Comparison of results from different codes:
URGENT, US, SRW and pySRU for zero emittance calculations

This document compares the results of undulator emission by different codes (US. URGENT. SRW and pySRU).

The calculations are:

- Flux emission or radiance at an aperture (x,y) placed at a given distance for a monochromatic photon energy E0
- Flux spectrum integrated over the aperture
- Power density distribution (versus x,y) at the aperture.

Zero emittance has been used for all calculations in this document.

The purpose of the document is a validation of our pySRU code. This code calculates the emission at an aperture I(x,y) for a photon energy E0, thus I(E0,x,y). For different energies one can calculate the stack array I(E,x,y). Integration over the zero axis gives the power density P(x,y). Integration over axes 1 and 2 gives the energy spectrum I(E). Certainly, this is not the most efficient way for computing the spectrum and the power density, but in this document it is done in this way for testing the pySRU results. Other more efficient formulas will be added to pySRU for quick spectral and power density calculations, as used in the other codes.

The calculated cases are 1) the figure 2.5 of the X-ray Data Booklet http://xdb.lbl.gov/Section2/Sec_2-1.html, and 2) the ESRF electron beam with undulators at various K values: K=0.25 (SHADOW_DEFAULTS), K=1.68 (ESRF_NEW_OB), and K=4.0 (ID16_NA).

Parameters of the cases studied

XRAY_BOOKLET

ElectronBeamDivergenceH = 1e-30
ElectronBeamDivergenceV = 1e-30
ElectronBeamSizeH = 1e-30
ElectronBeamSizeV = 1e-30
ElectronEnergySpread = 1e-30
ElectronCurrent = 1.0
ElectronEnergy = 1.3
Kv = 1.87
NPeriods = 14
PeriodID = 0.035
distance = 100.0
gapH = 0.2
gapV = 0.2

ID16_NA

ElectronBeamDivergenceH = 1e-30
ElectronBeamDivergenceV = 1e-30
ElectronBeamSizeH = 1e-30
ElectronBeamSizeV = 1e-30
ElectronEnergySpread = 1e-30
ElectronCurrent = 0.2
ElectronEnergy = 6.04
Kv = 4.0
NPeriods = 77
PeriodID = 0.026
distance = 20.0
gapH = 0.015
gapV = 0.015

ESRF_NEW_OB

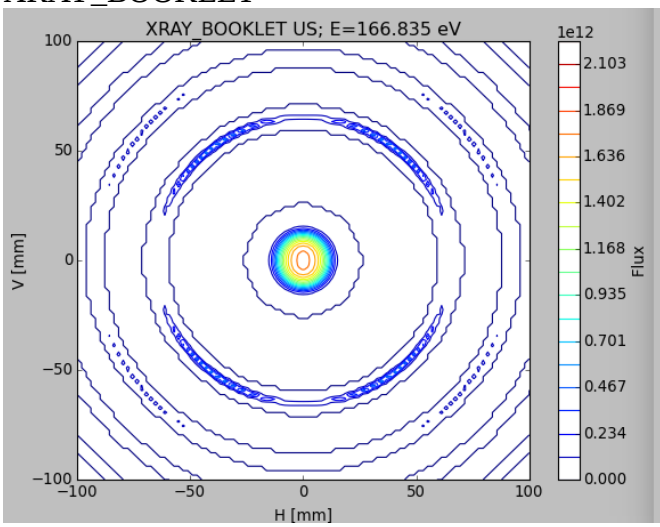
ElectronBeamDivergenceH = 1e-30
ElectronBeamDivergenceV = 1e-30
ElectronBeamSizeH = 1e-30
ElectronBeamSizeV = 1e-30
ElectronEnergySpread = 1e-30
ElectronCurrent = 0.2
ElectronEnergy = 6.0
Kv = 1.68
NPeriods = 222
PeriodID = 0.018
distance = 30.0
gapH = 0.001
gapV = 0.001

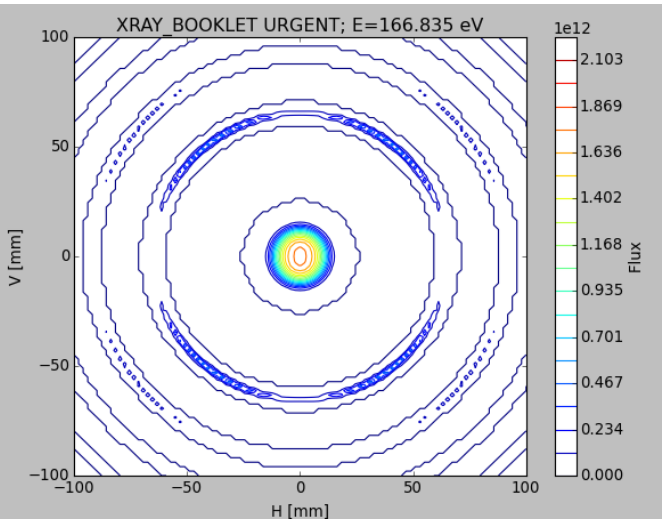
SHADOW_DEFAULTS

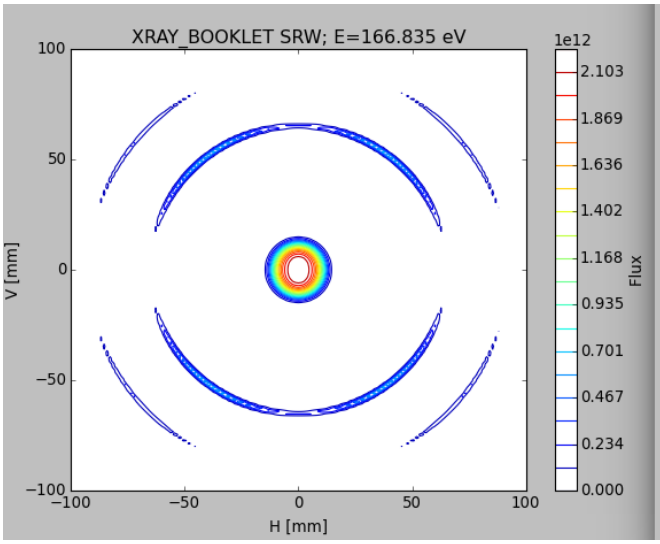
ElectronBeamSizeH = 1e-30
ElectronBeamSizeV = 1e-30
ElectronBeamDivergenceH = 1e-30
ElectronBeamDivergenceV = 1e-30
ElectronEnergySpread = 1e-30
ElectronCurrent = 0.2
ElectronEnergy = 6.04
Kv = 0.25
NPeriods = 50.0
PeriodID = 0.032
distance = 10.0
gapH = 0.002
gapV = 0.002

