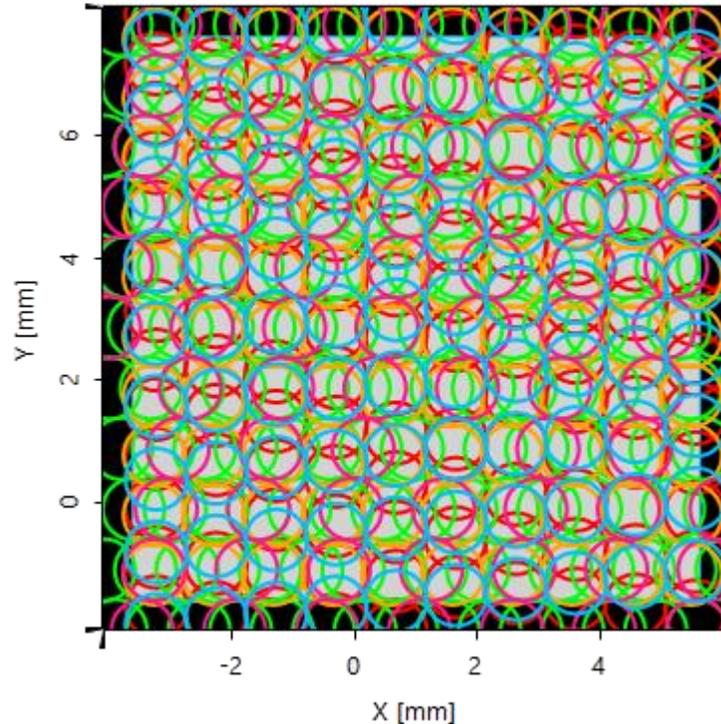


# Footprint Analysis of Lightguides for AR/MR Applications

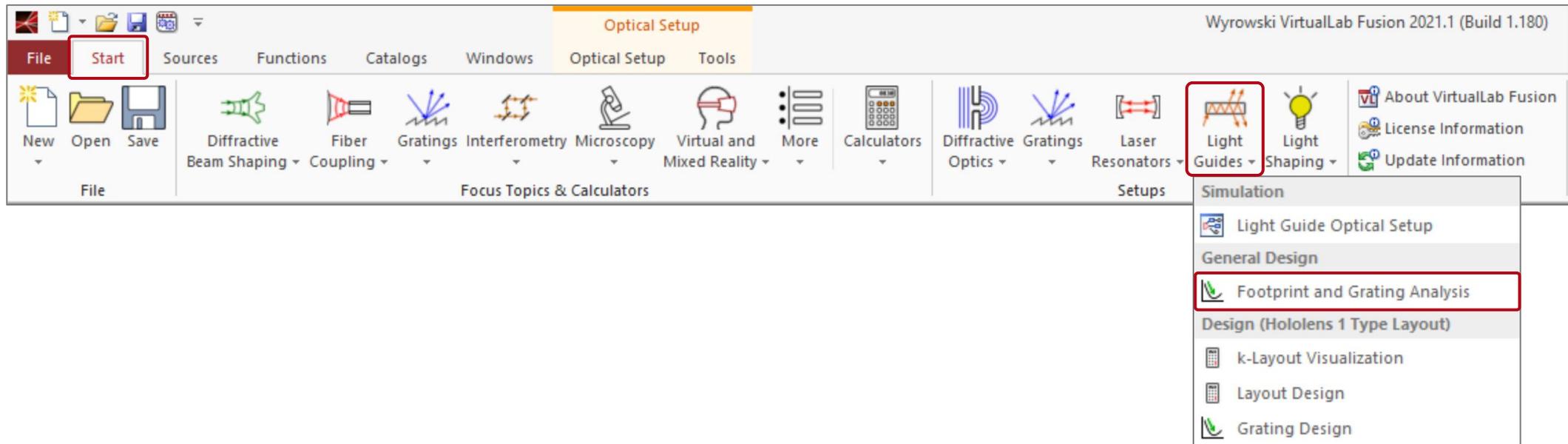
# Abstract



A major part of the design process of any kind of lightguide system for augmented or mixed reality applications is the configuration of the grating regions for the incoupler, outcoupler and eye pupil expander. For this purpose, a fast and simple overview of the light propagation and occurring grating interactions is very helpful: the analysis of the footprints. With the *Footprint and Grating Analysis Tool* VirtualLab provides a powerful tool to support the optical engineer during this process. In this document, the options and capabilities of this versatile tool are discussed.

