Napari PSF simulator (napari-psf-simulator)

Fernando Caprile

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Ms.C. in Physics

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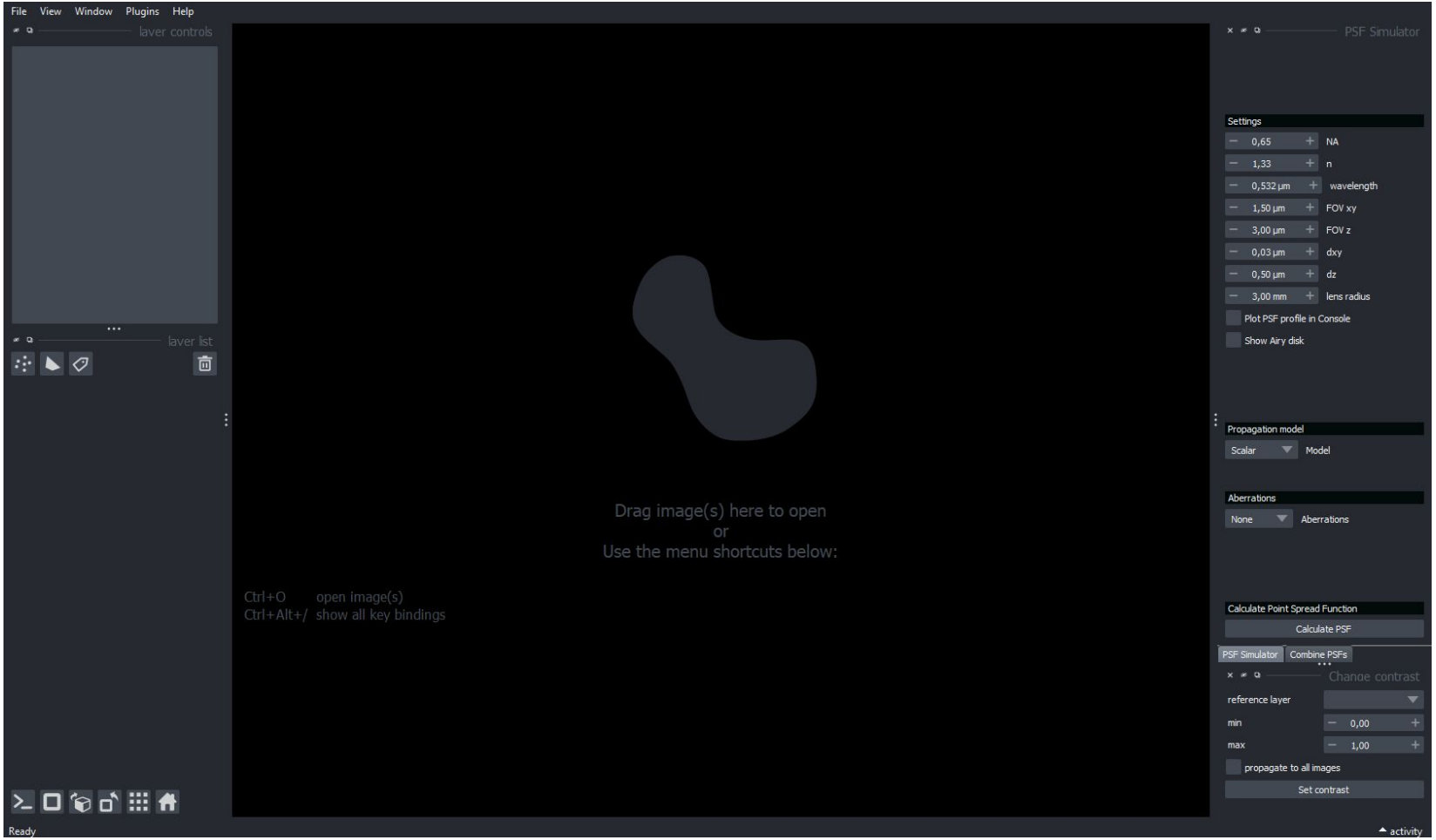
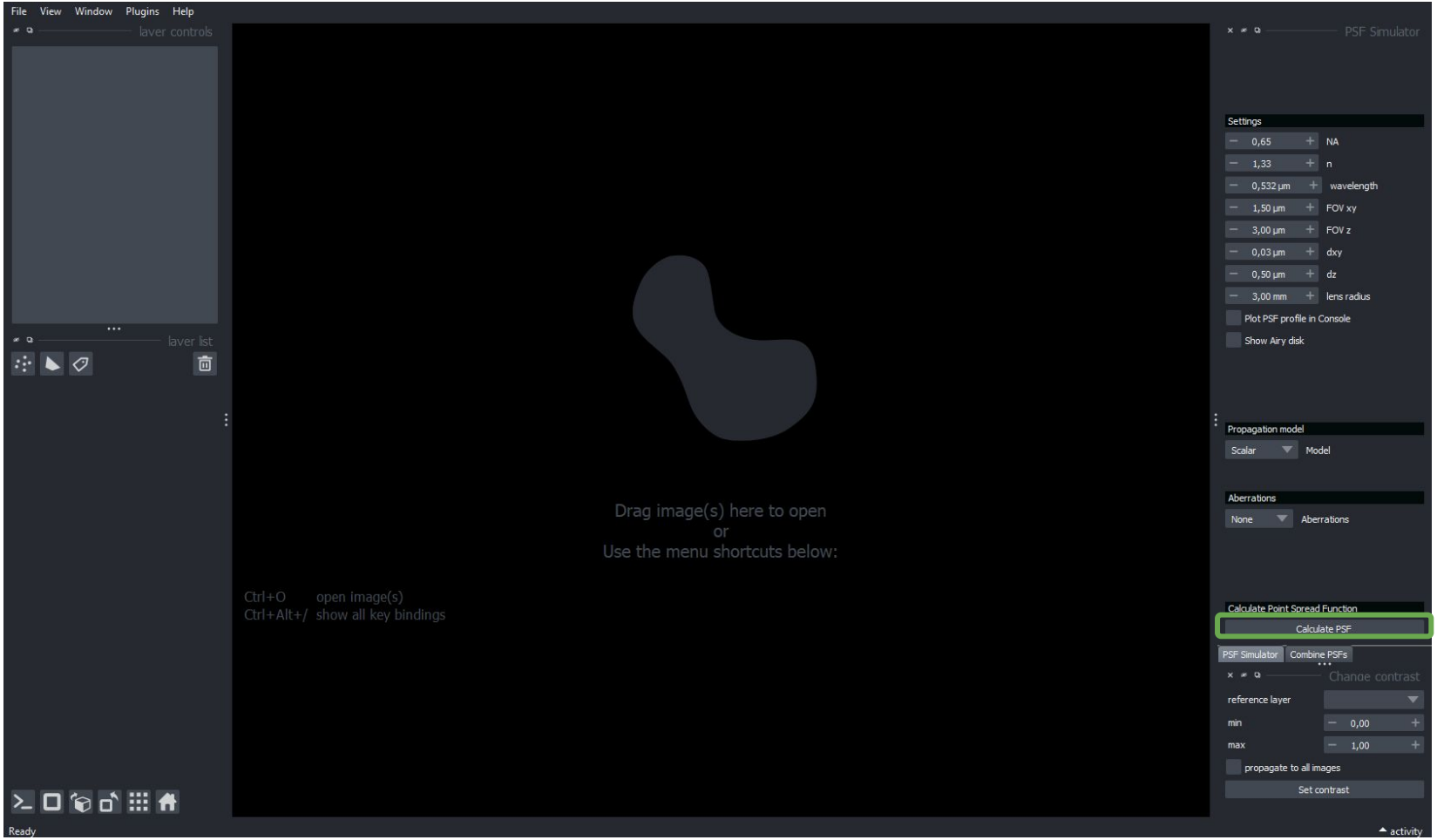
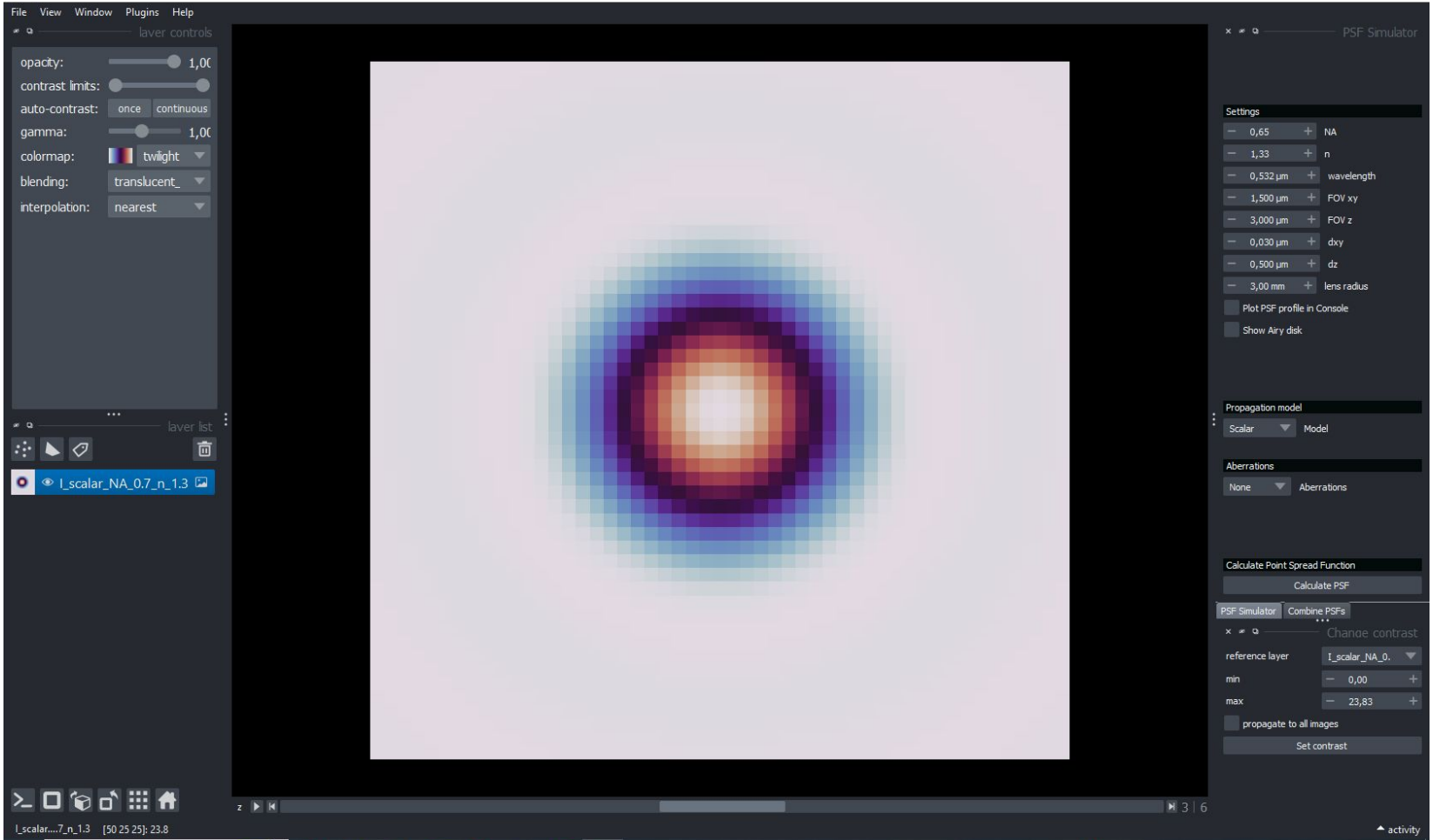
Scalar approximation



