

ADVANCED PHOTON SOURCE

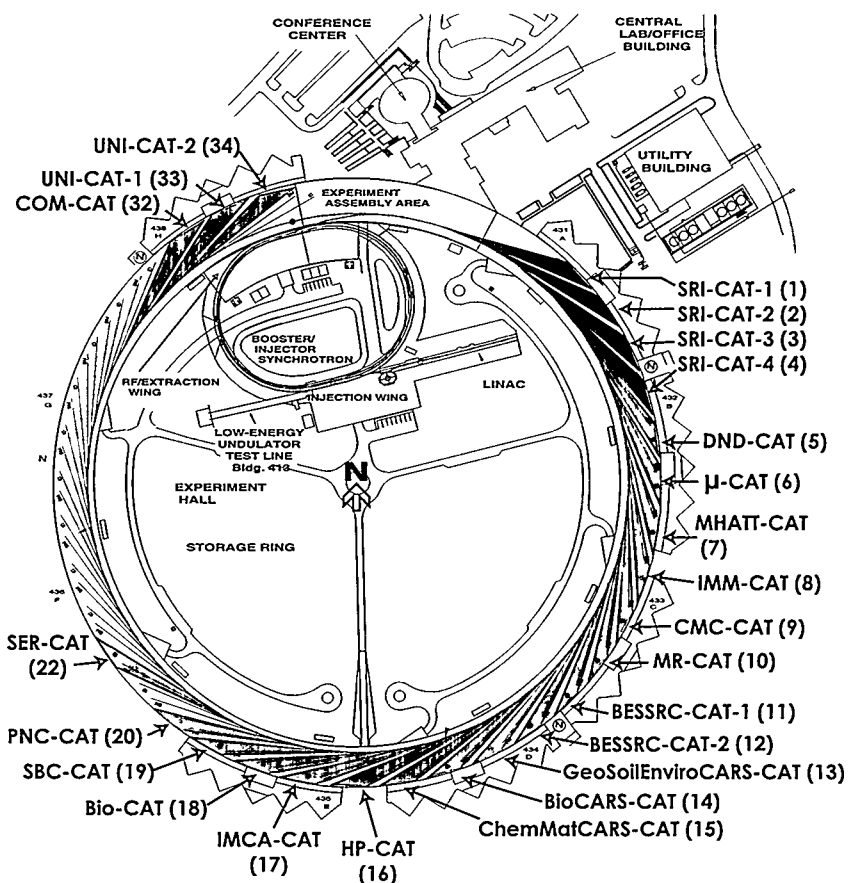
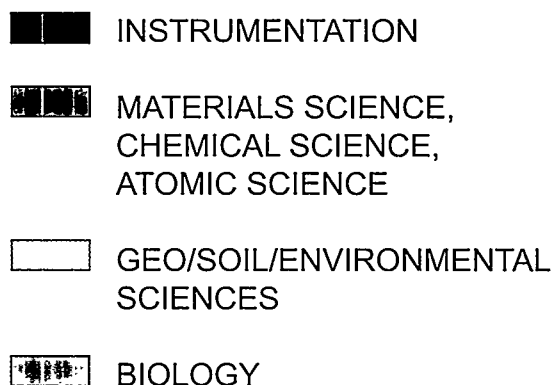
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CAT Guide and Beamline Directory

A Key to APS Collaborative Access Teams

November 1999
Argonne National Laboratory



CAT ACRONYM	CAT NAME	SECTOR	BEAMLINE(S)
SRI-CAT	Synchrotron Radiation Instrumentation	1	1-BM, 1-ID
		2	2-BM, 2-ID
		3	3-ID
		4	4-ID
DND-CAT	DuPont–Northwestern–Dow	5	5-BM, 5-ID
mCAT	Midwest Universities	6	6-ID
MHATT-CAT	Center for Real-Time X-ray Studies	7	7-BM, 7-ID
IMM-CAT	IBM–MIT–McGill	8	8-BM, 8-ID
CMC-CAT	Complex Materials Consortium	9	9-BM, 9-ID
MR-CAT	Materials Research	10	10-ID
BESSRC-CAT	Basic Energy Sciences Synchrotron Radiation Center	11	11-ID
		12	12-BM, 12-ID
CARS-CAT	Consortium for Advanced Radiation Sources		
	GeoSoilEnviroCARS	13	13-BM, 13-ID
	BioCARS	14	14-BM, 14-ID
	ChemMatCARS	15	15-ID
HP-CAT	High-Pressure	16	under development
IMCA-CAT	Industrial Macromolecular Crystallography Association	17	17-BM, 17-ID
Bio-CAT	Biophysics	18	18-BM, 18-ID
SBC-CAT	Structural Biology Center	19	19-BM, 19-ID
SER-CAT	Southeast Regional	22	under development
PNC-CAT	Pacific Northwest Consortium	20	20-BM, 20-ID
COM-CAT	Commercial	32	32-ID
UNI-CAT	A University–National Laboratory–Industry	33	33-BM, 33-ID
		34	34-ID

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CAT Guide and Beamline Directory

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The Advanced Photon Source

Facility Overview

The Advanced Photon Source (APS), a national user facility for synchrotron radiation research, is located at Argonne National Laboratory, approximately 25 miles southwest of Chicago, Illinois. The APS is considered a third-generation synchrotron radiation facility (specifically designed to accommodate insertion devices to serve as radiation sources) and is one of three such facilities in the world. Currently, it is the most brilliant source in the United States for research in such diverse fields as biology, medicine, materials science, chemistry, geology, agriculture and soil science, physics, and manufacturing technology.

Researchers use the APS either as members of Collaborative Access Teams (CATs) or as Independent Investigators (IIs). CATs are responsible for designing, building, and operating beamlines in one or more sectors, each sector consisting of an insertion-device (ID) beamline and a bending-magnet (BM) beamline. Each beamline is designed to accommodate a specific type of research program(s) and is optimized accordingly.

User Program

CAT members are entitled to use 75% of the available beam time to pursue CAT research goals. The remaining 25% of the available beam time must be made available to IIs, who are selected by the CAT through a proposal process determined by each CAT and approved by the APS. Prospective IIs submit proposals to the APS User Office, which screens each proposal for completeness, logs it in, arranges for review, then forwards it to the appropriate CAT(s). Proposal forms can be downloaded from the World Wide Web (WWW) at the following address: http://www.aps.anl.gov/xfd/communicator/useroffice/IIprop_form.html. This document, the *CAT Guide and Beamline Directory*, was written to help prospective IIs determine which beamlines are suitable for their specific experiments. Further information can be obtained from the APS User Office or the individual CATs (contact information is provided on the inside back cover of this document).

Summary Beamline / Scientific Programs Table

BEAMLINE	CAT	SCIENTIFIC FOCUS	PROGRAMS	SOURCE	STATUS *
1-BM	SRI	Synchrotron instrumentation and techniques, time-resolved studies	<ul style="list-style-type: none"> -Use and generation of polarized x-rays -Time-resolved studies, dispersive diffraction and spectroscopy 	BM	O II
1-ID	SRI	Synchrotron instrumentation and techniques, high-energy x-rays, optics development	<ul style="list-style-type: none"> -High-energy x-ray scattering techniques -High-heat-load x-ray optics development 	Und A (3.3 cm)	O II
2-BM	SRI	Synchrotron instrumentation and techniques, x-ray lithography, microtomography	<ul style="list-style-type: none"> -Deep x-ray lithography -X-ray microtomography -Development of x-ray optics -Beam diagnostics instrumentation -X-ray microprobe studies 	BM	II
2-ID-B	SRI	Synchrotron instrumentation and techniques, imaging, coherence	<ul style="list-style-type: none"> -High-resolution imaging -Coherent scattering -Interferometry 	5.5-cm Und	O II
2-ID-C	SRI	Synchrotron instrumentation and techniques, polarization spectroscopy	-High-resolution polarization-dependent x-ray spectroscopies	5.5-cm Und	O
2-ID-D/E	SRI	Synchrotron instrumentation and techniques, imaging, coherence	<ul style="list-style-type: none"> -High-resolution imaging -Coherence-based techniques 	Und A (3.3 cm)	O II
3-ID	SRI	Synchrotron instrumentation and techniques, resonant and non-resonant inelastic scattering	<ul style="list-style-type: none"> -Nuclear resonant scattering -Inelastic x-ray scattering 	2.7-cm Und	O II
4-ID	SRI	Synchrotron instrumentation and techniques, use of polarized x-rays	<ul style="list-style-type: none"> -Development of polarization optics and techniques for 0.5 - 100 keV -Development of high-heat-load front-end and optical components 	Und A (3.3 cm) & Circularly Polarized Und	D
5-BM	DND	Crystallography, EXAFS, polymer scattering, tomography	<ul style="list-style-type: none"> -Materials science and engineering -Polymer science -Crystallography -Surface science -Catalysis -Imaging 	BM	O C

5-ID	DND	Crystallography, EXAFS, polymer scattering, tomography	<ul style="list-style-type: none"> -Materials science and engineering -Polymer science -Crystallography -Surface science -Catalysis 	Und A (3.3 cm)	O C
6-ID	μ	Materials science	<ul style="list-style-type: none"> -Magnetic scattering and spectroscopy -Liquid-surface studies -Surface scattering 	Und A (3.3 cm)	C
7-BM	MHATT	Real-time x-ray studies	<ul style="list-style-type: none"> -Real-time x-ray studies -X-ray microcharacterization -X-ray photon correlation spectroscopy 	BM	D
7-ID	MHATT	Real-time x-ray studies	<ul style="list-style-type: none"> -Real-time x-ray studies -X-ray microcharacterization -X-ray photon correlation spectroscopy 	Und A (3.3 cm)	O C
8-ID	IMM	Condensed matter physics, materials science	<ul style="list-style-type: none"> -Intensity fluctuation spectroscopy studies using coherent x-rays -Time-resolved x-ray scattering -X-ray scattering studies at very-low temperatures -X-ray magnetic scattering 	Und A (3.3 cm)	O C
9-BM	CMC	Materials science	<ul style="list-style-type: none"> -EXAFS of complex materials -X-ray surface scattering -General diffraction 	BM	C
9-ID	CMC	Materials science	<ul style="list-style-type: none"> -SAXS from complex materials -Liquid/solid surface scattering -EXAFS -General diffraction -Magnetic scattering 	Und A (3.3 cm)	C
10-ID	MR	Materials science, environmental science	<ul style="list-style-type: none"> -Spectroscopy of dilute environmental systems -Combined techniques for <i>in situ</i> characterization of materials -Zone plate microfocusing spectroscopy and imaging 	Und A (3.3 cm)	O C

* O = operational (beamlines identified as operational may have facilities still being commissioned.)

C = commissioning

D = design / construction

II = accepting Independent Investigator proposals

BM = bending magnet

Und = undulator

BEAMLINE	CAT	SCIENTIFIC FOCUS	PROGRAMS	SOURCE	STATUS *
11-ID	BESSRC	Spectroscopy, scattering, high-energy diffraction, magnetic Compton scattering	<ul style="list-style-type: none"> -Materials science: x-ray scattering, high-energy diffraction, dichroism, magnetism -Geoscience -Atomic physics -Chemistry: spectroscopy (EXAFS, XANES), time-dependent spectroscopy of excited states 	Elliptical Multipole Wiggler	D
12-BM	BESSRC	Spectroscopy, x-ray scattering, diffraction	<ul style="list-style-type: none"> -Materials science: x-ray scattering, diffraction and spectroscopy -Geoscience: mineral-liquid interface characterization by x-ray scattering and spectroscopy -Chemistry: EXAFS and XANES spectroscopy of actinides and lanthanides -Atomic physics 	BM	O C
12-ID	BESSRC	Materials science, atomic physics, geoscience	<ul style="list-style-type: none"> -Materials science: elastic and inelastic scattering, MOCVD, x-ray standing waves, electrochemistry -Geoscience: mineral-liquid interface characterization -Chemistry: small-angle scattering -Atomic physics, spectroscopy 	Und A (3.3 cm)	O C
13-BM	CARS GSECARS	Geosciences, environmental science, soil science	<ul style="list-style-type: none"> -High-pressure diffraction in diamond-anvil cell -High-pressure diffraction in multi-anvil press -Microspectroscopy and XRF microprobe -Microtomography 	BM	O
13-ID	CARS GSECARS	Geosciences, environmental science, soil science	<ul style="list-style-type: none"> -High-pressure diffraction in diamond-anvil cell -High-pressure diffraction in multi-anvil press -Microspectroscopy and XRF microprobe -Microcrystal diffraction -Surface diffraction -X-ray absorption fine structure spectroscopy 	Und A (3.3 cm)	O

14-BM	CARS BioCARS	Structural biology	-Large unit cell (virus) crystallography -Small unit cell (protein) crystallography -MAD phasing -Time-resolved crystallography -Laue diffraction -Study of microcrystals	BM	O
14-ID	CARS BioCARS	Structural biology	-See above	Wiggler A (8.5 cm)	O
15-ID	CARS ChemMat- CARS	Dynamic and structural condensed matter physics	-Time-dependent chemical crystallography scattering -Static and time-dependent surface scattering studies of surface and interfacial properties -Small-angle and wide-angle x-ray scattering -Coherent x-ray scattering studies of dynamic properties	Und A (3.3 cm)	C
16-BM	HP	High-pressure research	-Under development	BM	D
16-ID	HP	High-pressure research	-Under development	Und A (3.3 cm)	D
17-BM	IMCA	Pharmaceutical macromolecular crystallography	-Structures of protein-ligand complexes - <i>De novo</i> protein structures -Drug design -Protein engineering -Crystallographic methods development	BM	O
17-ID	IMCA	Pharmaceutical macromolecular crystallography	-See above	Und A (3.3 cm)	O
18-ID	Bio	Static and dynamic studies of partially ordered biological systems	-Fiber diffraction -X-ray scattering -X-ray absorption/emission spectroscopy -X-ray imaging and tomography	Und A (3.3 cm)	O

* O = operational (beamlines identified as operational may have facilities still being commissioned.)

C = commissioning

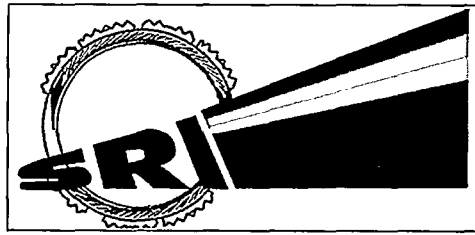
D = design / construction

II = accepting Independent Investigator proposals

BM = bending magnet

Und = undulator

BEAMLINE	CAT	SCIENTIFIC FOCUS	PROGRAMS	SOURCE	STATUS *
19-BM	SBC	Macromolecular crystallography	-Structural biology	BM	O
19-ID	SBC	Macromolecular crystallography	-Structural biology	Und A (3.3 cm)	O
20-BM	PNC	Materials science, environmental science	-Materials science -Environmental science -Surface science	BM	D
20-ID	PNC	Materials science, environmental science	-Materials science -Environmental science -UHV/surface science, MBE growth -X-ray microbeams	Und A (3.3 cm)	O
22-BM	SER	Macromolecular crystallography	-Structural biology	BM	D
22-ID	SER	Macromolecular crystallography	-Structural biology	Und A (3.3 cm)	D
32-ID	COM	Materials characterization	-Analytical materials characterization -"Fee-for-service" analyses	Und A (3.3 cm)	D
33-BM	UNI	Materials science and condensed matter physics	-Materials science -Ceramic science -Phase transitions -Surface science -Thin-films structure and growth -Materials physics	BM	D
33-ID	UNI	Materials science and condensed matter physics	-Materials science -Ceramic science -Phase transitions -Surface science -Thin-films structure and growth -Materials physics	Und A (3.3 cm)	O
34-ID	UNI	Microfocusing and coherent x-ray scattering	-Coherent x-ray diffraction -Microbeam scattering	Und A (3.3 cm)	D
* O = operational (beamlines identified as operational may have facilities still being commissioned.) C = commissioning D = design / construction II = accepting Independent Investigator proposals BM = bending magnet Und = undulator					



Synchrotron Radiation Instrumentation CAT

Overview

SRI-CAT is organized into instrumentation developers and scientific members, with the developers coming primarily from the Experimental Facilities Division of the APS, as well as from Purdue University, University of Houston, National Institute of Science and Technology, Lawrence Berkeley National Laboratory, Stanford Synchrotron Radiation Laboratory, Cornell High Energy Synchrotron Source, and many Australian institutions managed by the Australian Nuclear Science and Technology Organization.