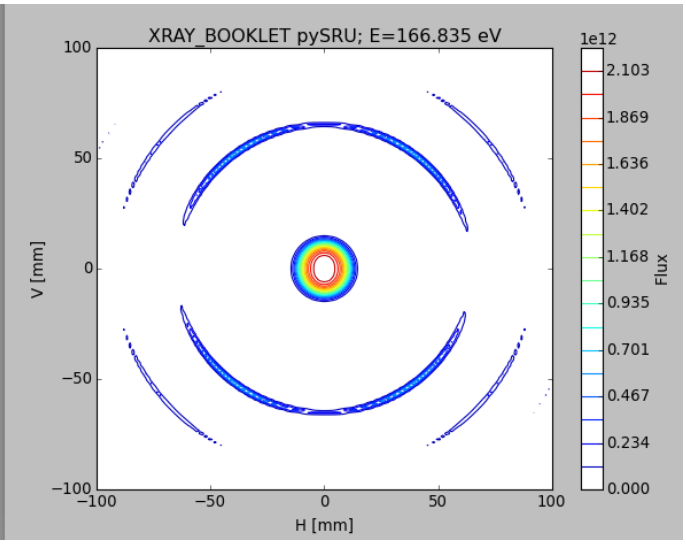
Radiance at first harmonic

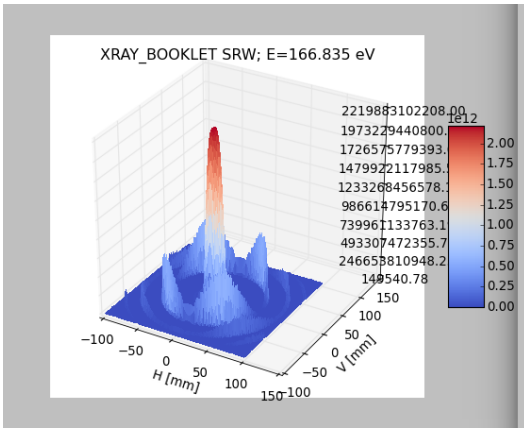
XRAY_BOOKLET

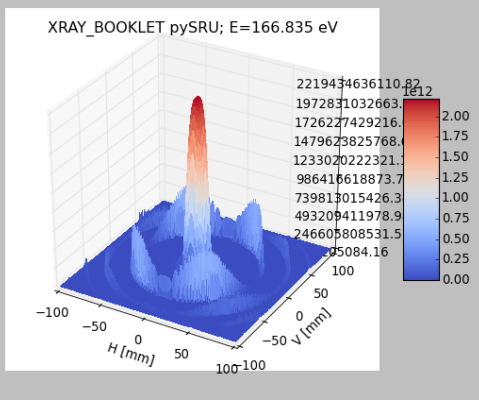




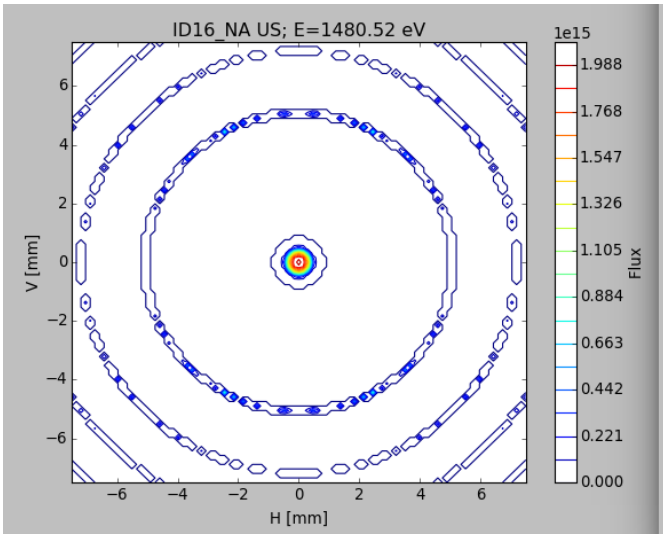


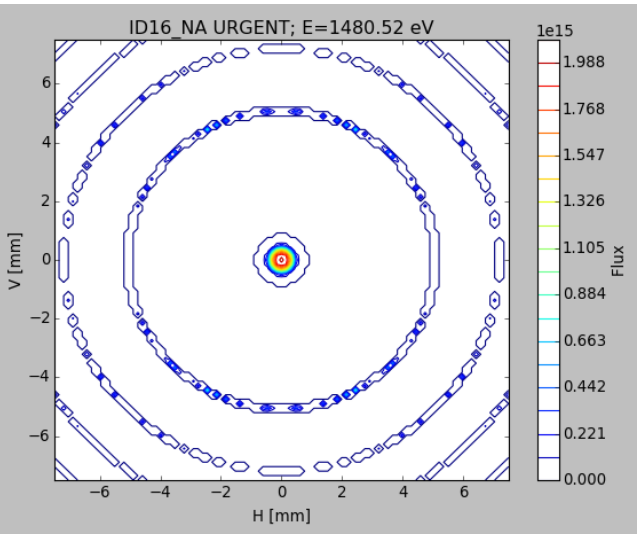


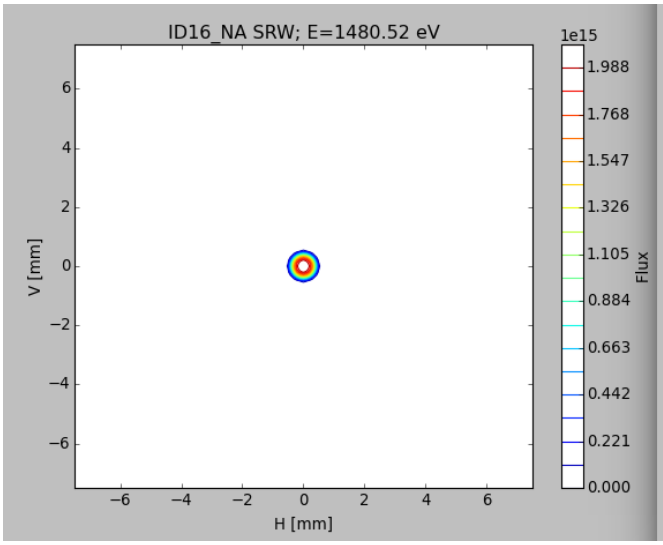


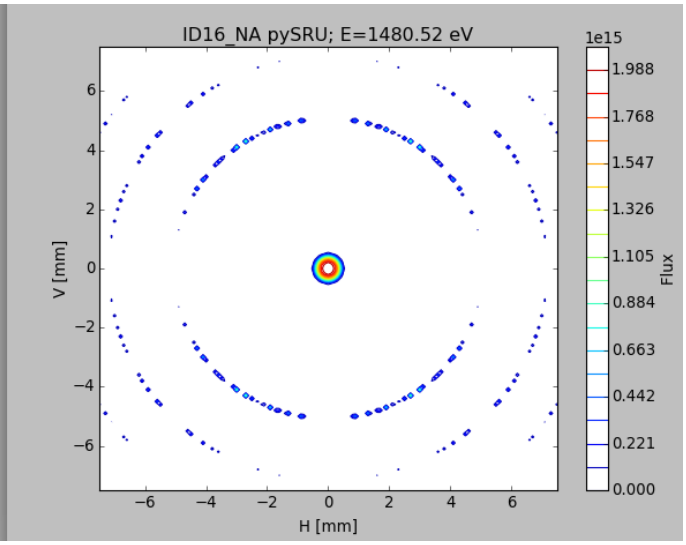


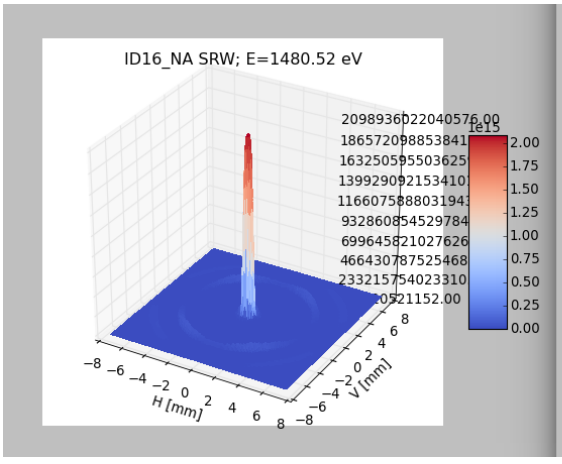
ID16_NA

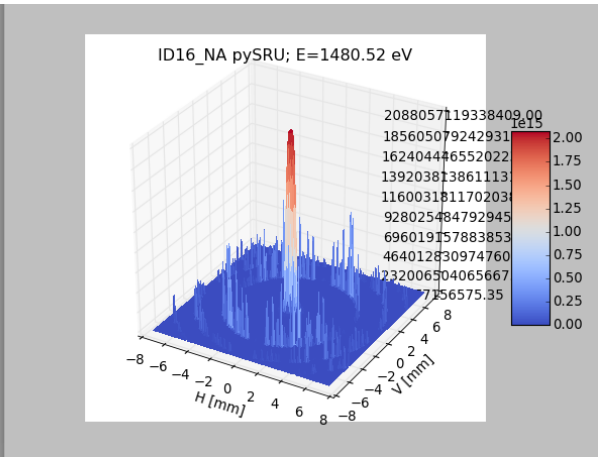

ID16_NA US; E=1480.52 eV
1e15
1.988
1.768
1.547
1.326
1.105
0.884
0.663
0.442
0.221
0.000
Flux
V [mm]
H [mm]


ID16_NA URGENT; E=1480.52 eV
1e15
1.988
1.768
1.547
1.326
1.105
0.884
0.663
0.442
0.221
0.000
Flux
V [mm]
H [mm]

