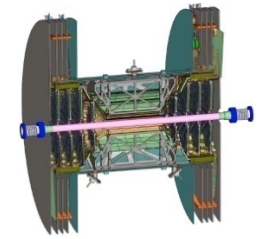


High Density Interconnect (WBS 1.4.3) Extension Cables (WBS 1.4.4)

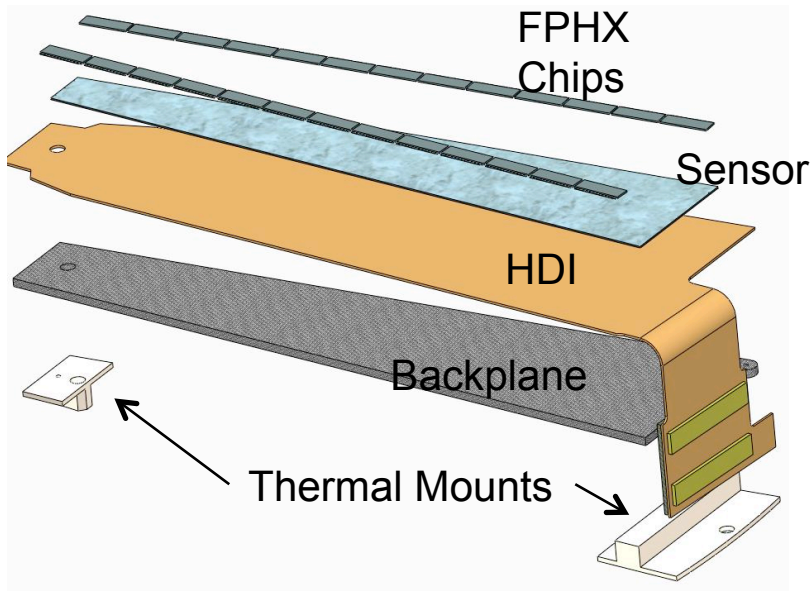
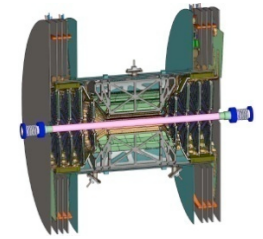
Douglas Fields
University of New Mexico



Talk Outline

- Production Overview
 - HDI
 - Design
 - Q/A
 - Bending
 - Production Issues & Solutions
 - Extension cables
 - Design
 - Q/A
 - Production Issues & Solutions
- Summary Technical, Cost, and Schedule

FVTX Production HDI Wedge Assembly



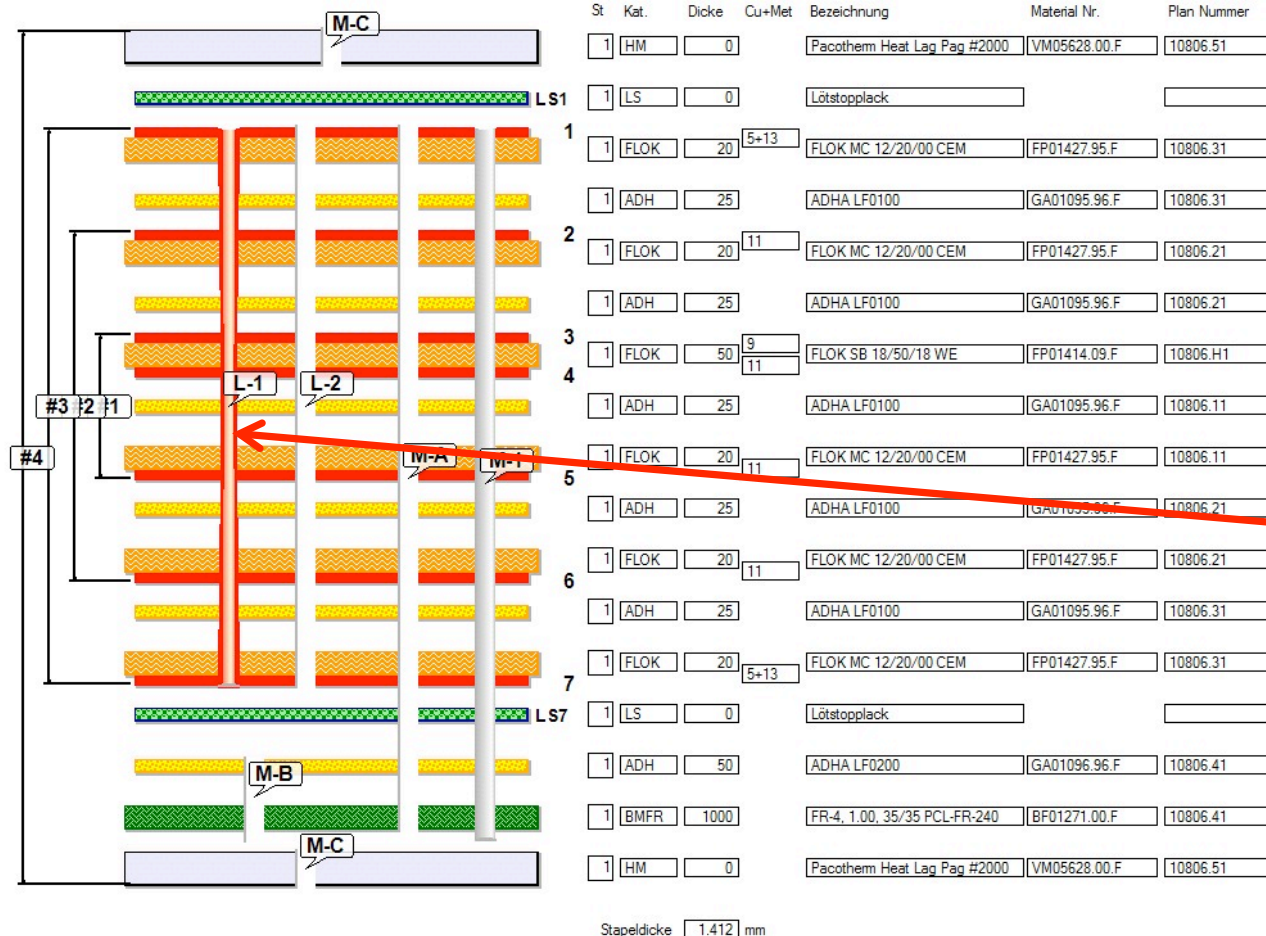
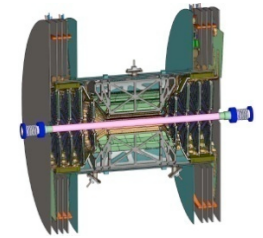
HDI trace count

2 R/O lines x LVDS pair x 26 chips	104	100 Ω impedance
4 Download and Reset lines	4	100 Ω impedance
2 Clocks/side x LVDS pair	8	100 Ω impedance
1 Calibration line/side	<u>2</u>	50 Ω impedance
	118	

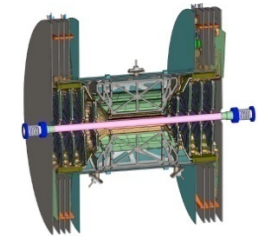
Traces are 40 microns wide with 100 micron spacing

- **High Density Interconnect (HDI) –** polyimide flex cable to supply bias to sensor and power to FPHX chips, and transfer clock and data to and from the chips to the read-out electronics
 - ~320 μ m thick
 - 7 copper planes, 6 Kapton films
 - Thickness/Rad length < 0.004