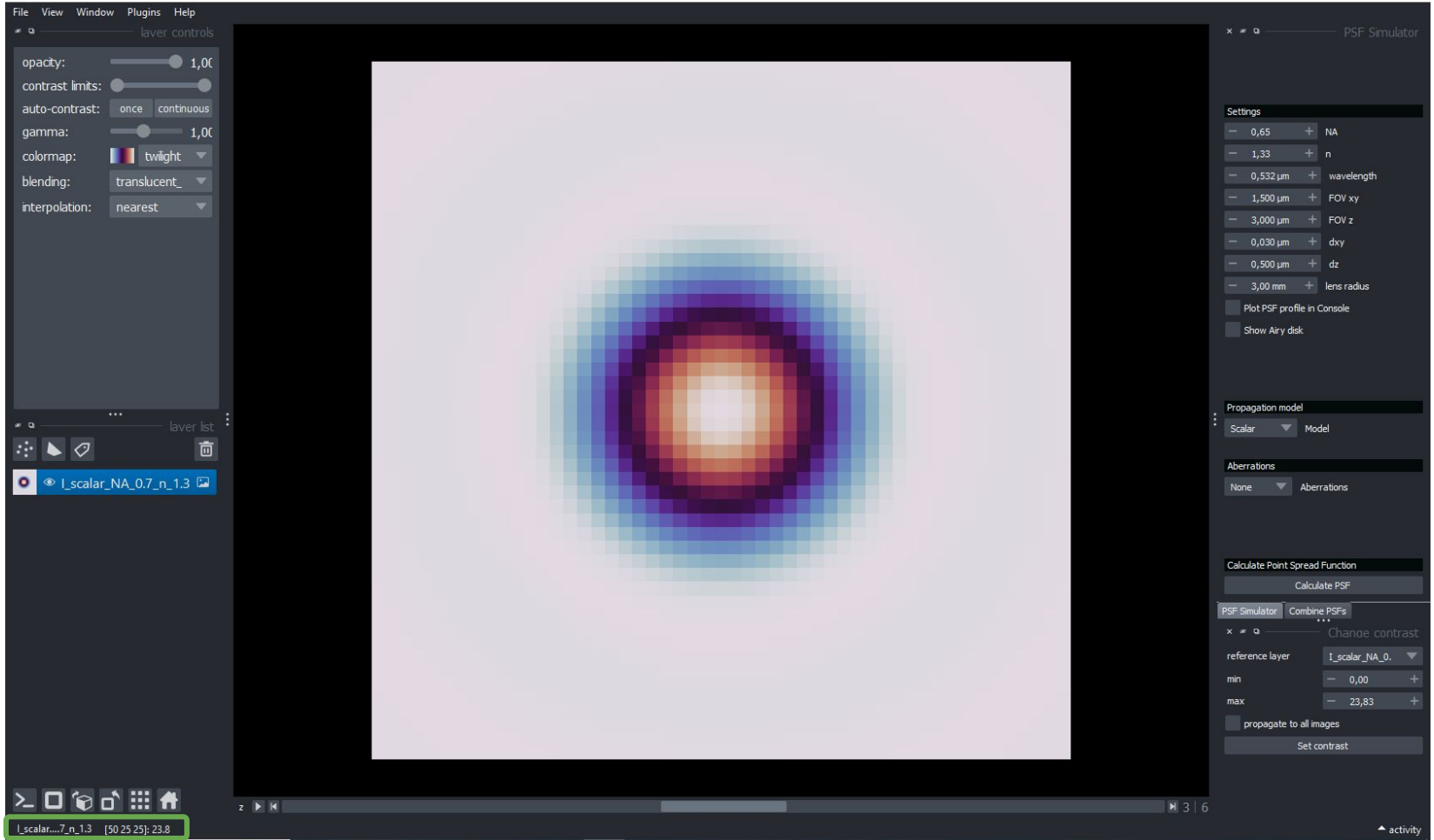
Scalar approximation



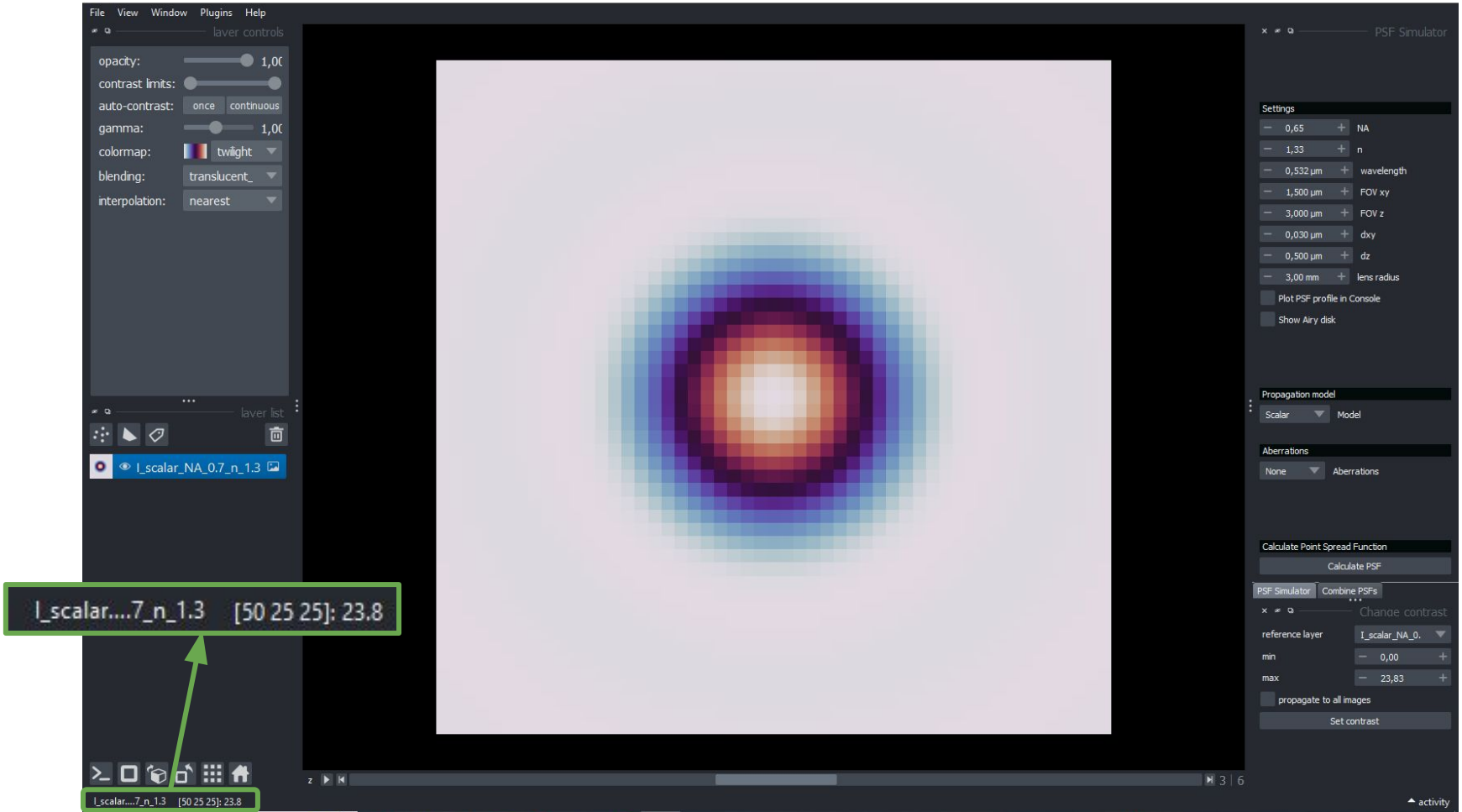
Scalar approximation



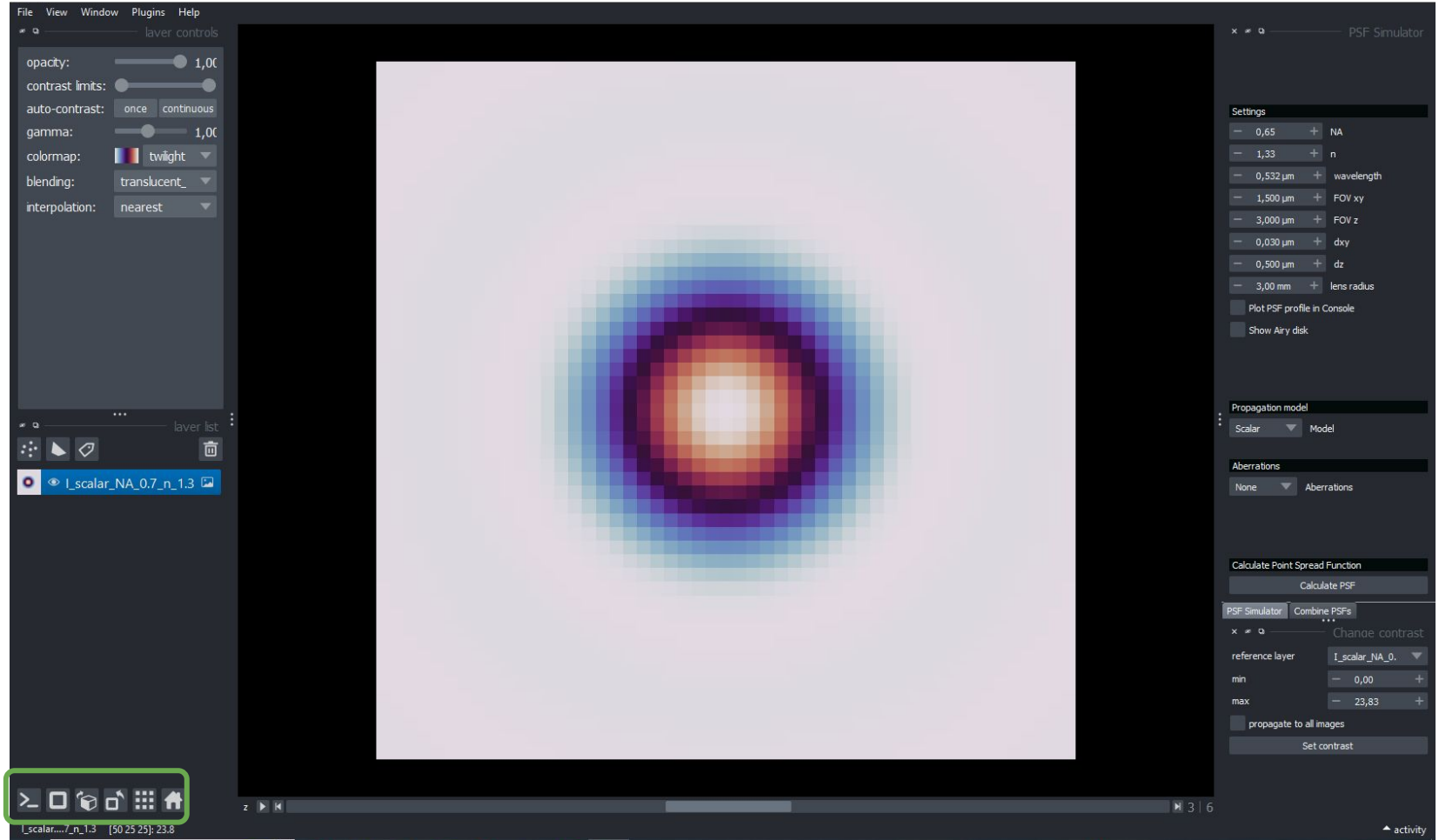
Scalar approximation



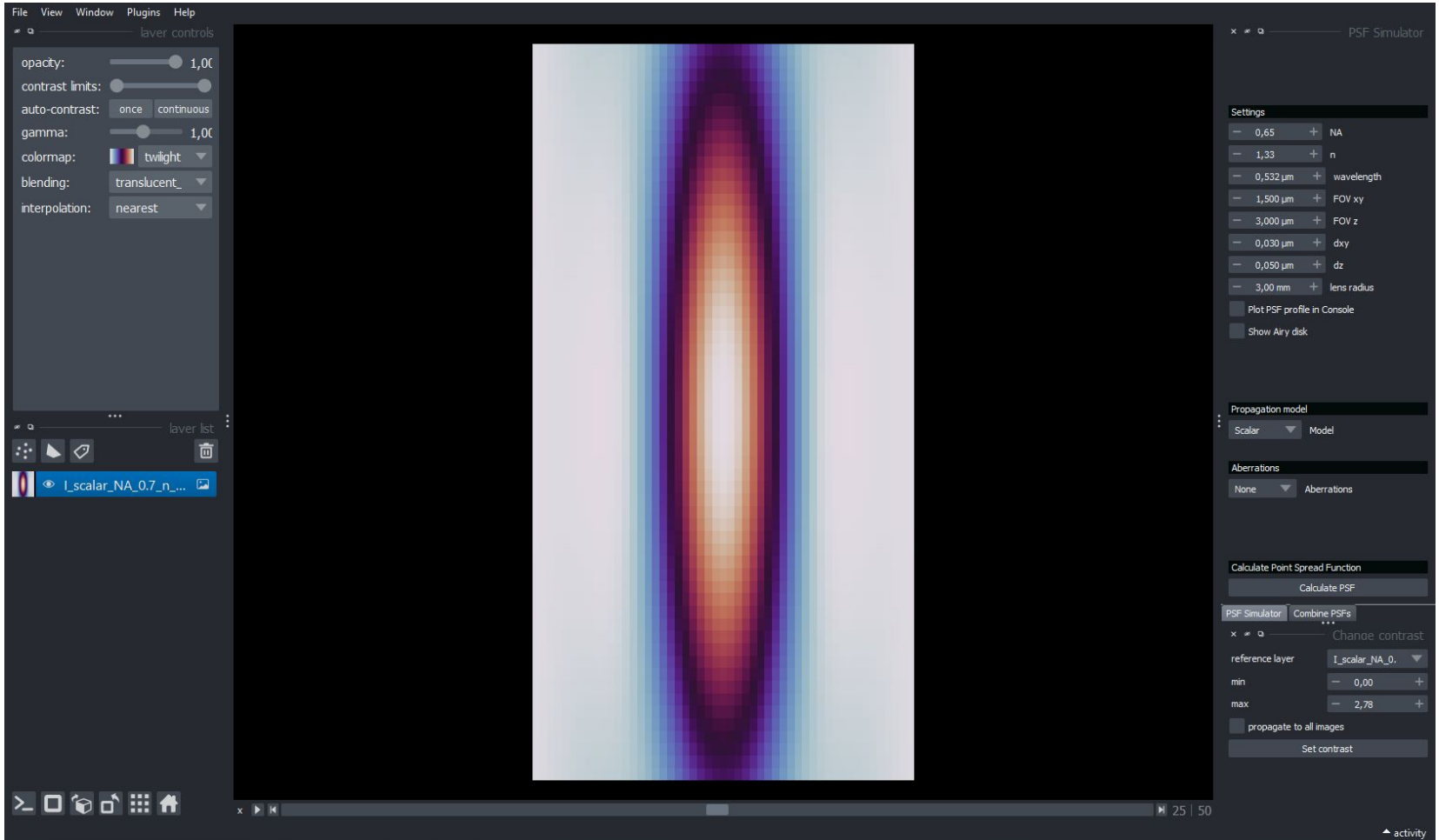
Scalar approximation



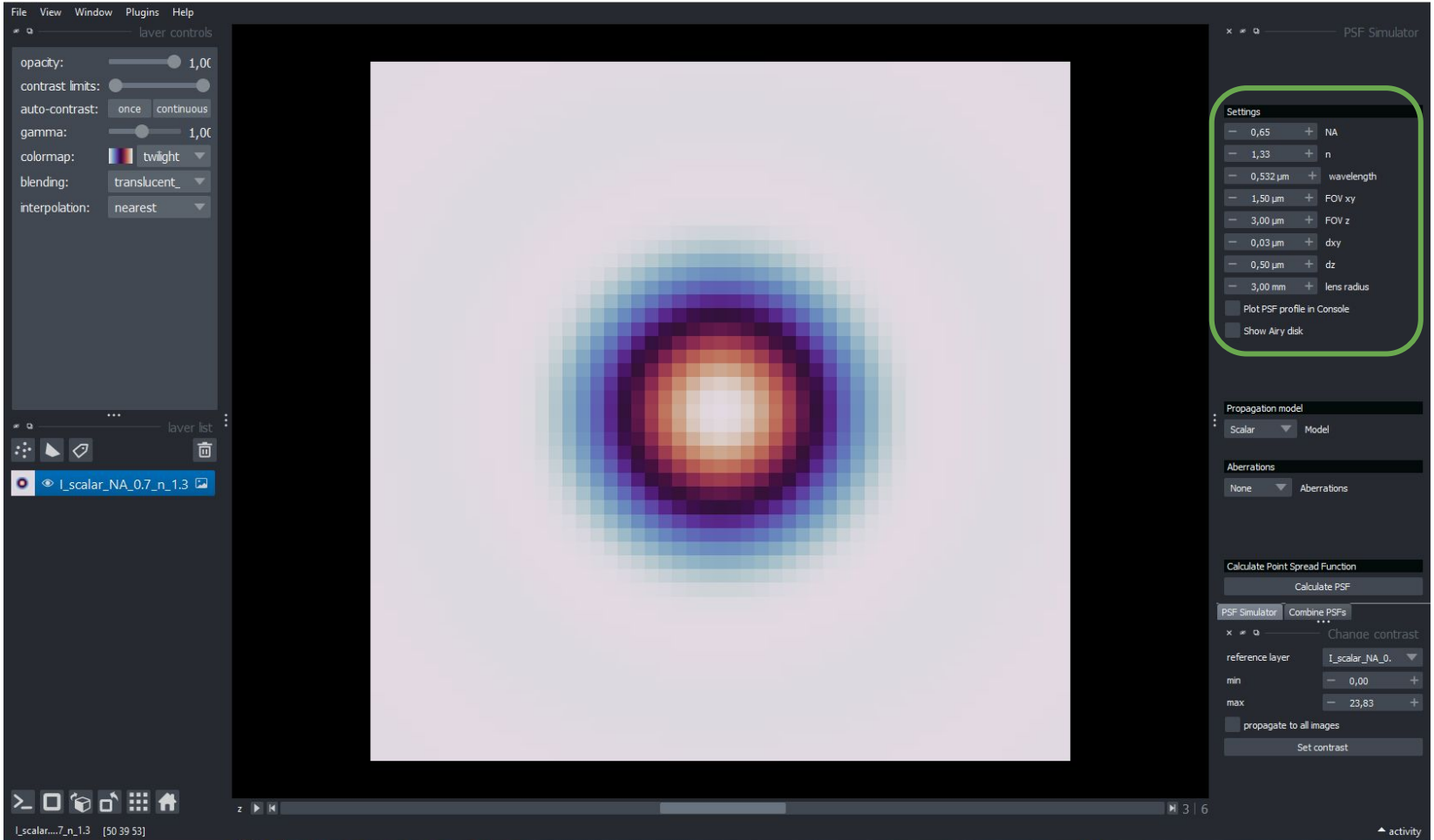
Scalar approximation



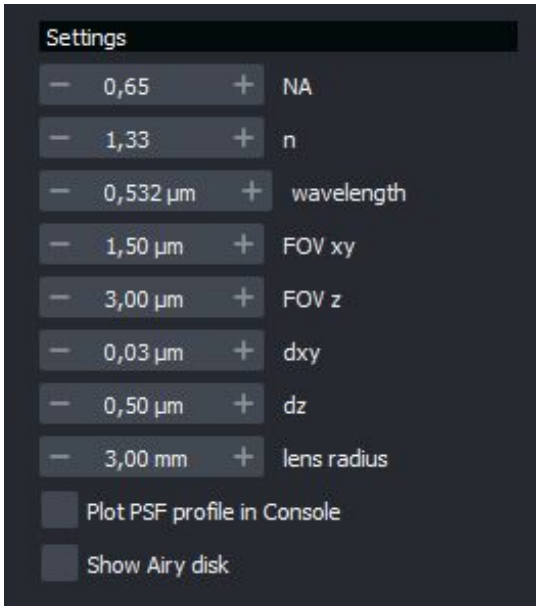
Scalar approximation



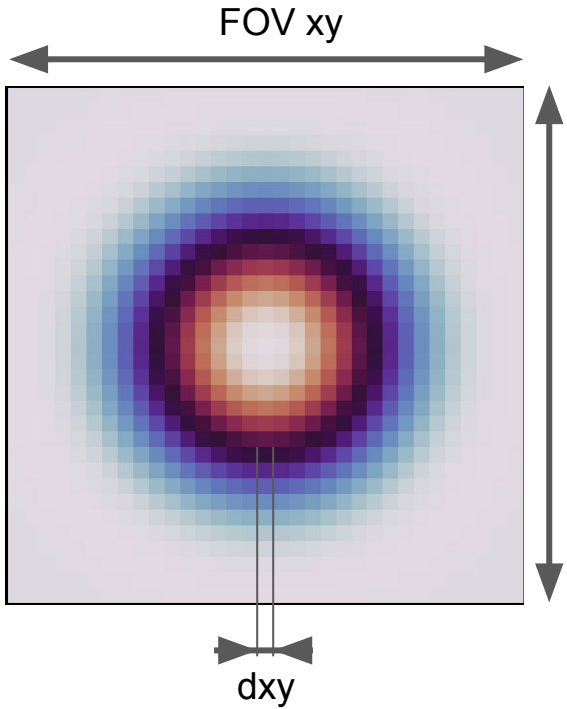
Base settings

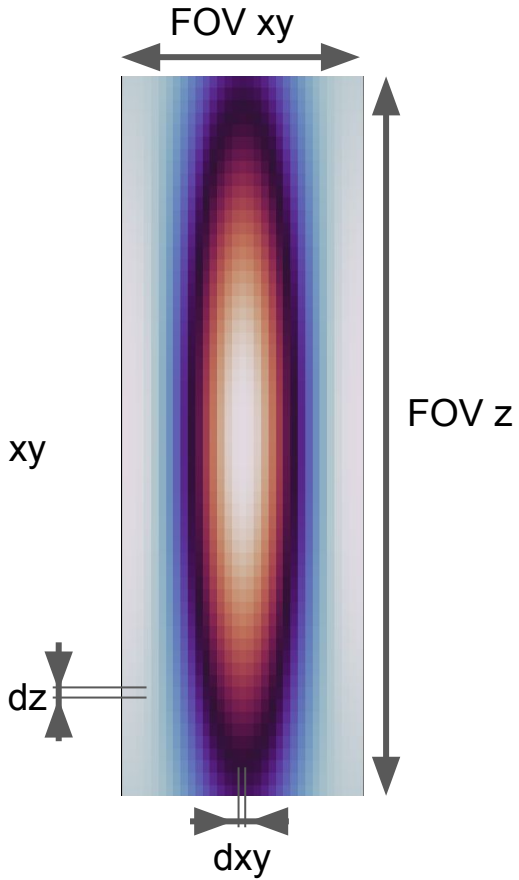


Base settings

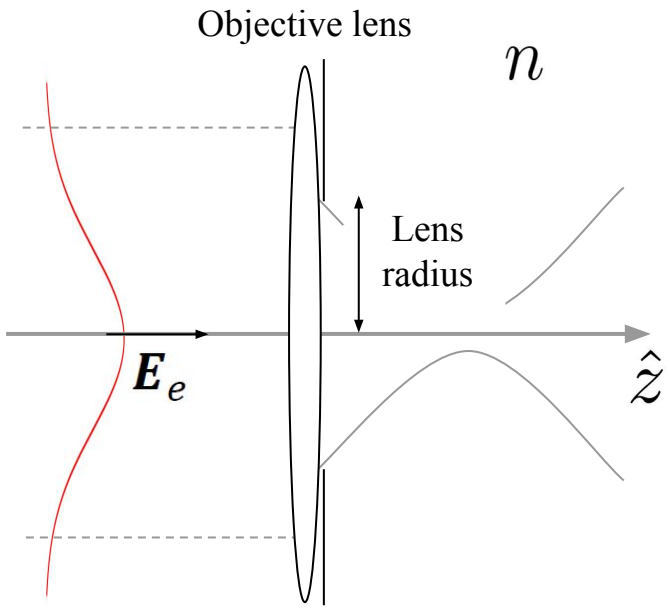


Resolution settings



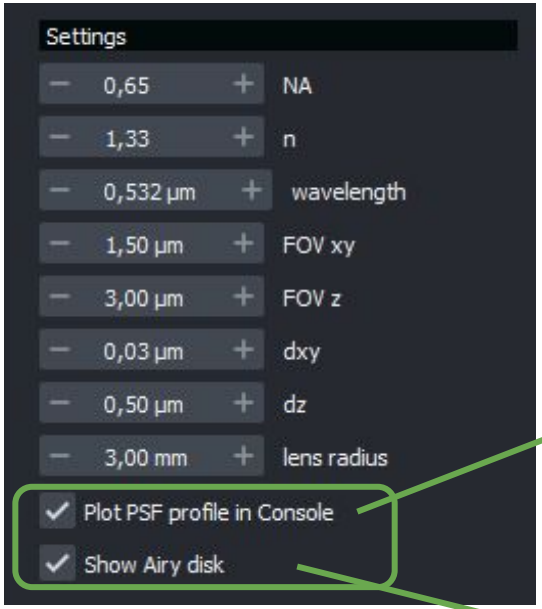


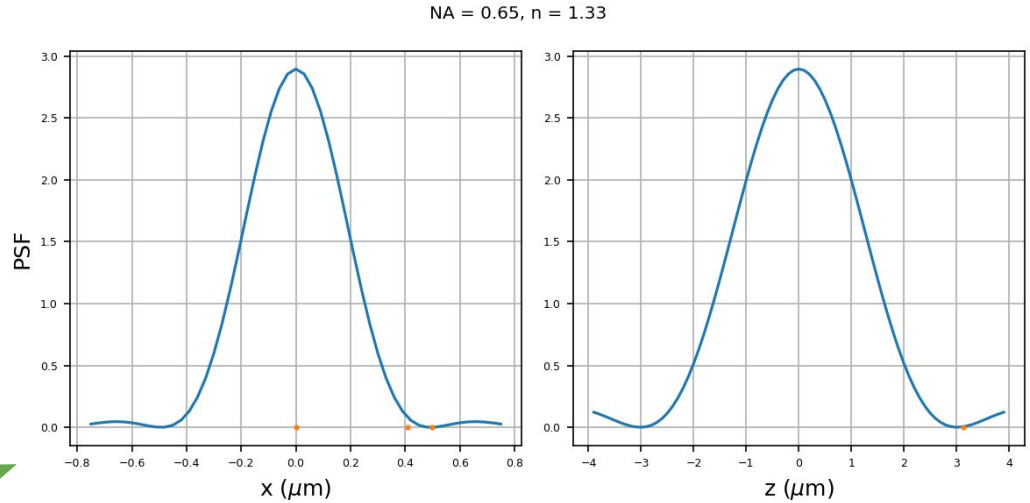
Optical system settings

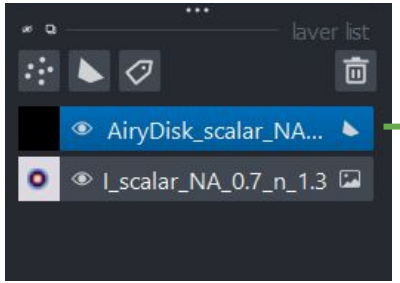


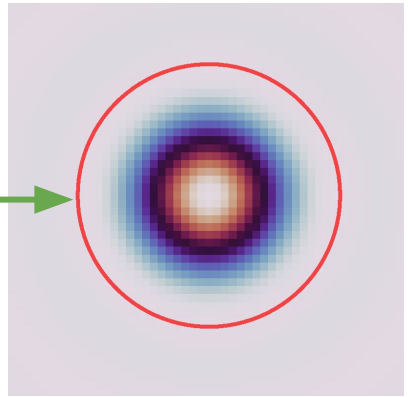
Show Airy disk and plot profile along X and Z

Show Airy disk and plot profile along X and Z

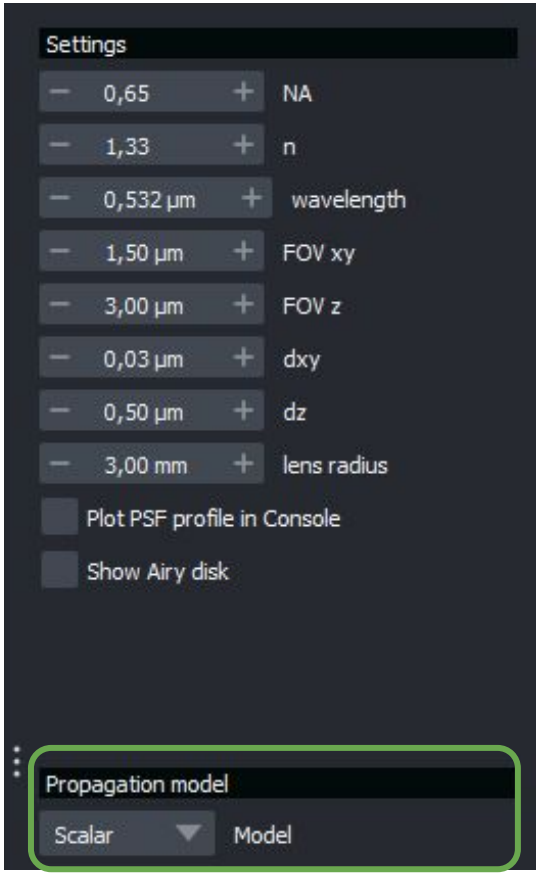








Vectorial simulation



Vectorial simulation: PyFocus

