Accelerating Equipments Development at IHEP&HERT

OCT.,22nd @Shanghai,China

The 2026 international workshop on the high energy Circular Electron Positron Collider (CEPC)

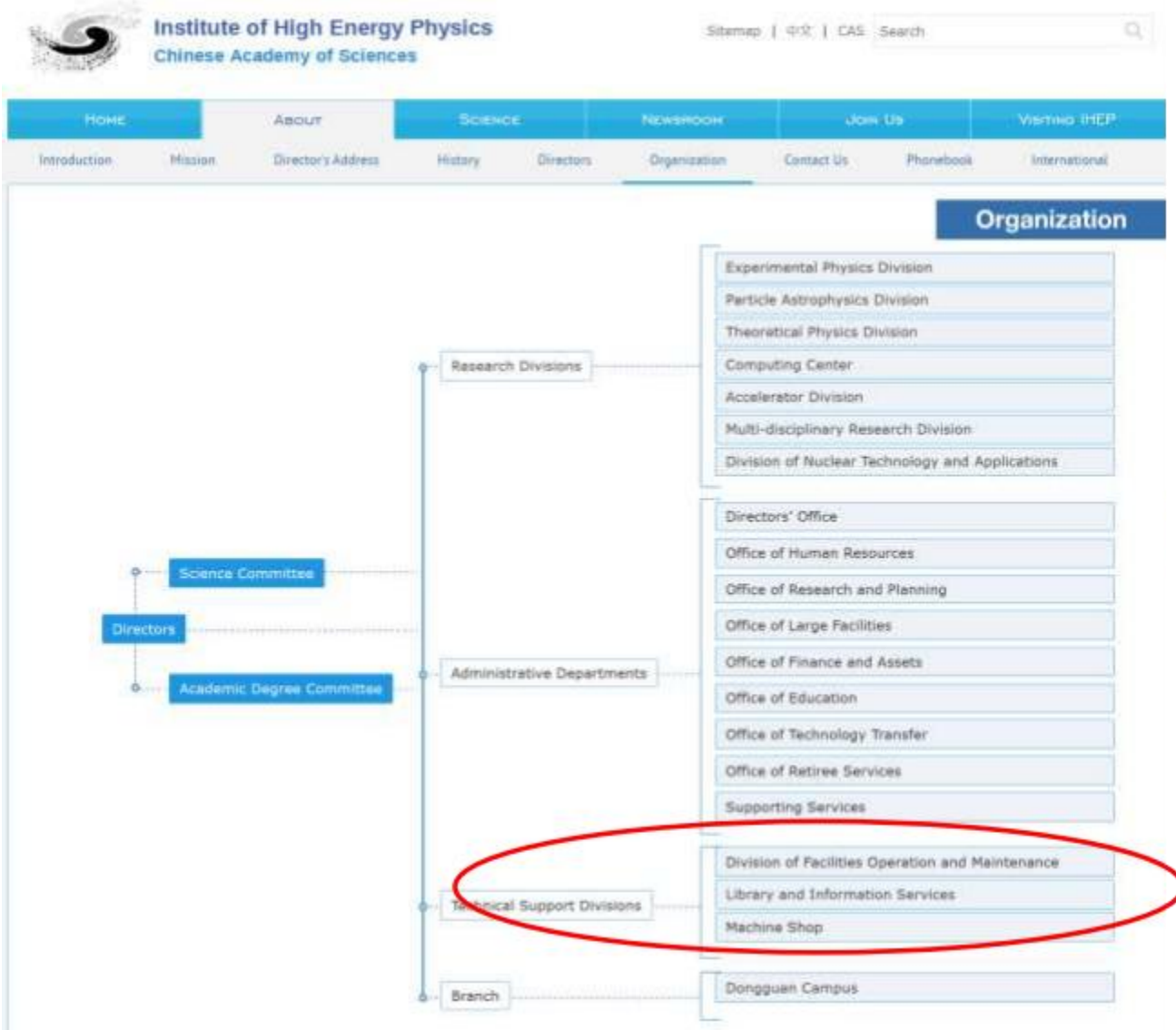
zhangzj@ihep.ac.cn; +8613810771939.

Outline

1 Brief Introduction
2 Magnets
3 Accelerating Structure and RT Cavities
4 SRF Cavities Couplers and Cryomodules
5 Facilities Serviced by HERT
6 Summary

1. Brief Introduction

- IHEP organization





- In year2013, the company(HERT) was established.
- Be responsible for the international development cooperation.

1. Brief Introduction

History

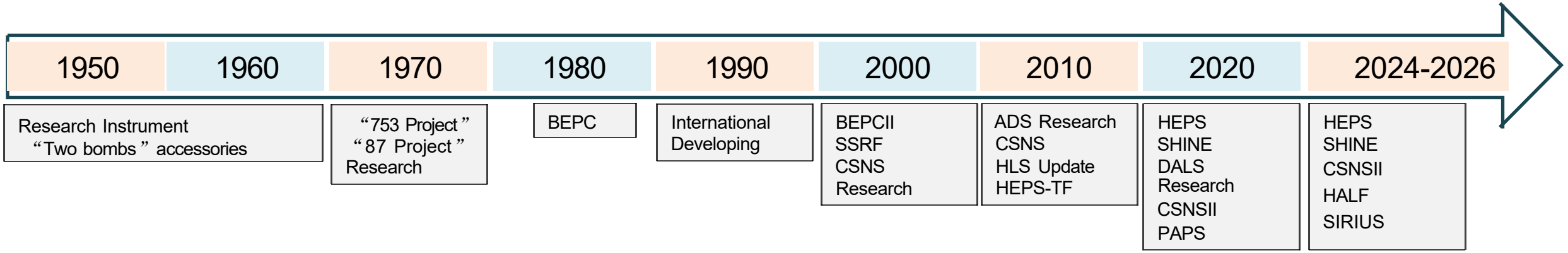
2026.4
HE-Racing(Jinan) Technology Co., Ltd

1950.5
Institute of Modern Physics·Technician Team
1953.10
Institute of Physics·Machine shop
1958.7
Institute of Atomic Energy·1st Workshop

1973.2
Institute of High Energy Physics,CAS·Machine shop

2013.4
Beijing HE-Racing Technology Co.,Ltd

2024.6
Huairou Divsion of HERT



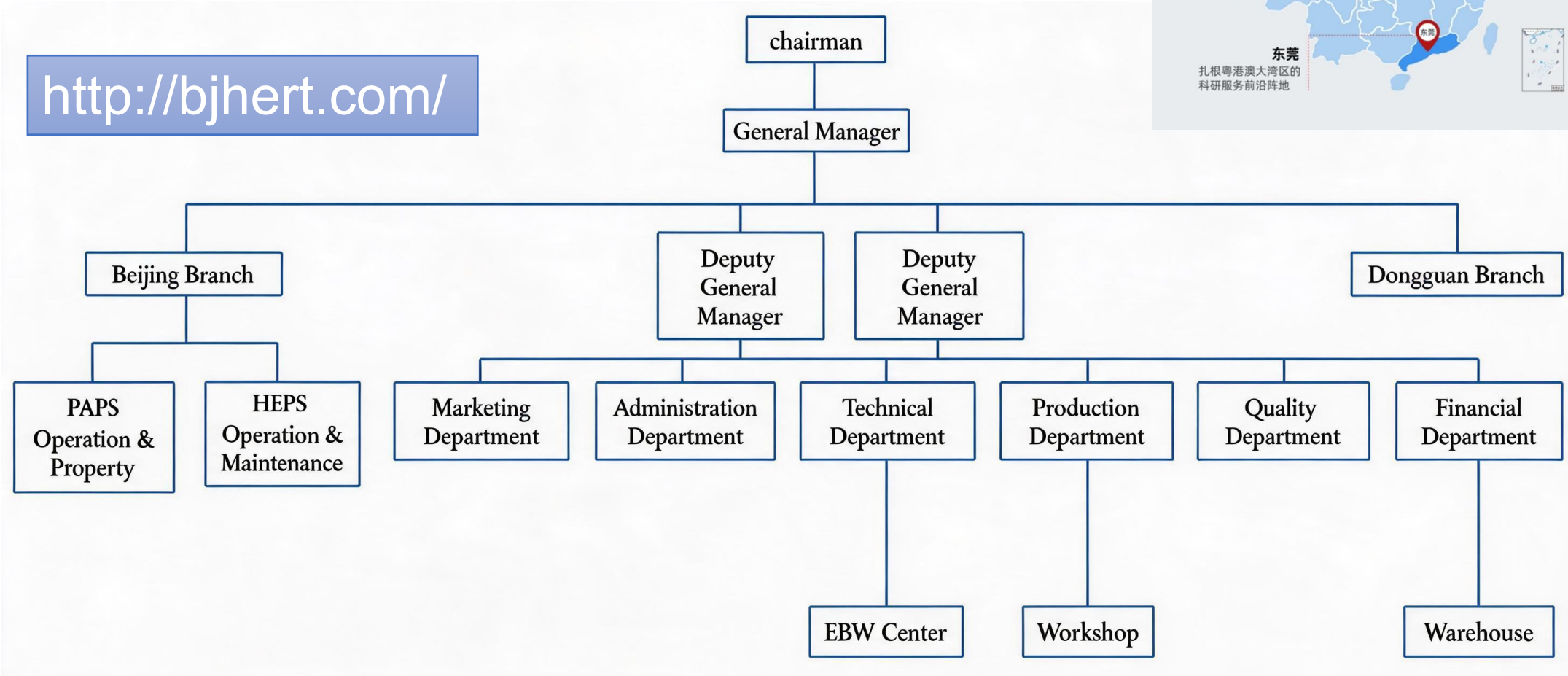
1. Brief Introduction

HERT Organization

In April 2026, the company's headquarters was officially relocated to Jinan to further integrate R&D and industrialization resources and boost the high-quality development of high-end precision equipment business.



http://bjhert.com/



1. Brief Introduction

高能锐新 HE-RACING TECHNOLOGY

- **Main Products:**
  - Magnets
  - Accelerating Structure and RT Cavities
  - SRF Cavities, Couplers and cryomodules.
  - Insertion Devices
  - Microwave devices
  - RFQ and DTL
  - SLEDs

1. Brief Introduction

高能锐新 HE-RACING TECHNOLOGY

- **Project and Experience:**
  - BEPC/BEPCII, CSNS, SSRF, HEPS-TF, HLSII, THz, DCLS, SXFEL, CADS, SHINE,HEPS,DALS,HALF,CSNSII…
  - PLS/PLSII, PAL-FEL, PEFP, KEK-B, FIR/THz, RISP …
  - PEPII, SPEAR3, NSLSII, CLS, ILC-ATF2, LCLSII…
  - SPARK, LEG, E-XFEL, MAXIV, FERMI-Eletta, KIPT-ADS …

1. Brief Introduction

高能锐新 HE-RACING TECHNOLOGY

- **Machining Tools and Equipment:** (Total >500 sets)

编号	设备名称	品牌	型号	主要技术指标（行程（精度））mm	数量
1	加工中心	山崎马扎克	LGMazak	X/Y/Z:1050×510×560（0.008）	1
2	加工中心	哈斯	VF6	X/Y/Z:1626×813×762（0.01）	1
3	加工中心	沈阳机床	VMC 850E	X/Y/Z:850×510×540（0.02）	3
4	车铣中心	山崎马扎克	LGMazak QTN	直径Ø380×1033（0.01）	1
5	车削中心	山崎马扎克	LGMazak Nexus	直径Ø360×1063（0.01）	1
6	车削中心	山崎马扎克	LGMazak Nexus	直径Ø280×300（0.01）	2
7	线切割	沙迪克	AQ550Ls	X/Y/Z:550×350×320（0.003）	1
8	线切割	阿奇夏米尔	CA30	X/Y/Z:600×400×350（0.002）	1
9	氢气炉	北方华创	MHF5060	Φ500×600 （1100℃，±5℃）	1
10	氢气炉	北方华创	MHF3040	Φ300×400 （1100℃，±5℃）	1
11	三坐标	海克斯康	Classical	X/Y/Z:900×1200×800（0.0026）	1
12	检漏仪	INFICON	UL1000 Fab	最小检漏漏率：5×10-12mbar•L/s	1
13	真空炉	兰州真空	ZRT-3580-14W5	Φ1150×1650 （1300℃，±5℃）	1
14	电子束焊机	泰克米特	LARA52	X/Y/Z: 3300×1000×1300	1
15	电子束焊机	排达	THDW-9	X/Y/Z: 1050×500×700	1
16	四柱压力机	山东滕州	YQ32-200T	200T	1
17	网络分析仪	罗德施瓦茨	ZNB8	Max. 8.5GHz	1



1. Brief Introduction

高能锐新 HE-RACING TECHNOLOGY

■ EBW machines



EBW machine (3 sets)







Laser Welding machine

1. Brief Introduction

高能锐新 HE-RACING TECHNOLOGY

Qualifications and Honors:



- 北京正负电子对撞机“重大技术装备”
- 北京正负电子对撞机改造工程（BECPII）建设中做出重大贡献；
- 中国散裂中子源工程“重大贡献参建单位”；
- 美国布鲁克海文实验室（BNL）NSLSII 磁铁贡献奖；
- 硬X射线自由电子激光装置”项目优秀设备研制供应商”











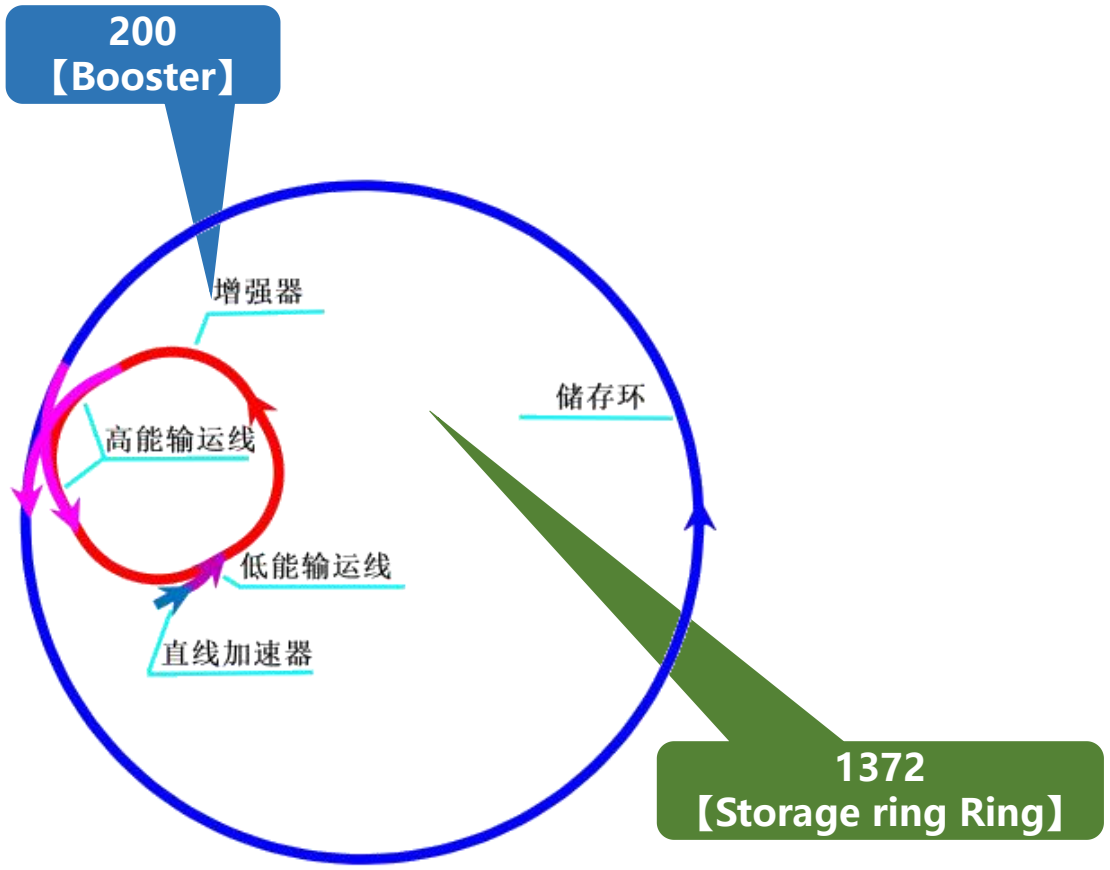






2. Magnets (HEPS)

2.1 Magnet List (1572 Sets in Total)



Booster Magnets		
Description	**Qty. (set)**	**Period**
Dipole	130	2019.12~2021.12
Sextupole	70	2019.12~2021.12

Storage Ring Magnets		
Description	**Qty. (set)**	**Period**
Sextupole	294	2020.05~2022.05
LG Dipole	98	2020.12~2023.06
Quadrupole	686	2020.12~2023.12
B&D magent	294	2020.12~2023.12

2. Magnets (HEPS)

高能锐新 HE-RACING TECHNOLOGY

2.2 Booster Magnets



2. Magnets (HEPS)

2.2.1 Booster Magnets (Dipole)



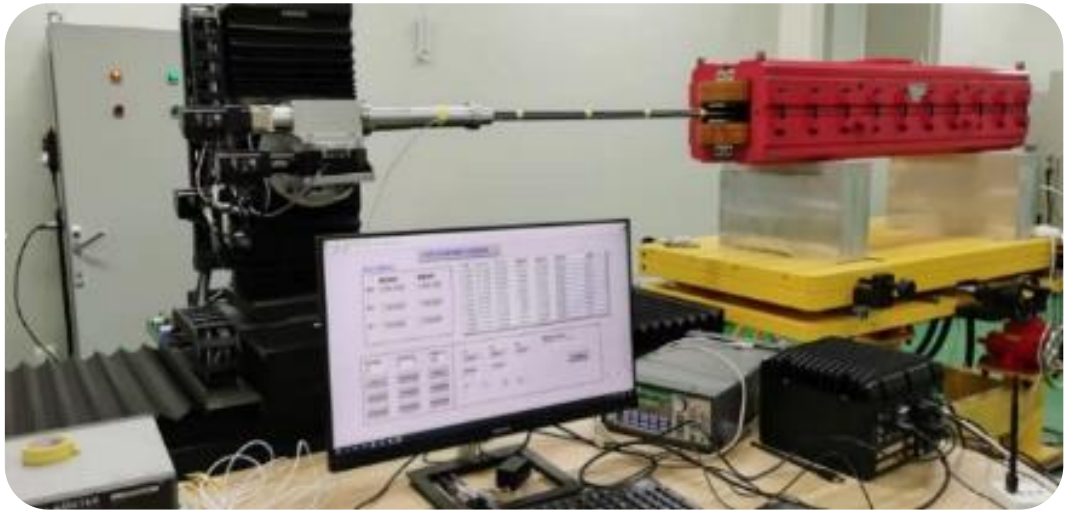
Core:

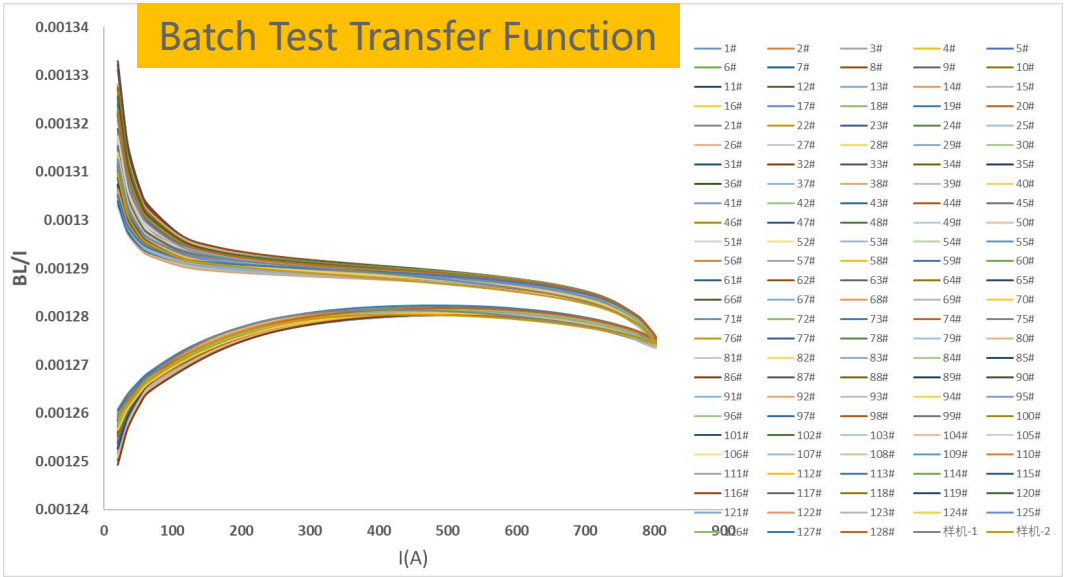
- Lamination type
- Glued and Welded

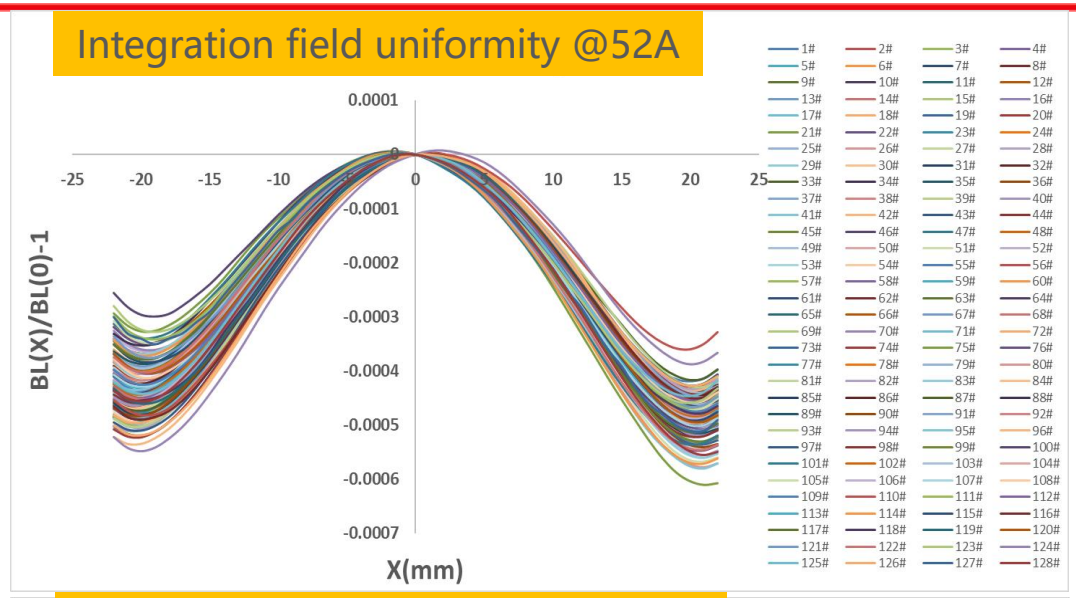
Parameters	Value	Unit
QTY.	130	set
Leff	1.450	m
Max. Field(@6GeV)	0.68	T
Min. Field(@500MeV)	0.05	T
Bending Radius	29.540	m
Gap	34.00	mm
Good Field Area (H×V)	30×20	mm
Uniformity(@0.5GeV, 6GeV)	1×10^{-3},5×10^{-4}	-
Integral Gradient Discretness	0.1%	-

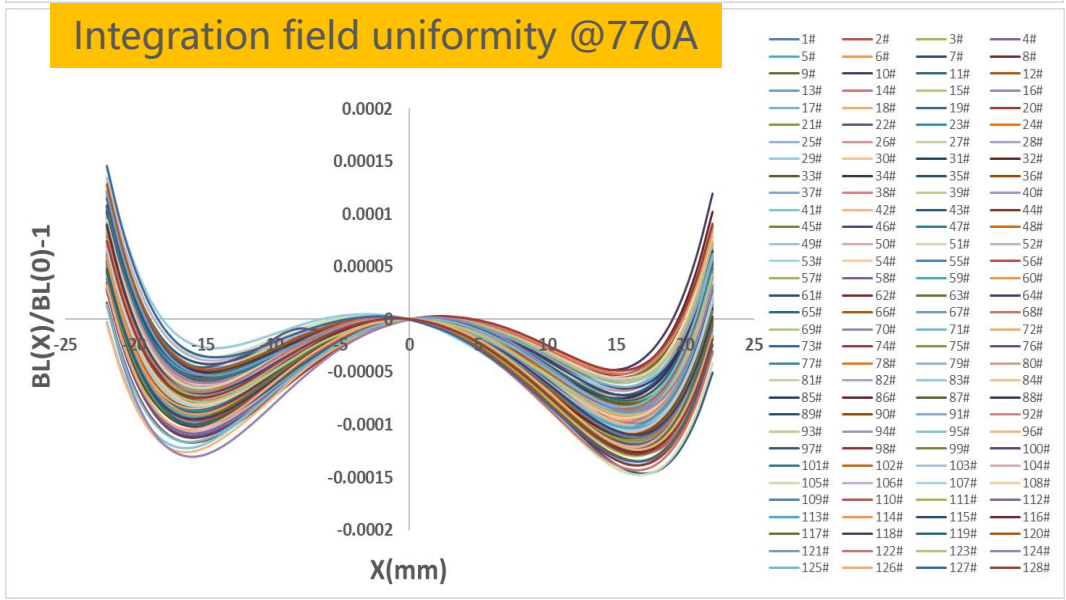
2. Magnets (HEPS)

