Chinese Industry for CEPC

Jinlin Gao

CEPC Industrial promotion Consortium （CIPC）

2024.7.9 Tokyo

Contents

Background And Target

- **Significance of CEPC large-scale Scientific Engineering**
- **The CEPC is an important part of the world plan** for high-energy physics research. It will support a comprehensive research program by scientists from throughout the world.
- **The CEPC is a giant leap for China from the BEPC-II**, the presently operating *e+e* collider at IHEP in Beijing. It will **bring China to the forefront of world high-energy physics**, and **push a wide range of advanced technologies to an extent** never imagined before.

Background And Target

- **Who is the CIPC?**
- That is CEPC Industry Promotion Consortium (CIPC).
- Many Relevant Enterprises that participating in the research and industrialization of key technologies related to the CEPC .
- **What does the CIPC to do?**
- To support and organize relevant enterprises participating in the industrialization CEPC.
- Enhance the technology level of our own enterprises, expand business channels and obtain achievements transfer to enterprises.
- Supporting the Strategic Landing of Made in China 2025 and Promoting the Leap Development of China's Industry.

CEPC Industrial Promotion Consortium (CIPC)

As the world's most advanced accelerator,CEPC put forward the following directions:

Established in Nov. 7 , 2017

1) Superconduting materials (for cavity and for magnets)
2) Superconductiong cavities
3) Cryomodules
4) Cryogenics
5) Klystrons
6) Magnet technology
7)Vacuum technologies
8) Mechanical technologies
9)Electronics
10) SRF
11) Power sources
12) Civil engineering
13) Precise machinery
.....

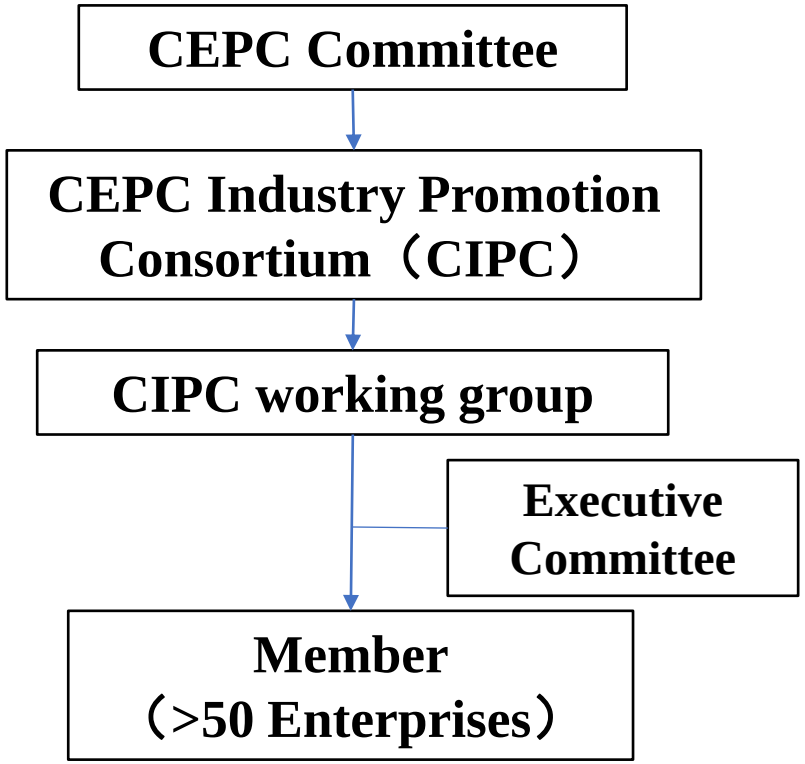
More than 50 companies joined in first phase of CIPC,

And 70 companies now.

Contents

CIPC Organization

CIPC Working group meetings were held on Nov. 24,2017 and Mar. 14 2018. The Executive Committee was established, and the CIPC charter has been drafted and adopted.



CIPC Logo on the plaque

The representatives of CIPC

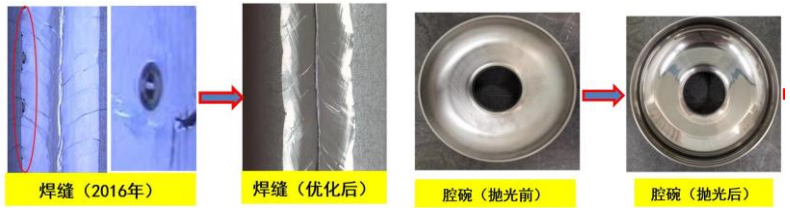
序号	姓名	单位	职务	备注
1	高金林 Gao Jinlin	北京中科富海低温科技有限公司 Beijing Sinoscience Fullcryo Technology Co., Ltd.	总经理 GM	主席 Chairman
2	薛华实 Xue Huashi	上海上创超导科技有限公司 Shanghai creative superconductor technology Co., Ltd.	总经理 GM	副主席 vice chairman
3	李　明 Li Ming	中国瑞联集团控股有限公司 China RuiLian Group Ltd.	主席 Director	副主席 vice chairman
4	黄　浩 Huang hao	昆山国力电子科技股份有限公司 Kunshan national power electronic Technologies Inc.	总经理 GM	副主席 vice chairman
5	刘大炜 Liu Dawei	成都飞机工业集团有限责任公司 Chengdu aircraft industry Group Ltd.	厂长/高工 Director	副主席 vice chairman

Five representatives of entrepreneurs form the CIPC working group.

Milestones in CIPC Progress

Contents

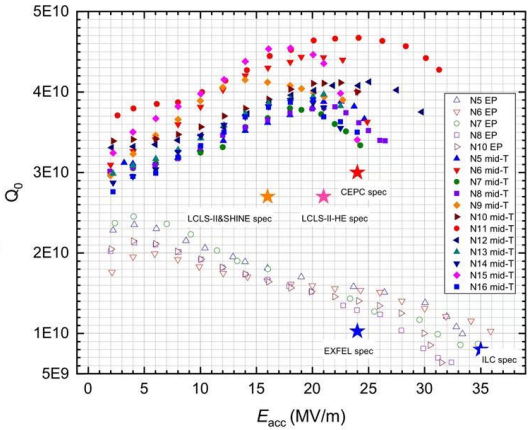
Superconducing Cavities



N2 Cooling system

Cryotrap

High performance 1.3GHz 9 Cell cavity



9cell cavities test results (Jiyuan Zhai)

