

# DAPHNE System Overview

Matt Toups

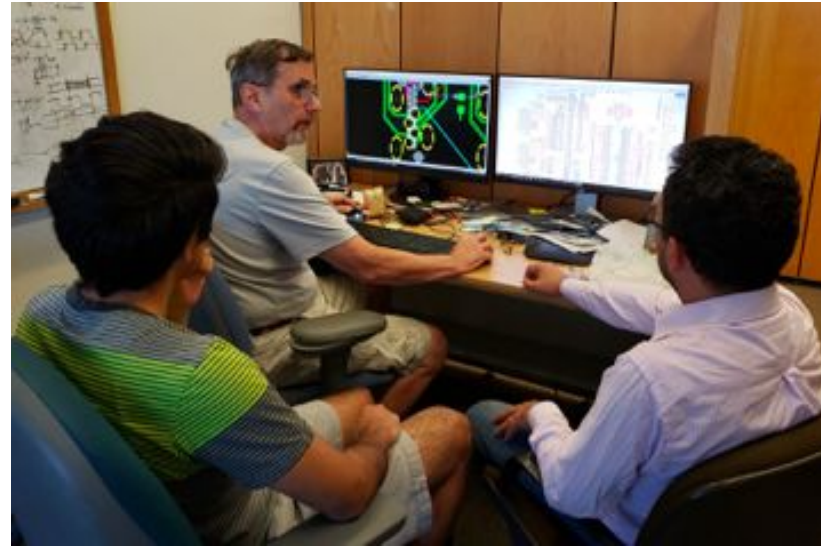
5/15/2020

# Outline

- Introduction
- DUNE Single Phase (SP) Photon Detection (PD) System
- DUNE SP-PD Electronics
- DAPHNE
- Summary

# DAPHNE

- Detector electronics for Acquiring PHotons from NEutrinos
  - Warm readout electronics for the DUNE SP-PD
- Developed as a partnership between FNAL and Latin America based off of the FNAL design of the Mu2e cosmic ray veto FEB
  - Visits to FNAL by Javier Castaño and Juan Vega Martinez in 2019



# DAPHNE Mini-Review

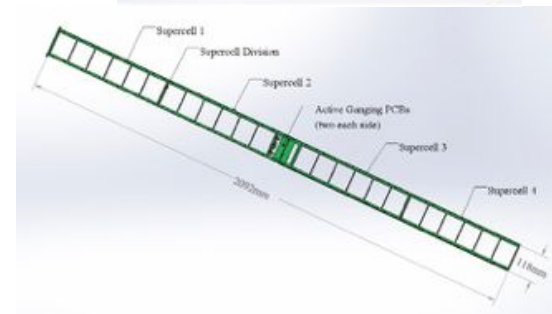
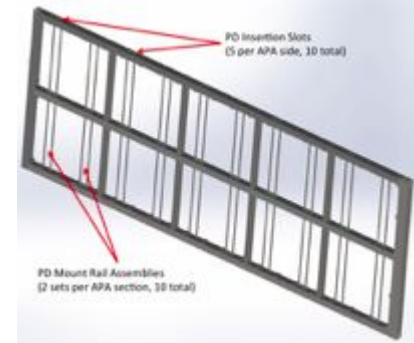
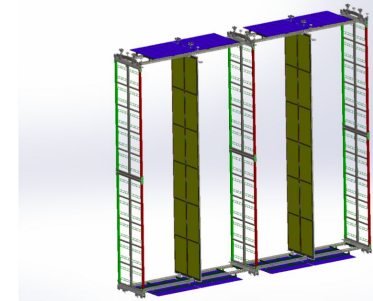
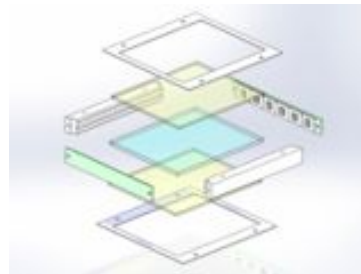
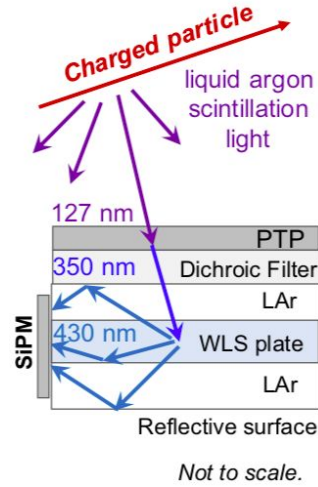
- Purpose is to review DAPHNE design before fabricating prototype boards
  - Mini-review will also provide input for SP-PD 60% design review
- Scope of mini-review is DAPHNE and its interfaces, but we will briefly introduce the larger system in this talk
- Documents Terri requested be prepared for this mini-review are on EDMS: <https://edms.cern.ch/project/CERN-0000206906>
  - Note: There are 2 pages of documents at the above link
- Thank you Terri Shaw, Paul Rubinov, and Jamieson Olsen!