Research Focus

The principal mission of SRI-CAT is to develop new and unique forefront instruments and techniques to advance the use of synchrotron radiation. To that end, research programs involve the design, construction, and operation of standard and specialized insertion devices; diagnostics of radiation from these insertion devices; development of high-heat-load optics; the design, construction, and testing of various standard and modular beamline components; and the development of strategic instruments and techniques. Among those instruments/capabilities are the application of microbeam techniques, the development of scientific capabilities at high energies (>50 keV), the application of coherence-based techniques, the development of 0.5- to 4-keV scientific capabilities, the development of ultrahigh-resolution inelastic scattering techniques, and the application of nuclear coherent spectroscopy. The insertion-device beamline in sector 4 is currently being developed to provide variably polarized x-rays with energies from 0.5 keV to 100 keV and higher. In the low-energy range (0.5 keV to 3 keV), a helical undulator with grazing-angle reflective optics will be used; for energies above 3 keV, a standard APS undulator A with crystal optics will be used as the radiation source. These unique tunable polarization and energy capabilities on one beamline will provide scientists with the ability to cover all important absorption edges from M to K for magnetic spectroscopy experiments, spectro-microscopy, and resonant magnetic scattering.

CAT contacts:	Dennis Mills, Executive Director	tel 630.252.5680	dmm@aps.anl.gov
	Efim Gluskin, Program Director	tel 630.252.4788	gluskin@aps.anl.gov
	Trudy Bolin, CAT Manager	tel 630.252.0801	bolitru@aps.anl.gov
	Linda Shoudis, Admin. Asst.	tel 630.252.0160	ljs@aps.anl.gov

Beamline 1-BM / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques, polarization, and time-resolved studies

Scientific programs: Use and generation of polarized x-rays, time-resolved studies, dispersive diffraction, and spectroscopy

Bending magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^8 ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad
1-BM acceptance	3.7 mrad

Optics & Optical Performance

- vertical collimating mirror
25.5 m from source
bent cylinder
- bent-crystal monochromator
31.5 m from source
horizontal focus
- vertical focusing mirror
45.5 m from source
cylindrical bend
- PSL double-crystal monochromator
27.2 m from source
sagittal focus
Si(111) crystal
 10^{-4} energy resolution (dE/E)
35 mm beam offset
water cooling

Experiment Stations

- 1-BM-A
first optics enclosure
collimating mirror
PSL monochromator
- 1-BM-B
white, pink, and monochromatic beam station
dispersive modes
- 1-BM-C
monochromatic beam station

Detectors

- NaI scintillation counters
- ionization chambers
- Si(Li) energy dispersive detectors
- CCDs

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME
- SPEC

Beamline Support Equipment/Facilities

- 6-circle Huber diffractometer

Beamline contacts: Peter Lee
Jin Wang

tel 630.252.0162
tel 630.252.9125

pllee@aps.anl.gov
wang@aps.anl.gov

Beamline 1-ID / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques, high-energy x-rays, and optics development

Scientific programs: High-energy x-ray scattering techniques and high-heat-load x-ray optics development

Insertion-device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV Σ_x Σ_y	359 μm 21 μm
source divergence at 8.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- Kohzu double-crystal constant off-set monochromator
 - 30 m from source
 - 4–20 keV energy range Si(111)
 - 10^{-4} energy resolution (dE/E) at 10 keV
 - 35 mm offset
 - liquid-nitrogen cooling
- high-energy monochromator
 - 35 m from source
 - 30–150 keV energy range

Experiment Stations

- 1-ID-A
 - white beam first optics enclosure
 - Kohzu monochromator
- 1-ID-B
 - white beam station
 - high-energy studies
- 1-ID-C
 - monochromatic beam station

Detectors

- NaI scintillation
- ionization chambers
- Princeton Instruments CCD
- Ge & Si(Li) solid state detectors
- image plate

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME, SPEC
- SPEC

Beamline Support Equipment/Facilities

- 6-circle diffractometer

Beamline contacts: Dean Haeffner
Wah Keat Lee

tel 630.252.0126
tel 630.252.7759

haeffner@aps.anl.gov
wklee@aps.anl.gov

Beamline 2-BM / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques, x-ray lithography, and microtomography

Scientific programs: Deep x-ray lithography, x-ray microtomography, development of x-ray optics, beam diagnostics instrumentation, and x-ray microprobe studies

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy Σ_x Σ_y	145 μm 36 μm
source divergence at critical energy $\Sigma_{x'}$ $\Sigma_{y'}$	6 mrad 47 μrad
2-BM acceptance	2.0 mrad

Optics & Optical Performance

- vertical deflecting mirror
24.9 m from source
0.15° incident angle
Cr, Pt coatings
plane figure
- double multilayer monochromator
27.4 m from source
unfocussed
- Kohzu double-crystal monochromator
28.8 m from source
unfocussed
- vertical deflecting mirror
49.4 m from source
0°–2° incident angle, variable
Pt coating
plane figure

Experiment Stations

- 2-BM-A
white beam first optics enclosure
- 2-BM-B
pink and monochromatic beam station

Detectors

- energy dispersive detector
- scintillation detector
- ionization chambers
- peltier-cooled CCD camera

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME; NT and MacOS workstations
- SPEC

Beamline Support Equipment/Facilities

- precision scanning stage for x-ray lithography
- micropositioning system
- 6-circle diffractometer

Beamline contacts: Derrick Mancini
Francesco DeCarlo

tel 630.252.0147
tel 630.252.0148

mancini@aps.anl.gov
decarlo@aps.anl.gov

Beamline 2-ID-B / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques, imaging, and coherence

Scientific programs: High-resolution imaging, coherent scattering, and interferometry

Insertion Device Source Characteristics (nominal)

source	5.5 cm undulator
period	5.50 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	6.57
energy range 1st harmonic	0.4 - 7.0 keV
energy range 1st - 5th harmonics	0.4 - 25.0 keV
on-axis peak brilliance at 4.0 keV	4.2×10^{18} ph/sec/mrad ² /mm ² /0.1%bw
source size at 4.0 keV Σ_x Σ_y	359 μm 21 μm
source divergence at 4.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μrad 9.0 μrad

Optics & Optical Performance

- high-heat-load mirror M1
29.5 m from source
0.15° incident angle
plane figure
Pt, Rh, and Si coatings
- horizontal focusing mirror M2B
31.1 m from source
1.25° incident angle
spherical figure
Pt, Rh, multilayer coatings
- vertical focusing mirror M3B
31.6 m from source
1.25° incident angle
cylindrical figure
Pt, Rh, multilayer coatings
- multilayer spherical grating monochromator
46.8 m from source
0.5–4.0 keV energy range
600, 1200, and 1800 lines/mm gratings
100–4000 resolution E/dE
1.5 mm hor. x 0.5 mm vert. beam size FWHM

- microprobe zone plate
60.3 m from source
60 nm x 60 nm focus size
 10^7 – 10^8 ph/sec/0.1% bw microprobe flux

Experiment Station

- 2-ID-B

Detectors

- absolute-calibrated photodiodes
- avalanche photodiodes
- dispersive LEGe fluorescence detector
- thinned/backside-illuminated CCD camera

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME
- Windows NT CCD camera controller

Beamline Support Equipment/Facilities

- scanning/holographic microscope
- 2-circle goniometer
- image processing workstations
- fast scan stage (0.8 nm resolution)

Beamline contacts: Ian McNulty
Sean Frigo

tel 630.252.2882
tel 630.252.9374

mcnulty@aps.anl.gov
frigo@aps.anl.gov

Beamline 2-ID-C / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques and polarization spectroscopy

Scientific programs: High-resolution polarization dependent x-ray spectroscopies and spectro-microscopy

Insertion Device Source Characteristics (nominal)

source	5.5 cm undulator
period	5.50 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	6.57
energy range 1st harmonic	0.4 - 7.0 keV
energy range 1st - 5th harmonics	0.4 - 25.0 keV
on-axis peak brilliance at 4.0 keV	4.2×10^{18} ph/sec/mrad ² /mm ² /0.1%bw
source size at 4.0 keV \sum_x \sum_y	359 μ m 21 μ m
source divergence at 4.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μ rad 9.0 μ rad

Optics & Optical Performance

- high-heat-load mirror M1
29.5 m from source
0.15° incident angle
plane figure
Pt, Rh, and Si coatings
- horizontal focusing mirror M2C
30.6 m from source
1.25° incident angle
spherical figure
Pt, Rh, and Si multilayers coatings
- vertical focusing mirror M3C
41.4 m from source
1.00° incident angle
spherical figure
Rh and Si coatings

- multilayer spherical grating monochromator
50 m from source
0.5–3.0 keV energy range
 10^{-3} – 10^{-4} monochromaticity dE/E
2.5 mm hor. x 0.25 mm vert. beam size
 10^{11} – 10^{13} ph/sec flux at sample

Experiment Station

- 2-ID-C

Detectors

- 16-channel hemispherical electron/ion analyzer
- total electron yield
- total fluorescence via photodiode

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME

Beamline Support Equipment/Facilities

- UHV x-ray photo-emission spectroscopy chamber
- UHV photo-emission microscope (PEEM)
- UHV reflectometer
- UHV scanning stage microscope

Beamline contact: John Freeland

tel 630.252.9614

freeland@aps.anl.gov

Beamline 2-ID-D & 2-ID -E / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques, imaging, and coherence

Scientific programs: High-resolution imaging and coherence-based techniques

Insertion-device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV \sum_x \sum_y	24 μrad 6.9 μrad

Optics & Optical Performance

- high-heat-load mirror M1
29.5 m from source
0.15° incident angle
plane figure
Pt, Rh, and Si coatings
- Kohzu monochromator
62.0 m from source
2–32 keV energy range Si(111)
10⁻⁴ monochromaticity dE/E
4.2 mm hor. x 1.6 mm vert. beam size FWHM
10¹¹–10¹³ ph/sec flux at sample
- zone plate microprobe
71.0 m from source
0.1 μm hor. x 0.1 μm vert. focus size
10¹¹ ph/sec/ μm^2 /0.1% bw flux

Experiment Stations

- 2-ID-D
- 2-ID-E

Detectors

- ionization chambers
- NaI scintillation detector
- avalanche photodiodes
- CCD cameras

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME

Beamline Support Equipment/Facilities

- optical table with six degrees of freedom
- scanning microscope
- high-resolution x-ray spectrometer
- image processing workstation

Beamline contacts:

Barry Lai
Zhonghou Cai
Jorg Maser

tel 630.252.6405
tel 630.252.0144
tel 630.252.1081

blai@aps.anl.gov
cai@aps.anl.gov
maser@aps.anl.gov

Beamline 3-ID / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques, resonant and non-resonant inelastic scattering

Scientific programs: Nuclear resonant scattering (inelastic nuclear resonant scattering, lattice dynamics of thin films, amorphous materials, and vibrational properties of biomolecules), and inelastic x-ray scattering (momentum-resolved lattice dynamic)

Insertion Device Source Characteristics (nominal)

source	2.7 cm undulator
period	2.70 cm
length	2.5 m
effective K_{\max} (at minimum gap = 8.5 mm)	2.18
energy range 1st harmonic	5.1 - 16.0 keV
energy range 1st - 5th harmonics	5.1 - 60.0 keV
on-axis peak brilliance at 7.9 keV	1.3×10^9 ph/sec/mrad ² /mm ² /0.1%bw
source size at 8.0 keV Σ_x Σ_y	359 μm 21 μm
source divergence at 8.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- Kohzu HLM-2 double-crystal monochromator
diamond (111) nondispersive crystals
water cooling
- high-resolution monochromator

energy	resolution
13.8 keV	6 meV
14.4 keV	5.5, 2, 0.85, and 0.66 meV
21.5 keV	1 meV
23.8 keV	3.5 and 1 meV
- Zeiss mirror
Zerodur substrate
Pd coating
two groove, collimating and horizontal
focusing
bendable for vertical focusing
0.8 m length

Experiment Stations

- 3-ID-A
white beam first optics enclosure
- 3-ID-B
monochromatic beam station
x-ray optics development
nuclear resonant scattering
- 3-ID-C
monochromatic beam station
inelastic x-ray scattering
- 3-ID-D
monochromatic beam station
nuclear resonant scattering

Detectors

- avalanche photodiodes
- PIN-diodes, Si, CdZnTe (Amptek)
- ionization chambers
- NaI
- Si(Li)

Beamline Controls and Data Acquisition

- VME-based motion control, EPICS software
- Graphical user interface: MEDM implemented on Sun workstations, Solaris operating system

Beamline Support Equipment/Facilities

- Kohzu high-angular resolution stages (12.5 nrad)
- 6-circle diffractometer
- optical tables
- Euler cradle
- misc. linear stages
- Oxford 7-T superconducting magnet/cryostat, Oxford microscope cryostat
- optical tables

Beamline contacts: Ercan Alp
Wolfgang Sturhahn

tel 630.252.4775
tel 630.252.0163

eea@aps.anl.gov
sturhahn@aps.anl.gov

Beamline 4-ID / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques and use of polarized x-rays

Scientific programs: Development of polarization optics/techniques for 0.5–3 keV (magnetic circular dichroism, resonant magnetic scattering, and fluorescence), development of polarization optics and techniques for 3–100 keV (magnetic scattering, magnetic circular dichroism, and magnetic Compton scattering), and development of high-heat-load front-end and optical components

Circularly Polarized Undulator (nominal)*

period	12.8 cm
length	2.3 m
effective K_{mx} (for both horizontal and vertical fields)	2.65
peak field B_{mx}	0.28 Tesla
maximum currents at B_{mx}	1.4 kA horizontal 0.32 kA vertical
energy range 1st harmonic (helical mode)	0.44 - 3.0 keV
energy range 1st harmonic (linear mode)	0.8 - 3.0 keV
energy range 1st - 5th harmonics (linear mode)	0.8 - 10.0 keV
on-axis peak circular brilliance at 1.5 keV	1.0×10^{18} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak linear brilliance at 1.9 keV	7.0×10^{17} ph/sec/mrad ² /mm ² /0.1%bw
switching frequency	0 - 10 Hz
switching rise time	20 ms
source size at 1.5 keV \sum_x \sum_y	359 μ m 21 μ m
source divergence at 1.5 keV $\sum_{x'}$ $\sum_{y'}$	27 μ rad 14.7 μ rad

* Sector 4 will be equipped with two canted insertion devices, a standard Undulator A and an elliptically polarized undulator.