# The Footprint and Grating Analysis Tool

- The *Footprint and Grating Analysis* tool is a feature of the *Light Guide Toolbox Gold Edition*.
- It can be initialized in the *Light Guides* section of the *Start* ribbon.



# Basic Workflow to Operate the Tool

26: Footprint and Grating Analysis\*

Optical Setup

Field of View Angles for Design

#	$\alpha$	$\beta$
1	0°	-8°
2	-16°	0°
3	0°	0°
4	16°	0°
5	0°	8°

Efficiency of Zeroth Order  Efficiency of All Other Orders

Validity:

Add Range of Field of View Angles

Range ( $\alpha$ ,  $\beta$ )

Center ( $\alpha$ ,  $\beta$ )

Number of Angles

Validity:

Edit Angle  
Add Angle  
Add Angle Range  
Remove Angle

With these settings the computational time can be reduced. For more info move the mouse over the **i** symbol.

Step 1: Choose setup to analyze. It can be generated e.g. with the *Layout Design* tool as explained in:

[Light Guide Layout Design Tool](#)

But please note that the *Footprint and Grating Analysis* tool is not restricted to a specific type of layout. You can load a file or select one from the already open documents, directly.

Step 2: Define the field of view range that the tool should consider.

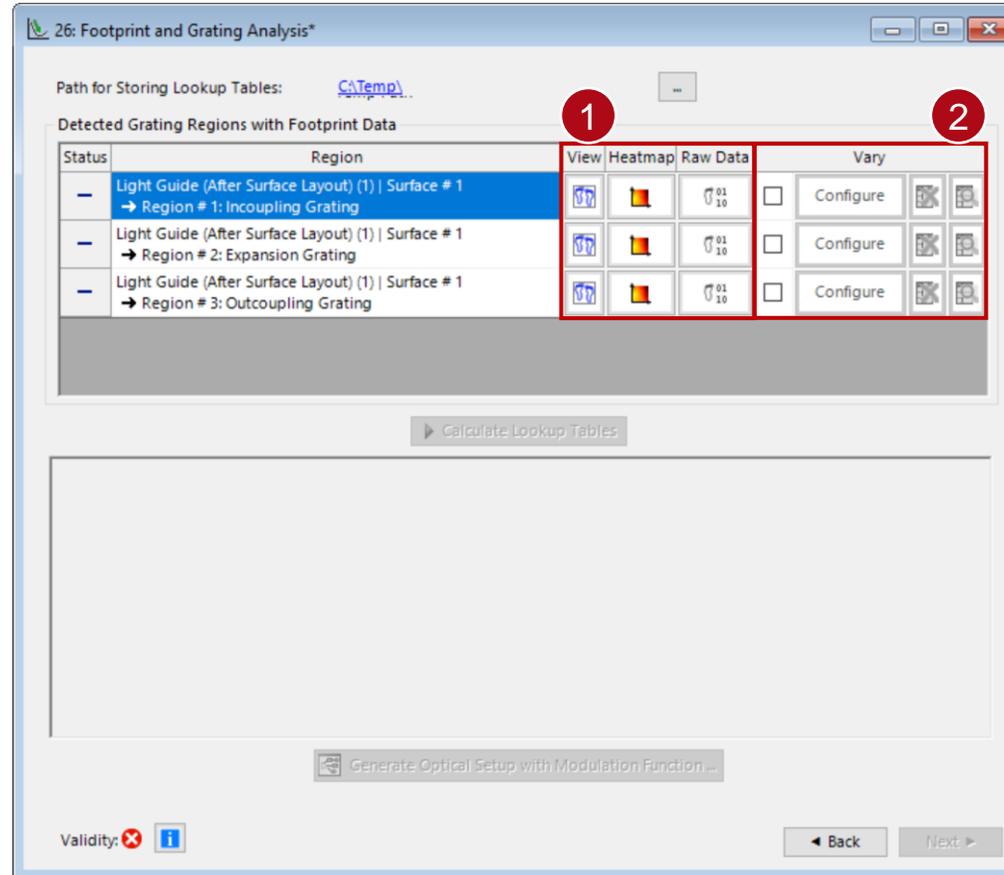
Step 3: Click the *Analyze* button. Detailed information about the progress of the analysis is provided in the panel below the button.

```
[11/12/2021 07:18:36]: Extraction of footprint and grating data started ...
[11/12/2021 07:18:36]: New incident direction detected for Incoupling Grating: (0; 0.13917; 0.99027)
[11/12/2021 07:18:36]: New incident direction detected for Incoupling Grating: (0.69459; 0.069067; -0.71609)
[11/12/2021 07:18:36]: New incident direction detected for Expansion Grating: (0.44231; 0.53999; -0.71609)
[11/12/2021 07:18:36]: New incident direction detected for Outcoupling Grating: (0.76366; 1.4912E-06; -0.64562)
[11/12/2021 07:18:36]: New incident direction detected for Expansion Grating: (-0.53999; 0.53999; -0.64562)
[11/12/2021 07:18:36]: Number of detected different directions at grating regions = 5
[11/12/2021 07:18:36]: Number of footprints found for Incoupling Grating: 2
[11/12/2021 07:18:36]: Number of footprints found for Expansion Grating: 22
[11/12/2021 07:18:36]: Number of footprints found for Outcoupling Grating: 85
[11/12/2021 07:18:36]: Extraction of footprint data finished.
```

