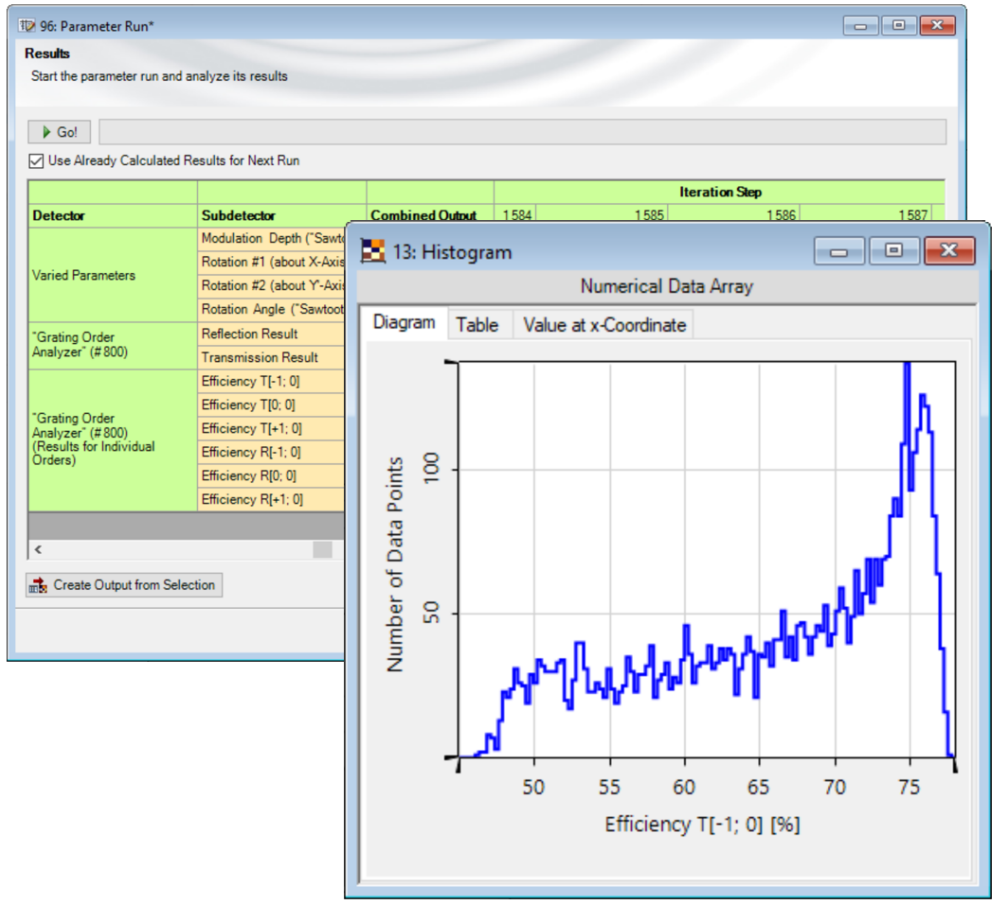
Tolerancing with Random Distributions using the Programmable Mode of the Parameter Run

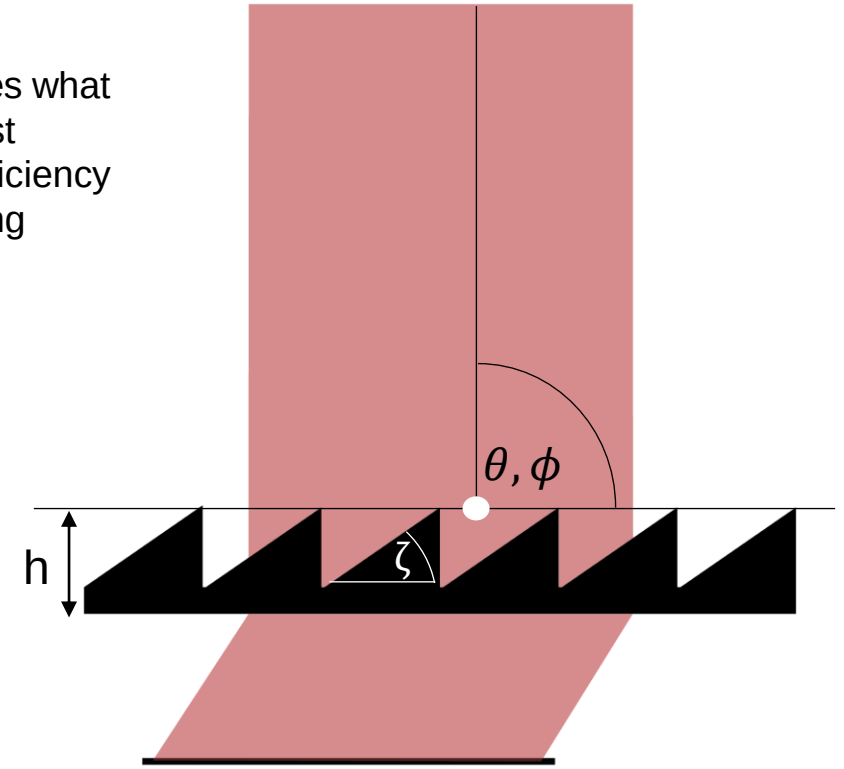
Abstract



When investigating the effect of manufacturing deviations on an optimized system in VirtualLab Fusion, randomly varied Parameter Runs can be used. Depending on the kind of manufacturing process, it may be that the deviations for the different parameters follow different random distribution rules. While the default Random mode of the Parameter Run assumes a uniform distribution, in this use case we want to show how to use a programmable Parameter Run to apply different random distributions to each of the parameters involved in the tolerancing. As illustration we have selected the example of a sawtooth grating, for which we investigate the minimal efficiency of the minus first transmission order.

Task Description

Task: According to the allowed tolerances what is the minimal efficiency of the minus first transmitted order? How is the overall efficiency distributed among the different emanating orders in that case?

