# Tutorial 96.01 Tutorial Lighting Toolbox

This tutorial gives an introduction to the concepts and the usage of the Lighting Toolbox. Analysis and Design of Grating Cells Arrays are demonstrated.

Keywords: Lighting Toolbox, grating cells array, shaping, far field source, camera detector

Required Toolboxes: Lighting Toolbox

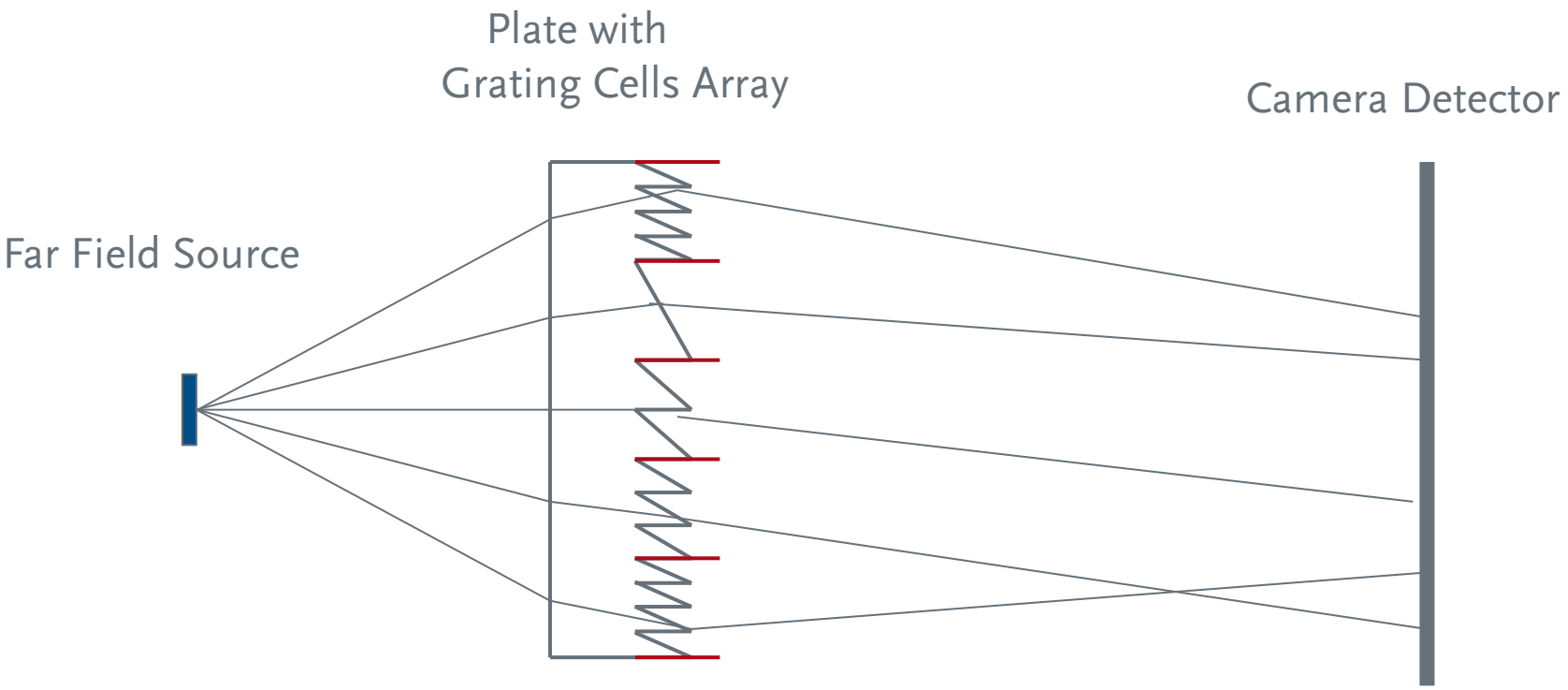
Related Application Scenarios: 317.01

LightTrans

# General Concept

- The Lighting Toolbox provides an innovative light shaping concept which is based on an array of grating cells.
- VirtualLab™ offers the possibility to design the grating cell array (GCA) to generate an arbitrary light pattern at a specified plane.
- The designed GCA system can be analyzed by spatially partial coherent light.
- Also a rigorous analysis of the gratings can be taken into account during the simulation.

# General Optical Setup within the Lighting Toolbox




- The VirtualLab™ Lighting Toolbox allows the design and the analysis of GCA elements in transmission and reflection mode.

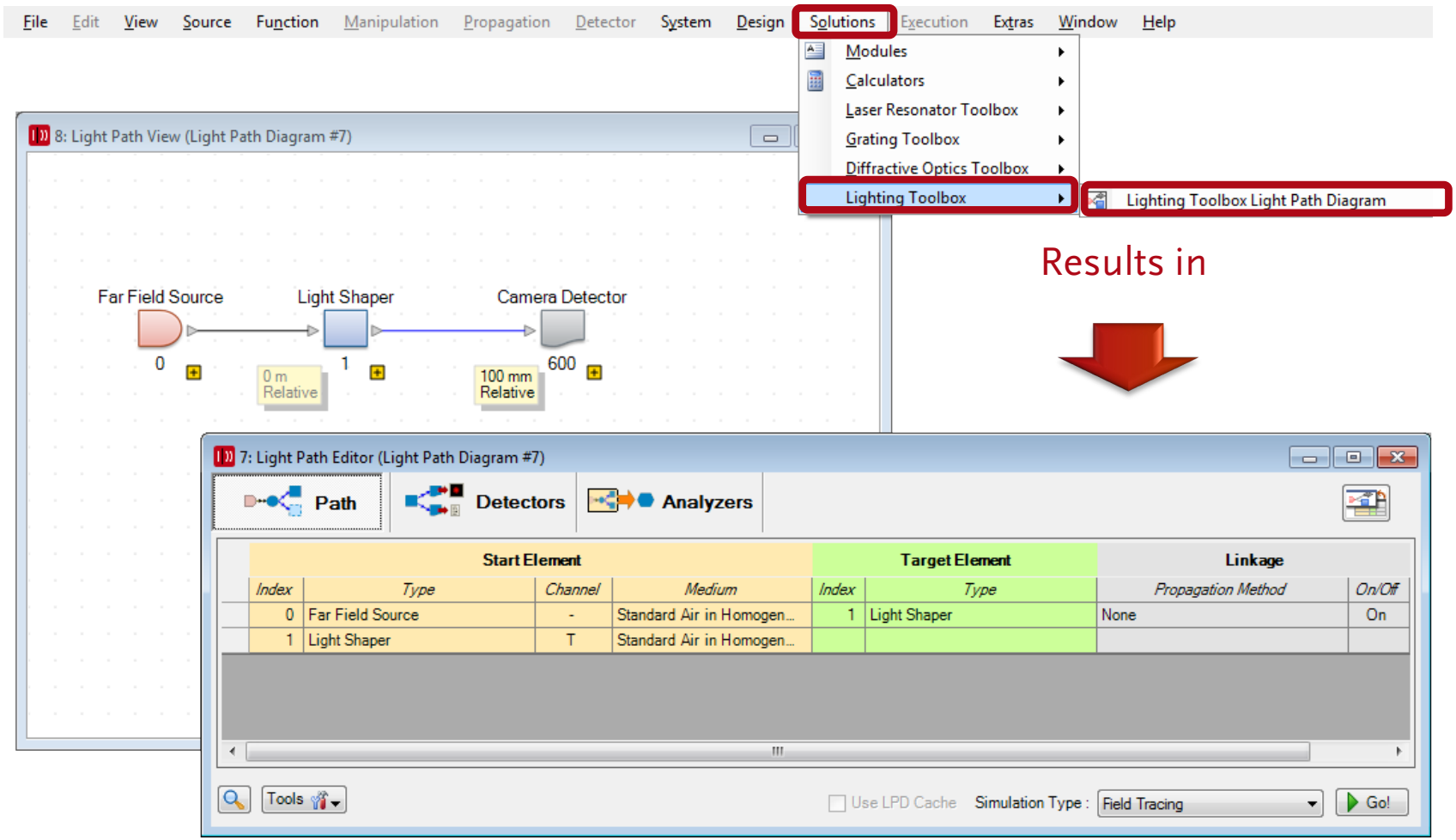
# Workflow

# General Workflow of GCA Design

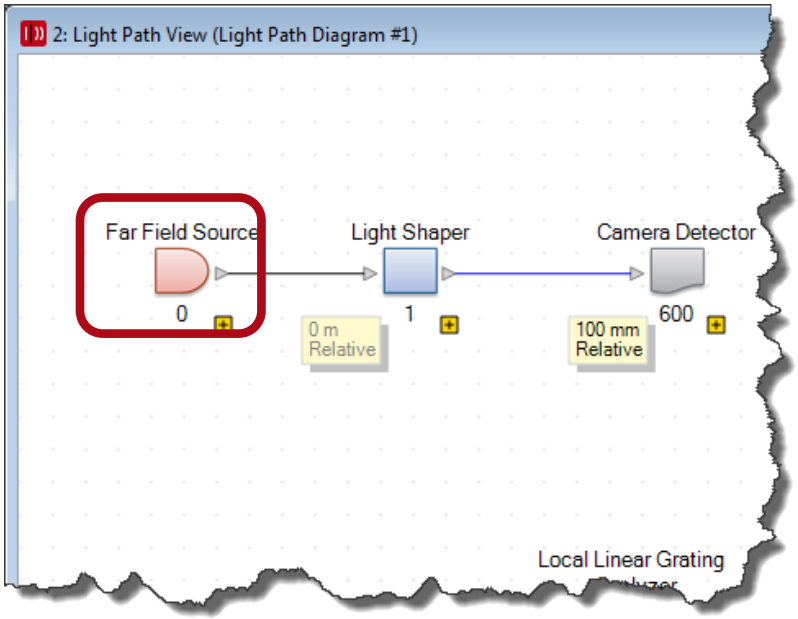
1. Open a Lighting Toolbox LPD and define the geometry of the system. All system parameters have to be specified within this LPD.
2. Open a GCA design document and define design parameters including the target light pattern. The design refers to the LPD.
3. Start the GCA design. The design results in a new LPD containing the designed GCA.
4. Use the resulting LPD for further analysis of the designed GCA element.

