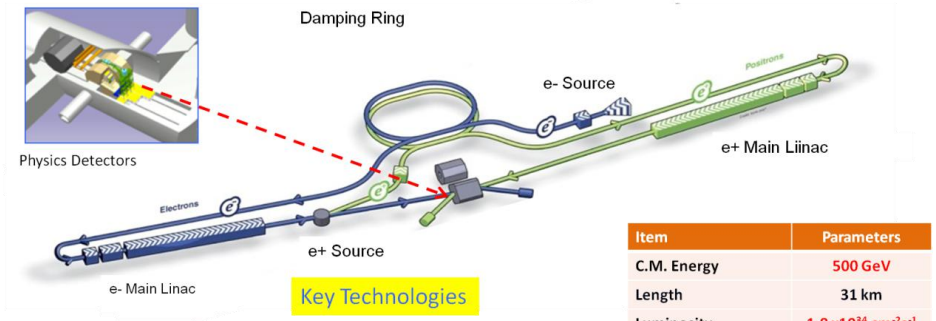
Industry-Academia collaboration in China
-Introduction of CEPC Industry Promotion Consortium (CIPC)

J. Gao

Institute of High Energy Physics

Asian Linear Collider Workshop
May 28 to June 1, 2018, Fukuoka, Japan

ILC Collaboration



Item	Parameters
C.M. Energy	500 GeV
Length	31 km
Luminosity	1.8×10^{34} cm^{-2}s^{-1}
Repetition	5 Hz
Beam Pulse Period	0.73 ms
Beam Current	5.8 mA
Beam size (y) at FF	5.9 nm
SRF Cavity G. Q_0	31.5 MV/m $Q_0 = 1 \times 10^{10}$

China has been working ILC collaboration since 2005 as ILC GDE member (IHEP)

ILC 500GeV needs ~16000 1.3GHz 9cell cavitites

Since 2017

ILC 250GeV Higgs factory needs ~8000 1.3GHz 9cell cavitites

CEPC CDR Accelerator Chain and Systems

10 GeV

Electron

1) Injector

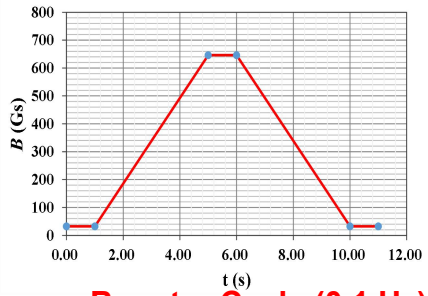
L=1.2km

Positron

2) Booster

C=100km

Energy Ramp
10 ->45/120GeV



Booster Cycle (0.1 Hz)

Three rings in the sane channel:

- **CEPC & booster**
- **SppC**

3) Main Ring

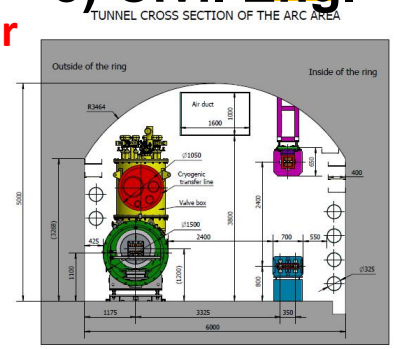
C=100km

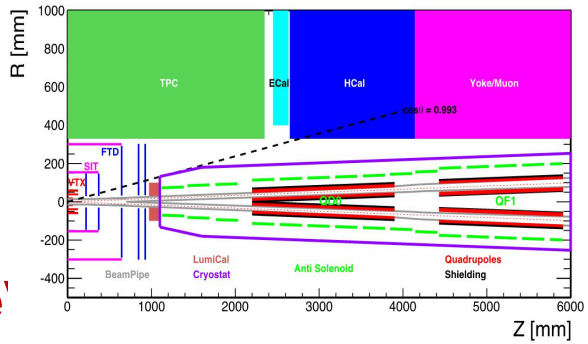
45/120 Ge

The key systems of CEPC:

1) Linac Injector
2) Booster
3) Collider ring
4) MDI
5) Civil Eng.

5) Civil Eng.





4) Detector Machine Interface (MDI)

CEPC CDR Parameters

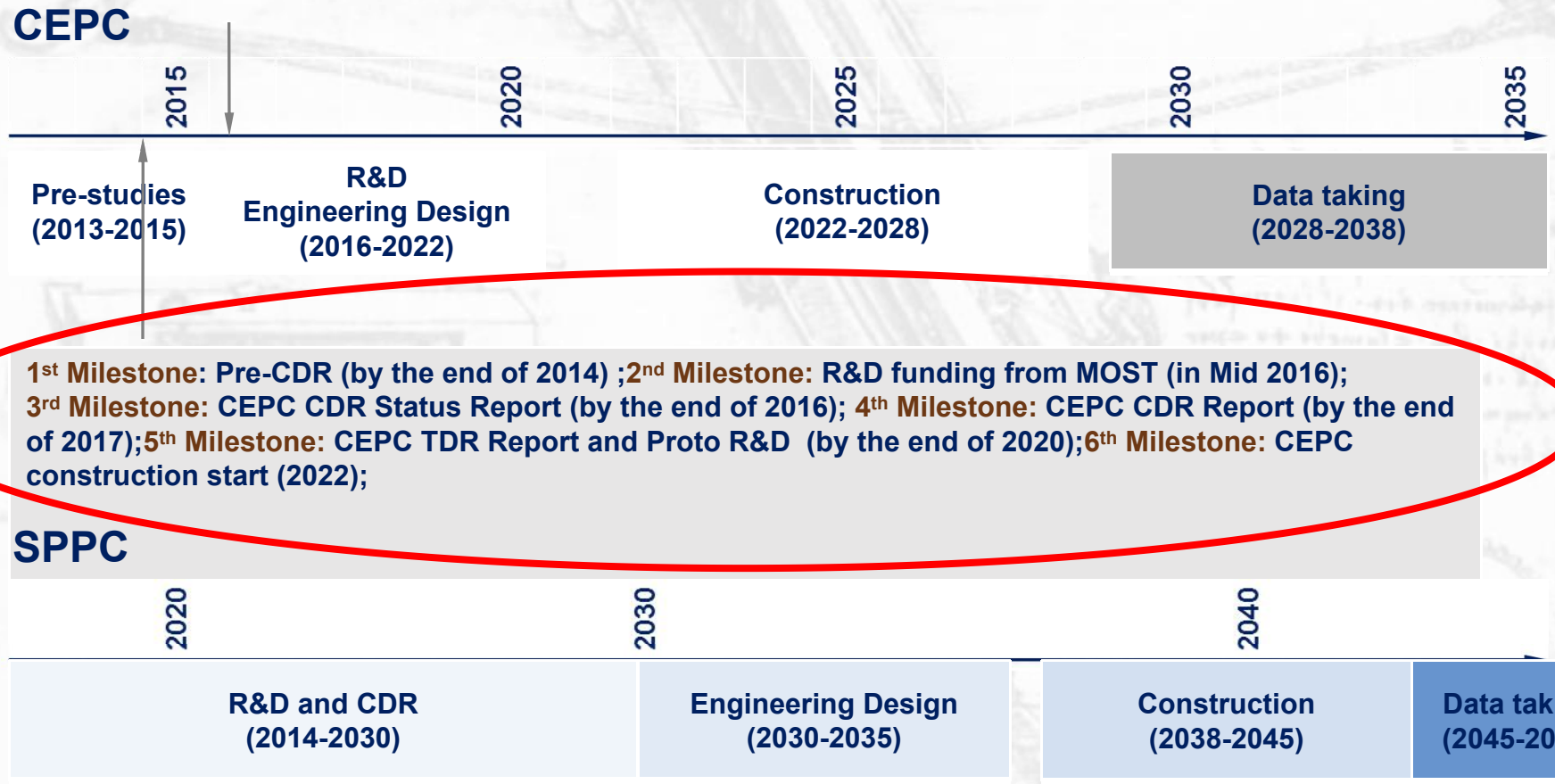
	Higgs	*W*	*Z（3T）*	*Z（2T）*
Number of IPs	2			
Beam energy (GeV)	120	80	45.5	
Circumference (km)	100			
Synchrotron radiation loss/turn (GeV)	1.73	0.34	0.036	
Crossing angle at IP (mrad)	16.5×2			
Piwinski angle	2.58	7.0	23.8	
Number of particles/bunch N_e (10^{10})	15.0	12.0	8.0	
Bunch number (bunch spacing)	242 (0.68μs)	1524 (0.21μs)	12000 (25ns+10%gap)	
Beam current (mA)	17.4	87.9	461.0	
Synchrotron radiation power /beam (MW)	30	30	16.5	
Bending radius (km)	10.7			
Momentum compact (10^{-5})	1.11			
β function at IP β_x^* / β_y^* (m)	0.36/0.0015	0.36/0.0015	0.2/0.0015	0.2/0.001
Emittance $\varepsilon_x/\varepsilon_y$ (nm)	1.21/0.0031	0.54/0.0016	0.18/0.004	0.18/0.0016
Beam size at IP σ_x/σ_y (μm)	20.9/0.068	13.9/0.049	6.0/0.078	6.0/0.04
Beam-beam parameters ξ_x/ξ_y	0.031/0.109	0.013/0.106	0.0041/0.056	0.0041/0.072
RF voltage V_{RF} (GV)	2.17	0.47	0.10	
RF frequency f_{RF} (MHz) (harmonic)	650 (216816)			
Natural bunch length σ_z (mm)	2.72	2.98	2.42	
Bunch length σ_z (mm)	3.26	5.9	8.5	
HOM power/cavity (2 cell) (kw)	0.54	0.75	1.94	
Natural energy spread (%)	0.1	0.066	0.038	
Energy acceptance requirement (%)	1.35	0.4	0.23	
Energy acceptance by RF (%)	2.06	1.47	1.7	
Photon number due to beamstrahlung	0.29	0.35	0.55	
Lifetime _simulation (min)	100			
Lifetime (hour)	0.67	1.4	4.0	2.1
F (hour glass)	0.89	0.94	0.99	
Luminosity/IP L (10^{34}cm^{-2}s^{-1})	2.93	10.1	16.6	32.1

SppC parameters

Parameter	Value	Unit
Main parameters		
Circumference	100	km
Beam energy	37.5	TeV
Lorentz gamma	39979	
Dipole field	12.00	T
Dipole curvature radius	10415.4	m
Arc filling factor	0.780	
Total dipole magnet length	65442.0	m
Arc length	83900	m
Total straight section length	16100	m
Energy gain factor in collider rings	17.86	
Injection energy	2.10	TeV
Number of IPs	2	
Revolution frequency	3.00	kHz
Revolution period	333.3	μs
Physics performance and beam parameters		
Nominal luminosity per IP	1.01E+35	$cm^{-2}s^{-1}$
Beta function at initial collision	0.75	m
Circulating beam current	0.73	A
Nominal beam-beam tune shift limit per	0.0075	
Bunch separation	25	ns
Bunch filling factor	0.756	
Number of bunches	10080	
Bunch population	1.5E+11	
Accumulated particles per beam	1.5E+15	
Normalized rms transverse emittance	2.4	μm
Beam life time due to burn-off	14.2	hour
Turnaround time	3.0	hour
Total cycle time	17.2	hour

Total / inelastic cross section	147	mbarn
Reduction factor in luminosity	0.85	
Full crossing angle	110	μrad
rms bunch length	75.5	mm
rms IP spot size	6.8	μm
Beta at the 1st parasitic encounter	19.5	m
rms spot size at the 1st parasitic encoun	34.5	μm
Stored energy per beam	9.1	GJ
SR power per ring	1.1	MW
SR heat load at arc per aperture	12.8	W/m
Critical photon energy	1.8	keV
Energy loss per turn	1.48	MeV
Damping partition number	1	
Damping partition number	1	
Damping partition number	2	
Transverse emittance damping time	2.35	hour
Longitudinal emittance damping time	1.17	hour

CEPC-SPPC Timeline (preliminary and ideal)



CEPC Industrial Promotion Consortium (CIPC)

Established in Nov. 7 , 2017

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

More than 50 companies joined in first phase of CIPC，
and more will join later....

