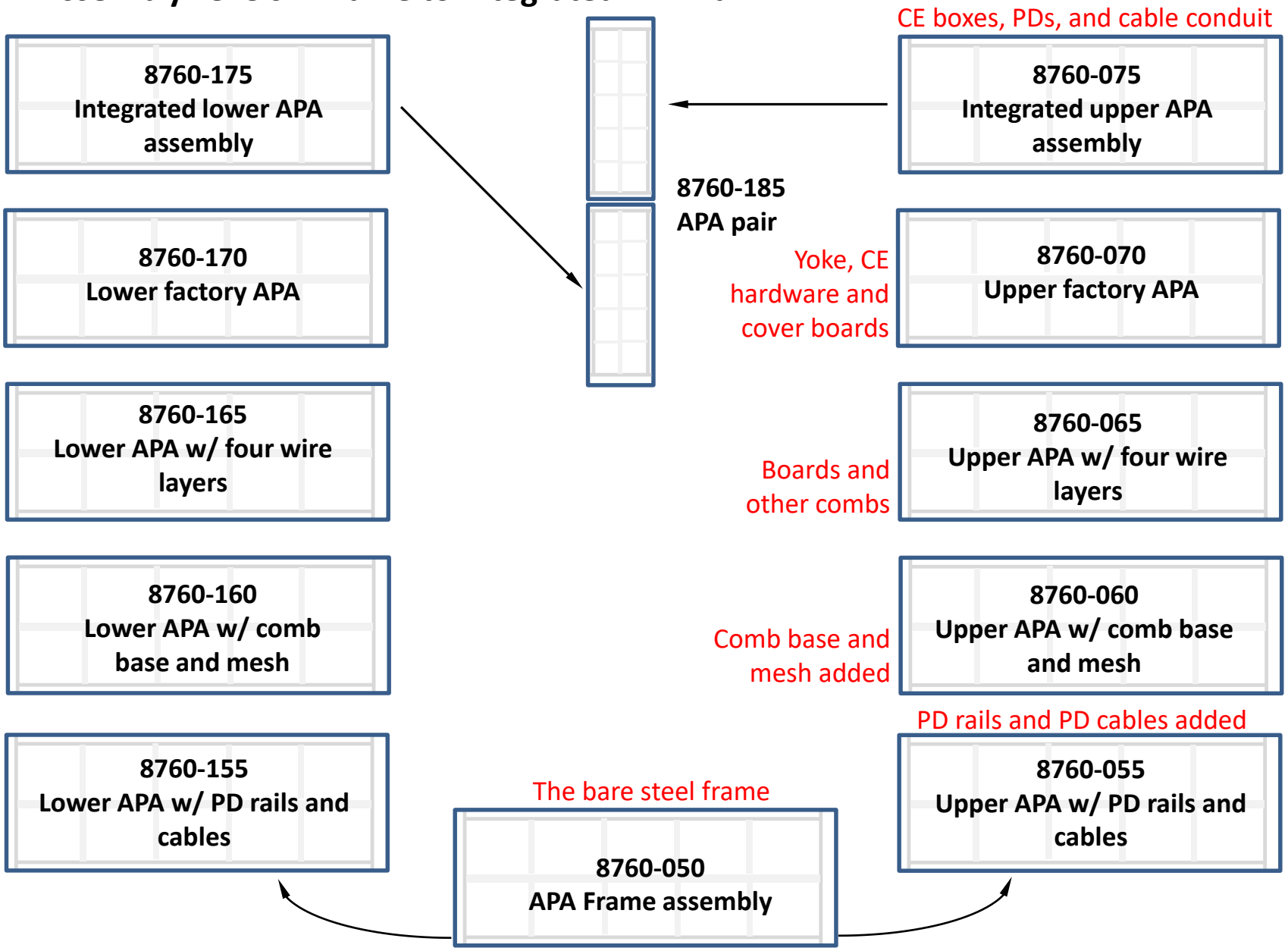
…it will push up the end of the comb base and comb, causing a height mismatch with the side board…

…unless the end of the comb base is undercut as shown here:



2. Are the specifications and drawings for standard and custom components substantially complete and available in EDMS? Are they of sufficient maturity to proceed to final design?
3. Have interfaces with other detector components been addressed and documented? Do risks of design changes in other systems have appropriate mitigation strategies?

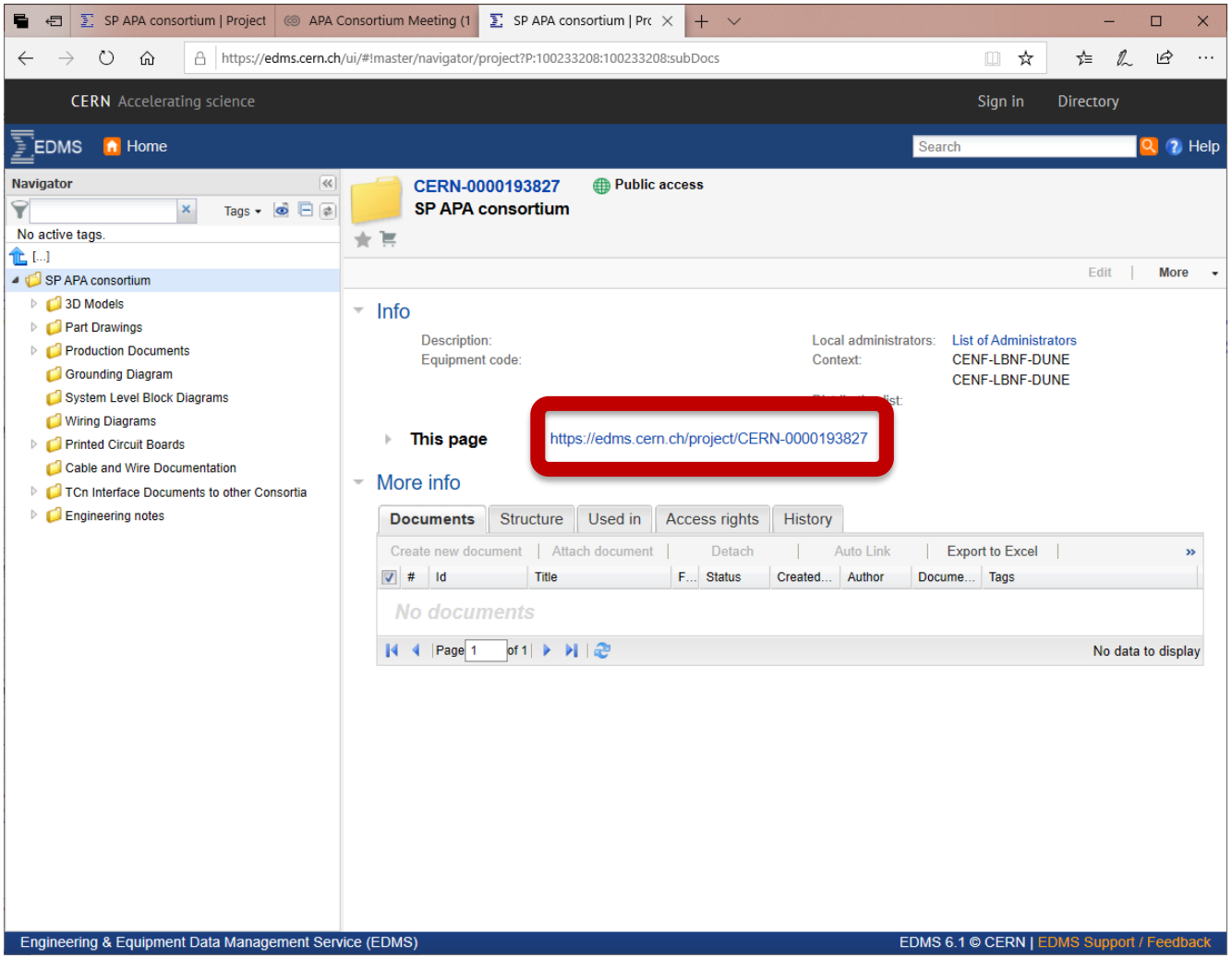
APA Assembly Levels – Frame to Integrated APA Pair



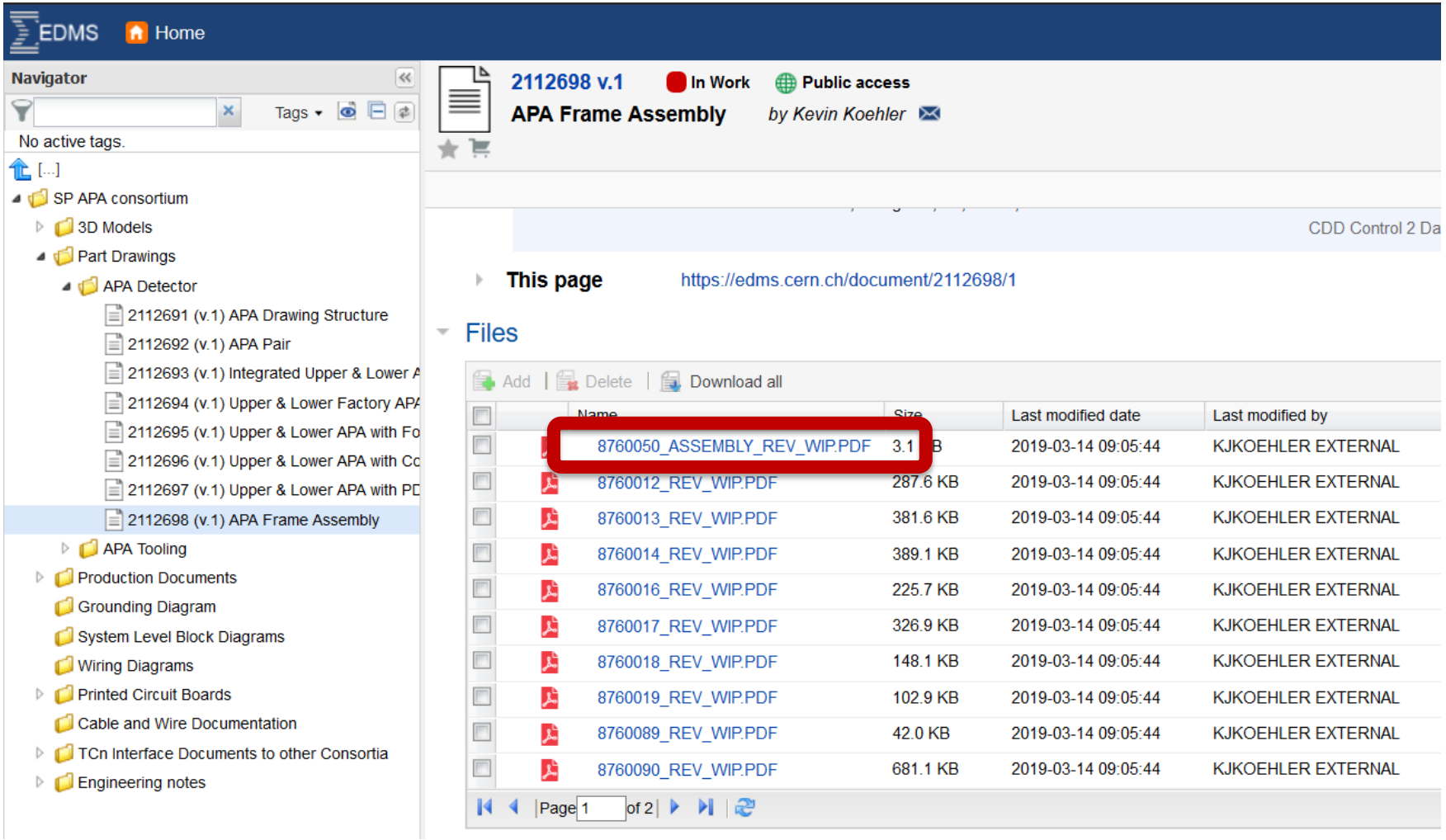
Slide compliments of Kevin Koehler

Link direct to SP APA Consortium.

