Sources and Optics for XAS

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Stanford Synchrotron Radiation Laboratory

X-ray absorption Spectroscopy

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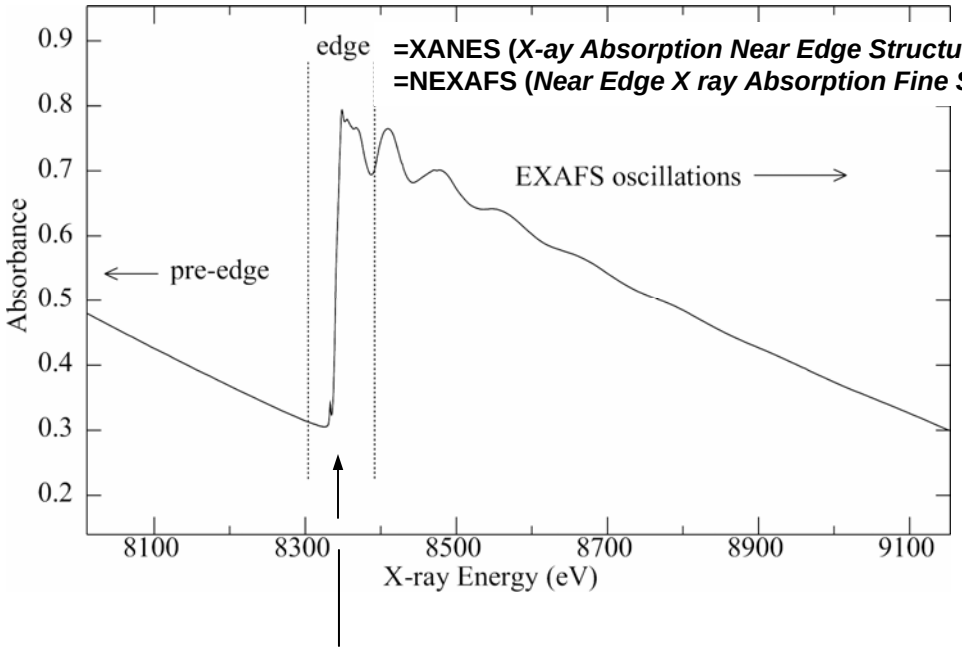
Basic Experiment :



(EXAFS = *Extended X ray Absorption Fine Structure*)

Xanes

EXAFS

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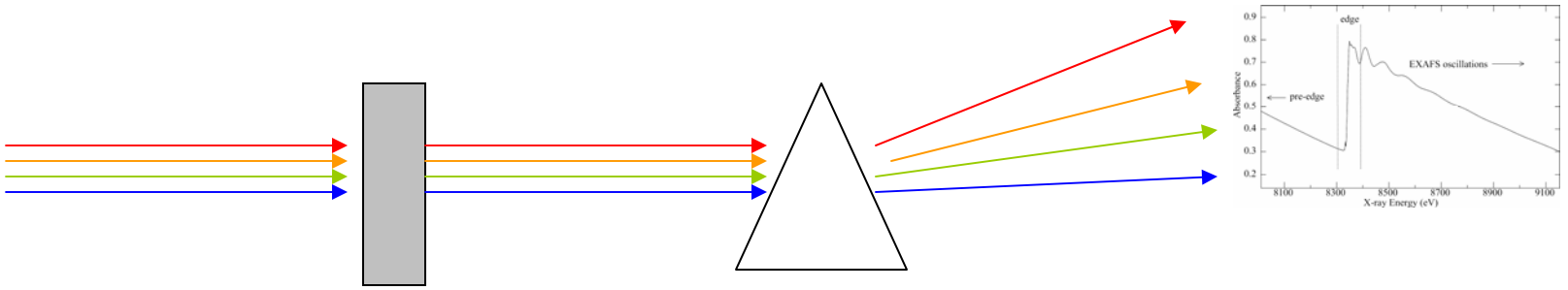
Two ways of collecting data

White Beam Energy Dispersive



Spectrum in Single Shot

Optics and Detector are not Available

LCLS/fast changes

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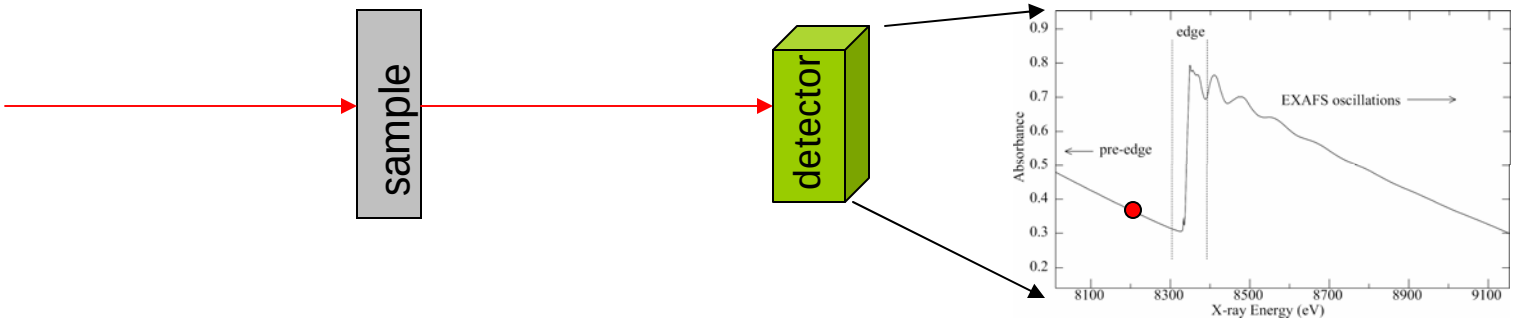
Two ways of collecting data

Monochromatic "Scanning" Measurement



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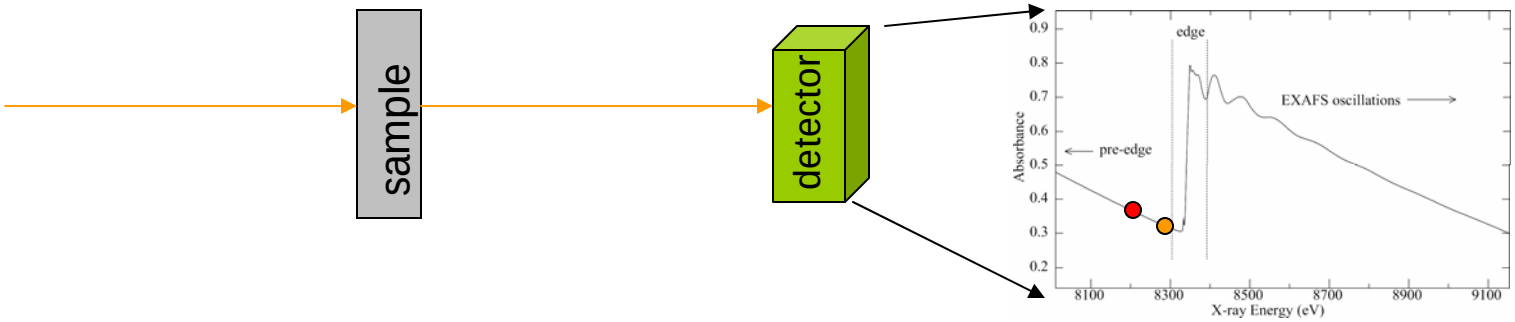
Two ways of collecting data

Monochromatic "Scanning" Measurement



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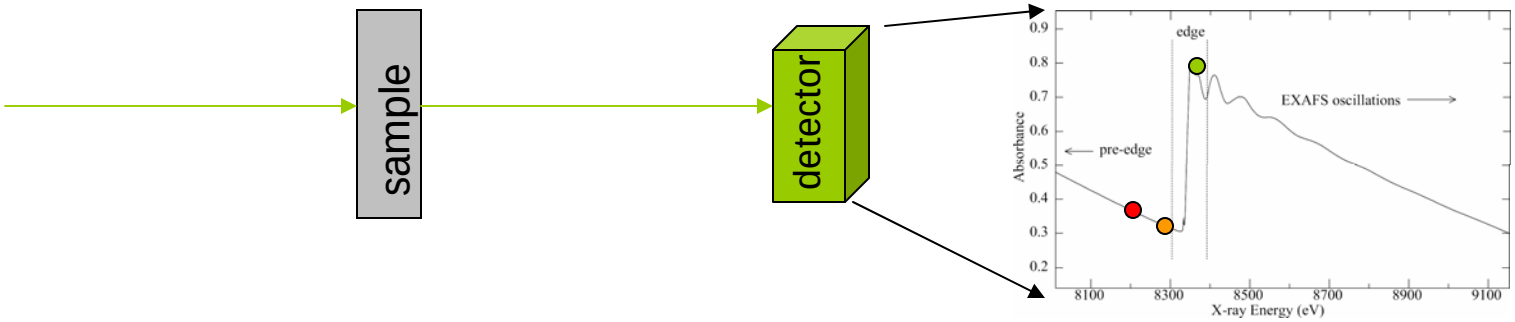
Two ways of collecting data

Monochromatic "Scanning" Measurement



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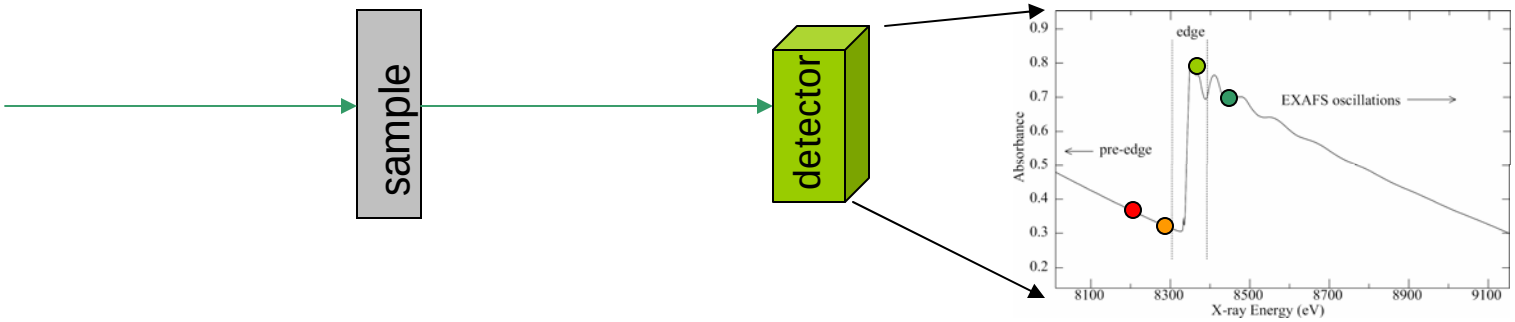
Two ways of collecting data