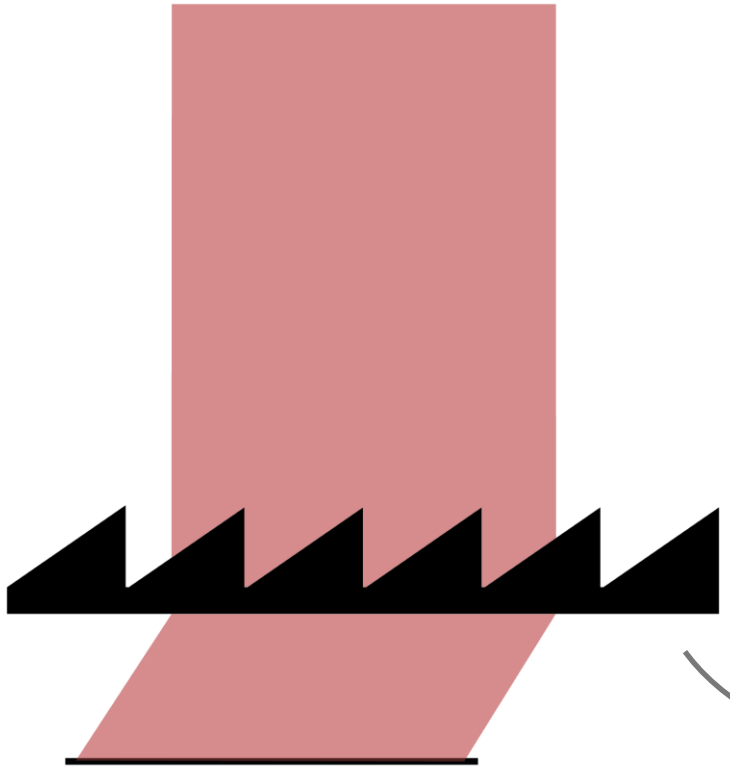


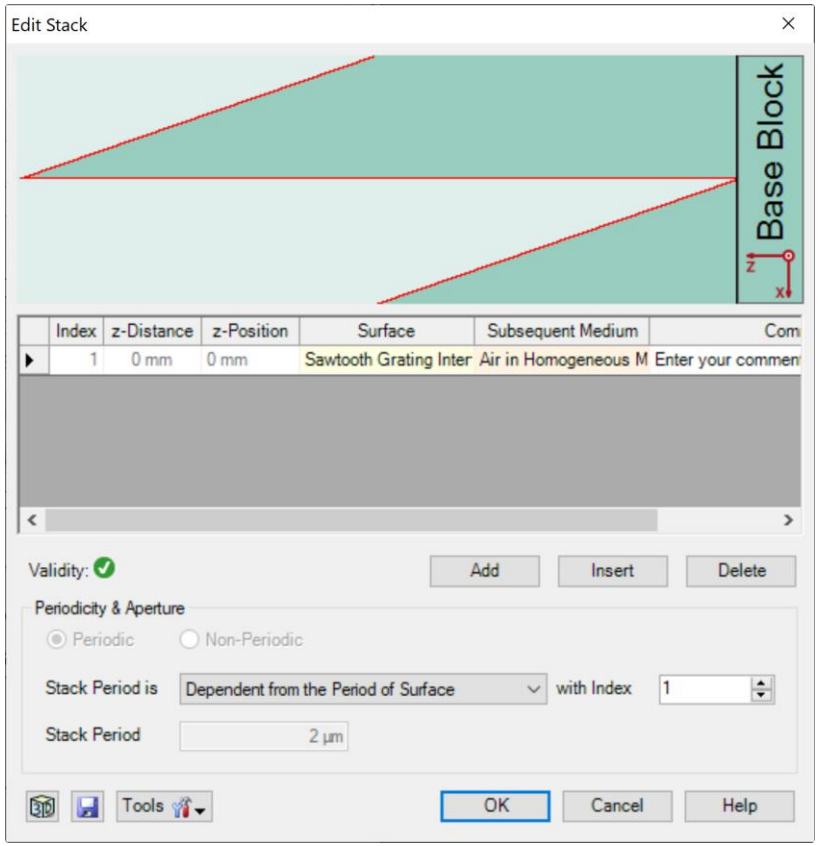
Source: Ideal Plane Wave
- 532 nm wavelength

Sawtooth Grating (fixed parameters):
- 2 µm period
- fused silica
- 1 mm thickness

Sawtooth Grating (parameters for tolerancing):
- blaze angle ζ: 30° (2° tolerance, normal distribution)
- rotation angle θ: normal distribution between -5° and 5°
- rotation angle ϕ: uniform distribution between -5° and 5°
- modulation depth h: 1 µm (0.25 µm tolerance, evenly distributed)

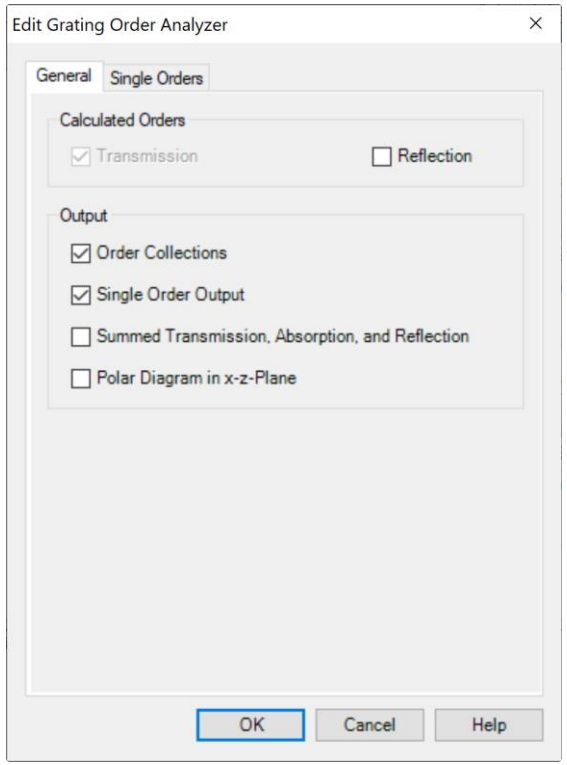
The System in VirtualLab Fusion – Components

