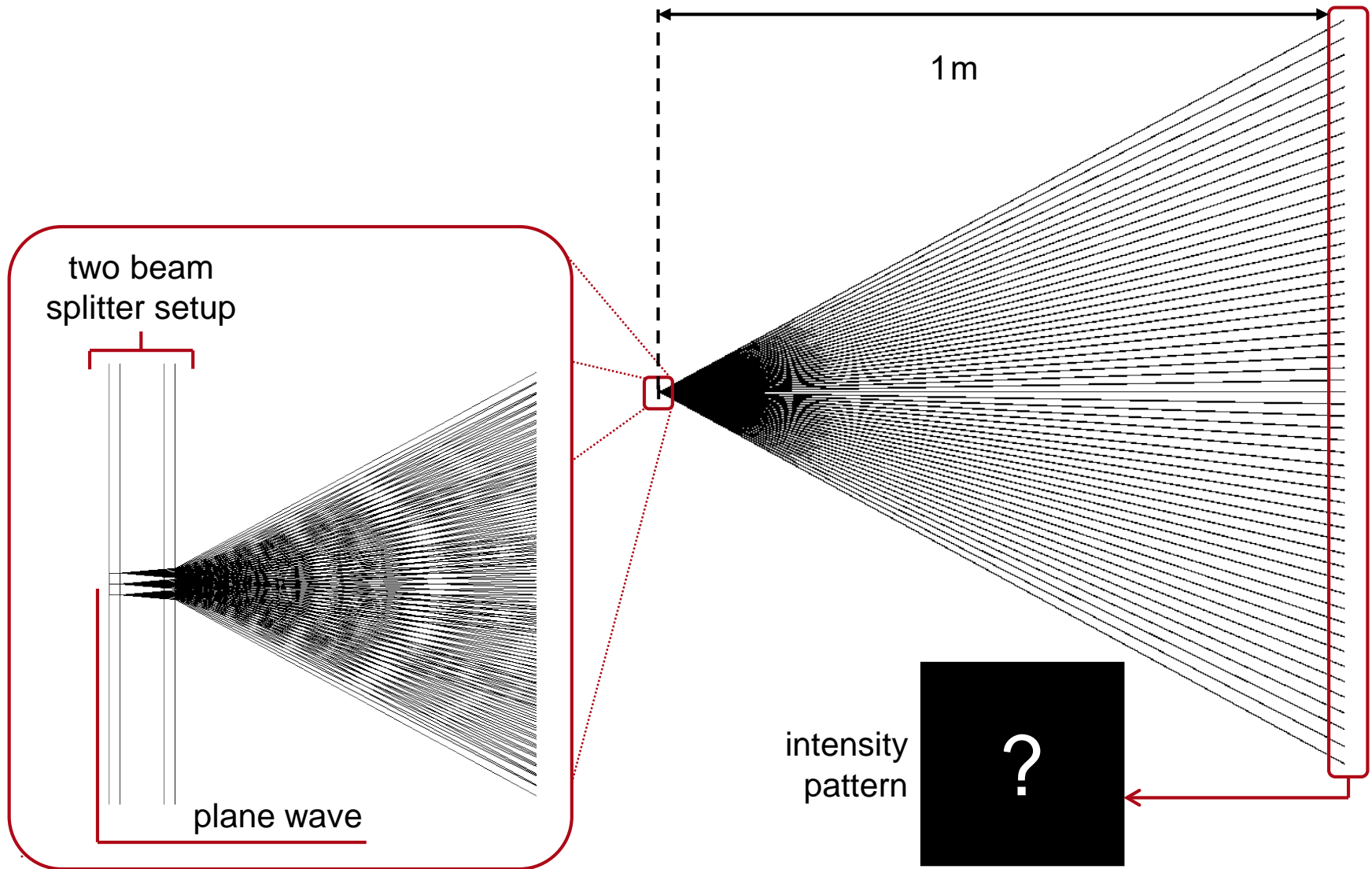


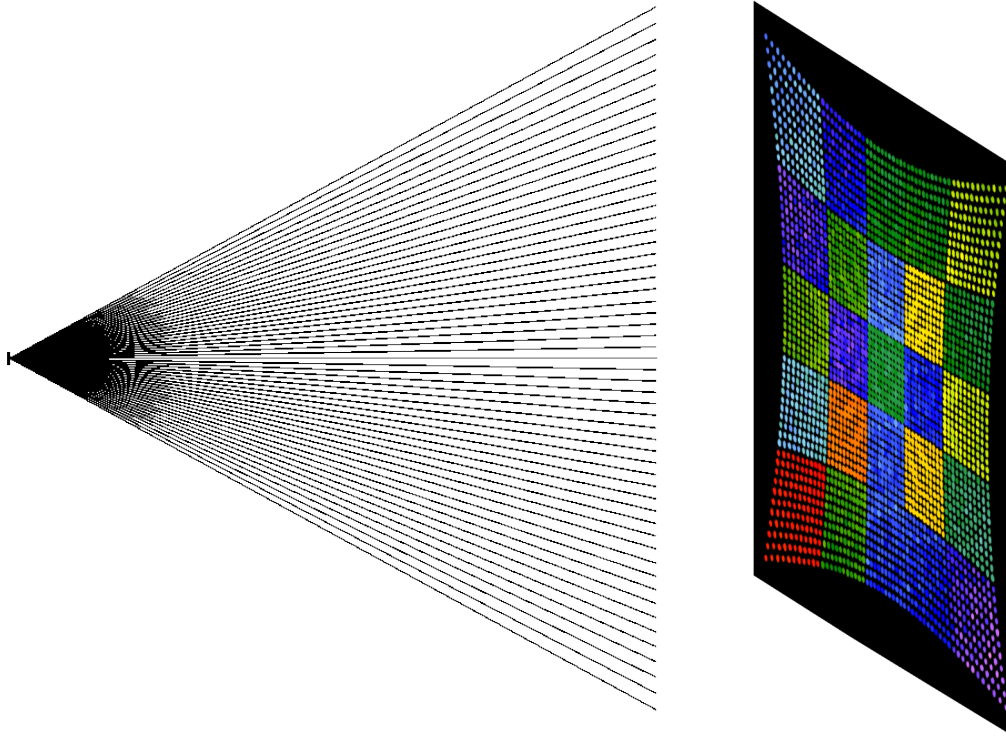
Virtual And Mixed Reality > Pattern Generation

