

Microscopy System with Structured Illumination

Abstract

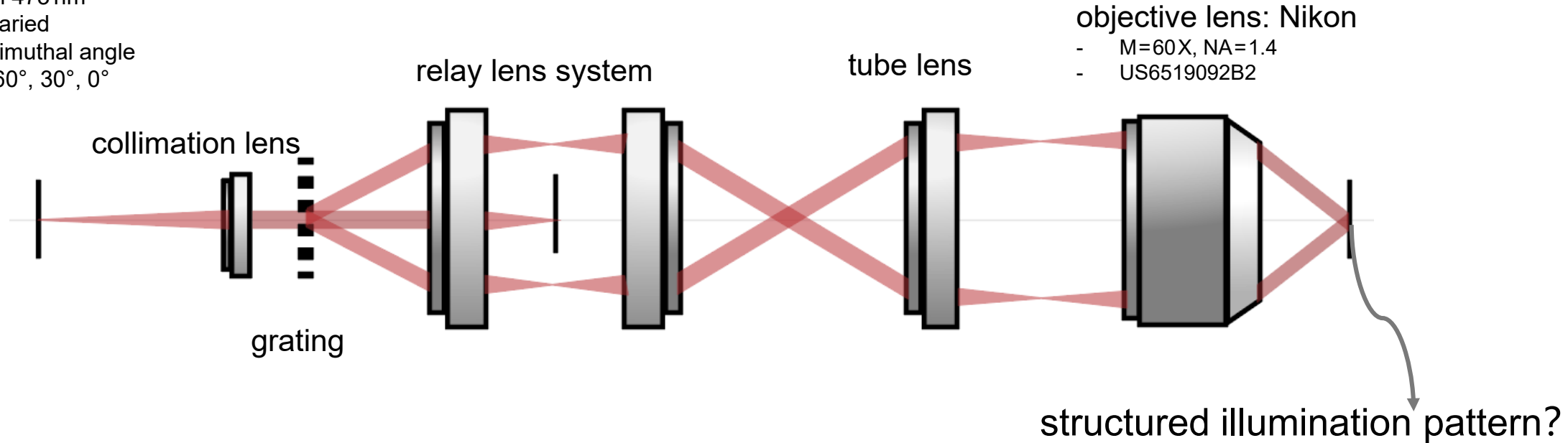
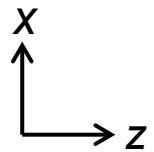


The microscopy system with structured illumination for fluorescent samples can improve the resolution of the microscopy system by a factor of 2 compared with the resolution predicted by Abbe theory. VirtualLab Fusion provides a fast way to investigate the structured illumination pattern by the incident wave property. The polarization of the incident wave and its influence on the contrast of the structured illumination pattern is investigated.

Scenario

input plane wave

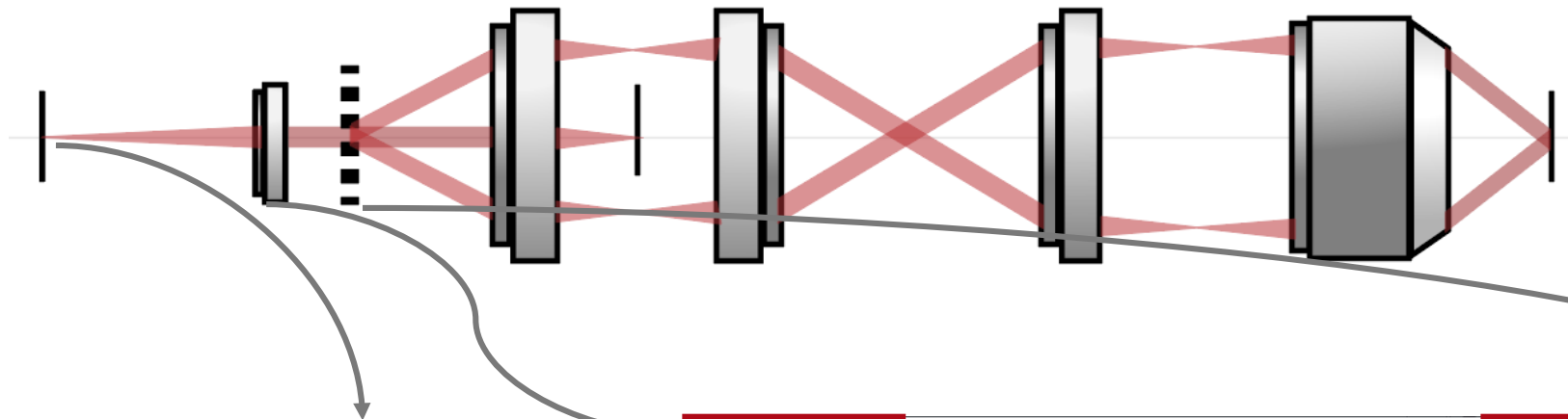
- wavelength 473 nm
- linearly polarized with the azimuthal angle $\phi = 90^\circ, 60^\circ, 30^\circ, 0^\circ$



