



Development of heavy ion radiotherapy facilities in China

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Background



HIMM* facilities in China



Status of HIMM-1 facility



Prospect

lanzhou ion therapy co., LTD.



***HIMM:** Heavy Ion Medical Machine. It is the product produced by Lanith company, and Lanith is affiliated to IMPCAS.

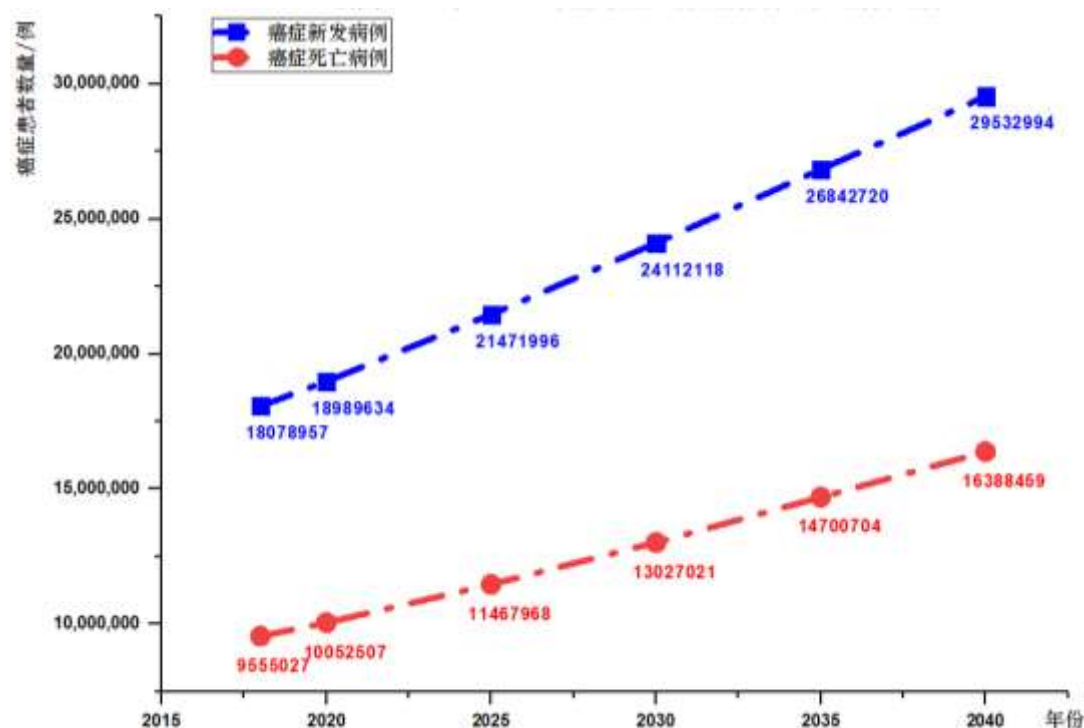
01 Background





Current status of cancer in global and China

The global cancer cases predicted by IARC form 2018-2040

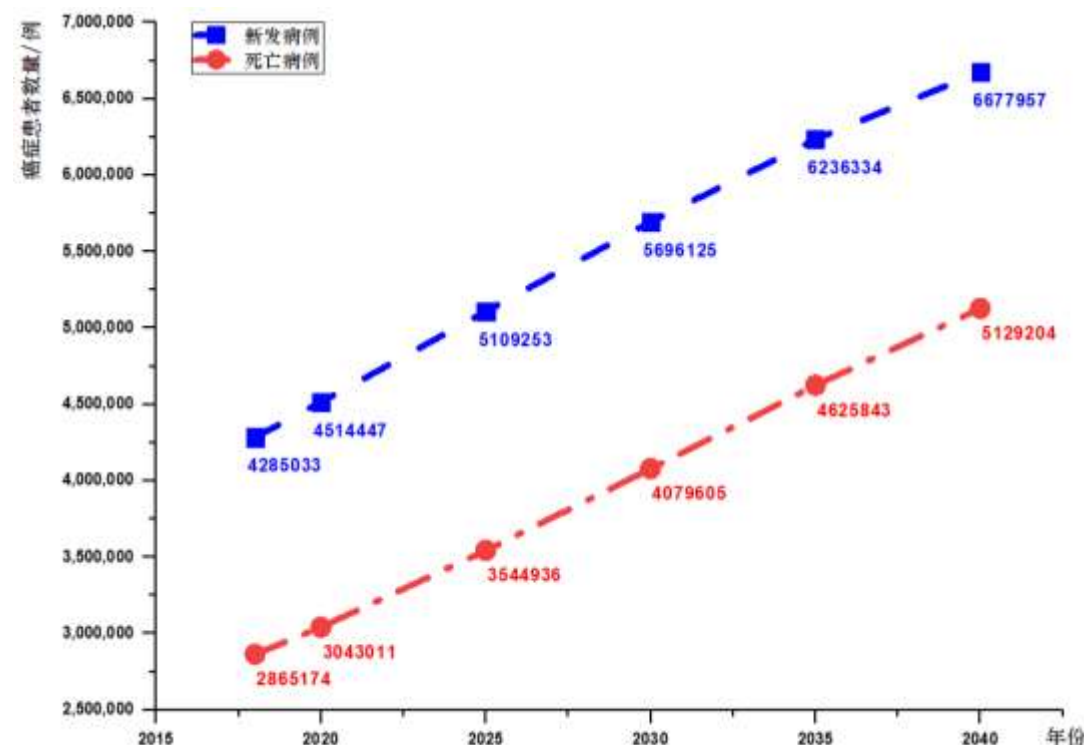


*数据来源: 世界卫生组织国际癌症研究中心数据库, <https://gco.iarc.fr/today/en/wjs>

19 million → 29.5 million 2.4%/year

10 million → 16.4 million 2.6%/year

The cancer cases in China predicted by IARC form 2018-2040



*数据来源: 世界卫生组织国际癌症研究中心数据库, <https://gco.iarc.fr/today/en/wjs>

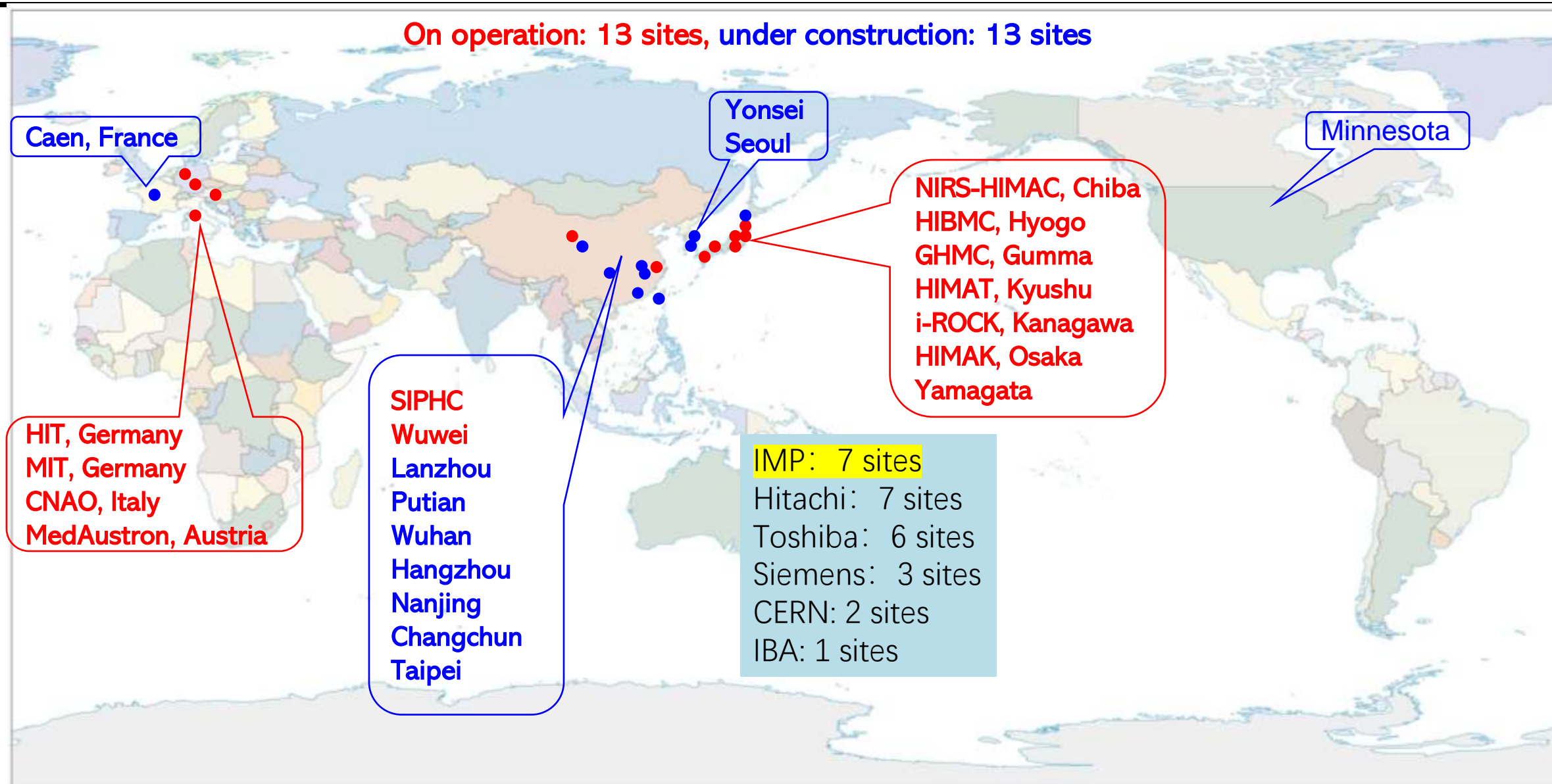
4.5 million → 6.6 million 2.2%/year

3 million → 5.1 million 2.9%/year



Heavy ion radiotherapy facilities in the world

On operation: 13 sites, under construction: 13 sites



02 Heavy ion radiotherapy facilities in China





Heavy ion facilities in China



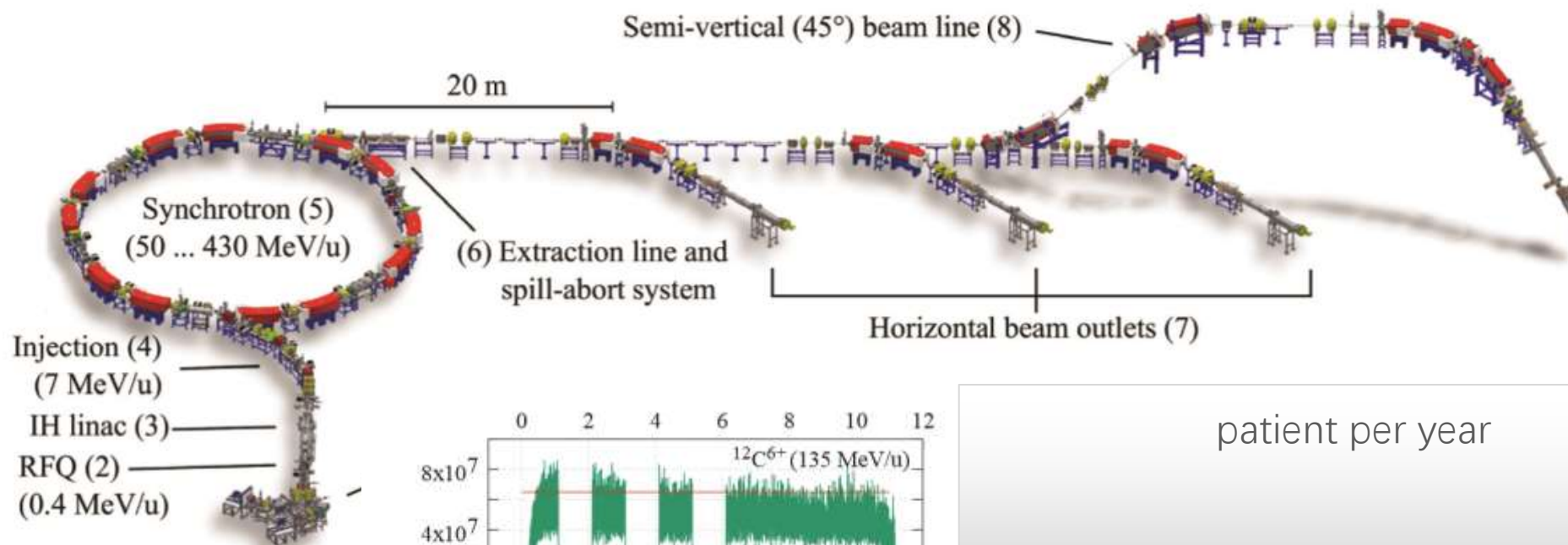
■ In operation

1. Shanghai proton and heavy ion center (Siemens)
2. Wuwei Heavy ion therapy center (IMP)

■ Under construction: 9 sites

1. Lanzhou Heavy ion therapy hospital (IMP)
2. Xuzhou heavy ion center (Hitachi)
3. Mazu Health center (IMP)
4. Renmin hospital of wuhan university (IMP)
5. Zhejiang cancer hospital (IMP)
6. Jiangsu cancer hospital (IMP)
7. The First Bethune Hospital of Jilin University (IMP)
8. Heyou international hospital (Hitachi)

