ESRF | The European Synchrotron

Modelling synchrotron radiation beamlines with OASYS

Transport of power in a Beamline

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June 8th 2023

Transport of power in a Beamline

Outline:

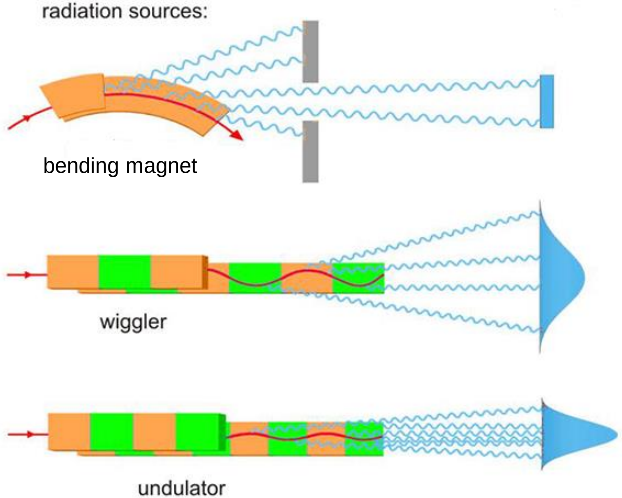
- Source emission: Flux and power spectra.
- Optical elements: characteristics and absorbed power.
- Flux and power that arrive to the sample

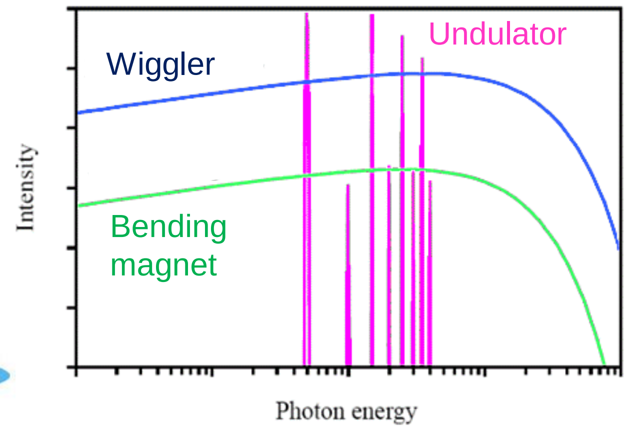
XOPPY

Simulation of source emission

- Source spectrum (Photon flux or power vs Energy)

XOPPY





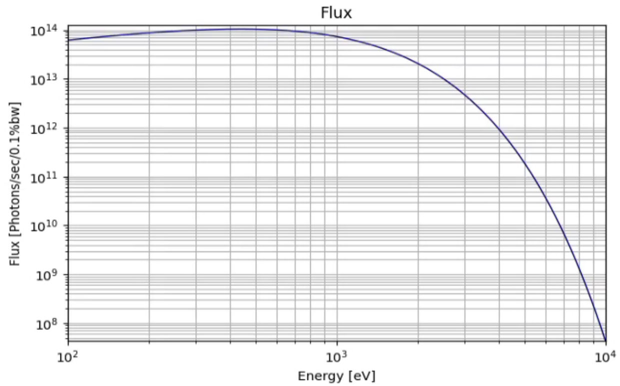
INPUT FOR THE SIMULATIONS

Electron beam parameters

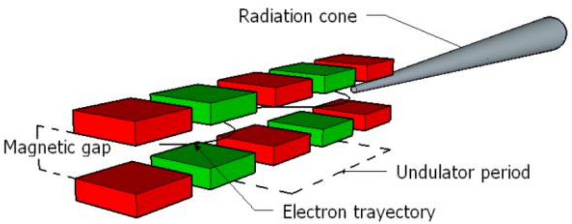
XOPPY: Sources

Bending magnet or insertion device characteristics

Source spectrum

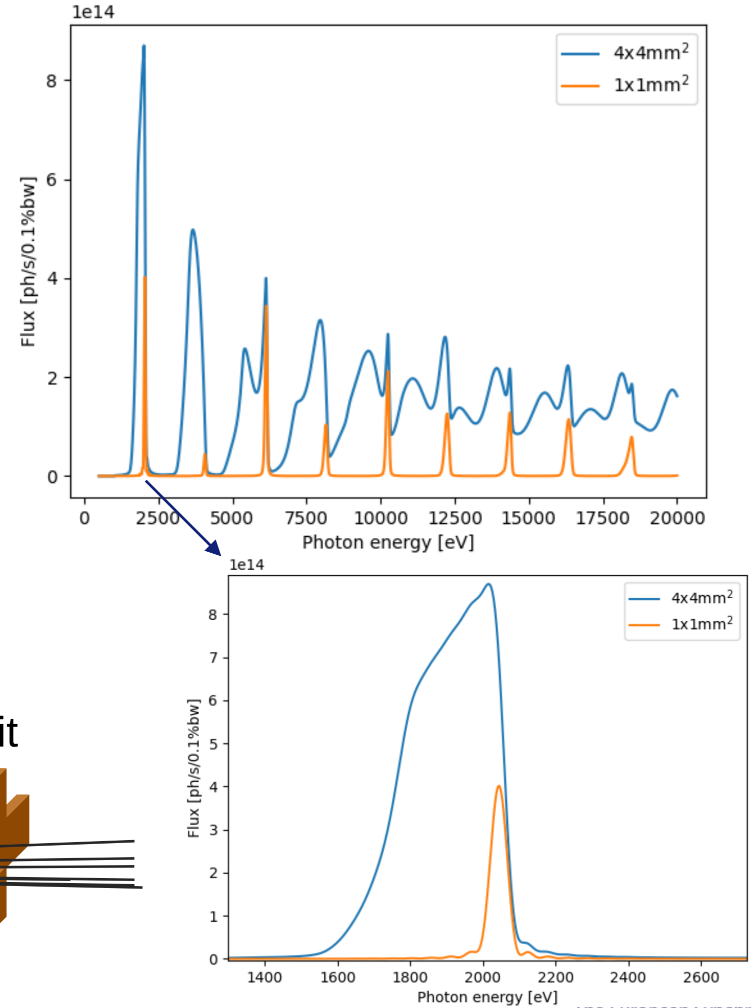


Undulator emission simulation



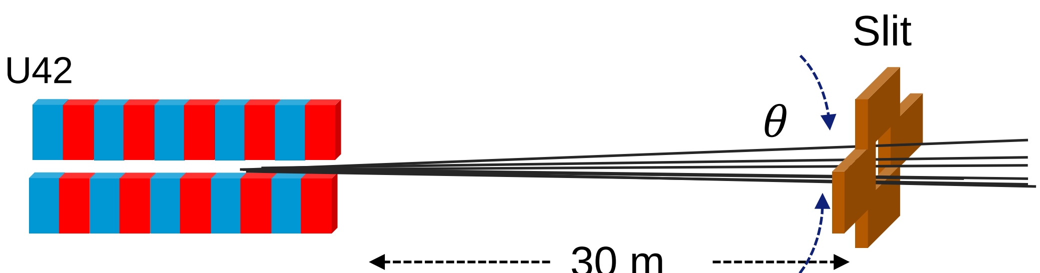
XOPPY

Undulator Spectrum



$$K \equiv \frac{eB_0\lambda_u}{2\pi mc} = 0.9337 B_0[T]\lambda_u[cm]$$

$$\lambda_n = \frac{\lambda_u}{2\gamma^2 n}\left(1 + \frac{K^2}{2} + \gamma^2\boldsymbol{\theta}^2\right)$$



