Cold Electronics Mechanicals QC for ProtoDUNE-SP

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Contents

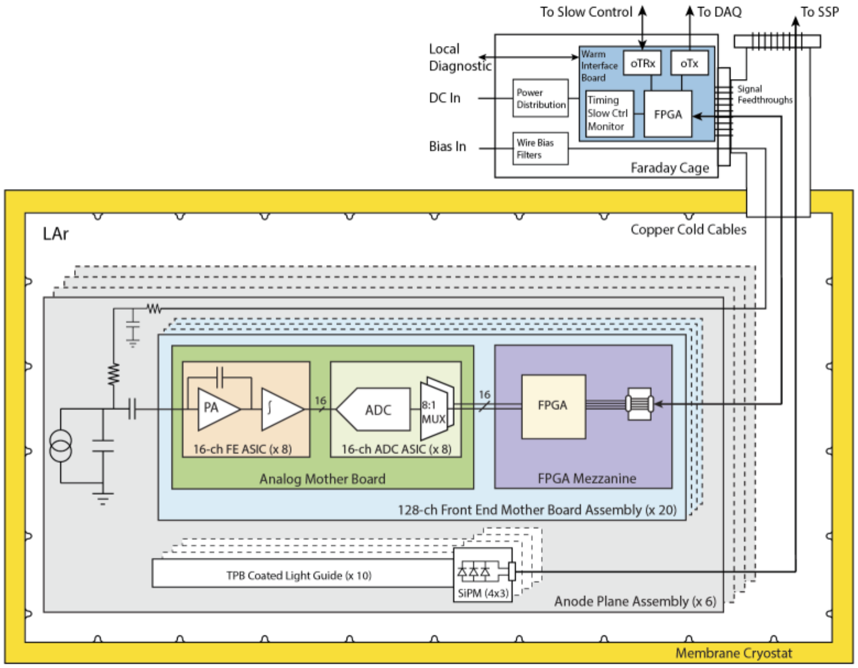


Figure 1: Overview of the ProtoDUNE-SP cold electronics readout system.

1 Introduction

The Deep Underground Neutrino Experiment (DUNE) consists of a neutrino beam from the Fermilab accelerator complex to the Sanford Underground Research Facility (SURF) in South Dakota, a near detector at Fermilab, and four 10 kton fiducial volume Liquid Argon Time Projection Chamber (LArTPC) far detector modules approximately 1 mile underground at SURF [1] [2]. The ProtoDUNE Single Phase (SP) experiment is a ∼700 ton LArTPC detector which will be deployed at CERN in a test beam in 2018 [3]. ProtoDUNE-SP is a critical prototype for the first 10 kton DUNE far detector module.

Particles in the ProtoDUNE-SP detector are observed by ionization electrons created by particle interactions in the active volume of the LArTPC which drift in an electric field from cathode to anode-plane assemblies (APAs). Each APA contains wires which collect charge from the drift electrons, either by inducing a current on the wire as the electron drifts past, or collecting the electron charge directly on the wire. The charge signals on the wires are processed, digitized, and read out by the TPC cold electronics (CE).

The ProtoDUNE-SP CE readout chain consists of the cold Front-End (FE) and ADC ASICs which are mounted on front-end motherboard (FEMB) assemblies, copper cold cable, warm flanges mounted on cryostat signal feed-throughs, and warm interface electronics contained in a shielded Warm Interface Electron-

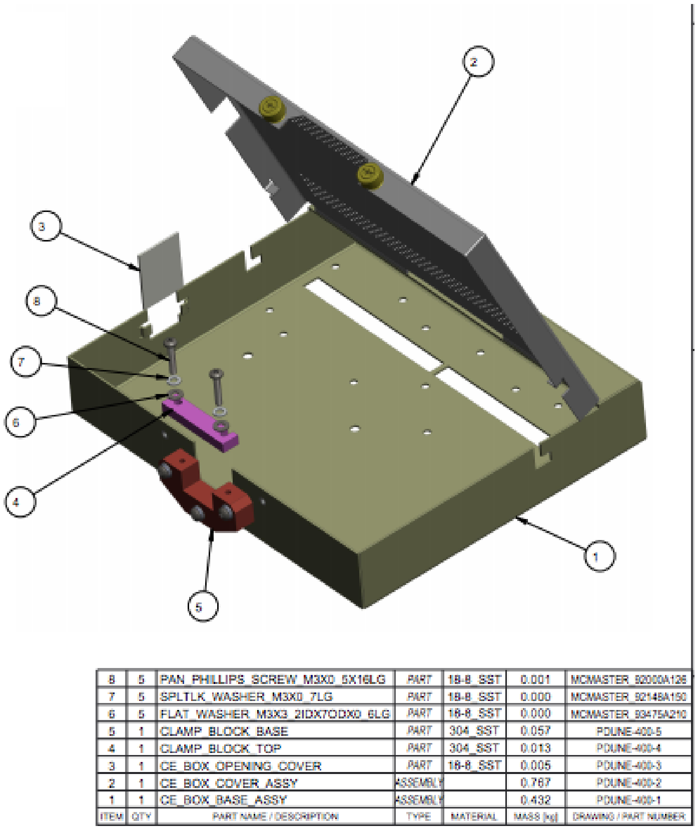
Component	Description	Temp	Quantity
FE ASIC	Wire charge amplification and shaping	LAr	960
ADC ASIC	Charge digitization and serialization	LAr	960
FEMB	8 FE and 8 ADC ASICs and transmission of data to CE flange; enclosed in CE Box [4]	LAr	120
Cold cable bundles	12 twin-axial data lines/bundle; 18 twisted-pair LV wires/bundle	LAr/ room	120
Cold SHV cable	SHV coaxial cablel HV for wire-bias, FC termination and electron diverters	LAr/ room	48
Signal feed-through	Tee pipe with 3×14" Conflat flanges; internal cable support structure; GAr flow control	GAr	6
Warm flange	Connection between cold cable and warm electronics	room	6
WIB	Pass LV power and clock/control to the FEMB; pass data from FEMB to DAQ	room	30
PTC	Pass LV power and clock/control to the WIBs; return clock	room	6
PTB	LV power and clock/control distribution in WIEC	room	6
WIEC	Contains 1 PTC, 1 PTB 5 WIBs/flange; provides Faraday shield and cooling	room	6

Table 1: Overview of the cold electronics system components.

ics Crate (WIEC), as shown in Figure 1. The FEMB are individually enclosed in CE Boxes which provide ESD protection, a Faraday shield, and local cable strain relief.

The warm interface electronics contained in the WIEC are the Warm Interface Boards (WIBs), Power and Timing Cards (PTCs), and Power and Timing Backplane (PTB) which handle clock, control, configuration, and data transmission between the DAQ/timing systems and the CE. The signal feed-through is comprised of a Tee pipe with a 14" conflat flange to mount the CE flange and an internal Crossing Tube Cable (CTC) support structure which provides cable strain relief as the cold cables pass through the cryostat lid and flow control for the gaseous Argon (GAr). SHV coaxial cables (8 per APA) carry APA wire-bias, Field Cage (FC) termination, and electron diverter High Voltage (HV) inside the cryostat. The critical components of the ProtoDUNE-SP CE are shown in Table 1.