SppC related Domestic Collaboration

"Applied High Temperature Superconductor Collaboration" was established in Oct. 2016.

- **Goal**:
  1) To increase the J_c of **IBS** by 10 times, reduce the cost to **20 Rmb/kAm @ 12T & 4.2K**;
  2) To reduce the cost of **ReBCO and Bi-2212** conductors to 20 Rmb/kAm @ 12T & 4.2K;
  3) Realization and Industrialization of iron-based magnet and SRF technology.
- **Working groups**: 1) **Fundamental science** investigation; 2) **IBS** conductor R&D; 3) **ReBCO** conductor R&D; 4) **Bi-2212** conductor R&D; 5) **performance** evaluation; 6) **Magnet and SRF** technology.
- **Collaboration meetings**: every 3 months, to report the progress and discuss plan for next months.

Beijing HE-Racing Technology Co., Ltd

EBW Machine

Forming Machine

Hydrogen Oven

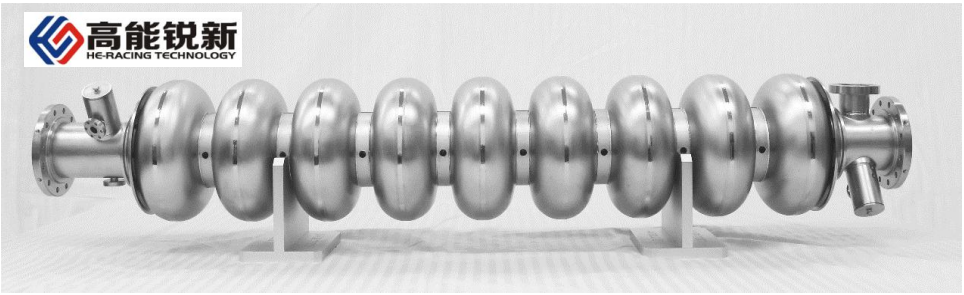
Vacuum Heat Treatment

Cleanroom Class 10

Cleanroom
Class 1000

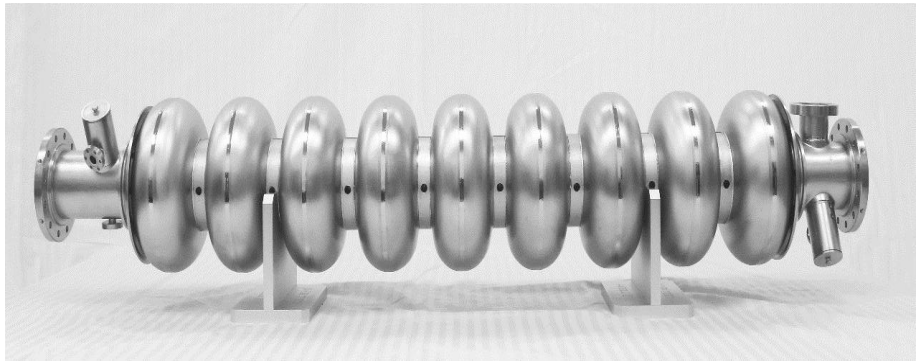
High pressure
rinsing machine

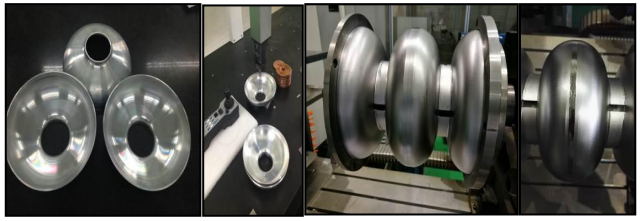
IHEP SCRF Industrialization

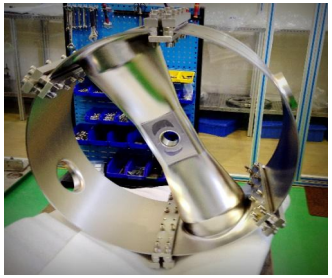
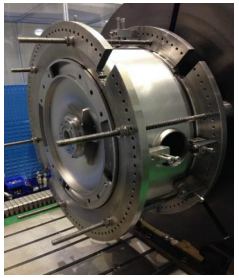


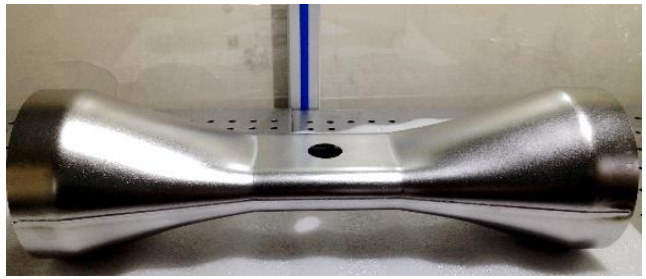
Quality control and cost reduction:

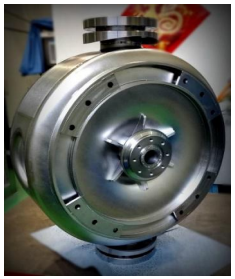
- **Niobium**: OTIC (EXFEL 35% 7 t, FRIB 50% 5 t, LCLS-II 50% 5.6 t …)
- **Cavity**: OTIC, HERT, BIAM (ILC, CADS, FRIB, HEPS, CEPC …)
- **Coupler**: HERT (ILC, CADS, RISP …), JNT
- **Cryomodule**: WXCX (EXFEL 60, LCLS-II 33, FRIB), HFJN (CADS)
  - LCLS-II cryomodule quality control (IHEP & SLAC-FNAL-JLAB collaboration)



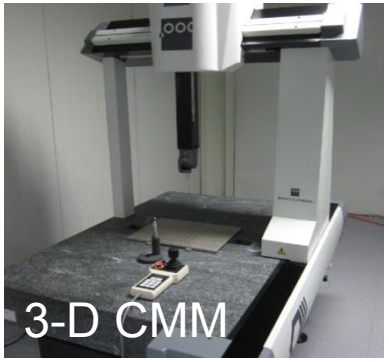


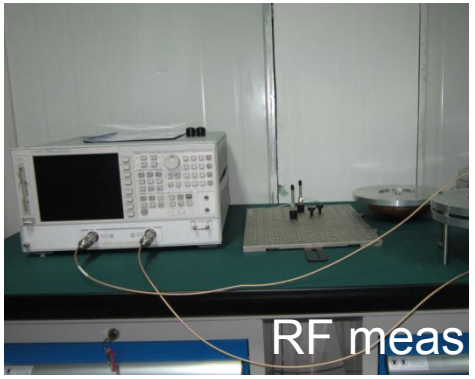



ILC 1.3GHz cavity capacity: ~200cavities/year

Ningxia OSTEC: SC Materials and Cavity fabrication

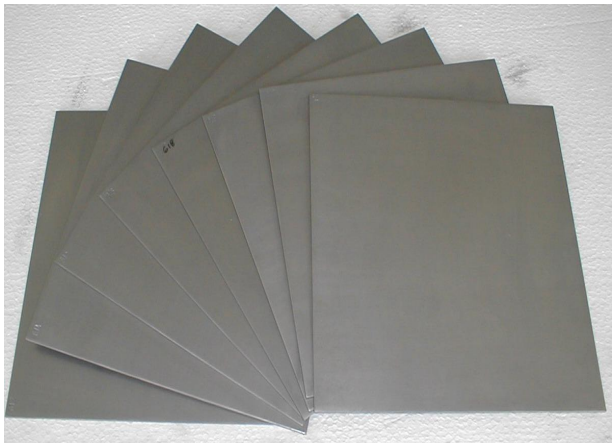
Ningxia Orient Superconductor Technology Co., Ltd (OSTEC)
(Founded by OTIC and PKU, 2011)



