Services Design for the CMS Phase II Inner Tracker

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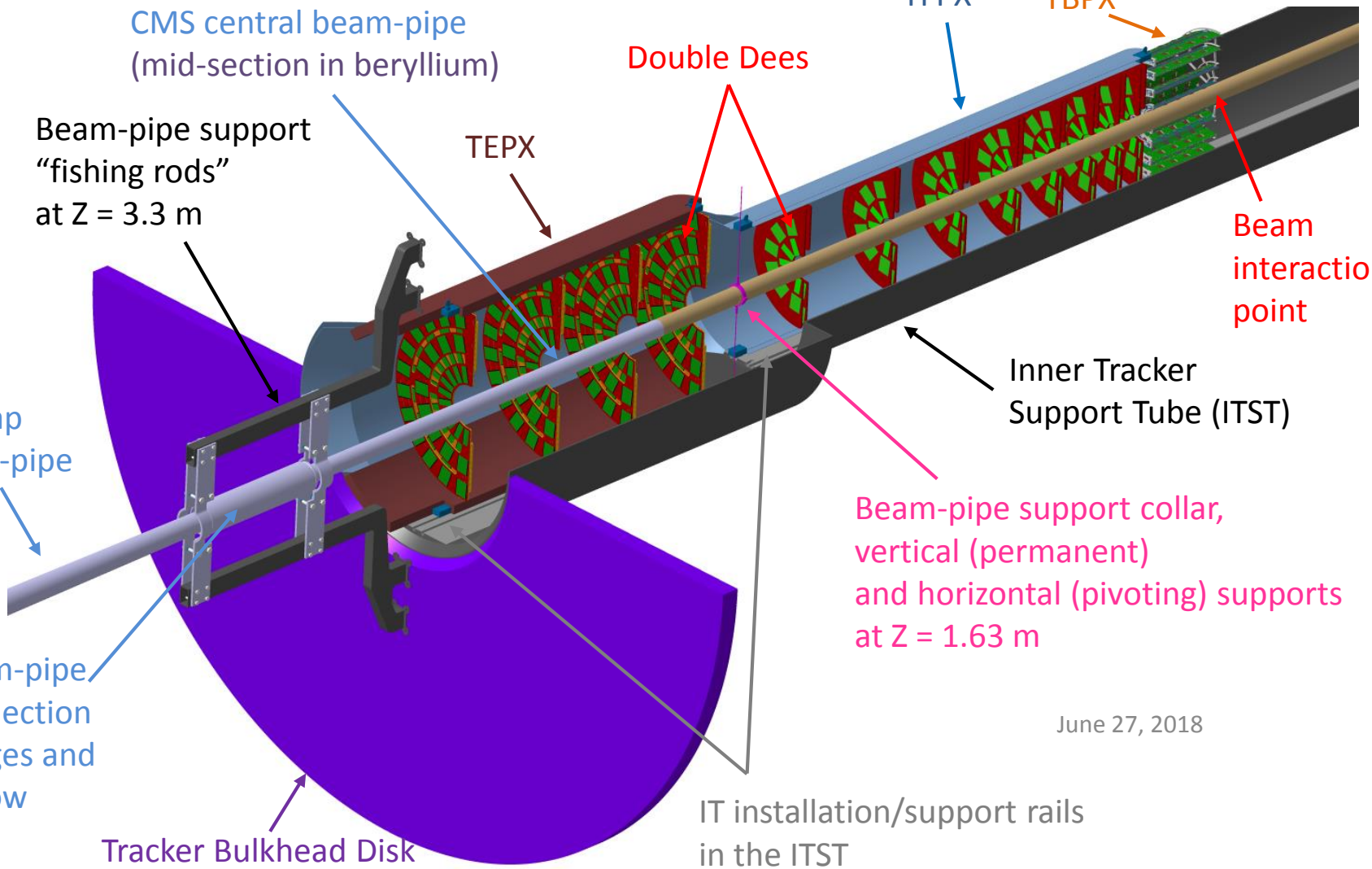
June 27, 2018

Outline

- Objective
- Cartridge design
  - Connectors
  - Putting it together
- Service cylinder
- Concluding remarks

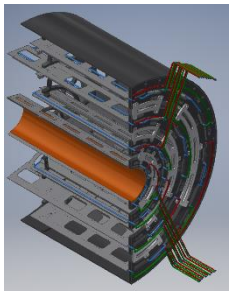
Inner Tracker region



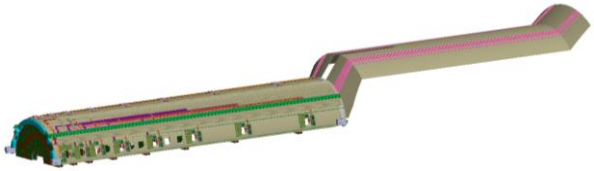
June 27, 2018

Challenges: Assembly of detectors to single service cylinder

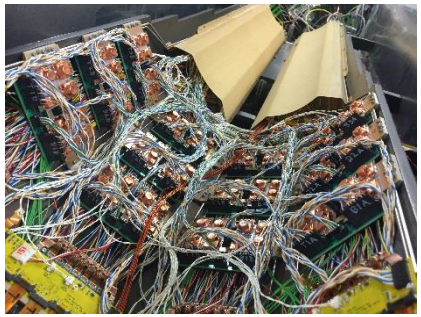
- Tracker Barrel Pixel Detector (TBPX) comes from Italy
- Tracker Forward Pixel Detector (TFPX) comes from USA
- Each detector to be **tested independently** at its **own centers** before being shipped to CERN
- **Modularity** for detector design important to allow each detector **to be assembled and tested independently** when sharing the service cylinder **at CERN**
- Three detectors (TFPX, TFPX, TEPX) share the same space as phase 1 (FPIX and BPIX) with increased services for phase 2. Not a lot of space!!



Phase 2 TBPX (Delivered from: INFN, Italy)

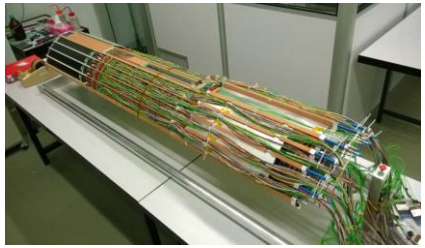


Phase 2 TFPX with service cylinder (Delivered from: USCMS, USA)



Phase 1 FPIX

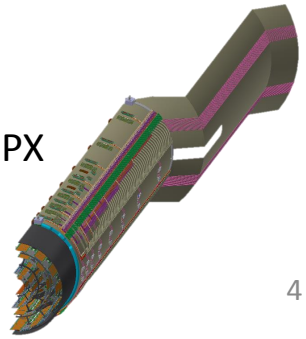
+



Phase 1 BPIX

=

Phase 2 TBPX+TFPX Trackers

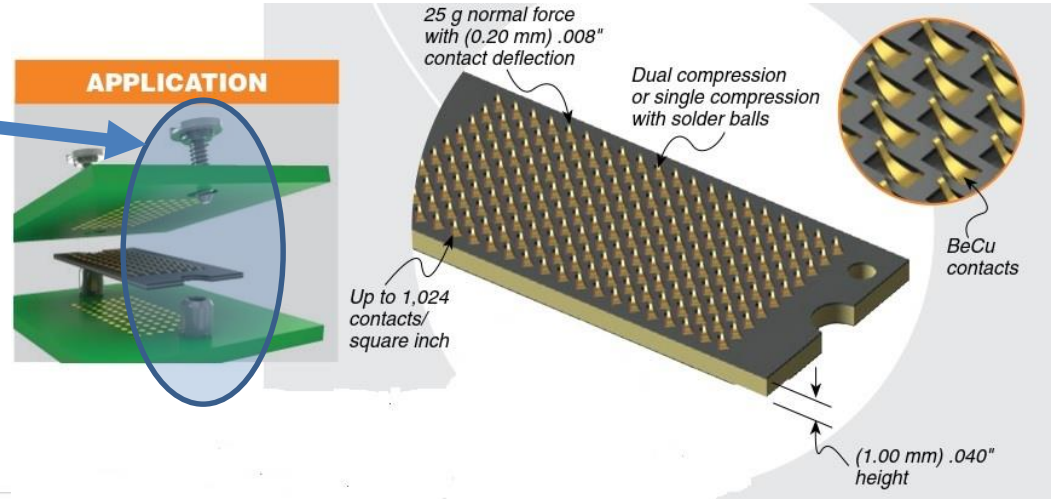


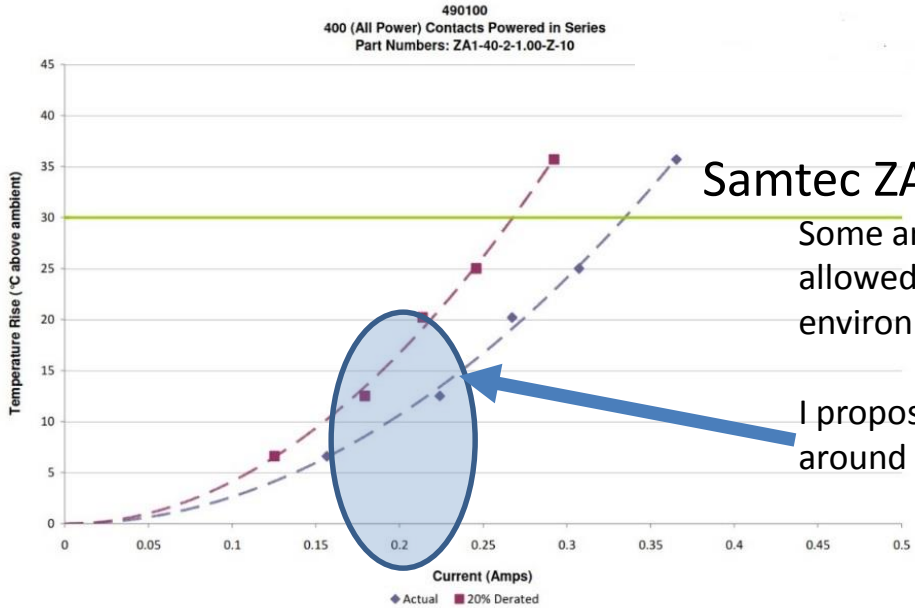
CARTRIDGE ASSEMBLY: CONNECTORS

Interposer Technology

Propose stacked PCBs with Interposers for all non-HV wiring

Assembly hardware designed for PCBs between 1.6 and 3.2 mm thick. Would need special consideration for thinner boards, including analyzing flexing.



