



Correcting Substrate Warp for X-Ray Reflectometry

By: Pavan Bhargava



Outline

- What is reflectometry?
 - How reflectometry works
 - Correction factors
- What is warp?
 - Complications with warp
- Warp Correction Methods
 - Software Correction
 - Vacuum Flattening
 - Slit Control

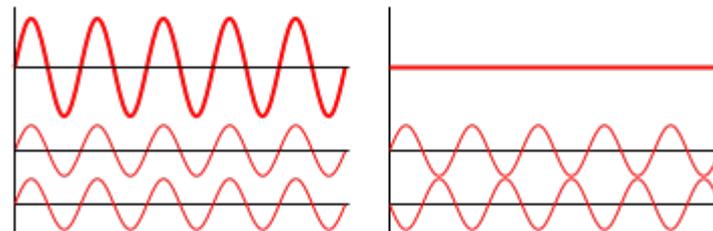
What is Reflectometry?



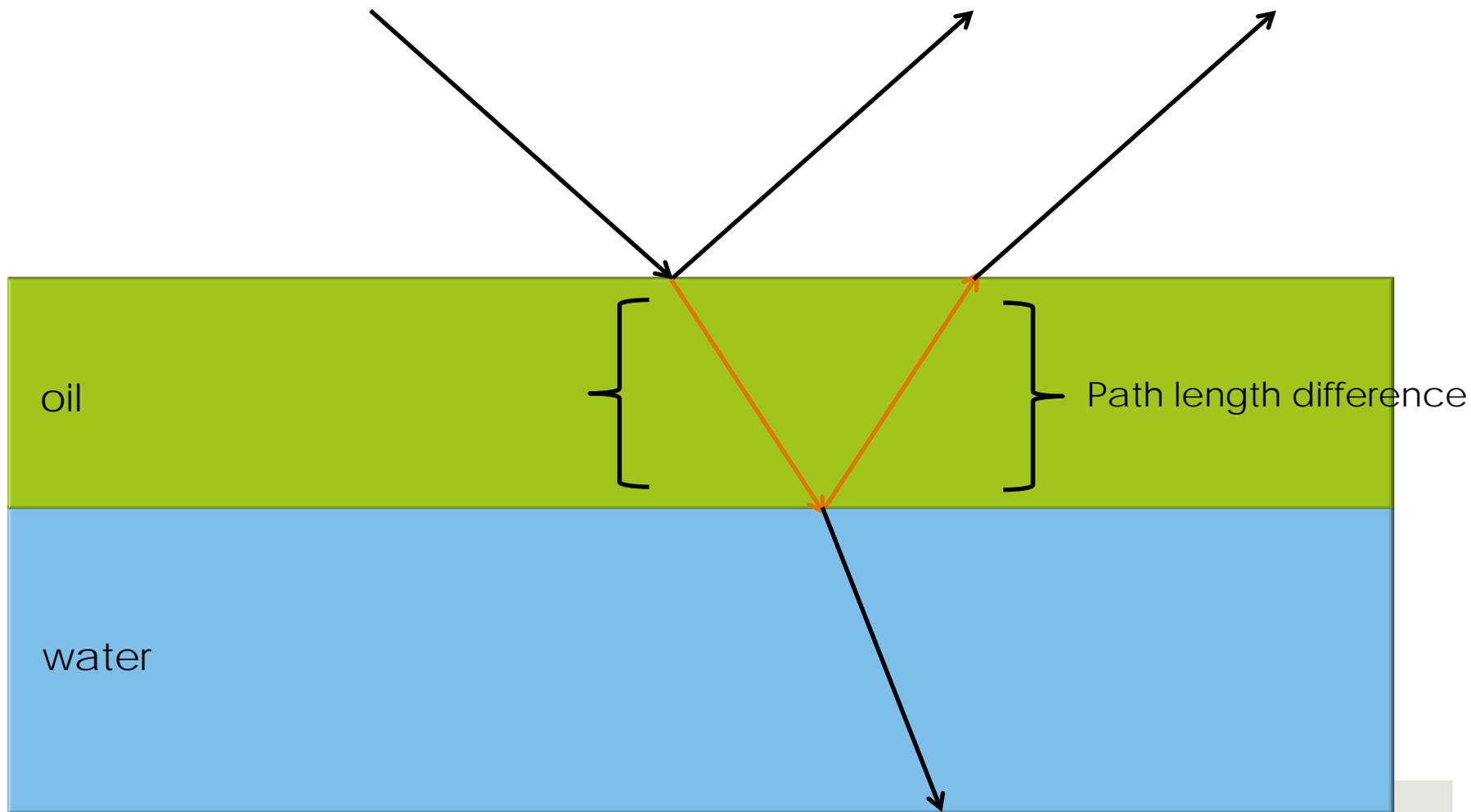


Reflected Intensity dependent on:

- Incident Angle
- Wavelength
- Layer Composition
- Layer Thickness

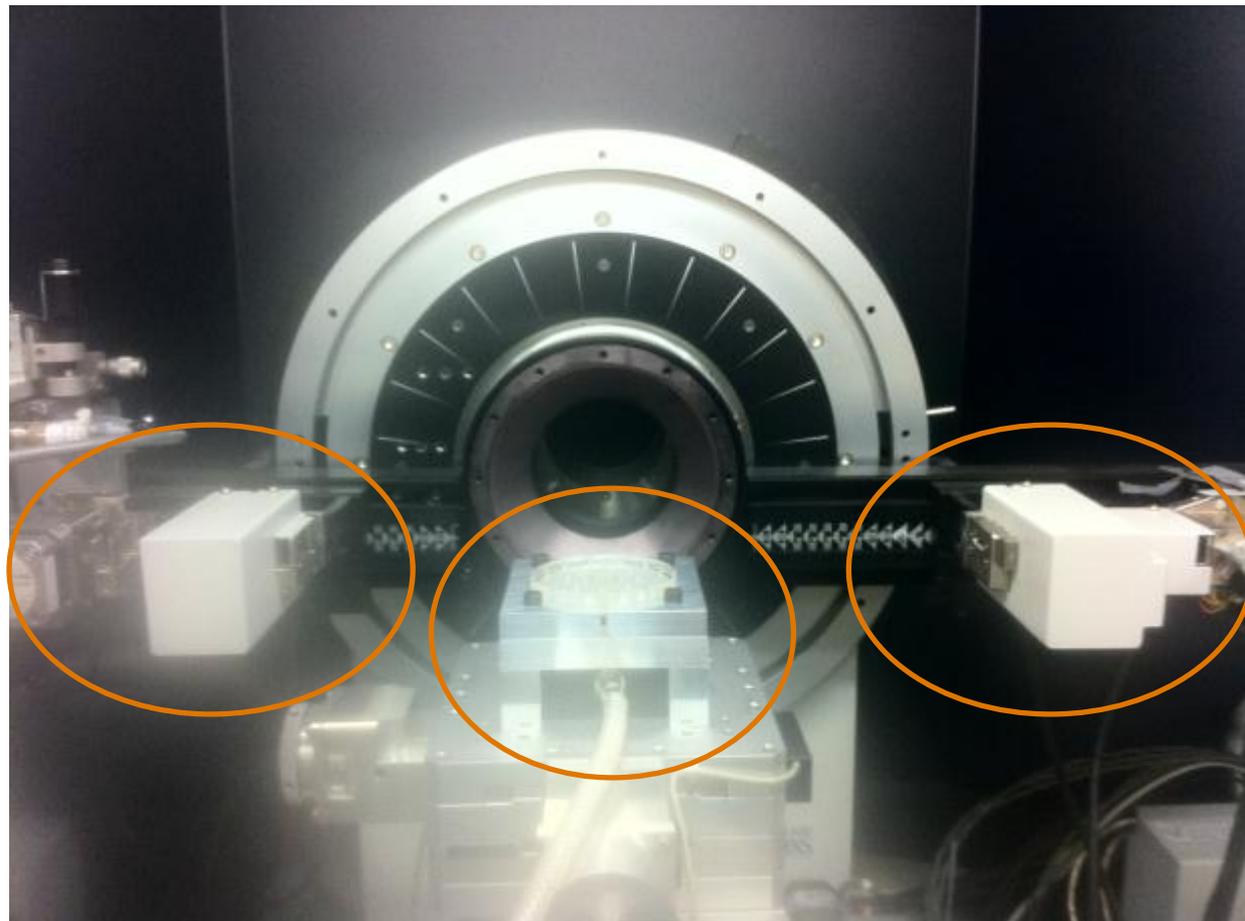


Constructive Interference Destructive Interference

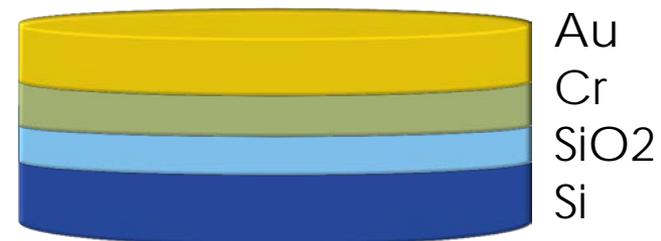
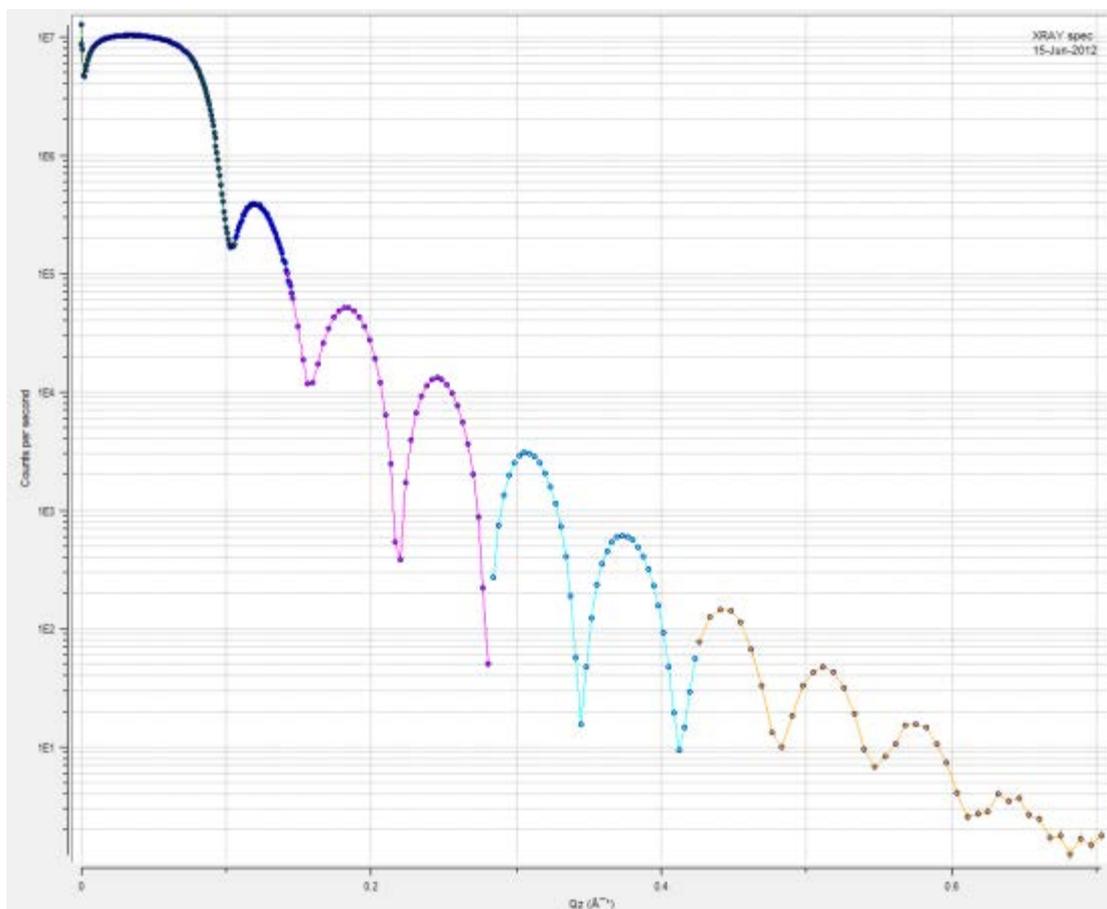




X-Ray Reflectometer Setup



Reflectivity Curve

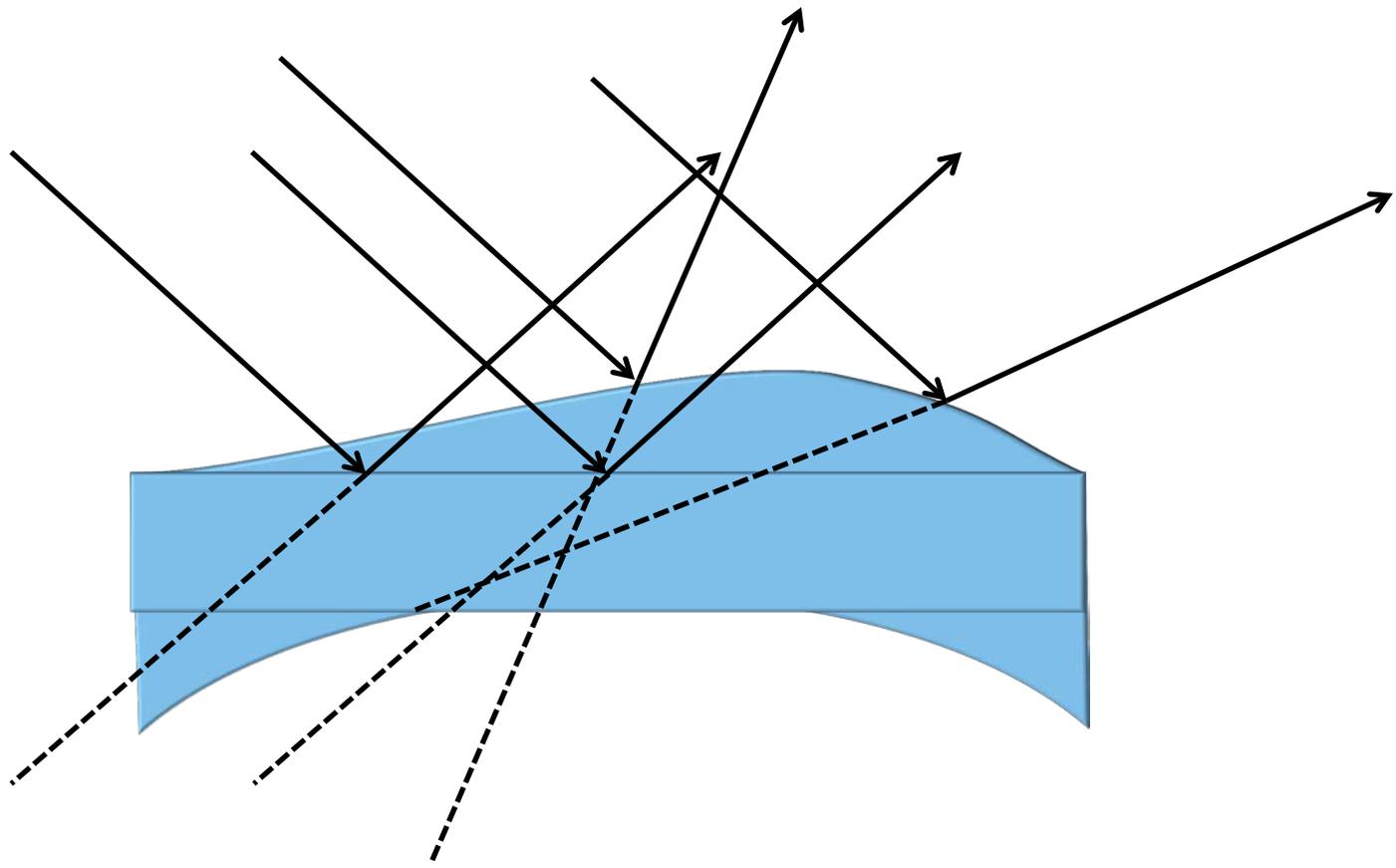




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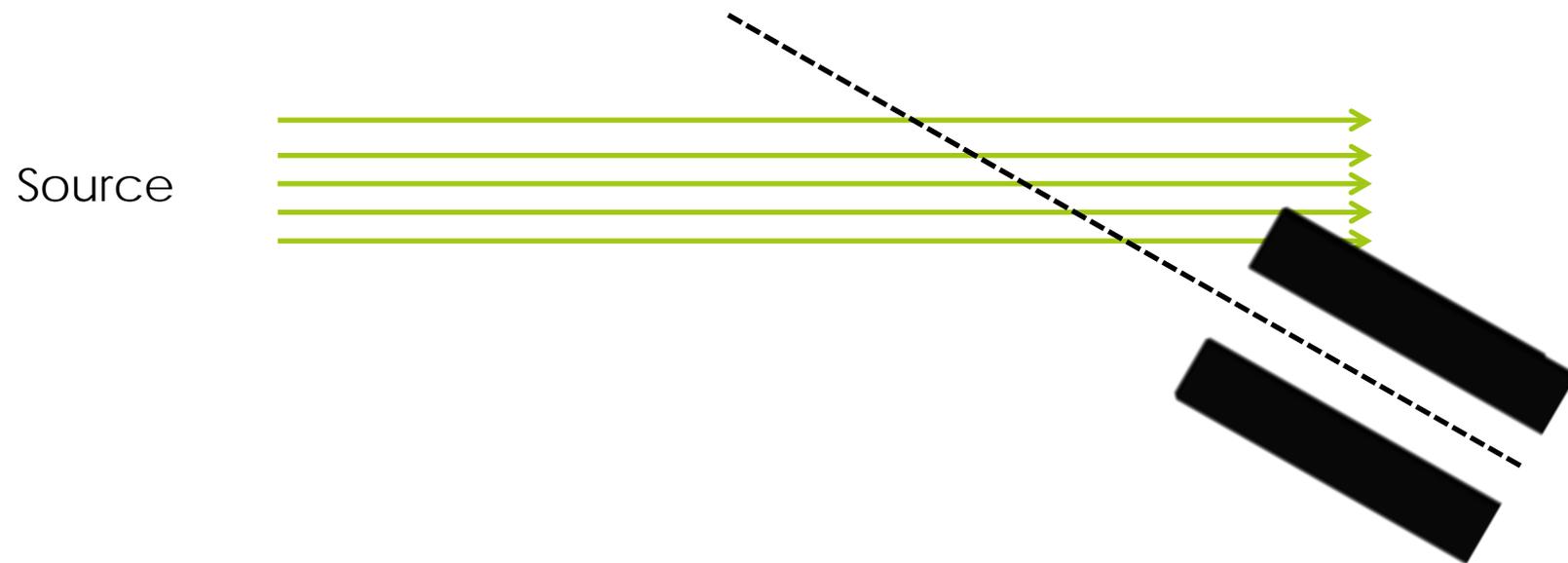
- What is reflectometry?
 - How reflectometry works
- Substrate warp
 - **Complications with warp**
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Substrate Warp

