

Resolution Investigation of a Microscopy System by Abbe Criterion

Abstract

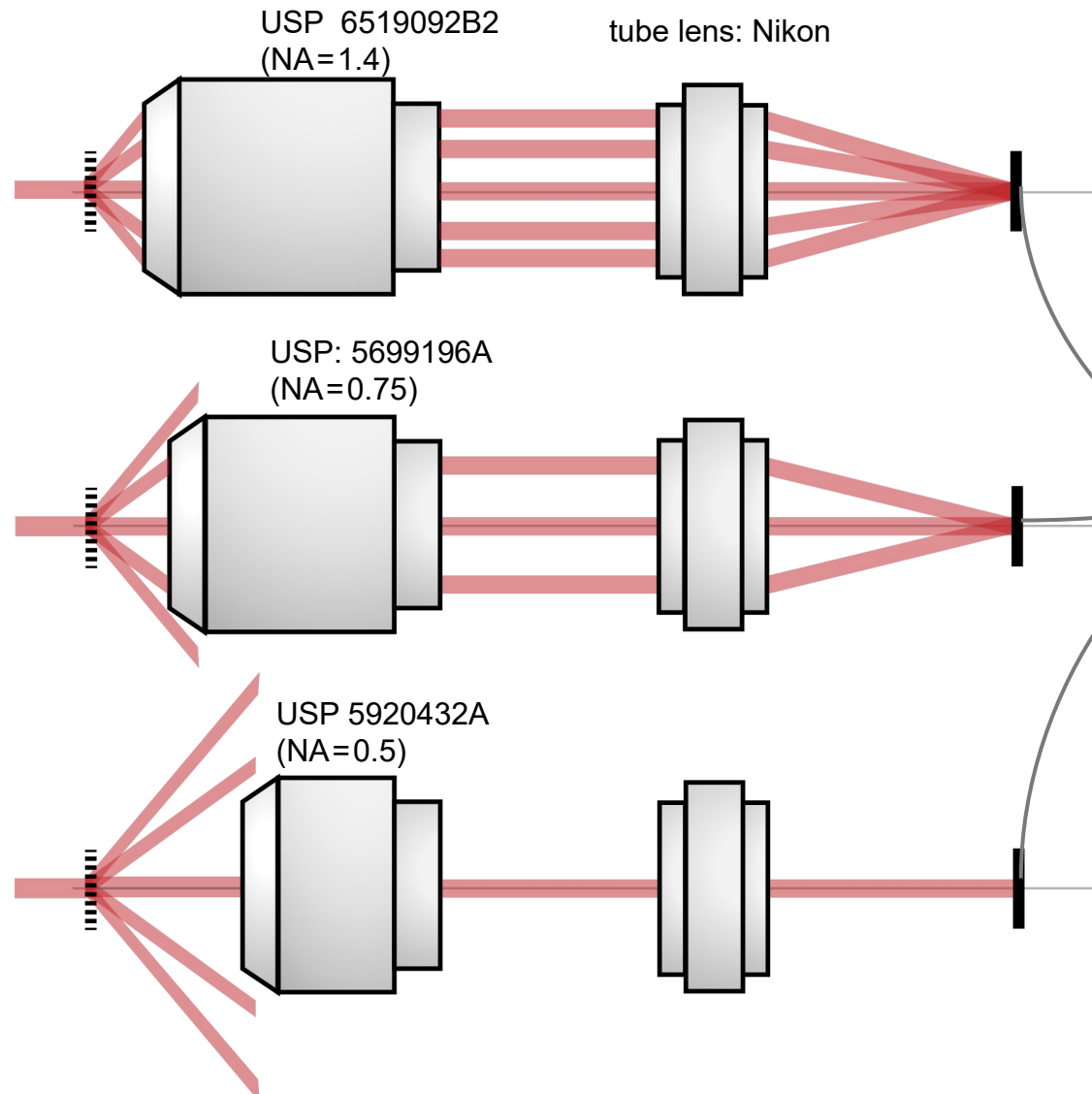
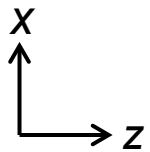


The resolution of a microscopy system is often characterized by Abbe criterion. It explained that the filtering of the grating (as a sample) diffraction orders in the back focal plane depends on the numerical aperture (NA) of the objective lens. When the higher diffraction orders are filtered out, the interference at the image plane does not happen, which leads to no image. This use case demonstrates how the NA influences the filtering effect and the resolution.