- https://edms.cern.ch/project/CERN-0000193827



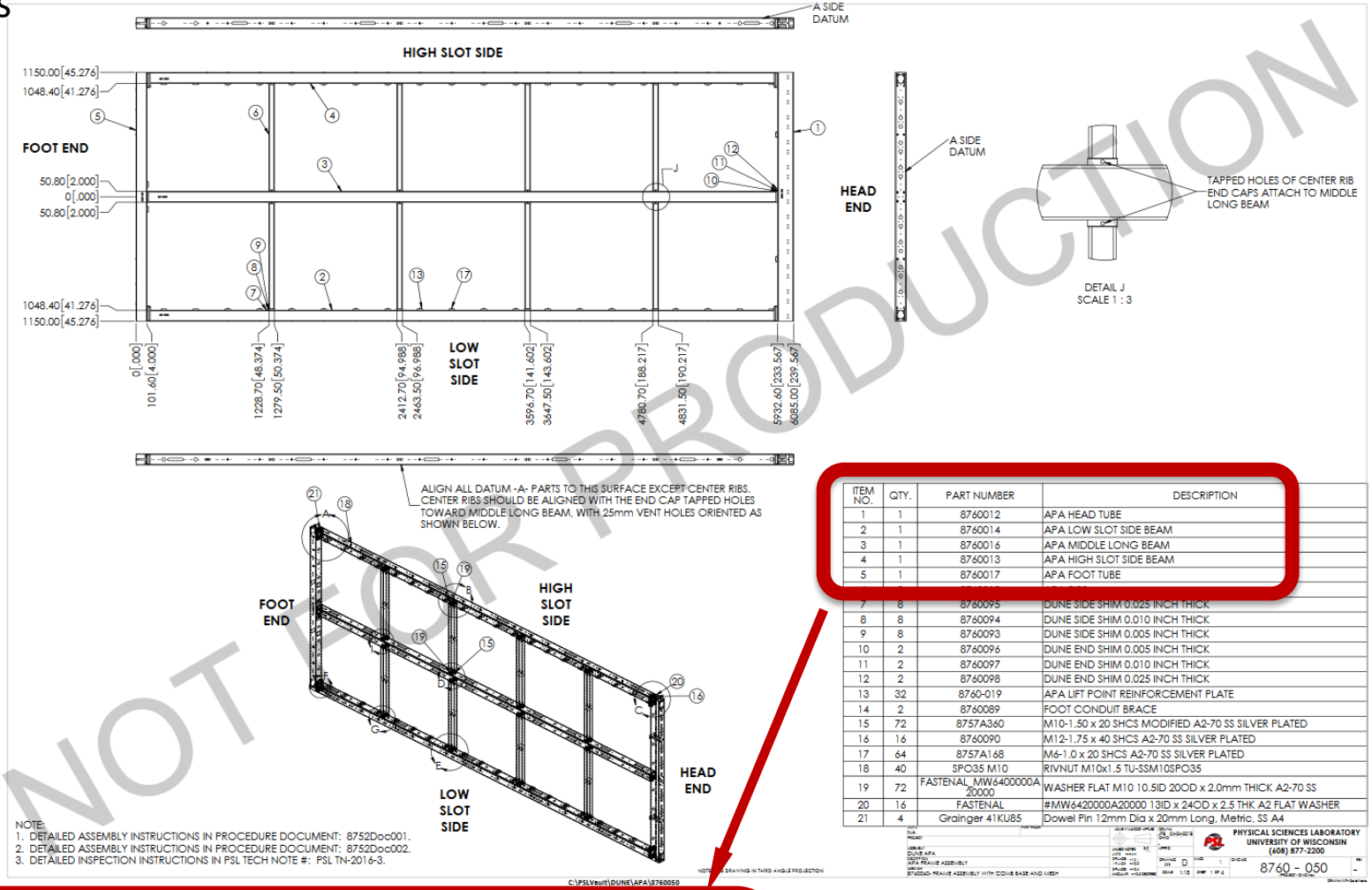
Drawings



SP APA Consortium→Part Drawings→APA Detector takes you to the assembly drawings

Opening one of the assembly documents takes you to the assembly drawing itself as well as all the parts listed on the BOM in that assembly.

Drawings

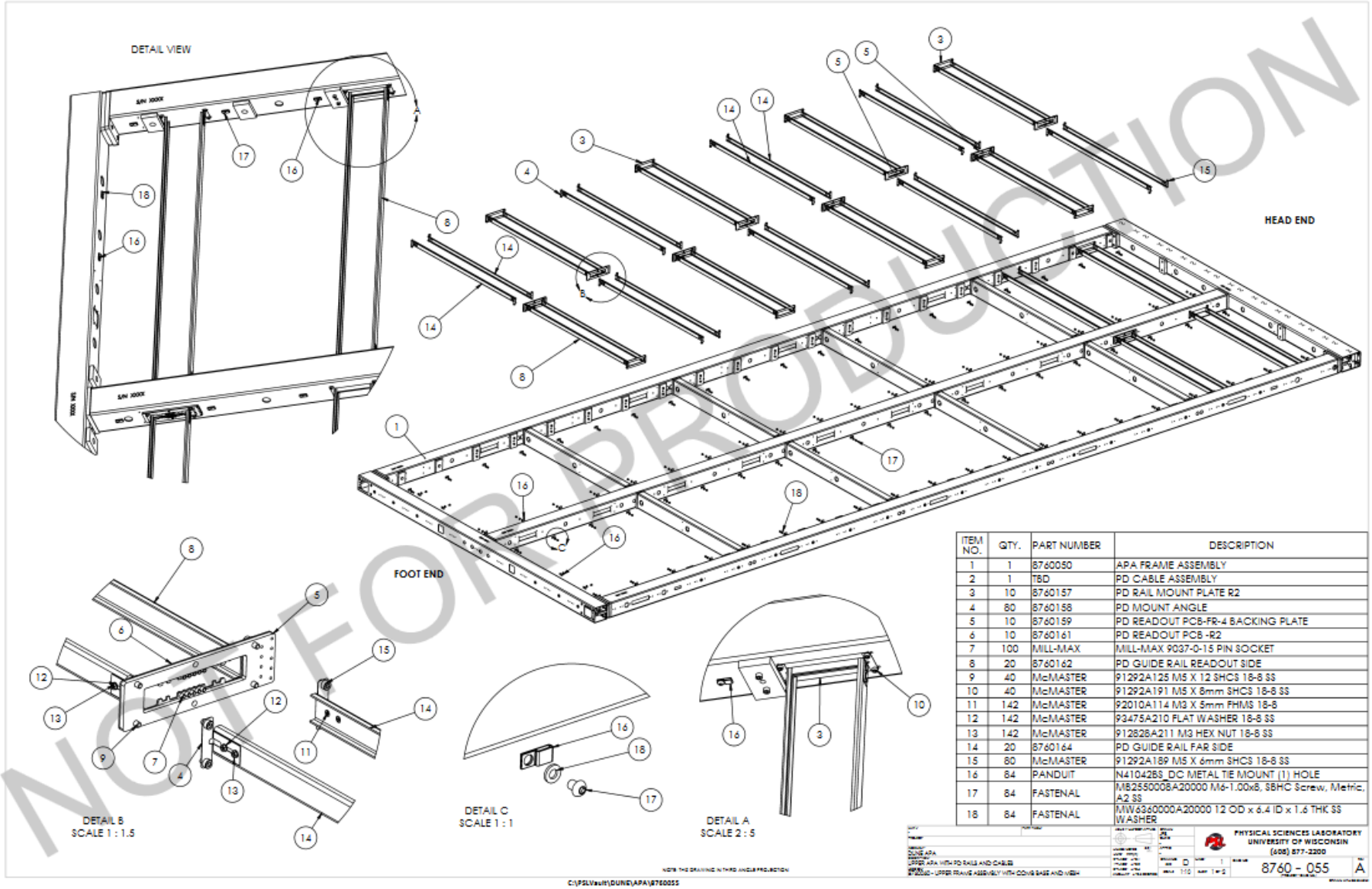


ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	8760012	APA HEAD TUBE
2	1	8760014	APA LOW SLOT SIDE BEAM
3	1	8760016	APA MIDDLE LONG BEAM
4	1	8760013	APA HIGH SLOT SIDE BEAM
5	1	8760017	APA FOOT TUBE
7	8	8760095	DUNE SIDE SHIM 0.025 INCH THICK
8	8	8760094	DUNE SIDE SHIM 0.010 INCH THICK
9	8	8760093	DUNE SIDE SHIM 0.005 INCH THICK
10	2	8760096	DUNE END SHIM 0.005 INCH THICK
11	2	8760097	DUNE END SHIM 0.010 INCH THICK
12	2	8760098	DUNE END SHIM 0.025 INCH THICK
13	32	8760-019	APA LIFT POINT REINFORCEMENT PLATE
14	2	8760089	FOOT CONDUIT BRACE
15	72	8757A360	M10-1.50 x 20 SHCS MODIFIED A2-70 SS SILVER PLATED
16	16	8760090	M12-1.75 x 40 SHCS A2-70 SS SILVER PLATED
17	64	8757A168	M6-1.0 x 20 SHCS A2-70 SS SILVER PLATED
18	40	SPO35 M10	RIVNUT M10x1.5 TU-SSM10SPO35
19	72	FASTENAL_MW6400000A 20000	WASHER FLAT M10 10.5ID 20OD x 2.0mm THICK A2-70 SS
20	16	FASTENAL	#MW6420000A20000 13ID x 24OD x 2.5 THK A2 FLAT WASHER
21	4	Grainger 41KU85	Dowel Pin 12mm Dia x 20mm Long, Metric, SS A4

ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	8760012	APA HEAD TUBE
2	1	8760014	APA LOW SLOT SIDE BEAM
3	1	8760016	APA MIDDLE LONG BEAM
4	1	8760013	APA HIGH SLOT SIDE BEAM
5	1	8760017	APA FOOT TUBE

These parts are included with the assembly drawing.

Assembly Drawing – 8760-055 Upper APA with PD rails and cables



ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	8760050	APA FRAME ASSEMBLY
2	1	TBD	PD CABLE ASSEMBLY
3	10	8760157	PD RAIL MOUNT PLATE R2
4	80	8760158	PD MOUNT ANGLE
5	10	8760159	PD READOUT PCB-FR-4 BACKING PLATE
6	10	8760161	PD READOUT PCB -R2
7	100	MILL-MAX	MILL-MAX 9037-0-15 PIN SOCKET
8	20	8760162	PD GUIDE RAIL READOUT SIDE
9	40	McMASTER	91292A125 M5 X 12 SHCS 18-8 SS
10	40	McMASTER	91292A191 M5 X 8mm SHCS 18-8 SS
11	142	McMASTER	92010A114 M3 X 5mm FHMS 18-8
12	142	McMASTER	93475A210 FLAT WASHER 18-8 SS
13	142	McMASTER	91828A211 M3 HEX NUT 18-8 SS
14	20	8760164	PD GUIDE RAIL FAR SIDE
15	80	McMASTER	91292A189 M5 X 6mm SHCS 18-8 SS
16	84	PANDUIT	N410428S_DC METAL TIE MOUNT (1) HOLE
17	84	FASTENAL	MB2550008A20000 M6-1.00x8, SBHC Screw, Metric, A2 SS
18	84	FASTENAL	MW6360000A20000 12 OD x 6.4 ID x 1.6 THK SS WASHER

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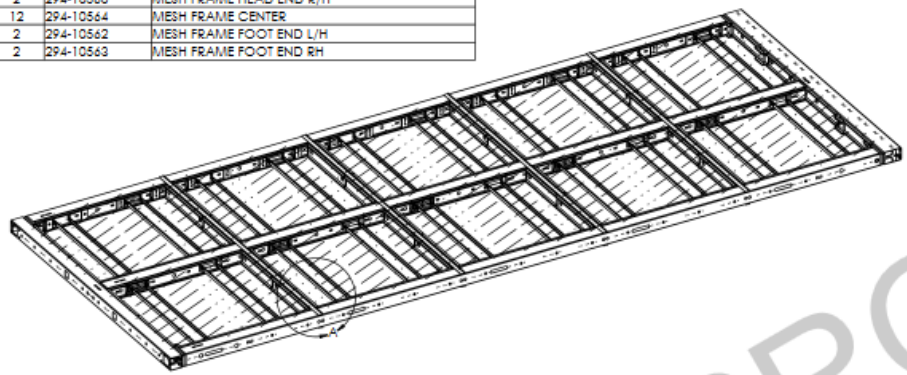
8760 - 055 A

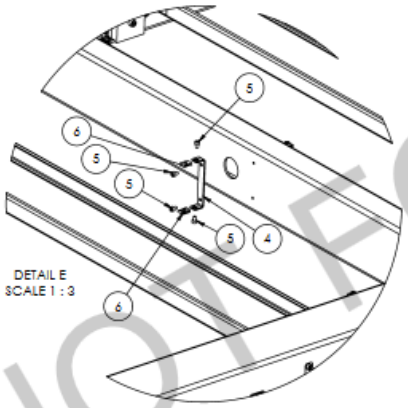
Assembly Drawing – 8760-060 Upper APA with Comb Base and Mesh