# **High-NA Pattern Generation by Combining Two Beam Splitter Elements**

# Task/System Illustration

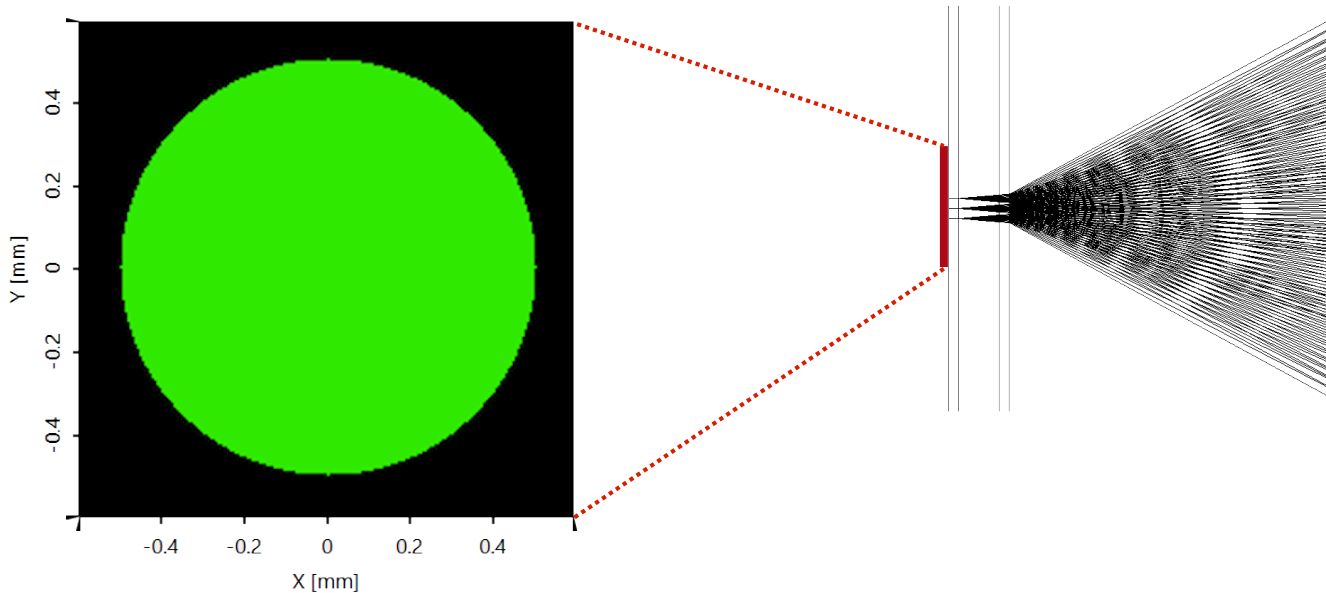


# Highlights



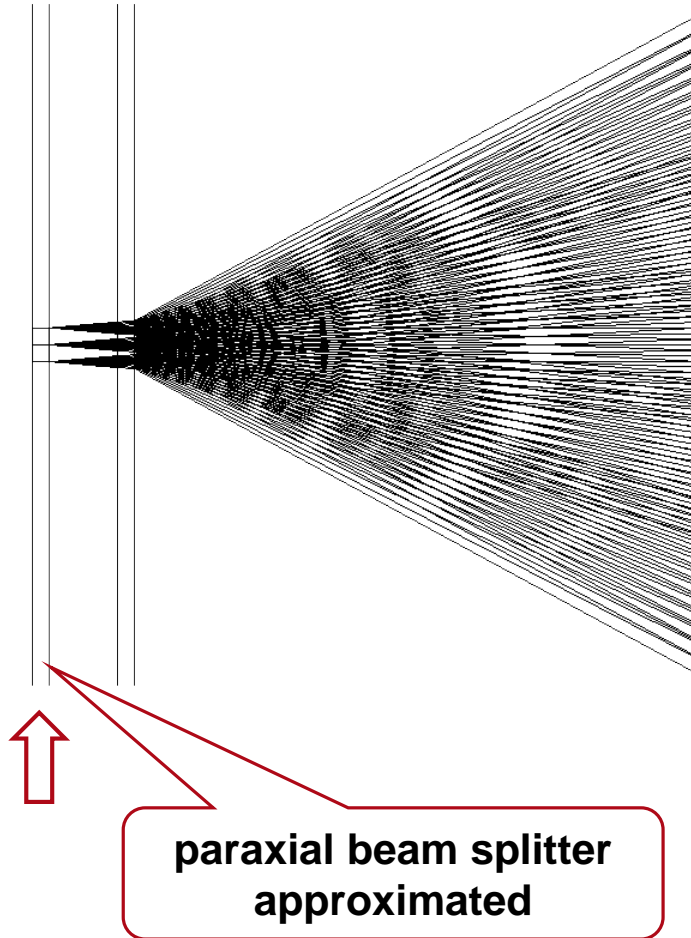
- simulation of high-NA diffractive optical elements including rigorous efficiency calculation