How is the contrast of the structured illumination influenced by the polarizations of the incident beam?

Building the System in VirtualLab Fusion

System Building Blocks



Edit Gaussian Wave

Polarization | Mode Selection | Sampling | Ray Selection

Basic Parameters | Spectral Parameters | Spatial Parameters

Medium at Source Plane
Air in Homogeneous Medium

Load | Edit | View

Source Field: Longitudinal and Lateral Offset

Distance to Input Plane: 0 mm

Lateral Offset: 0 mm

Edit Lens System Component

Coordinate Systems | Position / Orientation | **Structure** | Solver | Channel Configuration

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Plane Interface	Air in Homogeneous Me	Enter your com
2	0 mm	0 mm	Conical Interface	S-BSM14_OHARA in Ho	Zemax Interface
3	9 mm	9 mm	Conical Interface	S-TIH53_OHARA in Hon	Zemax Interface
4	2.5 mm	11.5 mm	Conical Interface	Abbe Number V_d Mater	Zemax Interface
5	80 μm	11.58 mm	Aspherical Interface	Air in Homogeneous Me	Zemax Interface

Edit Grating Component

Coordinate Systems | Position / Orientation | **Structure** | Solver | Channel Configuration

Component Size: 20 mm x 20 mm

Reference Surface (all Channels)
Plane Surface

Load | Edit | View

Aperture: Yes No

Grating Stack
 1D-Periodic (Lamellar) 2D-Periodic

Grating Period: 28 μm

Rectangular Grating | Load | Edit | View

On Front Side of Reference Surface On Back Side of Reference Surface

Homogeneous Medium Behind Surface
Air in Homogeneous Medium

Load | Edit | View

System Building Blocks

Edit Lens System Component

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	N-LAK22_SCHOTT in H	Zemax Interface
2	4 mm	4 mm	Conical Interface	SF10_SCHOTT in Homc	Zemax Interface
3	4 mm	8 mm	Conical Interface	Air in Homogeneous Mex	Zemax Interface

Edit Lens System Component

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	FD60-W_HOYA in Homc	Zemax Interf
2	3 mm	3 mm	Conical Interface	S-LAH63_OHARA in Hoi	Zemax Interf
3	2.6 mm	5.6 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
4	3.4 mm	9 mm	Conical Interface	S-LAH63_OHARA in Hoi	Zemax Interf
5	5 mm	14 mm	Conical Interface	GFK70_SUMITA in Hom	Zemax Interf
6	5.2 mm	19.2 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
7	150 μ m	19.35 mm	Conical Interface	Non-Dispersive Material	Zemax Interf
8	1000 μ m	20.35 mm	Conical Interface	LITHOTEC-CAF2_SCHC	Zemax Interf
9	6.3 mm	26.65 mm	Conical Interface	J-KZFH1_HIKARI in Hor	Zemax Interf
10	1.6 mm	28.25 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf
11	100 μ m	28.35 mm	Conical Interface	LITHOTEC-CAF2_SCHC	Zemax Interf
12	8 mm	36.35 mm	Conical Interface	J-KZFH1_HIKARI in Hor	Zemax Interf
13	1.1 mm	37.45 mm	Conical Interface	Air (Zemax) in Homogen	Zemax Interf