PyFocus – a Python package for vectorial calculations of focused optical fields under realistic conditions. Application to toroidal foci.

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[2] Departamento de Física, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires, Güiraldes 2620, C1428EHA, Ciudad Autónoma de Buenos Aires, Argentina

Paper DOI: https://doi.org/10.48550/arXiv.2110.00160
Documentation: https://pyfocus.readthedocs.io/en/latest/

Vectorial simulation: PyFocus

The field near the focus can
be obtained by:

$$\boldsymbol{E}_f = \frac{-ikf\, e^{-ikf}}{2\pi} \int_0^{2\pi} \int_0^{\alpha} \boldsymbol{E}_0 e^{i\boldsymbol{k}\cdot\boldsymbol{r}} \sqrt{cos(\theta)}\, sin(\theta) d\theta d\phi'$$

Vectorial simulation: PyFocus

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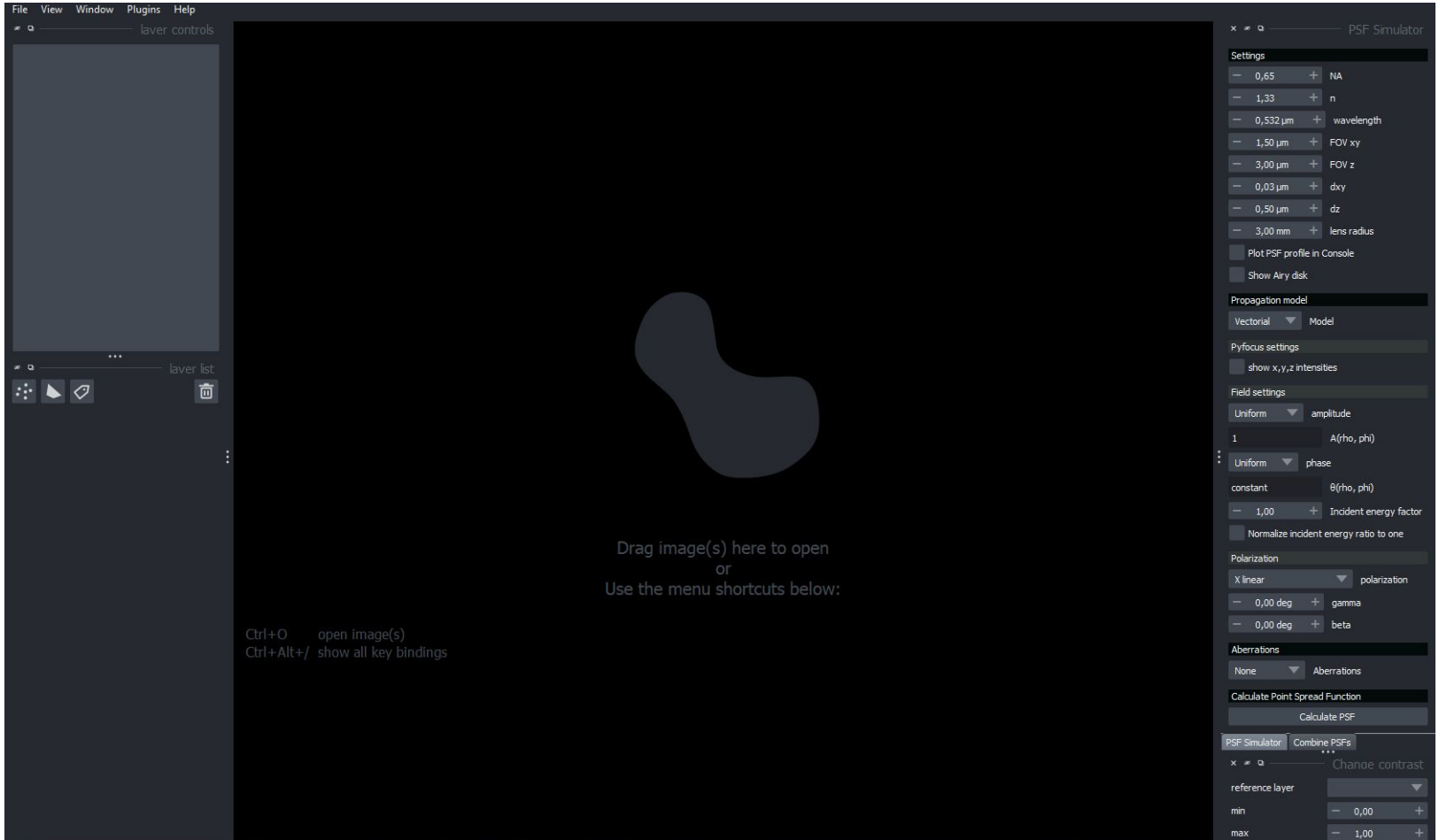
be obtained by:

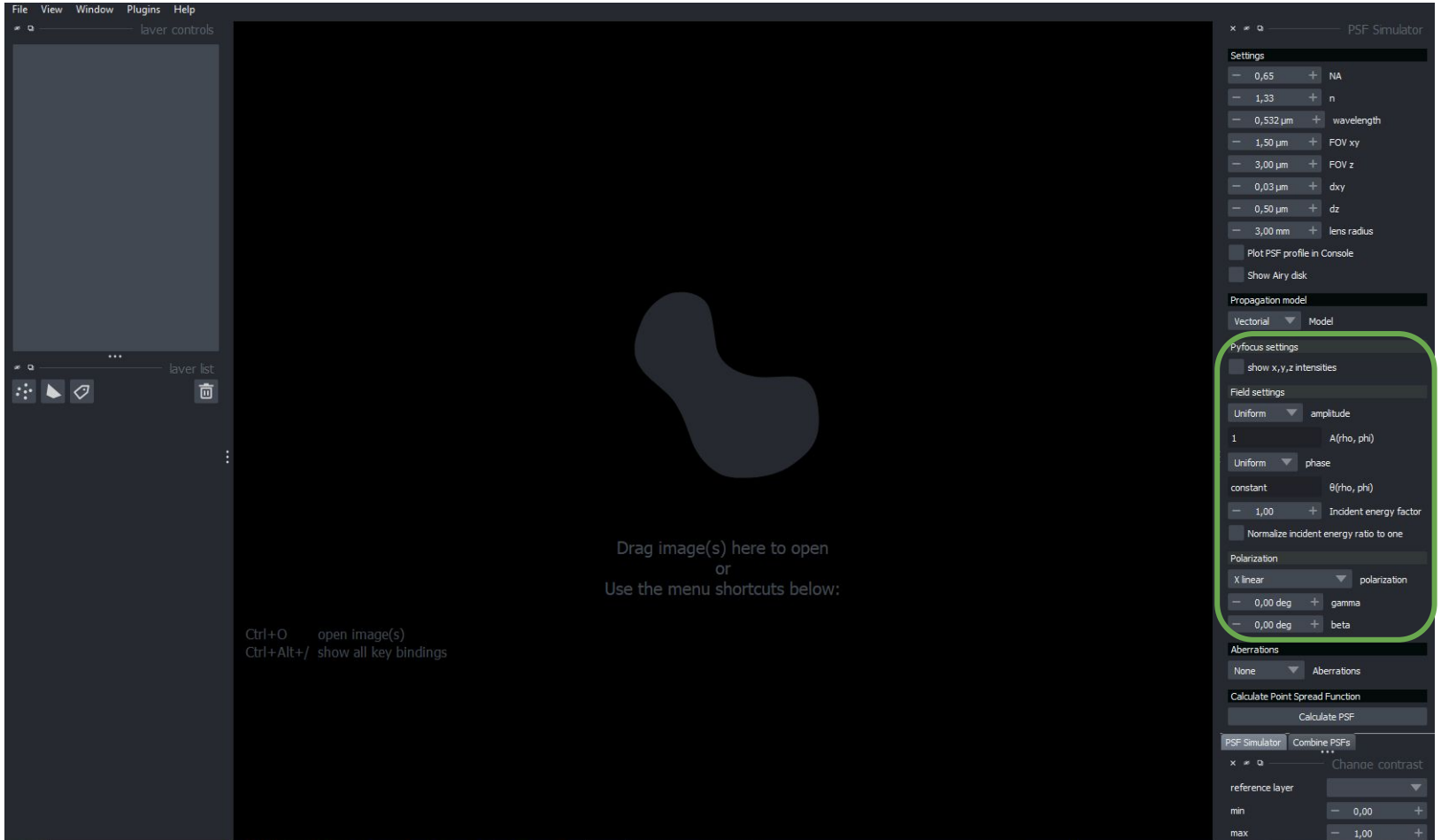
$$\boldsymbol{E}_f = \frac{-ikf\, e^{-ikf}}{2\pi} \int_0^{2\pi} \int_0^{\alpha} \boldsymbol{E}_0 e^{i\boldsymbol{k}\cdot\boldsymbol{r}} \sqrt{cos(\theta)}\, sin(\theta) d\theta d\phi'$$

