Top Anode Adapter Boards

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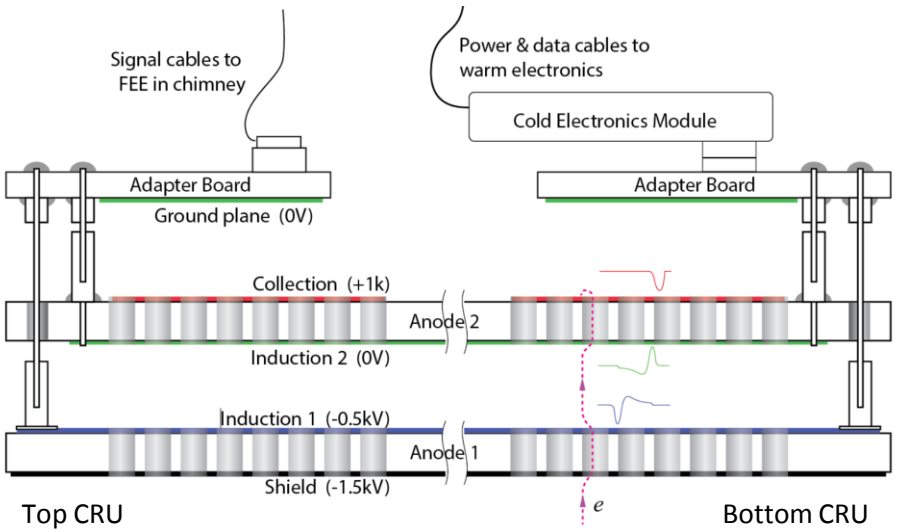
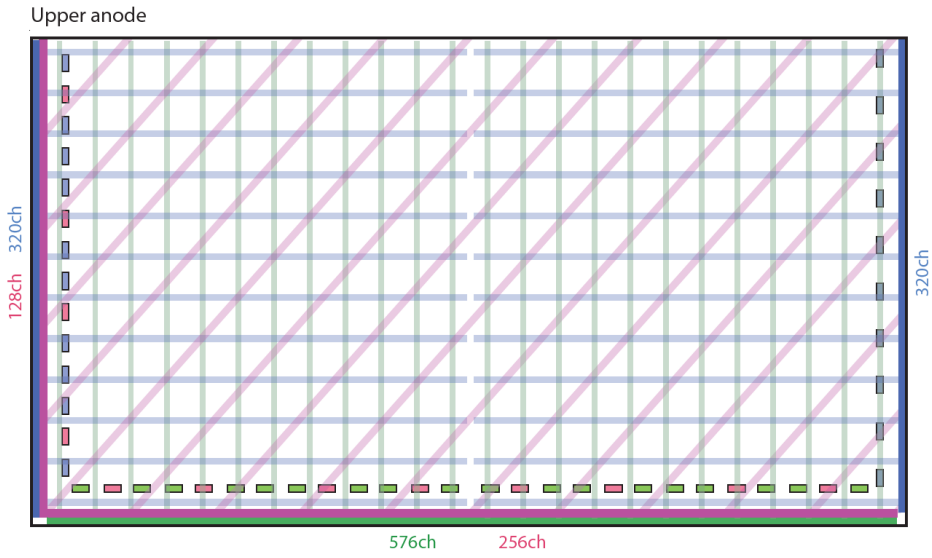
DUNE SPVD Top Electronics Conceptual Design Review

4 June 2021

1st Cold Box 3-View Design: CRU Layout

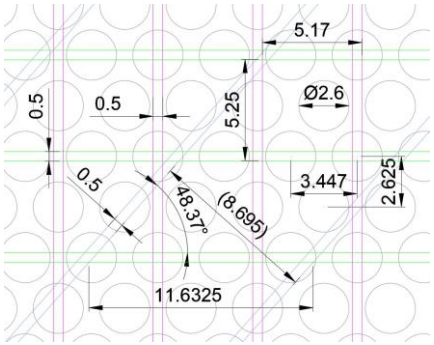


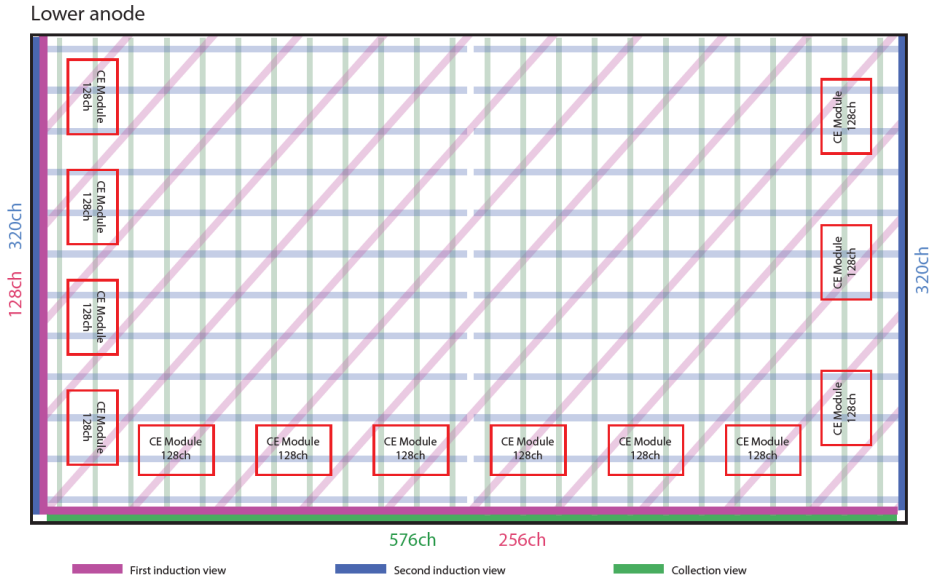


In this 3-view design, the 3rd (collection) view strips remain orthogonal to the beam. The 1st view is set along the diagonal of the CRP (48°).

