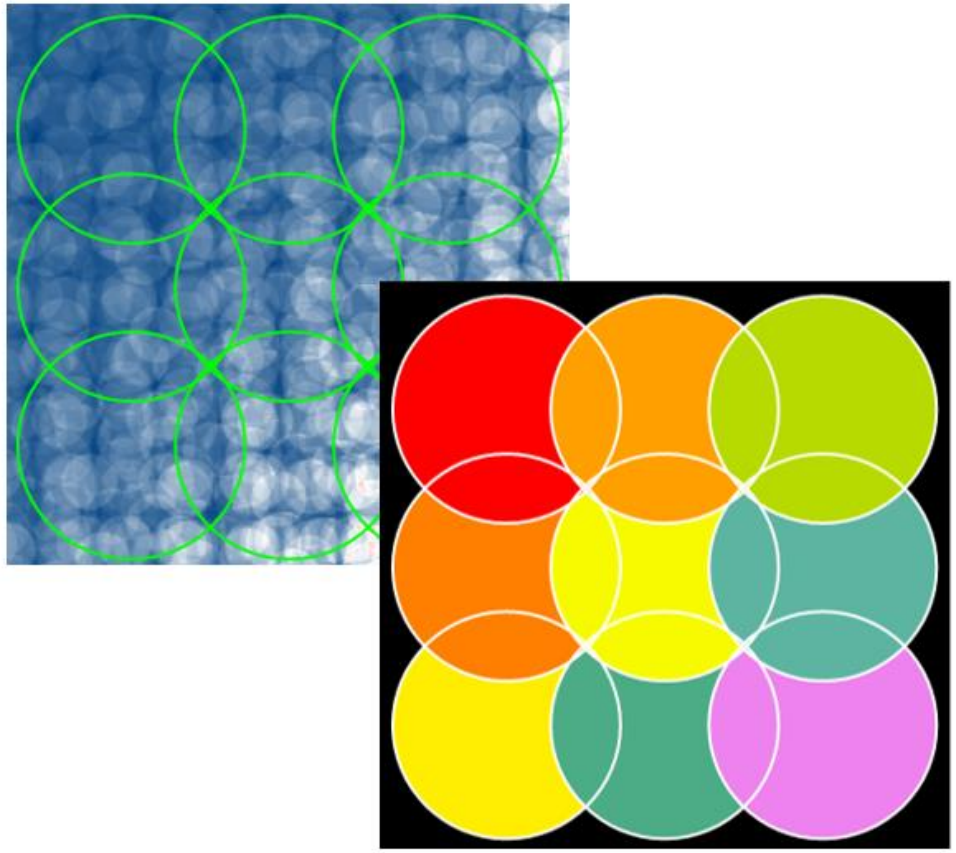
Uniformity Detector for Lightguide Systems

