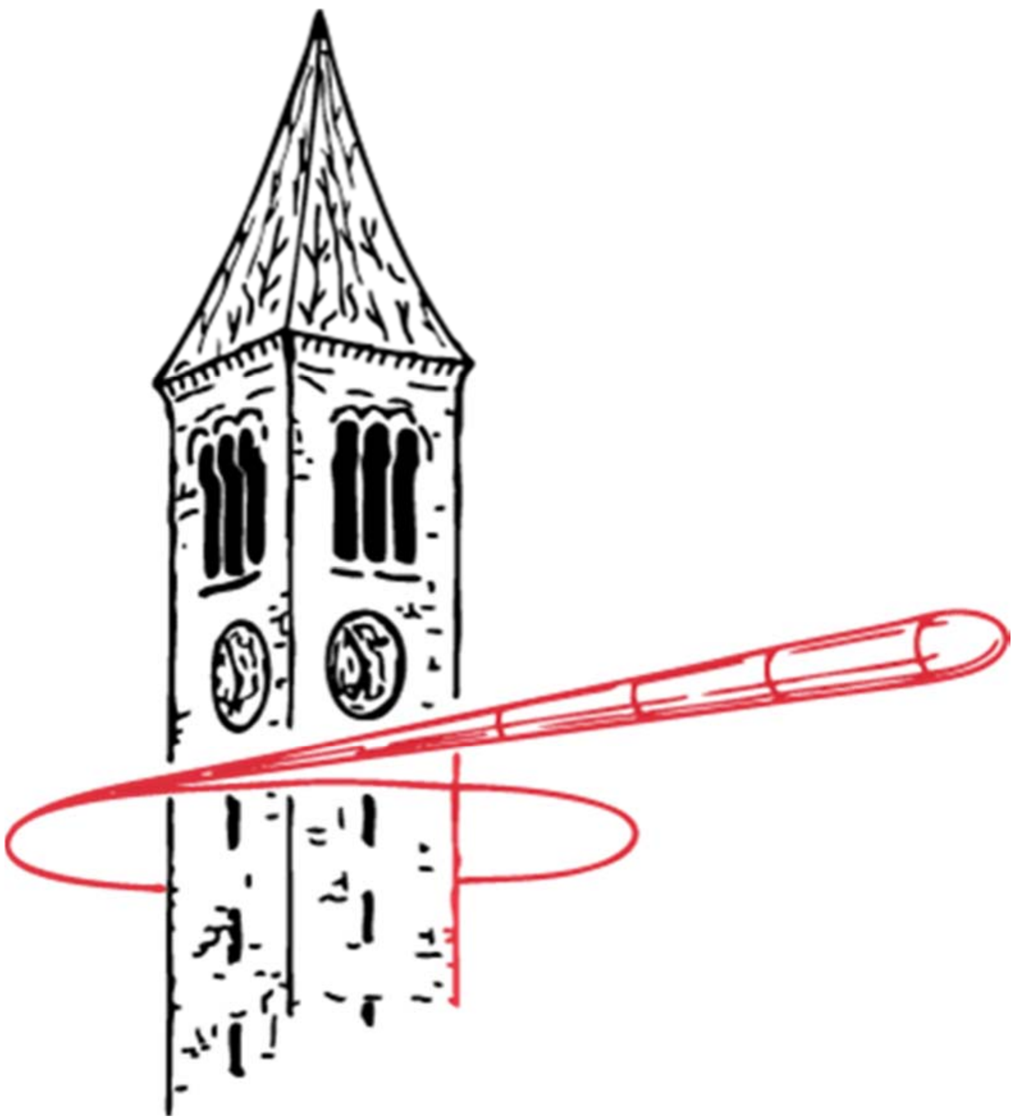
Cornell High Energy Synchrotron Source

Long Range Plan: FY 2016 – 2020



Contents

Introduction

This is the CHESS Long-Range Plan (LRP) for Fiscal Years (FY) 2016-2020.

After a period of vigorous community review and discussion, a vision has emerged of CHESS as a dynamic national center with a unique and scientifically exciting mission. The long-range plan described here responds to that vision by defining CHESS's high-level deliverables and how CHESS will be organized and funded to make those deliverables possible.

Detailed planning at the work package level is provided yearly in the CHESS Annual Operating Plan.

This is a living document. This plan will be updated annually to adapt to changing events, priorities, and actual versus projected funding.

CHESS Mission

The mission of the Cornell High Energy Synchrotron Source (CHESS) is to provide a national hard X-ray synchrotron radiation facility. This includes four sub-missions:

(1) operation as a synchrotron user facility;
(2) research and development of new synchrotron radiation technology and upgrading of the facility;
(3) integration of research and education in the training of the personnel who use and operate synchrotron radiation facilities; and,
(4) educational outreach to expose K-12 students and the public to synchrotron x-ray science and its application to materials research in age and experience appropriate forms.

CHESS provides synchrotron x-ray capabilities to individual investigators, on a competitive, peer reviewed, proposal basis. The facility is used by investigators from a wide range of science and engineering disciplines in academia, industry, government, non-profit, and international institutions. They conduct studies encompassing but not limited to the atomic and nanoscale structure, properties, *operando*, and time-resolved behavior of electronic, structural, polymeric and biological materials, protein and virus crystallography, environmental science, radiography of solids and fluids, and micro-elemental analysis, and other technologies for X-ray science.

Associated Background and Planning Documents

- CHESS 5-Year operating proposal
- New Science Made Possible by CHESS-U

Long-Range Planning Framework

NSF's Strategic Goals, Objectives, and Expectations for CHESS

The first strategic goal in the NSF strategic plan[1] is to "Transform the Frontiers of Science and Engineering" with the specific objective of providing "world-class research infrastructure to enable major scientific advances." CHESS's goal is to provide a world-class synchrotron x-ray facility that enables major scientific advances.