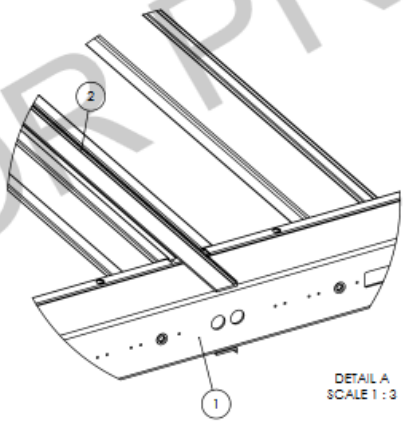
ITEM NO.	QTY.	PART NUMBER	DESCRIPTION
1	1	8760055	UPPER APA WITH PD RAILS AND CABLES
2	8	8760021	COMB BASE ASSEMBLY
3	2	294-10561	MESH FRAME HEAD END L/H
4	60	294-10559	MESH FRAME BRACKET
5	240	FASTENAL_MS25 30006A40000	#MS2530006A40000 M4x0.70x6, Socket Head Cap Screw, Metric, A4-70 Stainless Steel
6	120	294-10558	U CLIP
7	2	294-10560	MESH FRAME HEAD END R/H
8	12	294-10564	MESH FRAME CENTER
9	2	294-10562	MESH FRAME FOOT END L/H
10	2	294-10563	MESH FRAME FOOT END RH

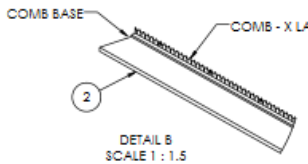
AS REQUIRED:

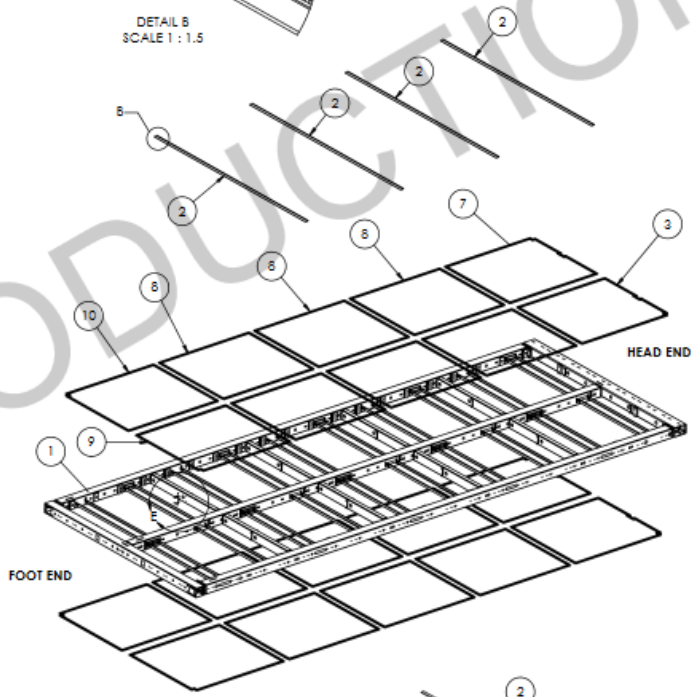
- 3M 2216 GREY EPOXY











NOTE:
1. AT FOUR LOCATIONS MARKED WITH *, PLACE ~25mm DIAMETER CIRCLE OF SILVER BEARING CONDUCTIVE EPOXY ON THE MESH BEFORE PLACING THE COMB BASE. EPOXY CIRCLE TO BE PRESSED FLAT INTO MESH TO MAKE ELECTRICAL CONTACT WITH THE FRAME. CENTER OF CIRCLE ~5cm FROM THE SIDE TUBE ON THE CENTERLINE OF THE RIB.
2. DETAILED ASSEMBLY INSTRUCTIONS IN PROCEDURE DOCUMENT: 8752Doc003.
3. DETAILED ASSEMBLY INSTRUCTIONS IN PROCEDURE DOCUMENT: 8752Doc004.

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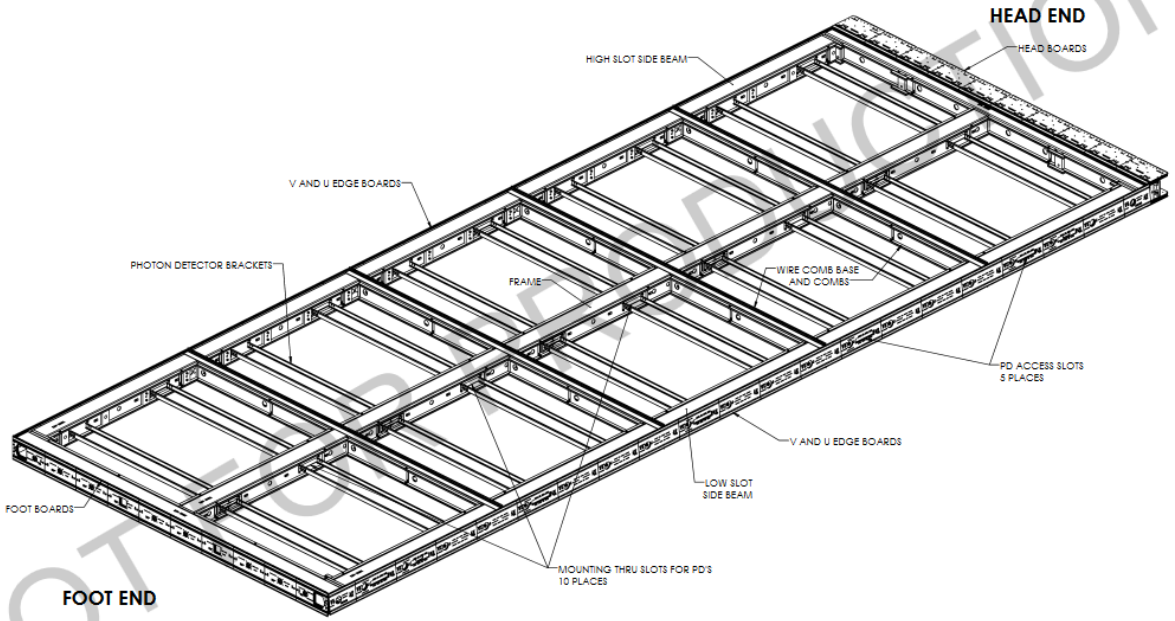
8760 - 060

C:\PSLVault\DUNE\APA\8760060

Assembly Drawing – 8760-065 Upper APA with Four Wire Layers



MESH FRAMES SHOWN BUT MESH OMITTED FOR CLARITY
SIDE FOOT AND HEAD BOARDS SHOWN BUT WIRES OMITTED FOR CLARITY

NOTE:
1. DETAILED ASSEMBLY INSTRUCTION PROCEDURE, X LAYER DOCUMENT: 8752Doc005.
2. DETAILED ASSEMBLY INSTRUCTION PROCEDURE, V LAYER DOCUMENT: 8752Doc006.
3. DETAILED ASSEMBLY INSTRUCTION PROCEDURE, U LAYER DOCUMENT: 8752Doc007.
4. DETAILED ASSEMBLY INSTRUCTION PROCEDURE, G LAYER DOCUMENT: 8752Doc008.

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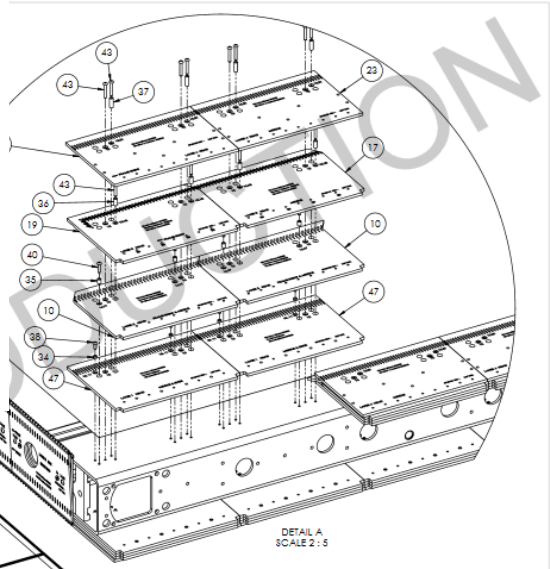
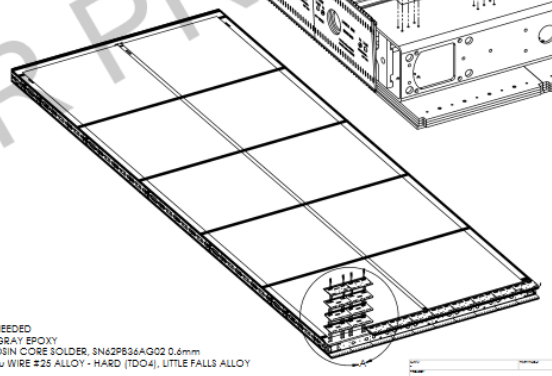
Includes BOM



27	8752C772	X LAYER WIRE COMB	40
27	8752C773	V LAYER LEFT WIRE COMB	8
28	8752C766	V LAYER MIDDLE WIRE COMB	24
29	8752C765	V LAYER RIGHT WIRE COMB	8
30	8752C766	U LAYER WIRE COMB	40
31	8752C774	G LAYER LEFT WIRE COMB	8
32	8752C767	G LAYER WIRE COMB	32
33	8752B693	EDGE BOARD LOCATING SLEEVE 8mm DIA	56
34	8752B767	APA HEAD ASSEMBLY HEAD TUBE 2.5mm SPACER	40
35	8752B768	APA HEAD ASSEMBLY HEAD TUBE 7.5mm SPACER	40
36	8752B769	APA HEAD ASSEMBLY HEAD TUBE 12.0mm SPACER	40
37	8752B750	APA HEAD ASSEMBLY HEAD TUBE 16.8mm SPACER	40
38	8757A160	M4-0.70 x 10 SHCS A2 SS SILVER PLATED	40
39	8757A161	M4-0.70 x 12 SHCS A2 SS SILVER PLATED	122
40	8757A162	M4-0.70 x 16 SHCS A2 SS SILVER PLATED	40
41*	8757A163	M4-0.70 x 16 FHSCS A2 SS SILVER PLATED	84
42	8757A165	M4-0.70 x 20 FHSCS A2 SS SILVER PLATED	40
43	8757A166	M4-0.70 x 25 SHCS A2 SS SILVER PLATED	122
44	8752B980	COMB CAP A	8
45	8752B981	COMB CAP B	24
46	8752B982	COMB CAP C	8
47	8760106	X BOARD - HEAD	20
48	8760110	X FOOT BOARD ASSEMBLY POSITION 4 & 7	2
49	8760106	V MIDDLE FOOT BOARD ASSEMBLY POSITION 4 & 7	2
50	8760112	U FOOT BOARD ASSEMBLY POSITION 4 & 7	2
51	8760114	G FOOT BOARD ASSEMBLY POSITION 4 & 7	2



NOTES:

PARTS AS NEEDED
- 3M 2216 GRAY EPOXY
- KESTER ROSIN CORE SOLDER, SN62PB36AG02 0.6mm
- .006" BeCu WIRE #25 ALLOY - HARD (TDO4), LITTLE FALLS ALLOY

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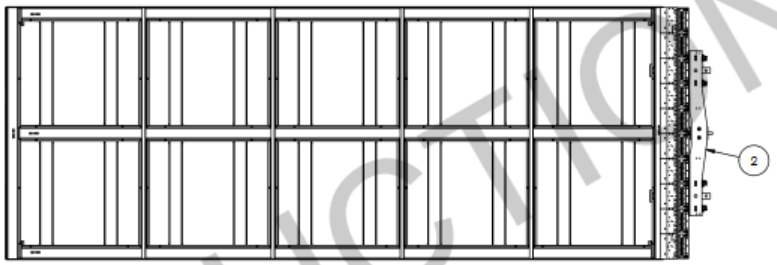
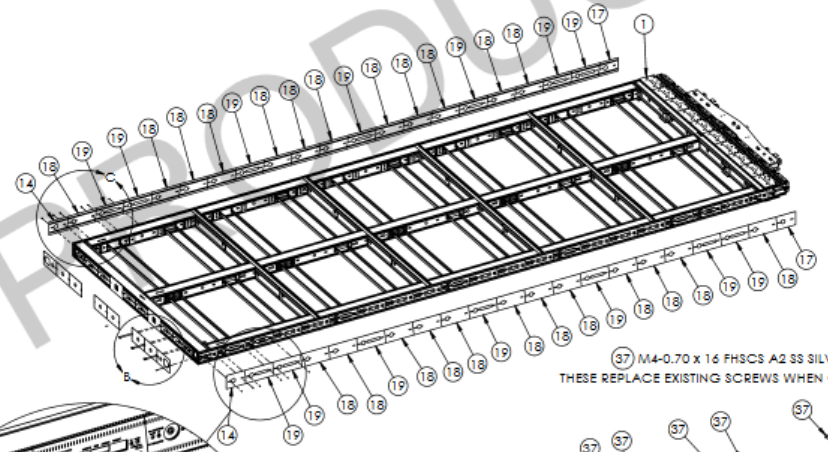
Assembly Drawing – 8760-070 Lower Factory APA (As built at factory)

