

Sirepo – software framework for X-ray optics simulations



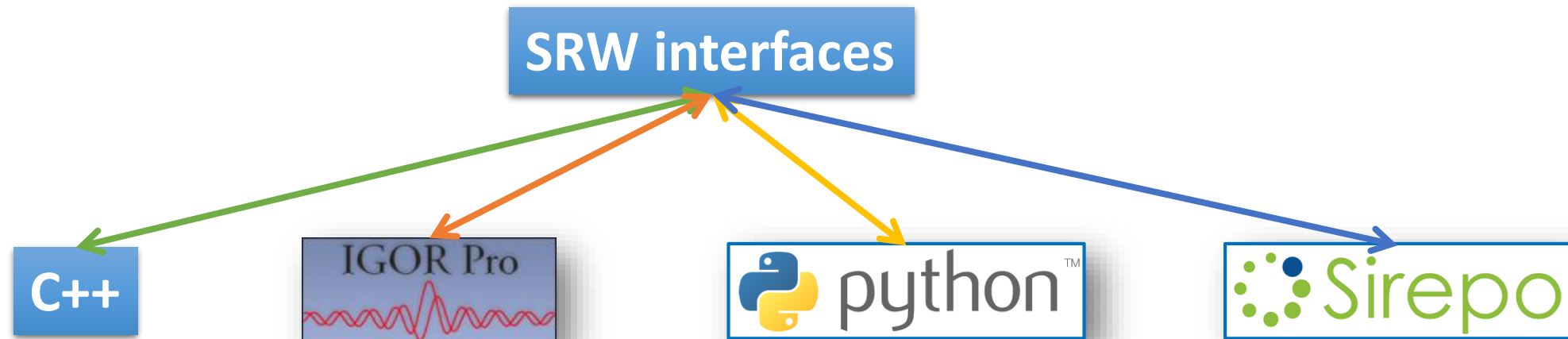
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Introduction

- **Sirepo** – an open-source Python/JavaScript framework for cloud computing
- **SRW** (Synchrotron Radiation Workshop) – allows to simulate synchrotron radiation and wavefront propagation through beamline optics
- SRW is written in C++ and has several interfaces



Distribution & Servers

Distribution:


- Source code:
 - **Sirepo** – <https://github.com/radiasoft/sirepo>
 - **SRW** – <https://github.com/ochubar/SRW>
- Docker containers – <https://hub.docker.com/r/radiasoft/sirepo/tags/>
- Vagrant boxes – <https://atlas.hashicorp.com/radiasoft/boxes/sirepo>

Servers:

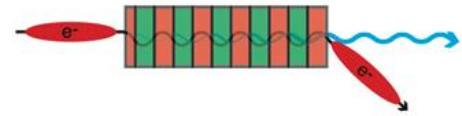
- <https://beta.sirepo.com/light> – globally available
- <https://expdev.nsls2.bnl.gov/light> – behind BNL firewall
- <http://nsls2expdev1.bnl.gov/light> – behind BNL firewall



