



Development of Equipment for Accelerator at HE Racing

Zhang Zhanjun

Institute of High Energy Physics, CAS, Beijing HE-Racing Technology Co., Ltd.

OCT. 24, CEPC-CIPC 2022



Outline



Brief Introduction



SRF Cavities



Couplers



Cavities & Cryomodules



Magnets



Summary



1. Brief Introduction

■ Main Products:

- ◆ Magnets and Insertion Devices
- ◆ Accelerating structures, SLEDs
- ◆ Microwave devices
- ◆ RFQ and DTL
- ◆ Super-conducting Cavities
- ◆ Couplers
- ◆ Cryomodules, etc.



1. Brief Introduction

■ 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 ...



2. SRF Cavities

2.1 Cavity R&D

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

SHINE
9Cell 高Q椭球腔
(1300MHz)



2022

HALF
单Cell 椭球腔
(500MHz)



HEPS
QWR腔
(166.7MHz)

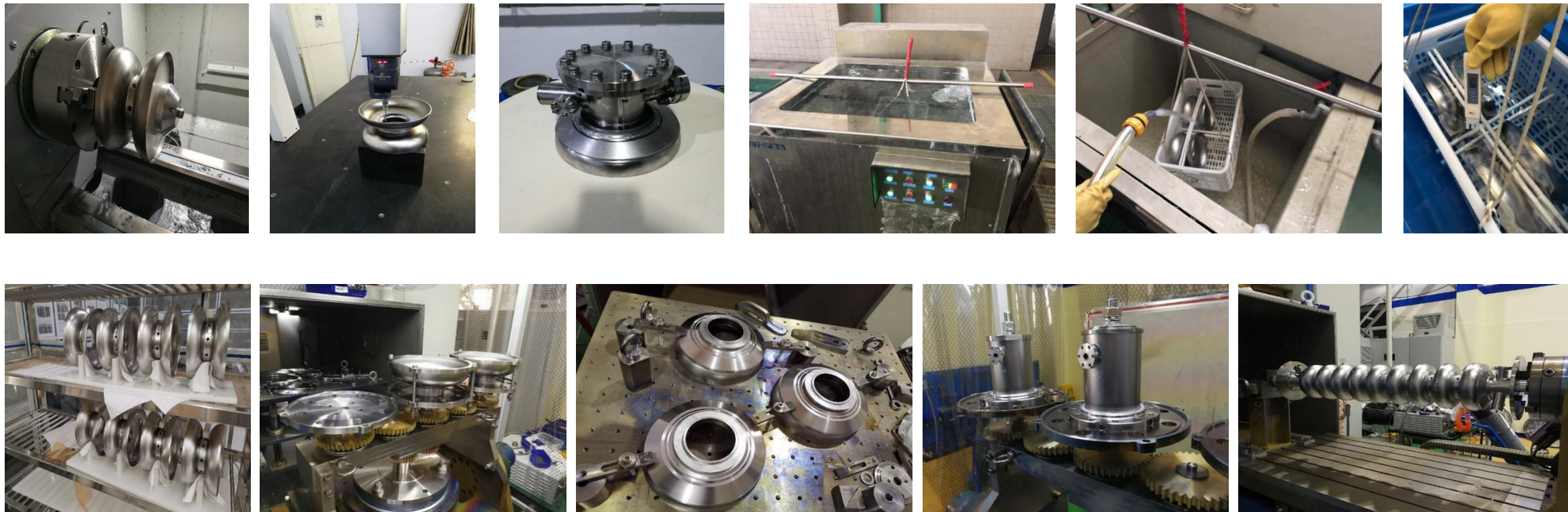




2. SRF Cavities

2.2 1.3GHz 9 Cell mass production

◆ Parts fabrication



20 cavities have been manufactured for High Gradient and High Q.



2. SRF Cavities

2.2 1.3GHz 9 Cell mass production

◆ Facility



Machining Area



Cold Trap and Fast Cooling System for EBW Machine

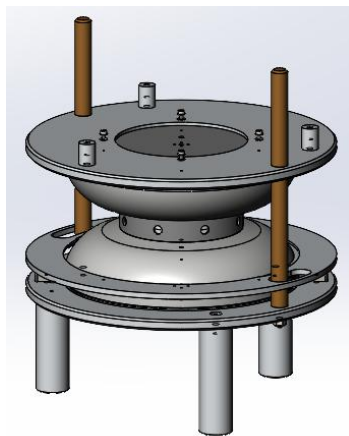




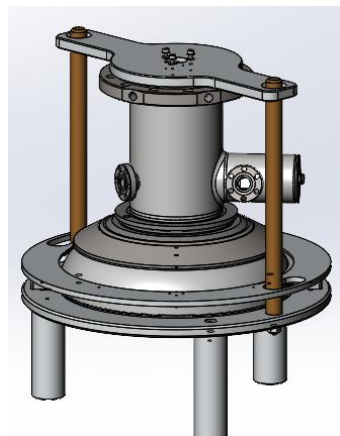
2. SRF Cavities

2.2 1.3GHz 9 Cell mass production

◆ Facility



RF measuring (manual)



