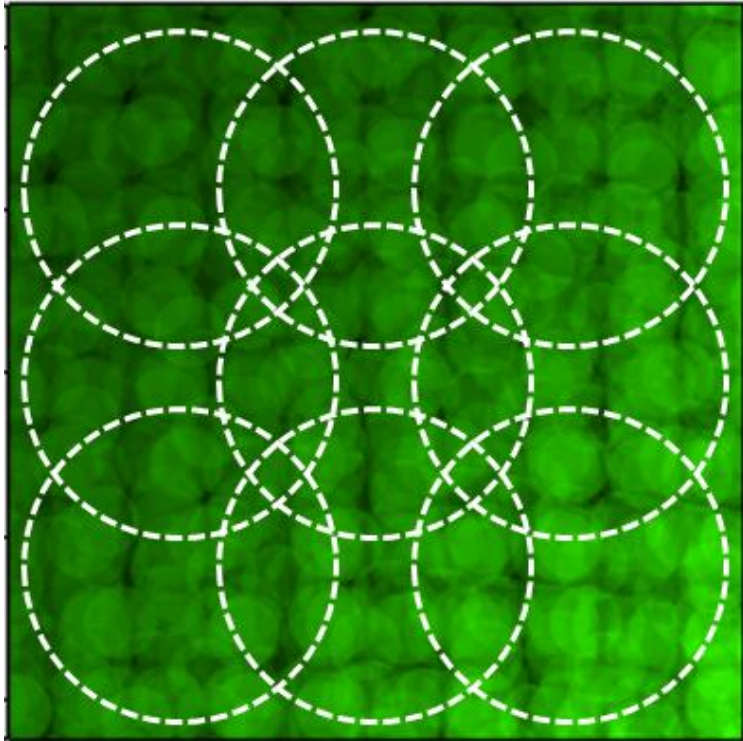


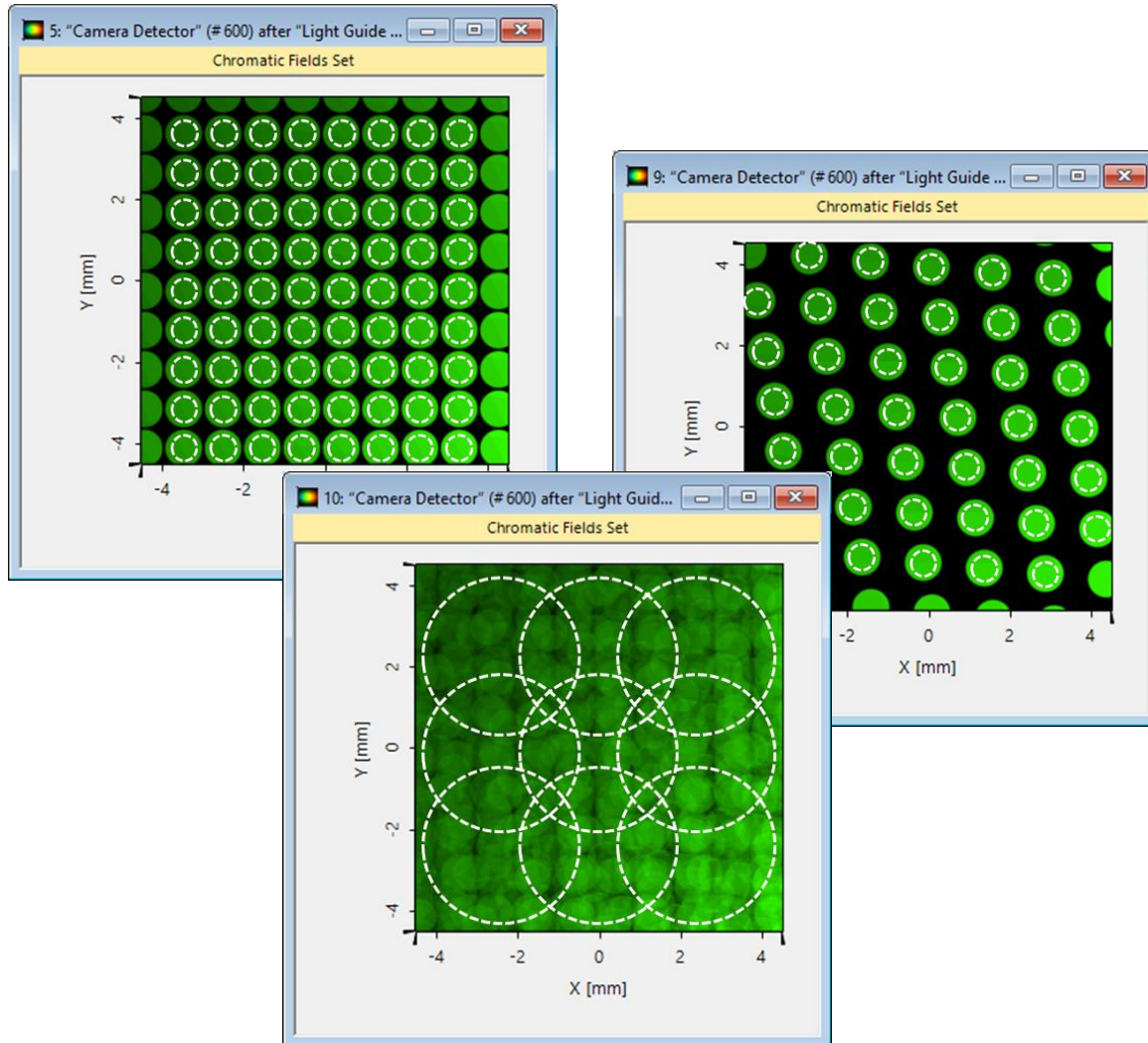
Uniformity Detector for Lightguide Systems

