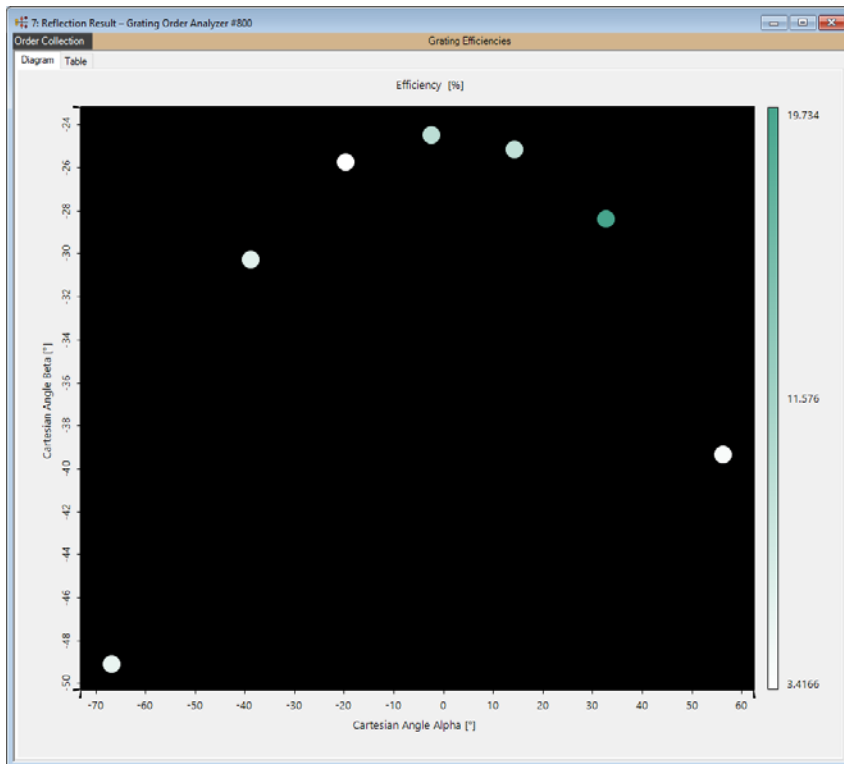# Grating Order Analyzer

Abstract

The analysis of the diffraction efficiencies of gratings is the typical modeling task with gratings. The efficiencies follow from the Rayleigh coefficients. Both quantities are given for each of the diffraction orders of a grating. VirtualLab Fusion enables the calculation of efficiencies and Rayleigh coefficients by the fully vectorial Fourier modal method (FMM). This is done by the Grating Order Analyzer, which can display the efficiencies and Rayleigh coefficients of the distinct orders in various ways.

Discrete Orders Generated by a Grating
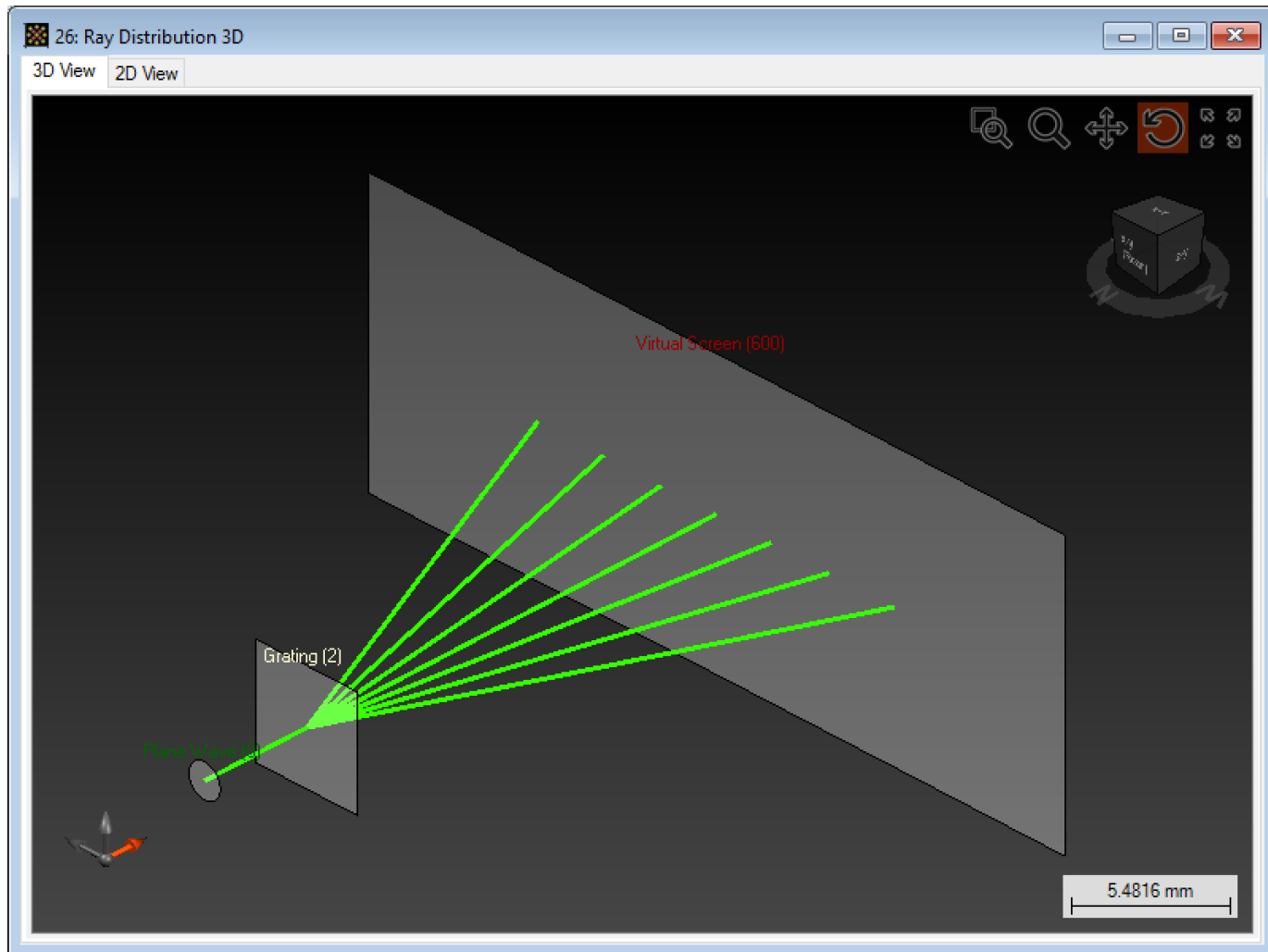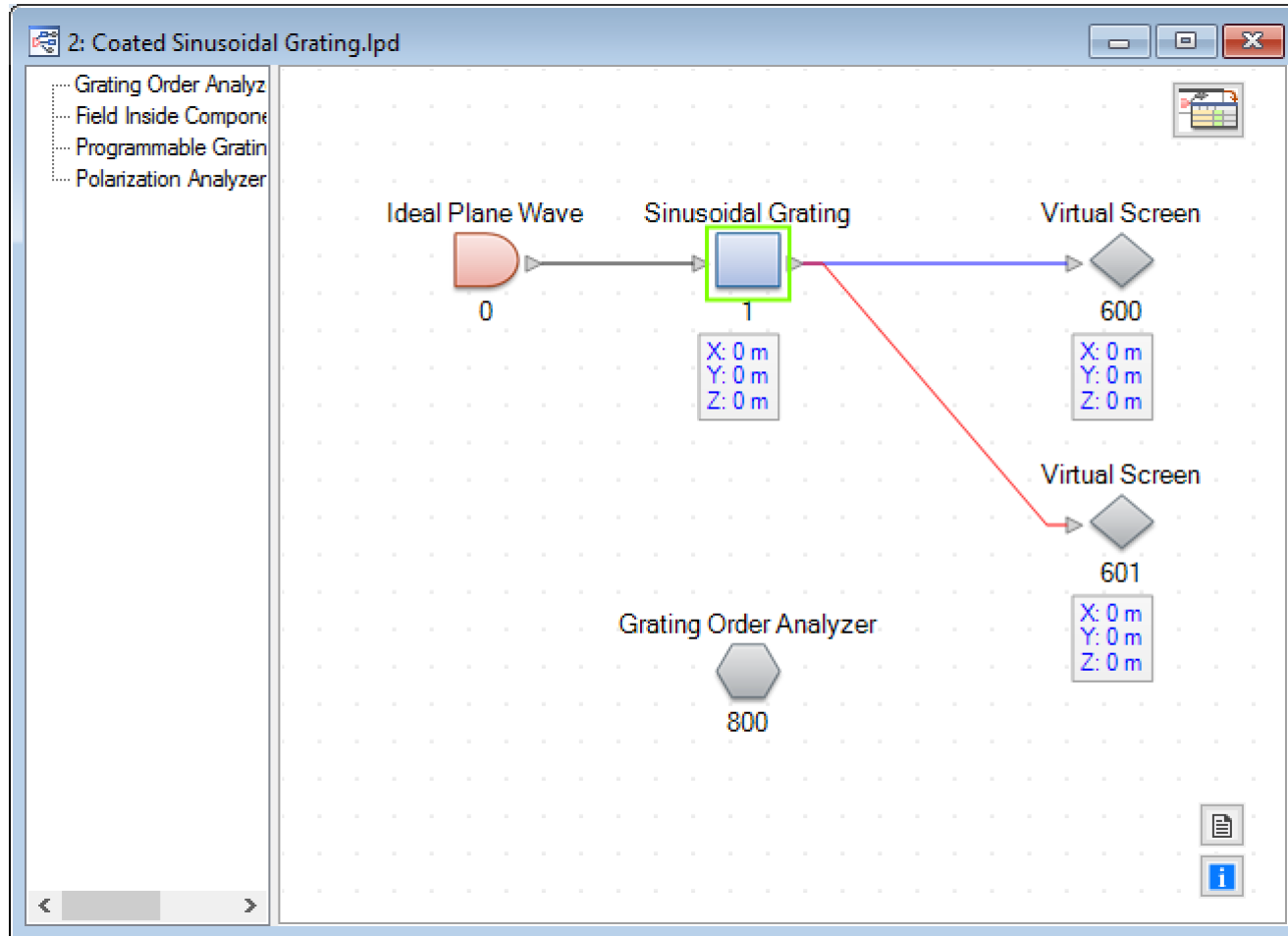
Grating Orders

