ESRF | The European Synchrotron

Modelling synchrotron radiation beamlines with OASYS

Transport of photons in a Beamline

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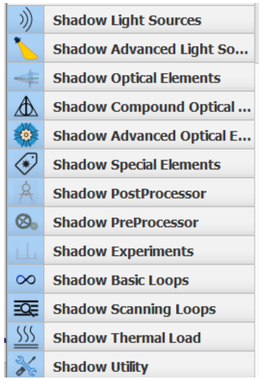

ShadowOui

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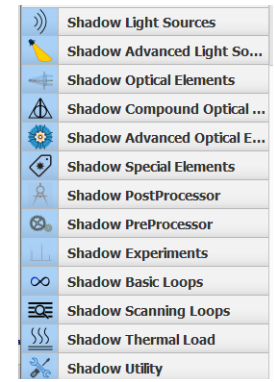
Transport of photons in a Beamline

Outline:

- Introduction to ray tracing
- Simulation of a beamline:
  - Slits and filters/windows
  - Mirror collimation and focusing
  - Crystals
  - Full beamline: Flux and power that arrive to the sample



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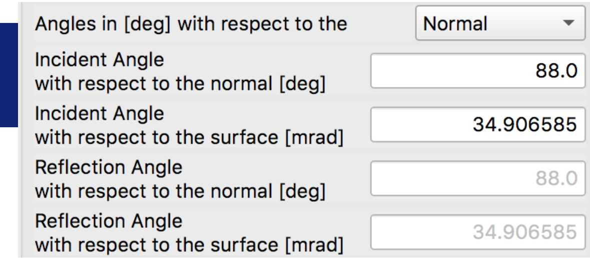
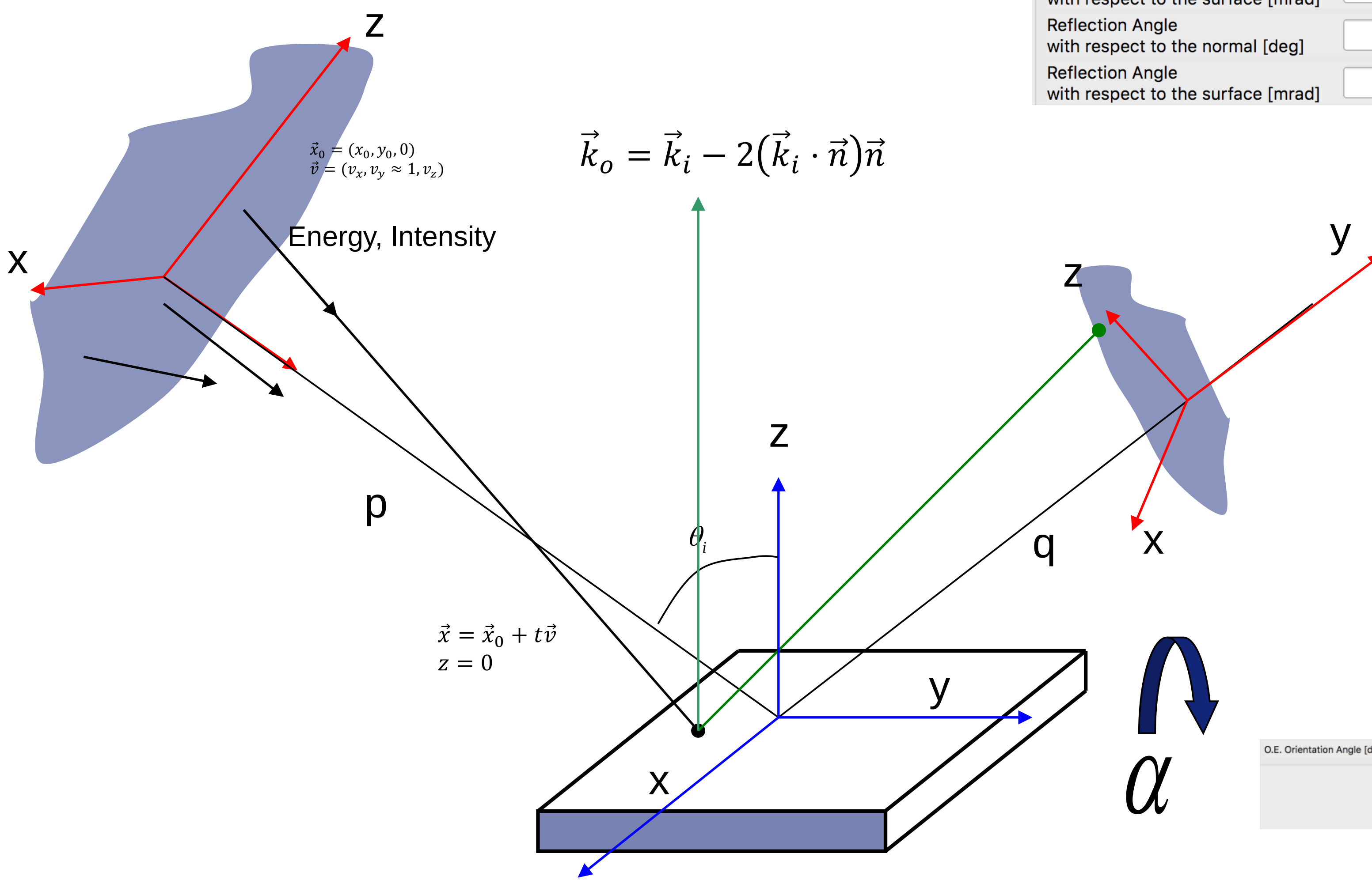
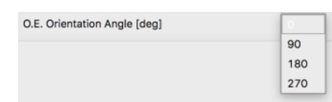
RAY TRACING (SCHEMATIC)