Edit Camera Detector

Detector Parameters

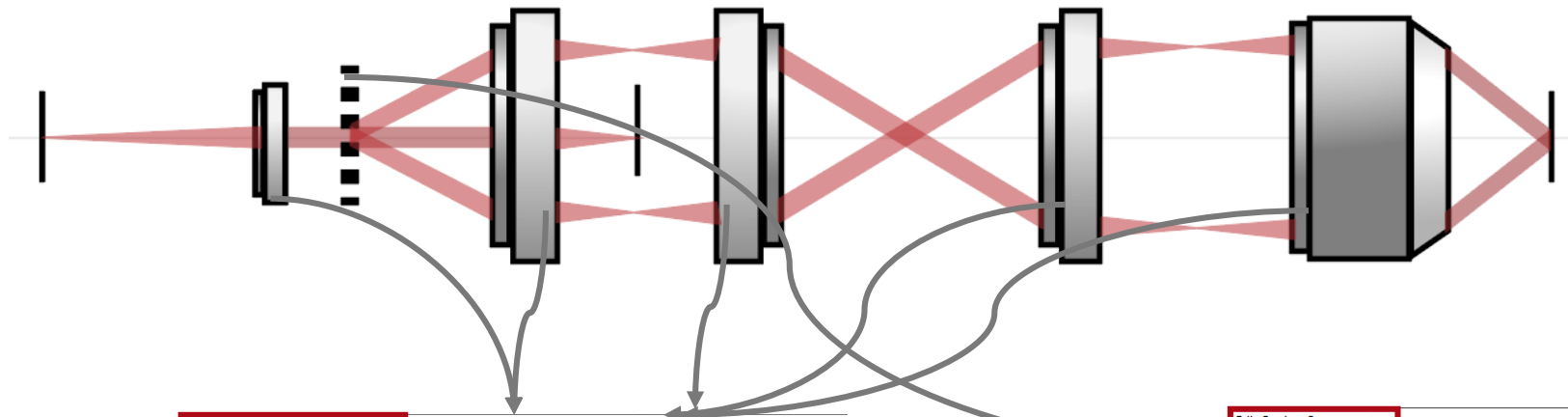
Detector Window and Resolution: Detector Function

Coherence Parameters
Summation Type: Coherent Summation

Components to Integrate
 Ex-Component
 Ey-Component
 Ez-Component

View Settings of Result
 Real Color
 False Color
 Midnight Sun

Solvers for Components



Edit Lens System Component

Solver | Sampling

Component Solver: **Local Plane Interface Approximation (LPIA)** [Edit]

The LPIA solver works in the spatial domain (**x domain**), locally, in a pointwise manner. The solver follows that

1. the input field on the surface is treated as a composition of local plane waves (LPWs),
2. the part of the surface seen by each LPW is considered a plane interface (locally), and,
3. the interaction of the LPW with the local plane interface can be modeled by the Fresnel (or the layer) matrix.

At an arbitrary location on the curved surface, an approximate local boundary condition is applied, which assumes the interaction of the LPW with the local plane interface. Thus, the Fresnel matrix (or layer matrix for coatings) can be used to connect input and output fields [Learn more about this solver](#).

input LPW output LPW

front behind

Edit Grating Component

Solver | Sampling

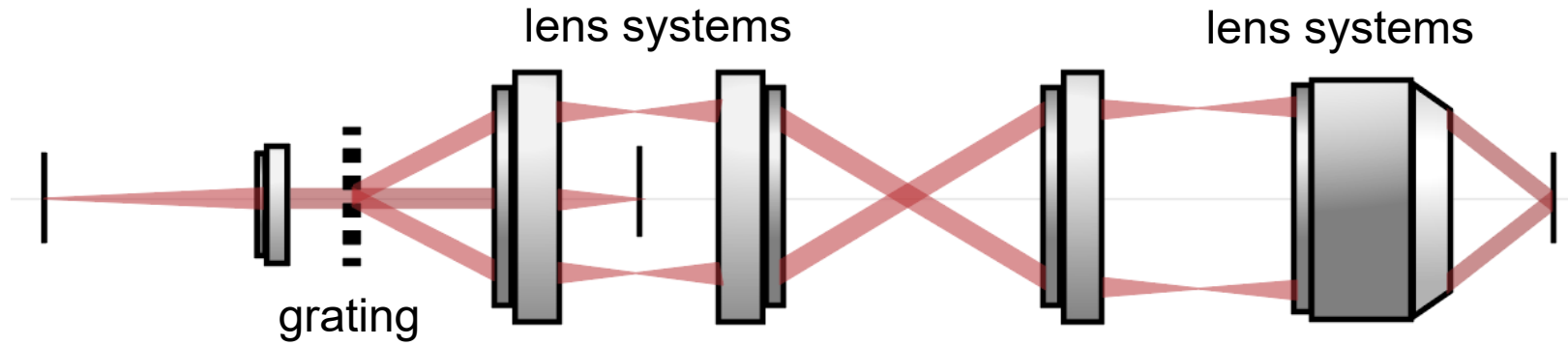
Component Solver: **FMM/RCWA [S-Matrix]** [Edit]

The FMM / RCWA solver works in the spatial frequency domain (**k-domain**). It consists of

1. an eigenmode solver for each periodically modulated layer and
2. an S-matrix for matching the boundary conditions between the layers.