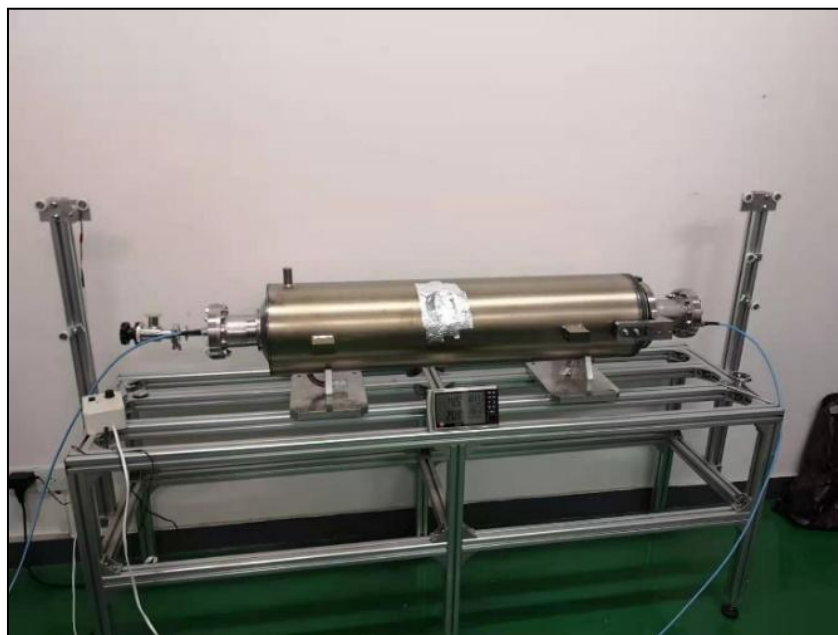
RF measuring (automatic)



2. SRF Cavities

2.2 1.3GHz 9 Cell mass production

◆ Facility



RF field measurement (in cleanroom)



2. SRF Cavities

2.2 1.3GHz 9 Cell mass production

◆ Facility



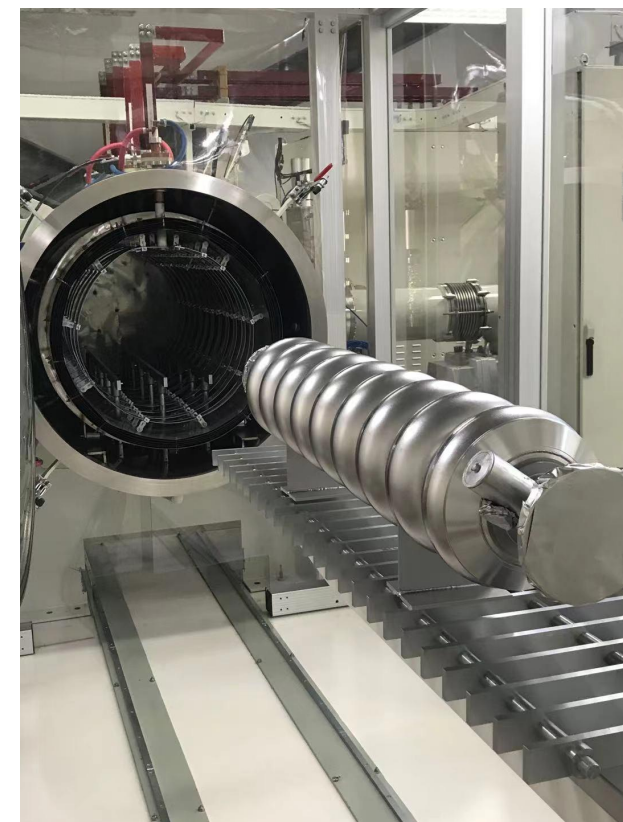
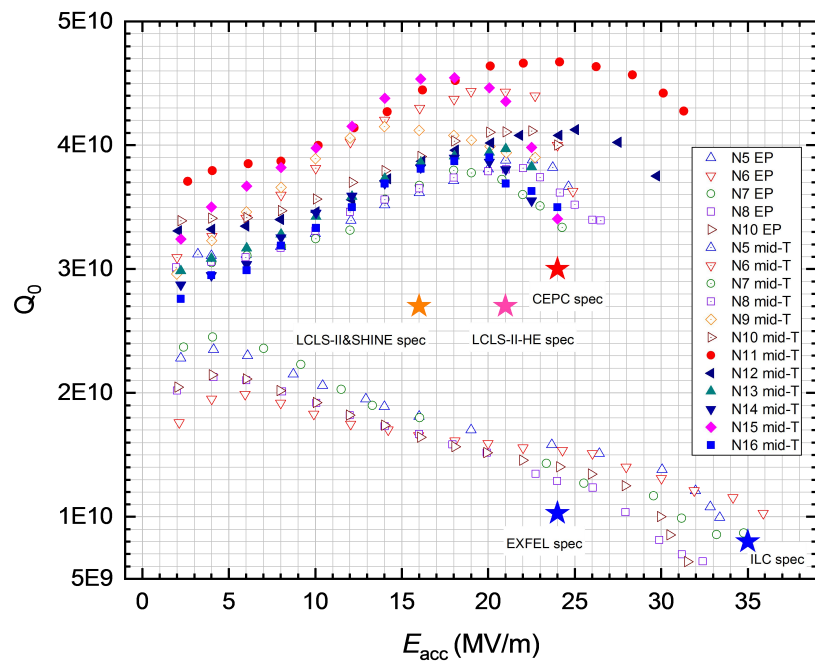
Vertical Test Facility (PAPS)



2. SRF Cavities

2.2 1.3GHz 9 Cell mass production

- All the cavities were dealt with EP & mid-T.
- The average E_{acc} of 6 cavities are about 27.7MV/m.
- The best cavity is No.11 with [4.7E10@24MV/m](#) and [4.3E10@31MV/m](#).
- All the cavities meet the requirements of SHINE, LCLS-II, and CEPC.