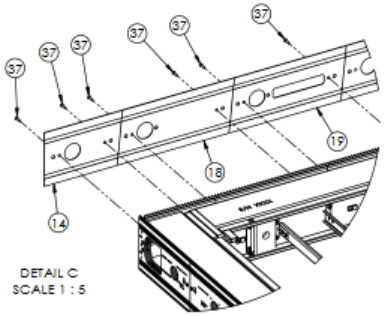
ITEM NO.	QTY.	PART NUMBER	DESCRIPTION	NOTES
1	1	8760065	UPPER APA WITH FOUR WIRE LAYERS	
2	1	8760080	YOKE ASSEMBLY	*
3	2	8760077	BRACKET, TEE, YOKE ASSEMBLY 4 X 4	
4	1	8760063	COVER, FOOT ASSEMBLY - LOW SLOT END	
5	1	8760068	COVER, FOOT ASSEMBLY - HIGH SLOT END	
6	6	8760066	COVER, FOOT ASSEMBLY - MIDDLE	
7	2	Field Cage Terminations PCB	Field Cage Terminations PCB	
8	1	87578358	SHV DISTRIBUTION PCB ASSEMBLY	
9	2	McMASTER-CARR_92871A253	SPACER UNTHREADED 6.30 ID 13.00 OD x 10.0mm LONG 18-8 SS	
10	2	McMASTER-CARR_92871A271	SPACER UNTHREADED 6.30 ID 13.00 OD x 25.0mm LONG 18-8 SS	
11	3	McMASTER-CARR_92871A280	SPACER UNTHREADED 6.30 ID 13.00 OD x 40.0mm LONG 18-8 SS	
12	100	FASTENAL_MS2510025A20000	M3-0.5 x 25mm SHCS SS A2-70	
13	84	8757A163	M4-0.70 x 16 FHSCS A2 SS SILVER PLATED	
14	2	87578034	COVER, SIDE, FOOT END	
15	4	8757A220	M12-1.75 x 180 SHCS A2-70 SS SILVER PLATED	
16	22	8757A176	M6-1.0 x 16mm SHCS A2-70 SS SILVER PLATED	
17	2	8760072	COVER, SIDE, HEAD END	
18	24	8760073	COVER, SIDE W/O SLOT	
19	14	8760074	COVER, SIDE W/ SLOT	
20	2	8757C267	COVER - HEAD - LEFT END	
21	18	8757C268	COVER - HEAD - MIDDLE & RIGHT END	
22	22	8757A224	M4-0.70 x 35 SHCS A2-70 SS SILVER PLATED	
23	20	87578352	CR PCB ASSEMBLY	
24	20	87578241	CE TO CR ADAPTER BOARD ASSEMBLY	
25	5	8757A247	M6-1.0 x 50mm SHCS A2-70 SS SILVER PLATED	
26	20	8760197	G BIAS FILTER BOARD ASSEMBLY	
27	40	8757A284	M4-0.70 x 30 FHSCS A2 SS SILVER PLATED	
28	1	8757C289	SIDE A - BIAS WIRE BUNDLE	
29	1	8757C290	SIDE B - BIAS WIRE BUNDLE	
30	9	8760088	CE TEE MIDDLE	
31	2	8760087	CE TEE ENDS	
32	20	8760085	CE BRACKET	
33	9	8760092	CE CLAMP BAR MIDDLE	
34	2	8760091	CE BRACKET CLAMP BAR END	
35	22	PENN ENGINEERING	SP-M4-2 SELF-CLINCHING NUTS - TYPES S, SS, CLS, CLSS, SP - METRIC	
36	40	8757A165	M4-0.70 x 20 FHSCS A2 SS SILVER PLATED	
37	2	8760183	COVER, FOOT ASSEMBLY POSITION 4 & 7	
38	9	8760186	CE CLAMP BAR MIDDLE PEM NUT	
39	2	8760187	CE BRACKET CLAMP BAR END PEM NUT	

* DOES NOT SHIP WITH APA FRAME

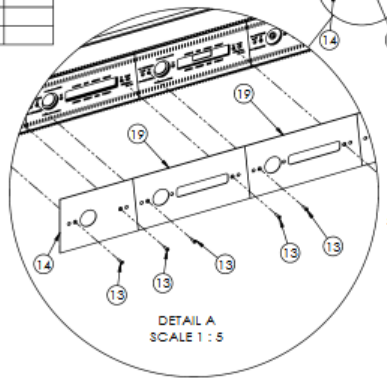




(37) M4-0.70 x 16 FHSCS A2 SS SILVER PLATED
THESE REPLACE EXISTING SCREWS WHEN COVERS INSTALLED

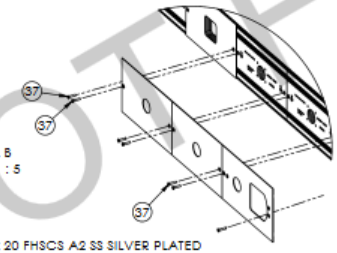


DETAIL C
SCALE 1 : 5



DETAIL A
SCALE 1 : 5

(13) M4-0.70 x 16 FHSCS A2 SS SILVER PLATED THESE REPLACE EXISTING SCREWS WHEN COVERS INSTALLED



DETAIL B
SCALE 1 : 5

M4-0.70 x 20 FHSCS A2 SS SILVER PLATED

NOTES:
1. DETAILED ASSEMBLY INSTRUCTIONS IN PROCEDURE DOCUMENT: 8752Doc009.
2. DETAILED ASSEMBLY INSTRUCTIONS IN PROCEDURE DOCUMENT: 8752Doc010.

