

The Chinese nuclear tests, 1964–1996

Thomas C. Reed

A combination of intellectual rigor, technical sophistication, hard work, and intelligence gathering brought China into the world's nuclear club in record-shattering time.

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The visitors from China seemed innocuous enough. The five of them had flown in from Beijing to attend the 1989 American Physical Society Conference on Shock Waves in Condensed Matter in Albuquerque, New Mexico. Danny Stillman, director of the technical intelligence division at Los Alamos National Laboratory, met the visitors' plane, took care of their transportation and food needs, and escorted them through the National Atomic Museum in Albuquerque. All five visitors seemed to be jolly academic tourists, but appearances can be—and in this case were—deceptive. In the next year or two, all five were revealed to be top scientists in the Chinese Academy of Engineering Physics, the equivalent of the combined US nuclear weapons laboratories at Los Alamos, Livermore, and Sandia. Those visitors from China were scouting the American turf.

In June of 1988, another guest traveled to Los Alamos by himself: Yang Fujia was a multitasking Chinese technocrat with an ill-defined agenda. (In China, family names come first, and I will observe that custom in the material that follows. The professor's family name is Yang; Fujia is the equivalent of "Tom.") Besides serving as the director of the Shanghai Institute of Nuclear Research, Yang held positions at Fudan University and in several international scientific bodies. Stillman welcomed Yang's visit, for he had learned that the best source of intelligence was often simple and direct questions posed to a knowledgeable visitor.

For starters, Stillman asked the professor, "Does the Chinese nuclear weapons program have a prompt burst reactor?" Such an experimental reactor, typically located in a remote area, can operate supercritically for a fraction of a second and thereby simulate the efflux of radiation and particles from a nuclear detonation. Yang's answer: "Of course."

Stillman pulled out a map of Sichuan Province. "Can you show me where it is?" He thought he already knew the answer, but much to his surprise, Yang pointed to a location off in the mountains, a considerable distance west of the known Chinese nuclear weapons facilities.

Stillman fired a third fastball, right over the plate: "Can you arrange an invitation for me to visit that facility?" "Certainly," the professor responded. "Just send me a copy of your resumé and tell me what other nuclear weapons facilities in China you would like to visit."

Thus began a most remarkable unveiling of the Chinese nuclear weapons program, a deliberate disclosure of its nu-

clear crown jewels to a central player in the American nuclear intelligence community. Chinese officials knew exactly who Stillman was. It is clear they chose to show him, firsthand, the achievements of their nuclear world. They wanted Stillman to take the information home, to tell the American government, the scientific community, and the citizenry at large all about China's technical capabilities. Why would the Chinese government do that? Nuclear weapons design information is supposed to be a deep, dark secret.

For one thing, the Chinese probably sought deterrence. An American awareness of Chinese nuclear capabilities should lead to a more cautious American military posture around Taiwan and in the Pacific Ocean. Or perhaps it was an intelligence gimmick. Chinese scientists often displayed the inner workings of their technical devices to American visitors just to see how they would react. A raised eyebrow or a sudden scowl could confirm or discount a year's work. Maybe Chinese nuclear technology was no longer top secret. With the coming of Deng Xiaoping's regime around 1980, the proliferation of nuclear technology into the third world had become state policy. Perhaps it was time to let the Americans have a look.

The most likely reason for the Chinese hospitality, however, was a simple yearning for scientific respect. I had found that same phenomenon in the Soviet nuclear weapons laboratories: Excellent scientists, having done incredibly good work for decades, had published nothing. In their lives behind the iron or the bamboo curtain, those scientists had received neither recognition from their countrymen nor accolades from the international scientific community. (See the article "Trinity at Dubna" by myself and Arnold Kramish, *PHYSICS TODAY*, November 1996, page 30.)

It would take another half decade for the windows to open into the Soviet nuclear world, but the opportunities came faster in China. Mao Zedong died in 1976; within four years Deng Xiaoping had consolidated power and was leading China in new, more pragmatic directions. By the end of the 1980s, perestroika was sweeping the Soviet and Chinese worlds. Chinese leaders were seeking respect from the Western world. By the time the Stillman tours were over, they had earned it.

As an experienced intelligence officer, Stillman made it a point to travel with, and always be in the company of, another American. After a diplomatic delay caused by the

difficulties at Tiananmen Square in 1989, Stillman and his intelligence deputy from Los Alamos, H. Terry Hawkins, landed in Shanghai on 3 April 1990.

Touring Shanghai

The first stop was Fudan University, an enormous, fenced, and guarded complex in the northeast quarter of Shanghai. Fudan is home to dozens of research institutes, technical centers, and state-level laboratories. During a tour of one such facility—the Institute of Modern Physics, directed by Yang—bright and motivated students were doing cutting-edge research with antique equipment amazingly acquired in the flea markets of Shanghai. They worked in unheated laboratories, drafty because of broken windows. It was Stillman's first exposure to the contrasting cultures of old and new, a disparity he would encounter often throughout China.

Fudan University was and remains a prime component of the Chinese nuclear weapons complex, with its faculty pursuing research as directed and its best graduates fed into the weapons empire. China has other equally large and prestigious universities—for example, Tsinghua and Beijing universities—but Fudan is still the intellectual fount of nuclear knowledge. While at Fudan, Stillman dined with its then recently retired president, Xie Xide. At that time Xie was a prime example of the interconnected Chinese system: She served in 1990 as chairman of the Shanghai Communist Party Central Committee, which made her the *de facto* mayor of Shanghai. Earlier, she had graduated from Smith College and MIT; in the immediate future she would assume control of the Center for American Studies at Fudan, part of the vast technical-intelligence system evaluating Western technology. Xie was charming, fluent in colloquial English, and supportive of the Stillman visit, an imprimatur that opened many a door during the weeks that followed.

The next day Stillman visited the Shanghai Institute of Nuclear Research (SINR), also directed by the ubiquitous Yang. That institute employed more than a thousand people, half of them scientists. It had been in existence since 1960. One topic of discussion at the SINR was the mysterious domes of light that had emanated from the Soviet Union's missile test ranges during the previous year. (See box 1 on page 51.) Discussions at the SINR resulted in a gift to Stillman of 35-mm photos (one of which is reproduced in the box) but no explanations. His hosts were puzzled and interested in American thoughts.

Stillman's visit to the SINR also produced his first insight into the extensive hospitality extended to Pakistani nuclear scientists during that same late-1980s time period. As we shall see, that cooperation, initiated earlier in the decade, led to a joint nuclear test in China soon after Stillman's departure.

Chengdu and the inland nuclear empire

The third day of Stillman's visit began with a nerve-racking experience of air travel in China: The thousand-mile flight from Shanghai to Chengdu, capital of Sichuan Province (site of the devastating magnitude-7.9 earthquake in May 2008) and the heart of the inland nuclear empire, was on an antique Boeing 707. Stillman's guide and interpreter, while assuming the head-between-the-knees position during the harrowing takeoff, assured his guest, "This is a good American airplane. Do not worry." Upon his arrival in Chengdu, Stillman was met by one of the affable Chinese scouts he had first met and hosted in New Mexico the year before. It was only within China that those individuals would reveal their seniority in the Chinese nuclear establishment.

In the following days, the Stillman party traveled by

treacherous road from Chengdu to Zitong, Mianyang, and then Science City, the intellectual capital of the blossoming Chinese nuclear empire on Mianyang's outskirts. In talks with his hosts along the way, Stillman came to understand the depth of the 1989 Tiananmen confrontations between generations. At that time, massive riots had erupted throughout China; in Chengdu crowds of students burned buildings while their elders passively looked on, accepting the system as it was.

On the periphery of Science City, Stillman visited a relativistic electron-beam accelerator in an industrialized building equipped with crane hoists capable of positioning large targets. Stillman's hosts acknowledged that the accelerator was used to generate bursts of electromagnetic energy, which simulated a distant nuclear detonation. Those hosts later inquired about US work on x-ray lasers while disclosing their own achievements with prompt burst reactors.

The tour next brought Stillman face-to-face with another of the mysterious visitors to New Mexico: the director of the Southwest Institute of Fluid Physics—a euphemism for the Chinese high explosives test facilities. That institute has access to nine test facilities: three outdoors in the hills well beyond Science City and six containment vessels—large steel spheres that contain the energy released by a few pounds of high explosive. The explosives are wrapped around heavy metals simulating uranium, and the vessels are sealed so as to recover the valuable and sometimes toxic metals involved in the experiment. Four large containment vessels were located in Science City and two smaller ones were housed indoors at the Institute of Applied Physics in Chengdu. All the test facilities were carefully instrumented to collect reams of data. The Chinese scientists were not simply conducting proof-of-principle tests; they wanted to understand the dynamics of nuclear pit implosions.

Science City, the immense central laboratory and office complex that today manages the Chinese nuclear weapons program, was undergoing final completion at the time of Stillman's first visit. It had been constructed during the previous decade to replace the Soviet-planned (and subsequently targeted) complex at Haiyan, well to the north. It was also to replace the intermediate facility at Zitong. At the entrance to Science City stood a towering sculpture symbolizing an exploding nuclear weapon core. Once inside the complex, Stillman found a modern, high-rise administration building, gracious dormitories and guesthouses, the high-explosive test facilities described earlier, a computation center—home to one of China's first supercomputers—and a vast array of experimental laboratories and machine shops. Stillman was warmly greeted. As he was the first American visitor to Science City, his hosts and all their associates were curious, welcoming, and as forthcoming as the security guidelines would allow.

On the road back to the Chengdu airport, modernity was left behind and old China reappeared. Stillman's motorcade encountered a car-wash station along its route. He assumed it reflected some radiological danger left behind in Science City. Not so. The shed turned out to be a tollbooth, operated by a local mountain clan. Even the credentials of foreign dignitaries visiting the heart of the Chinese nuclear weapons complex could not effect a waiver. The government driver could only avoid further delay by paying the "car wash" fee and moving on.

Xi'an

The next stop was Xi'an, which most visitors think of as home to the ancient terra cotta soldiers, but it is also the nearest city



Locations of early nuclear facilities in China. Atom symbols mark research and production facilities. The test site is marked with a mushroom cloud.

to the Northwest Institute of Nuclear Technology. The NINT's expertise lies in the diagnostics of nuclear detonations. It houses almost a thousand scientists working in Earth sciences, radiochemistry, instrumentation, microcomputers, and nuclear hardening. As was becoming the custom, Stillman's escort at the NINT was fluent in English and a recent graduate of a US center of technical excellence, in this case with a PhD in physics from Caltech. Xi'an and the NINT bore the unmistakable Soviet imprint of Stalinist architecture and workmanship: buildings that looked and felt old immediately upon completion; broken windows secured against the cold with cardboard; elevators that delivered their passengers within a foot or so of the desired floor level. But those inconveniences were forgotten upon the visitors' arrival at the most sophisticated flash x-ray equipment they had ever seen—instrumentation to support implosion diagnostics and radiation-hardening tests. The scientific staff at the NINT asked all the right questions; they had an uncanny familiarity with US nuclear test procedures.

At that time weapons safety was not at the top of the Chinese priority list. In response to questions from Stillman, his hosts admitted their weapons were not "one point safe," meaning they did not use insensitive high explosives, and therefore an accidental detonation could, in fact, have produced some nuclear yield. The Chinese stockpile situation was remedied during the decades that followed. The Chinese scientists also understood the impact of thermal cycling on high explosives; they did not allow their nuclear weapons to remain exposed to sunlight for extended periods of time. That led Stillman to raise a discussion of weapons security: "Do Chinese nuclear weapons contain design features or pro-

TECTIVE devices to preclude their unauthorized use?" The NINT director responded that terrorism was not a consideration in their nuclear weapons designs, that Chinese discipline precluded unauthorized use. At that time the Chinese weapons program relied on "politically reliable" guards, not electronics. The director did agree, however, that those safety and security policies needed to change. I suspect that such changes have since taken place.

The illuminating discussions in Xi'an were but the prelude to another nerve-wracking flight, to Beijing aboard a rickety Russian aircraft. Beijing is not only China's capital; it is home to an array of nuclear weapons program offices including the Institute of Applied Physics and Computational Mathematics. One of the managers of the IAPCM turned out to be another of the anonymous visitors to New Mexico the year before.

Nuclear weapons design has grown to be highly dependent on computational support, but in 1990 Chinese nuclear researchers had only one supercomputer capable of performing two-dimensional hydrodynamic calculations. Known as the Galaxy-2, it was located at its producing factory in Changsha, 1300 km south of Beijing. The location of that machine in Hunan Province, coupled with the complexity of the advanced weapons designs planned for testing in 1992, meant the designers in Beijing had to commute to Changsha, which they did until the second Galaxy-2 was up and running in Beijing in 1993.

The second trip

Stillman returned to the US for the summer of 1990 and traveled back to China in the autumn to visit the experimental

side of the Chinese nuclear program. He again flew to Chengdu and spent an entire morning in a motorcade to a hitherto unknown facility. Once on site it was identified as the Southwest Institute of Nuclear Physics and Chemistry. The location was mountainous and remote, and the facilities were hidden in canyons. The guesthouse was comfortable and modern. However, the main attraction was the never-seen fast burst reactor, called FBR-2, first discussed by Stillman and Yang two years earlier.

On that historic afternoon, the Stillman delegation passed through heavy security—guards all armed with Kalashnikovs. Site badges bore the emblem 596, commemorating the June 1959 Soviet abandonment of their Chinese comrades. (See box 2 on page 52.) FBR-2 was capable of delivering an intense flux of neutrons and gamma rays within microseconds, thereby simulating the radiation emitted during an actual nuclear device detonation. (The trick was to shut the reactor down before it blew the laboratory away.) Stillman had known there must be such a device somewhere in China, which is why he had asked Yang about it. But when they arrived, American delegation members learned that a first-generation machine, FBR-1, had gone into operation 14 years earlier but had been long abandoned in favor of the new one. The Americans were given a complete tour of the fast burst reactor facility.

They then revisited Science City, where Stillman learned far more than on his first trip there. For example, he was able to inspect the high-explosive test facilities. Adjacent to those test chambers were impressive flash x-ray machines, designed to illuminate implosions as they took place. Framing cameras nearby could operate at millions of frames per second. Pins within the imploding spheres delivered further data on implosion symmetry. The technology was state-of-the-art by any standard.

On to Lop Nur

From back in Chengdu the group flew to Urumqi, the capital of Xinjiang Province and the city nearest the Chinese nuclear weapons test site, known in the West as Lop Nur. Landing was followed by a grueling six-hour drive through mountains and desert to the new town of Malan, a settlement that does not appear on any maps of China but that serves as home for around 2000 members of the People's Liberation Army—a highly autonomous organization encompassing all the Chinese armed services—and perhaps 8000 civilians. The Stillman party was welcomed in the middle of the night with a lamb barbecue and an unending supply of fresh fruit. The serving staff at the banquet, all female PLA privates, spoke some English; the interpreters all spoke fluent English, including colloquialisms. Their regular jobs were to translate a flood of US publications into Mandarin for use by scientists at the test base.

The VIPs attending the Stillman visit had flown in from Beijing. Most spoke excellent English, and it seemed like they all talked about their children's achievements in the US. Even the engineer responsible for drilling vertical test shafts at Lop Nur had worked in the US during World War II; by 1990 his children were all enrolled in America's top engineering schools. The midnight barbecue in the Chinese desert seemed much like a cookout in the hills above Los Alamos.



Entry sculpture at Science City, a complex, built in the 1980s near Mianyang in central China, that is the heart of the Chinese nuclear weapons program. The fragmented top of the sculpture symbolizes disassembling material in a nuclear explosion; the rods represent emerging gamma radiation. (Courtesy of Danny Stillman.)

In the morning the convoy again formed up for the two-hour ride into the test site itself, a facility seven times larger than the US Nevada Test Site. Stillman passed electric power substations, impressive VIP quarters, a high-bay building for assembling nuclear test devices, and a radioactive decontamination facility to deal with industrial waste and mishaps. Communications security was tight. At the time of Stillman's visit, drilling rigs were at work on 2- to 2.5-m diameter holes for nuclear device emplacement. Drilling technology was archaic by US standards; the drillers were advancing through the underlying granite at a rate of only two meters per day.

With the water table 20–40 m underground, most nuclear tests conducted in vertical shafts at Lop Nur were fired in water-saturated granite. The depth of burial equation used by the Chinese for such tests is $DOB = 120 Y^{1/3}$, where Y is the nuclear yield in kilotons and DOB is the required depth of burial in meters. The factor of 120 changes as a function of the test-site geology but is appropriate for the Chinese granite formations. The firing depth calculated by this equation is actually the “safety depth,” scaled to accommodate

Box 1. The mysterious light domes

In 1987 the US and the Soviet Union signed the Intermediate-Range Nuclear Forces Treaty, in which they agreed to eliminate all missiles with ranges of 625–3500 miles (1000–5600 km) by June 1991. Iridescent spheres appeared above the atmosphere off Scandinavia and northern China in 1988. One example provided by Danny Stillman is shown here. Such domes expanded very rapidly, at around 3 km/s, with the centers remaining quite transparent. They stopped appearing in mid-1991. Could the light domes have been related to testing a defense system against incoming missiles? Could they result from self-destruct mechanisms on the missiles? To this day the origins of the domes of light are classified top secret in Russia. Outsiders know only two things for certain: The dome phenomena happened, and no one in the West really knows why.



110% of the expected yield.

The Chinese nuclear diagnostics were every bit as good as those used in American nuclear tests—if not better. For example, the NINT scientists showed Stillman several Chinese-built 5-megahertz oscilloscopes; their fastest scopes could record 1.5-gigahertz signals, well above the contemporary western capability.

NINT scientists had also developed and fielded a dual-axis PINEX (pinhole neutron experiment) “camera” to provide dual images in the deuterium–tritium burn region of a boosted primary—the fission portion of a thermonuclear device—during implosion, at exactly the desired moment. The unique dual-axis capability allowed the Chinese researchers to image either two time-sequenced events in a specific region of burn inside the nuclear device or to record events at two separate locations in the device at any given moment.

During the evenings at Lop Nur, Stillman was shown videotapes of some earlier nuclear-effects experiments. One such test, the CHIC-12 event, surrounded the nuclear explosive with a variety of targets placed at a distance: submarine-pen doors, underground military command bunkers, military aircraft, tanks, and even animals caged in place with instruments attached. Stillman noted with interest that Chinese procedures were identical to those followed in the US.

A bit of background

The NINT personnel were all PLA people—responsible for recording nuclear test data, then performing the radiochemical analysis of the bomb debris to ascertain device performance. Any nuclear nation should consider its nuclear tests to be giant physics experiments. The Chinese weaponeers understood that well; other proliferators do not. Many states have considered their early nuclear shots to be political demonstrations or simple proof tests. In China, however, extremely sophisticated instrumentation was used on even the first nuclear test.

Data from a nuclear test are collected in several ways. Prompt diagnostics involve pipes or tunnels that allow the collection of real-time data and its conversion to electrical signals before the entire experiment is blown away. A hundred optical, coaxial, and multiconductor cables send confirmation of the detonation process to nearby trailers, out of fireball or shock range. Optical and electromagnetic instrumentation, located still farther away, can give a quick estimate of internal device performance.

Radiochemistry, which involves the collection of post-explosion bomb debris, is indispensable to the testing organization. Nuclear device designers usually position trace elements at key locations in their experiments so as to ascertain temperatures, neutron flux, burn efficiencies, and so forth as the explosion proceeds—an event that unfolds fully in less than a microsecond. Chinese nuclear tests employed those techniques to good effect.

For the first five years of China’s nuclear testing program, all such tests were conducted in the atmosphere: six by airdrop or missile delivery and two, including the country’s first, atop 100-meter-high steel towers. Although China never signed the Limited Test Ban Treaty of 1963, its scientists always attempted to minimize fallout. No surface bursts sucked up great clouds of radioactive debris until China began to study nuclear weapons effects during the 1970s.

There was more than one reason to move away from atmospheric and surface-burst testing. As the third world gained traction in its campaign to preclude such tests, and as the Treaty on the Non-Proliferation of Nuclear Weapons was headed toward ratification, environmental benefits and proliferation control were the oft-stated reasons for opposing atmospheric nuclear tests. Such bans have another advantage, however: They give the testing nation added security. Collection of fallout debris by a foreign observer half a world

away can provide good insight into the technology being tested by one's rivals. (See, for example, the article "Detecting the Soviet Bomb: Joe-1 in a Rain Barrel" by Herbert Friedman, Luther Lockhart, and Irving Blifford, *PHYSICS TODAY*, November 1996, page 38.) Without tests in the atmosphere, competing and inquisitive neighbors can no longer collect the evidence. By making it harder for other nations to understand their devices, it becomes easier for the testing nation to bluff.

In 1969, with two years of preparatory study, China conducted its first nuclear detonation in an excavated tunnel. That was as much a rock dynamics experiment as it was a device test. Armed with the resulting data, NINT researchers then undertook a painstakingly thorough examination of subterranean nuclear testing phenomena. Six years elapsed until their next underground test, after they had gained a full understanding of rock mechanics, sampling techniques, and environmental hazards.

The tests themselves

Atop a tower on 16 October 1964, China's first nuclear device, 596, was successfully fired. US intelligence analysts were astonished by the lack of plutonium in the fallout debris and by the speed with which China had broken into the nuclear club, but that was only the beginning. Eighteen months later, in the spring of 1966, China entered the thermonuclear world with the detonation of a boosted-fission, airdropped device that used lithium-6, a primary source of tritium when bombarded with neutrons. That test, their third, achieved a yield of 200–300 kilotons. By the end of the year, they made the leap to multistage technology with a large two-stage experiment that yielded only 122 kilotons, but it again displayed ^6Li in the bomb debris. The principle of radiation implosion had been tested. The Chinese then closed the circle on 17 June 1967, unambiguously marching into the H-bomb club with a 3.3-megaton burst from an aircraft-delivered weapon that again used ^6Li and displayed multiple isotopes from an enriched uranium primary. There was no plutonium in that device, since the nuclear reactor at Jiuquan was only then coming on line.

On 27 December 1968, the Chinese bid Lyndon B. Johnson's administration farewell with an improved, airdropped 3-megaton thermonuclear device that for the first time used plutonium in the primary. The Chinese nuclear scientists did not feel the need to test that new primary separately. They simply included it in a second-generation H-bomb design that went off as planned.

It is clear from the reactor-to-bomb progression times that by 1968 China had unequivocally entered the European nuclear cartel on a par with the UK. Furthermore, China had become a thermonuclear power. It had achieved the leap from the initial A-bomb test to a 3.3-megaton thermonuclear blast in a record-breaking 32 months. It had taken the US more than seven years to accomplish that feat.

And just as the first Chinese A-bomb had been achieved despite the Great Leap Forward of 1958–60 and the Soviet withdrawal of support, so it was with the country's second landmark nuclear event—the H-bomb. China achieved full thermonuclear status in 1968 despite having its weapons laboratories torn apart by the Cultural Revolution. In May 1966, Mao called on the youth of China to rise up, disregard established authority, and seek out and purge the Old Guard—people who Mao felt had regressed from revolutionaries to bureaucrats. The resulting chaos shredded the academic community, decimated the economy, continued for almost a decade, and led to the deaths of millions.

An interesting confirmation of Chinese nuclear sophis-

Box 2. The story of 596

On 15 January 1955, Mao Zedong decreed the start of work on a Chinese A-bomb. In April of that year, the Soviet Union agreed to provide vigorous assistance to the Chinese atomic-energy cause. In February 1957 Soviet advisers began to help plan the industrial infrastructure needed to produce nuclear materials and weapons. In April 1957 the Soviet leadership gave E. D. Vorobiev—the scientific director of Chelyabinsk-40, a closed town in the Soviet nuclear weapons program—the specific job of bringing China into the nuclear age. During the next 12 months, Vorobiev moved to Beijing and led teams of Soviet specialists in training their Chinese counterparts. On 15 October 1957, the collaboration may have reached its apogee with the signing of the Sino-Soviet New Defense Technical Accord, which even called for the delivery of a prototype Soviet nuclear weapon to China.

But in 1958 the relationship began to sour. Mao initiated his Great Leap Forward; Nikita Khrushchev began to think Mao unstable. The Soviet leader visited Beijing during July, was rudely received, left early, and decided to terminate all Soviet assistance to the Chinese nuclear weapons program. He formally advised the Chinese government of the decision on 20 June 1959—in the sixth month of 1959. The Chinese took that to be the date of ultimate treachery, and 596 appeared as a symbol on their weaponeers' shoulder patches. Five years later the first device they tested was named 596.

tication may be found in the short time needed to certify a primary for the Chinese H-bomb. After their first nuclear test, in 1964, the Chinese conducted only three nuclear detonations prior to their first two-stage thermonuclear experiment in 1966. The US and the Soviets required dozens of preliminary fission tests before going thermonuclear. The UK fired nine fission devices prior to its 1957 *Grapple* experiments.¹

At every stop in China, Stillman found English speakers translating US documents night and day. At every stop he found alumni of prestigious US schools working on the challenges of nuclear weapons design while absorbing every scrap of information gleaned from visitors. In 1990 Stillman met Yu Min, the generally acknowledged father of the Chinese H-bomb. An incredibly talented man, Yu did, in fact, design the first Chinese thermonuclear weapon; but it is generally thought that he did so with the assistance of intelligence from abroad, diagnostic indicators from other nations' tests, access to an enormous library of western publications, and the support of a vast array of intellectual talent—much of it trained in the West.

The role of Klaus Fuchs

One previously unrecognized source of Chinese insight was Klaus Fuchs, a brilliant German physicist and communist who had fled Germany prior to World War II, had sought refuge in the UK, and was then relocated to the US when the blitz decimated the British nuclear weapons program. At Los Alamos Fuchs played a leading role in the conception and development of the wartime A-bomb and, in time, the conceptualization of the H-bomb. During the war he also passed those secrets to his Soviet handlers. When the war ended, Fuchs returned to the UK and the Atomic Energy Research

Establishment at Harwell—with his wartime treachery still unknown.

In 1949, however, Fuchs's past caught up with him when American cryptographers broke the Soviet wartime codes. Having saved copies of wartime transmissions from the Soviet embassy in Washington to its home office in Moscow, American sleuths identified Fuchs as a spy. After lengthy interrogation Fuchs confessed and in 1950 was sentenced to prison by a British court.

Nine years later, on 23 June 1959, Fuchs was released from the UK's Wakefield Prison. He immediately immigrated to Dresden in East Germany, where he settled into teaching physics.

One important "pupil" who paid Fuchs an early visit was Qian Sanqiang. In 1959 Qian was the designated mastermind of Mao's A-bomb program. In July of that year, Qian made his way to East Germany, where he met with Fuchs at length. (H. Terry Hawkins, now a senior fellow at Los Alamos, told Stillman in 2006, "I read this report in an unclassified publication, that this meeting took place shortly after Fuchs returned to East Germany. Fuchs gave Qian information that greatly assisted the Chinese program." Also see <http://www.oldatlanticlighthouse.wordpress.com/category/klaus-fuchs/>.) During those long summer days of 1959, Fuchs gave Qian a full tutorial on the design and operation of Fat Man. In all likelihood, he also added his thoughts on the role of radiation pressure in thermonuclear weapons.

Later developments

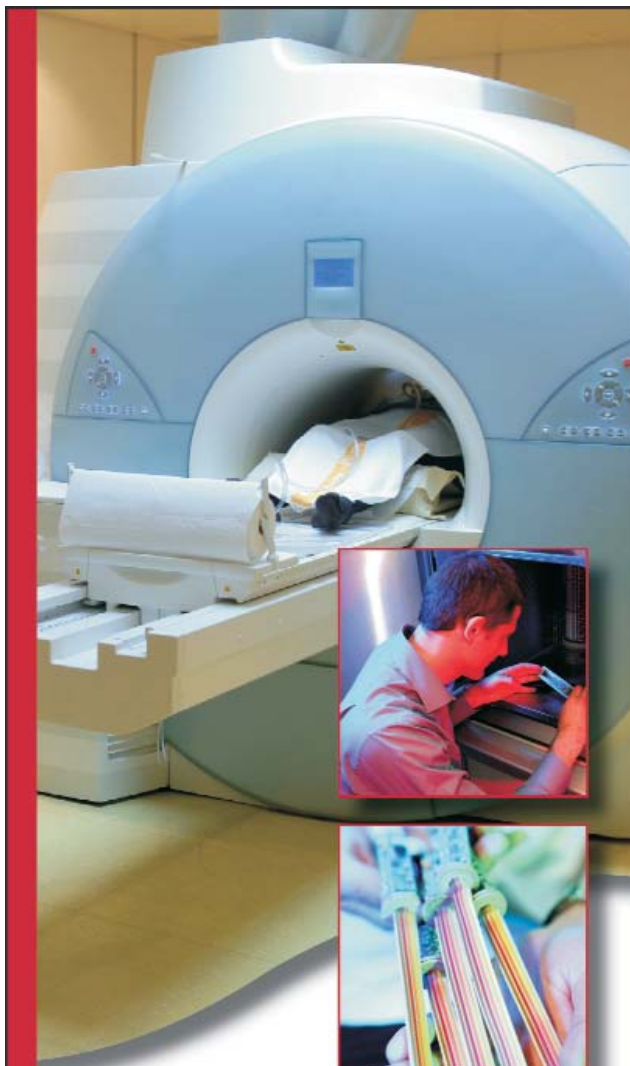
During his time in China and during subsequent discussions with Chinese scientists visiting the US, Stillman was given a complete rundown on the Chinese nuclear test program: the date of every event, the purpose of each test, its yield, and the lessons learned. A tabulated summary of those tests accompanies the online version of this article, at <http://www.physicstoday.org>. Those test results, along with other insights into the Chinese nuclear program, were confirmed to me by leaders of the Chinese Academy of Engineering Physics during their visits to the US in 2005. Here are some additional developments and conclusions:

- In 1982 China's premier Deng Xiaoping began the transfer of nuclear weapons technology to Pakistan and, in time, to other third world countries. Those transfers included blueprints for the ultrasimple CHIC-4 design using highly enriched uranium, first tested by China in 1966.
- A Pakistani derivative of CHIC-4 apparently was tested in China on 26 May 1990.
- After four failed experiments, Chinese researchers fired a successful enhanced radiation weapon, a neutron bomb, on 19 December 1984.
- The Chinese bid farewell to atmospheric nuclear testing on 16 October 1980 with a 700-kiloton airburst. It was the last such atmospheric test by any nuclear power. They continued to test underground until 29 July 1996.
- During the 1990s China conducted underground hydro-nuclear experiments—though not full-scale device tests—for France at Lop Nur.

Over a period of 15 years, an intellectually talented China achieved parity with the West and preeminence over its Asian peers in the design of nuclear weapons and in understanding underground nuclear testing. China now stands in the first rank of nuclear powers.

Reference

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