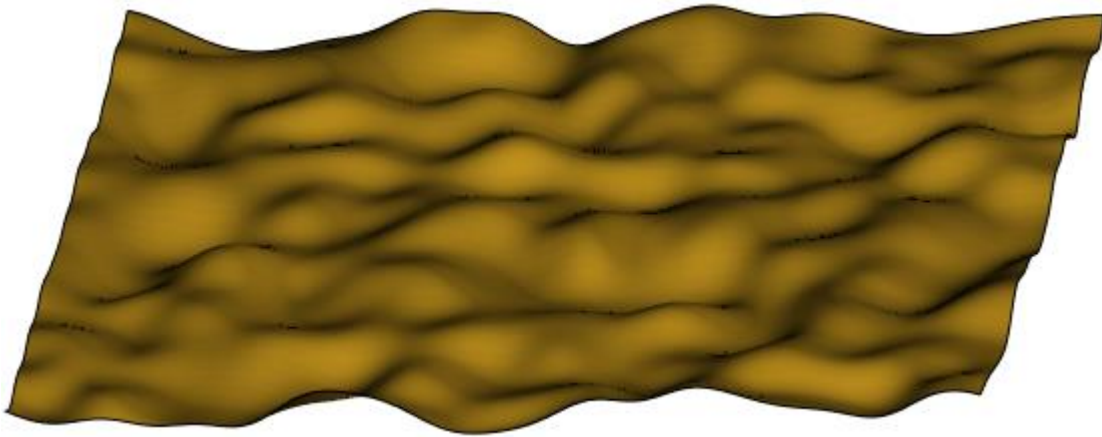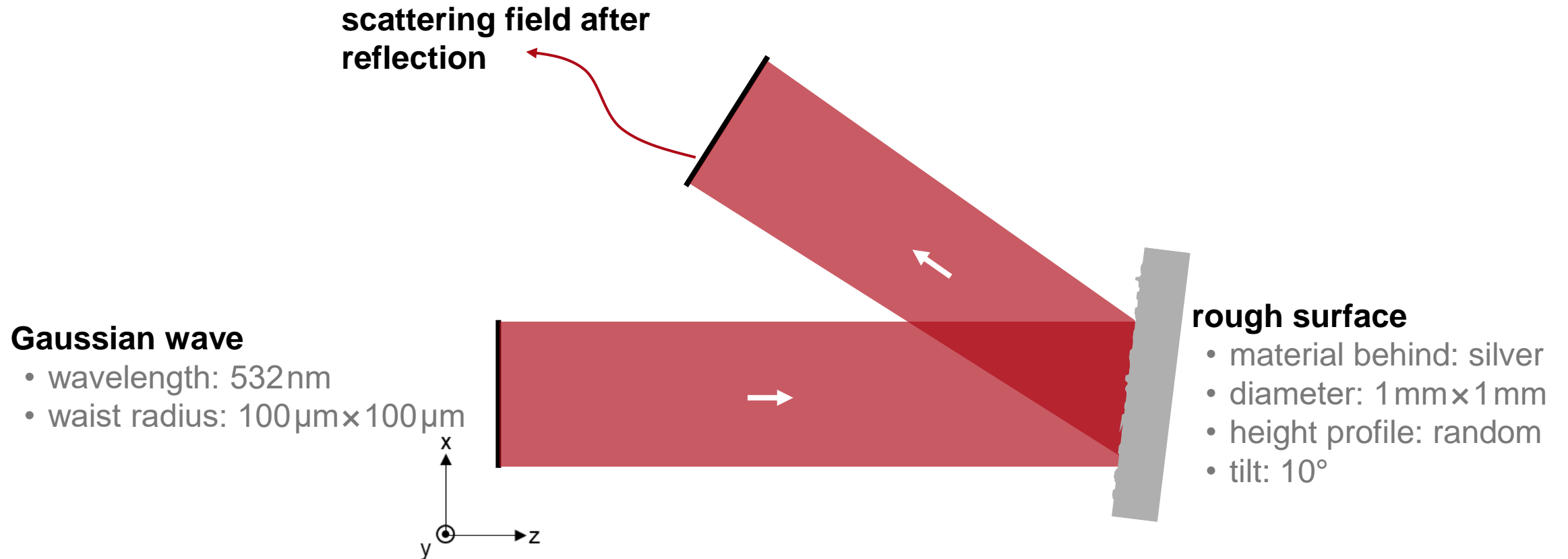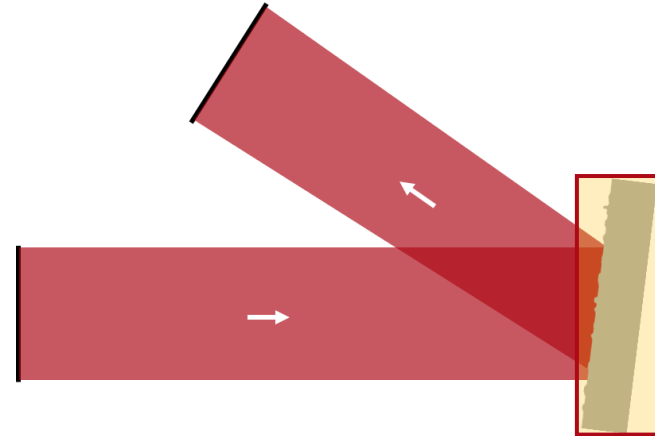# Reflection at a Rough Surface