- When a grating is illuminated with a laser beam, it generates a set of discrete orders depending on the period.

- The deflection of the grating orders is defined by the two-dimensional grating equation.

- The grating structure as well as the incident light determine the efficiencies of the orders.

- The efficiencies can be calculated by the Fourier modal method available in VirtualLab.

- If a linear grating is illuminated under an angle (conical incidence) the scattered orders of the grating are in general not distributed on a straight line.

- This is also included in the simulation of grating systems in VirtualLab.
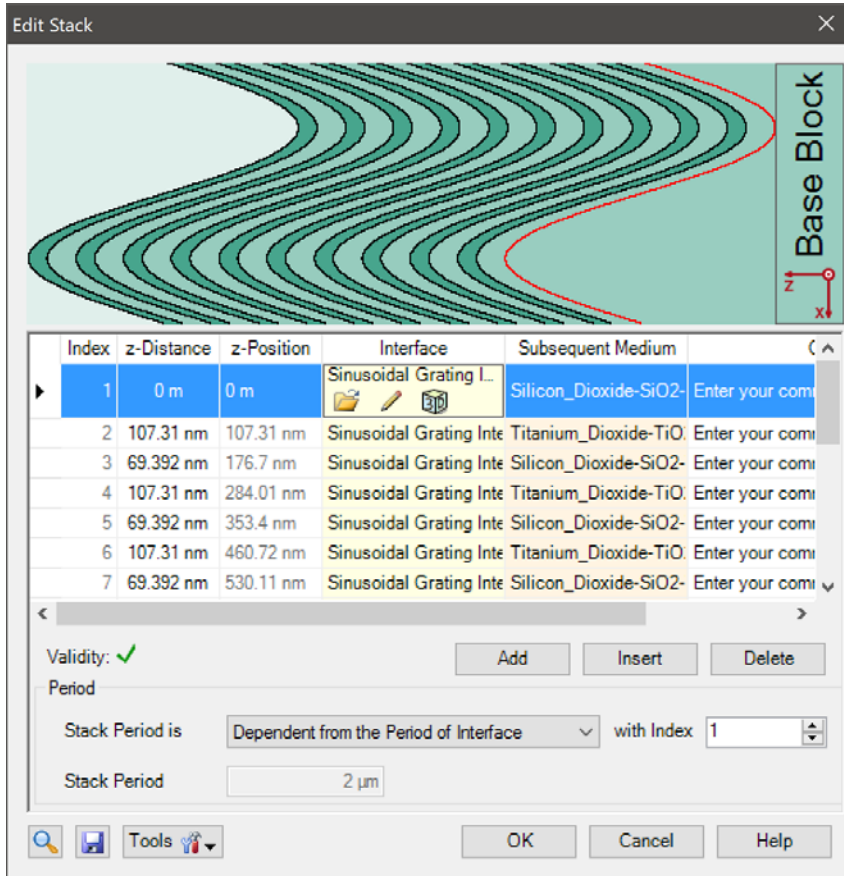
Conical Incidence on a Grating
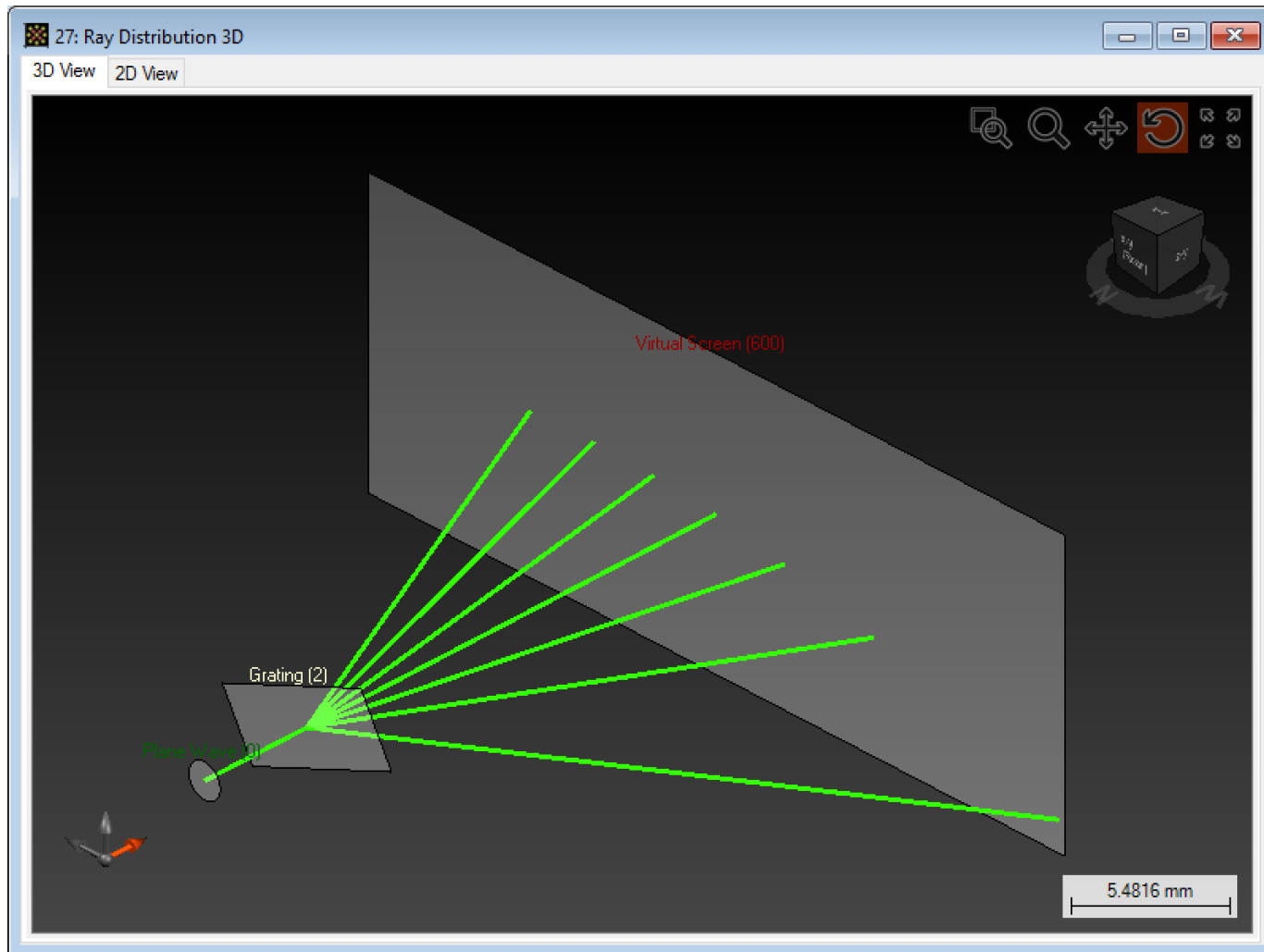
Applied VirtualLab Techniques and Tools