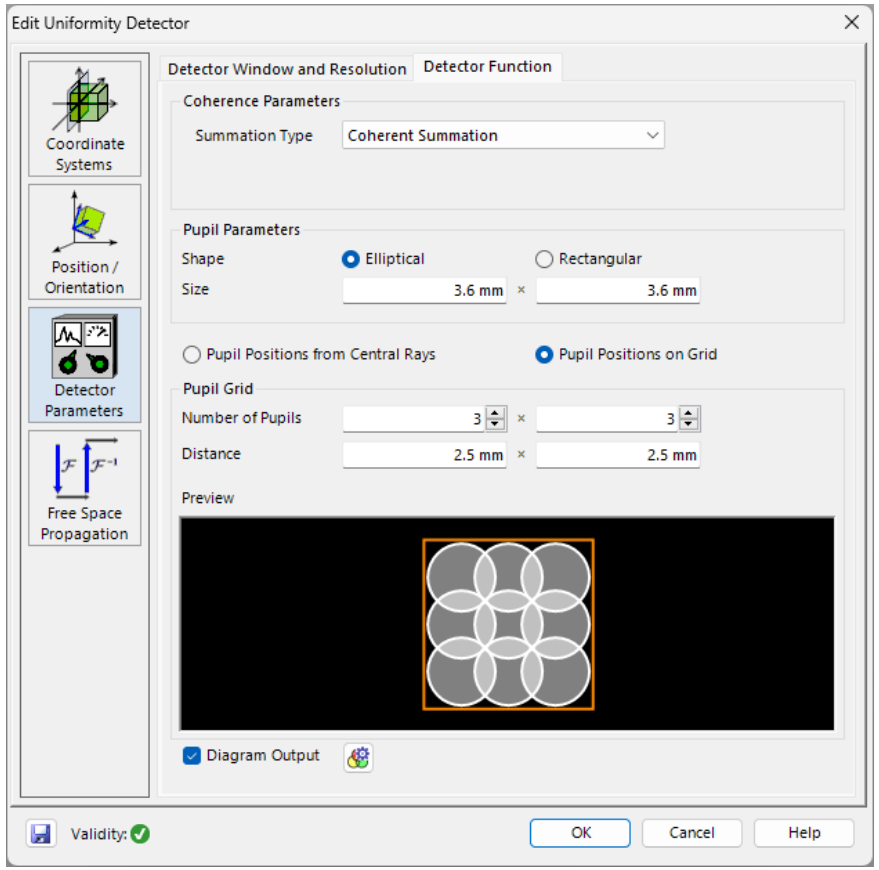
Abstract

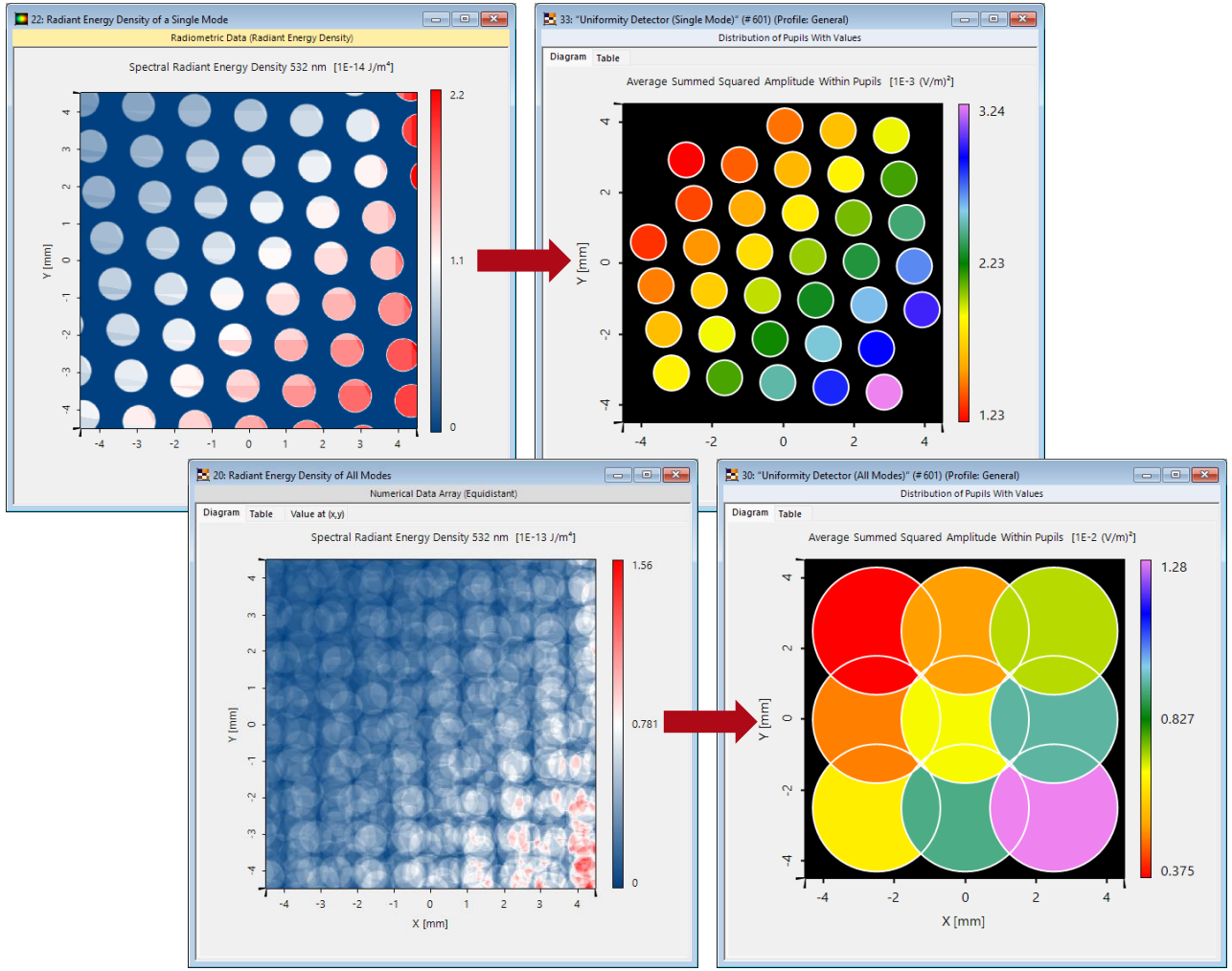


For the performance evaluation of lightguide systems in the field of AR/MR (augmented or mixed reality) devices, the lateral uniformity of the light distribution in the eyebox is one of the most crucial parameters. In order to measure and optimize the lateral uniformity during the design process, VirtualLab Fusion provides a Uniformity Detector, which offers tools for such investigations. In this document, we demonstrate the configuration options of the Uniformity Detector.

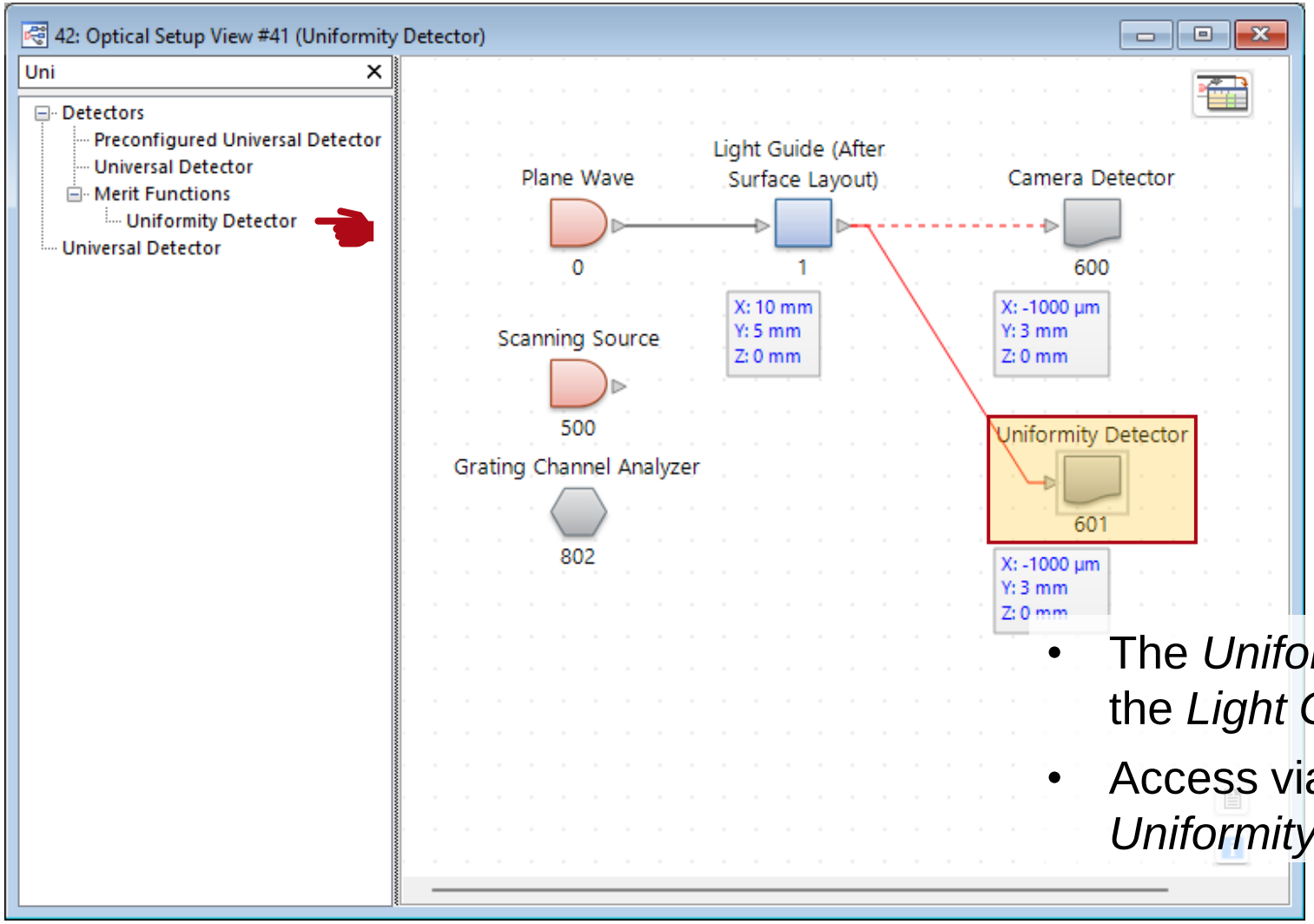
This Use Case Shows...

How to use the *Uniformity Detector* of the *Light Guide Toolbox* to calculate the uniformity across the specified pupils?