Optics & Optical Performance

Hard x-ray branch optics and optics performance

- double-crystal monochromator
 - 3.0–50.0 keV energy range Si(111)
 - 5 mm hor. x 2 mm vert. acceptance
 - 1°–60° Bragg angle rotation range
 - 10 arcsec Bragg accuracy
 - 0.5 arcsec resolution
 - 10–35 mm beam offset, variable
 - liquid-nitrogen cooling

Insertion Device Source Characteristics (nominal)*

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μ m 21 μ m
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μ rad 6.9 μ rad

• Mirror

two groove, torroidal figure
80.5 mm sagittal radius, focusing
345 mm sagittal radius, collimating
18–7 km meridional radius, adjustable
800 mm L x 30 mm W
1.5–3.85 mrad angular range

Intermediate x-ray branch optics and optics performance

- horizontal focusing mirror M1C
 - 28.6 m from source
 - 1.1° incident angle
 - plane figure
 - Pt, Rh, Si, and multilayer coatings
- horizontal focusing mirror M2C
 - 31 m from source
 - 1.1° incident angle
 - spherical figure (R=1610 m)
 - Pt, Rh, Si, and multilayer coatings

continued on pg. 16

Beamline contacts: John Freeland
George Srajer

tel 630.252.9614
tel 630.252.3257

freeland@aps.anl.gov
srajerg@aps.anl.gov

Beamline 4-ID / SRI-CAT

Scientific focus: Synchrotron instrumentation and techniques and use of polarized x-rays

Scientific programs: Development of polarization optics/techniques for 0.5–3 keV (magnetic circular dichroism, resonant magnetic scattering, and fluorescence), development of polarization optics and techniques for 3–100 keV (magnetic scattering, magnetic circular dichroism, and magnetic Compton scattering), and development of high-heat-load front-end and optical components

continued from pg. 15

- vertical focusing mirror M3C
 - 41.4 m from source
 - 1.00° incident angle
 - spherical figure
 - Rh coating
- multilayer spherical grating monochromator
 - 50 m from source
 - 0.5–3.0 keV energy range
 - 10^{-3} – 10^{-4} monochromaticity dE/E
 - 2.5 mm hor. x 0.25 mm vert. beam size
 - 10^{11} – 10^{13} ph/sec flux at sample

Experiment Stations

- 4-ID-A
 - white beam first optic enclosure
- 4-ID-B and -D
 - white and monochromatic “hard” x-ray stations
- 4-ID-C
 - soft x-ray station

Beamline Controls and Data Acquisition

- Sun UNIX running Epics with VME, SPEC

Beamline contacts: John Freeland
George Srajer

tel 630.252.9614
tel 630.252.3257

freeland@aps.anl.gov
srajerg@aps.anl.gov



E.I. Du Pont de Nemours & Co-Northwestern University-The Dow Chemical Company CAT

Overview

The DND-CAT is a team of senior scientists and engineers formed jointly by the E.I. Du Pont de Nemours Co., Northwestern University, and the Dow Chemical Company to develop, build, and operate facilities dedicated to advancing x-ray research on new materials. The ability to characterize the increasing numbers of new and advanced materials with specifically engineered properties is closely coupled with the ability to analyze their molecular structure.

Research Focus

The scientific thrust of DND-CAT is concentrated in three main areas: the study of the atomic structure of bulk materials, the study of two-dimensional atomic structures (e.g., surfaces, interfaces, and thin films), and polymer science and technology.

Atomic Structure of Bulk Materials

In addition to crystallographic determinations of unknown compounds, this aspect of DND-CAT's program concentrates on the determination of defects and local atomic arrangements in materials. For example, the arrangement of dopant atoms and other lattice defects in metals, catalysts, and semiconductors is under study. In addition, DND-CAT researchers are extensively studying catalysts under realistic conditions of high temperature and pressure. Catalysts of interest include supported metal and bimetallic catalysts (e.g., Pd, Pd-Re), zeolites, and catalysts for environmentally benign chlorofluorocarbons.

Study of Two-Dimensional Structures

The structure of surfaces at interfaces is a primary factor controlling the properties of materials in many technologically important applications. Some of these include catalysis, corrosion, tribology, crystal growth, and ion transport through biomembranes. DND-CAT researchers will use a custom-designed ultra-high-vacuum system to study buried interfaces, thin films, and surfaces to determine mechanisms of film growth, segregation at grain boundaries, surface melting, and other two-dimensional phenomena.

Polymer Science and Engineering

The third major area for DND-CAT is polymer physics, chemistry, and engineering. Areas of interest include solution characterization of polymers and their precursors, structure formation, polymer melt rheology, fiber formation, structure/property/processing relationships, and mechanical properties.

CAT contacts:	John Quintana, Director	tel 630.252.0221	jpq@nwu.edu
	Jerrie Lea Hopf, Program Asst.	tel 630.252.0222	jhopf@nwu.edu
	WWW Site		http://tomato.dnd.aps.anl.gov/

Beamline 5-BM / DND-CAT

Scientific focus: Crystallography, EXAFS, and polymer scattering tomography

Scientific programs: Material science and engineering, polymer science, crystallography, surface science, catalysis, and imaging

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- 4.5–80 keV spectral range (white beam)

Experiment Stations

- 5-BM-B
monochromatic beam station
- 5-BM-C
monochromatic and white beam beam station
powder diffraction
- 5-BM-D
monochromatic and white beam station
general purpose station for
EXAFS
crystallography
x-ray scattering

Detectors

- spectroscopy-grade ionization chambers
- Lytle detector
- Fuji BAS 2000 image-plate system
- scintillation detectors
- avalanche photodiodes
- Mar 135 mm CCD detector
- Spectra Source CCD camera for imaging applications
- EG&G Ortec Iqlet solid-state detector

Beamline Controls and Data Acquisition

- Linux running custom control code for motors and actuators on all systems
- SPEC used to control diffractometers and surface-science instruments
- Vendor-supplied software used to control CCD detectors

Beamline Support Equipment/Facilities

- 6-circle diffractometer
- 2-circle powder diffractometer
- Mar CCD detector system
- Fuji BAS 2000 image-plate system

Beamline contacts: John Quintana
JerrieLea Hopf

tel 630.252.0221
tel 630.252.0222

jpq@nwu.edu
jlhopf@nwu.edu

Beamline 5-ID / DND-CAT

Scientific focus: Crystallography, EXAFS, polymer scattering, and tomography

Scientific programs: Material science and engineering, polymer science, crystallography, surface science, and catalysis

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- 7–18 keV spectral range
- cryogenic Si(111) crystals
fixed-gap channel cut configuration
- energy range limited due to crystal size

Experiment Stations

- 5-ID-B
monochromatic general-purpose beam station
4-circle Huber goniometer
Mar CCD
single-crystal diffraction
EXAFS
- 5-ID-C
monochromatic beam station
surface science using custom UHV system
surface scattering
standing waves
- 5-ID-D
small- and wide-angle scattering
polymer scattering station

Detectors

- spectroscopy-grade ionization chambers
- Lytle detector
- Fuji BAS 2000 image-plate system
- scintillation detectors
- avalanche photodiodes
- Mar 135 mm CCD detector
- Spectra Source CCD camera for imaging applications
- EG&G Ortec Iglet solid-state detector

Beamline Controls and Data Acquisition

- Linux running custom control code for motors and actuators for all systems
- SPEC used to control diffractometers and surface-science instruments
- Vendor-supplied software used to control CCD detectors

Beamline Support Equipment/Facilities

- 6-circle diffractometer
- 2-circle powder diffractometer
- custom UHV system
- Mar CCD detector system
- Fuji BAS 2000 image-plate system

Beamline contacts: John Quintana
JerrieLea Hopf

tel 630.252.0221
tel 630.252.0222

jpq@nwu.edu
jlhopf@nwu.edu



Midwest Universities CAT

Overview

The Midwest Universities CAT was organized in 1990. At present, its member institutions include Ames Laboratory/Iowa State University, University of Missouri at Columbia, Georgia Institute of Technology, Washington University, University of Wisconsin at Madison, University of Nebraska at Lincoln, Kent State University, State University of New York at Stony Brook, Michigan State University, and the Institut für Festkörperforschung Forschungszentrum Jülich GmbH. The main undulator line of the sector features a four-circle diffractometer for single-crystal work, a liquid surface reflectometer, and a new surface science chamber. In addition, a high-energy side station (30-120 keV) is currently under construction and will run in parallel with the main undulator line [3-22 keV for Si (111) monochromating crystals].

Research Focus

Research efforts are focused in the areas of magnetic scattering and spectroscopy, as well as in resonant- and nonresonant-scattering studies of magnetic materials. The technique of circular magnetic x-ray dichroism (CMXD) offers tremendous potential as a tool for studies of the electronic states associated with magnetic order in ferromagnetic materials of fundamental and technological interest. Resonant and nonresonant magnetic x-ray scattering measurements offer important and complementary means of determining magnetic structures in materials that are ill-suited, by reasons of size or chemical composition, to traditional neutron measurements (e.g., for magnetic structure studies of metastable phases and surfaces).

Research efforts in the surface-scattering program are centered on the study of the kinetics and growth of two-dimensional systems, the role of defects in epitaxy, ordered non-epitaxial overlayers, phase transitions, and investigations of liquid surfaces. The surface chamber constructed for this sector will enable surface-scattering investigations to expand into new areas: real-time growth characterization in a variety of growth environments, low-Z adsorbate systems, and two-dimensional surface kinetics. A liquid surface diffractometer will be used to probe the chemistry and physics of monolayer films at liquid surfaces, as well as of realistic models of biological membranes.

General scattering programs include microdiffraction techniques, coherent scattering, high-temperature processing of materials, studies of liquid crystals and polymers, and strain in thin films and interfaces.

Work on the high-energy side station will include techniques such as nonresonant magnetic scattering, radial distribution function analysis of disordered and partially ordered materials, and *in situ* time-resolved measurements of high-temperature materials processing.

CAT contacts:	Alan Goldman, Director	tel 515.294.3585	goldman@ameslab.gov
	Paul Miceli, Deputy Dir.	tel 573.882.8328	pfm@wald.physics.missouri.edu
	Doug Robinson, Beamline Scientist	tel 630.252.0247	drobinsn@iastate.edu
	Laura Morisco, CAT Coordinator	tel 630.252.0243	

Beamline 6-ID / μ -CAT

Scientific focus: Materials science

Scientific programs: Magnetic scattering and spectroscopy, liquid surface studies, and surface scattering

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μ m 21 μ m
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μ rad 6.9 μ rad

Optics & Optical Performance

- Kohzu double-crystal constant-offset monochromator
29.5 m from source
3.2–20 keV energy range Si(111)
 10^{-4} energy resolution (dE/E) at 10 keV
25 mm offset
liquid-nitrogen cooling
- 3-stripe vertically focusing 70 cm mirror
60 cm active length (clear aperture)
Al, Rh, Pt coating stripes
12, 23, 31 keV high-energy cutoffs at 0.15°
1:1 vertical focusing (variable) at 6-ID-B
< 0.5 arcsec meridional slope error
< 5 arcsec sagittal slope error
3 Å rms roughness

Experiment Stations

- 6-ID-A
white beam first optics enclosure
Kohzu monochromator
- 6-ID-B
monochromatic beam station
4-circle diffractometer
liquid surface reflectometer
- 6-ID-C
monochromatic beam station
UHV surface science chamber

Detectors

- NaI detectors
- ionization chambers
- 3-element Si energy dispersive array detector

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME
- SPEC control software

Beamline Support Equipment/Facilities

- 6K Displex
- 3.4 K^o Heliplex
- polarization modifier
- polarization analyzer

Beamline contacts: Alan Goldman
Doug Robinson

tel 515.294.3585
tel 630.252.0247

goldman@ameslab.gov
drobinson@iastate.edu

MHATT-CAT

Center for Real-Time X-ray Studies

Overview

The Center for Real-Time X-ray Studies CAT (MHATT-CAT) was formed in 1989 as a university-industry partnership between the University of Michigan, Howard University, and Bell Laboratories (Lucent Technologies). MHATT-CAT's facilities include two fully instrumented beamlines (one based on an undulator and the other on a bend magnet) to exploit the unique characteristics of the APS. A high-speed communications network between the participating institutions and the APS is planned to facilitate the involvement of students in the MHATT-CAT collaboration and to maximize participation in research at national user facilities.

Research Focus

MHATT-CAT's research program is focused on time-dependent structural phenomena across a broad range of materials systems, including thin films, polymers, liquid crystals, and biomaterials. The undulator line serves as the host for microprobe studies of high-temperature superconductors, interconnects, and optical fibers; for the development of coherent x-ray scattering techniques; and for the application of ultrafast lasers. The sector is expected to develop into an international gathering point for scientists and engineers with strong interest in time-resolved structural studies.

Beamline 7-ID / MHATT-CAT

Scientific focus: Real-time x-ray studies

Scientific programs: Real-time x-ray studies, x-ray microcharacterization, and x-ray photon correlation spectroscopy

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV Σ_x Σ_y	359 μm 21 μm
source divergence at 8.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- BESSRC-type double-crystal fixed-exit HHL monochromator
 - 30 m from source
 - 5–50 keV energy range
 - 10^{-4} energy resolution (dE/E) at 10 keV
 - 35 mm offset
 - liquid-nitrogen cooling
- pink-beam mirror filter
 - 30 m from source (centered on HHL mono)
 - 6–10 keV energy range
 - 0.03 energy resolution (dE/E)

Experiment Stations

- 7-ID-A
 - white beam first optics enclosure
 - HHL monochromator
- 7-ID-B
 - white beam station
 - 5 m x 7 m
- 7-ID-C
 - monochromatic and pink beam station
 - 5 m x 7 m
 - diffraction
- 7-ID-D
 - monochromatic and pink beam station
 - 5 m x 6 m
 - diffraction

Detectors

- NaI scintillation
- ionization chambers
- various CCD detectors
- Amptek Si detector

Beamline Controls and Data Acquisition

- EPICS
- SPEC
- k-Space Associates real-time CCD data acquisition
- LabView VI environment

Beamline Support Equipment

- Newport/Micro-Control 6-circle Kappa goniometer (7-ID-C)
- Huber 4-circle goniometer (7-ID-B)
- two xyz optical tables (4 ft x 6 ft)

Beamline contacts: Eric Dufresne
Tom Sanchez
Ernest Williams

tel 630.252.0274
tel 630.252.0276
tel 630.252.0209

dufresne@umich.edu
sanchez@xpcs.mhatt.aps.anl.gov
williams@mail.mhattcat.howard.edu



IBM-MIT-McGill CAT

Overview

The IBM-MIT-McGill CAT (IMM-CAT) was organized by individual scientists from the three institutions to build and operate a sector at the APS optimized for research involving dynamic phenomena in materials science, physics, chemistry, and recently, structural biology.

Research Focus

IMM-CAT's research involves a broad range of topics emphasizing processes and phenomena that take place over time, such as the growth of thin films. Experiments conducted by CAT member scientists fall primarily into the following four areas:

1. Time-resolved x-ray-scattering studies of bulk phase transition kinetics.
2. Grazing-incidence scattering studies of surface structure and kinetics.
3. Scattering studies of the structure and kinetics of buried interfaces.
4. Studies of dynamics by x-ray intensity fluctuation spectroscopy and related coherent x-ray methods.

A primary goal is to aid the development and understanding of new materials, which may lead to improved products such as magnetic disk drives, computer chips, and computer displays, as well as improvements in processing techniques.

For example, the study of interfaces where layers of magnetic materials meet helps in the engineering of materials with more desirable magnetic properties for use in magnetic disks (used for information storage). Research into thin polymer films can lead to improved coatings, such as those used for lubricants in magnetic disk drives and for orienting liquid-crystal films in flat panel displays.

The construction of a bending-magnet beamline devoted to structural biology is under consideration.