For most fields, 2D
numerical integration

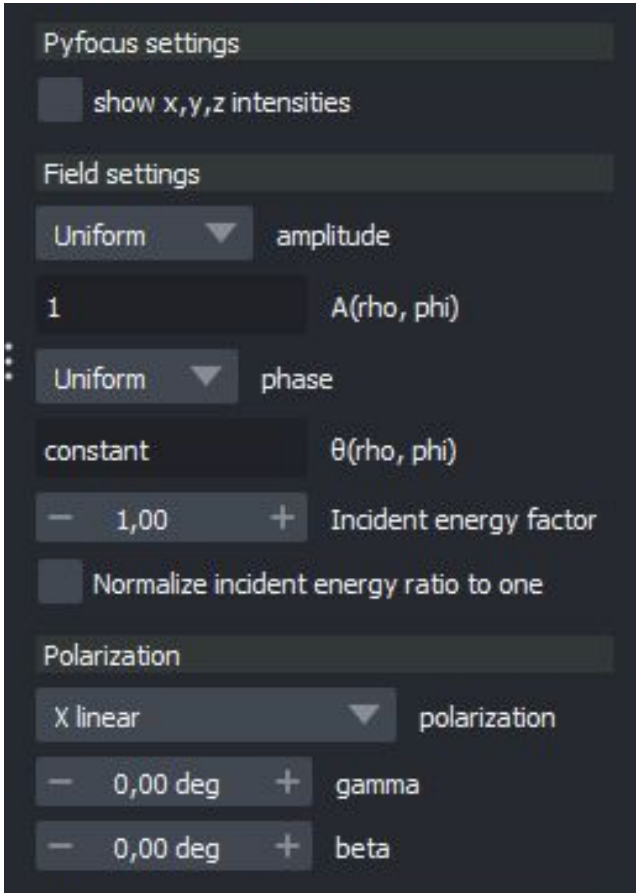
Vectorial simulation: PyFocus settings



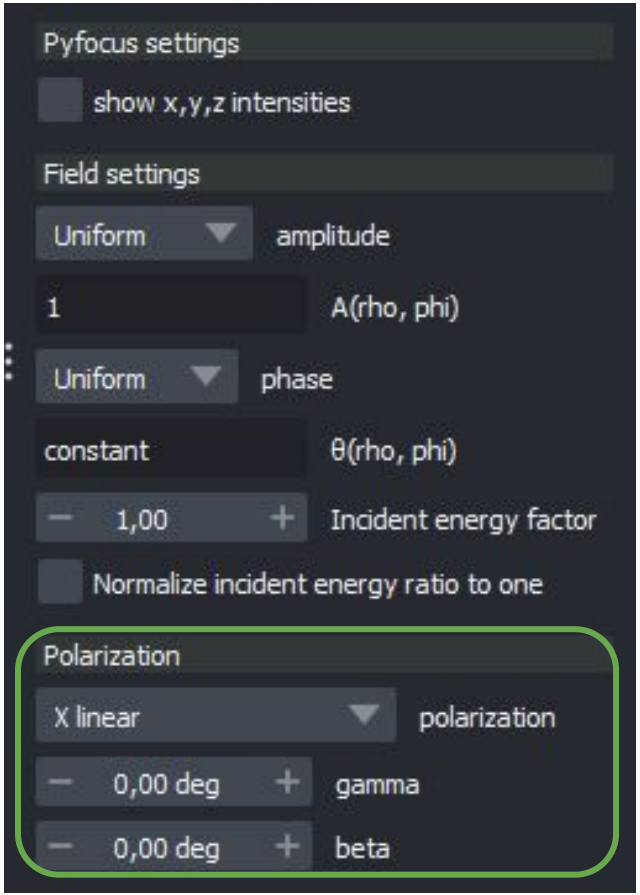
Vectorial simulation: PyFocus settings



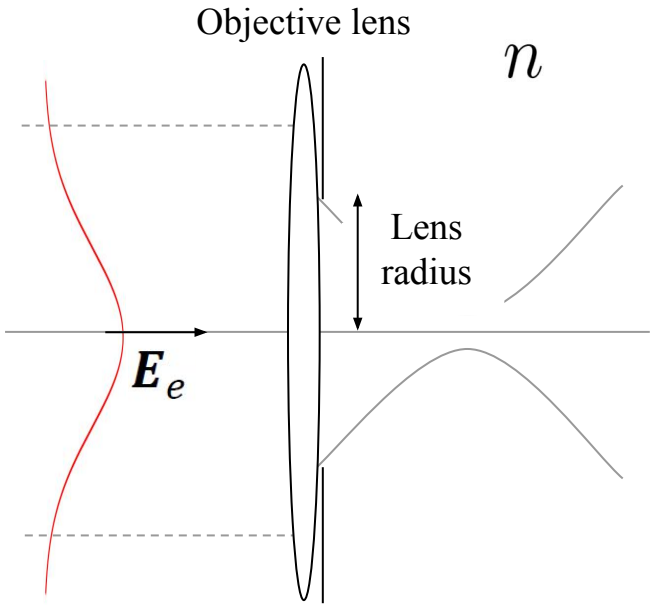
Vectorial simulation: Field settings



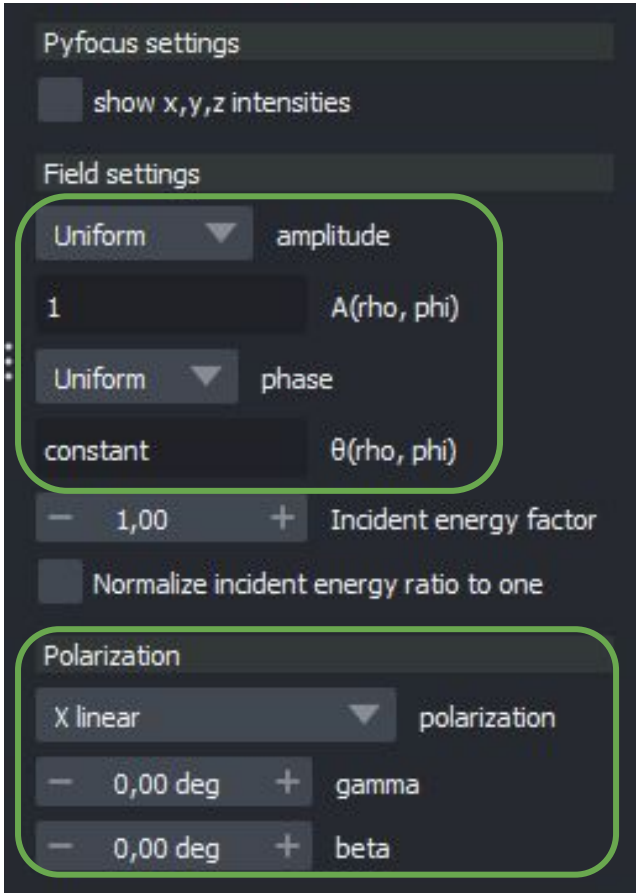
Vectorial simulation: Field settings



$$\boldsymbol{E}_e = E_e\left(\cos(\gamma)\hat{\boldsymbol{x}} + \sin(\gamma)e^{i\beta}\,\hat{\boldsymbol{y}}\right)$$



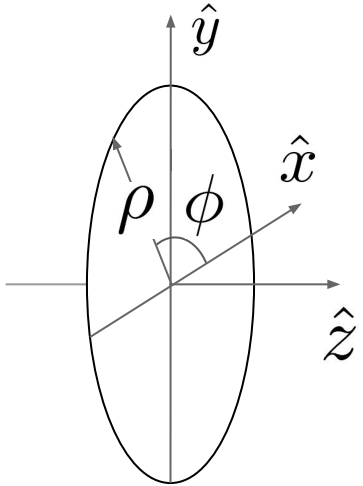
Vectorial simulation: Field settings



$$\boldsymbol{E}_e = E_e\left(\cos(\gamma)\hat{\boldsymbol{x}} + \sin(\gamma)e^{i\beta}\,\hat{\boldsymbol{y}}\right)$$

$$E_e = A(\rho,\phi)e^{i\theta(\rho,\phi)}$$

Objective lens



Vectorial simulation: Default simulation

Pyfocus settings

show x,y,z intensities

Field settings

Uniform amplitude

1 A(rho, phi)

Uniform phase

constant θ(rho, phi)

