

Sirepo – an open-source browser interface for X-ray source and optics simulations

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70 YEARS OF
DISCOVERY

A CENTURY OF SERVICE

ORNL, November 9, 2017

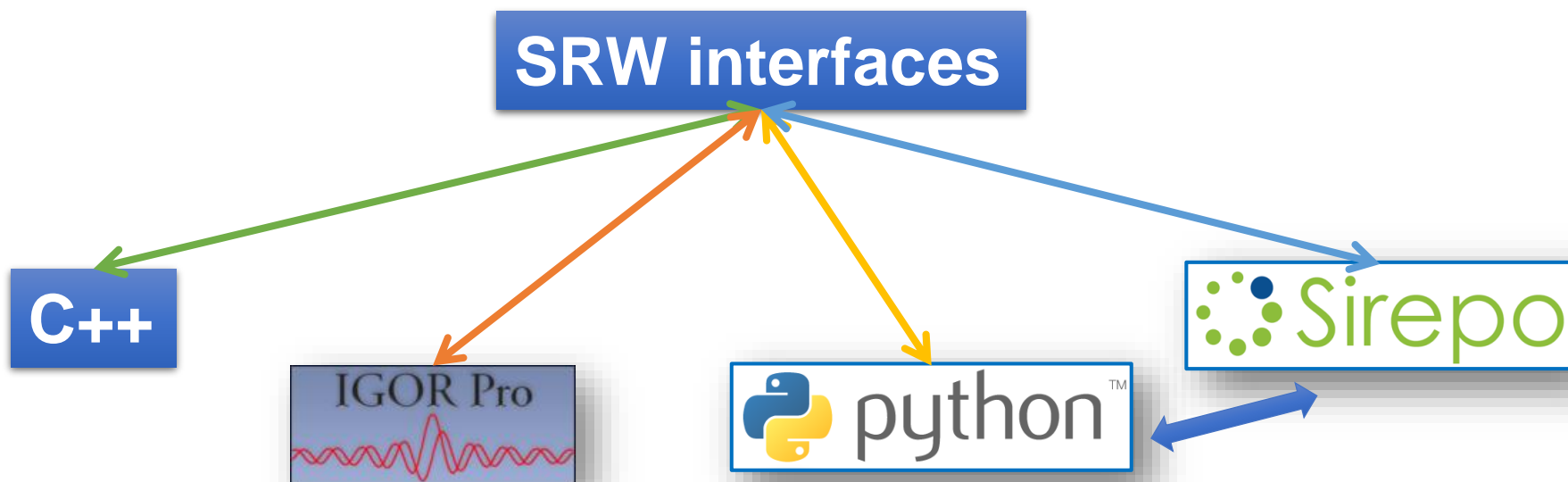


Outline

- 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 browser interface for cloud computing, developed in collaboration with RadiaSoft LLC within an SBIR project



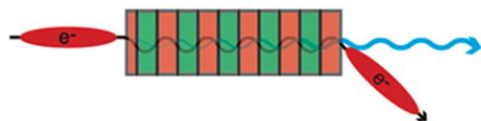
Concept of “Virtual Beamline”

Distribution of Sirepo

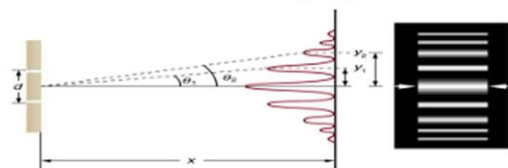


Synchrotron Radiation Workshop

Synchrotron Radiation



Wavefront Propagation



Light Source Facilities



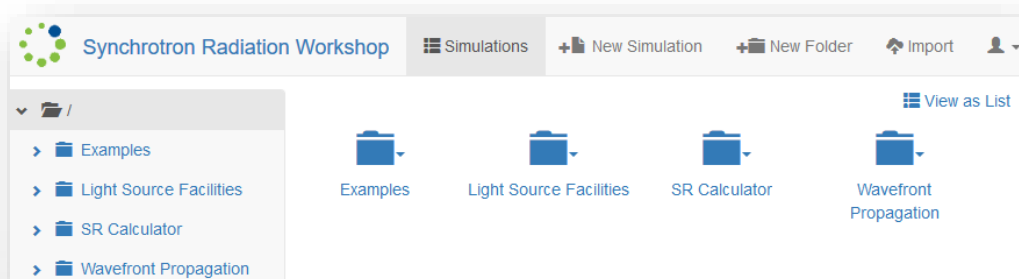
Expert users only

Distribution:

