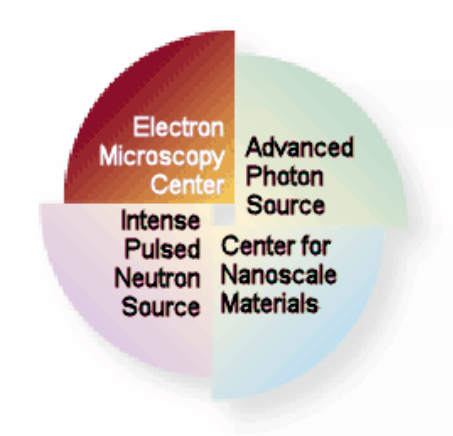
Argonne NATIONAL LABORATORY

The Advanced Photon Source Today and Tomorrow…..



J. Murray Gibson

APS/CNM/IPNS/EMC User Meeting Presentation

May 3, 2006

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

William T. (Bill) Oosterhuis was a pioneer in the support of synchrotron radiation science and the emergence of national user facilities such as the Advanced Photon Source (above). The thousands of users and employees of these facilities owe him a great debt of thanks, and the nation benefits from the scientific bounty of synchrotron radiation research.

WILLIAM OOSTERHUIS 1940 - 2005

Bill Oosterhuis legacy…..

October 27, 1977 SSRL experimental hall ground breaking

Argonne NATIONAL LABORATORY

Symposium in Celebration of the Tenth Anniversary of APS Operations

May 4, 2006

Argonne Guest House

In recognition of the achievements of seven individuals who played key leadership roles in bringing the Advanced Photon Source from concept to completion:

David Moncton
Yanglai Cho
Joanne Day
John Galayda
Bob Kustom
Gopal Shenoy
Ed Temple

Symposium
"APS: The Path to Success"

5:00 p.m. to 6:30 p.m.

Argonne Guest House, Conference Room A

J. Murray Gibson
"The Fellowship of the Ring: What Dave's Team Built"

Rod Gerig
"The Legacy of the APS Accelerator Complex"

Efim Gluskin
"The Perfect X-ray Factory"

Dennis Mills
"Users at the APS"

Dinner

7:00 p.m.

Argonne Guest House Dining Room

After-dinner Remarks

8:15 p.m.

Entertainment tonight at the APS banquet…

Safety first - new electrical safety requirements for users

- Electrical safety awareness training is now required even to plug in a piece of electrical equipment (ESH377)
- Electrical safety training is required to perform any electrical work (even cutting and splicing a wire) (ESH371)
- All electrical equipment brought on site must be inspected by APS unless it has been labeled or tested by a nationally recognized testing laboratory
  - Why?
    - *For your safety*
    - *Required by the revised Argonne ES&H manual reflecting NEC, OSHA, and DOE regulations.*
      - More info at http://www.aps.anl.gov/Safety_and_Training/Electrical_Safety/index.html
      - FYI: Los Alamos, Brookhaven, and SLAC already have such programs

What does not need to be inspected

- Electrical equipment and devices such as computer, lamps, tools, etc. that bear a listing mark or label from an OSHA recognized nationally recognized testing laboratory (NRTL) - do not need to be inspected.
  - Including *UL (Underwriters Laboratory), CSA (Canadian standards association)*, *FM (FM global technologies).*
- Equipment that is rated <50 volts and has power consumption of under 1 kilowatt
- Equipment rated 50 volts or greater with current less than 5 milliamps and stored energy <10 joules

Everything else electrical does need inspection and APS APPROVAL (identified in ESAF)

Safety comes first
we can help facilitate safe experiments

- We can offer assistance in repairing defective equipment (will cost if beyond simple)*
- We work with you to examine hazardous materials under safe conditions*

1mg explosive samples

- Everyone benefits when safety improvements come from assessments and lessons learned:

Newest state-of-the art laser facility at 7-ID has engineered controls to prevent inappropriate novice use

* *need advance notice*

We take our safety responsibility seriously

Front and side views

APS Detector Pool mar345 Image Plate detector:
515 mm * 398 mm * 350 mm, 53 kg (117 lb)

Heavy piece of equipment, not designed for the frequent relocation necessary as part of the APS Detector Pool.

Beamline personnel at Sector 7 noticed the safety hazards inherent in lifting the detector to position it at experiment-required height.

Thanks!

Suggestions made by Sector 7 personnel:

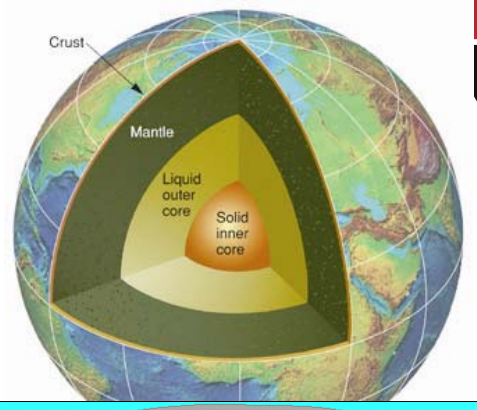
1. Add bottom plate to make it easier to lift the heavy detector.

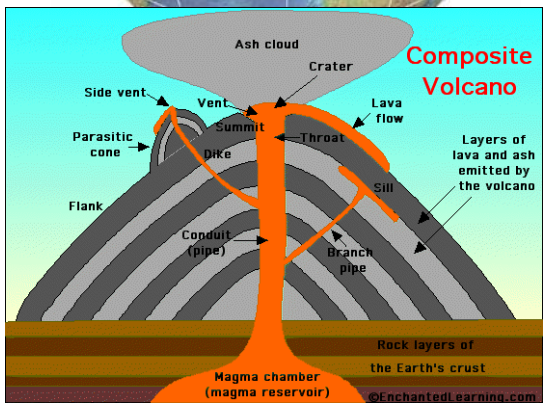
2. Purchase lift cart for safer transport and positioning of the detector at experiment height. The detector is transported with the cart in the lowered position.

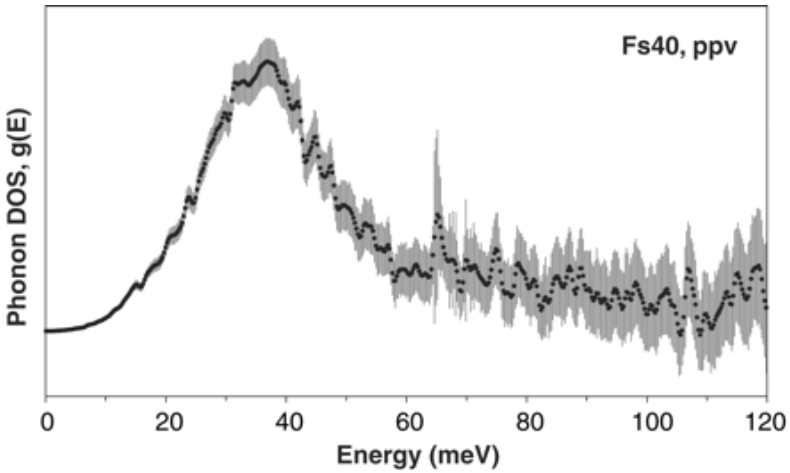
Both suggestions were implemented by the APS Detector Pool personnel on the two APS mar345 detectors.

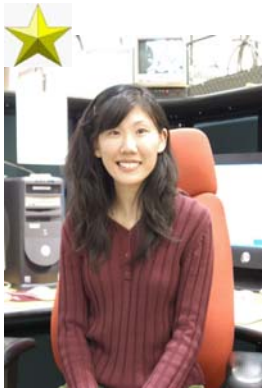
APS science: Iron at the earth's core boundary

- Studies at XOR 3-ID, GSECARS 13-IDD, HP-CAT 16-IDB show that post-perovskite containing large amounts of iron at Earth's core-mantle boundary can cause sluggish motion of seismic waves
- Offers alternative to the theory that core-mantle regions are partially melted, with important implications for understanding origin of volcanoes









