High Intensity Heavy-ion Accelerator Facility

I. INTRODUCTION

The High Intensity Heavy-ion Accelerator Facility (HIAF) has been approved as one of the large-scale national science and technology infrastructural facilities in 12th Five-Year Plan and has been constructing since the December of 2018 with a 7-year construction period and total budget of 1.67 billion CNY approved by the National Development and Reform Commission (NDRC), China. The HIAF project is organized by the Chinese Academy of Sciences (CAS) and implemented by the Institute of Modern Physics (IMP).

Fig.1 General Layout of the HIAF

The HIAF facility is a new generation, world-leading high-intensity heavy-ion accelerator complex. The facility is able to produce radioactive nuclides extremely far away from the line of beta stability. It can provide low energy heavy ion beams with the highest peak current in the world. It will be a state-of-the-art nuclear mass spectrometer which can provide pulsed heavy ion beams with a maximum energy of 4.25 GeV/u. The facility can provide a world-leading research platform to identify new nuclides, study weakly bound nuclear structures and reaction mechanisms, and especially measure the accurate masses of short-lived nuclei mass.

The HIAF project mainly consists of the accelerator complex, the experimental terminals, auxiliary devices and civil constructions. The accelerator complex is designed based on a combination of one superconducting linac and two synchrotrons. A series of new technologies are used in order to provide high-intensity, high-energy and high-quality heavy ion beams, and

to produce radioactive nuclides far away from the stable line. The experimental terminals are constructed around the HIAF beam lines, to provide an excellent research conditions for nuclear physics, atomic physics, the nuclear astrophysics and applications in materials and biology.

II. CONSTRUCTION PROGRESS

Since the start of the construction at the beginning of 2019, the HIAF project has run smoothly in the general design of facility, the research and development of key technologies and the manufacture of equipment prototypes, the construction of auxiliary system and civil engineering under the guidance of the regulations, the budget and the time schedule in the whole year.

1. Key technologies

In 2019, all the key technologies and their prototypes have been made a significant breakthrough, which means the most critical technical problems of the HIAF construction have been solved. All prototypes are scheduled to be completed in the middle of 2020. The magnetic core and the coils of the BRing fast ramping dipole prototype (Fig. 2), as well as a high-precision single copper wire with a large rectangular cross section (78m long, 25mm × 30mm / φ12.5mm) have been produced successfully. Two high-voltage modulates and one low-voltage modulate were tested for the full-energy storage fast-cycle pulse power source prototype (Fig. 3). The maximum current reaches up to 2000A with the ramping rate of 40000A/s. Moreover, the control system, the space vector PWM rectification technology and the operation mode were also tested individually. The prototype has been assembled in December and its commissioning will be started soon. A 750mm magnetic alloy core was successfully developed for the high-gradient wide-bandwidth fast-response MA core loaded RF prototype (Fig. 4). The tests shown an advanced level result compared with Hitachi products. A Zirconia ceramic lining has been developed for the prototype of ultra-thin-wall XHV vacuum chamber with ceramic lining (Fig. 5). The thickness of the lining is reduced from 5mm to 2mm. In addition, a magnetron sputtering gold-plated film on zirconia ceramic has been developed to solve the problem of beam impedance. A half aperture Canted-Cosine-Theta (CCT) superconducting magnet prototype (Fig. 6) combined with quadrupole and sextupole, has been fabricated. The key technologies related to coil former machining, coil winding and vacuum impregnation have been investigated.