# Idealized and Real Grating Results

The results of the *Footprint and Grating Analysis* tool can be divided in two areas:

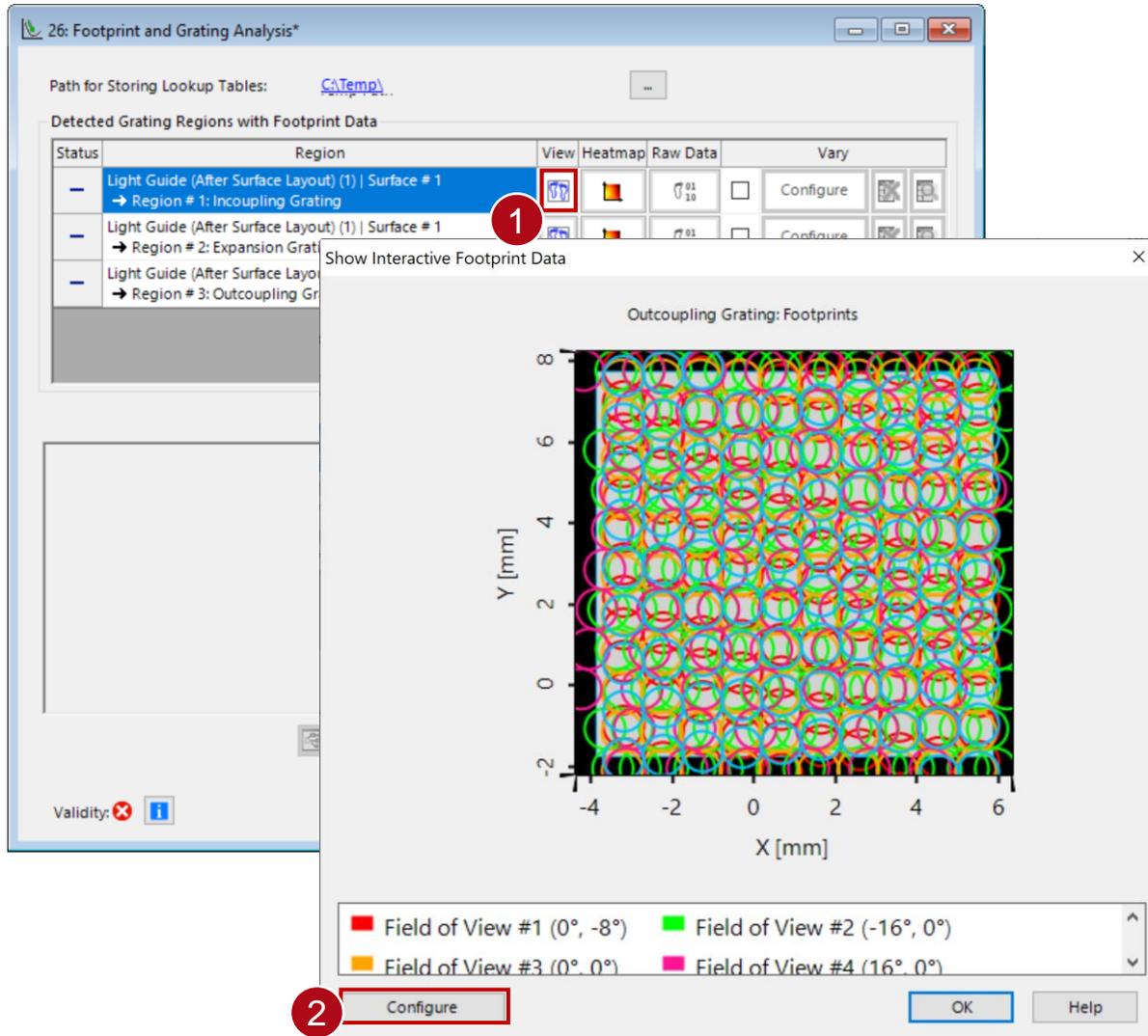
- The three left columns, *View (of footprints)*, *Heatmap* and *Raw Data*, give access to the results based on the positions of the interactions between beam and gratings.
- Thus, there is no difference whether idealized or real gratings are specified.
- Only the main direction of the beam and its diameter is considered.



