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U.S. Department
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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

Advanced Photon Source Update



ANL-09/08

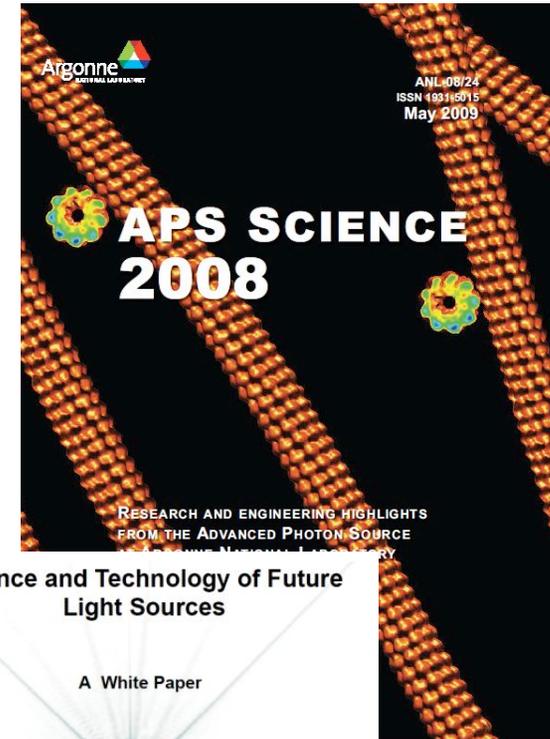
Renewal of the Advanced Photon Source



A white paper prepared for the
Department of Energy, Office of Science,
Office of Basic Energy Sciences
by the management and users of the
Advanced Photon Source

November 1st, 2008

Contact: jmgibson@aps.anl.gov



Science and Technology of Future Light Sources

A White Paper

Report prepared by scientists from ANL, BNL, LBNL and SLAC. The coordinating team consisted of Uwe Bergmann, John Corlett, Steve Dierker, Roger Falcone, John Galyuda, Murray Gibson, Jerry Hastings, Bob Hettel, John Hill, Zahid Hussain, Chia-Chang Kuo, Janos Kisz, Gabrielle Long, Bill McCuddy, Tor Raubenheimer, Fernando Saundale, John Seeman, Z-X Shen, Gopal Shenoy, Bob Schoenlein, Qun Shen, Brian Stephenson, Joachim Stöhr, and Alexander Zholents. Other contributors are listed at the end of the document.

Argonne National Laboratory
Brookhaven National Laboratory
Lawrence Berkeley National Laboratory
SLAC National Accelerator Laboratory

J. Murray Gibson
2009 User Meeting
May 4th 2009

Safety- ESAF system part of smooth running user access

APS - Experiment Safety Assessment Form

Main Menu || Search Criteria || Instructions || Logout ||

General | Experimenters | Description | Materials | Equipment | Lab Use

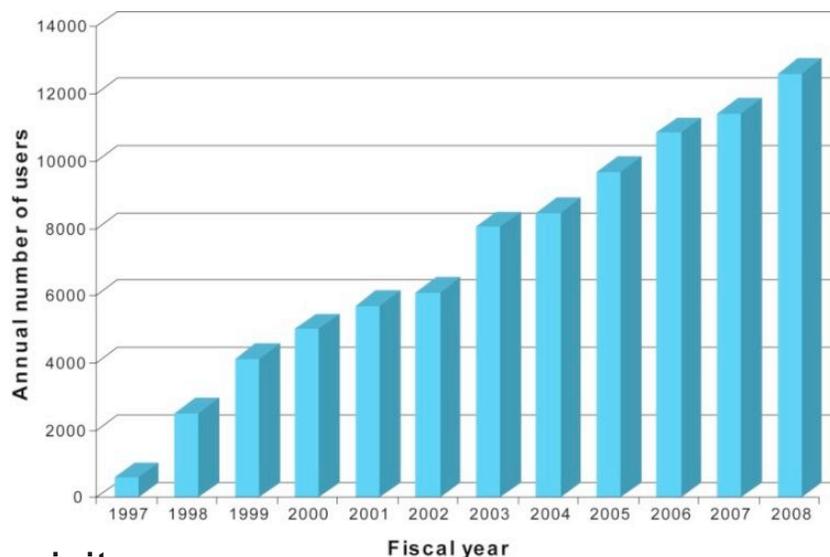
Status : Pending (Ingall) PI

NOTE : No experiment will be allowed to run until a properly completed and approved experiment : has been posted by an APS Floor Coordinator

Sector: 02 - XOR-02 Date Submitted: 03/31/2009

Experiment Title: Imaging and identification of particulate phosphorus within Antarctic marine plankton

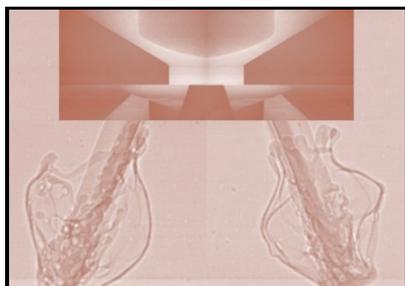
Micro fluorescence



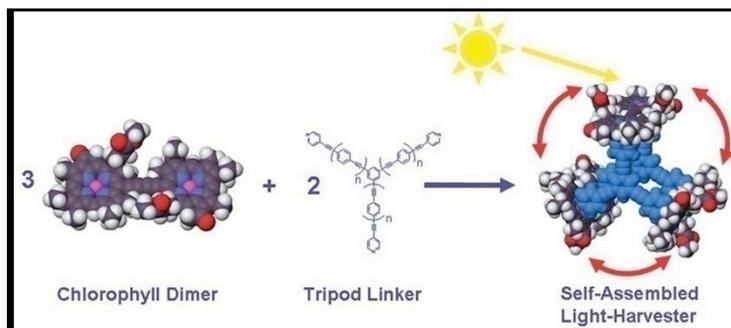
User visits per year

- Over 3000 ESAFs / Year
- ~3500 Unique Users / Year
- >13,000 Visits / Year
- Still need to be vigilant that hazards are properly identified and controls followed
- ANL is implementing a new lab-wide work planning and control system, based largely on the ESAF

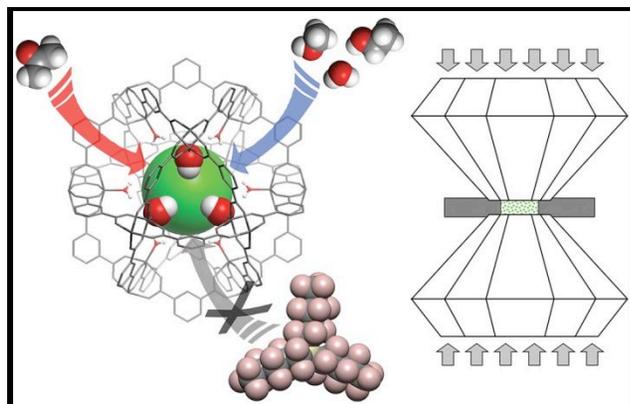
APS research addresses key challenges in energy...



Better burning



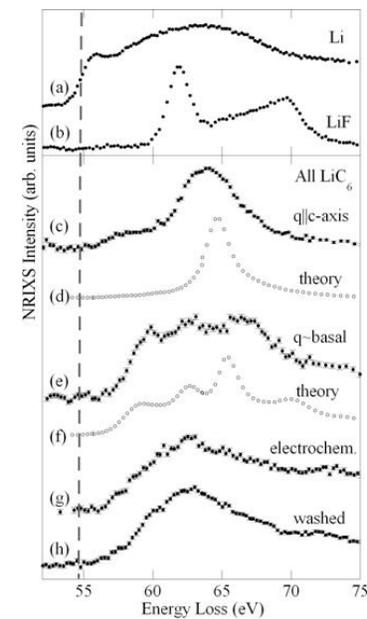
Natural solar cells



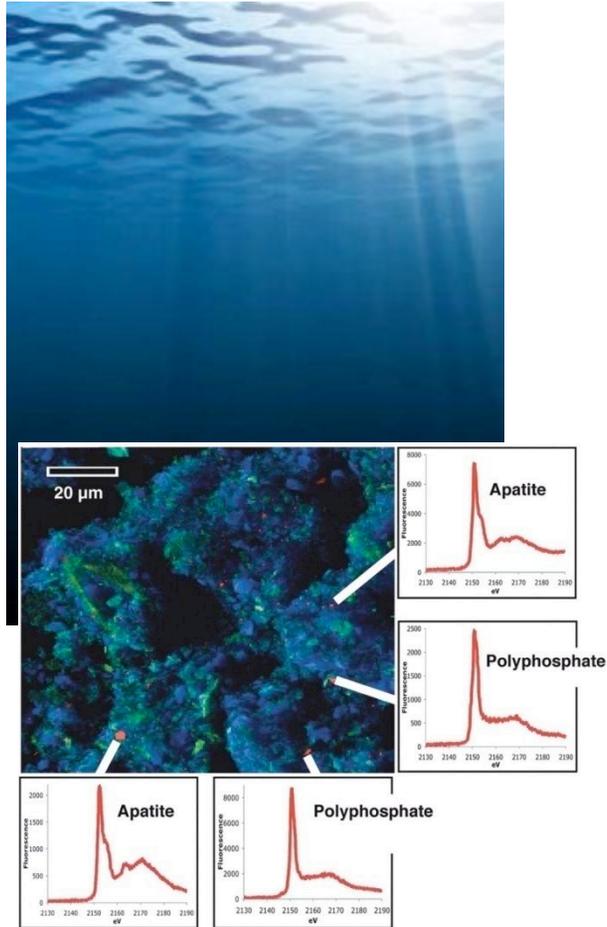
Storing hydrogen



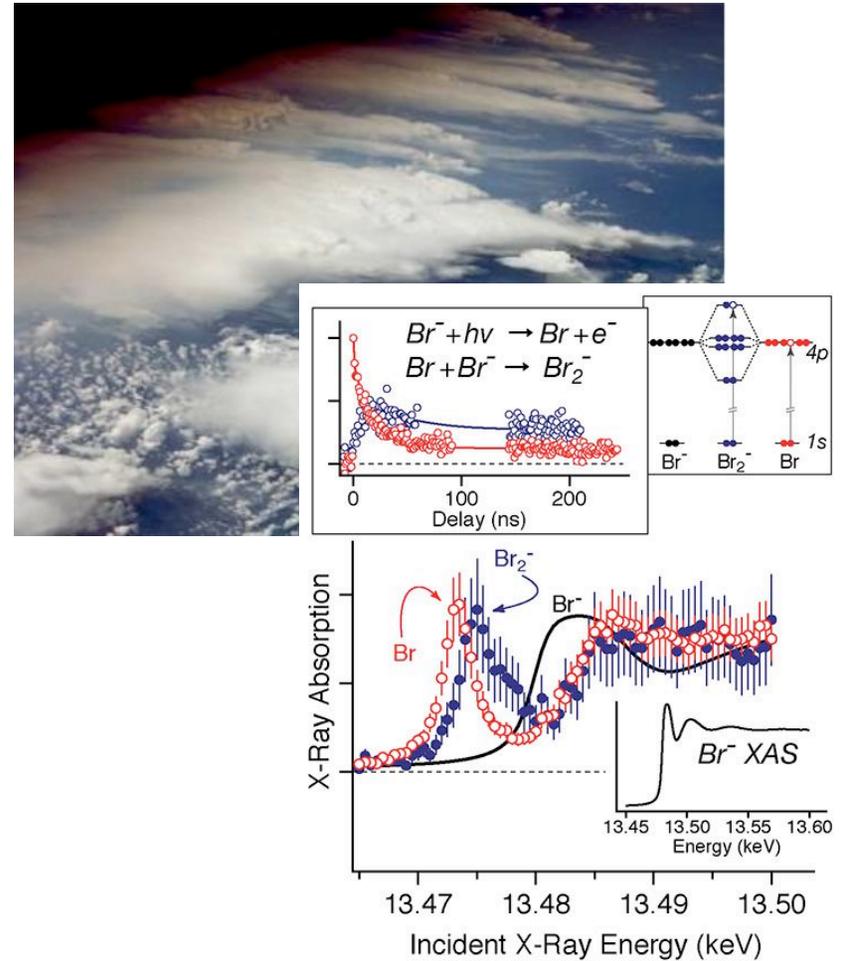
Better batteries



and climate change...

