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Pursuing Photon Sovereignty: China's Advanced Light Source Breakout

Jimmy Goodrich and Jackson Martin

Abstract

Advanced scientific light sources are foundational research infrastructure for semiconductor manufacturing, biomedicine, energy storage, and nuclear weapons stewardship. This report examines China's pursuit of "photon sovereignty" through the rapid expansion of a domestically controlled network of synchrotrons and X-ray free-electron lasers. Drawing on open sources, it identifies approximately sixteen operational light sources and at least twenty-one additional facilities under construction or active planning, with known investment in ongoing projects approaching $13 billion. This expansion is broadening China's scientific capabilities, reducing dependence on foreign infrastructure, and increasing access to advanced facilities across universities, research institutes, and industry. The strategic effects will be cumulative: more beamtime, broader spectral coverage, faster experimentation, and a larger trained user community could accelerate advances in foundational science, technology, and military capabilities. For the United States, China's expansion presents a dual challenge: protecting sensitive research while sustaining the infrastructure and scientific workforce needed to maintain U.S. leadership in photon science.

Keywords: Photon sovereignty, China science and technology policy, Semiconductor manufacturing, X-ray free-electron lasers

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Introduction

Advanced light sources generate controlled beams of photons (light particles) that literally shed light on the atomic building blocks of matter. The machines generating these beams are important research infrastructure for countries around the globe. By tuning the wavelength of the light produced by stadium-sized facilities, researchers can observe individual atoms and molecules as they arrange themselves, bond, and move.

That view of matter at its smallest scale can drive breakthroughs in fields increasingly central to U.S.-China competition, such as semiconductor manufacturing, biology and medicine, and nuclear stockpile maintenance. For decades, the West dominated the development of advanced light sources that have led to the discovery of new materials and won multiple Nobel Prizes.[1]

China's photon science infrastructure lagged that of the United States and Europe by a generation for most of the post-Cold War era. During this gap of roughly fifteen to twenty years, new facilities and capabilities came online in the West while China's progress stalled. As recently as 2009, China had only two synchrotron facilities, and they were out of date. Chinese researchers relied on international travel to conduct experiments that domestic light sources could not support.

That era is ending.

China is now building advanced light source infrastructure at a pace and scale unmatched by any other country. This report maps out the scope of China's buildout, featuring data on every operational, under-construction, and planned Chinese light source facility identifiable from government planning documents, institutional announcements, technical conference proceedings, and open-source research.

At least 21 Chinese advanced light source facilities are currently under construction or in active planning across the country, representing a known combined investment of roughly $13 billion (per authors' calculation). Because many of the documented Chinese projects lack publicly verifiable funding figures, we estimate the true scale of investment is likely considerably larger.

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[1] U.S. Department of Energy, "APS Lights the Way to 2012 Chemistry Nobel," October 15, 2012, https://www.aps.anl.gov/APS-News/APS-Lights-the-Way-to-2012-Chemistry-Nobel; European Synchrotron Radiation Facility , "Two long-term users of the ESRF win the Nobel Prize in Chemistry," October 7, 2009, https://www.esrf.fr/news/general-old/general-2009/nobel-prize; Cornell High Energy Synchrotron Source, "CHESS Celebrates 75 years of Synchrotron Light," https://www.chess.cornell.edu/chess-celebrates-75-years-synchrotron-light.

China's broader accelerator infrastructure also includes particle colliders, pulsed power facilities, and experimental concepts such as steady-state microbunching (SSMB).[2] These serve narrower communities or remain at early stages of development. This report focuses on general purpose synchrotrons and free electron lasers because they sit furthest upstream of the dual-use industries driving U.S.-China technological competition. In addition, tightening U.S. restrictions on foreign researcher access to DOE light sources have raised the stakes of China's domestic capacity in these specific facility types.

At the current pace of construction, China will complete roughly one major new light source facility every other year between now and the early 2030s. When complete, these facilities will give Chinese researchers access to cutting-edge photon science capabilities that match or exceed those available anywhere in the world. Experts interviewed for this report noted that China could very likely win a Nobel prize in science for the research results conducted on the advanced light sources that are set to begin operation in 2027.

By contrast, the pipeline for advanced light sources in the United States is significantly smaller. According to a March 2026 Department of Energy report, the U.S. currently has just two light source projects under construction—both of which are upgrades to existing facilities (ALS-U and LCLS-II-HE)—representing a combined investment of roughly $1.7 billion.[3] An additional seven light source expansion or R&D projects are in early planning stages, but the majority of these future concepts do not yet have estimated budgets.

The report first explains how advanced light sources work and why Beijing views them as strategic infrastructure. It then traces China's transition from dependence on foreign beamtime to a state-backed construction pipeline; profiles seven advanced facilities; and assesses the implications for semiconductor manufacturing, biomedicine, batteries, aerospace manufacturing, nuclear stewardship, and U.S. policy.

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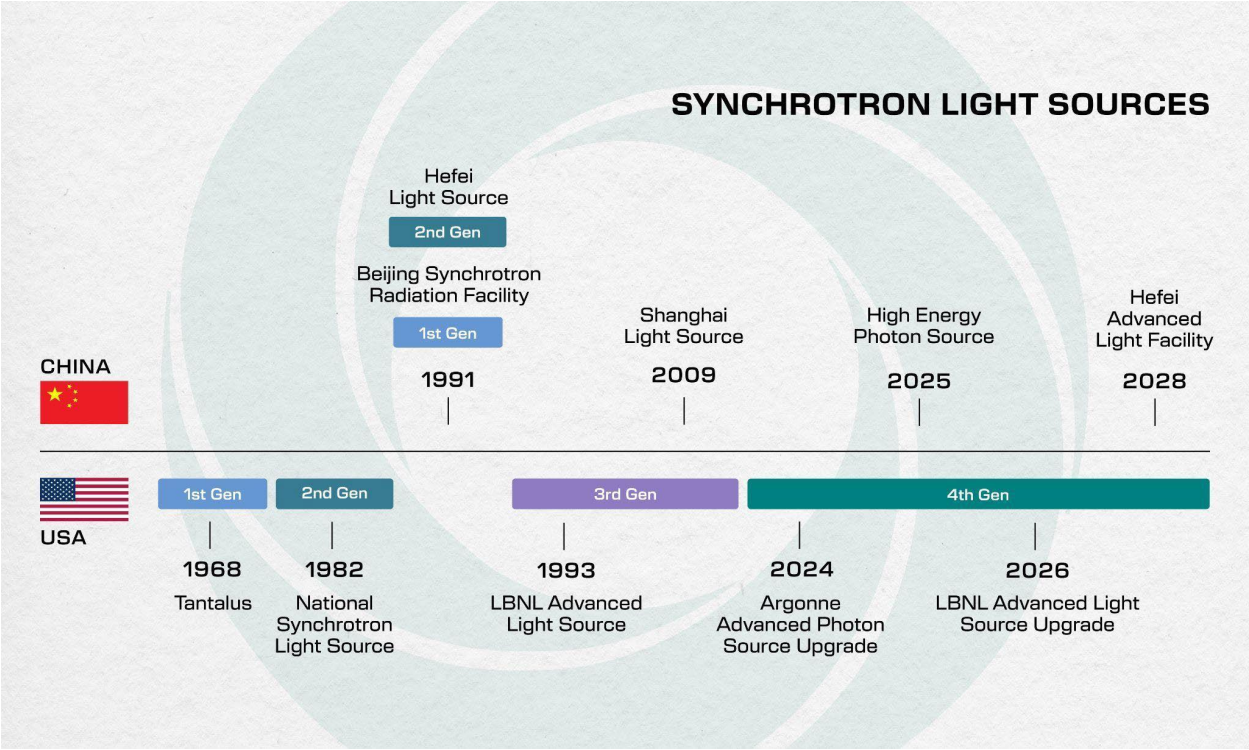
[2] Jimmy Goodrich, "China's Hidden Quest to Win in Pulsed Power Fusion," January 14, 2026, UC Institute on Global Conflict and Cooperation, https://ucigcc.org/publication/chinas-hidden-quest-to-win-in-pulsed-power-fusion/.

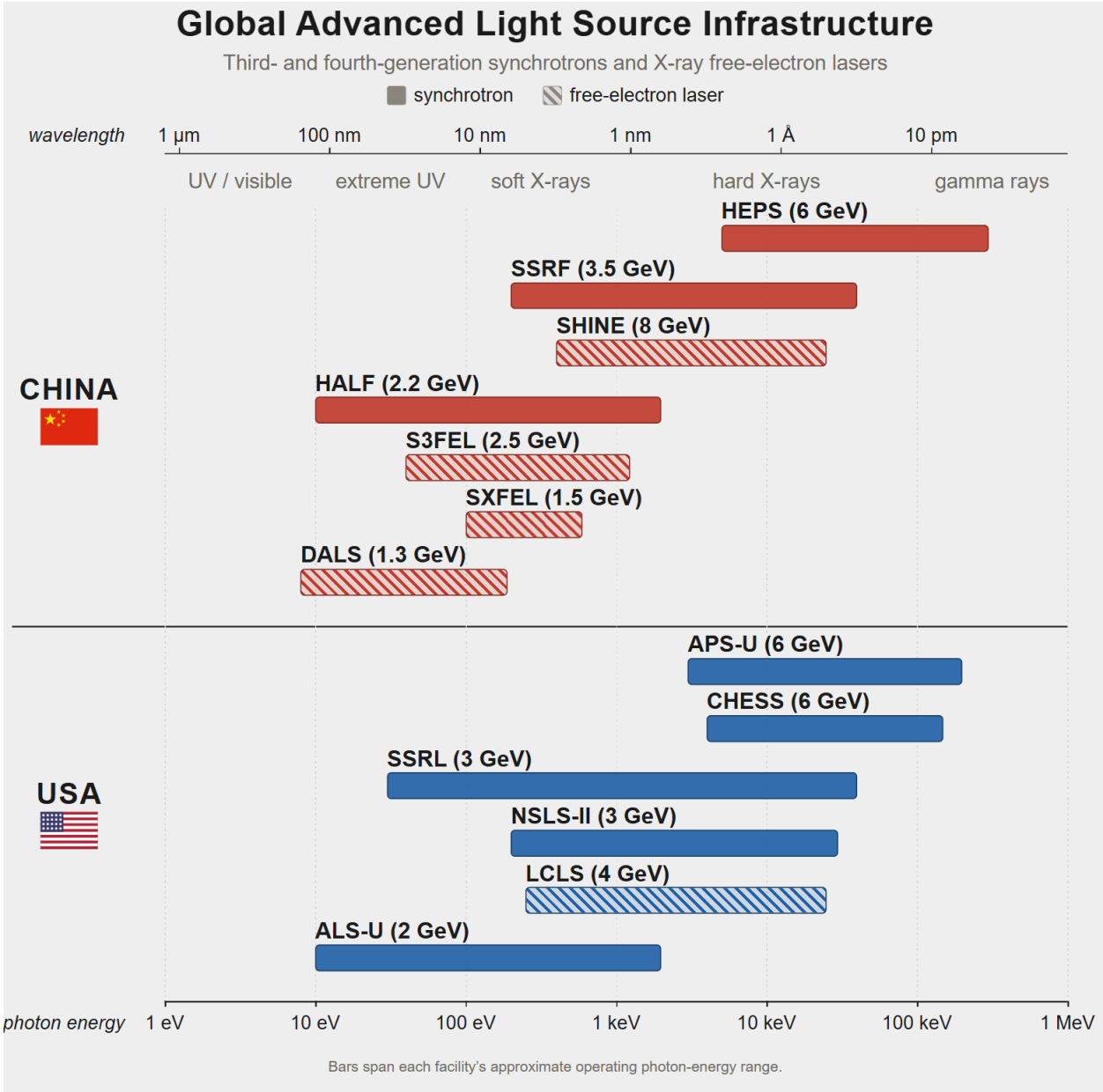
[3] U.S. Department of Energy Office of Science, "Summaries of Office of Science Facilities Under Construction and Proposed," March 27, 2026, https://science.osti.gov/-/media/About/pdf/scac/reports/SC-Facilities-master-3-27-26.pdf.