CAT contacts:	Simon Mochrie, Director D. Mark Sutton, Deputy Dir.	tel 617.253.6588 tel 514.398.6523	simon@lindy.mit.edu mark@physics.mcgill.ca
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Beamline 8-ID / IMM-CAT

Scientific focus: Condensed matter physics and materials science

Scientific programs: Intensity fluctuation spectroscopy studies using coherent x-rays, time-resolved x-ray scattering, x-ray scattering studies and very low temperatures, and x-ray magnetic scattering

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- horizontally deflecting mirror
29.2 m from source
6–30 keV energy range
water cooling
- transmission diamond monochromator
51.6 m from source
6–30 keV energy range
 $\Delta\lambda/\lambda=44 \times 10^{-6}$ energy resolution at 8 keV
symmetric Bragg diamond (111)
water cooling

Experiment Stations

- 8-ID-A
white beam first optics enclosure
- 8-ID-D
pink beam monochromator enclosure
- 8-ID-E
pink beam experimental station
- 8-ID-I
pink beam experimental end station

Detectors

- two PI direct detection CCD detectors
- PI optically coupled CCD detector
- photodiode array linear detector
- Amptek CZT and Si detectors

Beamline Controls and Data Acquisition

- Linux-based control system
- SPEC x-ray control software

Beamline Support Equipment/Facilities

- coherent small-angle scattering spectrometer
- time-resolved diffractometer
- He-3 cryostat on horizontally scattering spectrometer

Beamline contacts: Larry Lurio
Simon Mochrie
Mark Sutton

tel 630.252.0281
tel 617.253.6588
tel 514.398.6523

larry@slate.imm.aps.anl.gov
simon@lindy.mit.edu
mark@physics.mcgill.ca

CMC-CAT

Complex Materials Consortium CAT

Overview

The Complex Materials Consortium CAT (CMC-CAT) was organized by individuals who share a common research interest in complex materials and a strong dedication to the use of the unique properties of synchrotron radiation to structurally and functionally characterize them. This organization was subsequently formalized into a consortium containing the following institutional members: Exxon Research and Engineering Company, University of Pennsylvania, Brookhaven National Laboratory, Princeton University, University of California at Santa Barbara, Los Alamos National Laboratory, Oak Ridge National Laboratory, and the University of Tennessee.

Research Focus

Complex materials, broadly defined, are materials that possess unique and novel properties by virtue of the complexity of their molecules and/or the complexity of interaction between their molecules. These materials include polymers, surfactants, liquid crystals, biomaterials, membranes, and thin molecular films of hydrocarbons on solid or liquid surfaces. They also include novel synthetic materials such as fullerenes, fibers, polymer composites, and zeolites. A basic understanding of the molecular structure, morphology, and molecular dynamics of such materials, particularly under non-equilibrium conditions or at interfaces, is essential for the development and optimization of novel materials and processes for industry. It is equally important for obtaining a complete theoretical description of the equilibrium and non-equilibrium behavior of complex, multicomponent systems.

At the APS, CMC-CAT uses several experimental techniques to study complex materials on a variety of length and time scales. The techniques include small-angle and wide-angle x-ray scattering, x-ray diffraction, x-ray surface scattering, x-ray spectroscopy, magnetic scattering, and x-ray microtomography and imaging. The studies depend on novel technical developments such as ultrafast-high-resolution two-dimensional imaging detectors, high-speed data inversion and image-processing algorithms, and novel x-ray microfocusing devices. Using such techniques, CMC-CAT researchers study phenomena such as the dynamic response of polymers, membranes, fibers, and fluids to applied stresses; the kinetics of phase separation in mixed systems; the formation of pitting, corrosion, and protective layers on metals in electrolytic solutions; the formation of novel surface structures on catalysts undergoing reactions; the formation of cracks and voids in composite materials; and the flow of fluids through microporous solids such as oil-bearing rocks or sand.

CAT contacts:	Doon Gibbs, Director	tel 516.344.4608	doon@solids.phy.bnl.gov
	Thomas Gog, Assoc. Dir.	tel 630.252.0320	gog@anl.gov
	Arun Bommanavar, Beamline Scientist	tel 630.252.0333	arun@anl.gov

Beamline 9-BM / CMC-CAT

Scientific focus: Materials science

Scientific programs: EXAFS of complex materials, x-ray surface scattering, and general diffraction

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- white beam slits (APS design L3-20)
- double-crystal, cryo-cooled Si monochromator
- toroidal mirror
- monochromatic slits (APS design L4)

Experiment Stations

- 9-BM-A
white beam first optics enclosure
- 9-BM-B
monochromatic beam station
EXAFS
- 9-BM-C
monochromatic beam station
surface diffraction
general diffraction

Detectors

- Smart 1500 CCD
- scintillation counters

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME, SPEC

Beamline Support Equipment/Facilities

- UHV surface apparatus
- EXAFS instrumentation

Beamline contacts: Thomas Gog
Arun Bommannavar
Chitra Venkataraman

tel 630.252.0320
tel 630.252.0333
tel 630.252.0327

gog@anl.gov
arun@anl.gov
chitra@anl.gov

Beamline 9-ID / CMC-CAT

Scientific focus: Materials science

Scientific programs: SAXS from complex materials, liquid/solid surface scattering, EXAFS, general diffraction, and magnetic scattering

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV Σ_x Σ_y	359 μ m 21 μ m
source divergence at 8.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μ rad 6.9 μ rad

Optics & Optical Performance

Primary branch optics and optical performance

- white-beam slit
 - 4.5 mm x 4.5 mm input aperture
 - 2.1 mm x 2.1 mm max. output aperture
 - ctr. of output aperture adjustable w/ input aperture
- double-crystal Si(111) monochromator
 - 30.5 m from source
 - 3.1–22.5 keV energy range
 - 25.4 mm beam offset
 - 10^{-4} energy resolution (dE/E) at 10 keV
 - cryogenic cooling
- vertical-focusing mirror
 - 33 m from source
 - flat figure with bender
 - 600 mm x 120 mm
 - Au, Ni, Rh coatings
 - 0–4 mrad incident angle

- horizontal-focusing mirror
 - 34.5 m from source
 - flat figure with bender
 - 900 mm x 120 mm
 - Au, Ni, Rh coatings
 - 0–4 mrad incident angle

Secondary branch optics and optical performance

- side-station monochromator
 - 28 m from source
 - horizontal double crystal
 - 5–9.5 keV energy range
 - water-cooled diamond crystal
 - 1000 mm horizontal beam offset
 - 10^{-4} energy resolution
- vertical-focusing mirror
- horizontal-focusing mirror

Experiment Stations

- 9-ID-A
 - white beam first optics enclosure
- 9-ID-B & -C
 - monochromatic beam station
 - general diffraction
 - SAXS
 - EXAFS
 - liquids

Detectors

- Smart 1500 CCD
- BNL 2D WIRE
- BNL 1D WIRE

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS w/ VME, SPEC, etc.

Beamline Support Equipment/Facilities

- 6-circle diffractometer
- SAXS set up
- Bonse-Hart camera
- liquid surface reflectometer
- UHV surface apparatus

Beamline contacts: Thomas Gog
Arun Bommanavar

tel 630.252.0320
tel 630.252.0333

gog@anl.gov
arun@anl.gov



Materials Research CAT

Overview

The Materials Research CAT (MR-CAT) is composed of groups from four universities (University of Florida, Illinois Institute of Technology, Northwestern University, and University of Notre Dame), a major corporation (BP-Amoco) and a federal research laboratory (Argonne National Laboratory/Chemical Technology and Environmental Research Divisions).

Research Focus

The scientific program of MR-CAT focuses on the study of advanced materials *in situ* as a means of characterizing their structure and electronic properties, as well as understanding their preparation. The primary research techniques of wide- and small-angle scattering, diffraction (single-crystal and powder), absorption spectroscopy (XFS), reflectivity, standing waves, diffraction anomalous fine structure (DAFS), and time-dependent and microfocus techniques are being used to study the following *in situ*:

- structural phase changes, especially in non-equilibrium systems
- disordered systems (e.g., alloys and amorphous materials)
- growth, recrystallization, surfaces, and interfaces of electronic materials
- catalysts (*in situ* time-dependent studies)
- structure of static and dynamic confined liquids
- organic thin films and self-assembling systems
- polymers (e.g., dynamics of block copolymers, single-fiber studies)

CAT contacts: Bruce Bunker, Director
Carlo Segre, Deputy Dir.

tel 219.631.7219
tel 312.567.3498

bunker.1@nd.edu
segre@iit.edu

Beamline 10-ID / MR-CAT

Scientific focus: Materials science and environmental science

Scientific programs: Spectroscopy of dilute environmental systems, combined techniques for *in situ* characterization of materials, and zone plate micro-focusing spectroscopy and imaging

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μ m 21 μ m
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μ rad 6.9 μ rad

Optics & Optical Performance

- Daresbury/Fisons monochromator
 - 30 m from source
 - 4–30 keV energy range Si(111)
 - 1st crystal, IIT-design, cryo cooling w/
pseudo-fixed offset crystal cage
 - 2nd crystal, 240 mm with Bragg normal motion
 - 10^{-4} energy resolution (dE/E) at 10 keV
 - 35 mm offset
 - liquid-nitrogen cooling
- harmonic rejection mirror
- zone plate focusing

Experiment Stations

- 10-ID-A
 - white beam first optics enclosure
 - monochromator
- 10-ID-B
 - monochromatic beam station
 - all experiments 4 m x 12 m

Detectors

- Bruker 1k x 1k CCD
- Canberra Si energy-dispersive detector
- Daresbury/Lesker spectroscopy ionization chambers
- Lytle detectors

Beamline Controls and Data Acquisition

- Debian Linux running "MX"

Beamline Support Equipment/Facilities

- large Huber 8-circle goniometer with positioning
- X95 rail system for experiment alignment

Beamline contacts: Bruce Bunker
Carlo Segre

tel 219.631.7219
tel 312-567-3498

bunker.1@nd.edu
segre@iit.edu



Basic Energy Sciences Synchrotron Radiation Center CAT

Overview

The Basic Energy Sciences Synchrotron Radiation Center CAT (BESSRC-CAT) includes scientists from the Chemistry and Materials Science Divisions at Argonne National Laboratory (ANL), researchers from the ANL geophysics program, and scientists from the Department of Physics at Northern Illinois University. Its two sectors are developed and instrumented to serve the research needs of users with particular interests in materials science, chemical science, atomic physics, solid-state physics, and geosciences. The facility's two sectors are equipped with seven separate instrumental stations. One sector consists of an undulator and bending magnet with four experiment stations. The other sector has an elliptical multipole wiggler and is split into three beamlines with three experiment stations.

Research Focus

Scientific areas of interest include time-resolved studies of photoexcited states in photosynthetic materials, real-time investigations of chemical reactions, and time-dependent studies of phase transformations in crystalline compounds. Structural studies of actinide materials, studies of ultra-small crystals, trace-element analysis, and surface and interface studies also form part of the research focus. Examples of studies conducted include radiation-induced surface modification, impurity clustering at grain boundaries, measurements of the electrical double layer at electrodes in electrochemical cells, concentration profiling at dissimilar interfaces, studies of the magnetic structure of ultra-thin films, and others.

BESSRC-CAT has an MOCVD system in the undulator beamline for *in situ* growth studies of oxides and GaN and also an MBE system on line for structural studies of surfaces and interfaces under UHV conditions. There is an extensive research program in the use of small-angle x-ray scattering and anomalous small-angle x-ray scattering with particular emphasis on time-resolved measurements. BESSRC-CAT has established a research program directed towards the use of high-energy diffraction techniques to study the structure of materials. Additionally, an extensive research program is directed towards the use of circularly polarized x-rays in the study of the magnetic properties of materials, i.e., using XMCD, magnetic Compton scattering, and magnetic scattering.

CAT contacts:	Pedro Montano, Director	tel 630.252.1553	montano@anl.gov
	Mark Beno, Deputy Dir.	tel 630.252.3507	beno@anl.gov
	Jeanne Cowan, Admin. Asst.	tel 630.252.1553	cowan@anl.gov

Beamline 11-ID / BESSRC-CAT

Scientific focus: Spectroscopy, scattering, high-energy diffraction, and magnetic Compton scattering

Scientific programs: Materials science (x-ray scattering, high-energy diffraction, dichroism, magnetism), geoscience, atomic physics, and chemistry (spectroscopy [EXAFS, XANES], time-dependent spectroscopy of excited states)

Insertion Device Source Characteristics (nominal)

source	elliptical multipole wiggler
period	16.0 cm
length	2.8 m
number of poles	36, electromagnets 34, permanent magnets
effective $K_{x \text{ max}}$ (at max. current = 1.15 kA, $B_{\text{max}} = 0.087$ Tesla)	1.3
peak $K_{y \text{ max}}$ (at minimum gap = 24.0 mm)	14.4
switching frequency	0 - 10 Hz
critical energy (at minimum gap = 24.0 mm)	59.1 keV
energy range	5.0 - 200.0 keV
source size at critical energy \sum_x \sum_y	359 μm 21 μm
source divergence at critical energy $\sum_{x'}$ (FWHM 1.9 mrad, non-Gaussian) $\sum_{y'}$	820 μrad 47 μrad

Optics & Optical Performance

- focusing Bragg or flat Laue monochromator
- 11-ID-D
 - modified standard BESSRC monochromator
 - 4.8–50 keV energy range Si(220)
 - 20 mm fixed offset
 - cryo-cooled 1st and 2nd crystals
 - mirrors
 - Pt and Pd coatings
 - 2.8 mrad incident angle/Pt mirror
 - 4.0 mrad incident angle/Pd mirror
- 11-ID-B & -C
 - Bragg or Laue horiz. deflecting monochromator
 - 40–200 keV energy range
 - Si(311) or Si(220) crystal
 - water/Ga cooling

Experiment Stations

- 11-ID-A
 - white beam first optics enclosure
 - double-crystal monochromator (for 11-ID-D)
 - double (side-by-side) mirror system (for 11-ID-D)
 - side-deflecting monochromator (for B & C stations)
- 11-ID-B
 - magnetic Compton scattering
- 11-ID-C
 - high-energy diffractometer
- 11-ID-D
 - spectroscopy (EXAFS, XANES, dichroism)
 - x-ray scattering

Detectors

- ionization chambers
- Bicron
- solid-state detectors (Si and Ge)
- Canberra 9-element Ge

Beamline Controls and Data Acquisition

- 11-ID-B & -C
 - MacOS-EPICS
- 11-ID-B
 - Solaris-EPICS
 - SPEC
 - MacOS
 - Windows EPICS

Beamline Support Equipment/Facilities

- 11-ID-C
 - high-energy diffractometer (vertical, post mono)
 - diffractometer
 - analyzer
 - detector
- 11-ID-D
 - spectroscopy table
 - 8-circle Huber ψ goniometer

Beamline contacts: Anneli Munkholm
Uta Ruett
Mark Beno

tel 630.252.0395
tel 630.252.0383
tel 630.252.3507

munkholm@anl.gov
ruett@msd.anl.gov
beno@anl.gov

Beamline 12-BM / BESSRC-CAT

Scientific focus: Spectroscopy, x-ray scattering, and diffraction

Scientific programs: Materials science (x-ray scattering, diffraction, spectroscopy), geoscience (mineral-liquid interface characterization by x-ray scattering and spectroscopy), chemistry (EXAFS and XANES spectroscopy of actinides and lanthanides), and atomic physics

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy Σ_x Σ_y	145 μ m 36 μ m
source divergence at critical energy $\Sigma_{x'}$ $\Sigma_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- BESSRC standard monochromator
4–34 keV energy range Si(111)
35 mm offset
water cooling
UHV vacuum compatibility
- Mirrors (removable double-mirror system)
down deflection, flat figure, Pd coating
up deflection, toroidal figure, Rh coating
20 keV energy cutoff

Experiment Stations

- 12-BM-A
white beam first optics enclosure
white beam slits
monochromator and mirror system
- 12-BM-B
monochromatic beam station
x-ray scattering
diffraction
spectroscopy (EXAFS and XANES)

Detectors

- ionization chambers
- Bicron
- Lytle detector
- solid-state detectors
- single-element Si and Ge
- Canberra 9-element Ge

Beamline Controls and Data Acquisition

- SPARC station with Solaris operating system running EPICS with VME and SPEC software
- Windows NT running EPICS applications
- Macintosh with MacOS software running EPICS applications

Beamline Support Equipment/Facilities

- 12-BM-B
spectroscopy table
6-circle Huber goniometer

Beamline contacts: Jennifer Linton
Mark Beno
Pedro Montano

tel 630.252.5007
tel 630.252.3507
tel 630.252.6239

linton@msd.anl
beno@anl.gov
montano@anl.gov

Beamline 12-ID / BESSRC-CAT

Scientific focus: Materials science, atomic physics, and geoscience

Scientific programs: Materials science (elastic and inelastic scattering, MOCVD, x-ray standing waves, electrochemistry), geoscience (mineral-liquid interface characterization), chemistry (small-angle scattering), and atomic physics (spectroscopy)