2.2.1 Booster Magnets (Dipole)









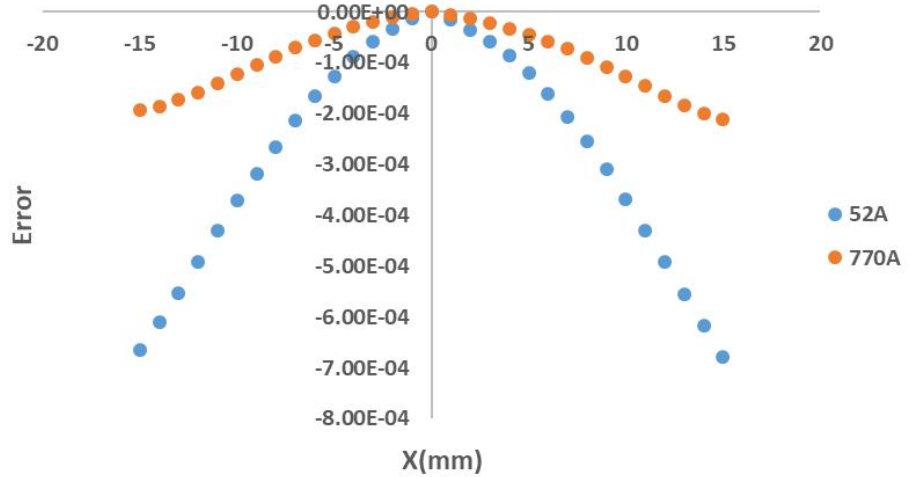
*康文 - HEPS增强器二极磁铁磁场测试报告

2. Magnets (HEPS)

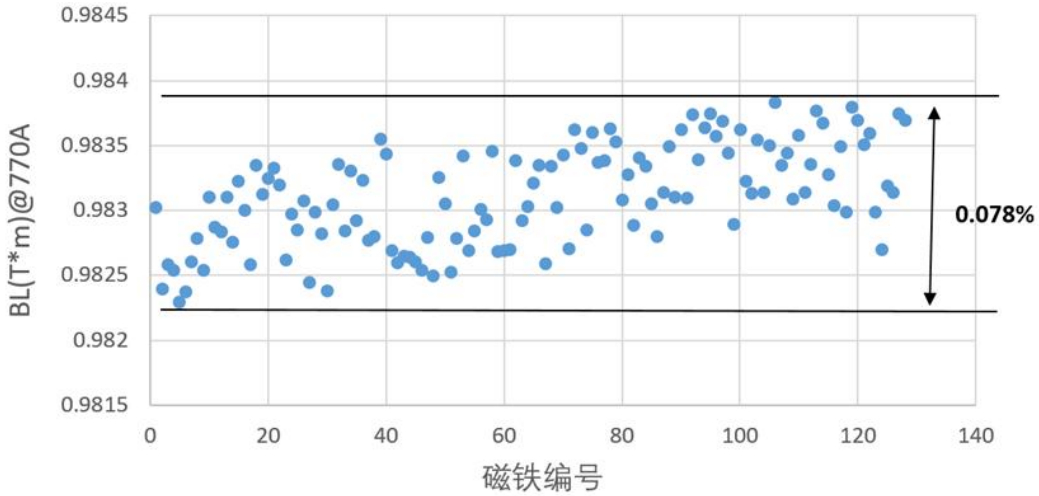
2.2.1 Booster Magnets (Dipole)



Field Distribution Error



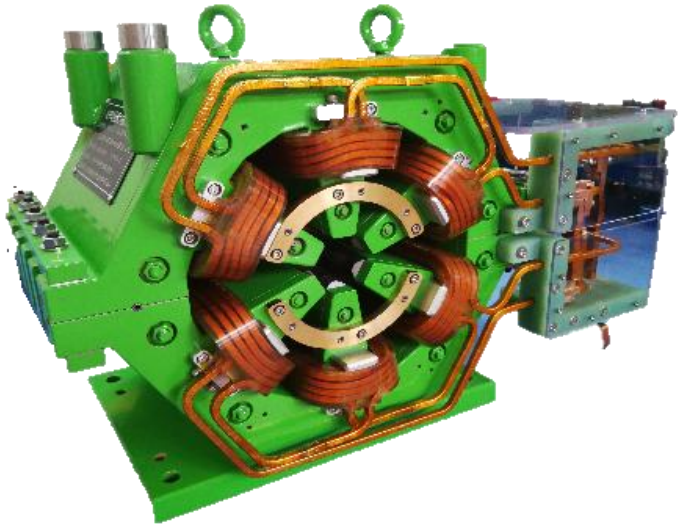
Batch Test Integral Field Discreteness



*康文 - HEPS增强器二极磁铁磁场测试报告

2. Magnets (HEPS)

2.2.2 Booster Magnets (Sextupole)



Core:

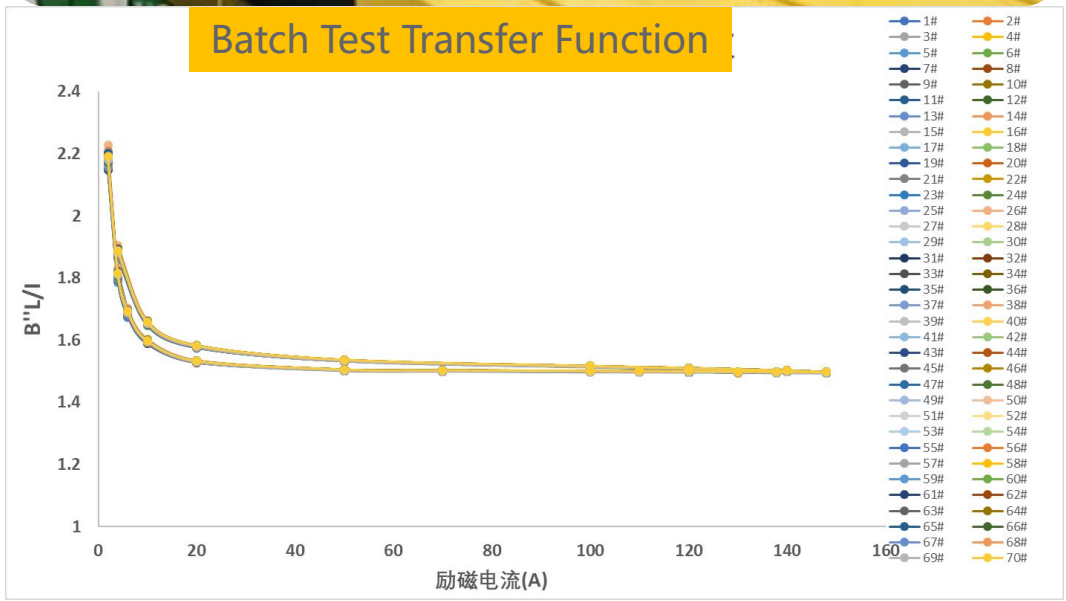
- Lamination type
- Glued

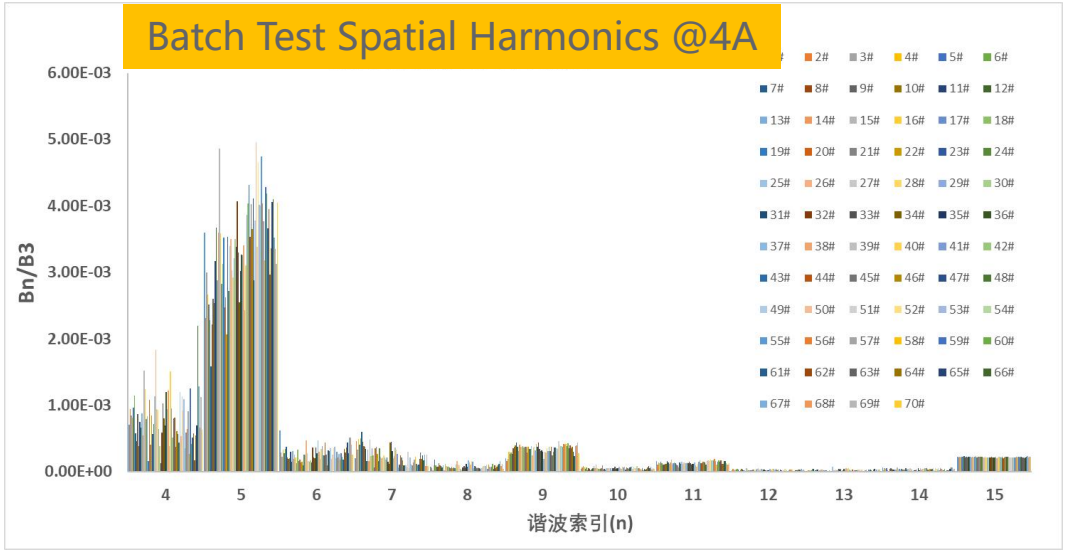
Parameters	Value	Unit
QTY.	70	set
Leff	0.2	m
Max. Field Gradient	1000	T/m^2
Min. Field Gradient	30	T/m^2
Good Field Radius	16	mm
Aperture	Φ40	mm
Harmonic Error(@0.5GeV, 6GeV)	5×10^{-3},1×10^{-3}	-
Integral Gradient Discretness	0.2%	-

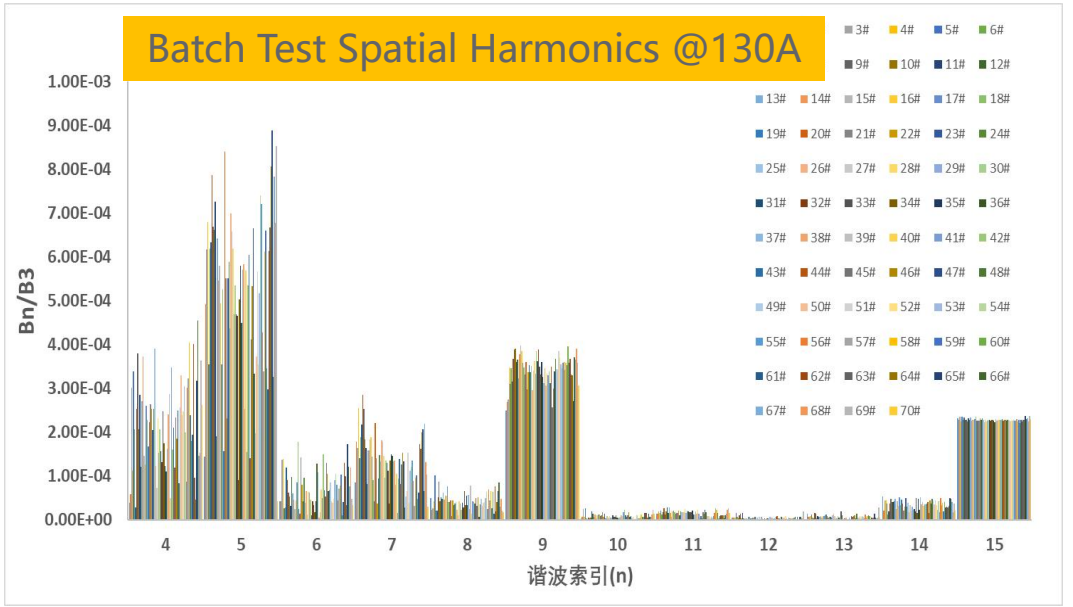
2. Magnets (HEPS)

2.2.2 Booster Magnets (Sextupole)







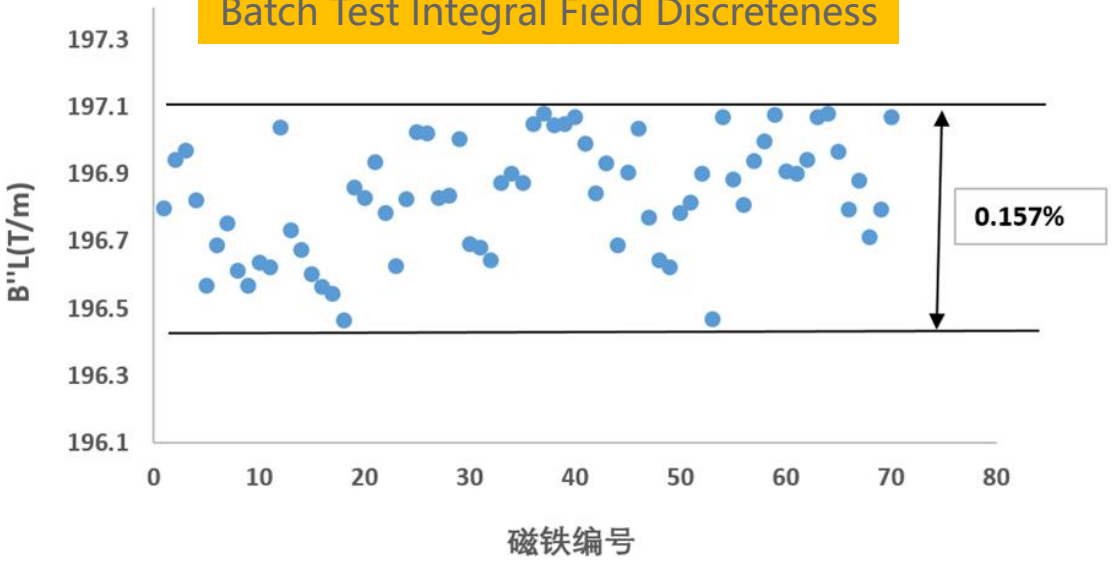


2. Magnets (HEPS)

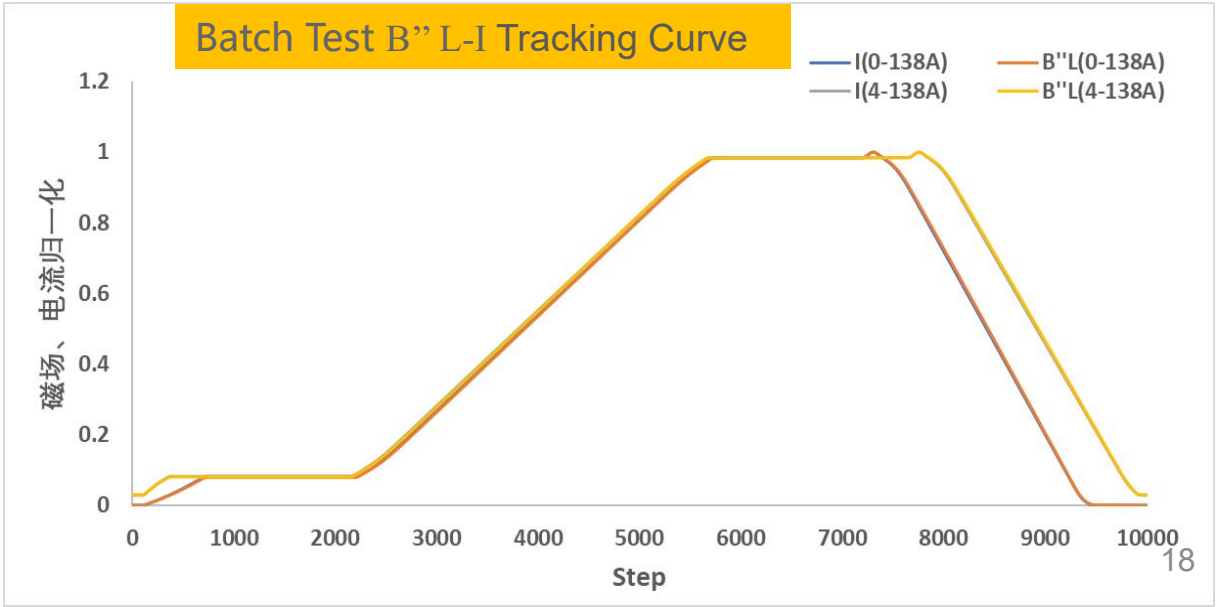
2.2.2 Booster Magnets (Sextupole)



Batch Test Integral Field Discreteness

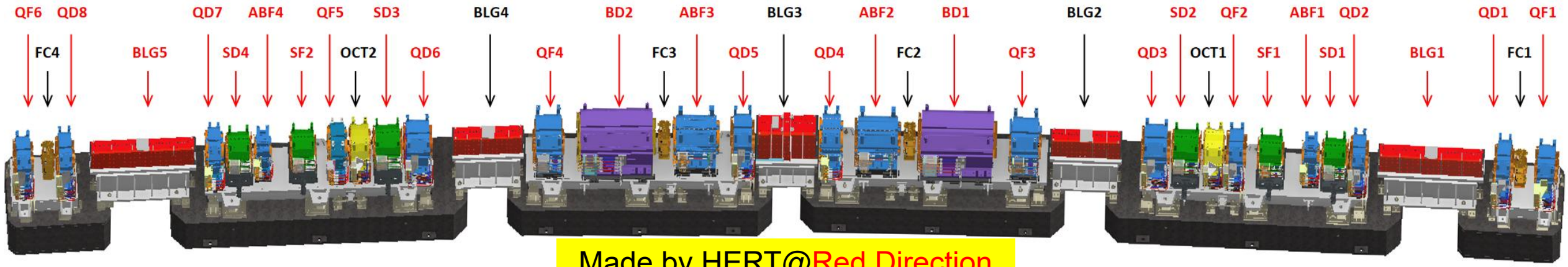


Batch Test B'' L-I Tracking Curve



2. Magnets (HEPS)

2.3 Storage Ring Magnets



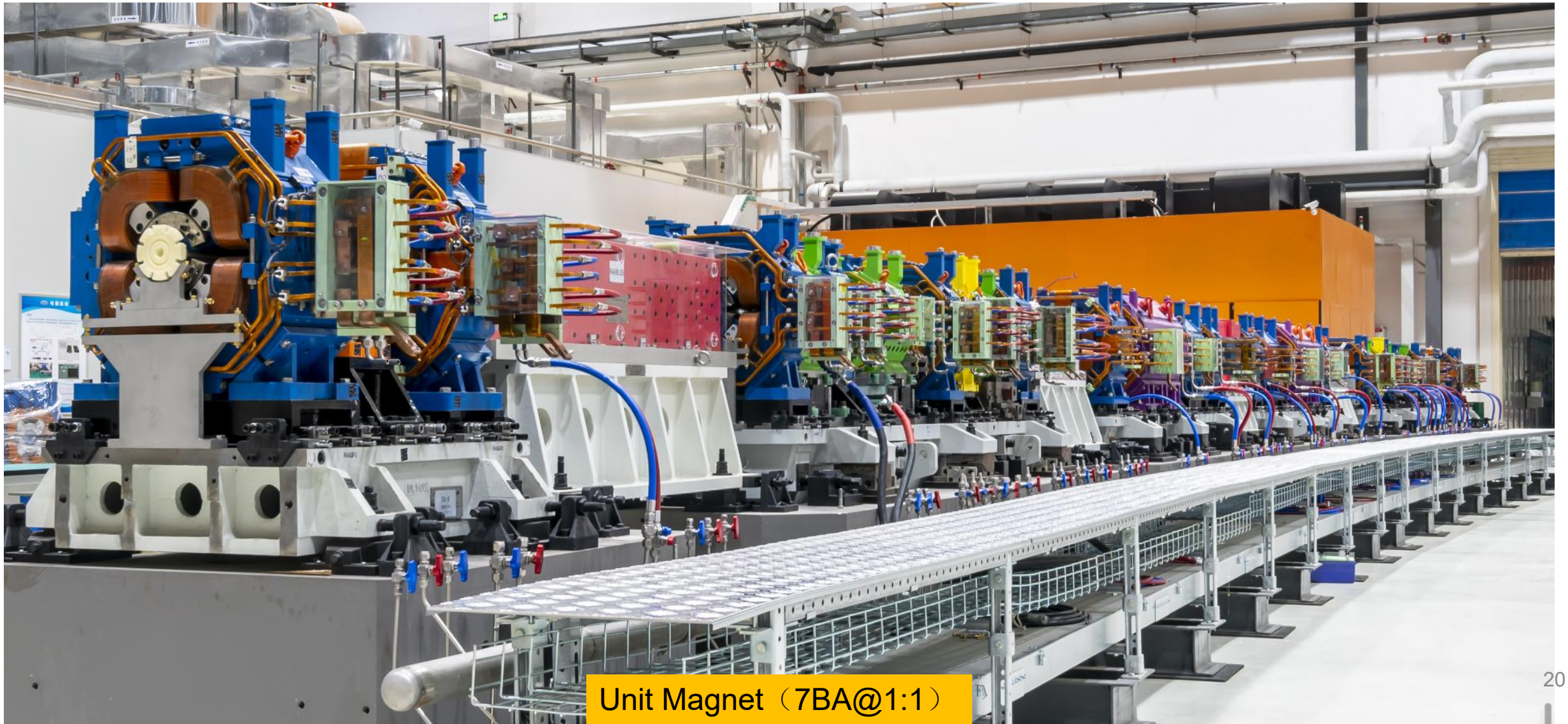
Made by HERT@Red Direction

Unit Magnet（7BA@Model and position indication）

2. Magnets (HEPS)

高能锐新 HE-RACING TECHNOLOGY

2.3 Storage Ring Magnets



Unit Magnet（7BA@1:1）

2. Magnets (HEPS)

2.3.1 Storage Ring Magnets (Dipoles)

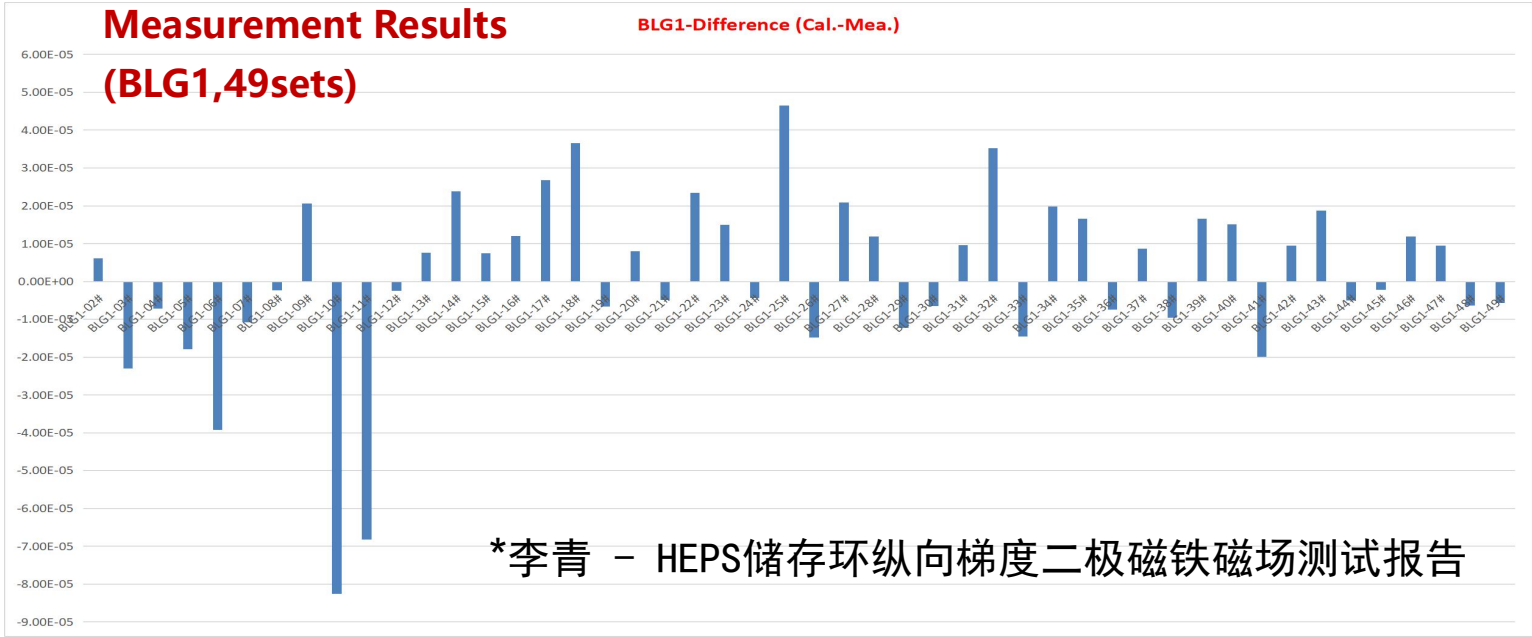


Permanent Magnet:

- **Core (DT4 Steel)**

TYPE	BLG1（Type I）	BLG5（Type II）
Qty（set）	48+1	48+1
Leff（m）	1.499	1.499
File （Gauss）	4838.4/3357.3/2863.6/	1283.7/2073.6/2863.6/
(5 steps)	2073.6/1283.7	3357.3/4838.4
Integral Field（Gauss m）	4322.0	4322.0
Integral Field Discreetness	1 × 10-4	1 × 10-4
Good Field Area (H×V) （mm）	[-11, 11] ×[-8, 8]	[-11, 11] ×[-8, 8]
Uniformity	4 × 10-4	4 × 10-4

Measurement Results (BLG1,49sets)



*李青 – HEPS储存环纵向梯度二极磁铁磁场测试报告

2. Magnets (HEPS)

2.3.2 Storage Ring Magnets (Quadrupole type I, 340sets)



Core:

- Lamination type
- Welded

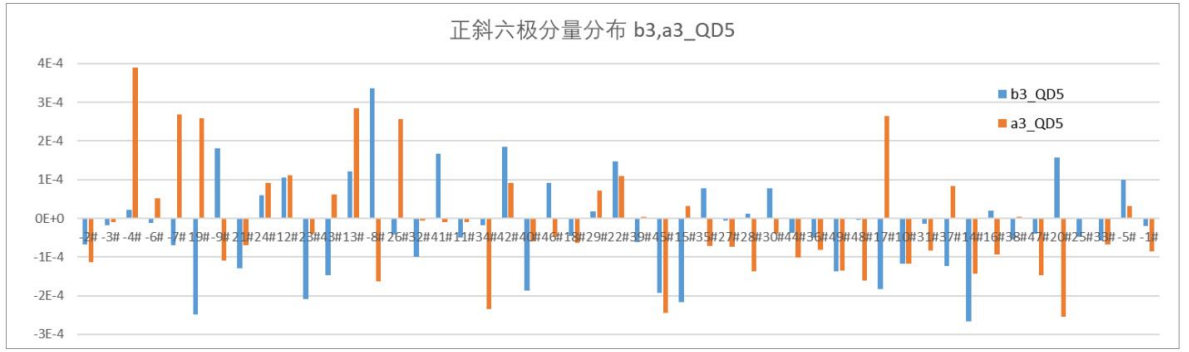
Description	QF1/6-245	QF1/6-201	QD2	QF2	QD3/6	QD5
QTY.(Set)	47+1	47+1	47+1	48+1	96+2	48+1
Core Length（mm）	245	201	180	201	327	260
Leff（mm）	255	211	190	211	337	270
Field Gradient（T/m）	78.2	77.5	73.7	77.2	78.7	74.2
Good Field Radius（mm）	5	5	5	5	5	5
Aperature (mm)	26	26	26	26	26	26
Harmonic Error	$B_3/B_2 \leq 4\times10^{-4}$, $B_4/B_2 \leq 4\times10^{-4}$, $B_5/B_2 \leq 2\times10^{-4}$, $B_n/B_2 \leq 1\times10^{-4}$ for n>5					
Integral Gradient Discreetness	0.2%	0.2%	0.2%	0.2%	0.2%	0.2%
Bonding Coil	None	None	None	None	None	None

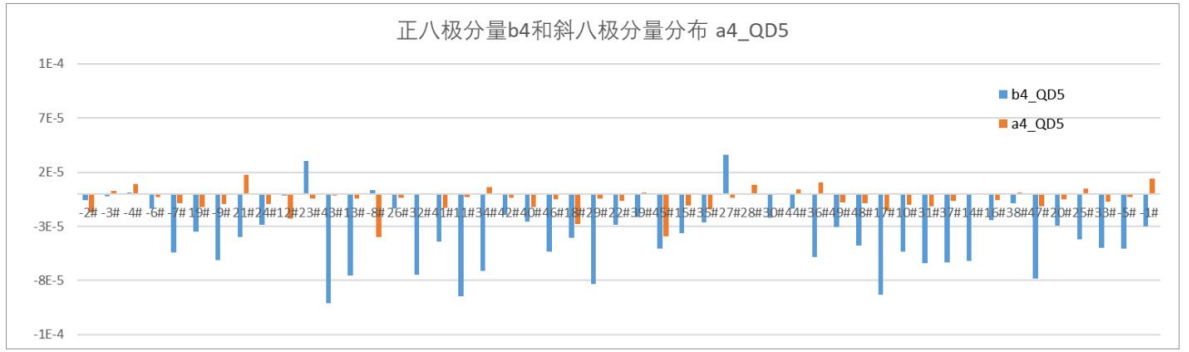
2. Magnets (HEPS)

2.3.2 Storage Ring Magnets (Quadrupole type I, 340sets)



Measurement Results (QD5, 49 sets)

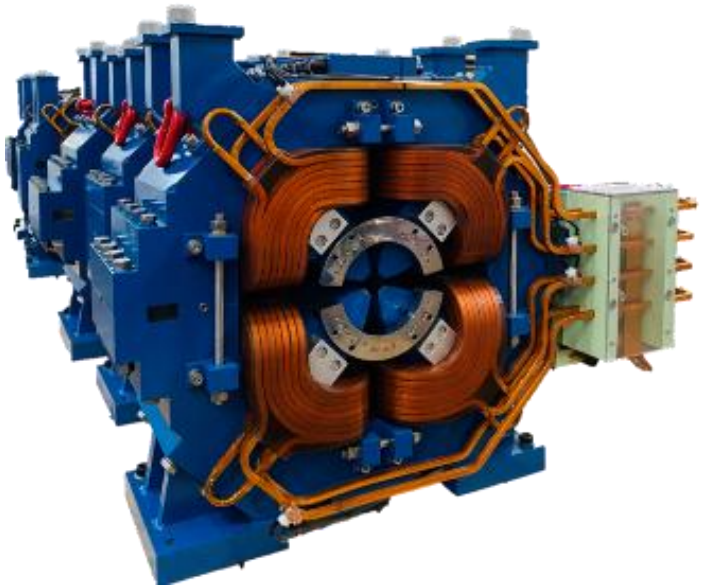




*杨梅 – HEPS储存环四极磁铁I型磁场测试报告

2. Magnets (HEPS)

2.3.3 Storage Ring Magnets (Quadrupole type II, 148sets)



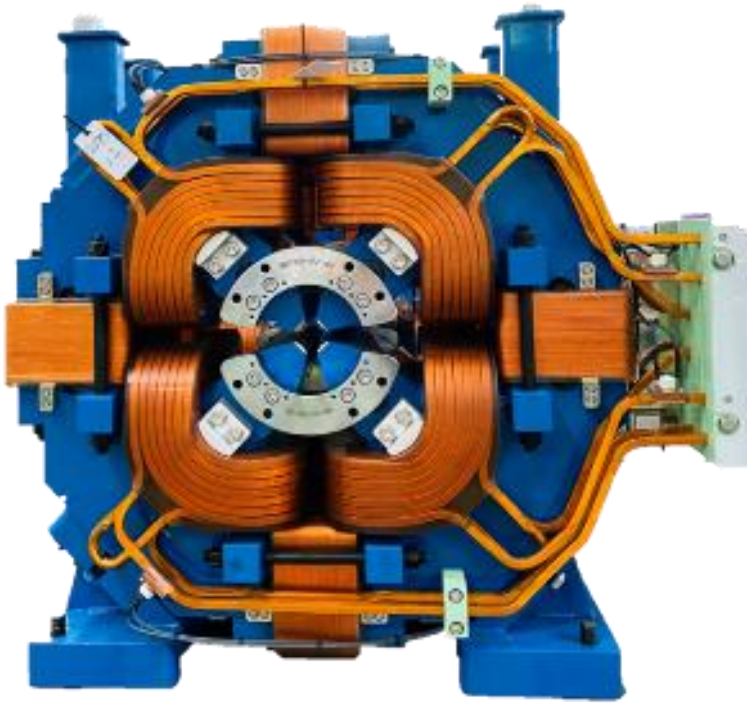
Core:

- DT4 Steel

Description	QD4	QF5	QD7
QTY.(Set)	48+1	48+1	49+1
Core Length（mm）	260	201	180
Leff（mm）	270	211	190
Field Gradient（T/m）	74.2	77.2	73.7
Good Field Radius（mm）	5	5	5
Aperature (mm)	26	26	26
Harmonic Error	$B_3/B_2 \leq 4\times10^{-4}$, $B_4/B_2 \leq 4\times10^{-4}$, $B_5/B_2 \leq 2\times10^{-4}$, $B_n/B_2 \leq 1\times10^{-4}$ for n>5		
Integral Gradient Discretness	0.2%	0.2%	0.2%
Bonding Coil	None	None	None

2. Magnets (HEPS)

2.3.4 Storage Ring Magnets (Quadrupole ,with bonding coil, 194sets)



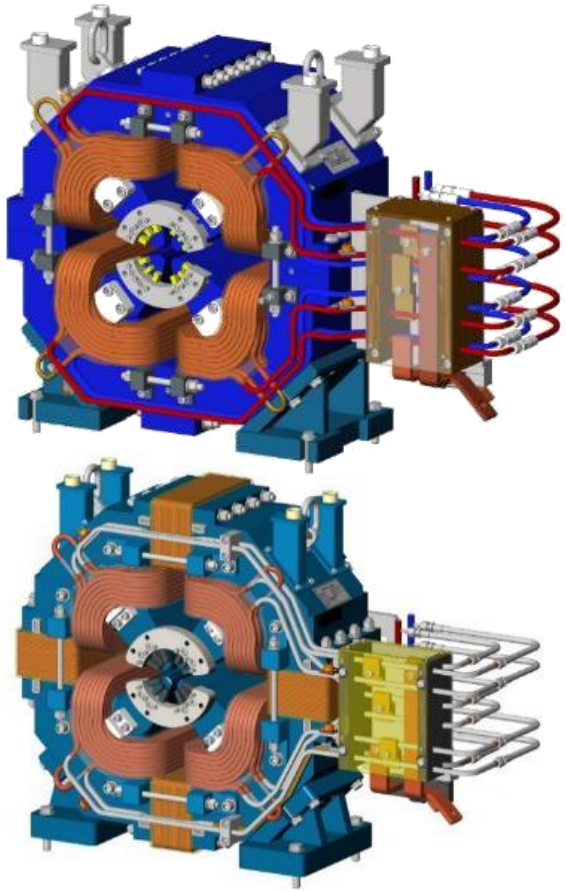
Description	QD1/8-192	QD1/8-180	QF3/4
QTY.(Set)	47+1	47+1	96+2
Core Length（mm）	192	180	374
Leff（mm）	202	190	384
Field Gradient（T/m）	77.4	68.7	79.6
Good Field Radius（mm）	5	5	5
Aperature (mm)	26	26	26
Harmonic Error	$B_3/B_2 \leq 4\times10^{-4}$, $B_4/B_2 \leq 4\times10^{-4}$, $B_5/B_2 \leq 2\times10^{-4}$, $B_n/B_2 \leq 1\times10^{-4}$ for n>5		
Integral Gradient Discretness	0.2%	0.2%	0.2%
Bonding Coil	Yes	Yes	Yes

Core:

- Lamination type
- Welded

2. Magnets (HEPS)

2.3.4 Storage Ring Magnets (Quadrupole ,Special, 4sets)



Core:

- DT4 Steel

Description	R02QF6	R48QF1	R02QD8	R48QD1
QTY.(Set)	1	1	1	1
Core Length（mm）	245	201	192	180
Leff（mm）	255	211	202	190
Field Gradient（T/m）	78.2	77.5	77.4	68.7
Good Field Radius（mm）	5	5	5	5
Aperature (mm)	26	26	26	26
Harmonic Error	$B_3/B_2 \leq 4\times10^{-4}$, $B_4/B_2 \leq 4\times10^{-4}$, $B_5/B_2 \leq 2\times10^{-4}$, $B_n/B_2 \leq 1\times10^{-4}$ for n>5			
Integral Gradient Discretness	0.2%	0.2%	0.2%	0.2%
Bonding Coil	None	None	Yes	Yes

2. Magnets (HEPS)

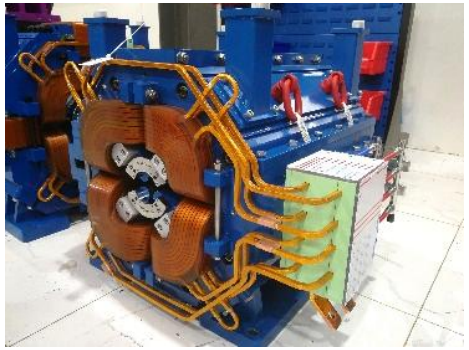
2.3.6 Storage Ring Magnets (B&D, 294sets)



Core:
- Lamination type
- Welded



Core:
- DT4 Steel

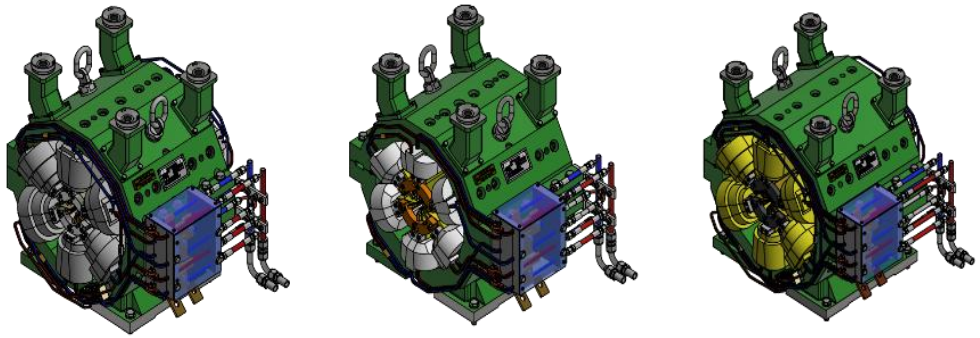


Core:
- Lamination type
- Welded

Description	BD12	ABF1/4	ABF2/3
QTY.(Set)	96+2	96+2	96+2
Core Length（mm）	1040	180	590
Leff（mm）	197.2	179.9	609.9
Field Gradient（T/m）	34.54	53.43	66.43
Good Field Radius（mm）	5	5	5
Aperature (mm)	45	30	30
Harmonic Error	$B_3/B_2 \leq 6\times10^{-4}$, $B_4/B_2 \leq 6\times10^{-4}$, $B_5/B_2 \leq 3\times10^{-4}$, $B_n/B_2 \leq 1.5\times10^{-4}$ for n>5		
Integral Gradient Discretness	0.2%	0.2%	0.2%
Bonding Coil	None	None	None

2. Magnets (HEPS)

2.3.7 Sextupole (3 types, 294 sets)



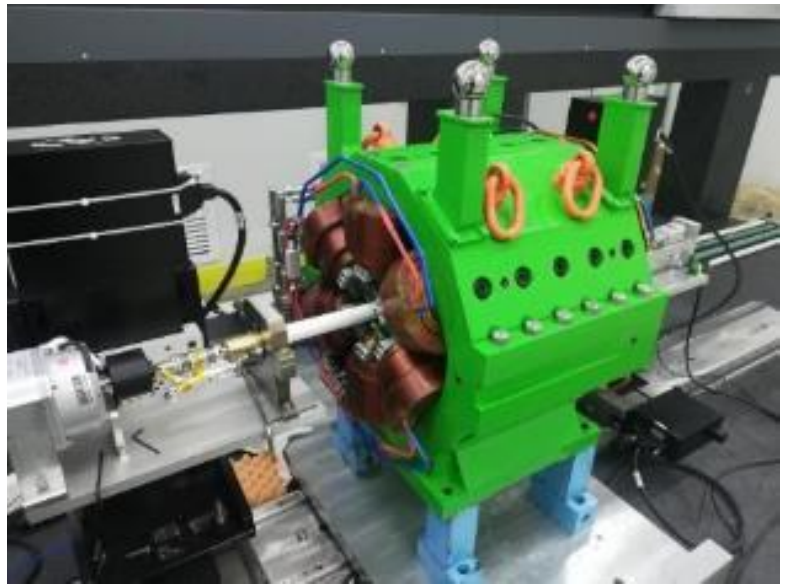
Core:

- Core (DT4 Steel)

Description	SD1&4	SD2&3	SF1&2
QTY.(Set)	96+2	96+2	96+2
Core Length（mm）	304	350	318
Leff（mm）	314	358	326
Field Gradient（T/m^2）	4588	7360	7494
Integral Gradient Discretness	6×10^{-3}		
Integral Gradient Discretness（Sorting）	3×10^{-3}		
Good Field Radius（mm）	5	5	5
Aperature (mm)	26	26	26
Harmonic Error	$B_4/B_3\leq5\times10^{-3}$, $B_5/B_3\leq2.5\times10^{-3}$, $B_n/B_3\leq1.25\times10^{-3}$ for n>5		
Bonding Coil	Yes	Yes	None

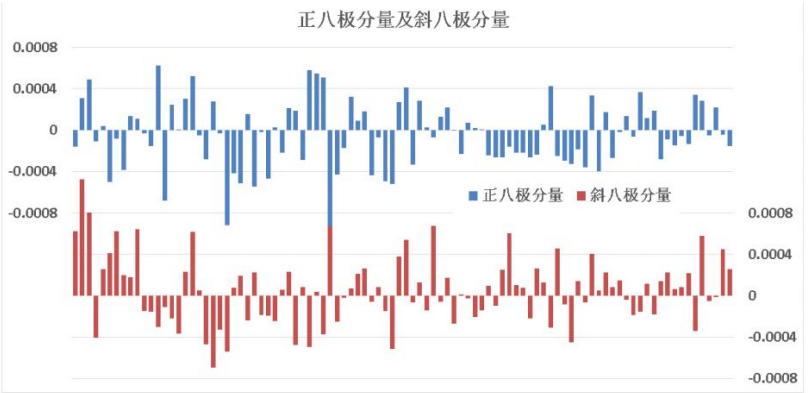
2. Magnets (HEPS)

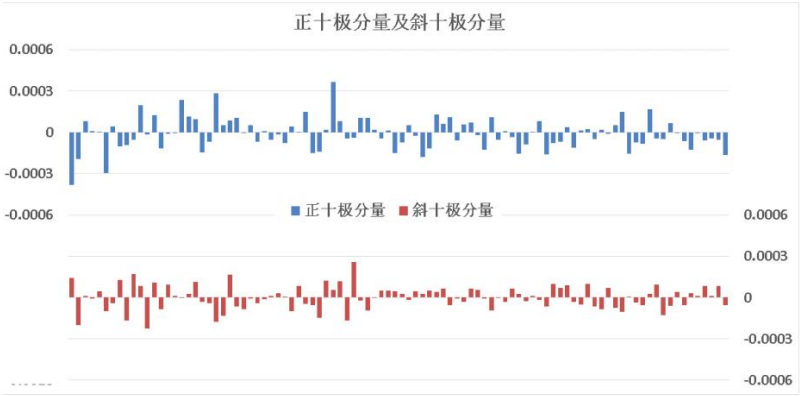
2.3.7 Sextupole (3 types, 294 sets)

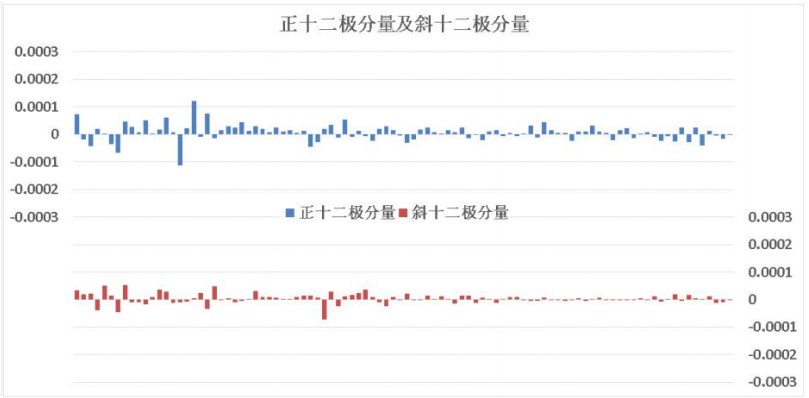


- 系统高阶场分量b9基本为常数(1.6E-04)。
- 由加工装配综合误差引起的八极、十极和十二极磁场如图 所示。

Measurement Results(SD23,98sets)







*孙献静 – HEPS储存环六极磁铁磁场测试报告

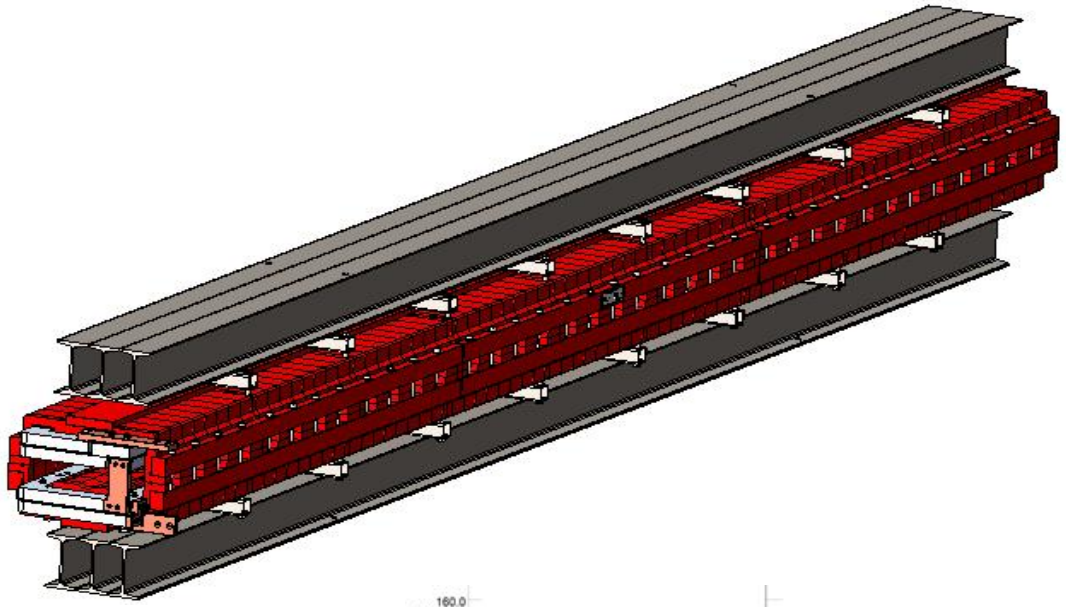
2. Magnets (HEPS)

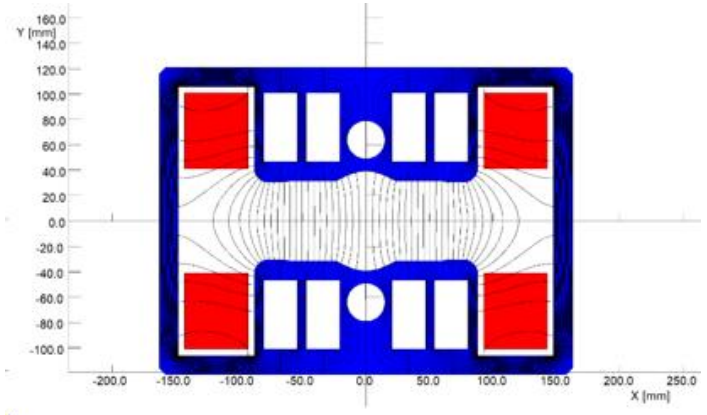
高能锐新
HE-RACING TECHNOLOGY



2. Magnets (CEPC)

2.4 CEPC Booster dipole-sextuple combined magnets





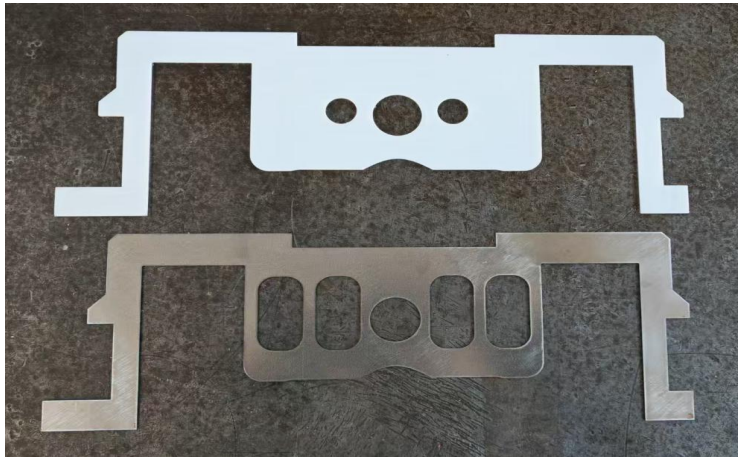
Core:

- **Lamination type**
- **Welded**

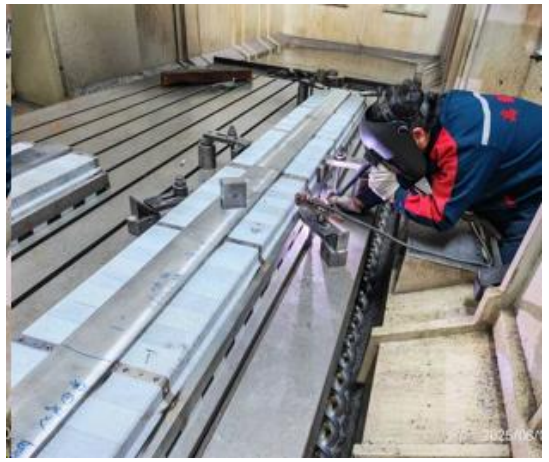
Parameters	Value	Unit
Magnetic length	4700	mm
Core Length	4608	m
Dipole Field [Gs] @180 GeV	564	Gs
Dipole Field [Gs] @120 GeV	376	Gs
Dipole Field [Gs] @30 GeV	95	Gs
GFR	±22.5	mm
Field errors	$\pm 1\times10^{-3}$	/
Gap	63	mm

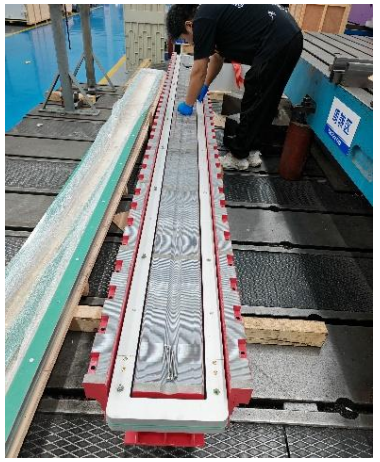
2. Magnets (CEPC)

2.4 Dipole combined with Sextupole (Prototype)

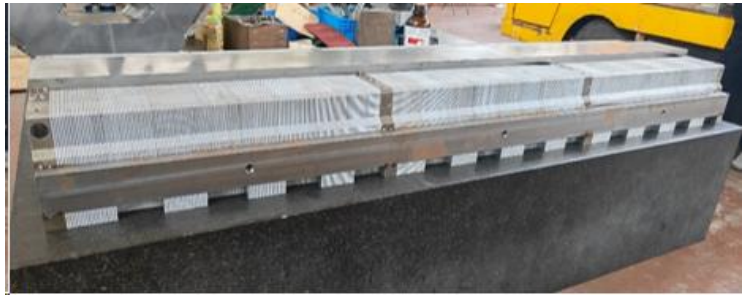


Lamination type (steel+plastic)





Integration of the full length core/ Installation of the coil

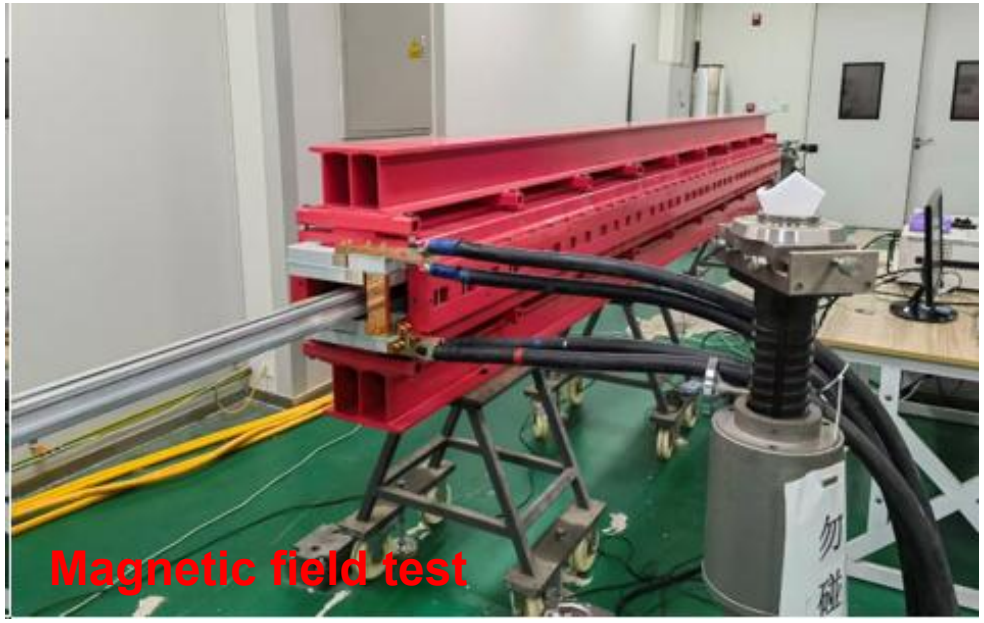


Stacking of the 1/3 length core unit



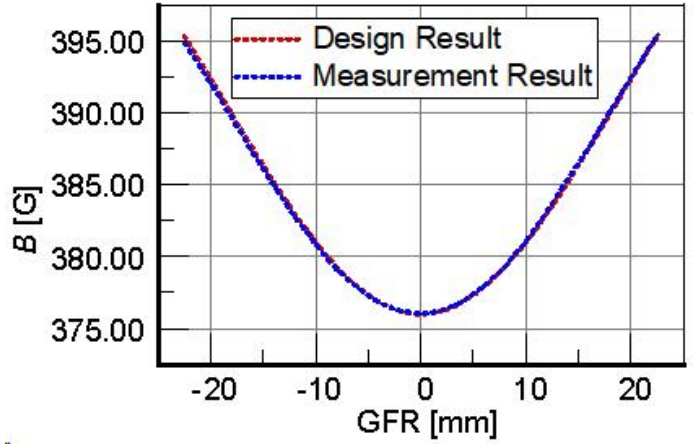
2. Magnets (CEPC)

2.4 Dipole combined with Sextupole (Prototype)



- ✓ A Hall probe magnetic field measurement system is used to measure the field of the prototype magnet.
- ✓ The measured field distribution at the magnet center plane is shown in the figure. For comparison, the simulated results are also shown in the figure and table. It can be seen as the dipole field reaches the required value, the sextupole field is 1.7% lower than the required one. So in the design for future magnet, sextupole field will increase by 1.7%.
- ✓ The effective length of the dipole is 4713mm whereas that of the sextupole is 4691mm.

