# 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

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U.S. DEPARTMENT OF ENERGY

BROOKHAVEN NATIONAL LABORATORY

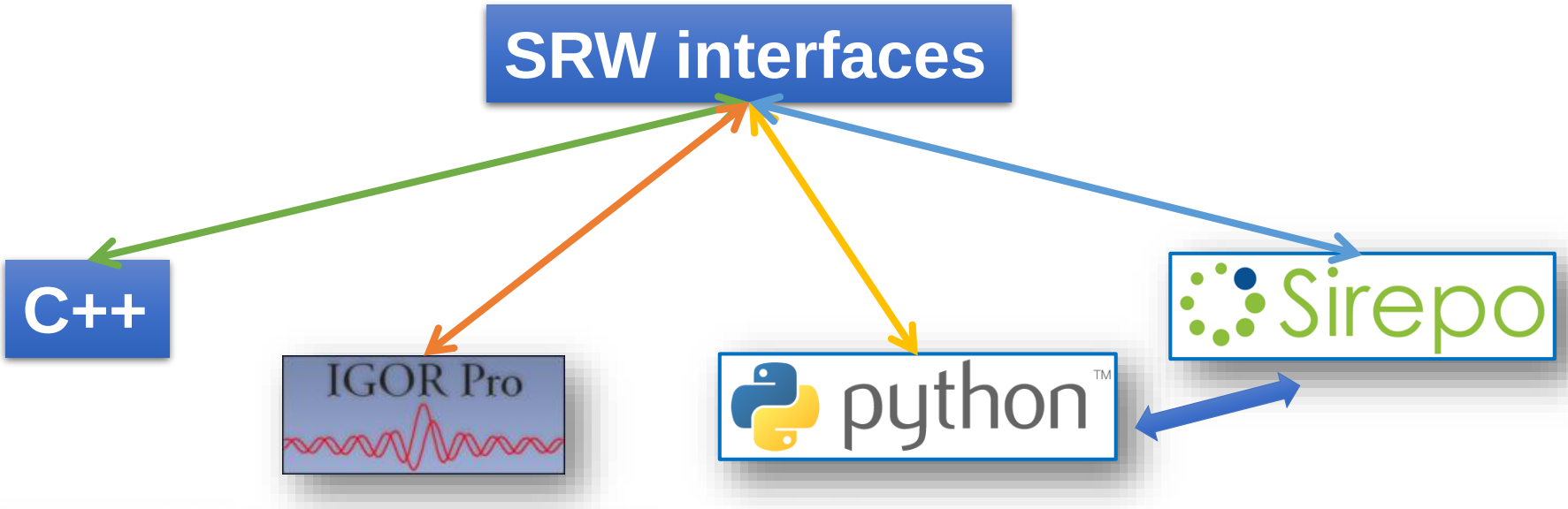
# Outline

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

- Demonstration of Sirepo

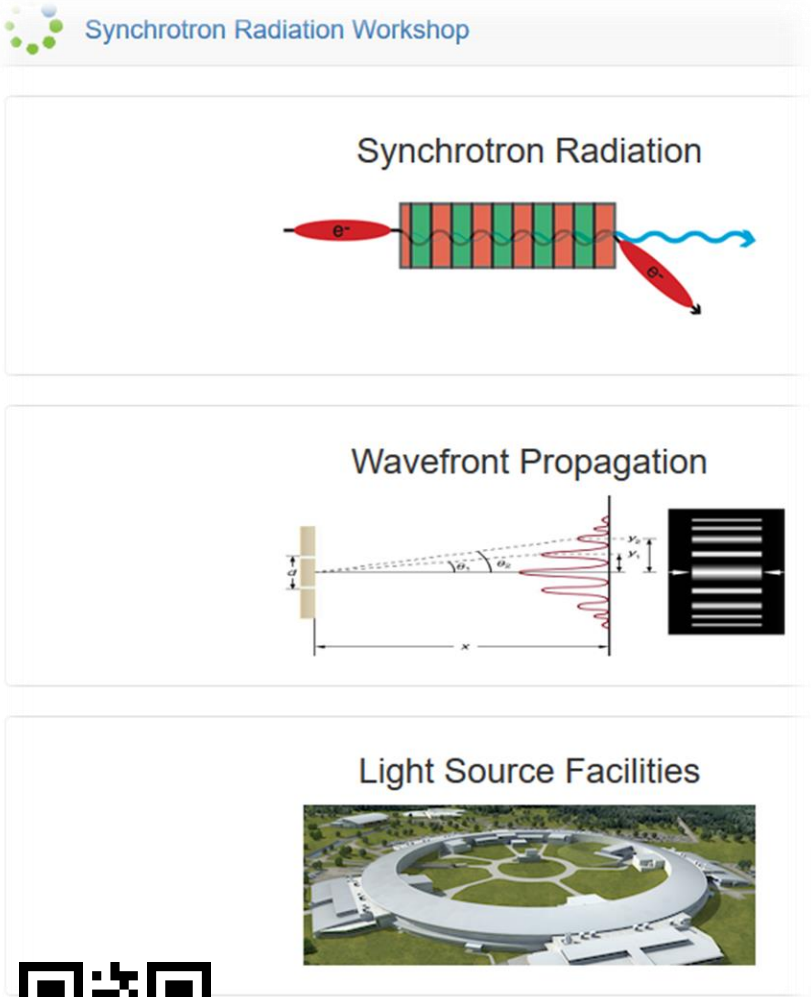
# Sirepo & SRW

- **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