Monochromatic "Scanning" Measurement



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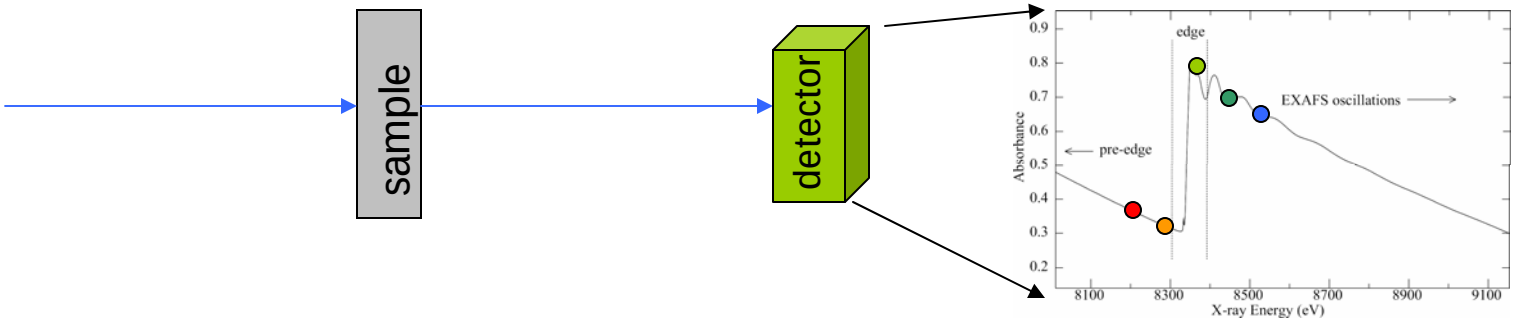
Two ways of collecting data

Monochromatic "Scanning" Measurement



Slow but doable

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Outline

- Sources
  - Wiggler vs. Undulator
- Slits
- Monochromator
  - Energy Resolution
  - “Glitches”
  - Harmonic rejection
- Mirrors
  - High Flux Density
- XAS BL Layout

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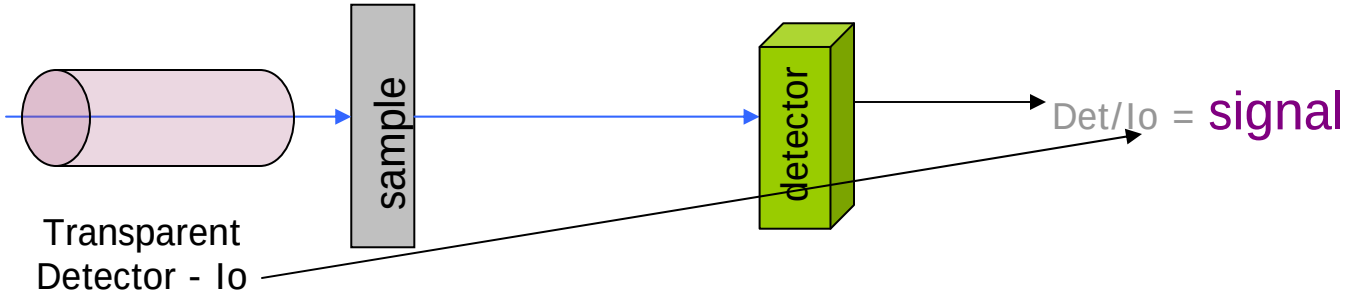
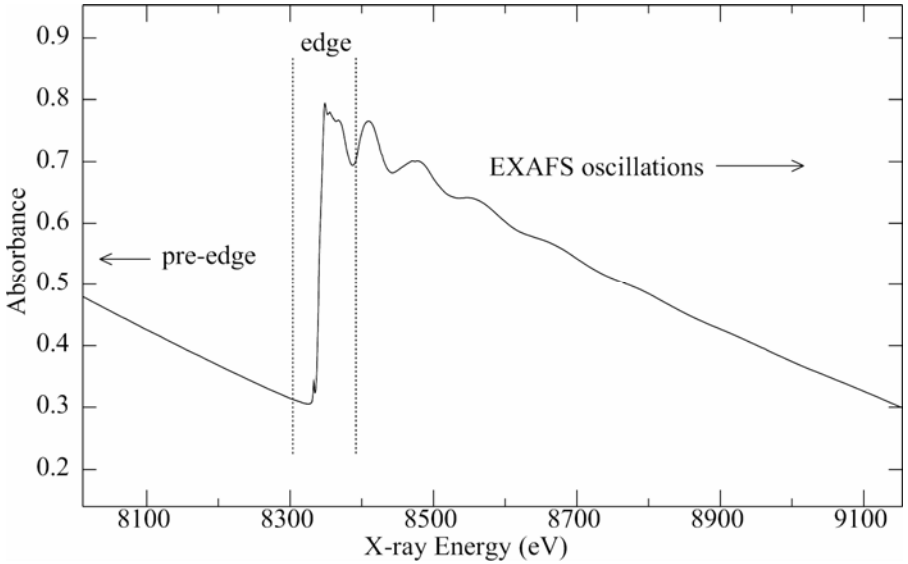
Measurement Requirements



Xanes

Energy Resolution



EXAFS

Very Robust Normalization

Homogeneous Beam

Very High Signal to Noise

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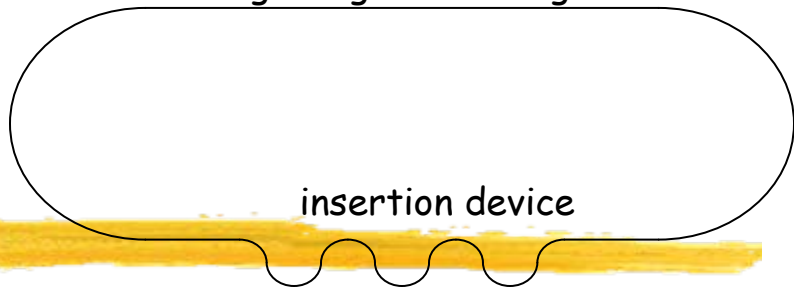
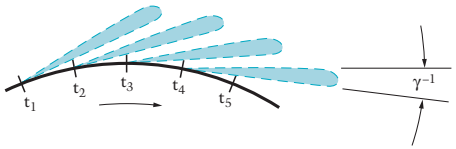
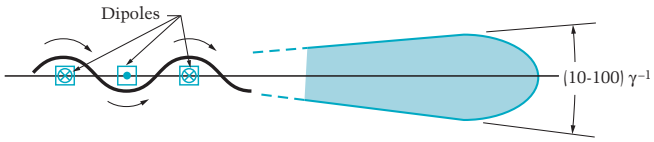
Sources





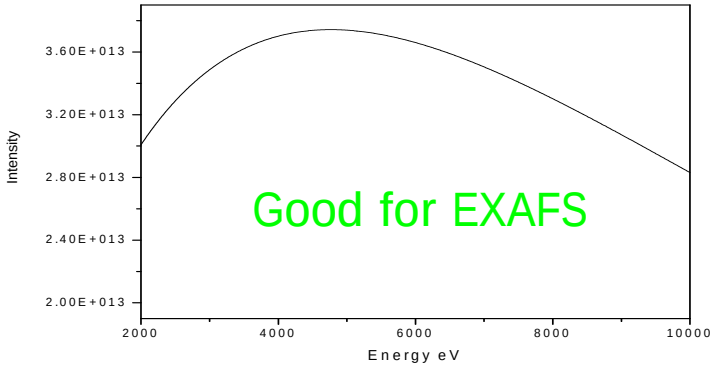
bending magnet - a “sweeping searchlight”