# DUNE SP-PD Overview (I)

LAr scintillation light collector based on the X-ARAPUCA concept

PD modules, ten per APA, each 209 cm long by 12cm wide, consist of 4 “supercells”, each of which consists of 6 X-ARAPUCAs

Photon detectors are mounted inside the APA frame structure on stainless steel rails.



# DUNE SP-PD Electronics (I)

Signals read out with 6 x 6 mm<sup>2</sup> SiPM photosensors Hamamatsu (Japan), FBK (Italy)

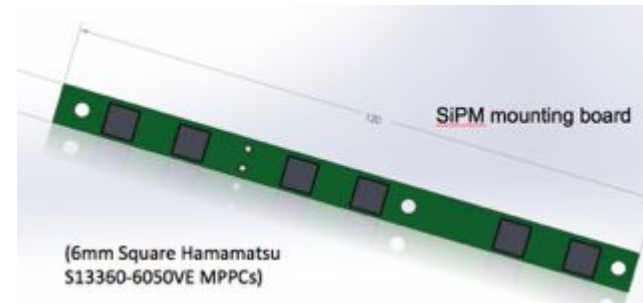
- 6 photosensors ganged passively

Cold active ganging electronics

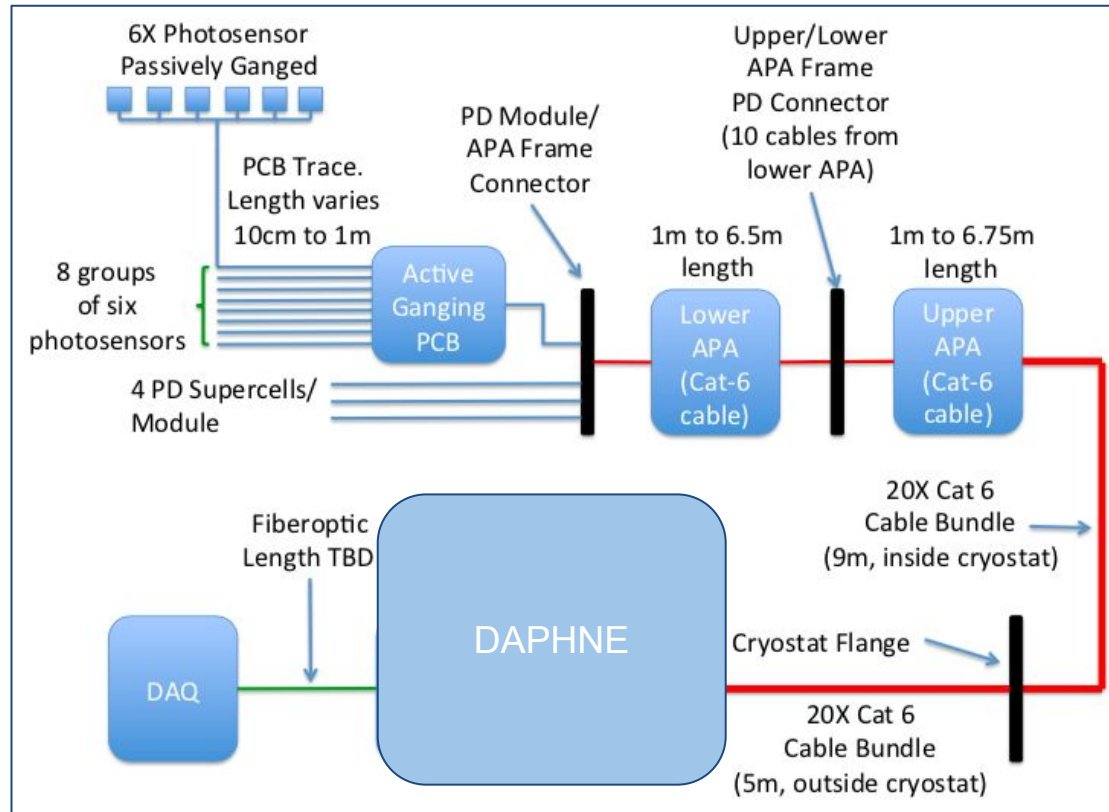
- Sums 8 groups of 6 photosensors

Individually shielded twisted pair cables carry signals from 4 X-ARAPUCA supercells through APA frame to feedthrough

