

Sirepo – an open-source cloud-based software interface for X-ray source and optics simulations

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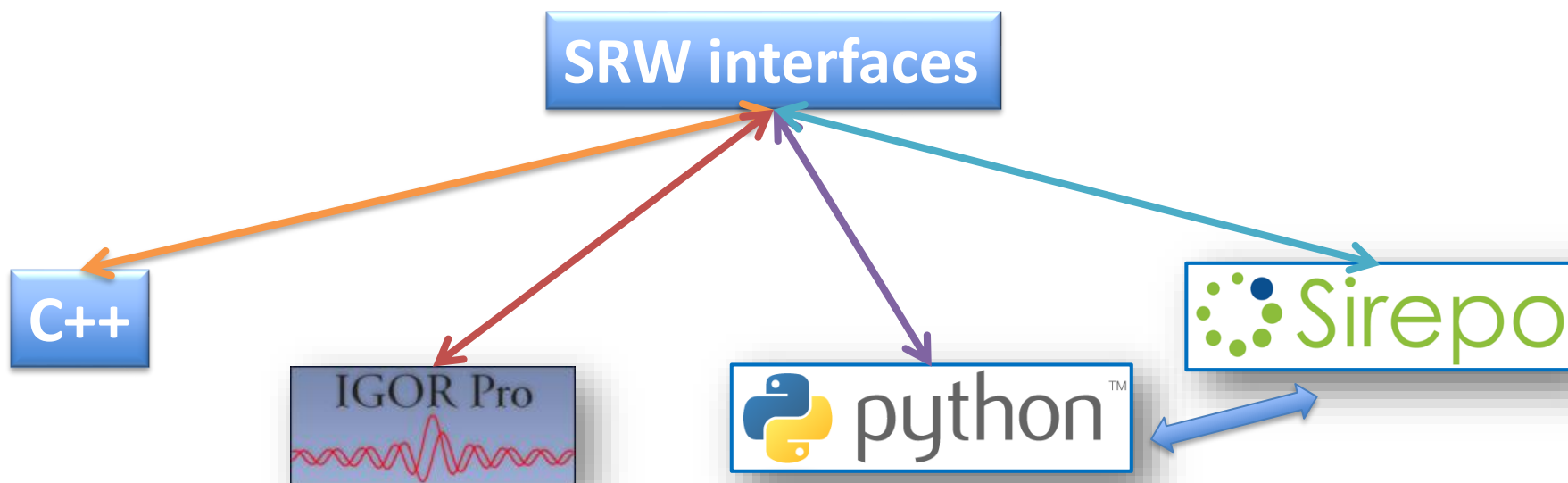


Outline

- Overview of Sirepo:
 - Sirepo & SRW
 - Distribution of Sirepo
 - Source page
 - Beamline page
 - Selected features
- Demonstration of Sirepo

Sirepo & SRW

- **SRW (Synchrotron Radiation Workshop)** – allows to simulate synchrotron radiation and wavefront propagation through beamline optics
- SRW is written in C++ and has several interfaces
- **Sirepo** – an open-source Python/JavaScript interface for cloud computing, developed in collaboration with RadiaSoft LLC within SBIR project



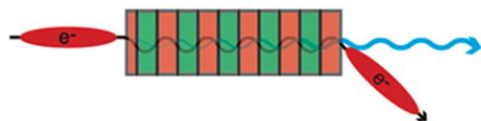
Concept of “Virtual Beamline”

Distribution of Sirepo

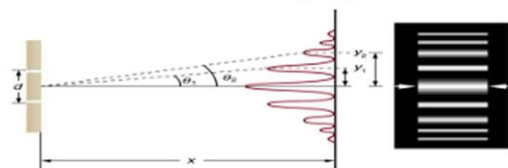


Synchrotron Radiation Workshop

Synchrotron Radiation



Wavefront Propagation



Light Source Facilities

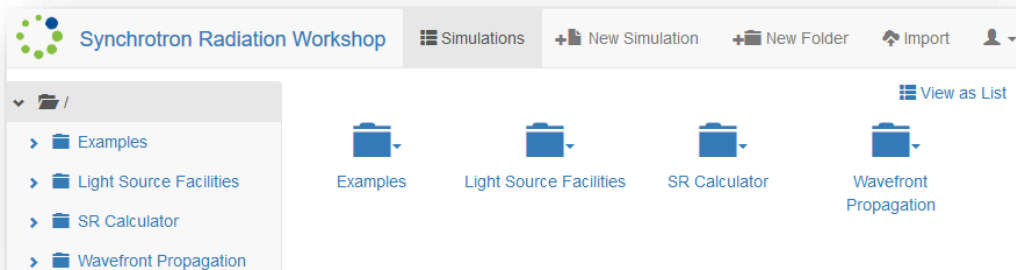


Distribution:

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

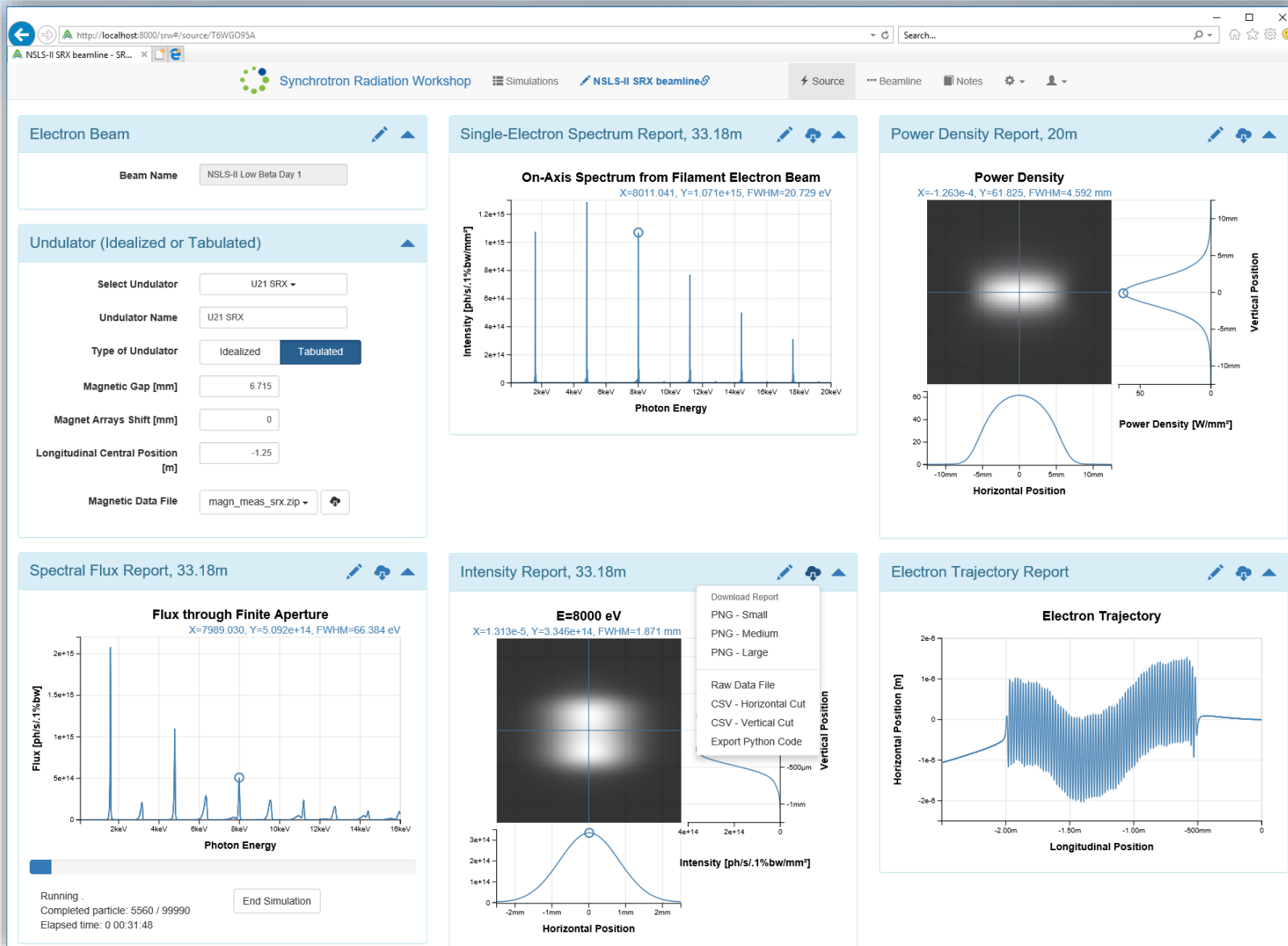
Servers:

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



Expert users only

Source page



Source page: definition of the beam

Electron Beam

Main

Position

Select Beam

NSLS-II Low Beta Day 1 ▼

Edit Beam

Beam Name

NSLS-II Low Beta Day 1

Energy [GeV]

3

Current [A]

0.5

RMS Energy Spread

0.00089

Beam Definition by

Twiss

Moments

Horizontal Twiss Parameters

Vertical Twiss Parameters

Emittance [nm]

0.9

0.008

Beta [m]

1.84

1.17

Alpha [rad]

0

0

Dispersion [m]

0

0

Dispersion Derivative [rad]

0

0

Save Changes

Cancel

NSLS-II Low Beta Day 1 ▼

Predefined Electron Beams

APS

DIAMOND Low Beta

ESRF BM

ESRF High Beta

ESRF Low Beta

ESRF-U BM

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

NSLS-II Low Beta Day 1 (copy 1) ✕

NSLS-II Low Beta Day 1 (vemit=30 pm) ✕

Source page: definition of the source

Undulator (Idealized or Tabulated)

Type of Undulator

Idealized

Tabulated

Magnetic Gap [mm]

6.72

Magnet Arrays Shift [mm]

0

Longitudinal Central Position [m]

1.305

Magnetic Data File

magnetic_measurements.zip

Idealized Undulator

Deflecting Parameter (K)

1.65776086

Period [mm]

20

Length [m]

3

Longitudinal Central Position [m]

0

Horizontal

Vertical

Magnetic Field [T]

0

0.88770981

Initial Phase [rad]