The eigenmode solver computes the field solution in the k domain for the periodically modulated medium in each layer. The S-matrix algorithm calculates the response of the whole layer system by matching the boundary conditions in a recursive manner. It is well-known for its unconditional numerical stability since, unlike the traditional transfer matrix, it avoids the exponentially growing functions in the calculation steps. [Learn more about this solver](#).

Summary

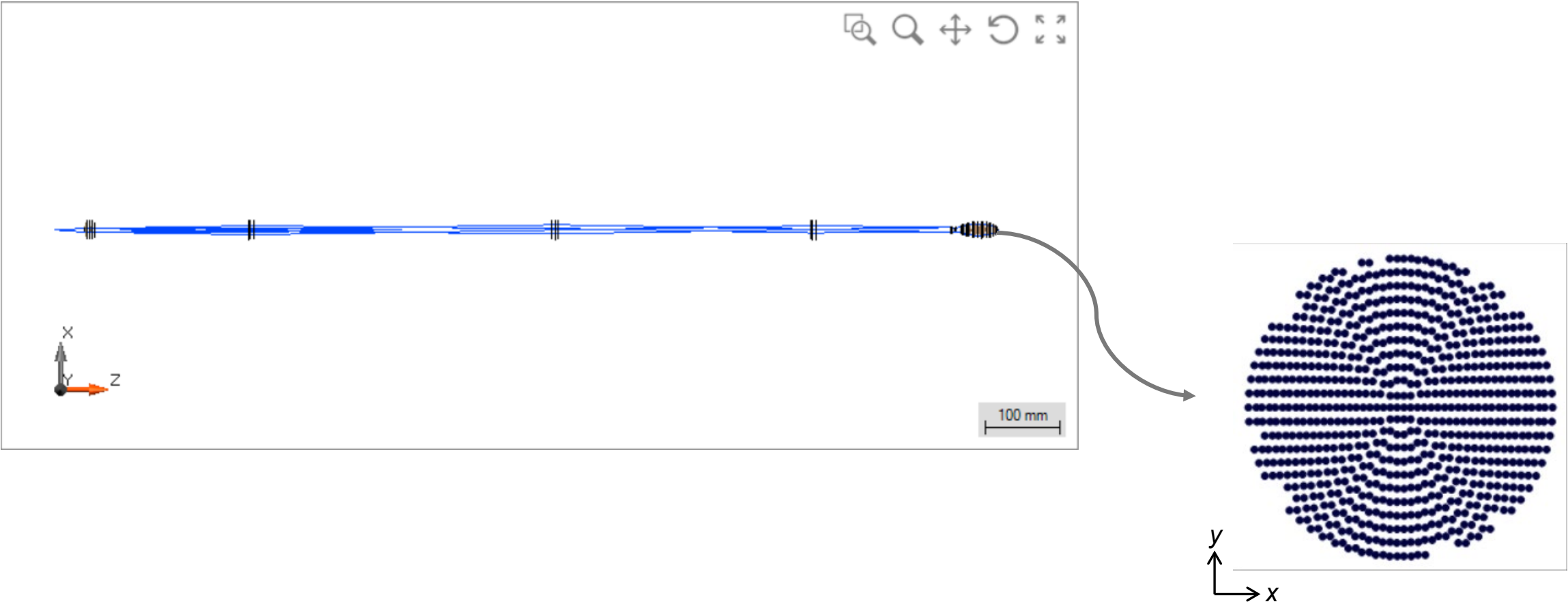


Components	Solvers
lens systems	Local Plane Interface Approximation (LPIA)
grating	Fourier Modal Method (FMM)

