

Napari PSF simulator (napari-psf-simulator)

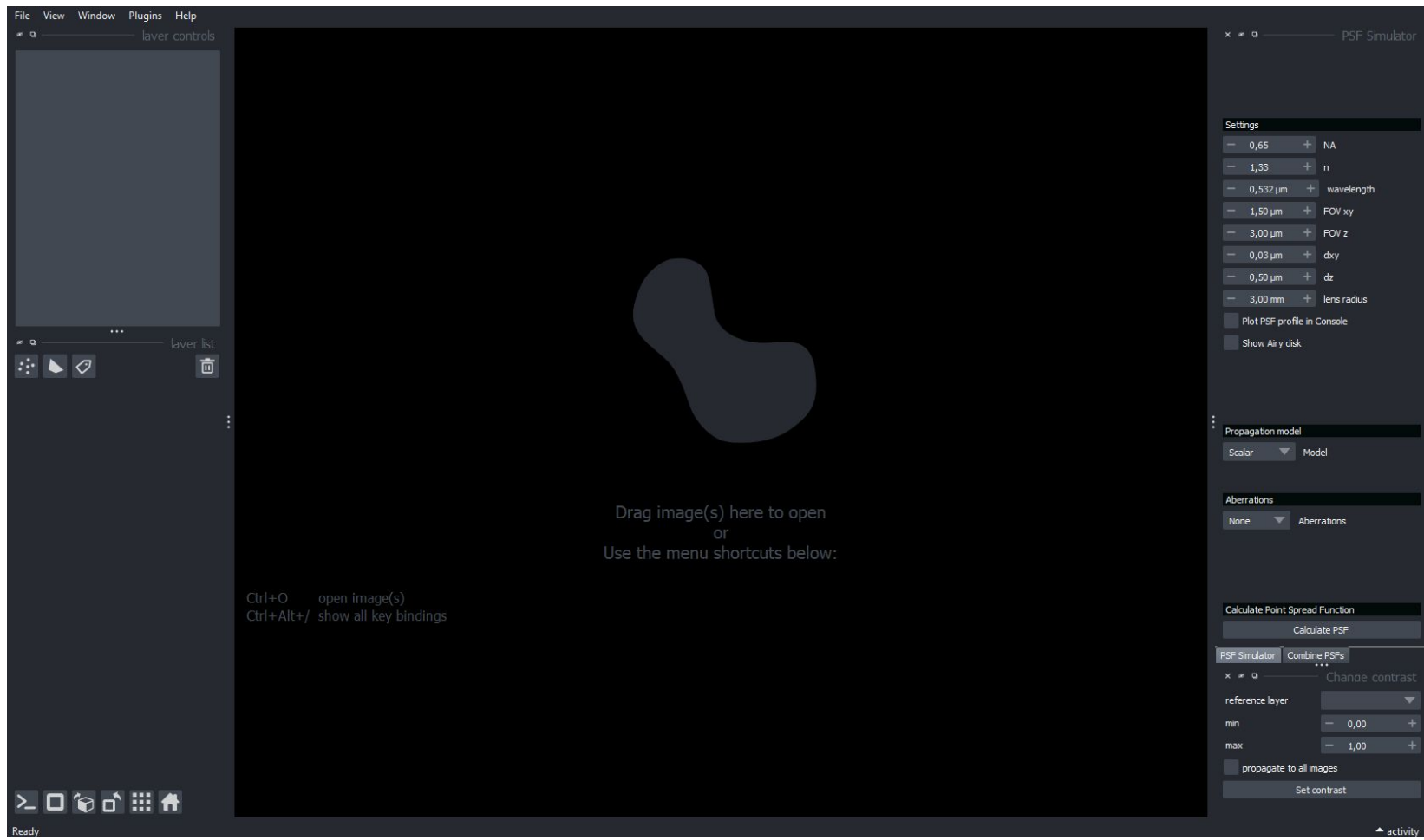


Fernando Caprile

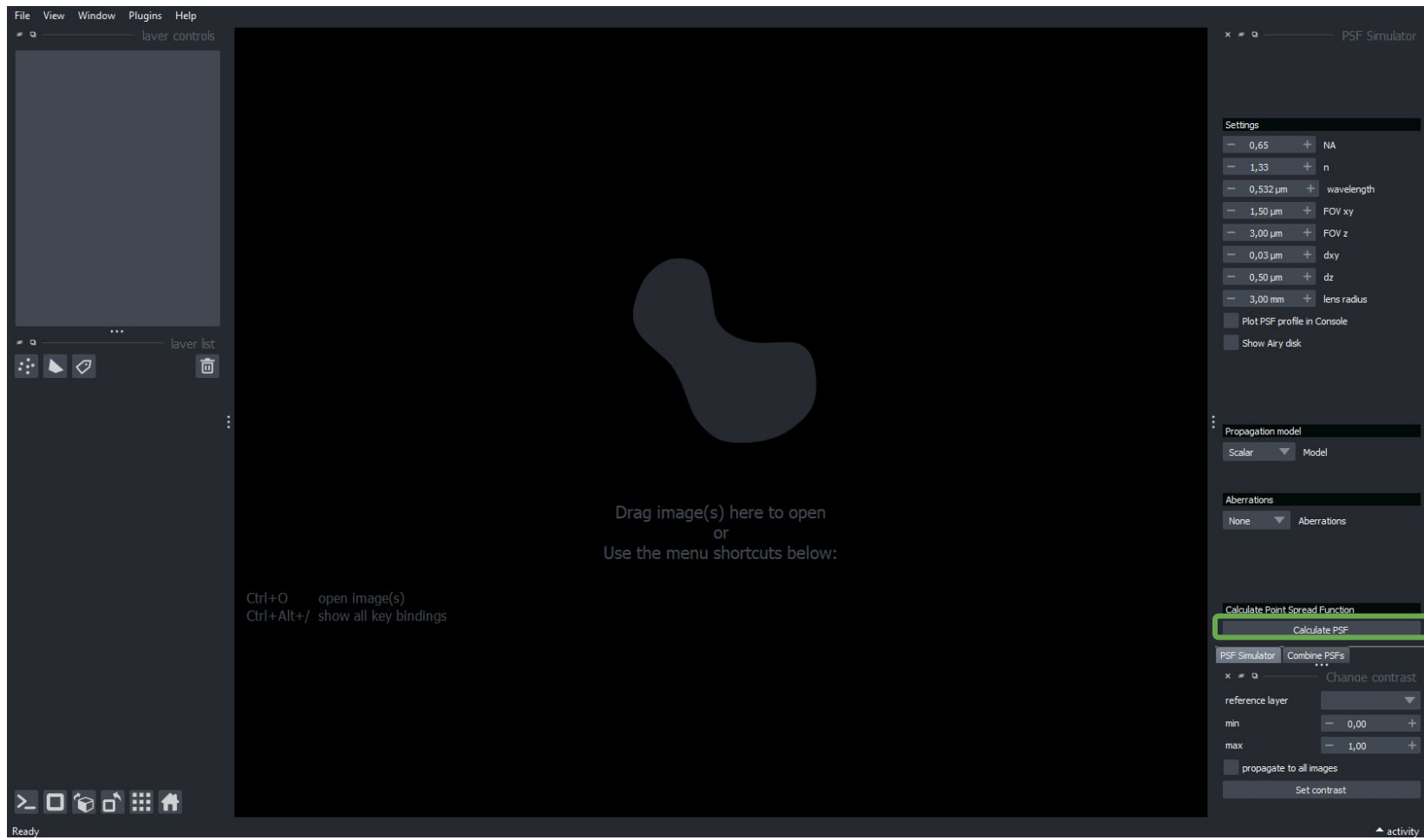
Data Scientist
Ms.C. in Physics

fcaprile@gmail.com

Scalar approximation



Scalar approximation



Scalar approximation

File View Window Plugins Help

layer controls

opacity: 1,00

contrast limits:

auto-contrast: once continuous

gamma: 1,00

colormap: twilight

blending: translucent_

interpolation: nearest

layer list

l_scalar_NA_0.7_n_1.3

z 3 6

PSF Simulator

Settings

0,65 NA

1,33 n

0,532 μm wavelength

1,500 μm FOV xy

3,000 μm FOV z

0,030 μm dxy

0,500 μm dz

3,00 mm lens radius

☐ Plot PSF profile in Console

☐ Show Airy disk

Propagation model

Scalar Model

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer l_scalar_NA_0.

min 0,00

max 23,83

☐ propagate to all images

Set contrast

l_scalar...7_n_1.3 [50 25 25]: 23.8

activity

Scalar approximation

File View Window Plugins Help

layer controls

opacity: 1,00

contrast limits:

auto-contrast: once continuous

gamma: 1,00

colormap: twilight

blending: translucent_

interpolation: nearest

layer list

l_scalar_NA_0.7_n_1.3

z 3 6

l_scalar...7_n_1.3 [50 25 25]: 23.8

PSF Simulator

Settings

0,65 NA

1,33 n

0,532 μm wavelength

1,500 μm FOV xy

3,000 μm FOV z

0,030 μm dxy

0,500 μm dz

3,00 mm lens radius

Plot PSF profile in Console

Show Airy disk

Propagation model

Scalar Model

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer l_scalar_NA_0.

min 0,00

max 23,83

propagate to all images

Set contrast

activity

Scalar approximation

File View Window Plugins Help

layer controls

opacity: 1,00
contrast limits:
auto-contrast: once continuous
gamma: 1,00
colormap: twilight
blending: translucent_
interpolation: nearest

layer list

I_scalar_NA_0.7_n_1.3

I_scalar....7_n_1.3 [50 25 25]: 23.8

z 3 | 6

PSF Simulator

Settings

0,65 NA
1,33 n
0,532 μm wavelength
1,500 μm FOV xy
3,000 μm FOV z
0,030 μm dxy
0,500 μm dz
3,00 mm lens radius
☐ Plot PSF profile in Console
☐ Show Airy disk

Propagation model

Scalar Model

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer I_scalar_NA_0.
min 0,00
max 23,83
☐ propagate to all images
Set contrast

Scalar approximation

File View Window Plugins Help

layer controls

opacity: 1,00

contrast limits:

auto-contrast: once continuous

gamma: 1,00

colormap: twilight

blending: translucent_

interpolation: nearest

layer list

l_scalar_NA_0.7_n_1.3

PSF Simulator

Settings

NA: 0,65

n: 1,33

wavelength: 0,532 μm

FOV xy: 1,500 μm

FOV z: 3,000 μm

dx: 0,030 μm

dy: 0,500 μm

dz: 3,00 mm

lens radius:

Plot PSF profile in Console

Show Airy disk

Propagation model

Scalar Model

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer: l_scalar_NA_0.

min: 0,00

max: 23,83

propagate to all images

Set contrast

z 3 | 6

activity

Scalar approximation

File View Window Plugins Help

layer controls

opacity: 1,00

contrast limits:

auto-contrast: once continuous

gamma: 1,00

colormap: twilight

blending: translucent_

interpolation: nearest

layer list

I_scalar_NA_0.7_n...