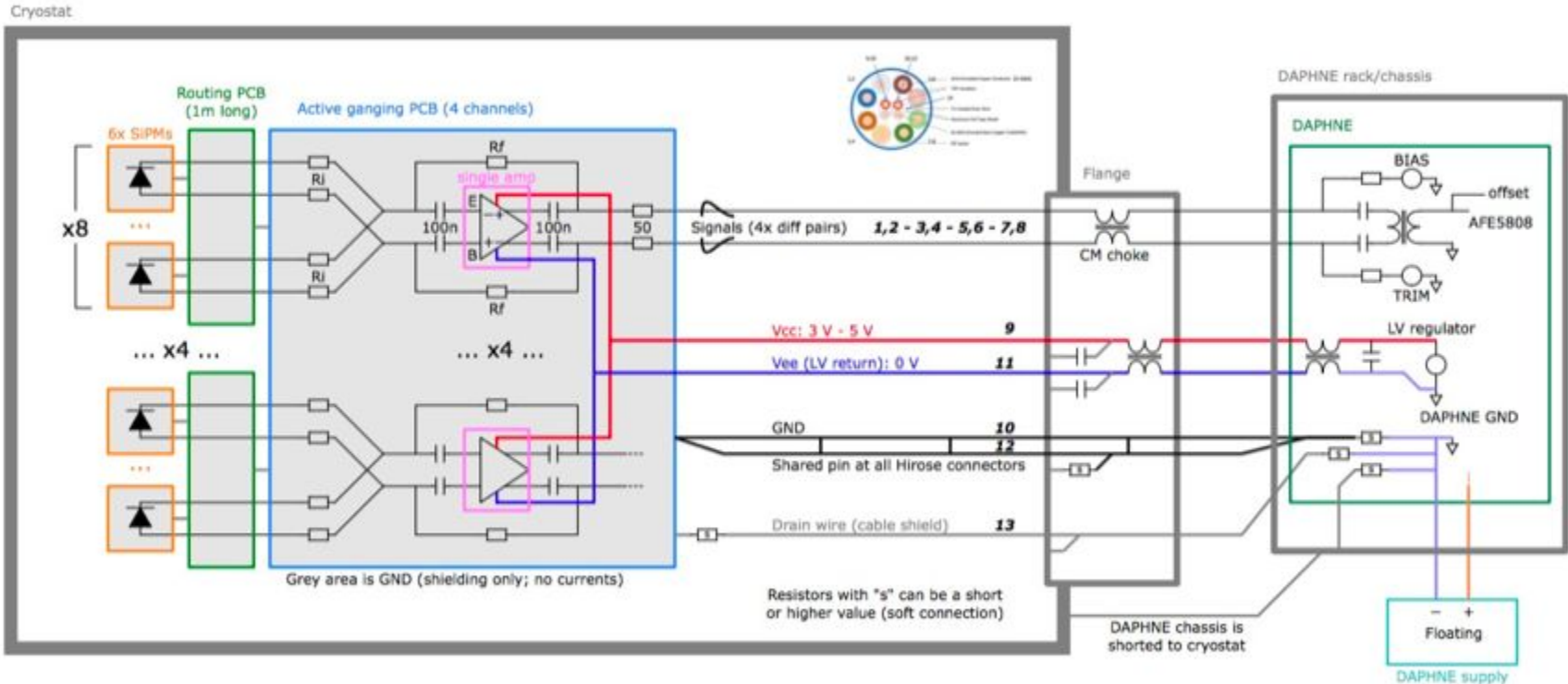
Warm Readout Electronics (DAPHNE) responsible for digitizing signals and shipping to DAQ