2. SRF Cavities

2.2 1.3GHz 9 Cell mass production



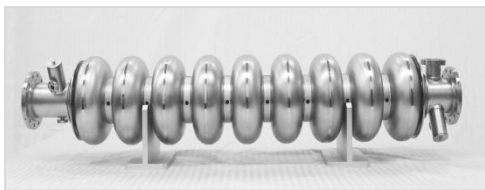


2. SRF Cavities

2.3 Cavity R&D since 2014



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

Spoke 012
ADS 注入器超导腔
小批量生产



2015

Spoke 021
ADS 主加速器超导腔
小批量生产



2016

HEPS-TF超导腔
第一支QWR超导腔
(166.7MHz)



2017

2018



2019

高Q值1.3GHz 9 Cell
高Q值1.3GHz 单 Cell



2020



2021

Cavity
HLS 超导腔
(500MHz)





2. SRF Cavities

2.3 Cavity R&D since 2014 (80 in total)

序号	科学装置	腔类型	频率 (MHz)	数量 (支)	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	3	19	垂测
3	C-ADS	Spoke, $\beta=0.12$	325	4	11.5	带束运行
4	C-ADS	Spoke, $\beta=0.21$	325	5	12	带束运行
5	C-ADS	Spoke, $\beta=0.24$	325	1	11.2	垂测
6	C-ADS	双Spoke, $\beta=0.51$	325	1	16	垂测
7	CSNSII	双Spoke, $\beta=0.51$	325	1	11	垂测
8	RISP	Spoke, $\beta=0.51$	325	7	11	垂测
9	HALS	单cell 椭球腔	500	1	16	垂测 (4K)
10	HEPS	单cell 椭球腔	500	1	16	垂测 (4K)
11	CEPC	2 cell 椭球腔	650	1	24	垂测
12	CEPC	5 cell 椭球腔	650	1	12	垂测 (4K)
13	PAPS	2 Cell 椭球腔	650	3	36	垂测
14	PAPS&SHINE	单cell 椭球腔	1300	28	43	垂测
15	ILC R&D	9 cell 椭球腔	1300	1	24	垂测
16	PAPS	9 cell 椭球腔	1300	2	25	垂测
17	SHINE	9 cell 椭球腔	1300	8	25	水平
18	DALS	9 cell 椭球腔	1300	8	27	垂测



3. Couplers

3.1 Coupler R&D since 2012



325MHz-ADS

2012



324MHz-CSNS

2013



162.5MHz-CADS

2014



325MHz-ADS

2015



500MHz-BEPC II

2016

Couplers



3. Couplers

3.1 Coupler R&D since 2012



1. 3GHz-自然基金



352MHz-BNCT



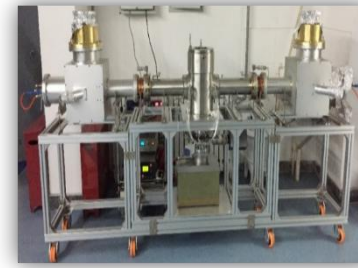
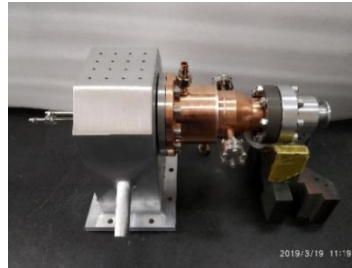
650MHz/1. 3GHz-CEPC



1. 3GHz-SHINE



166MHz-HEPS TF



2017

2018

2019

Couplers



3. Couplers

3.1 Coupler R&D since 2012



325MHz-RISP



500MHz-南方光源



324MHz-南方光源



166MHz-HEPS

2020

2022

Couplers



3. Couplers

3.1 Coupler R&D since 2012 (76 in total)

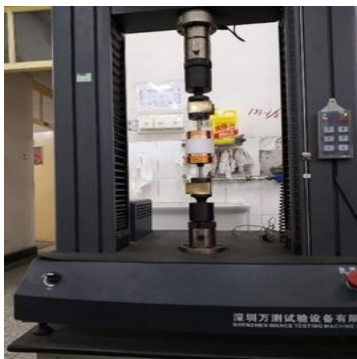
序号	科学装置	腔类型	频率 (MHz)	耦合器类型	数量	工作状态
1	HALF	DTL (NC)	80	同轴单窗	2	运行
2	IBS	HWR (SCC)	162.5	同轴单窗	2	测试
3	C-ADS	HWR (SCC)	162.5	同轴单窗	2	运行
4	HEPS-TF	QWR (SCC)	166.7	同轴单窗	2	测试
5	HEPS	QWR (SCC)	166.7	同轴单窗	10	测试
6	CSNS	Spoke (SCC)	324	同轴单窗	2	测试
7	C-ADS	RFQ (NC)	325	同轴单窗	8	运行
8	C-ADS	Spoke (SCC)	325	同轴单窗	7	运行
9	C-ADS	Buncher (NC)	325	同轴单窗	3	运行
10	CSNS	RFQ (NC)	325	同轴单窗	5	运行
11	BNCT	RFQ (NC)	325	同轴单窗	5	运行
12	BEPCII	1 cell (SCC)	500	同轴单窗	4	运行
13	HEPS	5Cell (NC)	500	同轴单窗	2	测试
14	PAPS	20cell (SCC)	650	可调单窗	2	研制
15	ILC R&D	9cell (SCC)	1300	可调双窗	2	测试
16	SHINE	9cell (SCC)	1300	可调双窗	8	测试
17	DALS	9cell (SCC)	1300	可调双窗	8	测试



3. Couplers

3.2 Coupler for 1.3GHz 9 Cell Cavity

◆ Fabrication



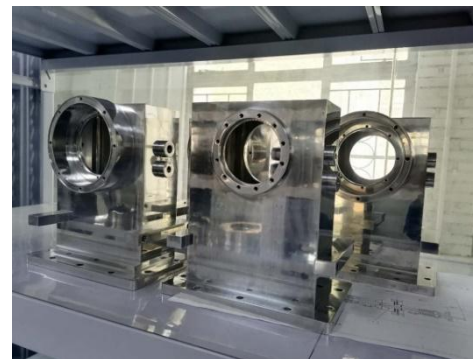
Strength Test (>100 MPa)



