Mechanical design of the vertex detector prototype

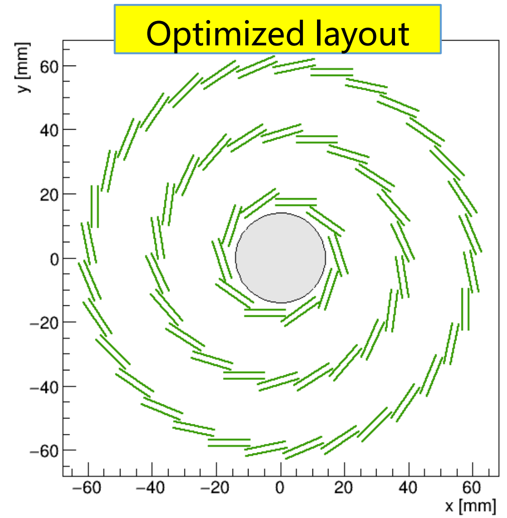
Jinyu Fu

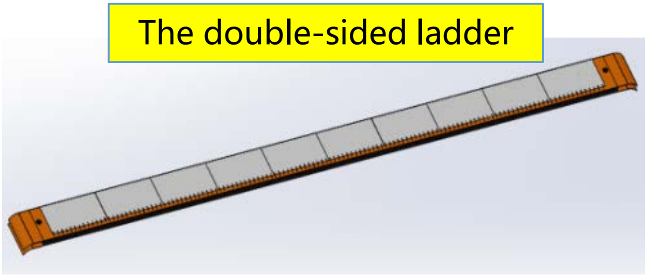
2022/4/22

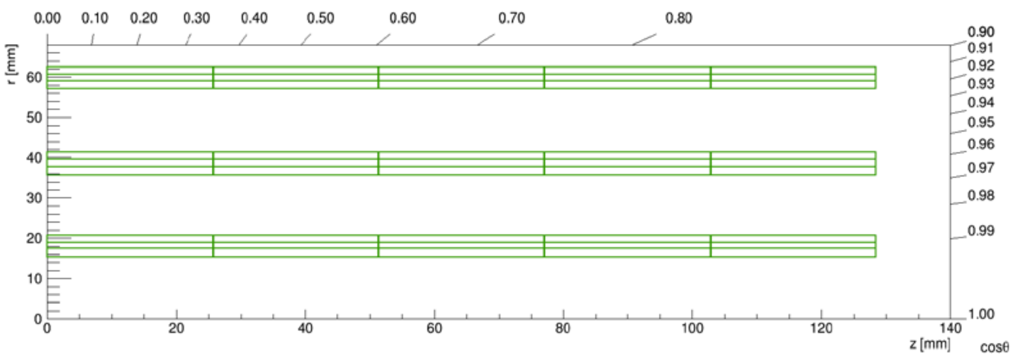
The CEPC vertex detector

Design parameters of the optimized CEPC vertex detector

	R (mm)	|z| (mm)	Number of ladders	Number of chips
Layer 1	16	125.0	10	200
Layer 2	18	125.0		
Layer 3	37	125.0	22	440
Layer 4	39	125.0		
Layer 5	58	125.0	32	640
Layer 6	60	125.0		



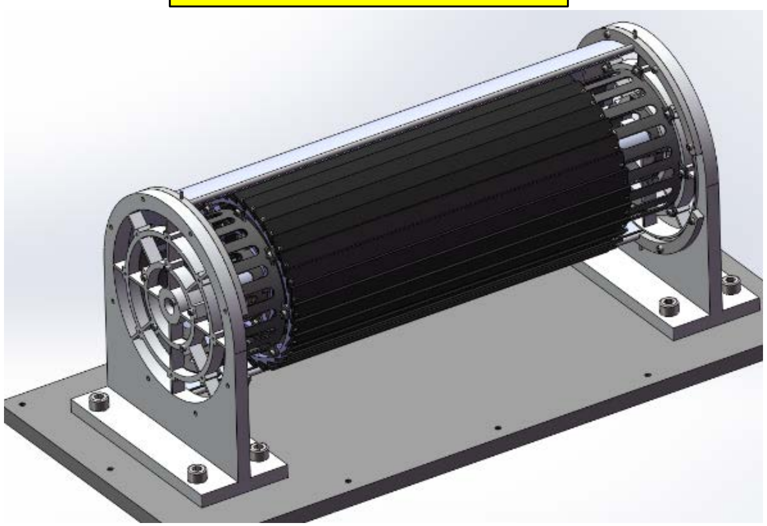




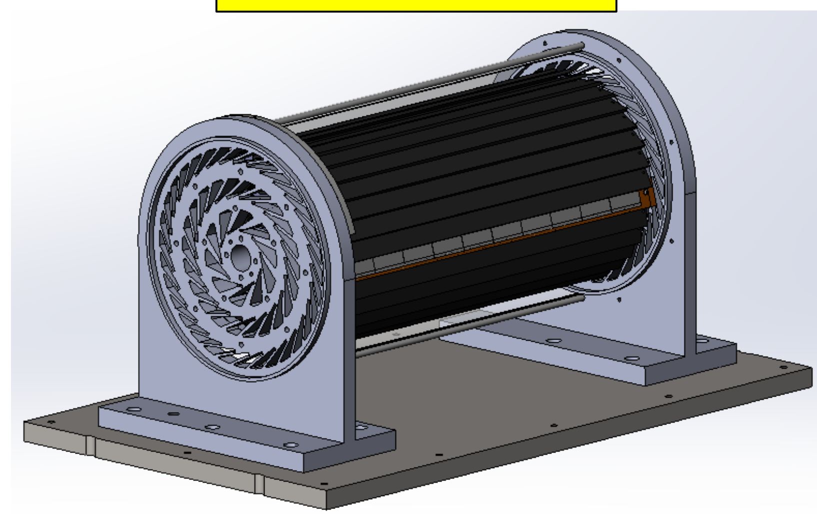
Mechanical design of the VTXD prototype

The mechanical structure of the VTXD prototype has been changed compared with the previous design after iterations with electronic (flex and sensor) design.

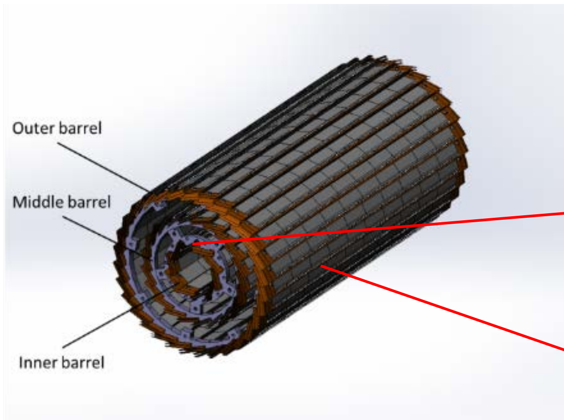
Previous structure



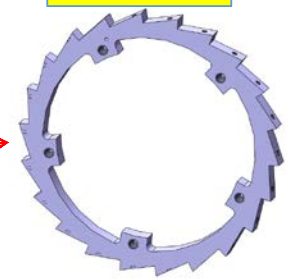
Updated structure



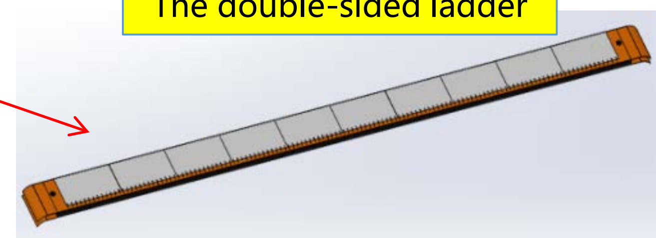
Main components of the VTXD



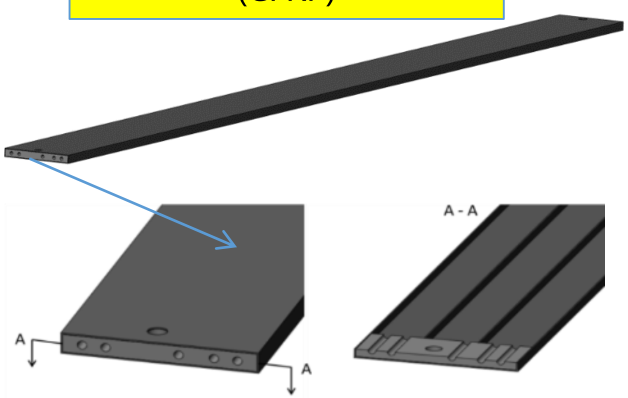
Side ring

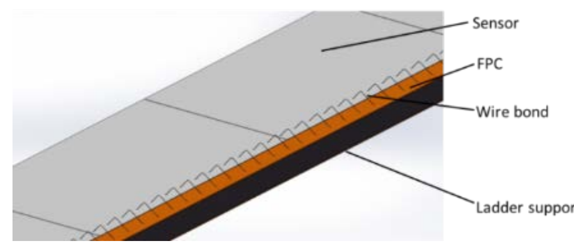


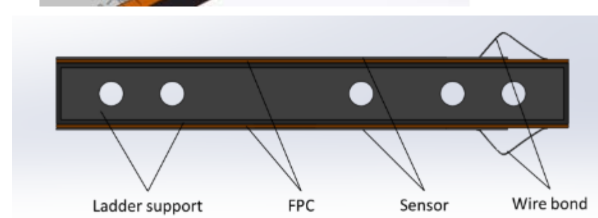
The double-sided ladder



Ladder support structure (CFRP)



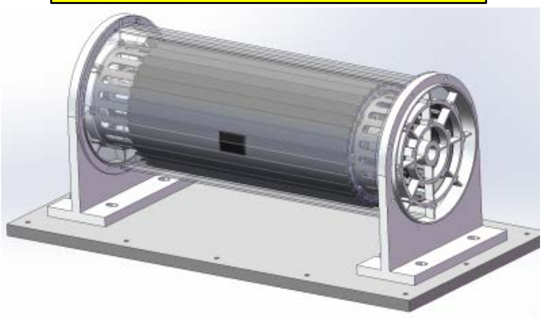




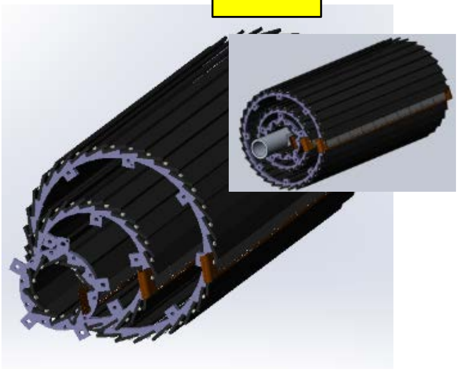
Material	Thickness (μm)	Radiation length X_0
CFRP support	*145*	*0.051%*

The previous prototype and tooling design

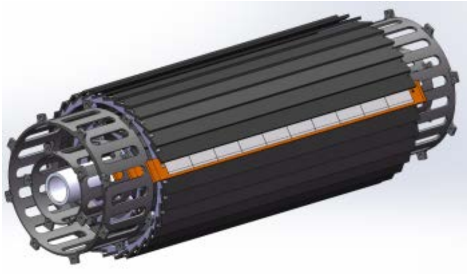
The assembly of VTX and support



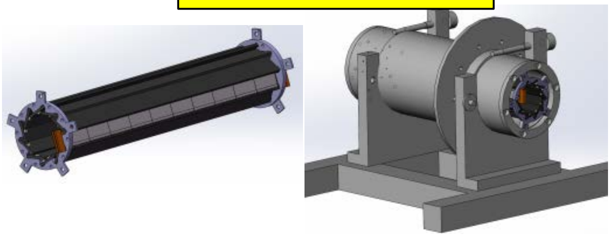
VTX



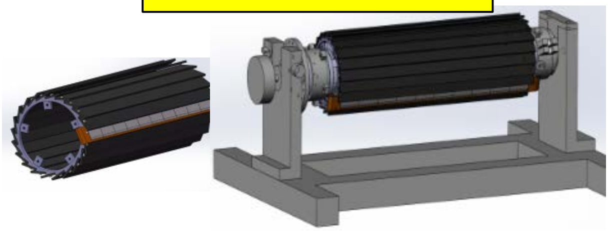
VTX + connecting flange



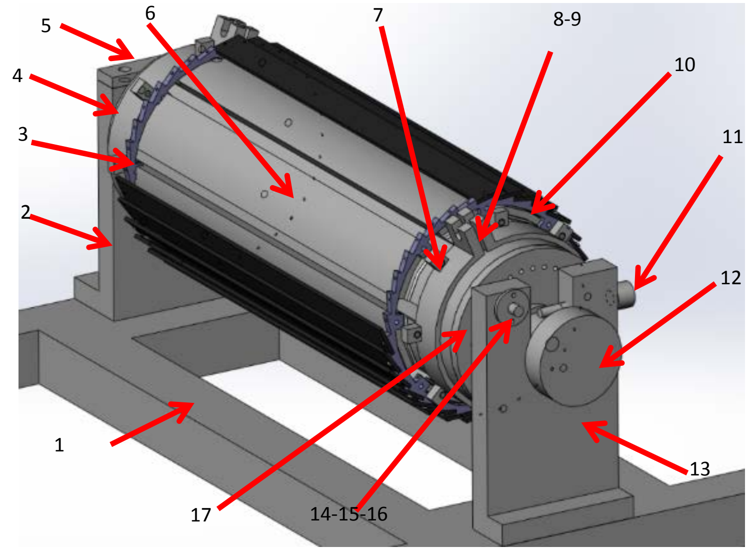
Inner barrel and tooling



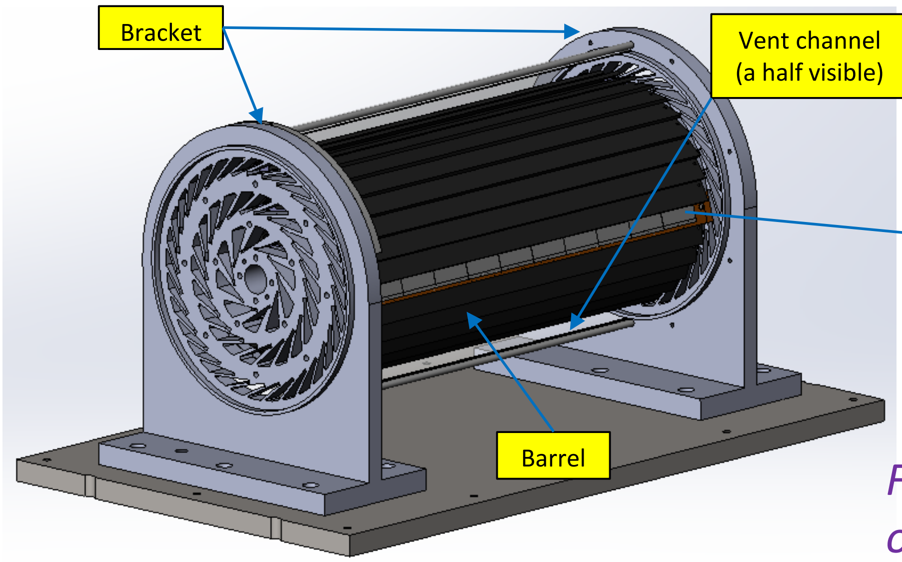
Middle barrel and tooling

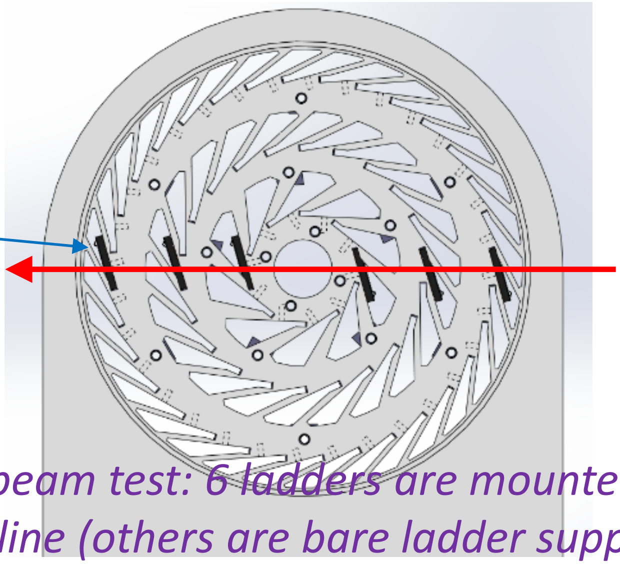


Outer barrel tooling



The updated VTXD prototype

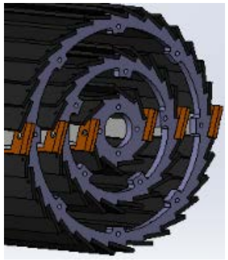




For beam test: 6 ladders are mounted on one line (others are bare ladder support).

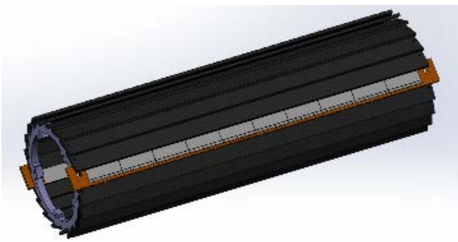
Differences compared with previous structure:

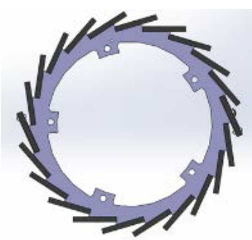
- No connecting flanges.
- Ladder size (slightly adjusted)
- For the innermost barrel, the ladders are also mounted from outside of the side rings.
- New bracket (The flex for all ladders can pass through the brackets along the axial direction at both ends of the VTXD almost without twist).

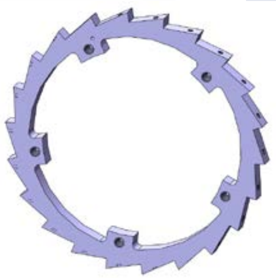


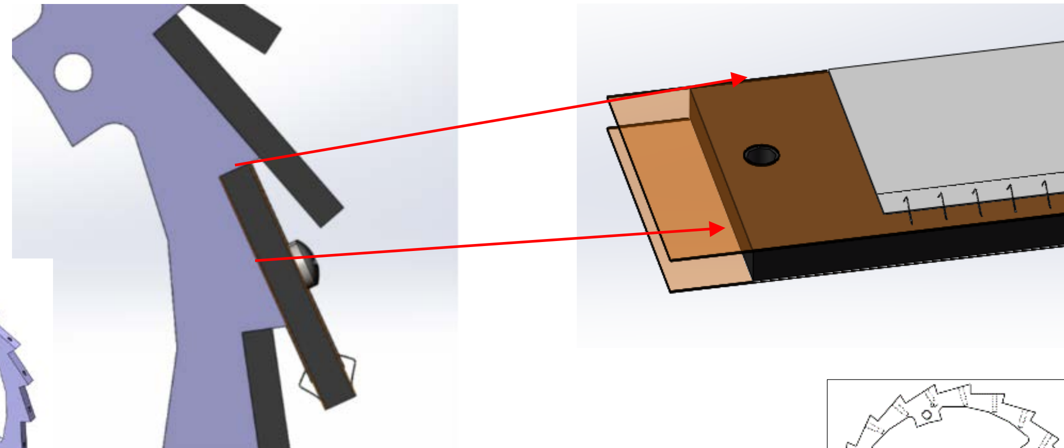
Ladder fixation on barrel

Edge constraint/alignment + screw tighten



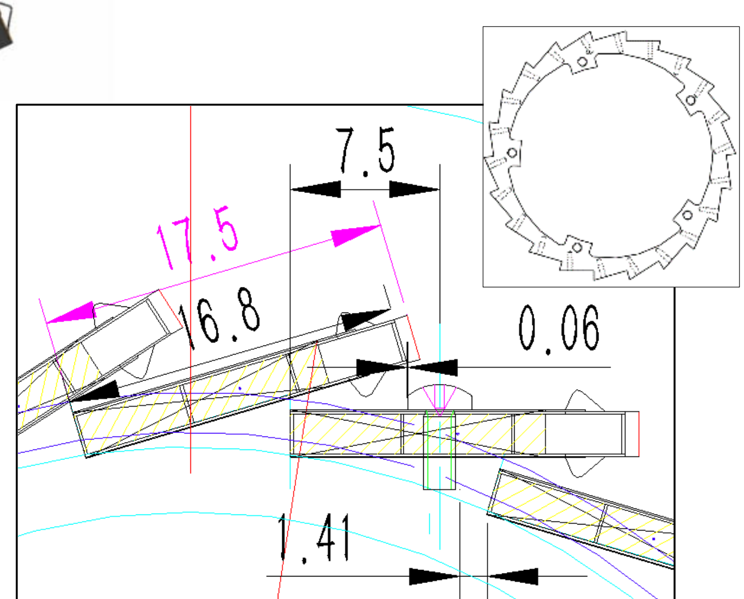




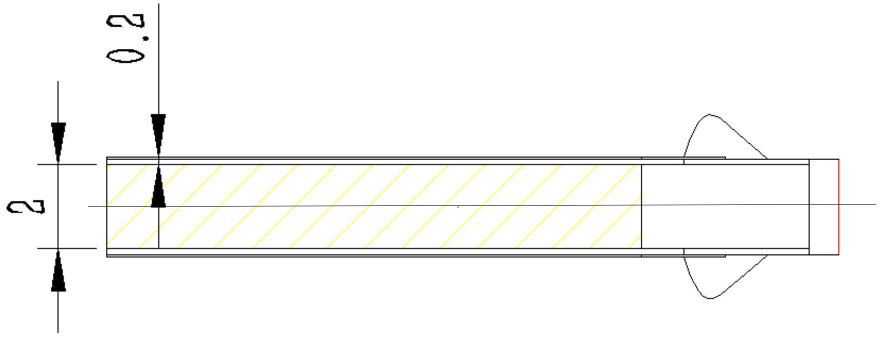


For the *middle barrel*, if all ladders are 17.5 mm wide:

- mounted in order
- leave the last one not installed

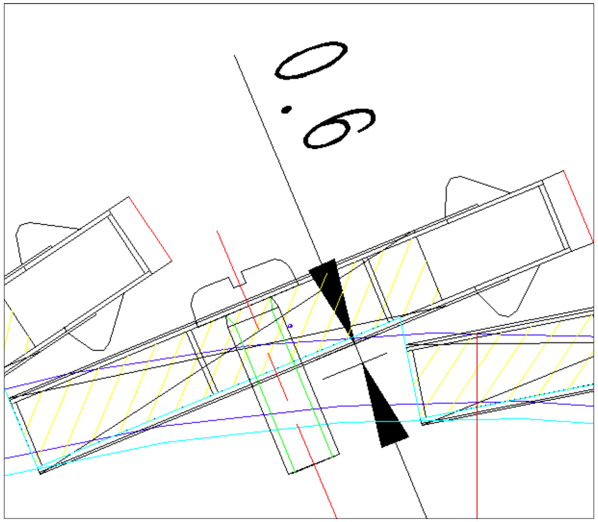


Gaps between adjacent overlapped ladders

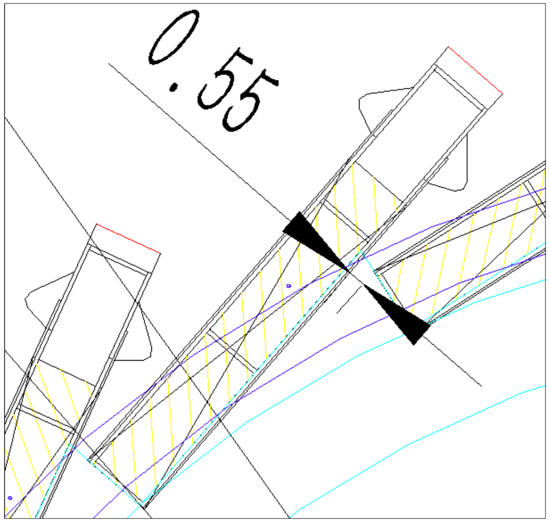


0.02+0.11+0.02+0.05 *(0.1)*=0.2 *(0.25)*

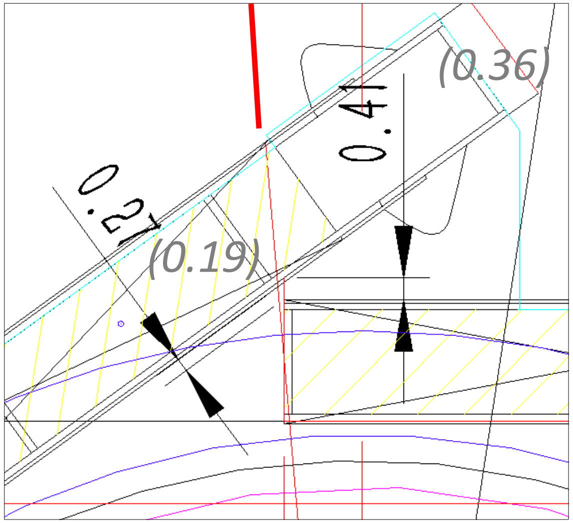
Outer barrel



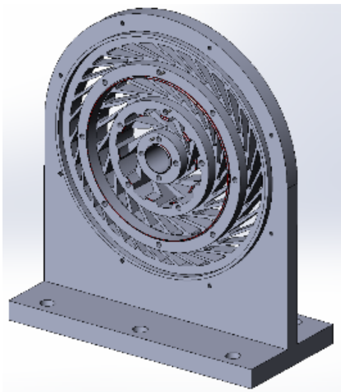
Middle barrel



Inner barrel



Structure details related to ladder and flex



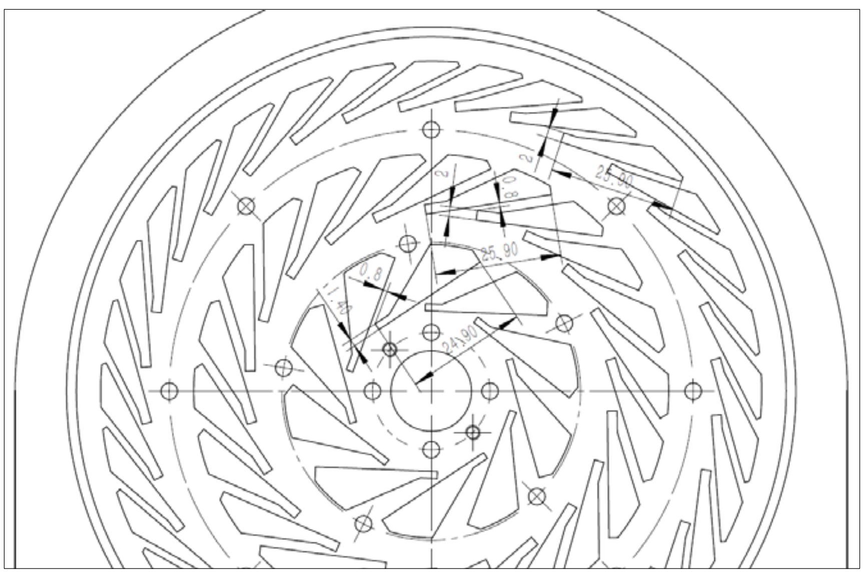
Flex end with socket

Socket: 21.5 mm(L) x 3 mm (w)x 1.5 mm (t)

Thickness of the Flex + metal pad under the socket(T):

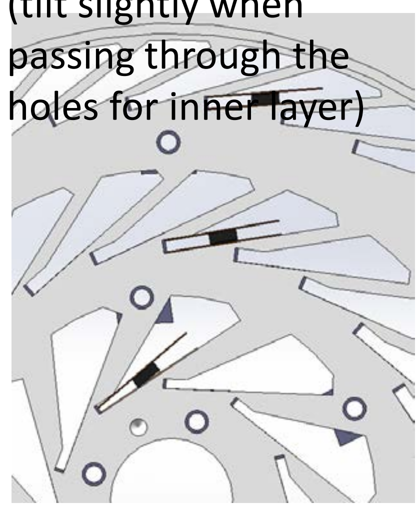
0.2 mm (*Max up to 0.3 is feasible*)

Total length of flex: (~140)+272.9+(~140) = 553 mm (related to the length of the metal pad)



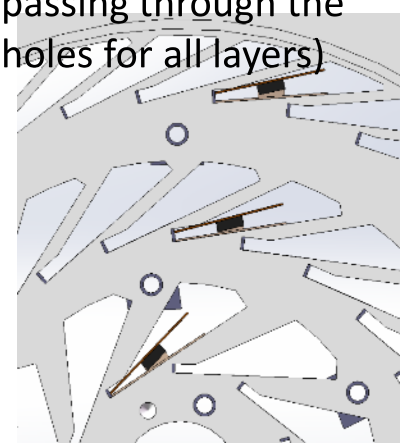
T=0.2

height required 1.9 mm (tilt slightly when passing through the holes for inner layer)



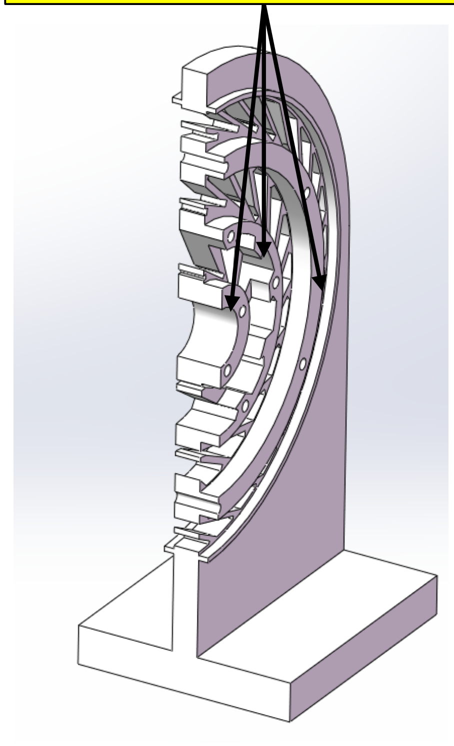
T=0.3

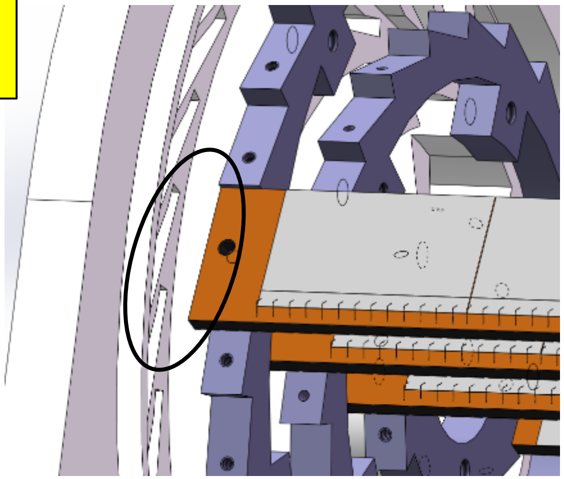
height required 2.1 mm (tilt slightly when passing through the holes for all layers)

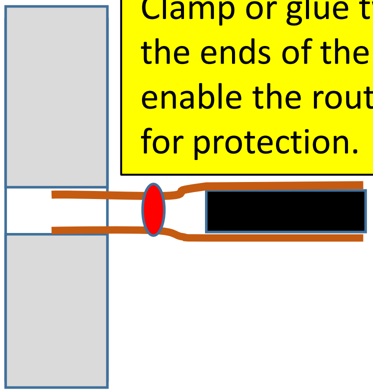


Structure details related to ladder and flex

These rings provide a transition region for flex routing.

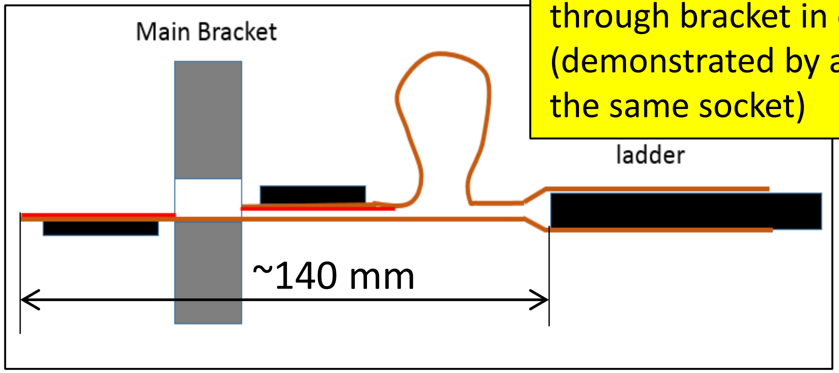




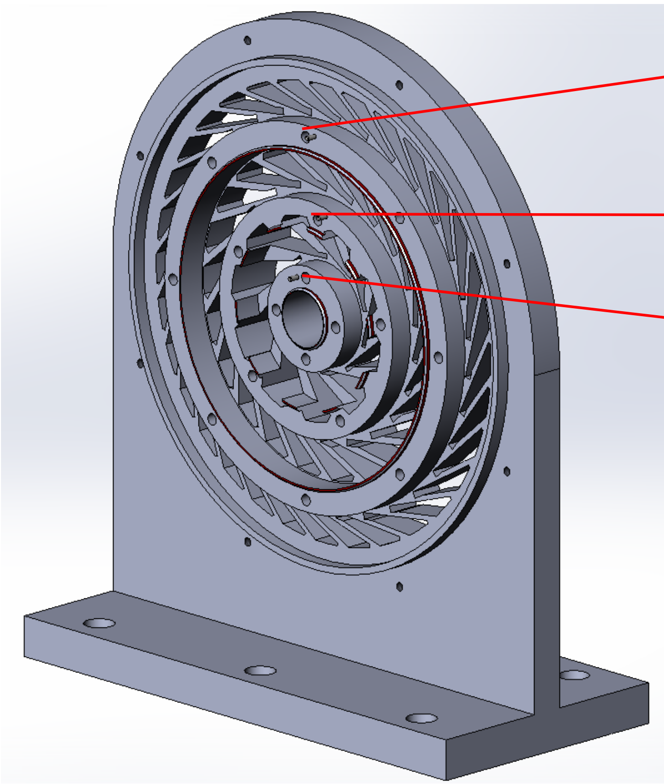


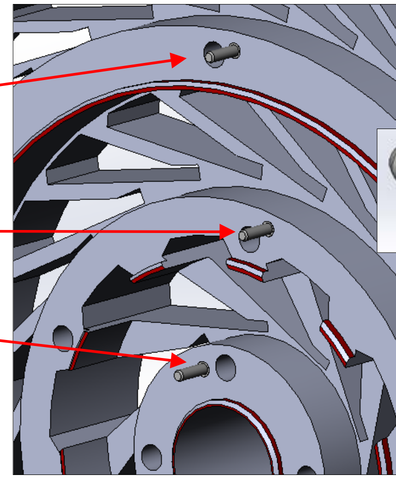
Clamp or glue two flex at the ends of the ladder to enable the routing and for protection.

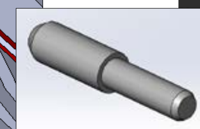
~140mm is required to pass each flex through bracket in order. (demonstrated by a similar flex with the same socket)

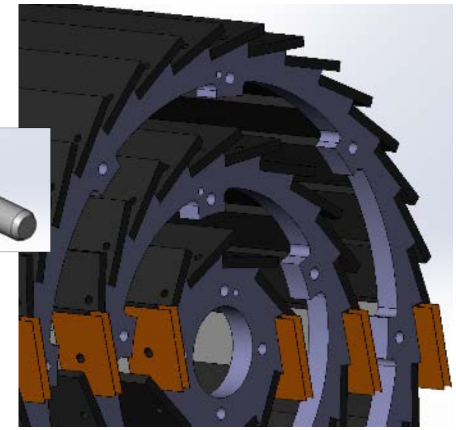


Barrels fixation on the brackets

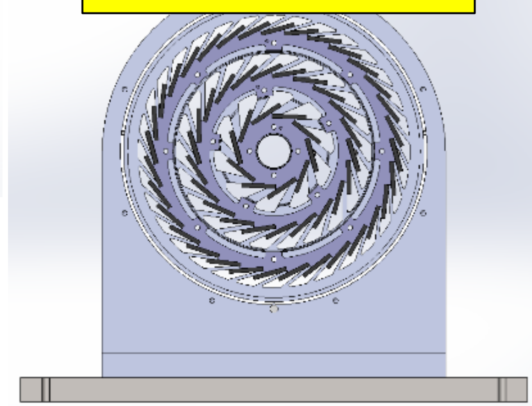


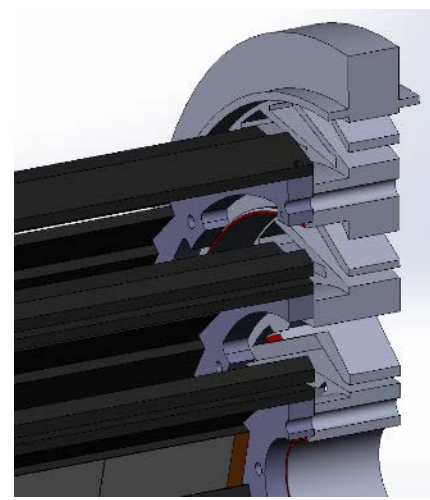






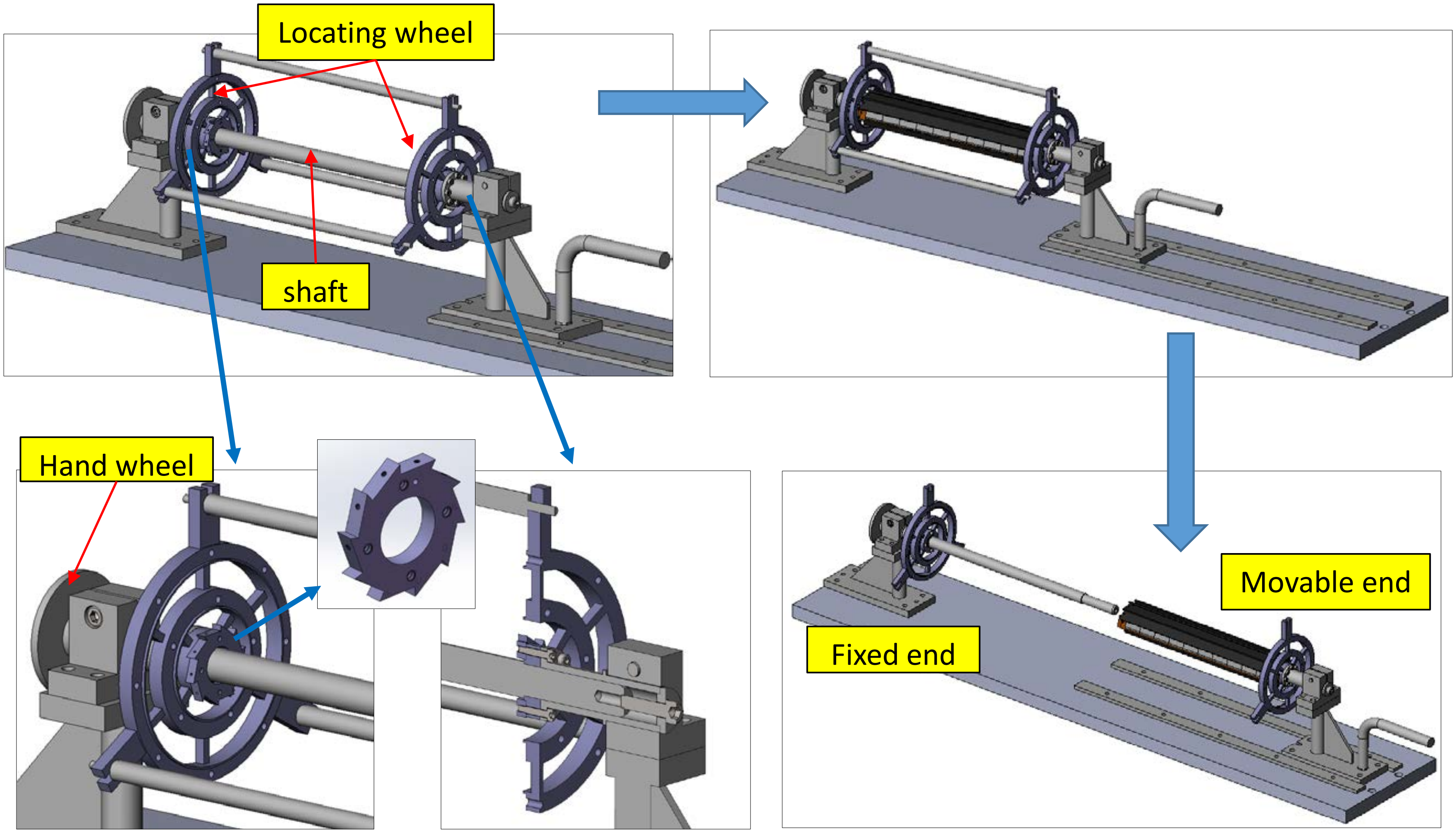
Cut view from middle of the barrel



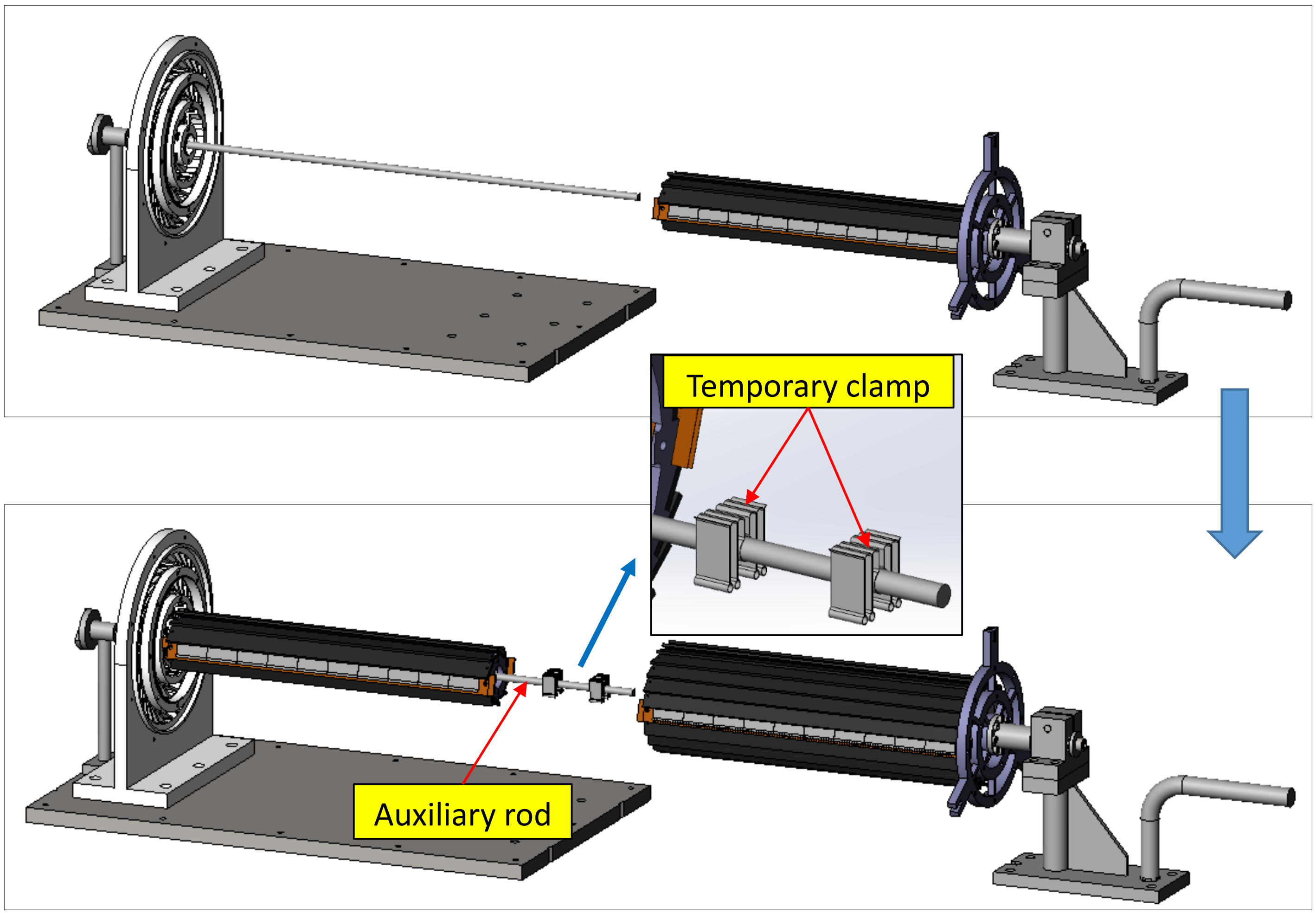


Barrels (side ring) are located on the main bracket by: ring + pin

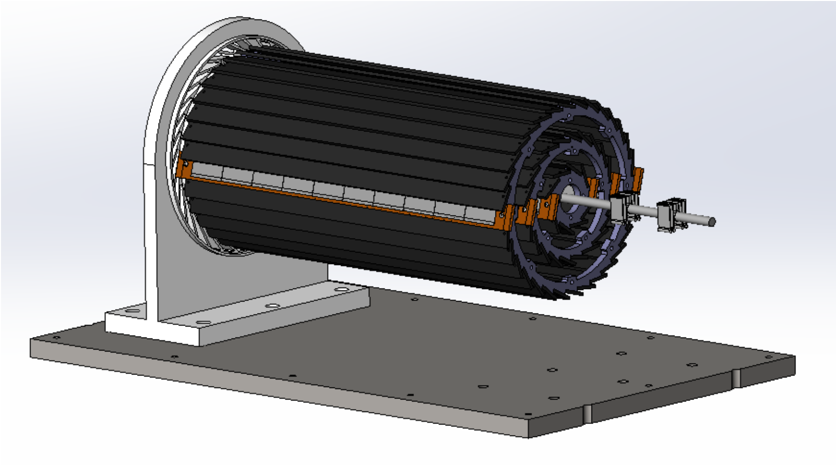
Tooling for barrels assembly

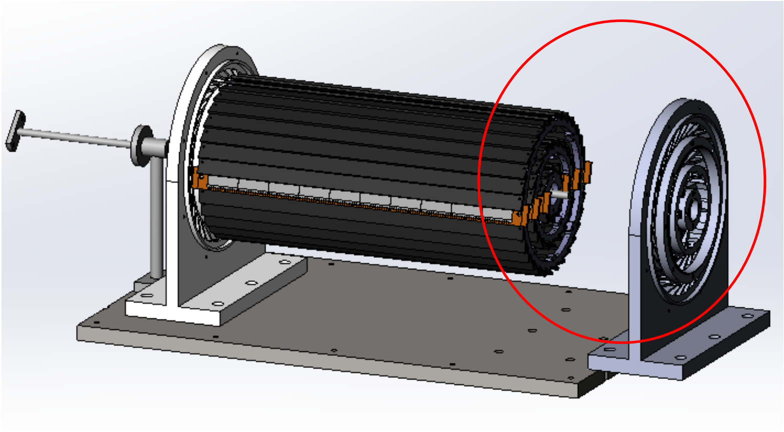


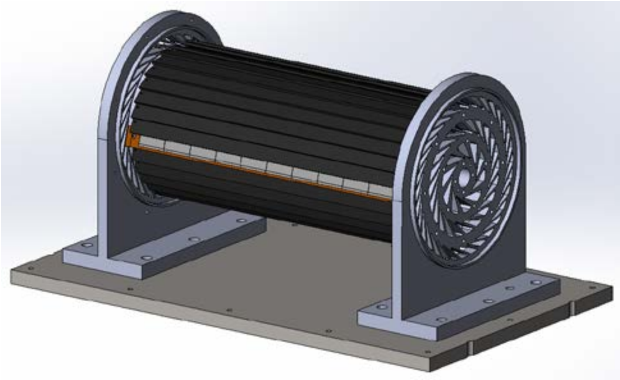
Barrel installation

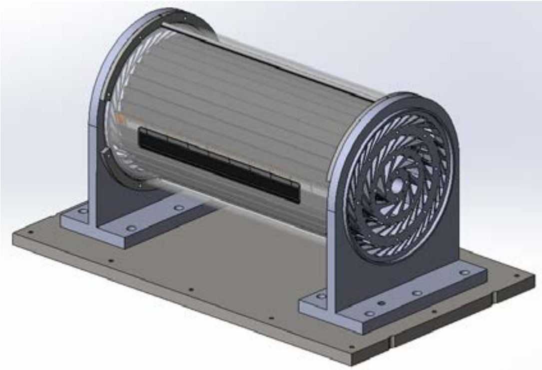


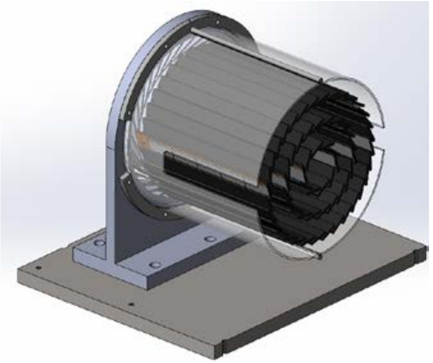
Barrels installation





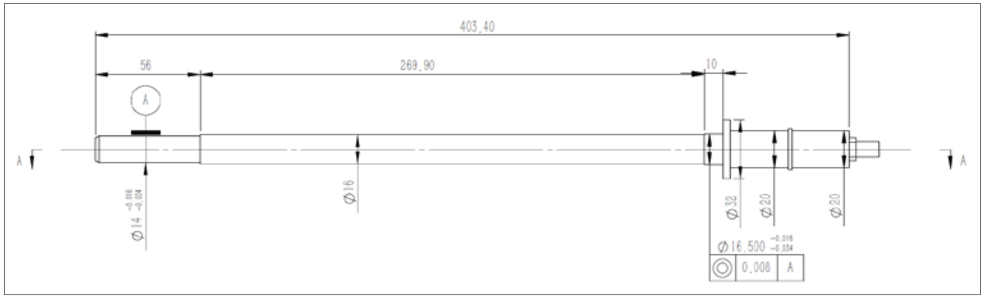






FEA for related components

1. Under self-weight the end of the cantilevered shaft sinks : 0.042mm



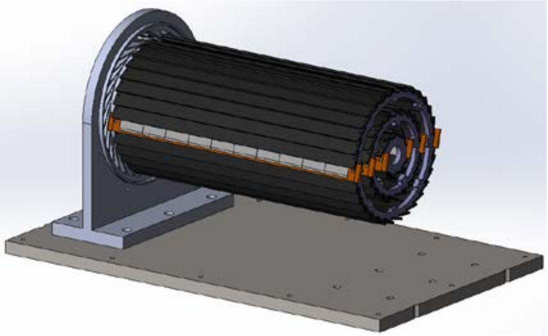
2. The cantilevered shaft with wheels and side-rings sinks: 0.17 mm (tooling being assembled)

3. The simply support shaft with wheels and side-rings sags: 3 um (tooling assembled)

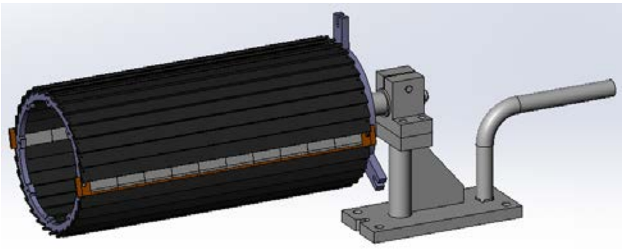
FEA for related components

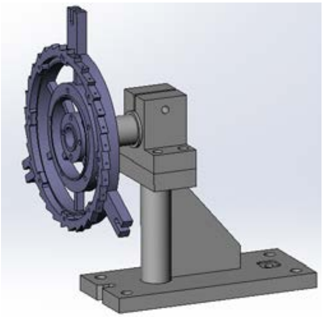
4. Three cantilevered barrels on the bracket sinks: (273/170) x 0.025= 0.04mm

Simplified model: weight of barrels and moment applied to bracket surfaces that contact the side rings



5. The cantilevered *outer barrel* on tooling sinks：(273/120) x 0.019= 0.04mm



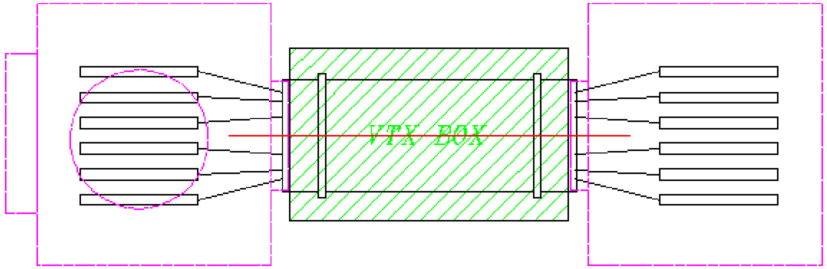


These results are basically acceptable for tooling manufacturing and prototype installation.

Summary

- Mechanical aspects of the VTXD prototype are mostly finalized.
- Mechanical design of the VTXD prototype has been updated to better meet the electronic needs and also for a better way to route flex of all full barrels.
- Design of new tooling is also being conducted.
- Necessary analyses have been done to assist in evaluating the feasibility of fabrication and installation.

➢ The box for VTXD beam test also need to be changed to fit the updated VTXD structure. Also the box will integrate the connections with those which are out side the box (like fan and electronic components).



Backup

Ladders Mechanics:

- Now: Carbon support samples available
- May: Pre-production carbon support ladders available
- August: Production of final carbon support ladders (if needed)

Ladders Assembly:

- May: Flex cable available
- May: Test of wire bonding and gluing on carbon support
- July: ASICs arrive to IHEP
- August: Wafer level test of ASICs
- September: Single chip and module testing
- September: Assembly of ladders with chips

Backup

Barrel Prototype:

- June: Production of installation tooling
- June: Installation mock-up
- July: Barrel support parts fabricated
- End September: Assembly first barrels
- October: Assembly of multiple ladders and readout tests
- Earlier November: Finish assembly of prototype
- November: Cosmic ray testing or BEPC beam test
- End November/December: DESY test beam