

# Cold Electronics: APA Wire Readout Connections

Matthew Worcester (BNL)  
representing the CE team

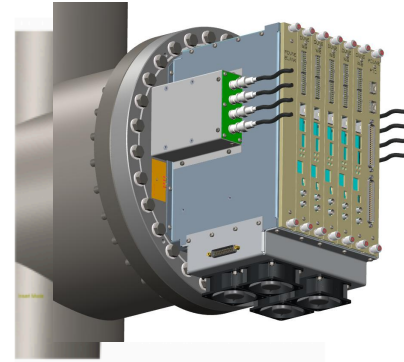
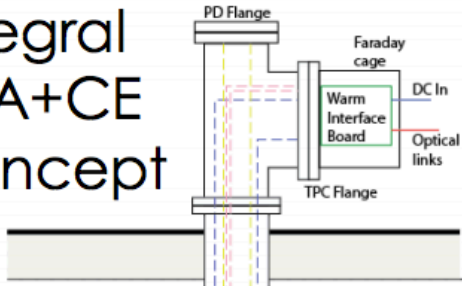
protoDUNE Electrical and Grounding Connections Review  
September 26, 2017

# Outline

- Cold Electronics
- Connections
  - To the APA
  - At the flange
- Channel Mapping
- Installation Procedures
- Summary

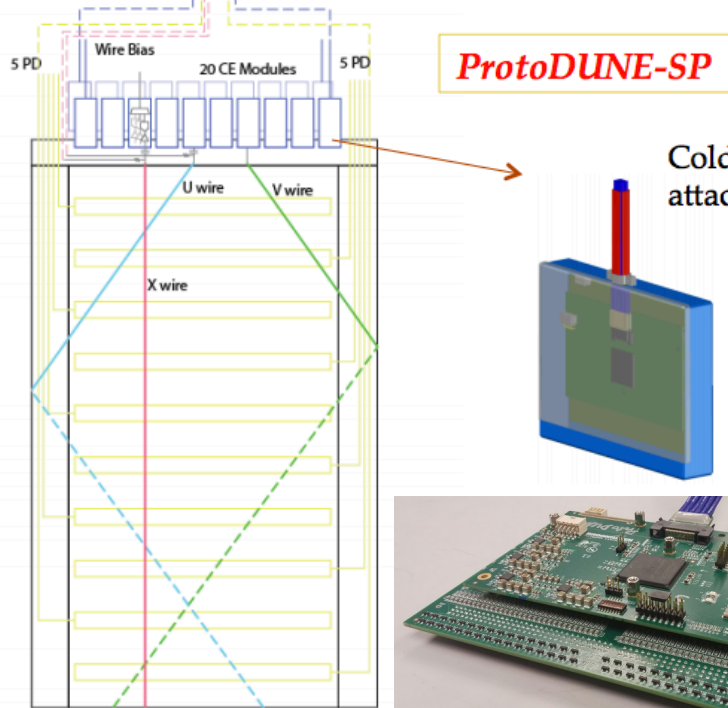
# Integrated LArTPC Readout

Integral  
APA+CE  
Concept



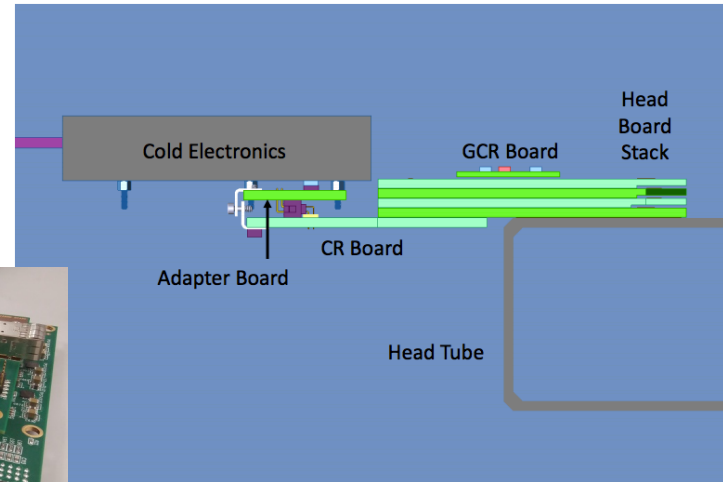
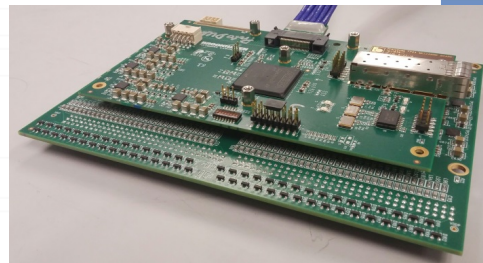
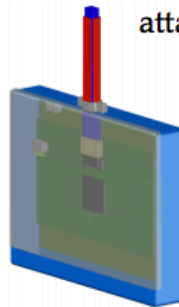
Each APA is isolated inside the cryostat and only connected to the detector ground through the CE at its own CE flange.

Warm Interface Electronics: interface from CE to DAQ with shielding and local real-time diagnostics.



*ProtoDUNE-SP*

Cold electronics module and its attachment to the APA frame

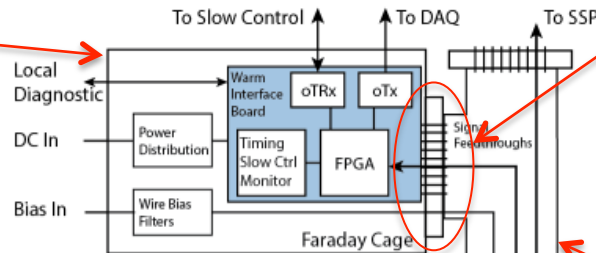


# protoDUNE-SP Cold Electronics

## Warm electronics

Warm Interface Electronics Crate

- Warm Interface Board
- Power and Timing Card
- Power and Timing Backplane



## CE flange

Flange assembly with cable strain relief and flange PCB for cable/WIB connection

## Signal feed-through

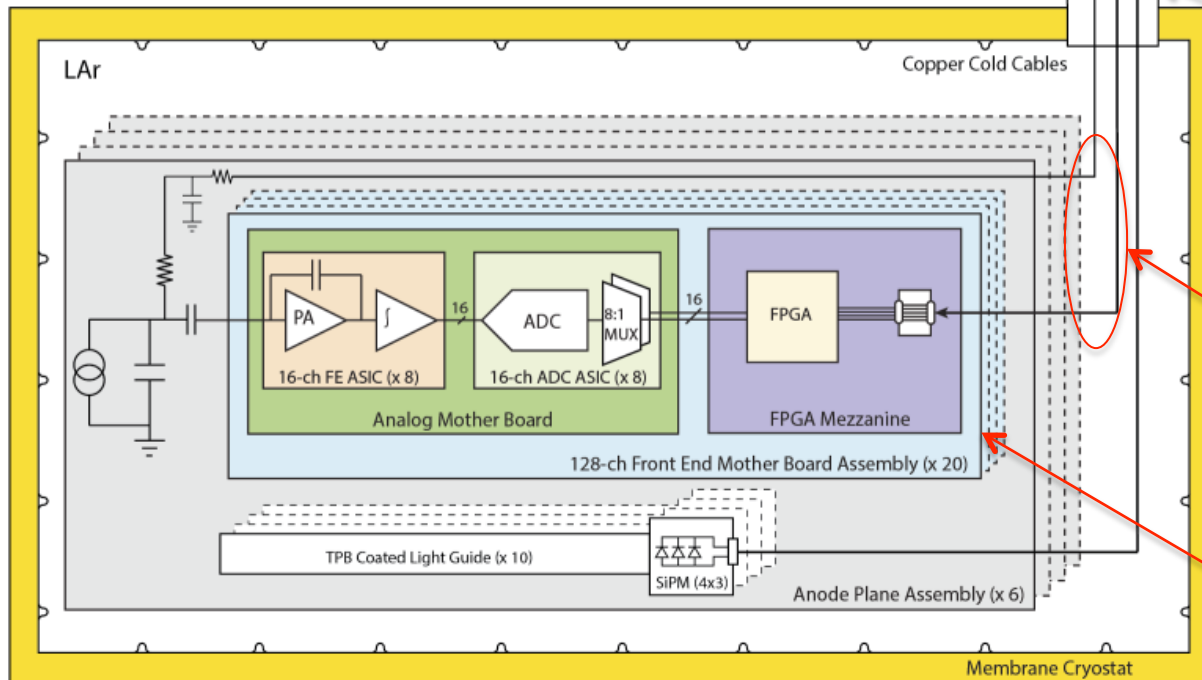
Tee pipe with 14" Conflat flanges and crossing tube cable (CTC) support