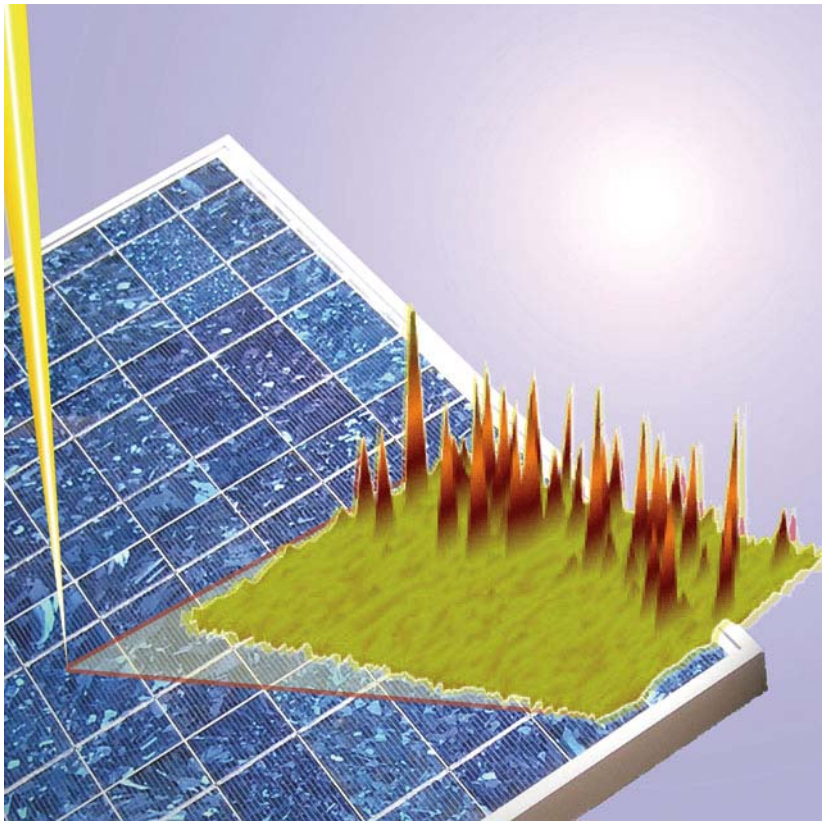
NRIXS spectra showing the phonon DOS for ppv phase of Fs40 at 130 GPa after temperature quench from 2000K.

W.L. Mao et al., Science, **312**(5773), 564 (28 April 2006)

APS science: Making solar cells the quick and dirty way

- Solar cell use limited by cost of semiconductor-grade crystalline silicon also used for integrated circuits
- Research at XOR 2-ID-D and XOR/PNC 20-ID-B shows lower-quality “dirty” silicon can be used to create practical solar cells by controlling size and spatial distribution of metal particles in the silicon lattice during crystallization

?

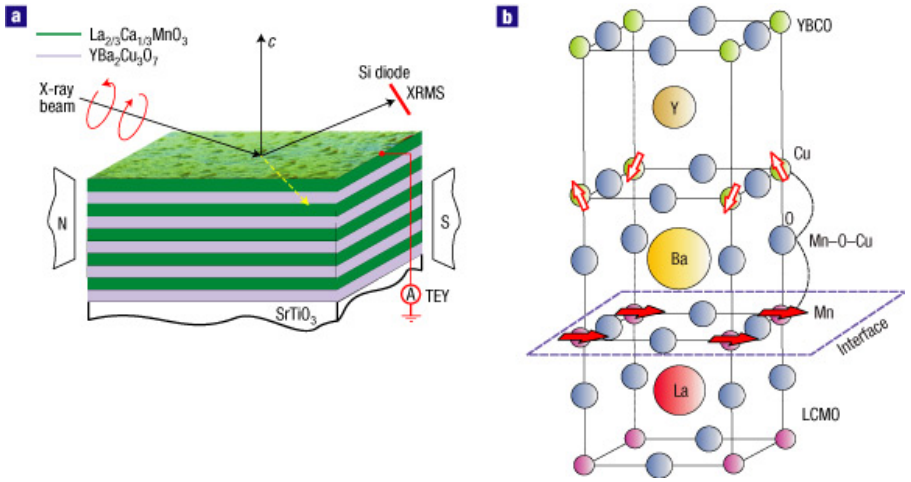


Artist's impression of an intense beam of synchrotron radiation (from the upper left) striking a solar cell, imaging the iron impurity. (Illustration: Tonio Buonassisi)

T. Buonassisi et al., J. Appl. Phys. **97**, 074901 (2005)

APS science: superconducting & magnetic oxide boundaries

- XMCD (at XOR 4-ID-C and ID08 of ESRF) at the Mn and Cu L absorption edge has visualized magnetic state at interface between Cu-based high-temperature superconductor and Mn-based ferromagnet
- Based on understood theoretical framework for magnetic interactions, this can only occur if there is a modification of the electronic structure at the interface of the two materials.
- Illustrates strong competition between superconducting and ferromagnetic states
- May have large impact on the physics of complex oxides, oxide-based devices



***a**, Schematic diagram of experimental setup used to obtain the XMCD and XRMS data. To obtain sizable magnetic dichroism, film plane is tilted with respect to the photon beam propagation direction. **b**, Atomic stacking sequence and arrangement of atoms at the YBCO/LCMO interface.*

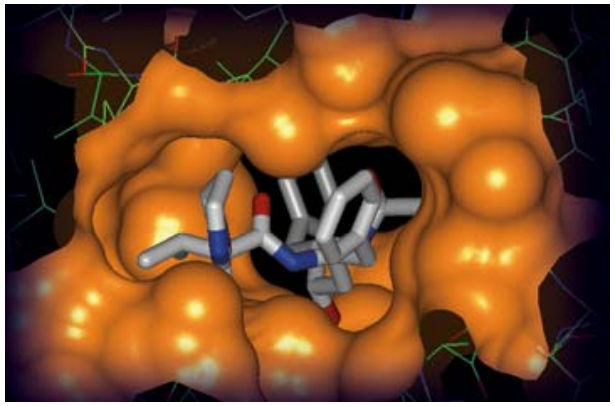
J. Chakhalian et al., Nature Physics **2**(4), 244-248.(2006).

APS science: slowing the progress of AIDS

Important weapon in battling the scourge of HIV has been forged from knowledge gained at the APS

AIDS caused by HIV virus, which produces 12 different kinds of proteins. Organic compounds that interact with these proteins, interfere with virus reproduction are potential drugs for treatment of AIDS.

- X-ray crystallographic studies at IMCA-CAT of protein HIV protease reveal atomic details of how compounds interact with protein.
- Also: determination at IMCA of crystallographic structure of the Abbott Laboratories pharmaceutical known as Kaletra®.
- Since FDA approval in 2000, Kaletra® has had positive impact on progression of the AIDS in patients infected with HIV virus.
- In 2002, Kaletra® became most-prescribed ("preferred") drug in its class for AIDS therapy; referred to as a drug that helped turn a situation where patients were dying from AIDS to a situation where patients are living with AIDS.

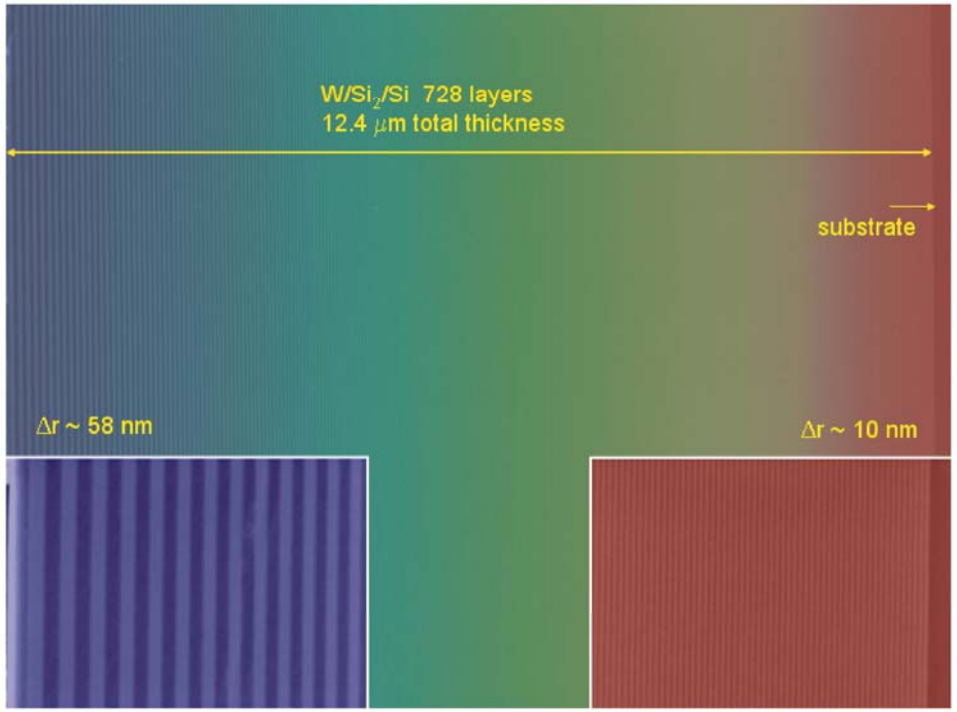


Close-up view of the drug binding site within HIV protease. A mathematically calculated surface (orange) shows the active site of the protein is a cavity inside the protein. The drug fits inside this cavity, much like a key fits into a lock. X-ray crystallography studies provided the scientific details of how the atoms of Kaletra® (carbon atoms are gray; nitrogens, blue; oxygens, red) interact with the viral protein.

