Design of the CEPC Beampipe and Vertex

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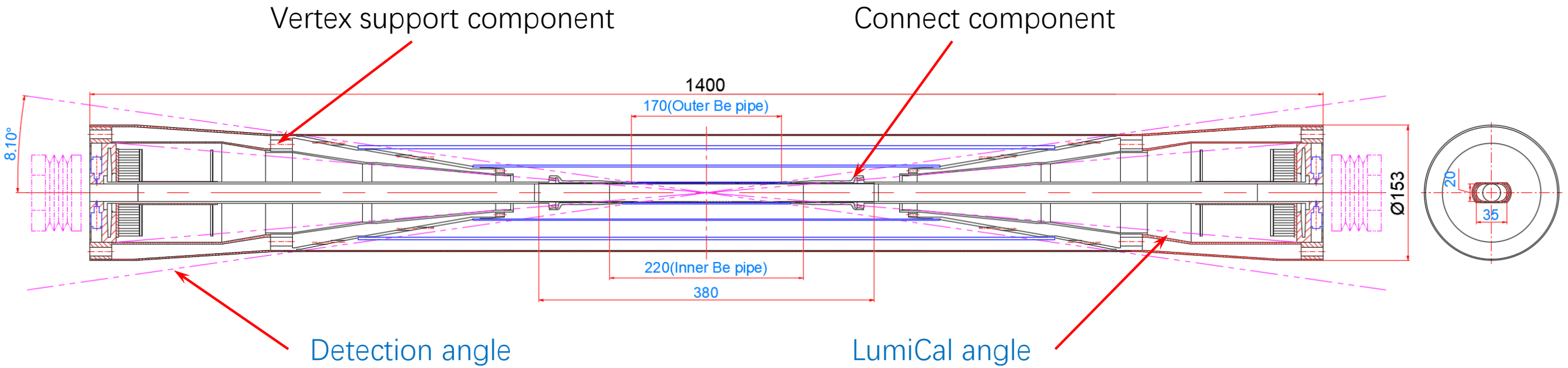
Beam pipe and area division of each sub detector :



Read lines: Detection angle and LumiCal angle

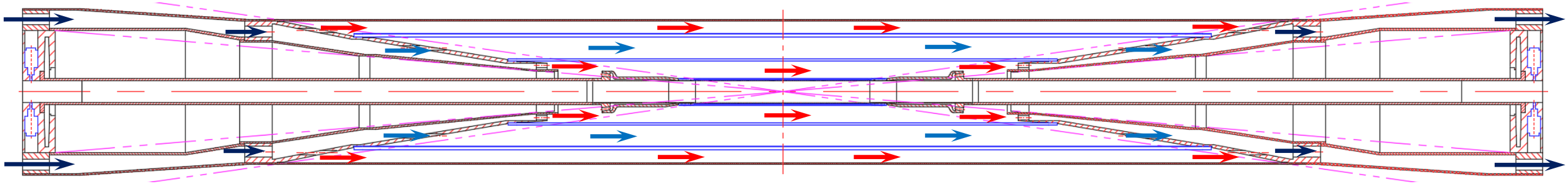
Between two detection angle lines: Vertex (Three double layers)
Between two read lines: Wind ducts and Cable ducts

Vertex --- Cooling design (July 5, 2023)

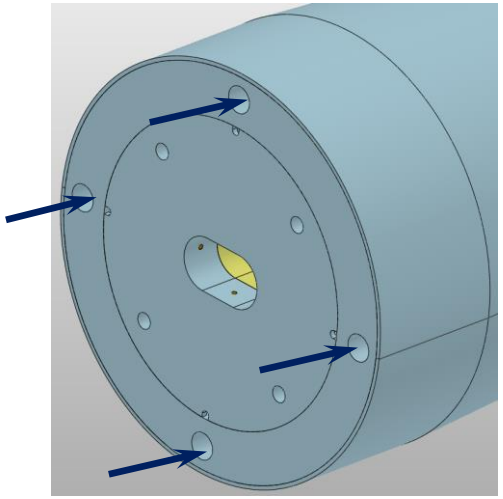
Air-cooled inlet

Air-cooled channels and support structures

Air-cooled outlet



Air-cooled inlet



Four inlets , four outlets

Cooled structure :