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- BESSRC standard monochromator
 - Si(111) crystal
 - 4–27 keV energy range
 - 35 mm offset
 - liquid-nitrogen cooling
 - 2nd crystal: Cu braid, liquid nitrogen cooling
 - UHV vacuum compatibility
- flat focusing monochromatic mirror
 - 40 m from source
 - Pt, Pd, and SiO₂ coatings
 - 2.5–4 mrad incident angle
 - ~100 μm focus in 12-ID-B

Experiment Stations

- 12-ID-A
 - white beam first optics enclosure
 - monochromator
 - quad photodiode
 - monochromator pinhole apertures

- 12-ID-B
 - spectroscopy
 - elastic and inelastic scattering
 - reflectivity
 - small-angle scattering
- 12-ID-C
 - atomic physics
 - small-angle scattering (low Q)
- 12-ID-D
 - MOCVD chamber
 - surface chamber
 - x-ray scattering

Detectors

- ionization chambers
- Bicron
- solid-state detectors
- single-element Si and Ge
- Canberra 9-element Ge
- 2-D proportional wire detector
- gold CCD camera

Beamline Controls and Data Acquisition

- 12-ID-B
 - Solaris running SPEC, Windows NT, and MacOS running EPICS applications
- 12-ID-C
 - Solaris running SPEC, Windows NT, and MacOS running EPICS applications
- 12-ID-D
 - Linux workstation running SPEC (non-EPICS version) and EPICS applications

Beamline Support Equipment/Facilities

- 12-ID-B
 - Huber 8-circle goniometer
 - spectroscopy
 - optics table
 - small-angle scattering instrumentation
- 12-ID-D
 - 6-circle goniometer
 - surface chamber
 - MOCVD apparatus

Beamline contacts: Jennifer Linton
Mark Beno
Pedro Montano

tel 630.252.5007
tel 630.252.3507
tel 630.252.6239

linton@msd.anl.gov
beno@anl.gov
montano@anl.gov



Consortium for Advanced Radiation Sources CAT

Overview

The Consortium for Advanced Radiation Sources (CARS) currently has four institutional members—The University of Chicago (the managing agent for CARS), Northern Illinois University, Southern Illinois University, and the Australian Nuclear Science and Technology Organization—and four national user groups—BioCARS for structural biology, GeoCARS for geophysical sciences, SoilEnviroCARS for soil/environmental sciences, and ChemMatCARS for chemistry and materials science. At present, CARS has developed or is developing five x-ray beamlines for use by the faculty and staff of its institutional members and national user groups for frontier research that exploits the unique characteristics of the APS as an x-ray source.

Research Focus

The scientific program and experiments carried out on CARS beamlines exploit the unique features of the x-rays emitted by both wiggler and undulator sources. Two main themes are (1) the study of samples with which x-rays interact very weakly because of their small size (area or volume), low concentration, large crystallographic unit cell dimensions, or necessity for monochromatic radiation of unusually narrow bandpass and (2) time-dependent studies of samples with which x-rays interact more strongly.

For BioCARS, the main thrust is to understand basic biological processes in structural terms. Experiments involve crystallographic studies of viruses, ribosomes, and other complexes with very large unit cells; studies of microcrystals; time-resolved crystallography; and phase determination by MAD techniques.

In GeoSoilEnviroCARS, research is designed to further knowledge of the composition, structure, and properties of earth and planetary materials and the processes they control. High-pressure research in both a diamond-anvil cell and a large-volume press; x-ray diffraction, scattering, and absorption spectroscopies from earth and planetary materials; and x-ray fluorescence microprobe analysis and microtomography should make possible major advances in understanding such diverse processes as earthquake development and nitrogen fixation in roots.

In ChemMatCARS, research focuses on several aspects of dynamic and structural condensed matter and materials chemistry. Research areas include surface and interfacial properties in soft condensed matter; molecular liquids and liquid metals; chemical crystallography with emphasis on dynamics of energy transfer, fast photochemical processes, and valence and element specific crystallography; the structure and properties of molecular aggregates; and interfacial and bulk properties of novel polymers and composites including supramolecular, mesoscopic, and nanometer structures.

CAT contacts:	Keith Moffat, Director	tel 773.702.9950	moffat@cars.uchicago.edu
	GSECARS Mark Rivers, Assoc. Dir.	tel 630.252.0422	rivers@cars.uchicago.edu
	BioCARS Wilfried Schildkamp, Assoc. Dir.	tel 630.252.0445	wilfried@cars.uchicago.edu
	GSECARS Steve Sutton, Assoc. Dir.	tel 630.252.0426	sutton@cars.uchicago.edu
	Joy Talsma, Exec. Admin.	tel 773.702.9506	talsma@cars.uchicago.edu
	ChemMatCARS P. James Viccaro, Assoc. Dir.	tel 630.252.0464	viccaro@cars.uchicago.edu

Beamline 13-BM / GSECARS-CAT

Scientific focus: Geosciences, environmental science, and soil science

Scientific programs: High-pressure diffraction in diamond-anvil cell, high-pressure diffraction in multi-anvil press, microspectroscopy and XRF microprobe, and microtomography

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^8 ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- VG double-crystal monochromator
 - 28 m from source
 - Si(111) or Si(220) crystal
 - water cooling
 - +30 mm offset
- vertical focusing mirror
 - 45 m from source
 - Si substrate
 - Pt, Rh, Si coatings
 - internal water cooling
 - elliptically bent flat geometry
 - 0–5 mrad grazing angle
 - 6:1 to 3:1 demagnification
- small Kirkpatrick-Baez microfocusing mirrors

Experiment Stations

- 13-BM-A
 - white beam first optics enclosure
- 13-BM-B
 - white beam second optics enclosure
- 13-BM-C
 - monochromatic beam station
 - diffraction
 - tomography
- 13-BM-D
 - white or monochromatic beam station
 - multi-anvil press high-pressure diffraction
 - tomography
 - microprobe
 - microspectroscopy

Detectors

- Canberra 16-element Ge detectors (two)
- Bruker 2K CCD detector
- Canberra single-element Ge and Si(Li) detectors
- Princeton Instruments visible light CCD cameras (two)

Beamline Controls and Data Acquisition

- Windows NT workstations running EPICS with VME
- SPEC, IDL, Bruker SMART and GADDS
- Princeton Instruments WinView and WinSpec

Beamline Support Equipment/Facilities

- 250-ton multi-anvil press with DIA and T-cup tooling (13-BM-D)
- laser Raman system in support laboratory

Beamline contacts: Mark Rivers
Stephen Sutton
Nancy Lazarz

tel 630.252.0422
tel 630.252.0426
tel 630.252.0423

rivers@cars.uchicago.edu
sutton@cars.uchicago.edu
lazarz@cars.uchicago.edu

Beamline 13-ID / GSECARS-CAT

Scientific focus: Geosciences, environmental science, and soil science

Scientific programs: High-pressure diffraction in diamond-anvil cell, high-pressure diffraction in multi-anvil press, microspectroscopy and XRF microprobe, microcrystal diffraction, surface diffraction, and x-ray absorption fine structure spectroscopy

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- VG double-crystal monochromator
 - 29 m from source
 - Si(220) crystal
 - cryogenic cooling
 - +50 mm offset
- vertical focusing mirror
 - 45 m from source
 - Si substrate
 - Pt, Rh, Si coatings
 - internal water cooling
 - Kirkpatrick-Baez geometry
 - 0–5 mrad grazing angle
 - 6:1 to 3:1 demagnification
- horizontal focusing mirror
 - 47 m from source
 - Si substrate
 - Pt, Rh, Si coatings
 - internal water cooling
 - Kirkpatrick-Baez geometry
 - 0–5 mrad grazing angle
 - 7:1 to 3:1 demagnification
- small Kirkpatrick-Baez microfocusing mirrors

Experiment Stations

- 13-ID-A
 - white beam first optics enclosure
- 13-ID-B
 - white beam second optics enclosure
- 13-ID-C
 - white or monochromatic beam station
 - x-ray absorption fine-structure spectroscopy
 - XRF microprobe
 - microspectroscopy
 - microcrystal diffraction
 - surface diffraction
- 13-ID-D
 - white or monochromatic beam station
 - multi-anvil press high-pressure diffraction
 - diamond anvil cell high-pressure diffraction

Detectors

- Canberra 16-element Ge detectors (two)
- Bruker 2K CCD detector
- Canberra single-element Ge and Si(Li) detectors
- Princeton Instrument visible light CCD cameras (two)

Beamline Controls and Data Acquisition

- Windows NT workstations running EPICS with VME
- SPEC, IDL, Bruker SMART and GADDS
- Princeton Instruments WinView and WinSpec

Beamline Support Equipment/Facilities

- 13-ID-C
 - Newport general-purpose diffractometer
- 13-ID-D
 - diamond-anvil cell with laser heating
 - two-circle diffractometer
 - 1000-ton multi-anvil press w/ DIA and T-cup tooling
- laser Raman system in support laboratory

Beamline contacts: Mark Rivers
Stephen Sutton
Nancy Lazarz

tel 630.252.0422
tel 630.252.0426
tel 630.252.0423

rivers@cars.uchicago.edu
sutton@cars.uchicago.edu
lazarz@cars.uchicago.edu

Beamline 14-BM / BioCARS-CAT

Scientific focus: Structural biology

Scientific programs: Large unit cell (virus) crystallography, small unit cell (protein) crystallography, MAD phasing, time-resolved crystallography, Laue diffraction, and study of microcrystals

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^8 ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

14-BM-C optics and optical performance

- 7–17 keV energy range
- 0.21 mm hor. x 0.35 mm vert. focal spot size
- CARS-design conical focusing mirror
25.731 m from source (on orbit along 3 mrad line)
Si substrate, Rh coating
water cooling at midplane
4.1 mrad design angle
horizontal focus: focusing monochromator
vertical focus: bender
- CARS-design bent Ge(111) monochromator
46.6 m from source (along 3 mrad centerline)
Ge(111) single crystal
water cooling
bent triangle horizontal focusing
- Misc. slits, collimators, filters, etc.

14-BM-D optics and optical performance

- 6.5–18.5 keV energy range
- 0.4 mm hor. x 0.6 mm vert. focal spot size
- CARS-design Si(111) double-bounce monochromator
23.860 m from source (on orbit along 5 mrad line)
6.5–18.5 energy range Si(111) crystal sets
 10^{-4} energy resolution (dE/E) at 10 keV
1.5 in. nominal offset (fixed-exit, up bounce)
water cooling
- CARS-design cylindrical focusing mirror
Si substrate, Rh coating
water cooling at midplane
25.731 m from source (variable height along 5 mrad line)
4.1 mrad design angle
horizontal focus: sagittal cylindrical figure
vertical focus: bender mechanism
- misc. slits, collimators, filters, etc.

Experiment Stations

- 14-BM-A
white beam first optics enclosure
8.6 m x 1.8 m x 2.8 m (L x W x H)
- 14-BM-B
pink beam optics enclosure
7.6 m x 1.2 m x 2.8 m (L x W x H)
- 14-BM-C
monochromatic beam station
5.2 m x 3.7 m x 2.8 m (L x W x H)
virus crystallography
- 14 BM-D
pink or monochromatic beam station
6.4 m x 2.2 m x 2.8 m (L x W x H)
MAD phasing
time-resolved Laue
protein crystallography

Detectors

- 60° kappa diffractometer (14-BM-D)
- single-axis diffractometer (14-BM-C)
- ADSC Q1, ADSC Q4, MAR345 and off-line image plate detectors
- NaI scintillation detectors
- Ge detector

Beamline contacts: Keith Moffat
Wilfried Schildkamp
Gary Navrotsky

tel 773.702.9950
tel 630.252.0445
tel 630.252.0444

moffat@cars.uchicago.edu
schildkamp@cars.uchicago.edu
navrotsky@cars.uchicago.edu

Beamline 14-BM / BioCARS-CAT

Scientific focus: Structural biology

Scientific programs: Large unit cell (virus) crystallography, small unit cell (protein) crystallography, MAD phasing, time-resolved crystallography, Laue diffraction, and study of microcrystals

Beamline Controls and Data Acquisition

- beamline controls: HP9000/778 HPUX 10.2 running EPICS via VME
- experiment: SGI 02 IRIX 6.3 running ADSC or MAR control software via in-house (kbscan>) software
- analysis: fast SGI 02 IRIX 6.5 running DENZO, MOSFILM, DPS, etc.

Beamline Support Equipment/Facilities

- cryo-coolers: Oxford CryoStream, Oxford CryoJet, MSC, and CARS LN₂/LHe₂ Cooler
- collimators, filters, slits, beam stop, CCD alignment camera
- beam position monitors (1 μ m resolution)
- beam flux monitors
- BL3 facility, sample prep areas, cold room

Beamline contacts: Keith Moffat
Wilfried Schildkamp
Gary Navrotski

tel 773.702.9950
tel 630.252.0445
tel 630.252.0444

moffat@cars.uchicago.edu
schildkamp@cars.uchicago.edu
navrotski@cars.uchicago.edu

Beamline 14-ID / BioCARS-CAT

Scientific focus: Structural biology

Scientific programs: Large unit cell (virus) crystallography, small unit cell (protein) crystallography, MAD phasing, time-resolved crystallography, Laue diffraction, and study of microcrystals

Insertion Device Source Characteristics (nominal)

source	wiggler A
period	8.50 cm
length	2.4 m
peak K_{\max} (at minimum gap = 18.1 mm)	8.74
critical energy (at minimum gap = 18.1 mm)	35.9 keV
energy range (wiggler mode)	5.0 - 200.0 keV
energy range 1st harmonic (undulator mode)	0.2 - 4.0 keV
energy range 1st - 5th harmonics (undulator mode)	0.2 - 15.0 keV
on-axis peak brilliance at 2.7 keV (undulator mode)	2.0×10^{18} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak brilliance at 29.9 keV (wiggler mode at minimum gap = 18.1 mm)	1.1×10^{17} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 29.9 keV (wiggler mode at minimum gap = 18.1 mm)	5.4×10^{15} ph/sec/mrad ² /0.1%bw
source size at critical energy \sum_x \sum_y	359 μ m 21 μ m
source divergence at critical energy \sum_x (FWHM 1.2 mrad, non-Gaussian) \sum_y	510 μ rad 47 μ rad

Optics & Optical Performance

- slits
- power filters
- CARS-design Si(111) monochromator
28.013 m from source (on orbit along
0 mrad line)
double bounce
6.5–18.5 energy range w/ Si(111) crystal sets
10⁻⁴ energy resolution (dE/E) at 10 keV
1.5 in. offset (fixed-exit, down bounce)
water or liquid-nitrogen cooling

- CARS design cylindrical focusing mirror
29.870 m from source (on orbit along
0 mrad line)
Si substrate, Rh coating
water cooling at midplane
4.1 mrad design angle
horizontal focus: sagittal cylindrical figure
vertical focus: bender

Experiment Stations

- 14-ID-A
white beam first optics enclosure
10.5 m x 1.7 m x 2.8 m (L x W x H)
- 14-ID-B
pink or monochromatic beam station
4.5 m x 2.6 m x 2.8 m (L x W x H)
MAD phasing
microcrystallography
virus/protein
Laue
time-resolved crystallography

Detectors

- ADSC Q4, MAR345 and off-line image plate detectors
- NaI scintillation detectors
- Ge fluorescence detector

Beamline Controls and Data Acquisition

- beamline controls: HP9000/778 HPUX 10.2 running EPICS via VME
- experiment: SGI 02 IRIX 6.3 running ADSC or Mar control software via in-house (kbscan>) software
- analysis: Fast SGI 02 IRIX 6.5 running DENZO, MOSFILM, DPS, etc.

