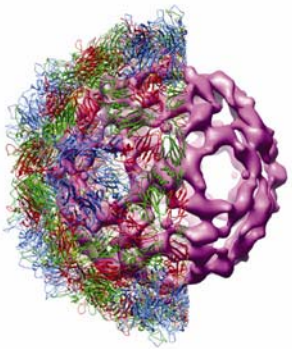
Argonne NATIONAL LABORATORY

... for a brighter future

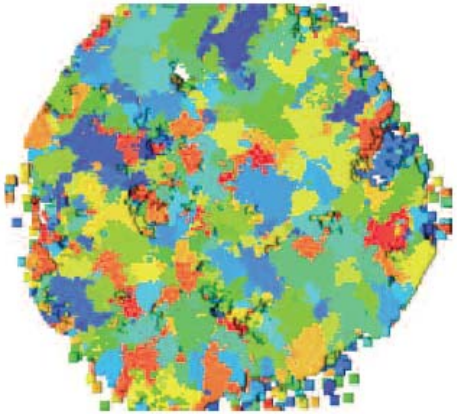
The APS and synchrotron facilities in the US and worldwide: a network perspective



J. Murray Gibson

Director, Advanced Photon Source

Associate Laboratory Director, ANL for Photon Sciences



Presented at the annual NUFO meeting, held at ANL, June 10th-12th 2009

U.S. Department of Energy

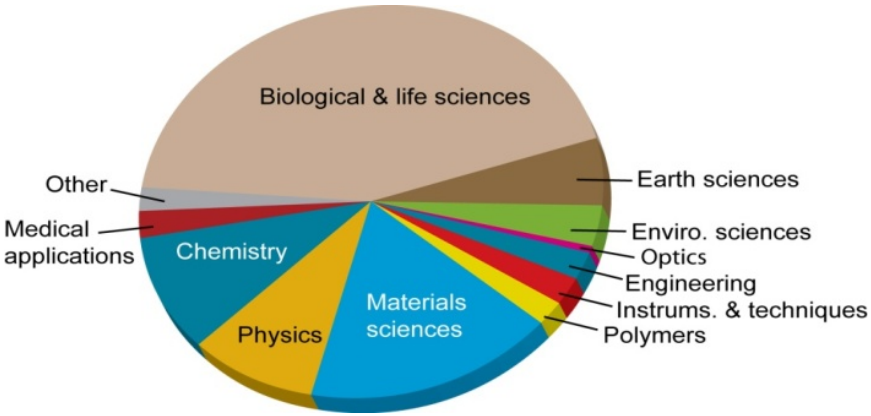
THE UNIVERSITY OF CHICAGO

Office of Science
U.S. DEPARTMENT OF ENERGY

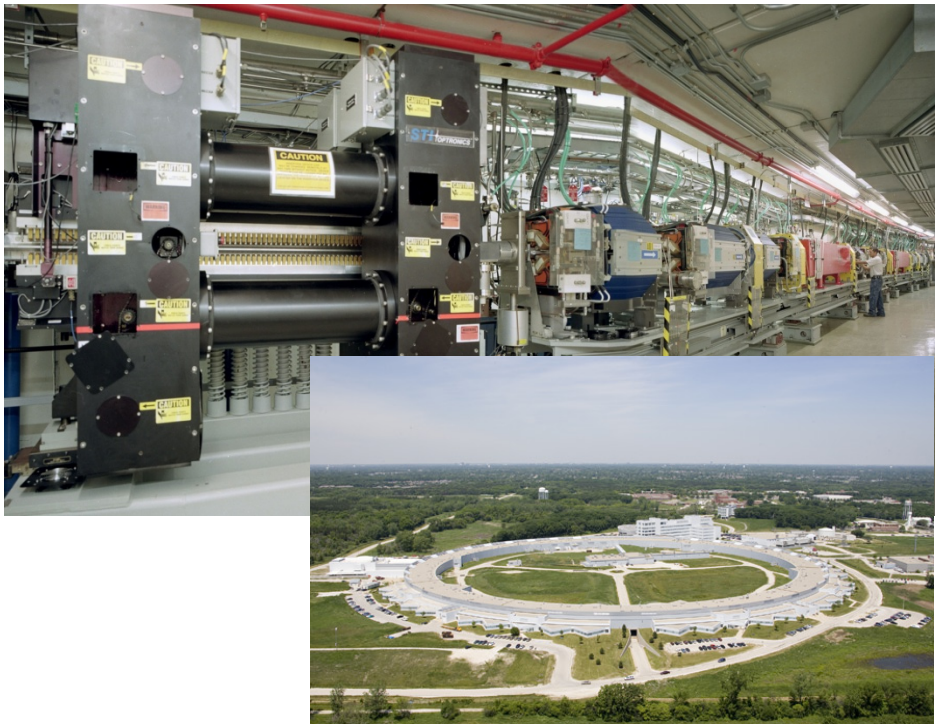
A U.S. Department of Energy laboratory managed by The University of Chicago

Synchrotron radiation – an essential tool for science

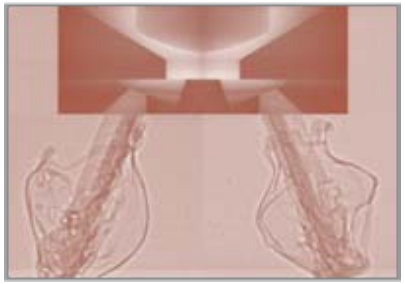
- ~10,000 US light source users
- > 60 operating synchrotron light sources user facilities world wide
- Touches almost all scientific and engineering disciplines