The purpose of this document is to describe the Quality Control (QC) procedures for the CE mechanical components: CE Box, signal feed-through, CE flange, WIEC, and cold cables. For the QC procedures for the CE electrical com-



ITEM	QTY	PART NAME / DESCRIPTION	TYPE	MATERIAL	MASS [kg]	DRAWING / PART NUMBER
8	5	PAN_PHILLIPS_SCREW_M3X0_5X16LG	PART	18-8_SST	0.001	MCMASTER_92000A126
7	5	SPLTLK_WASHER_M3X0_7LG	PART	18-8_SST	0.000	MCMASTER_92148A150
6	5	FLAT_WASHER_M3X3_2IDX7ODX0_6LG	PART	18-8_SST	0.000	MCMASTER_93475A210
5	1	CLAMP_BLOCK_BASE	PART	304_SST	0.057	PDUNE-400-5
4	1	CLAMP_BLOCK_TOP	PART	304_SST	0.013	PDUNE-400-4
3	1	CE_BOX_OPENING_COVER	PART	18-8_SST	0.005	PDUNE-400-3
2	1	CE_BOX_COVER_ASSY	ASSEMBLY		0.767	PDUNE-400-2
1	1	CE_BOX_BASE_ASSY	ASSEMBLY		0.432	PDUNE-400-1

Figure 2: CE Box mechanical assembly.

ponents, see DUNE DocDB 1809 [5]. For a full description of the ProtoDUNE-SP CE system, see the Technical Design Report [3]. The plans for production orders and shipment and acceptance testing at CERN, while not finalized, will also be described.

2 Cold Electronics Box

Each FEMB will be individually enclosed in a CE Box. The CE Box will provide electrostatic discharge (ESD) protection to the cold ASICs and circuitry on the FEMB, a Faraday shield, and built-in cable strain relief. The mechanical assembly is shown in Figure 2 and the design drawings are in DUNE DocDB 2611 [6].

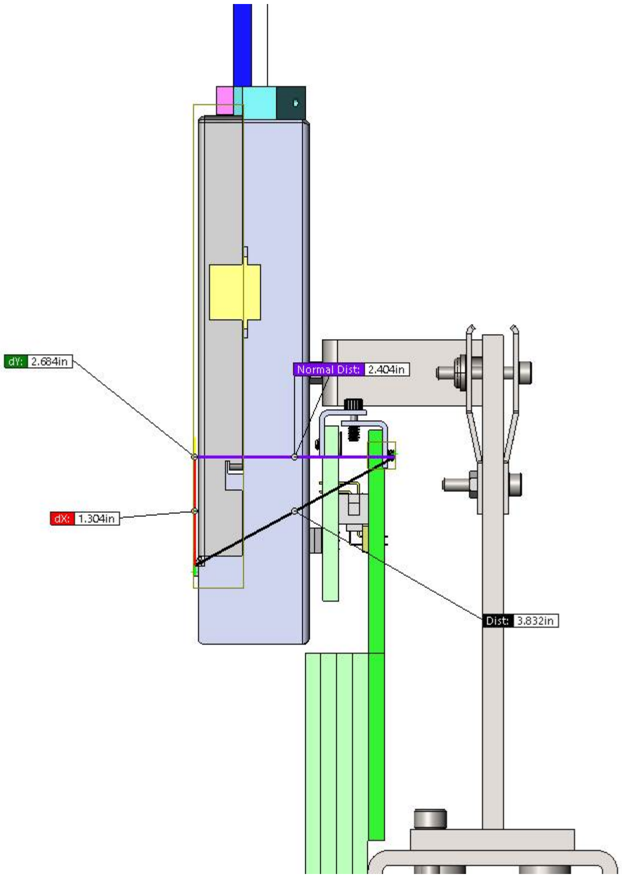


Figure 3: CE Box mounted to an APA.

2.1 QC

For initial testing, each production FEMB will be fully validated in LN2 such that any components which fail at cryogenic temperatures can be rejected and replaced. Each fully-tested FEMB with be "dressed" into a CE Box with all mounting hardware and both bundles of LV and data cold cable attached. Additionally, the interface bracket designed at PSL to connect the FEMB to the APA will be attached, as shown in Figure 3.

The entire FEMB, cable and CE Box unit will be tested in multiple thermal cycles in LN2. The criteria to pass one cycle of cryogenic testing will be full functionality of the FEMB, as detailed in the CE Electricals QA/QC Plan in DUNE DocDB 1809 [5], and no evidence of stress damage or loose attachment hardware upon return to room temperature.

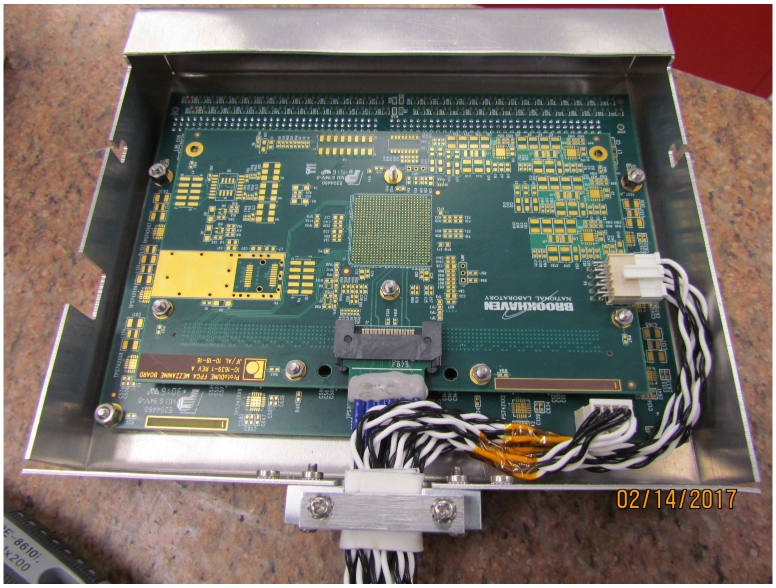


Figure 4: CE Box opened with an FEMB and expected cable routing inside the box.

2.2 Production

A prototype CE Box, shown in Figure 4, has been machined at BNL and used for assembly and cable connectivity testing. It has been slowly cryo-cycled in LN2 six times, with a seveth iteration done quickly to thermal shock the connectors. The cables remained connected when checked after each cycle.

3 more prototype boxes have been ordered from Zober Industries, whom we expect to use for the final production order of 150 units. The boxes will have their final assembly at BNL as part of dressing the tested FEMB.

FEMB units with box, cable and PSL adapter board will be shipped to CERN in custom containers designed and built by the same team at BNL that delivered the MicroBooBE electronics to Fermilab. The acceptance tests at CERN will be a visual inspection for damage and a repeat of the suite of FEMB QC tests at room temperature. Criteria for passing acceptance will be identical electronics performance to the measurements made at BNL during QC testing.