Beamline Support Equipment/Facilities

- cryo-coolers: Oxford CryoJet and CARS liquid-nitrogen/liquid-helium cooler
- collimators, filters, slits, beam-stop, CCD alignment camera
- beam position monitors (1 μ m resolution)
- beam flux monitors
- BL3 facility, sample-prep areas, cold room

Beamline contacts: Keith Moffat
Wilfried Schildkamp
Gary Navrotsky

tel 773-702-9950
tel 630.252.0445
tel 630.252.0444

moffat@cars.uchicago.edu
schildkamp@cars.uchicago.edu
navrotsky@cars.uchicago.edu

Beamline 15-ID / ChemMatCARS-CAT

Scientific focus: Dynamic and structural condensed matter physics

Scientific programs: Time-dependent chemical crystallography scattering, anomalous scattering, micro crystallography; static and time-dependent surface scattering, dynamic protein diffraction, and small beam probing of complex structural polymers; interfacial and bulk studies using small- and wide-angle x-ray scattering; and coherent x-ray scattering of polymer/metal nanocomposites, nano-colloidal, and opaque materials.

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- Kohzu Seiki monochromator HLD-3
3.1–22.5 keV energy range (for Si(111)
and 25-mm offset)
5°–40° angular range
25–35 mm offset
cryo-cooled Si or water-cooled diamond modes
- Oxford/SESIO vertically focusing mirror (A)
water cooling
white beam compatible
- Oxford/SESIO water-cooled 2nd steering mirror (B)
- modes of operation:
 - 1) monochromator w/ or w/out mirror(s)
 - 2) white beam mirror operation
- high-energy-resolution monochromator
 $dE/E \sim 10^{-5}$
used with Kohzu monochromator
- in-station optics
steering crystal or multilayer for surface science
microfocusing optics

Experiment Stations

- 15-ID-A
white beam first optics enclosure
- 15-ID-B
white beam station
crystallography
- 15-ID-C
pink beam station
surface science
- 15-ID-D
SAXS/WAXS
10 m L x 5.8 m H

Detectors

- Fuji image plates
- Bruker model 1500/1000 CCD
- Princeton Scientific model LN/CCD-1024SF CCD
- NaI
- ionization chambers
- avalanche photodiodes

Beamline Controls and Data Acquisition

- EPICS and SPEC in addition to IDL, Windows
NT and Sun Workstations running channel
access with tools such as MEDM
- electronics VM- and NIM-based

Beamline Support Equipment/Facilities

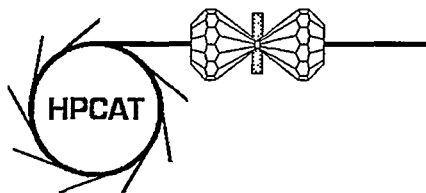
- Huber 6-circle (15-ID-B & -C)
- liquid surface spectrometer (15-ID-C)
- monochromatic beam chopper for time-resolved
studies
open time $\sim 2.4 \mu\text{sec}$
frequency $\sim 1.3 \text{ kHz}$
attenuation $\sim 2 \times 10^{-7}$ at 33 keV
- Nd:YAG laser ($\lambda=355 \text{ nm}$, 400 μJ at 1000 Hz)

Beamline contacts:

David Cookson
Timothy Graber
Yifei Jaski
P. James Viccaro

tel 630.252.0468
tel 630.252.0462
tel 630.252.0461
tel 630.252.0464

cookson@cars.uchicago.edu
graber@cars.uchicago.edu
ruan@cars.uchicago.edu
viccaro@cars.uchicago.edu



High-Pressure CAT

Overview

The High-Pressure Collaborative Access Team (HP-CAT) currently has three institutional members: the Carnegie Institution of Washington (managing member), Lawrence Livermore National Laboratory, and the University of Nevada, Las Vegas. These members pool resources and share expertise for the development, construction, and operation of sector 16. The purpose of HP-CAT is to provide its members with facilities for state-of-the-art educational and research activities and to assist the members and general users in operating these facilities; the goal is to advance high-pressure research with synchrotron radiation. The ultimate aim of HP-CAT is to set up a world-leading high-pressure research center at the APS and to make it accessible to the scientific community.

Research Focus

Extreme pressure conditions radically alter the properties of materials. With the recent advances and developments in the technology of pressure vessels, which can now reach several hundreds of gigapascal (1 GPa = 10 kbar), the pressure variable promises to add a whole new dimension in fundamental physics, chemistry, earth and planetary sciences, and material science and technology. HP-CAT is dedicated to the scientific exploration of these fields with a common focus on the high-pressure dimension.

In ultrahigh pressure research, the power of an integrated approach is far greater than the sum of individual techniques. Comprehensive understanding of high-pressure phenomena relies on the combination of complementary measurements. HP-CAT integrates x-ray diffraction and spectroscopy with samples at high pressures and variable temperatures (from cryogenic conditions to thousands of degrees). These techniques include single-crystal structure refinement using energy-dispersive x-ray diffraction, high-resolution angle-dispersive polycrystalline x-ray diffraction, high-resolution x-ray emission spectroscopy, x-ray absorption spectroscopy, nuclear resonance forward scattering, inelastic x-ray scattering, and Compton scattering. The structural, vibrational, electronic, and magnetic properties of materials can thus be measured *in situ* for identifying novel phenomena and transitions at high pressures.

CAT contacts:	Ho-Kwang (David) Mao, CAT Dir.	tel 202.686.4454	mao@gl.ciw.edu
	Malcolm Nicol, HP-CAT Member	tel 702.895.1725	nicol@physics.unlv.edu
	Choong-Shik Yoo, HP-CAT Member	tel 925.422.5848	yoo1@llnl.gov
	Daniel Häusermann, Proj. Man.	tel 630.252.0427	daniel.hausermann@anl.gov
	Markus Schworer-Bohning,	tel 630.252.0411	schwore@aps.anl.gov
	Beamline Scientist		

Beamline 16-BM / HP-CAT

Scientific focus: Study of materials at high pressures in the fields of physics, chemistry, materials science, and planetary science

Scientific programs: Studies of materials under high pressure and variable temperature using diamond-anvil cells and other high-pressure devices by energy-dispersive diffraction from single crystals and powders and EXAFS

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad/0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy $\sum x$ $\sum y$	145 μ m 36 μ m
source divergence at critical energy $\sum x'$ $\sum y'$	6 mrad 47 μ rad

NOTE: The design parameters of beamline 16-BM are currently undergoing detailed reviews. Hence, the general characteristics given below will be refined and altered in the near future. Therefore, these parameters should be regarded as indicative only.

Optics & Optical Performance

- water-cooled collimating mirror
- double-crystal monochromator
water-cooled 1st crystal
sagittally focusing 2nd crystal
- vertically focusing mirror
- small Kirkpatrick-Baez microfocusing mirrors

Experiment Stations

- 16-BM-B
white beam diffraction techniques using microfocusing
- 16-BM-C
EXAFS experiments

Detectors

- Ge and Si(Li) detectors
- other detectors to be defined

Beamline Controls and Data Acquisition

- Windows NT-UNIX-Linux workstations running EPICS with VME
- SPEC, IDL, and other suitable control and data acquisition programs

Beamline Support Equipment/Facilities

- custom-designed diffractometers and other sample handling stages
- diamond-anvil cells
- large-volume cell
- pressure measurement instrumentation
- cryostat
- optical spectrometers

Beamline contacts: Daniel Häusermann
Markus Schwoerer-Bohning

tel 630.252.0427
tel 630.252.0411

daniel.hausermann@anl.gov
schwoere@aps.anl.gov

Beamline 16-ID / HP-CAT

Scientific focus: Study of materials at high pressures in the fields of physics, chemistry, materials science, and planetary science

Scientific programs: Studies of materials under high pressure and variable temperature using diamond-anvil cells and other high-pressure devices by microfocus angle-dispersive diffraction from single crystals and powders, nuclear resonance forward scattering, inelastic scattering, Compton scattering, and emission and absorption spectroscopy

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μ m 21 μ m
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μ rad 6.9 μ rad

NOTE: The design parameters of beamline 16-ID are currently undergoing detailed reviews. Hence, the general characteristics given below will be refined and altered in the near future. Therefore, these parameters should be regarded as indicative only.

Optics & Optical Performance

- fixed-exit double-crystal monochromator
diamond(111)
water-cooled
- two-crystal branching monochromator
diamond(111)
water-cooled
- small Kirkpatrick-Baez microfocusing mirrors
- four-reflections / high-resolution monochromator
- vertically and horizontally focusing long mirrors

Experiment Stations

- 16-ID-B
monochromatic side-branch station for microbeam diffraction
- 16-ID-D
white and monochromatic station for diffraction, spectroscopy, new techniques, and developments
- 16-ID-E
white and monochromatic station for spectroscopy with high-resolution inelastic x-ray scattering spectrometer

Detectors

- avalanche photodiode system for nuclear scattering
- Si PIN diode system for inelastic scattering
- area detector for angle-dispersive diffraction (to be defined)
- other detectors to be defined

Beamline Controls and Data Acquisition

- Windows NT-UNIX-Linux workstations running EPICS with VME
- SPEC, IDL, and other suitable control and data acquisition programs

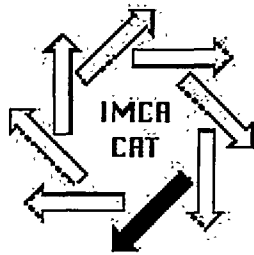
Beamline Support Equipment/Facilities

- custom-designed diffractometers and other sample handling stages
- diamond-anvil cells
- large-volume cell
- pressure measurement instrumentation
- cryostat
- laser-heating system
- optical spectrometers

Beamline contacts: Daniel Häusermann
Markus Schwoerer-Bohning

tel 630.252.0427
tel 630.252.0411

daniel.hausermann@anl.gov
schwoere@aps.anl.gov



Industrial Macromolecular Crystallography Association CAT

Overview

The Industrial Macromolecular Crystallography Association (IMCA) is a consortium of crystallographic groups from 12 companies with major pharmaceutical research laboratories in the United States. IMCA-CAT comprises both IMCA and the Center for Synchrotron Radiation Research (CSRRI) at the Illinois Institute of Technology. The 12 corporate members of IMCA are Abbott Laboratories; Bayer Corporation; Bristol-Myers Squibb Pharmaceutical Research Institute; Glaxo Wellcome Research Institute; Eli Lilly and Company; Merck and Company, Incorporated; Monsanto / Searle; Parke-Davis Pharmaceutical Research; Pharmacia and Upjohn, Incorporated; The Procter and Gamble Company; Schering-Plough Research Institute; and SmithKline Beecham Pharmaceuticals. IMCA-CAT is unusual in that a large fraction of research conducted by CAT members is expected to be proprietary. Member scientists function as competitors in the discovery research that arises from their data-collection efforts; however, they collaborate in methods development and collectively fund the operation of the beamlines.

Research Focus

Macromolecular crystallography is the primary research focus for IMCA, with the ultimate objective of facilitating the process of rational drug design. Traditional drug design methods involve testing thousands of compounds to determine biological activity. Rational drug design research attempts to elucidate biological processes in detail, which depends heavily on detailed knowledge of the atomic structure of the molecules involved. IMCA-CAT's insertion-device beamline is designed primarily for monochromatic and multiwavelength anomalous diffraction (MAD) experiments on small (<80 micrometer) protein crystals over an energy range of 6 to 20 keV. The bending-magnet line is designed mostly for monochromatic and MAD experiments on somewhat larger protein crystals over a similar energy range.

CAT contacts:	Andy Howard, Director	tel 630.252.0534	ahoward@psyche.csrri.iit.edu
	John Chrzas, Assoc. Director	tel 630.252.0522	john@sparky.csrri.iit.edu
	Virginia Brown, CAT Coordinator	tel 630.252.0520	vbrown@sparky.csrri.iit.edu

Beamline 17-BM / IMCA-CAT

Scientific focus: Pharmaceutical macromolecular crystallography

Scientific programs: Structures of protein–ligand complexes, *de novo* protein structures, drug design, protein engineering, and crystallographic methods development

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad/0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^8 ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- Daresbury double-crystal constant off-set monochromator
 - 28 m from source
 - 6–20 keV energy range Si(111)
 - 10^{-4} energy resolution (dE/E) at 10 keV
 - 35 mm offset below orbital plane
 - water cooling
- sagittally bent 2nd monochromator crystal
- Daresbury vertically focusing mirror

Experiment Stations

- 17-BM-A
 - white beam first optics enclosure
- 17-BM-B
 - white/monochromatic beam station
 - monochromatic macromolecular crystallography

Detectors

- Bruker 4-element CCD array for crystallography
- MAR345 image plate for crystallography
- fluorescence detector

Beamline Controls and Data Acquisition

- controls: Sun and Linux systems running EPICS with VME “MX” software (locally developed), running on UNIX
- data acquisition: proprietary software from Bruker and Mar

Beamline Support Equipment/Facilities

- 4° chill room in wet lab

Beamline contacts: Andrew Howard
John Chrzas

tel 630.252.0534
tel 630.252.0522

ahoward@psyche.csrrri.iit.edu
john@sparky.csrrri.iit

Beamline 17-ID / IMCA-CAT

Scientific focus: Pharmaceutical macromolecular crystallography

Scientific programs: Structures of protein- ligand complexes, *de novo* protein structures, drug design, protein engineering, and crystallographic methods development

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- Daresbury double-crystal constant off-set monochromator
 - 28 m from source
 - 6–20 keV energy range Si(111)
 - 10^{-4} energy resolution (dE/E) at 10 keV
 - 35 mm offset below orbital plane
 - liquid-nitrogen cooling

Experiment Stations

- 17-ID-A
 - white beam first optics enclosure
- 17-ID-B
 - monochromatic beam station
 - macromolecular crystallography
 - 3.5 m x 7 m

Detectors

- Mar 165-mm single-element CCD
- Bicron fluorescence detector

Beamline Controls and Data Acquisition

- controls: Sun and Linux systems running EPICS with VME “MX” software (locally developed), running on UNIX
- data acquisition: proprietary software from Bruker and Mar

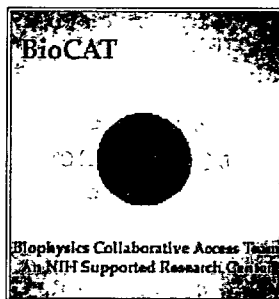
Beamline Support Equipment/Facilities

- 4° chill room in wet lab
- Oxford cryo-stream system

Beamline contacts: Andrew Howard
John Chrzas

tel 630.252.0534
tel 630.252.0522

ahoward@psyche.csrrri.iit.edu
john@sparky.csrrri.iit



Biophysics CAT

Overview

The Biophysics CAT (Bio-CAT) is organized as a national research resource to be used primarily to study the structure of partially ordered biological molecules, complexes of biomolecules, and cellular structures under conditions similar to those present in living cells. The goal of this research is to determine the detailed mechanism of action of biological systems at the molecular level. The techniques used are x-ray fiber diffraction, x-ray scattering, x-ray absorption/emission spectroscopy, and advanced imaging techniques such as diffraction enhanced imaging. The research conducted at Bio-CAT's beamlines complements that done by other APS CATs (specifically, those that emphasize protein crystallography: BioCARS, IMCA-CAT, and SBC-CAT).

Research Focus

Many biological macromolecules (e.g., enzymes) and complexes (e.g., viruses) can be crystallized and subjected to classic crystallographic analysis. However, in living cells, most biological systems are noncrystalline, and many biological structures cannot be studied in this manner because they cannot be crystallized, are transiently formed, or have structures or dynamical behaviors that change upon crystallization. For example, comparison of x-ray absorption spectra from crystalline and solution enzyme samples has shown that the processes of crystallization can change the microstructures sufficiently that crystallographic structural analysis alone would lead to incorrect interpretations of the enzymes' mechanisms of action.

All biological systems have some degree of spatial or dynamic order; this order can be probed by noncrystallographic diffraction and x-ray absorption. Of key interest to Bio-CAT scientists are the structures of small ordered domains such as single muscle fibers and connective tissues and studies of the time dependence of structural changes that occur as biomolecular complexes carry out their functions. Key research areas involve biological processes and systems of direct biomedical importance such as enzymes (particularly metalloproteins), DNA-binding proteins, proteins involved in gene expression, cell membranes, nerve cells, immune system components, the processes of cell transport, and cell motility.