SPHIC: Shanghai proton and heavy ion center

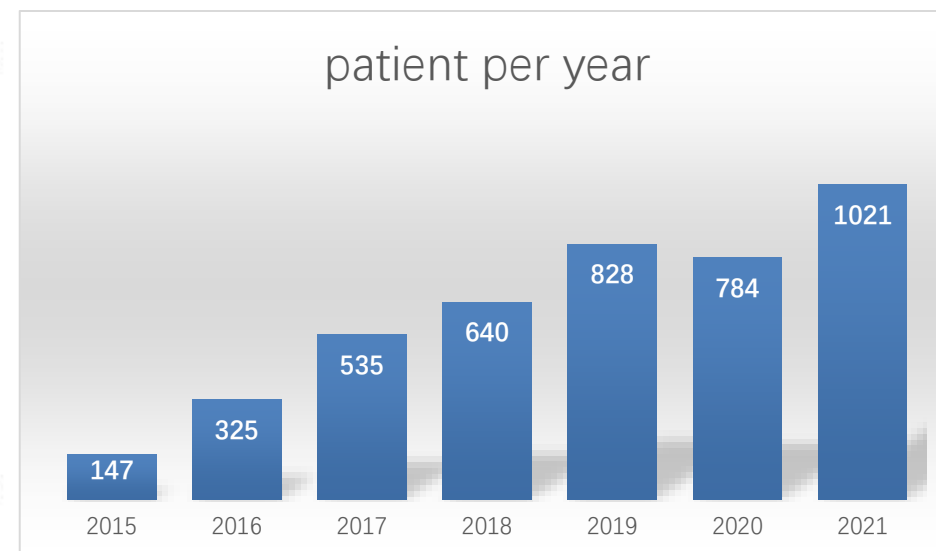
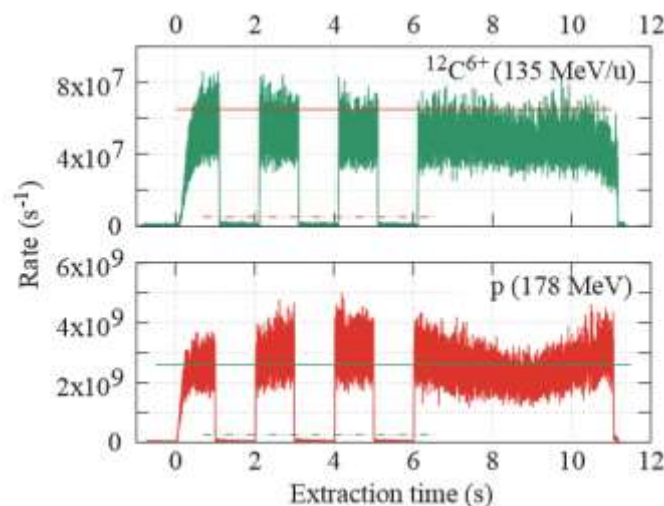


Vender: SIEMENS

Treatment rooms: 4

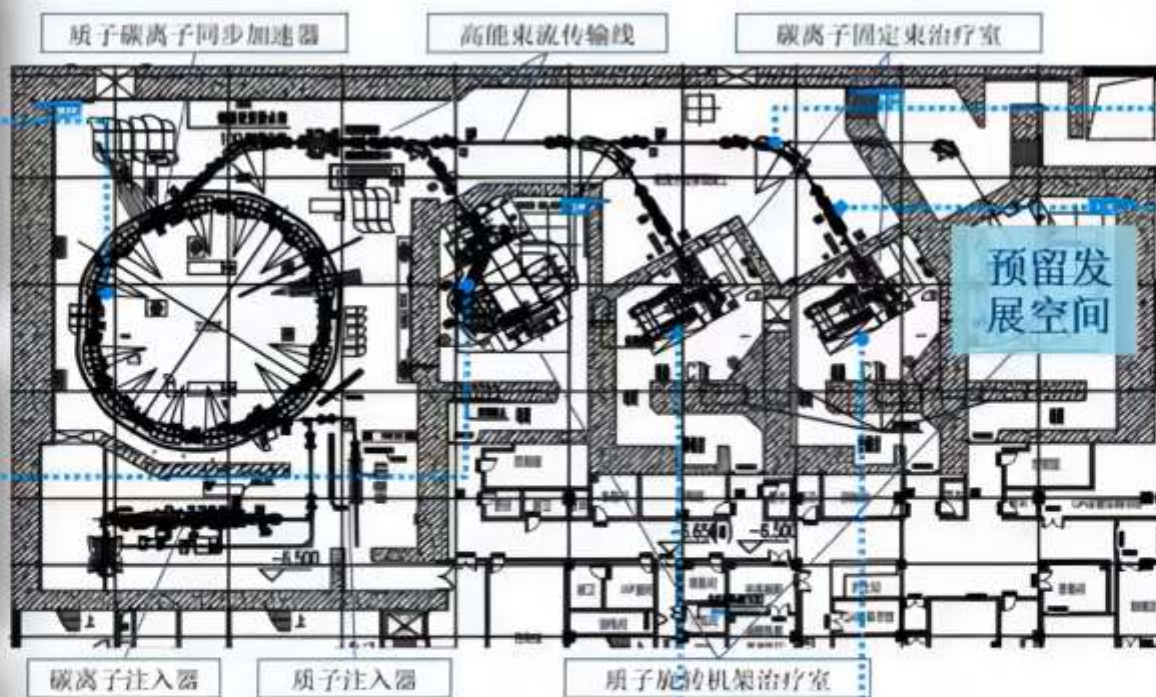
Proton: max. 2×10^{10} /spill

Carbon: max. 1.0×10^9 /spill





Xuzhou and Heyou heavy ion center*

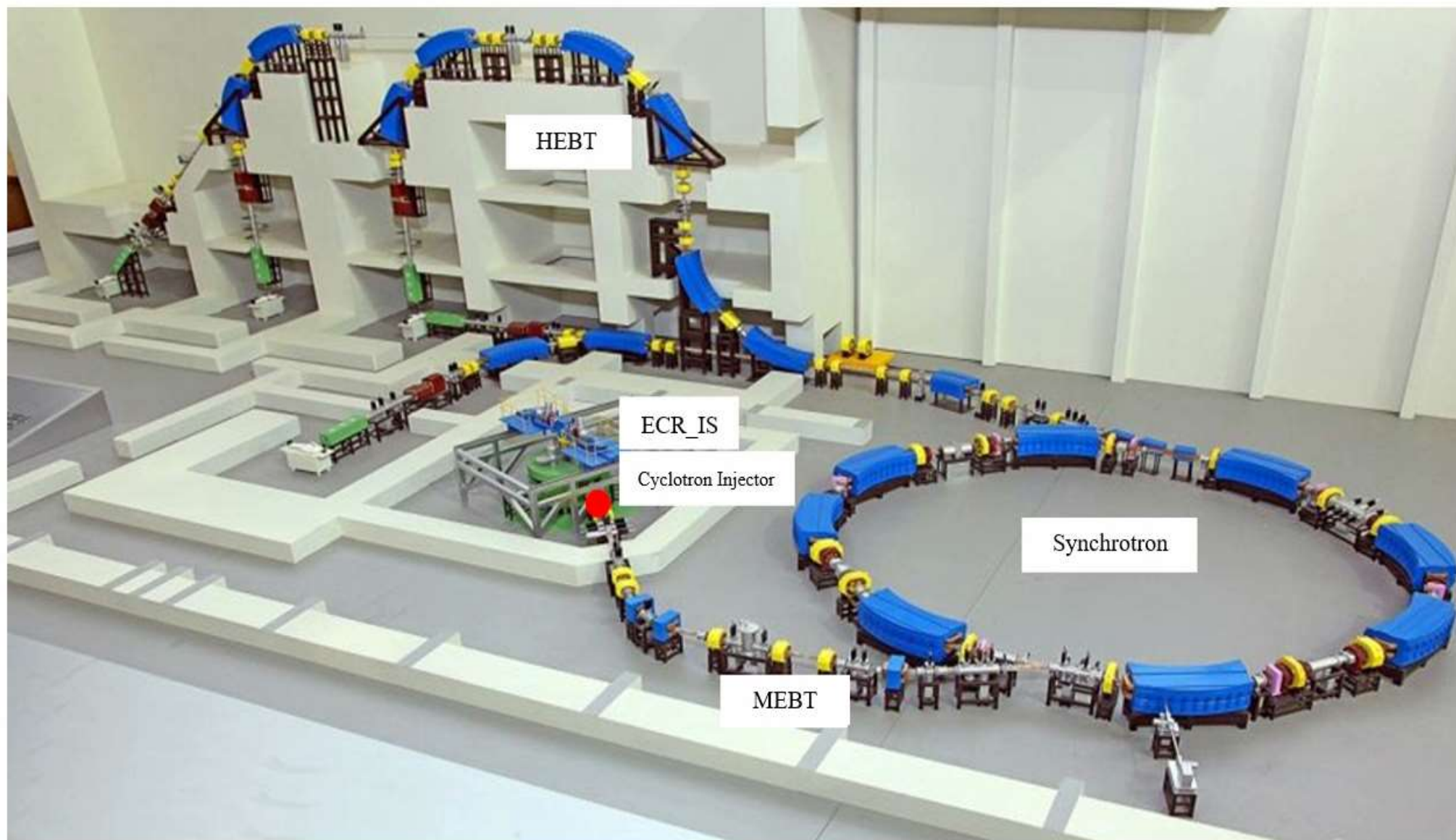


HIMM facilities in China





Principle of HIMM accelerator

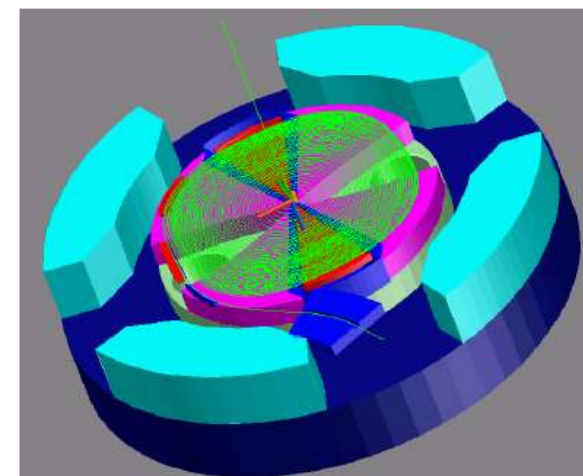
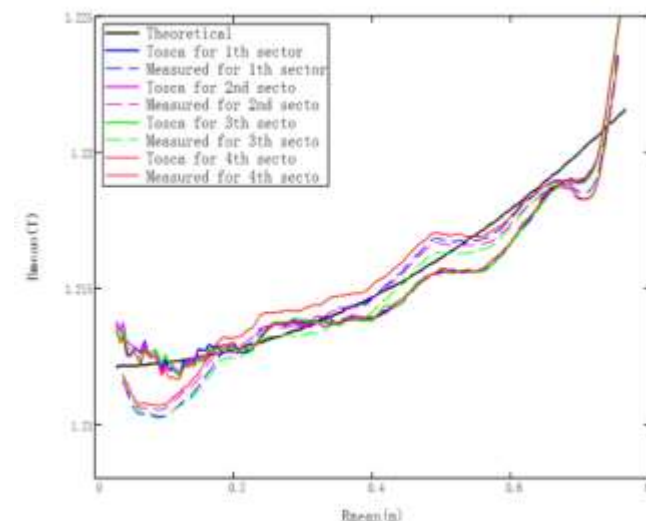