3 Signal Feed-through

ProtoDUNE-SP will have 6 signal feed-throughs, one per APA. Shown in Figure 5, the signal feed-through has two main components,

- Tee Pipe, which consists of three 14” Conflat flanges to attach to the cryostat crossing tube, the CE flange, and the Photon Detector (PD)

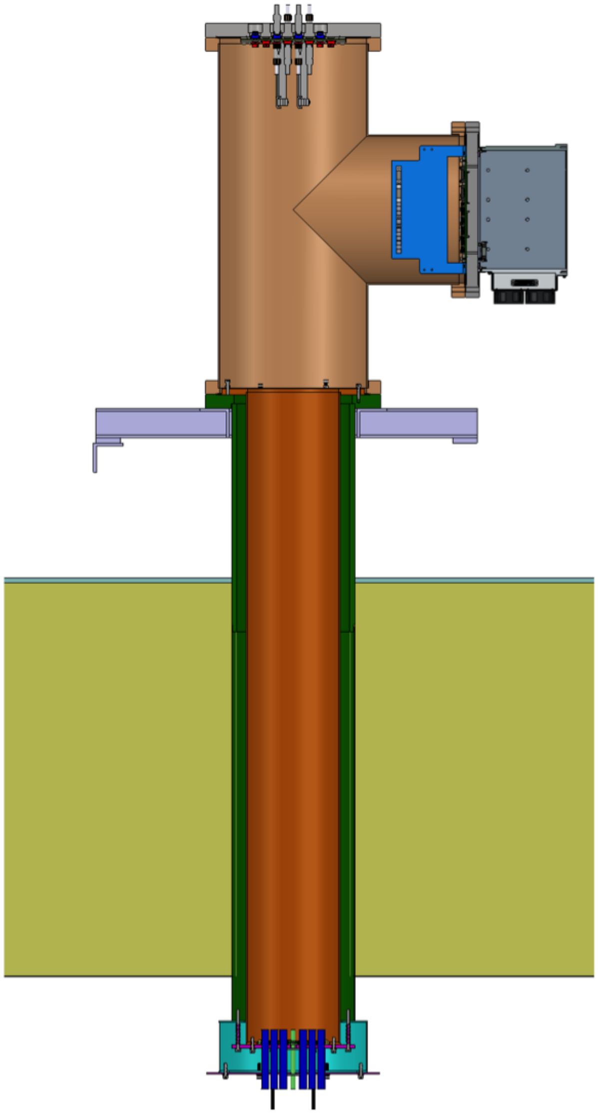


Figure 5: Tee pipe for the signal feed-through, shown in tan. Side port is for the CE flange, top port for the PD flange. Orange is the CTC inner tube; green is the cryostat crossing tube.

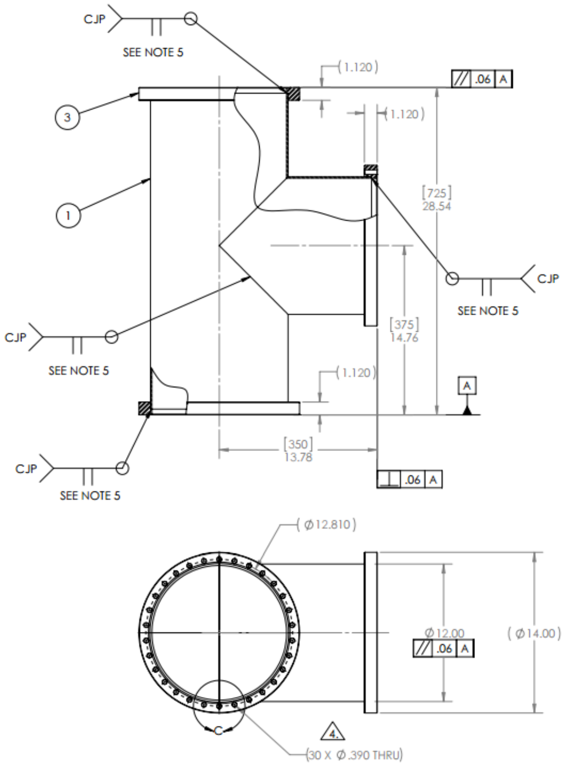


Figure 6: Tee pipe for the signal feed-through.

flange, and

- Crossing Tube Cable (CTC) support, which provides cable strain-relief at the bottom of the crossing tube and an inner tube baffle to control GAr flow up the feed-through.

3.1 Tee Pipe

The Tee Pipe will allow for the routing of the PD cables out of a custom PD flange on the top of the Tee structure, and the CE cables out of a second custom CE flange mounted vertically on the side opening of the Tee. Each of the flanges is a 14" Conflat stainless steel assembly that will bolt to the Tee pipe with off the shelf hardware. The CE flange will be covered in Section 4.1. The mechanical design is shown in Figure 6 and the assembly drawings are in DUNE DocDB 2126 [7].

A prototype Tee pipe has been ordered from MDC Vacuum Products, with delivery expected on 3/28. It will be tested with the CE flange and WIEC

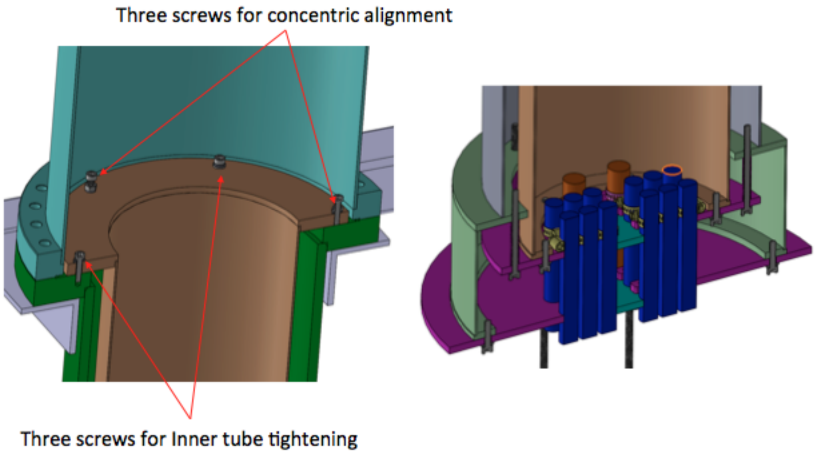


Figure 7: (a) Top attachment of the CTC assembly. (b) Cable support structure at the bottom of the crossing tube.

assembly already taking data with the 40% APA teststand currently using a temporary chimney, as described in Section 4.3.

3.2 CTC Support

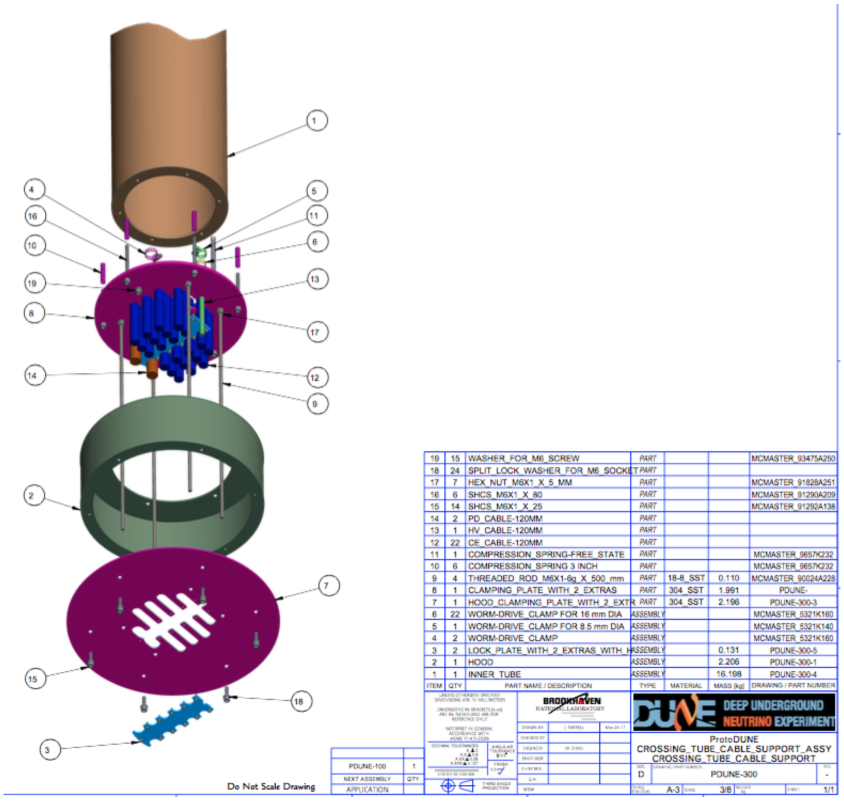
The CTC support structure will provide cable strain relief at the bottom of the cryostat crossing tube shown in Figure 5. The crossing tube cannot support the weight of the signal feed-through or CE and PD cables. Therefore, a platform will be constructed by CERN on top of the ProtoDUNE cryostat to take the load of the signal feed-through and cables.