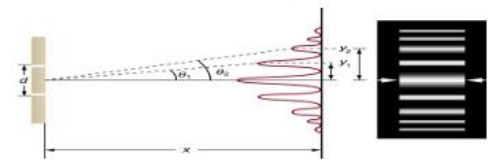
Landing page

 Synchrotron Radiation Workshop


Synchrotron Radiation





Wavefront Propagation



Light Source Facilities

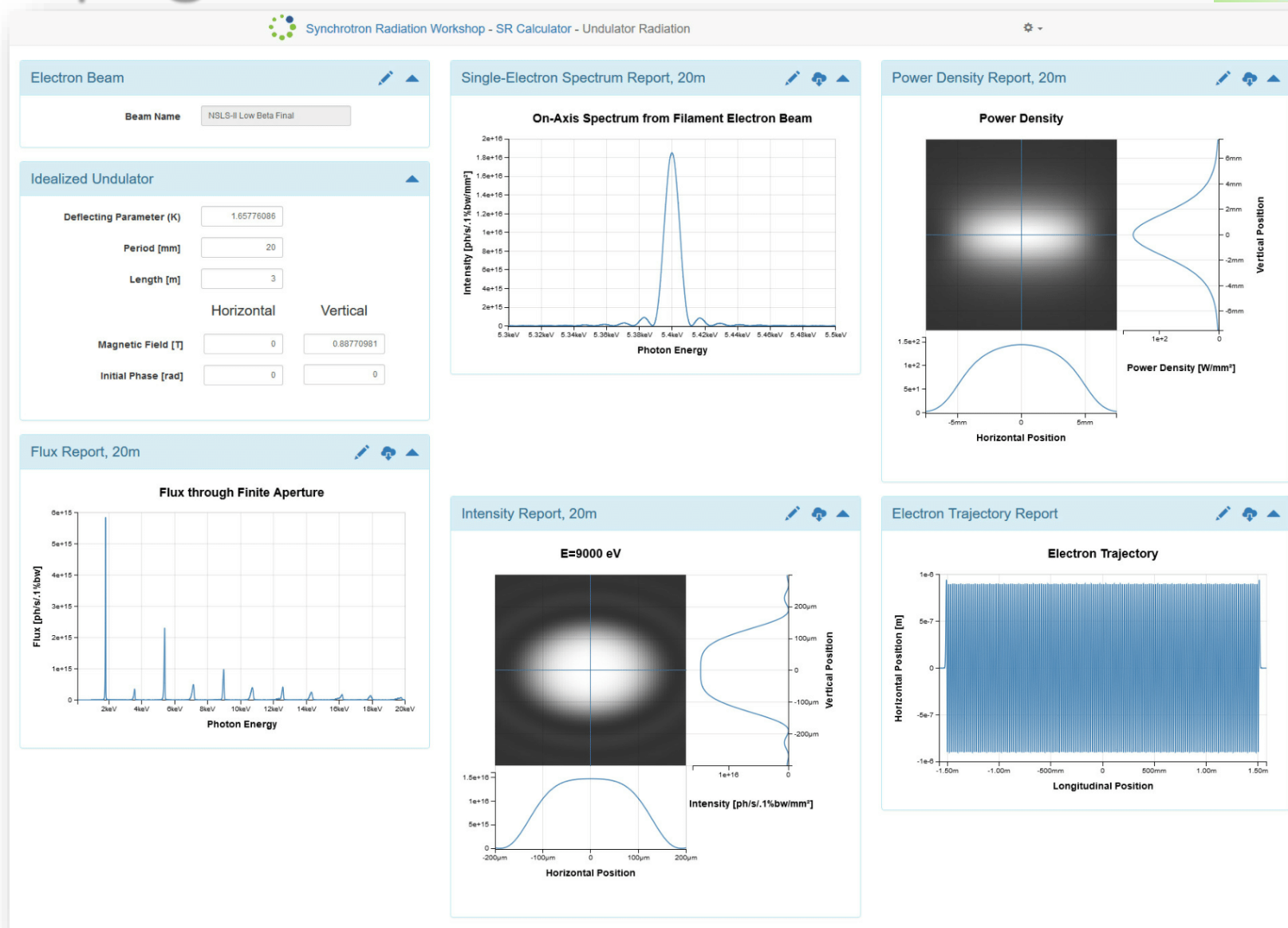


 Expert users only

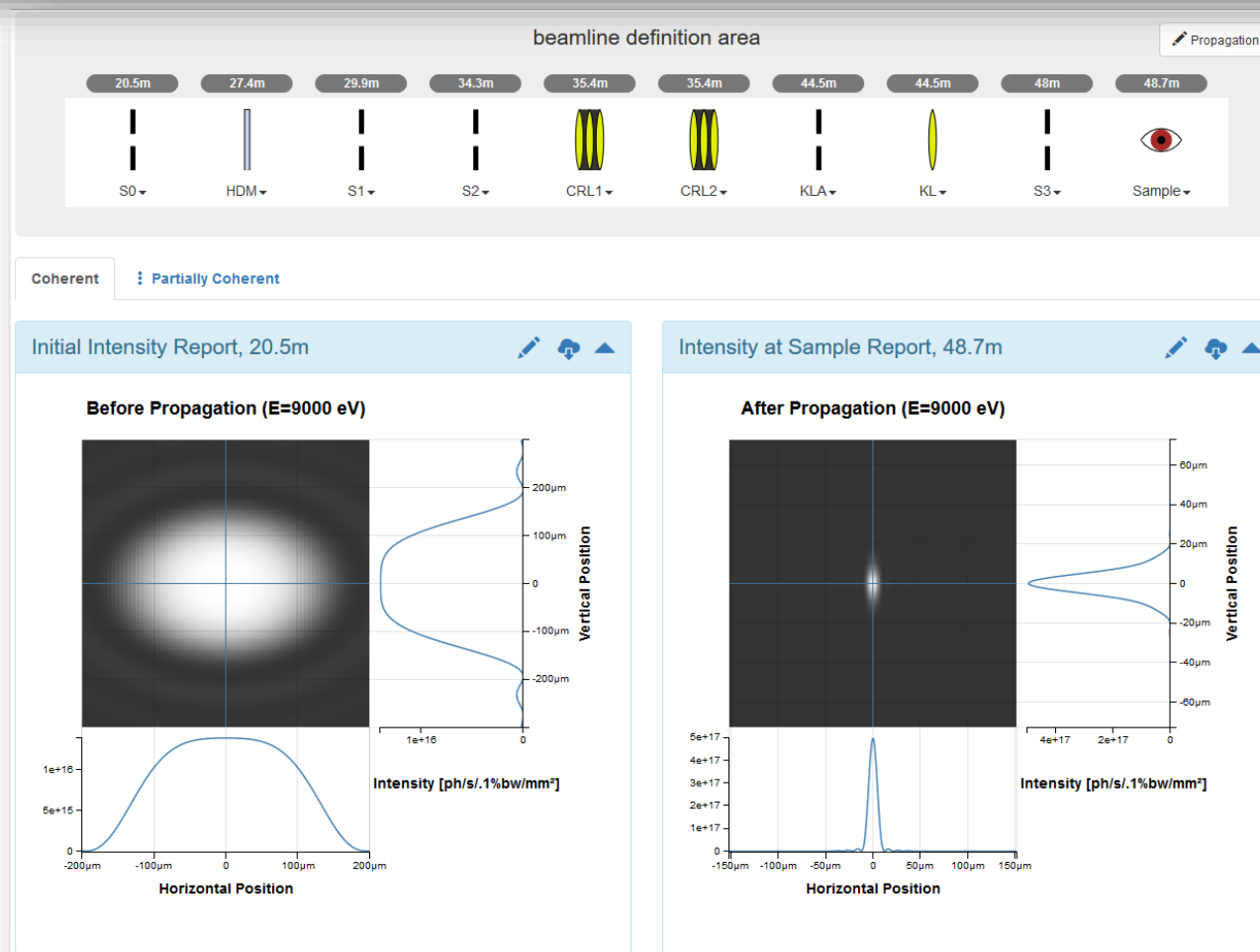
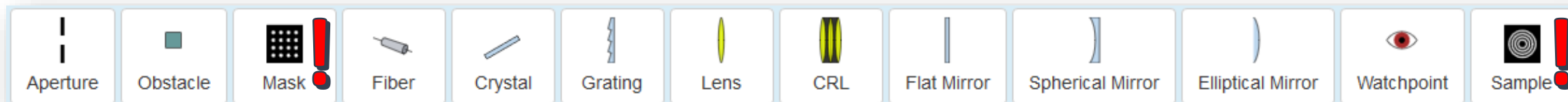




Source page

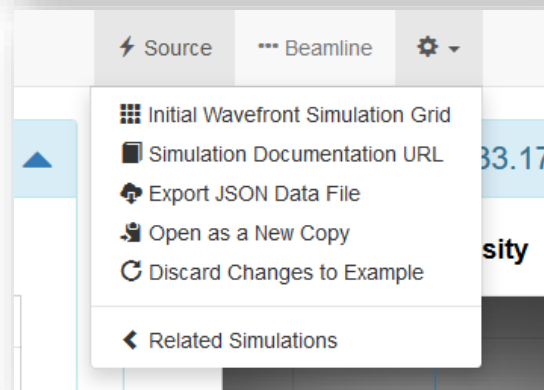
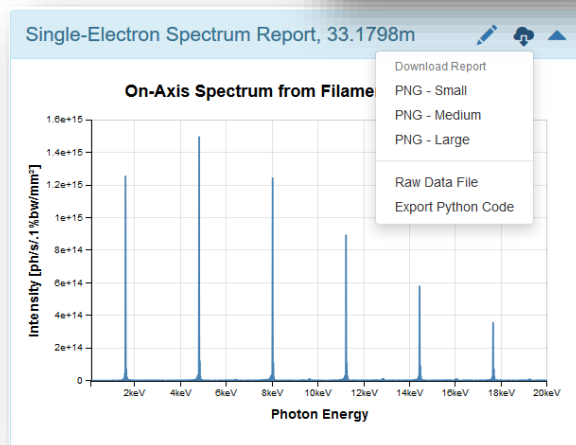