## Cold cable to FEMB

LV and data cable and APA wire-bias SHV cable

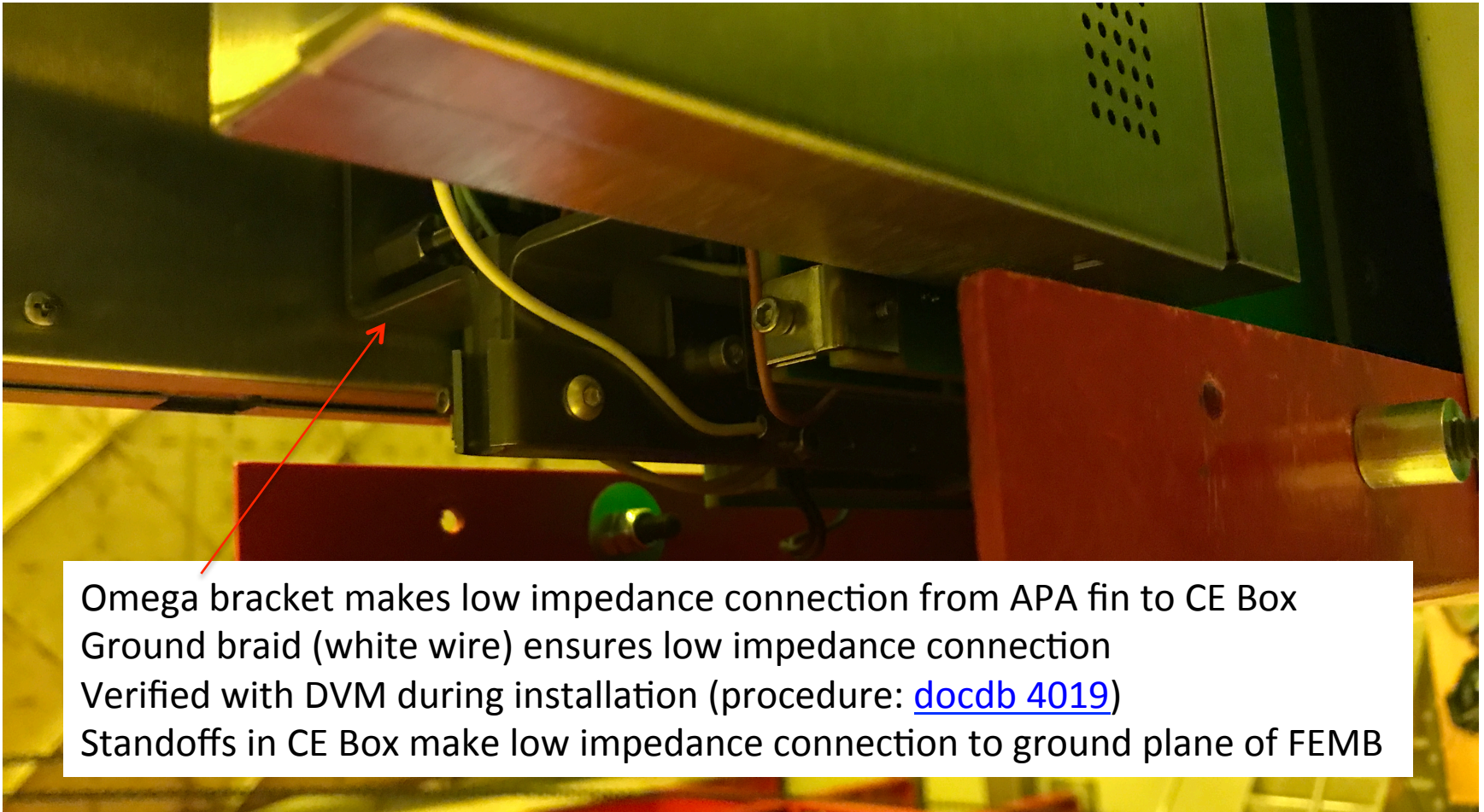
## Front End Motherboard

(FEMB) 128 channels of digitized wire readout enclosed in CE Box



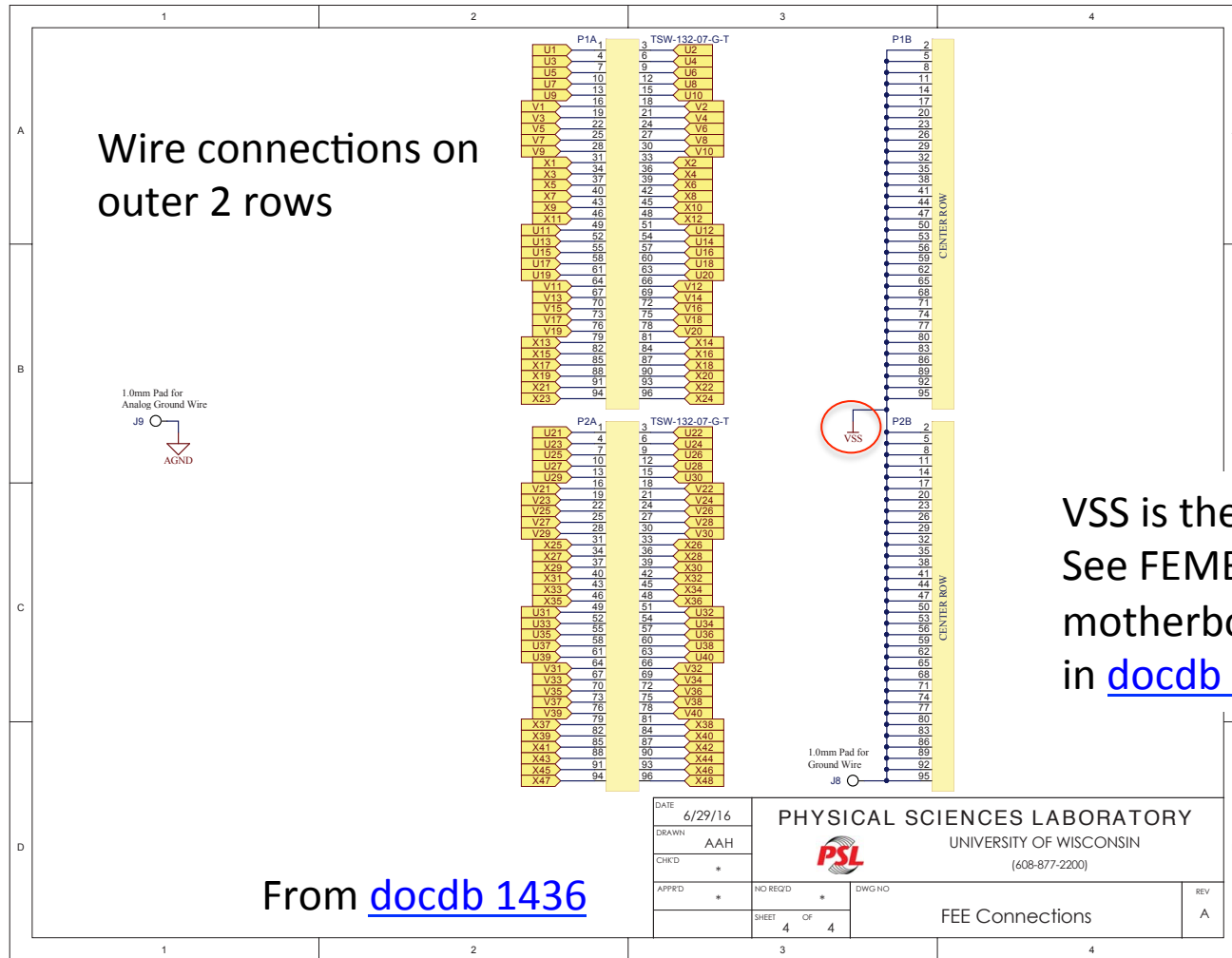


# CE Box to APA Frame Connection



Omega bracket makes low impedance connection from APA fin to CE Box  
Ground braid (white wire) ensures low impedance connection  
Verified with DVM during installation (procedure: [docdb 4019](#))  
Standoffs in CE Box make low impedance connection to ground plane of FEMB

# APA Wire to FE Connections



VSS is the power return  
See FEMB analog  
motherboard schematics  
in [docdb 1419](#)

From [docdb 1436](#)

# Cold LV Cable

| REVISION   |    |          |
|--|----|----------|
| 0  | MM | B Layers |
| 8/1/2016 ECN-276393  |    |          |
| ISSUE FOR REVIEW   |    |          |
| NOT RELEASED FOR PRODUCTION<br>USE FOR QUALITY, PRELIMINARY DESIGN, PROTOTYPING AND INFORMATIONAL PURPOSES ONLY  |    |          |
| BY SIGNING THIS DOCUMENT YOU ARE ACCEPTING THE CONDITIONS SET WITHIN. LISTED WITHIN THIS DRAWING WHERE NO DIRECTION FROM THE SAME'S PROCESS REQUIREMENTS WILL BE USED. |    |          |
| DATE: _____<br>COMPANY: _____<br>CUSTOMER SIGNATURE: _____<br>PRINTED NAME: _____<br>PHONE NO: _____<br>EXCEPTION: _____   |    |          |

**NOTES:**

- ITEM 1 AND PIN OUT NOT AVAILABLE AS STANDARD.**
- REPRESENTS A CRITICAL DIMENSION.
- REFER TO CRIMP SPECIFICATIONS PRINT FOR CRIMP AND STRIP DIMENSIONS, TOLERANCES, TOOLING, AND ITS REQUIREMENTS.
- REFER TO MMSDX-XX-XXX-X-XX.XX-X-X-XXX PRINT FOR IN-PROCESS VIEWS, DIMENSIONS, CRITICALS, ETC.
- 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).
- 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.
- PARTS TO BE PACKAGED IN LAYERS.

| C3-B-VE |    |    |              |
|---------|----|----|--------------|
| P1      | P2 | P3 | PAIRS        |
| 1       | 5  |    | TWISTED PAIR |
| 10      | 10 |    | TWISTED PAIR |
| 2       | 4  |    | TWISTED PAIR |
| 11      | 9  |    | TWISTED PAIR |
| 3       | 3  |    | TWISTED PAIR |
| 12      | 8  |    | TWISTED PAIR |
| 4       | 2  |    | TWISTED PAIR |
| 13      | 7  |    | TWISTED PAIR |
| 5       | 1  |    | TWISTED PAIR |
| 14      | 6  |    | TWISTED PAIR |
| 6       | 4  |    | TWISTED PAIR |
| 15      | 8  |    | TWISTED PAIR |
| 7       | 3  |    | TWISTED PAIR |
| 16      | 7  |    | TWISTED PAIR |
| 8       | 2  |    | TWISTED PAIR |
| 17      | 6  |    | TWISTED PAIR |
| 9       | 1  |    | TWISTED PAIR |
| 18      | 5  |    | TWISTED PAIR |

