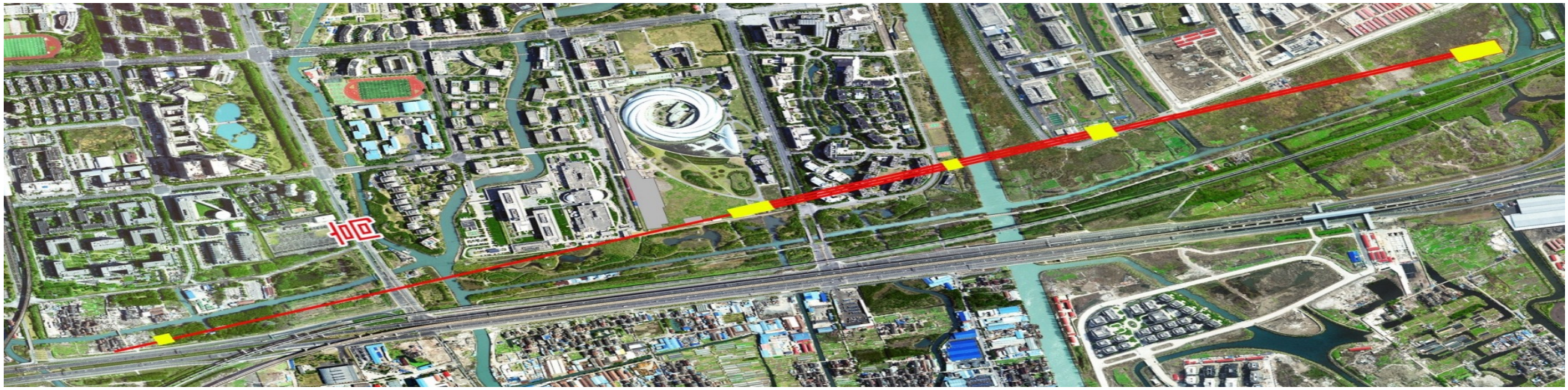
Asian School on Superconductivity and Cryogenics for Accelerators (ASSCA 2025)

Cryogenic Engineering in SHINE

Prof. Ouyang Zhengrong
ShanghaiTech University
(ouyangzhr@shanghaitech.edu.cn)



SHINE

March 28th, 2025

Outline

- **1. Overview of Cryogenic Engineering**
  - Introduction of Cryogenic
  - Introduction of Engineering
  - Overview of Cryogenic system
- **2. Case study - SHINE project**
  - Introduction of SHINE cryogenic system
  - Engineering experience of SHINE cryogenic system
- **3. Lessons Learned**
- **4. Outlook and Summary**

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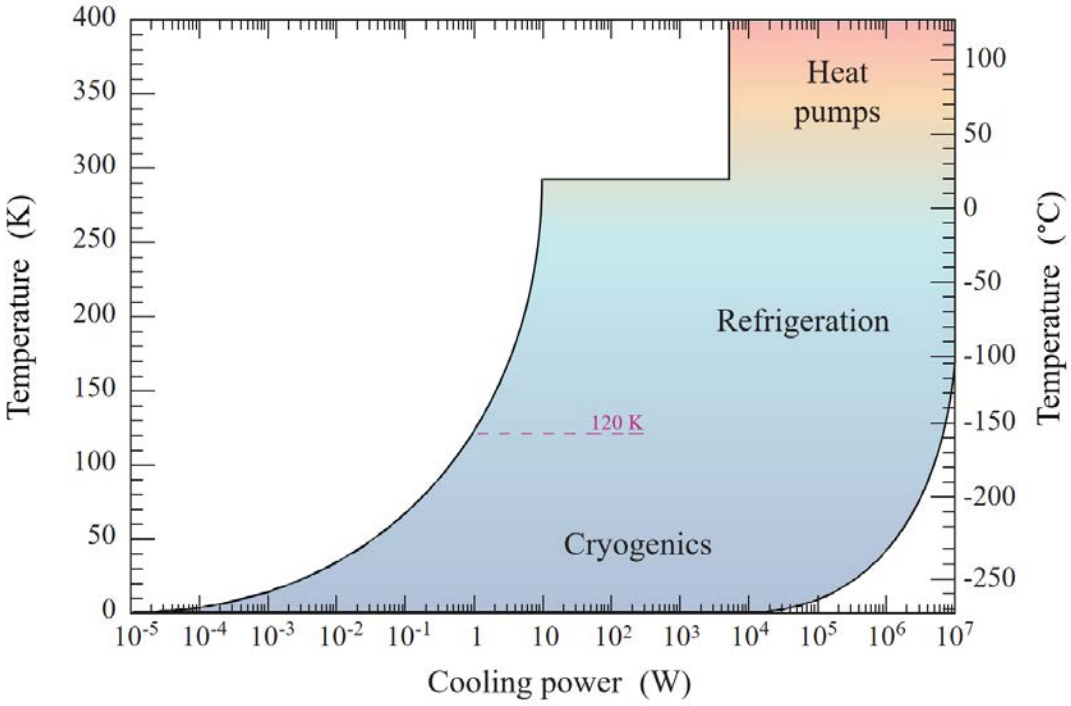
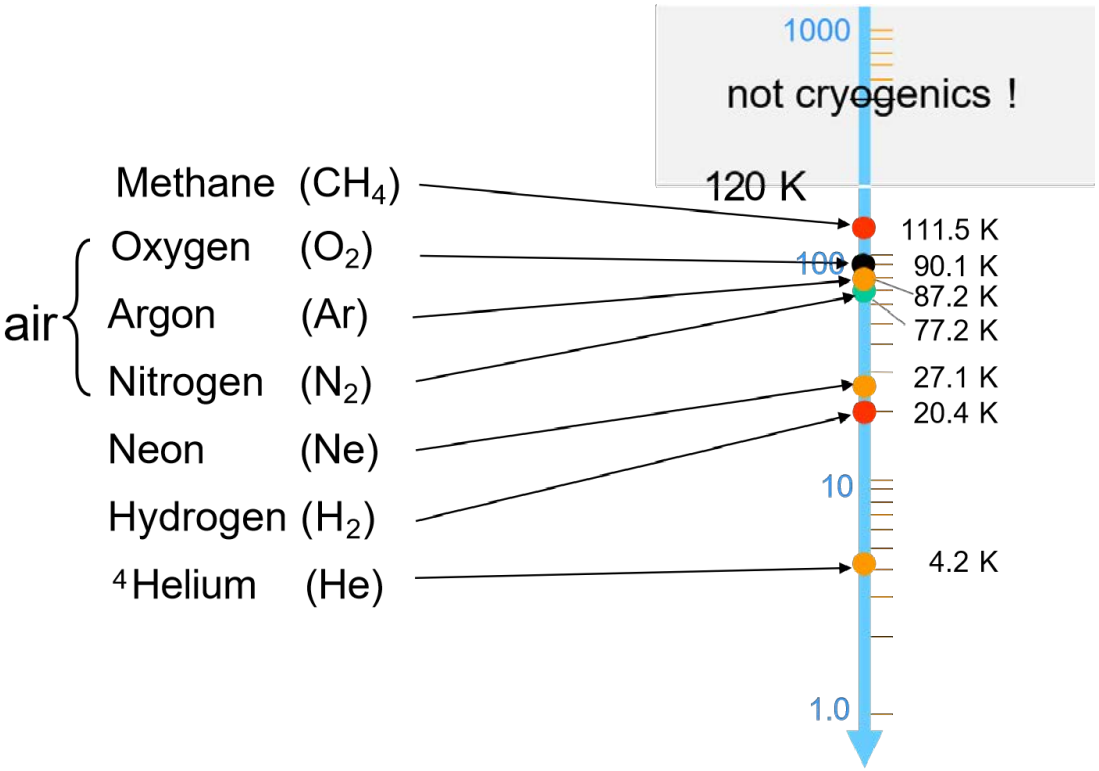
1. Overview of Cryogenic Engineering

- **What is Cryogenic?**





SHINE ➢ **In this lecture we focus on cryogenic >100W@1.8K-4.5K: Cryoplant**

1. Overview of Cryogenic Engineering

- ✓ **Cryogenic engineering** primarily involves technologies related to the production, maintenance, and application of extremely cold temperatures, typically below **120 K)**. Key technical aspects include:
- **Cryogenic Refrigeration & Liquefaction** – Technologies like **Stirling cycles, Gifford-McMahon (GM) coolers, pulse tube , and Joule-Thomson Bryton expansion** for cooling and liquefying gases (e.g., nitrogen, oxygen, helium, hydrogen).

- **Cryogenic Fluid Storage & Handling** – Insulation techniques (**vacuum jackets, multilayer insulation (MLI), superinsulation**) and specialized containers (**Dewar flasks, cryostats**) to minimize heat leakage.

- **Thermal Management & Heat Transfer** – Studying **cryogenic heat exchangers, counterflow designs, and Kapitza resistance** to optimize cooling efficiency.

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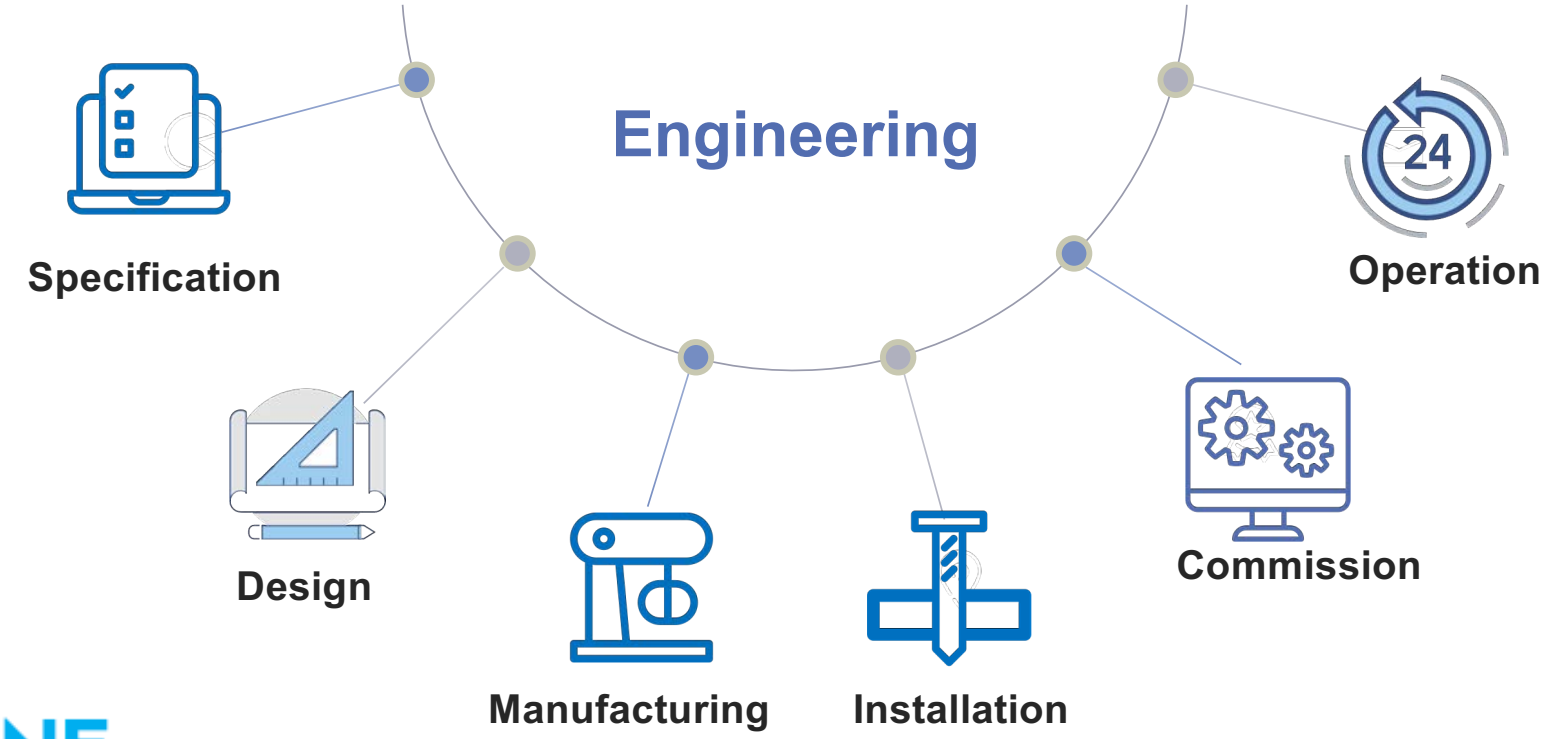
1. Overview of Cryogenic Engineering

- **What is Engineering? In a full life cycle perspective.**



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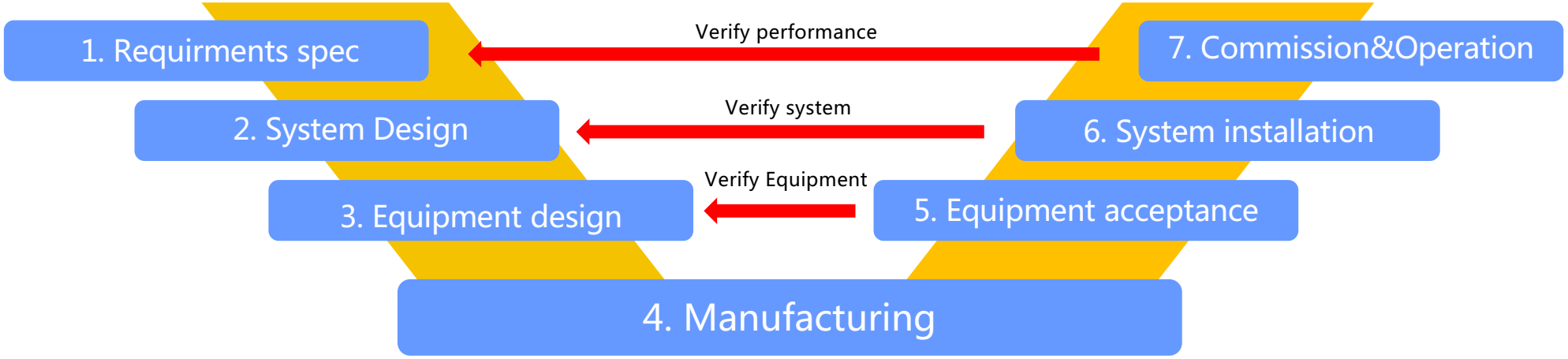
1. Overview of Cryogenic Engineering

- **What is Engineering? In a R&D perspective (V-shaped development)**



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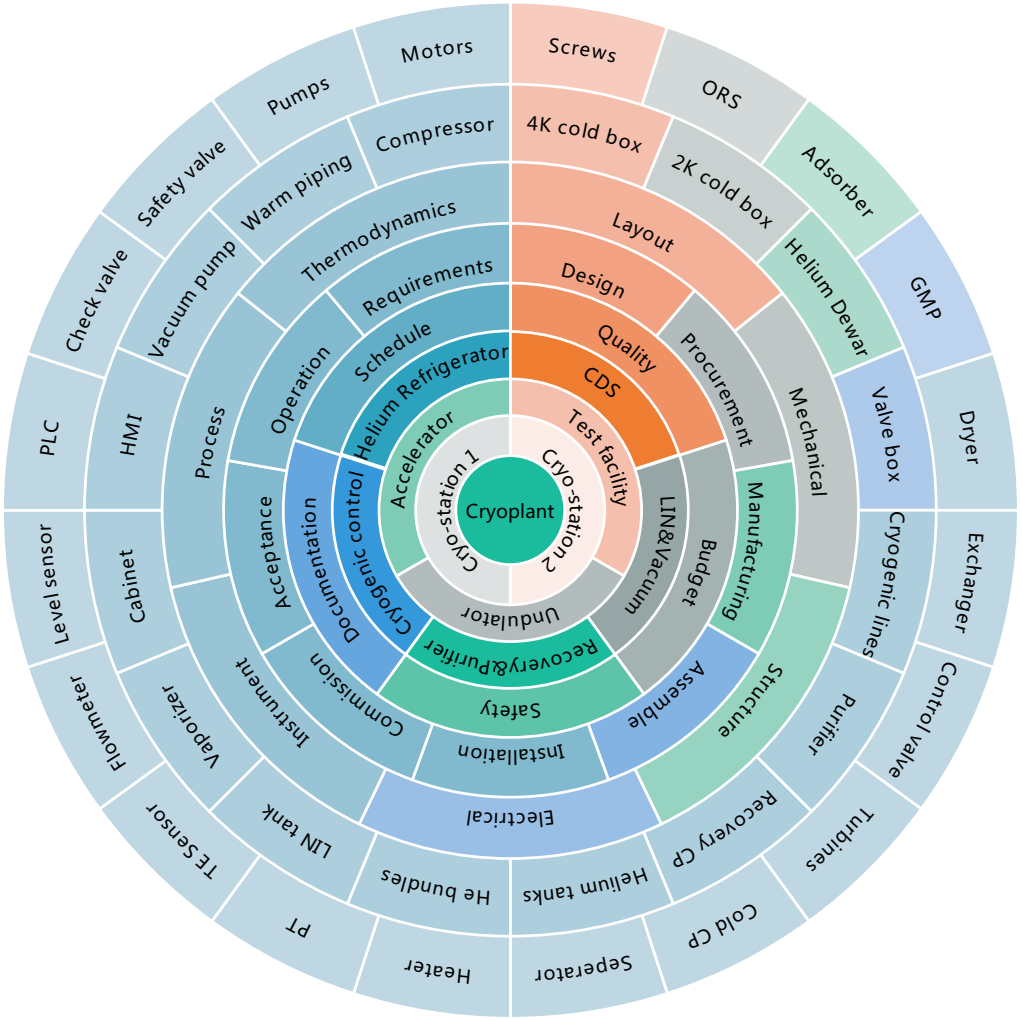
- **Cryogenic Engineering involves lots of development-verfication iterations**

1. Overview of Cryogenic Engineering

- **What is the combination of “Cryogenic” and “Engineering” ?**



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- **Cryogenic Engineering is complicated and takes long time to build**

1. Overview of Cryogenic Engineering

- Cryogenic Engineering is to Consturct the cryoplant follwoing the Blueprint

Blueprint

Cryo plant

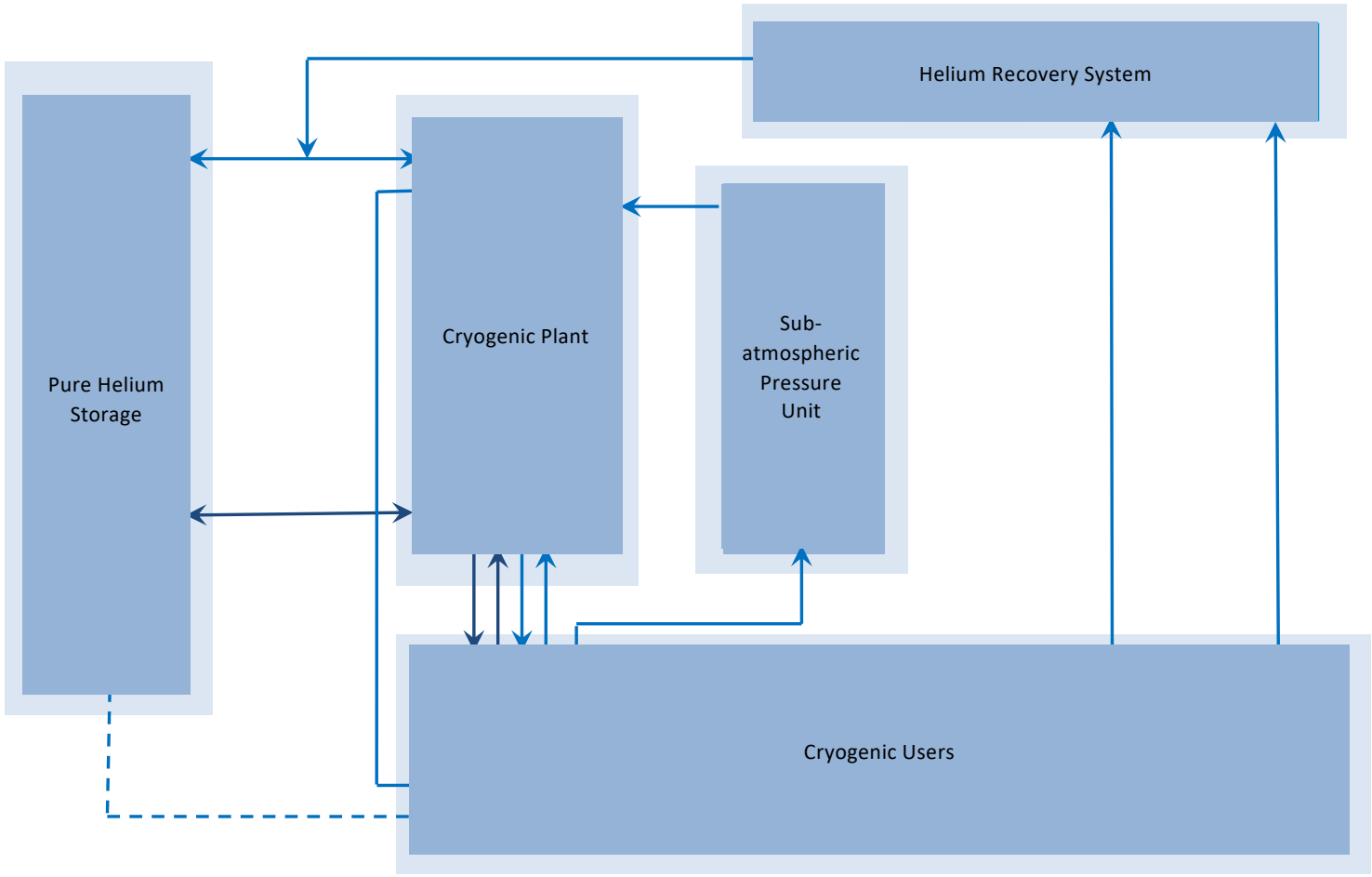
Construction

SHINE

- Cryogenic Engineering is to **Turn your dreams into reality**

1. Overview of Cryogenic Engineering

- **What does a cryogenic system consist of?**



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1. Overview of Cryogenic Engineering

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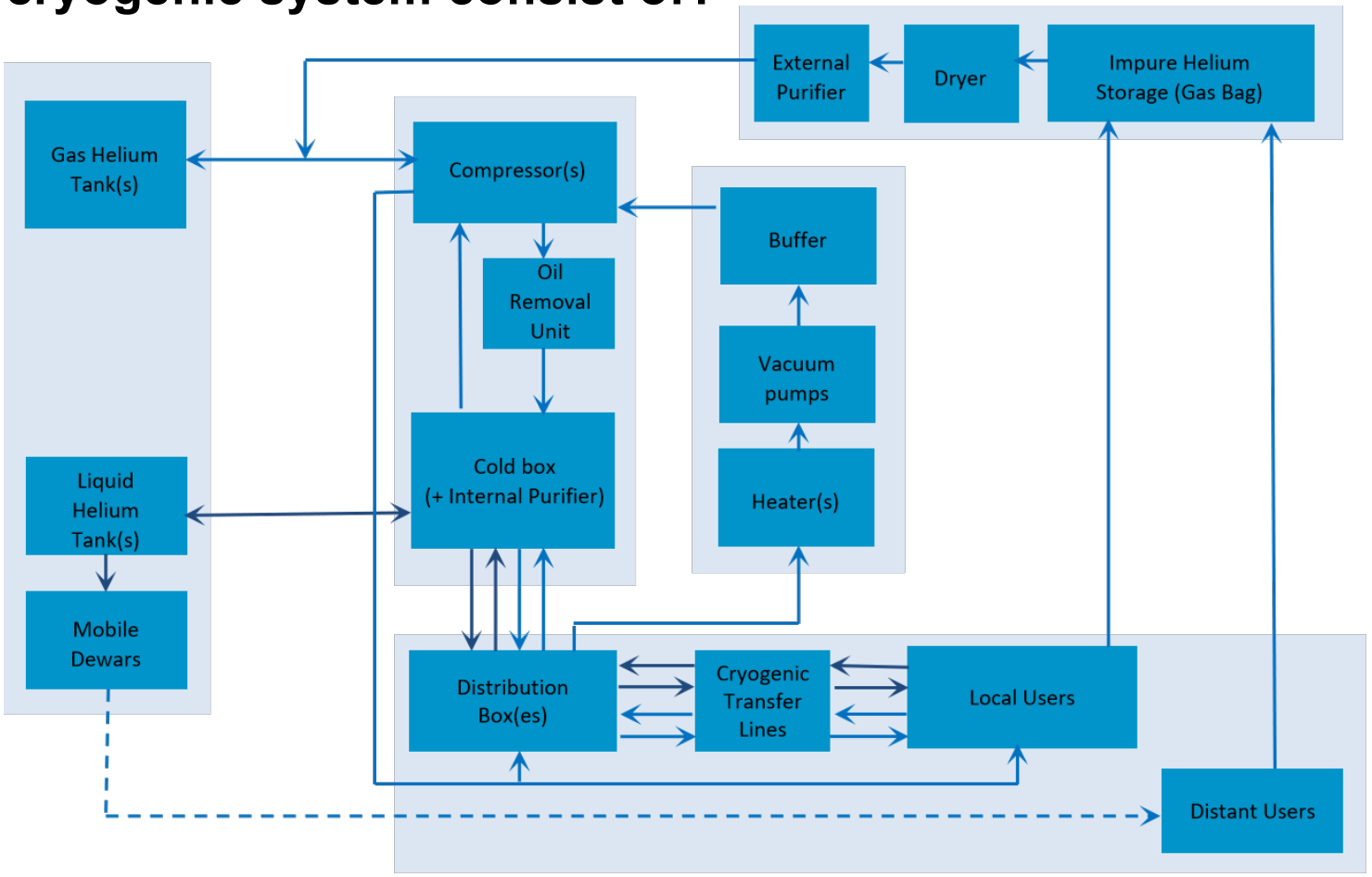

