Belle-II iTOP readout: production HV board and front board

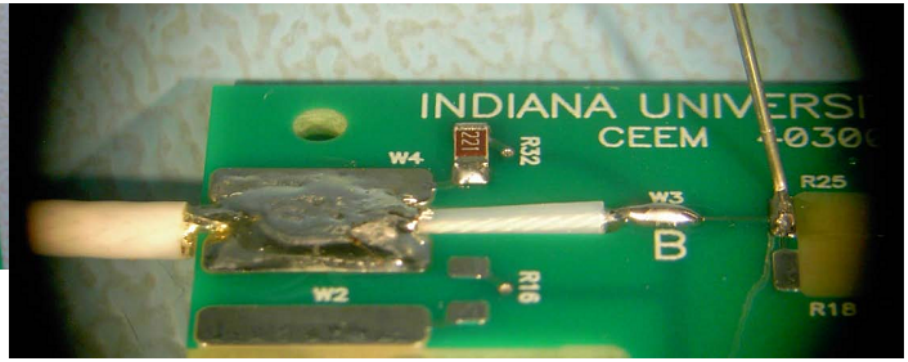
iTOP Electro-opto-mechanical working group meeting

@ Virginia Tech, 7/3/2013

Gerard Visser
Indiana University CEEM

Prototype active divider HV board

(borrowing slide from Gary with an update)



Here are the nominal design and measured voltages and currents at 3672 and 4692 V input:

	nominal @ 900V MCP	measured	nominal @ 1150V MCP	measured
input	-3672 V	**	-4692 V	**
(delta)	(108)		(138)	
K	-3564	-3560	-4554	-4549
(delta)	(270)		(345)	
MCP1N	-3294	-3294	-4209	-4209
(delta)	(900)		(1150)	
MCP1P	-2394	-2390	-3059	-3054
(delta)	(900)		(1150)	
MCP2N	-1494	-1489	-1909	-1902
(delta)	(900)		(1150)	
MCP2P	-594	-590	-759	-754
(delta)	(594)		(759)	
A	0	**	0	**
current	117 uA	118 uA	149.5 uA	151 uA
total pwr 8-ch	3.44 W	N/A	5.61 W	N/A

** the measurement is calibrated from the supply voltage (assumed to be dead on according to PS meter) and zero. The errors of the probe thus calibrated out amount to a few % in accordance with it's specifications.

Everything seems to be in order.

- "HV cable assy/test Run at -8000V without cleaning, Corona doping/coating" (I did apply some corona dope to other metal on the board to get this, but the cable connection was UNCLEANED and NO POTTING OR CORONA DOPE.)

- Current status: five boards completed / delivered, four used in cosmic / beam test, no HVB troubles (??). One additional board at Indiana w/o covers or cables

Prototype HV board (shown without ground covers)

- PCB dimension 104 mm × 95.6 mm
- ***Production version needs to be somewhat smaller (83 mm x 92 mm ?) – possible with encapsulation***
- Total power 3.4 W (@ 900V / MCP)
- Four channels on each side
- 4 layer PCB using blind vias, inner layer HV routing

Series resistor (1 MΩ) provides protection to photocathode

Cable input through resistors provides protection and noise filtering

5 screws (4 stainless steel, 1 Ultem 2300) clamp PCB between Gap-Pad sheets and aluminum ground cover plates

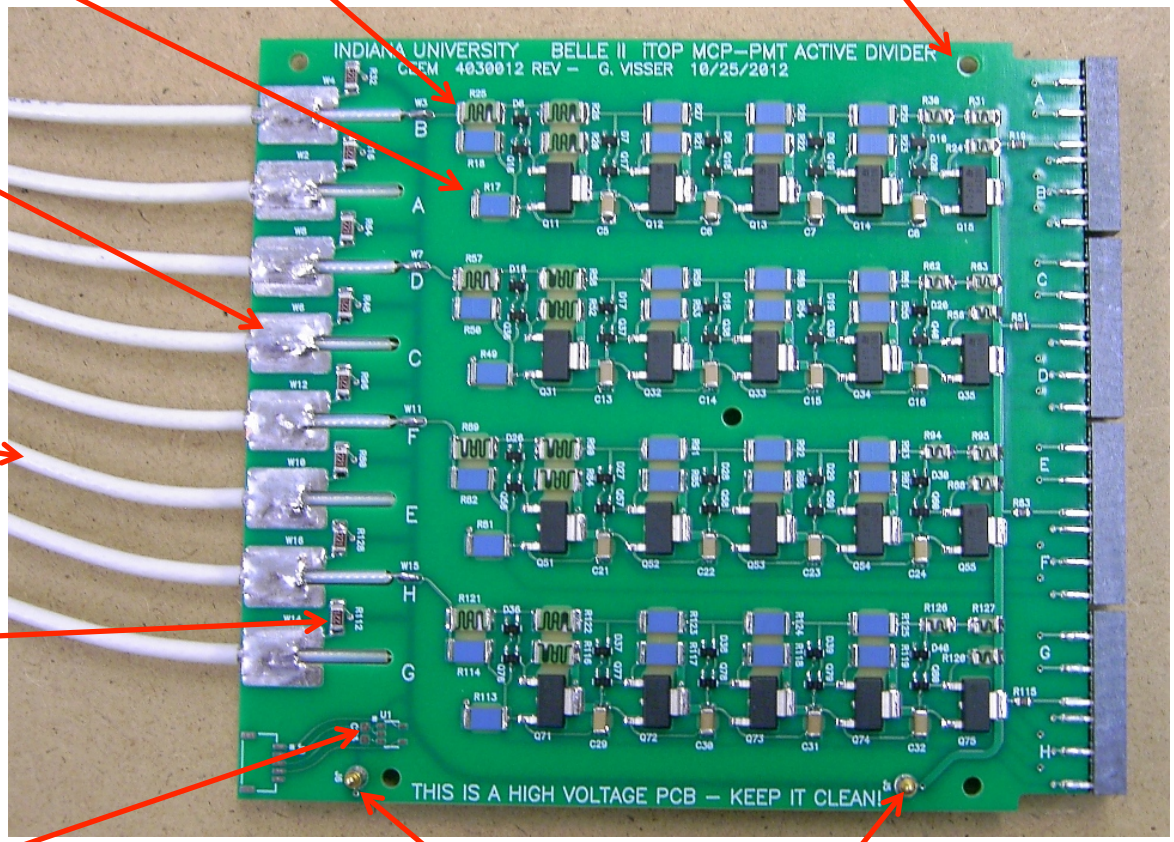
cable lays in slot in edge of PCB, braid soldered to slot (copper tape was needed here, next revision of board will have plated slot)

TESTED −8 kV HIPOT OK

Belden # 83284 (RG-316 type) teflon insulation, FEP jacket

surge-rated 220 Ω resistor in series with each cable ground (reconcile safety with EMI considerations)

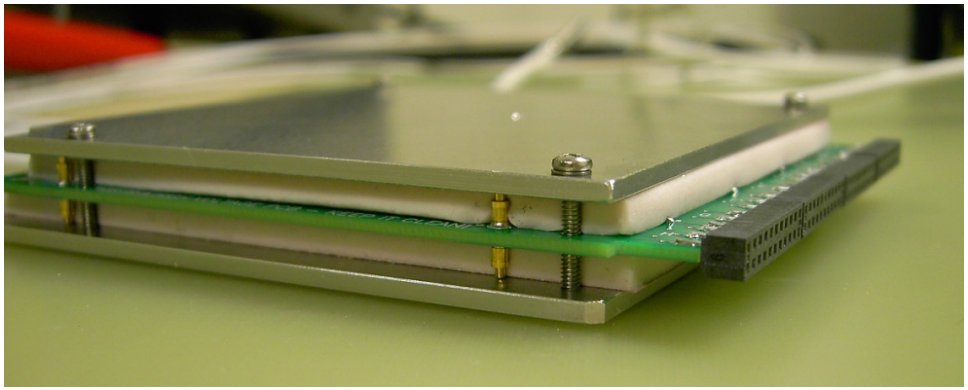
I^2C temperature sensor (future use)

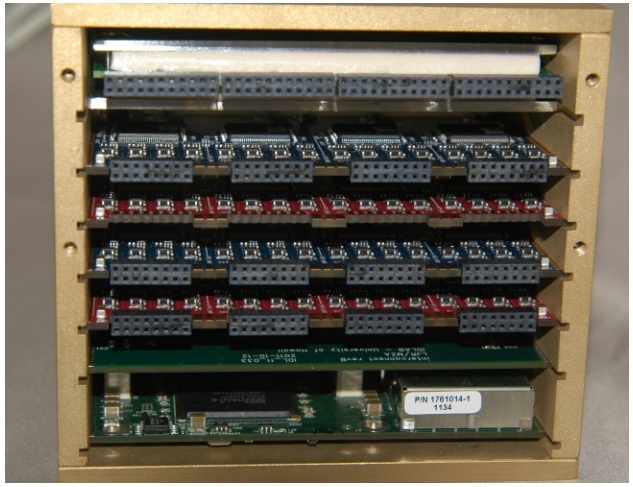


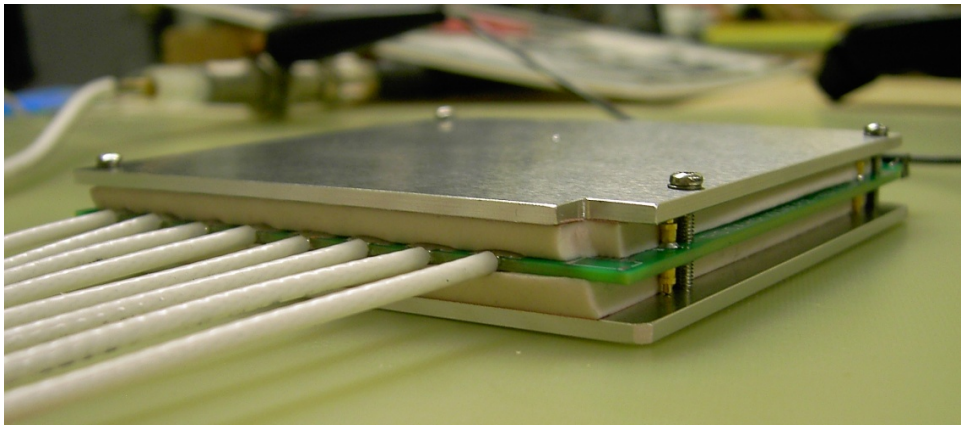
spring pin ground contacts (2 each top & bottom)

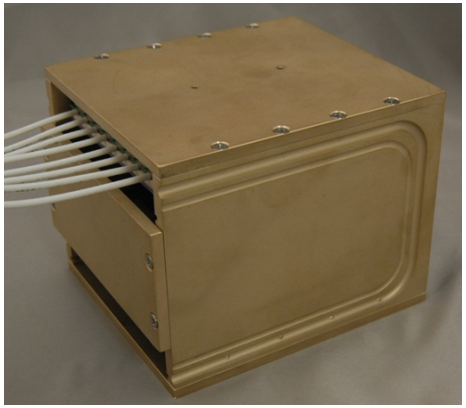
Front board connectors same as before (2 mm pin header / socket style)

Prototype HV board









The main issues are mechanical (as was discussed last time):

- Front board connectors have high insertion force and transverse constraints on mating
- Insufficient clearance in the box to route cables out the required holes in rear
- Insufficient (or at least not guaranteed reliable) thermal coupling
- Possibly insufficient clearance to remove boards for servicing

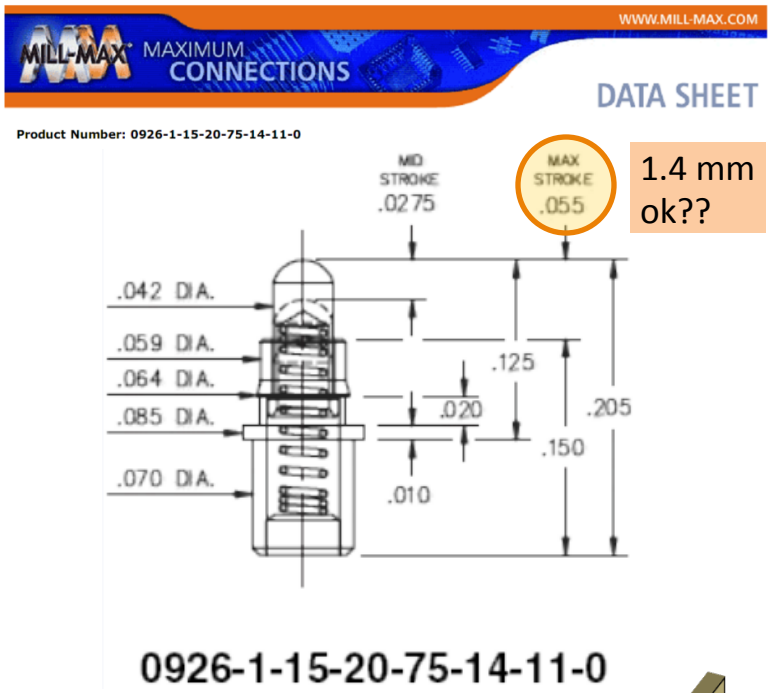
Production HVB to front board connections

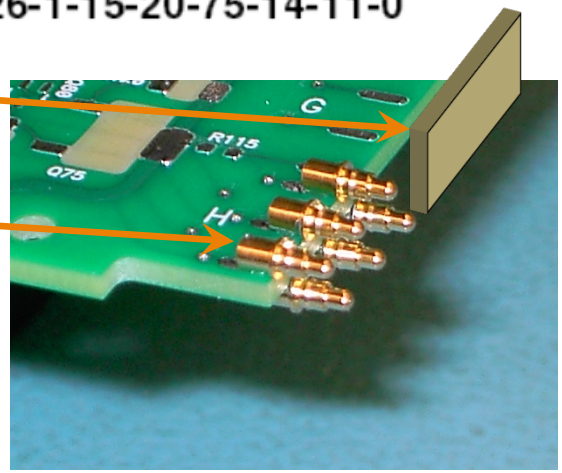
As discussed at the last meeting, we will change to one-piece spring-loaded connector systems for the front board. This offers several advantages:

- No transverse forces applied to front board, and large tolerance of location
- Connectors may be brought up to mating from any angle, easing installation of electronics boards
- The connectors can be very short, saving a few mm to use for HV cable routing at back of the box
- Front board may be easier to work with, having no connectors protruding from the back surface

For the front board, Mill-Max # 0926-1-15-20-75-14-11-0, is nearly ideal. We have to make a "carrier plate" to locate these in the correct position, and solder horizontally to the HV board.

To increase creepage distance, pin count will be reduced from prototype 48 pins to 42 pins by eliminating redundant grounds. (These are **not** signal grounds – **don't worry**!)



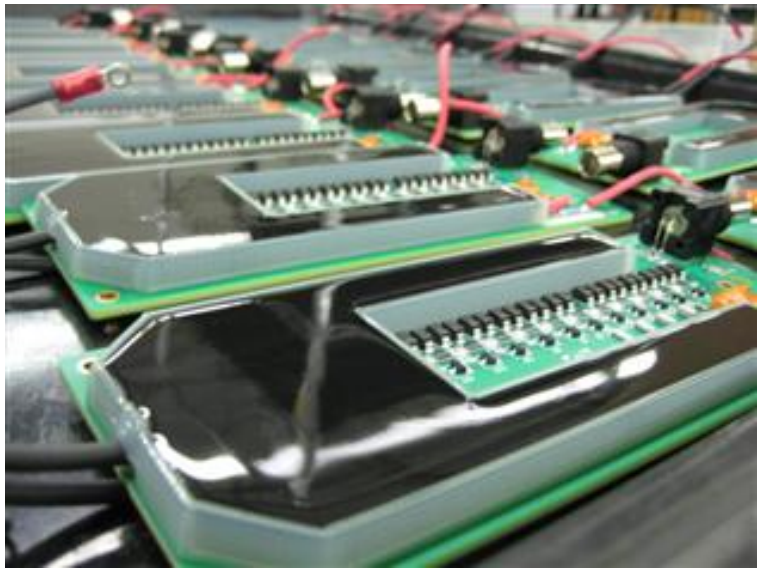


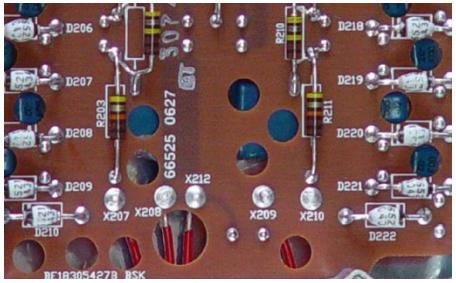
Production HVB epoxy encapsulation

It was hoped to have some details from a vendor to include here. But I have not received yet.

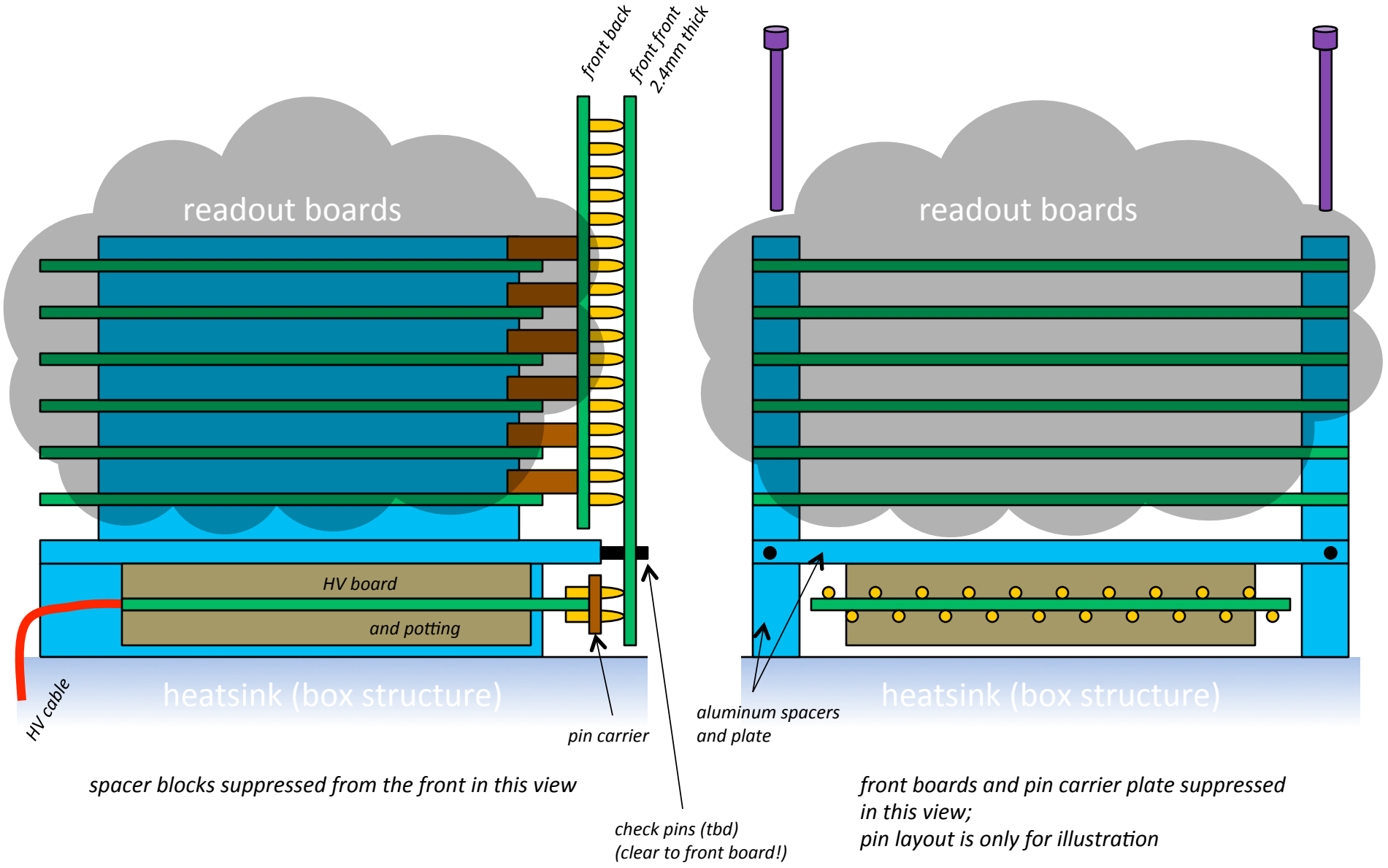
Some initial info:

- It is possible to fill between board and a heatsink plate
    - "Holey" board may be used
- An alternative is to encapsulate the board alone, ensure a flat top, and bond to heatsink in a second step
    - Double-sided tape, epoxy, or thin Gap-Pad w/ screws
- Potting frame may be needed in either case
    - 3D print the frames?





Production HV board and board stack sketch (not to scale)

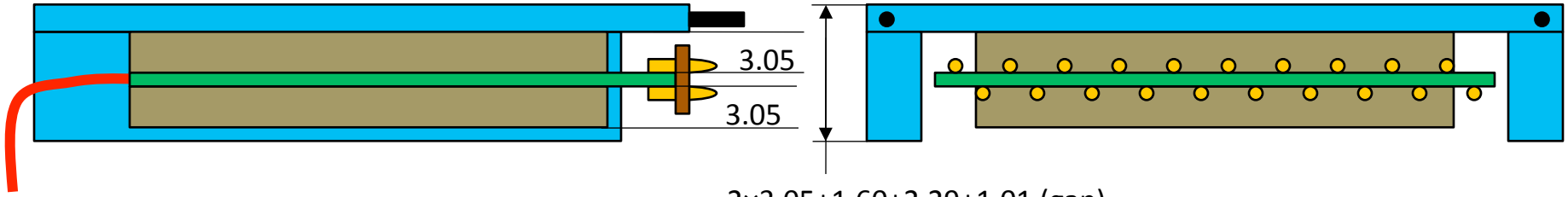


spacer blocks suppressed from the front in this view

front boards and pin carrier plate suppressed in this view;
pin layout is only for illustration

Production HV board assembly (not to scale)

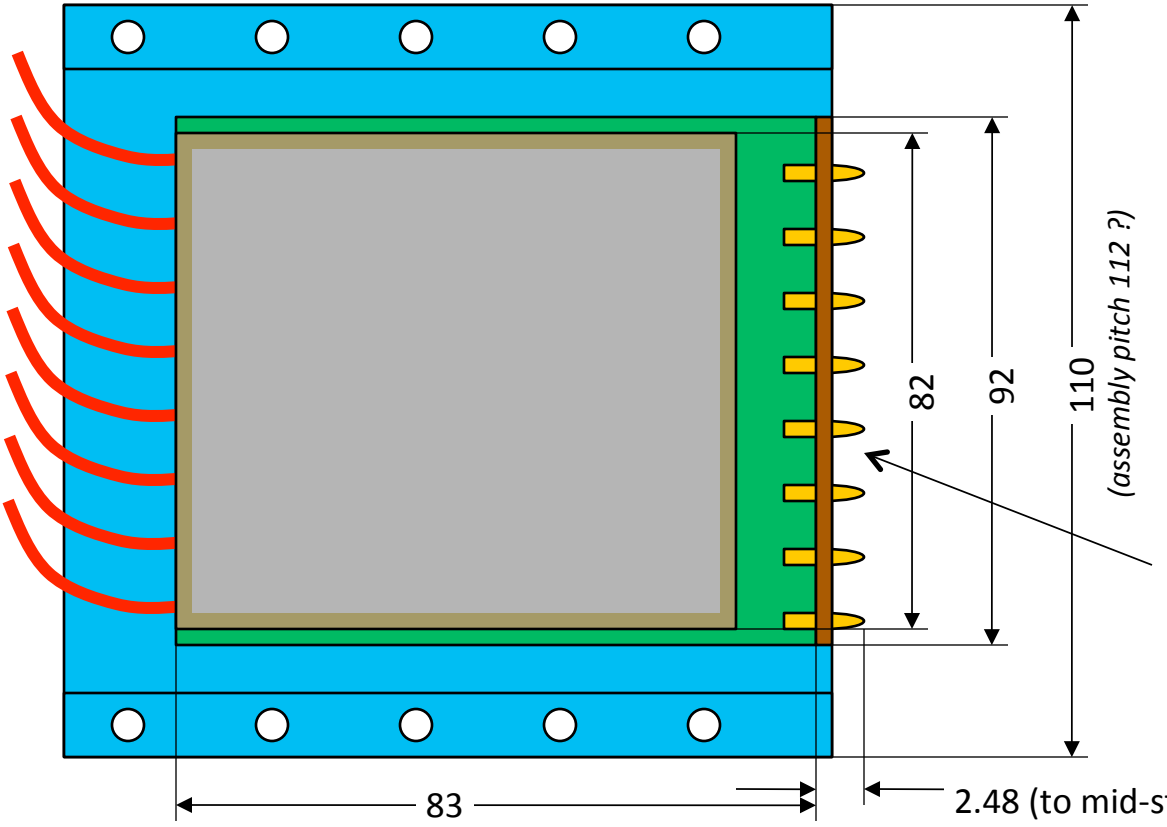
This may be one piece, or two, or four (spacer blocks, plate separable?)
Dimensions shown here are suggested design targets, for discussion.



spacer blocks suppressed from the front in this view

2×3.05+1.60+2.29+1.01 (gap)
= 11.00*

pin carrier plate suppressed in this view;
pin layout is only for illustration



*NOTE: If more than 11.00 is "no problem" then I would gladly use another 1 – 1.5 mm to increase creepage distance on the connector. (By making PCB thicker.)

Mill-Max # 0926-1-15-20-75-14-11-0
42 @ pitch 2.15
staggered top/bottom
pressed to carrier plate, then soldered to PCB

(creepage distance 1.85)

Other changes / questions for production HVB

• Do the cables need to come off at an angle (in the plane of the board)? This is probably possible, but it is complicated and not preferred.

• Divider ratio – any modifications needed from prototype?

0.3 : 1 : 1 : 1 : 0.68*

• Photocathode series resistor value (presently **1 MΩ**) ?

• Cable ground series resistor value (presently 220 Ω) ?

• The cable attachment will be changed to use a selectively plated slot to solder the ground braid to. Unplated slot was not successful, had to use copper tape on prototype.

• I^2C temperature sensor(s) to be added? (I.e. will support for this be added to SCROD?)

• A serial number IC?

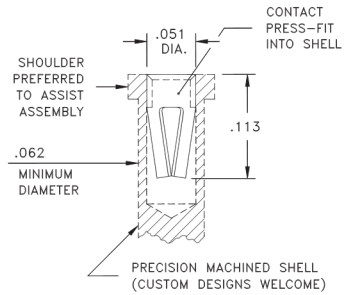
• I don't think it is practical to add any other monitoring circuits, but we can discuss...

*Note: Actually, prototype was 0.3 : 1 : 1 : 1 : 0.66 (combining two resistors that were available in stock, wasting some board space). Resistors have long lead time, need to place production order soon. They are not expensive.

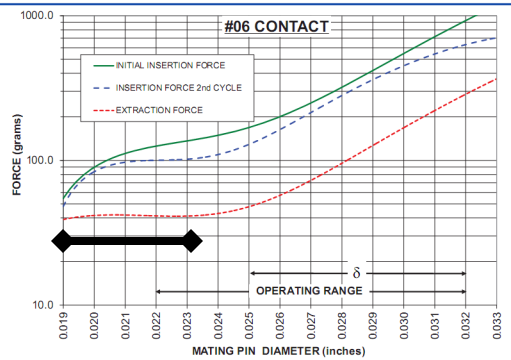
Front board – PMT pin sockets

#06 CONTACT

FOR .022-.032 DIAMETER PINS (δ=.007)
4-FINGER, GROUP D (see page 214)



CONTACT MATERIAL:
BERYLLIUM COPPER Alloy 172, Heat Treated



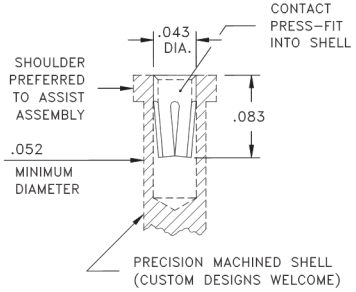
The insertion/extraction/normal force characteristics above were derived using 30 microinch gold plated contact and polished steel gauge pins having a bullet-shaped tip.

The curves represent typical average values; they are best used to compare the differences between similar size contacts and to guide you in selecting one that is suitable for your application. Your results may vary, so for your specification, we encourage you to obtain complimentary samples for your evaluation.

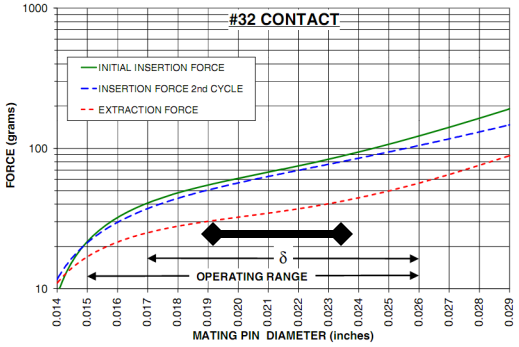
- Used successfully on Matt's prototype front board (Rev C 2011-10-12)
- Our pin diameter range does not lay within recommended range
- Body OD is large, reducing creepage distance
- Minimum pin length may be an issue (0.8 mm more than the ones below), I worry about reliability of the connection
- Nominal 1st insertion force 55 – 120 g

#32 CONTACT

FOR .015-.026 DIAMETER PINS (δ=.009)
6-FINGER, GROUP C (see page 214)



CONTACT MATERIAL:
BERYLLIUM COPPER Alloy 172, Heat Treated



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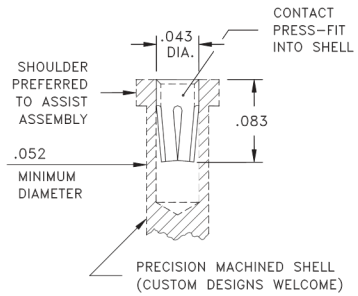
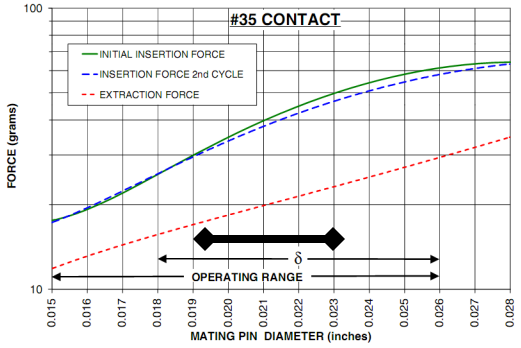
- For production design
- Nominal 1st insertion force 55 – 90 g

#35 CONTACT

FOR .015-.026 DIAMETER PINS (δ=.008)
6-FINGER, GROUP C (see page 214)



CONTACT MATERIAL:
BERYLLIUM COPPER Alloy 172, Heat Treated



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- Extra low force option (a back-up plan)
- Nominal 1st insertion force 30 – 50 g

Front board – PMT pin sockets

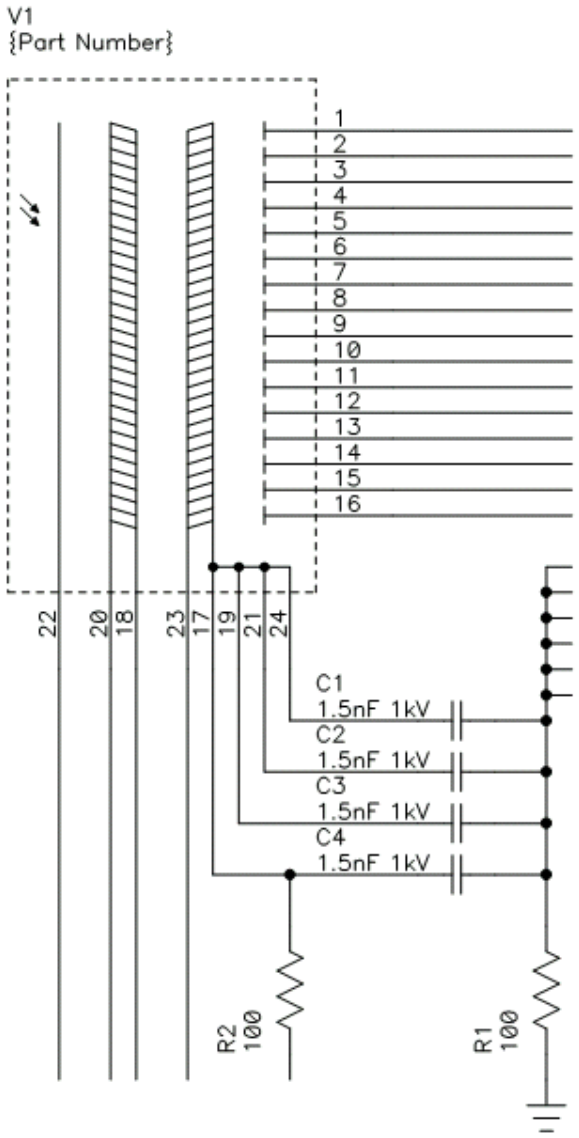
• SL-10 mechanical drawing says 0.50 mm pin diameter. Is it wrong, or is there a large, unspecified, tolerance? (I measure 0.57 mm on a mechanical sample tube. The difference is not insignificant, from the perspective of ensuring reliable connections.)

• I still believe that we should ask from Hamamatsu an official mechanical drawing that includes the pin diameter, length exposed out of the potting material, length from pin end to glass face, *and tolerances on the diameter, lengths, and locations of the pins*.

• In lieu of that, we ought to measure pin diameters (probably on a subset of pins) on each of the tubes that we have.

• Each pin end should be inspected (under microscope) for sharp edges, and deburred if necessary. If there are sharp edges, it is probably still ok for *single use* in a pin socket, but should not assume the pin socket will be re-useable for another insertion.

Front board – schematic



to front back board
2x 7 pins + 1x 8 pins per PMT

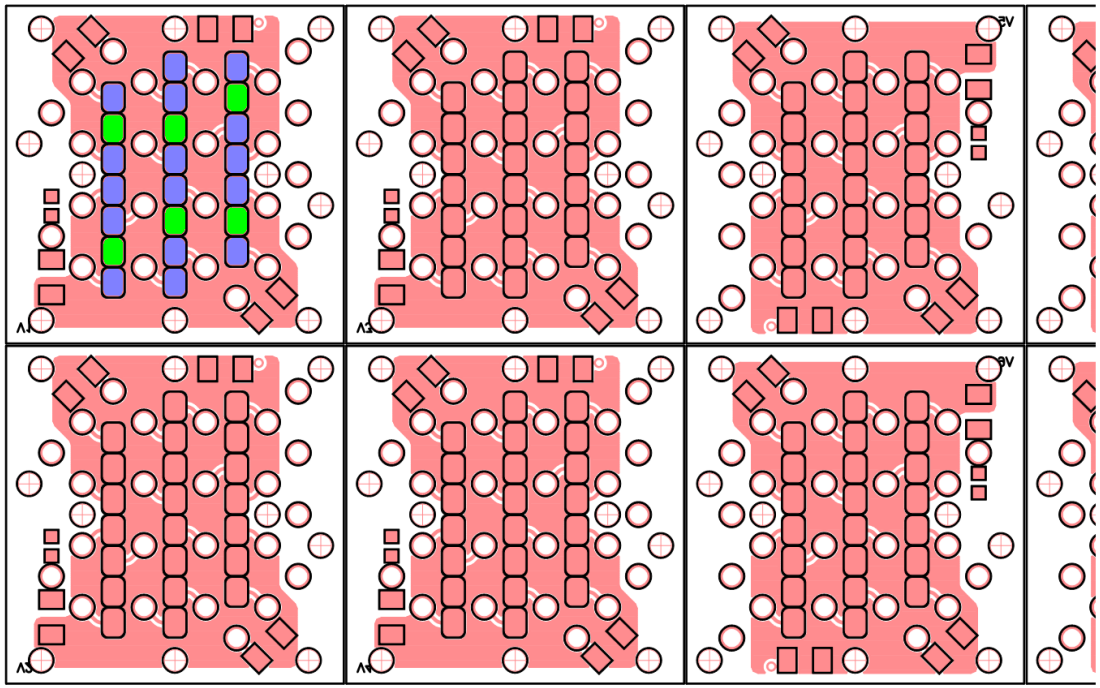
i.e. 6 signal ground pins per PMT
(prototype used 2 ground pins)

to HV board
5 pins per PMT
+ 2 pins HVB ground (common)

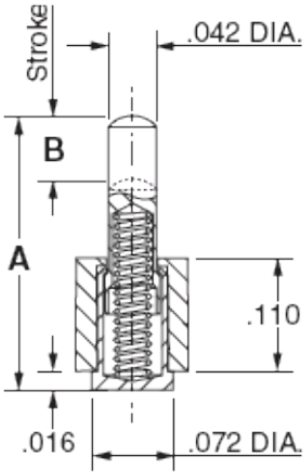
do we connect together the 4 bottom MCP pins?

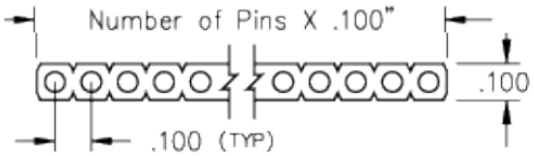
Front board – signal connector contact pad layout

Vertically oriented because same "routing channel" that is good for connectors is also good for HV trace routing (which must be vertical).
But, no problem, the front back board can route signals to any sort of horizontal connectors.



Product Number: 811-22-007-30-004101

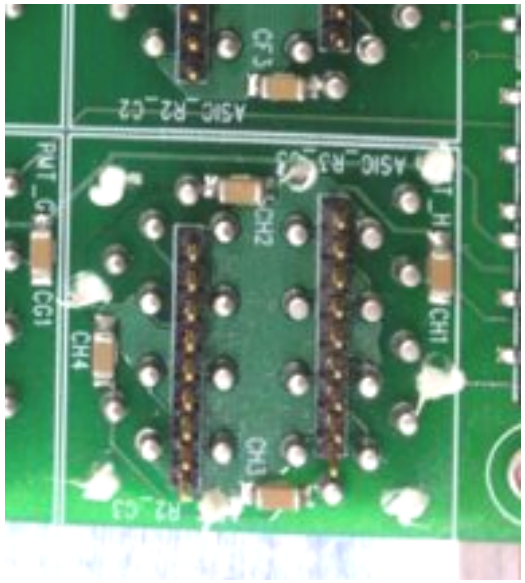




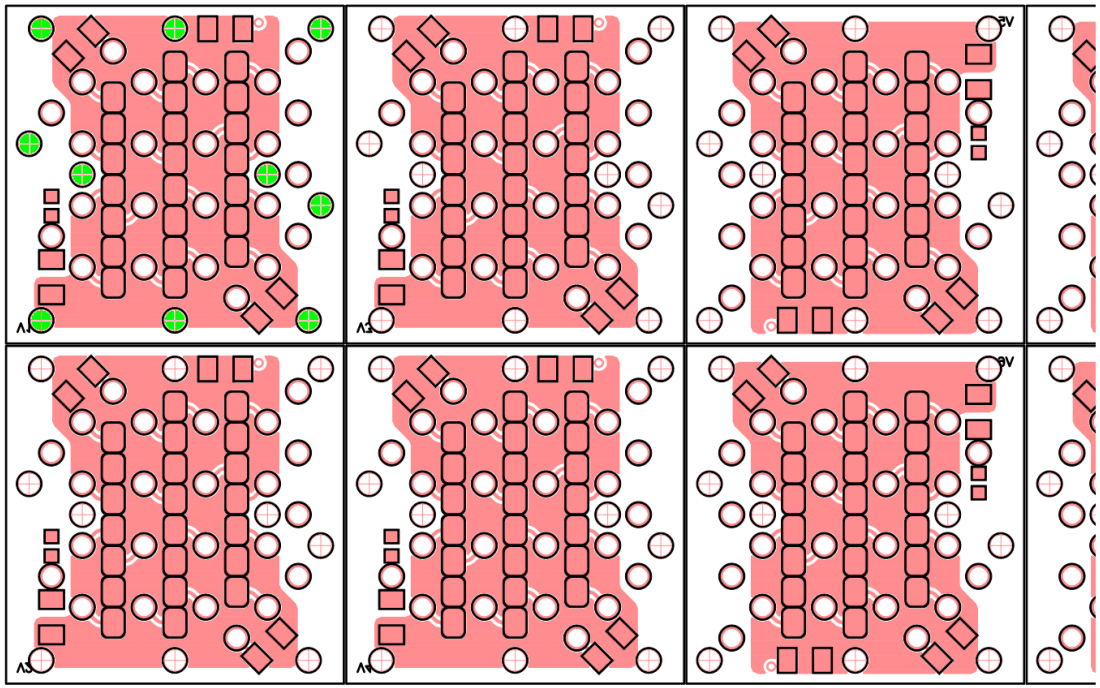
# Of Pins	A	B	Mill-Max Part Number
7	0.236	0.055	811-22-007-30-004101

Contact pads 1.65 mm × 2.24 mm, roughly this gives the mating position tolerance in assembly.
Are these values sufficient?
Note: Contact pads to HVB should be circular ~ 2.10 mm diameter.

Front board – PMT back potting access holes



holes ~2 mm diameter, 4 at corners and 4 at middle of edges, pronounced satisfactory by Suzuki-san; “a few more in the middle would be good”



proposed design, 1.8 mm diameter, 4 at corners and 4 at middle of edges, plus 2 more slightly more in middle

Backup slides

HVB channel schematic