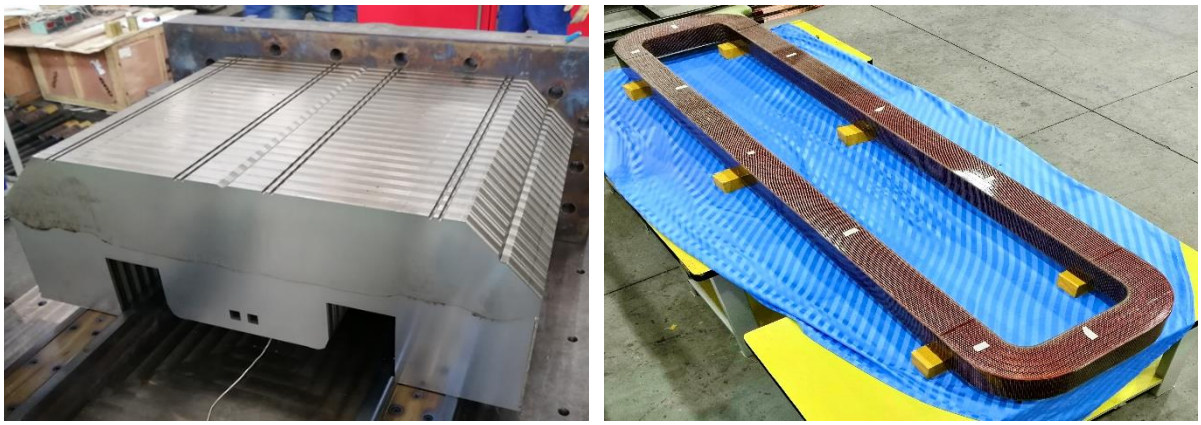

Fig. 2 Prototype of the BRing fast ramping dipole, magnetic core (left) and coils (right)

Fig. 3 Prototype of the full energy storage fast cycling pulse power supply (left) and the connections (right)

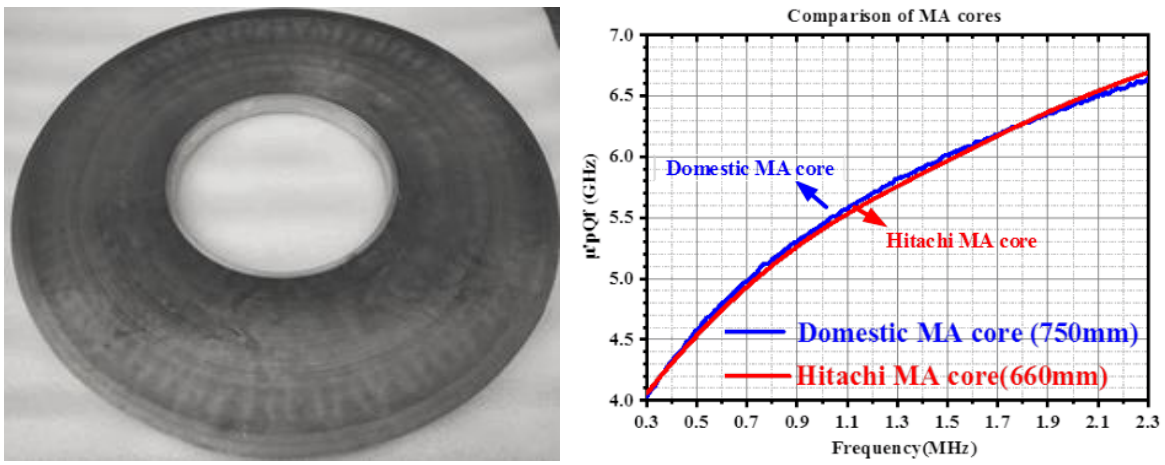

Fig. 4 Prototype of the MA core (left) and its measured static parameters (right)

Fig. 5 Prototype of ultra-thin walled ultra-high vacuum chamber with ceramic lining (left) and the device for magnetron sputtering gold-plated film on ceramic ring (right)

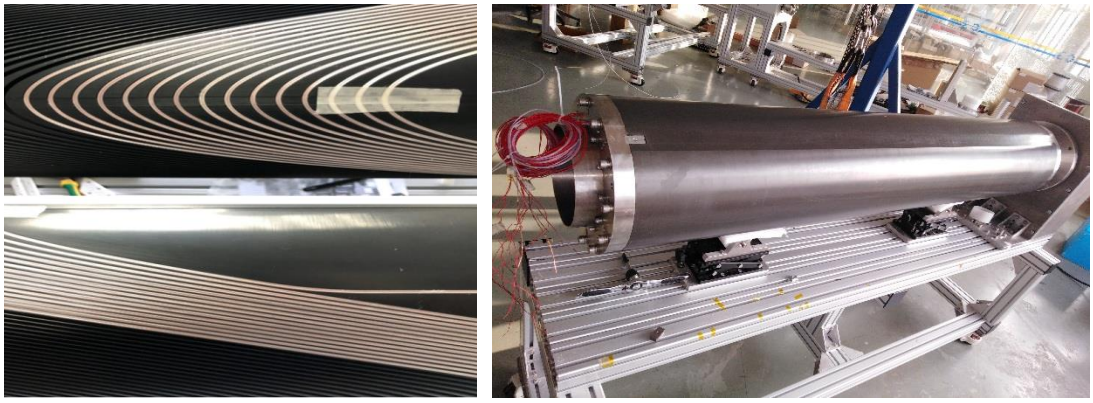

Fig. 6 Half aperture CCT superconducting magnet prototype

2. Civil construction

The 3-dimensional accelerator assembling drawing has been accomplished based on the HIAF general design frame in 2019. The 3-dimensional tunnel design has been established and its installation procedure has been simulated. All pipes have been distributed on the drawing and optimized to connect the devices, the buildings, the auxiliary devices, ect.. The logistics of the devices in tunnel was designed completely. The arrangement of all systems has been optimized, including the entrance and exit gates, the radiation protection shielding, the electronics equipment room, the cranes, etc. (Fig. 7)