Channel count per CRU

1st view:	384
2nd view:	640
3rd view:	576
Total:	1600

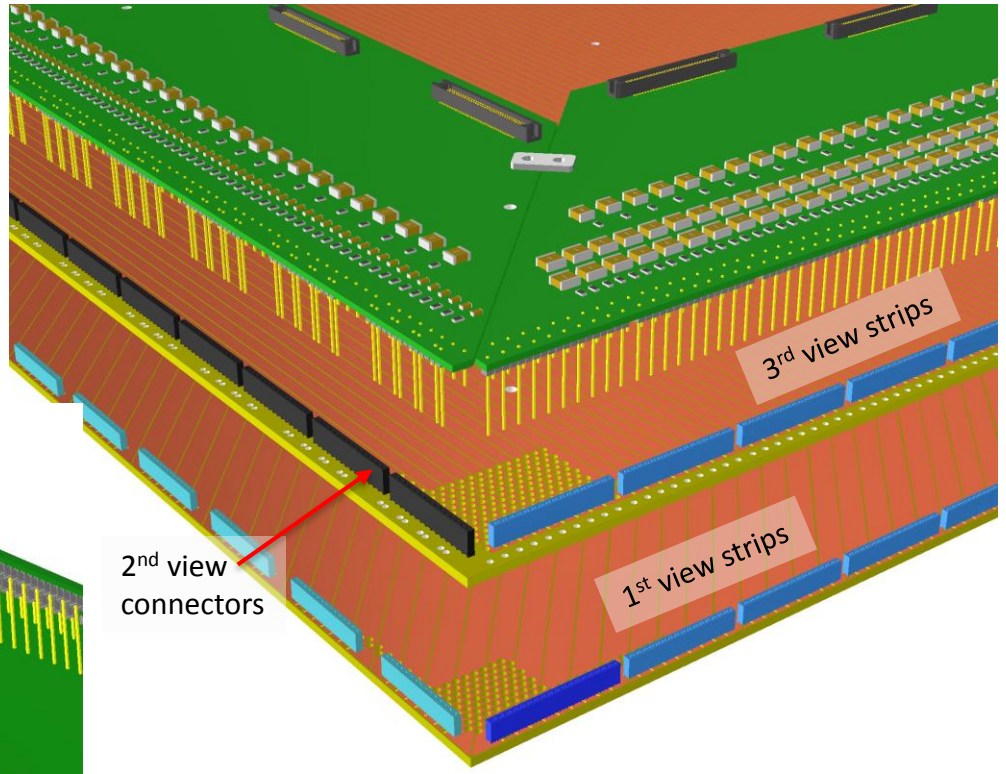


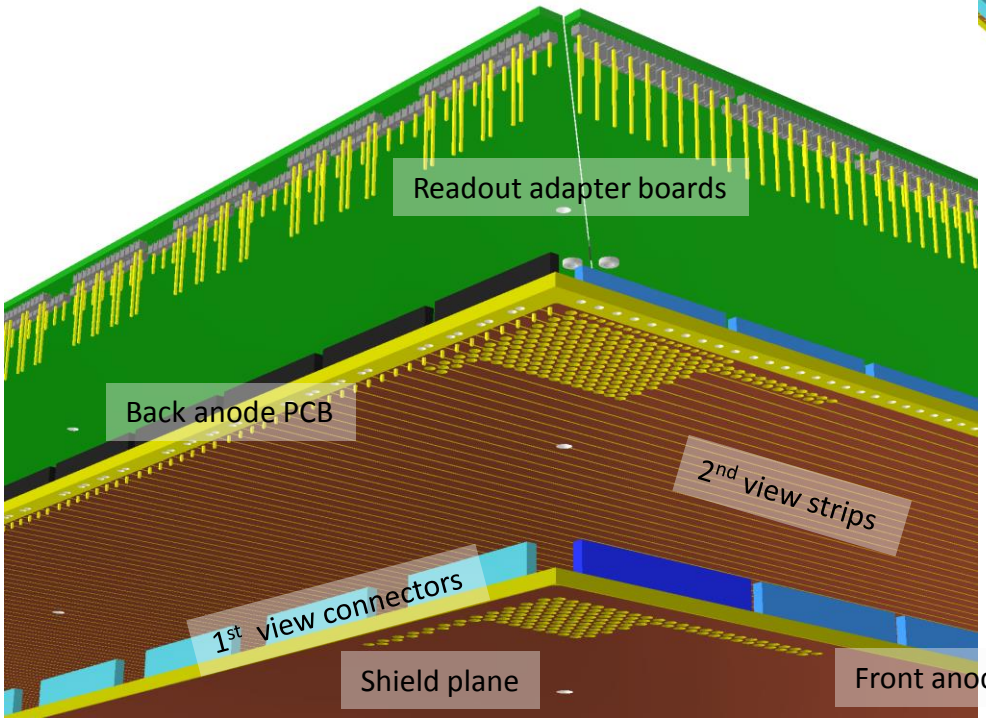


1st Cold Box 3-View Design : Top CRU Assembly Details

Both anode PCBs have the same perforation pattern, with 50+% transparency to liquid flow.