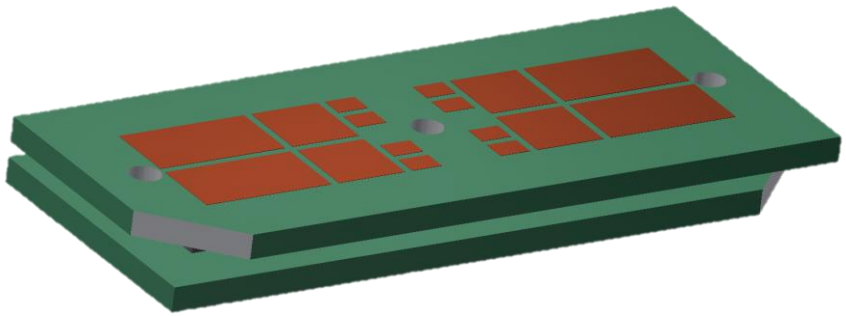


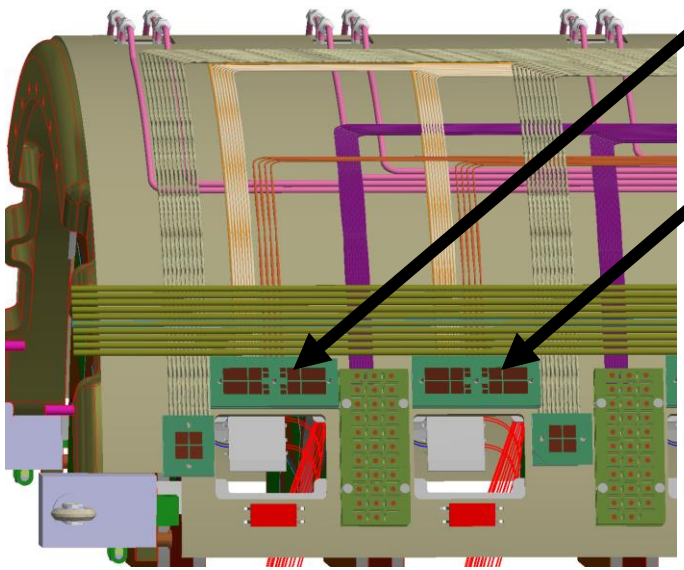
Samtec ZA1 Derating plot for all pins powered

Some argument about how much current per pin is really allowed. The plot is drawn for a maximum 30 C rise in a 75 C environment to avoid the material max of 105 C.

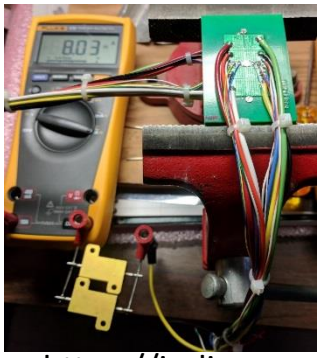
I propose operating near 15 C rise, limiting the current to around 200 ma per pin.

300 pin interposers for TFPX dee's

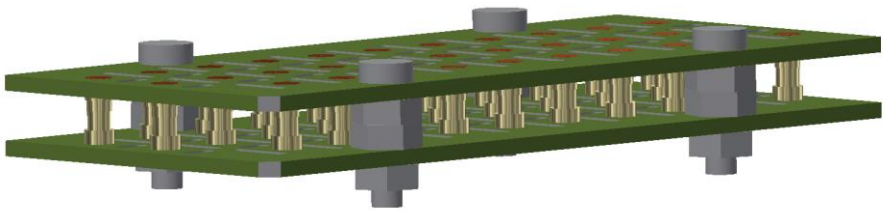


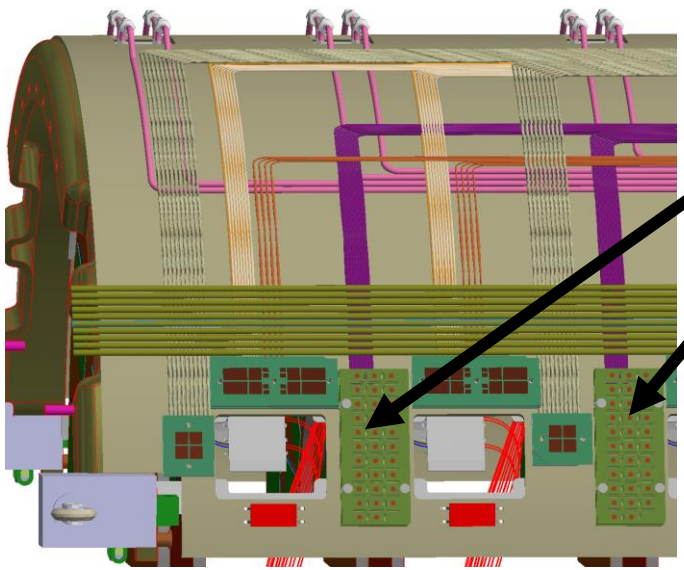


- 300 pin interposer to be used; one per dee, **16 total**. 1 on each side of the service cylinder
- The interposer will wire
  - 8 amp serial power conductors
  - 4 amp serial power conductors
  - High voltage return conductors
  - DSS control temperature conductors



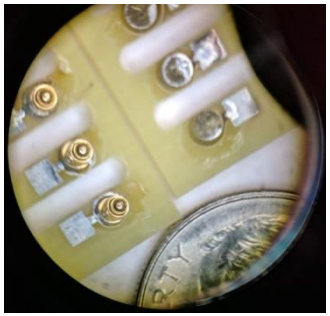
32 pin HV-in connectors for TBPX and TFPX

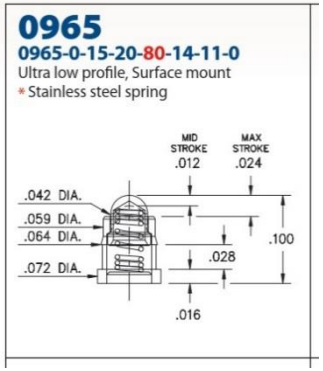




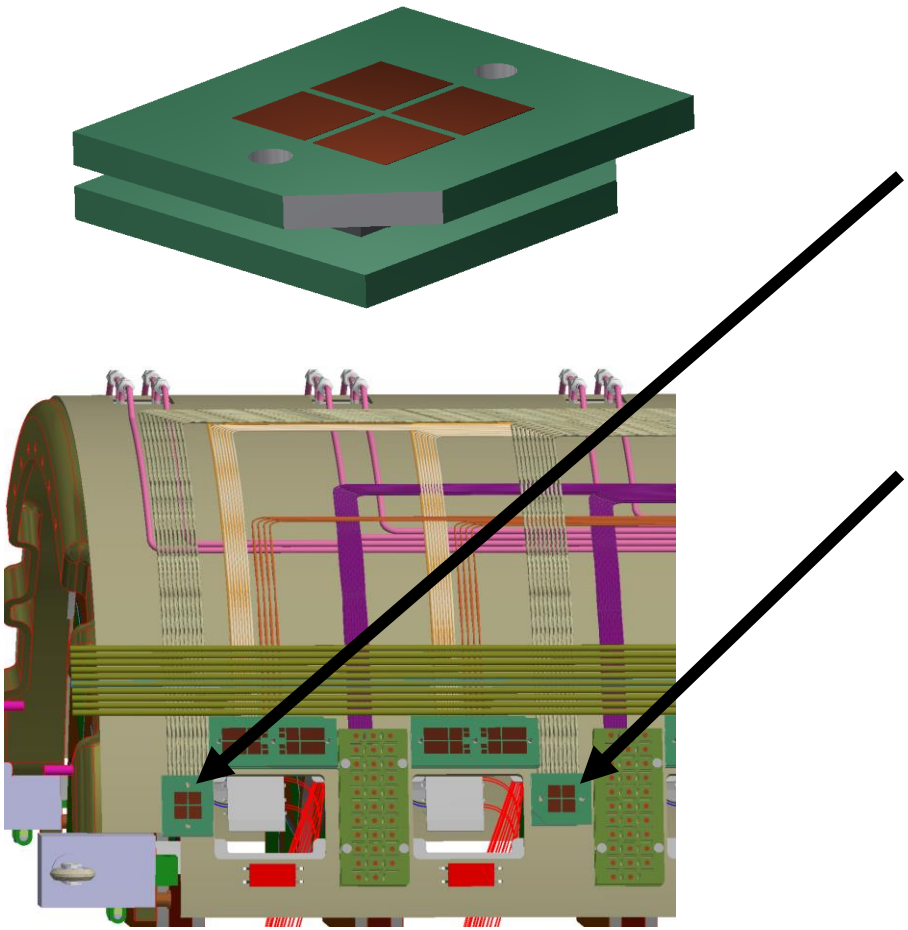
- In order to fit the HV in wires a new PCB was designed
- PCB uses electrical standard spacing needed for HV connections; however this takes up a lot of space
- 32 pin connector to accommodate for even dee. Same connector can be used for TBPX and TFPX to reduce number of parts at this stage
- **16 total** HV-in pcb boards for TFPX

https://indico.cern.ch/event/726414/





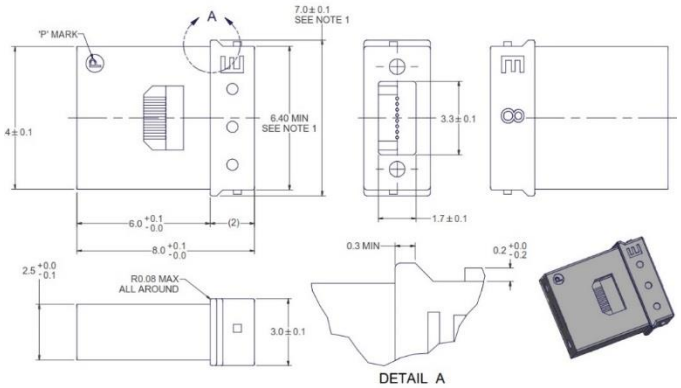
100 pin port card mechanism power for TBPX and TFPX

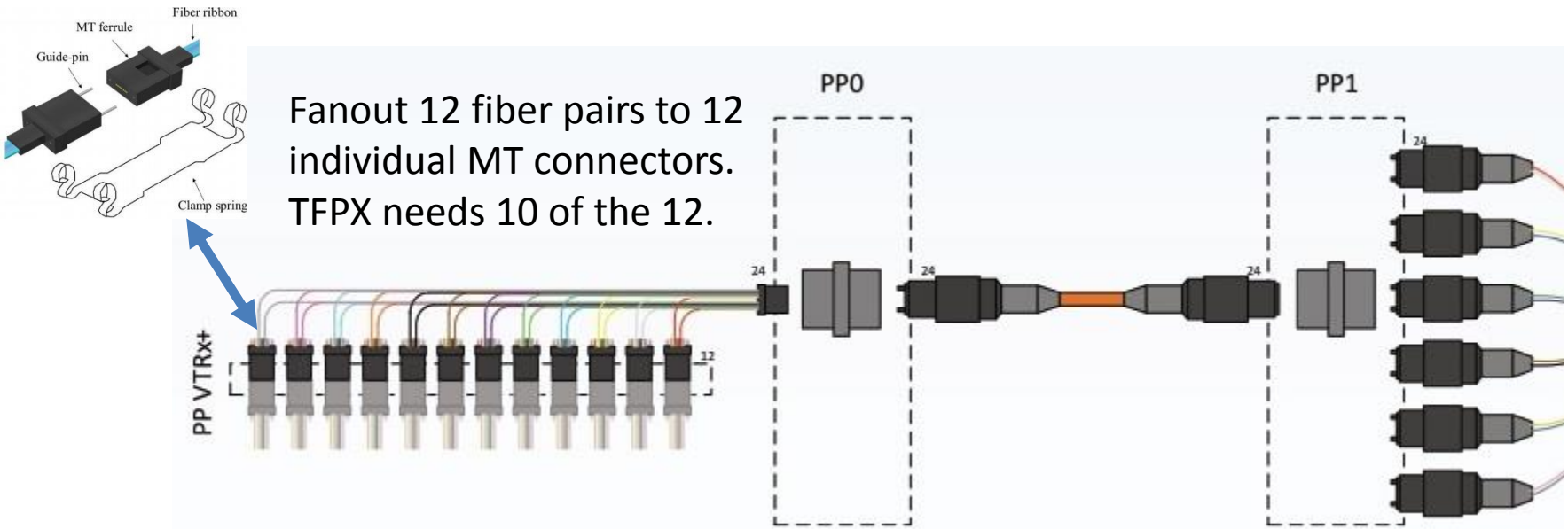


- For each port card mechanism the power will be provided for all port cards 100 pin interposer
- This component has to be close to port card mechanism assembly
- Only placed on one side of service cylinder (mirrored side will not have this component)
- **8 total** for TFPX