Three layer air cooled channel

↓ Take away

The heat generated
by chips and electronics

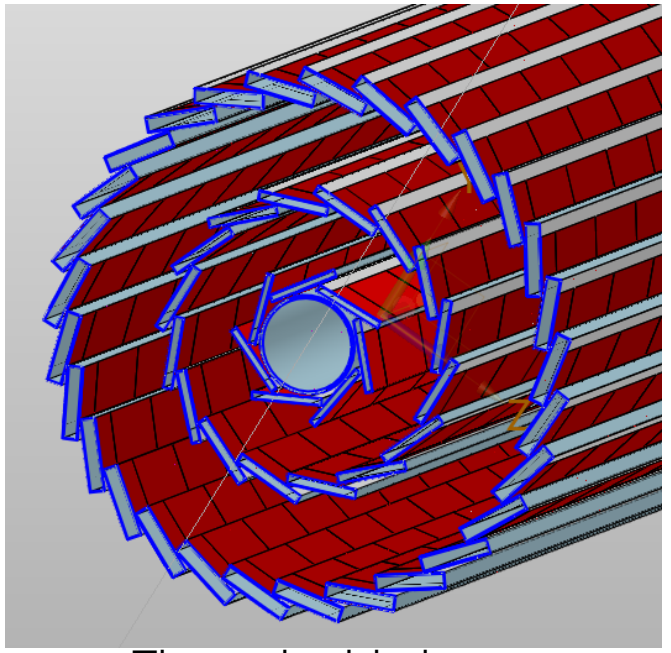
Design requirement

$T \leq 20$ °C

$\Delta T < 10$ °C or 7 °C

Vibration < 1μm (?)

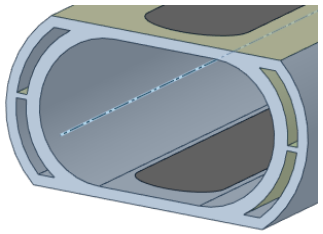
Air-cooled outlet

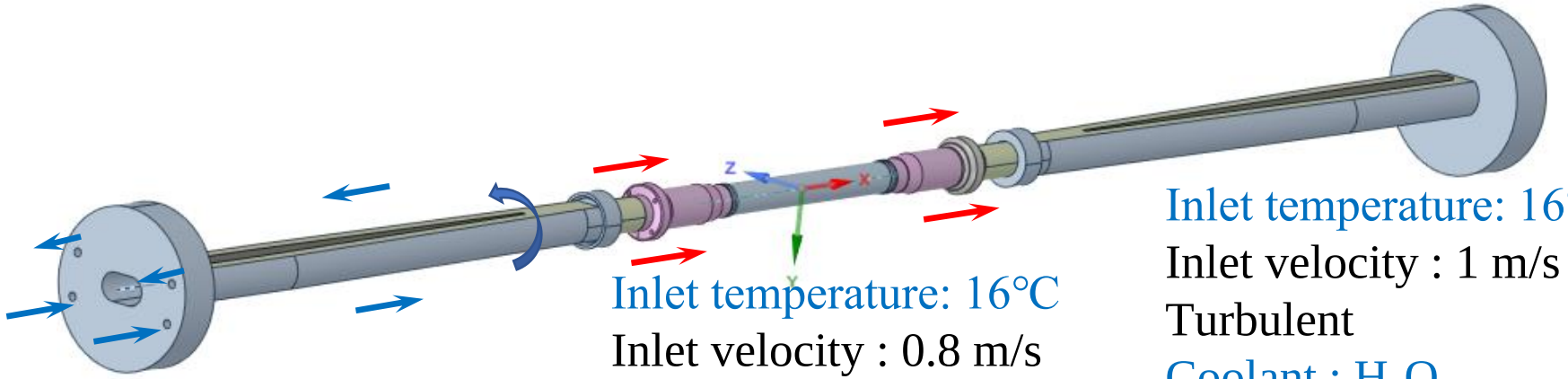


Three double layers

Thermal analysis 1--- Beampipe (July 5, 2023)