To provide cable strain relief at the bottom of the ∼1 meter high crossing tube, an assembly will have to hang down the crossing tube, supported by the Tee pipe and platform. The CTC will both attach to the top crossing tube Conflat flange with additional support from L-brackets, as shown in Figure 7(a), and support the cables at the bottom of the crossing tube with gaskets to hold the cable bundles mounted to detachable clamp plates, as shown in Figure 7(b).

An inner tube connects the top and bottom of the CTC. It also controls the GAr flow through the ullage in the signal feed-through. A purging port for the GAr is provided on the CE flange. The mechanical design and assembly drawing is shown in Figure 8 and the design drawings are in DUNE DocDB 2883 [8]. Prototype structures will be ordered following the PRR.

3.3 QC

The QC to validate the signal feed-through will be visual inspection for mechanical defects and partial assembly of the Tee pipe and CTC structure. The Tee pipes will be tested for vacuum performance by the manufacturer, and be



ITEM	QTY	PART NAME / DESCRIPTION	TYPE	MATERIAL	MASS [kg]	DRAWING / PART NUMBER
19	15	WASHER_FOR_M6_SCREW	PART			MCMASTER_93475A250
18	24	SPLIT_LOCK_WASHER_FOR_M6_SOCKET	PART			
17	7	HEX_NUT_M6X1_X_5_MM	PART			MCMASTER_91828A251
16	6	SHCS_M6X1_X_80	PART			MCMASTER_91290A209
15	14	SHCS_M6X1_X_25	PART			MCMASTER_91292A138
14	2	PD_CABLE-120MM	PART			
13	1	HV_CABLE-120MM	PART			
12	22	CE_CABLE-120MM	PART			
11	1	COMPRESSION_SPRING-FREE_STATE	PART			MCMASTER_9657K232
10	6	COMPRESSION_SPRING 3 INCH	PART			MCMASTER_9657K232
9	4	THREADED_ROD_M6X1-6g_X_500_mm	PART	18-8_SST	0.110	MCMASTER_90024A228
8	1	CLAMPING_PLATE_WITH_2_EXTRAS	PART	304_SST	1.991	PDUNE-
7	1	HOOD_CLAMPING_PLATE_WITH_2_EXTR	PART	304_SST	2.196	PDUNE-300-3
6	22	WORM-DRIVE_CLAMP FOR 16 mm DIA	ASSEMBLY			MCMASTER_5321K160
5	1	WORM-DRIVE_CLAMP FOR 8.5 mm DIA	ASSEMBLY			MCMASTER_5321K140
4	2	WORM-DRIVE_CLAMP	ASSEMBLY			MCMASTER_5321K160
3	2	LOCK_PLATE_WITH_2_EXTRAS_WITH_H	ASSEMBLY		0.131	PDUNE-300-5
2	1	HOOD	ASSEMBLY		2.206	PDUNE-300-1
1	1	INNER_TUBE	ASSEMBLY		16.198	PDUNE-300-4

Figure 8: Assembly drawing for the CTC structure.

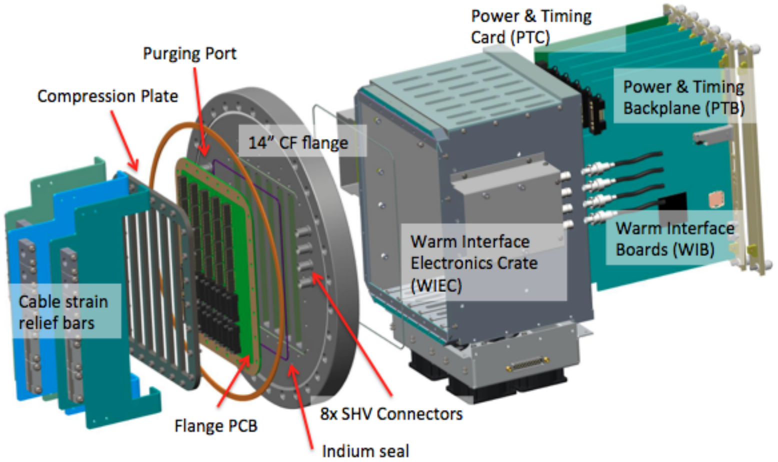


Figure 9: TPC readout electronics flange. The mechanical components are (1) the CF flange assembly including compression plate and strain relief bars and (2) the WIEC.

delivered with a certification of leak check. At BNL they will be inspected and labelled. To ensure mechanical compatibility a 14" Conflat flange will be installed on each of the top (PD) and side (CE) ports of the Tee.

Additionally, a top of the CTC inner tube will be inserted into the bottom flange of the Tee. The cable clamp structure at the bottom of the CTC will be assembled at BNL and checked for mechanical defects. Criteria for passing the QC testing is no visible damage to any parts, and all tested mechanical assemblies are compatible.

3.4 Production

Both of these items will be ordered from a vendor and shipped to BNL for inspection. The current plan is to use MDC Vacuum Products for the Tee pipe and Zober Industries for the machining of the CTC structure. The units which pass inspection will be shipped to CERN in custom shipping crates designed and built at BNL. At CERN the acceptance testing will be inspection of all parts, with criteria for passing being no visible damage.

4 CE Warm Flange and WIEC

The ProtoDUNE-SP warm interface electronics are housed the Warm Interface Electronic Crate (WIEC) attached directly to the CE warm flange. The WIEC contains one PTC, up to five WIBs, and a passive Power and Timing Backplane (PTB) which fans out signals and LV power from the PTC to the WIBs.

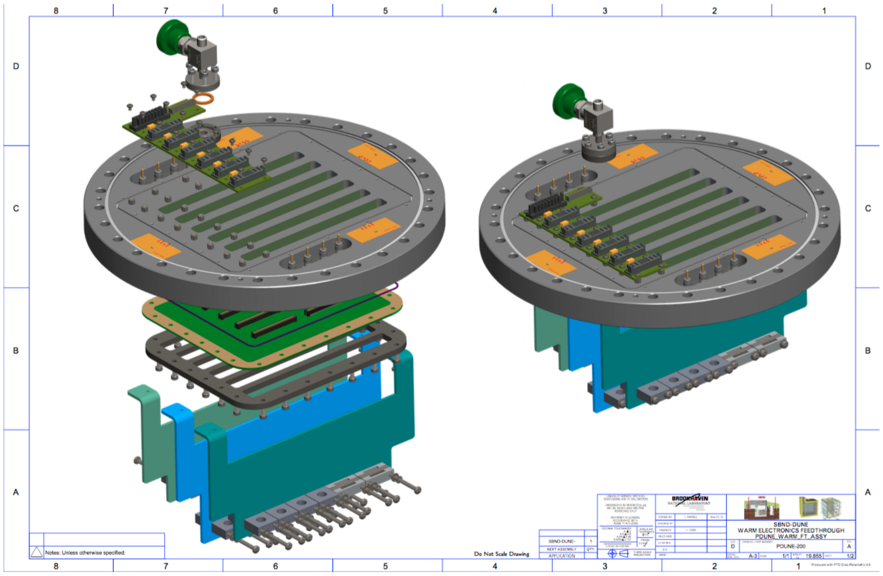


Figure 10: CE flange assembly including compression plate, strain relief bars and purge port.