	Design Requirements	Simulation Results	Prototype Magnetic Field	Error
B0[Gs]	376.00	376.00	376.00	/
S[Gs/mm^2]	0.106925	0.106928	0.105114	1.7% ↓



2. Magnets (PWFA)

高能锐新 HE-RACING TECHNOLOGY

2.5 Dipole & Quadrupole

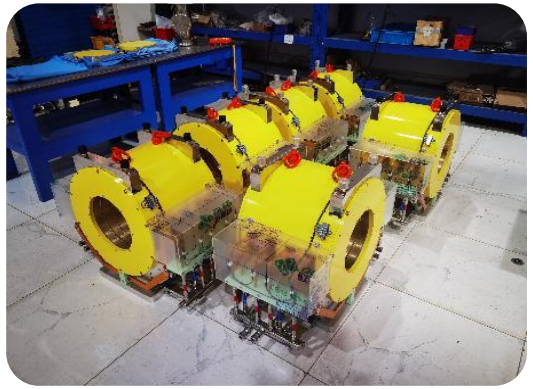


2. Magnets (HALF)

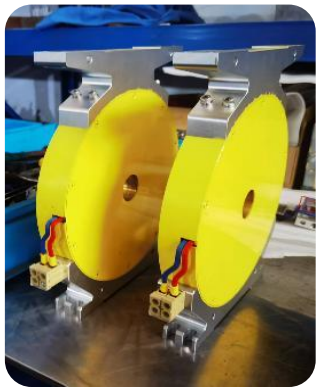
2.6 Injector (Solenoid and Corrector)

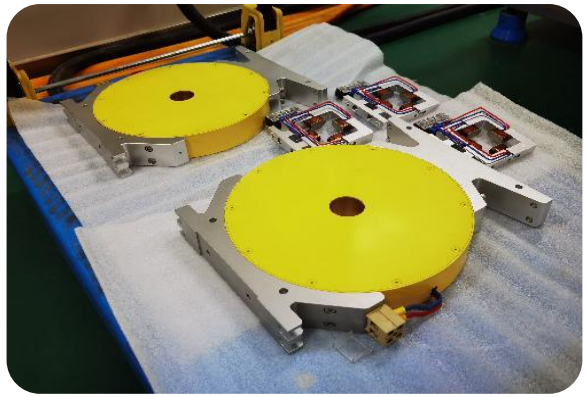


Middle（2sets)

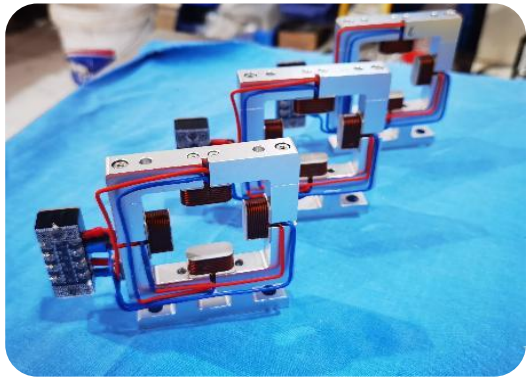


Long（2sets)





Short（2sets)

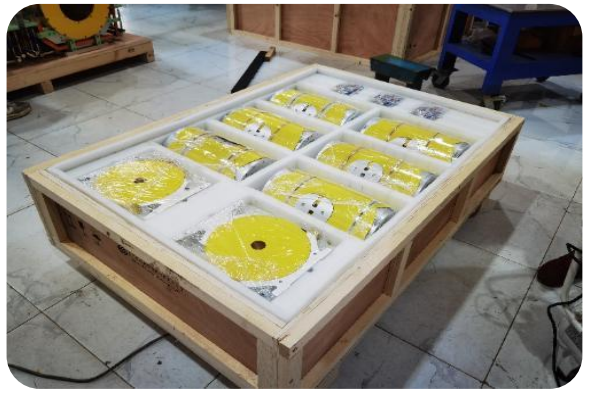


Corrector（3sets)



Corrector coils（6sets)





Packing

2. Magnets (HALF)

2.6 Storage Ring Magnets (Quadrupole,Bias Quadrupole &Sextupole,537sets)



Quadrupole,Bias Quadrupole



Sextupole

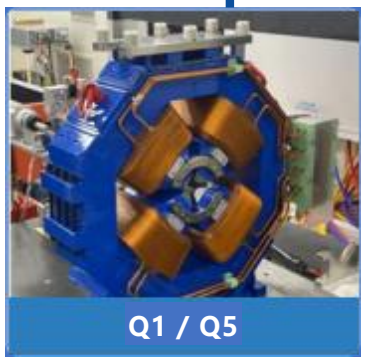
2. Magnets (HALF)

高能锐新 HE-RACING TECHNOLOGY

■ Speciations(Quadrupole &Bias Quadrupole)

Quadrupole

4types, 80sets/type, 320set in total


Q1 / Q5


Q2 / Q6

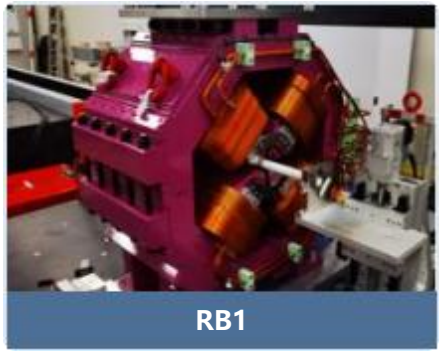

Q3 / Q4

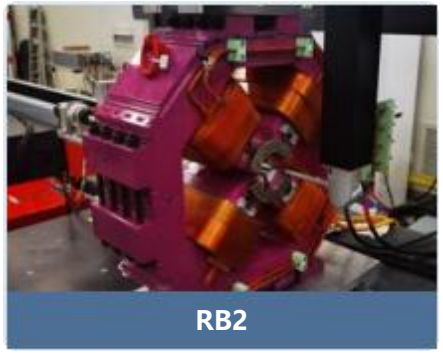

Q7 / Q8

Types	Q1 / Q5	Q2 / Q6	Q3 / Q4	Q7 / Q8
Aperatrue/ mm	36	36	36	31
Leff/ mm	170	150	150	160
Gradient/ T·m-¹	43.4 / 41.3	−35.8 / −35.4	−24.7 / 20.6	−53.7 / −44.8

Bias Quadrupole

2types, 40sets/type, 80set in total


RB1


RB2

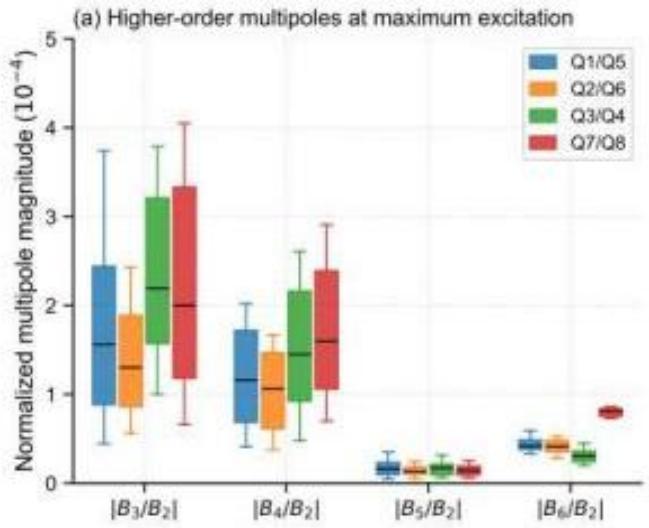
Types	RB1	RB2
Aperatrue/ mm	39	36
Leff/ mm	360	220
Gradient/ T·m-¹	42.2	45.4

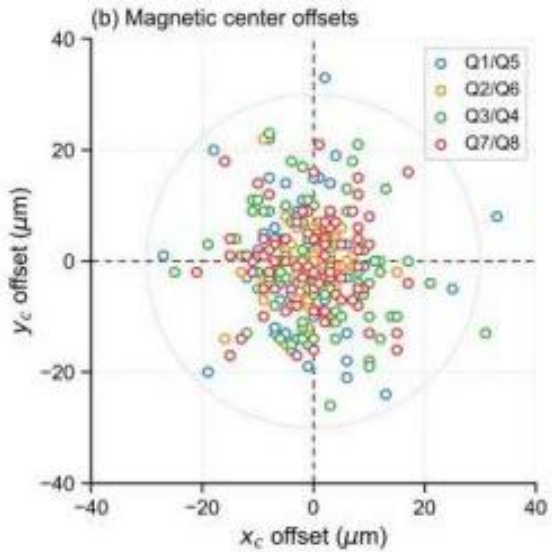
Harmonic Error	$B_3/B_2 \le 5\times10^{-4}$ | $B_4/B_2 \le 5\times10^{-4}$ | $B_5/B_2 \le 3\times10^{-4}$ | $B_n/B_2 \le 1.5\times10^{-4}$ $(n > 5)$

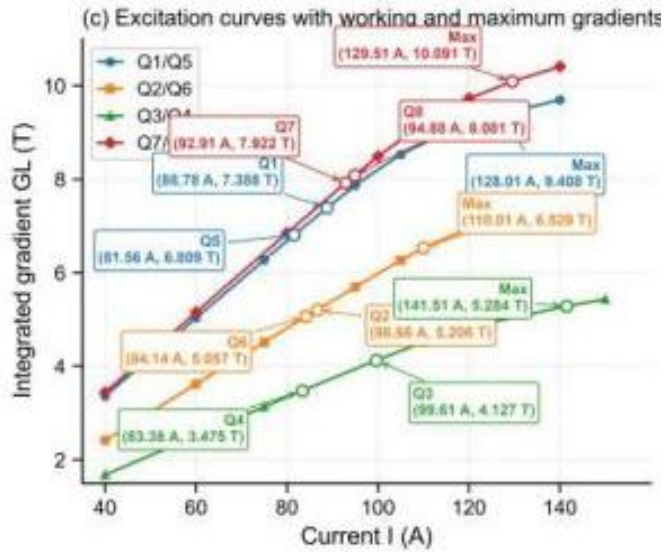
2. Magnets (HALF)

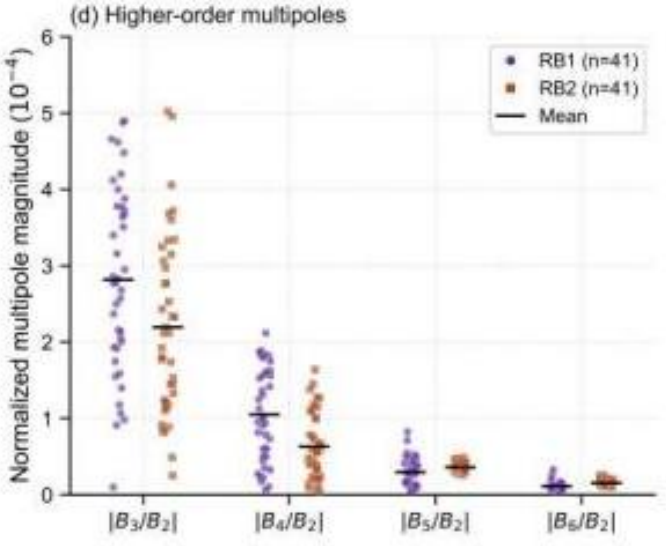
高能锐新 HE-RACING TECHNOLOGY

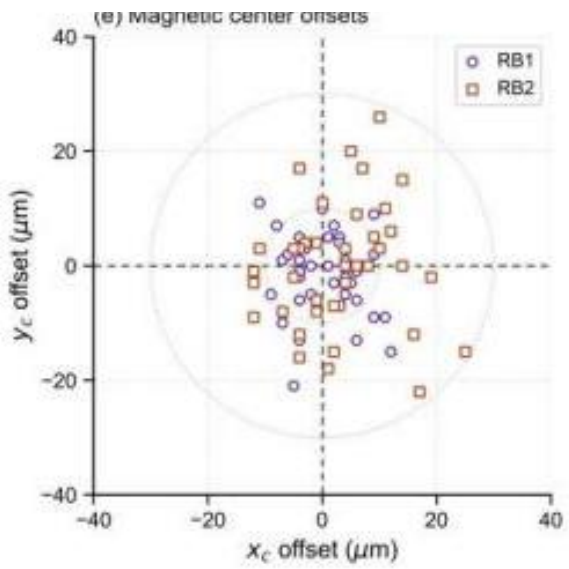
■ Measuremet Results (by NSRL)

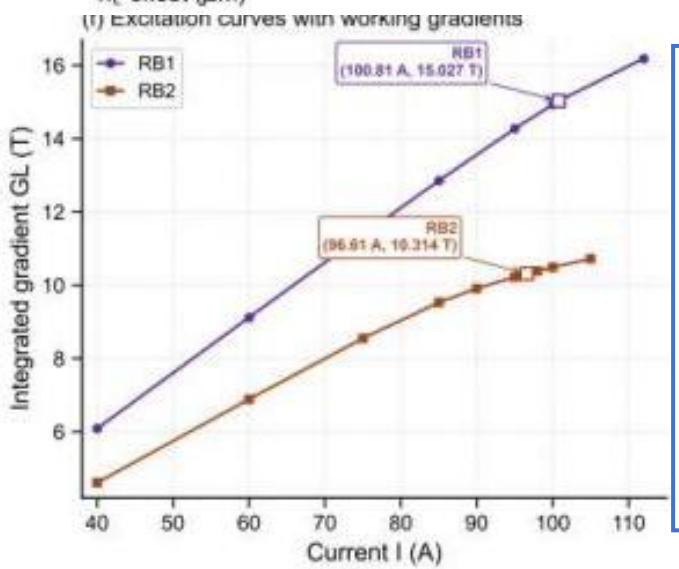












324件四极 + 82件RB

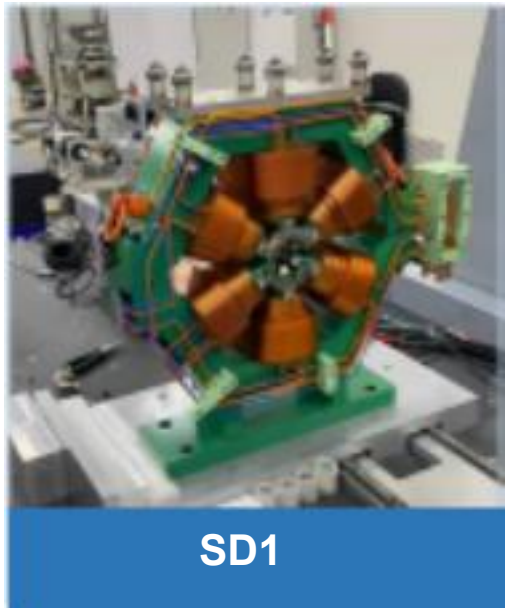
各类磁铁的高阶量、磁中心分布和励磁曲线总体稳定。

6件磁铁出厂磁测超差，经调整后达标。

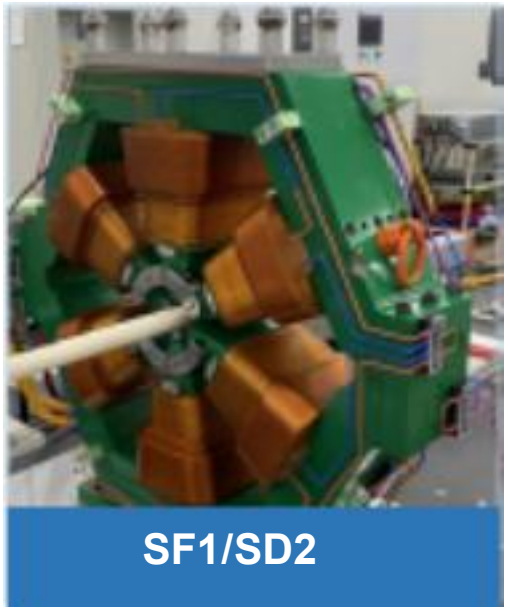
*孙天昊- HALF储存环磁铁系统进展报告

2. Magnets (HALF)

■ Sextupole

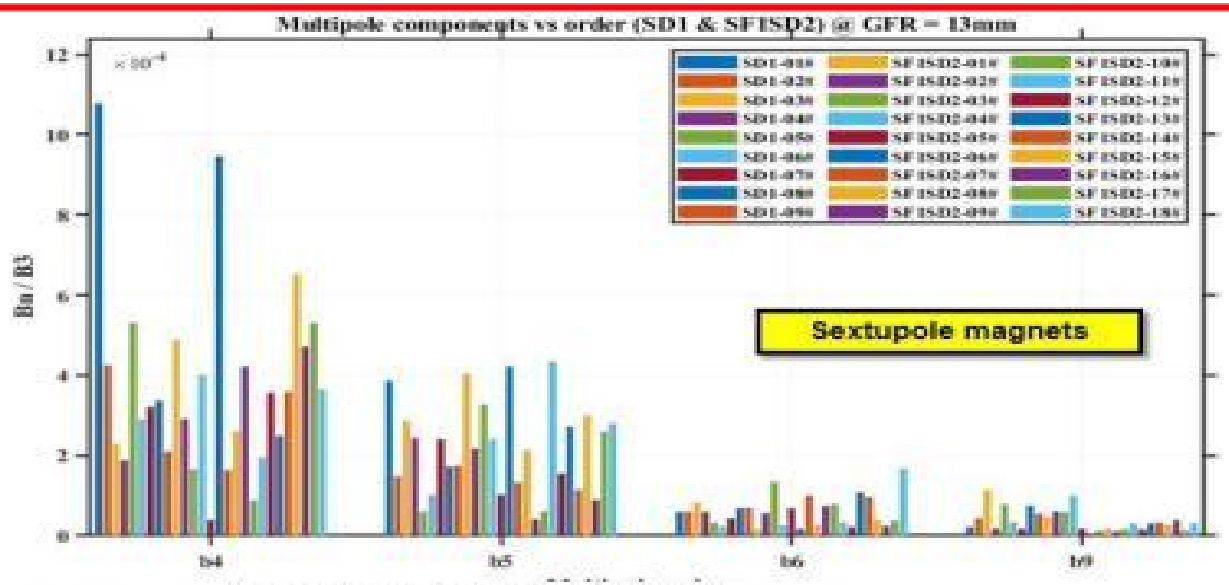


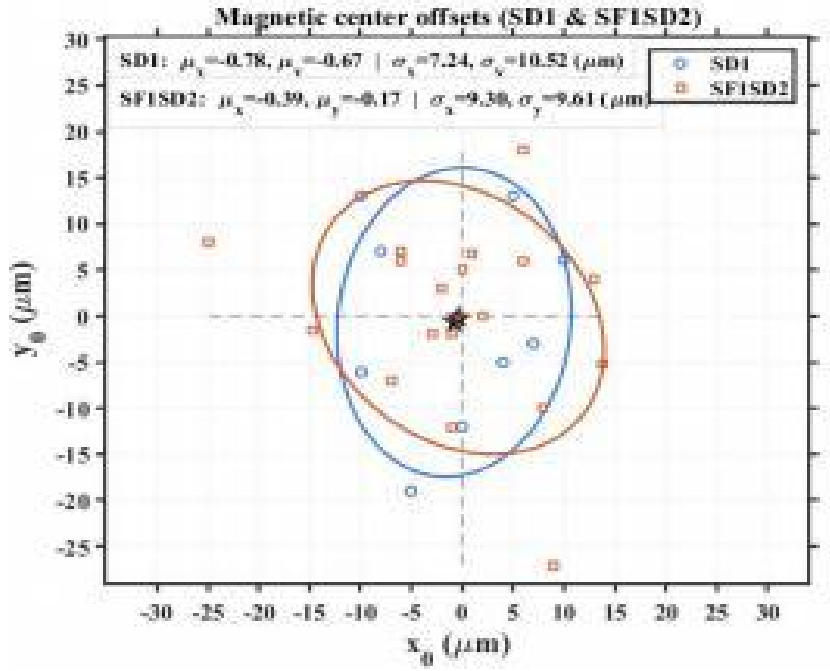
SD1



SF1/SD2

Types	SD1	SF1/SD2
Qty. (set)	40	80
Aperatrue / mm	45	45
Leff / mm	150	150
Gradient / T·m^{-2}	2500	1900
Harmonic Error	B4 /B3 ≤ 2.5×10-3 B5 /B3 ≤ 1.5×10-3 B_n /B2 ≤ 1.0×10-3^4 (n > 5)	