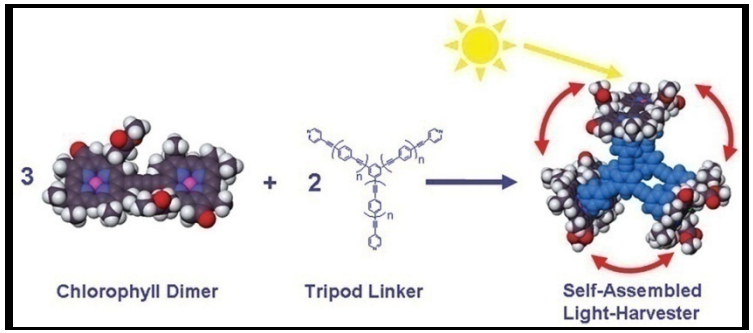
FY08 users by discipline



APS research addresses key societal challenges

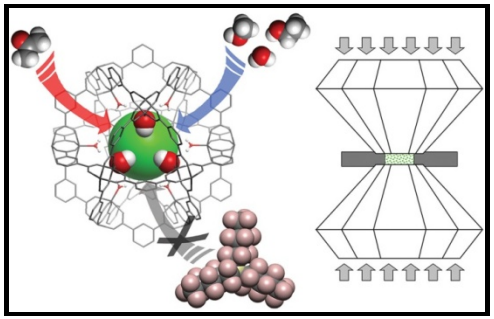


Better burning

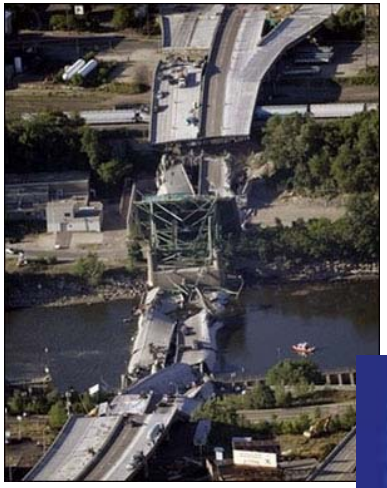


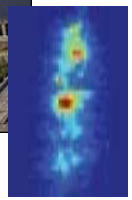
Natural solar cells

How sea animals capture carbon

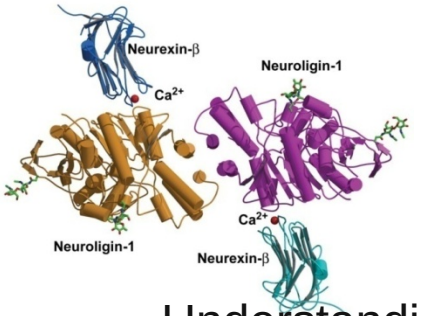


Storing hydrogen

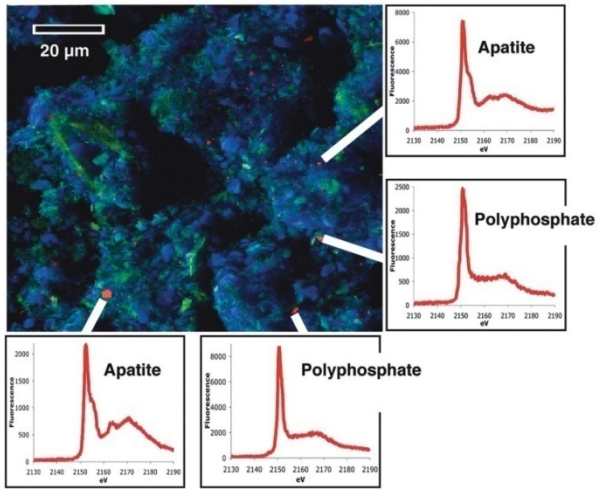




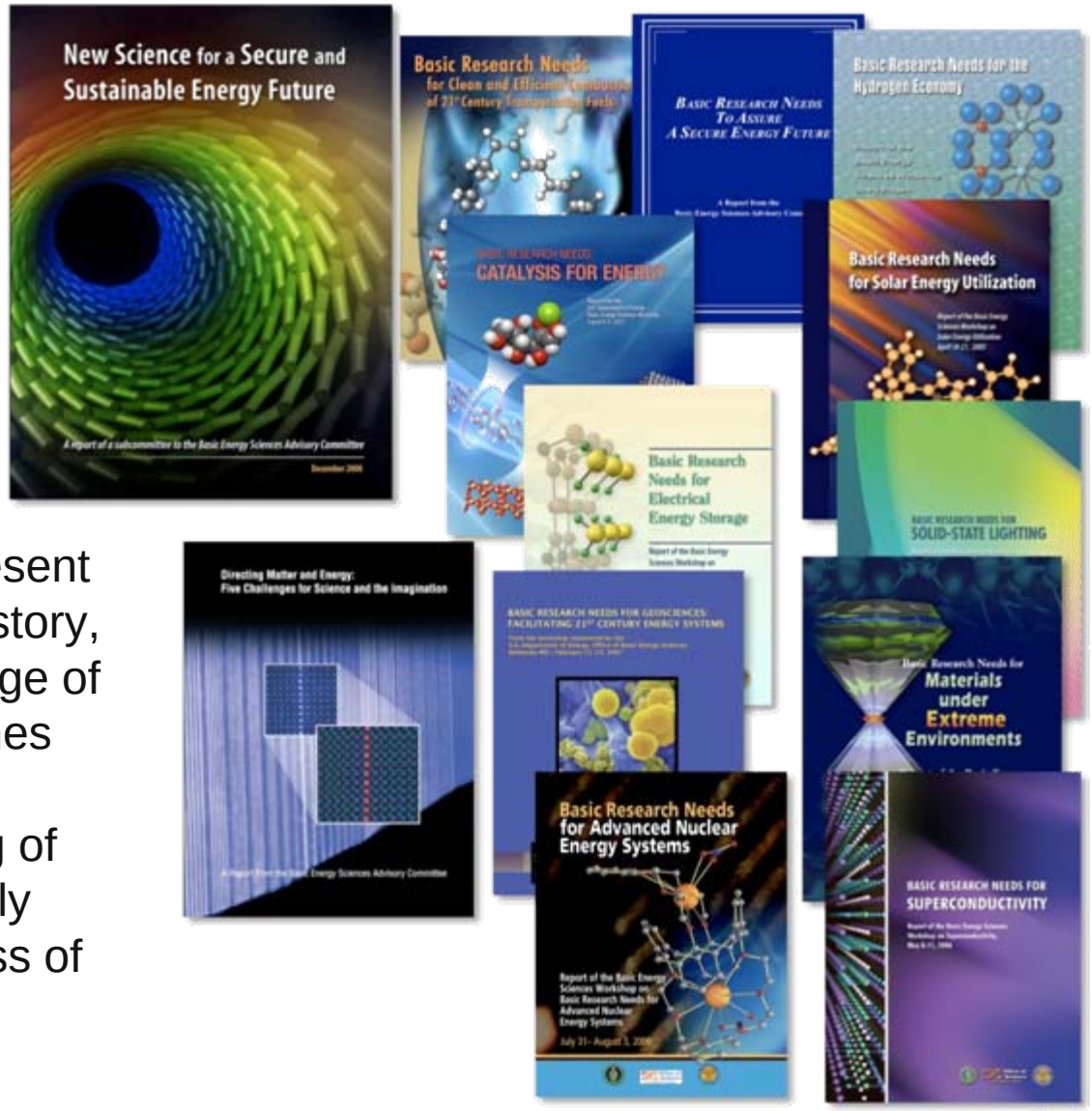
Infrastructure failure



Understanding autism



Synchrotrons are essential to energy science research

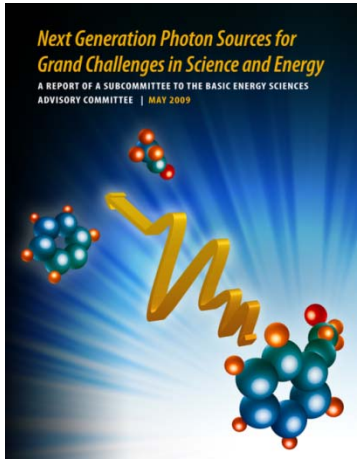


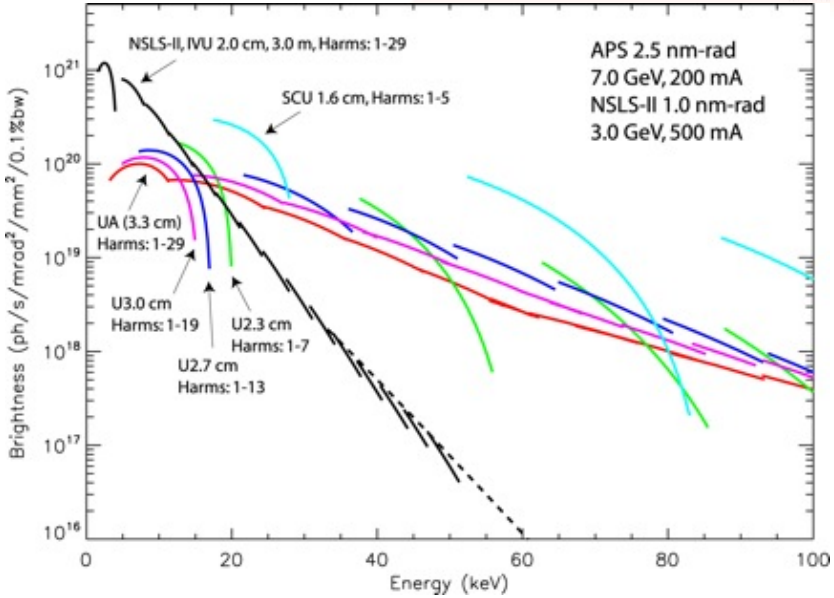
"DOE's light sources represent an extraordinary success story, enabling an enormous range of science across all disciplines mentioned in this report. Maintaining and upgrading of this resource base is clearly critical to the broad success of grand challenge science"

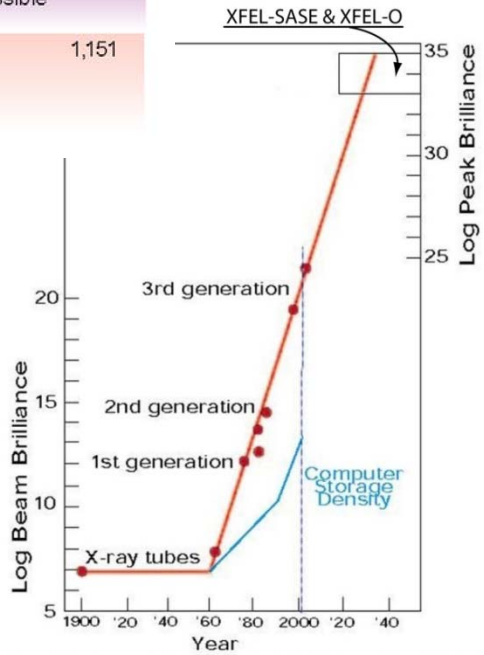
Synchrotrons around the world

Desire for new capability and increased access

Source Name	Location	Type	1st Year Operation	Characteristic Energy	Beam-lines	Users (2007)
Advanced Light Source	California	Third-gen storage ring	1993	3.2 keV (12 keV super-bend)	43	1,784
Advanced Photon Source	Illinois	Third-gen storage ring	1996	19.5 keV	60	3,420
Linac Coherent Light Source	California	Free-electron laser	2009	N/A	4 (instmnts)	N/A
National Synchrotron Light Source	New York	Second-gen storage ring	1982	7.1 keV	65	2,219
National Synchrotron Light Source II	New York	Third-gen storage ring	2015	2.4 keV	~58 possible	N/A
Stanford Synchrotron Radiation Laboratory	California	From second to third-gen storage ring	1973 (upgraded in 2004)	7.5 keV	34	1,151







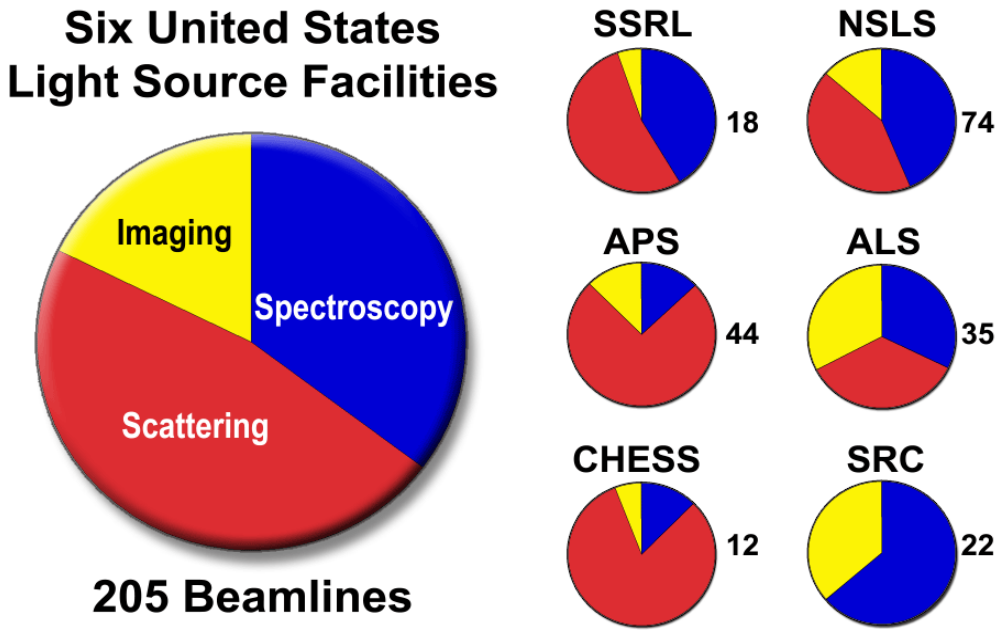
Networking of light sources in the USA

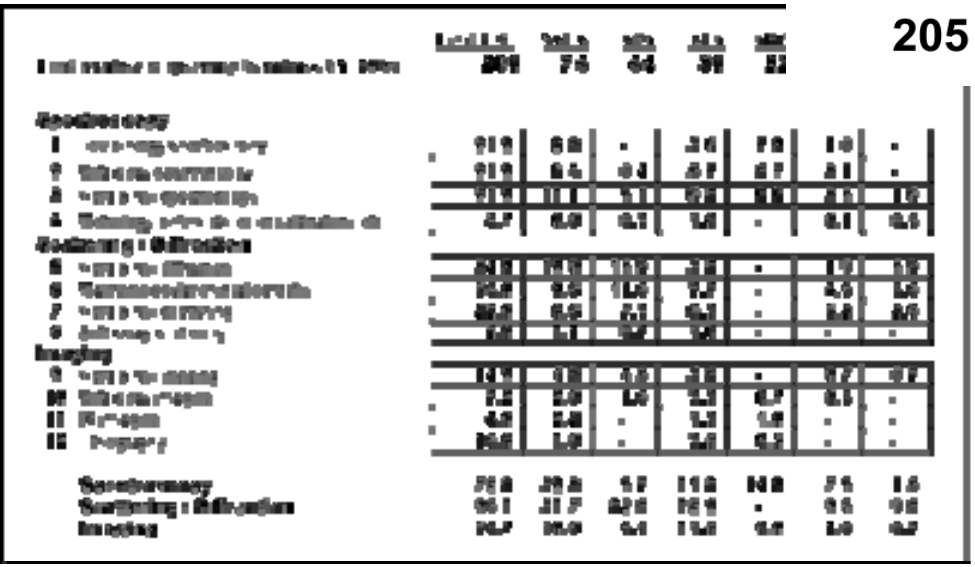
- Joint organization of the Synchrotron Radiation Conference
- User societies work together on advocacy
  - SNUG (Synchrotron and Neutron User's Groups)
    - *Monthly conference call with DOE facility directors*
  - NUFO
- DOE calls regular meetings, conference calls as issues come up
  - e.g. metrics beyond "reliability and availability"
- Extensive technical collaborations
  - e.g. undulators for the LCLS

Distribution of Beamline Techniques Reveals Important Differences in the U.S. Light Sources

From DOE

Classifying the instruments at the light sources by the twelve categories of beamlines reveals some of the differences among the facilities. For example, the APS, a hard x-ray light source, emphasizes scattering while the ALS, a soft x-ray light source, emphasizes spectroscopy and imaging. A further breakout of the twelve categories of instruments, four in each of the three major categories of spectroscopy, scattering, and imaging at all six U.S. light sources is shown in the table below.