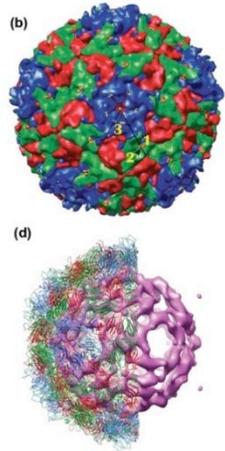


how sea animals capture carbon

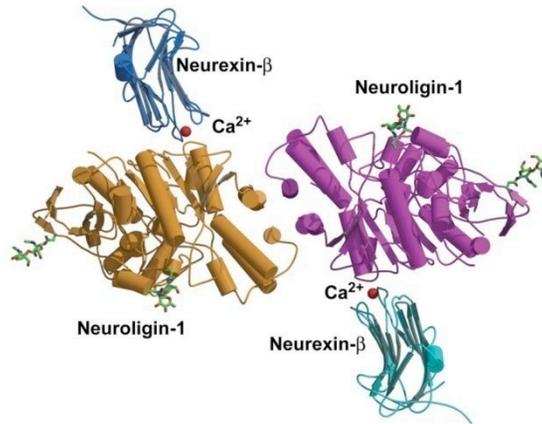


understanding free radicals in the atmosphere

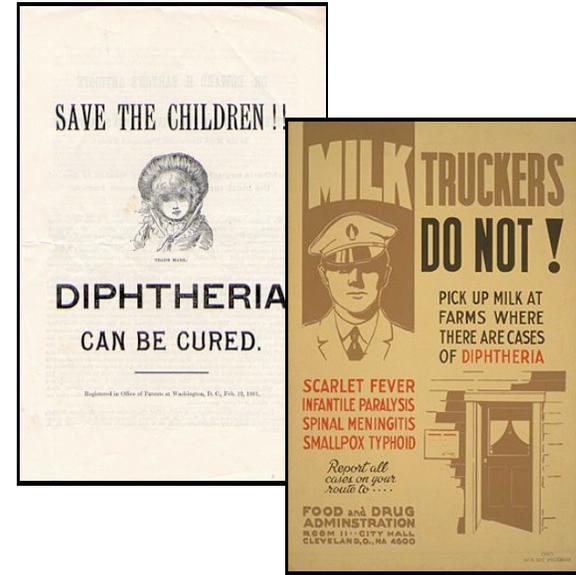
human health...



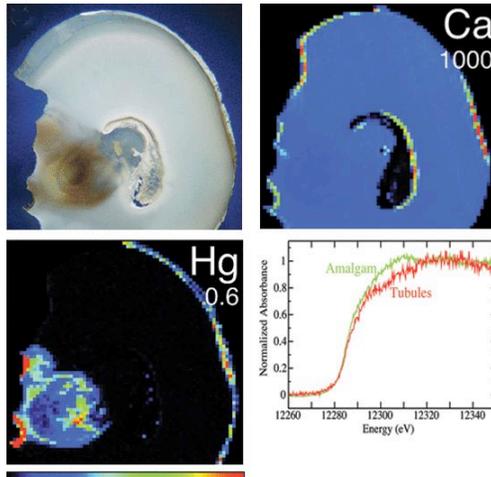
viruses that attack cancer



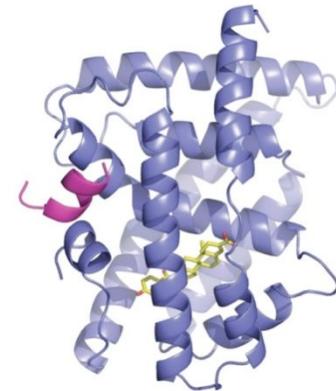
understanding autism



taming a killer

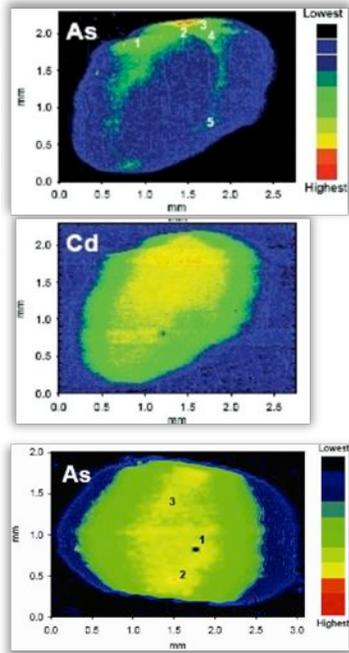


safer dentistry

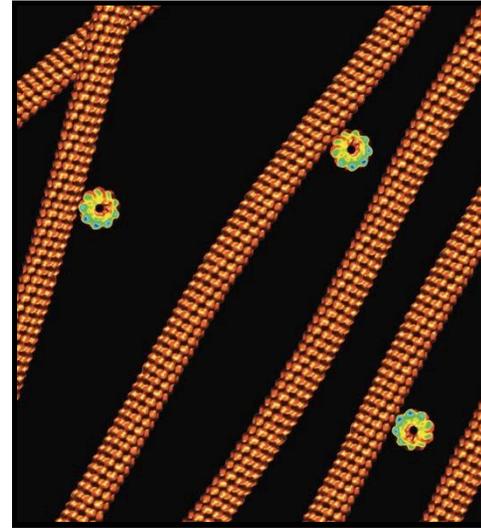


living with obesity

food and water...



is brown rice good for you?

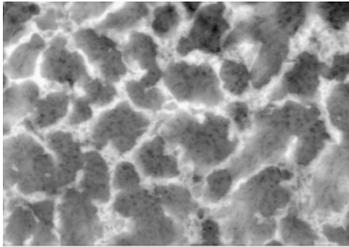
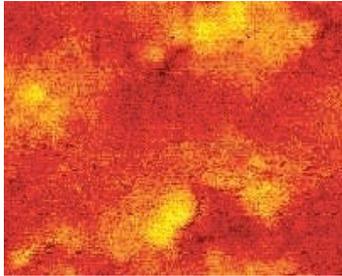


understanding plant viruses



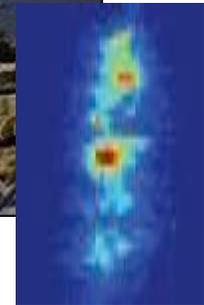
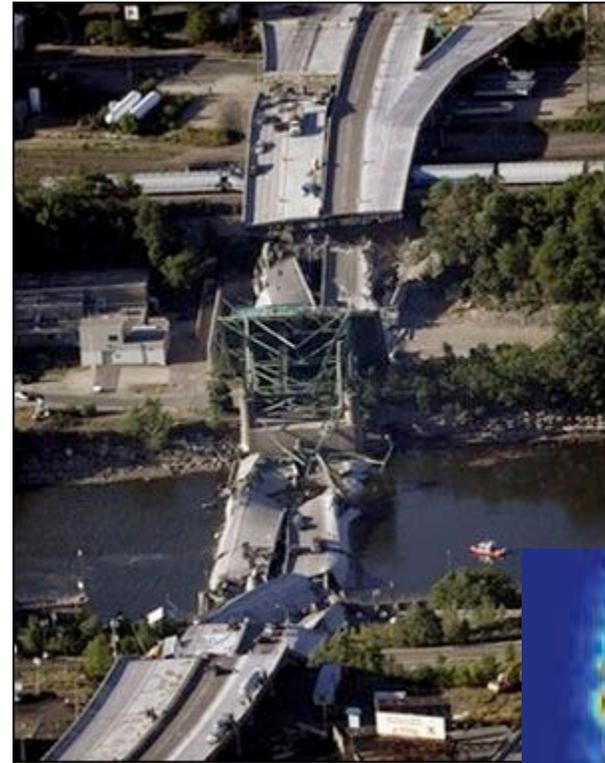
jets and aerosols

better infrastructure...

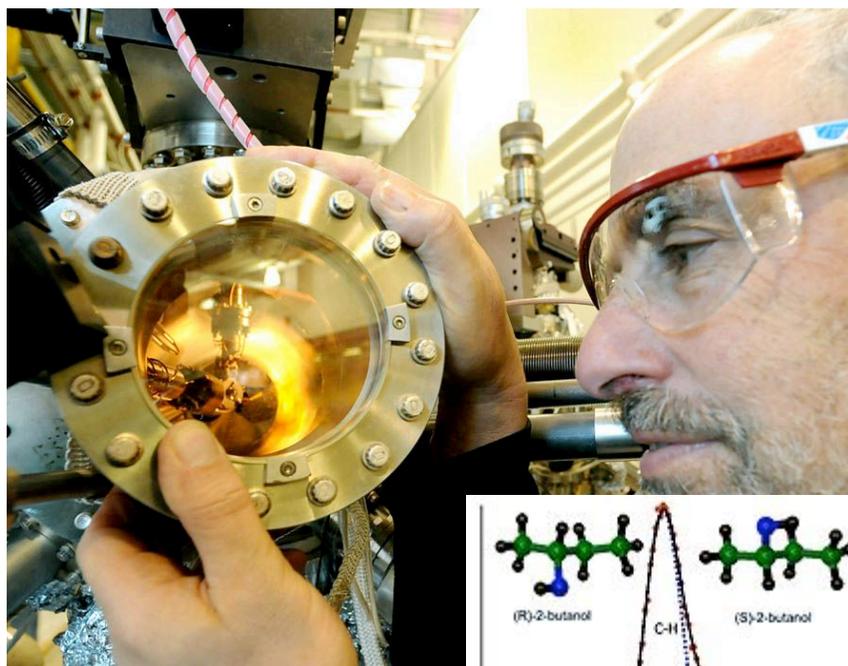


oxide scales
could save \$1B for
US hydrogen industry

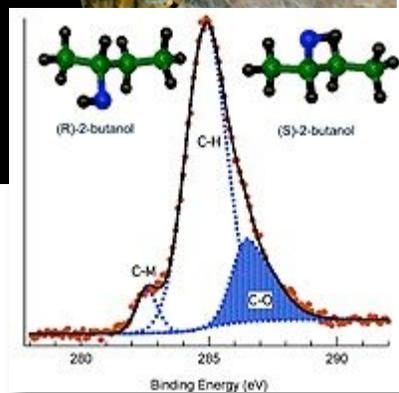
understanding metal fatigue
could save lives and money



ancient history...