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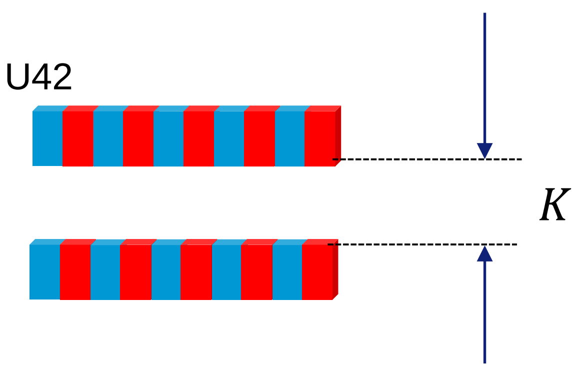
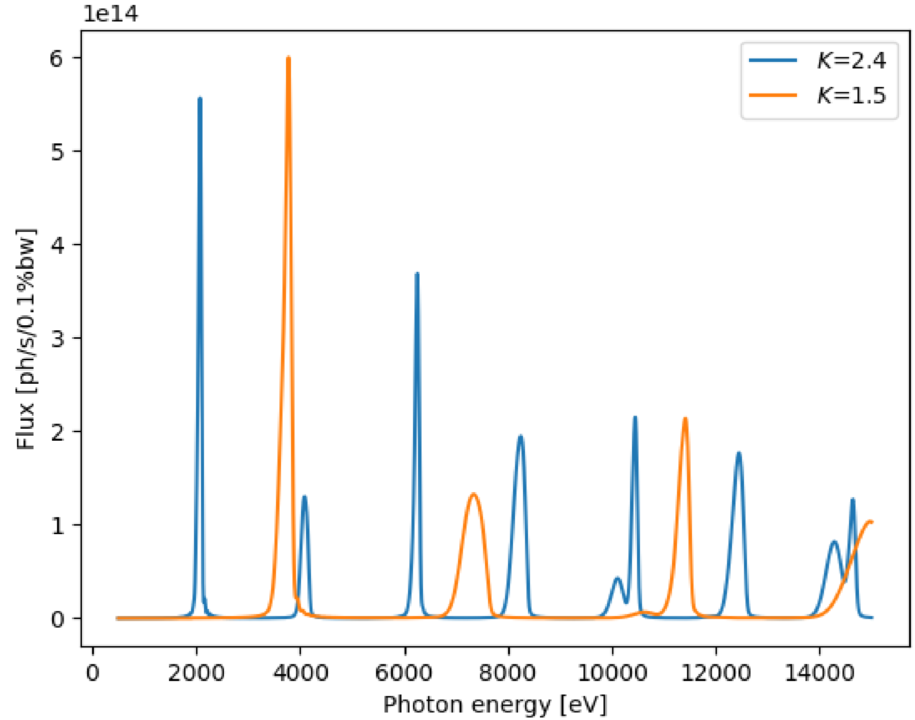
Undulator emission simulation

XOPPY

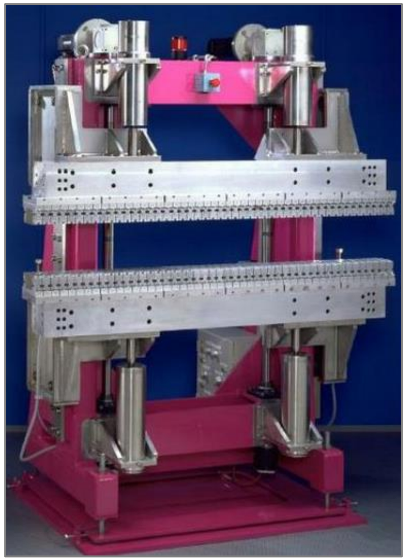
Undulator Spectrum

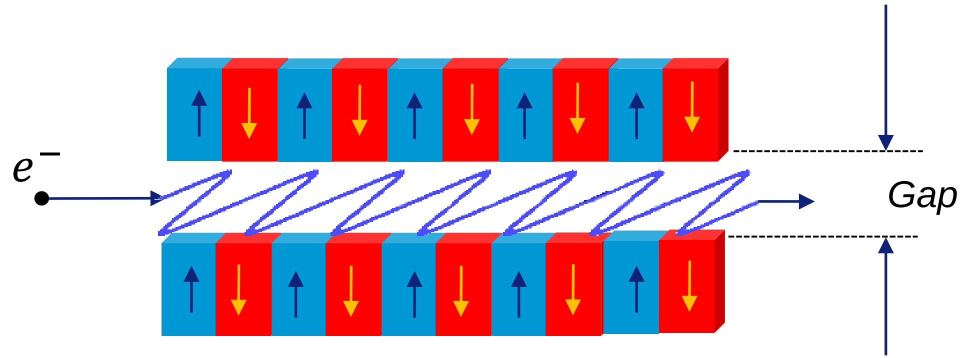
$$\lambda_n = \frac{\lambda_u}{2\gamma^2 n}\left(1 + \frac{\boldsymbol{K}^2}{2} + \gamma^2\theta^2\right)$$





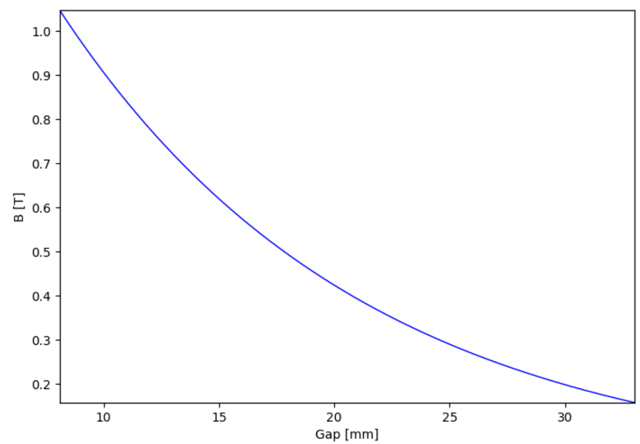
Undulator emission simulation (gap)