Abstract

When designing optical elements or components due to deviations introduced by fabrication processes, the function of the final elements may differ from the idealized model. For the modeling of a real surface with a specific roughness in this example a customized surface is used. In addition, the scattering effect introduced by the unevenness of the surface is investigated.

Modeling Task

scattering field after reflection

Gaussian wave
- wavelength: 532 nm
- waist radius: 100 µm × 100 µm

rough surface
- material behind: silver
- diameter: 1 mm × 1 mm
- height profile: random
- tilt: 10°

Connected Modeling Techniques: Rough Surface

Available modeling techniques for microstructures:

Methods	Preconditions	Accuracy	Speed	Comments
Functional Approach	-	low	very high	diffraction angles acc. to grating equation; manual efficiencies
Thin Element Approximation (TEA)	smallest features > ~10λ	high	very high	inaccurate for larger NA and thick elements; x-domain
	smallest features < ~2λ	low	very high	
Fourier Modal Method (FMM)	period < ~ ($5\lambda \times 5\lambda$)	very high	high	rigorous solution; fast for structures and periods similar to the wavelength; more demanding for larger periods; k-domain
	period > ~ ($15\lambda \times 15\lambda$)	very high	slow	

In this example, the smallest feature size is much larger compared to the operating wavelength of light. Thus, a solver like **Thin Element Approximation (TEA) is accurate and fast!**

Rough Surface

Note: The height is scaled to make the roughness visible in a small area.

z × 20

10 μm

z-Extension from -79.9 nm to 65.1 nm; altogether 145 nm.

TEA algorithm allows users to adapt the accuracy.
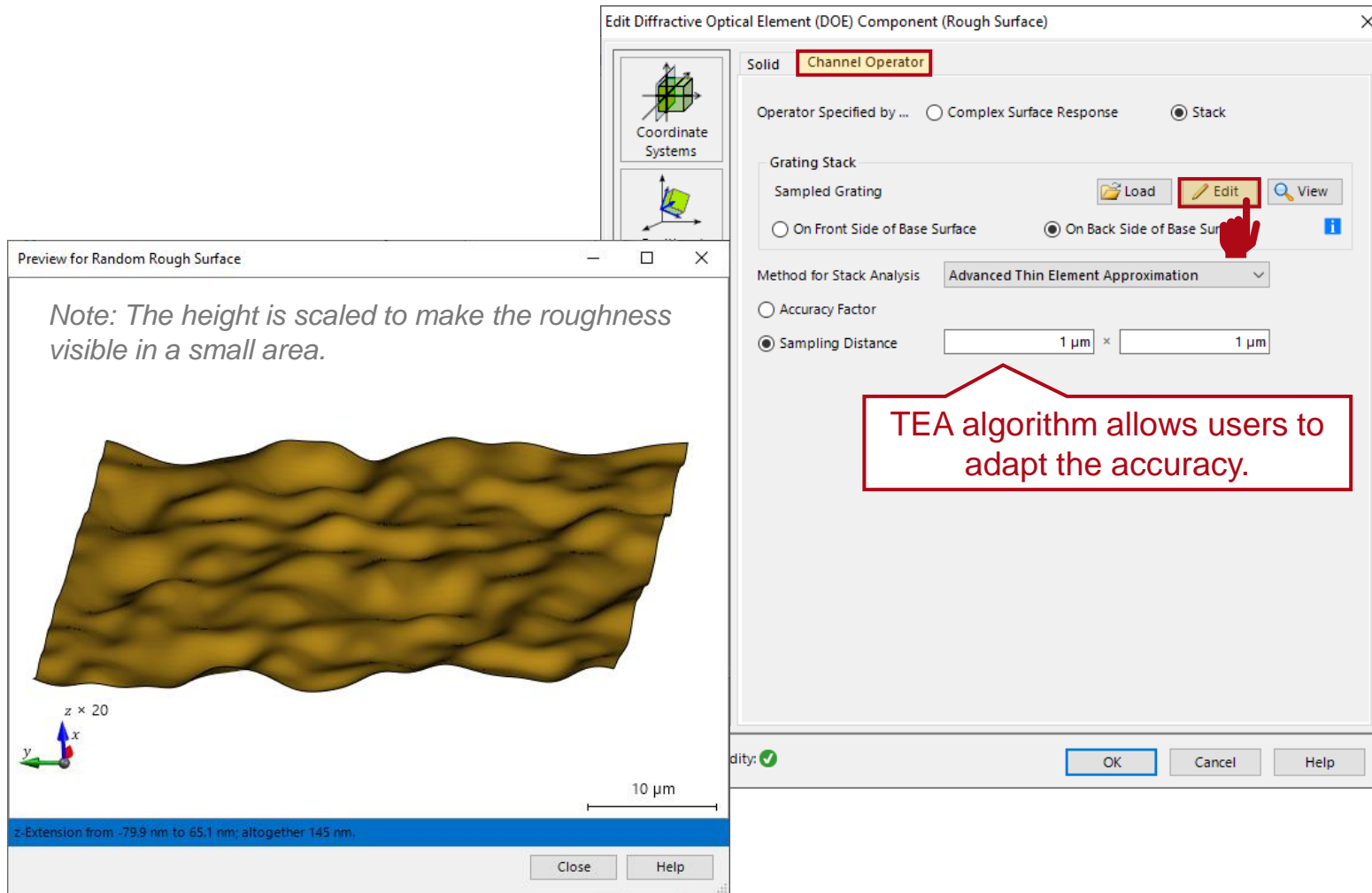
For this modeling task, we use the Diffractive Optical Element (DOE) component to benefit from the inbuilt advanced TEA field solver. The shape of the modeled structures can by defined by using a surface. For further details on this component, please refer to this use case:

Diffractive Optical Element (DOE) & Microstructure Component
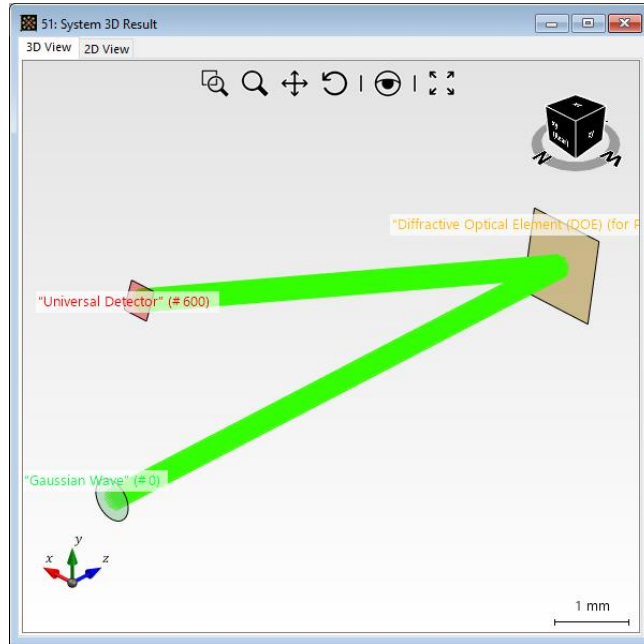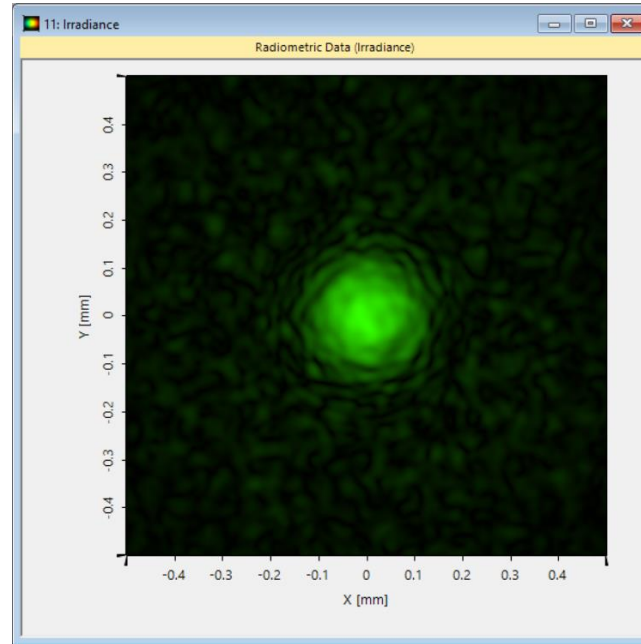
Rough Surface
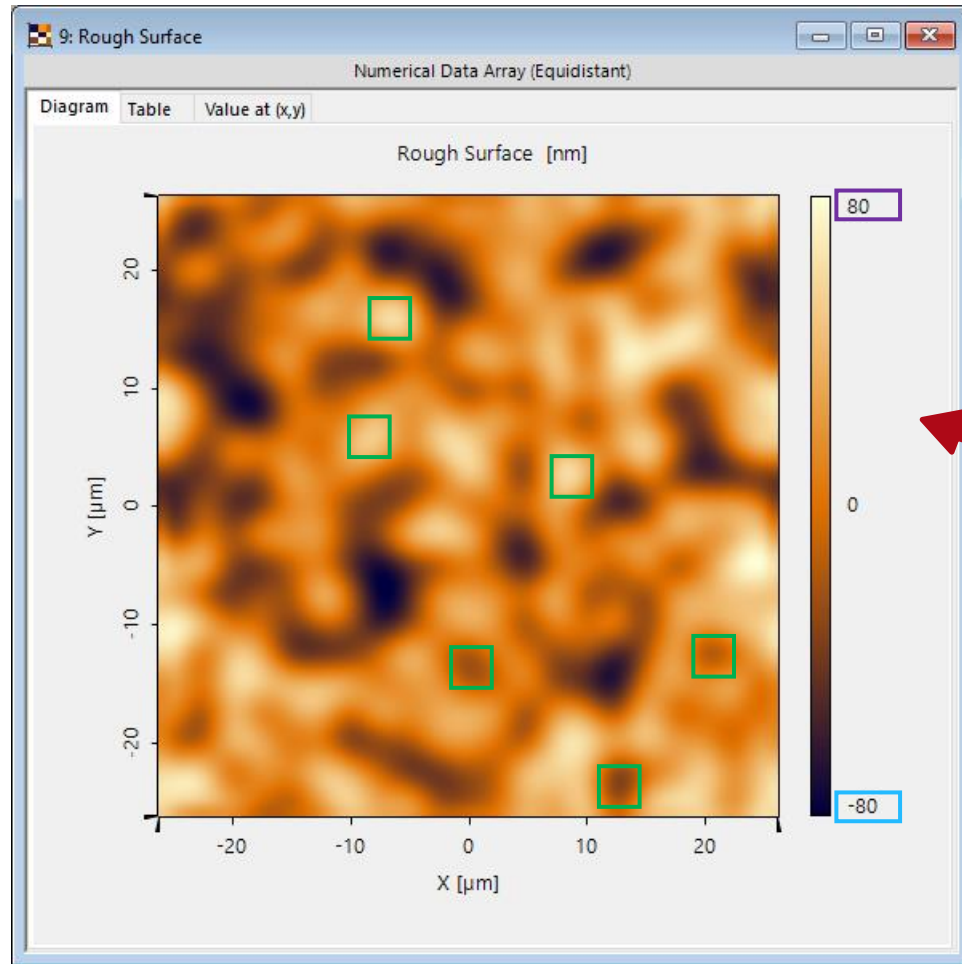
The seed is used to generate reproducible random height values.