Abstract

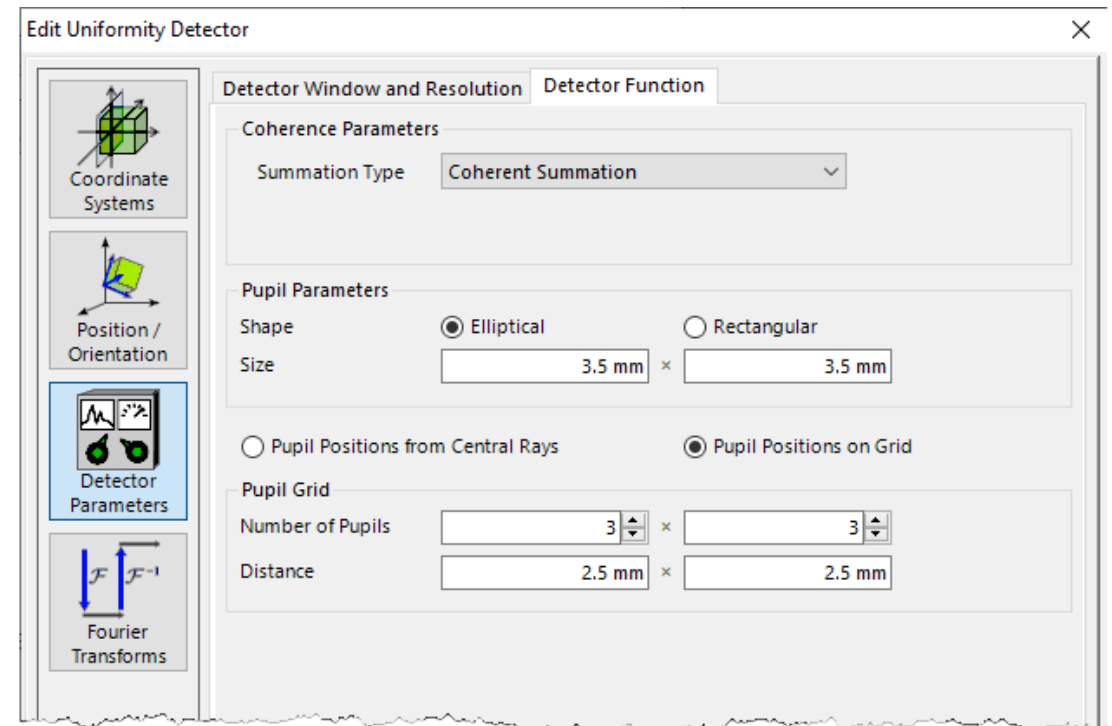


For the evaluation of the performance of lightguide systems in the field of AR/MR (augmented or mixed reality) devices, the lateral uniformity of the light distribution in the eyebox is one of the most crucial parameters. For the purpose of measuring and optimizing the lateral uniformity during the design process, VirtualLab Fusion provides the *Uniformity Detector*, which enables the required investigations. In this document we demonstrate the available options and how to operate the Uniformity Detector.