Power return at FEMB FM

Power return at flange PCB

Power return at FEMB AM

9x 20 AWG twisted pair

From [docdb 1755](#)

| 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: 2°

XXX: ±.01(0.3)

XXXX: ±.005(0.13)

XXXXX: ±.0020(0.051)

DO NOT SCALE DRAWING SHEET SCALE: 1:1

FLATING: CONTACT AREA: 000010 GOLD OVER .000050 NICKEL  
REMAINDER: 000020 REF BRIGHT ACID TIN OVER .000050 NICKEL

F:\DWG\SW\FASD\193000\ASD-193456-01.SLDDRW

**SECRETARY NOTE**

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**samtec**

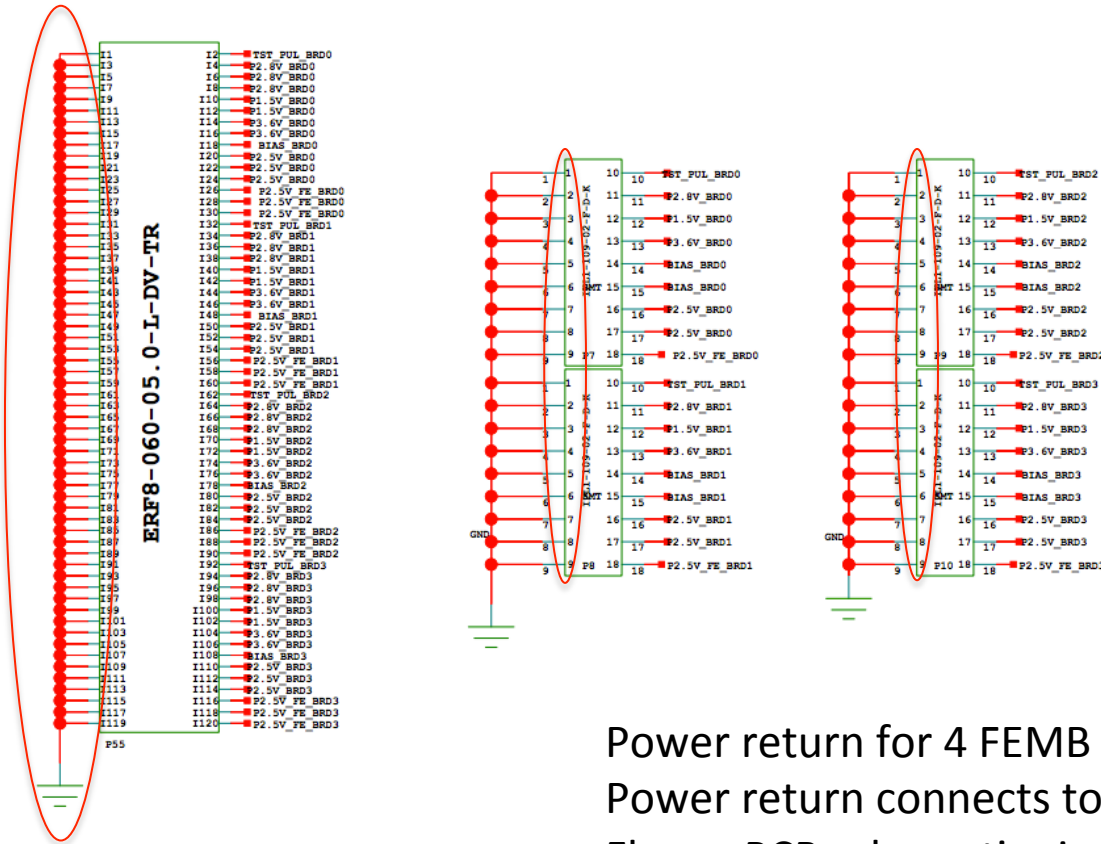
520 PARK EAST BLVD, NEW ALBANY, IN 47150  
PHONE: 812-944-6733 FAX: 812-948-5047  
e-Mail: info@SAMTEC.com code 55322

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

Mezzanine schematics:  
[docdb 1419](#)

# Power Return at the Flange

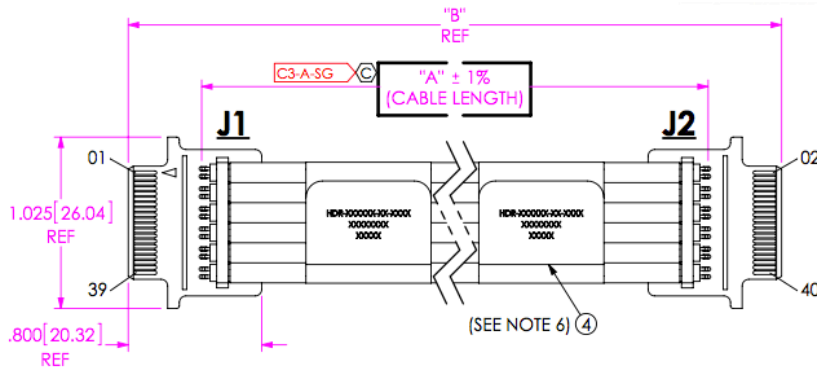
Return from WIB LV output connected to ground at flange



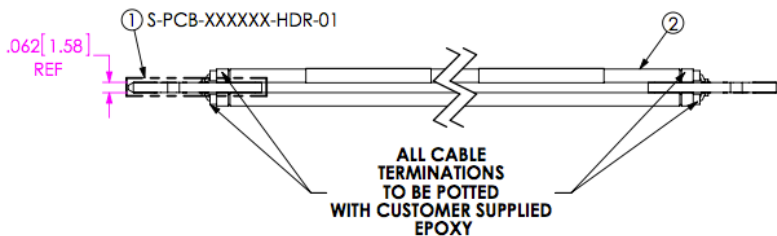
Power return for 4 FEMB (1 WIB)  
Power return connects to ground at flange  
Flange PCB schematics in [docdb 2777](#)

# Cold Data Cable

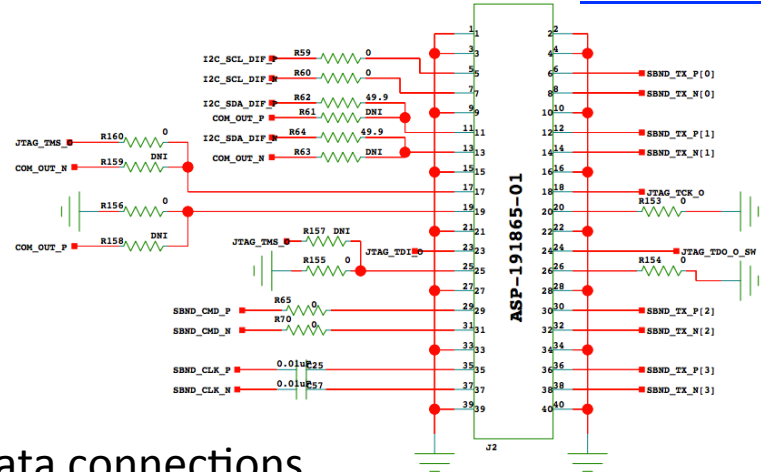
12 twin-axial 26 AWG cables  
High-speed data, clock, control, programming  
Cable drawings in [docdb 1755](#)



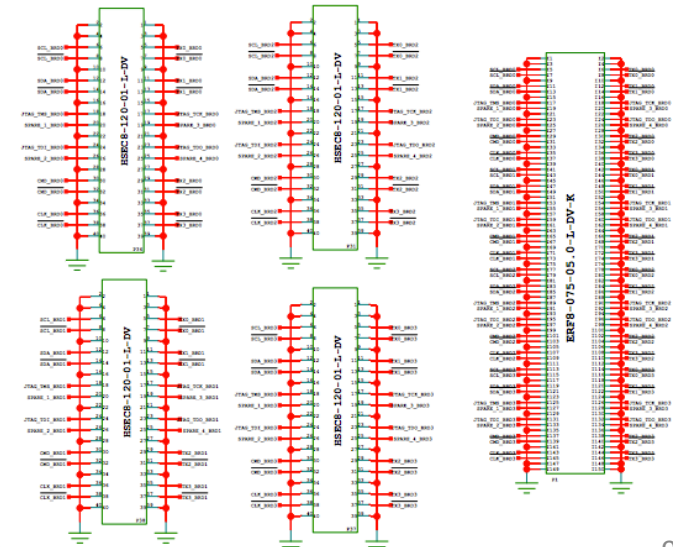
[docdb 2777](#)



[docdb 1419](#)