NOTE THIS DRAWING IN THIRD ANGLE PROJECTION

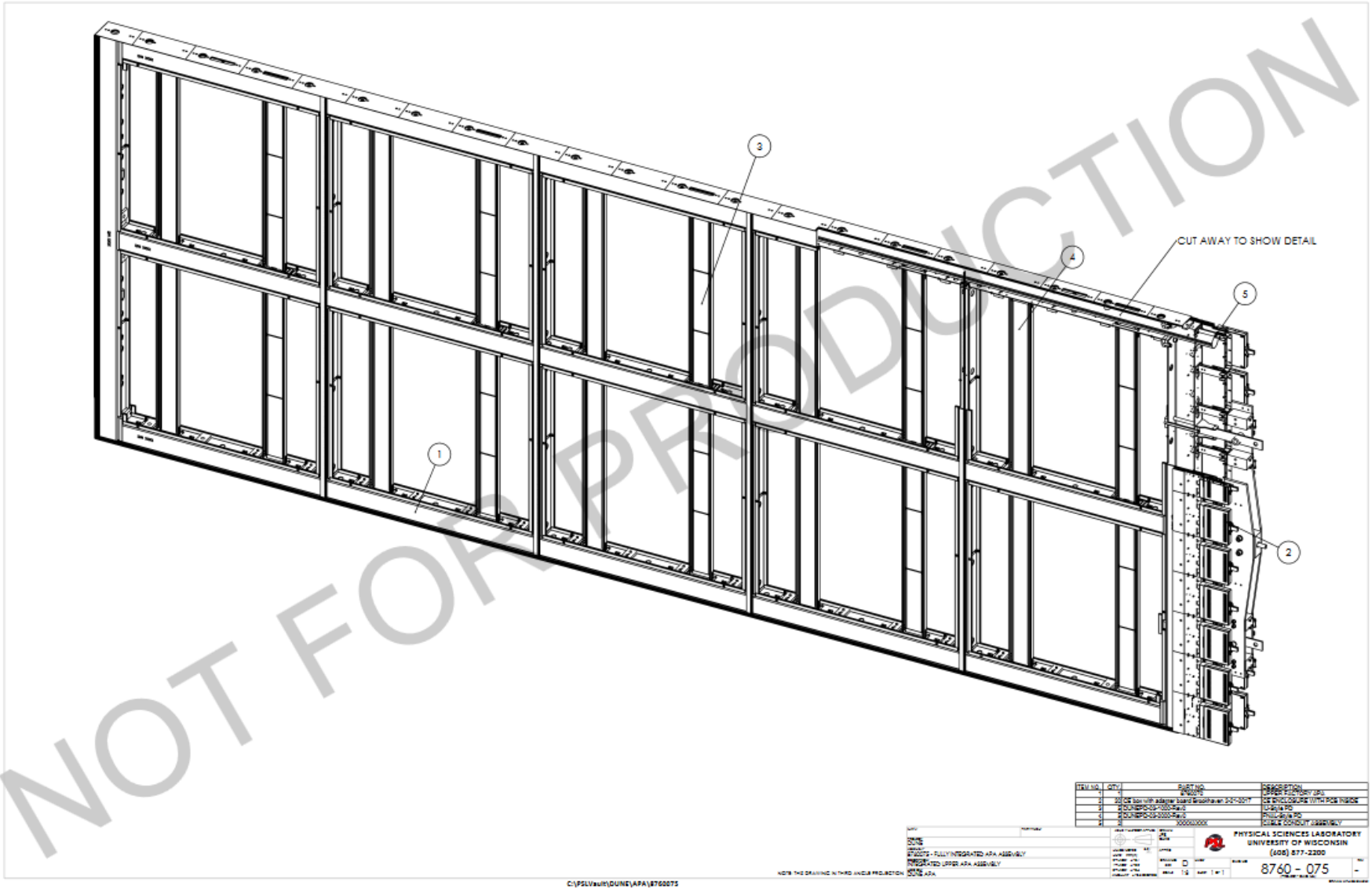
C:\PSLVault\DUNE\APA\8760070

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

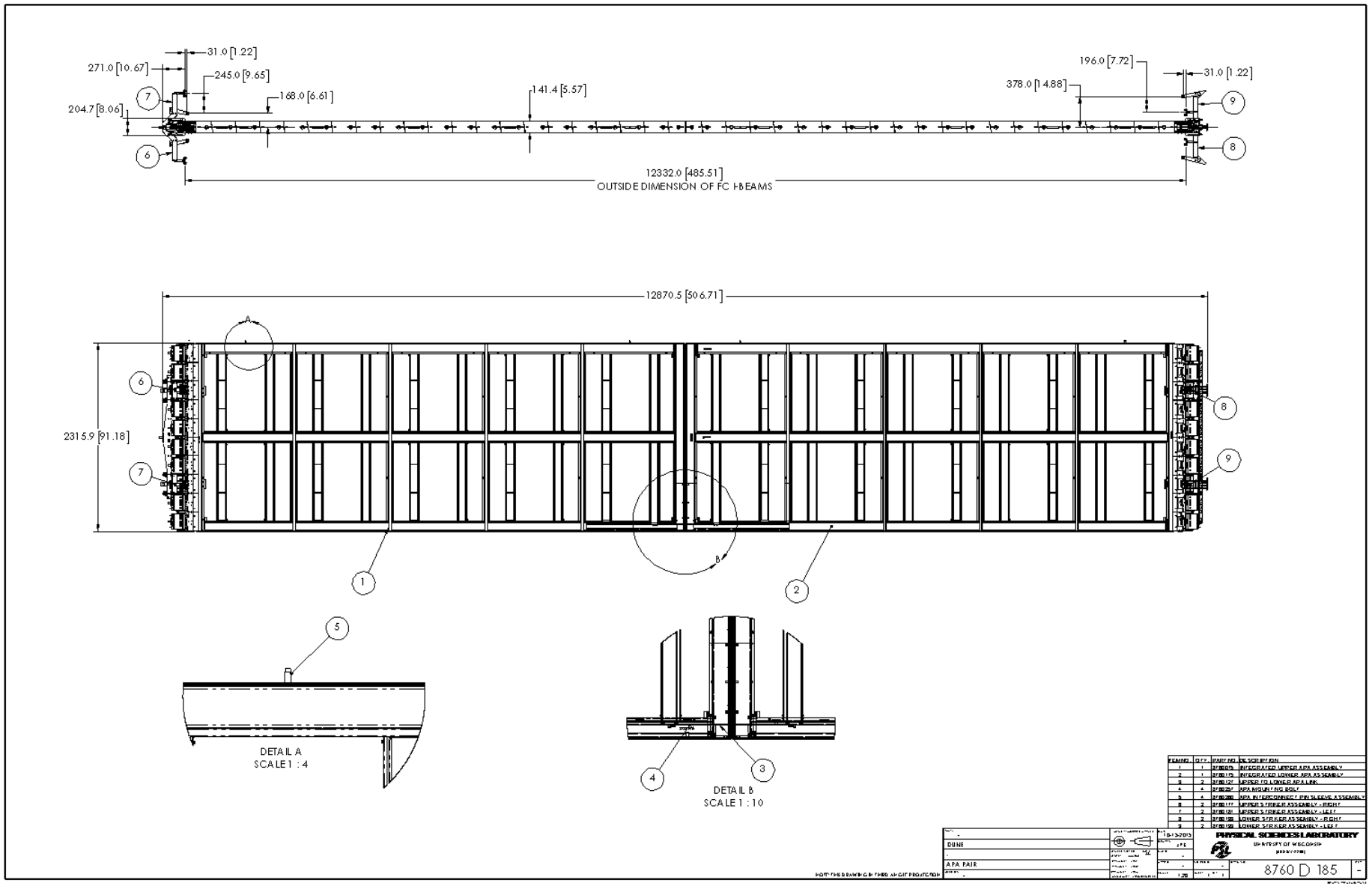
DUNE APA
UPPER FACTORY APA
8760070- FULLY INTEGRATED UPP ER APA ASSEMBLY

D
8760 - 070

Assembly Drawing – 8760-075 Integrated Upper APA Assembly



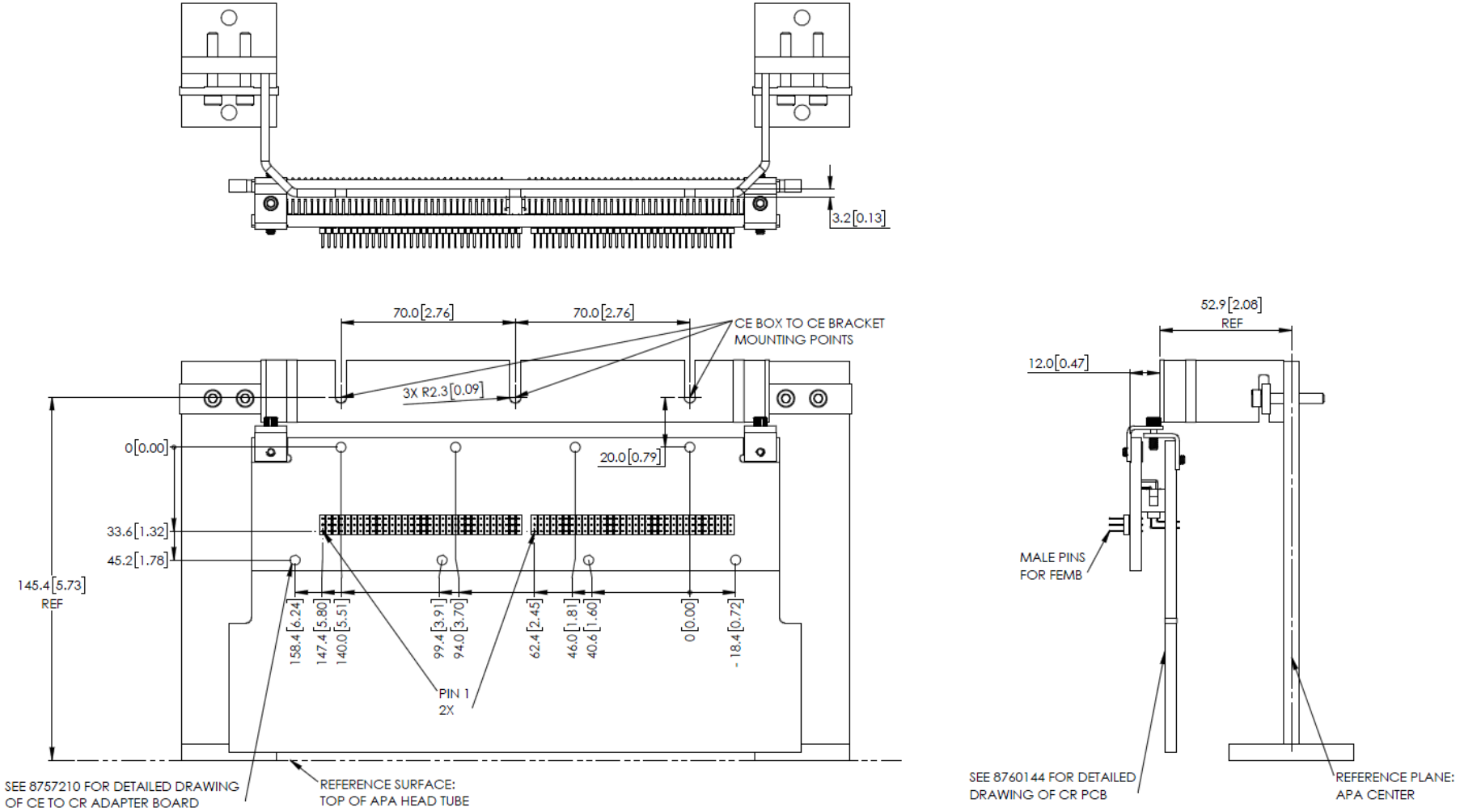
Assembly Drawings – 8760-185 APA Pair



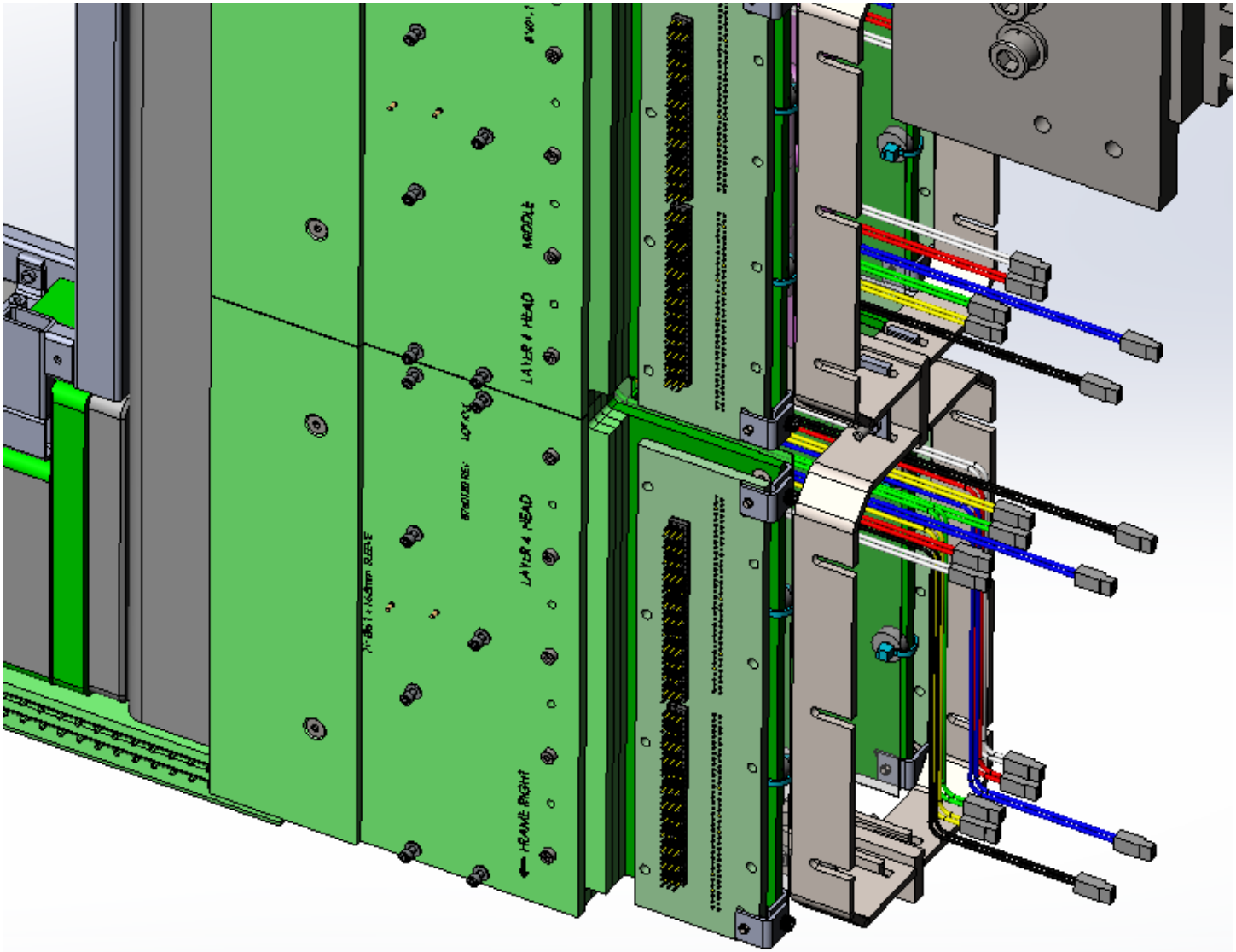
2. Are the specifications and drawings for standard and custom components substantially complete and available in EDMS? Are they of sufficient maturity to proceed to final design?
3. Have interfaces with other detector components been addressed and documented? Do risks of design changes in other systems have appropriate mitigation strategies?