PSF Simulator

Settings

0,65 NA

1,33 n

0,532 μm wavelength

1,500 μm FOV xy

3,000 μm FOV z

0,030 μm dxy

0,050 μm dz

3,00 mm lens radius

Plot PSF profile in Console

Show Airy disk

Propagation model

Scalar Model

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer I_scalar_NA_0.

min 0,00

max 2,78

propagate to all images

Set contrast

25 | 50

activity

Base settings

File View Window Plugins Help

layer controls

opacity: 1,00
contrast limits:
auto-contrast: once continuous
gamma: 1,00
colormap: twilight
blending: translucent_
interpolation: nearest

layer list

l_scalar_NA_0.7_n.1.3

PSF Simulator

Settings

- 0,65 +	NA
- 1,33 +	n
- 0,532 μm +	wavelength
- 1,50 μm +	FOV xy
- 3,00 μm +	FOV z
- 0,03 μm +	dxy
- 0,50 μm +	dz
- 3,00 mm +	lens radius

☐ Plot PSF profile in Console
☐ Show Airy disk

Propagation model

Scalar Model

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer l_scalar_NA_0.

min 0,00 +
max 23,83 +

☐ propagate to all images

Set contrast

z 3 | 6

l_scalar...7_n.1.3 [50 39 53]

activity

Base settings

Settings

—	0,65	+	NA
—	1,33	+	n
—	0,532 μm	+	wavelength
—	1,50 μm	+	FOV xy
—	3,00 μm	+	FOV z
—	0,03 μm	+	dxy
—	0,50 μm	+	dz
—	3,00 mm	+	lens radius
<input type="checkbox"/>	Plot PSF profile in Console		
<input type="checkbox"/>	Show Airy disk		

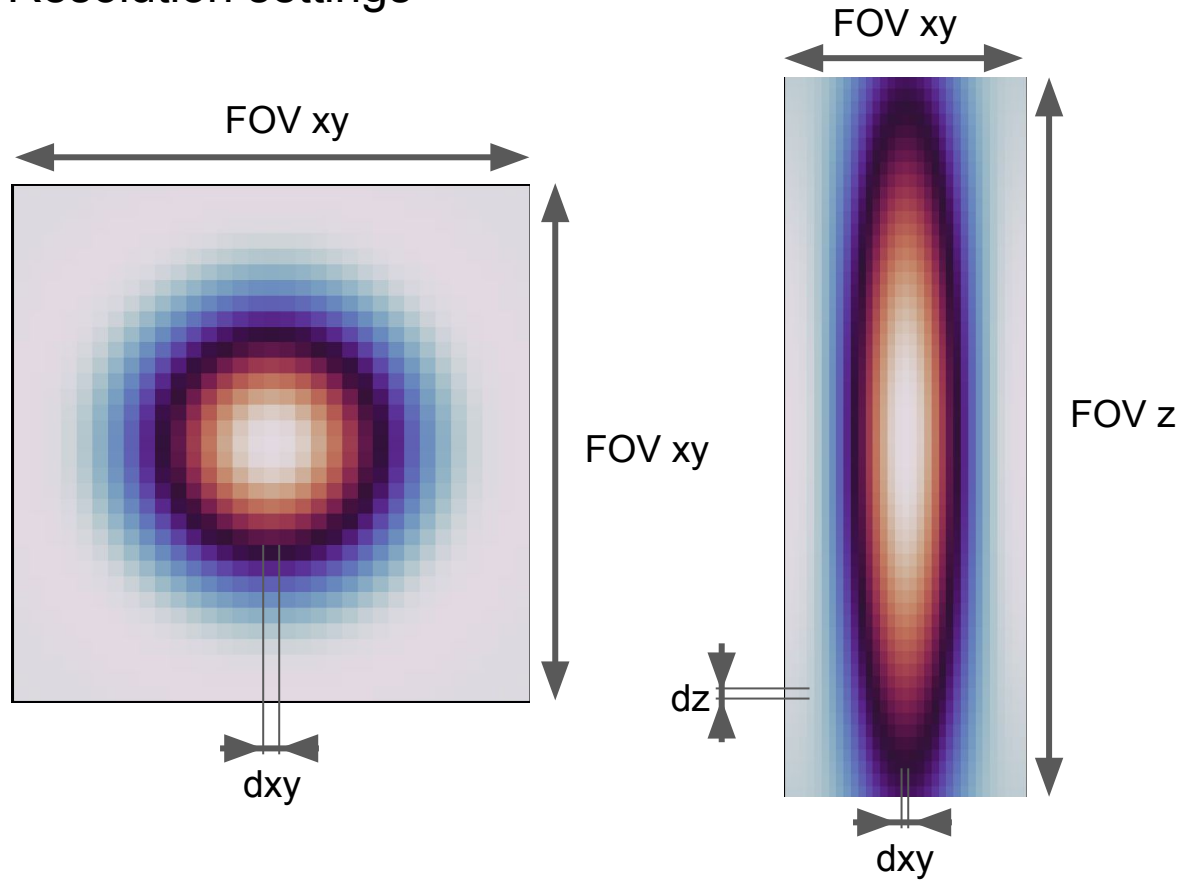
Resolution settings

Settings

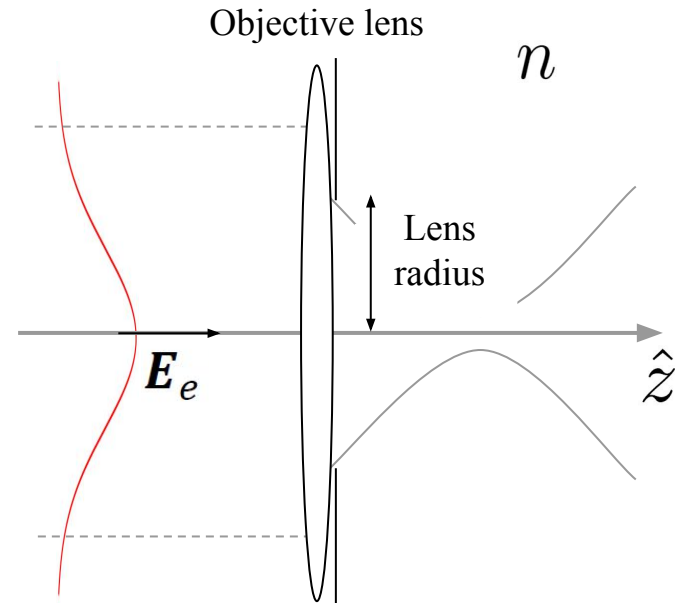
-	0,65	+	NA
-	1,33	+	n
-	0,532 μm	+	wavelength
-	1,50 μm	+	FOV xy
-	3,00 μm	+	FOV z
-	0,03 μm	+	dxy
-	0,50 μm	+	dz
-	3,00 mm	+	lens radius

☐ Plot PSF profile in Console

☐ Show Airy disk



Optical system settings



Show Airy disk and plot profile along X and Z

Settings

—	0,65	+	NA
—	1,33	+	n
—	0,532 μm	+	wavelength
—	1,50 μm	+	FOV xy
—	3,00 μm	+	FOV z
—	0,03 μm	+	dxy
—	0,50 μm	+	dz
—	3,00 mm	+	lens radius

☒ Plot PSF profile in Console

☒ Show Airy disk

Show Airy disk and plot profile along X and Z

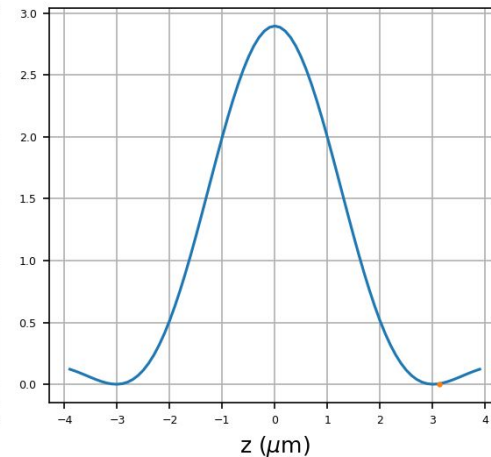
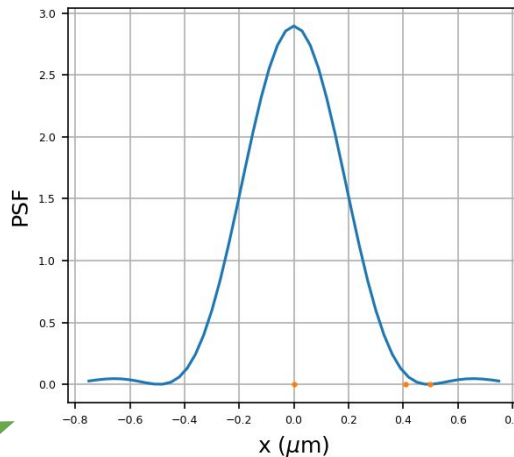
Settings

— 0,65	+	NA
— 1,33	+	n
— 0,532 μm	+	wavelength
— 1,50 μm	+	FOV xy
— 3,00 μm	+	FOV z
— 0,03 μm	+	dxy
— 0,50 μm	+	dz
— 3,00 mm	+	lens radius

☒ Plot PSF profile in Console

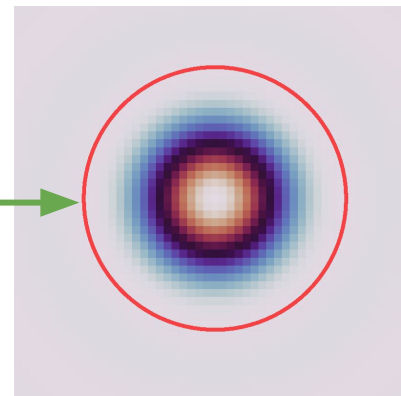
☒ Show Airy disk

NA = 0.65, n = 1.33

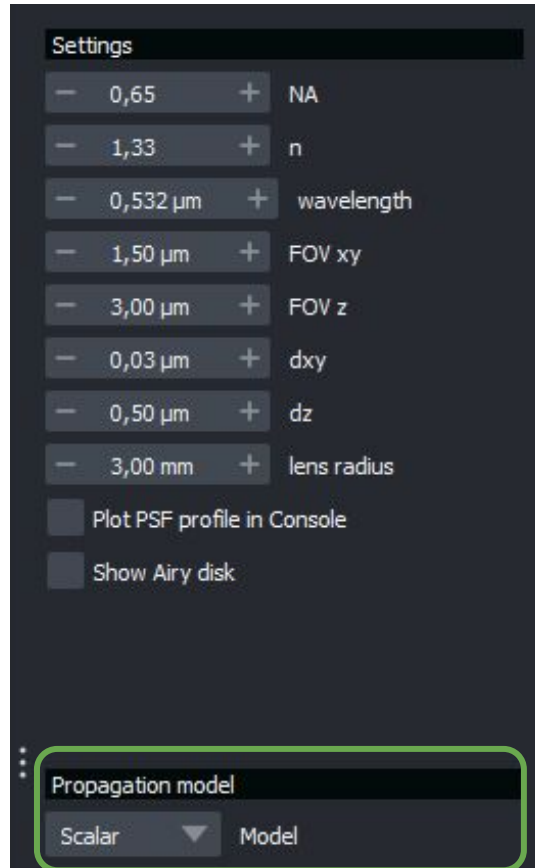


layer list

- ☒ AiryDisk_scalar_NA...
- ☒ I_scalar_NA_0.7_n_1.3



Vectorial simulation



Vectorial simulation: PyFocus

**PyFocus – a Python package for vectorial calculations of
focused optical fields under realistic conditions.**

Application to toroidal foci.