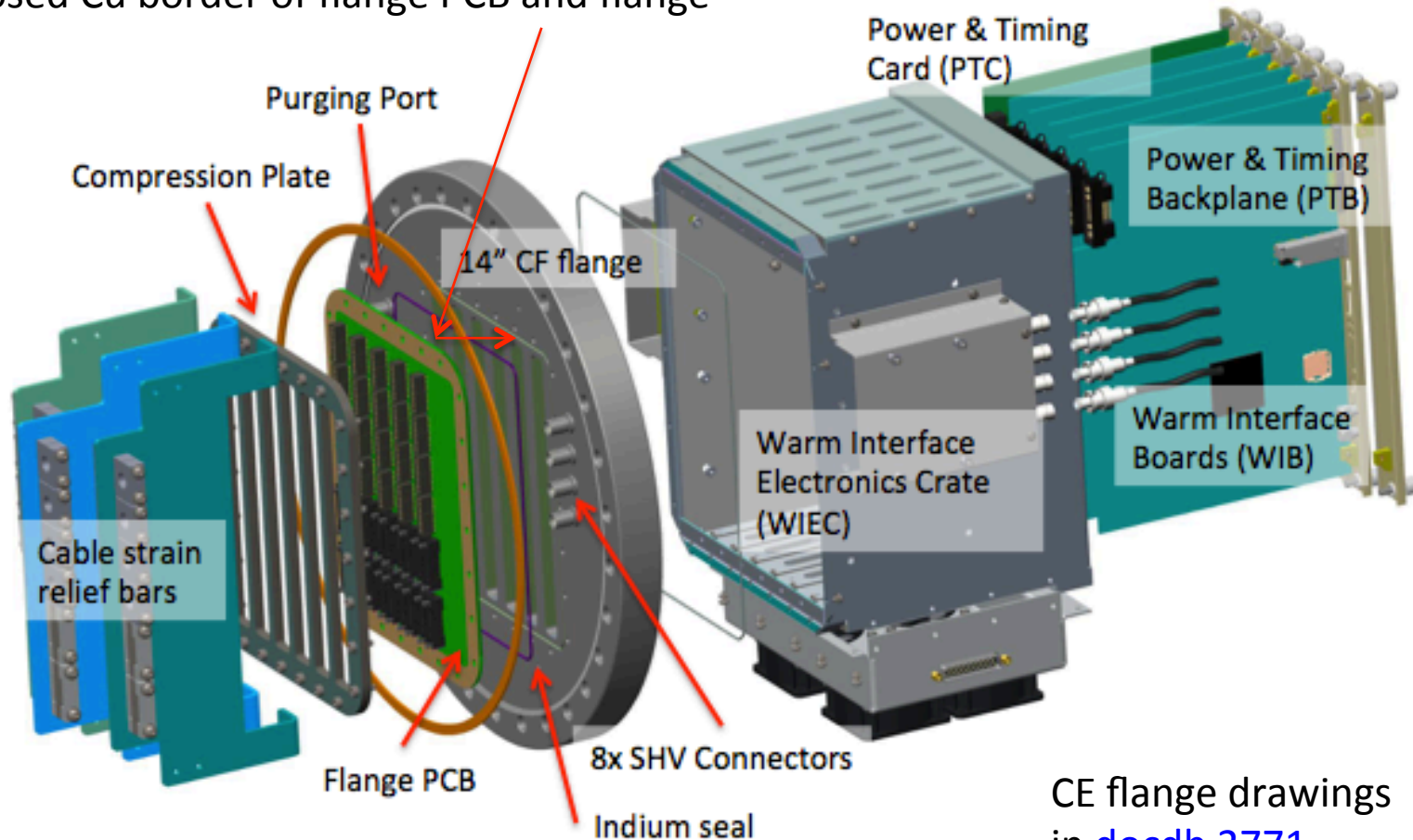
Data connections  
at FPGA mezzanine and flange PCB





# CE Flange

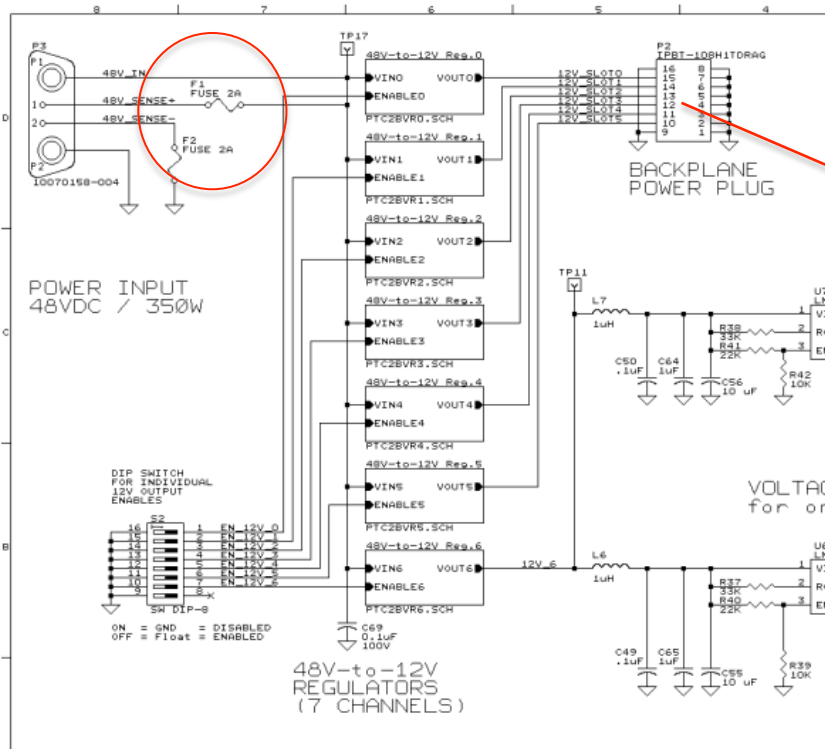
Ground connection made physically between exposed Cu border of flange PCB and flange



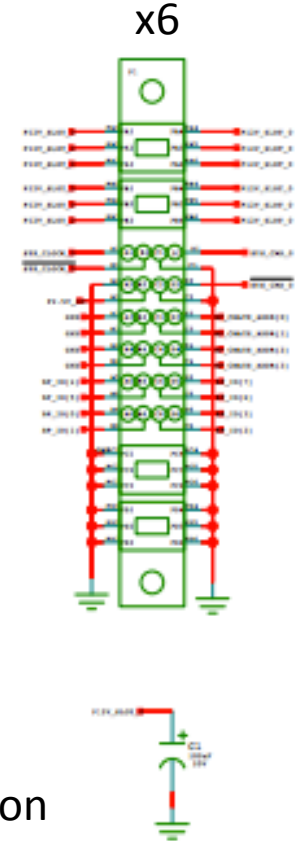
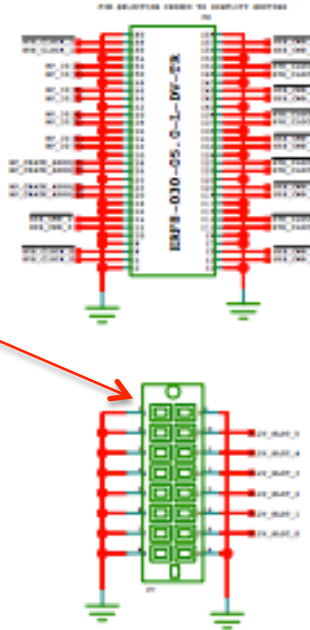
CE flange drawings in [docdb 2771](#)

# LV Power to the WIB

48V in from Weiner PL506: [docdb 1959](#)  
2x10 AWG power and 2x20 AWG sense lines  
Sense lines fused on Power & Timing Card



PTC V2 schematics  
in [docdb 2988](#)



PTC ground connection  
made to flange via power  
connector on Power & Timing Backplane.  
Full PTB schematics in [docdb 3327](#)