FVTX Production HDI Stackup



Laser-drilled 70 micron through vias



FVTX Production HDI

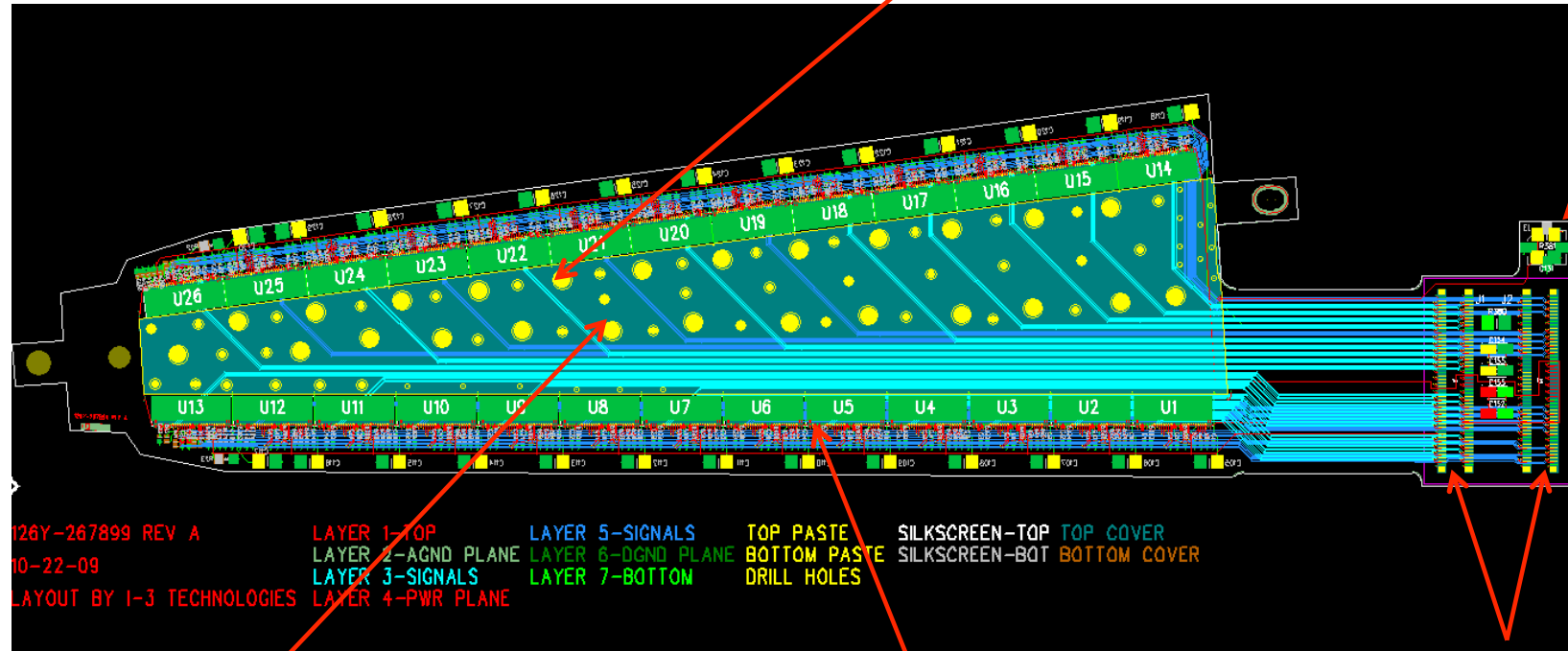
Layer Thickness and Radiation Thickness

Radiation lengths (cm) of
Layers: copper:1.43 kapton: 28.6 epoxy: 44.37

	#of layers	fraction of layers	R_L	Production	Imp target	Ref plane (layer)
top covercoat	1	0.2	0.171287	10		
copper 1	1	0.8	6.713287	18	50 SE	2
kapton 1	1	1	0.874126	20		
epoxy 1	1	1	0.270453	15		
copper 2	1	0.9	7.552448	11		
kapton 2	1	1	1.398601	20		
epoxy 2	1	1	0.270453	15		
copper 3	1	0.1	0.839161	9	100 DIFF	2,4
kapton 3	1	1	1.748252	50		
copper 4	1	0.9	7.552448	11		
epoxy 3	1	1	0.270453	15		
kapton 4	1	1	1.398601	20		
copper 5	1	0.1	0.839161	11	100 DIFF	2,4
epoxy 4	1	1	0.270453	15		
kapton 5	1	1	1.398601	20		
copper 6	1	0.9	7.552448	11		
epoxy 5	1	1	0.270453	15		
kapton 6	1	1	0.874126	20		
copper 7	1	0.2	1.678322	18	50 SE	6

(Total thickness)/(Radiation length): 0.00419

Holes for out-gassing designed in

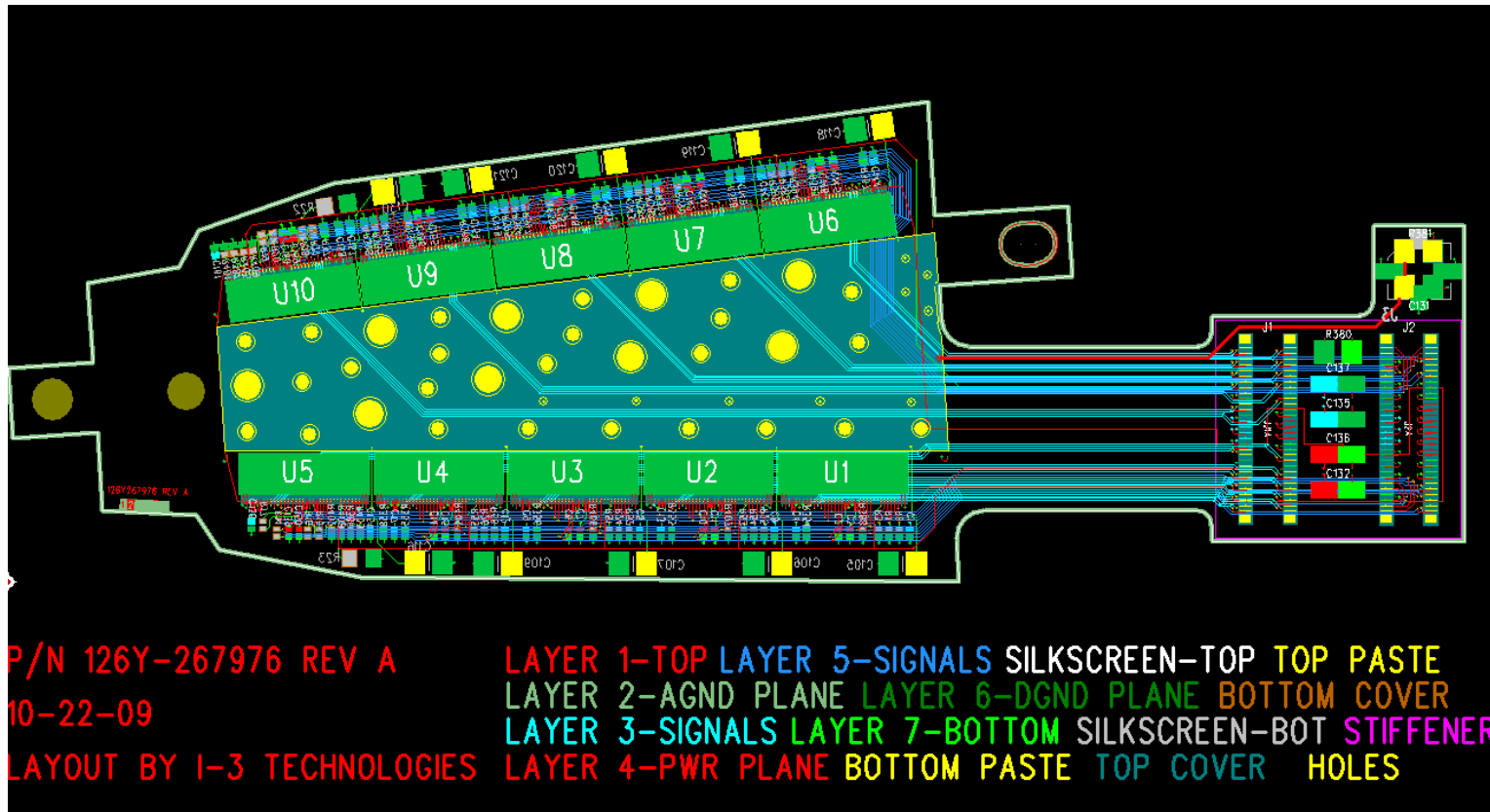
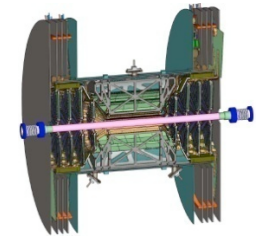