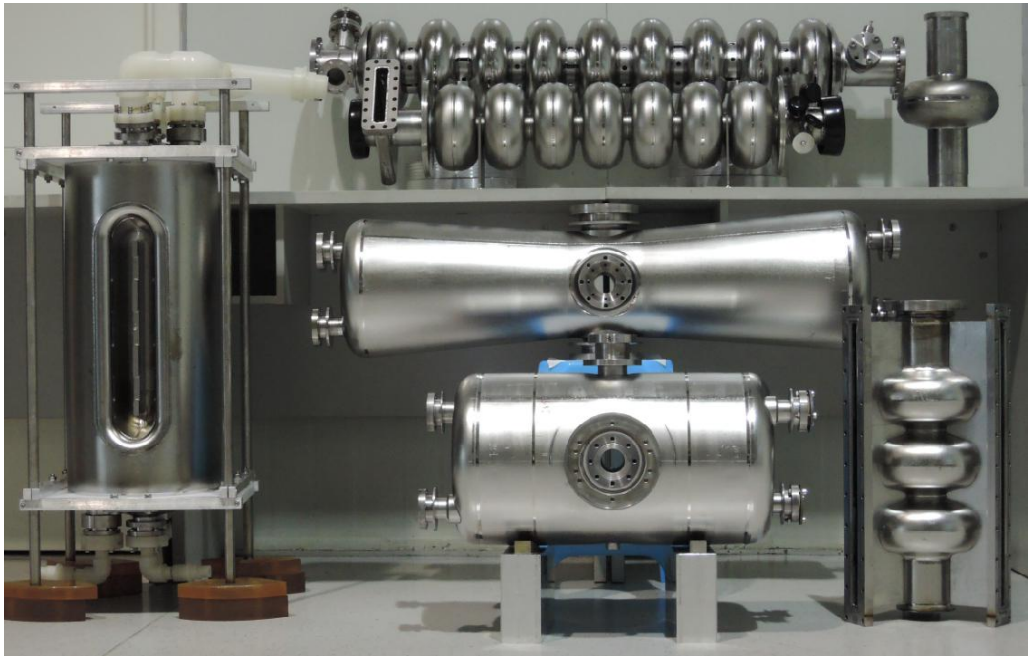


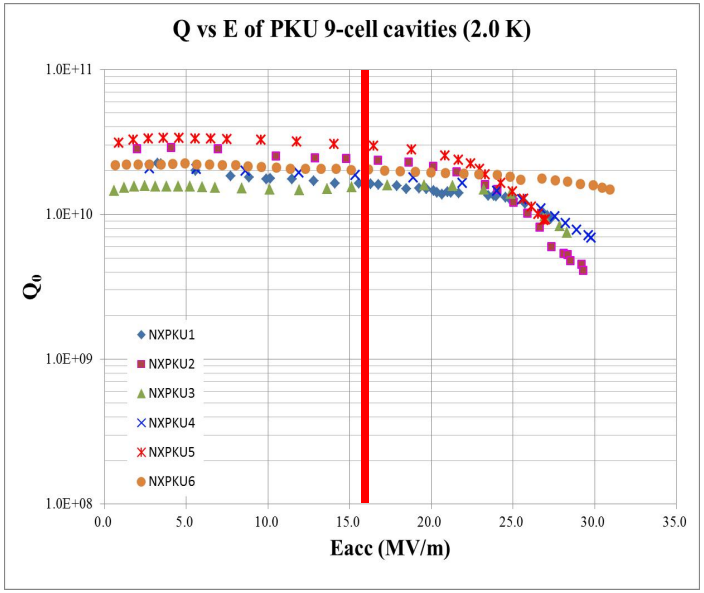
High RRR Nb in OTIC and SRF cavities built by Ningxia OSTEC

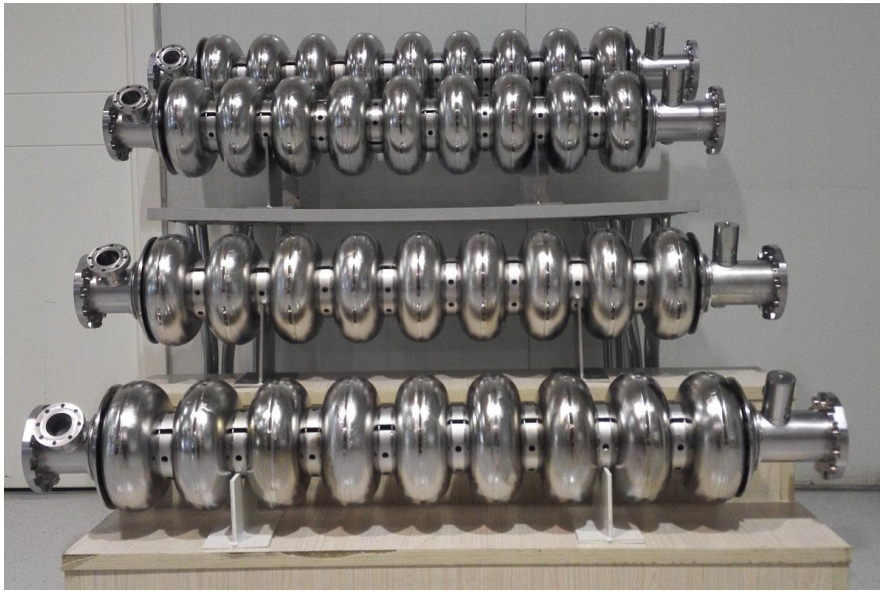
High RRR Nb ingot



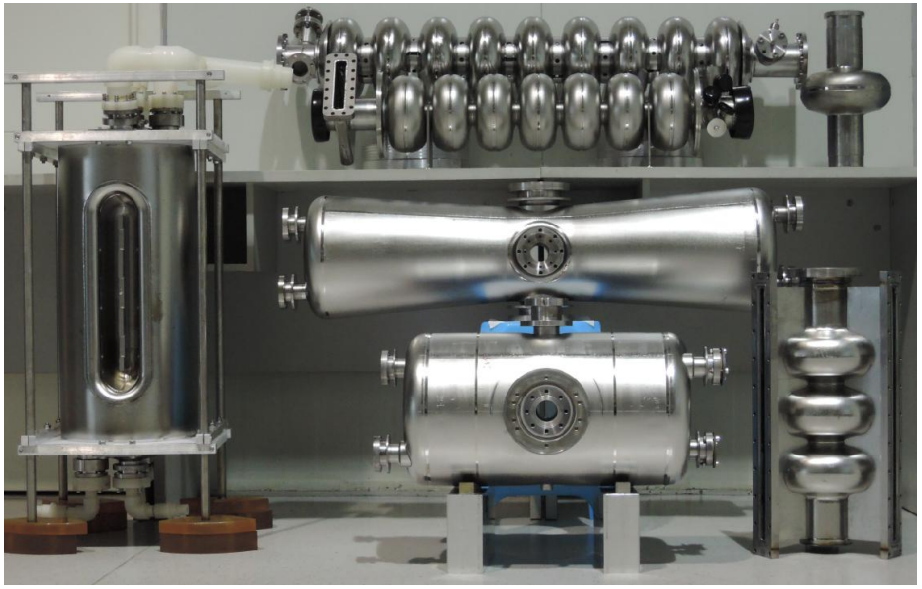
High RRR Nb sheet







1.3GHz 9cell large grain superconductor cavities



SRF Cavity built by Ningxia OSTEC

Cavity post process facility at Ningxia OSTEC

BCP

HPR

Vacuum furnace

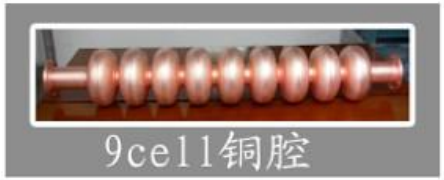
Vacuum furnace

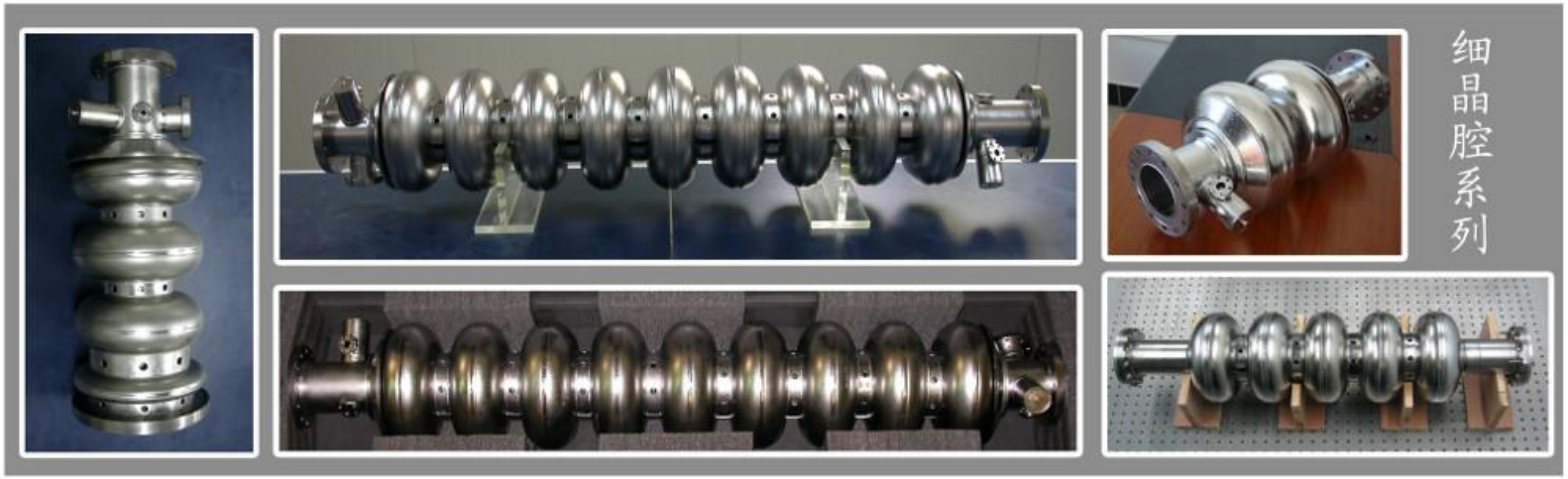
Ningxia OSTEC

ILC 1.3GHz cavity capacity: ~200 cavities/year

超高装（中山）科技有限公司

ChaoGao Zhuang (zhongshan) Scientific Technology Co., Ltd.





1.3G SC cavities

Acheivement in SC accelerator technologies

25MeV连续波超导质子直线加速器（二）

和超高装（中山）科技有限公司

ILC 1.3GHz cavity capacity:
~200 cavities/year

Wuxi Creative technologies Co., Ltd.

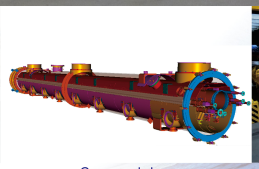
CREATIVE TECHNOLOGIES

Products

Produce for EXFEL

Chinese government delegation led by Vice Prime Minister Liu Yandong visits European XFEL and DESY

Upper Assembly



Cryomodule

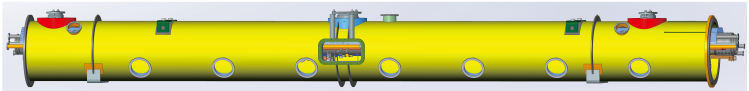
Vacuum Vessel

无锡市创新低温环模设备科技有限公司
WUXI CREATIVE TECHNOLOGIES CO.,LTD.

CREATIVE TECHNOLOGIES

Products

Produce for LCLS Ⅱ



Cryomodule

Cryomodule Vacuum Vessel

Upper Assembly

Produce for SINAP

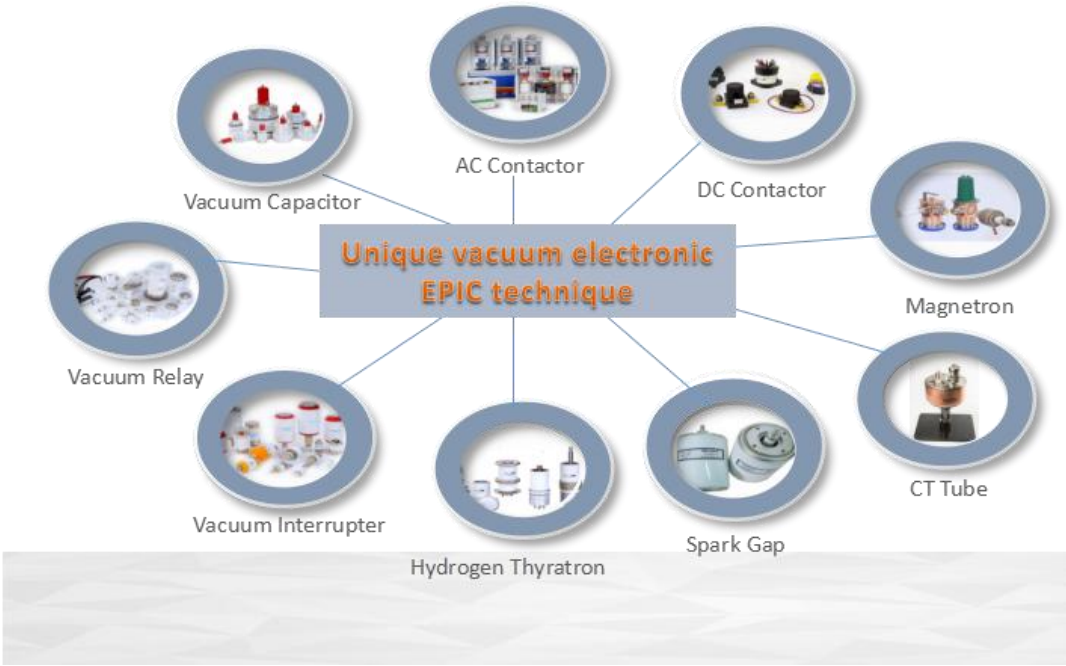
Magnet Support

Undulators

Undulators

无锡市创新低温环模设备科技有限公司
WUXI CREATIVE TECHNOLOGIES CO.,LTD.