Geometric-Optics Simulations

by Ray Tracing

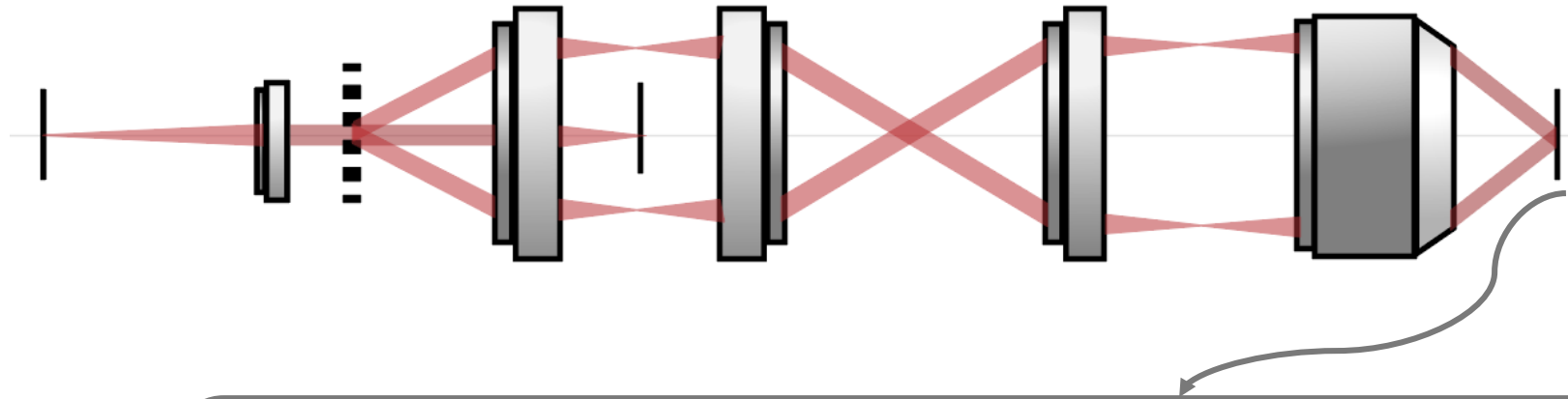
Results: Ray Tracing



Fast Physical-Optics Simulations

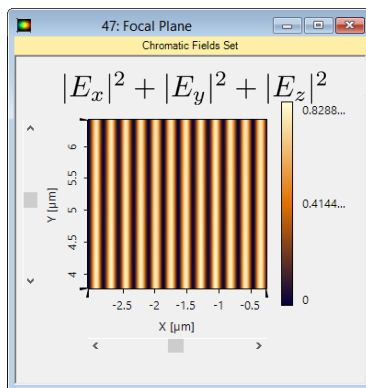
by Field Tracing

Structured Illumination Pattern at Focal Plane

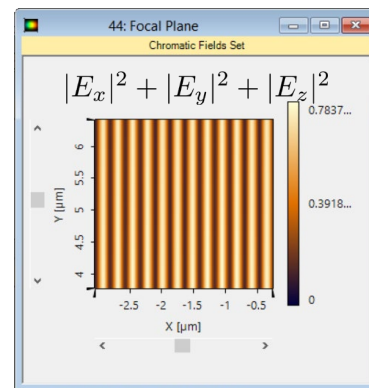


Contrast is decreasing as the azimuthal angle decreases.

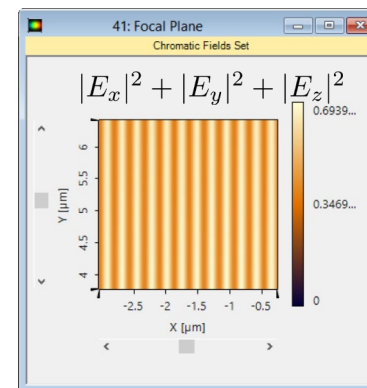
$\phi = 90^\circ$



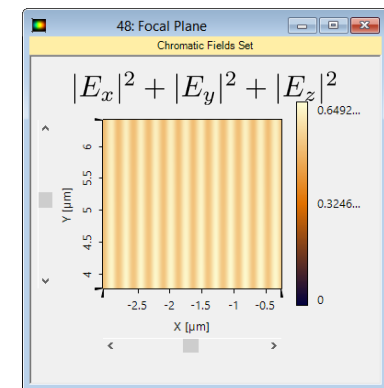
$\phi = 60^\circ$



$\phi = 30^\circ$



$\phi = 0^\circ$



Document Information

title	Microscopy System with Structured Illumination
document code	MIC.0015
version	1.0
edition	VirtualLab Fusion Basic
software version	2020.2 (Build 1.116)
category	Application Use Case
further reading	<ul style="list-style-type: none">- <u>Debye-Wolf Integral Calculator</u>- <u>Analyzing High-NA Objective Lens</u>- <u>Resolution Investigation for Microscope Objective Lenses by Rayleigh Criterion</u>