Each CRU has 8 unique FEE adapter boards, carrying 50 cable connectors to the FEE inside the roof chimneys.

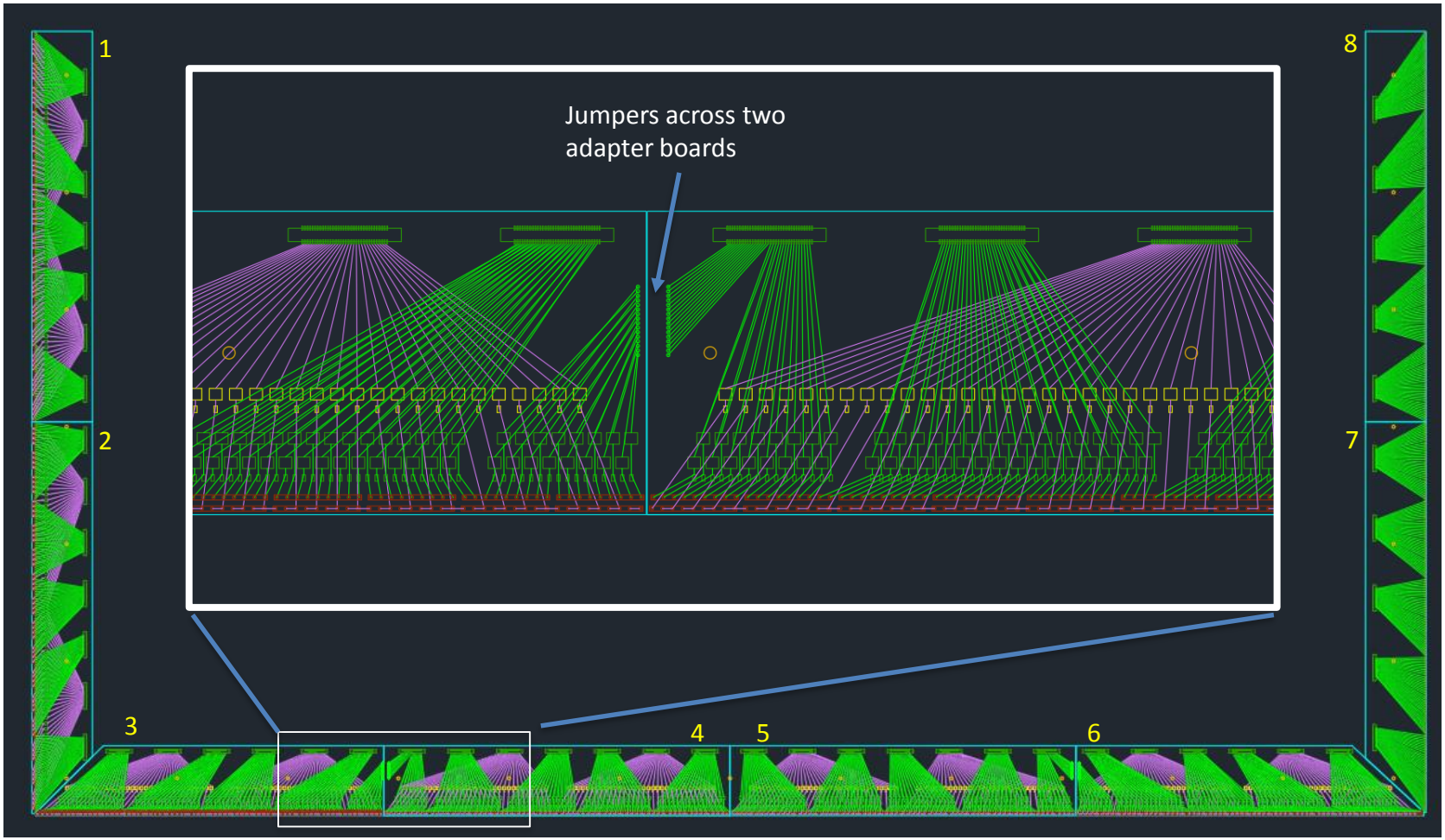




Since the FEE for the top anode are all AC coupled, the 2nd view strips must be grounded through high value resistors on the adapters.