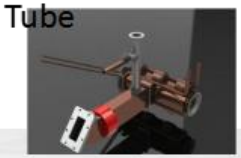
Kunshan GuoLi Electronic Technology Co., Ltd.



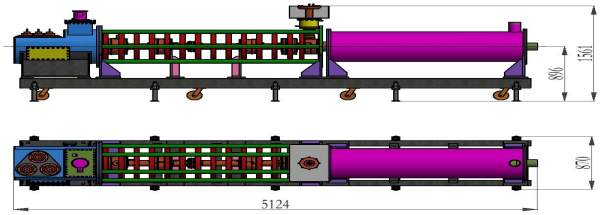
Future 5-Years Development Products

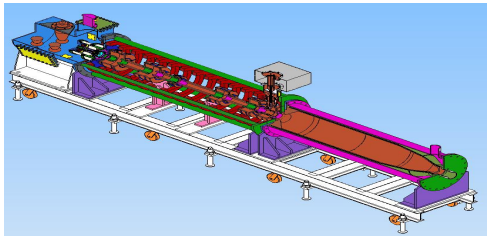
Klystron

Industrial X-Ray Tube



Accelerating Tube





Preliminary mechanical design for UHFKP8001

CEPC 650MHz Klystron

Yellow River Conservancy Commission

YREC grew out of the Reconnaissance, Planning, Design and Research Institute of Yellow River Conservancy Commission established under the umbrella of the Ministry of Water Resources in 1956. The scope of business covers a wide range of specialized fields: 1) planning of river basin and regional management and development, 2) study of major subjects in river management and development, and 3) investigation, designing, consulting, supervision, and construction, general contracting of water conservancy and hydropower projects, ecological and environmental improvements, buildings, highways, thermal power plants, public utilities and associated facilities. National key High-tech Enterprises, with National Enterprise Technology Center, with the first postdoctoral research workstation in the National Basin system.

YREC has accumulated rich experience in silt-laden river management and development; prepared hundreds of comprehensive and special plans oriented to harnessing and developing the Yellow River. It has undertaken a large number of large-scale engineering surveys and designs with domestic and international influence, such as the Yellow River Xiaolangdi Water Control Project, the Yellow River Guxian Water Control Project, the Middle Route Project of South-to-North Water Transfer, and the West Route of the South-to-North Water Transfer Project, Coca Codo Sinclair Hydropower Station etc. The projects cover more than 30 countries and regions in the country and the world.

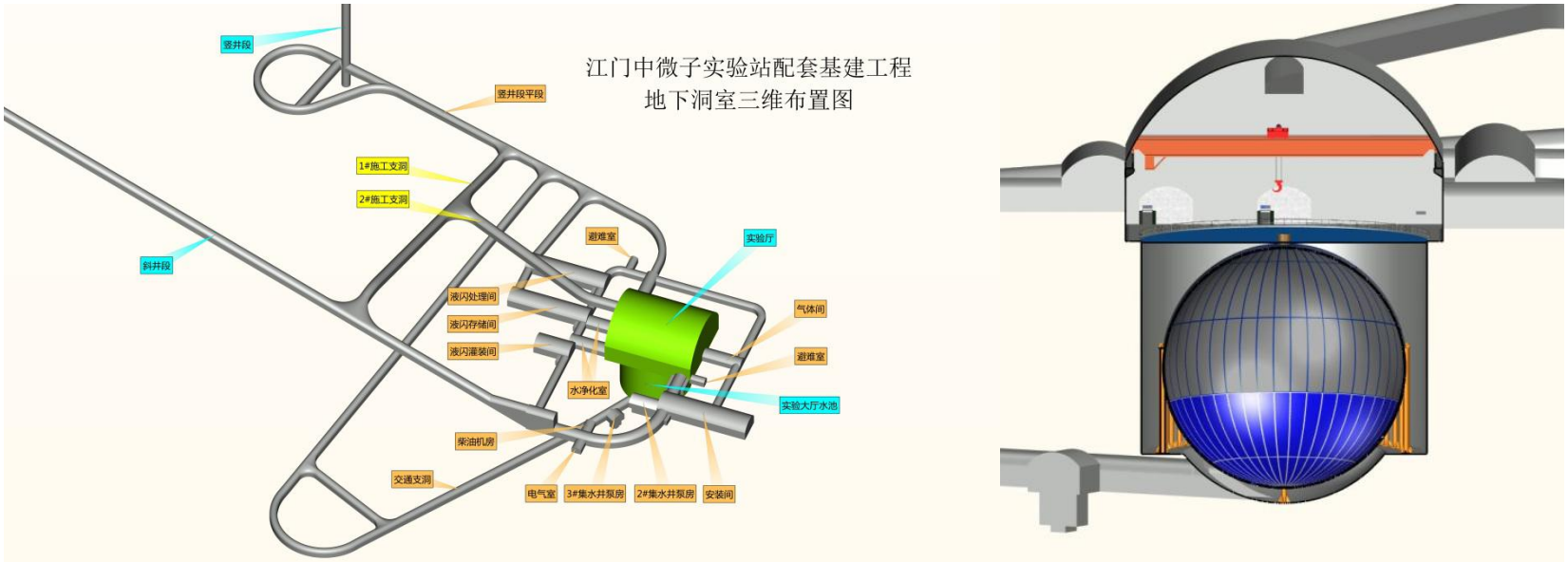
Project Case—Daya Bay Reactor Neutrino Experimental Station Construction Supporting Project

China•Shenzhen•Infrastructure Project

Underground works mainly include five underground laboratory halls, tunnels and a small amount of ground construction and facilities.

The main tunnel section is 2176m x 6.2m x 7.1m (length x width x height), and the size of the largest experiment hall(1#) is 42m x 19.30m x 25.15m (length x width x height).

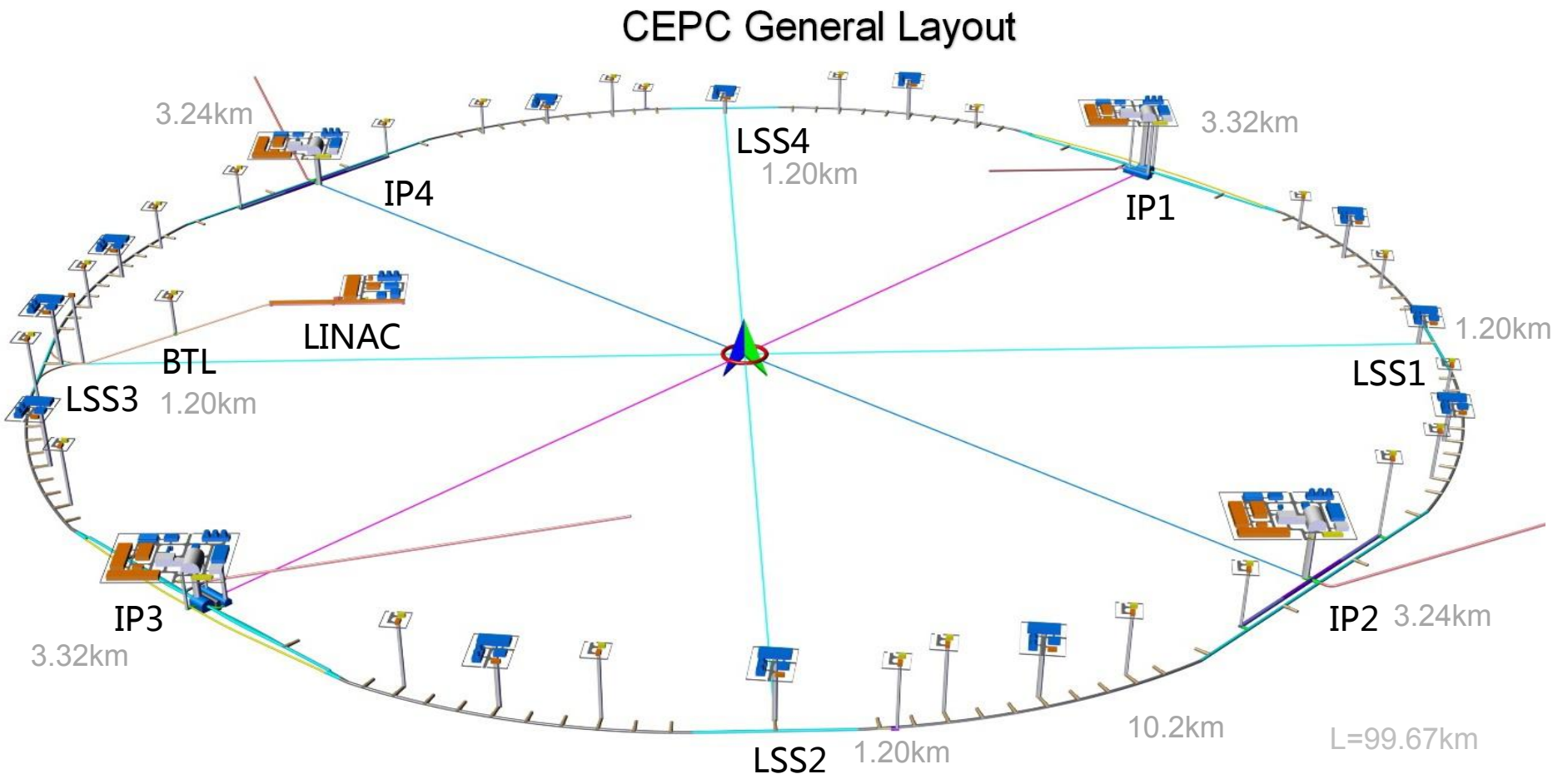
Project Case—Jiangmen Neutrino Experimental Station Supporting Infrastructure Project