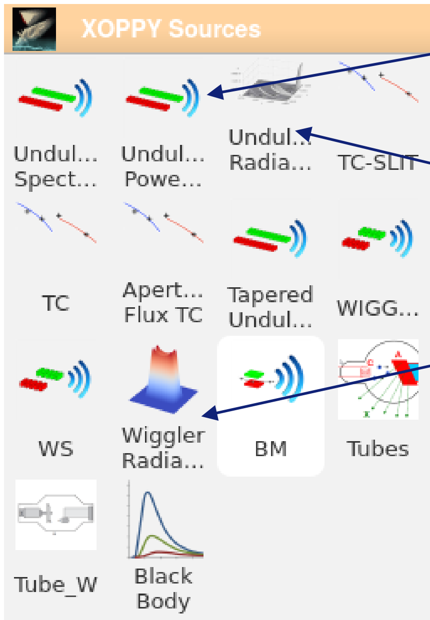
$$K = 0.9337 B_0[T] \lambda_u[cm]$$

ESRF-EBS ID
Light Source



$$B_0 = a * e^{\left(-b\pi * \frac{gap}{\lambda_u}\right)}$$

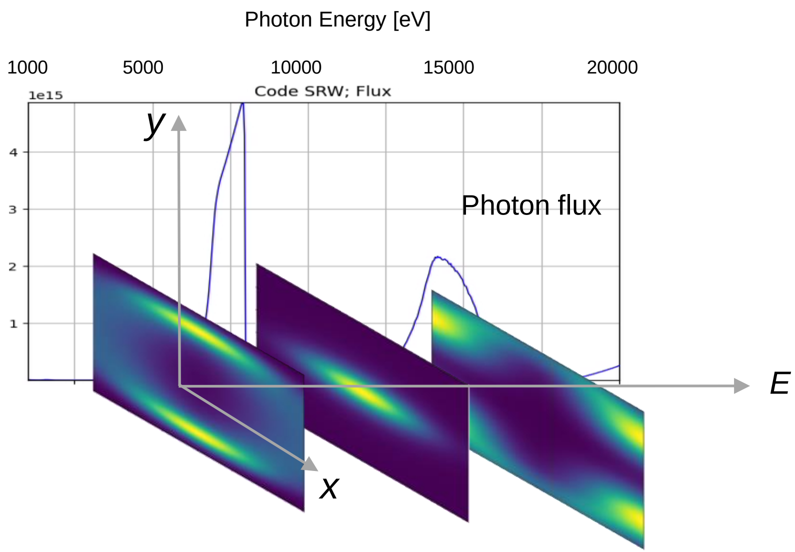
Simulation of source emission



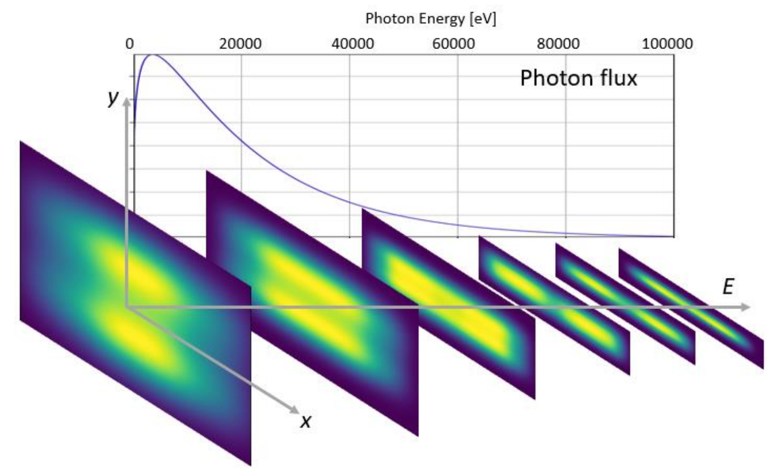
- Undulator power density (*power* vs *x*, *y*)
- Undulator spectral flux density (*flux/power* vs *x*, *y*, *E*)
- Wiggler spectral flux density (*flux/power* vs *x*, *y*, *E)*

Simulation of source emission

Undulator spectral flux density
(*flux/power* vs *x, y, E*)

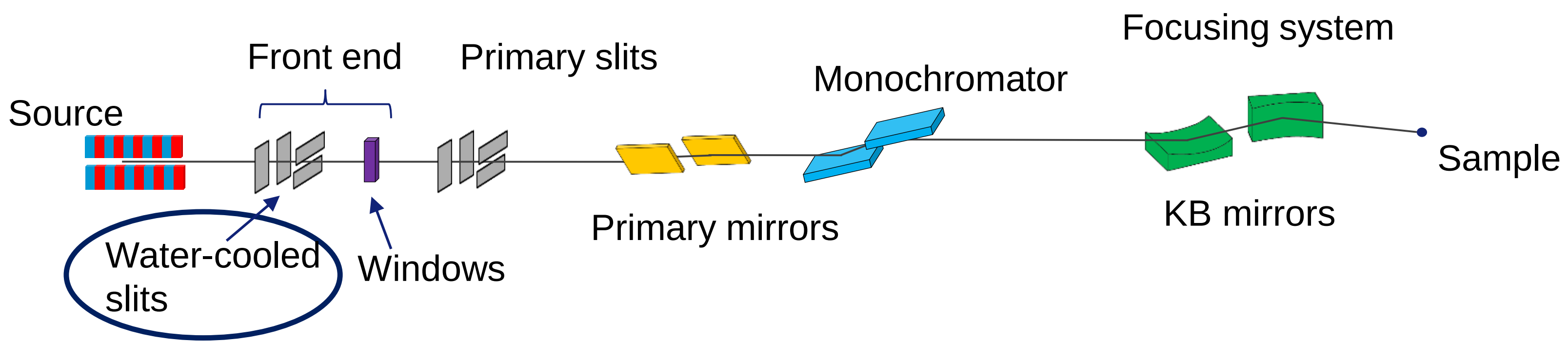


Wiggler spectral flux density
(*flux/power* vs *x, y, E*)



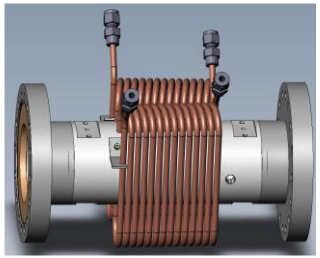
Power transport on a beamline

Optical components that could be present in a beamline:



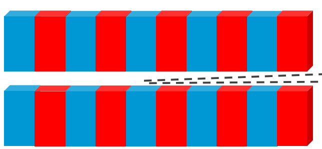
Undulator power density (*Power* vs *x, y*)

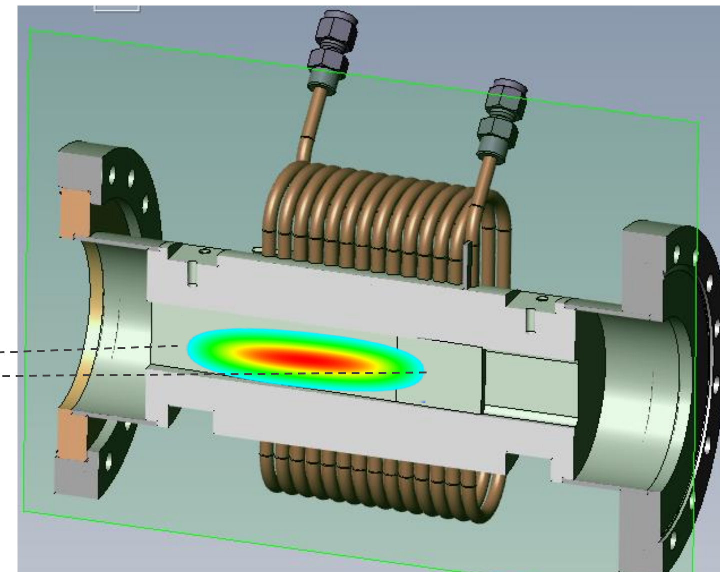
For example, this tool is very useful to get the heat load on a slit:



Water cooled
beamline slit

undulator



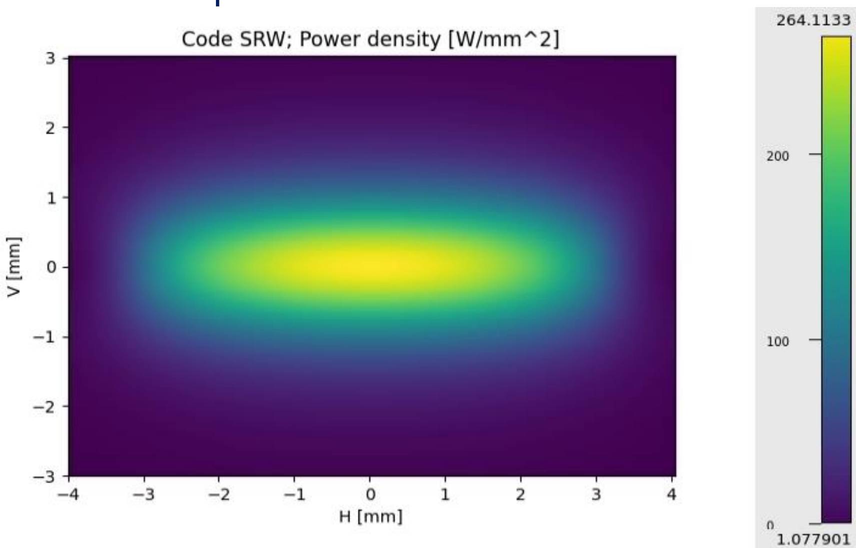


Undulator power density (*Power* vs *x, y*)