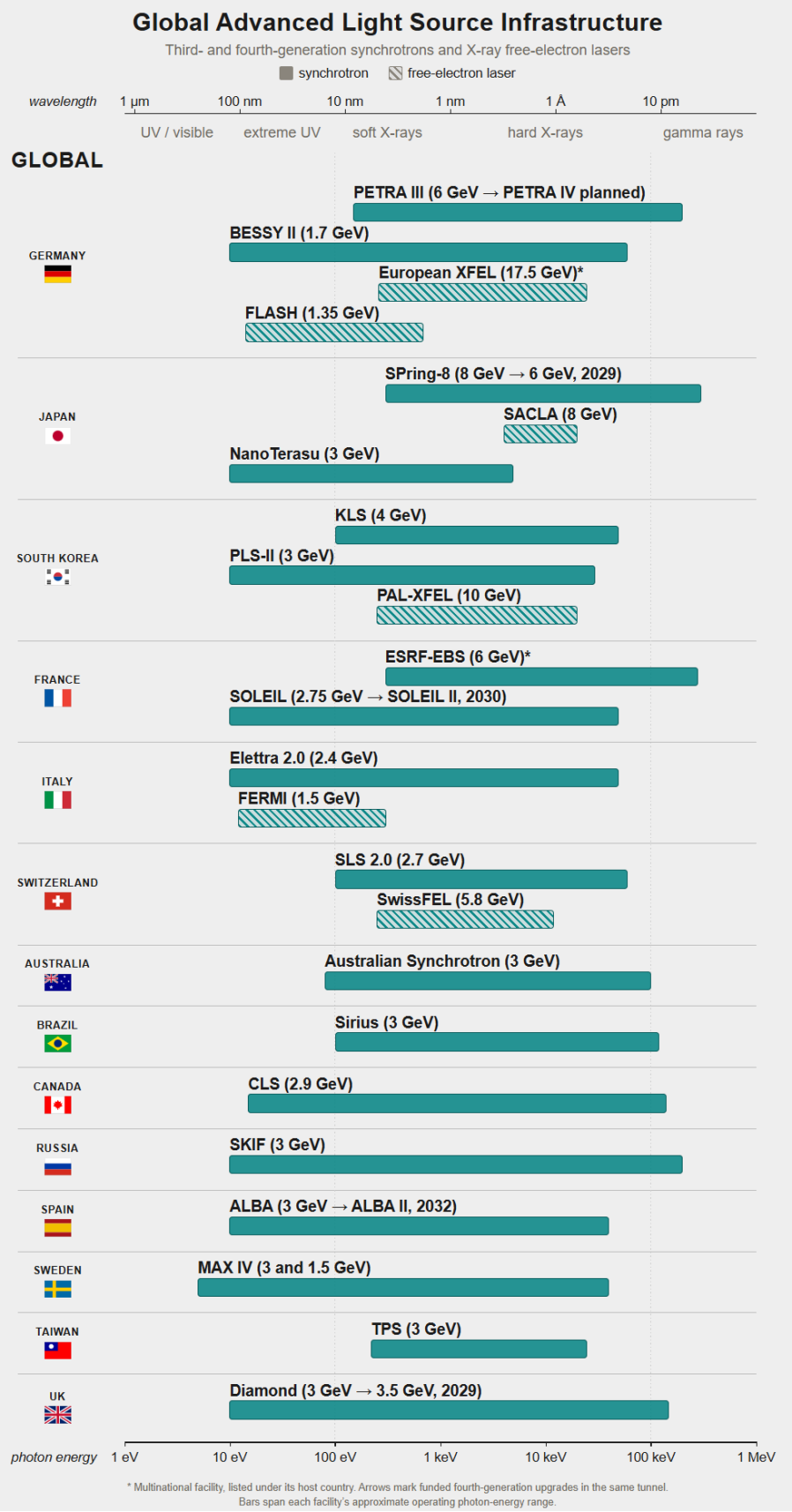


The PRC will soon be on par with the United States in 4th generation synchrotron facilities.

China's Light Source Infrastructure Buildout

Status	Light Source Facilities	Known Funding (USD)
Operational	16	$406 M
Construction	9	$6.8 B
Planned	12	$6.1 B


Global Advanced Light Source Infrastructure
Third- and fourth-generation synchrotrons and X-ray free-electron lasers
synchrotron
free-electron laser
wavelength
1 µm
100 nm
10 nm
1 nm
1 Å
10 pm
UV / visible
extreme UV
soft X-rays
hard X-rays
gamma rays
CHINA
HEPS (6 GeV)
SSRF (3.5 GeV)
SHINE (8 GeV)
HALF (2.2 GeV)
S3FEL (2.5 GeV)
SXFEL (1.5 GeV)
DALS (1.3 GeV)
USA
APS-U (6 GeV)
CHESS (6 GeV)
SSRL (3 GeV)
NSLS-II (3 GeV)
LCLS (4 GeV)
ALS-U (2 GeV)
photon energy
1 eV
10 eV
100 eV
1 keV
10 keV
100 keV
1 MeV
Bars span each facility's approximate operating photon-energy range.


Global Advanced Light Source Infrastructure
Third- and fourth-generation synchrotrons and X-ray free-electron lasers
synchrotron
free-electron laser
wavelength
1 µm
100 nm
10 nm
1 nm
1 Å
10 pm
UV / visible
extreme UV
soft X-rays
hard X-rays
gamma rays
GLOBAL
GERMANY
PETRA III (6 GeV → PETRA IV planned)
BESSY II (1.7 GeV)
European XFEL (17.5 GeV)*
FLASH (1.35 GeV)
JAPAN
SPring-8 (8 GeV → 6 GeV, 2029)
SACLA (8 GeV)
NanoTerasu (3 GeV)
SOUTH KOREA
KLS (4 GeV)
PLS-II (3 GeV)
PAL-XFEL (10 GeV)
FRANCE
ESRF-EBS (6 GeV)*
SOLEIL (2.75 GeV → SOLEIL II, 2030)
ITALY
Elettra 2.0 (2.4 GeV)
FERMI (1.5 GeV)
SWITZERLAND
SLS 2.0 (2.7 GeV)
SwissFEL (5.8 GeV)
AUSTRALIA
Australian Synchrotron (3 GeV)
BRAZIL
Sirius (3 GeV)
CANADA
CLS (2.9 GeV)
RUSSIA
SKIF (3 GeV)
SPAIN
ALBA (3 GeV → ALBA II, 2032)
SWEDEN
MAX IV (3 and 1.5 GeV)
TAIWAN
TPS (3 GeV)
UK
Diamond (3 GeV → 3.5 GeV, 2029)
photon energy
1 eV
10 eV
100 eV
1 keV
10 keV
100 keV
1 MeV
* Multinational facility, listed under its host country. Arrows mark funded fourth-generation upgrades in the same tunnel.
Bars span each facility's approximate operating photon-energy range.

What is a light source?

Advanced light sources, including synchrotrons and X-ray free electron lasers, allow researchers to image materials and biological structures at atomic resolution, observe chemical reactions as they unfold, and develop new manufacturing processes.[4] They serve as foundational research infrastructure for thousands of researchers each year across materials science, structural biology, chemistry, and engineering. This breadth makes them critical to research in semiconductors, pharmaceuticals, battery technology, and nuclear weapons stewardship—industrial and strategic domains central to U.S.-China competition in the 21st century.

What Is a Light Source?

Advanced light sources are massive particle accelerators that function as the world's most powerful microscopes. Despite the name, they do not produce visible light. They produce intensely bright beams of X-rays designed to photograph the atomic world.

Ordinary light waves are too large to capture an individual atom. Seeing the fundamental building blocks of matter requires light with incredibly tiny waves. Advanced light sources are industrial-scale factories built to produce this exact type of light.

Inside large facilities, powerful magnets accelerate electrons to nearly the speed of light. As these electrons race along their path and change direction, they throw off blinding flashes of high-energy X-rays. Scientists channel these X-ray beams into specialized experimental stations. The X-rays strike a physical sample and scatter, allowing computers to generate highly detailed images of the atoms inside.

The ability to map how atoms and molecules assemble and interact is a prerequisite for modern technological breakthroughs. Whether researchers are engineering targeted pharmaceuticals, designing higher-capacity solid-state batteries, or developing next-generation semiconductor materials, they rely on light sources to visualize and manipulate these atomic architectures.

Fourth-generation synchrotrons squeeze electron beams into extraordinarily tight bunches, producing X-rays hundreds of times brighter and more coherent than their predecessors, bright enough to image individual atoms in real time. XFELs take a different approach, using linear accelerators to generate X-ray laser pulses so intense and so brief (measured in femtoseconds, or millionths of a billionth of a second) that they can capture chemical reactions mid-stride. Together, these two types of machines represent the current frontier of photon science infrastructure.

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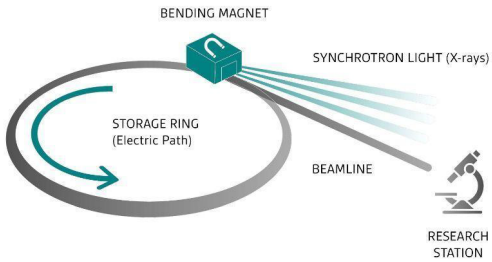
[4] Nathan Collins, "Synchrotrons, the Swiss Army knives of science," SLAC National Accelerator Laboratory, https://www6.slac.stanford.edu/research/slac-science-explained/synchrotrons; Ali Sundermier, "XFELs: Spying on atoms and molecules," SLAC National Accelerator Laboratory, https://www6.slac.stanford.edu/research/slac-science-explained/xfels; Research Areas, Lawrence Berkeley National Laboratory, https://als.lbl.gov/science/research-areas/.

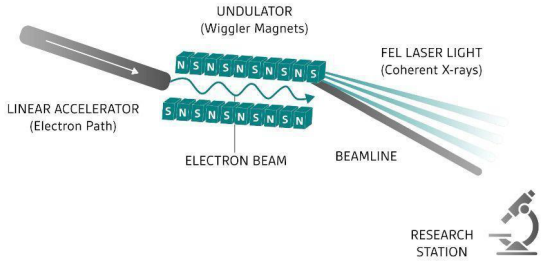
SYNCHROTRONS



- Electrons are accelerated to near light speed and injected into a circular storage ring.
- Powerful magnets bend the electrons around the ring, and bending forces them to emit intense X-ray and UV light.
- Special magnet sections called undulators and wigglers make that light brighter and more focused.
- Researchers place samples (a protein crystal, a battery electrode, a semiconductor wafer) in the beam's path and use detectors to capture how the light scatters, absorbs, or diffracts, revealing the sample's internal structure.

- Electrons are accelerated to near light speed in a straight line accelerator.
- The electron bunches pass through a long series of alternating magnets called an undulator.
- The undulator makes the electrons "wiggle," causing them to emit X-rays.
- The emitted X-rays and electrons reinforce each other, creating an ultra-bright, ultra-short X-ray pulse.
- The result is an X-ray laser pulse that is extremely bright and extremely short, lasting just femtoseconds (millionths of a billionth of a second), fast enough to capture atoms mid-motion.

FREE-ELECTRON LASERS (FEL)



Countries that previously reached the photon science frontier developed capability through sustained public investment, open user access, university and industry partnerships, and repeated upgrades. The United States began with the conversion of SLAC's SPEAR collider into a synchrotron facility and later built a national network of user facilities.[5] Universities, companies, and government laboratories helped develop beamlines and use them for both basic and applied research. This model trained accelerator scientists and users, allowed industrial needs to shape new instruments, and helped move discoveries into commercial applications. The Advanced Light Source (ALS), for example, contributed to foundational research behind extreme-ultraviolet lithography.[6]

Europe and Japan developed similar systems through international and national institutions. The European Synchrotron Radiation Facility combined government funding with competitive academic access and proprietary industrial research, while Japan's

[5] "Stanford Synchrotron Radiation Project (SSRP)," SLAC National Accelerator Laboratory, https://ahro.slac.stanford.edu/history-bits/ssrp.

[6] Aliyah Kovner, "Planning a New Era of Discovery with the Upgraded Advanced Light Source," August 24, 2026, Lawrence Berkeley National Laboratory, https://newscenter.lbl.gov/2026/08/24/planning-a-new-era-of-discovery-with-the-upgraded-advanced-light-source/.

SPring-8 created a formal public-use system that also supported company-operated beamlines.[7] These arrangements helped build broad user communities and connect photon science to industrial problems, including materials and manufacturing research conducted through Toyota's beamline at SPring-8.[8]

China entered this field later and initially relied heavily on foreign facilities, particularly for experiments requiring high-brightness X-rays and specialized beamlines. Chinese researchers used synchrotrons and free-electron lasers in the U.S., Japan, Europe, and elsewhere to conduct experiments, build expertise, and develop the user communities needed to operate comparable infrastructure at home. That dependence made access vulnerable to foreign scheduling constraints, travel restrictions, and the limited availability of beamtime for strategically important research. Chinese planners therefore came to view advanced light sources not simply as research instruments, but as national infrastructure.

China's expanding network of domestic facilities is intended to provide access across a wider range of wavelengths and experimental conditions, from high-brightness synchrotron X-rays to high-repetition-rate free-electron-laser pulses. China's effort is thus not merely to acquire individual machines, but to reproduce the broader ecosystem that the United States, Europe, and Japan built over decades: facilities, beamlines, trained operators, academic users, industrial partnerships, and a continuing pipeline of upgrades. The next section examines the dependence that made this buildout strategically important and the extent to which China is now attempting to replace foreign photon infrastructure with domestic capacity.

China's Light Source Dependence

Decades behind the west, the Beijing Synchrotron Radiation Facility (BSRF), which opened to users in 1991, was China's first synchrotron light source.[9] China's first dedicated synchrotron, the Hefei Light Source (HLS) at the National Synchrotron Radiation Laboratory (NSRL), came online the same year and supported research in soft X-ray and vacuum ultraviolet science.[10] But China entered the 21st century with only

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[7] European Synchrotron Radiation Facility, History, https://www.esrf.fr/home/about/History.html; Japan Synchrotron Radiation Research Institute, "History," https://spring8.jp/archive/en/about_us/history/.

[8] Toyota Central R&D Labs., Inc., "Development of World's First Measurement Technique for 3D Stress Distribution inside Crystalline Material Grains," December 20, 2019, https://spring8.jp/archive/en/news_publications/press_release/2019/191220/.

