



Mega-Science Projects in China and their Economic Impact

China has been using mega science projects to create or accelerate local economies. This paradigm with respect to laboratory, industry, and university collaboration is not only of significant interest but also unique. This presentation will explain the Chinese approach and provide specific examples of the benefits experienced.

The Scientific Geography of China



The Science of China



HIRFL



BEPC



BEPCII

China

E.T. calling? Researchers who possess a **quantum radar** technology that is part of the global very long baseline array to observe the most distant objects in the universe.

Ronans for solstices? Prospects for Team Spain oil fields are looking promising. Industry support for basic research in geology, paleontology, and chemistry.

Archaeology lamp. A lack of research funds has kept archaeologists from excavating the burial mound of Qin Shihuangdi, the first emperor of a unified China.

Lost location. Tibet's Yangbajain Observatory captures energetic cosmic-ray particles in the thin, crystalline air high in the Himalayas.

Hub city. Like Chicago, Wuhan is a communications hub with a leading university and institutes, which are noted for research on optical fibers, telecommunications, rice breeding, and biological pest control.

Jurassic cemetery. China's major dinosaur fossil site is the 140-million-year-old deposit at Zigong.

Valley of diatoms. Astronomers dream of a \$200 million international radio observatory with dozens of dishes tucked into astronomically superb valleys in an undeveloped region of isolated Guizhou province.

Fossil trees. The 350-million-year-old Chongqing fossil beds rank with the Burgess shales as a record of early evolution. Discovered just over a decade ago, only 200 meters of the 30-kilometer beds have been excavated.

Southern independence. Guangdong province takes the lead among local governments in supporting research to revive its economic furnace. Top institutions include **South China University** (Sun Yat-sen) University and **South China Agricultural University**.

Right now world. Biotechnology. **North Island** is the site of field tests of genetically modified plants on a scale unknown in the West. Even larger field tests are going on in central Hunan province.

Science island. Provincial capital is home to elite **University of Science and Technology of China**, the national synthesis research center, and four CAS institutes on a key island whose "major" is host of the local CAS branch.

Advanced and. Three space launch facilities handle China's needs for reconnaissance, communications, weather, and research satellites.

Heavy metal. Industrial Shenyang is home to the highly rated Institute of Metal Science, specializing in advanced amorphous metals and directed by one of China's top female scientists.

Mixed in the Miaoan. Avian and plants that lived 15 million years ago by an undisturbed lake are superbly preserved in Shaanxi.

Who's on first? Scientists at Nanjing University are running neck-and-neck with Peking University for prominence in international journals. Purple Mountain observatory has made the area a leader in astronomical instruments.

Shanghai surprise. Municipal and regional authorities are pumping funds into Fudan and other major universities, a new life science research center, a biotech park, a 3.5-generation synchrotron radiation facility to join 16 CAS institutes and 24 state key labs in bid for high-tech leadership.

Model city. Singapore is planning a 70-square-kilometer, self-contained replica of itself east of the ancient city of Suzhou. The township could have 600,000 people by 2020 and be a magnet for multinationals and high-tech industries.

East of darkness. Fujian province, home of the Chinese diaspora, now focuses on trade with Taiwan. Xiamen University boasts a top-rated state key lab for physical chemistry of the solid surface.

Silk partnership. Although Taiwan remains China's political nemesis, it is also China's largest trading partner, for products ranging from toys to computers, and is scientific collaborator in a growing number of projects.

Deep pockets. Will Hong Kong investment Japan Li Ke-Qiang's \$110 million gift propel Shanghai University into the front ranks? Stay tuned.

Brain drain. Booming Special Economic Zones like the city of Shenzhen are siphoning off talented youths who might otherwise have chosen science.



DYB Neutrino



YBJ Cosmic Ray Obs.

The Science of China

HIRFL

BEPC

BEPCH

China

HIRFL-CSR

CEFR

BRIF

SSRF

SG-ICF

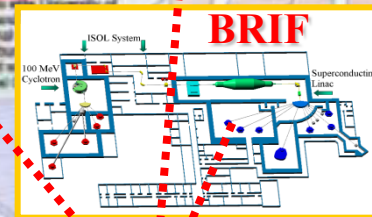
DYB Neutrino

YBJ Cosmic Ray Obs.

Dragon-1

HLS

EAST



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Leafy forest. The Yangtze River Observatory captures energetic cosmic-ray particles in the thin, crystalline air high in the Himalayas.

Hub city. Like Chicago, Wuhan is a communications hub with a leading

性能: 20MeV
流强: 2.5A
束斑: 1.1mm

处于世界领先水平,“神光一号”直线激光加速器

Valley of silence. Astronomers dream of a \$200 million international radio observatory with dozens of dishes tucked into acoustically superb valleys in an unspoiled region of isolated Gubei province.

Fossil trees. The 350-million-year-old Chongqing fossil beds rank with the Burgess shales as a record of early evolution. Discovered just over a decade ago, only 200 meters of the 30-kilometer beds have been excavated.

500 km

Center for reconnaissance, communications, weather, and research satellites

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South paragon. Although Taiwan remains China's political nemesis, it is also China's largest trading partner, for products ranging from toys to computers, and is a scientific collaborator in a growing number of projects.

Deep pockets. Will Hong Kong investment supercede Li Ke-qiang's \$110 million gift to Shanghai University into the front ranks? Stay tuned.

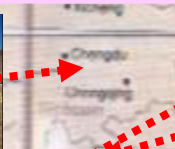
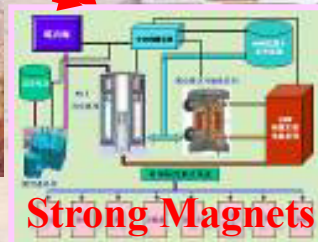
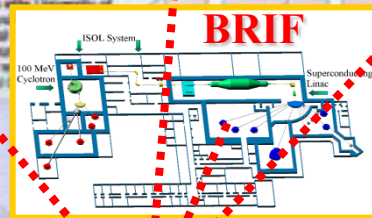
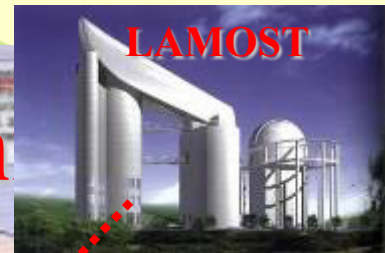
Brain drain. Booming Special Economic Zones like the city of Shenzhen are siphoning off talented youths who might otherwise have chosen science.

Counting down. With less than 20 months left before Beijing lands zero, Hong Kong is going all out to become an R&D base for China. The ultramodern University of Science and Technology appears to be China's top scientific center by a landslide.

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Accelerator-based Mega-science Projects in China and Their Impact on Economy

ZHANG, Chuang
IHEP

Second International Accelerator Conference
September 7, 2011, San Sebastian, Spain

ACKNOWLEDGEMENT

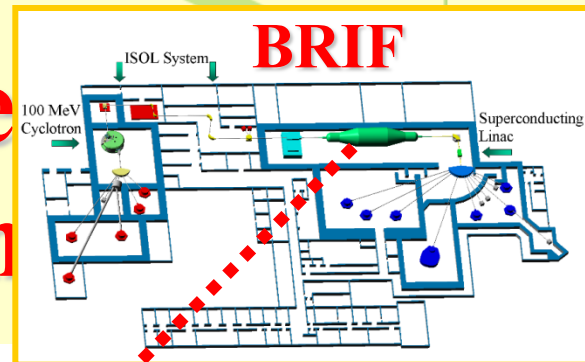
The speaker is grateful to M.W.Fan of CIAE, Y.J.Yuan, X.H.Cai and D.Q.Gao of IMP, H.P.Yan of SINAP, W.M.Li and Y.L.Hong of USTC, K.Z.Zhang of CAEP, R.J.Shi, C.X.Ma, J.B.Zhao and Y.Y.Zhong of IHEP for providing material, comments and many stimulating discussions. He would like to thank all the colleagues who have been working at the projects and their technology transfer.