1st Cold Box 3-View Design : Top Adapter Boards Details

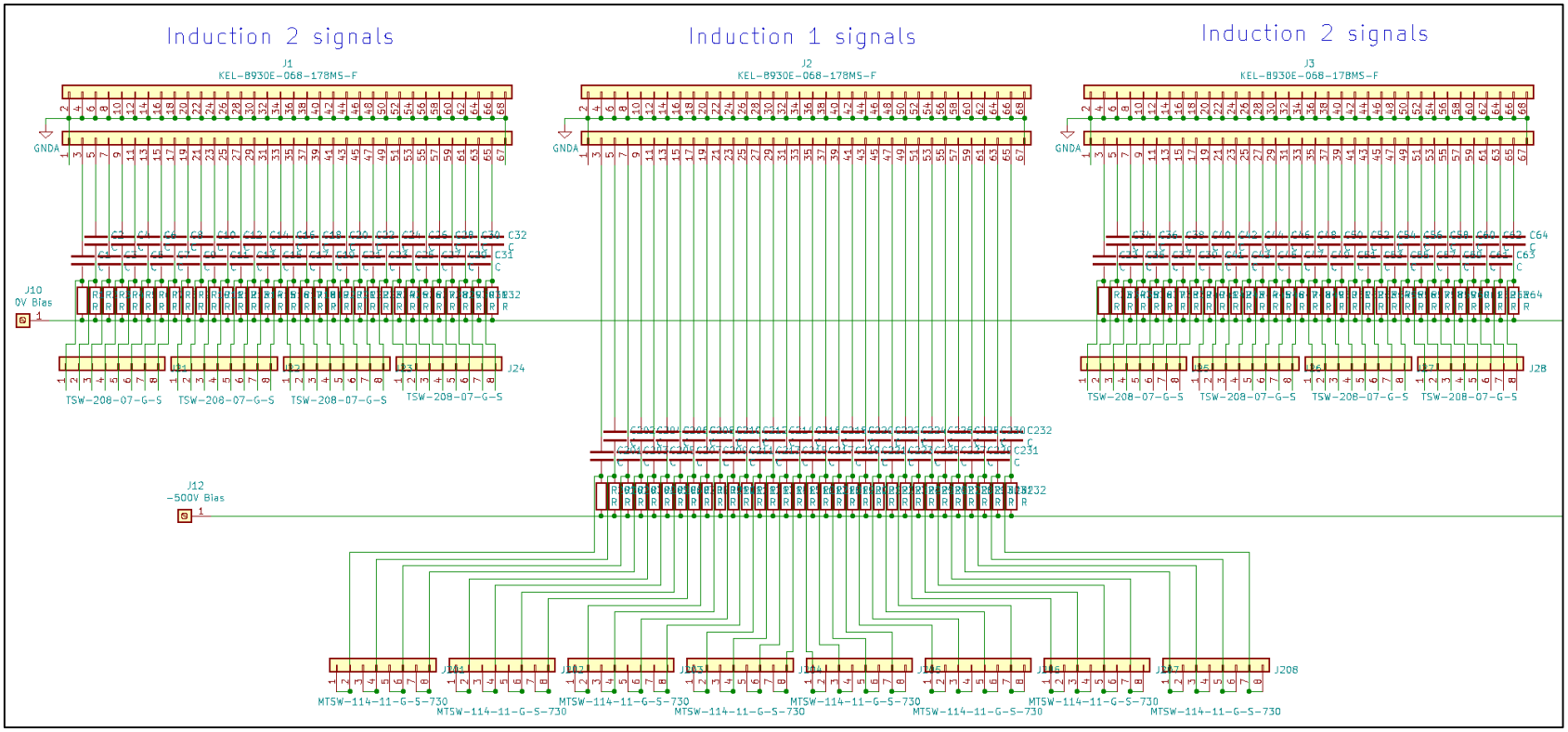
The top anode FEE requires the collection signals and induction signals segregated into their only connectors of 32chs. In doing to, some channels must be bridged from one board to another.



Top Adapter Boards Schematics: board 1 & 2

Board 1 & 2 have identical schematics, but different physical layout. They read out the two induction plane signals along one short edge of the anode. The second induction plane is nominally at 0V bias. An RC network is added to these channels to ensure proper bias of the strips, and allow some adjustment of the bias voltage. Capacitors used here are TDK CGA5H4NP02J682J115AA, 6.8nF, 630V.

Induction 1 inputs are nominally biased at ~-400V. The capacitors used are Kemet C2220C562JFGACTU, 5.6nF, 1.5kV.