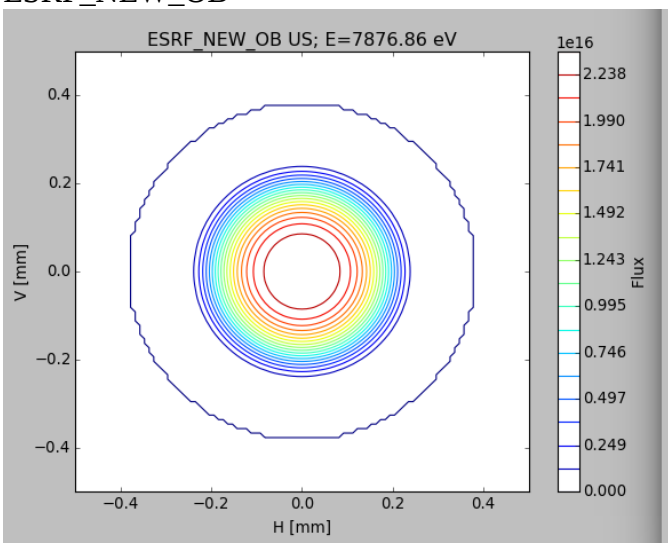

ID16_NA SRW; E=1480.52 eV
1e15
1.988
1.768
1.547
1.326
1.105
0.884
0.663
0.442
0.221
0.000
Flux
V [mm]
H [mm]

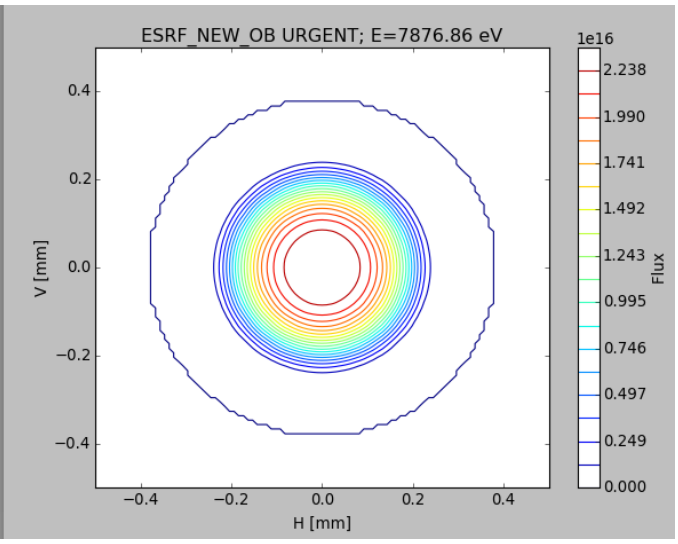

ID16_NA pySRU; E=1480.52 eV
1e15
1.988
1.768
1.547
1.326
1.105
0.884
0.663
0.442
0.221
0.000
Flux
V [mm]
H [mm]

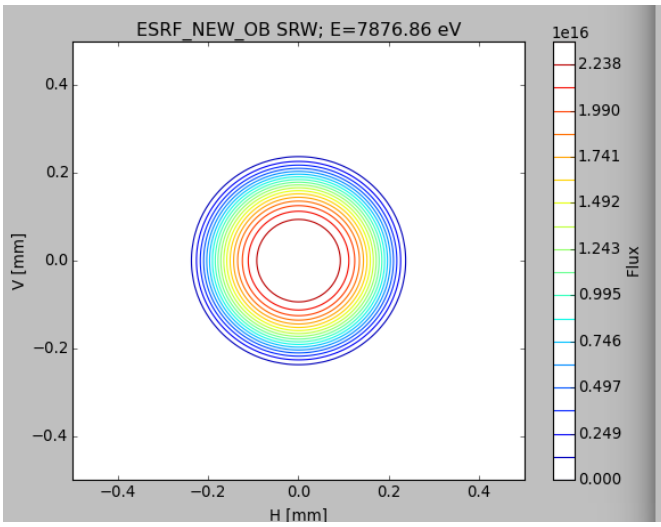

ID16_NA SRW; E=1480.52 eV
1e15
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
H [mm]
V [mm]

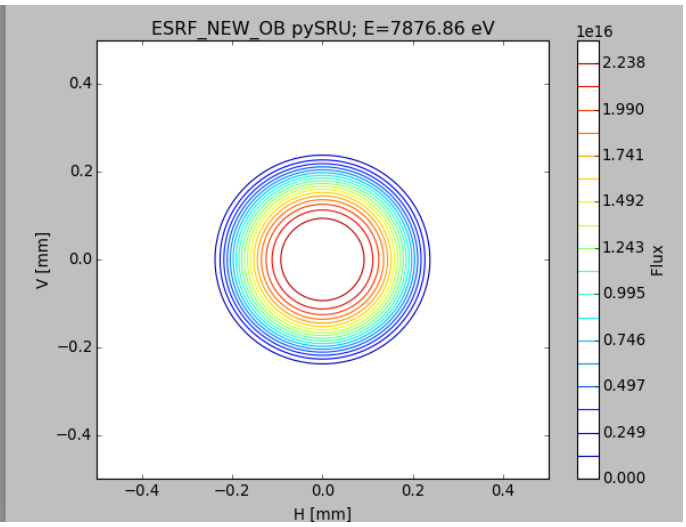

ID16_NA pySRU; E=1480.52 eV
1e15
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
H [mm]
V [mm]

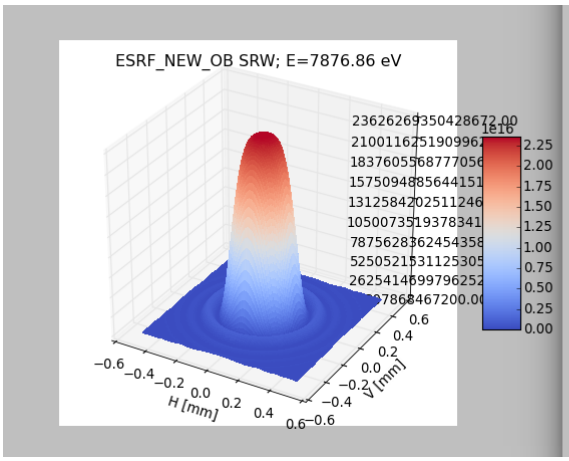
ESRF_NEW_OB

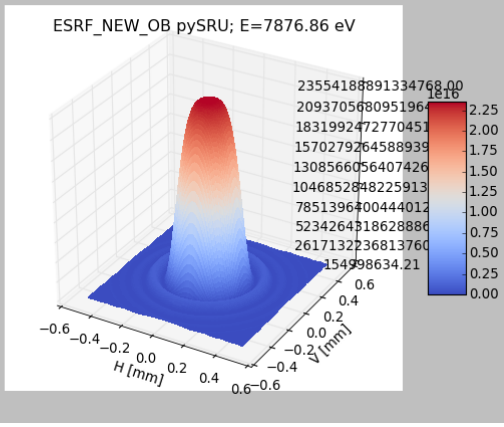

ESRF_NEW_OB US; E=7876.86 eV
1e16
2.238
1.990
1.741
1.492
1.243
0.995
0.746
0.497
0.249
0.000
Flux
V [mm]
H [mm]


ESRF_NEW_OB URGENT; E=7876.86 eV
1e16
2.238
1.990
1.741
1.492
1.243
0.995
0.746
0.497
0.249
0.000
Flux
V [mm]
H [mm]

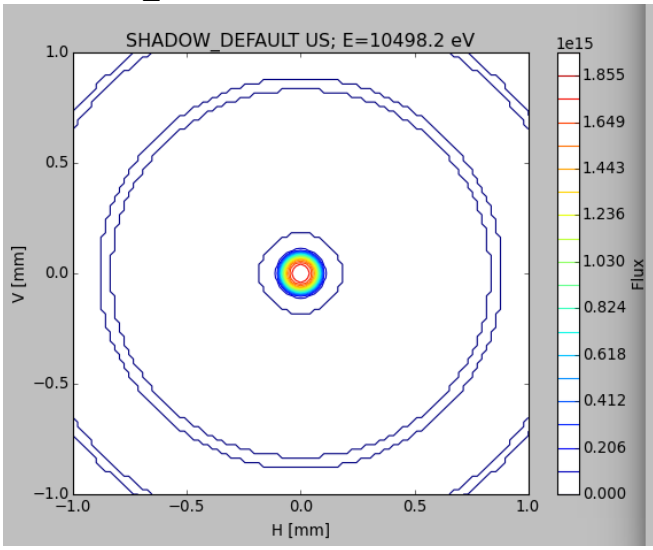

ESRF_NEW_OB SRW; E=7876.86 eV
1e16
2.238
1.990
1.741
1.492
1.243
0.995
0.746
0.497
0.249
0.000
Flux
V [mm]
H [mm]