Note: can't
provide beams
for multiple
rooms
simultaneous

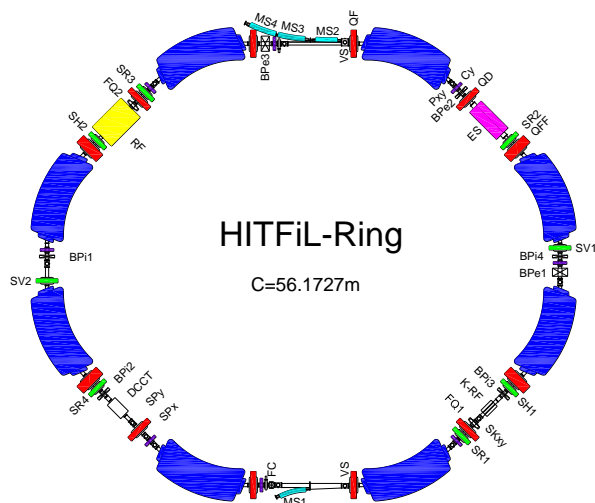


Design of the cyclotron injector

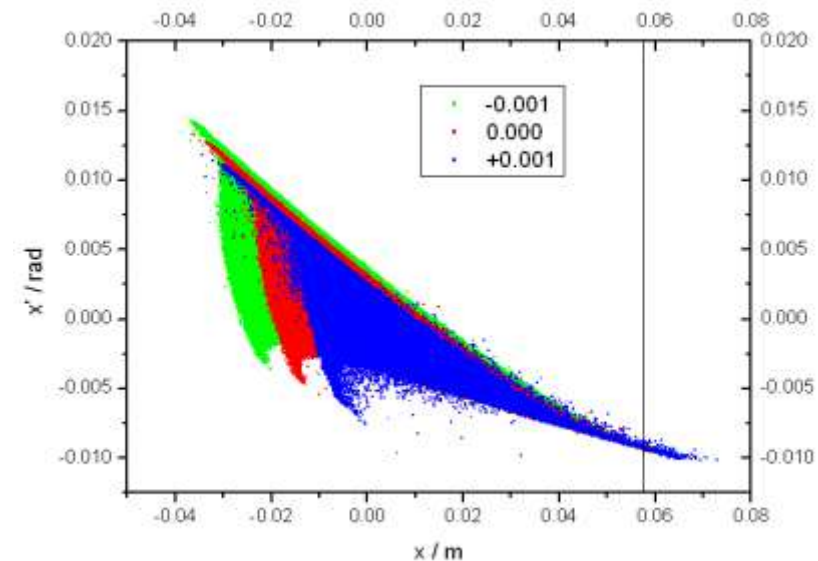
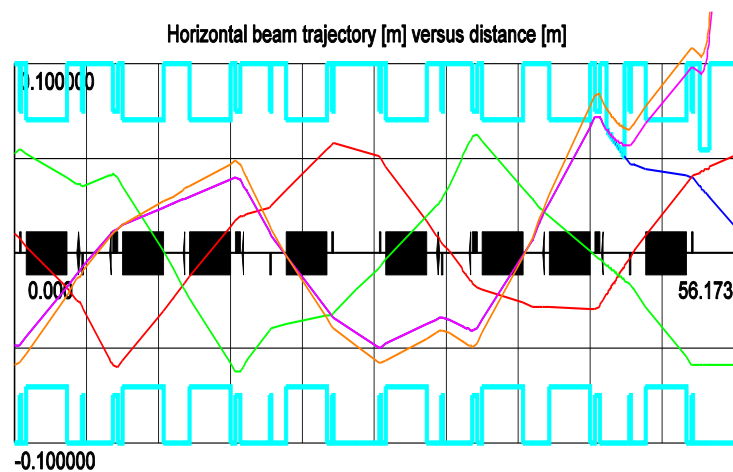
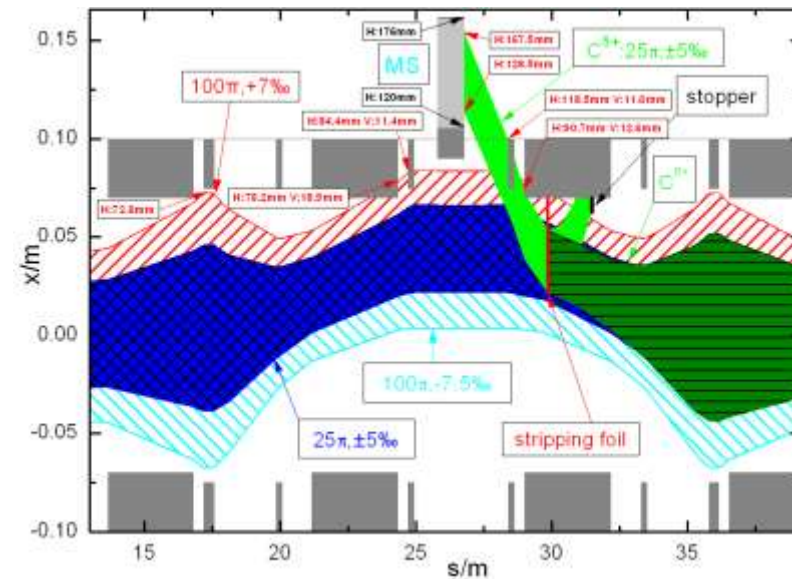
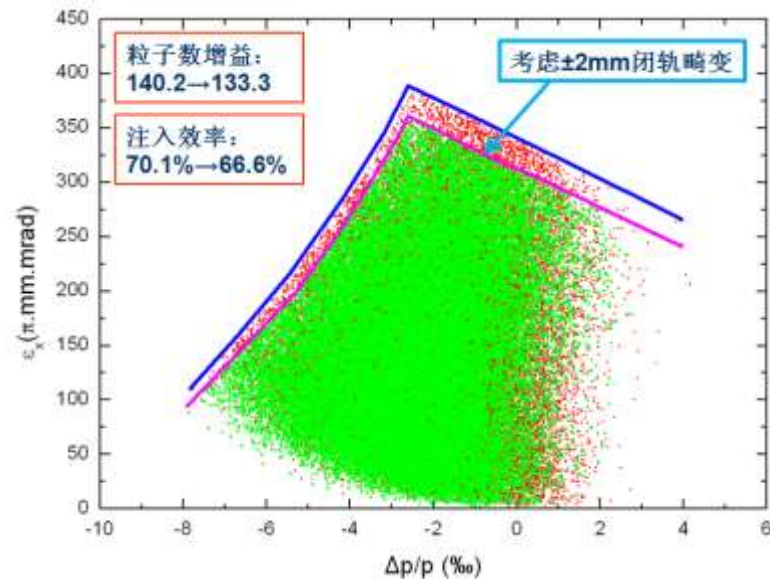
Beam		Magnet	
Particle	$^{12}\text{C}^{5+}$	Diameter (m)	2.92
E_k (MeV/u)	~ 6.3	Height (m)	1.52
I (euA)	$> 10\text{uA}$	Number of sectors	4
Dp/p	$\leq \pm 5e-3$	Angle of the sector $^\circ$	56
E (pi`mm`mrad)	25(5sigma)	Radius of the sector (mm)	840
Accelerator		B_{IC} (T)	1.212T
R_{inj} (cm)	75	B_{max} (T)	1.8T
R_{ext} (cm)	2.7		
F_r (MHz)	7.755		
Harmonic	4		



Design of the synchrotron

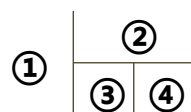


Beam	
Particle	12C6+
Ek (MeV/u)	120-400
part. number	4e8
Acclerator	
circumference	56.2
Q_x / Q_y	1.68/1.23
H	1 or 2