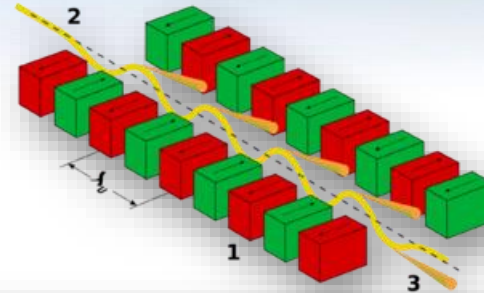
0

0

Symmetry

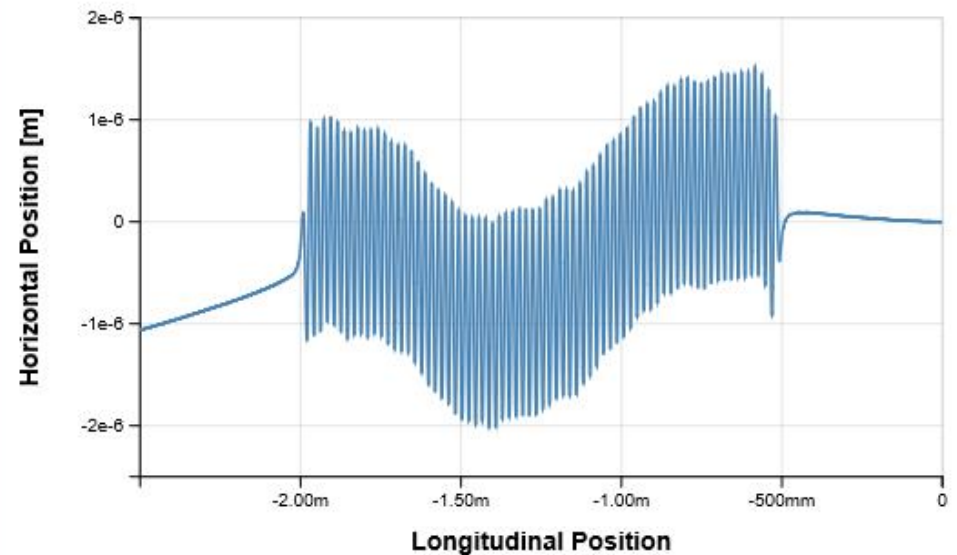
Symmetrical

Anti-symmetrical

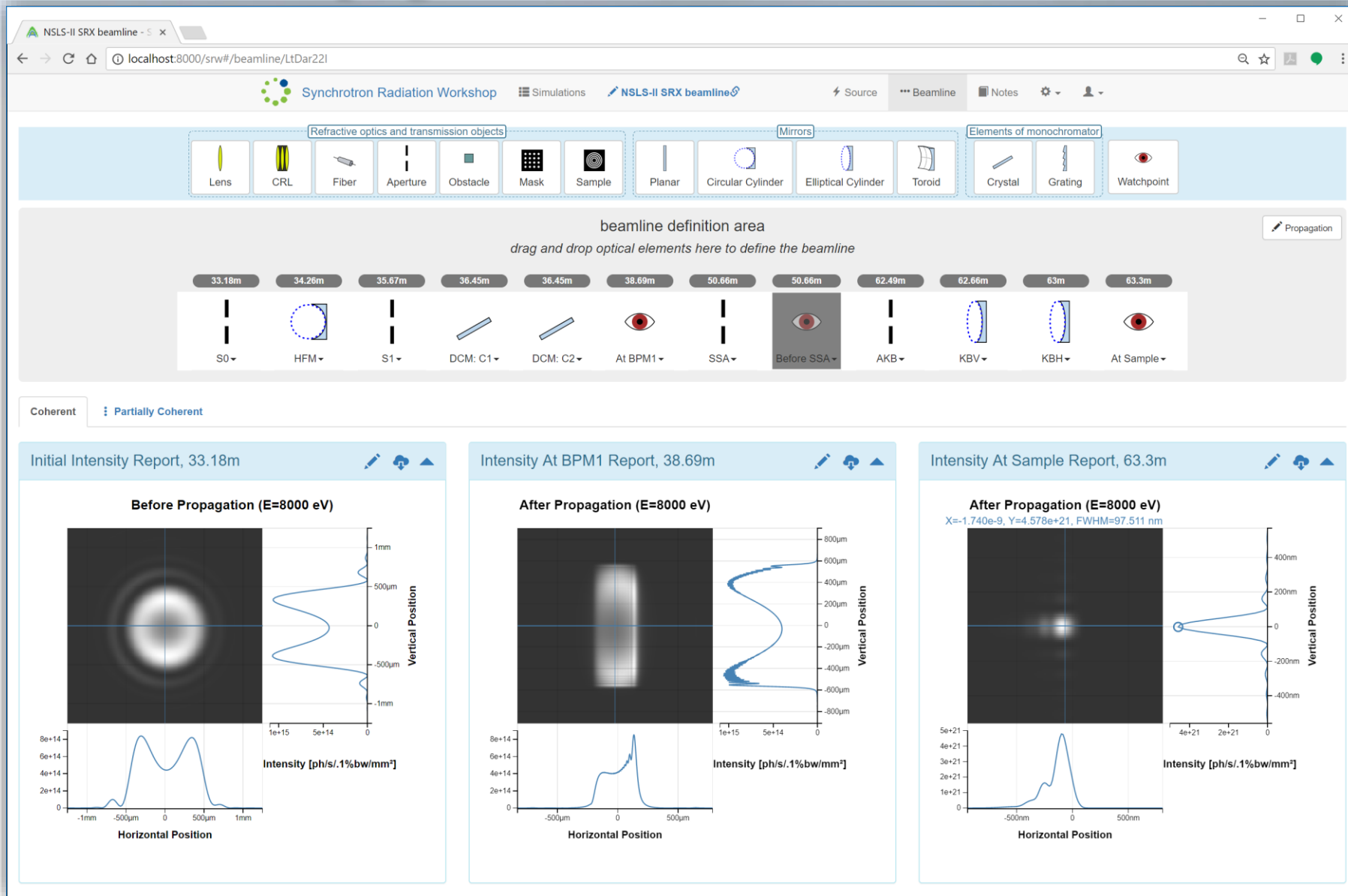