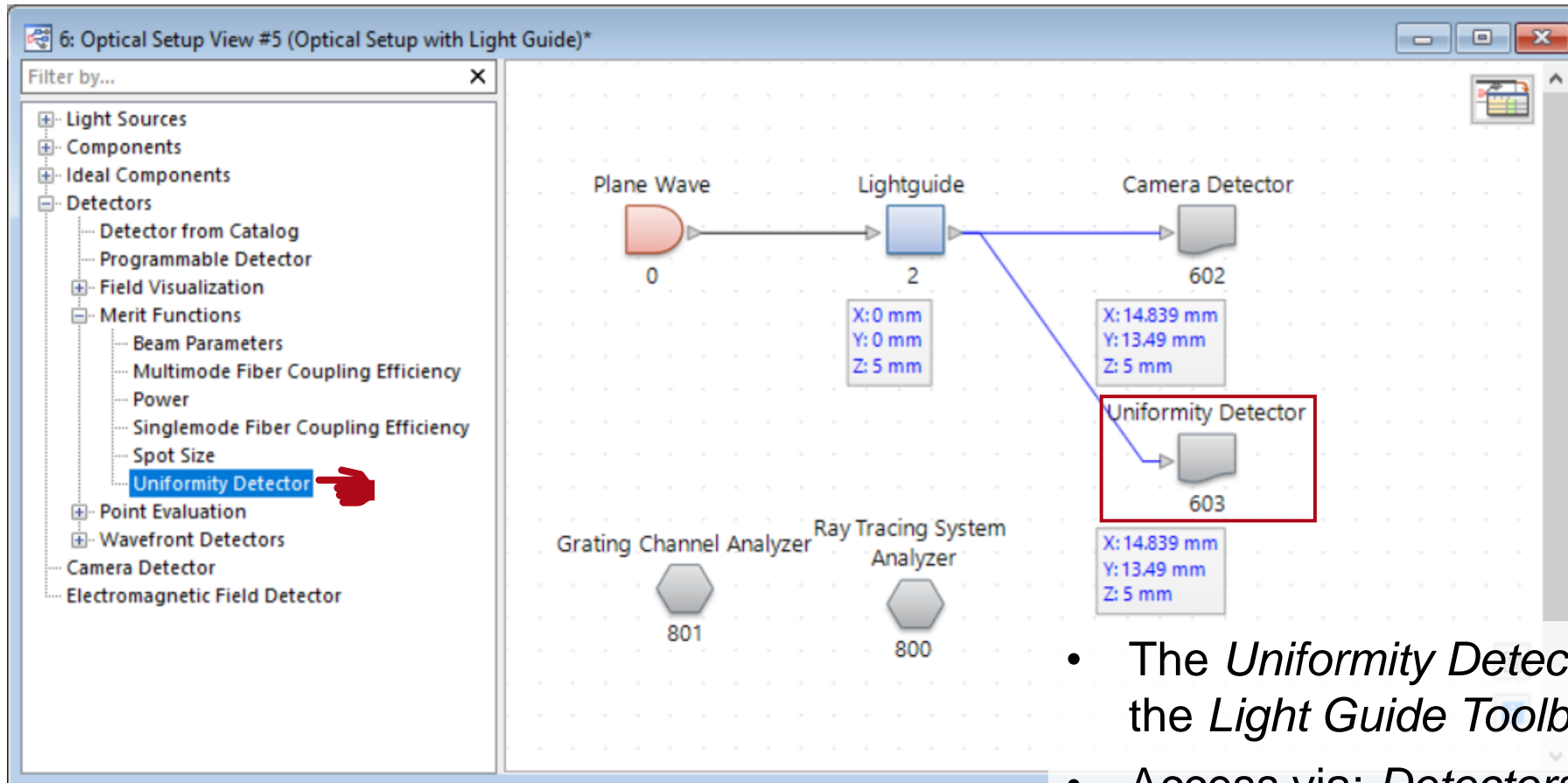
This Use Case Shows ...