Outline

- **Accelerator-based mega-science projects in China**
- **Impact of the accelerator projects to economy**
- **Collaboration between academia and industry**
- **Concluding remarks**

1. Accelerator-based mega-science projects in China



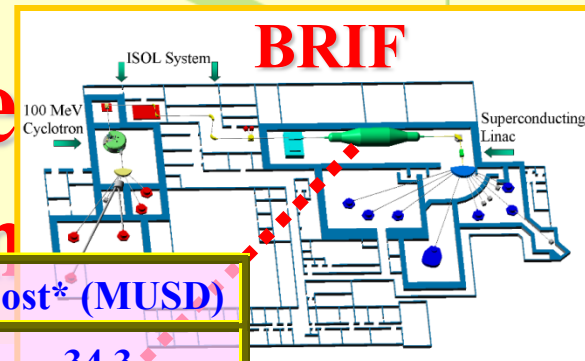




HIRFL-CSR



BEPC & BEPCII



BRIF

Machine	Host Lab	Constr. Period	Cost* (MUSD)
BEPC	IHEP	84-88	34.3
BEPCII	IHEP	04-09	91.4
HLS-I	NSRL	84-89	11.4
HLS-II	NSRL	99-04	16.9
HIRFL	IMP	84-89	32.9
HIRFL-CSR	IMP	00-08	49.1
DRAGON-1	CAEP	98-03	42.9
SSRF	SINAP	05-09	187.7
BRIF	CIAE	11-	55.7
CSNS	IHEP	11-	238.6



CSNS



HLS

1.1 BEPC and BEPCII (THPZ012...)

$1 \times 10^{31} \text{cm}^{-2} \text{s}^{-1}$