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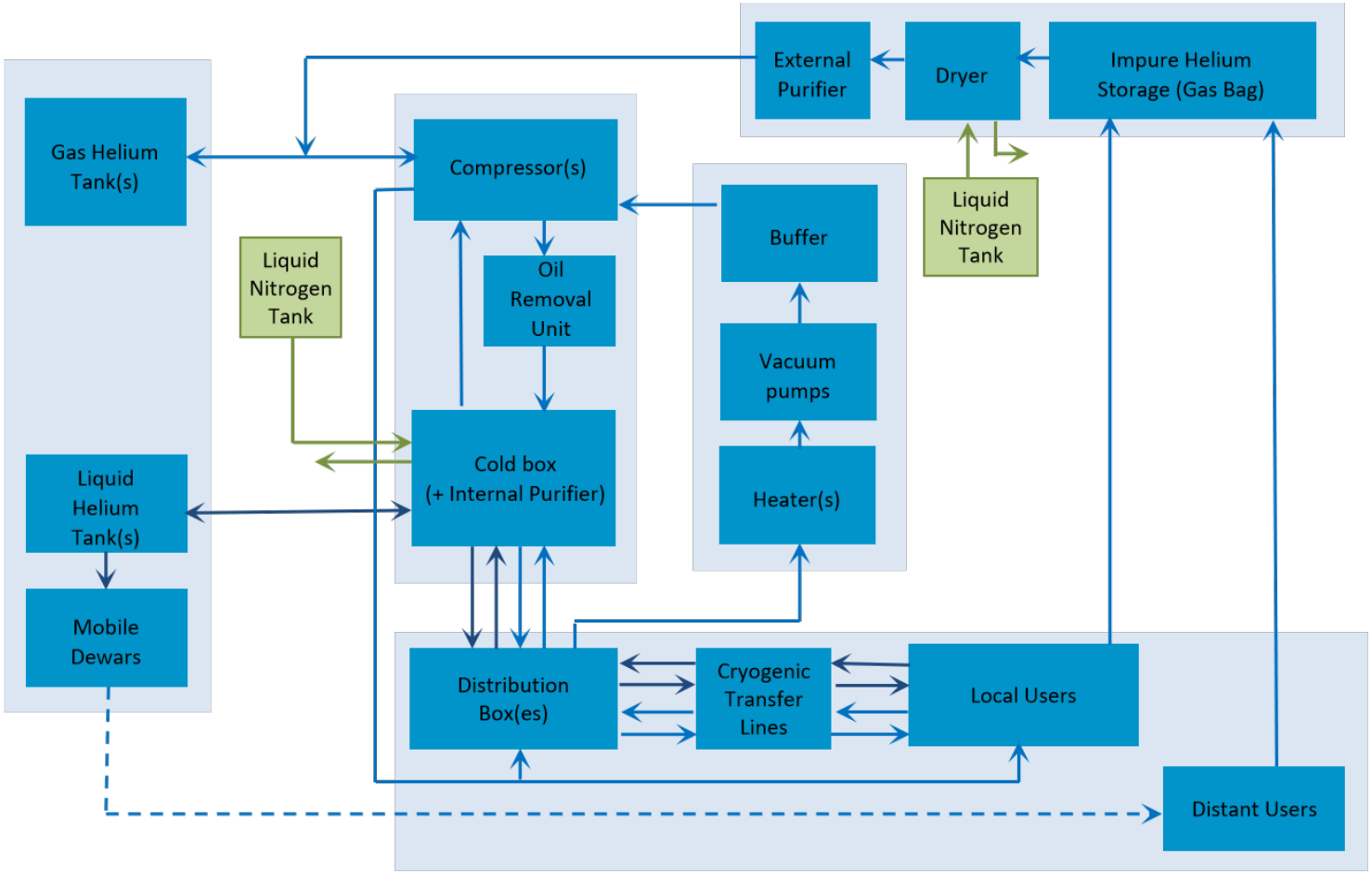
1. Overview of Cryogenic Engineering

- **What does a cryogenic system consist of?**



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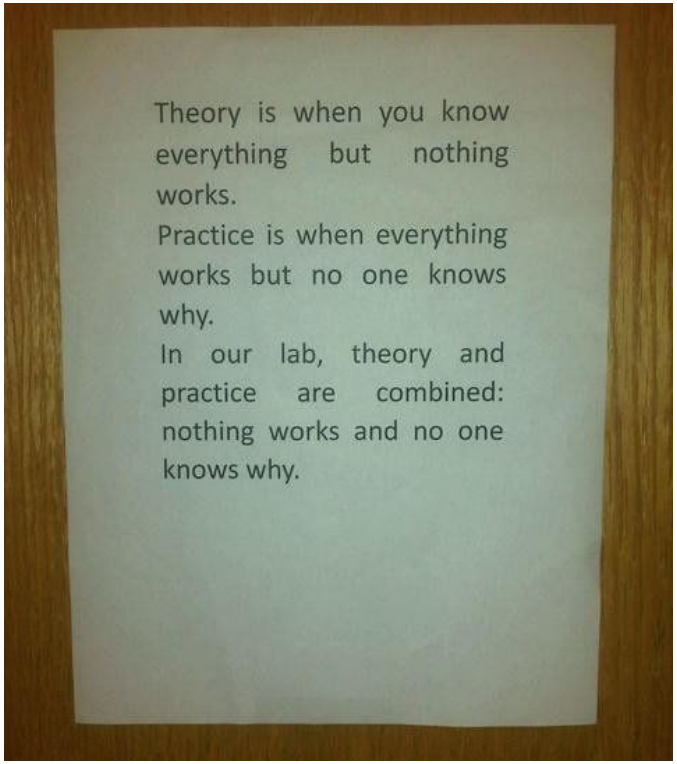
1. Overview of Cryogenic Engineering

- **纸上得来终觉浅，绝知此事要躬行。** ***Real understanding comes through lived experience***



SHINE - **We take SHINE real project to share the experience of Cryogenic Engineering**

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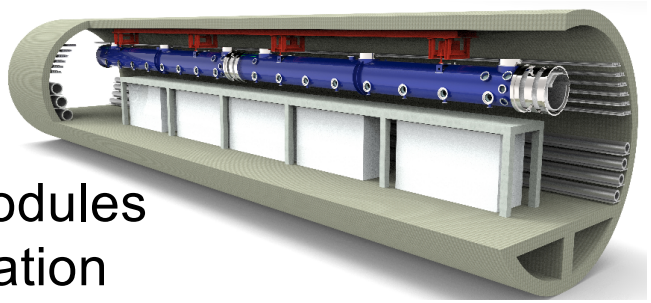
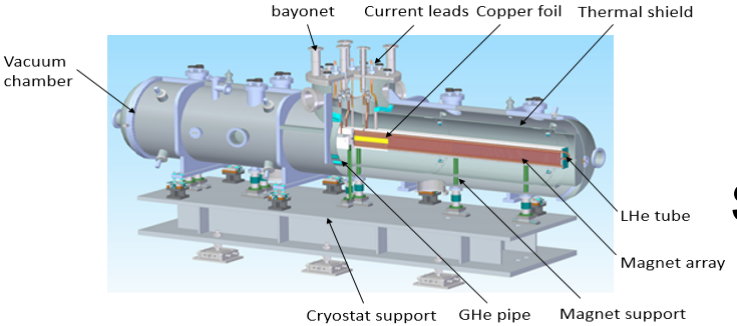
End users of SHINE cryogenic system

1

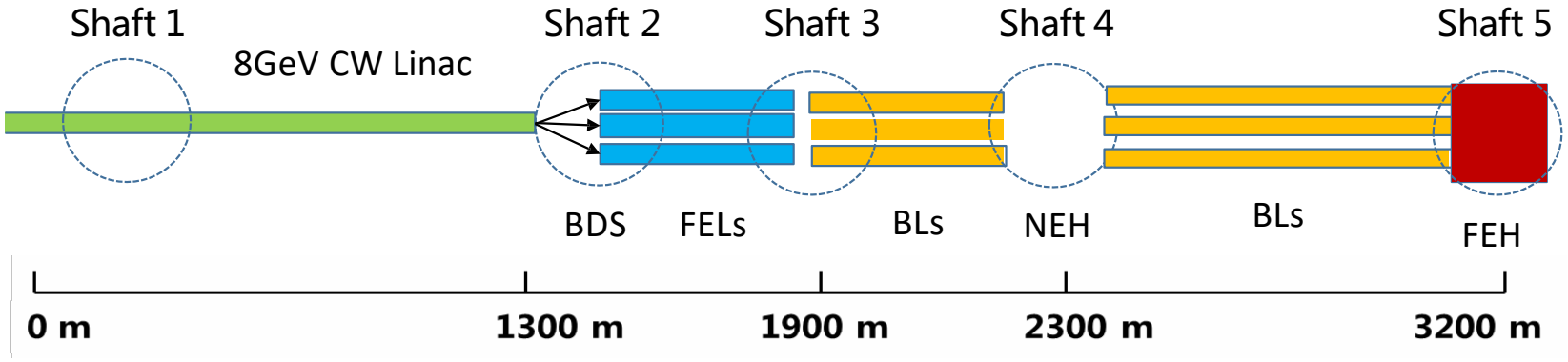
Cryomodules Operation





2

SC Undulators Operation



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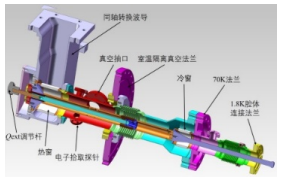

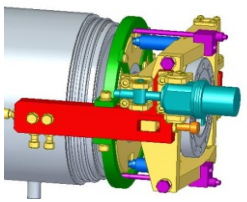

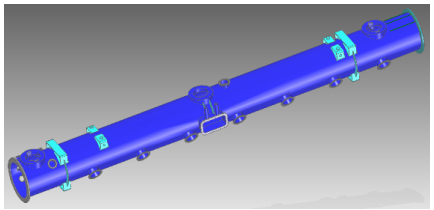

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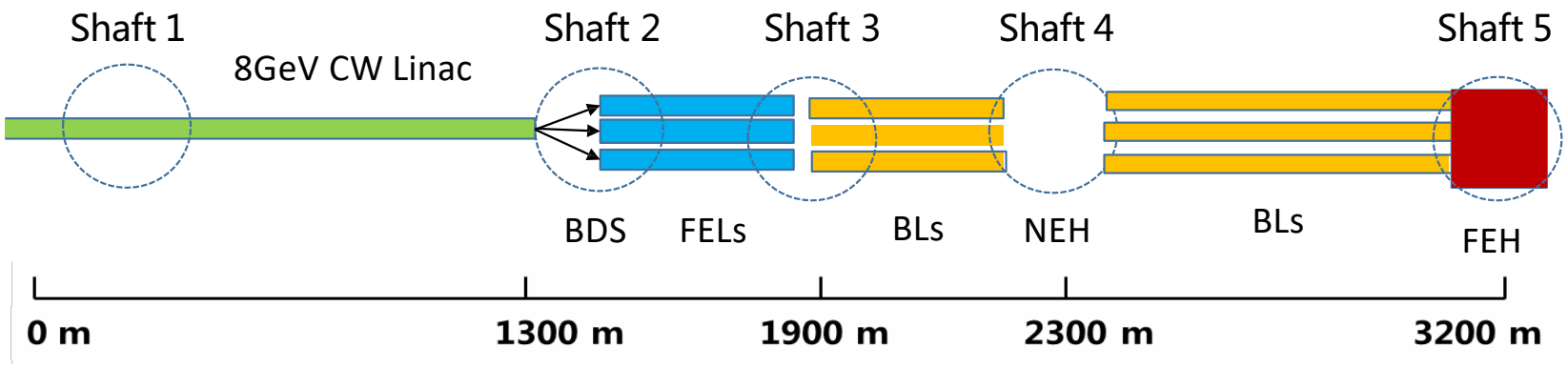
Test of Cryomodules (components and assembled)

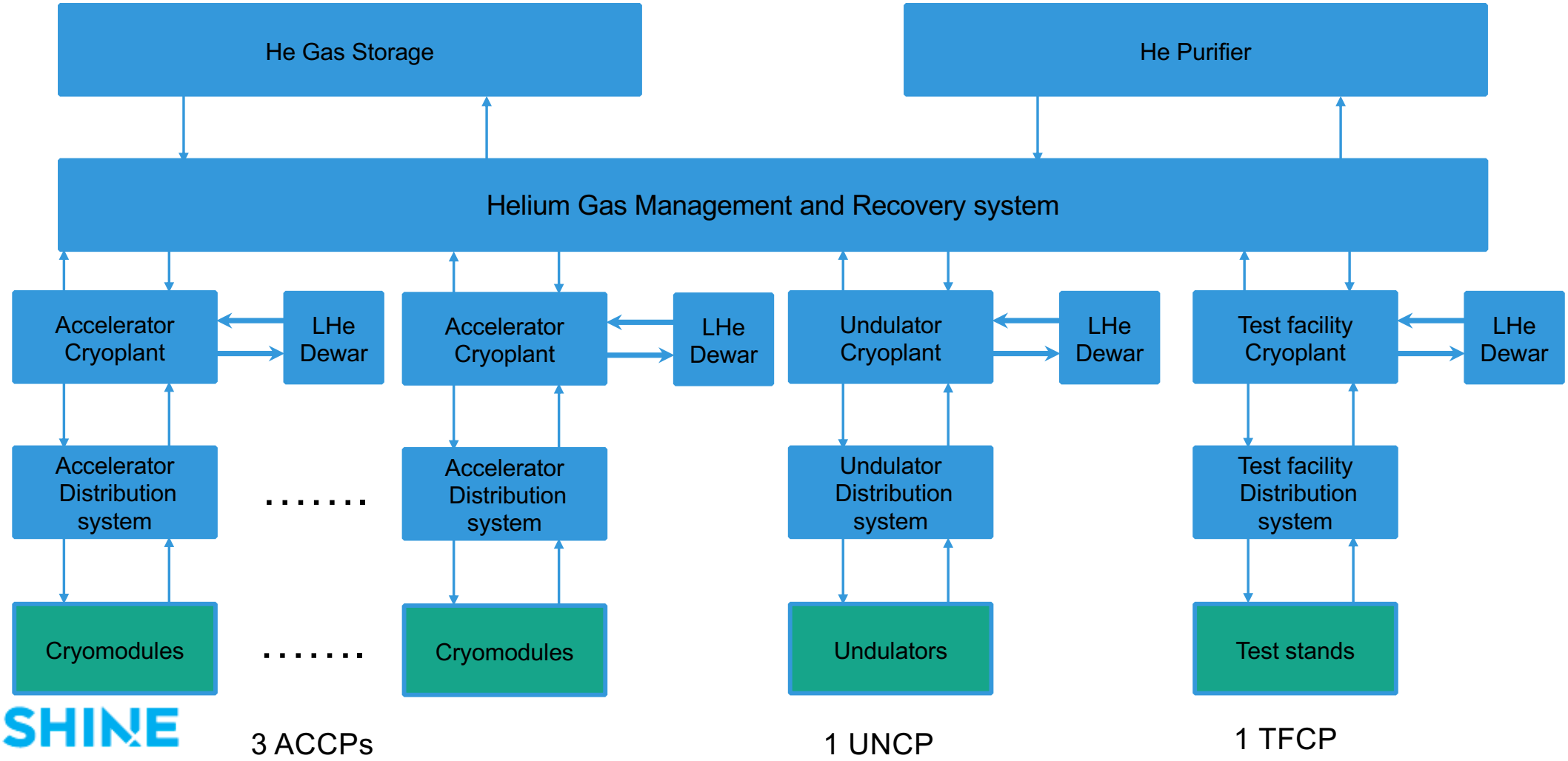
Function of SHINE cryogenic system



- 1. Provide adequate cryogenic cooling to the linac consists of SRF cavities;
- 2. Supply cryogenic cooling to the superconducting undulator lines
- 3. Fulfill the cryogenic requirements from the SHINE SRF test facility

SHINE

SHINE cryogenic architecture



SHINE cryogenic system capacity

Cryoplants	Numbers	Total Heat loads @ Temperature			Status
Accelerator cryoplant (ACCP)	3	12kW@2K	4.5kW@4.5K	45kW@40K	Under construction
Undulator Cryoplant (UNCP)	1	*500W@4.4K?*		*26kW@60K?*	To be specified
Test Facility Cryoplant (TFCP)	1	1kW@2K	350W@4.5K	3.75kW@40K	Under operation

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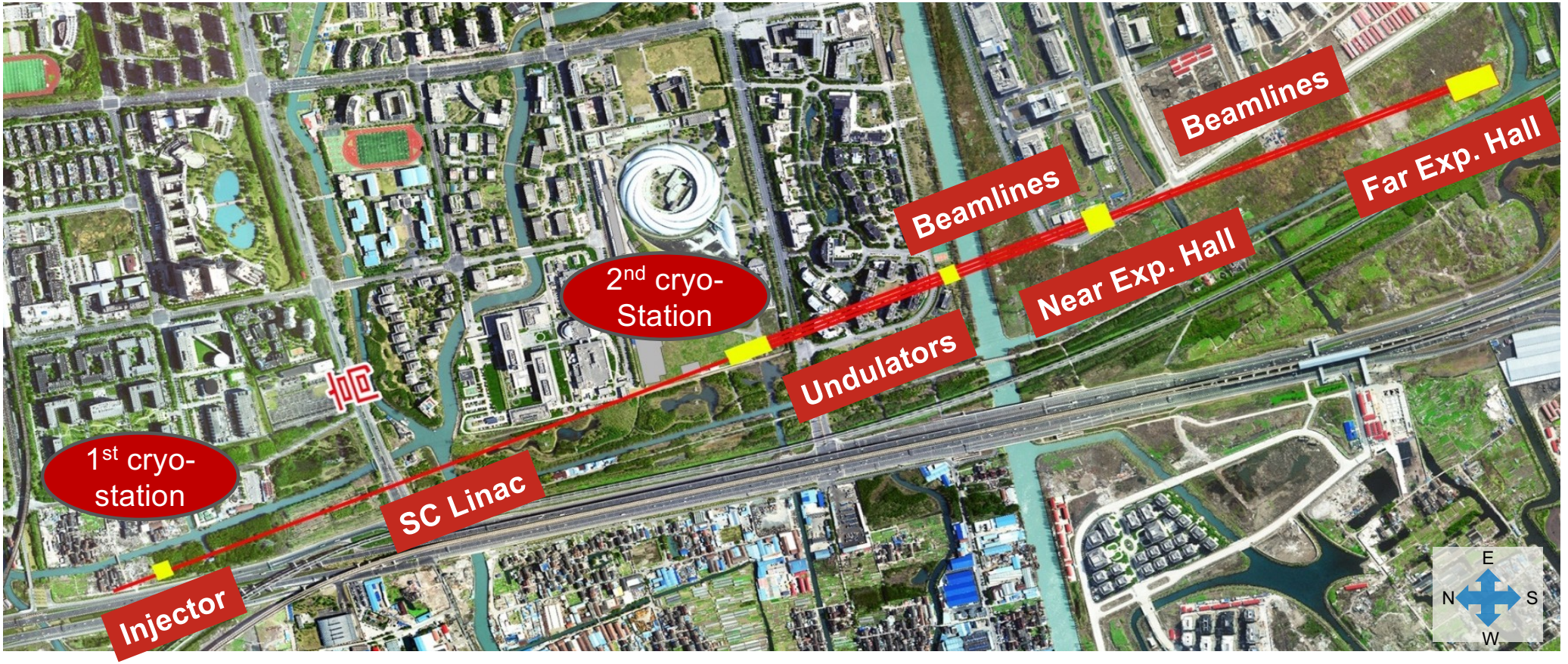
SHINE cryogenic system layout



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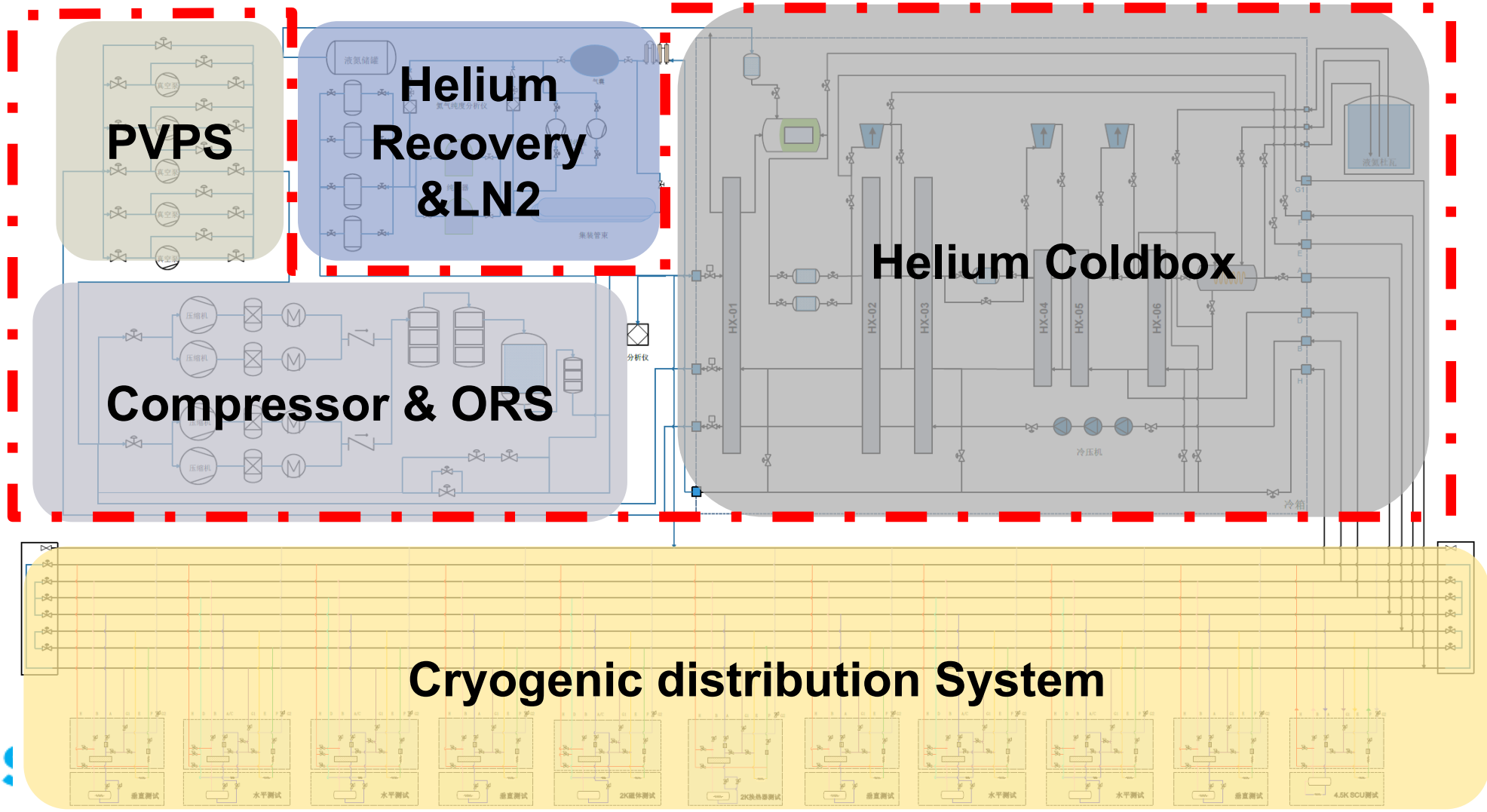
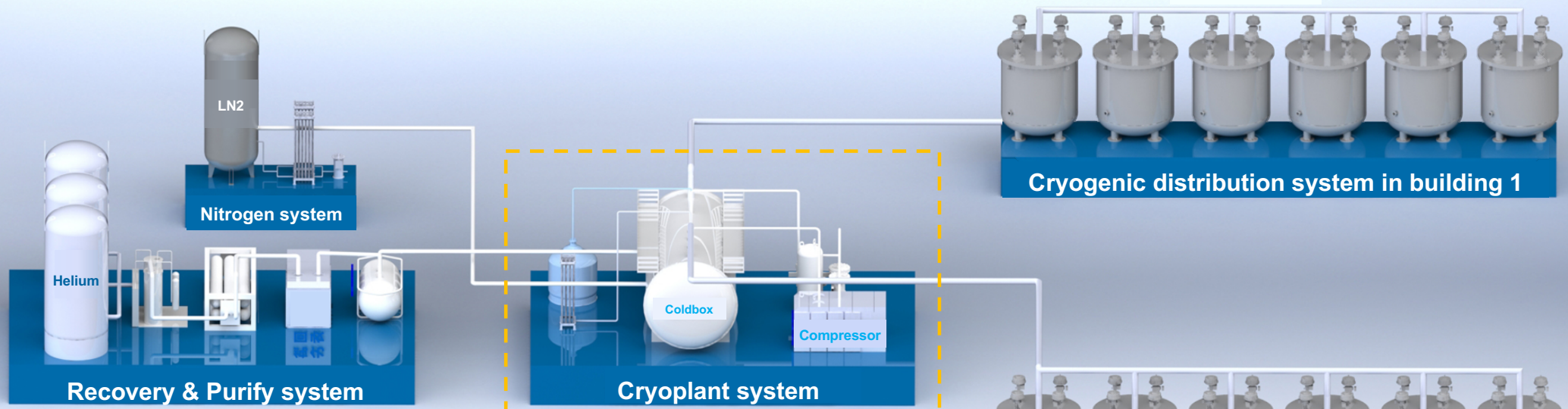
- 2 Cryo-stations are located in the two ends of SC linac