Scenario

input plane wave
- wavelength 532 nm
- linearly polarized along y direction

grating period
- 800 nm



image?
How are the images of the grating, defined by the interference patterns, influenced the different NAs of the objective lenses?

Building the System in VirtualLab Fusion

System Building Blocks

The diagram illustrates the system building blocks for an optical system. The main diagram shows a light source (Plane Wave) passing through a 1D Periodic Grating, then through a Lens System Component, and finally being detected by a Camera Detector. The building blocks are detailed in the following panels:

Edit Plane Wave

Basic Parameters

Medium at Source Plane
Air (Zemax OS) in Homogeneous Medium

Source Field: Longitudinal and Lateral Offset
Distance to Input Plane
Lateral Offset: 0 mm

Input Field: Position, Size and Shape

Automatic Setting
 Manual Setting Apply Lateral Offset of Source Field

Edit 1D Periodic Grating: Functional Modeling Component

Parameters

Grating Period
Selected Order And Ideal Efficiencies Tr
Selected Order And Ideal Efficiencies Re
Material Behind: "Abbe Number V_d Mat

Edit Lens System Component

Index	Distance	Position	Type	Homog
1	0 mm	0 mm	Plane Interface	Index_c
2	150 μm	150 μm	Plane Interface	S-NSL3
3	650 μm	800 μm	Conical Interface	LASF38
4	3.6 mm	4.4 mm	Conical Interface	Air (Zem
5	100 μm	4.5 mm	Conical Interface	GFK70
6	3.75 mm	8.25 mm	Conical Interface	Air (Zem
7	100 μm	8.35 mm	Conical Interface	J-F5_H
8	1 mm	9.35 mm	Conical Interface	GFK70
9	6.8 mm	16.15 mm	Conical Interface	Air (Zem
10	150 μm	16.3 mm	Conical Interface	J-KZFH
11	1 mm	17.3 mm	Conical Interface	LITHO1
12	9.4 mm	26.7 mm	Conical Interface	Air (Zem
13	150 μm	26.85 mm	Conical Interface	LK7FL

Edit Camera Detector

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

System Building Blocks

The diagram illustrates the system building blocks and their corresponding software interfaces. The main diagram shows a light path starting from a plane wave source, passing through a 1D periodic grating, then through a lens system, and finally being captured by a camera detector. Three software windows are shown, each linked to a component in the diagram:

- Edit Plane Wave:** Shows parameters for the source field, including polarization, mode selection, and medium at the source plane.
- Edit 1D Periodic Grating: Functional Modeling Component:** Shows parameters for the grating, such as grating period and material behind.
- Edit Lens System Component:** Shows a detailed view of the lens system with a table of interface parameters.

The **Edit Lens System Component** window displays the following table:

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Plane Interface	Index_c	
2	168.95 μm	168.95 μm	Plane Interface	Air (Zemax)	
3	1.2414 mm	1.4104 mm	Conical Interface	Index_c	
4	9.193 mm	10.603 mm	Conical Interface	Air (Zemax)	
5	99.384 μm	10.703 mm	Conical Interface	Index_c	
6	5.5158 mm	16.219 mm	Conical Interface	Air (Zemax)	
7	993.84 μm	17.212 mm	Conical Interface	Index_c	
8	3.6772 mm	20.89 mm	Conical Interface	Air (Zemax)	
9	198.77 μm	21.088 mm	Conical Interface	Index_c	
10	1.1926 mm	22.281 mm	Conical Interface	Index_c	
11	7.3544 mm	29.635 mm	Conical Interface	Air (Zemax)	
12	198.77 μm	29.834 mm	Conical Interface	Index_c	
13	1.6895 mm	31.524 mm	Conical Interface	Index_c	

