



... for a brighter future

APS Renewal Instrumentation Part I

*Denis Keane, Director DND-CAT, PUC Chair
Scientific Advisory Committee (SAC) Meeting
January 20-22, 2009*



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Areas Covered in Part I

- **Introduction**
- **Instrument Groups**
 - Crystallography
 - Bulk Probes
 - Spectroscopy
 - Surface Probes

Introduction

■ Today's presentations

■ Renewal Steering Committee

- Denny Mills, PSC, Chair – Techniques II
- Denis Keane, PUC (DND) – Techniques I
- Paul Fuoss, APSUO (MSD) – Integration with Science Cases
- Other Members: Rod Gerig, PSC; George Srajer, XSD; Bob Fischetti, PUC/LSC (GM/CA); John McLean, AES; Dan Neumann, SAC (NIST)

■ Basis

- Instrument Groups
 - Beamline Proposals
 - LOIs, CAT/CDT Proposals
 - Open Forum of January 9, 2009
 - Committee members
- Science Drivers & Integration
 - All of the above
 - Science Cases
 - Renewal Workshop of October, 2008

Introduction II

■ Comments

- Several CATs provide multiple techniques and will continue to do so, based on funding and APS reviews**
 - GSE-CARS**
 - ChemMat-CARS**
 - HP-CAT**
 - DND-CAT**
- Difficult to account for distributed capabilities in some cases**
- Can miss synergies when categorizing by technique (SAXS/WAXS/PDF on one beamline?)**

■ Definition

- Beamline**
 - Operates independently of others**
 - May have dedicated or shared source**
 - Has dedicated shutter**
- Station**
 - Enclosure for experiments**
 - One beamline can have several stations**

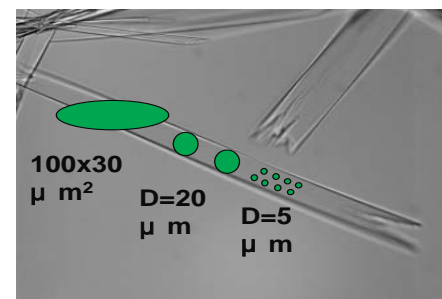
Macromolecular Crystallography

■ Some Comments

- APS leads the world in PDB deposits
- Around 40% of APS users are MX researchers
- All MX beamlines are CATs (non-XOR)
- Four sectors are “new”: SER, GM/CA, NE, LS (last 3 canted IDs)
- One rebuilt/new sector has been discussed with 1 micron beams (not currently in list of LOIs but LSC is considering again)

■ Summary of Beamline Renewal Proposals and Sector LOIs/Proposals

- Emphasis on advanced detector technology
 - *Proposal for APS support of anticipated PAD detectors*
- Additional key needs are in small beams
 - New focusing optics
 - Beam stability – especially angular stability
 - Beamline stability