- using beam splitter designs in more complex optical systems including higher order stray light

# Specification: Light Source



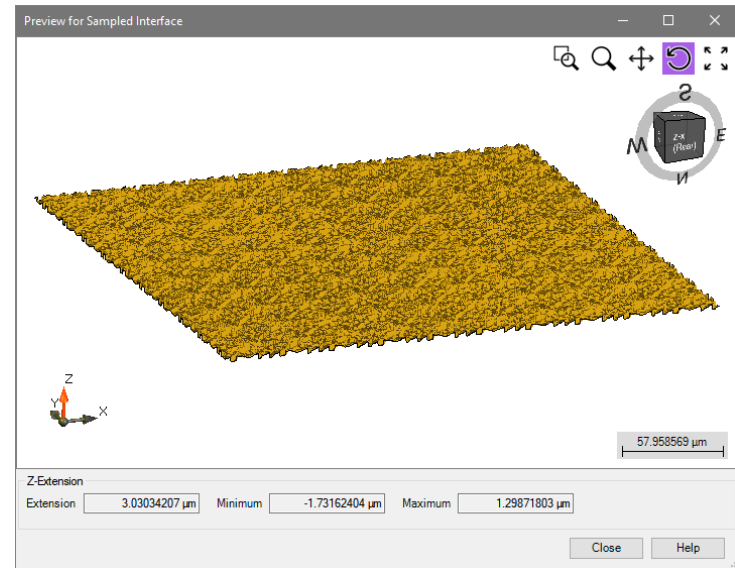
Parameter	Description / Value & Unit
type/number	plane wave
wavelength	532 nm
polarization	linear in x-direction (0°)
aperture	1 mm × 1 mm (circular)

