



千瓦级国产氦制冷机工程研制进展

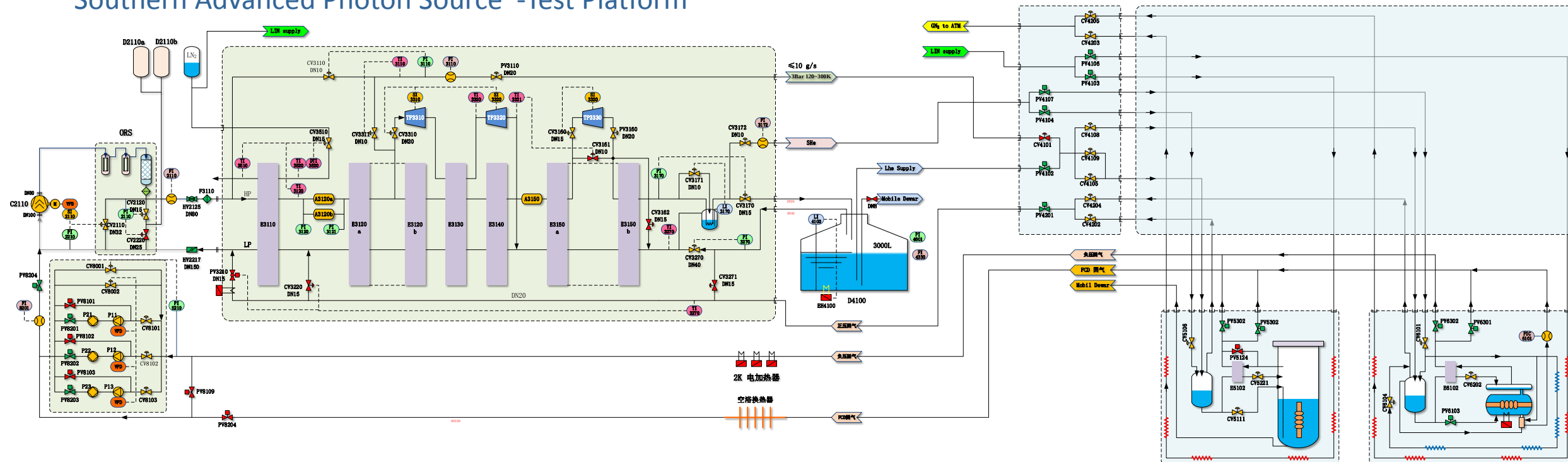
Development of Kilowatt Class 4.5K Helium Refrigerator

Lianyou XIONG

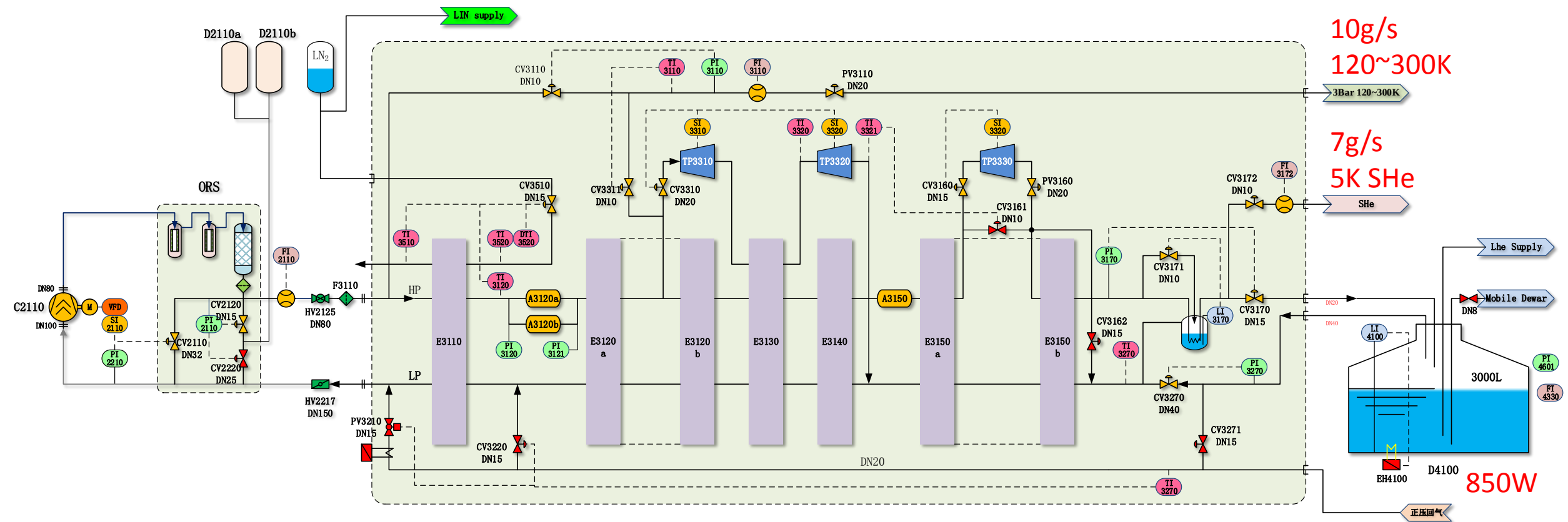
2021-10-24

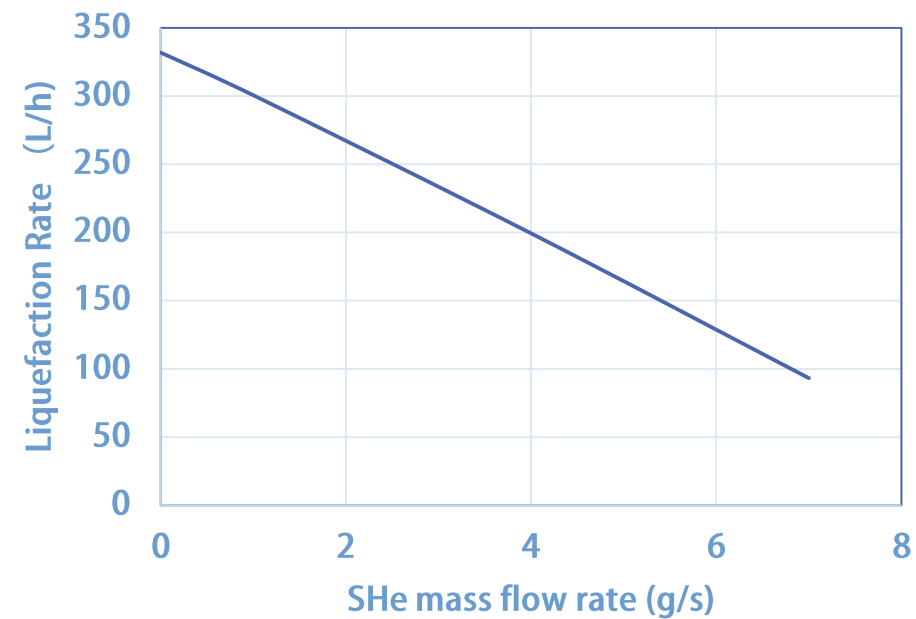
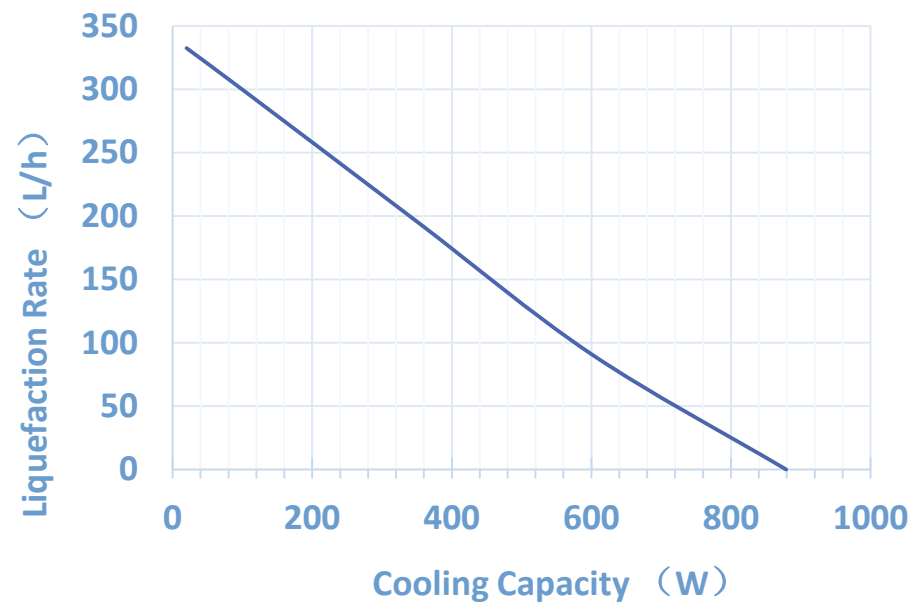
南方光源研究测试平台 SAPS-TP

Southern Advanced Photon Source -Test Platform

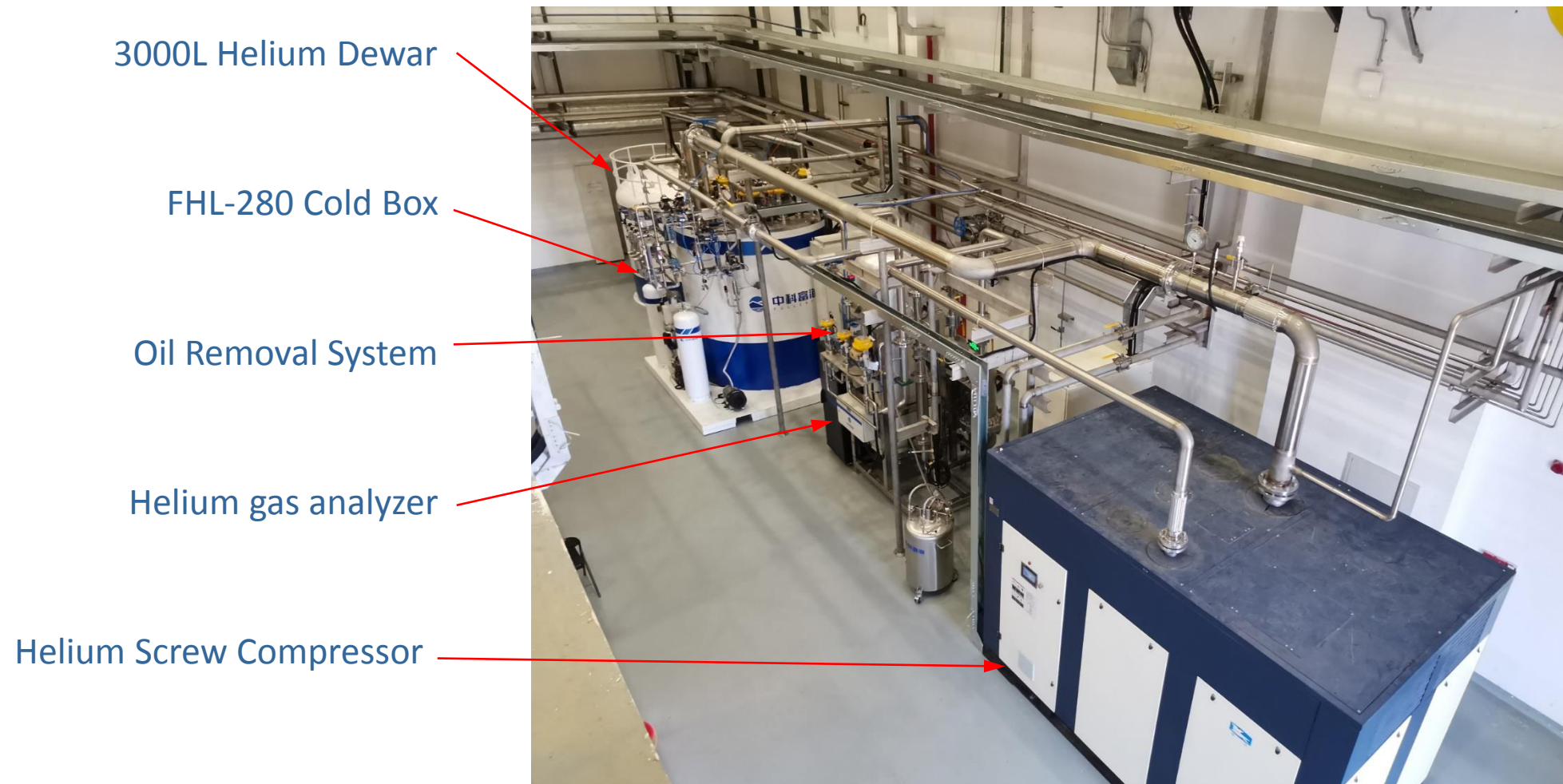


No.	Mode	Capacity requirements
1	Refrigeration mode (with LN ₂ Precooling)	Cooling Power: 850W@4.5K
2	Liquefaction mode (with LN ₂ Precooling)	Liquefaction rate: 280L/h
3	Mixing mode (with LN ₂ Precooling)	Cooling Power: 300W@4.5K Liquefaction rate: 150L/h





FHL-280 Cryogenic System Layout at SAPS-TP site



3000L Helium Dewar



FHL-280 Cold Box

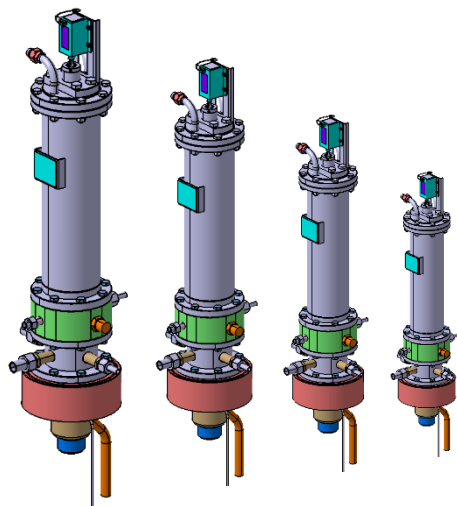
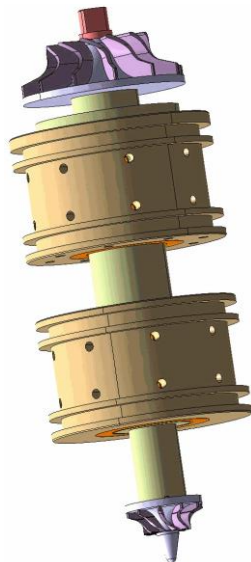


Oil Removal System & Helium gas analyzer



Helium Screw Compressor





Serialized Turbo-expanders

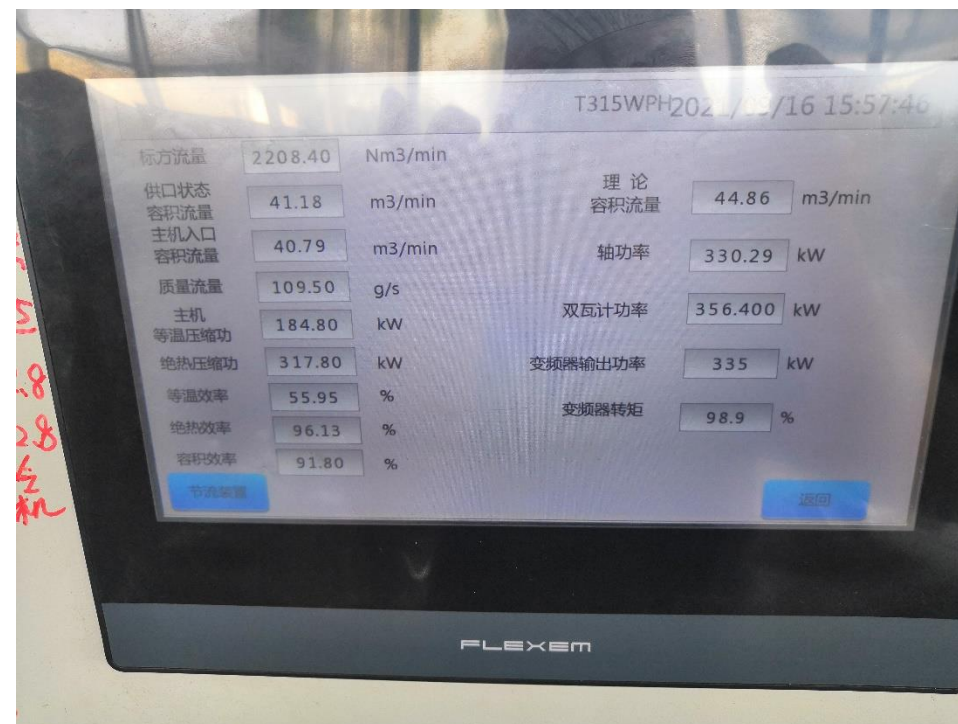
Helium liquefier	FHL-40	FHL-70	FHL-100	FHL-140	FHL-180	FHL-240	FHL-280	FHL-400
Liquefaction Capacity L/h	40~70	70~100	100~140	140~180	180~240	240~280	280~310	310~420
Compression power kW	75~90	90~132	132~160	160~200	200~250	250~315	315~355	355~425

Helium refrigerator	FHLR-40	FHLR-70	FHLR-100	FHLR-140	FHLR-180	FHLR-240	FHLR-280	FHLR-400
Refrigeration Capacity W	160 ~250	250~320	320~450	450 ~580	580~750	750 ~900	900 ~1000	1000 ~1800
Compression power kW	75~90	90~~132	132~160	160~200	200~250	250~315	315~355	355~425



Serialized Cold Boxes

Oil-injected Helium gas Screw compressor (T315WPH)



FAT results:

- Adiabatic efficiency : > 85%
- Noise: 78 db

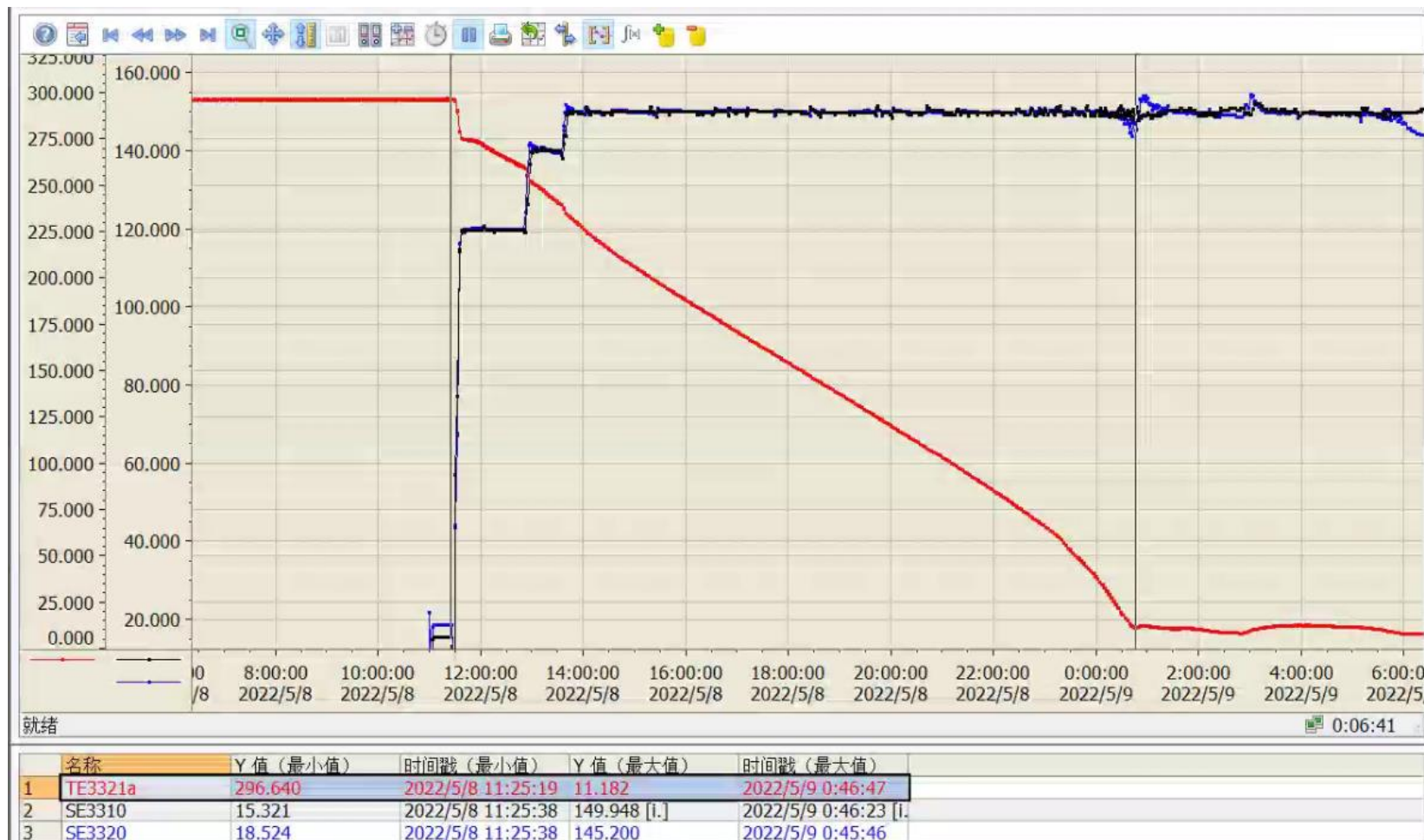


Serialized Helium Dewar

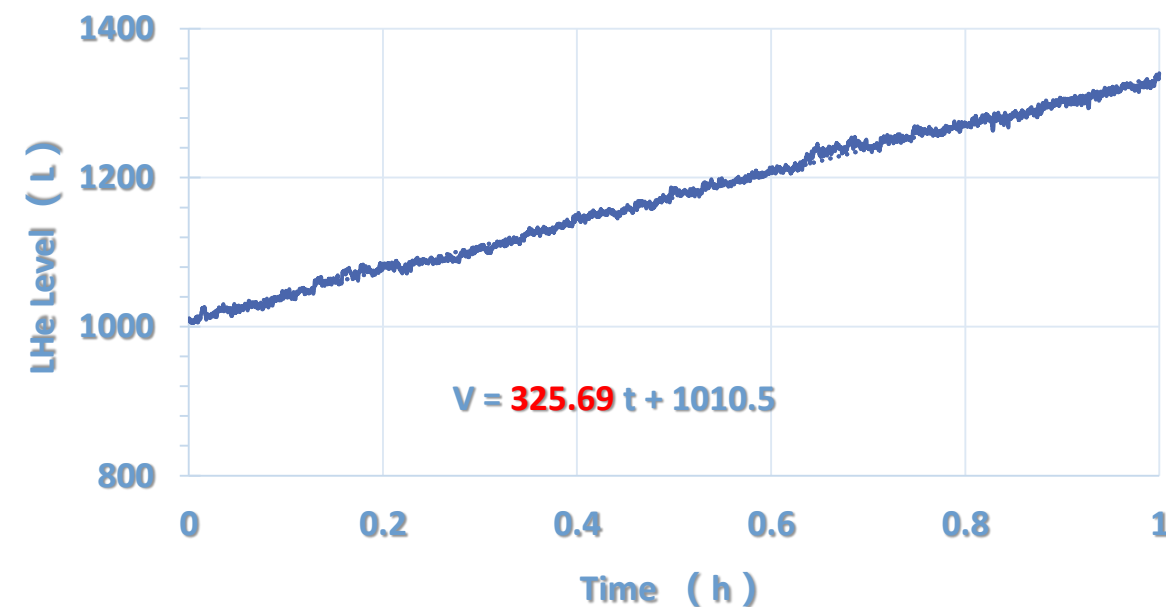
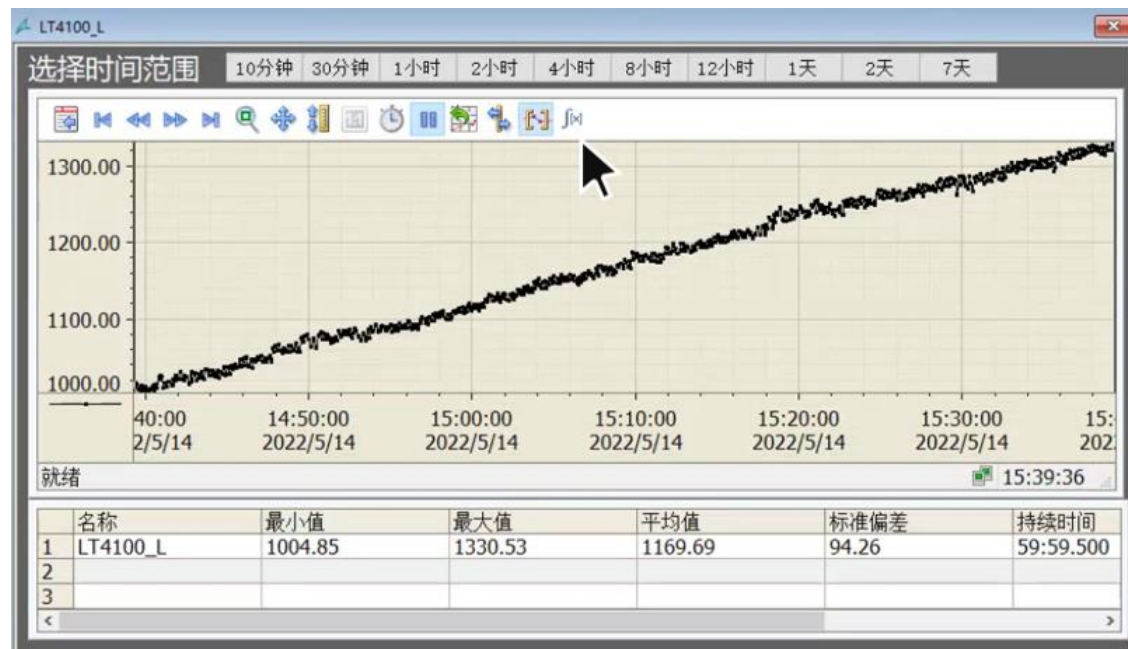
Technical Data	Capacity L	Weight empty kg	Static Evaporation rate %/ day	Working pressure MPa	Design pressure MPa	Diameter mm	Height mm
FHDW-100	100	100	1.5	0.07	0.09	650	1500
FHDW-150	150	130	1.45	0.07	0.09	750	1550
FHDW-200	200	160	1.25	0.07	0.09	850	1600
FHDW-250	250	160	1.25	0.07	0.09	850	1700
FHDW-350	350	180	1.2	0.07	0.09	850	1800
FHDW-400	400	235	1.2	0.07	0.09	850	1800
FHDW-500	500	260	1	0.07	0.09	1100	1900
FHDW-1000	1000	450	0.8	0.07	0.09	1400	2050
FHDW-2000	2000	950	0.8	0.07	0.09	2000	2200
FHDW-3000	3000	1400	0.8	0.07	0.09	2000	2610
FHDW-5000	5000	2300	0.5	0.07	0.09	2400	3200
FHDW-10000	10000	5000	0.5	0.07	0.09	2600	4100
FHDW-20000	20000	5950	0.3	0.07	0.09	3300	4220



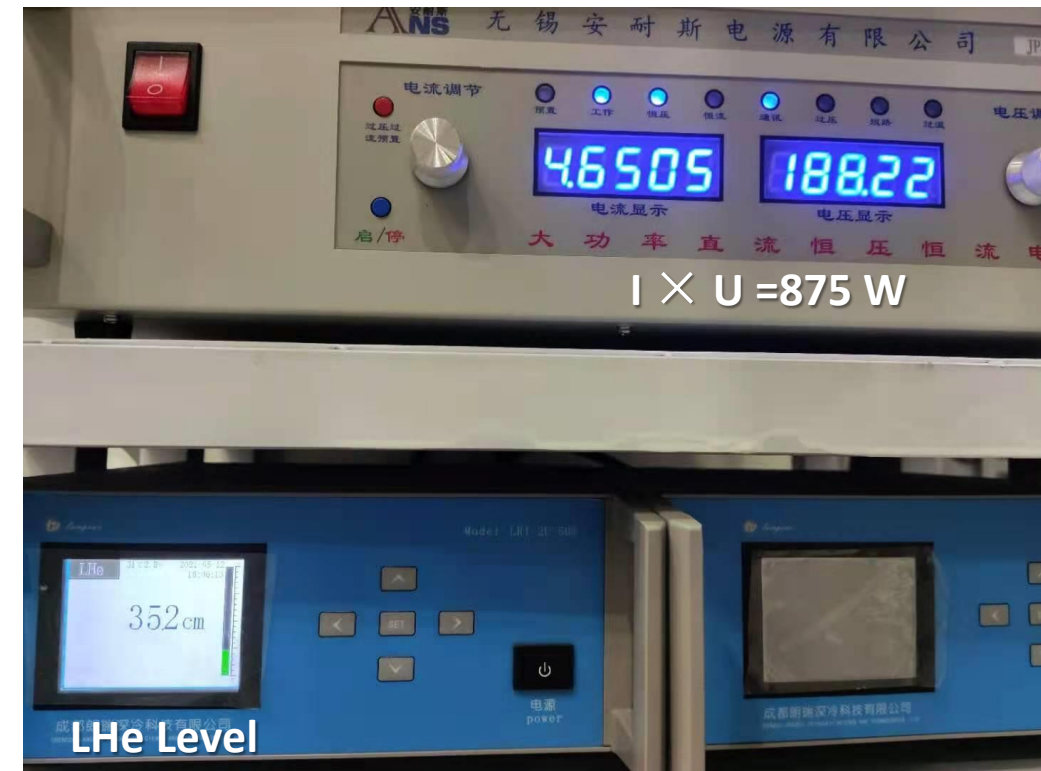
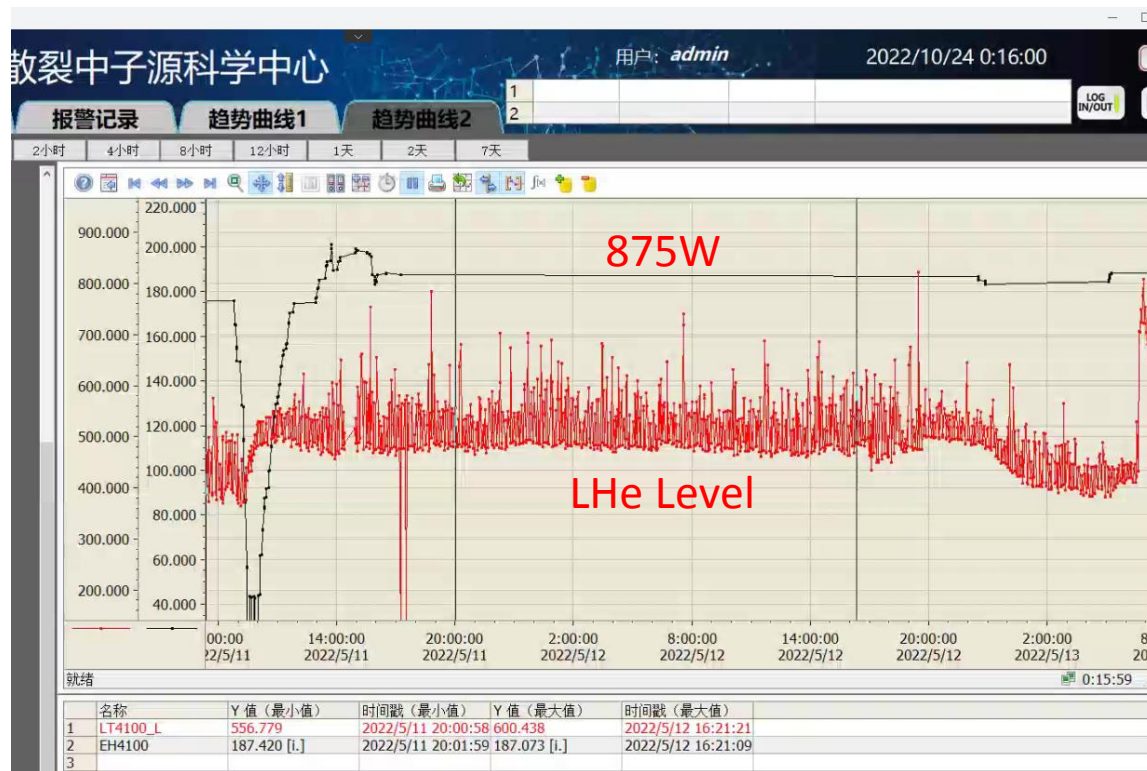
	Helium gas analyzer
Model	HY-0080P-HEM
Gas	Helium gas (5N)
Feeding pressure	10 ~16 bara
Return pressure	1~1.5 bara
Gas tight	$<1 \times 10^{-7} \text{Pa.m}^3/\text{s}$
H ₂ O Measuring range	0~200vpm
N ₂ Measuring range	0~100vpm
CxHy Measuring range	0~30vpm
Oil Measuring range	0~250ppb
Measuring Accuracy	$\pm 2 \text{ (ppb/vpm) / 10\%}$
Resolution	0.1 vpm (Gas) / 1 ppb (Oil)
I/O	DC 4/ 4~20mA
Power Supply	AC220V $\pm$ 10%, 50Hz <600W
Size	600×800×1600mm
Weight	170kg



FHL-280 Cool-down with Warm Dewar



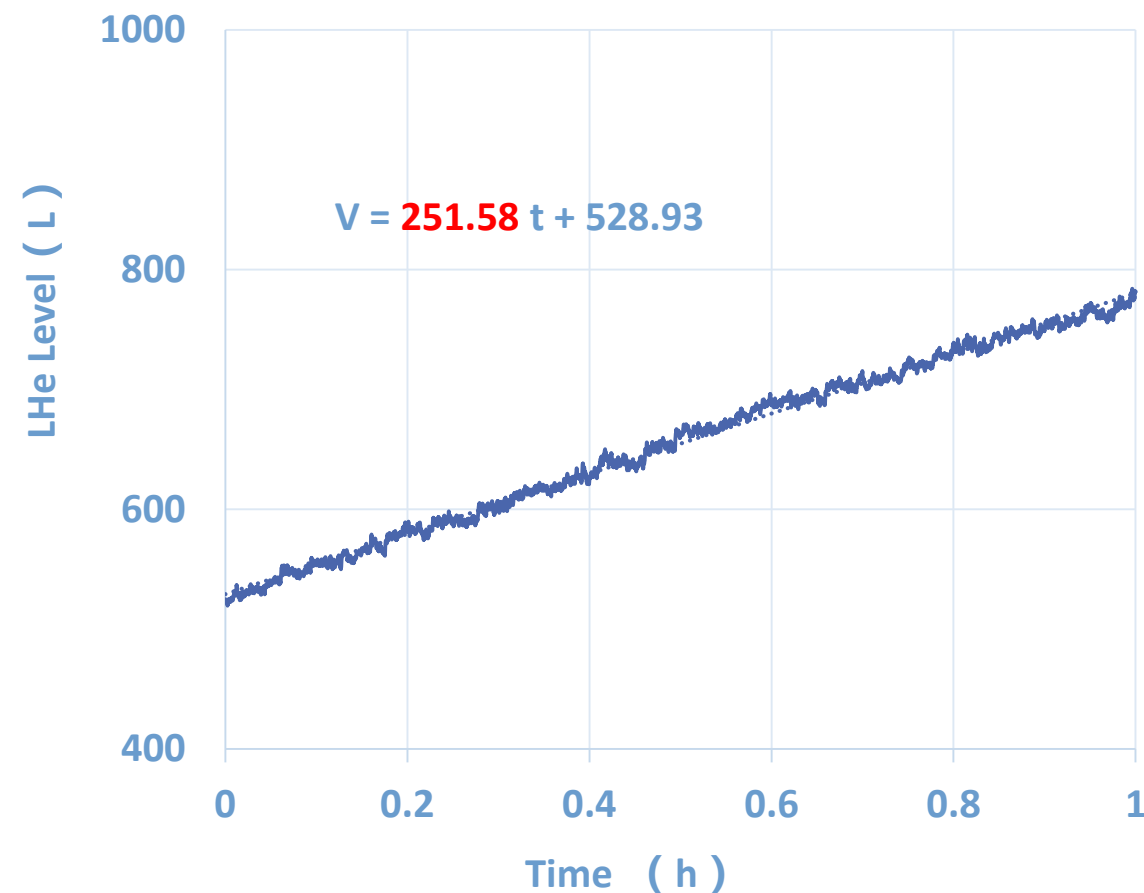
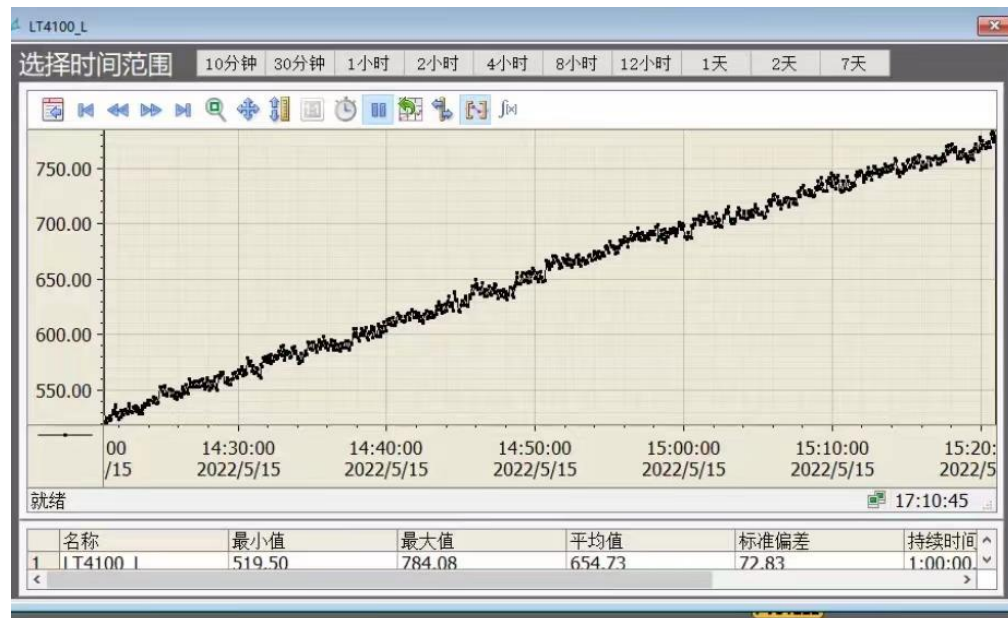
FHL-280 Liquefaction Performance Test



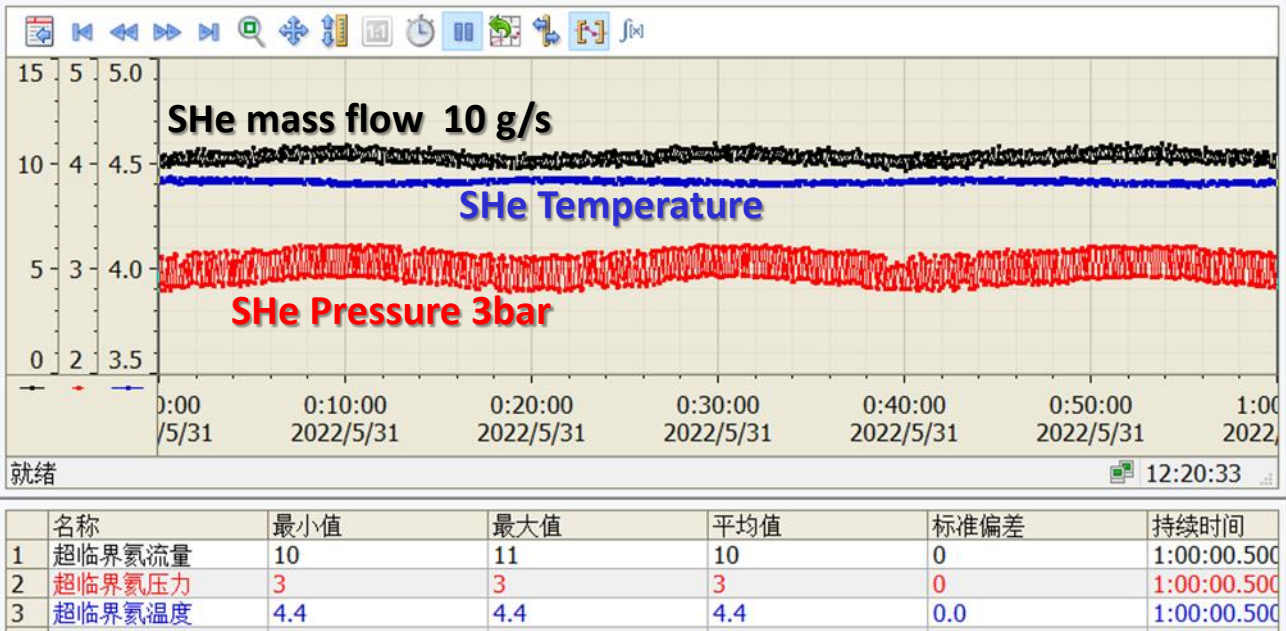
FHL-280 Refrigeration Performance Test



FHL-280 Refrigeration Performance Test



FHL-280 Mixing mode Performance Test



FHL-280 SHe Supply Test



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南方光源研究测试平台制冷机调试成功

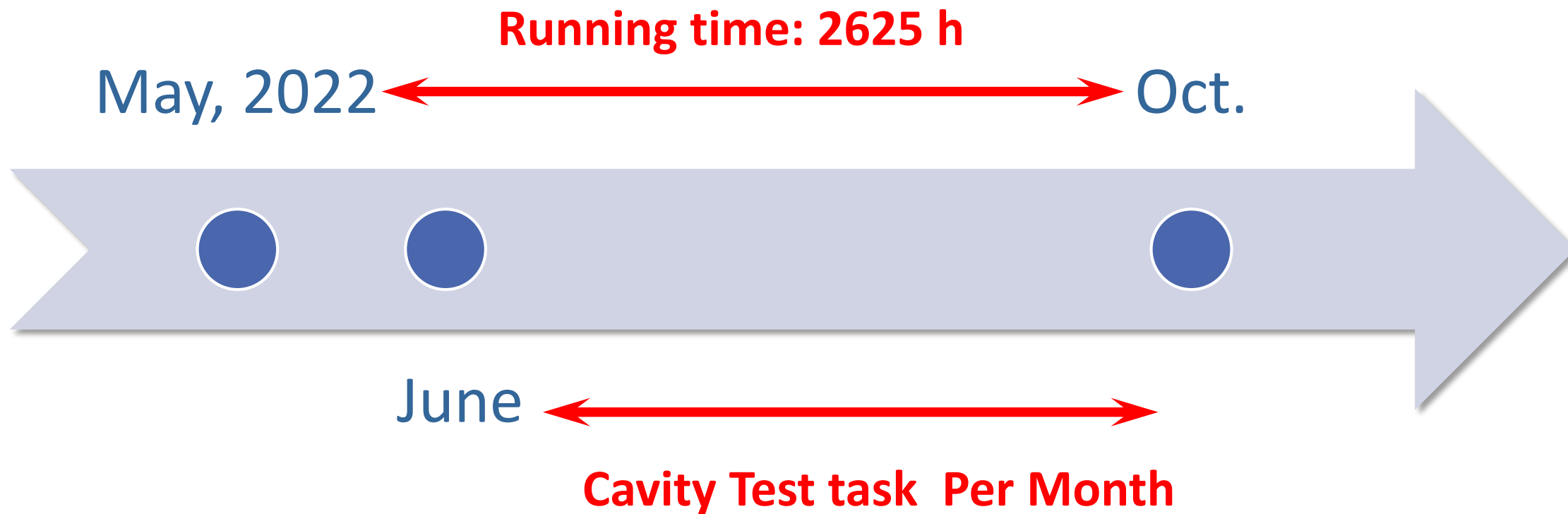
2022-05-18 | 文章来源: 东莞研究部 | 【大 中 小】

5月16日,南方光源研究测试平台项目850W@4.5K国产氦制冷机在项目现场调试成功,测试结果表明其关键技术指标均优于合同规定的验收指标。

大型氦制冷机涉及的设备多,工艺复杂,施工难度大。项目组克服了设备组装、调试的困难以及疫情的影响,坚守岗位,稳步推进,4月初成功产出液氦。近一个月的制冷功率测试过程中,持续24小时运行工况下,制冷机稳定提供850W@4.5K冷量。此外,项目组还完成了液化率测试和混合工况测试等。

氦制冷机是南方光源研究测试平台的关键设备之一,该套氦制冷机设备的调试成功,为实现超导腔在2K温区的垂直测试和水平测试提供了有力的技术保障和支持。

大型氦制冷机在国内外各种大科学装置上都有广泛的应用,但相关产品一直依赖进口。本次研制的国产850W@4.5K氦制冷机依托南方光源研究测试平台开展,其成功调试表明项目实现了关键核心设备的国产化突破,并为未来相关大型氦制冷机的研制积累了宝贵的经验,为氦制冷机研发的自主创新能力提升和产业化提供了有力的技术保证。





FHL-400 Helium liquefier

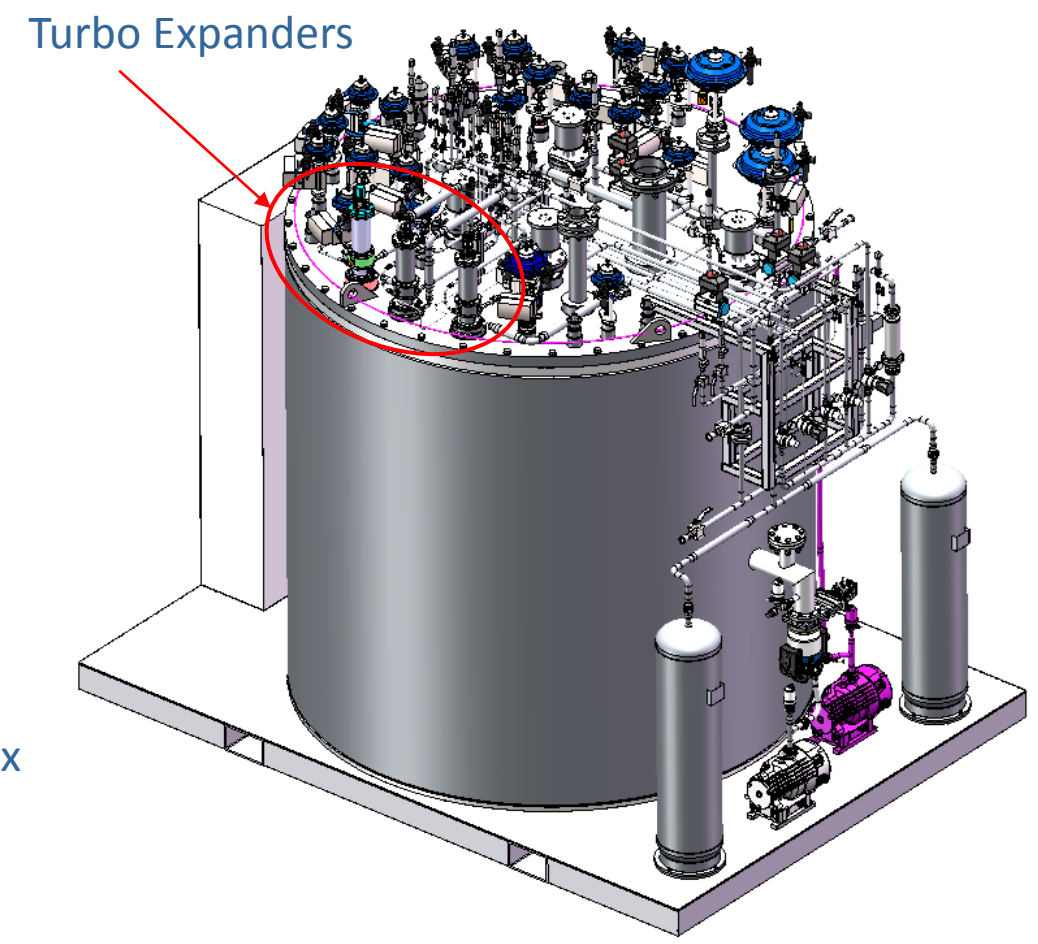
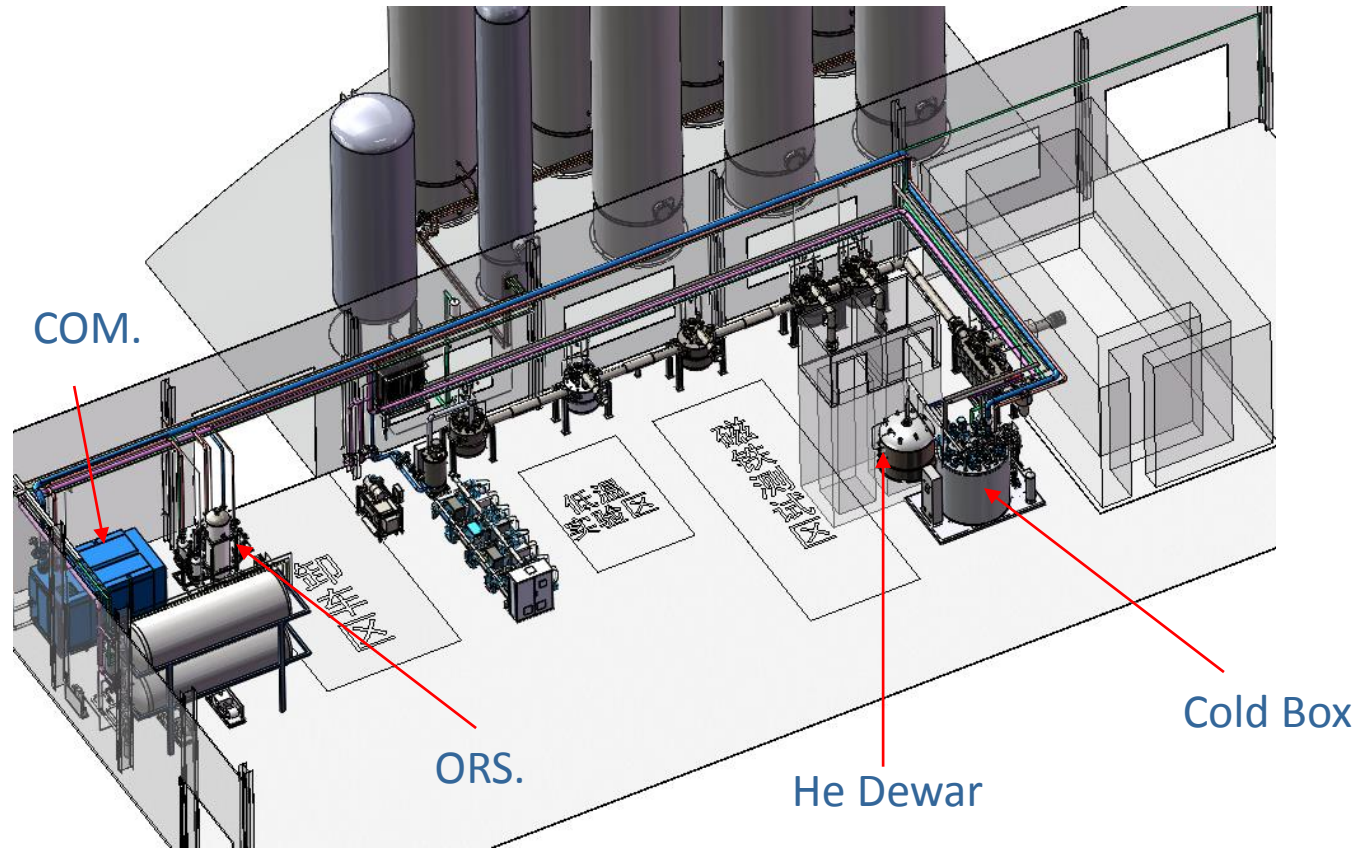
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Advanced Energy Science and Technology Guangdong Laboratory

Mode	SC Cavity LHe (g/s)	Coupler 4.5-75K (W)	Thermal shield 50-75K (W)	4.5K Equivalent Capacity (W)	Compression Power (kW)	COP ⁻¹ (W/W)
2K Mode	11.3	1073	1340	1388	440	317
2K Standby (wo LN ₂)	3.4	305	473	419	400	955
4.5K Standby (wo LN ₂)	3.49	317	472	430	348	810