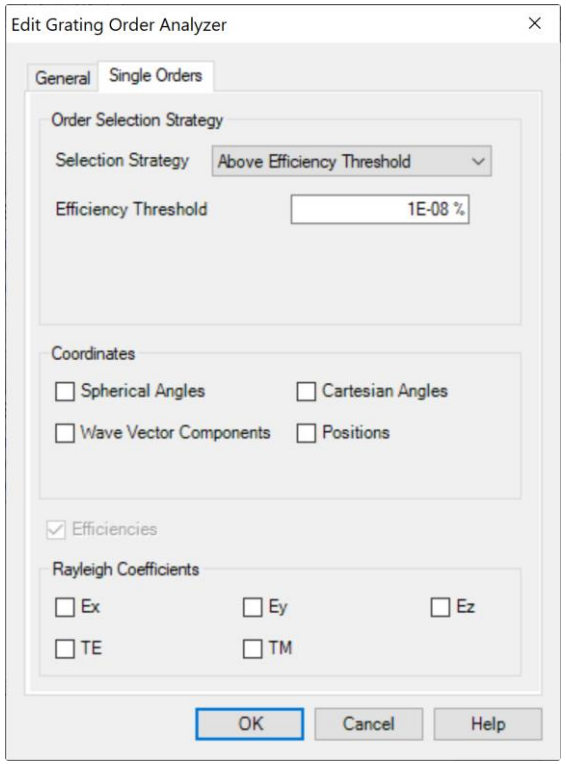


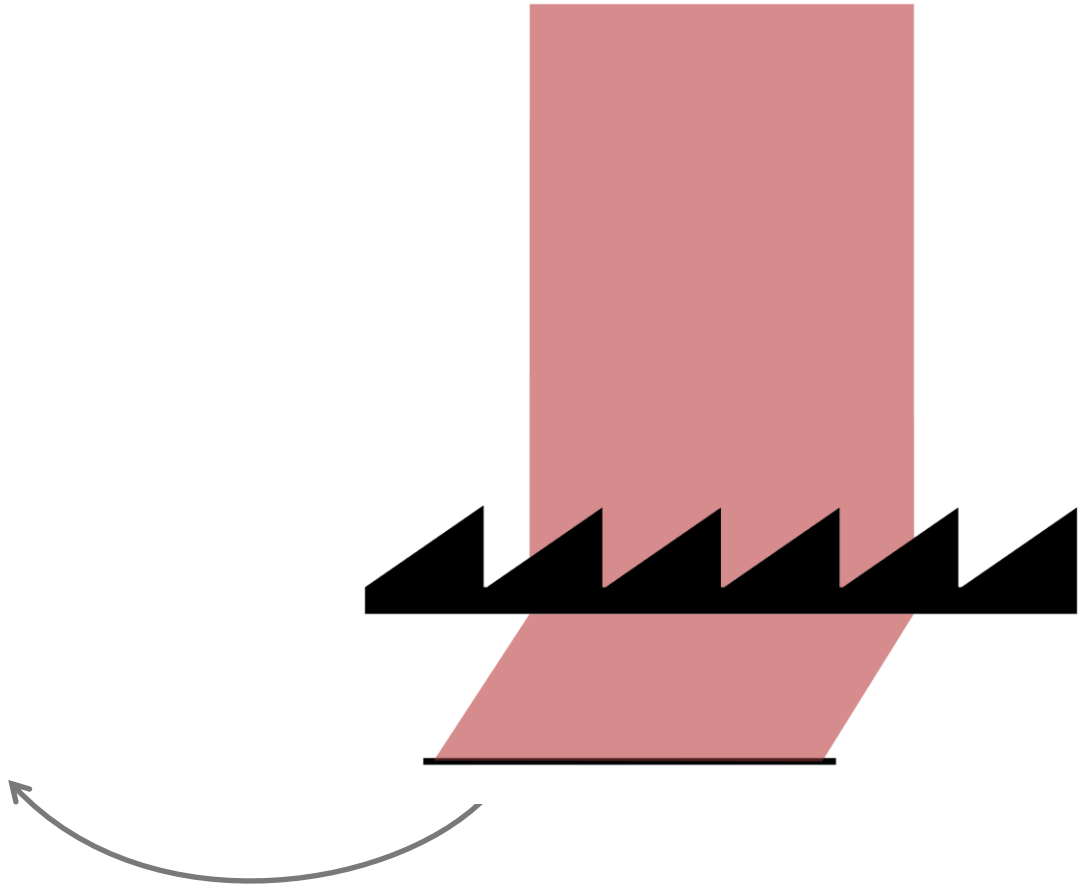


The grating is modeled using a Sawtooth Grating Interface. In the configuration dialog of the surface, the period, blaze angle and modulation depth can be adjusted.