- The right-most column, *Vary*, allows for an in-depth investigation of the configured real gratings.
- For this purpose, all parameters of the grating structures (except the period) can be varied (two at the same time).
- The grating part of the tool is presented in more detail in the following use case:

[Grating Analysis and Smoothly Modulated Grating Parameters on Lightguides](#)

# Interactive Footprint Data

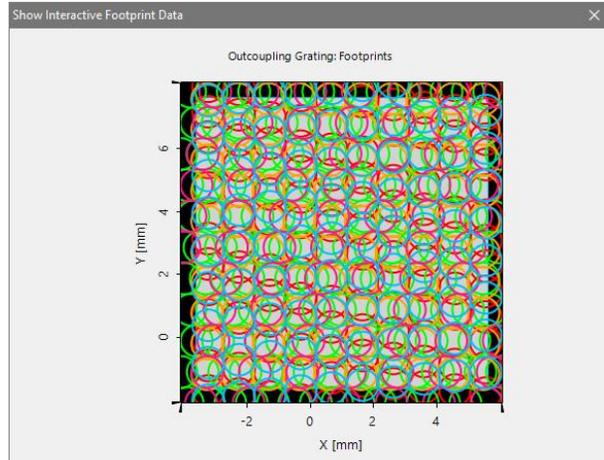


The *Interactive Footprint Data* document provides a color-coded illustration of all the beam footprints hitting a given grating region, with different colors for the different modes of the configured field of view (FOV). The user can select which FOV modes are to be displayed in the figure.

## Notes

- *If partially impinging beams are recorded by VirtualLab Fusion, depends on the "Channel Resolution Accuracy" setting in the base optical setup.*
- *No matter how small or modulated the light portion is, that hits the region, this display does not differentiate and will always depict the full, same sized footprint circle.*