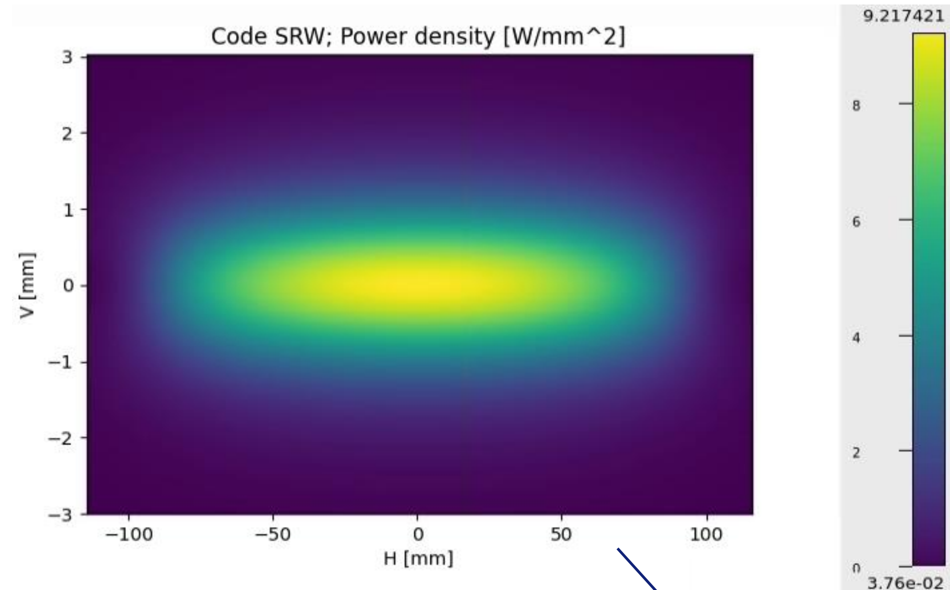
Undulator Power Density

In most of the beamlines at the ESRF the are horizontal slits at 16 m from the source:

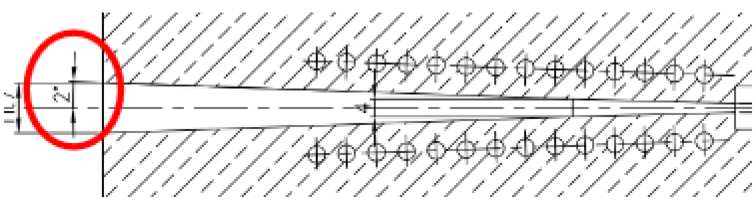
Perpendicular to the beam



Project over the slit surface (2º angle)



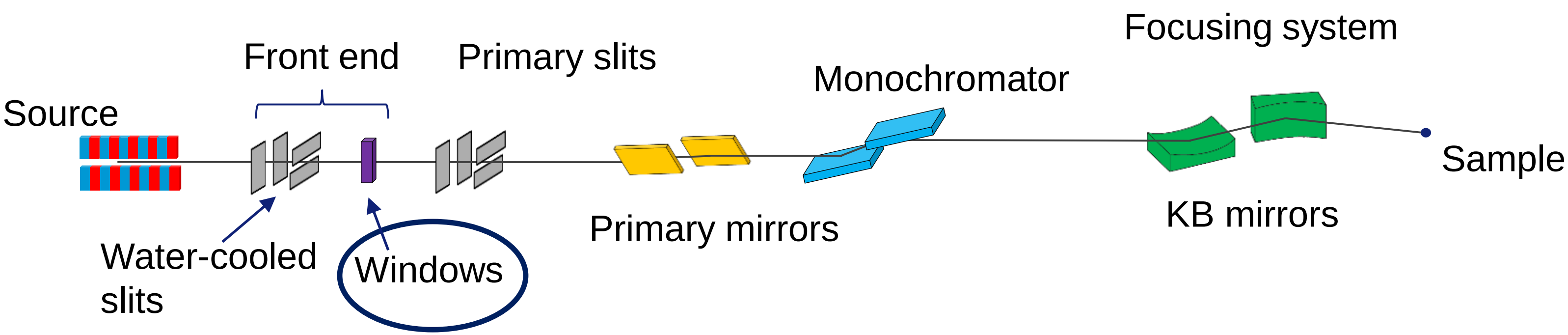
X-ray beam

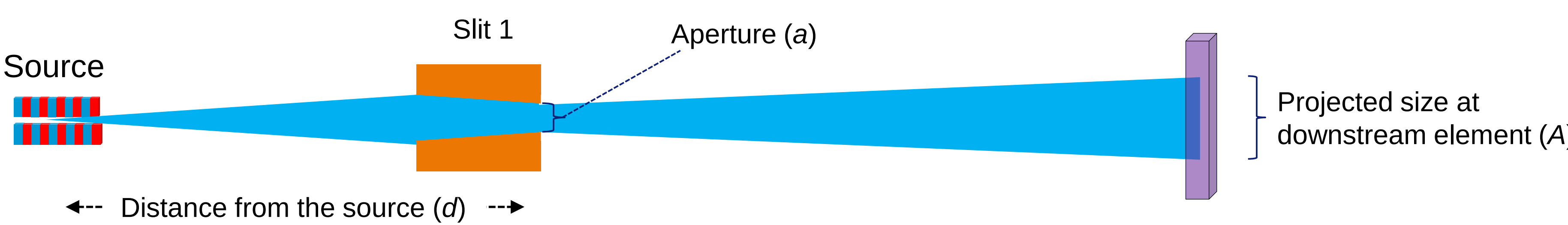


Finite element analysis

Power transport on a beamline

Optical components that could be present in a beamline:

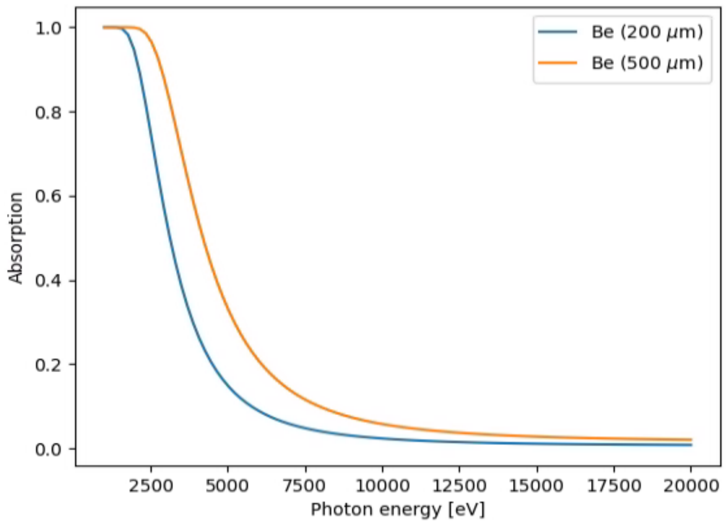




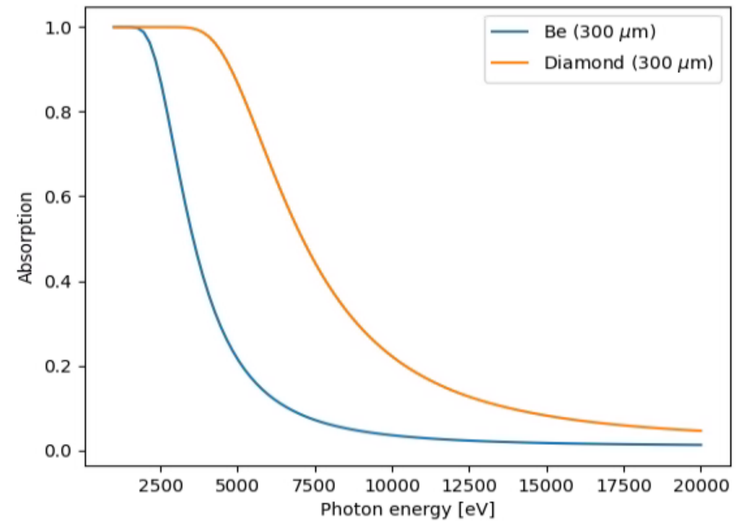
$$A = \frac{D}{d} a$$

Filter (window) absorption

Filters of different thickness

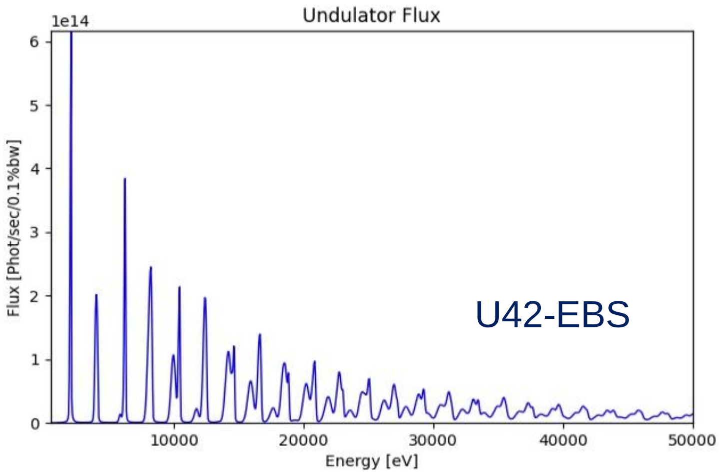


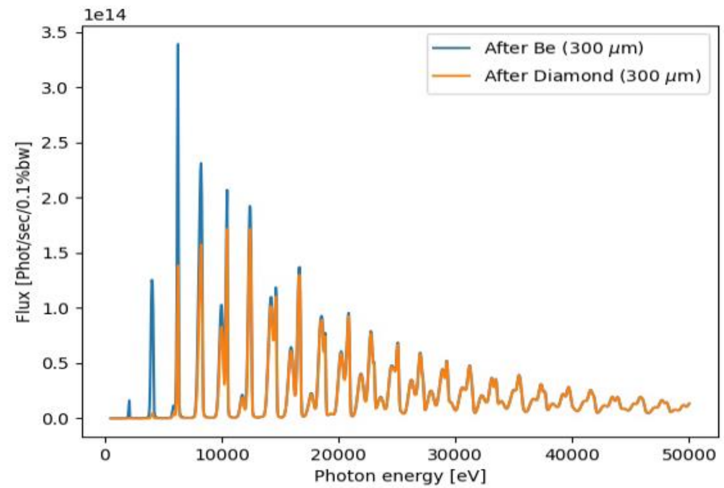
Filters of different materials

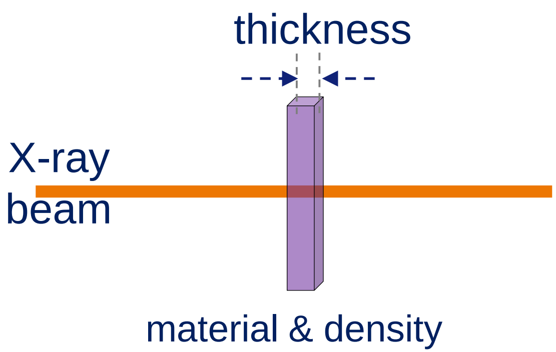


Power absorbed by a filter

Heat load on filters @ 23 m with a projection of 2 mm x 1 mm:







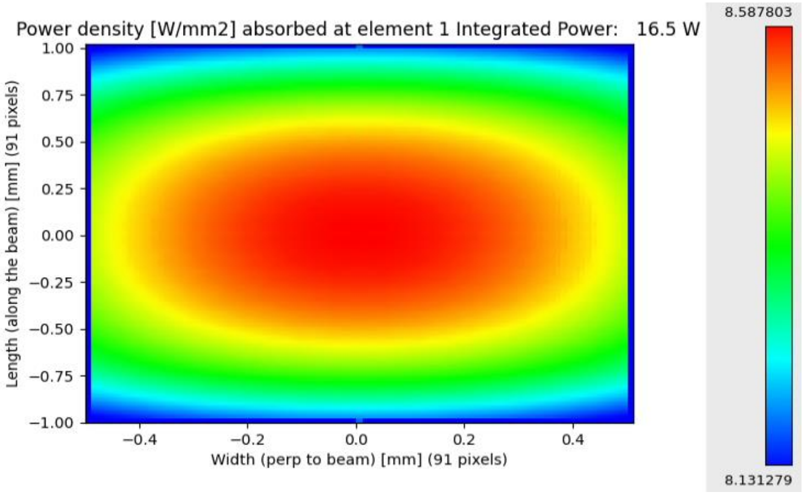
Material	Thickness [μm]	Absorbed Power [W]
Be	300	19
Diamond	300	40

Power absorbed by a filter

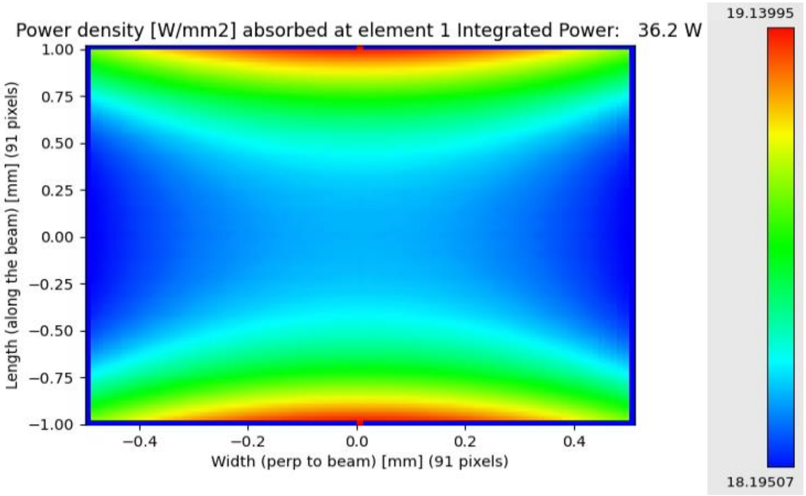
Heat load on filters @ 23 m with a projection of 2 mm x 1 mm:

SRCALC-IDPOWER

Be (300 μm)

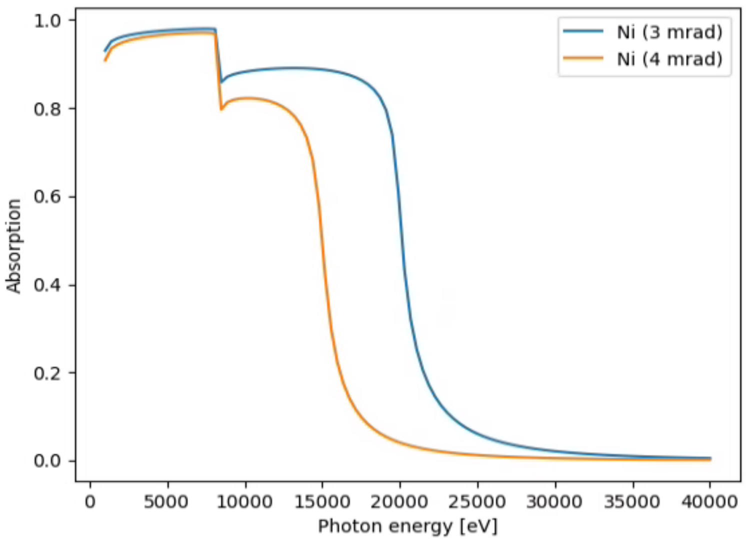


Diamond (300 μm)