# DUNE SP-PD Electronics (II)

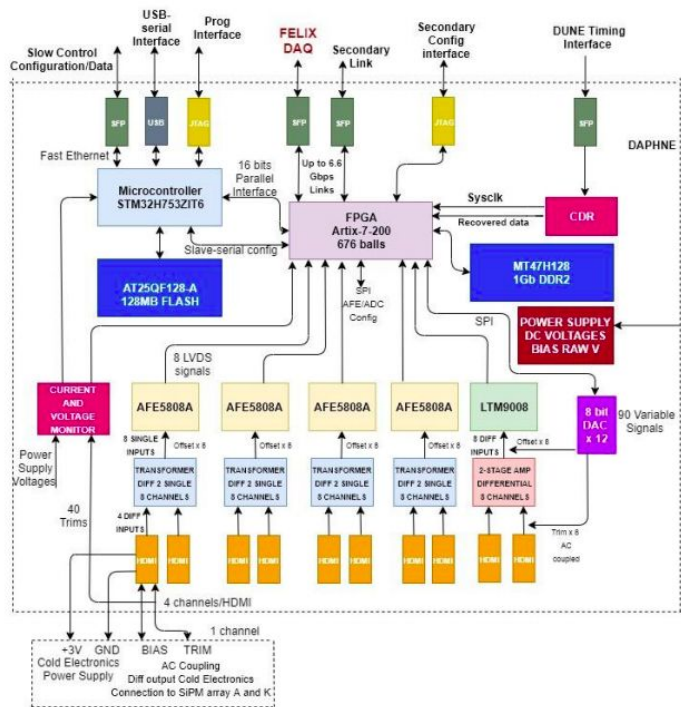


# DAPHNE Grounding (Talk by C. Gotti)





# DAPHNE (Talk by J. Castaño)



## DAPHNE (Detector electronics for Acquiring PHotons from NEutrinos)

- 40 channels/65 Msp/14 bits
- Bias-Trim Voltage supply
- Cold Electronics power supply + 3V
- Gigabit link up to 6.6 Gb/s to FELIX DAQ/full-mode protocol
- DUNE Timing interface

Interface to DAQ/Slow controls (all links are optical)

- Slow controls interfaces to Microcontroller
- DAQ investigating 4.8 Gbps FELIX data link compatible with Artix-7 FPGA (TPC data link runs at 9.6 Gbps)
- Timing interface

External 48V supply (see backups)

# DAPHNE Kick-off Summary

- Brief set of talks to introduce system and the system experts to reviewers
  - Please feel free to contact us with any questions after this kick-off
- Expect to keep kick-off meeting to less than 90 minutes
- Indico meeting page located here: <https://indico.fnal.gov/event/43239/>

## DAPHNE Review Kick-off Meeting

 Friday May 15, 2020, 11:00 AM → 12:35 PM US/Central

 Deywis Moreno Lopez (UAN) , Matthew Toups (FNAL)

**11:00 AM** → 11:15 AM **System Overview**  
Speaker: Matthew Toups (FNAL)

**11:15 AM** → 11:35 AM **DAPHNE Hardware description**  
Speaker: Javier Castaño (UAN)

**11:35 AM** → 11:55 AM **DAPHNE Firmware description**  
Speaker: Manuel Arroyave (EIA)

**11:55 AM** → 12:15 PM **Grounding Overview**  
Speaker: Claudio Gotti (INFN Milano Bicocca)

**12:15 PM** → 12:30 PM **Summary of Documentation**  
Speaker: Deywis Moreno Lopez (UAN)

# Backups

# DAPHNE Power Delivery

The power delivery system used in ProtoDUNE was highly informative in the development of the current system. There are a few significant differences.

|                     | ProtoDUNE                        | Current system                              |
|---------------------|----------------------------------|---|
| <i>Supply</i>       | Each SSP : 20 VDC @ 1.5A         | Each DAPHNE : <u>48</u> VDC @ <u>0.55</u> A |
| <i>Power Device</i> | Wiener crate w/ MPV8030, MPV8060 | Wiener crate w/ MPV80 <u>60</u> i           |
| <i>Bias Voltage</i> | Provided externally              | Generated on DAPHNE                         |

The 25 meter cable run between power supply and load will result in voltage drop in the long cables. The ability to sense the supply voltage at DAPHNE is very important. The power delivery system provides for this.