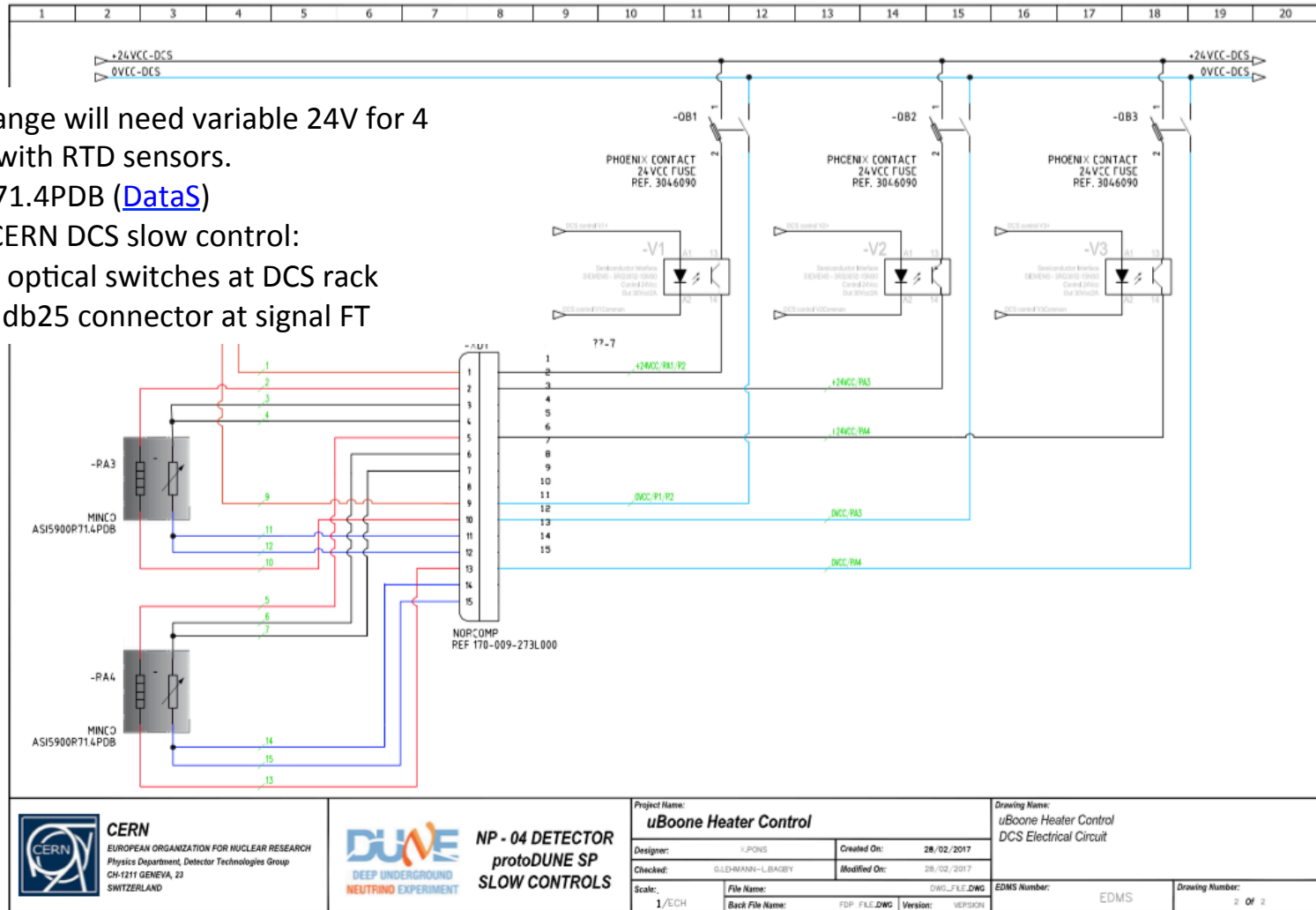
# Flange Heaters

Each PD and CE flange will need variable 24V for 4 adhesive heaters with RTD sensors.

MINCO ASI5900R71.4PDB ([DataS](#))

24V provided by CERN DCS slow control:

- isolate 24V with optical switches at DCS rack
- isolate shield of db25 connector at signal FT

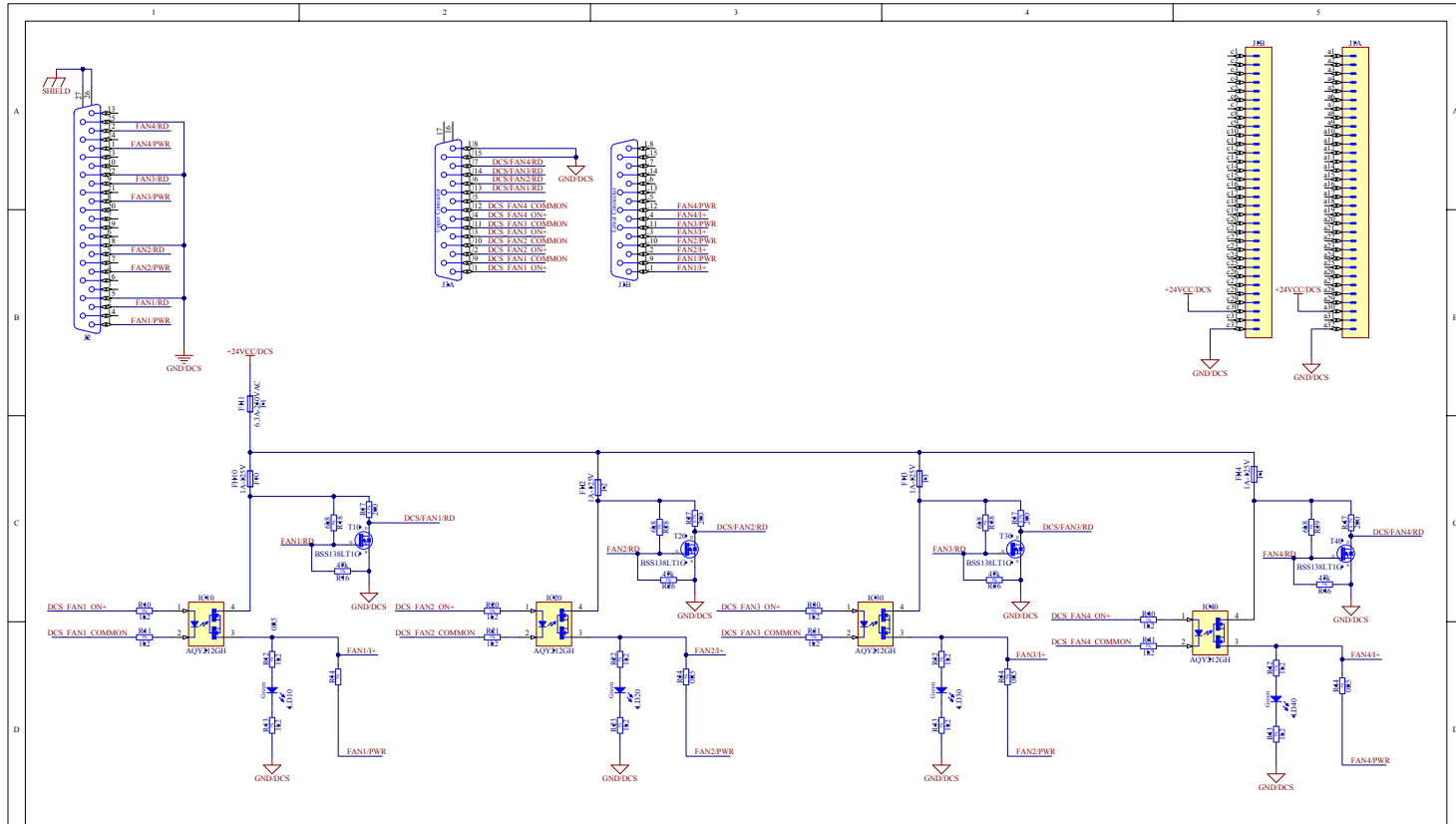


|   |                            |
|---|----------------------------|
| Project Name:<br><b>uBoone Heater Control</b> |                            |
| Designer:<br>J.FONS                           | Created On:<br>28/02/2017  |
| Checked:<br>GILDHANN-LIBBY                    | Modified On:<br>28/02/2017 |
| Scale:<br>1/ECH                               | File Name:<br>DWG_FILE.DWG |
| Back File Name:<br>FDP_FILE.DWG               | Version:<br>VERSION        |


|  |                           |
|--|---------------------------|
| Drawing Name:<br><b>uBoone Heater Control<br/>DCS Electrical Circuit</b> |                           |
| EDMS Number:<br>EDMS   | Drawing Number:<br>2 Of 2 |



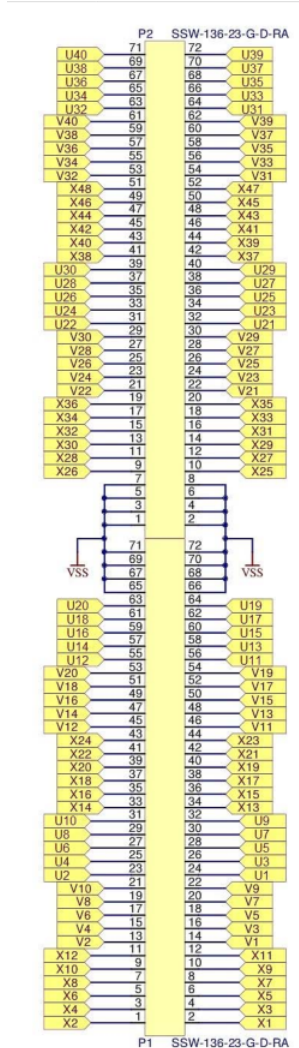
# WIEC Fans



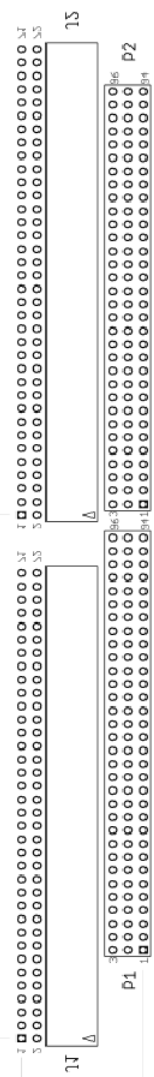
- Each WIEC is cooled by 4 brushless fans supplied by DCS power supply up to 24V
  - Aavid PEAD26025BH ([data sheet](#))
  - Isolate 24V with optical switches at DCS
  - Isolate shield of DB25 connector at signal FT

|  |  |            |                           |
|--|--|------------|---------------------------|
| Project/Equipment  |  | -          |                           |
| Document   |  | Designer   | X Pons                    |
| EP-DT-DD   |  | Drawn by   | X Pons                    |
|   |  | Checked by | M Worcesster              |
| <p style="text-align: center;"><b>protoDUNE SP</b><br/><b>WIEC FAN Control V10</b></p>   |  | Lead Mod   | X Pons                    |
| <p style="text-align: center;"><small>European Organization for Nuclear Research<br/>CH-1211 Geneva 23 - Switzerland</small></p> |  | Proj       | WIEC Fan Power V10 S01006 |
|  |  | Print Date | 02.06.2017 11:04:01       |
|  |  |            | Sheet 1 of 1              |
|  |  | EDA-       | A3                        |