The System in VirtualLab Fusion – Analyzer

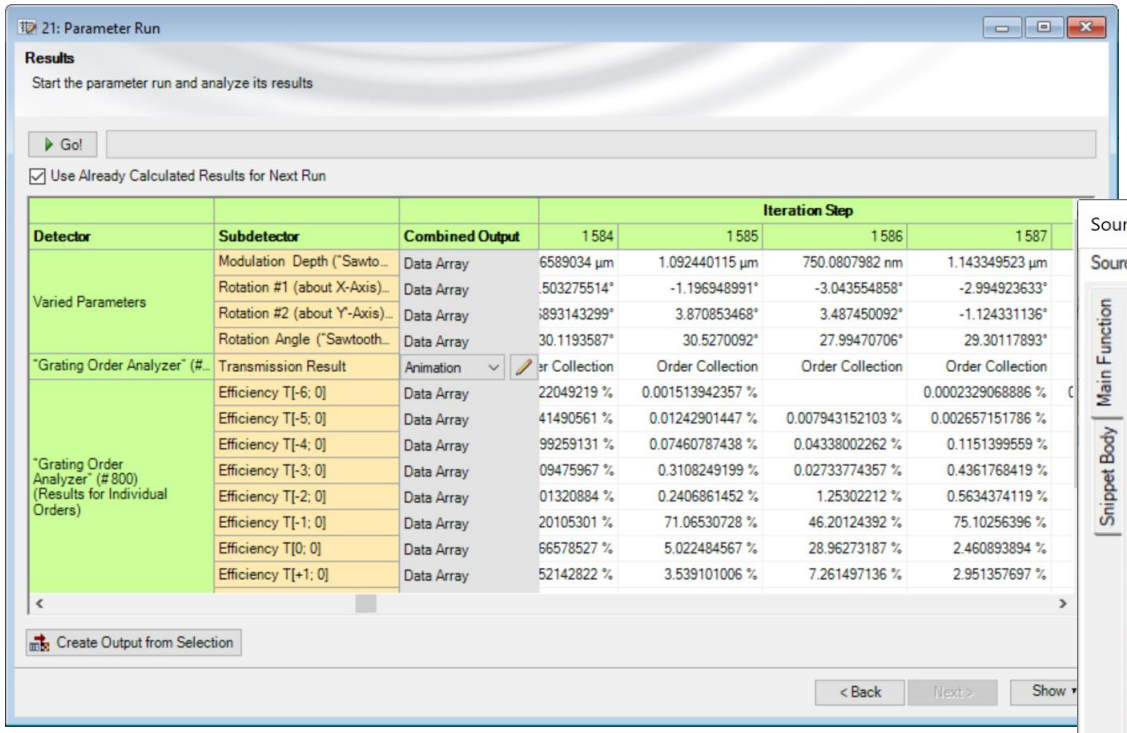


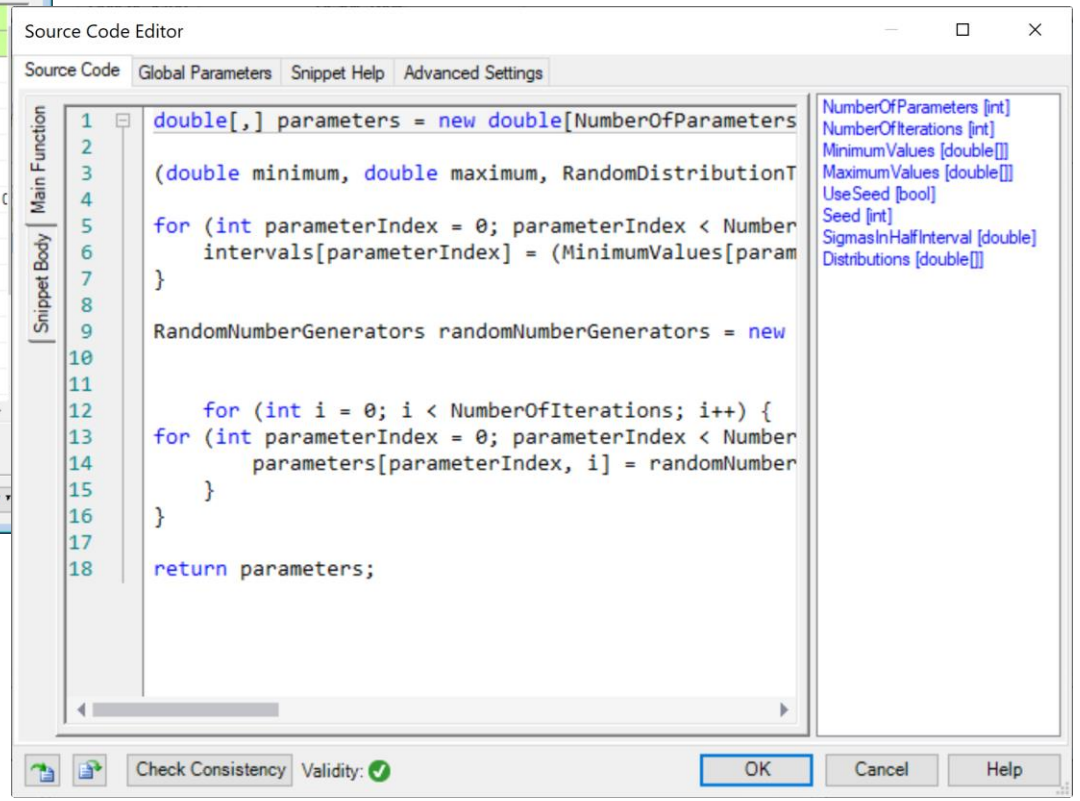




In a Grating Optical Setup the Grating Order Analyzer enables an easy analysis of the grating. It provides different output formats that allow the user to determine how overall energy is distributed among the different emanating orders. In addition, the fully vectorial field information in the form of the Rayleigh coefficients per order is also accessible.

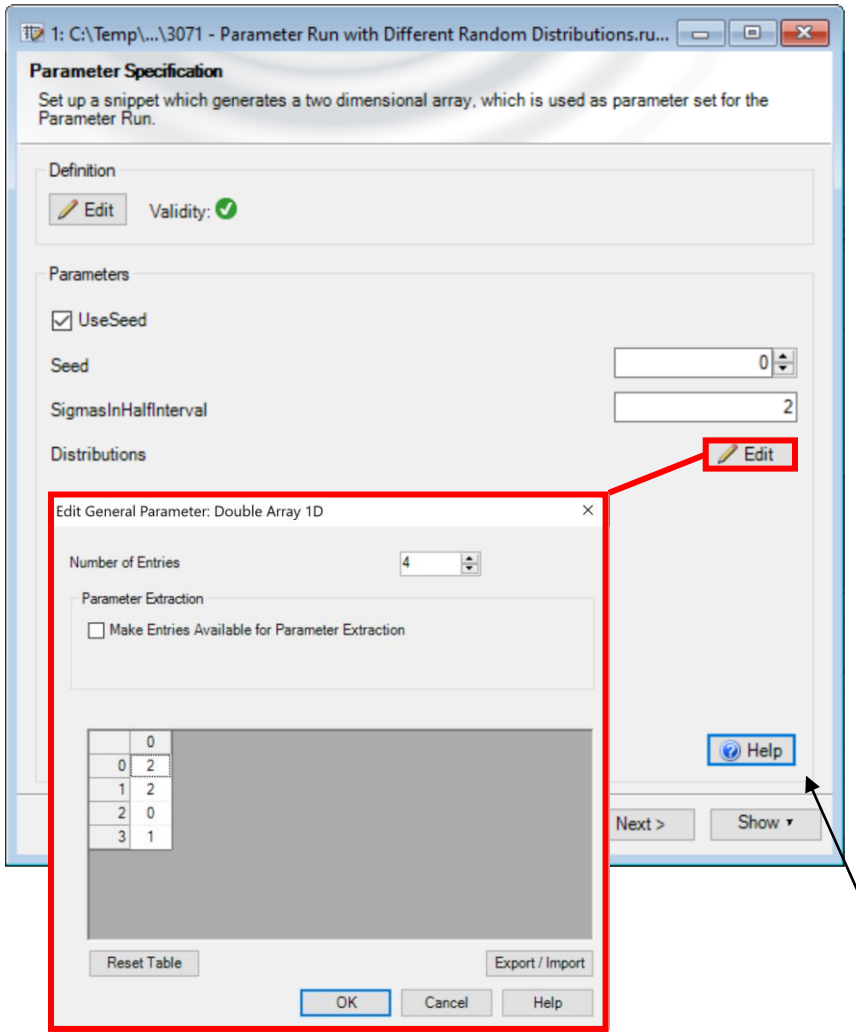
Programmable Parameter Run





To investigate the manufacturing deviations, we use a programmable Parameter Run. Inside, a seed-based random distribution function is used to achieve the different combinations. Through a parameter in the programmable Parameter Run, it is possible to assign to each parameter either a normal or a uniform distribution, as illustrated in the next page.

Options of the Programmable Parameter Run



Use Seed

- Allows for reproducible results

Seed

- Define a specific seed to recreate a particular distribution of the randomly generated Parameter Run

SigmasInHalfInterval

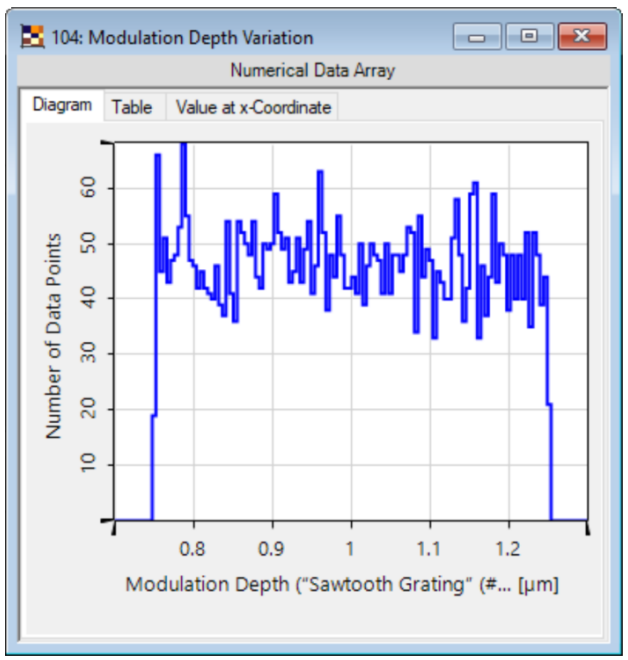
- Determine the width of the distribution, more information can be found in the “Help” document

Distributions

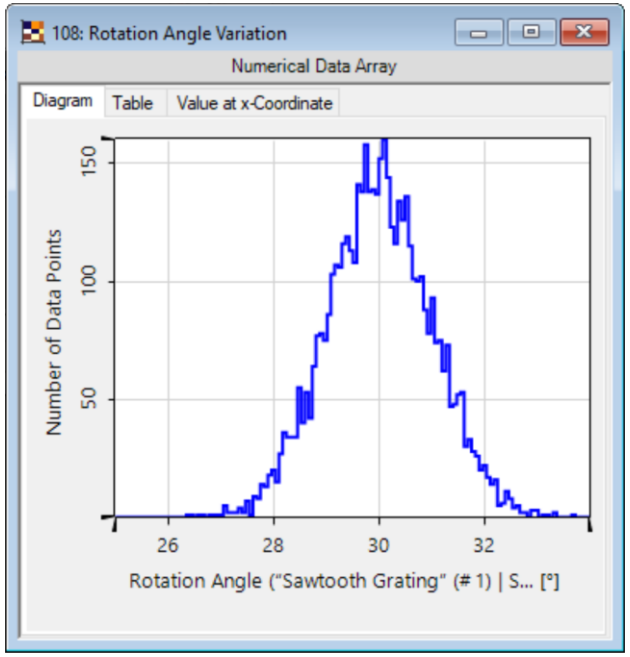
- Choose either a “Uniform”, “Normal” or “Cutoff-Normal” Distribution for each individual varied parameter
- The distribution type is coded with numbers: 0 – uniform, 1 – normal, 2 – cutoff-normal; more information can be found in the “Help” document

Note: In the “Help” document you can find a short explanation of all used parameters and the function of the component.