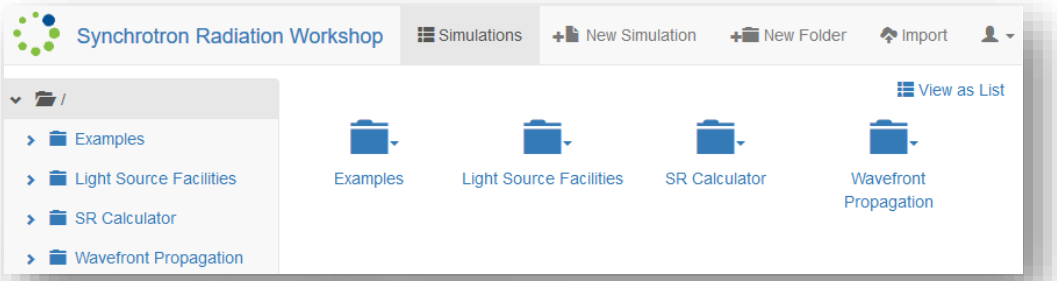



**Distribution:**

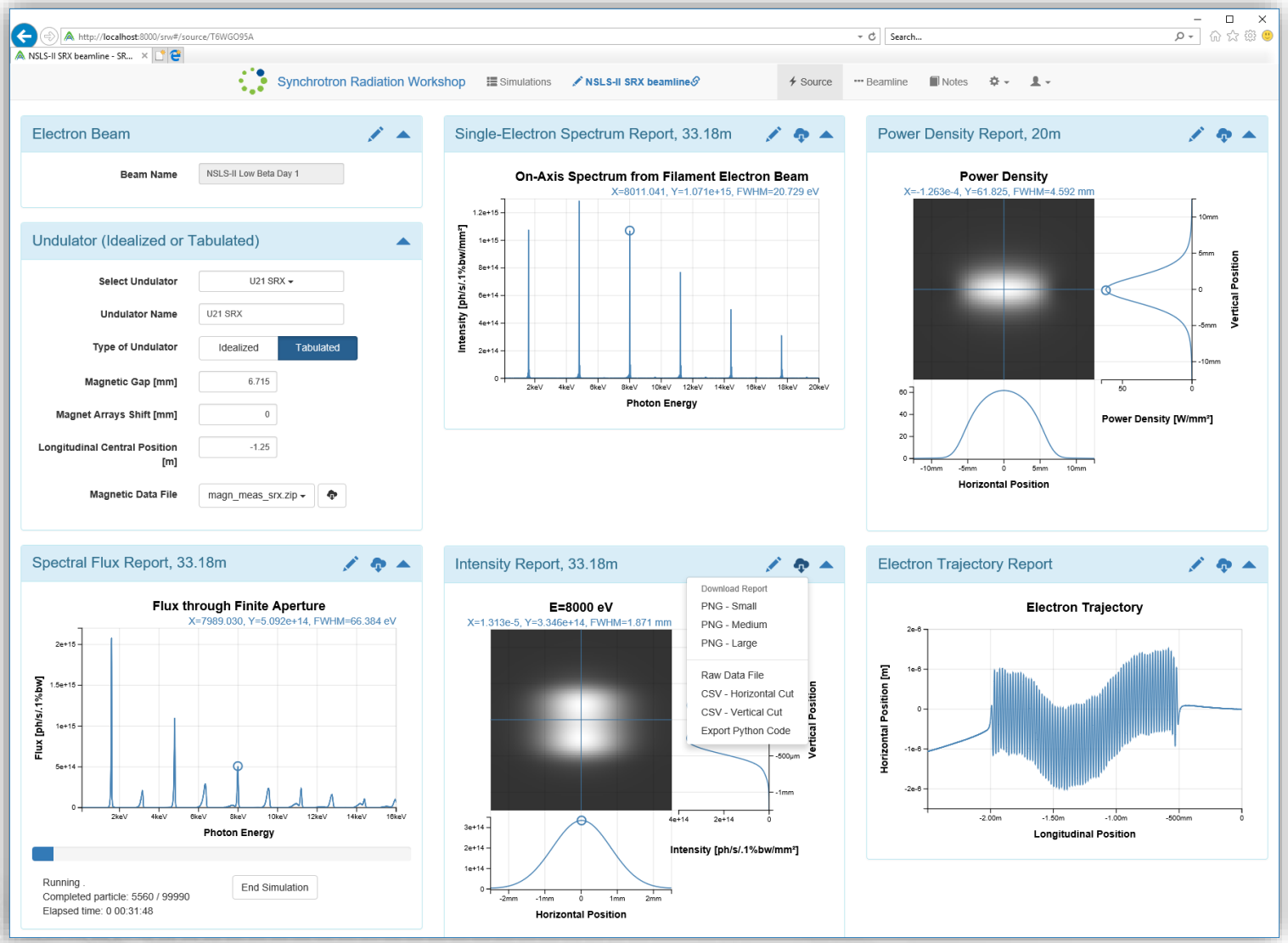
- **Source code:**
  - https://github.com/radiasoft/sirepo
  - https://github.com/ochubar/SRW
- **Docker containers:**
  https://hub.docker.com/r/radiasoft/sirepo/tags/
- **Vagrant boxes:**
  https://atlas.hashicorp.com/radiasoft/boxes/sirepo