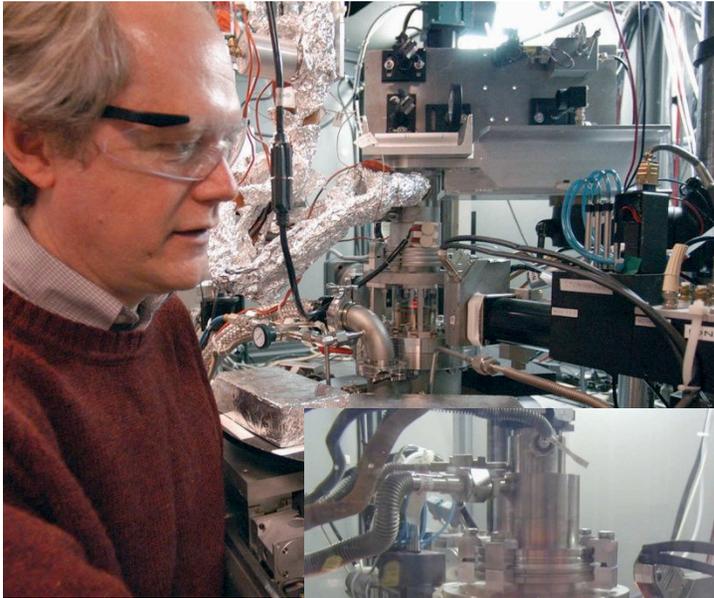
life began with a twist



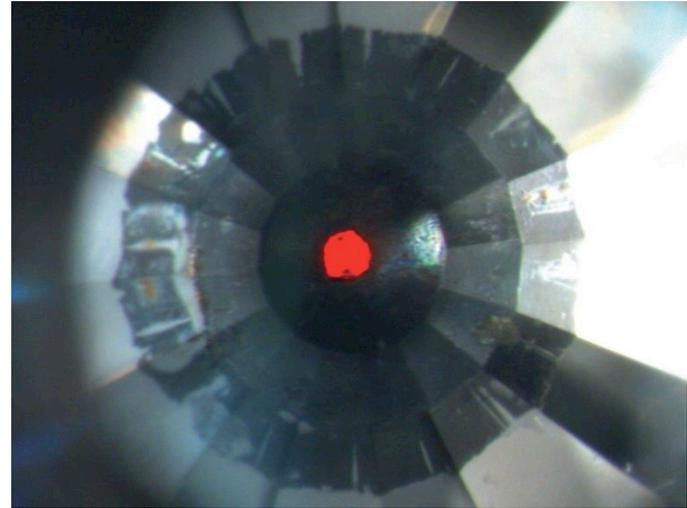
trading with the enemy in 1000BC



basic science that could enable new technology...

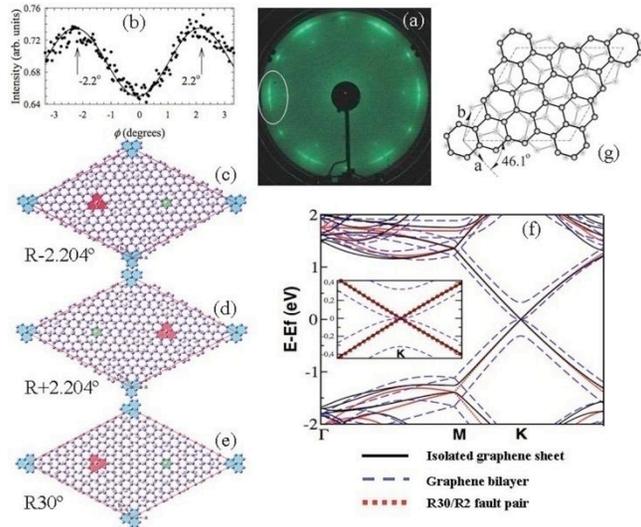


making waves for efficient lighting

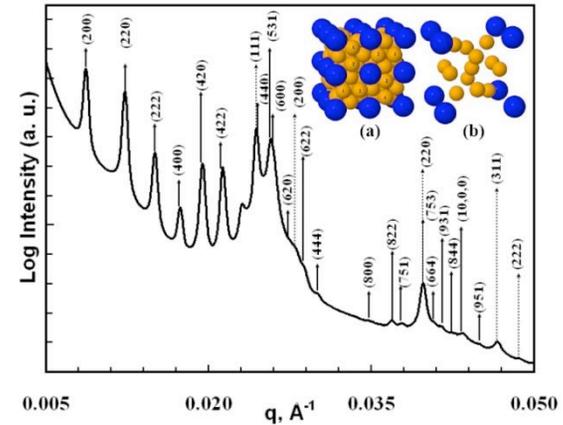


solid oxygen holds surprise
at HP

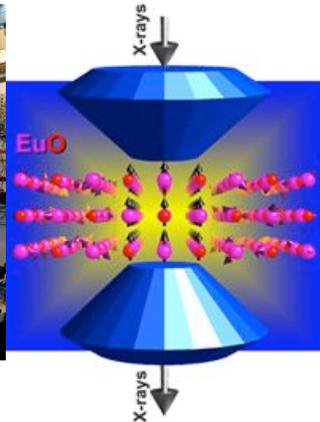
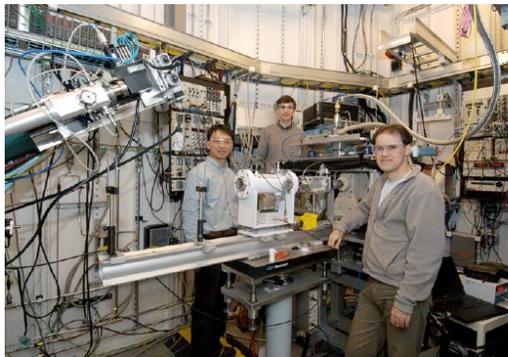
and enhance economic competitiveness



the road to “graphene” electronics



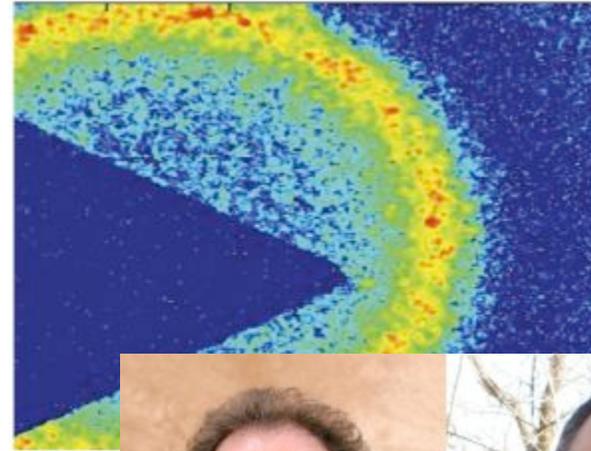
self-assembly of polymers



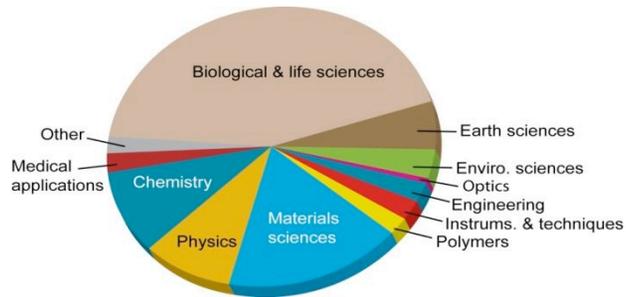
better magnetic materials

The Compton Award

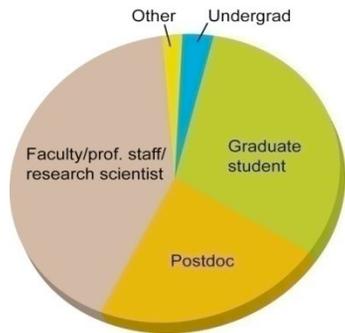
- To Gerhard Grubel, Simon Mochrie and Mark Sutton for their pioneering development of X-ray Photon Correlation Spectroscopy
- This technique can access unique information on the dynamical behavior of systems, valuable in understanding polymers, glasses and many other important materials
- The method relies on source coherence and is one area we plan to strengthen in the renewal and upgrade of APS



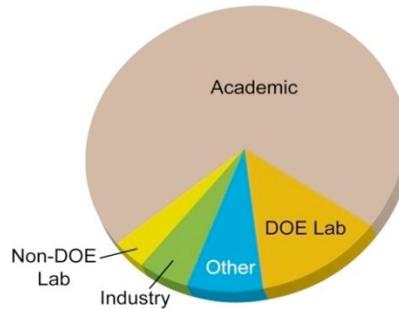
User data – FY08



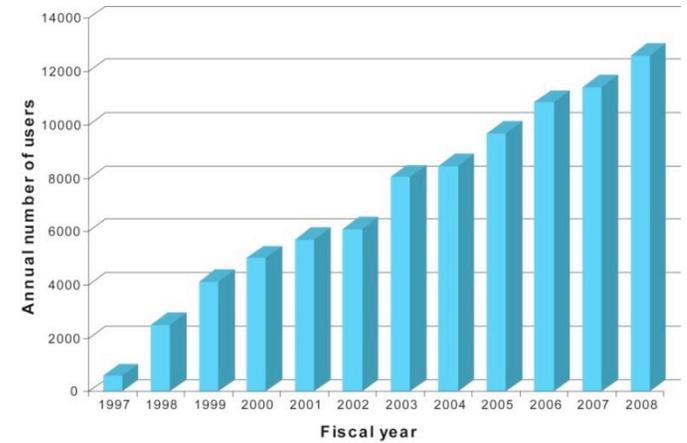
FY08 users by discipline



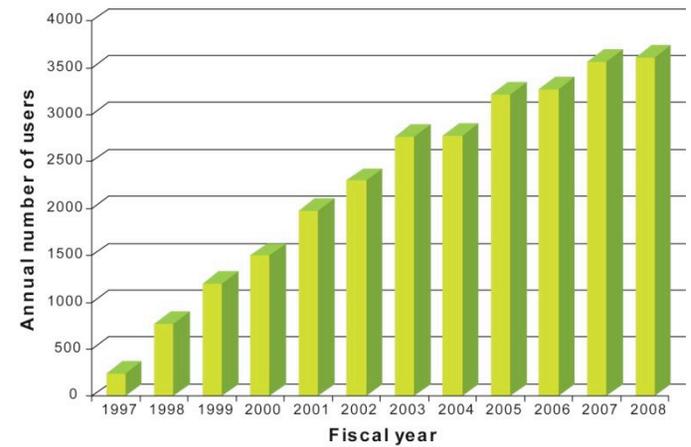
FY08 users by employment



FY08 users by institution



APS user total visits*.



User visits (unique) to the APS*.

*Includes users never at the APS but listed as co-proposers, mail-in, badged co-proposers, and remote/off-site.

Improved web access for MX (and other) beamlines

A plan view of the APS experiment hall provides the foundation for information display.

Click here to see a table of energy ranges for beamlines that support MAD/SAD.