Overview- TFCP P&ID



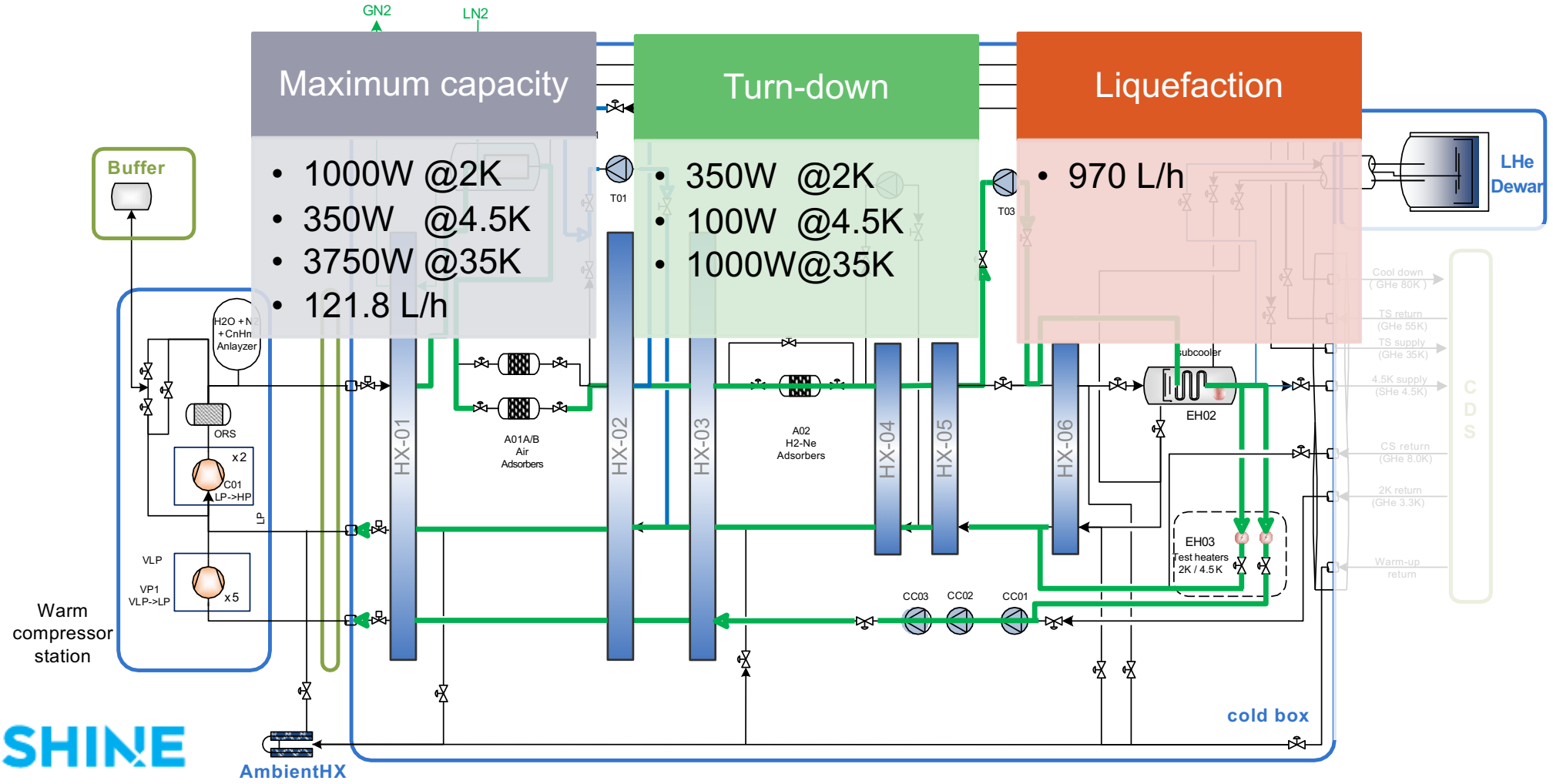
Overview- TFCP layout



Cryoplant system

- Warm Compressor Station
- Oil Removal System
- Cold box
- Dewar
- Helium Analysis
- Regeneration skid
- Process Pumps

Overview – general target



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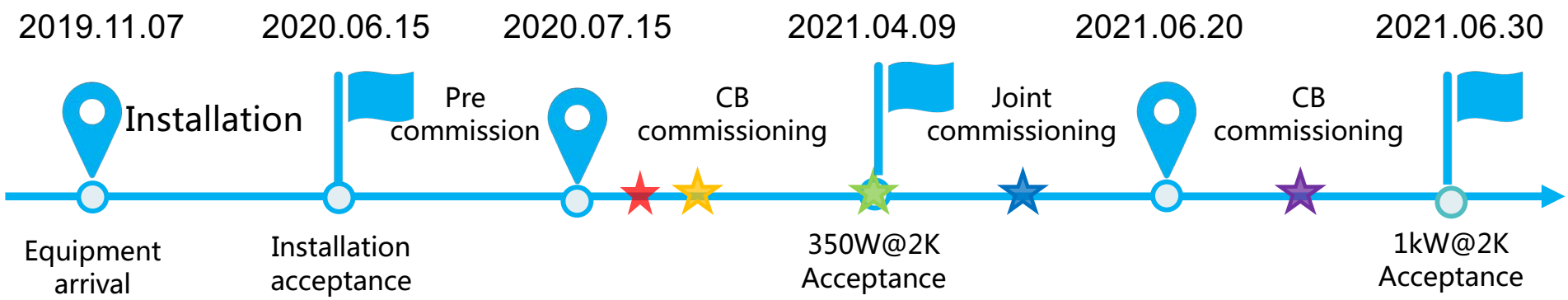
Overview- Installation and commissioning Progress



★	2020.10.30	First drop of LHe
★	2020.12.02	First arrival of 2K
★	2021.04.09	350W@2K Acceptance
★	2021.06	Cryomodule first arrival to 2K
★	2021.06.25	Cryoplant cold power reached 1kW@2K
★	2021.06.30	1kW@2K Acceptance

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SRF test facility cryoplant status

- The cryogenics system for SHINE SRF test facility has turned into operation since 07.2021.
- Series tests including horizontal test, vertical test, magnet test, superconducting undulator test have been carried out to support the SHINE SRF developments.

1kW@2K Cold box

Cryogenic distribution in No.1 test hall

CDS in No.2 test hall

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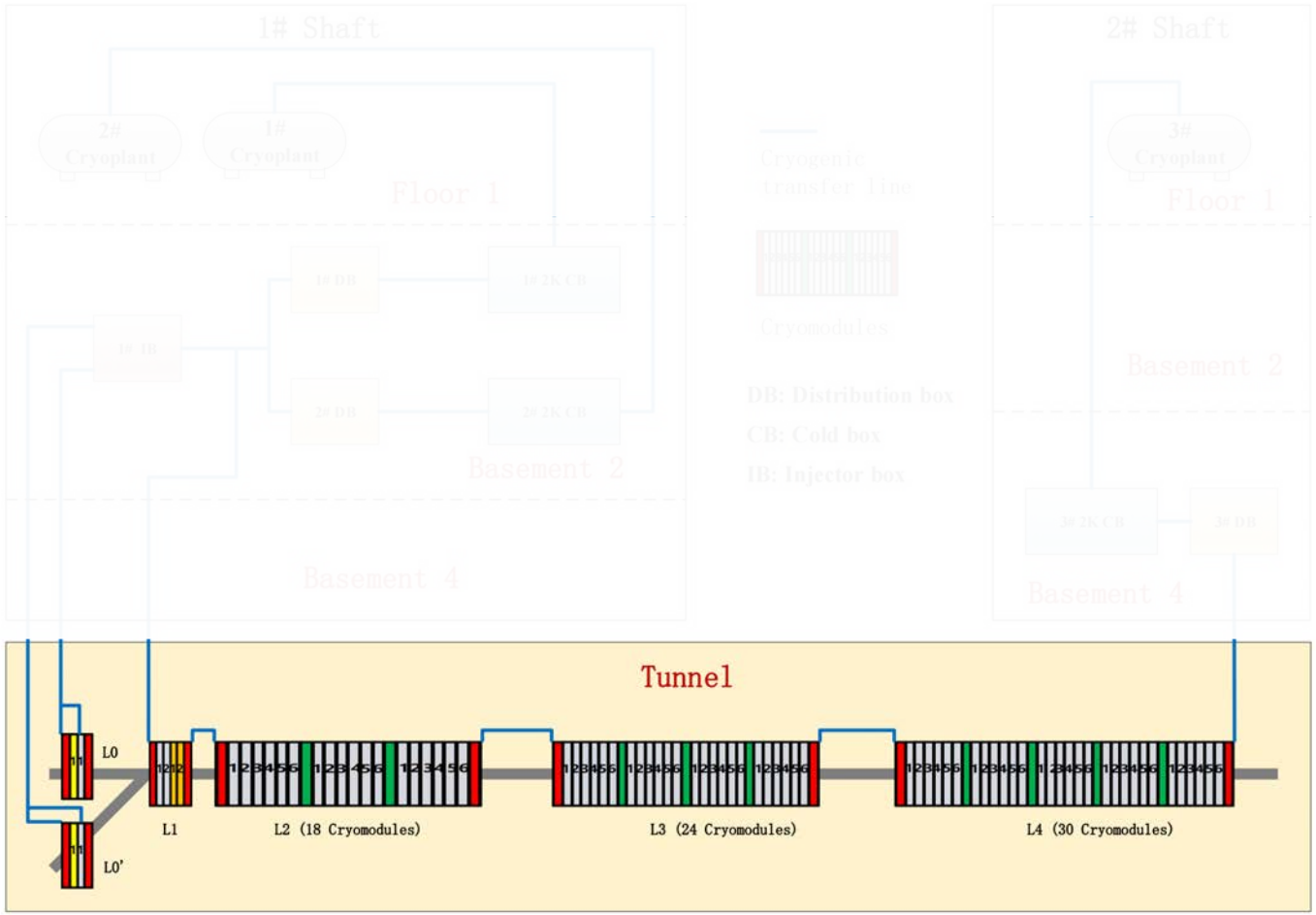
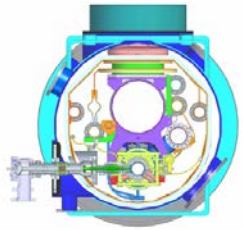
SHINE accelerator cryogenic architecture

Cryoplnat

CDS and 2K CB

SRF Linac





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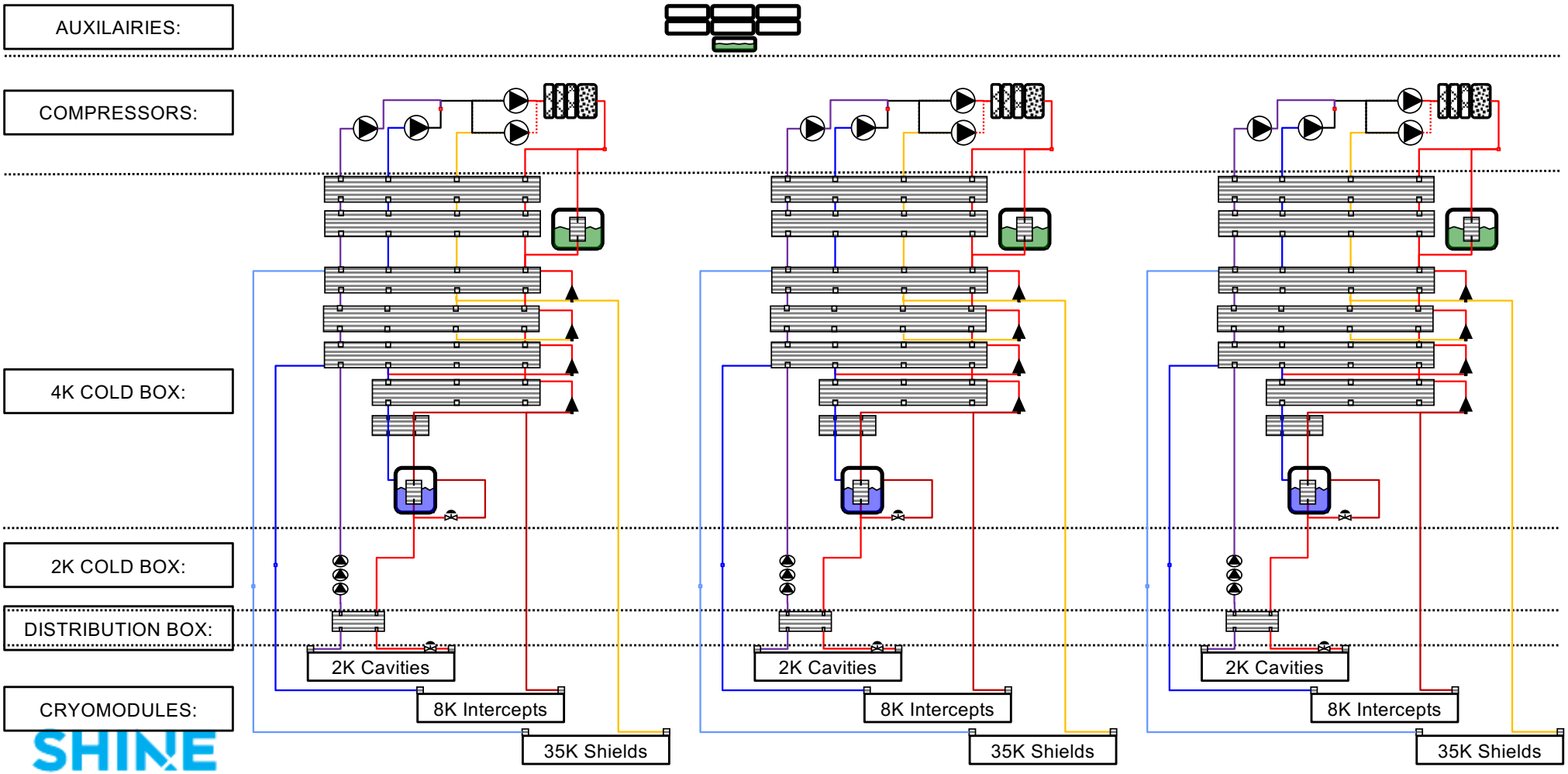
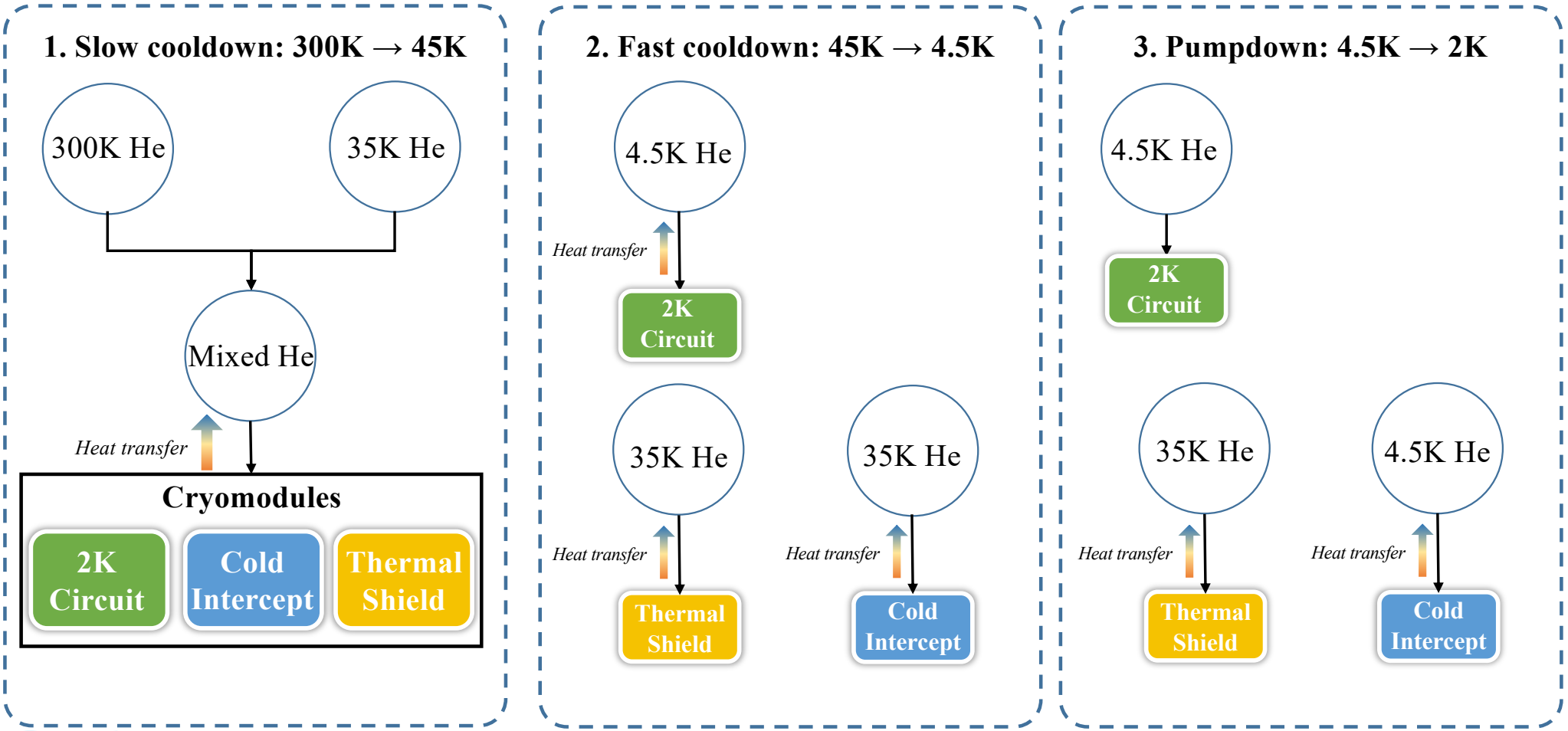
SHIEN ACCP cryogenic process overview



Cooling down process



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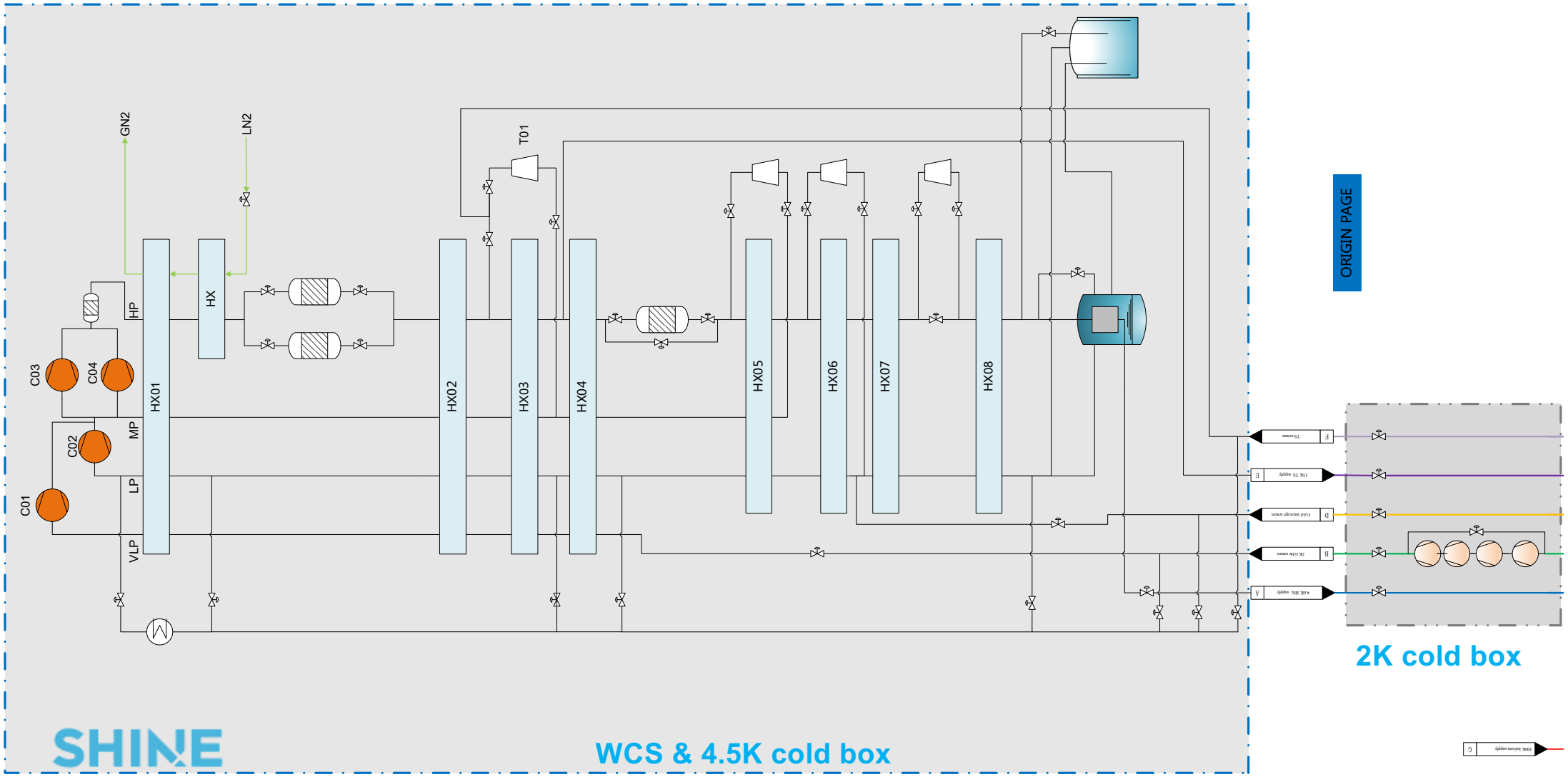
Process design of accelerator cryogenic system



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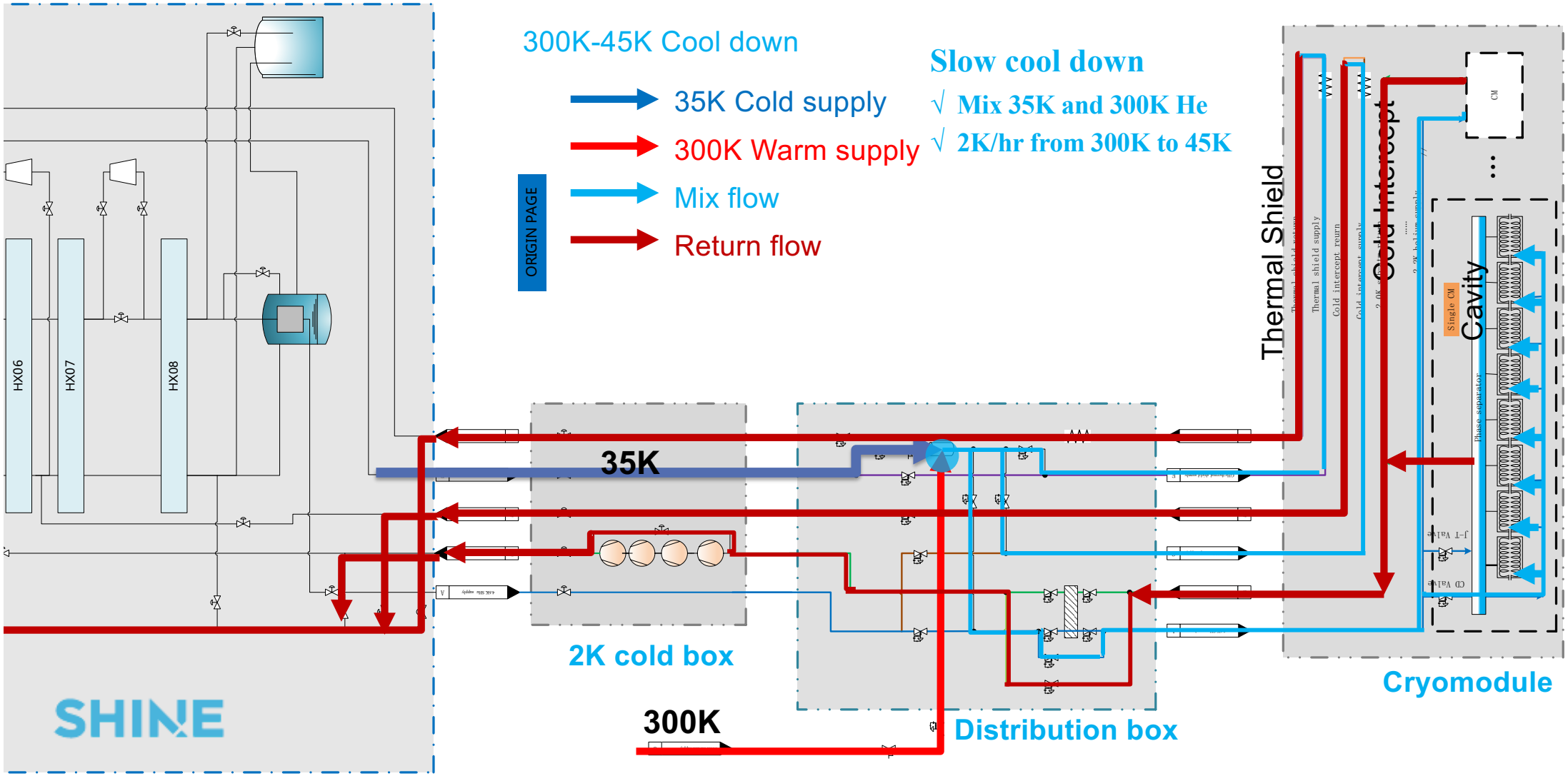