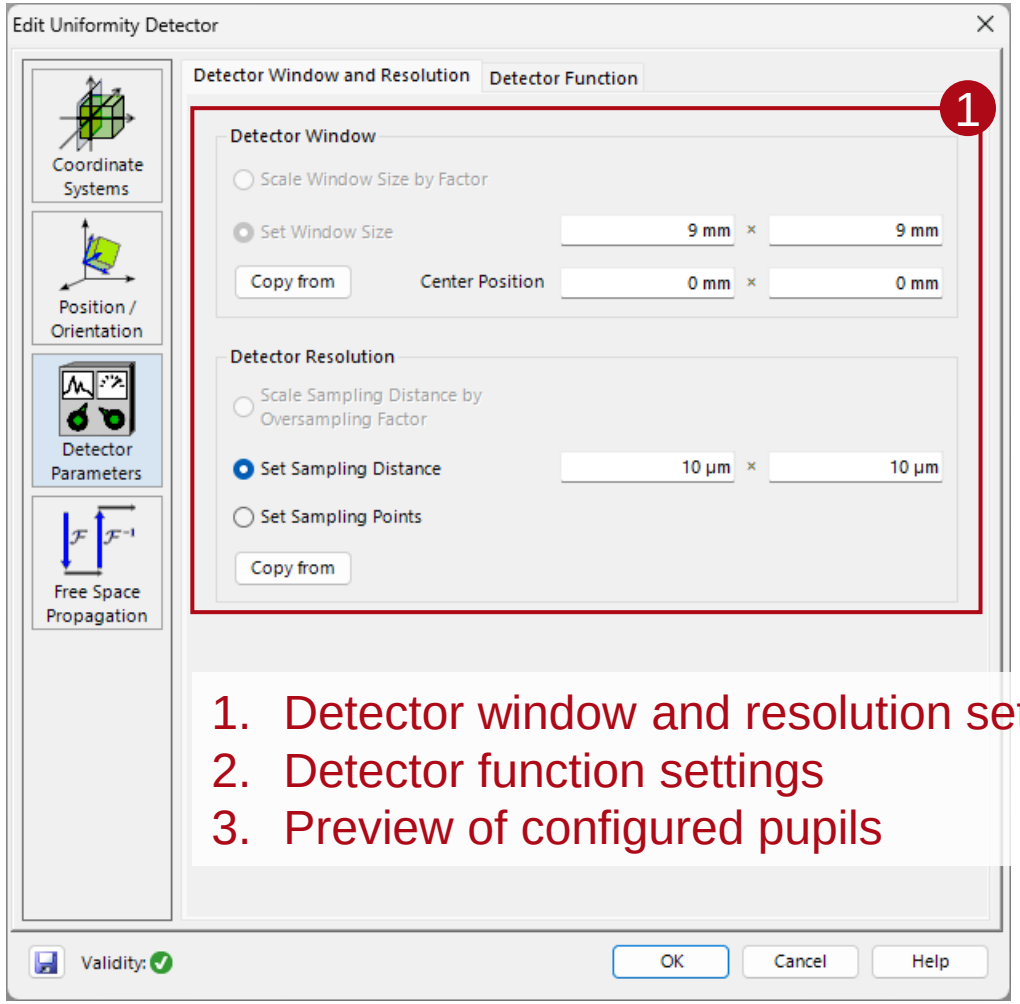


Uniformity Detector

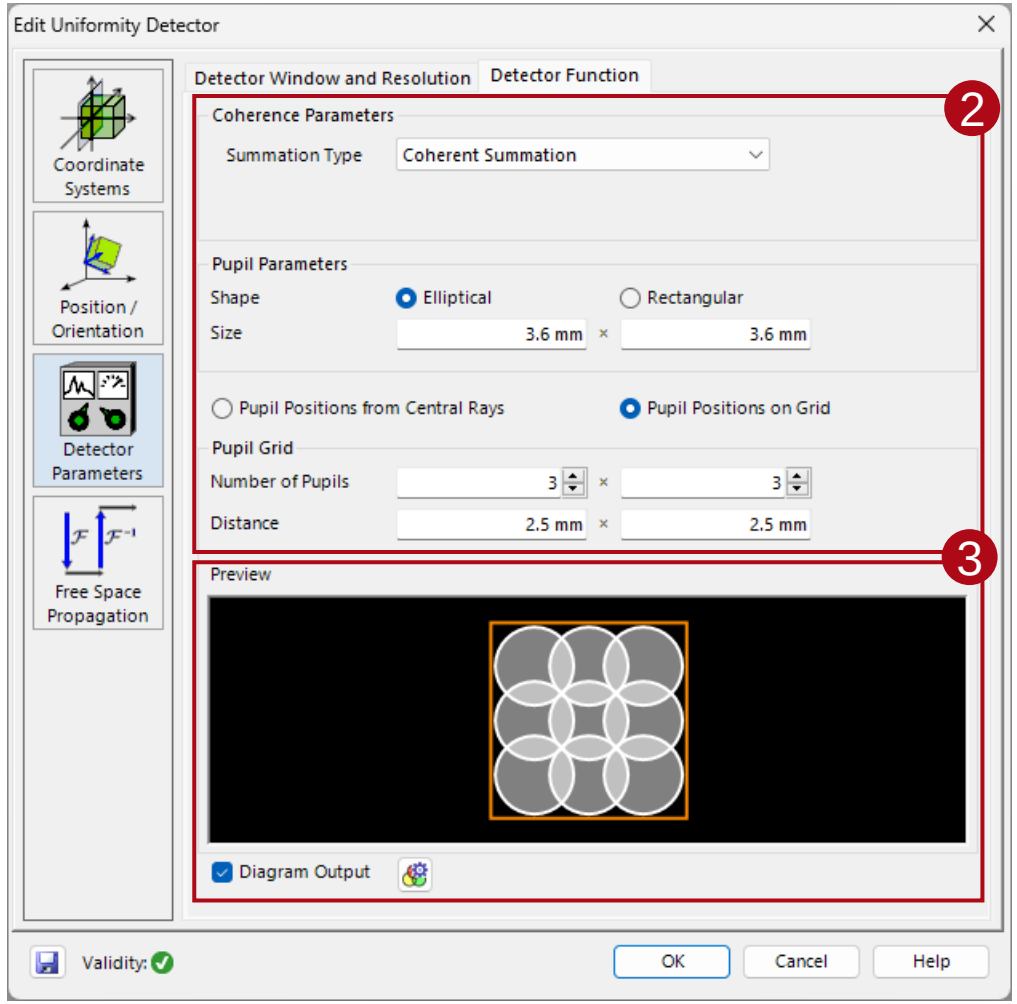


- The *Uniformity Detector* is only available in the *Light Guide Toolbox*.
- Access via: *Detectors* > *Merit Functions* > *Uniformity Detector*