$1 \times 10^{33} \text{cm}^{-2} \text{s}^{-1}$

1. 2. 第一對撞點實驗室
4. 高頻站
7. 輸運線隧道
10. 核物理實驗室
12. 同步輻射實驗東廳

3. 儲
5. 第
8. 直
11. 輸
13. 同

Storage Ring(s)



北京正負電子對撞機

隧道
走廊
中心

Injector



BES Detector



BSRF



Electron Collider

- Experi. hall
- on of ring mag. and computer center
5. 2nd I.R. Experi. hall
7. Tunnel of Trans. line
9. Klystron gallery
- Experi. hall
11. Power sta. of trans. line
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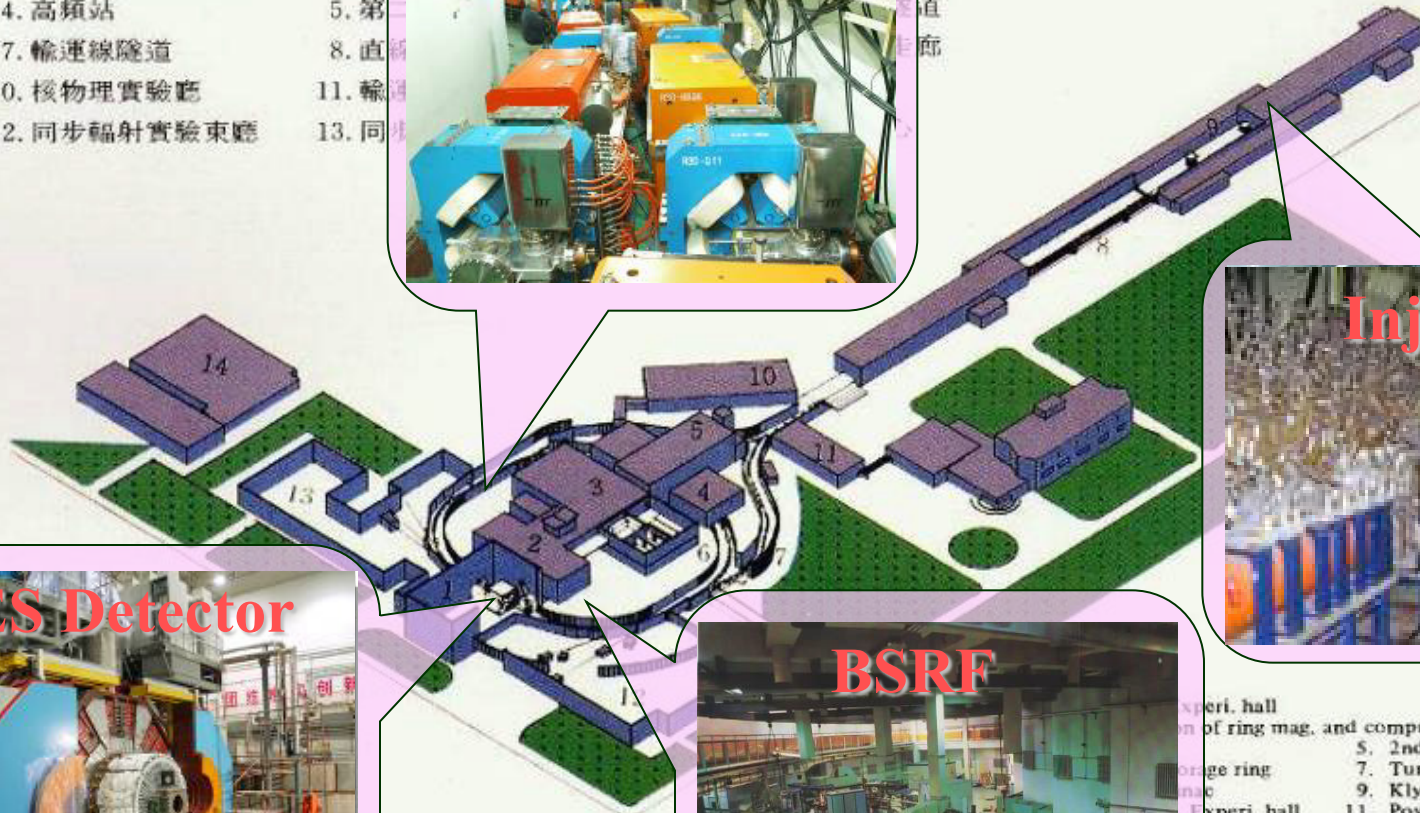
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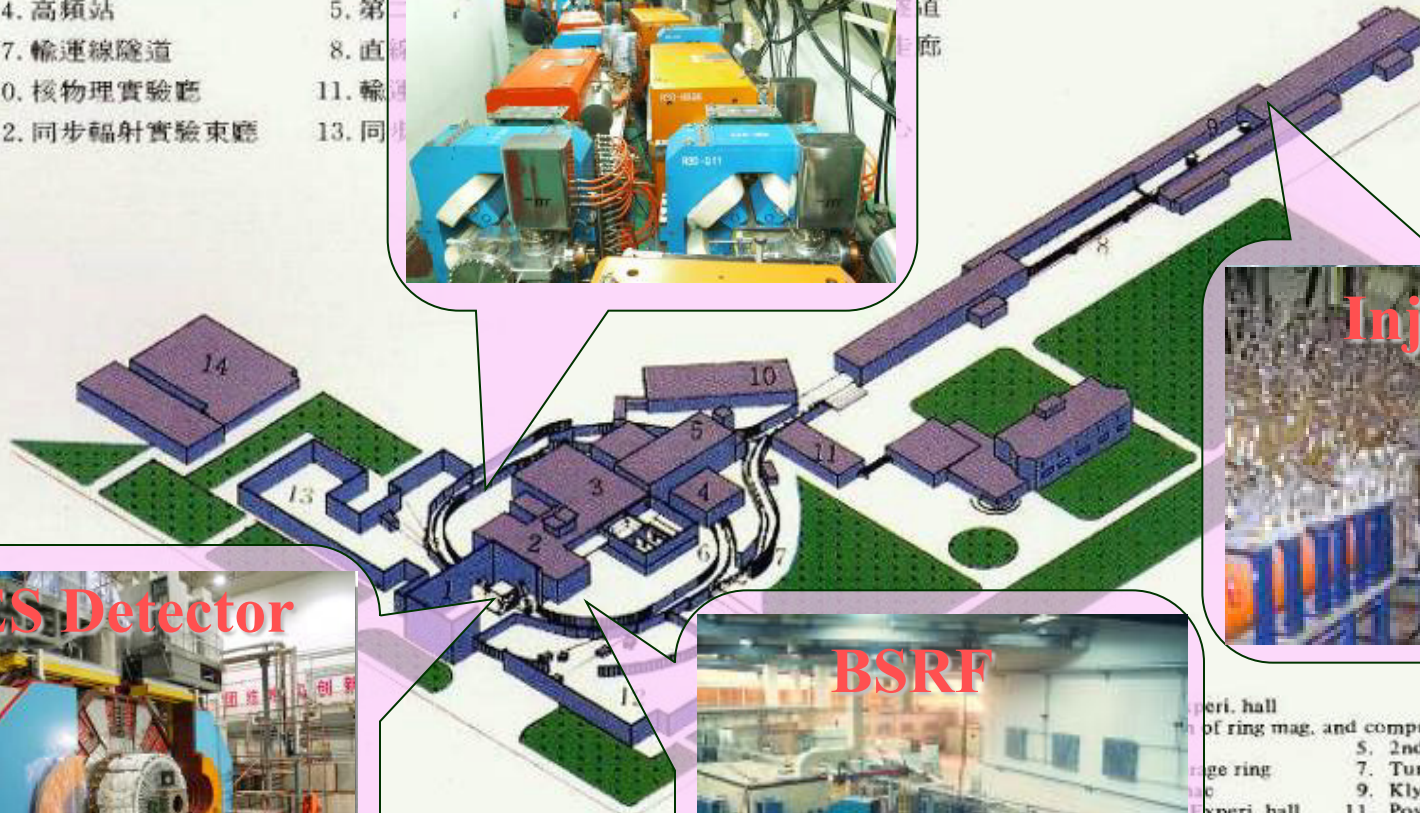
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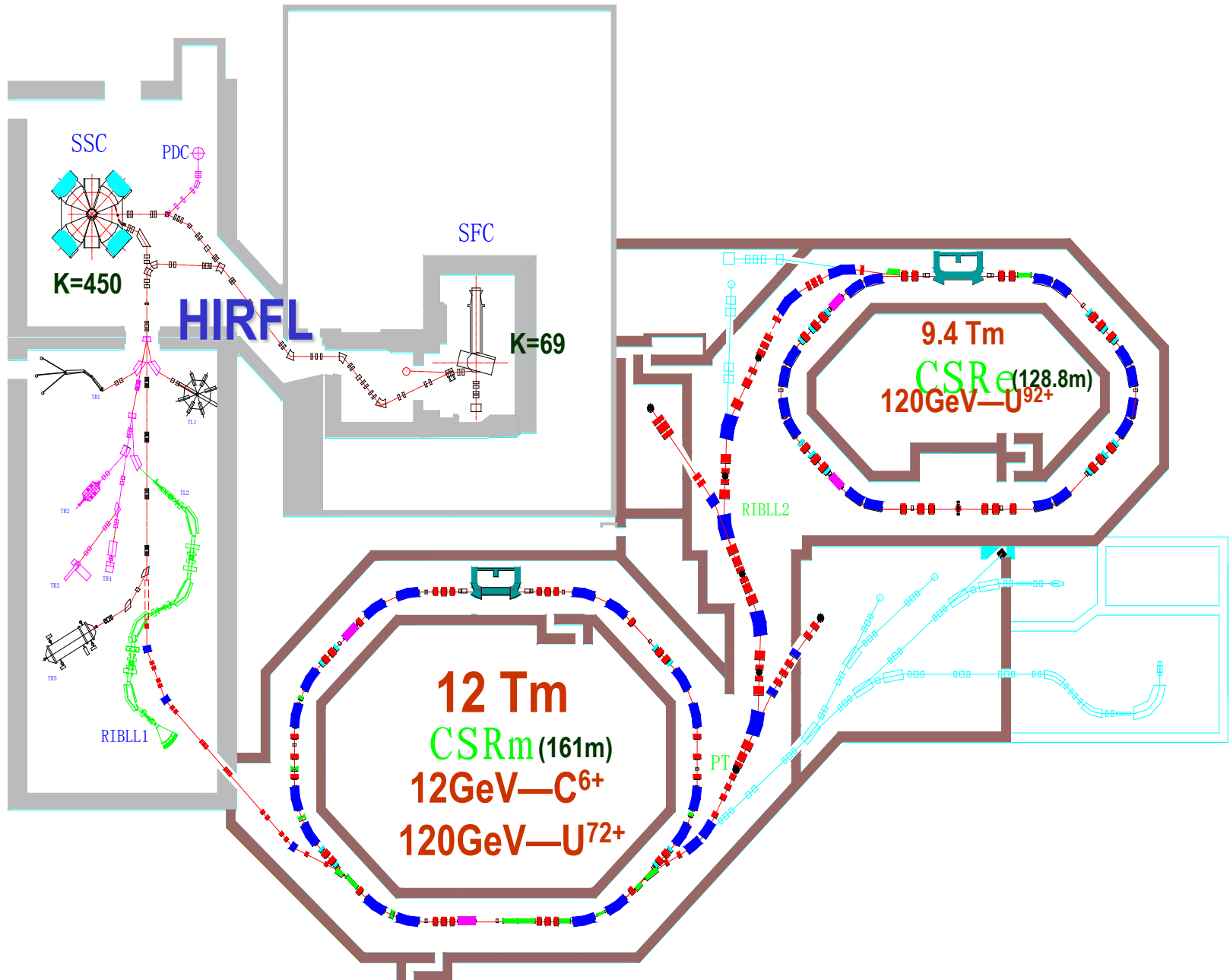
BSRF