− 1,00 + Incident energy factor

Normalize incident energy ratio to one

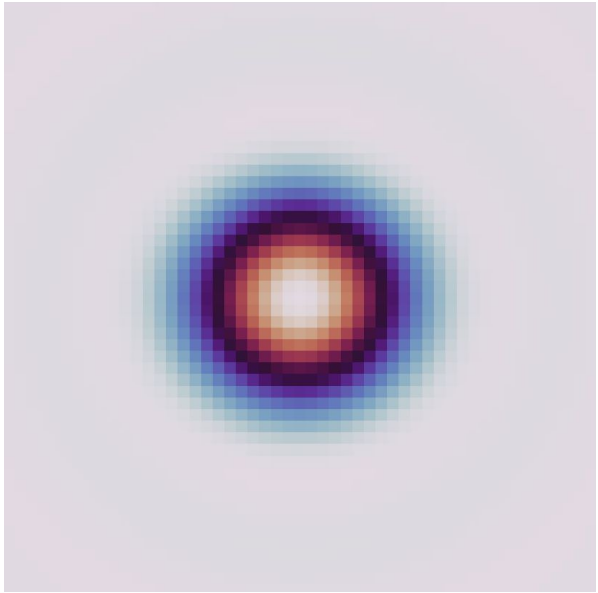
Polarization

X linear polarization

− 0,00 deg + gamma

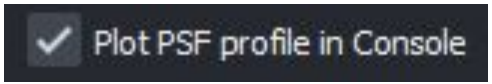
− 0,00 deg + beta

Uniform incident field with X linear polarization

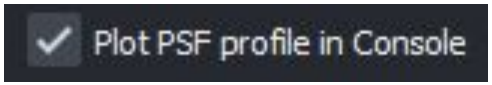


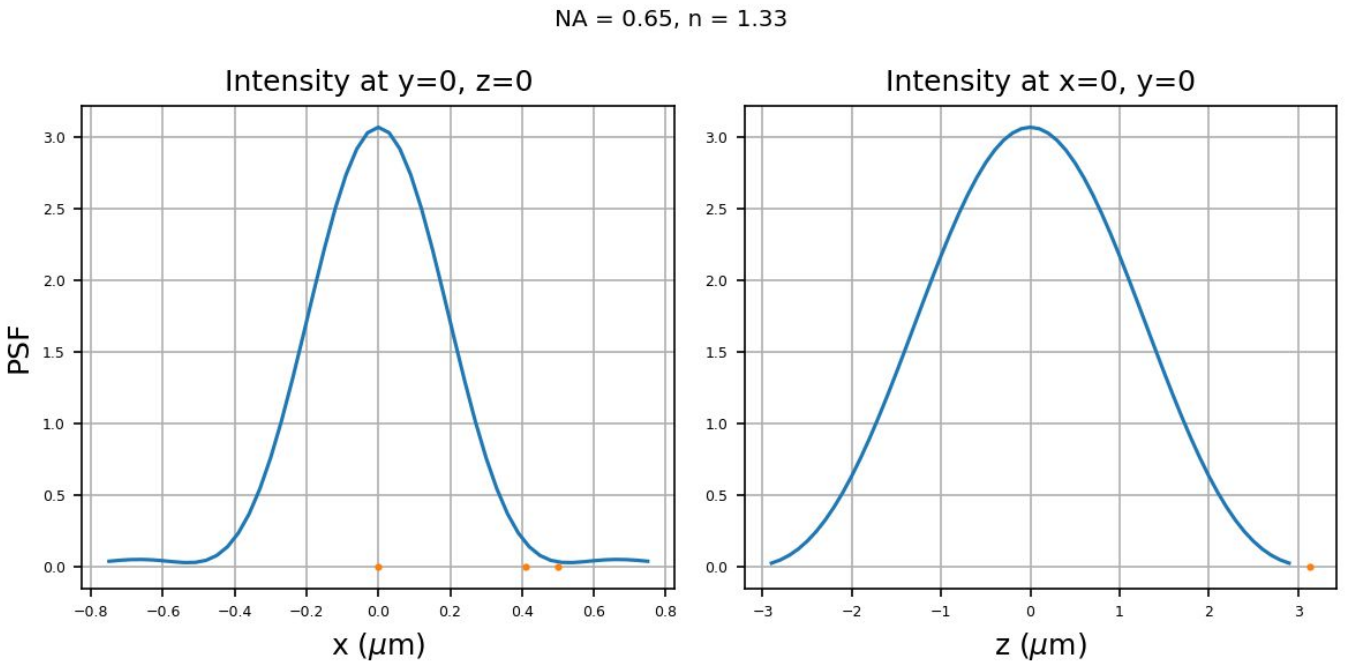
Simulation time: 34 sec

Vectorial simulation: Intensity of the X, Y and Z components

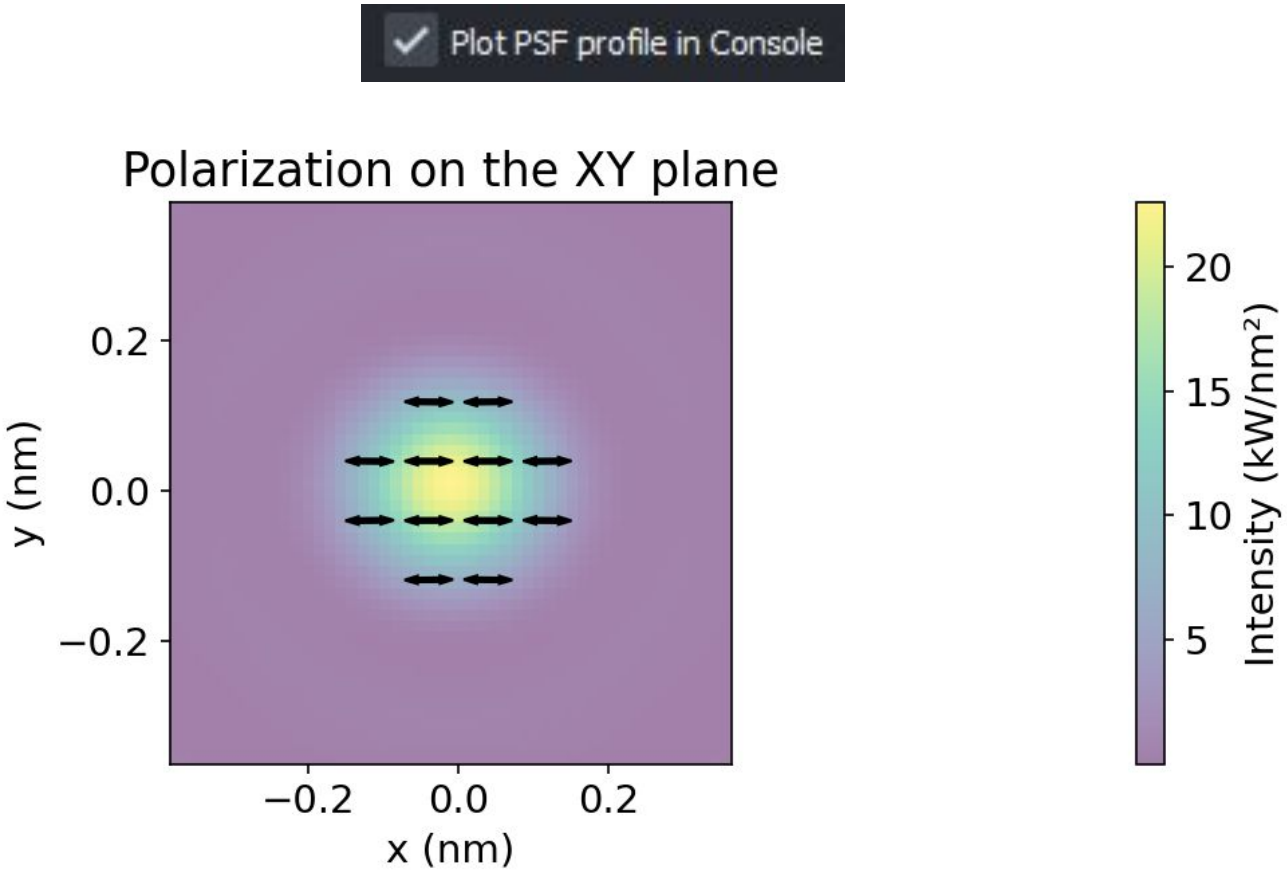


Vectorial simulation: Intensity of the X, Y and Z components

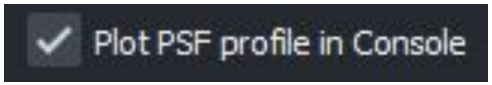


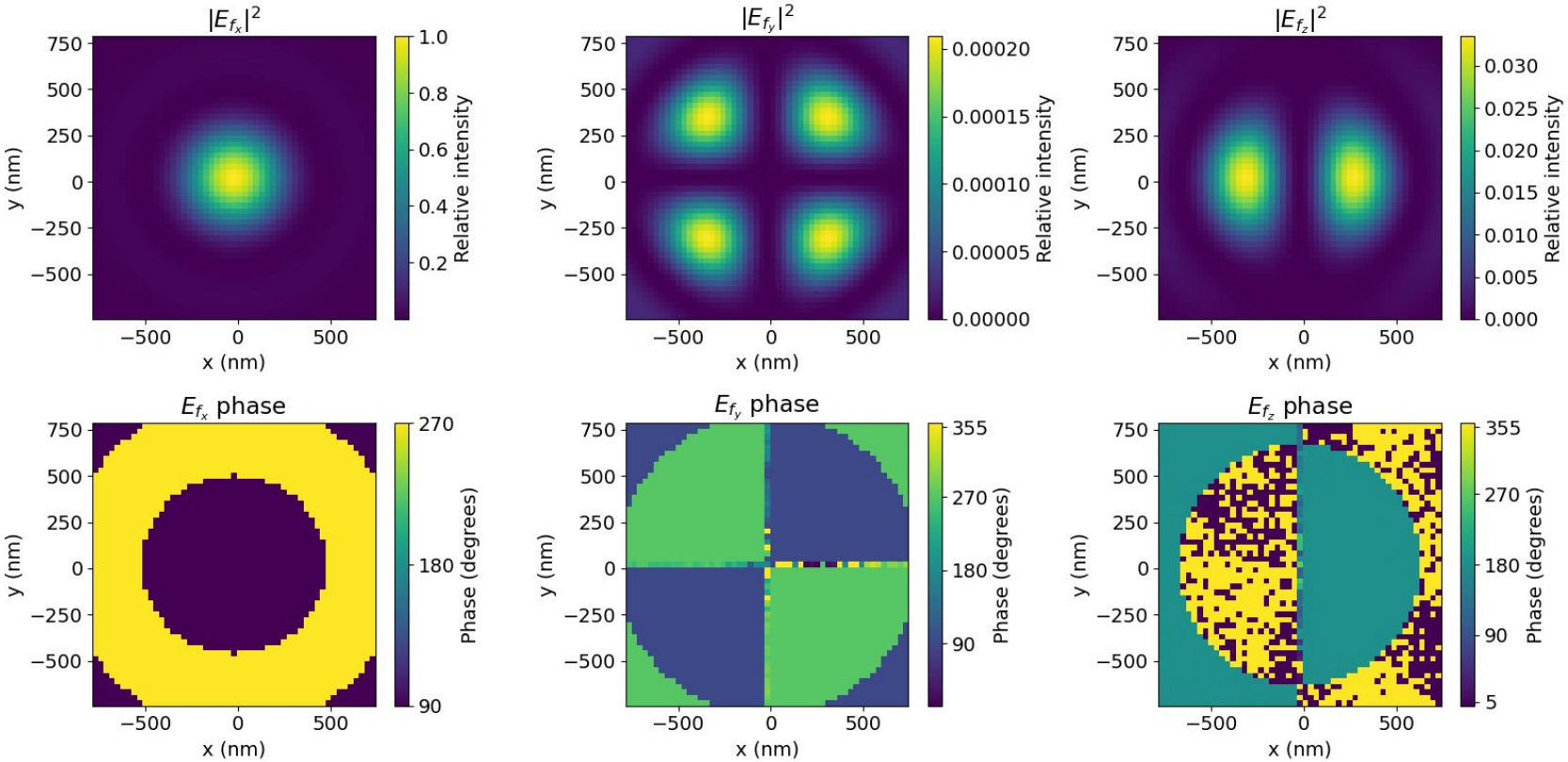


Vectorial simulation: Intensity of the X, Y and Z components

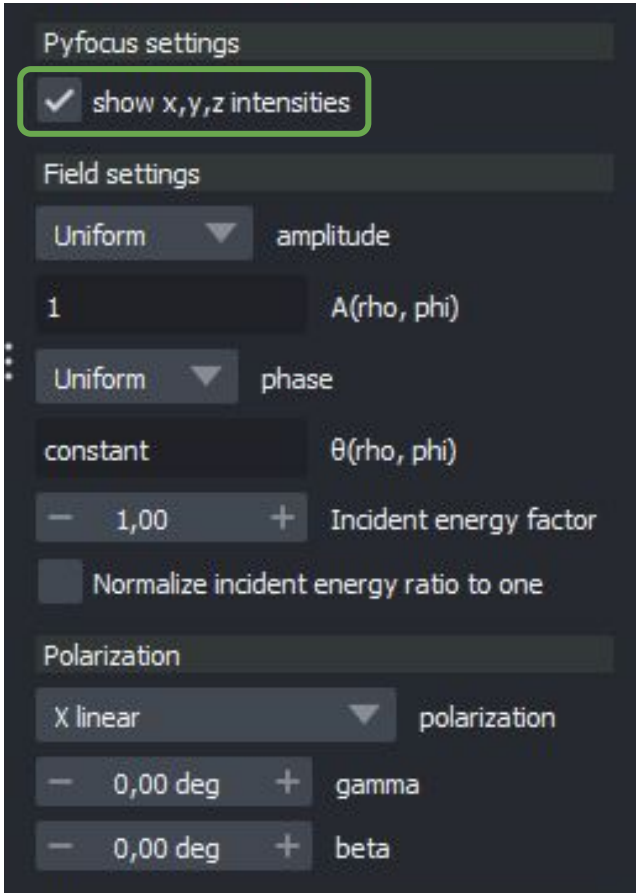


Vectorial simulation: Intensity of the X, Y and Z components

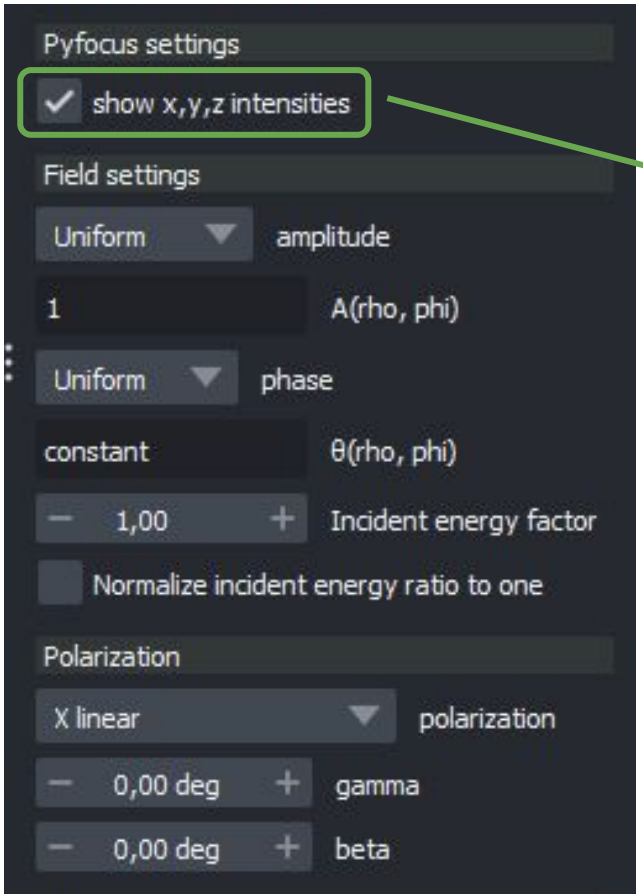


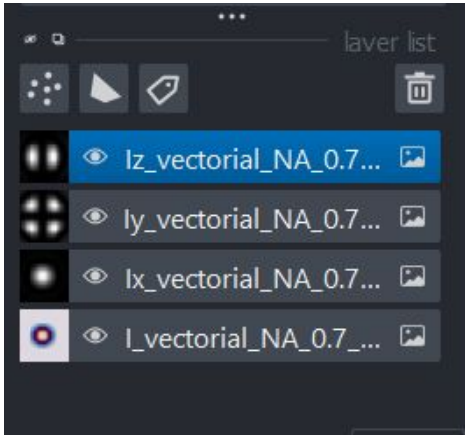


Vectorial simulation: Intensity of the X, Y and Z components

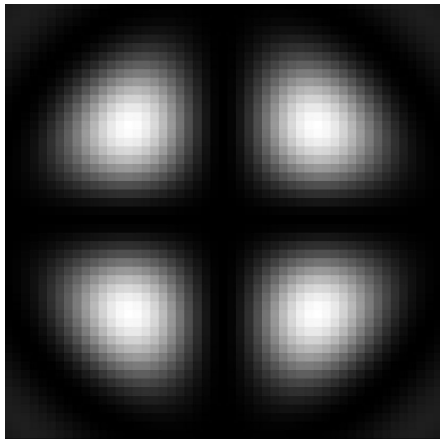


Vectorial simulation: Intensity of the X, Y and Z components

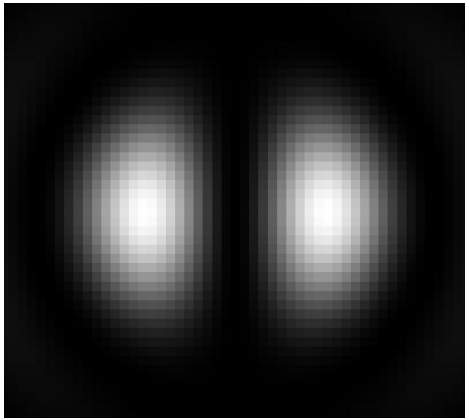




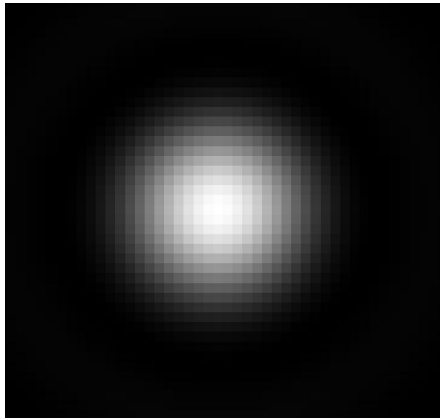
Iy



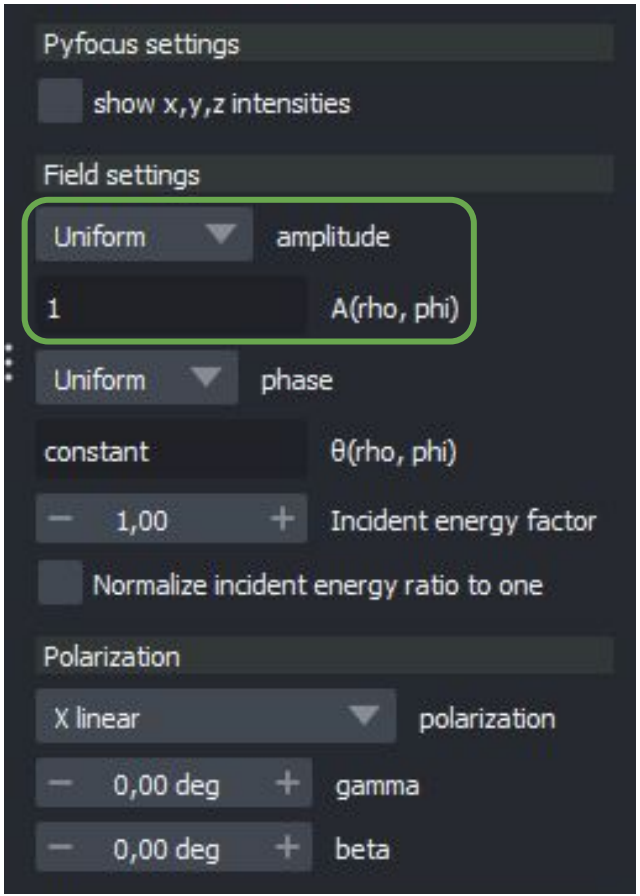
Ix



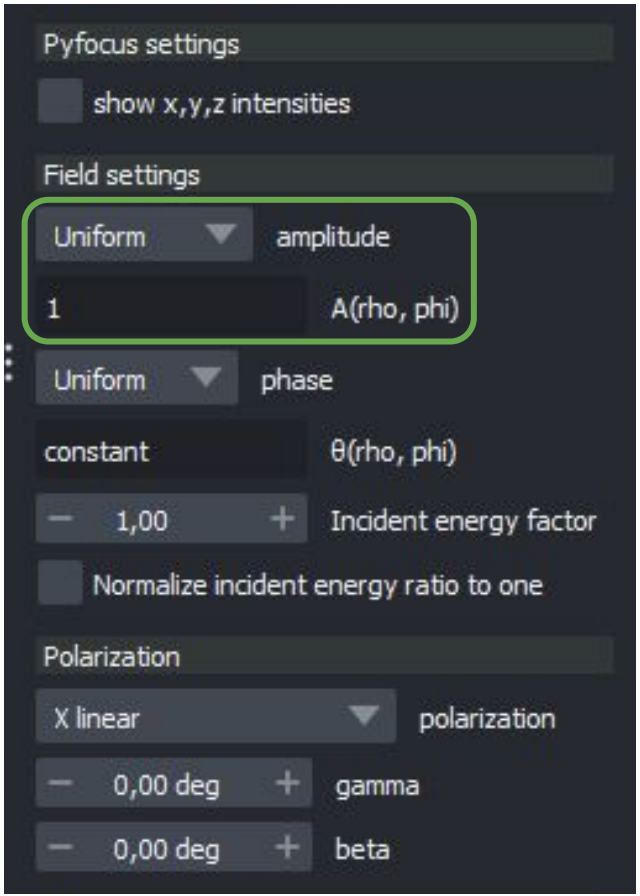
Iz

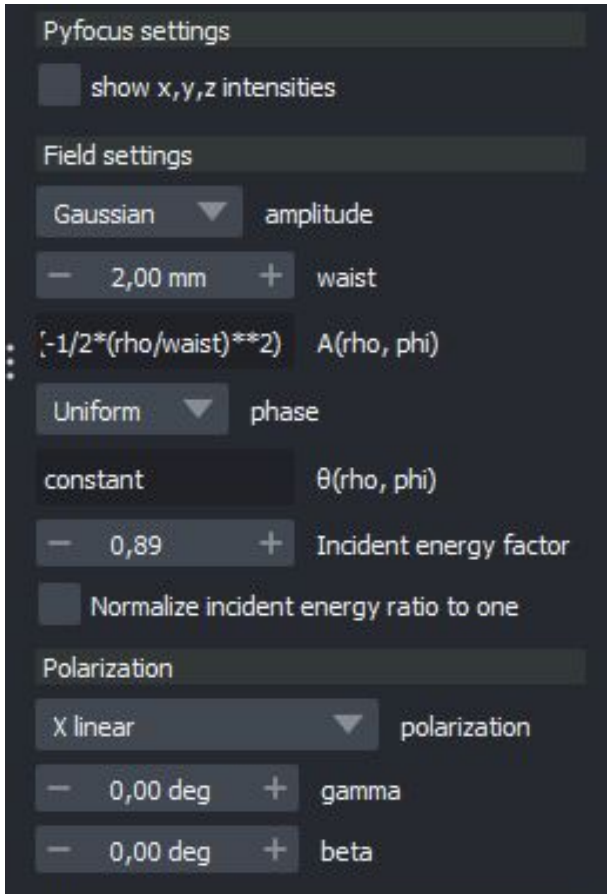


Vectorial simulation: Amplitude setting

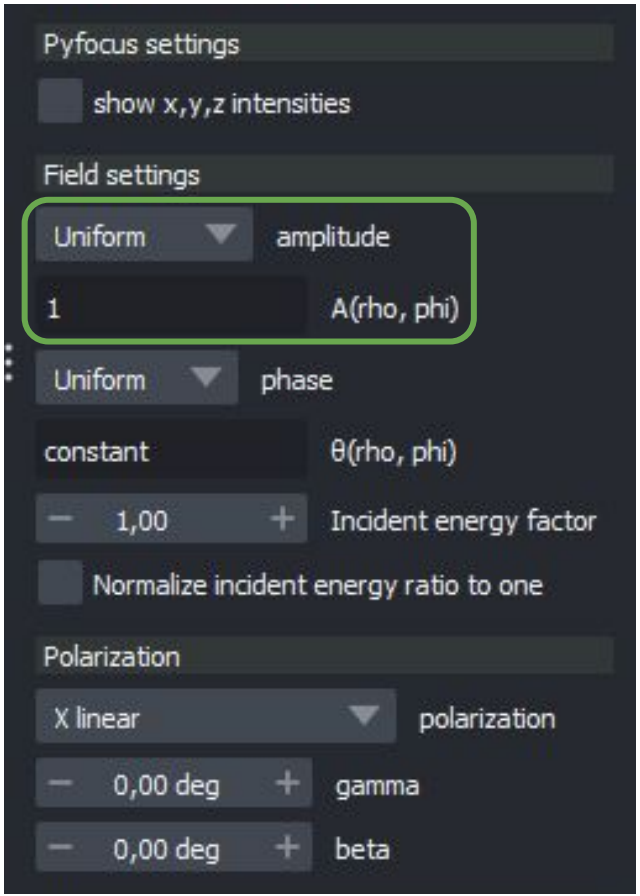


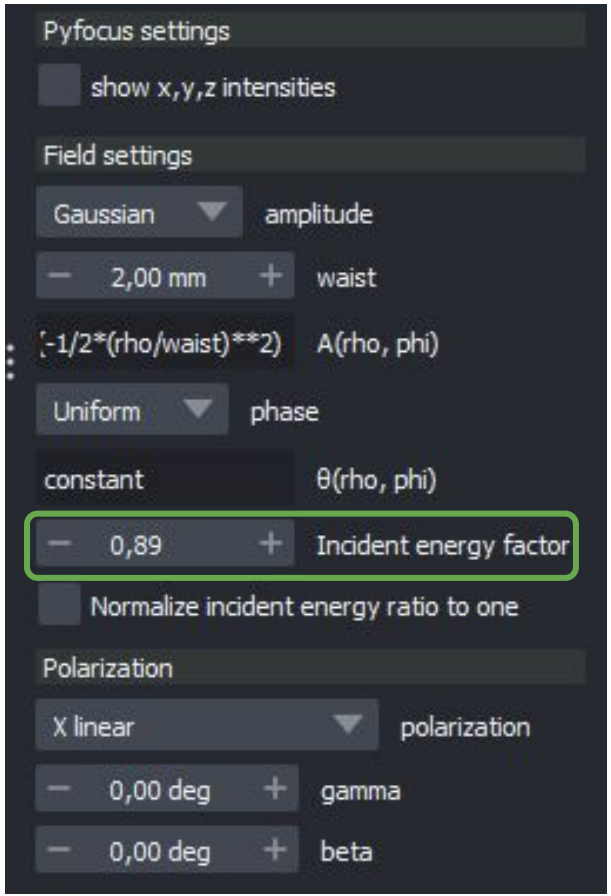
Vectorial simulation: Gaussian amplitude





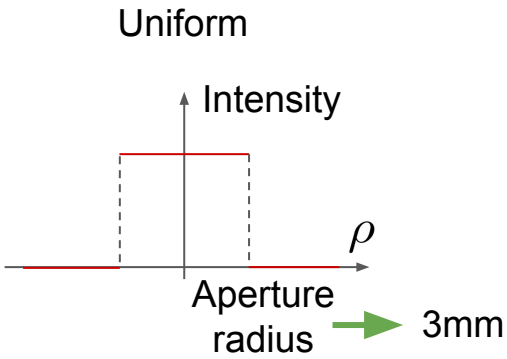
Vectorial simulation: Gaussian amplitude