This value corresponds to half the width of a Gaussian, which is used for the convolution of the random height distribution to generate the random height surface.
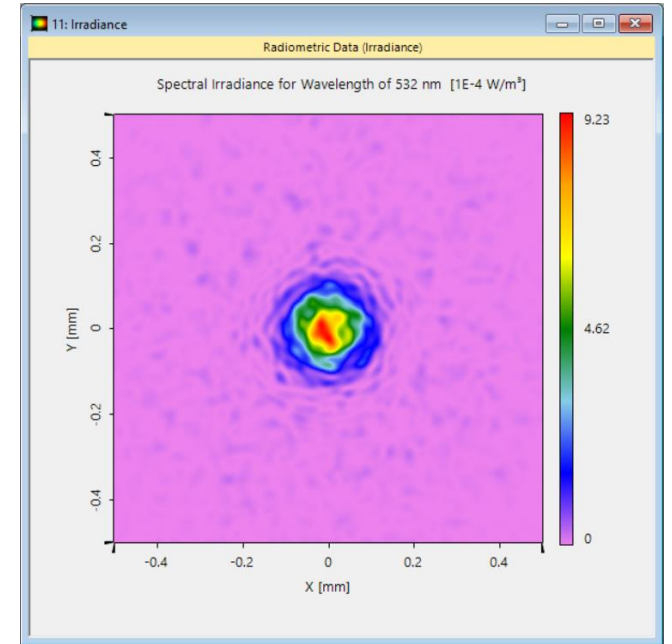
Simulation Results

system 3D view

Irradiance (real color)

Irradiance
(false color - reverse rainbow)

Document Information

title	Reflection at a Rough Surface
document code	DOE.0007
document version	1.0
required packages	-
software version	2023.2 (Build 2.30)
category	Application Use Case
further reading	• Diffraction Pattern Calculation from a Reflection-Type Diffractive Beam Splitter • Diffractive Optical Element (DOE) & Microstructure Component • How to Work with the Programmable Interface & Example (Spherical Surface)