Partial schematic of board 1 & 2

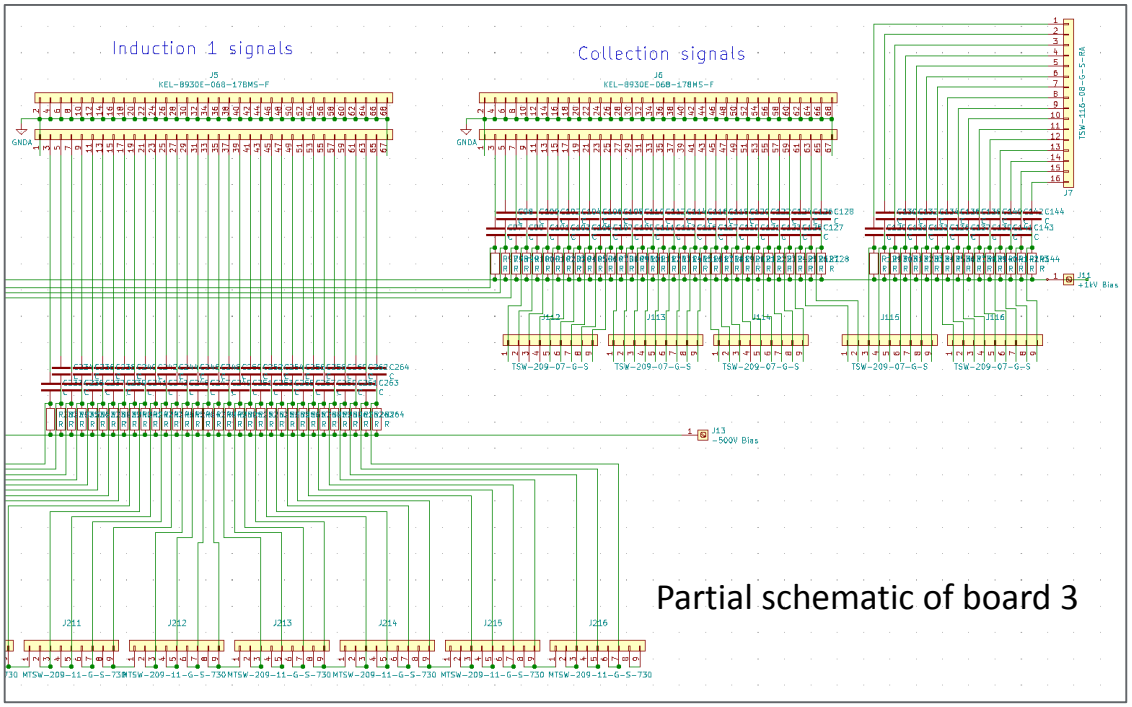
Top Adapter Boards Schematics: board 3 - 6

Board 3 – 6 read out the collection and induction 1 channels along the long edge of the anode.

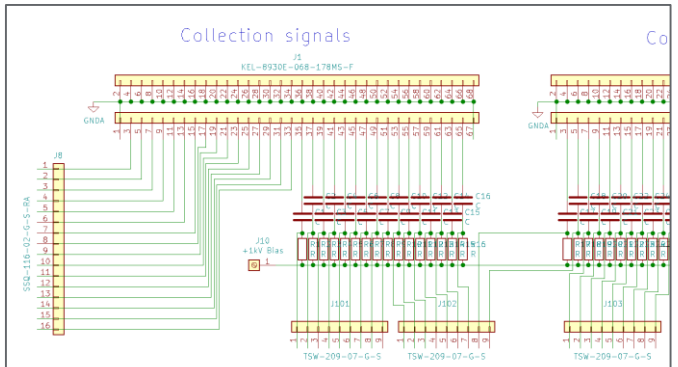
Board 3 & 4 have a total of 13 cable connectors but the same number of input channels. Signals from half of one connection on board 4 comes from board 3 through a pair of jumper connectors.

Board 5 & 6 are similar to board 3 & 4.

The capacitors used for the collection plane signals are Kemet C2225C392JGGACTU, 3.9nF, 2kV