Sample File


Filename: Coated Sinusoidal Grating.lpd

Grating Specification

- For the demonstration of the Grating Order Analyzer for 1D gratings we use a coated sinusoidal grating.

- The grating parameters can be specified within the stack that can be accessed in the edit dialog of the grating component.

Grating Order Analyzer

- After the grating structure has been defined you can configure the grating order analyzer.

- Various output options can be specified.

- This is done through the edit dialog of the analyzer which is opened by double clicking on the light path element in the light path view.


Double Click
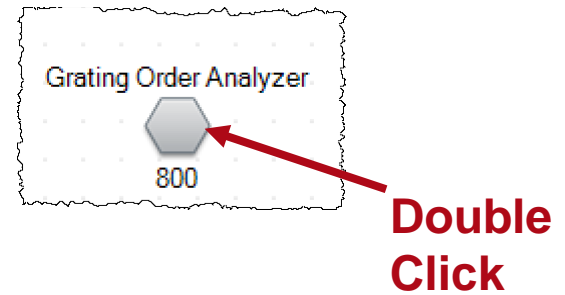
- The options of the analyzer will be explained in the following slides.

Grating Order Analyzer
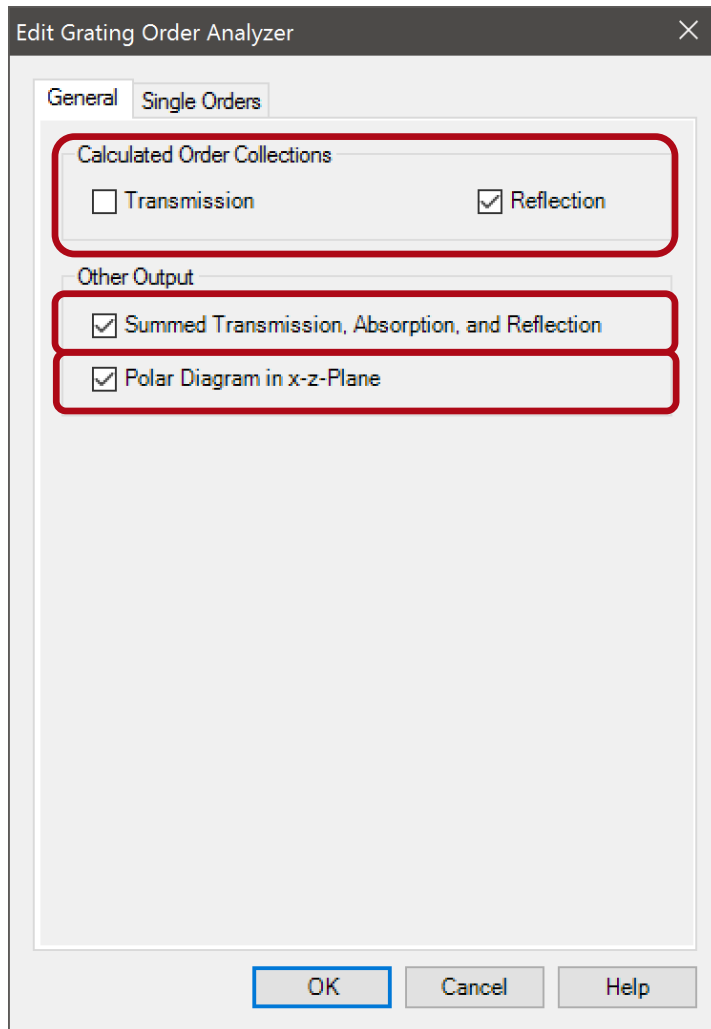
- In the *General* tab page you can select whether transmission and/or reflection shall be analyzed.