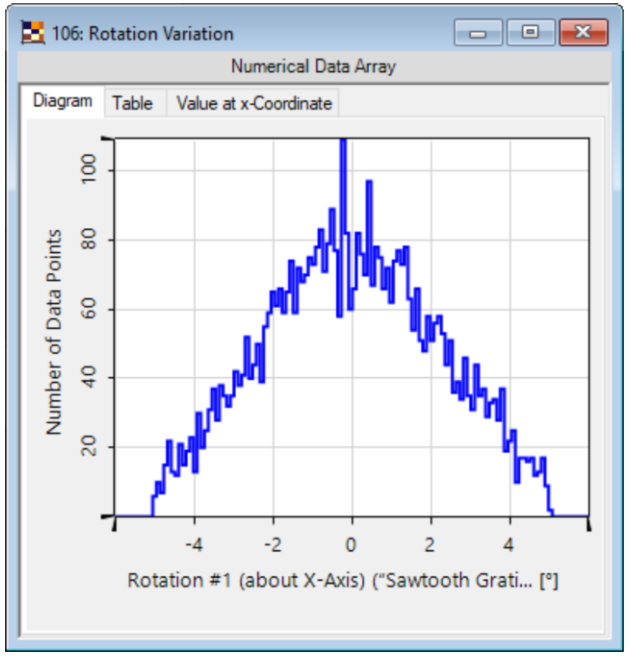
Distribution Types



uniform distribution



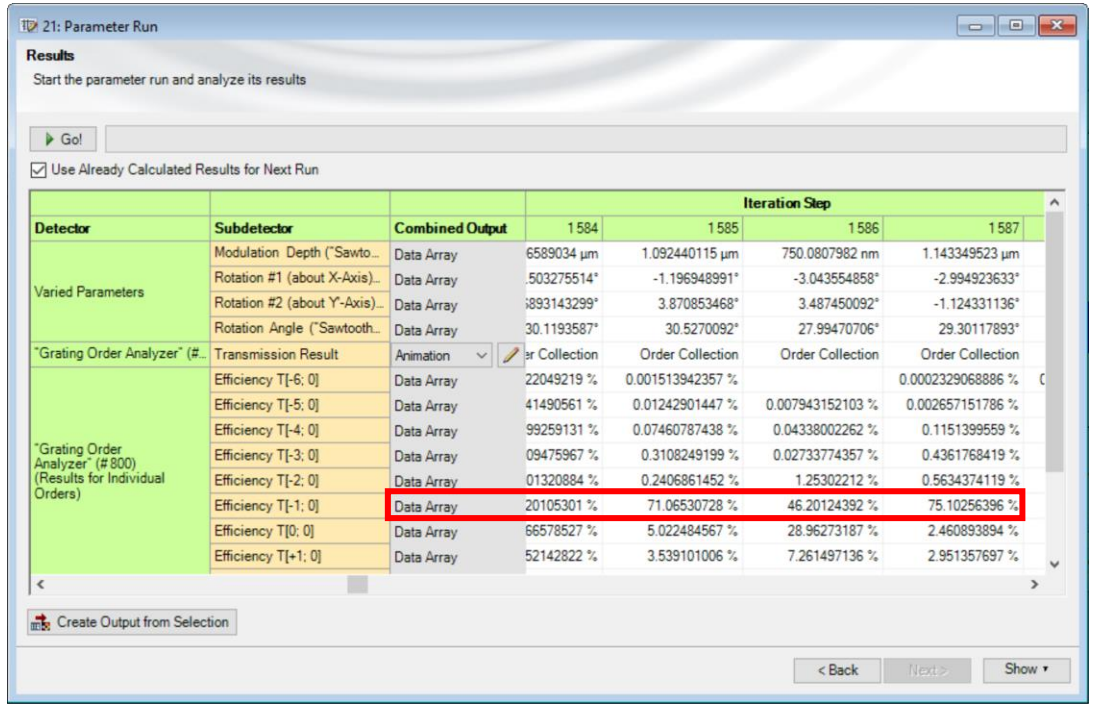
normal distribution



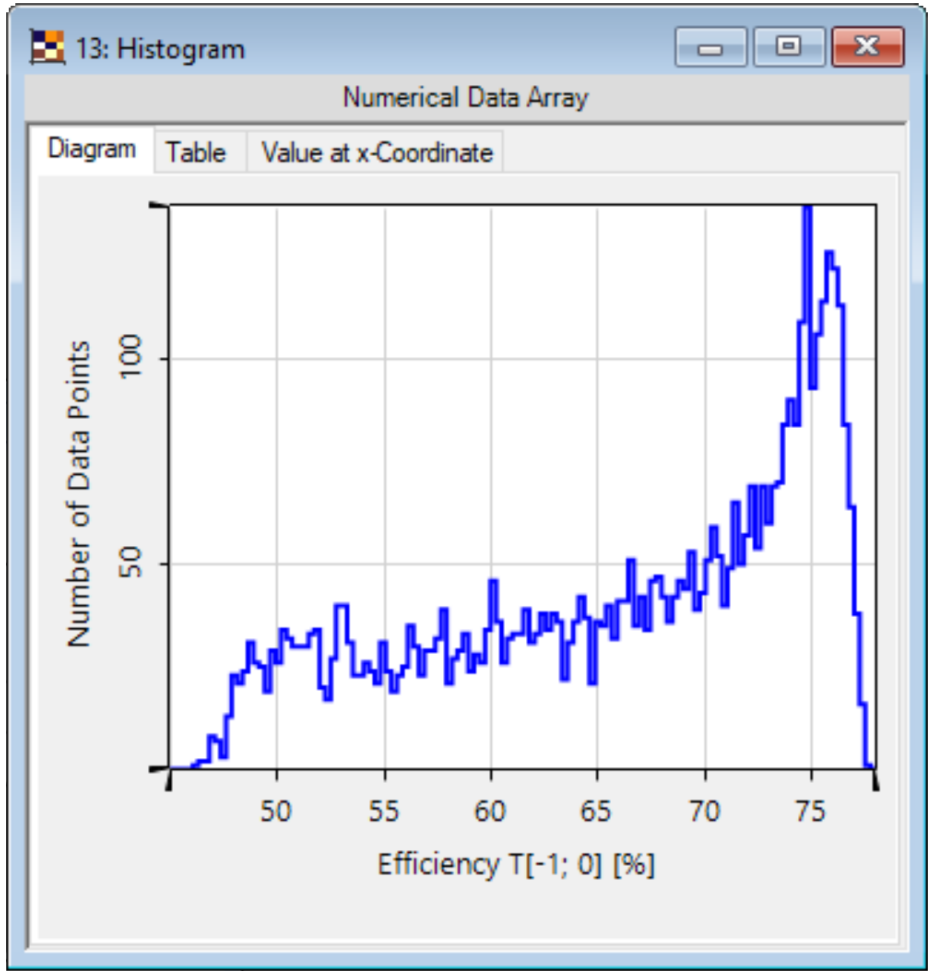
cutoff-normal distribution

In the case of a uniform distribution, the number of points will be evenly distributed over the allowed range. The normal and cutoff normal distributions both assume a Gaussian profile for the probability of a point being taken. The difference between the standard normal distribution and the cutoff normal