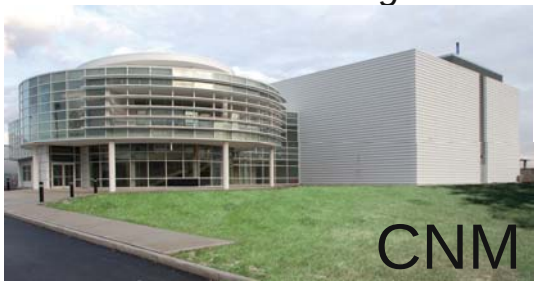
V. Stoll, et al., Bioorg. Med. Chem. **2002**, *10*, 2803-2806.

APS science: Sharper focusing of hard x-rays

- A new type of linear zone plate (multilayer Laue lens - MLL) for nm-scale focusing of hard x rays produced by sectioning a multilayer and illuminating it in Laue diffraction geometry
- Coupled wave theory calculations indicate that focusing to 5 nm or smaller with high efficiency should be possible
- Partial MLL structures with outermost zone widths small as 10 nm have been fabricated and tested with 19.5-keV synchrotron radiation
- Focal sizes to 30 nm with efficiencies up to 44% measured



An image of one side of an MLL cross section obtained with a scanning electron microscope.

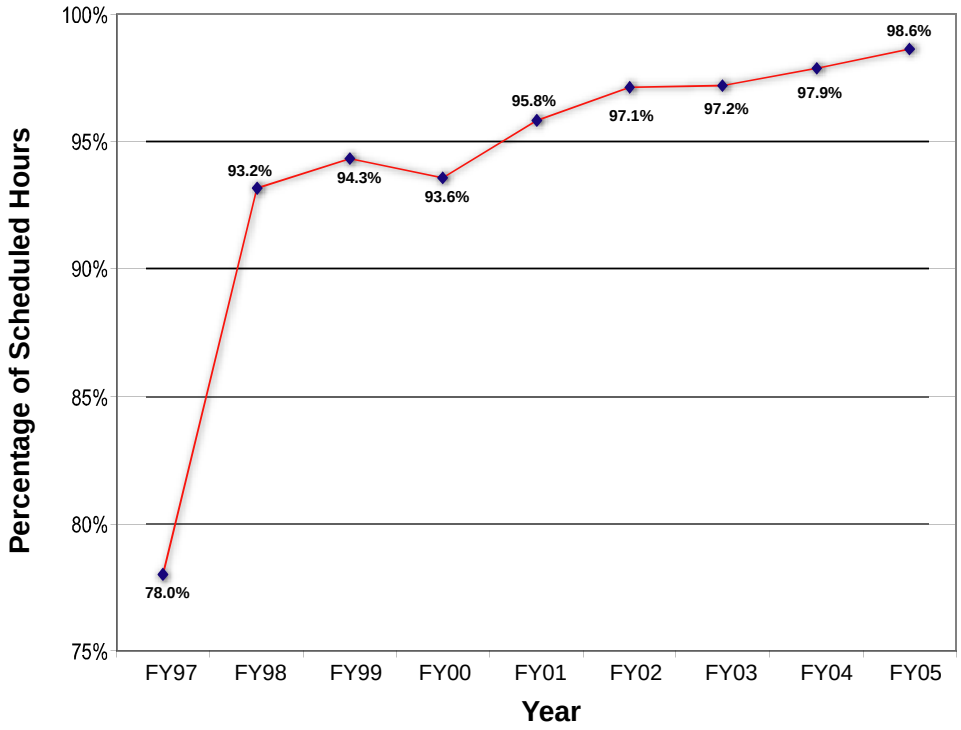


R&D 100

H. C. Kang et al., Phys. Rev. Lett. **96**, 127401 (2006)

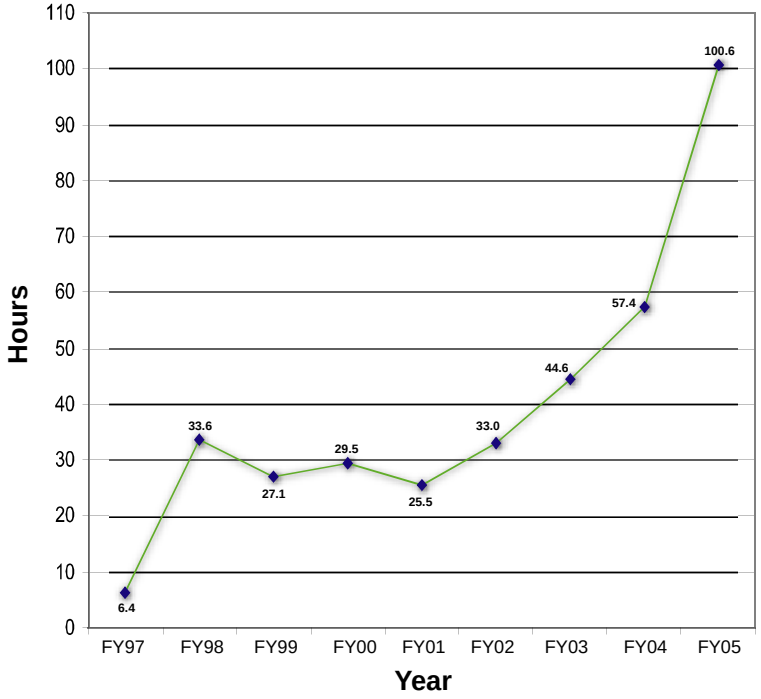
Excellent record of improved APS reliability and availability

X-ray Availability



FY05 is best yearly operation for any third-generation hard x-ray source in the history of these facilities.*

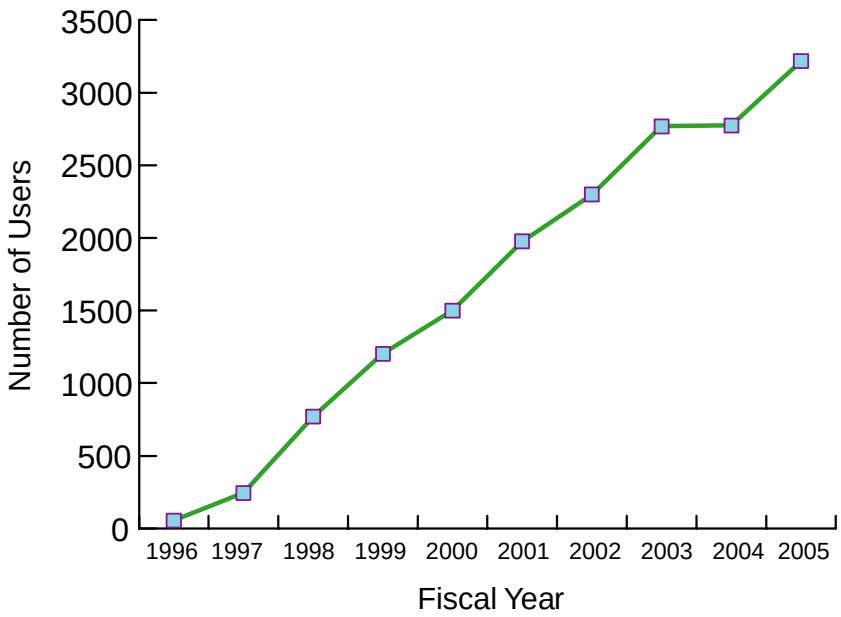
MTBF



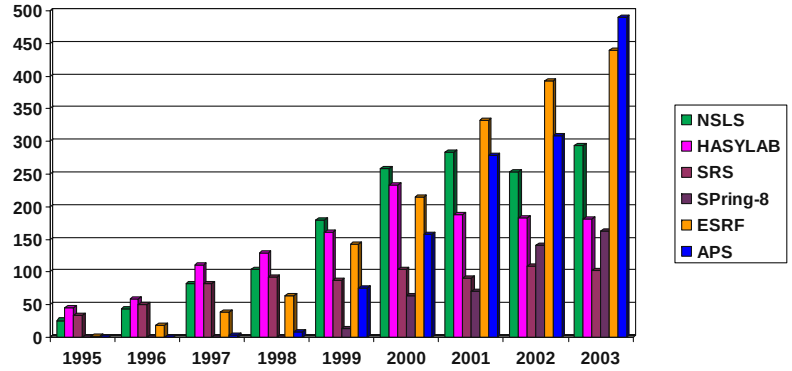
*Based on data available from ESRF and SPring-8