FHL-400 Helium liquefier Layout





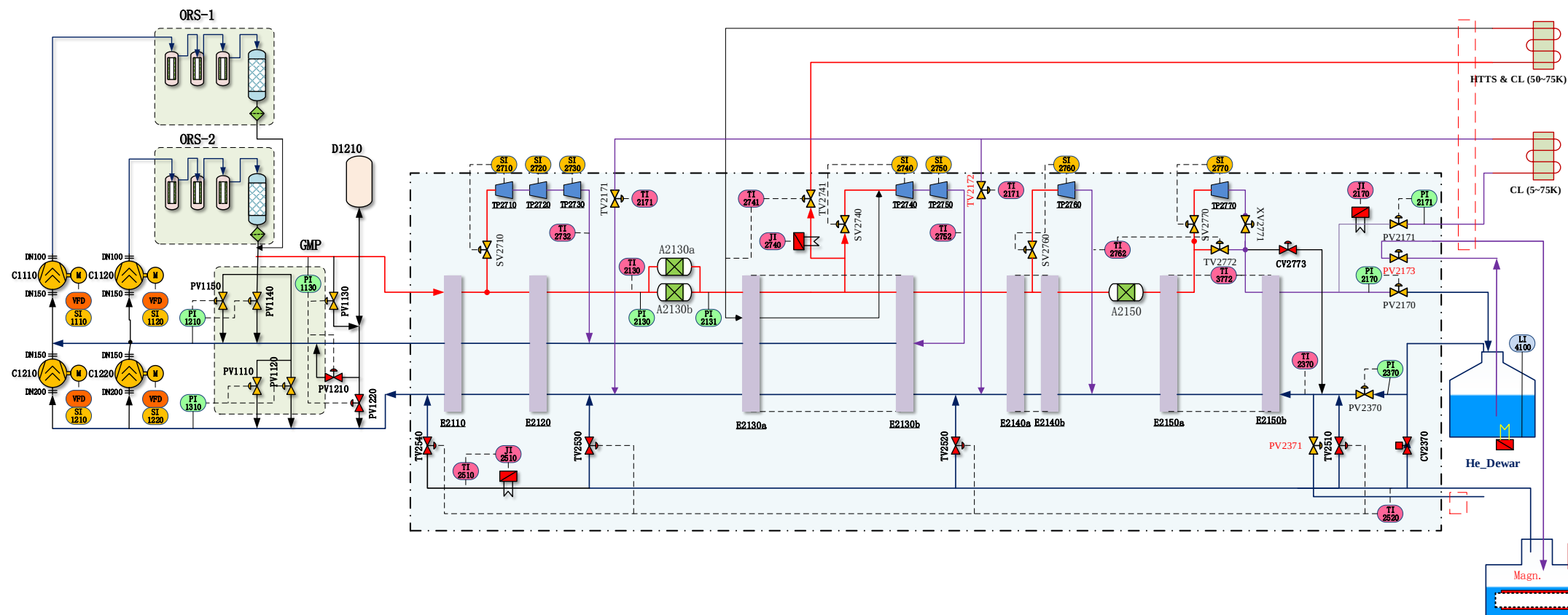
FHR-4000W@4.5K Helium Refrigeration Equipment

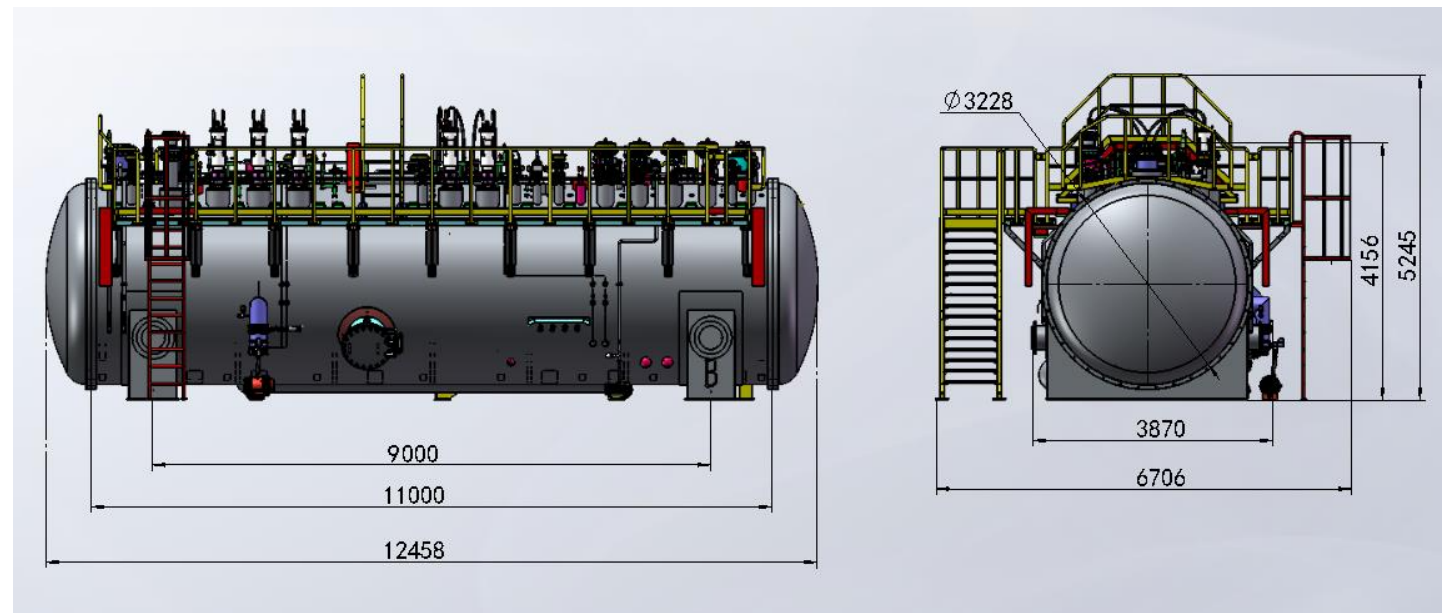
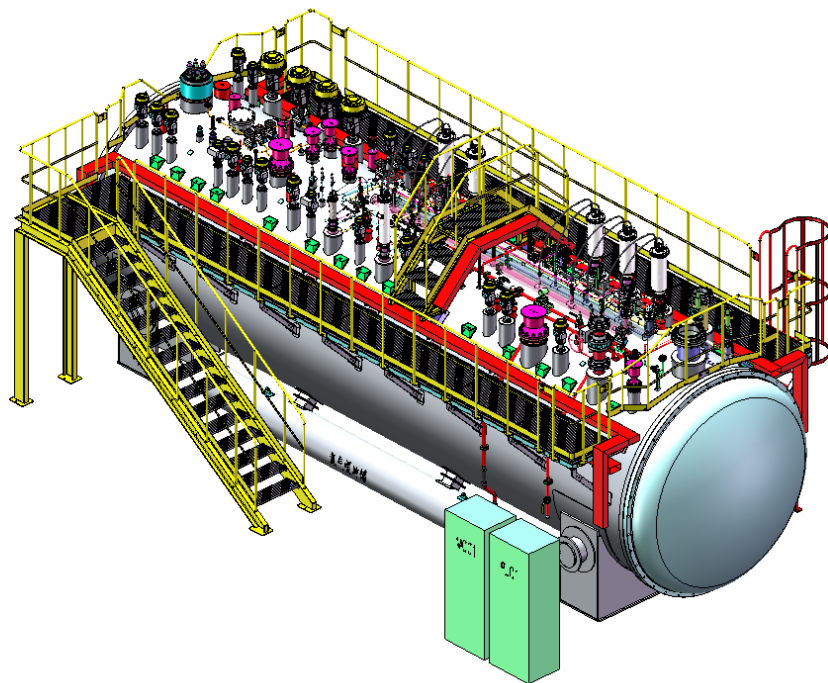
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Technical Data	Requirements	Equivalent performance @ 4.5K
Refrigeration capacity @ 4.5K (SC Magnet)	≥ 2350 W	2350 W
Refrigeration capacity @ 5-75K (Thermal Shield)	≥ 3165 W	543 W
Refrigeration capacity @ 50-75K (SC current leads)	≥ 12.9 kW	753 W
Total Equivalent Refrigeration capacity @ 4.5K		3646

FHR-4000W@4.5K Helium Refrigeration Equipment





~ 55 tone

Thanks