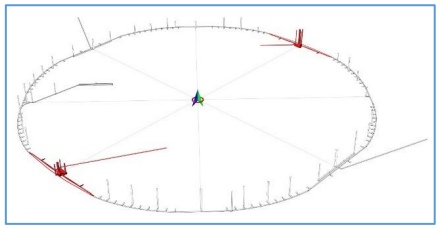
China•Jiangmen•Infrastructure Project

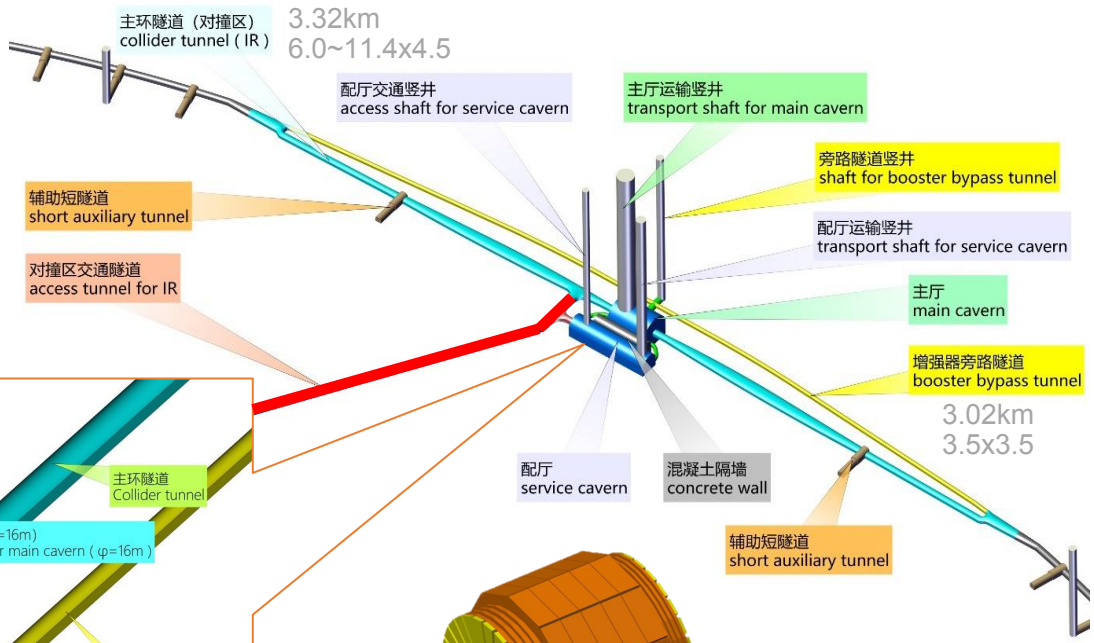
Underground works mainly include shafts, inclined shafts, experimental halls, and auxiliary caverns. The upper excavation section of the experimental hall is 55.65m×48.4m×27.4m (length×width×height). It is the largest underground cavern in China's public data.

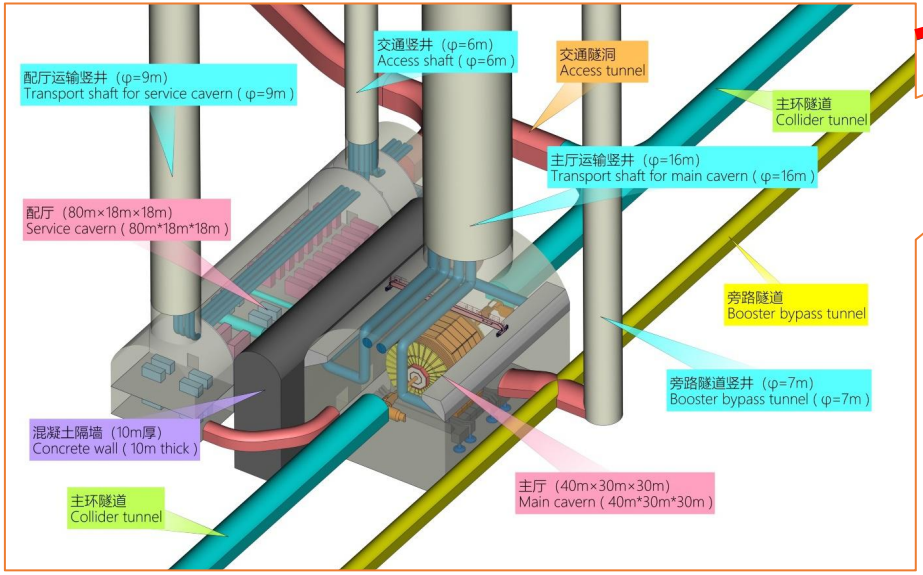
CEPC Civil Enginnering, Siting and Implementation

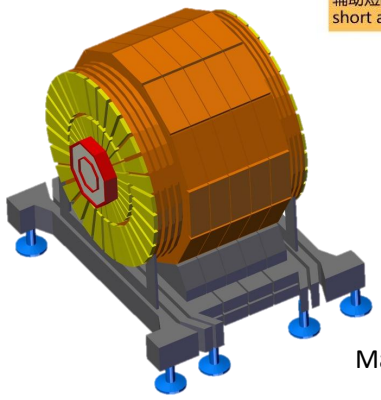


IP1 / IP3





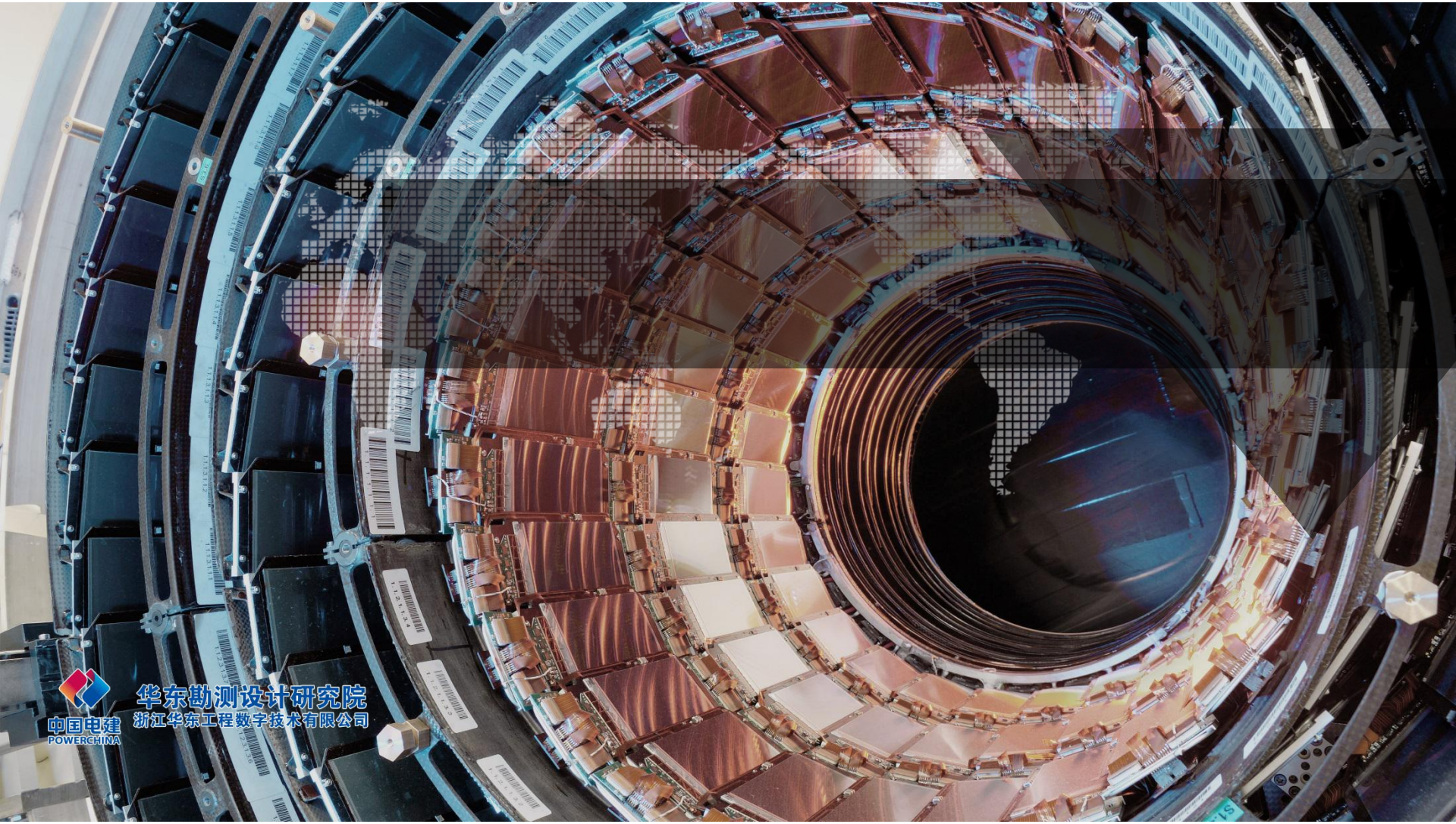




Main detector
主探测器

HUADONG Engineering Corporation Limited

(HDEC)