各项指标满足要求

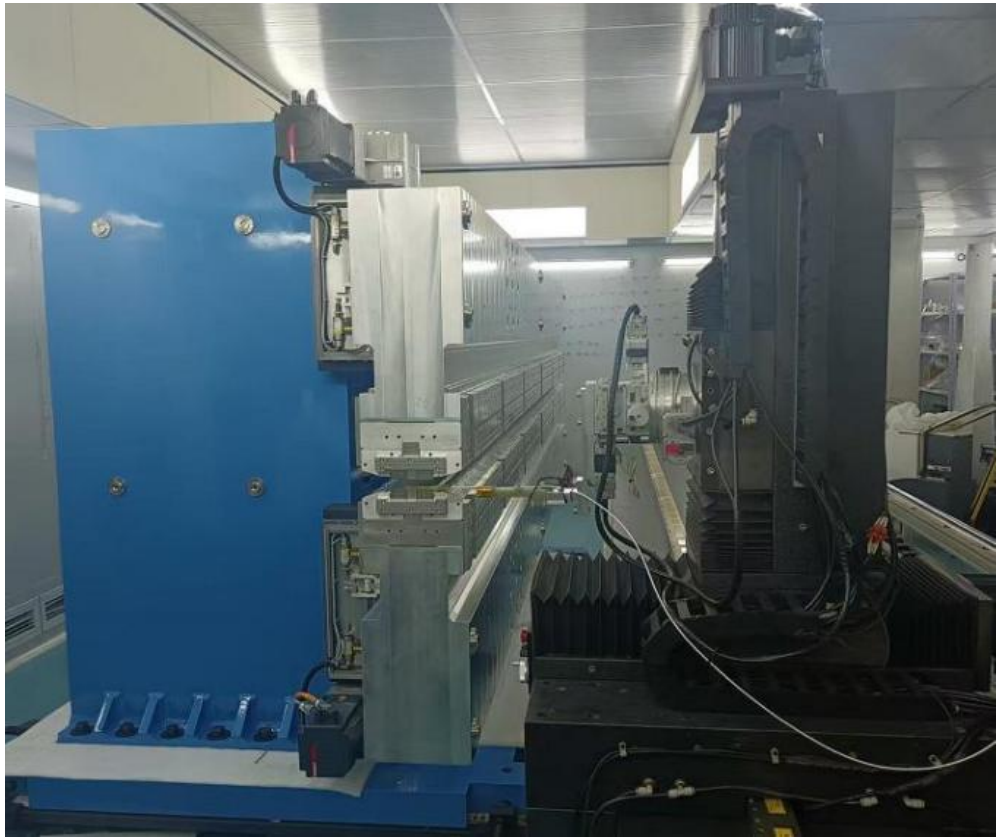
磁中心偏移量：
均值 < 1um

*孙天昊- HALF储存环磁铁系统进展报告

2. Magnets (HALF)

高能锐新 HE-RACING TECHNOLOGY

■ Helical Undulators

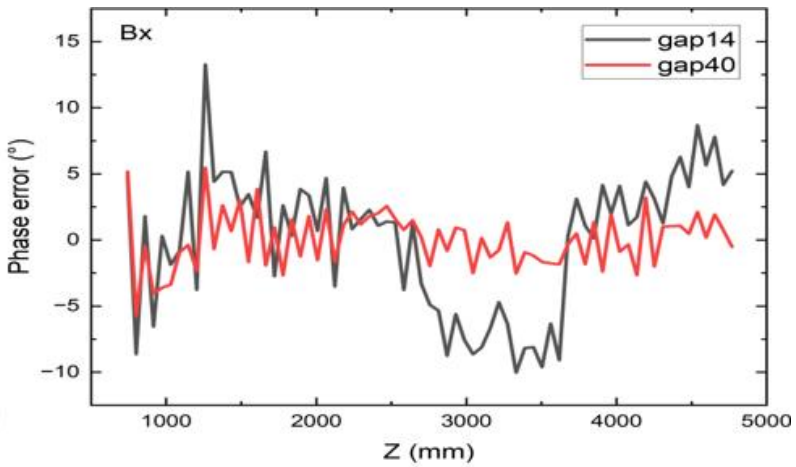


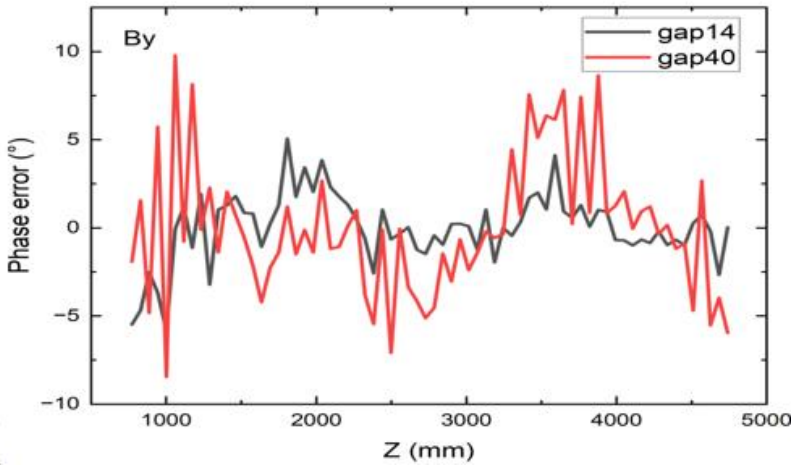
纯永磁上下各三排磁块阵列
国内首台六阵列圆极化波荡器

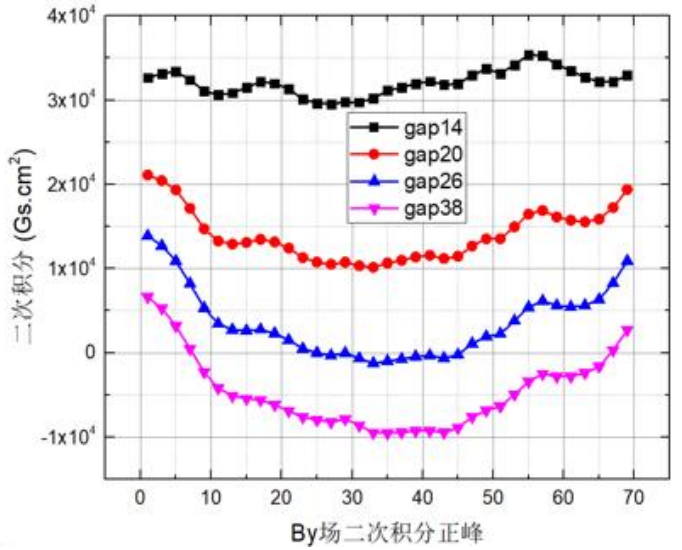
Content	Specificaton
Magnet	NdFeB，≥1.32 T
Length	≤4200 mm
Period	115±0.02 mm
Number	35
Max.K	$K_x^2+K_y^2$＞157.87 ($K_{x,\ y}$>7.5)
Operating Gap	14-40mm
GFR（0.5%roll off）	Bx ≥±2mm@14mm ≥1.7mm @40mm By ≥±1mm@14mm ≥1.4mm @40mm
First field integral (X≤±13)	＜±100 @ operating gap
Second field integral(X≤±13)	＜±20000 @ operating gap
RMS phase error	10° @ operating gap

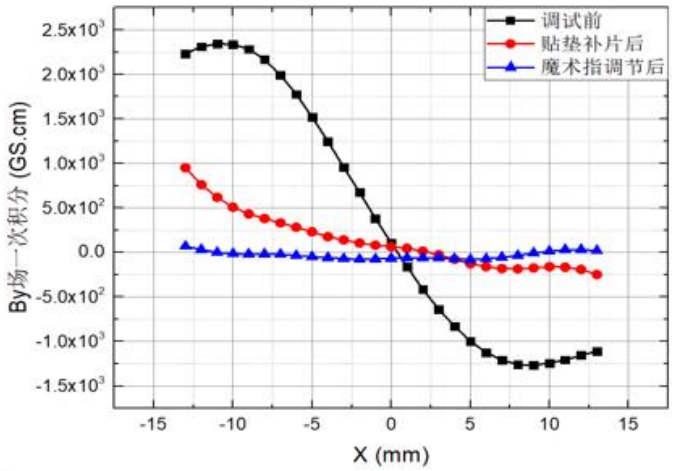
2. Magnets (HALF)

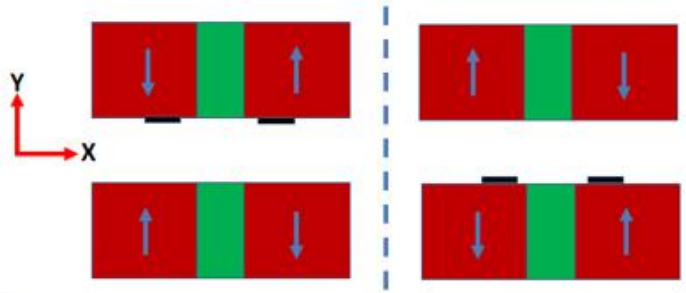
■ Helical Undulators











相位误差无需优化即实现全工作间隙达标

采用磁极+垫补片方案解决了磁间隙关联性、多极场偏大的问题

各项指标满足甲方需求

2. Magnets (HALF)

高能锐新 HE-RACING TECHNOLOGY

In-vacuum undulator IVU-21a

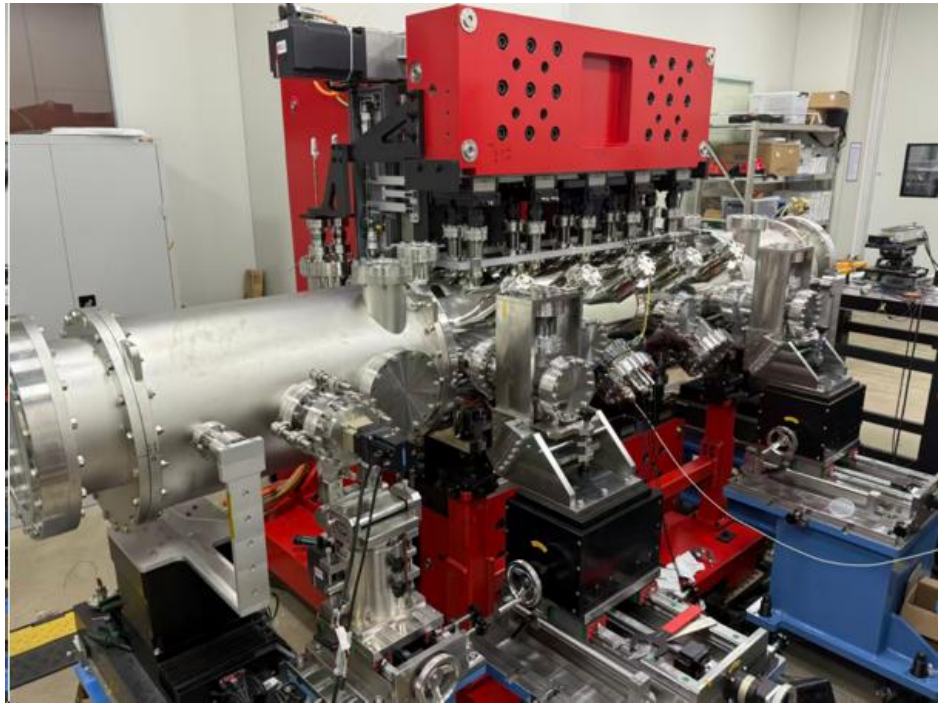


Content	Specificaton
Magnet	NdFeB，≥1.32 T
Length	≤4200 mm
Period	20.7±0.02 mm
Number	182
Max.*K*	≥2.08
Operating Gap	6-20mm
GFR （0.5%roll off）	≥±10mm@gap≤12mm ≥±9mm@gap≤15mm ≥±8mm@gap≤18mm ≥±7mm@gap≤20mm
First field integral (X≤±13)	＜±100 @ operating gap
Second field integral(X≤±13)	＜±20000 @ operating gap
RMS phase error	≤3.5˚(gap：6-9 mm)； ≤5.0˚(gap：9-20 mm)

2. Magnets (HALF)

高能锐新 HE-RACING TECHNOLOGY

In-vacuum undulator IVU-21b

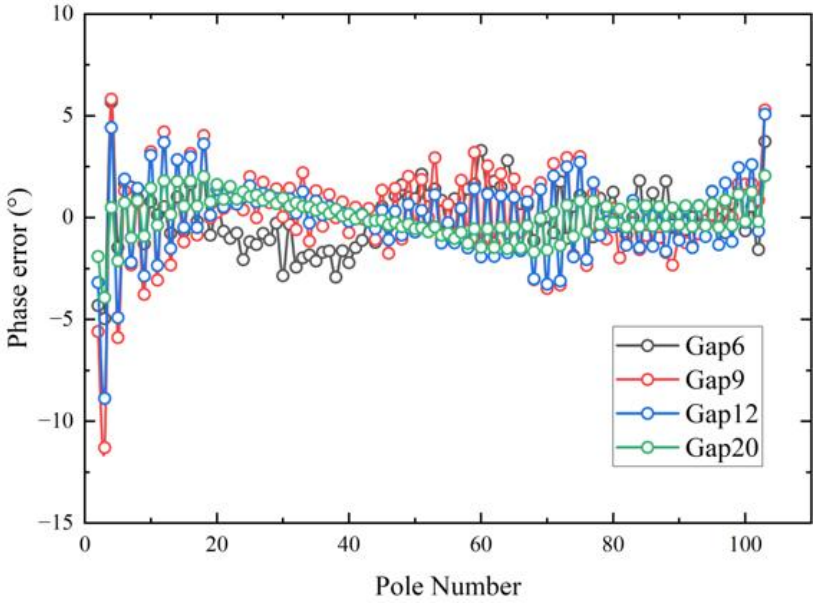


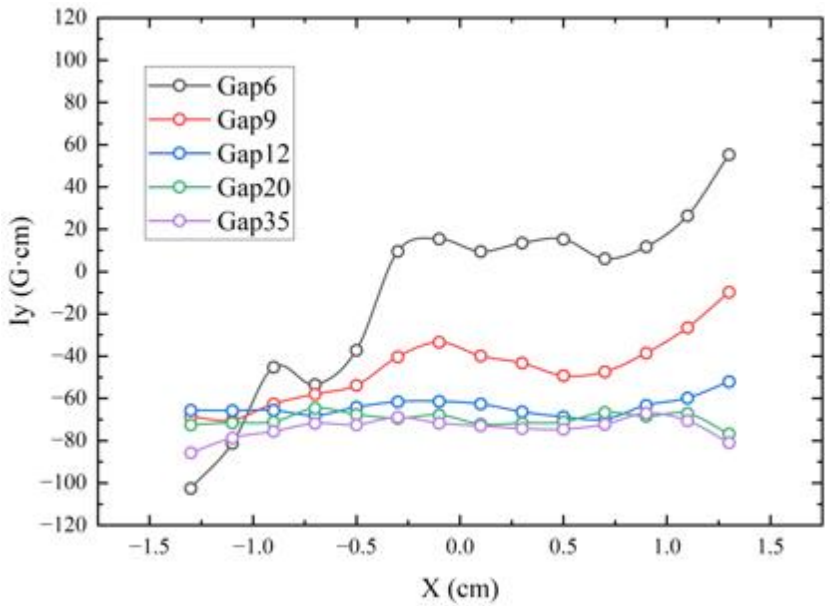
完成出厂验收
各项指标均达到或优于设计指标

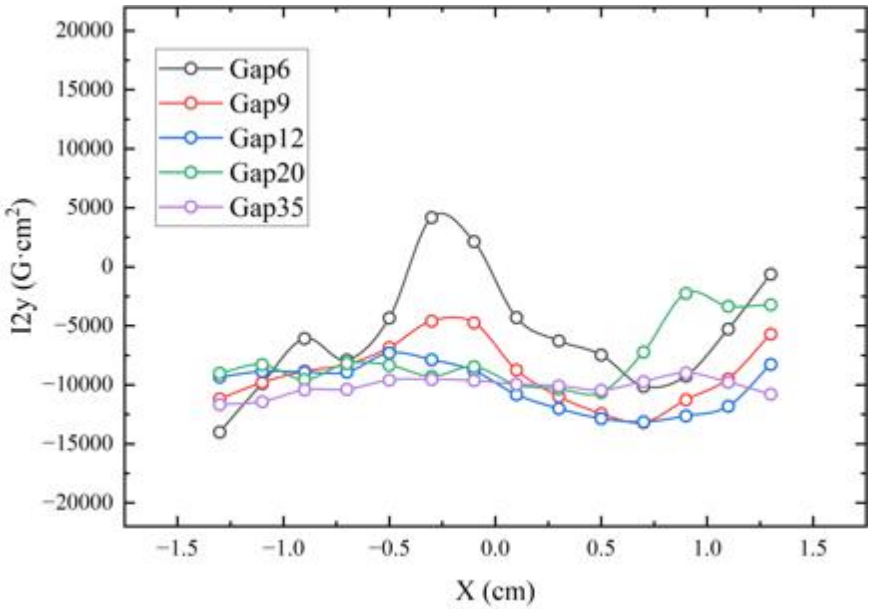
Content	Specificaton
Magnet	NdFeB，≥1.32 T
Length	≤1500 mm
Period	20.7±0.02 mm
Number	52
Max.*K*	≥2.08
Operating Gap	6-20mm
GFR （0.5%roll off）	≥±10mm@gap≤12mm ≥±9mm@gap≤15mm ≥±8mm@gap≤18mm ≥±7mm@gap≤20mm
First field integral (X≤±13)	＜±100 @ operating gap
Second field integral(X≤±13)	＜±20000 @ operating gap
RMS phase error	≤3.0˚(gap：6-9 mm)； ≤4.0˚(gap：9-20 mm)

2. Magnets (HALF)

■ IVU-21b







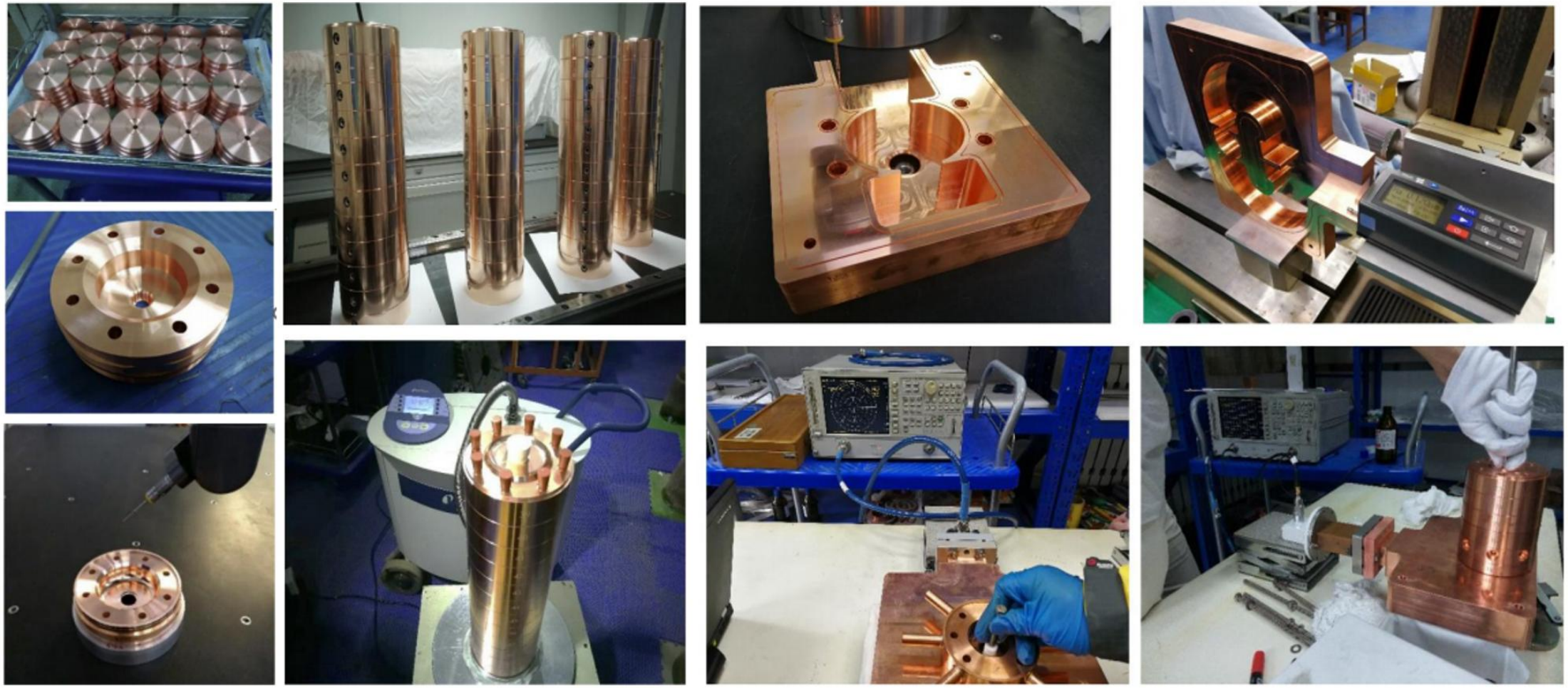
Gap[mm]	Phase error[°]	合同约定值
6	1.40	<3°
7	1.37	
8	1.92	
9	1.92	
10	1.84	<4°
12	1.65	
14	1.41	
16	1.20	
18	1.03	
20	0.88	

Gap[mm]	6	8	10	12	14	16	18	20	35	合同约定值
积分四极场[G]	37	10	2	-7	-11	-16	-4	-8	-8	ABS＜100
积分六极场[G/cm]	-116	-65	-37	-27	-11	-10	25	11	-3	ABS＜200
积分八极场[G/cm²]	-7	26	10	12	18	25	5	19	22	ABS＜200
一次积分[G·cm]	11	-39	-49	-59	-68	-69	-67	-68	-72	ABS＜100
二次积分[G·cm²]	-1891	-7908	-8099	-8709	-9210	-9505	-8648	-8913	-10026	ABS＜20000

3. Accelerating Structure and RT Cavities

高能锐新 HE-RACING TECHNOLOGY

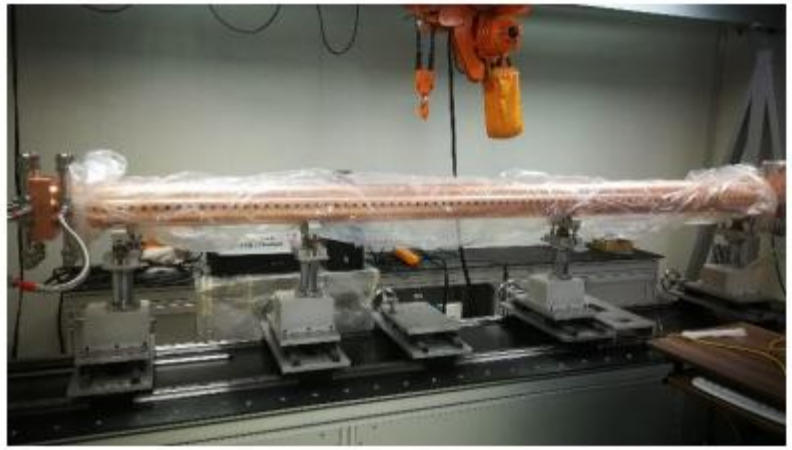
3.1 S Band Accelerating Structures (HEPS 9 sets)



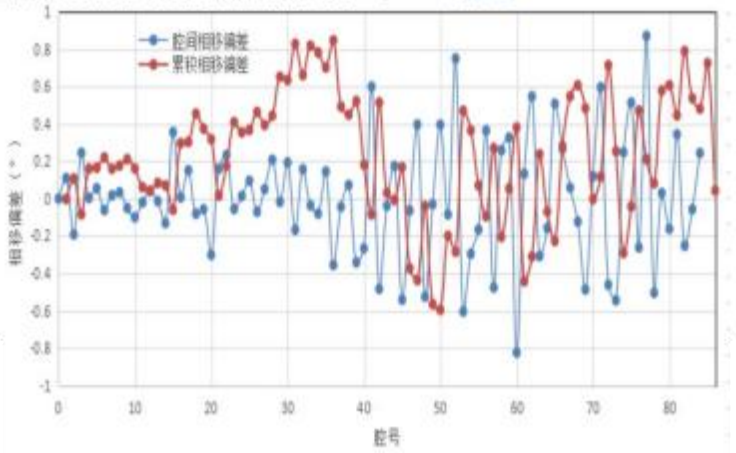
3. Accelerating Structure and RT Cavities

3.1 S Band Accelerating Structures (HEPS 9 sets9 sets)

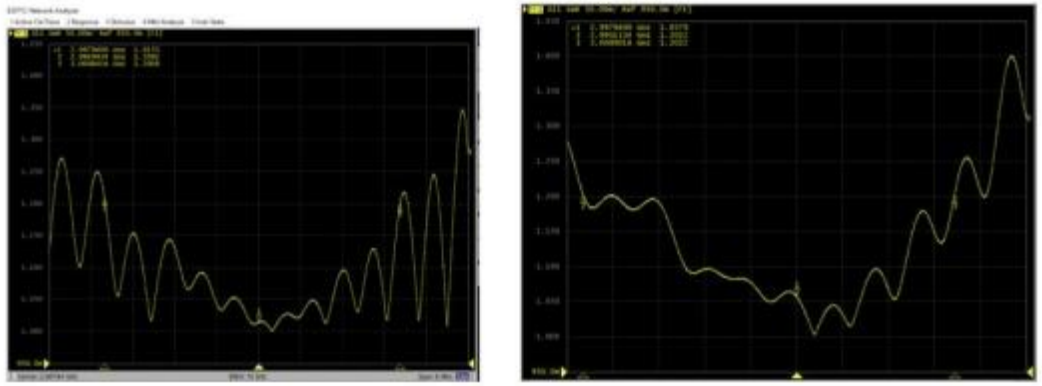
- 将根据采购方的要求，协助进行加速管的测试与调谐



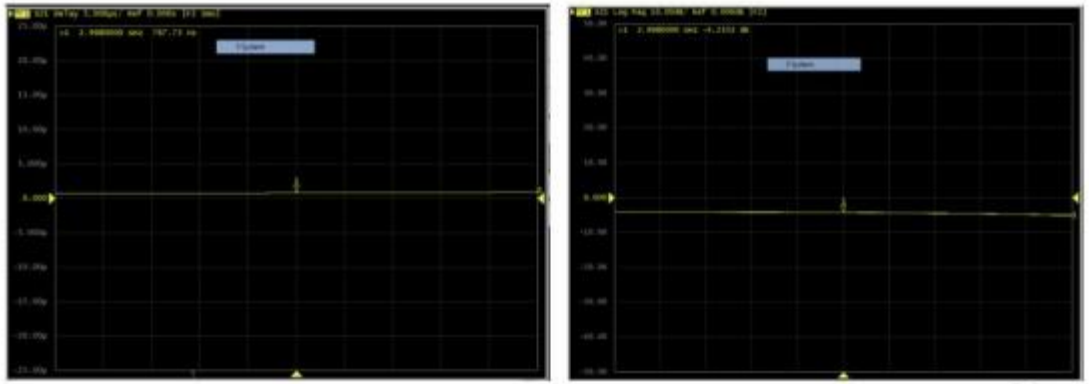
- 调整腔间相移和累积相移误差±2°以内



- 完成输入/输出耦合器驻波比测试（≤1.1）



- 填充时间与衰减测试



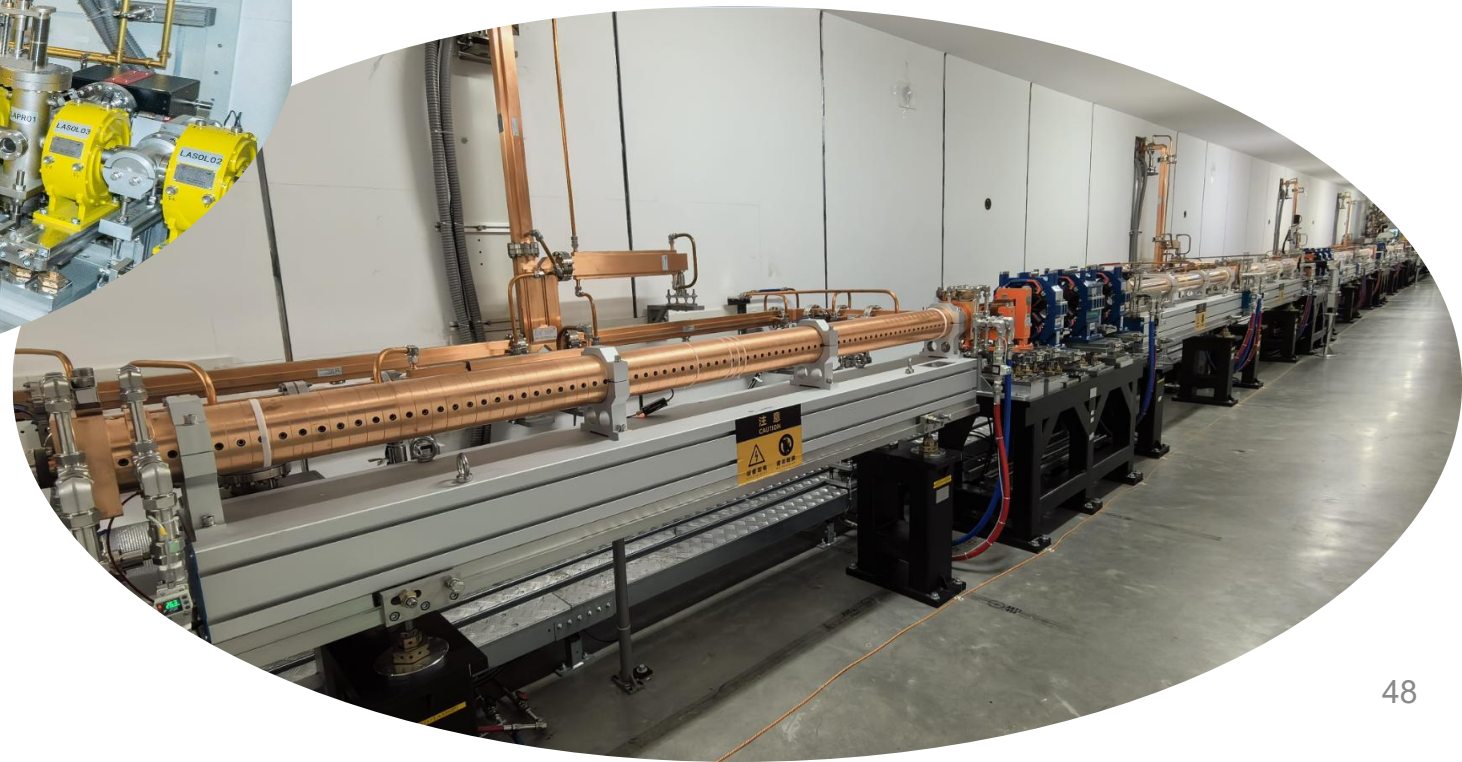
3. Accelerating Structure and RT Cavities