In addition, the NSF expects CHESS to fulfill two critical strategic priorities detailed in the cooperative agreement.

1. Demonstrate national need.
    a. NSF expects proposal pressure at CHESS to be comparable to that at the Department of Energy synchrotrons.
    b. NSF expects CHESS to broaden its user base (increase percentage of non-Cornell and industrial users).
    c. NSF expects CHESS to use Cornell reviewers only in cases where their expertise is critical to a decision on a proposal.
    d. NSF expects CHESS to make progress in broadening participation at all levels of the organization of women and minorities underrepresented in science technology engineering and mathematics.
2. Produce and enable unique capabilities and unique science including materials science.
    a. NSF expects CHESS to pursue facility, beamline, and experimental station upgrades that will create unique national capabilities within the scope of the proposal.
    b. NSF expects CHESS to work with the user community to pursue leading edge research identified in the proposal and to produce unique science that will take advantage of the proposed upgrades.

The Division of Materials Research (DMR) will monitor the degree to which CHESS meets NSF's expectations through annual management and or technical site visits, interim reports (i.e. monthly highlights and facility news) run cycle, annual, and final reports on a regular schedule to inform the NSB updates.

Components that make CHESS strong

Cornell also provides a vibrant research environment. CHESS is located on the central Ithaca campus of Cornell University. Cornell's open campus provides CHESS users convenient access both to CHESS and to adjacent nanofabrication, electron microscopy, biotech, plant science, art museum, and materials growth/characterization facilities. CHESS is administered by the Cornell

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[1]Investing in Science, Engineering, and Education for the Nation's Future: NSF Strategic Plan for 2014 - 2018, March 2014. (http://www.nsf.gov/about/performance/strategic_plan.jsp).

Laboratory for Accelerator Based Sciences and Education (CLASSE) and benefits from both the matrixed staff and the lab's infrastructure.

As shown in figure 1, the three areas where CHESS seeks to make an impact are (1) User Science, (2) Technology Development, and (3) Education and Training. The places where CHESS has the greatest potential for impact are in the regions where these areas overlap.

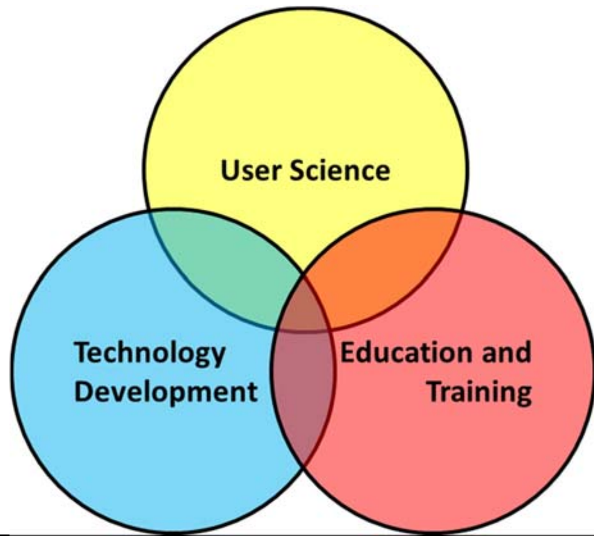


Figure 1: CHESS impact areas

CHESS Core Values and Strategic Principles

Principles are:

1. Consider the scientific needs of CHESS users.
2. Consider the unique capabilities and strengths of CHESS.
3. Consider the world situation.
4. Consider unique local strengths that can be leveraged.
5. As opportunities arise, leverage NSF investment by using funding from other federal agencies (e.g., DOE, NIH, ONR), state government, and/or private sources to enable high-impact science capabilities and/or projects.[2]
6. Broaden participation in the NSF science enterprise by engaging individuals, institutions, and geographical areas "that do not participate in NSF research programs at rates comparable to others."[3]

[2] A recent example is the upgrade of the x-ray optics and load frame equipment funded by the Air Force Research Laboratory.

[3] From Executive Summary, Broadening Participation at the National Science Foundation: A Framework for Action, August 2008.

High-Level Planning Assumptions

For the period FY 2016-2020, CHESS has made the following *conservative* assumptions:

- The six NSLS-II project beamlines will be operational.
- The NEXT beamlines will begin operations at NSLS-II in 2017.
- APS will begin the APS-U upgrade project after the completion of LCLS-II. Major construction will occur sometime after 2020.
- CESR-TA will continue to operate CESR for part of the year during 2016-2017 for accelerator physics research.
- CLEO will be removed from CESR in the summer of 2016.
- The East RF system will move into the CLEO pit during the summer of 2017.
- The CHESS-U upgrade project will proceed to completion before the end of the current operating award. The baseline CHESS-U schedule maintains the number of user x-ray beam days.

Programmatic Support of CHESS

NSF base funding

During the current 5-year award (which began in April 2014), NSF base funding of $20M/year will enable the following on-going CHESS activities:

- Operation of CESR for x-ray operations and support of CHESS x-ray facilities.
- Education and outreach
- Graduate students
- Post-docs

NSF base funding will also enable the following finite duration activities:

- Installation of undulators on A/G and, if scheduling permits, F lines
- Upgrading of A, G, and F-lines for undulator operations

NSF supplementary funding

- REU award: CLASSE has a Research Experience for Undergraduates REU program.[4] This award was renewed in January 2015.

NIH supplementary funding

The National Institutes of Health (NIH) provides additional annual operating funds as a supplement to the CHESS operating award. These funds are used to pay for 3 – 4 CHESS staff members. This support has now been incorporated directly into the MacCHESS award.

NIH supports MacCHESS, which provides enhanced user support and facilities for macro-molecular crystallography and bioSAXS users. This five-year award was renewed in June, 2013.

