

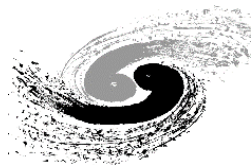
Recent Process of the Cryogenic system for HEPS

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OUTLINE



1 Brief introduction

2 Helium cryogenic system

3 Nitrogen cryogenic system

4 Summary

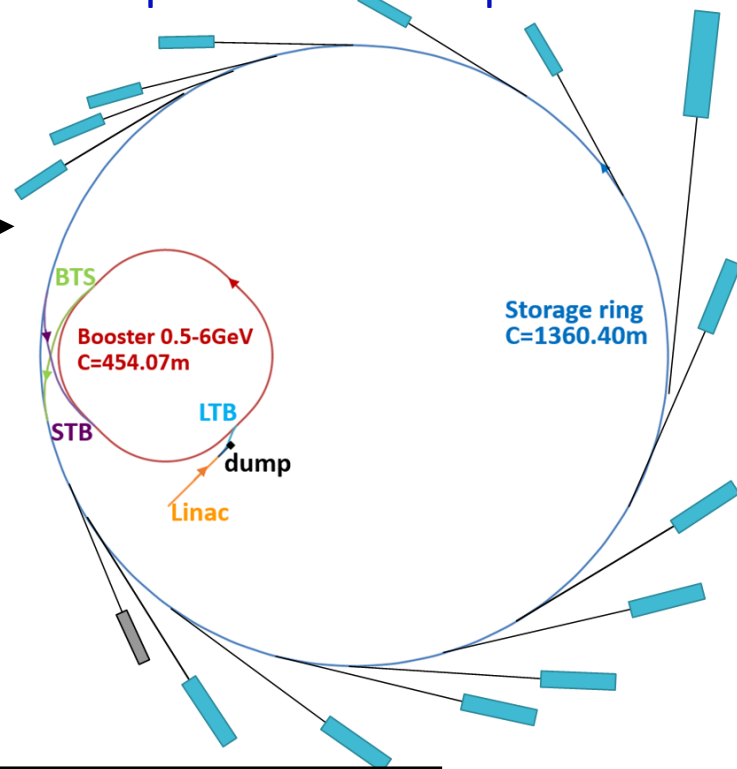
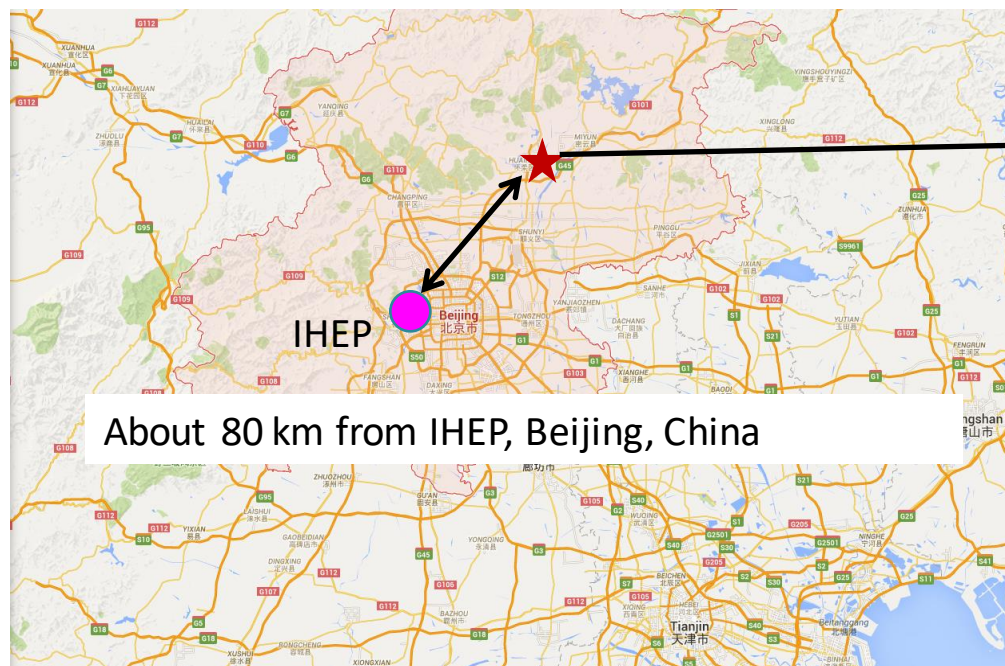


New light source



Number of users and new research fields increased rapidly

HEPS, High Energy Photon Source just based on these requirements. simple diagram. 15 beam lines will be built.



Main parameters	Value	Main parameters	Value
Beam energy	6 GeV	Emittance	$< 60 \text{ pm} \cdot \text{rad}$
Circumference	1360.4 m	Brightness	$> 10^{22}$



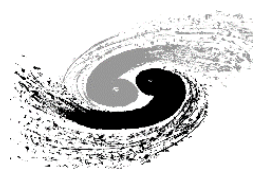
New light source infrastructure



- Design of the infrastructure almost has been completed
- Foundation ceremony was held at 28th, Jun 2019
- Project period is 6.5 years.



- Main buildings magnifier, include accelerator relative building and SR experimental hall, cryogenic hall, environmental monitoring stations, etc.



New light source infrastructure



- Cryogenic hall is one of the first buildings and will be completed in April 2021.
- Infrastructure will be finished in 2023

Cryogenic hall, Feb 2021





● Helium cryogenic system

- ❑ Used to cool down **five 166.6MHz** and **two 499.8MHz** superconducting cavities working at 4.5K;
- ❑ Cooling capacity **~2000 W@4.5K**;
- ❑ Auxiliary system, impure helium gas recovery and purify system.

● LN₂ cryogenic system

- ❑ Used to cool down CPMU and Cryostal-Monochromator, **cryogenic devices of Beam line station ...**;
- ❑ Precooling of the helium refrigerator;
- ❑ Shields of the cryomodules
- ❑ Cooling capacity **~50kW@80K**.