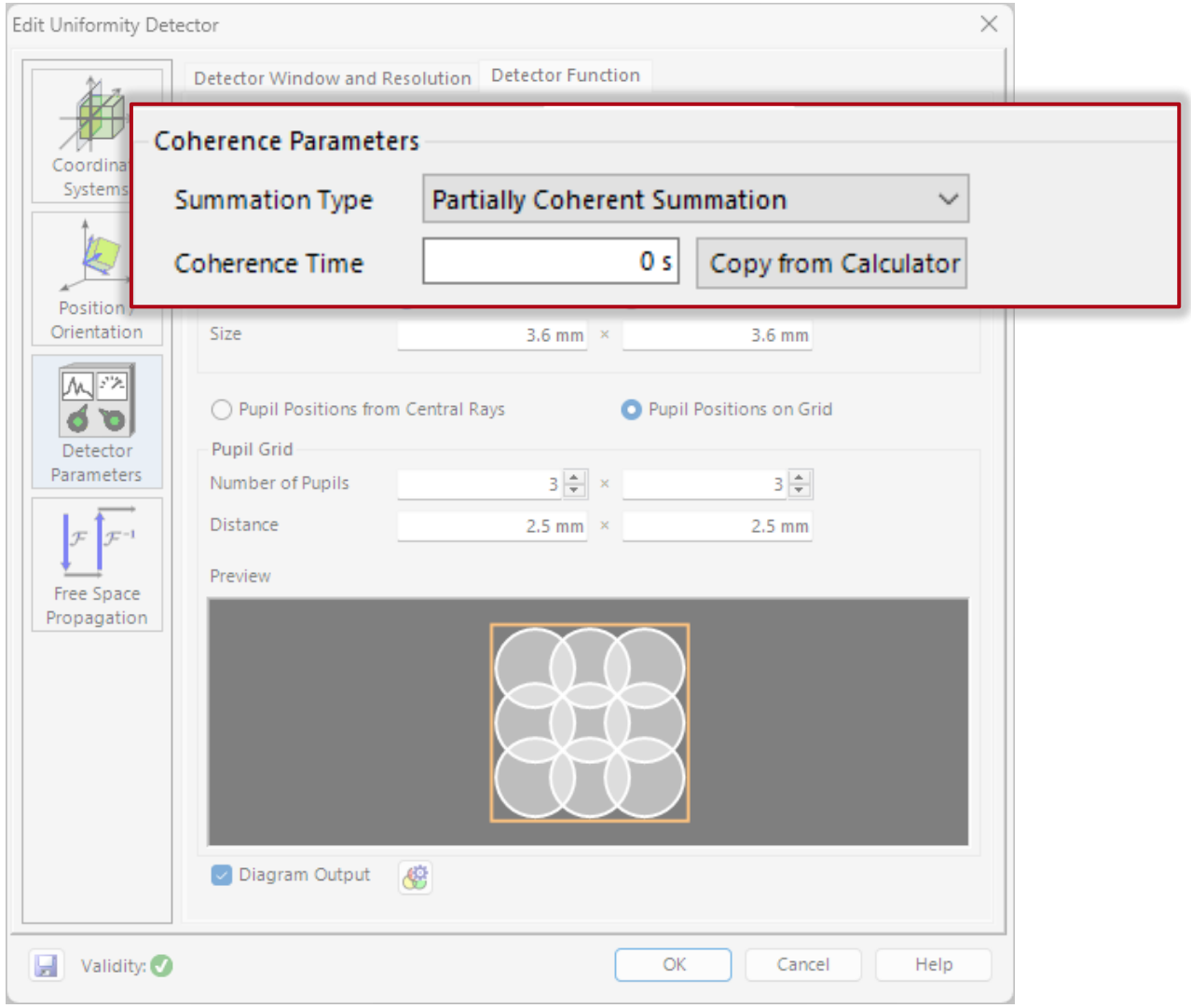
Edit Dialog of the Uniformity Detector



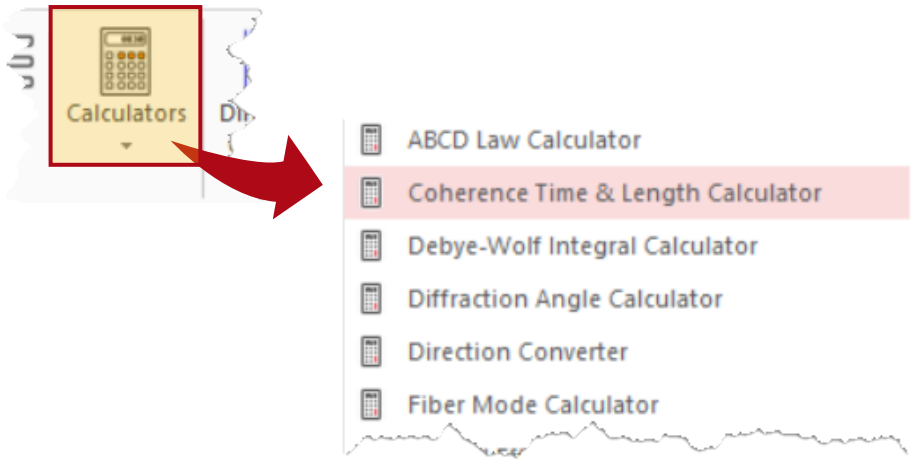
1. Detector window and resolution settings
2. Detector function settings
3. Preview of configured pupils



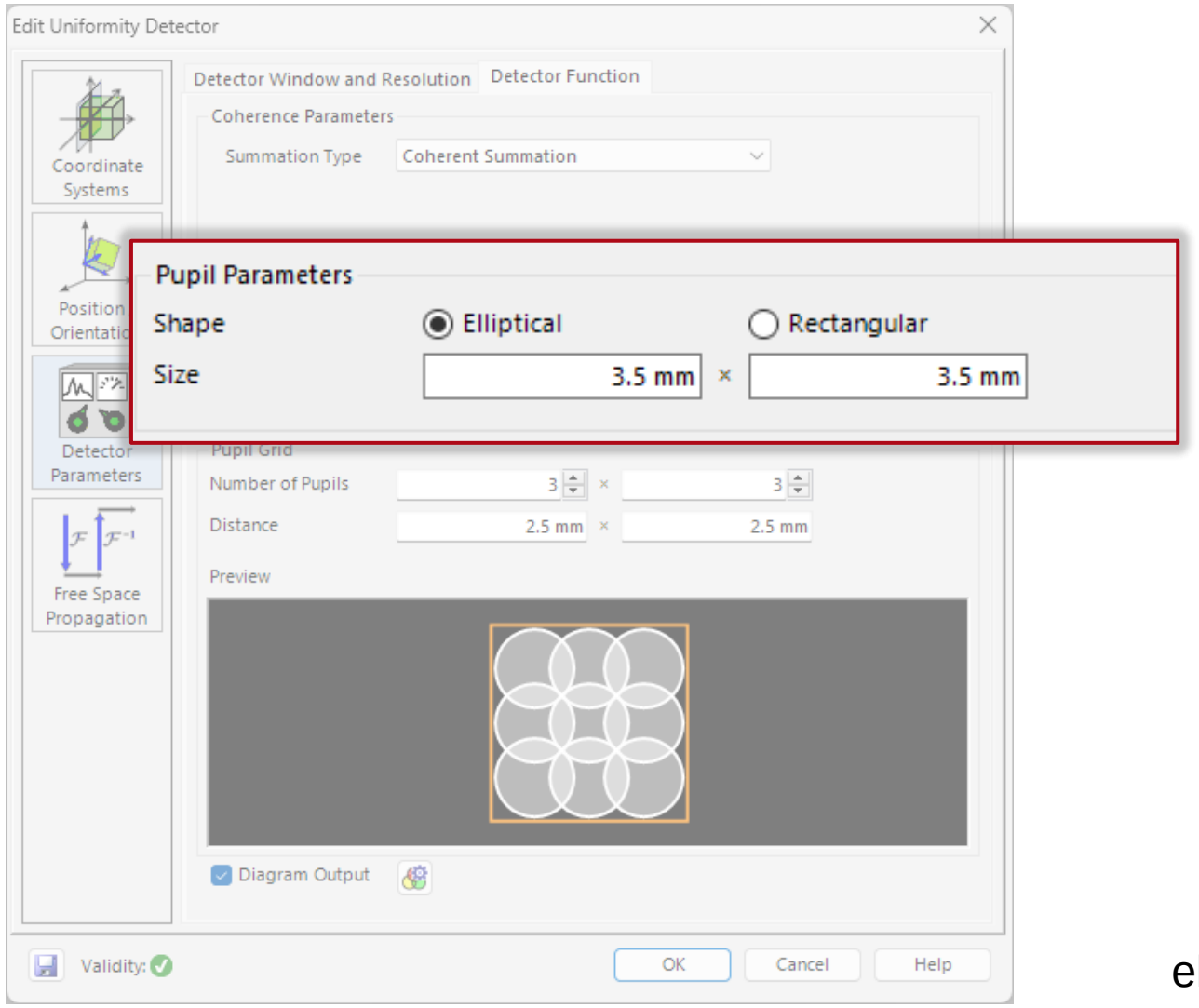
Detector Function: Coherent Parameters



- If there is more than one coherent mode, the mutually coherent modes can be considered as coherent, incoherent, or partially coherent.
- For the *Partially Coherently Summation*, you can specify the degree of coherence by specifying a *Coherence Time* (or copying it from a *Coherence Time & Length Calculator*).