System Building Blocks

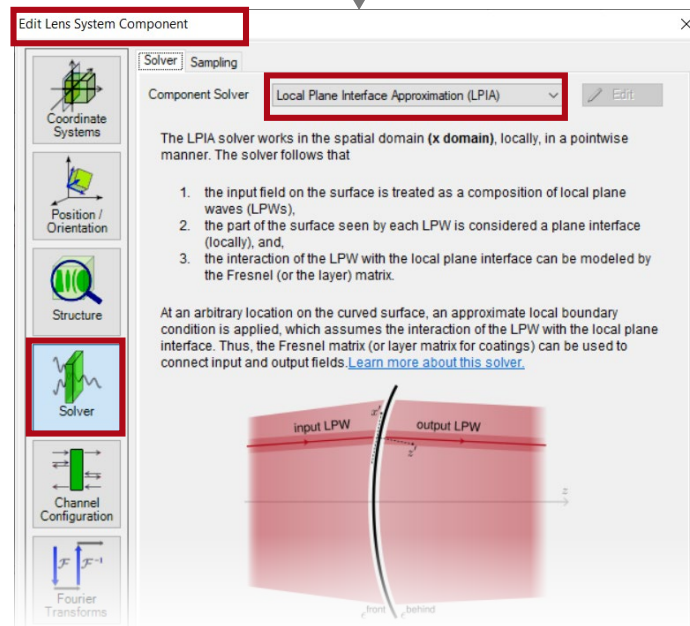
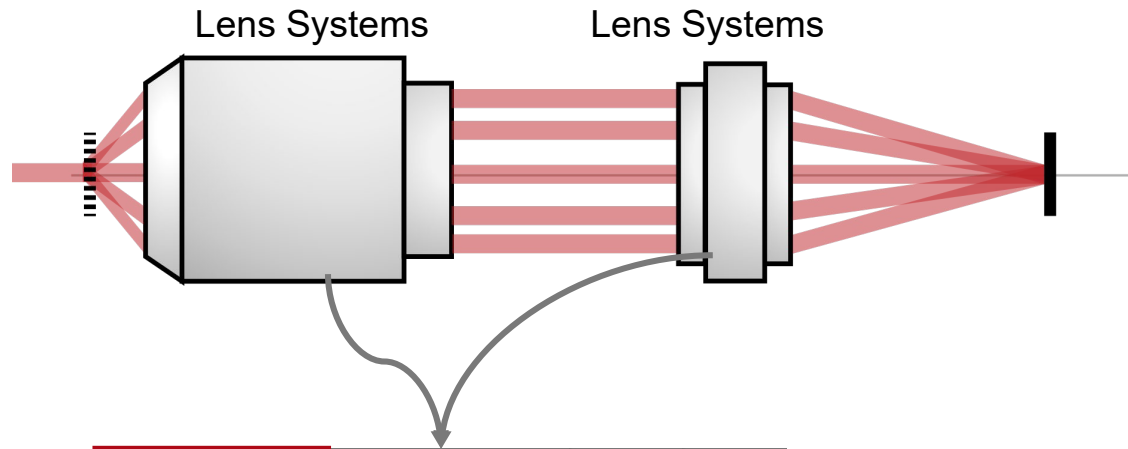
The diagram illustrates the building blocks of an optical system. A light source (plane wave) passes through a 1D periodic grating, then through a lens system, and is finally captured by a camera detector. Each component is linked to a specific configuration window:

- Edit Plane Wave:** Shows polarization and mode selection options.
- Edit 1D Periodic Grating: Functional Modeling Component:** Shows grating parameters like period and material.
- Edit Lens System Component:** Shows a table of lens parameters.
- Edit Camera Detector:** Shows detector window and resolution settings.

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	Index_d	
2	1.2383 mm	1.2383 mm	Conical Interface	Index_d	
3	4.4577 mm	5.696 mm	Conical Interface	Air (Zem	
4	643.89 μm	6.3399 mm	Conical Interface	Index_d	
5	1.4364 mm	7.7763 mm	Conical Interface	Air (Zem	
6	941.08 μm	8.7173 mm	Conical Interface	Index_d	
7	495.3 μm	9.2126 mm	Conical Interface	Index_d	
8	1.8822 mm	11.095 mm	Conical Interface	Air (Zem	
9	10.401 mm	21.496 mm	Plane Interface	Air (Zem	
10	4.1605 mm	25.657 mm	Conical Interface	Index_d	
11	594.36 μm	26.251 mm	Conical Interface	Index_d	
12	1.2383 mm	27.489 mm	Conical Interface	Index_d	
13	9223 μm	30.412 mm	Conical Interface	Air (Zem	