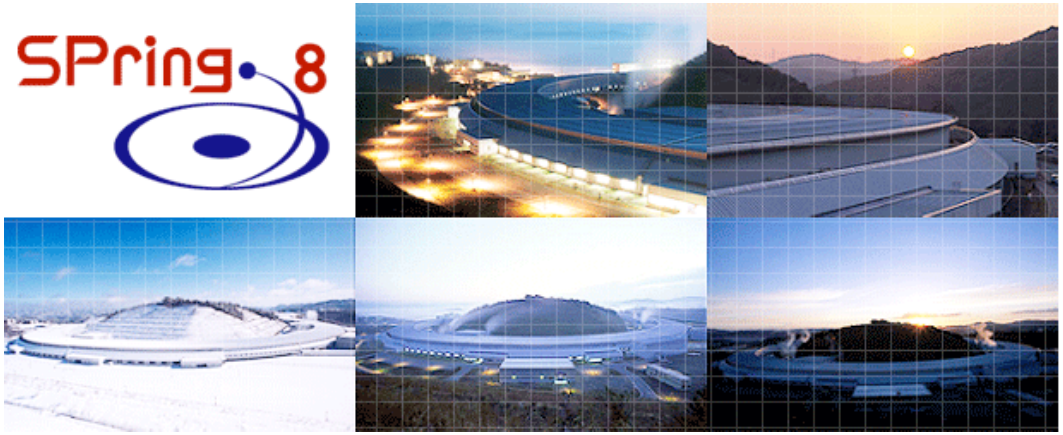


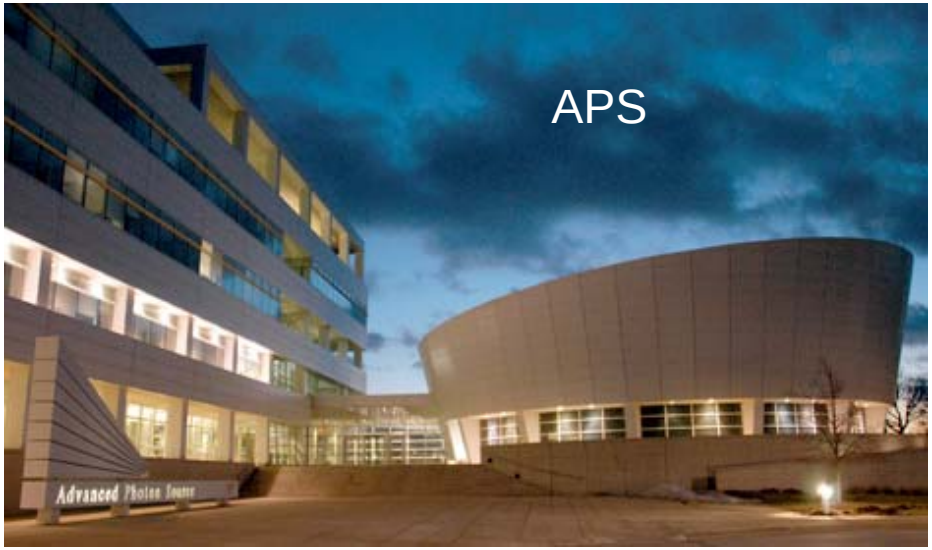


Networking of light sources worldwide

Three-way meetings – APS, ESRF and SPring-8

Have met every 18 months since 1995 (next March 2010 in Japan)



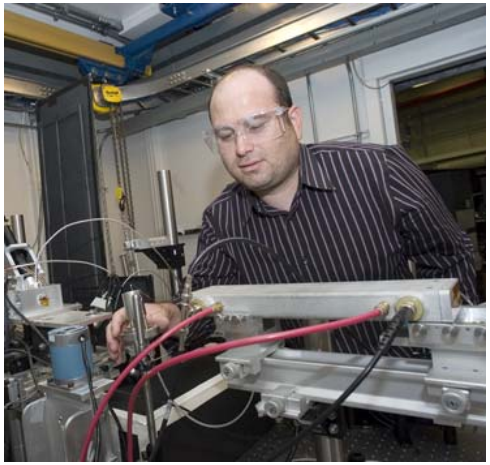


APS Collaborative support of other light sources (2008-09 only)

- Review and Advisory Committees:
  - ALS, CAMD, CLS (Canada), Diamond (UK), DESY (Germany), Elettra (Italy), ESRF (France), LCLS, NSLS, NSLS-II, NSRRC (Taiwan), PF (Japan), PLS (Korea), Sesame (Jordan), SPring-8 (Japan), SSRF (China), SSRL
- Technical assistance (machine)
  - ALS, ANKA (Germany), Australian Light Source, DESY (Germany), Diamond (UK), Elettra (Italy), ESRF (France), FERMI (Italy), LCLS, MAX-lab (Sweden), NSLS, NSLS-II, NSRRC (Taiwan), PF (Japan), PLS (Korea), Sesame (Jordan), SLS (Switzerland), SRS (UK), SSRF (China), SSRL
- Accelerators (not light sources):
  - BINP (Russia), CESR, Cockcroft Institute (UK), GSI (Germany), HEPI (Armenia), ILC, INFN (Italy), ISIS (UK), FNAL, LHC (Geneva), SNS, TJNAF
- Just as many examples of the reverse, i.e. support for APS from others

SESAME – diplomacy through science

- A synchrotron facility in Amman, Jordan established with the help of donations from many countries
  and UNESCO
  - Proposed by Herman Winick and Gustaf Voss 1997
  - BESSY1 (800MeV) donated 2003, many other donations since
  - Planning a third-generation 2.5 GeV source, still in need of support
  - "Soft" opening in 2008
  - Training of potential users around the world



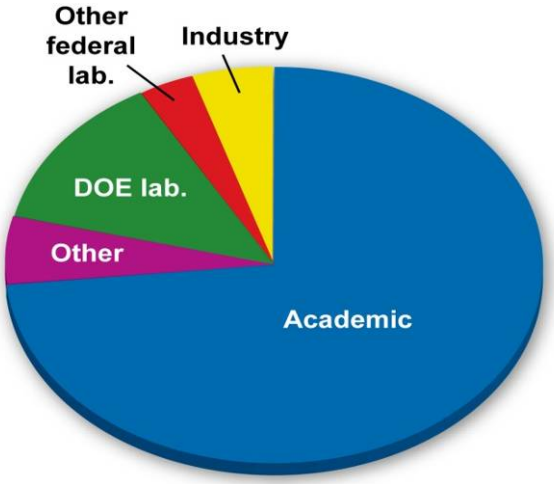
Grad student Guvenc Akgul at APS

Accelerator science and technology - a key issue for the health of many current and future NUFO facilities

- New developments on accelerator technology are critical for future light sources
- Ideas and trained accelerator physicists and engineers
- Have relied heavily on high-energy physics (DOE/NSF) in the past
  - Upcoming Office of Science Workshop this year
- Role for both DOE and NSF

Industrial access to user facilities

- Industrial users typically represent about 10% for most light sources
- In some cases industrial use may be “masked” through academic collaborators, so the fraction may be larger
  - *Partnerships were favored under the Collaborative Access Team system – has been difficult to create new ones with facility-run dedicated beamlines - aiming at virtual partnerships?*



APS users by institution (FY07)

- Access models, e.g. rapid-access and additional user support for smaller companies, should be evaluated
- Re-evaluate proposal review criteria which may be biased in favor of academic access

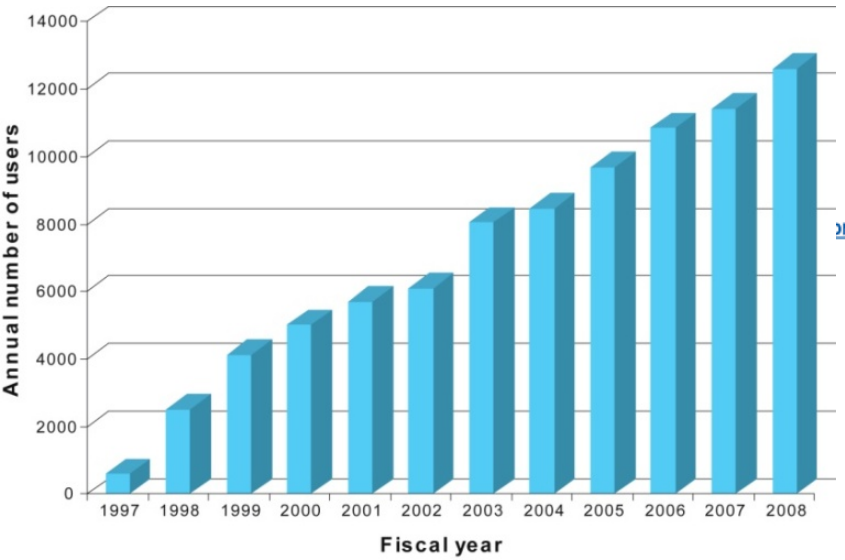
Argonne's Major Initiatives

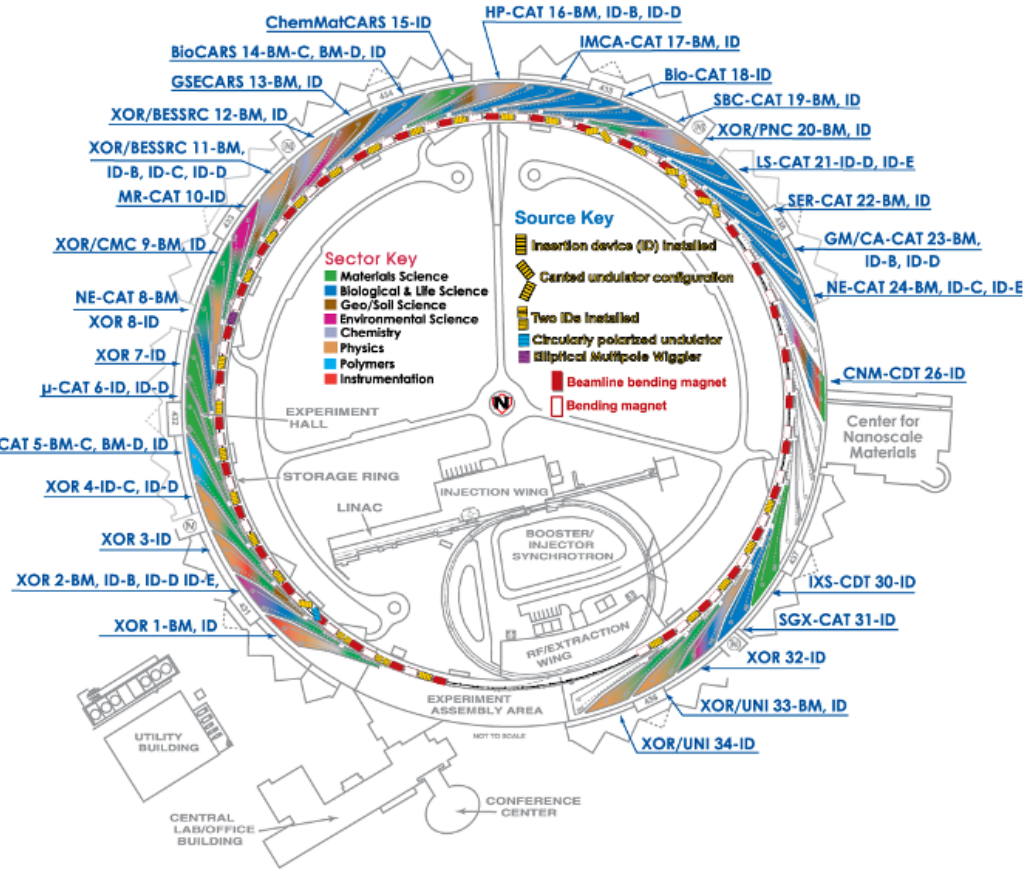
- Energy Storage
- Alternative Energy
- Nuclear Energy
- Materials & Molecular Design & Discovery
- National Security
- Hard X-ray Sciences
- Leadership Computing

APS has grown steadily

- We have 61 operating beamlines (end of FY2009)