The current deadline for general-user proposals (GUPs), and a link to the GUP proposal system, are prominently displayed.

Useful links.

Instructions. Essential.

Choose a preferred access mode and the sectors matching that mode are highlighted.

The information in this top section can be displayed by either discipline or technique; in this case, the list is of techniques. Clicking on any of them displays only the sector numbers (on the "experiment hall") where that technique is available.

Click on a visible MX sector number on the experiment hall planview...
...and this pane appears.
This is the main source of information for each sector:

1. A status indicator. Green = operational/accepting general users.
2. This links to information in the APS Beamline Directory (http://beam.aps.anl.gov/pls/apsweb/beamline_display_pkf.beamline_dir).
3. Click here to be directed to the operator's Web site.
4. Techniques supported at the beamline.
5. Source energy range for this beamline.

New General User Program Advisory Committee reviewing proposal system for improvements

■ Current Issues

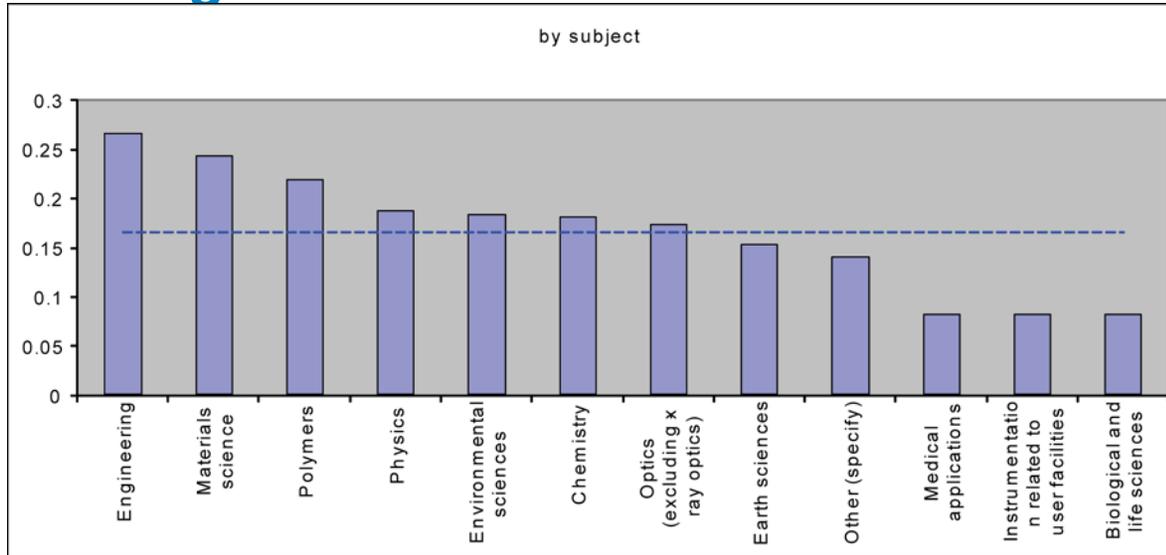
- Consideration of a Block Allocation Grant system for MX General User Proposals
- Publication of General User data by beamline
 - *Cut-off scores?*
 - *Average score needed to obtain time?*
 - *Decision: running annual average score to obtain time at a specific beamline*
- Other Issues? Contact an Advisory Committee member or the User Office.

■ Members

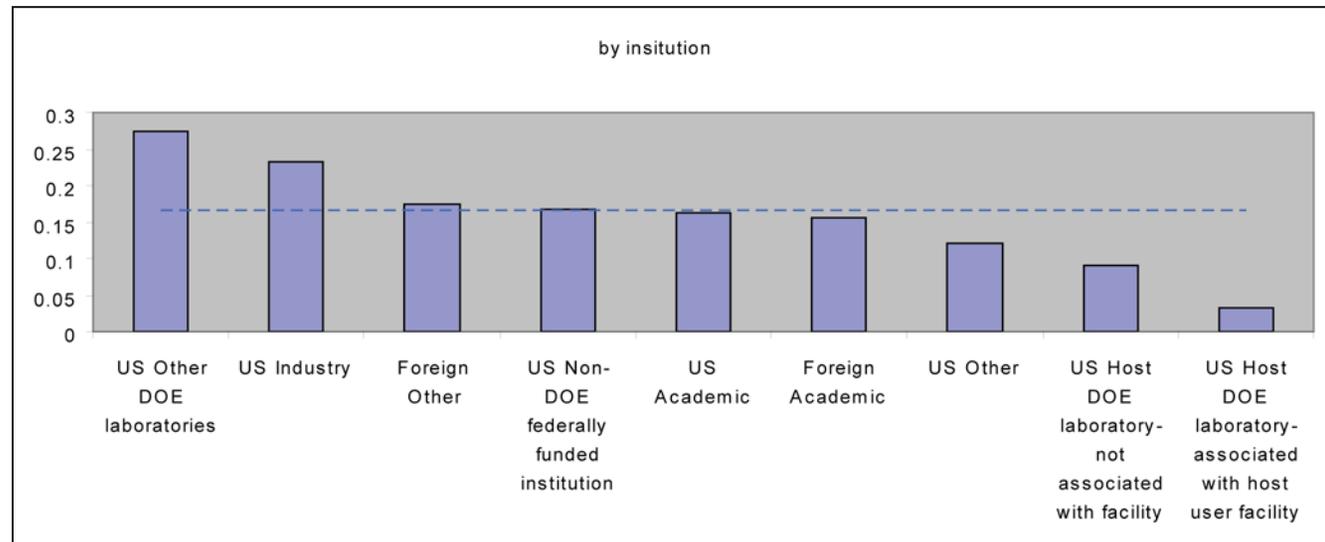
- Bruce Bunker (PUC)
- Keith Brister (Life Sciences Council/chair of former GUPEC)
- Jonathan Lang (XOR)
- Robert Leheny (GU)
- Steve Sutton (PUC/NUF)
- Jon Tischler (BAC)
- Paul Zschack (co-Chair original AU Advisory Committee)

Susan Strasser, *ex-officio*
Meg Vigliocco-Hagen, *ex-officio*
Reports to Denny Mills

Don't get no time?...



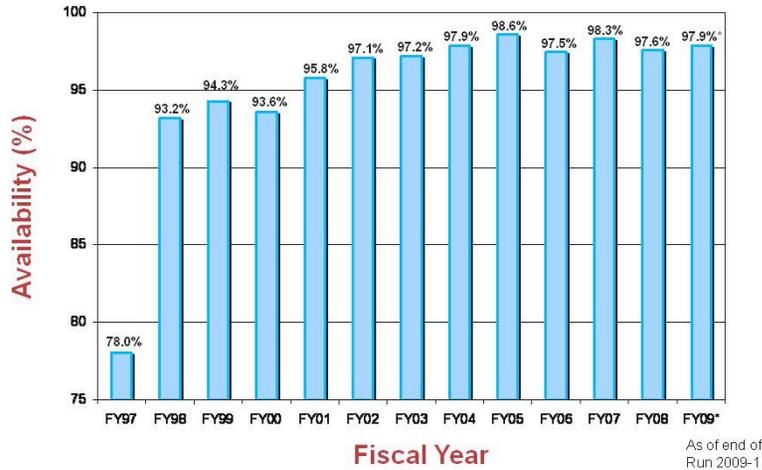
17% of proposers do not get time at all at APS over a two-year period*



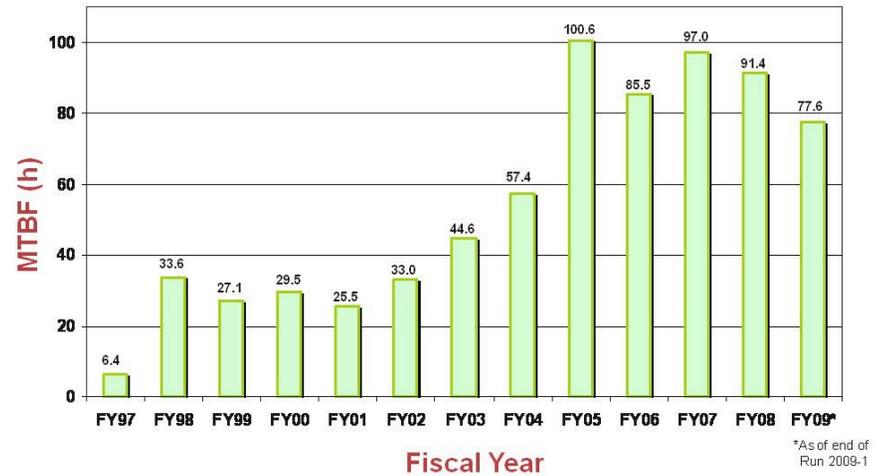
rejection rate ↑

* based on analysis of proposal creators in the period 2005, 2006

Our machine availability and reliability remains high



but challenged by obsolete components



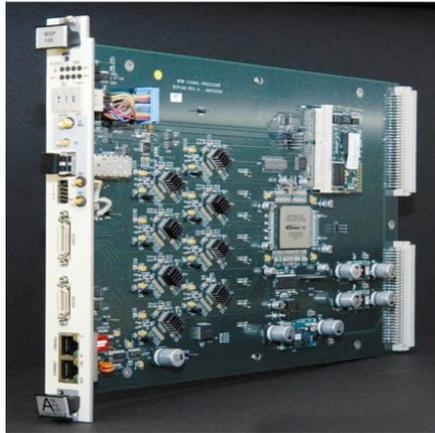
We're making a list...