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Conical Interface	E-SK10_HIKARI in Homc	Zemax Interface
2	5.1 mm	5.1 mm	Conical Interface	J-LAF7_HIKARI in Homc	Zemax Interface
3	2 mm	7.1 mm	Conical Interface	Air (Zemax) in Homogon	Zemax Interface
4	7.5 mm	14.6 mm	Conical Interface	BASF6_SCHOTT in Hon	Zemax Interface
5	5.1 mm	19.7 mm	Conical Interface	KZFH1_HIKARI in Homc	Zemax Interface
6	1.8 mm	21.5 mm	Conical Interface	Air (Zemax) in Homogon	Zemax Interface

Solvers for Components



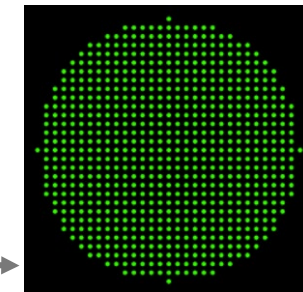
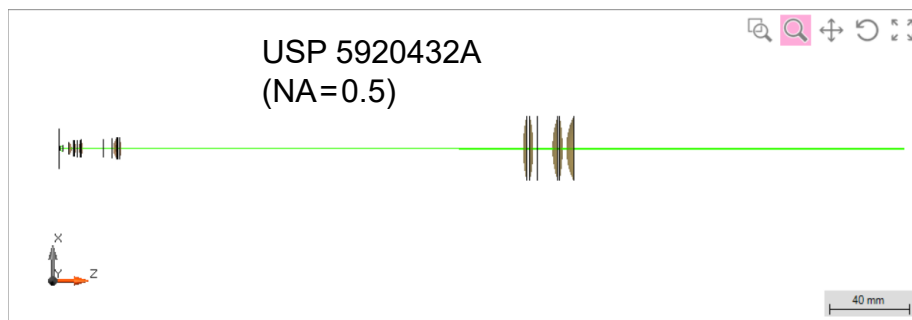
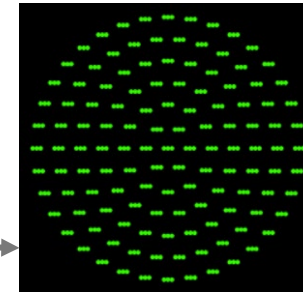
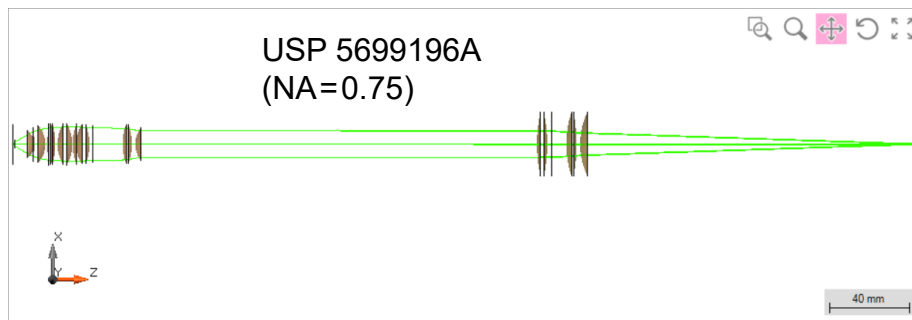
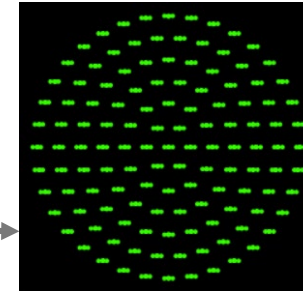
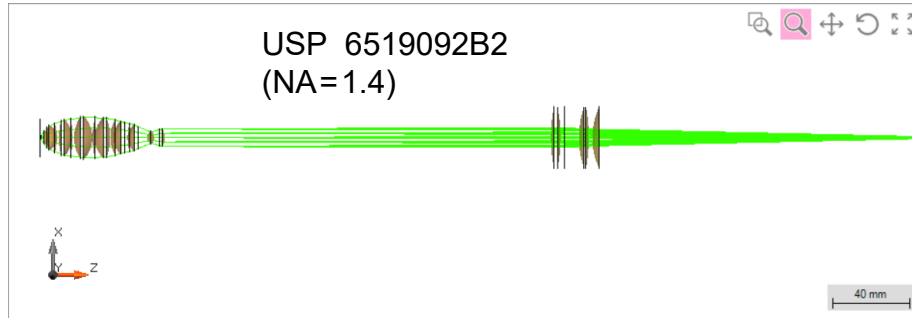
Components Solvers