ONR supplementary funding

The Office of Naval Research (ONR) supports In-Sitμ, which provides enhanced user support and facilities for studies of the crystal-scale behavior of engineering alloys. This three-year award began in 2014.

[4] http://www.nsf.gov/pubs/2013/nsf13542/nsf13542.htm

External support for CHESS-U

The goal of the CHESS-U project is to upgrade both CESR and the X-ray beamlines. CHESS-U will reconfigure CESR to operate with only a single type of particle, raise the beam energy, increase the beam current, and, within those restrictions, minimize the beam emittance and upgrade or rebuild the X-ray beamlines.

Accelerator Upgrade: The CHESS-U upgrade will improve the quality of the particle beam. It will increase the energy from 5.3 to 6.0 GeV, increase the current from 100 to 200 milliamps, and reduce CESR's particle beam emittance from the present 100 nm-rad at 5.3 GeV to around 30 nm-rad at 6.0 GeV. We will engineer the lattice to minimize coupling between the vertical emittance and the horizontal emittance. By keeping the coupling below 1%, we will maintain the vertical emittance of the beam below 300 pm-rad. CHESS-U will provide space for up to 10 independently tunable insertion devices that will deliver X-rays to as many as 12 experimental stations.

Beamline Upgrade: The single CHESS-U particle beam will enable us to operate state-of-the-art undulators (X-ray sources). Each beamline will optimize its undulator design for specific types of experiments by taking advantage of either conventional undulators, cryo-cooled superconducting undulators, or the customizable and cost-effective Cornell Compact Undulator (CCU). CHESS-U X-ray optics will generate beams with diameters ranging from 0.1 microns to several millimeters at the sample position.

CHESS is currently negotiating the detailed terms of the award agreement for the CHESS-U upgrade. The sponsor prefers to remain anonymous at this time.

Achieving the Mission: Major Activities and Planning

Operation as a Synchrotron User Facility

1.1.1. Operations and maintenance of storage ring (CESR)

CHESS will operate CESR for 180 days each year. The yearly average goal for X-ray days for users shall consist of not less than 140 days of running with 11 X-ray stations operating simultaneously. The X-ray flux delivered by bend magnet beamlines should deliver 10^{10} photons/second/mm^2 at 10 keV, insertion device beamlines should deliver 10^{12} photons/second/mm^2 at 10 keV with 90% reliability.

It is understood that the CHESS mission includes R&D on CESR operational modes and x-ray beamlines, and this may impact beam availability. Hence, as accelerator and x-ray beam line configurations are optimized, variations on these performance goals may be altered in consultation with NSF, so long as the overall x-ray research capability provided to the user community remains the same or is improved.

1.1.2. X-ray beamline operations

Continue to improve and upgrade the x-ray beamlines, CESR, and the facility infrastructure necessary for performance of the CHESS mission. Projects include but are not limited to cryogenics, superconducting RF capabilities, advanced insertion devices, x-ray optics, hutches, end-station equipment, computing equipment, etc. Improvement and upgrade projects outside the scope of this award must not diminish the quantity or quality of x-ray beam time for users.

1.1.3. Safety Program

Cornell University strives to maintain a safe living, learning and working environment. Faculty, staff, students, and other members of the Cornell community must conduct university operations in compliance with applicable federal, state, and local regulations, University Health and Safety Board requirements, and other university health and safety standards.

We strive to establish a culture of safety, which entails much more than simply compliance with a set of rules. A culture of safety is embodied by the following practices:

- Each of us takes responsibility for our own safety and that of people we work with, supervise, or host.
- Safety is valued on par with (or above) scientific achievement and/or task completion.
- Safety concerns are always taken seriously and addressed.
- Safety challenges are approached with intellectual rigor.
- New activities are planned from the start with safety in mind.
- New participants receive relevant safety training immediately & are inculcated with the values of a positive safety culture.
- Every person values and strives for continuous improvement of laboratory safety

The CHESS Safety Manual and the CLASSE Safety Handbook detail the safety programs.

1.1.4. CHESS X-ray User Program Office

The CHESS X-ray User Administration Office is responsible for the administering the x-ray user program. Each year the user office arranges visits for thousands of users, attendees of workshops and meetings, as well as educational event planning and execution (along with educational programs staff). For scientific proposal and project management, they handle all aspects of proposal announcements, submission, external quality and safety review, scheduling, tracking, statistics collection and handling, reporting, external communications and publicity. Responsibilities also include communications strategies (mailing lists, monthly eNewsletters, annual reports, web sites) recordkeeping, and check-in of users and student visitors.

1.1.5. MacCHESS User Program

The National Institutes of Health (NIH), through its National Institute of General Medical Sciences (NIGMS), funds MacCHESS for two purposes: core research as motivated by the important biomedical problems and support to all structural biologists making use of the CHESS facility for crystallographic and small-angle X-ray scattering experiments, as well as for novel experiments requiring special equipment and staff assistance not readily available at other synchrotron sources. Macromolecular Diffraction at the Cornell High Energy Synchrotron Source (MacCHESS) provides a facility for developing new technology and for advancing the research goals of structural biologists as well as the broader biological research community. MacCHESS has a strong commitment to training future leaders, who will be able to translate advances in synchrotron science and structural biology into valuable biomedical applications. Guidance in determining MacCHESS's major emphases is provided by the MacCHESS Advisory Committee.

