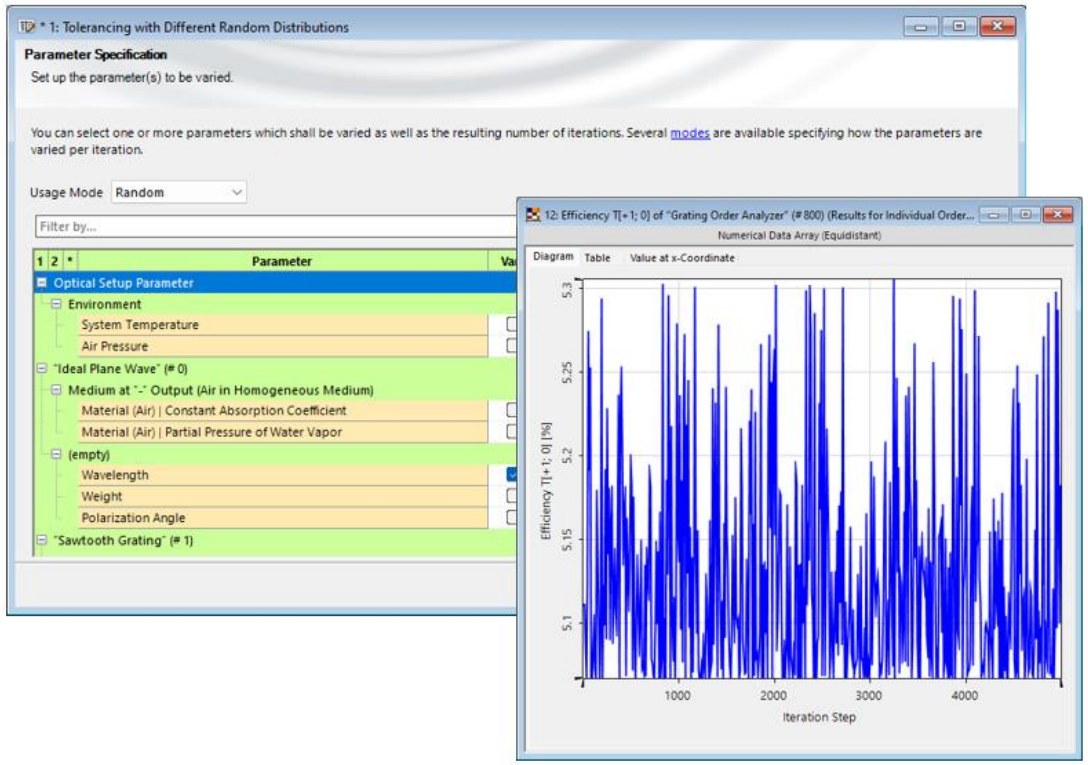
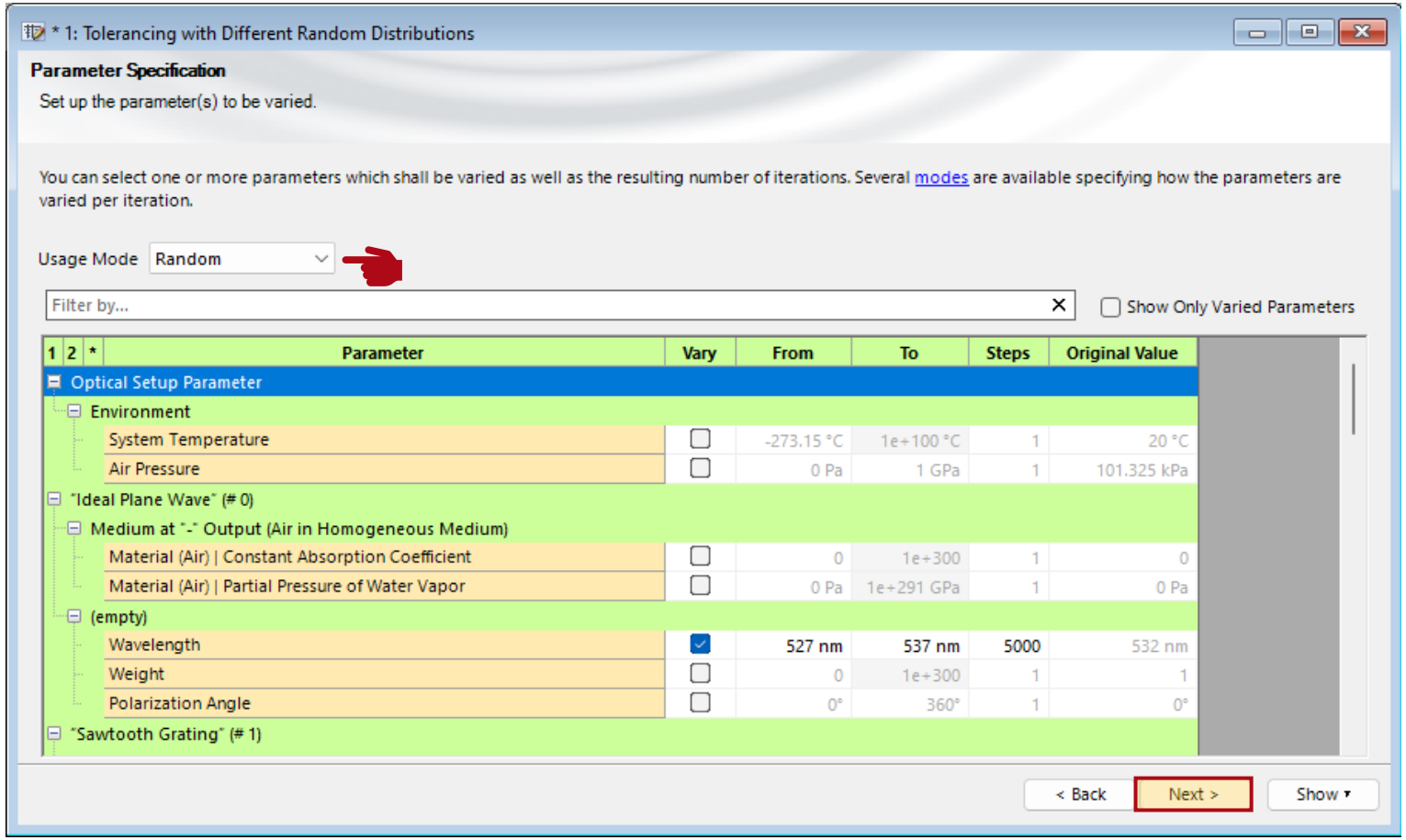
Tolerancing with Random Distributions

Abstract



For systems with many parameters, investigating tolerance can be done by randomly varying the parameters within given boundaries. VirtualLab Fusion offers various random distributions to assist optical engineers in this task. Within the Parameter Run document, users can specify uniform, normal and asymmetrical normal distributions for the parameters.

Where to find the Components?