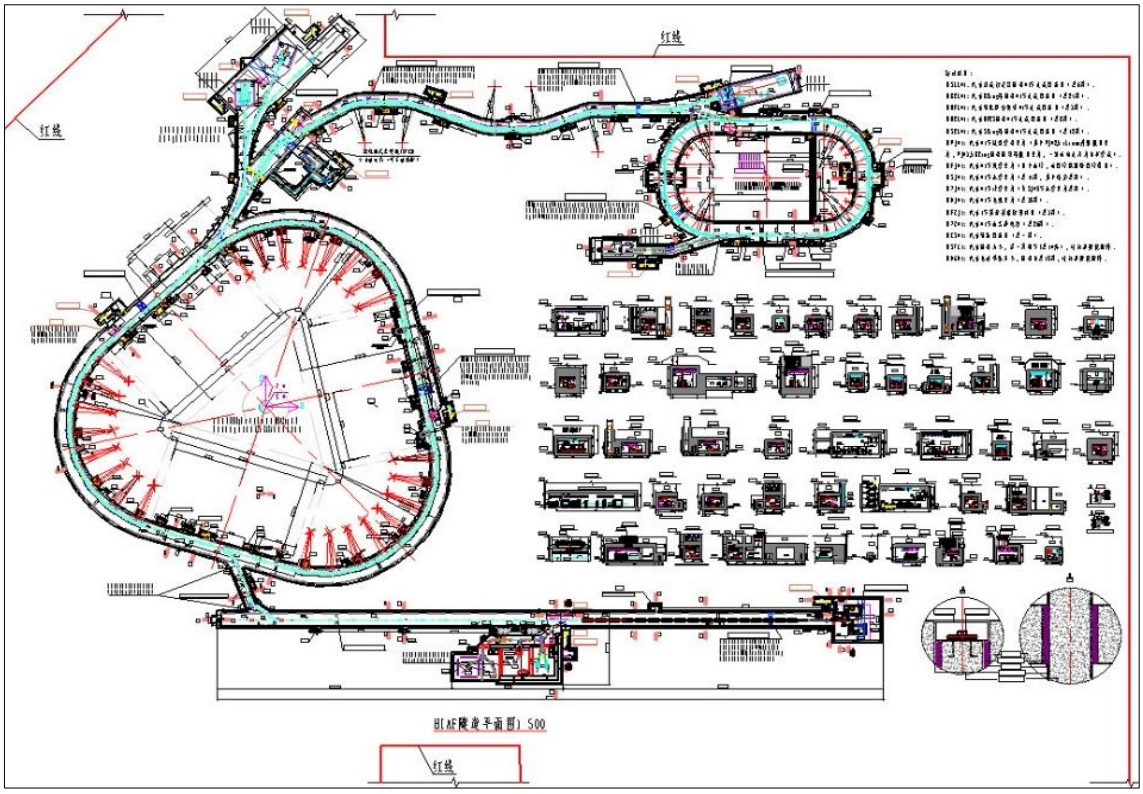

Fig. 7 Schematic Layout of the accelerator complex and its tunnel

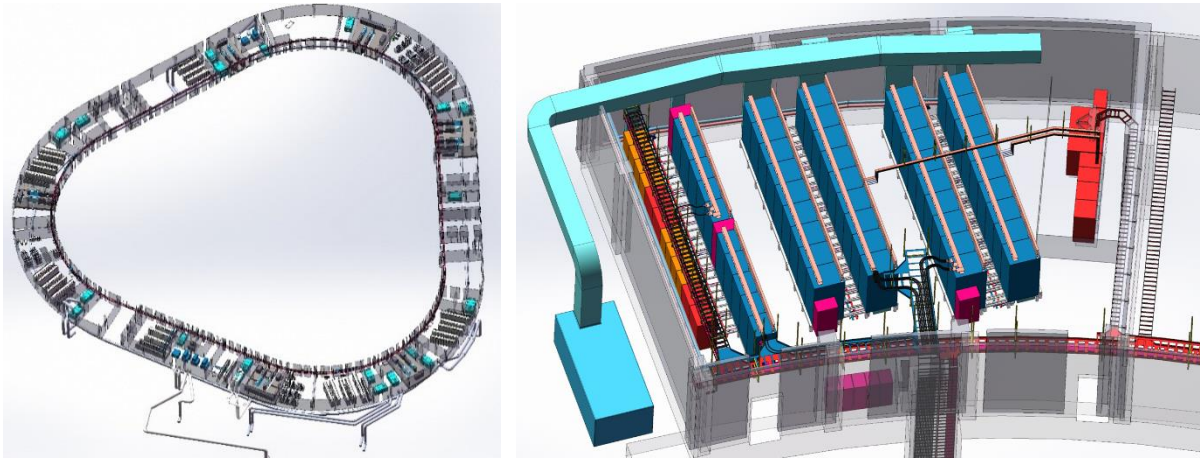

Fig. 8 No.1 power center (left) and the room for power supplies PC-B02

Both of the campus layout and the tunnel layout have been initially sketched in accordance with the technical requirements and the tunnel layout by the civil engineering companies in cooperation with IMP. The buildings, the civil structures, the water supply and drainage, the electricity are all included in this work. The assessment of the design work will be organized next.

3. Civil construction and auxiliary system

The total civil construction and auxiliary system budget of both HIAF and CiADS projects

is 2.35 billion CNY. In 2019, about 6.6 million cubic meters (about 85%) of earthwork construction has been completed, the total earthwork construction will be accomplished in September 2020. The water supplies construction was started in December 2019 and will be finished in October 2020. The power grid construction is scheduled to be completed in September 2020. The East Road will be completed in June 2020.

Fig. 9 Overview of the HIAF campus on 4th December 2019