目标：铍管段温度不能超过20℃



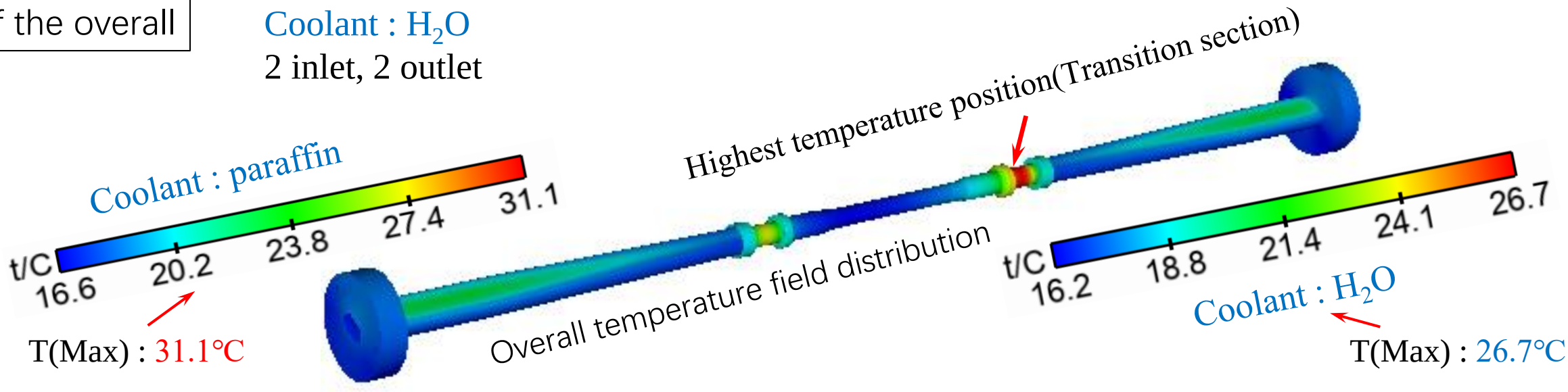


Inlet temperature: 16℃
Inlet velocity : 1 m/s
Turbulent
Coolant : H_2O
2 inlet, 2 outlet

Inlet temperature: 16℃
Inlet velocity : 0.8 m/s
Laminar
Coolant : Paraffin or H_2O
4 inlet, 4 outlet

Inlet temperature: 16℃
Inlet velocity : 1 m/s
Turbulent
Coolant : H_2O
2 inlet, 2oulet

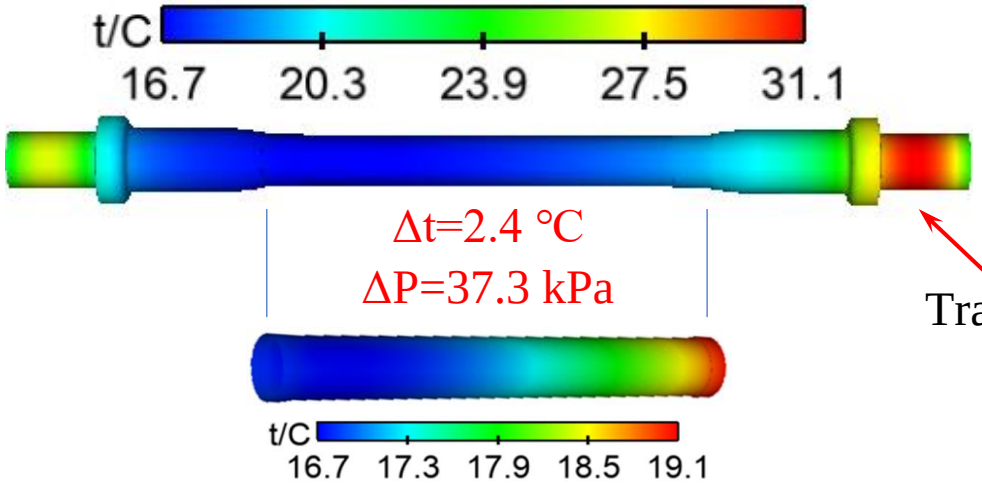
Results
Of the overall



Thermal analysis --- Beampipe (Central Be pipe) (July 5, 2023)