[9] Robert Crease, "China's next big thing: a new fourth-generation synchrotron facility in Beijing," August 15, 2019, *Physics World*, https://physicsworld.com/a/chinas-next-big-thing-a-new-fourth-generation-synchrotron-facility-in-beijing.

[10] Ibid.

two synchrotron facilities and a photon science infrastructure that lagged the United States by a generation.

Light source facilities are classified by technological generation, each representing a major leap in brightness and precision. China has historically entered each generation roughly fifteen years behind the West. The European Synchrotron Radiation Facility (ESRF) in Grenoble, France became the world's first third-generation source in 1992.[11]

The absence of equivalent domestic third generation facilities was a perceived concrete constraint on the pace of Chinese science well into the beginning of the 21st century. Chinese Physicist Ding Hong (丁洪), a member of the Chinese Academy of Sciences and professor at Shanghai Jiao Tong University, recalled that when he and his colleagues were pursuing iron-based superconductor research in 2008, critical experiments still had to be conducted overseas.[12] China's existing synchrotrons lacked the specialized beamlines (angle-resolved photoemission spectroscopy, ARPES) required for Ding's work.[13] These instruments use precisely tuned beams of light to map how electrons behave inside a material.

China's equivalent, the Shanghai Synchrotron Radiation Facility (SSRF), came online in 2009 and helped bolster China's photon sovereignty.[14] Official figures suggest that SSRF has become a major national research platform. Since opening, it has served more than 47,000 users from nearly 800 institutes across China.[15] That is more than the publicly reported total for Canada's CLS, though still well below Japan's SPring-8.[16]

Other major synchrotrons outside China also report thousands of users or user visits each year. Diamond Light Source (UK) reported over 11,000 user visits in 2024 and 2025,

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[11] European Synchrotron Radiation Facility, History, https://www.esrf.fr/home/about/History.html.

[12] "第四代光源快速建设中，第三代光源典范上海光源正答"发展之问"," May 7, 2024, *上观新闻*, https://stcsm.sh.gov.cn/xwzx/mtjj/20240507/d8115c2a40db4979a7d86885a88f73d9.html.

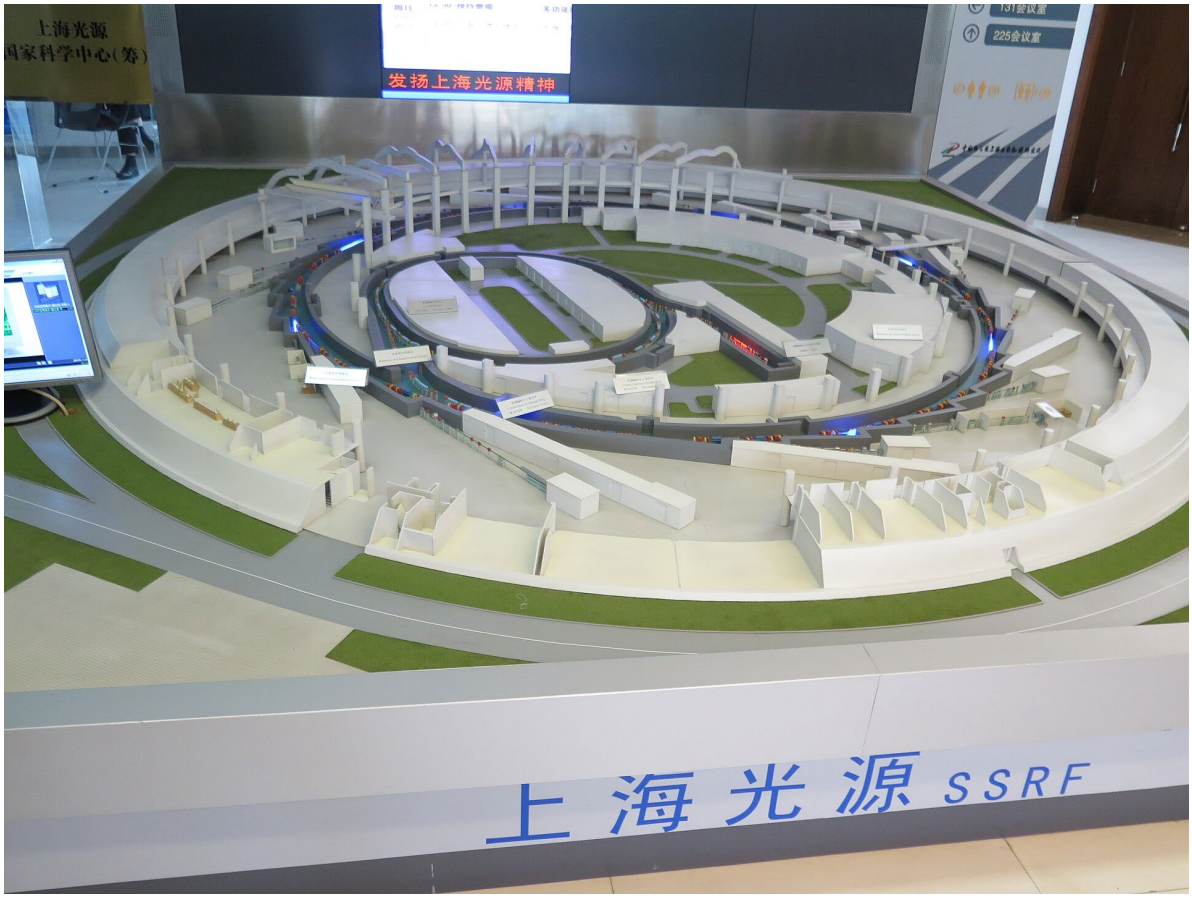
[13] "angle-resolved photoemission ARPES and metals," June 19, 2019, La Physique Autrement, https://www.youtube.com/watch?v=BejOga-L4kw.

[14] Robert Crease, "China's next big thing: a new fourth-generation synchrotron facility in Beijing," August 15, 2019, *Physics World*, https://physicsworld.com/a/chinas-next-big-thing-a-new-fourth-generation-synchrotron-facility-in-beijing.

[15] "第四代光源快速建设中，第三代光源典范上海光源正答"发展之问"," May 7, 2024, *上观新闻*, https://stcsm.sh.gov.cn/xwzx/mtjj/20240507/d8115c2a40db4979a7d86885a88f73d9.html.

[16] "Canadian Light Source 2025 Annual Report," 2025, https://www.lightsource.ca/documents/reports/2025-annual-report.pdf; Canadian Light Source, "About Us," https://www.lightsource.ca/about/about-us.php; Japan Synchrotron Radiation Research Institute, "Survey on SPring-8 usage and needs," https://user.spring8.or.jp/?lang=en&p=48311.

while the Australian Synchrotron reports 6,000 research visits per year.[17] SSRF has become a key domestic alternative for Chinese researchers who would otherwise compete for limited beamtime.



Scale model of the Shanghai Synchrotron Radiation Facility (SSRF).

Nevertheless, Chinese demand for beamtime on domestic light sources continued to grow. SSRF Director Zhao Zhentang (赵振堂) said in 2021 that the facility could only accommodate less than 60% of user applications for machine time.[18] "Among all the publications by Chinese scientists that made use of synchrotron light sources, about half had used light sources in other countries."

Chinese researchers were doing the fundamental science that feeds commercial innovation in contested technology sectors on foreign equipment and on foreign land.

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[17] The Australian Synchrotron, https://www.ansto.gov.au/facilities/australian-synchrotron; Diamond Light Source, "Annual Review 2024/2025," https://www.diamond.ac.uk/dam/jcr%3A11d98fb9-23c0-4aa3-be62-90102a30701a/Annual%20Review%202024-25%20final.pdf.

[18] Weijie Zhao, "Zhentang Zhao: past and future of the Shanghai Synchrotron Radiation Facility," *National Science Review*, Volume 8, Issue 12, December 2021, https://doi.org/10.1093/nsr/nwab185.

That dependence on external facilities created a potential point of leverage for the United States.

This dynamic has recently drawn the attention of U.S. policymakers. The Senate Intelligence Committee is proposing to prohibit citizens of China and Russia without permanent U.S. residence from accessing Department of Energy national laboratories without a waiver.[19] At a Senate Energy and Natural Resources Committee hearing in February 2025, Paul Dabbar, former DOE Undersecretary for Science, called for a default "ban [on] Chinese nationals at the national labs."[20] For a Chinese research community that has long relied on American facilities for beamtime, proposals to limit access to American facilities carry real consequences.

The restrictions would close a door American institutions held open for decades. Zhao credits that openness as a crucial asset for developing the SSRF. "American scientists performed many rounds of reviews for us and helped us improve our design," Zhao said in the same 2021 interview.[21] U.S. policymakers must decide whether to keep granting Chinese scientists access to American machines while Beijing builds its own under a science and technology strategy centered on self-reliance.[22]

Strategic Motivations for China's Light Source Localization

China's leadership believes that advanced scientific platforms are a cornerstone of national power. Xi Jinping has directed the country's planners to "scientifically plan the layout of forward-looking, strategically oriented, and application-supporting major scientific and technological infrastructure" (要科学规划布局前瞻引领型、战略导向型、应用支撑型重大科技基础设施). [23]

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[19] Mitch Ambrose, US Lawmakers Aim to Limit Citizens of China and Russia from Accessing DOE Labs," June 17, 2024, *American Institute of Physics*, https://www.aip.org/fyi/us-lawmakers-aim-to-limit-citizens-of-china-and-russia-from-accessing-doe-labs.

[20] Bochen Han, "US should consider barring Chinese citizens from its national labs, Senate hears," February 21, 2025, *South China Morning Post*, https://www.scmp.com/news/china/science/article/3299527/us-should-consider-barring-chinese-citizens-its-national-labs-senate-hears.

[21] Weijie Zhao, "Zhentang Zhao: past and future of the Shanghai Synchrotron Radiation Facility," *National Science Review*, Volume 8, Issue 12, December 2021, https://doi.org/10.1093/nsr/nwab185.

[22] Jimmy Goodrich, "China's Fortress Economy," July 30, 2024, https://ucigcc.org/publication/chinas-fortress-economy/.

[23] Xinhua, "习近平在中共中央政治局第三次集体学习时强调 切实加强基础研究 夯实科技自立自强根基," February 22, 2023, https://www.news.cn/politics/leaders/2023-02/22/c_1129386597.htm.

Xi has made clear that this directive applies to the country's light source infrastructure through personal involvement in overseeing China's light source build out. In November 2018, Xi visited the Shanghai Zhangjiang Science City and toured an exhibit featuring models of SHINE, the Soft X-ray Free Electron Laser, and the SSRF second-phase beamline project and called for accelerating the construction of "a world-class cluster of major science and technology infrastructure" (世界一流的重大科技基础设施集群).

State leaders and media continue to emphasize the strategic importance of advanced light sources. In May 2026, Executive Vice Premier Ding Xuexiang, a Politburo Standing Committee member who heads the Central Science and Technology Commission, toured HEPS in Beijing and called for faster breakthroughs in basic research. Chinese state media regularly describe advanced light sources as "foundational pillars of a great power" (大国重器, otherwise directly translated as "heavy weapons of the state").[24]

Developing this infrastructure at scale is a central goal of Beijing's broader push for indigenous innovation in strategic science and technology. Wang Yifang (王贻芳), who led the Chinese Academy of Sciences' Institute of High Energy Physics from 2011-2024, said in 2021: "For research related to strategic national development, we cannot expect to rely on foreign synchrotron radiation facilities—we can only build our own (很多与国家发展战略相关的研究，我们不能期望依靠国外的同步辐射装置来开展，只能建设我们自己的同步辐射装置)."[25]

The strategic imperative to reduce reliance on foreign light source infrastructure has intensified as the United States has moved toward restricting Chinese researchers' access to DOE facilities. Pending Senate legislation introduced in March 2025 would bar Chinese nationals from all seventeen DOE national laboratories, which include the light source facilities where much synchrotron research takes place.[26] China's investment in light source infrastructure began well before these restrictions took shape, but constrained access has created urgency for projects already underway.

Tracking China's Rapid Buildout

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[24] Jackson Martin, "The Technocracy: Making the MOST of Institutional Power to Advance China's Innovation," December 10, 2024, https://macropolo.org/the-technocracy-most-institutional-power-china-innovation/?rp=e; Xinhua, "《新闻联播》报道丁薛祥副总理实地视察高能同步辐射光源," May 8, 2026, https://www.ihep.cas.cn/dkxzz/HEPS/xwdt/2026/202605/t20260508_8197723.html.
[25] 扈永顺, "中国科学院院士王贻芳：用一束光探索微观世界," *瞭望*, July 19, 2021, https://lw.xinhuanet.com/2021-07/19/c_1310069567.htm.
[26] GATE Act of 2025, S. 929, 119th Cong. (2025), https://www.congress.gov/bill/119th-congress/senate-bill/929/text.

China’s ascension to a leading light source superpower did not happen overnight. Eight years since Xi’s visit to SHINE, the models Xi inspected have moved from renderings to reality. The Soft X-ray FEL user facility is now operational, the SSRF Phase II beamlines have entered service, and SHINE has advanced from design to final equipment installation and commissioning, with completion on track for 2027.