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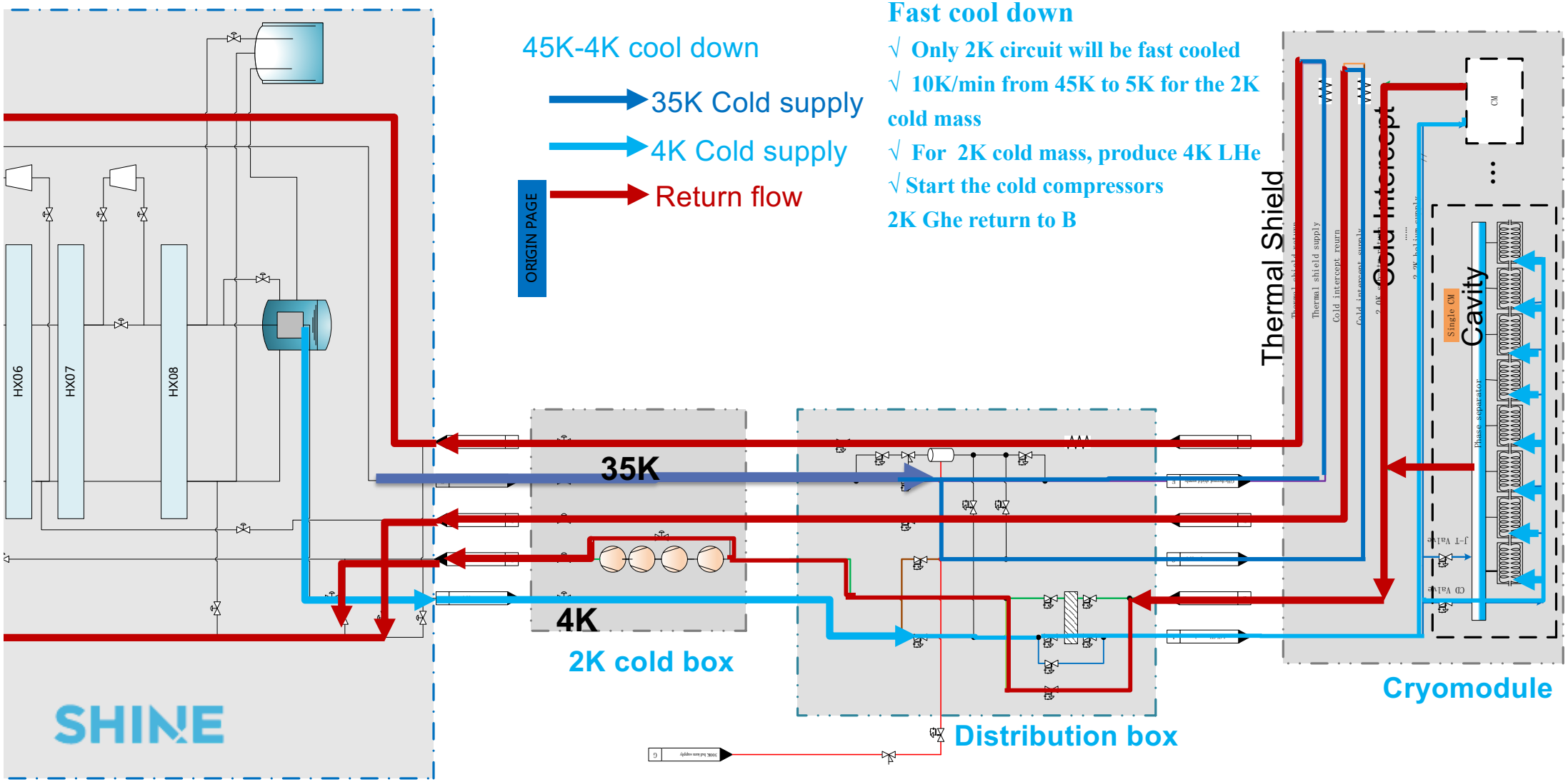

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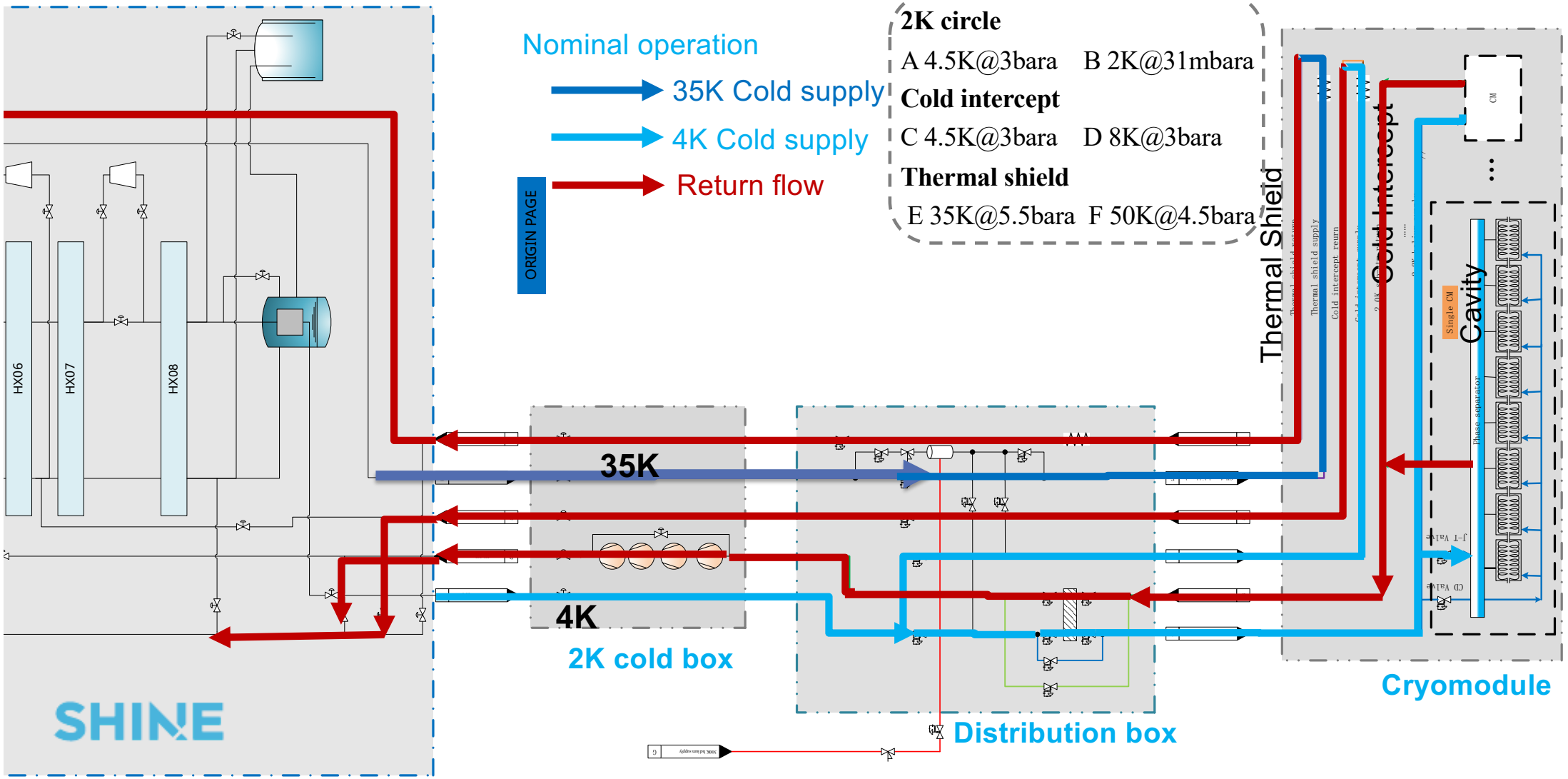
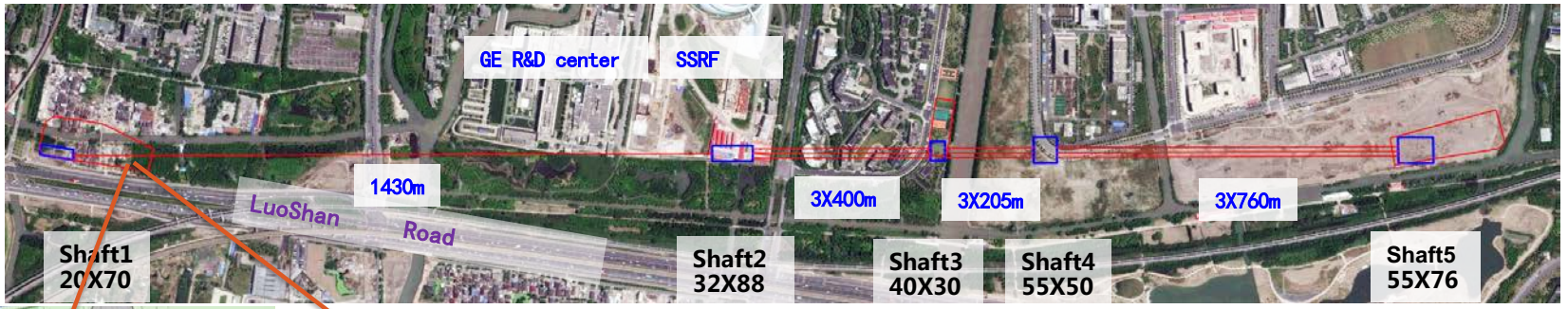
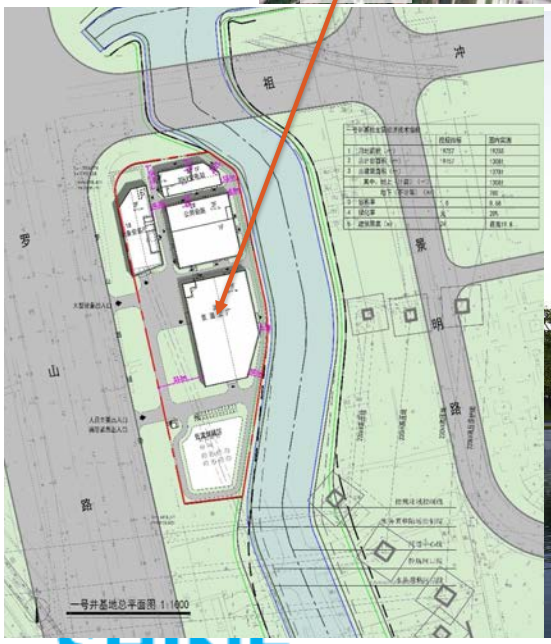


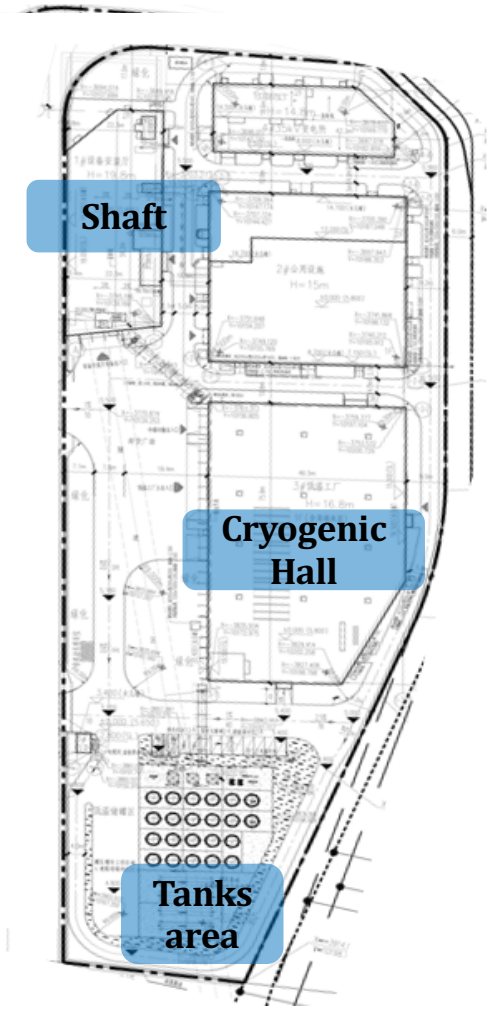
Cryo-station at No. 1 Shaft

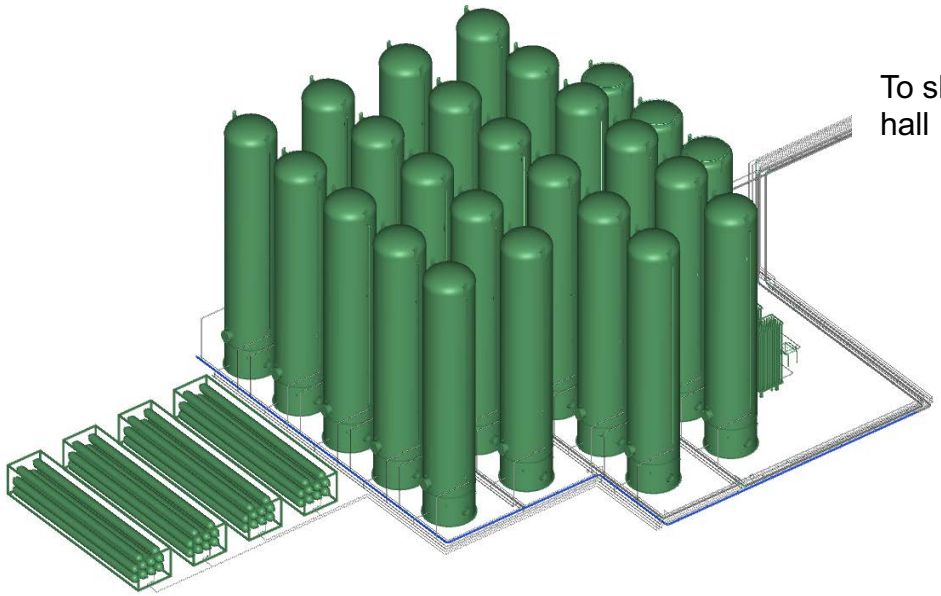




- Two accelerator cryoplants with 4kW@2K will be installed

Cryo-station at No. 1 Shaft





To shaft/cryogenic hall

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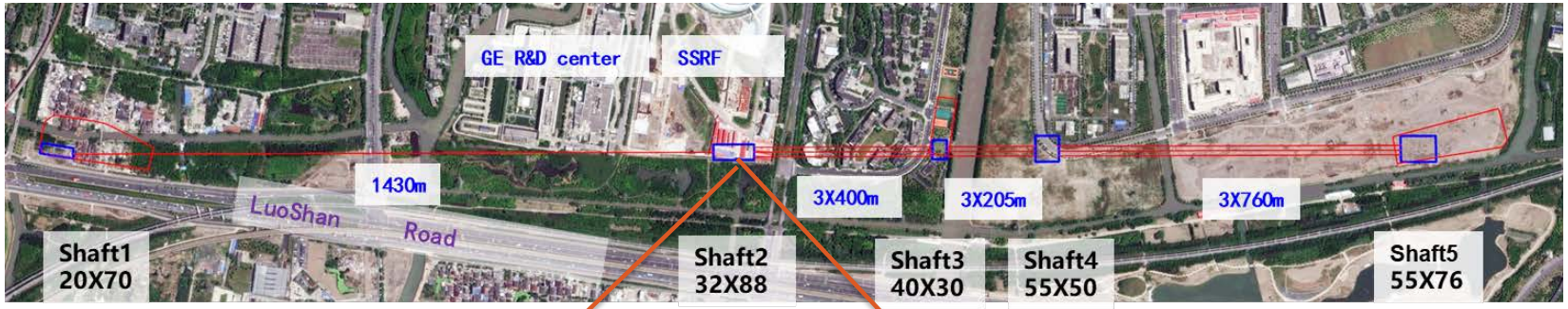
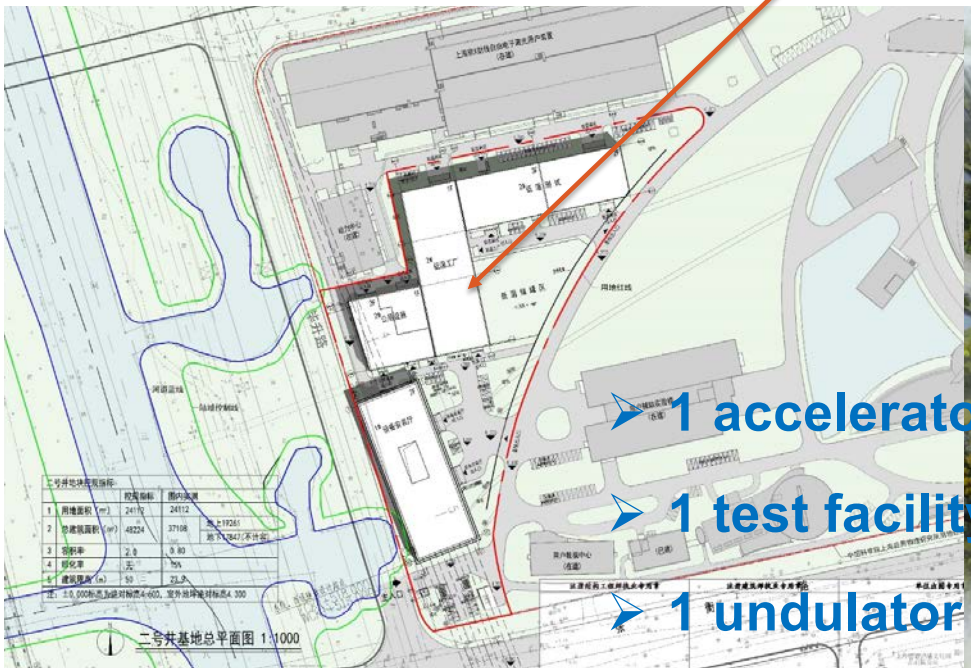
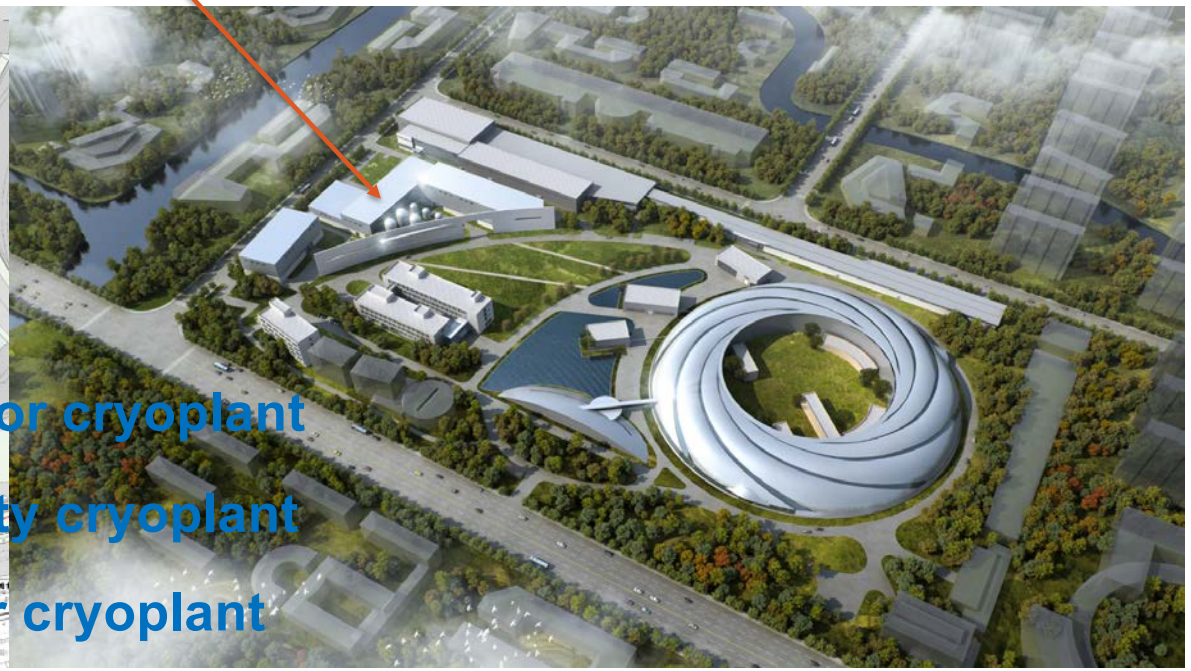
Cryo-station at No. 2 Shaft

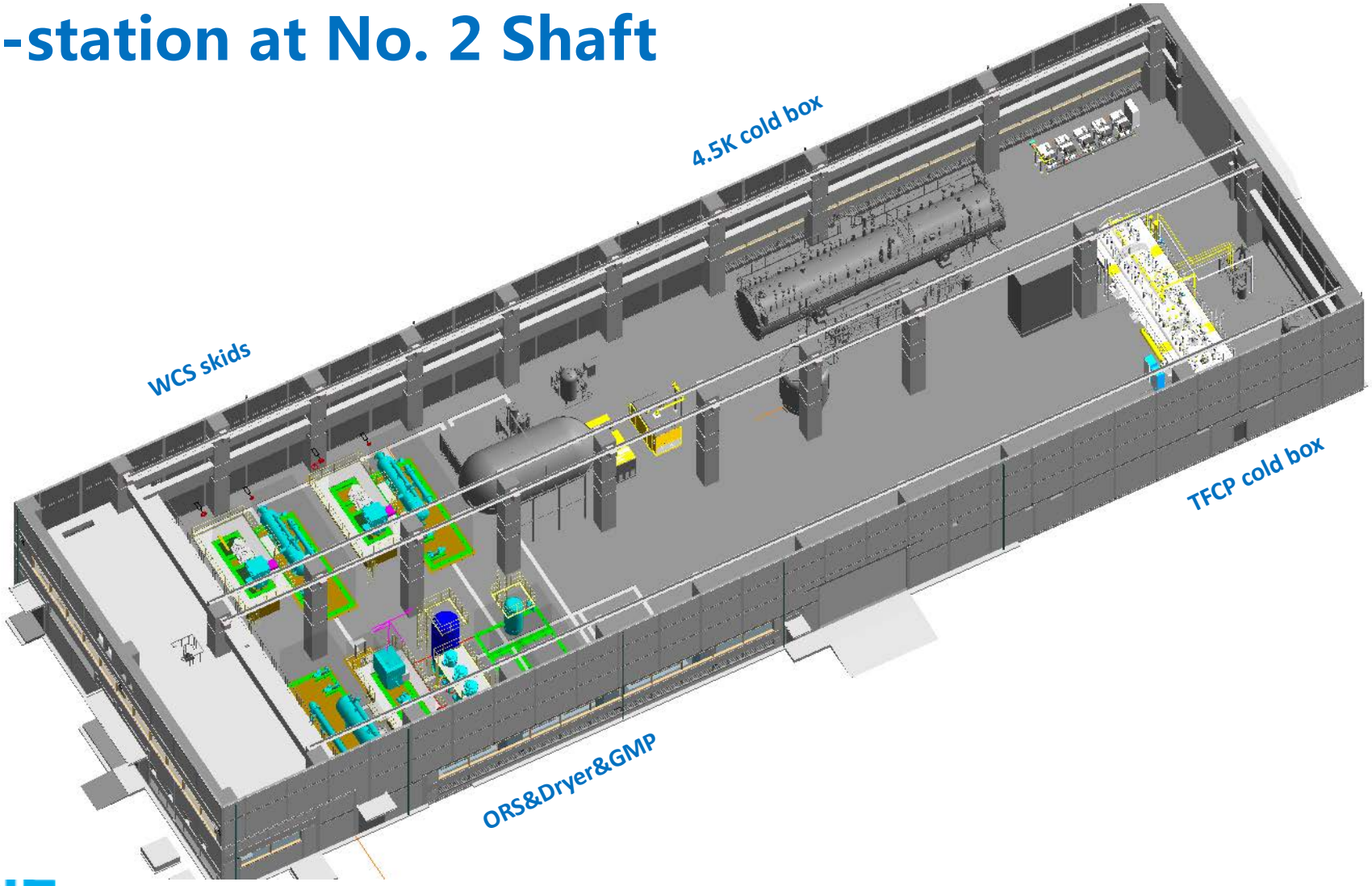






- 1 accelerator cryoplant
- 1 test facility cryoplant
- 1 undulator cryoplant

Cryo-station at No. 2 Shaft



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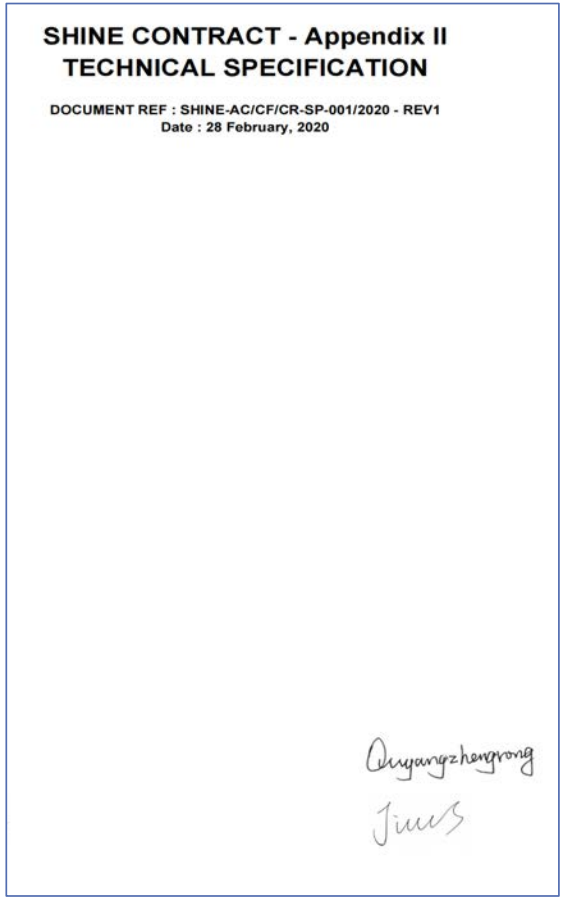
Specification

Technical sepcification

- Codes and Norms
- Site condition / Utility interfaces
- Performance
- Key component (WCS and Cold box)
- Spare parts
- Control
- Instrumentation, interlocks and electrical design
- Requirements on design, manufacture and mounting
- Test
- Quality management
- Documentation