OUTLINE



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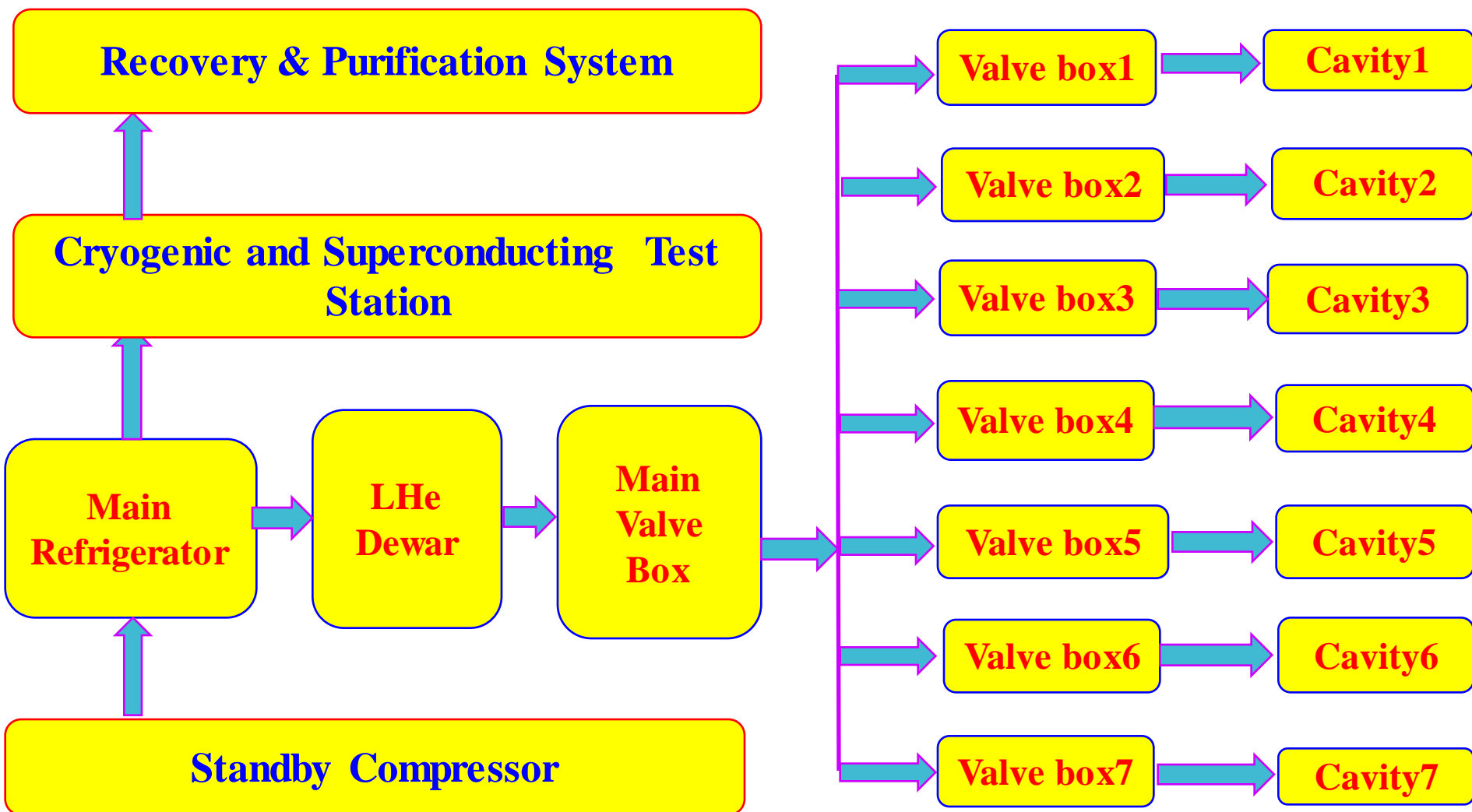
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He Cryogenic system

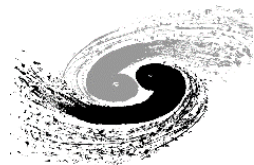




Heat loads



No	Name	Heat load	Total	
1	499.8MHz SC Cryo-module	Static heat load (W)	2×40	80
		Dynamic heat load (W)	2×85	170
2	166.6MHz SC Cryo-module	Static heat load (W)	5×5	250
		Dynamic heat load (W)	5×80	400
3	Common Parts	Main valve box	1×50	50
		Distribution valve box (W)	15×7	105
		Cryogenic transfer Line (W)	200×0.5	100
		Helium Dewar and heater (W)	1	80
4	Margin 30% (W)			371
5	Total heat loads (W)		1606	
6	Total heat loads after upgrade (W)		2000	



Key technologies



- System optimization design
- High performance cryomodules
- High performance cryogenic transfer lines
- Precision measurement and automatic control
- Fast Recovery of System Faults
- Special requirements, $\pm 3\text{mbar}$ pressure fluctuation inside the cavity helium vessel
- Key technologies guide the design direction

