Construction of Bending Magnet Beamline at the APS for Environmental Studies

Poster presented at the EMSP Workshop, July 27-30, 1998

EMSP project 54800

Pacific Northwest Consortium- Collaborative Access Team

(PNC-CAT)

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Project Summary

The goal of this project is to construct a bending magnet based synchrotron radiation beamline at the Advanced Photon Source. It will join an undulator based beamline which is currently in the late stages of commissioning, and together they will provide a powerful facility for synchrotron research in environmental problems. The project term is approximately half complete, and substantial progress has been made. The beamline design is complete, and many components have been ordered or are under construction. Since the start of the project, additional funding has been secured from DOE-BES which has allowed us to expand the original scope of the beamline. It will now include a fully equipped second experimental enclosure and additional focusing optics to improve performance. The rest of this presentation describes in detail the design, construction status, and expected capabilities of the bending magnet beamline.

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PNC-CAT

The Pacific Northwest Consortium Collaborative Access Team (PNC-CAT) was formed to develop a sector at the Advanced Photon Source (APS) at Argonne National Laboratory. The lead institutions and spokespersons are:

University of Washington	Prof. Edward Stern
Pacific Northwest National Laboratory	Dr. Steve Heald
Simon Fraser University	Prof. Daryl Crozier

In addition to this EMSP project, the PNC-CAT has received funding from DOE-BES, NSF, and NSERC in Canada. We also acknowledge generous support from our member institutions.

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Project Status and Schedule

- Design complete
- First optics enclosure (FOE) and Experimental enclosure complete
- Beamline utilities installed
- Radiation validation of FOE complete
- Most major beamline components under construction
- Mono. beam in FOE planned for early 1999
- Beam in experimental enclosure in late 1999
- Final focusing optics installed in early 2000 (funded by BES)