Chinese top science planners have also carried Xi’s mandate forward through successive Five-Year Plans, extending the buildout beyond Shanghai. HEPS has entered trial operation in Beijing, HALF has begun injector commissioning in Hefei, DALS is advancing in Dalian, and S3FEL has begun full-scale construction in Shenzhen, with additional facilities advancing in Dongguan, Jinhua, and Wuhan.

Each facility represents a decade or more of planning, USD hundreds of millions in public investment, and the coordinated effort of physicists, engineers, and state planners working toward a shared timeline.

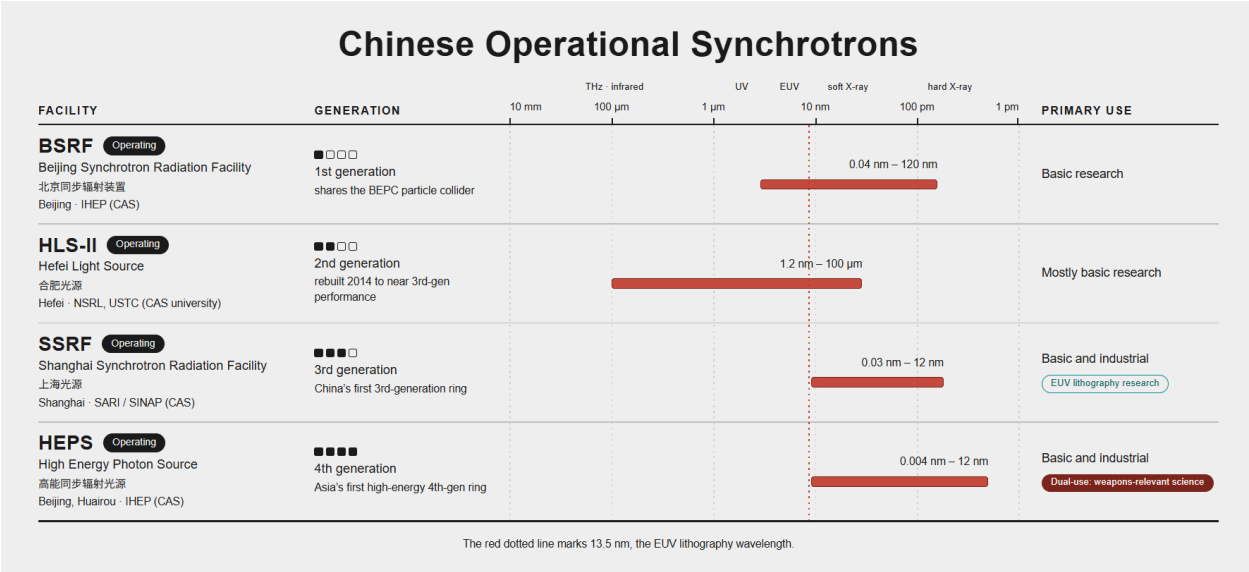
In China, planning for such large scientific facilities is coordinated through the national system for major scientific and technological infrastructure (国家重大科技基础设施) and managed by the National Development and Reform Commission (NDRC) Department of Innovation and High-Tech Development (创新和高技术发展司). Central government support for such infrastructure begins with inclusion in the National Medium- and Long-Term Science and Technology Development Plan (国家中长期科学和技术发展规划) and is operationalized through Five-Year Plans for major S&T infrastructure construction (国家重大科技基础设施建设规划). China’s light sources feature regularly in both.

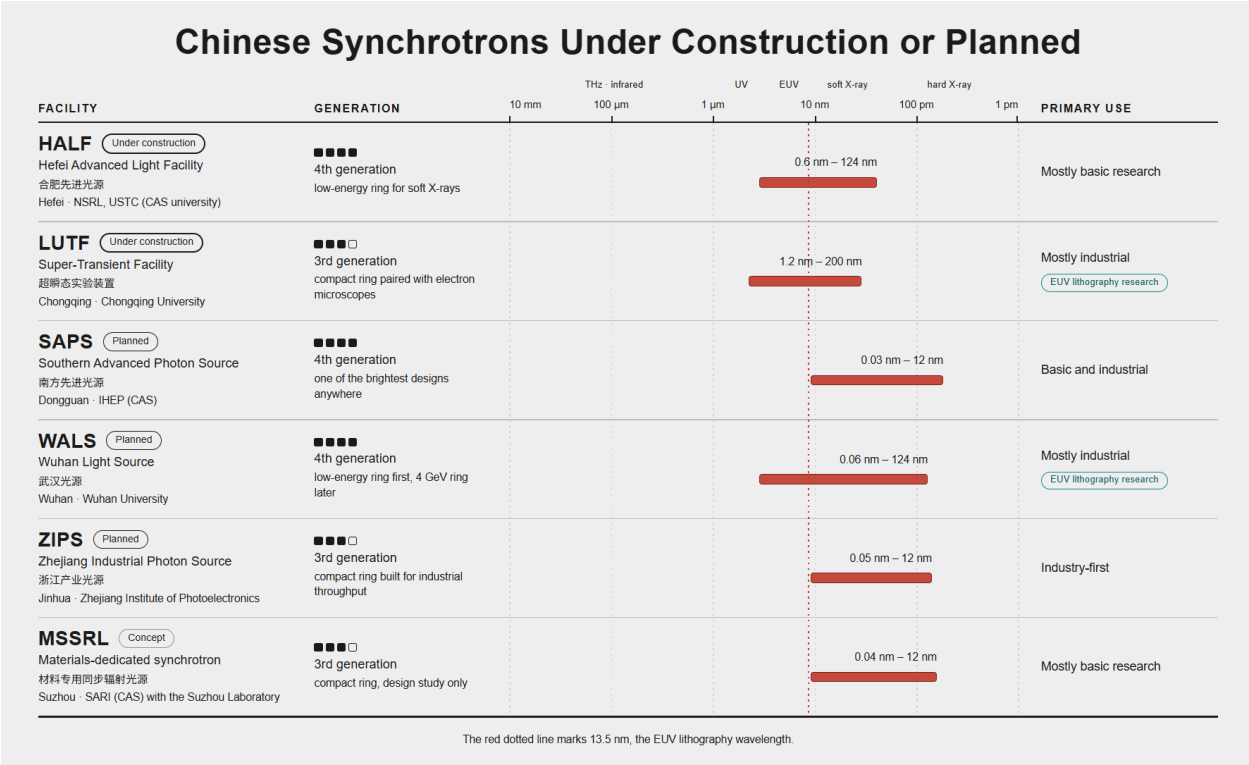
PRC Light Source Facility Inclusion in National Five-Year Plans

Five-Year Plan	Facility
7th FYP (1986-1990) 9th FYP (1996-2000)	National Synchrotron Radiation Laboratory
12th FYP (2011-2015) 13th FYP (2016–2020) 14th FYP (2021–2025)	High Energy Photon Source
13th FYP (2016-2020)	Shanghai High Repetition Rate XFEL (SHINE)
14th FYP (2021–2025) construction ongoing	Hefei Advanced Light Facility Dalian Advanced Light Source Super-Transient Synchrotron Radiation Light Source
Submitted application for 15th FYP (2026-2030)	Steady-State Microbunching EUV Light Source

Planning for indigenous light source capabilities began as early as 1983 when the State Planning Commission officially approved the construction of the NSRL in Hefei, well before American restrictions took shape. That early investment is now compounding rapidly. Nine facilities are currently under construction, with a further twelve in active planning. China's approximately 16 already operational facilities have provided a functioning domestic light source ecosystem that previous generations of Chinese researchers could not have imagined.

China's new generation of light sources includes state-of-the art fourth-generation synchrotrons and high-repetition-rate X-ray FELs with specifications that rival the most advanced machines in the United States and Europe. The High Energy Photon Source (HEPS) in Beijing, which began user operations in June 2026, now ranks among the world's brightest hard X-ray sources. The Shanghai High Repetition Rate XFEL and Extreme Light Facility (SHINE) places China alongside only the United States and Europe in operating a megahertz-class X-ray-free electron laser. The Hefei Advanced Light Facility (HALF) and the proposed Dalian Advanced Light Source (DALS) will fill out a full-spectrum photon ecosystem spanning ultraviolet through hard X-ray wavelengths.


Chinese Operational Synchrotrons
FACILITY
GENERATION
THz · infrared
UV
EUV
soft X-ray
hard X-ray
10 mm
100 µm
1 µm
10 nm
100 pm
1 pm
PRIMARY USE
BSRF Operating
Beijing Synchrotron Radiation Facility
北京同步辐射装置
Beijing · IHEP (CAS)
1st generation
shares the BEPC particle collider
0.04 nm – 120 nm
Basic research
HLS-II Operating
Hefei Light Source
合肥光源
Hefei · NSRL, USTC (CAS university)
2nd generation
rebuilt 2014 to near 3rd-gen performance
1.2 nm – 100 µm
Mostly basic research
SSRF Operating
Shanghai Synchrotron Radiation Facility
上海光源
Shanghai · SARI / SINAP (CAS)
3rd generation
China's first 3rd-generation ring
0.03 nm – 12 nm
Basic and industrial
EUV lithography research
HEPS Operating
High Energy Photon Source
高能同步辐射光源
Beijing, Huairou · IHEP (CAS)
4th generation
Asia's first high-energy 4th-gen ring
0.004 nm – 12 nm
Basic and industrial
Dual-use: weapons-relevant science
The red dotted line marks 13.5 nm, the EUV lithography wavelength.


Chinese Synchrotrons Under Construction or Planned
FACILITY
GENERATION
THz · infrared
UV
EUV
soft X-ray
hard X-ray
10 mm
100 µm
1 µm
10 nm
100 pm
1 pm
PRIMARY USE
HALF Under construction
Hefei Advanced Light Facility
合肥先进光源
Hefei · NSRL, USTC (CAS university)
4th generation
low-energy ring for soft X-rays
0.6 nm – 124 nm
Mostly basic research
LUTF Under construction
Super-Transient Facility
超瞬态实验装置
Chongqing · Chongqing University
3rd generation
compact ring paired with electron microscopes
1.2 nm – 200 nm
Mostly industrial
EUV lithography research
SAPS Planned
Southern Advanced Photon Source
南方先进光源
Dongguan · IHEP (CAS)
4th generation
one of the brightest designs anywhere
0.03 nm – 12 nm
Basic and industrial
WALS Planned
Wuhan Light Source
武汉光源
Wuhan · Wuhan University
4th generation
low-energy ring first, 4 GeV ring later
0.06 nm – 124 nm
Mostly industrial
EUV lithography research
ZIPS Planned
Zhejiang Industrial Photon Source
浙江产业光源
Jinhua · Zhejiang Institute of Photoelectronics
3rd generation
compact ring built for industrial throughput
0.05 nm – 12 nm
Industry-first
MSSRL Concept
Materials-dedicated synchrotron
材料专用同步辐射光源
Suzhou · SARI (CAS) with the Suzhou Laboratory
3rd generation
compact ring, design study only
0.04 nm – 12 nm
Mostly basic research
The red dotted line marks 13.5 nm, the EUV lithography wavelength.

Chinese Operational FELs

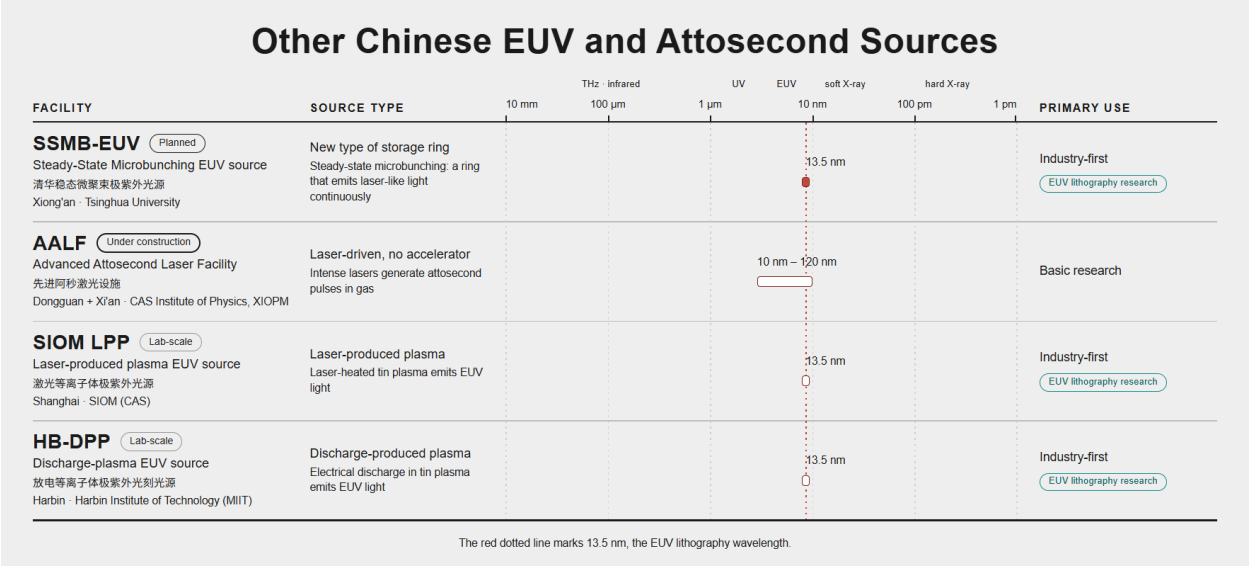
FACILITY	ACCELERATOR & PULSE RATE	THz · infrared / UV / EUV / soft X-ray / hard X-ray (10 mm, 100 µm, 1 µm, 10 nm, 100 pm, 1 pm)	PRIMARY USE
CTFEL Operating CAEP Terahertz Free Electron Laser 太赫兹自由电子激光装置 Chengdu · CAEP Institute of Applied Electronics	Superconducting linac continuous oscillator, 54 million micropulses per second China's first superconducting FEL	71 µm – 430 µm	Mostly basic research Nuclear weapons complex (CAEP)
DCLS Operating Dalian Coherent Light Source 大连相干光源 Dalian · DICP (CAS)	Room-temperature linac 50 pulses per second seeded FEL (HGHG)	50 nm – 150 nm	Basic research
FELiChEM Operating Hefei Infrared Free Electron Laser 合肥红外自由电子激光装置 Hefei · NSRL, USTC (CAS university)	Room-temperature linac pulsed oscillator two infrared oscillators	2.5 µm – 200 µm	Basic research
SXFEL Operating Shanghai Soft X-ray FEL 上海软X射线自由电子激光装置 Shanghai · SARI / SINAP (CAS)	Room-temperature linac 50 pulses per second SASE and seeded lines	2 nm – 20 nm	Basic research

The red dotted line marks 13.5 nm, the EUV lithography wavelength.