Technical Team （HERT）

Cavities-High performance 1.3GHz 9 Cell cavity

A. Improve welding quality--- Eacc

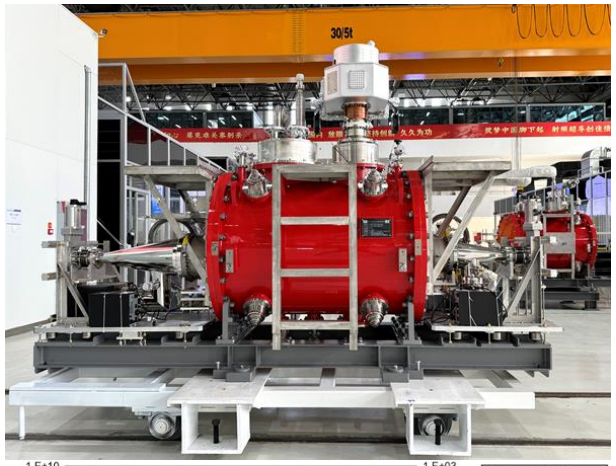
★Single cavity: 45MV/m；

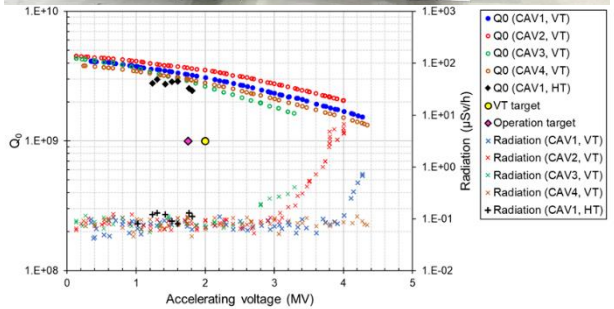
★ 9cell cavity: 24MV/m to 30-35MV/m；

B. Improve surface quality--- Ra1.6 to Ra0.4；

C. Update equipment to increase efficiency--- General welding， 3days to 1.5 days/cavity；

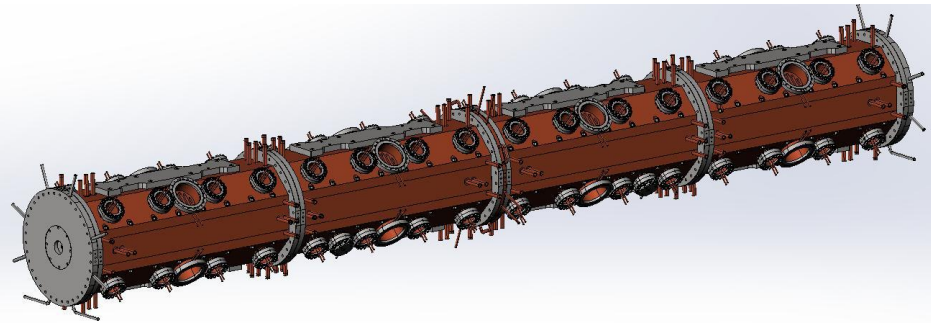
Superconducting Cavities

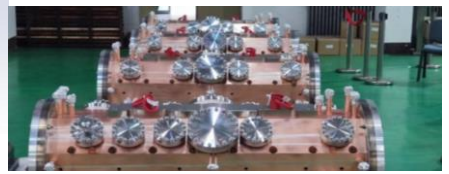




The first 500 MHz superconducting module manufactured by Beijing HE-Racing Technology Co., Ltd. successfully completed the horizontal and high-power test at low temperatures, and the test results were better than the design indicators of HEPS

Group photo of the on-site acceptance of the accelerated structure

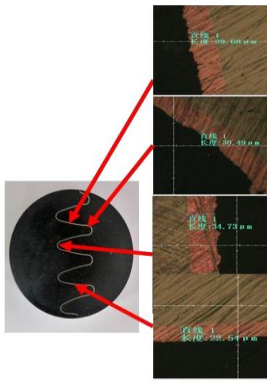




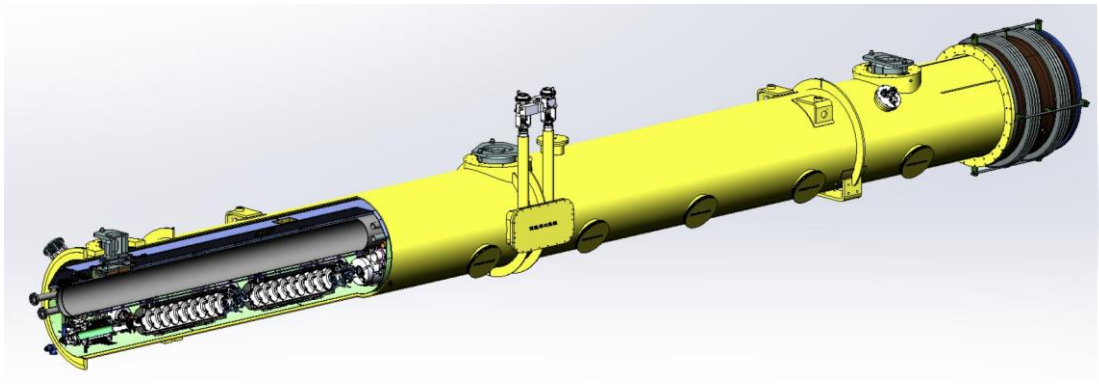
Couplers /Cryomodules

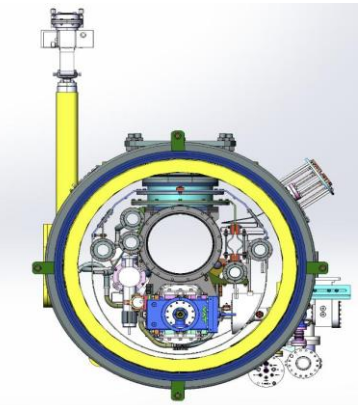
序号	科学装置	腔类型	频率（MHz）	耦合器类型	数量	工作状态	功率指标
1	HALF	DTL(NC)	80	同轴单窗	2	运行	
2	IBS	HWR (SCC)	162.5	同轴单窗	2	测试	
3	C-ADS	HWR (SCC)	162.5	同轴单窗	2	运行	连续波15kW
4	HEPS-TF	QWR (SCC)	166.6	同轴单窗	2	测试	
5	HEPS	QWR (SCC)	166	同轴单窗	2	测试	行波250kW,驻波100kW
6	CSNS	Spoke (SCC)	324	同轴单窗	2	测试	行波300kW，占空比5%
7	C-ADS	RFQ (NC)	325	同轴单窗	8	运行	
8	C-ADS	Spoke (SCC)	325	同轴单窗	7	运行	连续波10kW
9	C-ADS	Buncher (NC)	325	同轴单窗	3	运行	连续波7kW
10	CSNS	RFQ (NC)	325	同轴单窗	5	运行	
11	BNCT	RFQ (NC)	325	同轴单窗	5	运行	95kW,占空比80%
12	BEPCII	1 cell (SCC)	500	同轴单窗	4	运行	行波250kW,驻波100kW
13	HEPS	5Cell (NC)	500	同轴单窗	2	测试	行波250kW,驻波100kW
14	PAPS	2Ccell (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	连续波14kW;驻波7kW
17	DALS	9cell (SCC)	1300	可调双窗	8	测试	连续波14kW;驻波7kW

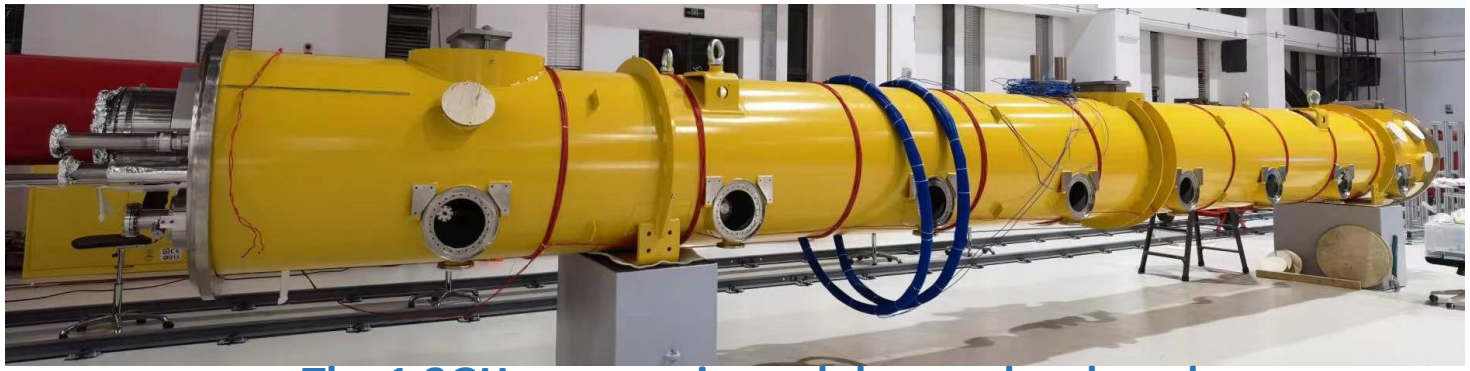
Thickness (um)							
peak	26	24	30	19	23	29	33
valley	29	33	29	27	34	35	35
slope	36	37	29	32	28	30	26
	32	28	36	22	28	30	28
pipe	36	35	37	35	35	32	31



Copper Plating







The 1.3GHz cryogenic module was developed and assembled and delivered

- 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.

Superconducting magnets

参建加速器领域所有
国家重大科学工程
(共计12项，已建成6项)

1. 北京正负电子对撞机
2. 兰州重离子加速器
3. 合肥同步辐射光源
4. 上海同步辐射光源
5. 中国散裂中子源
6. 硬X射线自由电子激光装置
7. 高能同步辐射光源
8. 强流重离子加速器装置
9. 加速器驱动嬗变研究装置
10. 合肥先进光源