1.1.6. InSitμ: a new center at CHESS sponsored by the US Office of Naval Research

Mission:

- Build understanding and model crystal-scale behavior of engineering alloys
- Support High Energy X-ray Diffraction (HEXD) experiments at A2 and F2 CHESS stations
- Support Finite Element-based polycrystal finite-element program developed at Cornell by P. Dawson (FEpX)
- Provide enhanced support for industrial users
- Provide training on both experiment and simulation

1.1.7. X-ray Detector Integration and Support

The availability of a pool of shared, capable x-ray detectors is essential for the health and advancement of x-ray instruments and methods supported for the user program. In addition to commercially-sourced x-ray detectors, the fabrication and prototyping of new advanced detectors, in conjunction with the Gruner group (in the Cornell Physics Department), has always been a strength of CHESS and a means for CHESS users to gain access (and provide feedback) to technology on the frontier. Developing hardware and software to aide integration with experiments at the x-ray stations also involves the operations and IT teams. Fast, robust and scalable computer networking and storage is also necessary to support large data rates and large data sets.

Research and Development, Upgrading the Facility

1.1.8. Unique Program: CHESS Compact Undulators (CCU)

In the summer of 2014, CESR was reconfigured so that the "pretzel orbit" for both electrons and positrons is on-axis in the Southern arc. While making accelerator operations considerably more complex, this change enables undulator operations. Two 150 cm long undulators fabricated by KYMA were installed in the West flare and currently feed both the A-line and G-line experimental stations. The A-line x-ray optics were completely rebuilt to handle the significantly higher power densities of the undulators.

The ERL beam line moved out of L0 and into L0E in the spring of 2015. Ultimately, this will create additional space to expand the F-line experimental stations and x-ray optics.

The CLEO particle physics detector was removed from CESR in the summer of 2016. The CLEO removal was made possible by the ERL move and by Thomas Jefferson Laboratory purchasing the large CLEO solenoid.

Transitioning to undulator operations makes CHESS the 5^{th} 3^{rd} generation (undulator operations) high-energy storage ring (E >= 5 GeV) synchrotron in the world. The others are APS, ESRF, PETRA-III, and Spring-8.

1.1.9. Unique Program: X-ray optics and beam diagnostics program

Beamline diagnostics will continue to be developed so that source qualities, stability and feedback systems can be engineered and evaluated. Video BPMs for source and full-beam imaging are quite different. CHESS has developed in-house scientific and engineering staff expertise to address new challenges in this area. CHESS has pioneered the development of video-based beam position monitors (VBPMs). VBPMs use visible light luminescence resulting from an X-ray beam passing through a medium. VBPMs provide position information by calculating the mathematical centroid of the luminescence imaged by the video camera. VBPMs provide X-ray beam cross-sectional profiles useful for beam diagnostic purposes. These VBPMs provide time-critical information needed to stabilize the X-ray beam positions to between 2-10 microns.

1.1.10. Unique Program: tapered-glass capillary x-ray optics

Single-bounce focusing optics, using appropriately shaped tapered-glass capillaries, have had a great impact on CHESS scientific productivity. Our in-house glass drawing tower allows custom designs to be realized quickly, allowing the beam size and divergence to be tailored to a particular X-ray application. Started in 1996 by scientist D. Bilderback, and continued now by scientist R. Huang, optimized capillaries have been drawn for applications such as confocal X-ray microscopy, high angular resolution X-ray diffraction and standing waves on quantum well laser structures, X-ray fluorescence mapping of fish ear stones, small angle X-ray scattering, diffraction at high pressure, device mapping, solution shearing, and microcrystallography. Numerous new capillaries are in use at CHESS; many have focal spots below 10 microns. A new metrology stage built with air bearings on a granite block will push measurement resolution from 1 to 0.1 micron, providing better feedback on how to improve custom capillary shaping.

1.1.11. Unique Program: microfabricated spoked-channel arrays

Ever improving microfabrication techniques provide a new approach to developing X-ray optics for a diverse range of applications. Graduate student David Agyeman-Budu works with staff scientists Arthur Woll and Ken Finkelstein to bring critical microfabrication skills to bear on three long-term projects: (1) X-ray transmission; (2) Si and Ge pixilated arrays of energy filtering; and (3) a novel technique to determine elemental composition analysis was developed using Spoked Channel Arrays (SCAs), achieving 10x improvement compared to what is currently available. SCAs are lithographically fabricated by deep reactive ion etching silicon to form channels with a fan-shape arrangement that points towards a focus. We have fabricated SCAs with 1, 2 and 5 micron wide channels, and the optic functions to give depth information in addition to collecting fluorescence from the sample under investigation.

1.1.12. Unique Program: high-speed x-ray detectors

Many unique detector developments and rapid prototyping of experiments occur by a synergy between Sol Gruner's group in the Cornell Physics Department and CHESS. This involves co-support of relevant personnel and leveraging of grants from NIH, DOE, and the Keck Foundation by the CHESS award. Most importantly, it involves the use of CHESS as a proving ground for the detector technologies, an arrangement that has resulted in one of the strongest and most productive detector groups in the world. This collection of people has been very successful in providing detector technology to the larger community, including the first applications of large-scale CCD detectors and pixel array detectors (PADs) at hard X-ray synchrotrons. The group has also facilitated the migration of the technology developed to the commercial sector so that it is available to the larger community.

1.1.13. Project to transition to single beam operations: CHESS-U

Overview

The objective of the CHESS-U project is to optimize the CESR for x-ray operations. CHESS-U will configure CESR for single beam operations, reduce the emittance (the product of beam width and divergence and a principal figure of merit for synchrotron light sources) by a factor 6, increase the current to 200mA, raise the energy to 6.0 GeV, enable tremendous flexibility in the pulse structure, provide space for additional insertion devices and longer x-ray beamlines, and rebuild the front ends (up to the shield wall). The improved performance is achieved by reconfiguring a single sextant of CESR, dividing the arc into 6 evenly spaced double bend achromats, with a 4m long drift space between each achromat available for insertion devices. To further improve the quality of the x-ray source, the new electron beam optics focus the beam horizontally and vertically on passage through insertion devices, eliminating dispersion that enlarges the beam due to electron beam energy spread. At the completion of this project, CHESS will simultaneously operate 10 independent insertion-device x-ray beamlines with Advanced Photon Source (APS) level x-ray quality and unique experimental capabilities.