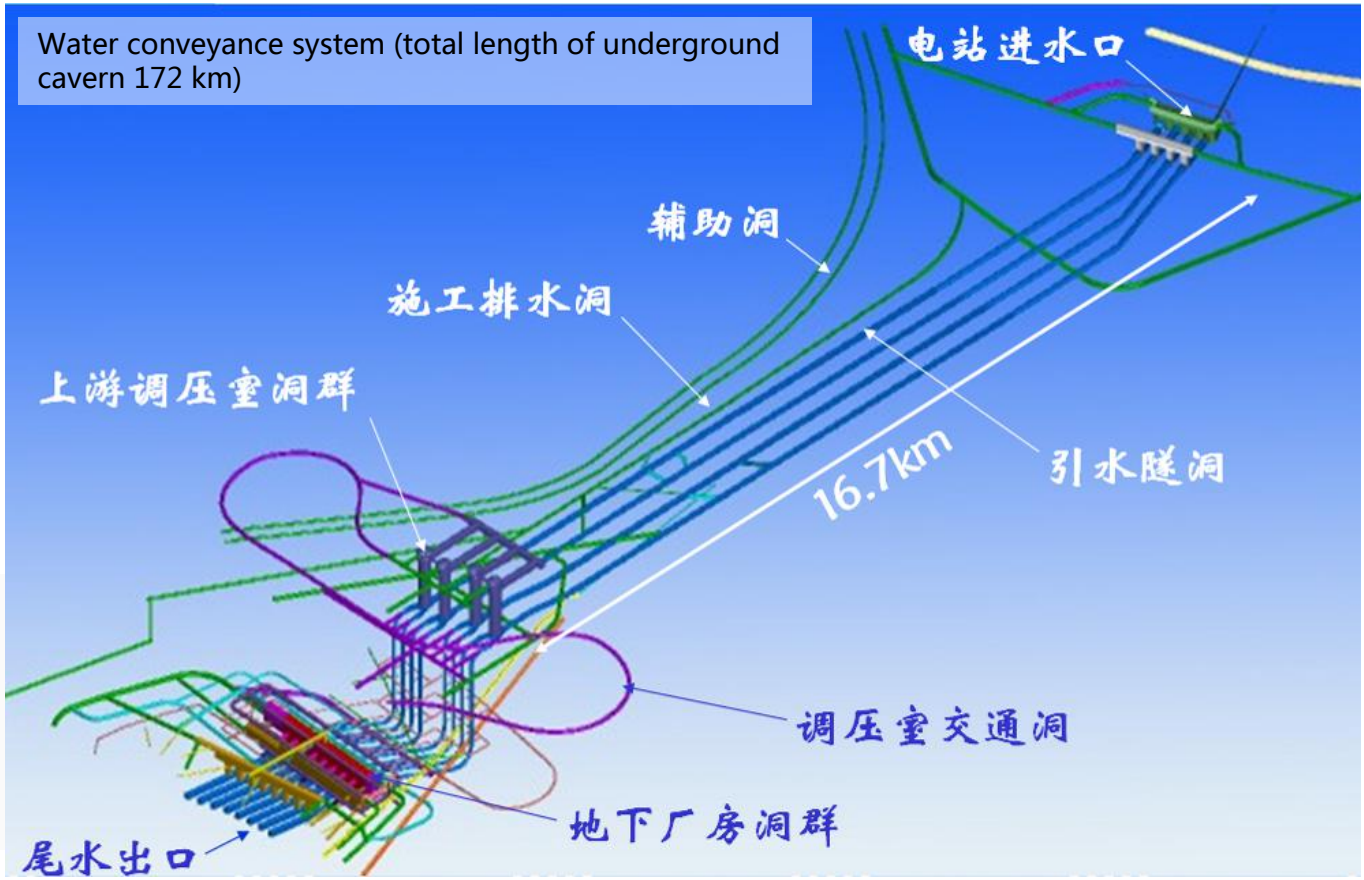
Jinping II Hydropower Station

Location：Sichuan Province, China

Installed Capacity：4,800MW(8X600MW)

Completion Year：2012

Project Characteristics：
It is the hydropower station with highest head, largest installed capacity and best efficiency on the Yalong River, and the long diversion-type development is adopted. There are four diversion tunnels with a length of about 17.6km each, maximum overburden thickness of 2525m and max. tunnel diameter of 13m. It is the hydraulic tunnel of the largest comprehensive scale in the world. Thick overburden, high geostress, groundwater and rock outburst involved in design and construction are all of the world-class technical problems.



Basic Physics Laboratory-Jinping Dark Matter Experimental Hall

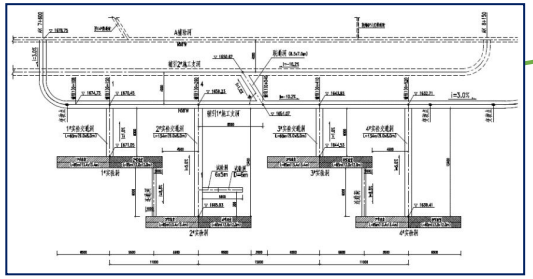
Underground Basic Physics Laboratory in Jinping II Hydropower Station

- The first deep underground laboratory in China
- 4,000 m3 (Phase 1)

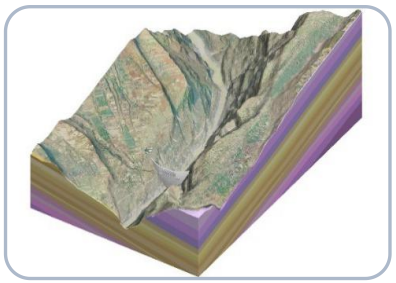
  120,000 m3 (Phase 2)
- Experiments conducted:

  Rock mechanics,Basic physics,

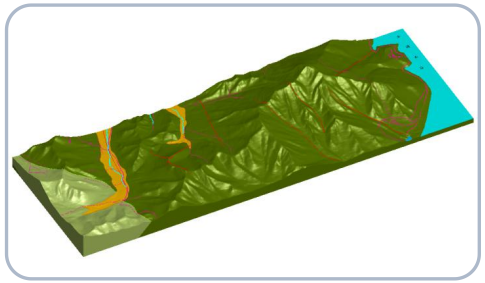
  Seismic research



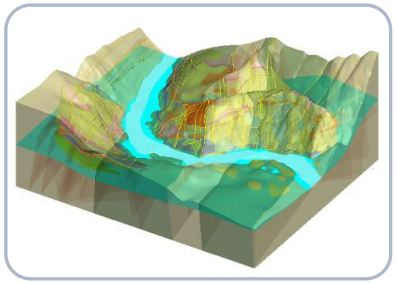
3D survey and design system for engineering geology- Display of project achievement



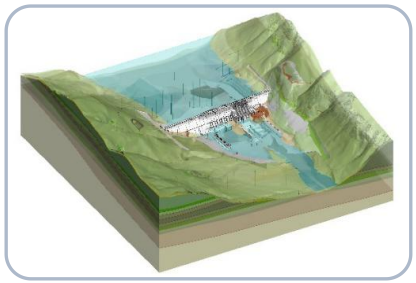
Baihetan Hydropower Station on the Jinsha River



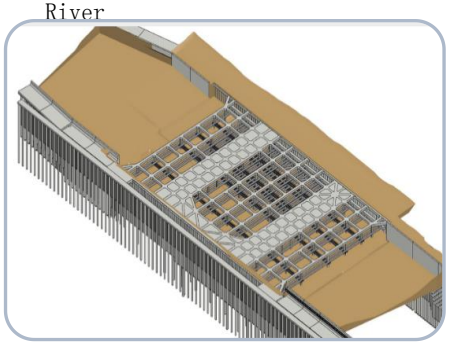
Urban Water Supply Project in Central Jilin



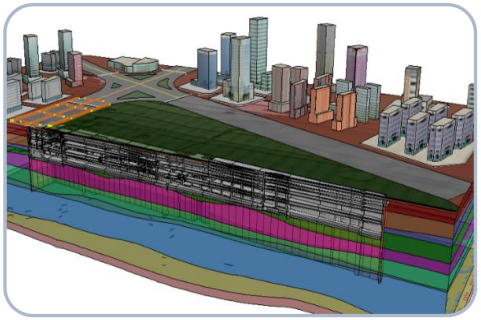
Miaowei Hydropower Station on the Lancang River



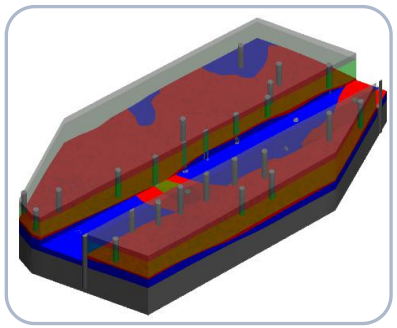
Longkaikou Hydropower Station



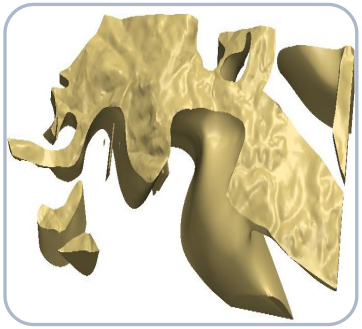
Reconstruction Project of Diandong Water Conservancy Project



Ningbo Metro Station

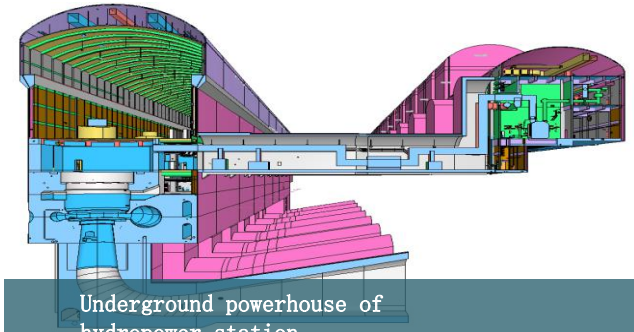


Wulin Station of Hangzhou Metro

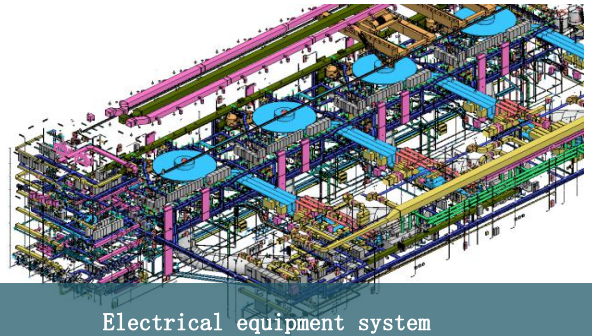


Yongtai Pumped Storage Power Station

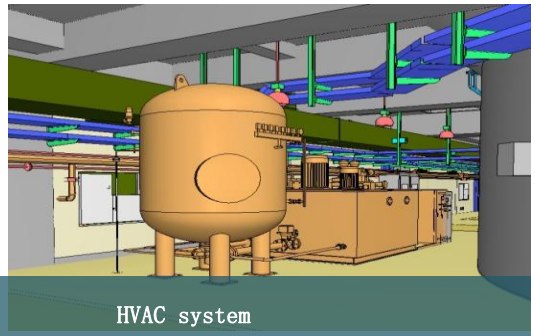
Display of plant 3D design system



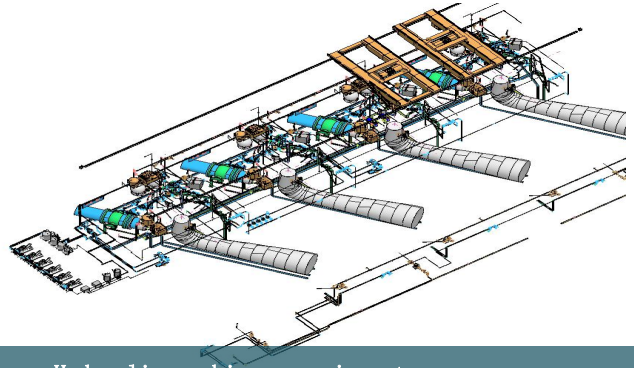
Underground powerhouse of hydropower station



