SSRL Scattering Beam Lines

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Beam Line Operations

- Storage Ring and Beam Lines Overview
- Beam Line Optical Elements
- Beam Characteristics and Quality
- Resources and Acknowledgements
Generic Synchrotron Components

- photon beam line
- e-beam focusing elements
- bending
- vacuum chamber
- injection system
- rf-cavity
- e-
- Insertion device beam line
Typical Beam Line Optical Concept

your sample

monochromator
- double crystal
- Si(111) or Si(220)
- LN or water cooled

monochromator entrance slits
variable vertical aperture defines mono acceptance.

mirror
- cylindrical/toroidal figure for collimating /focusing
- Rhodium-coated silicon
- harmonic rejection, power filter.

mirror slits
variable gap defines BL acceptance.

beam

source

~12 meters

~12 meters
**SSRL Scattering Beam Line Sources**

**Two Types: Bend Magnets & Wigglers**

- Continuous spectrum with half-power point “critical energy” $\varepsilon_c(\text{keV}) = 0.665B(T)E^2(\text{GeV})$
- 250 microradian vertical divergence at critical energy but broad horizontal fan.

**Bend Magnets:** BL1-5 and BL2-1 (50 Watts/350mA/horizontal milliradian, $\varepsilon_c = 7.8$ keV.)

**Wigglers:** 7-2 (19 poles, 1.7 kW, 11.6 keV), 10-2 (30 poles 1.9 kW, 7.6 keV), 11-3 (2.1 kW, 11.7 keV)
BL7-2 Source Spectra
Beam Line Optical Elements

- Focusing and Collimating Mirrors
- Monochromators
- Apertures
- Filters
Mirrors

**BL7-2:** 1.2 m long, central 0.8 m with cooling and vertical focusing/collimating optical figure

**BL10-2:** 1.2 m, vertically and horizontally focusing cylindrical mirror
Mirrors Reflectivity vs. Angle

Rh coated mirror surface

Reflectivity vs. Energy (keV)

- 6.8 mrad
- 4.0 mrad
- 2.7 mrad

Adjustable low-pass filter for harmonic rejection.
Select a narrow energy band pass from the broad spectrum synchrotron source; typical crystal mono energy resolution ~1e-4 (or better)

above left - LN mono crystal mount plate
above right – side scattering mono
lower right – LN mono first crystal with cooling channel bundle
employ higher index monochromator crystal (e.g., Si(111) >> Si(220))

use a collimating mirror upstream of monochromator to reduce vertical angular spread (BL7-2 M0 mirror can be used to collimate the beam at the expense of vertical spot size)

reduce horizontal angular acceptance if monochromator is preceded by toroidal focusing mirror (BL2-1, BL10-2)

reduce monochromator vertical angular acceptance with monochromator entrance slits.
Beam Characteristics/Quality

Beam Characteristics:

- Intensity
- Position, Size and shape
- Monochromaticity: energy resolution and harmonic rejection

**Beam Quality = Stability** in the above three characteristics
**Beam Stabilizing Efforts**

- Mirror Pitch Feedback
- Mirror Coolant (LCW) Temperature Stabilization
- SPEAR3 Tunnel Temperature Stability
Mirror Pitch Feedback at SSRL

Concept

Compensates for floor and beam line support frame motion

- Error signal obtained from position sensitive detector located near beam focus
- Error signal used to control piezo high voltage via PI feedback algorithm
- Piezo provides mirror fine pointing control with typical full range of motion +/-~30urad
Mirror Coolant (LCW) Temperature Stabilization

Last time: “0.6 degree C temperature change in mirror cooling water is enough to degrade image quality. Feed back system holds to +/- 0.1 degrees C”

1. Coolant exterior piping insulation.
2. BL local heater feedback.
3. 20-gallon mixing tanks.
Cooling water exterior piping insulation reduced the effect of outdoor temperature on mirror cooling temperature by 50%. The data scatter reduction in second plot can be interpreted as the effect of the shading from direct sun, wind and rain provide by insulation. With optics sensitive to <0.05 °C variation in cooling water temperature, the addition of the insulation results in improved focused x-ray beam stability.
Mirror Coolant Temperature Variations Drive Mirror Focusing Instabilities

Beam Line 2-1
m0 Mirror LCW Temp and MPF Control Voltage

Correlation coefficient = 0.89

Beam Line 2-1
m0 Mirror LCW Temp vs. MPF Control Voltage

0.44 MPF control volts/0.1 °C

Correspondingly:
2.8 μradians 2-theta pointing correction/0.1 °C mirror LCW or
36 μ corrected vertical beam motion at sample/0.1 °C mirror LCW

y = -4.37x + 166.6
R² = 0.94
Scattering Beam Line Engineers

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