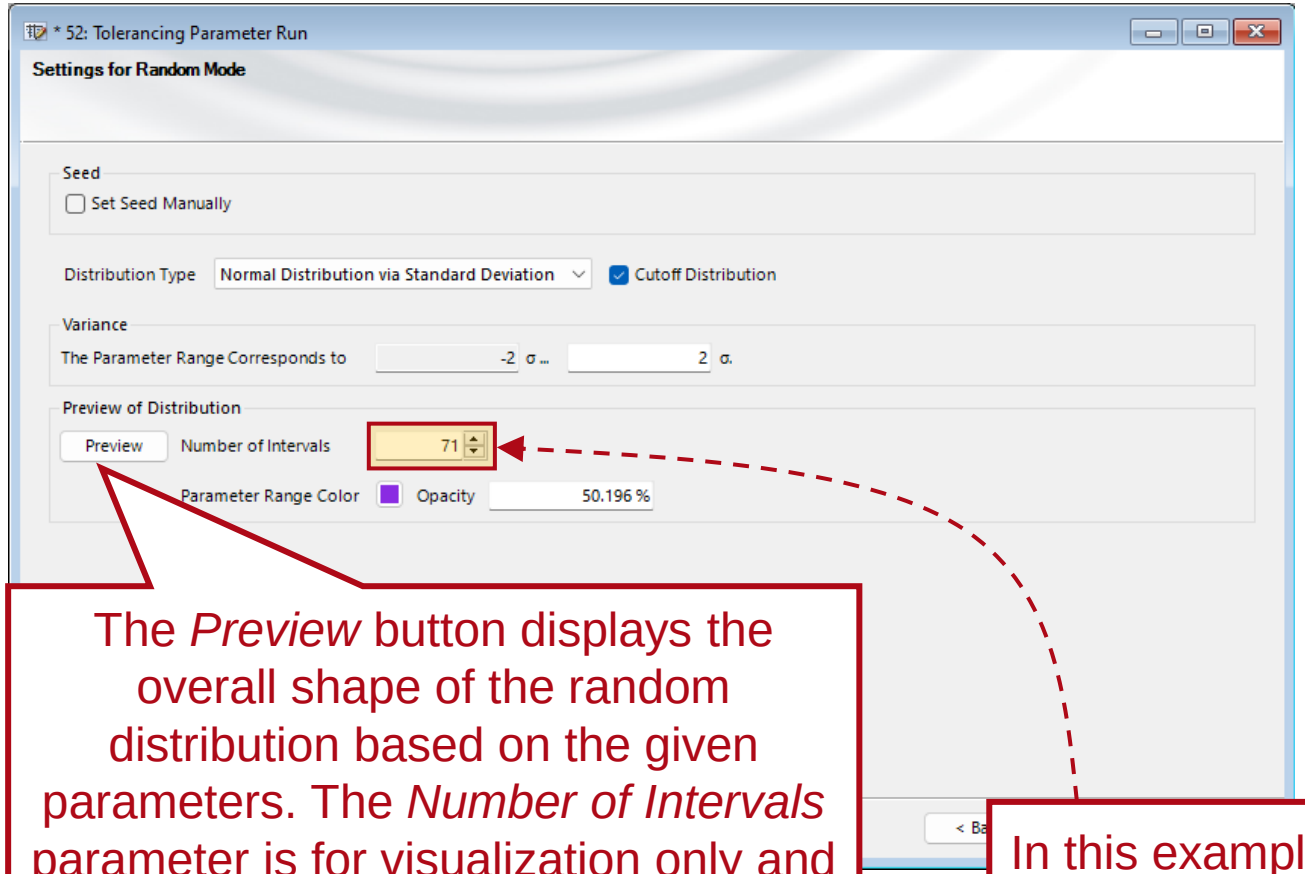


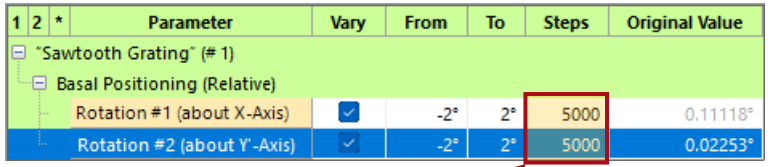
The *Property Browser* can be found at the right side of the main window. It shares the same panel with the *VirtualLab Explorer*, the *Assistant* and *Distributed Computing*.

The displayed options and properties are dependent on the type of active* document (e.g., data array, optical setup etc.).

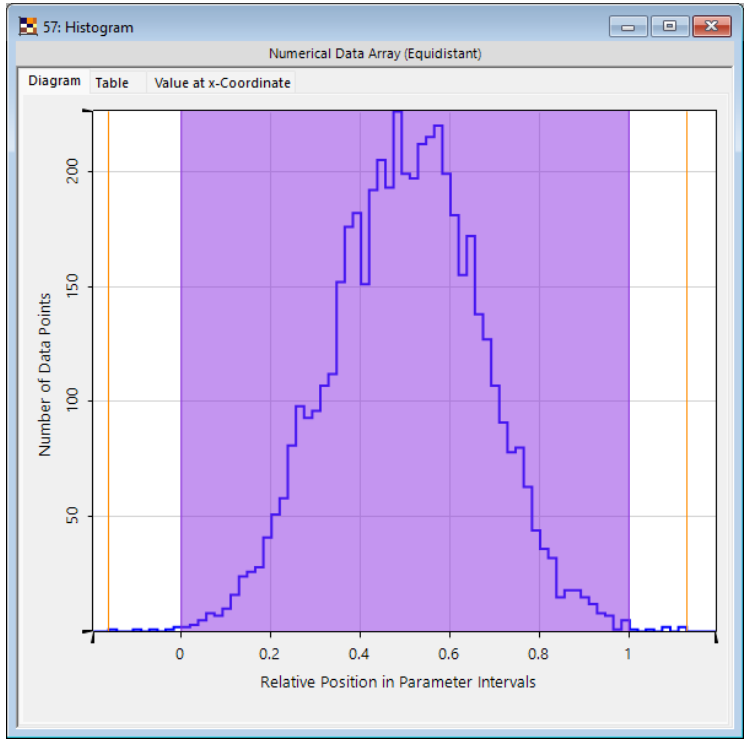
**The active document is the last document the user have clicked on.*

Preview of the Distribution





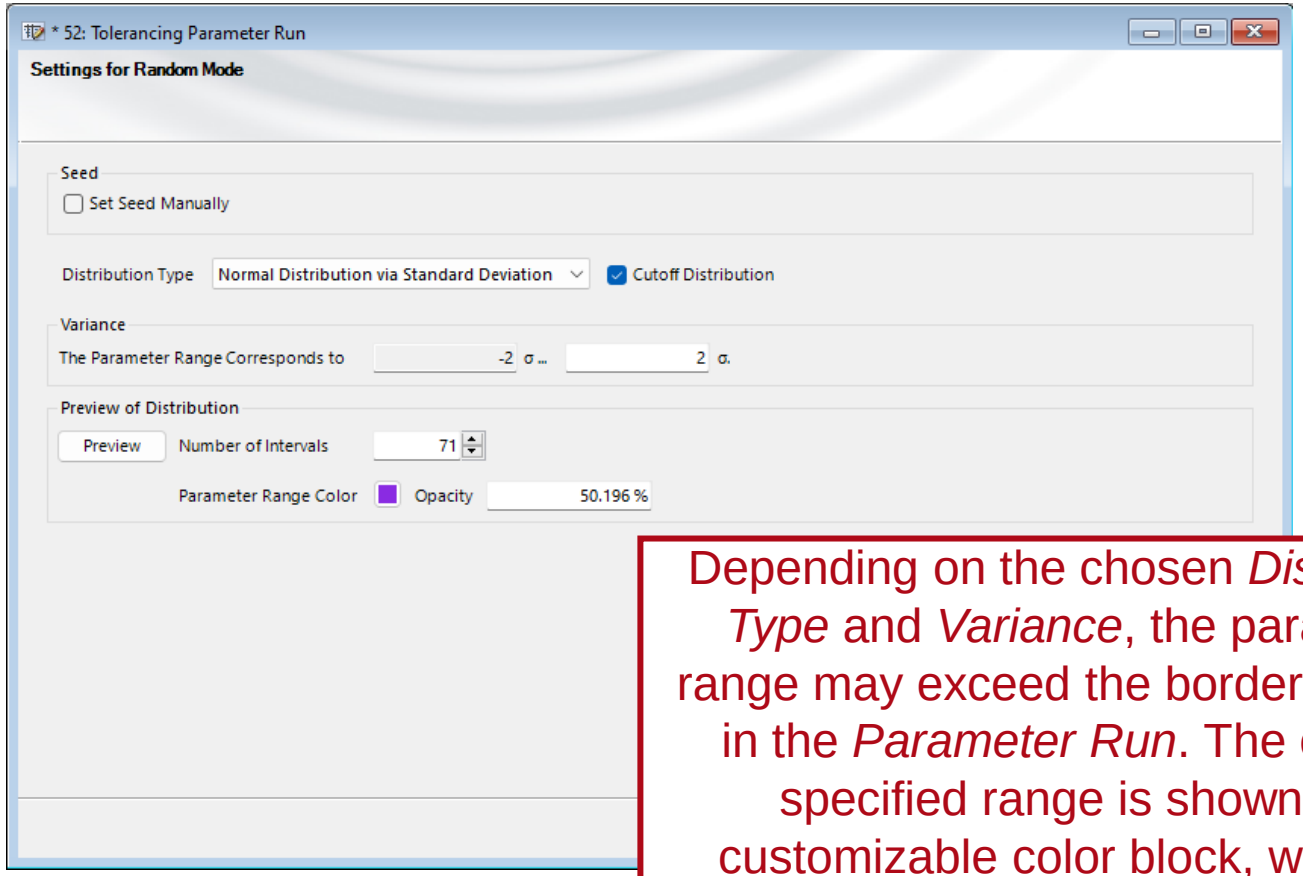
1 2 *	Parameter	Vary	From	To	Steps	Original Value
	"Sawtooth Grating" (# 1)					
	Basal Positioning (Relative)					
	Rotation #1 (about X-Axis)	☑	-2°	2°	5000	0.11118°
	Rotation #2 (about Y'-Axis)	☑	-2°	2°	5000	0.02253°

