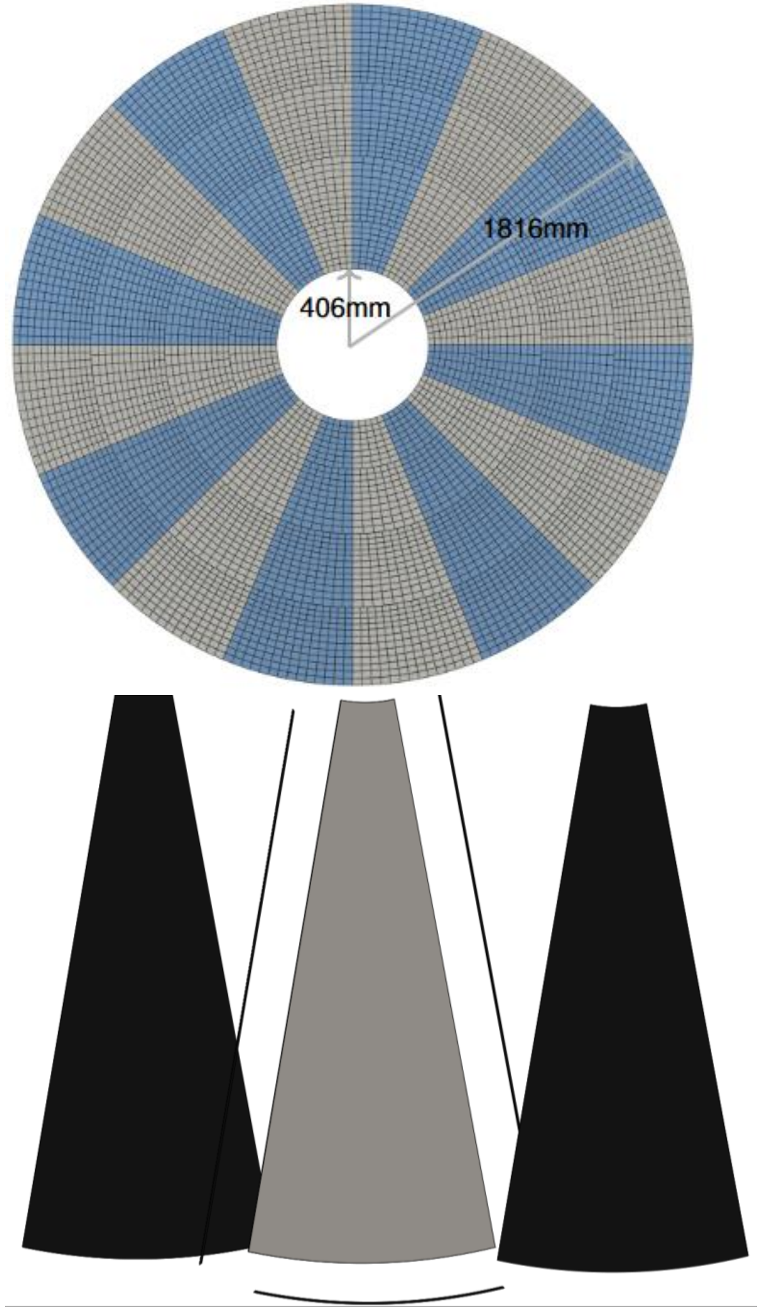
机械例会周汇报

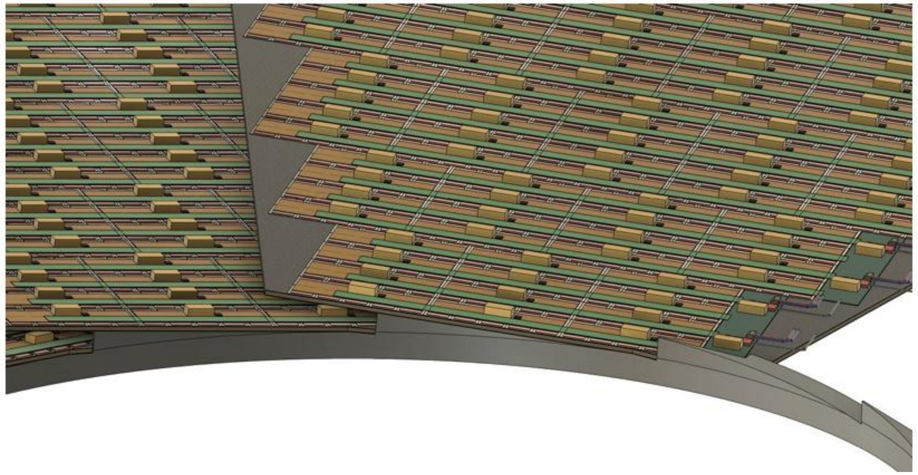
李宇杰

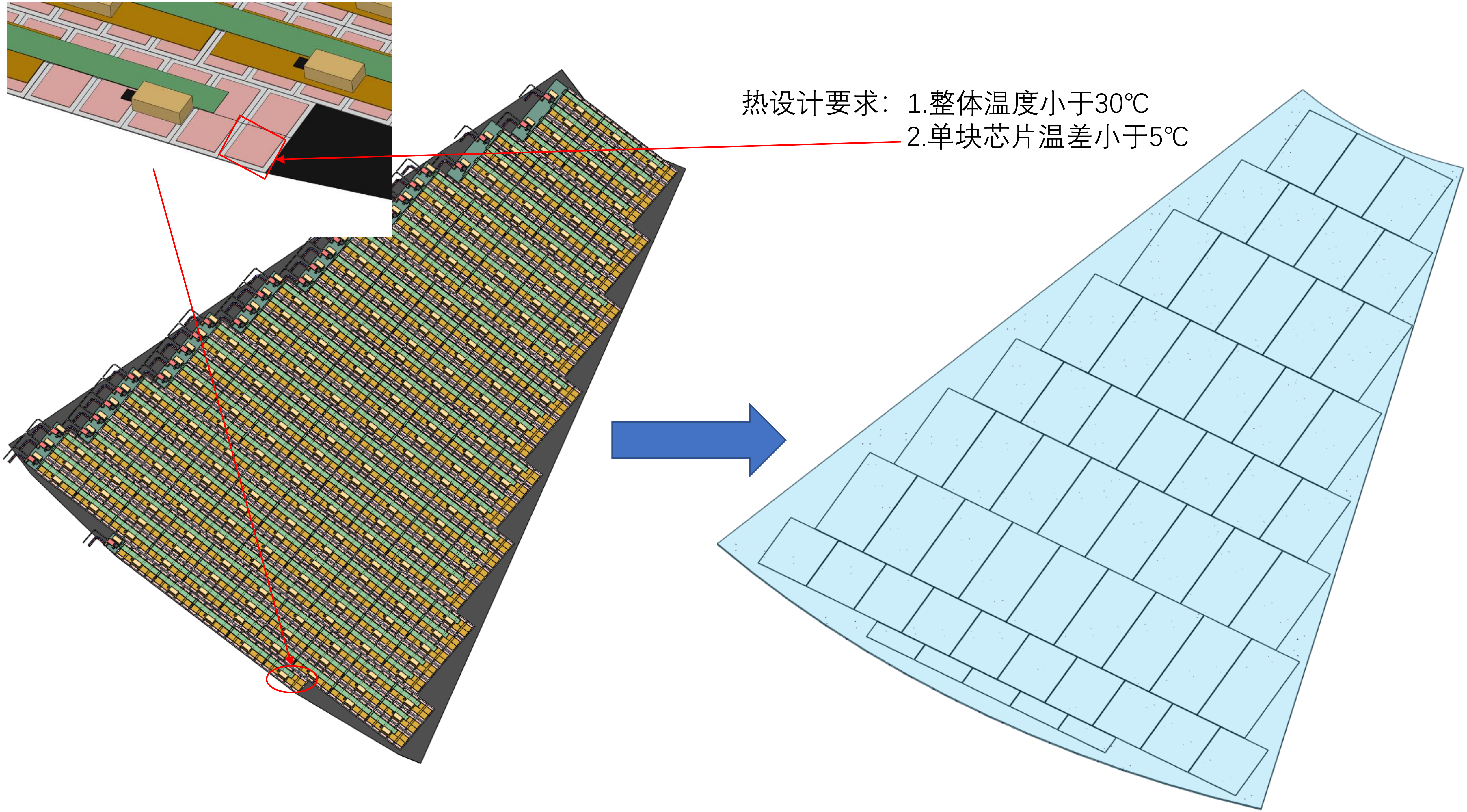
2025/05/12

OTK端盖



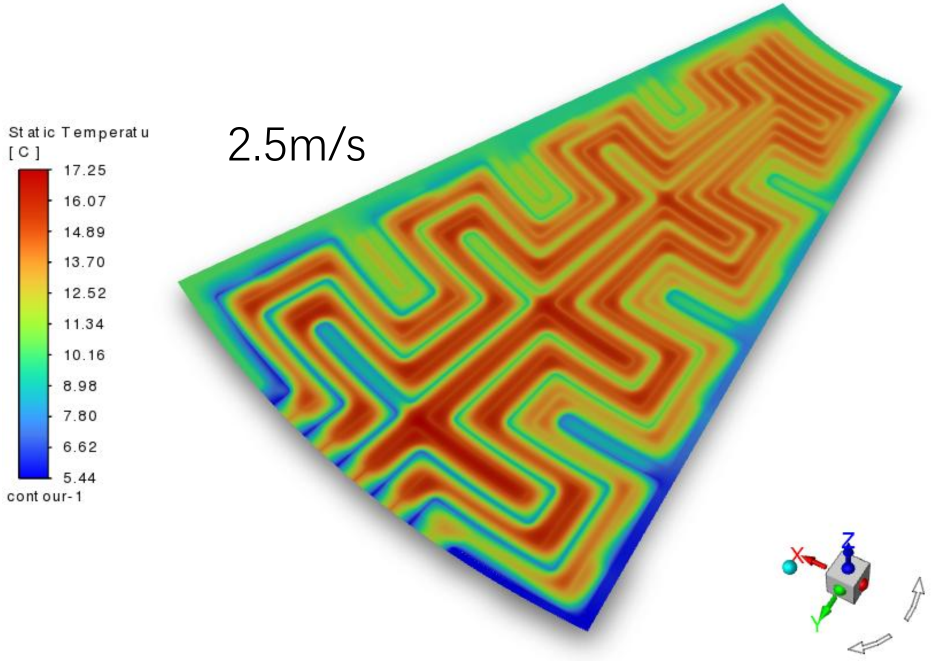
Back up方案（sensor 2cm×2cm）




热设计要求：1.整体温度小于30℃
2.单块芯片温差小于5℃

6个回路

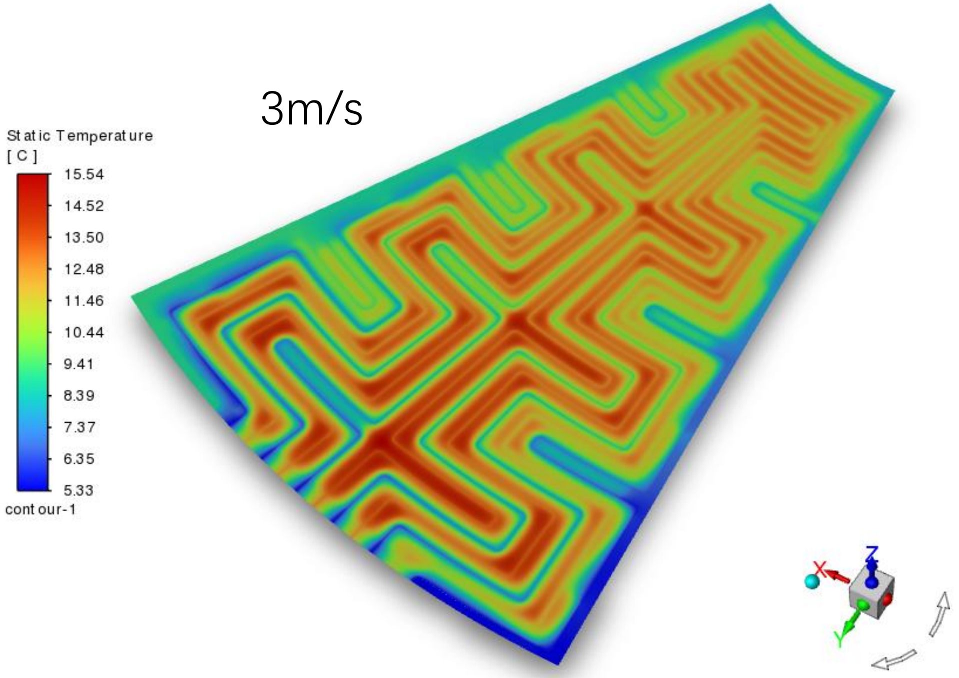
2.5m/s



Calculation complete.

Area-Weighted Average Static Temperature	[C]
outlet1	10.312224
outlet2	12.584002
