XIE Jialin: Father of China's High Energy Accelerators

By XIN Ling (Staff Reporter)

The name of physicist XIE Jialin (Hsieh Chia-lin) is related to many *firsts* in China and the world. He invented the world's *first* high energy medical accelerator for electron beam therapy. He developed the *first* linear accelerator in China. He was the chief designer of the Beijing Electron-Positron Collider (BEPC), China's *first* collider and large-scale scientific facility and one of the high energy research hubs in the world. He built the Beijing Free Electron Laser facility, on which saturated oscillation was realized for the *first* time in Asia... For more than half a century Xie has used his intelligence and insights to push China towards the frontier of accelerator sciences. He became laureate of the national top science award in February, 2012.

Professor Xie Jialin. *Courtesy Liu Jie from IHEP*

From Standford to New China: the making of a leading accelerator scientist

The legend of Xie Jialin as an accelerator scientist began in the early 1950s when he worked at the Microwave Laboratory, Standford University. There he participated in developing the world's first electron linear accelerators (linacs) and learned a lot from colleagues including his doctoral supervisors, M. Chodorow and E. Ginzton, and Wolfgang K. H. Panofsky, who later built the Standford Linear Accelerator.

"In the spring of 1953, a cancer expert from Chicago came to our lab and asked if we could help him build an electron accelerator for medical use. X-rays therapy for cancer was popular at that time, but high energy electron beams can hit the tumors more effectively with less side effects," the 92-year-old professor recalls.

Xie Jialin was sent for the mission. All he had was an accelerating tube and part of a klystron, which were provided by Standford and needed to be taken apart for transportation and put together in Chicago through a series of complicated operations. His team comprised an engineer and four technicians from a local cosmetics plant and a radar veteran: none of them had ever seen an accelerator before.

Xie and his diligent assistants worked around the clock. "There are many differences between an ordinary electron accelerator and one dedicated to radiation therapy. We optimized the klystron to ensure stable and safe output, expanded the electron beams and enabled them to rotate for irradiation on the human body."

From the accelerator's design, development to clinical tests, Xie had encountered and defeated numberless difficulties, and his team finally tasted the joy of victory. In early 1955, the 45MeV electron medical accelerator was applied to its first patient, a big news in the city. This is the first high energy medical accelerator for electron beam therapy in the world.

To Xie's joy, the accelerator was still in operation two decades after it was invented. When Panofsky, then director of SLAC, visited China in 1976, his first word to Xie was "I'm glad to tell you that the machine you made in Chicago is still running".

The success was a great inspiration for Xie. He not only accumulated experiences on nearly every detail of making a high energy electron accelerator, but built self-

XIE Jialin (sitting) and his coworkers work at the 45 MeV medical linac in Chicago in 1955.

confidence and a life-long belief in "learning by doing".

After he returned China in late 1955, Xie joined the CAS Institute of Modern Physics (now Institute of High Energy Physics, IHEP) and set out to use what he had learned in the United States to serve his homeland. His first goal was to build a 30MeV electron linac.

The condition for scientific research was extremely shabby in China at that time. Xie had hardly any equipment or professional workers, and technology transfer was prohibited by developed nations. He had to start from scratch.

To "grow wheat before making bread", he launched training courses for young researchers on basic subjects such as electronics, microwave technology and nuclear physics, and sent them abroad for short academic visits. He also set up a microwave lab, a modulator lab and a precision machine shop to develop major components and devices on their own.

With the world's most powerful klystron and its modulator Xie's team had worked out, the 30MeV electron linac was put in place in Beijing in 1964. It is China's first linac and could be extended and upgraded into an advanced electron accelerator with very high energy capacities.

Soon the accelerator was applied to basic research, nuclear detector calibration and other fields.

"The 30MeV linac project not only marked the beginning of accelerator sciences in China, but trained a number of young researchers and laid a solid foundation for the construction of Beijing Electron-Positron Collider," remarks YE Minghan, Member of the Chinese Academy of Engineering and Xie's colleague at IHEP.

Success of BEPC and BFEL: an internationally-minded strategist

Amid domestic political turmoil, Xie and 17 senior scientists proposed to Premier ZHOU Enlai on China's high energy physics research and the construction of a high energy particle accelerator.

The accelerator program was kicked off in 1977. The original plan was to build a 50GeV proton synchrotron for fixed target experiments in suburban Beijing, with Xie as its chief designer. However, due to a national economic restructuring, the synchrotron plan was abandoned and IHEP scientists had to start all over again.

Different voices came to Xie about where the accelerator should go. Among them, Xie was particularly interested in Panofsky's suggestion on a 2.2GeV electron-positron collider.

"A 2.2GeV electron-positron collider has a clearly-defined scientific goal. Besides, it can be used not only as an advanced particle accelerator but a synchrotron radiation facility, and its moderate scale just fits within the budget," Xie explains.

Xie carried out extensive investigations and organized several rounds of discussions with home and overseas colleagues including T. D. Lee, a Chinese born American physicist and Nobel Laureate with Columbia University.

"Based on his experience and insights, Xie worked out a thorough and well-grounded analysis on all alternative choices, and persuaded everyone in our team that the 2.2GeV collider scheme was the best choice," Ye recalls.

Some doubted China's capacity to build such an advanced machine. For China, a laggard of science for so long, numerous technical challenges were lying ahead. As a foreign expert had put it, the BEPC project was "like jumping on a flying train from the platform — to end up in a beautiful catch or smashing into pieces".

"However, I was confident we can overcome all technical hurdles. In fact, by building the 30MeV linear electron accelerator we had already finished the pre-research of the collider's injector. And thanks to government support and the opening-up policy, we can get more aid from western scientists and industries."