# Setting up the system geometry

# Generate a new Lighting Toolbox LPD

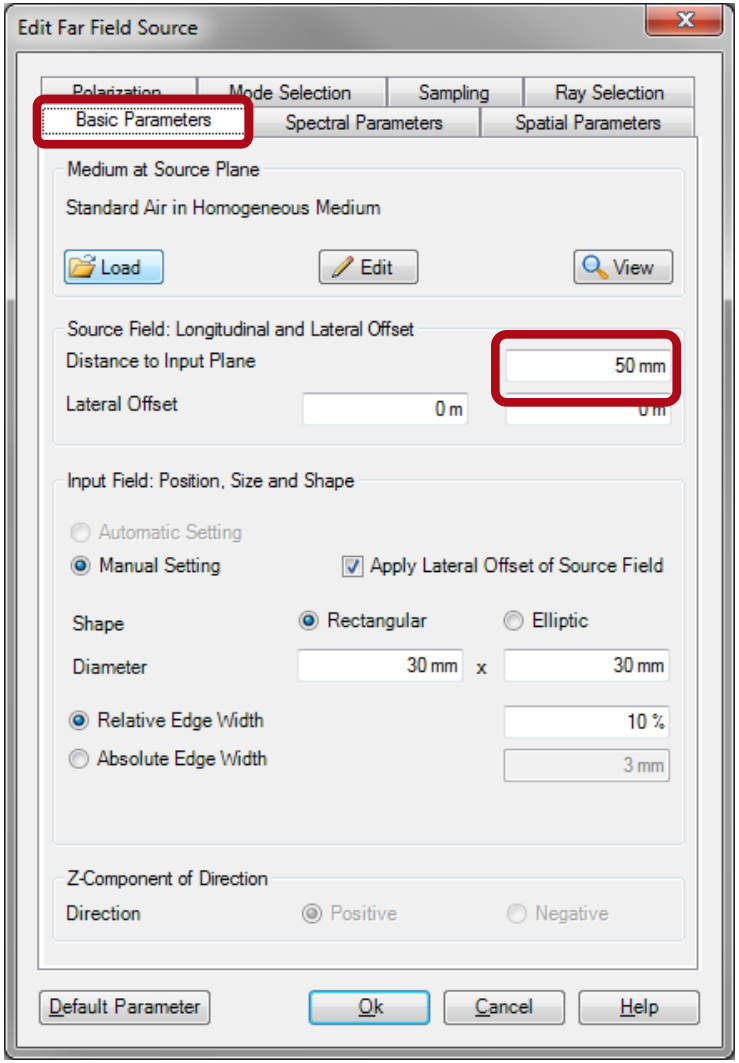


# Light Source



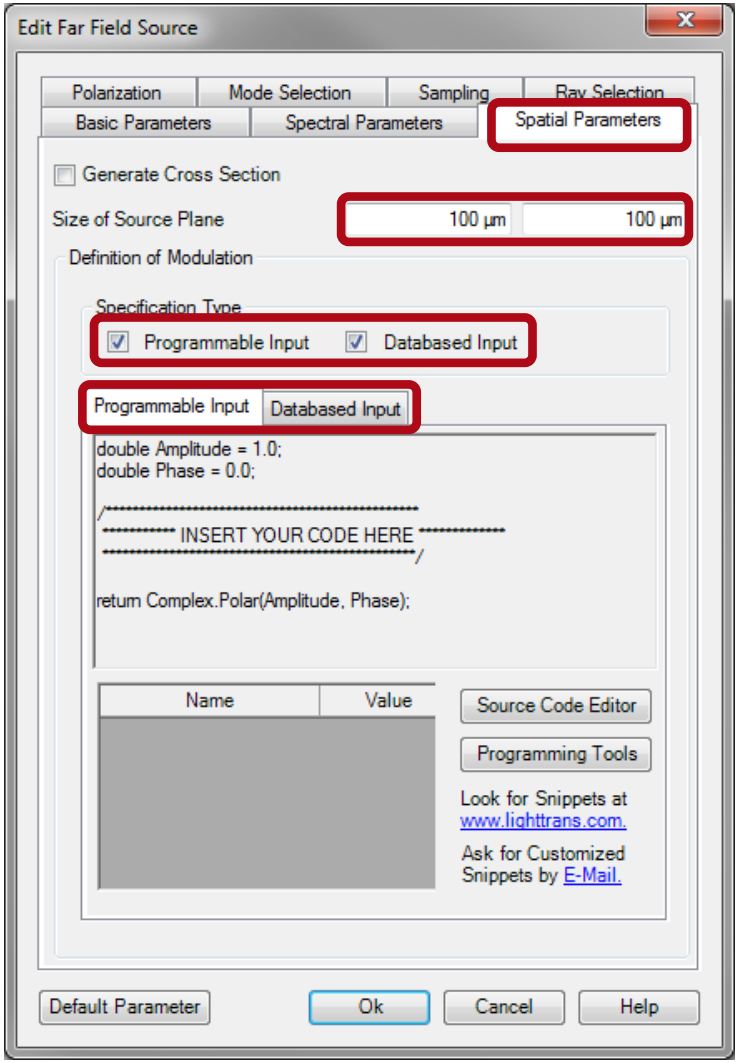

- The Far Field Source can be edited by double clicking on the icon in the Light Path View.
- The edit dialog allows the specification of spectral and spatial parameters as well as the definition of mode selection and polarization.

# Edit Dialog Far Field Source (Basic)



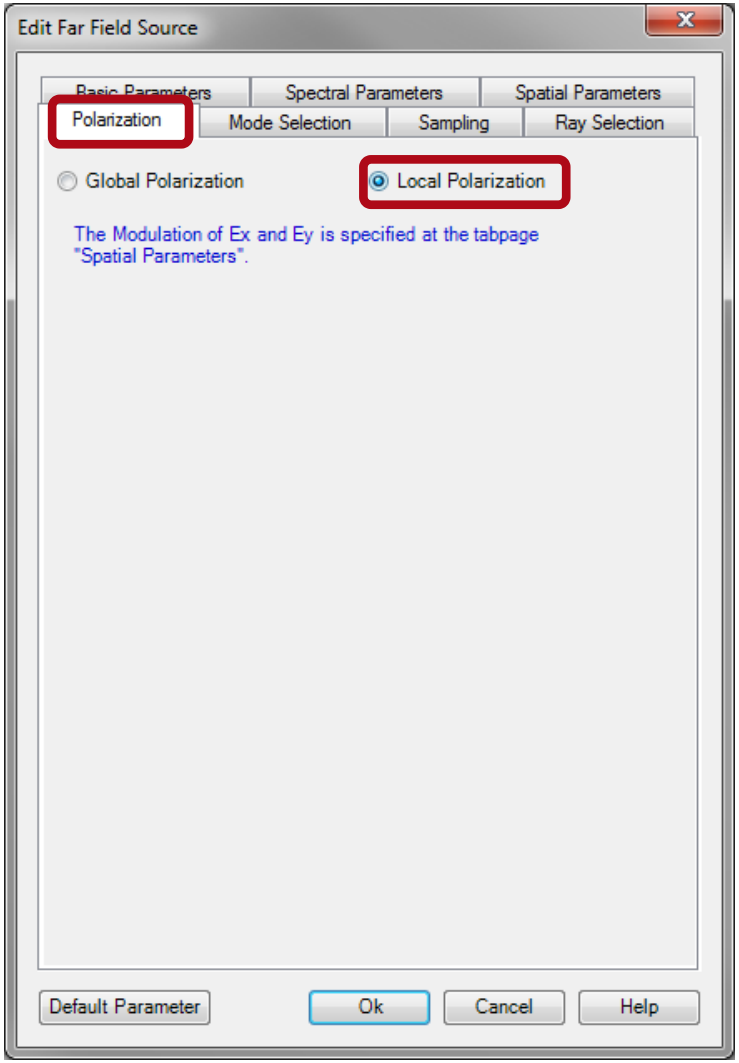

- The distance between the Far Field Source and the light shaping component is entered directly in the edit dialog of the Far Field Source.
- This distance cannot be changed within the LPD.