# Specification: First Beam Splitting Element

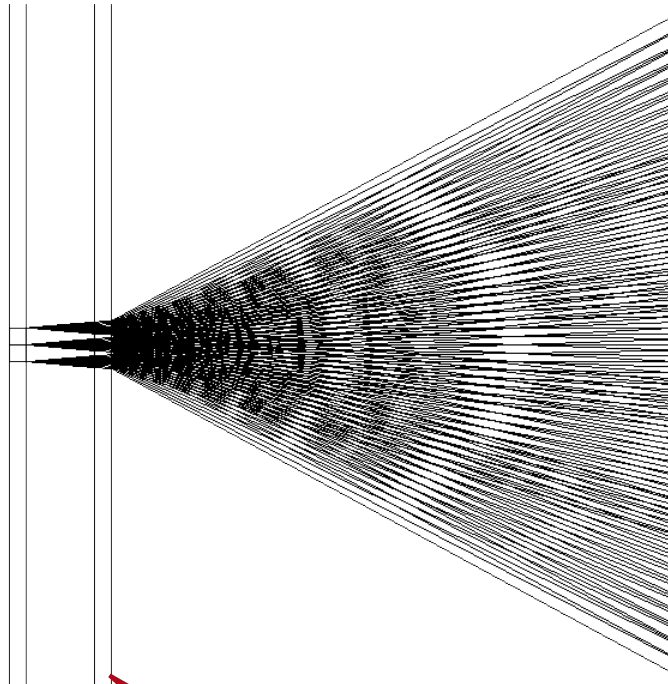


Parameter	Value & Unit
number of orders	11×11
order separation	1°×1°
period	30.35μm × 30.35μm
pixel size	690nm×690nm
discrete height levels	8
material	fused silica

surface profile



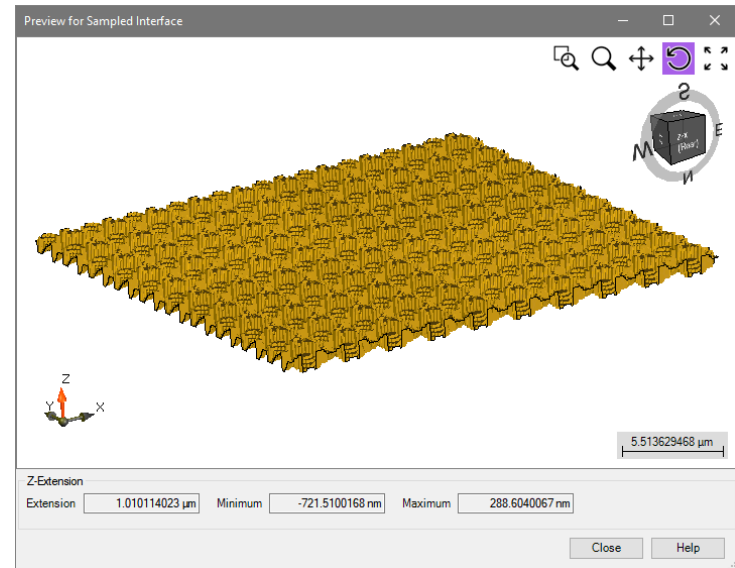
# Specification: Second Beam Splitting Element



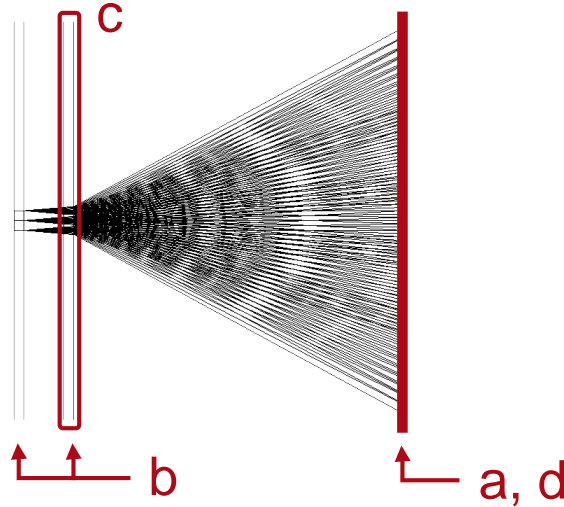
↑  
**high-NA beam splitter**

Parameter	Value & Unit
number of orders	5×5
order separation	11°×11°
period	2.73μm×2.73μm
pixel size	130nm×130nm
discrete height levels	8
material	fused silica

