CHESS
CORNELL HIGH ENERGY
SYNCHROTRON SOURCE

CHESS

AT-A-GLANCE

CHESS/Wilson Lab | Cornell University | 161 Synchrotron Drive | Ithaca, NY 14853 | 607-255-7163

Engaging research communities

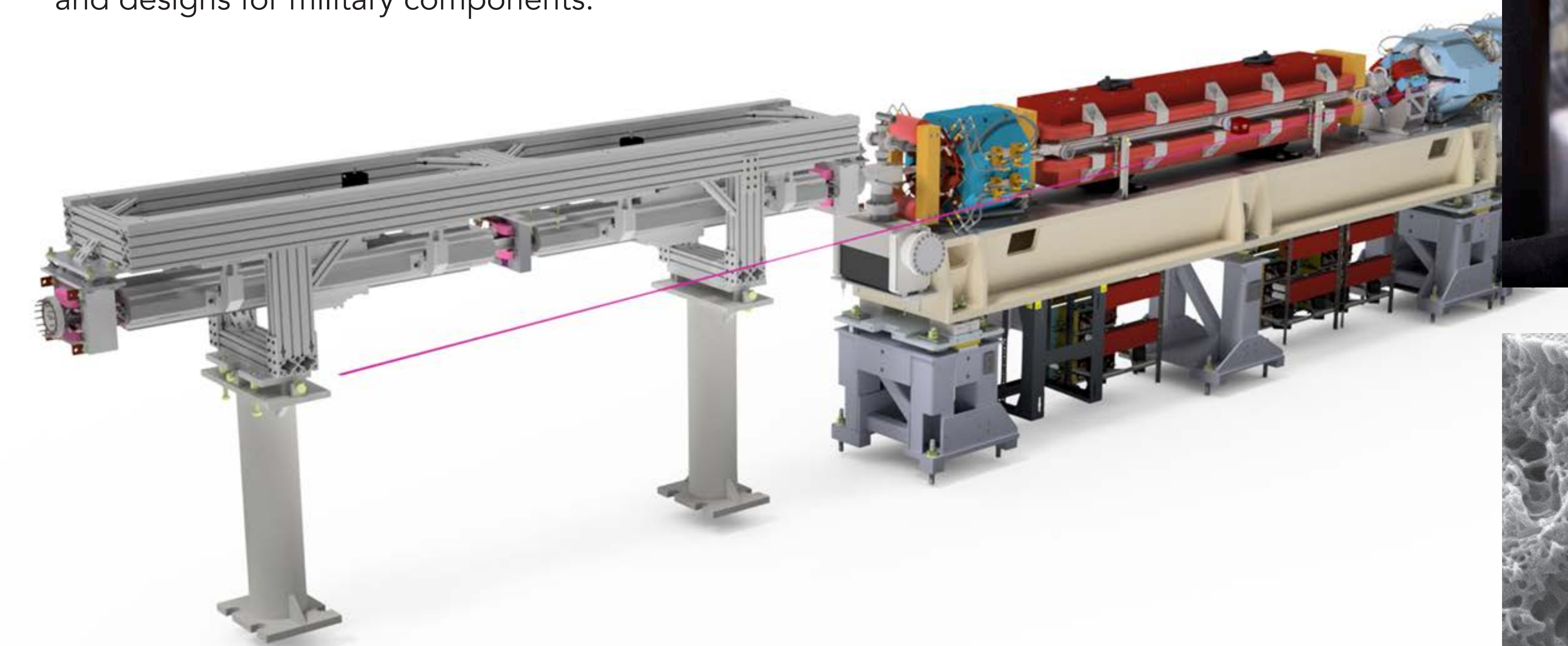
Now. And into the future.

CHESS *is a high-intensity X-ray source* which provides our users state-of-the-art synchrotron radiation facilities for research in Physics, Chemistry, Biology, and Environmental and Materials Sciences.

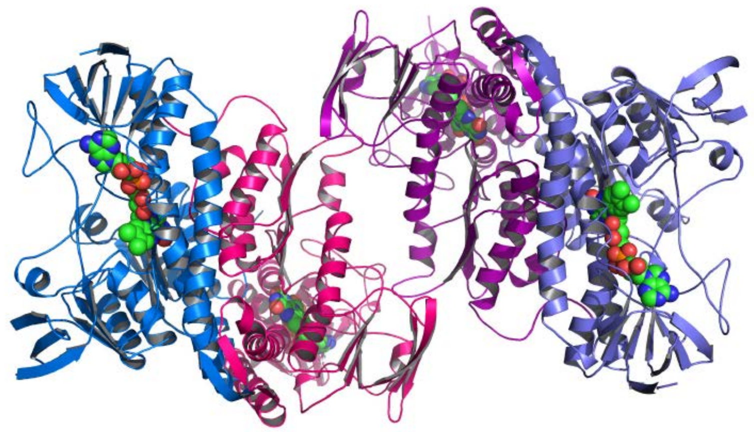
The National Science Foundation, NSF, supports the Center for High-Energy X-ray Sciences at CHESS (CHEXS at CHESS) and operates beamlines optimized for the structural characterization of quantum materials, structural metals and biological systems, as well as X-ray spectroscopy of systems ranging from enzymes to energy materials.