Sensor

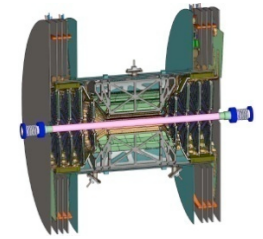
Connectors

FPHXs

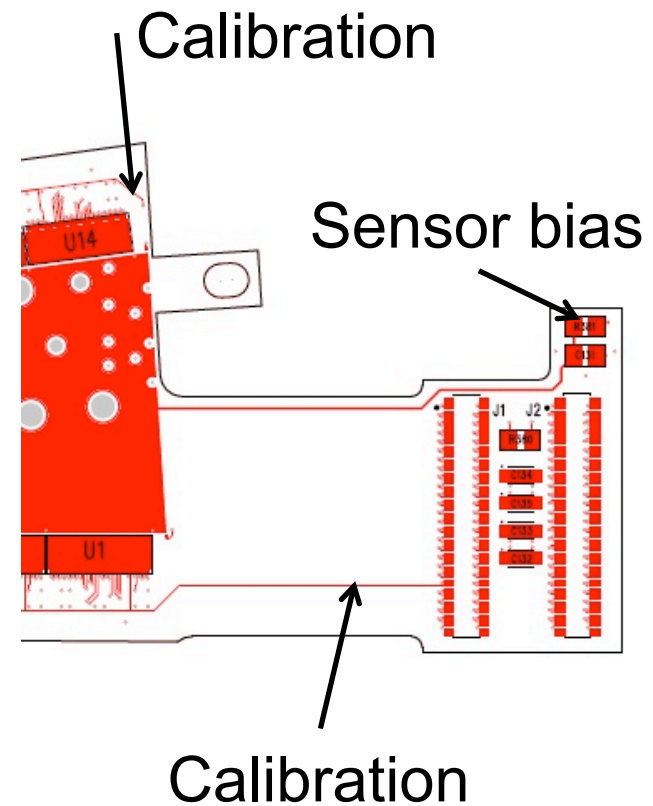
FVTX HDI Production Design



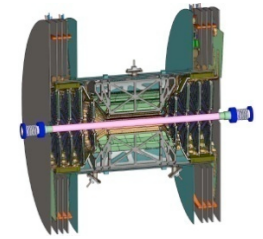
FVTX Production HDI Layout



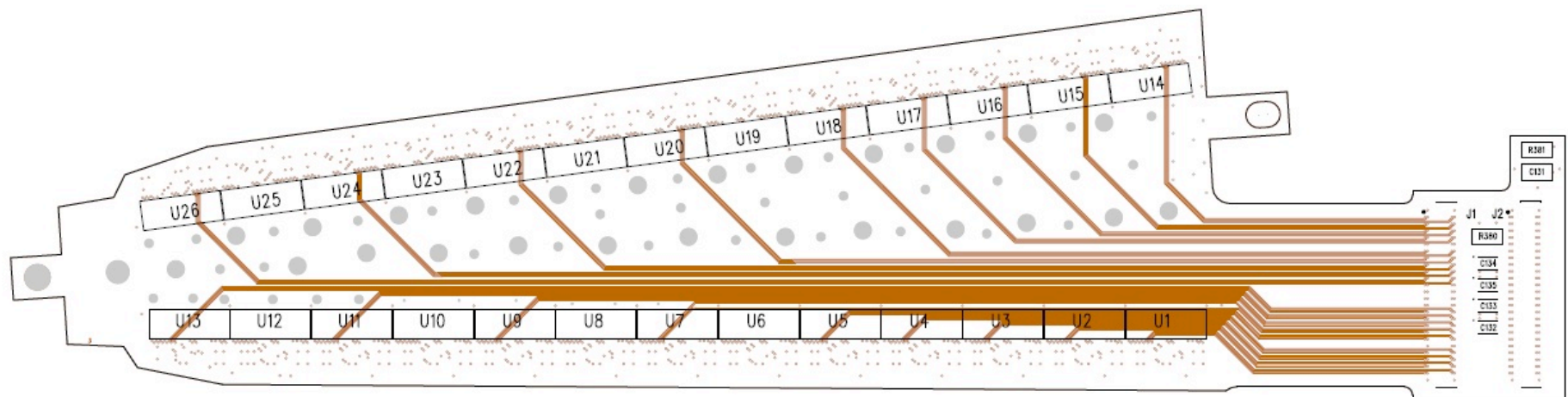
- Layer 1
 - Vias to internal and bottom layers
 - Calibration line
 - Sensor bias
 - Ground planes under FPHX



FVTX Production HDI Layout



- Layer 3
 - Read-out LVDS lines (partial)
- Layers 2, 4, and 6 are ground planes



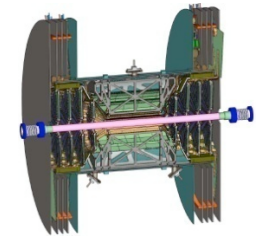
126Y-267899 REV A
12-10-09
LAYOUT BY I-3 TECHNOLOGIES

LAYER 3-SIGNALS

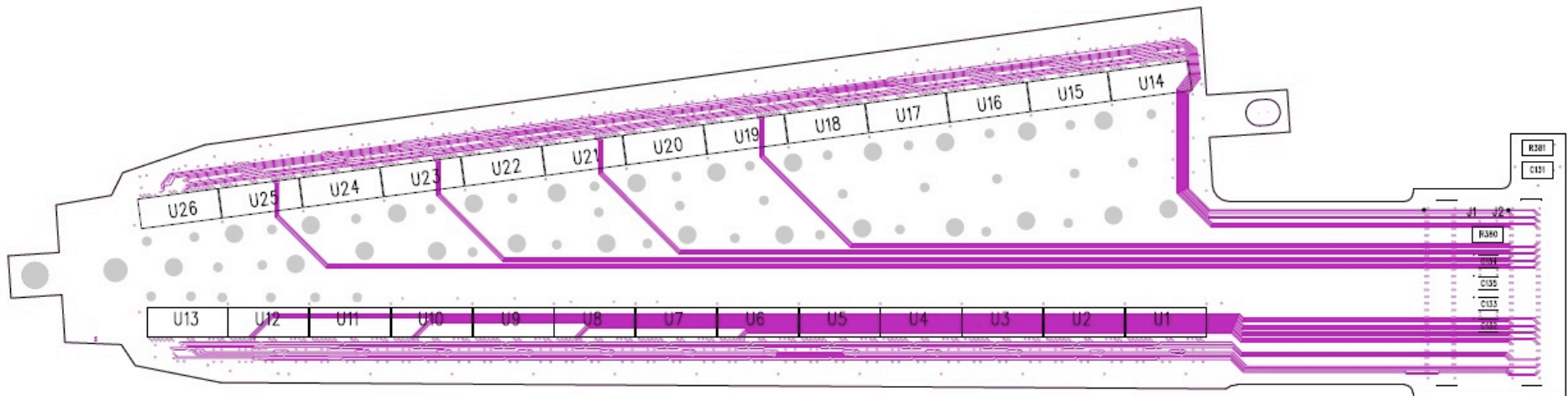
SILKSCREEN-TOP

DRILL HOLES

FVTX Production HDI Layout



- Layer 5
 - Clocks and control
 - Remaining read-out LVDS



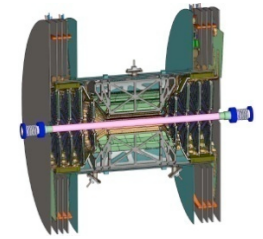
126Y-267899 REV A
12-10-09
LAYOUT BY I-3 TECHNOLOGIES