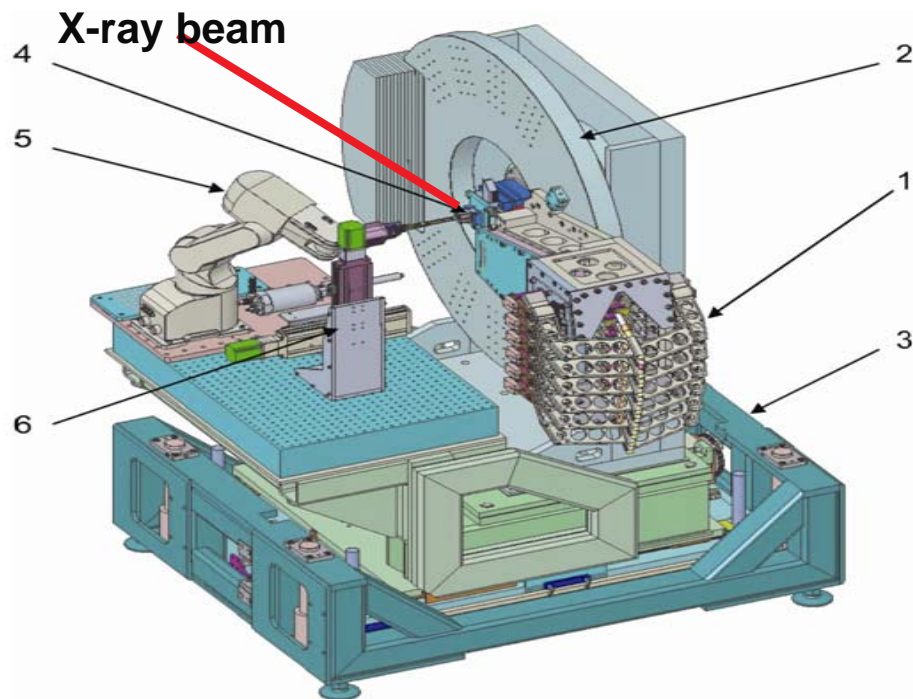
MX Beamlines

Existing BL Operator (% currently)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
14IDB, 14BMC BioCARS (2)	14ID rebuild 2008 (2)	BSL3, Laue crystallography (also in time resolved)	UNIQUE
17IDB, 17BMB IMCA (CARS) (2)	17ID rebuild 2008 (2)	Industrial collaboration, MAD/SAD	
19IDD, 19BMD SBC (2)	Upgrade/move(?) including 1 micron beams (3)	MAD/SAD, Ultralow temperature (15K)	1 μm UNIQUE
21IDD, 21IDF, 21IDG LS-CAT (3)	Complete side bounce station 21IDE – ongoing now (4) – 2 canted undulators	MAD/SAD	200-100 μm
22IDD, 22BMD SER-CAT (2)	(2)	MAD/SAD	200-100 μm
23IDB, 23IDD GM/CA-CAT (2)	(2) – 2 canted undulators	MAD/SAD, microbeams	200-5 μm
24IDC, 24IDE NE-CAT (2)	(4) – 2 canted undulators, complete 24BM, add final ID station	MAD/SAD, microbeams	200-20 μm
31ID SGX (1)	(1)	SAD	
16.0 (equivalent)	20.0 (equivalent)	Canted and Tandem IDs no new BLs	

Powder Diffraction and Crystallography Instruments

■ Some Comments

- Powder Diffraction is an integral part of Real Materials in Real Conditions but can it be made into Real Time?
- Part of a continuum of reciprocal space techniques complementary to imaging: single crystal, powder, WAXS, PDF, EXAFS, SAXS
- One of many techniques for High Pressure research on HP-CAT



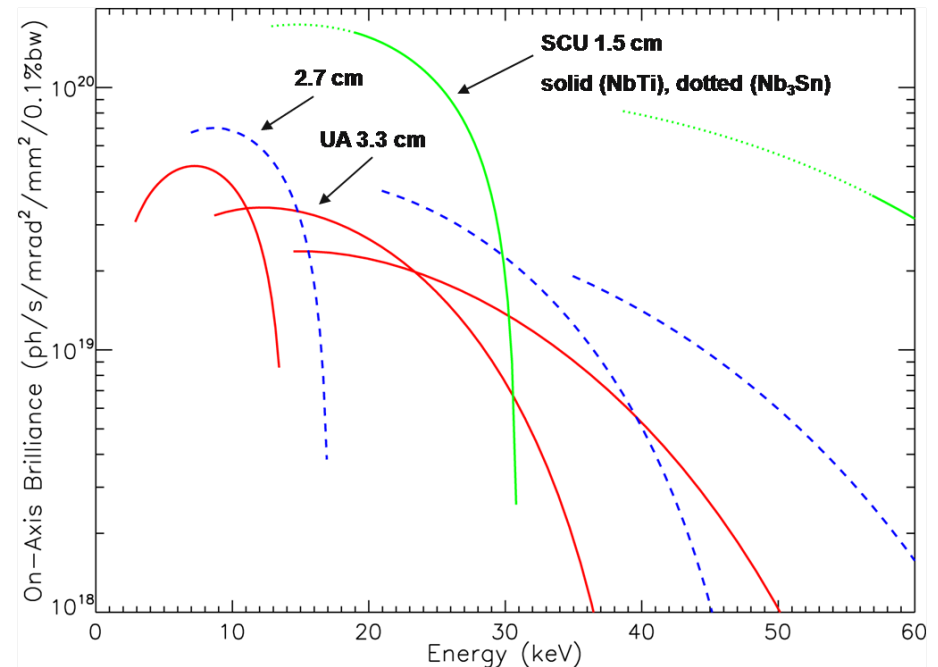
Powder Diffraction and Crystallography Beamlines