SHINE CONTRACT - Appendix II
TECHNICAL SPECIFICATION

DOCUMENT REF : SHINE-AC/CF/CR-SP-001/2020 - REV1
Date : 28 February, 2020

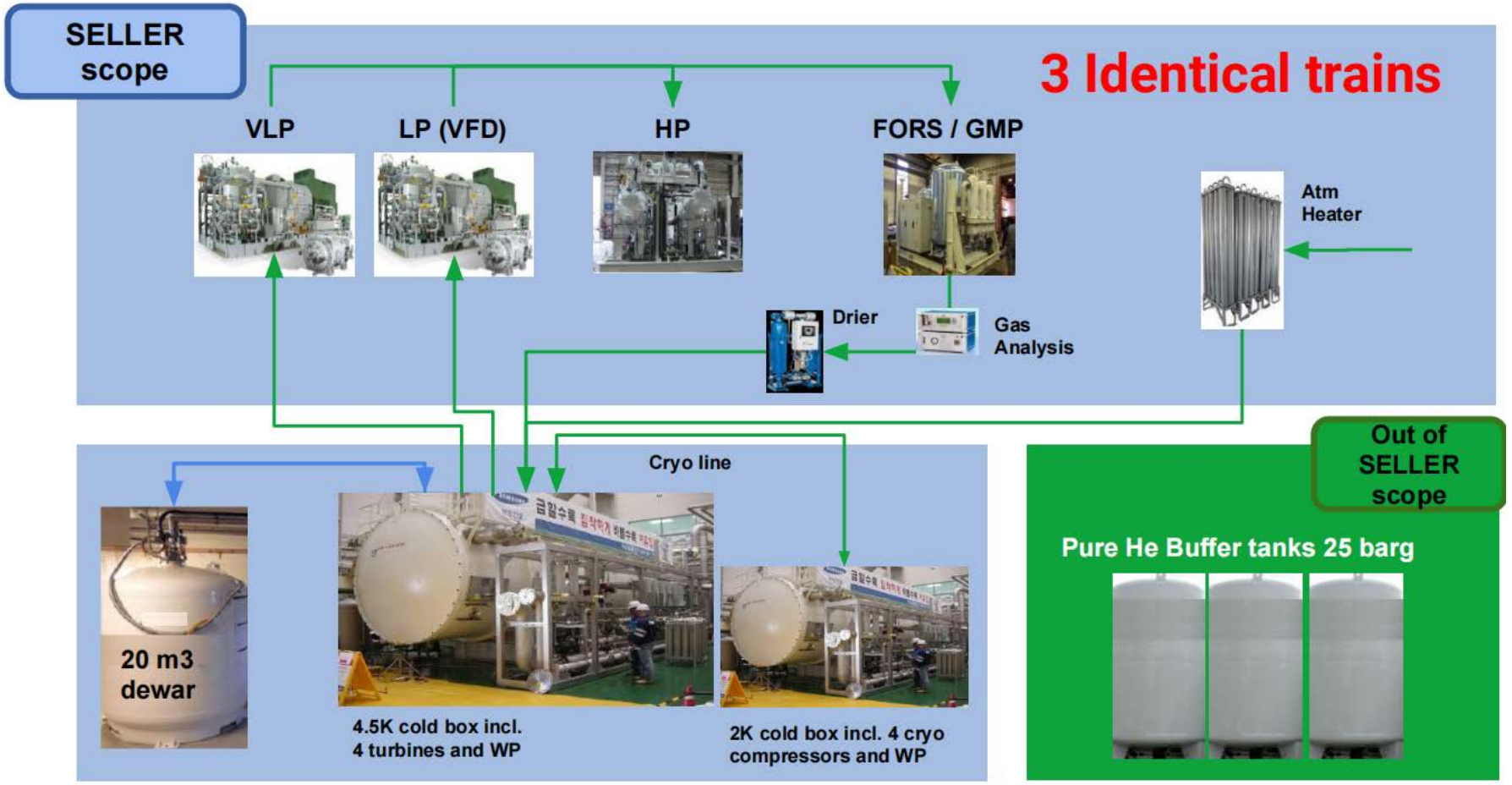
SHINE

SHINE Cryoplant Specification

TABLE OF CONTENTS

The technical specification is very important and the key document of Engineering

SHINE ACCP scope



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- ALaT scope of equipments

SHINE ACCP scope

- GHe storage
- ● LN2 storage
- ● Distribution box
- ● Helium recovery
- ● Interconnection warm line
- ● Interconnection cryogenic transfer line between 4.5K and 2K cold box
- Interconnection cryogenic transfer line between 2K cold box and Cryomodules
- ● Utilities (IA, LN2,CW)
- ● On site installation and supervision

SHINE

- **3x 4.5K Cold boxes (CB) with LN2 precooling and Warm Panel**
- **3x 2K CB including 4x Cold Compressors (CC) from AL-aT and Warm Panel**
- **3 x warm compression station (WCS), including for each:**
  - ○ 1x Very Low Pressure (VLP) compressor
  - ○ 1x Low Pressure (LP) compressor with VFD
  - ○ 1x High Pressure (HP) compressor
  - ○ 1x Oil Removal System (ORS) + 1x Full Flow Dryer + 1x GMP
- **3x Dewar 20 m3 (one per 4.5K CB) with 1x coaxial cryoline + 1x single cryoline**
- **Spare parts for 2 years + critical spares (Cold and Warm Compressors, Turbines)**

ALaT

SHINE Cryogenic supplier matrix

Helium Refrigerator

Air Liquide

MAYEKAWA MYCOM

KAESER KOMPRESSOREN

WEKA®

WESSINGTON CRYOGENICS

CDS and auxiliary system

VACREE

XLT 新连通

TRIUMPH GASES EQUIPMENT

合肥聚能电物理高技术开发有限公司
Hefei Juneng Electro Physics High-tech Development Co., Ltd

CryoPride PRIDe CRYOGENIC TECHNOLOGY

TOKO VALEX Shanghai

BAUER GROUP

Leybold

中核集团 CNNC

Installation

SCG 上海市安装工程集团有限公司 SHANGHAI INSTALLATION ENGINEERING GROUP CO.,LTD.

SHINE

Operation

中科富海 FULLCRYO

SHINE ACCP operation modes

- **There are 8 steady-states operation modes to be calculated:**

  -Nominal design;
  -Nominal Turndown;
  -2K standby Single String;
  -2K standby Full Linac;
  -1.8K;

  } With subatmospheric operation (CC running)

  -4.5K standby Single String;
  -4.5K standby Full Linac;
  -Maximum liquefaction;

  } Without subatmospheric operation (CC off)

-Load of the cold box will adapt to the customer power requirement.

-Some signals from operators or upper control level will be required for mode change (CC starts, operation in full linac, in 4.5K standby…)

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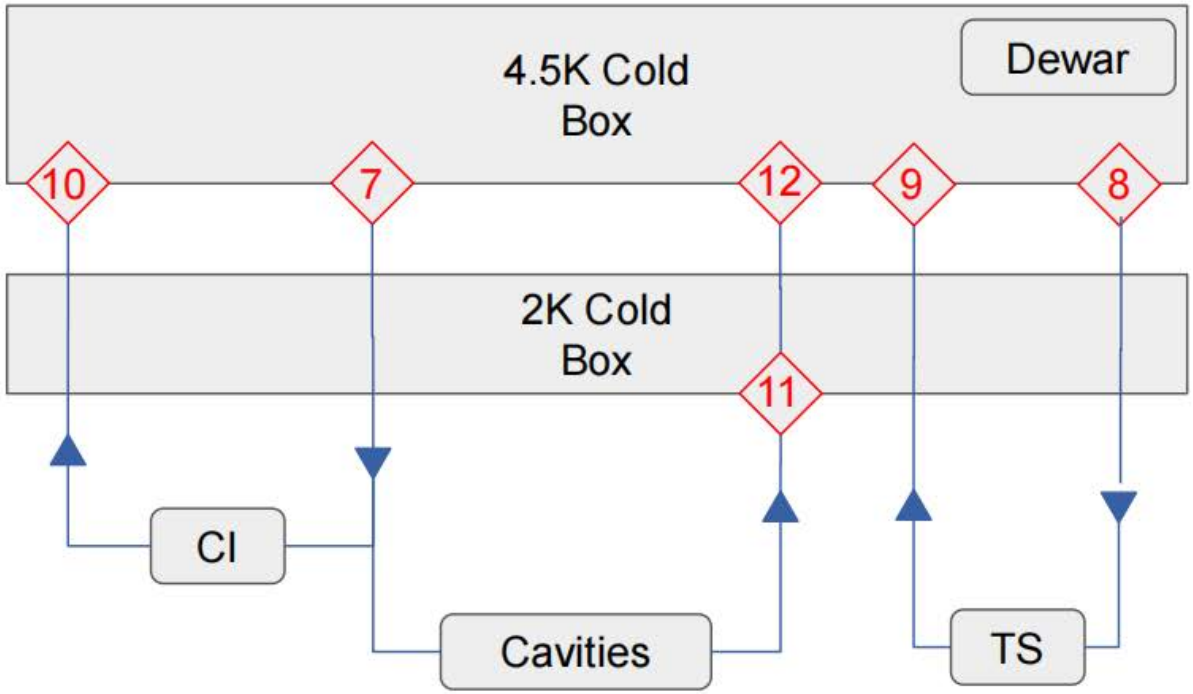
Steady states operation

- **On steady states operations :**
  - **4 Loads are required function of the operation mode**
    - Thermal Shield: TS
    - Cold Intercepts: CI
    - Cavities
    - Liquefaction rate: Dewar



SHINE

Steady states operation-2K performance

Load case	Q1 (W)	Conditions at diamond 7 (CB Supply)		Conditions at diamond 11 (CB Return)	
Nominal	4 000	≥3 bara	4.5K	≥ 0.0256 ba	3.5K
Nominal TD	2 649.1	≥3 bara	4.5K	≥ 0.0275 ba	3.43K
2K standby single string	289.1	≥3 bara	4.5K	≥ 0.028 ba	5.06K
2K standby Full linac	575.7	≥3 bara	4.5K	≥ 0.0274 ba	4.05K
4.5K standby Single string	384.6	≥3 bara	4.5K	≥ 1.2 ba	7.0K
4.5K standby Full linac	671.2	≥3 bara	4.5K	≥ 1.2 ba	5.7K
Maximum liquefaction	337	≥3 bara	4.5K	≥ 1.2 ba	5.7K
1.8K	2 083	≥3 bara	4.5K	≥ 0.0125 ba	3.1K

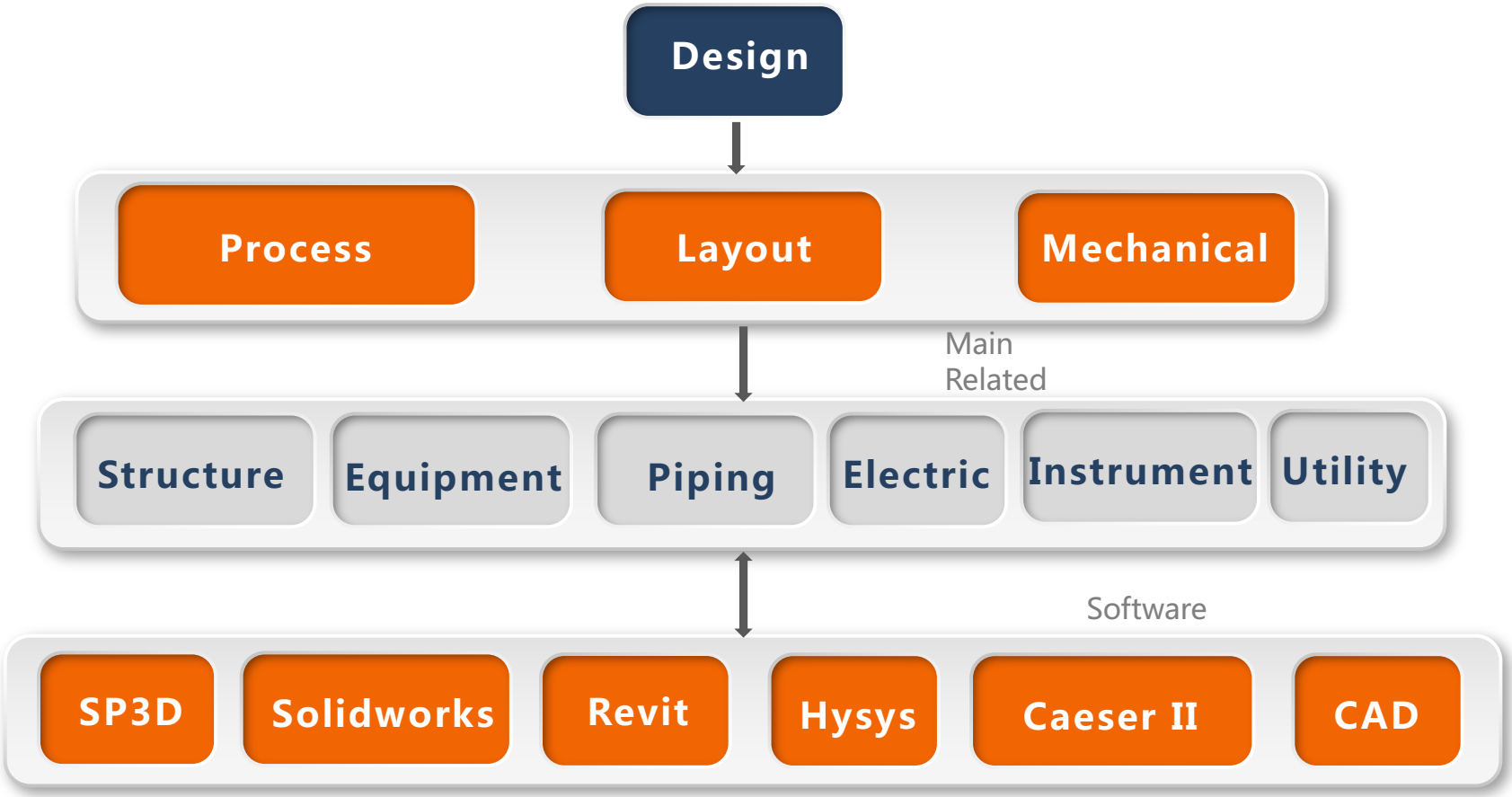
SHINE

- **186 g/s** of mass flow rate will be used to test the 2K cold compressor

Design

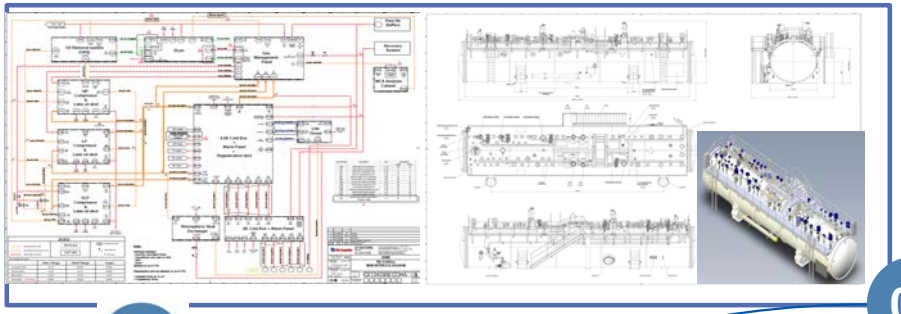
SHINE

Engineering design of “plant”