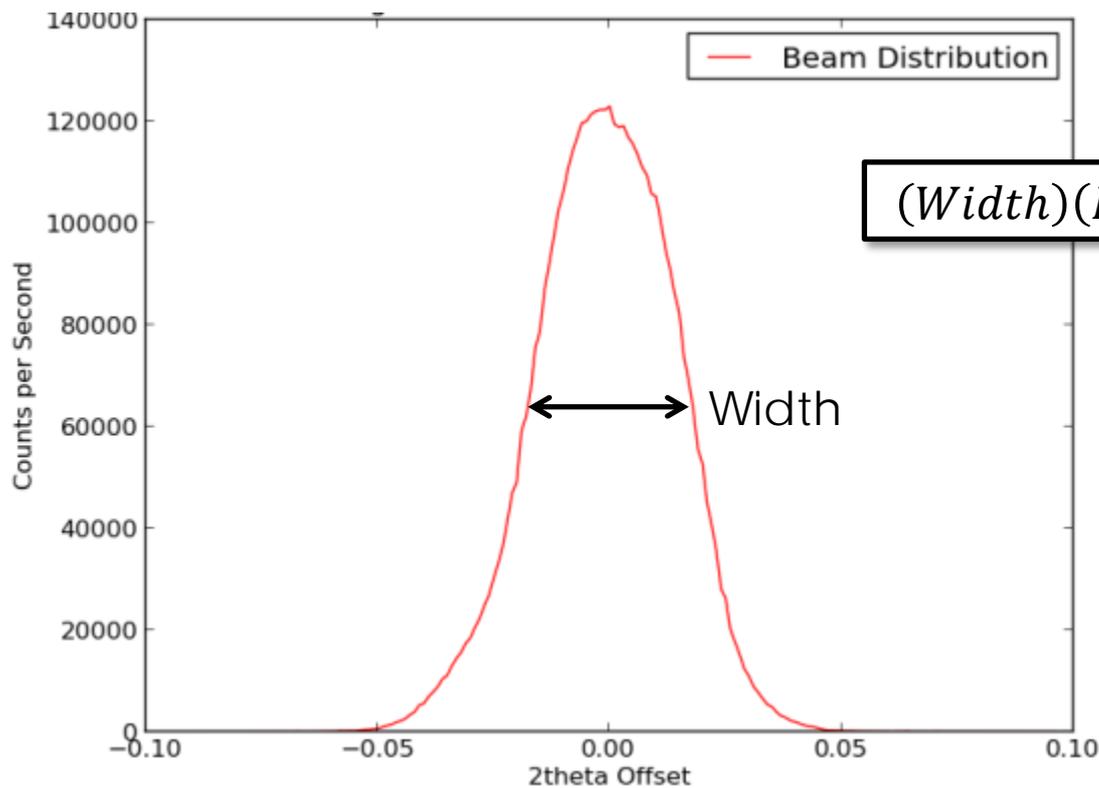




Detector Scan

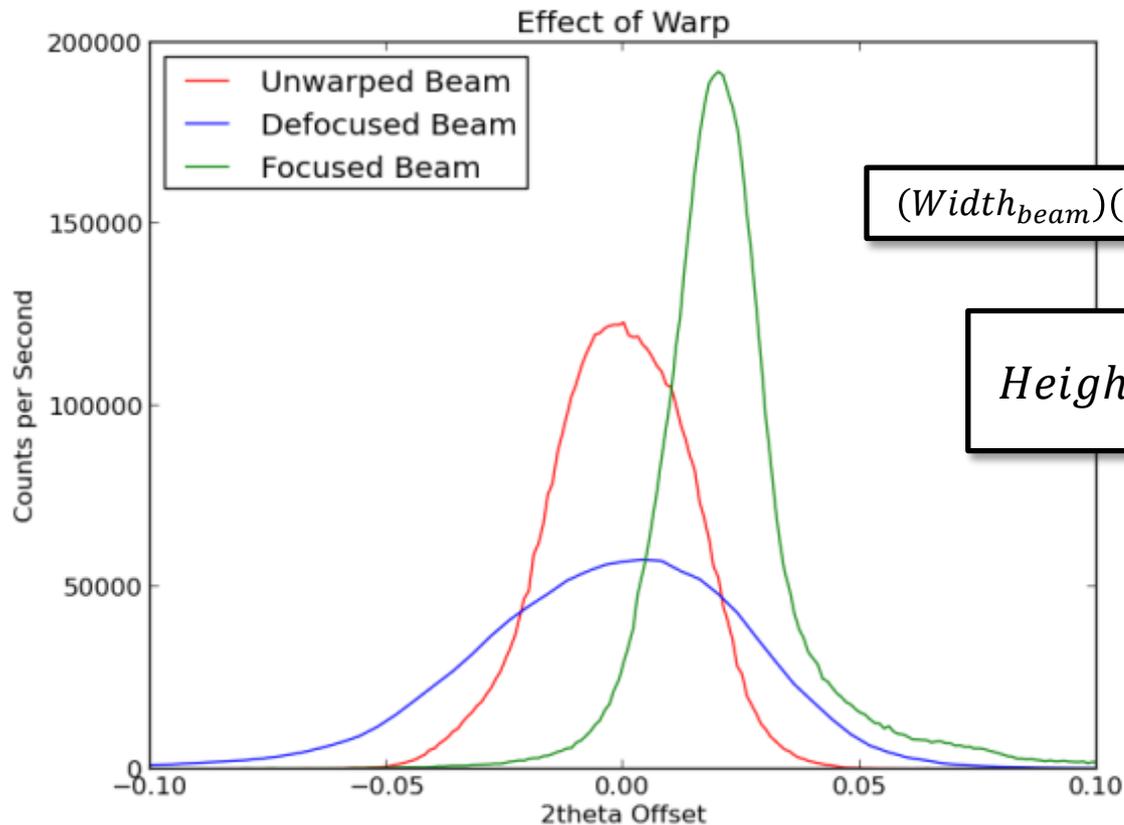


Divergence of Incident Beam



$(Width)(Height) \propto \text{Integrated Intensity}$

Warp Effects – Reflected Angle

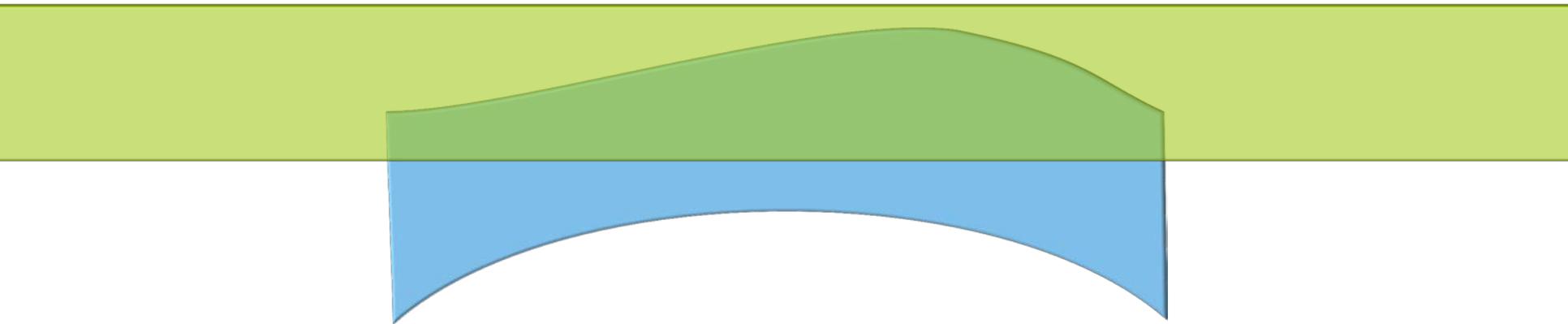


$$(Width_{beam})(Height_{beam}) = (Width_{warp})(Height_{warp})$$

$$Height_{beam} = \frac{Width_{warp}}{Width_{beam}} * Height_{warp}$$

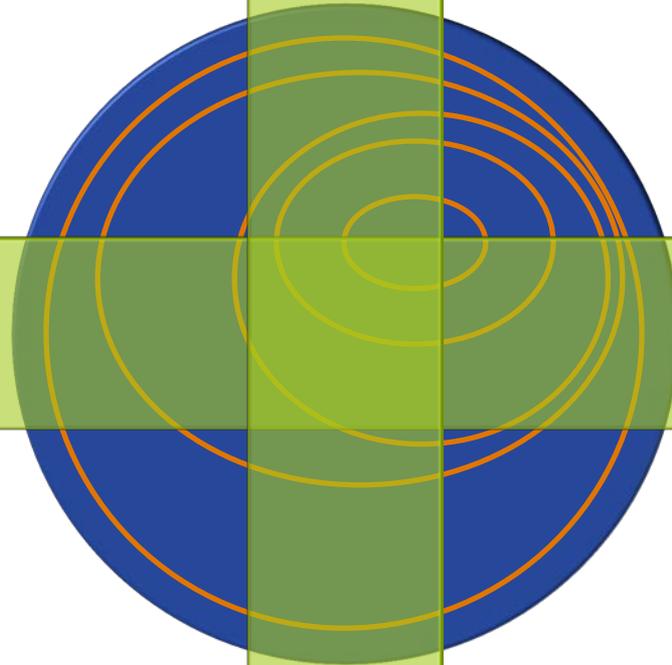


Warp Effects - Footprint

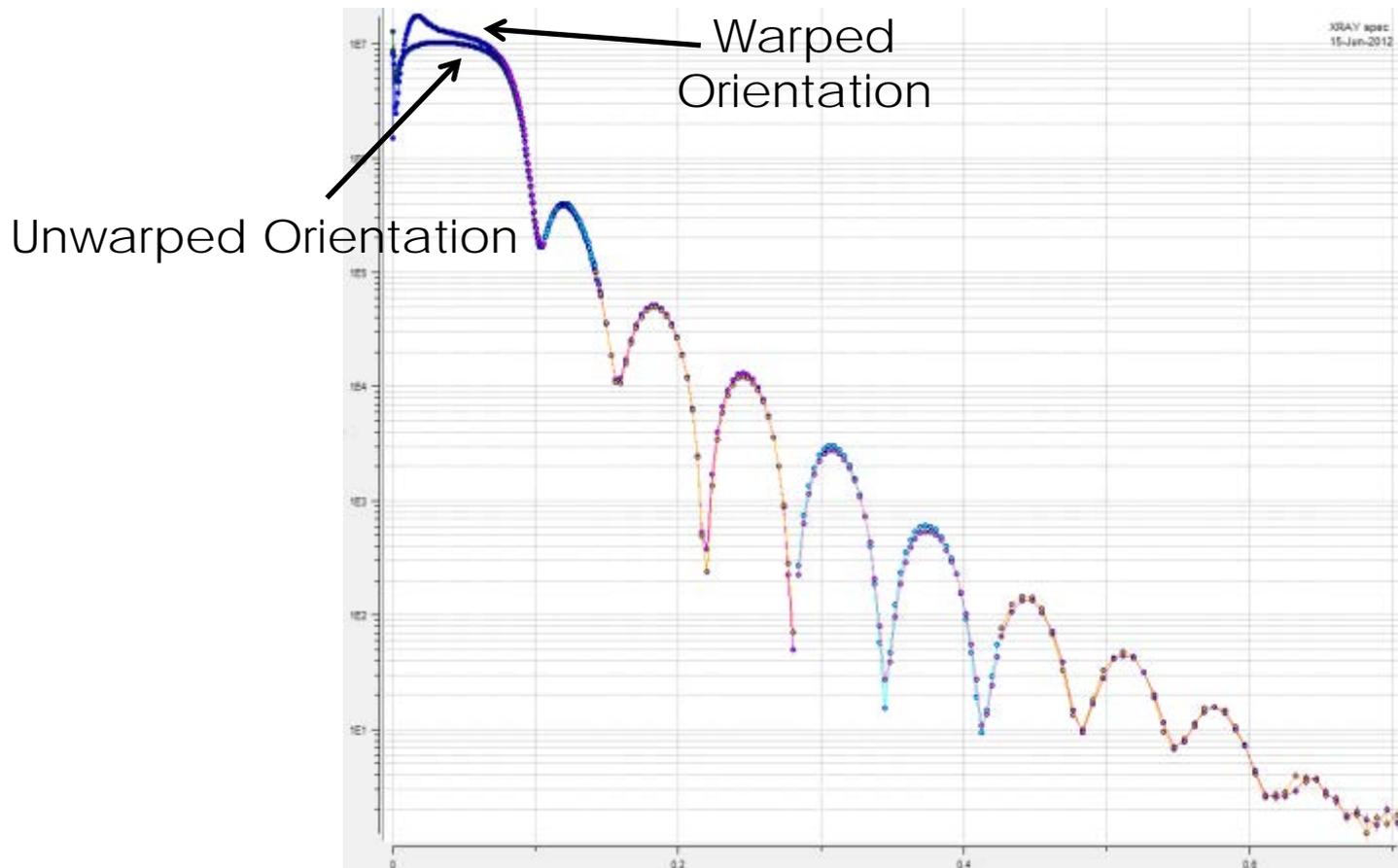




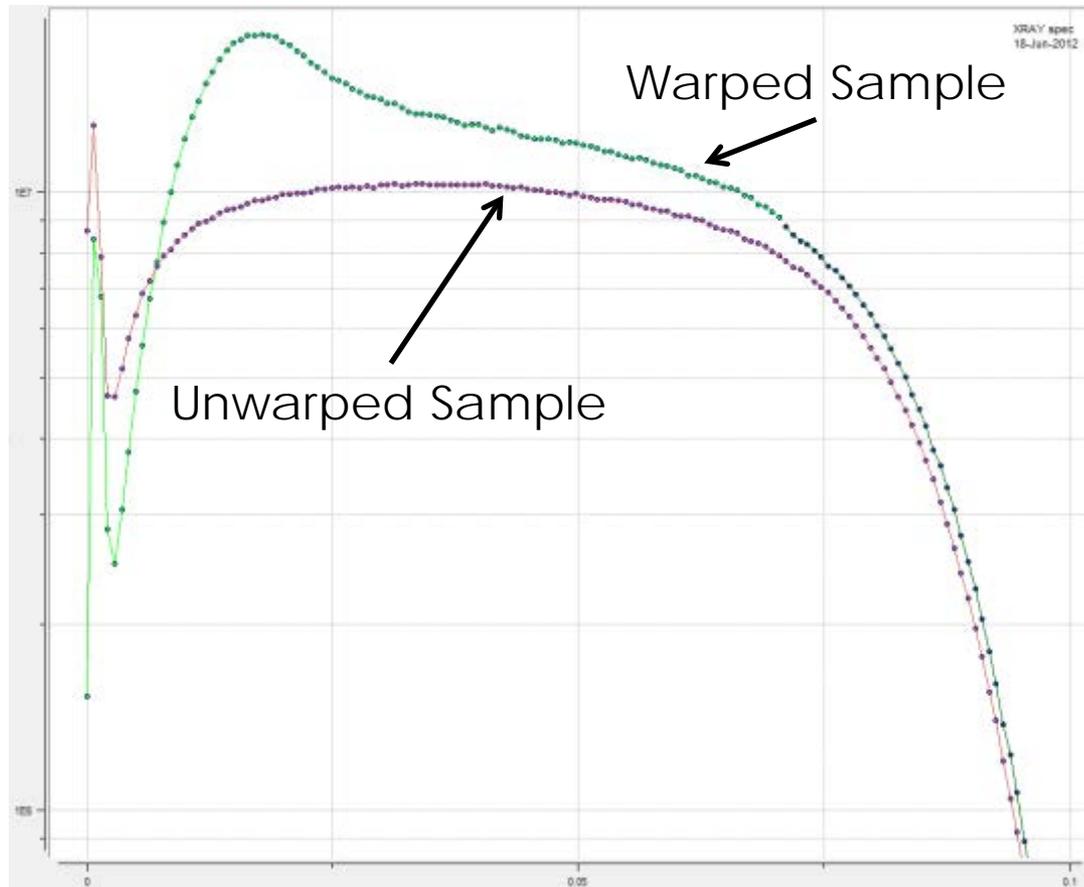