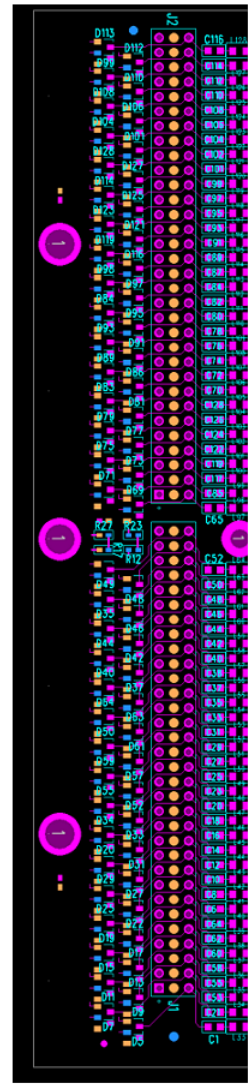
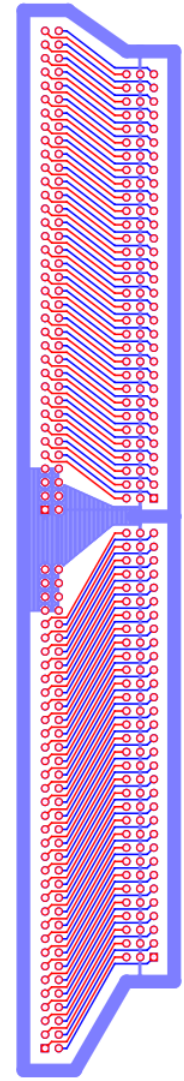
# protoDUNE Mapping



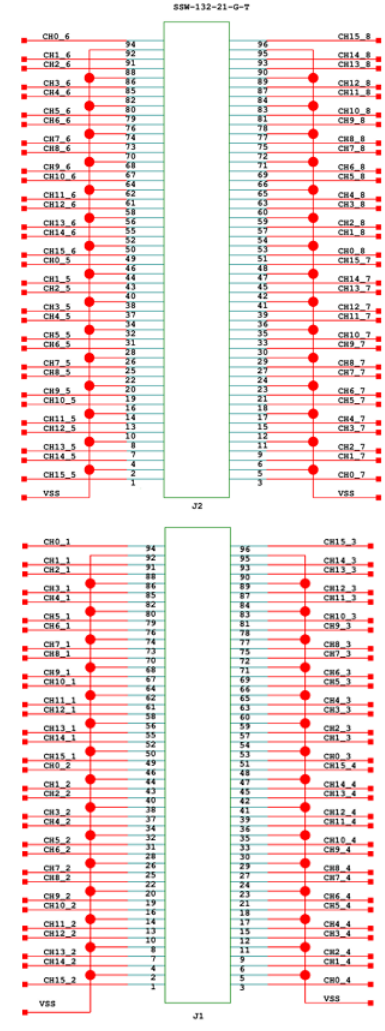
**CR board from DUNE  
Docdb 1482**



**CR adapter from DUNE  
Docdb 2060**



**Analog Mother Brd (IO-1637-1C)**



# Wire to FE Channel Matrix

| Plane | Wire (m) | Pin number |             |             |       |
|-------|----------|------------|-------------|-------------|-------|
|       |          | CR.P1      | CR Adpt. J1 | CR Adpt. P1 | AM J1 |
| X2    |          | 1          | 1           | 3           | 3     |
| X4    |          | 3          | 3           | 6           | 6     |
| X6    |          | 5          | 5           | 9           | 9     |
| X8    |          | 7          | 7           | 12          | 12    |
| X10   |          | 9          | 9           | 15          | 15    |
| X12   |          | 11         | 11          | 18          | 18    |
| V2    |          | 13         | 13          | 21          | 21    |
| V4    |          | 15         | 15          | 24          | 24    |
| V6    |          | 17         | 17          | 27          | 27    |
| V8    |          | 19         | 19          | 30          | 30    |
| V10   |          | 21         | 21          | 33          | 33    |
| U2    |          | 23         | 23          | 36          | 36    |
| U4    |          | 25         | 25          | 39          | 39    |
| U6    |          | 27         | 27          | 42          | 42    |
| U8    |          | 29         | 29          | 45          | 45    |
| U10   |          | 31         | 31          | 48          | 48    |
| X14   |          | 33         | 33          | 51          | 51    |
| X16   |          | 35         | 35          | 54          | 54    |
| X18   |          | 37         | 37          | 57          | 57    |
| X20   |          | 39         | 39          | 60          | 60    |
| X22   |          | 41         | 41          | 63          | 63    |
| X24   |          | 43         | 43          | 66          | 66    |
| V12   |          | 45         | 45          | 69          | 69    |
| V14   |          | 47         | 47          | 72          | 72    |
| V16   |          | 49         | 49          | 75          | 75    |
| V18   |          | 51         | 51          | 78          | 78    |
| V20   |          | 53         | 53          | 81          | 81    |
| U12   |          | 55         | 55          | 84          | 84    |
| U14   |          | 57         | 57          | 87          | 87    |
| U16   |          | 59         | 59          | 90          | 90    |
| U18   |          | 61         | 61          | 93          | 93    |
| U20   |          | 63         | 63          | 96          | 96    |

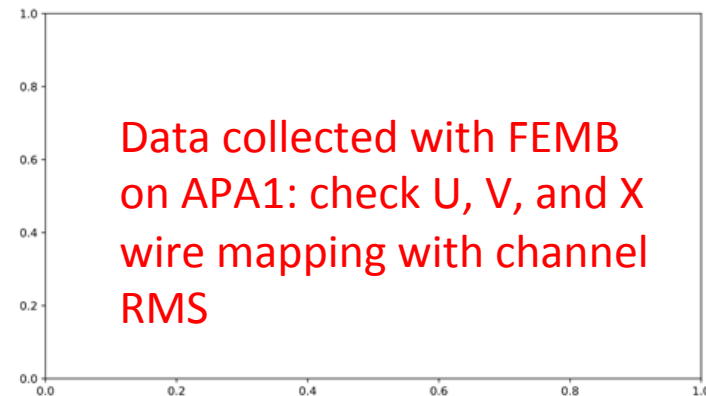
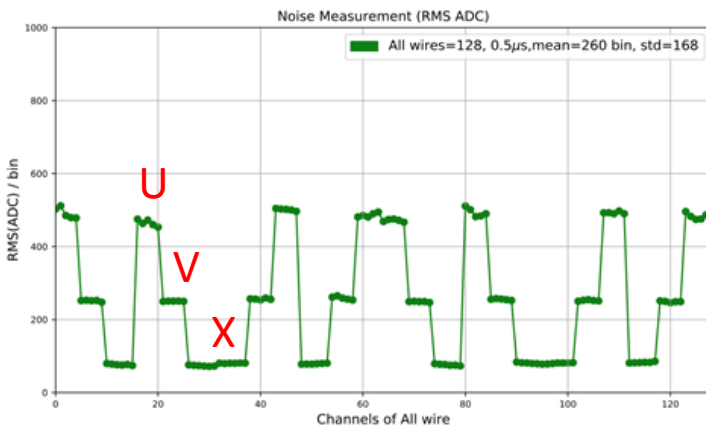
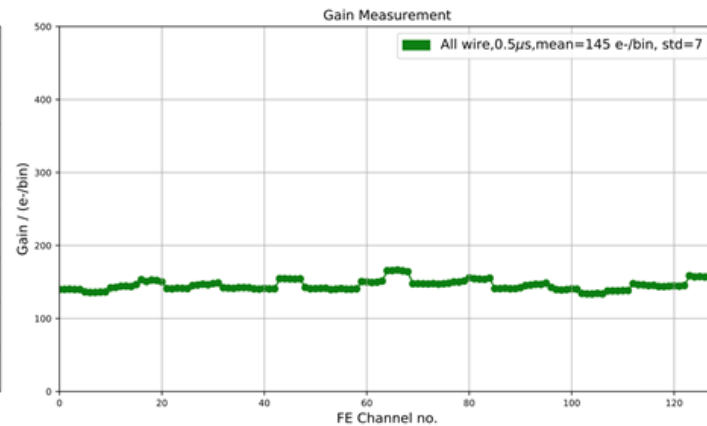
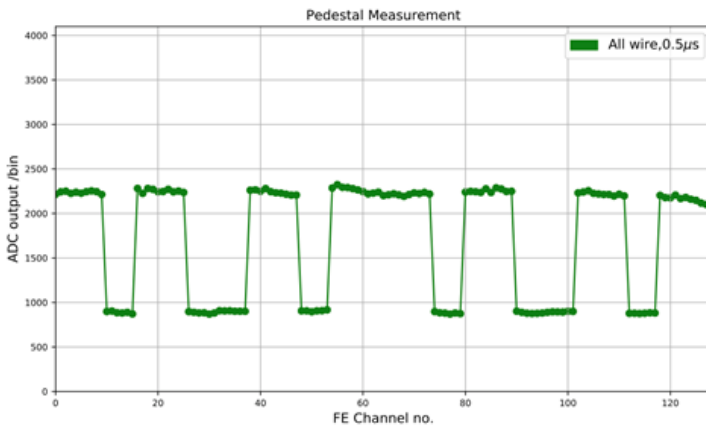
| Plane | Wire (m) | Pin number |             |             |       |
|-------|----------|------------|-------------|-------------|-------|
|       |          | CR.P1      | CR Adpt. J1 | CR Adpt. P1 | AM J1 |
| X1    |          | 2          | 2           | 1           | 1     |
| X3    |          | 4          | 4           | 4           | 4     |
| X5    |          | 6          | 6           | 7           | 7     |
| X7    |          | 8          | 8           | 10          | 10    |
| X9    |          | 10         | 10          | 13          | 13    |
| X11   |          | 12         | 12          | 16          | 16    |
| V1    |          | 14         | 14          | 19          | 19    |
| V3    |          | 16         | 16          | 22          | 22    |
| V5    |          | 18         | 18          | 25          | 25    |
| V7    |          | 20         | 20          | 28          | 28    |
| V9    |          | 22         | 22          | 31          | 31    |
| U1    |          | 24         | 24          | 34          | 34    |
| U3    |          | 26         | 26          | 37          | 37    |
| U5    |          | 28         | 28          | 40          | 40    |
| U7    |          | 30         | 30          | 43          | 43    |
| U9    |          | 32         | 32          | 46          | 46    |
| X13   |          | 34         | 34          | 49          | 49    |
| X15   |          | 36         | 36          | 52          | 52    |
| X17   |          | 38         | 38          | 55          | 55    |
| X19   |          | 40         | 40          | 58          | 58    |
| X21   |          | 42         | 42          | 61          | 61    |
| X23   |          | 44         | 44          | 64          | 64    |
| V11   |          | 46         | 46          | 67          | 67    |
| V13   |          | 48         | 48          | 70          | 70    |
| V15   |          | 50         | 50          | 73          | 73    |
| V17   |          | 52         | 52          | 76          | 76    |
| V19   |          | 54         | 54          | 79          | 79    |
| U11   |          | 56         | 56          | 82          | 82    |
| U13   |          | 58         | 58          | 85          | 85    |
| U15   |          | 60         | 60          | 88          | 88    |
| U17   |          | 62         | 62          | 91          | 91    |
| U19   |          | 64         | 64          | 94          | 94    |