The WIB is the interface between the DAQ system and up to four FEMBs. It receives the system clock timing and control signals from the timing system and provides processing and fan-out to the four FEMBs. The WIB also receives the high-speed data from the four FEMBs and transmits it to the DAQ system over optical fiber.

Figure 9 shows the entire CE flange and WIEC assembly. The WIBs are attached directly to the TPC readout electronics flange on the cryostat feed-through. The flange board is a PCB with connectors to the cold signal and LV cables fitted between the compression plate on the cryostat side, and sockets for the WIB on the warm side. Cable strain relief is also provided directly on the flange, which is mounted vertically to the cryostat feed-through.

4.1 Warm Flange

The CE warm flange consists of a cable support structure and squash plate on the cold signal feed-through side, a stainless steel 14" Conflat flange with 8 SHV connectors, and a purge port on the warm electronics side. The mechanical design is shown in Figure 10 and the design drawings are in DUNE DocDB 2771 [9].

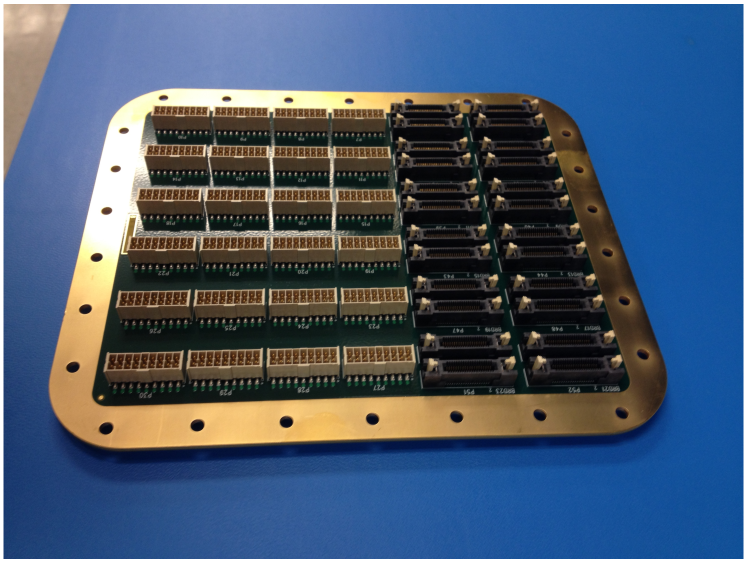


Figure 11: CE flange PCB (connectors to cold cable side).

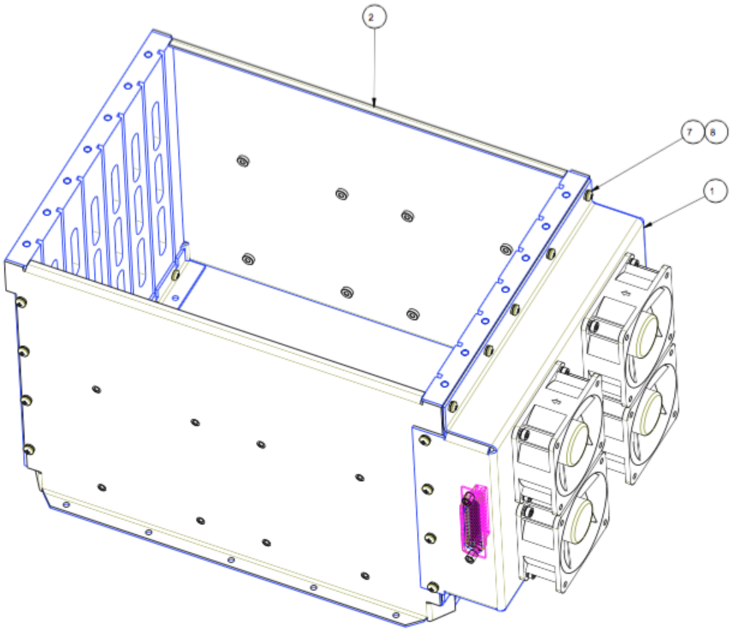


Figure 12: WIEC mechanical drawing.

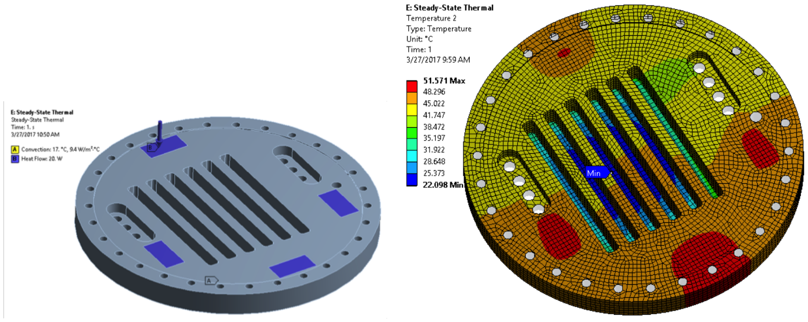


Figure 13: (a) locations of 4 heaters with RTD; (b) thermal simulation of the warm flange with 17°C applied to the cold side and 5W per heater: the coolest point is >22°C on the flange PCB.

4.2 Flange PCB

The CE warm flange Printed Circuit Board (PCB) provides the electrical connection between the CE inside the cryostat volume and the warm readout electronics. The cold cables plug into connectors on the cold side of the PCB, and sockets for the WIBs to plug into are provided on the warm side. The flange PCB is assembled directly onto the stainless steel flange with an Indium seal and held in place by the steel squash plate. A prototype PCB (cold side) is shown in Figure 11 and the schematics, layout, and BOM are in DUNE DocDB 2777 [10].

Based on the thermal model of the signal feed-through, the GAr temperature at the warm flange should be approximately 17°C during regular operation. However, the dew point at the CERN site can reach up to 21°C. We require that, if the WIEC electronics are off, the flange can be warmed above the dew point before enabling power to the cold electronics. Therefore, the warm flange will have 4 heater units with built-in RTD monitoring and control attached to the warm face of the flange, as shown in Figure 13(a). Thermal simulation shows that 5W to each heater, well within the operating range of the device, can achieve >22°C at the minimum temperature point on the flange PCB, as shown in Figure 13(b).

4.3 WIEC

The WIEC provides a Faraday shield around the warm interface electronics, and a Power and Timing Backplane (PTB) to distribute LV power and timing signals inside the crate. It attaches directly to the CE flange on the warm side. At full capacity it contains 1 PTC and 5 WIBs, each powering and reading out 4 FEMB for a total of 20 FEMB (1 complete APA wire readout) per signal feed-through. The mechanical design is shown in Figure 12 and the assembly drawings are in DUNE DocDB 2774 [11].

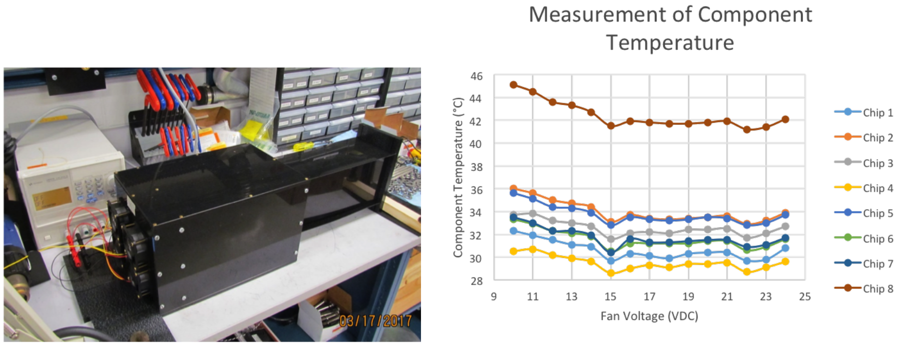


Figure 14: (a) mock WIEC with 4 fans; (b) WIB component temperature as a function of fan voltage.