Bellow fatigue testing



Adjustment mechanism



waveguide



Copper plated parts



Ceramic Window EBW



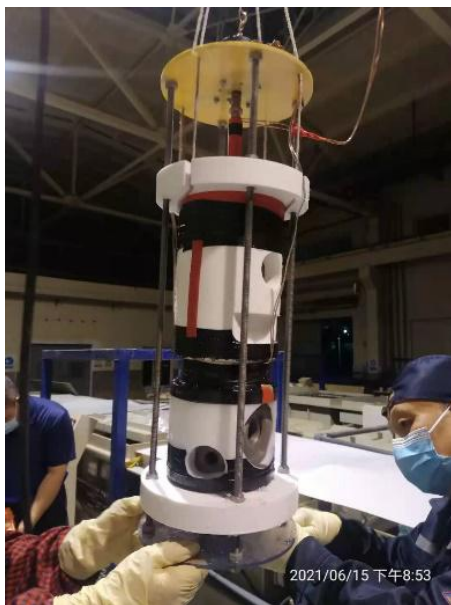
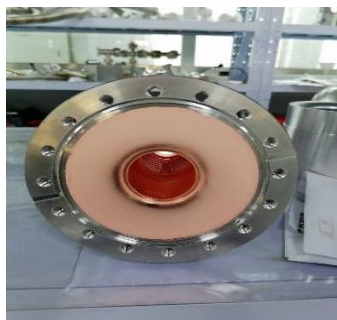
Ceramic



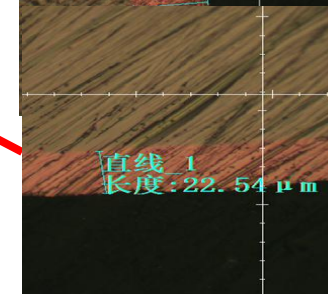
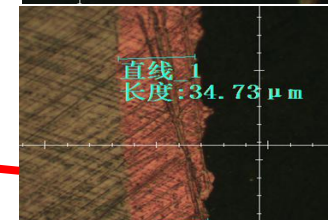
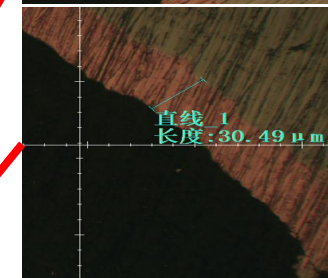
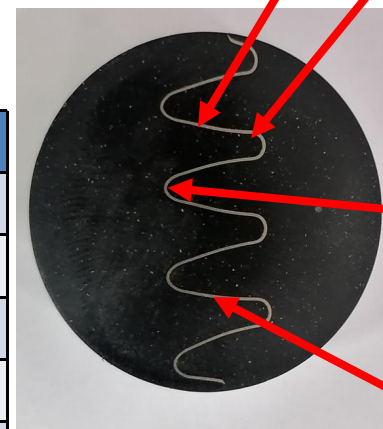
3. Couplers

3.2 Coupler for 1.3GHz 9 Cell Cavity

◆ Copper Plating(Outer conductor)



	Thickness (um)						
peak	26	24	30	19	23	29	33
valley	29	33	29	27	34	35	35
slope	36	37	29	32	28	30	26
	32	28	36	22	28	30	28
pipe	36	35	37	35	35	32	31





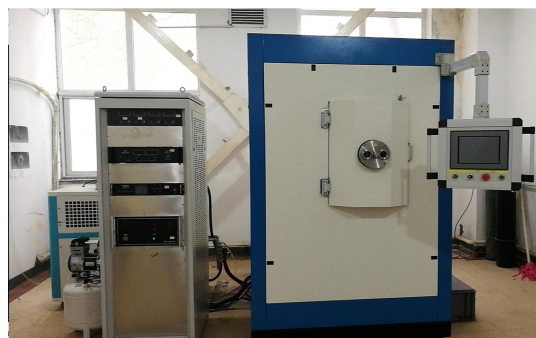
3. Couplers

3.2 Coupler for 1.3GHz 9 Cell Cavity

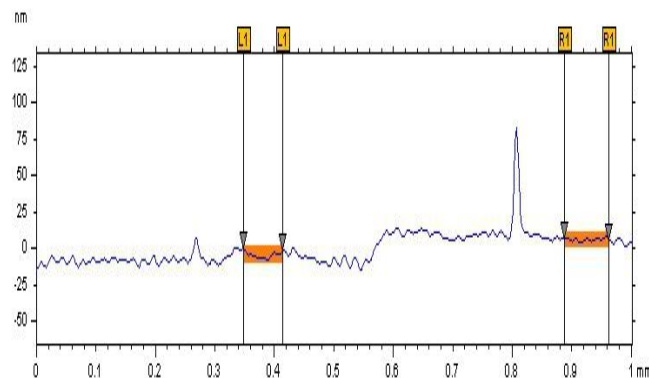
◆ TiN Plating(window)



Sample

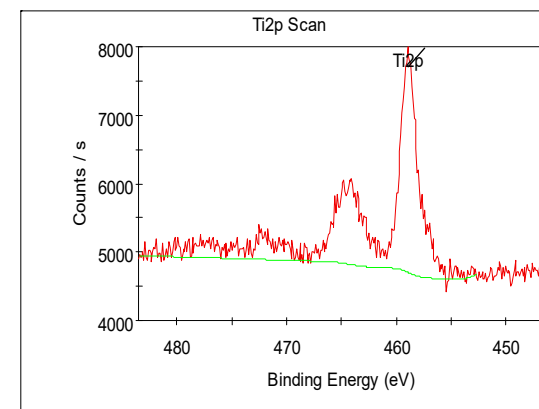


Coating Oven

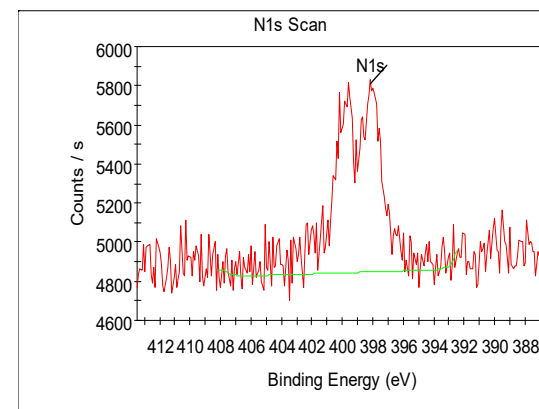


1
StpHt 10.8 nm
TIR 98.6 nm
Avg -1508 nm
Slope 0.000781 °

Thickness (10nm)