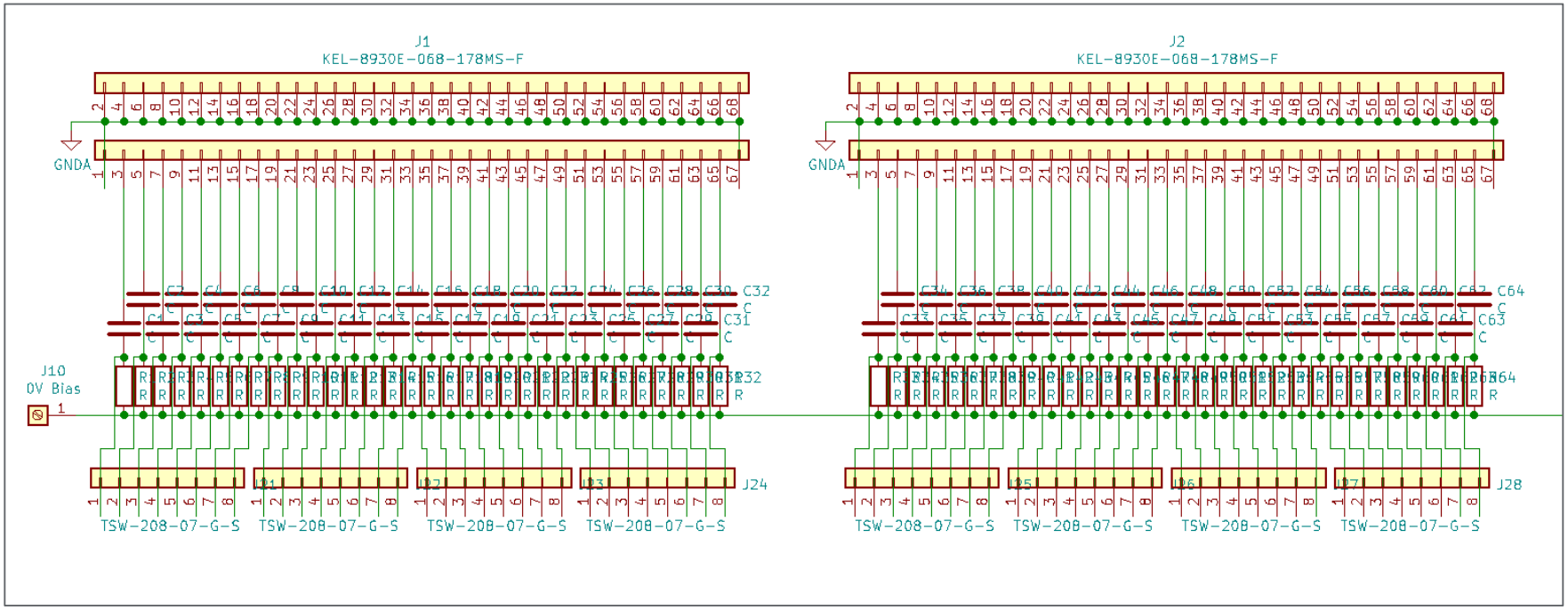
Partial schematic of board 3



Partial schematic of board 4

Top Adapter Boards Schematics: board 7 & 8

Board 7 & 8 have identical schematics, but different physical layout. They read out only the 2nd induction signals nominally at 0V bias. An RC network is added to these channels to ensure proper bias to the strips, and allow some adjustment of the bias voltage. Capacitors used here are TDK CGA5H4NP02J682J115AA, 6.8nF, 630V.



Partial schematic of board 7&8

Other Relevant Features of the Adapter Boards

- All 8 boards are 4 layer PCBs with a thickness of 2mm.

  Layer 1: connectors to FEE, Rs & Cs, signal traces

  Layer 2: signal traces

  Layer 3: bias bus

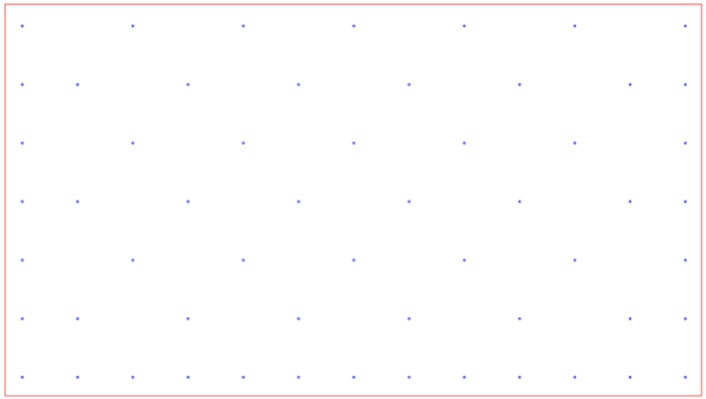
  Layer 4: ground plane, bias lines, input pin headers

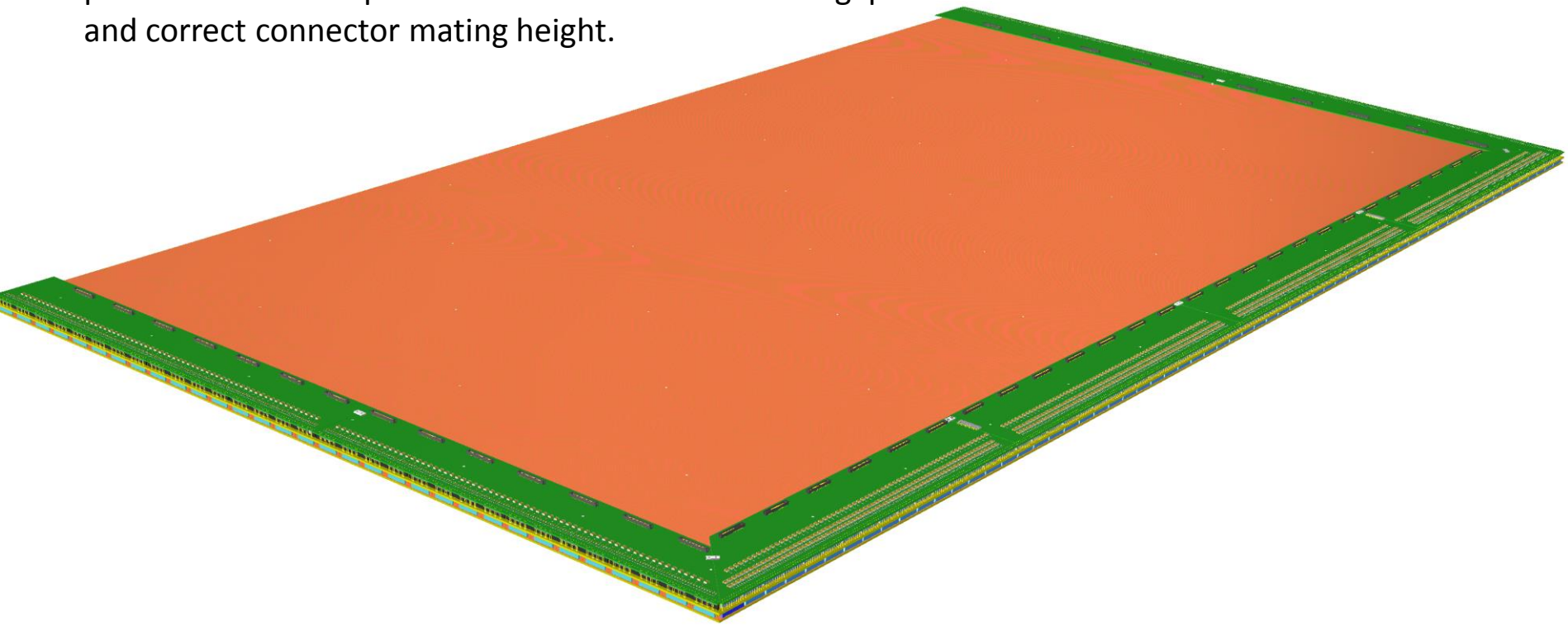
- The ground plane of each PCB can be interconnected or left isolated.
- The copper surface on the ground plane is mostly exposed to form a reverse E field on the exit side of the collection anode plane to speed up charge collection.
- Strip bias connections between boards, and to the power supplies are made by soldering wires on soldering pads. This gives low profile connections to avoid interference with the composite frame above.
- Since the 1st induction strips are very wide, and they intercept the anode edges at ~45° angle, the readout pitch is more than 1cm. The pin headers chosen have 0.2” maximum pitch, so each strip has two pin connections to the adapter boards. We can decide in the future whether to keep the redundance signal connection, or the simplicity of fewer pins.