User visits



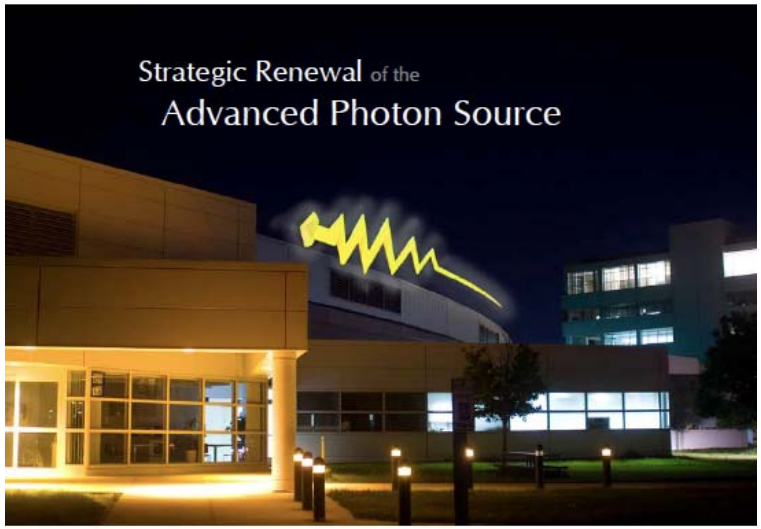


Support for adequate staffing and operational budgets

- The DOE's Office of Science, Office of Basic Energy Sciences has been increasing light-source operating budgets recently to allow adequate staffing on beamlines
  - Optimum number, internationally benchmarked, is 4-5 per beamline
  - Today APS operates 30 of the 61 beamlines (7 beamlines in 2001)
  - As a result, more than half of all beamtime is now open for general competition
  - We have hired ~50 PhD beamline scientists since 2001
    - *many new early career staff*
  - Our overall staff number (~460) has not increased significantly, due to efficiency improvements
- Administration, agency and congressional support has been essential to realize this – user advocacy has been particularly important

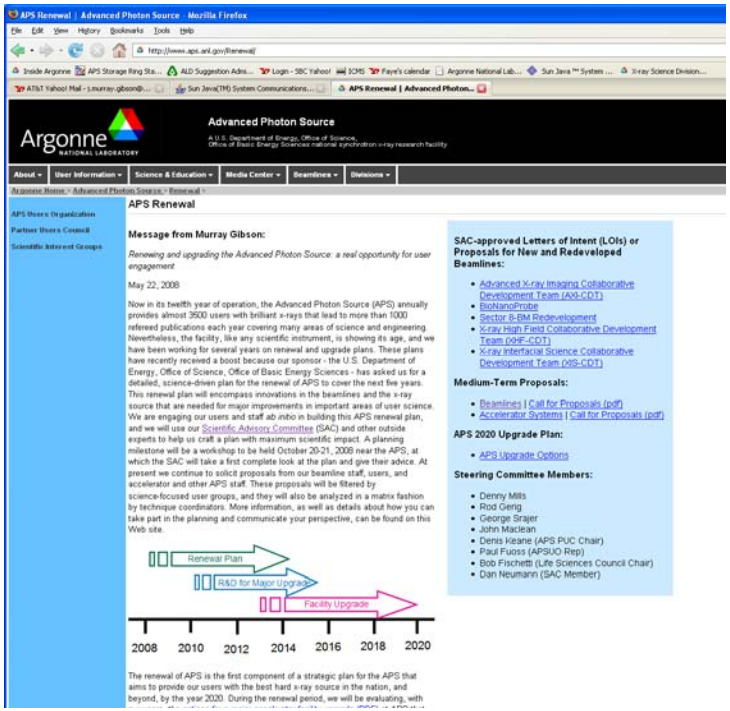
Strategic planning for the renewal of APS

Argonne NATIONAL LABORATORY | Advanced Photon Source



Proposal for approval
of Conceptual Design (CD-0)

Submitted to the US Department of Energy
Office of Basic Energy Sciences
May 31, 2009

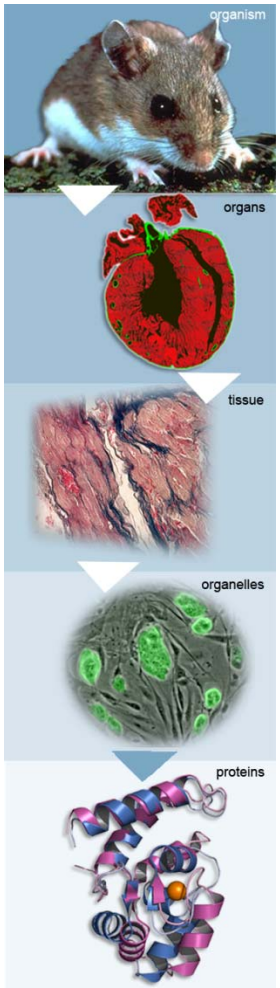


Renewal will revolutionize capabilities

- Machine upgrade
  - Higher current, longer, optimized insertion devices, improved stability, ultrafast (~1ps) x-ray pulses
- New and upgraded beamlines addressing key science drivers
- Enabling technical capabilities
  - Detectors, optics, nanopositioning, data analysis software

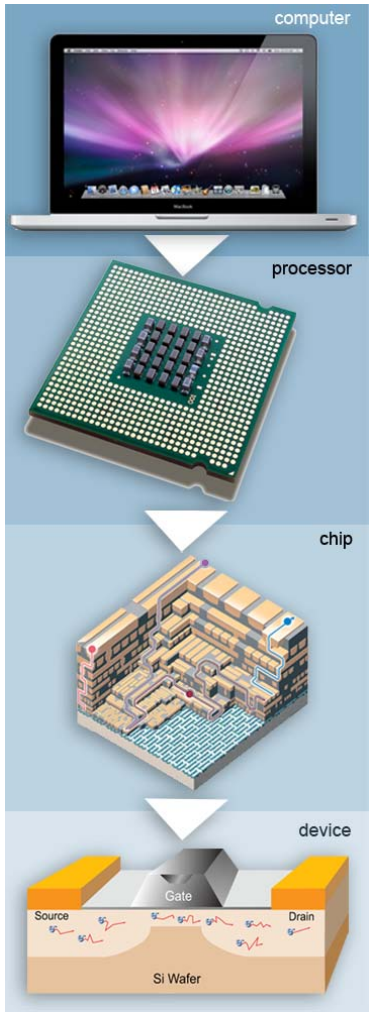
- Proposal (for DOE's CD-0) submitted May 31st, describes vision of the upgraded APS…

Mastering hierarchical structures through imaging



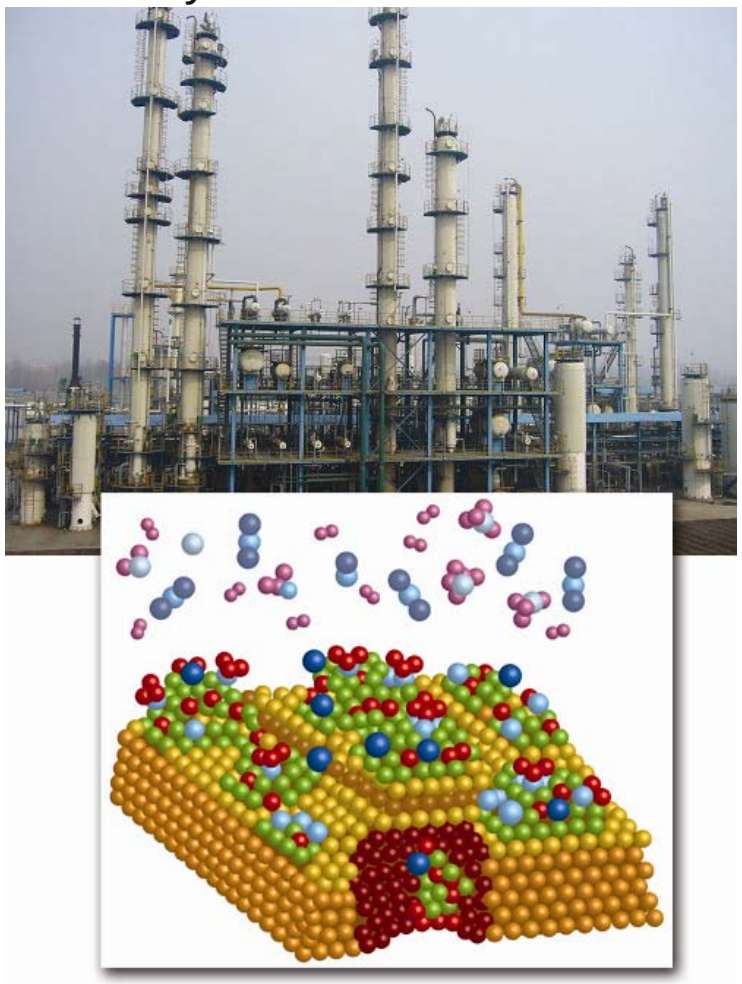
"Imaging specific molecules and their interactions in space and time will be essential to understand how genomes create cells, how cells constitute organisms and how errant cells cause disease. Molecular imaging must be extended and applied from nanometre to metre scales…", Roger Tsien

- Hierarchical structures are key to life, machines and complex nanostructured materials
- High-energy x-rays offer a unique tool to probe all relevant length scales and understand their interconnection