- In addition you can specify whether you would like to evaluate the summed transmission, absorbtion and reflection values and whether you would like to show a polar diagram.
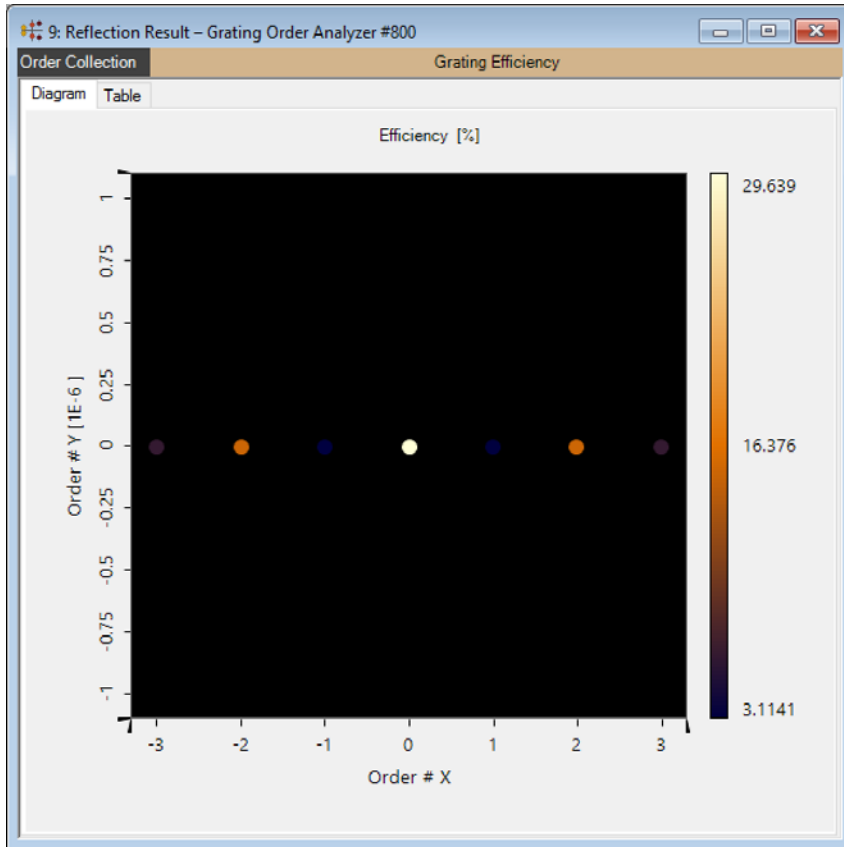
Grating Order Analyzer
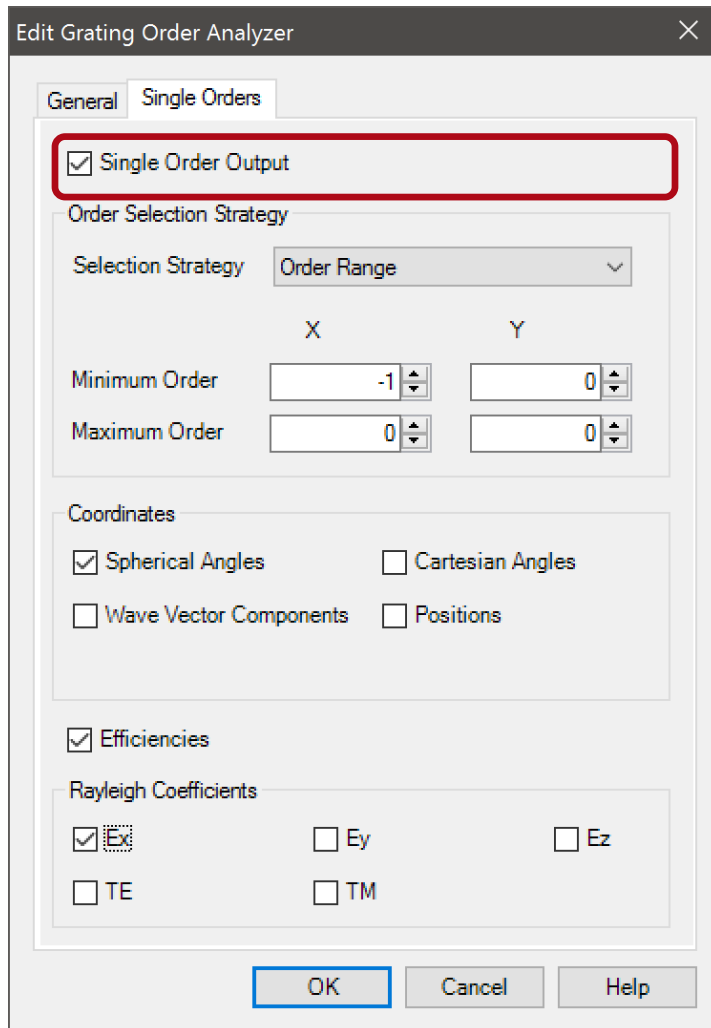
- In the *Single Orders* tab you can select whether information for single orders shall be logged.

- This option is very helpful if you would like to use the parameter run or the parametric optimization of VirtualLab to analyze and optimize specific orders of a grating.
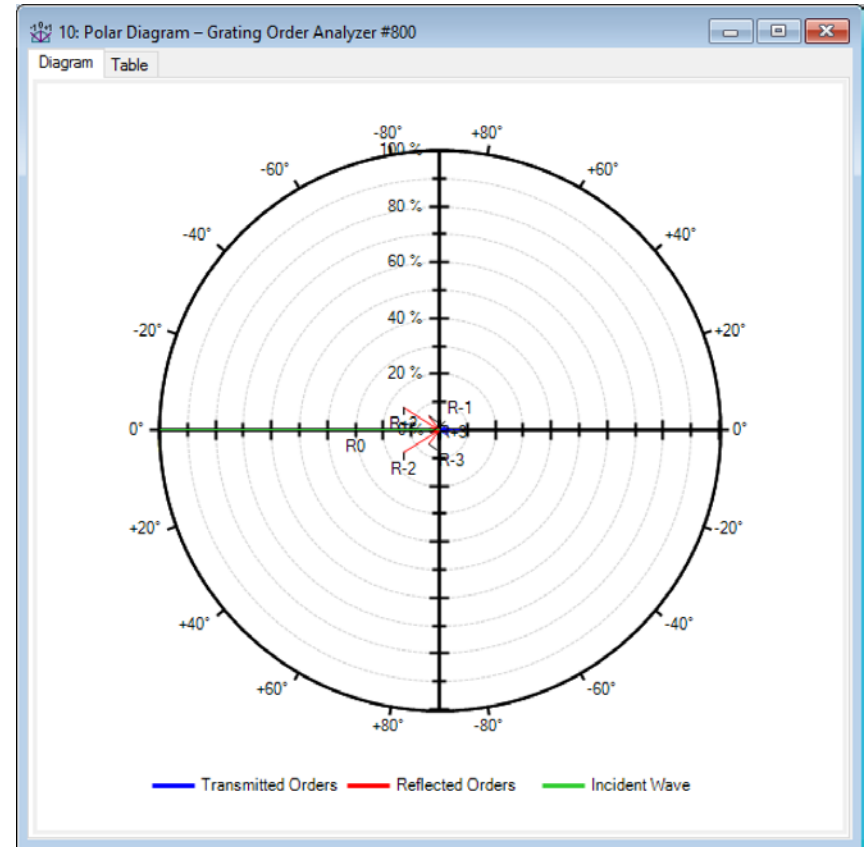
Options for Single Order Output

Parameter	Description
Order Selection Strategy	The user can define which order shall be evaluated. The user can define whether to analyze **All** orders, analyze only those orders which have an efficiency **Above a Given Threshold** or calculate only orders in a manually defined **Order Range**. Depending on the selection strategy the user has to define additional parameters.
Coordinates	Logging of the coordinates of the orders is also supported. The user can specify whether to show the coordinates in **Spherical Angles**, **Cartesian Angles**, **Wave Vector Components** or **Positions**. For the Position calculation a z-distance between the grating and the screen has to be specified.
Efficiencies	The user can select whether efficiencies shall be logged.
Rayleigh Coefficients	In addition it is possible to log the Rayleigh coefficients. The user can select to show the coeffient E_x, E_y, E_z, **TE** or **TM**.

