Prototype mechanical design and CEPC vertex mounting

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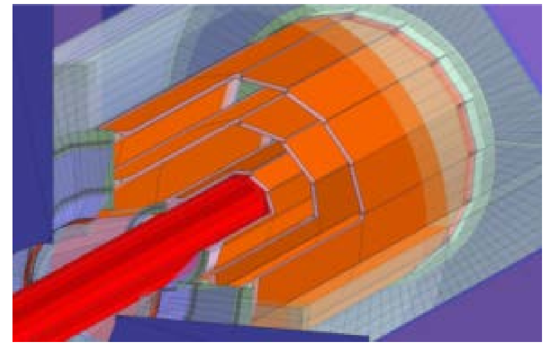
2019-11-28

Layout of CEPC Silicon Vertex Detector

- from TDR

	R (mm)	$\|z\|$ (mm)	Current z in total
Layer 1	16	62.5	130.6 mm
Layer 2	18	62.5	
Layer 3	37	125.0	263.1 mm
Layer 4	39	125.0	
Layer 5	58	125.0	263.1 mm
Layer 6	60	125.0	



6 layer of sensors (3 layer barrels, each has sensors mounted double sides)

* **Working temperature range:** 20-50 ℃

* **Power dissipation:**

  Final goal: ≤ 50 mW/cm2. (air cooling)

  Current (short term) goal: ≤ 200 mW/cm2. (air cooling)

* **Single point resolution**: currently in CDR range from 2.8-6 μm, eventually we aim for only one type of pixel sensor with single point resolution of 3-5 μm.

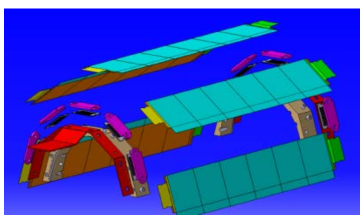
Challenges

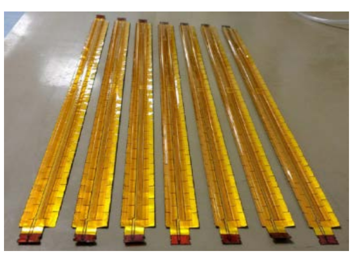
Material budget: 0.15% X/X_0 (radiation length) for each single sensor layer.

Position stability: (caused by any vibration) should be better than the sensor's single point resolution which is within 3-5 μm.

All challenges to the design mainly come from these two key requirements, which requires the development of ultra light material with high stiffness besides the feasible structure design. Carbon fiber composite is the first choice to make the support structure (low CTE, high modulus, low density).

Mu3e
0.1% X/X_0

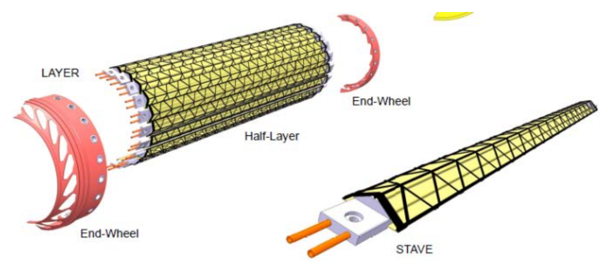




Mock-up ladders made of tape heaters

Made of aluminium-polyimide laminate (25 μm thickness each), laser structured meander for heating and temperature measurement.