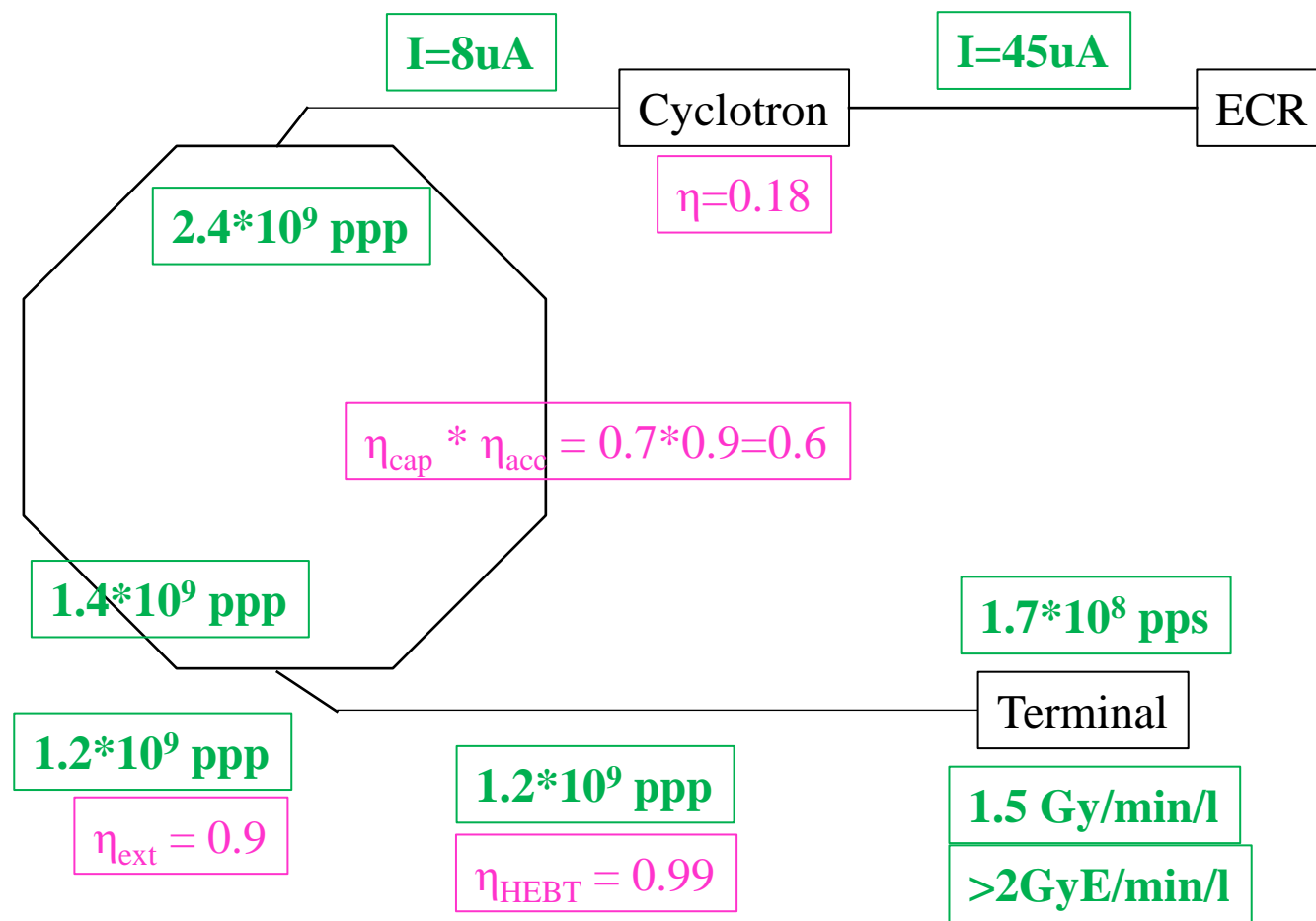
Photograph of the HIMM facility



① Synchrotron ② Cyclotron ③ HEBT ④ Data center

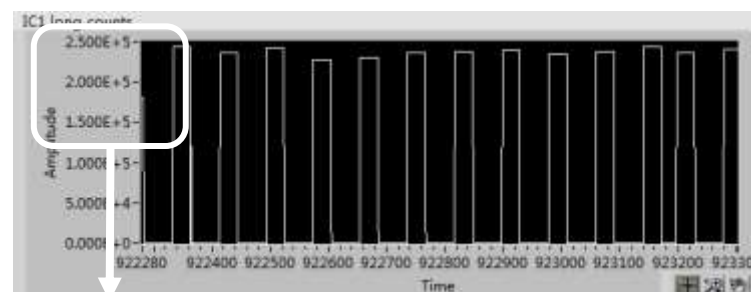
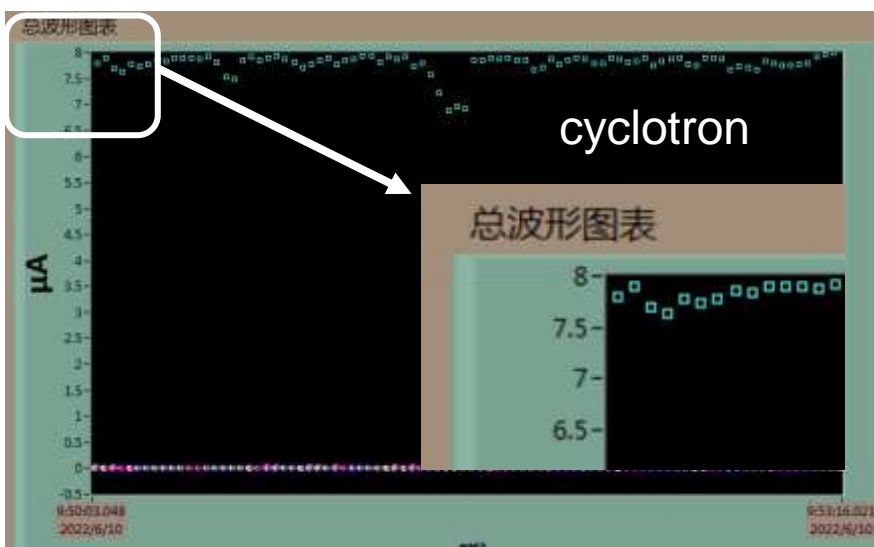
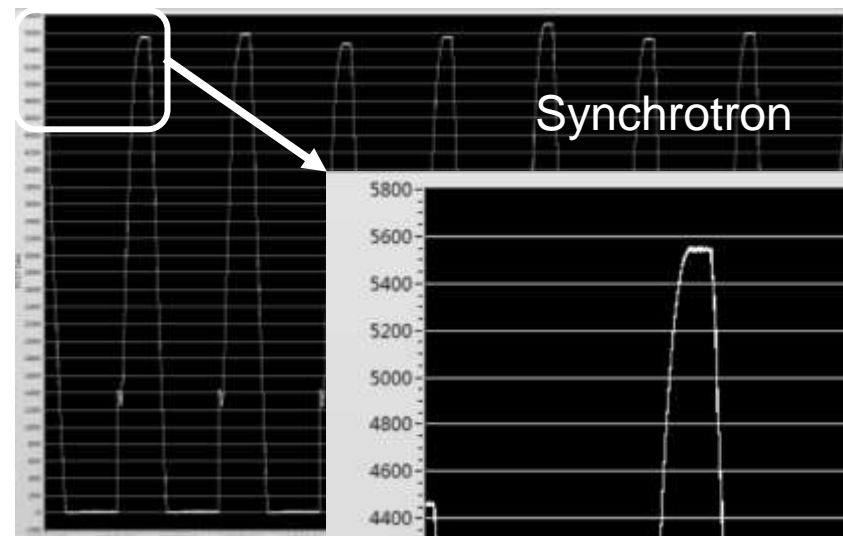
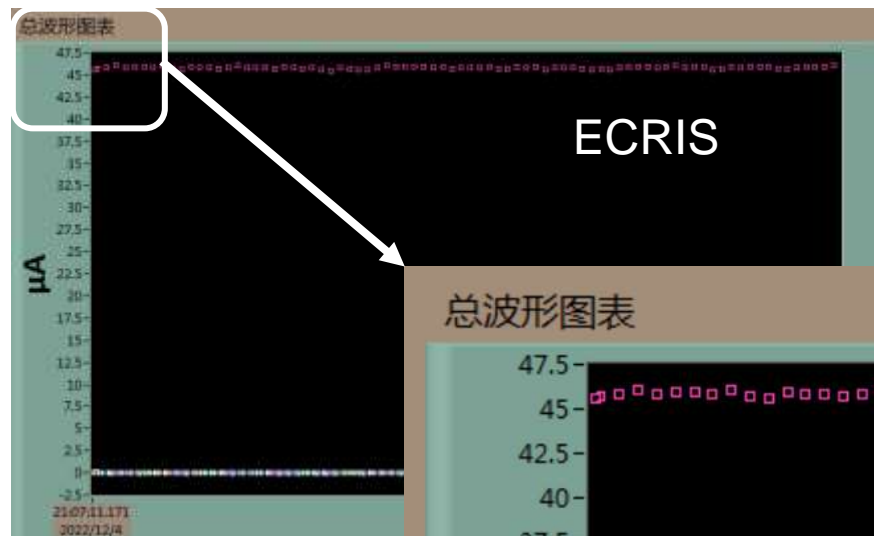


Beam intensity----generalization

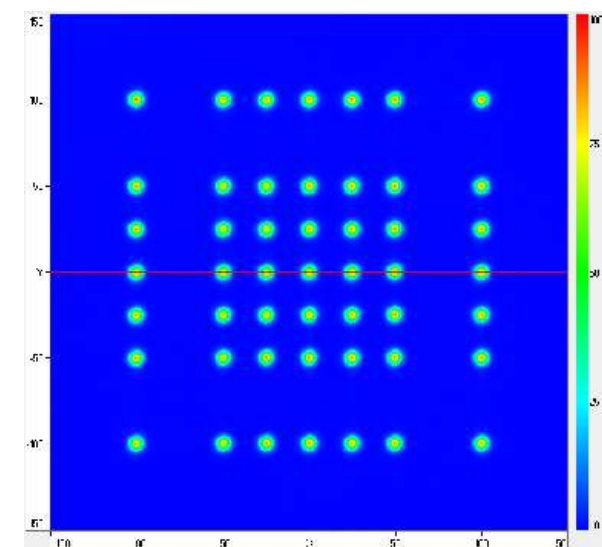




Beam commissioning



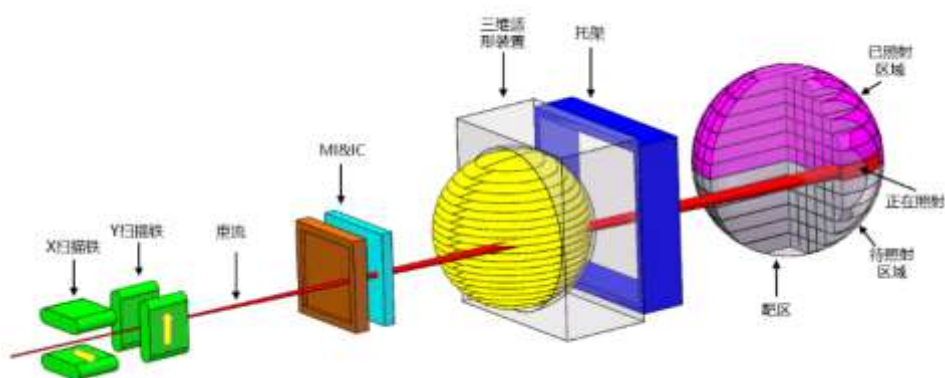
Particle number:
IC count \times coefficient
 $= 2.45e5 \times 5000 = 1.22e9$ ppp



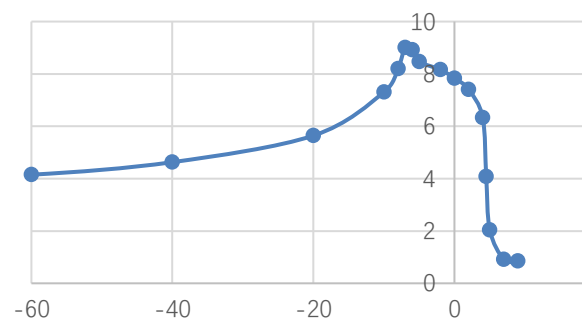


Carbon ion Flash Cell irradiation experiment

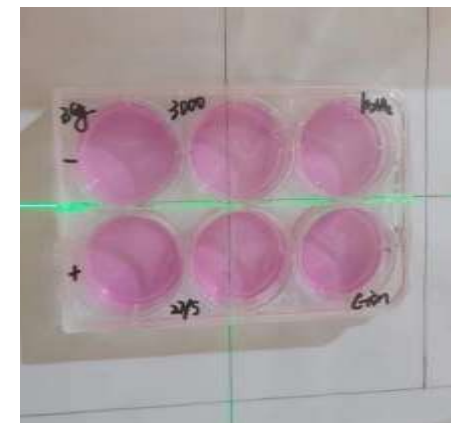
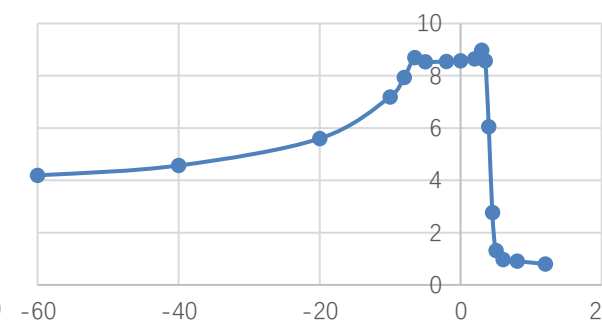
- Dose rate: 40Gy/s, 60Gy/s, 80Gy/s, 120Gy/s
- Dose per fraction: 1Gy, 2Gy, 4Gy, 8Gy, 12Gy
- Target size: 20mm*20mm*10mm, and 20mm*20mm*4mm