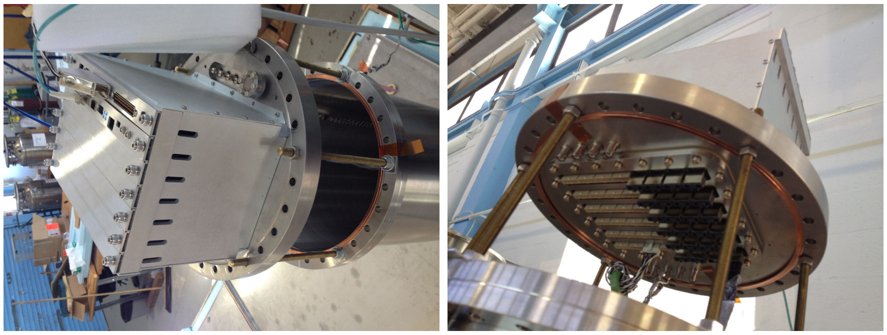


Figure 15: Top (left) and bottom (right) of full warm flange assembly, including flange PCB and WIEC. Cable strain relief bars are not installed.

The WIEC is cooled by 4 brushless fans, supplied by a variable power source up to 24V. A mock WIEC with 4 fans has been assembled and tested at BNL. The mock WIEC, shown in Figure 14(a), contains one WIB with thermal sensors attached to 8 components on the WIB. The temperature of the WIB components never exceeds 46°C under normal fan speed, as shown in Figure 14(b), well within the manufacturer limits.

A full prototype warm assembly, including prototype CE flange, flange PCB, and WIEC is being tested for electronics performance on the 40% APA teststand at BNL, as shown in Figure 15. The goal of the 40% APA teststand is to test the CE system with a full readout chain through the WIB and multiple FEMB taking wire data while cold. The teststand consists of a prototype APA from PSL with ~4 meters as the longest APA wire length. It is contained in a cold box such that the FEMB reading out the wire data can be submerged in LN2 and operated at cryogenic temperature. It is described in more detail in the CE QA/QC Electricals Plan in Dune DocDB 1809 [5].

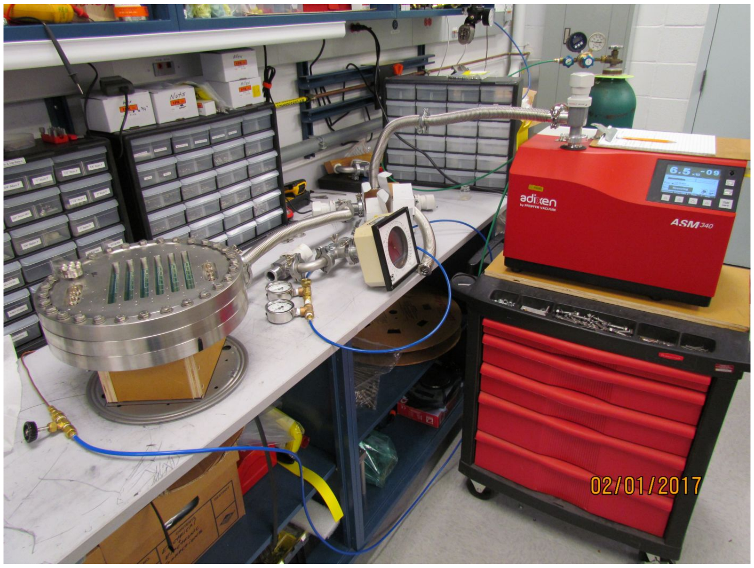


Figure 16: QC test setup for CE flange pressure tests.

4.4 QC

During cryostat purge the flange structure is expected to experience a 1 PSI pressure differential from the outside atmosphere as the interior of the cryostat is evacuated. During normal operation with the cryostat filled with LAr, the maximum pressure differential is expected to be 5 PSI above atmosphere from the cold side of the flange.

The CE flange assemblies will be visually inspected for damage upon receipt from the vendor. They will be assembled with the flange PCB and squash plate and pressure tested following the CE Flange QC pressure test described in DUNE DocDB 1809 [5]. The criteria to pass the pressure tests are leakage rate $< 10^{-9}$ mbar L/sec with 5 PSI positive pressure differential applied to cold side. The flange PCB will also be inspected after testing for visible damage.

Two prototype CE flanges with prototype PCBs have already passed these criteria with the pressure test setup shown in Figure 16. Additionally, they have both survived 20 PSI differential pressure tests without damaging the flange PCB or stainless steel assembly [5]. HV will also be applied to each of the 8 SHV connectors on the CE flange to check for continuity and discharge up to 3 kV. We estimate that 3 weeks will be needed to pressure/HV test all CE warm flanges.

Each of the CE flanges which pass the pressure QC tests will be assembled with a WIEC. These will be the final warm flange units and not disassembled. Each warm flange unit will undergo a suite of QC tests:

- Read out of 4 FEMB with cold cable in each WIEC slot. Checks: me-

Figure 17: Prototype cold cable bundles; left: data; right: LV.

chanical insertion of WIB into WIEC and flange PCB connectors, electrical connections between cold cable and WIB via flange PCB. Criteria to pass: no dead channels or excess noise beyond bench tests of FEMB.

- Measure air flow and WIB surface temperatures with all 4 fan units per DUNE DocDB 1809 [5]. Checks: warm electronics overtemperature. Criteria to pass: all surface temperature readings within operational limits of WIB electronic components.
- Measure temperature on the flange PCB with all 4 heater units operational. Checks: flange PCB can be warmed above dew point. Criteria to pass: lowest temperature on flange PCB >22°C.

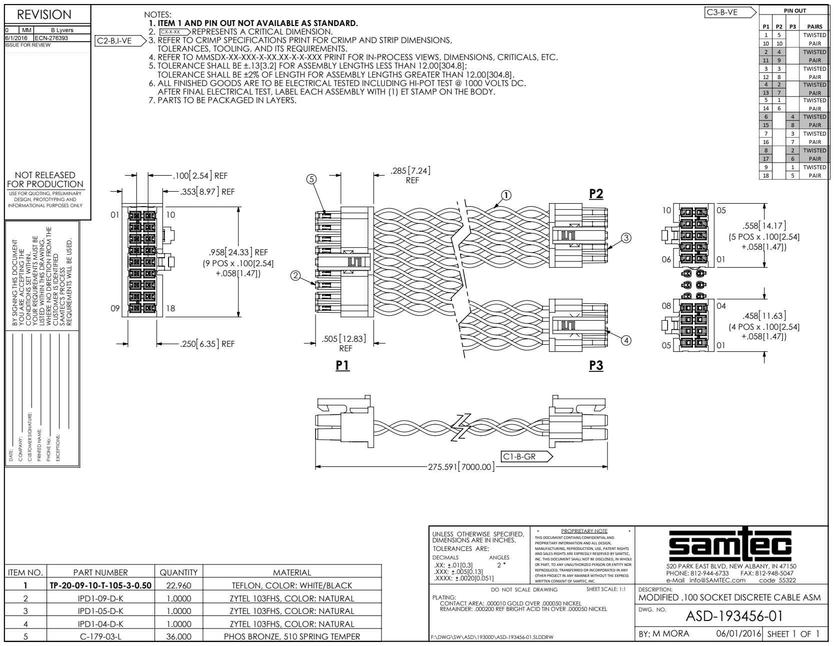
It is estimated that 3 weeks will be needed to validate all CE warm flange units.