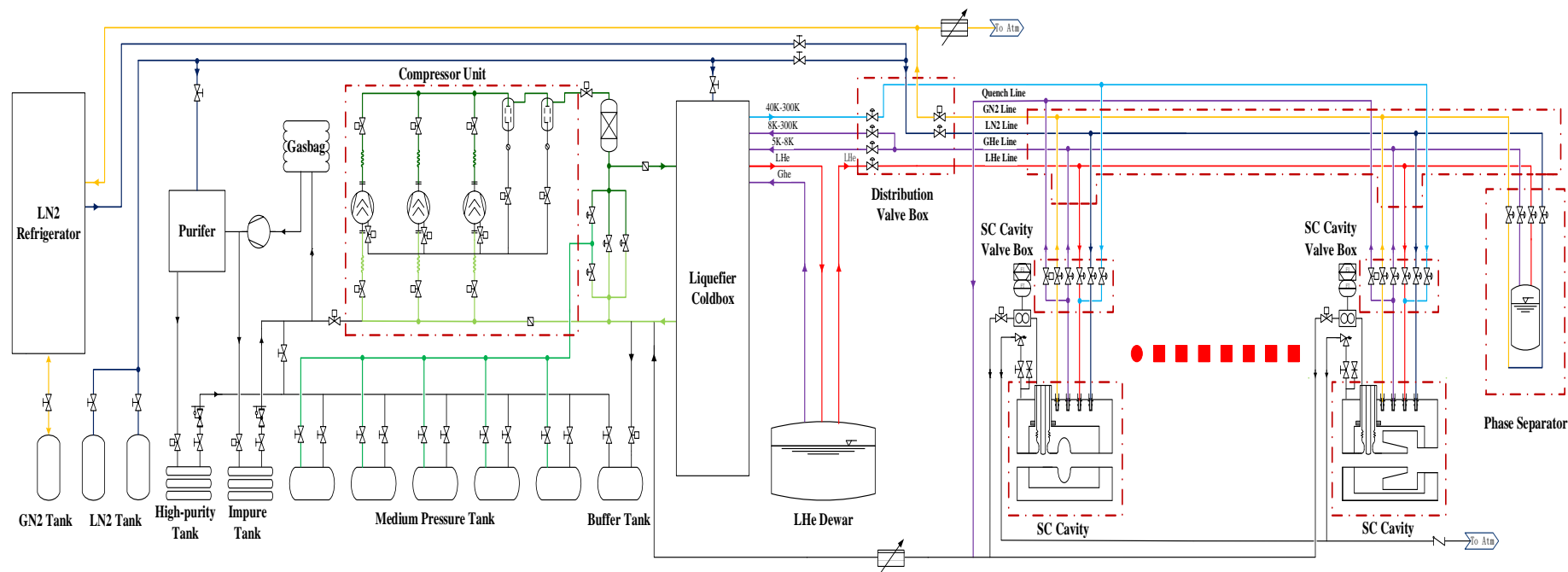


Simplified flow chart



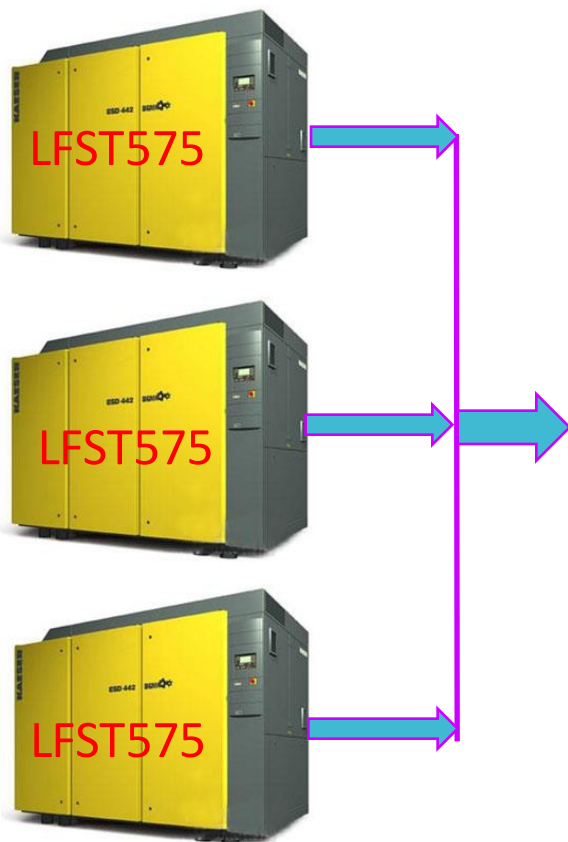
- Helium refrigerator
- Cold box, LHe dewar, Compressors
- Helium storage and purified system

- Cryogenic distribution system
- Valve boxes
- Multi-tunnel cryogenic transfer line





Helium Refrigerator

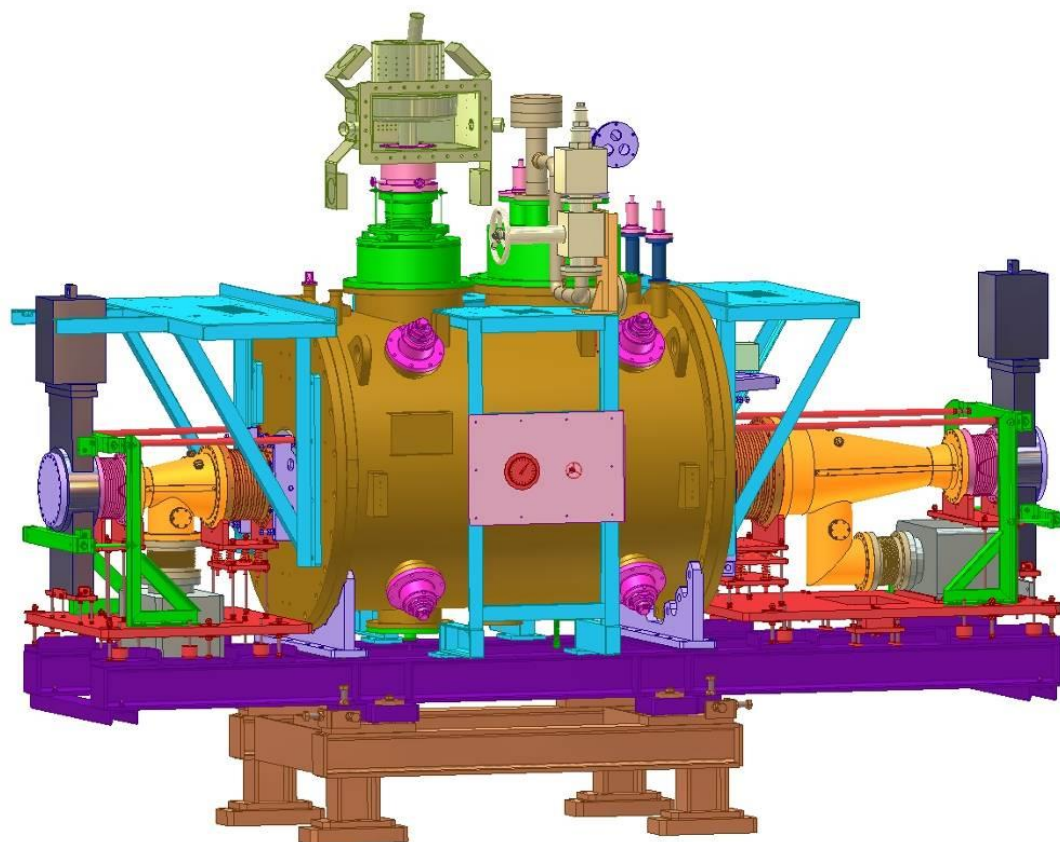


Core: Operation with low failure rate.

- ❑ Helium refrigerator is one of the most key equipments of the cryogenic system and will be made by *Linde*.
- ❑ Two LFST575 type compressors with frequency converter can make 2kW@4.5K cooling capacity;
- ❑ The cooling capacity can be adjusted between 1.5 and 2 kW by the frequency converter;
- ❑ Compressor is the large power equipment, two compressors online operation and one compressor as spare make the whole refrigerator running with higher efficiency.