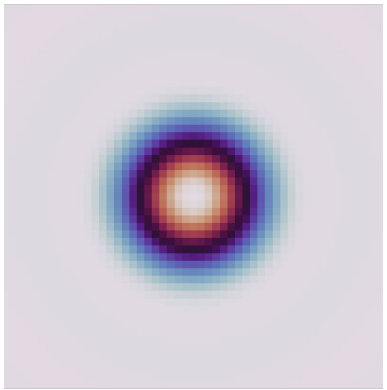


$$\frac{\text{Energy of custom field}}{\text{Energy of uniform field}}$$

Vectorial simulation: Gaussian amplitude



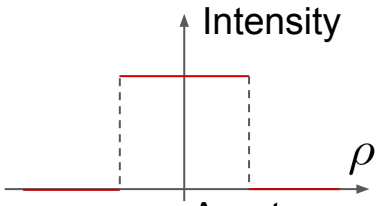
Incident energy factor: 1



Intensity at the center:
22.6 kW/nm^2

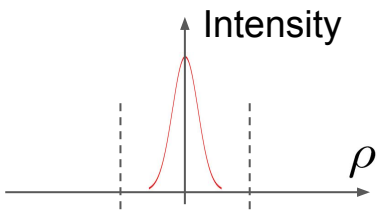
Vectorial simulation: Gaussian amplitude

Uniform

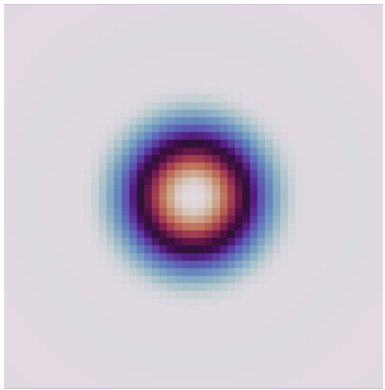


3mm

Waist: 1mm

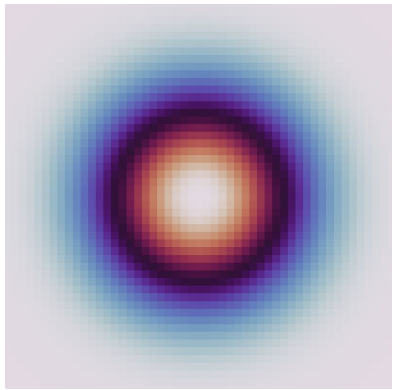


Incident energy factor: 1



Intensity at the center:
22.6 kW/nm^2

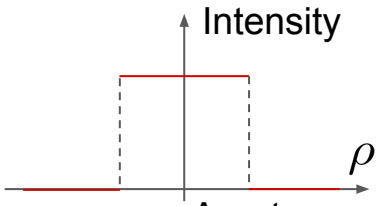
Incident energy factor: 1



Intensity at the center:
9.01 kW/nm^2

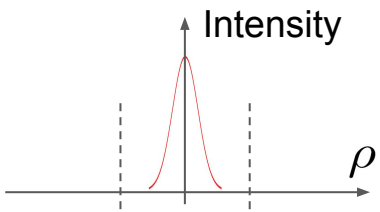
Vectorial simulation: Gaussian amplitude

Uniform

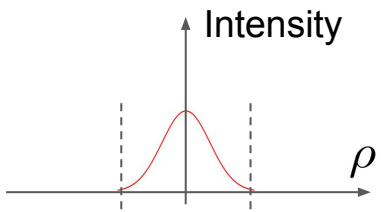


3mm

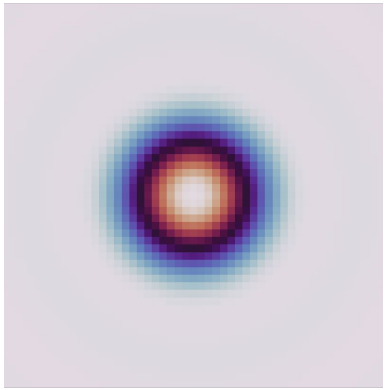
Waist: 1mm



Waist: 2mm

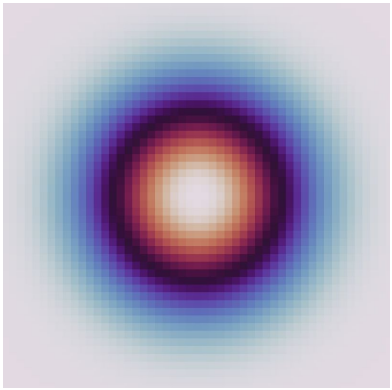


Incident energy factor: 1



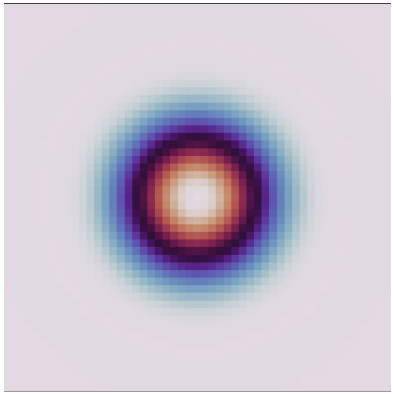
Intensity at the center:
22.6 kW/nm^2

Incident energy factor: 1



Intensity at the center:
9.01 kW/nm^2

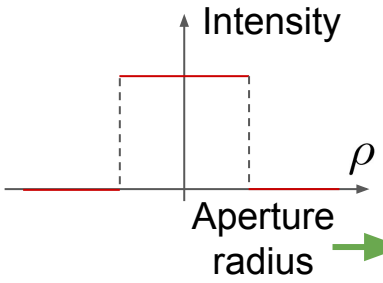
Incident energy factor: 0.89



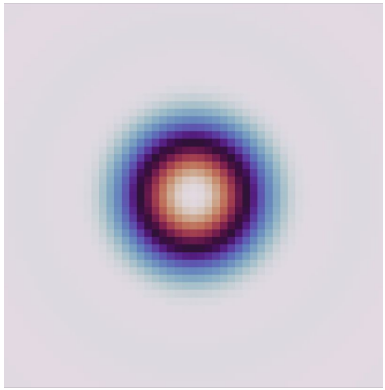
Intensity at the center:
16.8 kW/nm^2

Vectorial simulation: Gaussian amplitude

Uniform

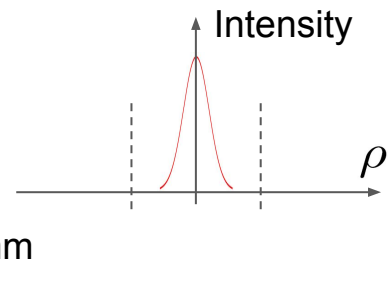


Incident energy factor: 1

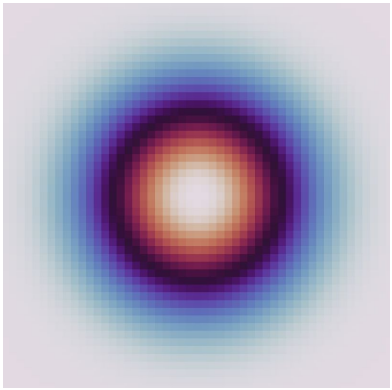


Intensity at the center:
22.6 kW/nm^2

Waist: 1mm

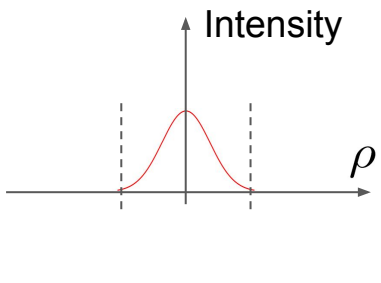


Incident energy factor: 1

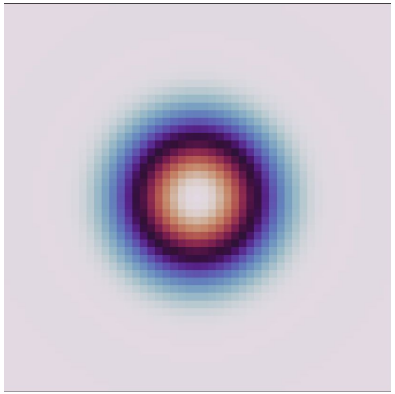


Intensity at the center:
9.01 kW/nm^2

Waist: 2mm

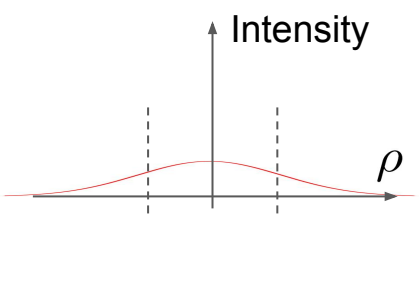


Incident energy factor: 0.89

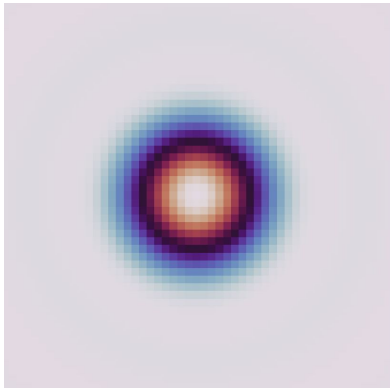


Intensity at the center:
16.8 kW/nm^2

Waist: 10mm

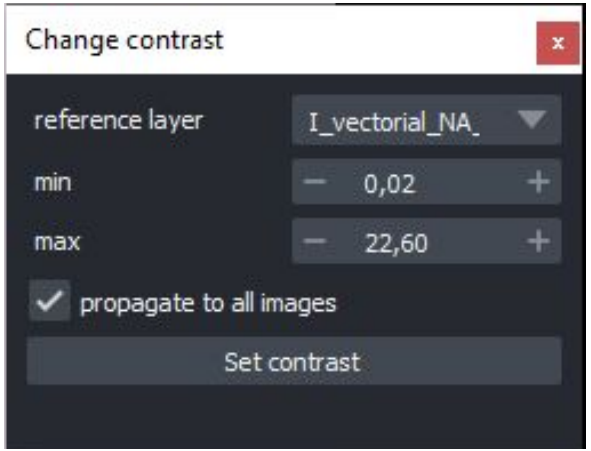


Incident energy factor: 0.09

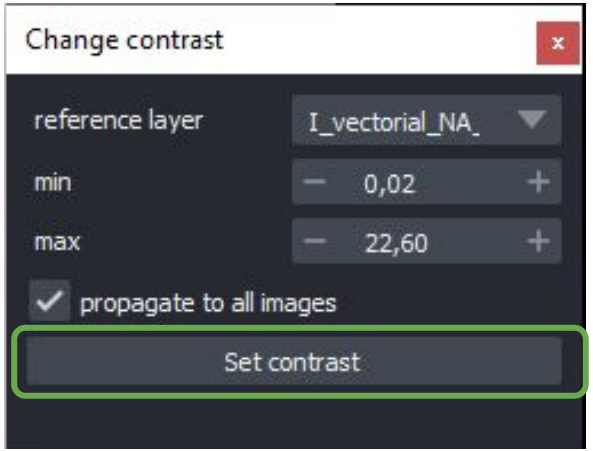


Intensity at the center:
1.92 kW/nm^2

Vectorial simulation: Intensity contrast

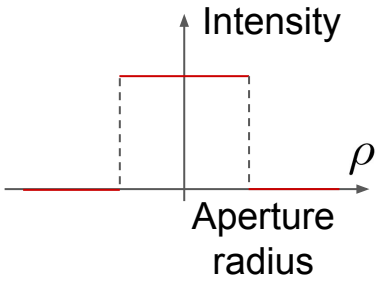


Vectorial simulation: Intensity contrast

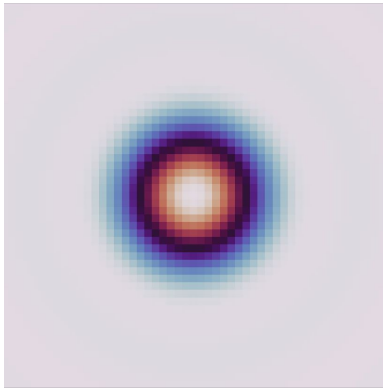


Vectorial simulation: Intensity contrast

Uniform

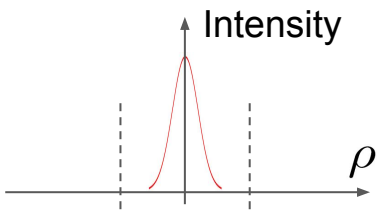


Incident energy factor: 1

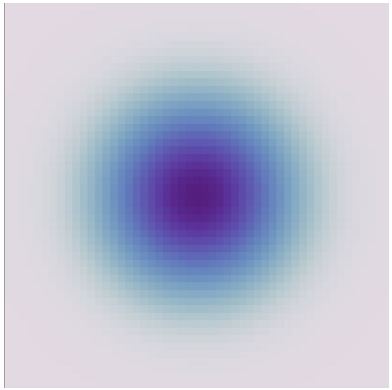


Intensity at the center:
22.6 kW/nm^2

Waist: 1mm

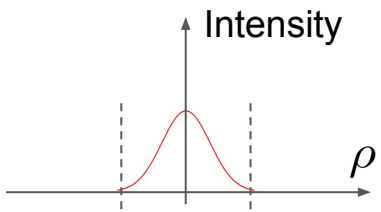


Incident energy factor: 1

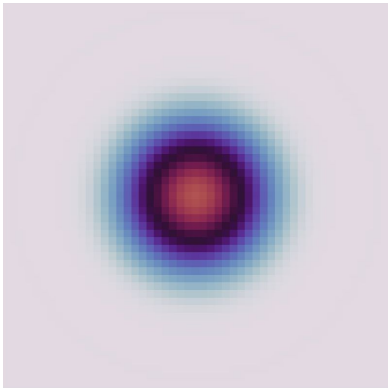


Intensity at the center:
9.01 kW/nm^2

Waist: 2mm

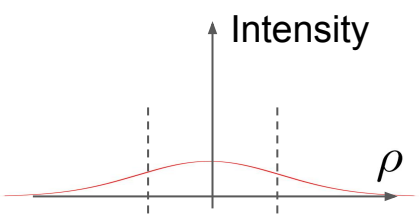


Incident energy factor: 0.89

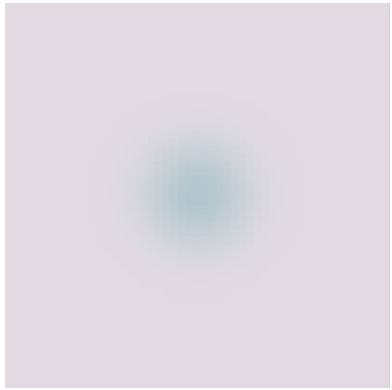


Intensity at the center:
16.8 kW/nm^2

Waist: 10mm

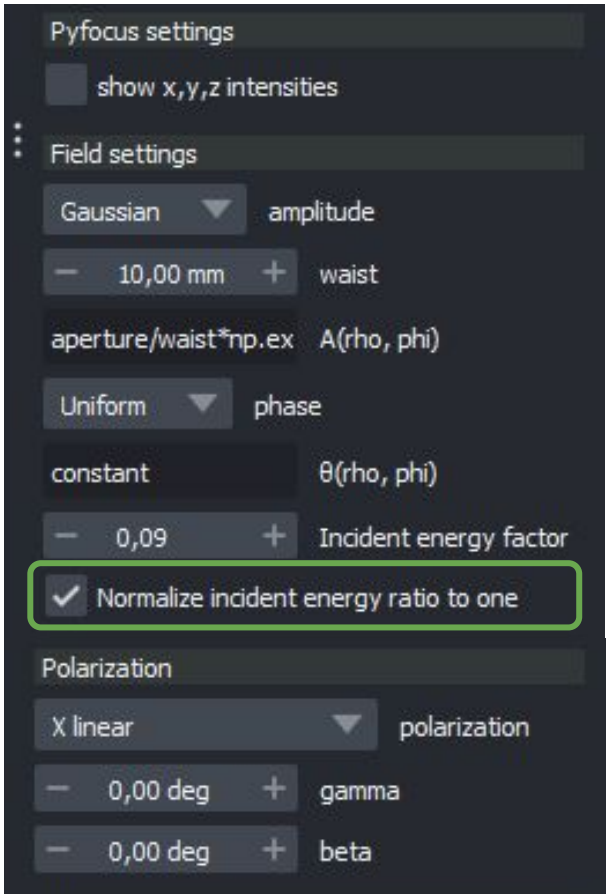


Incident energy factor: 0.09



Intensity at the center:
1.92 kW/nm^2

Vectorial simulation: Incident energy ratio



Vectorial simulation: Incident energy ratio

Pyfocus settings

show x,y,z intensities

Field settings

Gaussian amplitude

10,00 mm waist

aperture/waist*np.ex A(rho, phi)

Uniform phase

constant θ(rho, phi)