Chinese FELs Under Construction or Planned

FACILITY	ACCELERATOR & PULSE RATE	THz · infrared / UV / EUV / soft X-ray / hard X-ray (10 mm, 100 µm, 1 µm, 10 nm, 100 pm, 1 pm)	PRIMARY USE
SHINE Under construction Shanghai High-repetition-rate XFEL and Extreme Light Facility 上海硬X射线自由电子激光装置 Shanghai, Zhangjiang · ShanghaiTech + SARI/SINAP	Superconducting linac up to 1 million pulses per second hard X-ray; peer of LCLS-II and European XFEL	0.05 nm – 3.1 nm	Basic research Dual-use: weapons-relevant science
S3FEL Under construction Shenzhen Superconducting Soft X-ray FEL 深圳中能高重复频率X射线自由电子激光装置 Shenzhen, Guangming · IASF (city institute)	Superconducting linac up to 1 million pulses per second soft X-ray and EUV	1 nm – 30 nm	Basic and industrial
DALS Planned Dalian Advanced Light Source 大连先进光源 Dalian · DICP (CAS)	Superconducting linac up to 1 million pulses per second EUV; 20,000× the pulse rate of DCLS	6.5 nm – 180 nm	Mostly basic research EUV lithography research
WILL Planned Western Light Source IR/THz FEL 西部光源红外太赫兹自由电子激光装置 Chengdu · CAEP Institute of Applied Electronics	Superconducting linac high-average-power oscillator long-wavelength successor to CTFEL	2.4 µm – 3 mm	Mostly basic research Nuclear weapons complex (CAEP)

The red dotted line marks 13.5 nm, the EUV lithography wavelength.



The sweeping policy support of advanced scientific infrastructure introduced by Xi's directives is encouraging new Chinese actors to spearhead advanced light source projects. Several of the newest facilities profiled in this report are led by municipal governments and local universities operating outside the traditional CAS pipeline, a sign that the institutional base for advanced photon science in China is widening.

China's light source strategic breakout has direct implications for U.S. national security and competitiveness. Advanced light sources serve as upstream enablers for semiconductor extreme ultraviolet (EUV) lithography research, pharmaceutical development, next-generation battery technology, high-energy-density physics experiments relevant to nuclear weapons stewardship, and more. The DOE Office of Science assessed in 2021 that the United States has been rapidly outpaced by China and the EU in synchrotron beamline capacity over the past two decades.[27] Chinese researchers have meanwhile continued to leverage U.S. facilities for strategically sensitive work while their own facilities are still in the start-up phase. A 2025 Stanford Review investigation documented extensive use of U.S. synchrotron beamlines at Argonne and Lawrence Berkeley national laboratories by researchers affiliated with HPSTAR, a PRC-based high-pressure physics institute.[28] HPSTAR is on the U.S. Commerce Department's Entity List for its ties to China's nuclear weapons complex.

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[27] BESAC Subcommittee on International Benchmarking, "Can the U.S. Compete in Basic Energy Sciences?," 2021, https://science.osti.gov/-/media/bes/pdf/reports/2021/International_Benchmarking-Report.pdf

[28] Garret Molloy and Elsa Johnson, "Stanford Earth Sciences Chair Collaborates with China's Nuclear Program," December 1, 2025, https://stanfordreview.org/investigation-stanford-earth-sciences-chair-collaborates-with-chinas-nuclear-program/.

As China's domestic photon science capacity grows, researchers and firms will depend less on foreign facilities as the strategic value of related research domains increases. China's pipeline of planned facilities surpasses that of the United States in scale and several facilities are designed for capabilities no American machine currently provides (DALS and S3FEL, profiled in this report), raising the prospect that China could field a more capable national photon science ecosystem within the next decade.

Profiles of Major Advanced Facilities

Only a handful of advanced industrialized countries operate fourth-generation synchrotrons and X-ray free-electron lasers (XFELs), the most advanced class of light sources. Fourth-generation synchrotrons squeeze electron beams into extraordinarily tight bunches, producing X-rays hundreds of times brighter and more coherent than their predecessors, bright enough to image individual atoms in real time. XFELs take a different approach, using linear accelerators to generate X-ray laser pulses so intense and so brief (measured in femtoseconds, or millionths of a billionth of a second) that they can capture chemical reactions mid-stride. Together, these two types of machines represent the current frontier of photon science infrastructure.

Until recently, the synchrotron and XFEL frontier was dominated by the United States, Europe, and Japan. Sweden's MAX IV, which opened in 2016, was the first purpose-built fourth-generation synchrotron.[29] Brazil's Sirius and France's upgraded ESRF-EBS followed in 2020.[30] The United States completed its upgrade of the Advanced Photon Source (APS) at Argonne National Laboratory in 2026.[31] XFELs, the European XFEL in Hamburg and LCLS-II at SLAC in California are the world's two premier hard X-ray free-electron laser facilities, joined by smaller machines in Japan, South Korea, and Switzerland. China, until very recently, had no fourth-generation synchrotrons and no hard X-ray free-electron laser.

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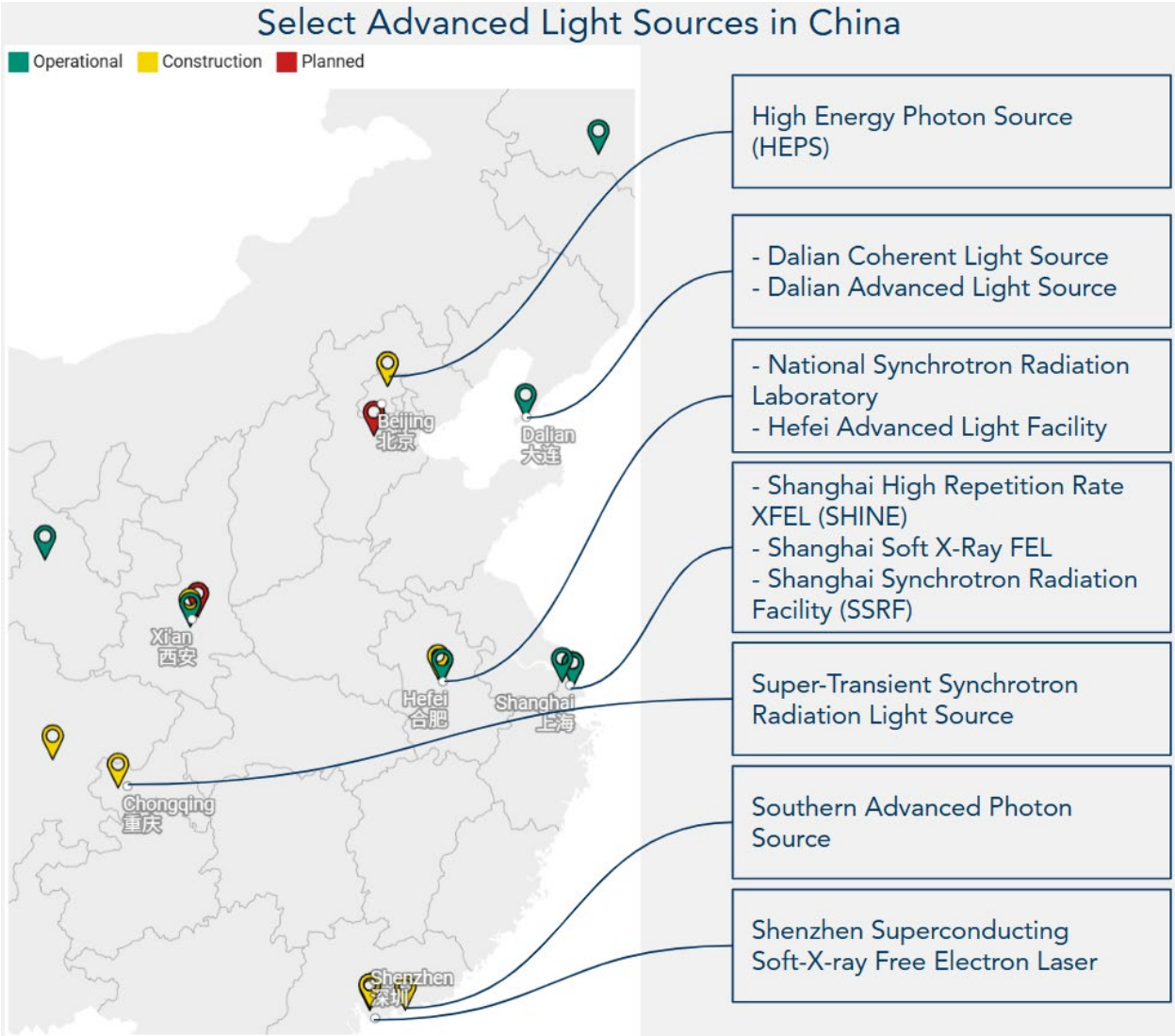
[29] MAX IV, "The MAX IV facility," https://www.maxiv.lu.se/about-us/the-max-iv-facility/.

[30] Brazilian Center for Research in Energy and Materials, "Bilateral partnership between Brazil and China: CNPEM and IHEP sign cooperation agreement," June 1, 2023, https://cnpem.br/en/bilateral-partnership-between-brazil-and-china-cnpem-and-ihep-sign-cooperation-agreement/; European Synchrotron Radiation Facility, "Opening of ESRF-EBS, a new generation of synchrotron," August 25, 2020, https://www.esrf.fr/home/news/general/content-news/general/opening-of-esrf-ebs-a-new-generation-of-synchrotron.html.

[31] Andre Salles, "Argonne celebrates successful completion of the Advanced Photon Source Upgrade," February 5, 2026, Argonne National Laboratory https://www.anl.gov/article/argonne-celebrates-successful-completion-of-the-advanced-photon-source-upgrade.

Aerial view of the Advanced Photon Source at Argonne National Laboratory, Illinois.

The profiles below cover seven of China's most advanced and promising next-generation light source projects: two fourth-generation synchrotrons (HEPS in Beijing and HALF in Hefei), two major free electron lasers (SHINE in Shanghai and S3FEL in Shenzhen), a specialized EUV free electron laser (DALS in Dalian), a novel synchrotron-electron microscope hybrid (LUTF in Chongqing), and a commercially oriented synchrotron (ZIPS in Jinhua). Several of these newer projects, particularly LUTF, ZIPS, and S3FEL, are being designed around industrial applications from the outset, reflecting a shift from earlier facilities that served primarily academic research. When complete, these and other facilities will give China a national photon science infrastructure rivaling that of any single country in the world.



High Energy Photon Source (HEPS), Beijing (Operational 2026)

HEPS is China's flagship fourth-generation synchrotron and the first newly built from the ground up (not upgraded) high-energy fourth-generation light source in Asia. The facility is the signature project of the Institute of High Energy Physics (IHEP, 中国科学院高能物理研究所), a Chinese Academy of Sciences (CAS) institution established in 1973 that operates China's broadest portfolio of accelerator-based research infrastructure,

spanning particle colliders, synchrotron light sources, spallation neutron sources, and space-based X-ray telescopes.[32]

IHEP built China's first synchrotron light source, the Beijing Synchrotron Radiation Facility (BSRF), which opened in 1991 as a secondary facility on the Beijing Electron-Positron Collider. Under former director Wang Yifang (王贻芳), who led the institute from 2011 to 2024, IHEP also pioneered China's free-electron laser technology: IHEP scientist Xie Jialin (谢家麟) led design and construction of the Beijing Free Electron Laser under the 863 High Tech R&D Program (国家高技术研究发展计划), and the facility opened in 1993, establishing process knowledge that informed subsequent FEL projects in Dalian and Shanghai.[33]

Located in Beijing's Huairou Science City, HEPS was first proposed by IHEP in 2008 and broke ground in June 2019 at a cost of 4.76 billion RMB (~$660 million).[34] The machine operates at 6 GeV, the same energy class as the upgraded APS at Argonne National Lab, and achieved a world-class electron beam emittance of 93 picometers in January 2025.[35] Emittance is a key measure of beam quality; lower numbers mean a tighter, brighter beam. At 93 pm, HEPS produces X-rays roughly one trillion times brighter than sunlight. "HEPS will have a similar quality beam and be competitive with the upgraded APS," Eric Isaacs, former director of Argonne National Laboratory, told *Science* magazine.[36]

HEPS entered its commissioning phase in March 2025 and opened its first call for user proposals in March 2026, inviting researchers to apply for beamtime across all 14 Phase I beamlines, with the facility beginning user operations in June 2026 and an eventual capacity of 90 beamlines.[37] HEPS will serve users conducting materials science, biomedicine, semiconductors, aerospace engineering, and energy research.