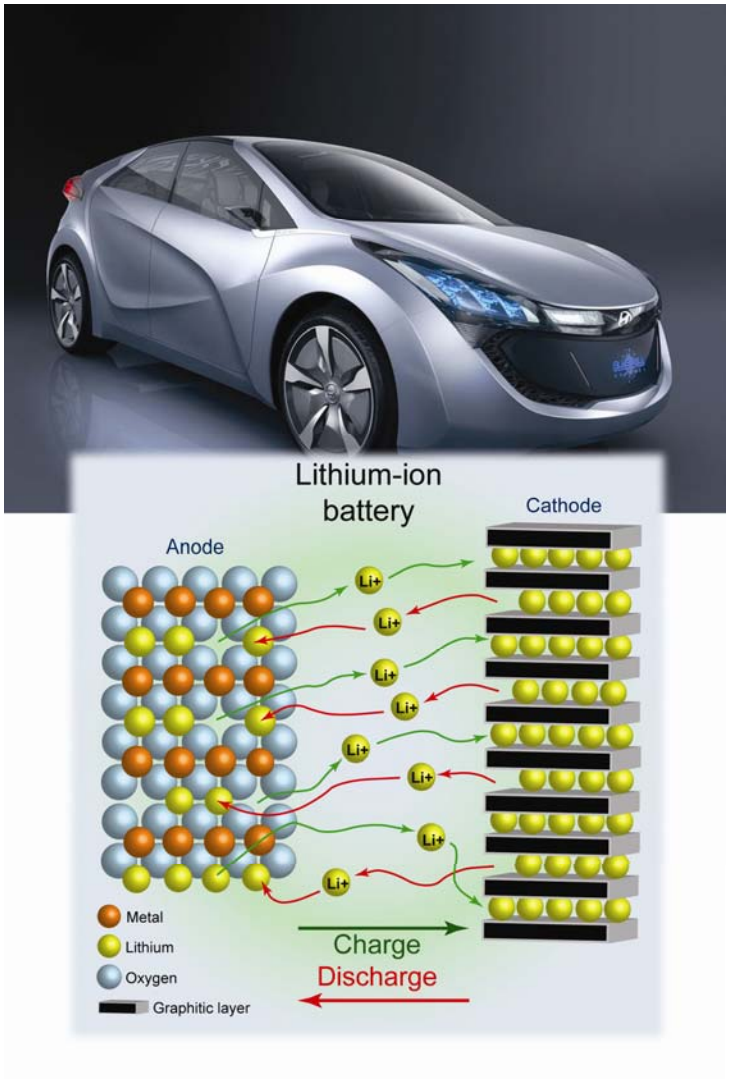


Real materials under real conditions in real time

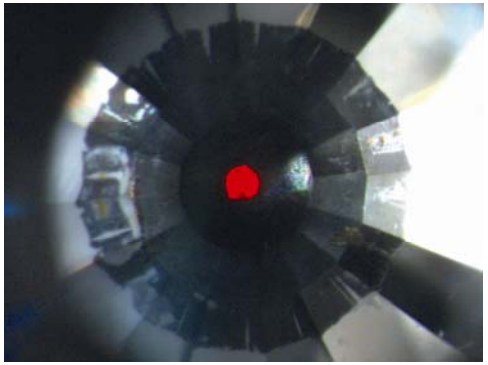
Catalysis

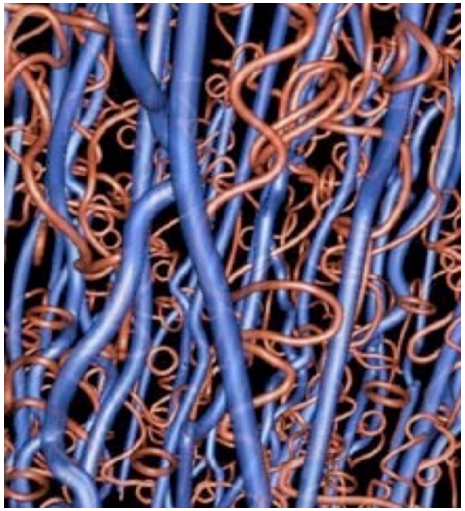


Batteries

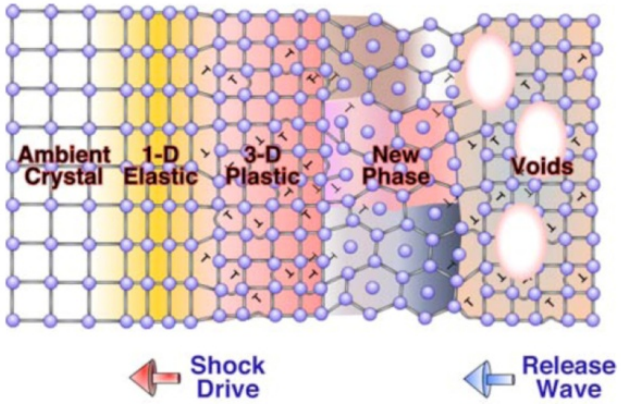


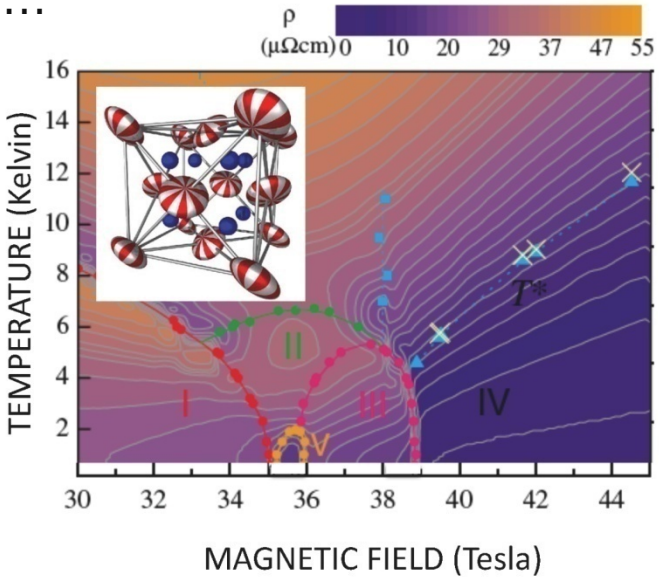
Materials under extreme conditions





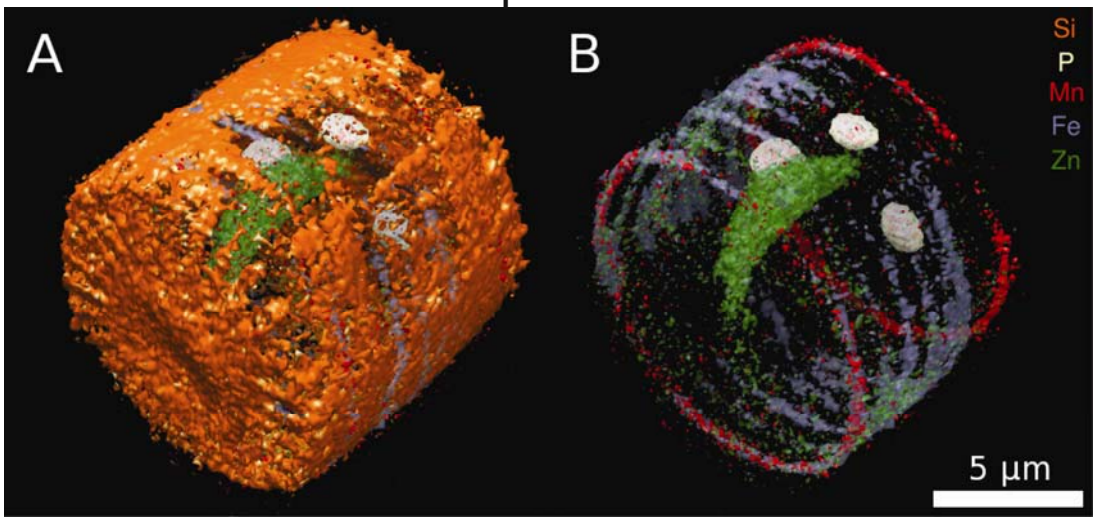
High pressures, high magnetic fields…



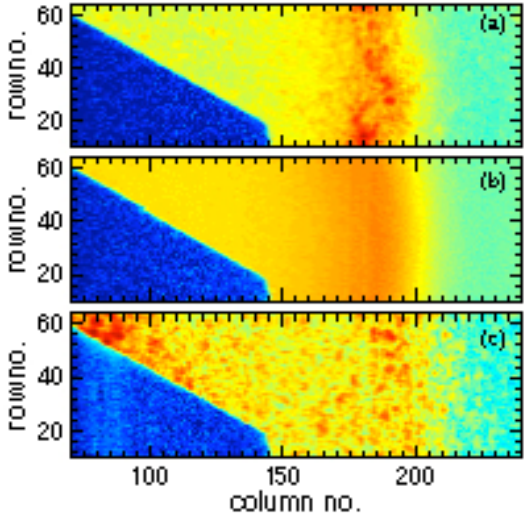


Imaging and coherence

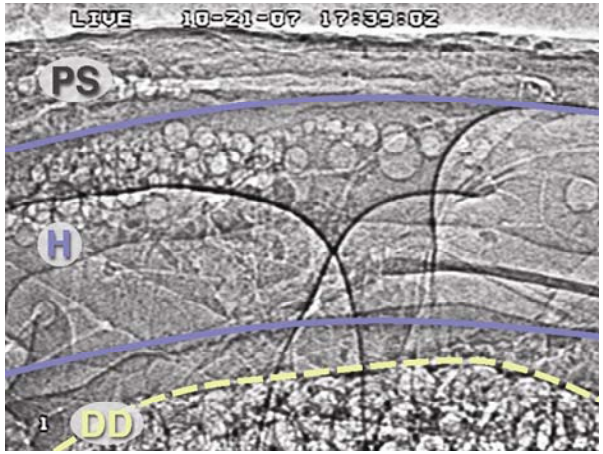
Carbon sequestration



Polymer nanostructures