0,09 Incident energy factor

Normalize incident energy ratio to one

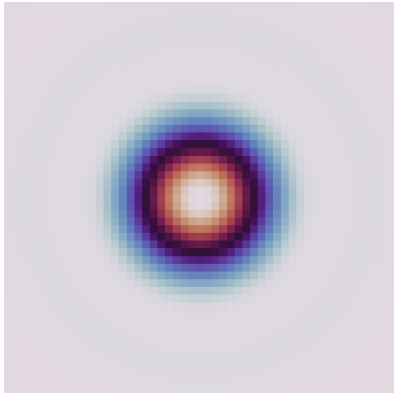
Polarization

X linear polarization

0,00 deg gamma

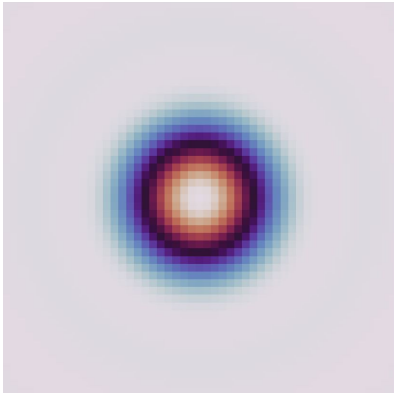
0,00 deg beta

Gaussian amplitude with 10mm waist normalized



Intensity at the center: 22.5 kW/nm^2

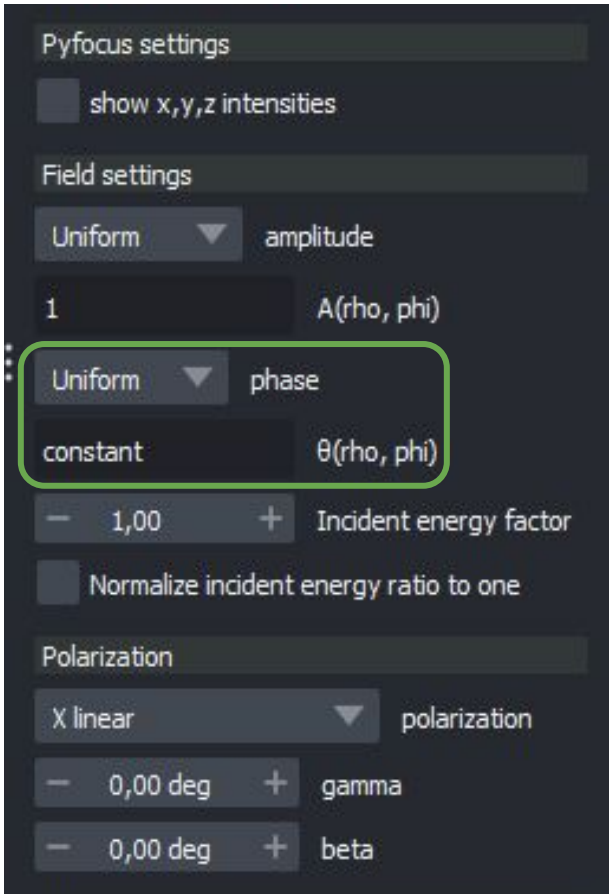
Uniform amplitude

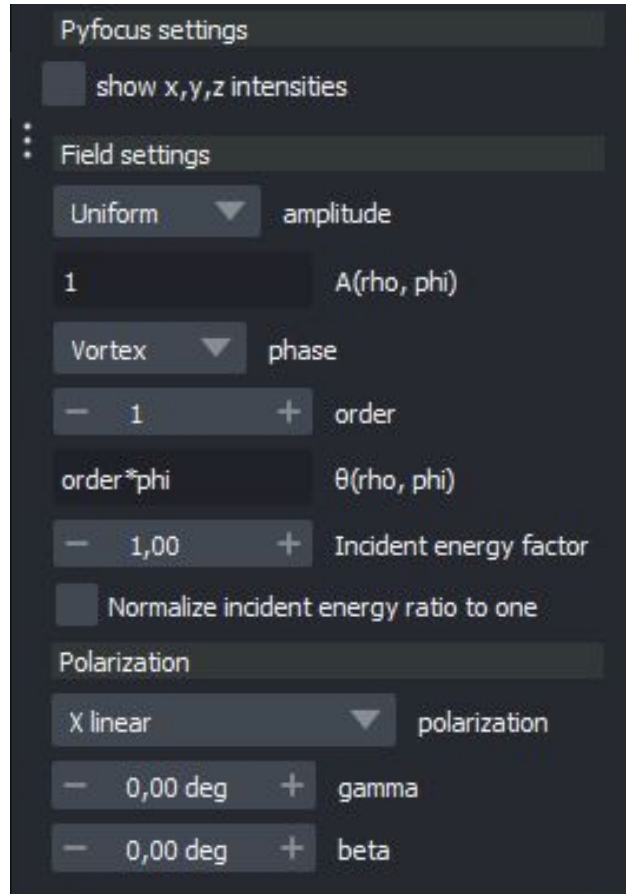


Intensity at the center: 22.6 kW/nm^2

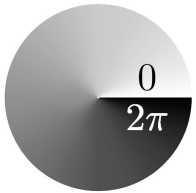
Vectorial simulation: Phase settings

Vectorial simulation: Vortex phase





Order = 1



Vectorial simulation: Vortex phase

Pyfocus settings

show x,y,z intensities

Field settings

Uniform — amplitude

1 — A(rho, phi)

Vortex — phase

1 — order

order*phi — θ(rho, phi)

1,00 — Incident energy factor

Normalize incident energy ratio to one

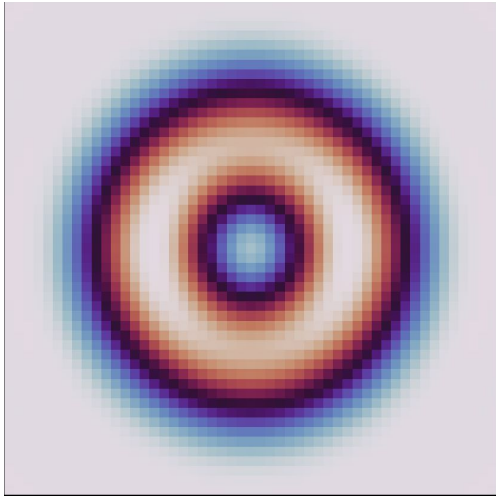
Polarization

X linear — polarization

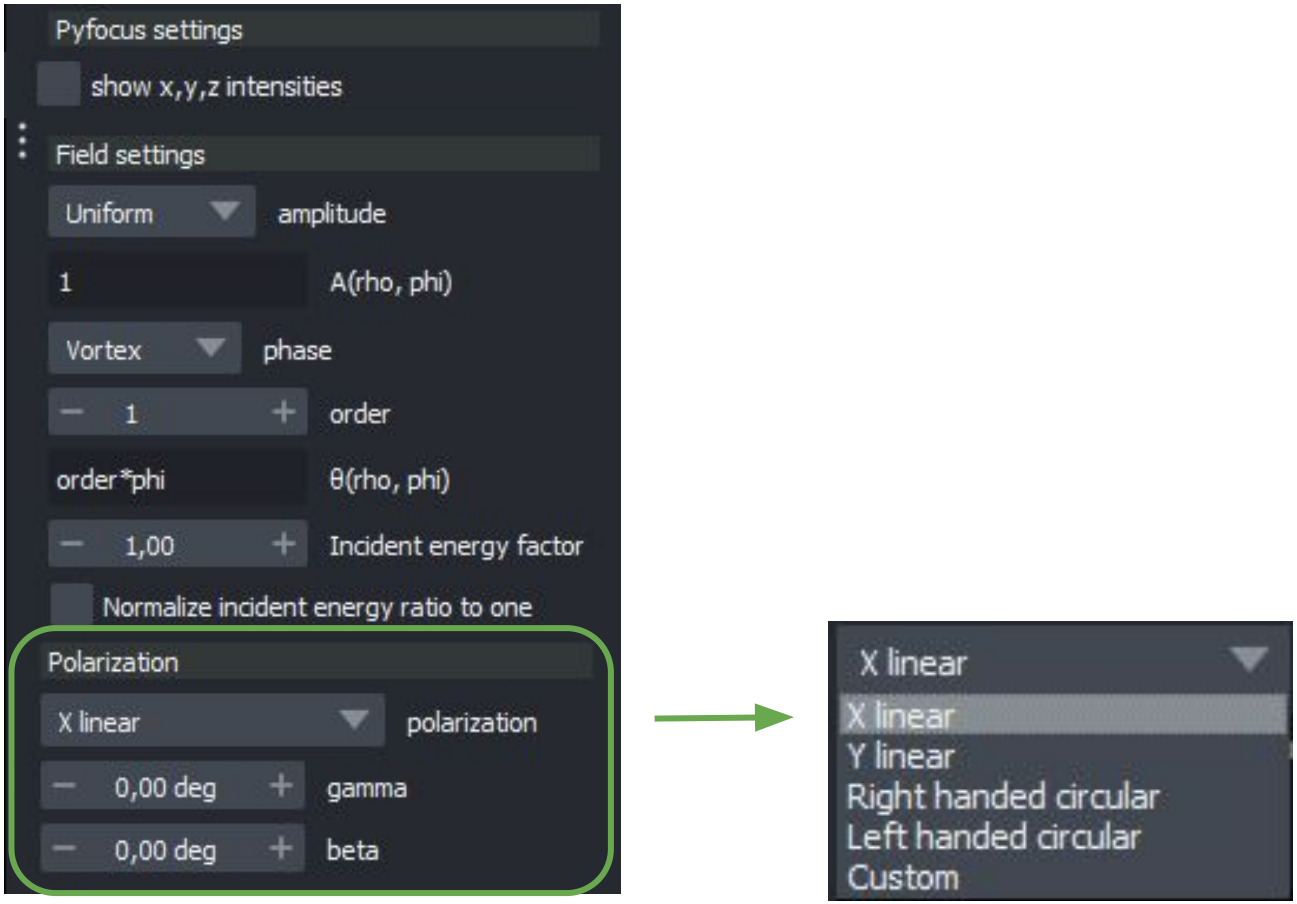
0,00 deg — gamma

0,00 deg — beta

Vortex phase with X linear polarization



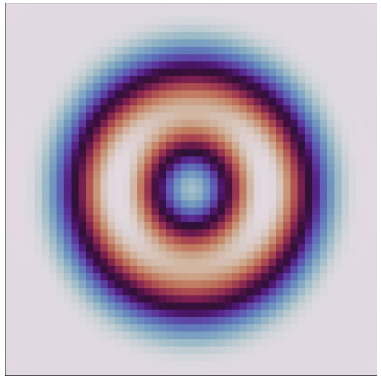
Vectorial simulation: Polarization setting



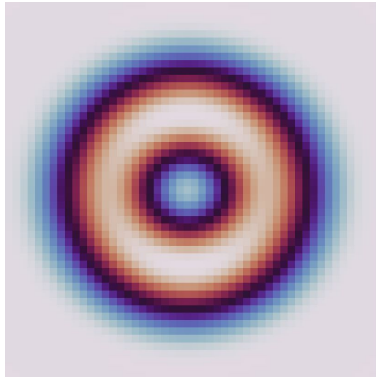
Vectorial simulation: Vortex phase for various polarizations

With
NA = 0.65
n = 1.3
FOVxy = 1.5µm

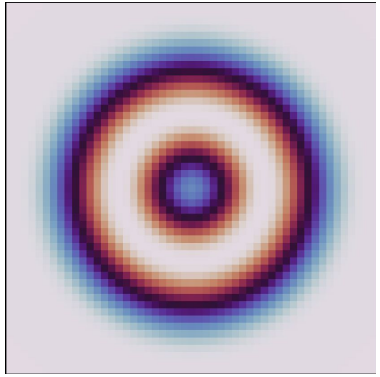
Y Linear



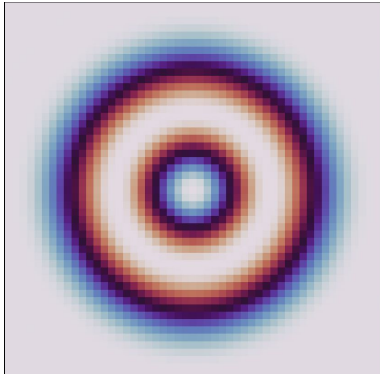
X Linear



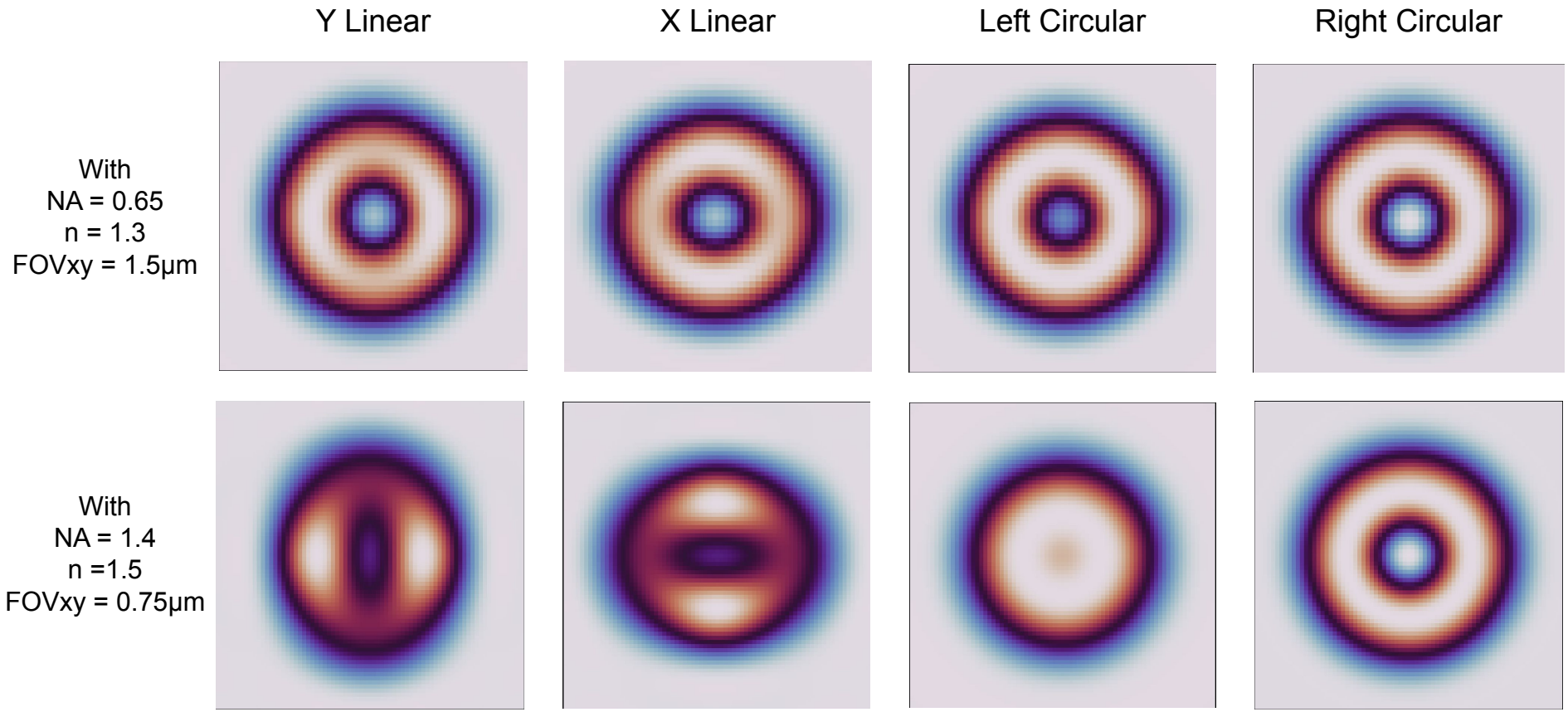
Left Circular



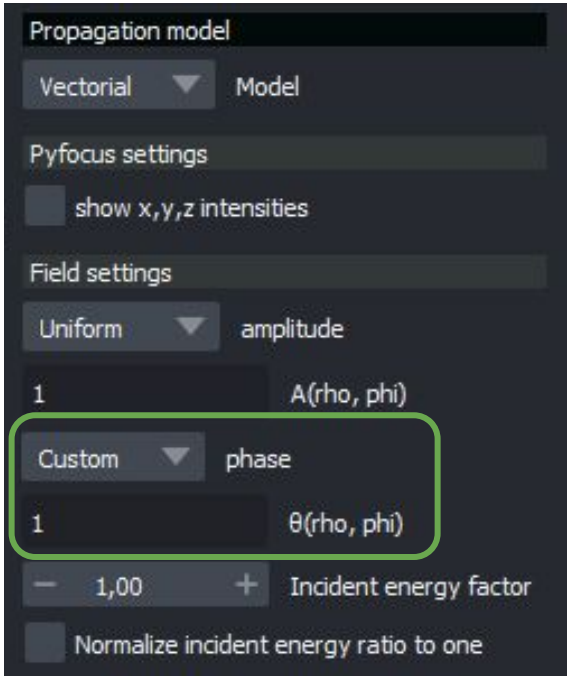
Right Circular



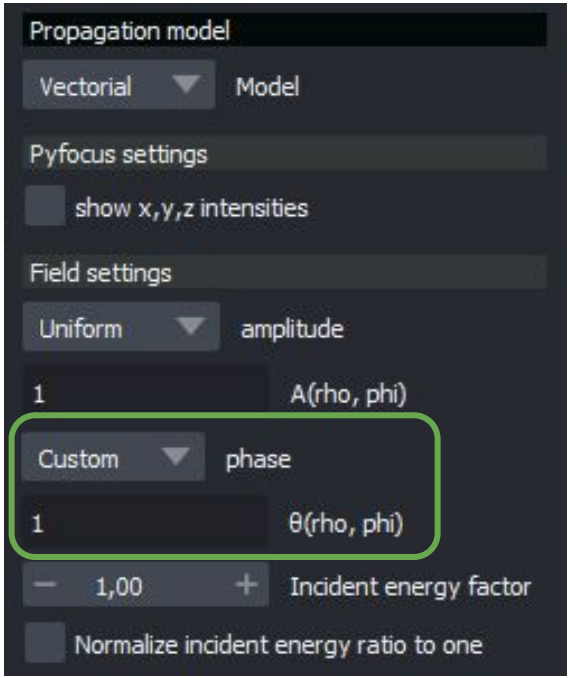
Vectorial simulation: Vortex phase for various polarizations