Intellectual Merit

This project will deliver several unique scientific capabilities: non-destructive 3D elemental mapping of plants and animals with submicron spatial resolution, to better understand where and how proteins bind metals; sub-microsecond x-ray diffraction to better understand how structural materials respond to sudden, high-impact deformations in a crash; time-resolved studies of the crystal-scale behavior of engineering alloys during loading and processing to better understand the response of engineering metal alloys in airplanes and heavy trucks, leading to cheaper lighter parts; and, high dynamic range diffraction to rapidly measure subtle lattice distortions and modulations in strongly correlated electron materials, resulting in new insights into high-Tc superconductivity. This knowledge and interpretation may lead to even higher Tc materials or even an explanation of the mechanism of high Tc superconductivity itself.

Working with the international user community, CHESS has prepared a science case for a 3rd generation, high-energy, high-flux synchrotron called “New Science Made Possible by CHESS-U.” The scientific themes were identified during the series of science workshops held in June 2016. This has been a real community effort and CHESS thanks everyone for their input and hard work. The Science Case is scheduled to be reviewed by an NSF panel in October 2016.

Broader Impacts

Worldwide, synchrotron radiation is a key multidiciplinary tool enabling major discoveries across diverse fields of physics, chemistry, materials, engineering, environmental and earth sciences, medical and biological sciences, and increasingly in areas of cultural heritage such as the study of paintings and archaeological objects. CHESS, a National User Facility, supports x-ray experimental stations and grants x-ray beam time via a competitive, proposal-based, peer-reviewed process. With over 1300 user visits each year from across the country and around the world, CHESS fills a vital national need for high-energy x-ray beams. High-energy x-rays (20-100 keV) have a wavelength short enough that diffraction can determine the distance between atoms and an energy well above electron binding energies, minimizing photoelectric absorption and enhancing penetration. High-energy x-ray beamlines are only possible at a handful of international facilities powered by high-energy storage rings (APS, CHESS, ESRF, Petra-III, and SPring-8). Even at these elite facilities, x-ray beamlines operating above 30keV are both rare and in high demand. The CHESS-U project is a cost effective means to increase significantly the number of world-class high-energy X-ray beamlines in the US. During the 12 month period when the APS goes dark for the APS-U upgrade, CHESS will be the only source of high energy x-rays in the US.

Additionally, CHESS/CESR plays a unique role in the advanced training of accelerator scientists, x-ray beamline scientists, and expert x-ray users. PhD students are routinely integrated into designing, building and daily operations of the storage ring and x-ray facilities. In addition to PhD research, Masters of Engineering students undertake thesis design projects; undergraduates from across the US participate in term time employment, summer internships, REU programs, and a unique program for community college students (SRCCS).

Integration of Research and Education

1.1.14. Graduate Research Assistantship Program

The CHESS Operating Award contains support for up to eight (8) Graduate Research Assistantships. These students must perform research which has direct benefit to the CHESS User community. Goal is to link beam line science program, post-doctoral associates, and graduate students.

1.1.15. Post-doctoral Associates Program

The CHESS Operating Award contains support for up to three (3) Post-Doctoral Research Associates. The CHESS funds are used to support 50% of a post-doctoral associate – external collaborators supply the remainder. This leveraging both increases the number of post-docs at CHESS and ensures a close connection to vibrant, well-funded external user programs.

1.1.16. Professional Workshops Program

CHESS offers several hands-on workshops each year to train users in advanced x-ray techniques. The topics evolve from year to year. Recent workshops include: BioSAXS Essentials, InSitμ: Combining Polycrystal Modeling and High Energy X-rays, XRF Mapping, and XES Workshop. Users attend lectures on theory and application software and then have the opportunity to take a data set on their own sample.

Educational and Outreach

1.1.17. Xraise: K-12 Programming

CHESS activities aimed at pre-K-12 are designed, overseen, and coordinated by two staff members trained as professional teachers: outreach director Lora Hine and assistant Erik Herman. They also coordinate outreach activities to the public and involve over two thirds of CHESS staff as event mentors. Undergraduate, graduate, and post-doc research projects are overseen by academic staff, senior scientists and management. The infrastructure to support these activities includes a dedicated "eXploration Station," a kid-powered science activities classroom, and a newly designed "Xraise" program web site designed to foster community involvement. Xraise works in concert with other outreach programs on campus (NSF funded CCMR and HHMI funded CIBT), providing a true "sum is greater than the parts" collaboration to reach diverse audiences.

1.1.18. Undergraduate internships, SRCCS and REU

As students move to college age and beyond, they continue to need experiences outside the classroom to reinforce knowledge, test abilities, and provide personal insights into career options. Some undergraduates work part-time during school and others work full-time over summers, balancing inquiry-based learning skills with teamwork and independent exploration. Projects produce long-term benefits to CHESS and X-ray user community. CHESS partners with the Cornell College of Engineering to host LSAMP students, in addition to continuing to host approximately a dozen REU students each year (under a separate NSF award). CHESS also funds a program "Summer Research for Community College Students" (SRCCS) which selects 4-5 students from (2-year) community colleges for eight-week internships in accelerator and X-ray sciences research, during which students attend/lead formal seminars, tour research facilities, enjoy social and recreational events, and build an interactive exhibit for Xraise.

1.1.19. Masters of Engineering Program

Engineering disciplines are vital to building new capabilities needed by the scientific community. Within walking distance of the Cornell College of Engineering, CHESS benefits enormously by providing students in MEng programs with "professional design project" experiences. Year-long projects provide ample time for students to design, build, test and commission substantial new equipment or operational projects. Students worked closely with engineering and science teams and gave periodic review presentations and final written reports.