Slits and Filters

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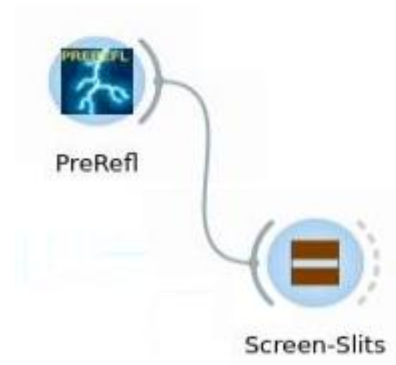
- Distance to the previous element
- Aperture
- Alignment

If filter:

- Type of material
- Thickness



Mirrors

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- Distance to the previous element
- Angle
- Orientation (from the previous element)
- Curvature/Type of mirror
- Coating
- Dimensions
- Slope errors…
- Misalignments…
- Etc…

Crystals

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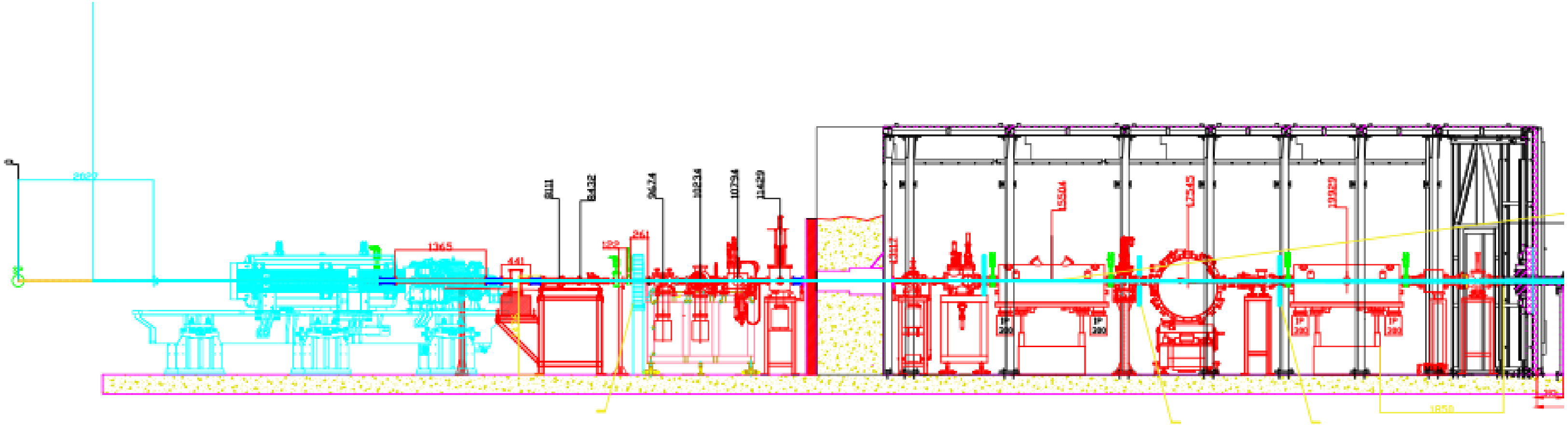
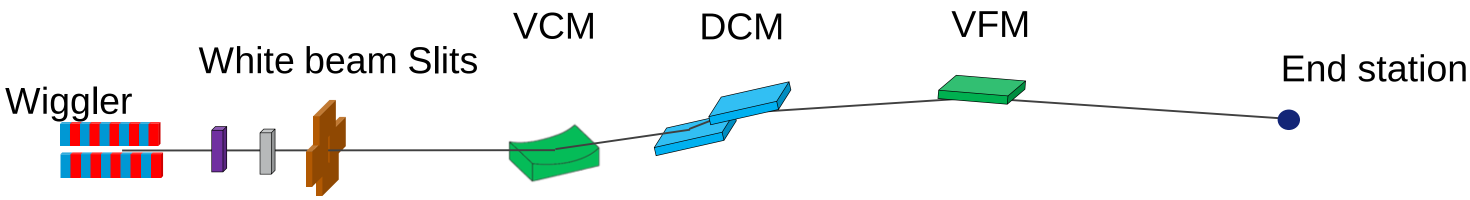
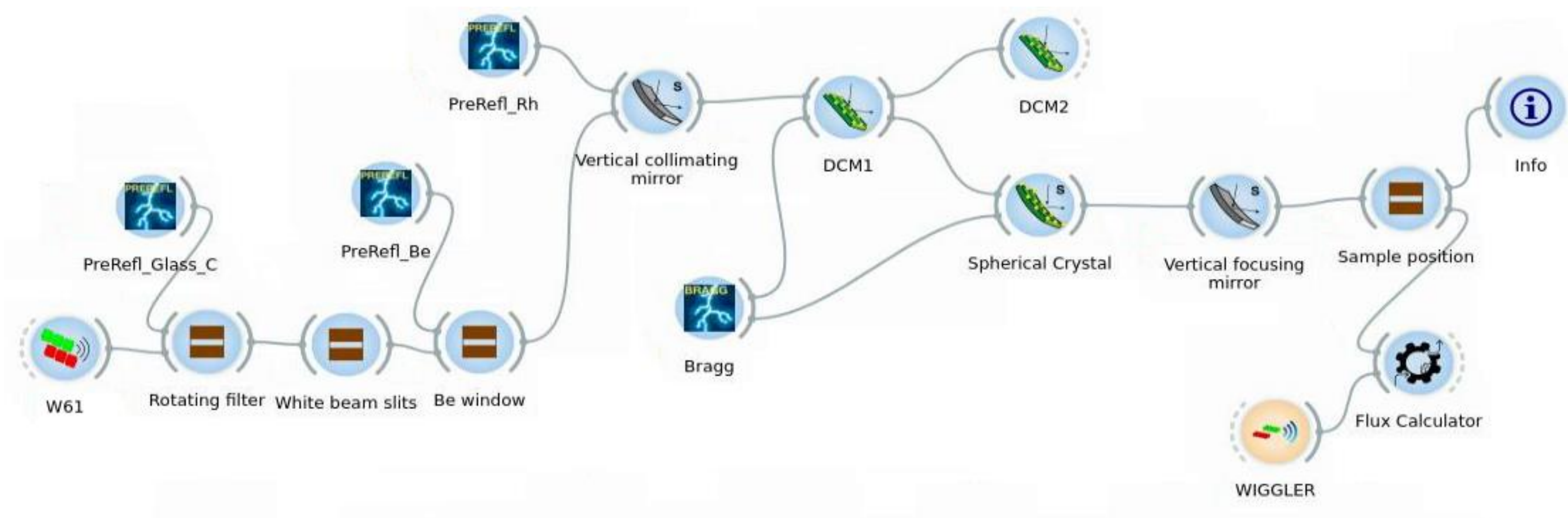
- Distance to the previous element
- Angle (auto defined Bragg angle)
- Orientation (from the previous element)
- Curvature
- Dimensions
- Material and Crystal cut
- Etc…