Electron Trajectory Report

Electron Trajectory



Beamline page

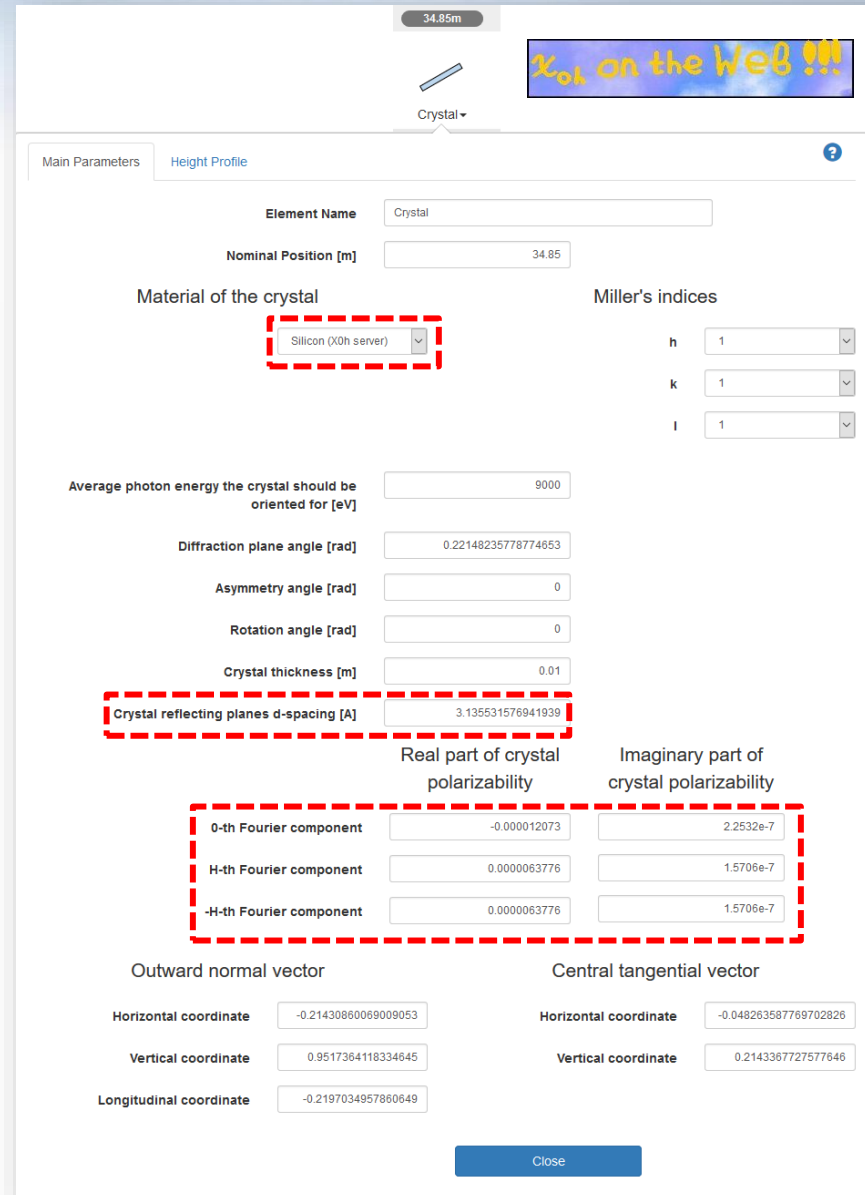
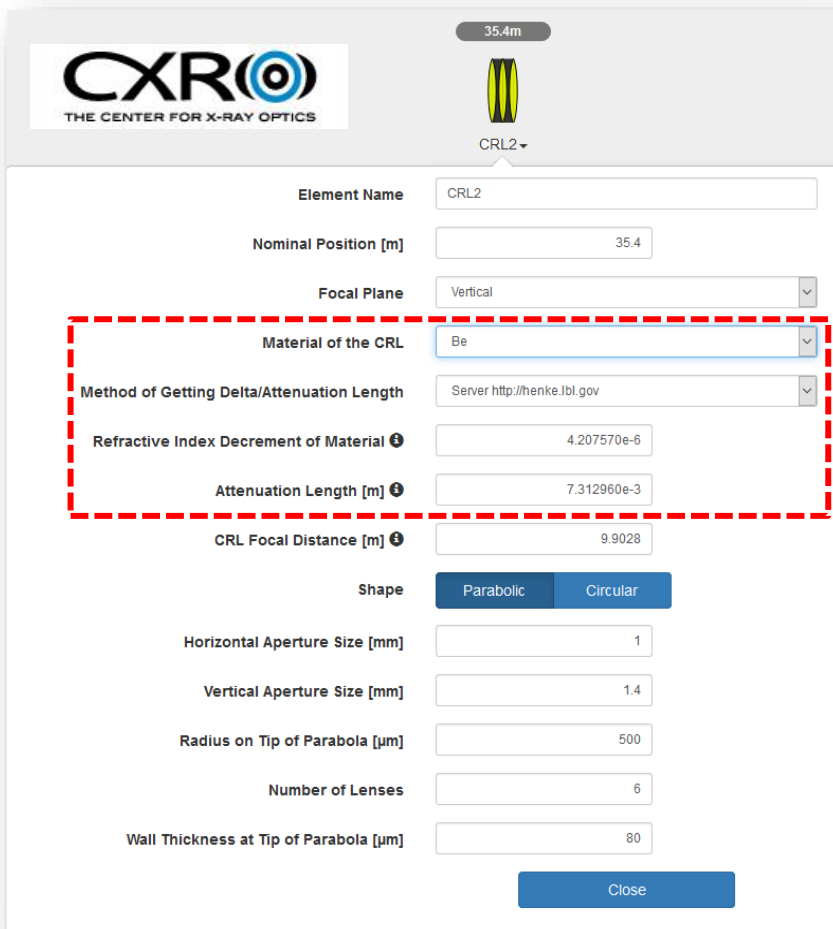