# Data of the Central FOV

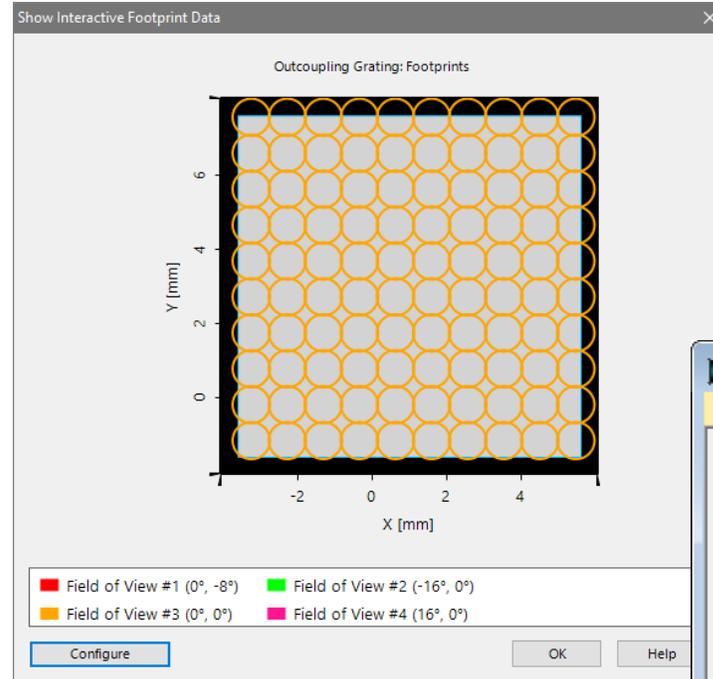


Configure Grating Layout and Footprint Diagram

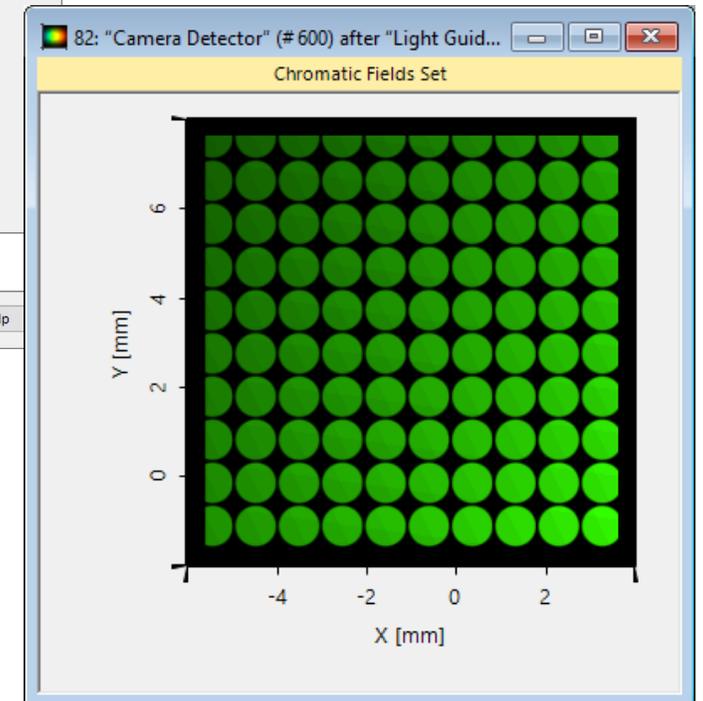
Region Border Color  Region Fill Color

Footprint Properties		Color
<input type="checkbox"/> Field of View Angle		
<input type="checkbox"/> #1 (0°, -8°)		<span style="color: red;">■</span>
<input type="checkbox"/> #2 (-16°, 0°)		<span style="color: green;">■</span>
<input checked="" type="checkbox"/> #3 (0°, 0°)		<span style="color: orange;">■</span>
<input type="checkbox"/> #4 (16°, 0°)		<span style="color: magenta;">■</span>
<input type="checkbox"/> #5 (0°, 8°)		<span style="color: cyan;">■</span>

OK Cancel Help



**Comparison**  
field tracing result  
of the same lightguide setup  
at the same plane



## Notes

- The footprint circles include the full soft edge of the beams.
- The footprint display refers to the coordinate system (CS) of the region's surface. The detector used to generate the adjacent comparison result has a mirrored CS.

# Data of Inclined FOV Mode

Outcoupling Grating: Footprints

Y [mm]

X [mm]

Field of View #1 (0°, -8°)    Field of View #2 (-16°, 0°)  
 Field of View #3 (0°, 0°)    Field of View #4 (16°, 0°)

Configure

Configure Grating Layout and Footprint Diagram

Region Border Color    Region Fill Color

Footprint Properties

<input type="checkbox"/>	Field of View Angle	Color
<input checked="" type="checkbox"/>	#1 (0°, -8°)	Red
<input type="checkbox"/>	#2 (-16°, 0°)	Green
<input type="checkbox"/>	#3 (0°, 0°)	Yellow
<input type="checkbox"/>	#4 (16°, 0°)	Pink
<input type="checkbox"/>	#5 (0°, 8°)	Blue

OK    Cancel    Help

Outcoupling Grating: Footprints

Y [mm]

X [mm]

Field of View #1 (0°, -8°)    Field of View #2 (-16°, 0°)  
 Field of View #3 (0°, 0°)    Field of View #4 (16°, 0°)

Configure    OK    Help

**Comparison**  
*field tracing result  
of the same lightguide setup  
at the same plane*

83: "Camera Detector" (#600) after "Light Guid..."