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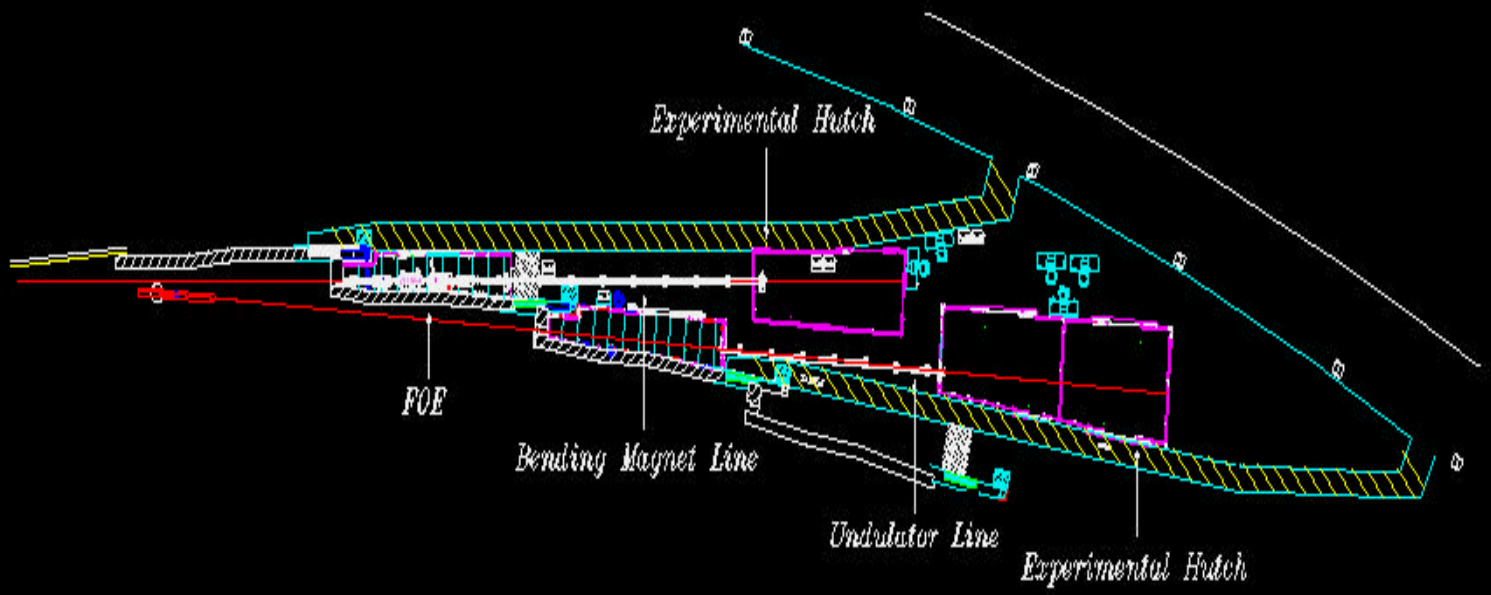
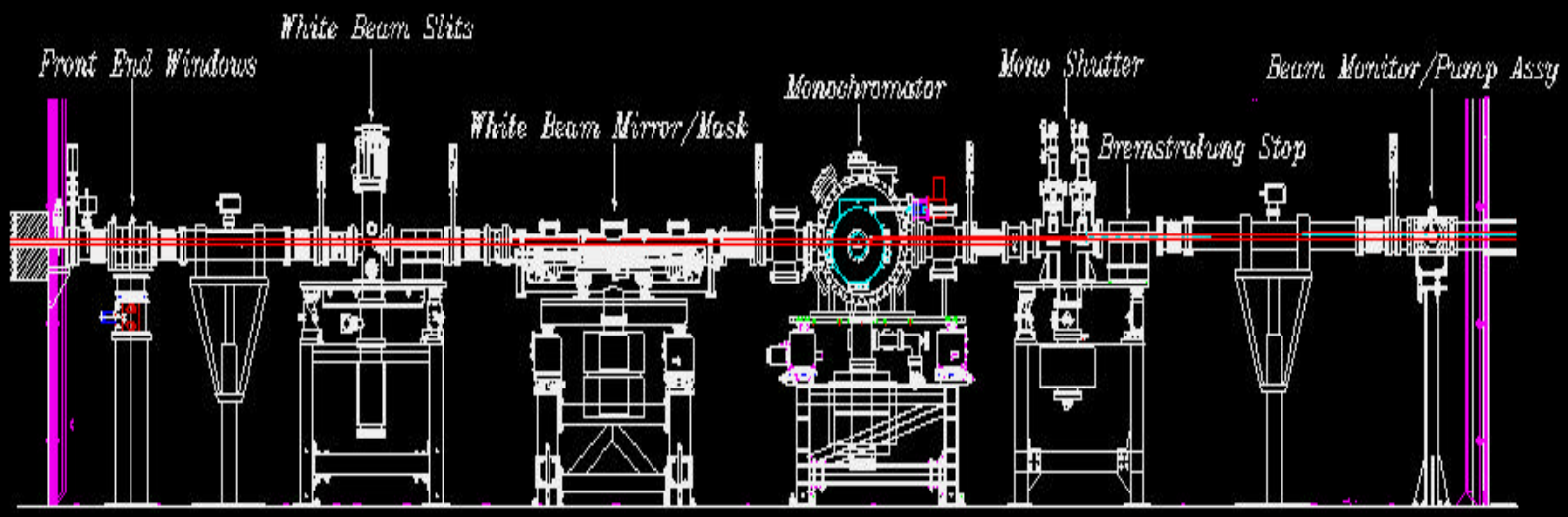
PNC-CAT Beamlines



FOE Components for Bending Magnet Line



Monochromator

This is the most important beamline component. We are using a copy of the monochromator that we have already tested on our undulator beamline. It is based on a design by the BESSRC-CAT. Some important parameters:

- Water cooled first crystal
- Fixed output beam
- Energy range: 2.3-27 keV (Si 111)
5-50 (Si 311)
- Sagittal focusing up to 4 mrad of beam

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Collimating/focusing pre-mirror

The pre-mirror will be used to collimate or focus the vertical fan of radiation from the source. In the collimation mode it will allow us to collect nearly the full vertical spread of radiation while maintaining good energy resolution. For experiments less sensitive to energy resolution, it can be bent to focus the beam at the sample position to sub-millimeter dimensions. The mirror will operate up to about 30 keV. For higher energy operation it can be dropped out of the beam.

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Beamline transport

The beamline transport components are based on APS designs, and include white beam slits, and beam stops and shutters. The white beam slits are a modified version of the APS filter chamber, and will contain a fixed set of vertical and horizontal apertures. The shutter and beam stop have special modifications to allow passage of both the premirror deflected beam and undeflected beam without the need to move beamline components. Both of these components are substantially complete.

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Expected Beamline Performance

Beamline performance for various configurations. The monochromator is assumed to be set at 10 keV with Si 111 crystals. The optical surface of the pre-mirror is taken as 100 X 1000 mm. The flux density is determined by averaging over a 0.5 mm diameter aperture at the focus.