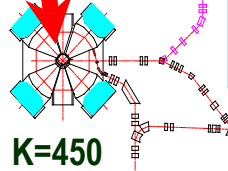


Electron Collider

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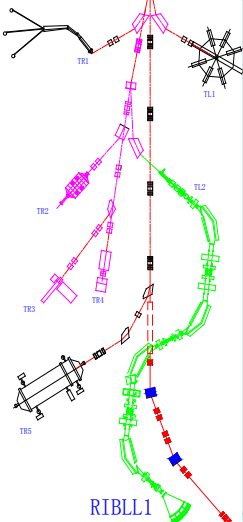
1.2 HIRFL LCCP





K=450

HIRFL



RIBLL1

SFC

K=69

9.4 Tm
CSRe (128.8m)
120GeV—U⁹²⁺

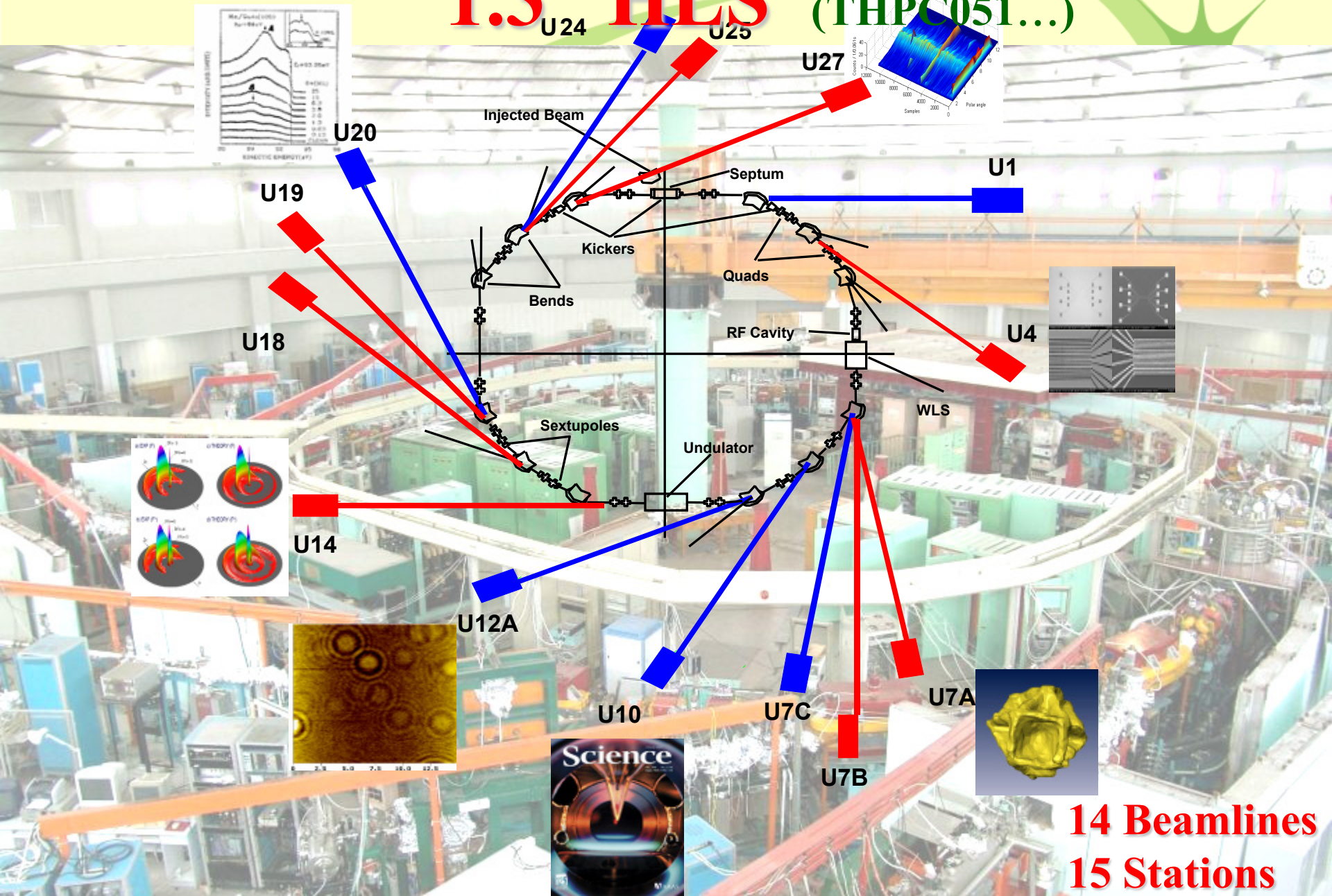
RIBLL2

12 Tm
CSRm (161m)
12GeV—C⁶⁺
120GeV—U⁷²⁺

PT



1.3 HLS (THPC051...)



14 Beamlines
15 Stations

1.4 SSRF (TUPC116...)

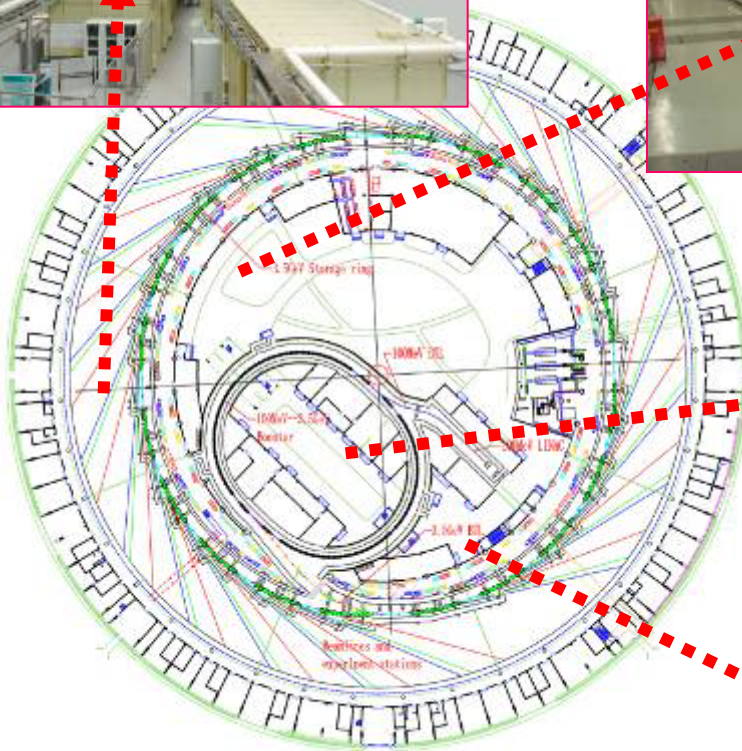


1.4 SSRF (TUPC116...)



$\epsilon_{x0}=3\text{nm}\cdot\text{rad}$
 $I_{\text{beam}}>300\text{mA}$

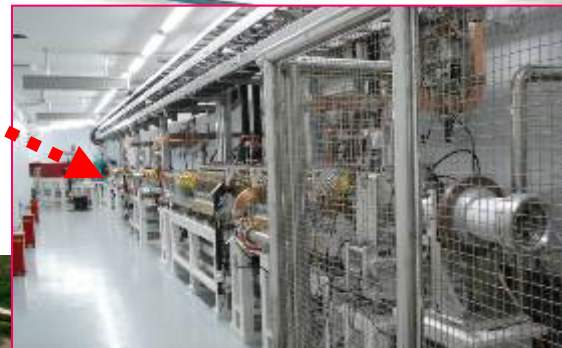
Storage Ring
3.5GeV, C=432m



Booster
3.5GeV, C=180m



Electron Linac
150MeV



1.5 Dragon-I Induction Linac

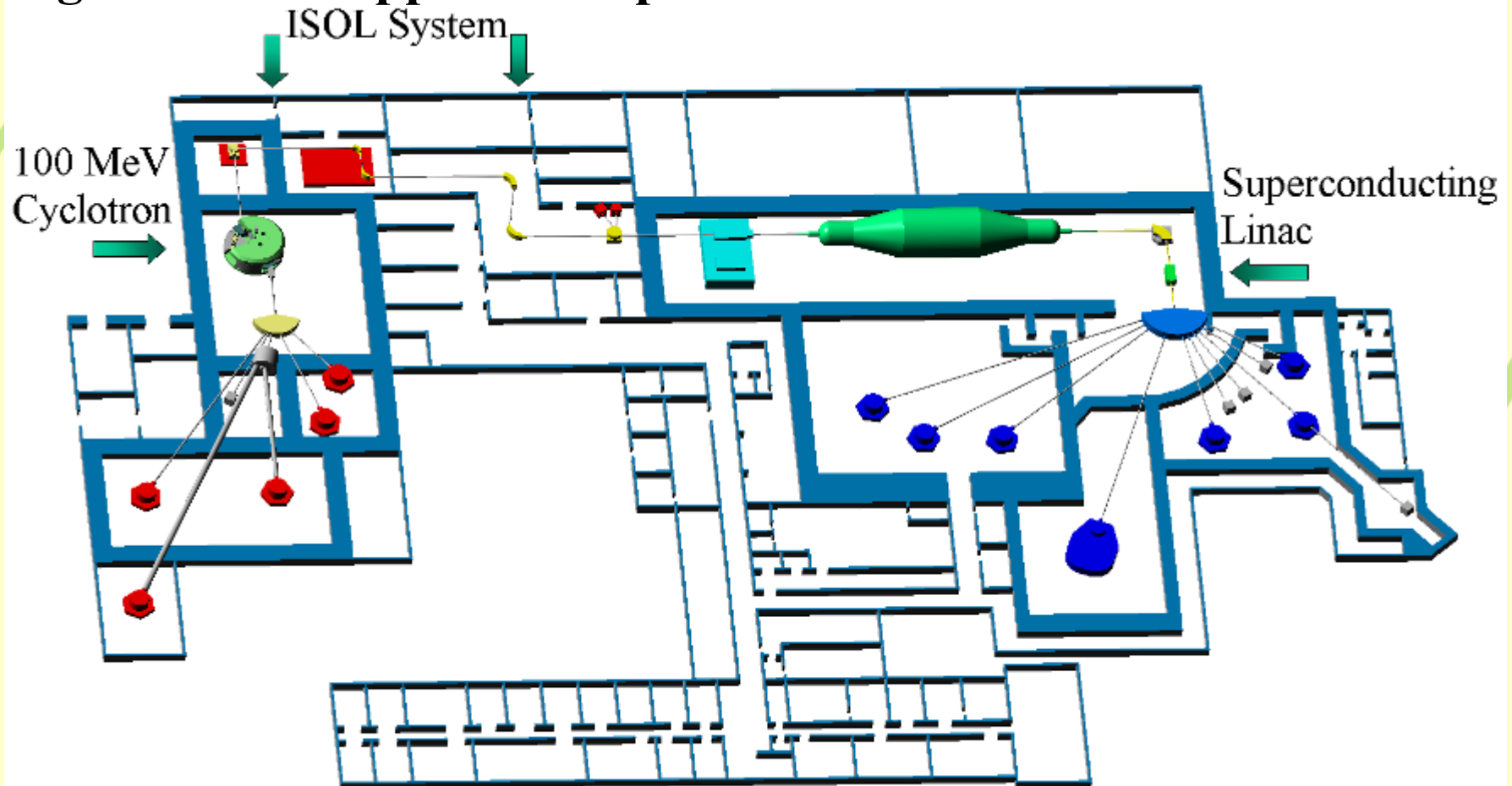


1.5 Dragon-I Induction Linac

	LIAXFU (CAEP)	DARHT-I (LANL)	AIRIX (CEA)	Dragon-I (CAEP)
Current	2.2kA	1.7kA	1.92kA	2.53 kA
Energy	12MeV	18~20MeV	18~20MeV	18.34 MeV
Spot size	~ 4mm	~ 1.3mm	~ 1.4mm	~ 1.1 mm
X-ray Dose	0.036 C/kg	0.08C/kg	0.09C/kg	0.11 C/kg

1.6 BRIF

The project is under construction. More than 40 proton-rich and 80 neutron-rich radioactive ion beams with beam intensity higher than 10^6 pps will be provided.