# DAPHNE Power Delivery - Power Supply

The power source is a 19" rack mounted WIENER system.

| Quantity | MFG           | Model      | Description                                       | Height | Channels      | Output      | Price      | Cost        | Vendor                                     |
|----------|---------------|------------|---|--------|---------------|-------------|------------|-------------|--|
| 2        | WIENER        | MPOD EC-LV | Full size 19" MPOD crate with 10 slots            | 8U     | 10 slots      |             | \$5,700.00 | \$11,400.00 | W-IE-NE-R                                  |
| 2        | WIENER        | option     | Reversed card cage, slots in rear                 |        | n/a           |             | \$143.00   | \$286.00    | W-IE-NE-R                                  |
| 20       | WIENER        | MPV8060i   | 0..60V DC @ 1A per channel                        |        | 8             | 48V @ 0.55A | \$2,862.00 | \$57,240.00 | W-IE-NE-R                                  |
| 1        | HP Enterprise | DL360e     | 1U Rack Server - 1 x Intel Xeon E5-2420 V2 2.2GHz | 1U     | 4 x 1Gb ports |             | \$568.05   | \$568.05    | <a href="http://Newegg.com">Newegg.com</a> |

Two Mpod EC-LV crates, populated with 10 MPV8060i in each crate can provide for 160 individually configurable 48V channels at up to 1 Amp each.

The MPOD EC-LV control board permits SNMP, SSH or HTTP (webpage) interface over ethernet. The power delivery system includes a 19" rack server to connect local control with experiment-wide control systems.

# DAPHNE Power Delivery - Power Cabling

MPV8060i provides each output channel with 8 contacts,

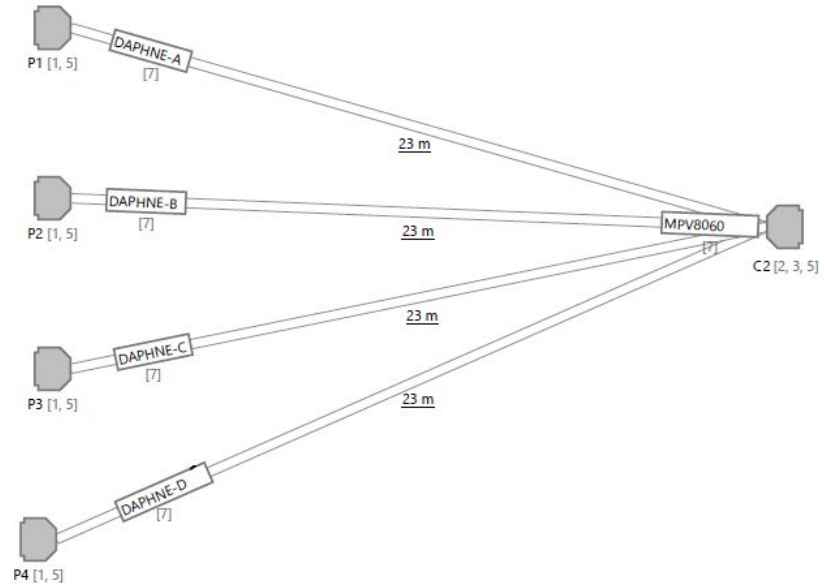
- [3x] VOUT, Return
- Sense+, Sense-

DAPHNE will connect to 6 contacts

- 48V, Return
- +48V, Return (redundant)
- Sense+, Sense-

Alpha Wire EcoCable Mini. [78126]

- ★ 6 pairs, 24 AWG, foil shielded, 4.2mm diameter
- ★ Low specific gravity, low outgassing, and halogen free.
- ★ 32% smaller and 44% lighter than standard 300V cable
- ★ Completely recyclable high-performance cable

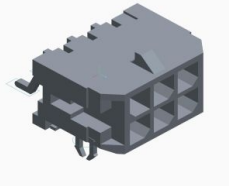


# DAPHNE Power Delivery - Power Connections

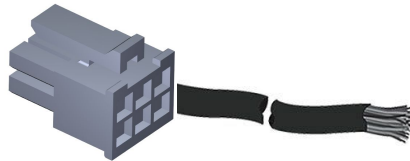
Each DAPHNE board will include a  
MOLEX 43045-0608 Micro-Fit 3.0 Right-Angle Header

- 3.00mm Pitch, Dual Row, 6 circuits
- Positive locking, PCB strain relief available
- 600V, 8.5A max current per contact