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

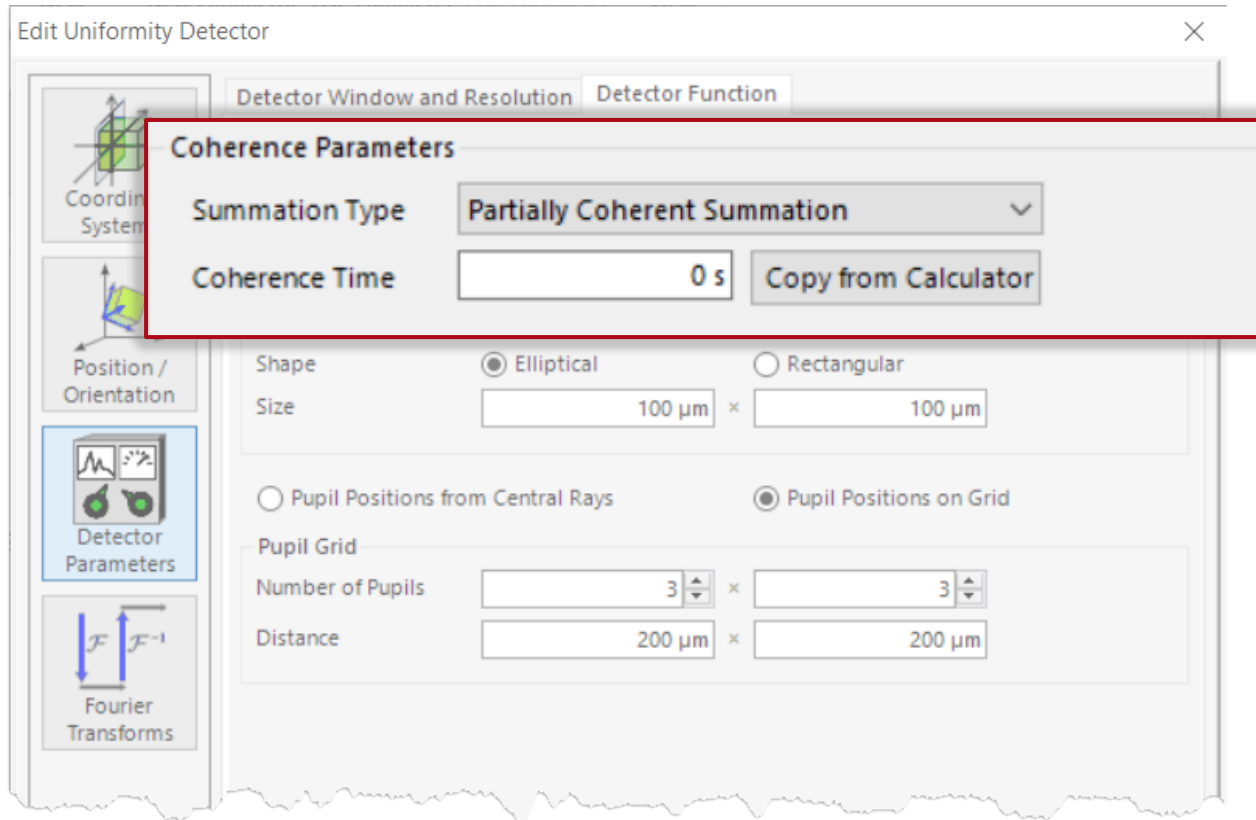


Uniformity Detector

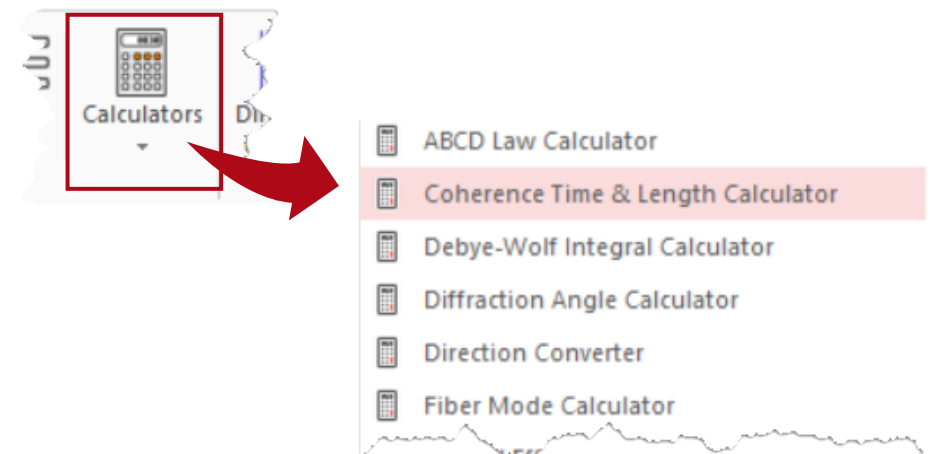


- The *Uniformity Detector* is only available in the *Light Guide Toolbox*.
- Access via: *Detectors > Merit Functions > Uniformity Detector*