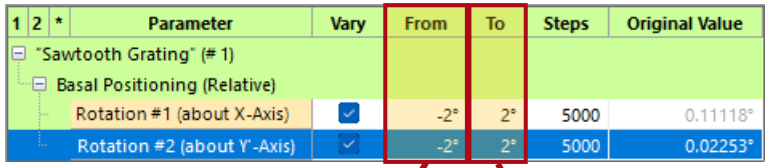


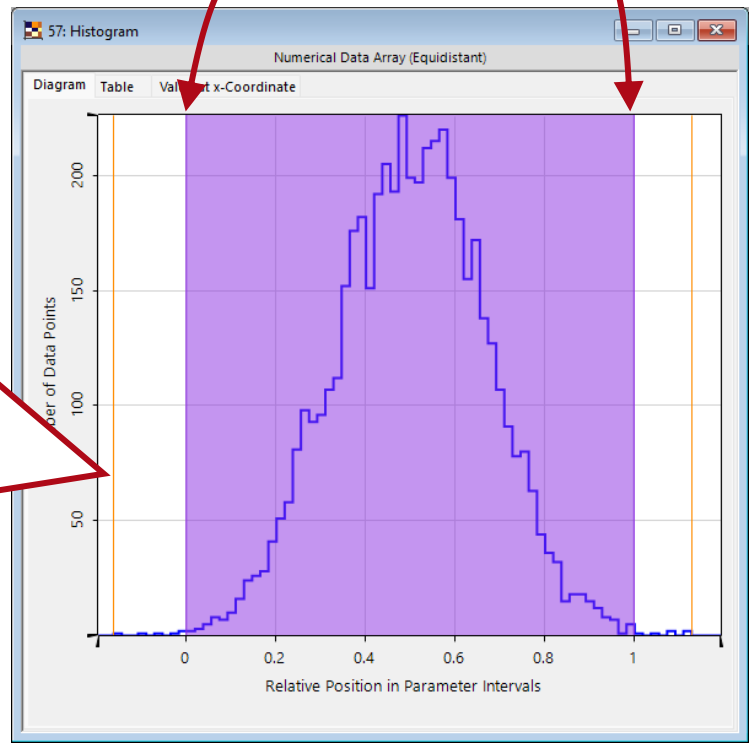
The *Preview* button displays the overall shape of the random distribution based on the given parameters. The *Number of Intervals* parameter is for visualization only and does not affect the number of iterations, which is defined in the *Steps* column on the previous page.

In this example, only 71 intervals are displayed, but the Parameter Run will iterate 5000 times.

Preview of the Distribution

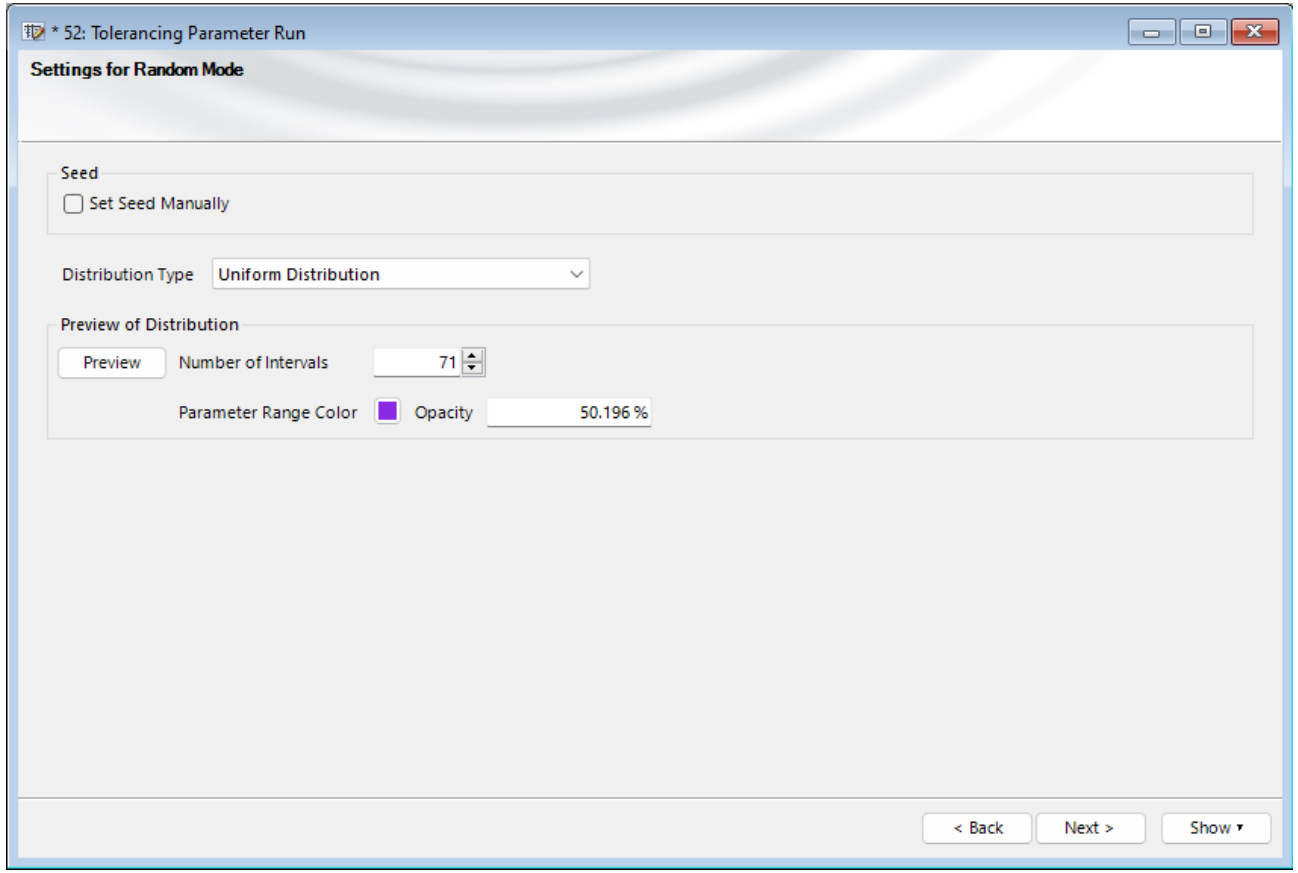


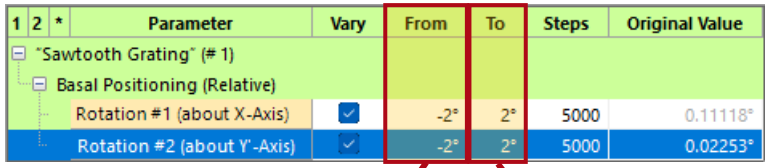


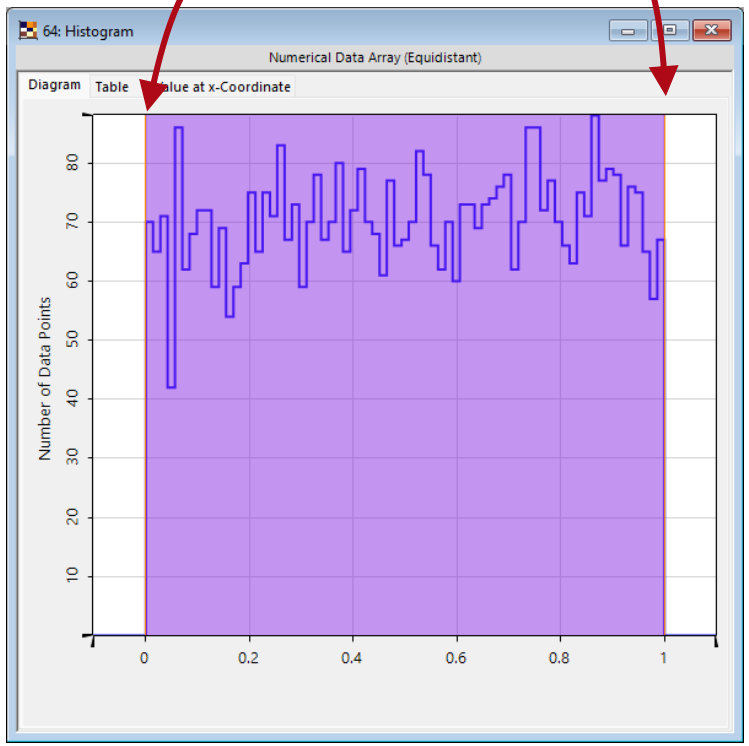


Depending on the chosen *Distribution Type* and *Variance*, the parameter range may exceed the borders defined in the *Parameter Run*. The original specified range is shown in a customizable color block, while the actual range is indicated by two yellow lines. The *Cutoff Distribution* parameter can prevent this overflow.