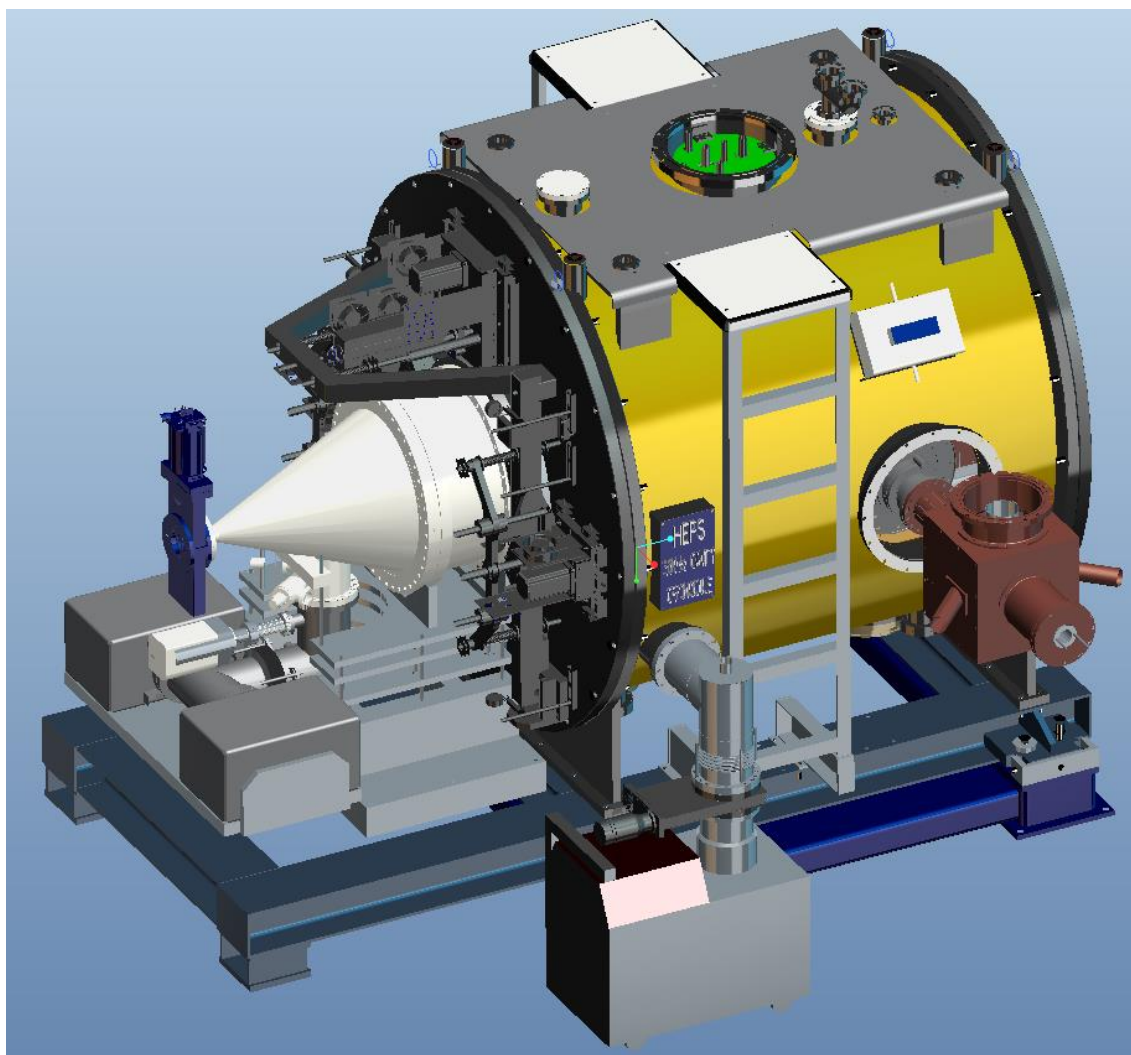
499.8 MHz Cryomodule



- ❑ This kind of cryomodule have been used in BEPC II more than 12 years;
- ❑ The spare cryomodule made by IHEP also has been in operation around 3 years;
- ❑ Relatively mature technology.



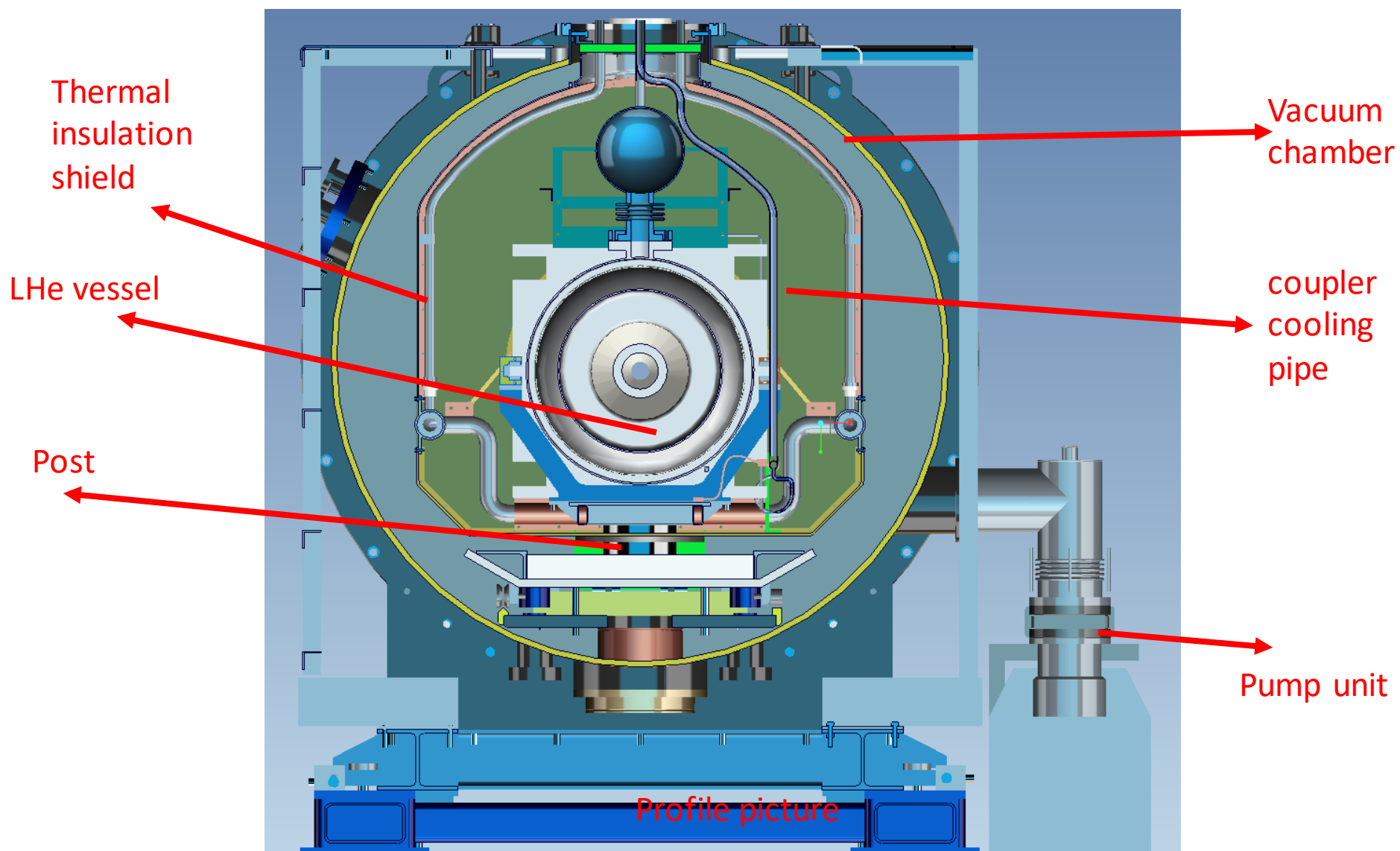
166.6 MHz Cryomodule



- ❑ Horizontal test has been finished ;
- ❑ the components and machine design of the real cryomodule has been finished;
- ❑ Thermal analysis on the process.