The National Institute of Health (NIH) and New York State (through NYSTAR) jointly support X-ray facilities for macromolecular crystallography and small angle scattering (MacCHESS) to understand the structure and function of the building blocks of life.

The new Materials Solutions Network at CHESS (MSN-C) funded by the Air Force Research Lab (AFRL) provides dedicated access to X-ray beamlines for Air Force and other Department of Defense materials researchers enabling breakthroughs in materials and designs for military components.



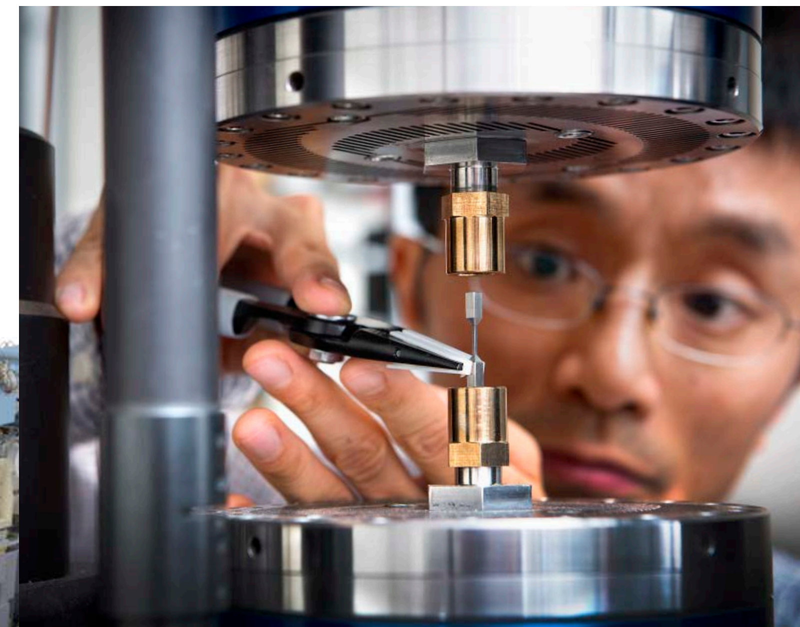
CHESS-U involved the installation of new undulator sources for all of the new beamlines.



BIOLOGY

CHESS is a **critical resource** for structure-based drug design supported by the protein structures obtained at the facility. **Research performed at CHESS directly impacts** the development of new therapeutic drugs. Structure-based drug design has created new drugs currently in clinical trials for both HIV and cancer.

Additionally, our staff members and users have developed tools and methods that will enable biologists with minimal X-ray expertise to conduct synchrotron experiments in plant phenotyping.

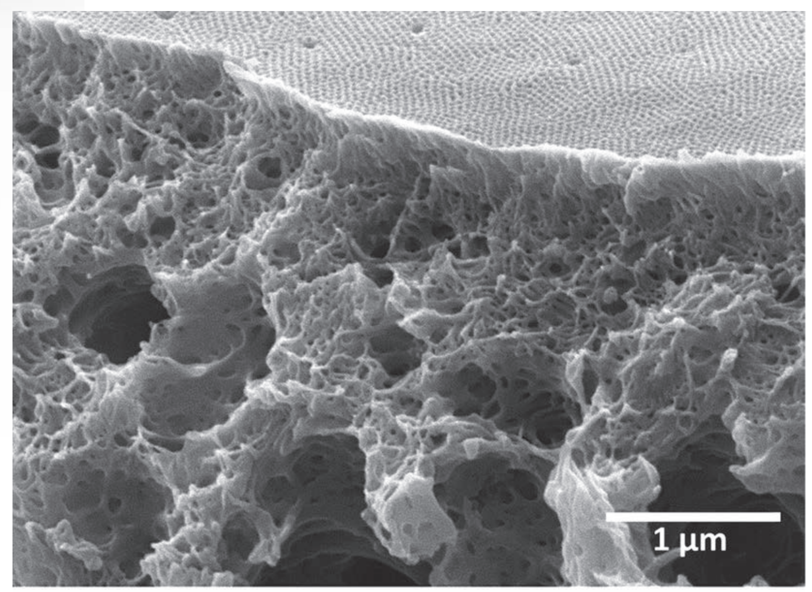


ENGINEERING

Over 90% of metallic engineering structures ultimately fail due to fatigue, but we truly do not know how a crack initiates nor how it grows in materials such as Titanium alloys.