Uniform Distribution

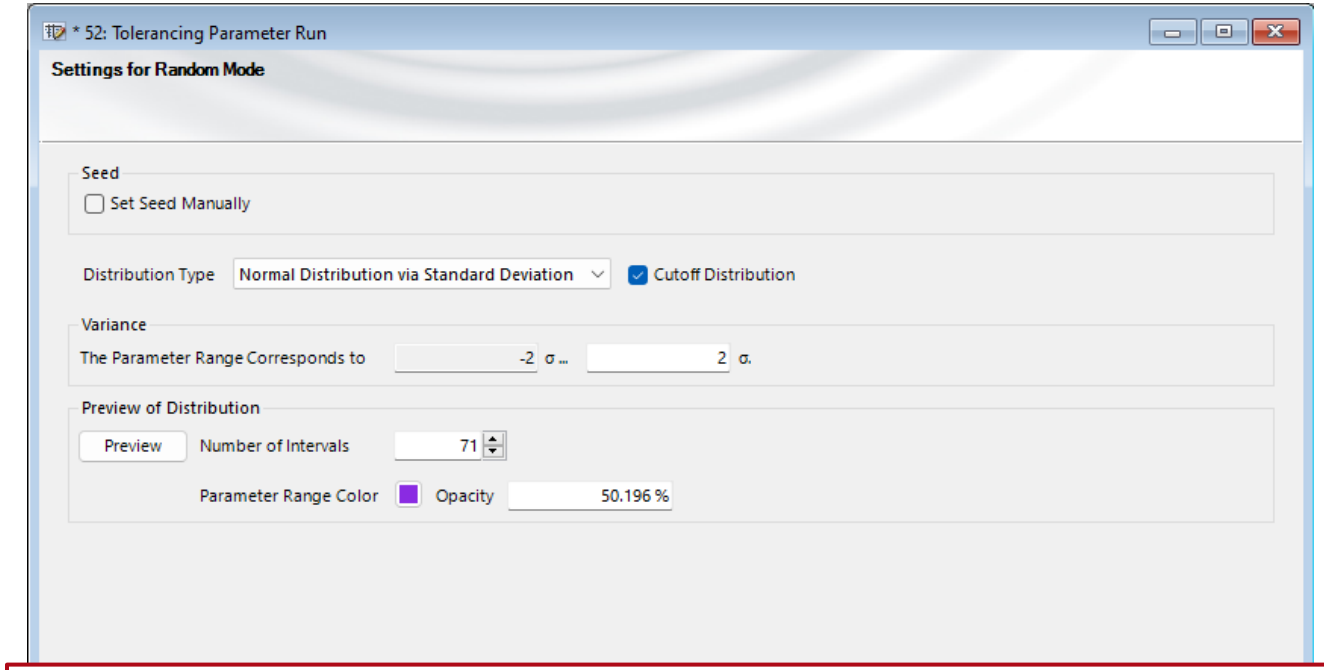


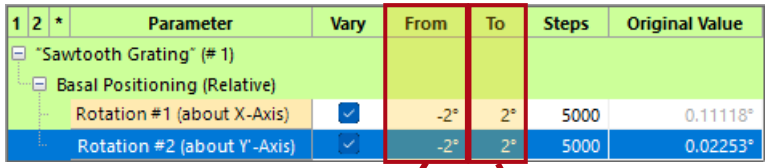


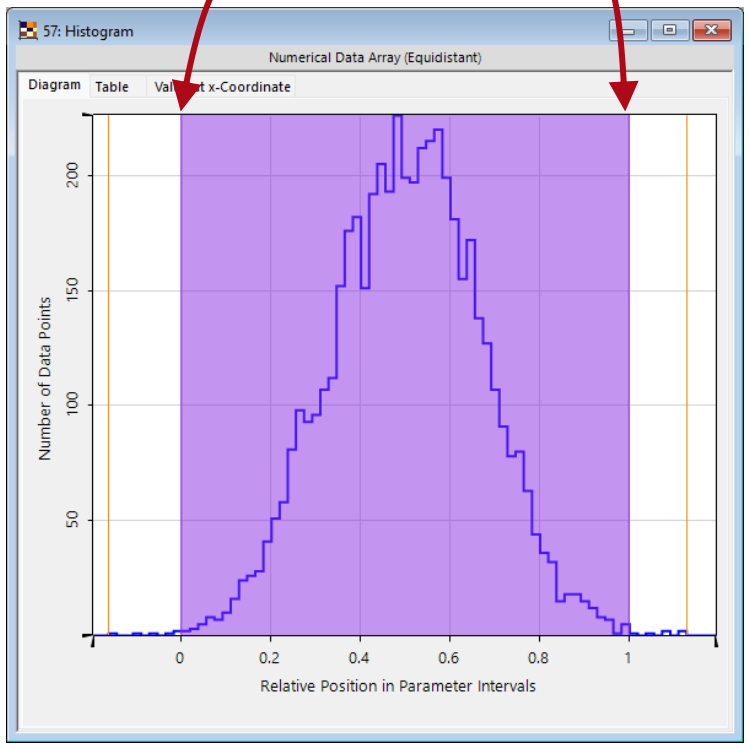


For a *Uniform Distribution*, all values in the parameter range have the same probability of being chosen by the random function.

Normal Distribution via Standard Deviation





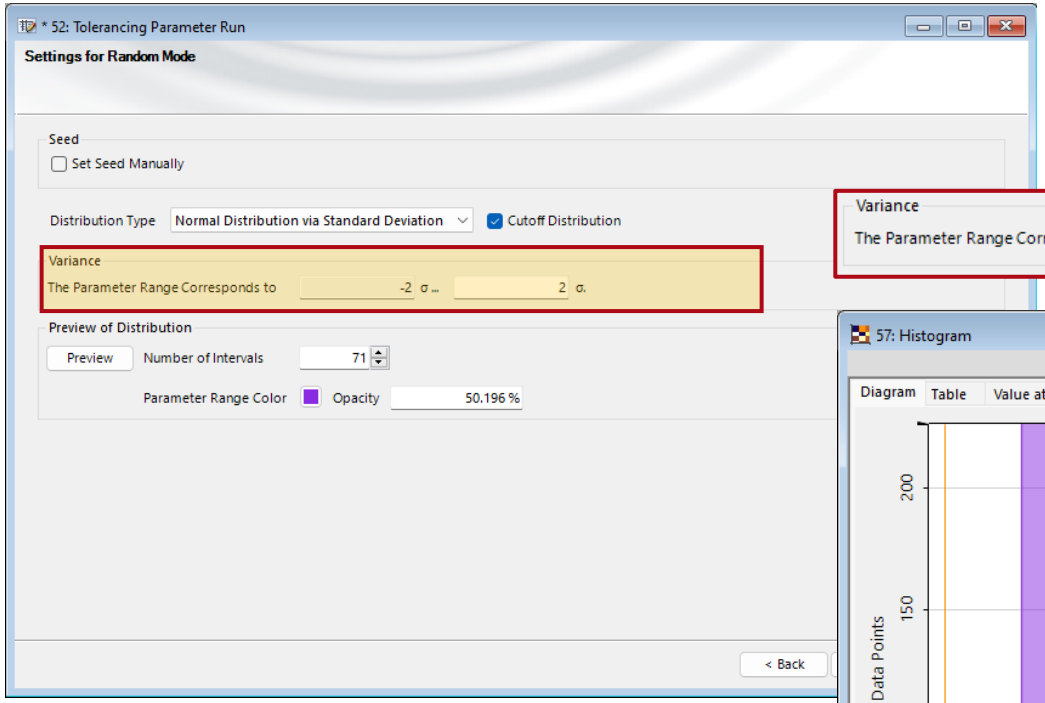


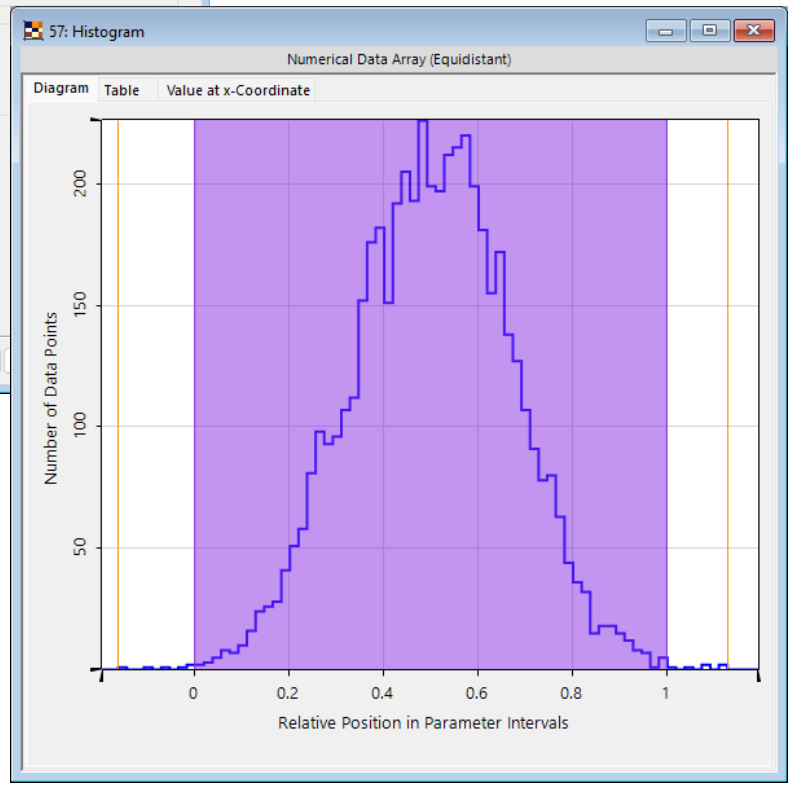
Normal distribution via Standard Deviation follows the formula of a Gaussian normal distribution:

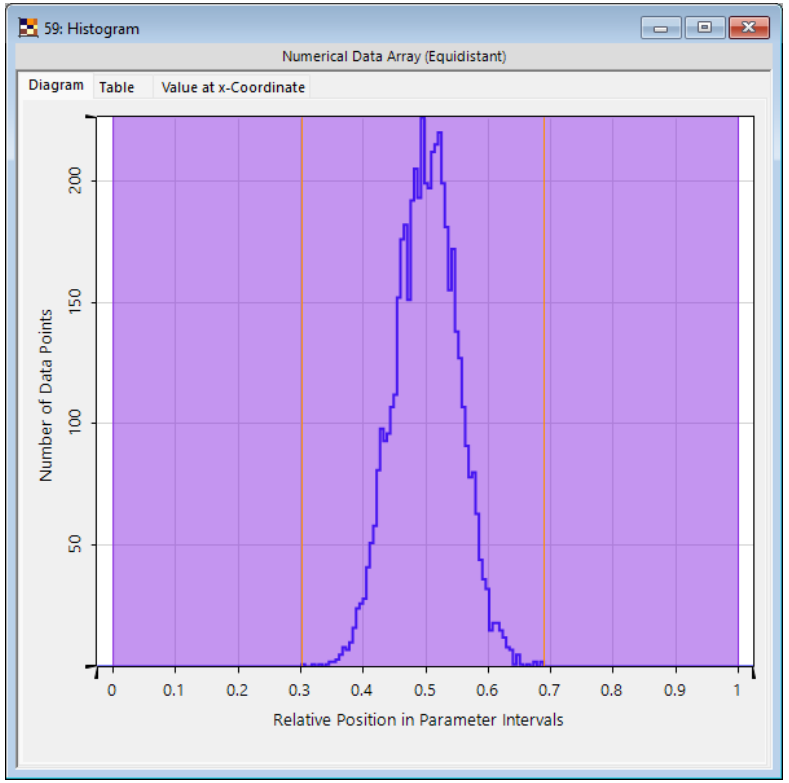
$$f(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\nu)^2}{2\sigma^2}}$$

with μ being determined as the center of the parameter range.

Normal Distribution – Parameter Range

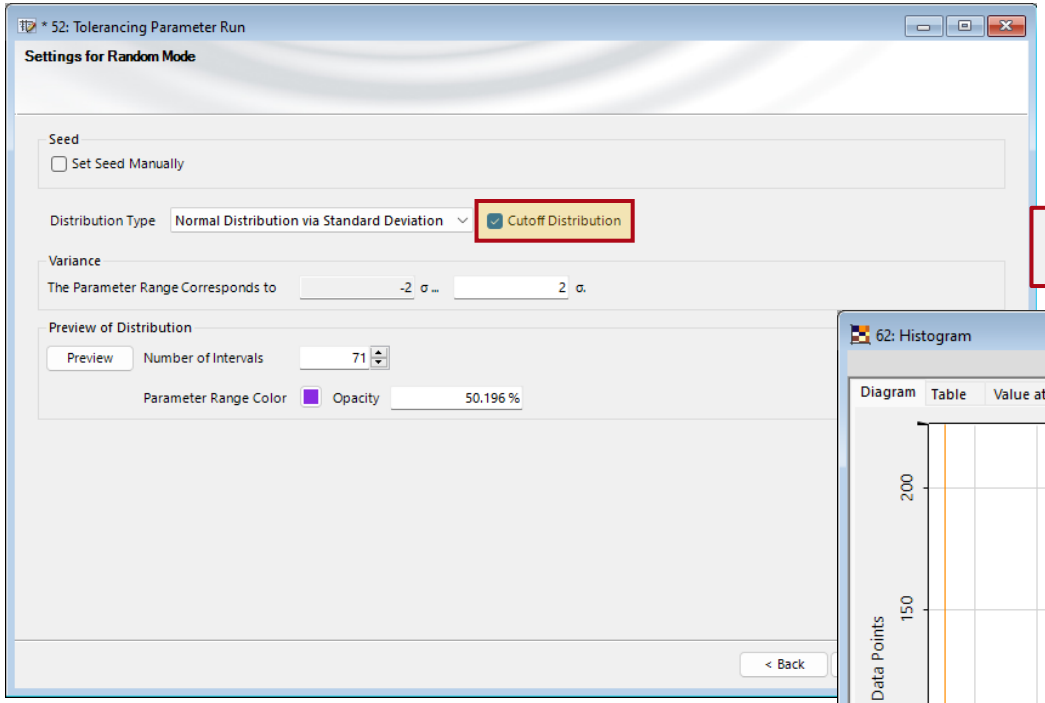


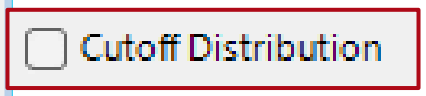


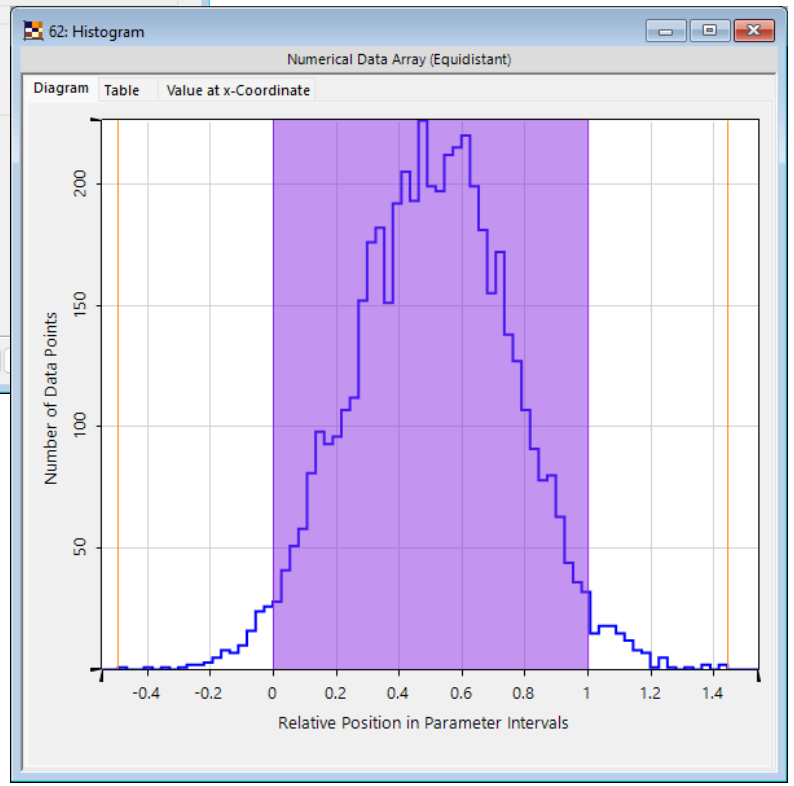


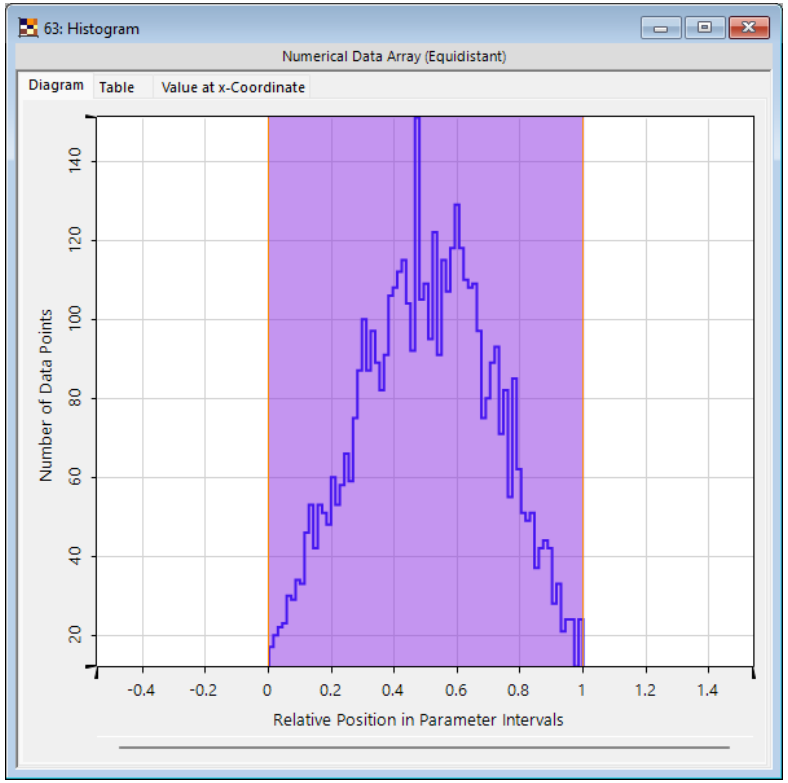
For this random distribution the user specifies the factor between parameter range and the standard deviation.