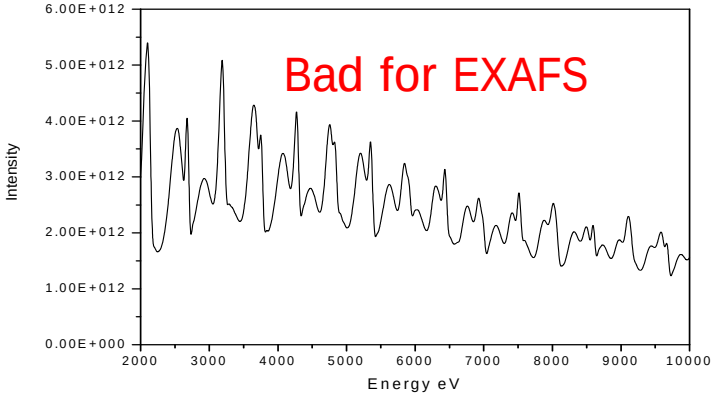
wiggler - incoherent superposition

undulator - coherent interference

Bend magnets and Wigglers



Undulators



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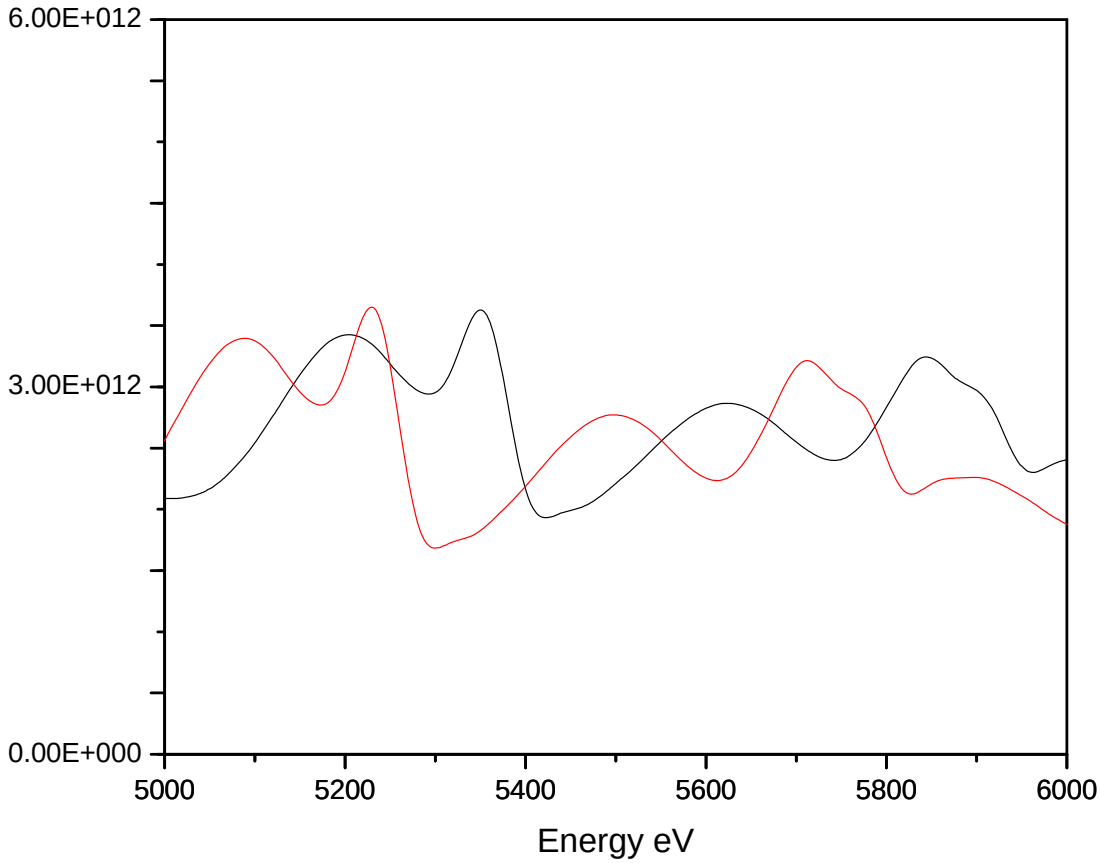
How to Use an Undulator

Changing the Undulator K – Scanning the Gap



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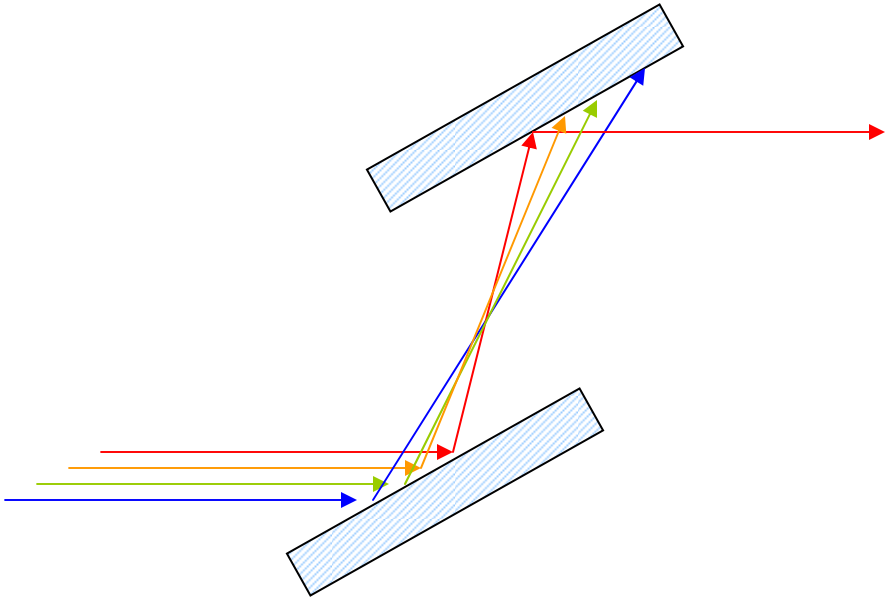
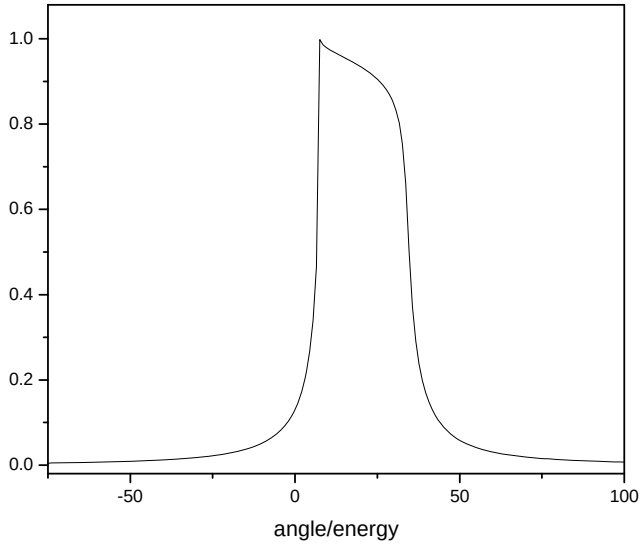
Double Crystal Monochromator





Bragg's Law:

Not Right!

$2d\sin(\theta) = h/E$

Double Crystal Monochromator

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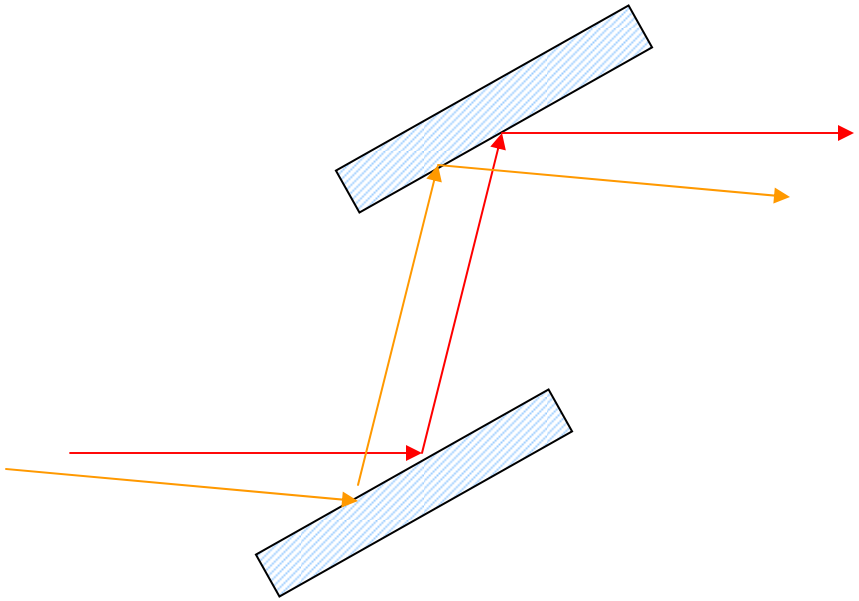
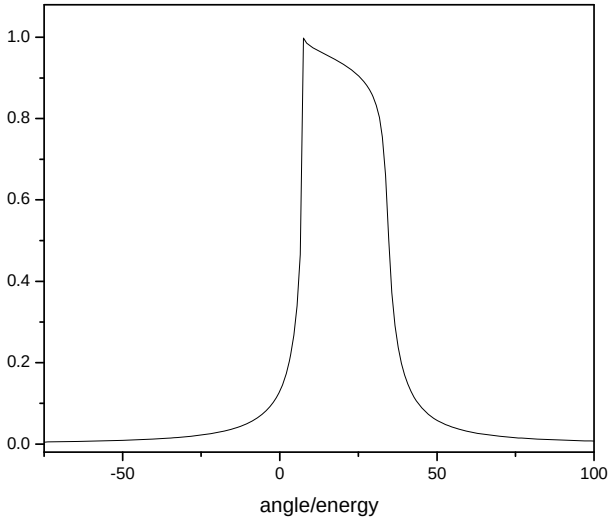
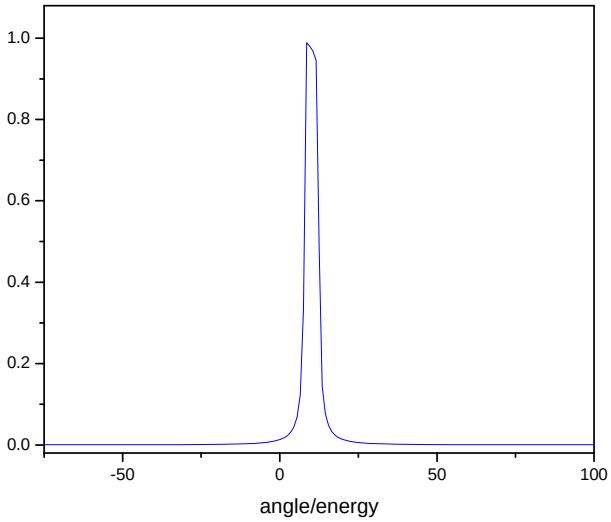
Increasing Energy Resolution