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1984年—2009年
北京正负电子对撞机Ⅰ期、Ⅱ期


1984年—2004年
合肥同步辐射加速器


2004年—2010年
上海同步辐射光源Ⅰ期、Ⅱ期


2011年—2018年
中国散裂中子源

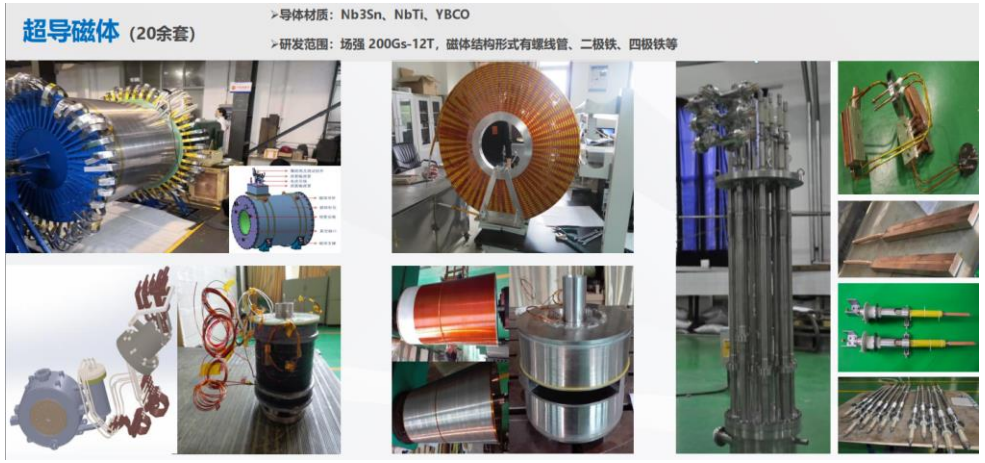

2019年—2025年
高能同步辐射光源


2023年—2029年
合肥先进光源

序号	项目名称	用户名称	极限真空度	数量	主材材质
1	高能同步辐射光源（HEPS）储存环不锈钢真空盒	北京高能物理研究所	$<5\times10^{-10}$Torr	532套	316LN/铬镐铜
2	高能同步辐射光源（HEPS）增强器真空盒	北京高能物理研究所	优于1×10^{-9}Torr	423套	316LN
3	HALF预研工程工艺测试平台真空室	中国科学技术大学同步辐射实验室	$\leq6.5\times10^{-8}$Pa	40套	TU1、316L
4	BEPCII储存环备用真空盒	北京高能物理研究所	$\leq5\times10^{-10}$Torr	2套	铝合金5083
5	LCS真空盒和支架	北京高能物理研究所	高于5E-10Torr	5套	316L
6	加拿大光源非圆截面异形真空盒	加拿大光源	$\leq1.0\times10^{-10}$Torr	7套	316LN
7	散裂中子源RCS 真空盒	北京高能物理研究所	$\leq6.7\times10^{-8}$Pa	47套	316L
8	散裂中子源异形真空盒	北京高能物理研究所	$\leq1.0\times10^{-6}$Pa	6套	316L
9	散裂中子源LRBT真空盒	北京高能物理研究所	$\leq1.0\times10^{-7}$Pa	150余套	316L
10	BEPCII A&B类真空盒	北京高能物理研究所	≤5E-10Torr	A类29套 B类21套	铝合金5083、316L
11	聚束腔&散束腔	北京高能物理研究所	$\leq1.0\times10^{-8}$Pa	共5套	TU1、316L
12	废束站	北京高能物理研究所	$\leq4.4\times10^{-8}$Pa	各1套	弥散铜

List of magnet class items

序号	项目名称	用户名称	数量	合同签订时间	磁铁铁芯类型
1	高能同步辐射光源（HEPS）增强器四极磁铁	中国科学院高能物理研究所	150台	2019年	叠片式
2	高能同步辐射光源（HEPS）高能输运线二极&校正磁铁	中国科学院高能物理研究所	49台	2020年	叠片&DT4
3	慢速和快速轨道校正磁铁	中国科学技术大学	4台	2020年	DT4
4	偏转腔平台磁铁	中国科学院大连化学物理研究所	4台	2020年	DT4
5	实验终端四极、二极磁铁加工制作	中国科学院近代物理研究所	8台	2019年	DT4
6	HEPS技术研发与测试平台（PAPS）聚焦四极磁铁	中国科学院高能物理研究所	7台	2018年	DT4
7	45度二极磁铁、200mm四极磁铁、250mm四极磁铁	中科离子医学技术装备有限公司	3台	2016年	叠片
8	30度二极磁铁、200mm四极磁铁、250mm四极磁铁	中科离子医学技术装备有限公司	25台	2017年	叠片
9	上海质子治疗装置高能束运线及gantry二极和校正磁铁	中国科学院上海应用物理研究所	28台	2015年	叠片



List of items in the vacuum chamber and vacuum system category

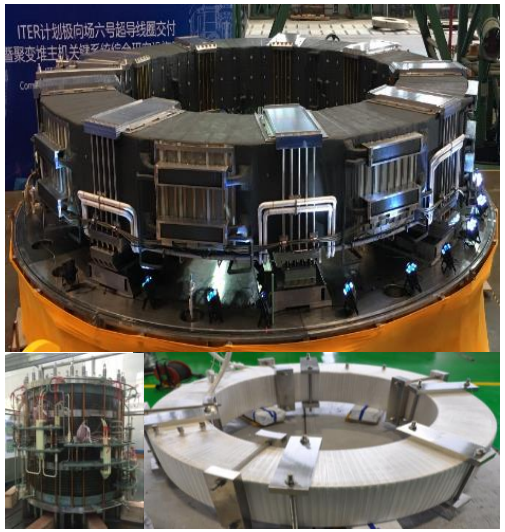
Superconducting magnets

Superconducting magnet related projects

- International Thermonuclear Experimental Reactor (ITER) Polar Field 6 magnet
- EAST Nb3Sn superconducting experimental magnet
- Steady-state strong magnetic field experimental device 40T hybrid magnet external superconducting magnet.

Key technical indicators

- Coil A: CICC superconducting conductor, armor material 316L, superconducting material Nb3Sn, operating current 14.1/13.4kA, maximum field strength 12.7T
- Coil B: CICC superconducting conductor, armor material 316L, superconducting material Nb3Sn, operating current 14.1/13.4kA, maximum field strength 11.3T
- Coil C: CICC superconducting conductor, armor material 316L, superconducting material Nb3Sn, operating current 14.1/13.4kA, maximum field strength 10T
- Coil D: CICC superconducting conductor, armor material 316L, superconducting material NbTi, operating current 14.1/13.4kA, maximum field strength 7.7T
- A+B+C+D central magnetic field 11.5T

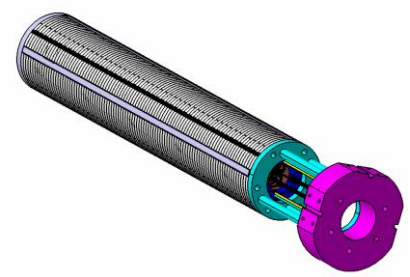


International Thermonuclear Experimental Reactor (ITER) polar field 6			
Outside diameter	Φ10.2m	CICC type onductors	316L
Inner diameter	Φ7.1m	Superconducting material	NbTi
height	1.13m	The operating current	48/52kA
Weight	265t	Magnetic field strength	7.8T

Key technical indicators

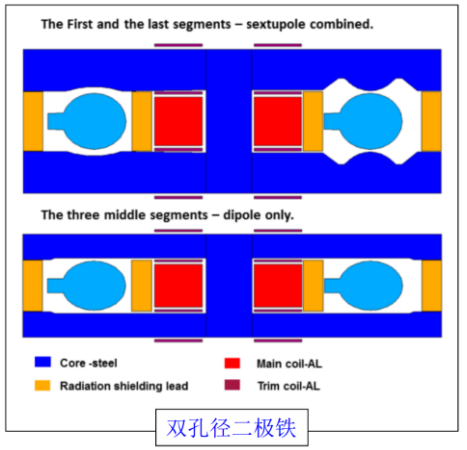
- Cross-sectional size of Nb3Sn superconducting cable (10.4mm*13.2mm)
- Winding withstand voltage and leakage rate detection: pressure 5MPa, for 10 minutes, leakage rate < 1.3E10 Pa m/s.
- Withstand Voltage Detection:
- Inter-turn insulation withstand voltage: before glue filling, 15V per turn, AC, for 1 minute.
- Terminal voltage, 2000V before glue filling, AC, for 1 minute.
- Voltage to ground ±5000V, DC, for 5 minutes.
- Withstand voltage detection to the ground, withstand voltage value 5000V, DC, for 5 minutes

Superconducting magnets



The QD0 superconducting quadrupole magnet is a cos2θ type double-aperture superconducting magnet with an iron core, and the centerlines of the two aperture are not parallel, and the angle is 33mrad.