White beam slit	Pre-mirror	Sagittal focus	Total flux (ph/sec)	Flux density (ph/sec/ mm^2)
1 x 10 mm	out	no	**2×10^{11}**	**4×10^{9}**
1 x 95	out	yes	**2×10^{12}**	**4×10^{11}**
3 x 95	collimating	yes	**5×10^{12}**	**8×10^{11}**
3 x 95	focusing	yes	**5×10^{12}**	**3×10^{12}**

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Experimental Capabilities

The bending magnet beamline will share instruments with the undulator lines. Many have reached the commissioning stage, and are described below along with some initial results. They include:

- Microfocusing optics
- Fluorescence detectors
- Diffraction/DAFS capabilities
- UHV/MBE and surface science capabilities

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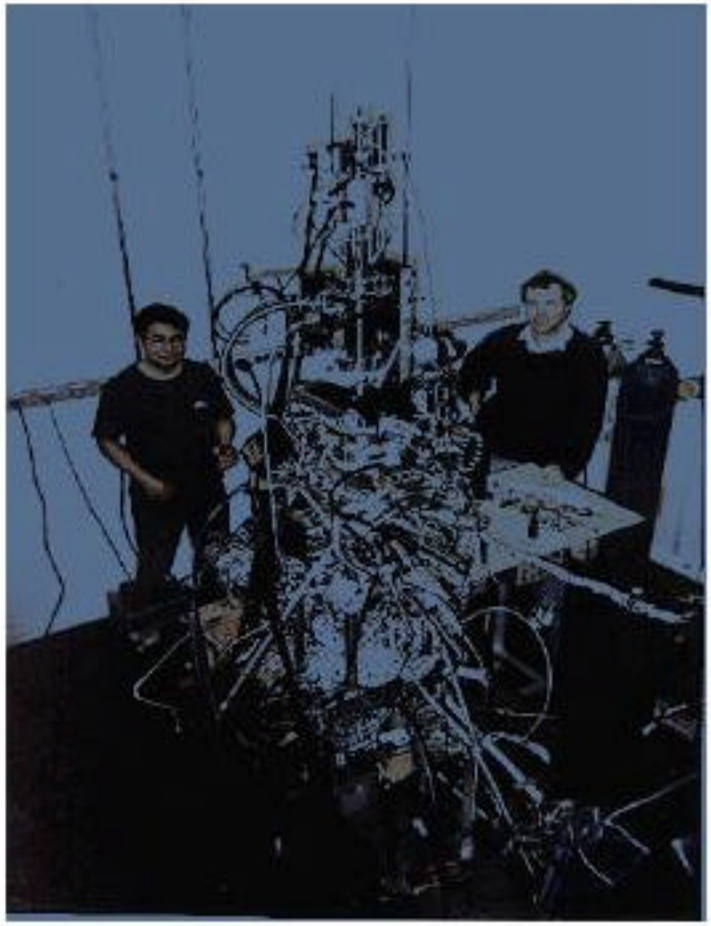
UHV MBE system under construction



Capabilities: *in situ* Glancing-angle XAFS (both E polarization), XSW, reflectivity; MBE, RHEED

Fluorescence Detectors

Fluorescence detection is often needed for studying dilute environmental samples. We have recently received a 13-element Ge detector from PGT, with electronics from XIA. The electronics will have special software to allow the detector to support multielement imaging as well as fluorescence XAFS. We also have under development a Rowland circle based high resolution fluorescence detector.

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Microfocusing Optics

X-ray microbeams are expected to play an important role in environmental studies. Three types of microfocusing optics are under development for the Undulator line, all of which are capable of sub-micron performance. They are tapered capillary x-ray concentrators, Kirkpatrick-Baez mirrors, and zone plates. These will also be available for use on the bending magnet line. Although the bending magnet brilliance is significantly less, the optics should still provide very useful microbeams. Some test images obtained with the tapered capillaries are given here. Some photos of the apparatus can be found here.