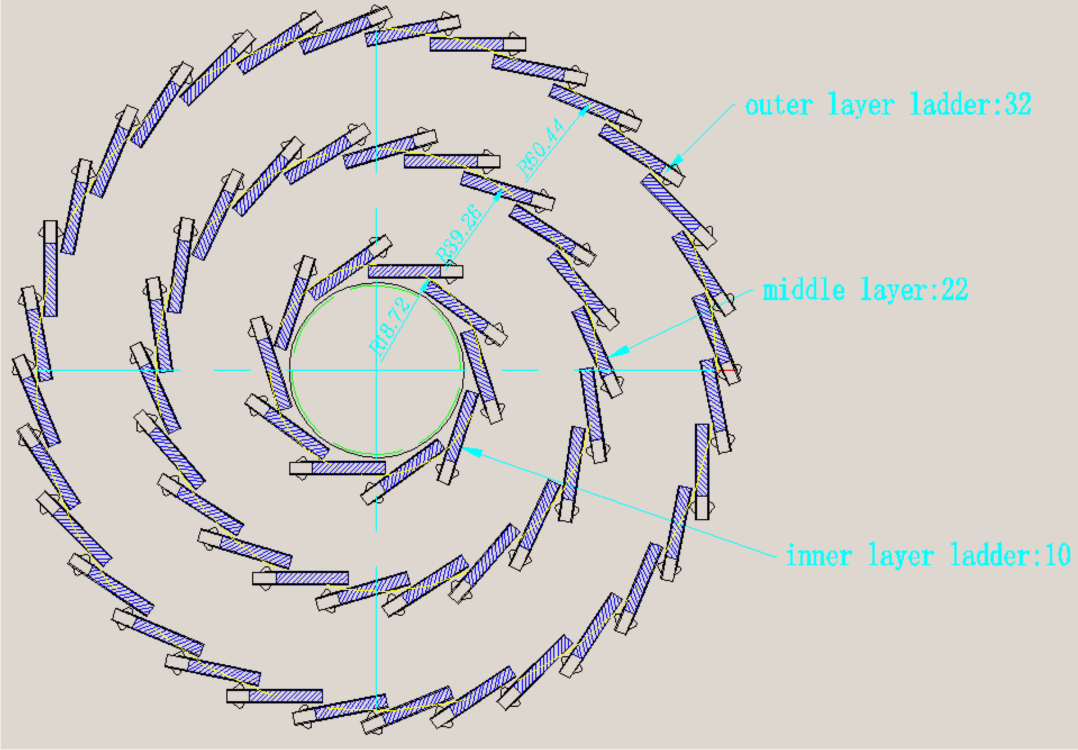
Alice ITS Upgrade
0.3% X/X_0

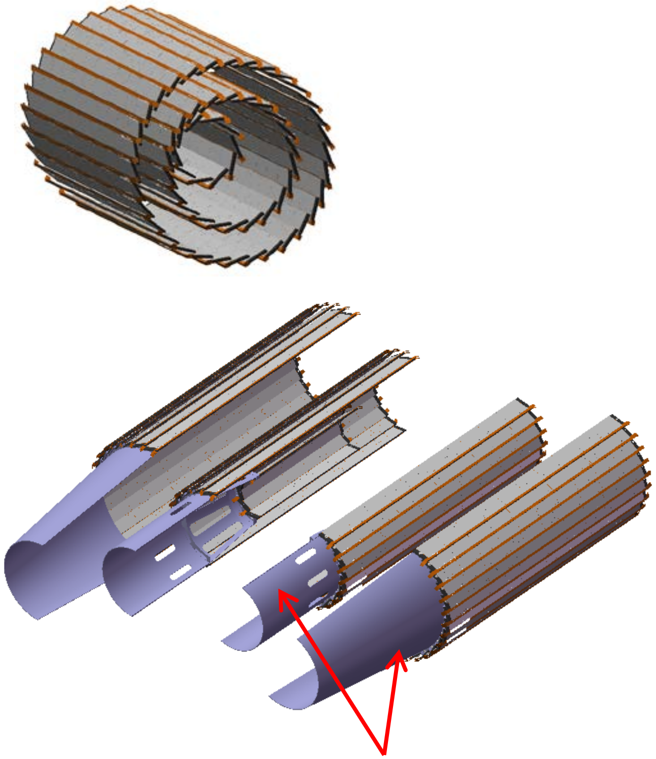


These two experiments both have pixel sensors on one side of the support. Our Material budget requirement is between them and closer to Mu3e, but the positon stability is higher than it.

Prototype design of VXD

Ladder layout - optimized





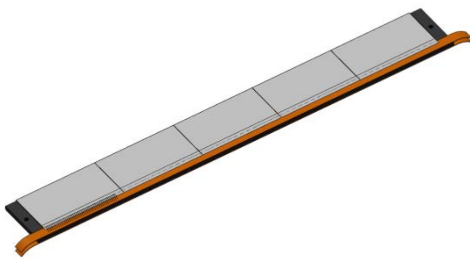
Half support barrel

Prototype design of VXD

Sensor chip : 14.8 x 25.6 x 0.05 mm (2 mm wide margin at one side for wire bonding)

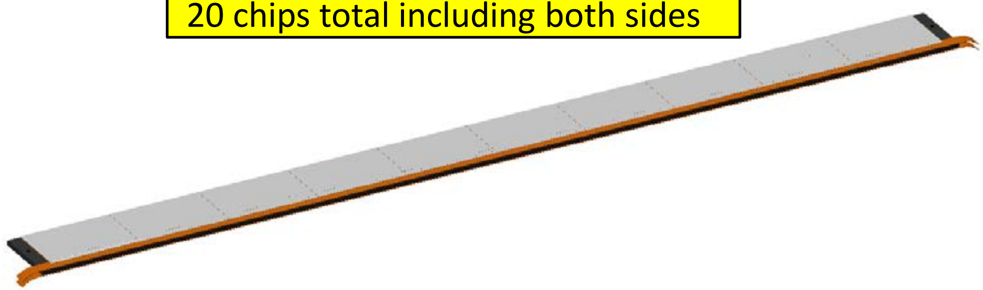
Ladder: support + chips + FPC

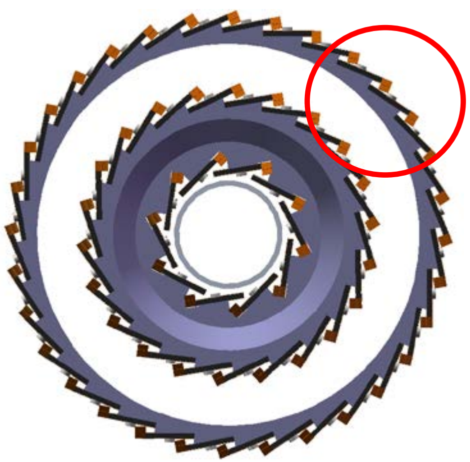
Ladder of inner layer:
10 chips total including both sides



0.1mm gap between chips

Ladder of outer two layers:
20 chips total including both sides





Ladder support

End Ring (CFRP): fix the end of ladder support.