Existing BL Operator (% currently)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
5BMC DND-CAT (50%)	Add focusing (50%)	Chemistry, Materials Science, tunable	
5IDB DND-CAT (25%)	Increase access through upgrade to 2 canted undulators (50%)	11-detector system could be upgraded to 11BM style for ultimate resolution	UNIQUE to APS
11BM XOR (100%)	(100%)	Improved multi-detector system	UNIQUE to APS
	New high-resolution 2-d detector based system (100%)	Materials Science	
13BMC GSE CARS(25%)	(25%)	Single Crystal Diffraction, Geology, Environmental Science	
15IDC ChemMatCARS (33%)	Upgraded optics (33%)	Single Crystal Diffraction, Materials Science, chemistry	
16IDB, 16IDD, 16BMB, 16BMD HPCAT (3.5)	Specialized IDs, canted IDs (4)	Powder diffraction, single crystal diffraction; High pressure, Geology, materials science	
5.8 (equivalent)	7.6 (equivalent)	New instrument for new beamline, canted IDs	

Bulk Probes

■ Some Comments

- Includes PDF, SAXS, diffraction and diffraction imaging
- APS is world competitive in (at least) several areas:
 - Dedicated PDF beamline
 - White beam Laue micro-diffraction
 - High Energy diffraction microscopy
- Detector technology (i.e. GE angio) key to current and future capabilities



High Energy Beamlines

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
1-ID XOR (100%)	Improved optics and detectors dedicated to part of existing 1ID program SCU (100%)	High energy studies of aggregate polycrystalline materials Materials science, engineering	~ μm spatial resol. 40-90 keV
	New beamline for HEDM ,SCU (100%)	Materials science, Hierarchical Imaging	~ μm spatial resol. 40-90keV
	New BM beamline for HE studies (100%)	Energy Dispersive Diffraction, High E tomography, Materials science	~ μm spatial resol.
11-ID-B XOR (50%)	Optimized ID. Dedicated for PDF (100%)	Materials science, chemistry	UNIQUE
11-ID-C XOR (50%)	Improved optics and detectors (100%)	High Energy Diffraction, PDF, materials science, chemistry	~ μm spatial resol
	New beamline for submicrofocus HE (100%)	High Pressure, Materials science	~ 200 nm spatial
6IDD XOR (50%)	(50%)	PDF, High E diffraction, Mat Sci	
13ID GSE (25%)	Canted ID (50%)	Geology, Environmental Science	
5BMD DND (25%)	Upgrade Monochromator (25%)	Materials Science, Chemistry	
3.0 (equivalent)	7.25 (equivalent)	Canted and Optimized IDs and one new BM BL	

SAXS beamlines

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
1ID XOR (25%)	New dedicated beamline, SCU (100%)	HE SAXS/WAXS Materials science	
5IDD DND (50%)	Canted ID (100%)	SAXS/WAXS; polymers, nanoscience Materials science, chemistry	Doubly focused, 50 μ m beam
8ID XOR (50%)	Optimize and dedicate station to GISAXS (50%)	GISAXS, polymers, materials science, chemistry	
12ID XOR (50%)	Canted ID upgrade underway (150%)	SAXS/WAXS/GISAXS/USAXS, chemistry, materials science	
15ID ChemMat CARS (33%)	Upgrade optics (33%)	SAXS, Chemistry, Materials Science	
18ID BioCAT (50%)	Tandem undulators to increase flux (50%)	Solution Scattering	Double focused ID
32ID XOR (25%)	To 12ID(?)	USAXS	
2.8 (equivalent)	4.8 (equivalent)	Canted IDs and one new ID BL	

Laue Diffraction Microscopy

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
34ID XOR (50%)	Triple Canted IDs, nanoprobe (200%)	3D microscopy, materials science, engineering	300 nm & 50 nm UNIQUE
0.5	2	Canted ID, new station	

Magnetic Scattering (non-resonant)

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
4IDD XOR (50%)	New ID, improved optics (50%)	XMCD, diffraction, physics, materials science	
6ID XOR (50%)	(50%)	diffraction	
11IDD XOR (50%)	(50%)	diffraction	
	New beamline (100%)	15T superconducting magnet, pulsed magnet, future high-field magnet outfield station	>30 keV, 100 μm x 100 μm
2	3	New beamline	

Spectroscopy and the APS Renewal

■ Bulk XAS

- Many BM beamlines currently support the technique: 5BMD, 9BM, 12BMB, 13BMD, 20BM; 10BM soon to be online
- 9BM already scheduled for upgrade/renewal with LDRD for catalysis
- Effort during renewal should be overall coordination of efforts especially in improving detectors, sample environments and software

■ Need for dispersive EXAFS on ID line at APS?