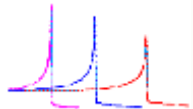


RF10-uniform distribution
of RBE dose (assumption)



RF10-uniform distribution
of physics dose

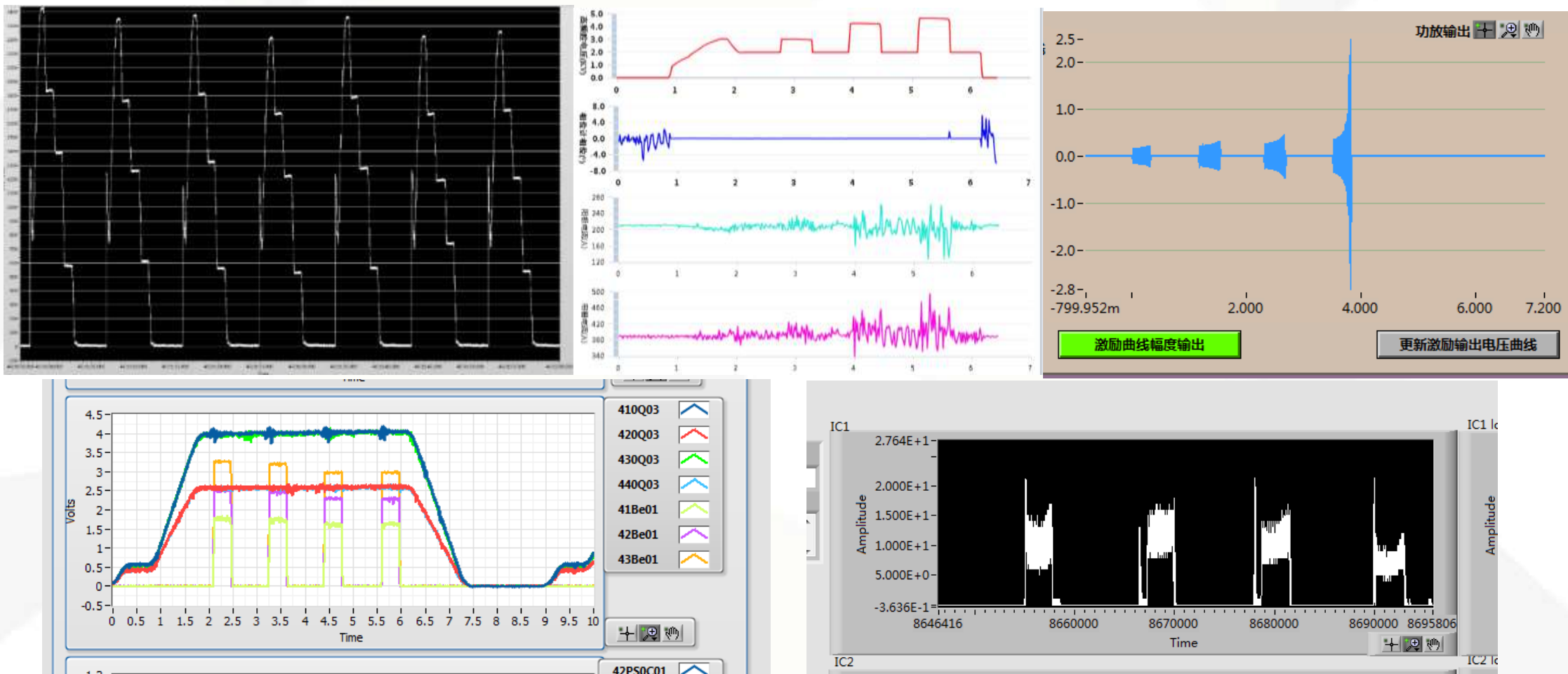




Multi-Energy operation

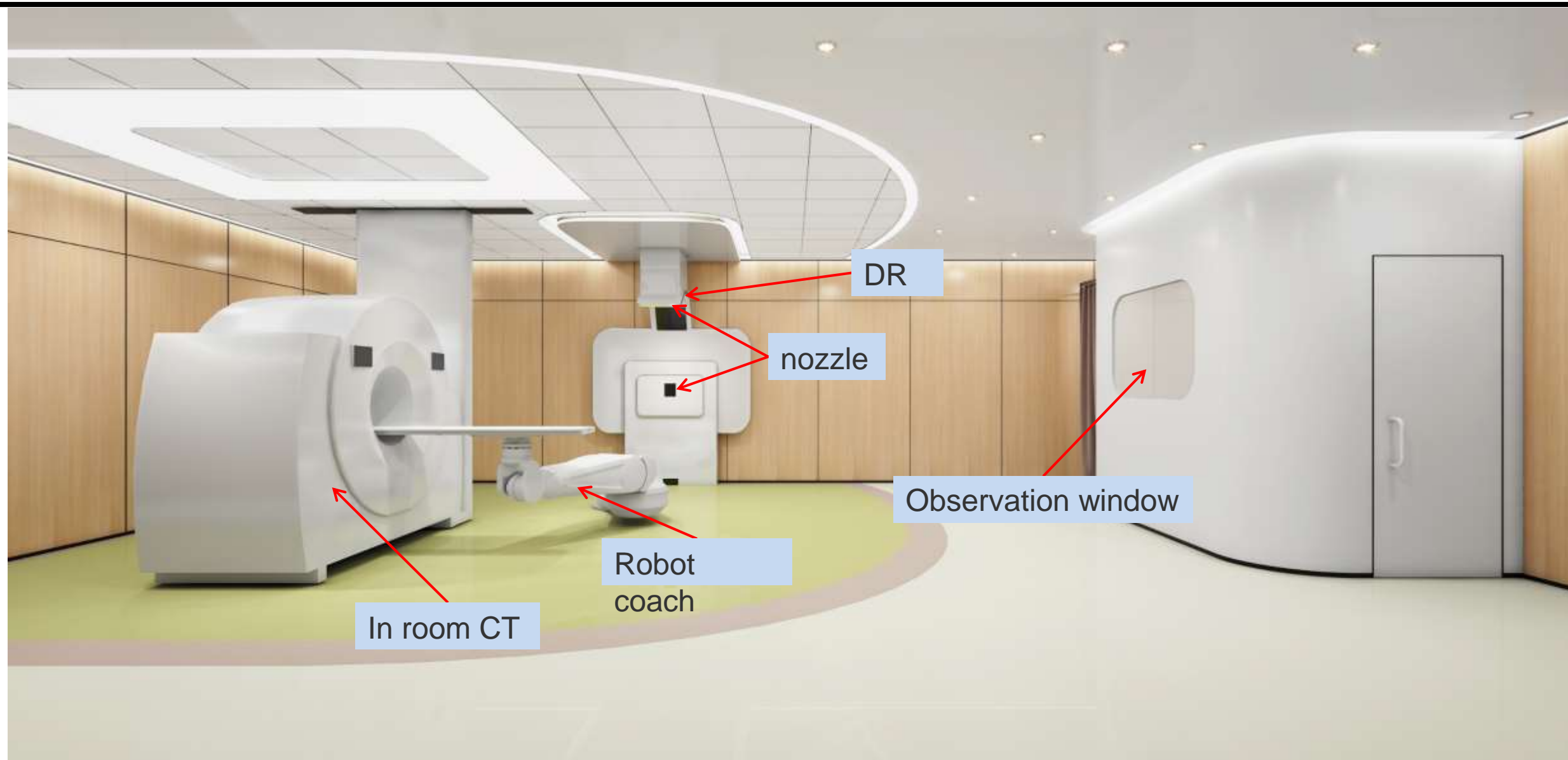


- Test in HIMM-2, the beam energies are 261.03/263.23/265.43/267.62MeV/u, the interval of the bragg peak is 2mm.
- The screenshots of the DCCT, RF, TRF, PS, IC, the time interval between different energy is 0.5s.





Equipment configuration in the treatment room





TCS: terminal control system



版本1.0.0.0

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LANZHOU KEJIN TAIJI CORPORATION LTD.

Username

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用户管理

登录

welcome
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肿瘤信息系统

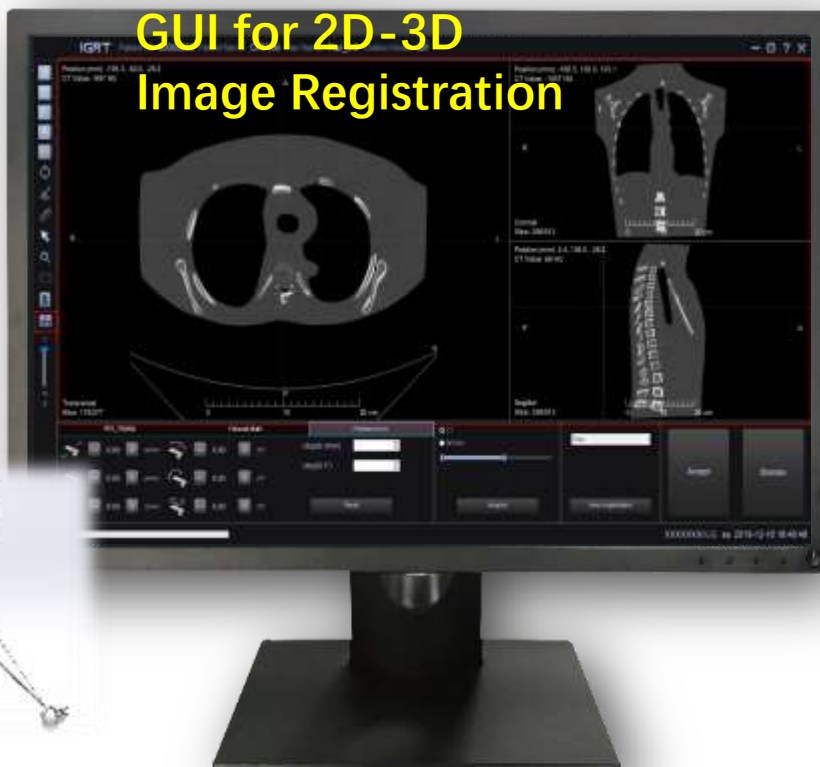
Imaging Guide Positioning System(IGRT)

- DR: CT / 2D:3D registration;
- CBCT: CT / 3D:3D registration ;
- CT: CT / 3D:3D registration ;