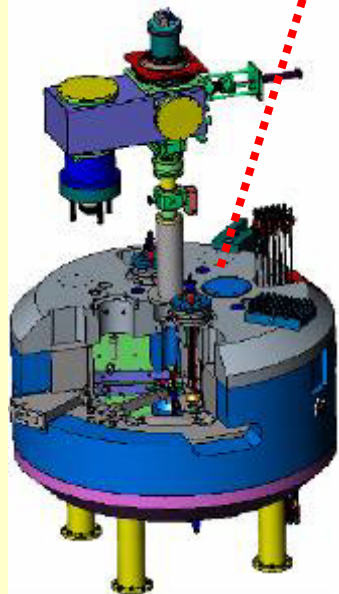


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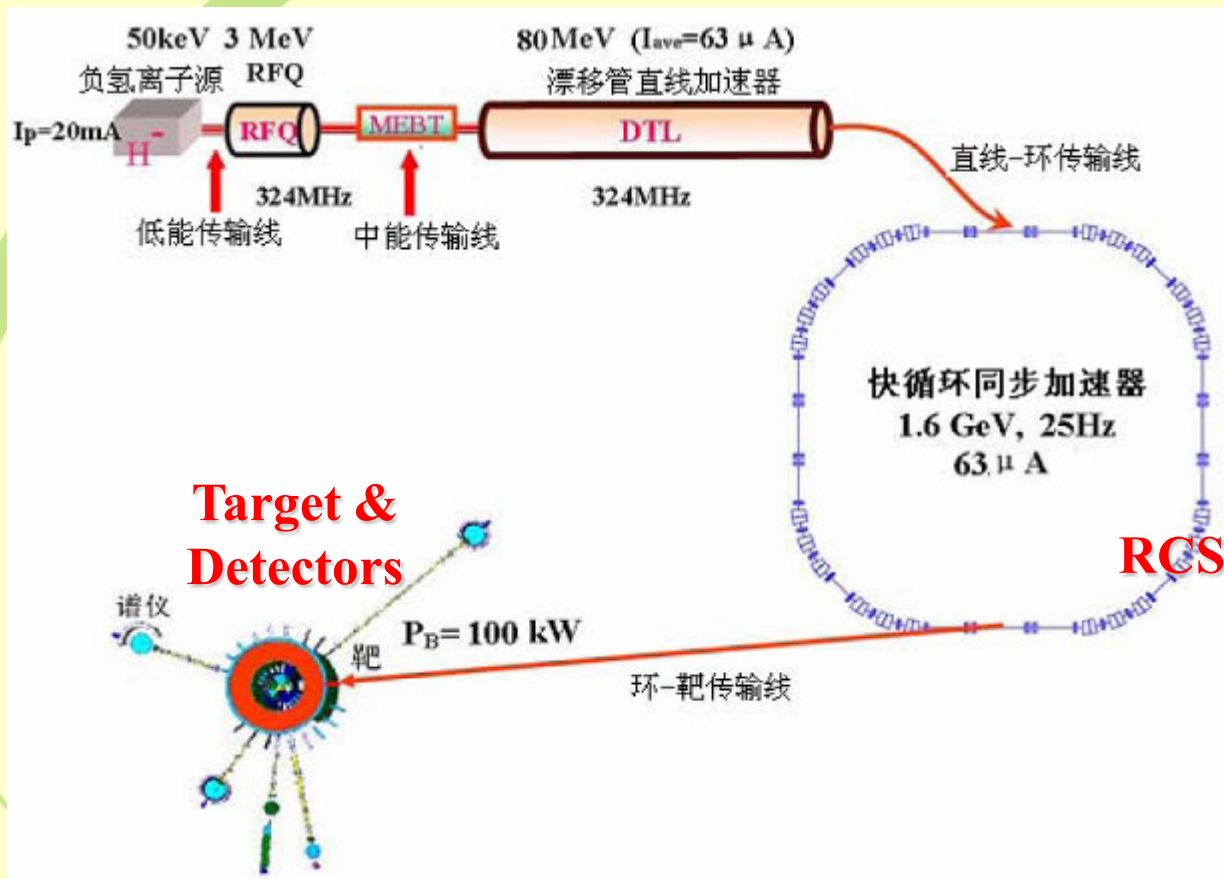
ISOL System

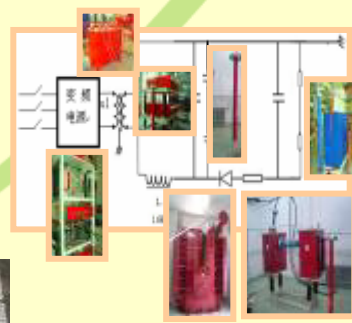
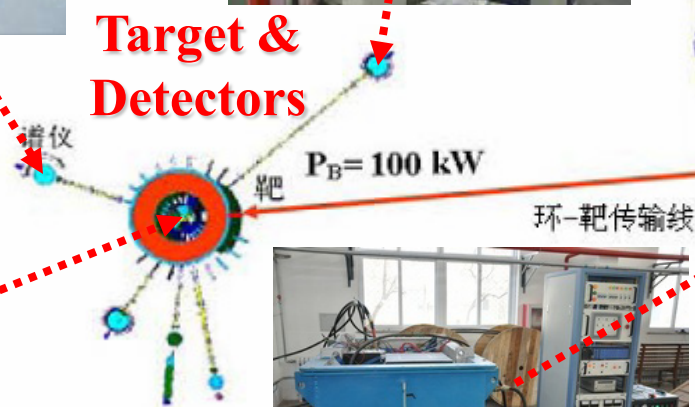
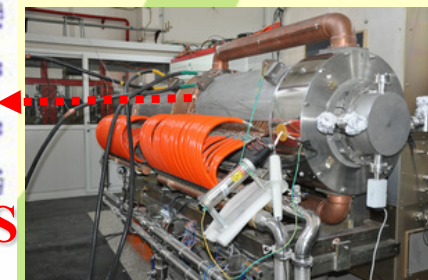
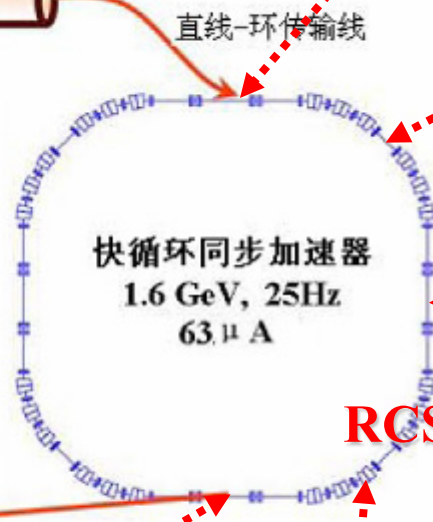
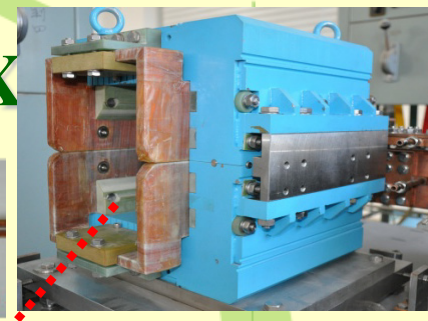
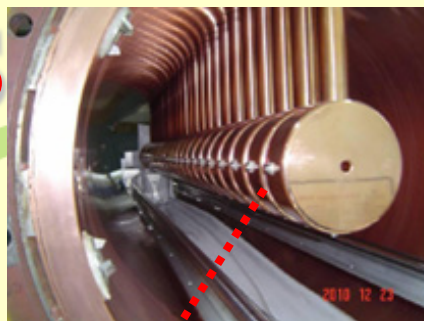
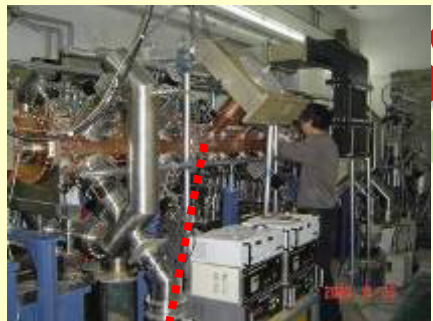
100 MeV
Cyclotron

Superconducting
Linac



1.7 CSNS (S.N.Fu, TUXA01)





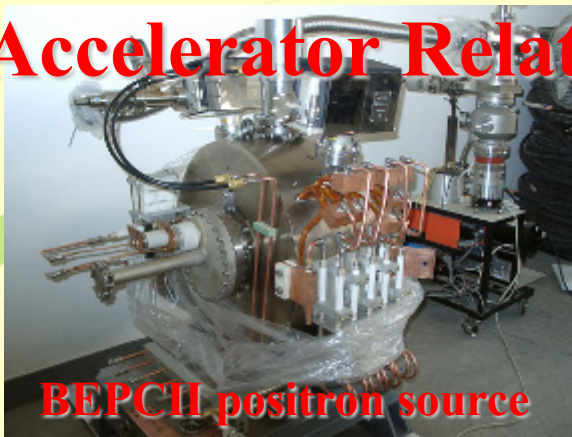
2. Impact of the accelerator projects to economy