**Servers:**

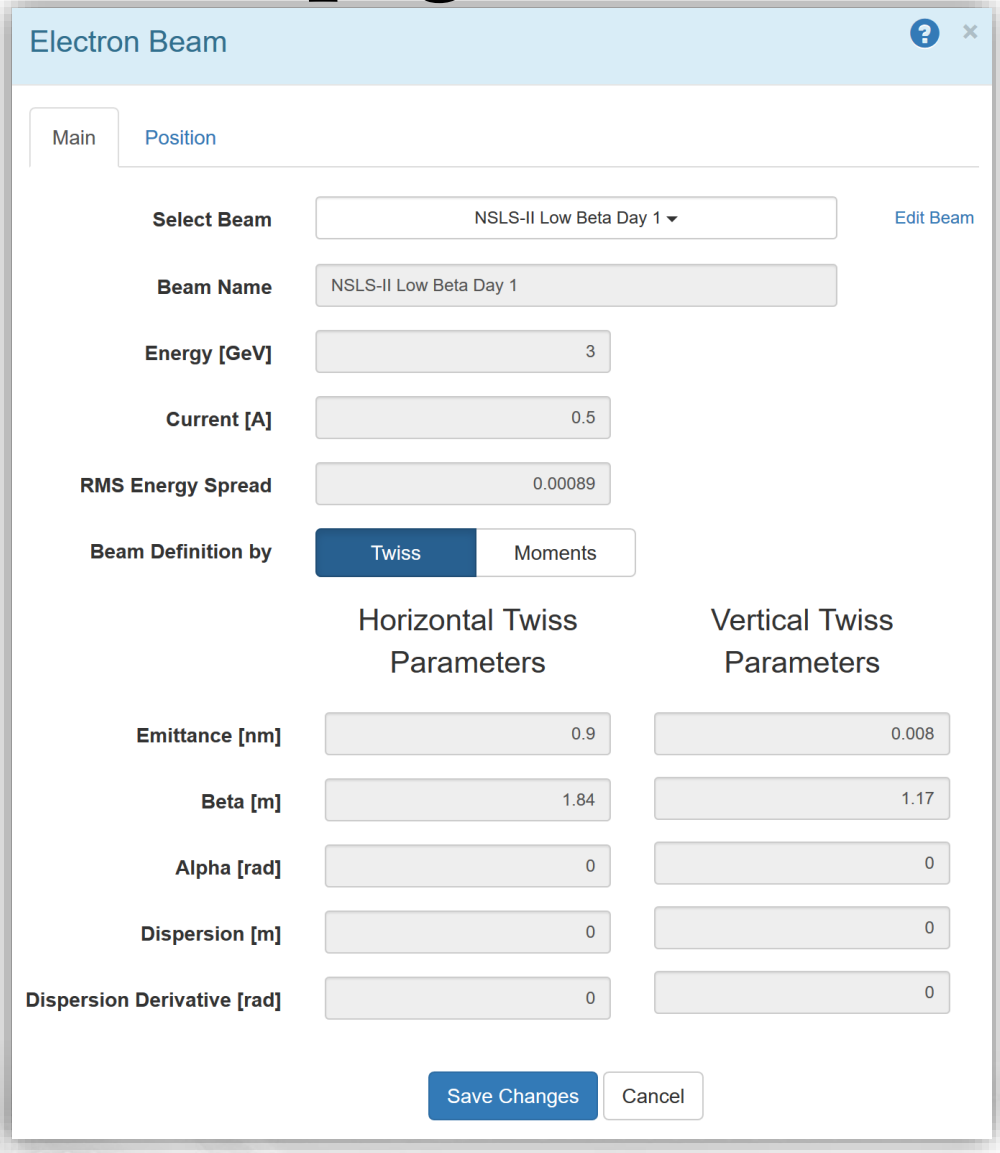
https://sirepo.com/light – globally available
https://expdev.nsls2.bnl.gov/light – behind BNL firewall
http://nsls2expdev1.bnl.gov/light – behind BNL firewall