Normal Distribution – Cutoff Distribution

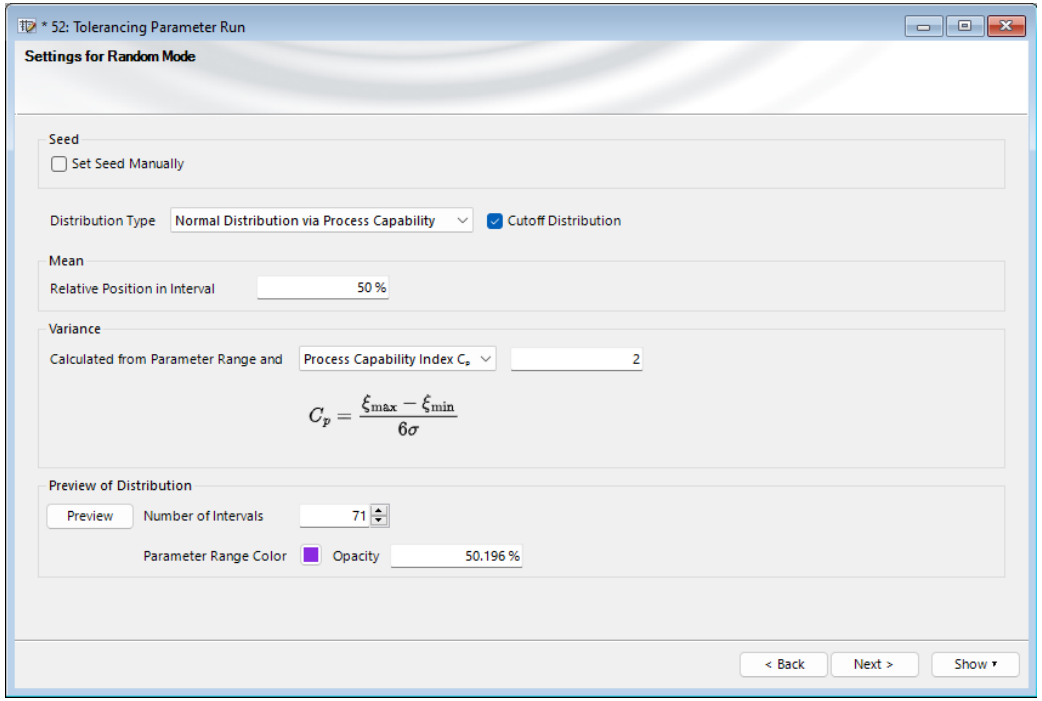


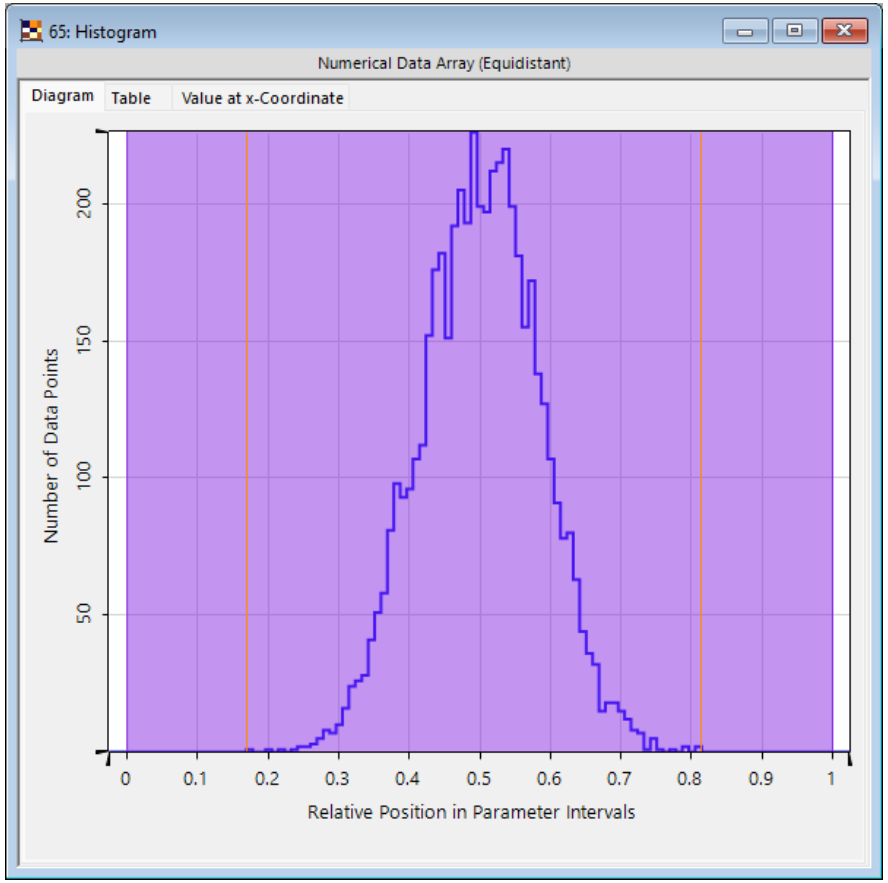






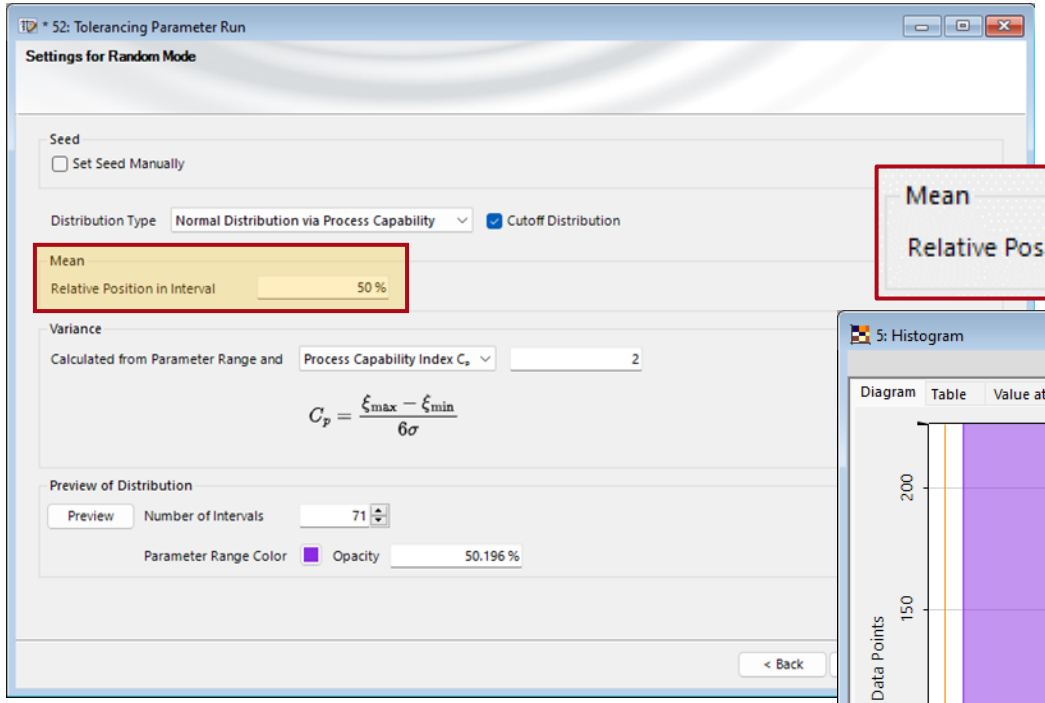
Normal Distribution via Process Capability