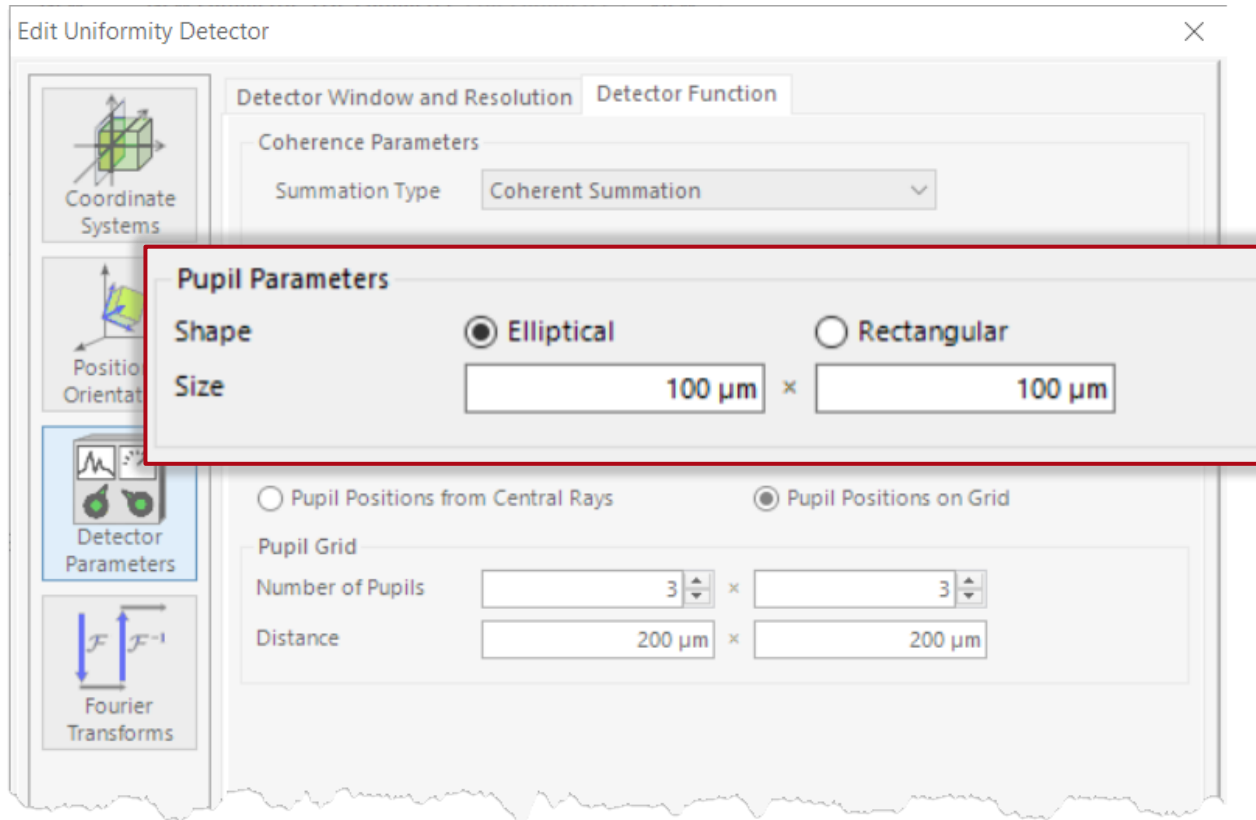
Detector Function: Coherent Parameters



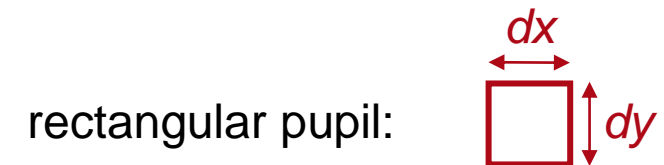
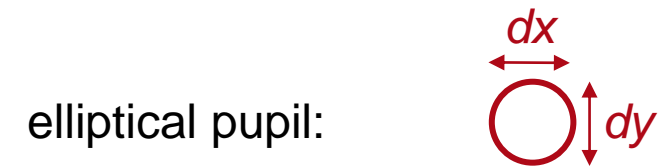
- If there is more than one coherent mode, the overlaying modes can be added coherently, incoherently, or partially coherently.
- For the *Partially Coherently Summation*, you can specify the degree of coherence by entering a *Coherence Time* (or copying it from a *Coherence Time & Length Calculator*).