Chromatic Fields Set

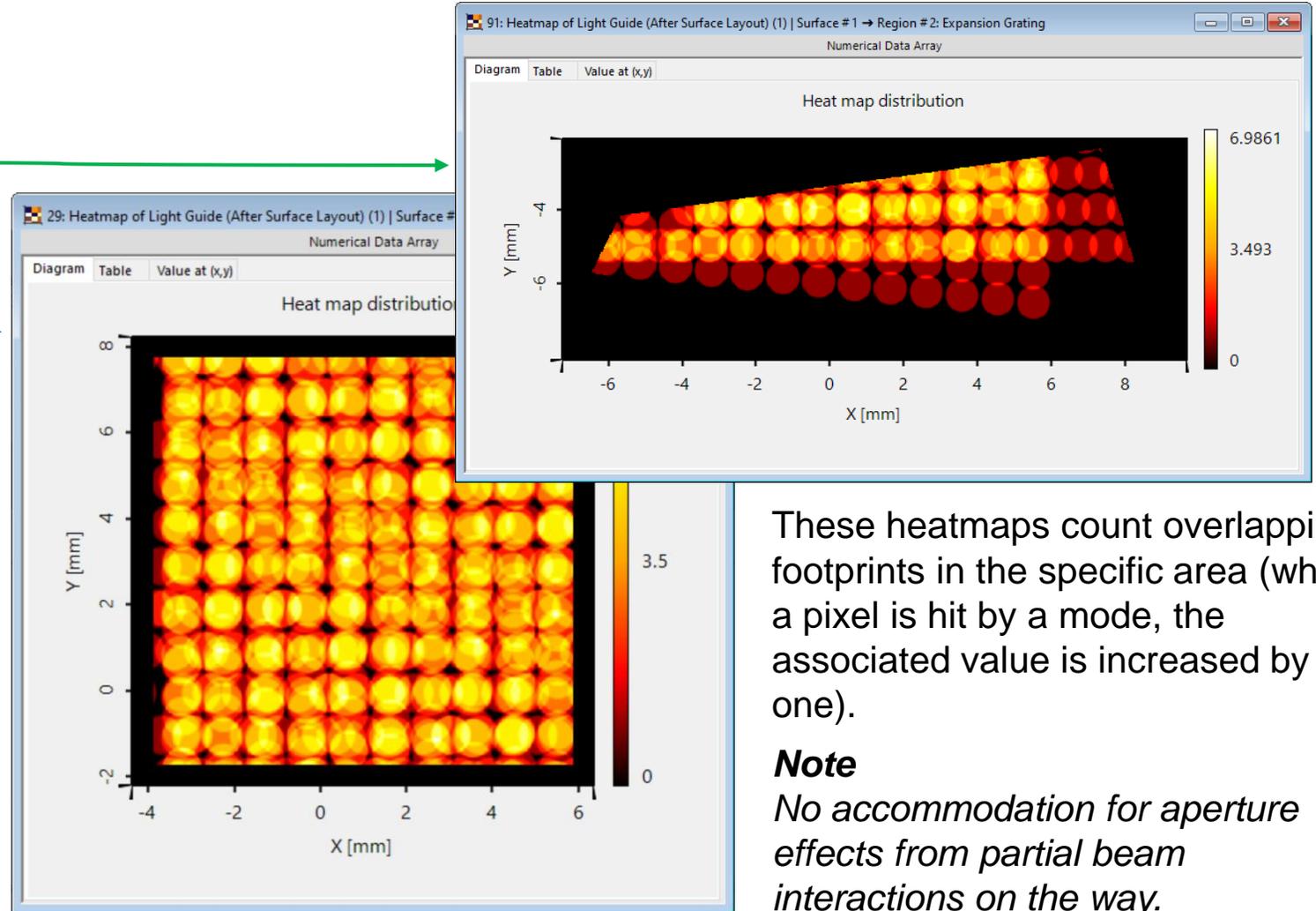
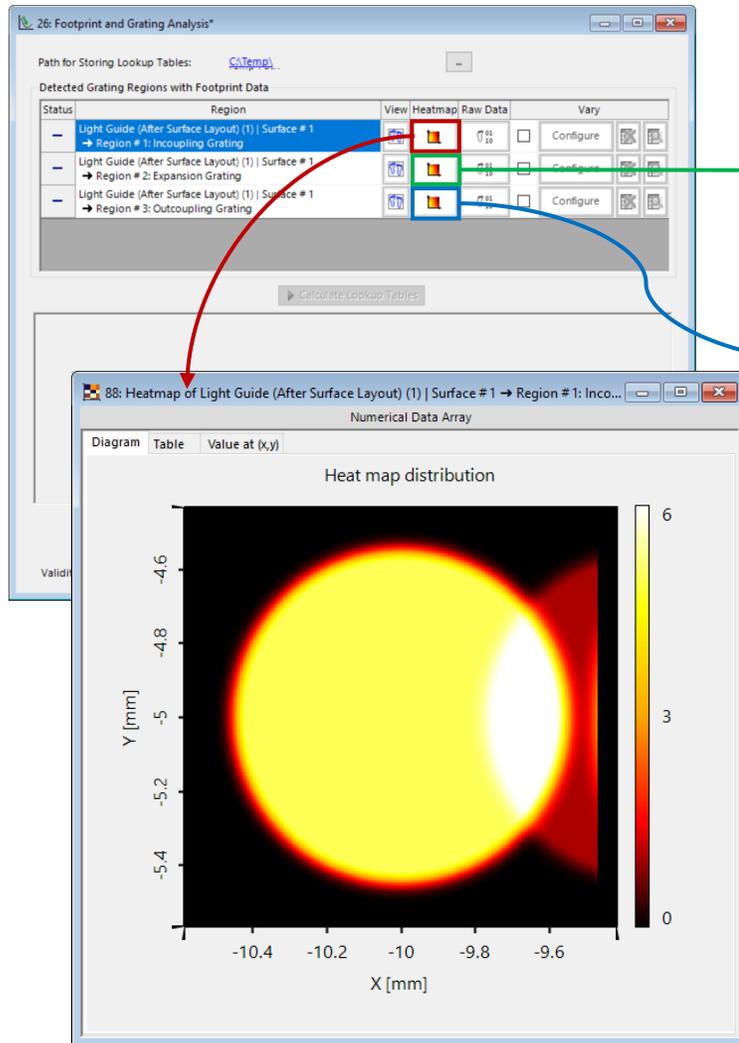
Y [mm]