Interface: Adapter Board and CE Box

Drawing 8760-302 from Kyle Zeug

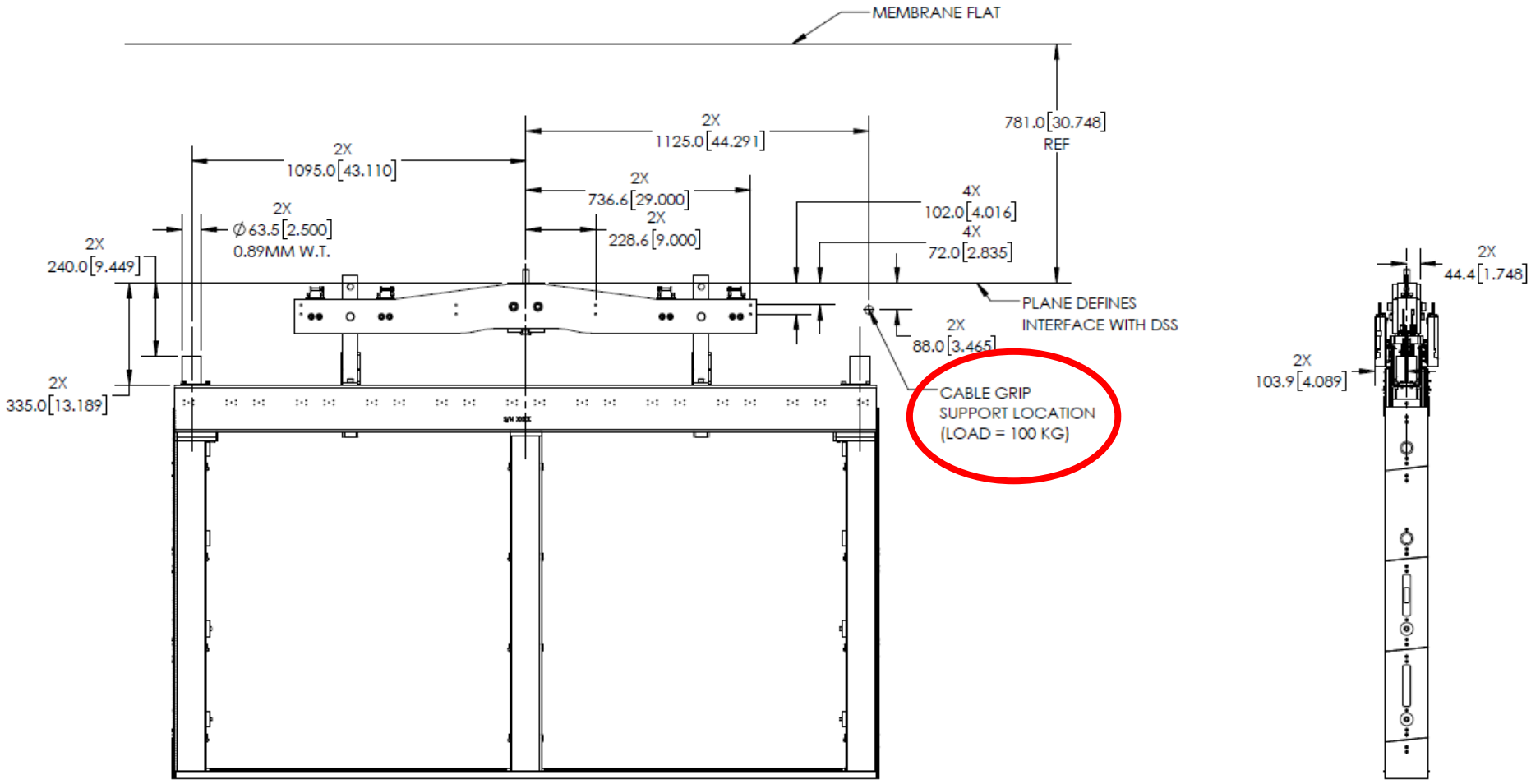


Interface: Adapter Board and CE Box

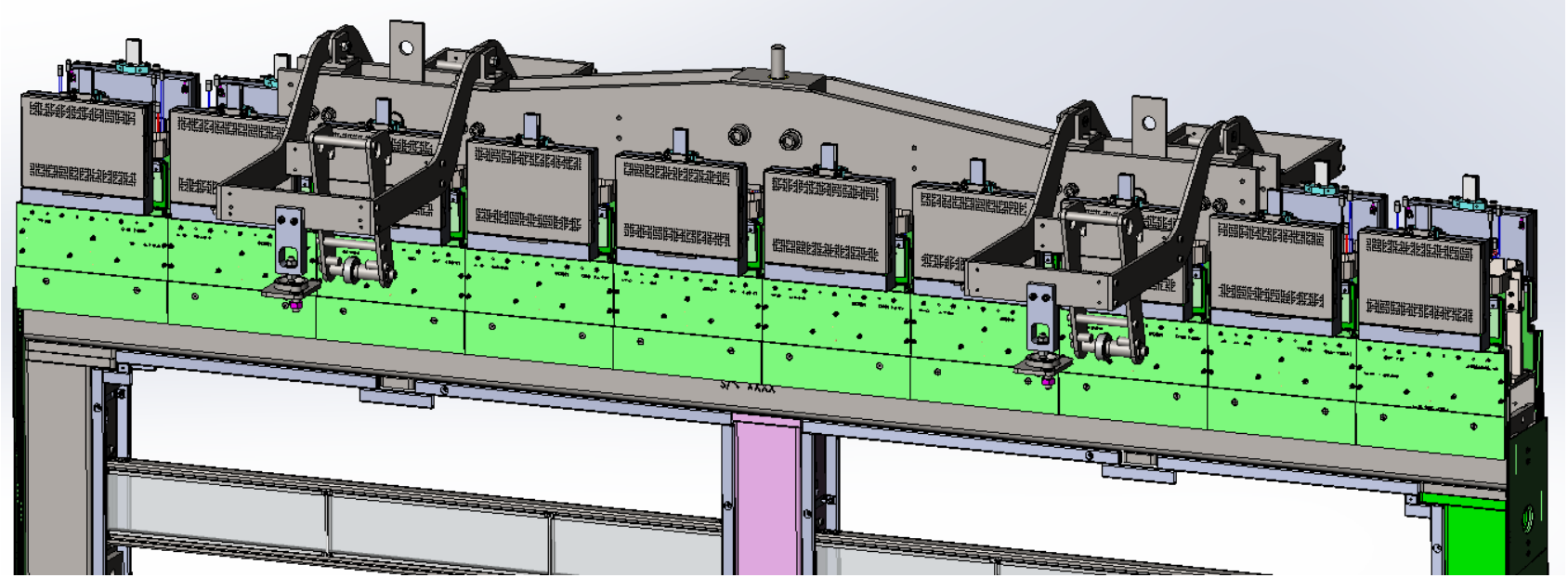


Interface: Upper APA Yoke to DSS

Drawing 8760-300 from Kyle Zeug

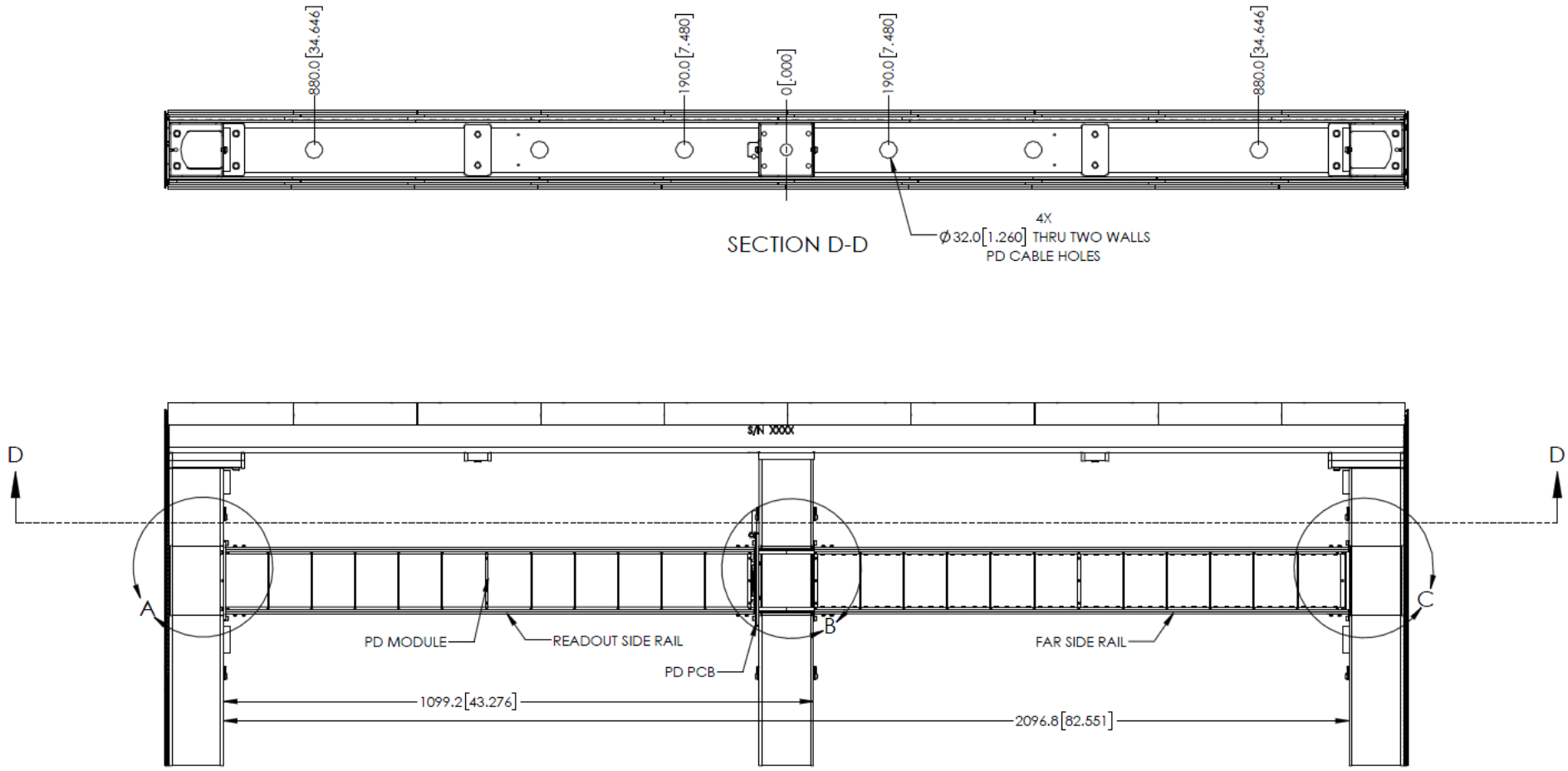


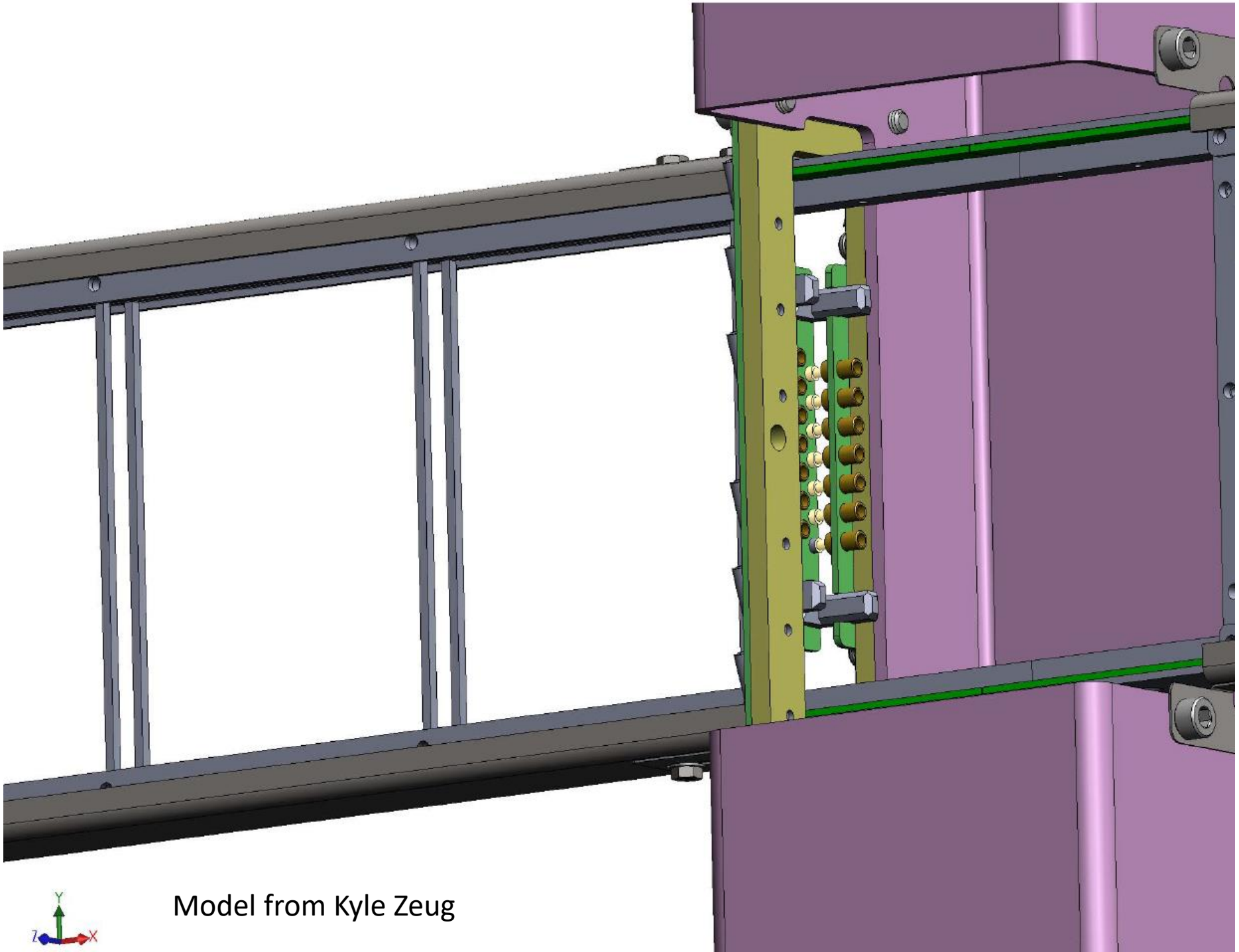
Interface: Upper APA Yoke to DSS



Interface: Photon Detector to APA Frame

Drawing 8760-300 from Kyle Zeug

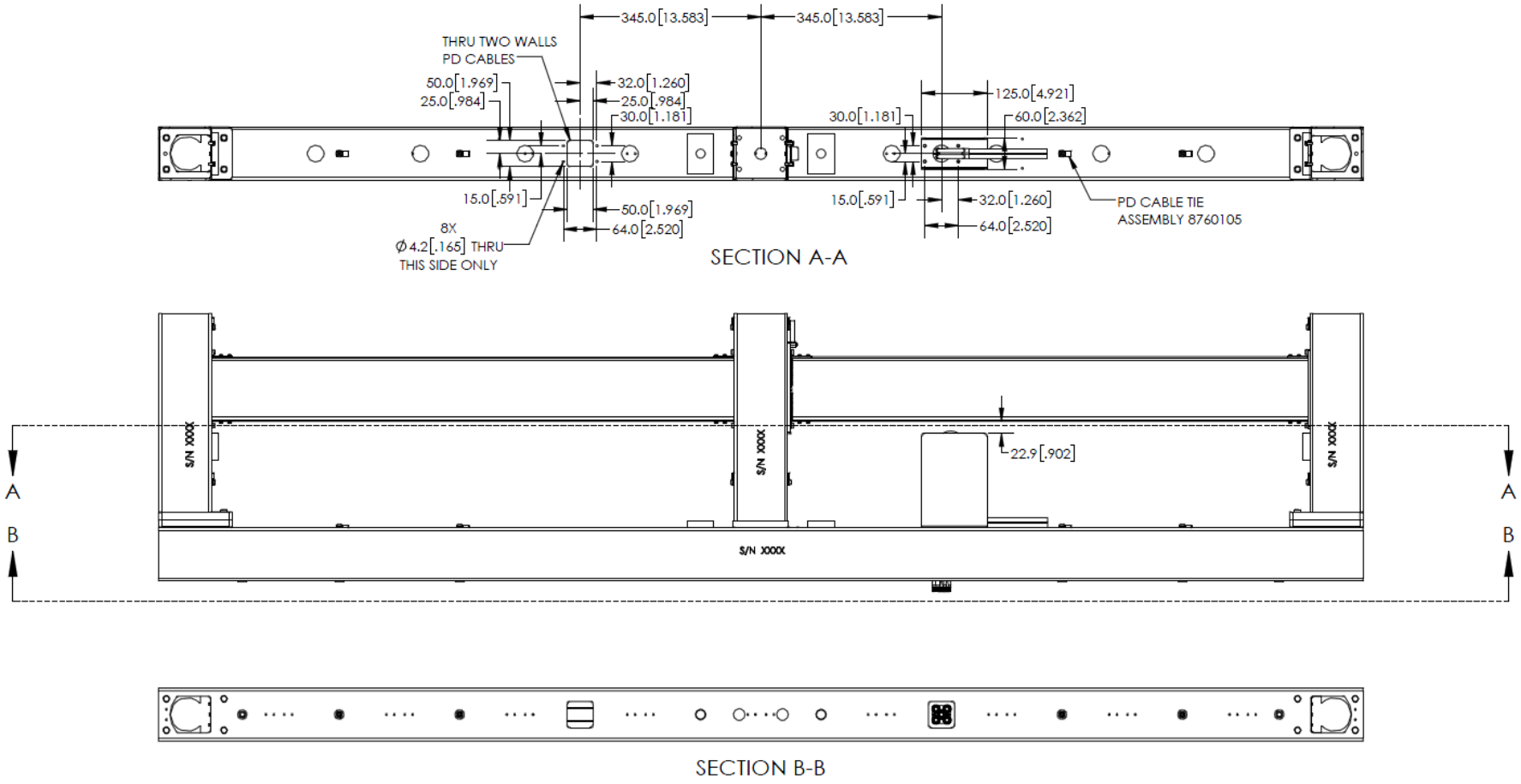




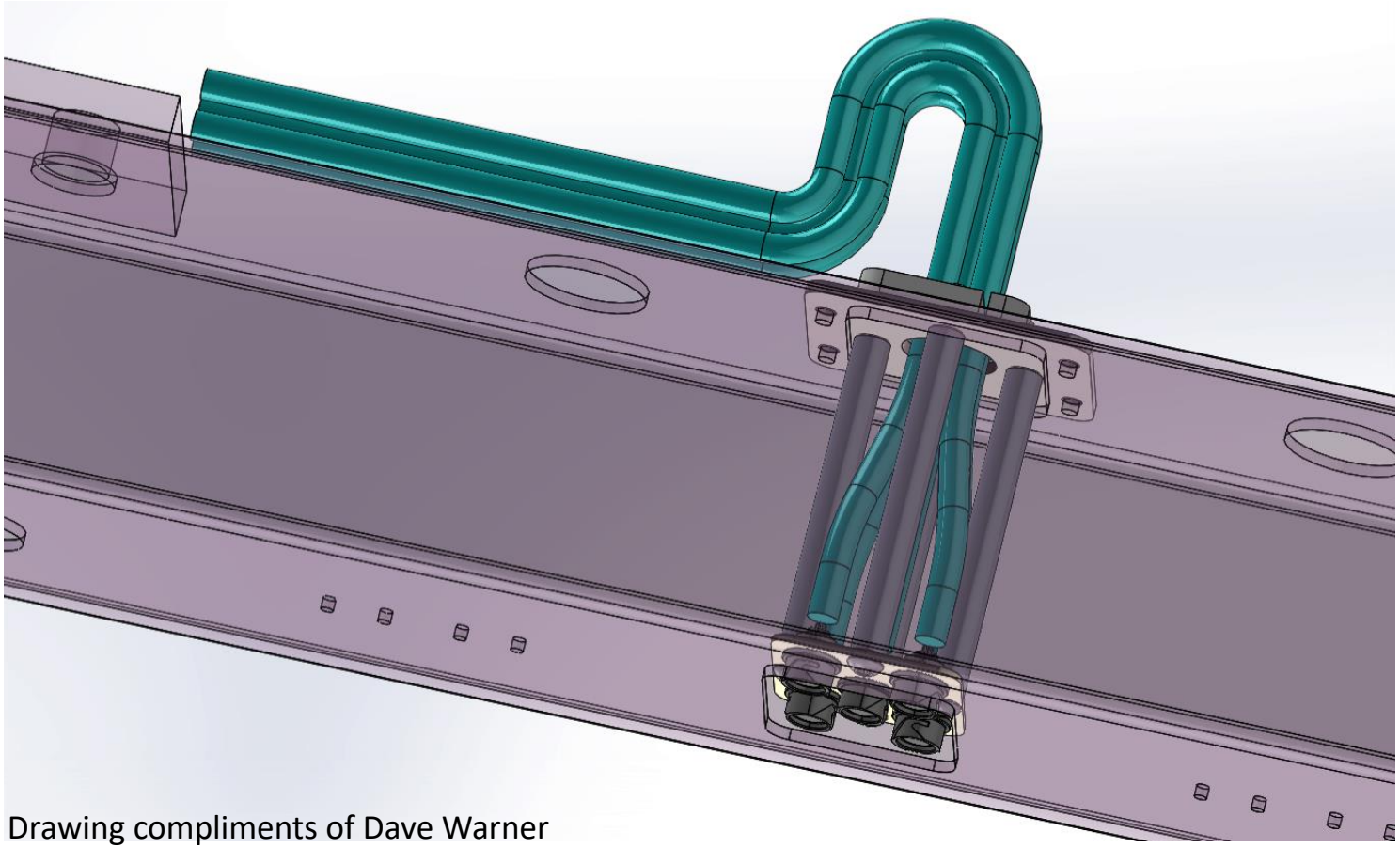
Model from Kyle Zeug

Interface: Photon Detector Cable Connection at Foot Tubes

Drawing 8760-303 from Kyle Zeug

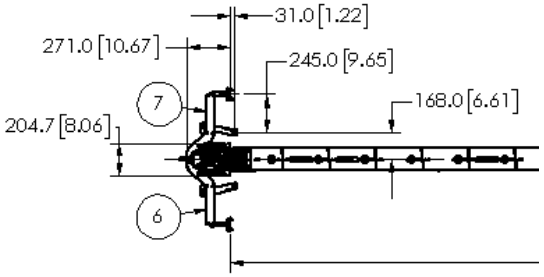


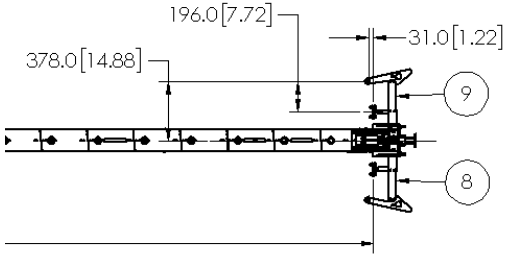
Interface: Photon Detector Cable Connection at Foot Tubes



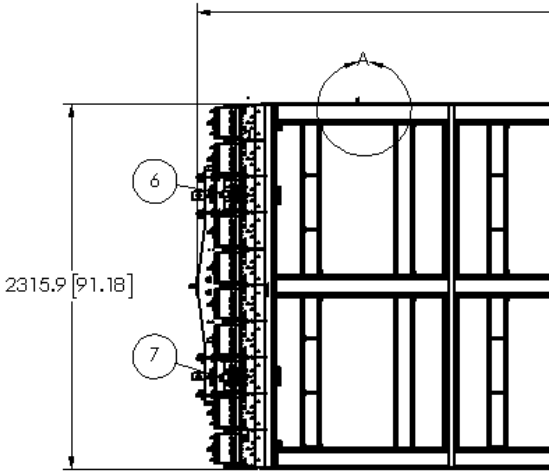
Drawing compliments of Dave Warner

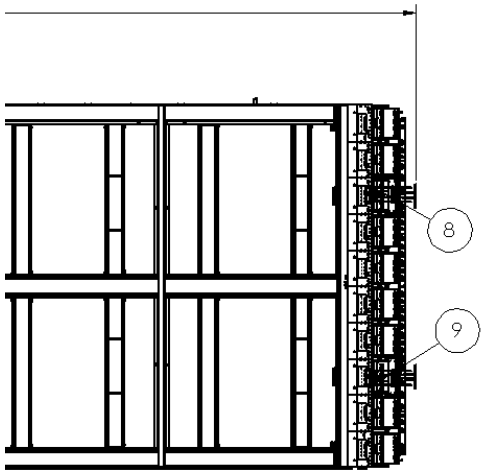
Interfaces: Field Cages to APAs





These excerpts from drawing 8760-185 (The assembled APA pair) show the locations of the field cage latches. Additional detail to be added.