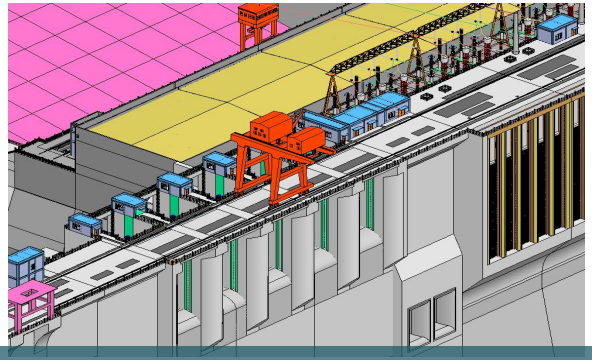
Electrical equipment system



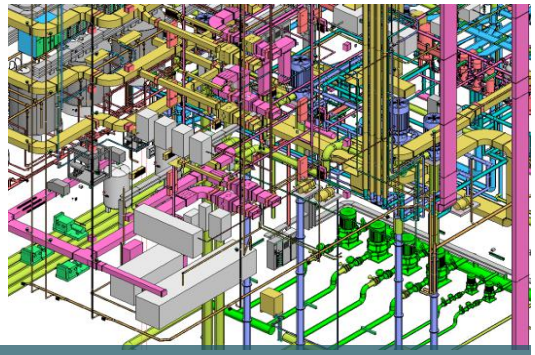
HVAC system



Hydraulic machinery equipment system



Hydraulic steel structure equipment system



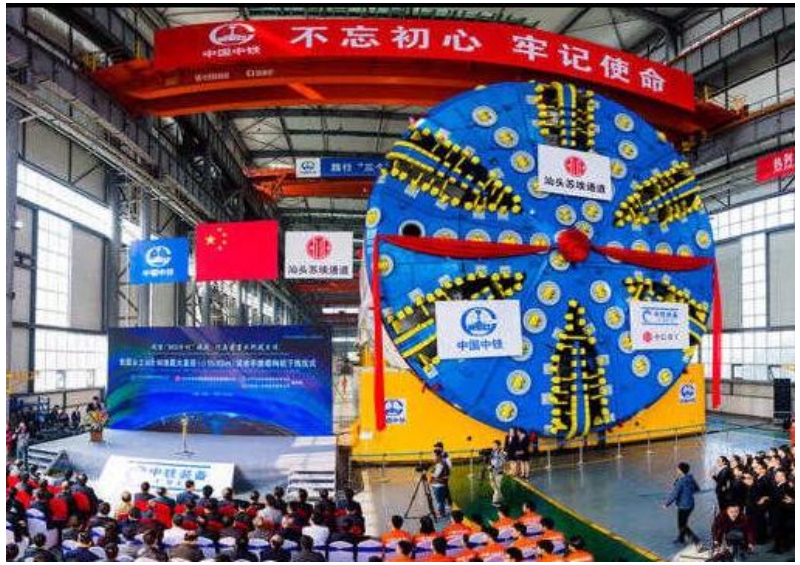
Water supply and drainage system

CREG (China Railway Engineering Equipment Group Co.,Ltd.)

中国中铁

CREG Underground Solutions

WIRTH



CREG (China Railway Engineering Equipment Group Co.,Ltd.) is a worldwide underground solutions provider for a full range of mechanized tunneling technology and services.

We draw together 3,000 employees including 500 designers to design and manufacture TBMs and associated equipment.

CREG products have been widely used in more than 30 cities in China and exported to many countries and regions including Malaysia, Singapore, India and Middle East. etc.

EPB TBM

Gripper TBM

Shield TBM

Slurry TBM

Product Range

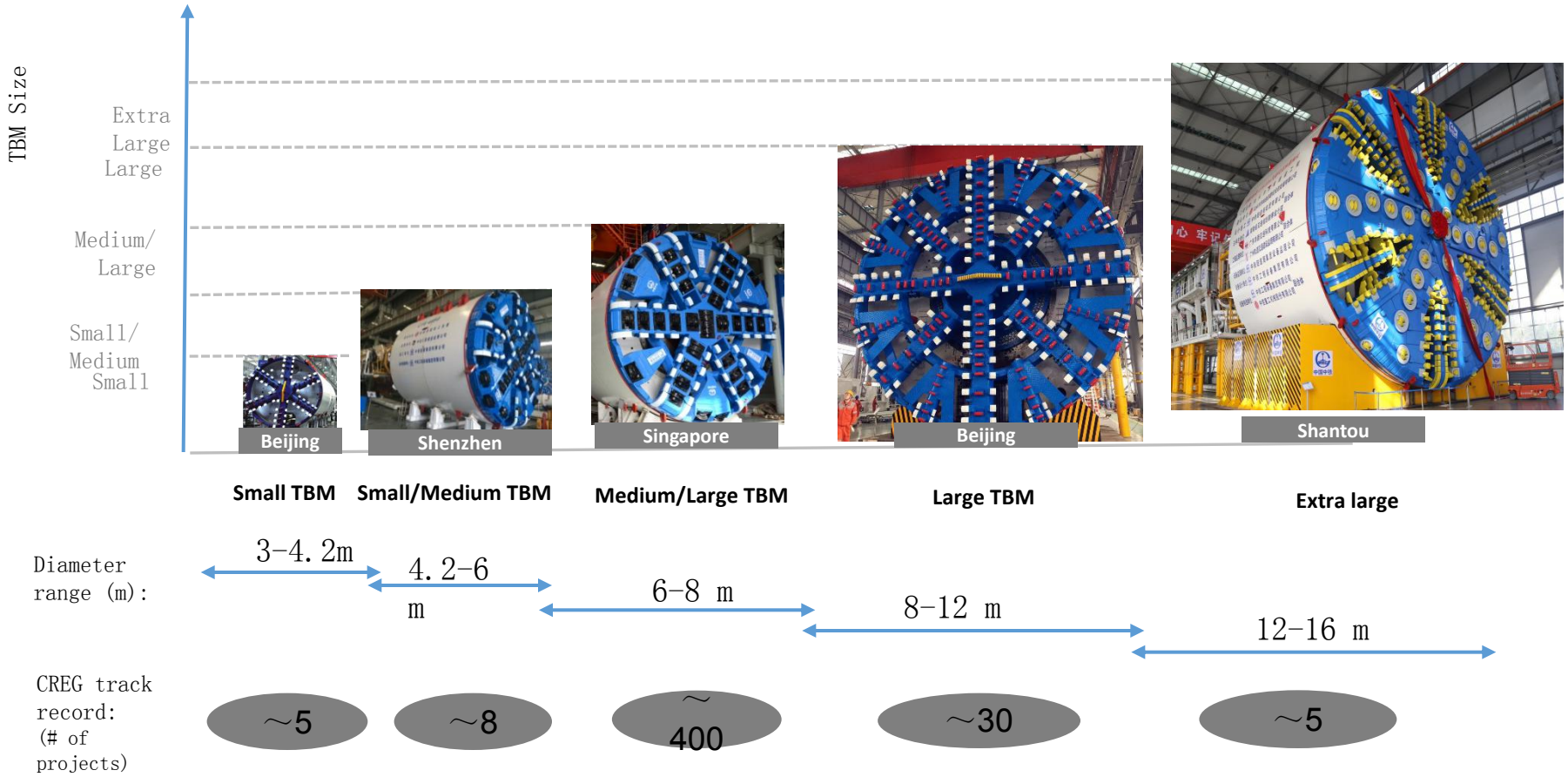
Reaming TBM

Rectangular TBM

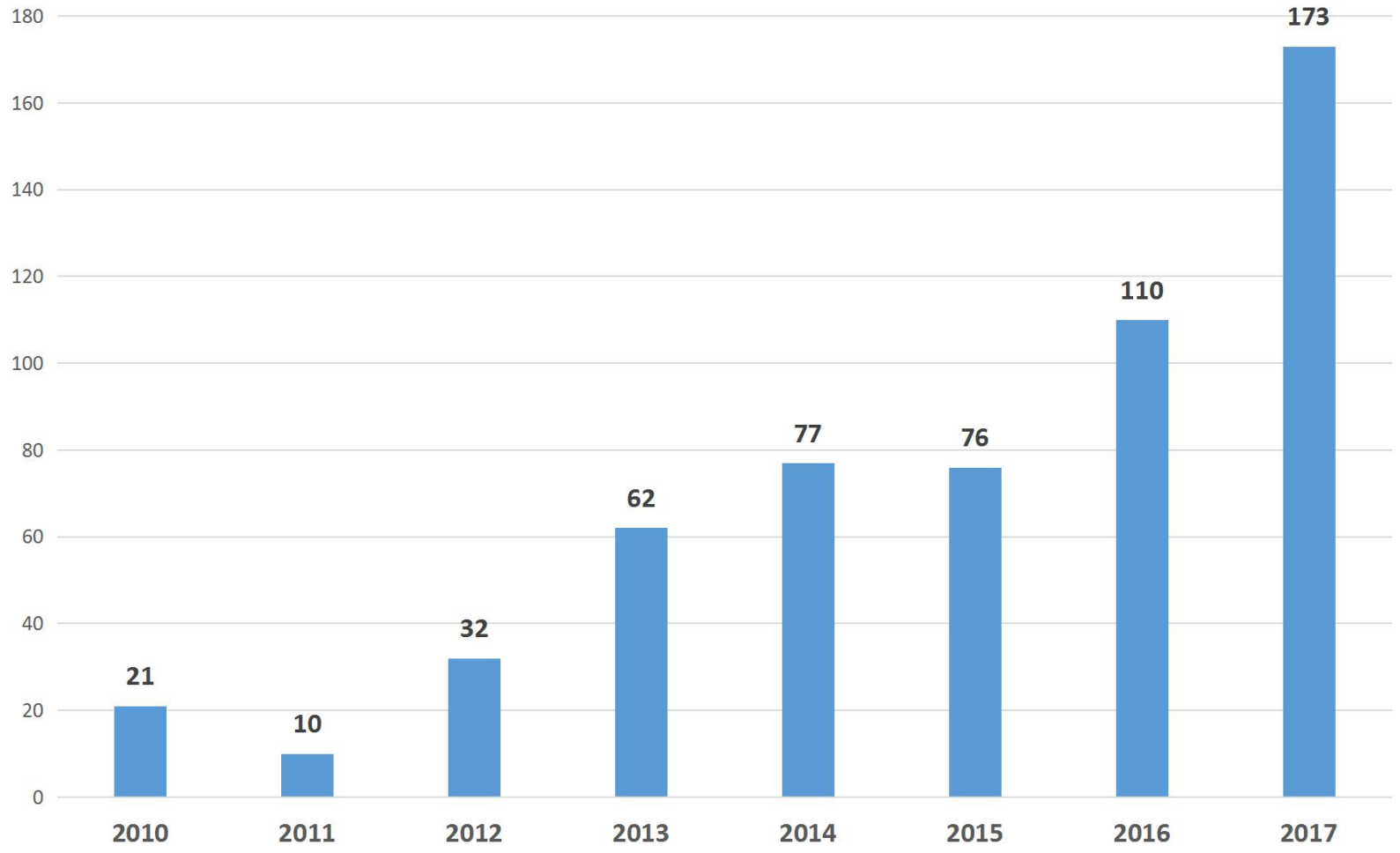
Pipe Jacking

Disc Cutters

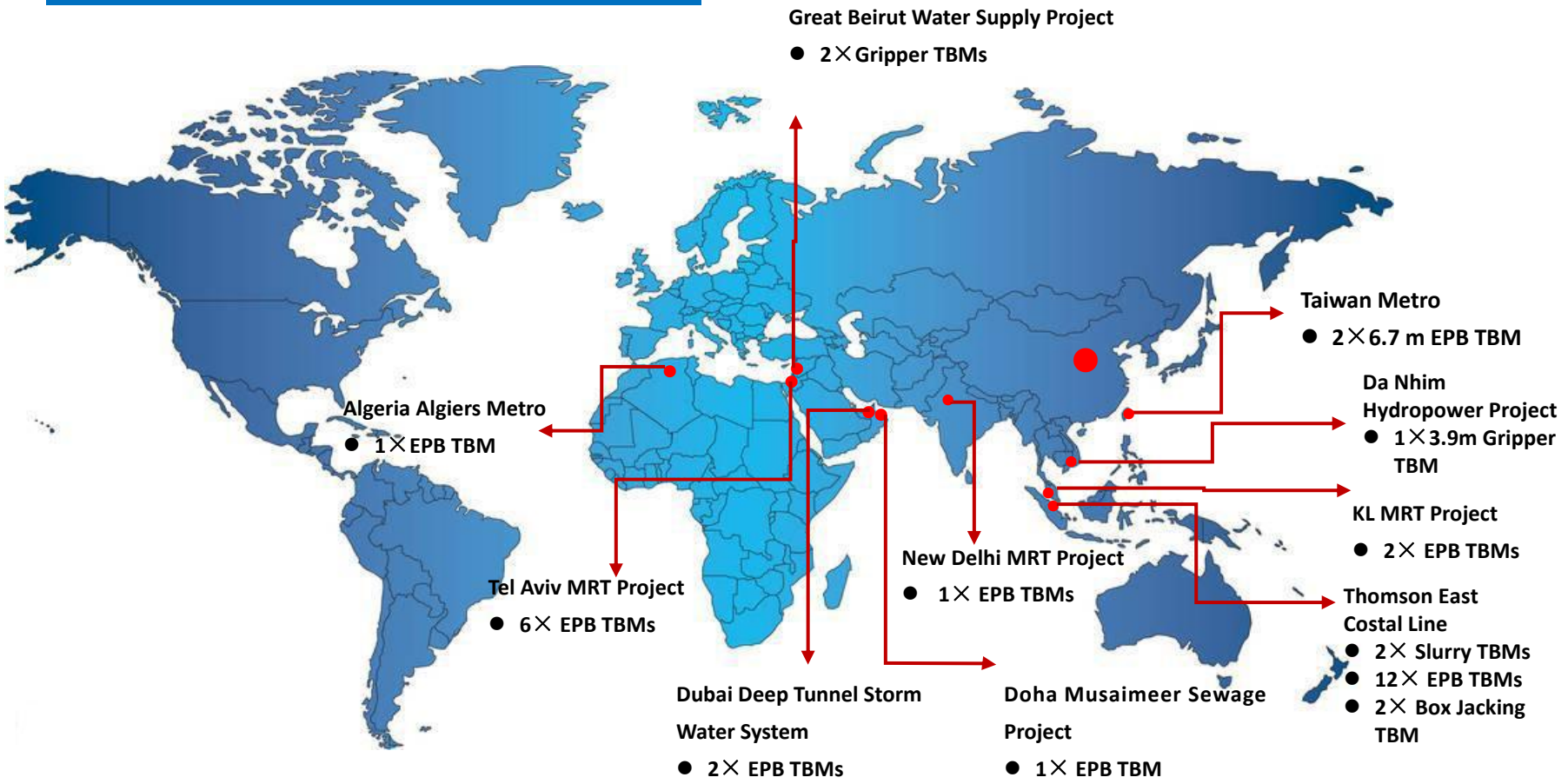
TBM is our main product, CREG has delivered TBMs (EPB & Slurry) over the entire diameter range relevant for tunneling projects



Number of CREG TBMs Delivered



CREG's Worldwide TBM Projects



- Drive Length: > 1000km
- Performance: hundreds of proven projects in over 40 cities

Malaysia, Singapore, India, Israel, Lebanon , Vietnam, Qatar, Algeria, UAE, Taiwan

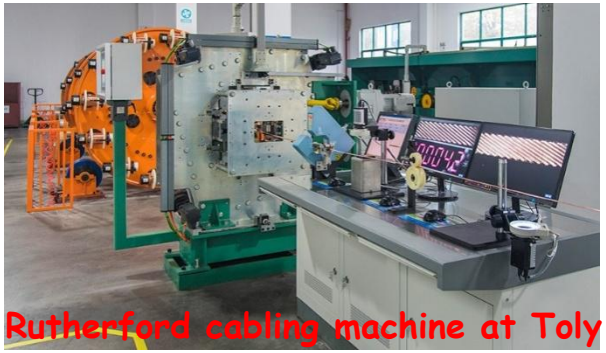
Superconducting Rutherford Cable R&D

西部超导

统力电工 TOLY ELECTRIC
永远环绕您的需求
Pursuing your needs forever

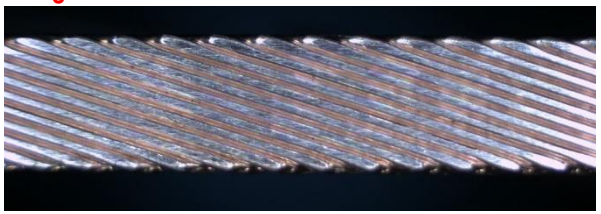
Collaboration between WST, NIN, Toly Electric and IHEP

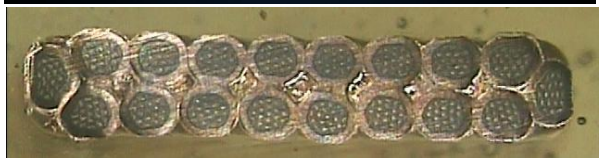
NIN



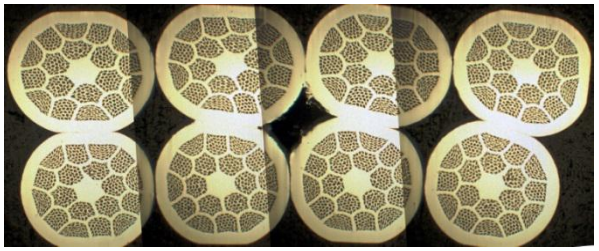
Rutherford cabling machine at Toly

Nb_3Sn Rutherford cable

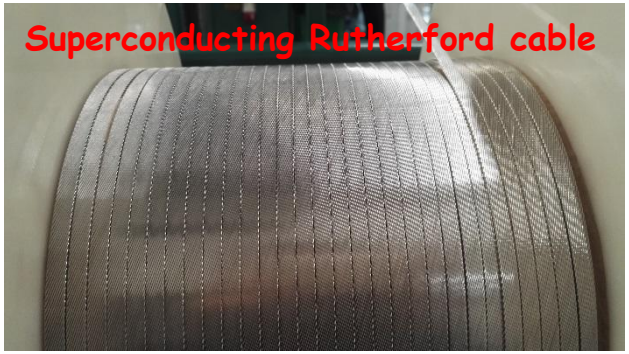




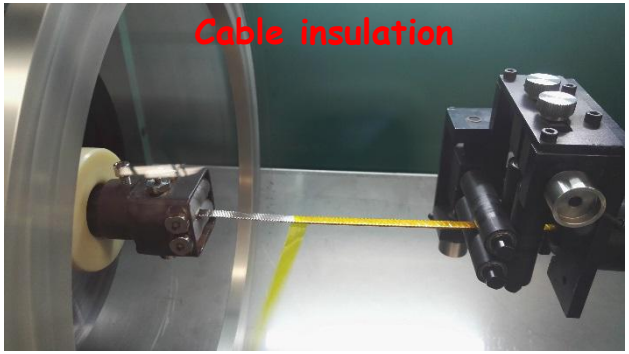
Bi-2212 Rutherford cable



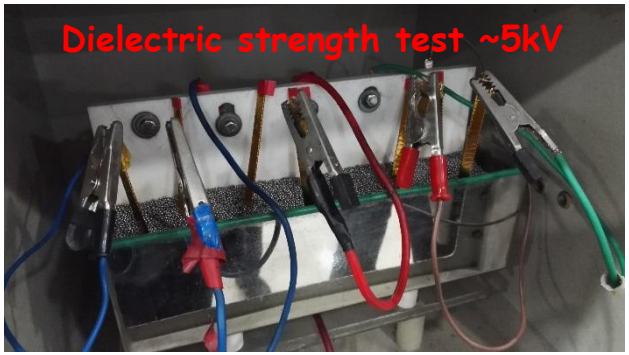
Superconducting Rutherford cable



Cable insulation



Dielectric strength test ~5kV



Insulated cable

China New Scientific Policies

January 23, 2018 : The China Reform and Development Committee (led by President J.P. Xi) had the meeting on Jan 23, 2018, and passed the plan of "Chinese Initiated International Large Scientific Plan and Large Sicentific Project"

March 28, 2018 : Chinese Government (led by Premier Minister Keqiang Li) made public details of "Chinese Initiated International Large Scientific Plan and Large Sicentific Project" :

...till 2020 China will prepare 3~5 projects (hopefully, CEPC is inside)and finally select 1~2 projects to construct...(hopefully, CEPC will be selected)

...Actively participate the other country or multicountries's initiated Large Scientific Pojects (hopefully, ILC will have good news from Japan at the end of 2018)

...Actively participate important international scientific organizations' sicientific projects and activities...

(translated by J. Gao)

Potential technical contribution to ILC 250GeV construction from China
(Just possibilities and hope, personal point of view)

Parameters	Value
C.M. Energy	250 GeV
Peak luminosity	1.35 x10^{34} $cm^{-2}s^{-1}$
Beam Rep. rate	5 Hz
Pulse duration	0.73 ms
Average current	5.8 mA (in pulse)
Av. field gradient	31.5 MV/m +/-20% Q_0 = 1E10
# 9-cell cavity	8012 (x 1.1)
# cryomodule	928
# Klystron	~200

Higgs factory (250GeV)

300 cryomodules (cold mass) or more? realistic

Three cavity production centers: 800-1000 cavities in total (ideal maximum case, needs great efforts…)

Damping ring magnets
Components like vacuum Chamber, etc
~1/3 or more?

Acknowledgements:

Thanks go to companyies who have kindly provided there information: Beijing HE-Racing Technology Co., Ltd;**Ningxia OSTEC; ChaoGao Zhuang (zhongshan) Scientific Technology Co., Ltd.;Wuxi Creative technologies Co., Ltd.;Kunshan GuoLi Electronic Technology Co., Ltd. ;Yellow River Conservancy Commission;HUADONG Engineering Corporation Limited (HDEC);*WST, NIN, Toly Electric***

Thank you for your attention