# Edit Dialog Far Field Source (Spatial)



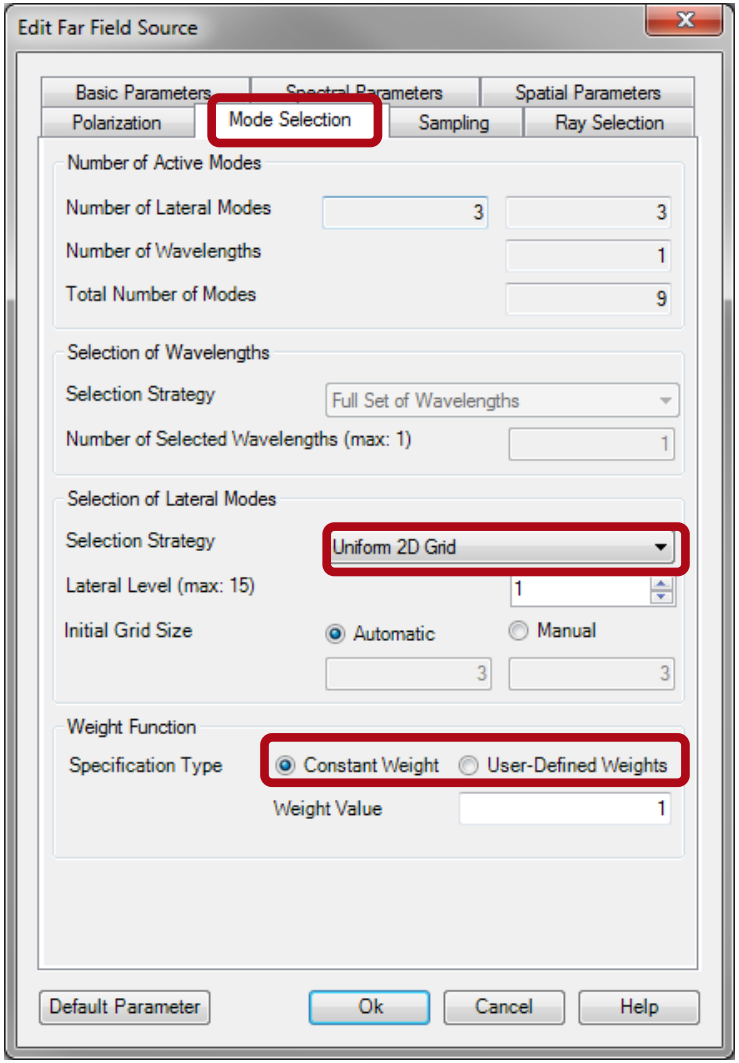

- The Far Field Source can be configured with an extended source area. The size of this area can be entered on the spatial tab.
- The source allows to specify an additional complex-valued modulation of the spherical wave.
- The modulation can be specified as data based and/or programmable input.

# Edit Dialog Far Field Source (Polarization)



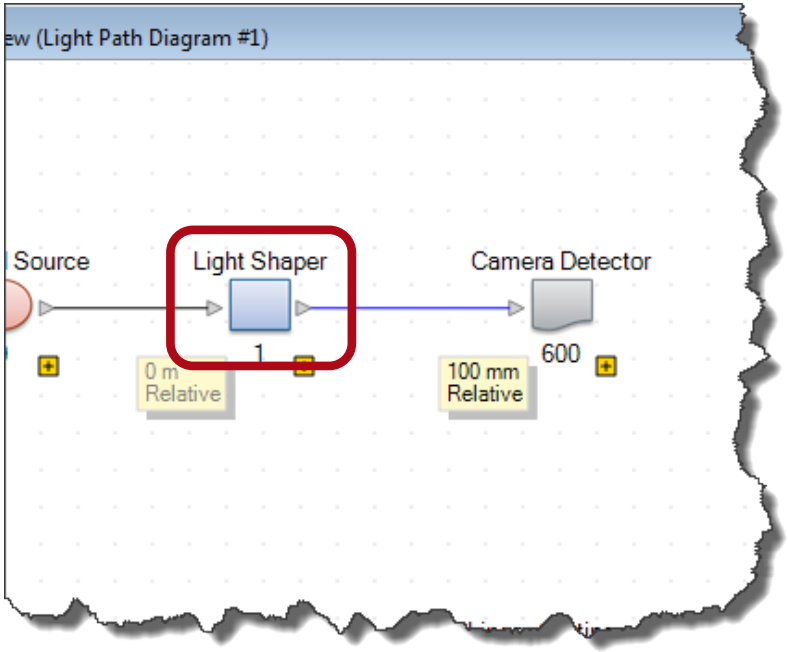

- The Far Field Source allows either a global polarization or the specification of a locally polarized field.
- The modulation of the different field components can be specified on the spatial parameters tab in case of local polarization.

# Edit Dialog Far Field Source (Mode Selection)



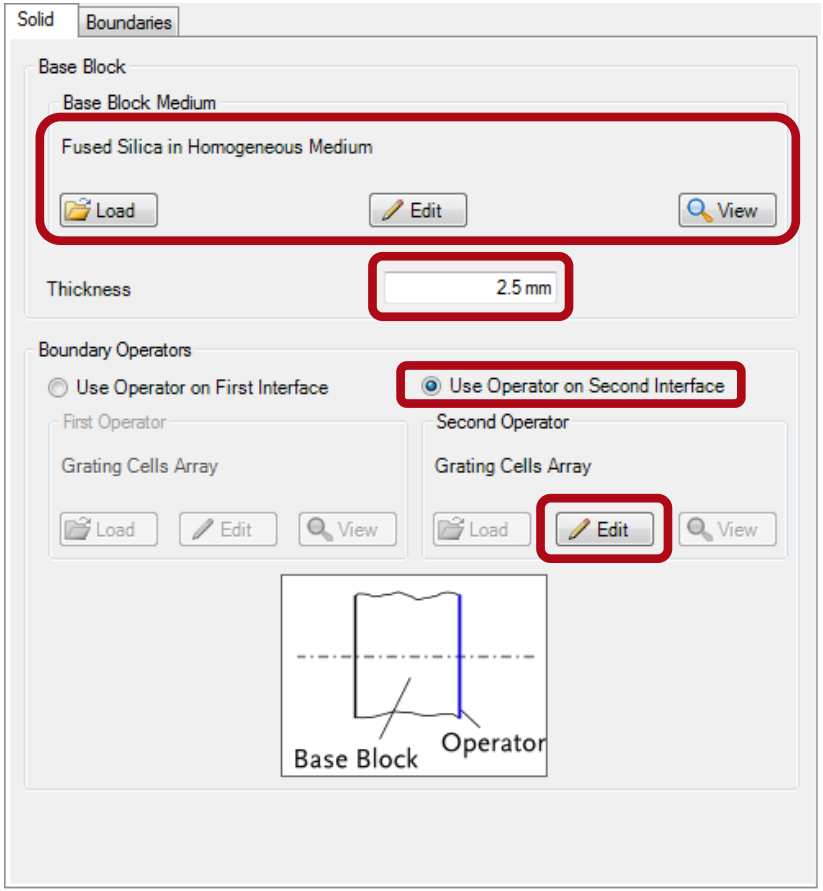

- In order to model an extended source area, a set of incoherent modes has to be generated by the source. This can be done on the mode selection page.
- The user can specify positions as well as weights for the modes.

# Light Shaper Element



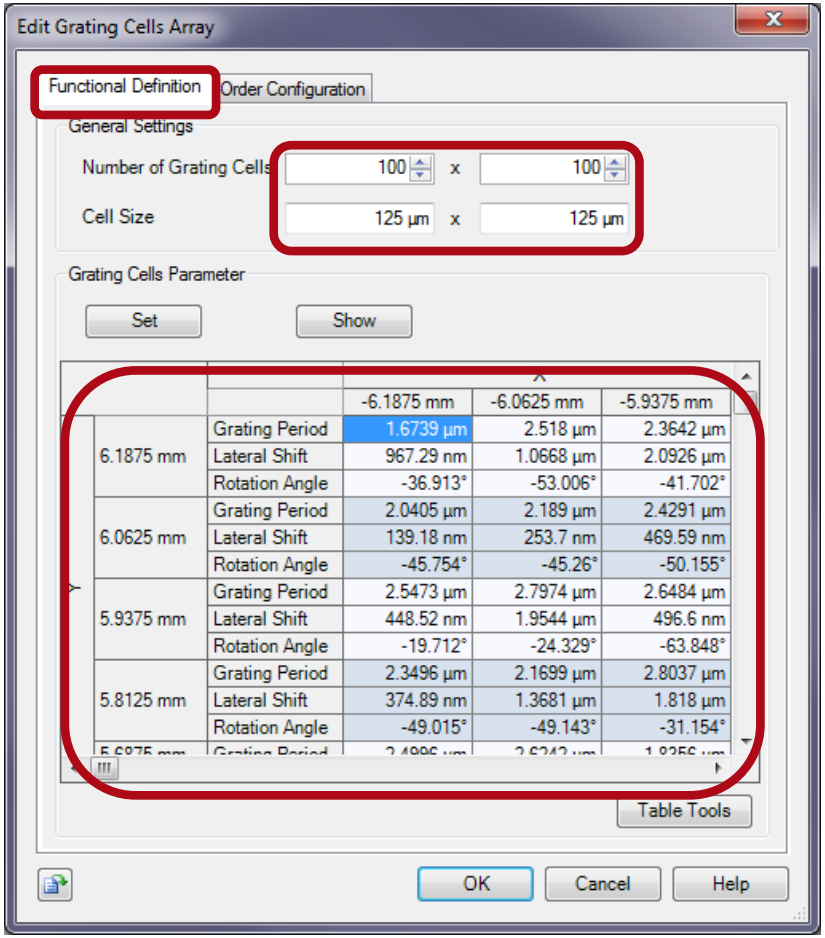

- The Grating Cells Array is placed on a plate.
- The plate can be edited by double clicking on the icon in the Light Path View.
- The plate can be rotated. This can be specified in the edit dialog and will be considered in the design.