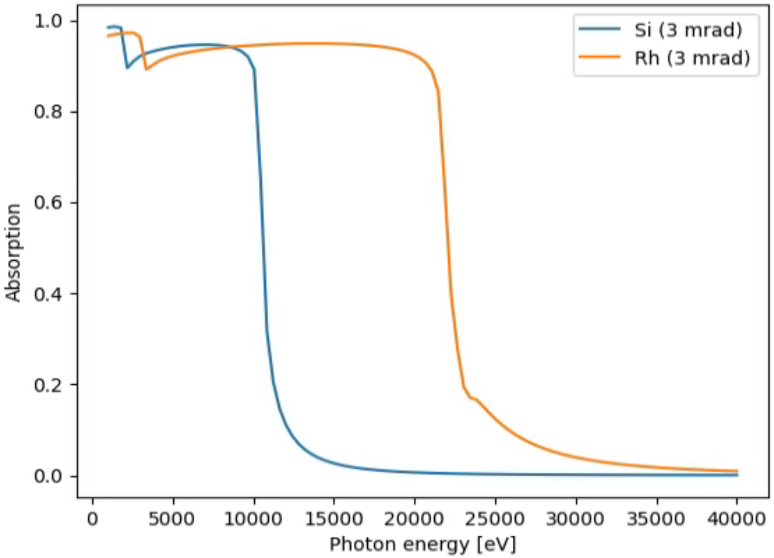


Mirror absorption

Same material, different angles



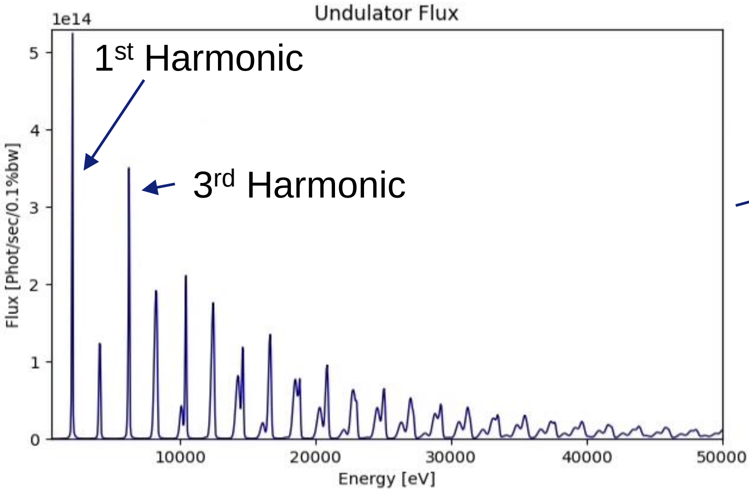
Same angle, different coatings

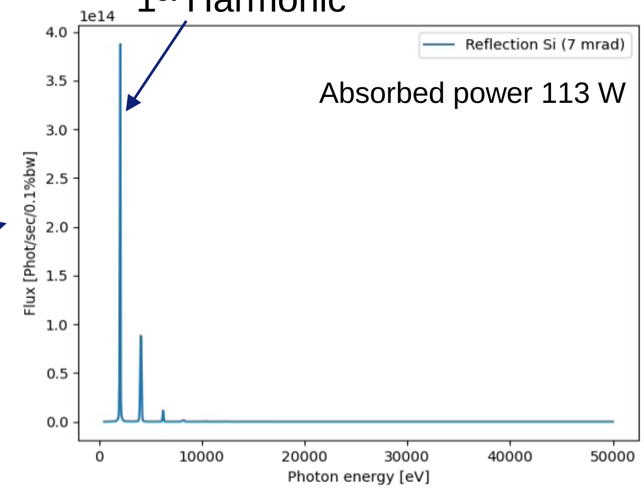


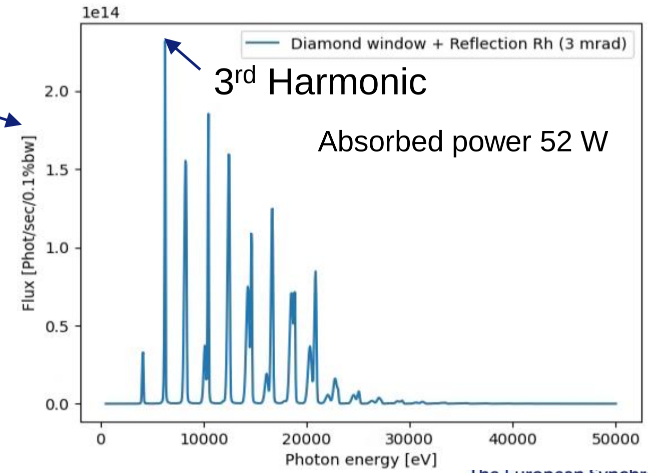
POWER

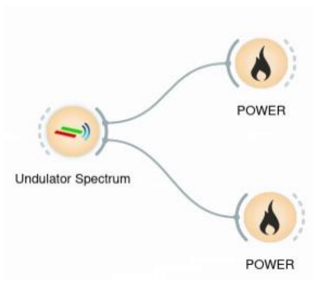
Mirror absorption

Example of reflection, primarily mirrors @ 30 m







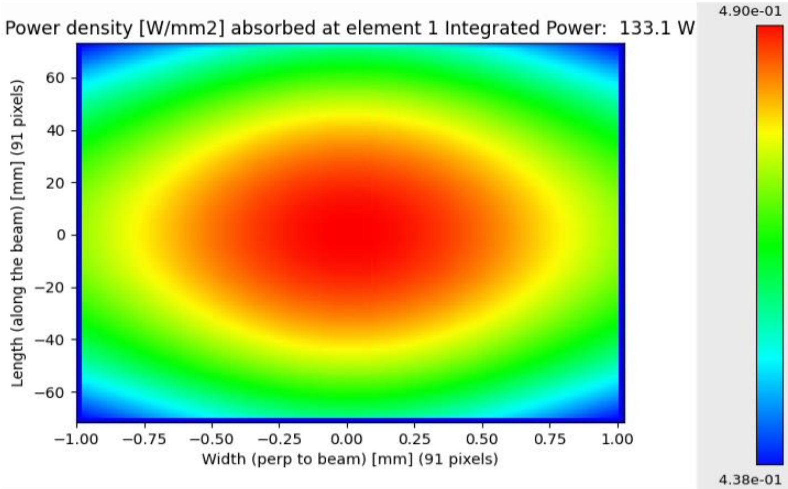


Power absorbed by a mirror

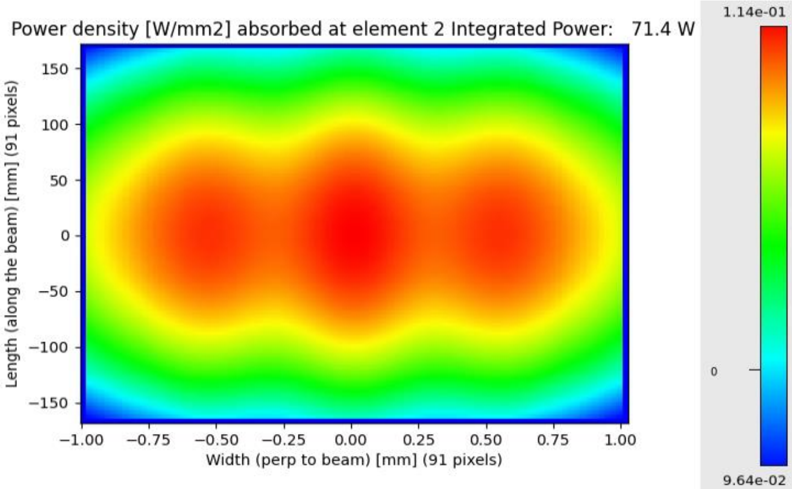
Heat load on mirrors @ 30 m:

SRCALC-IDPOWER

Si (7 mrad)

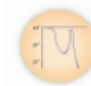


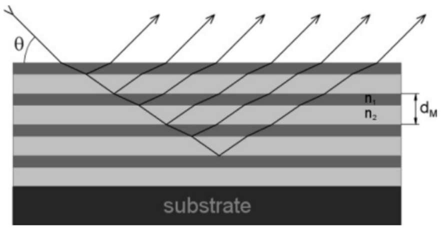
Diamond (100 μm) + Rh (3 mrad)