166.6 MHz Cryomodule



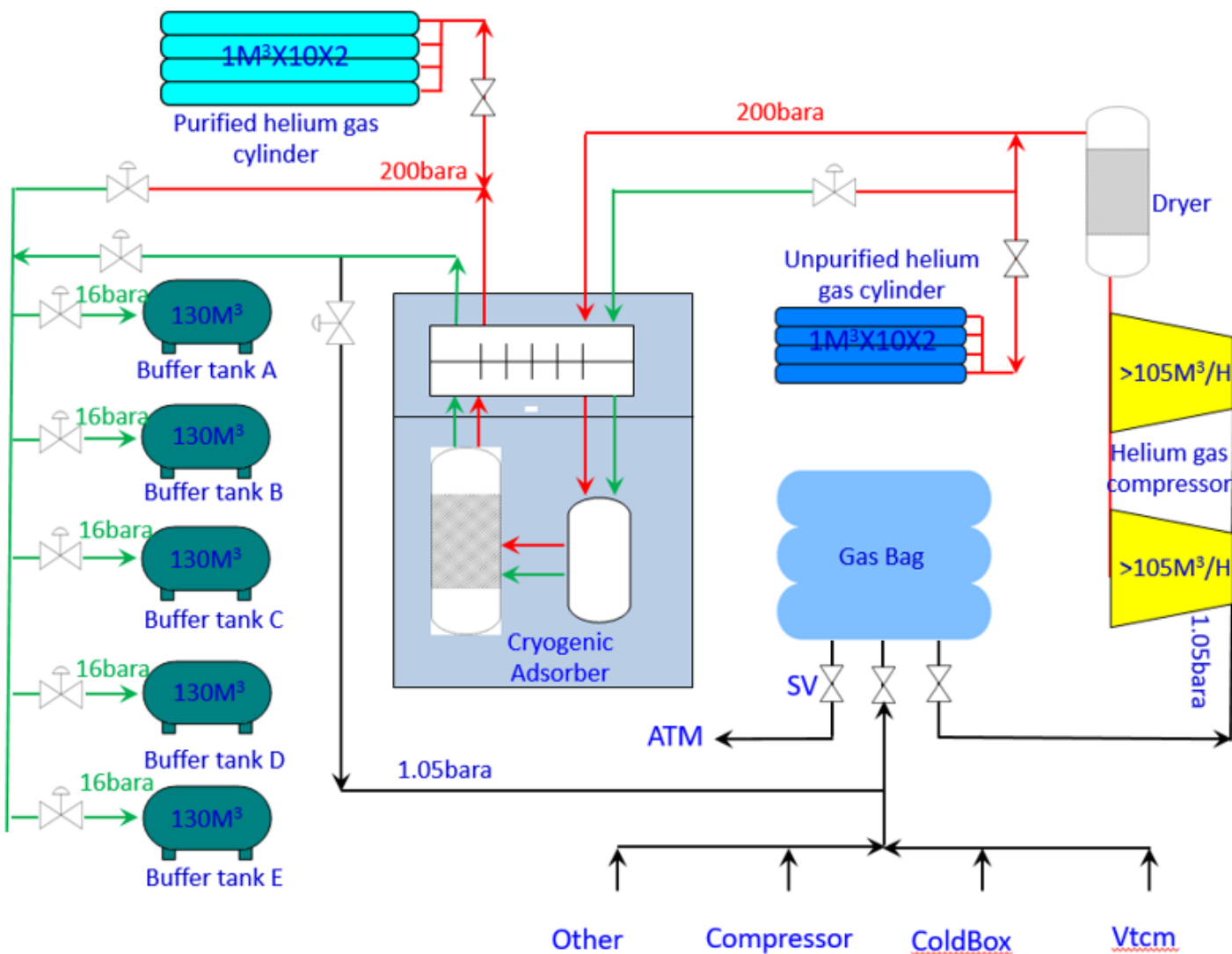


He Recovery & Purification System



- Helium gas is a scarce resource and it should can be recycle.
- Helium gas storage scale is big.
- Helium gas purified 99.999% for refrigerator.
- Helium recovery and purification system is very important for the stable operation of the cryogenic system.

Recovery & Purification System



Main performance	
Helium Gas Storage (NM³)	≤10000
Pressure (Bar)	≤200
Helium Gas recovery (NM³/H)	≥210
Purified Helium gas (%)	≥99.999
Operation Mode	Auto