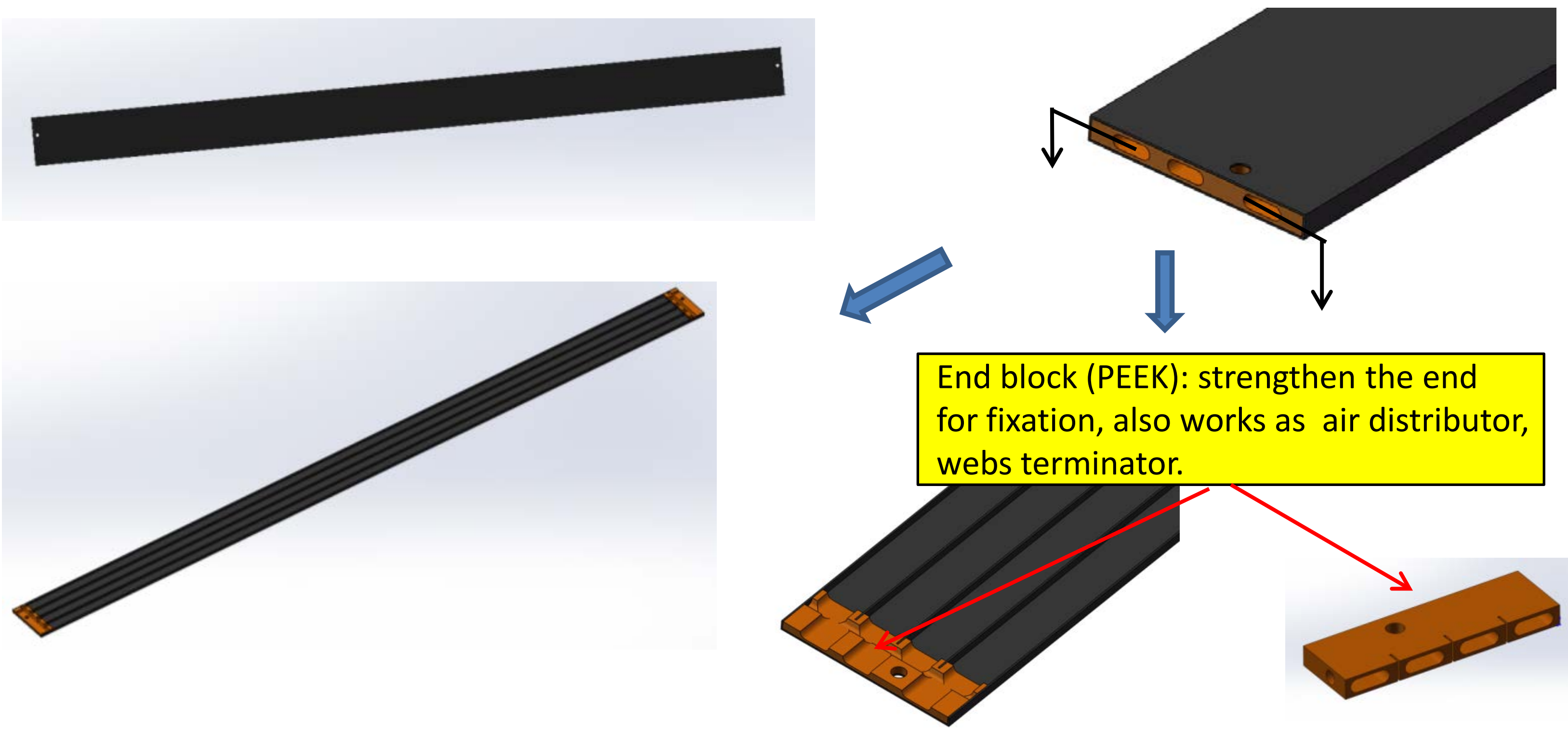
Ladder - support

Size: 264.1 x 16.8 x 2 mm (L x W x H), for outer and middle barrels.

131.6 x 16.8 x 2 mm for inner barrel. W is 2 mm wider than sensor.

Material: Carbon fiber in thickness of 0.15 mm (3 layers).

Channels inside the local support: to increase stiffness with less material, also work as a backup for air cooling from inside of the support.



Ladder - FPC & wire boding

FPC: shape and size of FPC of each ladder base on the current layout?

Can FPC be narrowed where it comes out of the ladder? The minimum width can be achieved?

Will there be connectors of the FPC and where?

Wire bonding: Height?

Materials of the ladder(?)- one side:

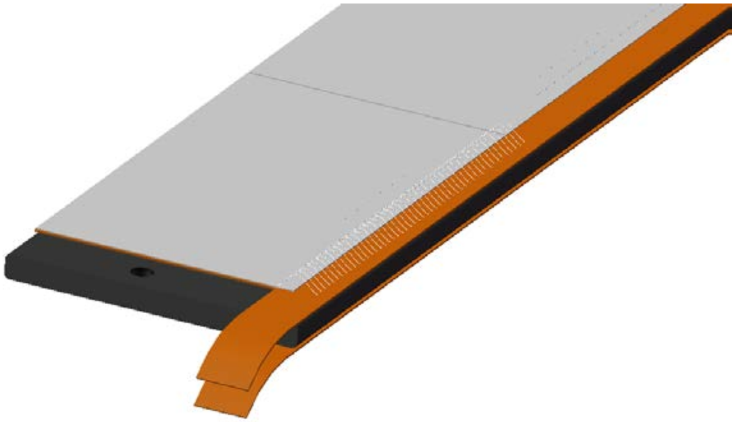
FPC: kapton 50, Cu two layer 12x2=24, adhesive 15x2=30 um(Mingyi)

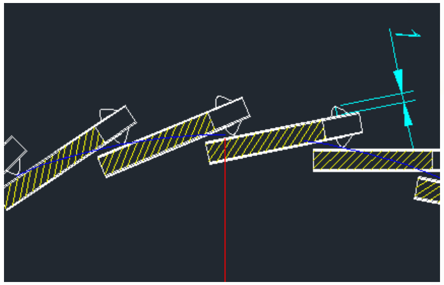
the ladder: glue + flex+ sensor 15+105 +15+50= 185 um

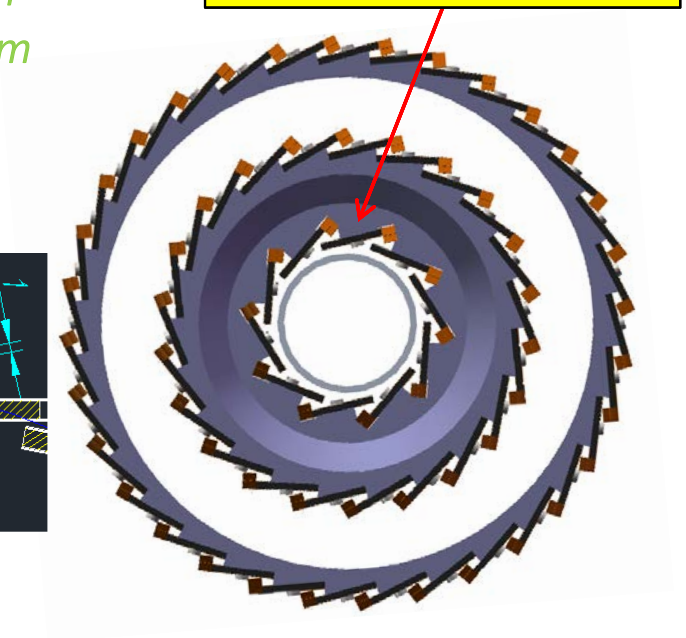
support : equivalent total thickness 0.15mmx3=0.45 mm

Material budget need to be comfirmed.

Due to space limitation and for easy installation, the ladders on inner layer are fixed onto the inner side of the neck flange, while those on middle and outer layers are fixed from outer side.



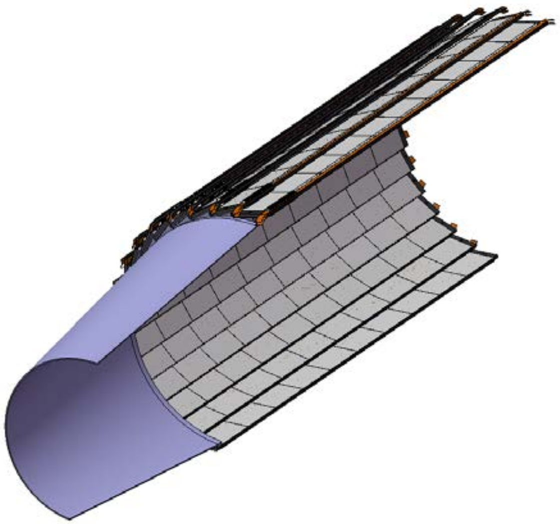


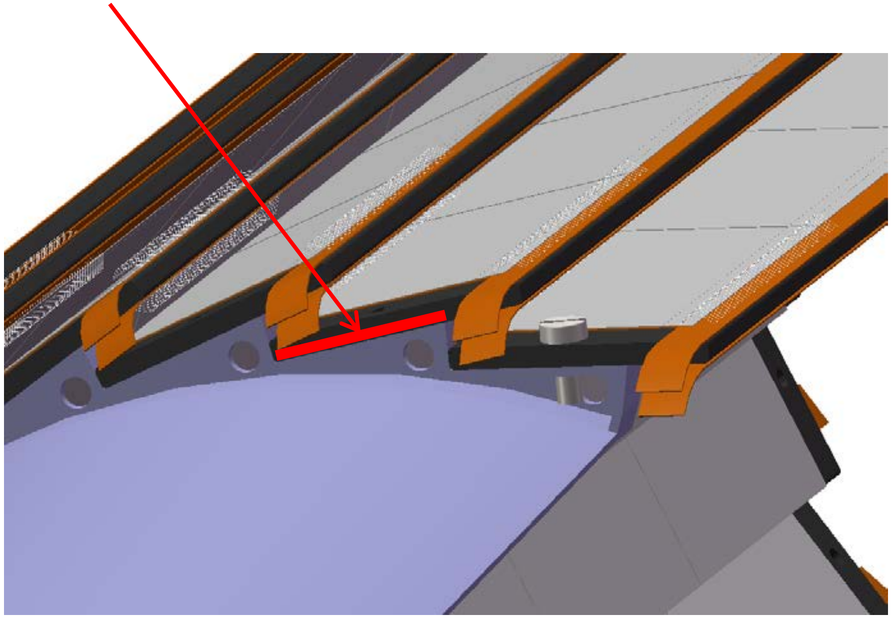


Ladder fixation

Option1: gluing.

Adhesive to be investigated, which has a good bonding strength at temperature lower than 80 ℃(?) but can be easily peeled off under certain temperature or by chemical method?

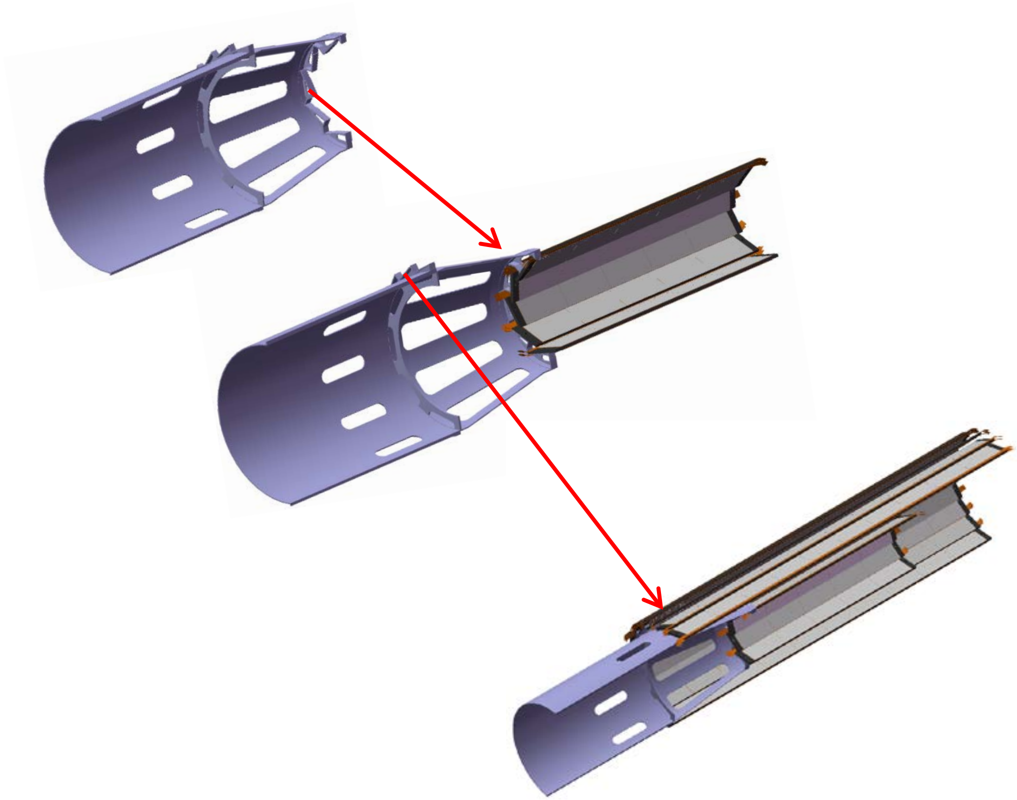


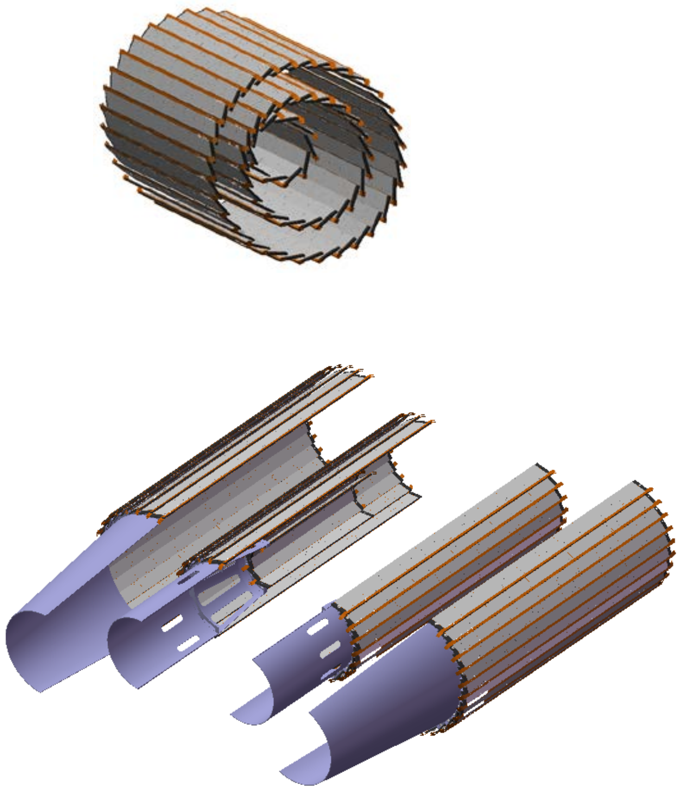


Option2: as a backup, using non-magnetic screw(e.g. copper) and nut (e.g. made of PEEK) glue on back side of the flange?