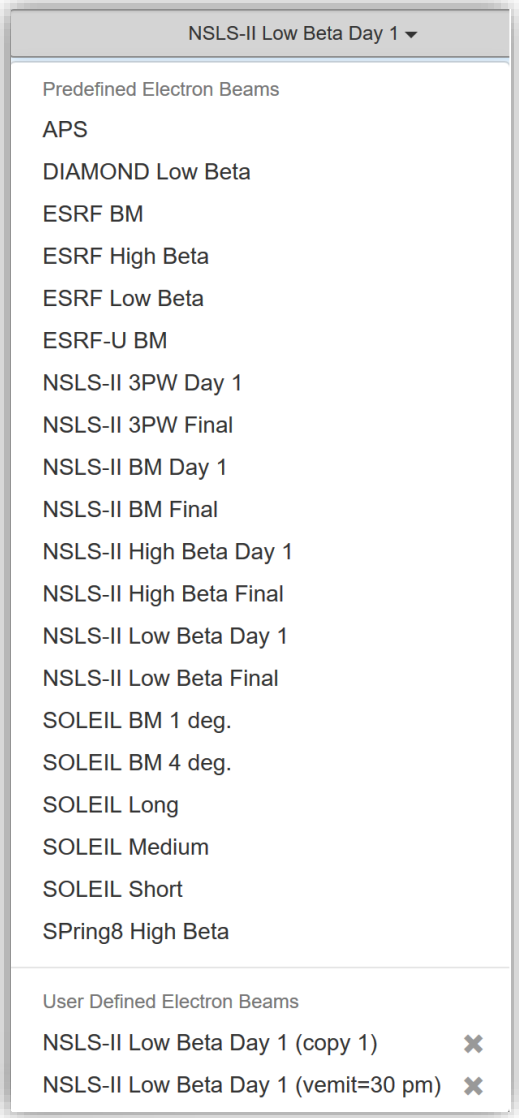


# Source page

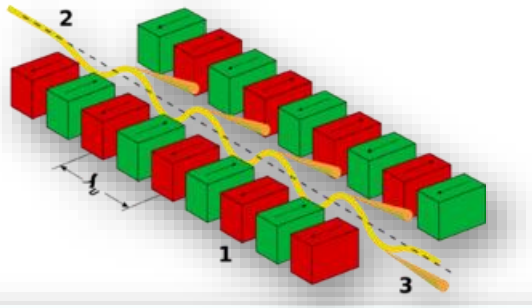

Synchrotron Radiation Workshop
Simulations
NSLS-II SRX beamline
Source
Beamline
Notes
Electron Beam
Beam Name
NSLS-II Low Beta Day 1
Undulator (Idealized or Tabulated)
Select Undulator
U21 SRX
Undulator Name
U21 SRX
Type of Undulator
Idealized
Tabulated
Magnetic Gap [mm]
6.715
Magnet Arrays Shift [mm]
0
Longitudinal Central Position [m]
-1.25
Magnetic Data File
magn_meas_srx.zip
Single-Electron Spectrum Report, 33.18m
On-Axis Spectrum from Filament Electron Beam
X=8011.041, Y=1.071e+15, FWHM=20.729 eV
Intensity [ph/s/.1%bw/mm²]
Photon Energy
Power Density Report, 20m
Power Density
X=-1.263e-4, Y=61.825, FWHM=4.592 mm
Vertical Position
Power Density [W/mm²]
Horizontal Position
Spectral Flux Report, 33.18m
Flux through Finite Aperture
X=7989.030, Y=5.092e+14, FWHM=66.384 eV
Flux [ph/s/.1%bw]
Photon Energy
Running .
Completed particle: 5560 / 99990
Elapsed time: 0 00:31:48
End Simulation
Intensity Report, 33.18m
E=8000 eV
X=1.313e-5, Y=3.346e+14, FWHM=1.871 mm
Download Report
PNG - Small
PNG - Medium
PNG - Large
Raw Data File
CSV - Horizontal Cut
CSV - Vertical Cut
Export Python Code
Vertical Position
Intensity [ph/s/.1%bw/mm²]
Horizontal Position
Electron Trajectory
Electron Trajectory
Horizontal Position [m]
Longitudinal Position