4. Project management

Many seminars and workshops were organized in 2019, including 10 review meetings, 42 regular meetings, 54 key technical symposiums, etc. The contract pre-assessment system was established. Totally, the budget of 192,127,200 CNY (97.6% of 2019 budget) has been paid for the HIAF project.

III. Cooperation and communication

A series of expert reviews, assessments and discussions have been organized in 2019, which have greatly promoted the collaboration between IMP and other institutes in the world on the HIAF project.

From 13th to 14th May, 2019, the review meeting on the design of the BRing fast ramping dipole prototype and the Kicker power supply was held in Lanzhou. (Fig. 10)

Fig. 10 Review of the HIAF BRing fast ramping dipole prototype

From 27th to 31st May, 2019, Dr. Fritz Caspers and Dr. Xavier Buffat from CERN visited IMP and discussed the topics related to the beam instabilities, the EMC work and others with Chinese colleagues. (Fig.11)

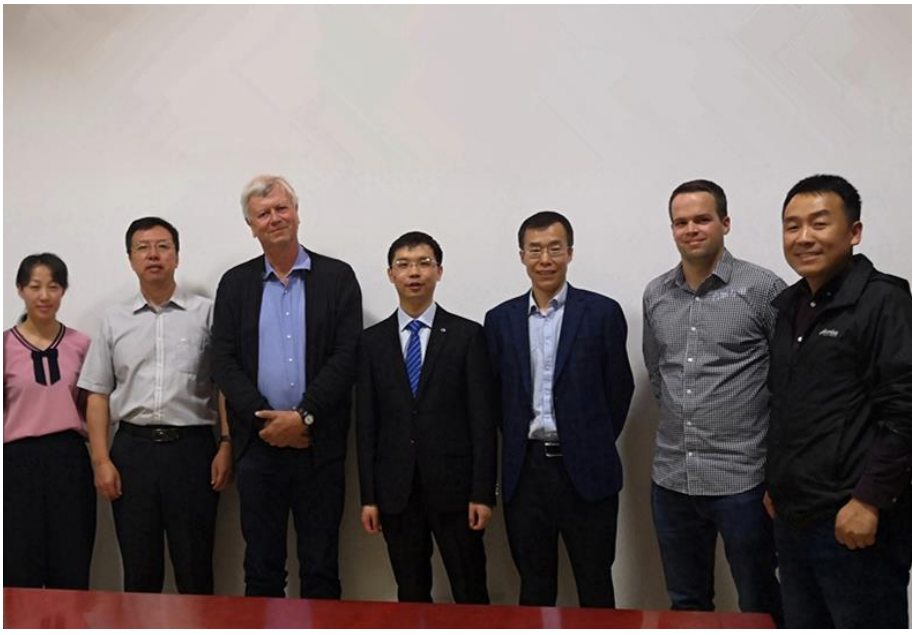

Fig. 11 Dr.Fritz Caspers and Dr.Xavier Buffat (CERN) visited IMP

On 25th June, 2019, the review meeting on the design of the HIAF BRing RF system was held in Lanzhou.