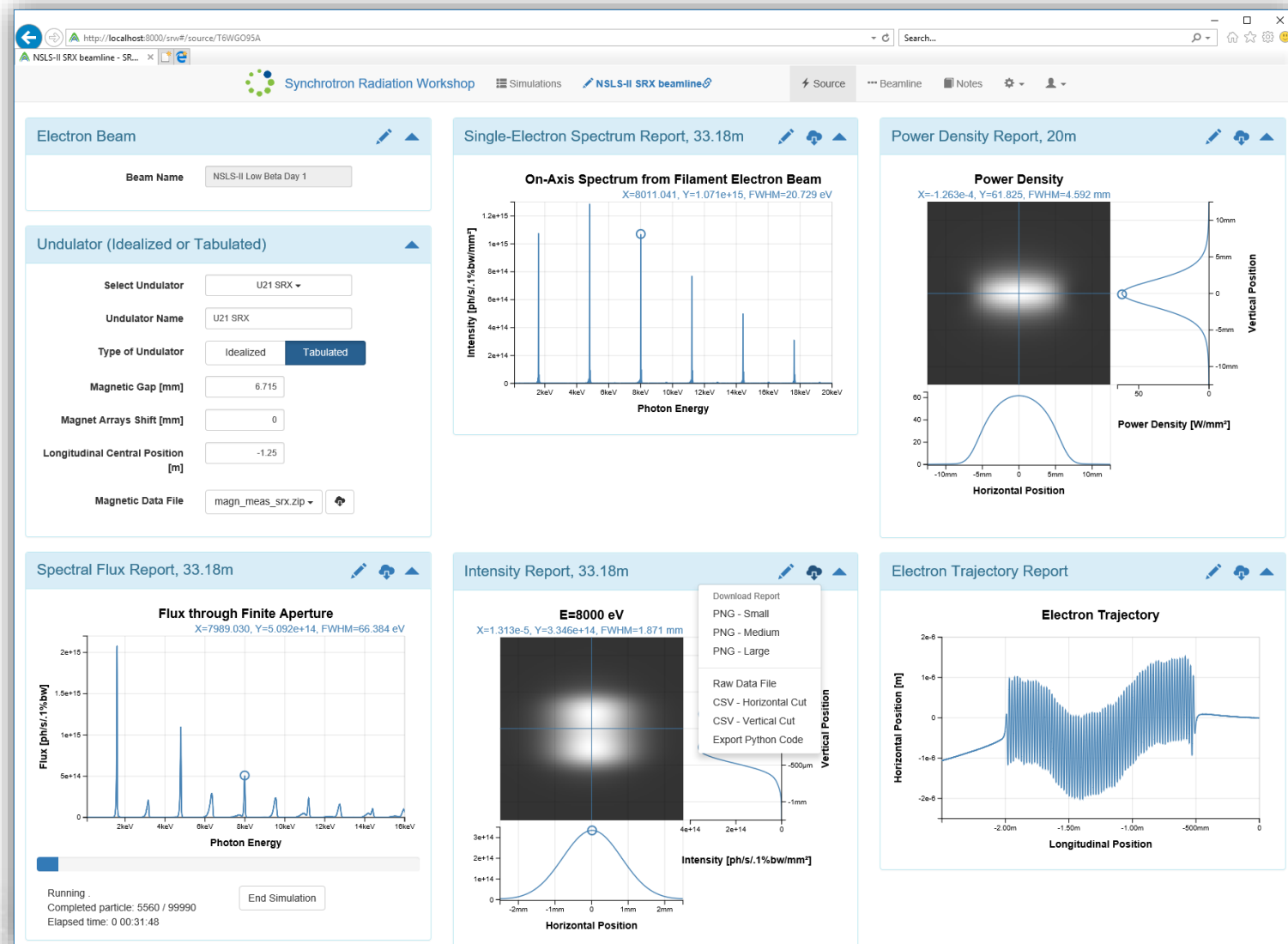
- **Source code:**
 - <https://github.com/radiasoft/sirepo>
 - <https://github.com/ochubar/SRW>
- **Docker containers:**
<https://hub.docker.com/r/radiasoft/sirepo/tags/>
- **Vagrant boxes:**
<https://atlas.hashicorp.com/radiasoft/boxes/sirepo>