Dynamic access to external databases

Data is dynamically queried from:

- http://henke.lbl.gov/optical_constants/
- <http://x-server.gmca.aps.anl.gov/xoh.html>

Python API for data access, JS for GUI



Intensity image resizing and scaling

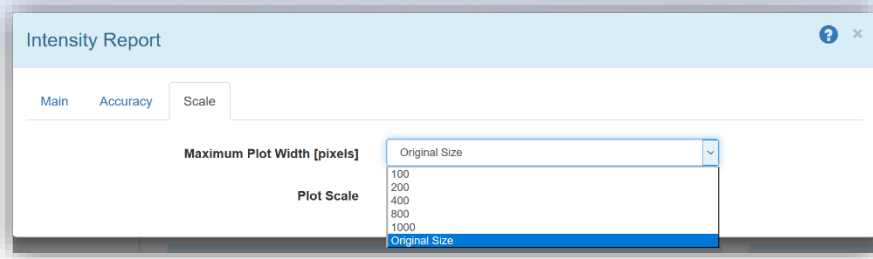
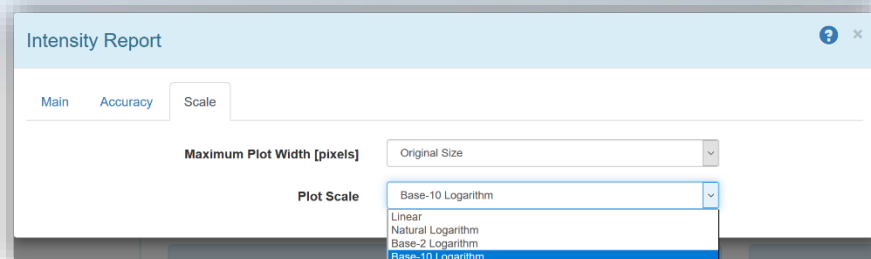
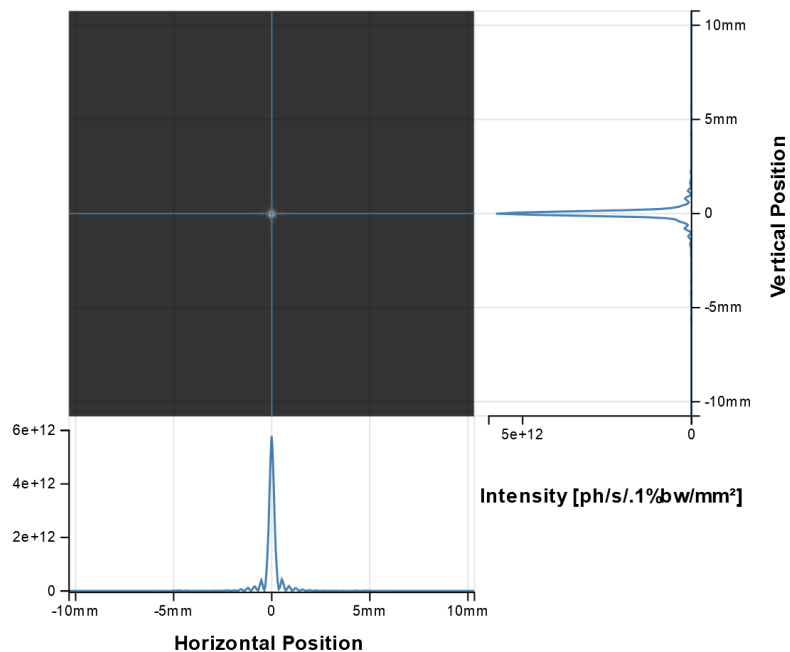