Accelerator AIP

Notes	Project	Group	Category	ICMS	FY Year To Start	FY09	FY09 Early Funding	FY10	FY11	FY12	FY13	FY14	FY15	Total	Impact	Likelihood	Risk
	Upgrades to Accelerator Control System	IT	Obsolescence	APS_1255510	09	150	148	350	425	425	400	0	0	1750	3	3	Very Extreme
	APS Water Systems Spares and Maintenance	MOM	Obsolescence	APS_1253319	09	280	140	150	165	180	200	0	0	975	3	3	Very Extreme
	Upgrades to APS Central Computing and Networks	IT	Obsolescence	APS_1255509	09	380	120	800	925	1000	1000	0	0	4105	2	3	Extreme
	Accelerator Controls Infrastructure Upgrades	Control	Obsolescence	APS_1255512	09	110	50	270	521	480	330	0	0	1711	2	3	Extreme
	SR photon monitor upgrade	DIA	Obsolescence	APS_1255148	09	70	70	140	140	210	0	0	0	560	3	2	Extreme
	SR and Injector Flag Upgrade	DIA	Obsolescence	APS_1255151	09	50		50	100	100	100	0	0	400	2	3	Extreme
	Oxford cryo-cooler and spare parts	MOM	Obsolescence	APS_1253174	09	16		0	141	0	0	0	0	157	3	2	Extreme
1	Booster Ramping Power Supplies	PS	Obsolescence	APS_1256828	10	0		600	412	0	0	0	0	1012	3	2	Extreme
	Linac Hot Spare for L4 and L5	RF	Obsolescence	APS_1257954	09	50	50	69	69	0	0	0	0	187	3	2	Extreme
	Reliability upgrade of SR secondary water systems	MOM	Obsolescence	475-07	09	55								55	3	2	Extreme
	Monopulse RF beam position monitor upgrade	DIA	Science enabling	APS_1255203	07	45	50	185	185	140				555	3	2	Extreme
	X-ray BPM enhancement	DIA	Science enabling	APS_1277144	08	30	50	250	250	250	250	220		1250	2	3	Extreme
	APPLE-style undulator design prototype	MD	Science enabling	APS_1277235	08	80	40							80	3	2	Extreme
	Insertion Device Control - Maintenance & Upgrade	Control	Obsolescence	APS_1255062	09	50	50	150	150	150	150	0	0	650	2	2	High
	Booster Bunch Cleaning	DIA	Obsolescence	APS_1257948	10	0		50	50	51	0	0	0	151	2	2	High
	Storage Ring Process Water Pumps' Obsolete Controller Replacement	MOM	Obsolescence	APS_1253317	10	0		50	50	60	0	0	0	160	2	2	High
	Booster Vacuum Ion Pump and Controller Replacement	MOM	Obsolescence	APS_1253927	09	90		90	90	90	90	0	0	450	2	2	High
	LINAC to PAR, PAR, PAR to BOOSTER Valve Controller Upgrade	MOM	Obsolescence	APS_1253928	12	0		0	0	140	0	0	0	140	2	2	High
	Maintain reliable performance of the APS front ends	MOM	Obsolescence	APS_1255169	12	0		0	0	500	500	446	0	1446	2	2	High
2	Storage Ring Dipole Spare Power Supply	PS	Obsolescence	APS_1256800	11	0		0	300	0	0	0	0	300	3	1	High
	Booster Kicker Power Supply Upgrade	PS	Obsolescence	APS_1256850	09	100	50	150	150	0	0	0	0	400	2	2	High
	UVC Power Supply Control System Upgrade	RF	Obsolescence	APS_1256749	09	40	50	80	80	0	0	0	0	200	2	2	High
	HOM Dampers	RF	Obsolescence	APS_1269799	09	150	50	150	275	275	275	0	0	1125	2	2	High
	Upgrade of SR fast correctors	PS	Science enabling	APS_1276313	09	40	40							40	2	2	High
	EX electromagnet undulator prototype	MD	Science enabling	APS_1277106	08	53	53							53	2	2	High
			Science enabling	APS_1255145	09	55		55	55					165	3	1	High
				APS_1253316	10	0		180	0	0	0	0	0				
					11	0		0	70	70							

Of machine investments to combat obsolescence ~5 years (\$20-30M)

not just reliable but constantly improving



Faster BPM processing



New IT infrastructure

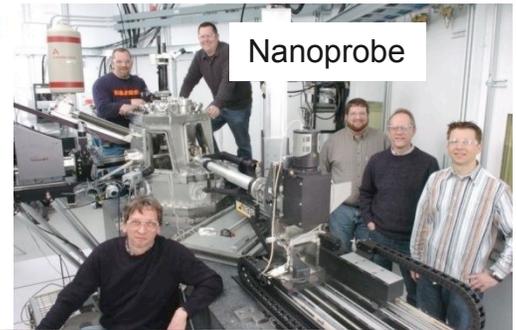
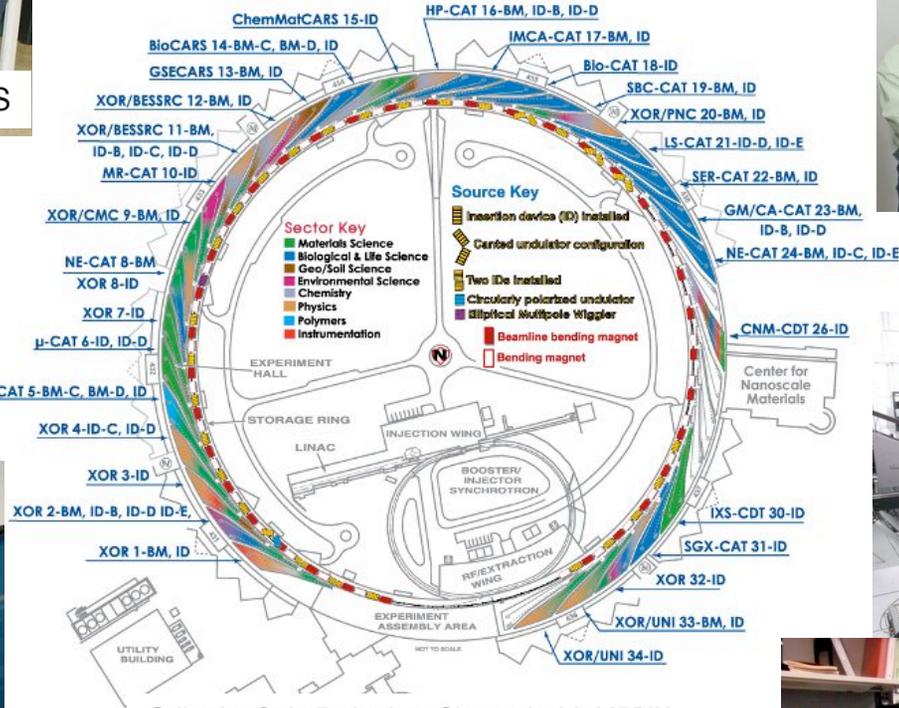
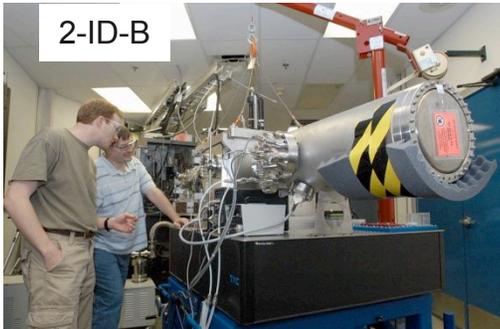


More reliable PSS

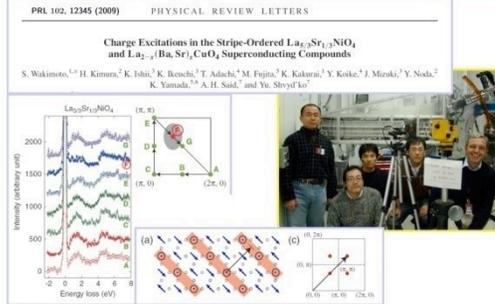


An EPICs project
– controlling
the hexapod

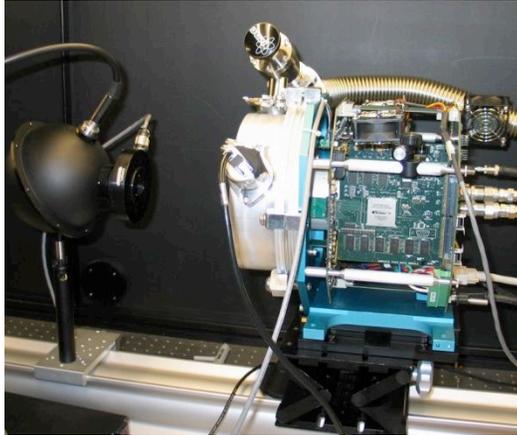
new instruments enable new science



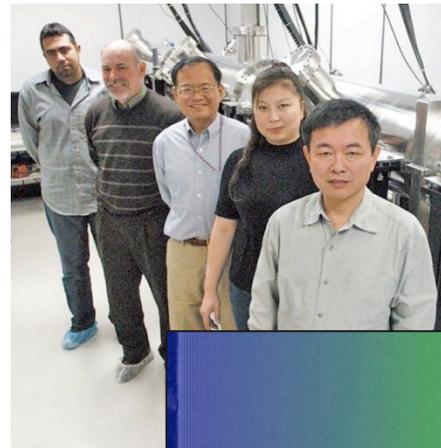
Collective Strip Excitations Observed with MERIX



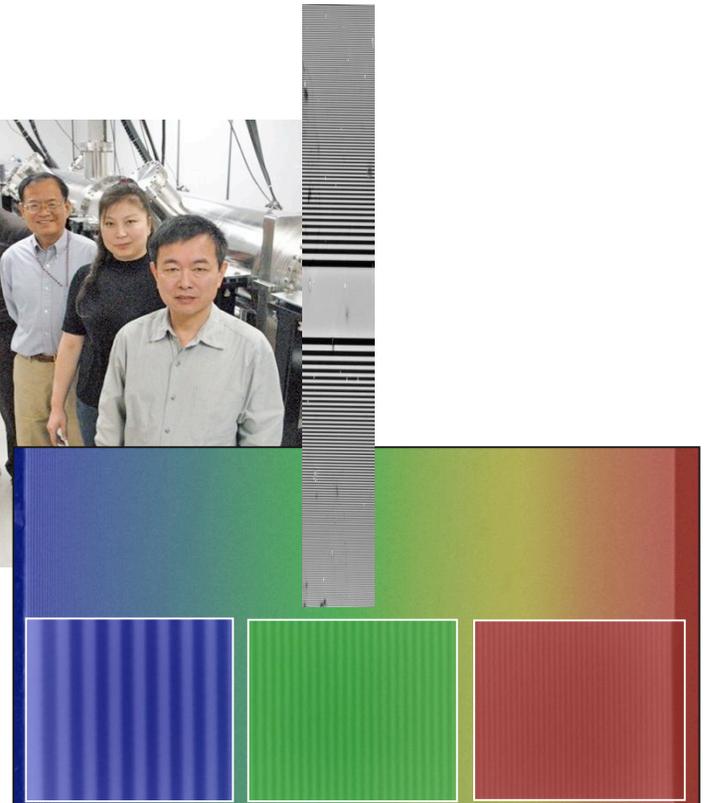
Detectors and optics developments



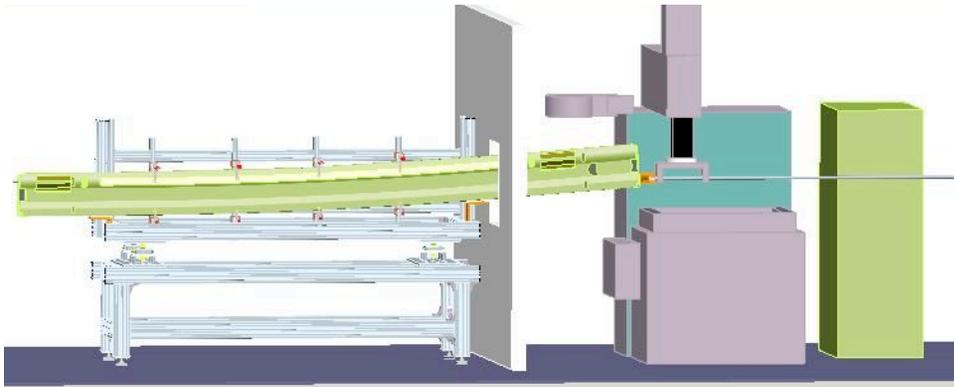
fast CCD from ANL-LBNL collaboration
now available to beamlines