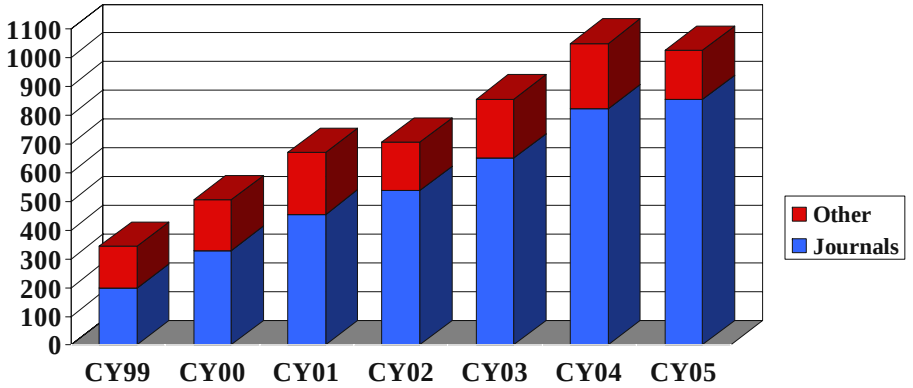
Growing APS user community and scientific impact

Number of unique APS users by fiscal year



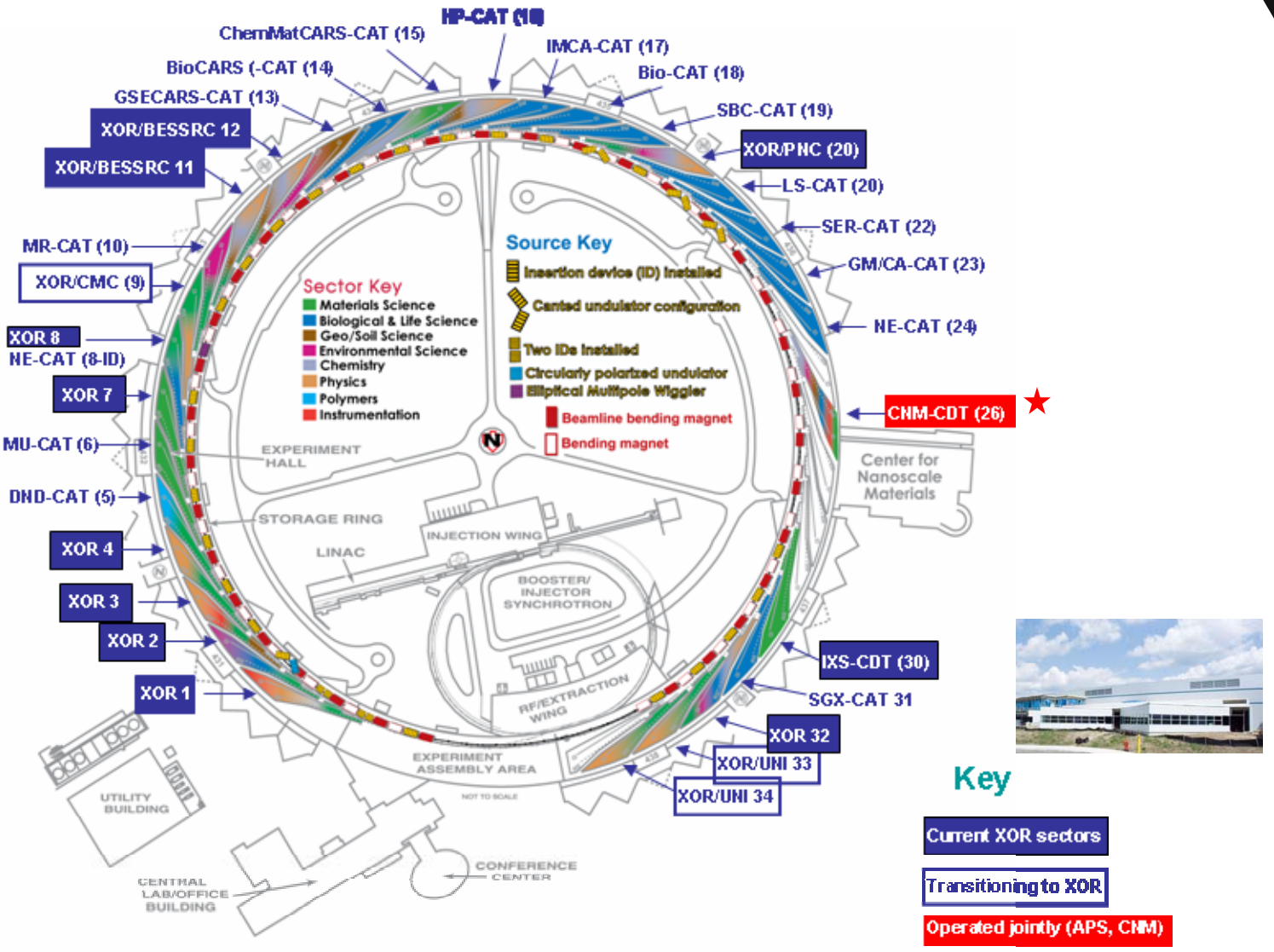
APS protein structures in international databank





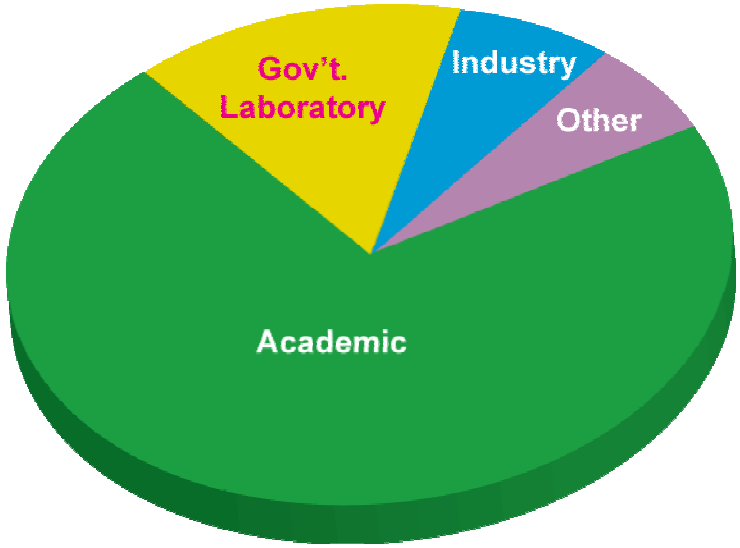
APS refereed publications by Calendar Year (CY)