Matching Accuracy : $< 1\text{mm}$

Time needed to match (3σ) : bone match $< 15\text{s}$; gray match $< 20\text{s}$

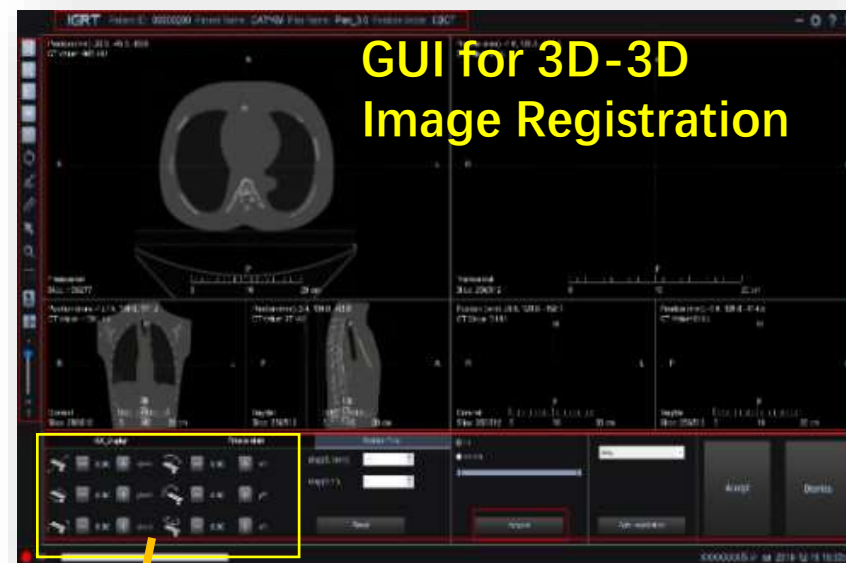
GUI for 2D-3D Image Registration



CT/DR



GUI for 3D-3D Image Registration

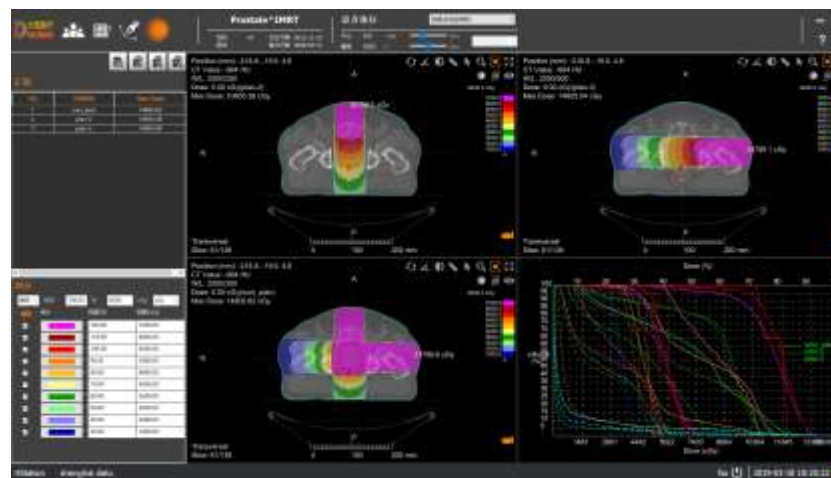
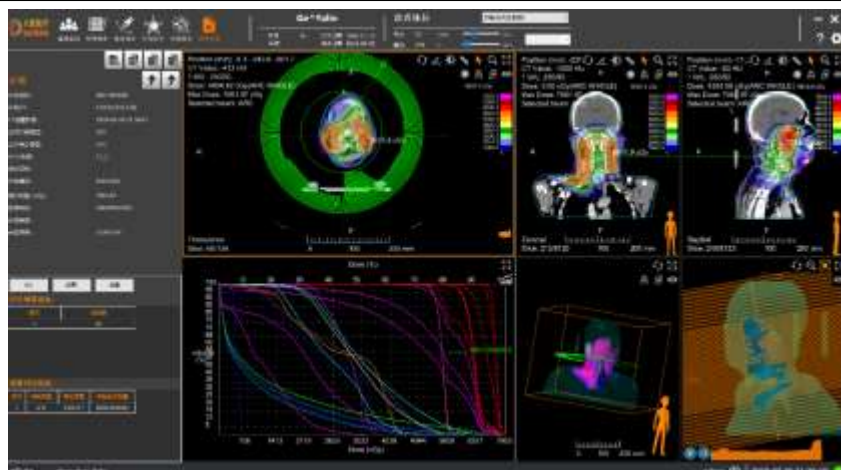


CT/CBCT





TPS: Treatment Planning System



- GPU based optimization engine
- Monte Carlo algorithm is adopted
- multi biological models and multi particle types
- Dose comparison of multiple therapeutic devices (X ray, proton, helium, carbon ion, etc.)
- Multimodal image fusion and registration
- Multi plan dose superposition and dose deformation superposition
-

Note: the customer can also choose RayStation

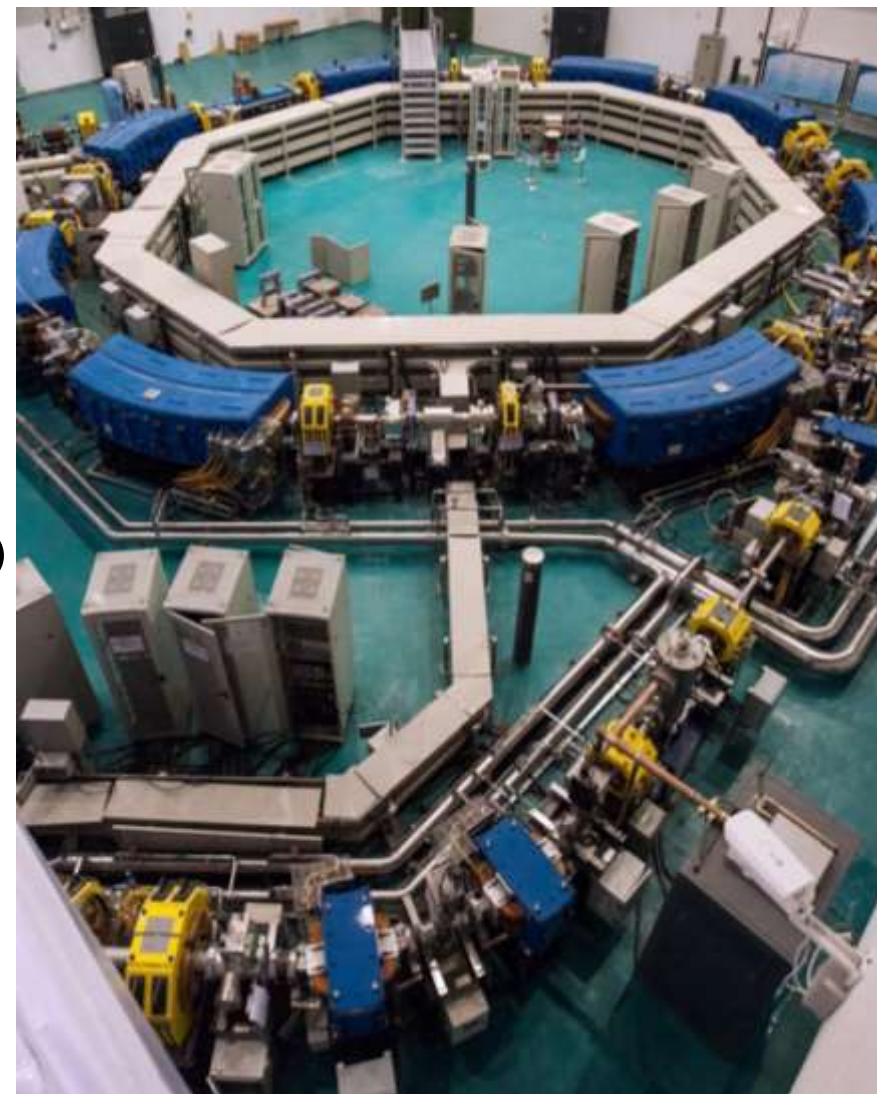
03 Status of HIMM facilities





HIMM-1 milestones

- 1 Apr. 2014, started the installation
- 2 Dec. 2015, beam commissioning finished
- 3 May 2018, get the test reports from CFDA
- 4 Nov. 2018 –May. 2019, clinical trials (46 cases)
- 5 Sep. 2019, get the certificate from CFDA(NMPA)
- 6 Mar. 2020, hospital started operation





国科离子



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



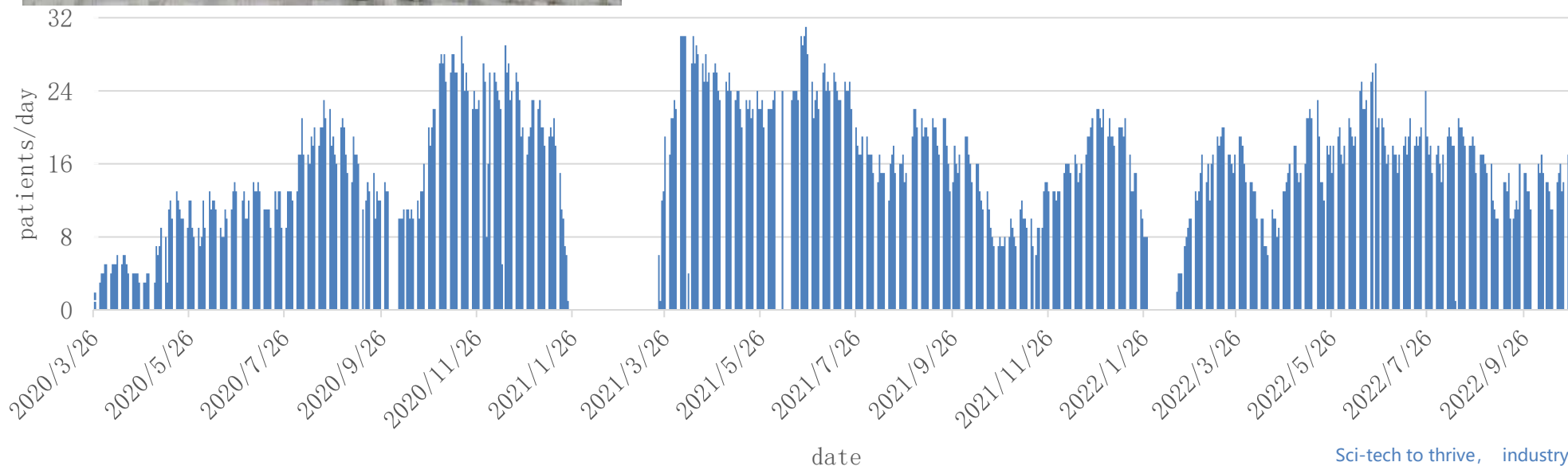
Status of HIMM-1

- March 26, 2020 started the operation

Number of patients



year	2020	2021	notes
patients	206	256	<10 months, 1 treatment room
Operating ratio	97.4%	97.1%	<10 months, 1 treatment room