# Edit Dialog of Plate



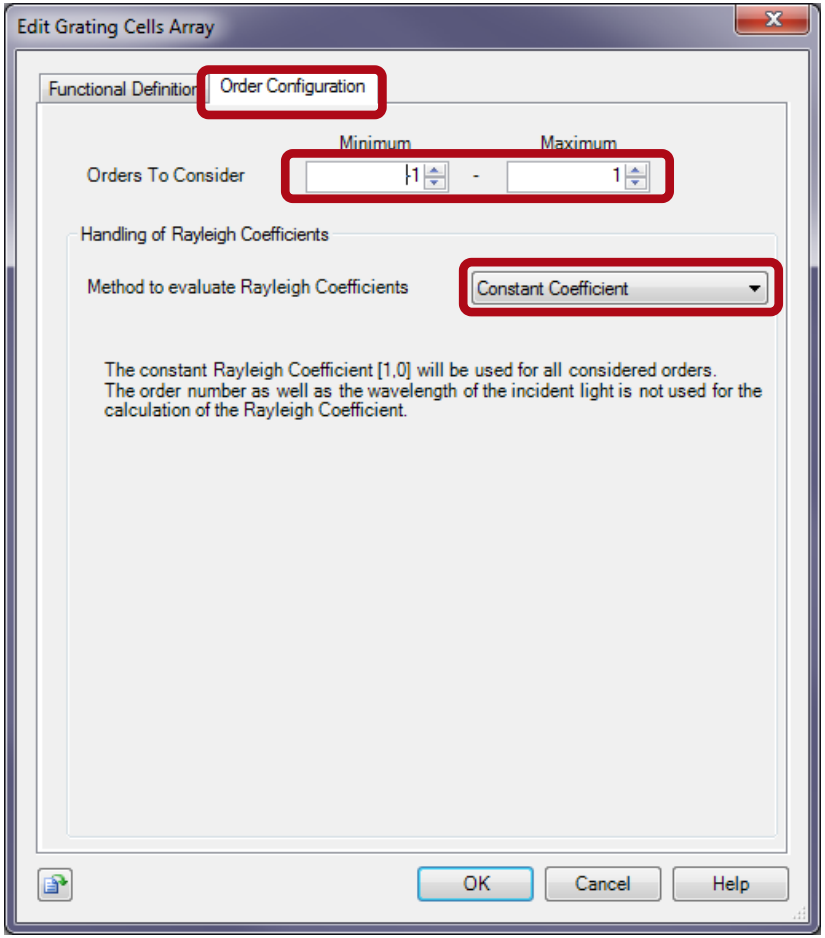

- The user can change the medium as well as the thickness of the plate on which the grating cell array is placed on.
- It is possible to place the operator on the first or on the second interface.
- By clicking on the edit button, the settings of the GCA operator can be changed.

# Edit Dialog of GCA Operator I




- On the functional definition page, the size and the number of cells can be configured.
- A table at the bottom of the dialog shows the parameters for all cells.
- The parameters can be edited directly or set from a given data array.

# Edit Dialog of GCA Operator II

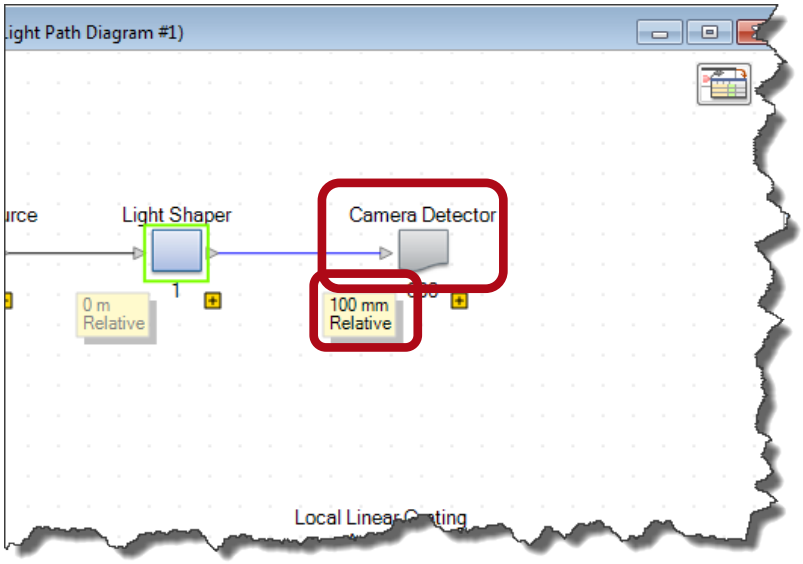



- The second page allows to specify which orders of the gratings are to be considered during the simulation.
- It is also possible to specify different weights for the orders by selecting other methods for the definition of the Rayleigh coefficients.

# Order Configuration of GCA Simulation

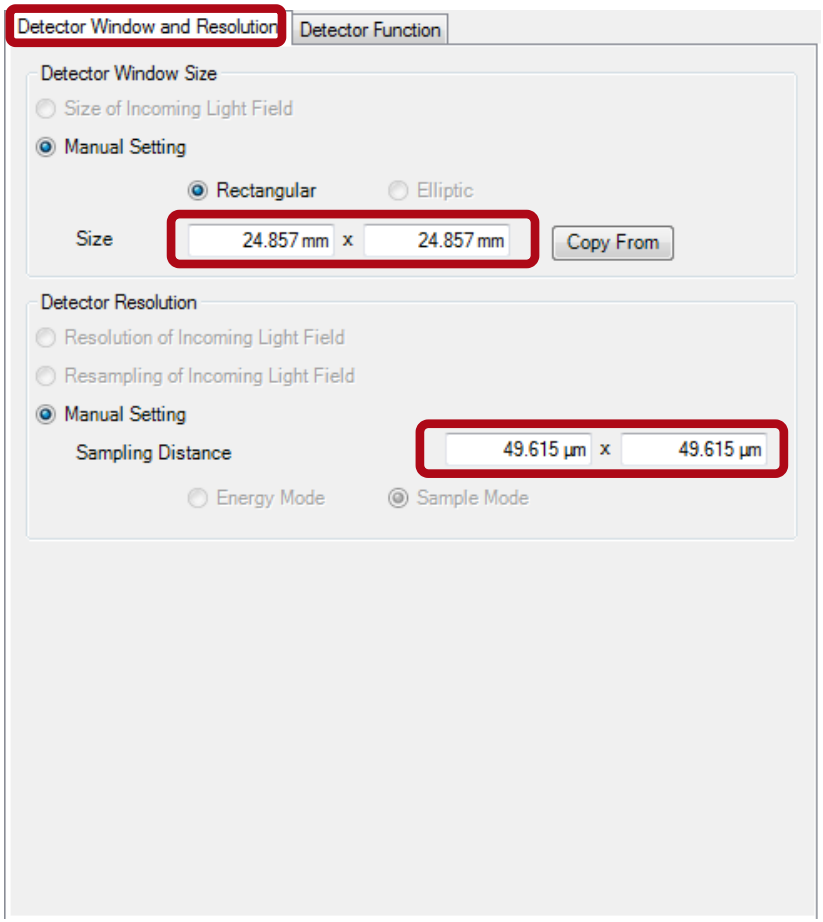
- The following methods for the evaluation of the Rayleigh coefficients are available:
  - Constant Coefficient: constant weight 1 is used.
  - Simple Look Up Table: real valued weights specified by the user for each order are used for the simulation.
  - Rigorous Look Up Table: weights that have been computed with the LLGA result generator (requires the Grating Toolbox) are used. For that purpose, the GCA is analyzed with the LLGA analyzer first. The output of the analyzer is the LLGA result generator that uses the information of the GCA and that can evaluate the Rayleigh coefficients by the usage of FMM or TEA.

# Camera Detector



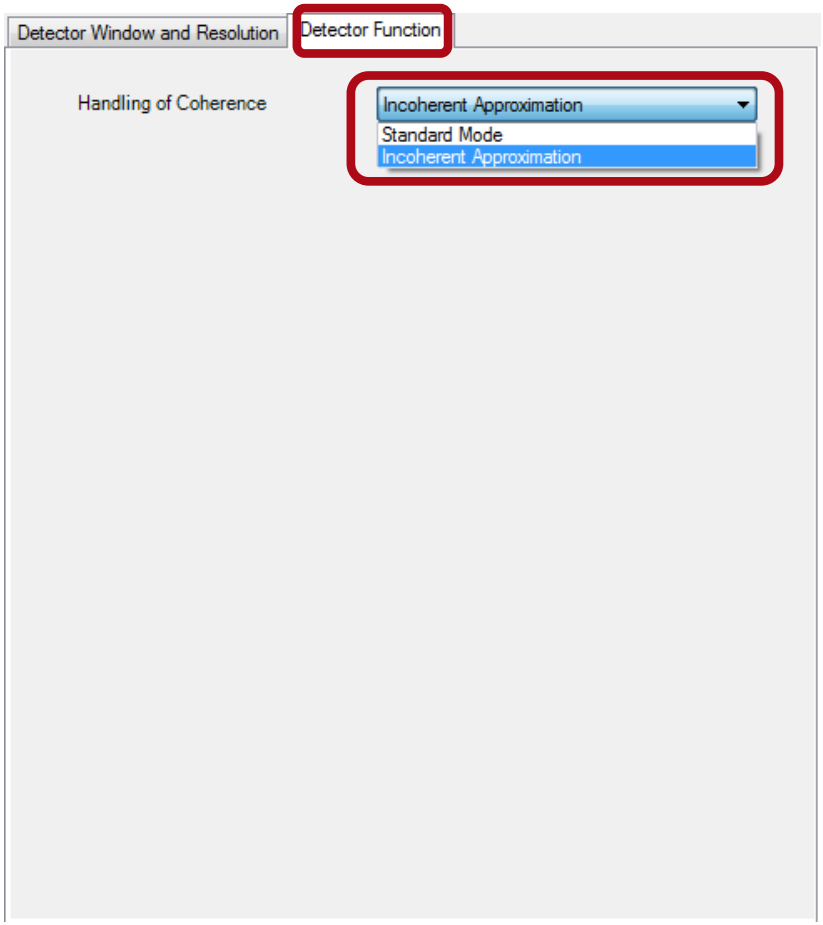

- The camera detector defines the target plane of the system.
- The detector can be edited by double clicking on the icon in the Light Path View.
- The distance between GCA element and target plane can be entered directly in the LPD View.