Lens Systems	Local Plane Interface Approximation (LPIA)
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Geometric-Optics Simulations

by Ray Tracing

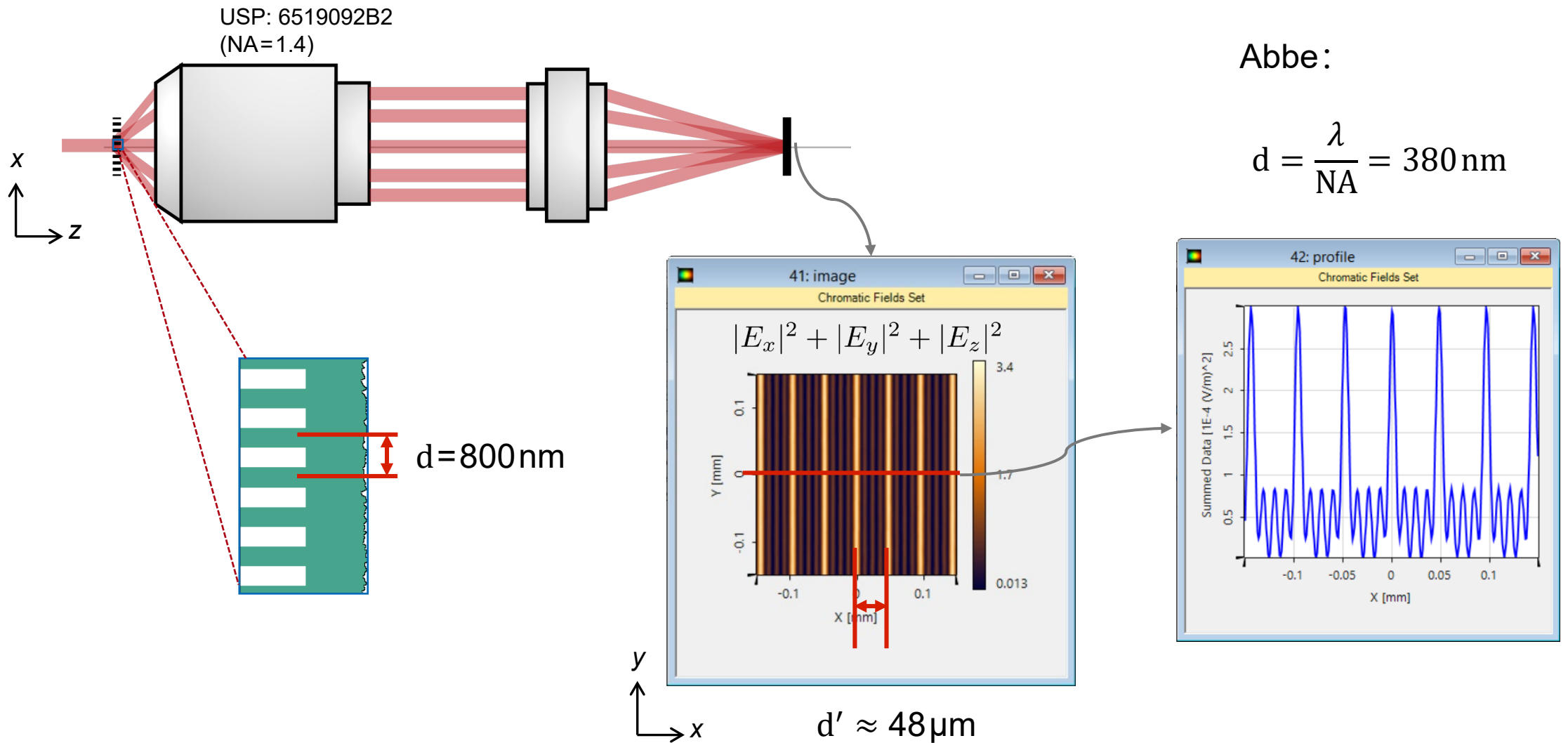
Results: Ray Tracing



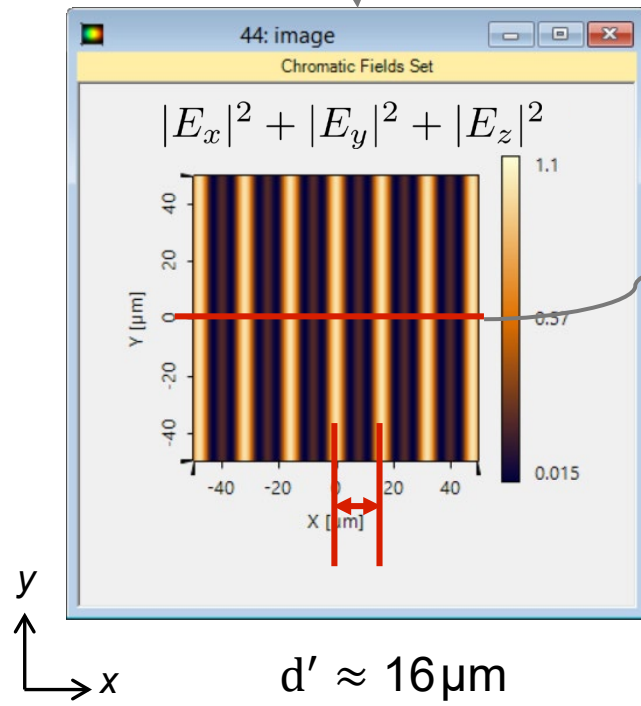
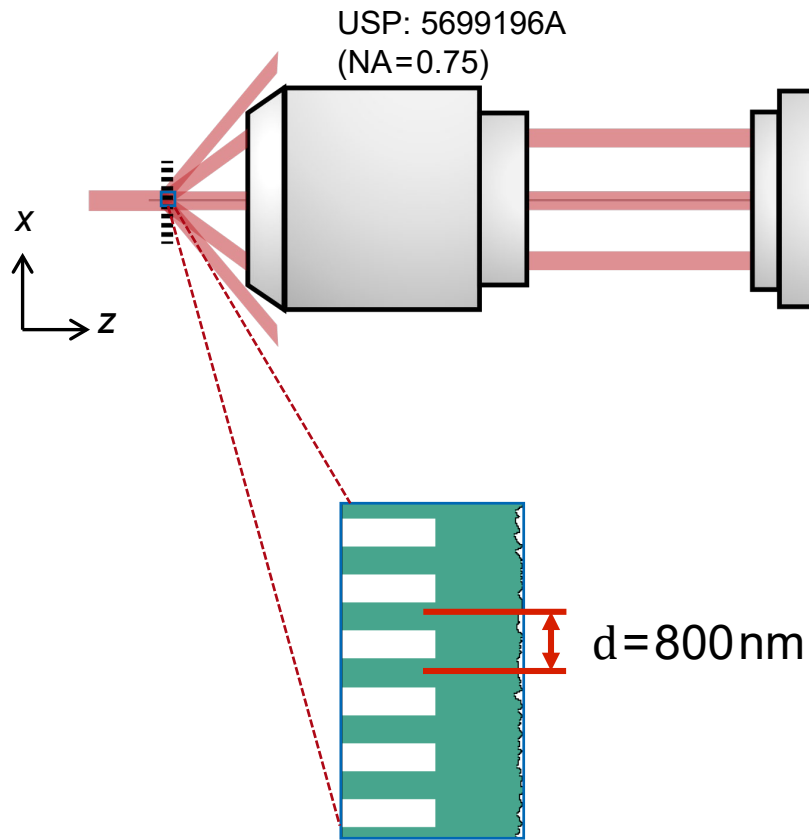
Fast Physical-Optics Simulations