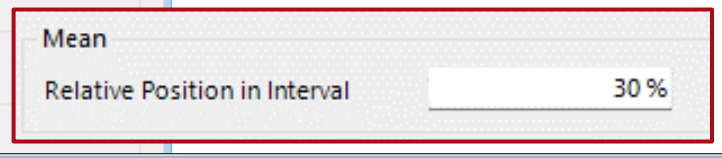


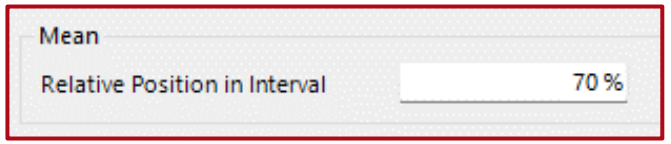


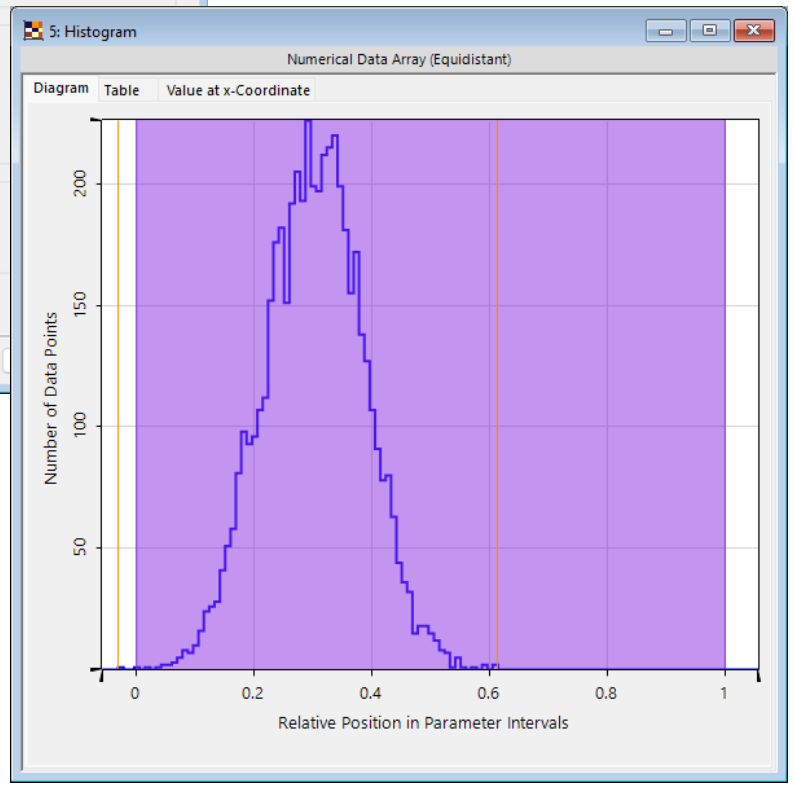
An asymmetrical normal distribution can be defined by *Process Capability*. Here the user can specify the mean μ and the *Process Capability* Indices to calculate the standard deviation.

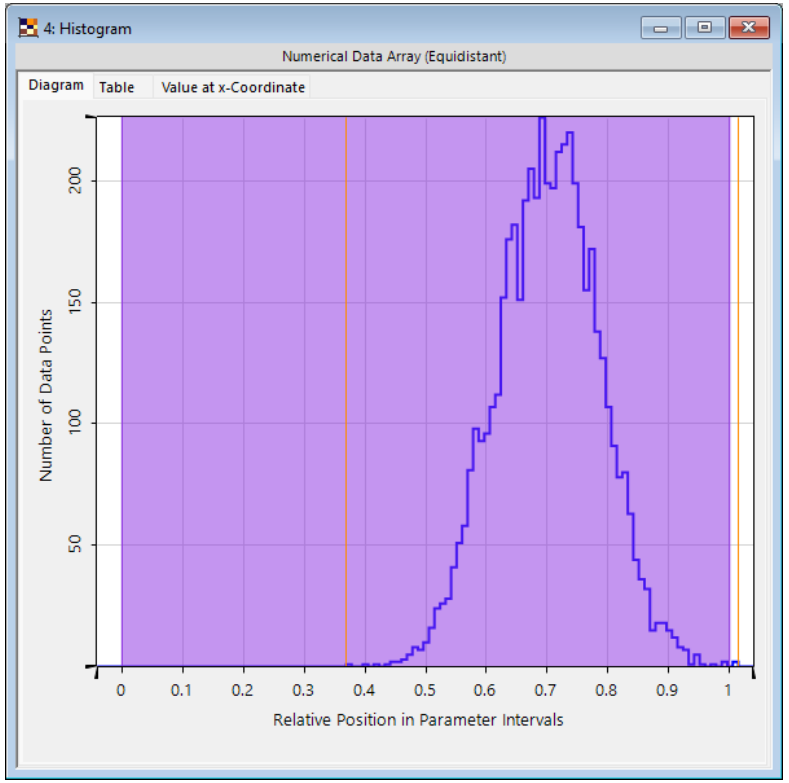
Normal Distribution – Relative Position in Interval





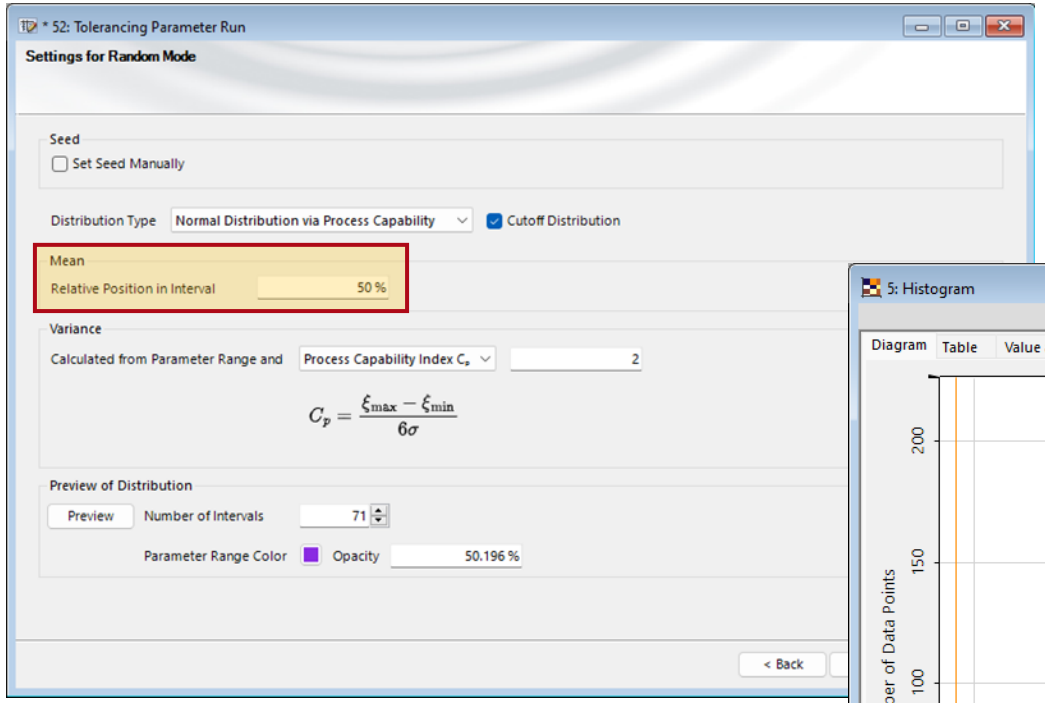




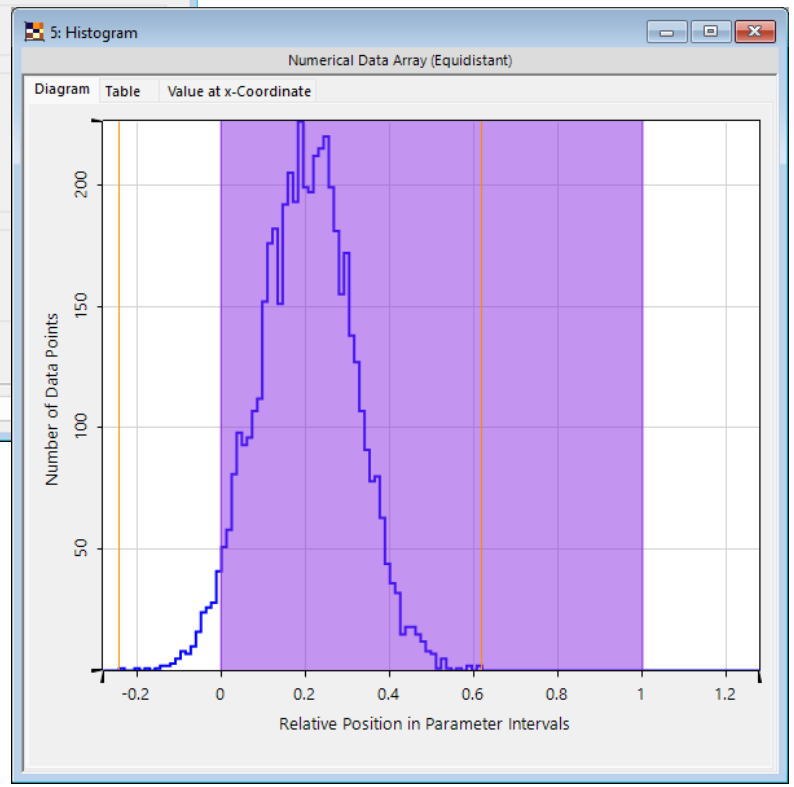


Contrary to the symmetric case, in the asymmetric case the mean can be determined by the user.