CHESS has recently developed the tools that make it possible to measure residual stress within structural materials with good enough spatial resolution and fidelity to be useful for structural designers.

The high-energy x-ray synchrotron radiation enables us to map residual stress in a practical engineering component.



MATERIALS

Scientists use techniques such as high-energy X-ray diffraction, diffuse scattering, and computed tomography to **examine the positions of atoms** in macroscopic materials under real engineering conditions.

By identifying relevant crystallographic factors, the development of future materials is advanced. High-resolution x-ray diffraction (XRD) is applied to see features as small as hundredths of a nanometer.

A Community of International Researchers

A Worldwide Impact on Discovery

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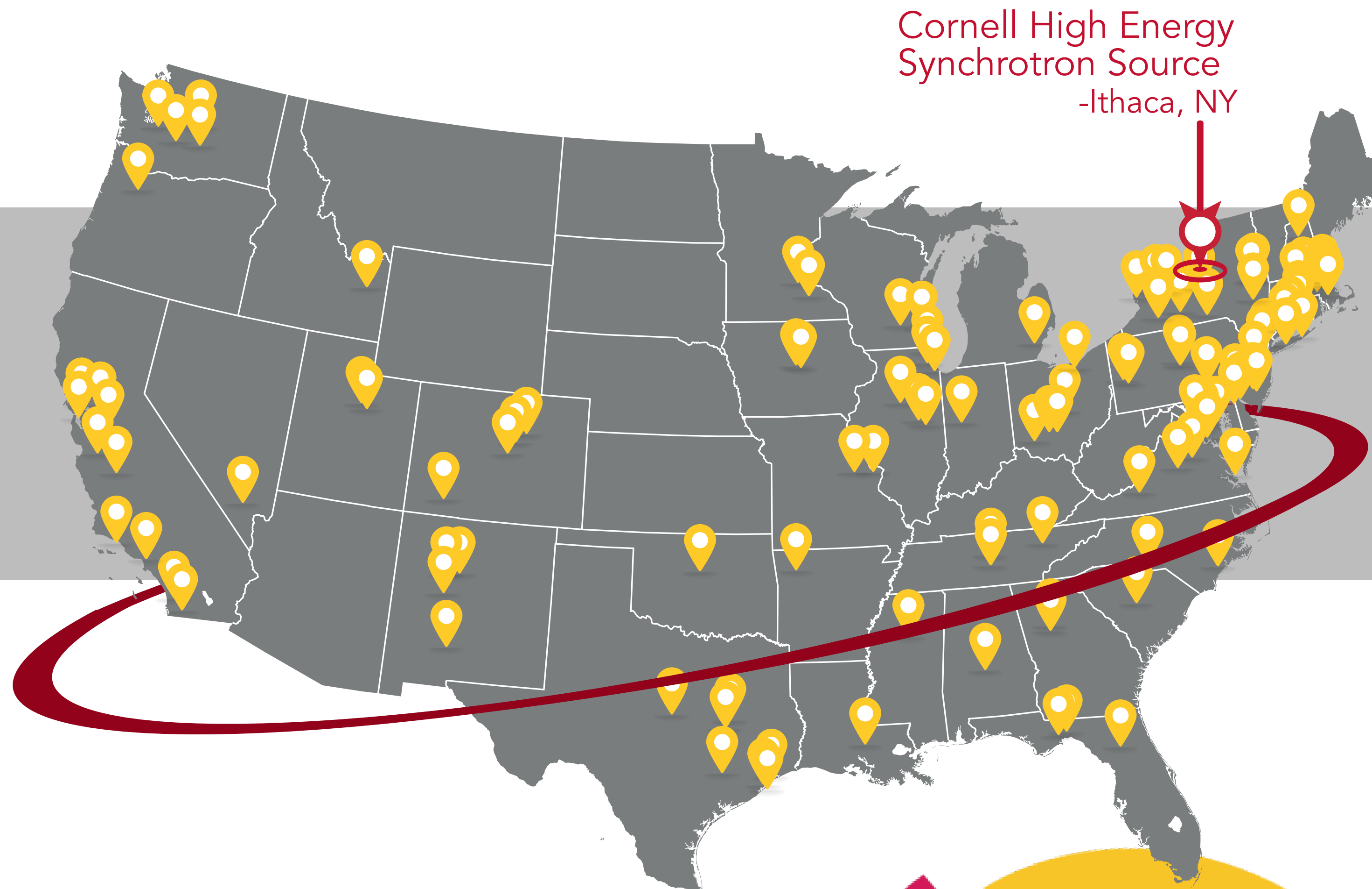
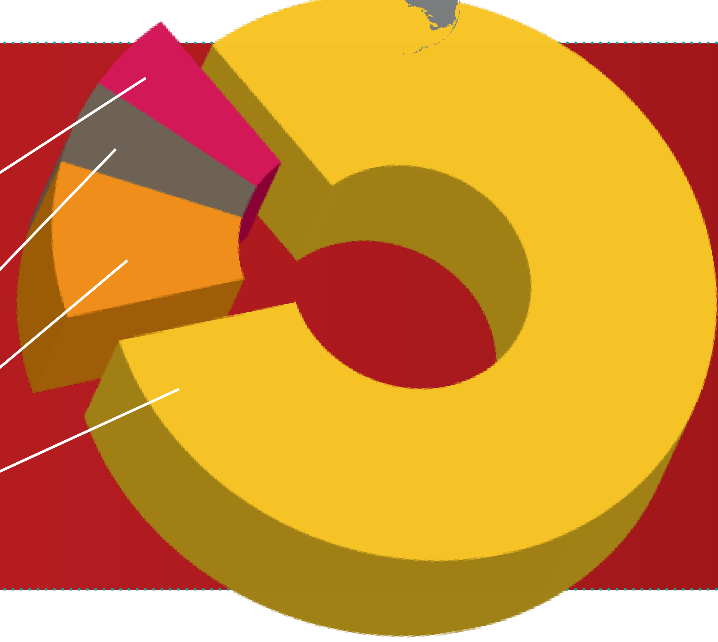
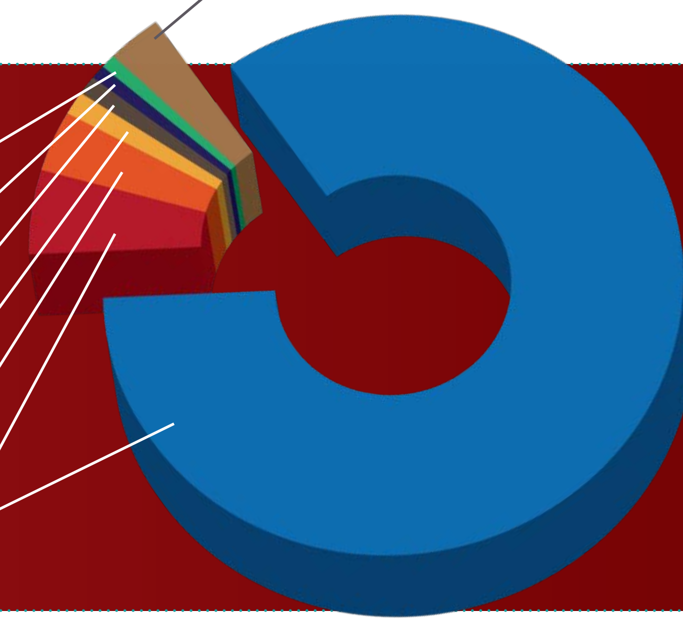
1,397 users traveled to CHESS to perform research between January 1, 2017 and June 4th, 2018.