Vertex assembling and cable routing

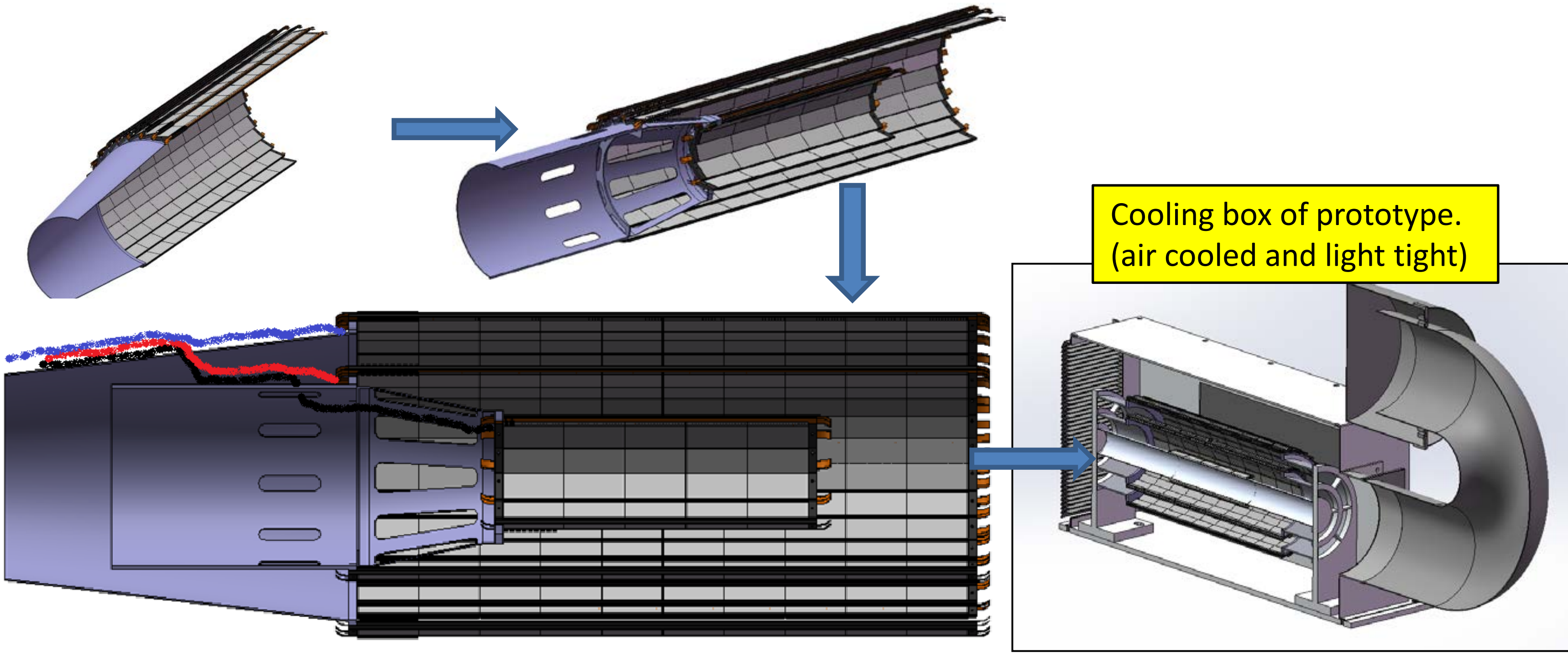
Ladders of inner and middle layers mounted to a half support barrel with double toothed rings.





Vertex assembling and cable routing

Ladders of outer layer mounted to a half support barrel which has one toothed ring.

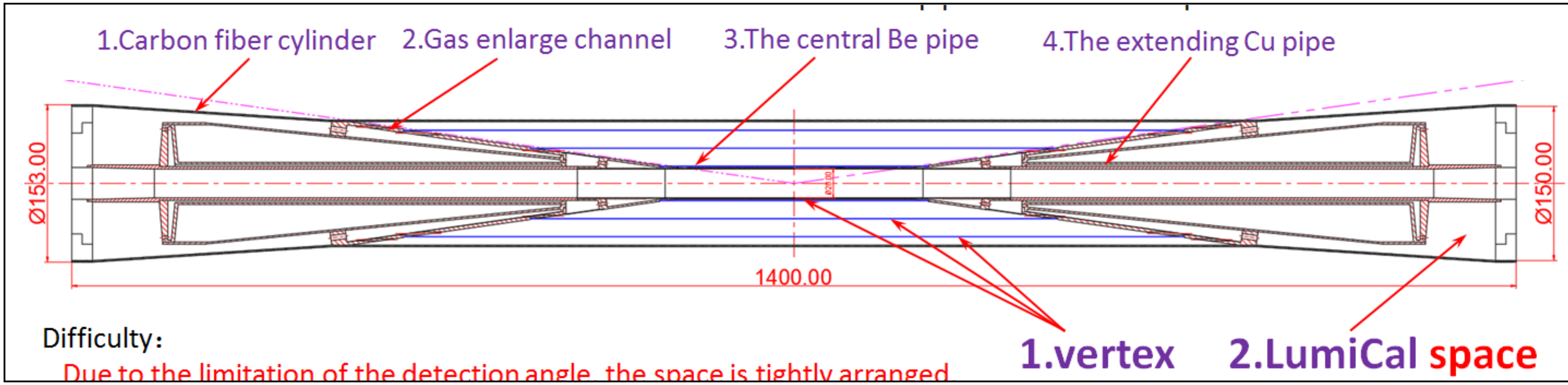


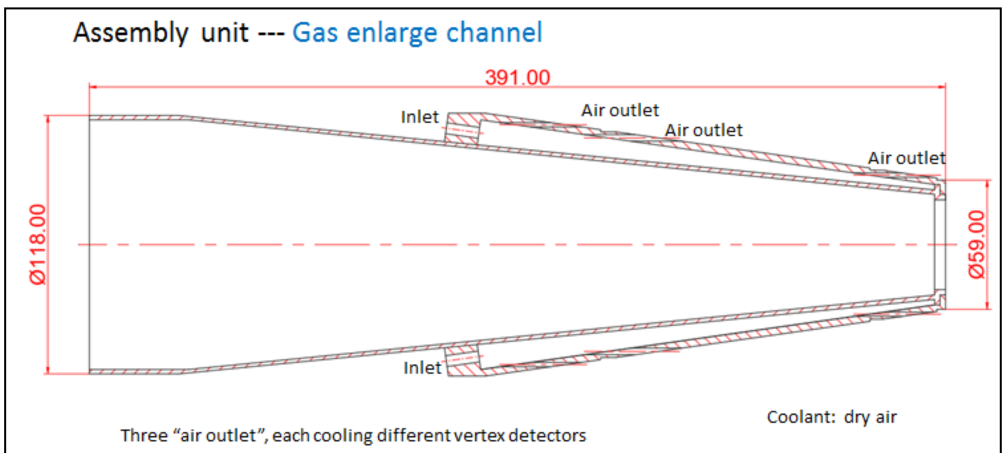
Assuming FPCs or cables of several ladders can be put together to form a bundle, and then rout out from the slotted hole on the support neck to next layer. Finally, go out to the outer layer and lead out together 。

In CEPC, What else are outside the vertex can block the cable routing this way? e.g. End cap?

Beam Pipe

- from Quan Ji

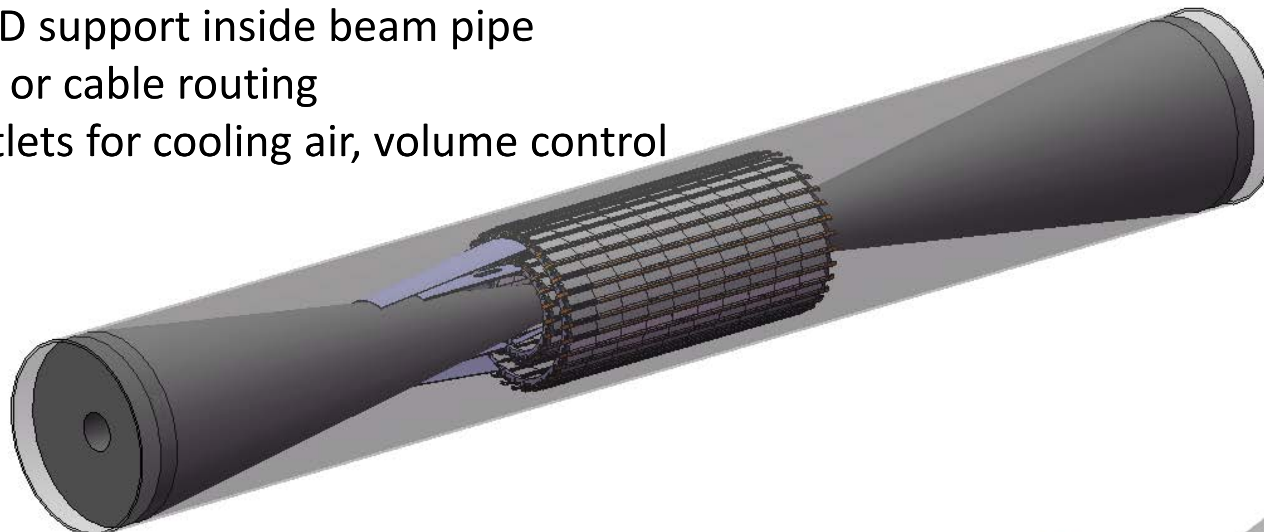




Installation of the VXD on CEPC
-interface with beam pipe

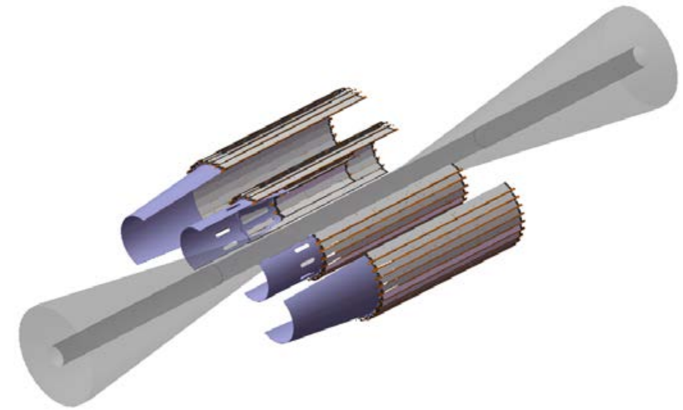
VXD interface with beam pipe:

1-fixation of VXD support inside beam pipe
2-space for FPC or cable routing
3-inlets and outlets for cooling air, volume control