LAYER 5-SIGNALS

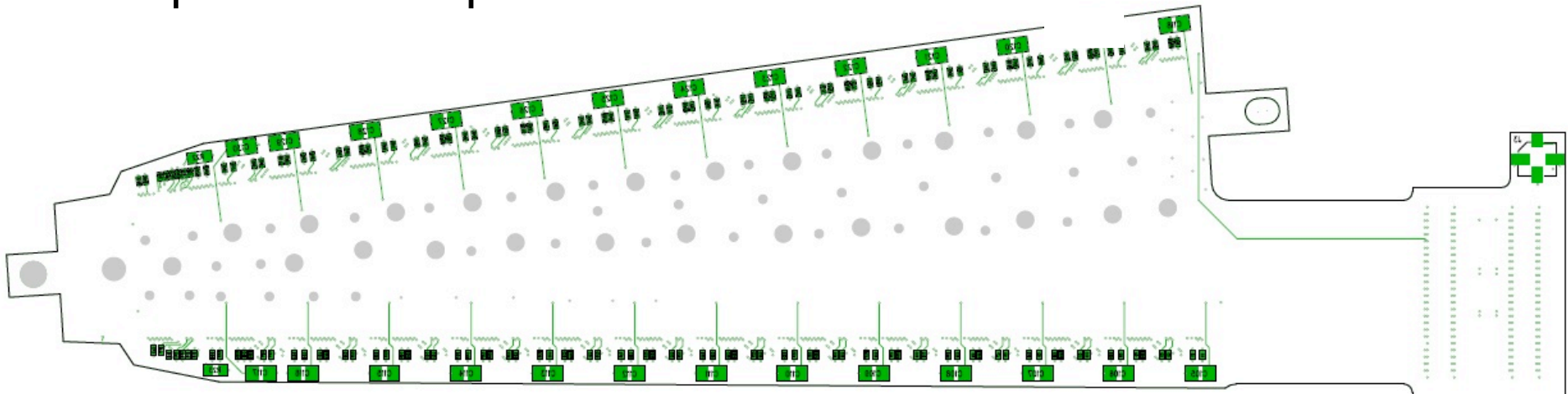
SILKSCREEN-TOP

DRILL HOLES

FVTX Production HDI Layout

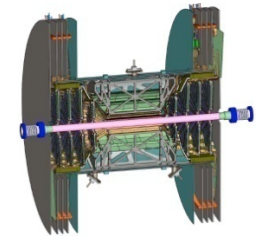


- Layer 7
 - Filtering and termination, passive components

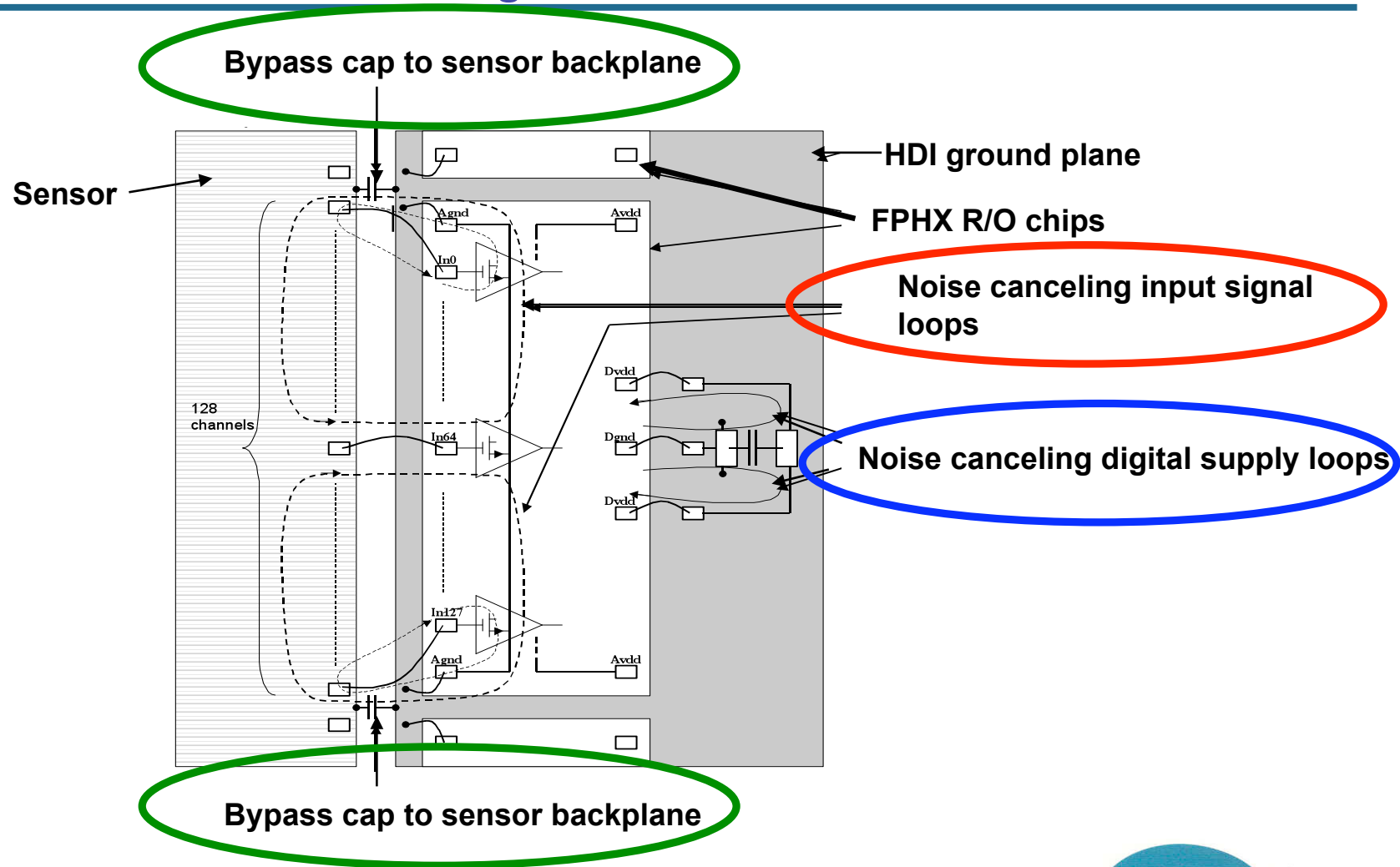


126Y-267899 REV A
12-10-09
LAYOUT BY I-3 TECHNOLOGIES

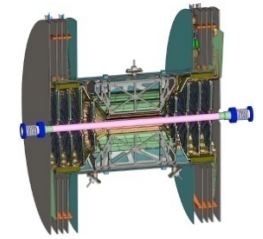
LAYER 7 BOTTOM DRILL HOLES SILKSCREEN-BOT



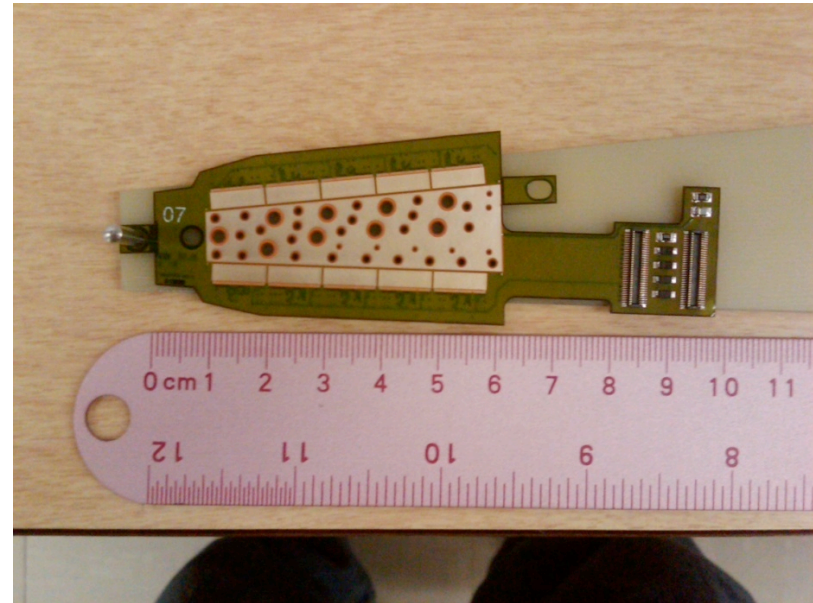
FVTX HDI Production Power Filtering



FVTX Production HDI Realization

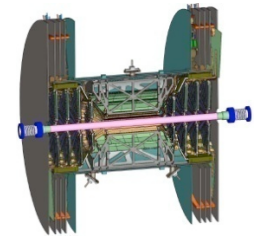


- Small wedge HDI production completed Oct 2010
 - 117 modules fully assembled and tested
 - 118 sensors available
- 1 wedge (with sensor) that doesn't allow bias



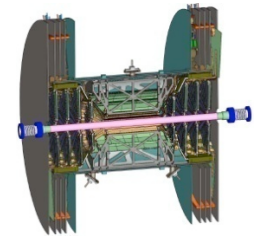
- Large wedge production (of first articles) completed in June 2010
 - 20 modules fully assembled and tested

FVTX Production HDI Testing



- HDIs are tested at UNM before being sent to SiDet for assembly.
 - Connected to test read-out with FPGA.
 - Signals are sent down every read-out pad for each FPHX separately.
 - FPGA programmed to look for appropriate patterns for each chip.
- Also tested each termination resistor, and leakage current from bias.
- Two HDIs (1 large and 1 small) found with broken traces and returned to Dyconex for replacement.
- A couple of HDIs that wouldn't connect.
 - Will add placement measurement of connectors to large HDI Q/A.

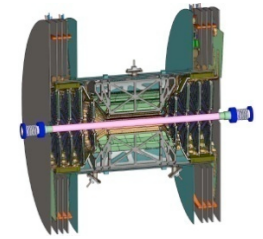
FVTX Production HDI Calibration and Data Taking with Source



- See D. Winter's talk next...