43045-0608



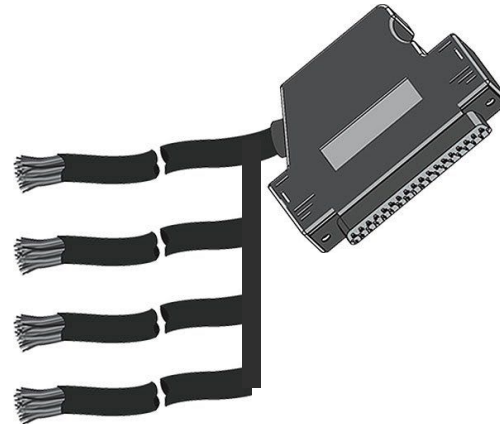
43025-0600



| From   | To    | Conductor      | Color  | Gauge  | From Contact PN |
|--------|-------|----------------|--------|--------|-----------------|
| P1.1   | C2.1  | CBL1.Black     | Black  | 24 AWG |                 |
| P1.2   | C2.20 | CBL1.Brown     | Brown  | 24 AWG |                 |
| P1.3   | C2.2  | CBL1.Red       | Red    | 24 AWG |                 |
| P1.4   | C2.21 | CBL1.Orange    | Orange | 24 AWG |                 |
| P1.5   | C2.4  | CBL1.Yellow    | Yellow | 24 AWG |                 |
| P1.6   | C2.23 | CBL1.Green     | Green  | 24 AWG |                 |
| P1.N/C | C2.19 | CBL1.Drainwire | White  | 24 AWG |                 |

Each MPV8060i module includes a standard 37p D-SUB connector  
A Multicomp SPC15230 connector will terminate the power cable.

- Accepts 28-20 AWG wires
- Screw fasteners locking
- 500V, 5A max current per contact
- 45° nickel plated backshell [SPC14997<sup>1</sup>]



| From  | To     | Conductor      | Color  | Gauge  | From Contact PN |
|-------|--------|----------------|--------|--------|-----------------|
| C2.1  | P1.1   | CBL1.Black     | Black  | 24 AWG |                 |
| C2.2  | P1.3   | CBL1.Red       | Red    | 24 AWG |                 |
| C2.4  | P1.5   | CBL1.Yellow    | Yellow | 24 AWG |                 |
| C2.5  | P2.1   | CBL2.Black     | Black  | 24 AWG |                 |
| C2.6  | P2.3   | CBL2.Red       | Red    | 24 AWG |                 |
| C2.8  | P2.5   | CBL2.Yellow    | Yellow | 24 AWG |                 |
| C2.9  | P3.1   | CBL3.Black     | Black  | 24 AWG |                 |
| C2.10 | P3.3   | CBL3.Red       | Red    | 24 AWG |                 |
| C2.12 | P3.5   | CBL3.Yellow    | Yellow | 24 AWG |                 |
| C2.13 | P4.1   | CBL4.Black     | Black  | 24 AWG |                 |
| C2.14 | P4.3   | CBL4.Red       | Red    | 24 AWG |                 |
| C2.16 | P4.5   | CBL4.Yellow    | Yellow | 24 AWG |                 |
| C2.19 | P1.N/C | CBL1.Drainwire | White  | 24 AWG |                 |
| C2.19 | P2.N/C | CBL2.Drainwire | White  | 24 AWG |                 |
| C2.19 | P3.N/C | CBL3.Drainwire | White  | 24 AWG |                 |
| C2.19 | P4.N/C | CBL4.Drainwire | White  | 24 AWG |                 |
| C2.20 | P1.2   | CBL1.Brown     | Brown  | 24 AWG |                 |
| C2.21 | P1.4   | CBL1.Orange    | Orange | 24 AWG |                 |
| C2.23 | P1.6   | CBL1.Green     | Green  | 24 AWG |                 |
| C2.24 | P2.2   | CBL2.Brown     | Brown  | 24 AWG |                 |
| C2.25 | P2.4   | CBL2.Orange    | Orange | 24 AWG |                 |
| C2.27 | P2.6   | CBL2.Green     | Green  | 24 AWG |                 |
| C2.28 | P3.2   | CBL3.Brown     | Brown  | 24 AWG |                 |
| C2.29 | P3.4   | CBL3.Orange    | Orange | 24 AWG |                 |
| C2.31 | P3.6   | CBL3.Green     | Green  | 24 AWG |                 |
| C2.32 | P4.2   | CBL4.Brown     | Brown  | 24 AWG |                 |
| C2.33 | P4.4   | CBL4.Orange    | Orange | 24 AWG |                 |
| C2.35 | P4.6   | CBL4.Green     | Green  | 24 AWG |                 |