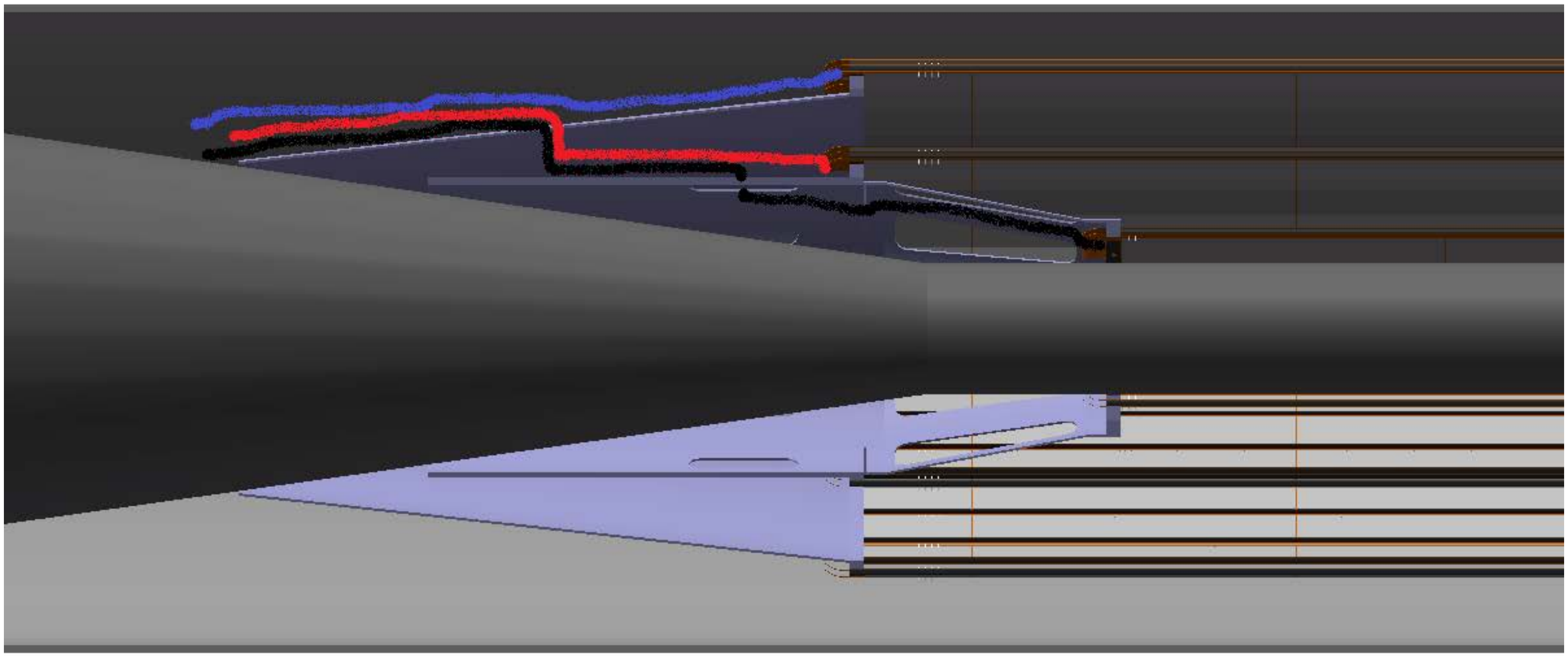


The latest ladder layout and preliminary estimation of air volume required by VXD has been provided to Quan.

More interactive work can be foreseen.



Cable routing at interaction area of CEPC

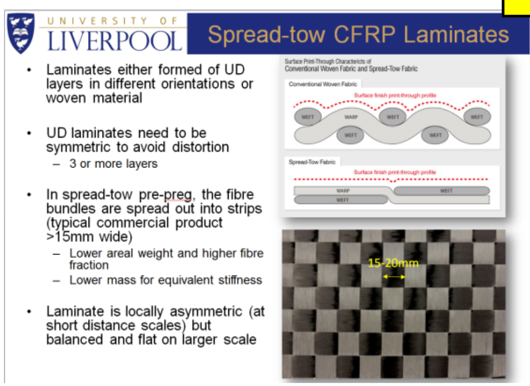


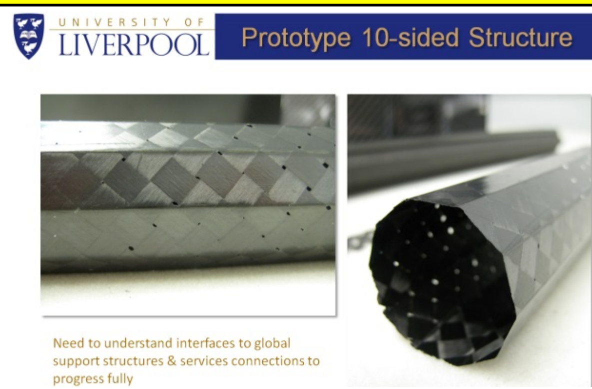
The same scheme as the cable routing inside the texting box.

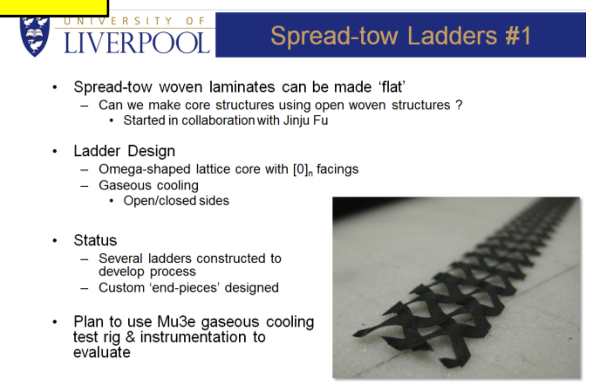
International collaboration

Tim Jones from University of Liverpool gave a talk about tracking mechanics on 2019 CEPC workshop, his presentation shows much of their design and studies on light weight mechanics. They would like to offer help on cable routing of VXD in MDI region and VXD support design.

Clips of slides are from Tim Jones' report







We had discussions about the cable routing at interaction area during this CEPC workshop. VXD ladder design was also discussed when i visited their Lab. And we will further discuss with them about specific aspects that they can help in follow-up meetings.