1st Cold Box 3-View Design : Top CRU Assembly

On each CRU, there are 58 4mm holes (picture to the right) designed into the anode PCBs and the adapter boards as mechanical support points to be attached to the composite frame to keep the PCBs flat and aligned. Details on the mechanical support is given in the CRP CDR presentations.

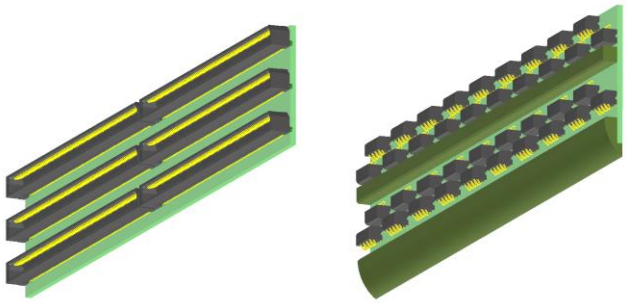
Each adapter board has 3 or 4 anchor points to the anode planes and the composite frame to ensure a unform gap and correct connector mating height.



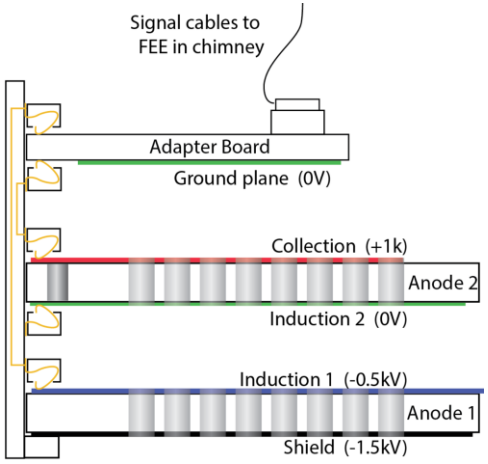


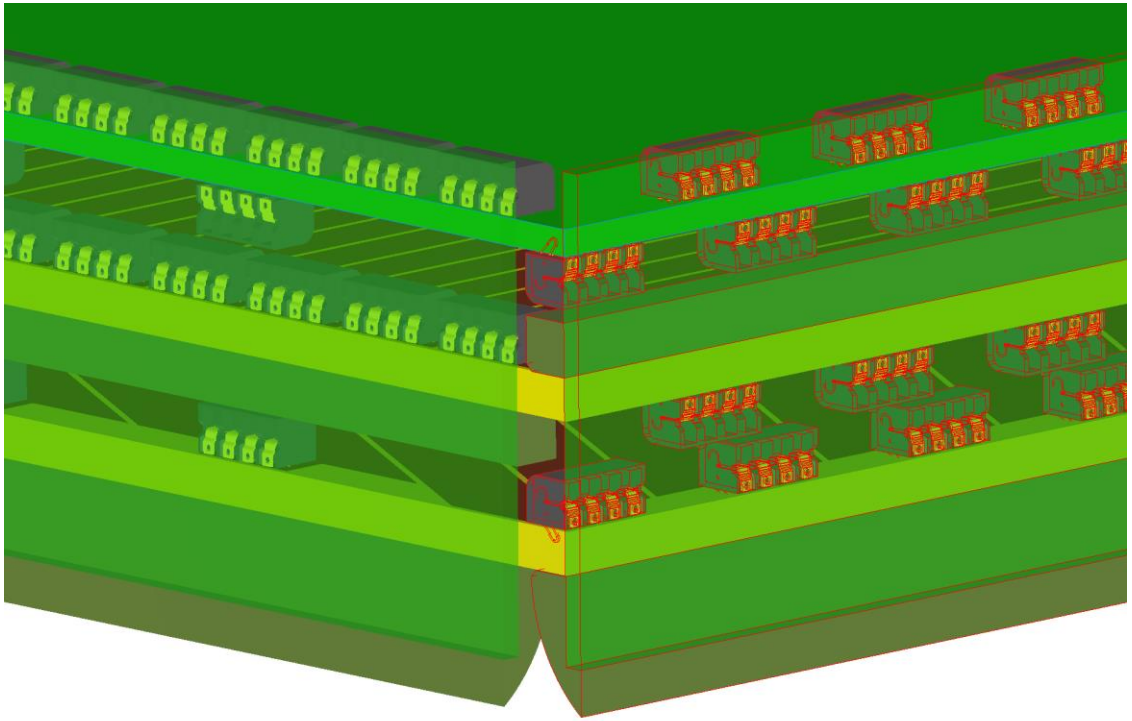
Using Edge Connectors to Minimize Soldering to the Anodes

Using card edge connectors to form “jumper board” that plugs into the edges of the 3 PCBs has the potential to significantly reduces the soldering work needed on the large anode and adapter PCBs, and speed up the assembly. This technique will be demonstrated in the next 50L setup with the ±30° strip pattern.