- **Promote Accelerator Related Technology**
- **Promote technology upgrades of enterprises**
- **Promote institution's accelerator production**
- **Promote the accelerator industry**
- **Promote regional economy**
- **Satisfy State's strategic demand**
- **Promote accelerator application in China**

2.1 Promote Accelerator Related Technology



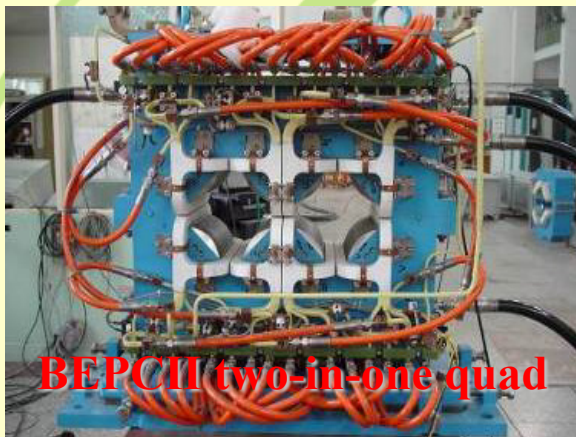
HIRFL-CSR SC ECR source



BEPCII positron source



QWR SC cavity at CIAE



BEPCII two-in-one quad



SSRF in-vacuum undulator



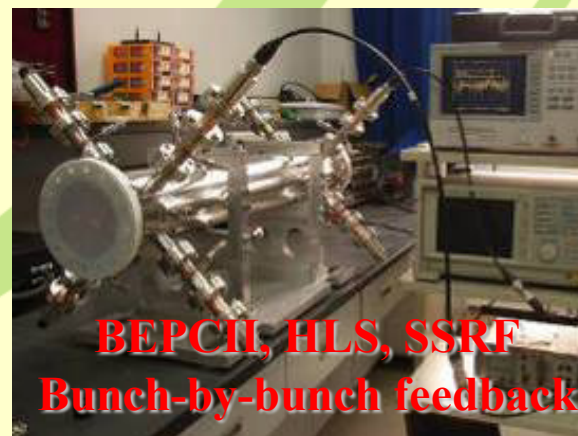
SSRF/BEPCII SC cavity



Ni-Fe-Zn ferrite of CAEP



HIRFL-CSR e-cooler



BEPCII, HLS, SSRF
Bunch-by-bunch feedback

2.2 Promote technology upgrades of enterprises

- **Construction of accelerator projects is joint efforts of both institution and industry.**
- **the institutes carry out design and R&D for key technologies of the projects, while factories go along for mass production.**
- **Typically, some hundreds of enterprises take part in a project for manufacturing its devices.**
- **The manufactures by a long way upgrade their technical capability during the project construction.**



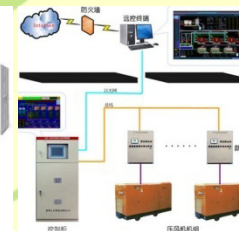
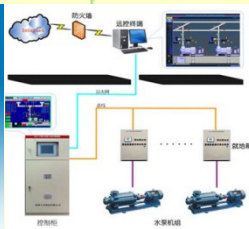
Weifang Huaguang Electronic Group Co. Ltd.

- Grew out of the Weifang Radio Factory, a small company with about 20 technical staff and 200 workers producing pocket radio sets when it took on manufacture of the BEPC electronics system.
- The factory produced more than 200 sets of high quality electronics devices for BEPC. As a result, the first CAMAC and NIM series products with international standard were then developed in China by the factory.
- Undergoing 20-years development, the Huaguang Electronic Group has become one of the top 100 electronics enterprises in China with more than 20 branch companies and 7000 employees involving electronics, computes, computer-to-plate system, SPC exchange systems, mobile communication and transmission equipment, and other fields.

华光高科
Huaguang High-Tech



潍坊华光高科电子有限公司



华光高科
Huaguang High-Tech



潍坊华光高科电子有限公司

Tianshui Electric Drive Research Institute Co. Ltd.

- One of R&D and production bases in electric drives and automation in China.
- Since 1999, TEDRI has produced high-precision power converters for HIRFL-CSR, BEPCII, HLS and CSNS.
- The company closely collaborated with institutions in main circuit design, technical topology structure, digital control board etc. And this has promoted the technology and product upgrade of the company.
- By applying the technology developed in accelerator power converters such as digital control, IGBT and others, new type of transducers were developed by TEDRI as its competitive products for solar and wind energy industry.



2.3 Promote institution's accelerator production



Institute	Project	Accelerator products
IHEP	BEPC CSNS	Magnets, microwave components, cryostats, permanent undulators, ICT, irradiation accelerators, medical accelerators, etc.
IMP	HIRFL CSR	Magnets, irradiation accelerators, vacuum freeze dryers, heavy ion treatment, etc.
NSRL	HLS	Accelerating structures, irradiation accelerators, medical accelerators, etc.
CAEP	DRAGON	Ferrite, amorphous magnetic materials, irradiation accelerators, high-voltage cables, high-speed camera, etc.
CIAE	BRIF	Irradiation accelerators, NDT, cyclotrons, etc.
SINAP	SSRF	Magnets, permanent undulators, electronics, irradiation accelerators, etc.

**a. IHEP 10MeV/40kW irradiation
L-band linac**



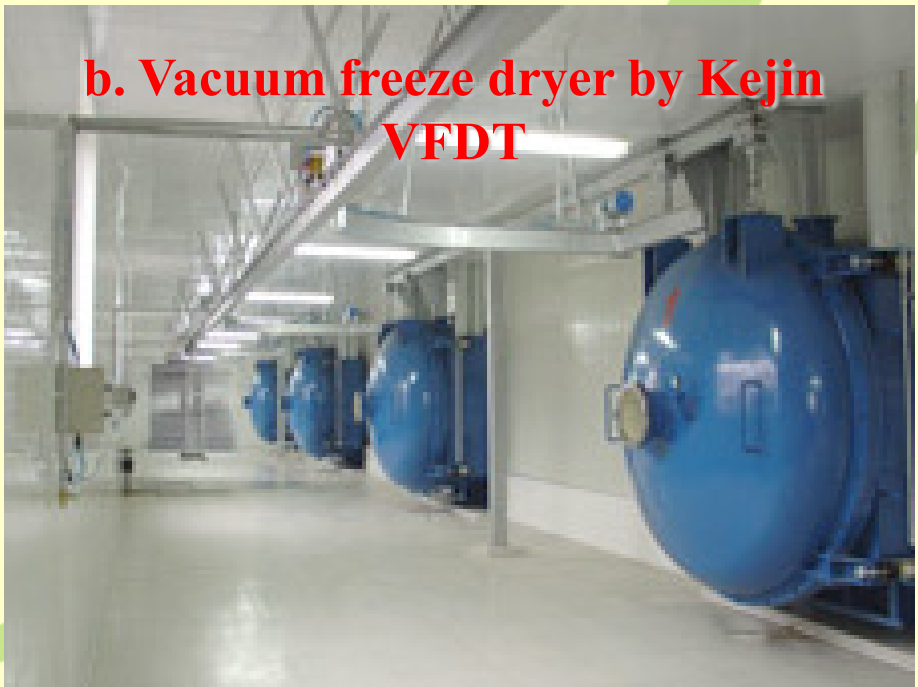
d. Irradiation linac by HUSTC-Aike



**c. CIAE 30MeV high intensity
cyclotron**



**b. Vacuum freeze dryer by Kejin
VFDT**



2.4 Promote the accelerator industry

- After years of efforts, tens of accelerator related enterprises were set up, involving scientific instruments, irradiation, ion implantation, non-destructive test, nuclear image as well as manufactures of magnets, power supplies, microwave components, vacuum devices, electronics and cryogenic apparatus and so on, forming an integrated accelerator industrial system in China.
- Shanghai Kelin Technology Development Co., Ltd. is one of these enterprises. Founded in 1989, the company has taken on the production of magnets, wigglers, undulators, bunchers, vacuum components, and RFQ cavities for BEPC, HLS, BEPCII, HIRFL-CSR, CSNS and BRIF.
- The company also produced magnets and vacuum devices for PEP-II, KEK-B and J-PARC. The Kelin has now dedicated in production of RFQ accelerators and proton therapy devices.