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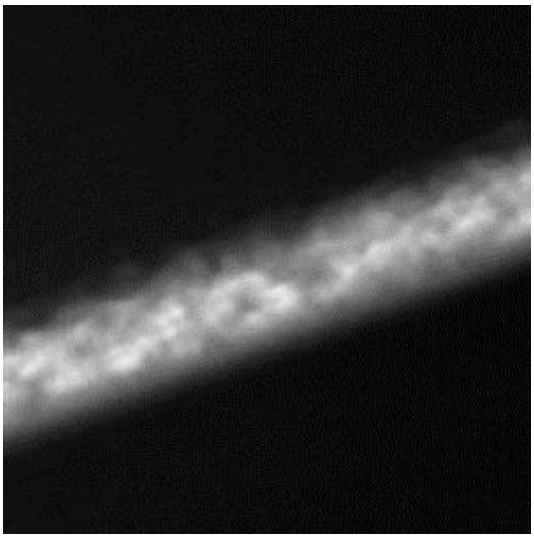
Some APS images using tapered capillary optics

Cu grid, 100x100 µm, 0.5 µm beam

Seashell growth band, 250x250 µm

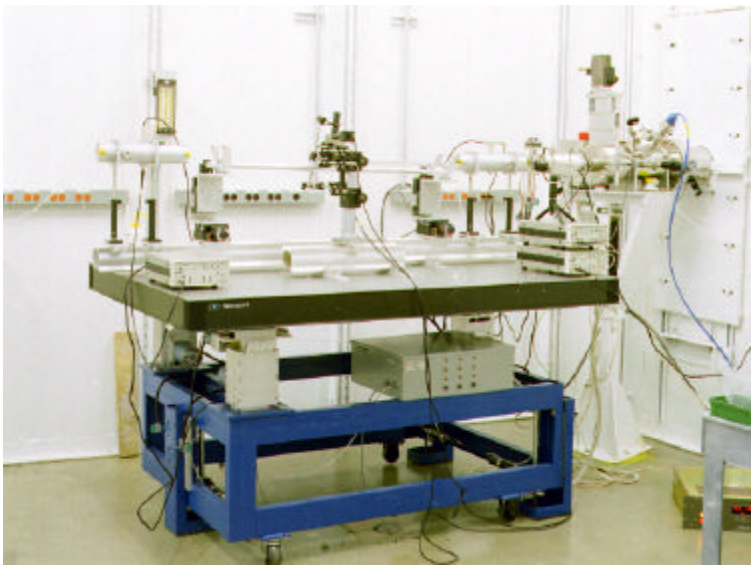
2.5 µm beam



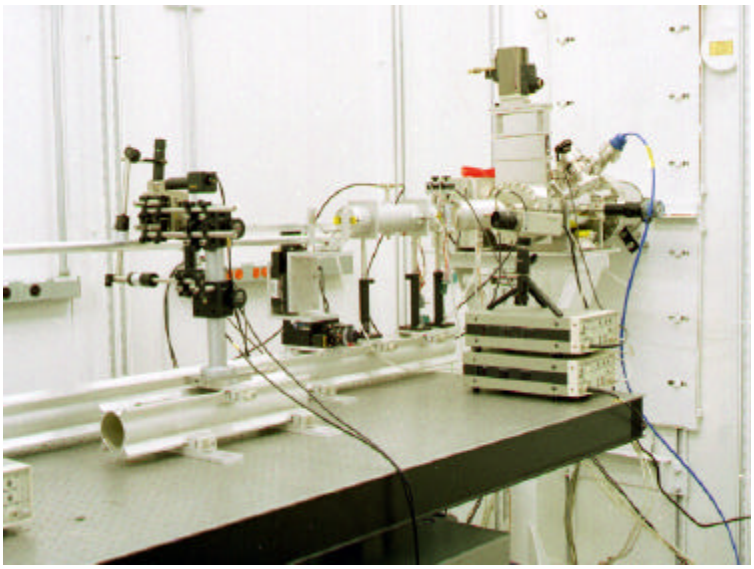
Ni test mask, 25 µm hole, 2.5 µm beam

Some photos of the tapered capillary microprobe set up on the undulator beamline. A very similar setup will be available on the bending magnet line.