Fernando Caprile^{1,2}, Luciano A. Masullo^{1,2*}, Fernando D. Stefani^{1,2*}

¹Centro de Investigaciones en Bionanociencias (CIBION), Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), Godoy Cruz 2390, C1425FQD, Ciudad Autónoma de Buenos Aires, Argentina

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:

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

Vectorial simulation: PyFocus

The field near the focus can
be obtained by:

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



For most fields, 2D
numerical integration

Vectorial simulation: PyFocus settings

File View Window Plugins Help

layer controls

layer list

Drag image(s) here to open
or
Use the menu shortcuts below:

Ctrl+O open image(s)
Ctrl+Alt+/ show all key bindings

PSF Simulator

Settings

0,65 NA
1,33 n
0,532 μm wavelength
1,50 μm FOV xy
3,00 μm FOV z
0,03 μm dxy
0,50 μm dz
3,00 mm lens radius

Plot PSF profile in Console
Show Airy disk

Propagation model

Vectorial Model

Pyfocus settings

show x,y,z intensities

Field settings

Uniform amplitude
1 A(rho, phi)
Uniform phase
constant B(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

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer
min 0,00
max 1,00

Vectorial simulation: PyFocus settings

File View Window Plugins Help

layer controls

layer list

Drag image(s) here to open
or
Use the menu shortcuts below:

Ctrl+O open image(s)
Ctrl+Alt+/ show all key bindings

PSF Simulator

Settings

- 0,65 NA
- 1,33 n
- 0,532 μm wavelength
- 1,50 μm FOV xy
- 3,00 μm FOV z
- 0,03 μm dxy
- 0,50 μm dz
- 3,00 mm lens radius

Plot PSF profile in Console

Show Airy disk

Propagation model

Vectorial Model

Pyfocus settings

- ☐ show x,y,z intensities

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1 A(rho, phi)

Uniform phase

constant B(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

Aberrations

None Aberrations

Calculate Point Spread Function

Calculate PSF

PSF Simulator Combine PSFs

Change contrast

reference layer

min 0,00

max 1,00

Vectorial simulation: Field settings

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 A(ρ , ϕ)

Uniform ▼ phase

constant $\theta(\rho$, $\phi)$

– 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear ▼ polarization

– 0,00 deg + gamma

– 0,00 deg + beta

Vectorial simulation: Field settings

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 A(rho, phi)

Uniform ▼ phase

constant $\theta(\text{rho}, \text{phi})$

− 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

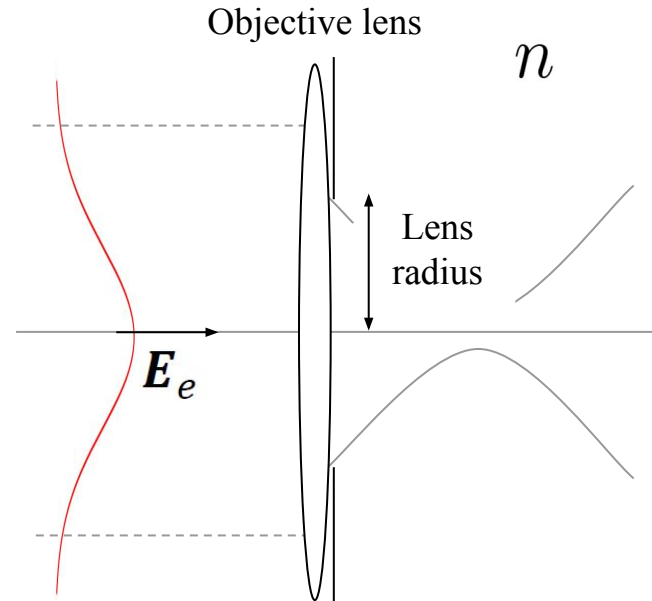
Polarization

X linear ▼ polarization

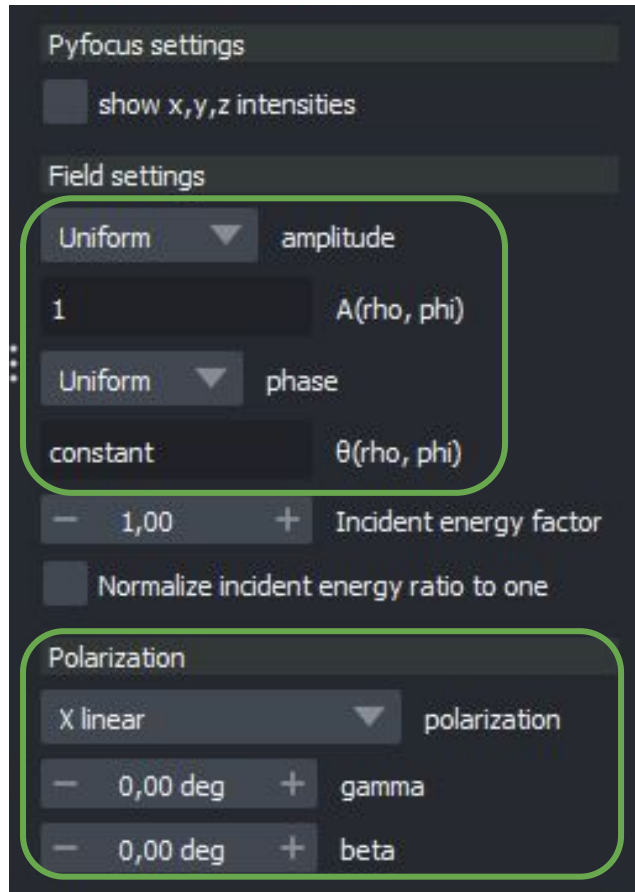
− 0,00 deg + gamma

− 0,00 deg + beta

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



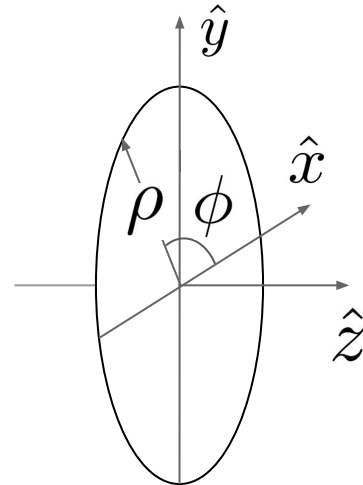
Vectorial simulation: Field settings



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

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

Objective lens



Vectorial simulation: Default simulation

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 A(rho, phi)

Uniform ▼ phase

constant $\theta(\text{rho}, \text{phi})$

− 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

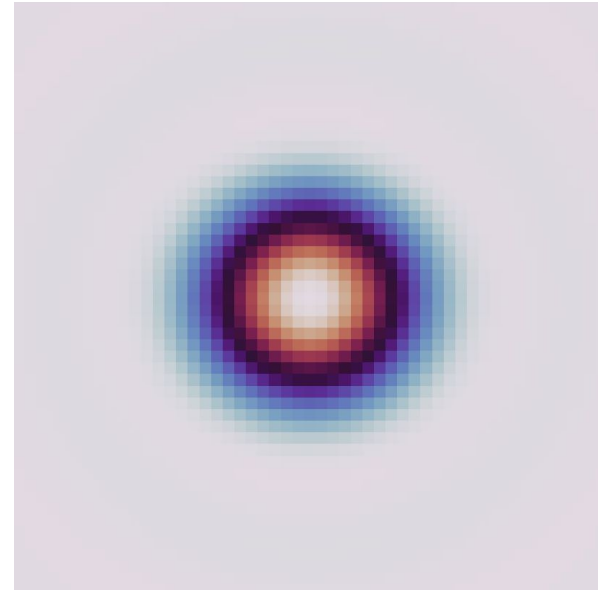
Polarization

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

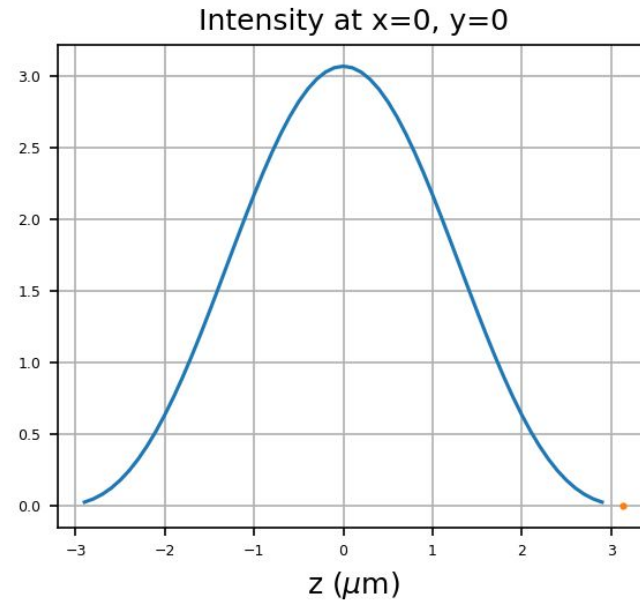
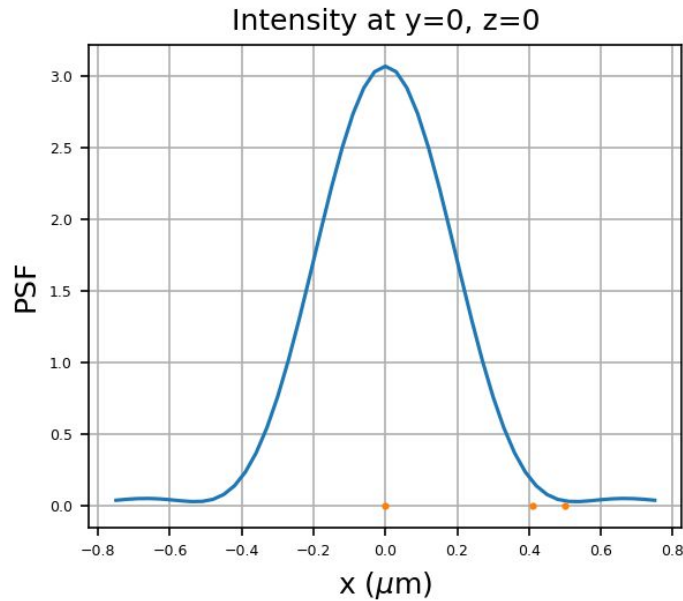