# Camera Detector : Size and Resolution




- On the first page of the edit dialog of the Camera Detector the window size and resolution can be specified.
- In the current version, the Camera Detector only supports manual specification of these parameters.

# Camera Detector : Parameters

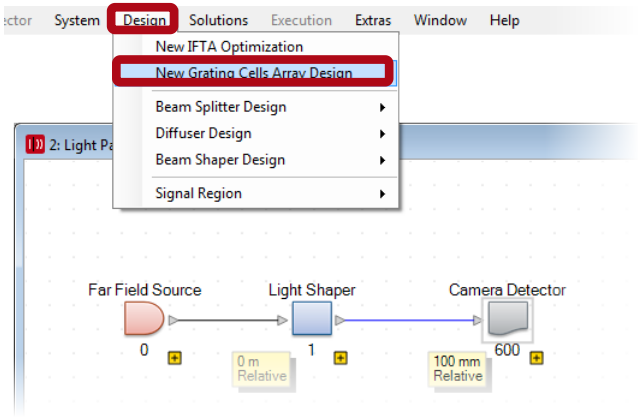



- The Camera Detector supports two modii to evaluate the incident field.
- In Standard Mode, the coherent modes after the GCA are interpreted coherently.
- The Incoherent Approximation evaluates the incident coherent modes by incoherent superposition.

# Design of the GCA

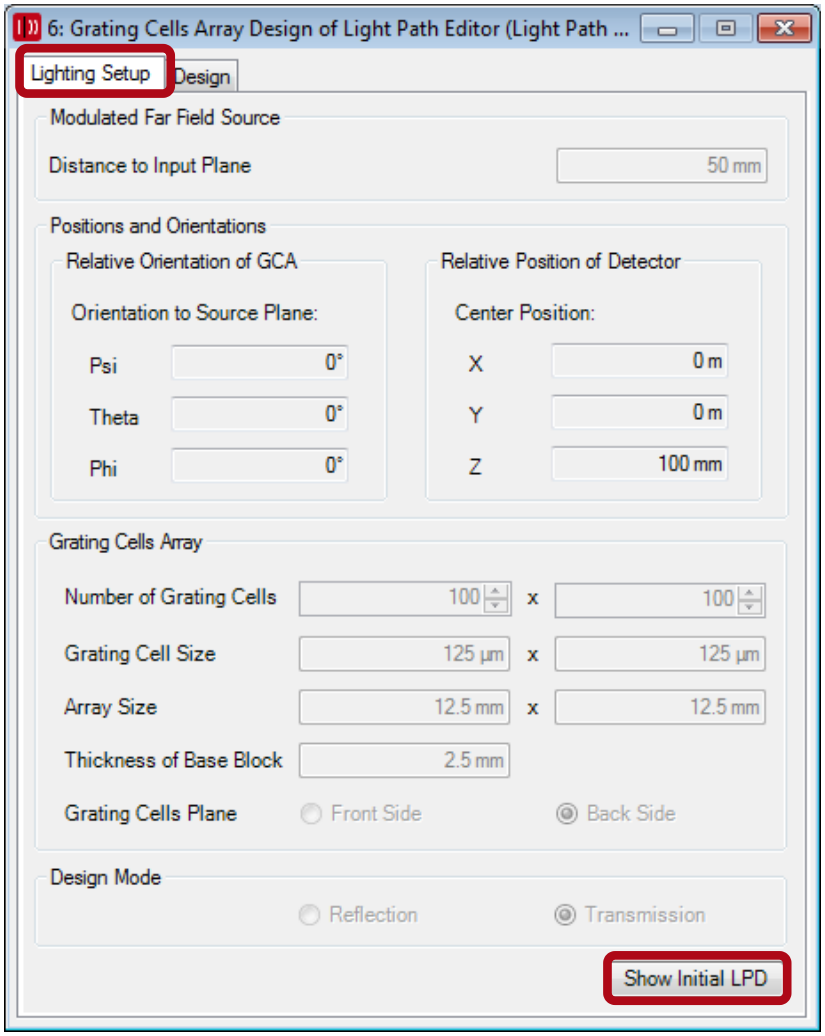
# Create Design Document

- To create a GCA design document, select a Lighting Toolbox LPD and select the menu item Design ➔ New Grating Cells Array Design.



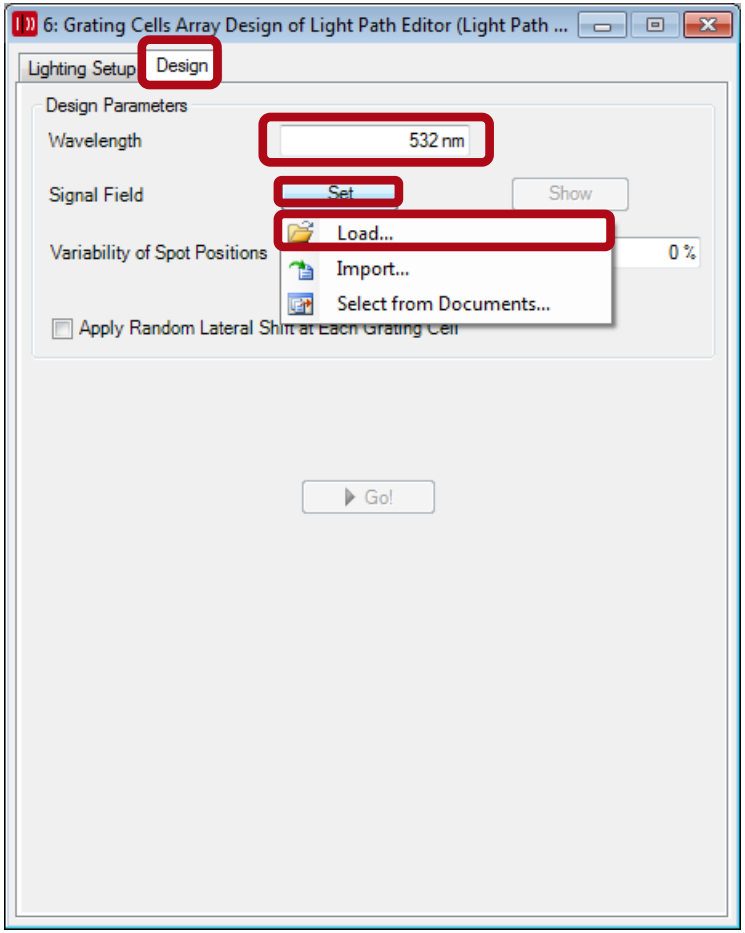

Results in

# GCA Design Document: Lighting Setup



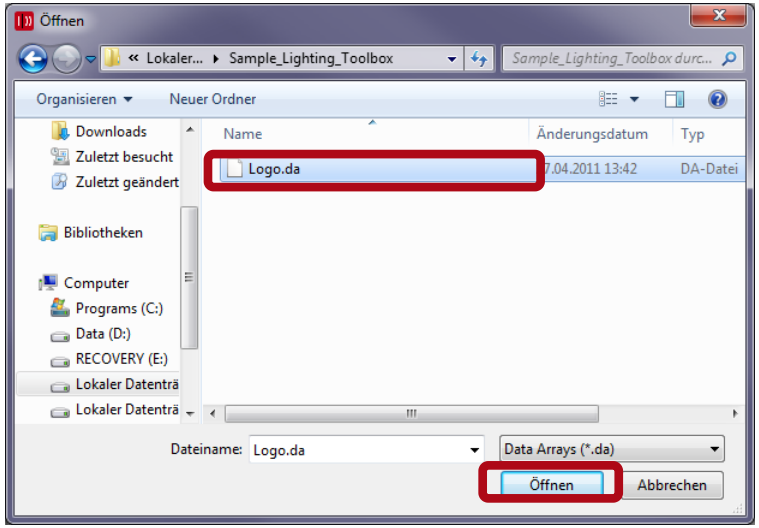

- On the page *Lighting Setup* a short summary of all structure parameters of the base system is given.
- By pressing on the *Show Initial LPD* button the initial system can be viewed.

# GCA Design Document: Design




- For the design, the design wavelength has to be specified.
- Also the target pattern in the detector plane needs to be defined.
- The pattern can be specified by a data array. The data array can be loaded or imported or selected from an open VirtualLab™ document.

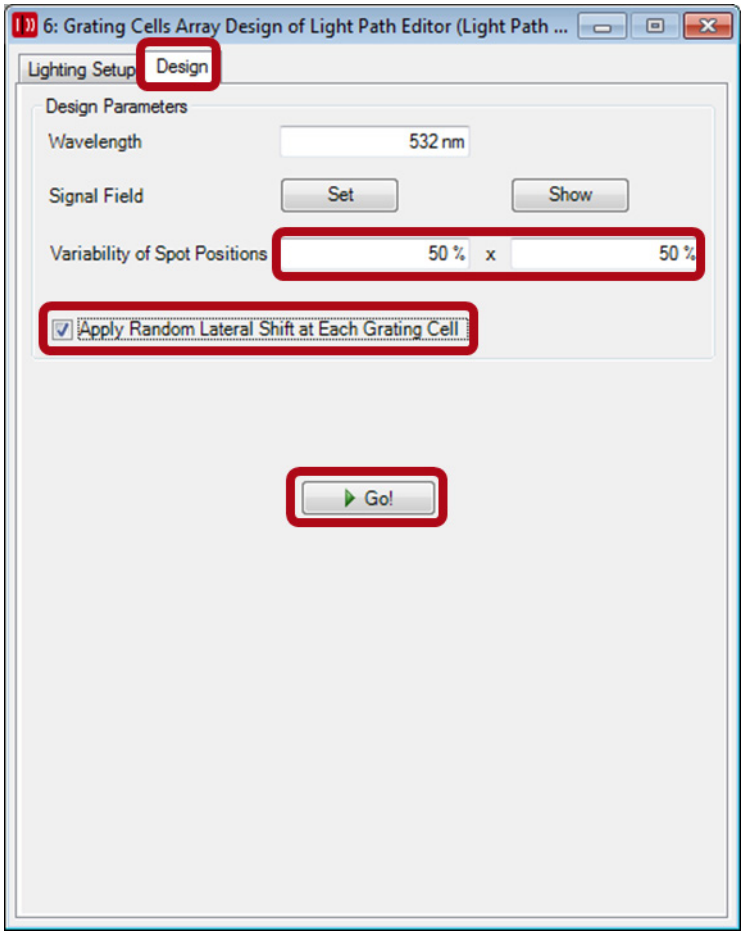
# Set Target Pattern




Target Pattern :


- The user can load the data array from file. The file extension is *.da.
- The import of data arrays is guided by a wizard. ASCII, bitmap and jpeg are supported formats.
- If the data array is already available as VirtualLab™ document it could be selected directed with the select option.