distribution is that in the case of the cutoff distribution the values outside of the parameter range will not be taken, but a new number inside the range is generated instead.

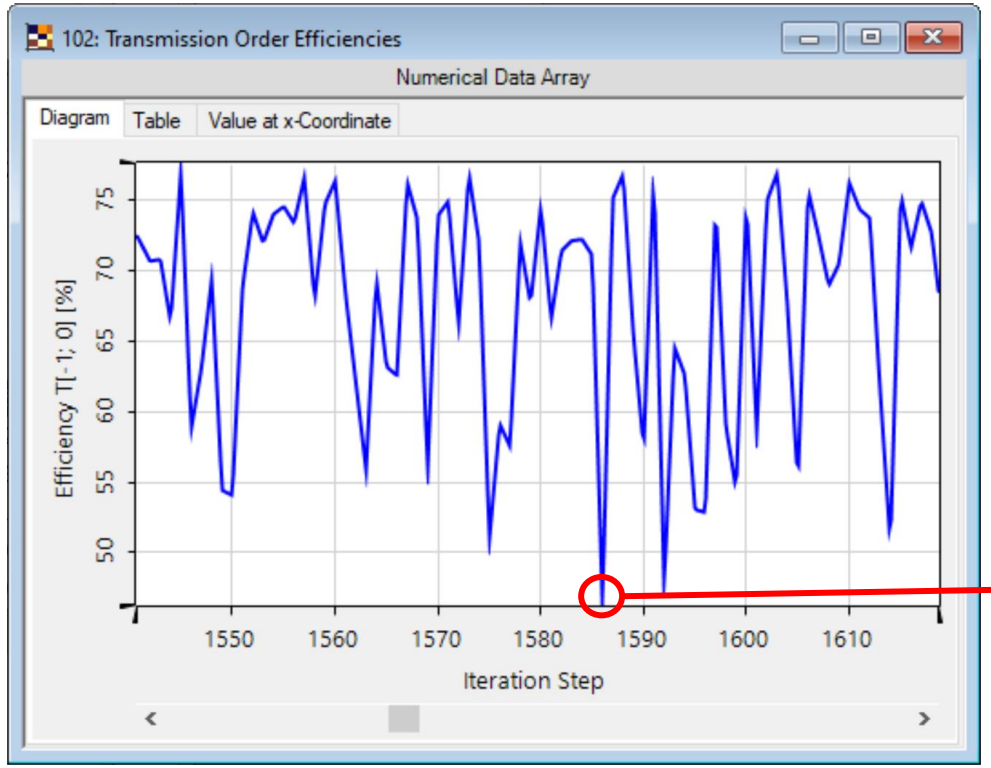
Statistical Distribution of the Efficiency

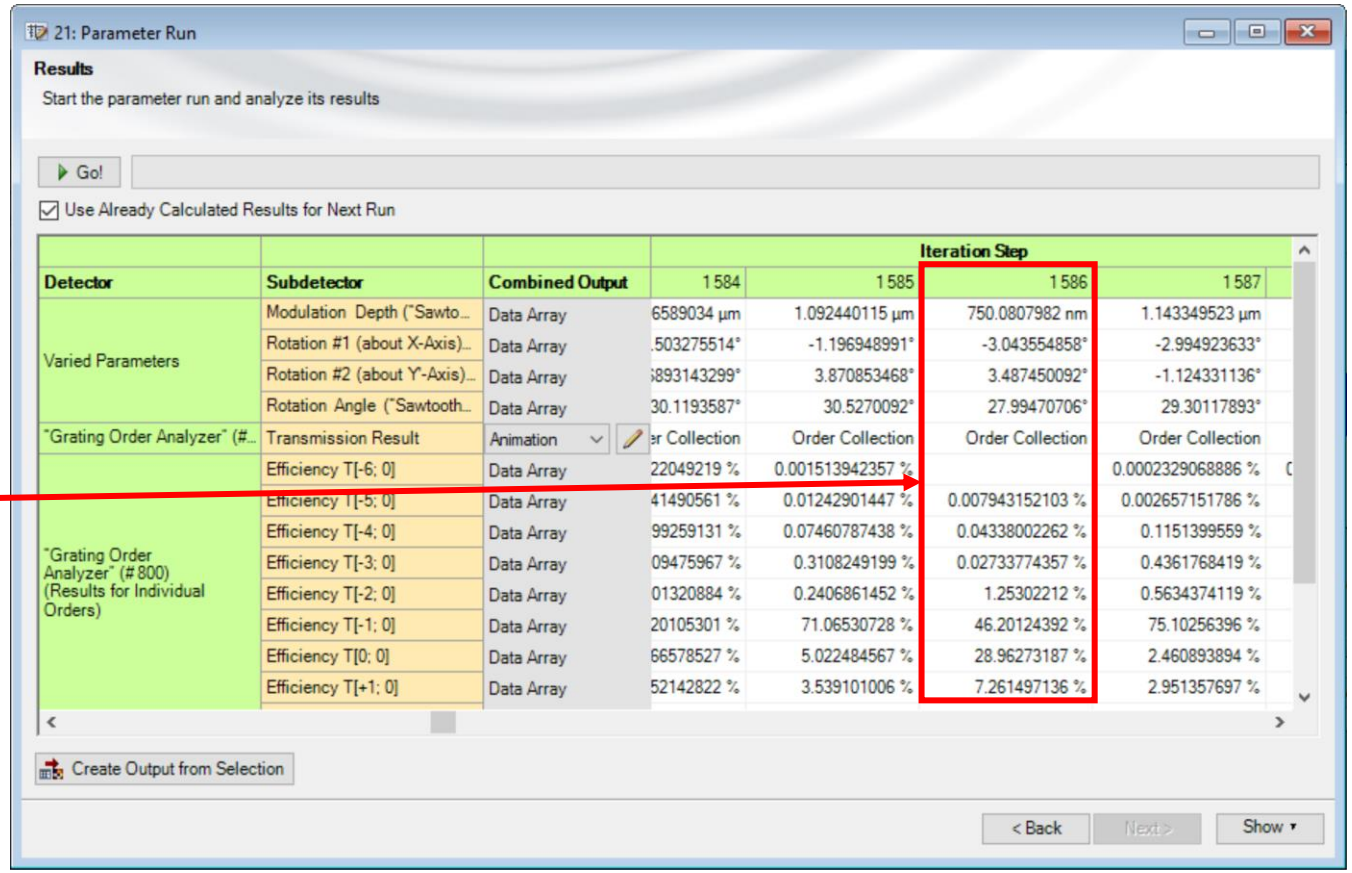


From the Parameter Run result it is possible to get an overview of the statistical distribution and range in which the efficiency of the order lies with the Histogram Detector (under Detectors in the Main Window) .