surface profile

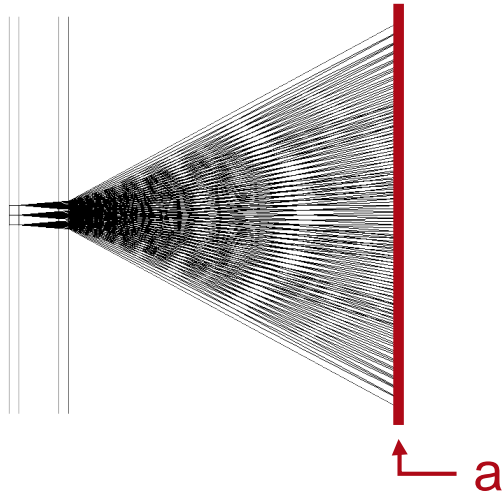


# Specification: Detectors

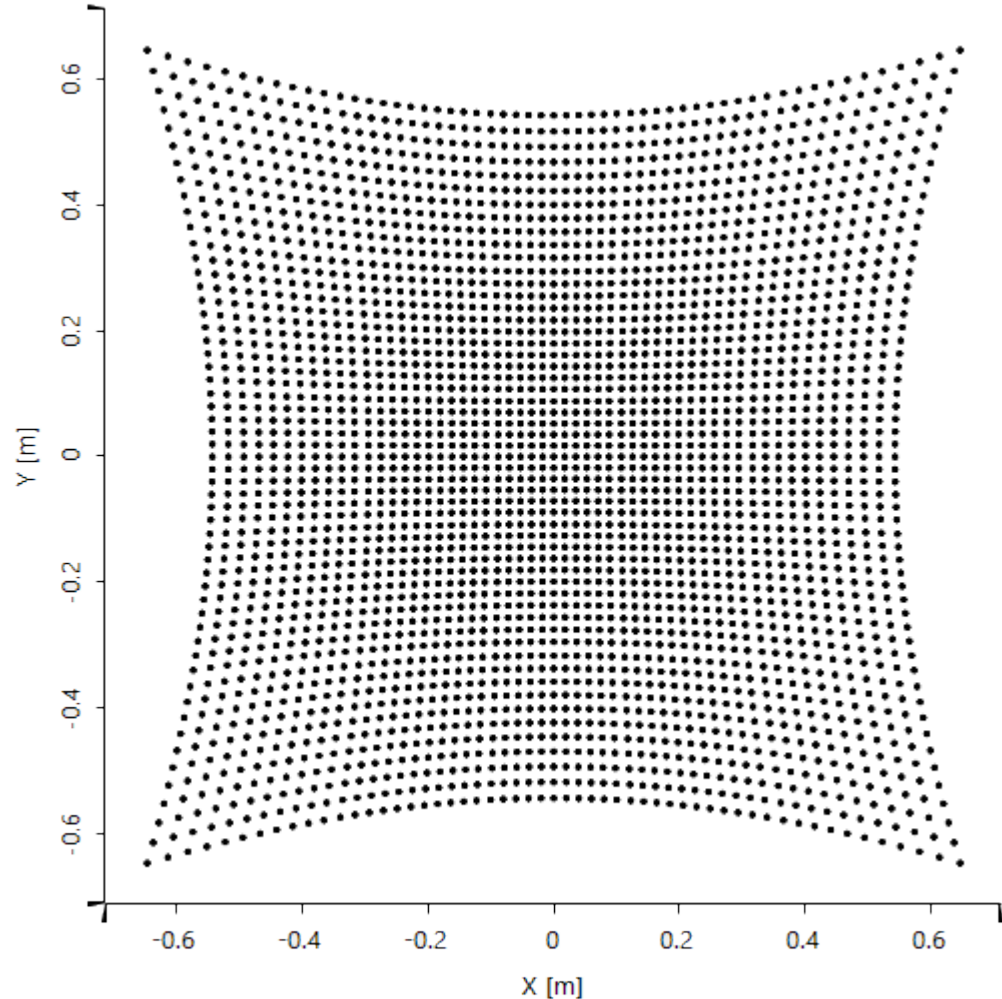


Position	Modeling Technique	Detector/Analyzer
a	ray tracing	spot diagram
b	field tracing	calculation of efficiencies assuming paraxial approximation provided by IFTA
c	Fourier modal method	rigorous calculation of diffraction efficiencies
d	field tracing	amplitude of $E_x$ & $E_z$