On 20th July, 2019, the symposium on the HFRS cryogenic system for the superconducting magnets and the Waterproof design for its tunnel was held in Lanzhou.

On 12th August, 2019, the review meeting on the design of the HIAF superconducting Linac was held in Lanzhou.

On 21st August, 2019, the review meeting on the design of the HIAF iLinac cryogenic system and the refrigerator tender technical documents was held in Lanzhou.

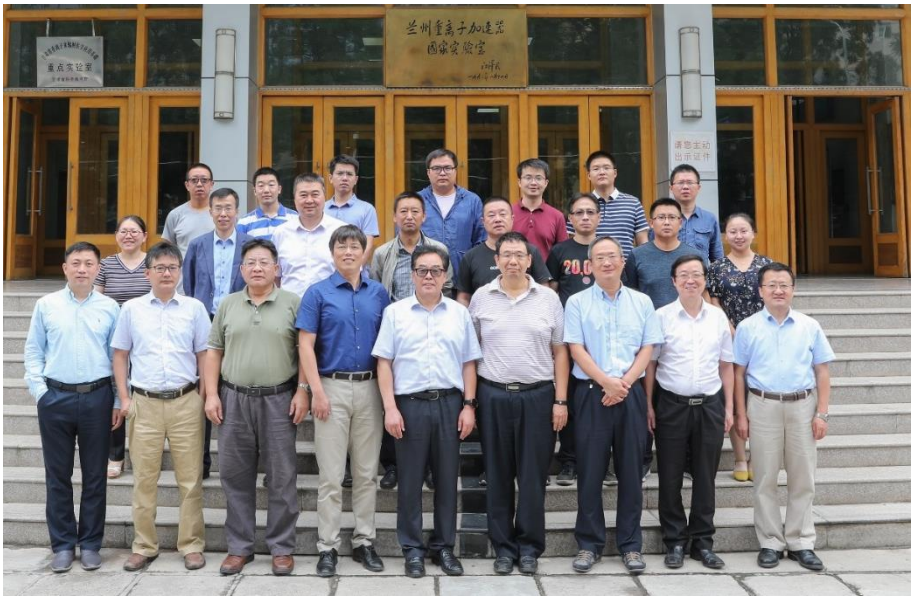

Fig. 11 Review meeting on the design of the HIAF iLinac cryogenic system

On 27th August, 2019, the meeting on the HIAF radiation protection was held in Lanzhou.

On 7th September, 2019, the review meeting on the design of the HIAF electron cooler and electron target was held in Lanzhou. (Fig. 12)

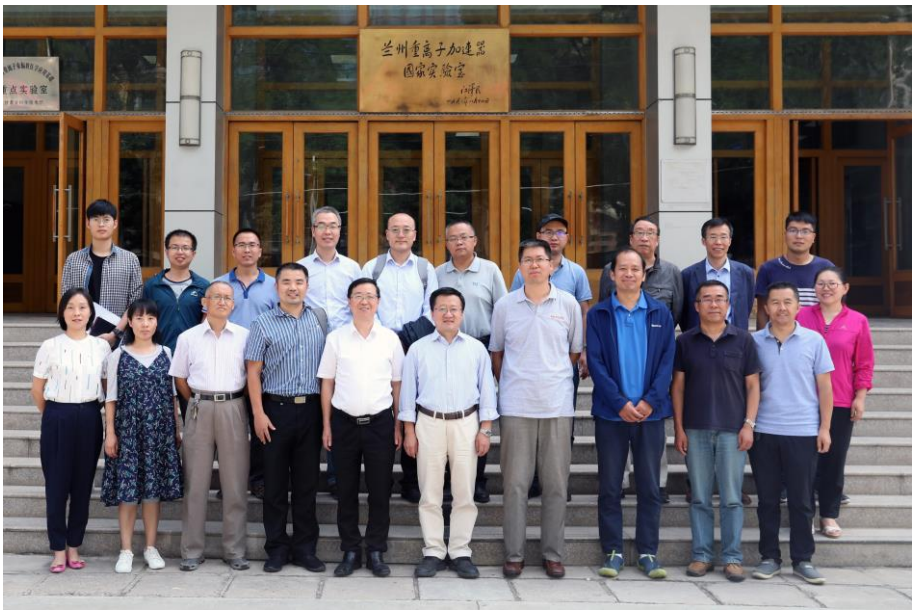

Fig. 12 Review meeting on the design of the electron cooler and electron target

On 11th October, 2019, the meeting on the design of the HIAF air conditioning system and ventilation system was held in Lanzhou.