FVTX Production HDI

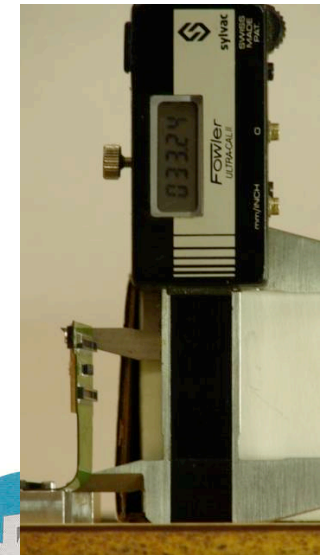
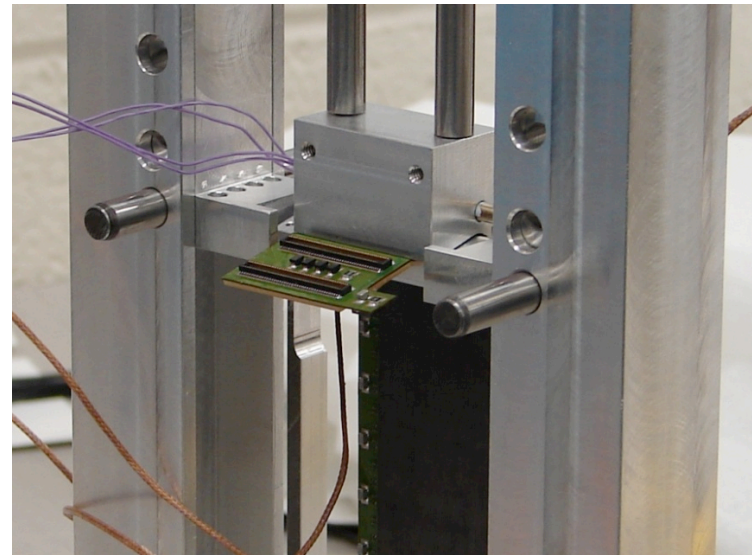
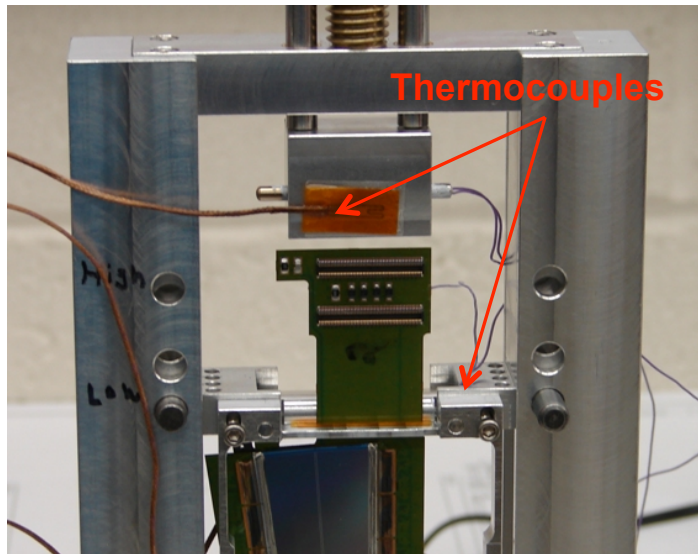
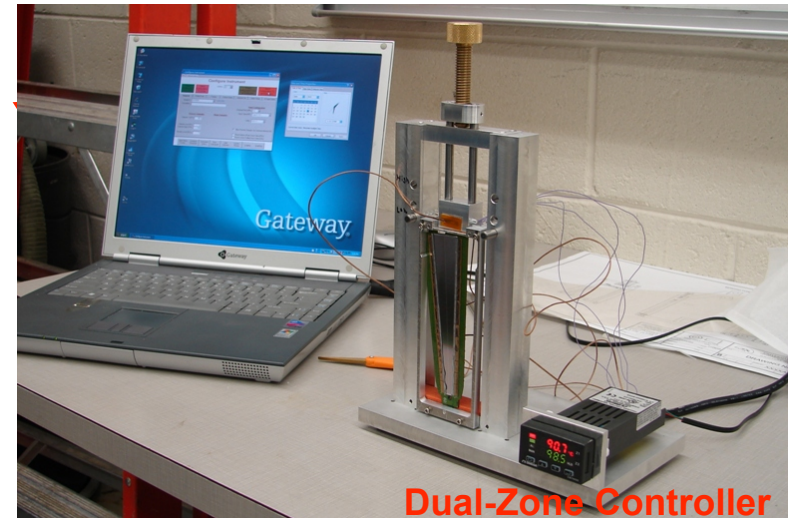
HDI Bending Jig and Heating System



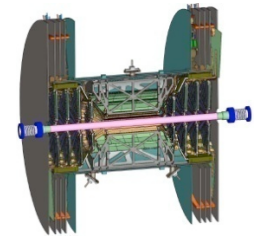
Heat the HDI at 100 C for 4-5 min.
Let it cool down to room temperature.

Over-bend the HDI to smaller radius.
3.5mm instead of 4.0mm

Two module were tested before and after bending. No damage was done to the module due to heating.

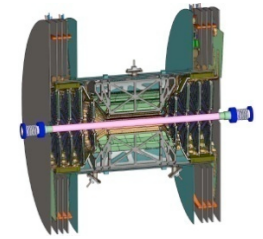


FVTX Production HDI Production Issues

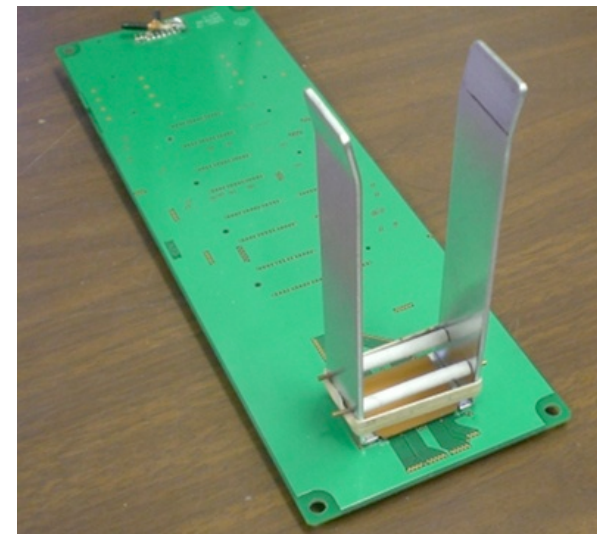
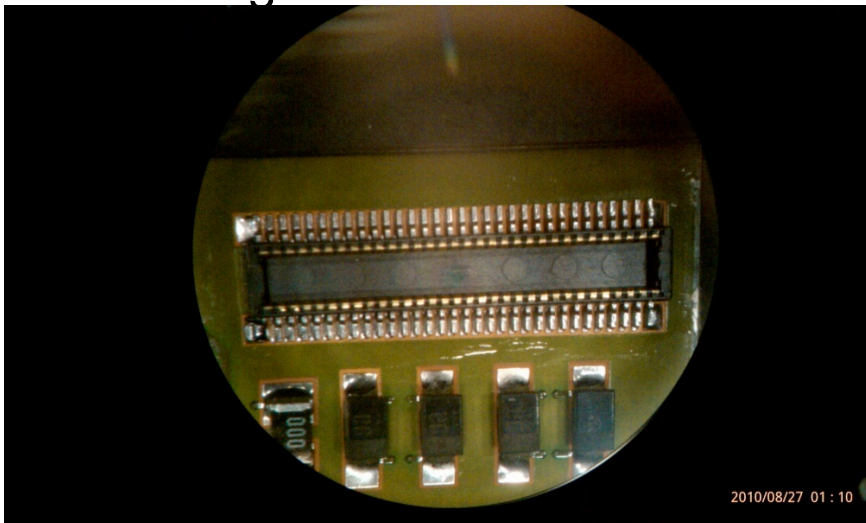


- Bending, even after over-bending, still relaxes somewhat.
 - We have built a jig to keep the HDIs with 90 degree bend. This seems to help.
 - We don't believe that this is a major issue.
 - It takes very little force to return to 90 degrees.
 - (IMHO) overlapping HDIs on a single half disk can be restrained together to keep them both at 90 degrees.

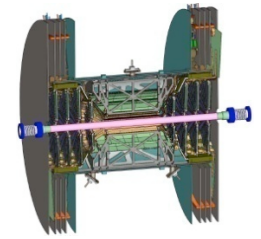
FVTX Production HDI Production Issues



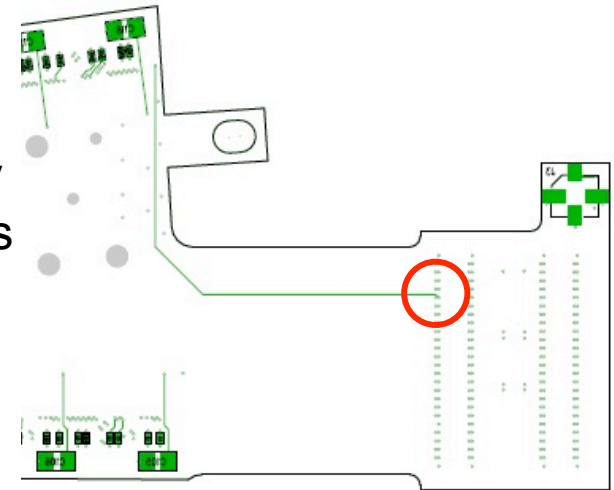
- Hirose connector disconnect/connect failures.
 - Dual 100-pin Hirose connectors failed to mate and had sufficient un-mating force to pull off connectors from surface mounts bonds.
 - Pull-off only occurred on hard PC interconnect boards.
- Q/A spacing to check for mis-alignment.
- Designed connector puller to keep connectors parallel during un-mating.



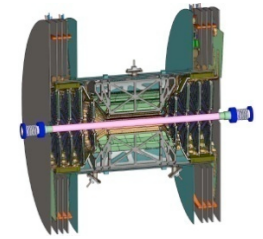
FVTX Production HDI Production Issues



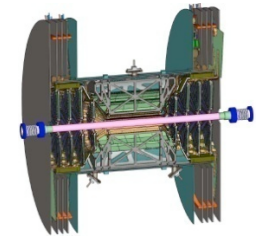
- Small HDI calibration left-side line fault
 - On small HDI production lot, several of the HDIs (all of which passed initial Q/A), failed to send calibration signal down one side.
 - Isolated the fail point to under stiffener.
 - Dyconex believes it understands the failure.
 - The area under the stiffener had no coverlay (to make a better bond to the stiffener), but this means that that area had a nickel/gold plating (used for wire-bond pads).
 - Nickel/gold plating is brittle and cracks can propagate to the copper underneath.
 - For small HDIs (already made), we will solder a wire to replace this broken trace.
 - Production large HDIs will have no plating in this region.
 - See D. Winter's talk for more information.