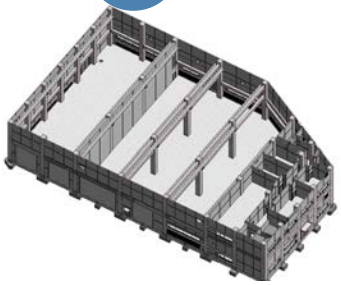


SHINE

SHINE Layout Design



01



①Space Utilization Planning

02

② Equipment Function Area Planning

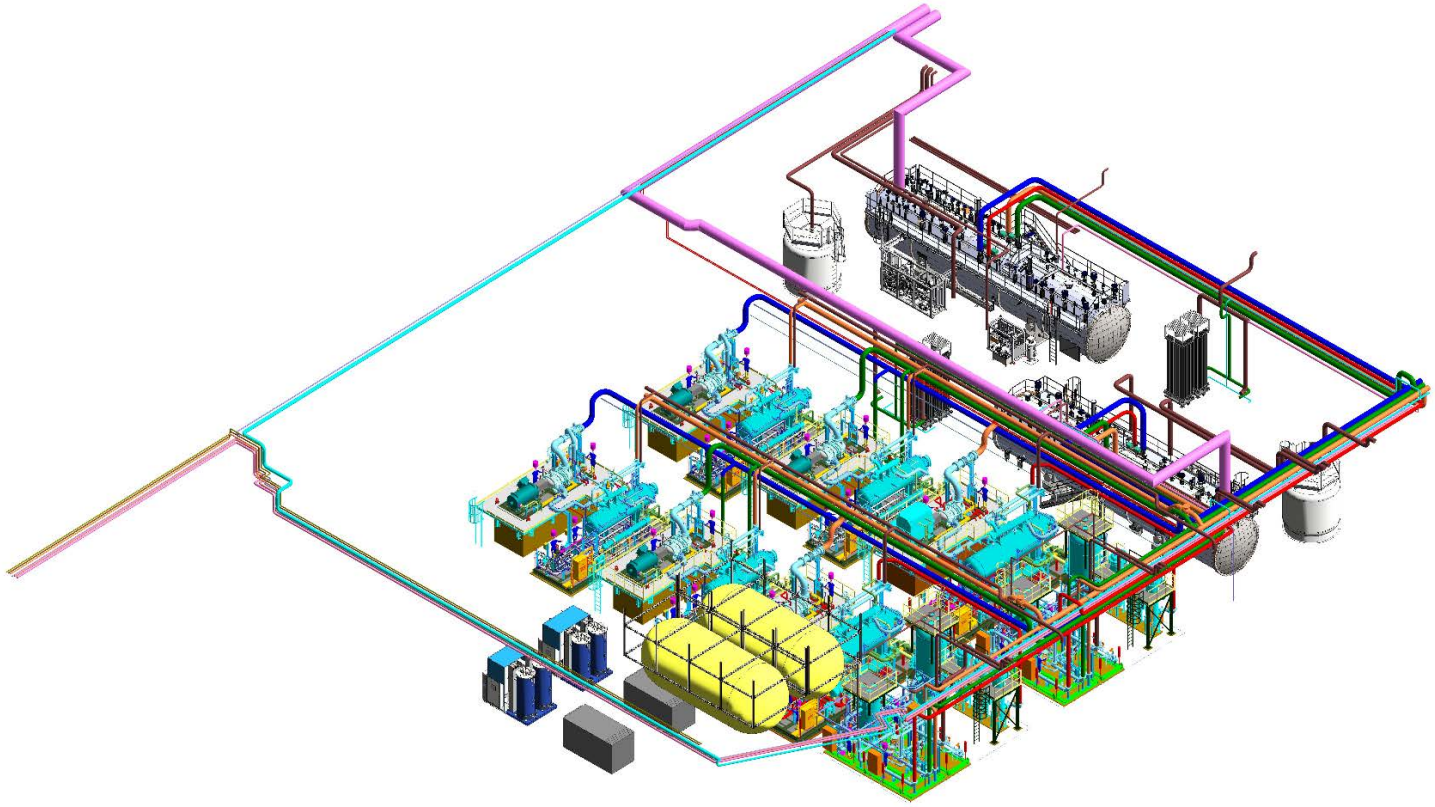
03

③ Piping Layout Planning

04

④ Functional area integration planning

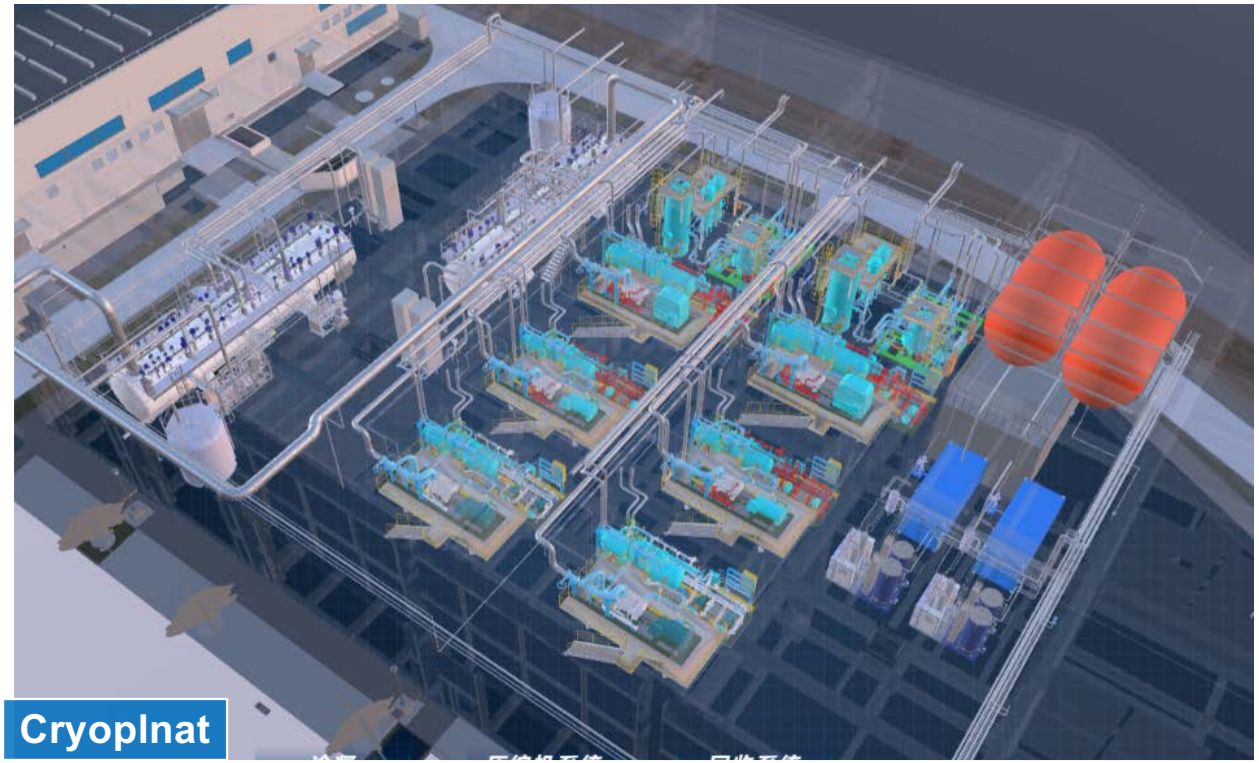
SHINE Layout Design-Piping complex



SHINE

SHINE Layout Design-3D model

➢ Cryo-station at Shaft 1

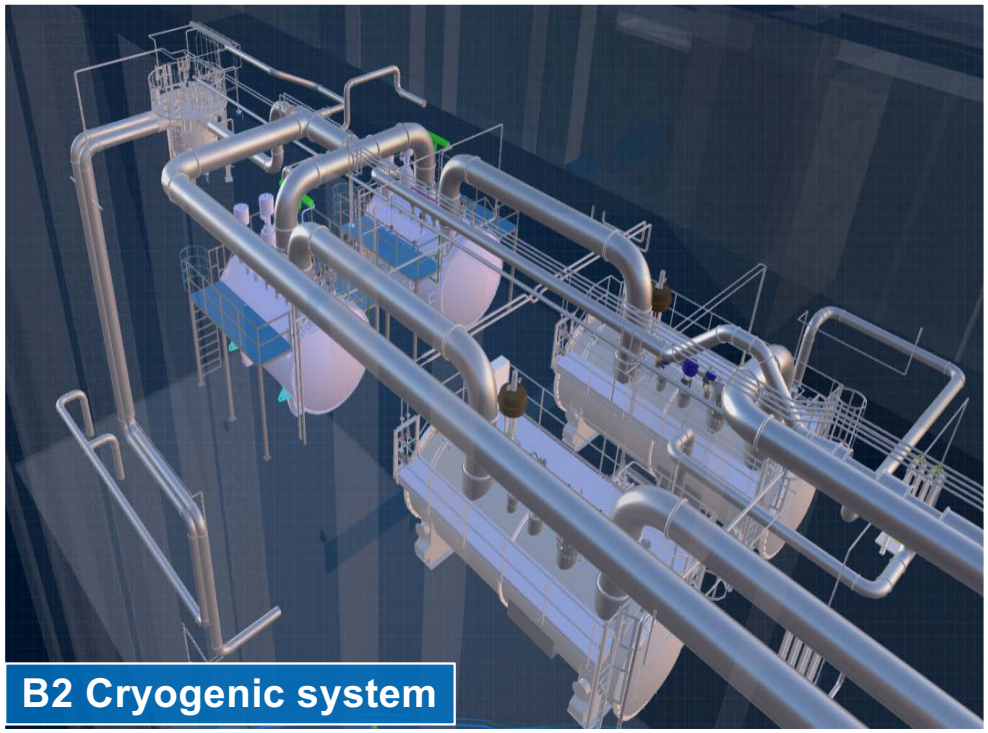


SHINE

SHINE Layout Design-3D model

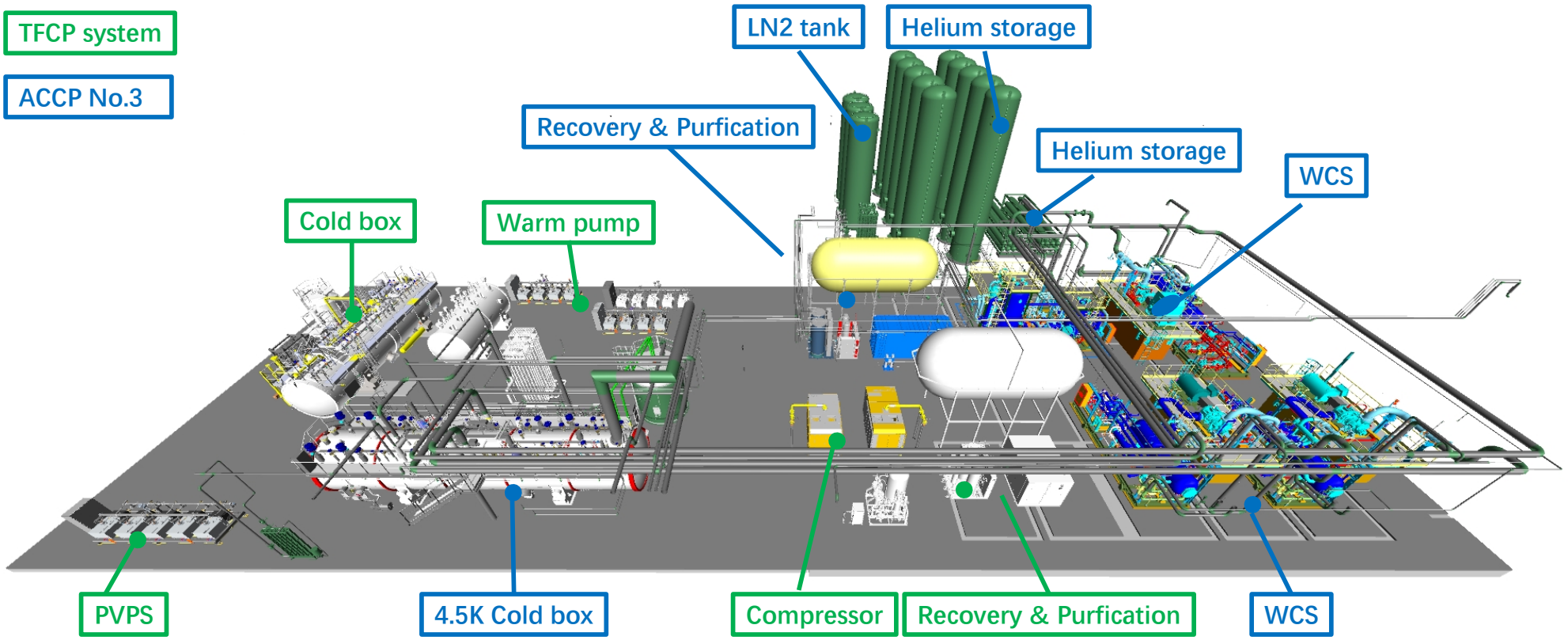
➢ Cryo-station at Shaft 1


Tanks area


B2 Cryogenic system

SHINE

Cryo-station at No. 2 Shaft



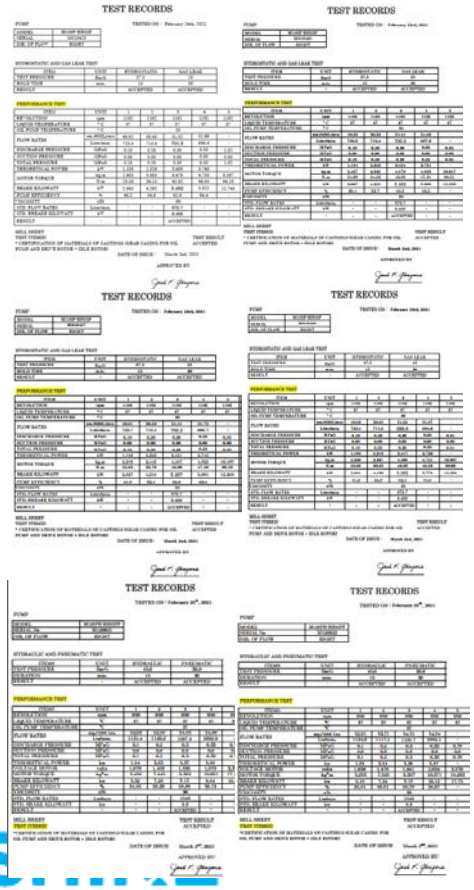
SHINE

Manufacutring

SHINE

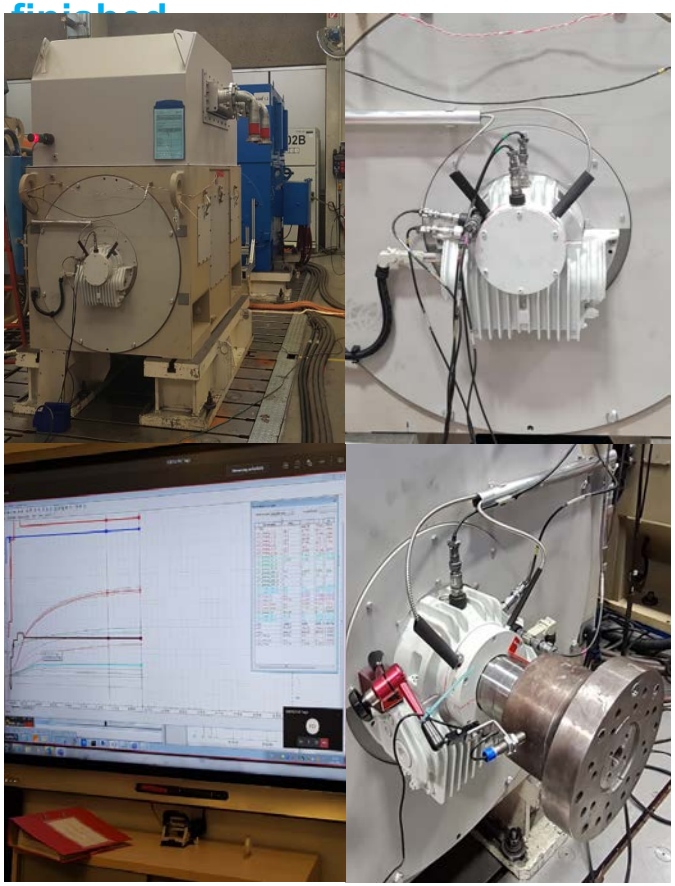
SHINE WCS manufacturing

Performance test of Oil pump

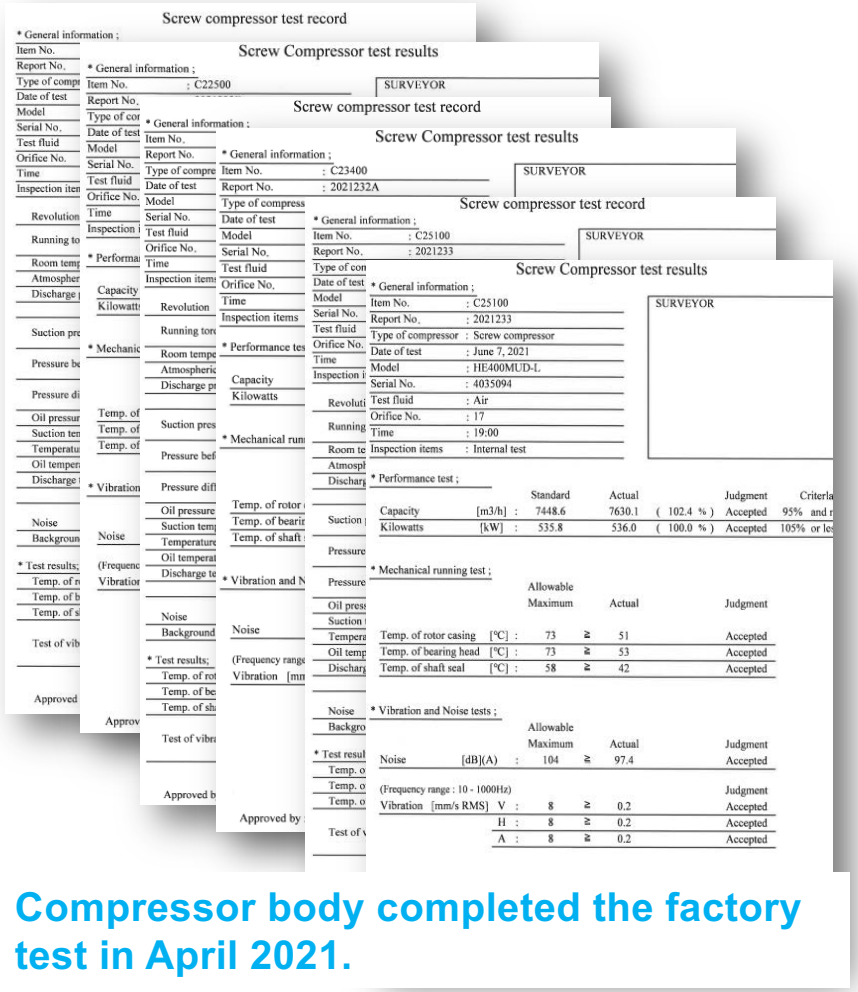


The assembly of the compressor body was completed on March 20,

April 1, 2021, motor tests



SHINE WCS manufacturing - Inspection



Screw compressor test record

Screw Compressor test results

Item No.	: C25100		
Report No.	: 2021233		
Type of compressor	: Screw compressor		
Date of test	: June 7, 2021		
Model	: HE400MUD-L		
Serial No.	: 4035094		
Test fluid	: Air		
Orifice No.	: 17		
Time	: 19:00		
Inspection items	: Internal test		

SURVEYOR

* Performance test ;

		Standard	Actual		Judgment	Criteria
Capacity	[m3/h] :	7448.6	7630.1	(102.4 %)	Accepted	95% and
Kilowatts	[kW] :	535.8	536.0	(100.0 %)	Accepted	105% or le

* Mechanical running test ;

		Allowable Maximum		Actual	Judgment
Temp. of rotor casing	[°C] :	73	≧	51	Accepted
Temp. of bearing head	[°C] :	73	≧	53	Accepted
Temp. of shaft seal	[°C] :	58	≧	42	Accepted

* Vibration and Noise tests ;

		Allowable Maximum		Actual	Judgment
Noise	[dB](A) :	104	≧	97.4	Accepted
(Frequency range : 10 - 1000Hz)					Judgment
Vibration [mm/s RMS]	V :	8	≧	0.2	Accepted
	H :	8	≧	0.2	Accepted
	A :	8	≧	0.2	Accepted

Compressor body completed the factory test in April 2021.

November 2021, the inspection before the compressor unit FAT

SHINE manufacturing - Cold box

Vacuum vessel production

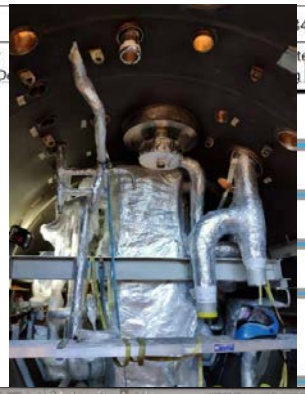
Installation of the internal support structure

Leak test

SHINE ➢ Quality Control - On-site follow-up (4K cold box / 2K cold box vacumm vessels)

SHINE manufacturing - Cold box Assemble

ID	Task Name	Duration	Start	Finish
19	**Long leads (cold box)**	**415 days**	**Thu 08/03/18**	**Wed 09/10/19**
20	BAHX	190 days	Mon 23/04/18	Fri 11/01/19
21	Cryogenic valves	120 days	Mon 16/07/18	Fri 28/12/18
22	Cryogenic compressors casing	200 days	Thu 08/03/18	Wed 12/12/18
23	Cryogenic compressors cartridge	300 days	Thu 08/03/18	Wed 01/05/19
24	Cryogenic turbines casing	415 days	Thu 08/03/18	Wed 09/10/19
25	Cryogenic turbines cartridge	415 days	Thu 08/03/18	Wed 09/10/19
26	**Cold box internals**	**120 days**	**Tue 17/07/18**	**Mon 31/12/18**
27	pressure vessels	65 days	Mon 17/09/18	Fri 14/12/18
28	piping material	50 days	Mon 01/10/18	Fri 07/12/18
29	Cold box top plate / vacuum vessel	120 days	Tue 17/07/18	Mon 31/12/18
30	**Warm panel**	**150 days**	**Mon 17/09/18**	**Fri 12/04/19**
31	Safety valves	130 days	Mon 17/09/18	Fri 15/03/19
32	Others	70 days	Mon 07/01/19	Fri 12/04/19
33	Control panel	60 days	Tue 23/10/18	Mon 14/01/19
34	**Warm compression station**	**220 days**	**Mon 19/11/18**	**Fri 20/09/19**
35	Cycle compressors	180 days	Mon 19/11/18	Fri 26/07/19
36	VLP vacuum pump skid	140 days	Mon 19/11/18	Fri 31/05/19





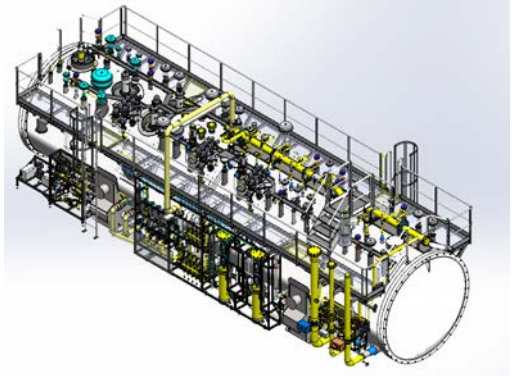




SHINE manufacturing - Cold box Assemble

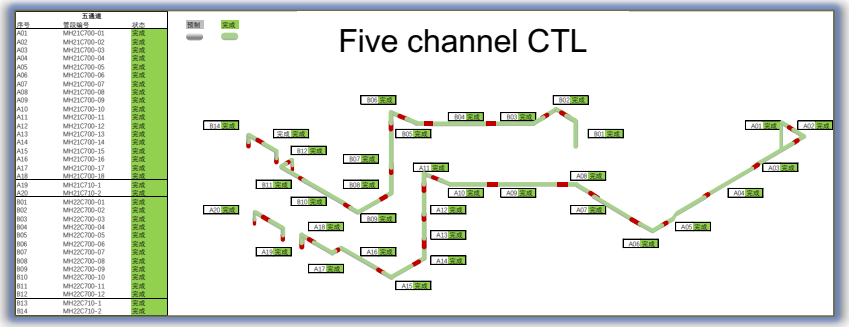
SCHXFEL Project - C1348 PM 103(4)

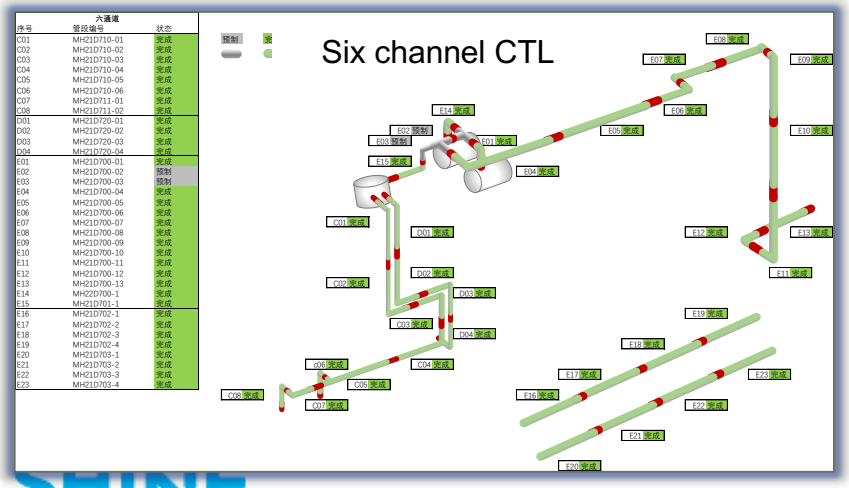
ID	Task Name	Duration	Start	Finish
37	Oil Removal Skid	140 days	Mon 11/03/19	Fri 20/09/19
38	**Cold Box Manufacturing**	**102 days**	**Mon 01/04/19**	**Tue 20/08/19**
39	Piping isometrics prefabrication	20 days	Mon 01/04/19	Fri 26/04/19
40	Pressure vessels preparation	20 days	Mon 01/04/19	Fri 26/04/19
41	Assembly on top plate	68 days	Mon 29/04/19	Wed 31/07/19
42	Final insulation	2 days	Thu 01/08/19	Fri 02/08/19
43	Closing	2 days	Mon 05/08/19	Tue 06/08/19
44	Warm panel premanufacturing	45 days	Mon 13/05/19	Fri 12/07/19
45	Assembly of warm panel	15 days	Mon 15/07/19	Fri 02/08/19
46	Assembly of control panel	15 days	Mon 15/07/19	Fri 02/08/19
47	Final tests	10 days	Mon 05/08/19	Fri 16/08/19
48	Packing/ preparation for shipment	2 days	Mon 19/08/19	Tue 20/08/19
49	**Delivery to SC HXFEL site**	**46 days**	**Wed 21/08/19**	**Wed 23/10/19**
50	Warm compression station	9 wks	Wed 21/08/19	Tue 22/10/19
51	Peripherals (local part)	3 wks	Thu 03/10/19	Wed 23/10/19
52	Cold box	9 wks	Wed 21/08/19	Tue 22/10/19
53	Turbines + casing	2 wks	Thu 10/10/19	Wed 23/10/19
54	**Site works**	**219 days**	**Wed 23/10/19**	**Mon 24/08/20**
55	**Installation work (client responsibility)**	**64 days**	**Wed 23/10/19**	**Mon 20/01/20**



SHINE-Cryo-station 1-CDS

➢ Cryogenic transfer line manufacturing





Installation

SHINE

SHINE cryogenic system construction schedule

TFCP SAT — 2021.7.13 — SRF TEST

ACCP Trian 1 — WCS site 2022.05 — Cold box site 2022.12 — SAT 2024.06 — Injector First Linac

ACCP Train 2 — Cold box arrival 2023.06 — Installation 2023.12 — SAT 2024.12 — 5GeV Linac

ACCP Train 3 — Cold box arrival 2023.08 — Installation 2024.05 — SAT 2025.06 — 8GeV Linac

SHINE

SHINE installation - Cold box

Transportation and handling simulation in advance

SHINE

Weight : 60t

L*W*H : 15m*4.5m*4.2m

SHINE installation - Cold box positioning

SHINE installation - Piping

Pre-installation

- 3D model guidance for installation

- Material Preparation
- Pipe routing
- Collision detection
- Construction arrangements

SHINE

SHINE installation - Piping

Quality check during installation



- Material check
- Cleanness check
- Welding check
- After welding check
- Etc.




SHINE installation - Piping

Test after installation

Pressure test

Cleanness test

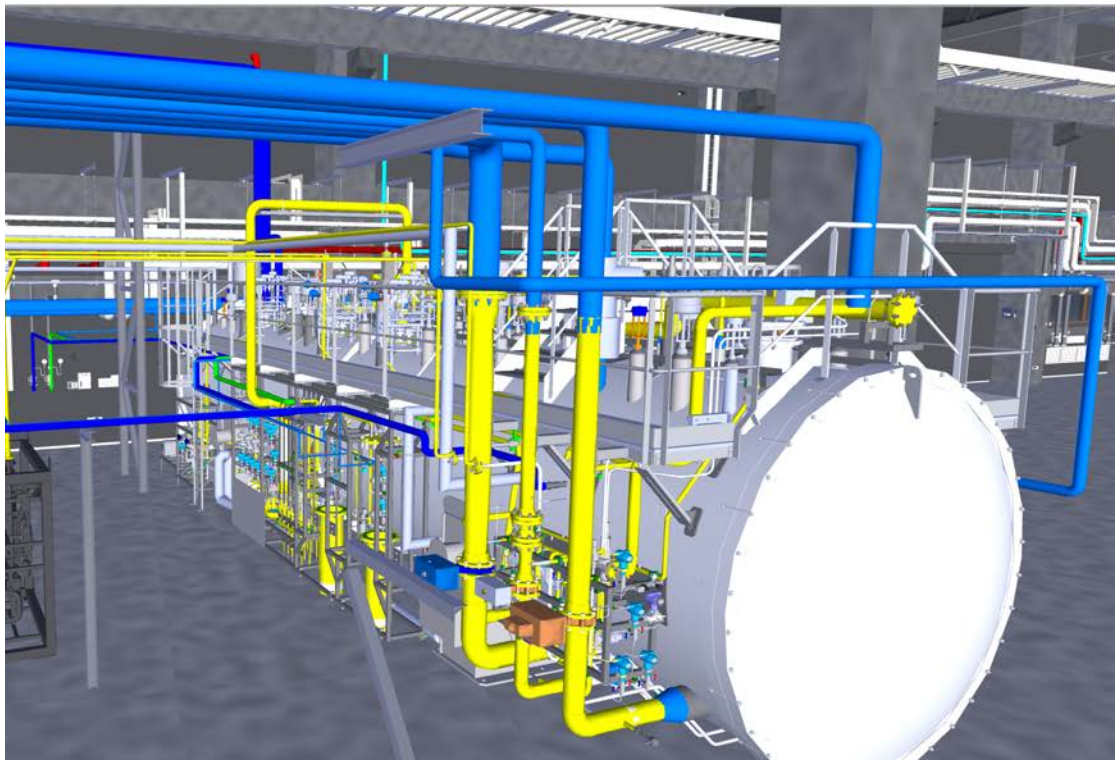
Leak test

Each pipe need to be tested after installation. Only if the radiation detection，pressure test，cleanness test and leak test etc. were passed, the pipe could be used.