4.5 Production

The current plan is for the CE flange to be manufactured by MDC Vacuum Products and the WIEC by Zober Industries. Following the CE mechanicals PRR final prototypes from those vendors will be ordered. The flange units which pass QC testing will be shipped to CERN in custom shipping containers designed and built at BNL. At CERN the acceptance testing will be inspection of all parts, with criteria for passing being no visible damage.

5 Cold Cable

Low voltage (LV) power will be provided via twisted-pair 20 AWG copper wire from the CE flange to the FEMB. One bundle of 18 wires is required for LV power to each FEMB, for a total of 120 bundles. Data and clock/control signals are provided via shielded 26 AWG twin-axial cable from the CE flange to the FEMB. One bundle of 12 twin-ax pairs is required for high-speed data links,



NOTES:

1. ITEM 1 AND PIN OUT NOT AVAILABLE AS STANDARD.

2. CX-X-XX REPRESENTS A CRITICAL DIMENSION.

3. REFER TO CRIMP SPECIFICATIONS PRINT FOR CRIMP AND STRIP DIMENSIONS, TOLERANCES, TOOLING, AND ITS REQUIREMENTS.

4. REFER TO MMSDX-XX-XXX-X-XX.XX-X-X-XXX PRINT FOR IN-PROCESS VIEWS, DIMENSIONS, CRITICALS, ETC.

5. TOLERANCE SHALL BE ±.13[3.2] FOR ASSEMBLY LENGTHS LESS THAN 12.00[304.8]; TOLERANCE SHALL BE ±2% OF LENGTH FOR ASSEMBLY LENGTHS GREATER THAN 12.00[304.8].

6. ALL FINISHED GOODS ARE TO BE ELECTRICAL TESTED INCLUDING HI-POT TEST @ 1000 VOLTS DC. AFTER FINAL ELECTRICAL TEST, LABEL EACH ASSEMBLY WITH (1) ET STAMP ON THE BODY.

7. PARTS TO BE PACKAGED IN LAYERS.

PIN OUT			
P1	**P2**	**P3**	**PAIRS**
1	5		TWISTED
10	10		PAIR
2	4		TWISTED
11	9		PAIR
3	3		TWISTED
12	8		PAIR
4	2		TWISTED
13	7		PAIR
5	1		TWISTED
14	6		PAIR
6		4	TWISTED
15		8	PAIR
7		3	TWISTED
16		7	PAIR
8		2	TWISTED
17		6	PAIR
9		1	TWISTED
18		5	PAIR

ITEM NO.	PART NUMBER	QUANTITY	MATERIAL
1	**TP-20-09-10-T-105-3-0.50**	22.960	TEFLON, COLOR: WHITE/BLACK
2	IPD1-09-D-K	1.0000	ZYTEL 103FHS, COLOR: NATURAL
3	IPD1-05-D-K	1.0000	ZYTEL 103FHS, COLOR: NATURAL
4	IPD1-04-D-K	1.0000	ZYTEL 103FHS, COLOR: NATURAL
5	C-179-03-L	36.000	PHOS BRONZE, 510 SPRING TEMPER

UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES.
TOLERANCES ARE:
DECIMALS ANGLES
.XX: ±.01[0.3] 2°
.XXX: ±.005[0.13]
.XXXX: ±.0020[0.051]

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e-Mail info@SAMTEC.com code 55322

DO NOT SCALE DRAWING SHEET SCALE: 1:1
PLATING:
CONTACT AREA: .000010 GOLD OVER .000050 NICKEL
REMAINDER: .000200 REF BRIGHT ACID TIN OVER .000050 NICKEL
F:\DWG\SW\ASD\193000\ASD-193456-01.SLDDRW

DESCRIPTION:
MODIFIED .100 SOCKET DISCRETE CABLE ASM
DWG. NO. ASD-193456-01
BY: M MORA 06/01/2016 SHEET 1 OF 1

Figure 18: LV power cold cable for FEMB.

clock/control, and backup JTAG programming to each FEMB, for a total of 120 bundles. Prototype cable bundles are shown in Figure 17.

5.1 LV Cable

The LV cable bundles will be manufactured by Samtec. The assembly drawing is shown in Figure 18 and is in DUNE DocDB 1755 [12].

5.2 Data Cable

The data cable bundles will also be manufactured by Samtec. The assembly drawing is shown in Figure 19 and is in DUNE DocDB 1755 [12], along with documentation on the cable insulation material and the results from the cable burn testing from Fermilab Fire & Life Safety.

5.3 SHV Cable

Coaxial cable with SHV connectors will provide HV (< 3 kV) to the APA wire-bias, field cage termination, and electron diverters inside the cryostat. Each TPC requires 8 SHV cables, with all 8 passing through the CE flange on SHV connectors attached directly to the stainless steel and electrically isolated from

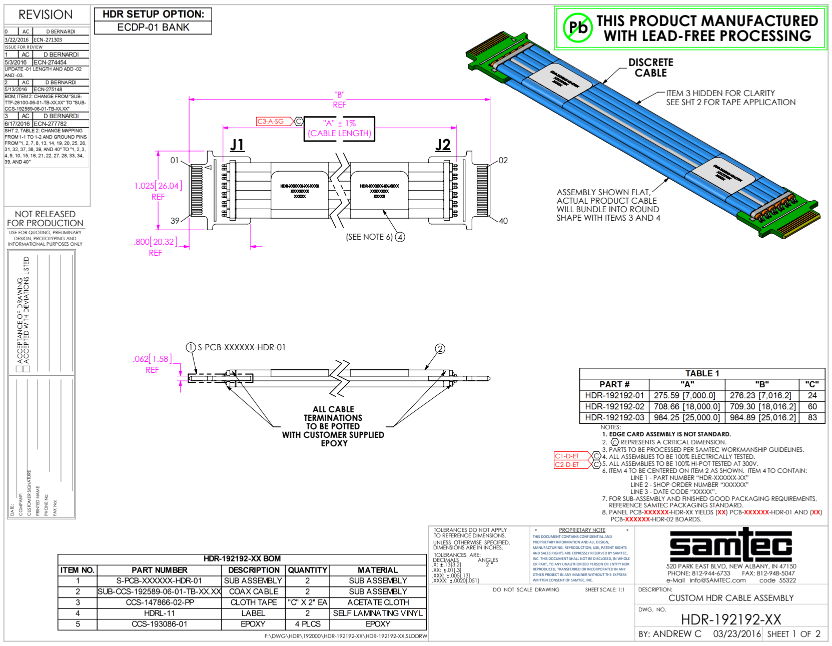

TABLE 1			
PART #	"A"	"B"	"C"
HDR-192192-01	275.59 [7,000.0]	276.23 [7,016.2]	24
HDR-192192-02	708.66 [18,000.0]	709.30 [18,016.2]	60
HDR-192192-03	984.25 [25,000.0]	984.89 [25,016.2]	83

NOTES:
1. **EDGE CARD ASSEMBLY IS NOT STANDARD.**
2. Ⓒ REPRESENTS A CRITICAL DIMENSION.
3. PARTS TO BE PROCESSED PER SAMTEC WORKMANSHIP GUIDELINES.
4. ALL ASSEMBLIES TO BE 100% ELECTRICALLY TESTED.
5. ALL ASSEMBLIES TO BE 100% HI-POT TESTED AT 300V.
6. ITEM 4 TO BE CENTERED ON ITEM 2 AS SHOWN. ITEM 4 TO CONTAIN:
   LINE 1 - PART NUMBER “HDR-XXXXXX-XX”
   LINE 2 - SHOP ORDER NUMBER “XXXXXX”
   LINE 3 - DATE CODE “XXXXX”.
7. FOR SUB-ASSEMBLY AND FINISHED GOOD PACKAGING REQUIREMENTS, REFERENCE SAMTEC PACKAGING STANDARD.
8. PANEL PCB-XXXXXX-HDR-XX YIELDS (XX) PCB-XXXXXX-HDR-01 AND (XX) PCB-XXXXXX-HDR-02 BOARDS.