Plot PSF profile in Console

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

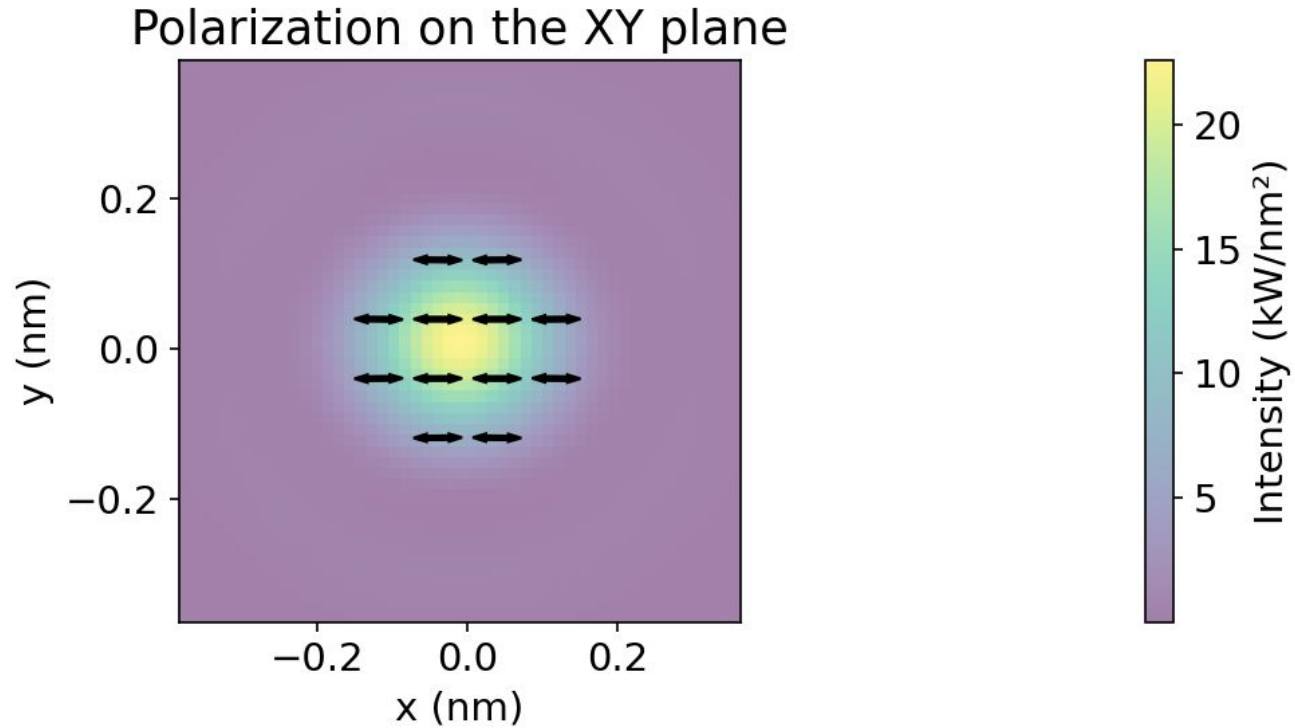
✓ Plot PSF profile in Console

NA = 0.65, n = 1.33



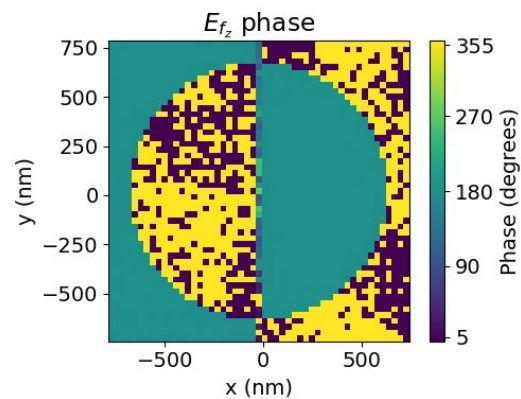
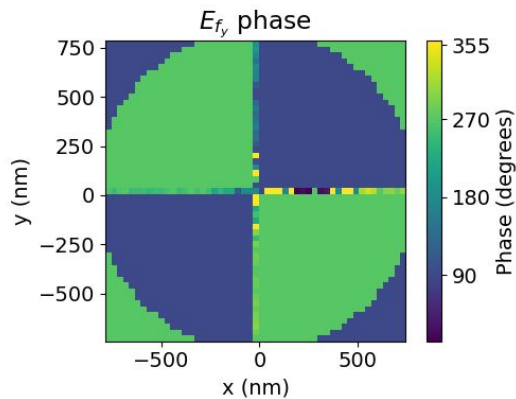
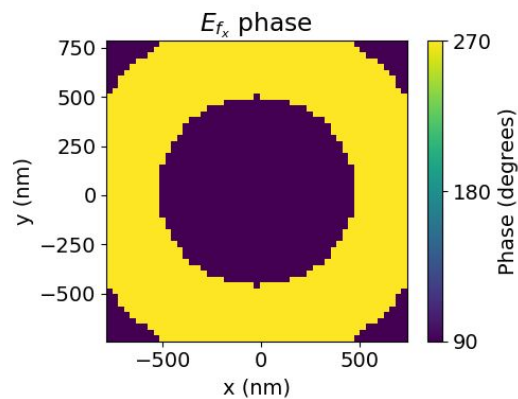
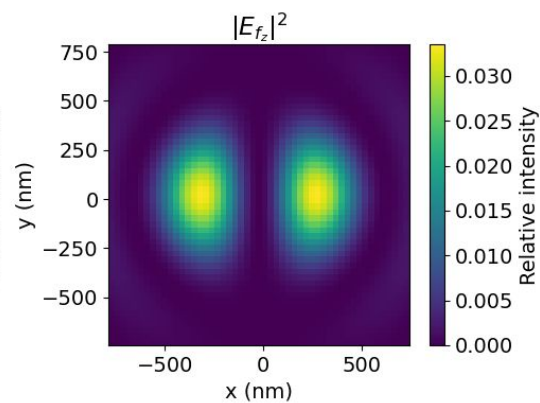
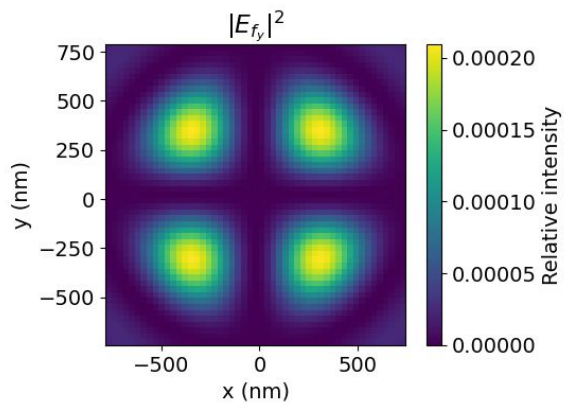
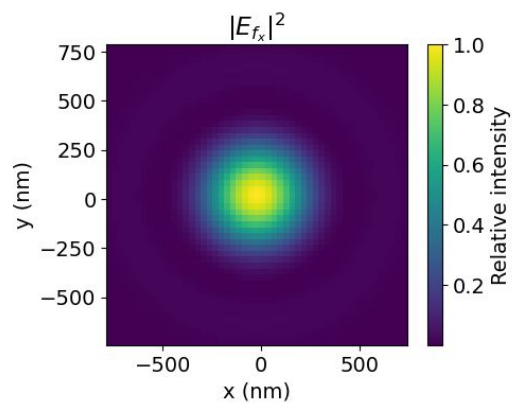
Vectorial simulation: Intensity of the X, Y and Z components

✓ Plot PSF profile in Console



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

✓ Plot PSF profile in Console



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

Pyfocus settings

☒ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 $A(\rho, \phi)$

Uniform ▼ phase

constant $\theta(\rho, \phi)$

— 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

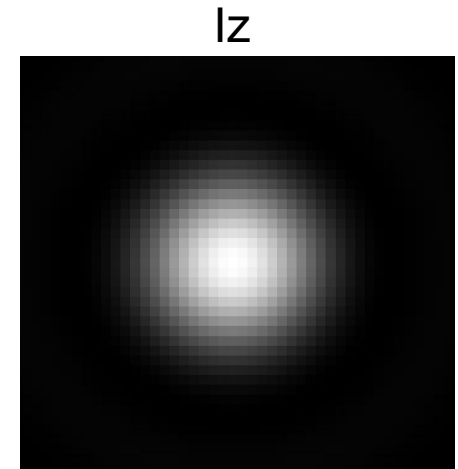
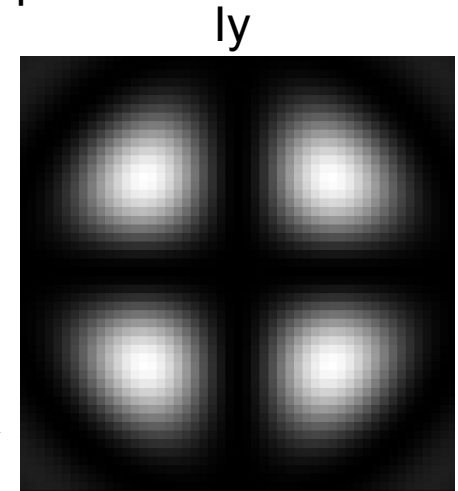
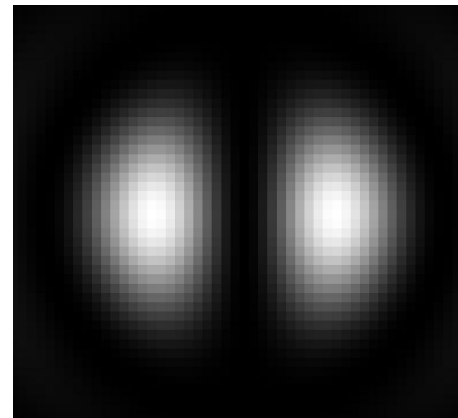
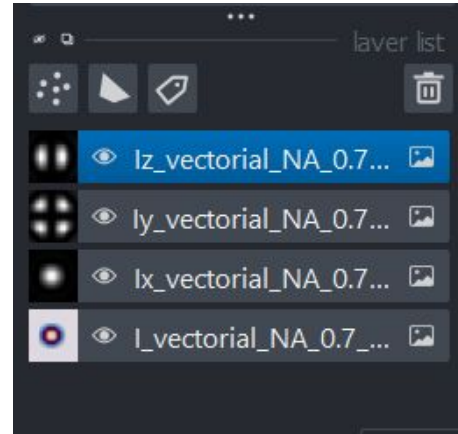
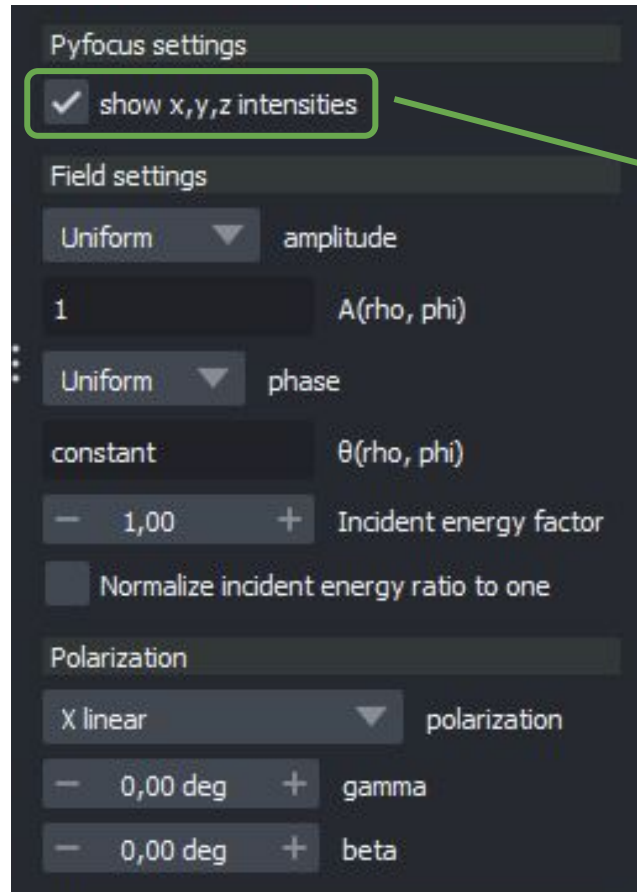
Polarization

X linear ▼ polarization

— 0,00 deg + gamma

— 0,00 deg + beta

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



Vectorial simulation: Amplitude setting

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ∇ amplitude

1 $A(\rho, \phi)$

Uniform ∇ phase

constant $\theta(\rho, \phi)$

- 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear ∇ polarization

- 0,00 deg + gamma

- 0,00 deg + beta



Uniform ∇

Uniform

Gaussian

Custom

Vectorial simulation: Gaussian amplitude

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform amplitude

1 $A(\rho, \phi)$

Uniform phase

constant $\theta(\rho, \phi)$

- 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear polarization

- 0,00 deg + gamma

- 0,00 deg + beta



Pyfocus settings

☐ show x,y,z intensities

Field settings

Gaussian amplitude

- 2,00 mm + waist

$-1/2 * (\rho / \text{waist})^2$ $A(\rho, \phi)$

Uniform phase

constant $\theta(\rho, \phi)$

- 0,89 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear polarization

- 0,00 deg + gamma

- 0,00 deg + beta

Vectorial simulation: Gaussian amplitude

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 A(rho, phi)