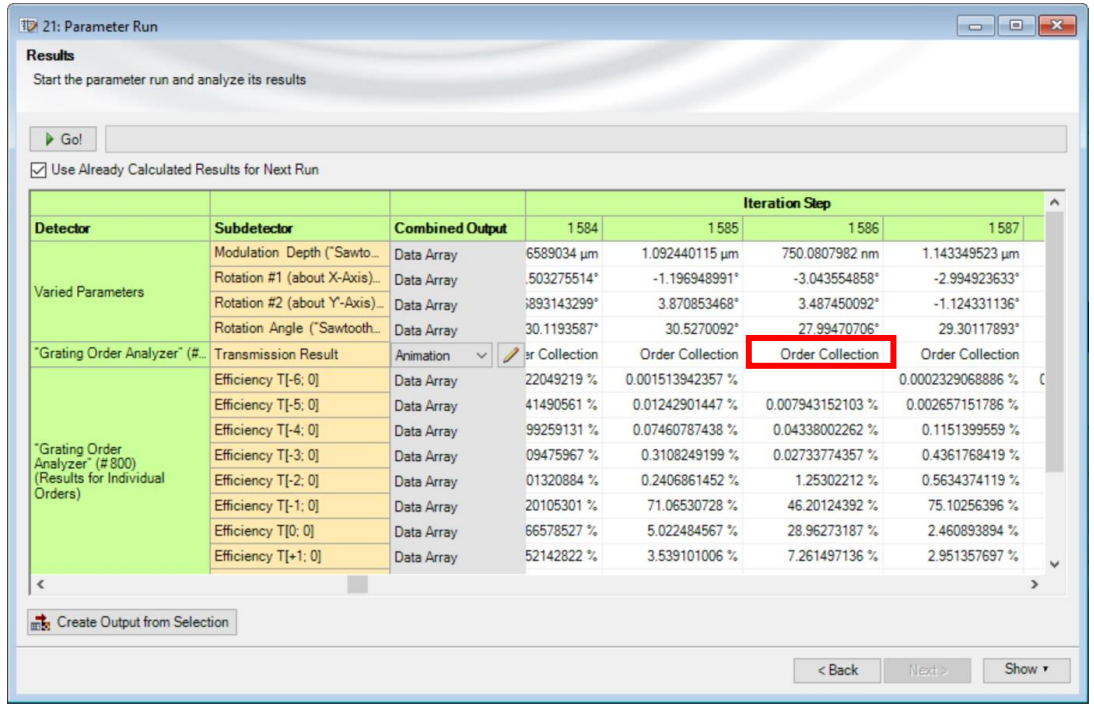
Tolerancing of the Grating

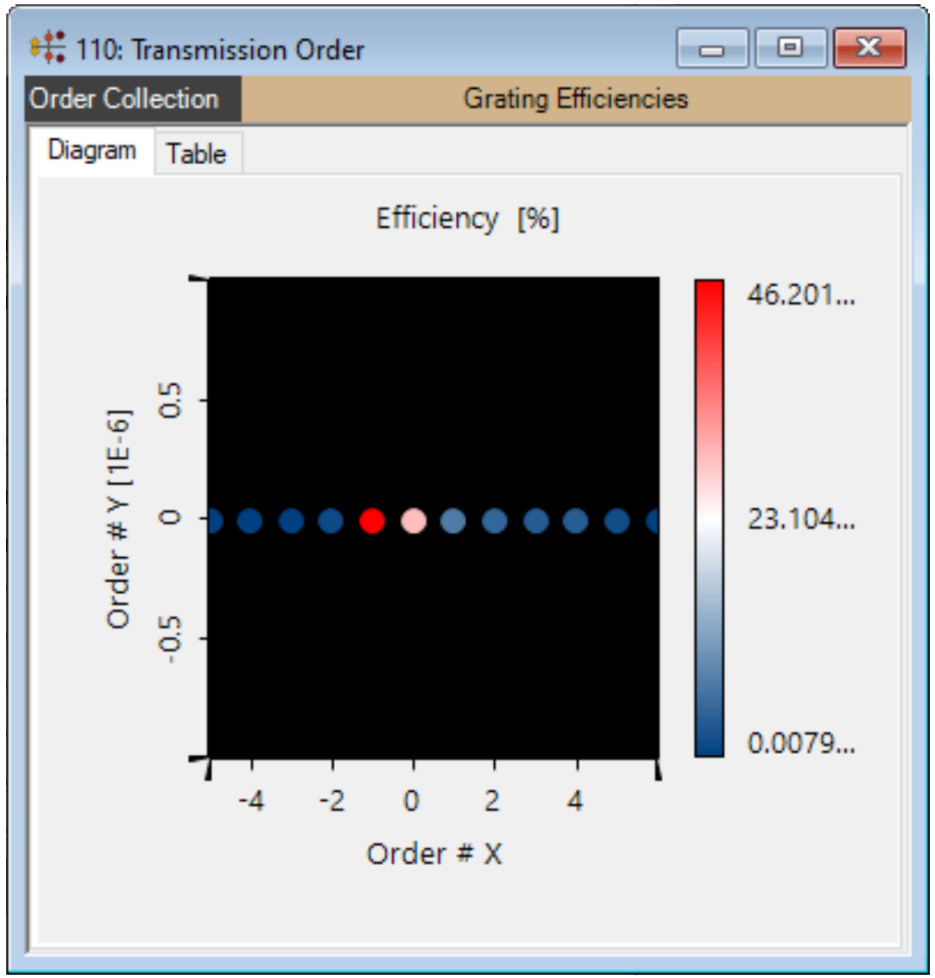




The iteration with minimal efficiency can also be determined and the results further investigated. You can use the detectors in the main window (under Detectors) to find the minimum.