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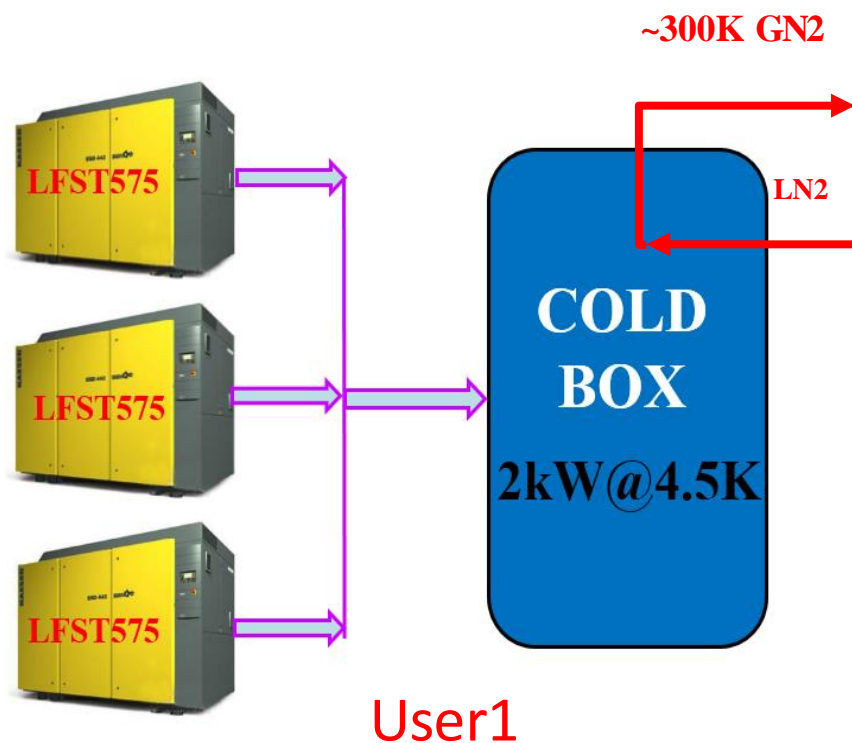
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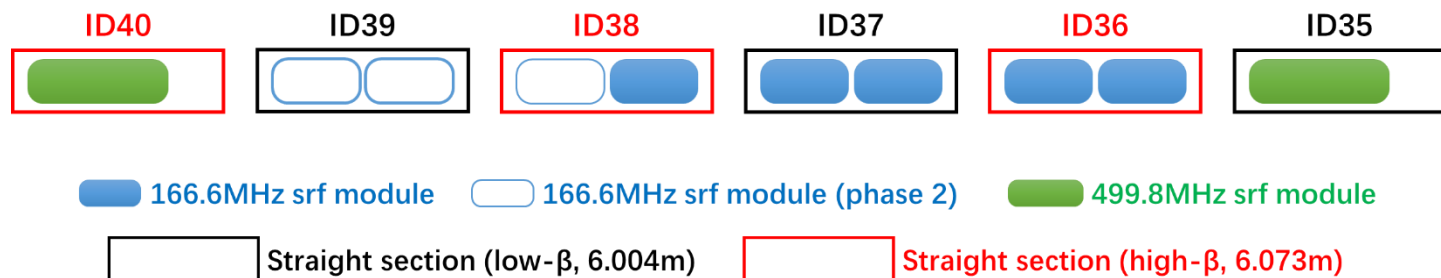


Users of the nitrogen cryogenic system



	名称	低温单色器	CPMU
B1/Id07	工程材料线站	1	2
B2/Id19	硬x射线纳米探针线站	1	0
B3/Id23	结构动力学线站	1	2
B4/Id09	硬x射线相干散射线站	1	0
B5/Id33	高分辨谱学线站	1	0
B6/Id31	高压线站	1	0
B7/Id21	硬x射线成像线站	1	1
B8/Id46	x射线吸收谱学线站	2	0
B9/Id05	低维结构探针线站	1	0
BA/Id02	生物大分子微晶衍射线站	1	0
BB/Id08	粉光小角散射线站	0	0
BC/Id45	高分辨纳米电子结构线站	0	0
BD/Id44	通用环境谱学线站	0	0
BE/Id30	x射线显微成像线站	1	0
BF/Id42	测试束线线站	1	1

User2



User3



Heat Loads



Name	User	Temperature	Number	Heat load	total
Beam line	Cryostal-Monochromator	80K	12	600W	10000W
	Transfer line		1400m	2W	
Storage Ring	SC cryostat thermal shield	80K	7	700W	4900W
	CPMU	80K	5	800W	4000W
	Helium refrigerator	80K	1	7000W	7000W

Total heat loads

~47kW(+margin 80%)

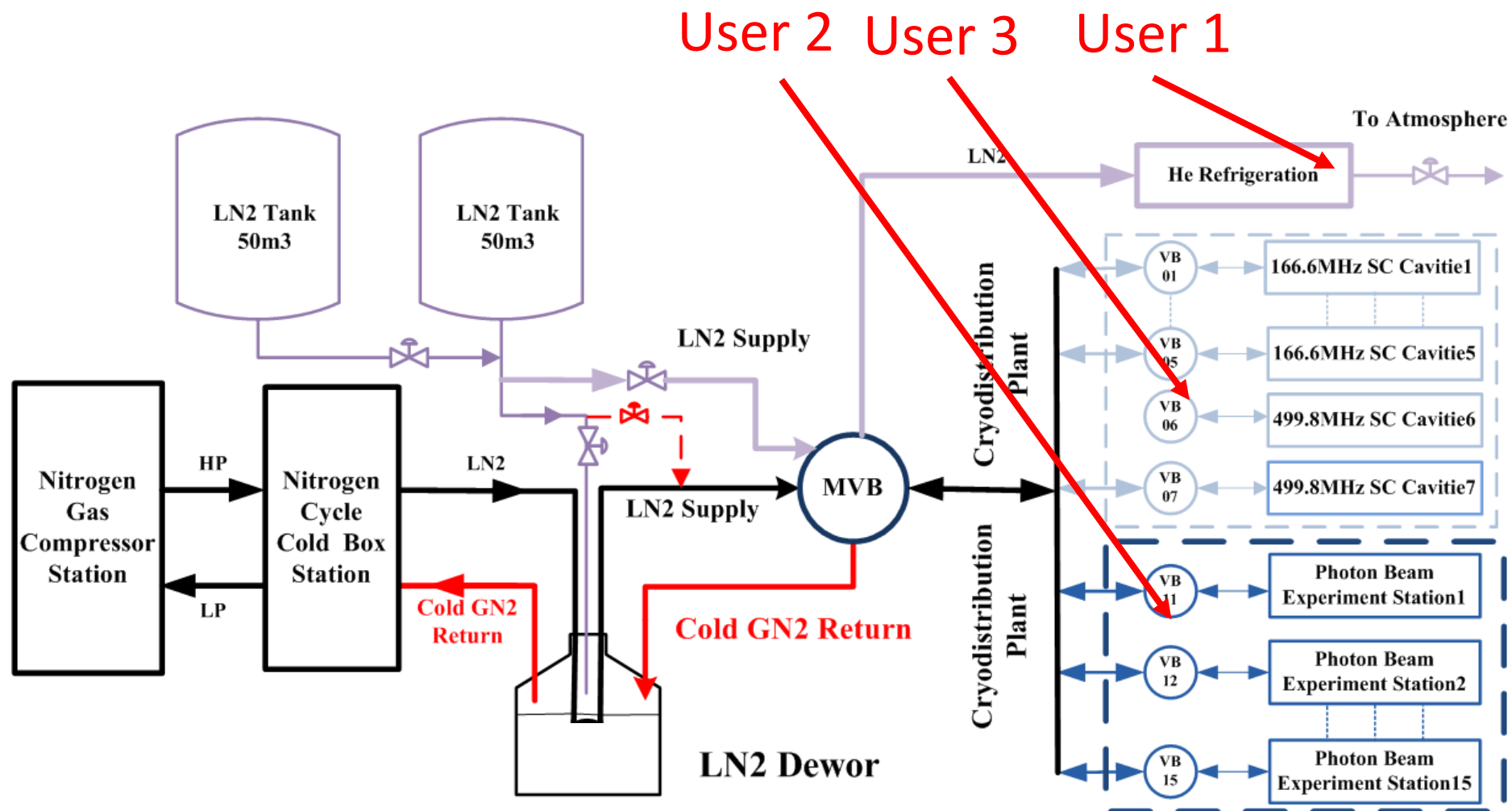
- ❑ Used to cool down 5 CPMU and Cryostal-Monochromator for **13 Photon Beam Station**.
- ❑ Precooling 1 Helium refrigerator and cooling 7 SC cryostat thermal shield.