Uniform ▼ phase

constant $\theta(\rho, \phi)$

- 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear ▼ polarization

- 0,00 deg + gamma

- 0,00 deg + beta



Pyfocus settings

☐ show x,y,z intensities

Field settings

Gaussian ▼ amplitude

- 2,00 mm + waist

$[-1/2*(\rho/\text{waist})^{**2}]$ A(rho, phi)

Uniform ▼ phase

constant $\theta(\rho, \phi)$

- 0,89 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear ▼ polarization

- 0,00 deg + gamma

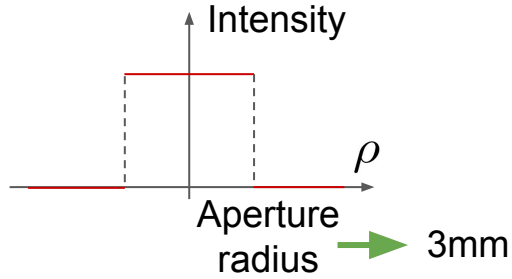
- 0,00 deg + beta

Energy of
custom field

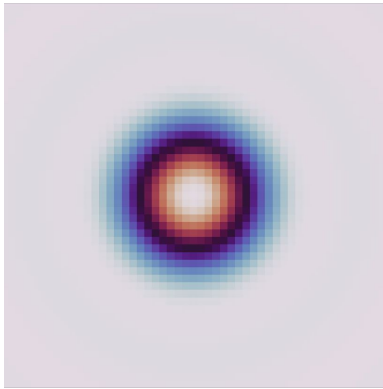
Energy of
uniform field

Vectorial simulation: Gaussian amplitude

Uniform



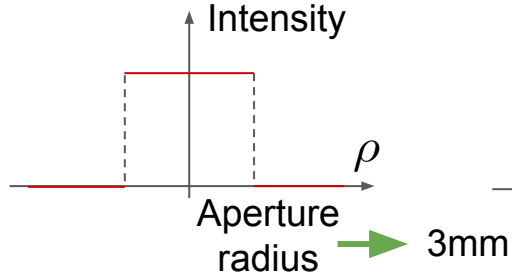
Incident energy factor: 1



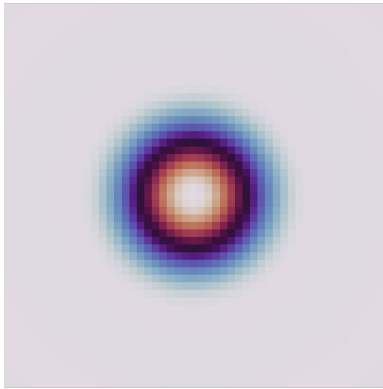
Intensity at the center:
22.6 kW/nm²

Vectorial simulation: Gaussian amplitude

Uniform

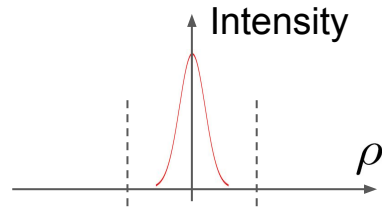


Incident energy factor: 1

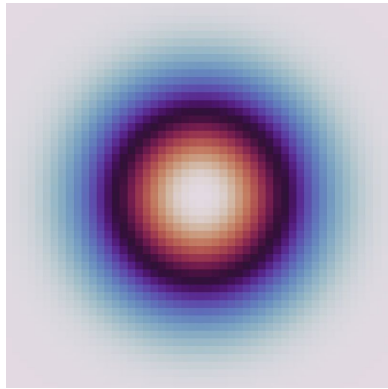


Intensity at the center:
22.6 kW/nm²

Waist: 1mm



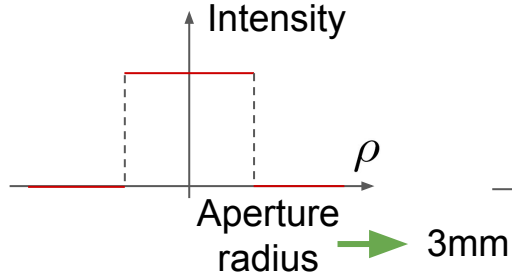
Incident energy factor: 1



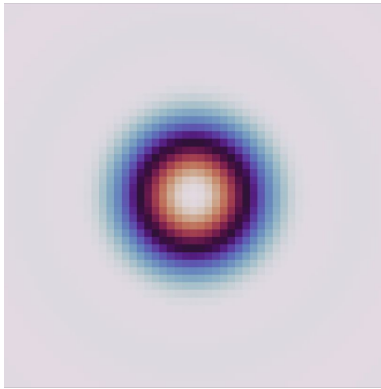
Intensity at the center:
9.01 kW/nm²

Vectorial simulation: Gaussian amplitude

Uniform

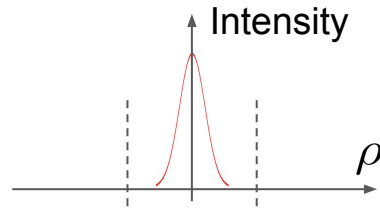


Incident energy factor: 1

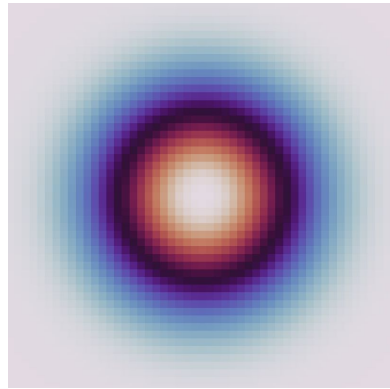


Intensity at the center:
22.6 kW/nm²

Waist: 1mm

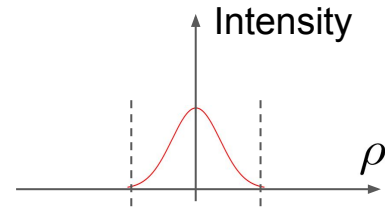


Incident energy factor: 1

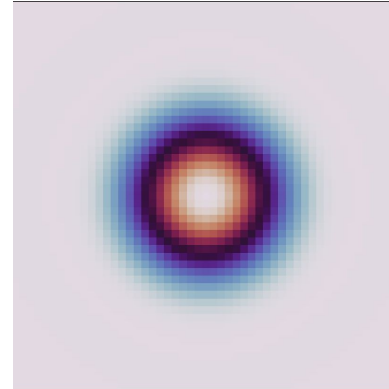


Intensity at the center:
9.01 kW/nm²

Waist: 2mm



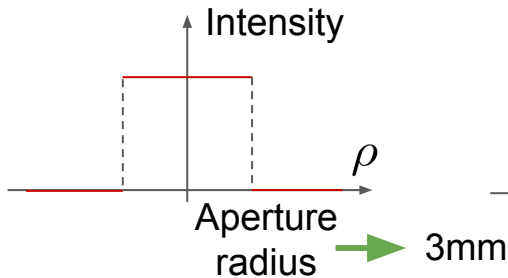
Incident energy factor: 0.89



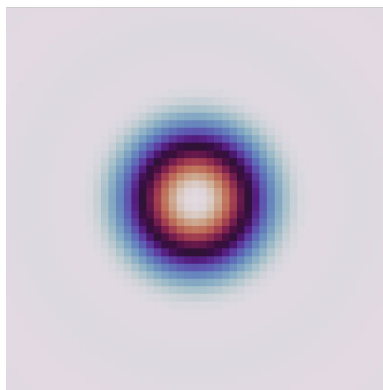
Intensity at the center:
16.8 kW/nm²

Vectorial simulation: Gaussian amplitude

Uniform

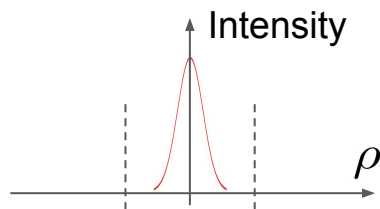


Incident energy factor: 1

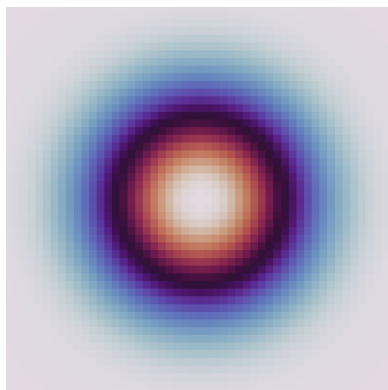


Intensity at the center:
22.6 kW/nm²

Waist: 1mm

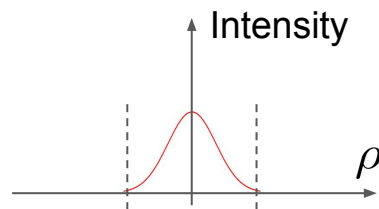


Incident energy factor: 1

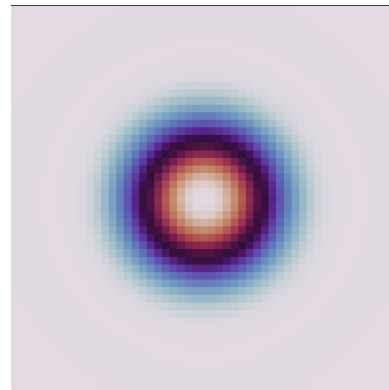


Intensity at the center:
9.01 kW/nm²

Waist: 2mm

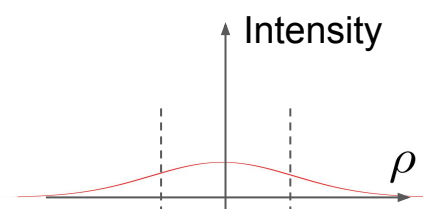


Incident energy factor: 0.89

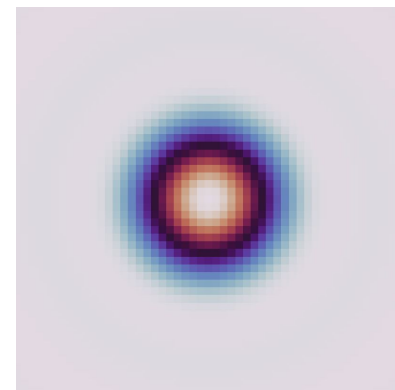