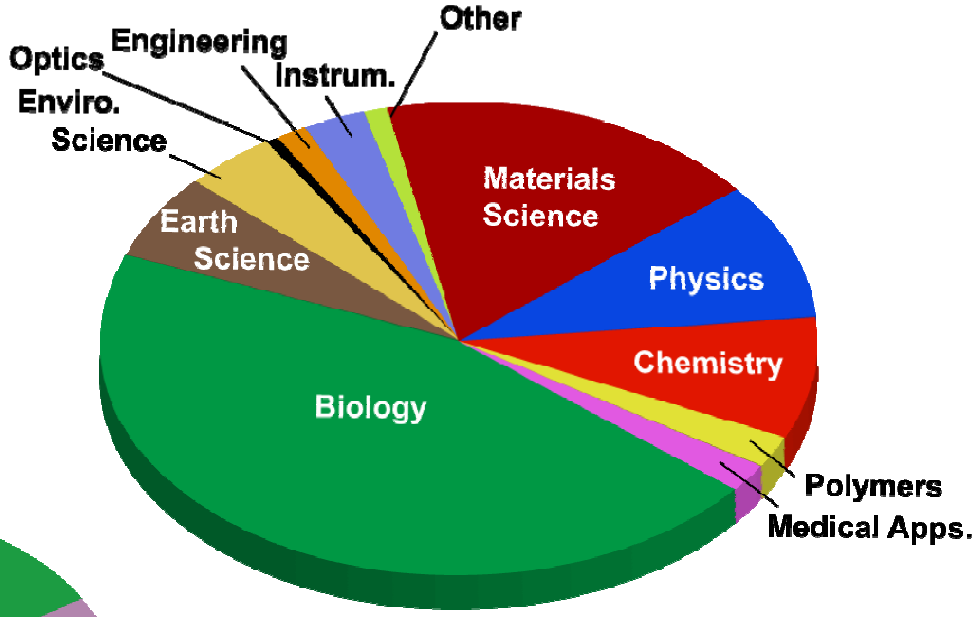
APS sectors thriving

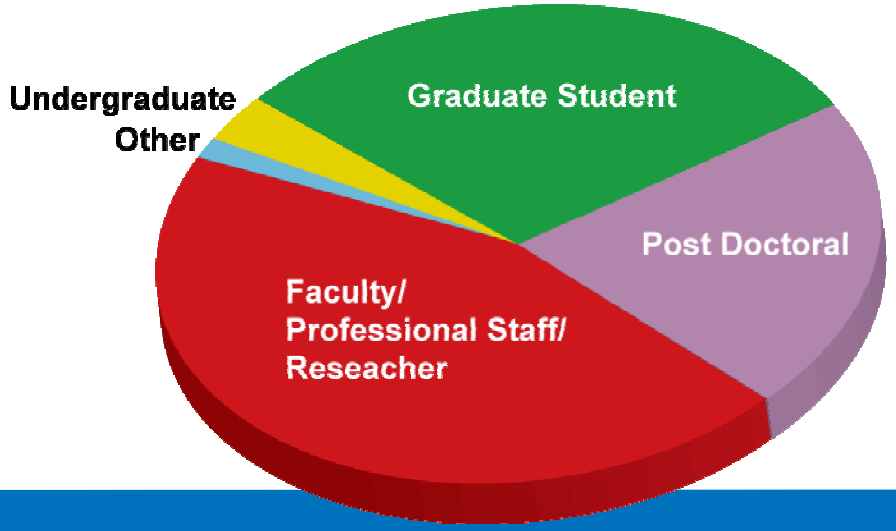


44 Beamlines Operating in FY 2005; 12 Under Construction; >68 Possible

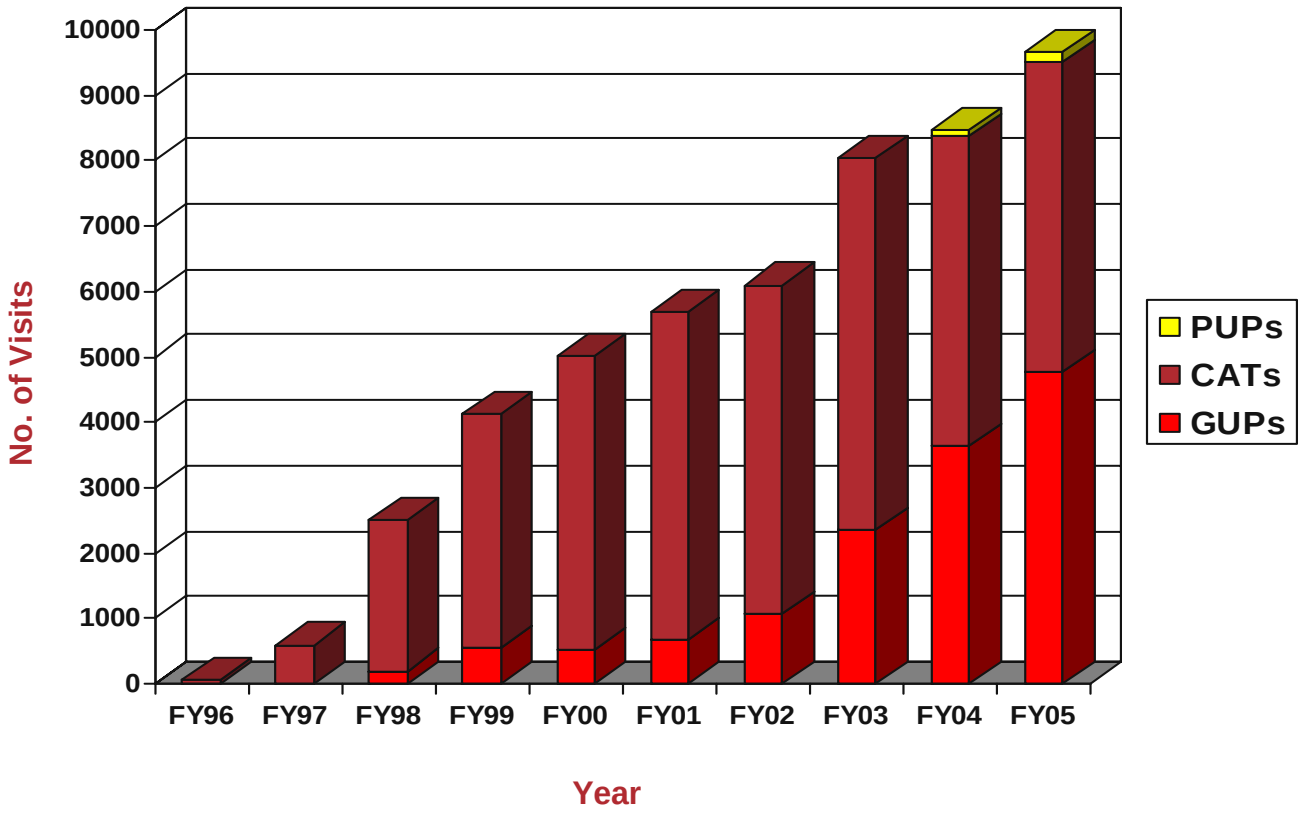
APS users – who are they and what do they do?







User visits to APS by user type



General User, Partner User, Collaborative Access Team Proposals

Partner User Access reviewed by Science Advisory Committee

- **If researchers require guaranteed beamtime that cannot be obtained through the General User program and if the proposed research will ultimately benefit the General User community (e.g., by providing new instrumentation or capabilities that will be available to General Users or expanding the APS user community), they can apply to become Partner Users on any beamline operated by the APS.**
- **Prospective Partner Users can compete for up to 30% of the total beamtime for up to three years by submitting proposals, which are peer-reviewed by a subset of the APS SAC. APS management makes the final decisions on the appointment of Partner Users.**
- **As indicated above, in addition to the importance of the science, the most significant criterion for proposal evaluation is the ultimate benefit to the APS General User community.**

No proposed changes to this mode of user access

General User Access "tweaked" after survey and review by APSUO, SAC and PUC

- **Proposed process for General User Proposals**
  - One type of proposal (valid for up to 2 years)
  - Proposals reviewed, rated, and given a maximum number of shifts by appropriate Proposal Review Panel
    - *The PRP reviewing the proposal will have the ability to effectively limit the term by limiting the number of shifts to be allocated under each proposal. Thus the PRP would be the ultimate determinant of proposal length (not over 2 years).*
  - PRP also selects proposals for further consideration as "project" proposals
    - *The PRPs select proposals to be evaluated further for project status on the basis of scientific merit, strong need for predictable access, etc.*
  - Project Proposals evaluated by SAC and APS
    - *If the SAC subcommittee and APS concurs with the PRP recommendation, the proposal would be guaranteed the recommended number of shifts for each cycle.*
    - *If the proposal is rejected for "project" status, it goes back in the GU pool.*
  - Proposals allocated beamtime by Beamtime Allocation Committee

Takes effect 1st run of CY 2007

A challenging year but we are hanging in there …

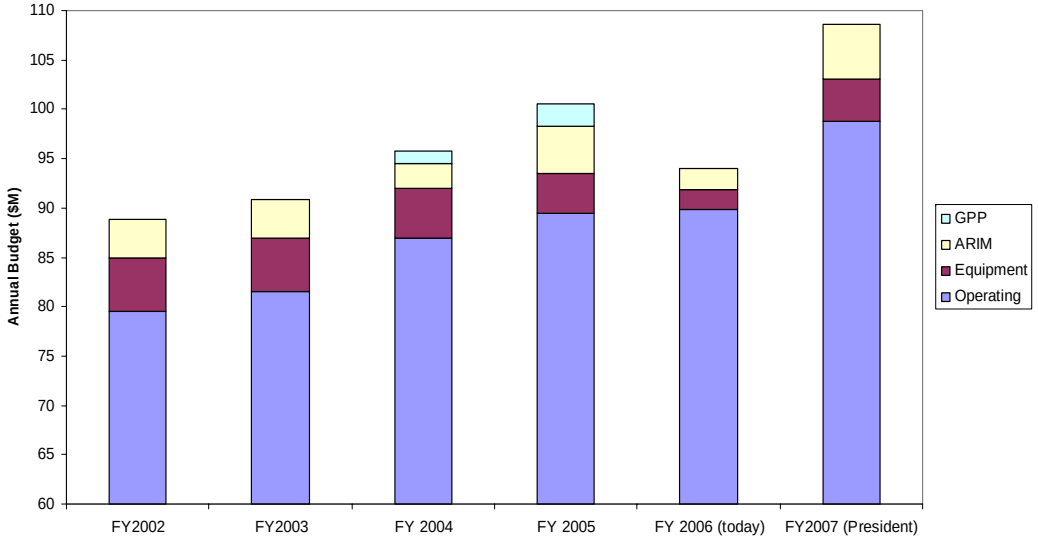
- Budget problems led to layoffs and reduced spending
  - Challenge shared across DOE Office of Science complex
- Reorganization improves efficiency and streamlines APS for future anticipated growth in each division
- Despite challenges, reviews and indicators are very positive for future

A new day is dawning……

Thanks to the American Competitiveness Initiative

Advocacy by users for facilities and science in general is rewarded

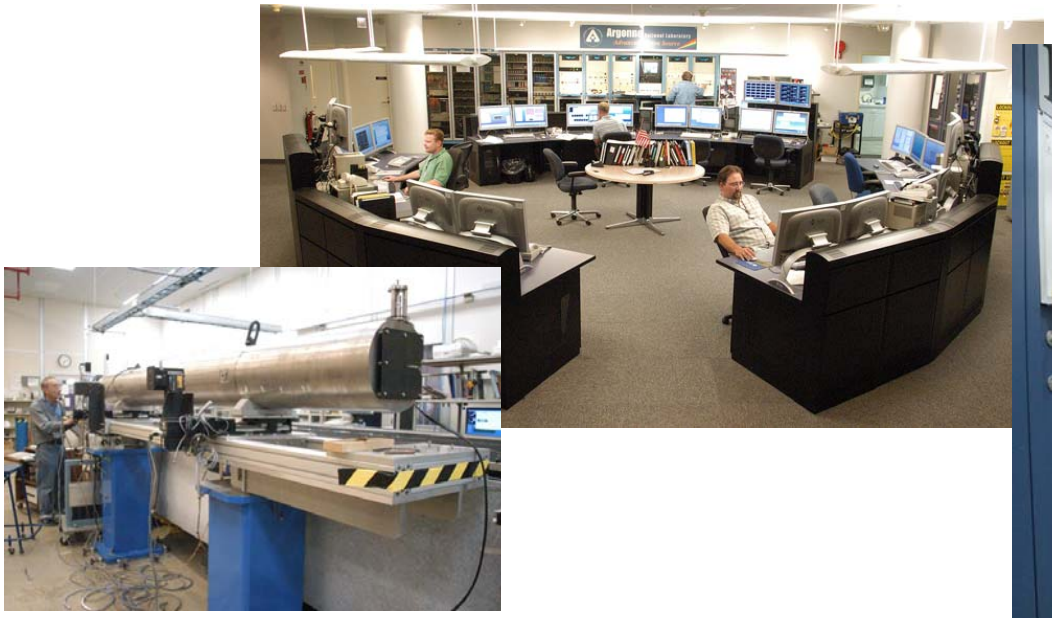
Increased Annual BES Operating Budget for APS

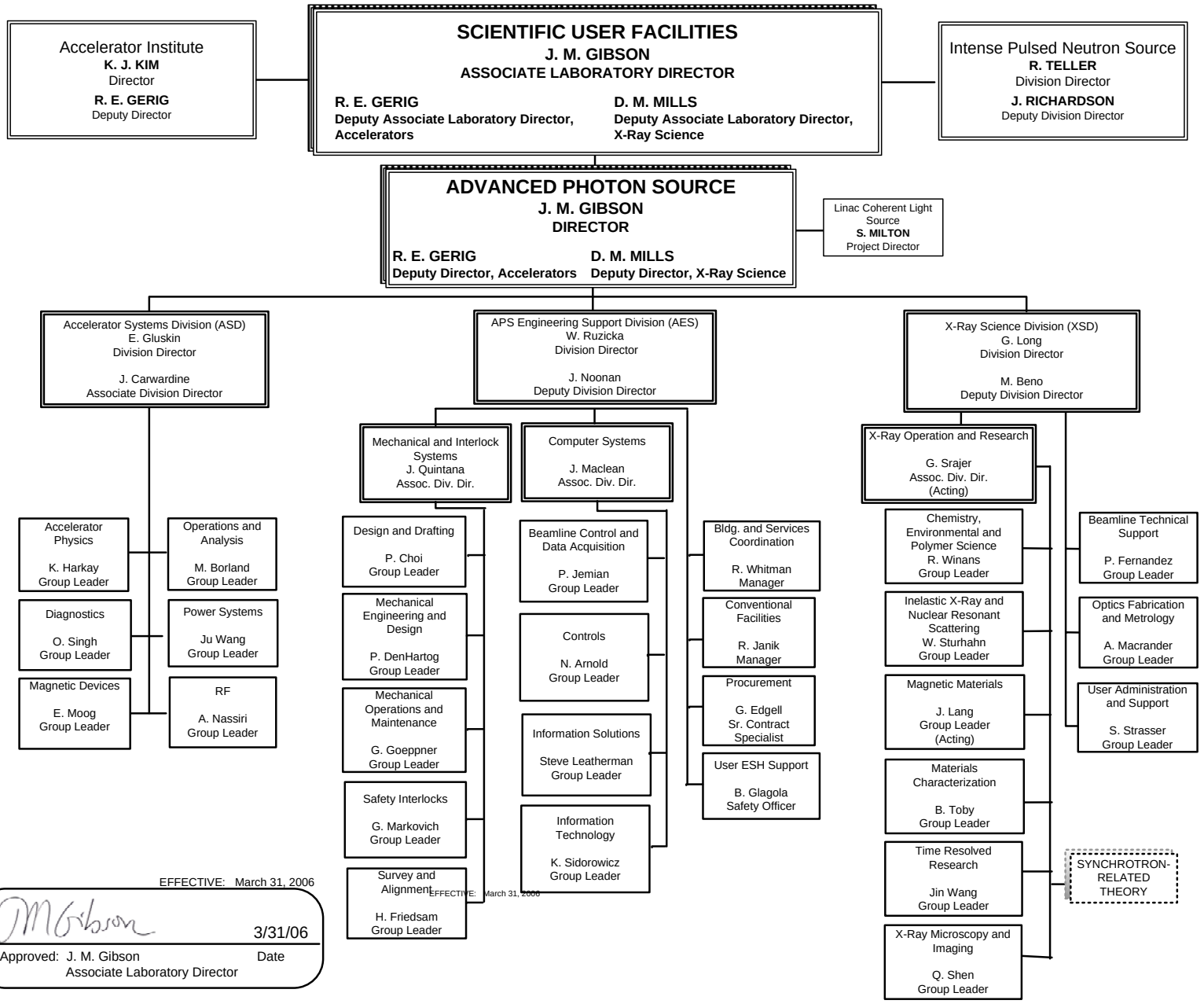


And potential for an APS 2010 upgrade

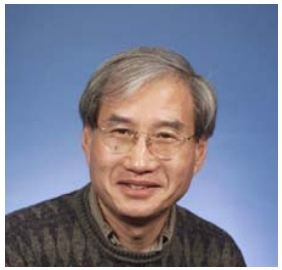
The New APS Organization

- Beamline science rises in scope and stature inside APS through new X-Ray Science Division (XSD)
- Accelerator Systems Division (ASD) takes intellectual control of the machine and provides a focus for future accelerator research
- APS Engineering Support (AES) Division (former AOD) provides state-of – the-art efficient and safe engineering design and operational support to both beamlines and machines, and existing and new ANL facilities (e.g. IPNS)




Accelerator Institute
K. J. KIM
Director
R. E. GERIG
Deputy Director
SCIENTIFIC USER FACILITIES
J. M. GIBSON
ASSOCIATE LABORATORY DIRECTOR
R. E. GERIG
Deputy Associate Laboratory Director, Accelerators
D. M. MILLS
Deputy Associate Laboratory Director, X-Ray Science
Intense Pulsed Neutron Source
R. TELLER
Division Director
J. RICHARDSON
Deputy Division Director
ADVANCED PHOTON SOURCE
J. M. GIBSON
DIRECTOR
R. E. GERIG
Deputy Director, Accelerators
D. M. MILLS
Deputy Director, X-Ray Science
Linac Coherent Light Source
S. MILTON
Project Director
Accelerator Systems Division (ASD)
E. Gluskin
Division Director
J. Carwardine
Associate Division Director
APS Engineering Support Division (AES)
W. Ruzicka
Division Director
J. Noonan
Deputy Division Director
X-Ray Science Division (XSD)
G. Long
Division Director
M. Beno
Deputy Division Director
Accelerator Physics
K. Harkay
Group Leader
Operations and Analysis
M. Borland
Group Leader
Diagnostics
O. Singh
Group Leader
Power Systems
Ju Wang
Group Leader
Magnetic Devices
E. Moog
Group Leader
RF
A. Nassiri
Group Leader
Mechanical and Interlock Systems
J. Quintana
Assoc. Div. Dir.
Computer Systems
J. Maclean
Assoc. Div. Dir.
Design and Drafting
P. Choi
Group Leader
Mechanical Engineering and Design
P. DenHartog
Group Leader
Mechanical Operations and Maintenance
G. Goeppner
Group Leader
Safety Interlocks
G. Markovich
Group Leader
Survey and Alignment
H. Friedsam
Group Leader
Beamline Control and Data Acquisition
P. Jemian
Group Leader
Controls
N. Arnold
Group Leader
Information Solutions
Steve Leatherman
Group Leader
Information Technology
K. Sidorowicz
Group Leader
Bldg. and Services Coordination
R. Whitman
Manager
Conventional Facilities
R. Janik
Manager
Procurement
G. Edgell
Sr. Contract Specialist
User ESH Support
B. Glagola
Safety Officer
X-Ray Operation and Research
G. Srajer
Assoc. Div. Dir.
(Acting)
Chemistry, Environmental and Polymer Science
R. Winans
Group Leader
Inelastic X-Ray and Nuclear Resonant Scattering
W. Sturhahn
Group Leader
Magnetic Materials
J. Lang
Group Leader
(Acting)
Materials Characterization
B. Toby
Group Leader
Time Resolved Research
Jin Wang
Group Leader
X-Ray Microscopy and Imaging
Q. Shen
Group Leader
Beamline Technical Support
P. Fernandez
Group Leader
Optics Fabrication and Metrology
A. Macrander
Group Leader
User Administration and Support
S. Strasser
Group Leader
SYNCHROTRON-RELATED THEORY
EFFECTIVE: March 31, 2006
3/31/06
Approved: J. M. Gibson
Associate Laboratory Director
Date
EFFECTIVE: March 31, 2006