Use Higher Order Reflection

Double Crystal Monochromator

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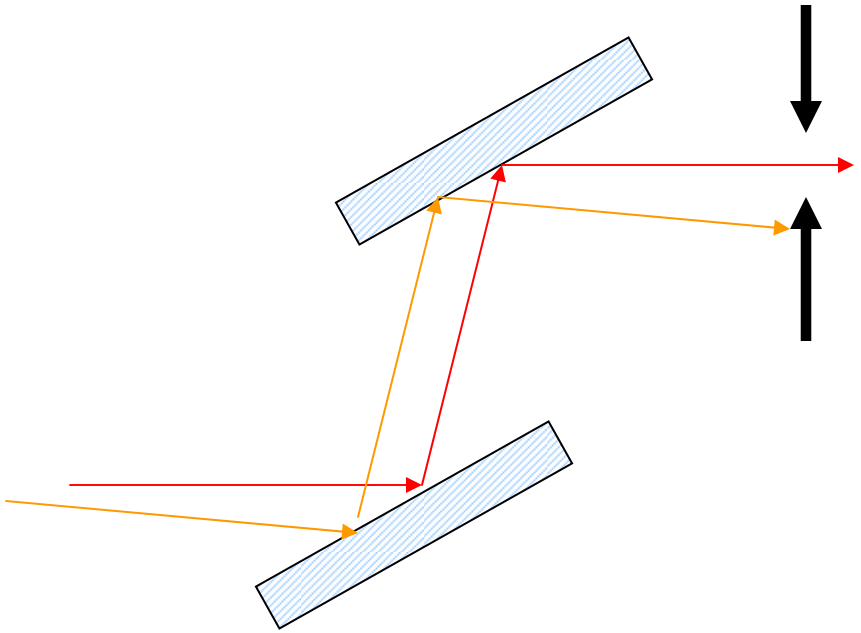
Increasing Energy Resolution



Use Narrower Io Slits

Double Crystal Monochromator

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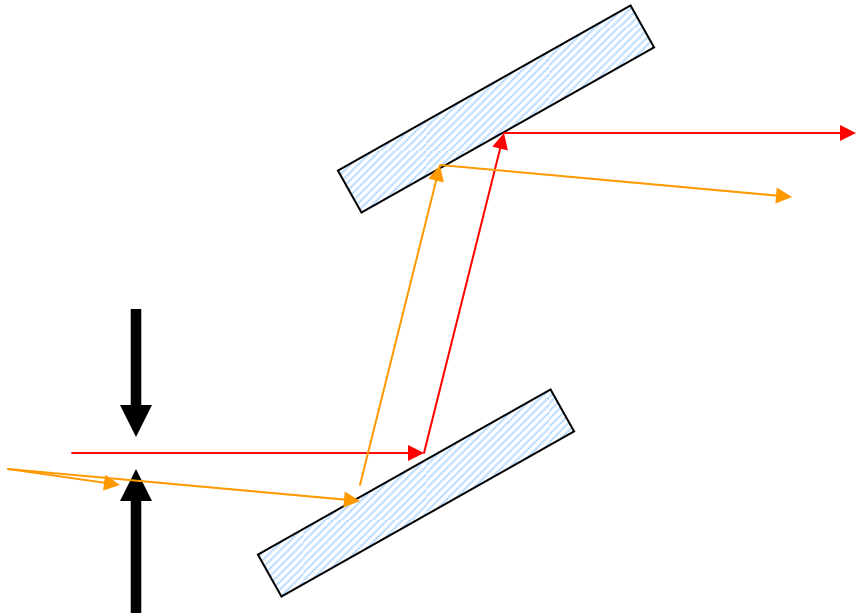
Increasing Energy Resolution



Use Narrower Mono Slits

Double Crystal Monochromator

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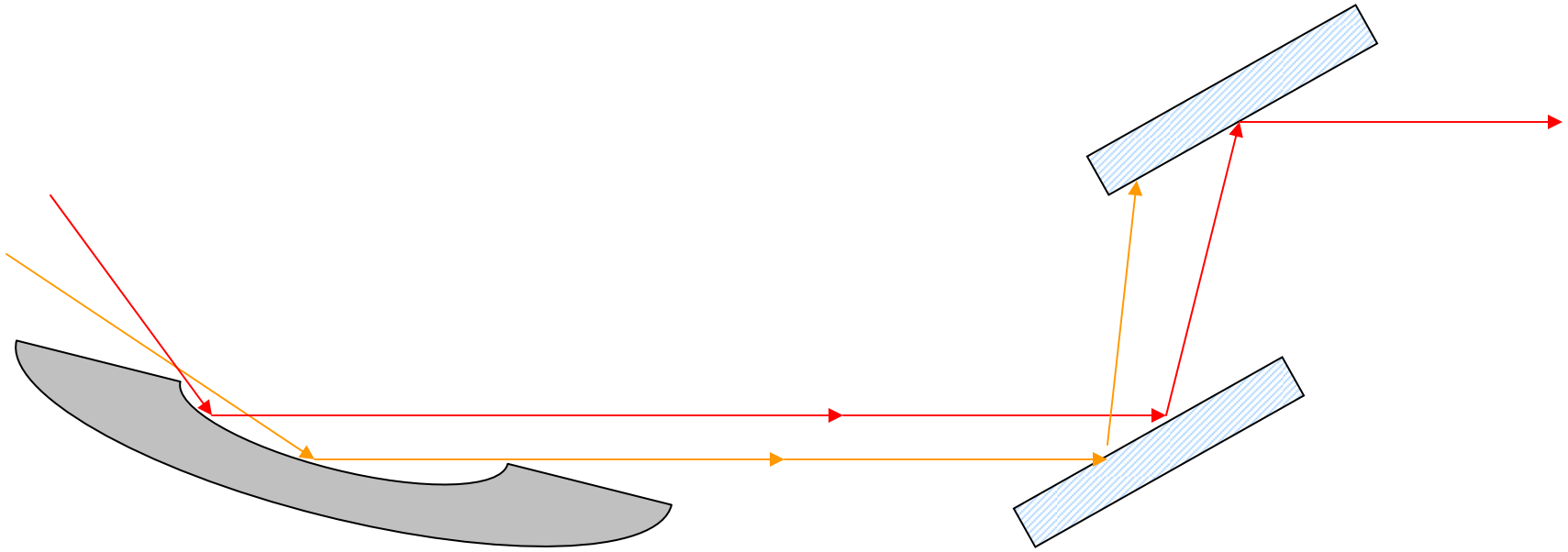
Increasing Energy Resolution



Use Collimated Beam

Double Crystal Monochromator

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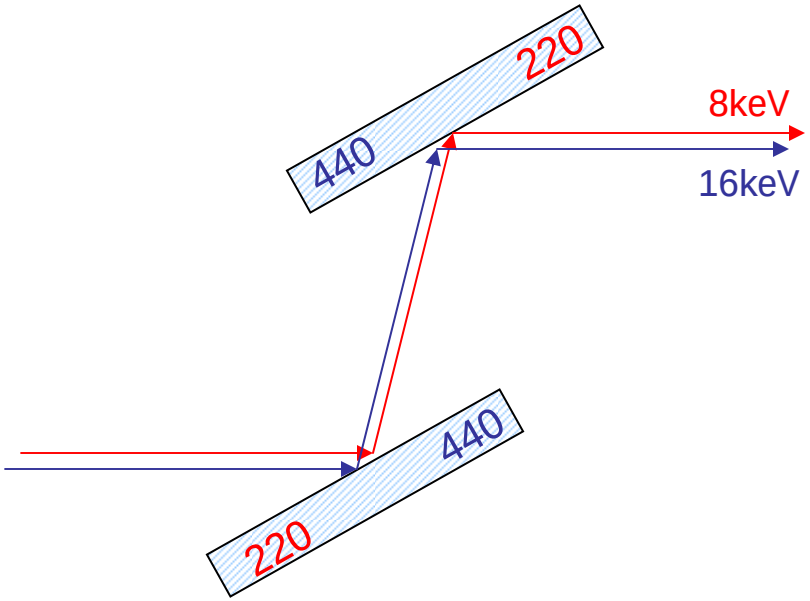
Harmonics Rejection



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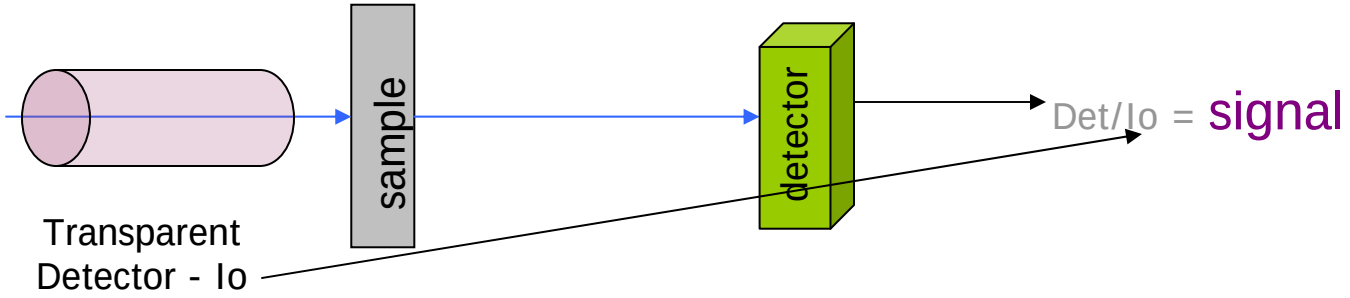
Why Harmonics are a Problem