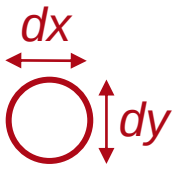


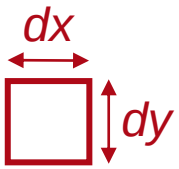
Detector Function: Pupil Parameters



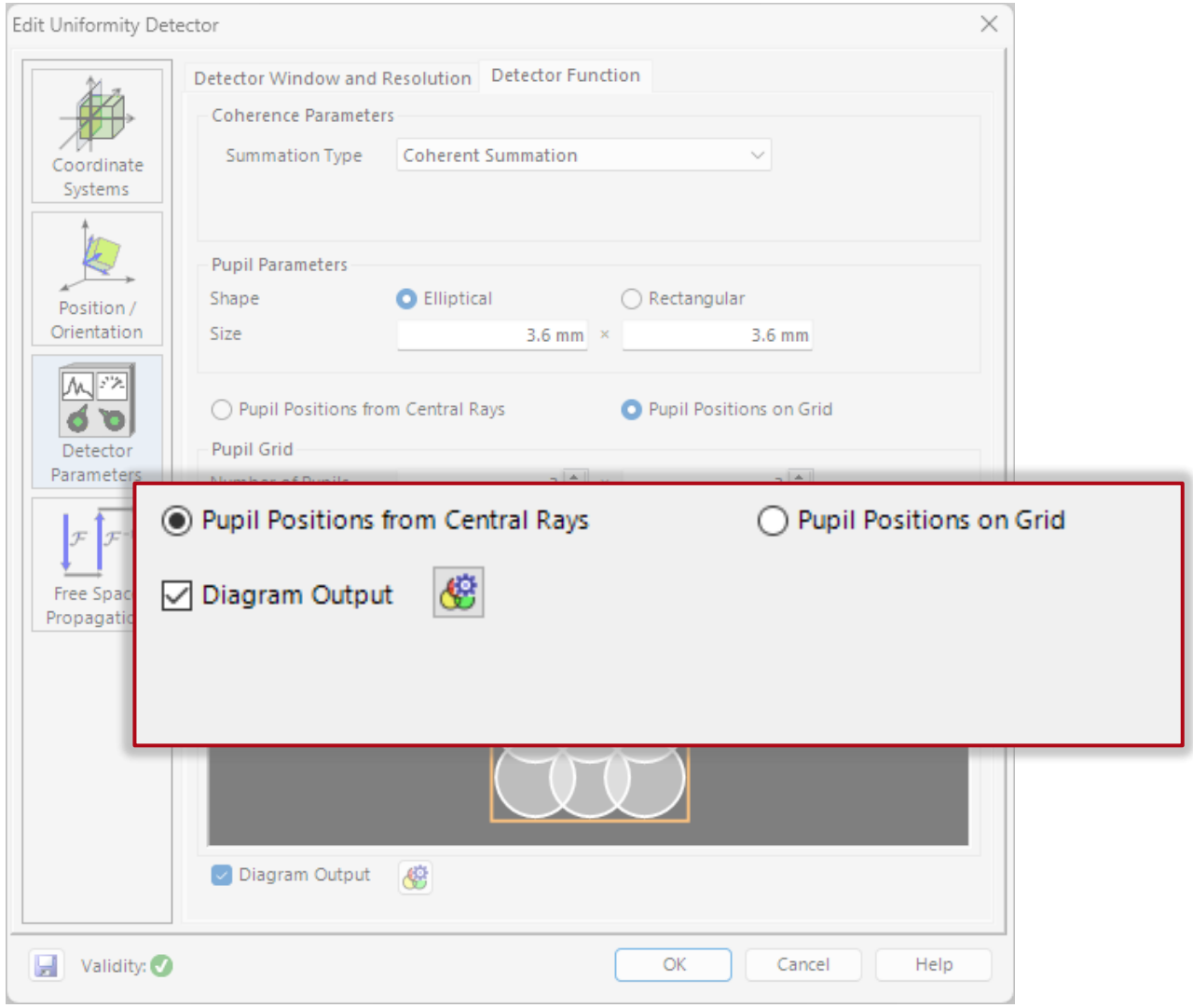
- The *Uniformity Detector* evaluates the summed squared amplitude of the impinging field components E_x, E_y, E_z in the configured regions of the detector window, which are called pupils. In the geometric zone (where the detector function is defined) this is physically equivalent to the *intensity* (i.e., length of the Poynting vector) of a field. For this reason, we will refer to this quantity as *I(x,y)* in this use case.

- Each pupil is defined by its size ($dx \times dy$) and shape, which can be either elliptical or rectangular. All pupils are the same size and shape.

elliptical pupil: 

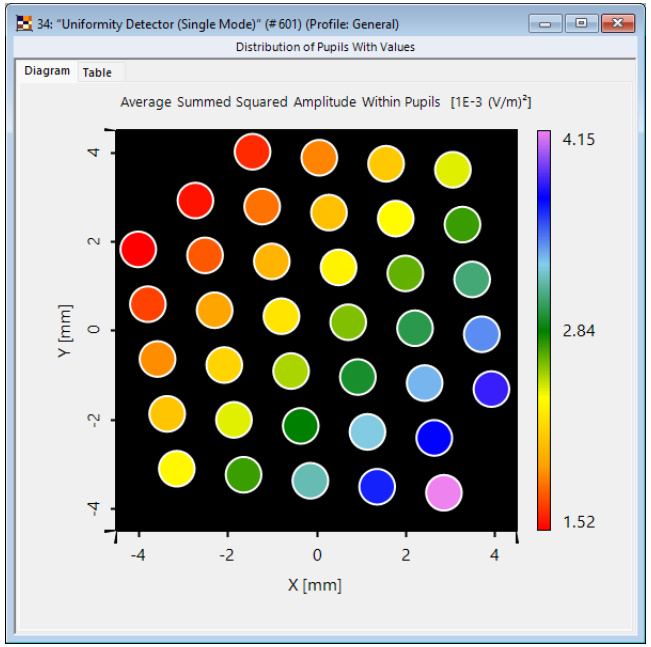
rectangular pupil: 

Detector Function: Pupil Positions

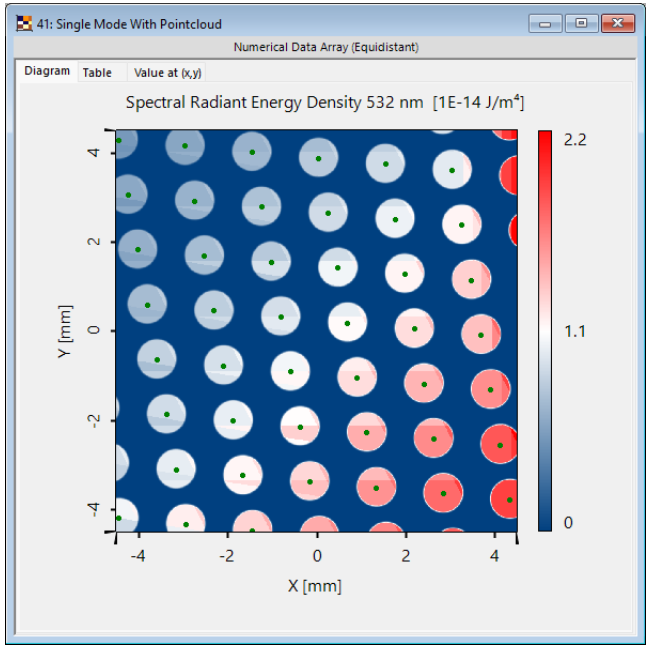


- Once, size and shape of the pupils are set, the number and positions of the pupils must be configured in the detector's window.
- The first option is to automatically determine the positions of the pupils based on the position of the central ray of each footprint.
- The second option allows the user to specify a custom grid. Please note that all pupils must be completely contained in the *Detector Window,* otherwise they will be ignored.