MT-MT Fiber Optics Junction

- For each port card mechanism 2 fiber optic pairs needed
- A single 24 wire bundle per dee
- Fiber optic bundles are part of each cartridge and routed along service cylinder with each installation of a cartridge



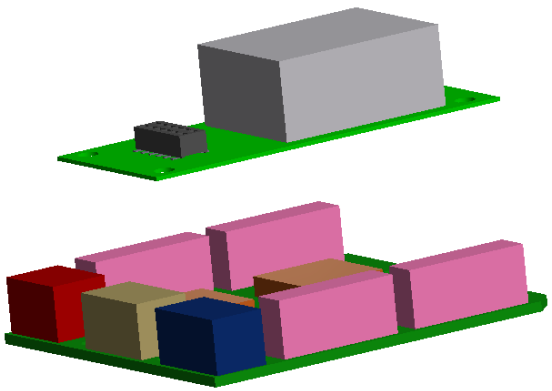


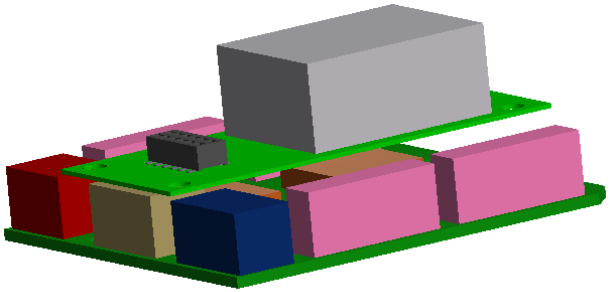
CARTRIDGE ASSEMBLY: PUTTING IT TOGETHER

Port Card Assembly

2nd Stage DC-DC Converter

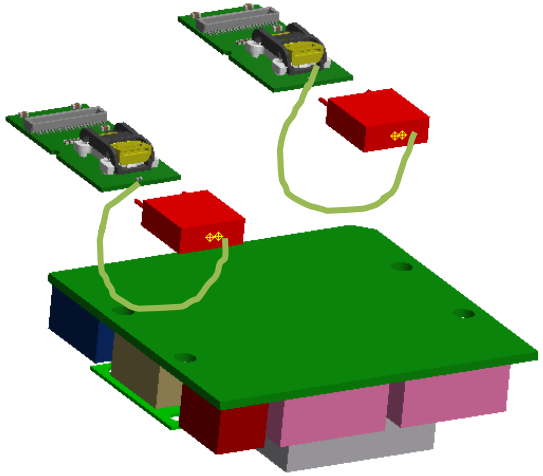
Design of DC-DC still ongoing. Shown is first design

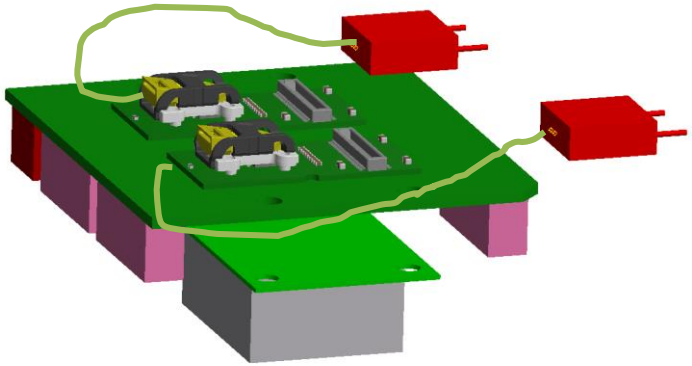




Versalinks

Each versalink has 2 pigtails each with 2 fiber optic cables into MT permanent connectors





Fiber optic connectors

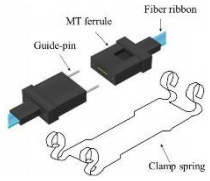
Port cards assembled to cartridge chassis

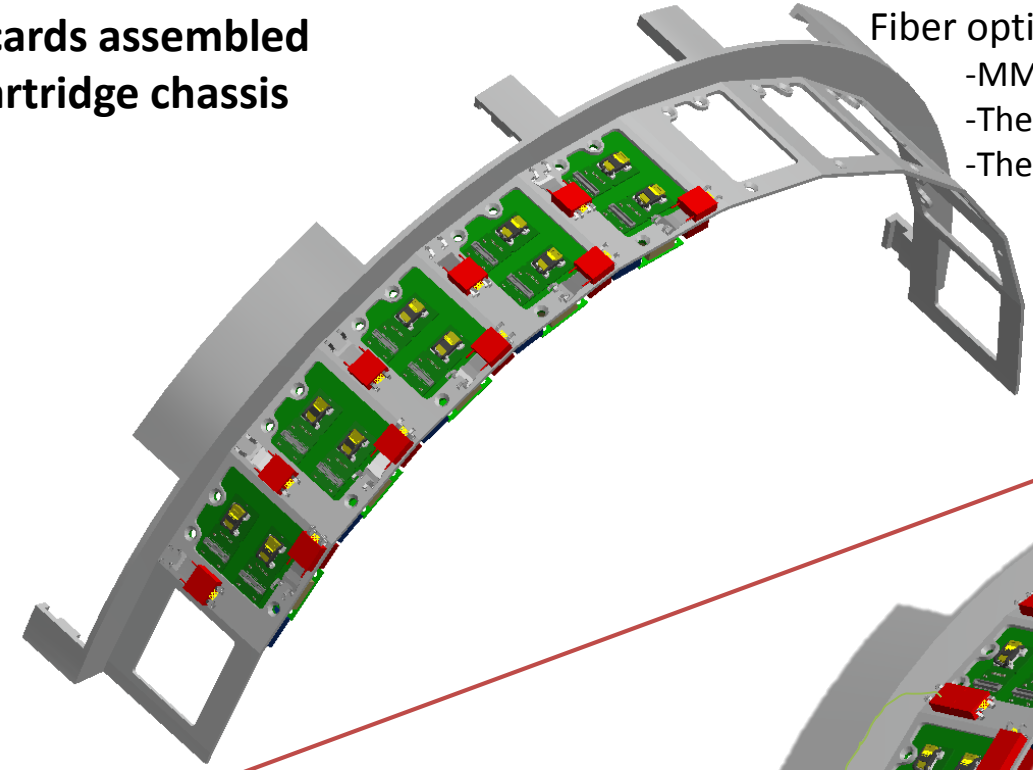
Fiber optic connector parts from US Conec, Ltd.

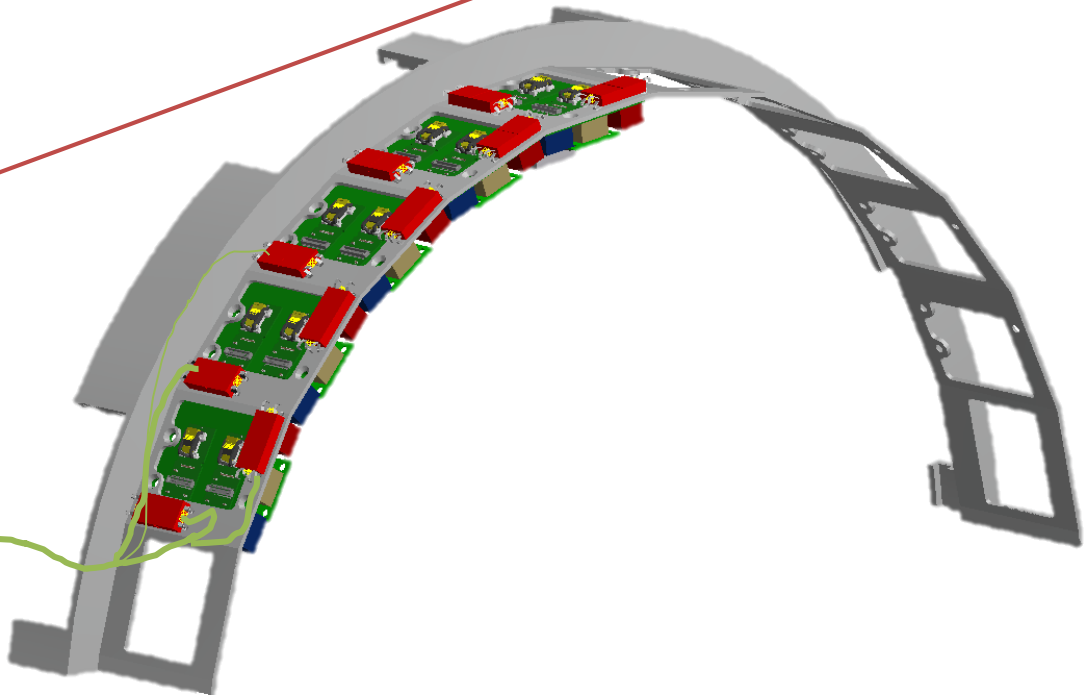
-MM Elite MT ferrule (17184)

-The individual guide pins (16735)

-The spring clamp (10405)