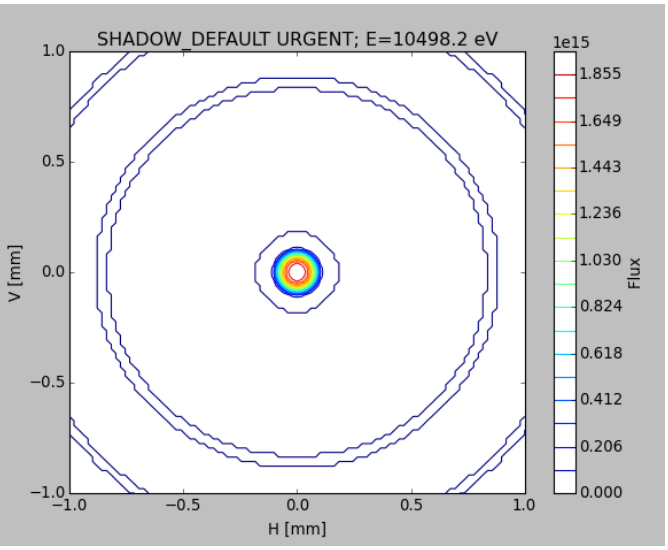

ESRF_NEW_OB pySRU; E=7876.86 eV
1e16
2.238
1.990
1.741
1.492
1.243
0.995
0.746
0.497
0.249
0.000
Flux
V [mm]
H [mm]

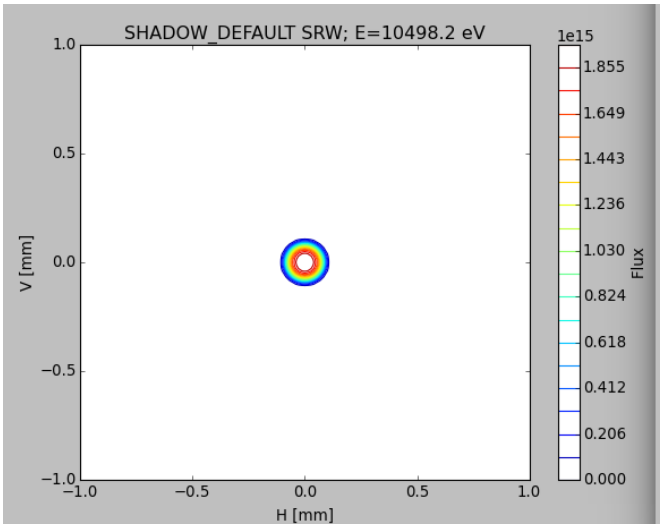

ESRF_NEW_OB SRW; E=7876.86 eV
1e16
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
H [mm]
V [mm]

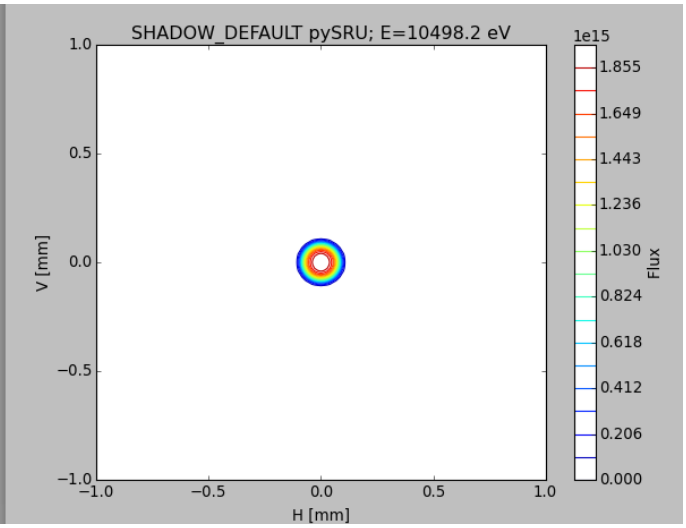

ESRF_NEW_OB pySRU; E=7876.86 eV
1e16
2.25
2.00
1.75
1.50
1.25
1.00
0.75
0.50
0.25
0.00
H [mm]
V [mm]