Two designs of the side jumper boards using commercial connectors





A corner of the ±30° anode assembly using the card edge connectors (PCB made transparent). Additional locking features need to be implemented to prevent the jumper boards falling out.

Summary

- The top FEE adapter boards consist of 8 unique PCBs. The cad drawings and schematics are complete and posted at EDMS (2479999).
- This version of the anodes and adapter boards use standard pin and socket connectors for board-to-board interconnect, a technique that has been successfully used in MicroBooNE, and ProtoDUNE electronics connections.
- Compared to the bottom CE adapter boards, additional DC bias feature is added to the 2nd induction signal lines to be compatible with the AC coupled nature of the top electronics.
- CERN PCB shop is working on the layout of the PCBs. A quote from a commercial vendor for the layout work is also available.

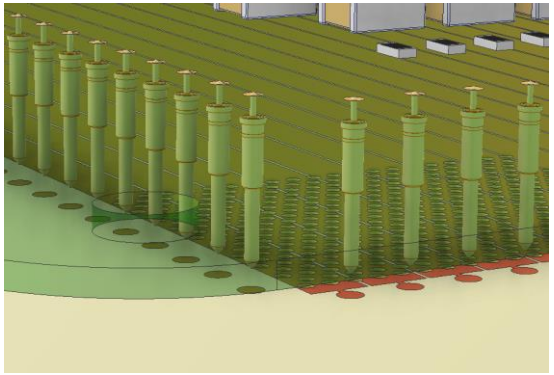
BACK UP SLIDES

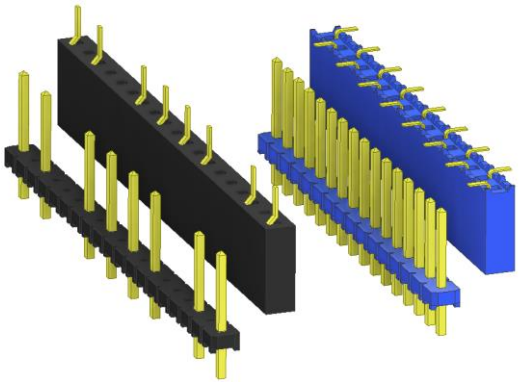
Interconnect Techniques, Vertical

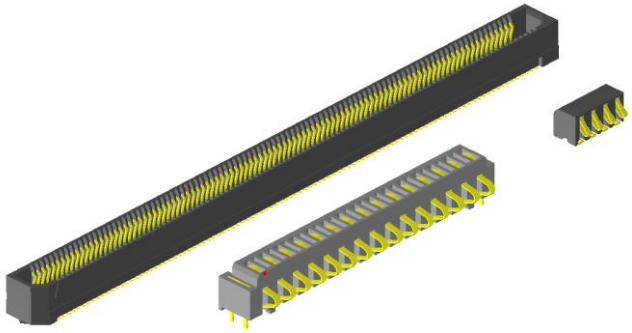
- Spring loaded “pogo” pins are used in the 50L demonstrator to connect the perforated anode PCB to the CE adapter board without issues.
- Tolerant of small movement or misalignment. Completely flat on the mating surface.
- Require constant force to maintain contact. May require more frequent mechanical supports between board to keep separation constant. Not sure of long-term cryogenic reliability.

- Standard board stacking connectors could be adapted to the non-standard pitches used on the PCBs. They can be customized to have certain positions skipped in fabrication.
- Flexible pin lengths, large wipe length
- Fragile protrusions on both mating surfaces
- Difficult to align and plug in on large PCBs
- Used in the 3-view 50L setup and the initial cold box test.

- Card edge and/or spring loaded RA connectors can be mounted on a vertical PCB that plugs into the stack of PCBs on the CRU.
- These PCBs are highly modular, can be assembled by commercial shops.
- Does not require PTHs, but may need gold plated edges on the anodes.
- Need custom locking mechanism
- Most promising option in minimizing labor at assembly sites
- Will be implemented in the next 50L test anodes.







Alignment and Plugging in of 3m Long Connectors

- To avoid simultaneously plugging in hundreds of pins along a 3m PCB edge, a special assembly sequence is developed for the 1st cold box anode.
- Each adapter board is plugged into the anode 2 first, with the pin headers connecting anode 1 and the adapter boards positioned through a set of large holes on anode 2, but not soldered to the adapters.
- Lower the adapter + anode 2 assembly over anode 1. Align and push the long pin headers all the way through the connectors on anode 1. Keep lowering the upper assembly until designed anode 1 to 2 spacing is reached.
- Pull the pin headers up into the plated through holes on the adapter board and solder them in place. Carefully clean the solder flux off. Repeat to solder all the connectors on this edge.
- Since the pins headers are soldered while in position, their alignment to the sockets are guaranteed. Reinserting the connectors should be easier (but should be avoided if possible).