Grating Order Analyzer – Outputs

Grating Order Collection

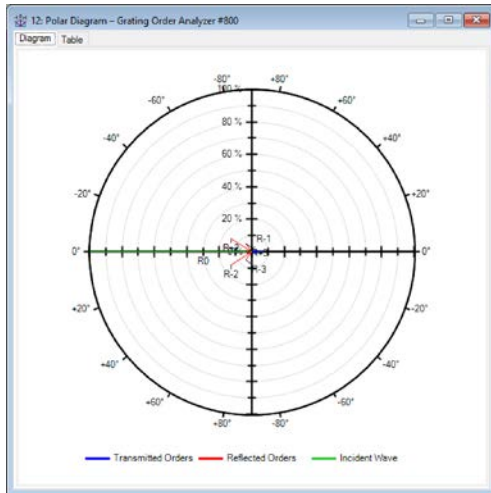Polar Diagram

Grating Order Analyzer – Outputs

- If the Grating Order analyzer is processed within the Light Path Diagram, the single order output values are logged into the detector results tab.

- These values are also available in the parameter run and the parametric optimization.

# Grating Order Output: Polar Diagram

Polar Diagram

- The polar diagram output of the Grating Order Analyzer plots the efficiencies of both the reflected and the transmitted orders versus the angles in the x-z-plane.

- It also provides a table of all angles and efficiencies of the displayed orders.

Configuring the Polar Diagram

- You can zoom into the polar diagram with the mouse wheel, the Property Browser and the ribbon.
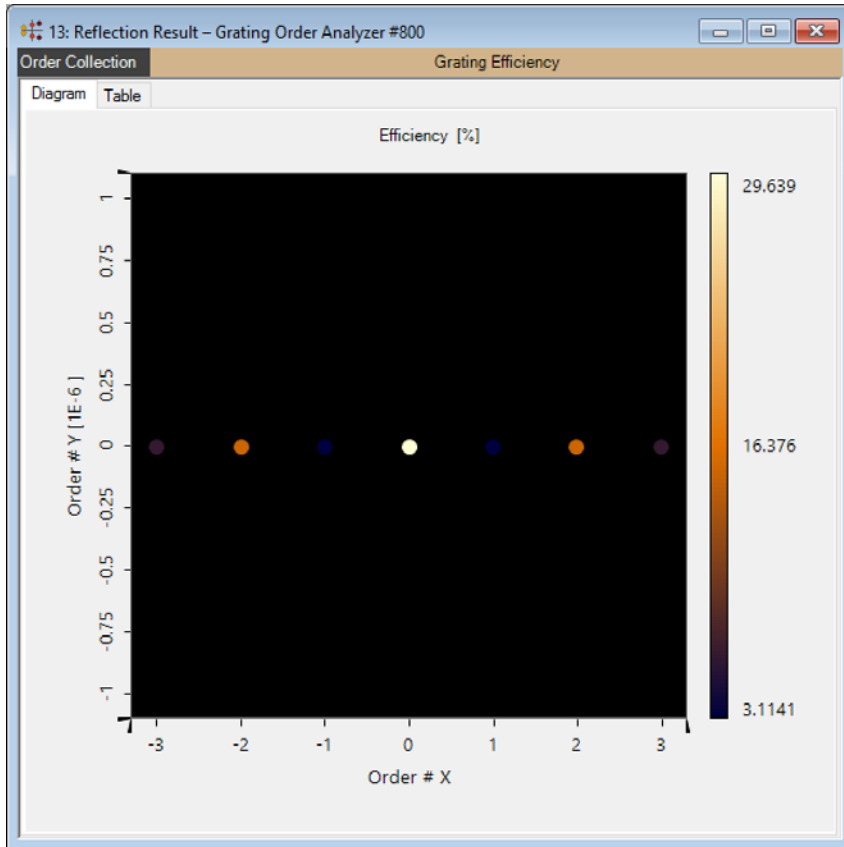
- You can configure which orders are shown by right-clicking on the diagram.
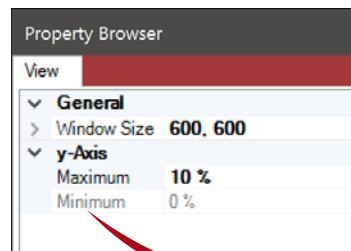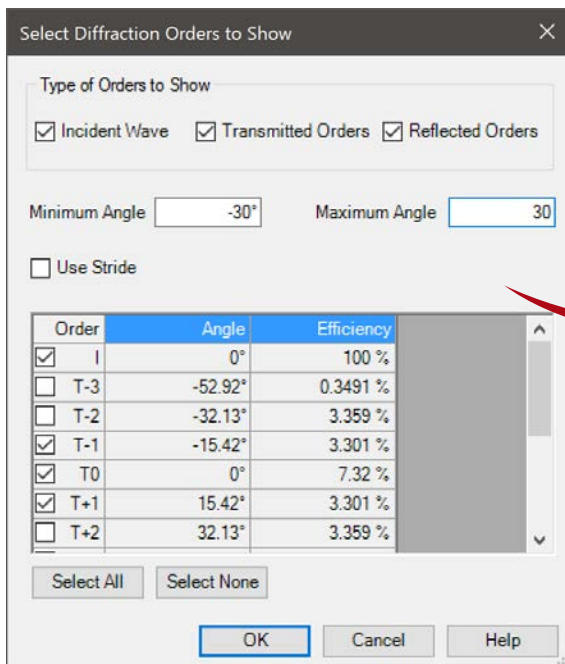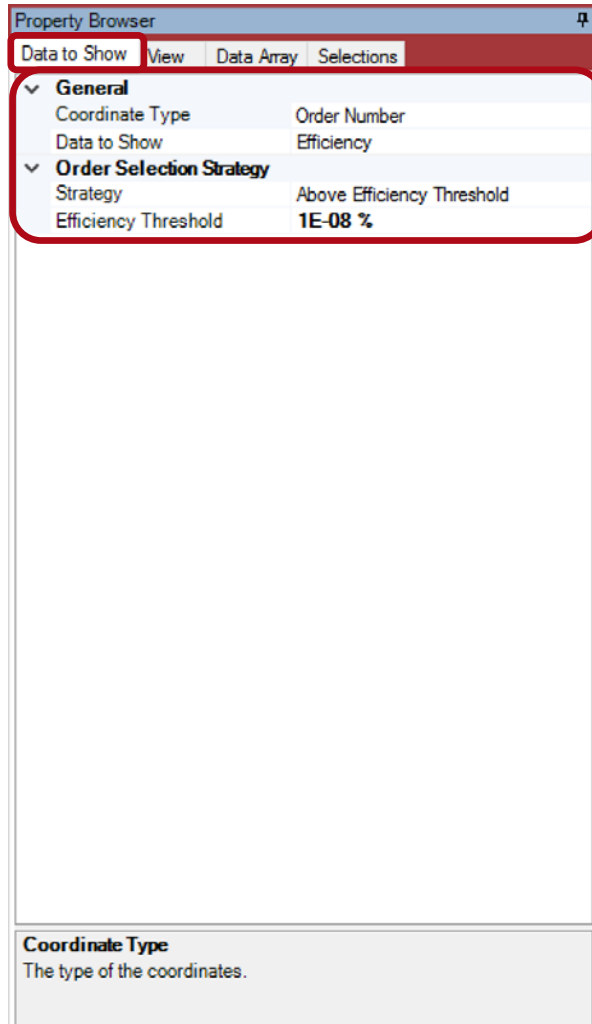

Results in
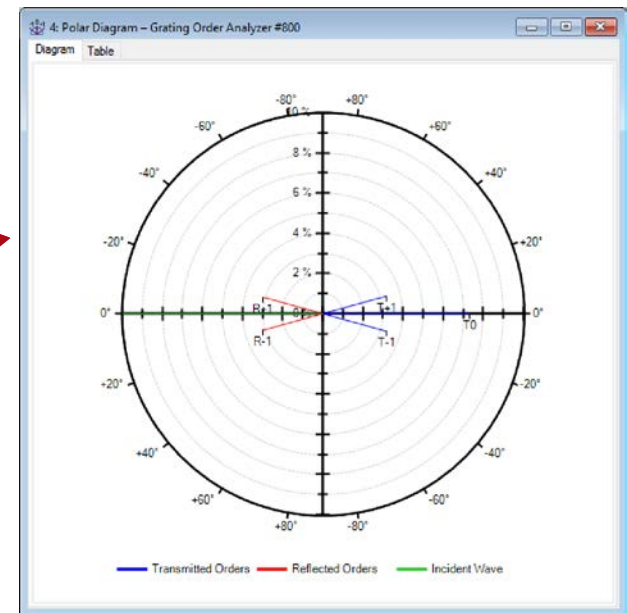
Grating Order Output: Order Collection

Grating Order Collection

- The Grating Order Collection object is used to visualize the calculated grating efficiencies or the Rayleigh coefficients over different coordinates.