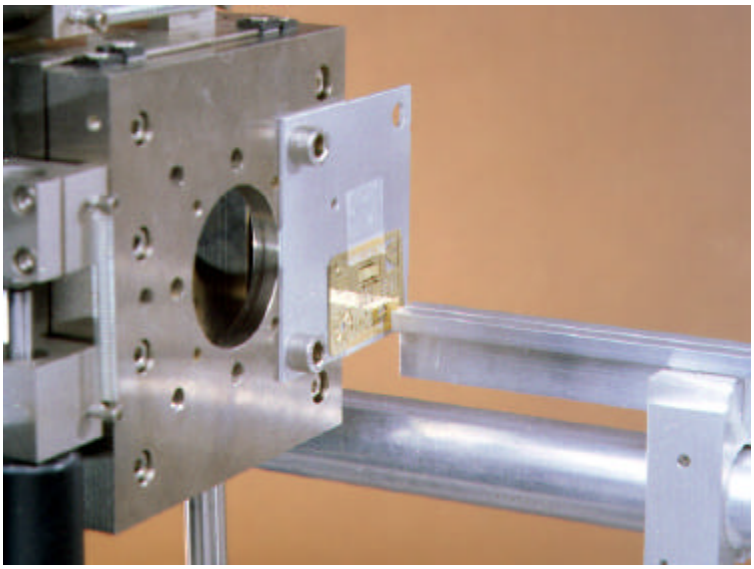
Overall view showing support table, detectors and capillary alignment rail



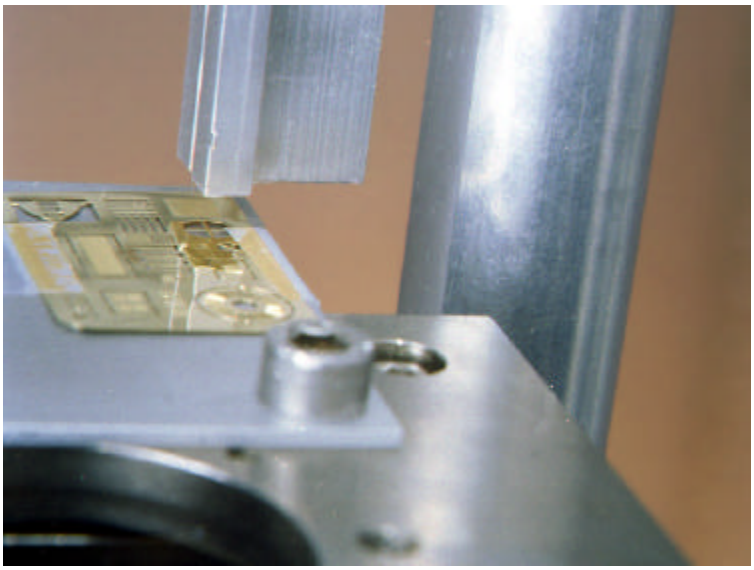
Closer view of table and alignment rail



Scanning stage with test target mounted near capillary end



Close up of capillary tip and test target



EXAFS and micro-EXAFS

It is expected that various forms of EXAFS spectroscopies will the dominant techniques applied to environmental problems on the bending magnet beamline. The monochromator and experimental equipment is being designed with this in mind. Here is an example of micro-EXAFS taken on a bending magnet beamline at the NSLS using a tapered capillary. Some photos of the apparatus can be found here. The APS line should have significantly better performance.

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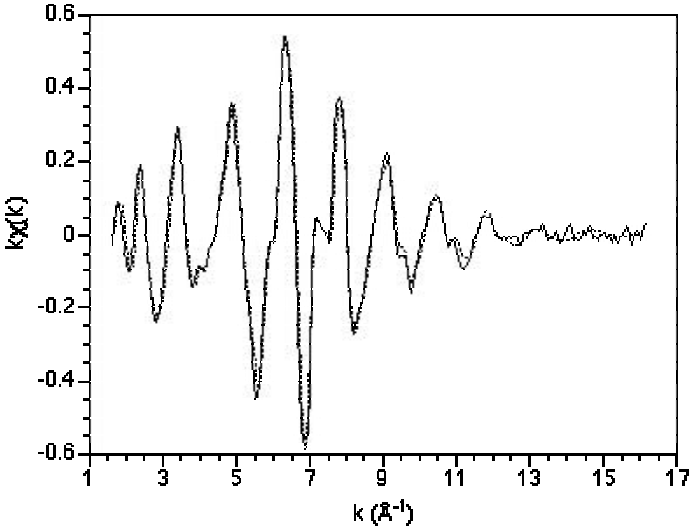
Comparison of bulk Cu XAFS (dotted line) with Cu microXAFS (solid line) taken at 2.7 micron resolution



Diffraction and DAFS

A small 4-circle diffractometer will be available for diffraction and DAFS experiments. This will complement a much larger 8 circle diffractometer permanently mounted on the undulator line. It is expected that simpler experiments will be carried out on the bending magnet line. The undulator line can be used for experiments requiring the ultimate in sensitivity. The diffractometers can be combined with micro-focusing optics to carry out micro-diffraction experiments.

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