Servers:

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



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]:

Magnet Arrays Shift [mm]:

Longitudinal Central Position [m]:

Magnetic Data File:

Idealized Undulator

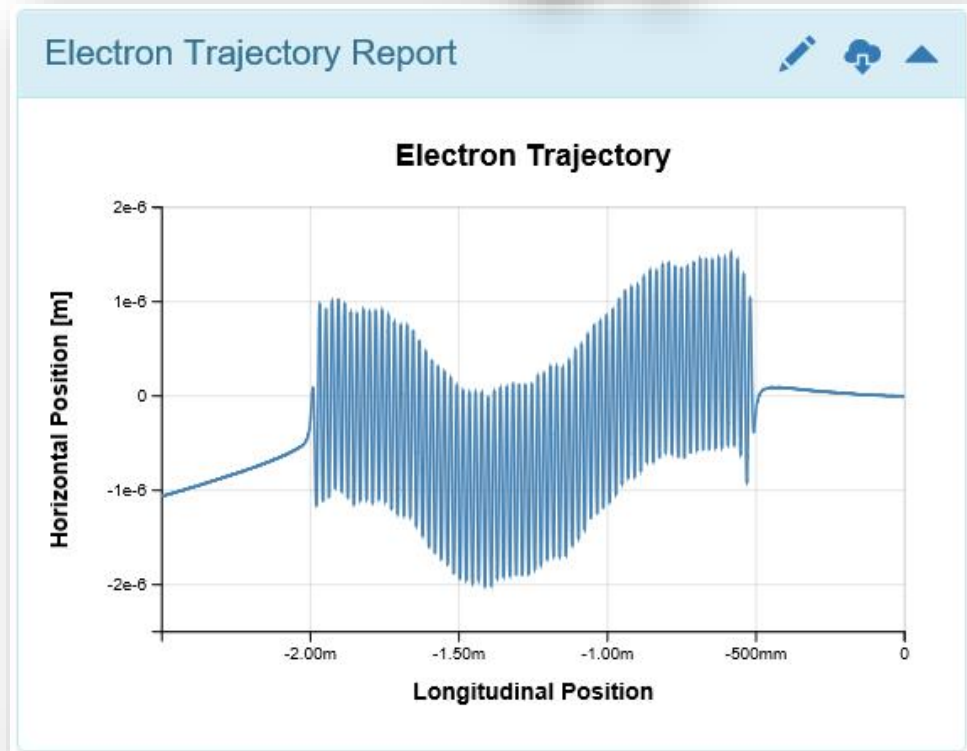
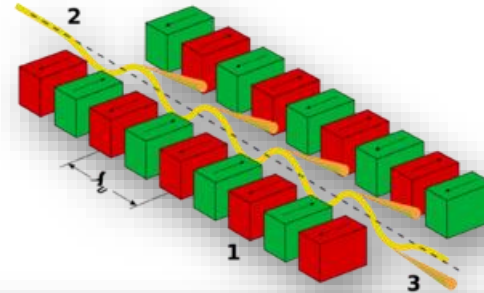
Deflecting Parameter (K):