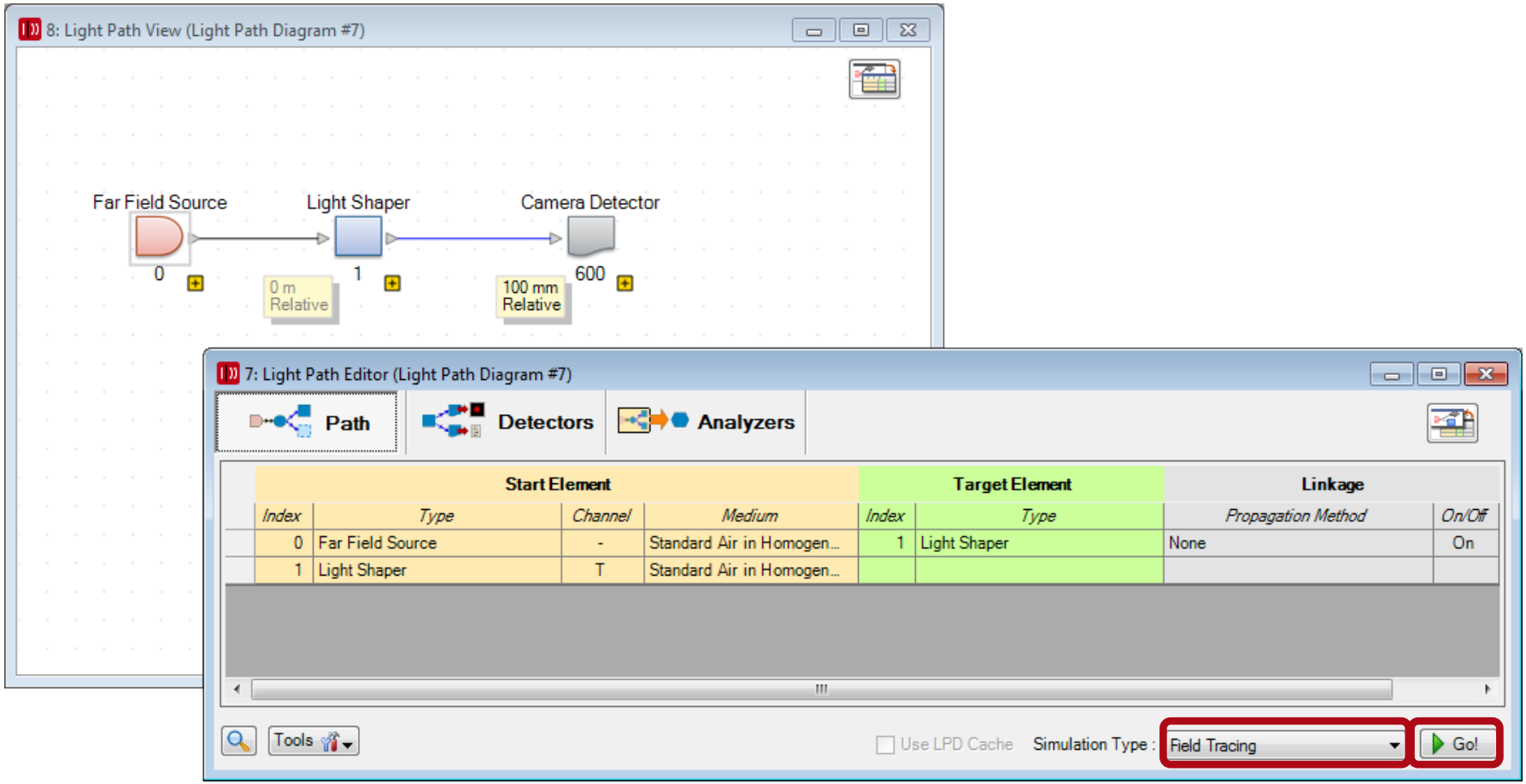
# GCA Design Document: Design




- *Variability of Spots Position* option and *Apply* Random *Lateral Shift at Each Grating Cell* option introduces a random shift of all spots in the target plane. This reduces pixel effects.
- By pressing on the GO button the design is performed and a new Light Path Diagram will be shown.