Timelines

Overview

Major Planned Deliverables Funded

FY 2016:

- User Operations (CHESS)
- Design and prototyping of accelerator and x-ray beamlines (CHESS-U)

FY 2017:

- User Operations (CHESS)
- Fabrication, acquisition, assembly and testing of components (CHESS-U)

FY 2018:

- User Operations (CHESS)
- Installation and commissioning of accelerator and x-ray beamlines (CHESS-U and CHESS).

FY 2019:

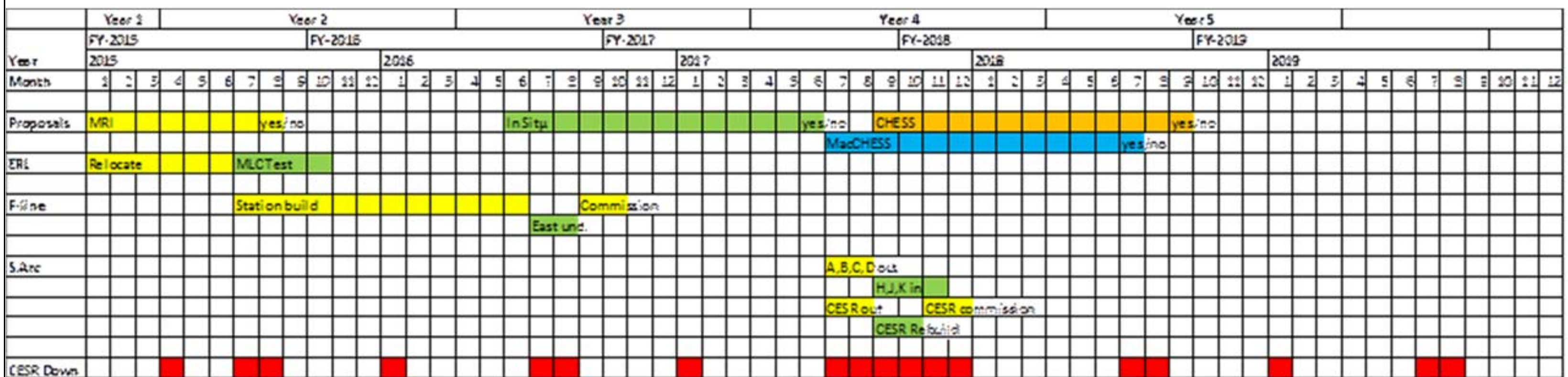
- User Operations

FY 2020:

- User Operations

Time Line Including South Arc Upgrade

Transitioning CESR to single beam operations is a critical goal. This upgrade is scheduled to occur in the 2017-2018 time frame as shown in the figure below.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CESR out
CESR commission
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Time LIne

Anticipated Challenges and Opportunities

Broadening Participation

Reaching out to new user communities (both scientific and under-represented groups).

Diversity

Continued effort at all levels (students, users, and permanent staff) required.

CHESS is collaborating with INCREASE to hold a workshop for faculty from Minority Serving Institutions (MSI) sometime in the late spring or early summer of 2017.

CHESS and REU

Need to recruit high quality students and provide high quality experience.

Management Plan

Overview and Management Structure

CLASSE is chartered as a Cornell University Center, which means that it is an interdisciplinary organization of faculty and staff to facilitate and promote research and education in the branches of science concerned with the development and uses of accelerators. Faculty members are from many Cornell departments, including Physics, Chemistry and Chemical Biology, Applied and Engineering Physics, Materials Science and Engineering, Molecular Medicine, etc., to facilitate student (undergraduate, graduate and post-doctoral) involvement for education, training and research opportunities and to involve the intellectual resources of the wider university community. The CLASSE Directorate is a mixture of faculty and senior professionals, whose purpose is to integrate research and education activities (e.g., accelerator R&D, X-ray Science, EPP) with technical functions requiring full-time operations staff (e.g., Technical Operations, Project Management, Safety, Administration).

CHESS is a unit within the Cornell Laboratory for Accelerator-based ScienceS and Education (CLASSE). The CHESS Director is appointed by Sr. Vice-Provost for Research R.A. Buhrman. J. Brock is CHESS Director and PI of this award. The CHESS Director reports jointly to Buhrman and the CLASSE Director, J.R. Patterson. R. Eichorn is CESR Technical Operations Director. L. Hine is Education and Outreach Director. B. Heltsley is CLASSE Safety Director. The CHESS Director is also the Associate Director of CLASSE. CHESS Associate Director E. Fontes is responsible for X-ray technical operations. Brock is responsible for X-ray scientific staff. CHESS Associate Director M. Miller is responsible for educational programs and the structural materials initiative. R. Cerione is MacCHESS PI. M. Szebenyi is MacCHESS Director. K. Dedrick is CHESS's User Office Director. Scientific staff oversee X-ray end stations. Detailed organizational charts are included as appendices.

CHESS-U is a project. Joel Brock is the PI. Dave Rice and Chris Connolly are the Project Managers responsible for the accelerator and x-ray beamline portions of CHESS-U respectively.