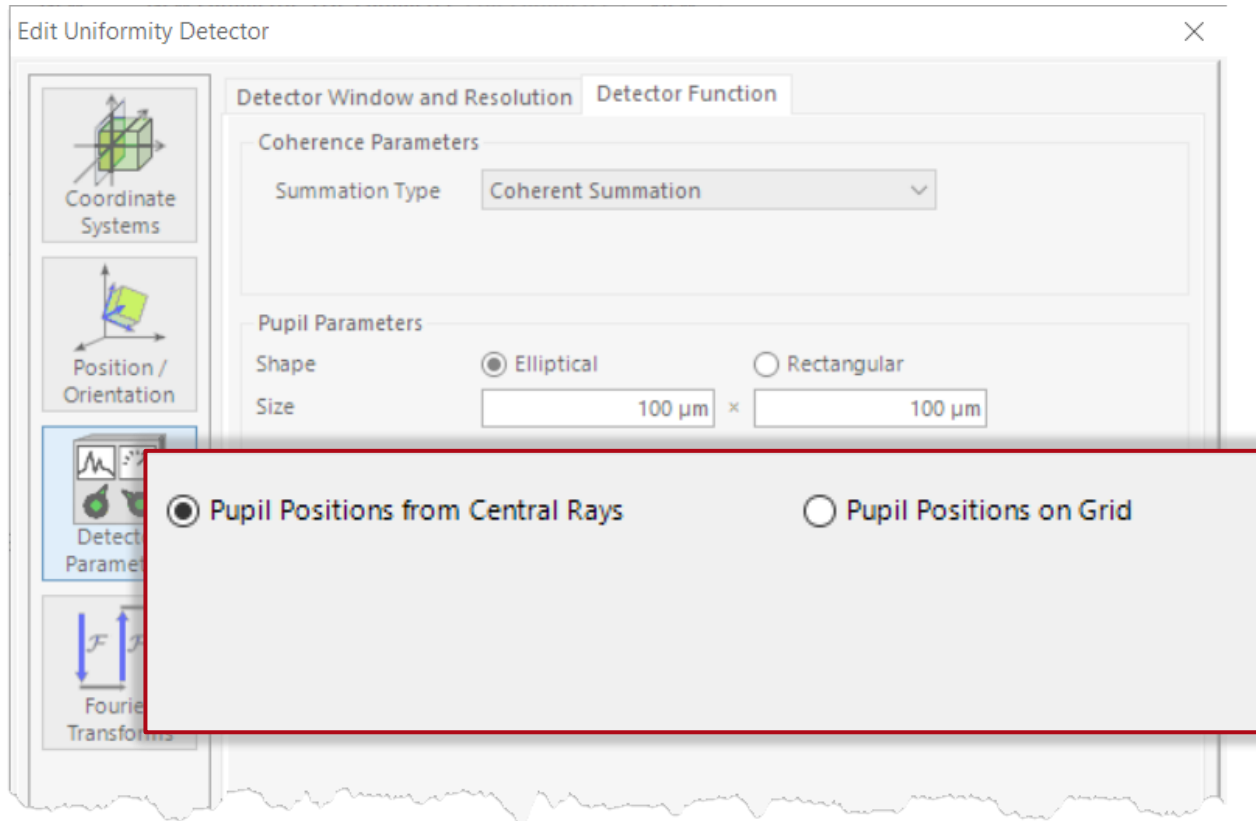
Detector Function: Pupil Parameters



- The *Uniformity Detector* evaluates the impinging intensity in configured local areas, which are called pupils.
- Each pupil is defined by its size ($dx \times dy$) and its shape, which can be set either elliptical or rectangular.

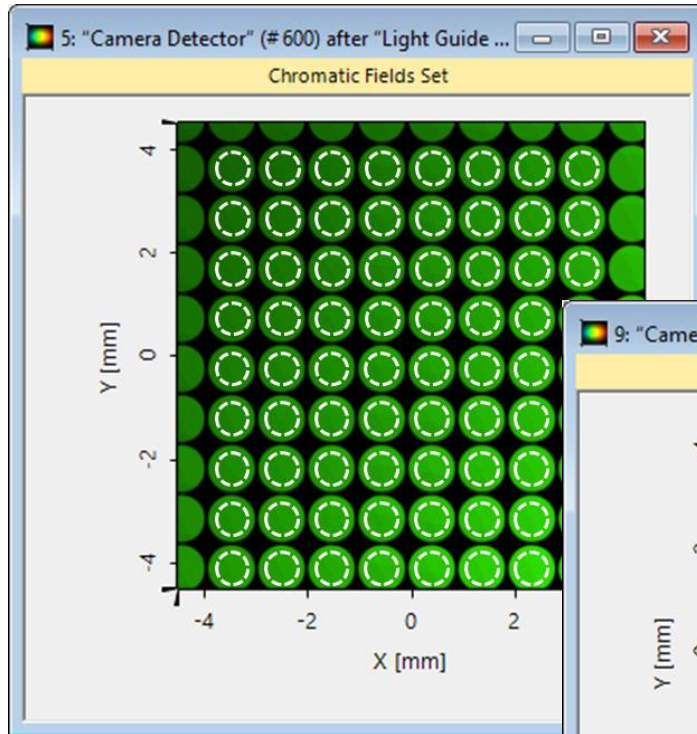


Detector Function: Pupil Positions

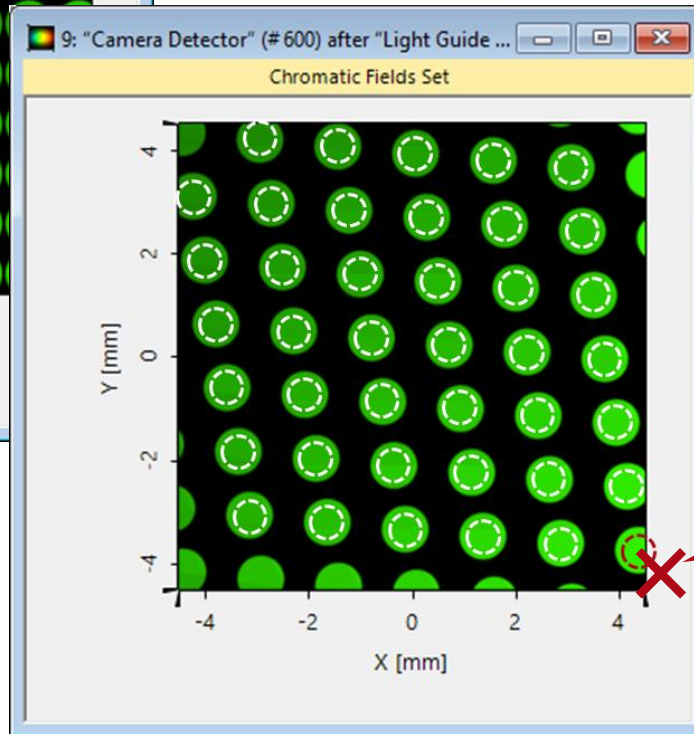


- Once the size and shape of the regarded pupils is set, the number and positions of the pupils in the window of detector must be configured.
- The first option is, to automatically determine the positions of the pupils according to the central ray of each individual footprint.
- The detector will only places pupils on spots, where the whole pupil is inside the detector window. All other partial footprints will be neglected.