outlet3	13.90171
outlet4	14.594654
outlet5	14.581904
outlet6	15.024097
Net	13.498479

3m/s

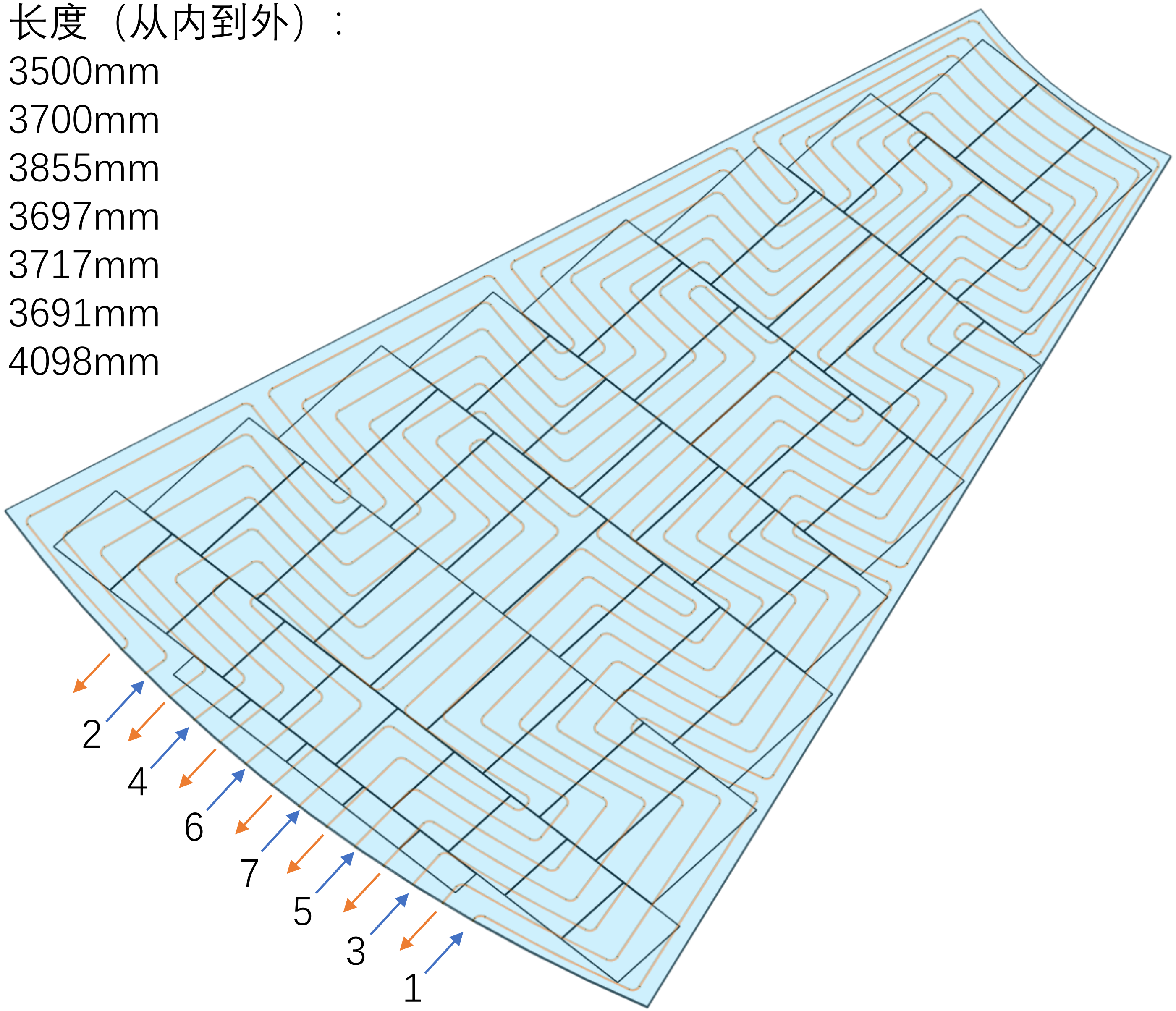


Area-Weighted Average Static Temperature	[C]
outlet1	9.0310168
outlet2	11.061417
outlet3	12.162755
outlet4	12.691906
outlet5	12.702322
outlet6	13.017466
Net	11.776746

7个回路

长度（从内到外）：

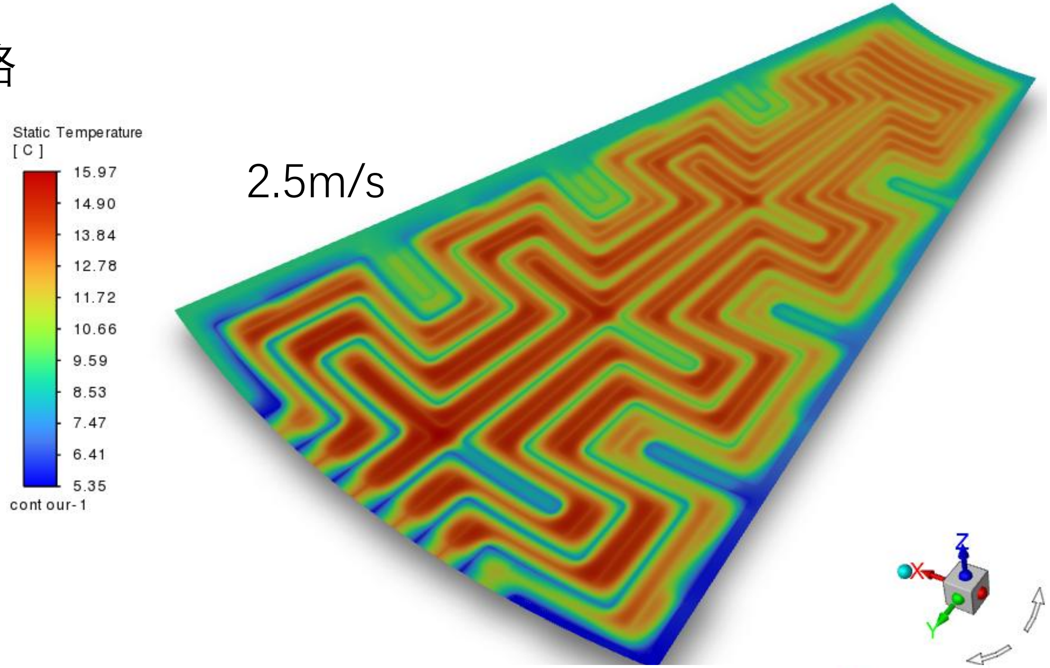
3500mm
3700mm
3855mm
3697mm
3717mm
3691mm
4098mm