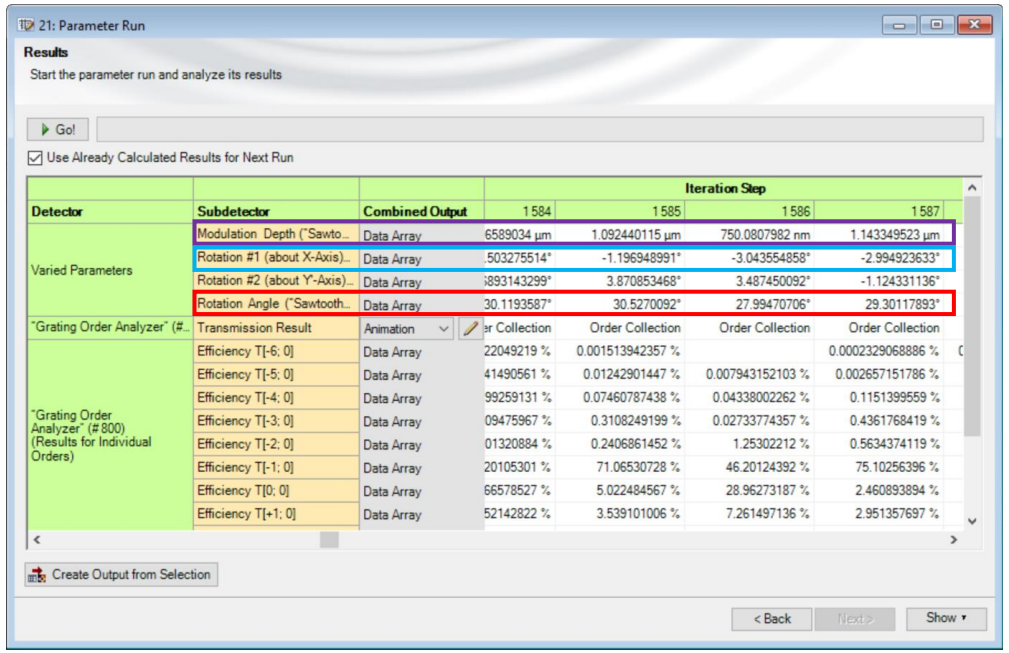
Order Efficiencies for Minimal Efficiency

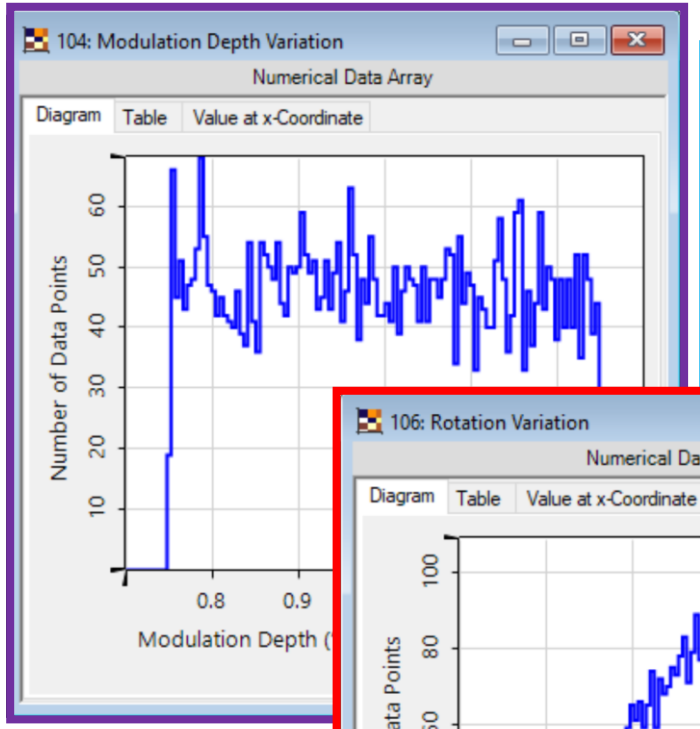


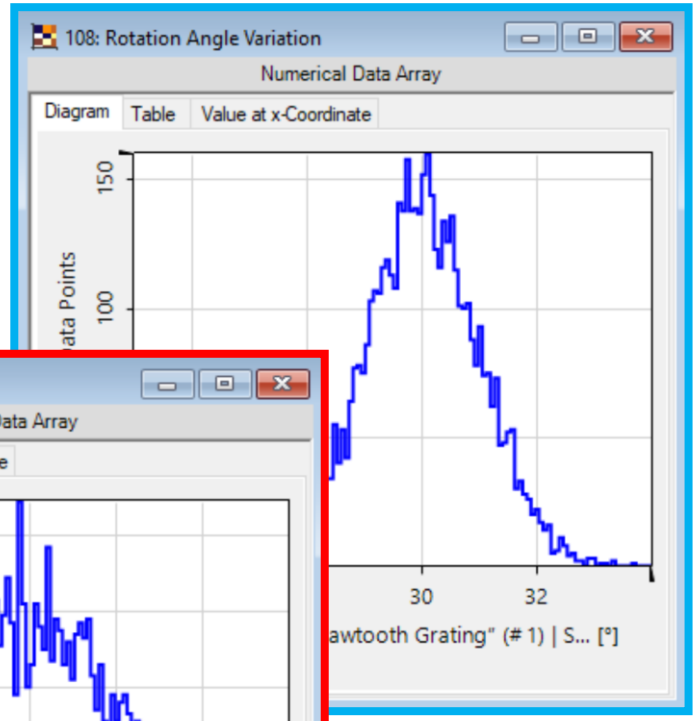


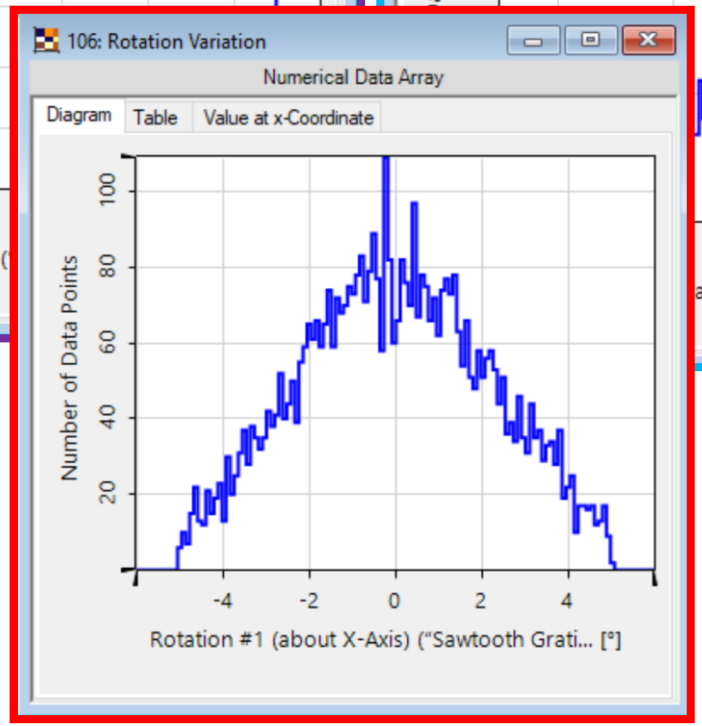
Additional information and the results of any individual iteration can be directly accessed in the Parameter Run document.

Random Distribution Types









For maximum flexibility it is possible to use different random distributions for different parameters in the same Parameter Run document.

Document Information

title	Tolerancing with Random Distributions using the Programmable Mode of the Parameter Run
document code	USP.0006
version	1.0
edition	VirtualLab Fusion Advanced
software version	2020.2 (Build 2.22)
category	Application Use Case
further reading	- Usage of the Parameter Run Document - Grating Order Analyzer