Magnet name	QD0 model magnet
Field gradient 磁场梯度(T/m) (In two apertures)	136
Magnetic length 长度(m)	0.5
Coil turns per pole线圈匝数	21
Excitation current (A）励磁电流(In two apertures)	2080
Coil layers线圈层数	2
Conductor超导缆参数	Rutherford Cable, width 3 mm, mid thickness 0.93 mm, keystone angle 1.9 deg, Cu:Sc=1.3, 12 strands
Stored energy 能量(KJ) (Double aperture)	5.0
Inductance电感 (H）	0.0023
Peak field in coil磁场峰值 (T)	3.4
Coil inner diameter内孔直径 (mm)	40
Coil outer diameter线圈外径 (mm)	53.2
X direction Lorentz force/octant 洛仑磁力(kN)	24.6
Y direction Lorentz force/octant 洛仑磁力 (kN)	-23.7



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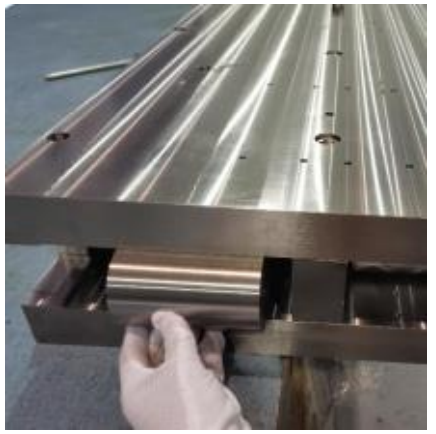


H (A/m)	B (T)	测试结果(T)	H (A/m)	B (T)	测试结果(T)
0	0		700.304	1.4875	
50.1354	0.6073		799.779	1.5105	
70.0304	0.7017		900.0498	1.5288	
80.3758	0.783		1000.321	1.5445	**1.59**
100.2708	0.897		1200.066	1.566	
120.1658	0.972		1399.812	1.584	
140.0608	1.0303		1500.083	1.5933	
149.6104	1.059		1600.354	1.5994	
159.9558	1.08		1800.1	1.6112	
170.3012	1.1		1999.845	1.624	
179.8508	1.119		2500.404	1.645	**1.66**
199.7458	1.1545	**1.50**	3000.166	1.6635	
229.9862	1.1984		3499.928	1.68	
249.8812	1.2235		4000.487	1.6985	
300.0166	1.2775	**1.52**	4500.249	1.712	
350.152	1.325		5000.011	1.727	**1.74**
400.2874	1.3605		6000.332	1.7513	
449.627	1.3895		6999.857	1.775	
499.7624	1.4155	**1.55**	8000.177	1.798	
600.0332	1.4518		9000.498	1.8173	

Single-aperture superconducting quadruple experimental magnet

CEPC main ring (650MHz) and Booster (1.3GHz) SC high frequency

Ningxia Oriental Superconducting Technology Co., LTD., founded in 2010, belongs to OTIC. It is mainly engaged in the manufacturing, welding and post-processing of SRF cavity, a key equipment in particle accelerators of large science facilities

The core component of the RF superconducting accelerator is the superconducting accelerating cavity. RF superconducting cavity, X-ray free electron laser, radionuclide physics research device are the key component of collider.

CEPC main ring (650MHz) and Booster (1.3GHz) SC high frequency

2011 DESY - XFEL
RRR300 Nb: 8 tons, 30% of the project

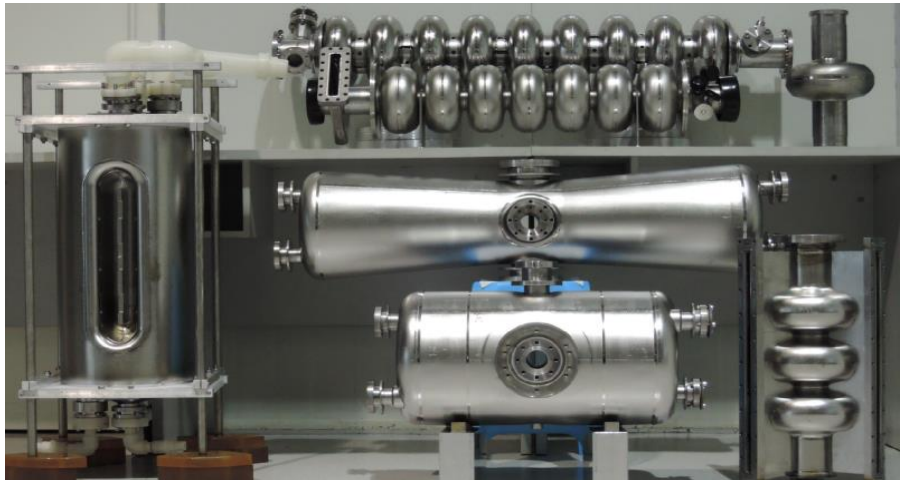
2012 Michigan State University - FRIB
RRR250 Nb: 8.5 tons, 70% of the project

2014 Fermilab - LCLS II
RRR300 Nb: 5 tons, 50% of the project

2017 INFN and STFC - ESS
RRR300 Nb: 12.5 tons, 100% of the project

2019 IBS - RISP, CERN - HL-LHC, Fermilab - PIP-II, Shanghai - SHINE
RRR300 niobium material procurement in progress

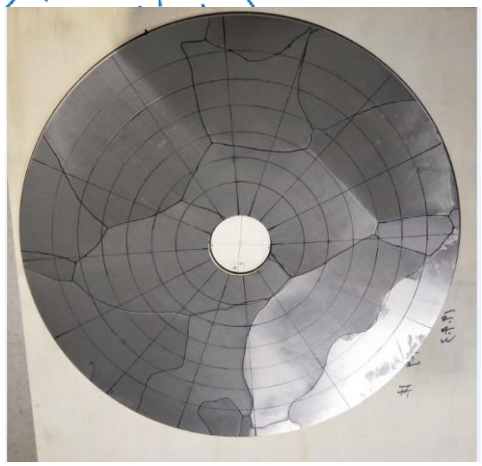
We had built the business relationship with many great customers such as DESY, MSU, Fermilab, JLAB, INFN, STFC, CERN, TRIUMF, RI, ZANON, IHEP, IBS, RRCAT etc.



High RRR Nb sheet

High RRR Nb sheet

CEPC main ring (650MHz) and Booster (1.3GHz) SC high frequency



SRF Cavity built by Ningxia OSTEC

The large grain niobium circular plate (RRR300) produced by OTIC can meet the manufacturing requirements of 1.3GHz-9Cell superconducting cavity.

At present, the company has provided a number of large grain 1.3GHz-9Cell SRF cavities for the Shanghai Hard X-ray Large Science Facility.

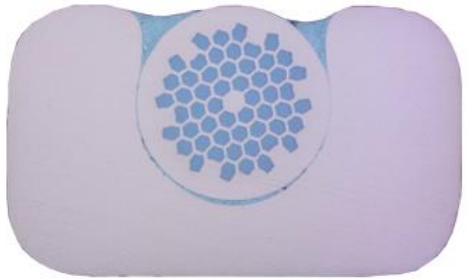
The second generation high-temperature SC tapes