These researchers came from 37 different states, and 22 different countries.





Where do CHESS Users Come From?



A Community of International Researchers

What our users say

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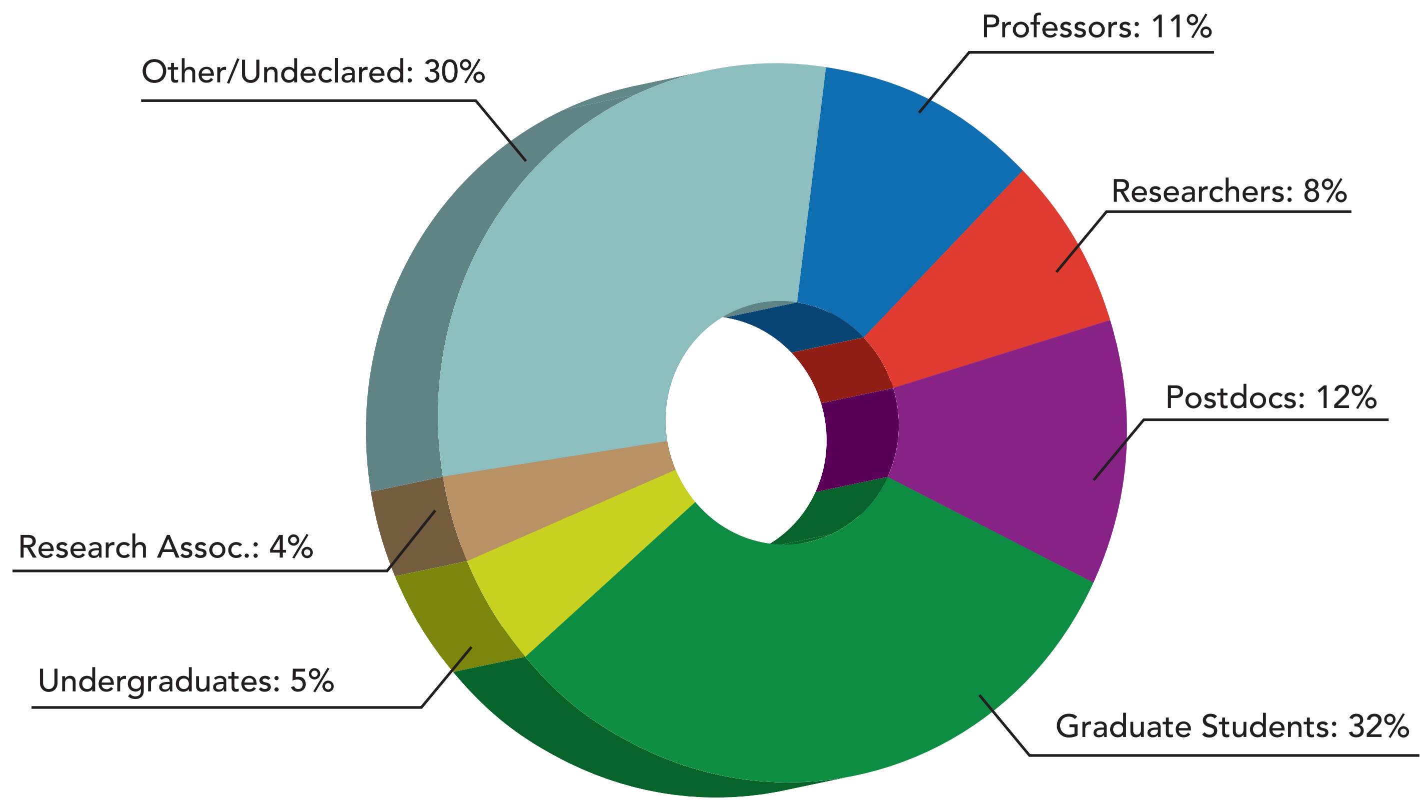
CHESS's ability to tailor beamline design allows users to explore new areas of research in engineering, biology & materials science.

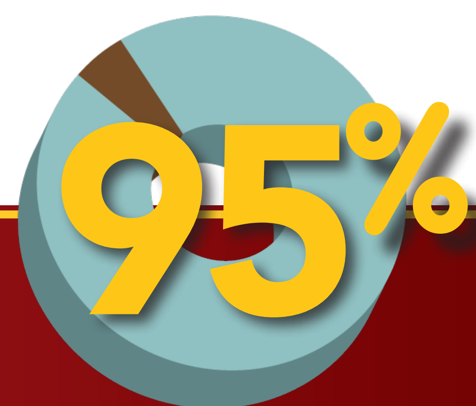


474

Graduate Students used CHESS for research

74

Undergraduates used CHESS for research



Users who were **completely satisfied** with the assistance received during their research at CHESS

"The beam and equipment performed flawlessly."

-CHESS User February 3, 2017

"The SEC-SAXS-MALS setup that Richard and his postdoc have built on G1 is world-class. CHESS is currently ahead of the curve in this area and the G1 team should be commended. My only advice is don't stop pushing to develop the technology even further."

-CHESS User February 5, 2017

"'We love running at CHESS primarily because it is a place where the staff are happy, knowledgeable and extremely helpful. I hope that you can maintain that special culture as you proceed through the upgrade and changes in operations funding."

-CHESS User November 15, 2017

"CHESS wins in its compactness, and friendly staff. Other labs should learn from CHESS."

-CHESS User May 4, 2018

"CHESS is our go-to facility for our experiments. The support from Rong, Arthur, and Louisa was exceptional."

-CHESS User May 10, 2018

"Very solid setup and implementation. The beamline staff were both enthusiastic and supportive of the experiments."

-CHESS User May 30, 2018

CHESS-U

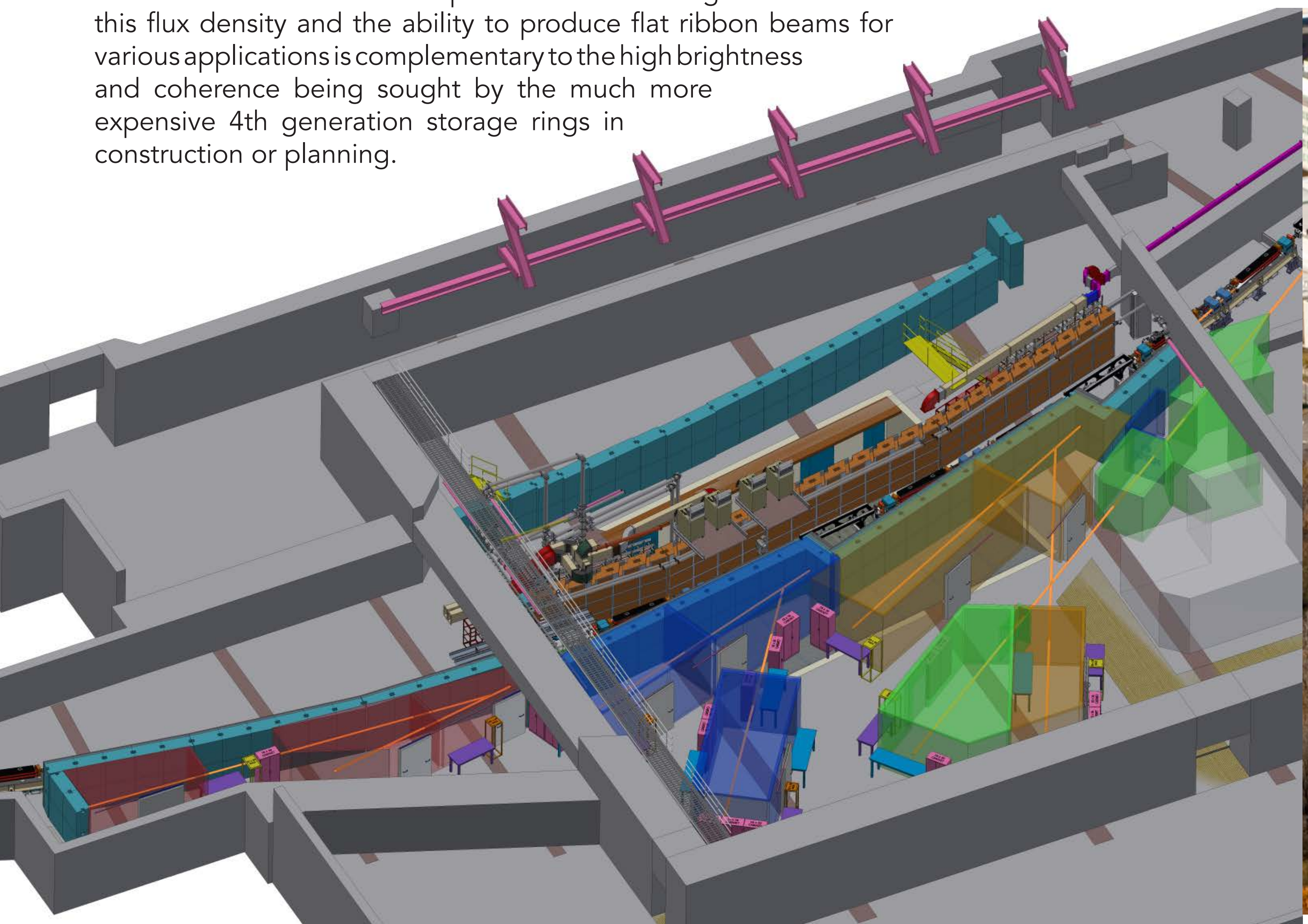
With the completion of CHESS-U, CHESS is the premier synchrotron source in the US for high-energy, high-flux X-ray studies.

One-sixth of the CESR storage ring was replaced with modern multibend achromats and the X-ray beamlines were either upgraded or replaced to take greatest advantage of the new undulator sources.

CHESS now operates with a single beam instead of counter-rotating electron and positron beams. This eliminates many of the performance limitations associated with the previous 2-beam operation.

The Cornell Electron Storage Ring, CESR, now operates at an energy of 6-GeV with a stored beam current of 200 mA to produce X-rays up to high energy (order 100 keV) for in situ and operando studies. The reduction of CESR beam emittance from the former 100 nm-rad at 5 GeV to around 30 nm-rad at 6 GeV achieved with double bend achromat (DBA) lattice conversion enables X-ray flux densities into small apertures that are comparable to that from existing undulators at high energy sources.

CHESS-U now fills a niche in performance in the lightsource world where this flux density and the ability to produce flat ribbon beams for various applications is complementary to the high brightness and coherence being sought by the much more expensive 4th generation storage rings in construction or planning.



On-Campus

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While other synchrotron laboratories are traditionally located at national labs, Cornell is the only U.S. university still operating a large accelerator complex. The university graduates roughly 20 percent of the nation's Ph.D.s trained in accelerator science and advanced X-ray technology, and approximately 60 undergraduates participate in CHESS laboratory research every year.

As part of the Cornell Laboratory for Accelerator-based Sciences and Education (CLASSE), CHESS is part of a long history at Cornell that has helped advance the frontiers of beam science. Cornell has led the way in developing the technology needed to produce and accelerate ultra-bright, high power beams for research, medicine and industry. Researchers at CLASSE study the behavior of very compact beams using the Cornell Electron Storage Ring (CESR), develop high power electron sources, and advance the superconducting technology that accelerates particles to near light speed.

The research at Cornell will increase the scientific reach of future accelerators and open new doors for industry.

CHESS-U

Timing is everything

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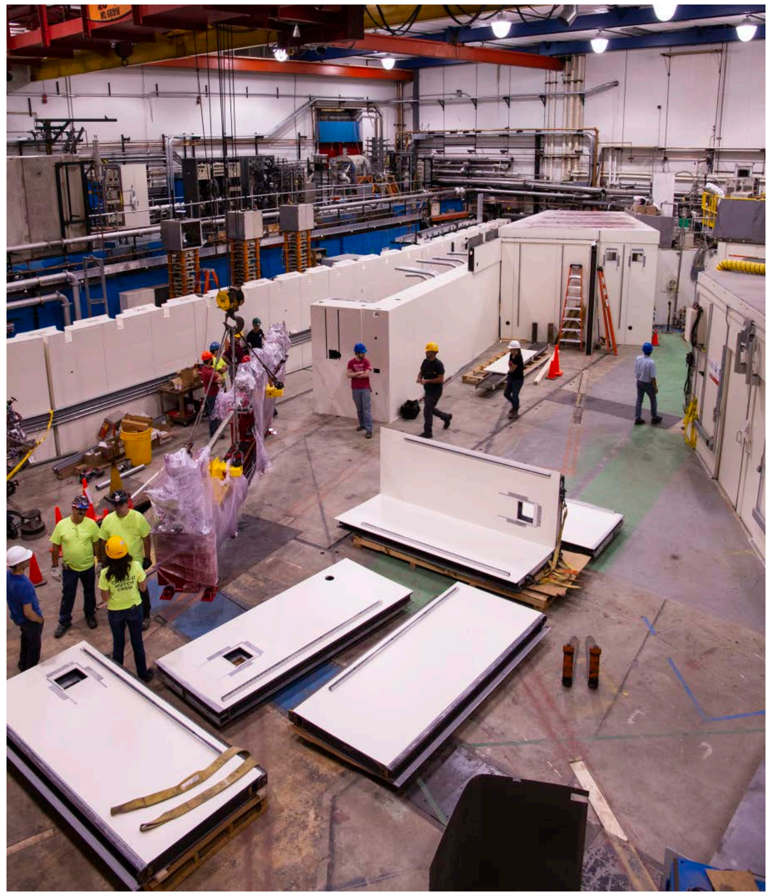
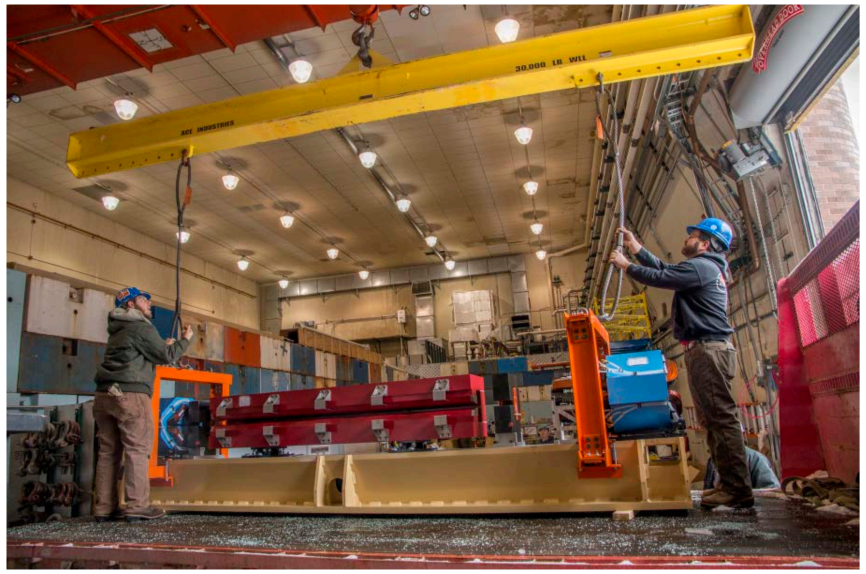
During 2017 and 2018, CHESS completed most of the installation of the $15M upgrade of CHESS-U. During much of this time CHESS was still operating for users, requiring precise timing and management of the project.

To reduce construction downtime, CHESS engineers worked with ADC of Lansing, NY to create a process for the quickest on-site installation of the hutches. To reach the tight deadlines of the project, the team implemented a highly-modular design consisting of a total of roughly 15 wall segments and 13 ceiling segments per hutch.



Top Left: CHESS's Ernie Fontes, left, inspects the pre-fabricated hutch at the ADC facility. This hutch was later disassembled and transported to Wilson Lab for a seemingly quick assembly, top right.

Bottom Left: The "CHESS-U Hutch Crew". bottom row: Elisabeth Bodnaruk, John Kopsa, John Conrad. Top row: Bill Miller, Kurt McDonald.



Top left: Tom Dugan, Sasha Temnykh, James Drake, and Eric Banta spent months assembling and testing the magnet-girder assemblies before installation.

Top Right: Sasha Temnykh precisely measures the magnets before installation.

Bottom: Ryan Alexander and Troy Gott, CLASSE Riggers, move the magnet-girder assemblies into Wilson Lab.

The production strategy of CHESS-U magnets was similar to what was used during CESR construction in the 1970's. All design, assembly of magnets and girders, magnetic field measurement and magnet alignment was done "in-house". For components fabrication, CHESS contracted local vendors.

To minimize the shut down ("dark") time, CHESS staff placed all new magnets on girders. When CESR operation was stopped for the upgrade, the girders were moved to the tunnel and fitted into the storage ring. Each of the twelve girders contain two horizontal focusing quadrupole magnets, one large combined function magnet (bends the beam trajectory and focuses the beam vertically), and four small correcting magnets. Prior to installation, all magnets went through a magnetic field measurement procedure and were accurately aligned in respect to each other and in respect to the girder.

CHESS-U

By the numbers

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1,075,080
Weight, in pounds, of the old shielding wall that was moved and reused for CHESS-U

8,520
Miles walked by staff during parking lot closure for CHESS-U construction

$8,993,530
Money spent on equipment and materials for CHESS-U

66
Number of people hired at CHESS since the start of the CHESS-U project

40 tons
Weight of the “40-ton door”, which was removed in 2018

7 miles
Length of networking cable installed

3.2 miles
Length of leak-tight ultra high vacuum weld bead needed for operation of CESR/CHESS

1
Beam

Outreach & Education

Training a Generation of Synchrotron Scientists

Xraise is the outreach group at CHESS which engages minds by facilitating direct interaction with physical phenomena and encouraging careful observation of the world. Xraise stimulates thinking and helps develop the next generation of scientists.

2,777 people took a guided tour of Wilson Lab and the CHESS hutches. July 2017 was the busiest month with 277 people!

20,625 minutes of videos have been watched by Xraise fans from around the world

Outreach Learning Experiences

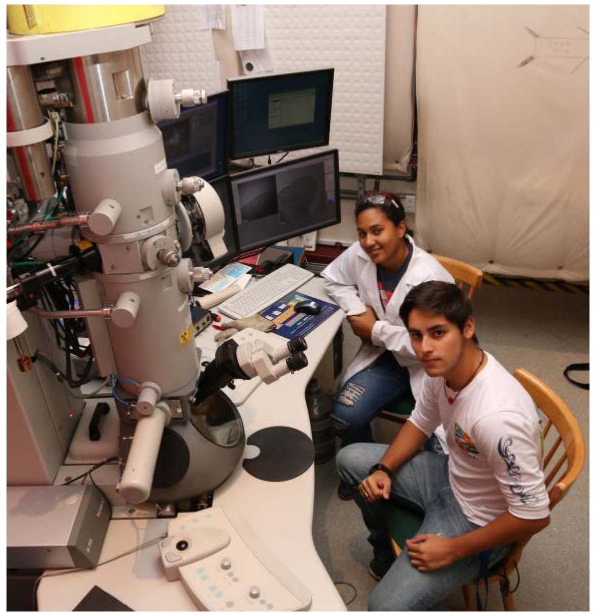
9,694 People have interacted with Xraise Junk Genies exhibits showcasing synchrotron science phenomena

8,876 Miles the Junk Genies exhibits have traveled as part of Xraise's mobile science exhibition. That is almost as much as driving from Ithaca to Australia!!

2,981 Uses of the Xraise Lending Library investigations and equipment by high school students across the U.S.

Students and mentors of the 2018 SRCCS/SUNRISE program.

Topher Flynn, left, student from Fort Lewis College, works with CHESS Staff Scientist Richard Gillilan in the CNF facility on campus to create microfluidic mixing chips to be used at the synchrotron.



Nicohl Cintron-Rodriguez and Guillermo Colon-Quintana, both from the University of Puerto Rico, perform research as part of the SUNRISE program at CHESS.

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