The Experiment



Warp Effects – Reflectivity



Warp Effects – Reflectivity

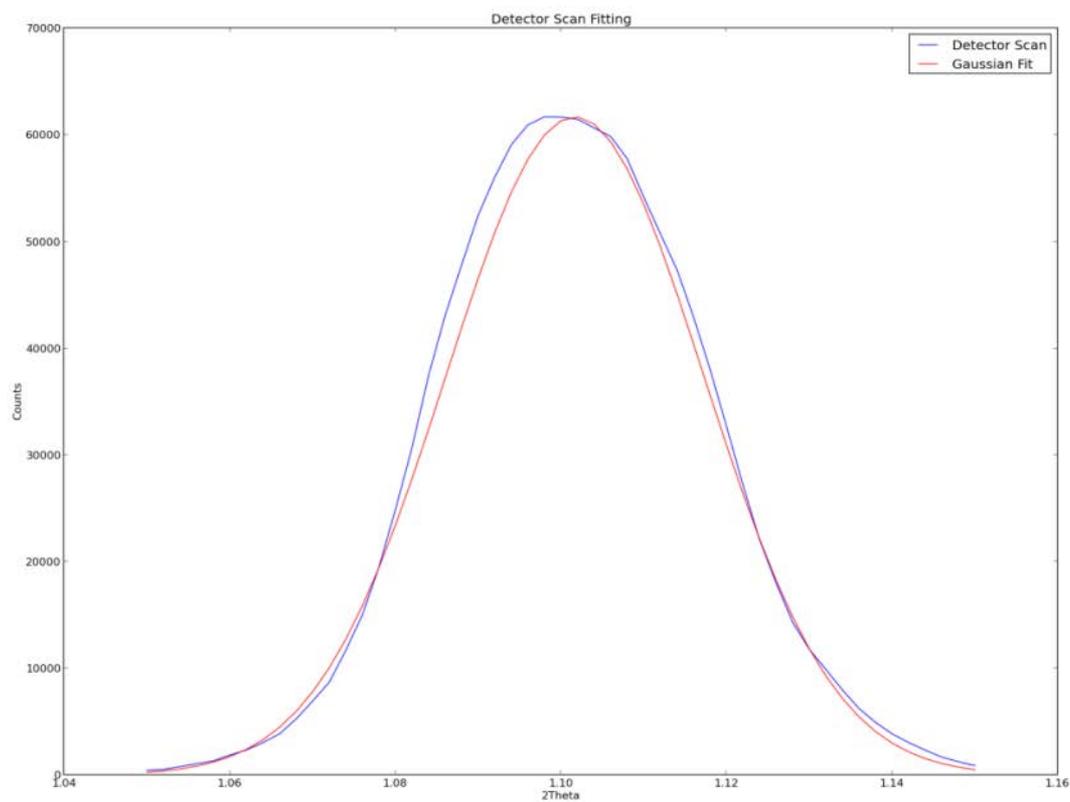




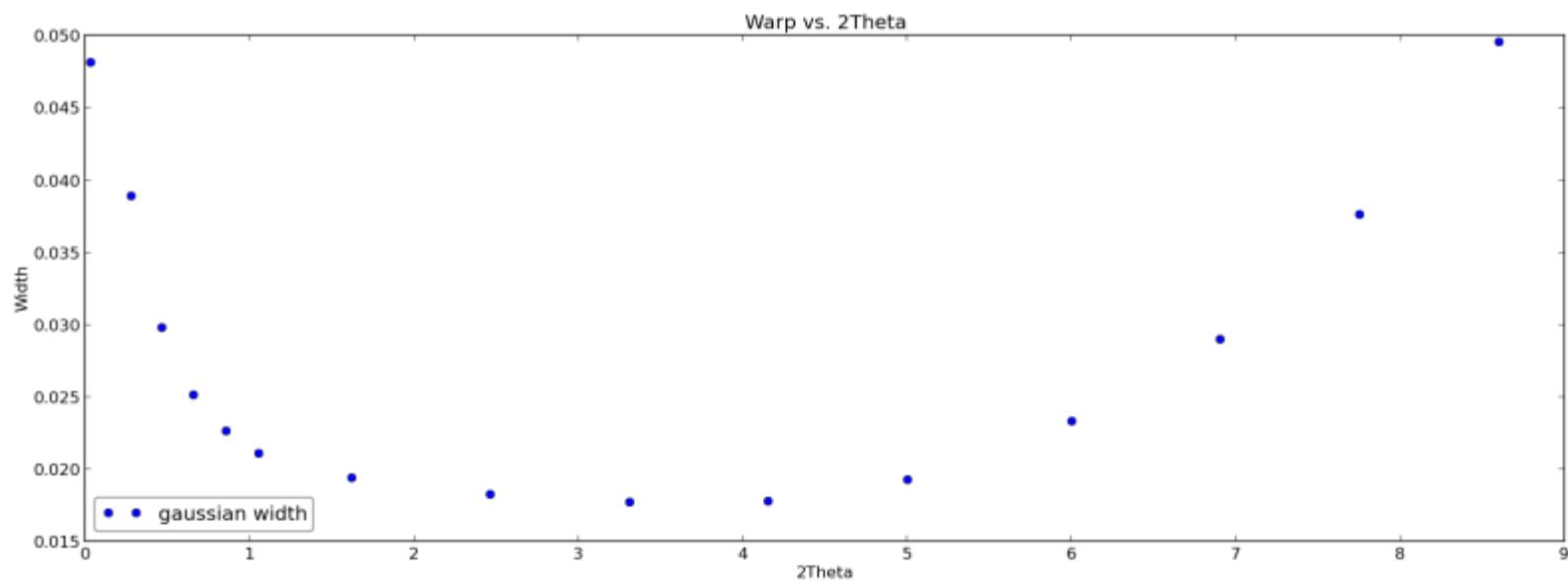
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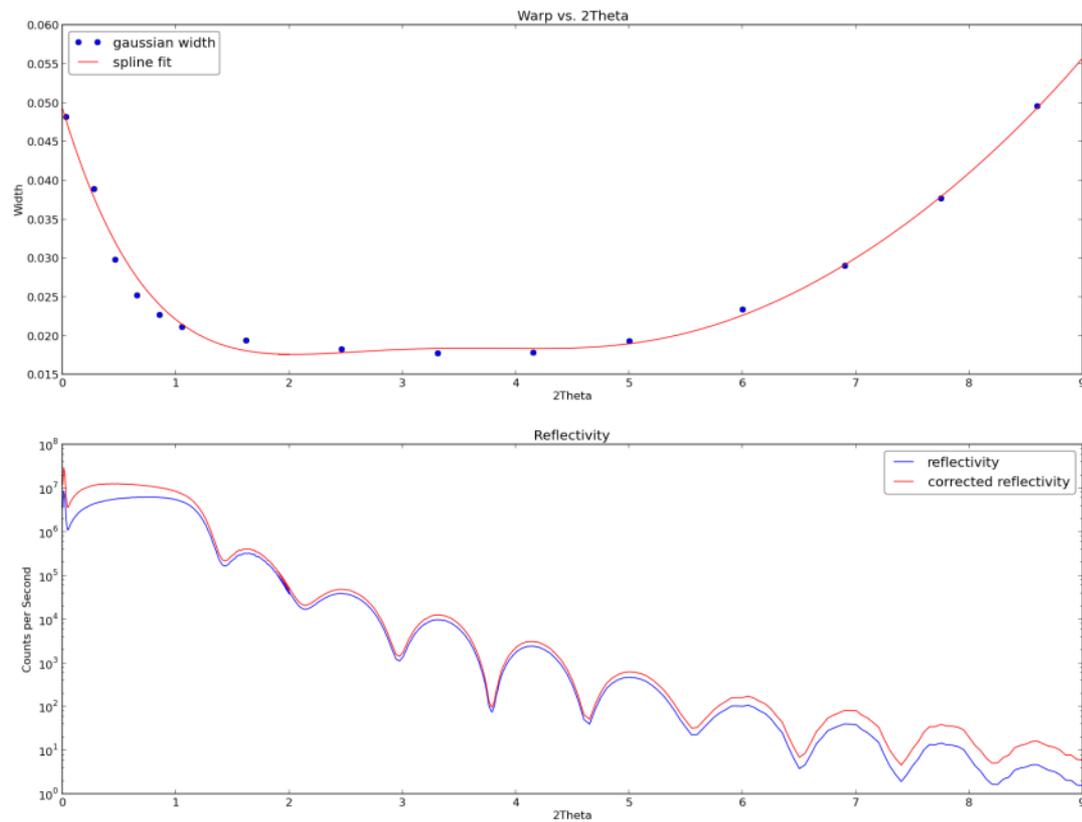
Software Correction



Software Correction

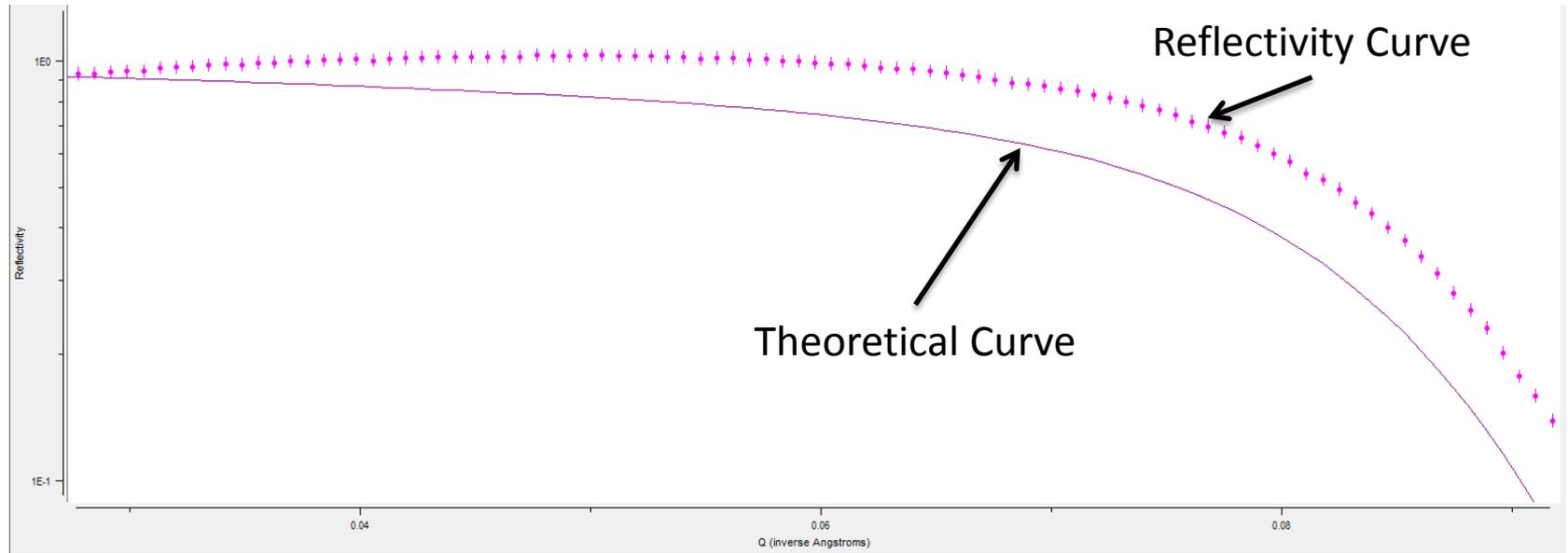


Software Correction

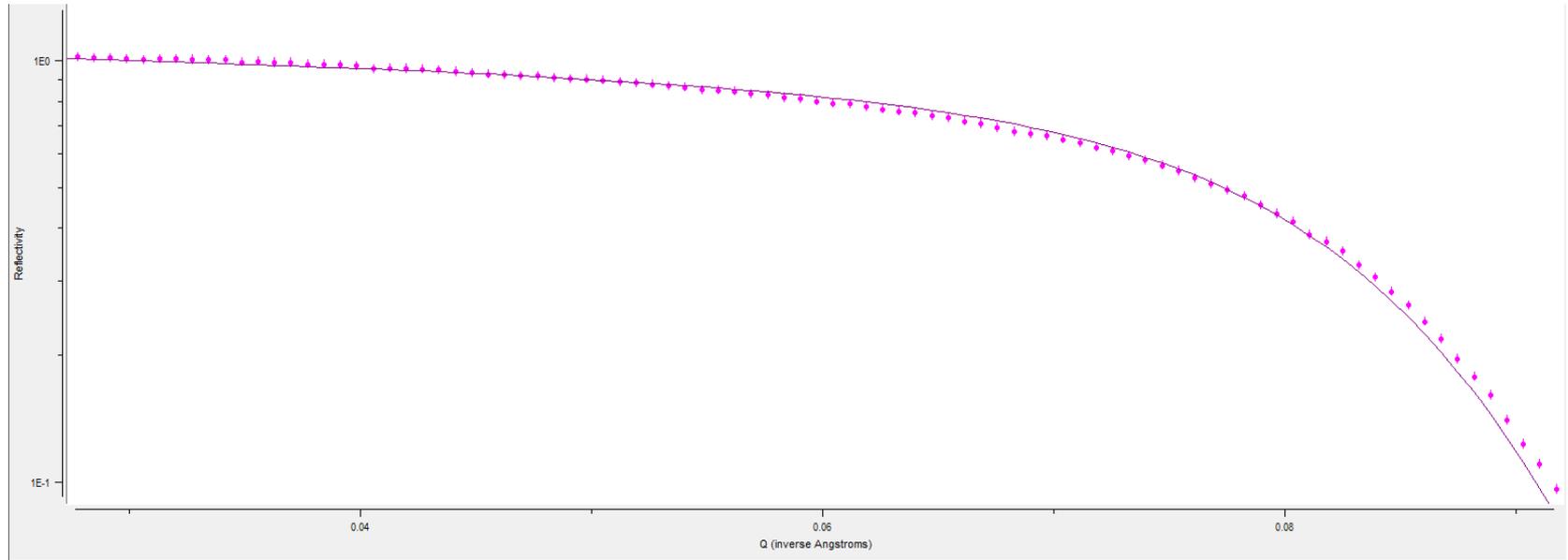




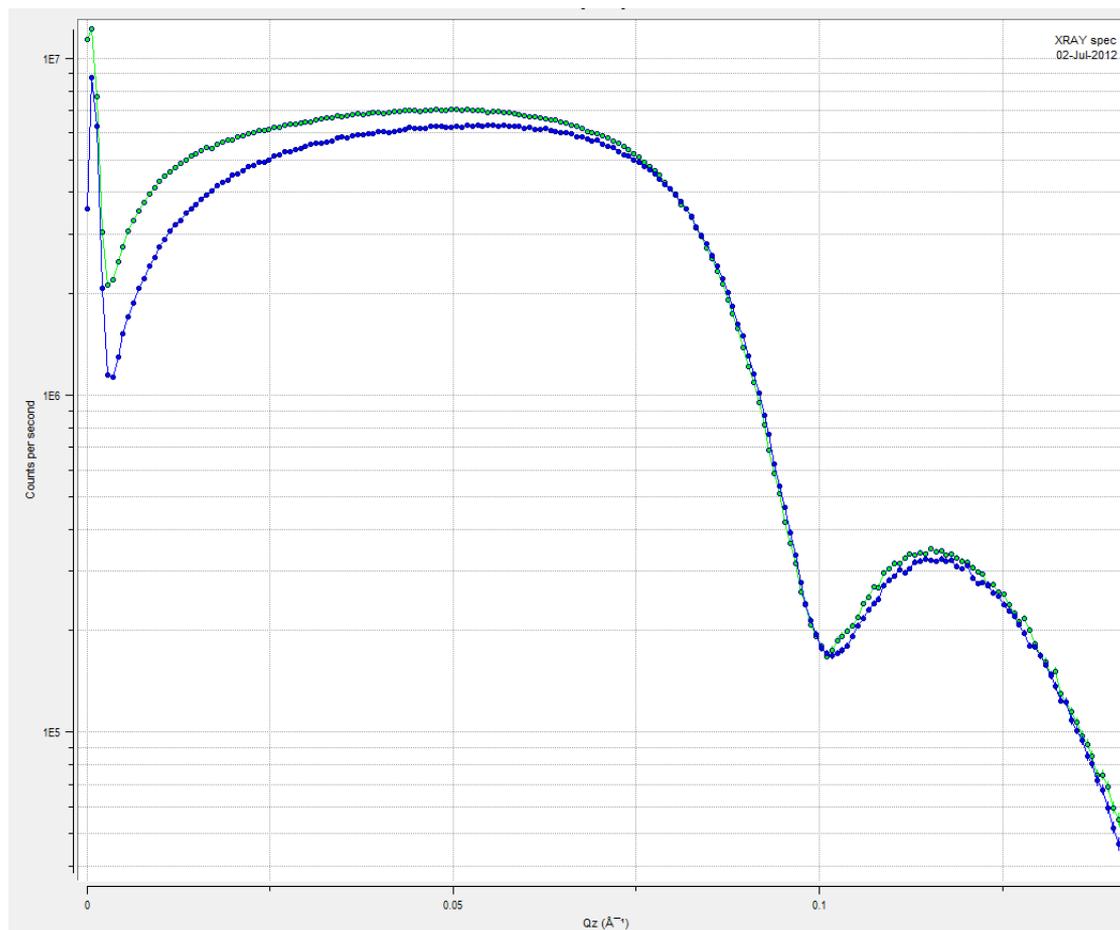
Uncorrected Sample



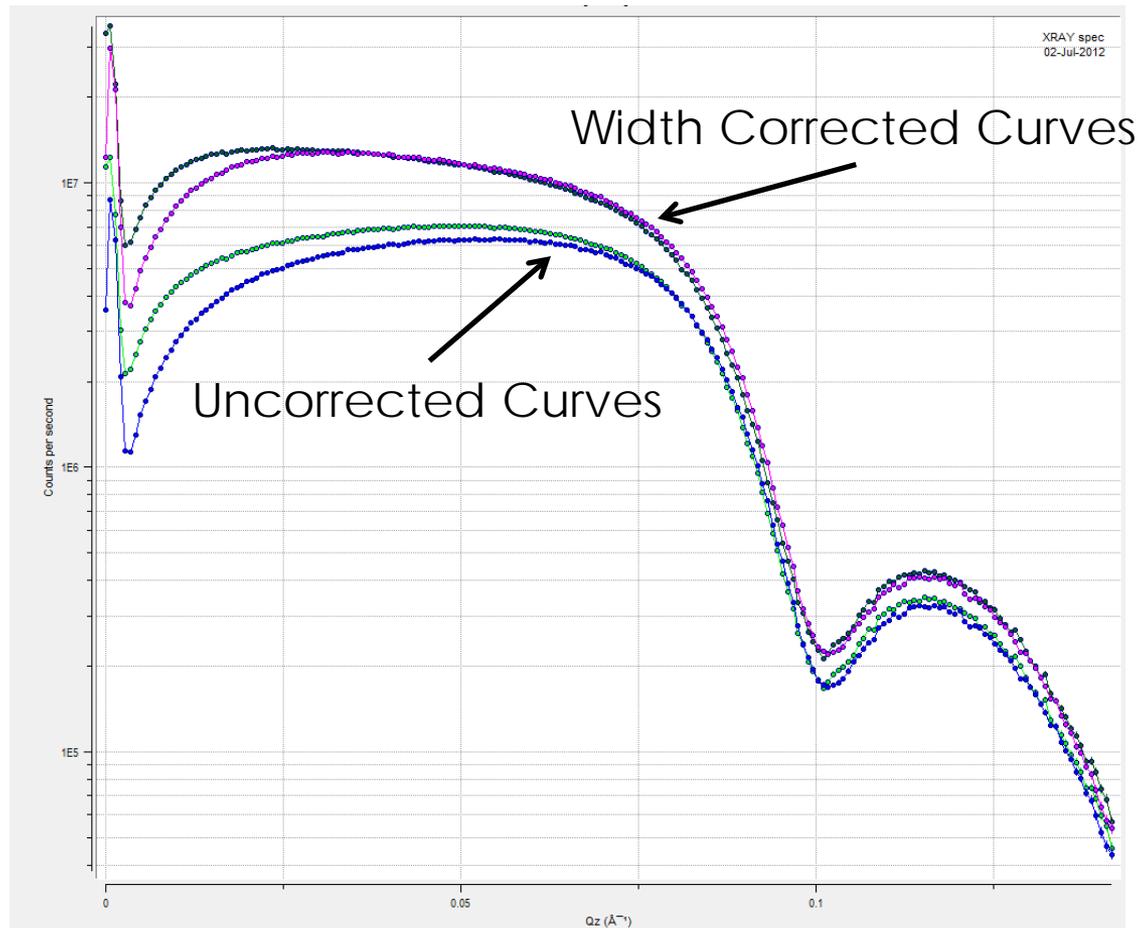
Width Corrected Sample



Uncorrected Reflectivity



Corrections Converge



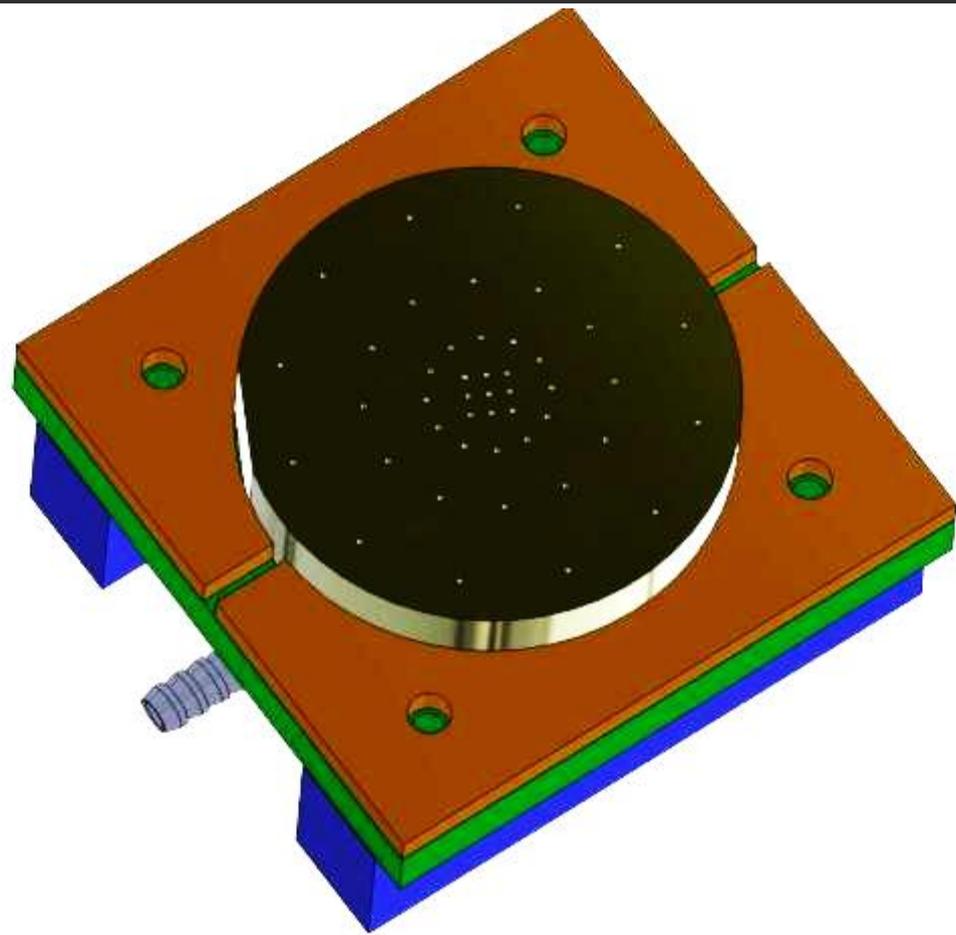


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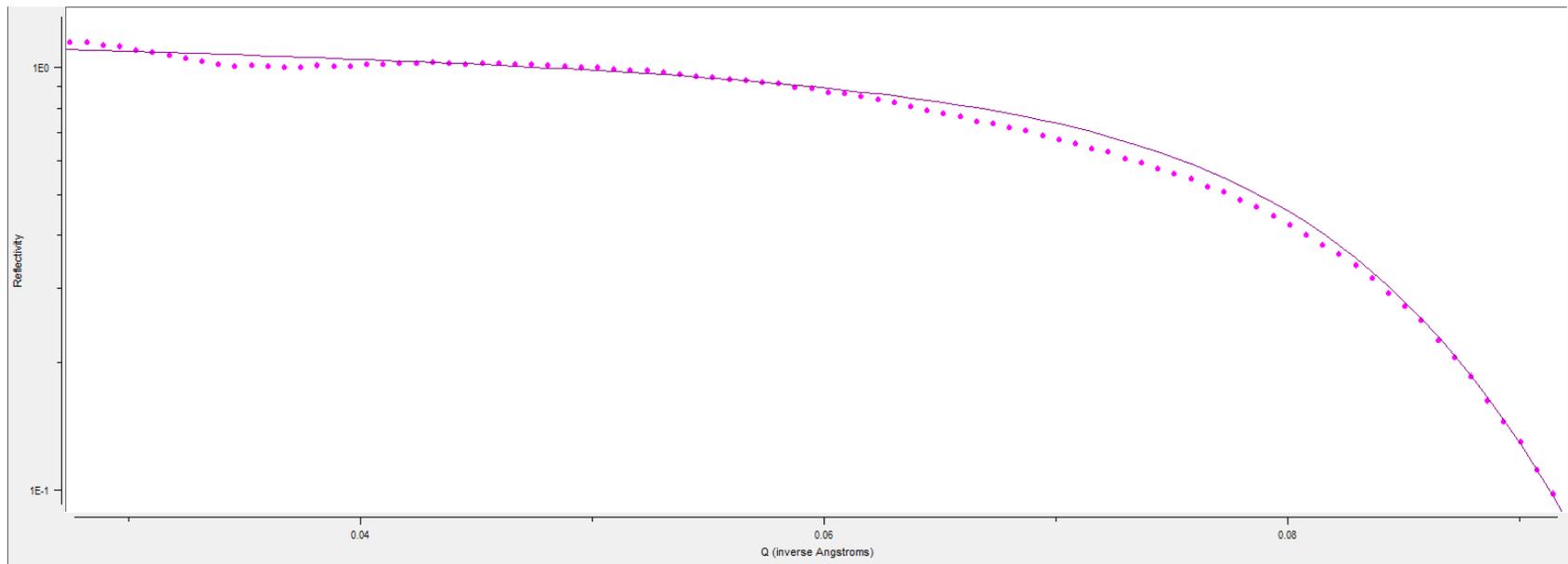
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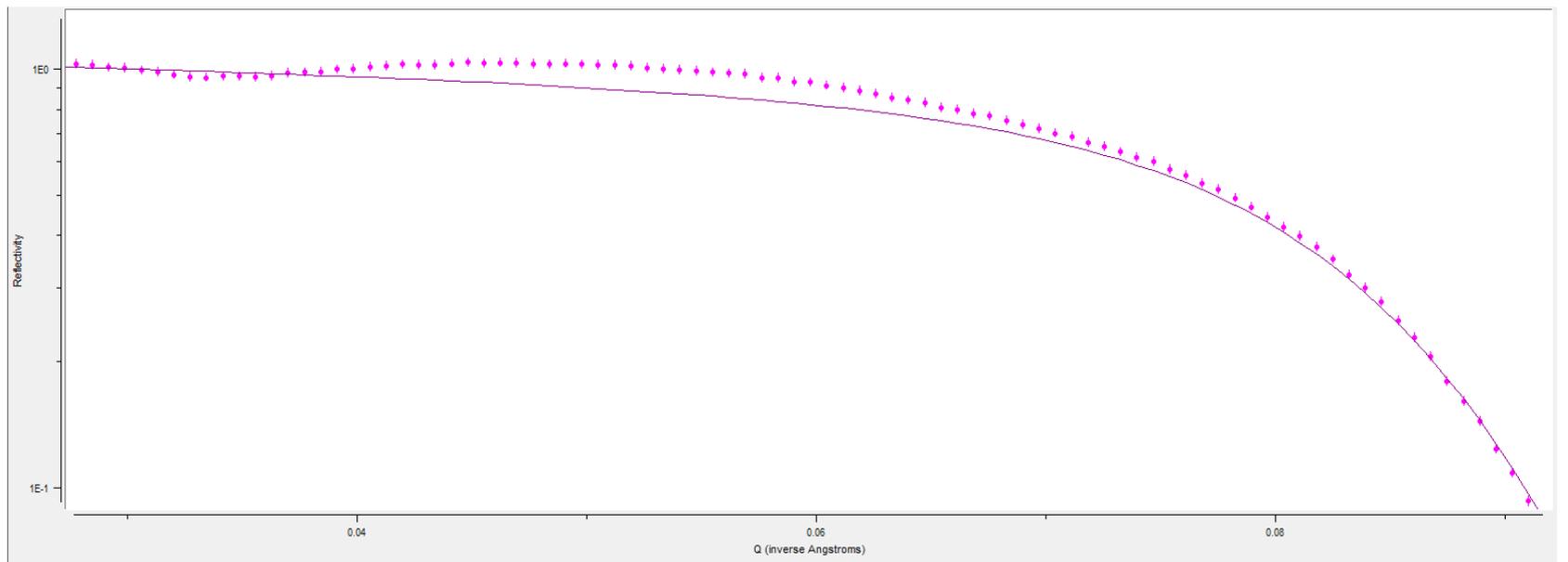
Vacuum Correction



Software Corrected Data - Vacuum Corrected Sample



Vacuum Corrected Sample



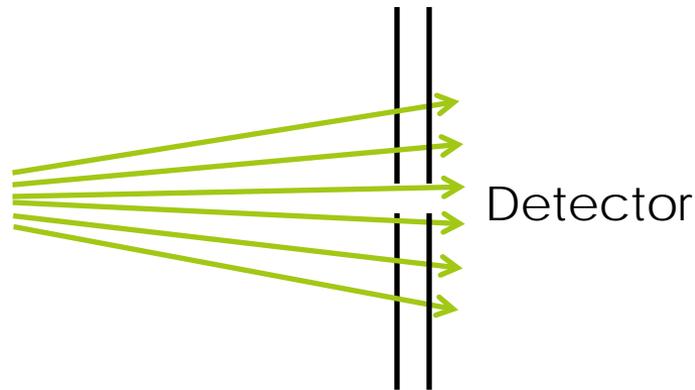


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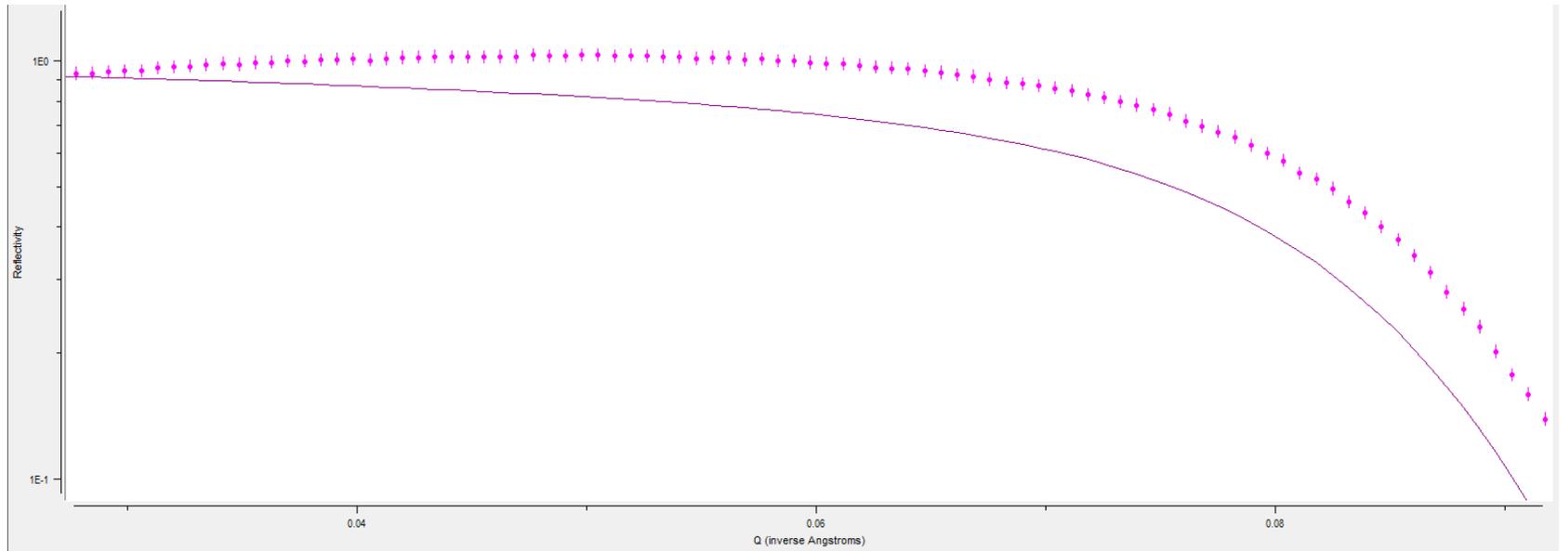
Slit Modification

- In cases where the sample increases the spread of the beam, the detector can be opened up to read a larger spread of angles.

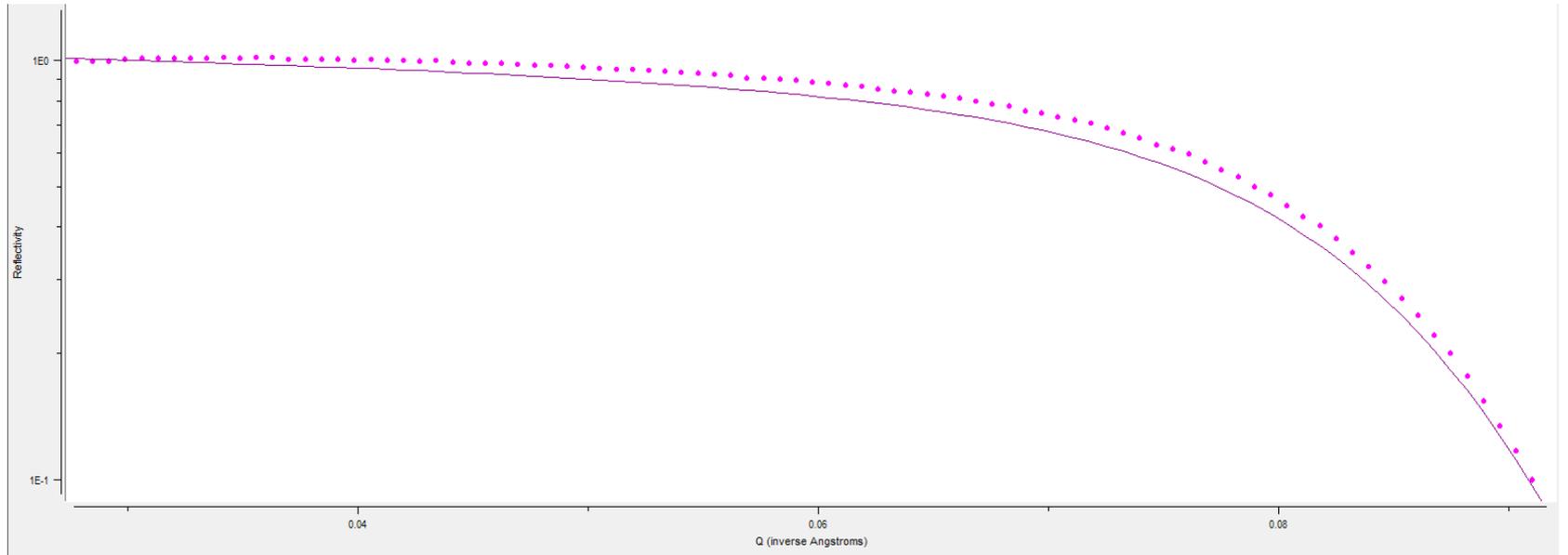




Uncorrected Sample



Sample Measured with Widened Slits





Discussion

	Pros	Cons
Software	Very good correction	Many measurements
Vacuum Sample Holder	Simple to implement	Introduces extra features
Wide Slits	Simple to implement	Decreases resolution

Future Work

- Machine different attachments to the vacuum system to allow for the use of samples of different sizes
- Investigate the source of the oscillation features in the vacuum corrected sample
- Detailed characterization of the x-ray beam for a better warp correction

Acknowledgements

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