$$\text{Required Measurement} = \frac{Det_F}{Io_F}$$

$$\text{Actual Measurement} = \frac{Det_F + Det_H}{Io_F + Io_H}$$

Double Crystal Monochromator

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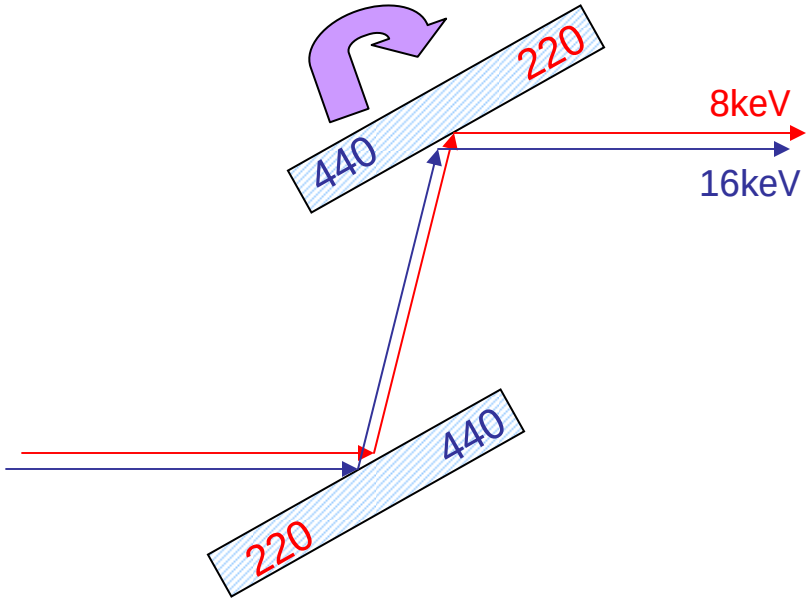
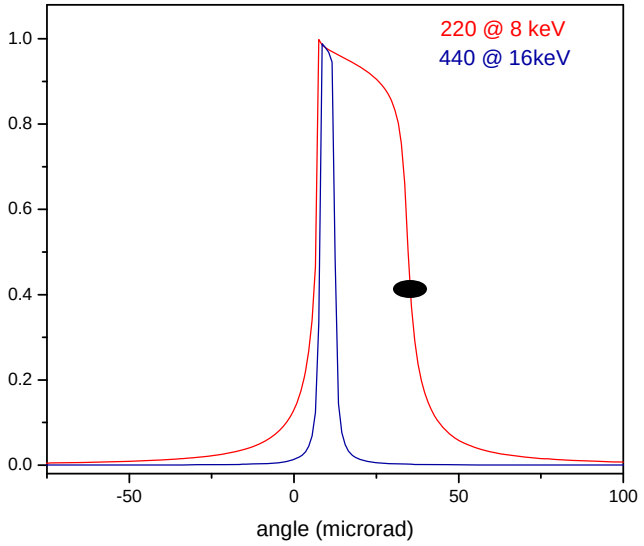
Harmonics Rejection





detuning

Double Crystal Monochromator

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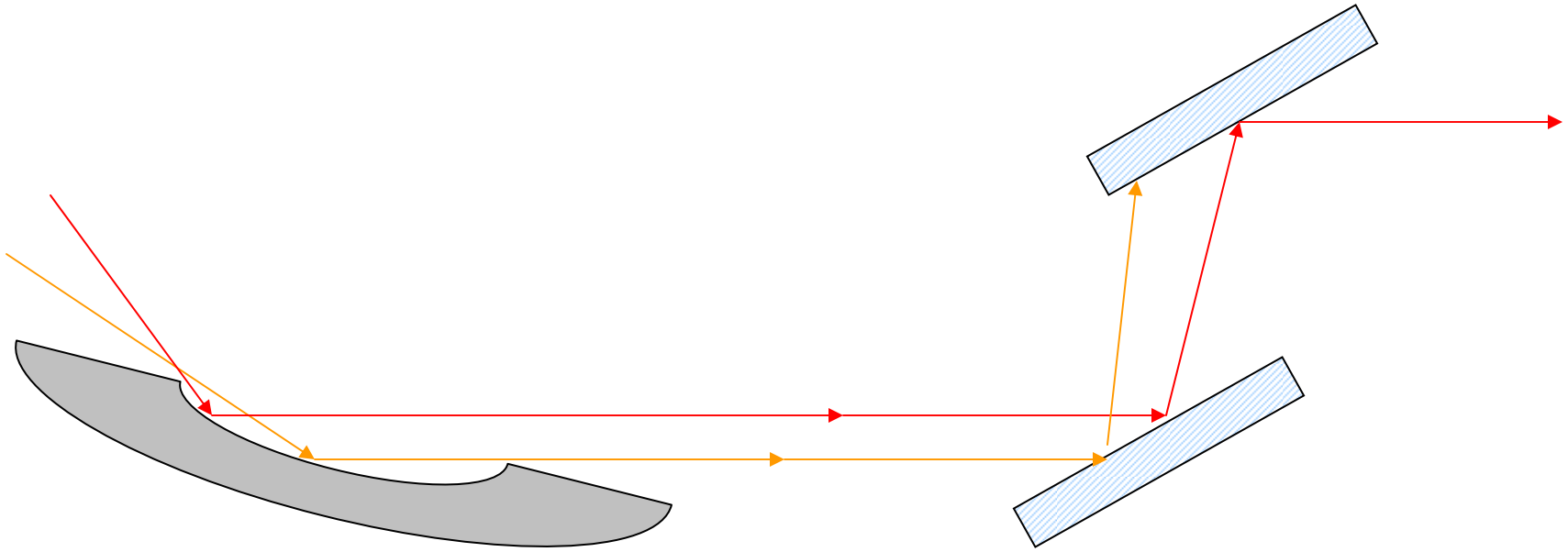
Collimating mirror for Harmonic Rejection



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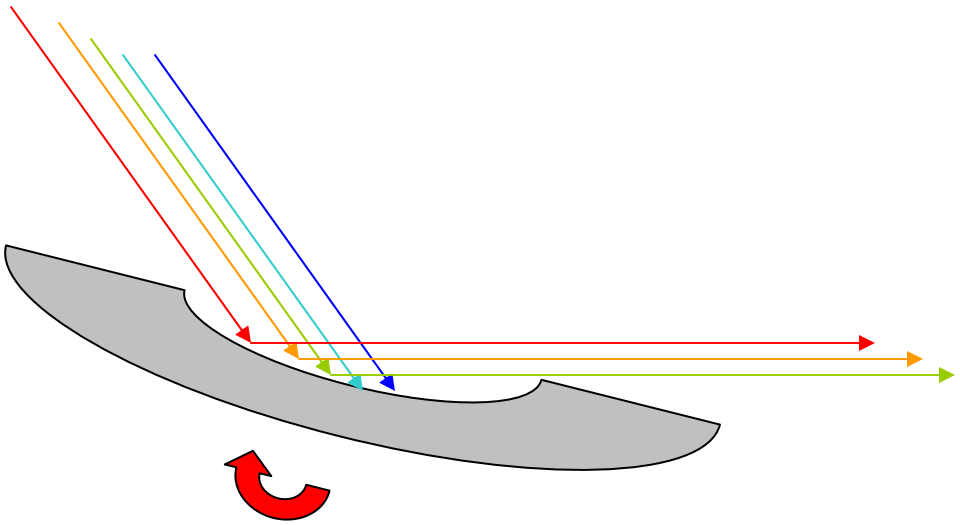
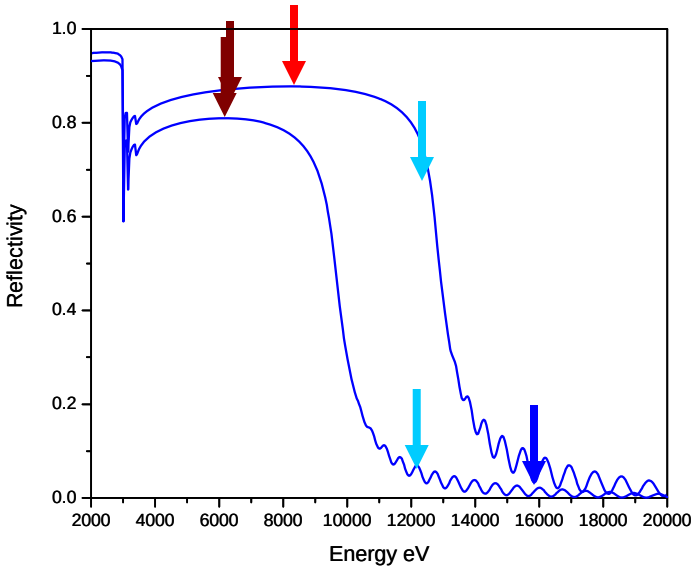
Harmonic Rejection Mirror





Ni kedge

Mn kedge

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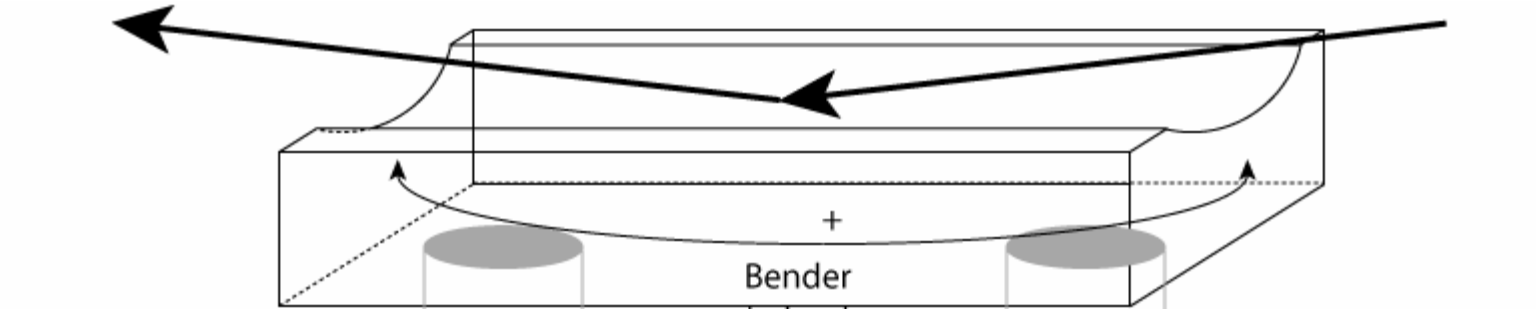
Focusing Mirror



A Cylindrical Mirror Bent into a Torous

Focuses Vertically and Horizonally

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XAS BL Optics Layout

Bend Magnet or

Wiggler Preferred.

Undulator – should be scanned.

Storage ring with straight sections

insertion device

Mo Slits

Collimating/ Harmonic Rejection Mirror

Mono Slits

Double Crystal Monochromator

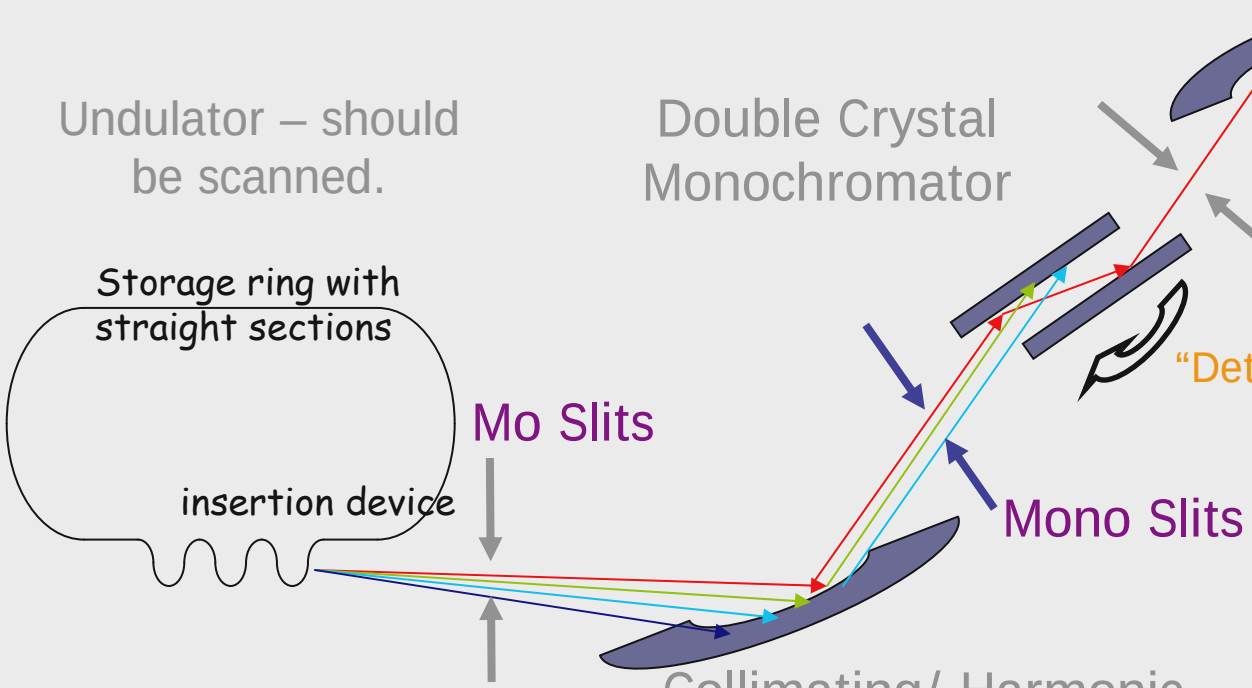
"Detune"

M1 Slits

Focusing Mirror

Io Slits

Expt. Hutch



1. Energy Resolution
2. Harmonic Rejection
3. High Flux Density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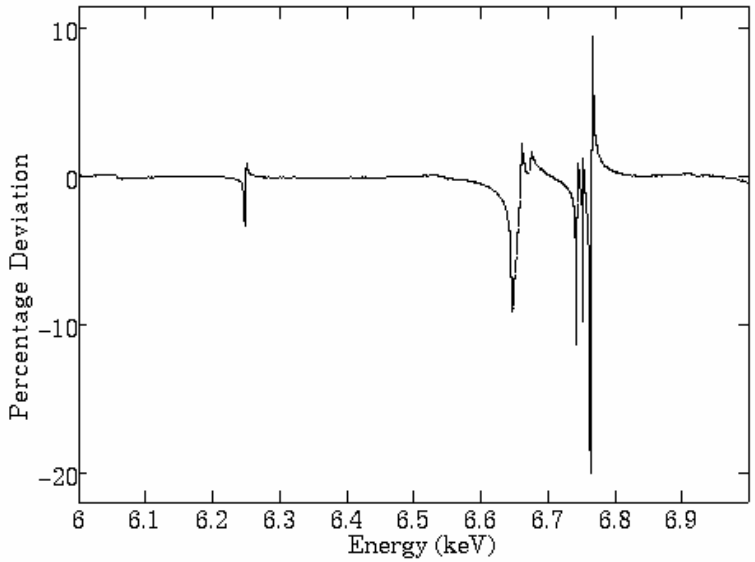
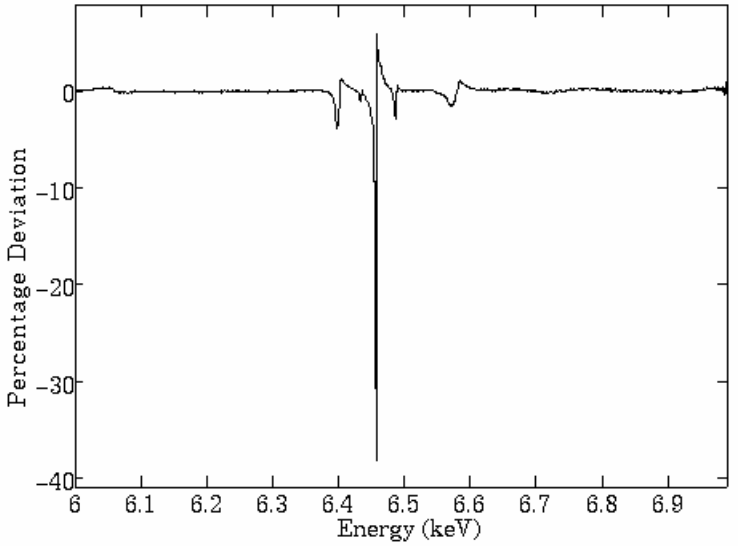
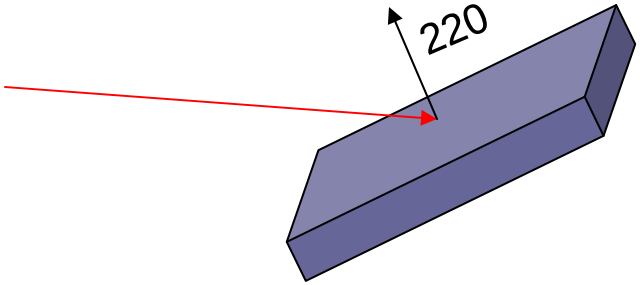
Monochromator “Glitches”

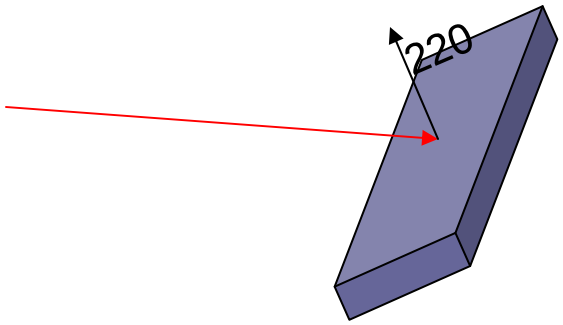
Si(220) phi=0 ° 6- 7 keV



Si(220) phi=90° 6- 7 keV







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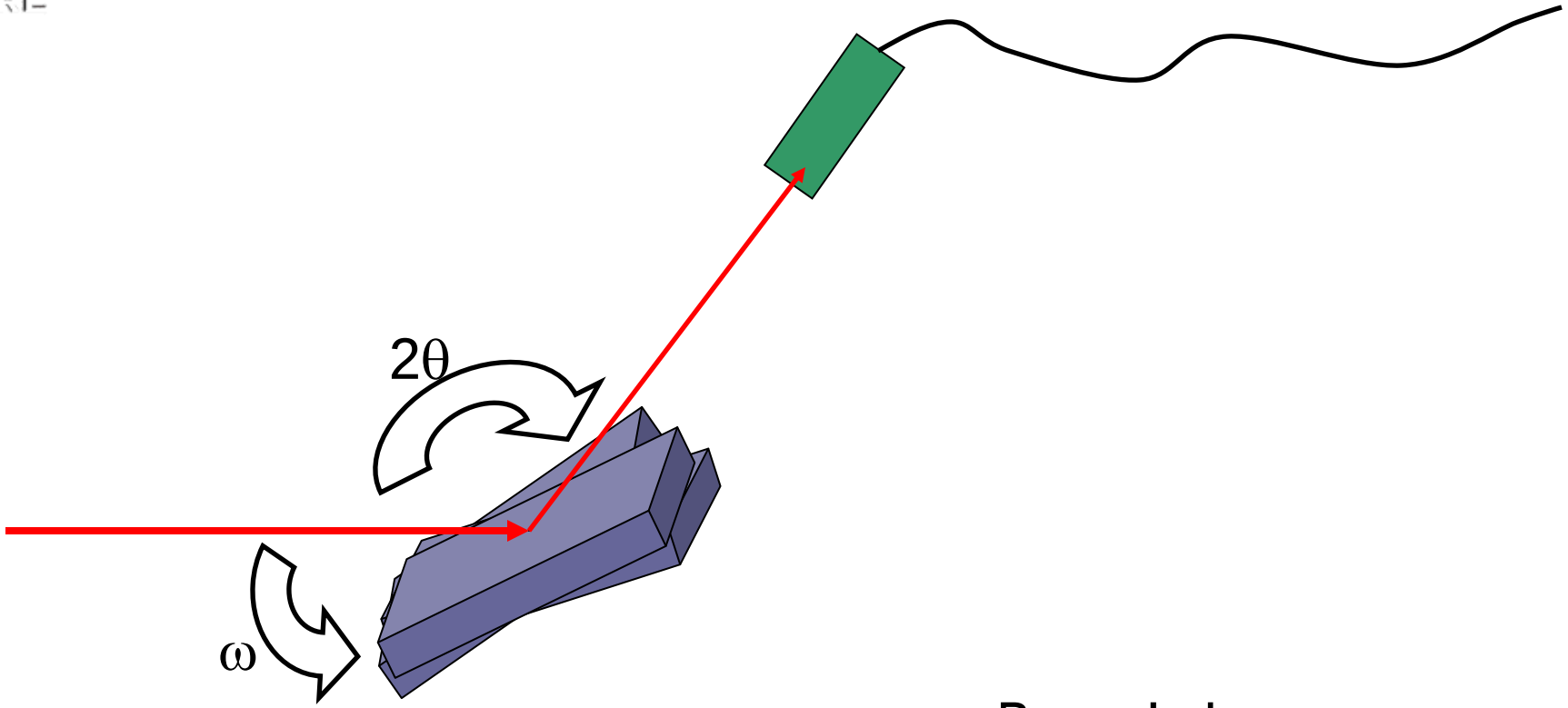
Scattering from a Single crystal



Bragg's Law:

$2d\sin(\theta) = h/E$

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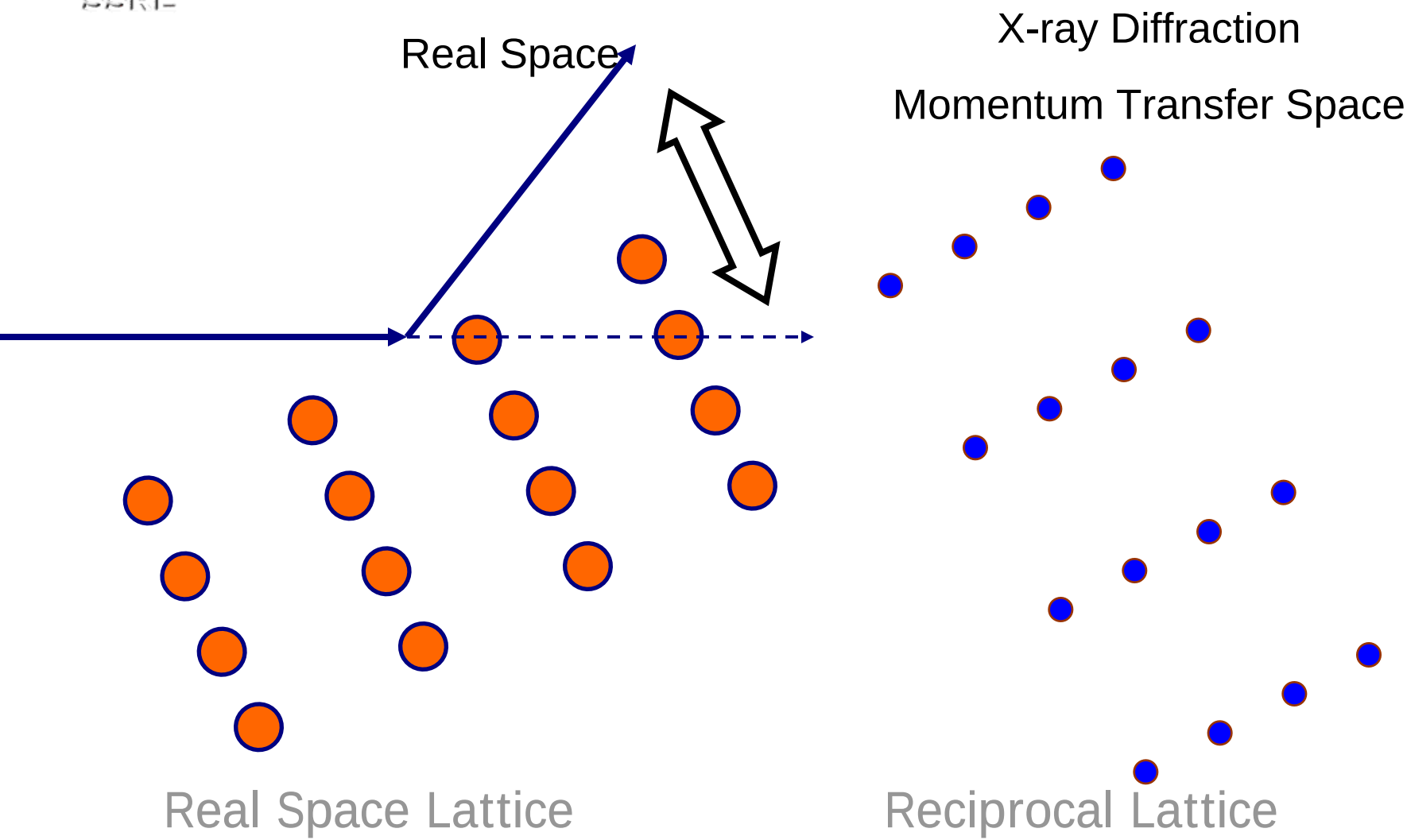
Scattering from a Single crystal



Scattering from a Single crystal

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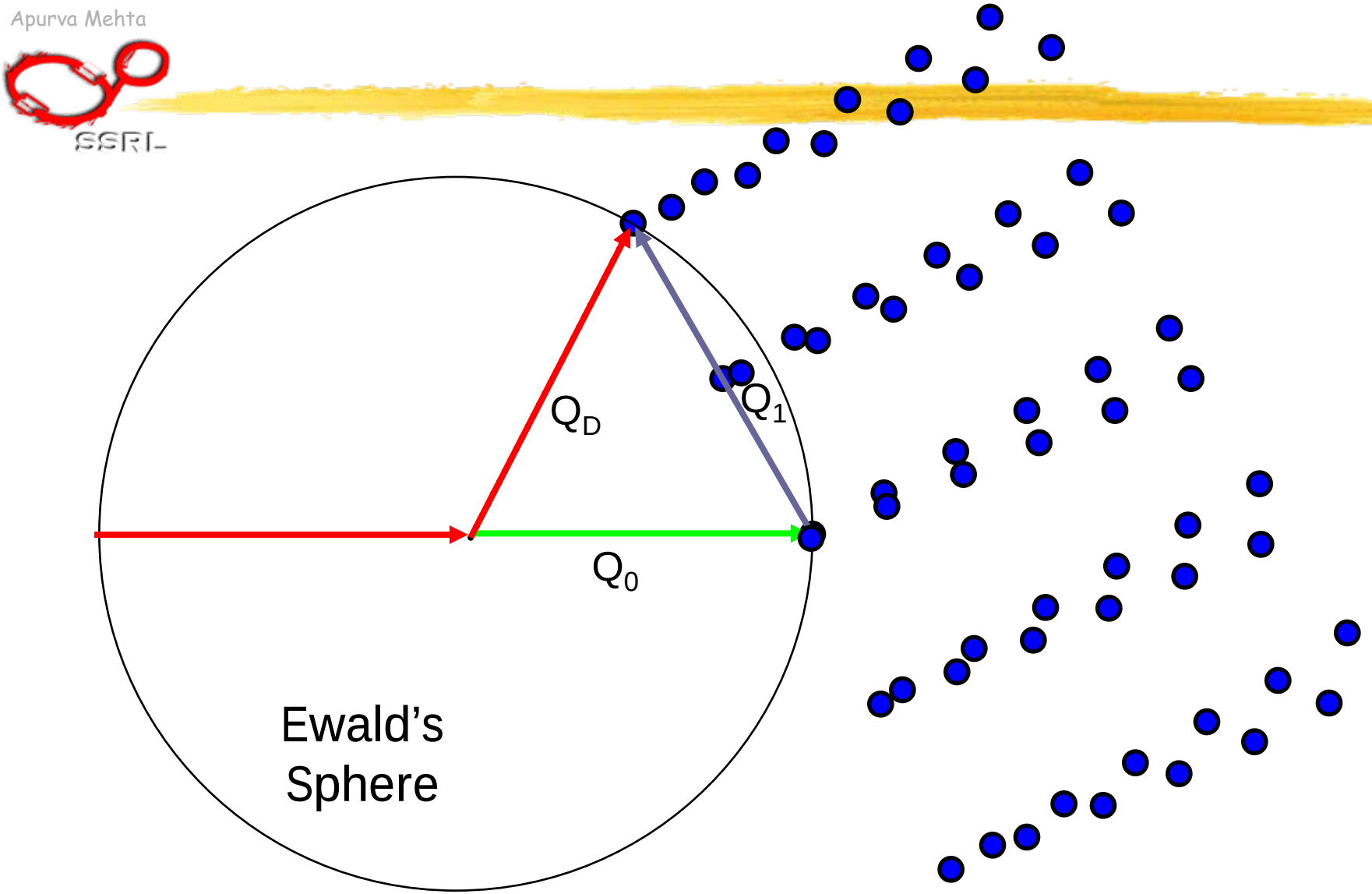

Multiple Reflections

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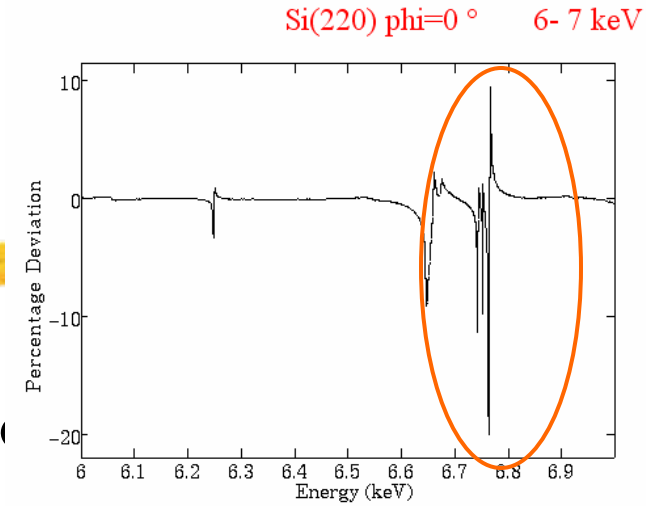

Resonance between the two reflections ⇨ Energy Transfer between the two

Multiple Reflections – Phi Rotation

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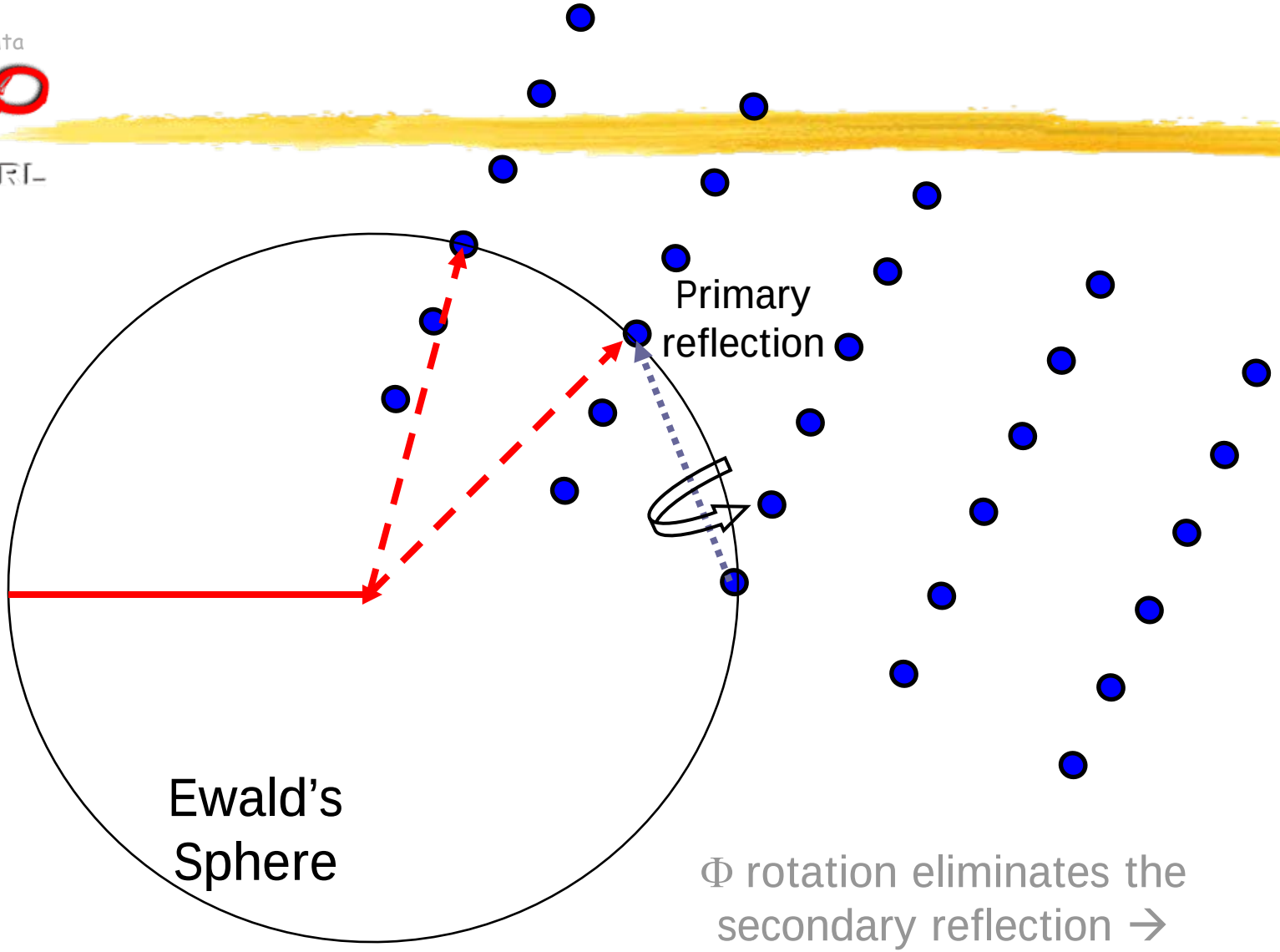

Φ rotation eliminates the secondary reflection → eliminates the resonance/glitch

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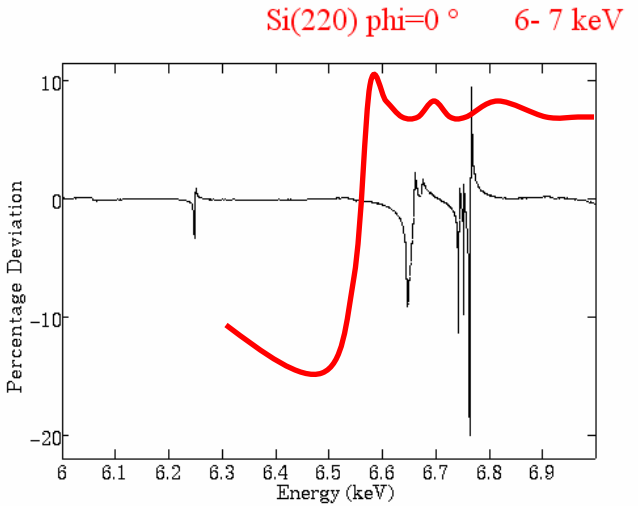
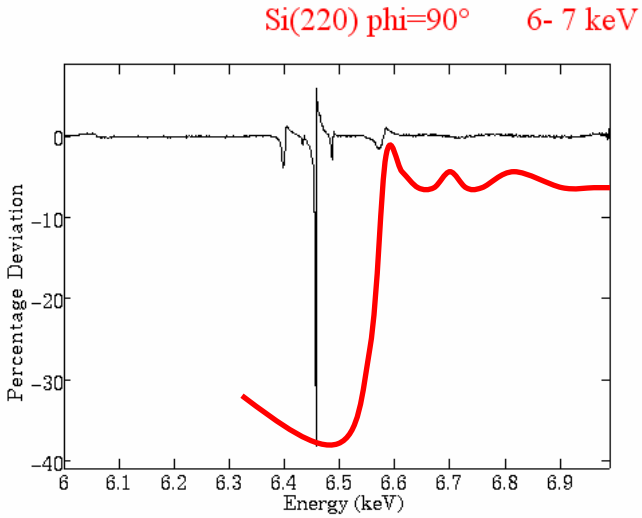
Monochromator “Glitches”





- Location Depends on Phi Orientation
- Severity depends on precise crystal orientation, difficult to predict
- Can not be eliminated, but sometimes can be made sufficiently narrow by slits adjustment that EXAFS are not affected.

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Preparation for an XAS Experiment

- Absorbing Element
  - K, L, M edge
  - BL with the appropriate energy range
- Energy Resolution
  - Monochromator crystal order (e.g., 111, 220)
    - Crystal Orientation – phi cut – “Glitch” spectrum.
  - Close Slits
  - Collimation of the beam prior to the Mono

XANES

- Harmonic Rejection Strategy
  - Mo angle adjustment for appropriate cut-off
  - Detune the monochromator
- Flux Density on the sample
  - Select an insertion device source if available
  - Adjust the M1 focus
  - Lower Order Monochromator Crystal
  - Open Slits

EXAFS

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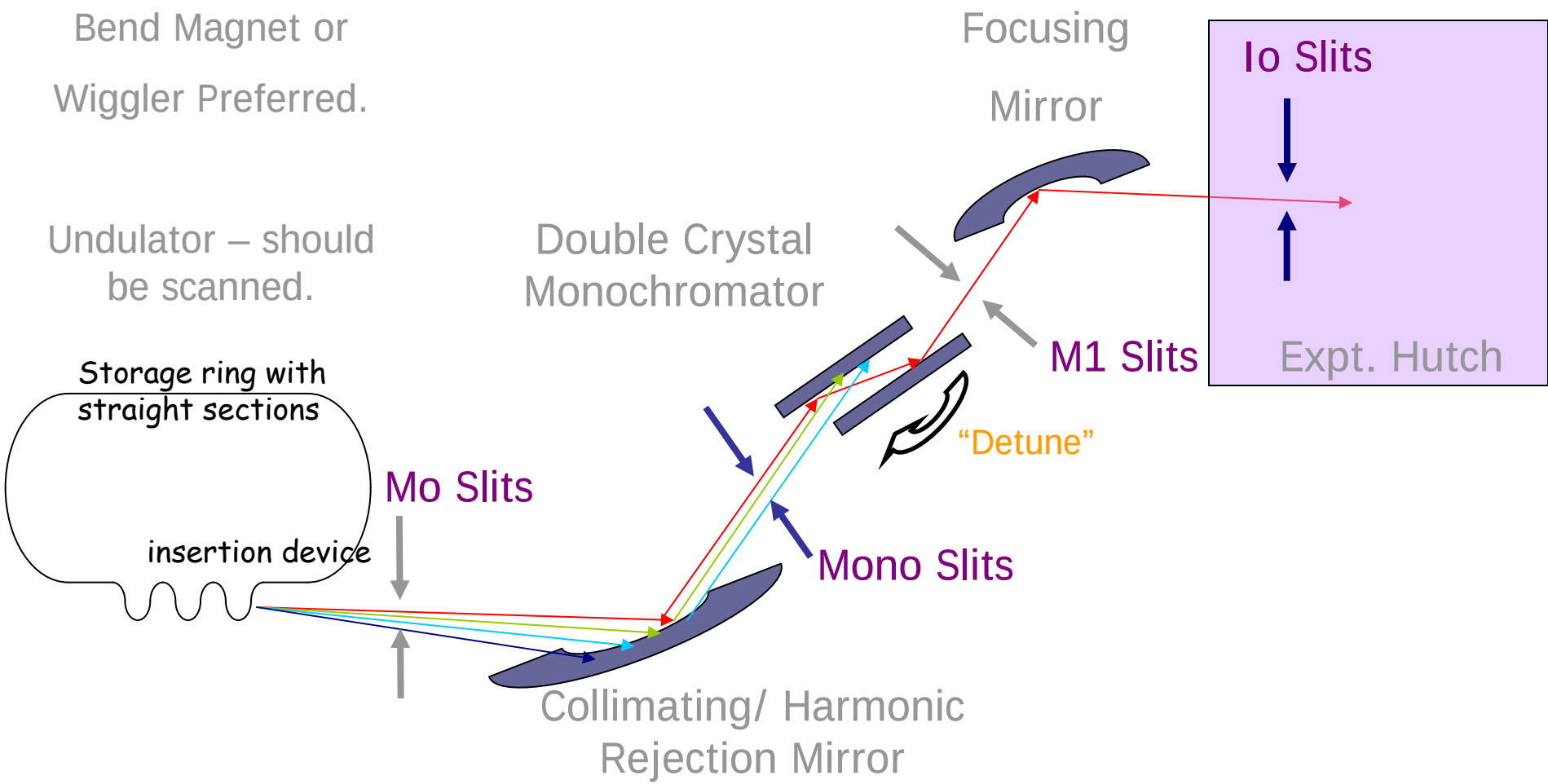
XAS BL Optics Layout



Thanks

Questions?

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XAS BL Optics Layout