# DAPHNE Power Delivery - Documentation

The DAPHNE LV cables and connectivity are documented

- Bill of Materials
  - Cable, Connectors, accessories
- Connection Table
- Cable Cut Specification
- Labels
  - part number, contents

| Revisions |            |          |  |  |
|-----------|------------|----------|--|--|
| Rev.      | Date       | Author   | Description  |  |
| A         | 2020-05-13 | Jon Amel | Initial design capture, need to confirm numbering @ DAPHNE |  |

| Bill of Materials |             |                 |                     |          |
|-------------------|-------------|-----------------|---------------------|----------|
| Id                | Type        | Manufacturer    | Part Number         | Quantity |
| 1                 | Connector   | Molex           | 43025-0608          | 4        |
| 2                 | Connector   | Multicomp       | SPC15230            | 1        |
| 3                 | Backshell   | TE Connectivity | 3-2198618-7         | 1        |
| 5                 | Heat Shrink |                 | Generic Heat Shrink | 5        |
| 6                 | Cable       | AlphaWire       | 78126               | 92 m     |
| 7                 | Label       |                 | 5100X1501A1         | 5        |

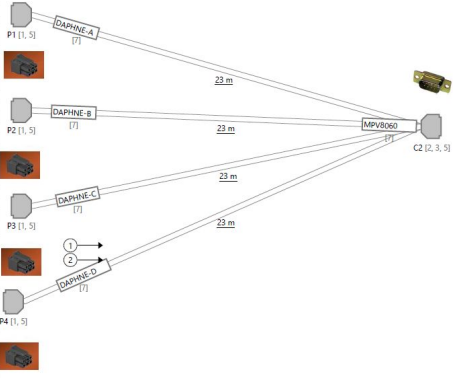
  

| From   | To    | Conductor     | Color  | Gauge  | From Contact PN |
|--------|-------|---------------|--------|--------|-----------------|
| P1.1   | C2.1  | CB1.Black     | Black  | 24 AWG |                 |
| P1.2   | C2.20 | CB1.Brown     | Brown  | 24 AWG |                 |
| P1.3   | C2.2  | CB1.Red       | Red    | 24 AWG |                 |
| P1.4   | C2.21 | CB1.Orange    | Orange | 24 AWG |                 |
| P1.5   | C2.4  | CB1.Yellow    | Yellow | 24 AWG |                 |
| P1.6   | C2.23 | CB1.Green     | Green  | 24 AWG |                 |
| P1.N/C | C2.19 | CB1.Drainwire | White  | 24 AWG |                 |

| From   | To    | Conductor     | Color  | Gauge  | From Contact PN |
|--------|-------|---------------|--------|--------|-----------------|
| P2.1   | C2.5  | CB2.Black     | Black  | 24 AWG |                 |
| P2.2   | C2.24 | CB2.Brown     | Brown  | 24 AWG |                 |
| P2.3   | C2.6  | CB2.Red       | Red    | 24 AWG |                 |
| P2.4   | C2.25 | CB2.Orange    | Orange | 24 AWG |                 |
| P2.5   | C2.8  | CB2.Yellow    | Yellow | 24 AWG |                 |
| P2.6   | C2.27 | CB2.Green     | Green  | 24 AWG |                 |
| P2.N/C | C2.19 | CB2.Drainwire | White  | 24 AWG |                 |

| From   | To    | Conductor     | Color  | Gauge  | From Contact PN |
|--------|-------|---------------|--------|--------|-----------------|
| P3.1   | C2.9  | CB3.Black     | Black  | 24 AWG |                 |
| P3.2   | C2.28 | CB3.Brown     | Brown  | 24 AWG |                 |
| P3.3   | C2.10 | CB3.Red       | Red    | 24 AWG |                 |
| P3.4   | C2.29 | CB3.Orange    | Orange | 24 AWG |                 |
| P3.5   | C2.12 | CB3.Yellow    | Yellow | 24 AWG |                 |
| P3.6   | C2.31 | CB3.Green     | Green  | 24 AWG |                 |
| P3.N/C | C2.19 | CB3.Drainwire | White  | 24 AWG |                 |