Example of Pupil Positions based on Central Rays



rectangular spot distribution



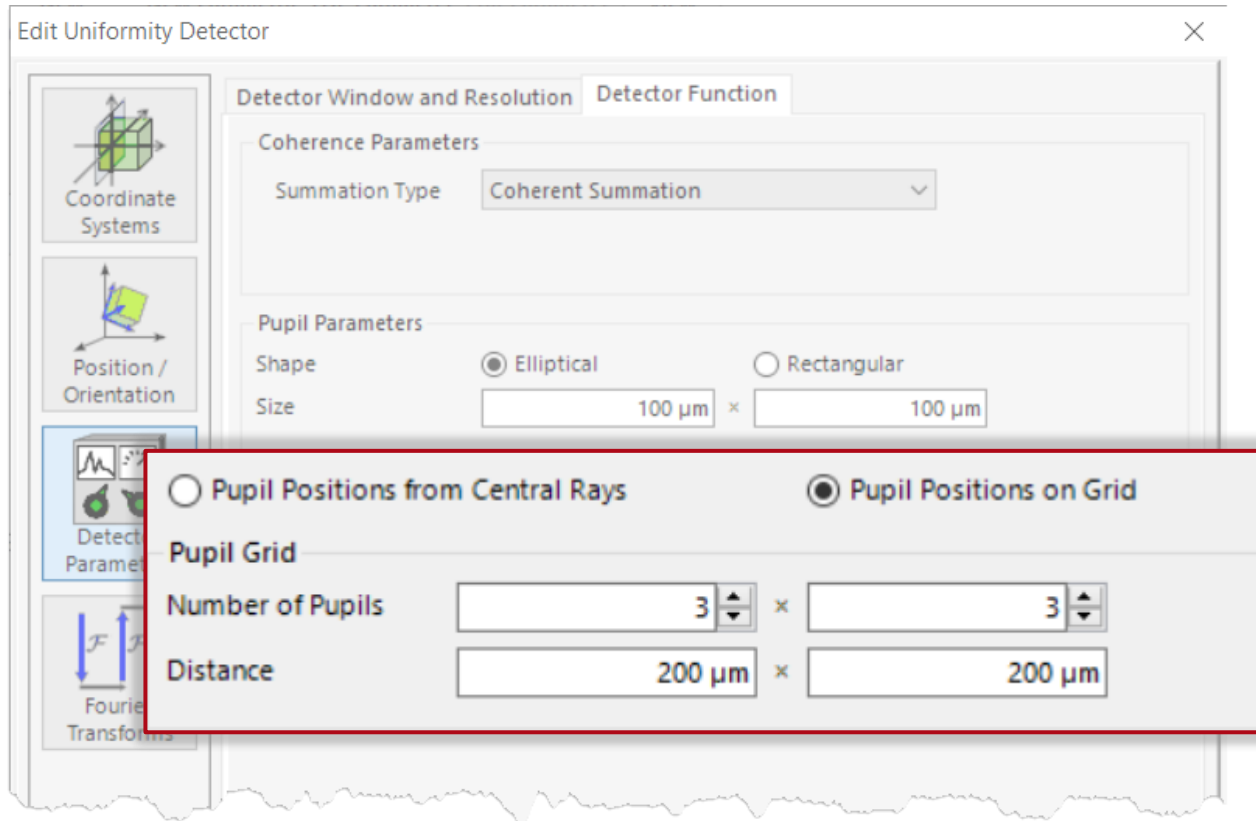
general spot distribution

- By using the option to position the evaluated pupils according to the central rays, the positions will be arranged automatically, no matter if the resulting beams are distributed on a rectangular grid or not.

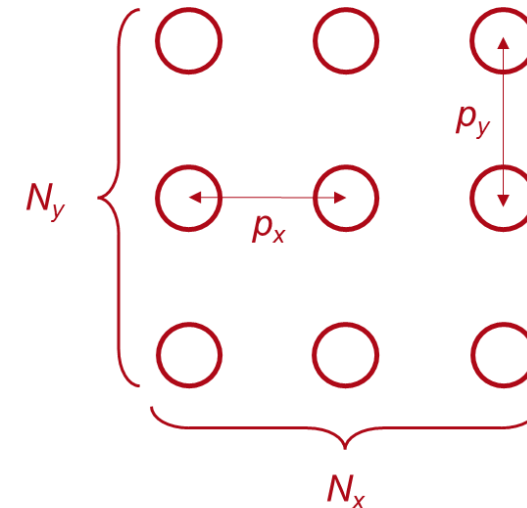
Pupil that do not fit into the detector window are neglected.

Note: The dashed circles are just for illustration of the pupils, while users will not see them in simulation.