X [mm]

## Notes

- *The footprint circles include the full soft edge of the beams.*
- *The footprint display refers to the coordinate system (CS) of the region's surface. The detector used to generate the adjacent comparison result has a mirrored CS.*

# Heatmap Documents

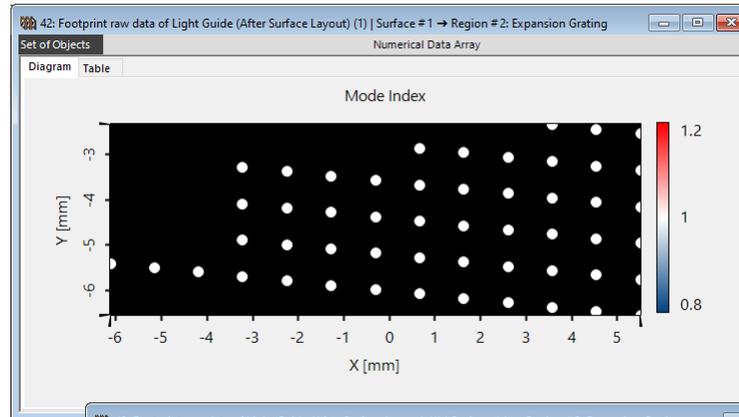
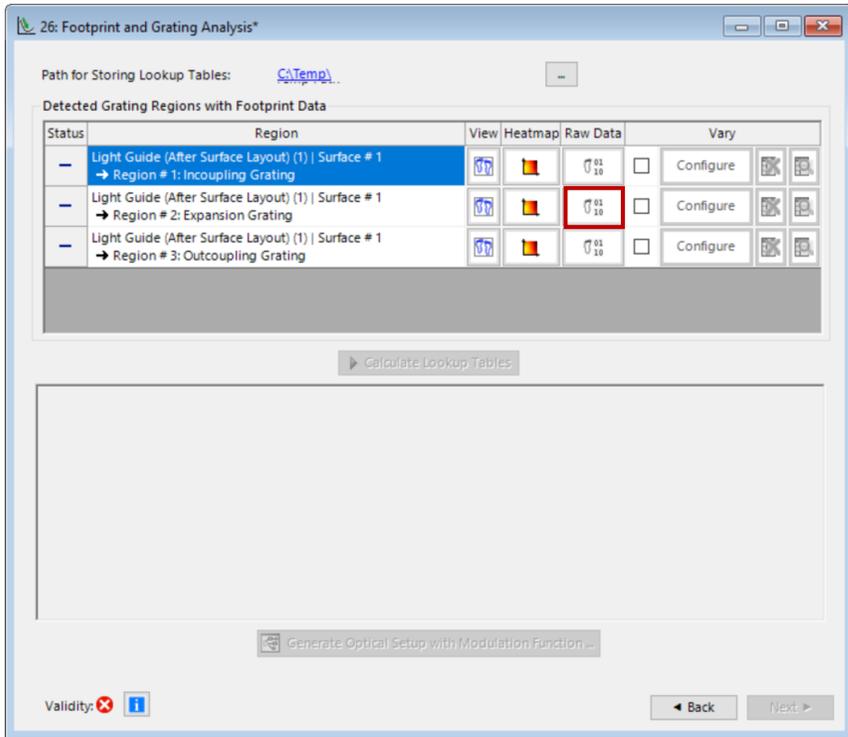


These heatmaps count overlapping footprints in the specific area (when a pixel is hit by a mode, the associated value is increased by one).