Period [mm]:

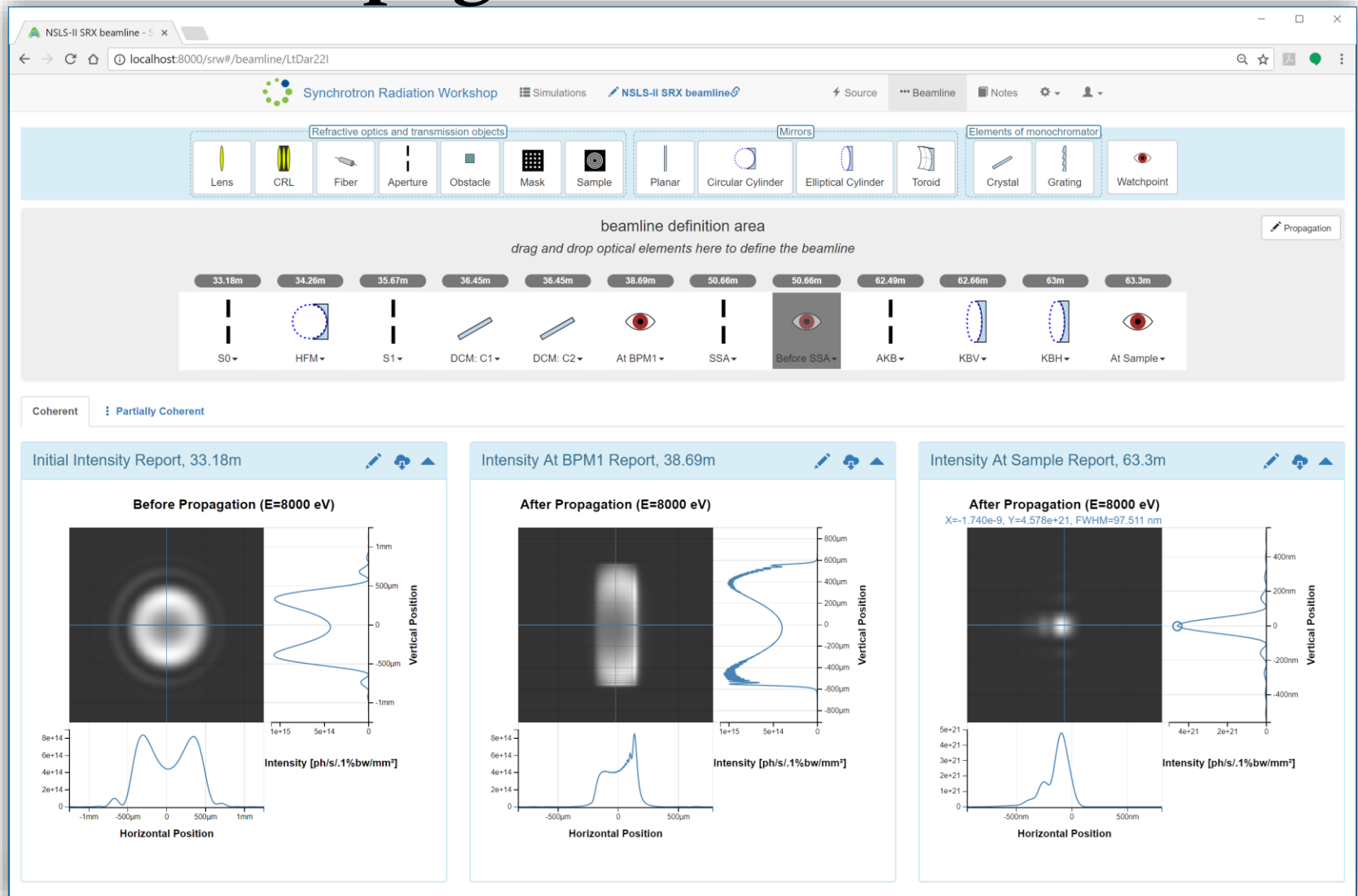
Length [m]:

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-symmetri"/>



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

CXRO
THE CENTER FOR X-RAY OPTICS

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: 4.207570e-6

Attenuation Length [m]: 7.312960e-3

CRL Focal Distance [m]: 9.9028

Shape: Parabolic

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

34.85m

Crystal

Element Name: Crystal

Nominal Position [m]: 34.85

Material of the crystal: Silicon (XOH 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]: 0.22148235778774853

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: 0.000012073

Imaginary part of crystal polarizability: 2.2532e-7

0-th Fourier component: -0.000012073

H-th Fourier component: 0.0000063776

-H-th Fourier component: 0.0000063776

Outward normal vector: Horizontal coordinate: -0.21430860069009053, Vertical coordinate: 0.9517364118334645, Longitudinal coordinate: -0.2197034957860649

Central tangential vector: Horizontal coordinate: -0.048263587769702826, Vertical coordinate: 0.2143367727577646

Close

Intensity image resizing and scaling

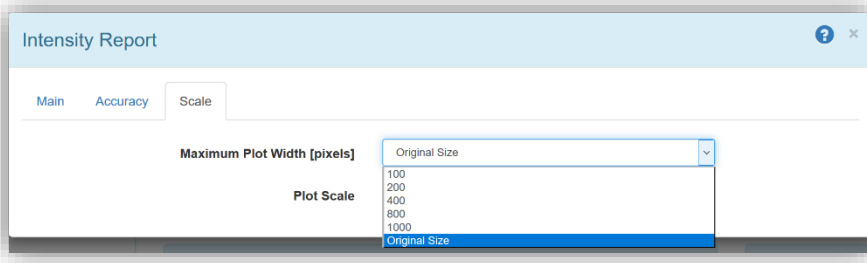
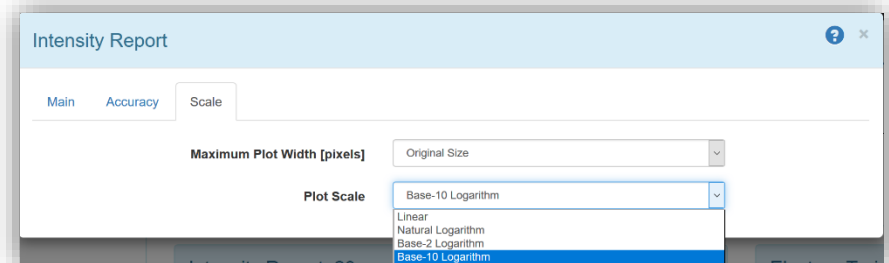
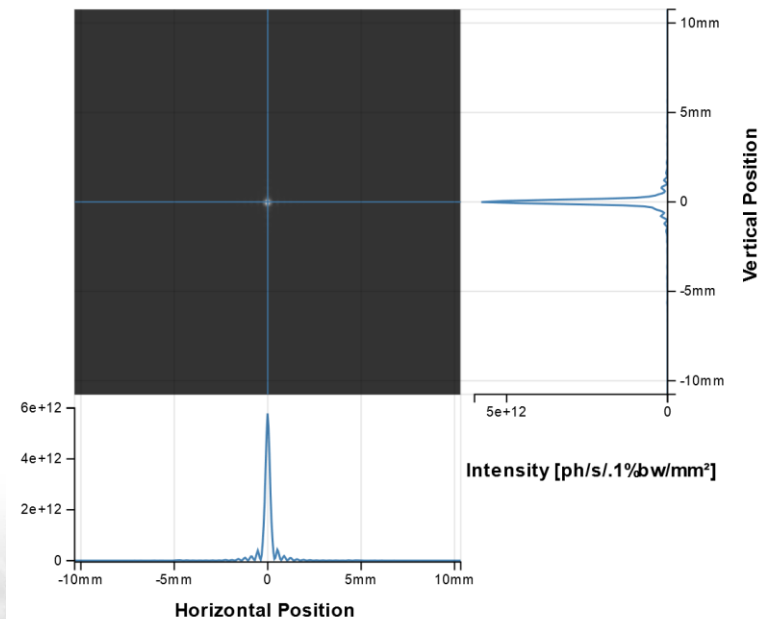