Beamline page

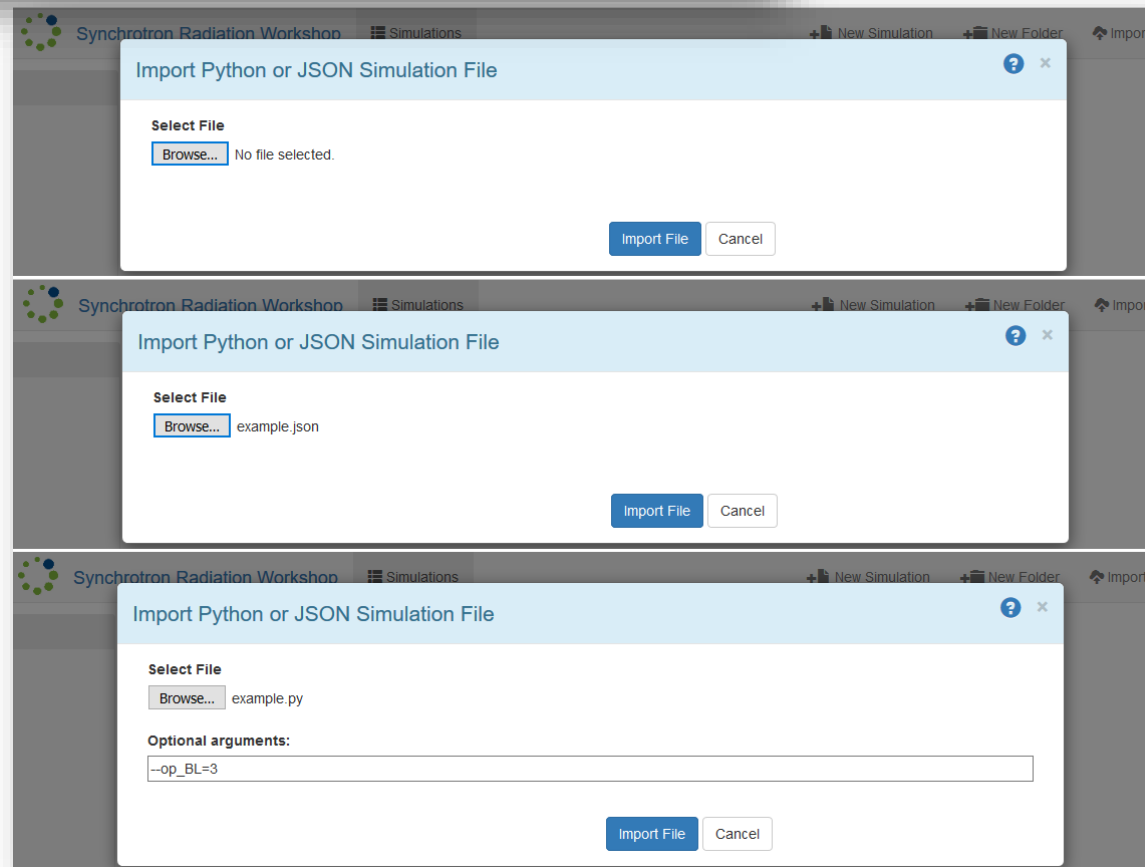


Data storage & exchange

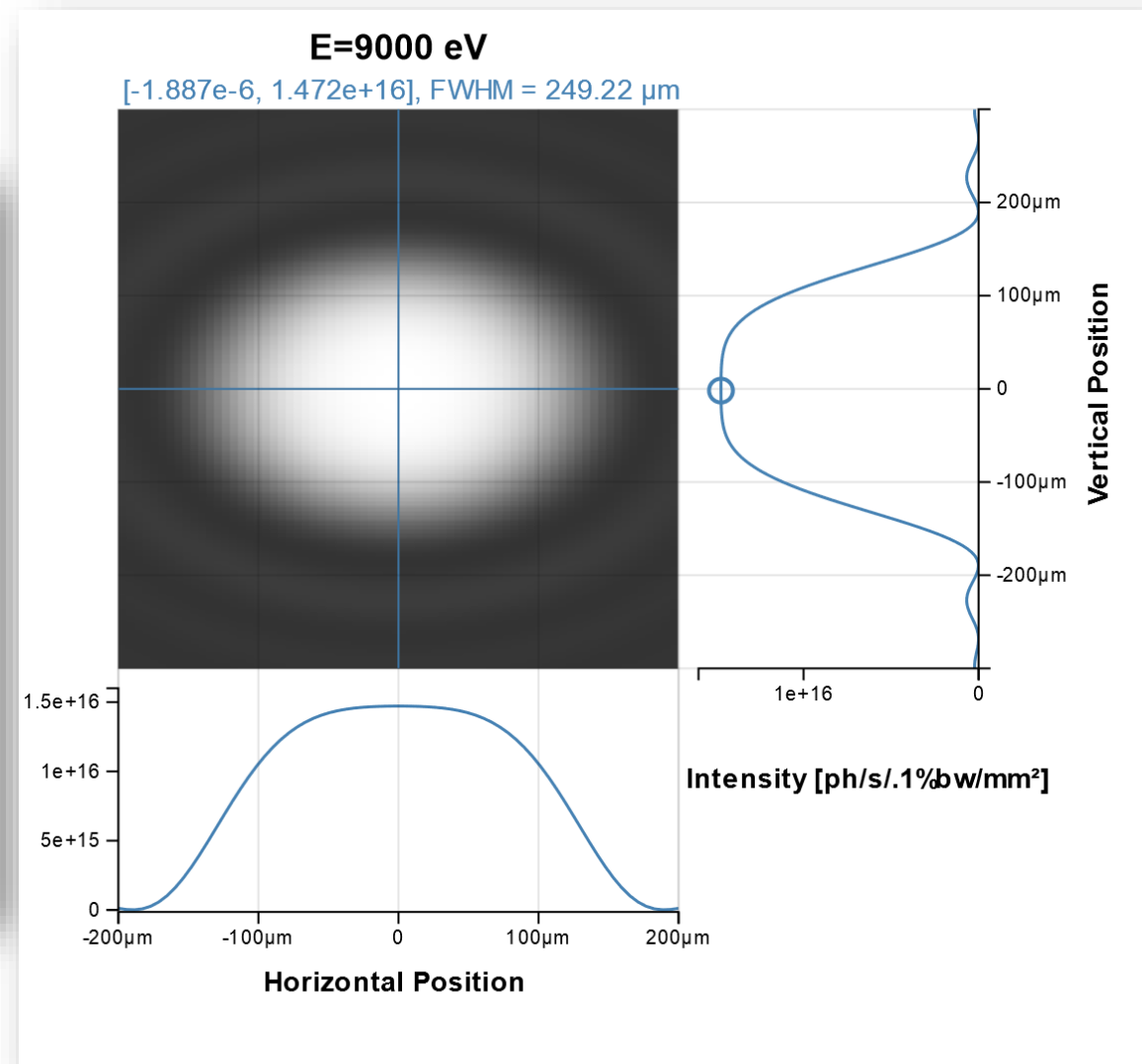
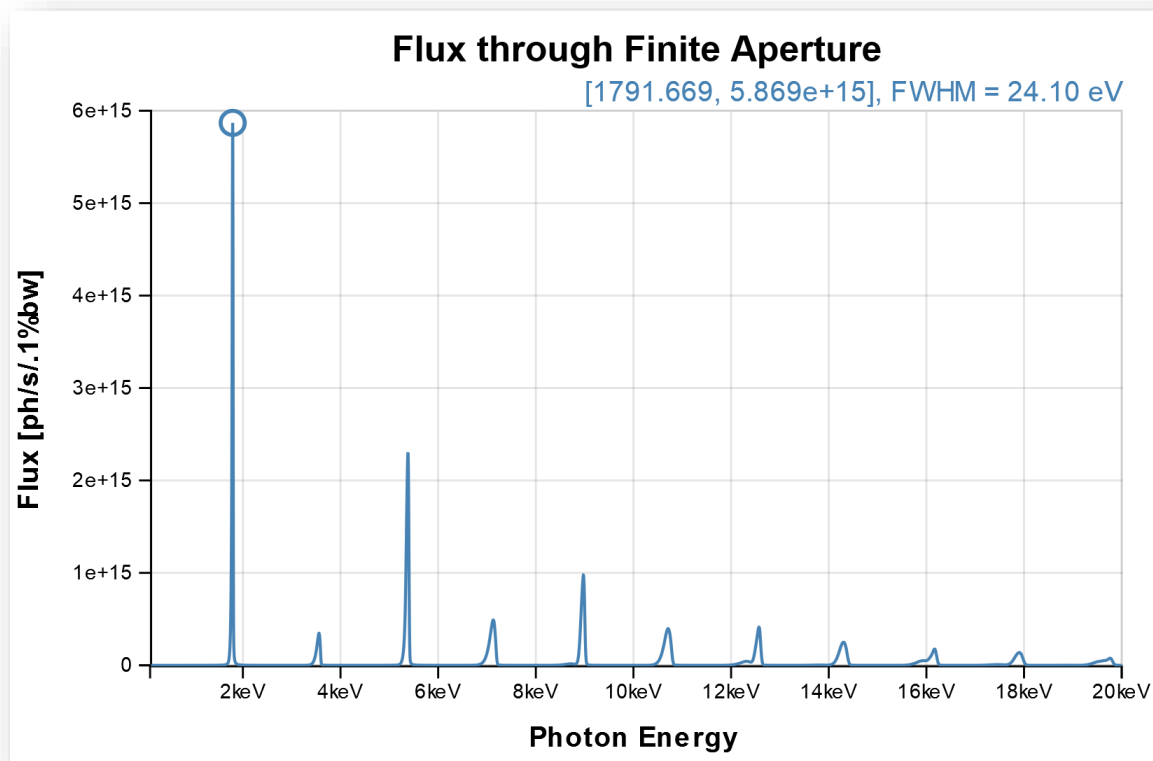
Export:



Import:



Interactive graphics



Closer to real world (electron beam)

Synchrotron Radiation Workshop - SR Calculator - Undulator Radiation

Electron Beam

Main Position

Select Beam: NSLS-II Low Beta Final [Edit Beam](#)

Beam Name: NSLS-II Low Beta Final

Energy [GeV]: 3

Current [A]: 0.5

Average Energy Deviation [GeV]: 0

RMS Energy Spread: 0.00089

Beam Definition by: **Twiss** Moments

	Horizontal Twiss Parameters	Vertical Twiss Parameters
Emittance [nm]	0.55	0.008
Beta [m]	2.02	1.06
Alpha [rad]	0	0
Dispersion [m]	0	0
Dispersion Derivative [rad]	0	0

APS (new parameters) ▾

Predefined Electron Beams

- APS
- DIAMOND Low Beta
- ESRF High Beta
- ESRF Low Beta
- NSLS-II 3PW Day 1
- NSLS-II 3PW Final
- NSLS-II BM Day 1
- NSLS-II BM Final
- NSLS-II High Beta Day 1
- NSLS-II High Beta Final
- NSLS-II Low Beta Day 1
- NSLS-II Low Beta Final
- SOLEIL BM 1 deg.
- SOLEIL BM 4 deg.
- SOLEIL Long
- SOLEIL Medium
- SOLEIL Short
- SPring8 High Beta

User Defined Electron Beams

- APS (copy 1) ✕
- APS (new parameters)
- NSLS-II High Beta Day 1 (copy 1) ✕



Closer to real world (tab. undulator)

Undulator (Idealized or Tabulated)

Type of Undulator: ☒ Idealized ☐ Tabulated

Magnetic Gap [mm]:

Magnet Arrays Shift [mm]:

Longitudinal Central Position [m]:

Magnetic Data File:

Idealized Undulator

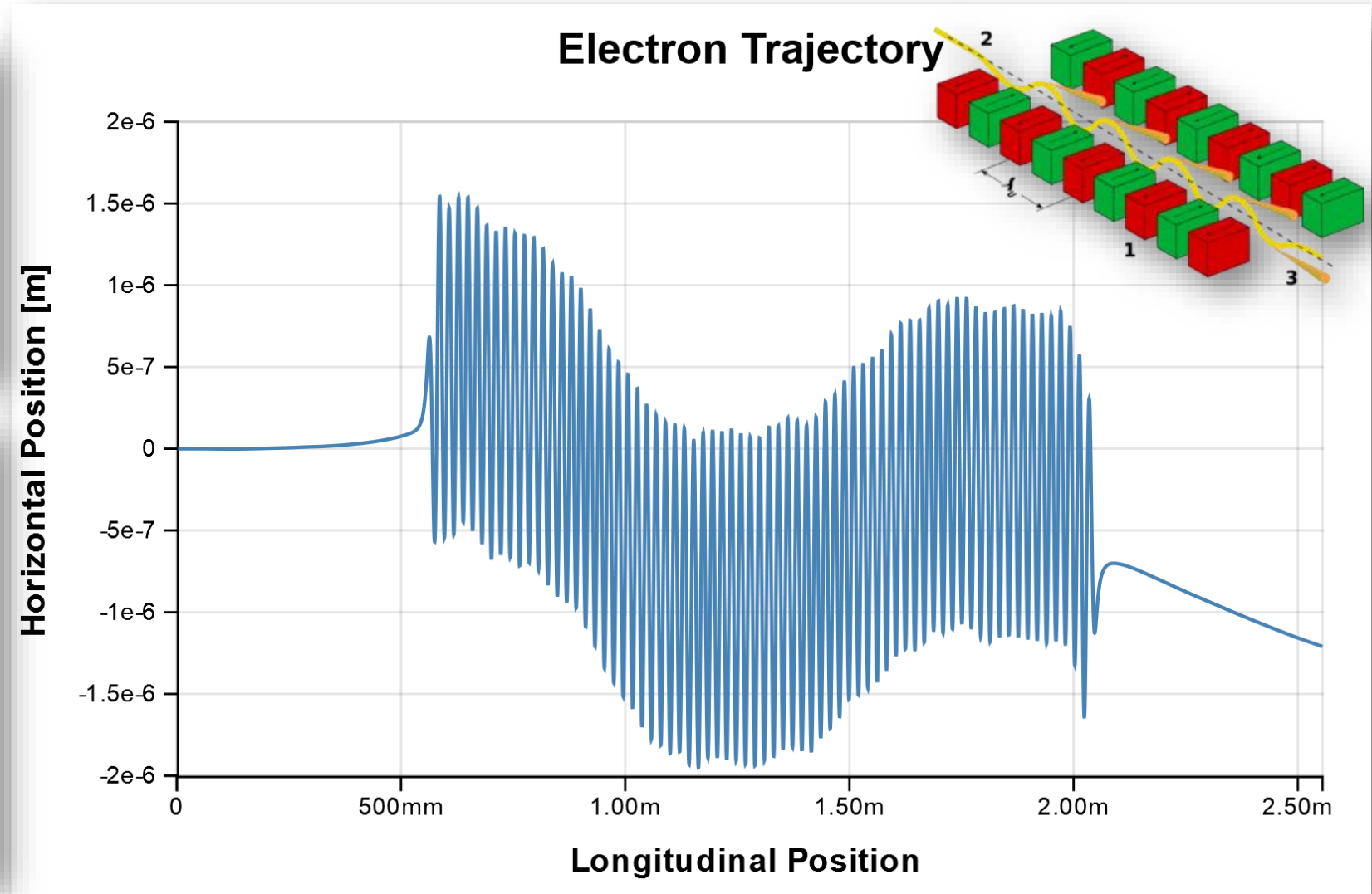
Deflecting Parameter (K):

Period [mm]:

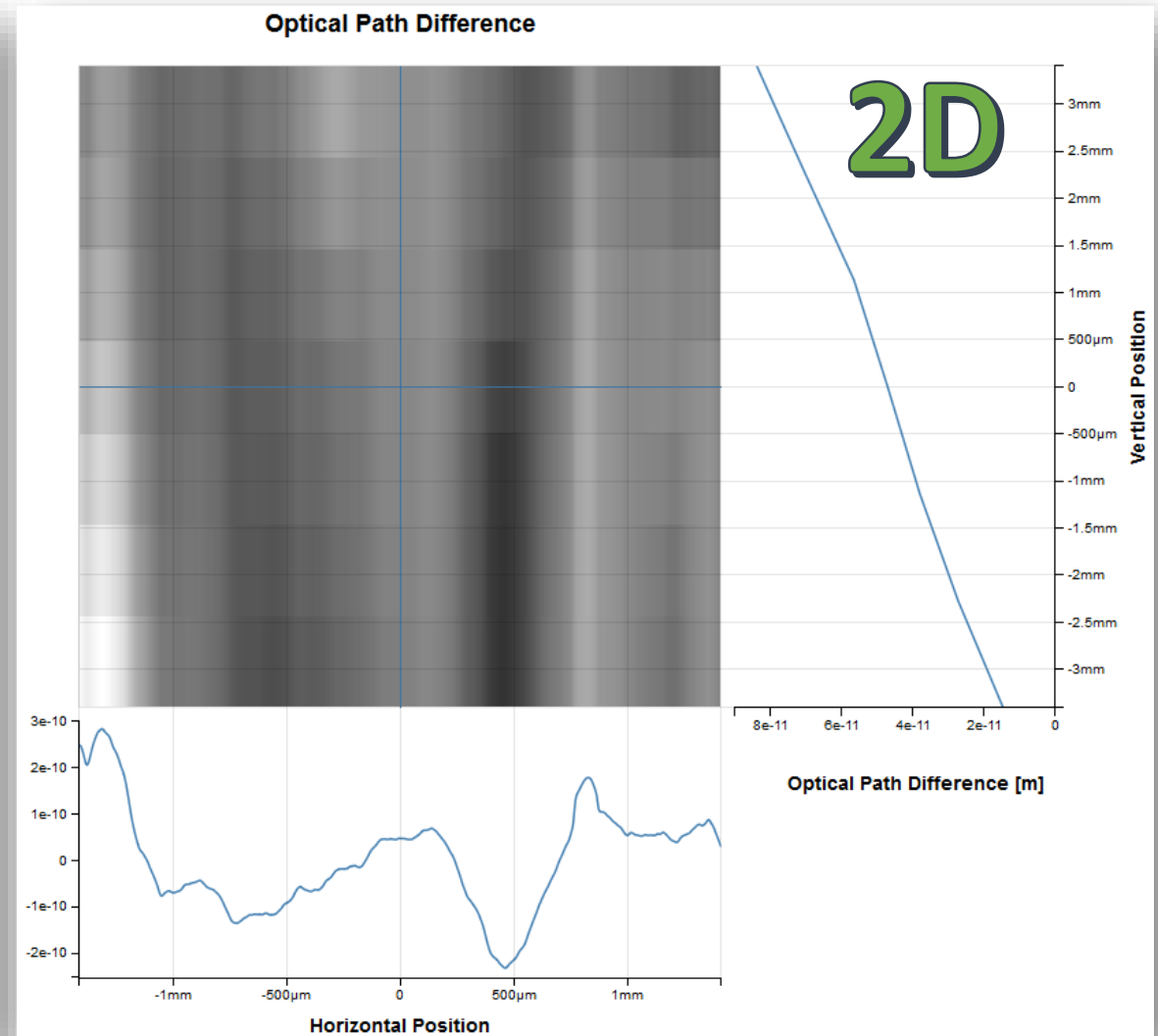
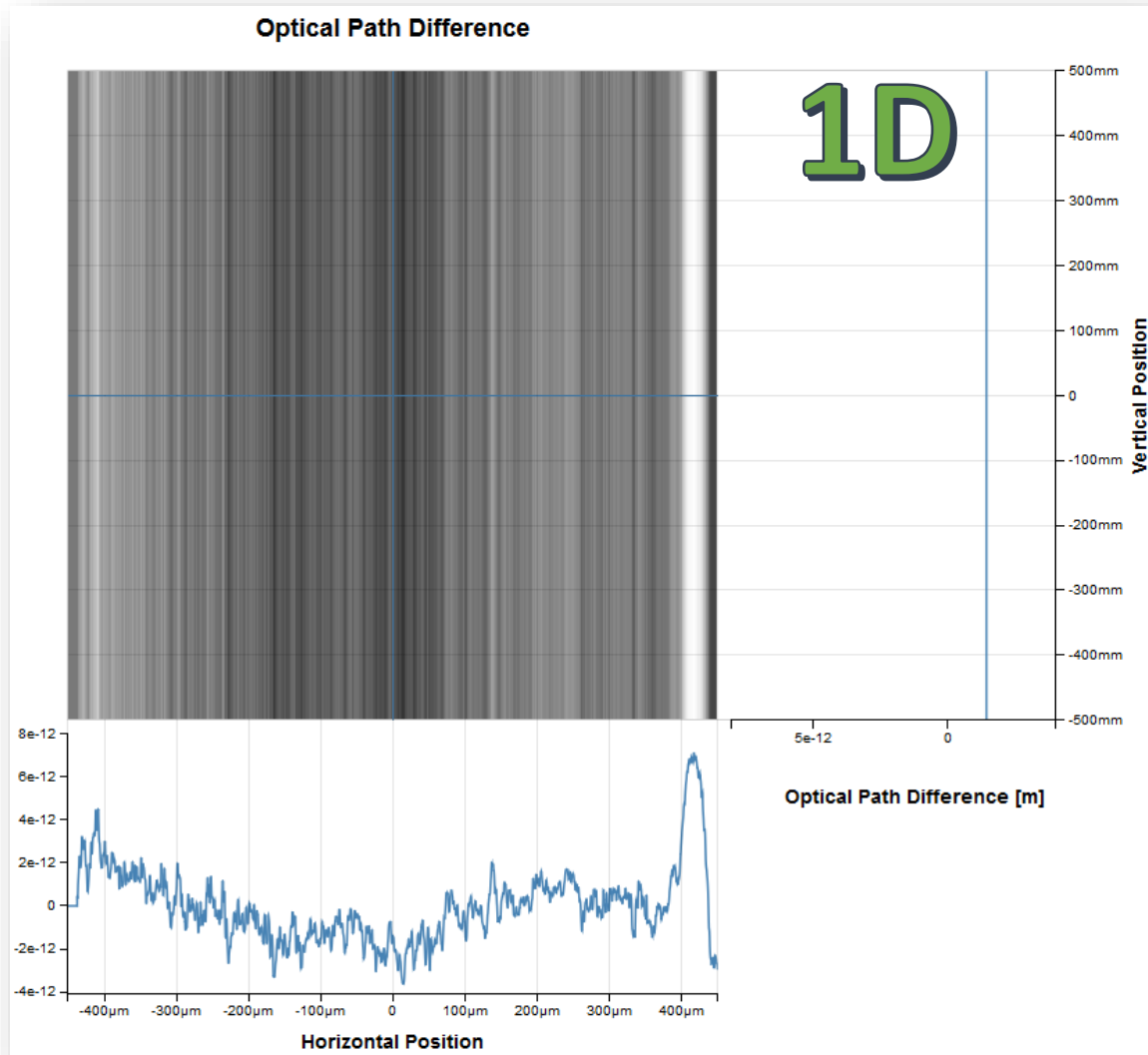
Length [m]:

Longitudinal Central Position [m]:

	Horizontal	Vertical
Magnetic Field [T]	<input type="text" value="0"/>	<input type="text" value="0.88770981"/>
Initial Phase [rad]	<input type="text" value="0"/>	<input type="text" value="0"/>
Symmetry	<input type="text" value="Symmetrical"/>	<input type="text" value="Anti-symmetrical"/>



Closer to real world (mirror profiles)



Closer to real world (delta, atten. len.)

Data is dynamically queried from http://henke.lbl.gov/optical_constants/



35.4m

CRL2

Element Name: CRL2

Nominal Position [m]: 35.4

Focal Plane: Vertical

Material of the CRL: Be

Method of Getting Delta/Attenuation Length: Server <http://henke.lbl.gov>

Refractive Index Decrement of Material: 4.207570×10^{-6}

Attenuation Length [m]: 7.312960×10^{-3}

CRL Focal Distance [m]: 9.9028

Shape: Parabolic Circular

Horizontal Aperture Size [mm]: 1

Vertical Aperture Size [mm]: 1.4

Radius on Tip of Parabola [μm]: 500

Number of Lenses: 6

Wall Thickness at Tip of Parabola [μm]: 80

Close

Fiber

Element Name: Fiber

Nominal Position [m]: 20

Plane of Focusing: Horizontal (fiber is parallel to vertical axis)

Horizontal Center Position [m]: 0

Vertical Center Position [m]: 0

Method of Getting Delta/Attenuation Length: Server <http://henke.lbl.gov>

	External	Core
Material	B	W
Refractive Index Decrement	5.555666×10^{-6}	3.645069×10^{-5}
Attenuation Length [m]	2.861690×10^{-3}	4.218890×10^{-6}
Diameter [m]	0.0001	0.00001

Close



Closer to real world (crystal data)

Data is dynamically queried from <http://x-server.gmca.aps.anl.gov/x0h.html>



34.85m

Crystal

Main Parameters Height Profile

Element Name Crystal

Nominal Position [m] 34.85

Material of the crystal Silicon (X0h server)