CAT contacts:	Grant Bunker, Director	tel 312.567.3385	bunker@biocat1.iit.edu
	Thomas Irving, Deputy Dir.	tel 312.567.3489	irving@biocat1.iit.edu
	Clareen Krolik, CAT Coord.	tel 630.252.0549	krolik@bio.aps.anl.gov

Beamline 18-ID / Bio-CAT

Scientific focus: Static and dynamic studies of partially ordered biological systems

Scientific programs: X-ray fiber diffraction, x-ray scattering, x-ray absorption/emission spectroscopy, and x-ray imaging and tomography

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- 3.5–35 keV energy range
- vertical beam size: 2 mm unfocused–
0.02 mm focused
- horizontal beam size: 5 mm unfocused–
0.01 mm focused
- Rosenbaum-Rock high-resolution monochromator #1
6.5°–38° Bragg angle range
1st crystal, Si(111), liquid-nitrogen cooling
2nd crystal, Si(111), 10 mm wide (stabil-
ized at 25°C, sagittally bent)
7:1 demagnification
35 mm beam offset (nominal)
motorized tune, twist, & roll control
(4 mm range, 50 nm resolution)

- Rosenbaum-Rock high-flux monochromator #2
6.5°–38° Bragg angle range
1st crystal, Si(400), liquid-nitrogen cooling
2nd crystal, Si(400), 10 mm wide (stabilized
at 25°C, sagittally bent)
7:1 demagnification
35 mm beam offset (nominal)
motorized tune, twist, & roll control
(4 mm range, 50 nm resolution)
- Rosenbaum-Rock vertical focusing mirror
plane mirror substrate:
Zerodur
1020 mm x 95 mm x 38 mm
2 Å rms roughness
4 μrad surface figure error, mounted
Pt, none, and Pd coating stripes
two motorized, encoded supports
dynamic, independent bending mechanisms at both ends
aberration correction via elliptical bending
11:1 demagnification

Experiment Station

- 18-ID-D
monochromatic beam station
12 m x 5 m x 3 m

Detectors

- Fuji BAS 2500 image plate scanner
- 1024 x 1024 CCD detector with 60 μm pixels
- fast-time-slicing plastic scintillator array
- Lytle fluorescence detector
- multilayer fluorescence analyzer

Beamline Support Equipment/Facilities

- small-angle camera (up to 8 m camera length)
- Huber 4-circle (small), Huber 2-circle with
quarter chi-segment
- Displex cryostat
- 3 ft x 5 ft optical table with five axes of motion

Beamline contacts: Grant Bunker
Tom Irving
Clareen Krolik

tel 312.567.3385
tel 312.567.3489
tel 630.252.0549

bunker@biocat1.iit.edu
irving@biocat1.iit.edu
krolik@bio.aps.anl.gov

Structural Biology Center

Structural Biology Center CAT

Overview

The Structural Biology Center CAT has constructed a national user facility at the APS for studies in macromolecular crystallography. Funded by the Department of Energy's Office of Biological and Environmental Research, the Structural Biology Center provides users with a full complement of instrumentation, ancillary facilities, software, and support staff to enhance the productivity of their research. The majority of beamtime is allocated to Independent Investigators through a proposal process, with a small amount of time reserved for research and development activities by SBC-CAT staff members.

Research Focus

The principal focus of the SBC-CAT research program is macromolecular crystallography. Designed as a rapid-throughput facility, the Structural Biology Center provides researchers with the ability to use both standard crystallographic techniques and multiple energy anomalous dispersion (MAD) phasing methods.

One current major program focuses on the study of macromolecular assemblies, with an emphasis on molecular recognition and interaction between macromolecules. Specific projects include molecular chaperones (bacterial and archael chaperonins 60, human hsc70 chaperone), protein/nucleic acid complexes (trp repressor/operator systems), and multimeric enzymes.

CAT contacts:	Andrzej Joachimiak, Director	tel 630.252.3926	andrzejj@anl.gov
	Carol Zimmer, CAT Coordinator	tel 630.252.0560	cmzimmer@anl.gov
	WWW Site		http://www.sbc.anl.gov

Beamline 19-BM / SBC-CAT

Scientific focus: Macromolecular crystallography

Scientific program: Structural biology

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- 6–20 keV standard spectral range
- 0.14 mm hor. x 0.06 mm vert. FWHM focused spot size
- Rosenbaum-Rock double-crystal monochromator
 - water cooled
 - sagittally focusing 2nd crystal
 - 6:1 demagnification
 - 6°–40° Bragg angle range
 - 1st crystals: Si(111), Si(220), Si(331)
 - 25 mm wide, common cooler carrier
 - 2nd crystals: Si(111), Si(220), Si(331)
 - exchangeable, 25 mm x 125 mm
 - 35 mm beam offset (nominal)

- Rosenbaum-Rock vertical focusing mirror
 - 9:1 demagnification
 - Zerodur plane mirror substrate
 - 1020 mm x 100 mm x 38 mm
 - 2 Å rms roughness
 - 1 μ rad surface figure error
 - Pt, none, Pd coating stripes (35 mm wide ea.)
 - two motorized, encoded supports
 - dynamic, independent bending mechanism at both ends
 - aberration correction via elliptical bending

Experiment Stations

- 19-BM-A
 - white beam first optics enclosure
- 19-BM-C
 - white beam optics enclosure
- 19-BM-D
 - monochromatic experiment station
 - kappa goniostat for macromolecular crystallography
 - guard slits
 - filter/shutter
 - detector support and positioner

Detectors

- SBC1 3k x 3k CCD
 - built by ANL-ECT
 - 210 mm x 210 mm active area
 - 1.8 sec readout

Beamline Controls and Data Acquisition

- Multiprocessor SG1 workstation, plus two UNIX work stations for data acquisition and data processing
- 3 HP workstations running EPICS, VME for beamline and detector control
- PMAC motor controller, software by ANL-ECT
- GUI for beamline control, data acquisition, and detector control by ANL-ECT

Beamline Support Equipment/Facilities

- Rosenbaum-Rock miniaturized kappa goniostat
- high-magnification-alignment cameras (two)
- Rosenbaum-Rock high-precision detector support and positioner
- liquid-nitrogen cryosystem sample cooler

Beamline contacts: Randy Alkire
Stephan Ginell
Andrzej Joachimiak

tel 630.252.3865 alkire@anl.gov
tel 630.252.3972 ginell@anl.gov
tel 630.252.3926 andrzej@anl.gov

Beamline 19-ID / SBC-CAT

Scientific focus: Macromolecular crystallography

Scientific program: Structural biology

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{16} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μ m 21 μ m
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μ rad 6.9 μ rad

Optics & Optical Performance

- 6–20 keV standard spectral range
- 0.08 mm hor. x 0.04 mm vert. FWHM focused beam size
- Rosenbaum-Rock monochromator #1
 - high-resolution double-crystal sagittal focusing
 - 1st crystal, Si(220), liquid-nitrogen cooled
 - 2nd crystal, Si(220), 10 mm wide (stabilized at 25°C, sagittally bent)
 - 7:1 demagnification
 - 6.5°–38° Bragg angle range
 - 35 mm beam offset (nominal)
 - motorized tune, twist, & roll control (4 mm range, 50 nm resolution)
- Rosenbaum-Rock monochromator #2
 - 1st crystal, Si(111), liquid-nitrogen cooled
 - 2nd crystal, Si(111), 10 mm wide, (stabilized at 25°C, sagittally bent)
 - 7:1 demagnification
 - 6.5°–38° Bragg angle range
 - 35 mm beam offset (nominal)
 - motorized tune, twist, & roll control (4 mm range, 50 nm resolution)

- Rosenbaum-Rock vertical focusing mirror
 - 11:1 demagnification
 - Zerodur plane mirror substrate
 - 1020 mm x 100 mm x 38 mm
 - 2 Å rms roughness
 - 1 μ rad surface figure error
 - Pt, none, and Pd coating stripes (35 mm wide ea.)
 - two motorized angle and weight adjustments, encoded supports
 - dynamic, independent bending mechanism at both ends
 - aberration correction via elliptical bending

Experiment Stations

- 19-ID-A
 - white beam first optics enclosure
- 19-ID-C
 - white beam optics enclosure
- 19-ID-D
 - monochromatic experiment station
 - kappa goniostat for macromolecular crystallography
 - guard slits
 - filter/shutter
 - detector support and positioner

Detectors

- SBC2 3k x 3k CCD
 - built by ANL-ECT
 - 210 mm x 210 mm active area
 - 1.8 sec readout

Beamline Controls and Data Acquisition

- Multiprocessor SG1 workstation, plus two UNIX workstations for data acquisition
- Three HP workstations running EPICS, VME for beamline and detector control
- PMAC motor controller, software by ANL-ECT
- GUI for beamline control & data acquisition, detector control by ANL-ECT

Beamline Support Equipment/Facilities

- Rosenbaum-Rock miniaturized kappa goniostat
- high-magnification alignment cameras (two)
- Rosenbaum-Rock high-precision detector support and positioner
- liquid-nitrogen cryosystem sample cooler

Beamline contacts: Randy Alkire
Stephan Ginell
Andrzej Joachimiak

tel 630.252.3865 alkire@anl.gov
tel 630.252.3972 ginell@anl.gov
tel 630.252.3926 andrzejj@anl.gov



Pacific Northwest Consortium CAT

Overview

The Pacific Northwestern Consortium CAT (PNC-CAT) includes a number of institutions in the Pacific Northwest regions of both the United States and Canada. Scientists from the lead institutions of the University of Washington, Pacific Northwest National Laboratories, and Simon Fraser University share several common research goals: specifically, a basic understanding of materials as related to their physical and chemical properties, the development of new strategies for environmental cleanup based on a fundamental understanding of the interaction of pollutants with the ambient environs, and structure-function properties of macromolecules.

Research Focus

Several innovative instruments, including an analytical x-ray microscope with 0.1- μm resolution and capability to measure diffraction, x-ray absorption fine structure (XAFS), and diffraction anomalous fine structure (DAFS), will enable investigators to characterize heterogeneous materials in new ways. These measurements can be combined with two- and three-dimensional imaging using absorption and phase contrast. UHV and MBE facilities are available for *in situ* investigations using surface diffraction and XAFS. Capabilities for time-resolved measurements in the nanosecond scale are planned. These techniques and instruments will be used to investigate materials science and environmental problems, on both a fundamental and applied level.

CAT contacts:	Edward Stern, Director	tel 206.543.2023	stern@phys.washington.edu
	Daryl Crozier, Associate Dir.	tel 604.291.4827	crozier@sfu.ca
	Steve Heald, Dir. of Construction	tel 630.252.9795	heald@aps.anl.gov

Beamline 20-BM / PNC-CAT

Scientific focus: Materials science and environmental science

Scientific programs: Material science, environmental science, and surface science

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- BESSRC-type monochromator
 - 29 m from source
 - 2–30 keV energy range
 - $1-2 \times 10^{-4}$ energy resolution (dE/E)
 - 35 mm offset
 - water cooling
 - 2nd crystal : 4 mrad acceptance for sagittal focusing
- bent mirror
 - 26 m from source
 - 2–30 keV energy range
 - 2.7 mrad glancing angle

Experiment Stations

- 20-BM-A
 - white beam first optics enclosure
- 20-BM-B
 - monochromatic general purpose station

Detectors

- ionization chambers
- 13-element Ge
- CCDs

Beamline Controls and Data Acquisition

- Sun, UNIX with EPICS/VME
- Windows NT with LabView
- SPEC

Beamline Support Equipment/Facilities

- MBE/UHV surface chamber

Beamline contacts: Steve Heald
Detong Jiang
Dale Brewe

tel 630.252.9795
tel 630.252.0581
tel 630.252.0582

heald@aps.anl.gov
jiang@pnc.aps.anl.gov
brewe@pnc.aps.anl.gov

Beamline 20-ID / PNC-CAT

Scientific focus: Materials science and environmental science

Scientific programs: Material science, environmental science, UHV/surface science-MBE growth, and x-ray microbeams

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV Σ_x Σ_y	359 μ m 21 μ m
source divergence at 8.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μ rad 6.9 μ rad

Optics & Optical Performance

- BESSRC high-heat-load monochromator
 - 31 m from source
 - 3–27 keV energy range, Si(111)
 - 6–50 keV energy range, Si(311)
 - $1-2 \times 10^{-4}$ energy resolution (dE/E), Si(111)
 - $0.5-1 \times 10^{-4}$ energy resolution (dE/E), Si(311)
 - 35 mm offset
 - liquid-nitrogen cooling
 - $\sim 10^{13}$ ph/sec flux at 10 keV, Si(111)
- toroidal focusing mirror
 - 34 m from source
 - 3–30 keV energy range
 - Al, Rh, Pt coatings (selectable)
 - 2.2–2.7 mrad glancing angle
 - $\sim 400 \times 200 \mu$ m (H,V) focal spot
- Kirkpatrick-Baez mirrors
 - 3–20 keV energy range
 - 1 μ m or 5 μ m focal spot (mirror dependent)
 - 4 mrad glancing angle
 - $\sim 10^{12}$ flux at 10 keV

- tapered capillaries
 - 3–30 keV energy range
 - $<0.5 \mu$ m focal spot
 - 150 μ m beam acceptance
 - 10^9-10^{10} ph/sec flux

Experiment Stations

- 20-ID-A
 - white beam first optics enclosure
- 20-ID-B
 - monochromatic beam station
 - microbeams
 - XAFS
- 20-ID-C
 - monochromatic beam station
 - diffraction
 - surface science

Detectors

- ionization chambers
- 13-element Ge detector
- NaI scintillation
- CCDs

Beamline Controls and Data Acquisition

- Sun UNIX with EPICS/VME
- Windows NT with LabView
- SPEC

Beamline Support Equipment/Facilities

- Huber surface diffractometer with UHV chamber (20-ID-C)
- MBE-capable surface XAFS, reflectivity and standing wave chamber (20-ID-B & C)
- diamond phase plate

Beamline contacts: Steve Heald
Detong Jiang
Dale Brews

tel 630.252.9795
tel 630.252.0581
tel 630.252.0582

heald@aps.anl.gov
jiang@pnc.aps.anl.gov
brews@pnc.aps.anl.gov



Southeast Regional CAT

Overview

SER-CAT, which represents institutions from the states of Alabama, Florida, Georgia, Kentucky, Missouri, North Carolina, South Carolina, Tennessee, and Virginia, as well as the Intramural Program of the National Institutes of Health, plans to build and operate a sector at the APS. The SER-CAT mission is to provide researchers from its member institutions with timely access to tunable, high-intensity x-rays for x-ray diffraction structural studies of biomolecules. SER-CAT plans to provide its users with a complete research facility, including a full complement of instrumentation, software, and support staff for high-throughput data collection and processing. SER-CAT also plans to provide 25% of its beam time to outside users through its Independent Investigator program via a proposal process.

Research Focus

The principal focus of the SER-CAT research program is macromolecular crystallography. The SER-CAT beamline designs are based on those of SBC-CAT; researchers will be able to use both traditional and multiple wavelength anomalous dispersion (MAD) techniques for structure determination and investigation.

The research interests of SER-CAT researchers are varied, ranging from DNA, protein and virus structures, to catalysts and basic materials science.

CAT contacts:	Bi-Cheng Wang, CAT Director	tel 706.542.1747	wang@BCL1.bmb.uga.edu
	Craig Smith, CAT Coordinator	tel 205.934.7233	smith@gold.cmc.uab.edu
	Gerold Rosenbaum, Project Dir.	tel 630.252.0643	rosenbaum@anl.gov
	John Unik, Project Administrator	tel 630.252.0640	junik@anl.gov

Beamline 22-BM / SER-CAT

Scientific focus: Macromolecular crystallography

Scientific program: Structural biology

Summary reflects projected performance parameters and planned equipment and hardware.