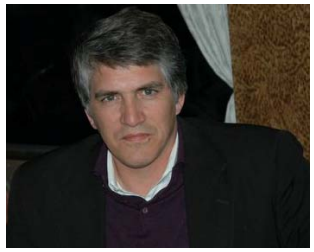
Advanced Photon Source



Director
Accelerator Institute

Deputy Director,
Accelerators

Deputy Director,
X-Ray Science



Project Director, LCLS

Director
Accelerator Systems Division

AES Deputy Director

Director
APS Engineering Support Division

XSD Deputy Director

Director,
X-Ray Science Division

Assoc. Div. Director,
Accel. Systems Div.

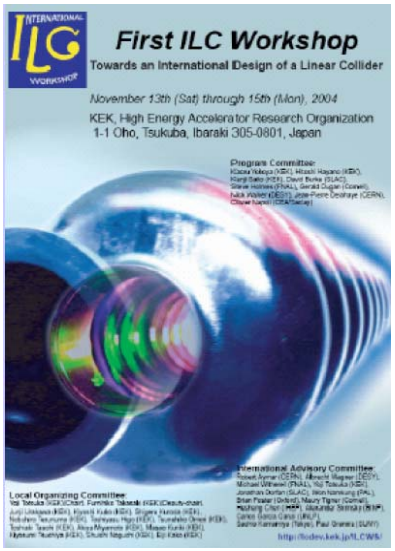
AES Assoc. Div. Director,
Mechanical and Interlock Systems

AES Assoc. Div. Director,
Computer Systems

Interim Assoc. Div. Dir.,
X-Ray Operations and Research

Accelerator and Detector Initiative at Argonne

- Accelerator technology is critical to the current and future facilities at Argonne: APS, IPNS, ATLAS, RIA…
- Major upgrade of the APS is sought
- Argonne and Fermi will team to secure the International Linear Collider project in Illinois
- Argonne has set up an Accelerator Institute to fertilize accelerator research with external partners
- This includes a component on **detectors**, critically important in most of Argonne's facilities



Strategy for expanded x-ray science at the APS

- Focus on the steps we need to take for optimal utilization and maximum scientific impact
- Look for accelerator enhancements that benefit all beamlines and create unique science opportunities
- New scientific capabilities for new research directions
  - Picosecond science at the APS
  - High-brilliance soft-x-ray beam line for “high energy” ARPES and resonant soft-x-ray scattering
  - BioNanoprobe
  - High magnetic field science
- Initiatives to optimize our scientific output
  - Beam line upgrades
  - X-ray detectors
  - Optics
  - Scientific software
- Independent CATs and the APS working together

Strategic plan for XOR optimized, dedicated beamlines

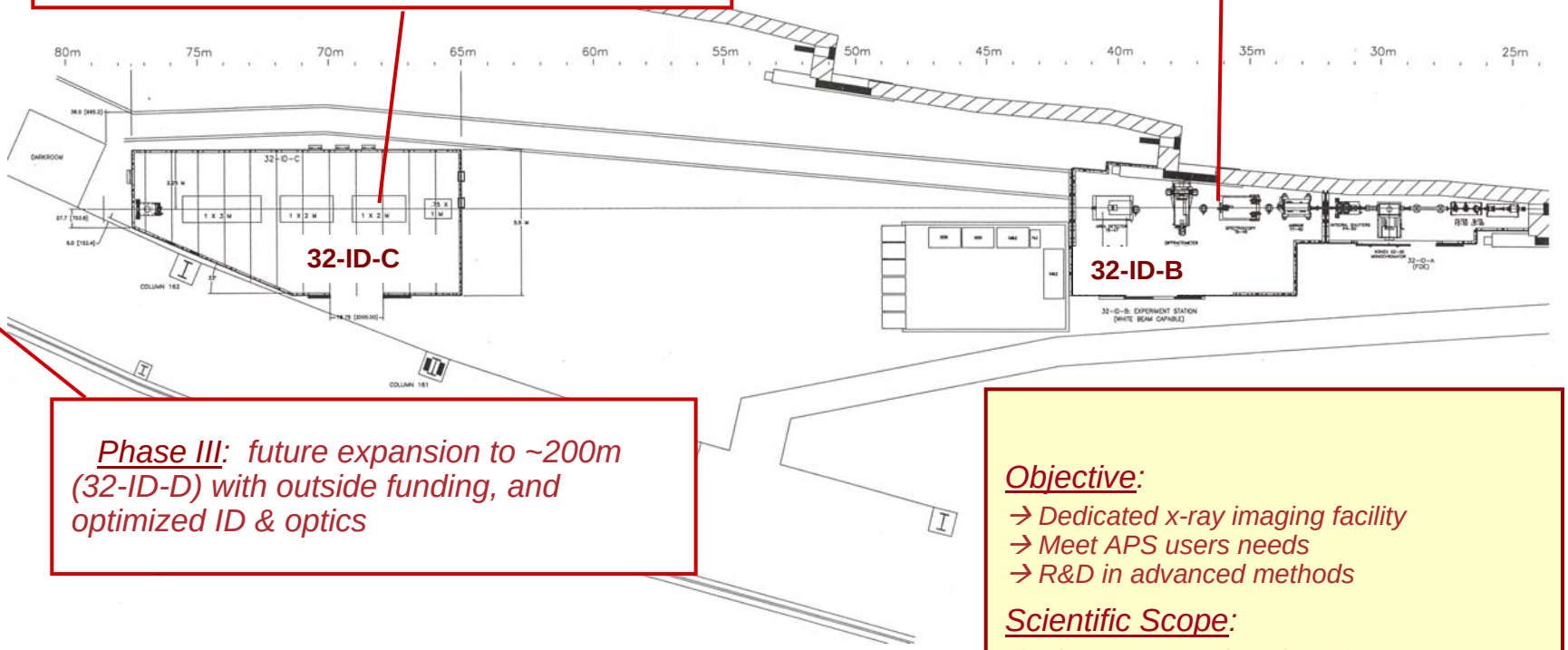
1-BM	Variable energy GISAXS, reflectivity, diffraction	MS, LS
1-ID	High-energy scattering, SAXS, powder diffraction, imaging	MS
2-BM	x-ray tomography	MS, LS
2-ID	2-32 keV STXM, microdiffraction, nanodiffraction	MS, LS, ES
3-ID	IXS, NRIXS	MS, LS, GS
4-ID-C	0.5 - 3 keV magnetic spectroscopy	MS
4-ID-D	2.6 - 45 keV magnetic spectroscopy	MS
7-BM	Ultra-fast imaging	Fluids
7-ID-B	Time-resolved white/pink beam imaging	MS, CS
7-ID-C	Time-resolved microbeam scattering	MS
7-ID-D	Laser pump/x-ray probe spectroscopy	CS, MS
8-ID-E	GISAXS	Thin films
8-ID-I	XPCS	Liquids, films
9-BM	XAFS	CS
9-ID-B	Liquid surface scattering	CS
9-ID-C	Resonant IXS	MS
11-BM	Powder diffraction	CS, MS
11-ID-B/C	High-energy powder diffraction, pdf, diffuse scattering	MS
11-ID-D	Laser pump/x-ray probe spectroscopy	CS
12-BM	XAFS, diffuse scattering, diffraction	CS, MS
12-ID-B	SAXS/WAXS	MS
12-ID-C	Time-dependant SAXS	MS, LS
12-ID-D	Surface/interface diffraction	MS
20-BM	XAFS, DAFS	ES, MS, CS
20-ID-B	Micro-XAFS	ES, MS, CS
20-ID-C	DAFS, XRR, surface-XAFS, laser pump-XAFS	ES, MS, CS
26-ID	Hard-x-ray nanoprobe	MS
30-ID	IXS, resonant IXS	MS
32-ID	Advanced full-field x-ray imaging	MS, LS
33-BM	Diffraction	MS
33-ID	Diffraction, surface/interface scattering	MS
34-ID-C	Coherent diffraction imaging	MS, LS
34-ID-E	3D-x-ray diffraction micro (and nano) scope	MS
New BM	Catalysis research (XAFS and WAXS)	CS
New ID	0.2 keV - 2.5 keV ARPES, resonant scattering, diffraction	MS
New ID	Hard-x-ray magnetic scattering (35 T magnet)	MS
New ID	ps-pulse science	CS
New ID	BioNanoprobe	LS

more on our web site www.aps.anl.gov

32-ID upgrade for advanced full-field x-ray imaging

Phase I: use of existing hutch and equipment, with upgrades to mono, Be windows, and pink-beam capability