Miller's indices h 1 k 1 l 1

Average photon energy the crystal should be oriented for [eV] 9000

Diffraction plane angle [rad] 0.22148235778774653

Asymmetry angle [rad] 0

Rotation angle [rad] 0

Crystal thickness [m] 0.01

Crystal reflecting planes d-spacing [Å] 3.135531576941939

Real part of crystal polarizability 0-th Fourier component -0.000012073 H-th Fourier component 0.0000063776 -H-th Fourier component 0.0000063776

Imaginary part of crystal polarizability 0-th Fourier component 2.2532e-7 H-th Fourier component 1.5706e-7 -H-th Fourier component 1.5706e-7

Outward normal vector Horizontal coordinate -0.2143086009009053 Vertical coordinate 0.9517364118334645 Longitudinal coordinate -0.2197034957860649

Central tangential vector Horizontal coordinate -0.048263587769702826 Vertical coordinate 0.2143367727577646

Close

Elliptical Mirror

Dimensions Mirror Error

Element Name Elliptical Mirror

Nominal Position [m] 20

Distance from Source to Mirror Center (p) [m] 20

Distance from Mirror Center to Second Focus (q) [m] 1.7

Tangential Size [m] 0.5

Sagittal Size [m] 0.01

Grazing Angle [mrad] 3.6

Coordinates of Central Normal Vector Horizontal 0 Vertical 0.99999352200069984 Longitudinal -0.0035999922240050381

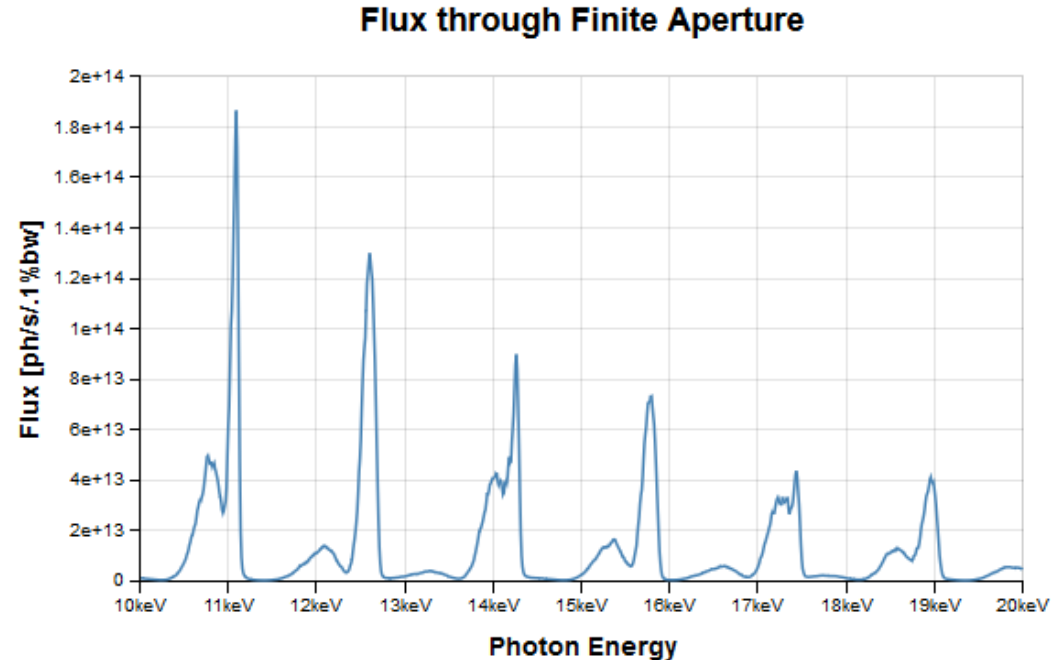
Coordinates of Central Tangential Vector Horizontal 0 Vertical -0.0035999922240050381

Close



Closer to real world (multi-electrons)

Spectral Flux for Finite Emittance Electron Beam, 20m



Running ...

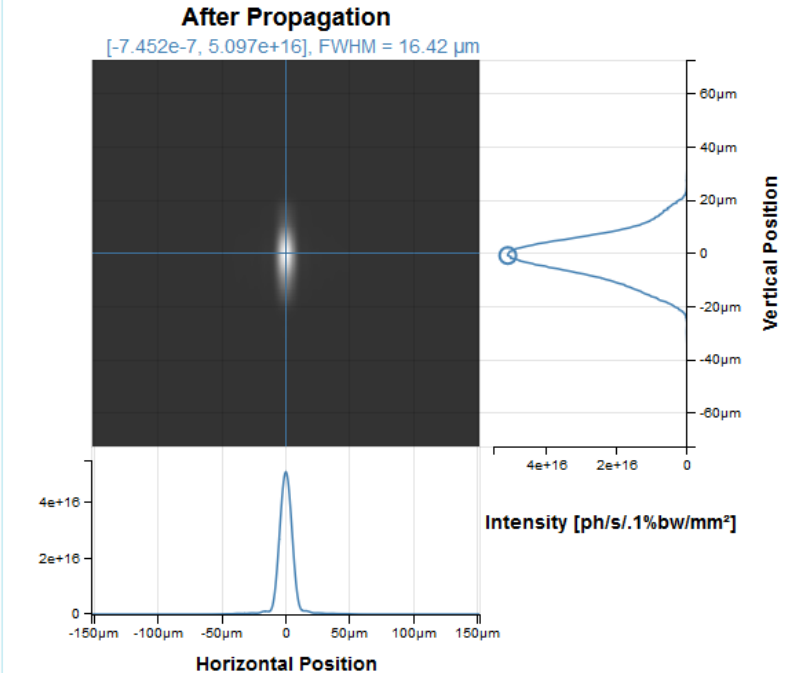
Completed particle: 9220 / 99990

Elapsed time: 0 00:49:54

End Simulation

Coherent Partially Coherent

Partially Coherent Intensity Report



Running .