- The user can configure the data that shall be shown by setting diverse options via the property browser.

Setup of Data to Show

- You can specify via the property browser which data shall be shown over which coordinates.

- In addition the user can select the order to be shown in the diagram.

- These settings are done on the **Data to Show** tab page of the property browser.
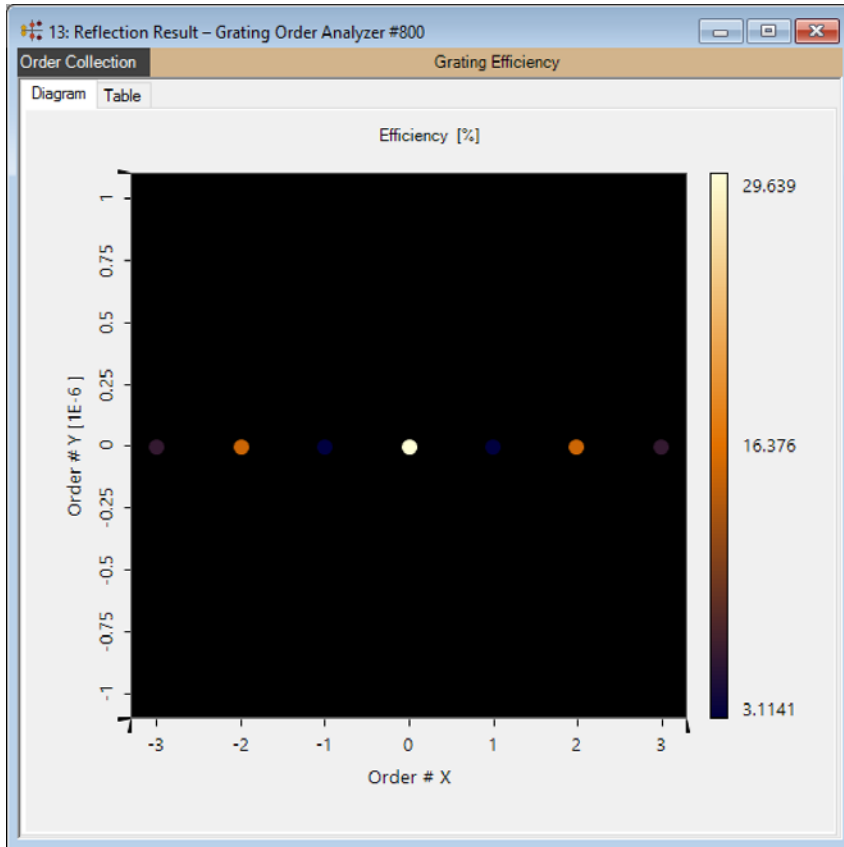
Setup of Data to Show

Option	Description
Coordinate Type	This property can be used to define the coordinates over which the data shall be visualized. Currently the order collection supports the visualization over **Cartesian Angles**, **Spherical Angles**, **Wave Number Vectors** and **Positions**.
Data to Show	It is possible to select the different data values that should be shown. The user can select to display the efficiency or the Rayleigh coefficient over the selected coordiante type. For Rayleigh coefficents E_x, E_y, E_z, **TM** and **TE** are supported.
Order Selection Strategy	The user can define which order shall be displayed. The user can define whether to show **All**, show only orders which have an efficiency **Above a Given Threshold** or show only orders for a manually defined **Order Range**. Depending on the selection strategy the user has to define additional parameters.

Setup of Additional View Settings
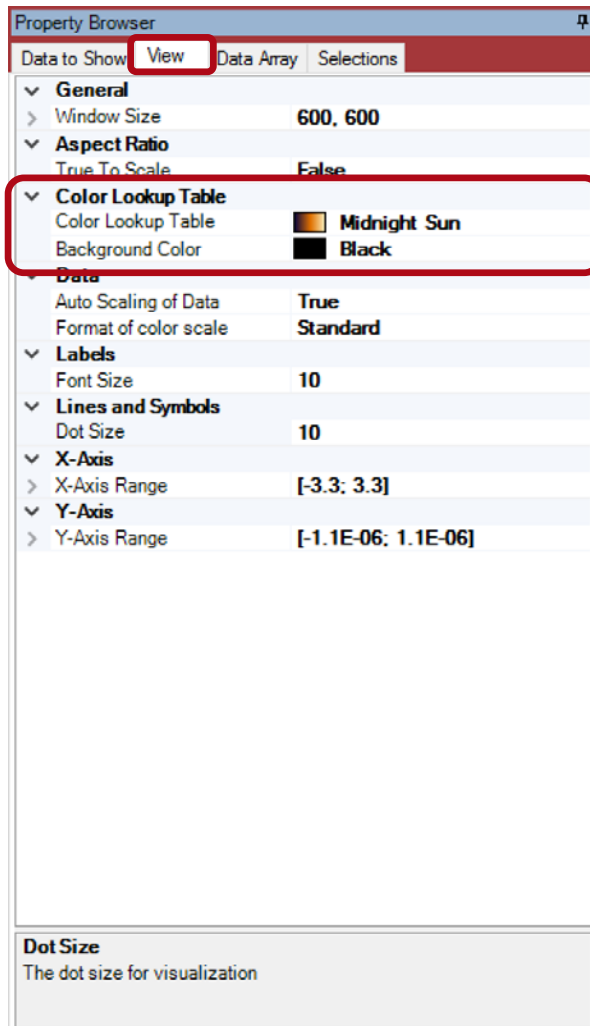
- In the **View** tab page of the property browser the user can set up additional view parameters.

- Most important for the customization of the view are the color settings.

- The user can select the background color for the view as well as the color lookup table that shall be used to define the colors for the displayed data values.