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad/0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^{13} ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- 6–20 keV standard spectral range
- 0.14 mm hor. x 0.06 mm vert. FWHM focused spot size
- Rosenbaum-Rock double-crystal monochromator
 - water cooling
 - 1st crystals: Si(111), Si(220), Si(331)
 - 25 mm wide, common cooler carrier
 - 2nd crystals: Si(111), Si(220), Si(331)
 - sagital focusing
 - exchangeable
 - 125 mm L x 25 mm W
 - 6:1 demagnification
 - 6°–40° Bragg angle range
 - 35 mm beam offset (nominal)

- Rosenbaum-Rock vertical focusing mirror
 - 9:1 demagnification
 - ULE plane mirror substrate
 - 1020 mm x 100 mm x 38 mm
 - 2 Å rms roughness
 - 1 μ rad surface figure error
 - Pt, none, Pd coating stripes (35 mm wide ea.)
 - two motorized angle and weight adjustments, encoded supports
 - dynamic, independent bending mechanism at both ends
 - aberration correction via elliptical bending

Experiment Stations

- 22-BM-A
 - white beam enclosure
- 22-BM-C
 - white beam optics enclosure
- 22-BM-D
 - monochromatic experiment station
 - kappa goniostat for macromolecular crystallography
 - adjustable collimator slits
 - filter/shutter
 - detector support and positioner

Detectors

- CCD area detector

Beamline Controls and Data Acquisition

- detector control and interface hardware and software to be defined
- beamline control and data acquisition software to be defined
- computers to be defined
- DC-servomotor; PMAC motor controller
- electrometer amplifiers; VME-based, computer-controlled V/F converter and scaler (ANL-ECT design)

Beamline Support Equipment/Facilities

- Rosenbaum-Rock miniaturized kappa goniostat
- high-magnification-alignment cameras (two)
- Rosenbaum-Rock high-precision detector support and positioner
- liquid-nitrogen cryosystem sample cooler

Beamline contacts: Gerd Rosenbaum
John Gonczy

tel 630.252.0643
tel 630.252.0642

rosenbaum@anl.gov
gonczy@anl.gov

Beamline 22-ID / SER-CAT

Scientific focus: Macromolecular crystallography

Scientific program: Structural biology

Summary reflects projected performance parameters and planned equipment and hardware.

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV Σ_x Σ_y	359 μ m 21 μ m
source divergence at 8.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μ rad 6.9 μ rad

Optics & Optical Performance

- 6–20 keV standard spectral range
- 0.08 mm hor. x 0.04 mm vert. FWHM focused beam size
- Rosenbaum-Rock monochromator
 - high-resolution double-crystal sagittal focusing
 - 1st crystal, Si(220), liquid-nitrogen cooling
 - 2nd crystal, Si(220), 10 mm wide (stabilized at 25°C, sagittally bent)
 - 7:1 demagnification
 - 6.5°–38° Bragg angle range
 - 35 mm beam offset (nominal)
 - motorized tune, twist, & roll control (4 mm range, 50 nm resolution)

- Rosenbaum-Rock vertical focusing mirror
 - 11:1 demagnification
 - ULE plane mirror substrate
 - 1020 mm x 100 mm x 38 mm
 - 2 Å rms roughness
 - 1 μ rad surface figure error
 - Pt, none, and Pd coating stripes (35 mm wide ea.)
 - two motorized, encoded supports
 - dynamic, independent bending mechanism at both ends
 - aberration correction via elliptical bending

Experiment Stations

- 22-ID-A
 - white beam enclosure
- 22-ID-C
 - white beam optics enclosure
- 22-ID-D
 - monochromatic experiment station
 - kappa goniostat for macromolecular crystallography
 - adjustable collimator slits
 - filter/shutter
 - detector support and positioner

Detectors

- CCD area detector

Beamline Controls and Data Acquisition (to be defined)

- detector control and interface hardware and software to be defined
- beamline control and data acquisition software to be defined
- computers to be defined
- DC-servomotor; PMAC motor controller
- electrometer amplifiers; VME-based, computer-controlled V/F converter and scaler (ANL-ECT design)

Beamline Support Equipment/Facilities

- Rosenbaum-Rock miniaturized kappa goniostat
- high-magnification alignment cameras (two)
- Rosenbaum-Rock high-precision detector support and positioner
- liquid-nitrogen cryosystem sample cooler

Beamline contacts: Gerd Rosenbaum
John Gonczy

tel 630.252.0643
tel 630.252.0642

rosenbaum@anl.gov
gonczy@anl.gov

COM-CAT

Commercial CAT

Overview

The Commercial Beamline Collaborative Access Team (COM-CAT) will be specializing in the application of synchrotron radiation to industrial problems. COM-CAT plans to operate a general-purpose beamline as an analytical service laboratory, providing both materials analysis and data interpretation for problems that require synchrotron radiation techniques for their solution. Funds for beamline construction were provided by the State of Illinois. Beamline operations will ultimately be funded on a fee-for-service basis.

Research Focus

Analyses based on synchrotron radiation are generally applicable to problems in materials science. Industrial companies have used synchrotron facilities to examine a wide variety of materials, including polymers, catalysts, candidate drugs, and biomolecules. COM-CAT expects to provide a convenient means to use synchrotron analysis capabilities to industrial organizations who either do not have current access to a beamline or require rapid turnaround of samples.

COM-CAT will, in its initial stages, construct and operate a single undulator beamline. To provide as broad a range of analytical capabilities as possible, the experimental facilities will consist of three permanent stations devoted to spectroscopy, single-crystal diffraction, small-angle scattering, and x-ray fluorescence. Zone plates will be used when microfocusing is required. To maximize use of the available beam, each table will have a permanent basic configuration. To use a downstream station, the upstream tables will be lowered below the flight path of the x-ray beam.

COM-CAT is also involved in outreach to the general industrial community. It has organized a workshop on industrial applications of synchrotron radiation and will provide on-site introductions to synchrotron radiation for potential customers.

CAT contacts:	Kevin D'Amico, Director	tel 630.252.3959	damico@aps.anl.gov
	Stephen Wasserman, Deputy Dir.	tel 630.252.3527	srw@anl.gov
	Cindy Doran, Secretary	tel 630.252.5564	doran@aps.anl.gov

Beamline 32-ID / COM-CAT

Scientific focus: Materials characterization

Scientific programs: Analytical materials characterization and capability for commercial customers

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- L5-90 standard component primary aperture
- Kohzu HLD-3 monochromator
- horizontally focusing mirror
Pd, Pt coating stripes

Experiment Stations

- 32-ID-A
white beam first optics enclosure
- 32-ID-B
white beam station
monochromatic experiments
spectroscopy
scattering
crystallography

Detectors

- Lytle detector
- multi-element energy dispersive detector
- ionization chambers
- scintillation counters
- CCD area detector

Beamline Controls and Data Acquisition

- Linux PC running SPEC

Beamline Support Equipment/Facilities

- 6-circle diffractometer; spectroscopy instruments
- crystallography station

Beamline contacts: Kevin D'Amico
Stephen Wasserman

tel 630.252.3959
tel 630.252.3527

kdamico@aps.anl.gov
srw@anl.gov



A University-National Laboratory-Industry CAT

Overview

The UNI-CAT is a collaboration between scientists from the University of Illinois, the Oak Ridge National Laboratory, the National Institute of Standards and Technology, and UOP Research and Development. The UNI-CAT mission is to instrument and operate x-ray research facilities at the APS that provide advanced x-ray techniques to a diverse scientific community. This goal is achieved through the development of two sectors at the APS that are designed for cutting-edge x-ray studies in materials, physics, chemistry, biology, and geology. This is a multi-purpose scattering facility capable of high-resolution scattering with excellent energy resolution and beam-focusing optics. Special capabilities in the UNI-CAT sectors also include a dedicated surface/interface diffraction station equipped with a molecular-beam epitaxy and chemical-vapor deposition facility, an ultra-small-angle x-ray scattering apparatus, an x-ray microscope, a topography station, a dedicated insertion-device beamline for microfocus and coherent x-ray diffraction, instrumentation for time-resolved x-ray scattering experiments, and reactive environment x-ray absorption spectroscopy.

Research Focus

The primary research areas of UNI-CAT members encompass materials sciences and condensed matter physics, and include techniques such as structural crystallography, diffuse x-ray scattering, magnetic x-ray scattering, ultra-small-angle x-ray scattering, x-ray microscopy, millivolt resolution spectroscopy, surface and interface scattering, absorption spectroscopy, x-ray topography, microbeam techniques, coherent x-ray diffraction, and time-resolved techniques. These research tools permit UNI-CAT scientists and collaborators to explore fundamental structure/property relationships in bulk solids, at surfaces, and at internal interface boundaries.

CAT contacts:

Haydn Chen, Director
Paul Zschack, Associate Dir.

tel 217.244.4666
tel 630.252.0860

unicat@uimr17.mrl.uiuc.edu
zschack@anl.gov

Beamline 33-BM / UNI-CAT

Scientific focus: Materials science and condensed matter physics

Scientific programs: Materials Science, ceramic science, phase transitions, surface science, thin-film structure and growth, and materials physics

Bending Magnet Source Characteristics (nominal)

source	APS bending magnet
critical energy	19.51 keV
energy range	1.0 - 100.0 keV
on-axis peak brilliance at 16.3 keV	2.9×10^{15} ph/sec/mrad ² /mm ² /0.1%bw
on-axis peak angular flux at 16.3 keV	9.6×10^{13} ph/sec/mrad ² /0.1%bw
on-axis peak horizontal angular flux at 5.6 keV	1.6×10^8 ph/sec/mradh/0.1%bw
source size at critical energy \sum_x \sum_y	145 μ m 36 μ m
source divergence at critical energy $\sum_{x'}$ $\sum_{y'}$	6 mrad 47 μ rad

Optics & Optical Performance

- 4–40 keV energy range
- collimating mirror
- double-crystal monochromator
- focusing mirror

Experiment Stations

- 33-BM-B
EXAFS
topography station
- 33-BM-C
general purpose scattering station

Detectors

- NaI scintillation counters
- gas-filled proportional counters (Xe, Ar)
- ionization chambers

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME, SPEC

Beamline Support Equipment/Facilities

- topography station (33-BM-B)
- EXAFS table (33-BM-B)
- Huber 4-circle diffractometer (33-BM-C)

Beamline contact: Paul Zschack

tel 630.252.0860

zschack@anl.gov

Beamline 33-ID / UNI-CAT

Scientific focus: Material Science and condensed matter physics

Scientific programs: Material science, ceramic science, phase transitions, surface science, thin-films structure and growth, and materials physics

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV Σ_x Σ_y	359 μm 21 μm
source divergence at 8.0 keV $\Sigma_{x'}$ $\Sigma_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- focused beam size 280 μm hor. x 100 μm vert.
- PSL double-crystal monochromator
 - 45 m from source
 - 4.0–40.0 keV energy range Si(111)
 - 10^{-4} energy resolution (dE/E)
 - 20–35 mm beam offset
 - liquid-nitrogen cooling
 - variable sagittal focus
- vertical focusing mirror
 - 2.0–4.0 mrad angle of incidence
 - Pt, Si, Rh coating stripes
 - variable vertical focus
- harmonic rejection mirror
 - 2.0–4.0 mrad angle of incidence
 - Pt, Si, Rh coating stripes

Experiment Stations

- 33-ID-D
 - general purpose scattering
 - USAXS station
- 33-ID-E
 - surface and interface scattering station

Detectors

- NaI scintillation counters
- ionization chambers
- gas-filled proportional counters (Xe, Ar)

Beamline Controls and Data Acquisition

- Sun UNIX running EPICS with VME, SPEC

Beamline Support Equipment/Facilities

- Huber 4-circle diffractometer (33-ID-D)
- Newport 6-circle goniometer w/ kappa geometry (33-ID-D)
- USAXS (33-ID-D)
- UHV surface/interface scattering chamber (33-ID-E)

Beamline contact: Paul Zschack

tel 630.252.0860

zschack@anl.gov

Beamline 34-ID / UNI-CAT

Scientific focus: Microfocussing and coherent x-ray scattering

Scientific programs: Coherent x-ray diffraction, microbeam scattering, and x-ray microprobe

Insertion Device Source Characteristics (nominal)

source	Undulator A
period	3.30 cm
length	2.47 m
effective K_{\max} (at minimum gap = 10.5 mm)	2.78
energy range 1st harmonic	2.9 - 13.0 keV
energy range 1st - 5th harmonics	2.9 - 45.0 keV
on-axis peak brilliance at 6.5 keV	9.6×10^{18} ph/sec/mrad ² /mm ² /0.1% bw
source size at 8.0 keV \sum_x \sum_y	359 μm 21 μm
source divergence at 8.0 keV $\sum_{x'}$ $\sum_{y'}$	24 μrad 6.9 μrad

Optics & Optical Performance

- beamline under design
- beam-splitting mirrors
- monochromators

Experiment Stations

- 34-ID-C
coherent beam diffraction station
- 34-ID-E
microbeam scattering station

Detectors

- various CCD cameras
- NaI scintillation counters

Beamline Controls and Data Acquisition

- To be determined

Beamline Support Equipment/Facilities

- Kappa diffractometer with surface science capability (34-ID-C)
- microbeam scattering table (34-ID-E)

Beamline contacts: Paul Zschack
Ian Robinson
Gene Ice

tel 630.252.0860
tel 217.244.2949
tel 423.574.2744

zschack@anl.gov
robinson@uimrl7.mrl.uiuc.edu
icege@ornl.gov

Directory

		BUILDING	SECTOR(S)	PHONE	FAX	E-MAIL
APS User Office		401	n/a	630.252.9090	630.252.9250	apsuser@aps.anl.gov
BESSRC-CAT	Basic Energy Sciences Synchrotron Radiation Center	433	11, 12	630.252.1553	630.252.0365	cowan@anl.gov
Bio-CAT	Biophysics	435	18	630.252.0549	630.252.0545	krolik@bio.aps.anl.gov
CARS-CAT	Consortium for Advanced Radiation Sources GeoSoilEnviroCARS BioCARS ChemMatCARS	434	13, 14, 15	630.252.0450	630.252.0443	franklin@cars.uchicago.edu
CMC-CAT	Complex Materials Consortium	433	9	630.252.0320	630.252.0339	gog@anl.gov
COM-CAT	Commercial	438	32	630.252.5564	630.252.3222	doran@aps.anl.gov
DND-CAT	DuPont–Northwestern–Dow	432	5	630.252.0222	630.252.0226	jhopf@nwu.edu
HP-CAT	High-Pressure	434	16 (under devel.)	630.252.0427	630.252.0443	daniel.hausermann@anl.gov
IMCA-CAT	Industrial Macromolecular Crystallography Association	435	17	630.252.0520	630.252.0521	vbrown@sparky.csrii.iit.edu
IMM-CAT	IBM–MIT–McGill	432	8	630.252.0281	630.252.0282	larry@lindy.mit.edu
MHATT-CAT	Center for Real-Time X-ray Studies	432	7	630.252.0209	630.252.0279	williams@mail.mhattcat.howard.edu
MR-CAT	Materials Research	433	10	219.631.7219	219.631.5952	bunker@nd.edu
mCAT	Midwest Universities	432	6	630.252.0247	630.252.0240	drobinsn@iastate.edu
PNC-CAT	Pacific Northwest Consortium	435	20	630.252.9795	630.252.0580	heald@aps.anl.gov
SBC-CAT	Structural Biology Center	435	19	630.252.0560	630.252.0564	cmzimmer@anl.gov
SER-CAT	Southeast Regional	363A	22 (under devel.)	630.252.0640	630.252.0641	junik@anl.gov
SRI-CAT	Synchrotron Radiation Instrumentation	431	1, 2, 3, 4	630.252.0160	630.252.0161	ljs@aps.anl.gov
UNI-CAT	A University–National Laboratory–Industry	438	33, 34	630.252.0860	630.252.0862	zschack@anl.gov

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(where XX is the sector number)