Intensity at the center:
16.8 kW/nm²

Waist: 10mm



Incident energy factor: 0.09



Intensity at the center:
1.92 kW/nm²

Vectorial simulation: Intensity contrast

Change contrast

reference layer

I_vectorial_NA_

min

—

0,02

+

max

—

22,60

+

☒ propagate to all images

Set contrast

Vectorial simulation: Intensity contrast

Change contrast

reference layer

I_vectorial_NA_

min

—

0,02

+

max

—

22,60

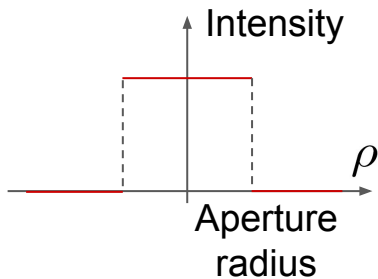
+

☒ propagate to all images

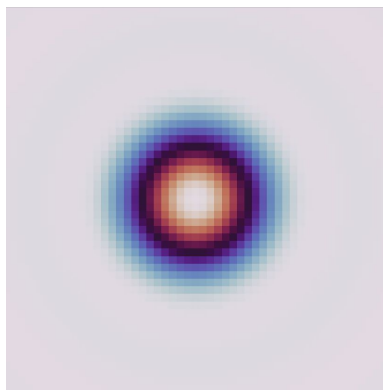
Set contrast

Vectorial simulation: Intensity contrast

Uniform

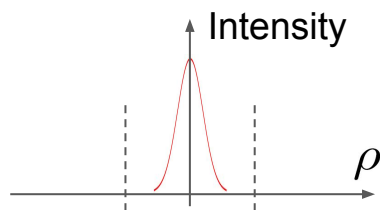


Incident energy factor: 1

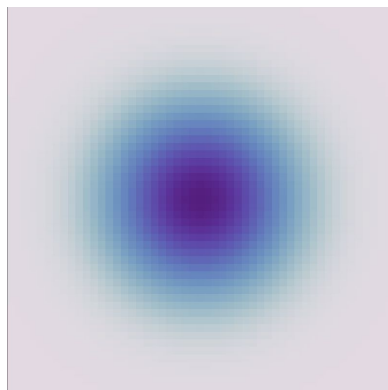


Intensity at the center:
22.6 kW/nm²

Waist: 1mm

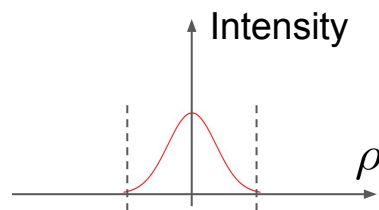


Incident energy factor: 1

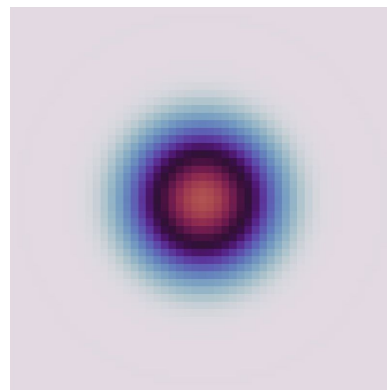


Intensity at the center:
9.01 kW/nm²

Waist: 2mm

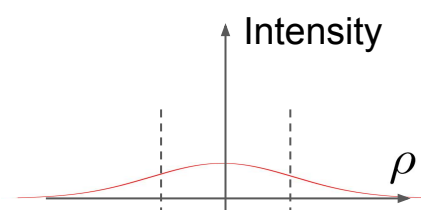


Incident energy factor: 0.89

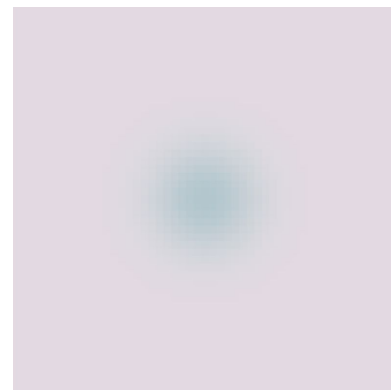


Intensity at the center:
16.8 kW/nm²

Waist: 10mm



Incident energy factor: 0.09



Intensity at the center:
1.92 kW/nm²

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 $\theta(\rho, \phi)$

0,09 Incident energy factor

☒ Normalize incident energy ratio to one

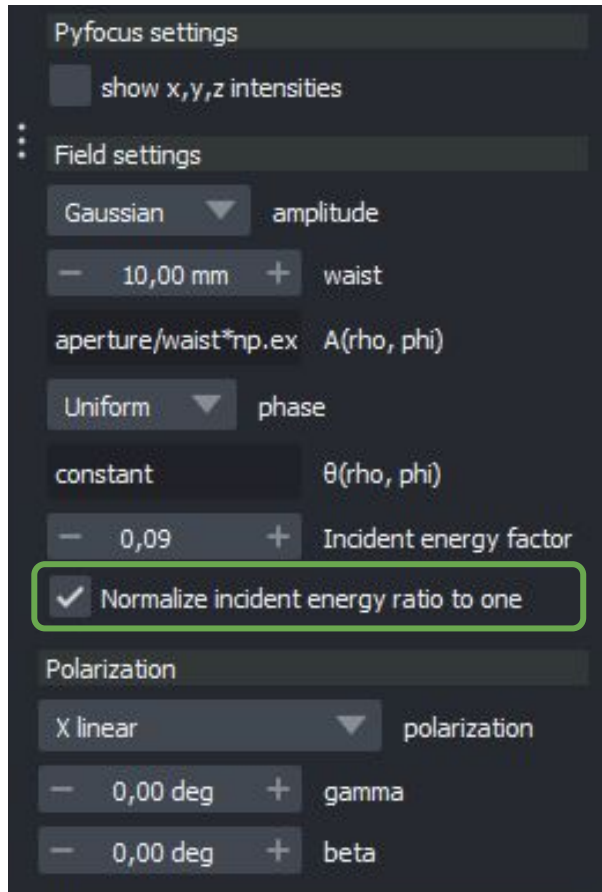
Polarization

X linear polarization

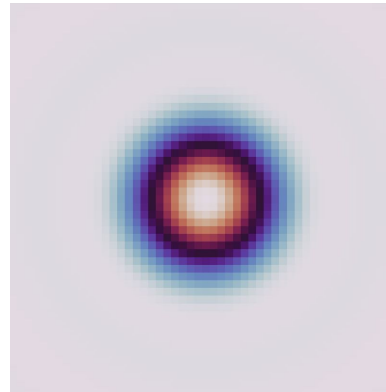
0,00 deg gamma

0,00 deg beta

Vectorial simulation: Incident energy ratio

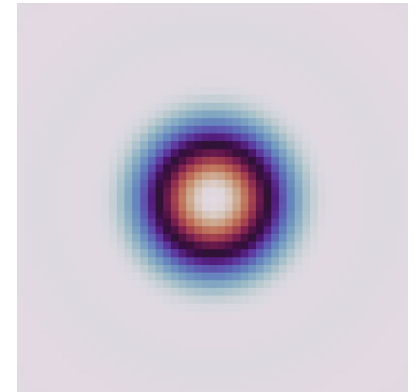


Gaussian amplitude with
10mm waist normalized



Intensity at the center:
22.5 kW/nm²

Uniform amplitude



Intensity at the center:
22.6 kW/nm²

Vectorial simulation: Phase settings

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 $A(\rho, \phi)$

Uniform ▼ phase

constant $\theta(\rho, \phi)$

— 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear ▼ polarization

— 0,00 deg + gamma

— 0,00 deg + beta



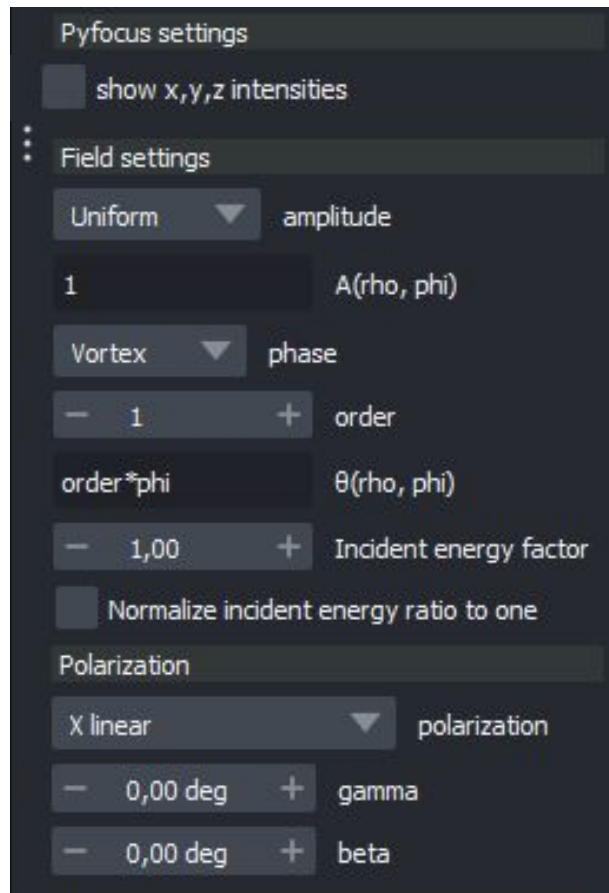
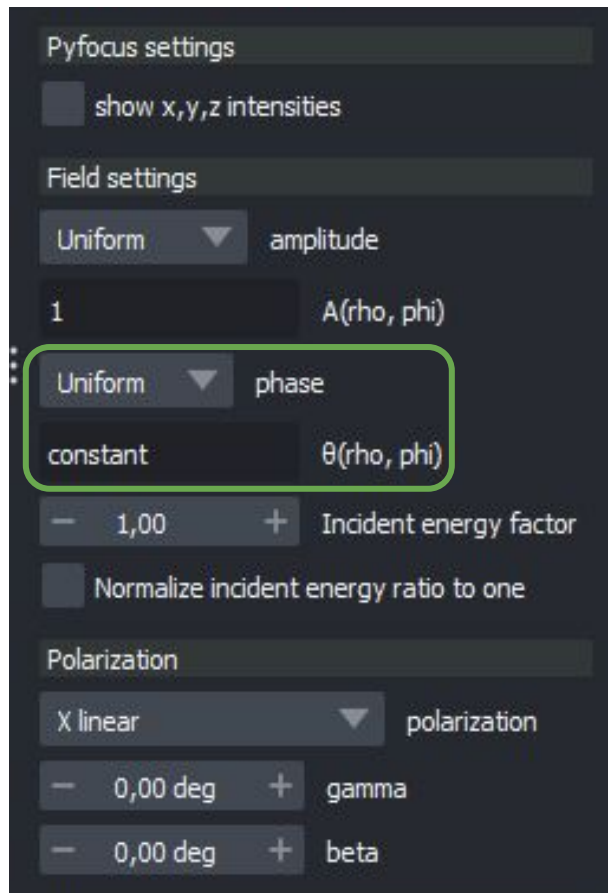
Uniform ▼

Uniform

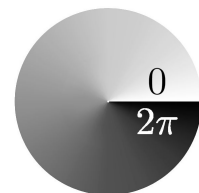
Vortex

Custom

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 $\theta(\text{rho}, \text{phi})$