Example of View Customization

Visualization

View Settings

Example of View Customization

Visualization

View Settings

Example of View Customization
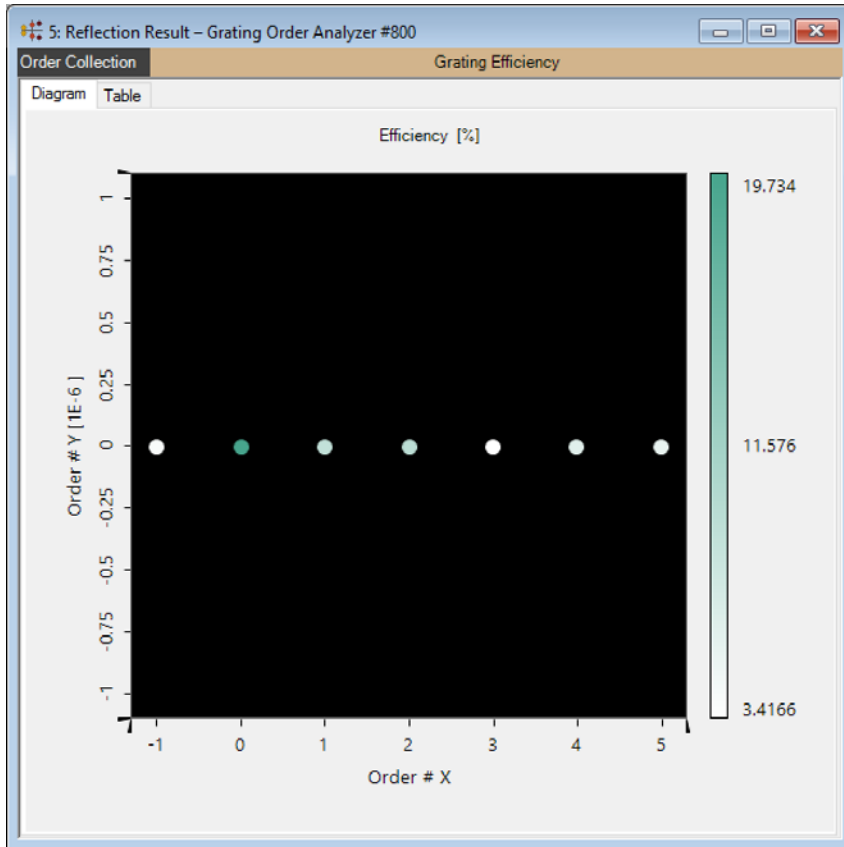

Visualization

View Settings

Visualization of Conical Incidence

Define Conical Incidence
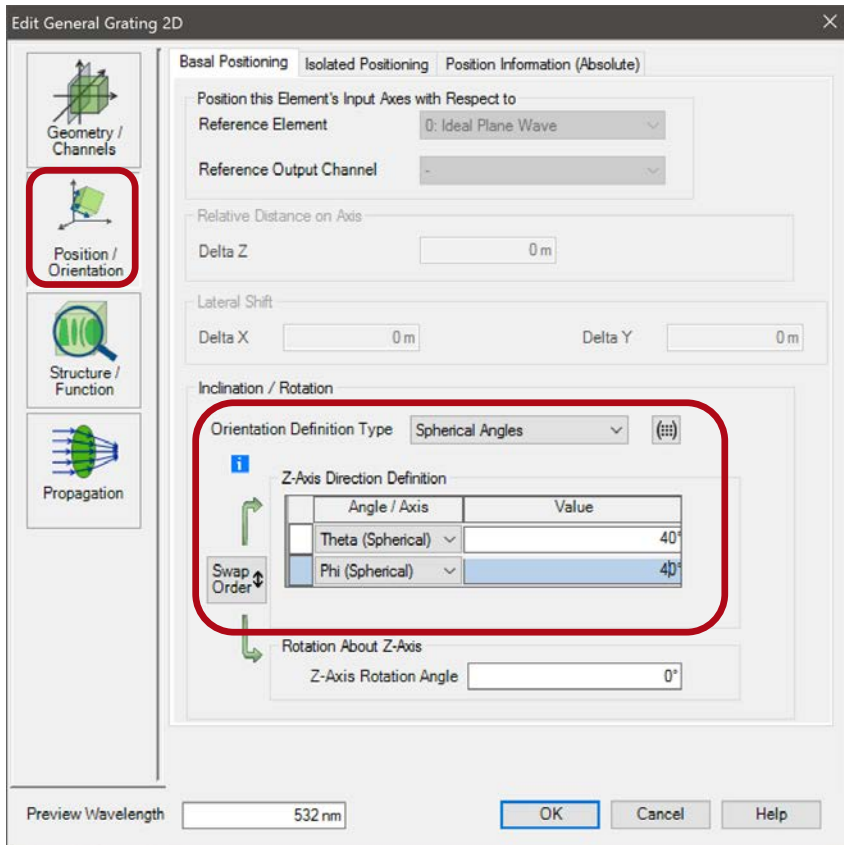
- Within the positions and orientation definition of the grating the user can define an arbitrary orientation.

- This is done in the *Position / Orientation* tab within the edit dialog of the grating.

- For this use case we use *Theta* = 40° and *Phi* = 40°.

Result – Grating Efficiencies over Order Number

Visualization

View Settings

Result – Grating Efficiencies over Order Position
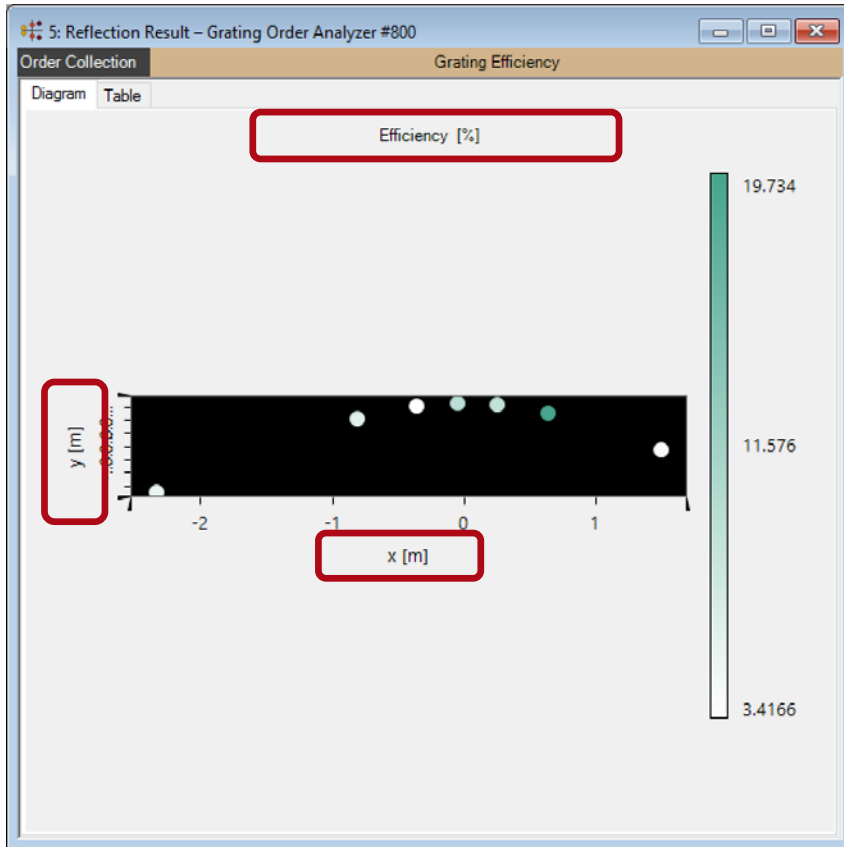
Visualization

View Settings

Result – Grating Efficiencies over Cartesian Angles
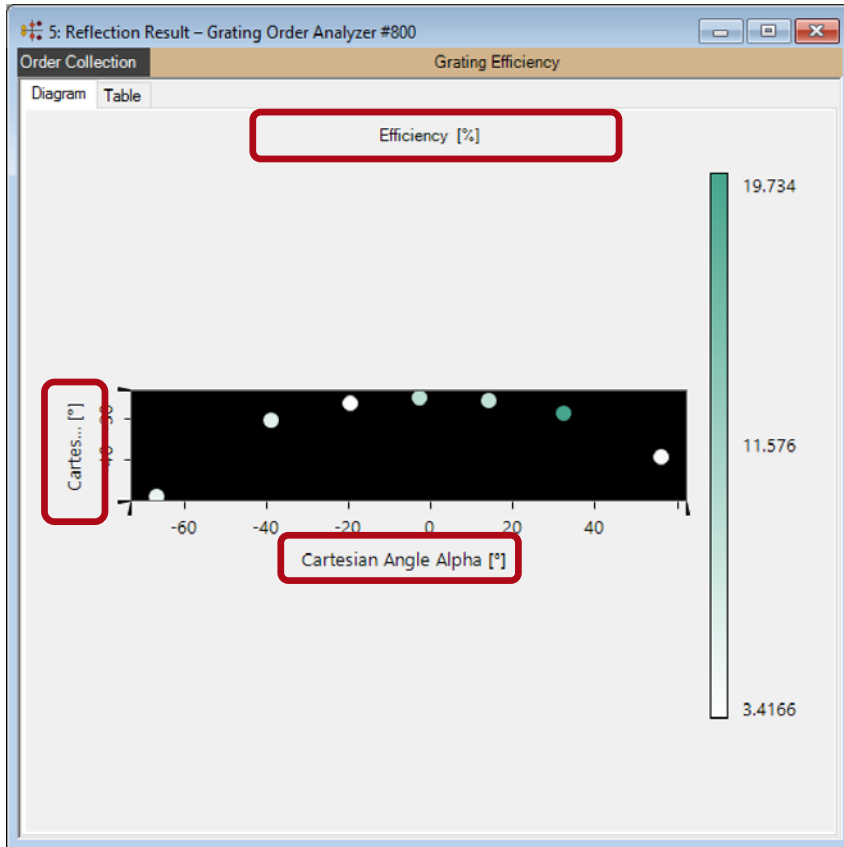
Visualization

View Settings

Result – Grating Efficiencies over Spherical Angles
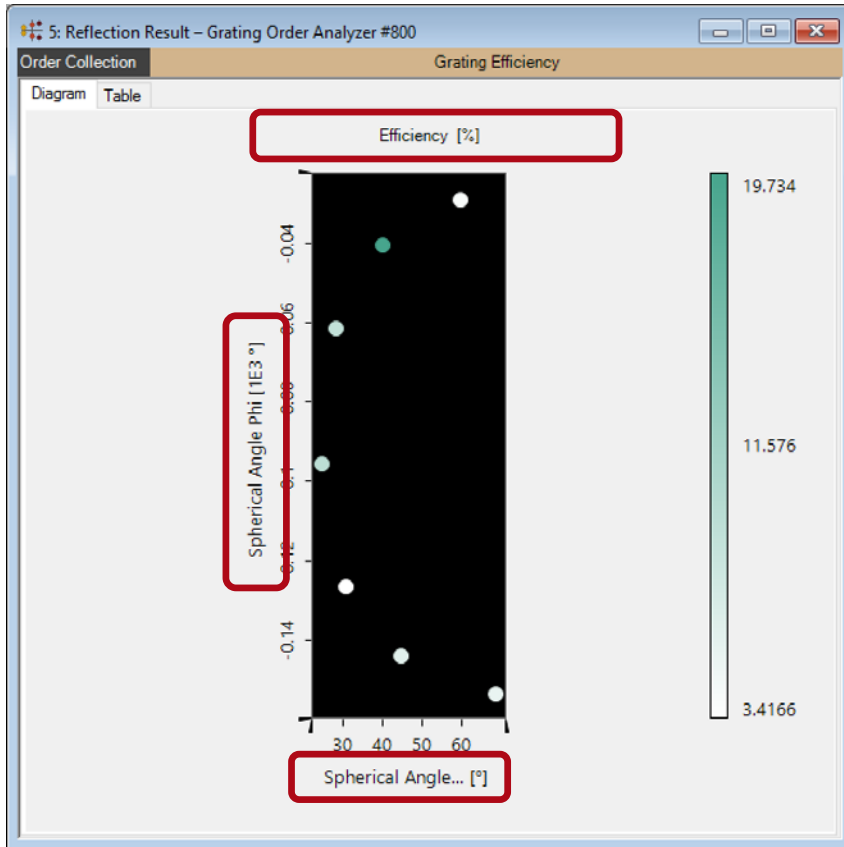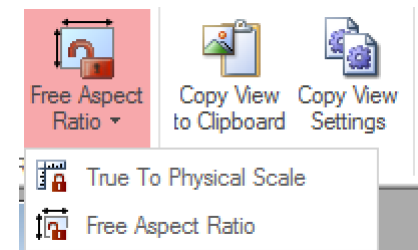

Visualization

View Settings

Tips & Tricks: Aspect Ratio
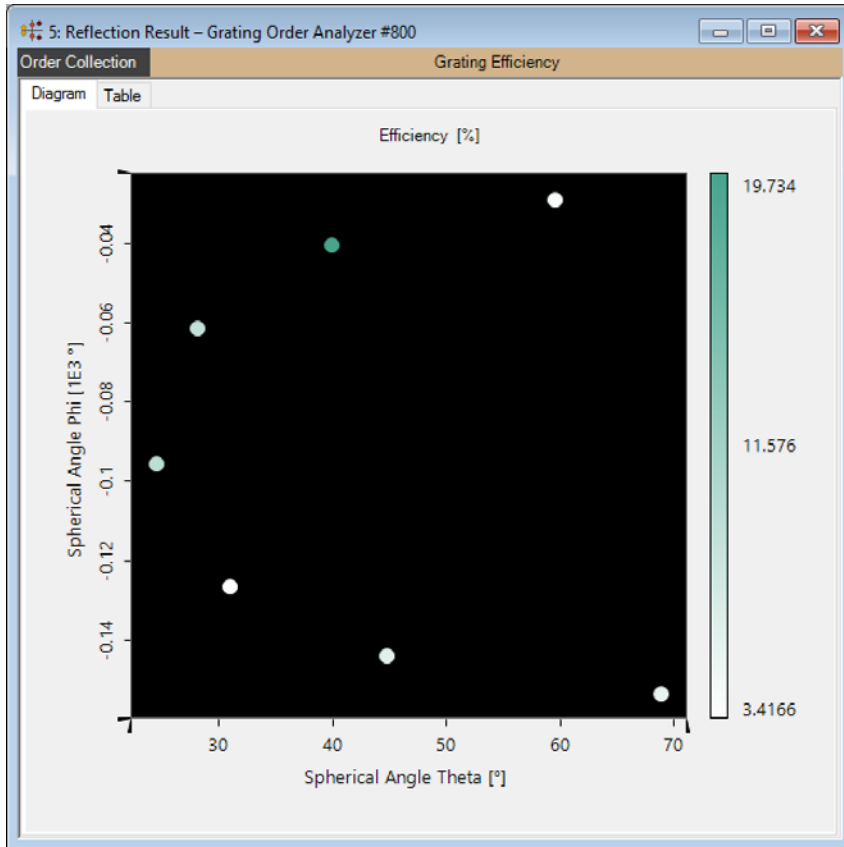
Free Aspect Ratio

- Depending on the coordinate range which is displayed it could be helpful to change the aspect ratio of the data.

- The aspect ratio can be adapted via the property browser or via the corresponding ribbon entry:

Document Information

title	Grating Order Analyzer
version	1.0
VL version used for simulations	7.0.3.4
category	Feature Use Case