# Results: Ray Tracing



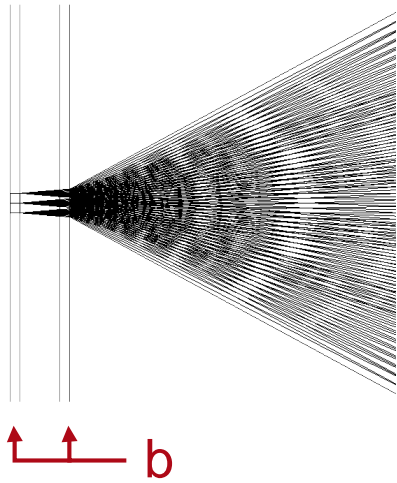
spot diagram



combination of both beam splitter – generation of  $55 \times 55$  orders with  $55^\circ \times 55^\circ$  angular distribution



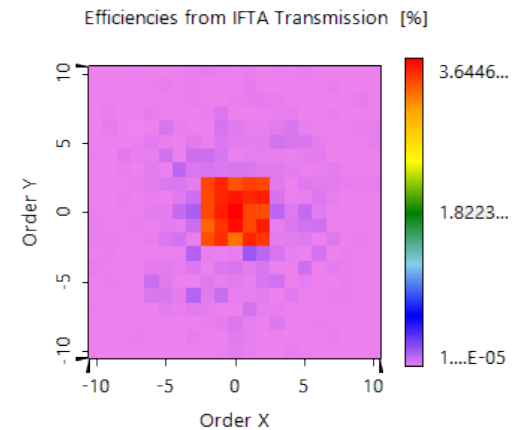
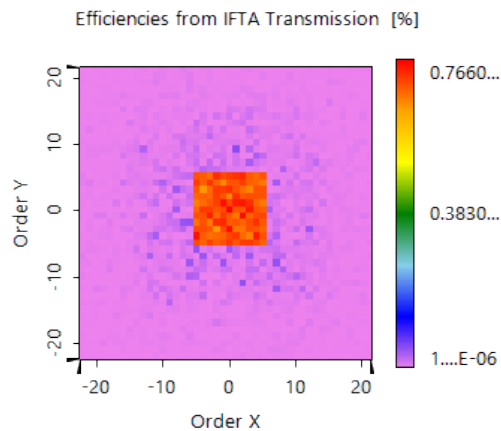
# Result: Efficiencies from IFTA Design



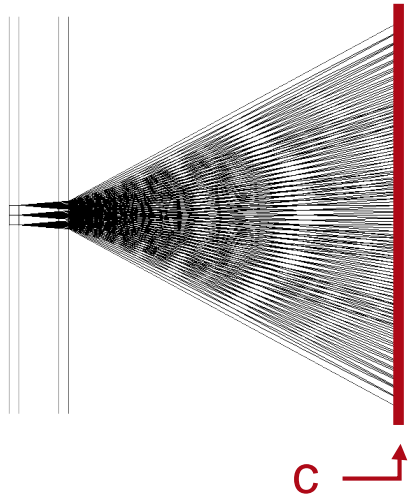
efficiencies paraxial beam splitter

efficiencies calculated by IFTA are sufficiently accurate for paraxial beam splitter designs