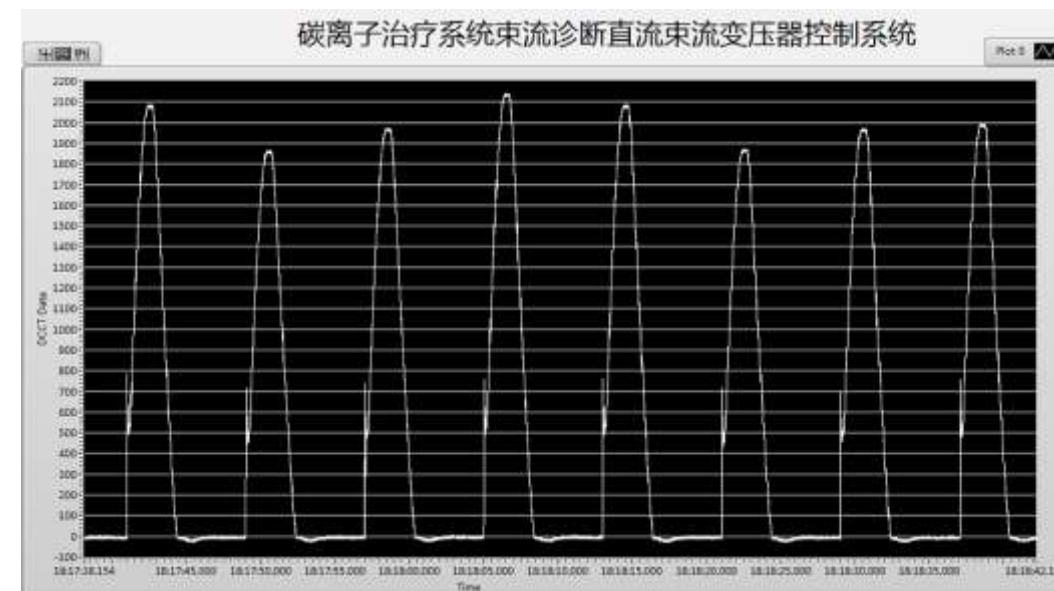
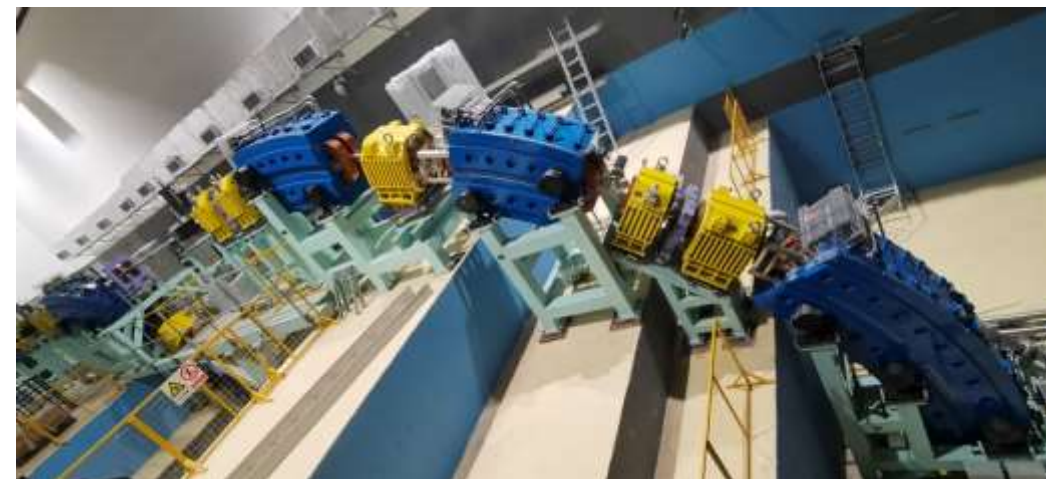
HIMM-2

- Oct. 2022.10, The clinical trial started
- Will start operation at the beginning of 2023



HIMM-3

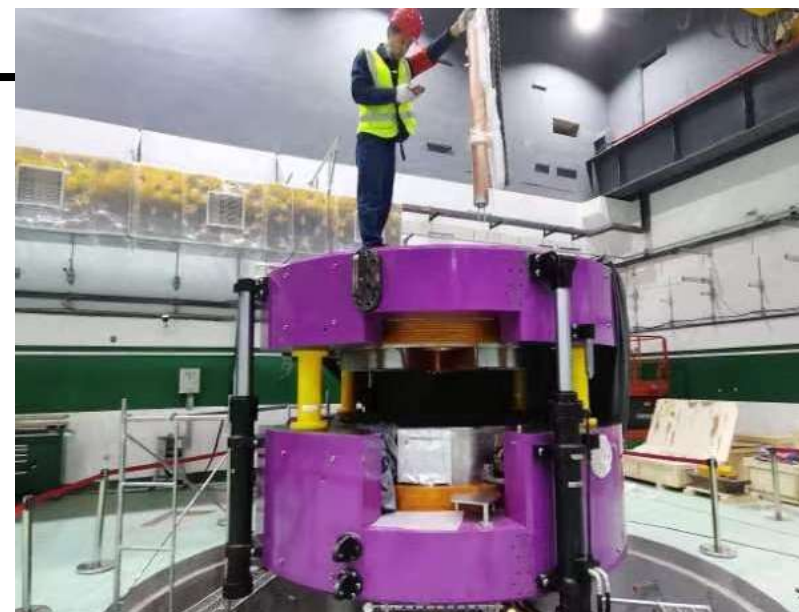
- Contract was signed in Nov. 2019
- Installation started in May 2022
- beam commissioning finished in Dec. 2022
- Expected to be put into clinical use in May 2023





HIMM-4

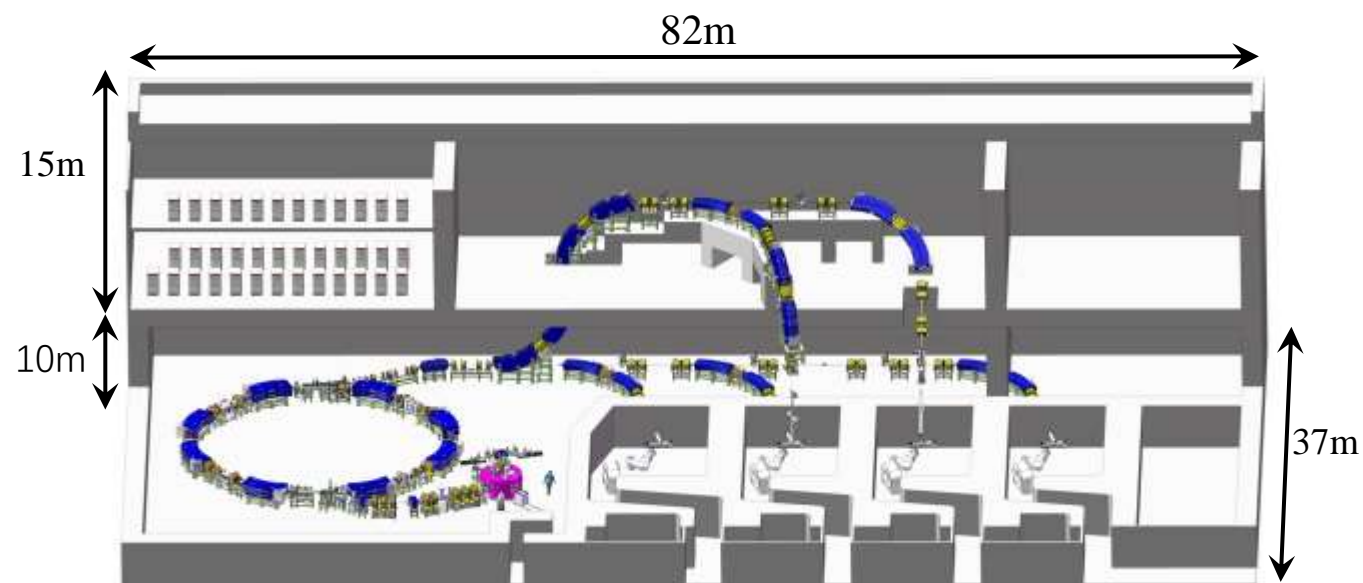
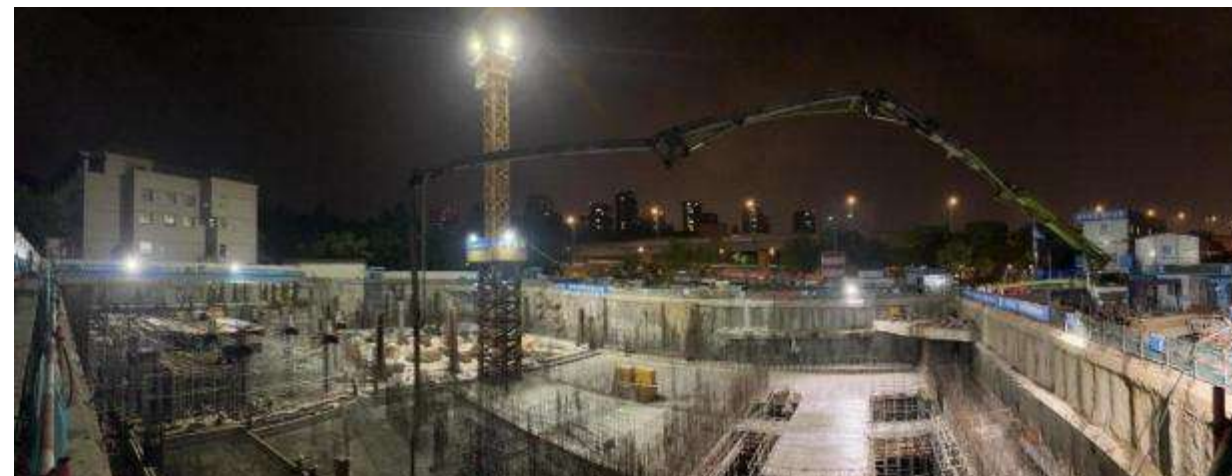
- Nov. 2022, Installation started
- Expected to be put into clinical use in May 2023





HIMM-5

- Contract was signed in Nov. 2020
- Expected to be installed in Feb. 2023





HIMM-6/7

- Contract are signed in 2021 and 2022
- The civil design has been completed and the building construction is in progress



04 Prospect





Particle therapy facility in operation world wide



The proton and heavy ion radiotherapy facilities are mainly located at the countries in America, Europe and Asia. The total number of facilities is **105**, which are distributes as follows:

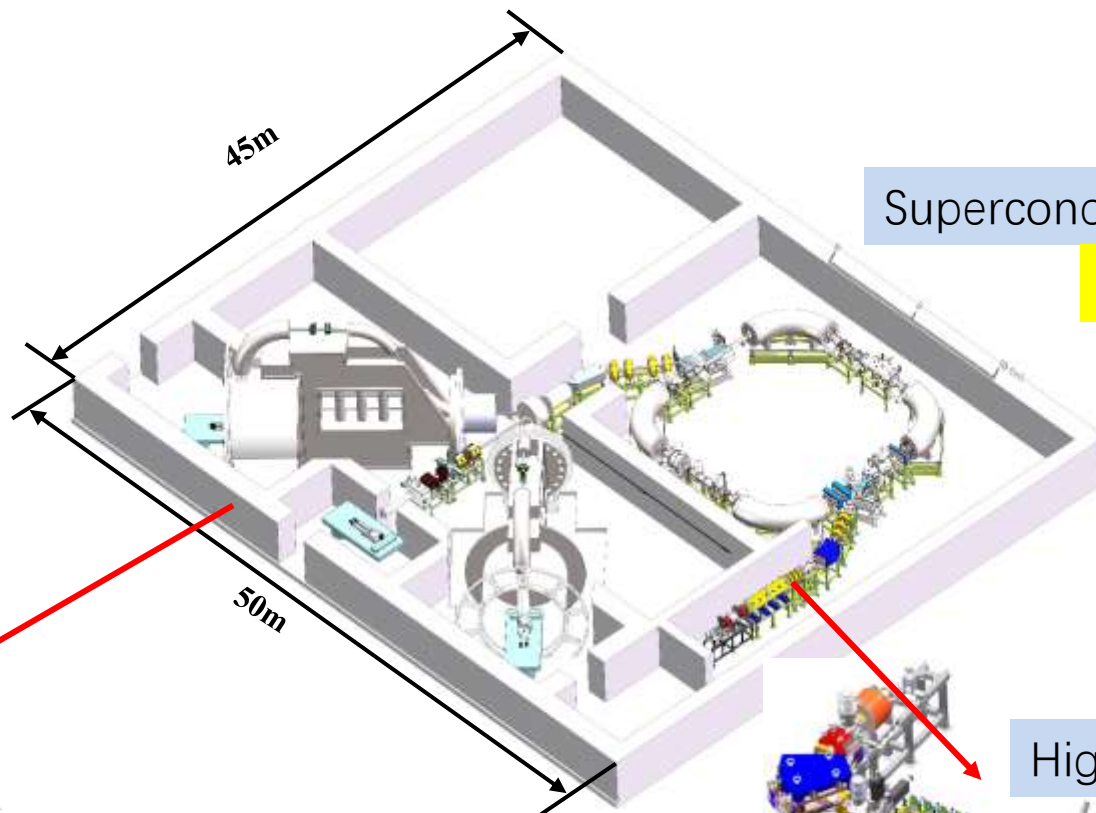
- America has **38** operating proton therapy facilities
- The **35** facilities in Europe are mainly located at Germany, France, Italy, Spain, Netherlands, Russia etc.
- The **32** facilities in Asian are mainly located at Japan, China, South Korea and India.

There are over 14,000 linear accelerators in global, over 3,300 after_loading units in global, but only 104 particle therapy facilities in global!
It has huge development space for particle therapy in the future!



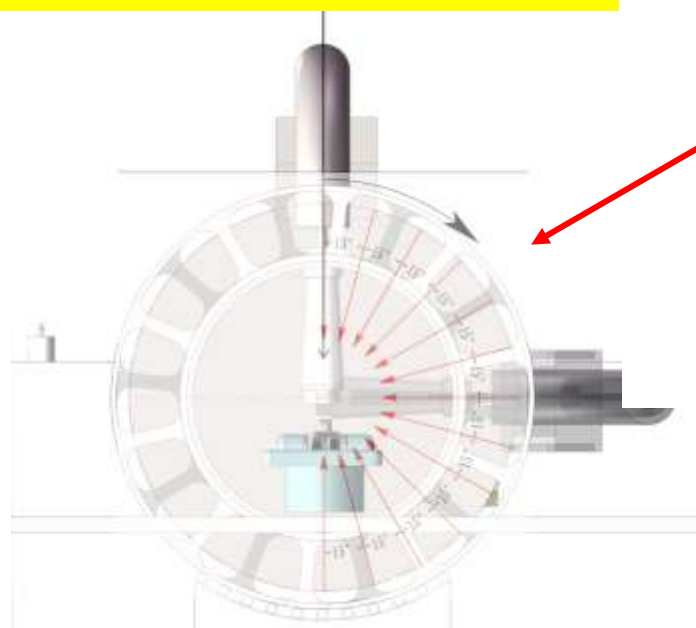
Reduce the size of the facility

- the total number of particle therapy facility in operation is 104, but only 13 of them are heavy ion facility. Why?
- Size of the conventional heavy ion facility (4 treatment rooms): **70m×45m**

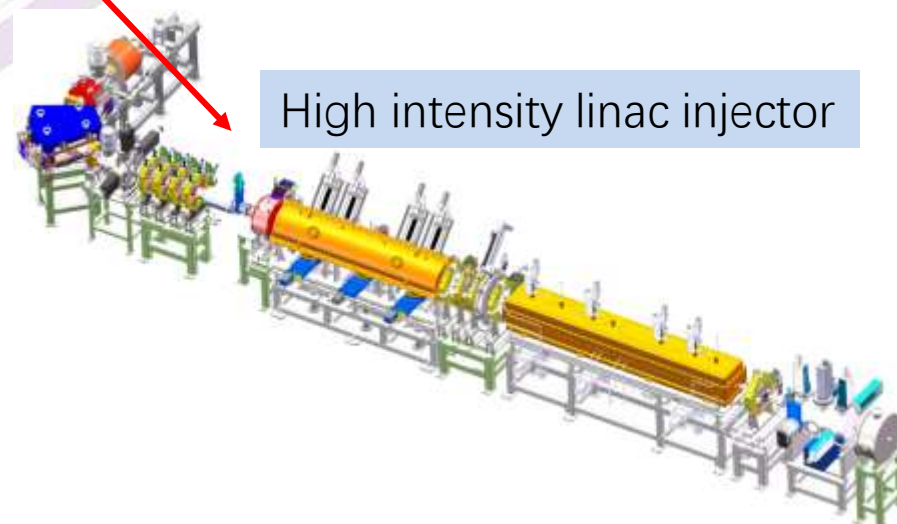


Superconducting heavy ion facility

• **Footprint: 50m×45m**



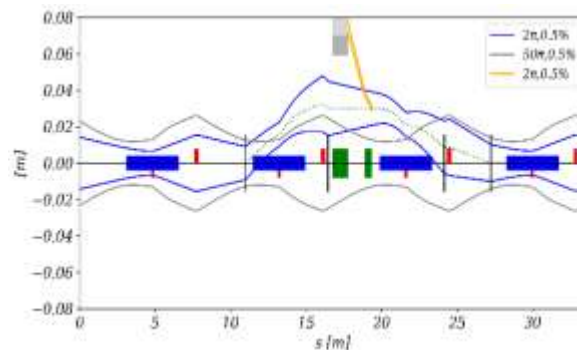
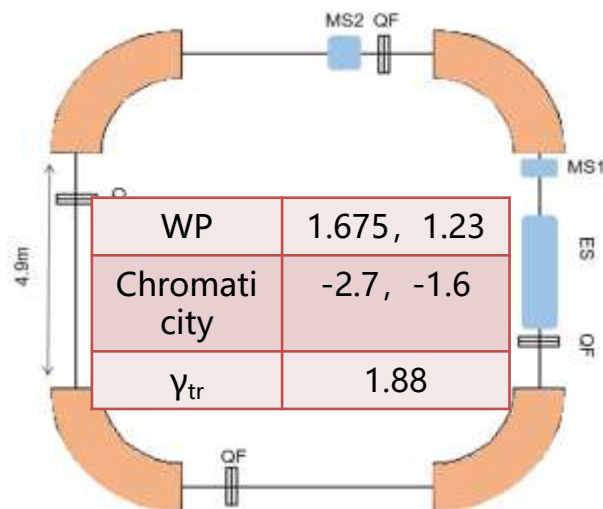
Superconducting gantry



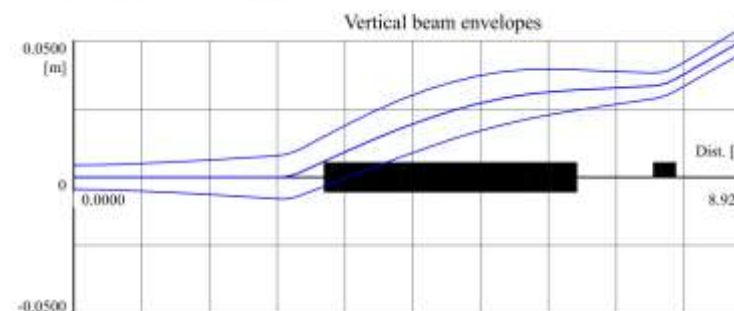
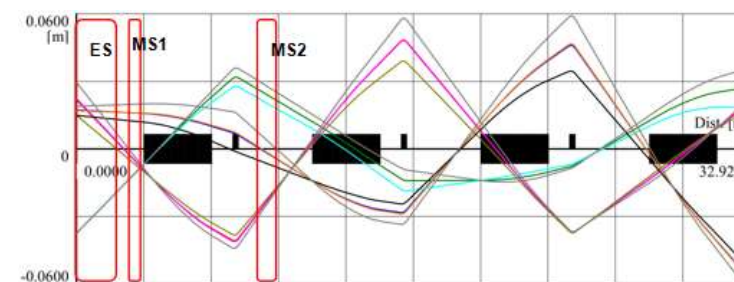
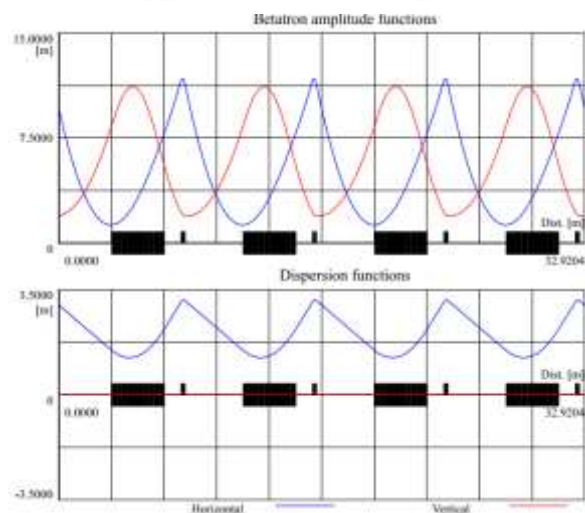
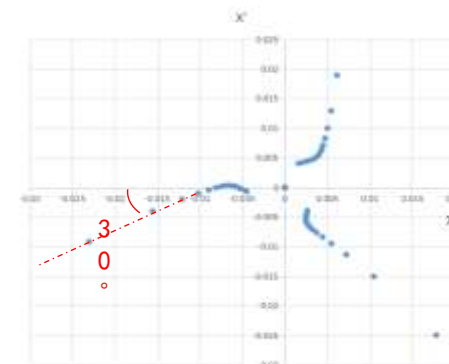
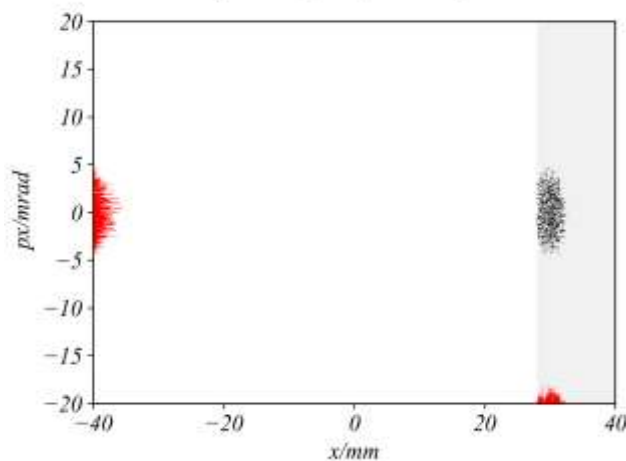
High intensity linac injector



Synchrotron with superconducting magnets



phase space (turn=1)

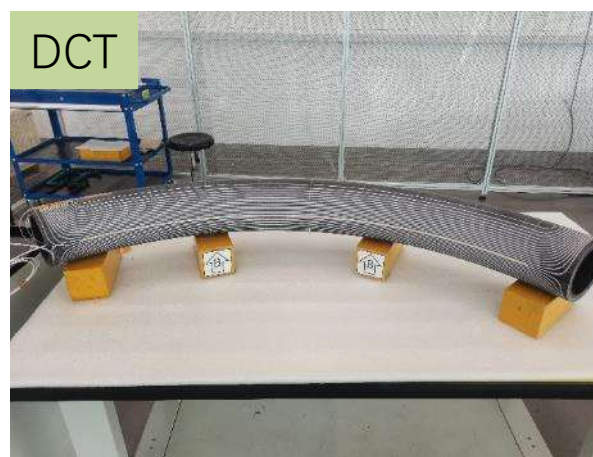
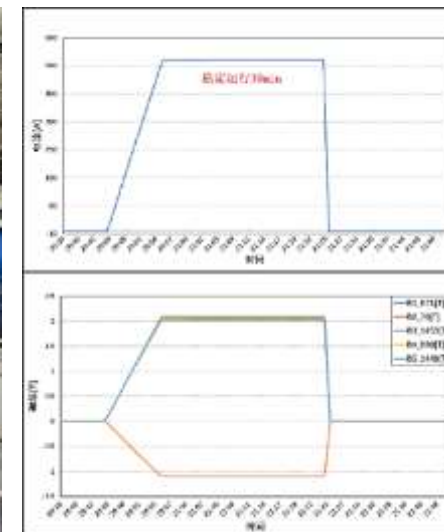


Testing of the superconducting magnet

First generation: straight dipole



Second generation: Arc-shaped dipole





Prospect

- Currently, there are totally 8 HIMM facilities in operation or under construction in China. This number will be expanded to 15 in the next 5 years as our prediction.
- In the next 10 years, we hope that we can assembly more than 30 HIMM facilities worldwide (including 25 in China).
- The small size of the synchrotron with superconducting magnets will replace the old version (conventional magnet) in next 5 years.



Thank you for your attention!