Completed particle: 60 / 99990

Elapsed time: 0 00:02:43

End Simulation



Closer to real world (real samples)

20m 20m

Sample Watchpoint

Element Name: Sample

Nominal Position [m]: 20

Image or NumPy File: R5.tif

Resolution [nm/pixel]: 2.480469

Thickness [μm]: 10

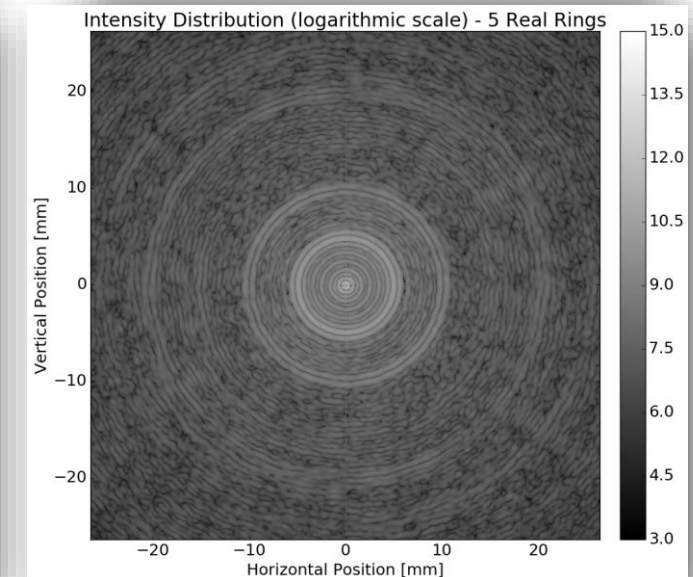
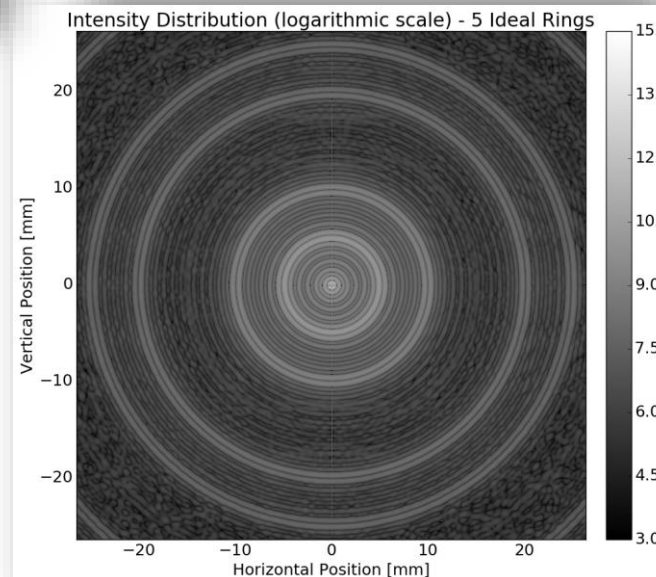
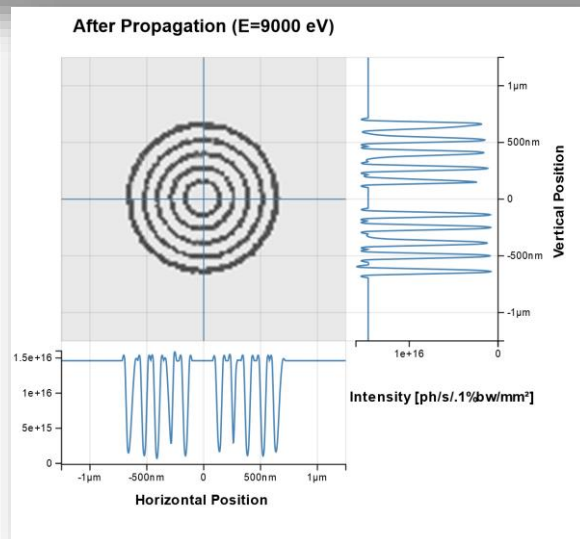
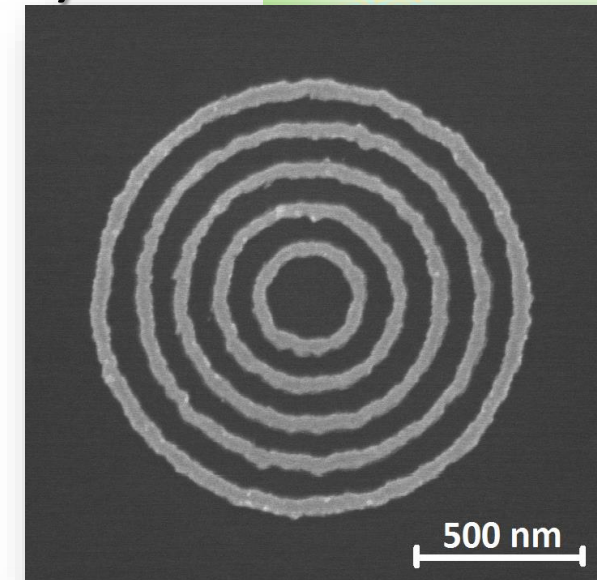
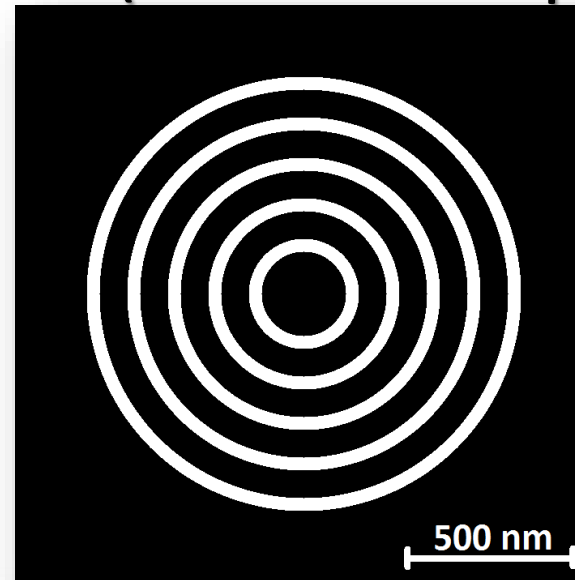
Material of the mask: Au

Method of Getting Delta/Attenuation Length: Server <http://henke.lbl.gov>

Refractive Index Decrement of Material: 3.738856×10^{-5}

Attenuation Length [m]: 3.389020×10^{-6}

Close



New virtual beamlines

- NSLS-II CHX beamline (idealized and tabulated undulator)
- NSLS-II SMI beamline (low div. and normal div. modes)
- NSLS-II FMX beamline
- NSLS-II ESM beamline
- LCLS SXR beamline
- ...



Usage & contributions

Sirepo and SRW are used at the light source facilities around the world:

- NSLS-II
- LCLS
- APS
- ALS
- ELETTRA in Italy
- European XFEL in Germany
- ESRF and SOLEIL in France
- PSI in Switzerland
- Diamond Light Source in UK
- LNLS in Brazil

Interested? Try out today:
<https://beta.sirepo.com/light>



Want to contribute? Fork on Github:
<https://github.com/radiasoft/sirepo>



Acknowledgements



- My supervisor Dr. Oleg Chubar (Tchoubar) (NSLS-II, BNL)
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