Ray tracing of SESAME MS



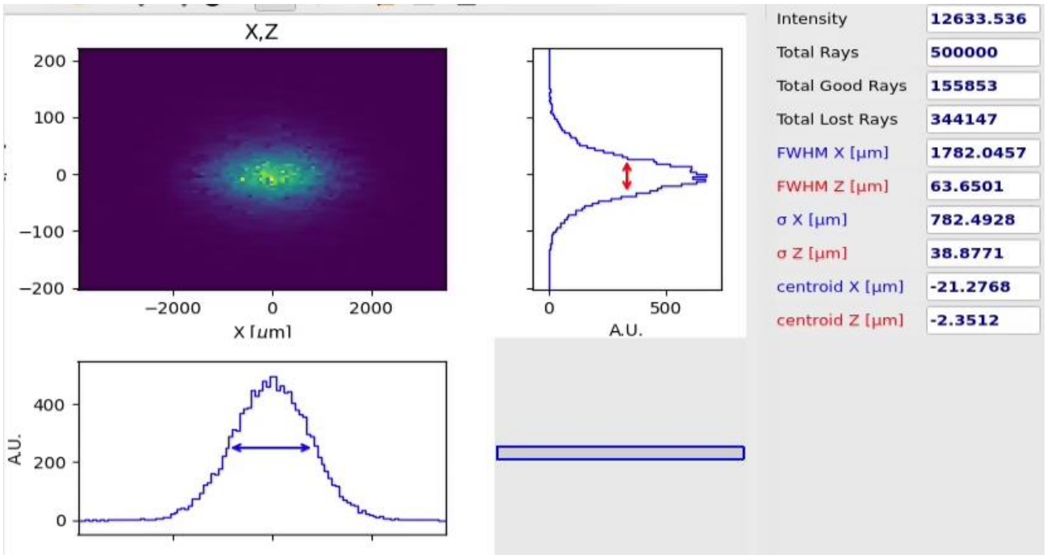


Ray tracing of SESAME MS



Ray tracing of SESAME MS

Flux at 15 keV in the order of 2×10^{13} photons/s



*ideal surfaces

RESOURCES

You have more material here:

- the ShadowOuiTutorial: https://github.com/oasys-kit/ShadowOui-Tutorial
- The OASYS Schools: https://github.com/oasys-kit/oasys_school

We did not treat important issues like:

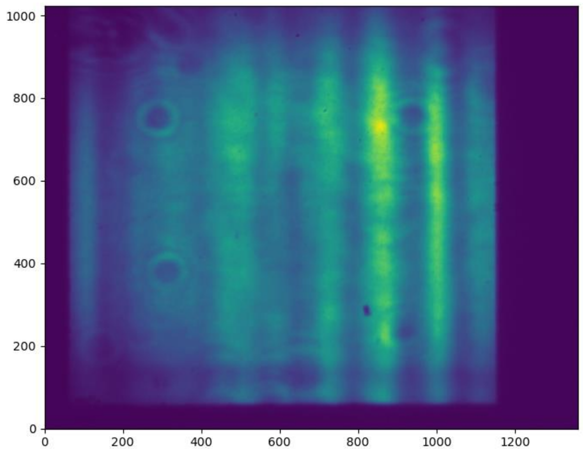
- Surface errors in mirrors [see tutorial example 20]
- Focusing with lenses [CRLs, transfocators] [see tutorial example 24]
- Hybrid ray tracing [to include coherence effects]
- Wave optics calculations using the SRW code

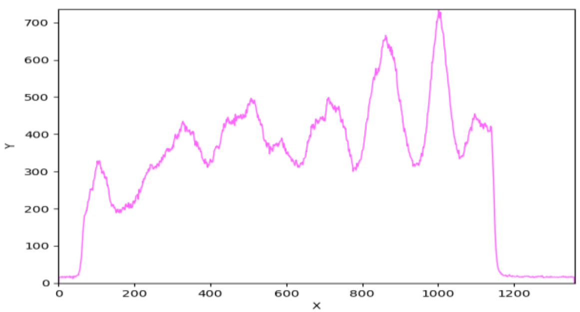
Additional Slides

SLOPE ERRORS

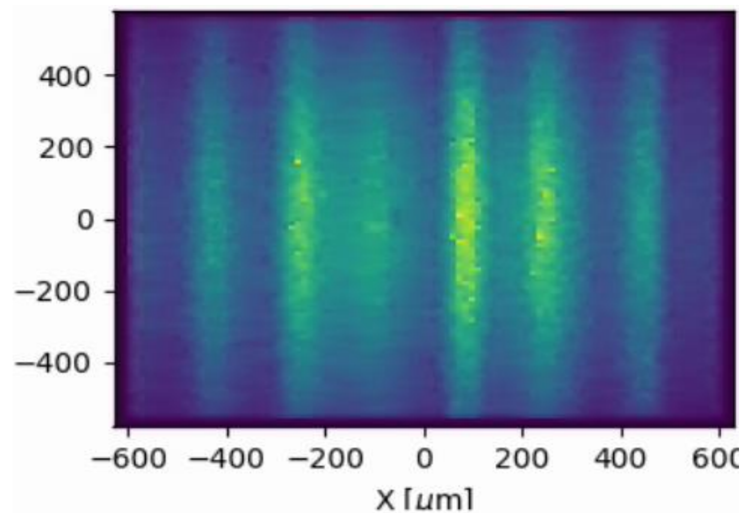
Comparison of simulation and measurements: Unfocused beam profile at the sample position.