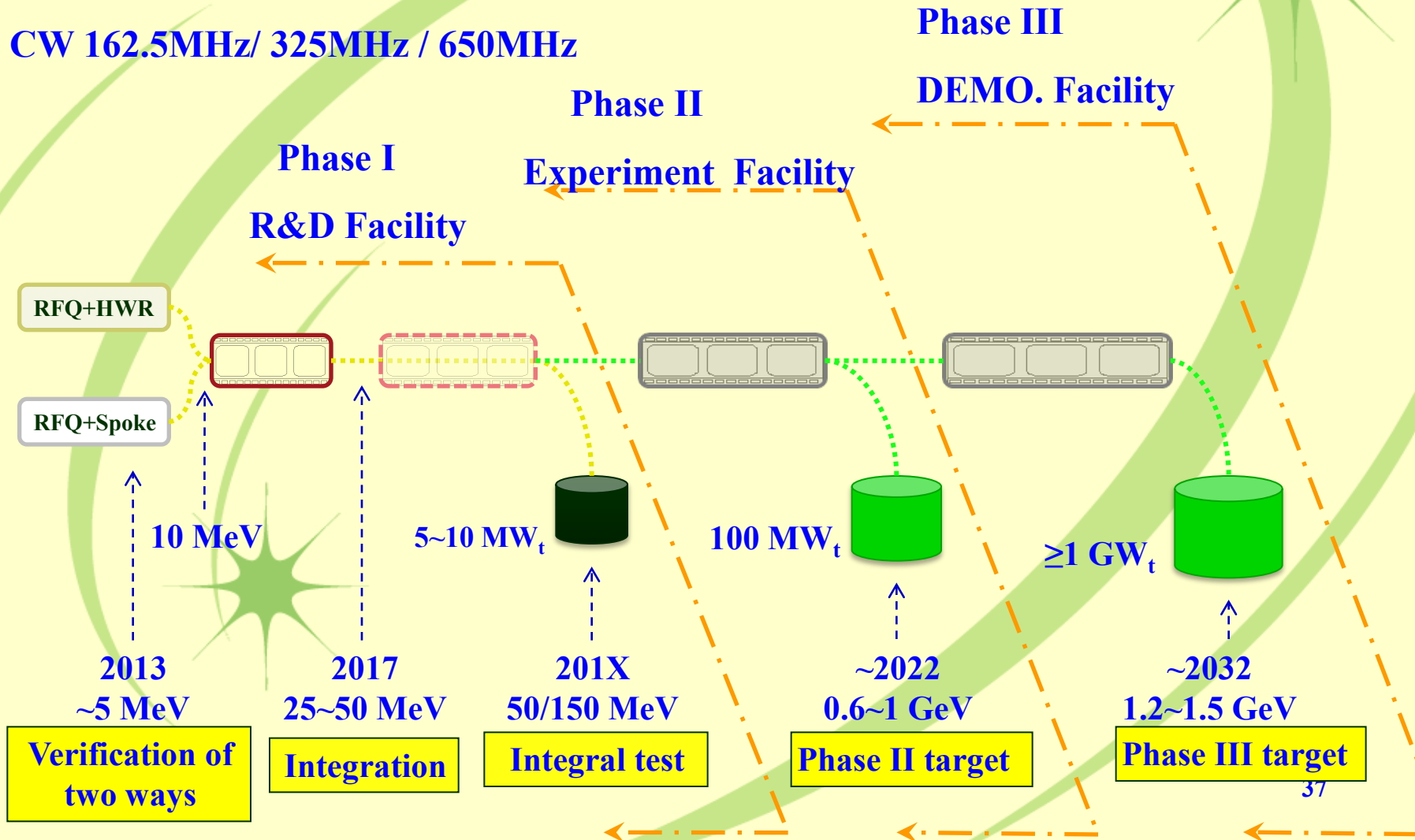
2.5 Promote regional economy

- Construction of the projects promotes the regional economy in scientific research, technology development, talent support, infrastructure upgrade, and also employment.
- The R&D platforms jointly established by institutions and industry play an essential role in the long term development of the regions. IHEP is the core institute of the CCRTMR and ECRITE.
- IMP and SINAP have been developing the ion therapy facilities, which will greatly affect on the medical and health undertakings as well as regional economy.
- Based on the CSNS project, CAS and Guangdong Province have implemented a comprehensive strategic partnership. A non-power nuclear technology park is planed in Dalang where CSNS is constructed, including industrial irradiation, ICT and RFQ accelerators.



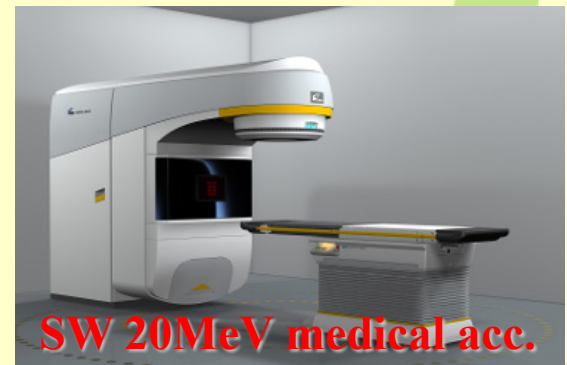
2.6 Satisfy State's strategic demand

e.g. ADS Roadmap in China



2.7 Promote accelerator application in China

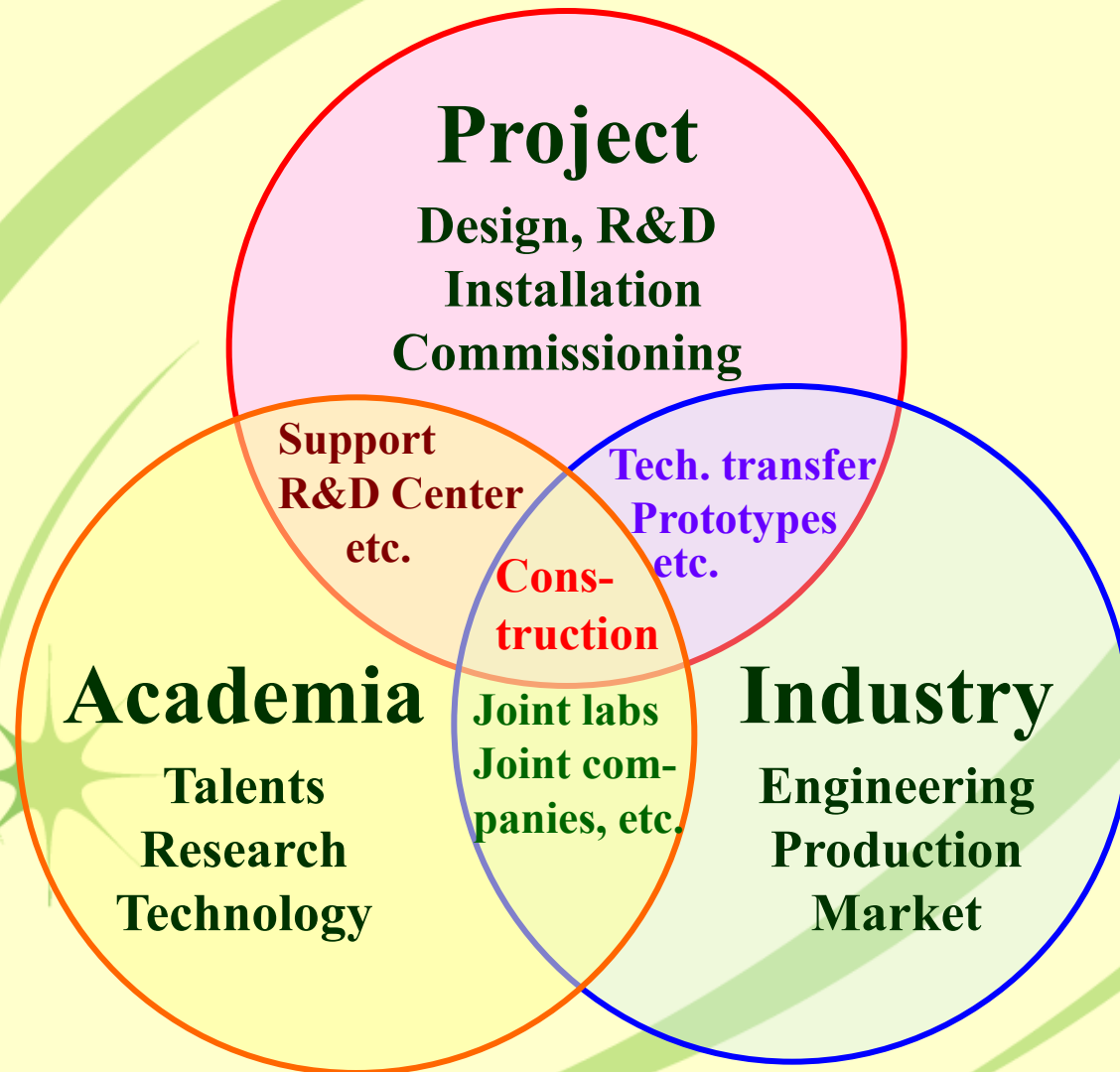
- The construction of the accelerator projects and the significant progress of accelerator industry have greatly promoted the application of accelerators in the fields of research, industry, agriculture, nuclear transmutation, energy sources, environment, medicine and so on.
- The accelerator products with “designed and made in China” can be seen everywhere in these application fields.