Results
Of the Central Be pipe

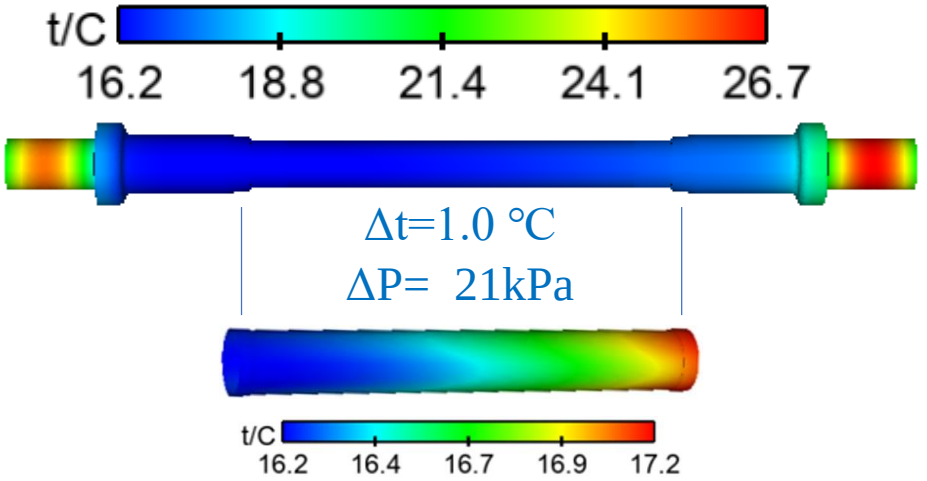
Coolant : paraffin



Outer surface temperature
of the outer Be pipe

Transition section

Coolant : H_2O

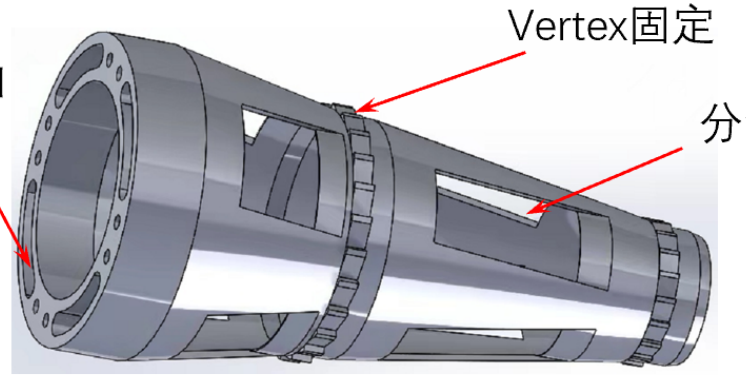


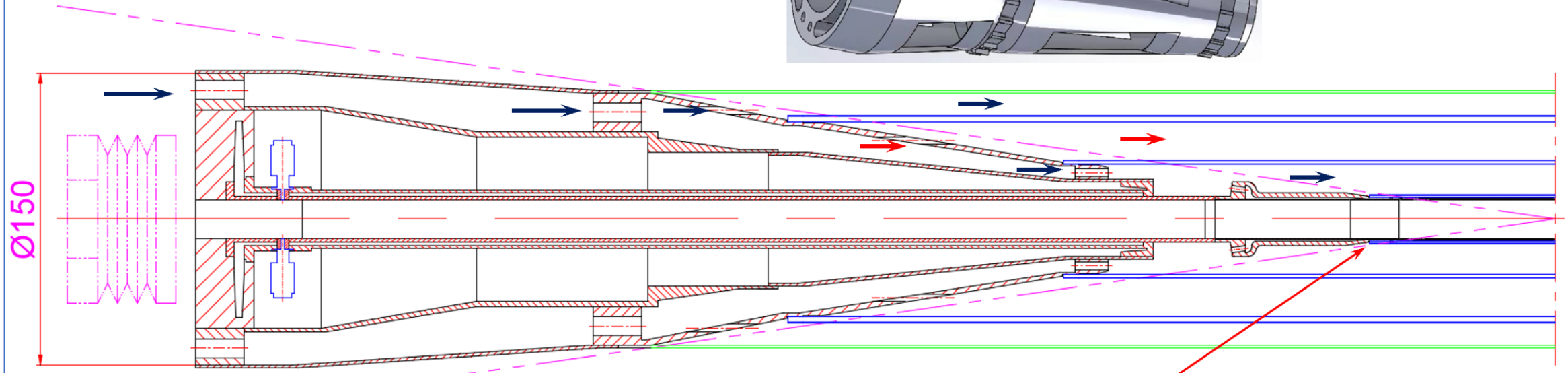
Outer surface temperature
of the outer Be pipe