As the chief designer and project manager of BEPC, Xie showed outstanding leadership and was famous for his six principles on the collider's construction: use only tested and best technologies; focus on simple and reliable design; leave room for improvements; *etc*. These principles are still used today in building big scientific facilities in China.

"Leadership is an art. For the leader of a scientific project, he must be both professionally competent and considerate enough to take everything into account, from the nation's fundamental realities to 'human relations'. In this sense, Professor Xie is a role model of all-round strategic scientists," acclaims CHEN Hesheng, CAS Member and leader of the BEPC upgrade project.

In October 1988, with the first collision of electrons and positrons in a badminton racket shaped collider lying under IHEP, the construction of BEPC declared a success. It is a milestone in the history of science and technology in China. It is also regarded as an example of early Sino-US scientific cooperation, as a result of government promotion and the international vision and connections of Xie Jialin.

The luminosity of BEPC proved to be three times higher than SLAC's SPEAR, and the precise measurement of the tau mass carried out at BEPC aroused world attention. Soon the Beijing Synchrotron Radiation Facility started to work as an experiment platform for multiple disciplines.

A big success as BEPC was, Xie never stopped his steps towards the summit of accelerator science. In 1986, he set eyes on an emerging technology — free electron laser (FEL).

"An FEL is different from an ordinary laser in that it is based on electrons produced by an accelerator," Xie notes. "It has the widest frequency range of any laser type, is widely tunable, and thus became a hotspot in scientific research soon after it was invented at Standford in 1977."

Xie realized that it was going to be a very challenging task, as it called for extremely high quality electron beams. The beams shall be very intense and stable while their emittance and energy spread need to be as low as possible. In 1987, his proposal for building the Beijing Free Electron Laser (BFEL) won support from the National High-tech R&D Program.

To cut costs, he made the best use of the old machines at IHEP. For instance, BFEL's injector was largely based on the 30MeV linac built two decades ago. And an unused quadrupole magnet was remolded into the alpha magnet on the injector.

He also proposed the "feedforward control" method to improve the stability of electron beams in BFEL, an innovation in the world at that time.

With eight years of hard work and a total cost of only one tenth of similar FELs in the world, BFEL produced the first spontaneous emission in May 1993. By the end of that year, the lasing reached saturation. "In fact, it was the first infrared free electron laser with saturated oscillation in Asia, after those built in the US and Europe," says ZHANG Chuang, IHEP researcher and Xie's colleague.

In the new millennium, Xie devotes much of his research time to a new endeavor: developing new types of linacs. As linacs are widely applied to scientific study and industrial production, Xie has been long thinking of simplifying their structure and cutting their costs.

His method is to reduce a linac's three subsystems to two, by merging the electron gun and klystron. With the help of his doctoral students and colleagues, the prototype of the world's first such new-type compact linac was born at IHEP in 2004.

An inspirational pioneer

As a world-class accelerator scientist, Xie has inspired generations of researchers with his profound learning and noble personalities: perseverance, pure-heartedness, and patriotism.

"Scientific research is an endless journey of conquering difficulties. I'm an ordinary person, neither very clever nor talented. My experience confirms one thing: we'll all get somewhere as long as we keep working hard," Xie was quoted as saying after he received the supreme award on February 14, 2012.

In the eye of IHEP colleagues, "Professor Xie always looks beyond fame and wealth". "The highest position he's ever held was deputy director of our institute. In 1986, when he was almost at the summit of his career, he chose to step down and turn to the development of BFEL. He often says it's important to leave opportunities to young people," says WU Gang, an IHEP researcher and Xie's colleague.

Many coworkers and friends believe that, besides an intense interest in making radio devices from a very young age, Xie's legendary success was deeply rooted in his profound love for China, his motherland.

Courtesy Liu Jie from IHEP

Professor Xie at his IHEP office in January, 2010.

More than sixty years ago, on September 20, 1951, Xie boarded the ship President Cleveland for China. He had just received his PhD from Standford and was eager to go home for family reunification and participate in building new China. But his dream was shattered at Honolulu. The US authorities prevented him and several other Chinese scientists from continuing their journey.

Four years later, after he invented the world's first high energy medical linac in Chicago, Xie was offered the permanent citizenship of US. But he was determined to go back — "my knowledge was crucial for China. China needed me and I must do my part."

As Xie often told his eldest son, XIE Yaning, a researcher at the synchrotron radiation laboratory of IHEP, "a man is forgivable for not becoming a hero. But he's unforgivable if he doesn't even bring a stone to build his nation."

This patriotism has greatly influenced many of Xie's students, including GAO Jie, who joined IHEP in 2004 after working for the Linear Accelerator Laboratory (LAL), French National Centre for Scientific Research for over a dozen years.

In the summer of 1996, Gao obtained his HDR from Université Paris-Sud at Orsay, and was invited to give a three-day lecture on future linear electron-positron colliders in Beijing. On the first day of the lecture, Prof. Xie arrived on his old bicycle.

"I'll never forget his words for me during that meeting. He said to stay abroad is to 'add icing to the cake', but to return is 'offering coal in the snow'," Gao remembers well.

At the end of 2004, Gao gave up his research post in France and joined IHEP, where his respectable teacher has been working since its establishment.

"Professor Xie is a great teacher, a well cultivated gentleman, both in Chinese and western terms, and a lifelong friend," Gao says. "I feel lucky and happy for being able to return and work for my country, just like Professor Xie has done."

Now, Professor Xie still goes to IHEP every week. He said he likes to talk to young people and listen to their thoughts. He will stay active in the realm of accelerator science, because for him, it's a career that he has loved and pursued with all his life.