3. Collaboration between academia and industry

- Institutions directly produce accelerator products
- Institutions establish high-tech companies
- Institutions and enterprises set up joint R&D platforms to promote industrialization
- Institutions or its relying companies and enterprises establish joint companies
- Institutions transfer technology to enterprises for industrial production

Collaboration between academia and industry in an accelerator project



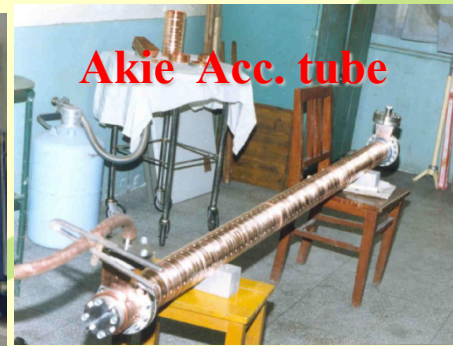
3.1 Institutions directly produce accelerator products

- As described in the previous section, the institutions may apply the technology developed in the project construction to exploit accelerator products in their machine shop or in collaboration with industry.
- In this way, the institutions need to set up a technical development sector to conduct the R&D activities, production and market.
- Very often, this is a step towards establishment of independent companies in order to extend the business.



3.2 Institutions establish high-tech companies

- IMP developed its first vacuum freeze dryer in 1994 based on the technology accumulation from HIRFL. A few production lines with such dryers were produced in the following years.
- To meet the growing demands from high quality green foodstuff markets, Lanzhou Kejin Vacuum Freeze Dry Technology Co. Ltd was established in 1999. Its key technological members are those who have worked long in HIRFL and are well experienced in technology.
- After years' efforts, the company has become a leading enterprise in China engaged in food freeze drying and design, manufacture, installation and test of the facilities.
- USTC Aike Science and Technology Co. Ltd. mentioned above is another example.



3.3 Institutions and enterprises set up joint R&D platforms to promote industrialization

- The Wuxi EL PONT Radiation Technology Co., Ltd. is used to work at high-voltage accelerator production and their application in irradiation.
- Taking advantage of electron linac technology of BEPC, IHEP and EL PONT established the Electron Irradiation Accelerator Engineering Research Center of Jiangsu Province in 2007.
- Since then, EL PONT and IHEP have worked closely together in the research and development of industrial irradiation accelerators.
- With the joint efforts, the 10MeV/20kW S-band irradiation linac were successfully accomplished and put on market. The 10 MeV/30kW linac system is in progress.



3.4 Institutions or its relying companies and enterprises establish joint companies

- The Shangdong Huate Magtenism Co., Ltd. is a top-ranking enterprise in the fields of magnetic separators, de-ironing separators, coal mining equipments, metal detecting devices, and others. IHEP has developed superconducting technology in the BEPCII construction.
- To upgrade the products of the company, Huate and IHEP signed an agreement on collaboration in development and production of superconducting de-ironing separators in 2006.
- For two years, engineers of both side worked together and the first SC de-ironing separator was produced in 2008 with its magnetic field of 4320 Gs.
- The superconducting separators have now become Huate's competitive products.



Leading magnetic equipment supplier of the world

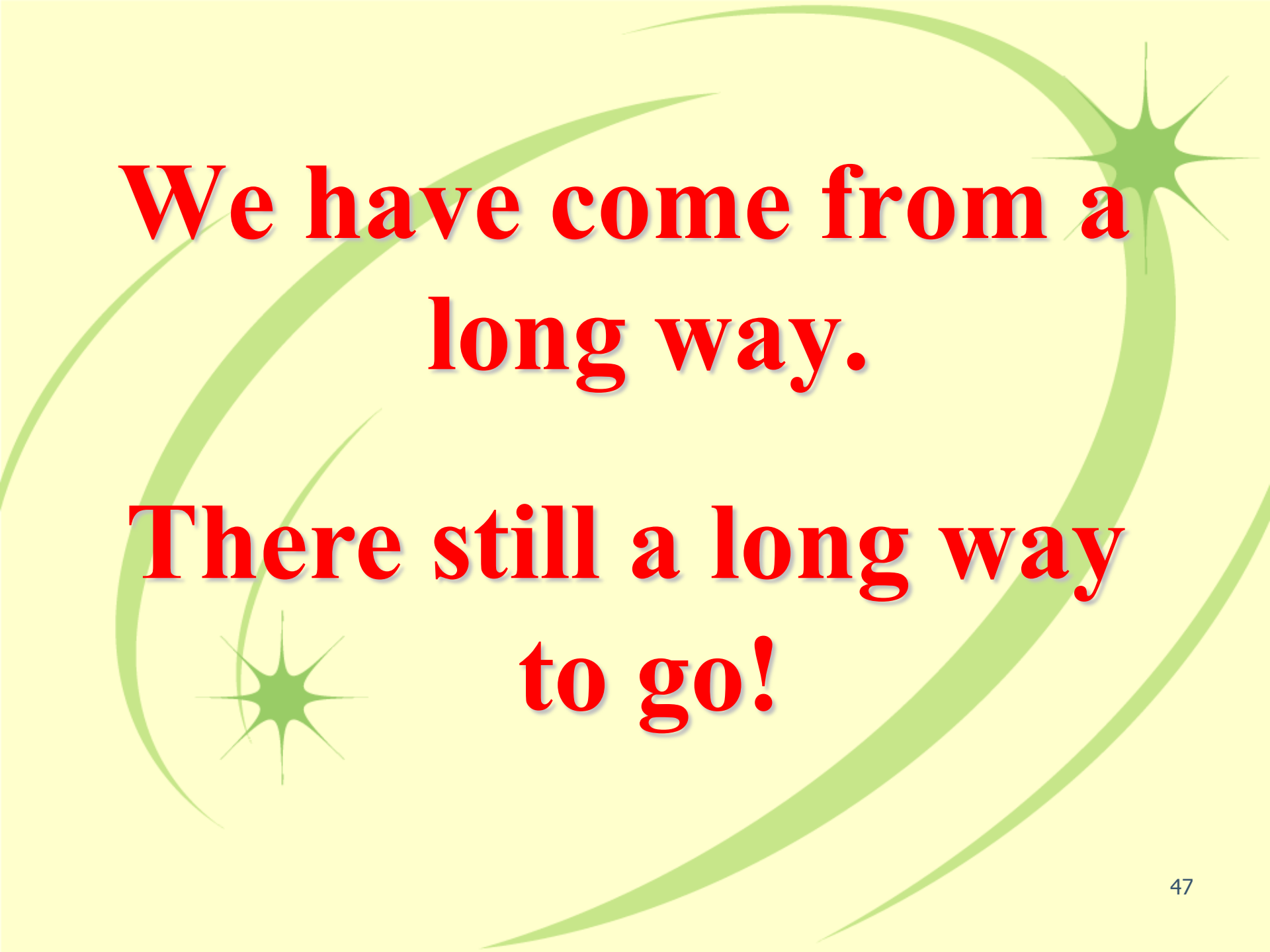
3.5 Institutions transfer technology to enterprises for industrial production

- Founded in 2001, Vanform Electron Linac Technology Co., Ltd. is a high-tech enterprise in the field of irradiation electron linac production and application.
- The company imported the 10MeV/15kW electron linac technology from IHEP.
- With a close collaboration with IHEP, NSRL and other institutions, Vanform has carry out the R&D for 10MeV/(1-60) kW series electron linacs and their commercial production.



4. Concluding remarks

- Along with the rapid development of national economy in China, a number of accelerator based mega-science projects were constructed in China;
- Construction of accelerator projects promote the science and technology progress and bring about a positive impact on economy.
- Basic approach:
 - based on the technology developed with large accelerator projects;
 - institutions perform further research according to demands of market, and establish some R&D platforms with industry to carry out the engineering development;
 - industrial enterprises carry through the large-scale production and go on the technology innovation as a main body in collaboration with institutions.



**We have come from a
long way.**

**There still a long way
to go!**



**Thank you for
Attention**