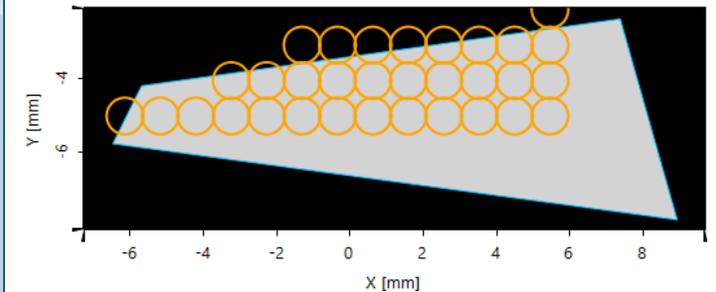
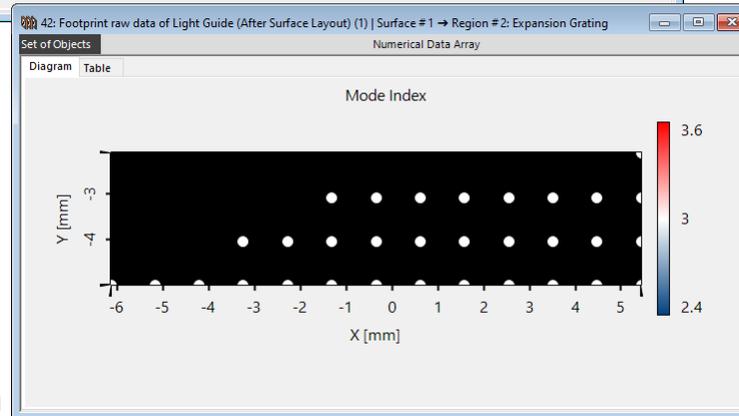
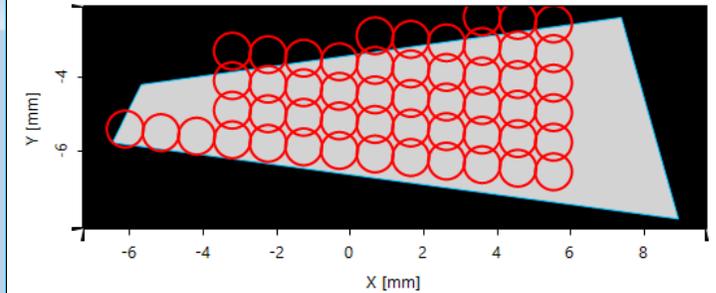
**Note**

*No accommodation for aperture effects from partial beam interactions on the way.*

# Footprint Raw Data Documents



*corresponding footprint diagrams*



- The *Raw Data* result depicts the central position of every footprint for each FOV mode.
- This information can be used to determine the number of interactions and may serve as base for considering a suitable number of support points in case an optical setup with modulation function should be created. The latter is explained in more detail in the use case: [Grating Analysis and Smoothly Modulated Grating Parameters on Lightguides](#)

# Document Information

title	Footprint Analysis of Lightguides for AR/MR Applications
document code	LIG.0008
document version	1.0
software edition	<ul style="list-style-type: none"><li>• VirtualLab Fusion Advanced</li><li>• VirtualLab Fusion Light Guide Toolbox Gold</li></ul>
software version	2021.1 (Build 1.180)
category	Feature Use Case
further reading	<ul style="list-style-type: none"><li>- <a href="#"><u>Grating Analysis and Smoothly Modulated Grating Parameters on Lightguides</u></a></li><li>- <a href="#"><u>Construction of a Light Guide</u></a></li><li>- <a href="#"><u>Modeling of a “HoloLens 1”-Type Layout with Light Guide Component</u></a></li><li>- <a href="#"><u>Light Guide Layout Design Tool</u></a></li><li>- <a href="#"><u>k-Domain Layout Visualization</u></a></li><li>- <a href="#"><u>Simulation of Lightguide with 1D-1D Pupil Expander and Real Gratings</u></a></li></ul>