

# ASU's world-class science facilities are transforming student lives, careers

## CXFEL project first in the world to offer hands-on student training on new compact accelerator technology

By Joe Caspermeyer, ASU News

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Recently, a cohort of bright, talented undergraduate students took their very first steps into a research lab unlike any other in the world.

A year ago, many of the students didn't even know the lab existed. But at Arizona State University, innovation shows up in many unexpected places, including a special underground lab unbeknownst to most passersby.

Across from a popular university light-rail stop is an ASU Biodesign Institute basement lab — the compact X-ray free electron laser, or CXFEL, project — that is at the forefront of a scientific revolution. When fully operational, it will be the world's first compact X-ray laser to take on biology, bioenergy and drug discovery and development applications.

"I've driven by this building so many times," said student worker Albert Richardson, an ASU sophomore who is double-majoring in physics and mechanical engineering. "Surprisingly, before I joined this project, I didn't really know what it was all about. But now, I would never have guessed that just after one year at college I'd be in the basement of this building and working on a \$100 million project."

(Video: <https://www.youtube.com/watch?v=2PouxqiENcl>)

During the past decade, CXFEL Director William Graves has gone from blank canvas to now formally commissioning the CXFEL to begin its cutting-edge research and opening a national-lab-caliber research operation at ASU.

“Over the last 10 years we’ve come from an empty lot to a world-class laboratory housing the world’s first compact X-ray laser,” Graves said. “Our students have played a huge role in this success, helping from the very beginning when we were digging a hole in the ground to now carrying out the most advanced femtosecond science.”

And for this first cadre of students, every day after classes, they get to join an 80-member strong team on the \$90.8 million funded National Science Foundation phase of the project, where a second instrument is being built in tandem to expand the research program.

At the first-of-its-kind CXFEL facility, the students are gaining valuable hands-on experience working alongside their faculty mentors, staff scientists and technicians to help commission and open the new state-of-the-art facility.

“We try to take students on early in their careers so that they can be with us for a number of years and slowly progress to larger and larger problems,” said Mark Holl, CXFEL chief engineer. “And seeing them evolve to the capability of taking on larger problems is extremely validating. It’s extremely enriching.”

Richardson and fellow engineering and physics student Gavin Russo are working on a project to shield computers chips from any potentially damaging radiation that may come from the powerful X-rays that are generated by the instrument.

“We’re working with equipment that’s precise down to one-thousandth of an inch or even less than that in some cases,” Russo said. “And working with equipment that in some cases can be worth as much as a house. I never would’ve gotten my hands on that if I didn’t get to work in a laboratory like this one.”

The project is drawing students from a variety of scientific disciplines.

“The team is amazing,” said Alexis Vasquez, a computer systems engineering major. “I love that. It’s just like a family sort of feeling.

“The most exciting aspect that I got to experience was the CAD software. It takes a month or two to design the part, then you have to get it manufactured, and you have to test everything. If it’s off by a millimeter, it can throw off the whole scale of the whole part.”

These experiences help the students gain confidence in doing lab research, as well as asking questions.

Holl mentioned that the student's research exposure feeds directly into the innovation talent development ecosystem at ASU, as the CXFEL team has hired several undergraduate students into staff positions or who continue the program through graduate school.

This was the case with Alan Dupre, who started out as an undergraduate student worker and now is a graduate student who often works in what looks like a live sports director control truck but in this case is the main control room for the lab.

"You can have whoever is sitting here go back and forth between all of these different display screens to rapidly assess the status from the real-time data coming from the instruments," Dupre said.

This system monitors the path of the electrons as they are first accelerated close to the speed of light and then travel through a series of magnets that steer and direct the beam to an interaction point with a laser beam to generate powerful and short X-ray pulses.

At a critical interface, a high-powered laser beam is fired directly at an eight-degree angle onto the path of the electron beam moving near the speed of light, generating X-rays. By embedding ultra-high-speed cameras at several points along the beam, their team can image this interaction and show proof of stable X-rays being produced.

The electrons, having done their job, are then put into a dump, while the X-rays continue their path to collide with molecules in the soon-to-be-completed adjacent sample chamber room.

There, they will bombard molecules, like proteins, to reveal for the first time their 3D structure and how they may work to target a cell or drug or make bioenergy.

Getting to know the various aspects of this system takes every undergraduate student on a rapid journey through such diverse fields as engineering, physics, biology, computer science and AI.

The undergraduate training experiences will be expanded soon by a National Science Foundation Research Experiences for Undergraduates, a three-year, \$350,000 award to run a CXFEL summer internship program. The project will be led by Holl and Sabine Botha, co-investigator and physics research scientist.

"Within this highly unique and diverse research environment, the CXFEL project offers students a unique opportunity to glean insights into the design, construction and management aspects of bringing a midscale X-ray facility into operation and participate in the first experiments at these novel X-ray sources," Botha said. "That means that next summer we are going to have our first cohort of students joining us from universities all over the U.S."

Botha is a mentor to Annelise Velarde, a computer programmer. Together, they are employing the latest state-of-the-art AI tools to help in the data analysis once the first experiments begin. They hope that these tools will be able to understand and build more accurate 3D models of how proteins work, or how a virus enters a cell.

“I’m learning all these different things, making all these connections, getting to see so many parts of engineering — it’s just really cool,” Velarde said. “What my parents say, too, is that this is just such a crazy once-in-a-lifetime opportunity. Up until getting this job I really did not know what I wanted to do with my life.”

Such experiences have ultimately led some of the students into seeing entirely new horizons for their careers — to move on and help solve other major societal challenges, like the energy grid.

“The reason I’m double-majoring in physics, as in engineering, is because I want to work on nuclear fusion technologies,” Russo said. “I hope to work at a start-up out there that is developing these technologies and maybe even be the first start-up to push net-positive energy onto the grid.”

One thing is for sure — the students’ lives and future opportunities have already been transformed by hands-on experience in ASU’s world-class research facilities and a laser lab like no other in the nation.

“Jumping straight from my freshman year into hands-on research with this level of precision technology has just been a huge honor, for sure,” Albertson said. “As a local Arizonan, it definitely blows my mind that this is just in the basement of Biodesign C.”

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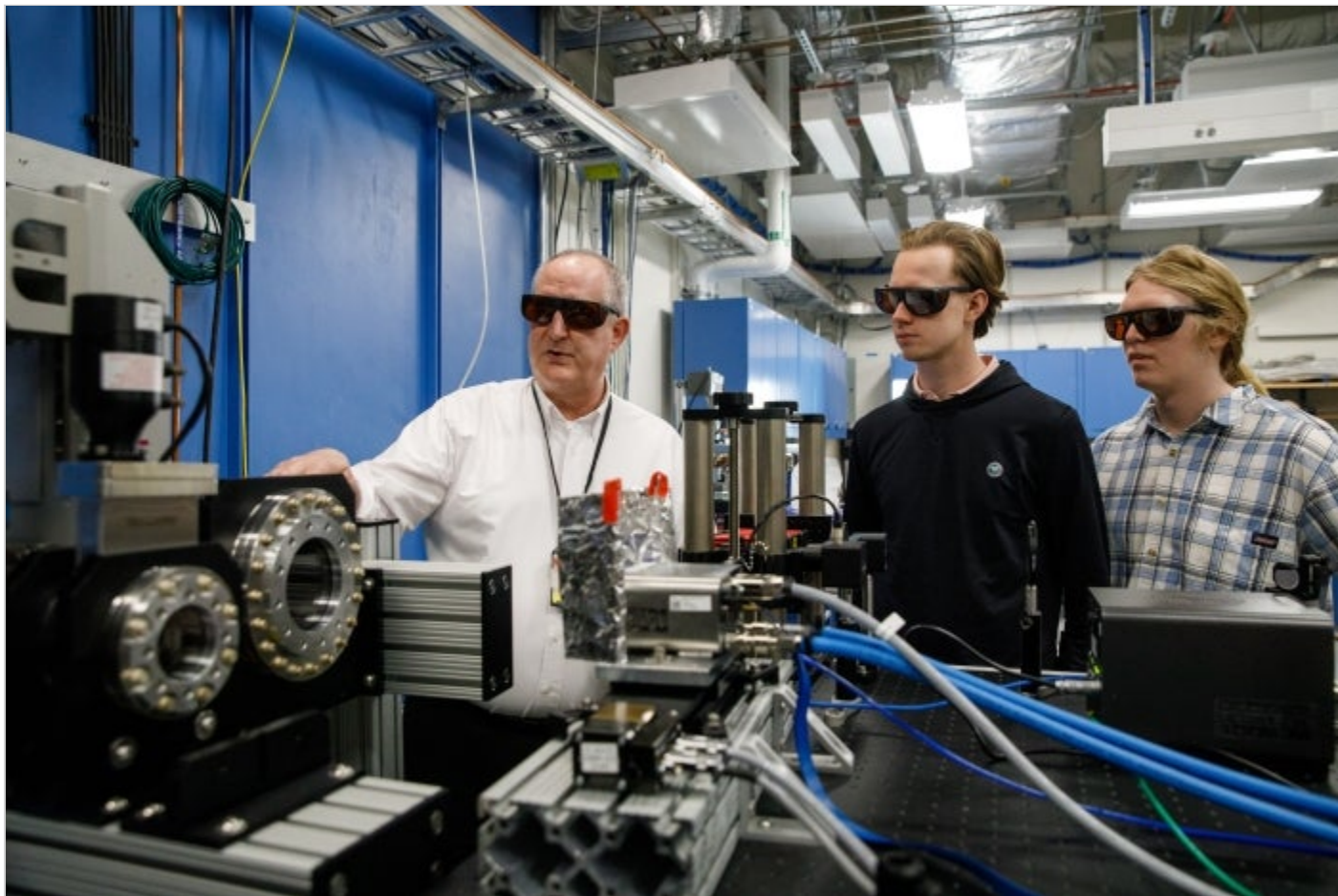
*This story originally appeared on [ASU News](#).*

## **Main image**



ASU research scientist Sabine Botha (right) is a mentor to Annalise Vallarde (left), a student computer programmer who recently joined the CXFEL project. Together, they are employing the latest state-of-the-art AI tools to help in the data analysis once the first experiments begin. They hope that these tools will be able to understand and build more accurate 3D models of how proteins work, or how a virus enters a cell. Photo by Andy DeLisle/ASU Knowledge Enterprise

**Text image(s)**



From left: CXFEL Chief Engineer Mark Holl works with students Gavin Russo and Albert Richardson to examine the optics setup in the experimental sample chamber hutch. Powerful X-rays continue their path to collide with molecules in this soon-to-be-completed sample chamber room. Photo by Andy DeLisle/ASU Knowledge Enterprise





The CXFEL project is drawing students from all scientific disciplines, including biology, physics, engineering and AI. “The team is amazing,” said Alexis Vasquez (left) a computer systems engineering major. “I love that. It’s just like a family sort of feeling. The most exciting aspect that I got to experience was the CAD software.” Photo by Andy DeLisle/ASU Knowledge Enterprise