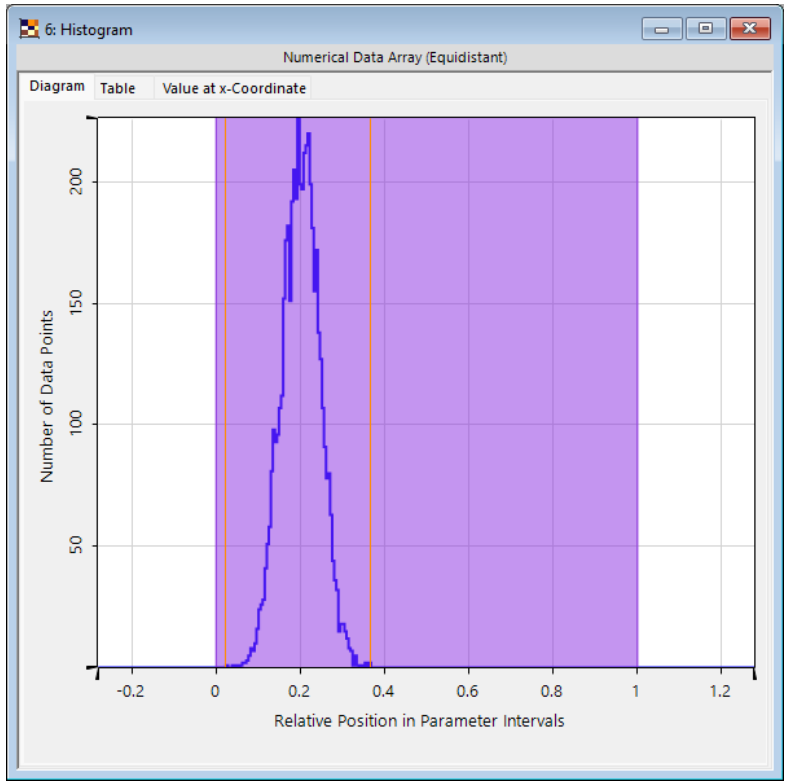
Normal Distribution – Process Capability index



Process Capability knows to different indices C_p and C_{px} to define the standard deviation. In case of the former the standard deviation is independent of the mean position, while in the latter it is depended.



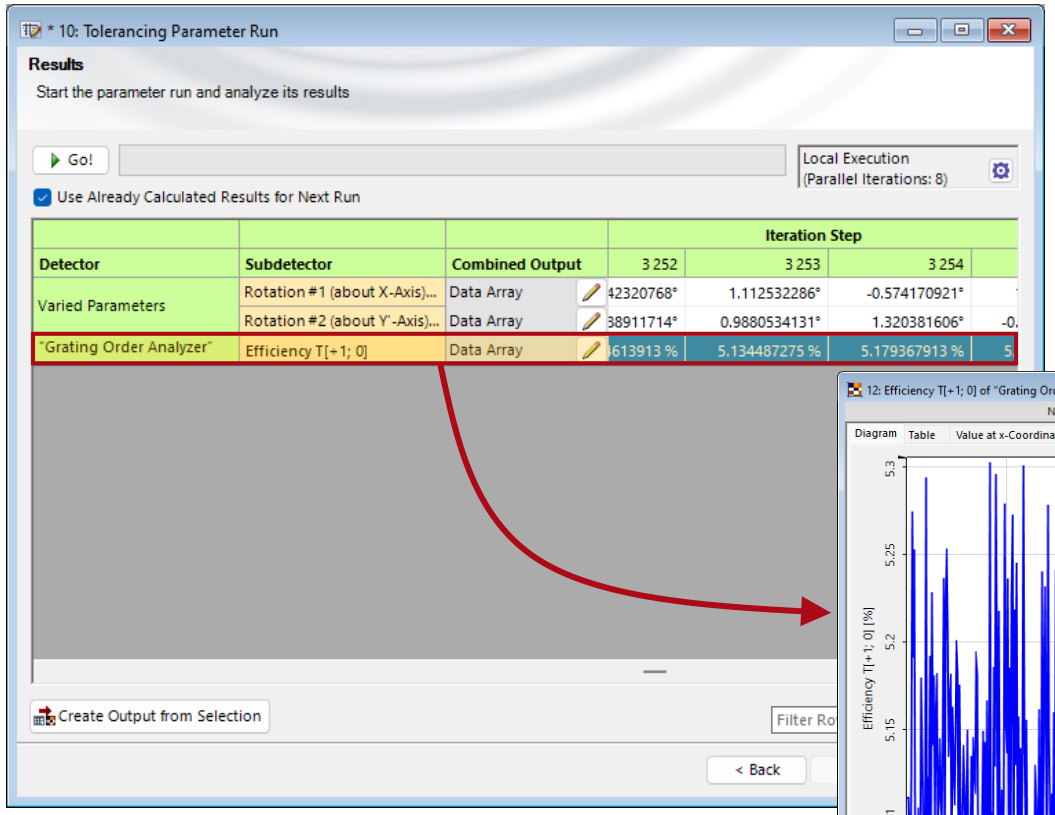
C_p

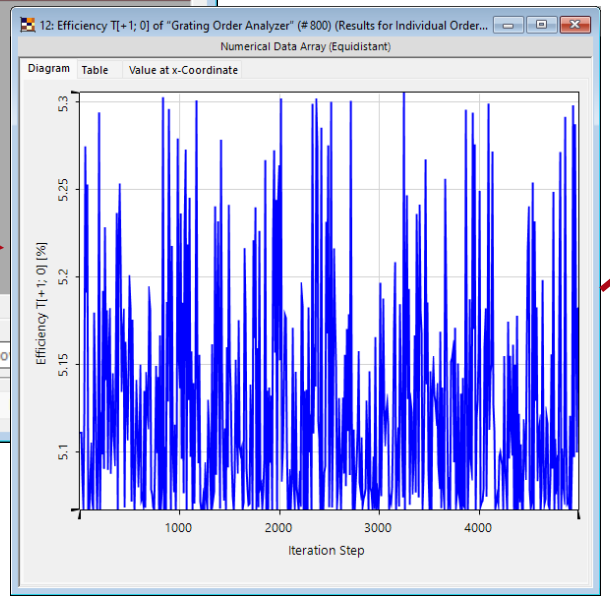


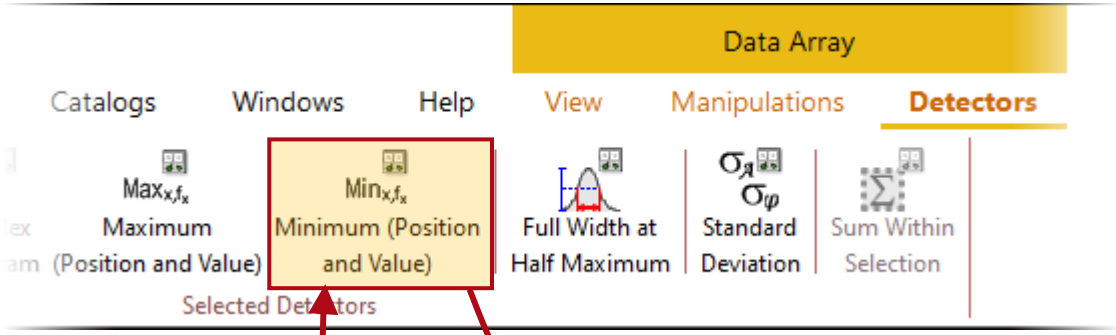
C_{px}

Analysis of the Result

To e.g. find the minimum efficiency of a specific grating which has been tilted between -2°/2°:







Minimum Value of 'Efficiency T[+1; 0]'	5.0667 %
Minimum Position of 'Efficiency T[+1; 0]'	2620

Document Information

title	Tolerancing with Random Distributions
document code	SWF.0057
document version	1.0
required packages	-
software version	2024.1 (Build 1.132)
category	Feature Use Case
further reading	