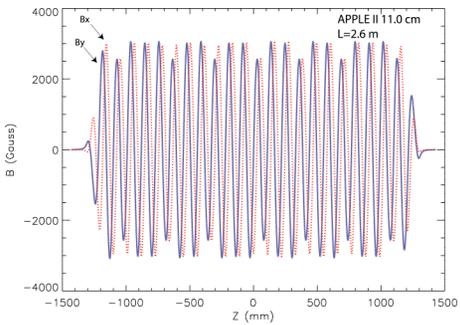
Optics group reaches 16nm
resolution with MLL



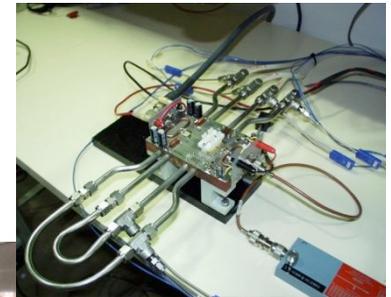
On the drawing board



Getting the beam to IEX – a new BM chamber

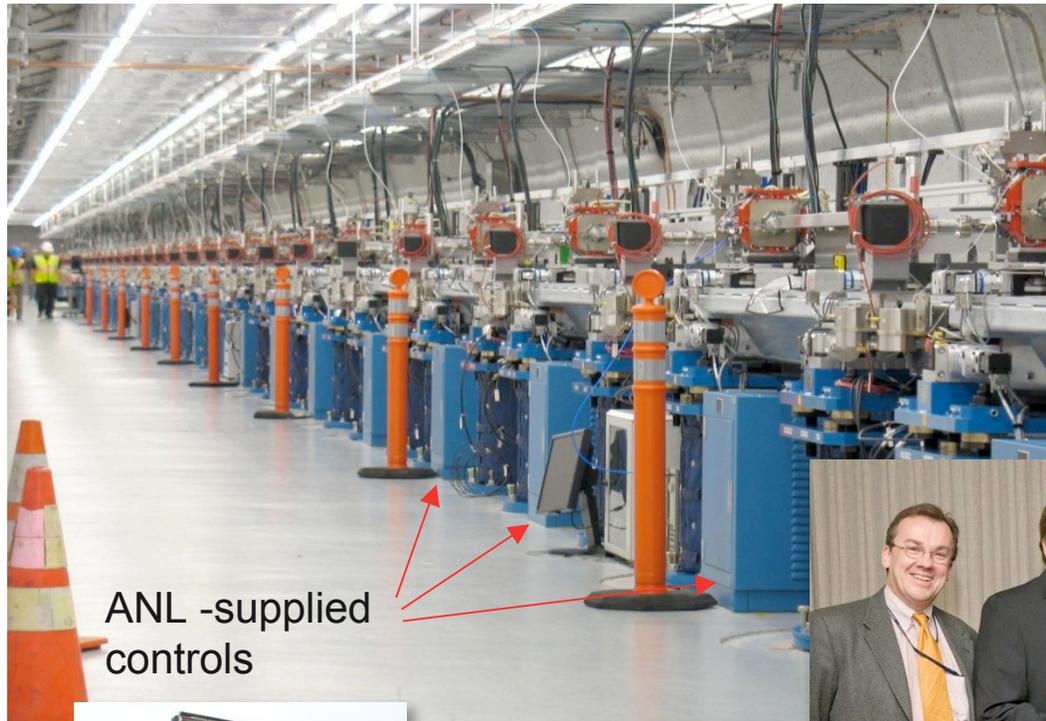


and cleverly messing up an undulator



a step to solid-state RF

ANL delivered LCLS undulator system already lasing at 0.15nm!

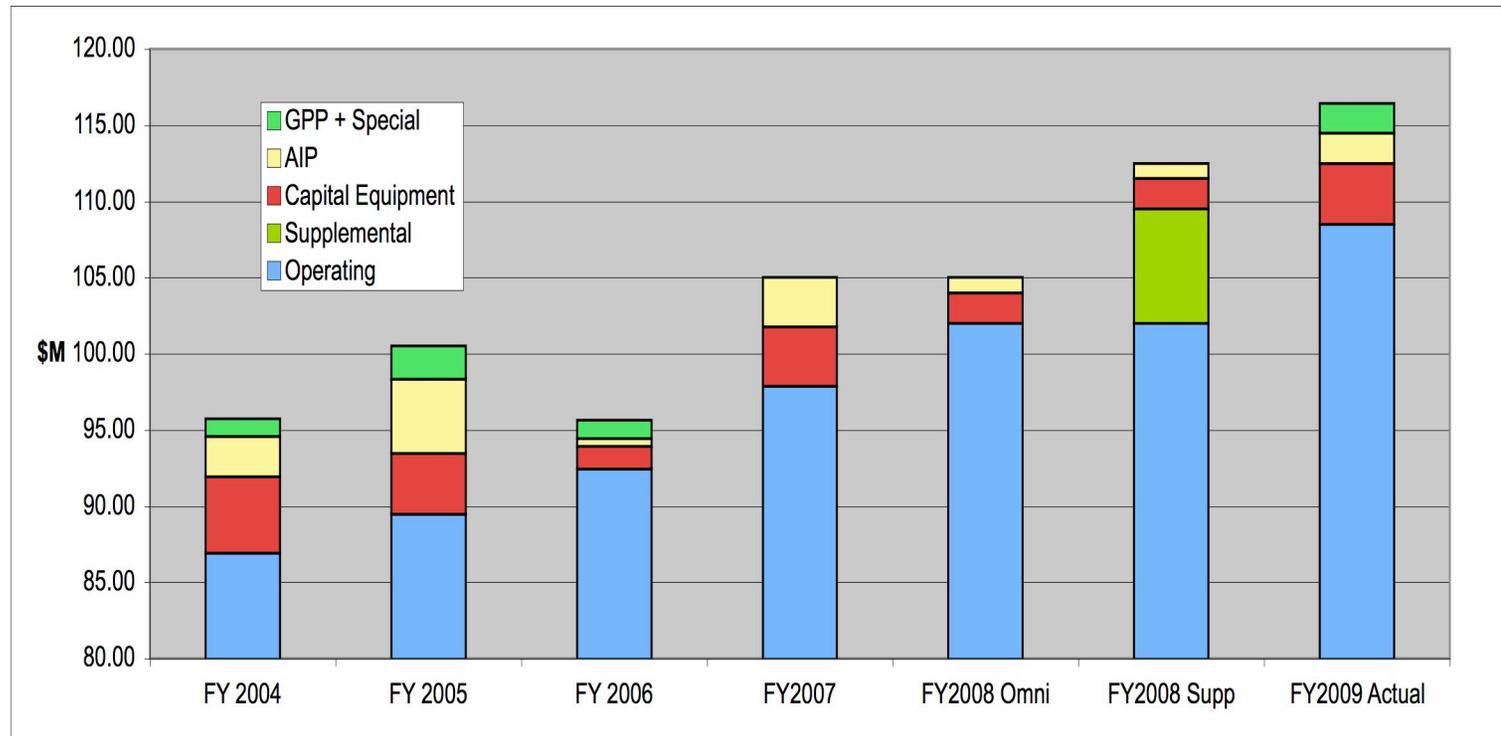


- Excellent performance by APS engineered systems
 - Support and Mover System
 - <1 micron backlash
 - Cavity BPMs
 - 300 nm position resolution
 - Resolve kick angle as a function of undulator slider x-position variations at the 10-nrad level



APS has been well supported by DOE and Congress

- “Full funding of light sources” in 2009 Omnibus Bill (added \$9.5M to APS base budget, and \$1.94M for IEX beamline construction project)



Stimulus package also helps directly and indirectly
possible extra AIP/Capital from \$24M allocated to light sources

Where is APS today and what is next?

- Defining the state of the art in hard x-ray science
 - Leading the world in key areas
 - *Protein structure*
 - *Materials under extreme conditions*
 - Satisfying the needs of the largest user community in North America
 - *Responsive and safe*
 - Providing world-leading reliability
 - *Challenges from increasingly obsolete components*
 - And innovating the source and measurement tools

APS Renewal – a real opportunity to bring APS to the state of the art and develop new capabilities

APS Renewal

Message from Murray Gibson:

Renewing and upgrading the Advanced Photon Source: a real opportunity for user engagement

May 22, 2008

Now in its twelfth year of operation, the Advanced Photon Source (APS) annually provides almost 3500 users with brilliant x-rays that lead to more than 1000 refereed publications each year covering many areas of science and engineering. Nevertheless, the facility, like any scientific instrument, is showing its age, and we have been working for several years on renewal and upgrade plans. These plans have recently received a boost because our sponsor - the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences - has asked us for a detailed, science-driven plan for the renewal of APS to cover the next five years. This renewal plan will encompass innovations in the beamlines and the x-ray source that are needed for major improvements in important areas of user science. We are engaging our users and staff *ab initio* in building this APS renewal plan, and we will use our [Scientific Advisory Committee \(SAC\)](#) and other outside experts to help us craft a plan with maximum scientific impact. A planning milestone will be a workshop to be held October 20-21, 2008 near the APS, at which the SAC will take a first complete look at the plan and give their advice. At present we continue to solicit proposals from our beamline staff, users, and accelerator and other APS staff. These proposals will be filtered by science-focused user groups, and they will also be analyzed in a matrix fashion by technique coordinators. More information, as well as details about how you can take part in the planning and communicate your perspective, can be found on this Web site.

Timeline:

- Renewal Plan: 2008 - 2010
- R&D for Major Upgrade: 2010 - 2014
- Facility Upgrade: 2014 - 2020

The renewal of APS is the first component of a strategic plan for the APS that aims to provide our users with the best hard x-ray source in the nation, and beyond, by the year 2020. During the renewal period, we will be evaluating, with our users, the options for major customer facility needs (MCFNs) at APS that

SAC-approved Letters of Intent (LOIs) or Proposals for New and Redeveloped Beamlines:

- Advanced X-ray Imaging Collaborative Development Team (AXI-CDT)
- BioNanoProbe
- Sector 8-BM Redevelopment
- X-ray High Field Collaborative Development Team (XHF-CDT)
- X-ray Interfacial Science Collaborative Development Team (XIS-CDT)

Medium-Term Proposals:

- Beamlines | [Call for Proposals \(pdf\)](#)
- Accelerator Systems | [Call for Proposals \(pdf\)](#)

APS 2020 Upgrade Plan:

- APS Upgrade Options

Steering Committee Members:

- Denny Mills
- Rod Gerig
- George Strajer
- John Maclean
- Denis Keane (APS PUC Chair)
- Paul Fuoss (APSUCO Rep)
- Bob Fischetti (Life Sciences Council Chair)
- Dan Neumann (SAC Member)

- New and improved beamlines
- Higher current, new IDs and long straight sections
- Improved beam stability
- Better detectors and software
- Offers 10-100 times improvement and new capabilities
- Estimated cost \$350M
- Hope to begin in 2011

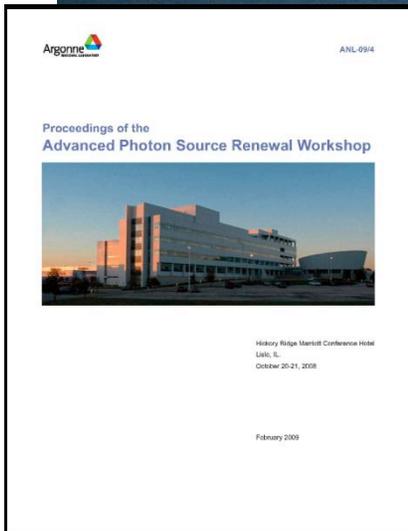
APS renewal workshop Oct 2008 with SAC, staff and users



Kendra Greenlee (North Dakota State University) speaks to the attendees of the “Life Sciences” breakout session.