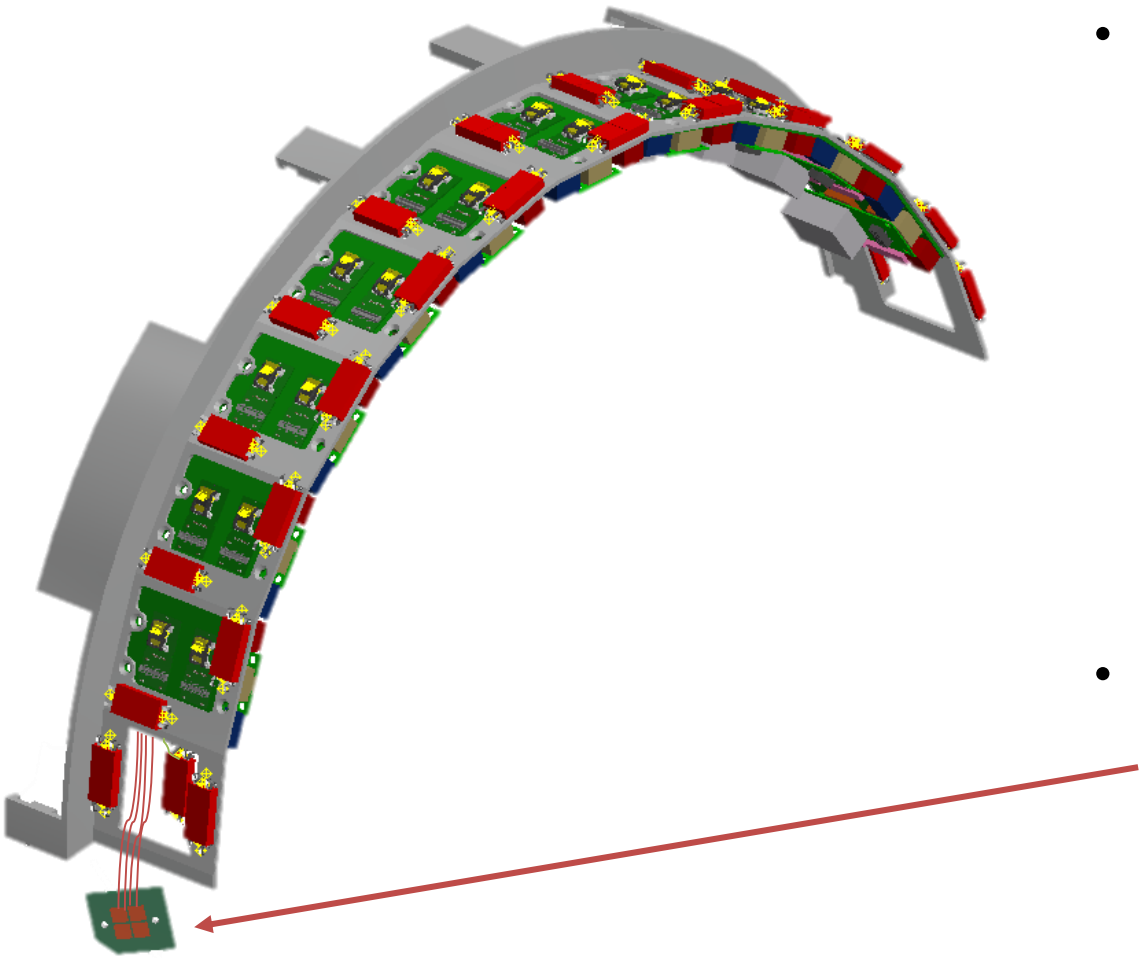




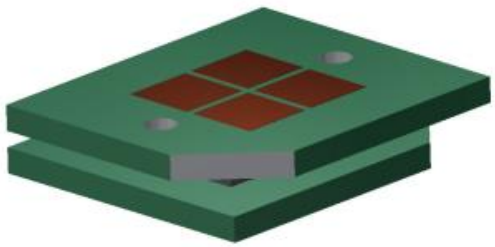
24 wire fiber optic fan out going out to PP0

24 fiber wires same connector to PP0

Port card power

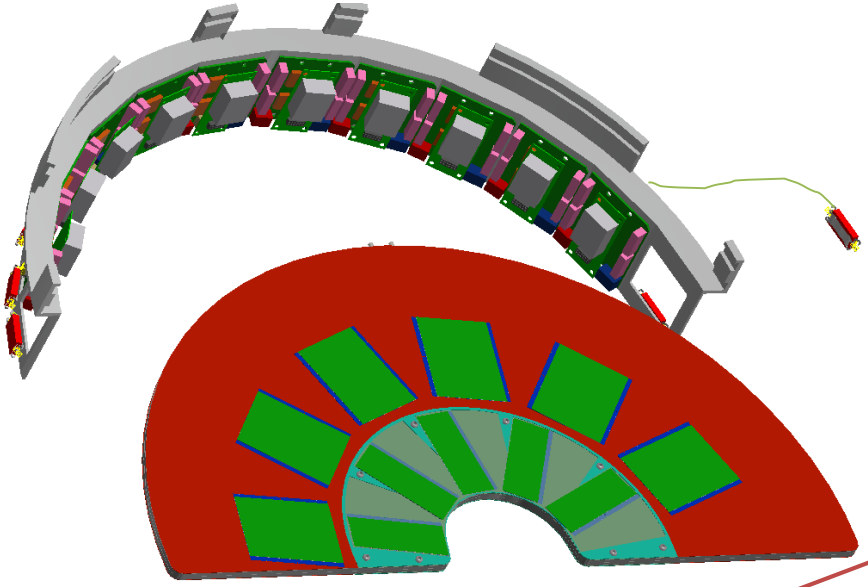


- The power to all port cards for an even and odd dee for a cartridge is provided by a single 100 pin interposer sandwich



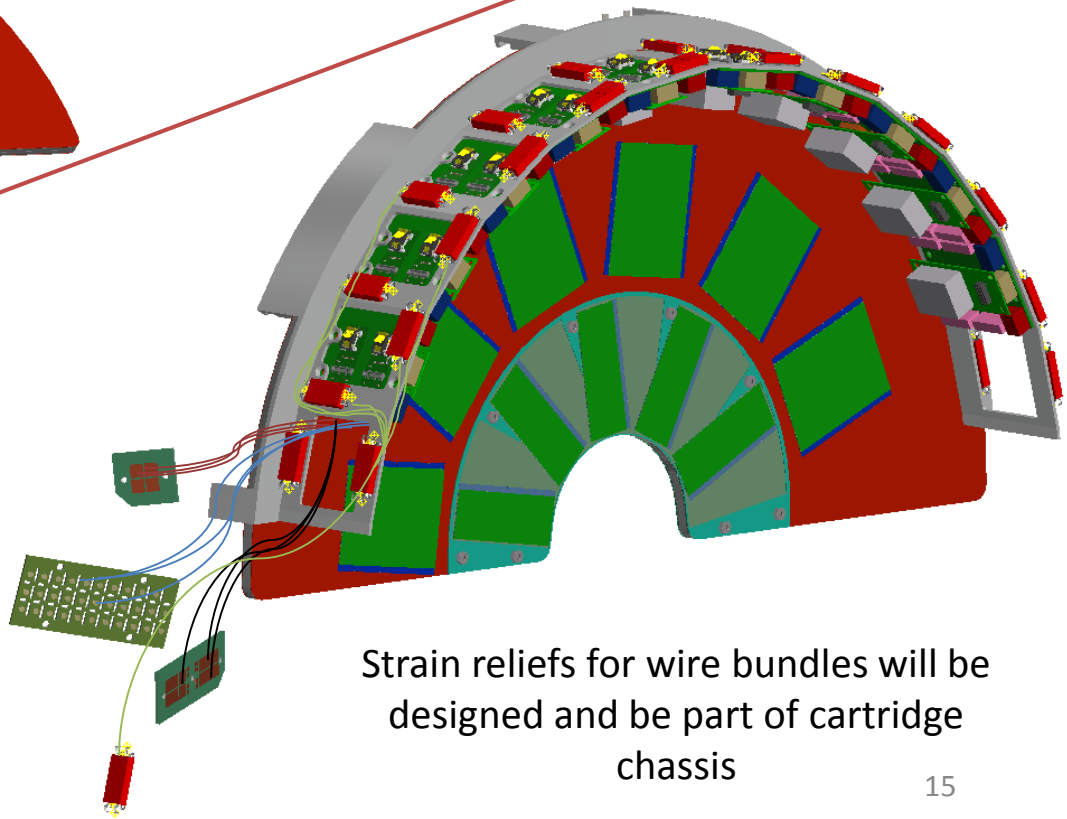
- The female pigtail shown connects to all port cards in this cartridge and exits out to service cylinder to make the mating connection

Dees on cartridge



Dees are slid into slots in cartridge and screwed in place from top into square nuts on dee sandwich

Dees assembled on cartridge chassis



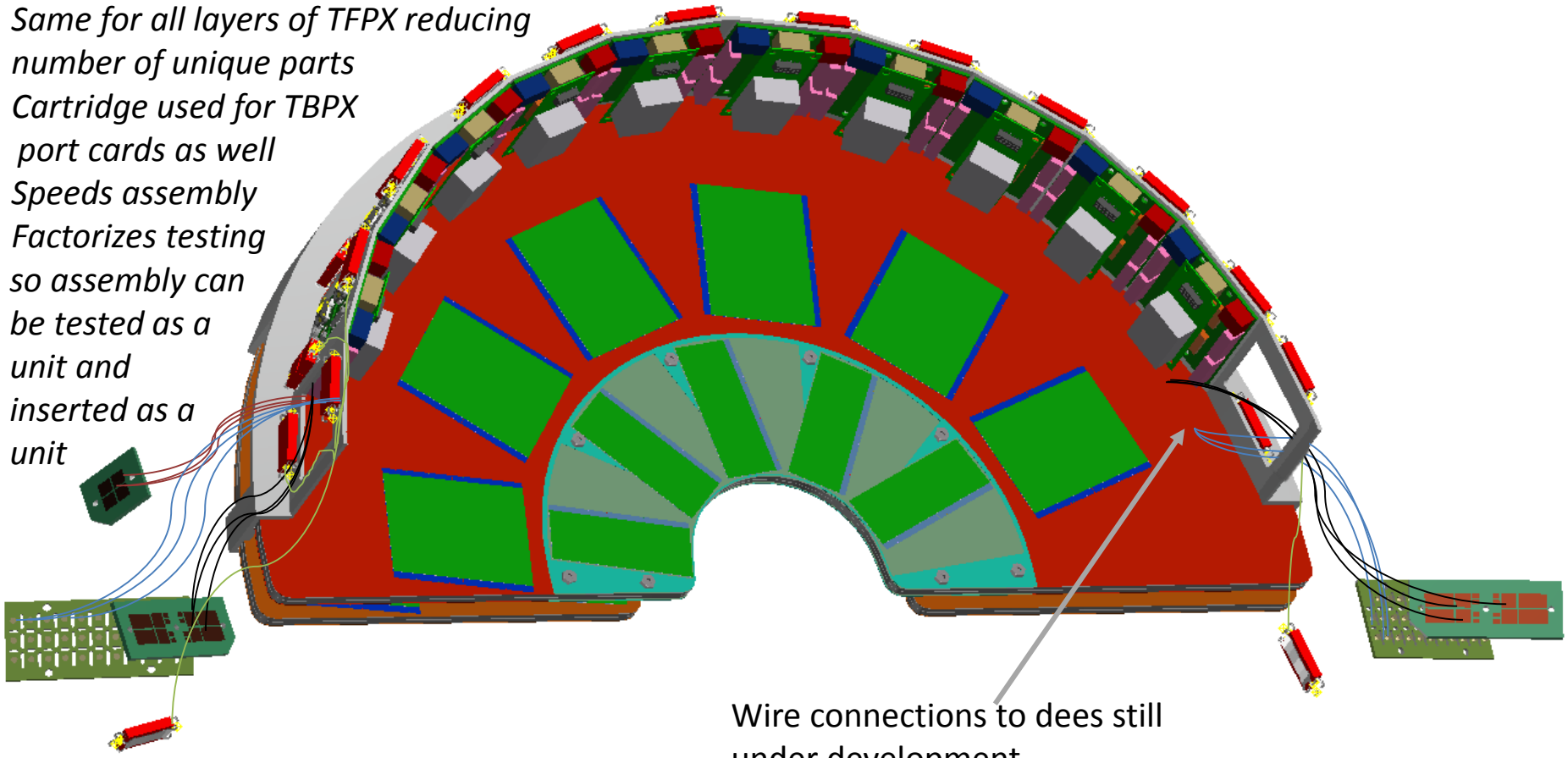
Female PCB's for high voltage, serial power, temperature are wired