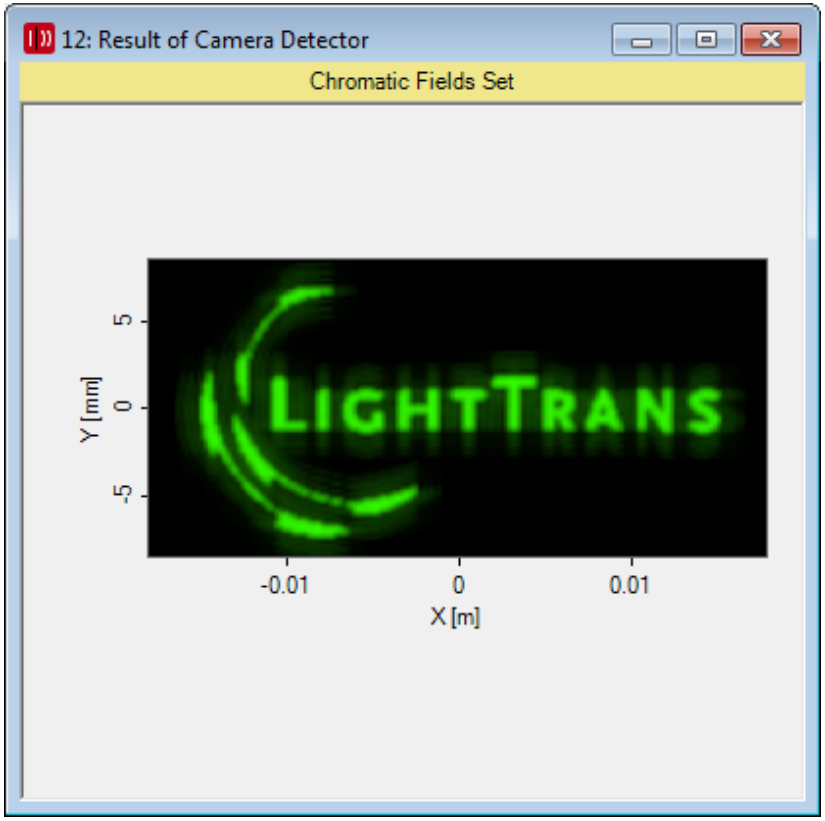
# Analysis of the designed GCA system

# Resulting System (Field Tracing)

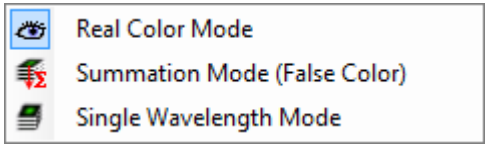



Results in

# Field Tracing Result

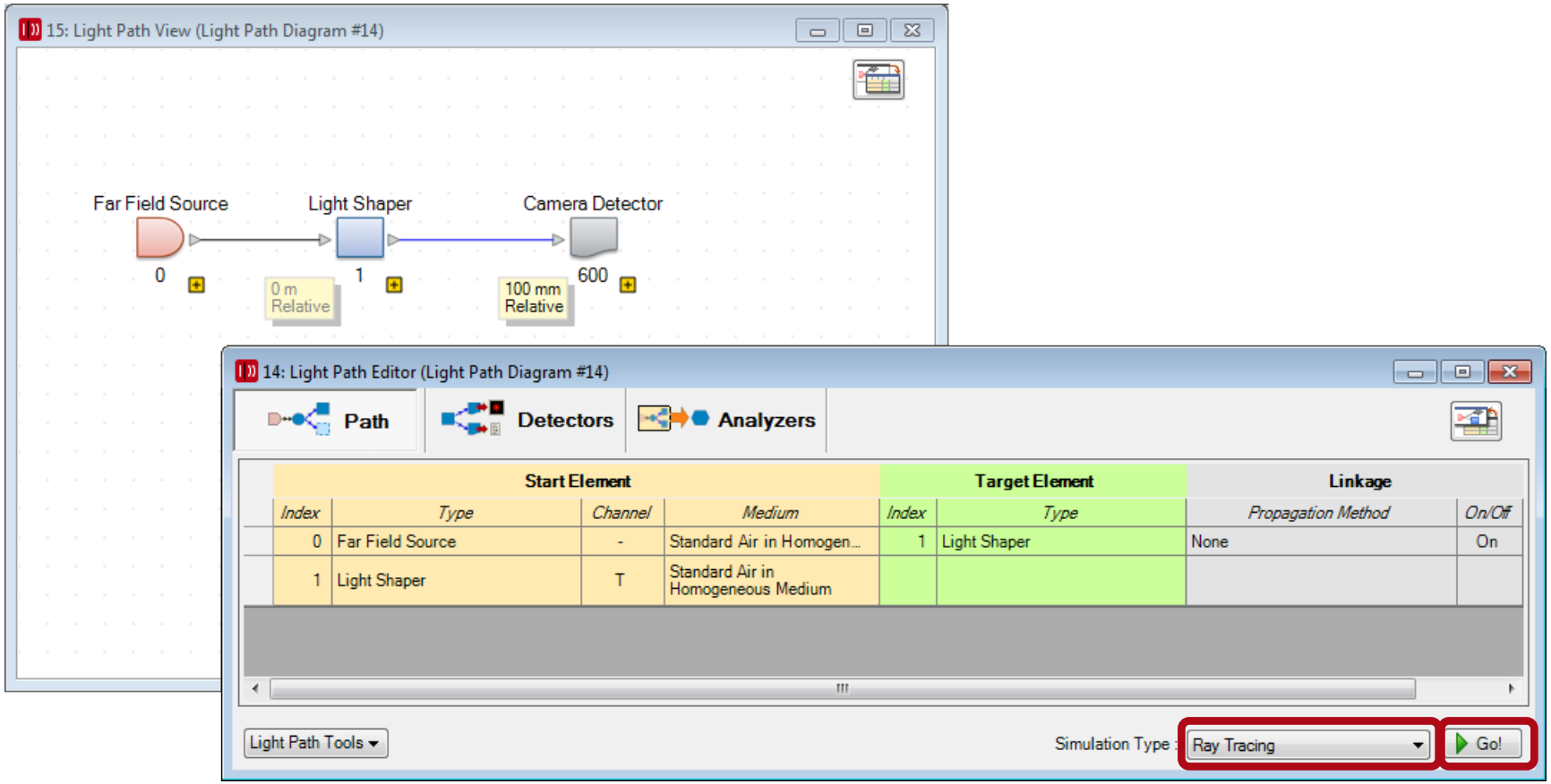



- The result of the camera detector is a chromatic fields set.
- The following view modes are available :



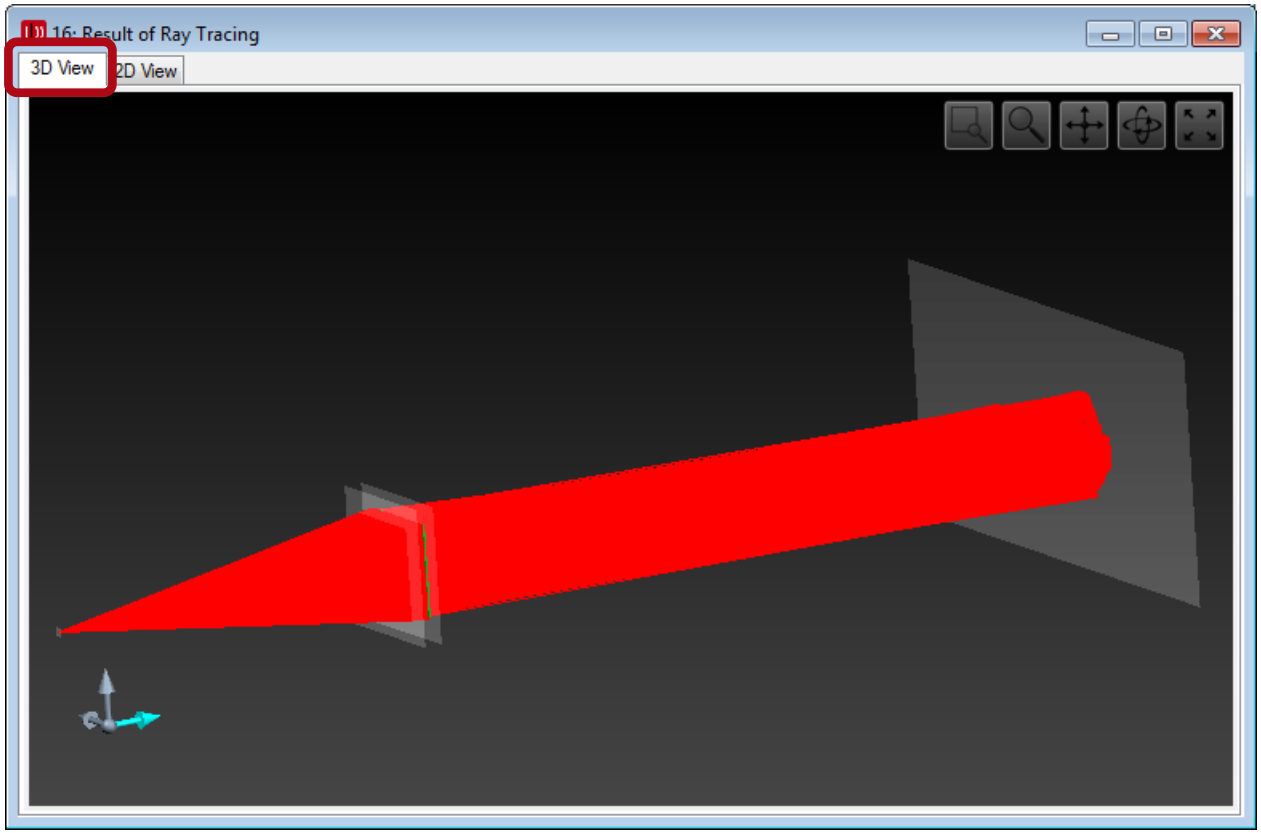

- The view mode can be changed via context menu, toolbar or property browser.

# Resulting System (Ray Tracing)

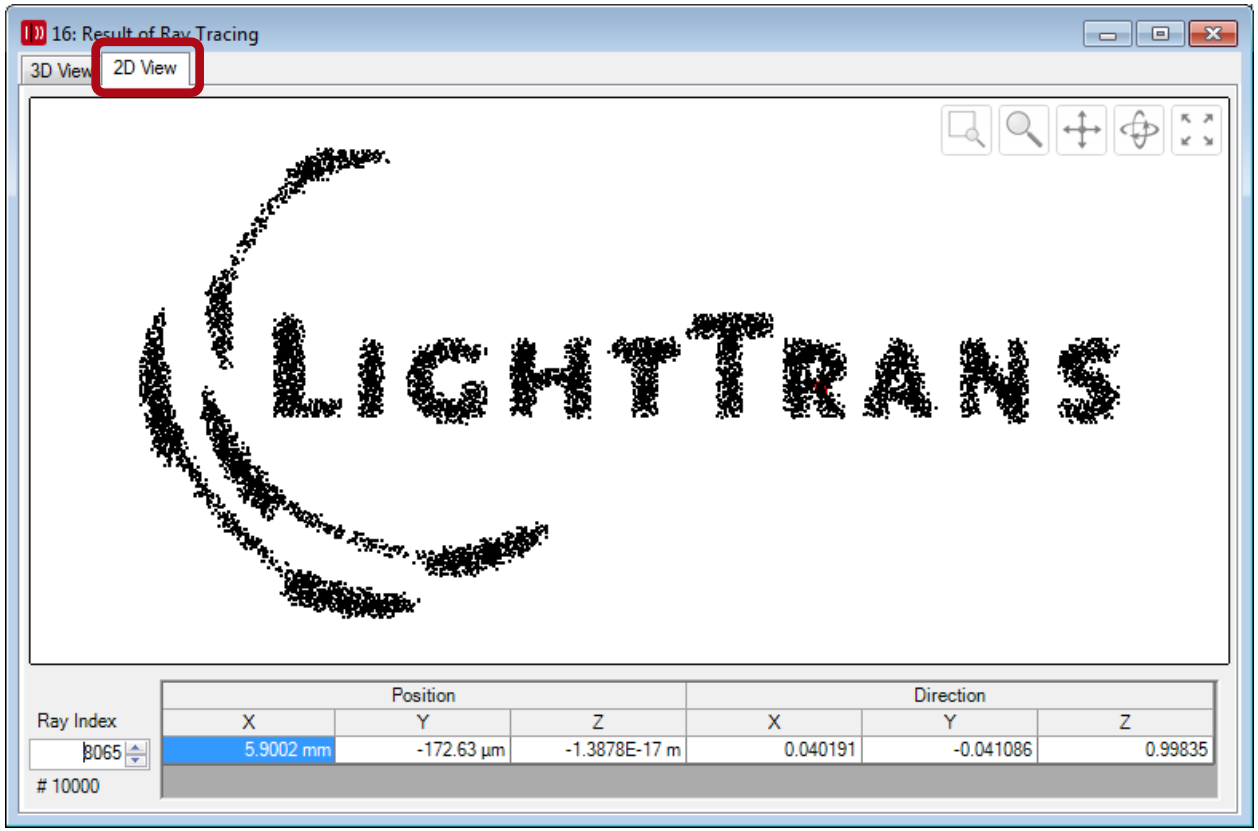



Results in

# Ray Tracing Result (3D view of rays)



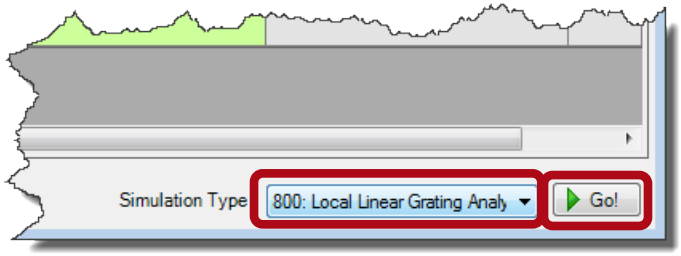
# Ray Tracing Result (2D view of spots)