Superconducting wires

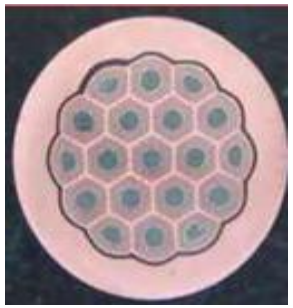
MgB_2

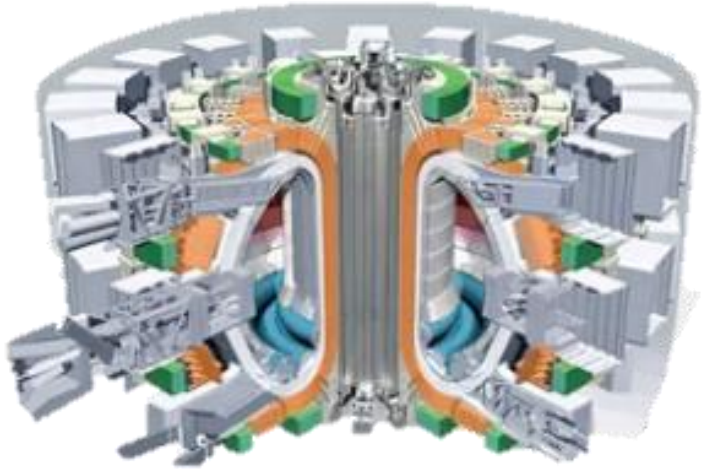
Monolith （NbTi）

Wire in Channel （NbTi）



Nb_3Sn



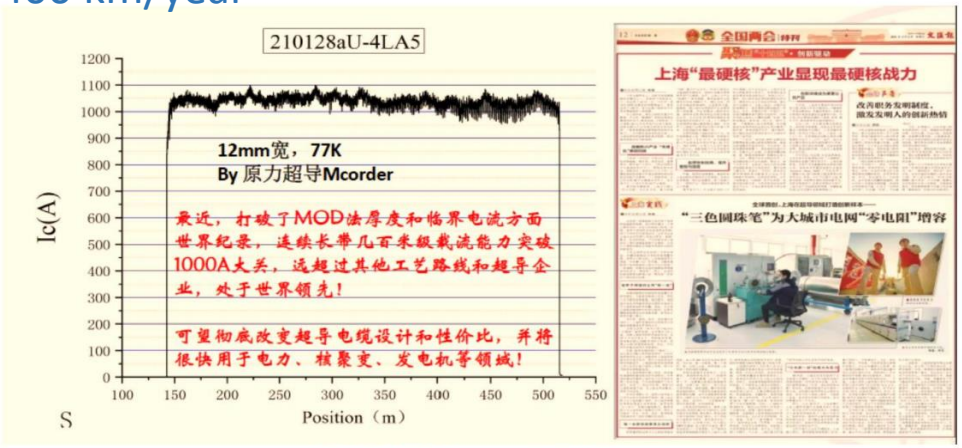


	MgB2	Monolith (NbTi)	Wire in Channel (NbTi)	Nb_3Sn
Specifications	1.0mm~1.5mm	0.5mm~1.6mm (round wire)	1.6*1.1mm~3.4*2.0mm	0.65mm~1.65 mm
Copper ratio range	0.15	0.6~10	4~20	1.0
Critical current	(@3T, 20K): 200A~500A	(@4T, 4.2K): 150A~1100A	(@4T, 4.2K): 400A~2000A	(@12T, 4.2K): 200A~800A

Western Superconducting Materials Technology Co., Ltd. was established in Xi'an Economic and Technological Development Zone in 2003, and has built the world's only full-process production enterprise of niobium-titanium (NbTi) rods, superconducting wires and superconducting magnets, realizing the "zero breakthrough" in the industrialization of superconducting wires and applications in China.

The second generation high-temperature SC tapes

The superconducting layer produced by Shangchuang Superconductor has a production capacity of 20-40mm up to 400km/year, and a wide tape of 20-40mm; two-lane design; Yields up to 400 km/year



1100A/12mm@400m

Coating and Low-temperature pyrolysis

High-temperature crystallization

1.2-km 35 kilovolt superconducting power cable transmission line

Length: 1.2 km

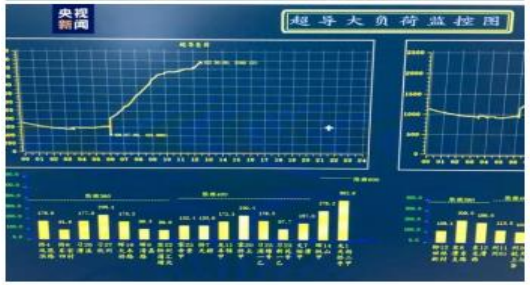
Loading Current: 2.2 kA

Loading Voltage: 35 kV

HTS Materials: 2G tapes from SCsC & SST

Cable Structure: Three-phase integrated

Total area: Save 70% of underground pipegallery space



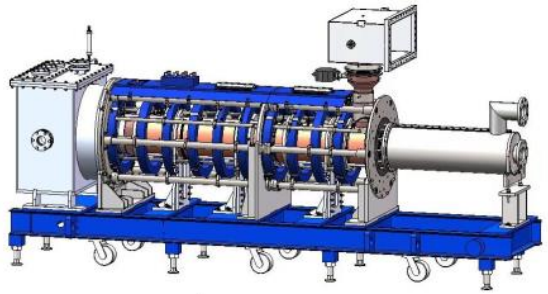
Full load operation (2160.12A) on August 18th

2G-HTS cable

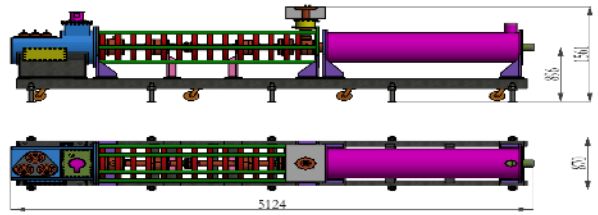
high efficiency klystron direction

2020年 650MHz/800kW速调管样管

2023年 650MHz/800kW多注速调管束流管



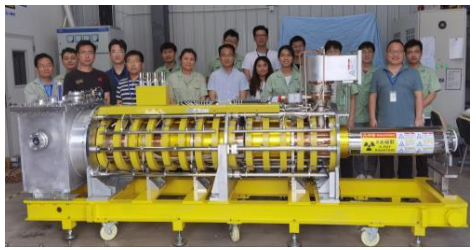
2023年 324MHz脉冲速调管

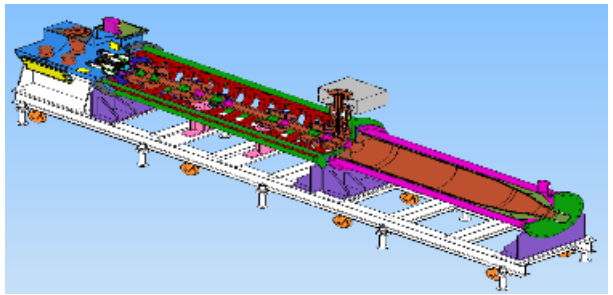


Preliminary mechanical design forUHFKP8001

2021年 650MHz/800kW高效率速调管样管

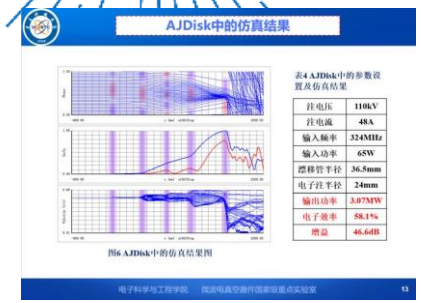
2022年 648MHz脉冲速调管

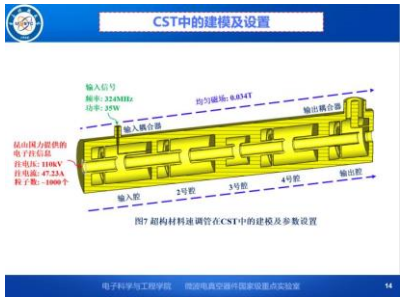


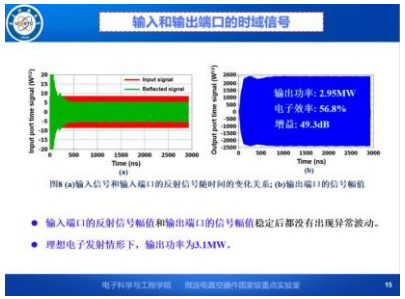


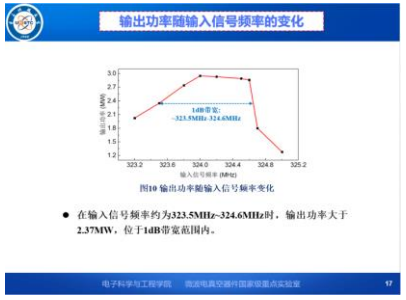
Kunshan National Research Institute has successively developed 650MHz/800KW klystron sample tubes, 650MHz/800KW high-efficiency klystron sample tubes, 648MHz pulse klystron tubes, 650MHz/800KW multi-injection klystron beam tubes, and the latest 324MHz pulse klystron tubesElectro vacuum products for 50 years. Provide high power thyristor of GL1536A in batches for BEPCII in 2012.

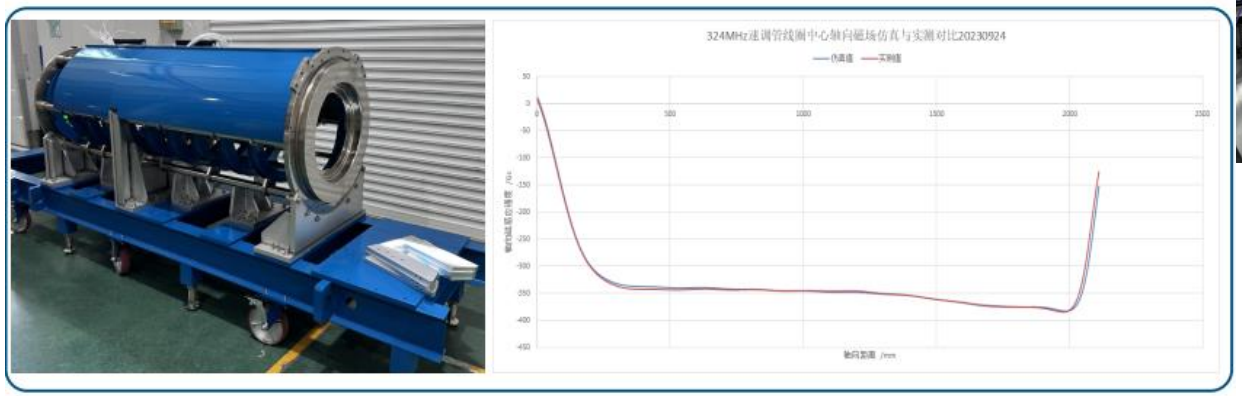
high efficiency klystron direction



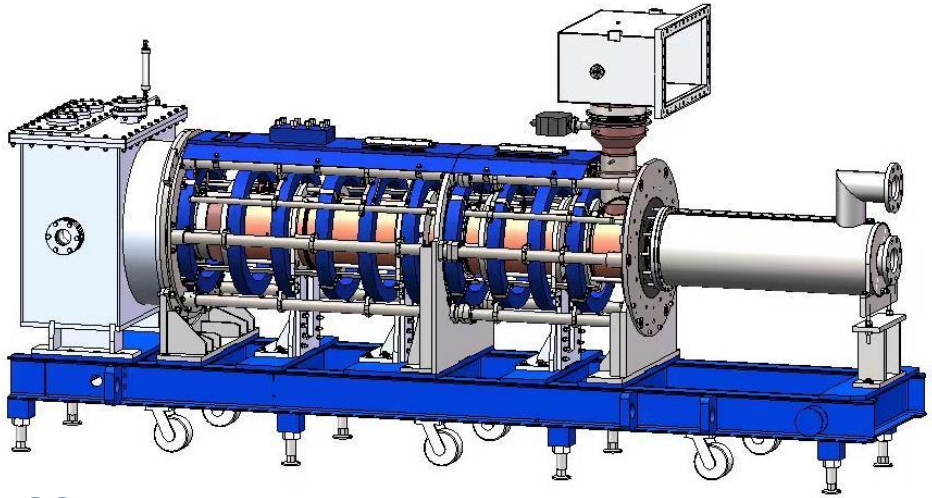




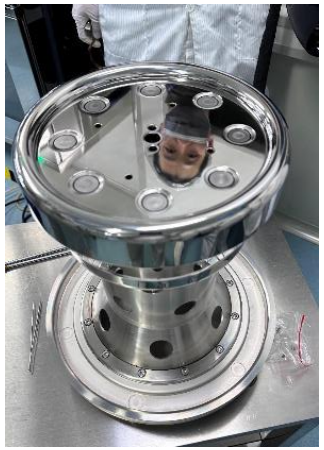


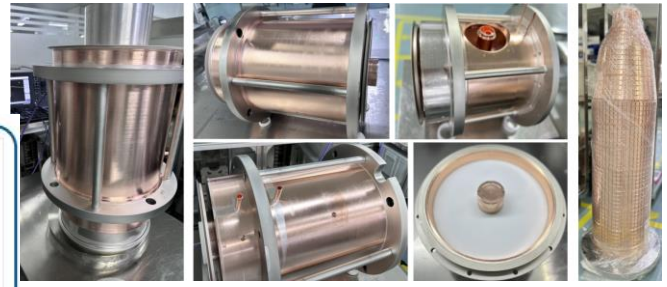


324MHz Focusing coil system for klystrins



324MHz Mechanical design of klystron tubes

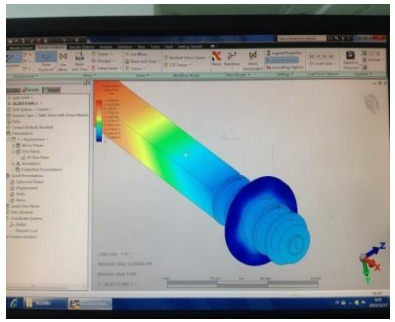




324MHzThe cavity, output window and collector of the klystron tube

Kunshan National Research Institute 's research and development of 324MHz klystron has completed mechanical design, component processing, cavity welding, tuning and focusing coil integration

Vacuum technologies



Anhui East China Optoelectronic Technology Research Institute Co., Ltd. specializes in special microwave and microelectronics, special light sources, special displays and other electronic components, and has established a R&D, design and simulation platform covering microwave, millimeter wave, terahertz and other professional directions, R&D and process test equipment and software

Vacuum technologies

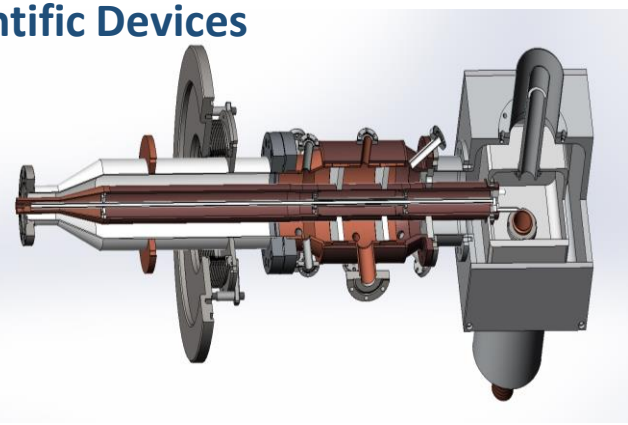
Microwave Vacuum Passive Devices - Product Demonstration of Big Scientific Devices

参数名称	指标
工作频率	162.5MHz
传输损耗	≤0.2dB
传输功率	≥14kw（CW）
真空漏率	优于1E-9mbar*L/s
材料磁导率	≤1.05
冷却方式	风冷
装配结构	陶瓷金属焊接
陶瓷镀膜	TiN
微波面镀膜	镀铜15-30微米
RRR∈	30,80

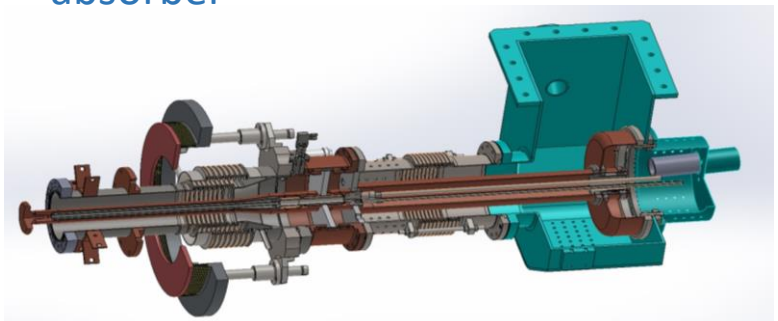
Cold-hot dual-window coupler

1.5GHz high-mode absorber

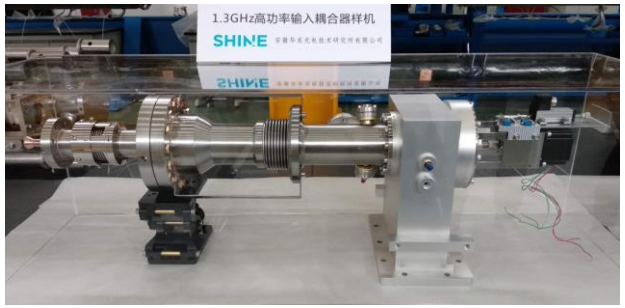
BNCT-RFQ coupler



162.5MHz Dual-window coupler



650MHz High power input coupler



1.3GHz Dual-window coupler

Anhui East China Optoelectronic Technology Research Institute Co., Ltd. has created a variety of products for large scientific projects, such as cold-hot double-window coupler, 162.5MHz double-window coupler, 1.3GHz double-window coupler, 650MHz high-power input coupler, 500MHz high-power input coupler, overweight RFQ coupler and other key equipment

Attracted the attention of International known industrial company

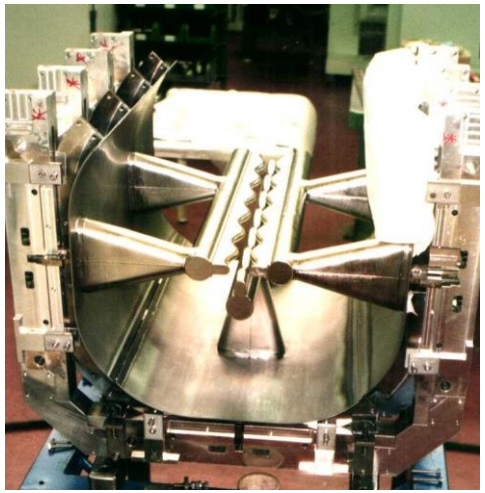
Zanon is located in Schio, North-East of Italy,
1 hour from Venice, where the mother company SIMIC has its main workshop.
Working closely for more than 30 years with the most important Physics Research Institutes in the world, from prototyping to series production.

HIGH TECHNOLOGY PRODUCTS

- RF Cavities
- Tuners
- Cryomodules
- Vacuum Chambers
- Cryostats
- Antennas
- Collimators
- Special parts

MAIN SECTORS

- Scientific Research
- Fusion Energy
- Aerospace
- Industry
- Medical



Attracted the attention of International known industrial company

Zanon working with Research Institutes fro early ’80.
R&D phase and Production of 45 cryomodules for TESLA Test Facility and XFEL Project at DESY-Hamburg

Zanon participated with aninternational consortium to produce the Ion Source prototype for ITER beam injectors.
Zanon’s scope comprised:

- Vacuum vessel
- Beam source support frame
- Beam source electrostatic shields
- Beam source handling tool

Attracted the attention of International known industrial company

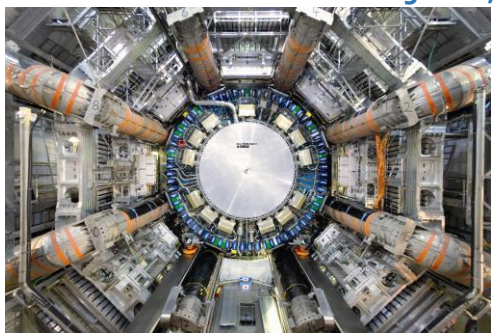
SIMIC is among the Leaders in the Fusion Energy sector and is among the main contributors to ITER project. **Working in Fusion Energy for more than 15 years**.

ITER PROTOTYPES & SERIES PRODUCIONS

- VACUUM VESSEL PROTOTYPE
- DIVERTOR PROTOTYPES and SERIES
- MAGNETS SYSTEM (70 Radial Plates and 10 TFCoils – very large and complex projects)

Weight of TF COIL - 320 tons/ each

SIMIC is working with CERN & many other Research Institutes for more than 20 years.
SIMIC is among the main contributors of LCH Project, at CERN.



ENDCAP CRYOSTAT FOR ATLAS
Material: Alluminium AL 5083
Diam: 5.500 mm
Thk: 160 mm
Weight: 40.000 kg Cryogenic Tests at 90K Super Insulation Leak Test <1X10-8 mbar. l/s

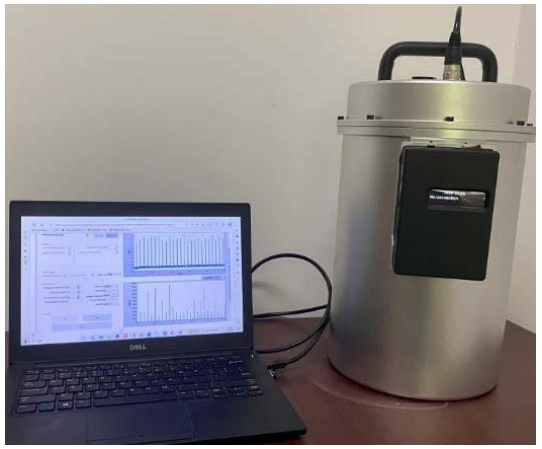
250 CRYOMODULES FOR LHC
Material: AISI 304 L, Aluminium, Cu-Ni
Weigth: 2000 Kg
Length: 6.650 mm Pressure test up to 25 bar; He Leak test < 1x10-8 mbar.l/s 3D Dimensional inspection, Instrumentation test

Integrated Radiation Monitoring System

Gamma Detector:

Through the energy compensation method, the low energy segment of 50KeV~250KeV is realized

Accurate and real-time response (obtaining a third-party test report) solves industry problems



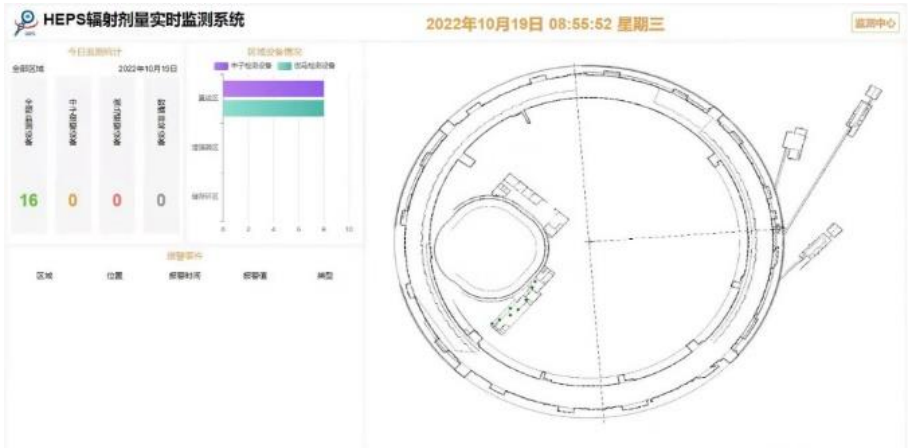
Neutron detector:

Successfully developed the first set of strong pulse neutron detector in China

Real-time measurement of strong pulse neutron flux/dose

Wide-energy region measurement: Thermal neutron 0.025 eV - high-energy neutron GeV Neutron measurement in the energy region

High time resolution: Effective observation of accelerator pulsed neutron bundles ns



Terminal information system

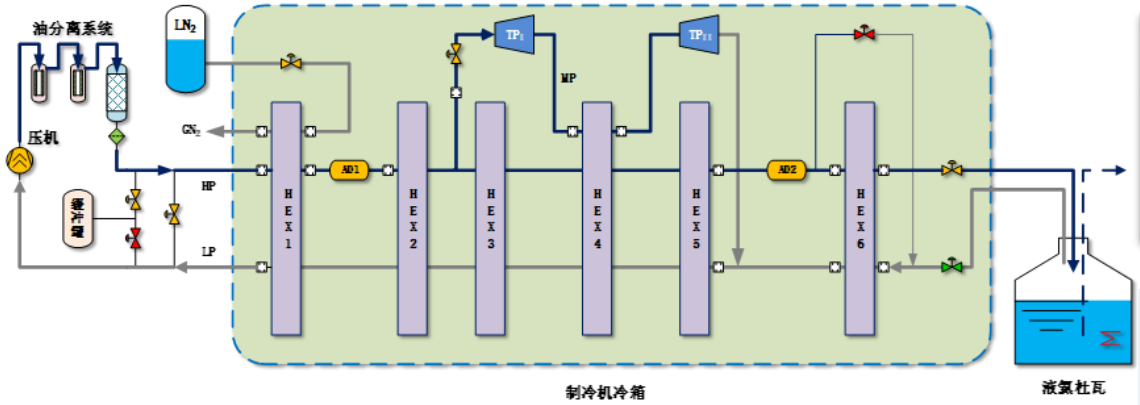
1. Upgrade the digital board and readout, to 1: N mode (1 central console, N devices)

There is no need for secondary instruments, and it truly realizes long-distance transmission and large-scale deployment

2. Based on the B/S architecture, access to the EPICS system to connect the radiation protection monitoring data with

Accelerator control and other data paths, so that any terminal in the network can access