Ingredients (Ti)



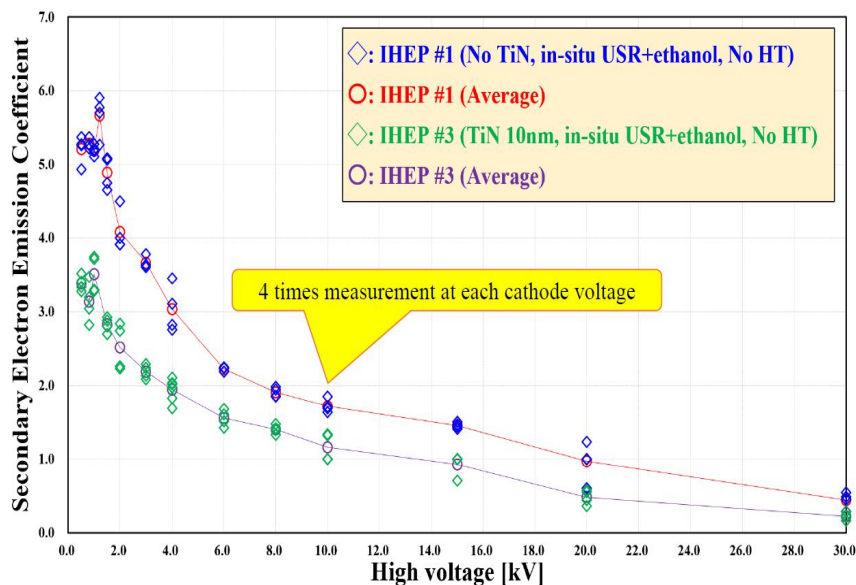
Ingredients (N)



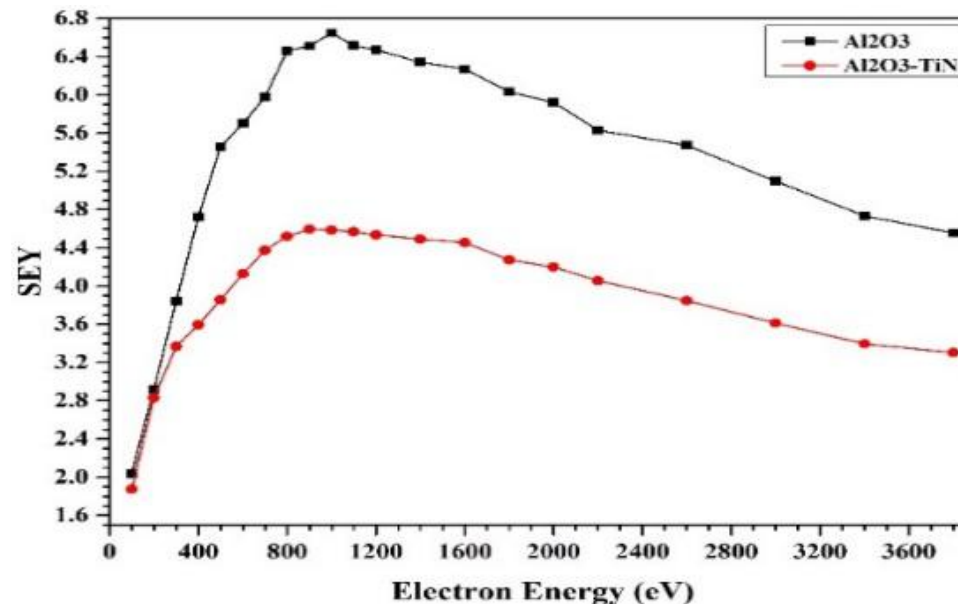
3. Couplers

3.2 Coupler for 1.3GHz 9 Cell Cavity

◆ TiN Plating(window)



Tested by KEK



Test by CAEP



3. Couplers

3.2 Coupler for 1.3GHz 9 Cell Cavity

◆ Assembly and Vacuum Baking



Cleaning

Assembly



Vacuum Pumping



3. Couplers

3.2 Coupler for 1.3GHz 9 Cell Cavity

◆ Hi-power Conditioning



Leak test, baking and conditioning (PAPS)