# Enhanced Analysis of the designed GCA system

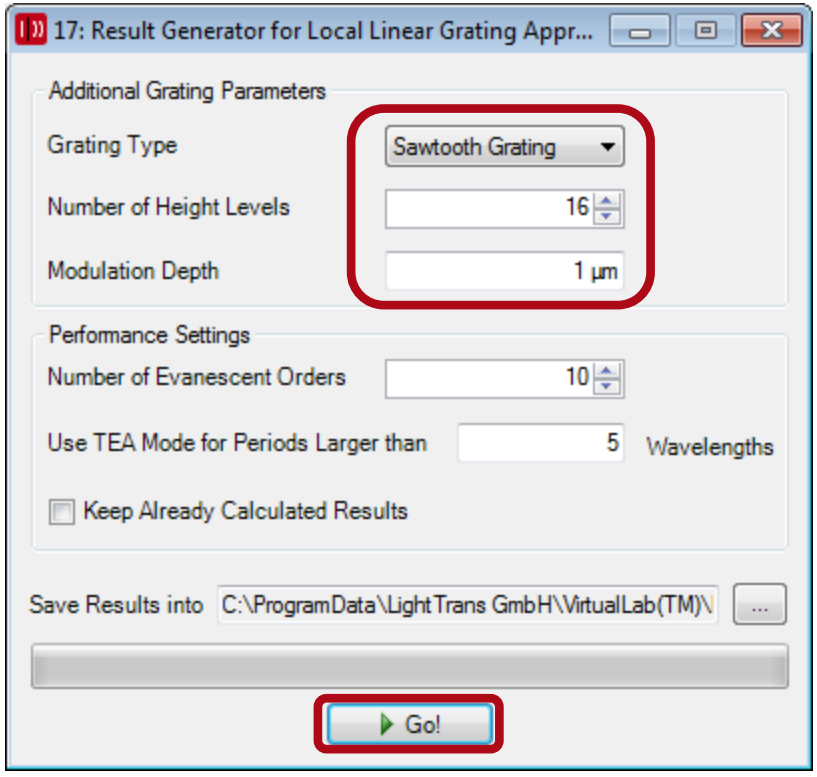
# LLGA Analyzer

- VirtualLab™ also offers the possibility to use the Grating Toolbox for rigorous analysis of the efficiencies of the gratings within the GCA array.
- Therefore the LLGA Analyzer has to be triggered.
- The minimum/maximum orders entered in the GCA edit dialog are used to generate a look up table.



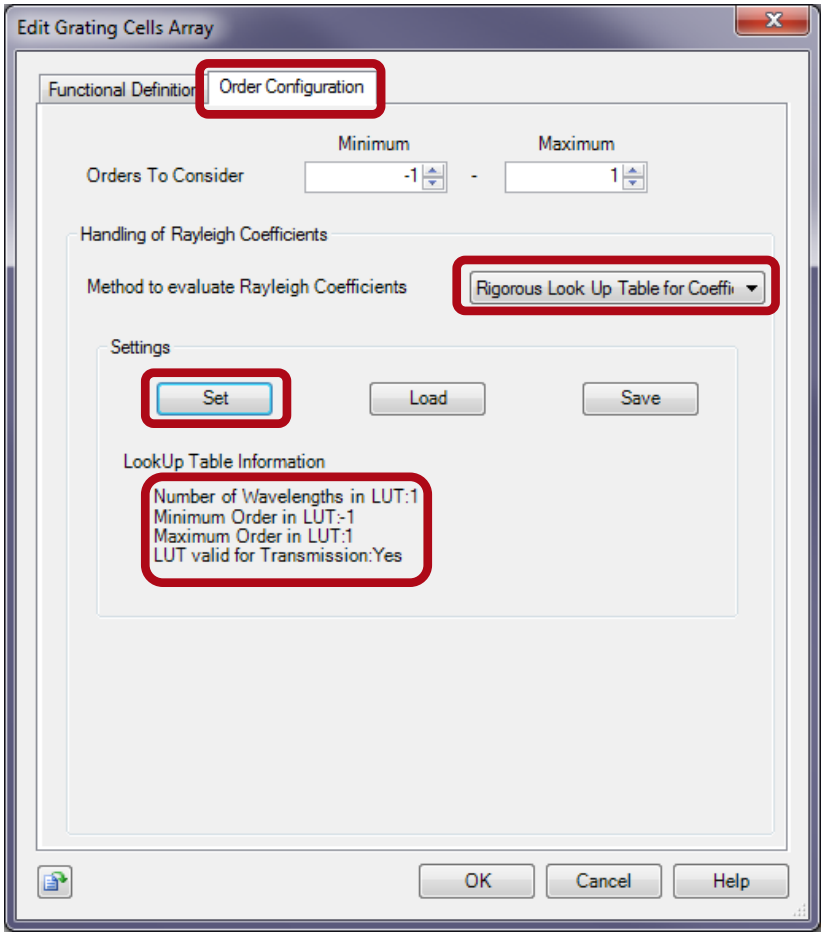

Results in

# LLGA Result Generator




- The LLGA result generator can be used to calculate the efficiencies of the gratings within the GCA with FMM or TEA.
- Several setting for the gratings to simulate can be specified (see manual).
- Pressing the GO! button triggers the analysis of the gratings.

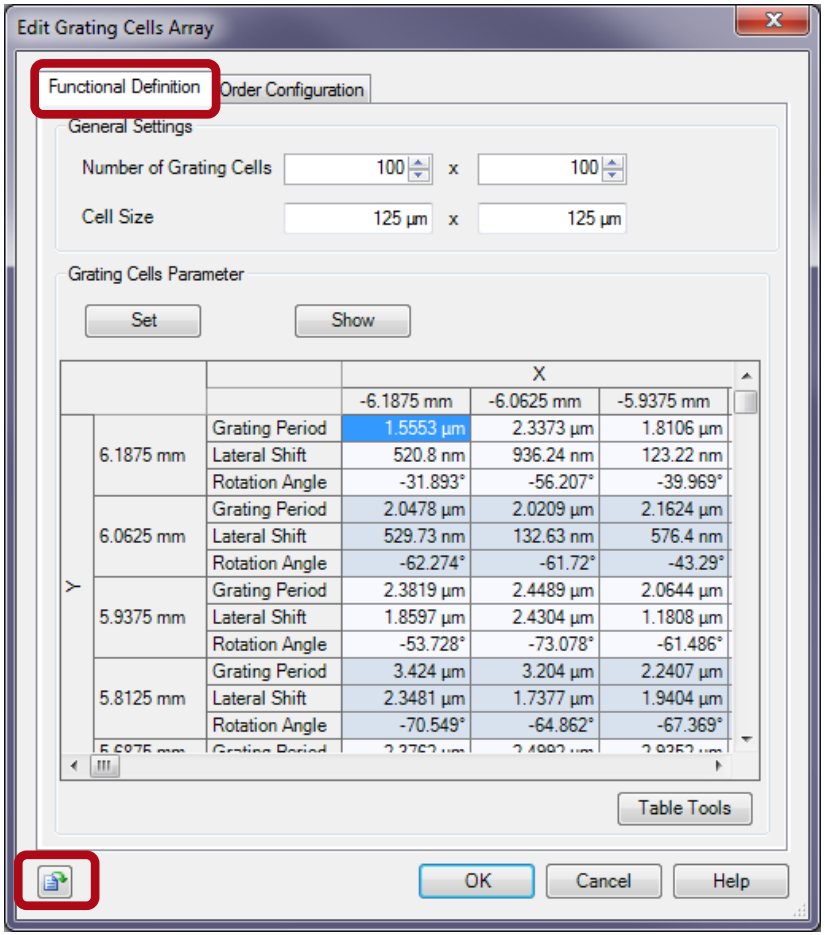
# LLGA Result Generator




- After the LLGA result generator has finished, the results can be set into the GCA operator by clicking on the set button within the GCA edit dialog.
- Alternatively, the results can be loaded from XML file.
- The information of the LLGA result generator which is set are displayed on the bottom of the edit form.

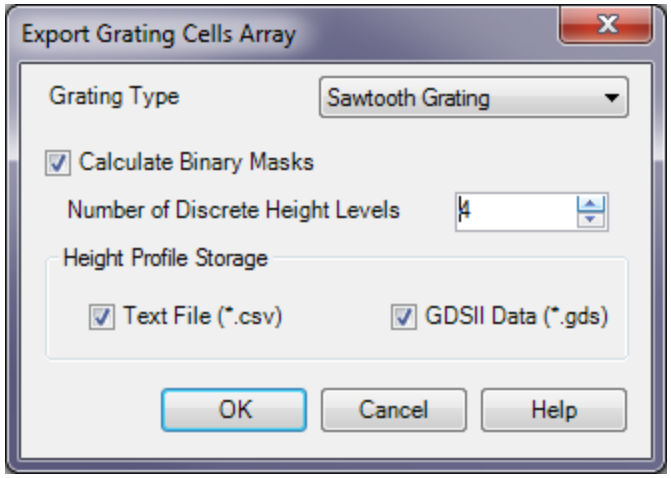
# Fabrication Export

# GCA Edit Dialog : Fabrication Export




- To export the GCA parameters the *Export* button in the edit dialog of the GCA operator needs to be clicked.
- The following formats are available :
  - CSV (comma seperated values)
  - GDSII (binary layers)

# Fabrication Export Dialog




- The fabrication export allows the specification of the grating type.
- If binary masks shall be calculated, the GDSII export is available.
- The CSV format contains all grating parameters in matrix form.