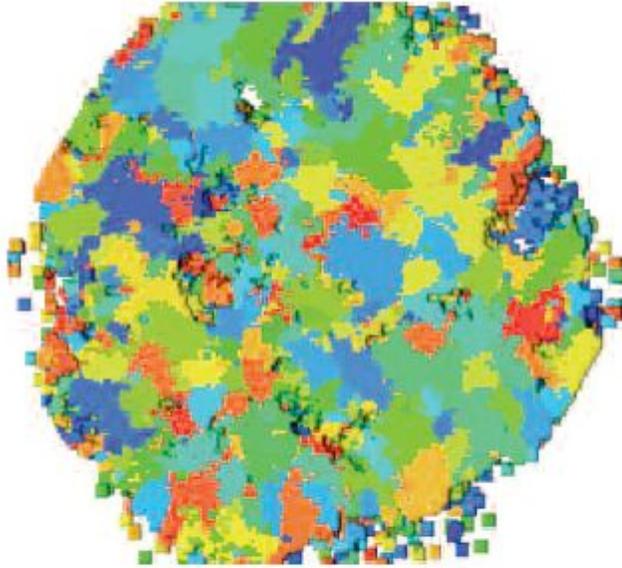
Gene Ice (gesturing at left) of Oak Ridge National Laboratory makes a point at the breakout session on “Engineering Applications/Applied Science.”



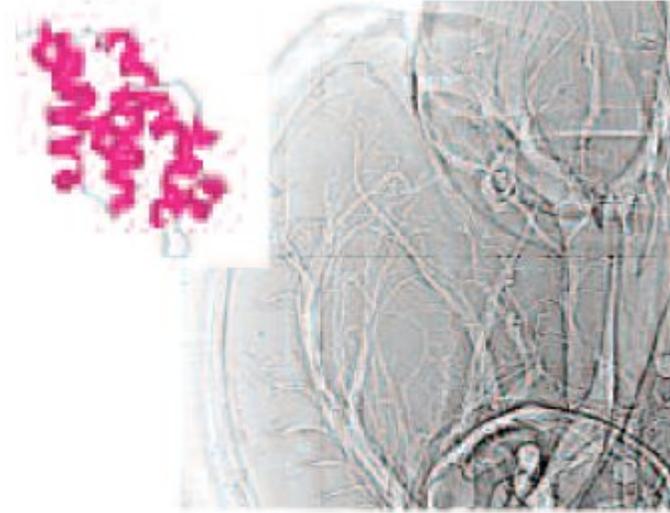
Participants in the APS Renewal Workshop heard two days of talks on possible future research directions at a renewed APS.

Many thanks to Renewal steering committee – Mills, Gerig, Srajer, Maclean, Fuoss, Fischetti, Keane, Neumann

Mastering Hierarchical Structures Through X-Ray Imaging



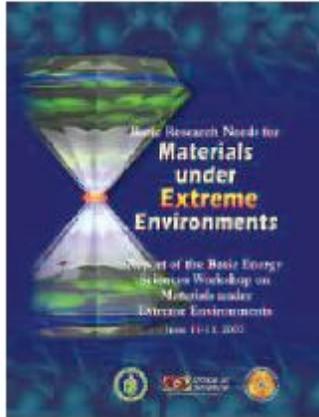
Three-dimensional distribution of grains in a 1-mm cube of aluminum. (Courtesy R. Suter et al., Carnegie Mellon University)



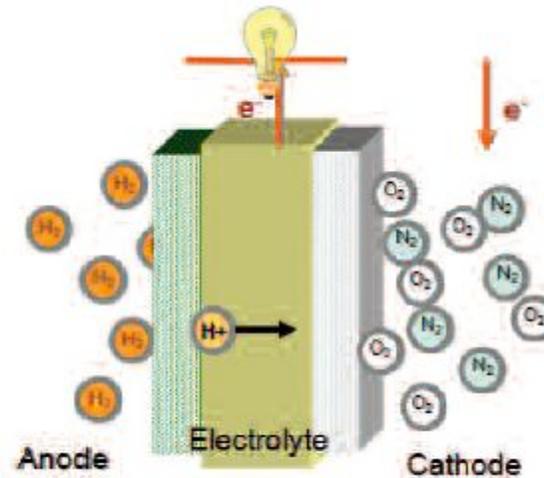
Images from proteins and living organisms will help connect the dots in understanding how genetics controls health and disease. (Courtesy W.K. Lee, ANL; © 2007 Socha et al.; licensee BioMed Central Ltd.)

- How can we make stronger, lightweight materials?
- How do we control the transport of environmental contaminants and store CO₂ in rock?
- How do we make clean biofuels from renewable ligno-cellulose?
- How do proteins fit together to make organisms?

Real materials in real conditions in real time



The cover of this BESAC report shows a diamond anvil cell. APS is a world-leader in high-pressure research.

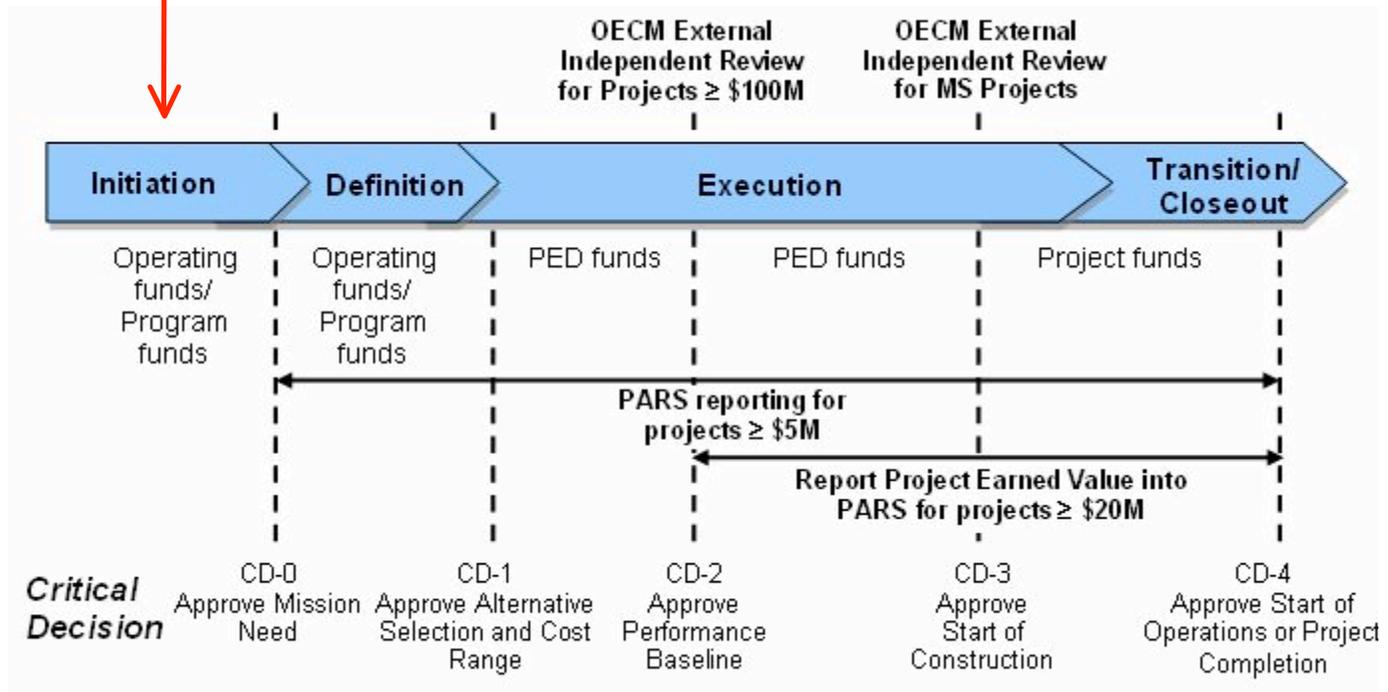


Schematic of an H₂ fuel cell. (Courtesy D. Myers, Argonne National Laboratory)

- How can we get the specificity of enzymes in catalysts?
- How can we load a battery efficiently with mobile ions to improve power/weight ratio?
- Can we imitate photosynthesis?
- How do we manufacture efficient lighting cost-effectively?
- Can we control nucleation to make better smarter materials?
- Can we develop new superconductors for the electric grid?

Where are we now on the Renewal project?

- We have been asked to submit a proposal for CD0, which we hope to get before the end of this fiscal year, so that the project could begin in 2011



We've got lots of invaluable user input to work with...



ANL-09/4

Proceedings of the Advanced Photon Source Renewal Workshop



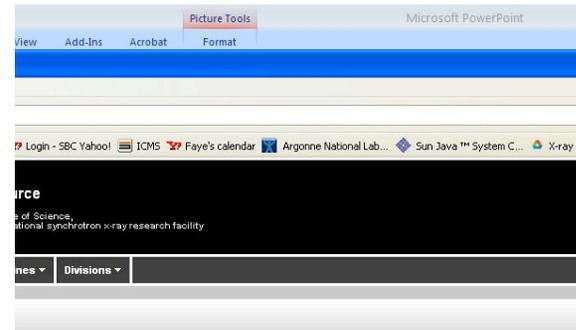
Hickory Ridge Marriott Conference Hotel
Lisle, IL
October 20-21, 2008

February 2009

Source: a real opportunity for

Photon Source (APS) X-rays that lead to more many areas of science scientific instrument, is several years on renewal and a boost because our Science, Office of Basic science-driven plan for the renewal plan will encompass that are needed for major We are engaging our users , and we will use our side experts to help us ining milestone will be a APS, at which the SAC heir advice. At present we f, users, and accelerator

other APS staff. These proposals will be filtered by science-focused users ps, and they will also be analyzed in a matrix fashion by technique dinators. More information, as well as details about how you can take in the planning and communicate your perspective, can be found on this site.