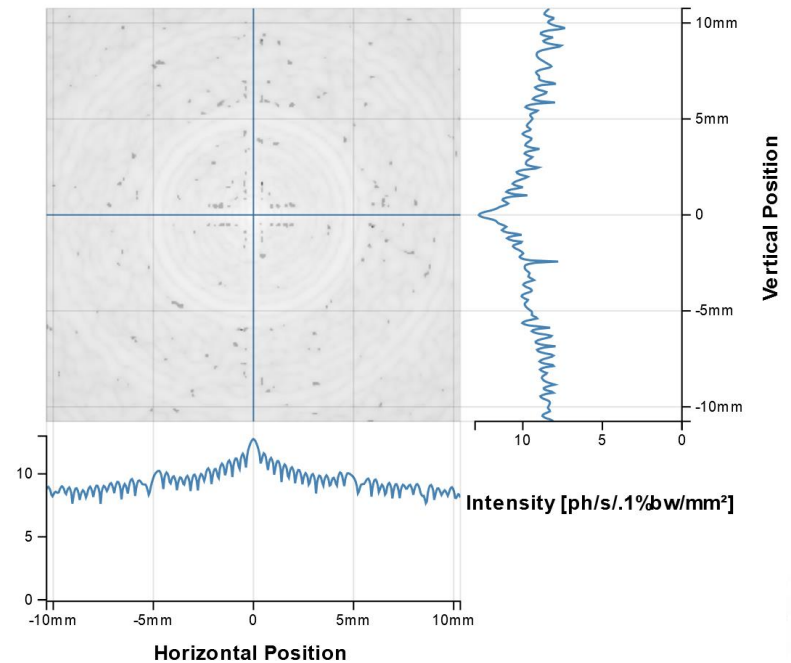
Image resizing option implemented in Sirepo and SRW using SciPy to optimize amount of data transferred from server to client

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

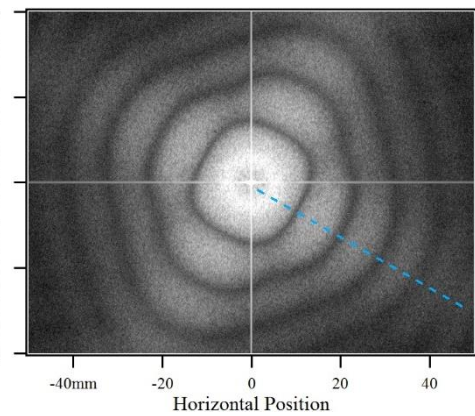
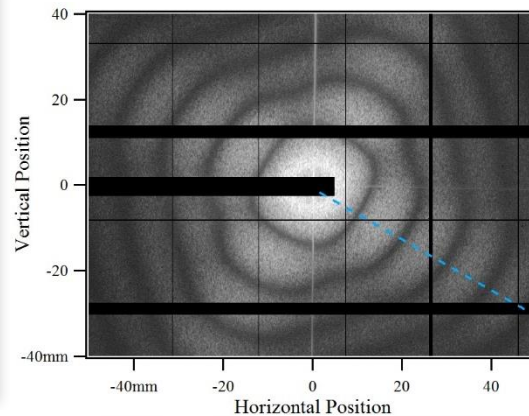
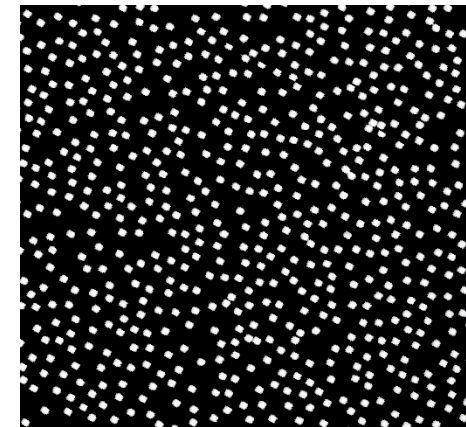
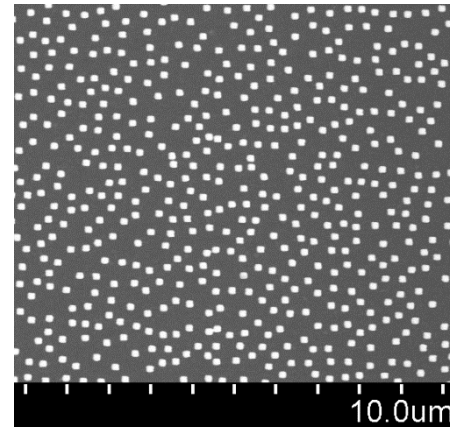
Method of Getting Delta/Attenuation Length: Server <http://henke.lbl.gov>