by Field Tracing

Results: Image of Grating for NA=1.4

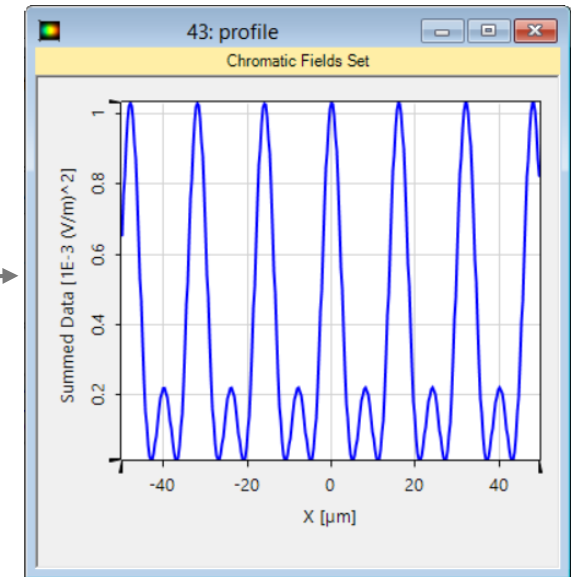


Results: Image of Grating for NA=0.75

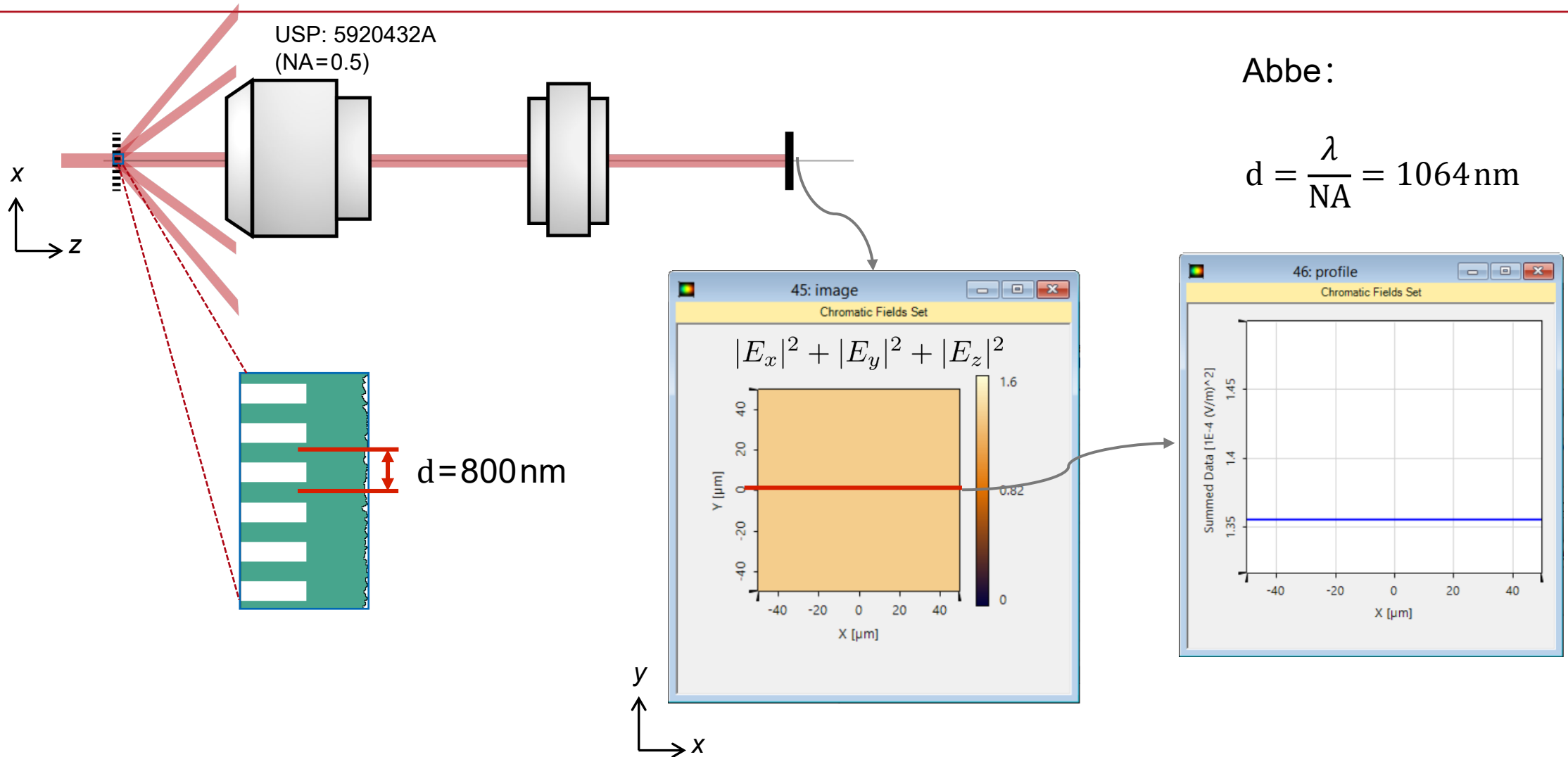


Abbe:

$$d = \frac{\lambda}{\text{NA}} = 709 \text{ nm}$$



Results: Image of Grating for NA=0.5



Document Information

title	Resolution Investigation of a Microscopy System by Abbe Criterion
document code	MIC.0020
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>