4. Cavities and Cryomodules

4.1 Develop the cavity post-processing technology.



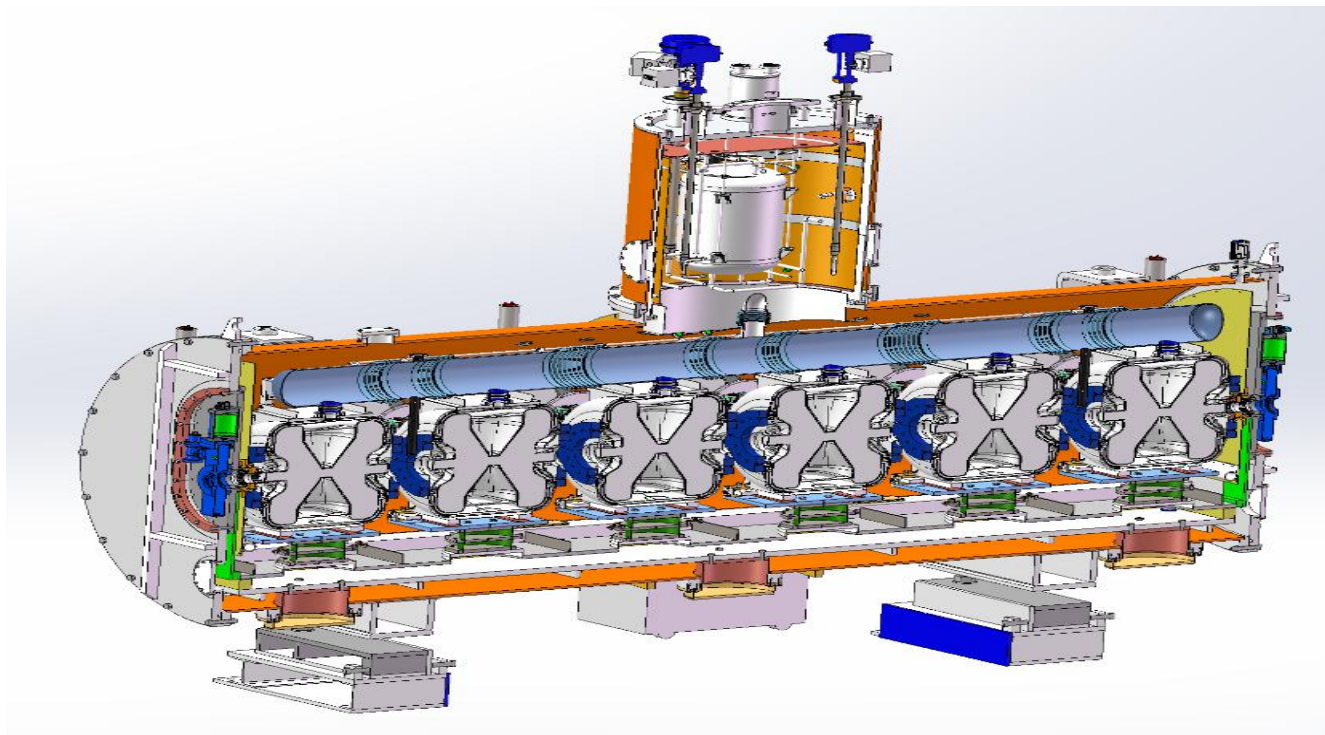
Cavities for SSR2 (RISP project of SSR2)



4. Cavities and Cryomodules

4.2 Develop the cryomodule assembly technology.

◆ Spoke 051 325MHz cavities Cryomodule(for SSR2)



Cryomodule for SSR2
(will be tested by the end of year 2021)



4. Cavities and Cryomodules

4.2 Develop the cryomodule assembly technology.

◆ Spoke 051 325MHz cavities Cryomodule(for SSR2)



Cryomodule for SSR2
(will be tested by the end of year 2022)



4. Cavities and Cryomodules

4.2 Develop the cryomodule assembly technology.

◆ Spoke 051 325MHz cavities Cryomodule(for SSR2)



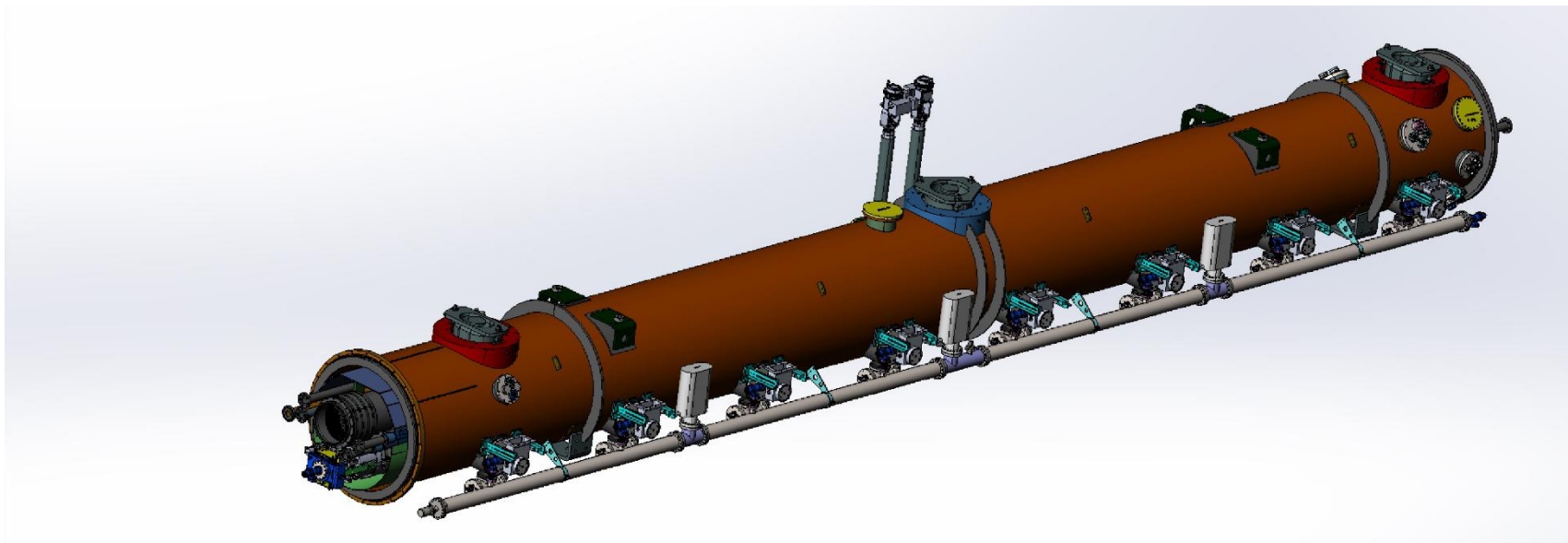
Cryomodule for SSR2
(will be tested by the end of year 2022)



4. Cavities and Cryomodules

4.2 Develop the cryomodule assembly technology.

◆ 1.3GHz 9 Cell cavities Cryomodule (for DALIS)



Cryomodule for DALIS
(will be tested at the beginning of year 2023)



4. Cavities and Cryomodules

4.2 Develop the cryomodule assembly technology.

◆ 1.3GHz 9 Cell cavities Cryomodule (for DALS)