Refractive Index Decrement of Material: 3.227904×10^{-5}

Attenuation Length [m]: 4.069870×10^{-6}

Center Position [nm]: Horizontal 0 Vertical 0

Close



SRW and Sirepo extension:

Sample scattering simulation using microscopy imaging:
Python+NumPy/SciPy/PIL

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

Data storage & exchange

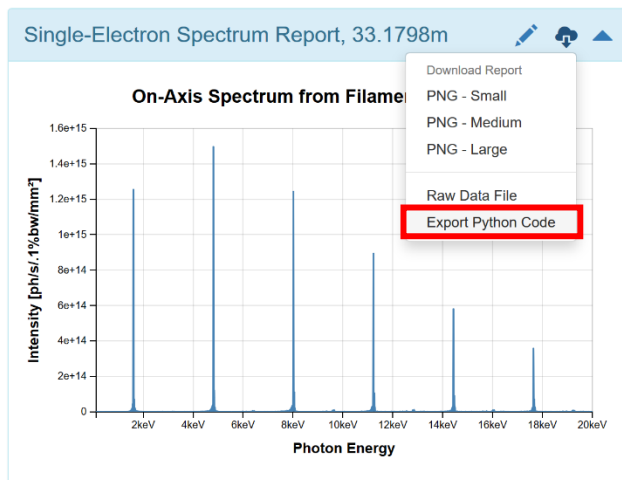
Export:

- 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



Self-Extracting Simulation: Tabulated Undulator Example

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

Send to Server

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



Sign in to GitHub
to continue to Sirepo (Beta)

Username or email address

Password

[Forgot password?](#)

Sign in

New to GitHub? [Create an account.](#)

New Folder

Import

Sign In with GitHub



Wavefront
Propagation

Demonstration of Sirepo

<https://sirepo.com>

<https://jupyter.radiasoft.org>

Summary:

- A user-friendly browser interface “Sirepo” for portable reproducible SRW simulations developed in collaboration with RadiaSoft LLC and deployed at NSLS-II
- Virtual beamlines: 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 for optical constants for particular photon energy and material in one click
- Advanced import-export features & OAuth2
- Sirepo supports many other simulation codes, new codes can be integrated easily: <https://github.com/radiasoft/sirepo/wiki/Hello-World-Application>

Acknowledgements

Experiment development:

Oleg Chubar



David Bruhwiler
Robert Nagler
Paul Moeller



Mikhail Zhernenkov
*Elaine DiMasi



Andrei Fluerasu
Lutz Wiegart
Yugang Zhang

SRX team:

Juergen Thieme
Garth Williams
*Karen Chen-Wiegart

ESM team:

Elio Vescovo
Andrew Walter

Metrology group:

Mourad Idir
Konstantine Kaznatcheev
Lei Huang

ID group:

*Charles Kitegi
Dean Hidas
Marco Musardo



Center for Functional Nanomaterials

Julien Lhermitte