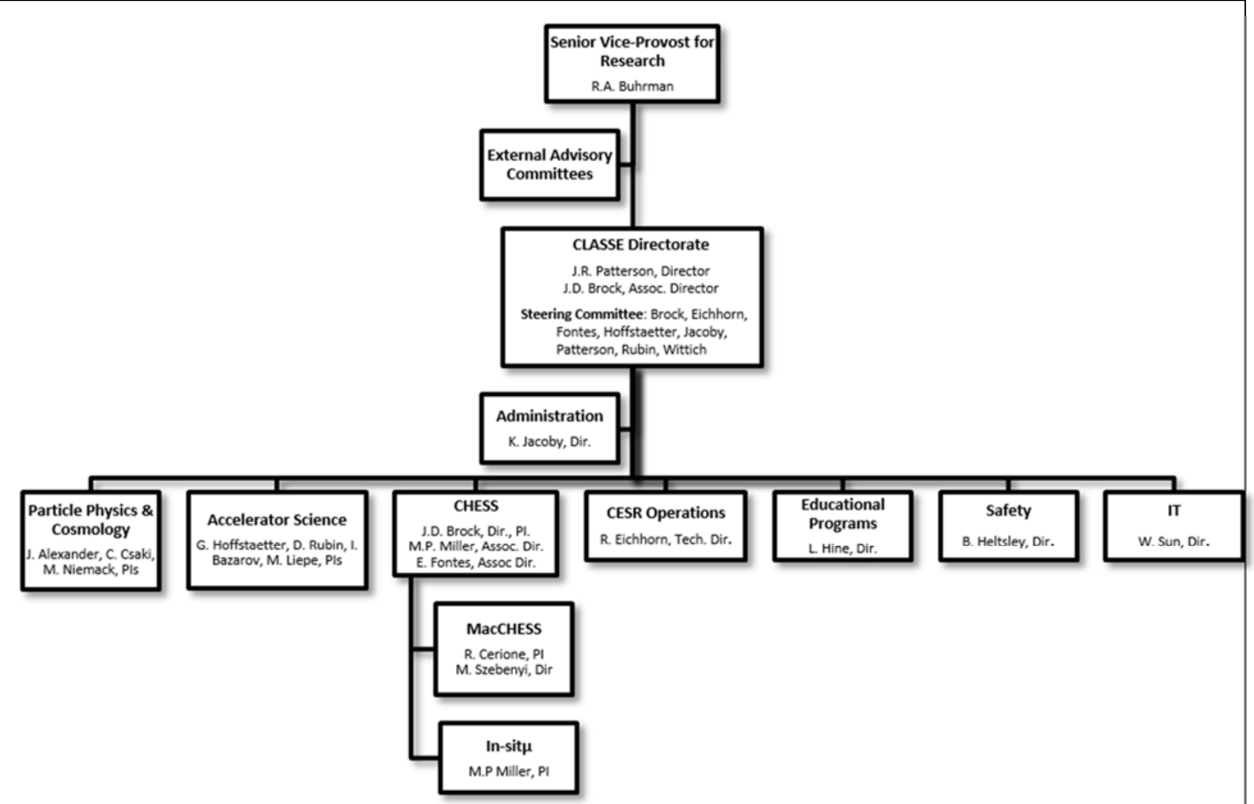


Figure X: CLASSE Org Chart (September 2016)

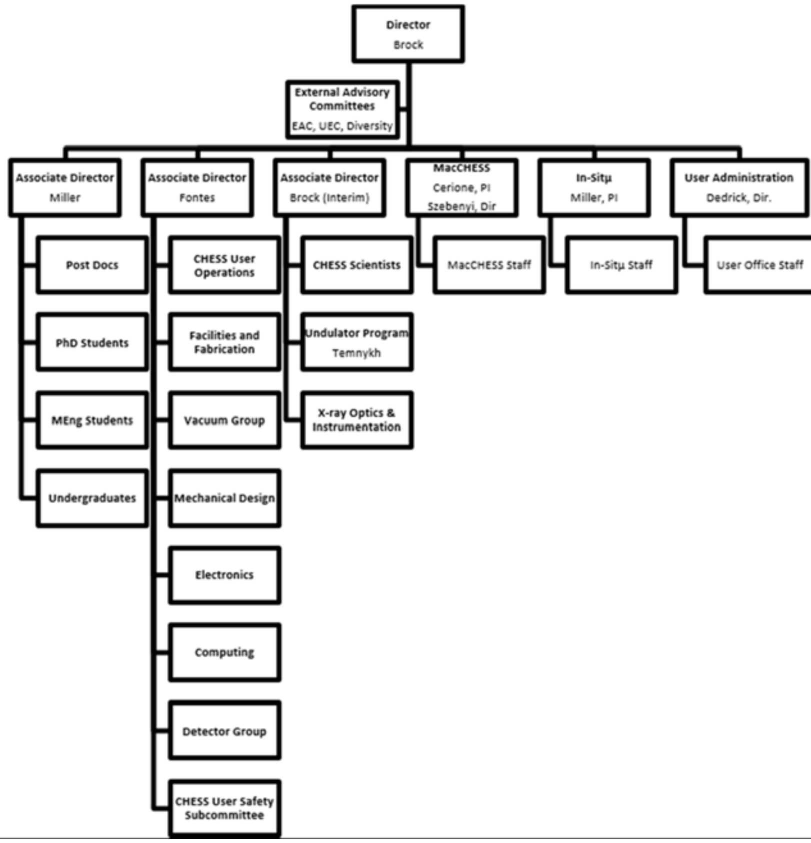


Figure X: CHESS Org Chart (September 2016)

Management of Accelerator Systems

The accelerator physics/operations group has designed/built/maintained and operated the synchrotron injector and CESR storage ring at Wilson laboratory for 4 decades. It has the expertise and technical skill sets to keep large projects operating smoothly, and also all the administrative infrastructure to co-ordinate development of new groups and directions. The facilities under management and development include an up to 12 GeV synchrotron, an up to 8 GeV electron/positron storage ring, 5 MW transformer pad, klystron gallery, closed circuit helium refrigerator and recovery plant, cooling towers, instrumentation and computer controls group, ERL injector test facility, etc. The PI connects to CLASSE's technical infrastructure and operating capability via CLASSE Directorate Chair Ritchie Patterson, the Technical Director, Ralf Eichorn, and co-PI Dave Rubin. Rubin, a well-known accelerator physicist, is presently PI for the CESR-TA project that is using CESR for low-emittance experiments. This is a highly experienced team.