SHINE

SHINE installation

3D Model

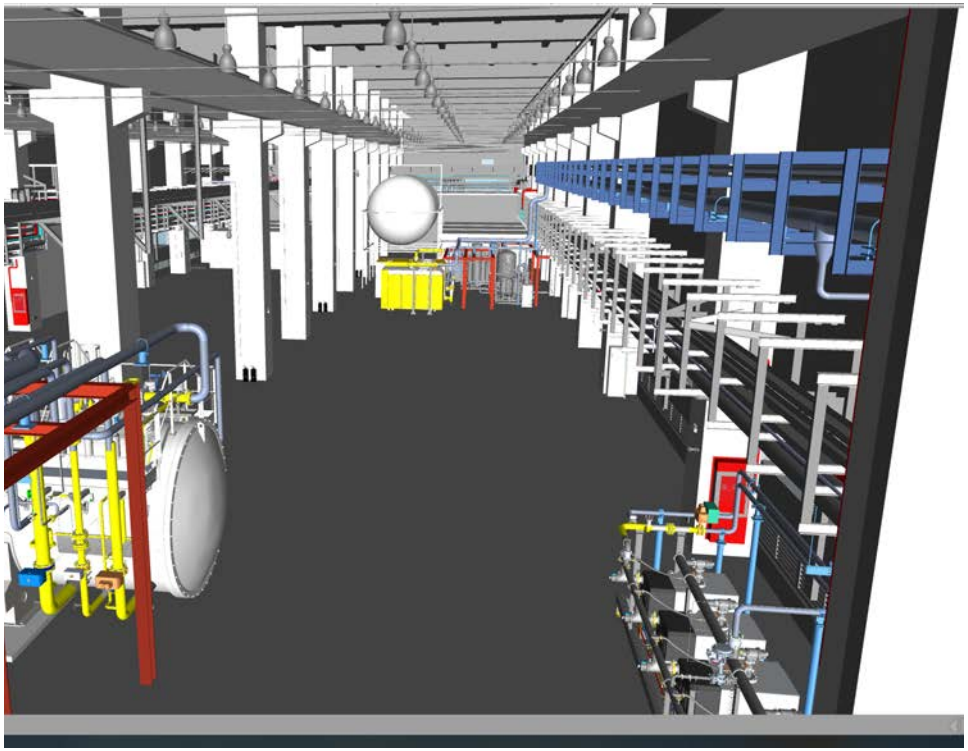


Photos

SHINE

SHINE installation

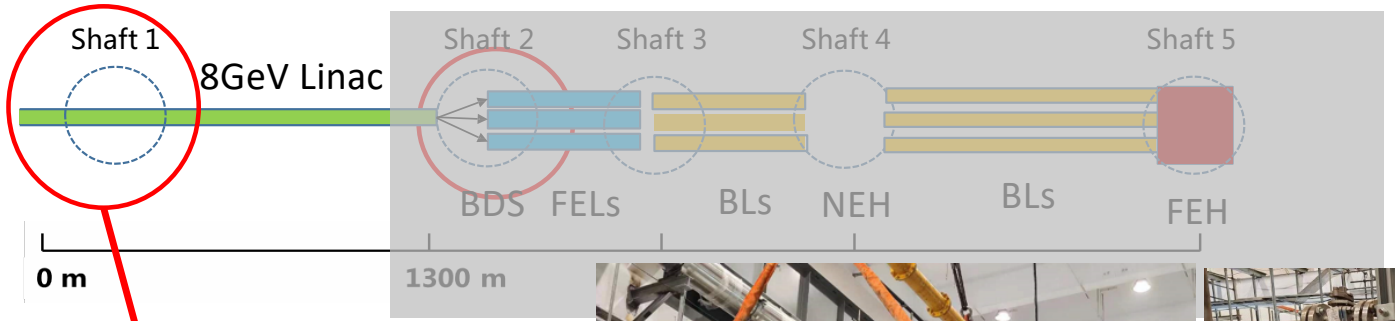
3D Model



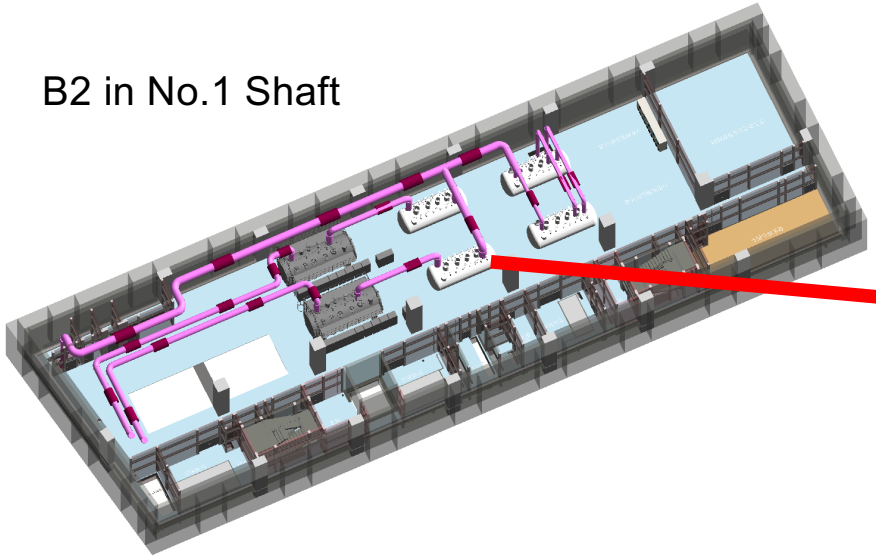
Photos

SHINE

SHINE Cryogenic system construction



B2 in No.1 Shaft

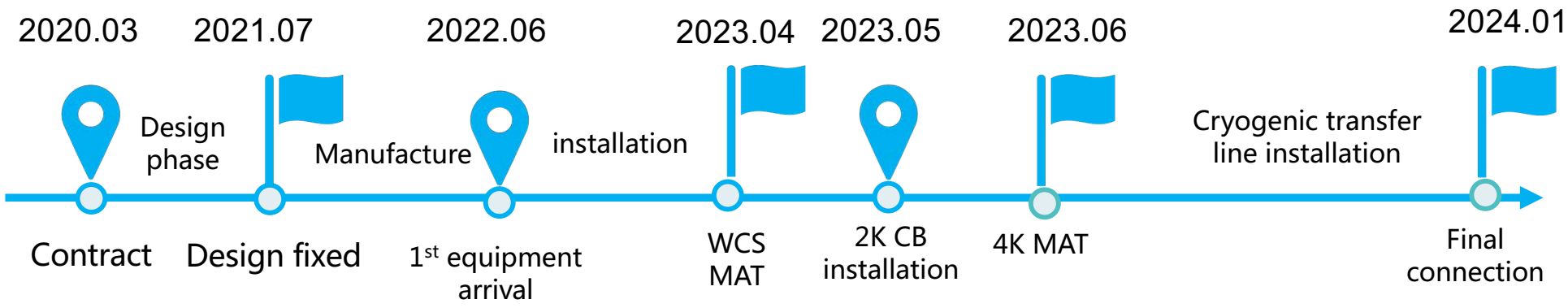


2K cold boxes (X2) & Distribution box (X3) installation done

1st WCS commissioning finished

SHINE 1st Cryoplant

Cryoplant installation milestones



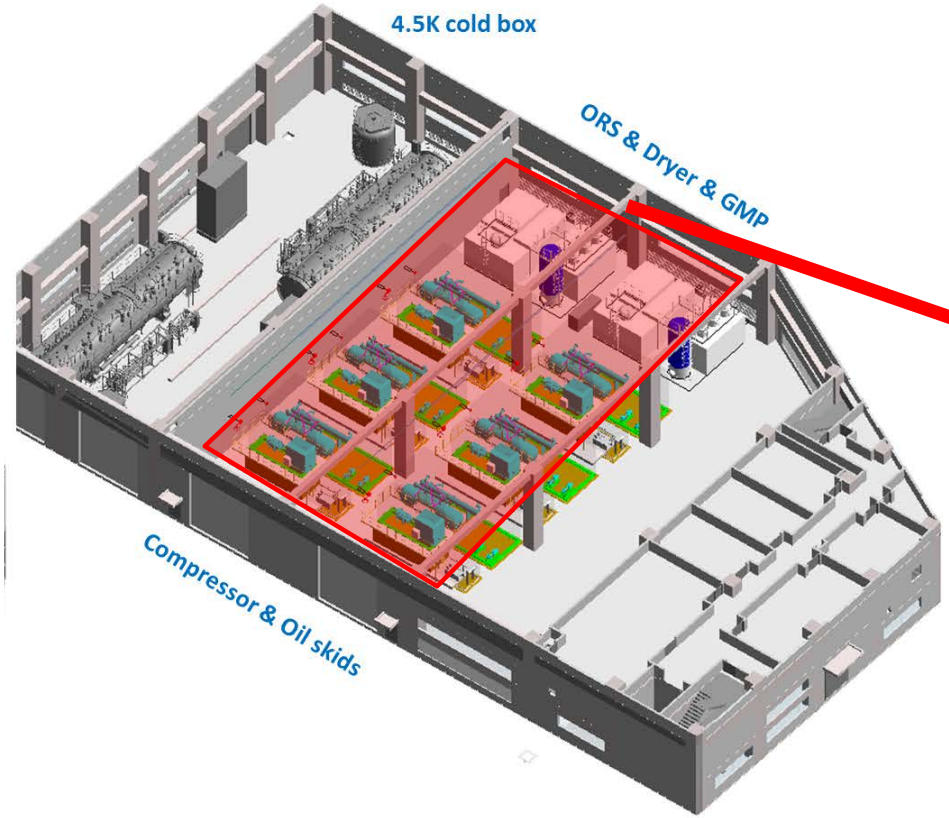
2020.03	Contract with ALAT
2021.07	BDR1/BDR/DDR1/DDR2 Design fixed
2022.06	1st train of equipment arrived at site
2023.04	WCS1 MAT
2023.04	2K CB installation finished
2023.05	4K CB MAT
2024.01	4K CB & 2K CB final connection

SHINE

SHINE

Installation Progress

1st train of WCS installation finished at early April, 2023.



SHINE

SHINE

Installation Progress-WCS

Equipment location

Equipment erection

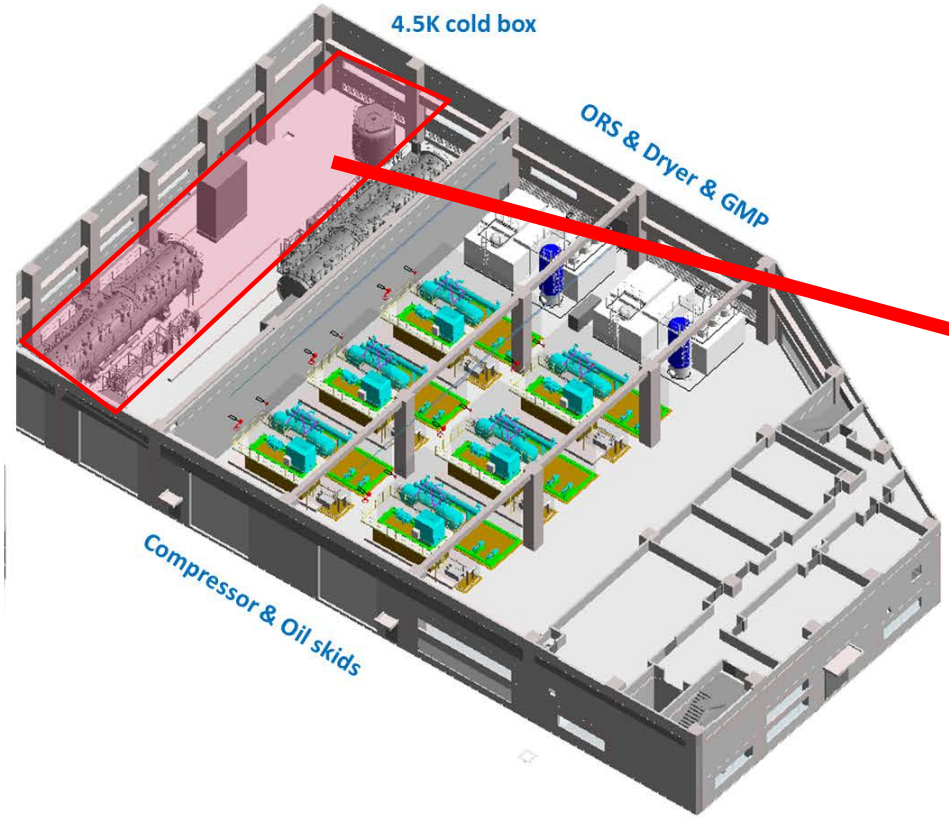
Insulation installation

SHINE

SHINE

Installation Progress-4K CB

1st train of 4K CB installation finished at early June, 2023.



SHINE

SHINE

Installation Progress-4K CB

Location of 4K CB

Main process pipe installation

Main compountents installation

Size: nearly

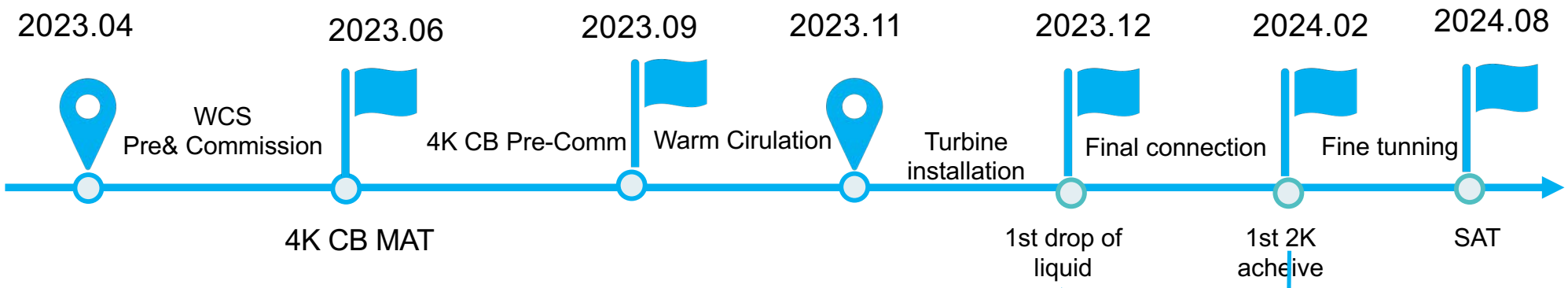
20000mm*5000mm*5000mm

Weight:

Nearly 90tons

Commission

SHINE Commission



2023.04 WCS commission start

2023.06 4K CB pre-commission start

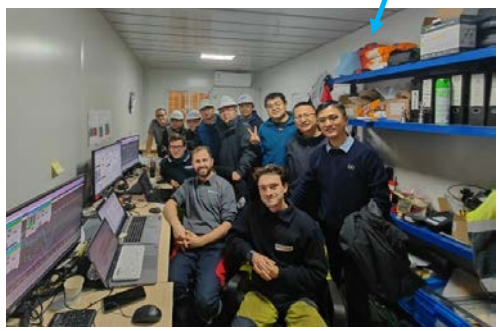
2022.07 WCS Performance test

2023.09 Warm circulation

2023.12 1st drop of liquid (4.5K)

2024.01 4K & 2K cold box finnal connection

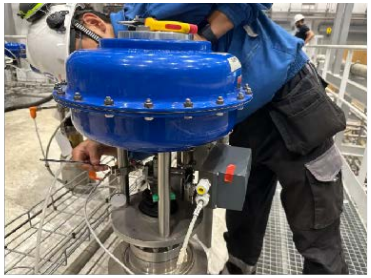
2024.02 1st 2K acheive

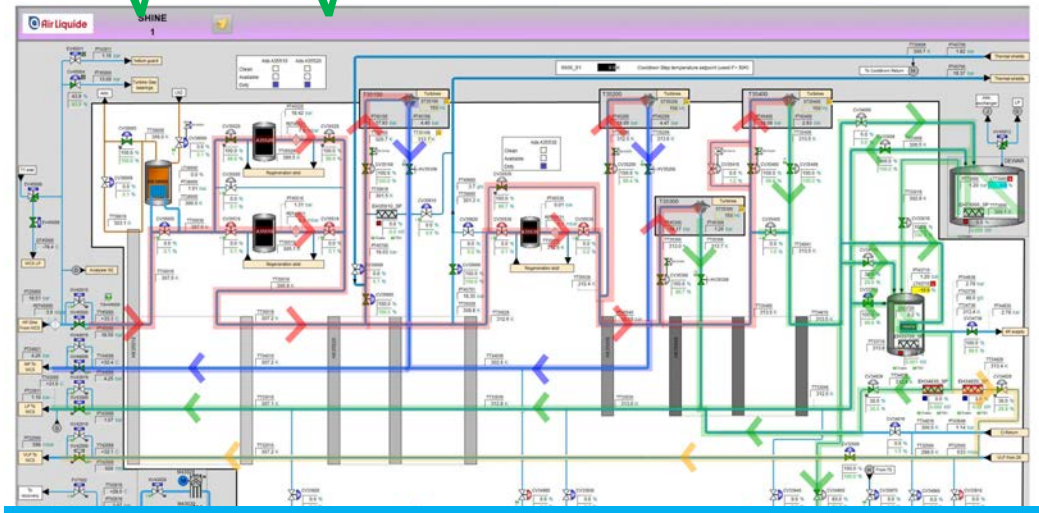


SHINE

SHINE ACCP Train 1 4.5K cold box commissioning

Main steps	Pre Commissioning activities					Commissioning activities		
	Power and Network config.	Electrical loop checks	ORS and ads. drying	Leak tests and conditi oning	Compres sor start and Warm sequenc es tests	Turbine installation	Cold sequences testings and Tuning	Performance tests and customer training
	√	√	√	√	√	√	√	





2 months has been spent in the warm circulation to remove the particles in the system, especially to the turbine filter

SHINE Commission - 4.5K cold box

07.20

Adsorber regeneration

Adsorber regeneration

08.28

Dummy Turbine install

Conditioning

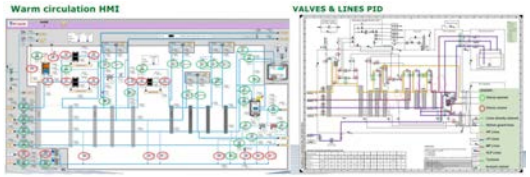
Dumm turbine install

loop check

09.11

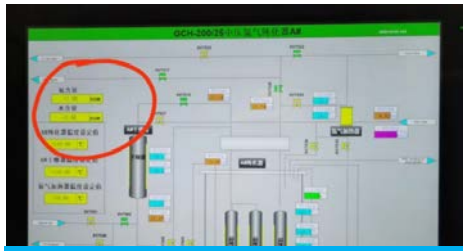
warm circulation

Turbine&filter cleaniess check



Particles found

10.20



HP : 1.8PPM N2
WP : 0.5PPM N2

Purification

11.21

Pre-comm : 4 m
Circulation : 3 m

→11.21 Pre-comm finish

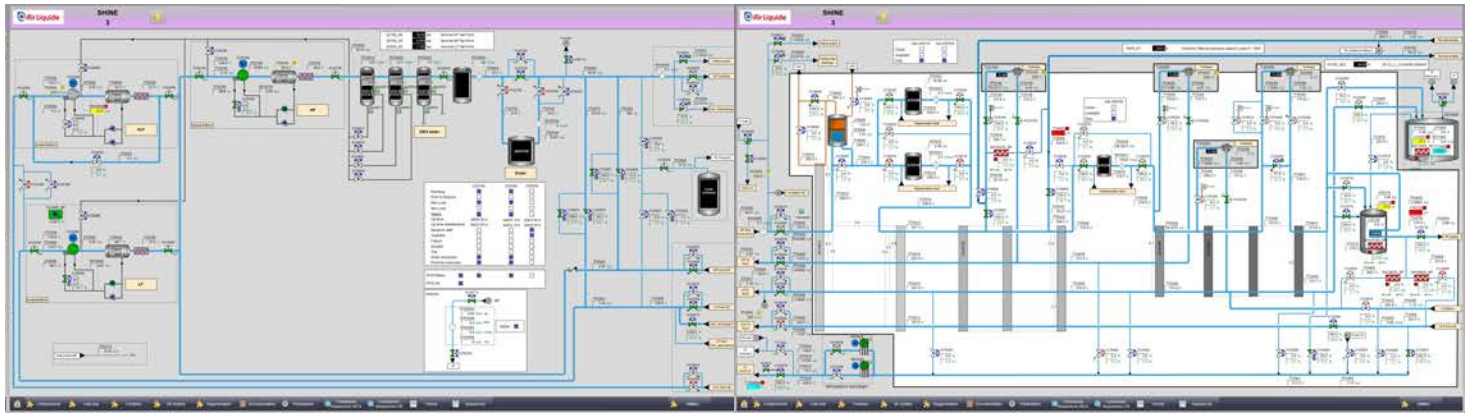
NO.11

Warm circulation

Oil contents→Re-circulation
T2 check→Turbine install

SHINE

ACCP2-4.5 K cold box

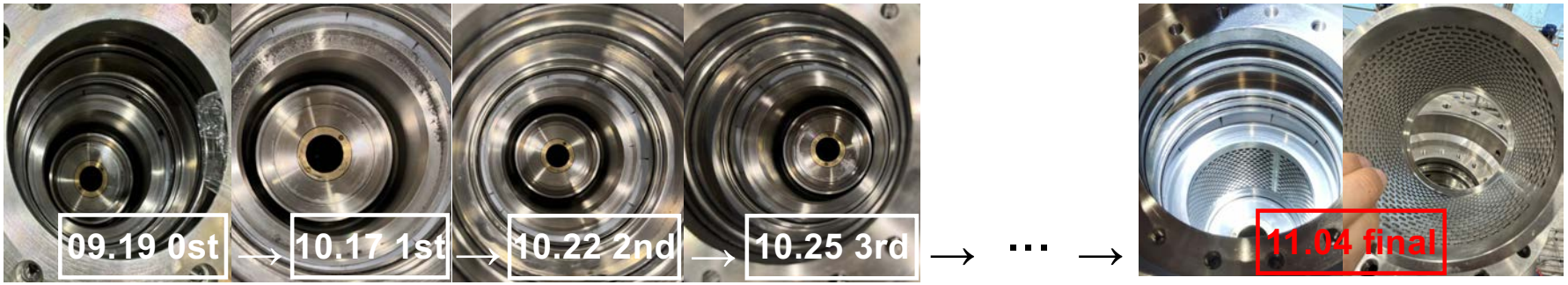


Records of filter check

- Duration of warm circulation：19 days（10.17→11.04）
- Turns of filter dis/assemble：10 rounds

4K warm circulation done!!!!

Filter cleanness check



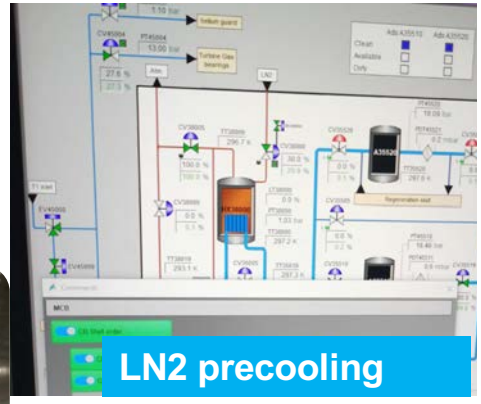
SHINE Commission - 4.5K cold box

Turbine installation

11.23

First cool down

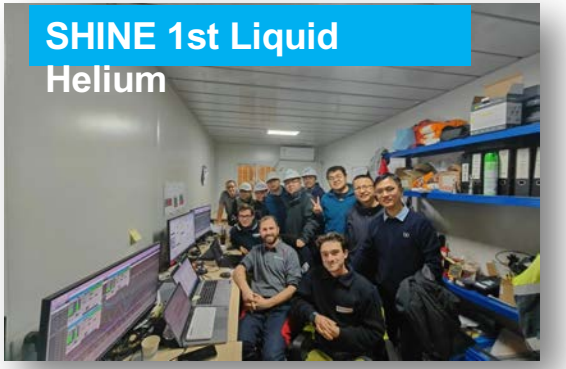
11.29



LN2 precooling

First drop of Liquid Helium

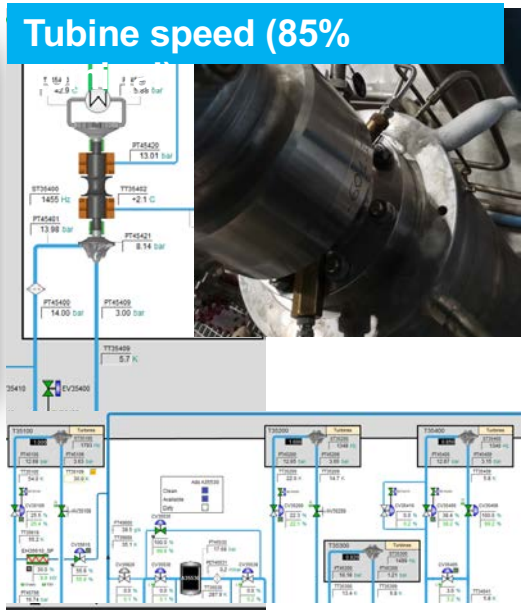
12.06



SHINE 1st Liquid Helium

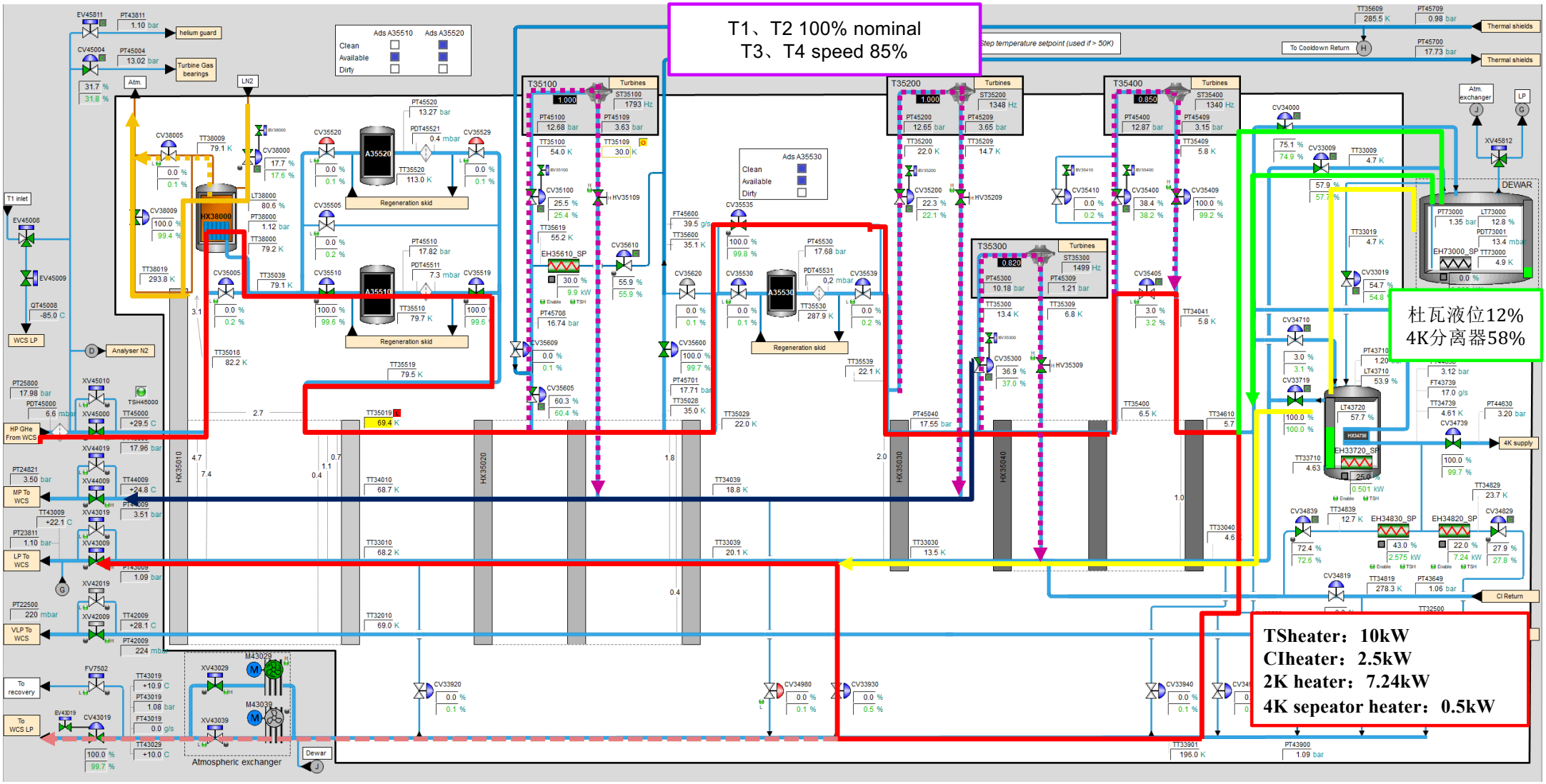
4 Turbines operation

12.11

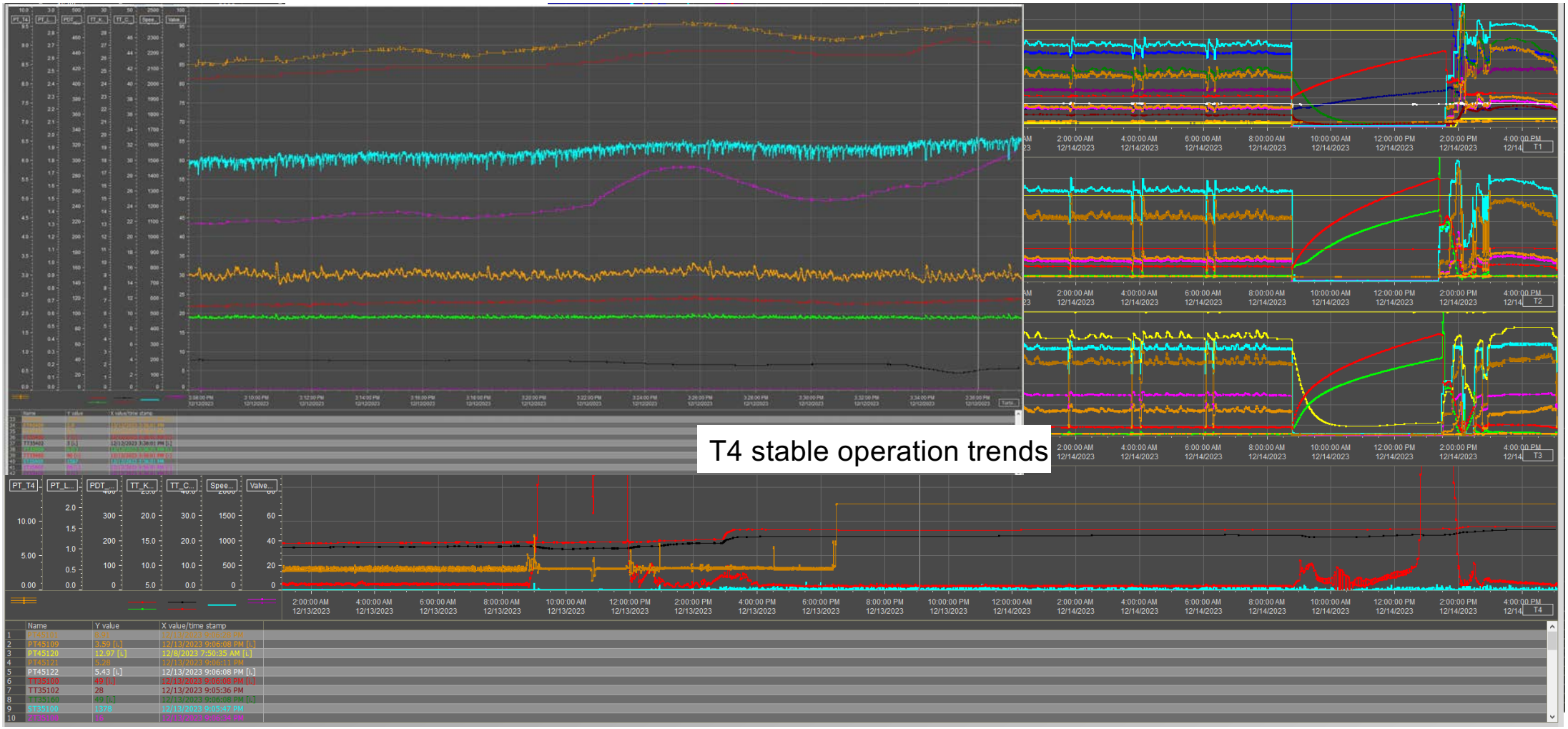


Tubine speed (85%

SHINE Commission - 4.5K cold box



SHINE Commission - 4.5K cold box



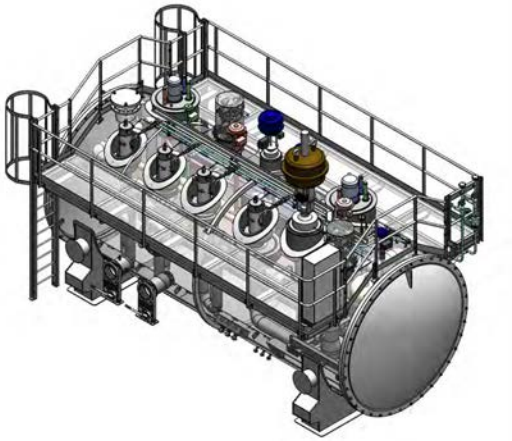
SHINE Commission - 2K cold box

2K system conditioning (CC、TS、CI)