- Thousand meters nitrogen transfer line with high performance, like low heat loads, easy maintenance and stable operation with big temperature difference, etc.
- How to recovery the low pressure cold nitrogen gas, cryogenic fans usage need further investigation.
- Combining decentralized control with centralized control.
- Few cases are available for the reference.



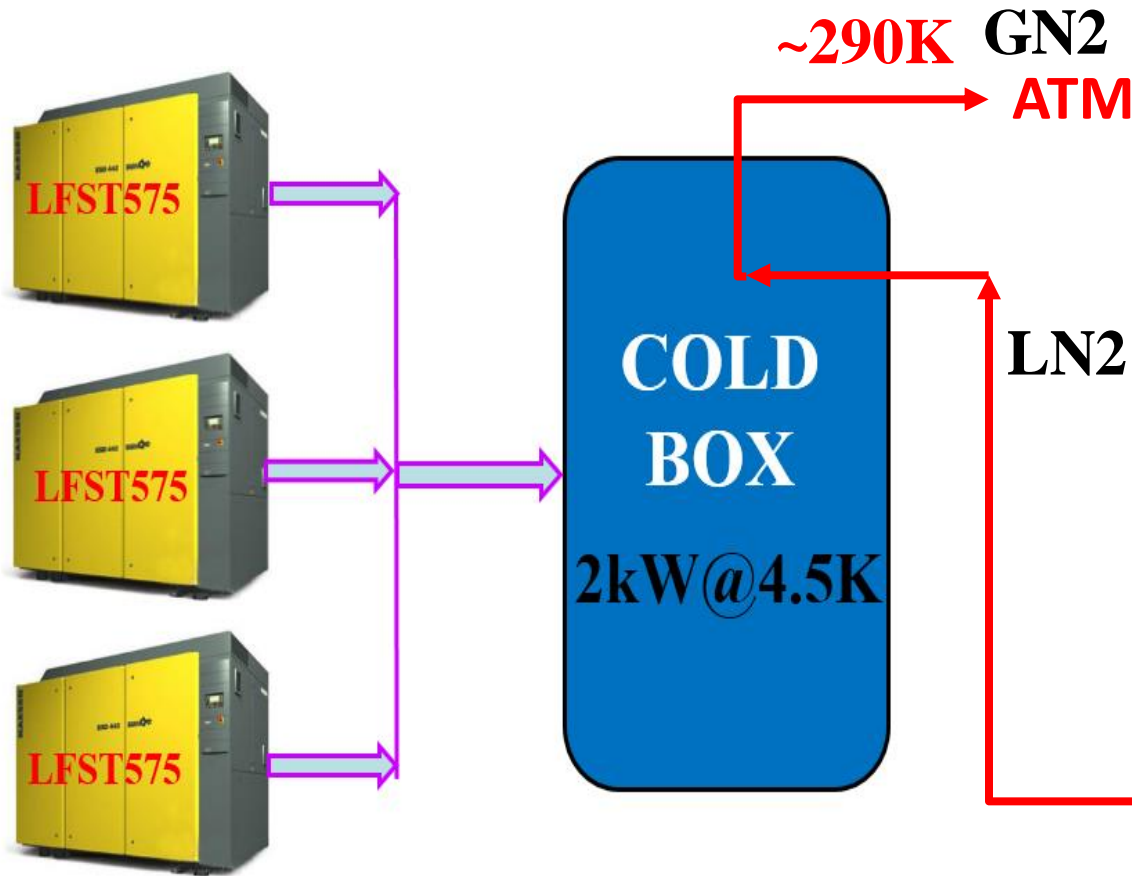
Simple flow chart



User has it's characteristic



LN2 plant for Helium refrigerator



**No cooling capacity can be recovered
LN2 supplied by the tanker**

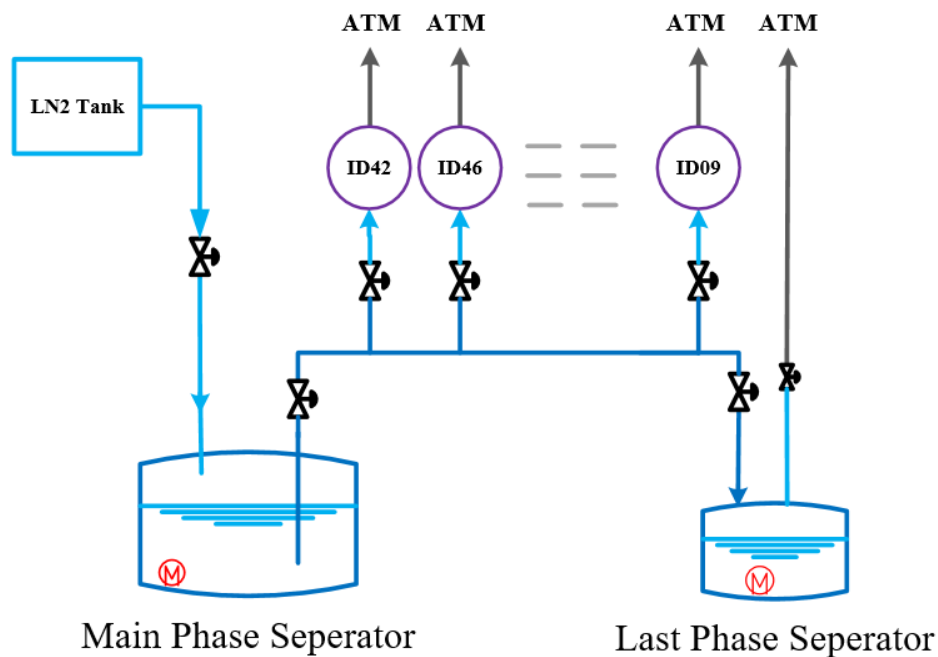




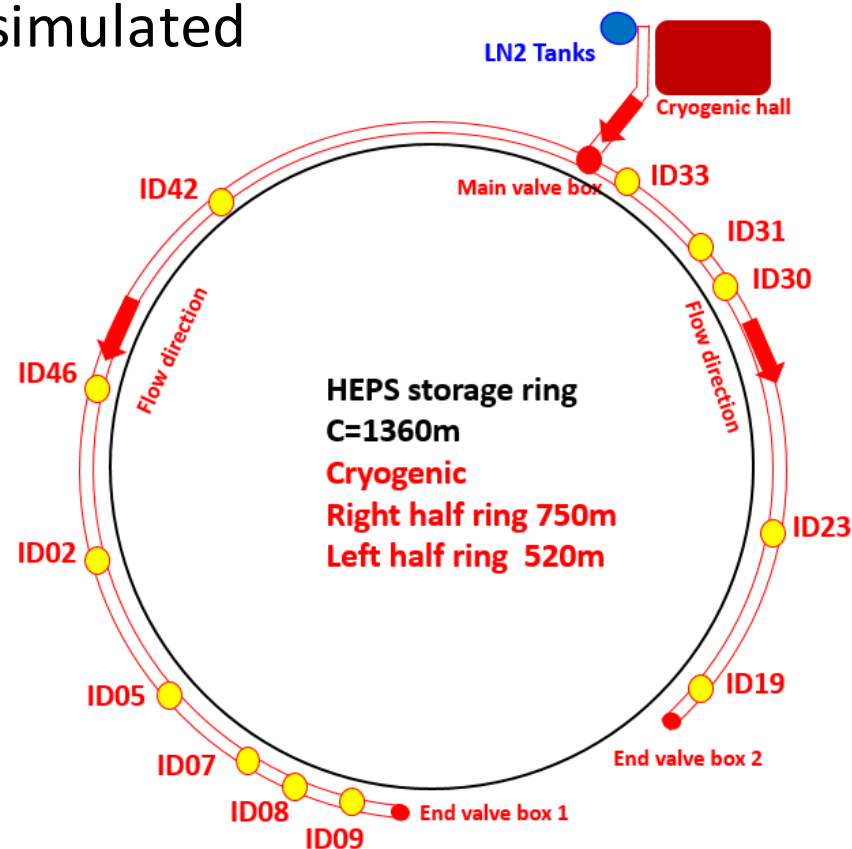
LN2 plant for photon beam lines



- ❑ 5 CPMU and 13 Crystal-Monochromator for Photon Beam Stations
- ❑ Liquid nitrogen cryogenic line of right half ring is 750m and left half ring 520 .
- ❑ Cryogenic distribution progress is simulated