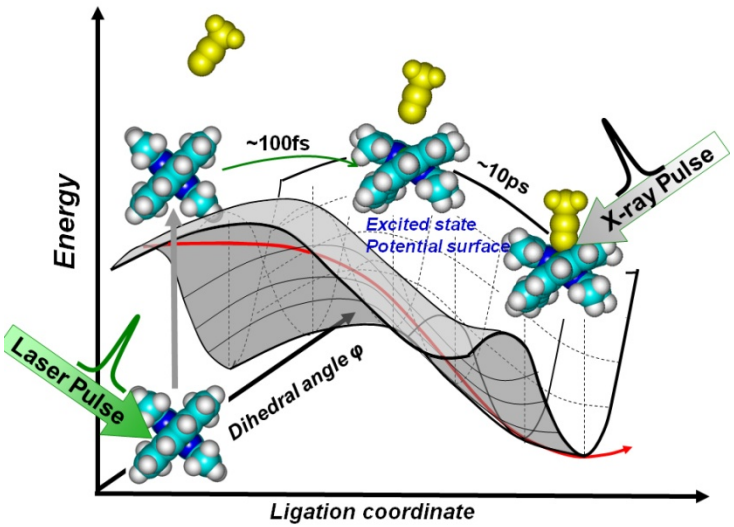


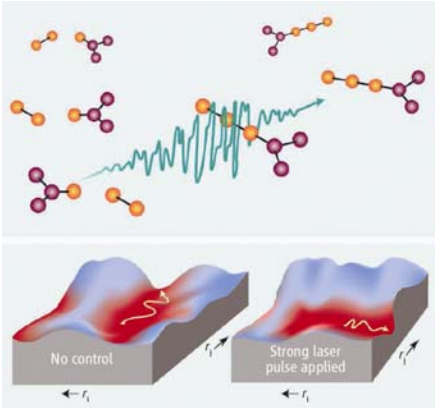
Organisms at work



Ultrafast dynamics

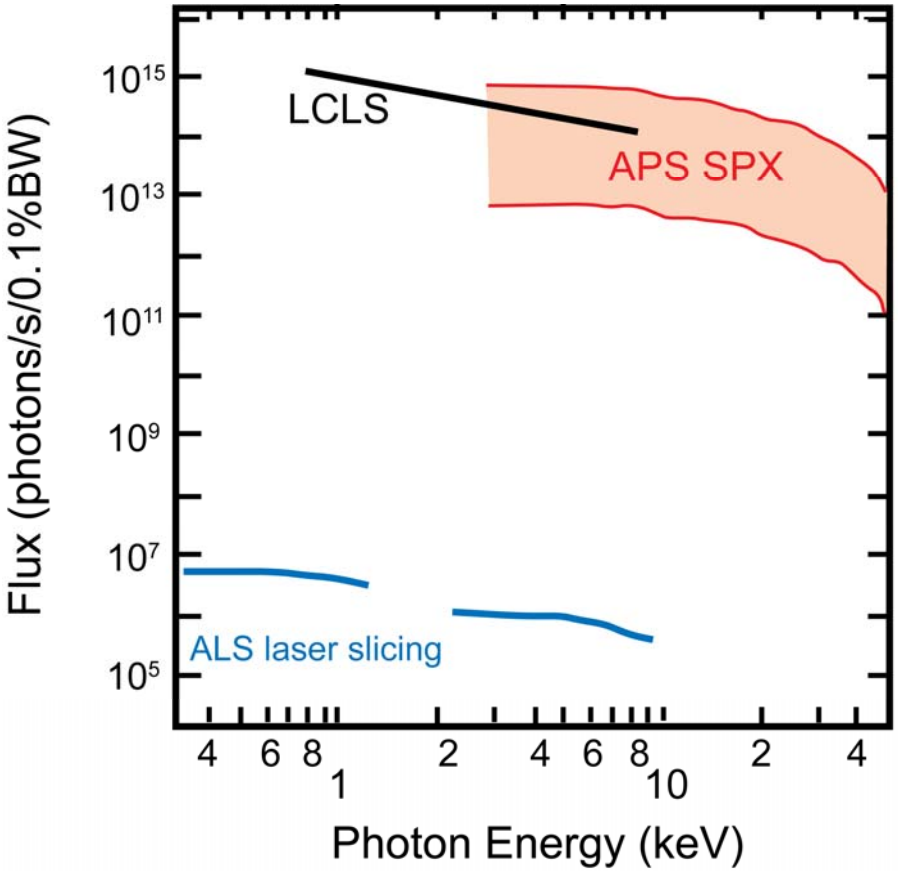
Photosynthesis





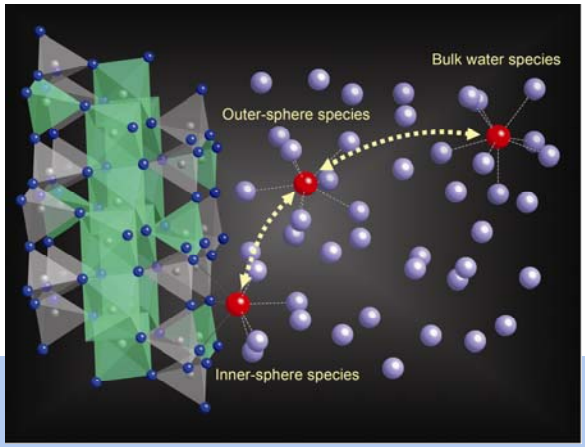
New reaction paths

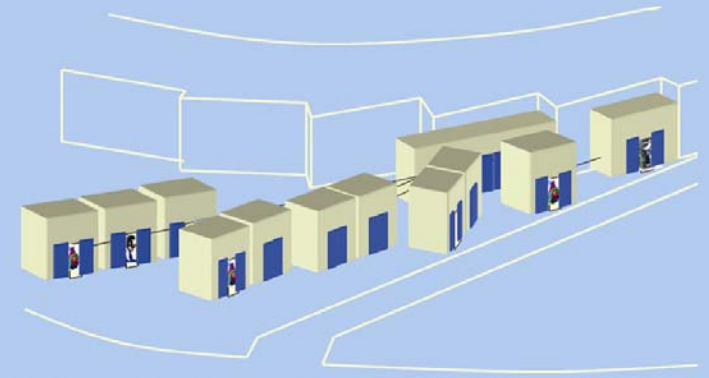
Short Pulse (~1ps) X-Rays (SPX)



Interfaces in complex systems

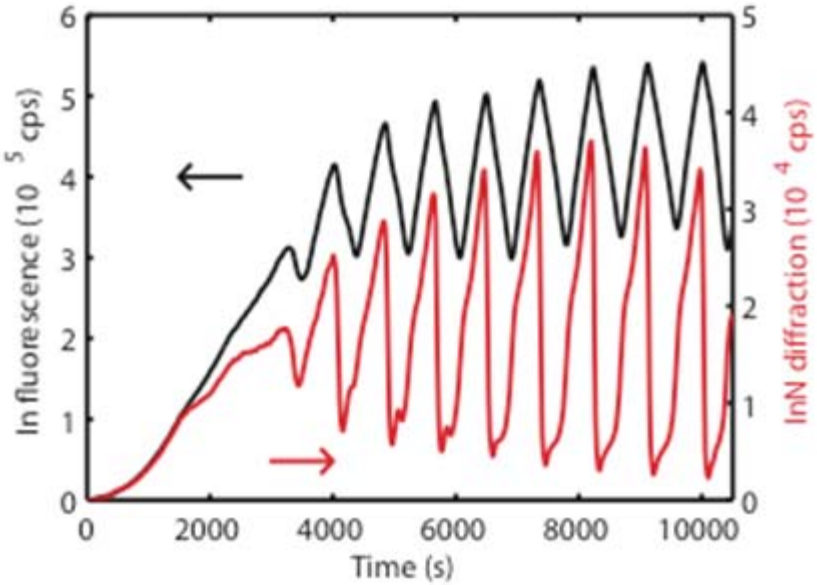
Geochemistry

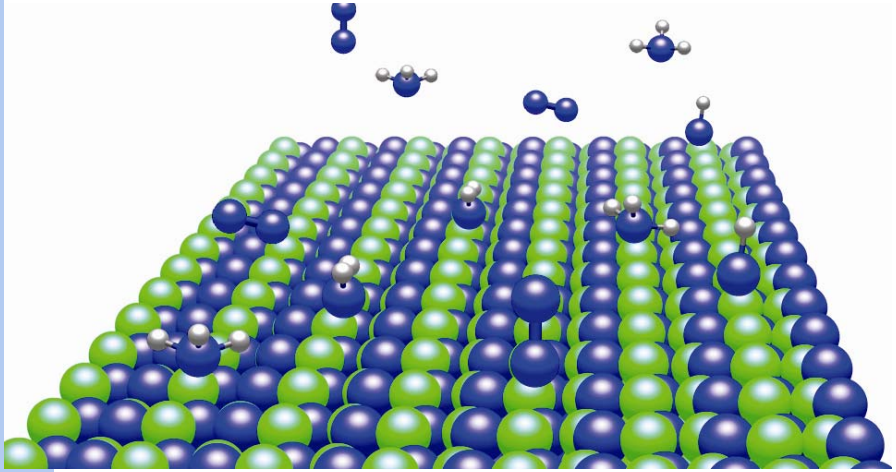




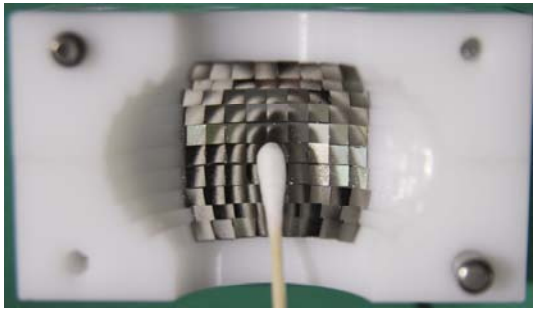
Conceptual layout of the X-Ray Interface Science facility