# Wire to FE Channel Matrix II

| Plane | Wire (m) | Pin number |             |             |       |
|-------|----------|------------|-------------|-------------|-------|
|       |          | CR.P2      | CR Adpt. J2 | CR Adpt. P2 | AM J2 |
| X26   |          | 9          | 9           | 3           | 3     |
| X28   |          | 11         | 11          | 6           | 6     |
| X30   |          | 13         | 13          | 9           | 9     |
| X32   |          | 15         | 15          | 12          | 12    |
| X34   |          | 17         | 17          | 15          | 15    |
| X36   |          | 19         | 19          | 18          | 18    |
| V22   |          | 21         | 21          | 21          | 21    |
| V24   |          | 23         | 23          | 24          | 24    |
| V26   |          | 25         | 25          | 27          | 27    |
| V28   |          | 27         | 27          | 30          | 30    |
| V30   |          | 29         | 29          | 33          | 33    |
| U22   |          | 31         | 31          | 36          | 36    |
| U24   |          | 33         | 33          | 39          | 39    |
| U26   |          | 35         | 35          | 42          | 42    |
| U28   |          | 37         | 37          | 45          | 45    |
| U30   |          | 39         | 39          | 48          | 48    |
| X38   |          | 41         | 41          | 51          | 51    |
| X40   |          | 43         | 43          | 54          | 54    |
| X42   |          | 45         | 45          | 57          | 57    |
| X44   |          | 47         | 47          | 60          | 60    |
| X46   |          | 49         | 49          | 63          | 63    |
| X48   |          | 51         | 51          | 66          | 66    |
| V32   |          | 53         | 53          | 69          | 69    |
| V34   |          | 55         | 55          | 72          | 72    |
| V36   |          | 57         | 57          | 75          | 75    |
| V38   |          | 59         | 59          | 78          | 78    |
| V40   |          | 61         | 61          | 81          | 81    |
| U32   |          | 63         | 63          | 84          | 84    |
| U34   |          | 65         | 65          | 87          | 87    |
| U36   |          | 67         | 67          | 90          | 90    |
| U38   |          | 69         | 69          | 93          | 93    |
| U40   |          | 71         | 71          | 96          | 96    |

| Plane | Wire (m) | Pin number |             |             |       |
|-------|----------|------------|-------------|-------------|-------|
|       |          | CR.P2      | CR Adpt. J2 | CR Adpt. P2 | AM J2 |
| X25   |          | 10         | 10          | 1           | 1     |
| X27   |          | 12         | 12          | 4           | 4     |
| X29   |          | 14         | 14          | 7           | 7     |
| X31   |          | 16         | 16          | 10          | 10    |
| X33   |          | 18         | 18          | 13          | 13    |
| X35   |          | 20         | 20          | 16          | 16    |
| V21   |          | 22         | 22          | 19          | 19    |
| V23   |          | 24         | 24          | 22          | 22    |
| V25   |          | 26         | 26          | 25          | 25    |
| V27   |          | 28         | 28          | 28          | 28    |
| V29   |          | 30         | 30          | 31          | 31    |
| U21   |          | 32         | 32          | 34          | 34    |
| U23   |          | 34         | 34          | 37          | 37    |
| U25   |          | 36         | 36          | 40          | 40    |
| U27   |          | 38         | 38          | 43          | 43    |
| U29   |          | 40         | 40          | 46          | 46    |
| X37   |          | 42         | 42          | 49          | 49    |
| X39   |          | 44         | 44          | 52          | 52    |
| X41   |          | 46         | 46          | 55          | 55    |
| X43   |          | 48         | 48          | 58          | 58    |
| X45   |          | 50         | 50          | 61          | 61    |
| X47   |          | 52         | 52          | 64          | 64    |
| V31   |          | 54         | 54          | 67          | 67    |
| V33   |          | 56         | 56          | 70          | 70    |
| V35   |          | 58         | 58          | 73          | 73    |
| V37   |          | 60         | 60          | 76          | 76    |
| V39   |          | 62         | 62          | 79          | 79    |
| U31   |          | 64         | 64          | 82          | 82    |
| U33   |          | 66         | 66          | 85          | 85    |
| U35   |          | 68         | 68          | 88          | 88    |
| U37   |          | 70         | 70          | 91          | 91    |
| U39   |          | 72         | 72          | 94          | 94    |

# Pedestals



Channel pedestals applied with AC coupling between FE and ADC ASICs  
U/V wires have high baseline and X wires have low baseline

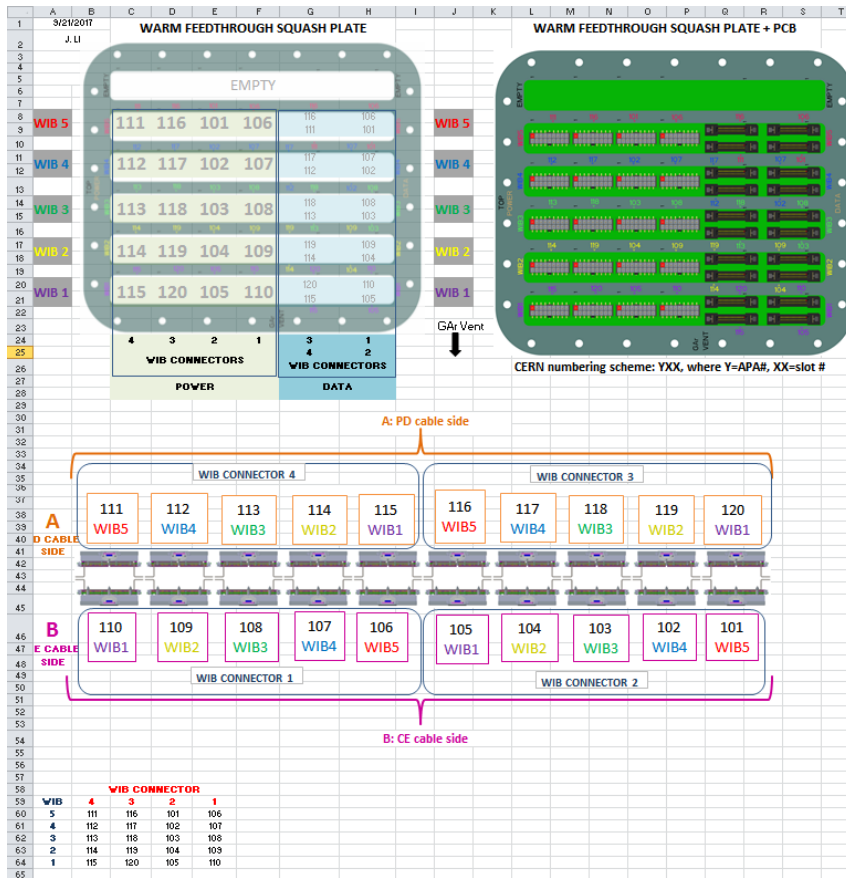
# FEMB to WIB Map

- TPC readout channel mapping document developed by B. Viren
  - Work in progress: [docdb 4064](#)
- Proposal for FEMB to WIB cable map:

|                 |       |       |       |       |                 |       |       |       |       |
|-----------------|-------|-------|-------|-------|-----------------|-------|-------|-------|-------|
| Cryostat wall   |       |       |       |       |                 |       |       |       |       |
| WIB 5           | WIB 4 | WIB 3 | WIB 2 | WIB 1 | WIB 5           | WIB 4 | WIB 3 | WIB 2 | WIB 1 |
| WIB connector 4 |       |       |       |       | WIB connector 3 |       |       |       |       |
| APA Frame       |       |       |       |       |                 |       |       |       |       |
| WIB connector 1 |       |       |       |       | WIB connector 2 |       |       |       |       |
| WIB 1           | WIB 2 | WIB 3 | WIB 4 | WIB 5 | WIB 1           | WIB 2 | WIB 3 | WIB 4 | WIB 5 |
| TPC             |       |       |       |       |                 |       |       |       |       |

Table 10: FEMB-WIB connectivity proposal #1. The table shows mapping from the  $2 \times 10$  physical FEMB location on the top of the APA to WIB addresses following a  $1 \times 5 \times 4$  layout.