内径：630	1500 96等分	630	15.625		1500 112等份	630	13.39285714
外径：2130		645.625	31.25			643.3929	26.78571429
		676.875	31.25			670.1786	26.78571429
		708.125	31.25			696.9643	26.78571429
		739.375	31.25			723.75	26.78571429
		770.625	31.25			750.5357	26.78571429
		801.875	31.25			777.3214	26.78571429
		833.125	31.25			804.1071	26.78571429
		864.375	31.25			830.8929	26.78571429
		895.625	31.25			857.6786	26.78571429
		926.875	31.25			884.4643	26.78571429
		958.125	31.25			911.25	26.78571429
		989.375	31.25			938.0357	26.78571429
		1020.625	31.25			964.8214	26.78571429
		1051.875	31.25			991.6071	26.78571429
		1083.125	31.25			1018.393	26.78571429
		1114.375	31.25			1045.179	26.78571429
		1145.625	31.25			1071.964	26.78571429
		1176.875	31.25			1098.75	26.78571429
		1208.125	31.25			1125.536	26.78571429
		1239.375	31.25			1152.321	26.78571429
		1270.625	31.25			1179.107	26.78571429
		1301.875	31.25			1205.893	26.78571429
		1333.125	31.25			1232.679	26.78571429
		1364.375	31.25			1259.464	26.78571429
		1395.625	31.25			1286.25	26.78571429
		1426.875	31.25			1313.036	26.78571429
		1458.125	31.25			1339.821	26.78571429
		1489.375	31.25			1366.607	26.78571429
		1520.625	31.25			1393.393	26.78571429
		1551.875	31.25			1420.179	26.78571429
		1583.125	31.25			1446.964	26.78571429
		1614.375	31.25			1473.75	26.78571429
		1645.625	31.25			1500.536	26.78571429
		1676.875	31.25			1527.321	26.78571429
		1708.125	31.25			1554.107	26.78571429
		1739.375	31.25			1580.893	26.78571429
		1770.625	31.25			1607.679	26.78571429
		1801.875	31.25			1634.464	26.78571429
		1833.125	31.25			1661.25	26.78571429
		1864.375	31.25			1688.036	26.78571429
		1895.625	31.25			1714.821	26.78571429
		1926.875	31.25			1741.607	26.78571429
		1958.125	31.25			1768.393	26.78571429
		1989.375	31.25			1795.179	26.78571429
		2020.625	31.25			1821.964	26.78571429
		2051.875	31.25			1848.75	26.78571429
		2083.125	31.25			1875.536	26.78571429
		2114.375	15.625			1902.321	26.78571429
		2130				1929.107	26.78571429
						1955.893	26.78571429
						1982.679	26.78571429
						2009.464	26.78571429
						2036.25	26.78571429
						2063.036	26.78571429
						2089.821	26.78571429
						2116.607	26.78571429
						2130	13.39285714

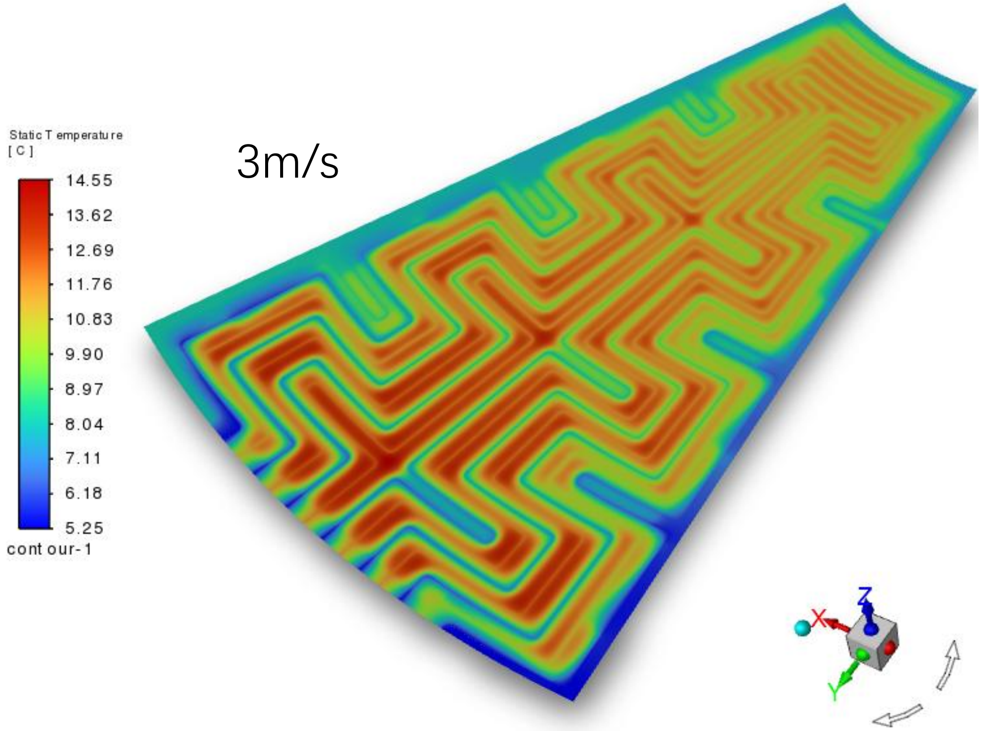
7个回路

2.5m/s



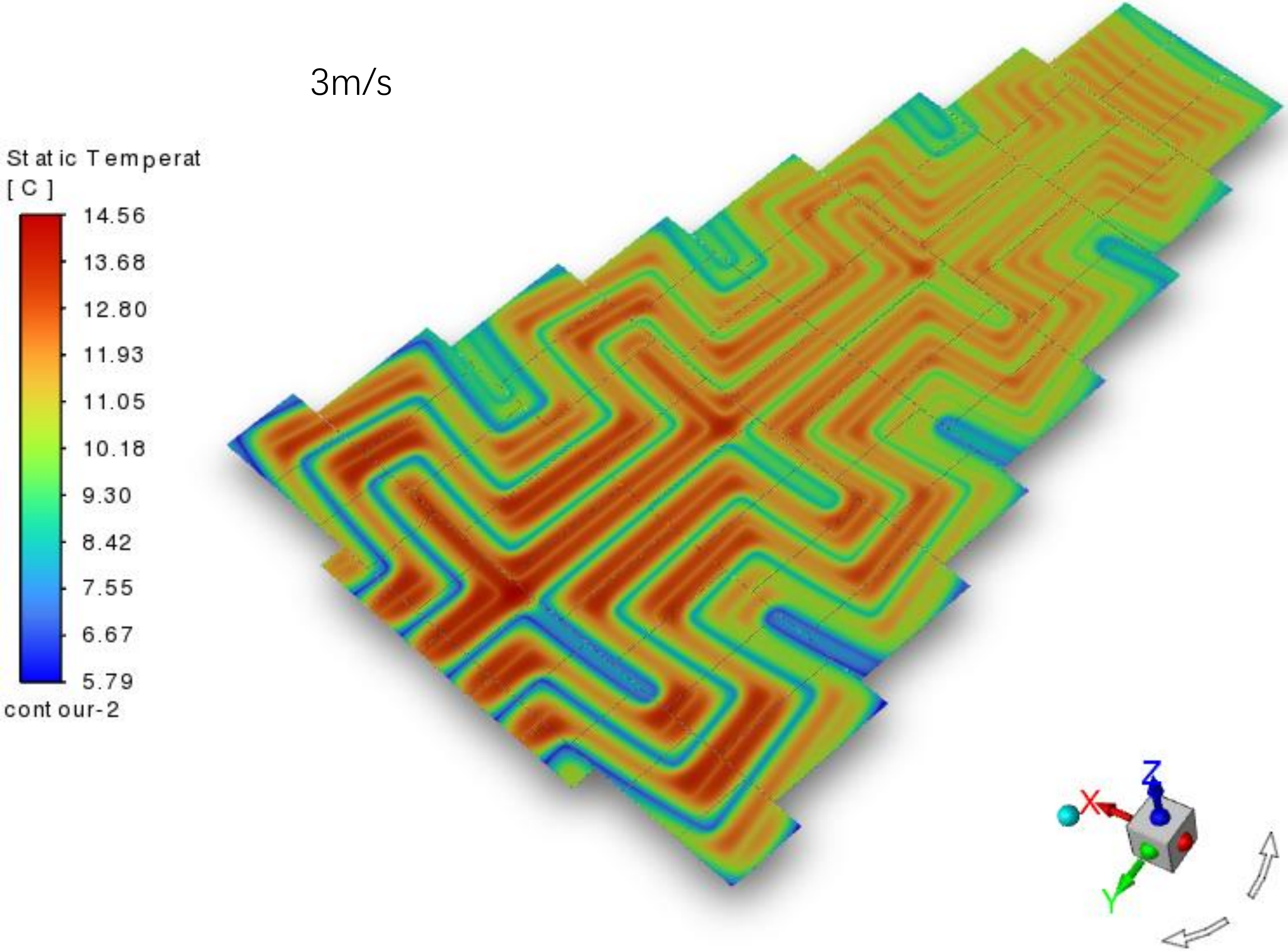
Area-Weighted Average Static Temperature	[C]
oulet5	13.636118
outlet1	9.2202477
outlet2	11.458981
outlet3	12.746466
outlet4	13.515022
outlet6	13.522561
outlet7	13.812392
Net	12.55938