FVTX Production HDI Production Issues



- THE major issue: Production lot of large HDIs failed electrical tests.
- History:
 - Dyconex produced prototype large HDIs successfully with 70 micron laser-drilled through vias.
 - Dyconex produced first items (25) large HDIs with production design with 70 micron laser-drilled through vias.
 - Dyconex produced complete production order of small HDIs (150) with 70 micron laser-drilled through vias.
 - Dyconex produced prototype order of long extension cables with 70 micron laser-drilled through vias.
- So, it came as a surprise to hear that the failed lot of large HDIs had problems with the plating of the through vias...
 - Jon Kapustinsky travelled back to Dyconex (Switzerland) to discuss issues.
 - We held several phone conferences to discuss the issue and solutions.

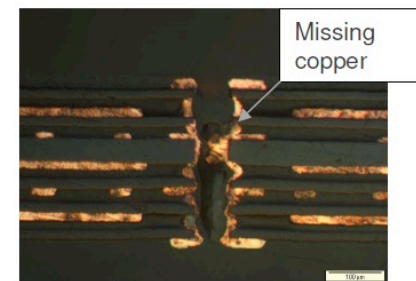
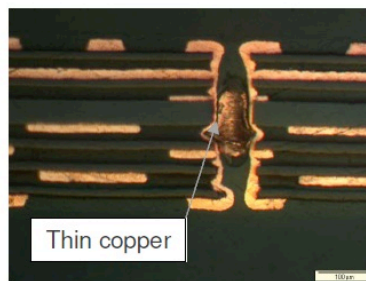
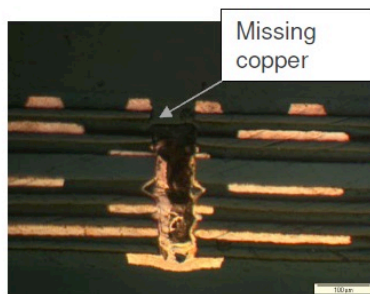


FVTX Production HDI Production Issues

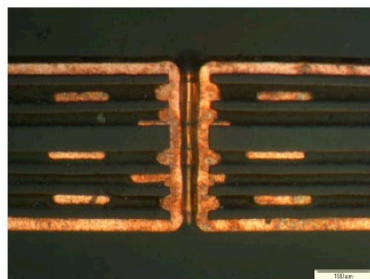
- Micro-sections of vias with problems:



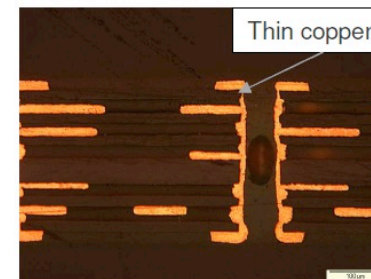
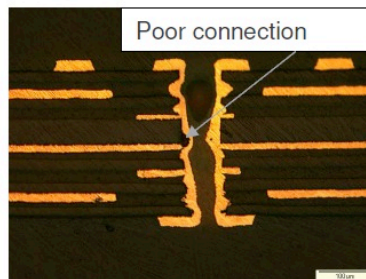
BPXO 10918.H1 Microsection Pictures



Microsections from PCBs with „opens“ found in electrical test.



Quality of plating from pre-runner panel is good.

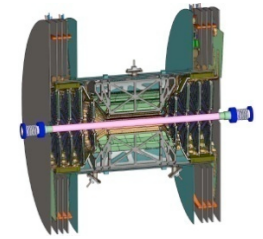


Microsections at final inspection show plating quality issues.

3. November 2010 2

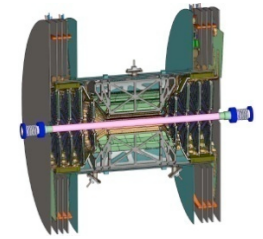
Ian Kilburn -This information is CONFIDENTIAL property of Dyconex. Unless duly approved in writing by authorized Dyconex personnel, any dissemination, in full or in parts, is strictly prohibited.-

FVTX Production HDI Production Issues



- Dyconex suggested that the safest (for schedule) way to proceed was to move to 100 micron mechanically-drilled through vias.
 - Larger pads, and accept 25% breakout (industry standard).
 - Because of this, in some places on internal layers, there was only 40 microns between pads and adjacent traces.
 - This was the reason it wasn't designed that way.
 - However, Dyconex believed that this wasn't a concern.
 - The large HDI production restarted with the new via features.

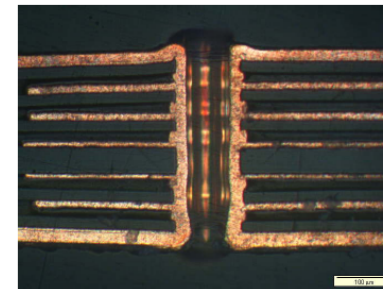
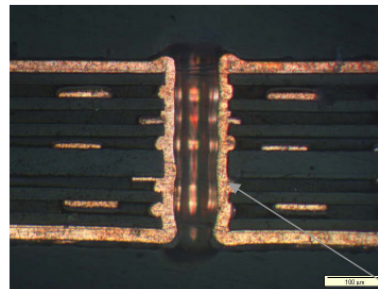
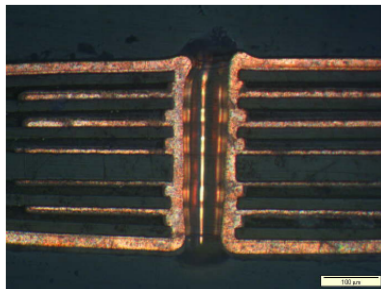
FVTX Production HDI Production Issues



- Successful mechanical drilling run:
BQPT 10918.H1 Microsection Pictures



Mechanically drilled holes at 100 μ m diameter



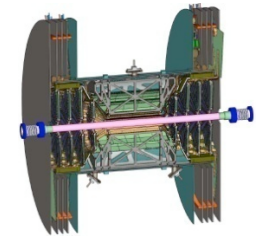
Quality of hole drill and plating in print is adequate.

Mis-registration acceptable

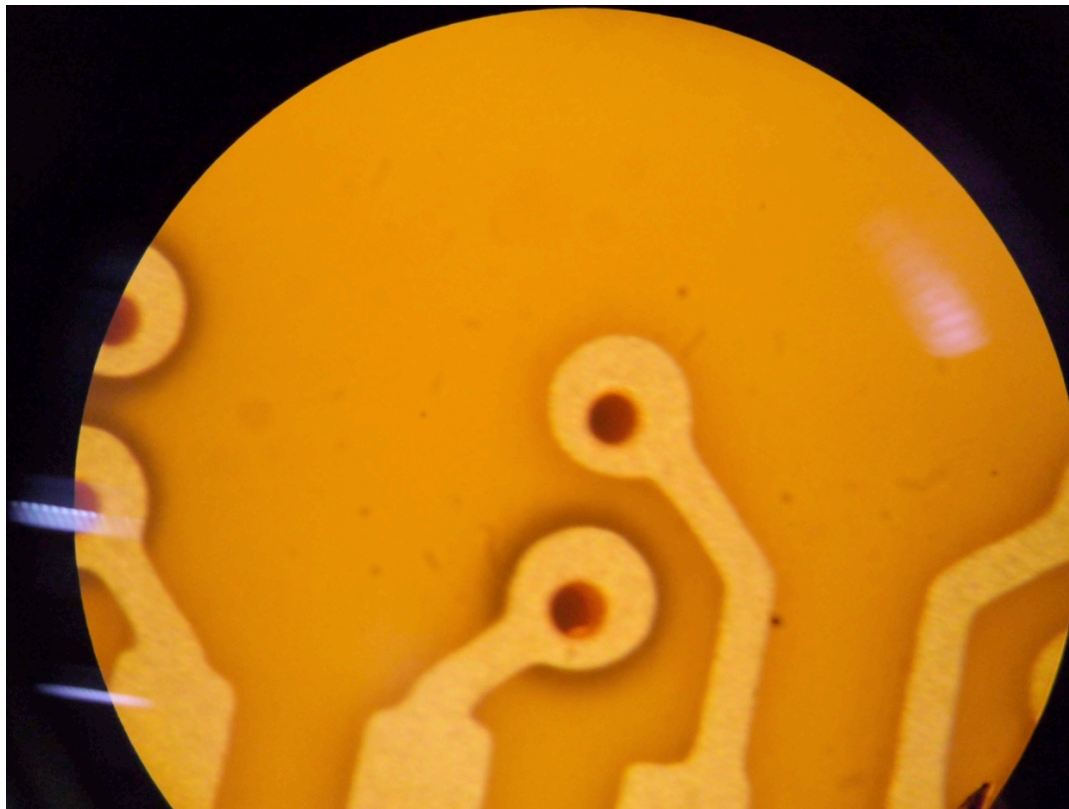
8. November 2010 2

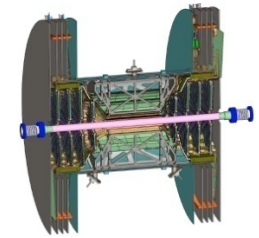
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FVTX Production HDI Production Issues