高能锐新 HE-RACING TECHNOLOGY

3.1 S Band Accelerating Structures (HEPS 9 sets)



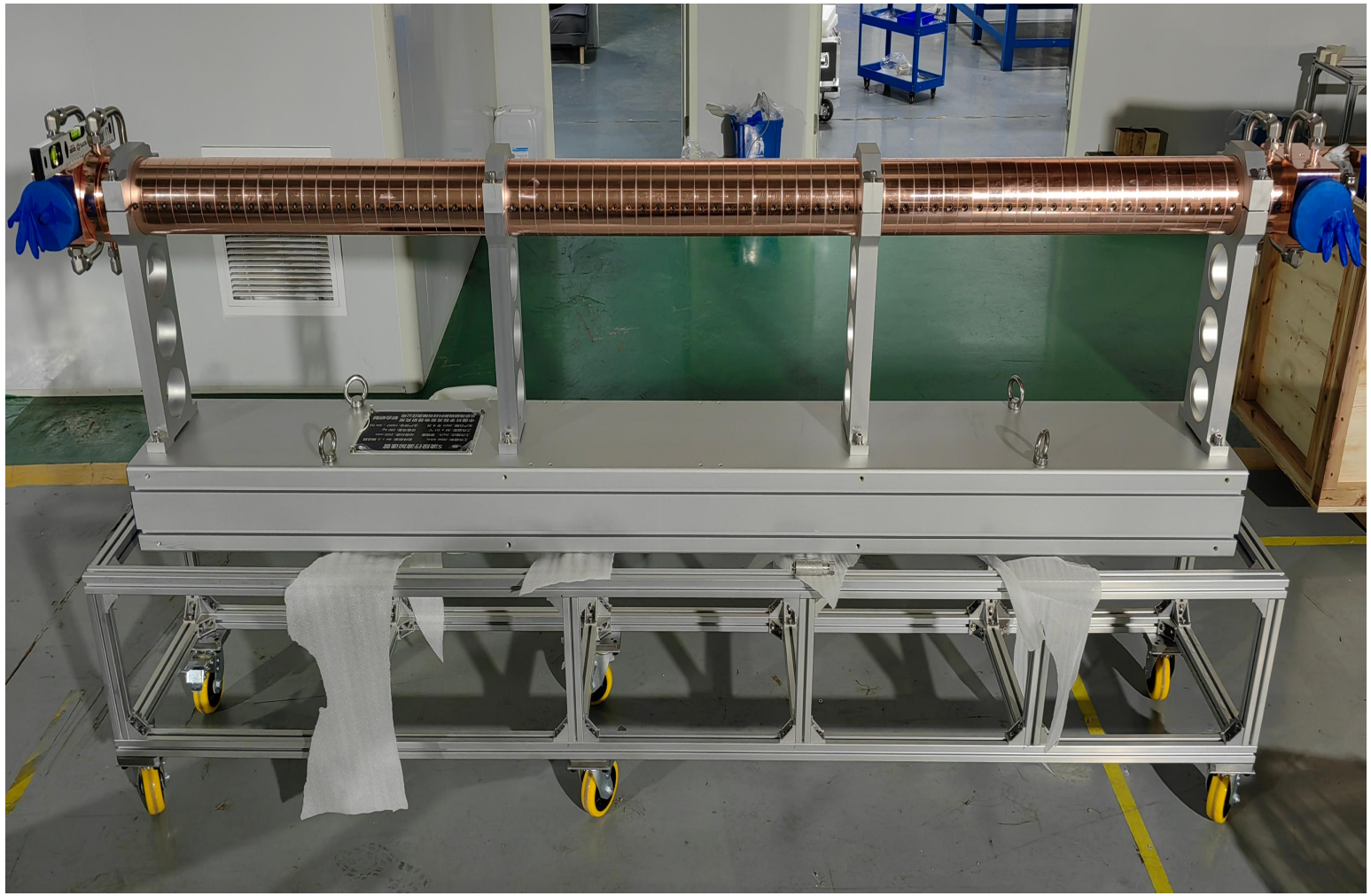
HEPS Linac



3. Accelerating Structure and RT Cavities

高能锐新 HE-RACING TECHNOLOGY

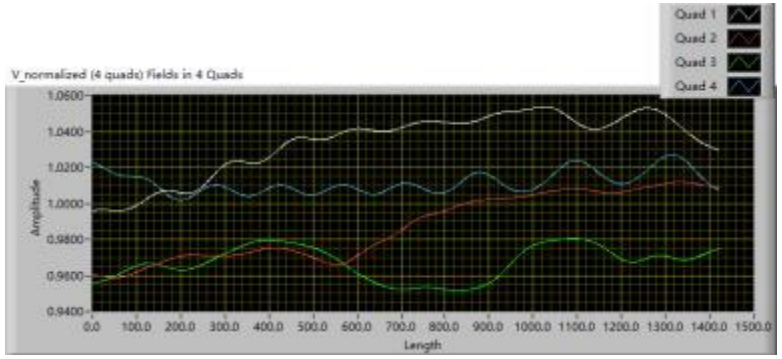
3.2 S Band Accelerating Structures (PWFA 2 sets)

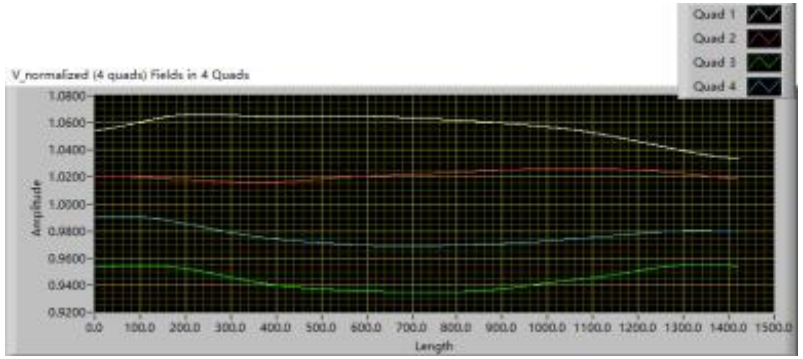


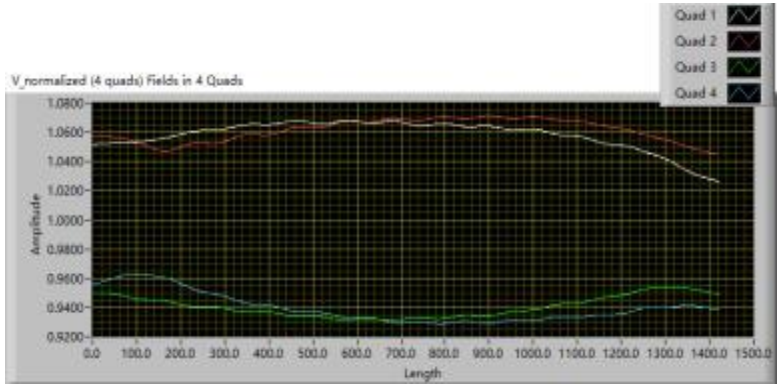
3. Accelerating Structure and RT Cavities

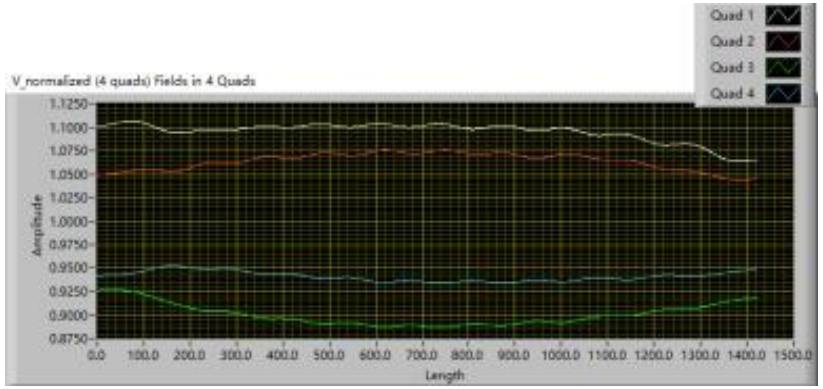
3.2 RT Cavities (RFQ)











3. Accelerating Structure and RT Cavities

高能锐新 HE-RACING TECHNOLOGY

3.3 RT Cavities (DTL)







图 5 漂移管 Z 向绝对值偏差



图 3 漂移管 X 向同轴偏差

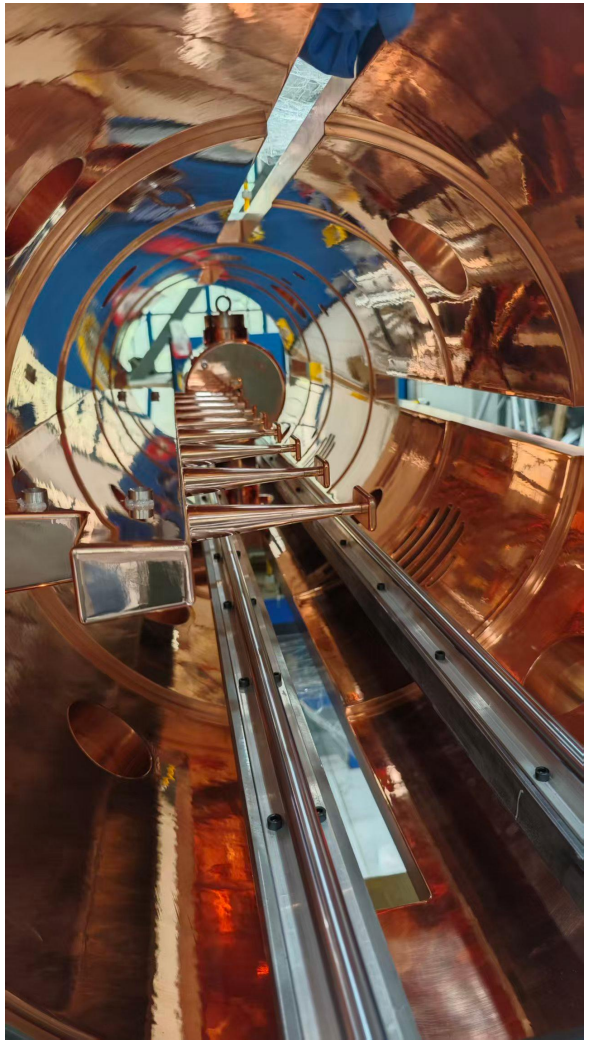


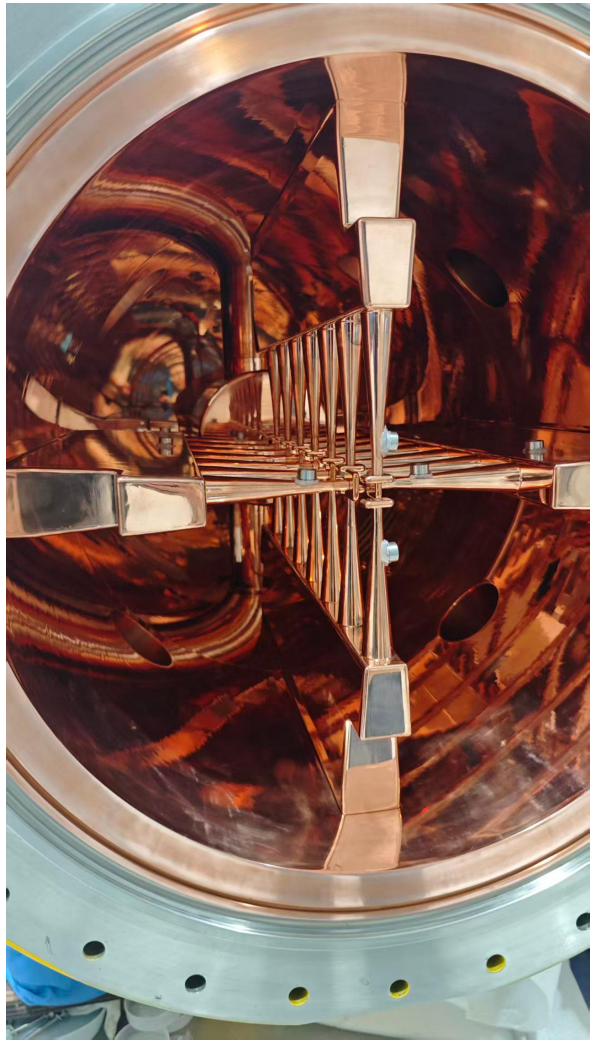
图 4 漂移管 Y 向同轴偏差

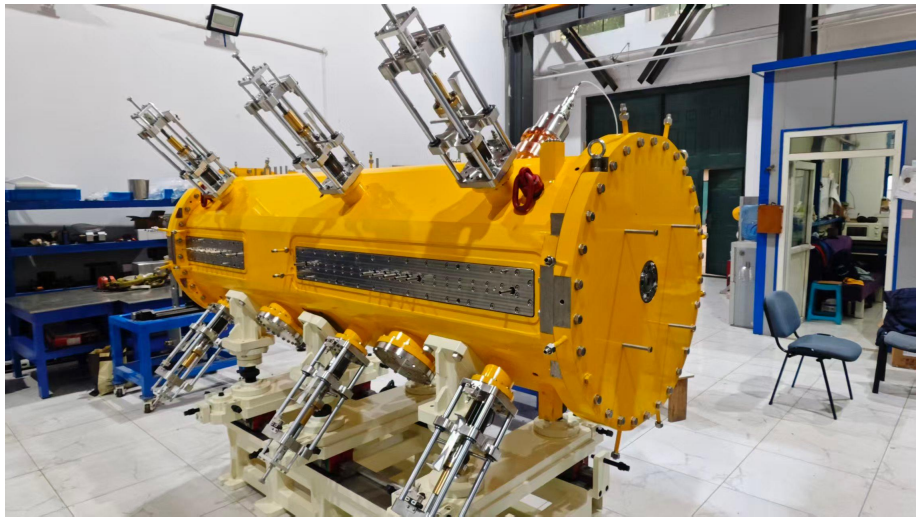
3. Accelerating Structure and RT Cavities

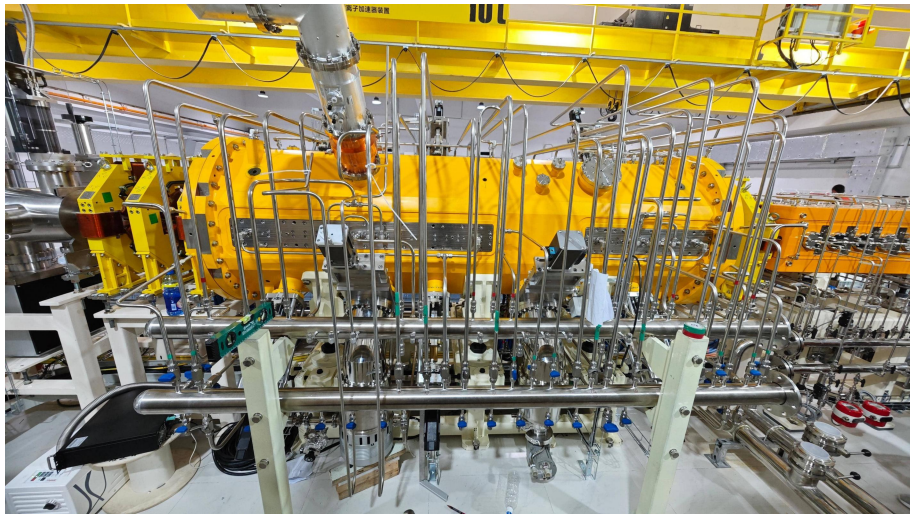
高能锐新 HE-RACING TECHNOLOGY

3.4 RT Cavities (CH-DTL)









4. SRF Cavities Couplers and Cryomodules

高能锐新 HE-RACING TECHNOLOGY

2.1 Cavities (270 Pieces)

序号	科学装置	腔类型	频率（MHz）	数量（只）	测试梯度（MV/m）	工作状态
1	HEPS-TF	QWR	166.7	2	19	垂测
2	HEPS	QWR	166.7	10	14	水平
3	CiADS	Spoke， β=0.12	325	4	11.5	带束运行
4	CiADS	Spoke， β=0.21	325	5	12	带束运行
5	CiADS	Spoke， β=0.24	325	1	11.2	垂测
6	CiADS	双Spoke， β=0.51	325	1	16	垂测
7	CSNSII	双Spoke， β=0.51	325	4	13	垂测
8	RISP	Spoke， β=0.51	325	7	12	垂测
9	HEPS	单CELL 椭球腔	500	4	16	垂测（4K）
10	BIIU	单CELL 椭球腔	500	2	16	垂测（4K）
11	HALF	单CELL 椭球腔	500	2	16	垂测（4K）
12	CSNSII	6CELL椭球腔	648	1	24	垂测
13	CEPC	2CELL椭球腔	650	1	24	垂测
14	CEPC	5CELL椭球腔	650	3	12	垂测（4K）
15	PAPS	2CELL椭球腔	650	3	36	垂测
16	CiADS	6CELL椭球腔	650	1	24	垂测
17		5CELL椭球腔	975	1	17	垂测
18	PAPS&SHINE	单CELL 椭球腔	1300	28	43	垂测
19	ILC R&D	9CELL 椭球腔	1300	1	24	垂测
20	PAPS	9CELL 椭球腔	1300	2	25	垂测
21	SHINE先导	9CELL 椭球腔	1300	8	25	水平
22	SHINE小批2次	9CELL 椭球腔	1300	20	25	垂测
23	SHINE批量1	9CELL 椭球腔	1300	72	25-30	垂测
24	SHINE批量2	9CELL 椭球腔	1300	64	25-30	部分垂测
25	ZJ Lab	9CELL 椭球腔	1300	9	25	垂测
25	DALS	9CELL 椭球腔	1300	8	23	水平
26	HALF	1CELL 椭球腔	1500	2	/	垂测

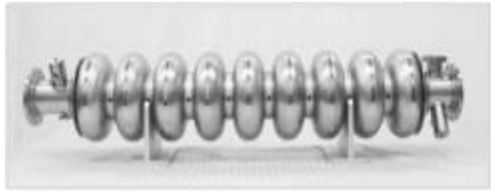
4. SRF Cavities Couplers and Cryomodules

高能锐新 HE-RACING TECHNOLOGY

4.2 Cavities-Pictures



Spoke 024
第一支超导腔
(325MHz)



9 Cell 超导腔
第一支椭球腔
(1.3GHz)





2 Cell 超导腔
5 Cell 超导腔
(650MHz)



双Spoke腔
(325MHz)



Spoke 051
SSR2超导腔
(325MHz)



QWR Cavity
HEPS超导腔
(166.7MHz)

2014 2015 2016 2017 2018 2019 2020 2021

Spoke 012
ADS 注入器超导腔
小批量生产



Spoke 021
ADS 主加速器超导腔
小批量生产



HEPS-TF超导腔
第一支QWR超导腔
(166.7MHz)





高Q值1.3GHz 9 Cell
高Q值1.3GHz 单 Cell





Cavity
HLS 超导腔
(500MHz)



SRF Cavities

高能锐新 HE-RACING TECHNOLOGY

4.2 Cavities-Pictures

PAPS
2Cell 椭球腔
(650MHz)





CSNSII
双Spoke 051
(325MHz)



HEPS
单Cell 椭球腔
(500MHz)



DALS
9Cell 高Q椭球腔 (1300MHz)

2021 2022 2023

SHINE
9Cell 高Q椭球腔
(1300MHz)



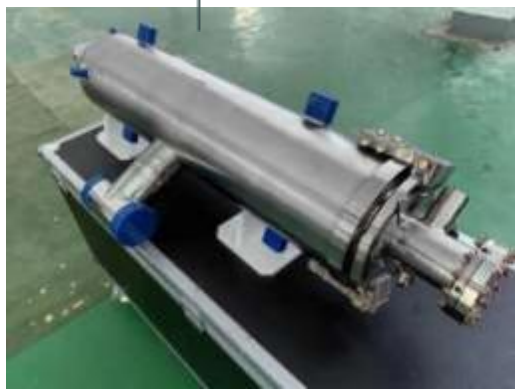
HALF
单Cell 椭球腔
(500MHz)



HEPS
QWR腔
(166MHz)



SHINE
(1300MHz)

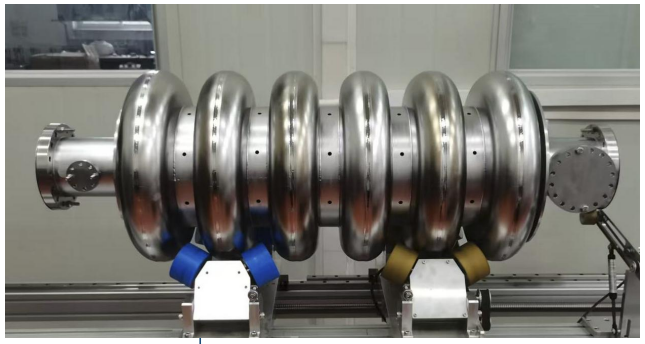


4. SRF Cavities Couplers and Cryomodules

4.2 Cavities-Pictures



CSNSII
双Spoke 051
(325MHz)



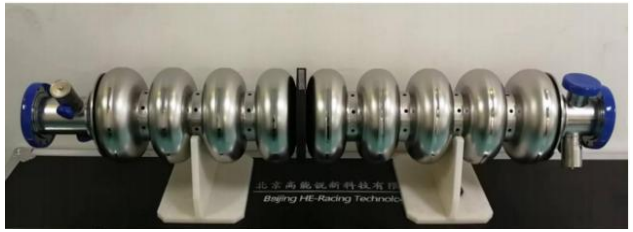
CSNSII
6Cell椭球腔
(648MHz)



HALF
1Cell 椭球腔 (1500MHz)

2024-2025

SHINE
9Cell 高Q椭球腔
(1300MHz)



5Cell 椭球腔
(975MHz)