2. Are the specifications and drawings for standard and custom components substantially complete and available in EDMS? Are they of sufficient maturity to proceed to final design?
3. Have interfaces with other detector components been addressed and documented? Do risks of design changes in other systems have appropriate mitigation strategies?

Making design changes during development requires care and flexibility from all involved. It's impossible to predict ahead of time what changes are going to arise but there are steps we take to minimize negative impact:

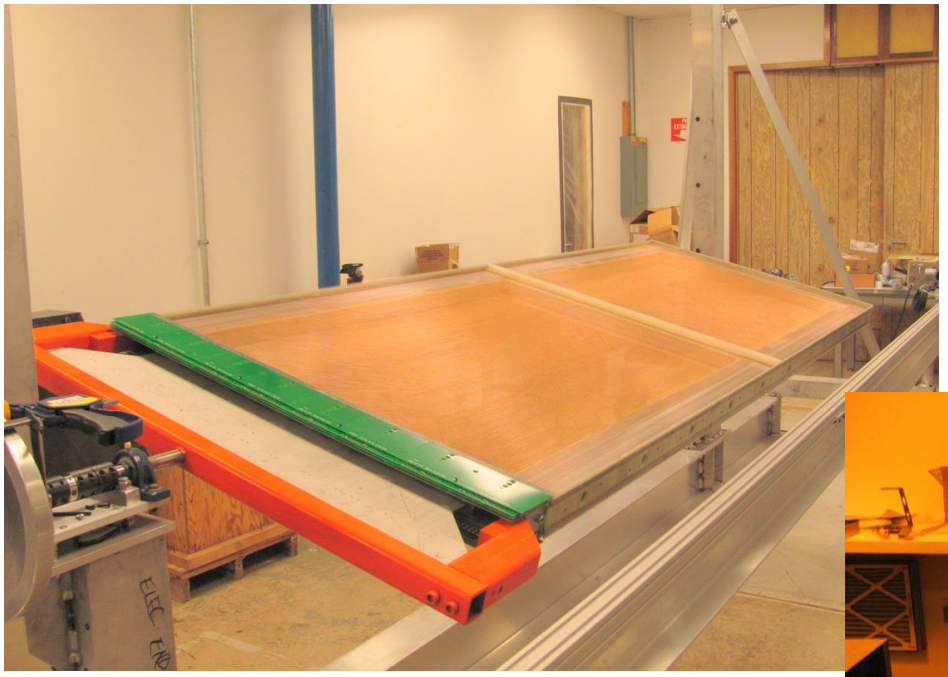
- Interfaces have been established early. They are modified as needed based on discussions between the groups on both sides of the interface.
- Regular weekly meetings so the people within a group, and those from other affected groups, have a place to propose and discuss desired changes.
- Presentations at collaboration meetings help inform other groups of the overall direction of each group.
- Individual conversations between people working on connected systems keep each group in touch with the directions of other groups.