Example of Pupil Positions Based on Central Rays

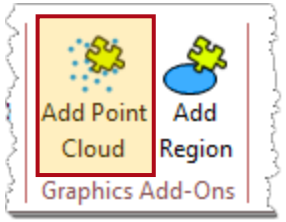


Uniformity Detector



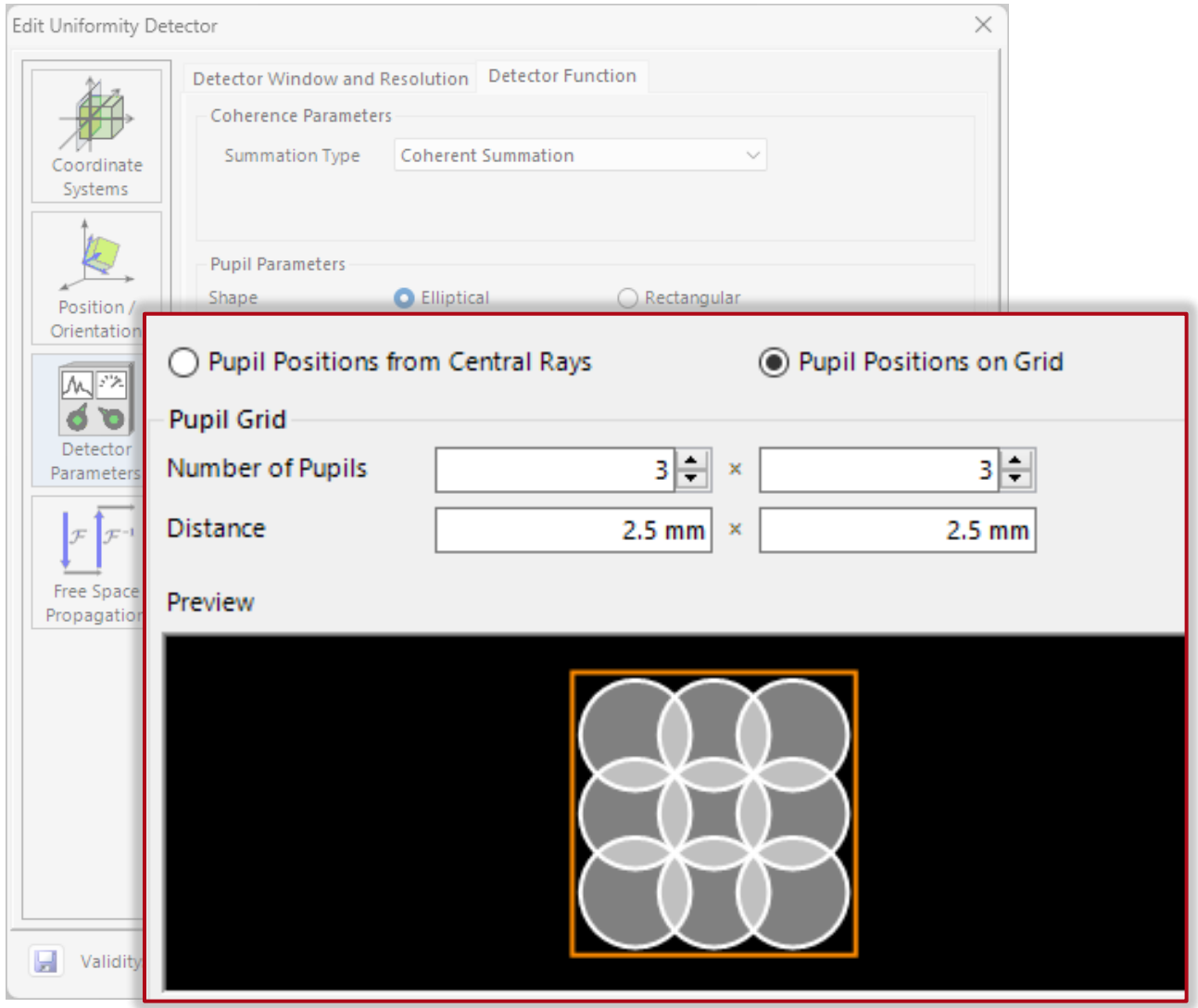
Universal Detector with *Graphic Add-on*

- With the option to position the evaluated pupils according to the central rays, the positions are automatically arranged regardless of whether the resulting rays are distributed on a rectangular grid or not.
- The *Graphics Add-ons*, can be used to sketch the distribution of the pupils on the field result, also showing that the pupils that do not fit in the detector window are neglected.

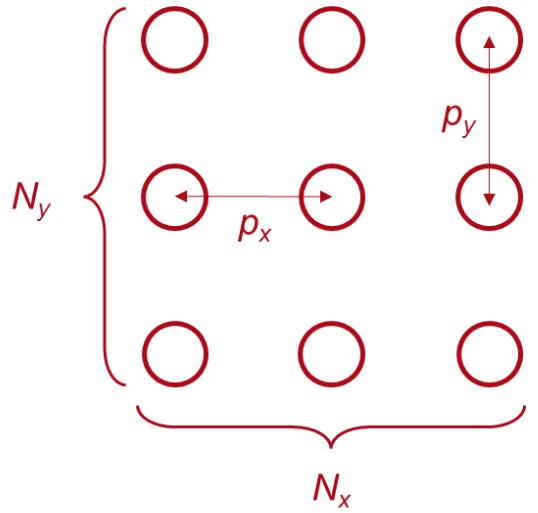


More information under:
Add Point Cloud to Data Array

Example of Pupil Positions Based on Pupil Position on a Grid



- As a second option, an equidistant rectangular grid of pupils can be defined, which is specified by the number of pupils $N_x \times N_y$ and the distance between their centers $p_x \times p_y$.
- This grid is centered in the detector window.