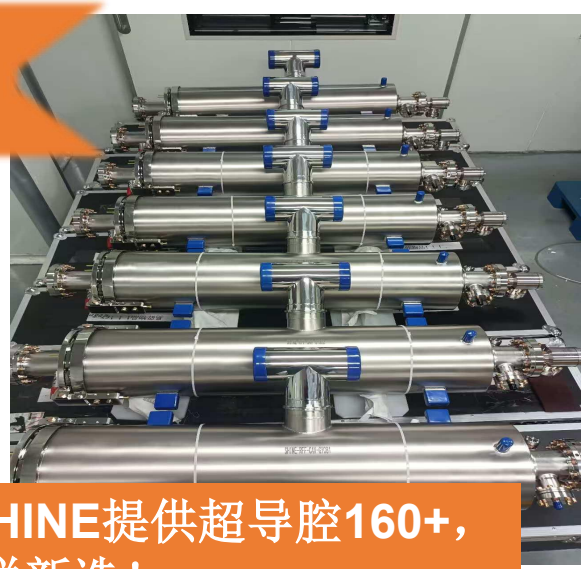
56

4. SRF Cavities Couplers and Cryomodules

2.1 Cavities(1.3GHz 9 cell cavities)



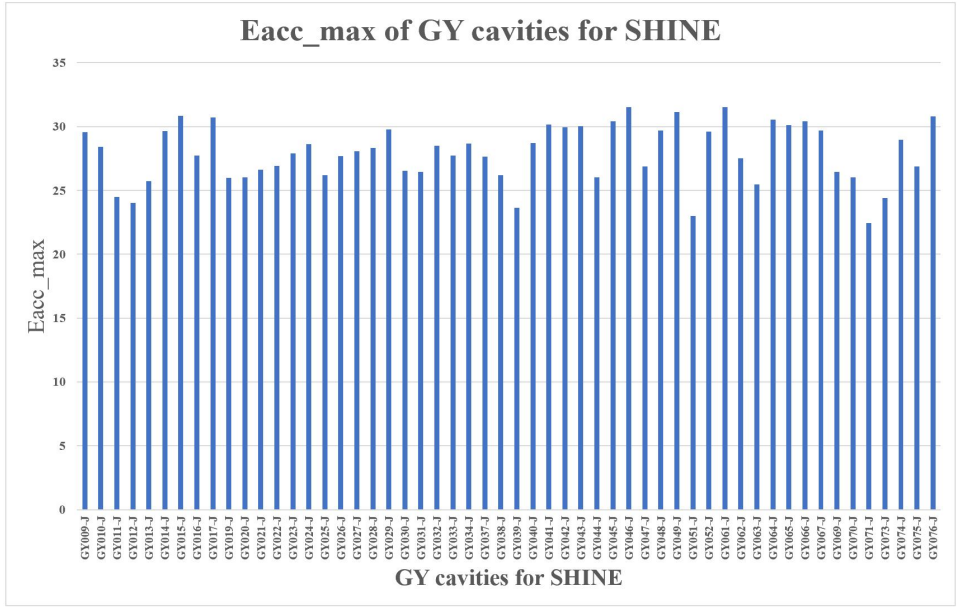
祝贺
SHINE首次出光

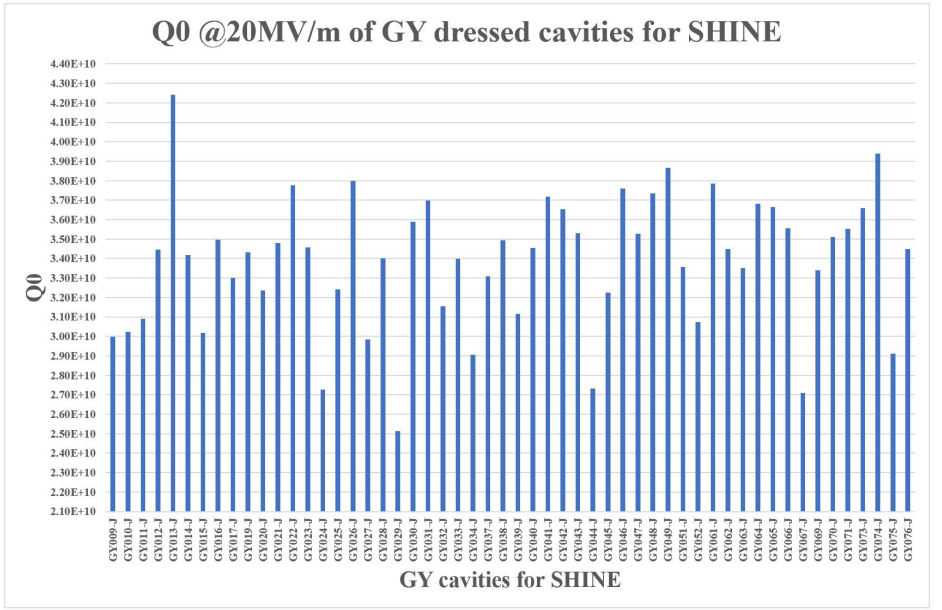


2018-2026年，锐新公司共计为SHINE提供超导腔160+，
硬核发动机-1.3GHz 9cell超导腔锐新造！









4.3 Couplers-Parameters List (80 Pieces)

Item	Facility	Cavity Type	Frequency (MHz)	Window Type	Qty.	Remark	Power
1	SERI	DTL(NC)	80	Coaix, Plate	2	Online	
2	IBS	HWR (SCC)	162.5	Coaix, Plate	2	Test	
3	CiADS	HWR (SCC)	162.5	Coaix, Plate	2	Online	CW 15kW
4	HEPS-TF	QWR (SCC)	166.7	Coaix, Plate	2	Test	
5	HEPS	QWR (SCC)	166.7	Coaix, Plate	10	Online	TW250kW,SW100kW
6	CSNS	Spoke (SCC)	324	Coaix, Plate	2	Test	TW300kW， 5%
7	CiADS	RFQ (NC)	325	Coaix, Plate	8	Online	
8	CiADS	Spoke (SCC)	325	Coaix, Plate	7	Online	CW,10kW
9	CiADS	Buncher (NC)	325	Coaix, Plate	3	Online	CW,7kW
10	CSNS	RFQ (NC)	325	Coaix, Plate	5	Online	
11	BNCT	RFQ (NC)	325	Coaix, Plate	5	Online	95kW, 80%
12	BEPCII	1 cell (SCC)	500	Coaix, Plate	4	Online	TW,250kW,SW,100kW
13	HEPS	5Cell (NC)	500	Coaix, Plate	2	Test	TW 250kW,SW 波100kW
14	PAPS	2Ccell (SCC)	650	Cylinder	2	Test	
15	ILC R&D	9cell (SCC)	1300	Cylinder	2	Test	
16	SHINE	9cell (SCC)	1300	Cylinder	8	Test	CW14kW;SW7kW
17	DALS	9cell (SCC)	1300	Cylinder	8	HT	CW14kW;SW7kW
18	SHINE	9cell (SCC)	1300	Cylinder	4	Test	CW14kW;SW7kW

4.3 Couplers-Pictures



325MHz-ADS



324MHz-CSNS



162.5MHz-CADS



325MHz-ADS



500MHz-BEPCII

2012 2013 2014 2015 2016

4. SRF Cavities Couplers and Cryomodules

高能锐新 HE-RACING TECHNOLOGY

4.3 Couplers-Pictures



1.3GHz 352MHz-BNCT 650MHz/1.3GHz-CEPC 1.3GHz-SHINE 166.6MHz-HEPS TF

2017 2018 2019

4. SRF Cavities Couplers and Cryomodules

高能锐新 HE-RACING TECHNOLOGY

4.3 Couplers-Pictures



325MHz-R ISP





500MHz





324MHz



166MHz-HEPS



1300MHz-DALS/SHINE



CSNS 325MHz

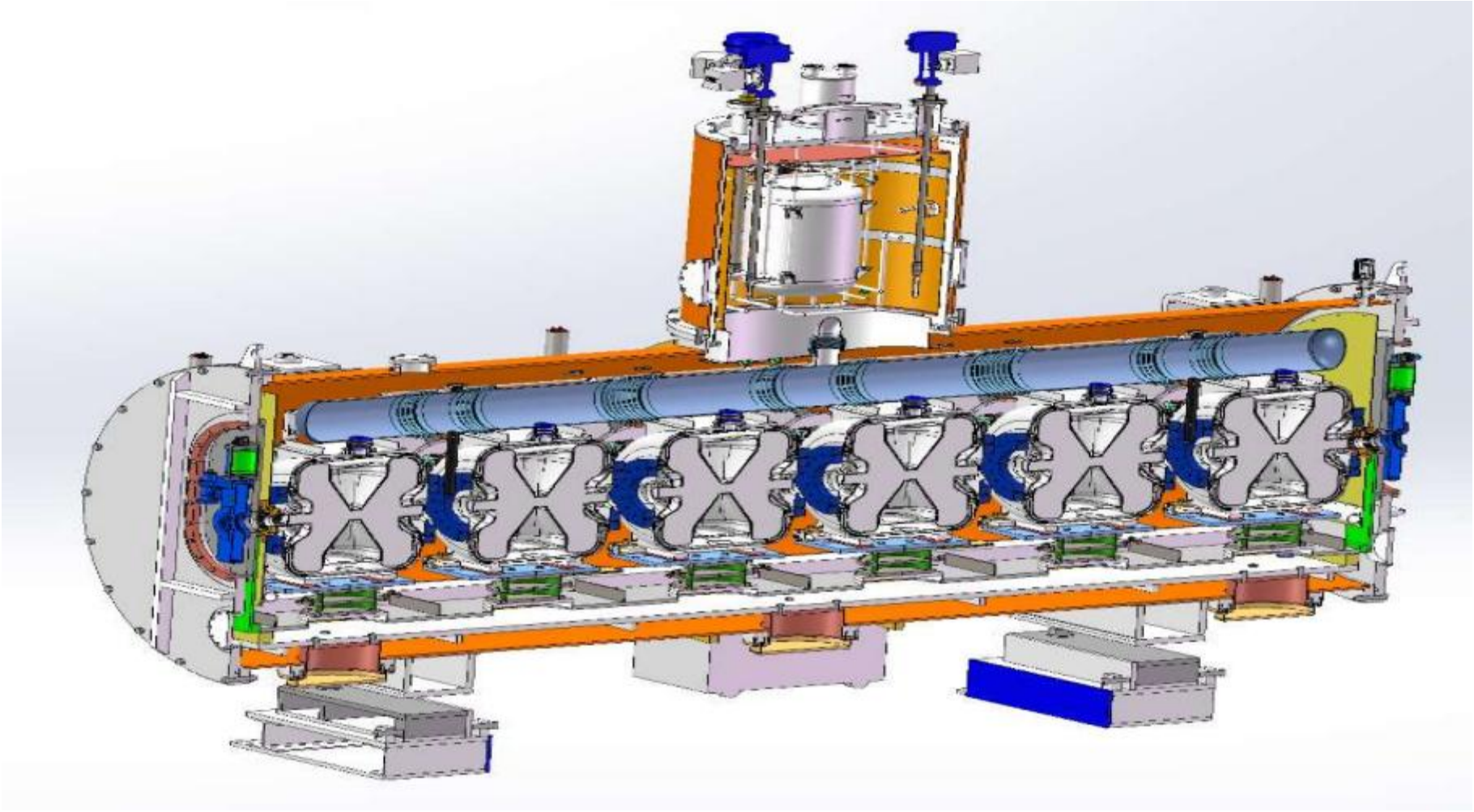
2020

2021

2022-2023

高能锐新 HE-RACING TECHNOLOGY

4.4 SSR2 Spoke 325MHz Cavity cryomodule-3D model



4.4 SSR2 Spoke 325MHz Cavity cryomodule-Assembly at RISP



Cavity string alignment



Cryomoduel complete

4.5 Double Spoke 325MHz Cavity cryomodule-Cavities VT

CSNS-II SRF Cavities

	324 MHz Double Spoke Resonator	648 MHz 060 5-cell Elliptical Cavity	Units
Frequency	324	648	MHz
β_g or β_{opt}	0.5 (β_{opt})	0.6 (β_g)	
Beam aperture	50	96/130	mm
E_p/Eacc	3.72	2.76	
B_p/Eacc	7.83	5.14	mT/(MV/m)
R/Q	451	274.8	Ω
E_{acc}(Max.)	9	16	MV/m
V_{acc}(Max.)	6.25	11.152	MV

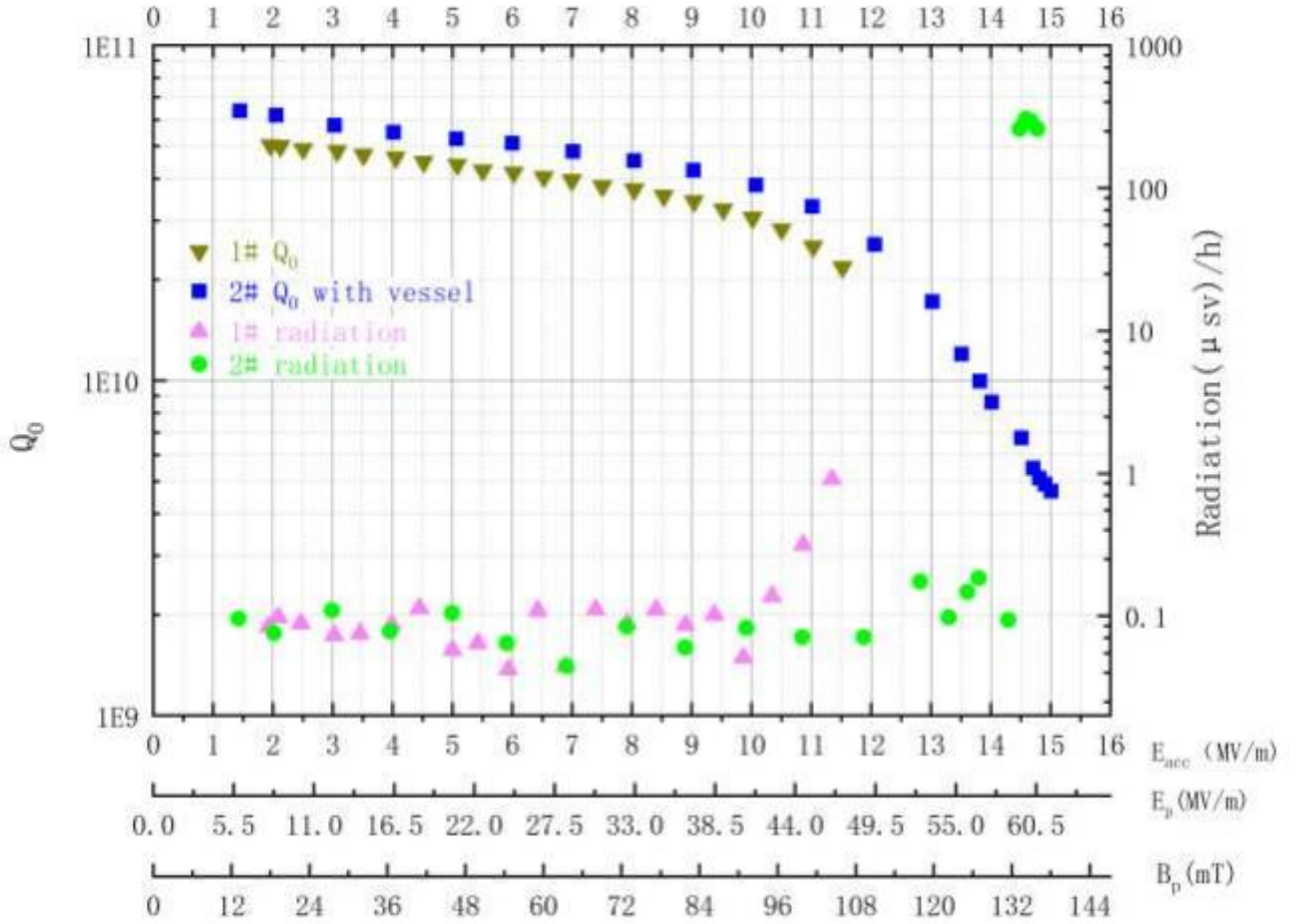


20 Spoke Cavities for CSNS-II

4.5 Double Spoke 325MHz Cavity cryomodule-Cavities VT



Cavity HPR



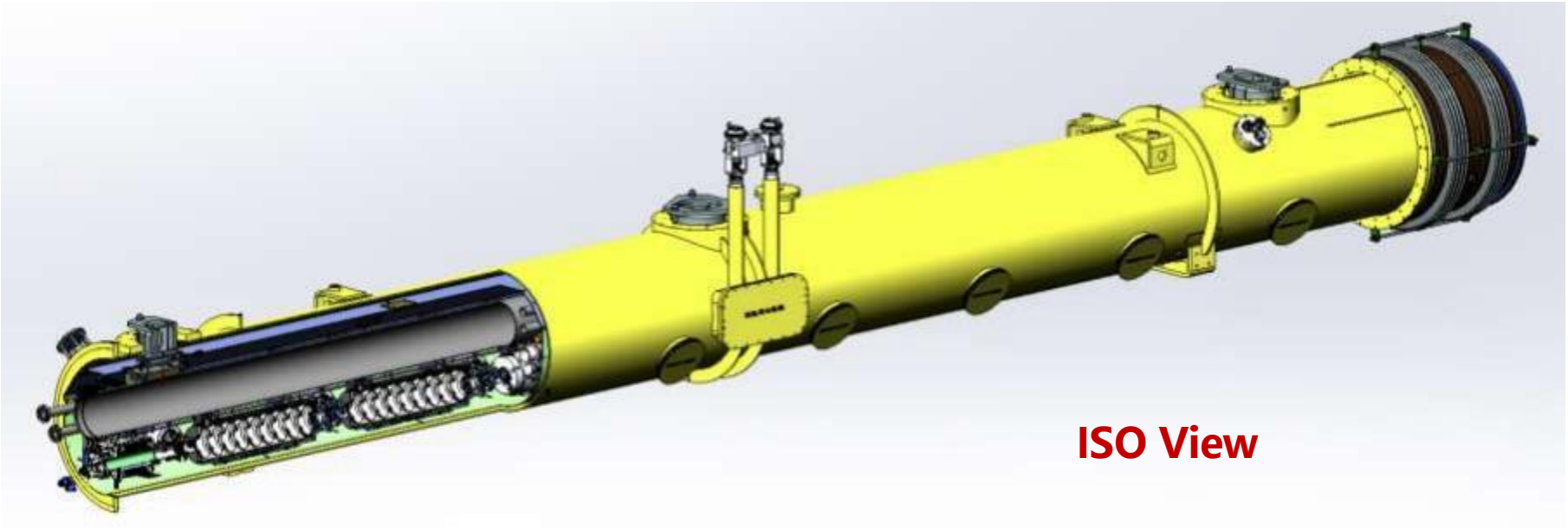
VT Results

4.5 Double Spoke 325MHz Cavity cryomodule- Cryomodule

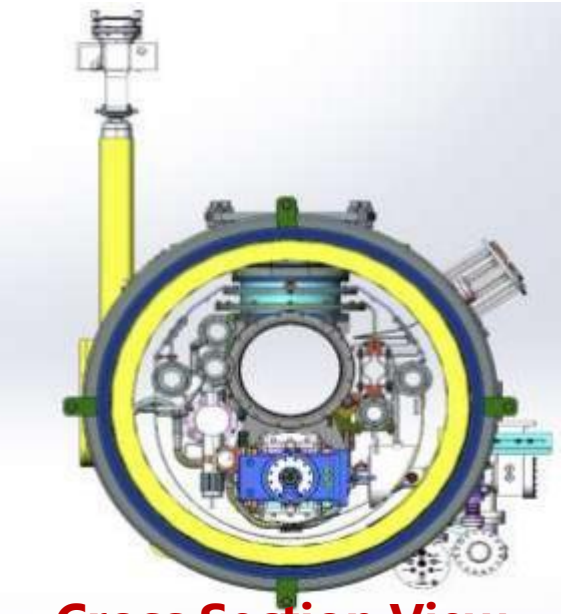


General Assembly

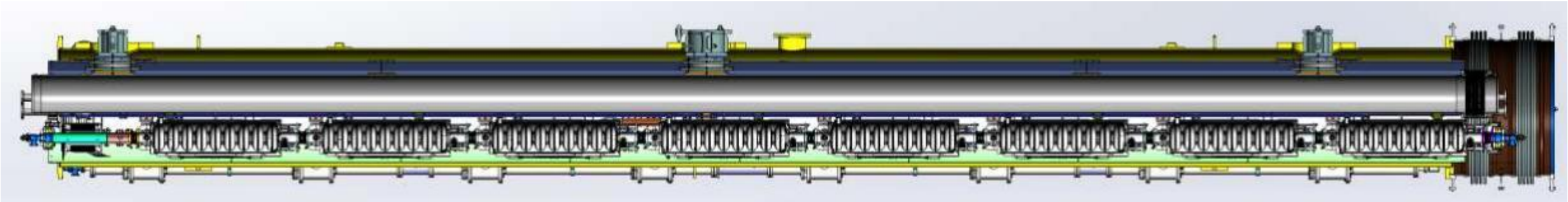
4.6 1.3GHz cryomodule-3D model



ISO View



Cross Section View



LongitudinalSection View

高能锐新 HE-RACING TECHNOLOGY

4.6 1.3GHz cryomodule-General assembly



Cryomodule assembly and HT test was finished.

Q0 3.8E10@16MV/m; 3.6E10@21MV/m;
Average Max. Eacc 23.1MV/m

Key process:

(1) HPR cavity before assembly;

(2) Do RT coupler conditioning before cooling down;

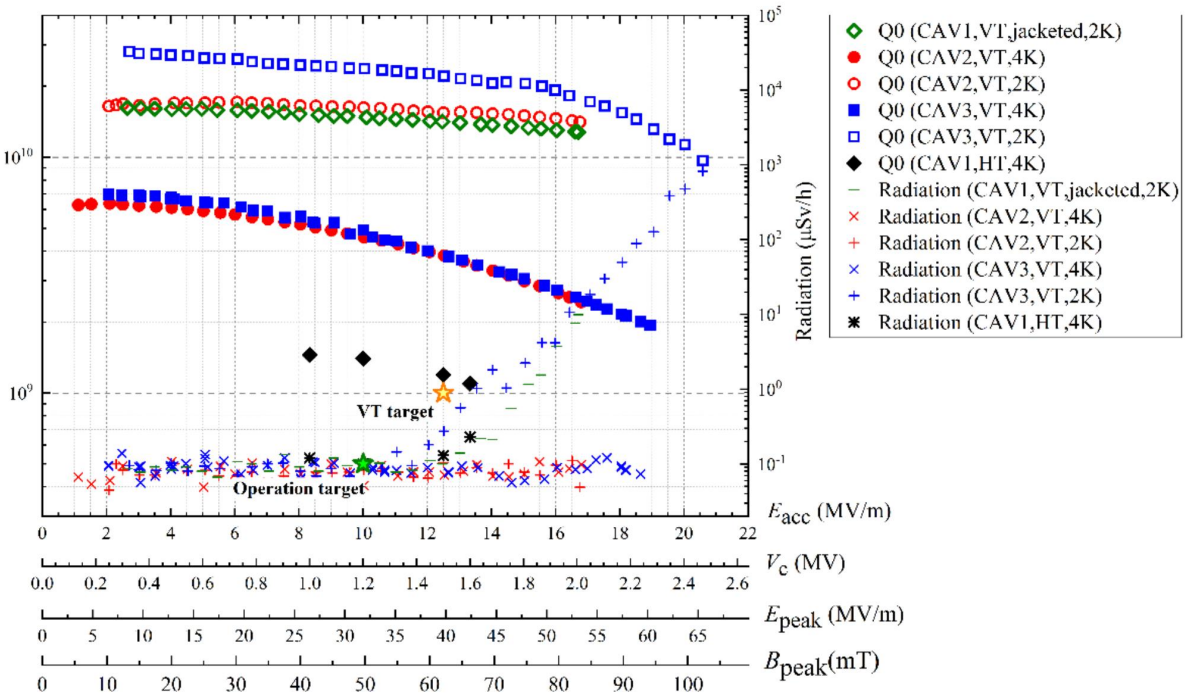
(3) Optimize anchor connection;

4. SRF Cavities Couplers and Cryomodules

4.7 166MHz cryomodule (HEPS)