# Source page: definition of the beam



# Source page: definition of the source



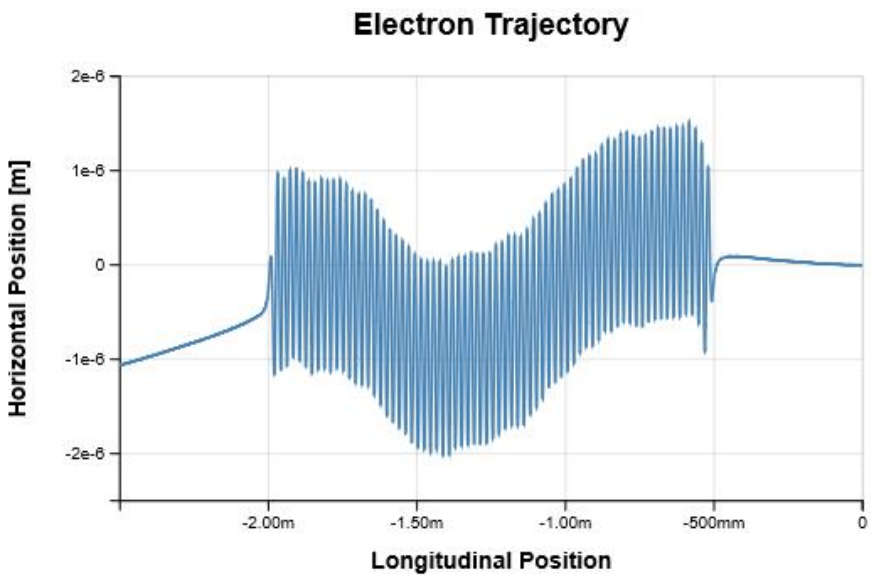

**Undulator (Idealized or Tabulated)**

| | |
|---|---|
| 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 |

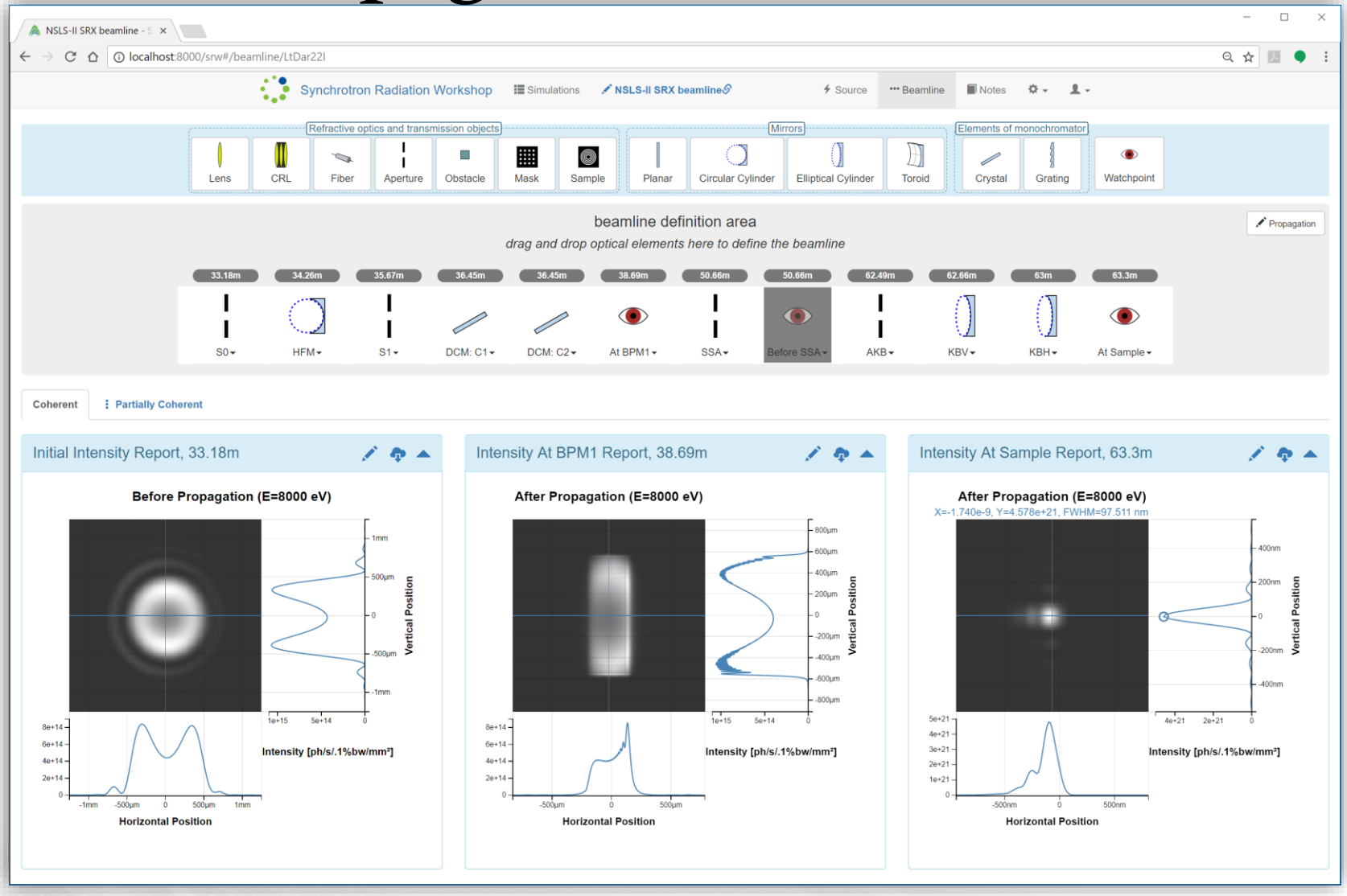
**Idealized Undulator**

| | Horizontal | Vertical |
|---|---|---|
| Deflecting Parameter (K) | 1.65776086 | |
| Period [mm] | 20 | |
| Length [m] | 3 | |
| Longitudinal Central Position [m] | 0 | |
| Magnetic Field [T] | 0 | 0.88770981 |
| Initial Phase [rad] | 0 | 0 |
| Symmetry | Symmetrical | Anti-symmetri |