Strain reliefs for wire bundles will be designed and be part of cartridge chassis

Assembled cartridge

Modular design

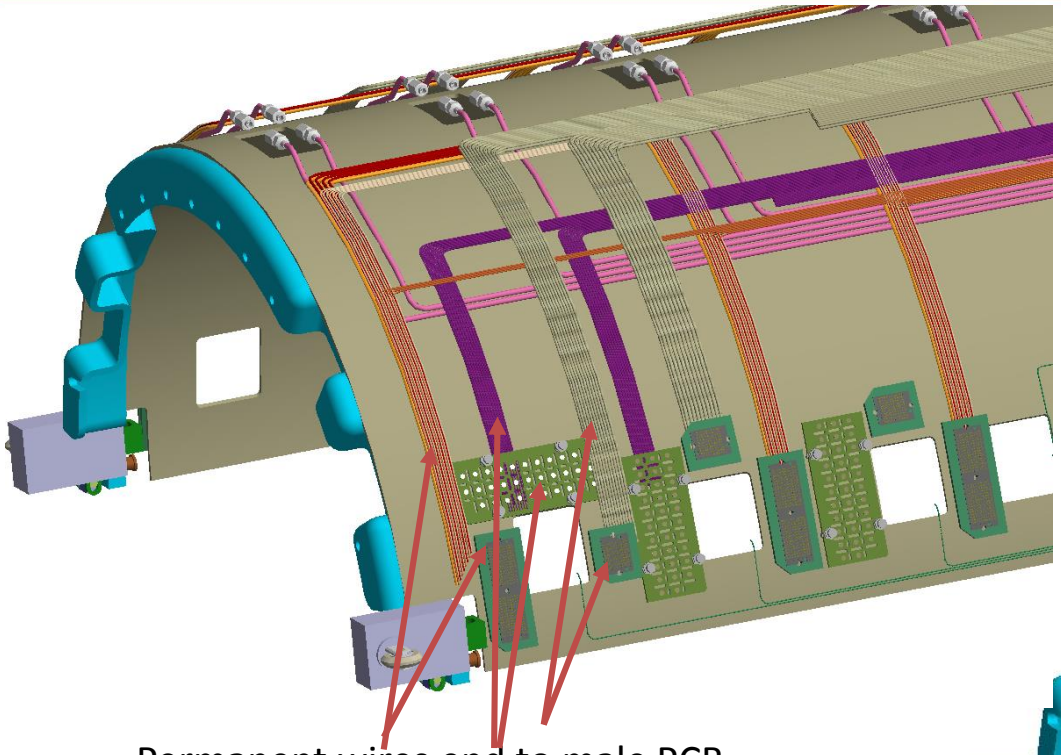
- *Same for all layers of TFPX reducing number of unique parts*
- *Cartridge used for TBPX port cards as well*
- *Speeds assembly*
- *Factorizes testing so assembly can be tested as a unit and inserted as a unit*



Wire connections to dees still under development

Each pigtail bundle exits to either side of the service cylinder to attach to its male counterparts

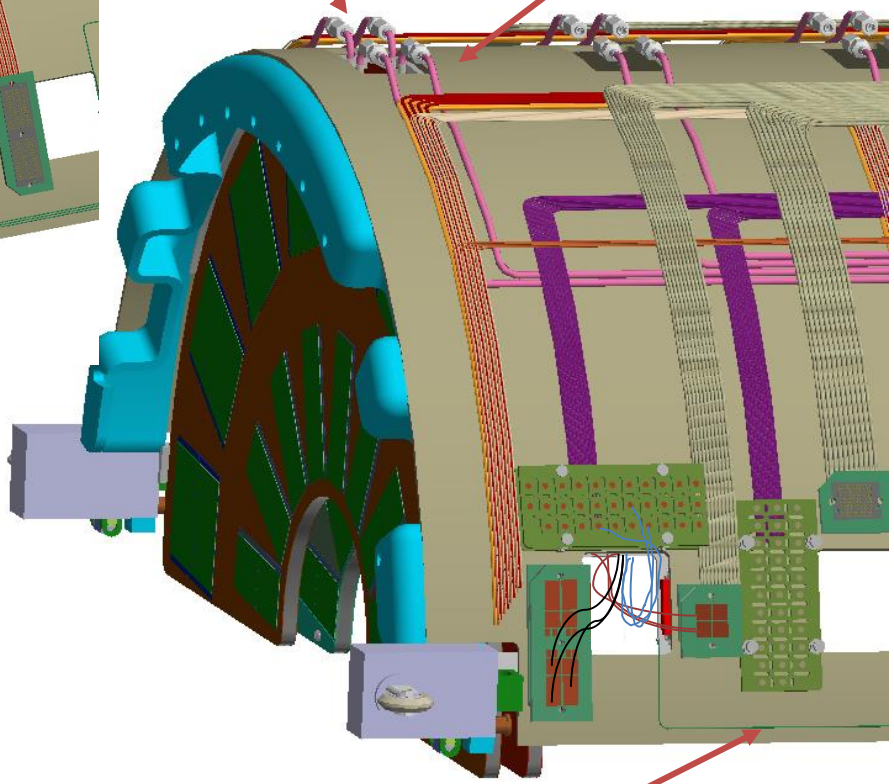
Attaching cartridge to service cylinder



Permanent wires end to male PCB boards attached to service cylinder

Dee female fitting for cooling tubes connected to male fittings permanent on service cylinder

Space available IF cooling needed for port cards



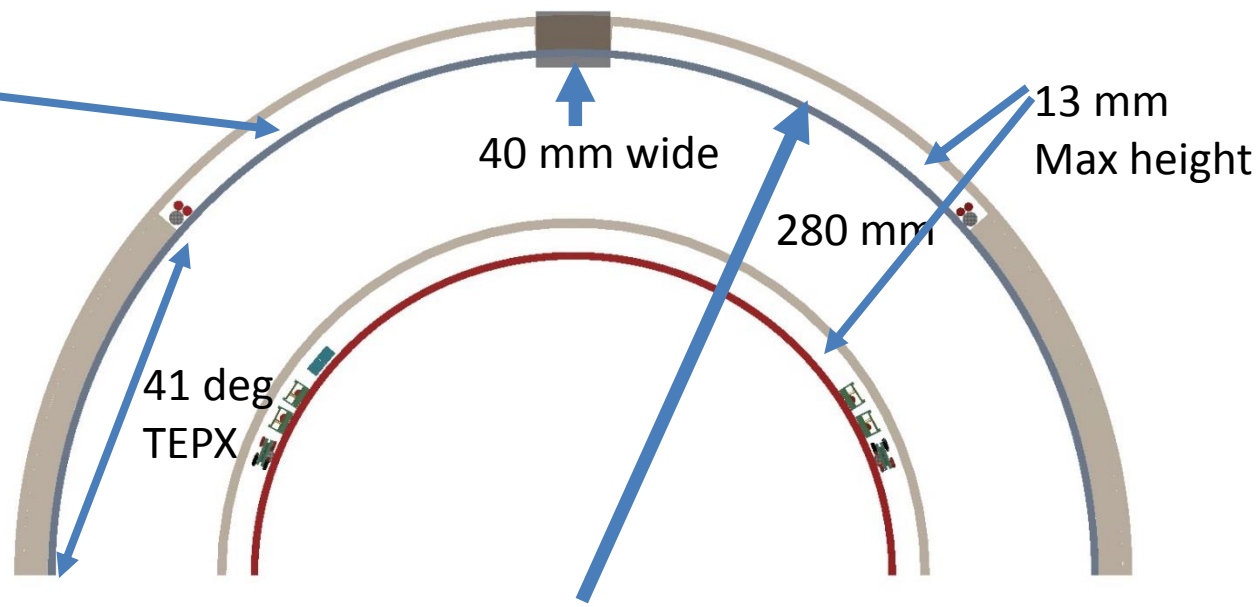
24 wire fiber optic bundle to PP0

SERVICE CYLINDER

TFPX and TBPX available cross section area

	Value	Units
Radius of service cylinder in TEPX region	280.00	mm
Maximum usable height on service cylinder	13.00	mm
Height reserved for cover and cable management	1.00	mm
Angle occupied by each of two TEPX reserved areas on 180 degree cylinder	41.00	degrees
Width of slot in service cylinder	40.00	mm
Approximate angle equivalent of slot	8.20	degrees
Available area over 180 degrees (sum of 2 large openings)	**5378.99**	mm-sq
Area of each opening	2689.50	mm-sq

Cross sectional area limiting factor at larger OD of service cylinder. White area within 12mm boundaries is available space for both TFPX and TBPX services plus 1mm cover



¼ IT wiring/plumbing estimates

IT Services Placeholder Values
ITServices_v1.4

New wire diameters

	dia. from IT services V1.4 (mm)	New diameter of cable (mm)	count TBPX –Long only	count TFPX	Comments
8 amp SP conductors	2.2	1.53	28 (0L1,0L2,12L3, 16L4)	64 (2 in per dee, 2 out per dee)	
4 amp SP conductors	1.7	1.10	20 (6L1,14L2,0L3,0L4)	64 (2 in per dee, 2 out per dee)	
HV conductors	1.1	0.56	240 (30L1, 70L2, 60L3, 80L4)	432 (22 ODD, 32 Even)	
HV return conductors	1.1	0.56	24 (3L1,7L2,6L3,8L4)	64 (4/dee)	
Temperature conductors	0.5	0.5	48 (6L1, 14L2, 12L3,16L4)	128 (8 wires/dee)	2 wire type rtds (24 AWG solid core wire kapton). Need to add RTDs and wires to measure on service cylinder
LpGBT power conductors	? (1.524)	1.10	86 (2 wires/port card)	160 (2 wires/port card)	Sized assuming similar resistance loss as 4 am SP conductors
Fiber optic cables	?	**0.5 (guess)**	9 (3L1,3L2,1L3, 2L4)	16 (1/dee)	Assuming fiber bundle with 12 connections
Port Cards			**43 (15L1,14L2,6L3, 8L4)**	80 (5/dee)	
Cooling tubes	2.2		20 (loops 1L1, 2L2,3L3, 4L4)	32 (2/dee)	

Need to reduce wire diameters or type of wire to reduce total area taken up by the services

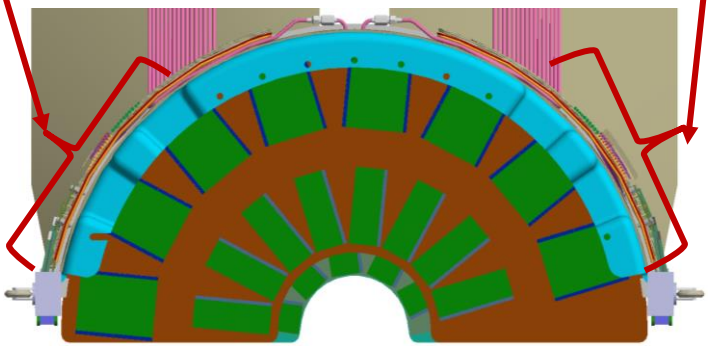
Charlie Strohman (https://indico.cern.ch/event/709400/)

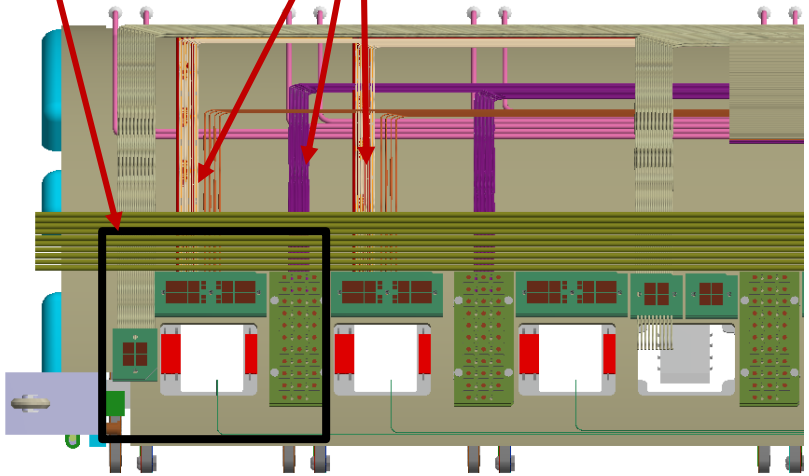
TFPX connector break down

- Connectors placed on the service cylinder for TFPX are mirrored so that odd and even dee side of service cylinder is similar (no port card interposer on odd dee side)
- For TFPX each connector is near the port card assembly exit on the service cylinder
- Wires for male connectors attached to service cylinder are flushed and permanent to service cylinder. TBPX services are placed on top of TFPX permanent services

Odd dee
TBPX Services

Even dee
TBPX Services

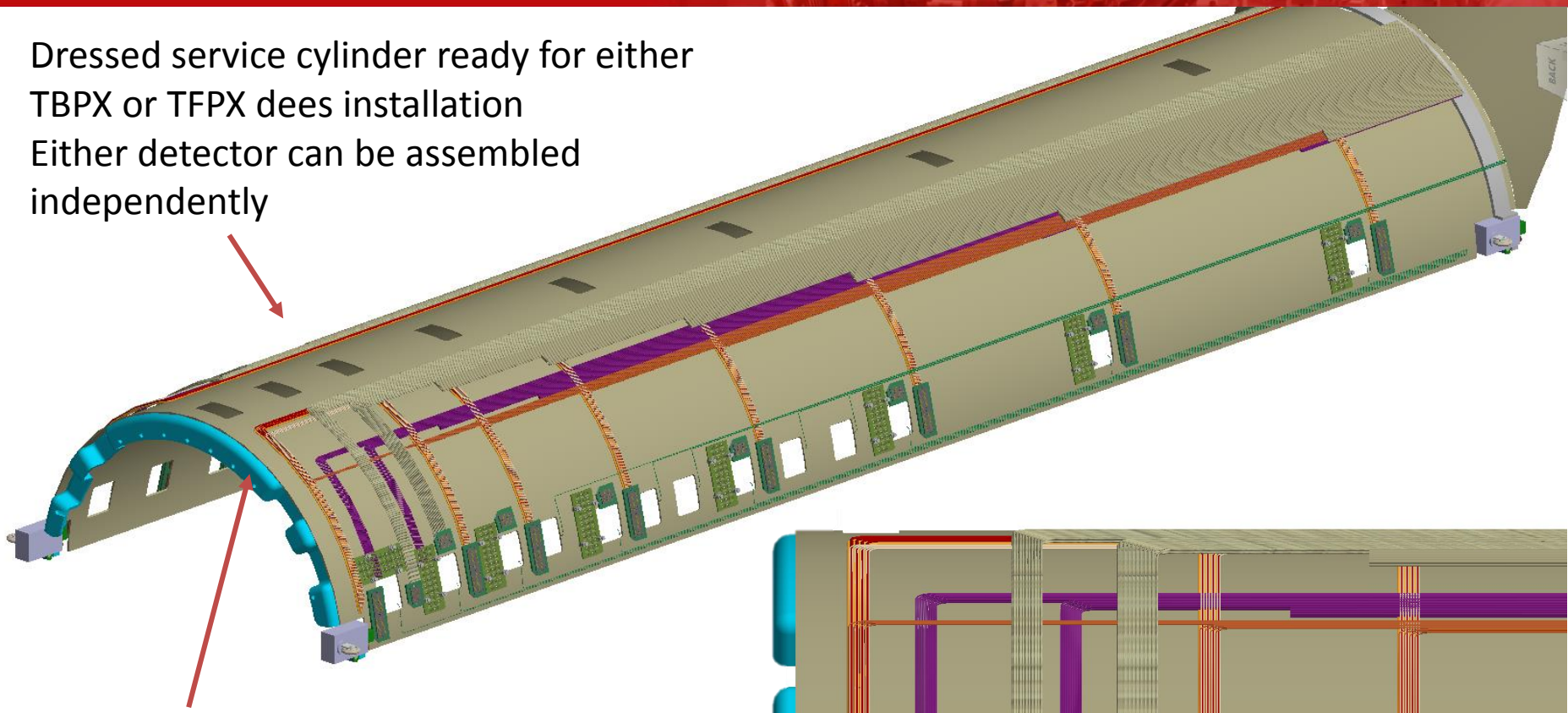




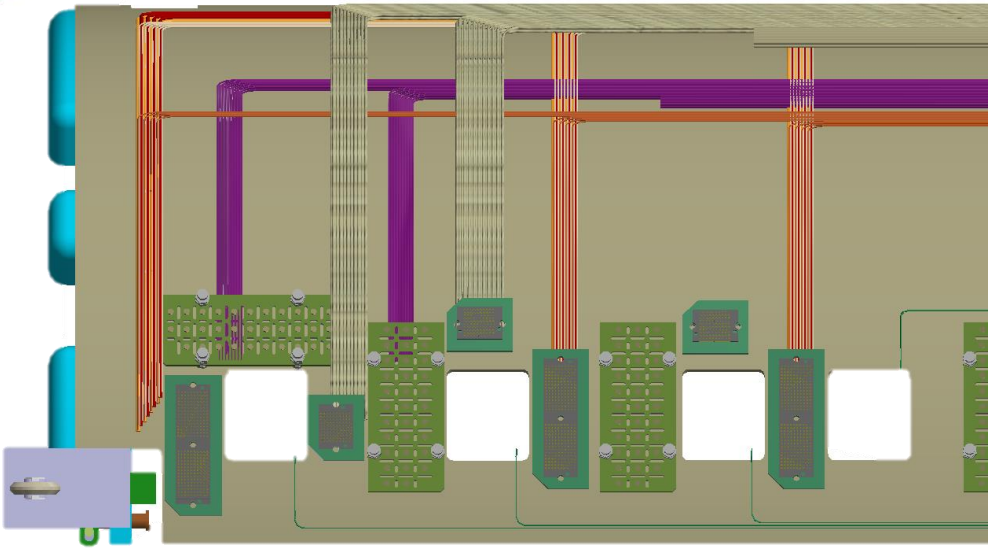
Dee	300 pin interposer	100 pin interposer	HV-in PCB board	Cassette/port card assemblies
Even	8	8	8	8
Odd	8		8	
Total	**16**	**8**	**16**	**8**

TFPX wiring permanent services

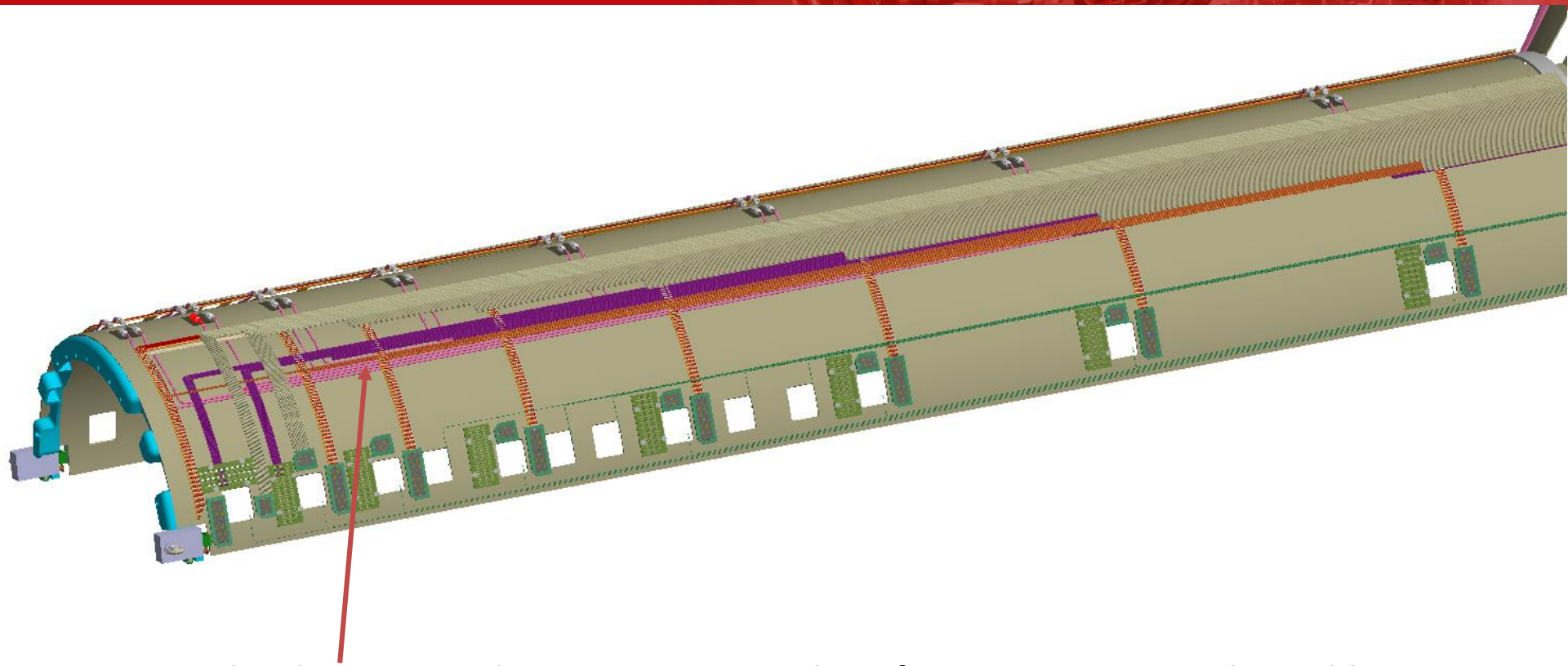
- Dressed service cylinder ready for either TBPX or TFPX dees installation
- Either detector can be assembled independently



- Interface flange holding the cantilevered TBPX detector
- Same mechanism holds the wheels for the service cylinder (wheel mechanism from BPIX phase 1)

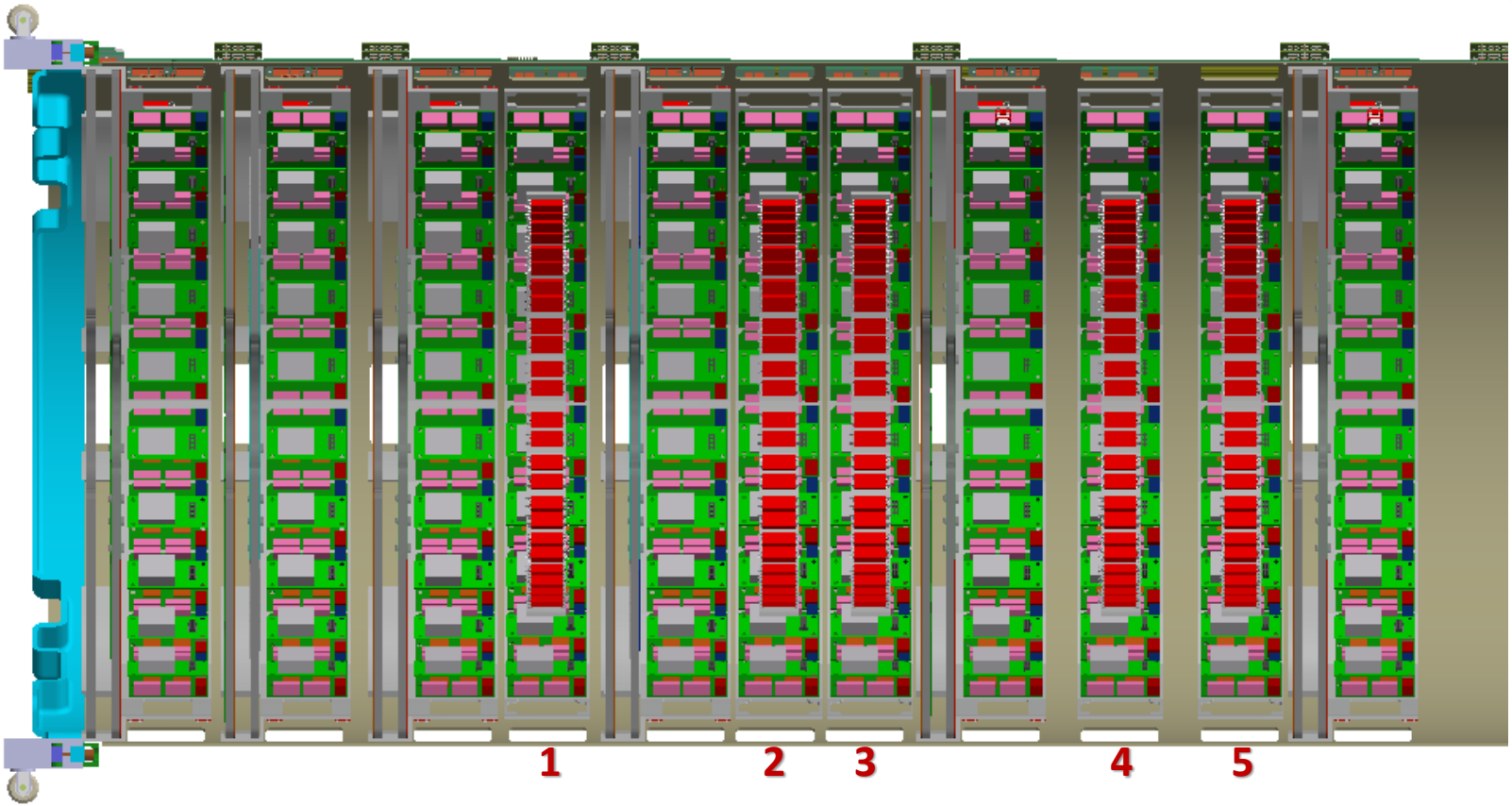


All TFPX services



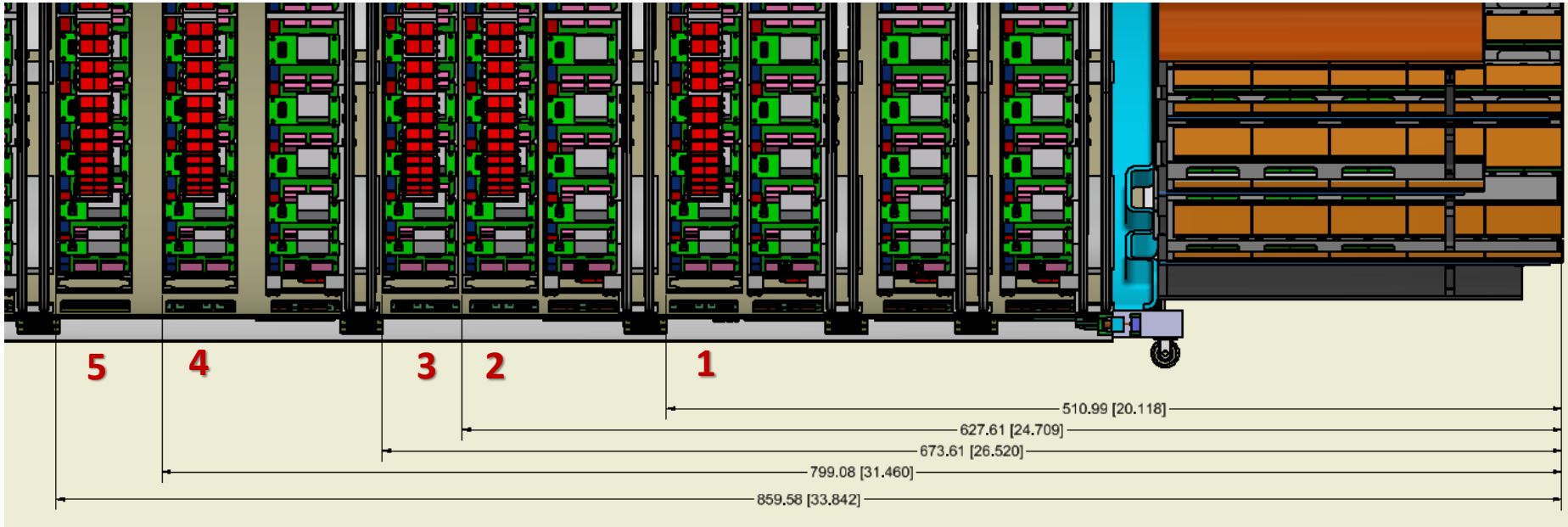
- Cooling lines run under wires to remove heat for services wires and possibly begin the onset of boiling (need to verify total heat load)
- Capillaries could connect to detector dees directly with tube step up happening inside service cylinder (not much coiling at PP0). Working on this
- Space available for cooling loops for port cards IF needed. Working on this as well ☺

TBPX port cards



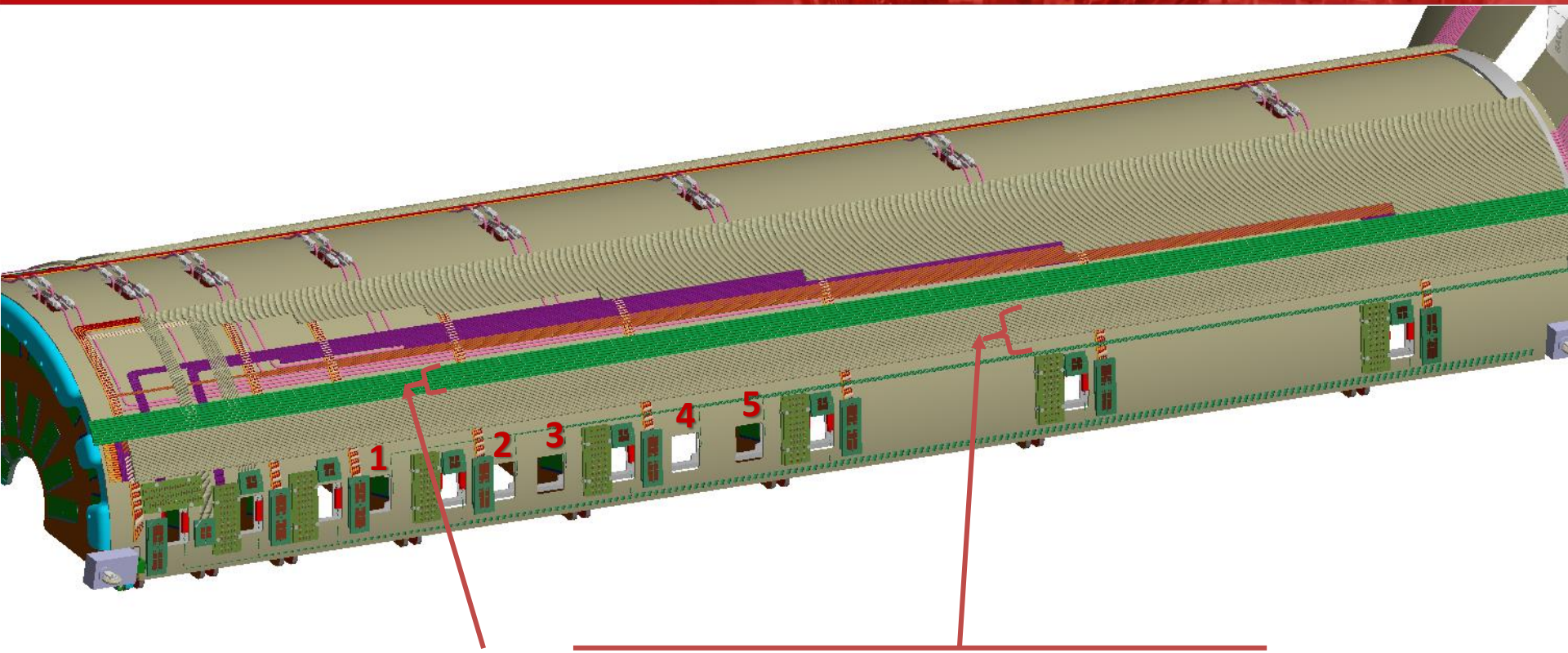
- Due to space constraints and to reduce material near z=0 region TBPX port cards are installed inside TFPX service cylinder
- 50 total port cards in 5 cartridge like assemblies
- Cartridges with layer of red fiber optic cables used only to show TBPX port card cartridges. Each TBPX port card cartridge has e-link interposer and port card power interposer

E-link length for TBPX



- The last port card assembly is successfully placed between layers 3 and 4 of TFPX by moving TFPX layer 3 closer to Z=0 by 15 mm
- New length to last port card assembly is **0.85m** (length of E-Link cable longer due to routing in R; not shown)
- To keep TBPX e-links connections within 1m due to manufacturer limits, routing of cabling will need to be optimized. Otherwise last port card assembly can be placed on top of TBPX L4

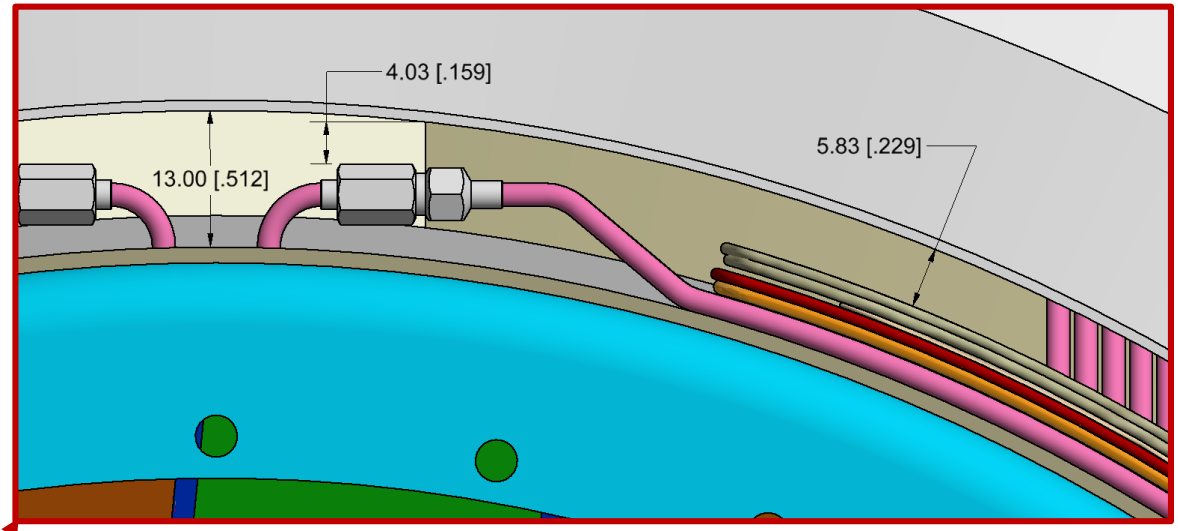
TBPX services

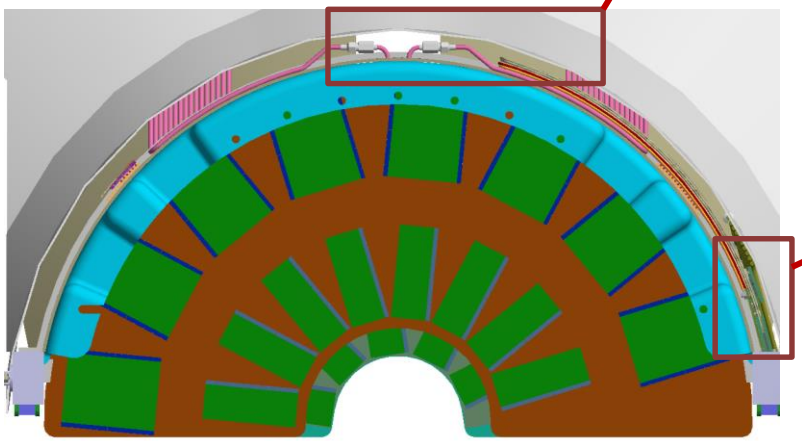


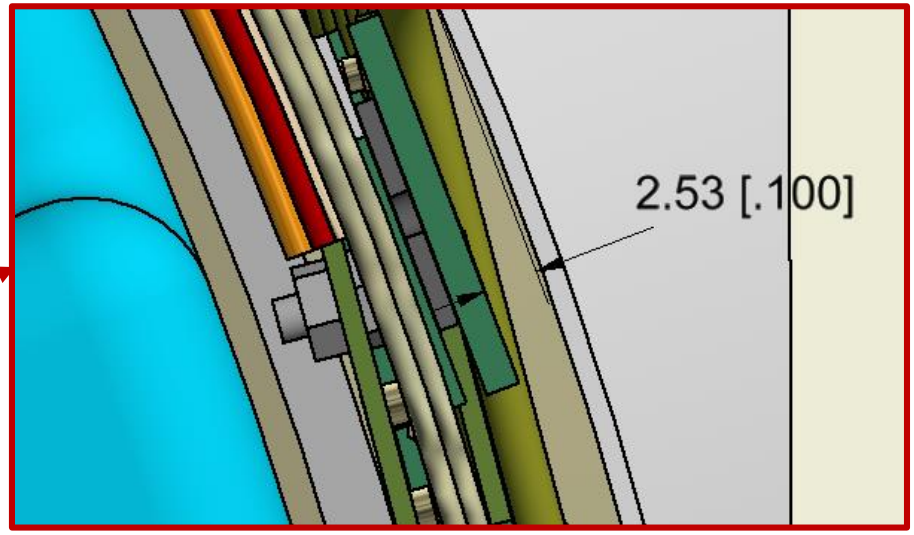
- TBPX cooling lines (green), high voltage, serial power, and temperature run directly to PP0 from the detector (space for intermittent connectors if needed is possible)
- E-links run on top of TBPX wires and into each port card location (1 through 5) possibly using an interposer as interface between TBPX cartridge and service cylinder
- TBPX cartridges can be tested with detector and installed with detector following same testing technique for TFPX

Integration space constraint changes can be reached: Theoretically

- Models show best case scenario 2.53mm between connectors to upper boundary limit (not optimized)
- Wiring (due to smaller ID changes) and cooling (still under discussion) show space may be enough. Mockups needed to verify

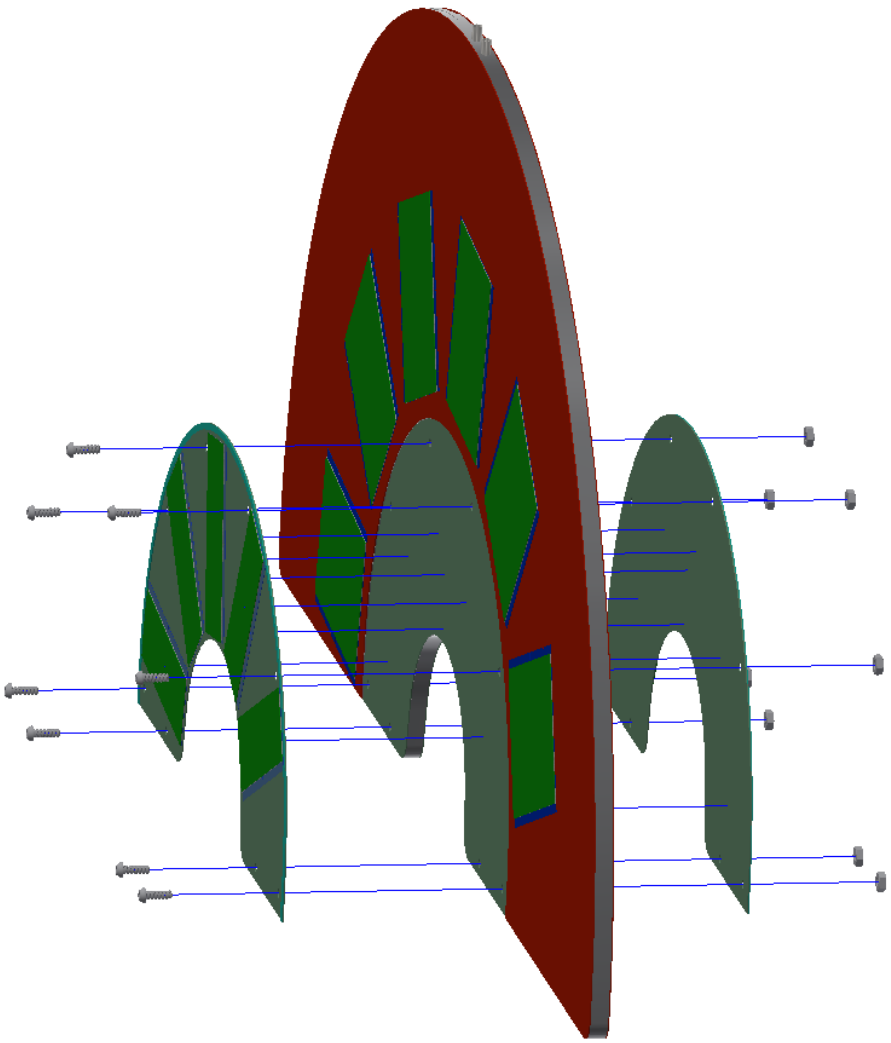






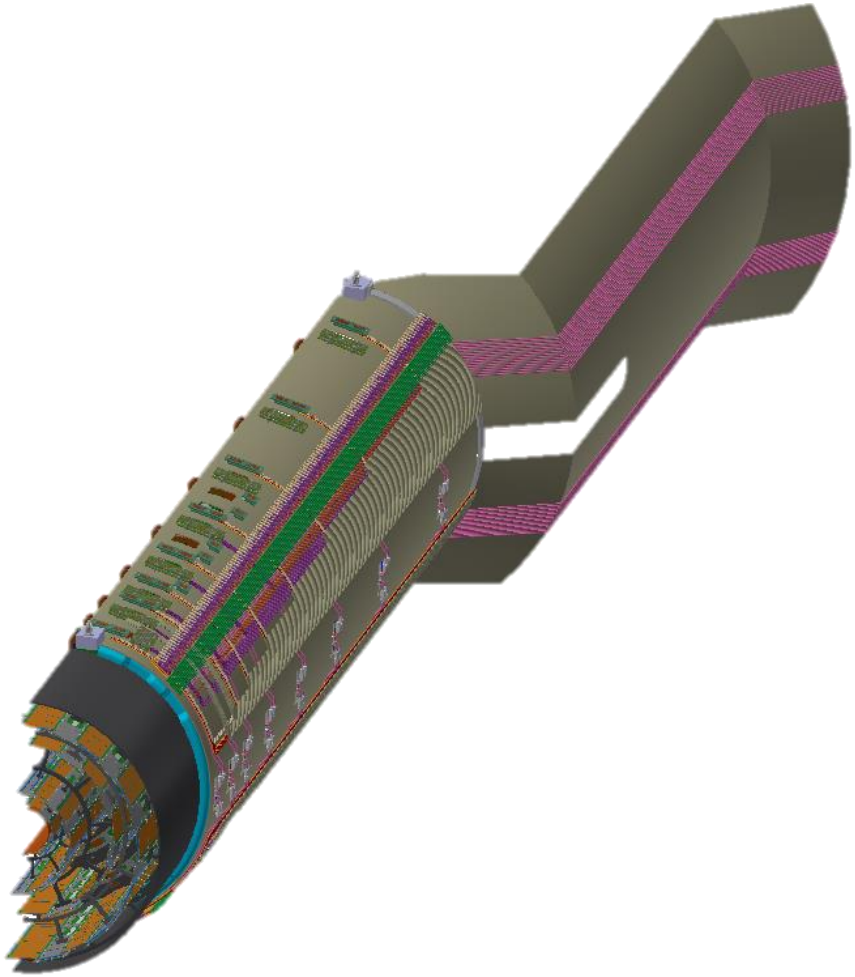
Inner Composite plate removed

- Additional carbon fiber layup with modules already glued and wired is used (pre-assembled)
- Tubes, foam, carbon fiber structure behind remains the same
- Easy to remove-fast installation/maintenance
- More mass due to additional layer of carbon fiber, thermal contact material (under study), nuts and bolts (materials also being studied)
- Thermal interface must be studied
- Design of removable layer must be optimized to hold the weight of modules and wiring with minimal deflection
- Lots of work to bring this idea to fruition



Concluding remarks

- New cartridge design to allow modular installation of TBPX and TFPX shown as a possibility
- Design of removable inner ring for odd dee is under development
- Testing and simple mockups construction to begin this summer to verify CAD models, test installation procedure and material selection



THANK YOU!
QUESTIONS?

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