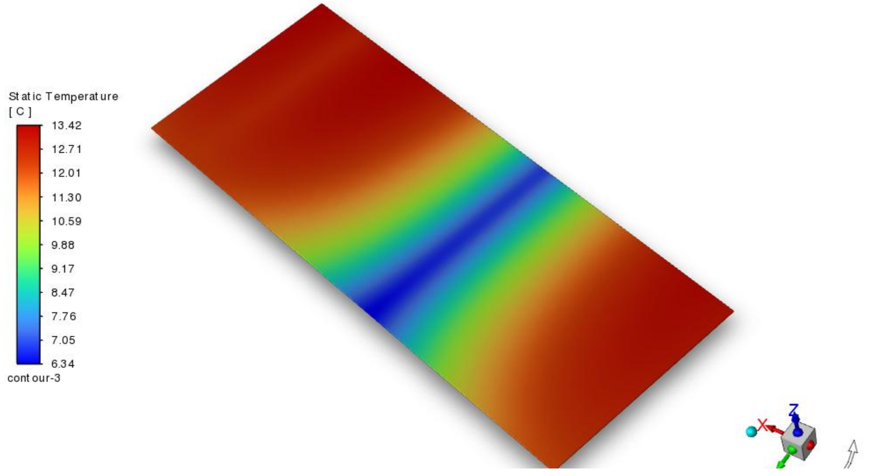
3m/s

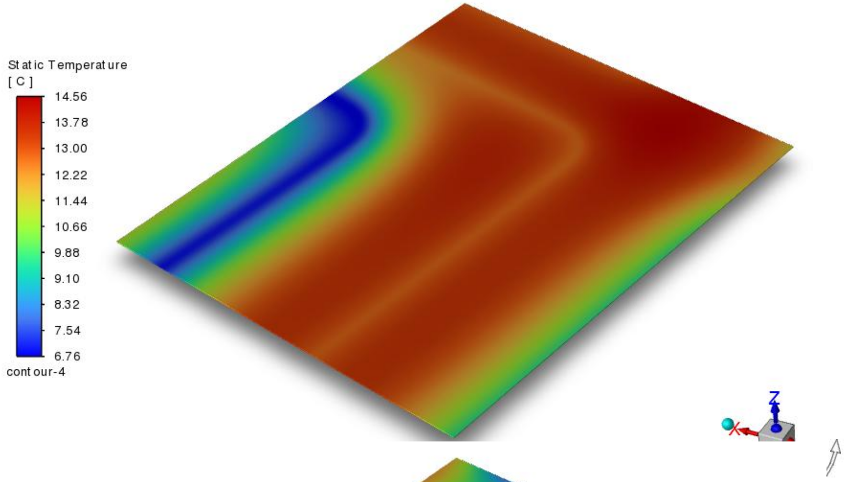


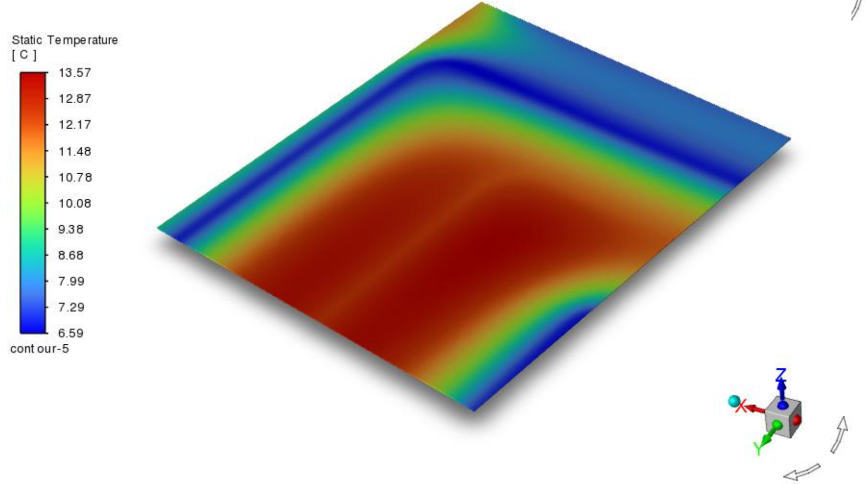
Area-Weighted Average Static Temperature	[C]
oulet5	11.936771
outlet1	8.1724207
outlet2	10.156618
outlet3	11.244131
outlet4	11.847932
outlet6	11.874706
outlet7	12.080131
Net	11.04514

3m/s









增大管径，减小流速！

为何选择蒸发式CO_2冷却?

•超高传热效率

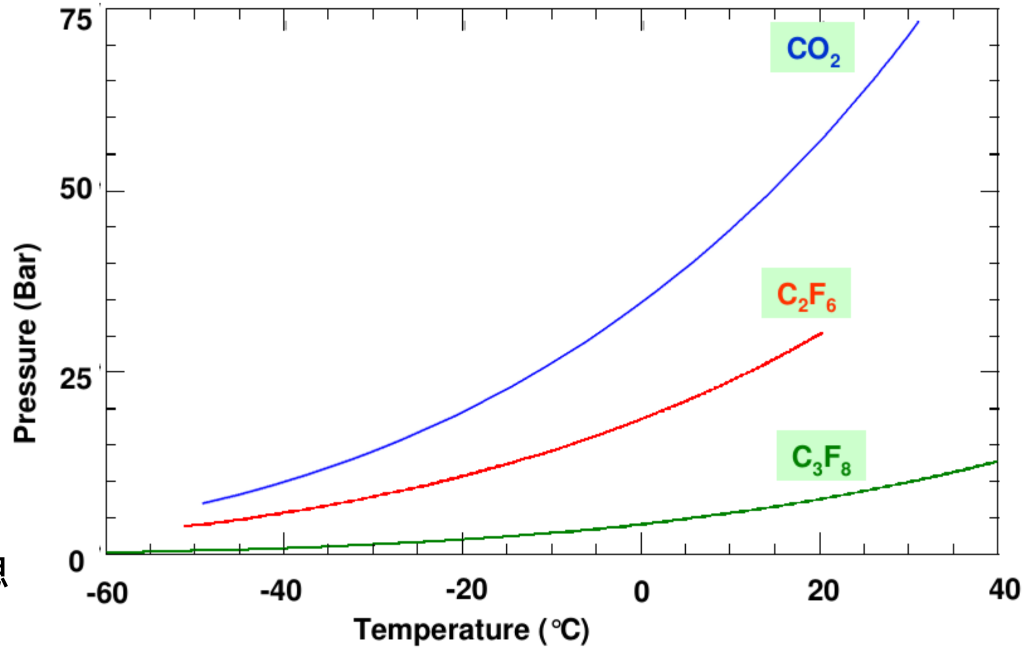
→ 传热系数（α）远高于单相 → 降低传感器与流体间温差（ΔT）

•低流量 & 紧凑设计

→ 质量流量（$\dot{m}$）低 → 管道直径（∅）更小 → 材料成本与体积减少

•全域均匀冷却

→ 管道温度近乎恒定（仅受微小压差Δp影响） → 长距离管线仍保持稳定



常见抗辐射制冷剂

为何选择CO_2?

•抗辐射性极强

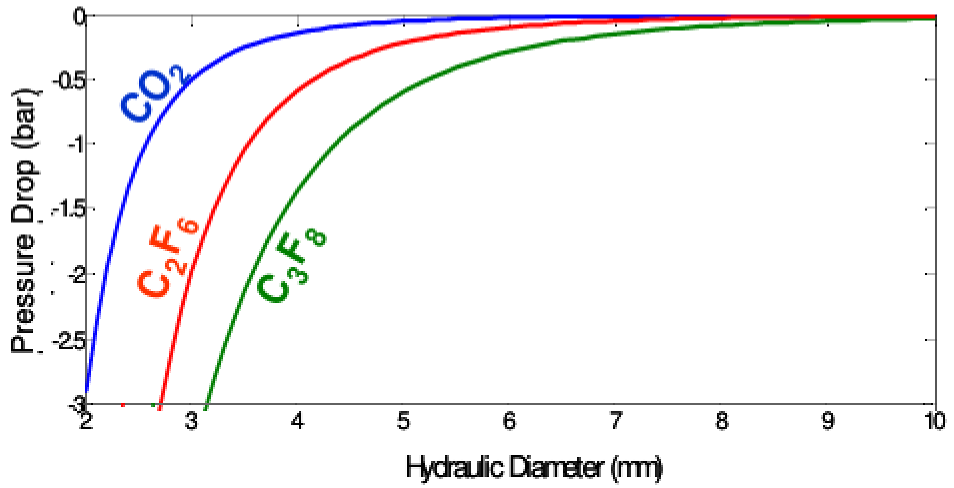
→ 传统制冷剂易被电离辐射破坏，CO_2稳定性卓越

•高压 & 小管径

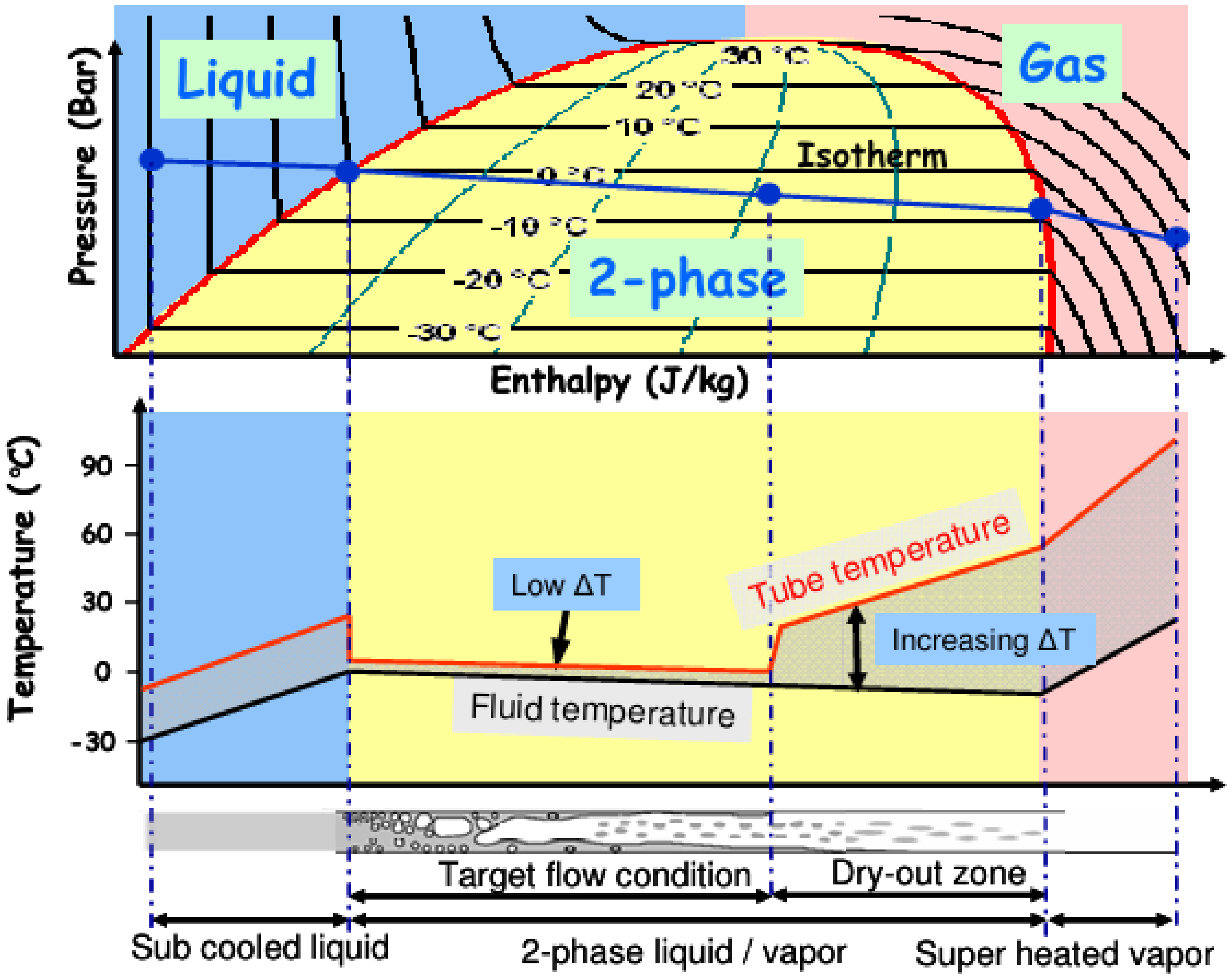
→ 高压流体 → 温降（温度滑移）极小 → 适用于微型化系统

•环保无毒

→ 零臭氧层破坏（ODP=0） → 比CFC制冷剂更可持续

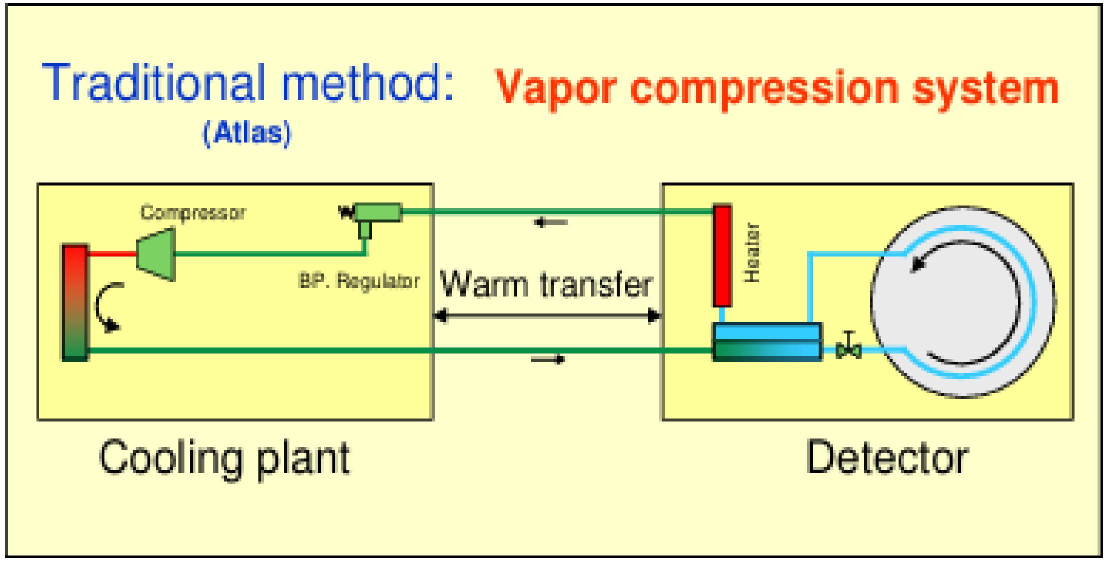


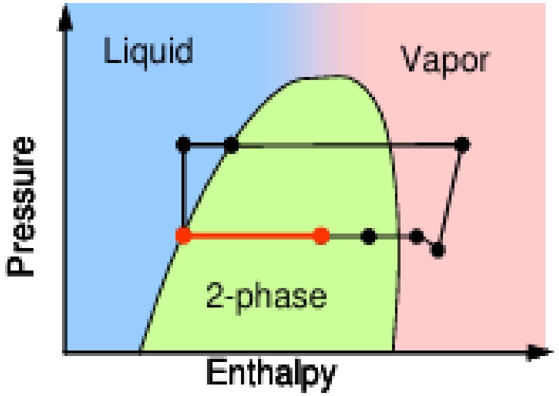
一定流速下压降与管径的关系

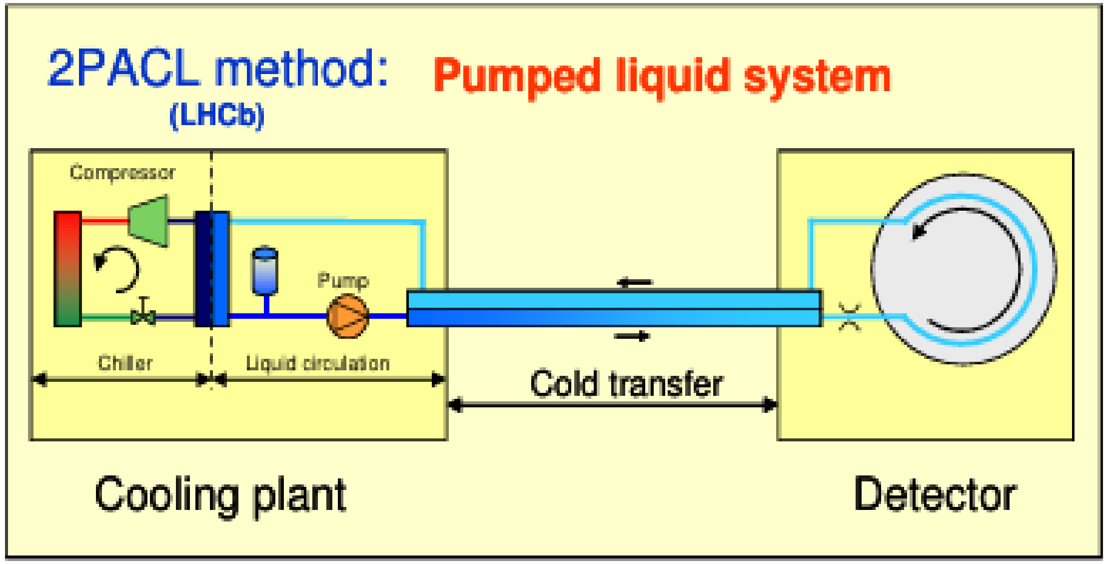


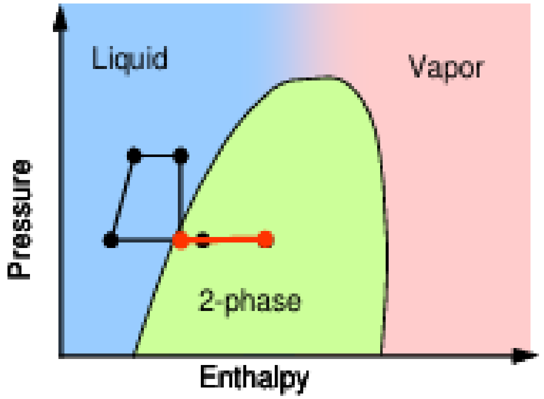
CO_2压力焓图

黑线是流体温度，红线是管壁温度





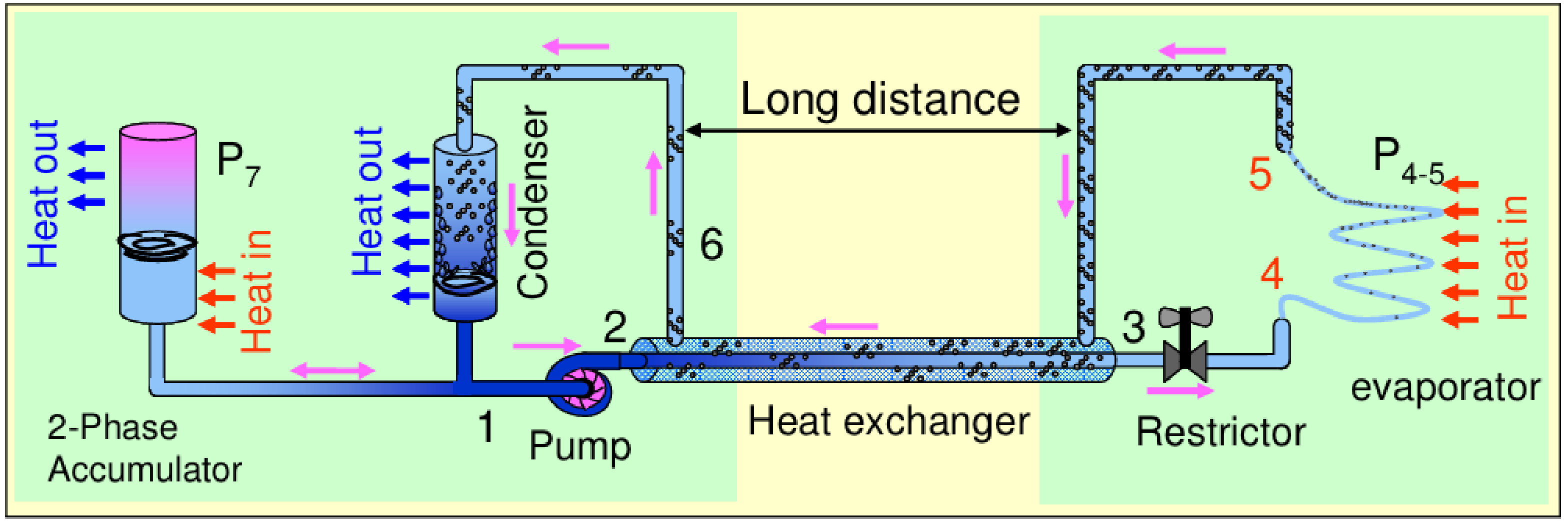


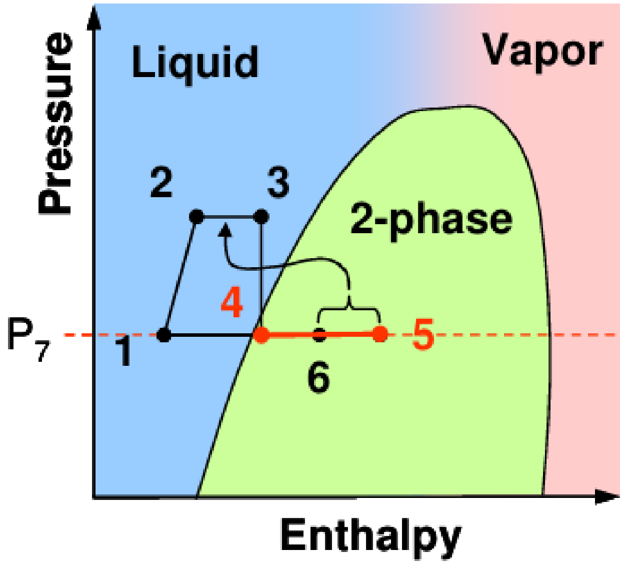


传统压缩系统的优点在于可以使用温暖的运输管线；而泵送系统则需要冷却传输管道并且需要适当的绝缘层。绝缘层会增加额外的空间需求，但管道较小，因此所涉及的质量很可能较低。

传统压缩系统的缺点是探测器内存在加热器，以蒸发剩余的液体，同时需要无油压缩机比无油泵通常更难找到。两相蓄能器泵送方法的主要优点是探测器内部有一个完整的被动蒸发器部分。在难以接触的探测器区域，不需要执行器或重要传感器。

二氧化碳两相蓄能器泵送系统（2PACL）



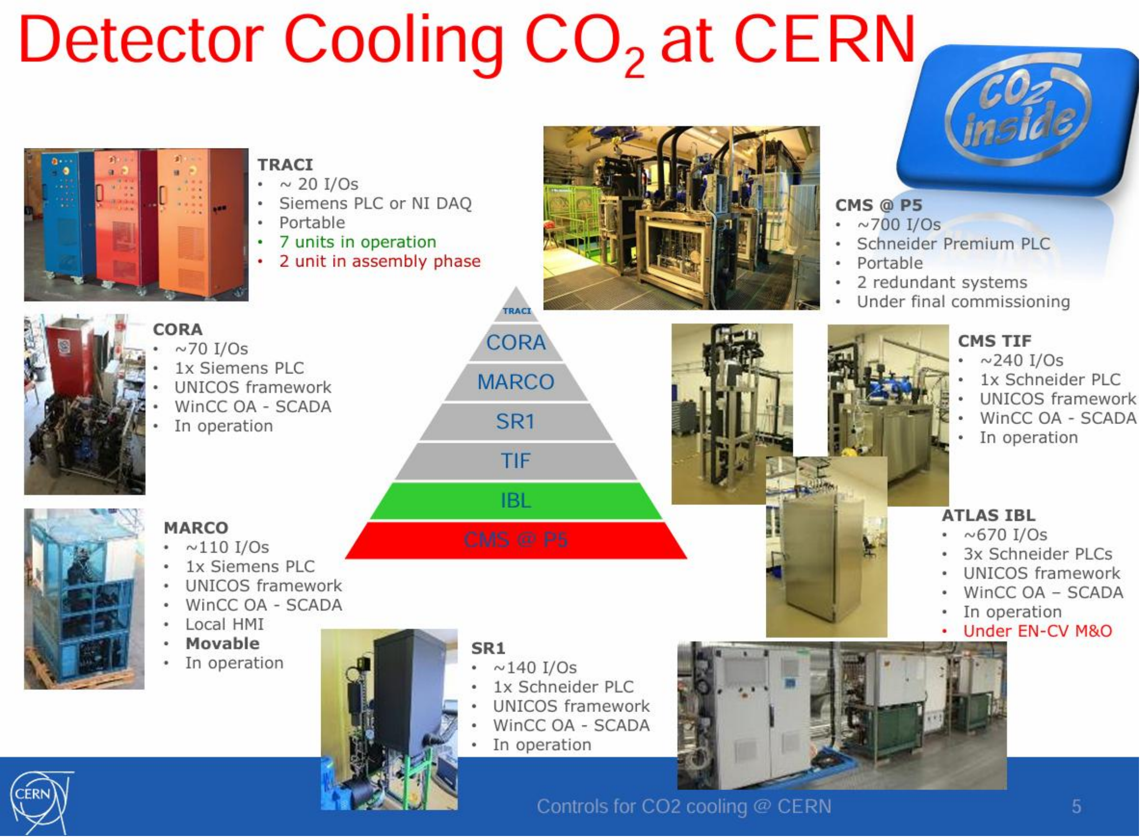


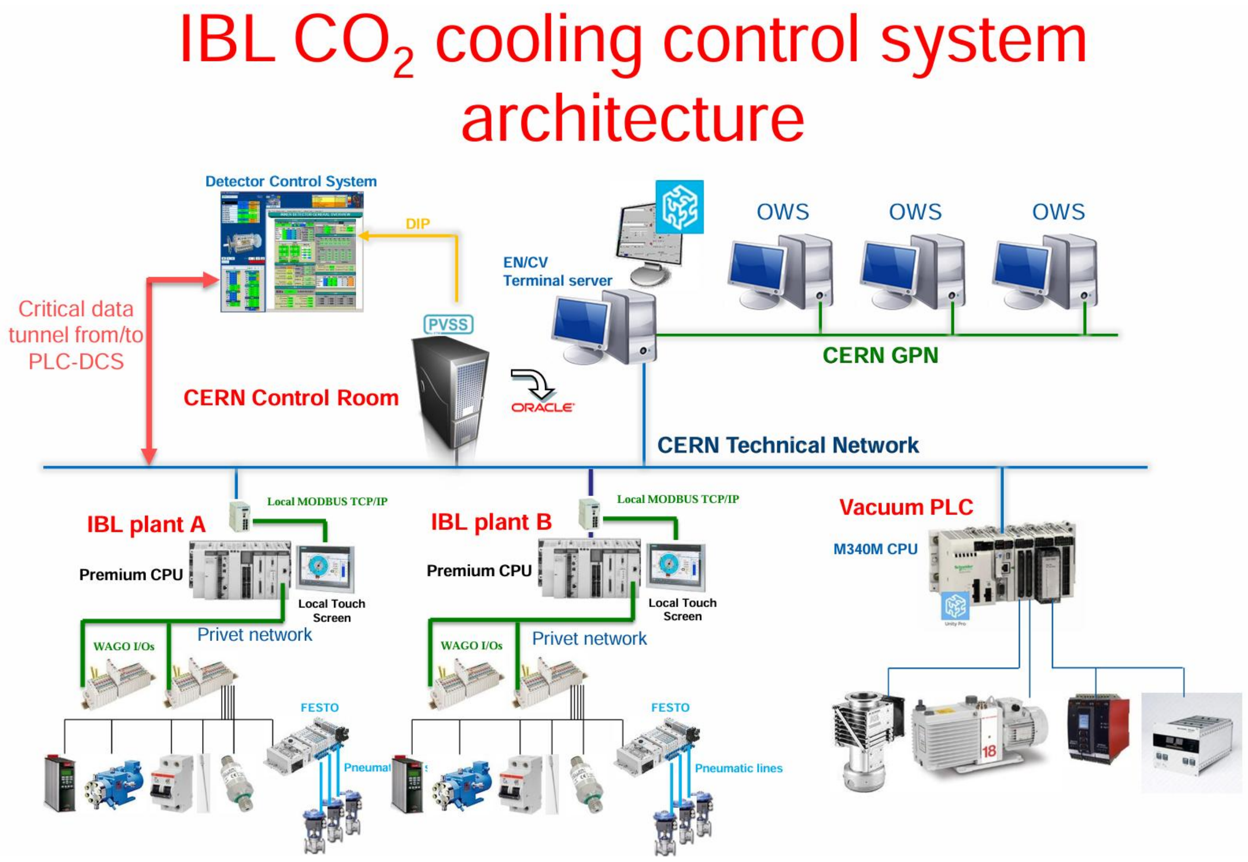
•**蓄能器**：与系统并联，始终包含液态和气态CO_2的饱和混合物。蓄能器温度直接决定系统饱和压力（即蒸发温度）。

•**关键组件**：泵、内部热交换器、蒸发器、冷凝器、蓄能器。

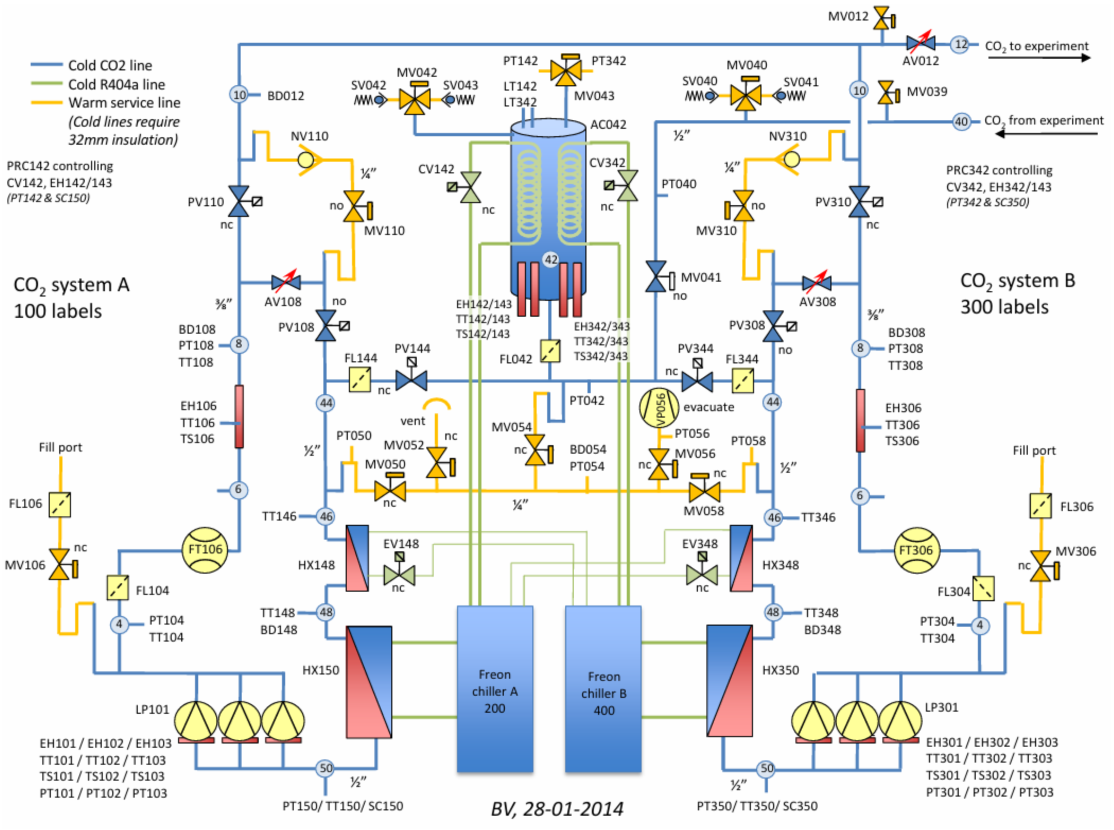
二氧化碳两相冷却控制系统

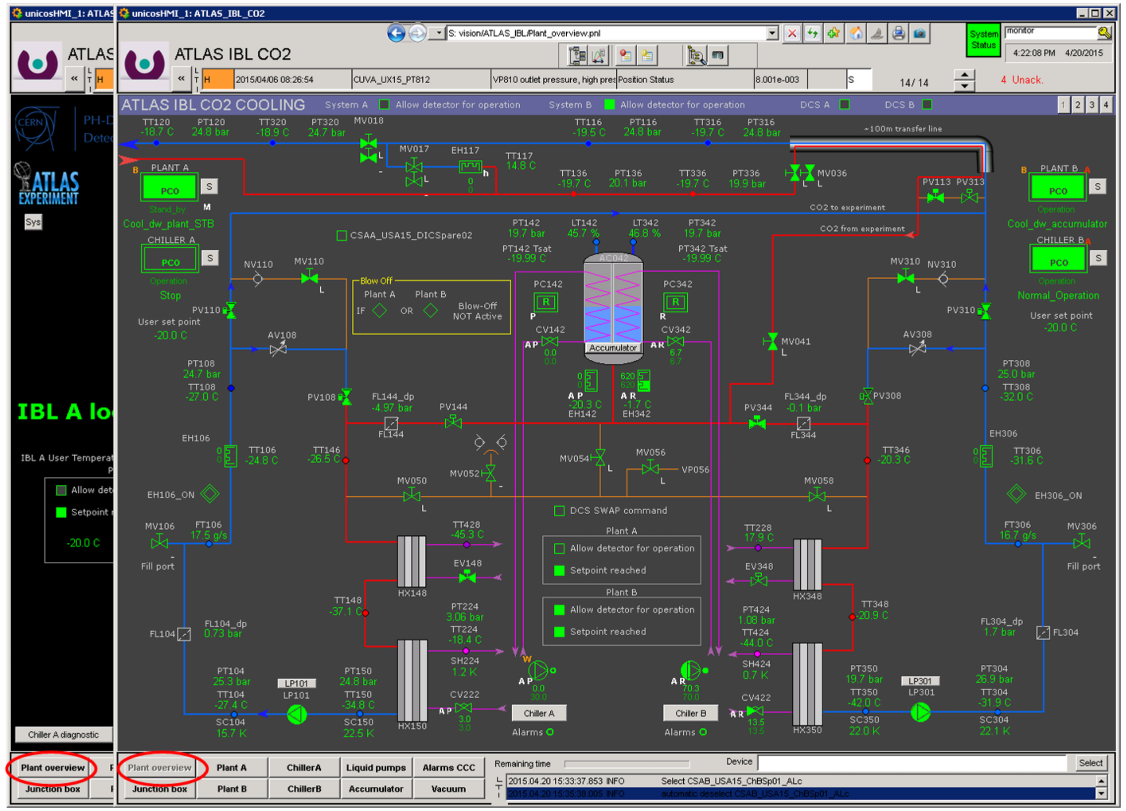
CERN开发的标准化工业控制系统框架，集成SCADA、PLC和现场层设备，支持模块化编程与自动化代码生成





Atlas IBL CO2 cooling plants





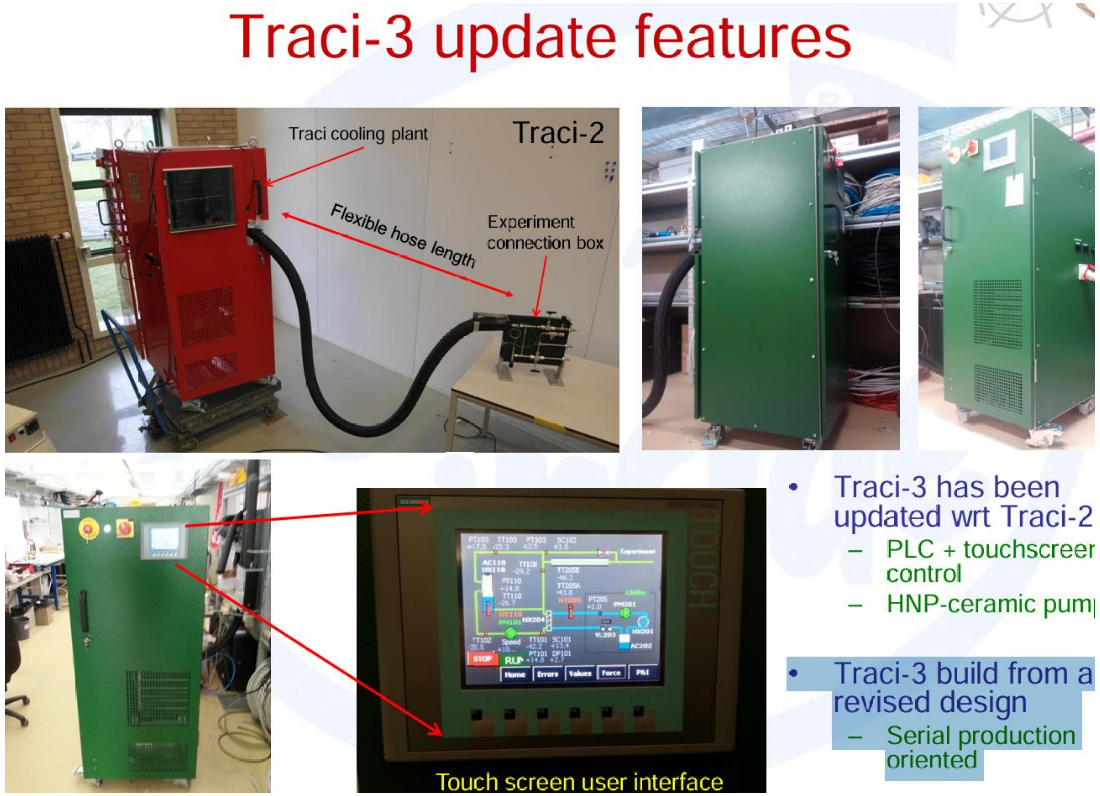
主要系统元素：

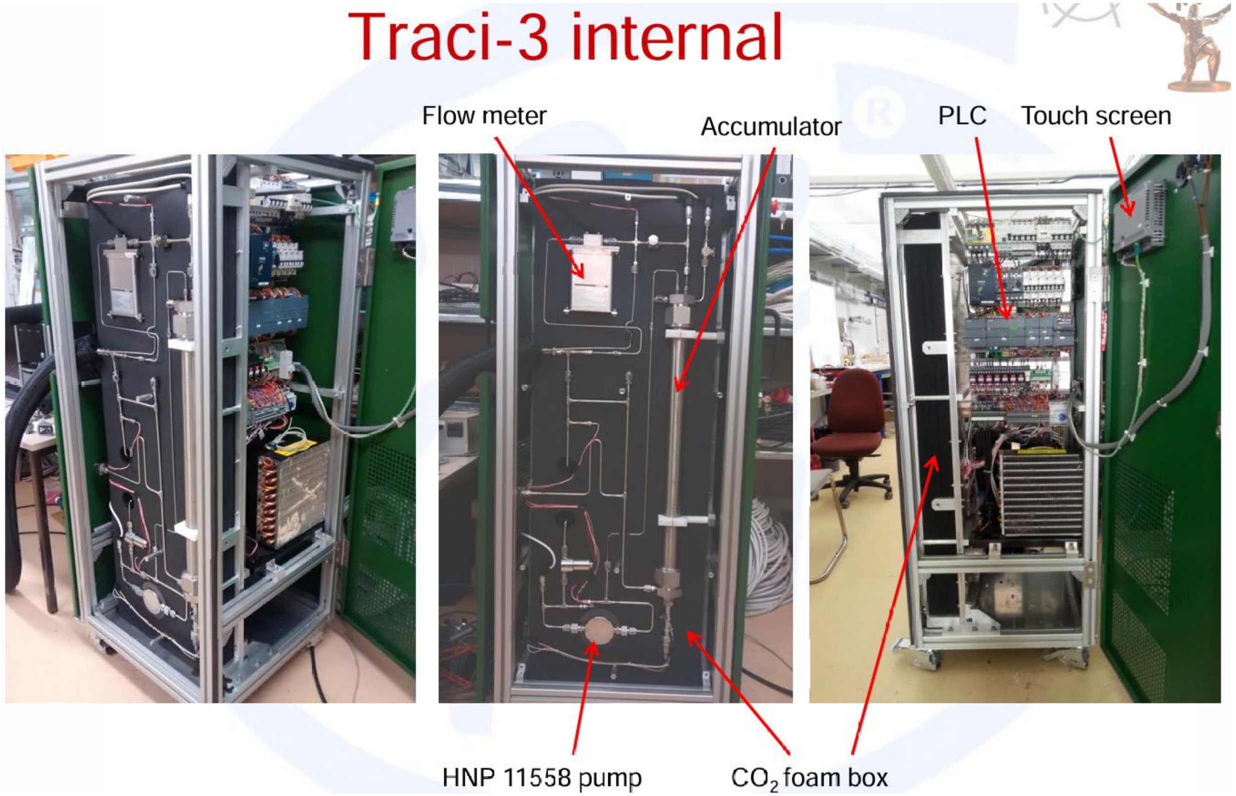
2个独立的、冗余的冷却站核心

2个独立的、冗余的两级冷冻机

1个带有冗余控制的共同蓄冷器

Traci


Traci-3 update features
Traci cooling plant
Traci-2
Flexible hose length
Experiment connection box
Touch screen user interface
• Traci-3 has been updated wrt Traci-2
– PLC + touchscree control
– HNP-ceramic pum
• Traci-3 build from a revised design
– Serial production oriented


Traci-3 internal
Flow meter
Accumulator
PLC
Touch screen
HNP 11558 pump
CO_2 foam box

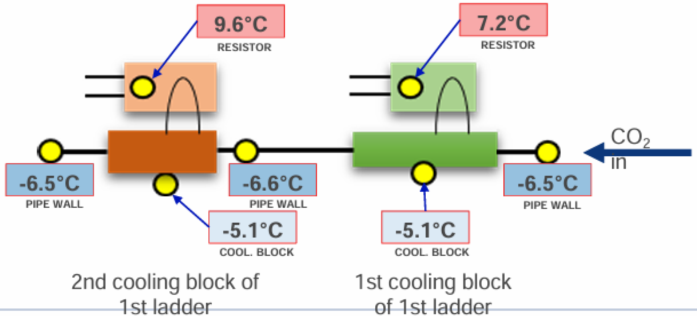
Traci

实验对象:
CMS Outer Tracker的CO_2冷却管道系统，重点测试TB2S ladders串联结构的温度分布及预热器性能。
核心目标:
评估CO_2两相流在低温条件下的热传递效率。
验证预热器对液态CO_2向两相流转换的作用。
识别冷却系统的潜在问题（如干燥现象、热接触不良）

Results – “Module” Temperatures

CO2 Set Point	28 bar (-8 °C)
Dummy Load Power	144 W
Preheater Power	10 W
Flow	1.44 g/s

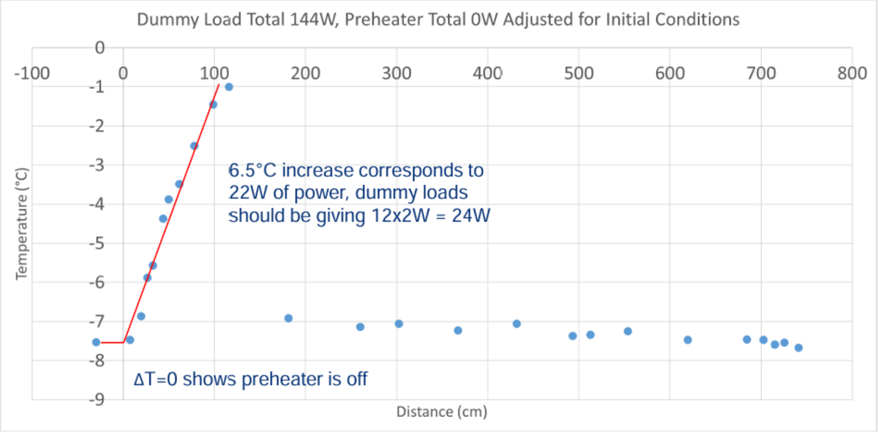
- Comparison of measured temperatures on the pipe wall, on the cooling blocks and on the resistor plates with 2W per resistor.
- Cooling blocks close in temperature to the pipe wall (ΔT_{max}=1.5°C).
- Resistors hotter than cooling block (ΔT_{max}=14.7°C).
- Thermal paste was used (DC 340), however it may be interesting exploring this thermal contact further.



Results – Dummy Loads Only

CO2 Set Point	28 bar (-8 °C)
Dummy Load Power	144 W
Preheater Power	0 W
Flow	1.44 g/s

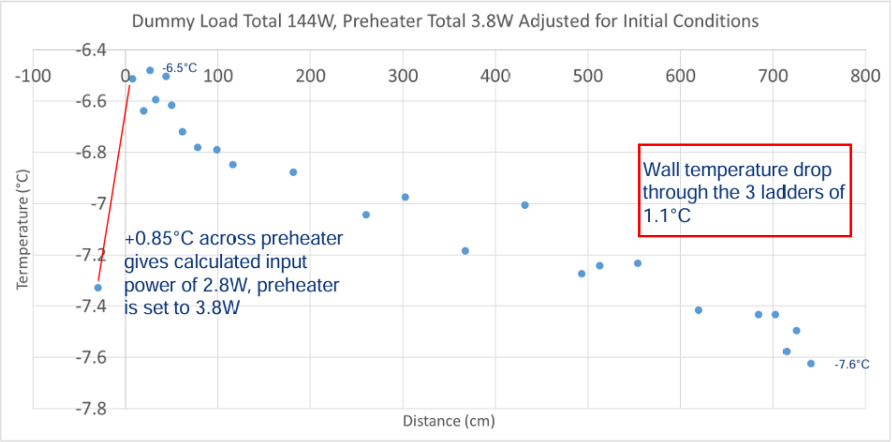
- Superheating visible, ΔT consistent with fully liquid flow, before sudden transition.



Results – Preheater Turned On

CO2 Set Point	28 bar (-8 °C)
Dummy Load Power	144 W
Preheater Power	3.8 W
Flow	1.44 g/s

- Two phase flow after preheater, with 1.1°C temperature drop due to pressure drop.
- Power of 148W gives ≈40% vapour quality.



目前两相流仿真需要完善的地方：

正确定义因压降而变化的沸腾温度

需要的计算资源更多，对计算性能要求更高

下一步工作计划：

做一个类似于Traci的小型二氧化碳冷却样机进行二氧化碳两相流实验