Large-scale cryogenic refrigeration & liquefaction equipment

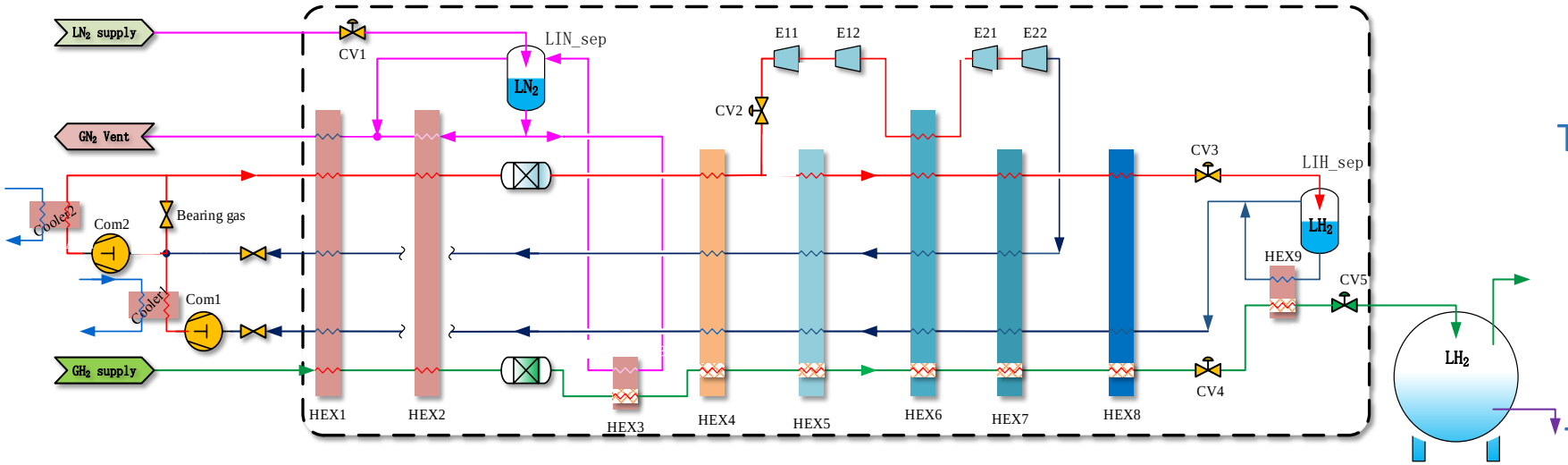


Helium Liquefier	FHL-40	FHL-70	FHL-100	FHL-140	FHL-180	FHL-240	FHL-280	FHL-400
Liquefaction Rate(L/h)	40~70	70~100	100~140	140~180	180~240	240~280	280~310	310~420
Rated Power of Compressor(kW)	75~90	90~132	132~160	160~200	200~250	250~315	315~355	355~425

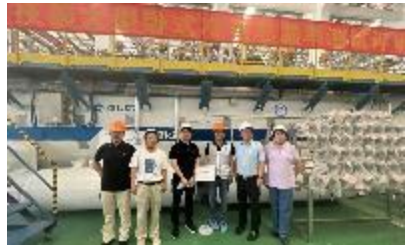
Helium Refrigerator	FHR-40	FHR-70	FHR-100	FHR-140	FHR-180	FHR-240	FHR-280	FHR-400
Cooling Power(W)	160 ~250	250~320	320~450	450 ~580	580~750	750 ~900	900 ~1000	1000 ~1800
Rated Power of Compressor(kW)	75~90	90~~132	132~160	160~200	200~250	250~315	315~355	355~425

Large-scale cryogenic refrigeration & liquefaction equipment

Hydrogen liquefaction system



The 1.5TPD hydrogen liquefaction



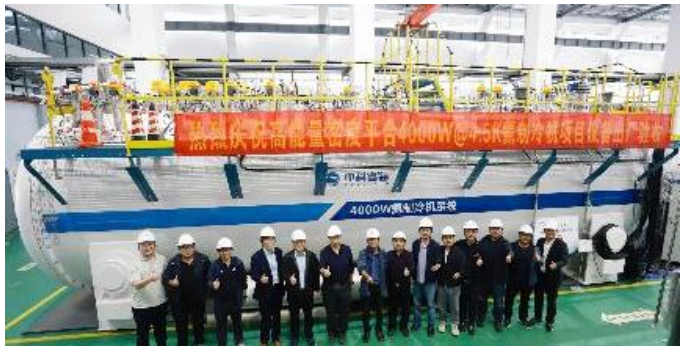
The 5TPD hydrogen liquefaction

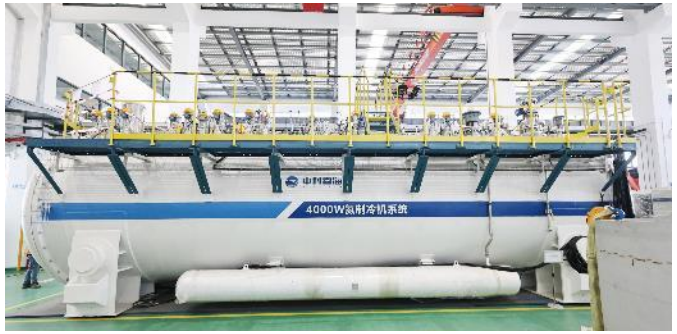
The 5TPD hydrogen liquefaction

Hydrogen liquefaction rate	Liquefaction energy consumption	Liquefaction energy consumption	Turboexpander efficiency
3070.2L/h	98.66%	12.98KWh/kg	80%

Large-scale cryogenic refrigeration & liquefaction equipment

国内首台4kW氦制冷机项目通过专家出厂验收
First 4kW helium refrigerator in China passes inspection





中科富海4000W@4.5K氦制冷机产品通过专家组鉴定，完成出厂验收

Fullcryo 4000W@4.5K helium refrigerator passed the expert inspection, completing factory acceptance

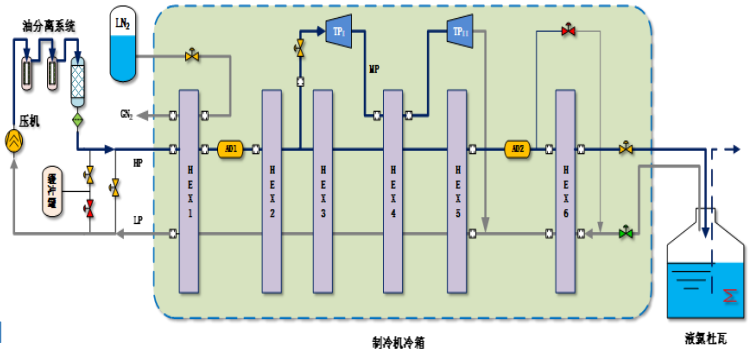
2023年11月29日，中科富海为先进能源科学与技术广东省实验室高能量密度测试平台提供的4000W@4.5K氦制冷机产品顺利通过用户及专家组现场验收，达到出厂要求，为超导腔和超导磁体提供必要的低温工作环境，保障各项研究测试的顺利进行。

On November 29, 2023, the 4000W@4.5K helium refrigerator provided by Fullcryo for the high Energy Density test platform of Guangdong Advanced Energy Science and Technology Laboratory passed the site acceptance by the user and experts, meeting the factory requirements, and was applied in the superconducting cavity and superconducting magnets.

Large-scale cryogenic refrigeration & liquefaction equipment

国内首台18kW氦制冷机项目通过专家出厂验收

First 18kW helium refrigerator in China passes inspection



- 由中国科学院理化所研发设计，中科富海集成制造
  It was developed by the Institute of Physics and Chemistry of the Chinese Academy of Sciences, and integrated and manufactured by Fullcryo.
- 该长度28m、直径4.2m的超大型卧式冷箱实现超高真空、极微泄漏目标，是能够将氦气从常温降低至-269℃的必备条件
  The super large horizontal cold box with a length of 28m and a diameter of 4.2m achieves ultra-high vacuum and extremely low leakage.
- 整套万瓦级卧式冷箱系统是全国乃至世界上最大的冷箱系统，标志着中国液氦/超流氦温区的大型低温制冷设备研发和制造能力迈上新台阶。
  The horizontal cold box at megawatt-level is the largest of its kind in China and even in the world.
- 验收意见：该系统超目标完成。
- 现场测试：1.内部各通道打压气密性测试，压力降为0，优于目标值0.02 bar；2.整体真空氦检，集合漏率为9.1×10-10Pa.m³/s，优于目标值1×10-7Pa.m³/s。
- Experts' opinion on acceptance: The horizontal cold box system has exceeded the set targets.
  On-site testing: 1. The airtightness test of each internal channel revealed a pressure drop of 0, surpassing the target value of 0.02 bar. 2. The overall leakage rate is 9.1×10-10 Pa.m³/s, surpassing the target value of 1×10-7 Pa.m³/s.
- 整套大型低温系统可实现三种工况调节模式： 氦制冷机等效制冷量大于18kW@4.5K；超流氦温区制冷量大于 4kW@2K
  Expected Goals: Achieving 3 operational mode adjustments:
  the cooling capacity ≥ 18kW@4.5K; the cooling capacity in the superfluid helium temperature range ≥4kW@2K.

Contents

Summary

- **Driven by the great scientific project of CEPC,** CIPC members will participate in pre-research, industrialization and construction, and achieve breakthroughs on key-technologies, equipment manufacturing and industrialization.
- **CIPC members** actively participate in the construction and operation of CEPC, constantly enhance the R&D capabilities of enterprises, master core technologies, help solve major technical engineering problems, and **promote the rapid development of Chinese manufacturing industry.**

Acknowledgements:

Thanks go to companyies who have kindly provided there information:
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Shanghai creative Superconductor Technologies Co., Ltd.
Kunshan GuoLi Electronic Technology Co., Ltd
Anhui East China Optoelectronic Technology Research Institute Co., Ltd
Zanon
SIMIC
Beijing High Energy New Technology Co., Ltd
Beijing Sinoscience Fullcryo Technology CO.， Ltd

Thank you for your kind attention

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