| From   | To    | Conductor     | Color  | Gauge  | From Contact PN |
|--------|-------|---------------|--------|--------|-----------------|
| P4.1   | C2.13 | CB4.Black     | Black  | 24 AWG |                 |
| P4.2   | C2.32 | CB4.Brown     | Brown  | 24 AWG |                 |
| P4.3   | C2.14 | CB4.Red       | Red    | 24 AWG |                 |
| P4.4   | C2.33 | CB4.Orange    | Orange | 24 AWG |                 |
| P4.5   | C2.16 | CB4.Yellow    | Yellow | 24 AWG |                 |
| P4.6   | C2.35 | CB4.Green     | Green  | 24 AWG |                 |
| P4.N/C | C2.19 | CB4.Drainwire | White  | 24 AWG |                 |



| From  | To     | Conductor     | Color  | Gauge  | From Contact PN |
|-------|--------|---------------|--------|--------|-----------------|
| C2.1  | P1.1   | CB1.Black     | Black  | 24 AWG |                 |
| C2.2  | P1.3   | CB1.Red       | Red    | 24 AWG |                 |
| C2.4  | P1.5   | CB1.Yellow    | Yellow | 24 AWG |                 |
| C2.5  | P2.1   | CB2.Black     | Black  | 24 AWG |                 |
| C2.6  | P2.3   | CB2.Red       | Red    | 24 AWG |                 |
| C2.8  | P2.5   | CB2.Yellow    | Yellow | 24 AWG |                 |
| C2.9  | P3.1   | CB3.Black     | Black  | 24 AWG |                 |
| C2.10 | P3.3   | CB3.Red       | Red    | 24 AWG |                 |
| C2.12 | P3.5   | CB3.Yellow    | Yellow | 24 AWG |                 |
| C2.13 | P4.1   | CB4.Black     | Black  | 24 AWG |                 |
| C2.14 | P4.3   | CB4.Red       | Red    | 24 AWG |                 |
| C2.16 | P4.5   | CB4.Yellow    | Yellow | 24 AWG |                 |
| C2.19 | P1.N/C | CB1.Drainwire | White  | 24 AWG |                 |
| C2.19 | P2.N/C | CB2.Drainwire | White  | 24 AWG |                 |
| C2.19 | P3.N/C | CB3.Drainwire | White  | 24 AWG |                 |
| C2.19 | P4.N/C | CB4.Drainwire | White  | 24 AWG |                 |
| C2.20 | P1.2   | CB1.Brown     | Brown  | 24 AWG |                 |
| C2.21 | P1.4   | CB1.Orange    | Orange | 24 AWG |                 |
| C2.23 | P1.6   | CB1.Green     | Green  | 24 AWG |                 |
| C2.24 | P2.2   | CB2.Brown     | Brown  | 24 AWG |                 |
| C2.25 | P2.4   | CB2.Orange    | Orange | 24 AWG |                 |
| C2.27 | P2.6   | CB2.Green     | Green  | 24 AWG |                 |
| C2.28 | P3.2   | CB3.Brown     | Brown  | 24 AWG |                 |
| C2.29 | P3.4   | CB3.Orange    | Orange | 24 AWG |                 |
| C2.31 | P3.6   | CB3.Green     | Green  | 24 AWG |                 |
| C2.32 | P4.2   | CB4.Brown     | Brown  | 24 AWG |                 |
| C2.33 | P4.4   | CB4.Orange    | Orange | 24 AWG |                 |
| C2.35 | P4.6   | CB4.Green     | Green  | 24 AWG |                 |

| Notes |  |  |
|-------|--|--|
| ①     | Cable length estimated at 75ft (23m)                           |  |
| ②     | Voltage drop estimated at 1.06V. +48V becomes +46.94V (-2.21%) |  |

| Drawn By | Name | Date       | Eng. Approved | Mgr. Approved | QA | Version |
|----------|------|------------|---------------|---------------|----|---------|
| JAM      | JAM  | 2020/06/13 |               |               |    | A1      |

File: DAPHNE-LV Rev: A  
 Description: Provides 48VDC and remote sense for 4 DAPHNE units  
 Part Number: DAPHNE-LV  
 Version: A1

LSA PHYSICS  
 UNIVERSITY OF MICHIGAN

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