HDR-192192-XX BOM				
ITEM NO.	PART NUMBER	DESCRIPTION	QUANTITY	MATERIAL
1	S-PCB-XXXXXX-HDR-01	SUB ASSEMBLY	2	SUB ASSEMBLY
2	SUB-CCS-192589-06-01-TB-XX.XX	COAX CABLE	2	SUB ASSEMBLY
3	CCS-147866-02-PP	CLOTH TAPE	"C" X 2" EA	ACETATE CLOTH
4	HDRL-11	LABEL	2	SELF LAMINATING VINYL
5	CCS-193086-01	EPOXY	4 PLCS	EPOXY

F:\DWG\HDR\192000\HDR-192192-XX\HDR-192192-XX.SLDDRW

TOLERANCES DO NOT APPLY TO REFERENCE DIMENSIONS.
UNLESS OTHERWISE SPECIFIED, DIMENSIONS ARE IN INCHES.
TOLERANCES ARE:
DECIMALS ANGLES
.X: ±.13[3.2] 2°
.XX: ±.01[.3]
.XXX: ±.005[.13]
.XXXX: ±.0020[.051]

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DO NOT SCALE DRAWING SHEET SCALE: 1:1

520 PARK EAST BLVD, NEW ALBANY, IN 47150
PHONE: 812-944-6733 FAX: 812-948-5047
e-Mail info@SAMTEC.com code 55322

DESCRIPTION: CUSTOM HDR CABLE ASSEMBLY
DWG. NO. HDR-192192-XX
BY: ANDREW C 03/23/2016 SHEET 1 OF 2

Figure 19: Data cold cable for FEMB.

the CE flange PCB. These will be manufactured by a vendor specified by Fermilab.

5.4 QC

Samtec will provide certification of cable continuity at room temperature for all bundles. 10% of the data cable bundles received at BNL will be tested in the cold cable test setup to ascertain the cryogenic yield. The criteria to pass is a Bit Error Rate better than 10^{-13} without loss after active equalization.

Assuming the yield is high, both LV and data cable bundles will be assembled into FEMB units: with FEMB, CE Boxes, and cable attached. These will be the final FEMB units and must pass the electronics QC tests described in DUNE DocDB 1809 [5].

Each SHV cable will be tested to ensure that its connector can hold up to 3 kV in GAr.

6 Schedule

ProtoDUNE-SP cold electronics is scheduled to install beginning in June 2017 through early 2018 for data-taking in the CERN test beam in the fall of 2018, prior to the long shutdown at CERN. The driver of the ProtoDUNE-SP CE

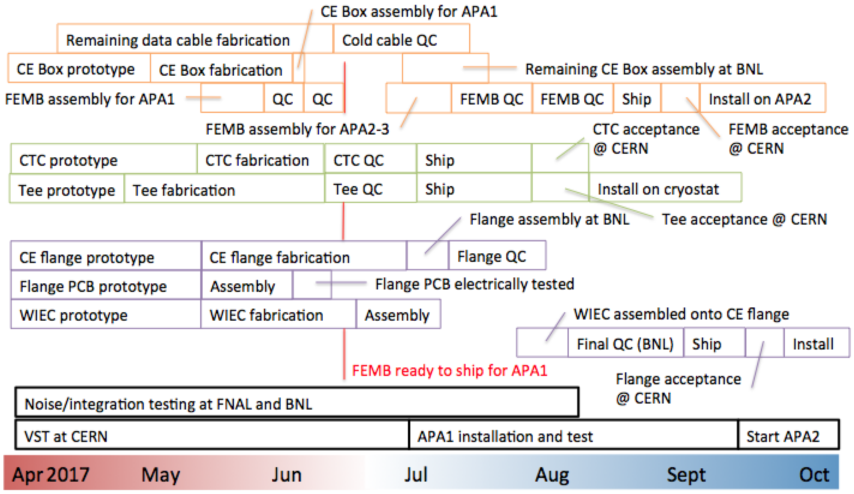

Figure 20: ProtoDUNE-SP mechanical component QA/QC, production and installation schedule from April 2017 through October 2017.

installation schedule is the production of the final FE and ADC ASICs, expected to be complete in May 2017.

The assembly and testing of the mechanical components must follow the installation schedule, and components must arrive at CERN by August 2017. To complete this, the schedule shown in Figure 20 has been developed. The final CE mechanical components to be ready to install at CERN are expected to be the warm flange assemblies.

7 Conclusion

The LArTPC CE mechanical system for the ProtoDUNE-SP detector includes everything from the CE Boxes in the LAr, through transmission of the digital wire data via the warm flange and WIEC. A comprehensive set of QA tests are ongoing for all components to ensure operation in the ProtoDUNE-SP detector within the requirements specified in [13]. The result of this QA program will be a full suite of QC validation testing at BNL during the summer of 2017, with all mechanical components validated prior to shipping to CERN.

Vendors for production of all mechanical assemblies have been identified and nearly all prototypes have been produced and tested. The schedule for installation and commissioning for the ProtoDUNE-SP cold electronics is aggressive, mostly due to the long shutdown at CERN driving the ProtoDUNE-SP detector construction and a mechanicals production and QC schedule to meet this goal has been developed.

References

[1] J. Strait et al. *Long-Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE) Conceptual Design Report Volume 3: Long-Baseline Neutrino Facility for DUNE June 24, 2015*. URL: `http://arxiv.org/abs/1601.05823`.

[2] R. Acciarri et al. *Long-Baseline Neutrino Facility (LBNF) and Deep Underground Neutrino Experiment (DUNE) Conceptual Design Report, Volume 4 The DUNE Detectors at LBNF*. URL: `http://arxiv.org/abs/1601.02984`.

[3] The DUNE Collaboration. *The Single Phase ProtoDUNE Technical Design Report*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=1794`.

[4] J. Fried. *ADC Serializer, FEMB Design*. URL: `https://indico.bnl.gov/conferenceDisplay.py?confId=2098`.

[5] Linda Bagby et al. *Cold Electronics QA/QC for SBND and ProtoDUNE-SP*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=1809`.

[6] Jessica Li and Jason Farrell. *ProtoDUNE Cold Electronics Box*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=2611`.

[7] Jason Farrell. *ProtoDUNE-SP Signal Feed-through Tee Pipe*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=2126`.

[8] Jason Farrell and Jessica Li. *ProtoDUNE-SP Signal Feed-through CTC Support*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=2883`.

[9] Jason Farrell. *ProtoDUNE-SP Cold Electronics Warm Flange*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=2771`.

[10] Jack Fried. *ProtoDUNE Prototype Flange Board*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=2777`.

[11] Jason Farrell. *ProtoDUNE-SP Cold Electronics Warm Interface Electronics Crate*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=2774`.

[12] Hucheng Chen. *Prototype ProtoDUNE Cold Cables*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=1755`.

[13] Matthew Worcester and Milind Diwan. *DUNE Cold Electronics Requirements*. URL: `http://docs.dunescience.org:8080/cgi-bin/ShowDocument?docid=1807`.