— 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

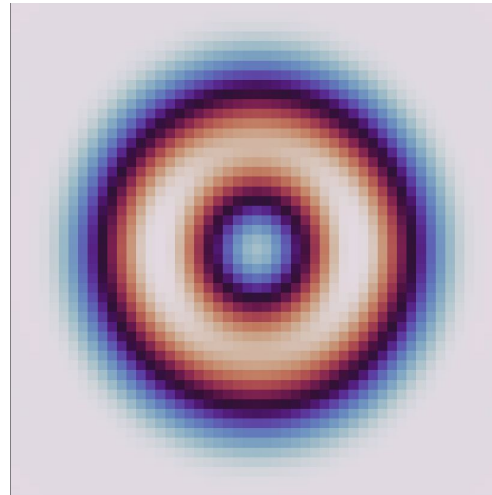
Polarization

X linear ▼ polarization

— 0,00 deg + gamma

— 0,00 deg + beta

Vortex phase with X linear polarization



Vectorial simulation: Polarization setting

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 $A(\rho, \phi)$

Vortex ▼ phase

— 1 + order

order* ϕ $\theta(\rho, \phi)$

— 1,00 + Incident energy factor

☐ Normalize incident energy ratio to one

Polarization

X linear ▼ polarization

— 0,00 deg + gamma

— 0,00 deg + beta



X linear ▼

X linear

Y linear

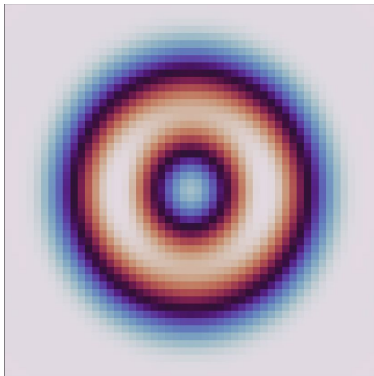
Right handed circular

Left handed circular

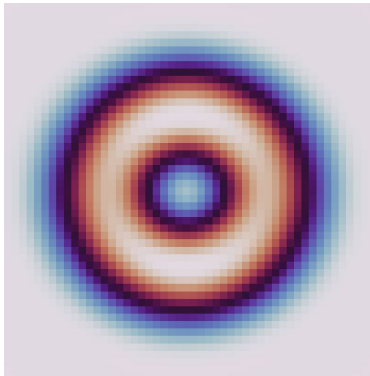
Custom

Vectorial simulation: Vortex phase for various polarizations

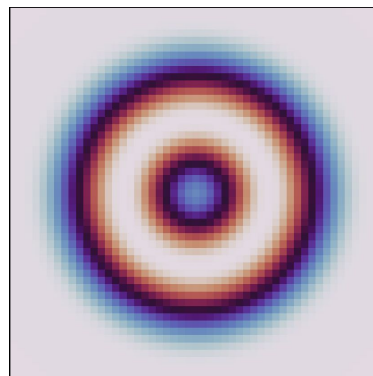
Y Linear



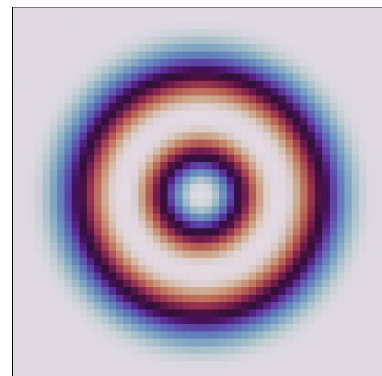
X Linear



Left Circular



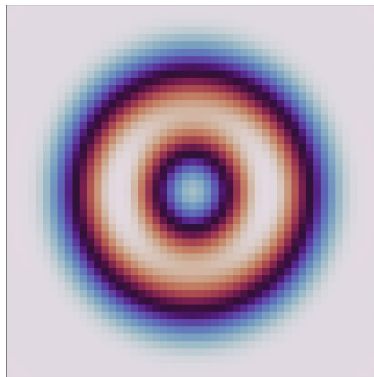
Right Circular



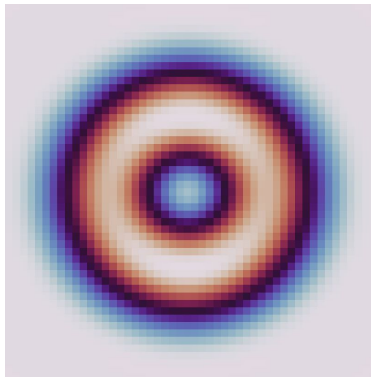
With
NA = 0.65
n = 1.3
FOVxy = 1.5 μ m

Vectorial simulation: Vortex phase for various polarizations

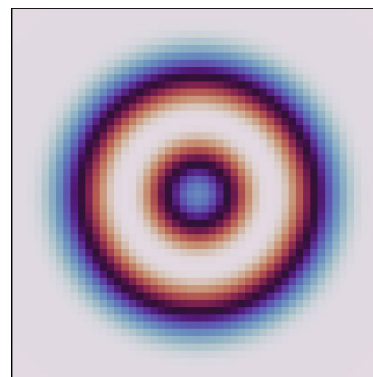
Y Linear



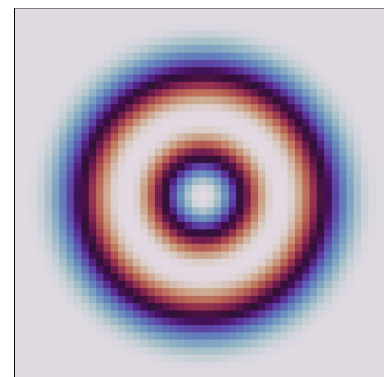
X Linear



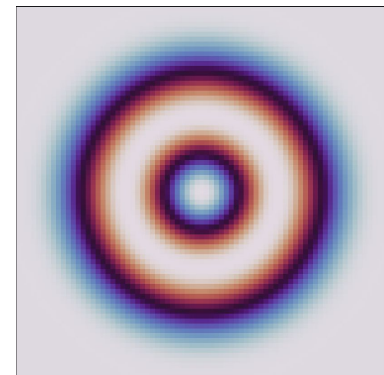
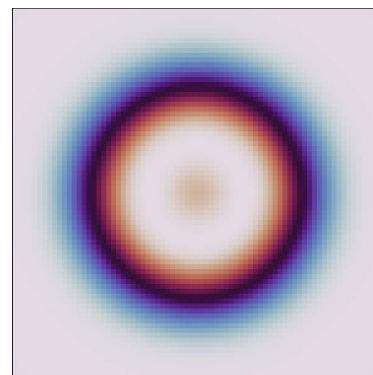
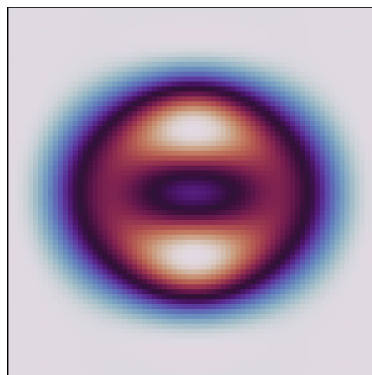
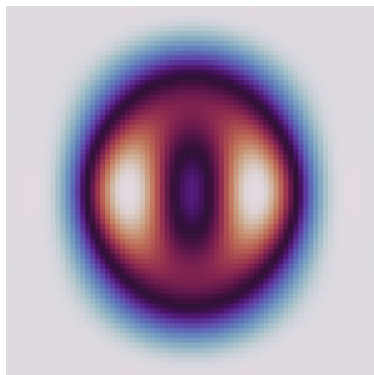
Left Circular



Right Circular



With
NA = 0.65
n = 1.3
FOVxy = 1.5 μ m



With
NA = 1.4
n = 1.5
FOVxy = 0.75 μ m

Vectorial simulation: Custom phase (amplitude)

Propagation model

Vectorial ▼ Model

Pyfocus settings

☐ show x,y,z intensities

Field settings

Uniform ▼ amplitude

1 A(rho, phi)

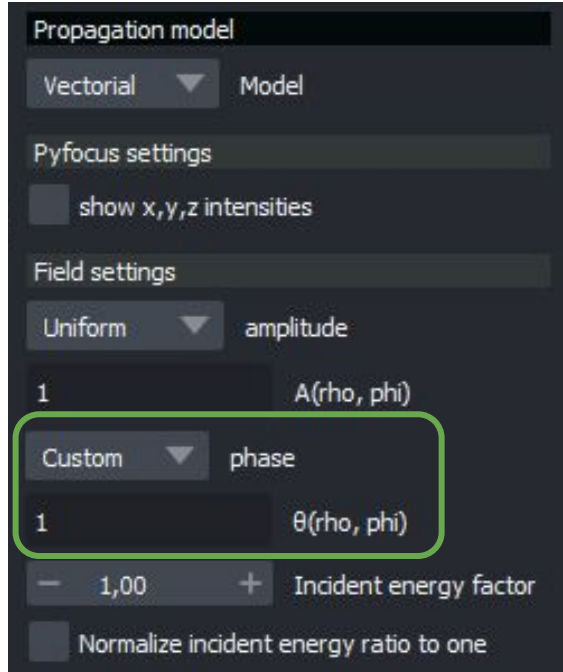
Custom ▼ phase

1 $\theta(\text{rho}, \text{phi})$

— 1,00 + Incident energy factor

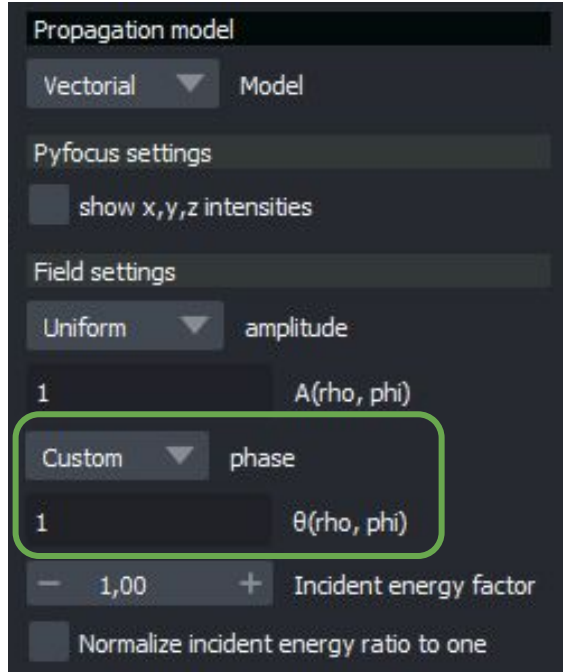
☐ Normalize incident energy ratio to one

Vectorial simulation: Custom phase (amplitude)



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

Vectorial simulation: Custom phase (amplitude)

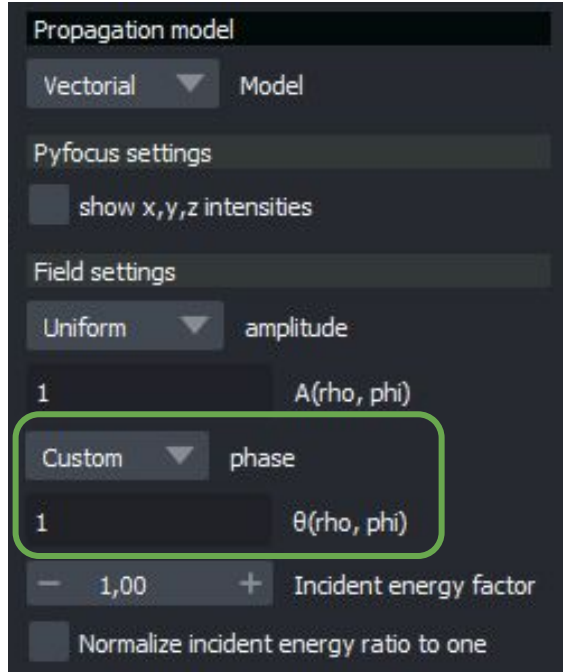


$$\frac{\text{rho}}{\text{lens radius}}$$

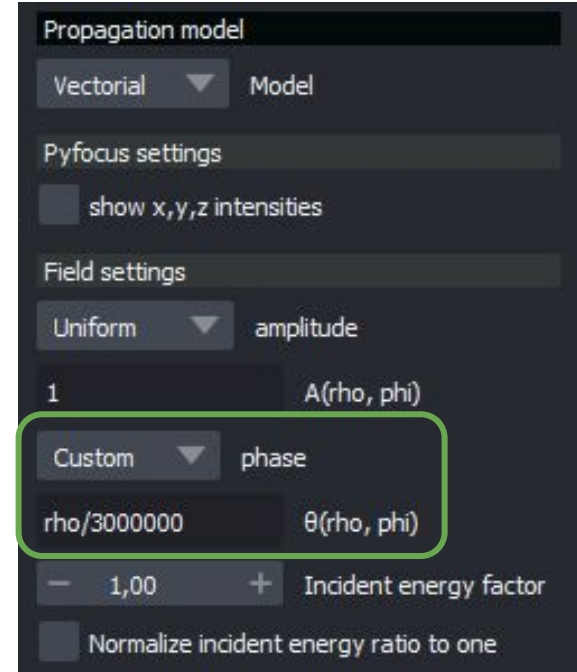
Units must be in nm

$$3\text{mm} = 3000000\text{nm}$$

Vectorial simulation: Custom phase (amplitude)