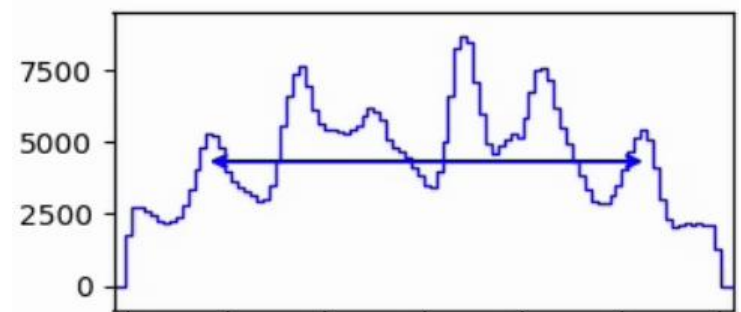
Measurement





Simulation





APPROXIMATING EMISSION AT RESONANCE BY GAUSSIANS

ONUKI & ELLEAUME UNDULATORS, WIGGLERS AND THEIR APPLICATIONS, CRC PRESS, 2002

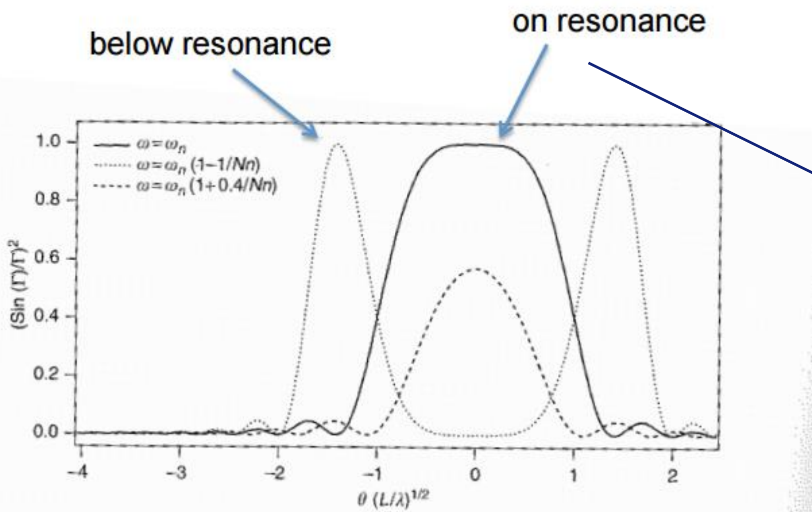


Figure 3.3 Graph of $(\sin(\Gamma)/\Gamma)^2$ as a function of the angle $\theta = \sqrt{\theta_x^2 + \theta_z^2}$ for three different frequencies. ω_n is an abbreviation for $n\omega_1\,(0, 0)$.

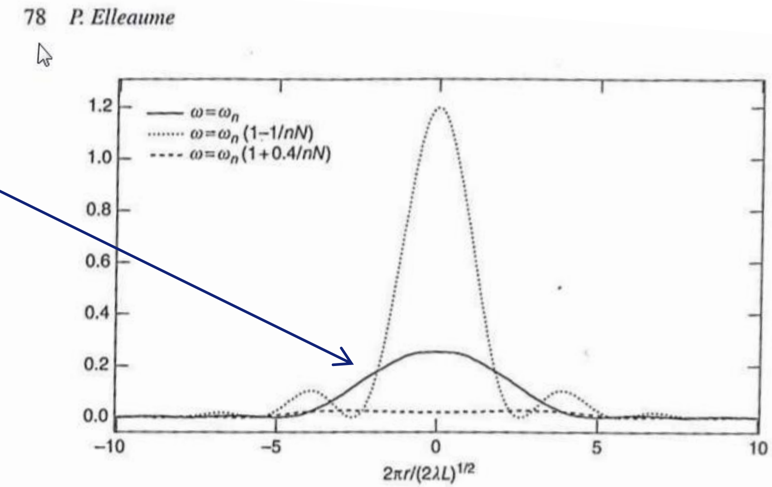


Figure 3.4 Spectral flux per unit surface in the middle of the undulator for three frequencies close to the on-axis resonant frequency $\omega_n = n\omega_1(0, 0)$.

Even on resonance, beam is not fully Gaussian
But for resonance, can be reasonably approximated as Gaussian

$$\sigma_r = \frac{2.704}{4\pi}\sqrt{\lambda L} \approx \sqrt{\frac{\lambda L}{2\pi^2}}$$

$$\sigma_{r'} = 0.69\sqrt{\frac{\lambda}{L}} \approx \sqrt{\frac{\lambda}{2L}}$$

$$\sigma_r \sigma_{r'} = \frac{1.89\lambda}{4\pi} \approx \frac{\lambda}{2\pi}$$

Undulator radiation approximated by Gaussians (at resonances) are not Fourier pairs (like beams following the Gaussian Shell-model)