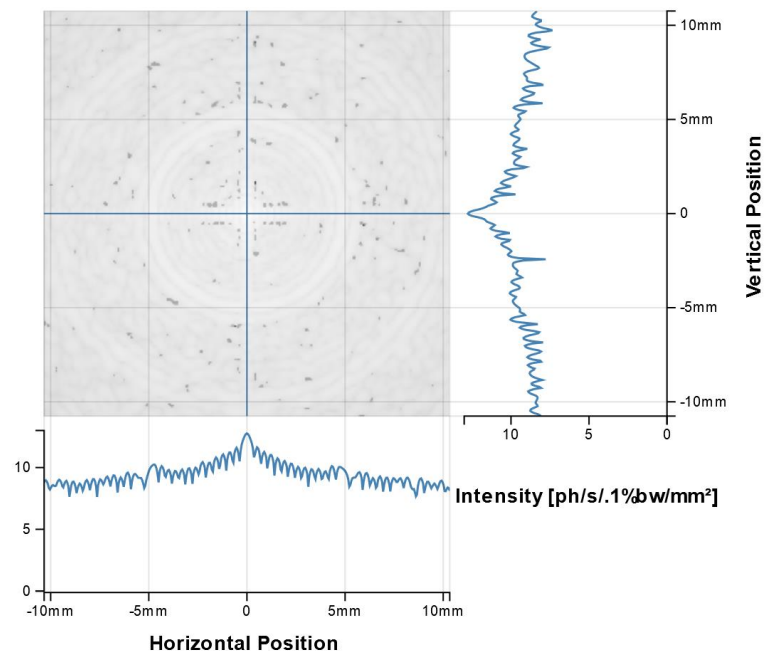
Image resizing option implemented in Sirepo and SRW using SciPy to optimize amount of data transferred from server to client

After Propagation (E=9646 eV)



Selection of scales (linear & logarithmic) implemented in Sirepo and SRW using NumPy to allow better insight into the resulted intensity

After Propagation (E=9646 eV)



Simulation of scattering experiments

35.4m

44.5m

44.5m

48m

48.7m

64.746m

CRL

KLA

KL

S3

Sample

Detector

Element Name

Sample

Nominal Position [m]

48.7

Image or NumPy File

CHX_-_random_-_test1_q02.tif

Resolution [nm/pixel]

20

Thickness [μm]

0.05

Material of the mask

Au

Method of Getting Delta/Attenuation Length

Server <http://henke.lbl.gov>

Refractive Index Decrement of Material

3.227904e-5

Attenuation Length [m]

4.069870e-6

Horizontal

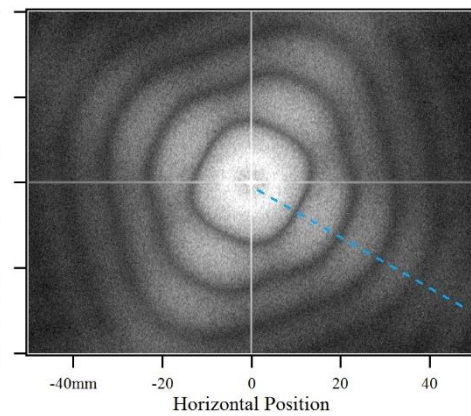
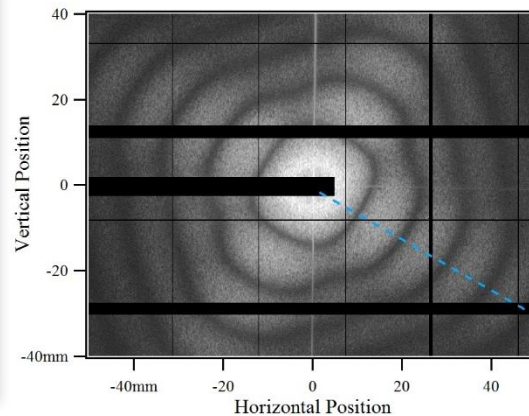
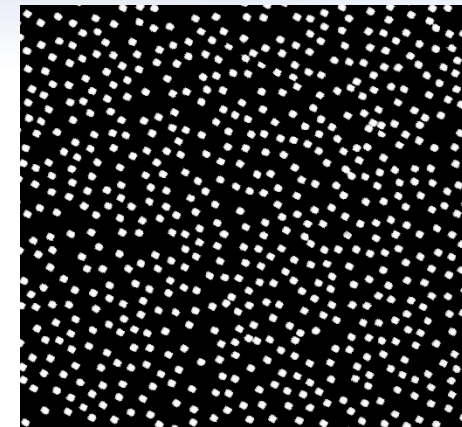
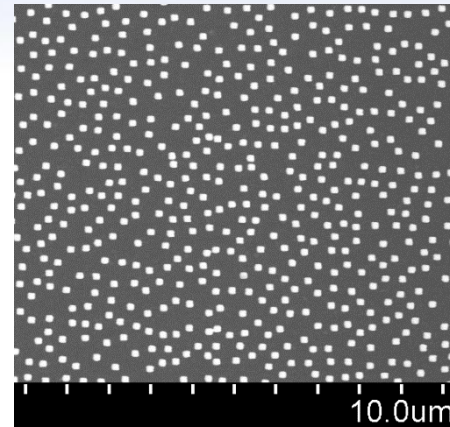
Vertical