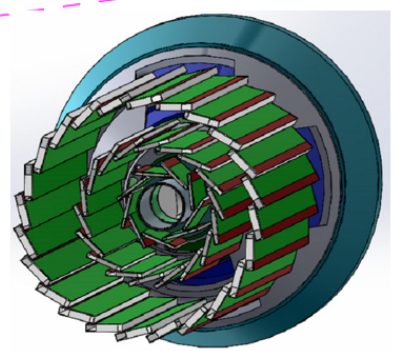
结论： 铍管段的温度不会影响Vertex的冷却

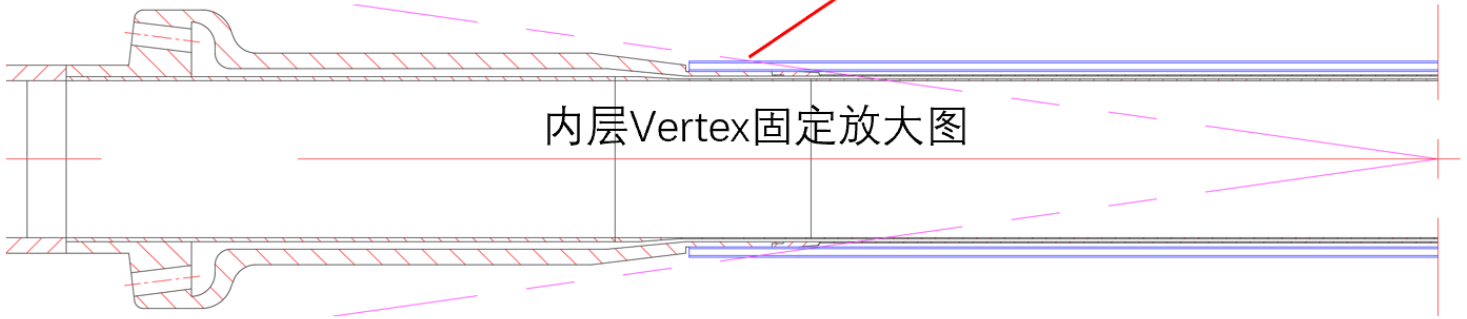
提出问题：最内层的Vertex的冷却难题

Vertex的风冷与支撑结构









从对Vertex工作温度的设计要求, 分析风冷设计的难点

1. 最外层的温度梯度，很难满足设计要求 (太长了)