**Cryomodule for DALS
(will be tested at the beginning of year 2023)**



4. Cavities and Cryomodules

4.2 Develop the cryomodule assembly technology.

◆ 1.3GHz 9 Cell cavities Cryomodule (for DALIS)



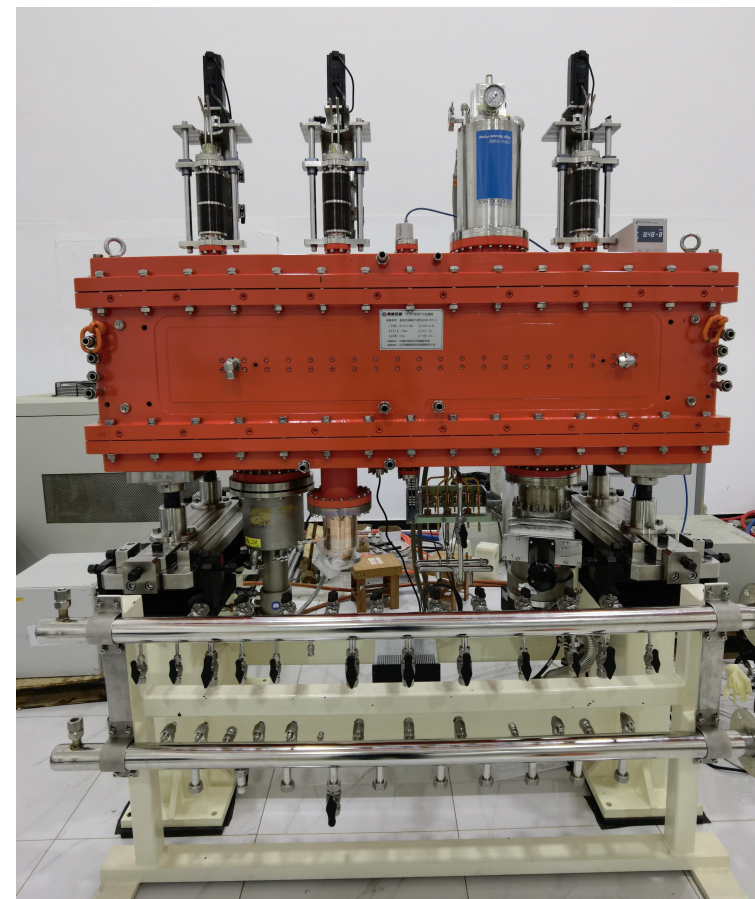
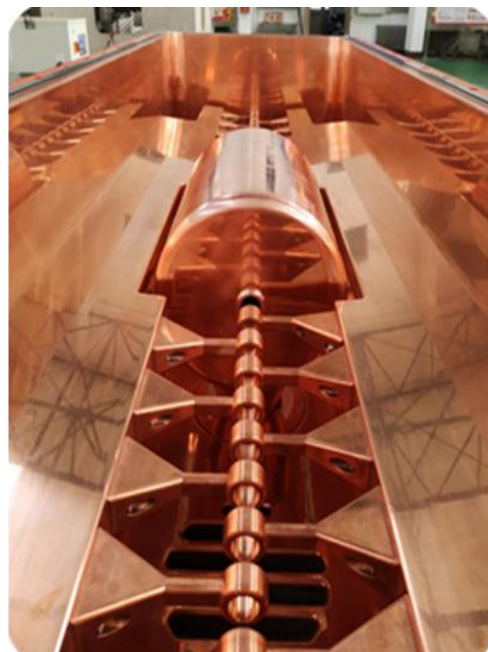
Cryomodule for DALIS
(will be tested at the beginning of year 2023)