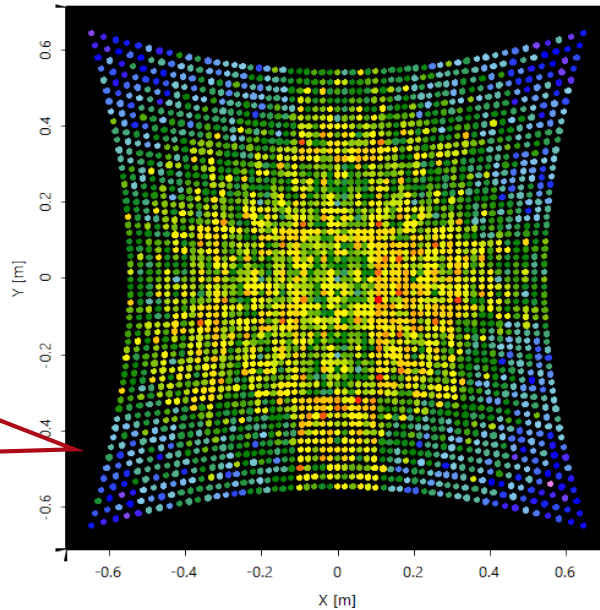
efficiencies high-NA beam splitter



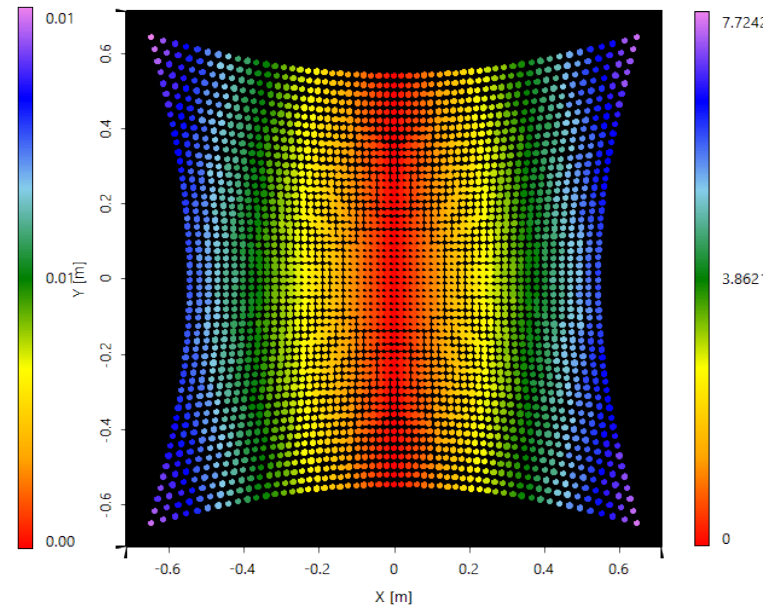
# Result: Amplitude Evaluation



amplitude of  $E_x$   
Amplitude of Ex-Component [V/m]

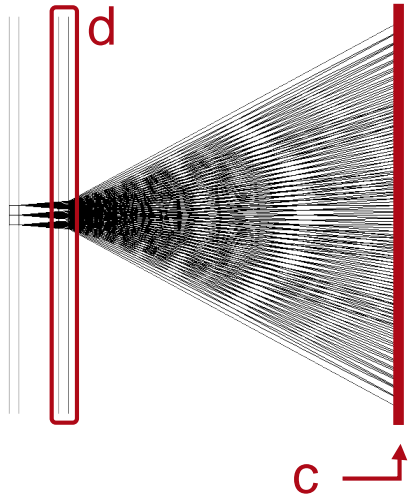


amplitude of  $E_z$   
Amplitude of Ez-Component [mV/m]



simulation time:  
~6s

# Result: FMM Analysis of Second Beam Splitter

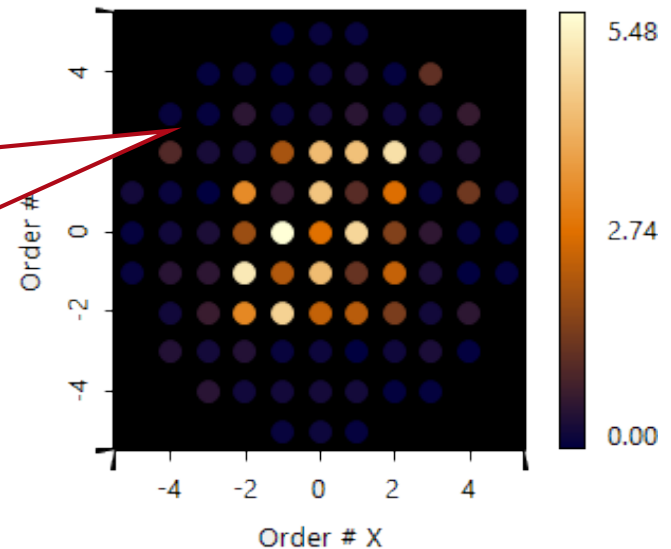


in order to calculate the diffraction efficiencies for the high-NA beam splitter without paraxial approximation a more accurate method has to be applied