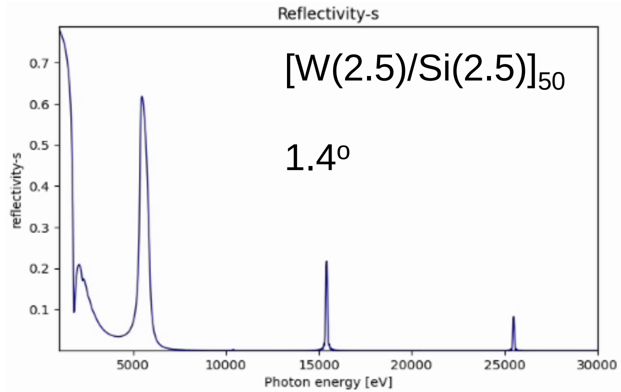
Other optical elements in XOPPY

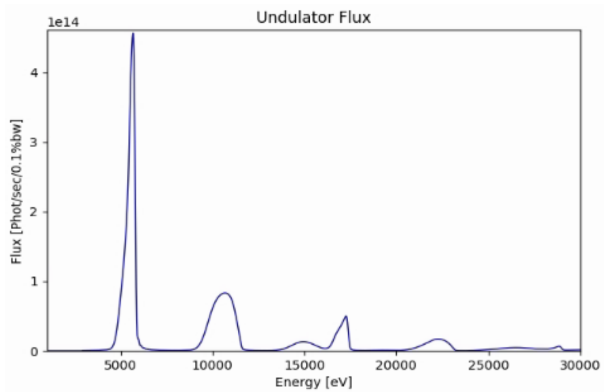
Multilayers

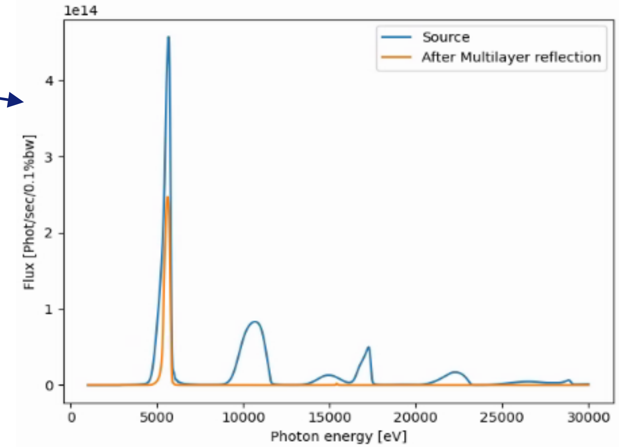




$$m\lambda = 2 d_M sen\theta \sqrt{1 - \frac{2\bar{\delta}}{sen^2\theta}}$$

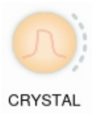




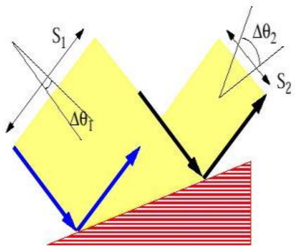


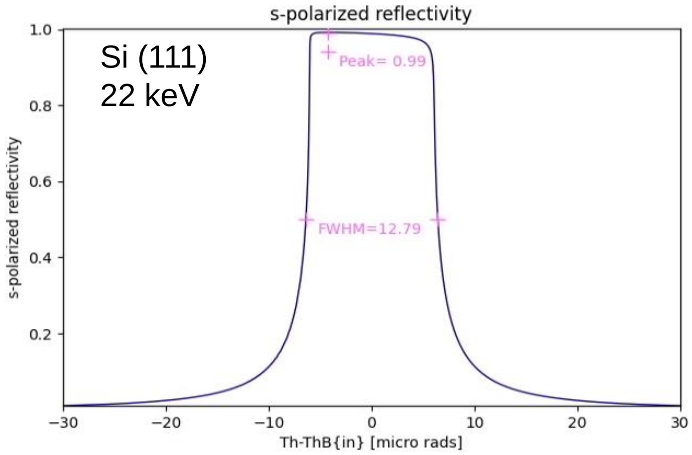
Other optical elements in XOPPY

Crystals

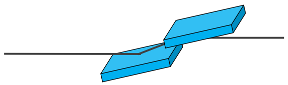


Bragg or reflection

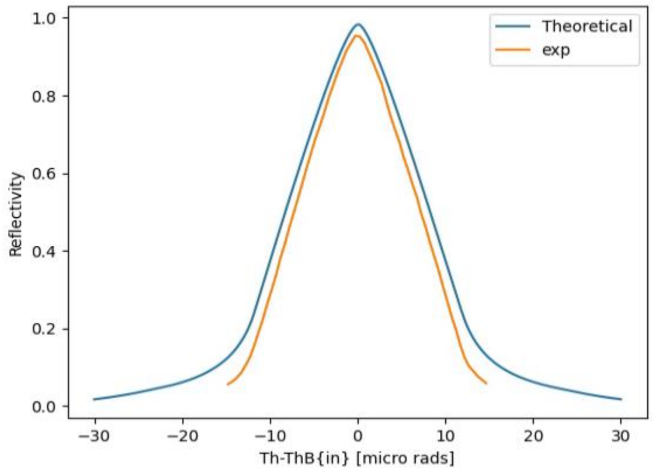




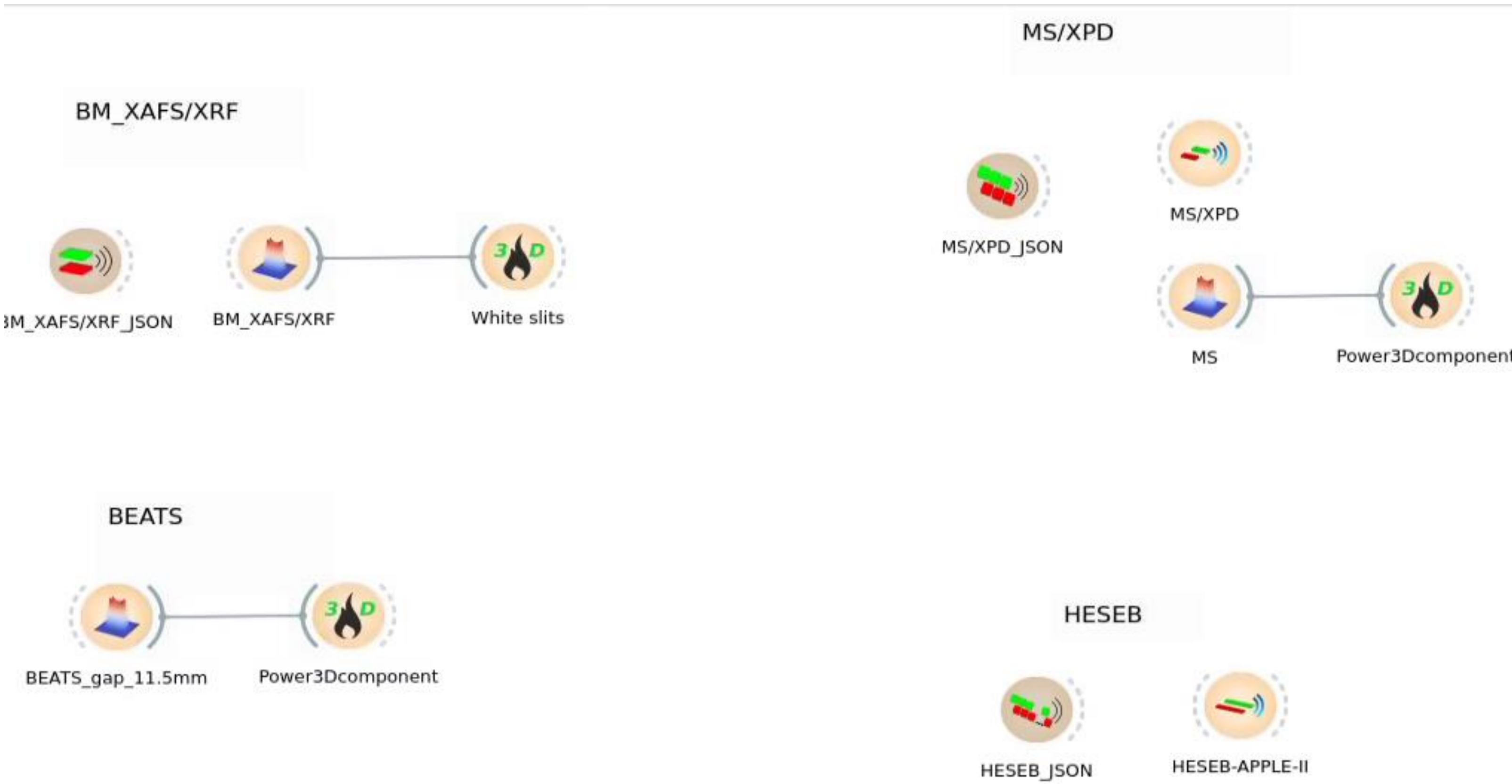
Double crystal monochromator



Rocking curve



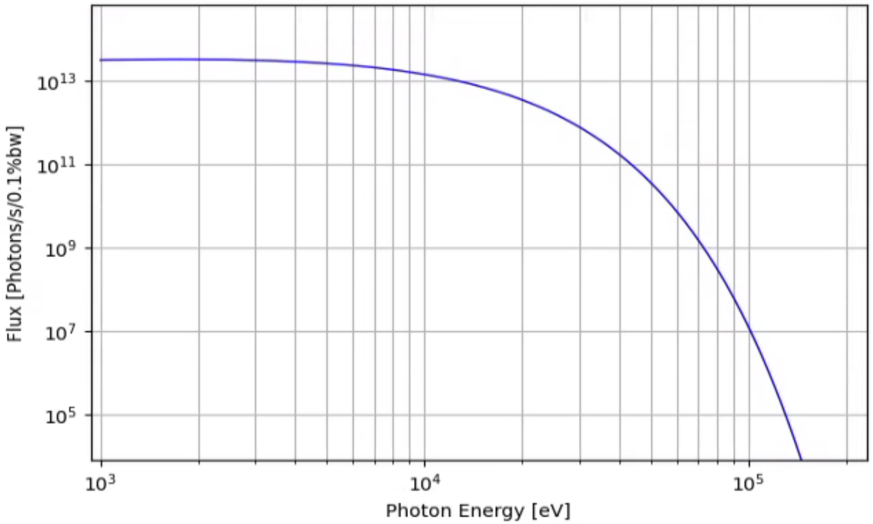