**Electron Trajectory Report**



# Beamline page

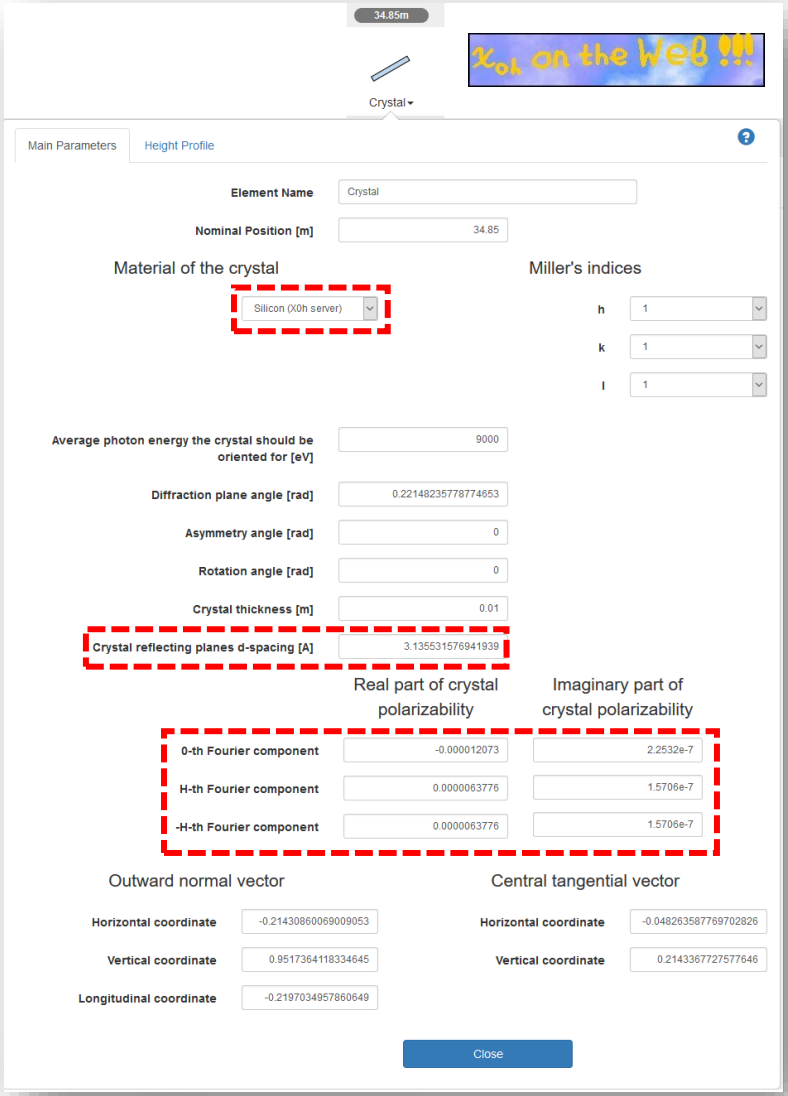


# Dynamic access to external databases

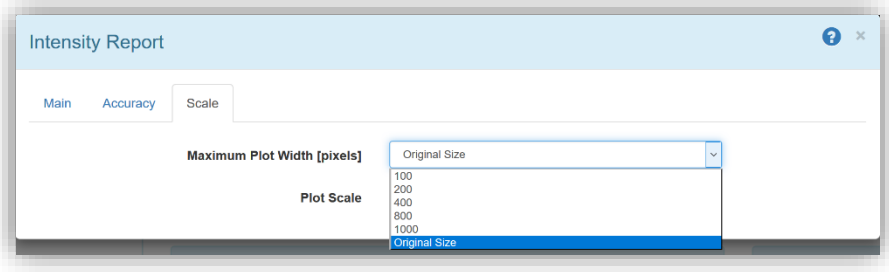
Data is dynamically queried from:

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

**Python API** for data access

# Intensity image resizing and scaling



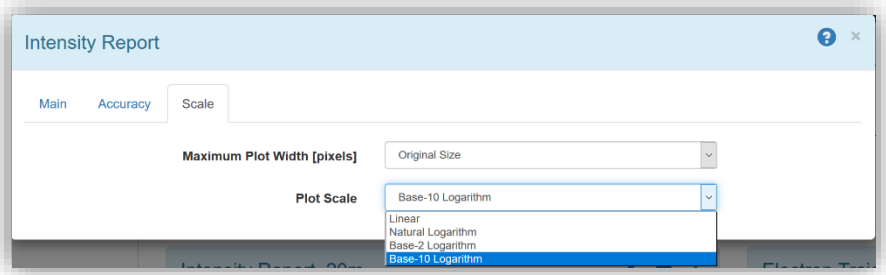
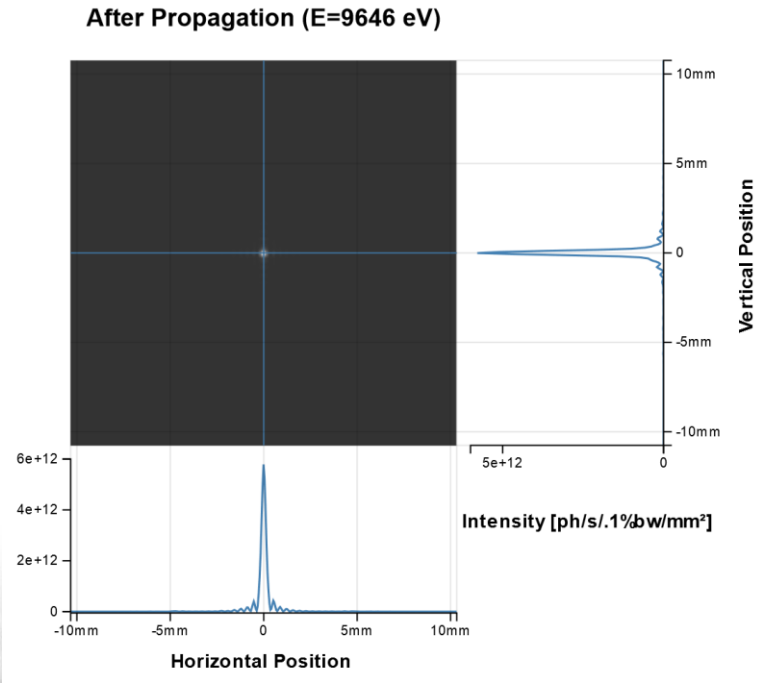
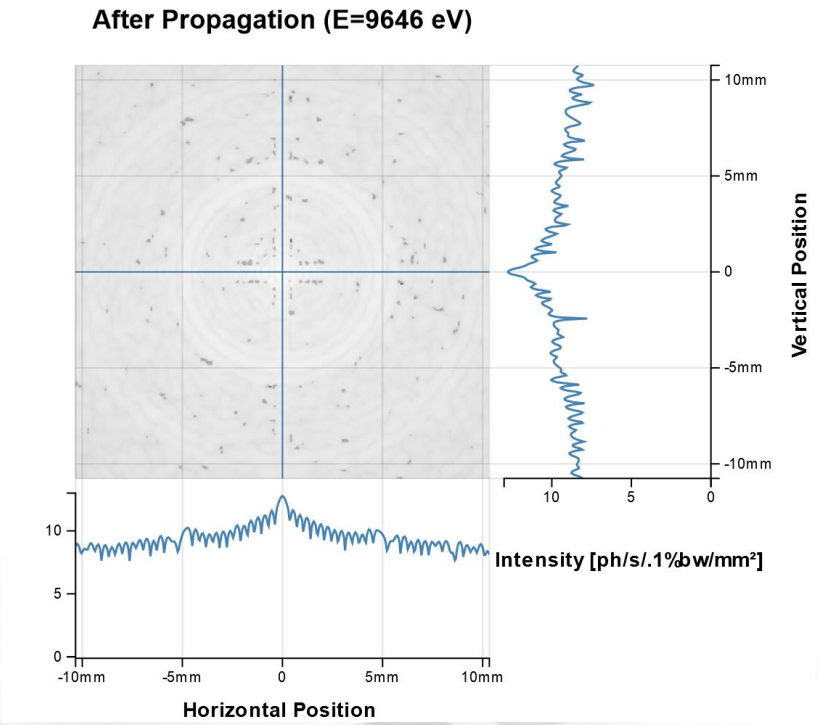