Solid-state lighting

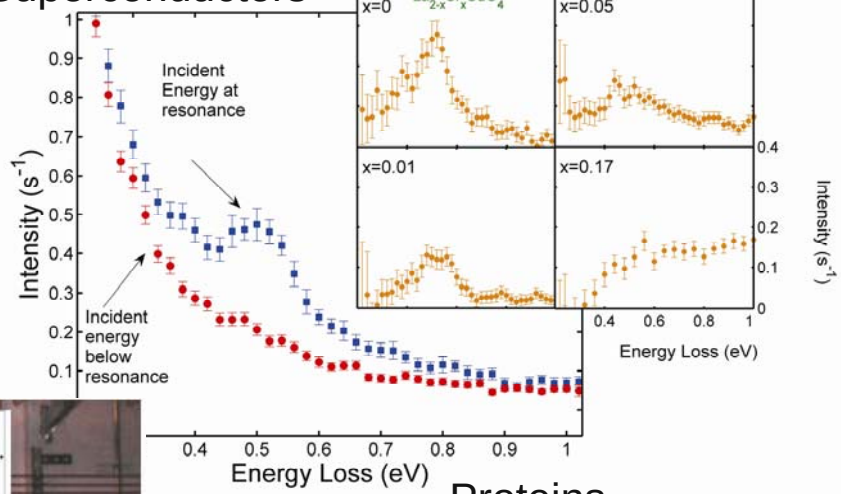


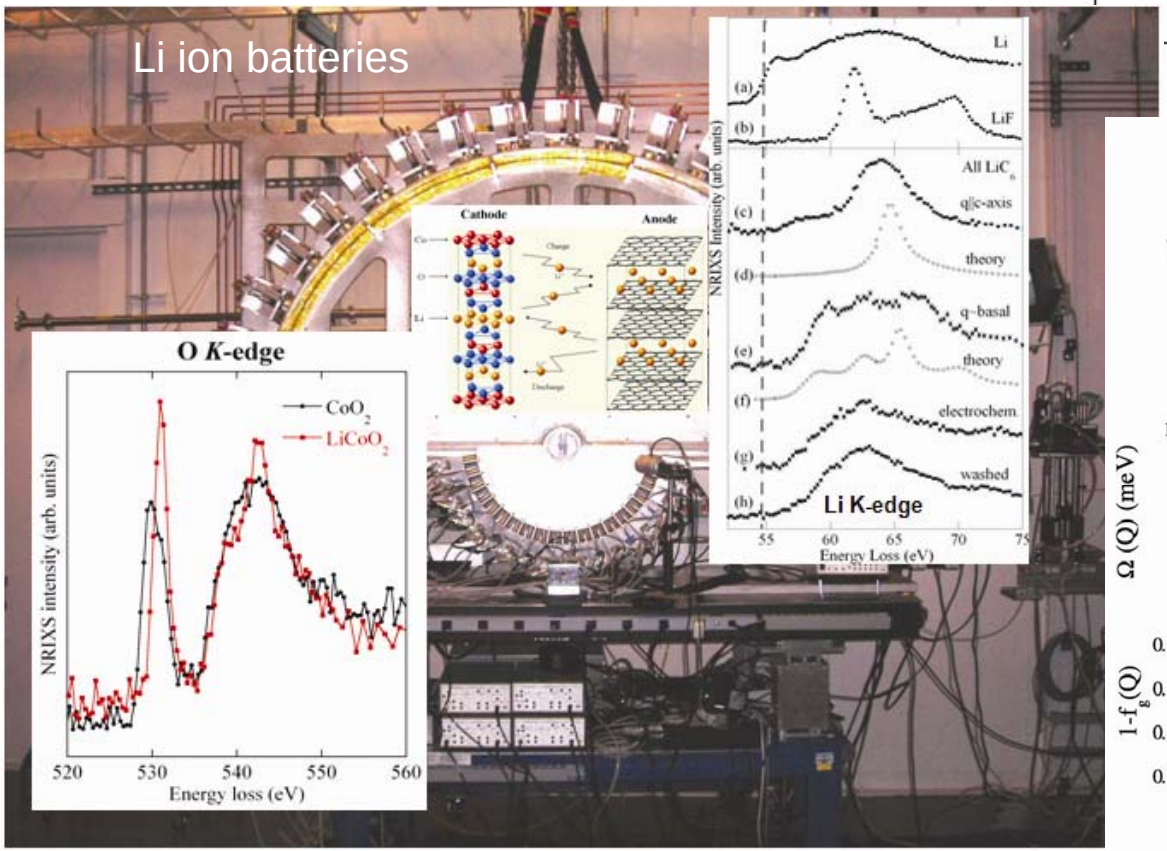


High-resolution spectroscopy

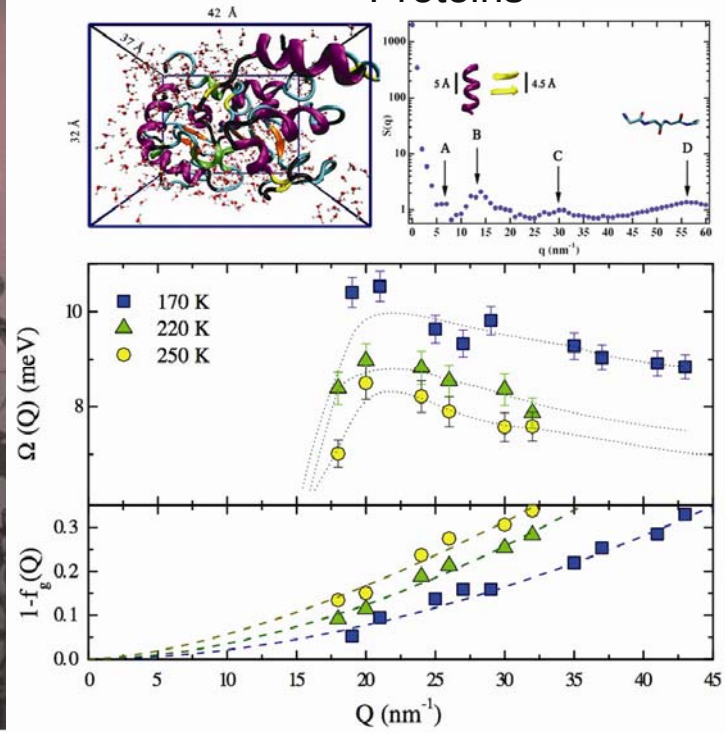


Superconductors



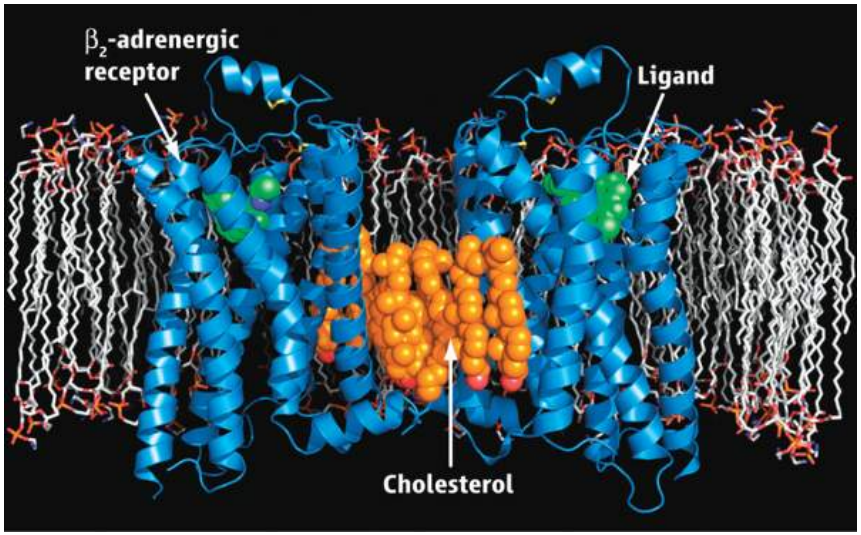


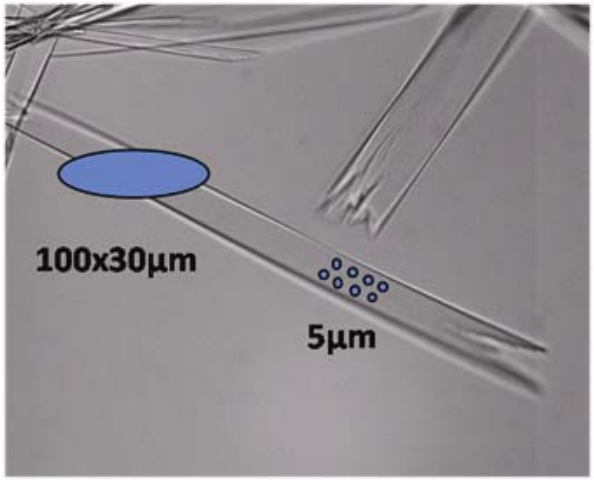
Proteins



Connecting proteins to organisms

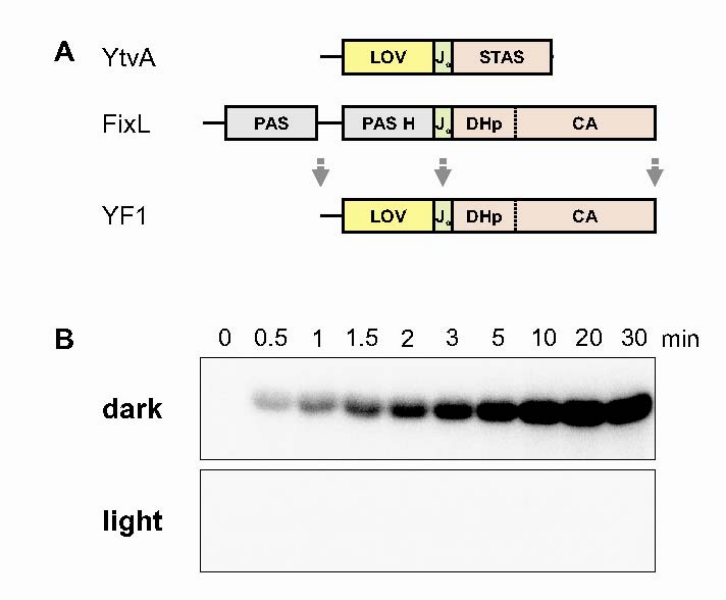
GPCR Membrane protein





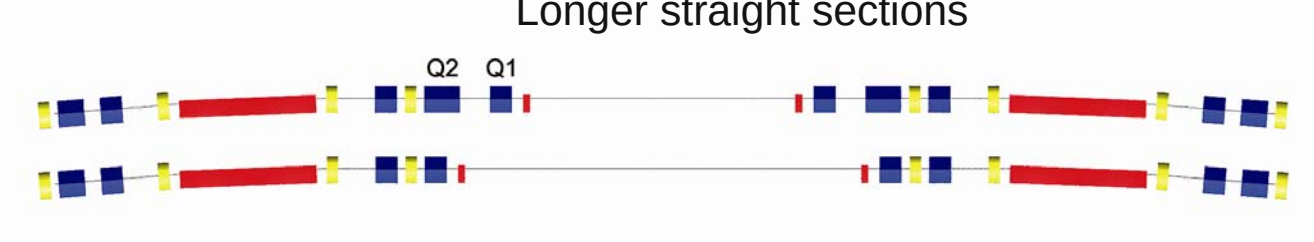
Microcrystallography

Optogenetics

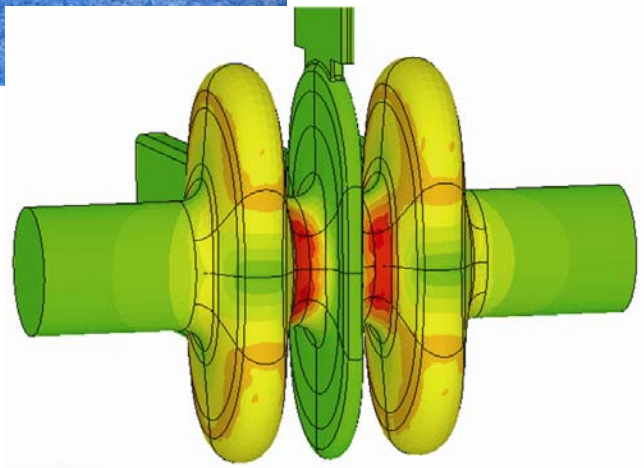


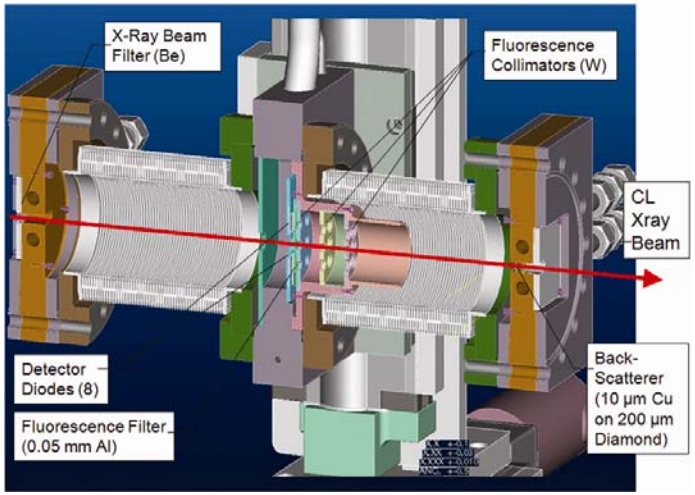
Accelerator upgrades

Longer straight sections



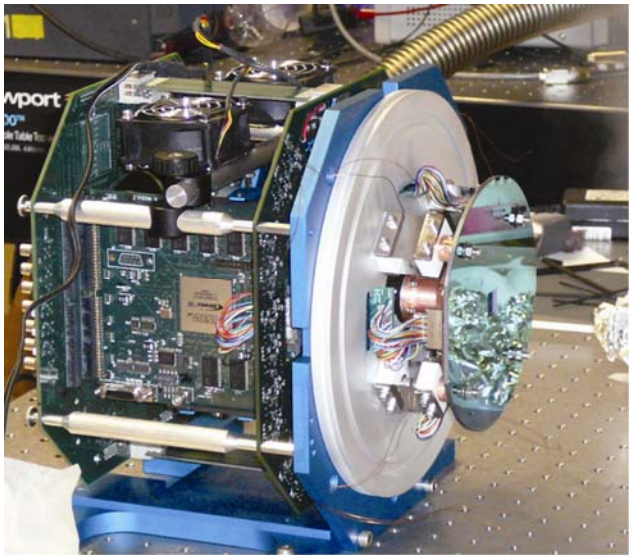
SPX “crab” cavities



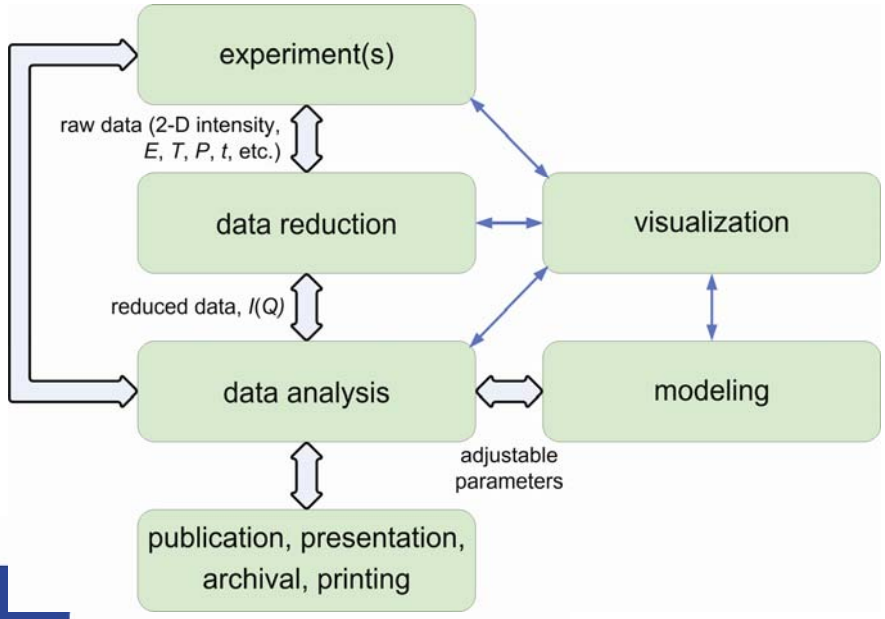


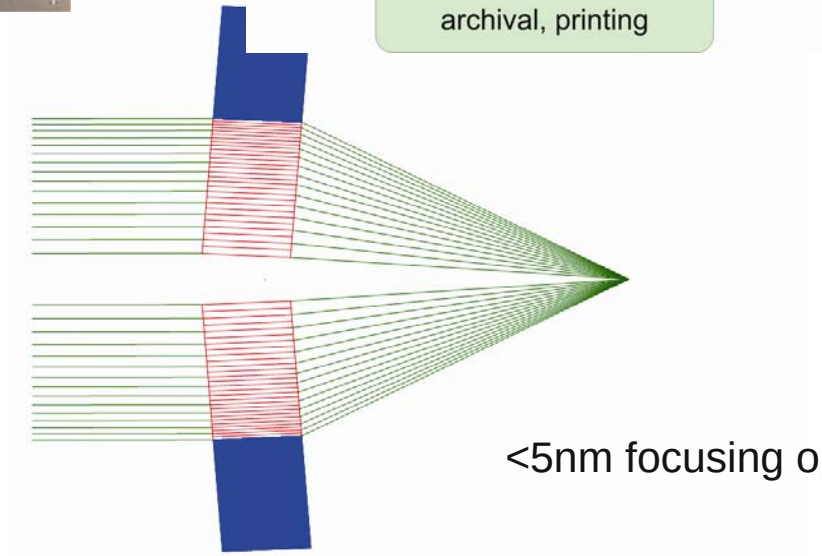
X-ray beam position monitors

Enabling technical capabilities



Detectors

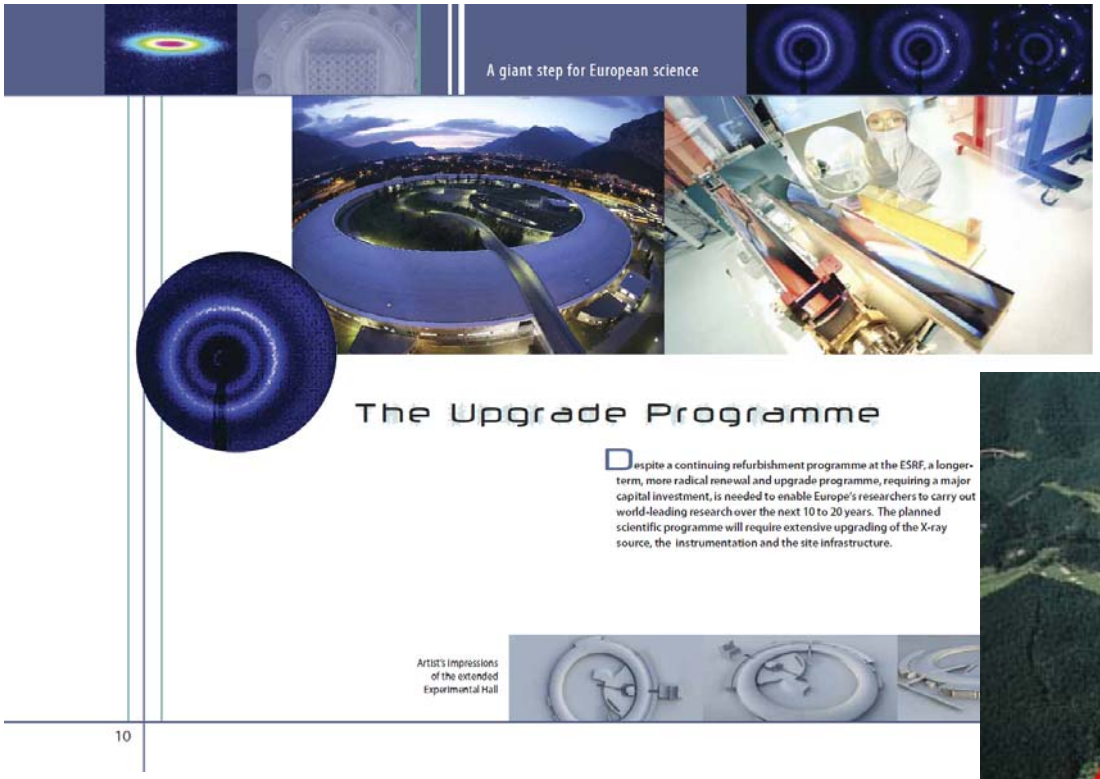




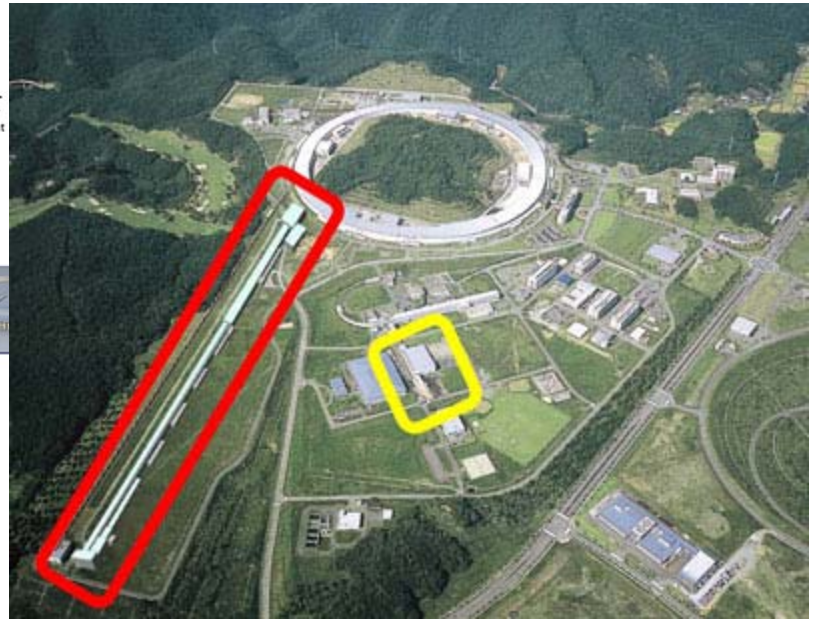
<5nm focusing optics