4. Cavities and Cryomodules

4.3 Cavities (Room Temperature).

◆ DTL

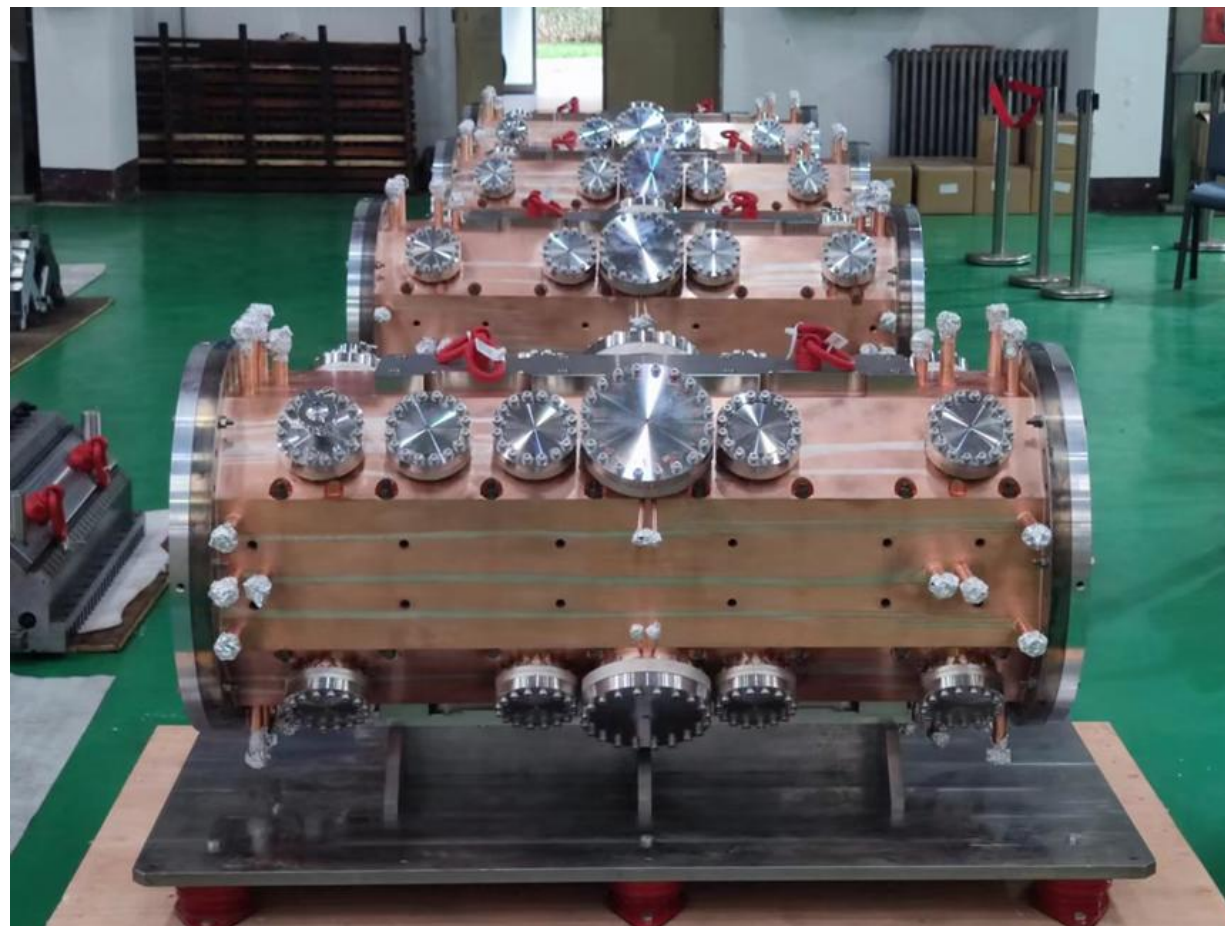




4. Cavities and Cryomodules

4.3 Cavities (Room Temperature).

◆ RFQ for BNCT





5. Magnets

5.1 CEPC full size booster Dipole

★The longest dipole used for accelerator in domestic.





5. Magnets

5.2 Magnets for HEPS

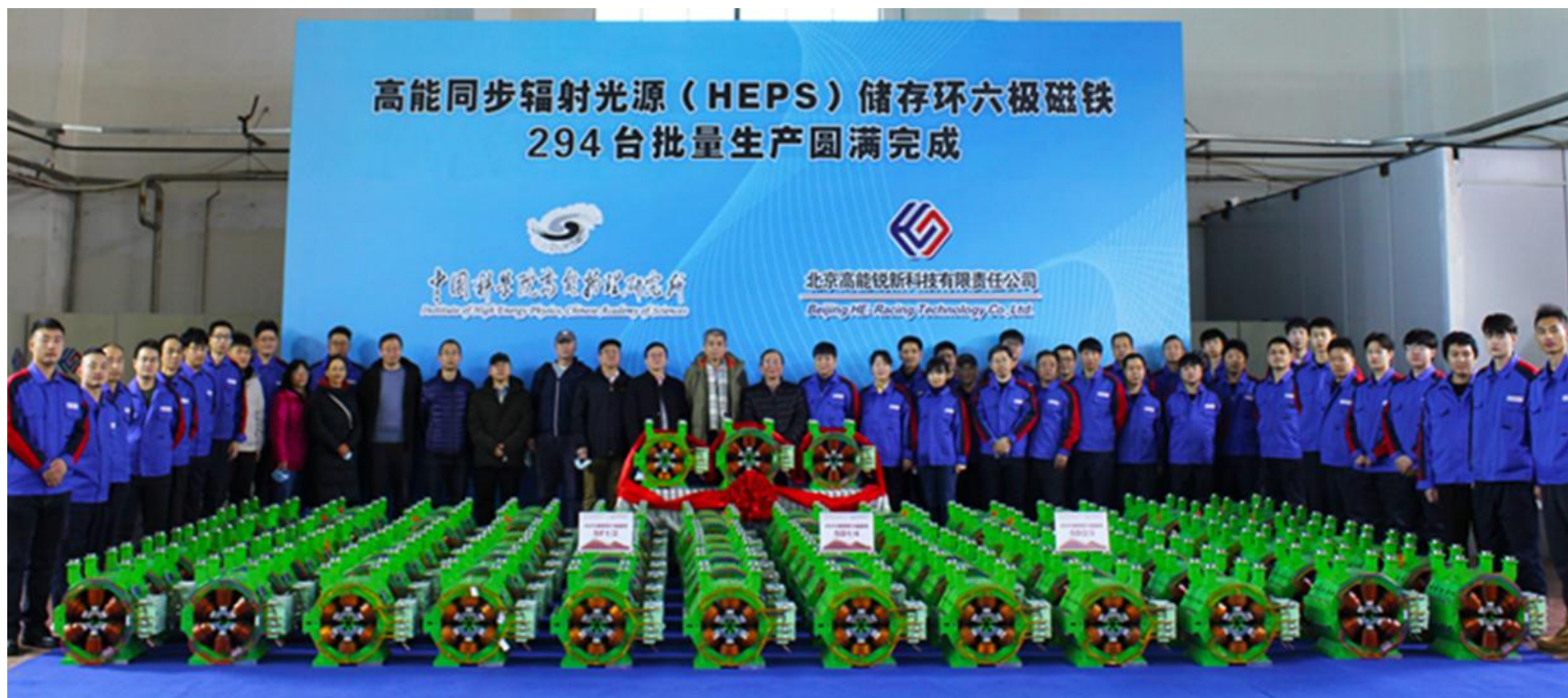


Dipoles and Sextupoles for Booster



5. Magnets

5.2 Magnets for HEPS



Sextupoles



5. Magnets

5.2 Magnets for HEPS



Quadupoles



6. Summary

- HERT full with the experience for accelerator key technology and components R&D and manufacture.
- HERT has Successfully developed the several prototype for SRF cavities and Couplers.
- HERT is willing to undertake more R@D work for CEPC Accelerator key technologies with domestic and international companies and institutes



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



北京高能锐新科技有限责任公司
Beijing HE-Racing Technology Co., Ltd.