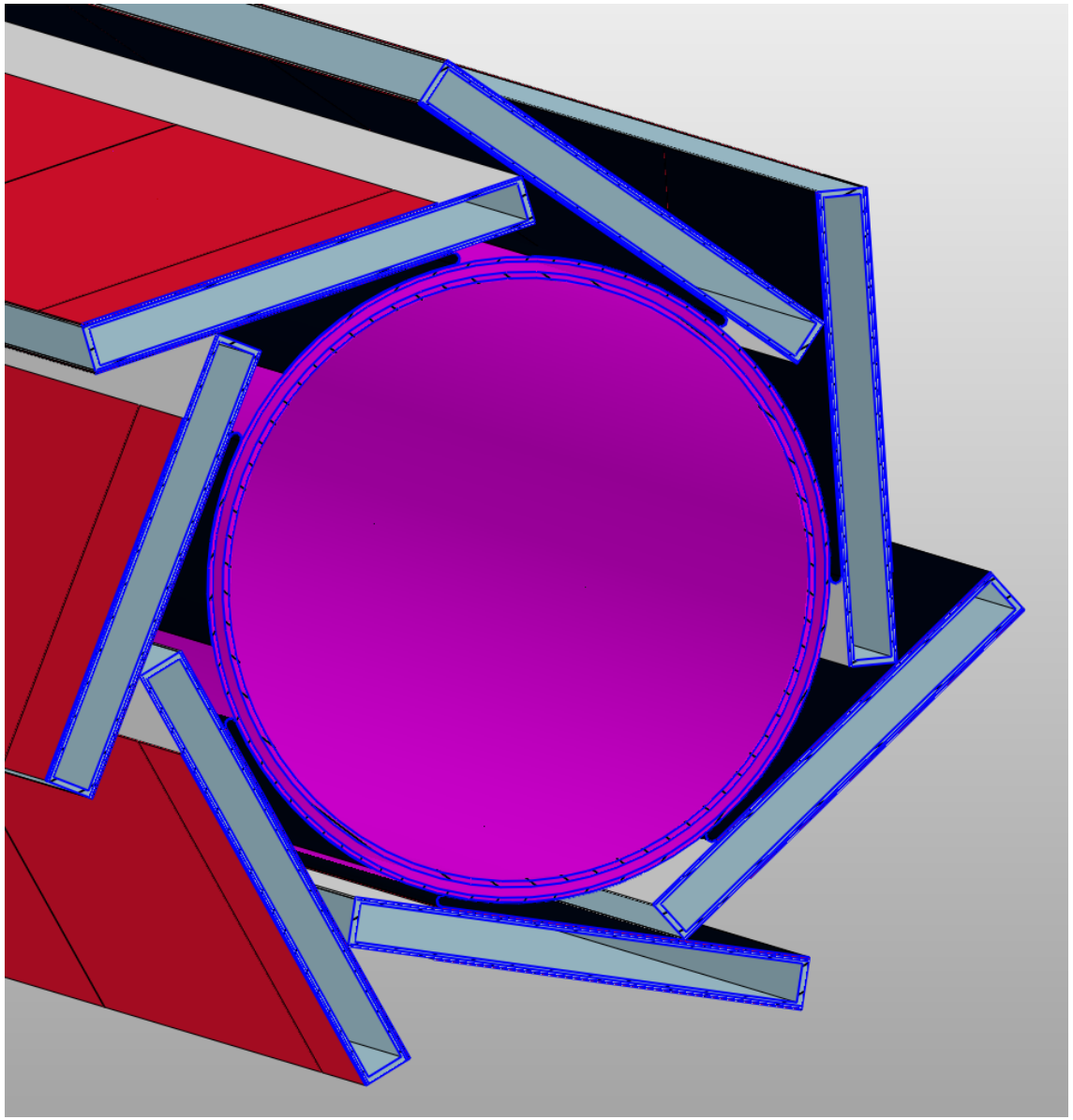
总长790, 芯片 25.6 X 30 = 768