Right half ring





LN2 plant for SRF cryomodules



- Nitrogen refrigerator

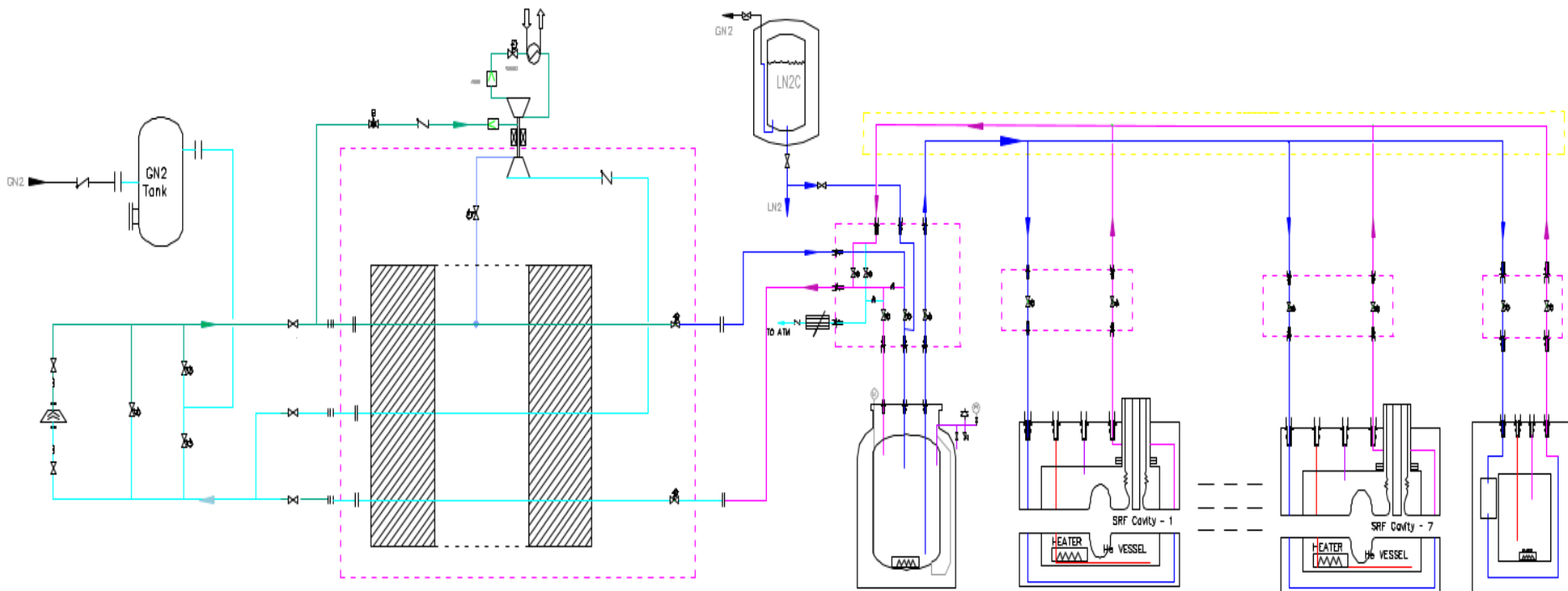
- Cold box, LN2 dewar, Compressor

- Nitrogen storage and LN2 Tanks

- Cryogenic distribution system

- Mail valve box, thermal insulation shield

- Multi-tunnel cryogenic transfer line for cold GN2 and LN2





- Cryogenic systems in the preliminary design.
- As a user facility, stability and reliability are the important factors for the design of the cryogenics system.
- Cryogenic flow chart design has been finished.
- New type cryomodule's development and auto control have be paid much more attention.
- Large scale nitrogen cooling capacity recovery still big challenge, which need to be overcome.
- With the progress of the design, new difficulties will arise.

High Energy Photon source
2019~2025
Huairou district, Beijing , China



Thanks for you attention !