01.17

2K Cold box warm circulation

01.22

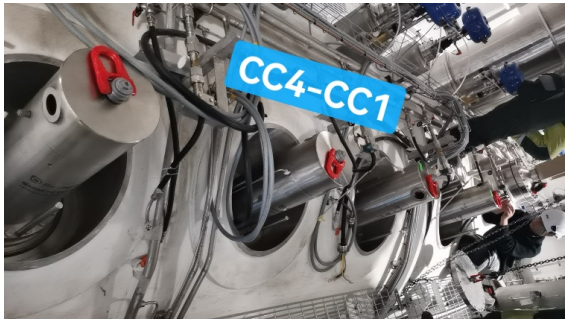


Helium purification

01.26

Cold compressors installation

01.29

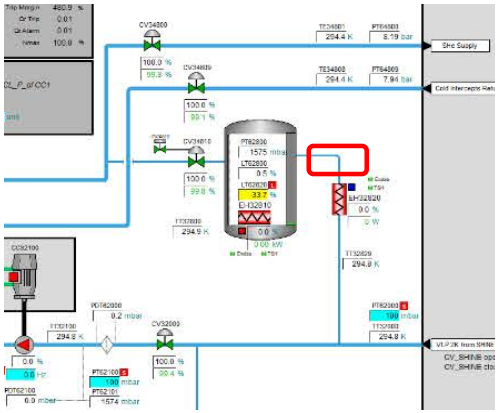


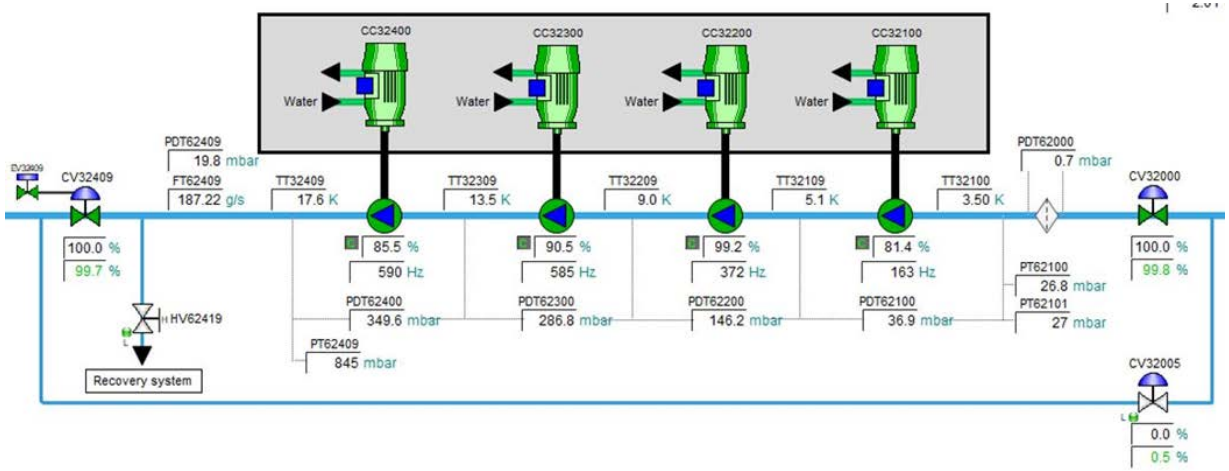
SHINE

SHINE Commission - 2K cold box

20240227

First reach nominal mode 2K，mass flow **187g/s**，Inlet temperature 3.5K， CC Margin 14.5%





- **A static mixer was added before the electrical heater inside the 2K CB in order to reduce the flow instability in case the mass flow rate is higher than ~120g/s taking the lessons learned in IBS project**

SHINE

SHINE Commission - 2K cold box

- **Oscillation was observed when the supercritical turbine T4 turned into operation and many different measures have been applied to eliminate such effect in order to reach the nominal performance of the whole cryoplant**






SHINE Commission - 2K cold box

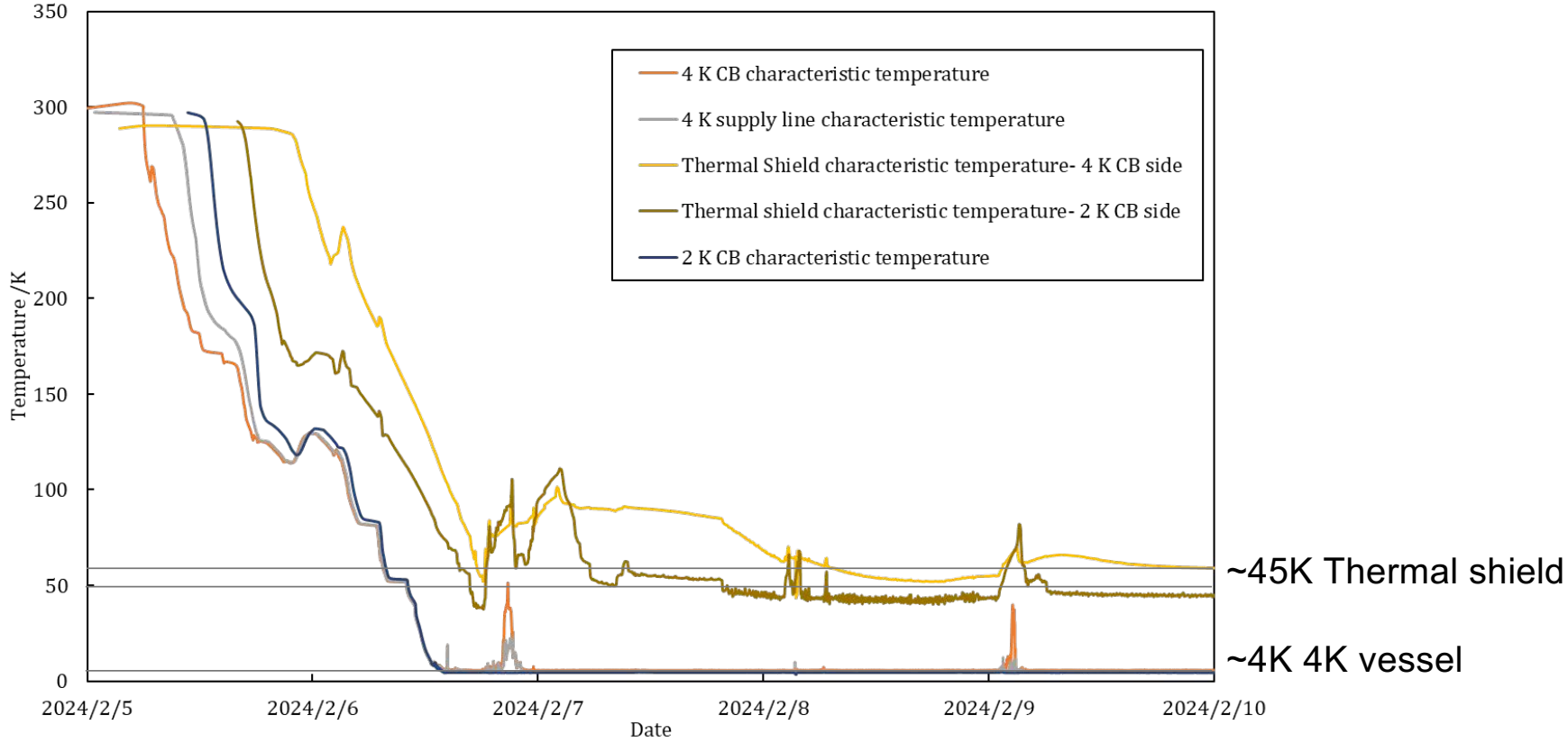
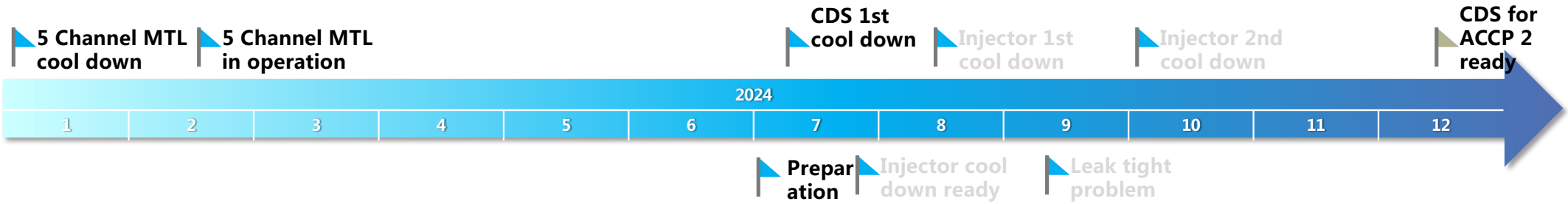


Figure3： The characteristic temperature changes during cooling down progress

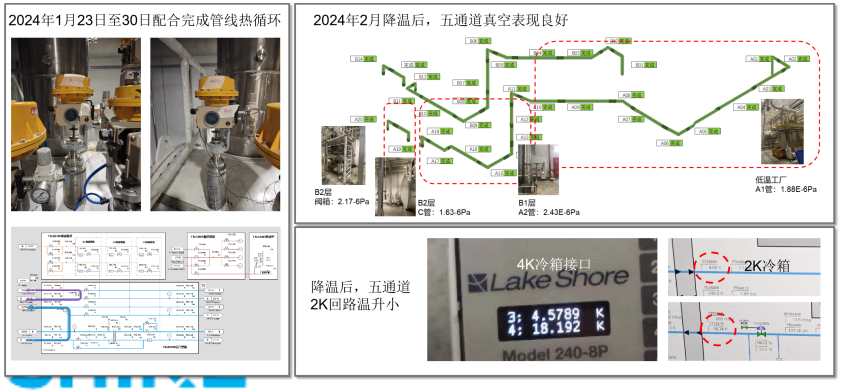
SHINE

Commission of CDS at Cryo-station 1

➢ Commission of CDS at Cryo-station 1 had been finished

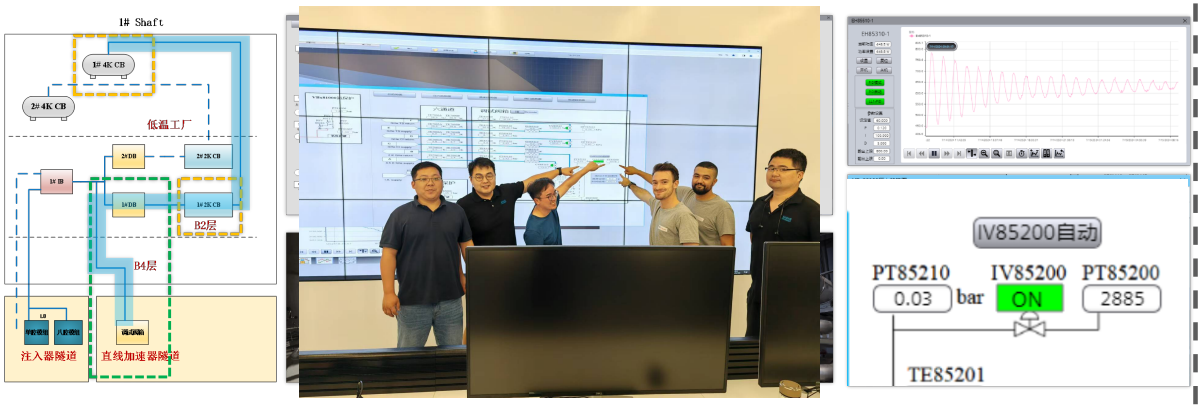


✓ 5 Channel MTL low heat load, vacuum tight, no frozen



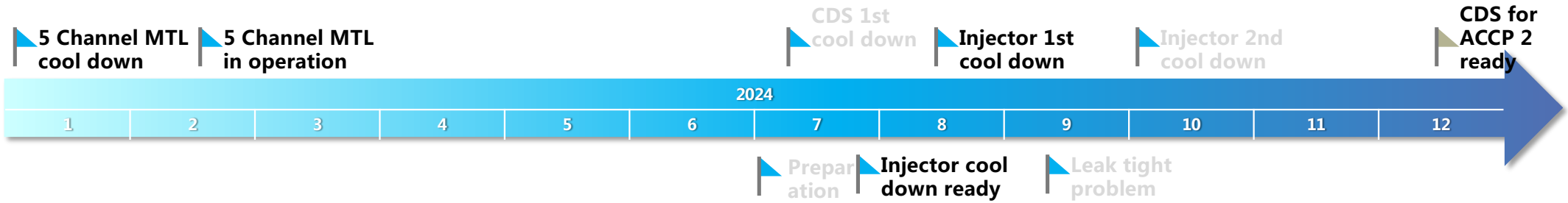
✓ First cool down of CDS verified the design and control ;

✓ **First achieve 2K in the user side (feed-cap - test box)。**

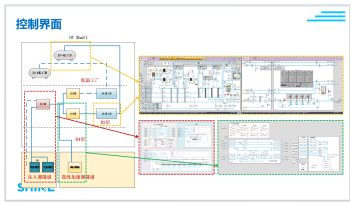


Commission of CDS at Cryo-station 1

➢ Commission of CDS at Cryo-station 1 had been finished

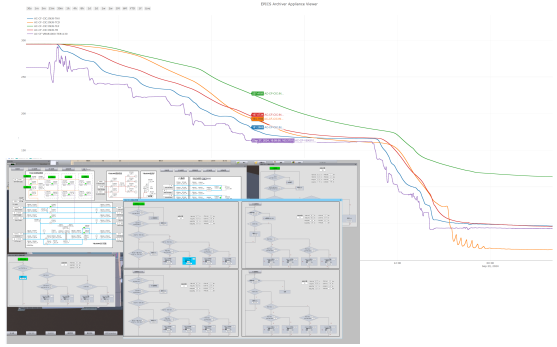


✓ 19th July Cool down proposal review



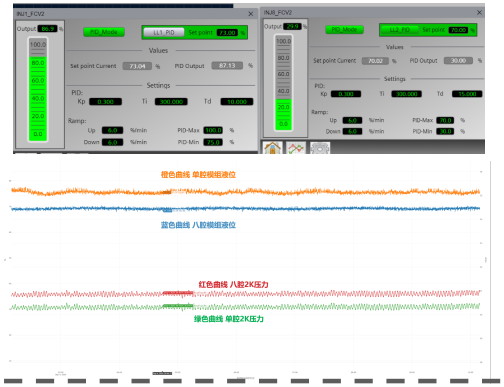
✓ 17th Aug Before cool down check

✓ Auto PID control was implemented



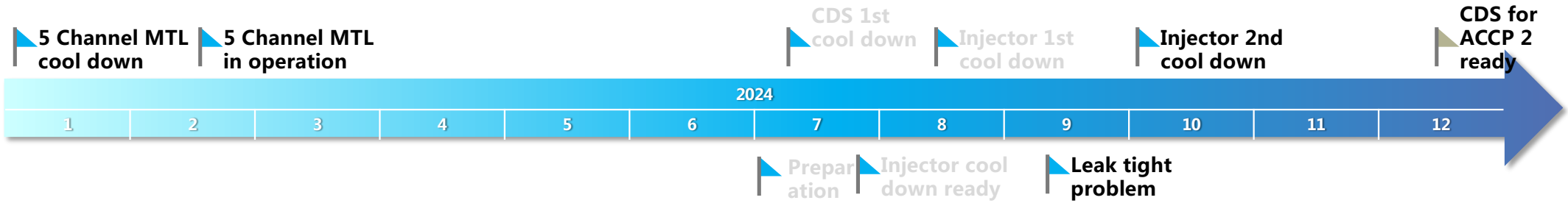
✓ PID control to achieve Inj8 liquid level **70.5±0.5%** , Inj1 : **75±1%** ;

✓ 2K pressure **30.9±0.1mbar**。



Commission of CDS at Cryo-station 1

➢ Commission of CDS at Cryo-station 1 had been finished



➢ 7th Sep Sub-atmospheric circuit leak untight was observed

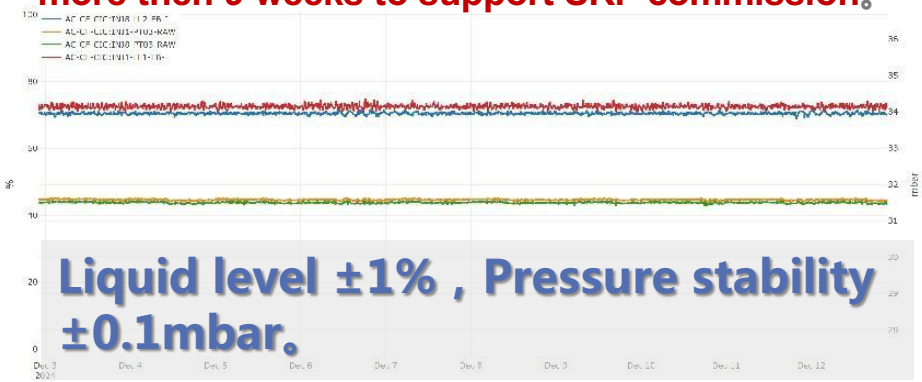
✓ Valve tight

✓ Leak check and tight

✓ Piping disconnection

✓ Commission finished in October turned into operation;

✓ **Since 18th Oct, long term continues stable operation more then 9 weeks to support SRF commission。**



Liquid level ±1% , Pressure stability ±0.1mbar。

Commission of CDS at Cryo-station 1

- **Cryogenic transfer line performance had been tested**

	制冷量	阀箱	低温管线
SHINE 1号井	8 kW@2 K	3	630 m
E-XFEL	4 kW@2 K	2	340 m
LCLS II	8 kW@2 K	2	255.2 m

2 ACCPs

SHINE	2K回路	漏热 W/m	设计值 W/m
五通道	4.5K供+ 2K回气	0.45	< 0.8
六通道		0.41	

同类装置	2K回路	每米漏热 W/m
EXFEL	4.5K供+ 2K回气	1.57
LCLS II		1.25

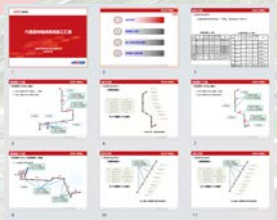
SHINE	回路	漏热 W/m	设计值 W/m
五通道	冷隔段回气	0.126	0.3
	冷屏	5.10	7.8
六通道	冷隔段	0.564	0.6
	冷屏	5.15	7.8

实测指标满足设计指标

Injector

Process
Laytou
Structure
Manufacture
Prodcution
FAT
Installation
Pre-comm
Commission
SAT

SAT



Outline

- 1. Overview of Cryogenic Engineering
  - Introduction of Cryogenic
  - Introduction of Engineering
  - Overview of Cryogenic system
- 2. Case study - SHINE project
  - Introduction of SHINE cryogenic system
  - Engineering experience of SHINE cryogenic system
- **3. Lessons Learned**
- 4. Outlook and Summary

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3. Lessons learned

Installation and commissioning

- Detailed communication with construction department should be done in advance to avoid misunderstanding.
- Enough manpower and spare parts are necessary if you want to speed up the installation.
- Important Tools(torque machine, leak detector…) need to be calibrated and checked before using.
- Never relax the quality standards(cleanness., welding…), otherwise you will pay 5 times effort to fixed problems.

WCS

- Cleanness check and filter check are very important for start-up.
- Purifier is useful especially if you want to save helium during commissioning.
- Oil content of Gas at outlet of ORS need to monitor regularly especially during the first several months of running.
- The N2 impurity will influence the analyzer's measurement of oil content.
- Pay attention to the cooling water if you want stable operation(water quality, flowmeter type…)

CB

- Vacuum for CB and cryogenic line need to be start as early as possible if you want to speed up.
- Cleanness of the adsorber filters and turbine inlet filters are very important.
- Warm circulation of the whole system should be done if possible.
- Get the Spare turbines ready before you start the cryoplant.

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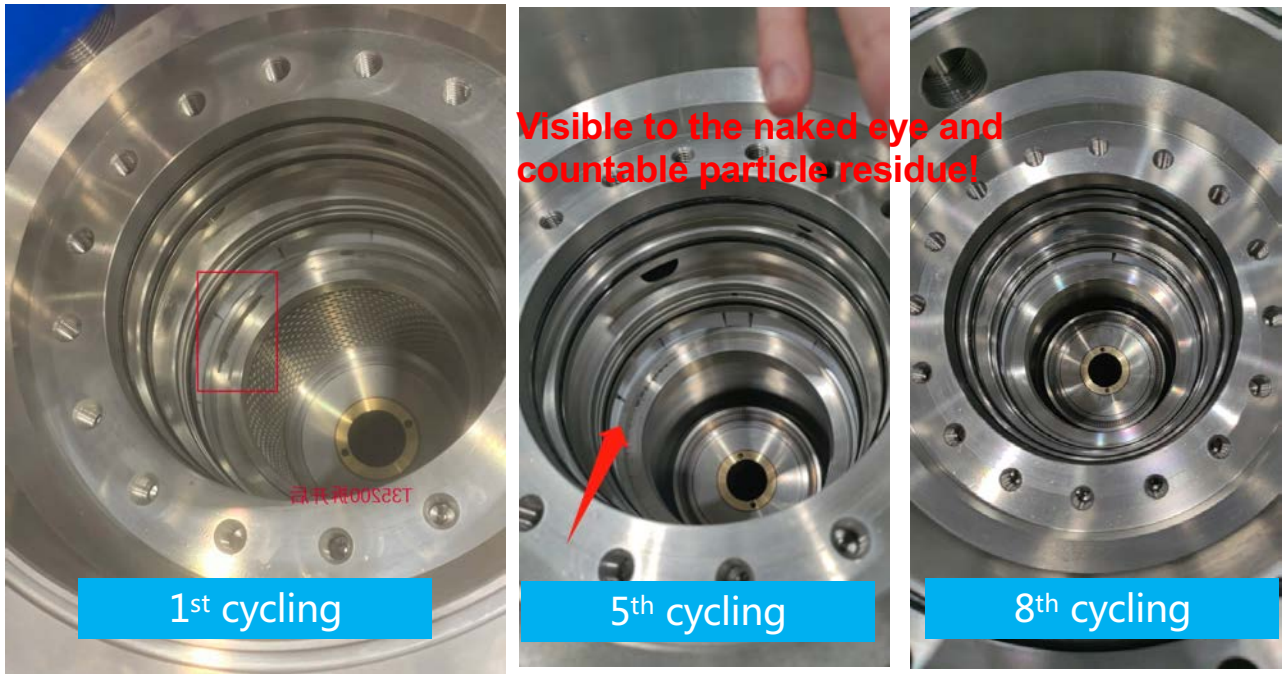
- During the room temperature cycling stage, there are many activated carbon particles/molecular sieve particles in the 80K&20K adsorber filter and the 4th stage turbine filter
- Solution: It took more than 2 months, after 11 rounds of room temperature cycling, multiple cycles of cleaning, which was severely time-consuming. The filling process needs to be improved



Outlook and Summary

SHINE


Your comments are highly appreciated!
Many thanks!