■ Microprobe based XAS

- APS may be lagging in K-B based systems – several upgrades are proposed
- Critical need for sample environments is cryogenic sample preservation

Nano/Micro XAS

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
2-ID XOR (33%)	Cryo-XRF beamline (100%) + room temperature microprobe (50%)	Biology	500 nm - 30 nm
	BioNanoProbe (50%)	Biology	~30 nm
13-ID GSECARS (50%)	Canted ID with improved KB focusing (100%)	Geology, Environmental Science	Scan large area, zoom in w/ sub- μ m beam
16ID HP-CAT (50%)	Canted ID with improved KB focusing (100%)	High Pressure Science	sub- μ m beam
18ID BioCAT (50%)	Dual inline undulators to improve flux , new optics (50%)	Biology	
20ID XOR (50%)	Canted ID with improved KB focusing (100%)	Environmental Science, Materials Science	Scan large area, zoom in w/ sub- μ m beam
26ID XOR/CNM (50%)	(50%)	Materials Science, Nanoscience	Better than 30 nm resolution, UNIQUE
3.8 (equivalent)	6.0 (equivalent)	Canted IDs and one new ID BL	

Time Resolved EXAFS

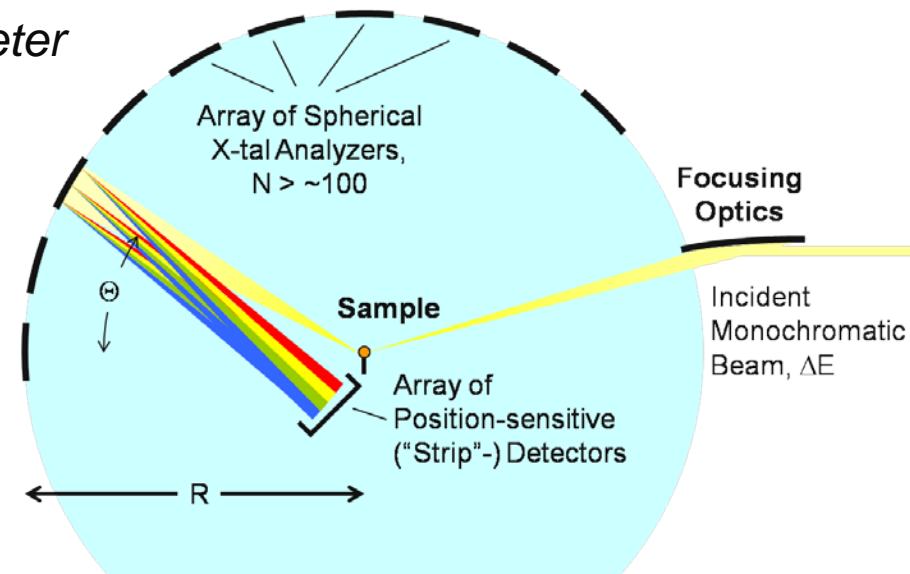
Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
7IDD XOR (50%)	improved focusing optics, HR emission spectroscopy (50%)	Laser pump-probe	Sub-ns resolution Psec pulse (?)
11IDD XOR (50%)	New ID, improved optics (50%)	Laser pump-probe	Sub-ns resolution
20IDD XOR (50%)	Canted ID, Detector and focusing upgrade (100%)	diffraction	Sub-ns resolution
1.5	2.0	1 canted ID	

XMCD

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
4IDC XOR (50%)	improved optics (50%)	Soft x-ray XMCD, PEEM, physics, materials science	
4IDD XOR (50%)	New ID, improved optics (50%)	XMCD, diffraction, physics, materials science	
	Low x-ray energy XMCD New beamline dual undulators (100%)	XMCD, physics, materials science	
1	2	New beamline	

Inelastic X-ray Scattering

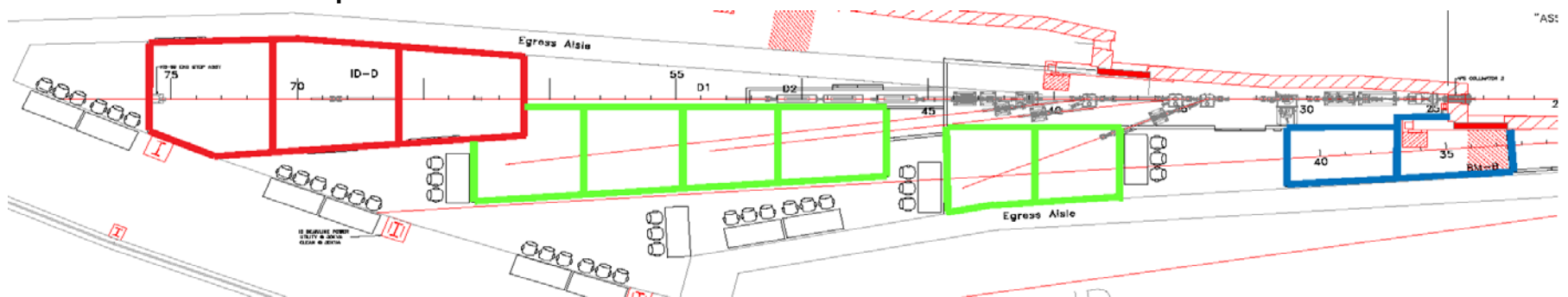
- Common needs
 - Improving the source
 - Long straight sections
 - Multiple optimized IDs – superconducting, in-vacuum
 - Higher electron current in APS storage ring
 - Advancing detectors
 - Ge-based strip detectors with ~ 100 crystal analyzers
 - Improved APD arrays for NRS
 - Proposing 2 new spectrometers
 - Multi-Analyzer Spectrometer with > 100 Analyzer/Detector Assemblies
 - Ultra-High Resolution Spectrometer
 - $100 \mu\text{eV}$
 - Using comb crystals



Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
3ID XOR (100%)	Source, new detectors (100%)	NRS, physics	0.5 meV and better
9ID XOR (50%)	Source, new focusing, new spectrometer, canted ID (100%)	Medium Resolution IXS	40-100 meV
16ID HP (25%)	Canted IDs (50%)	NRS, high pressure science	
20ID XOR (25%)	Canted IDs (50%)	LERIX, Materials Science	0.5-1eV
30ID XOR (100%)	Source, new detectors, new spectrometer (100%)	MERIX and HERIX, physics	To 100 μ eV
3 (equivalent)	4.0 (equivalent)	New IDs, canted IDs	

Surface Probes

- Covers many techniques:
 - GISAXS
 - Surface & Interface Diffraction/Scattering, including resonant scattering, XSW, reflectivity
 - Liquid Surface Scattering
 - XAFS
 - In-situ capabilities
 - Especially can benefit from dedicated station
 - Some centralized, some distributed
- New applications
 - X-ray Interface Microscopy
 - See surface steps
 - Can upgrade/compliment many existing surface/interface experiments



Surface Scattering (XSW, reflectivity, COBRA, etc.)

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
	XIS proposal, canted IDs, side bounce mono, BM (5)	XSW, XRIM. Surface science	4-40keV, 10 keV, 10keV ,30 keV
5ID DND (25%)	Canted ID, side-bounce mono (50%)	XSW, UHV chamber	
6ID XOR (33%)	Upgraded optics (33%)	UHV chamber	
12ID XOR (50%)	Canted ID, side bounce mono (50%)	MOCVD chamber, diffractometer	4.5-36keV
13ID GSE CARS (25%)	Canted ID, mirror offset (50%)	High energy interface diffraction/scattering – Mineral/water interface	5-100 keV
20ID XOR (25%)	Canted ID (33%)	MBE chambers, surface XAFS	
33ID, BM XOR (2)	Canted ID, side bounce mono, new larger station (3)	XSW, PLD	
3.6 (equivalent)	10.2 (equivalent)	New sector, canted IDs	

GISAXS

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
8-ID XOR (50%)	2 tandem undulators, new offset mono, new detectors (100%)	Polymer science, Materials science, chemistry	
12-ID XOR (25%)	Canted undulators, SAXS on 1.5 beamlines (75%)	Materials science, chemistry	
0.75 (equivalent)	1.75 (equivalent)	New ID, canted ID	

Liquid Surface Scattering

Existing BL Operator (% current)	Upgrade Proposal or LOI/New Proposal (% future)	Techniques and Disciplines	Beam Properties/ Unique?
6ID XOR (25%)	(25%)	Soft condensed matter	
9ID XOR (50%)	Canted ID, side-bounce mono (100%)	Soft condensed matter	
15ID ChemMat CARS (33%)	Upgraded optics (33%)	Soft condensed matter, Materials Science, Chemistry	
1.1 (equivalent)	1.6 (equivalent)	Canted ID	

Summary/Discussion Points

- Major capacity increases in
 - Surface scattering
 - High energy instruments
- Key optics improvements
 - New K-B mirrors for XAS micro/nano probes
 - Many side-bounce monochromators for canted ID beamlines
- Significant new instruments
 - IXS
- Development projects
 - High resolution 2-d powder diffraction
 - APS source stability improvements benefits all
- Detector needs
 - Pixel Array detectors for MX, SAXS
 - Fast spectroscopy (Si drift) for XAS
 - Ge strip detectors for IXS
 - APD arrays for NRS