Center Position [nm]

0

0

Close



SRW and Sirepo extension:

Sample scattering simulation using microscopy imaging:
Python/NumPy/SciPy/Pillow image processing library

Chubar, *et al.* Proc. SPIE (2017), 10.1117/12.2274481

Data storage & exchange

Export:

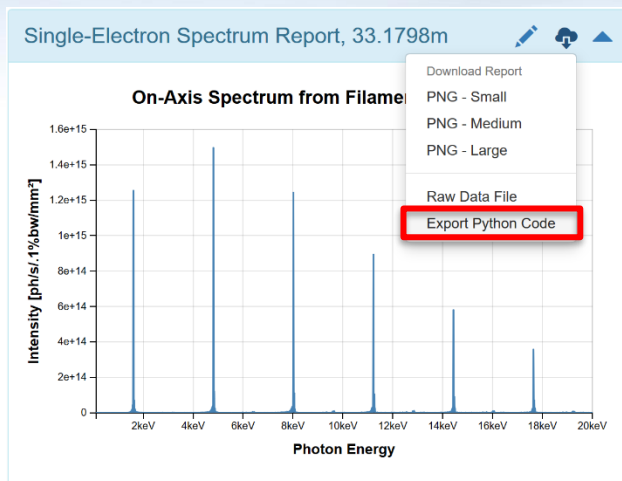
- Python script
- JSON file
- Zip-archive
- Self-extracting simulation



Tabulated Undulator
Example

- Open
- Open as a New Copy
- Rename
- Move
- Export as Zip
- Self-Extracting Simulation
- Python Source
- Delete

- Source
- Beamline
- Simulation Documentation URL
- Export JSON Data File
- Open as a New Copy
- Discard Changes to Example
- Related Simulations



Import Python or JSON Simulation File

Select File

Browse... example.json

Import File

Cancel

Import Python or JSON Simulation File

Select File

Browse... example.py

Optional arguments:

-op_BL=3

Import File

Cancel

Import:

- Python script
- JSON
- Zip-archive



Synchrotron Radiation Workshop - Sirepo

Self-Extracting Simulation: Tabulated Undulator Example

<https://expdev.nsls2.bnl.gov>

Send to Server

Synchrotron Radiation Workshop

Simulations

+ New Simulation + New Folder Import

Sign in with GitHub

Examples Light Source Facilities SR Calculator Wavefront Propagation

Sign in to GitHub to continue to Sirepo (Beta)

Username or email address

Password

Forgot password?

Sign in

New to GitHub? Create an account.

Demonstration of Sirepo

<https://expdev.nsls2.bnl.gov/light>

Summary:

- A new user-friendly web-interface Sirepo for portable reproducible SRW simulations developed in collaboration with RadiaSoft LLC and deployed at NSLS-II
- Virtual beamlines implemented: NSLS-II CHX, SMI, SRX, HXN, FMX, ESM, and LCLS-SXR
- All commonly used optical elements for “Virtual Beamline” are available
- Dynamic access to X-ray optics material properties from community databases helps obtain optical constants for particular photon energy and material in one click
- Advanced import-export features allow for easier exchange of simulations between colleagues and collaborators
- Demonstration at SPIE’17: <https://www.spiedigitallibrary.org/conference-proceedings-of-spie/10388/2274031/Sirepo--a-web-based-interface-for-physical-optics-simulations/10.1117/12.2274031.full?SSO=1>

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