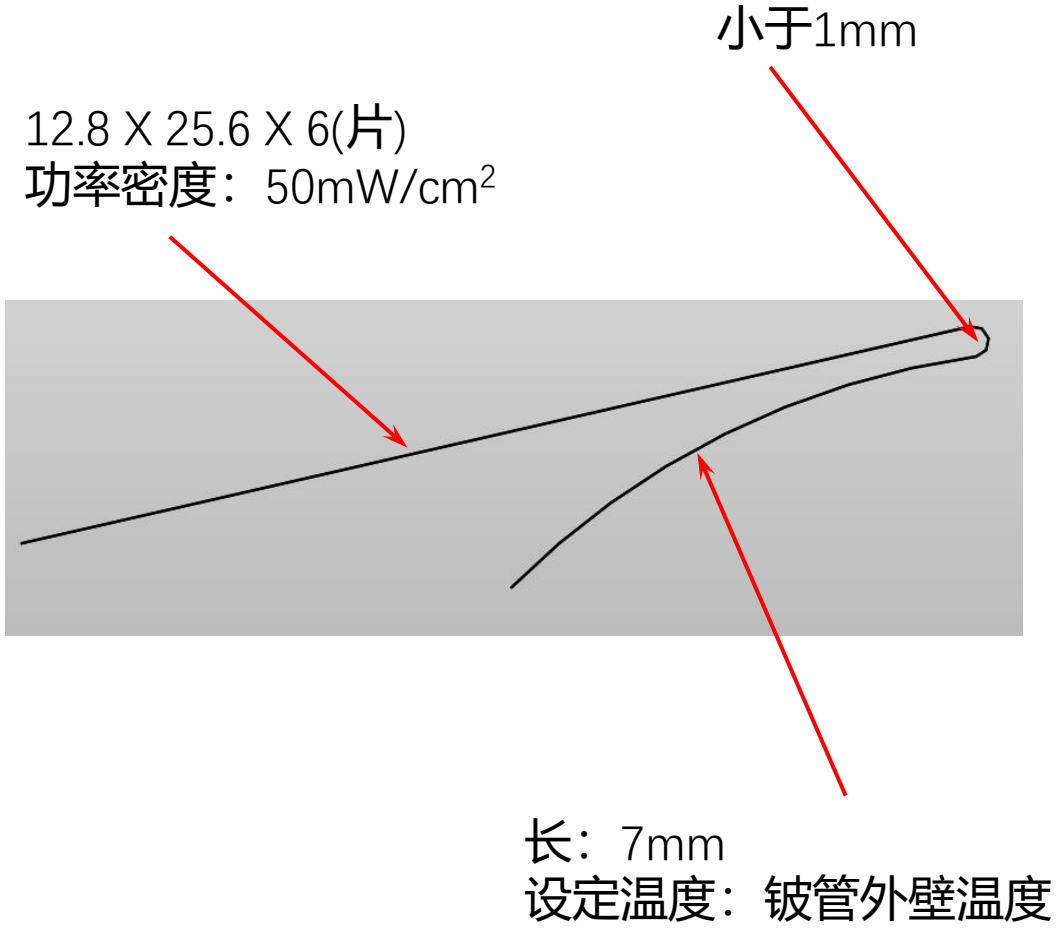
解决办法： 提高风速和降低初始温度
优化设计要求

2. 最内层的工作温度，很难满足设计要求 (太近了)