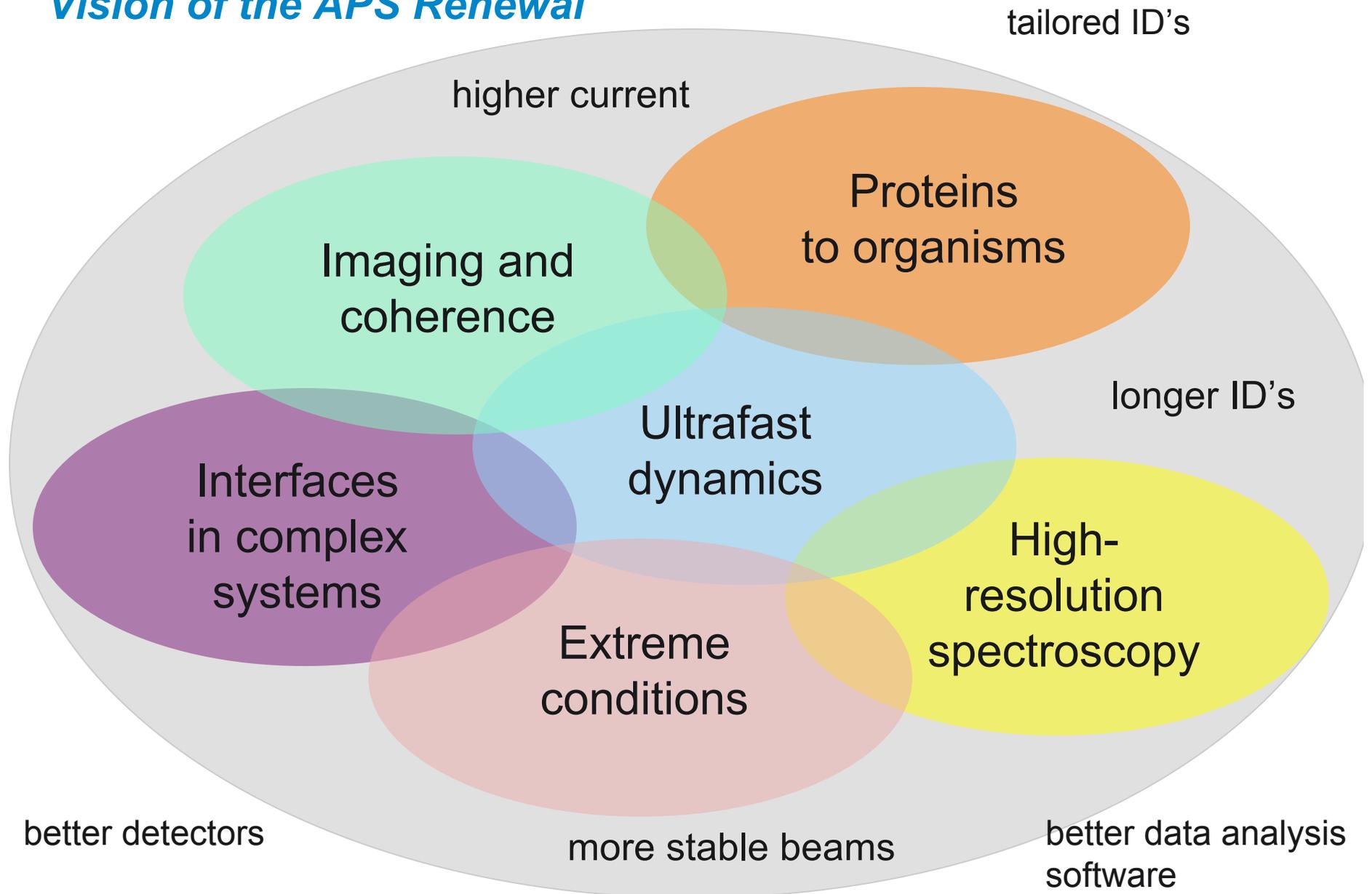


- [Renewal of the Advanced Photon Source White Paper](#)
- [Proceedings of the APS Renewal Workshop](#)
- [Science and Technology of Future Light Sources White Paper](#)
- [Summary of Instrumentation Presentations, 2009 Meeting of the APS Scientific Advisory Committee](#)
- [Instrumentation Open Forum \(January 9, 2009\)](#)
- [Renewal Workshop \(October 20-21, 2008\)](#)
- [Science Case Reports \(Final\)](#)
- [Letters of Intent for New/Redeveloped Beamlines](#)
- **Medium-Term Proposals:**
 - [Beamlines | Call for Proposals \(pdf\)](#)
 - [Accelerator Systems | Call for Proposals \(pdf\)](#)
- [APS 2020 Upgrade: Review of Options](#)
- [Science Teams](#)
- [Steering Committee](#)
- [Useful Links and Resources](#)

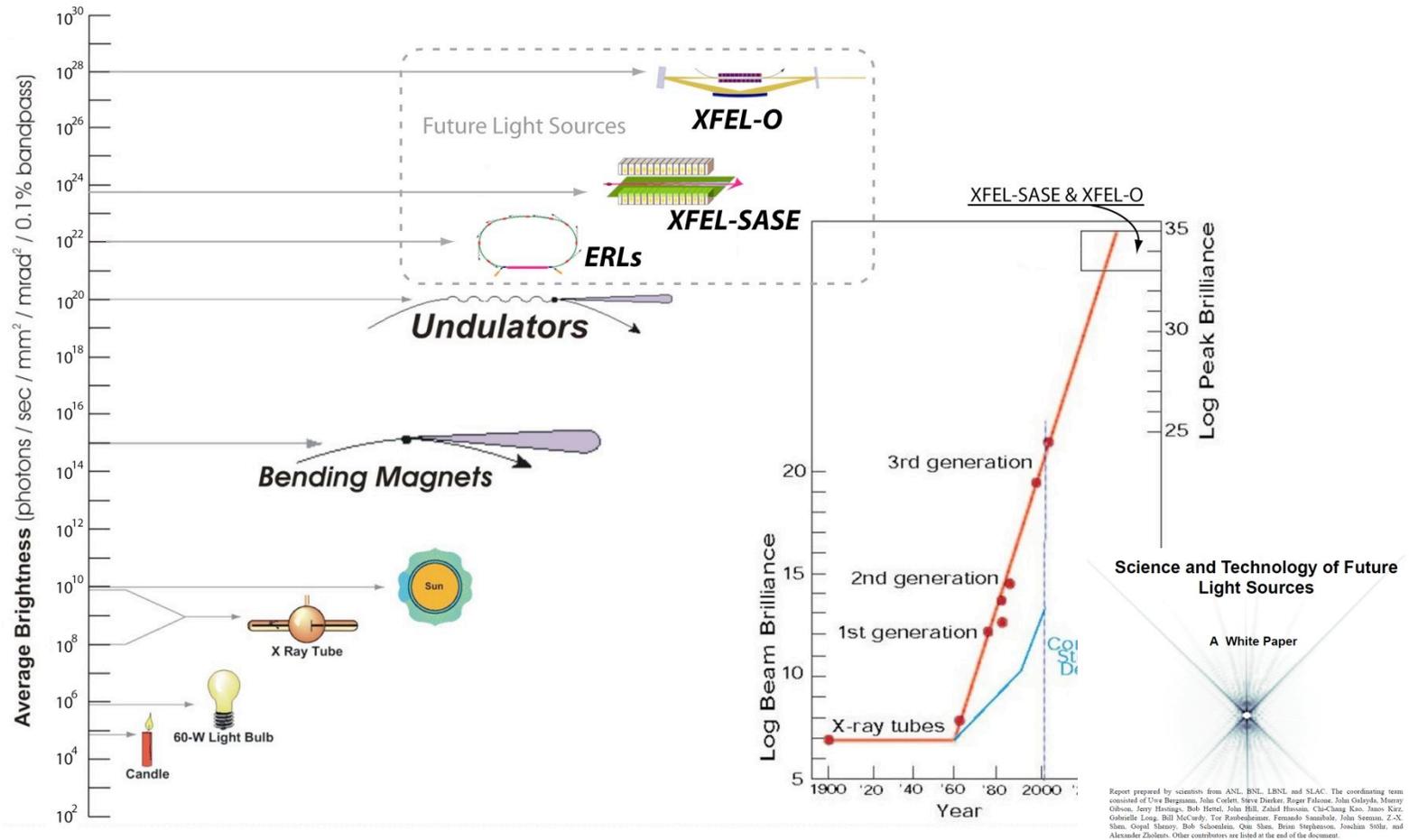
Outline of this afternoon's Renewal Discussion

- Introduction – Denny Mills
 - SAC view - Glenn Waychunas
 - Science drivers - Paul Fuouss
 - Accelerator upgrades – Rod Gerig
 - Vision for the Renewal – Murray Gibson
-
- Will describe a vision for the need and scope of the project

Vision of the APS Renewal

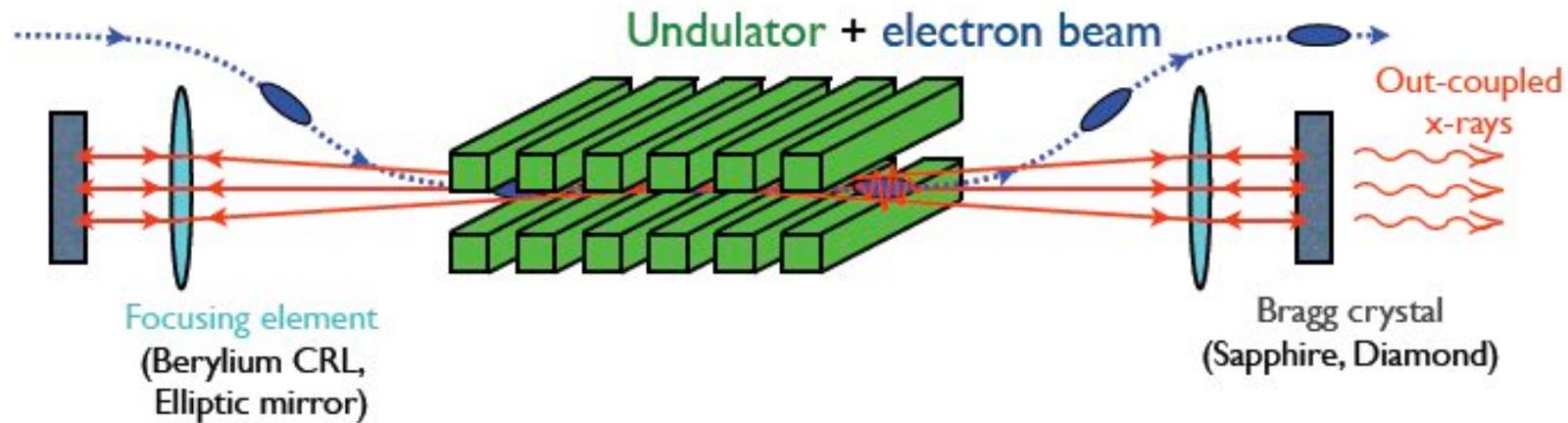


Beyond the renewal - new possibilities for future hard x-ray sources/upgrades?

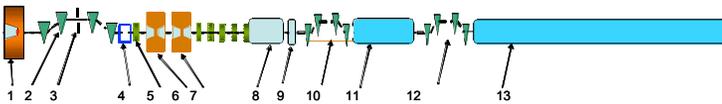


Offer far higher brilliance, coherence and shorter pulses

An X-Ray FEL Oscillator (XFEL O) looks very promising



- Concept developed by Kwang-Je Kim and Yuri Shvyd'ko
- Active R&D program addressing feasibility is going on with very promising results



Nurturing the next generation in important



11 Lee Teng Fellows under
Accelerator Institute



Science careers in
search of women

+Neutron/x-ray school and many other training courses

Conclusion

- We have much to be thankful for, due to the support of DOE and Congress, based on our user's productivity and needs
- And we have been asked to submit a proposal for CD-0 for our renewal and hope to see this critical project start in 2011
- We are well-situated as a part of ANL strategic plan (Eric Isaacs this afternoon)
- Still, we need to advocate further for needed budget increases in 2010 and support for the future
- And ensure that our vision is responsive to our user's needs so that we remain the choice hard x-ray source