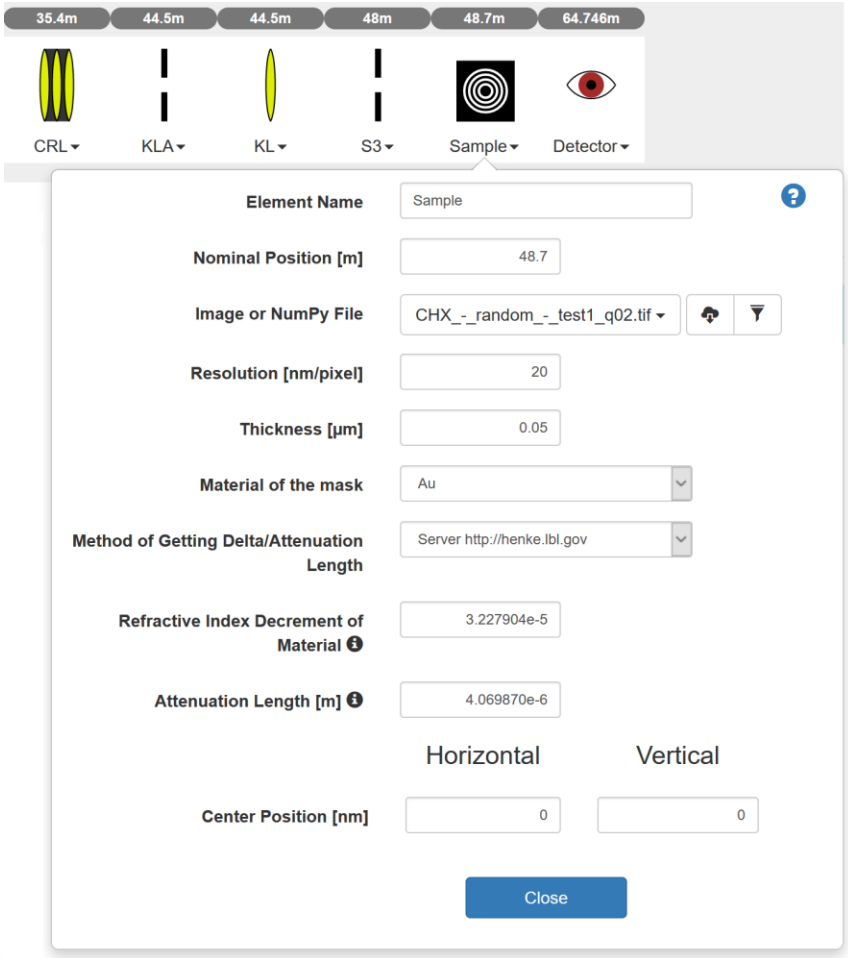

Image resizing option implemented in Sirepo and SRW using SciPy to optimize amount of data transferred from server to client

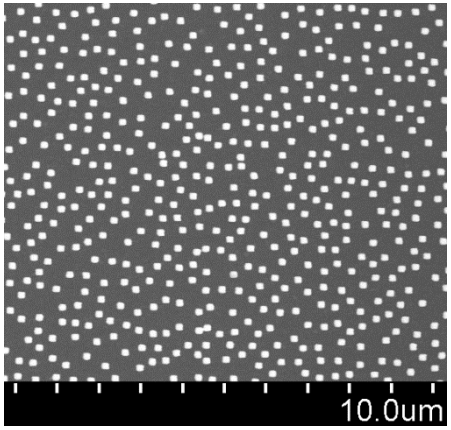


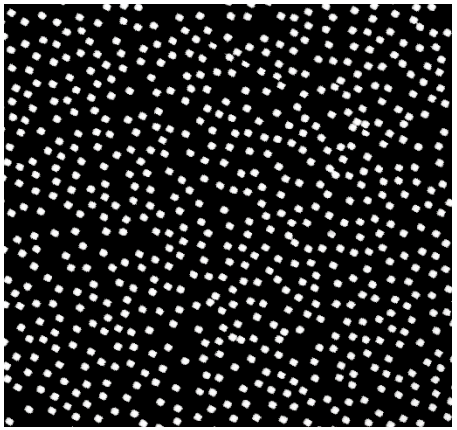

Selection of scales (linear & logarithmic) implemented in Sirepo and SRW using NumPy to allow better insight into the resulted intensity