Upgrades to SPring-8 and ESRF

European Synchrotron Research Facility (ESRF)
Grenoble-France

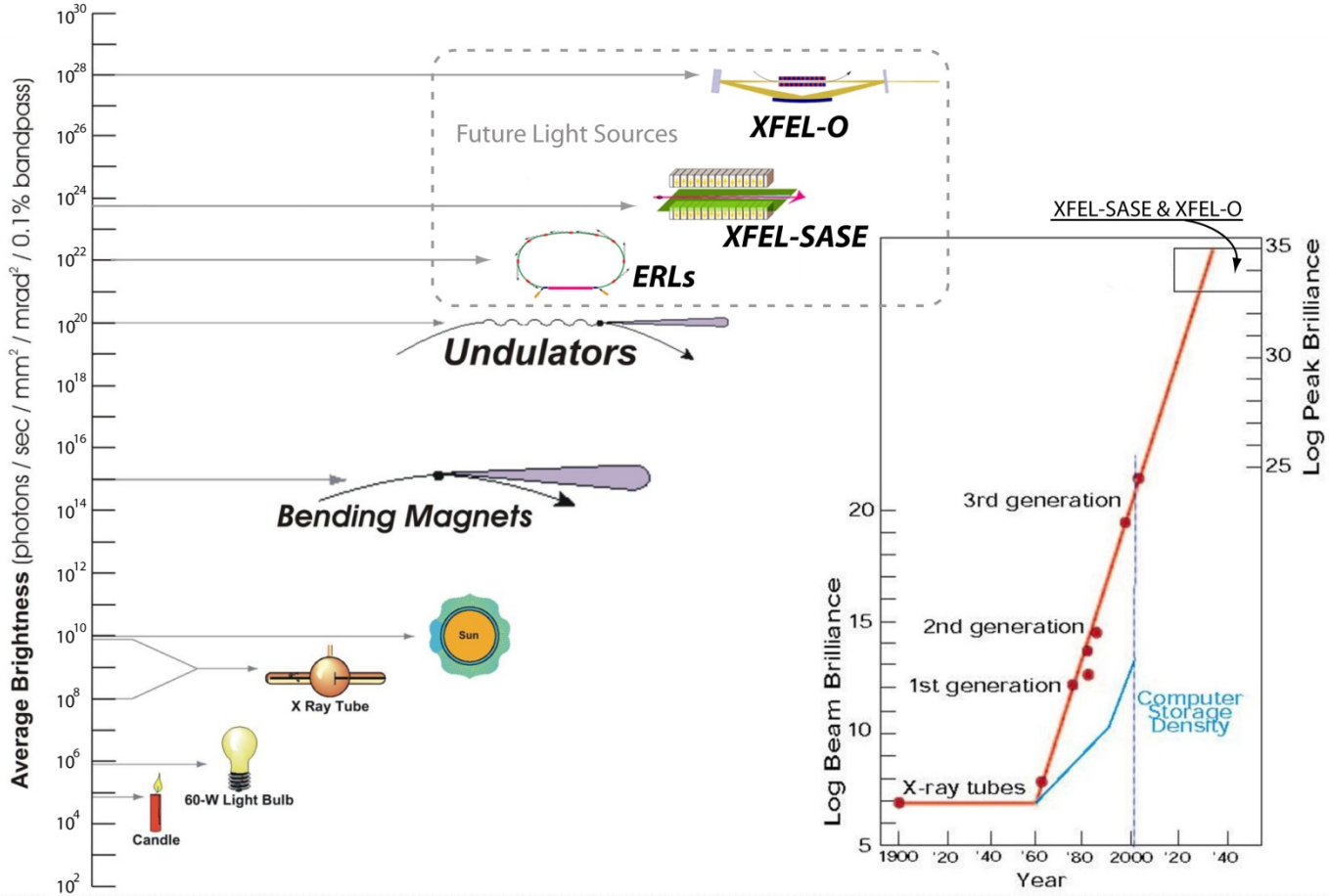


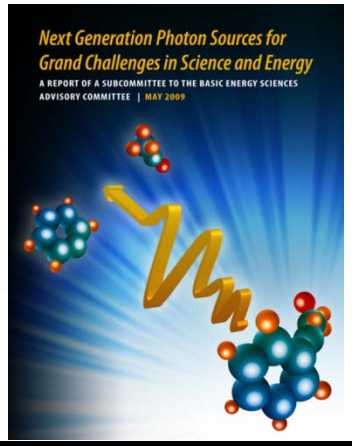
SPring-8 (Harima, Japan)



Both upgrade projects under construction

Beyond the renewal - new possibilities for future hard x-ray sources/upgrades?

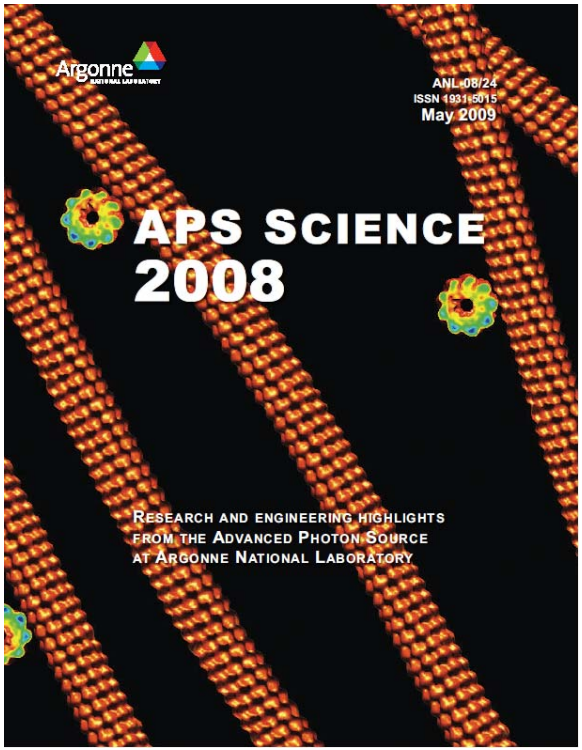




Offer far higher brilliance, coherence and shorter pulses

Conclusion

- Synchrotron radiation is a powerful tool for the new era of “Control Science”
- New and upgraded facilities are demanded worldwide
  - APS has a vision for a major renewal that is being considered by DOE
- Networking of light sources worldwide is strong but very informal
- There are general and important issues that light sources must address to reduce barriers to growing the user community and scientific impact
  - Particularly (but not only) for industrial users



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