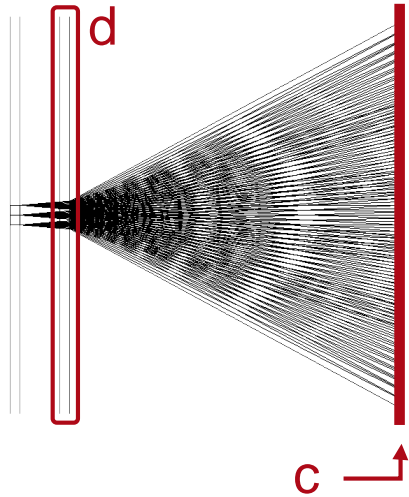
→ FMM is used

diffraction efficiencies  
calculated by FMM

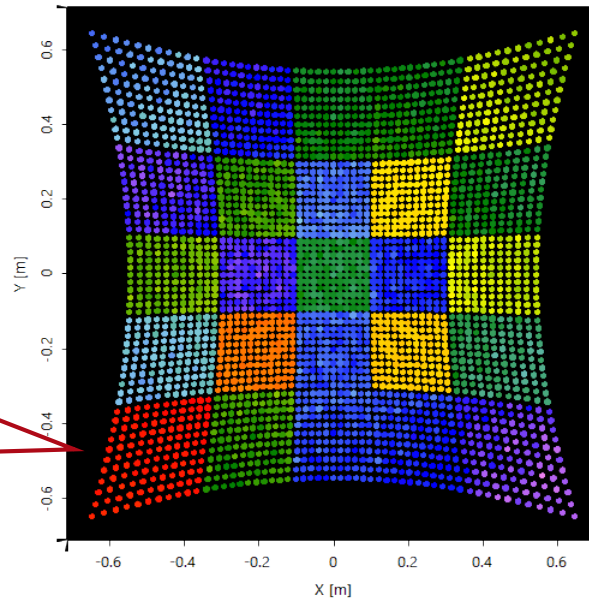
Efficiency [%]



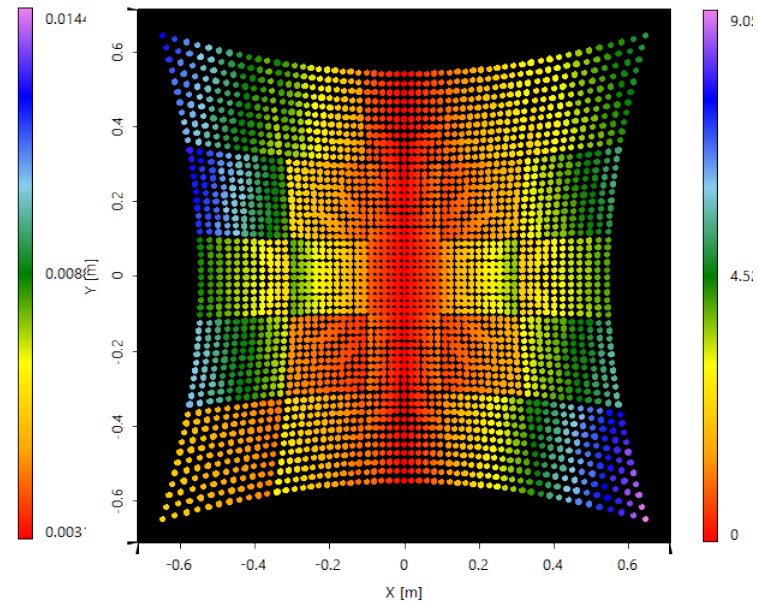
# Result: Field Tracing with Rigorous Efficiencies



amplitude of  $E_x$   
Amplitude of Ex-Component [V/m]



amplitude of  $E_z$   
Amplitude of Ez-Component [mV/m]



rigorous  
simulation time:  
~6s

# Document & Technical Info

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category	Virtual & Mixed Reality > Pattern Generation
author	Roberto Knoth (LightTrans)
VL version used for simulations	7.0.0.29

## Specification of PC Used for Simulation

Processor	Intel Core i7-4910MQ (4 cores)
RAM	32 GB
Operating System	Windows 10