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[32] "Institute of High Energy Physics," Chinese Academy of Sciences, *National Science Review*, Volume 4, Issue 6, November 2017, Pages 934–942, https://doi.org/10.1093/nsr/nwx141.
[33] Min Zhang and Qian Pan, "Jialin Xie wins China's top science award," February 23, 2012, https://newsline.linearcollider.org/2012/02/23/jialin-xie-wins-chinas-top-science-award/; Dennis Normile, "China opens unique free electron laser facility," January 15, 2017, https://www.science.org/content/article/china-opens-unique-free-electron-laser-facility.
[34] Y. Jiao et al., "The HEPS Project," *Journal of Synchrotron Radiation* 25, no. 6 (November 2018): 1611–18, https://pmc.ncbi.nlm.nih.gov/articles/PMC6225742/.
[35] Yan Dongjie, "Science Talk: Huairou science facility poised to revolutionize research," June 4, 2025, *China Daily*, https://www.chinadaily.com.cn/a/202506/04/WS683fd412a310a04af22c3203.html.
[36] Richard Stone, "China poised to turn on one of world's most powerful sources of x-ray light," November 22, 2024, https://www.science.org/content/article/china-poised-turn-one-world-s-most-powerful-sources-x-ray-light.
[37] Xinhua, "China's High Energy Photon Source targets trial run by end-2025," July 24, 205, https://www.chinadaily.com.cn/a/202507/24/WS6881901ca310ad07b5d91b03.html.

IHEP deputy director and HEPS vice-manager Dong Yuhui (董宇辉) has articulated an explicitly industrial vision for the facility, stating his expectation that "after the 15th Five-Year Plan, leading enterprises (龙头企业) can come to HEPS with questions and leave with solutions to help China's industrial transformation" toward advanced manufacturing.[38] State media reports that domestically produced "core equipment" accounts for more than 95% of the machine, and IHEP researchers described early trial experiments spanning aerospace component defect detection, power battery charge and discharge analysis, and semiconductor microelectronics—the kind of industrial work Dong has in mind. Ding Xuexiang's visit in May signaled the priority Beijing places on that work.

Hefei Advanced Light Facility (HALF) (Under Construction, Expected 2028)

HALF occupies the opposite end of the photon energy spectrum from HEPS. Located in Hefei, Anhui Province, HALF is a fourth-generation synchrotron optimized for the soft X-ray and vacuum ultraviolet range, a region of the spectrum especially valuable for studying electronic structures, chemical bonding, and quantum materials. The facility is being built by the National Synchrotron Radiation Laboratory (NSRL, 国家同步辐射实验室) at the University of Science and Technology of China (USTC). Construction began in June 2023, with a reported investment of ~$385 million (2.78 billion RMB) and completion expected in 2028.[39]

HALF is already moving quickly toward full completion. In September 2026, HALF produced a stable electron beam that traversed its 192-meter linear accelerator.[40] This accelerator is designed to supply electrons to the storage ring at an energy of 2.2 GeV. The project will next advance to storage-ring injection and further commissioning before producing synchrotron light for scientific experiments. The milestone marks progress toward the facility's opening, rather than the start of user operations.

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[38] Douyin video uploaded November 27, 2025, https://www.douyin.com/video/7577322456570924329.

[39] "合肥先进光源直线加速器成功实现电子束出束," *中国科学技术大学*, September 20, 2026, https://news.ustc.edu.cn/info/1048/96361.htm; "总投资超 27 亿元， 事关合肥这一"国之重器"," *合肥日报*, November 14, 2023, https://m.jiemian.com/article/10393587.html; Z. H. Bai et al, "Optimization and Update of The HALF Storage Ring Physics Design," 17th International Particle Accelerator Conference, May 2026, https://www.ipac26.org/prepress/pdf/TUP2627.pdf.

[40] "合肥先进光源直线加速器成功实现电子束出束," *中国科学技术大学*, September 20, 2026, https://news.ustc.edu.cn/info/1048/96361.htm.

Established in 1983 as China's first national laboratory, NSRL built the Hefei Light Source (HLS) between 1984 and 1991.[41] HLS was China's first dedicated synchrotron and specialized in vacuum ultraviolet and soft X-ray science, a role USTC has maintained for over forty years. A 2014 overhaul brought HLS-II close to third-generation performance, and it now operates ten experimental stations. NSRL also operates FELiChEM, China's first user-oriented infrared free electron laser, which began serving researchers in 2022.[42] As a university-hosted national laboratory, NSRL has graduated over 500 synchrotron-trained researchers in the past decade, feeding talent into China's growing network of light source projects.[43]

HALF will operate at 2.2 GeV with a natural emittance of 86 pm, producing soft X-rays over 100 times brighter than third-generation synchrotrons.[44] HALF will run at nearly the same energy and emittance as its closest U.S. counterpart, the Advanced Light Source Upgrade (ALS-U, scheduled to open in 2029) at Lawrence Berkeley National Laboratory.[45] Together with HEPS (6 GeV, optimized for hard X-rays) and the existing Shanghai Synchrotron Radiation Facility (SSRF, 3.5 GeV), HALF will complete a complementary trio of light sources spanning ultraviolet and soft X-rays through high-energy hard X-rays.

That spectrum coverage matters because different classes of scientific and industrial problems require different photon energies. Soft X-rays are particularly powerful for probing electronic structure, chemical bonding, and surface phenomena in advanced materials. These research areas are central to semiconductors, catalysis, batteries, and quantum systems. Hard X-rays, by contrast, enable deep-penetration imaging and high-resolution structural analysis, supporting protein crystallography, drug discovery, advanced manufacturing diagnostics, and geoscience research. By fielding major facilities across this energy range, China would establish a full-spectrum light source ecosystem comparable to those of only a handful of countries including the United States, Germany, France, and Japan.

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[41] Hefei Synchrotron Radiation Facility, May 27, 2025, National Synchrotron Radiation Laboratory, https://lssf.cas.cn/en/facilities/material/hsrf/202505/t20250527_5070218.html.

[42] National Synchrotron Radiation Laboratory, "历史进程," Accessed September 28, 2026, https://www.nsrl.ustc.edu.cn/lswh/list.htm.

[43] "科大/同步辐射实验室介绍," February 12, 2026, 中国化学会第七届高分子成型加工及其产业发展研讨会, https://www.chemsoc.org.cn/a6390.html.

[44] "Fourth-generation synchrotron radiation facility construction begins in E China," September 23, 2026, CGTN, https://news.cgtn.com/news/2023-09-22/Synchrotron-radiation-facility-starts-construction-in-E-China-1nju3a7qkU0/index.html.

[45] "ALS-U Approach," Lawrence Berkeley National Laboratory, https://als.lbl.gov/als-u/als-u-approach/; Ruby Barcklay, "Looking Forward to the Upgraded ALS," February 18, 2026, https://research.lbl.gov/2026/02/18/looking-forward-to-the-upgraded-als/.

Shanghai High Repetition Rate XFEL and Extreme Light Facility (SHINE) (Under Construction, Expected 2027)

SHINE, reportedly the largest single national major scientific infrastructure project in China's history, is moving toward full completion in 2027.[46] SHINE is the flagship project of the Shanghai Advanced Research Institute (SARI, 上海高等研究院) and its affiliate, the Shanghai Institute of Applied Physics (SINAP, 上海应用物理研究所), both operating under the Chinese Academy of Sciences. Together, SARI and SINAP function as China's closest institutional parallel to the U.S. Department of Energy's SLAC National Accelerator Laboratory. The two institutions built and now operate the Shanghai Synchrotron Radiation Facility (SSRF), China's first third-generation synchrotron, which has served over 47,000 users since opening in 2009, and the Shanghai Soft X-ray Free-Electron Laser (SXFEL), China's first coherent X-ray light source.[47] Led by CAS Academician Zhao Zhentang (赵振堂), the SXFEL project demonstrated advanced seeding techniques that pushed the facility's output into the "water window," a narrow band of X-ray wavelengths that can pass through water but is absorbed by carbon, allowing scientists to image biological molecules in their natural wet state.

Located in Shanghai's Zhangjiang High-Tech Park (张江综合性国家科学中心) near SSRF and SXFEL, SHINE occupies 3.1 kilometers of tunnels bored 30 meters underground.[48] The facility features an 8 GeV continuous-wave superconducting radiofrequency linear accelerator capable of delivering electron bunches at up to 1 MHz, or one million pulses per second. A higher repetition rate means researchers can collect data faster and run more experiments simultaneously. SHINE will place China among the small number of countries operating MHz-class X-ray free-electron lasers, alongside LCLS-II at SLAC in California and the European XFEL in Germany.[49] Phase I includes three undulator lines covering photon energies from 0.4 to 25 keV, three X-ray beamlines, and ten experimental endstations.

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[46] Yang Jing et al, "X 射线自由电子激光器研究进展," *Journal of Beijing University of Technology*, Vol. 51 No. 11, November 2025, https://journal.bjut.edu.cn/bjgydxxb/cn/article/pdf/preview/10.11936/bjutxb2025030003.pdf.

[47] Xinhua, "China upgrades Shanghai synchrotron light source to support sci-tech development," May 16, 2024, https://english.www.gov.cn/news/202405/16/content_WS66457be1c6d0868f4e8e726e.html.

[48] Zhao Zhentang et al, "Shanghai Hard X-Ray FEL Facility Progress Status," 15th International Particle Accelerator Conference, May 2024, https://proceedings.jacow.org/ipac2024/pdf/TUZN1.pdf.

[49] Ali Sundermier, "A new world record: LCLS approaches 100,000 pulses per second on the path to a million," December 9, 2025, https://www6.slac.stanford.edu/news/2025-12-09-new-world-record-lcls-approaches-100000-pulses-second-path-million; European XFEL, "European XFEL in international comparison," https://www.xfel.eu/facility/comparison/index_eng.html.

The tunnels housing SHINE have been pre-designed to accommodate additional undulator lines beyond the initial three, leaving room for significant future expansion. SHINE also integrates a 50-to-100 petawatt ultra-intense laser, a power level that would allow researchers to recreate conditions found inside stars and study how matter behaves under extreme pressure and temperature, experiments relevant to fusion energy research and national security applications.

Construction on SHINE began in April 2018. All tunnels were completed by the end of 2023. Civil infrastructure and building construction wrapped up in October 2025, and crews have moved into full equipment installation and commissioning. The facility is on track to produce first laser light by late 2026 and to reach full completion in 2027. The total cost has not been publicly disclosed, but estimates place the investment at a minimum of 10 billion RMB (~$1.4 billion). Its potential applications range from structural biology and ultrafast chemistry to high-energy-density physics and advanced materials characterization.

Dalian Coherent Light Source and Dalian Advanced Light Source (DCLS/DALS) (DCLS Operational 2017; DALS Planned)

China's light source ambitions extend beyond synchrotrons and hard X-ray FELs into a specialized niche: extreme ultraviolet (EUV) free-electron lasers. The Dalian Coherent Light Source (DCLS), built and operated by the Dalian Institute of Chemical Physics (DICP) under the Chinese Academy of Sciences, began operating in 2017 and remains the world's only FEL user facility operating exclusively in the 50 to 150 nanometer vacuum ultraviolet range. That wavelength band is uniquely suited for probing valence electrons, the outermost electrons in atoms that govern how molecules bond, react, and break apart.

Building on that foundation, DICP proposed the Dalian Advanced Light Source (DALS) to the Chinese Academy of Sciences and secured inclusion of a "pre-research project" (预研装置) under the 14th Five-Year Plan. The ~$415 million upgrade would replace the existing room temperature accelerator with a superconducting linear accelerator, boosting the repetition rate from 50 Hz to 1 MHz (a 20,000-fold increase) and extending the facility's reach into shorter wavelengths down to 6.5 nanometers.

The pre-research project achieved its target beam power in July 2025 and passed expert acceptance in August, positioning the full facility for construction pending central government approval. The twelve-year arc from initial proposal (2013) to validated prototype underscores how inclusion in the Five-Year Plan system lets projects advance

systematically under sustained state support, with preparatory work funded and executed on its own timeline before full construction is authorized.

The 6.5 nanometer figure puts DALS deep into the EUV range, the sliver of the spectrum between ordinary ultraviolet light and soft X-rays. EUV photons carry enough energy to knock loose the outermost electrons from atoms and molecules, making them exceptionally useful for studying chemical reactions. The same wavelength range is also where cutting-edge semiconductor lithography operates: the most advanced chips are patterned using 13.5 nanometer EUV light.

At these specifications, DALS would become the world's first continuous wave high-repetition-rate EUV FEL. Its primary scientific applications lie in atomic and molecular science, combustion chemistry, atmospheric science, and astrochemistry—fields where understanding how individual molecules absorb and release energy is fundamental. The facility's combination of high average power and tunable EUV output would also make it a valuable research platform for semiconductor lithography development, supporting work on EUV source physics, optics testing, and photoresist characterization.

Shenzhen Superconducting Soft X-ray Free Electron Laser (S3FEL) (Under Construction, Expected 2032)

S3FEL (深圳中能高重复频率 X 射线自由电子激光装置) is a high-repetition-rate soft X-ray free electron laser under construction in Shenzhen. The facility is being built by the Institute of Advanced Science Facilities, Shenzhen (IASF, 深圳综合粒子设施研究院), in collaboration with the Dalian Institute of Chemical Physics (DICP) under the Chinese Academy of Sciences. DICP brings direct FEL construction experience to the project, having built the Dalian Coherent Light Source (DCLS) and proposed the Dalian Advanced Light Source (DALS). Academician Yang Xueming (杨学明), who spearheaded the DALS proposal, is also leading S3FEL's design.

S3FEL received national approval in May 2023, began site preparation in September 2023, and entered full-scale construction in May 2026.[50] The surface facility spans approximately 1.7 kilometers. Instead of sitting on a conventional flat site, S3FEL features a unique architectural design that stretches directly across local hilltops and an adjacent reservoir. At its core is a 2.5 GeV superconducting linear accelerator that fires one million X-ray pulses per second, continuously. Traditional accelerators built with room-temperature components can typically fire only about 100 pulses per second. S3FEL's superconducting design closes that gap by a factor of 10,000, producing far

[50] Weiqing Zhang, "Shenzhen Superconducting Soft X-ray Free Electron Laser," August 19, 2024, https://indico.jacow.org/event/72/contributions/6361/.

brighter light on average and allowing researchers to study how materials change at the atomic level in real time.

First light is targeted for 2032. Phase I will feature four X-ray laser lines feeding 14 experimental stations. Two of the lines will produce high-intensity ultrashort pulses suited for capturing fast processes, while the other two will produce highly stable, precisely tuned pulses better suited for detailed spectroscopy. The facility will generate X-rays with wavelengths from 1 to 30 nanometers, serving users in quantum materials, energy catalysis, biomedicine, atmospheric science, and atomic physics. S3FEL will anchor a major new science center in the Guangdong-Hong Kong-Macao Greater Bay Area, providing key scientific research infrastructure for the region's advanced manufacturing and biotechnology industries.

S3FEL is being financed primarily through municipal government investment. In April 2026, a state-owned Shenzhen development company secured a thirty-year, 5 billion RMB (~$695 million) loan from China Everbright Bank for the project, which state media presented as a financing template for future major science facilities.

Laboratory for Ultrafast Transient Facility/Super-Transient Synchrotron Radiation Light Source (LUTF) (Under Construction, Expected 2026)

LUTF is Chongqing's first major scientific infrastructure project, a 3-billion-RMB (~$415 million) facility in the Western (Chongqing) Science City spearheaded by Chongqing University.[51] The facility pairs a synchrotron light source with a cluster of ultrafast electron microscopes in a single integrated complex.

Most synchrotrons are large, shared facilities serving hundreds of unrelated experiments, with electron microscopes housed in separate labs elsewhere. LUTF instead builds a smaller synchrotron specifically to work alongside electron microscopes on the same experiments at the same time. The synchrotron probes materials with photons; the electron microscopes probe them with electrons. Each technique captures different information. By housing both under one roof and synchronizing their measurements, researchers can watch how a material's atomic structure and electronic properties change together during a process like battery charging or metal fatigue, something neither instrument can fully reveal alone.

[51] Chongqing Municipal People's Government, "揭秘重庆首个大科学装置 超瞬态实验装置到底能干啥?," June 2, 2026, https://www.cq.gov.cn/zwgk/zfxxgkzl/fdzdgknr/zdxm/dtxx/202106/t20210603_9356920.html.

The synchrotron is being built in phases. Phase I is a compact 500 MeV storage ring with a circumference of 76.8 meters, designed to run at an unusually high beam current of 1,000 milliamps. That high current maximizes the total volume of light the ring delivers, which matters for techniques like EUV lithography testing and photoemission spectroscopy that consume large quantities of photons to produce usable data. The trade-off is that 500 MeV is low energy by synchrotron standards, limiting the ring to softer, longer-wavelength light. To address that, planners intend to add a 3.0 GeV ring in a later phase, which would extend LUTF's range into harder X-rays. Construction on Phase I broke ground in mid-2021, and the Chongqing Municipal Development and Reform Commission approved the preliminary design and cost estimate in November 2023.

The project is led by Professor Tang Wenxin (唐文新), director of Chongqing University's Electron Microscopy Center. LUTF's research agenda focuses on observing materials under the kinds of stress they face in real industrial use: mechanical load, high temperatures, magnetic fields, electrical currents, and radiation exposure. LUTF's target sectors include solid-state batteries, aerospace materials, advanced manufacturing, and EUV lithography.

Zhejiang Industrial Photon Source (ZIPS) (Planned)

Most of China's advanced light sources are designed to serve primarily basic research but will also lease out beam lines to industrial users. The Zhejiang Industrial Photon Source (ZIPS, 浙江产业光源大科学装置) in Jinhua, Zhejiang Province, represents a different model: a 2.6 to 2.7 GeV synchrotron designed from the outset to primarily serve commercial and industrial users. Planners surveyed over 100 regional companies to tailor the facility's beamlines to actual product development needs in sectors including lithium-ion batteries, pharmaceuticals, and semiconductor materials. The project explicitly draws on the model of Japan's Aichi Synchrotron Radiation Center (AichiSR), an industrial synchrotron that integrated local manufacturers like Toyota and Denso into its research ecosystem.

ZIPS is a joint venture of the Jinhua Municipal Government, Zhejiang Normal University, and the University of Science and Technology of China (USTC), with a planned investment of 2.5 billion RMB (~$345 million). The Zhejiang Institute of Photoelectronics (浙江光电子研究院) was established in 2022 to manage the facility, staffing it with 70 full-time researchers in collaboration with USTC's National Synchrotron Radiation Laboratory. The storage ring will have a circumference of approximately 200 meters with a target emittance below 5 nm·rad. Phase I plans call for 8 beamlines, with room to expand to 14.

Because building a full synchrotron takes years, the project is following a phased "three-step" strategy (三步走) designed to start serving companies immediately. The first step established shared laboratory instruments through the Zhejiang Institute of Photoelectronics. The second step funded dedicated "Jinhua beamlines" at existing national facilities: a soft X-ray beamline at the Hefei Light Source began trial operations in 2023, and pre-research is underway for a second beamline at the upcoming HALF. The third step is construction of ZIPS itself. As of early 2024, the project team has secured land in Jinhua's Jinyi New District, completed micro-vibration testing of the site's foundation, and is finalizing feasibility studies for submission to the NDRC.

Implications for U.S.-China Commercial Competition and National Security

China's rapid light source buildout will strengthen the country's capabilities across nuclear weapons stewardship, advanced semiconductor manufacturing, biomedical and pharmaceutical development, next-generation battery technology, and aerospace manufacturing. In each case, synchrotrons and free electron lasers serve as upstream enablers, providing the imaging and measurement tools that support downstream innovation.

Military Applications

Advanced light sources are not weapons-testing facilities, and most of their beamtime supports civilian science. Their military value lies in measuring how materials age, deform, fracture, change phase, and react under shock, extreme pressure, heat, and radiation. Such experiments do not reproduce the impact of a missile or an entire nuclear detonation. Instead, they produce the material-response data needed to test computer models and determine whether aging components remain reliable or replacement materials will perform as expected. Their clearest publicly documented military application, however, is nuclear stockpile stewardship.

In the United States, the National Nuclear Security Administration (NNSA) and DOE national laboratories already use advanced light sources for stockpile stewardship. NNSA relies in part on the Advanced Photon Source's Dynamic Compression Sector to generate experimental data used to validate physics models and simulation codes that support the annual certification of the safety and effectiveness of the U.S. nuclear arsenal without explosive nuclear testing.[52] Lawrence Livermore National Laboratory

[52] Washington State University Institute of Shock Physics, "The Dynamic Compression Sector," https://dcs-aps.wsu.edu/; Argonne National Laboratory, "Argonne researchers win defense programs award for nuclear safety work," January 4, 2023, https://www.anl.gov/article/argonne-researchers-win-defense-programs-award-for-nuclear-safety-work.

researchers also use the Linac Coherent Light Source (LCLS) to study high-energy-density matter and help validate models used in stockpile-stewardship codes.[53]

Experiments at the Dynamic Compression Sector illustrate how these measurements support weapons modeling. Livermore researchers detonated small samples of HNS and Composition B and fired rapid synchrotron X-ray pulses through the otherwise opaque reactions.[54] The resulting images allowed them to reconstruct the motion of components inside exploding-foil initiators and observe carbon particles forming within the explosives on nanosecond and nanometer scales. These measurements supplied data for testing detonation models and improving detonator performance. Livermore states that the research supports both stockpile stewardship and defense nonproliferation.

Public records point to a direct link between China's nuclear weapons establishment and the country's advanced light source programs. The China Academy of Engineering Physics (CAEP) is the Chinese technology complex responsible for researching, developing, and testing nuclear weapons. Leading CAEP researchers Deng Jianjun (邓建军) and Wu Qiang (吴强) are directly involved in HEPS's governance as members of its Science and Technology Committee (科技委员会).[55] This connection shows that HEPS was developed with direct input from the organization responsible for China's nuclear arsenal.

Semiconductor Manufacturing

Synchrotron and FEL beams tuned to extreme ultraviolet wavelengths let researchers examine, at atomic scale, how EUV light interacts with photoresists and silicon, the interactions that ultimately determine how cleanly a lithography system prints transistor patterns.

This is not a hypothetical application. Berkeley Lab's Center for X-Ray Optics used EUV light from the Advanced Light Source synchrotron to test the optics and masks for the first full-scale EUV lithography prototype, built through a consortium of Intel, Motorola, AMD, Micron, Infineon, and IBM working with Lawrence Berkeley, Lawrence Livermore,

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[53] Stefan Hau-Riege, "X-Ray Free-Electron Laser Science for High-Energy-Density Experiments," Lawrence Livermore National Laboratory, https://ldrd-annual.llnl.gov/archives/ldrd-annual-2016/hed/xray.
[54] Holly Auten, "Detonation Science Blasts into a New Frontier," https://str.llnl.gov/past-issues/julyaugust-2017/detonation-science-blasts-new-frontier.
[55] Institute of High Energy Physics High Energy Photon Source, "组织机构," https://heps.ihep.ac.cn/xmgk/zzjg/.

and Sandia National Laboratories. That research led directly to Intel's 2002 order of the first beta EUV stepper from ASML.[56] The Dalian Advanced Light Source (DALS) would push China's FEL reach to about 6.5 nanometers, well into the EUV range, creating a domestic platform for studying these exposure and materials-response processes.

Separately, Tsinghua University is developing a novel accelerator concept called steady-state microbunching (SSMB) based in the Xiong'an New Area outside Beijing that could theoretically produce kilowatt-level continuous EUV radiation at 13.5 nm, the wavelength used in advanced chip lithography. The concept has been validated at proof-of-principle level, but a full-scale SSMB-EUV light source remains years from realization.

Synchrotron-generated EUV already supports semiconductor manufacturing quality control, and researchers in China are developing EUV mask inspection tools at SSRF that would likely progress faster as new advanced facilities come online.[57] Taken together, stronger domestic EUV light source capabilities would allow Chinese teams to run this class of exposure and metrology work onshore.

Drug Discovery & Biotech

Intense X-ray beams are a key tool in drug discovery. When directed at crystallized protein samples, these beams generate diffraction patterns. Analysis of these patterns reveals the three-dimensional atomic structure of drug targets, enabling researchers to design molecules that bind with greater precision. BeiGene (百济神州) used SSRF to develop the anti-cancer drug Brukinsa, which received U.S. FDA approval in 2019 and became the first Chinese cancer drug to exceed one billion dollars in annual global sales.[58] The brighter beams at HEPS and SHINE will allow more research groups to conduct this work simultaneously and tackle more complex biological targets, reducing R&D time and improving success rates for domestic biopharma firms.[59]

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[56] Dan Krotz, "The race to make the next generation of semiconductor chips: extreme ultraviolet lithography leads the field," June 4, 2022, https://newscenter.lbl.gov/2002/06/04/the-race-to-make-the-next-generation-of-semiconductor-chips-extreme-ultraviolet-lithography-leads-the-field/.

[57] Shuying Deng et al, "Development of a synchrotron-based EUV microscope for actinic mask inspection," Eighth International Workshop on Advanced Patterning Solutions, December 10, 2024, https://www.spiedigitallibrary.org/conference-proceedings-of-spie/13423/134231F/Development-of-a-synchrotron-based-EUV-microscope-for-actinic-mask/10.1117/12.3053151.short.

[58] "第四代光源快速建设中，第三代光源典范上海光源正答"发展之问"," May 7, 2024, *上观新闻*, https://stcsm.sh.gov.cn/xwzx/mtjj/20240507/d8115c2a40db4979a7d86885a88f73d9.html.