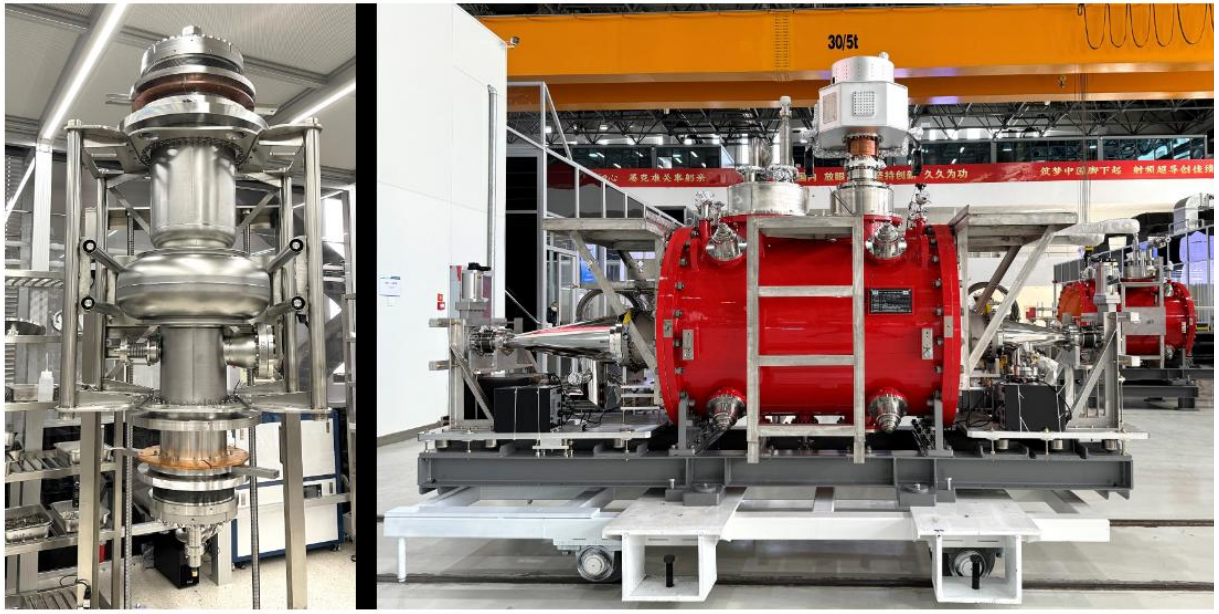


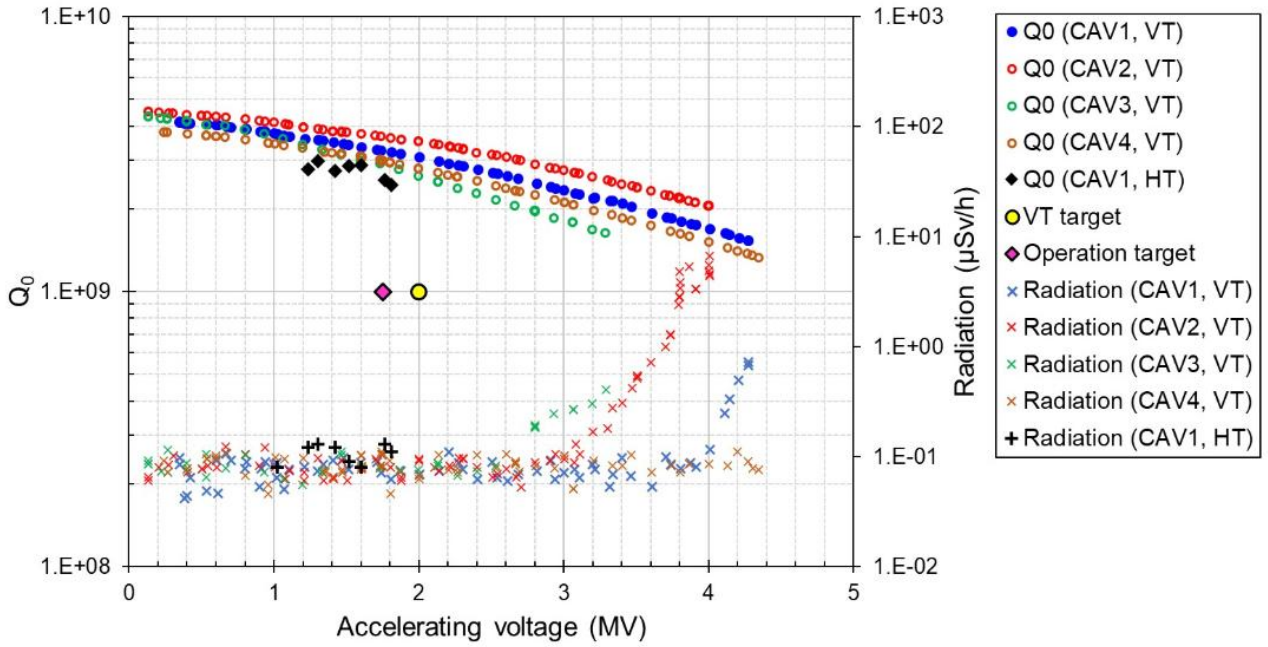




4. SRF Cavities Couplers and Cryomodules

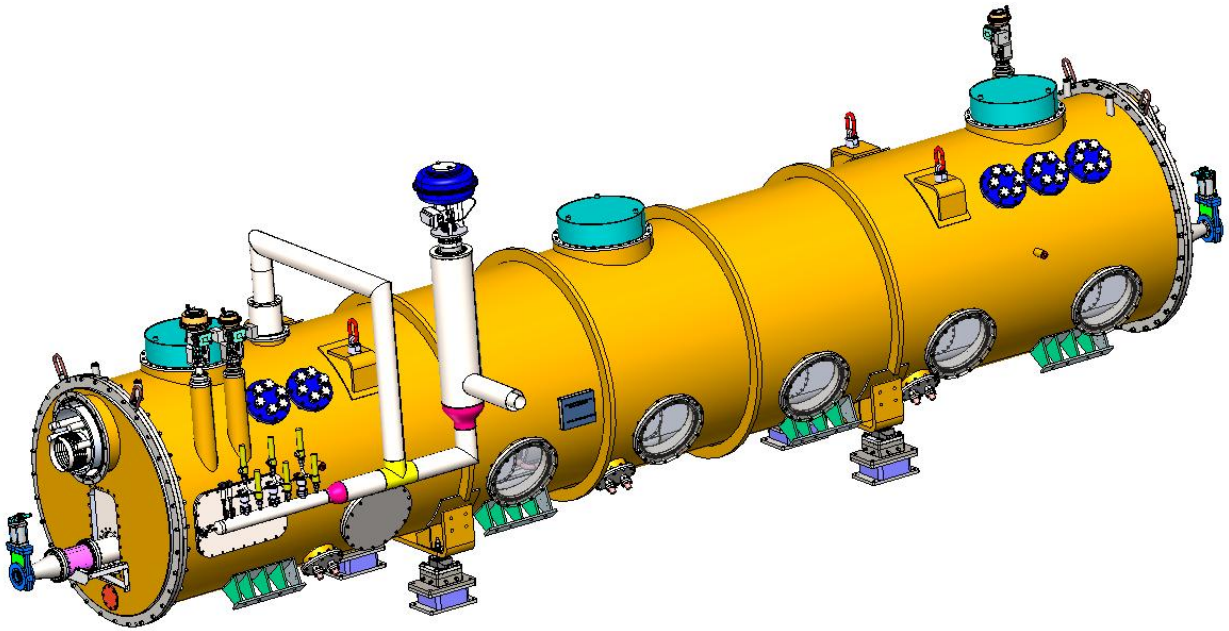
4.8 500MHz cryomodule (HEPS)

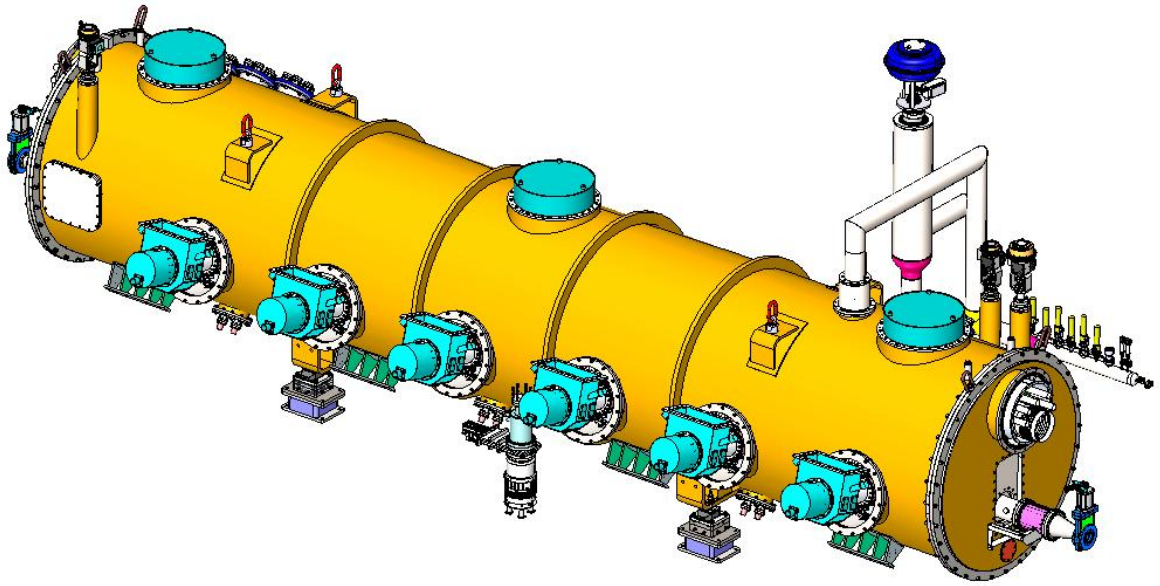




4. SRF Cavities Couplers and Cryomodules

4.9 650MHz cryomodule (CEPC)





4. SRF Cavities Couplers and Cryomodules

4.9 650MHz cryomodule (CEPC)





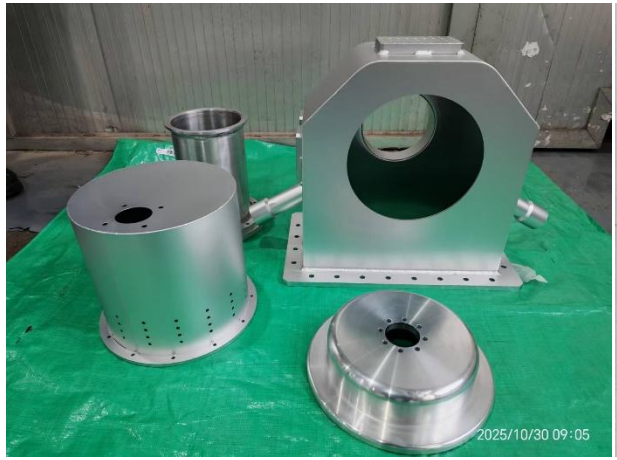




Cavity











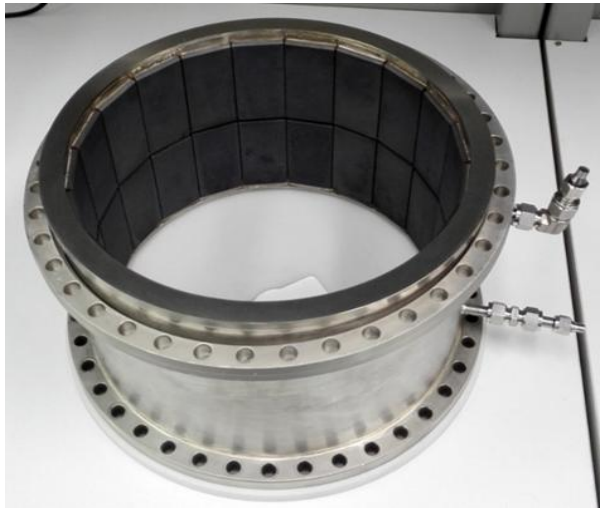
Coupler

4. SRF Cavities Couplers and Cryomodules

4.9 650MHz cryomodule (CEPC)

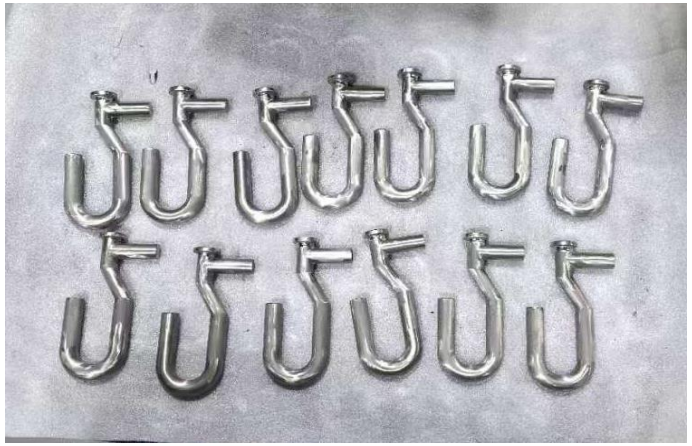


HOM Coupler(Cu)



Absorber





HOM Coupler(Nb)

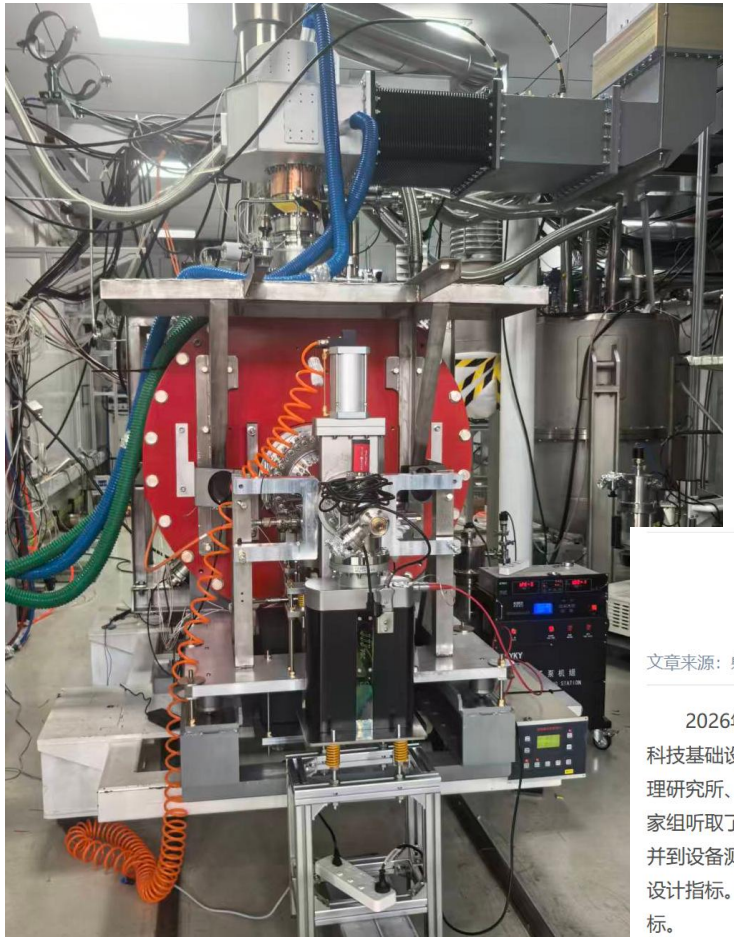
73

4. SRF Cavities Couplers and Cryomodules

高能锐新 HE-RACING TECHNOLOGY

■ 4.10 500MHz cryomodule (HALF)





Content	Specificaton
Frequency	499.8±2MHz
Length	≤3800 mm
Vc	≥2.6MV
Q0	≥5E8
Operation Temp.	4.5K
Static Heat Load	≤30W

HALF 500 MHz超导高频模组研制成功

文章来源：射频超导与低温研究中心、加速器中心、高能锐新（济南）科技有限公司 2026-10-10 【大】【中】【小】

2026年09月29日，在北京怀柔先进光源技术研发与测试平台（PAPS）召开了合肥先进光源（HALF）国家重大科技基础设施项目的“500 MHz超导高频模组及配套设备”出厂测试会。专家组由上海科技大学、中国科学院高能物理研究所、中国科学院上海高等研究院、清华大学、中国原子能科学院研究院、中国科学技术大学的8位专家组成。专家组听取了“HALF 500 MHz超导高频模组及配套设备研制及测试报告”，检查了自测结果，经过认真质询和讨论，并到设备测试现场对关键技术参数进行了抽测。测试结果表明500 MHz超导高频模组及配套设备主要及关键参数超过设计指标。例如：超导腔压达到2.1 MV，品质因数达到2.2 E+9,超导腔静态漏热低于23.5 W。各项结果均好于合同指标。

5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- CSNSII (Dongguan, Guangdong province)-Cavities and Couplers



5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- HEPS (Beijing)-Cavities and Couplers



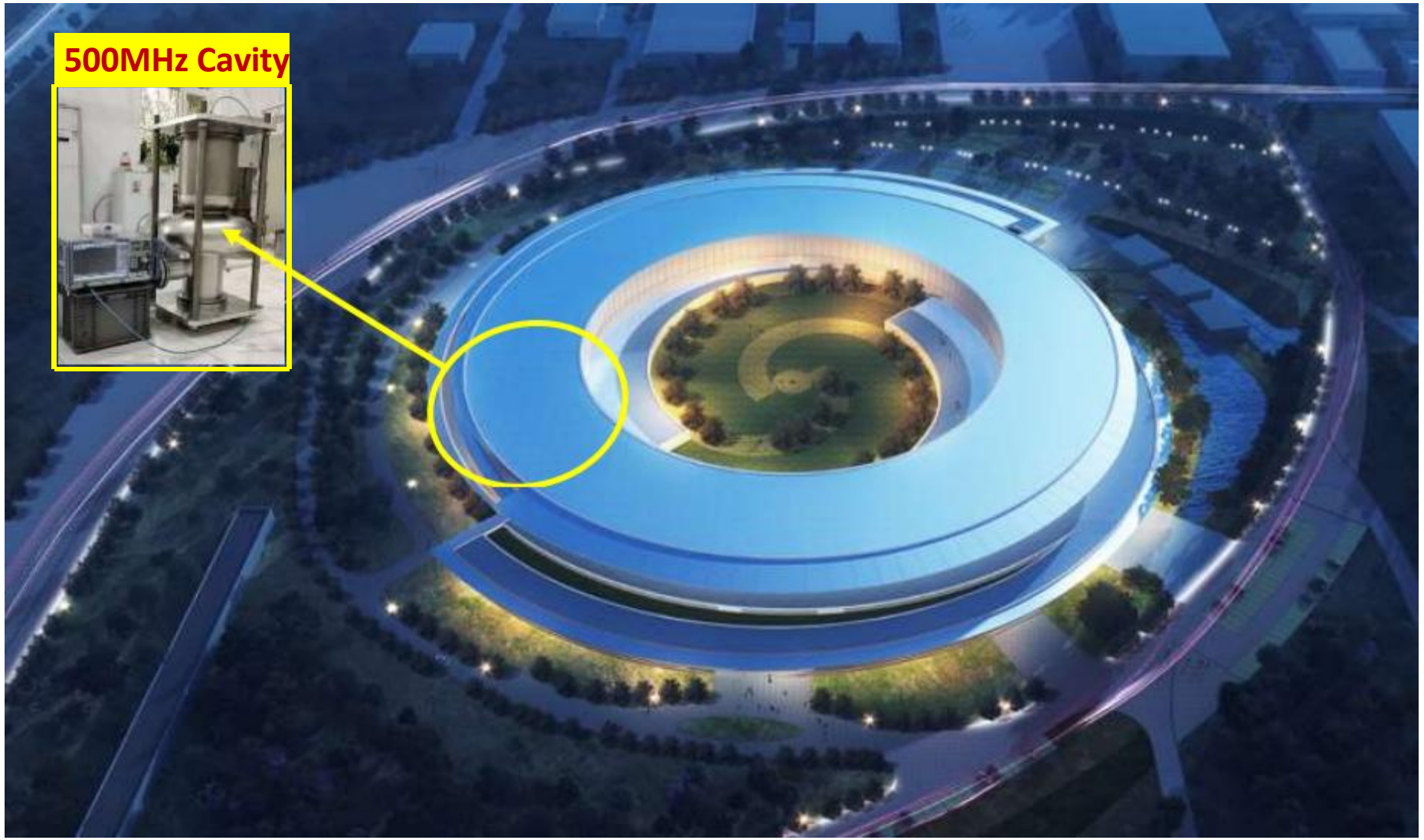
166MHz QWR cryomodule

500MHz single cell cryomodule

5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- HALF (Hefei, Anhui province)-Magnets and Cavities



5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- SHINE (Shanghai)-Cavities and Couplers







5. Facilities Serviced by HERT

- S3FEL (Shenzhen,Guangdong province)-Cryomodules

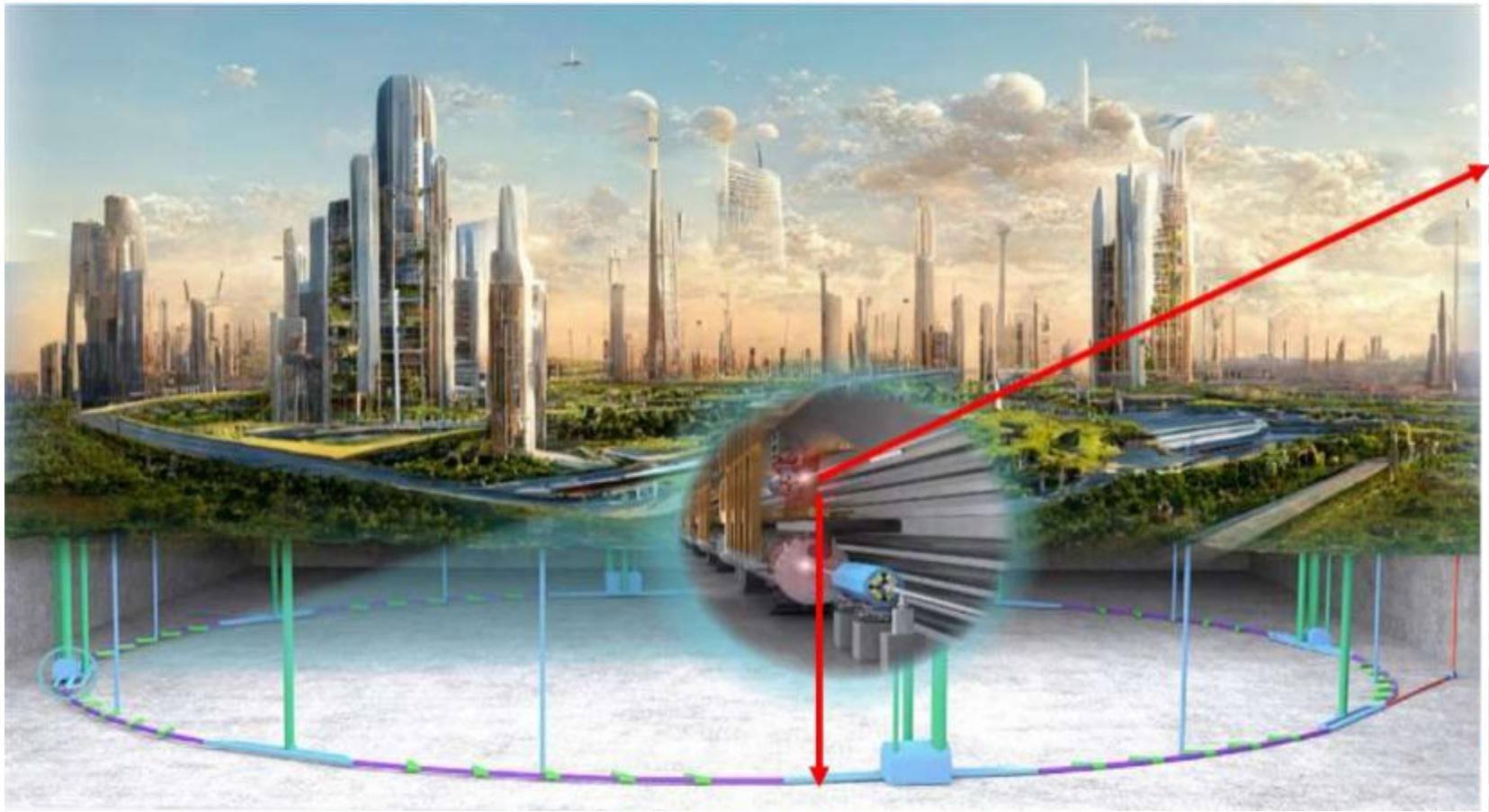




5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- CEPC research –Cavities and Couplers









5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- **PAPS operation (20 staff of HERT)**





5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- **PAPS operation (20 staff of HERT)**








5. Facilities Serviced by HERT

高能锐新 HE-RACING TECHNOLOGY

- **PAPS operation (20 staff of HERT)**





6. Summary

- HERT拥有加速器关键部件完整的研发制造经验；
- 我们为国内第四代光源HEPS以及正在建设的合肥先进光源HALF，提供了磁铁、插入件、低温模组等关键设备，同时面向其他国内外大科学装置开展装备研制与相关预研，比如CEPC 超长高精密二六极组合磁铁以及650MHz高性能模组研发与制造；
- HERT已经从科研配套加工单位，成长为全品类加速器核心装备供应商。随着济南总部落地，我们的产能和工程化能力得到进一步提升；
- 我们一直积极寻求与国内各研究所、高校、实验室的合作，希望能够承接相关部件研制任务，持续服务国内外大科学装置。

6. Summary

高能锐新 HE-RACING TECHNOLOGY

PAL 포항가속기연구소 Pohang Accelerator Laboratory

ibs Institute for Basic Science

KAERI

SLAC

FERMI @elettra

Cornell University Laboratory for Elementary-Particle Physics

SEOUL NATIONAL UNIVERSITY

KEK

Kawasaki

CERN

DESY

INFN Istituto Nazionale di Fisica Nucleare

LSU

Canadian Light Source

BERKELEY LAB LAWRENCE BERKELEY NATIONAL LABORATORY

BROOKHAVEN NATIONAL LABORATORY

Argonne NATIONAL LABORATORY

PAUL SCHERRER INSTITUT PSI

中国科学院高能物理研究所 Institute of High Energy Physics, Chinese Academy of Sciences

IMP 中国科学院近代物理研究所 Institute of Modern Physics, Chinese Academy of Sciences

SINAP 中国科学院上海应用物理研究所 Shanghai Institute of Applied Physics, Chinese Academy of Sciences

中国科学院大连化学物理研究所 DALIAN INSTITUTE OF CHEMICAL PHYSICS, CHINESE ACADEMY OF SCIENCES

中国原子能科学研究院 中核集团 CHINA INSTITUTE OF ATOMIC ENERGY

CAEP 中国工程物理研究院 CHINA ACADEMY OF ENGINEERING PHYSICS

中国科学院上海高等研究院 SHANGHAI ADVANCED RESEARCH INSTITUTE, CHINESE ACADEMY OF SCIENCES

IASF 深圳综合粒子设施研究院 Institute of Advanced Science Facilities, Shenzhen

清華大學

北京大學 PEKING UNIVERSITY

NSRL 中国科学技术大学 国家同步辐射实验室 NATIONAL SYNCHROTRON RADIATION LABORATORY

上海科技大学 ShanghaiTech University

哈爾濱工業大學 HARBIN INSTITUTE OF TECHNOLOGY

上海交通大學 SHANGHAI JIAO TONG UNIVERSITY

武漢大學 WUHAN UNIVERSITY 先进光源研究中心 Advanced Light Source Research Center

重庆大学 CHONGQING UNIVERSITY 超瞬态装置实验室 LABORATORY FOR ULTRAFAST TRANSIENT FACILITY (LUTF)

张江实验室 ZHANGJIANG LABORATORY



Thanks for your attention!

中国科学院高能物理研究所
Institute of High Energy Physics
Chinese Academy of Sciences

高能锐新（济南）科技有限公司
HE-Racing (Jinan) Technology Co.,Ltd.