Summary

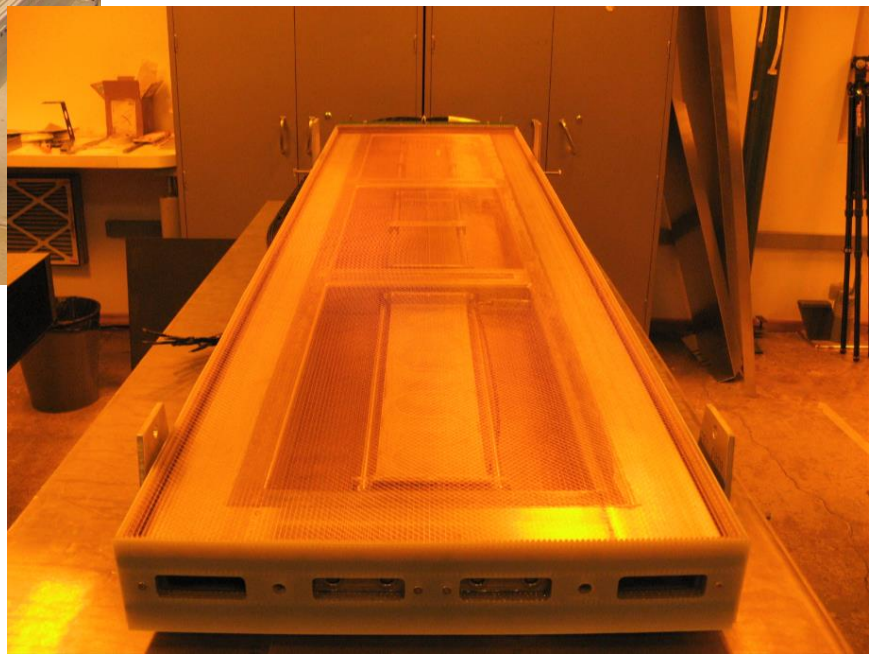
- DUNE APA design is based on several earlier prototypes.
- The design is nearly complete and drawings are available on EDMS. Some refinement of design is still underway.
- The interfaces between the APA and other systems is well defined.

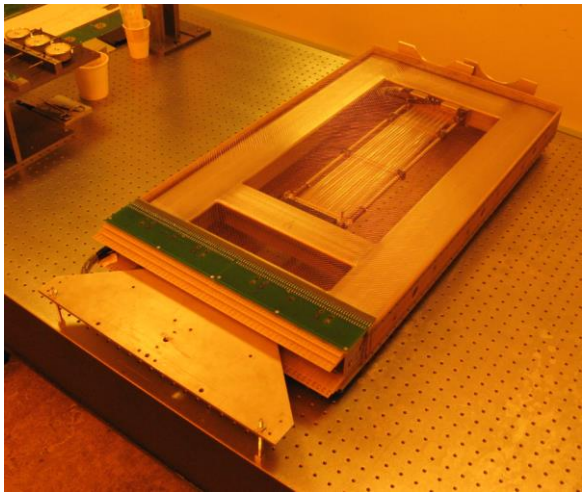
Backup Slides

History



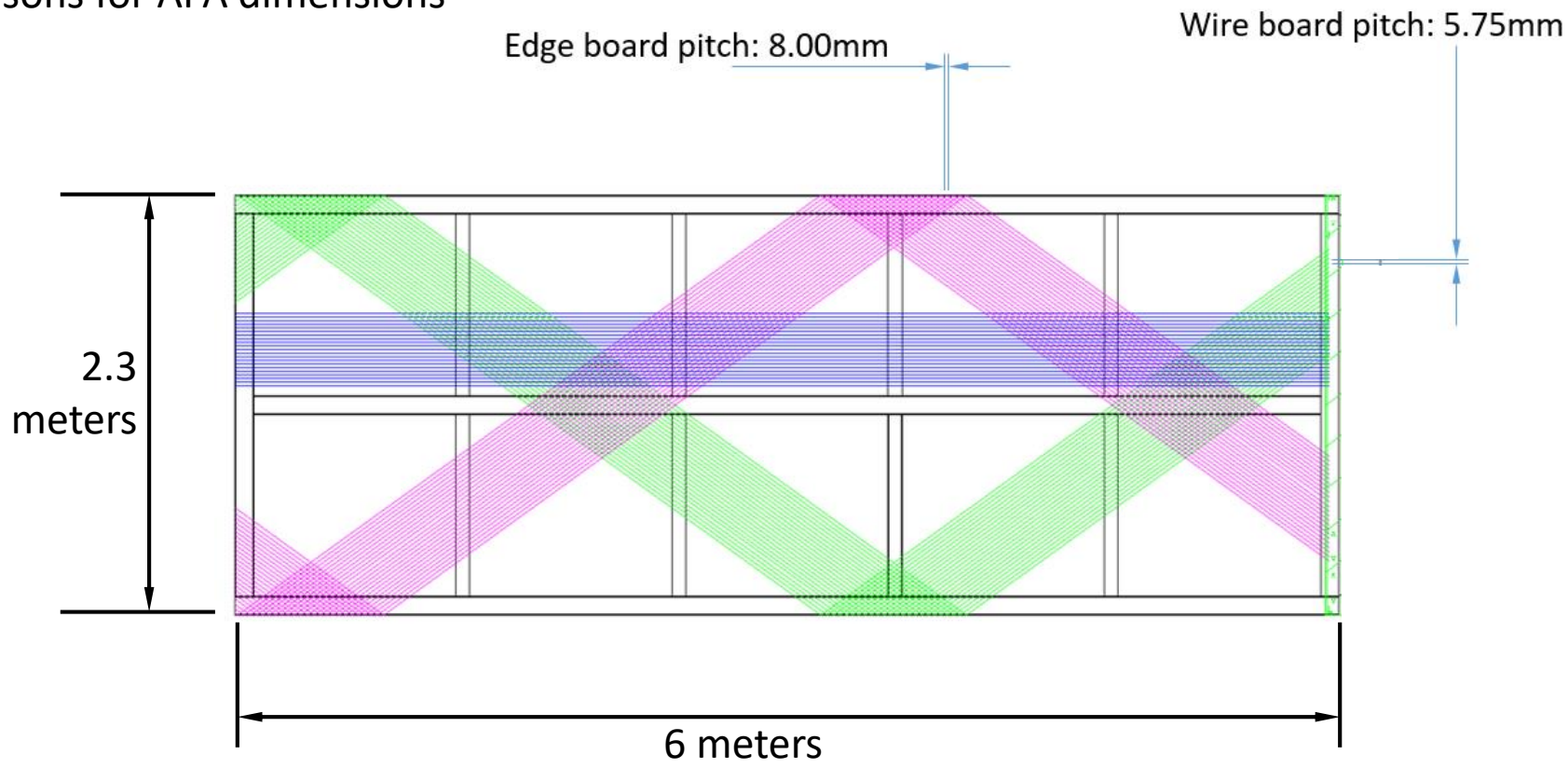
The “40%”. The first prototype APA. ~40% linear dimensions





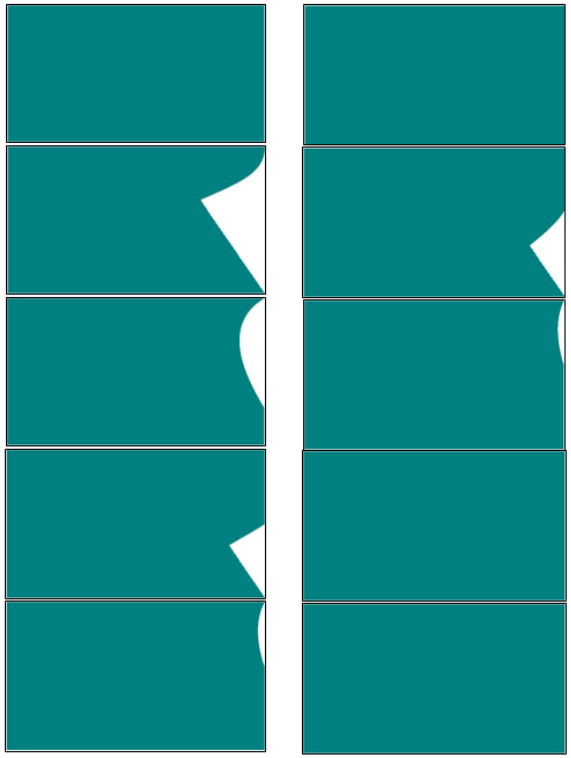
Long and short “35T” APA. Installed in cryostat and used at Fermi.

History
Reasons for APA dimensions



- 6 meters is ~20 feet – the standard, easy-to-buy length for hollow steel tubing.
- 2.3 meters is slightly under 8 feet. This was driven by the desire to keep transportation simple.

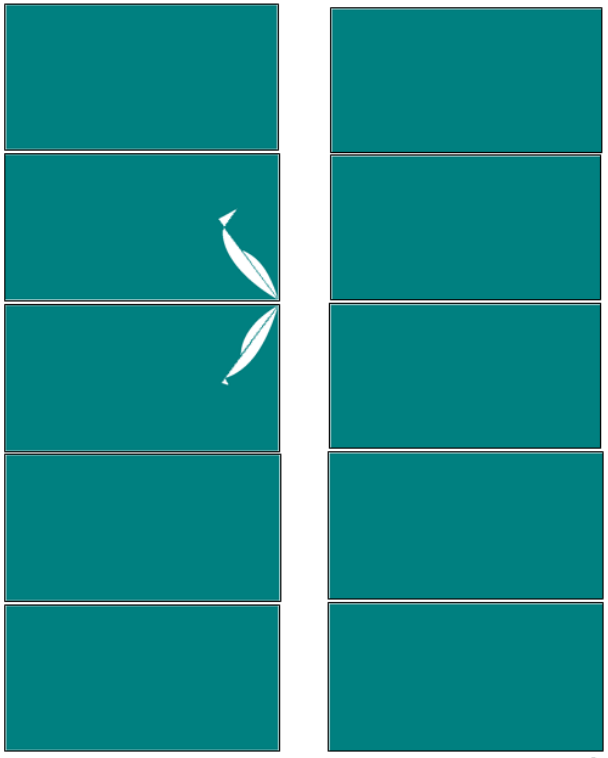
Changes from ProtoDUNE to DUNE Comb End to Edge Board Height Mismatch



> 0.5mm > 1.0mm

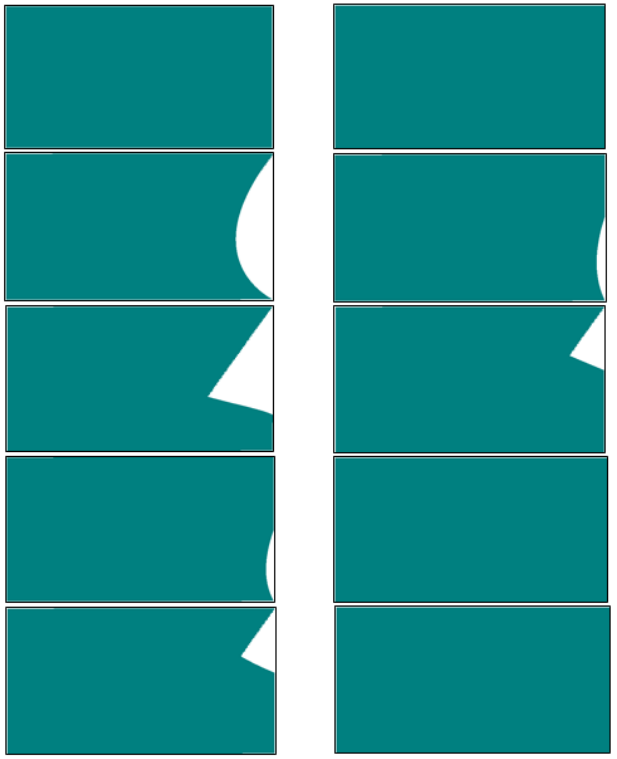
U-G layers

Shown here are the 3 spaces between wire planes on the A side of the APA. The white areas in the left hand view are the areas in that plane predicted to be more than 0.5mm over or under the target. The right hand view shows areas predicted to be more than 1 mm out.



> 0.5mm > 1.0mm

V-U layers



> 0.5mm > 1.0mm

X-V layers