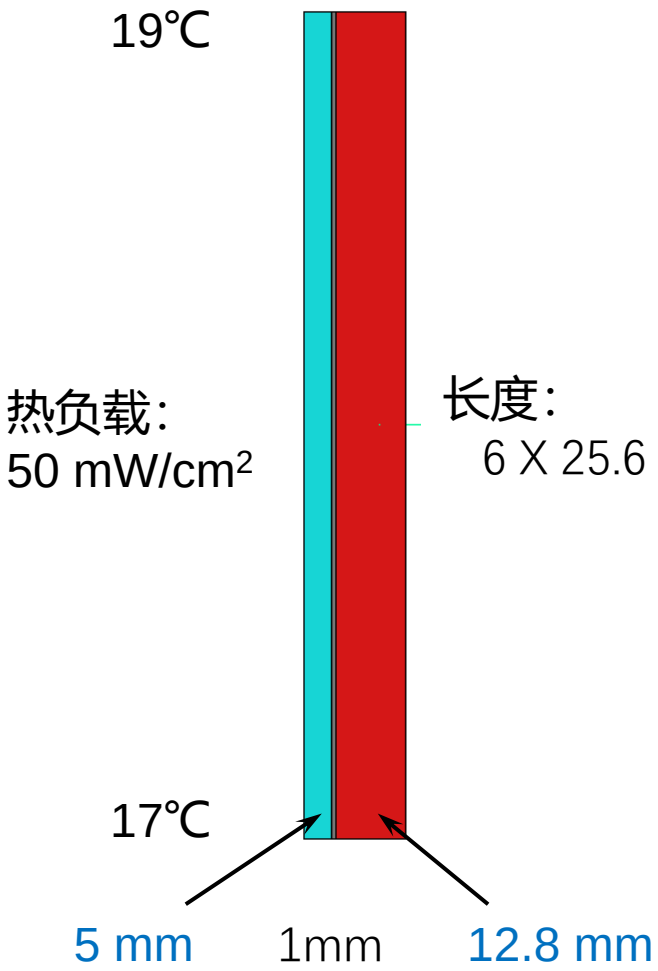
解决办法： ？借力铍管段的冷却，通过热传导间接冷却Vertex

间接冷却设计示意图: 通过石墨烯薄片，一端粘在铍管外壁，一端粘在芯片外壁，进行热传导冷却



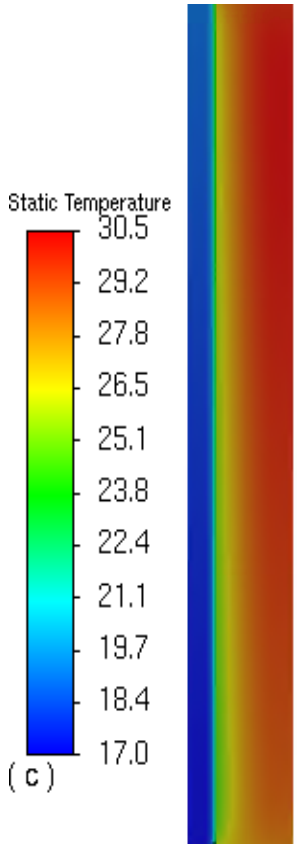


简化计算模型及计算结果: (陆友莲)

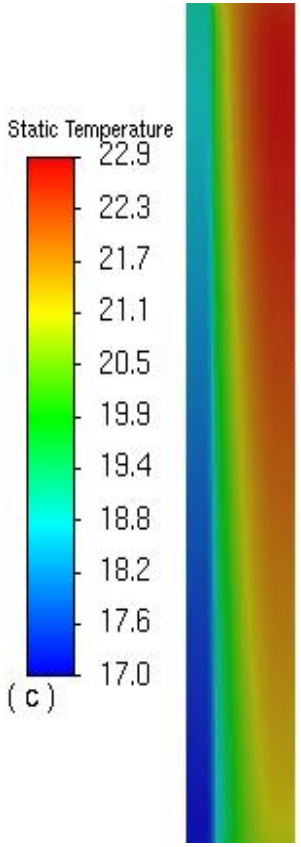


计算模型及参数

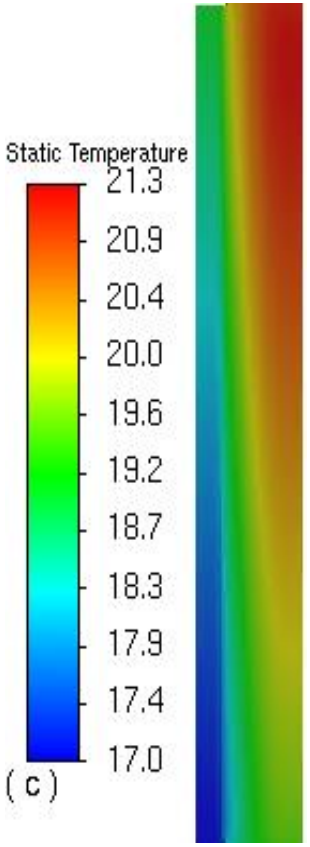
1μm



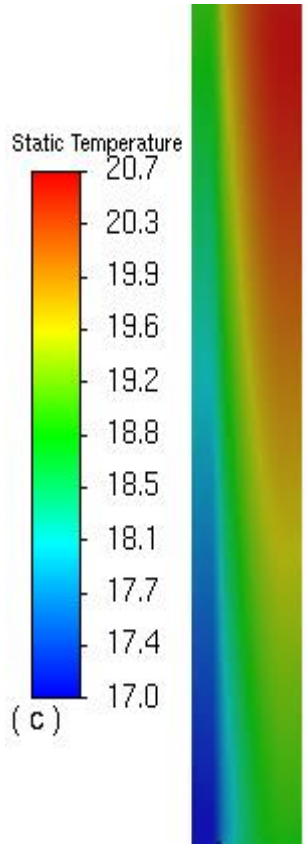
5μm



10μm



15μm



Number	Material	thickness	density	Specific heat	Conductivity
		μm	kg/m3	J/(kg.K)	W/(m.K)
①	Si	50	2419	713	148
⑤	graphene		1810	710	Kx=1500; Ky=1500; Kz=1

物性参数: 硅和石墨烯

结论:

1. 方法可行
2. 石墨烯厚度越厚越好

TDR Vertex设计，需要优化的参数: (建议)

Vertex 的位置: R1,R2,R3, L1,L2,L3

电子学的尺寸优化: 芯片及柔性线路板尺寸

风冷参数: 风速，风口大小，初始温度

冷却结构参数优化: Vertex support component

冷却方法: 穷举法 + 排除法

设计要求的参数优化：工作温度，温度差，振动要求