XOPPY FOR SESAME SOURCES



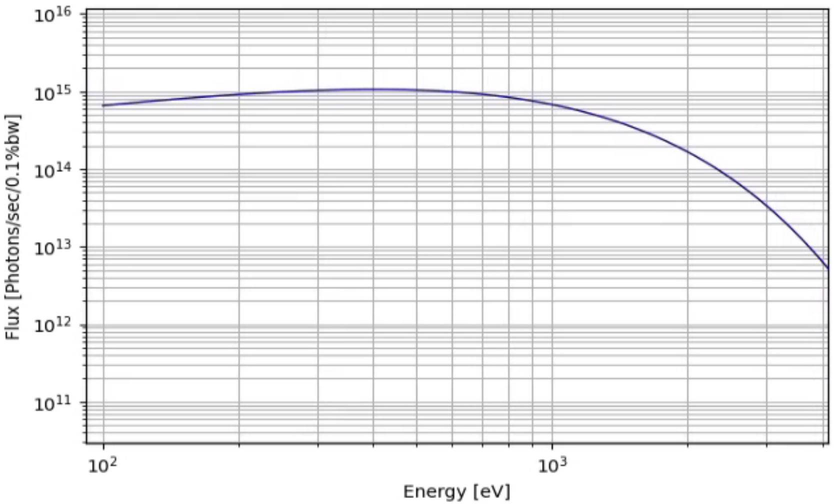
XOPPY FOR SESAME SOURCES

Example: Spectral flux at the white beam slits

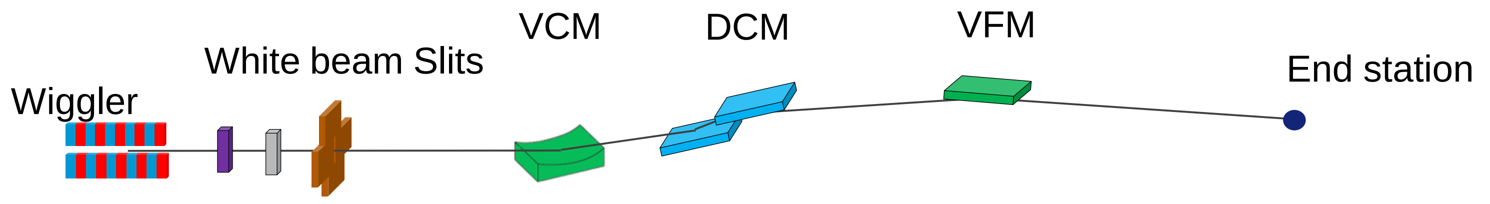
BM
XAFS/XRF

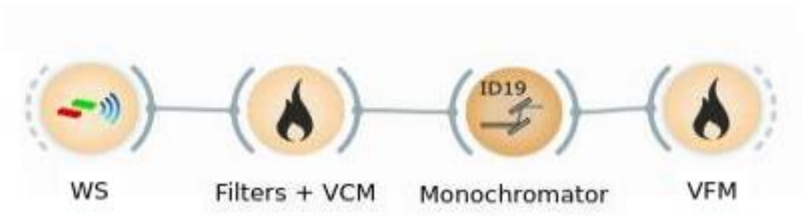


Wiggler
MS/XPD



Flux at sample estimation: SESAME MS



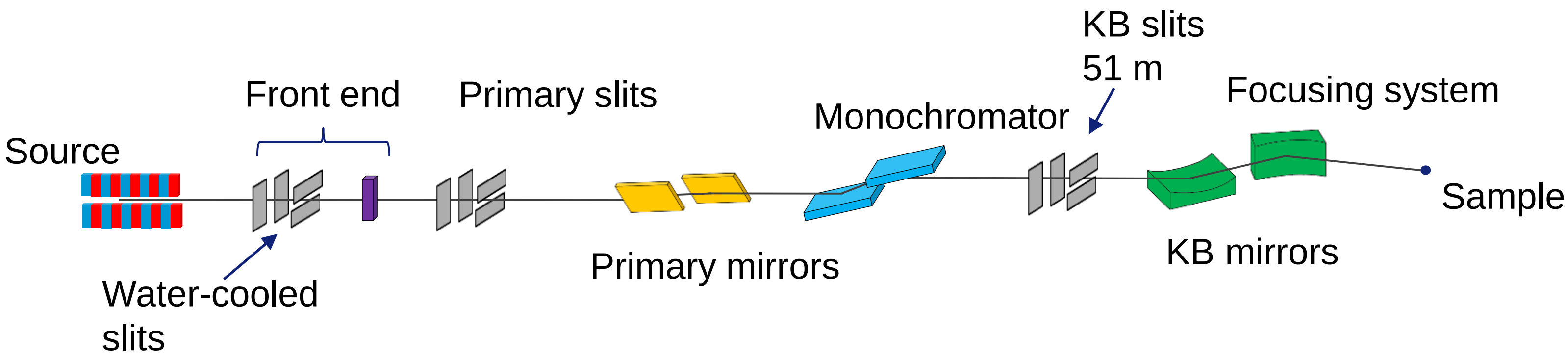


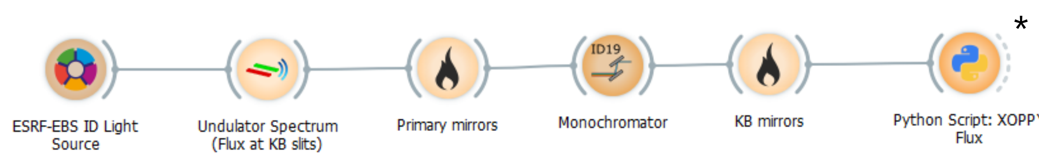
XOPPY

End of First Part

Calculation of flux at the sample position

Example of getting the flux at the sample position:





*see photon transport section

Power transport on a beamline

Optical components that could be present in a beamline: