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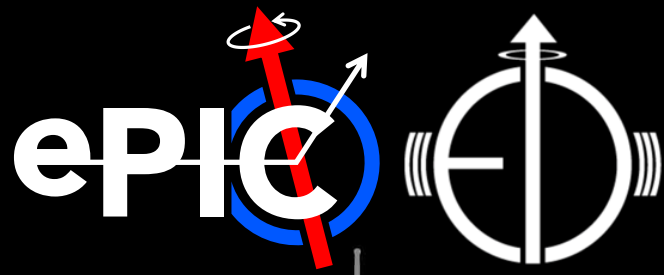
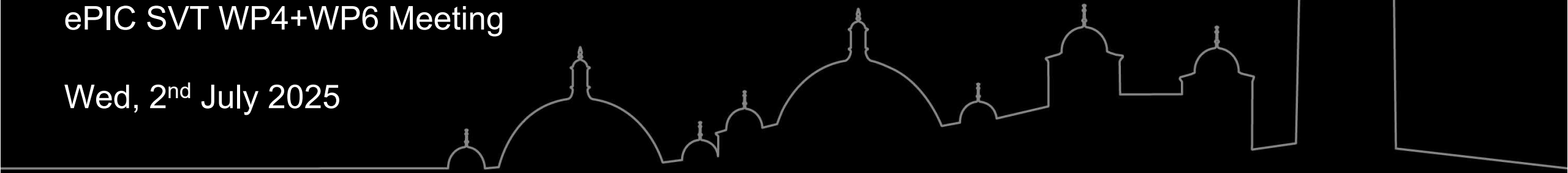


ePIC SVT RDO boards (OB & Disks)

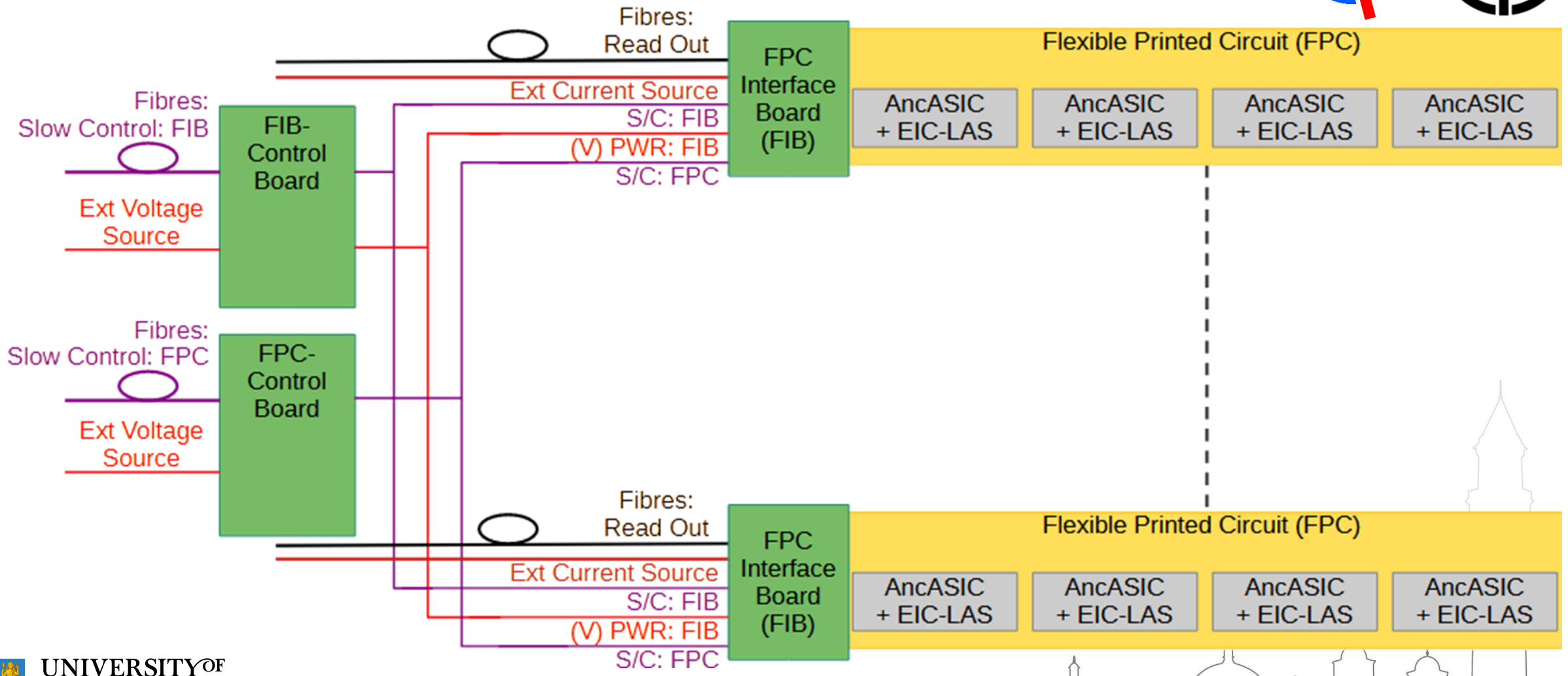
James Glover

ePIC SVT WP4+WP6 Meeting

Wed, 2nd July 2025



What we had


Fibres:
Read Out
Ext Current Source
S/C: FIB
(V) PWR: FIB
S/C: FPC
FPC
Interface
Board
(FIB)
Flexible Printed Circuit (FPC)
AncASIC
+ EIC-LAS
AncASIC
+ EIC-LAS
AncASIC
+ EIC-LAS
AncASIC
+ EIC-LAS
Fibres:
Slow Control: FIB
FIB-
Control
Board
Ext Voltage
Source
Fibres:
Slow Control: FPC
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Board
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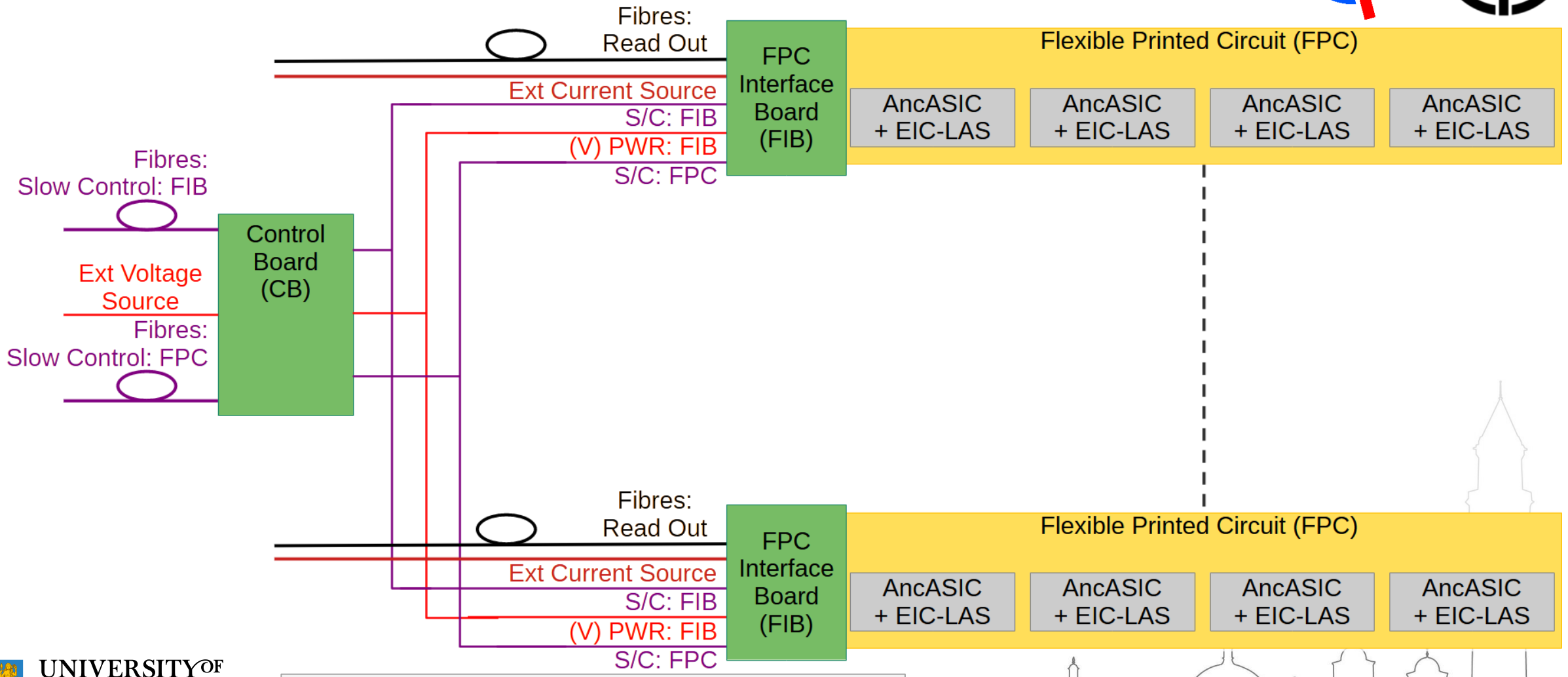
Flexible Printed Circuit (FPC)
AncASIC
+ EIC-LAS
AncASIC
+ EIC-LAS
AncASIC
+ EIC-LAS
AncASIC
+ EIC-LAS

What has changed?

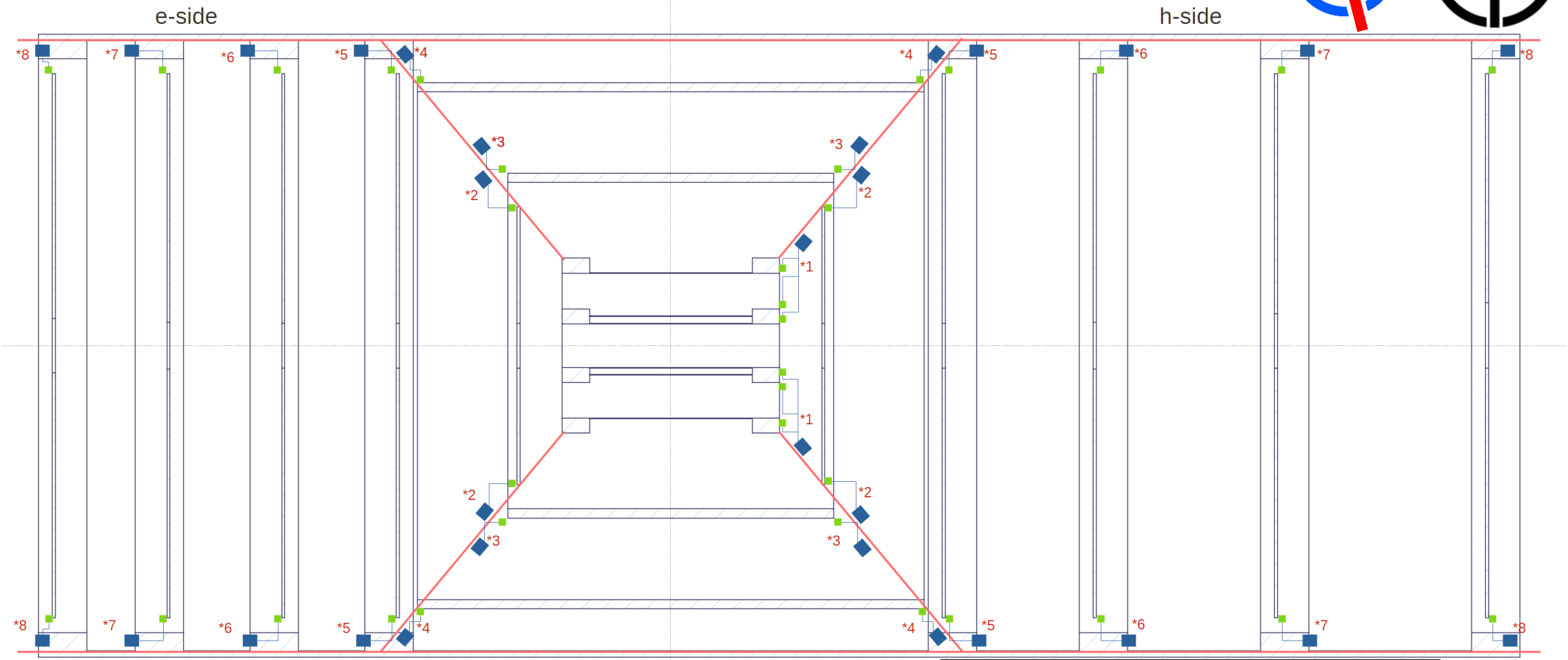
- Previously planning (hoping) to send S/Cs for as many VTRx+ (FIBs) as possible – utilise most of the 16 e-links of a lpGBT.
- Has become clear that VTRx+ I^2C is very specific, and communication will only work via the (3) I^2C master ports of a lpGBT.
- This greatly reduces the number of VTRx+ (FIBs) controllable by 1 lpGBT – if a 1:4 serial multiplexer is used:
  - Reduces from 1(lpGBT) : 48(VTRx+) (assuming 4 e-links reserved for onboard use).
  - To 1(lpGBT) : 12(VTRx+).
- Now, both FPC-CB and FIB-CB would be 1(parent) : 12(children) boards.

New OB/Disk Readout Architecture



See the internal FIB and CB designs in backup.

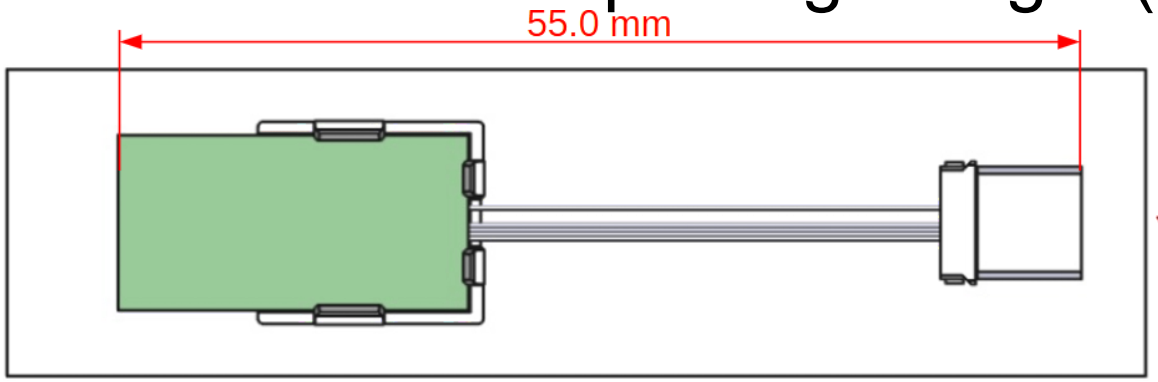
OB/Disk RDO board layout



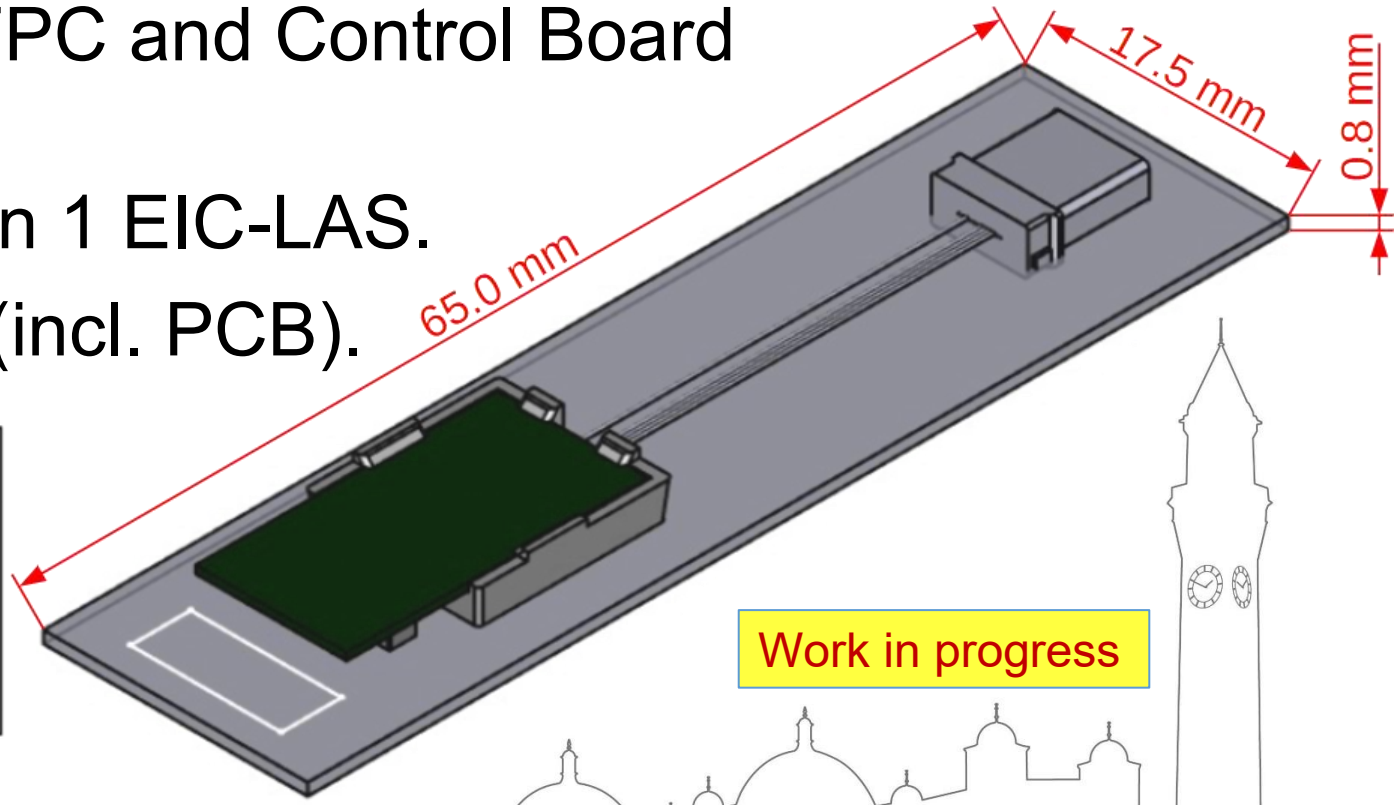
No change here!

Approximate FIB dimensions

- Shortest possible total length (5.5 cm) that CERN will produce.
- Prevent damage to VTRx+ pigtail, by mounting total length on the FIB.
- Allow space to bond/solder FPC and Control Board connections to FIB.
- Keep the board narrower than 1 EIC-LAS.
- ~4 mm total package height (incl. PCB).



No change here!



Work in progress

Control Board dimensions

- Less constrained than the FIB.
- Roughly same 65 mm length.
  - Total length of VTRx+ and pigtail still to be mounted on the PCB.
  - Space to bond/solder connections still needed.
- Additional space needed for:
  - Power regulation.
  - Monitoring.
  - lpGBT(s) – ~1 cm^2.
  - Serial multiplexers (FIB – Control Board only) – typ. <1 cm^2 per mux.
    - Such as Texas Instruments TCA9544A.
  - (Extra VTRx+ - if 2 lpGBTs are needed).

Work in progress

Control Board dimensions

- Assumed 65 × 17.5 mm additional area needed for 2nd VTRx+.
- Assumed 65 × 35 mm additional area to enable the addition of 2 lpGBTs, power regulation & monitoring, and 3 serial multiplexers.
- Total extra area: 65 × 52.5 mm (on top of the FIB dimensions).
- Board dimensions become 65 × 70 mm (same as old FIB-CB).
- Package height could be 20 mm (if DC/DCs are used).

- Consider whether everything can work with 1 lpGBT and 1 VTRx+.
- lpGBT connections will be saturated and limited to 4 e-links for internal use!

- FIB slow controls need to go through the lpGBT's I^2C master connections (3/lpGBT) and each I^2C master connects to a 1:4 serail multiplexer.
  - 1 Control Board connects to (up to) 12 FIBs.
- FPC slow controls planned to be sent via lpGBT e-links (16/lpGBT).
  - 1 Control Board connects to (up to) 12 FPCs (via the FIBs).
    - 4 e-links saved for internal CB use.
    - All e-links from 2nd (FIB S/C) lpGBT are also available for internal use.

Work in progress

Compare with FPC-CB and FIB-CB dimensions in backup.

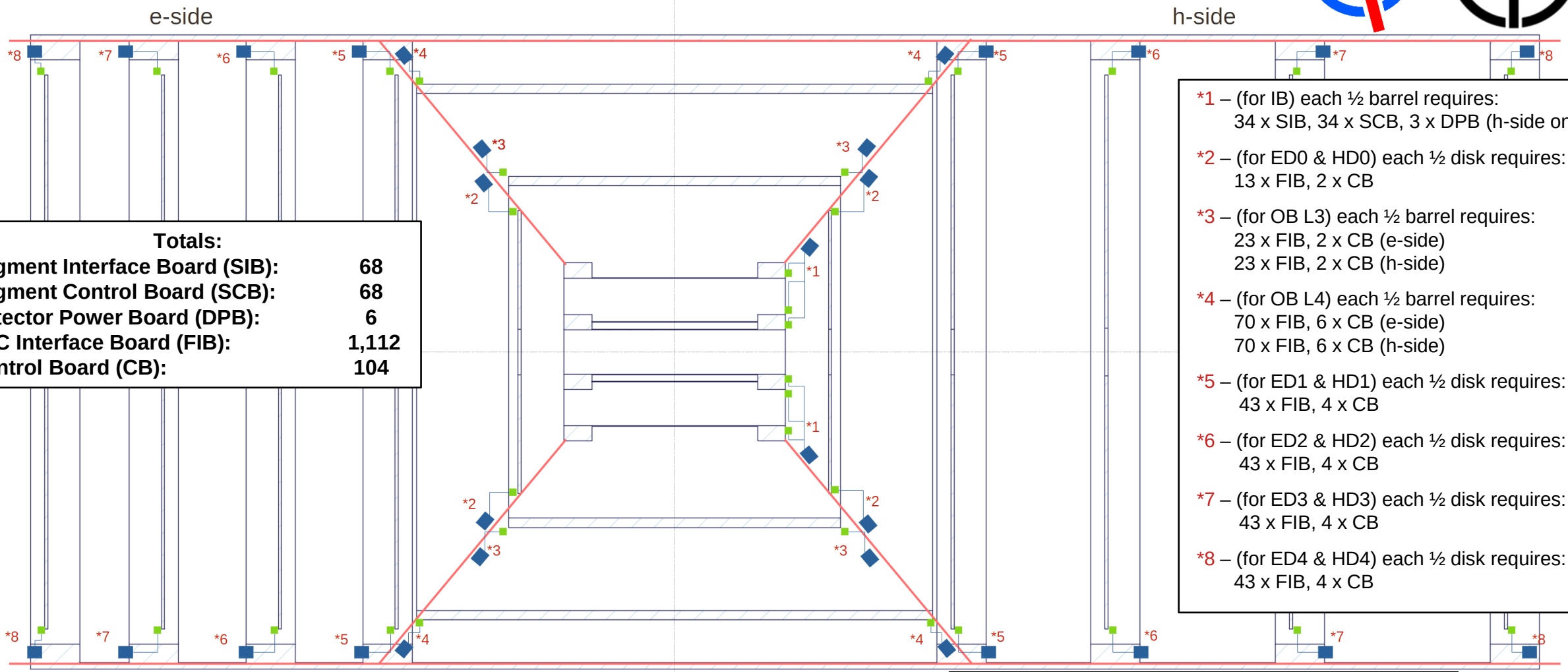
Powering the Control Board

- On board powering needs: VTRx+, lpGBT(s) and serial multiplexers
- External powering needs: VTRx+ (on up to 12 FIBs)
  - Up to 10 W needing to be supplied!
  - About 7 W burnt off on the board.
- ~104 of these control boards needed for whole SVT.
- Could be supplied by 54V @ 0.21A.
- 0.57 mm wire diameter needed.
  - Assuming aluminium wire and a V-drop of 10% over 100m.
- ~208 wires needed (source and return lines) from PSU to SVT.

Work in progress

Compare with FPC-CB and FIB-CB powering in backup.

New OB/Disk RDO board layout



Totals:	
Segment Interface Board (SIB):	**68**
Segment Control Board (SCB):	**68**
Detector Power Board (DPB):	**6**
FPC Interface Board (FIB):	**1,112**
Control Board (CB):	**104**

*1 – (for IB) each ½ barrel requires:
34 x SIB, 34 x SCB, 3 x DPB (h-side only)

*2 – (for ED0 & HD0) each ½ disk requires:
13 x FIB, 2 x CB

*3 – (for OB L3) each ½ barrel requires:
23 x FIB, 2 x CB (e-side)
23 x FIB, 2 x CB (h-side)

*4 – (for OB L4) each ½ barrel requires:
70 x FIB, 6 x CB (e-side)
70 x FIB, 6 x CB (h-side)

*5 – (for ED1 & HD1) each ½ disk requires:
43 x FIB, 4 x CB

*6 – (for ED2 & HD2) each ½ disk requires:
43 x FIB, 4 x CB

*7 – (for ED3 & HD3) each ½ disk requires:
43 x FIB, 4 x CB

*8 – (for ED4 & HD4) each ½ disk requires:
43 x FIB, 4 x CB

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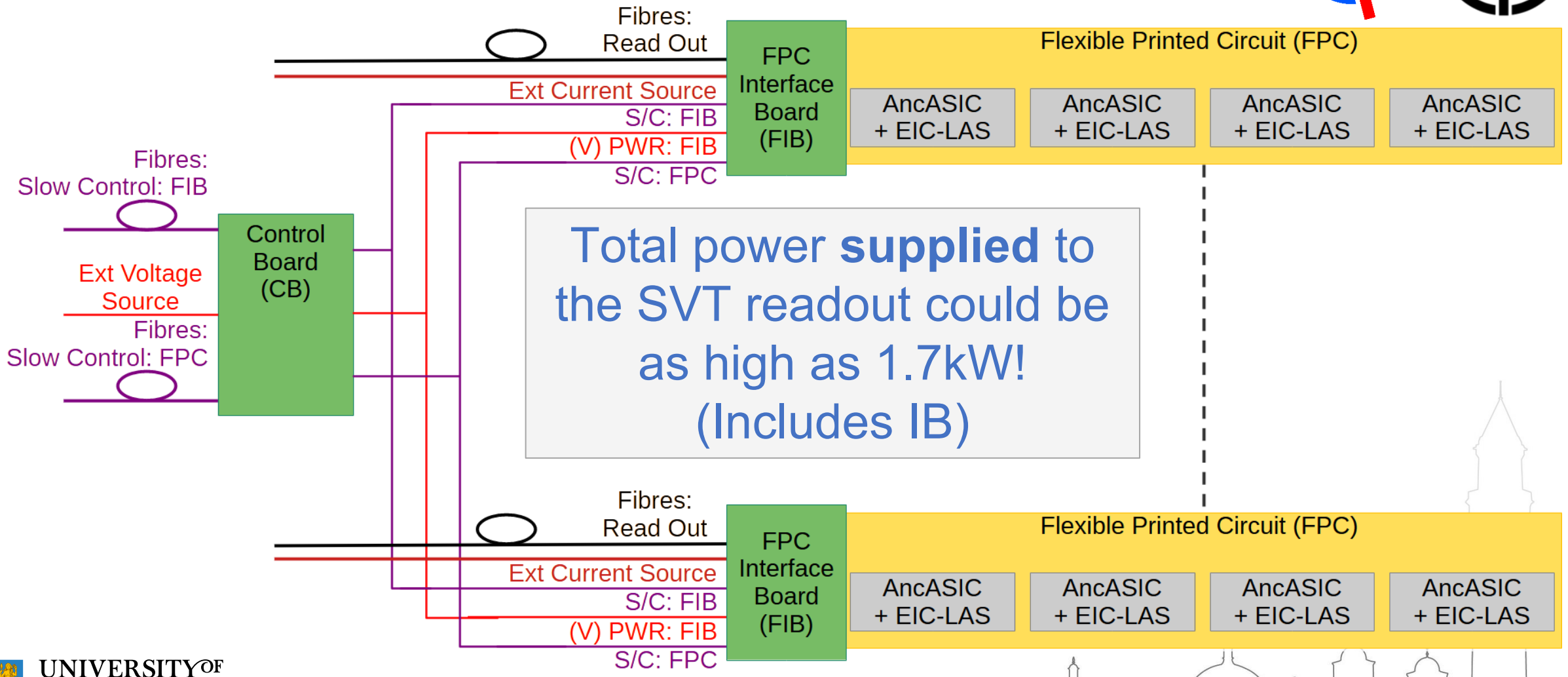
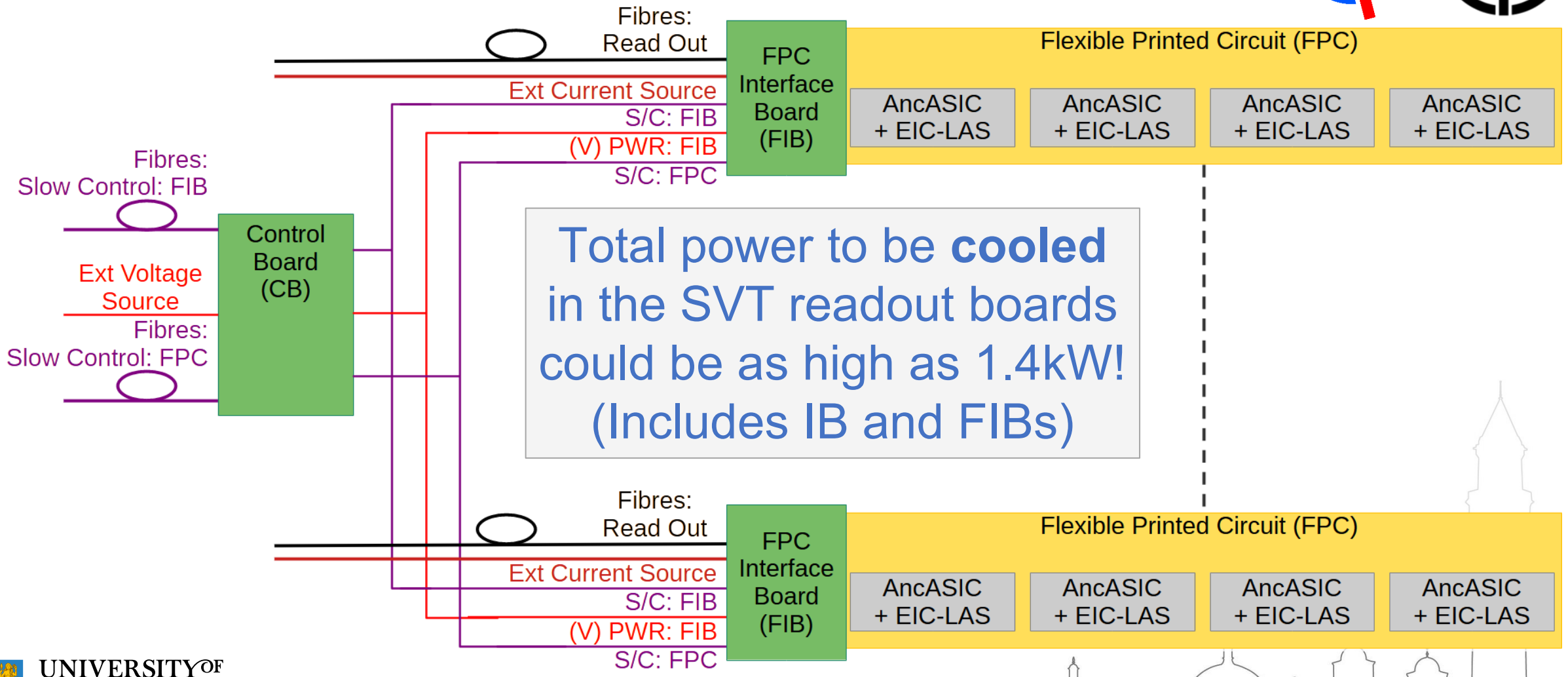
To old layout in backup.

Carbon fibre support structure (tube and cone)
Electronics boards (Interface Boards)
Electronics boards (Control Boards/Power Boards)

OB/Disk Readout Architecture



OB/Disk Readout Architecture



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Summary

Proposed to switch to a single Control Board (CB) from separate FIB-CBs and FPC-CBs.

Switch from:

- 104 FPC-CBs @ 65 × 47.5 mm, dissipating ~1.75 W per board.
- 32 FIB-CBs @ 65 × 70 mm, dissipating ~16.5 W per board.

To:

- 104 CBs @ 65 × 70 mm, dissipating ~7.1 W per board.

104 CBs @ 65 × 68.61 mm, dissipating ~6.83 W per board would be a like for like area and power match.

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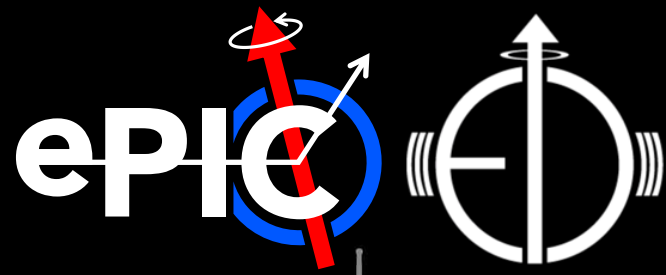
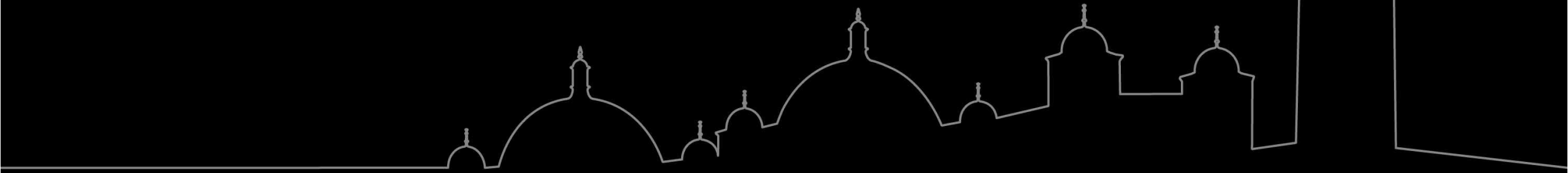


Thank you very much!

Any questions?



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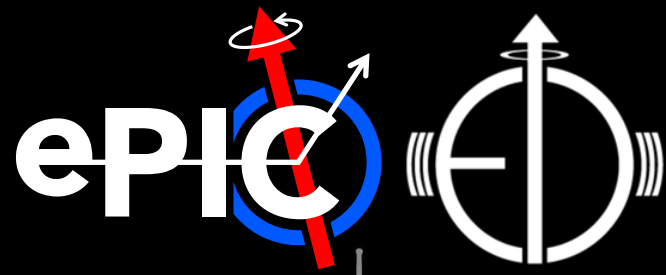
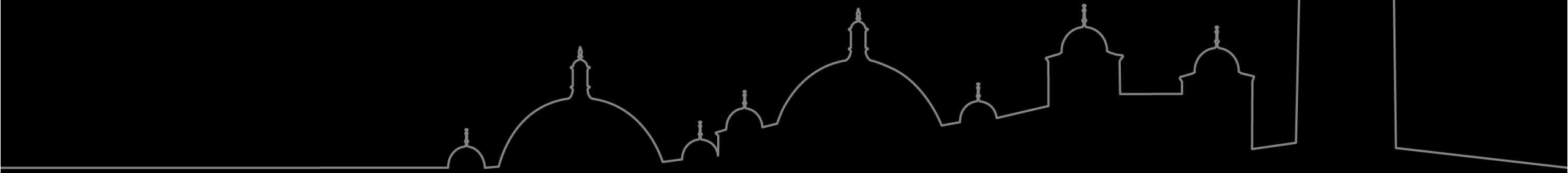
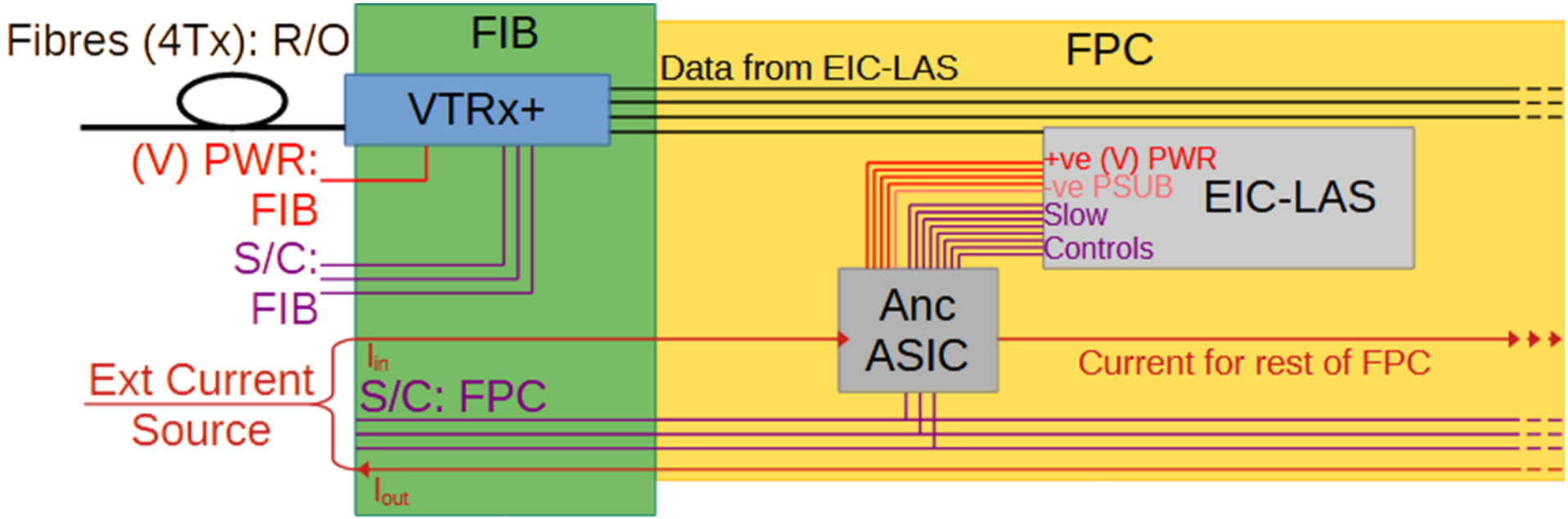


Additional (support) slides



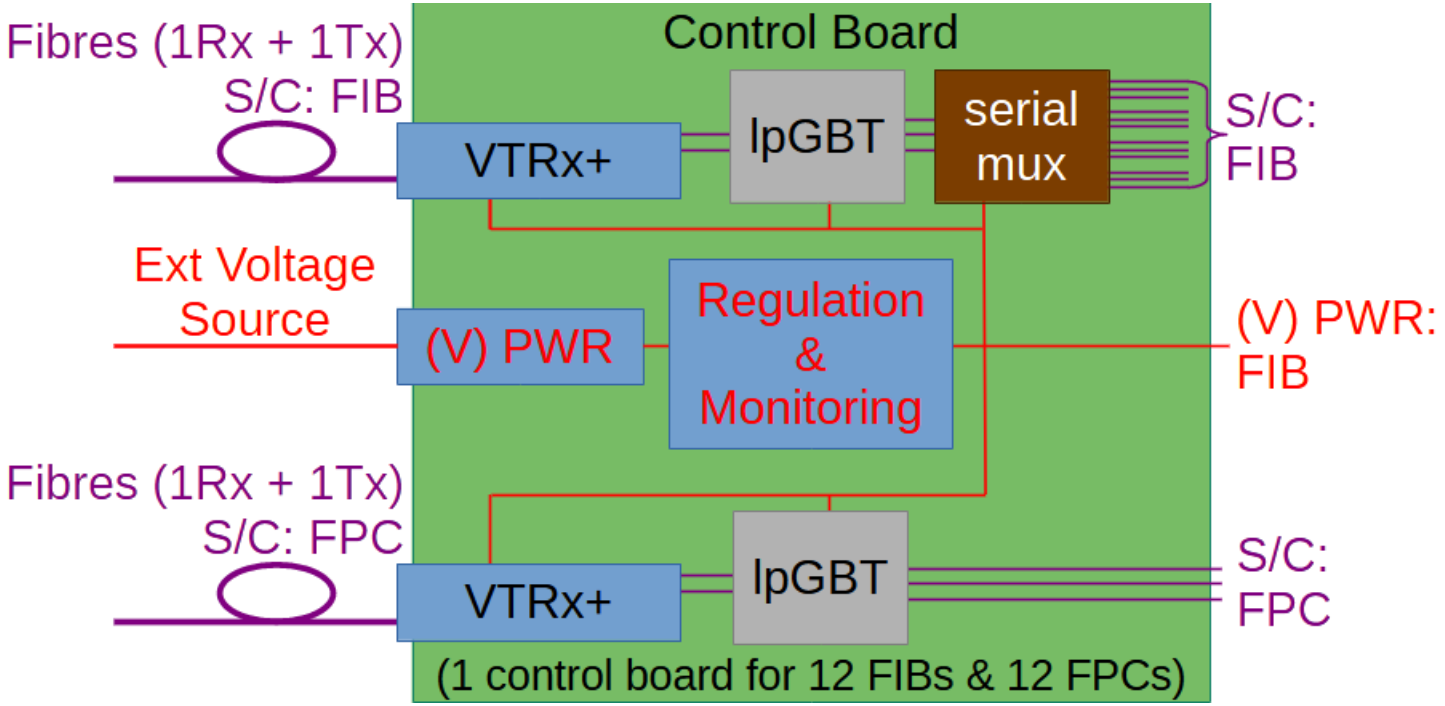
OB/Disc: FPC Interface Board (FIB)



Back to New OB/Disc Readout Architecture.

- FIB PWR and S/C for the VTRx+ (EIC-LAS data).
- FPC current supply and S/C for AncASIC to translate to 5 power domains (incl. -ve substrate bias) and slow control protocol for EIC-LAS.

OB/Disc: Control Board



- Use the lpGBT e-links for the FPC S/C commands.
- Use the lpGBT I²C master connections for the FIB S/C commands.

Back to New OB/Disc Readout Architecture.

FPC-Control Board dimensions

- Assumed 65 * 30 mm additional area to enable the addition of lpGBT, power regulation & monitoring to the area of the FPC Interface Board (FIB).
- Board dimensions become 65 * 47.5 mm
- Package height could be 20 mm (if DC/DC are used).

- FPC slow controls planned to be sent via lpGBT e-links.
  - 1 FPC-Control Board connects to (up to) 12 FPCs (via the FIBs).
    - 4 e-links saved for internal FPC-CB use.

Out of date

Back to CB dimensions.

FIB-Control Board dimensions

- Assumed 65 * 22.5 mm additional area to enable the addition of 12 serial multiplexers to the area of the FPC-Control Board.
- Board dimensions become 65 * 70 mm
- Package height could be 20 mm (if DC/DCs are used).

- If FIB slow controls utilise the 12 lpGBT e-links and each e-link connects to a 1:4 serail multiplexer.
  - 1 FIB-Control Board connects to (up to) 48 FIBs.
    - 4 e-links saved for internal FIB-CB use.

Out of date

Back to CB dimensions.

Powering the FPC-Control Board

- Only on board powering needs: VTRx+ and lpGBT – ~2W!
  - All 2W dissipated on this board.
- ~104 of these control boards needed for whole SVT.
- Could be supplied by 54V @ 40mA.
- 0.25 mm wire diameter needed.
  - Assuming aluminium wire and a V-drop of 10% over 100m.
- ~208 wires needed (source and return lines) from PSU to SVT.

Out of date

Back to CB powering.

Powering the FIB-Control Board

- Only on board powering needs: (many) serial multiplexers.
- External powering needs: up to 48 VTRx+ – ~36W!
  - Centralised power for up to 48 FIBs.
  - About 22W burnt off on the board – (water) cooling needed!
- Few of these control boards needed for whole SVT (~32).
- Could be supplied by 54V @ 0.75A.
- 1.1 mm wire diameter needed.
  - Assuming aluminium wire and a V-drop of 10% over 100m.
- ~64 wires needed (source and return lines) from PSU to SVT.

Out of date

Back to CB powering.

FIB quantities

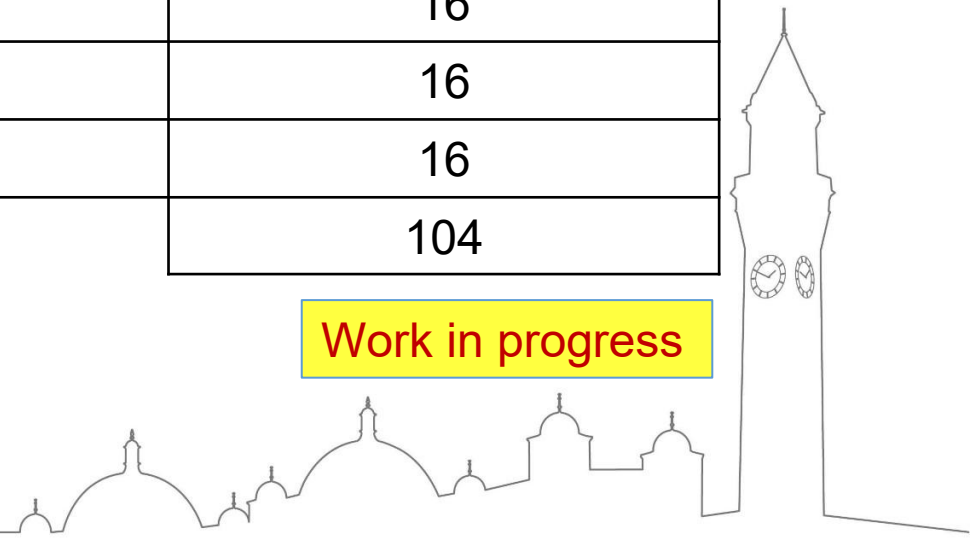
	e-side	h-side	Total
L3	46	46	92
L4	140	140	280
ED/HD0	26	26	52
ED/HD1	86	86	172
ED/HD2	86	86	172
ED/HD3	86	86	172
ED/HD4	86	86	172
			1,112

Work in progress

Control Boards

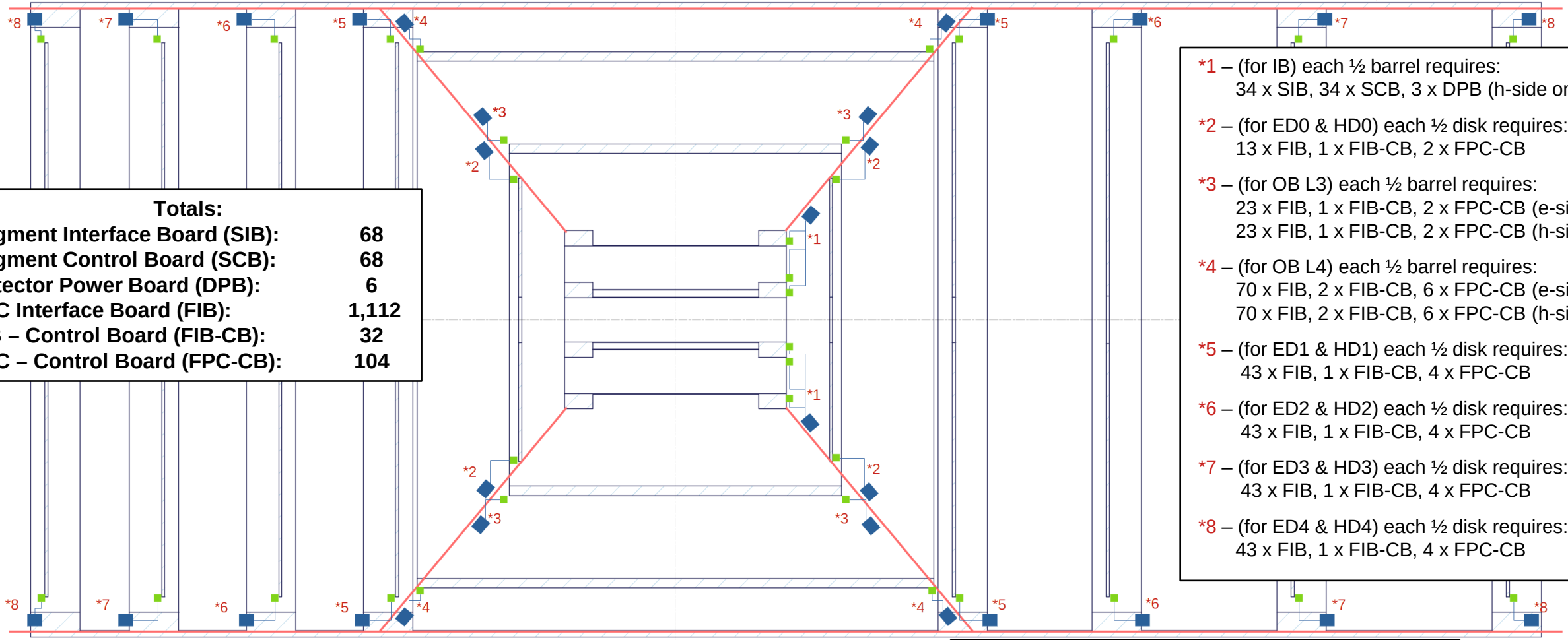
	e-side	h-side	Total
L3	4	4	8
L4	12	12	24
ED/HD0	4	4	8
ED/HD1	8	8	16
ED/HD2	8	8	16
ED/HD3	8	8	16
ED/HD4	8	8	16
			104

Work in progress



Old OB/Disk RDO board layout

Out of date



Totals:	
Segment Interface Board (SIB):	68
Segment Control Board (SCB):	68
Detector Power Board (DPB):	6
FPC Interface Board (FIB):	1,112
FIB – Control Board (FIB-CB):	32
FPC – Control Board (FPC-CB):	104

*1 – (for IB) each ½ barrel requires:
34 x SIB, 34 x SCB, 3 x DPB (h-side only)

*2 – (for ED0 & HD0) each ½ disk requires:
13 x FIB, 1 x FIB-CB, 2 x FPC-CB

*3 – (for OB L3) each ½ barrel requires:
23 x FIB, 1 x FIB-CB, 2 x FPC-CB (e-side)
23 x FIB, 1 x FIB-CB, 2 x FPC-CB (h-side)

*4 – (for OB L4) each ½ barrel requires:
70 x FIB, 2 x FIB-CB, 6 x FPC-CB (e-side)
70 x FIB, 2 x FIB-CB, 6 x FPC-CB (h-side)

*5 – (for ED1 & HD1) each ½ disk requires:
43 x FIB, 1 x FIB-CB, 4 x FPC-CB

*6 – (for ED2 & HD2) each ½ disk requires:
43 x FIB, 1 x FIB-CB, 4 x FPC-CB

*7 – (for ED3 & HD3) each ½ disk requires:
43 x FIB, 1 x FIB-CB, 4 x FPC-CB

*8 – (for ED4 & HD4) each ½ disk requires:
43 x FIB, 1 x FIB-CB, 4 x FPC-CB

Carbon fibre support structure (tube and cone)
Electronics boards (Interface Boards)
Electronics boards (Control Boards/Power Boards)

Back to new layout.

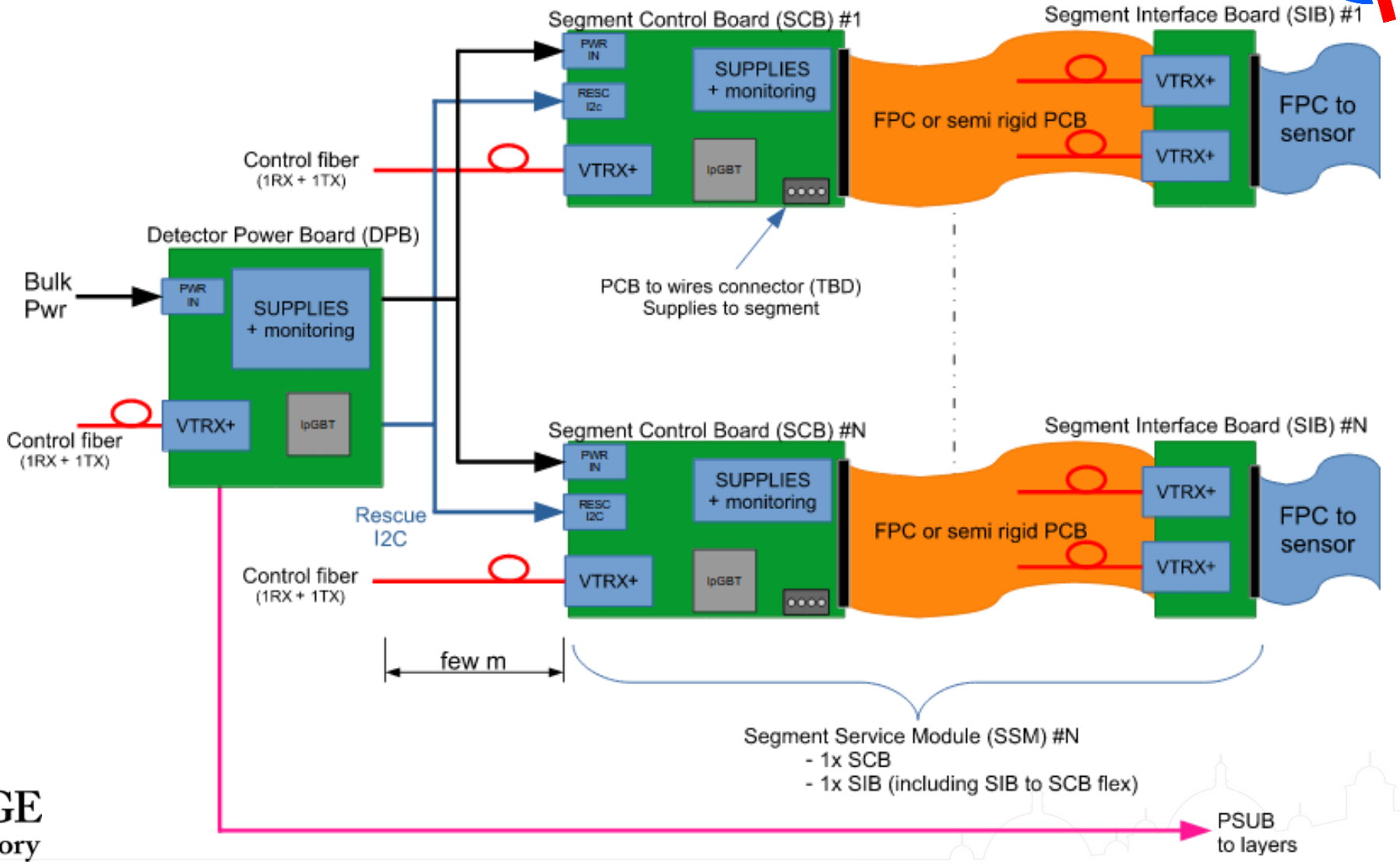
Current Source – PSU channels

Current assumptions on the number of SP chain needed in the SVT (OB + Disks) is ~1,100

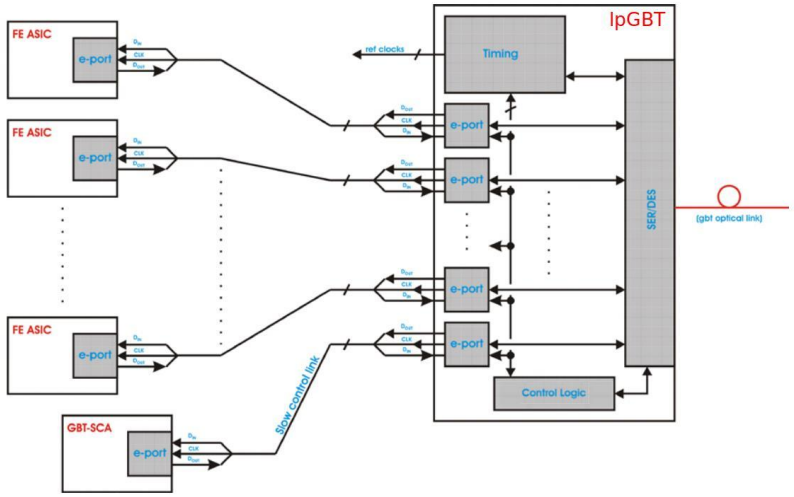
- Each of these need a current of >1.5 A.
- If copper wire is acceptable, wire diameter of >3.8 mm needed!
  - 5% power loss over 100m.
  - 10% power loss could bring this down to 2.7 mm diameter.
  - Aluminium would require a larger diameter.
- >2,000 wires needed (source and return lines) from PSU to SVT.

Work in progress

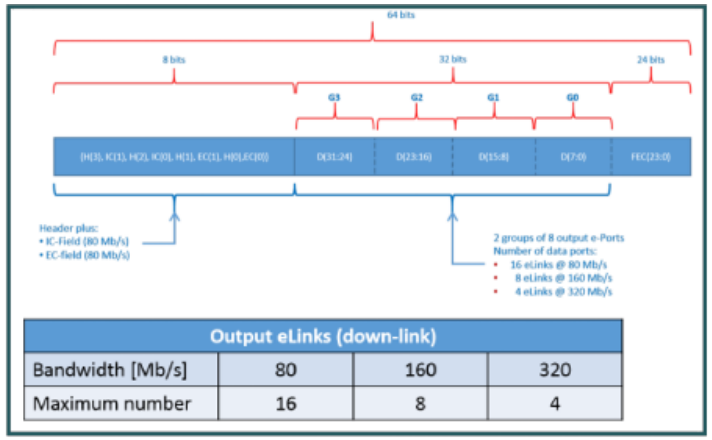
IB Readout Architecture



lpGBT Protocol



- Front Ends connect to “e-links”
- The fiber protocol includes “Forward Error Correction”
- Downlink runs at 2.56 Gbps
  - Downlink frame is 64bit wide, of which 32 bits are payload
  - 1.28 Gbps payload
  - Up to 16 e-links @ 80 Mbps
- Uplink runs at either 10.24 Gbps or 5.12 Gbps
  - Uplink frame is either 128bit or 256bit
  - 256bit frame contains 192bits of payload (7.68 Gbps)
  - Up to 24 e-links at either 160 Mbps or 320 Gbps



Output eLinks (down-link)			
Bandwidth [Mb/s]	80	160	320
Maximum number	16	8	4

Downlink

Line Rate: **2.56 Gbps**
32 out of 64 bits are data:
Payload = **1.280 Gbps**

Data Uplink

192 out of 256 bits are data:
Payload = **7.680 Gbps**

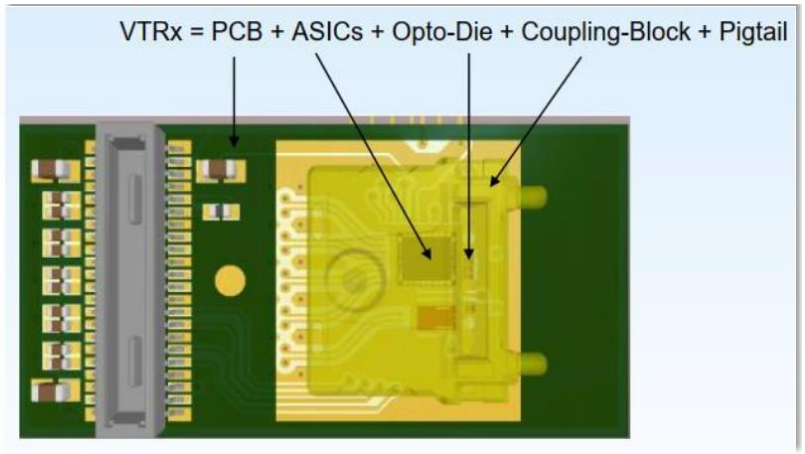
Input eLinks (up-link)												
Up-link bandwidth [Gb/s]	5.12						10.24					
FEC coding	FEC5			FEC12			FEC5			FEC12		
Bandwidth [Mb/s]	160	320	640	160	320	640	320	640	1280	320	640	1280
Maximum number	28	14	7	24	12	6	28	14	7	24	12	6

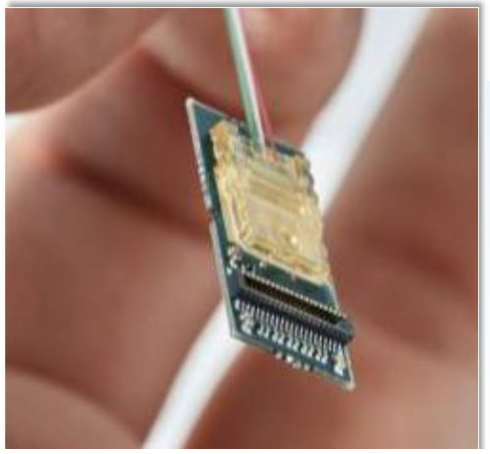
Field	5.12 Gbps FEC5	5.12 Gbps FEC12	10.24 Gbps FEC5	10.24 Gbps FEC12
Frame [bits]	128		256	
Header [bits]	2		2	
IC [bits]	2		2	
EC [bits]	2		2	
D [bits]	112	96	224	192
FEC [bits]	10	24	20	48
LM [bits]	0	2	6	10
Correction [bits]	5	12	10	24
# of eLink groups	7	6	7	6

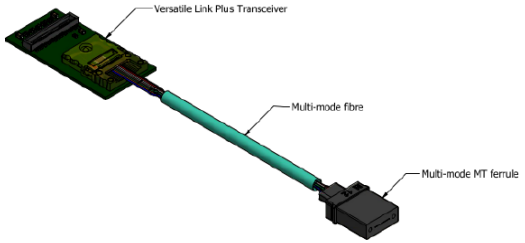
OAK RIDGE National Laboratory

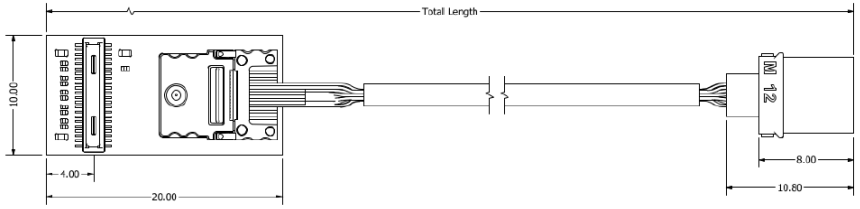
VTRx+ Front-end Module

- **Versatile**
  - Up to 4 Tx + 1 Rx, configurable by masking channels
- **Miniaturised**
  - 20 x 10 x 2.5 mm
- **Pluggable**
  - Electrical connector
- **Data-rate**
  - Tx: up to 4×10 Gb/s, Rx: 2.5 Gb/s
- **Environment**
  - Temperature: -35 to + 60 °C
  - Total Dose: 100 Mrad
  - Total Fluence: $1x10^{15}$ n/cm^2 and $1x10^{15}$ hadrons/cm^2
- **Status**
  - Pre-production ongoing
  - Solving problems with module assembly
  - Alignment of optical components
  - Ramping up to 2k modules/month in 2023









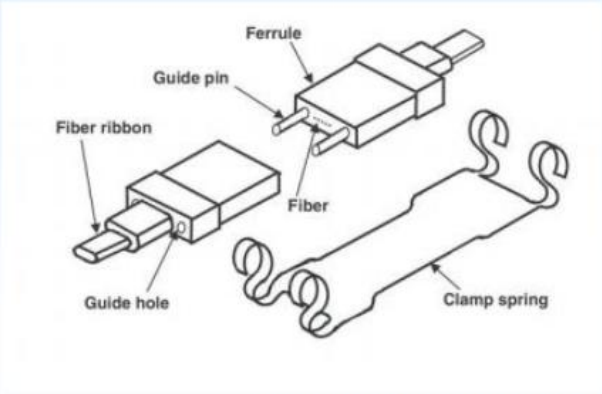
VTRx+ connectors

From: https://indico.cern.ch/event/799025/contributions/3486288/

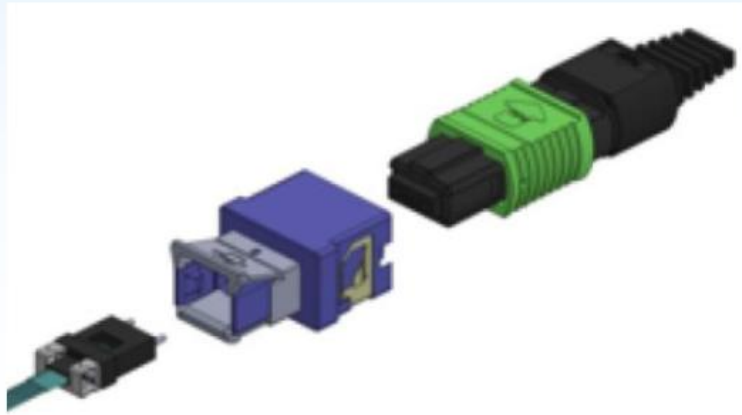
1.2 VTRx+ Pigtail

- Pigtail being finalized
  - Rad hard fibre
  - 5 individual fibres in loose tube
  - MT termination
  - Not dismountable

- Connection with MT Spring Clamp
  - Dense connectivity at expense of handleability

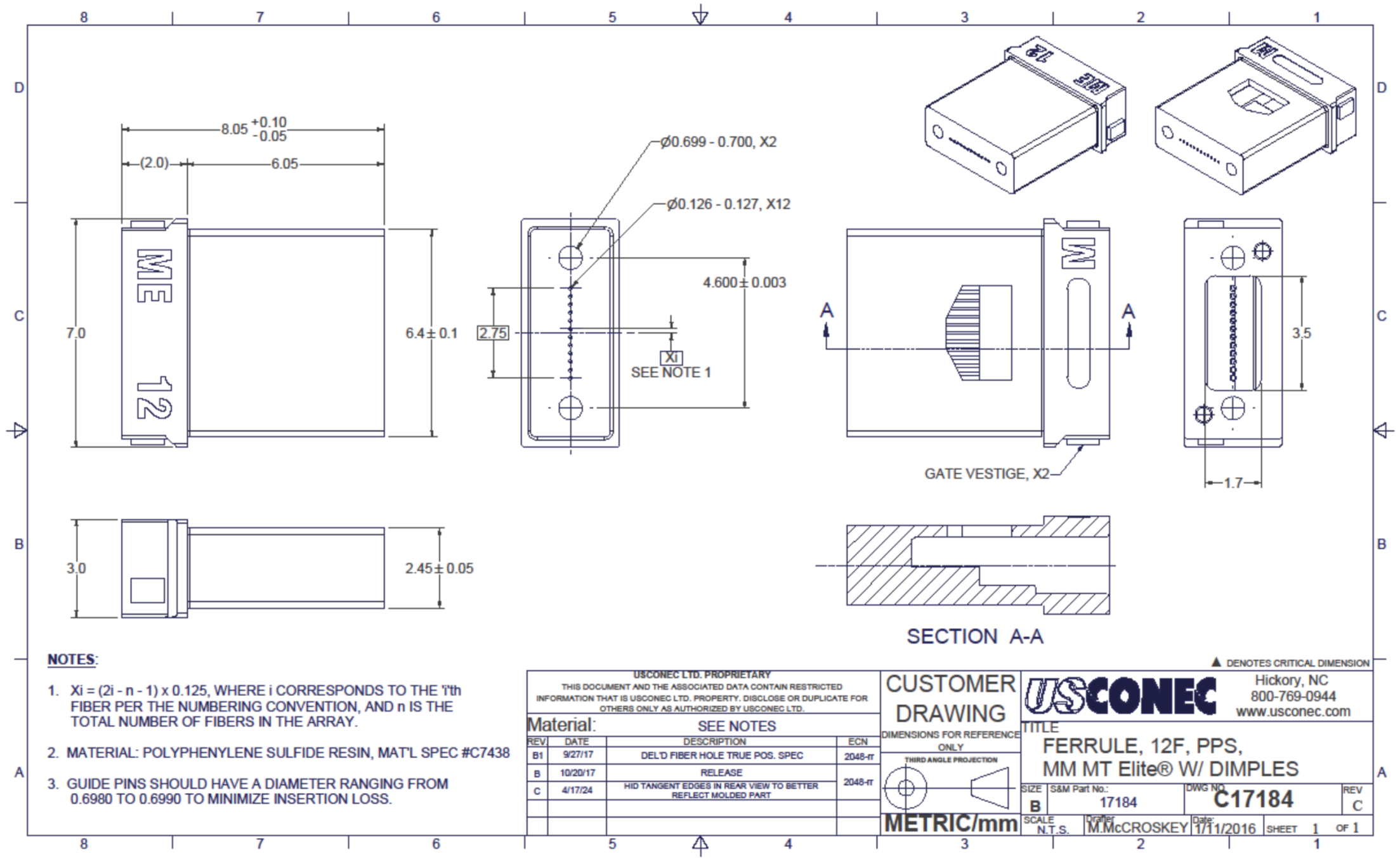


- Or with MT to MPO adapter
  - if you have space



TWEPP, 3 Sep 2019 francois.vasey@cern.ch 6

https://www.usconec.com/umbraco/rhythm/protectedfiles/download?path=%2ffiles%2fdrawings%2fC17184.pdf



NOTES:

1. Xi = (2i - n - 1) x 0.125, WHERE i CORRESPONDS TO THE 'i'th FIBER PER THE NUMBERING CONVENTION, AND n IS THE TOTAL NUMBER OF FIBERS IN THE ARRAY.
2. MATERIAL: POLYPHENYLENE SULFIDE RESIN, MAT'L SPEC #C7438
3. GUIDE PINS SHOULD HAVE A DIAMETER RANGING FROM 0.6980 TO 0.6990 TO MINIMIZE INSERTION LOSS.

▲ DENOTES CRITICAL DIMENSION

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Material: SEE NOTES

REV	DATE	DESCRIPTION	ECN
B1	9/27/17	DEL'D FIBER HOLE TRUE POS. SPEC	2048-rr
B	10/20/17	RELEASE	2048-rr
C	4/17/24	HID TANGENT EDGES IN REAR VIEW TO BETTER REFLECT MOLDED PART	

CUSTOMER DRAWING

DIMENSIONS FOR REFERENCE ONLY

THIRD ANGLE PROJECTION

METRIC/mm

USCONEC Hickory, NC 800-769-0944 www.usconec.com

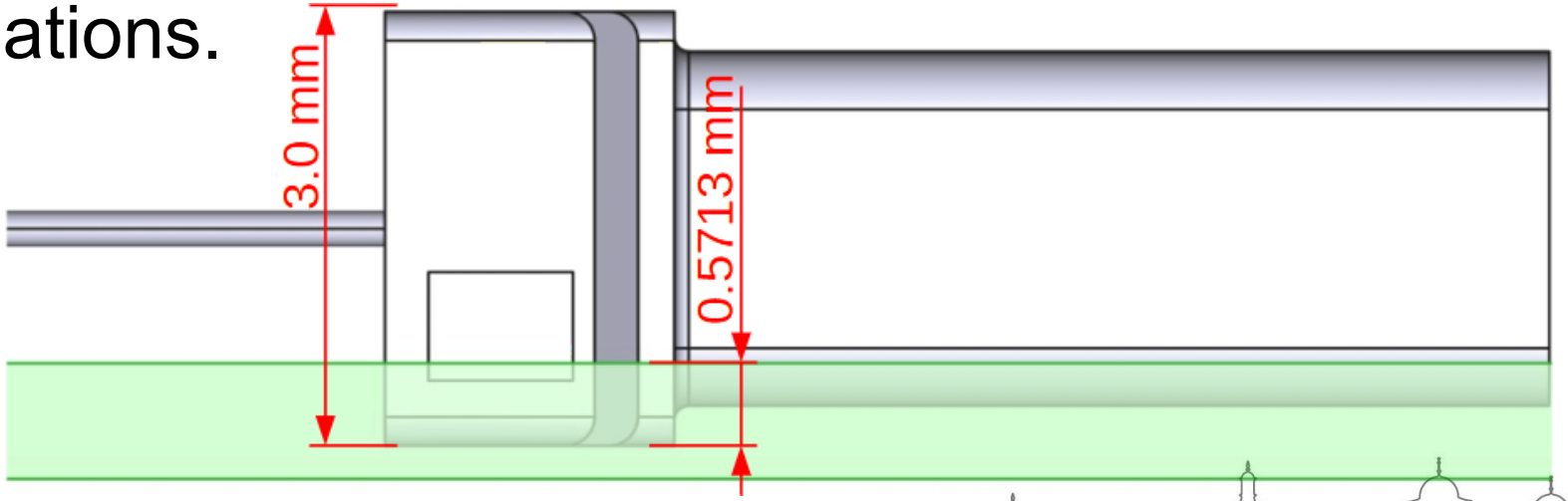
TITLE: FERRULE, 12F, PPS, MM MT Elite® W/ DIMPLES

SIZE	S&M Part No.:	DWG NO	REV
B	17184	C17184	C

SCALE N.T.S. | Drafter: M.McCROSKEY | Date: 1/11/2016 | SHEET 1 OF 1

Connector issue

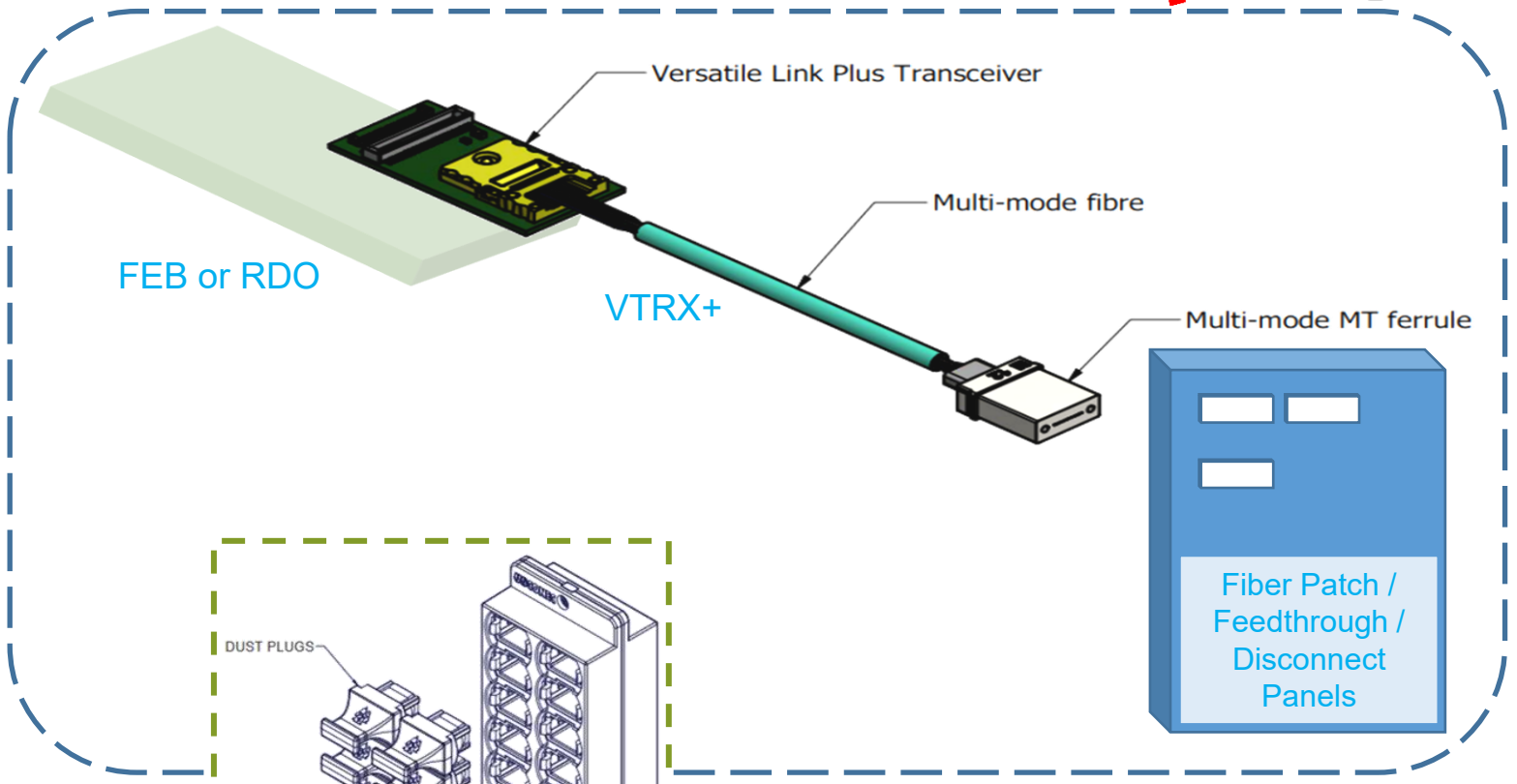
- The connector that CERN supply on the end of the fibres is thicker than the VTRx+ with clip.
- Fibres cannot lay completely flat.
- Need to look at options for mounting the connector to the PCB with adjustable position – to account for connector thickness and fibre length variations.



Services – VTRX+

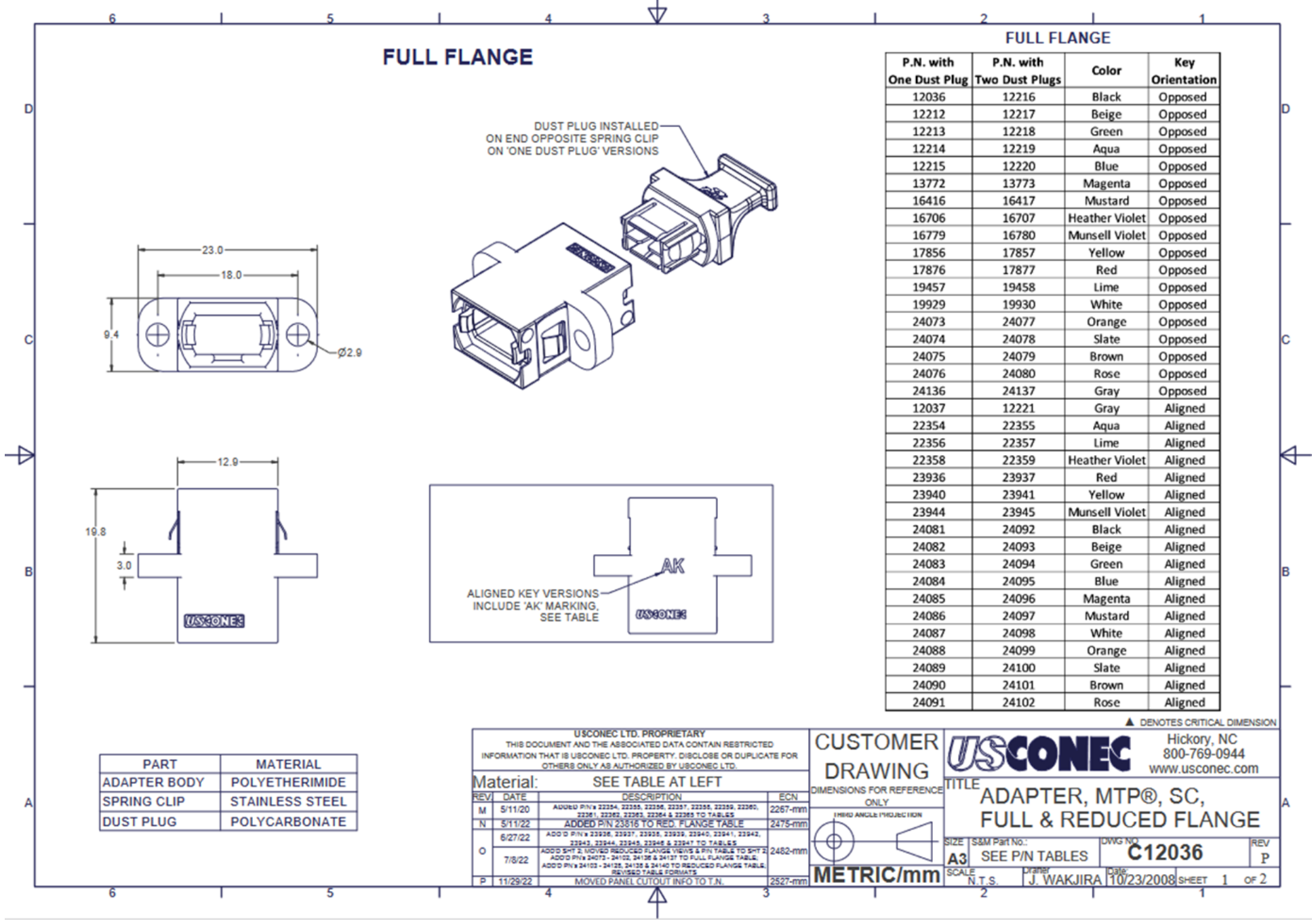
- Recently switch all applicable detectors over from RDOs to VTRX+ modules
- Modules will be placed on each detector
- The modules can only push the signal up to 2m in length so there needs to be a fiber patch to convert to MTP fiber
- Each module gets 1 fiber patch, locations will vary from detector to detector
- Total VTRX+ modules needed listed below

Sub-Detector	Qty
SVT	1579
MPGD EE	64
MPGD HE	64
MPGD IB	128
MPGD uRwell	384
TOF Disk	212
TOF Barrel	288
dRICH	1242
pfRICH	68



From: https://indico.bnl.gov/event/24729/contributions/97310/attachments/57760/99191/TIC%20Meeting%2024.10.07.pptx

Adapter – single MTP panel feedthrough



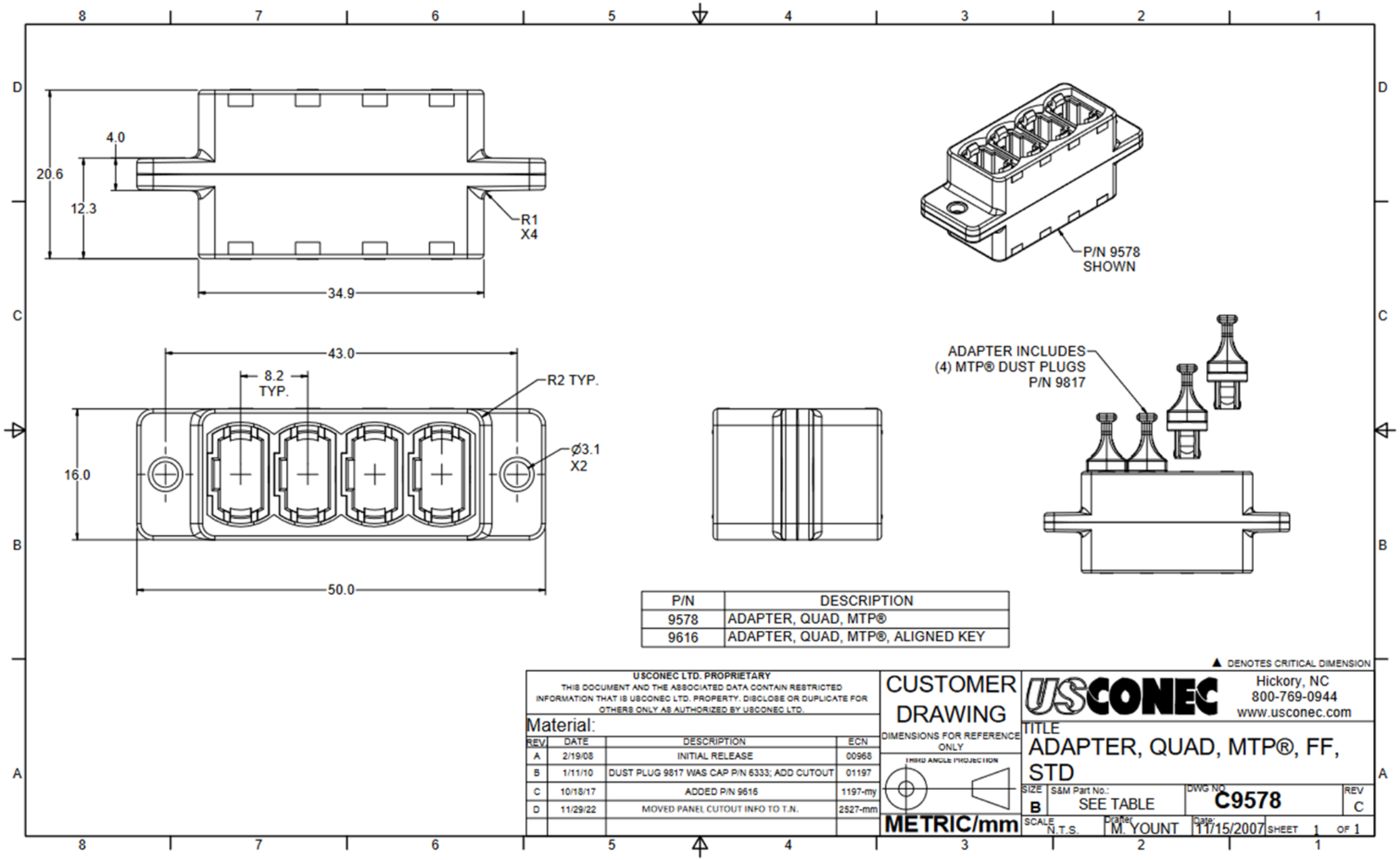
FULL FLANGE

P.N. with One Dust Plug	P.N. with Two Dust Plugs	Color	Key Orientation
12036	12216	Black	Opposed
12212	12217	Beige	Opposed
12213	12218	Green	Opposed
12214	12219	Aqua	Opposed
12215	12220	Blue	Opposed
13772	13773	Magenta	Opposed
16416	16417	Mustard	Opposed
16706	16707	Heather Violet	Opposed
16779	16780	Munsell Violet	Opposed
17856	17857	Yellow	Opposed
17876	17877	Red	Opposed
19457	19458	Lime	Opposed
19929	19930	White	Opposed
24073	24077	Orange	Opposed
24074	24078	Slate	Opposed
24075	24079	Brown	Opposed
24076	24080	Rose	Opposed
24136	24137	Gray	Opposed
12037	12221	Gray	Aligned
22354	22355	Aqua	Aligned
22356	22357	Lime	Aligned
22358	22359	Heather Violet	Aligned
23936	23937	Red	Aligned
23940	23941	Yellow	Aligned
23944	23945	Munsell Violet	Aligned
24081	24092	Black	Aligned
24082	24093	Beige	Aligned
24083	24094	Green	Aligned
24084	24095	Blue	Aligned
24085	24096	Magenta	Aligned
24086	24097	Mustard	Aligned
24087	24098	White	Aligned
24088	24099	Orange	Aligned
24089	24100	Slate	Aligned
24090	24101	Brown	Aligned
24091	24102	Rose	Aligned

▲ DENOTES CRITICAL DIMENSION

PART	MATERIAL
ADAPTER BODY	POLYETHERIMIDE
SPRING CLIP	STAINLESS STEEL
DUST PLUG	POLYCARBONATE

Adapter – 1x4 MTP panel feedthrough



P/N	DESCRIPTION
9578	ADAPTER, QUAD, MTP®
9616	ADAPTER, QUAD, MTP®, ALIGNED KEY

▲ DENOTES CRITICAL DIMENSION

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Material:

REV	DATE	DESCRIPTION	ECN
A	2/19/08	INITIAL RELEASE	00968
B	1/11/10	DUST PLUG 9817 WAS CAP P/N 6333; ADD CUTOUT	01197
C	10/18/17	ADDED P/N 9616	1197-my
D	11/29/22	MOVED PANEL CUTOUT INFO TO T.N.	2527-mm

CUSTOMER DRAWING
DIMENSIONS FOR REFERENCE ONLY
THIRD ANGLE PROJECTION
METRIC/mm

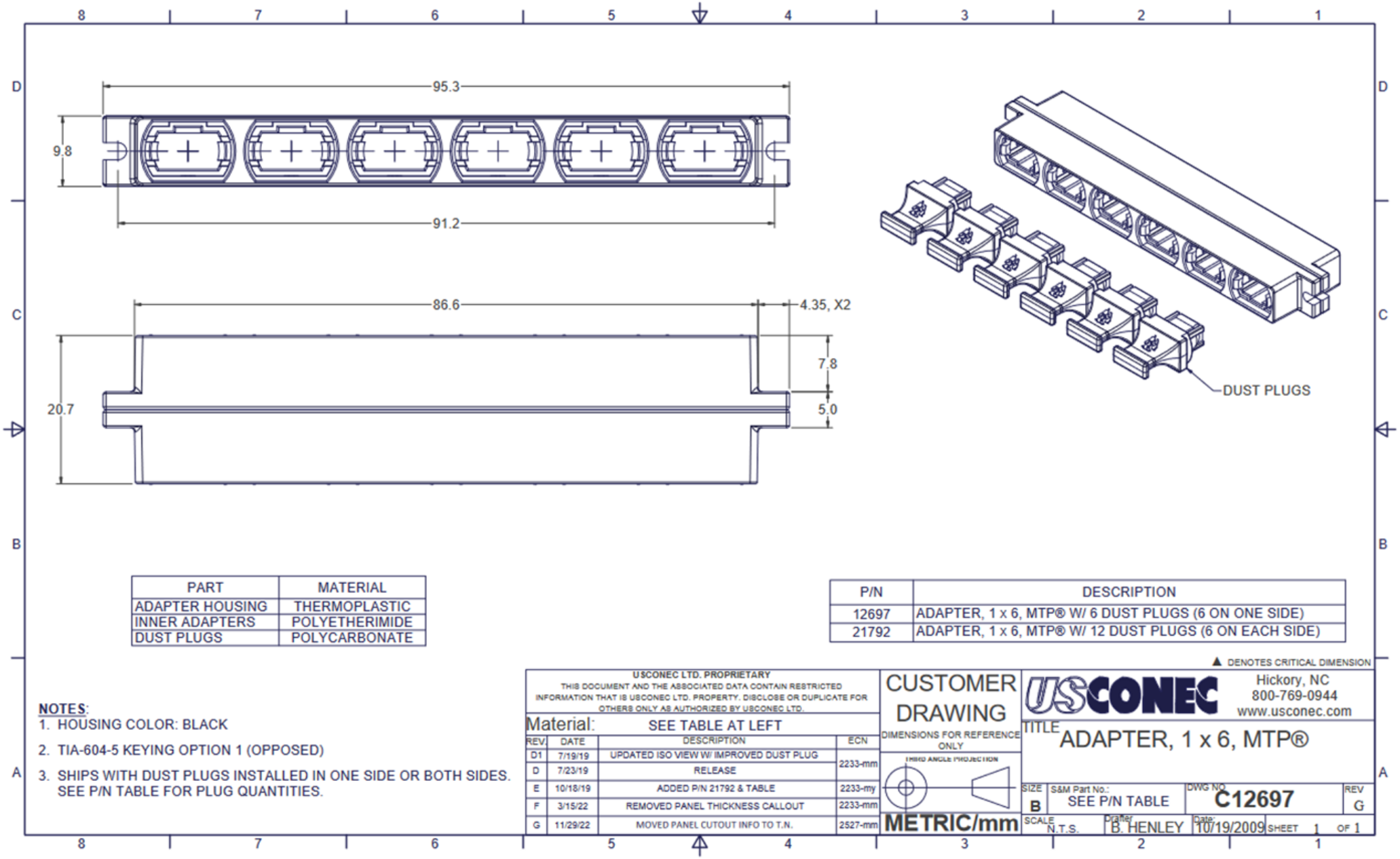
USCONEC
Hickory, NC
800-769-0944
www.usconec.com

TITLE
ADAPTER, QUAD, MTP®, FF, STD

SIZE	S&M Part No.:	DWG NO	REV
B	SEE TABLE	C9578	C

SCALE	Drafter	Date:	SHEET
N.T.S.	M. YOUNT	11/15/2007	1 OF 1

Adapter – 1x6 MTP panel feedthrough



PART	MATERIAL
ADAPTER HOUSING	THERMOPLASTIC
INNER ADAPTERS	POLYETHERIMIDE
DUST PLUGS	POLYCARBONATE

P/N	DESCRIPTION
12697	ADAPTER, 1 x 6, MTP® W/ 6 DUST PLUGS (6 ON ONE SIDE)
21792	ADAPTER, 1 x 6, MTP® W/ 12 DUST PLUGS (6 ON EACH SIDE)

▲ DENOTES CRITICAL DIMENSION

NOTES:
1. HOUSING COLOR: BLACK
2. TIA-604-5 KEYING OPTION 1 (OPPOSED)
3. SHIPS WITH DUST PLUGS INSTALLED IN ONE SIDE OR BOTH SIDES. SEE P/N TABLE FOR PLUG QUANTITIES.

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Material: SEE TABLE AT LEFT

REV	DATE	DESCRIPTION	ECN
D1	7/19/19	UPDATED ISO VIEW W/ IMPROVED DUST PLUG	2233-mm
D	7/23/19	RELEASE	
E	10/18/19	ADDED P/N 21792 & TABLE	2233-my
F	3/15/22	REMOVED PANEL THICKNESS CALLOUT	2233-mm
G	11/29/22	MOVED PANEL CUTOUT INFO TO T.N.	2527-mm

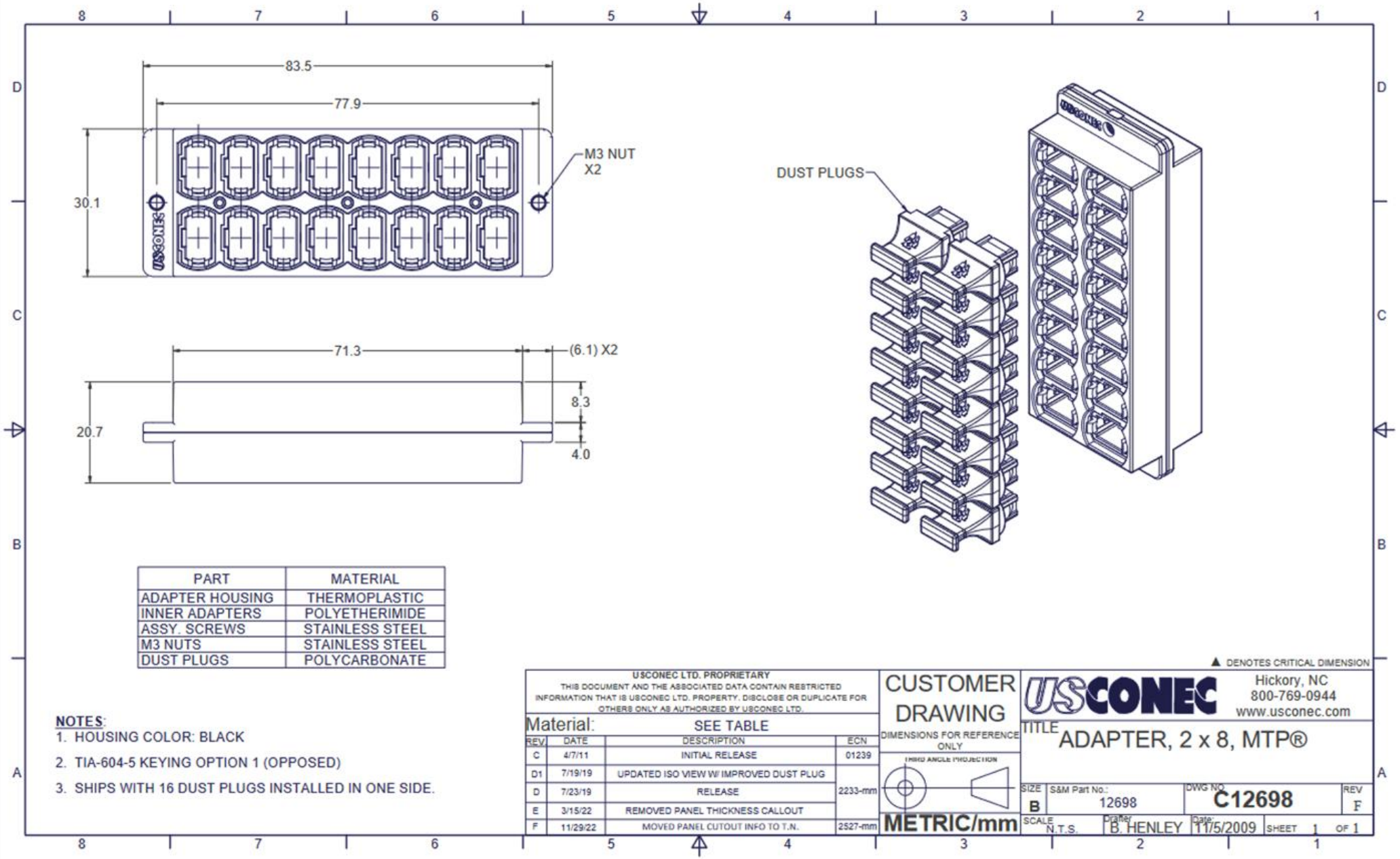
CUSTOMER DRAWING
DIMENSIONS FOR REFERENCE ONLY
THIRD ANGLE PROJECTION
METRIC/mm

USCONEC
Hickory, NC
800-769-0944
www.usconec.com

TITLE: ADAPTER, 1 x 6, MTP®

SIZE: B | S&M Part No.: SEE P/N TABLE | DWG NO: C12697 | REV: G
SCALE: N.T.S. | Drafter: B. HENLEY | Date: 10/19/2009 | SHEET 1 OF 1

Adapter – 2x8 MTP panel feedthrough



PART	MATERIAL
ADAPTER HOUSING	THERMOPLASTIC
INNER ADAPTERS	POLYETHERIMIDE
ASSY. SCREWS	STAINLESS STEEL
M3 NUTS	STAINLESS STEEL
DUST PLUGS	POLYCARBONATE

NOTES:
1. HOUSING COLOR: BLACK
2. TIA-604-5 KEYING OPTION 1 (OPPOSED)
3. SHIPS WITH 16 DUST PLUGS INSTALLED IN ONE SIDE.

▲ DENOTES CRITICAL DIMENSION

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Material: SEE TABLE

REV	DATE	DESCRIPTION	ECN
C	4/7/11	INITIAL RELEASE	01239
D1	7/19/19	UPDATED ISO VIEW W/ IMPROVED DUST PLUG	
D	7/23/19	RELEASE	2233-mm
E	3/15/22	REMOVED PANEL THICKNESS CALLOUT	
F	11/29/22	MOVED PANEL CUTOUT INFO TO T.N.	2527-mm

CUSTOMER DRAWING
DIMENSIONS FOR REFERENCE ONLY
THIRD ANGLE PROJECTION
METRIC/mm

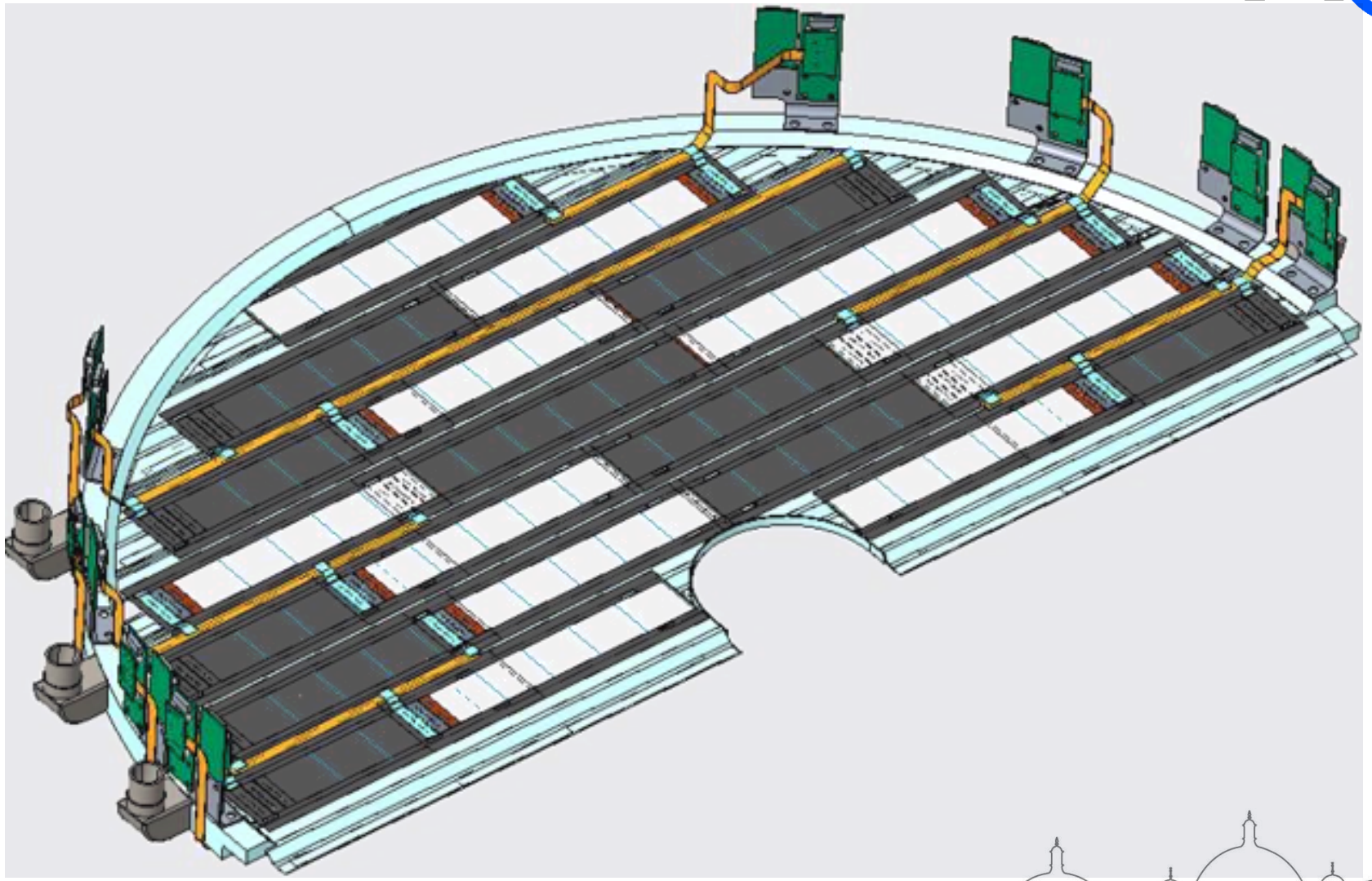
USCONEC
Hickory, NC
800-769-0944
www.usconec.com

TITLE: ADAPTER, 2 x 8, MTP®

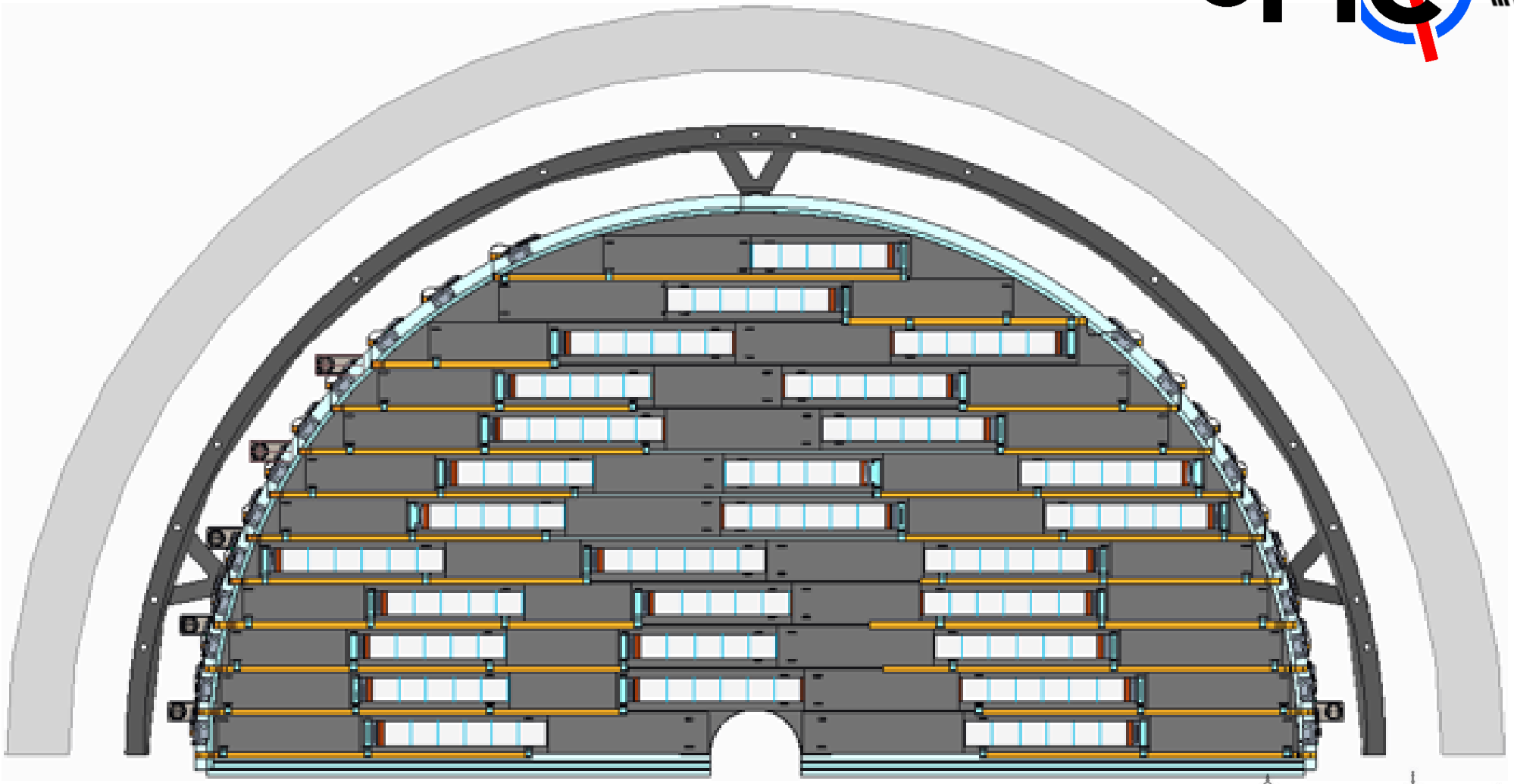
SIZE	S&M Part No.:	DWG NO.	REV
B	12698	C12698	F

SCALE N.T.S. | Drawn B. HENLEY | Date 11/5/2009 | SHEET 1 OF 1

ED/HD0 – Back



ED/HD1to4 – Back



ED/HD1to4 – Front