Vectorial simulation:
Custom phase (amplitude)

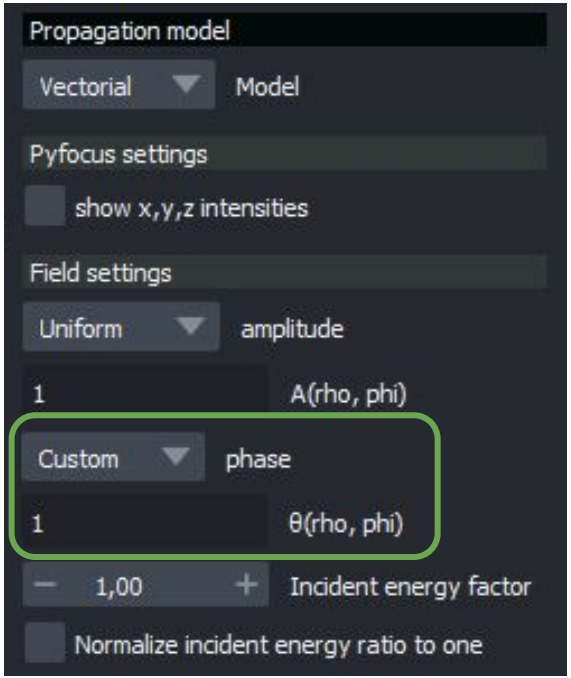


Vectorial simulation:
Custom phase (amplitude)



$$\frac{\text{rho}}{\text{lens radius}}$$

Vectorial simulation:
Custom phase (amplitude)

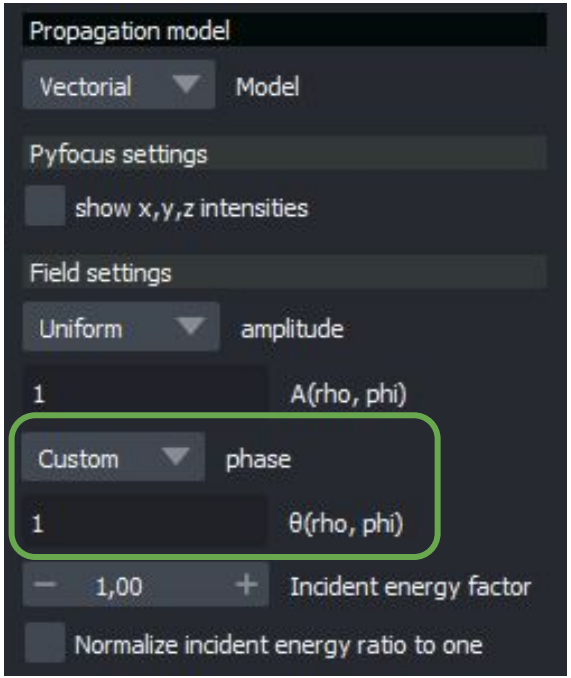


$$\frac{\text{rho}}{\text{lens radius}}$$

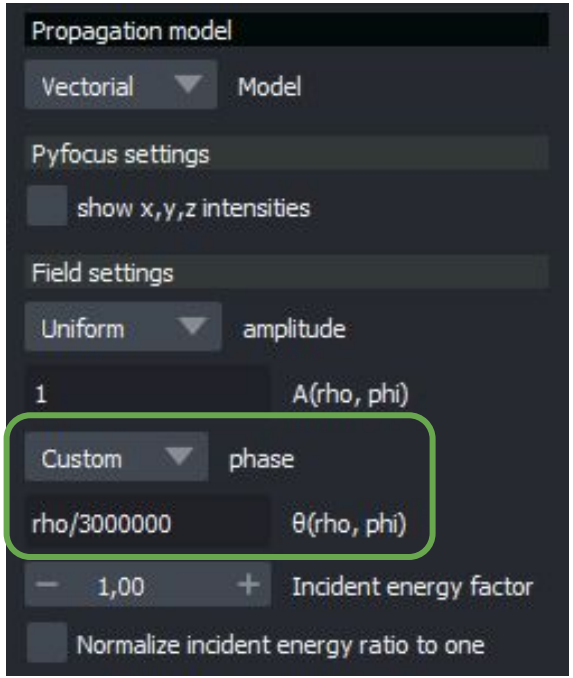
Units must be in nm

3mm = 3000000nm

Vectorial simulation:
Custom phase (amplitude)



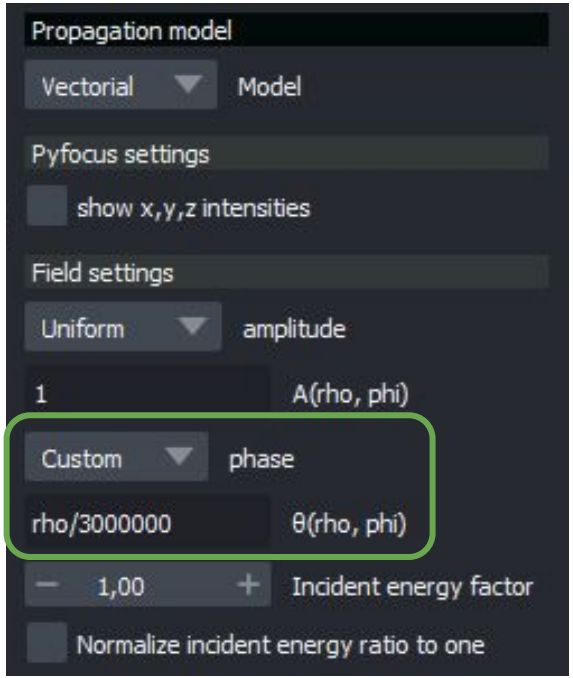
$$\frac{\text{rho}}{\text{lens radius}}$$

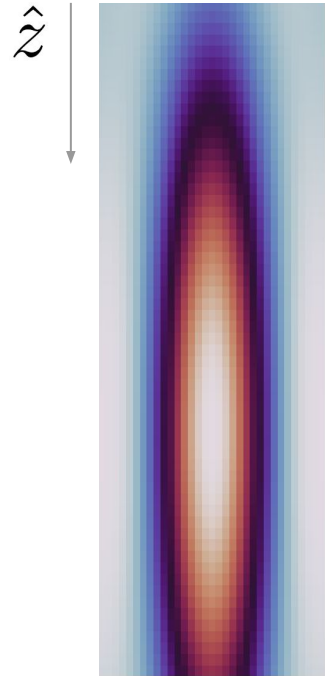


Units must be in nm

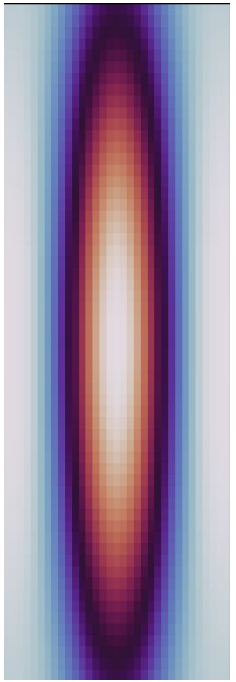
3mm = 3000000nm

Vectorial simulation:
Custom phase (amplitude)



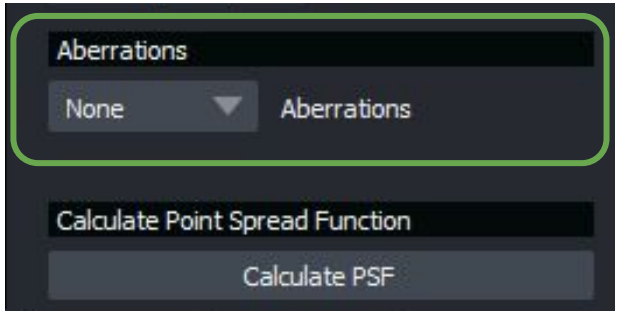


custom phase

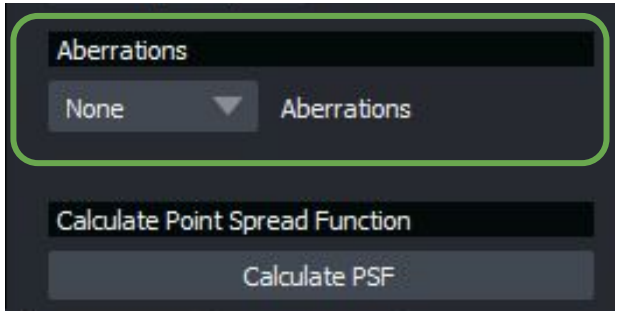


uniform field

Aberrations

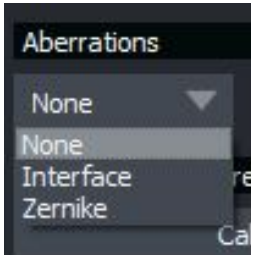


Aberrations

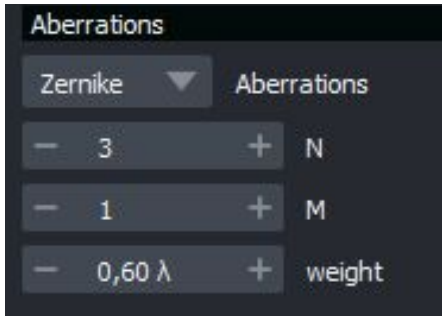


Scalar mode

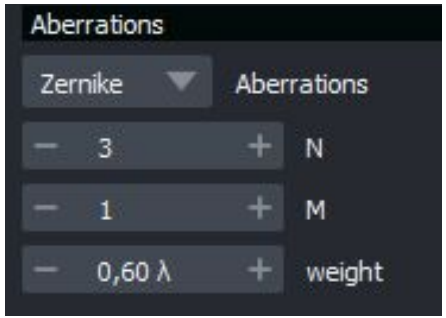
Vectorial mode



Aberrations: Zernike
Uniform field



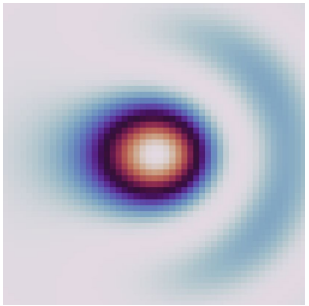
Aberrations: Zernike
Uniform field

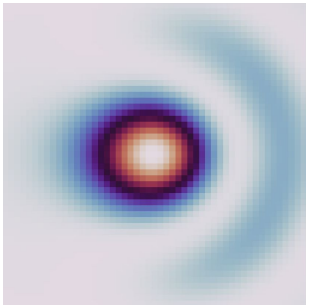


Scalar mode

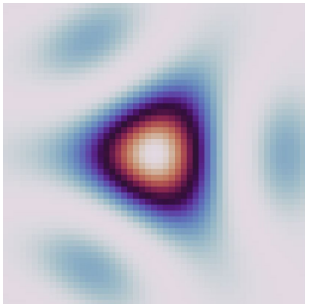
Vectorial mode

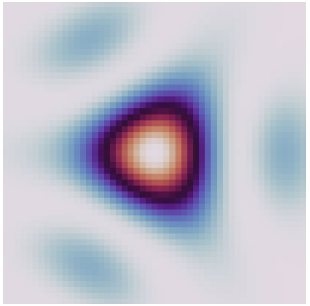
N = 3, M = 1,
weight = 0.6



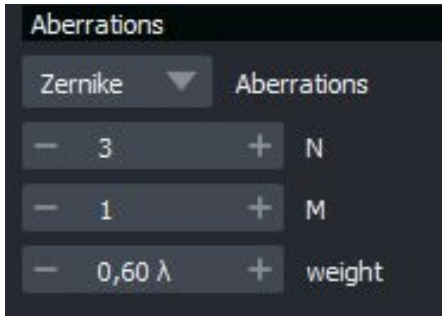


N = 3, M = 3,
weight = 0.6

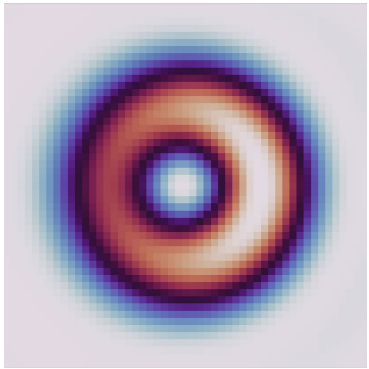




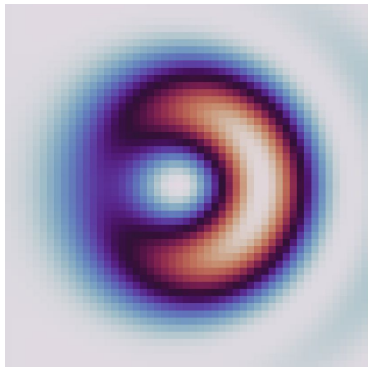
Aberrations: Zernike
Vortex phase with right handed circular polarization



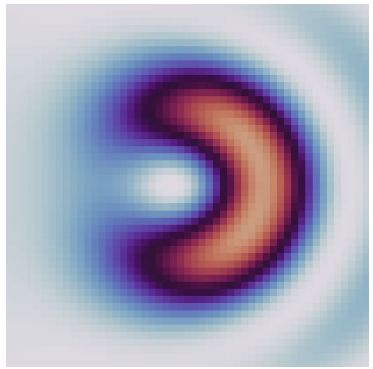
N = 3, M = 1,
weight = 0.15



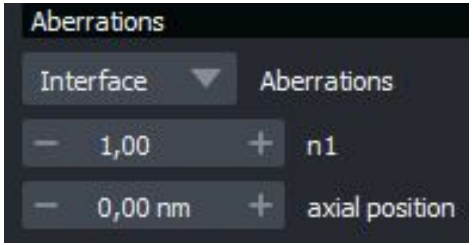
N = 3, M = 1,
weight = 0.4

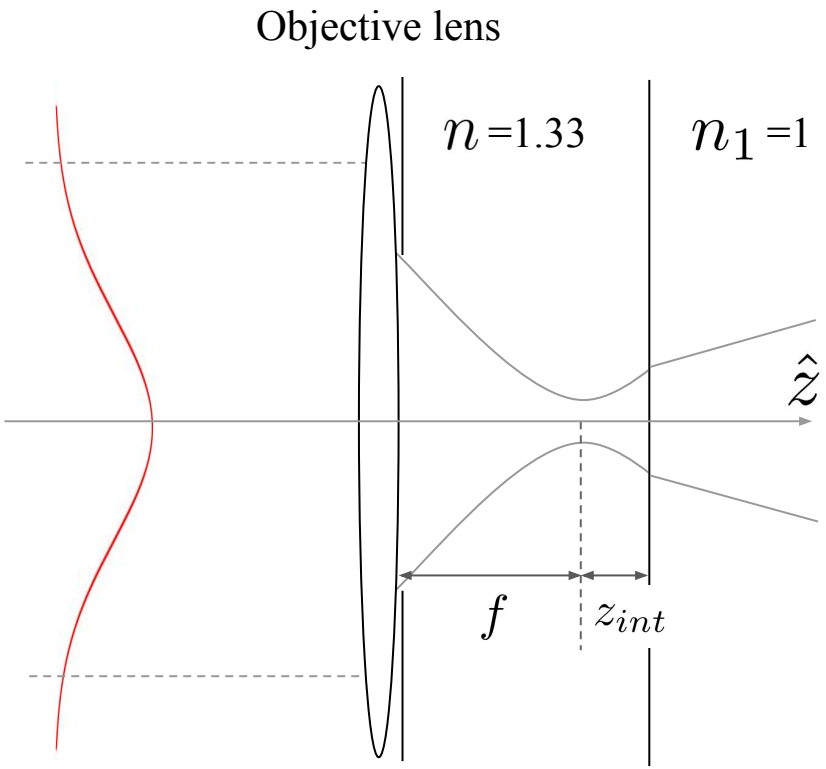


N = 3, M = 1,
weight = 0.6

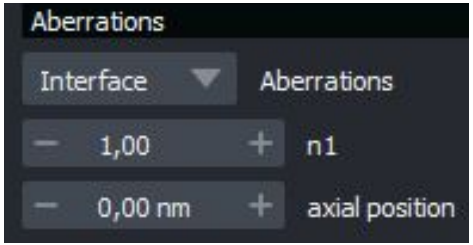


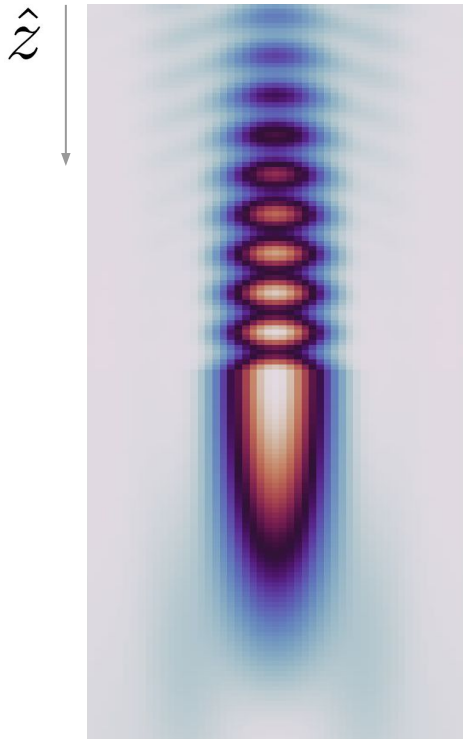
Aberrations: Vectorial simulation
Interface





Aberrations: Vectorial simulation
Interface, uniform field





Now, lets see it in action!