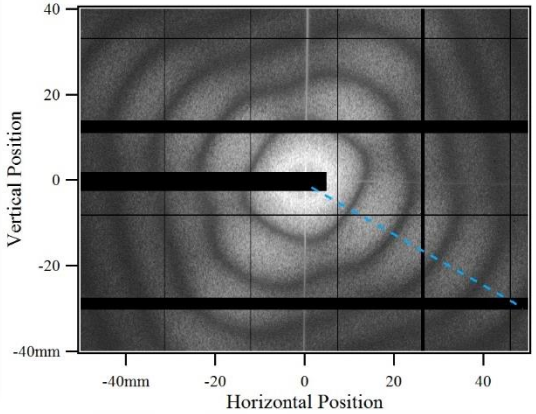


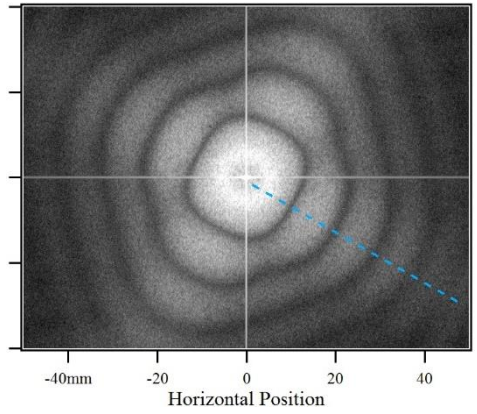
# Simulation of scattering experiments





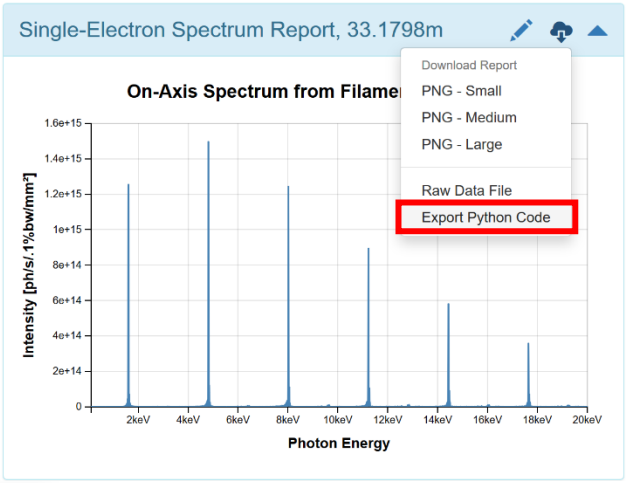




**SRW and Sirepo extension:**
Sample scattering simulation using microscopy imaging:
Python+NumPy/SciPy/PIL

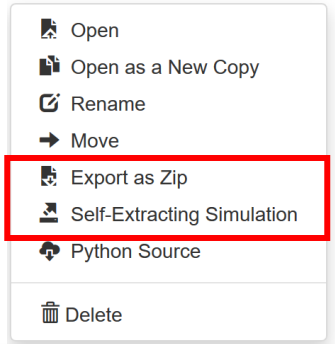
Chubar, *et al.* Proc. SPIE (2017), 10.1117/12.2274481

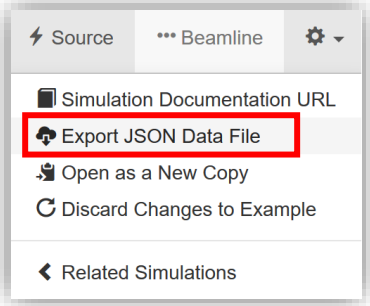
# Data storage & exchange

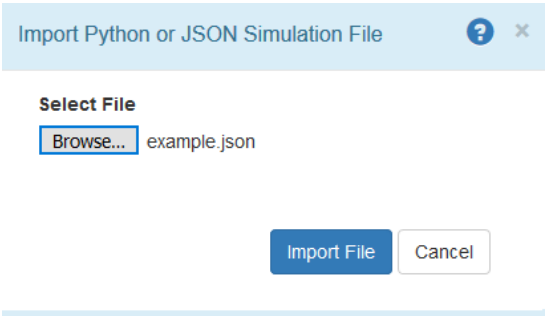
**Export:**
- Python script
- JSON file
- Zip-archive
- Self-extracting simulation

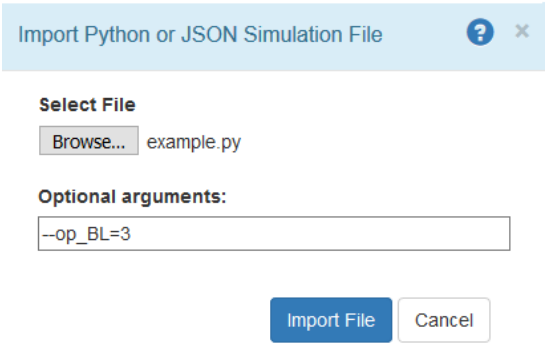



Tabulated Undulator Example

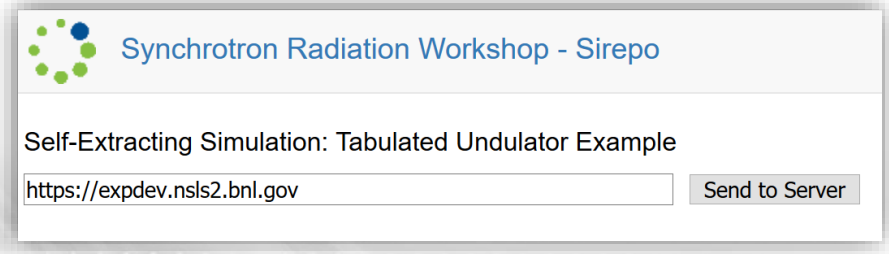


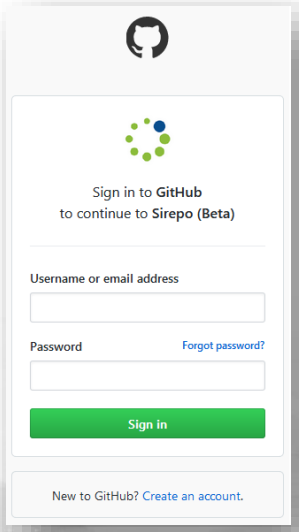



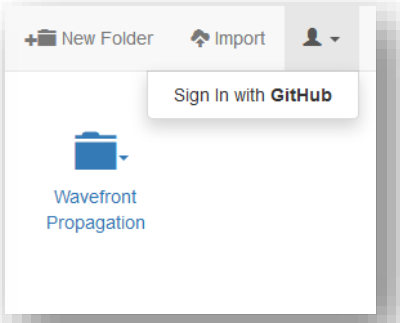




**Import:**
- Python script
- JSON
- Zip-archive



# 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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*Elaine DiMasi

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Lutz Wiegart
Yugang Zhang

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Garth Williams
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Andrew Walter

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Konstantine Kaznatcheev
Lei Huang

**ID group:**
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Dean Hidas
Marco Musardo

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Julien Lhermitte