Because of CHESS' dual mission, education and research are both equally important goals. Students are heavily involved in operating the facility. For example, graduate students in CLASSE routinely build and maintain accelerator and upstream portions of X-ray beamlines, working and learning behind the primary shielding walls. In this way, CLASSE serves a very important synergy with the national laboratories by training accelerator physicists and X-ray beamline scientists who go on to work at other national facilities.

Management Challenges

The matrix management structure of CLASSE both gives CHESS access to skill sets and resources that it cannot afford on its own and generates couplings between the various projects in CLASSE that must be managed. A SWOT analysis of CLASSE's matrix management structure appears in the table below.

Strengths	Opportunities
1. Provides CHESS with access to world-class accelerator physics faculty, research programs, and infrastructure. 2. Provides sophisticated technical skill sets that CHESS needs critically, but not full time. 3. Shared use gives CHESS access to state of the art storage ring built by other programs.	1. Transform a particle physics facility into a state of the art photon science facility. 2. Cost effective, sequential up-grades to CESR, insertion devices, x-ray optics, and x-ray detectors can be invented, developed, and executed. 3. Take advantage of latest advances in accelerator technology to provide high brightness x-ray beams.
Weaknesses	**Threats**
1. Financial support for matrixed staff is also matrixed. If other major programs in CLASSE lose their funding, CHESS may need to preserve critical skill sets. 2. Various projects in CLASSE may compete for space and personnel.	1. Re-organization, turn over in management, and natural evolution of priorities at funding agencies constantly alters the funding situation.

Roles and Meeting Dates of Internal and External Committees

The External Advisory Committee (EAC) meets twice annually to advise the Director on the utilization and development of CHESS facilities. The Vice Provost for Research selects EAC members from the scientific and engineering community. The EAC reports to the Vice Provost for Research. The EAC oversees and reports on the on-line Proposal Review Process annually.

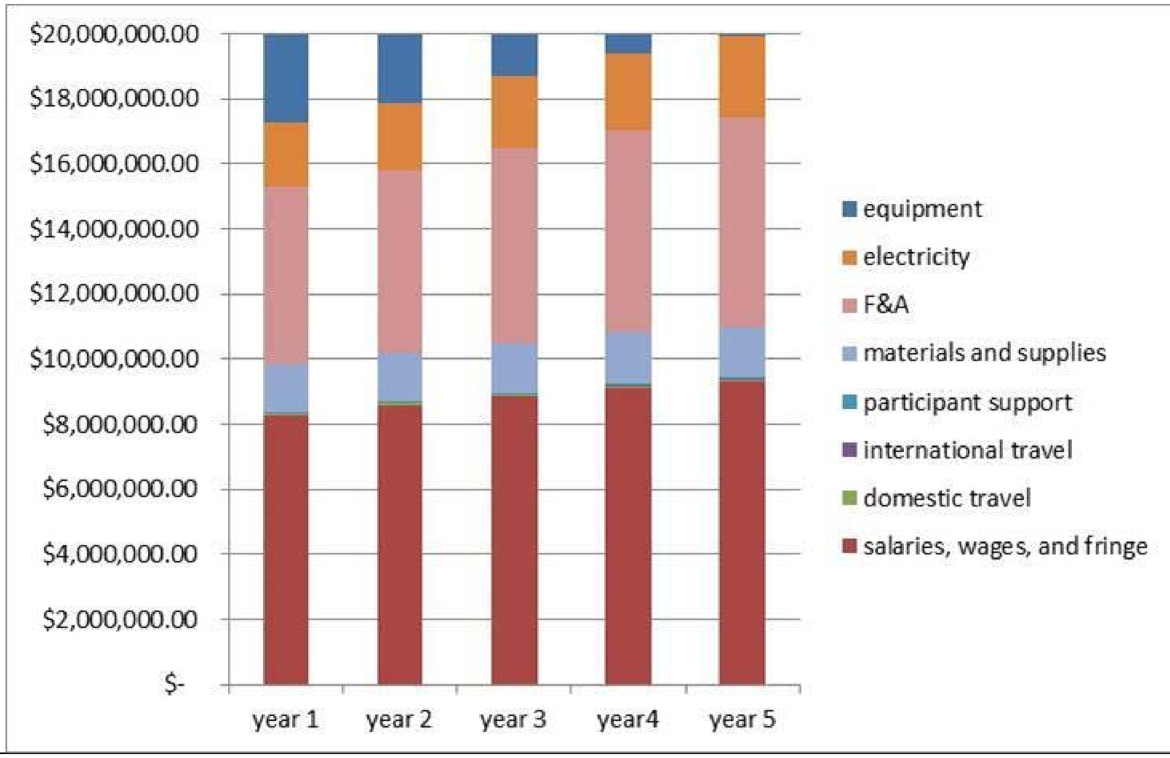
The EAC has chosen to have its on-site meeting in January or early February in order to be involved in the initial stages of the development of the annual operating plan. The EAC meets again by a web-based conference in late June or early July to review the final version of the annual operating plan.

The CHESS Users Executive Committee (UEC) is elected by the users of CHESS and meets annually to advise the Director on the utilization and development of CHESS facilities. Candidates for the UEC are nominated by the CHESS users. UEC members serve for two years. The UEC elects a vice chair each year. The vice chair succeeds the chair. The chair then serves an additional year on the UEC as past chair. The UEC holds a web-based meeting in January and has an in person meeting in June during the annual CHESS Users' Meeting.

The annual meeting of the Diversity committee will be in early fall of 2016.

Budget and Staffing Plans and Strategies

CHESS Funding Profile



Funding profile in current CHESS operating award.