From 26th to 29th November, 2019, Academician Wen-long Zhan and colleagues participated in the NON-IDEAL PLASMA PHYSICS Conference, visited IPCP RAS, JIHT RAS and ITEP RAS. Some memorandums were signed related on the high-energy density physics research.

IV. Milestones

On 23rd December, 2018, construction commencement ceremony of the HIAF project was launched in Huizhou, Guangdong Province. (Fig. 13)

Fig. 13 The HIAF construction ceremony in Huizhou

On 21st February, 2019, MA Xingrui, Deputy Secretary of Guangdong Provincial Party Committee, Governor of Guangdong Province, visited the campus and investigated the construction of the HIAF and CiADS projects. (Fig. 14)

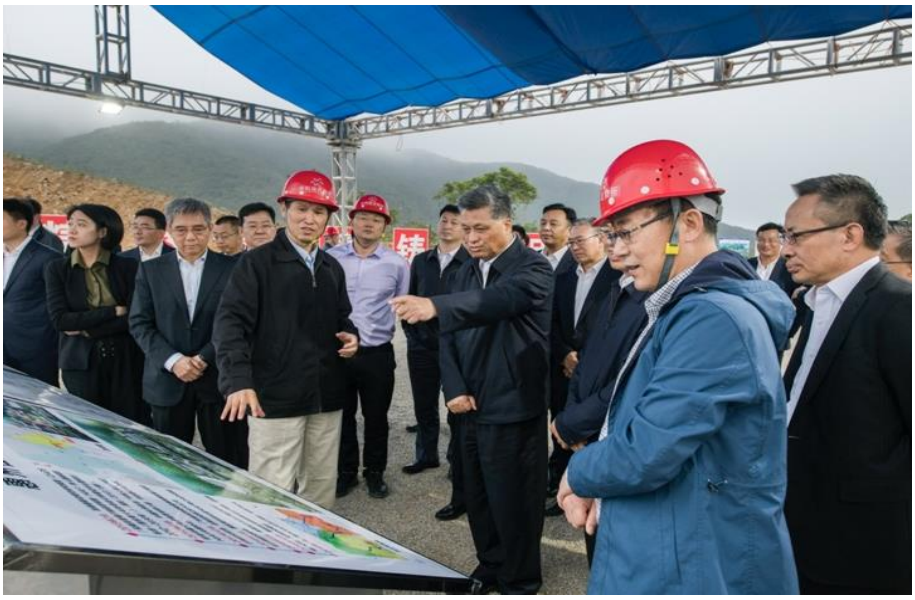

Fig. 14 MA Xingrui, Governor of Guangdong Province, visited the campus of HIAF and

CiADS

On 5th March, 2019, ZHEN Haitao, Deputy Chief of Department of Science and Technology of Guangdong Province, visited the campus and investigated the construction of the HIAF and CiADS projects.

On 14th March, 2019, CAO Dahua, Deputy Director of Guangdong Provincial Development and Reform Commission, visited the campus and investigated the construction of the HIAF and CiADS projects.

On 5th June, 2019, LIU Hua, Deputy Minister of Ministry of Ecology and Environment of the People's Republic of China, Director of National Nuclear Safety Administration, visited the campus and investigated the construction of the HIAF and CiADS projects. (Fig. 15)

Fig. 15 LIU Hua, Deputy Minister of Ministry of Ecology and Environment, visited the campus of HIAF and CiADS

On 12th August, 2019, QIN Weizhong, Deputy Governor of Guangdong Province, visited the Headquarter of HIAF and CiADS and investigated the construction progress.

On 10th December, 2019, LIN Keqing, Deputy Governor of Guangdong Province, visited the HIAF and CiADS campus.

On 26th December, 2019, the Headquarter of HIAF and CiADS started to construct.

On 31st December 2019, the People's Republic of China Real Property Ownership Certificate was issued to HIAF campus.