Phase II: expansion to ~77m by building a new white-beam capable hutch at 77m and beam transport



Phase III: future expansion to ~200m (32-ID-D) with outside funding, and optimized ID & optics

Objective:

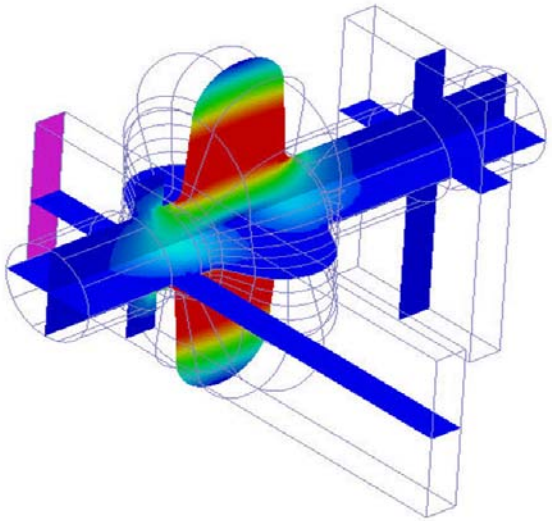
- → *Dedicated x-ray imaging facility*
- → *Meet APS users needs*
- → *R&D in advanced methods*

Scientific Scope:

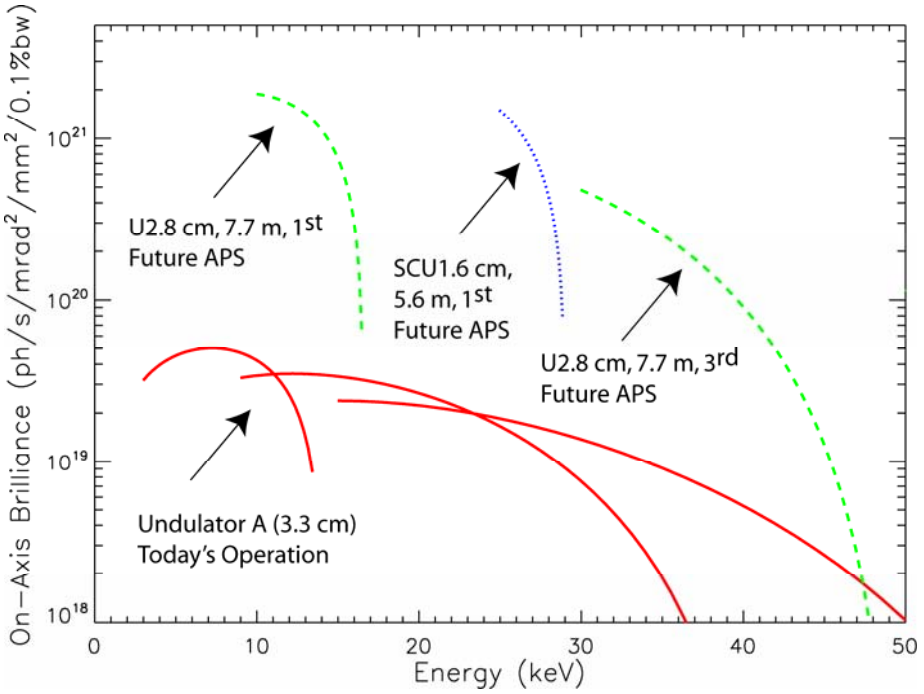
- → *Phase contrast imaging* ←
- → *DEI and USAXS imaging* ←
- → *Coherent Fresnel diffraction*
- → *Lens-based microscopy (TXM)*

APS 2010 upgrade

- We have the unique opportunity to bring APS to world-leading level in the next decade (proposal has been solicited by DOE-BES, due late 2006)
  - Reduce lattice emittance to ~1 nm with ID beamports unchanged
  - Most straight sections longer (8m), special undulators, utilizing unique properties of APS to tailor x-ray beams
  - “Crab” cavities for ps pulses and controlled coherence
  - Optimized and upgraded beamlines



Transverse deflecting RF cavity design for ps pulse production at APS

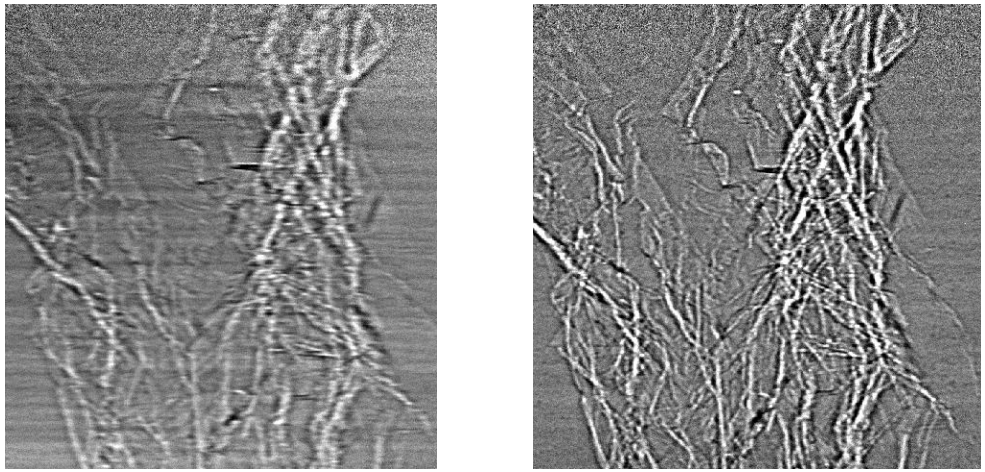


Making a smaller x-ray source at Sector 32

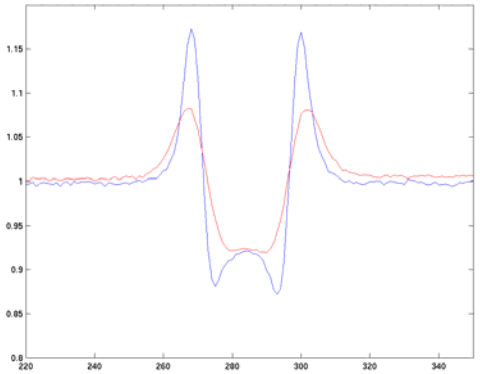
APS has unique flexibility to control beta functions by sector

Normal beta $FWHM_x$ = 560 μm Reduced beta $FWHM_x$ = 280 μm

200 μm ⟷



Aluminum stress crack sample, ~3mm thick



Effect of reduced beta function (blue line) on fresnel fringes around a carbon fiber

Revolutionary science from upgraded APS

- Chemical excited states give insight into photosynthesis for efficient and cheaper solar energy
- Ultrafast dynamics of magnetic and ferroelectric domains for information storage and computing
- Detecting sub zeptogram (10^{-21}g) quantities of metals in cells and soils – health and environment
- In-situ study of nucleation in liquids – leading to better controlled chemical synthesis and catalysis
- Materials under extreme magnetic fields – routes to quantum computing
- …

Conclusion

- APS has a brighter future!
- Planning for an upgrade began with the Office of Science 20 year plan several years ago, and now an APS upgrade is seriously being considered
  - Great opportunity given strong US administration support for physical sciences
- We need to engage users further in planning a proposed APS 2010 upgrade
  - Mark you calendars for ~Aug 9-11th workshop at APS
  - We must develop a scientific proposal for outside review submitted October 31, 2006
- Mike Borland will describe more about the APS 2010 upgrade next