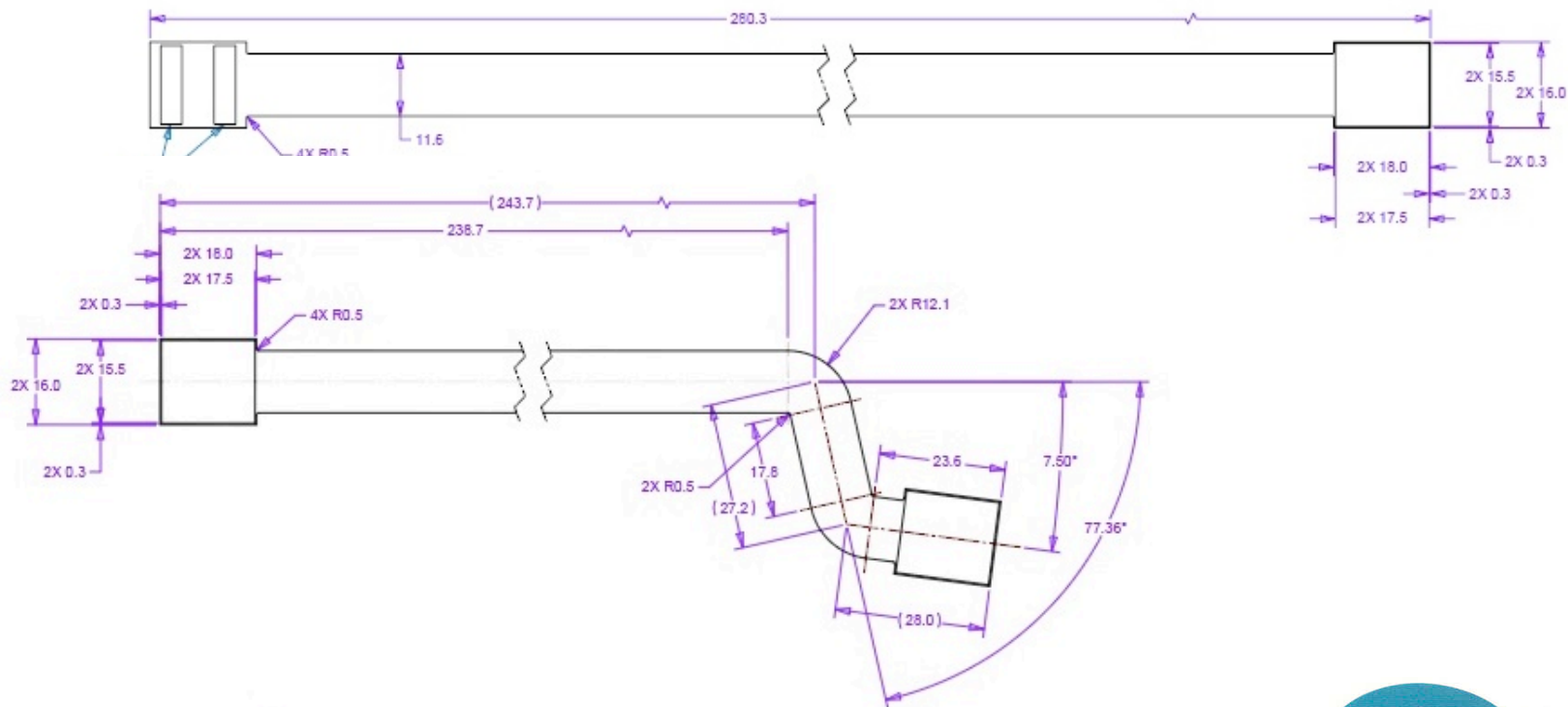
- Successful 40 micron etch:



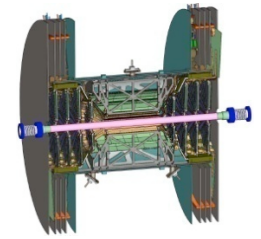


FVTX Production Extension Cables Design

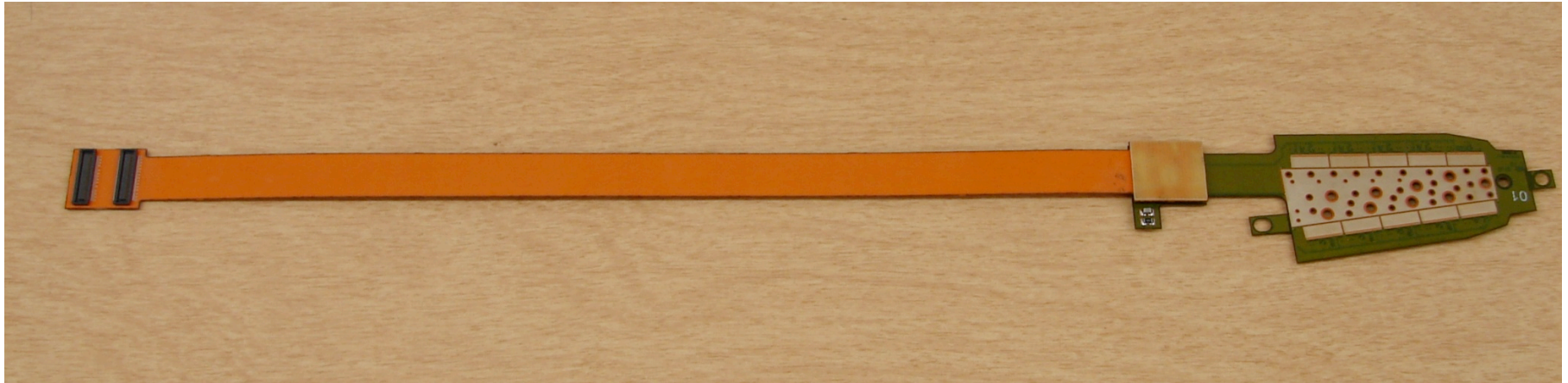
- Sixteen different mechanical outlines needed for the extension cables
- But, netlist the same (for all large, small).
- Stackup and most parameters the same as HDIs.



FVTX Production Extension Cables Prototypes

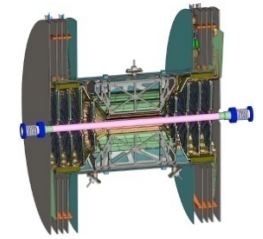


- 30 Prototypes delivered



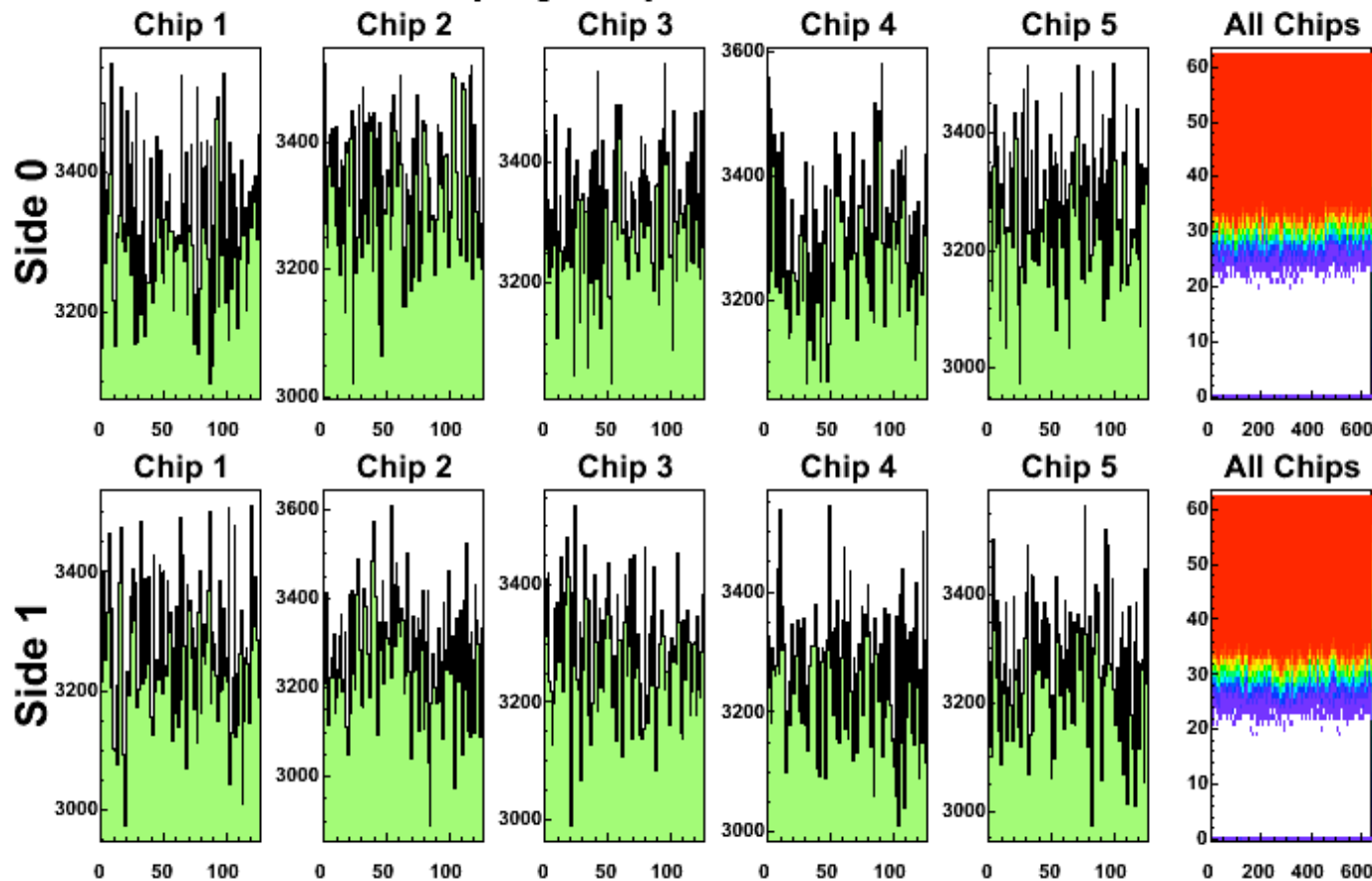
- Tested Wedge+Extension cable at clock frequencies of 9.1, 9.4 and 11MHz
- Noise measurements also checked.
- 1M pulses with no loss.
- Clock output good.