[59] Chen Jishizhan, and Chong Chen, "The HEPS synchrotron unleashes new medical frontiers," *Journal of Synchrotron Radiation* vol. 31,Pt 4 (2024), https://pmc.ncbi.nlm.nih.gov/articles/PMC11226166/.

Advanced light sources are increasingly essential not just for designing drugs, but for revealing the biological basis of disease. Their high-brightness beams let researchers capture everything from atomic-scale protein structures to three-dimensional images of human organs with cellular-level detail.[60] As China's light source infrastructure expands, those capabilities could strengthen domestic biomedical research well beyond drug discovery, including work on cancer and infectious diseases.

Battery Research

In battery research, synchrotron X-rays allow scientists to watch electrode materials degrade in real time during charging and discharging. HALF, whose injector began beam commissioning in September 2026, is designed to expand studies of electronic structure and chemical bonding, capabilities relevant to understanding battery materials. SSRF already provides beamtime for battery research, and HEPS will add the ability to image deep inside intact cells.[61] These are the instruments that firms like CATL will use as they improve solid-state battery technology.[62]

Aerospace Manufacturing

Aerospace manufacturers use synchrotrons to understand how defects form during production and how manufacturing affects the durability of components. High-energy X-rays can penetrate metal parts to measure internal stresses without cutting them apart. Rolls-Royce used Diamond's I12 beamline to examine a complete Trent 1000 fan blade, assessing a surface treatment intended to suppress crack formation and growth at its base.[63] The measurements revealed the depth and magnitude of the compressive stresses created by the treatment, giving engineers a way to assess its effectiveness while preserving the blade for further use.

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[60] Marek Grabowski et al, "Synchrotron radiation as a tool for macromolecular X-Ray Crystallography: A XXI century perspective," *Nuclear Instruments and Methods in Physics Research*, Volume 489, 2021 https://www.sciencedirect.com/science/article/abs/pii/S0168583X20305243; C.L. Walsh et al, "Imaging intact human organs with local resolution of cellular structures using hierarchical phase-contrast tomography," *Nature Methods* volume 18, pages1532–1541 (2021), https://www.nature.com/articles/s41592-021-01317-x.

[61] Ruilong Liu et al, "Li2S-LiI as a cathode sacrificial agent for high-performance Li-free anode all-solid-state batteries," *Energy Storage Materials*, Volume 84, 2026, https://www.sciencedirect.com/science/article/abs/pii/S2405829725008116.

[62] CATL, "CATL launches condensed battery with an energy density of up to 500 Wh/kg, enables electrification of passenger aircraft," April 19, 2023, https://www.catl.com/en/news/6015.html.

[63] Diamond Light Source, "Non-destructive strain measurement of a Trent 1000 fan blade," https://www.diamond.ac.uk/industry/Case-Studies/Case-Study-Rolls-Royce-fan-blade-strain.html.

Synchrotrons also reveal why defects arise during metal 3D printing. At the ESRF, a University College London–Rolls-Royce collaboration imaged titanium alloy printing at 40,000 frames per second, observing how molten metal moved and formed internal pores and spattered droplets.[64] These observations provide data for improving manufacturing conditions and testing computer models of the process. A 2024 study at Diamond involving Rolls-Royce examined directed energy deposition, which feeds metal powder into a laser-generated pool of molten metal.[65] Researchers found that excessive gas flow could increase internal porosity and compared the synchrotron observations with experiments on an industrial machine, linking defects to settings that manufacturers can adjust.[66]

China's new light sources are intended to support the same kinds of industrial problem solving. HEPS's published research objectives explicitly include observing how defects form during the growth and processing of single-crystal blades and studying stress and uneven chemical composition in high-temperature alloys during manufacture, use, and repair.[67] Wider domestic access to these measurements could help Chinese aerospace researchers test production methods and investigate component failures with less dependence on overseas beamtime. The industrial gains would depend on manufacturers translating those findings into repeatable production processes and validated components.

Conclusion

Yang Xueming (杨学明), a leading Chinese FEL scientist, captured the ambition behind China's pursuit of photon sovereignty in a January 2025 interview: "While studying in the United States, I hoped that one day, after returning to the motherland, I could personally build an internationally leading FEL facility, and participate in manufacturing more foundational pillars of a great power to drive new breakthroughs in our nation's S&T (**在美国留学**时，我的内心就种下了一颗梦想的种子，希望有一天回到祖国后，能够亲自建设一台国际领先的自由电子激光装置，参与制造更多大国重器来推动

[64] European Synchrotron Radiation Facility, "Aerospace and Automotive," https://www.esrf.fr/home/Industry/applications-and-case-studies/aerospace-and-automotive.html.
[65] Lorna Sinclair et al, "An in situ imaging investigation of the effect of gas flow rates on directed energy deposition," *Materials & Design*, VOL 108, (August 2024), https://publications.diamond.ac.uk/pubman/viewpublication?publicationId=18235.
[66] Ibid.
[67] Institute of High Energy Physics, "高能同步辐射光源项目概况," https://heps.ihep.ac.cn/xmgk/HEPSjj/.

我国科技实现新突破)."[68] Yang later led development of the Dalian Coherent Light Source and now oversees construction of a next-generation XFEL near Shenzhen. His career arc, from training on American infrastructure to building Chinese facilities designed to surpass it, traces China's rapid catch up in light source infrastructure and science.

China's rapid buildout of advanced light sources represents one element of a broader strategy to achieve self-reliance in the scientific infrastructure that underpins technological leadership.[69] As Xi Jinping put it: "Science and technology are the foundation of national strength and prosperity, and innovation is the soul of national progress."[70] In Chinese state media, advanced light sources are regularly described as "foundational pillars of a great power" (大国重器), placed alongside other prestige infrastructure projects in China's science and technology landscape. For Beijing, building world-class photon science facilities is not merely a matter of scientific utility; it is an expression of national ambition.

Within a decade, China will operate a national photon science ecosystem comparable in breadth and capability to that of any country in the world. The downstream effects will compound over time as Chinese researchers and firms leverage brighter beams, faster pulse rates, and broader spectral coverage to accelerate progress in semiconductors, pharmaceuticals, energy storage, and defense-relevant physics.

The United States retains significant strengths in photon science. Its national laboratories house world-class facilities, and American expertise in accelerator physics and beamline science runs deep. Yet the U.S. facility pipeline is thinner than China's, and American researchers increasingly compete for beam time on infrastructure from the 1990s.[71] The Advanced Photon Source upgrade at Argonne, completed in 2026, and the LCLS-II project at SLAC, demonstrate that the United States can still deliver frontier-class machines. It is an open question whether the current pace of renewal is sufficient to maintain technological leadership as China brings a dozen or more advanced facilities online over the next decade.

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[68] 蒲晓磊, "杨学明：一直在"追光"," *法治日报*, January 14, 2025, http://epaper.legaldaily.com.cn/fzrb/PDF/20250114/05.pdf.

[69] Jimmy Goodrich, "Beijing Calls for "Extraordinary Measures" to Boost Tech Self-Sufficiency," November 20, 2025, https://ucigcc.org/blog/beijing-calls-for-extraordinary-measures-to-boost-tech-self-sufficiency/.

[70] Xinhua, "习近平在 2014 年两院院士大会上的讲话," June 9, 2014, https://www.cae.cn/cae/html/main/col1/2014-06/09/20140609210446331951517_1.html.

[71] Brian Toby, "Getting Beamtime: Tricks of the Trade," Argonne National Laboratory, 2022, https://neutrons.ornl.gov/sites/default/files/BHToby_2022ProposalsNX.pdf.

Restricting Chinese access to U.S. light sources addresses a real concern about protecting sensitive research environments. While such limits help prevent operational knowledge from flowing into China, they are becoming less effective over time, with each new facility China commissions. Washington's photon dominance is a depreciating asset.

As that leverage erodes, new dynamics come into view. It remains unclear whether China will grant American researchers beam time at these new facilities, or tighten access in response to the bilateral tensions already limiting Chinese researchers at U.S. labs. The other involves talent. The same 2021 DOE Office of Science assessment concluded that the United States is already losing the global competition for scientific talent, finding that countries across Europe and Asia have built world-class research facilities and were offering the kinds of long-term research funding once distinctive to American institutions.[72] A dozen new Chinese light source facilities commissioned over the next decade will be a meaningful factor in the competition over scientific talent.

For U.S. policymakers, the central challenge is twofold: (1) sustaining American investment in next-generation light sources to ensure domestic researchers retain access to the best tools available, and (2) developing a realistic assessment of how China's expanding photon science capacity will reshape competition in the strategic technology domains that both countries have identified as priorities. The buildout documented here will not produce dramatic overnight shifts in any single industry. Its significance lies in the cumulative advantage that a full-spectrum, domestically controlled photon infrastructure will provide to Chinese science and industry over the coming decade and beyond.

[72] BESAC Subcommittee on International Benchmarking, "Can the U.S. Compete in Basic Energy Sciences?," 2021, https://science.osti.gov/-/media/bes/pdf/reports/2021/International_Benchmarking-Report.pdf

Appendix: China's Light Source Facilities

Synchrotrons & Free Electron Lasers			
Facility Name	**Type**	**Status**	**Year Online**
Beijing Synchrotron Radiation Facility (北京同步辐射装置, BEPC/BSRF)	Synchrotron	Operational	1991
National Synchrotron Radiation Laboratory (合肥同步辐射装置, NSRL/HLS)	Synchrotron (gen 2)	Operational	1991
Beijing Free Electron Laser (北京自由电子激光装置)	FEL	Operational	1993
Shanghai Synchrotron Radiation Facility (上海同步辐射光源, SSRF)	Synchrotron (gen 3)	Operational	2009
Dalian Coherent Light Source (大连相干光源, DCLS)	FEL	Operational	2017
Terahertz Free Electron Laser (太赫兹自由电子激光装置)	FEL	Operational	2017
Hefei Infrared Free Electron Laser (合肥红外自由电子激光装置)	Infrared FEL	Operational	2020
Shanghai Soft X-Ray FEL (上海软X射线自由电子激光装置, SXFEL)	XFEL	Operational	2022
High Energy Photon Source (高能同步辐射光源, HEPS)	Synchrotron (gen 4)	Operational	2026
Super-Transient Synchrotron Radiation Light Source (Phase 1) (超瞬态同步辐射光源, LUTF)	Synchrotron (gen 3)	Construction	~2026
Shanghai High Repetition Rate XFEL (上海硬X射线自由电子激光装置, SHINE)	XFEL	Construction	~2027
Hefei Advanced Light Facility (合肥先进光源, HALF)	Synchrotron (gen 4)	Construction	~2028
Wuhan Advanced Light Source (武汉先进光源)	Synchrotron (gen 4)	Planned	
Shenzhen Superconducting Soft X-ray FEL (深圳中能高重复频率X射线自由电子激光装置, S3FEL)	XFEL	Construction	~2032
Southern Advanced Photon Source (南方先进光源)	Synchrotron (gen 4)	Planned	
Dalian Advanced Light Source (大连先进光源, DALS)	FEL	Planned	
Zhejiang Jinhua Industrial Light Source (浙江产业光源, ZIPS)	Synchrotron	Planned	
Materials-Specific Synchrotron Radiation Light Source (材料专用同步辐射光源)	Synchrotron	Planned	
Storage Ring Coherent Light Source (储存环全相干光源)	Synchrotron	Planned	
Western Infrared Terahertz FEL (西部光源红外太赫兹自由电子激光装置)	FEL	Planned	
Shanghai Deep Ultraviolet FEL (上海深紫外自由电子激光)	DUV-FEL	Decommissioned	2009

Other Light Sources			
Facility Name	**Type**	**Status**	**Year Online**
Lanzhou Heavy Ion Research Facility (兰州重离子研究装置)	Heavy Ion Accelerator	Operational	1980
Qiangguang-1 (强光一号)	Pulsed Power	Operational	1998
Julong-1 (聚龙一号)	Pulsed Power (Z-pinch)	Operational	2010
China Spallation Neutron Source (中国散裂中子源)	Neutron Source	Operational	2018
Xi'an Proton Application Facility (西安200 MeV质子应用装置)	Proton Accelerator	Operational	2020
Harbin DPP-EUV (放电Xe等离子体极紫外光源实验装置)	Discharge Produced Plasma	Operational	2023
CAS Shanghai LPP-EUV Source (中科院上海光机所激光等离子体极紫外光源)	LPP-EUV	Operational	
High-Intensity Heavy-Ion Accelerator Facility (强流重离子加速器)	Collider	Construction	~2025
China Initiative ADS (加速器驱动嬗变研究装置)	Collider	Construction	~2026
Advanced Attosecond Laser Facility (先进阿秒激光设施)	Attosecond Facility	Construction	~2030
Advanced Attosecond Laser Facility (Xi'an) (先进阿秒激光设施西安部分)	Attosecond Facility	Construction	
Steady-State Microbunching EUV Light Source (清华SSMB-EUV光源)	SSMB	Planned	
Qiangguang-2 (强光二号)	Pulsed Power	Planned	
Electron-Ion Collider in China (中国极化电子-离子对撞机)	Collider	Planned	
Super Tau Charm Facility (超级陶粲装置)	Collider	Planned	
Circular Electron-Positron Collider (环形正负电子对撞机)	Collider	Planned	~2035