# FEMB to WIB Map



- Proposal will be implemented for cold box testing
- Preliminary APA slot to flange connector map developed
  - APA slot number scheme used for both CR board and CE Box installation
- CE Box ID matches label on CE data and LV cable bundles
  - CE Box ID mapped to APA slot in protoDUNE hardware DB



# WIB Data Format to DAQ

|    | Link B           |    |    |    |                   |    |   |   | Link A           |   |   |   |                   |   |   |   | notes               |
|----|------------------|----|----|----|-------------------|----|---|---|------------------|---|---|---|-------------------|---|---|---|---------------------|
|    | 15               | 14 | 13 | 12 | 11                | 10 | 9 | 8 | 7                | 6 | 5 | 4 | 3                 | 2 | 1 | 0 | bits                |
| 1  | K28.5            |    |    |    |                   |    |   |   | K28.5            |   |   |   |                   |   |   |   | Start of frame      |
| 2  | Checksum B[7..0] |    |    |    | Checksum B[15..8] |    |   |   | Checksum A[7..0] |   |   |   | Checksum A[15..8] |   |   |   |                     |
| 3  | Time Stamp       |    |    |    |                   |    |   |   | Errors           |   |   |   |                   |   |   |   |                     |
| 4  | Reserved         |    |    |    |                   |    |   |   |                  |   |   |   |                   |   |   |   |                     |
| 5  | S4               |    |    |    | S3                |    |   |   | S2               |   |   |   | S1                |   |   |   |                     |
| 6  | S8               |    |    |    | S7                |    |   |   | S6               |   |   |   | S5                |   |   |   |                     |
| 7  | CH2 [3:0]        |    |    |    | CH1 [11:8]        |    |   |   | CH1 [7:0]        |   |   |   | CH2 [11:4]        |   |   |   | Stream 1<br>[99:04] |
| 8  | CH3 [7:0]        |    |    |    | CH4 [11:4]        |    |   |   | CH4 [3:0]        |   |   |   | CH3 [11:8]        |   |   |   |                     |
| 9  | CH6 [3:0]        |    |    |    | CH5 [11:8]        |    |   |   | CH5 [7:0]        |   |   |   | CH6 [11:4]        |   |   |   | Stream 2<br>[99:04] |
| 10 | CH7 [7:0]        |    |    |    | CH8 [11:4]        |    |   |   | CH8 [3:0]        |   |   |   | CH7 [11:8]        |   |   |   |                     |
| 11 | CH2 [3:0]        |    |    |    | CH1 [11:8]        |    |   |   | CH1 [7:0]        |   |   |   | CH2 [11:4]        |   |   |   | Stream 3<br>[99:04] |
| 12 | CH3 [7:0]        |    |    |    | CH4 [11:4]        |    |   |   | CH4 [3:0]        |   |   |   | CH3 [11:8]        |   |   |   |                     |
| 13 | CH6 [3:0]        |    |    |    | CH5 [11:8]        |    |   |   | CH5 [7:0]        |   |   |   | CH6 [11:4]        |   |   |   | Stream 4<br>[99:04] |
| 14 | CH7 [7:0]        |    |    |    | CH8 [11:4]        |    |   |   | CH8 [3:0]        |   |   |   | CH7 [11:8]        |   |   |   |                     |
| 15 | CH2 [3:0]        |    |    |    | CH1 [11:8]        |    |   |   | CH1 [7:0]        |   |   |   | CH2 [11:4]        |   |   |   | Stream 5<br>[99:04] |
| 16 | CH3 [7:0]        |    |    |    | CH4 [11:4]        |    |   |   | CH4 [3:0]        |   |   |   | CH3 [11:8]        |   |   |   |                     |
| 17 | CH6 [3:0]        |    |    |    | CH5 [11:8]        |    |   |   | CH5 [7:0]        |   |   |   | CH6 [11:4]        |   |   |   | Stream 6<br>[99:04] |
| 18 | CH7 [7:0]        |    |    |    | CH8 [11:4]        |    |   |   | CH8 [3:0]        |   |   |   | CH7 [11:8]        |   |   |   |                     |
| 19 | CH2 [3:0]        |    |    |    | CH1 [11:8]        |    |   |   | CH1 [7:0]        |   |   |   | CH2 [11:4]        |   |   |   | Stream 7<br>[99:04] |
| 20 | CH3 [7:0]        |    |    |    | CH4 [11:4]        |    |   |   | CH4 [3:0]        |   |   |   | CH3 [11:8]        |   |   |   |                     |
| 21 | CH6 [3:0]        |    |    |    | CH5 [11:8]        |    |   |   | CH5 [7:0]        |   |   |   | CH6 [11:4]        |   |   |   | Stream 8<br>[99:04] |
| 22 | CH7 [7:0]        |    |    |    | CH8 [11:4]        |    |   |   | CH8 [3:0]        |   |   |   | CH7 [11:8]        |   |   |   |                     |
| 23 | CH2 [3:0]        |    |    |    | CH1 [11:8]        |    |   |   | CH1 [7:0]        |   |   |   | CH2 [11:4]        |   |   |   | idle                |
| 24 | CH3 [7:0]        |    |    |    | CH4 [11:4]        |    |   |   | CH4 [3:0]        |   |   |   | CH3 [11:8]        |   |   |   |                     |
| 25 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 26 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 27 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 28 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 29 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 30 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 31 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 32 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |
| 33 | K28.1            |    |    |    | K28.1             |    |   |   | K28.1            |   |   |   | K28.1             |   |   |   |                     |

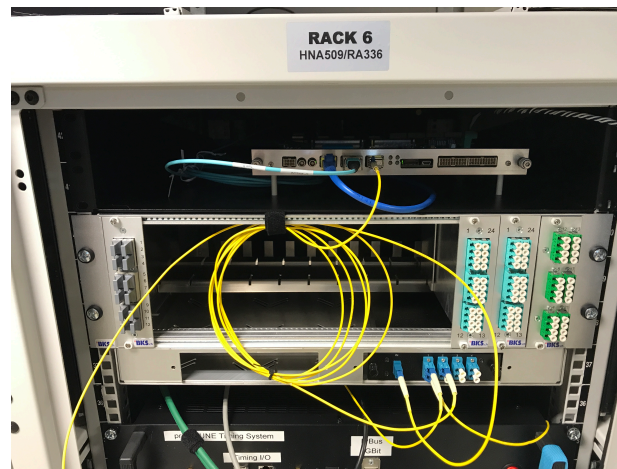
- Data format developed by BU, SLAC, and BNL

– 2 links per FEMB

- Format docs in BU repository

<http://gauss.bu.edu/redmine/projects/dune-wib/repository/docs>

- Successful preliminary WIB integration with timing system and RCE/FELIX on CERN VST





# APA1 Installation

- Installation procedures for CE Boxes on APA1 posted to [docdb 4019](#)
  - ESD and safe handling
  - QC and reception testing
- From APA1 installation, all electronics channels are expected to work at LAr temperature
- Procedures for hardware installation on the cold box also developed
  - feed-through Tee pipe and PD and CE flange installation on cold box
- Current status of CE Boxes on APA1:

| Date   | APA # [1-6] | APA Side [A, B] | APA Slot # [1-10] | WIB Slot # [0-3] | FEMB # [1-25] | Channel # [0-127] | ASIC # [1-8] | Note  | Entered in Hardware DB |
|--------|-------------|-----------------|-------------------|------------------|---------------|-------------------|--------------|---|------------------------|
| 9/1/17 | 1 B         |                 | 1                 | 0                | 10            |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 B         |                 | 2                 | 3                | 25            |                   |              | replace FEMB24 with FEMB25,. All channels OK                  | Y                      |
| 9/1/17 | 1 B         |                 | 3                 | 2                | 9             | 65                | 5            | 1 bad channels at RT, which is known to be good at LN2        | Y                      |
| 9/4/17 | 1 B         |                 | 4                 | 1                | 11            |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 B         |                 | 5                 | 0                | 3             |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 B         |                 | 6                 | 2                | 12            |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 B         |                 | 7                 | 3                | 16            |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 B         |                 | 8                 | 1                | 21            |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 B         |                 | 9                 | 3                | 7             |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 B         |                 | 10                | 2                | 4             |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 A         |                 | 11                | 2                | 1             | 123               | 8            | bad channel: the connection between FE input and wire is open | Y                      |
| 9/4/17 | 1 A         |                 | 12                | 1                | 17            |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 A         |                 | 13                | 2                | 20            |                   |              | All channels OK   | Y                      |
| 9/4/17 | 1 A         |                 | 14                | 3                | 13            |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 A         |                 | 15                | 0                | 8             |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 A         |                 | 16                | 1                | 2             |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 A         |                 | 17                | 2                | 15            |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 A         |                 | 18                | 3                | 23            |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 A         |                 | 19                | 0                | 5             |                   |              | All channels OK   | Y                      |
| 9/5/17 | 1 A         |                 | 20                | 1                | 14            |                   |              | All channels OK   | Y                      |

# Summary

- protoDUNE-SP requires ~10x more channels than previous LArTPC prototypes
  - Follows integrated APA+CE+warm interface readout plan
- TPC readout power and data connections mapped
  - from APA to FE
  - from FE to flange
- CE to Warm Interface mapping will be tested with cold box readout
  - Preliminary drawings based on DAQ input have been developed
- CE successfully installed on APA1
  - 2,560 channels with no dead channels in CE
  - Used APA slot numbering scheme from APA experts