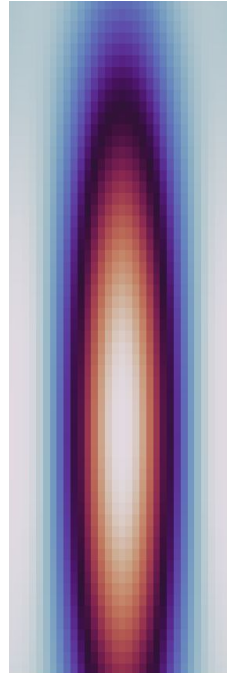
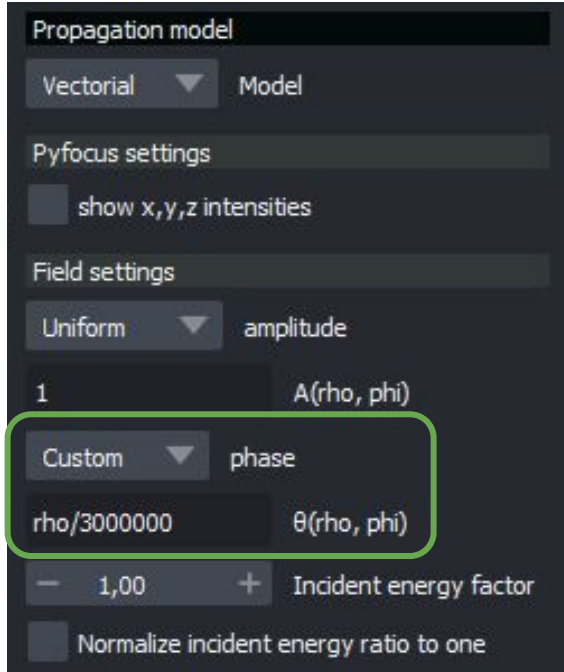
$\frac{\rho}{\text{lens radius}}$



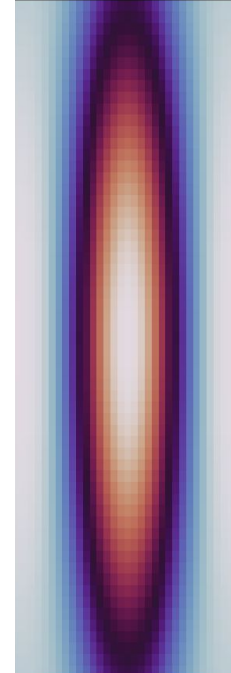
Units must be in nm

3mm = 3000000nm

Vectorial simulation: Custom phase (amplitude)



custom phase



uniform field

Aberrations

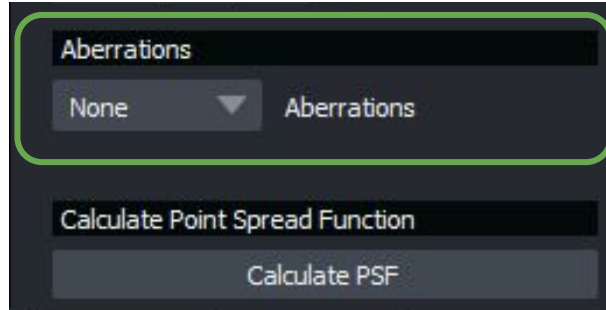
Aberrations

None ▼ Aberrations

Calculate Point Spread Function

Calculate PSF

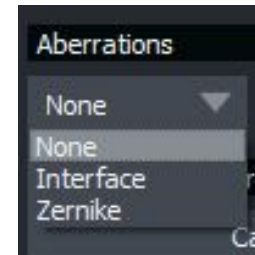
Aberrations



Scalar mode



Vectorial mode



Aberrations: Zernike

Uniform field

Aberrations

Zernike ▼ Aberrations

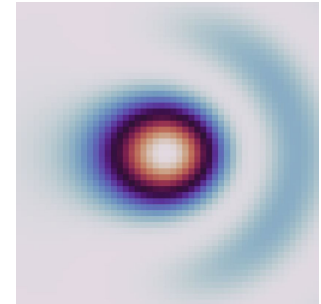
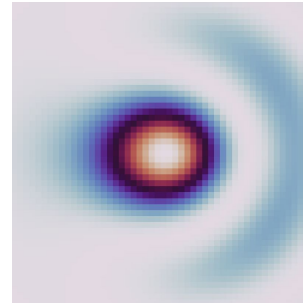
—	3	+	N
—	1	+	M
—	0,60 λ	+	weight

Aberrations: Zernike

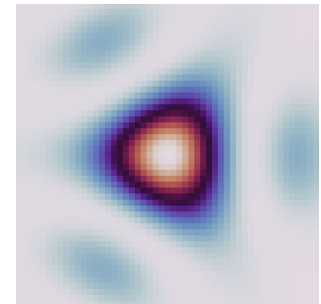
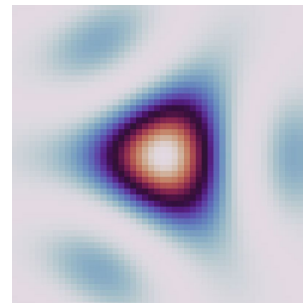
Uniform field

Scalar mode

Vectorial mode



$N = 3, M = 1,$
weight = 0.6



$N = 3, M = 3,$
weight = 0.6

Aberrations

Zernike ▾ Aberrations

— 3 +

N

— 1 +

M

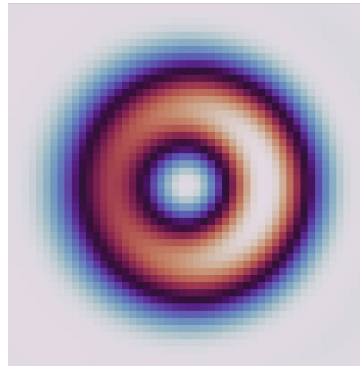
— 0,60 λ +

weight

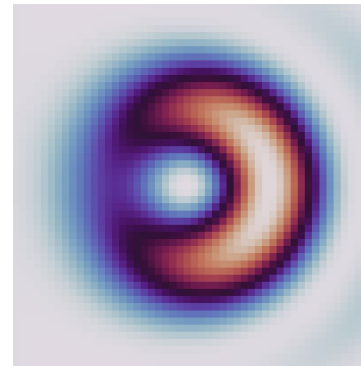
Aberrations: Zernike

Vortex phase with right handed circular polarization

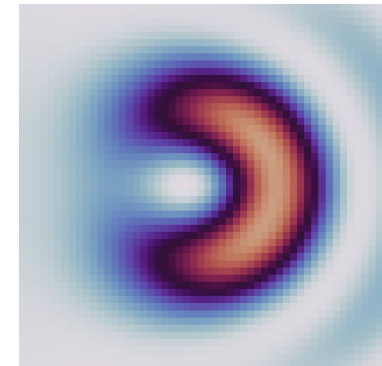
$N = 3, M = 1,$
weight = 0.15



$N = 3, M = 1,$
weight = 0.4



$N = 3, M = 1,$
weight = 0.6

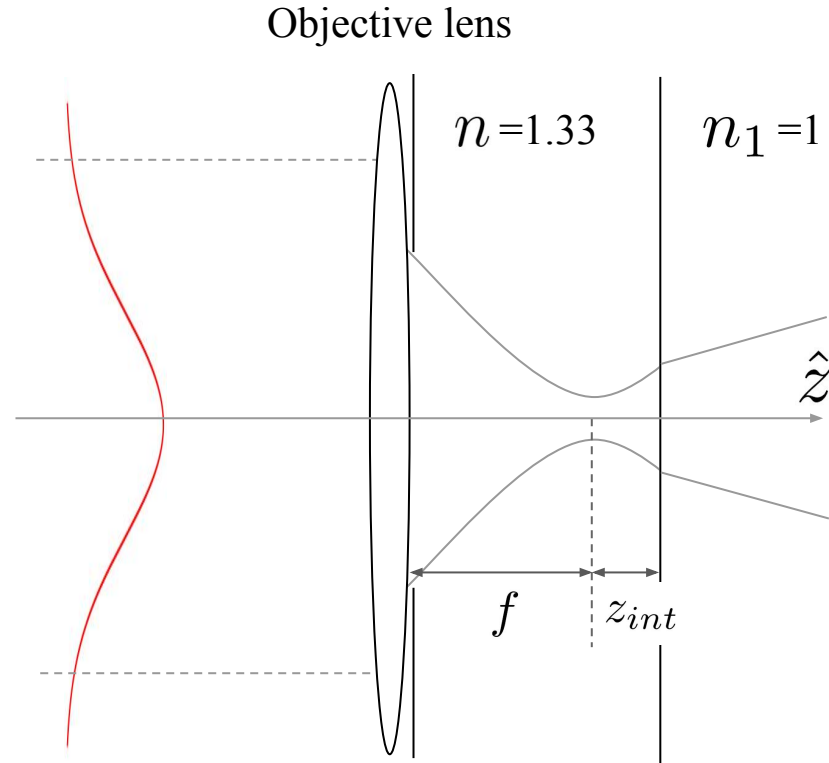
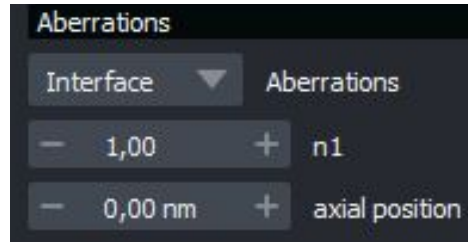


Aberrations

Zernike ▾ Aberrations

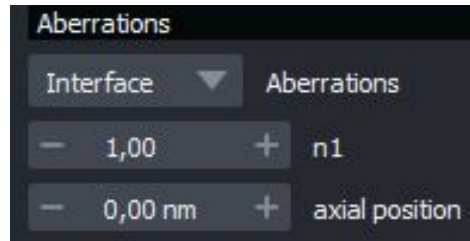
-	3	+	N
-	1	+	M
-	0,60 λ	+	weight

Aberrations: Vectorial simulation Interface

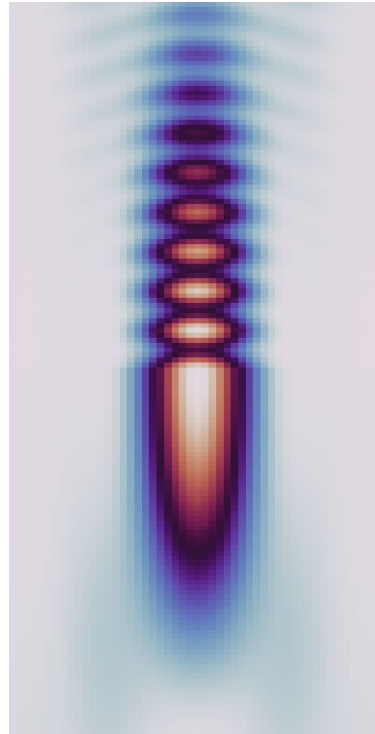


Aberrations: Vectorial simulation

Interface, uniform field



\hat{z}



Now, lets see it in action!