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Progress of beam pipe mechanical design

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- 1. Layout of beam pipe and design updates
- 2. Structural design and thermal-hydraulic calculation
- 3. Interface of detectors (Vertex, LumiCal, SIT) installation
- 4. Summary

1. Layout of beam pipe and design update



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Modular design concept:

Consist of: Be pipe, Extending Al pipe, Supporting tube for vertex

Detectors: Vertex (3 layers), Lumical



Design updates:

The preliminary structural design of beam pipe has been accomplished

- (1) Detailed design of Be pipe and thin Be pipe manufacturing process is being investigated ;
- (2) Preliminary design of Interface with detectors (Vertex, LumiCal, SIT).
- (3) Optimization of the Carbon fiber bracket for vertex;
- (4) Thermal-hydraulic calculation for the Be pipe and Vertex.



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2.1 Beryllium(Be) pipe

- Inner diameter (Be): Ø28×0.5 mm, length:240mm (BESIII: Ø63×0.8 mm, length:278mm)
- Out diameter (Be): Ø30×0.35 mm, length:230mm (BESIII: Ø66×0.6 mm, length:220mm)
- > 0.5mm Be can bear 3.3MPa, 0.35mm Be can bear 0.93MPa, The structure meets the strength requirement.





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2.1 Be pipe

Based on the current domestic manufacturing capability, it is possible to manufacture the thin-wall beryllium pipe with wall thickness of **0.15mm and inner diameter of 20mm**.

Difficulties of manufacturing:

To meets the requirements of length(150mm), strength, stiffness and ultra-high vacuum.



The critical pressure contrast of Be pipe with different wall thickness						
Version	Name	Wall thickness (mm)	Inside radius (mm)	External radius (mm)	Critical pressure (MPa)	Gap(coolant)
Previous design	Inner Be pipe	0.5	14	14.5	3.3053	0.5mm (Between inner and outer Be pipe)
	Outer Be pipe	0.35	15	15.35	0.9388	
New design	Inner Be pipe	0.2	10	10.2	0.5941	
	Outer Be pipe	0.15	10.7	10.85	0.2064	



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2.2 Structure for detectors installation and cooling ---Vertex

> The first layer vertex is mounted close to the center Be pipe.





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2.2 Structure for detectors installation and cooling ---Vertex



Air cooling channel + water cooling interlayer + embedded oil cooling pipe, very complex structure!



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2.2 Structure for detectors installation and cooling ---Vertex



2.2 Structure for detectors installation and cooling ---LumiCal (conceptual)

> A water-cooled interlayer is located inside the extending AL pipe.

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> The end face is connected with the accelerator vacuum tube. 500





The external strengthen pipe can form an air cooling channel and strengthen the whole structure.





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Very compact space! Need further careful design after the cable and connectors are determined.





2.4 Thermal-hydraulic calculation---Be pipe and Al pipe

Calculation model and condition



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2.4 Thermal-hydraulic calculation---Be pipe and Al pipe

- \checkmark Be pipe can be cooled down by paraffin oil in Z model.
- \checkmark Water is an effective coolant in the case of High Luminosity Z model.



Temperature distribution in Z model

Temperature distribution in High Luminosity Z model





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2.6 Thermal calculation---Vertex









The carbon fiber bracket to hold the vertex is very complex. It has been simplify to be 3 layer of cylinders for the preliminary cooling calculation.



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2.6 Thermal calculation---Vertex



The temperature of the zone between two air inlet is relatedly high due to low flow velocity. Structural optimization is needed.



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3.1 Carbon fiber bracket for Vertex

- The first layer: 9×vertex support, the Second layer:
 18×Vertex support, the third layer: 24 ×Vertex support.
- Both ends of the carbon fiber vertex support are fixed on the supporting tube by screws.











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When the width is set to be 16.8mm, the deflection of the carbon fiber

bracket can be reduced only by increasing the height.



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The recommended size of the carbon fiber bracket can match the current beam pipe structure.

High thermal conductivity rectangular carbon fiber tube needs to be developed.



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3.2 Preliminary design of LumiCal connecting structure

- Detection Angle range: 38~80mrad
- > On the detection path, as little mass as possible
- The structure of lumical is not yet determined, so the support and cooling structure should be further optimized and improved.



径向lumical

Summary: there is very little mass in the area of vertex detector angle.

3. Interface of detectors installation 3.3 Preliminary design of SIT connecting structure

- The detailed structure of SIT has not been designed. \geq
- The inner end ring and outer end ring are designed for the SIT support. \geq
- SIT outer end ring and SIT inner end ring are tensioned by four sets of adjusting rods \triangleright



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The supporting structure and cable connectors are located in the detection angle.

4. Summary

The preliminary structural design of beam pipe has been accomplished.

- Further optimization:
- (1) Cooling (Be pipe, Al pipe, Vertex ...)
- (2) The connection and interface with beam pipe and SIT (also with the outer detectors) is still need optimization to reinforce the strength and rigidity.
- (4) The thickness of beam pipe is potential to reduce to 0.15~0.2mm.

The manufacturing process need further study and a prototype is necessary.







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