Uniformity Detector Output

The *Uniformity Detector* provides the following output:

1. summed squared amplitude value within each pupil

$$I_n = \sum_{\text{region n}} I(x,y)$$

2. minimum and maximum value

$$I_{\min} = \min_n(I_n), \quad I_{\max} = \max_n(I_n)$$

3. uniformity error

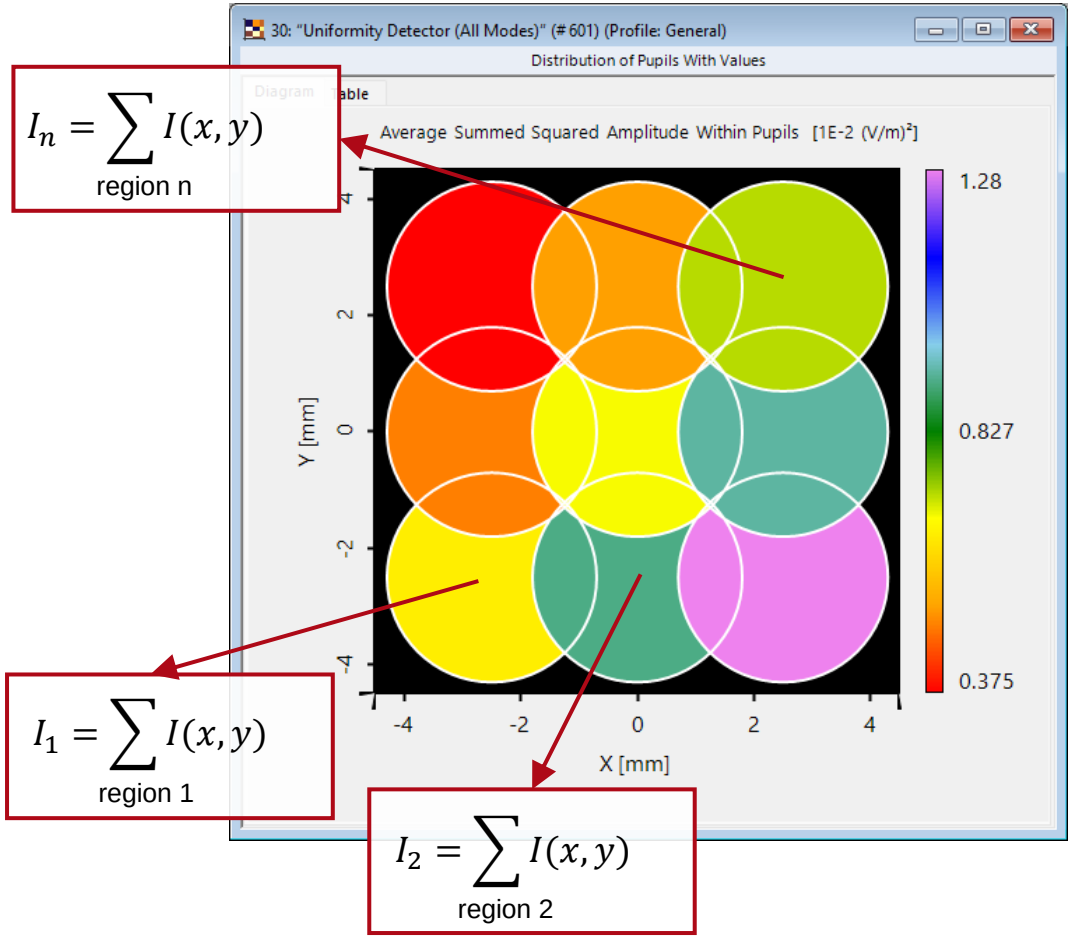
$$\delta(I) = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

4. arithmetic mean

$$\langle I \rangle = \frac{1}{n}\sum_{i=1}^{n} I_i$$

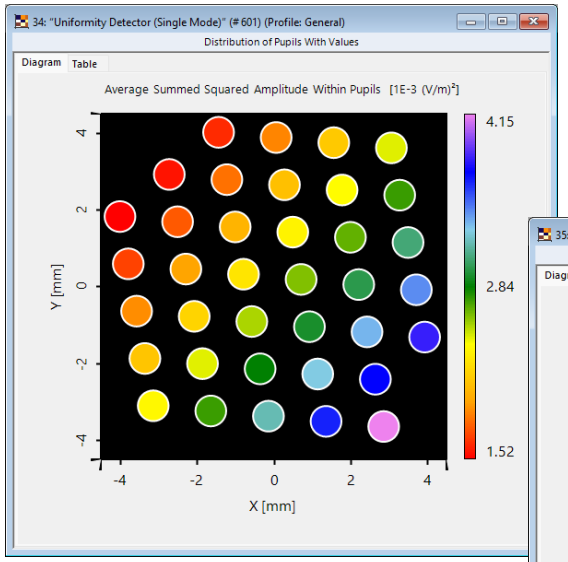
5. standard deviation

$$\sigma(I) = \sqrt{\frac{1}{n}\sum_{i=1}^{n}(I_i - \langle I \rangle)^2}$$

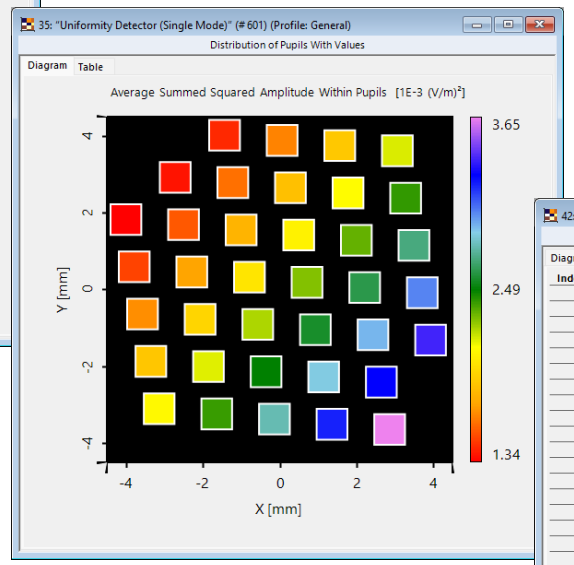


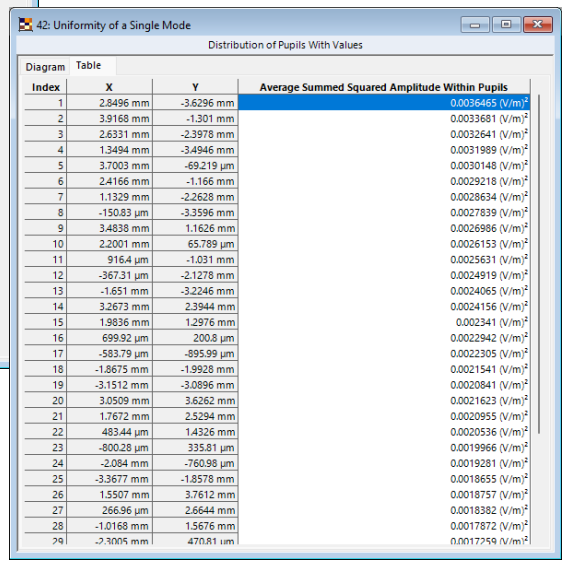
Uniformity Detector Diagram Output

pupils with elliptical shape:



pupils with rectangular shape:



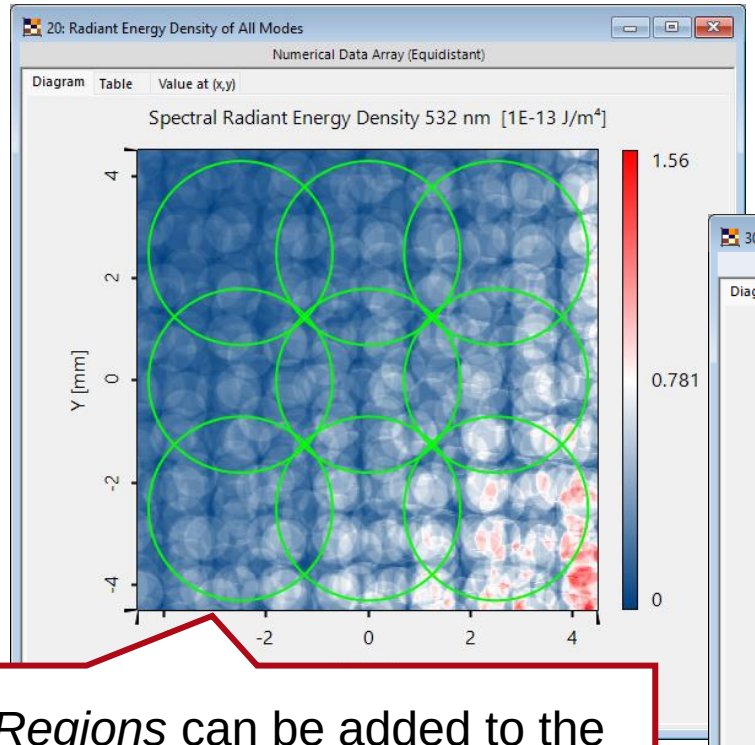


Index	X	Y	Average Summed Squared Amplitude Within Pupils
1	2.8496 mm	-3.6296 mm	0.0036465 (V/m)²
2	3.9168 mm	-1.301 mm	0.0033681 (V/m)²
3	2.6331 mm	-2.3978 mm	0.0032641 (V/m)²
4	1.3494 mm	-3.4946 mm	0.0031989 (V/m)²
5	3.7003 mm	-69.219 µm	0.0030148 (V/m)²
6	2.4166 mm	-1.166 mm	0.0029218 (V/m)²
7	1.1329 mm	-2.2628 mm	0.0028634 (V/m)²
8	-150.83 µm	-3.3596 mm	0.0027839 (V/m)²
9	3.4838 mm	1.1626 mm	0.0026986 (V/m)²
10	2.2001 mm	65.789 µm	0.0026153 (V/m)²
11	916.4 µm	-1.031 mm	0.0025631 (V/m)²
12	-367.31 µm	-2.1278 mm	0.0024919 (V/m)²
13	-1.651 mm	-3.2246 mm	0.0024065 (V/m)²
14	3.2673 mm	2.3944 mm	0.0024156 (V/m)²
15	1.9836 mm	1.2976 mm	0.002341 (V/m)²
16	699.92 µm	200.8 µm	0.0022942 (V/m)²
17	-583.79 µm	-895.99 µm	0.0022305 (V/m)²
18	-1.8675 mm	-1.9928 mm	0.0021541 (V/m)²
19	-3.1512 mm	-3.0896 mm	0.0020841 (V/m)²
20	3.0509 mm	3.6262 mm	0.0021623 (V/m)²
21	1.7672 mm	2.5294 mm	0.0020955 (V/m)²
22	483.44 µm	1.4326 mm	0.0020536 (V/m)²
23	-800.28 µm	335.81 µm	0.0019966 (V/m)²
24	-2.084 mm	-760.98 µm	0.0019281 (V/m)²
25	-3.3677 mm	-1.8578 mm	0.0018655 (V/m)²
26	1.5507 mm	3.7612 mm	0.0018757 (V/m)²
27	266.96 µm	2.6644 mm	0.0018382 (V/m)²
28	-1.0168 mm	1.5676 mm	0.0017872 (V/m)²
29	-2.3005 mm	470.81 µm	0.0017259 (V/m)²

The output of the pupil diagram contains information about their shape, size, position and evaluated quantity within the pupils. The pupils are colored according to the summed squared amplitude value of each pupil. Further, the *Table* tab lists detailed pupil coordinates and calculated values.

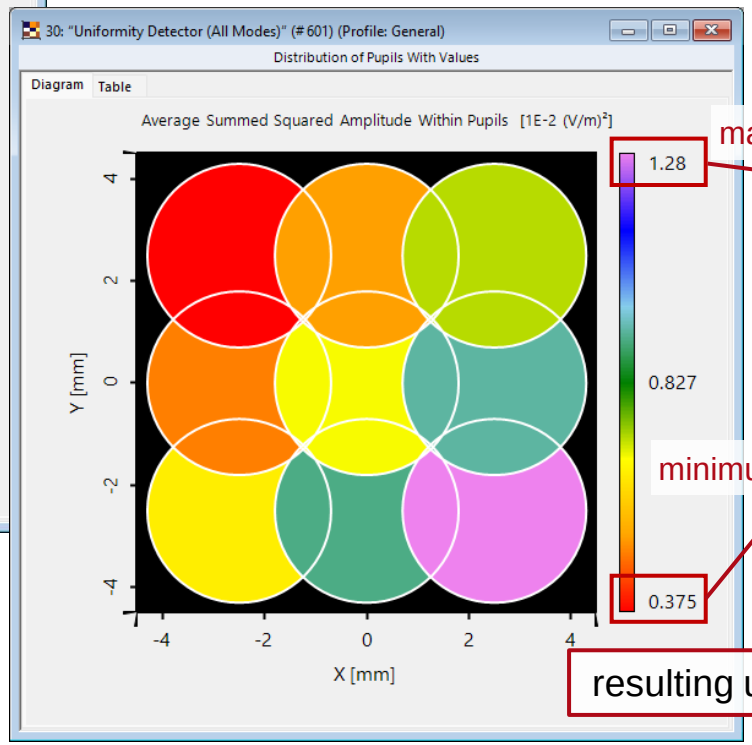
Examples of Uniformity Detector Output

camera detector output:



Regions can be added to the *Universal Detector* as a Graphic Add-on.

uniformity detector diagram output:



resulting uniformity error

Output data in *Detector Results* tab:

Value for Pupil around (-2.5 mm; -2.5 mm)	0.0064911 (V/m)²
Value for Pupil around (0 mm; -2.5 mm)	0.009129 (V/m)²
Value for Pupil around (2.5 mm; -2.5 mm)	0.012794 (V/m)²
Value for Pupil around (-2.5 mm; 0 mm)	0.0049074 (V/m)²
Value for Pupil around (0 mm; 0 mm)	0.0068023 (V/m)²
Value for Pupil around (2.5 mm; 0 mm)	0.0093089 (V/m)²
Value for Pupil around (-2.5 mm; 2.5 mm)	0.0037466 (V/m)²
Value for Pupil around (0 mm; 2.5 mm)	0.0052172 (V/m)²
Value for Pupil around (2.5 mm; 2.5 mm)	0.007187 (V/m)²
Minimum	0.0037466 (V/m)²
Maximum	0.012794 (V/m)²
Uniformity Error	54.697 %
Arithmetic Mean	0.007287 (V/m)²
Standard Deviation	0.0078206 (V/m)²

Document Information

title	Uniformity Detector for Lightguide Systems
document code	LIG.0016
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software version	2023.1 (Build 1.556)
category	Feature Use Case
further reading	• Modeling of a “HoloLens 1”-Type Layout with Light Guide Component • Light Guide Layout Design Tool • k-Domain Layout Visualization • Simulation of Lightguide with 1D-1D Pupil Expander and Real Gratings • Graphic Add-on