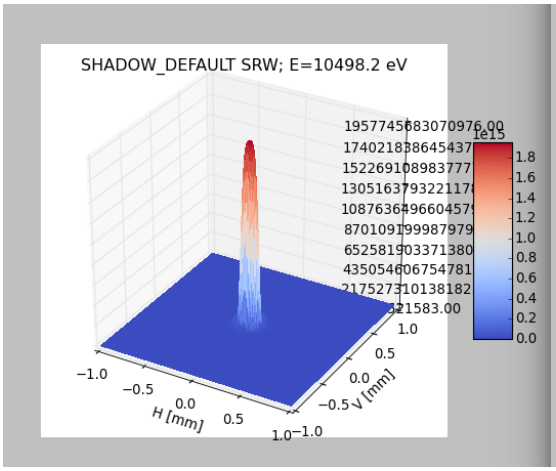
SHADOW_DEFAULT

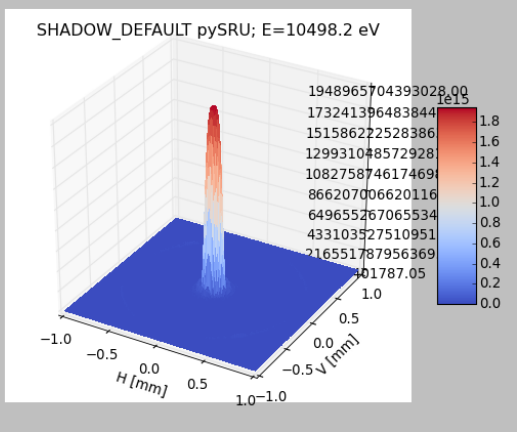








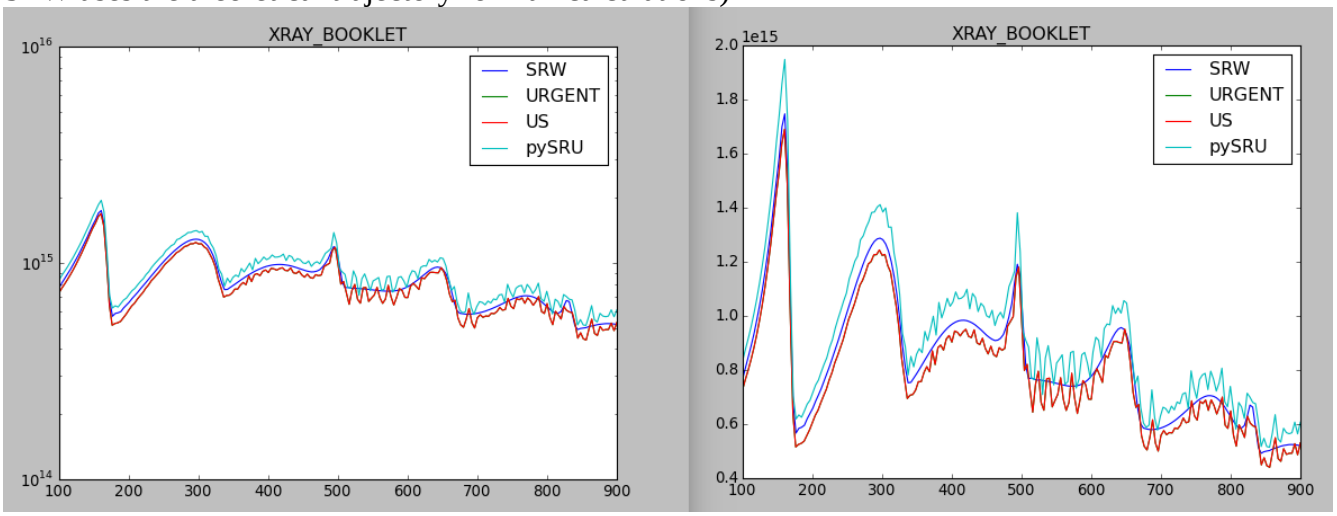




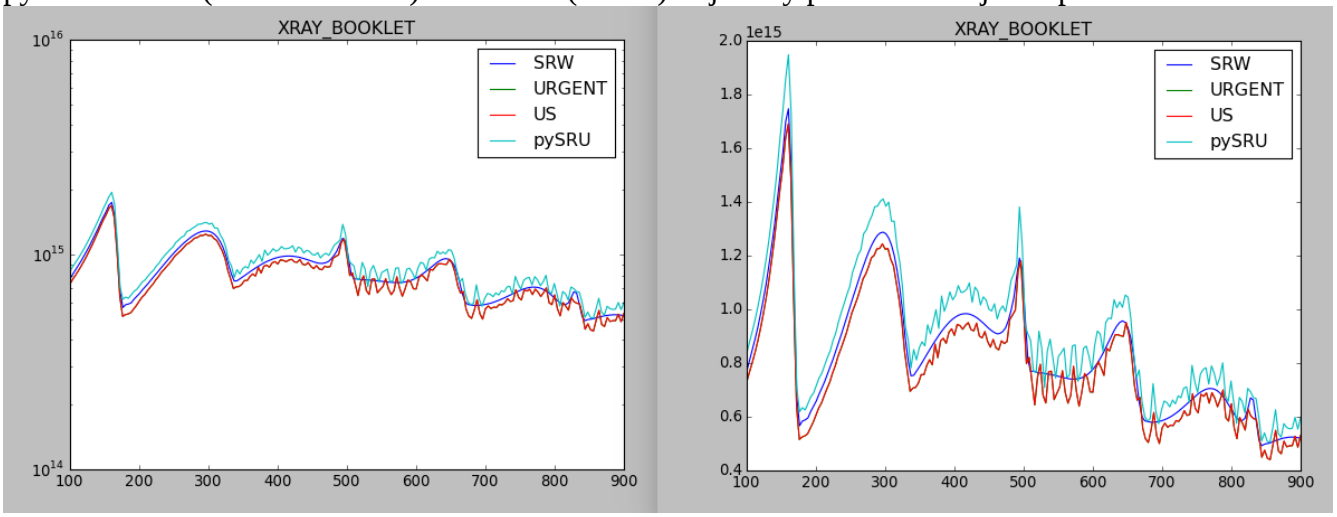
Energy spectrum

XRAY_BOOKLET

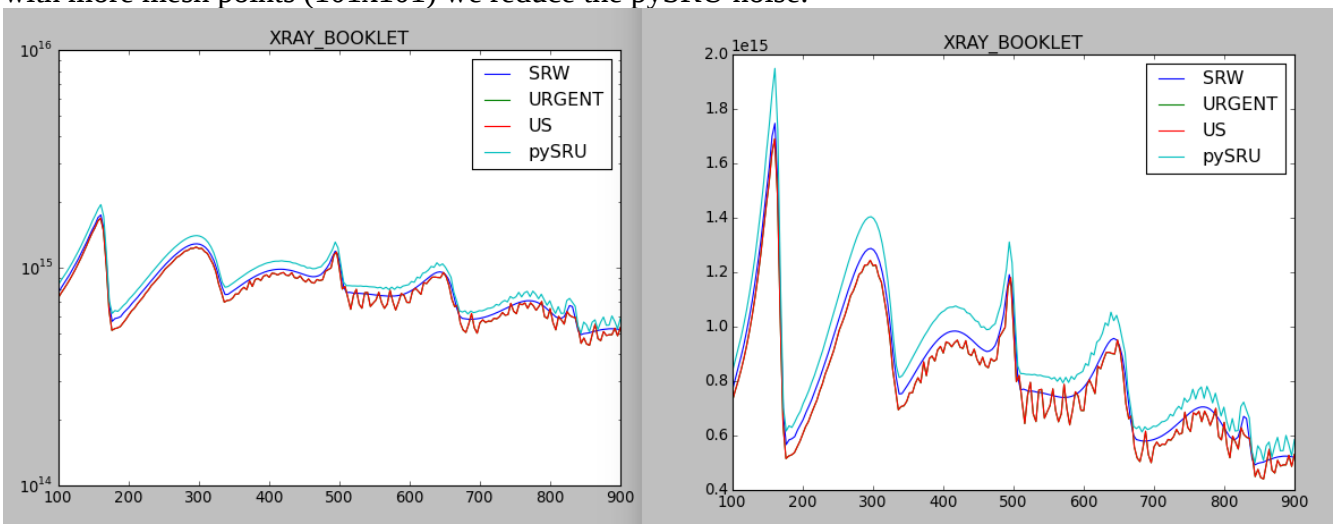
200 energy points. pySRU default (ODE+NEAR F)
(the pySRU flux is a bit higher because it used the full magnetic field with edges added -ODE- and SRW uses the theoretical trajectory for flux calculations)



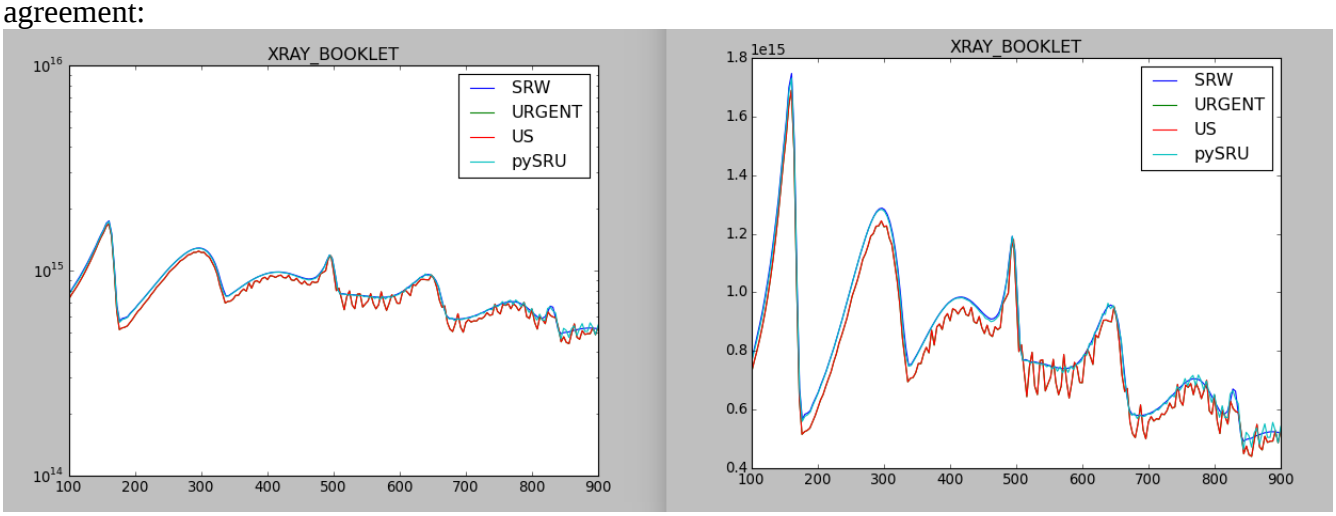
pySRU default (ODE+NEAR F) with more (20000) trajectory points: no major improvement



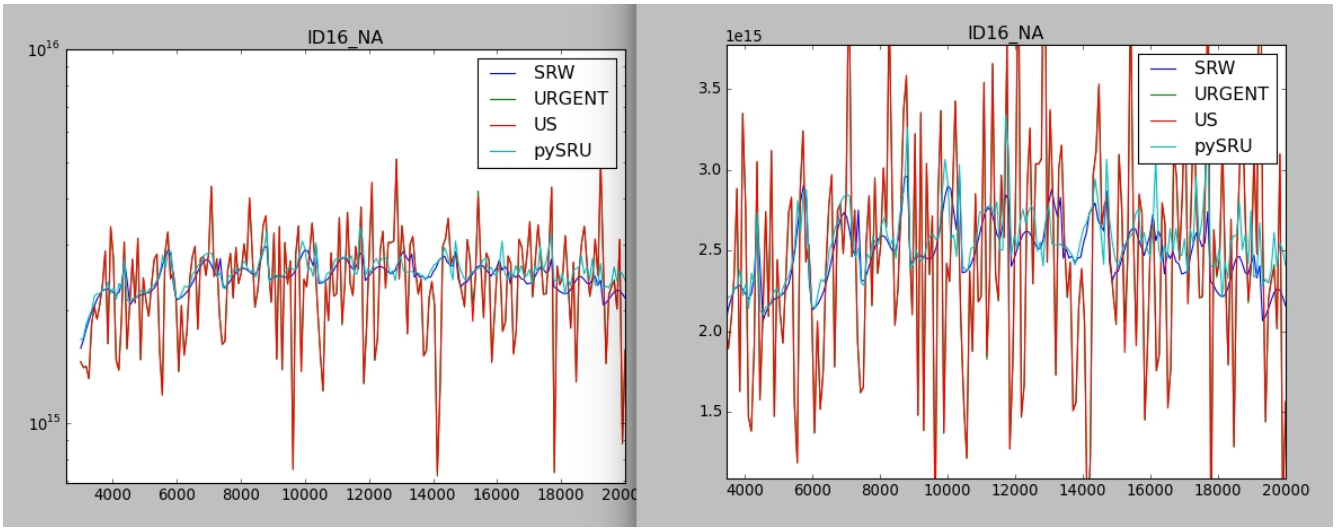
with more mesh points (101x101) we reduce the pySRU noise:



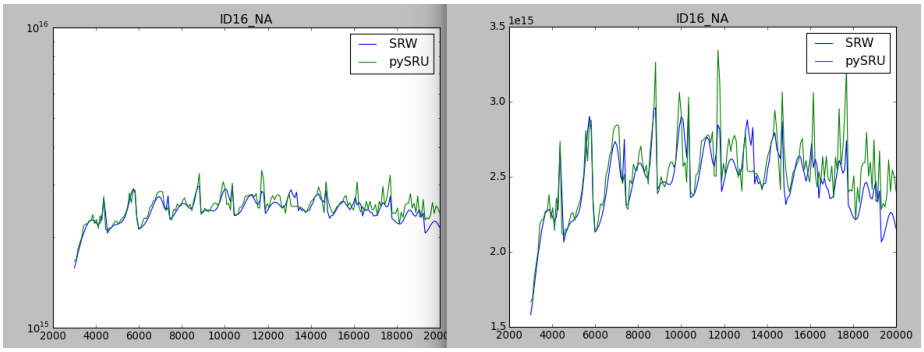
Using in pySRU analytical trajectory (N=14) and (101x101) we get a very good pySRU/SRW agreement:



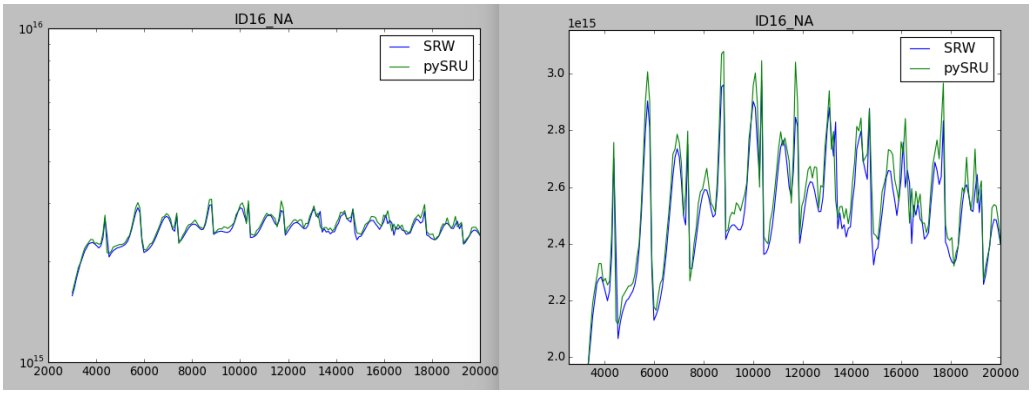
ID16_NA



US and URGENT fail to get something reasonable, at least for the inputs I used. This is the comparison pySRU and SRW only. Certainly pySRU needs more grid points, and SRW needs to increase a bit more the max harmonic number (used 31 here, before we used 21).

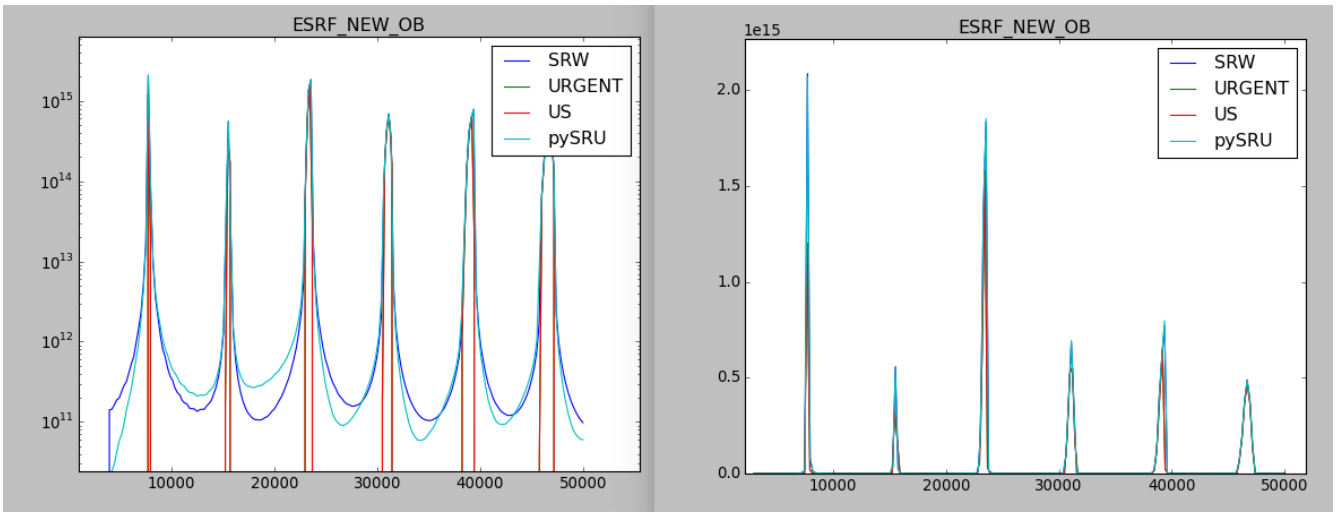


using up to 41 harmonics in SRW and 101x101 grid in pySRU we get:

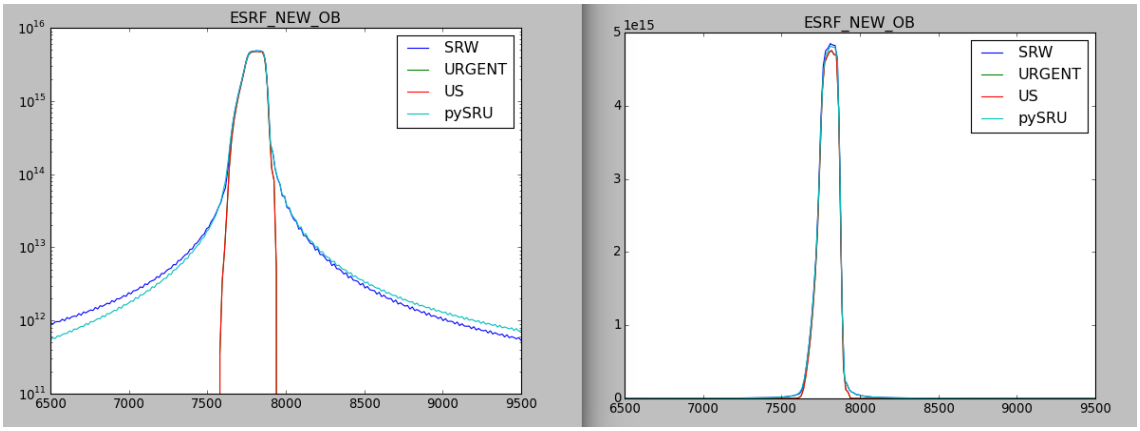


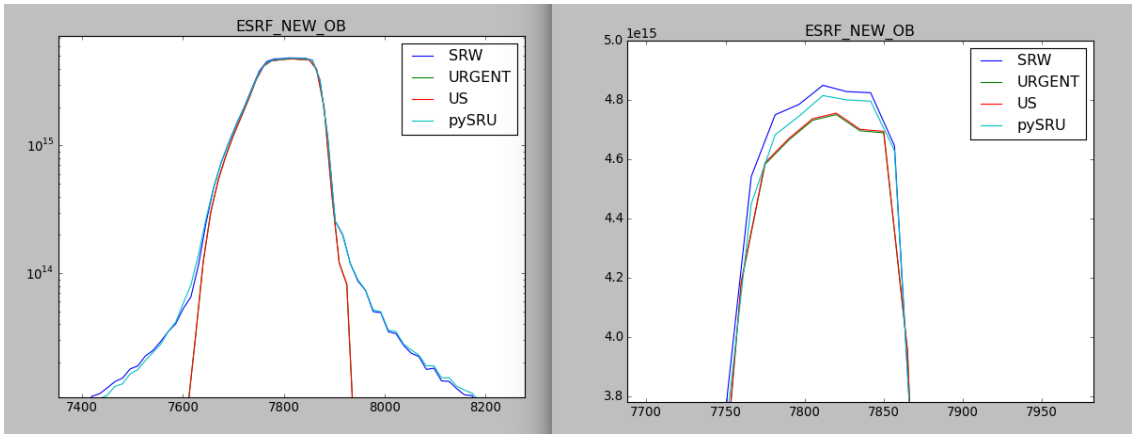
ESRF_NEW_OB

SRW Nmax=61; 101x101 mesh in pySRU:

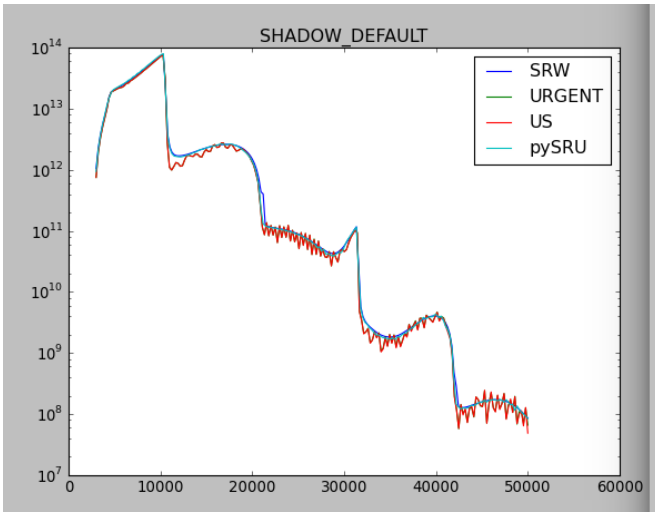


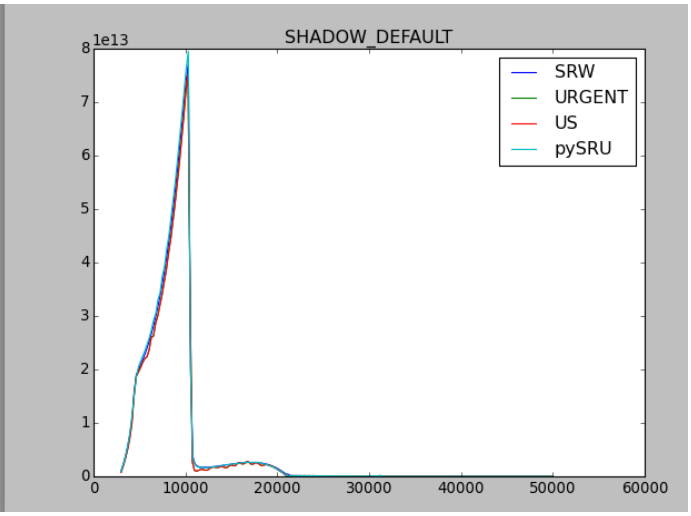
First peak:





SHADOW_DEFAULT

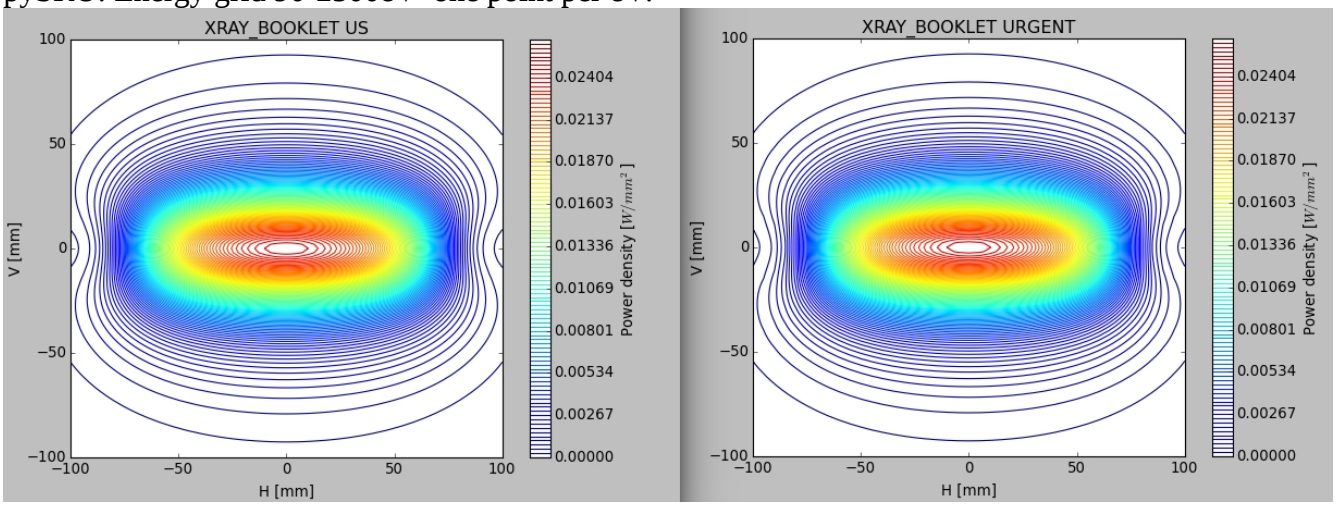


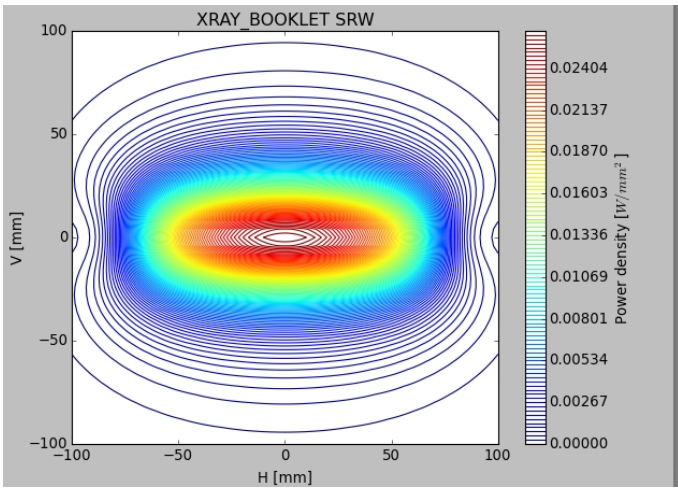


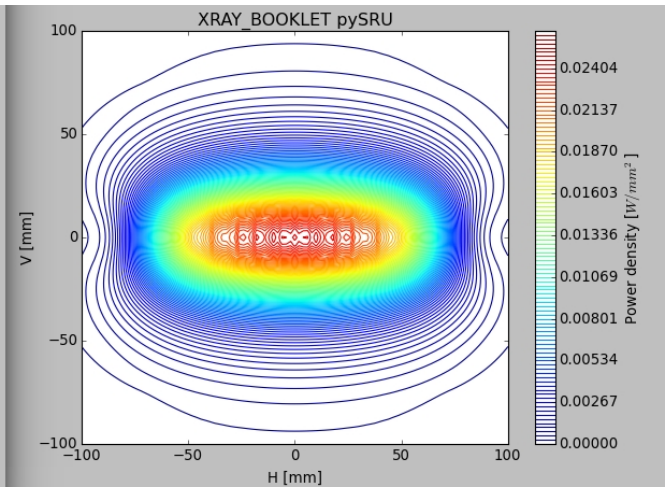
Power density

XRAY_BOOKLET

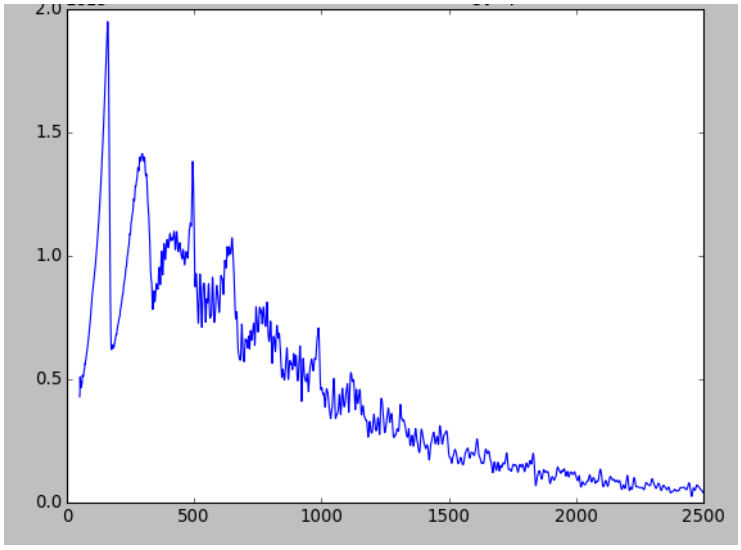
pySRU: Energy grid 90-2500eV one point per eV:

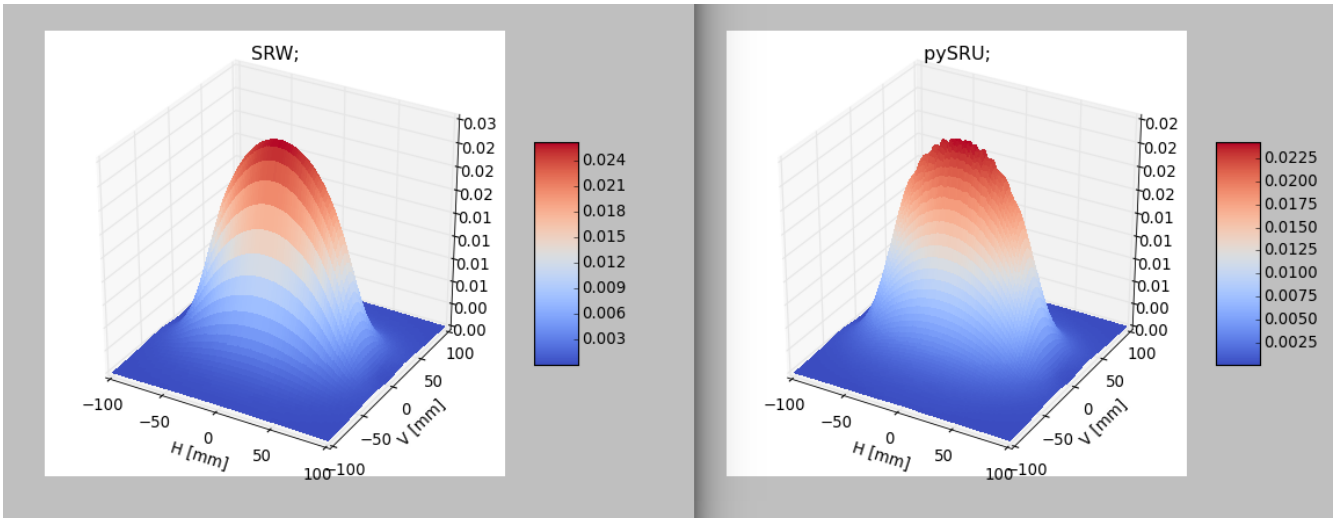




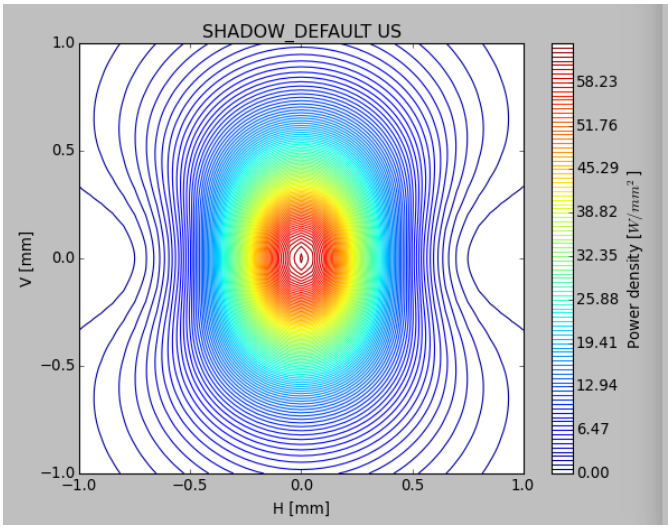


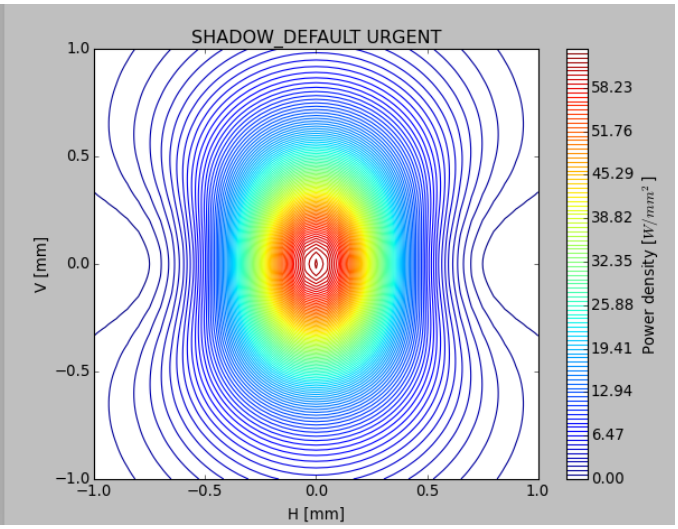
Spectrum by pySRU

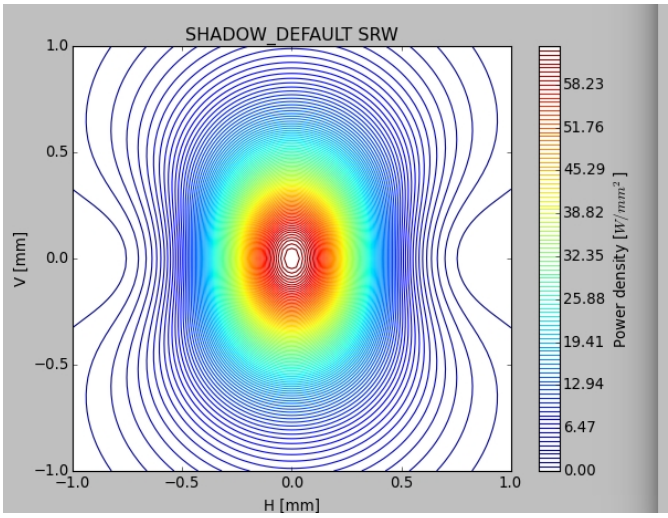


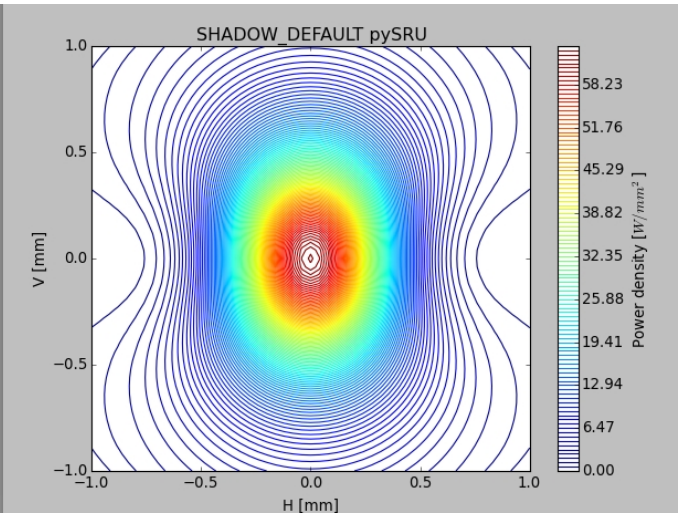


SHADOW_DEFAULT









Spectrum by pySRU