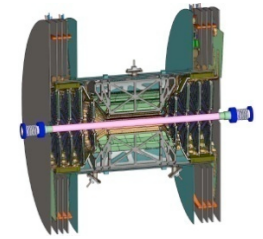
FVTX Production Extension Cables Prototypes



- Calibration on small wedge with extension cable.

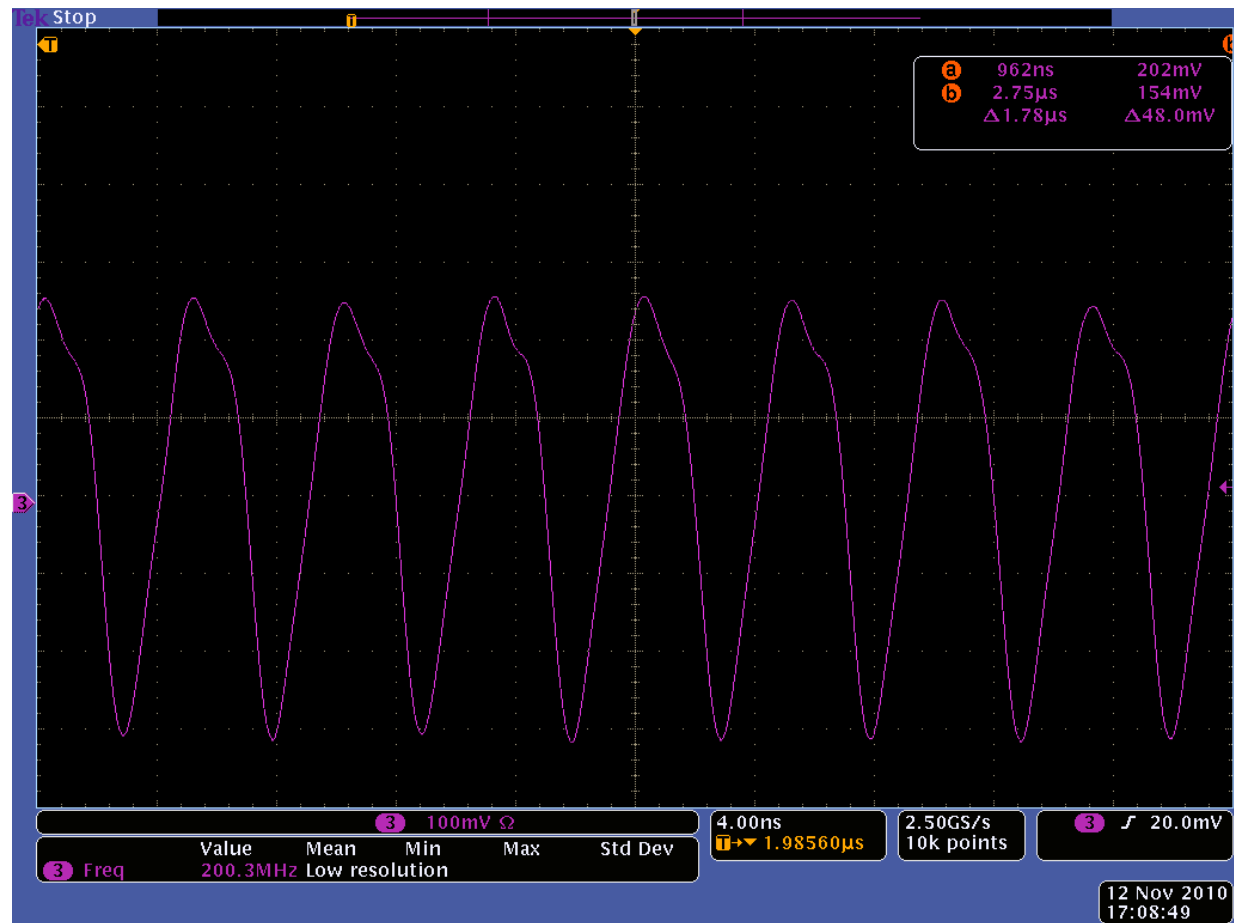
Chip by Chip Hit Distribution

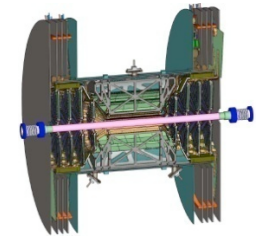




FVTX Production Extension Cables Prototypes

- Clock out check with extension cable.

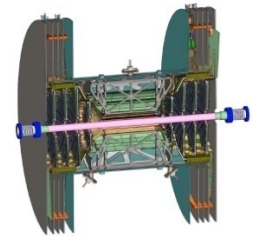




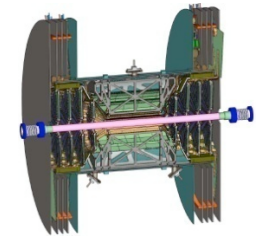
Summary

- Prototype design (WBS 1.4.3.1), procurement (WBS 1.4.3.2.1), testing (WBS 1.4.3.2.2), and re-design (WBS 1.4.3.2.3), is complete.
- All small HDIs delivered and assembled. (WBS 1.4.3.3)
- Large HDIs had issue with production, but are now on a new delivery schedule for Dec. '10. (WBS 1.4.3.3)
- Extension cable design complete. (WBS 1.4.4.1)
- Prototype extension cable delivered (WBS 1.4.4.2) and tested (WBS 1.4.4.3).
- Extension cables now also out for production. (WBS 1.4.4.4)
 - 45 – 50 work days for manufacture, - Feb. 11 delivery.

Backups



FVTX Production HDI Components



CAPACITOR, SMD 0201, 6.3V X5R	0.1u	ECJ-ZEB0J104K	104	40	47600	60000	26%	\$385.56
CAPACITOR, SMD 0805, 200V NP0	470p	08052A471JAT2A	27	11	12450	14000	12%	\$692.00
CAPACITOR, SM TANTALUM, 0805	10u	TCP0G106M8R	4	4	2200	3000	36%	\$351.00
RESISTOR, 1/20W 1% 0201 SMD, 100 OHM	100	CRCW0201100RFKED	8	8	4400	4500	2%	\$250.56
RESISTOR, 1/16W 1% 0603 SMD, 49.9 OHM	49.9	CRCW060349R9FKEA	2	2	1100	1200	9%	\$20.53
RESISTOR, 1/20W 1% 0201 SMD, 0.0 OHM	0.0	CRCW02010000Z0ED	26	10	11900	50000	320%	\$1,000.00
RESISTOR, 1/20W 1% 0201 SMD, 40.2 K	40.2 K	CRCW020140K2FKED	26	10	11900	20000	68%	\$820.00
RESISTOR, 1/8W 5% 0805 SMD, 1M	1M	CRCW08051M00JNEA	1	1	550	1000	82%	\$16.24
RESISTOR, 1/8W 5% 0805 SMD, 0.0 OHM	0.0	CRCW08050000Z0EA	1	1	550	1000	82%	\$16.24
PLUG, COAXIAL HV		H.FL-R-SMT	1	1	550	1000	82%	\$704.90
PLUG, B-TO-B, 0.4MM, 60 PIN		DF18C-60DP-0.4V	0	2	300	2000	567%	\$1,657.50
PLUG, B-TO-B, 0.4MM, 100 PIN		DF18C-100DP-0.4V	2	0	800	2000	150%	\$3,520.00

\$9,434.53

- All components except connectors, and bias and power filter caps on back side.
- All components delivered to MSE.