Detector Function: Pupil Positions

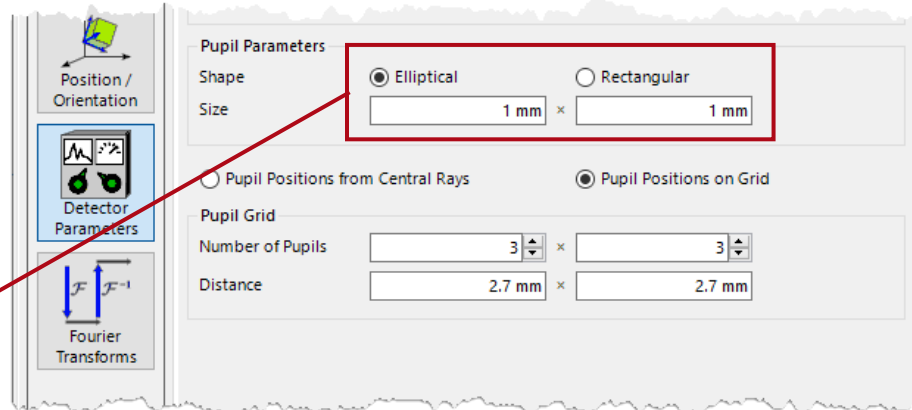
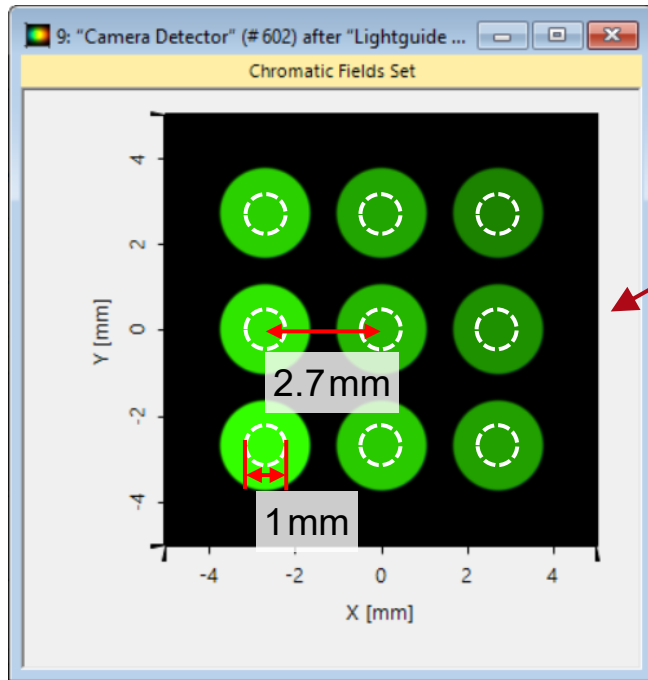


- As a second option, an equidistant rectangular grid of pupils can be defined, which is specified by the number of pupils $N_x \times N_y$ and the distance of their centers $p_x \times p_y$.
- This grid is centered around the center of the window of the detector.

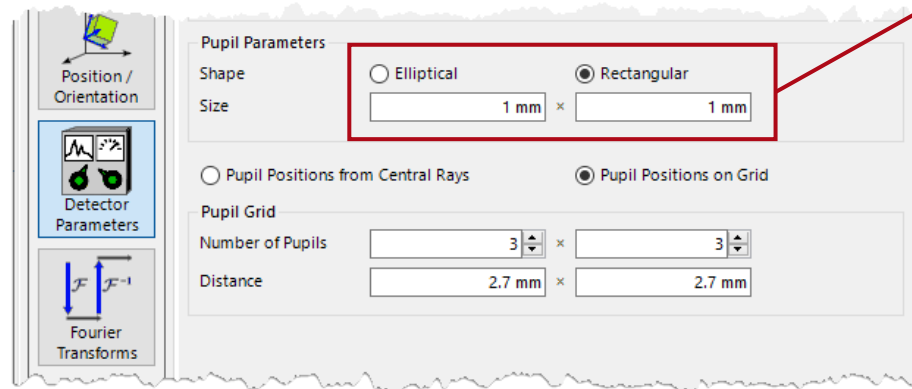
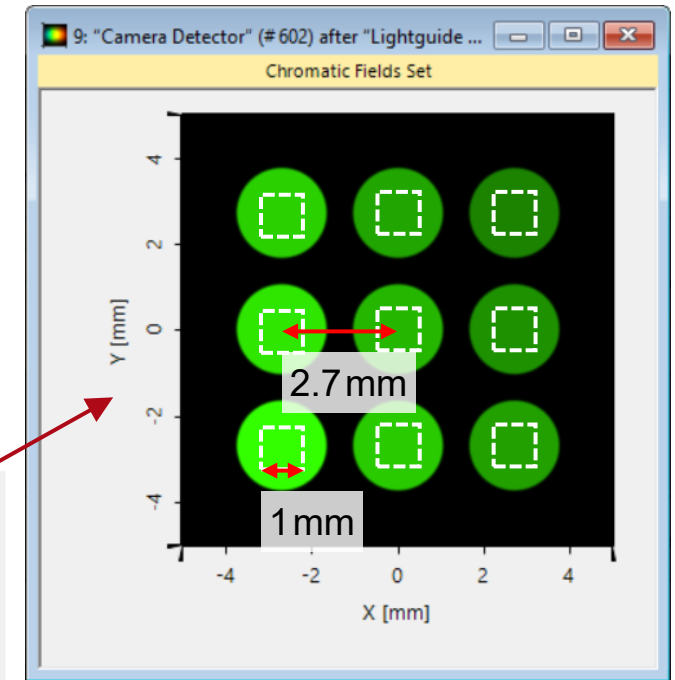


Example of Pupil Positions arranged on a Grid

pupils with elliptical shape:

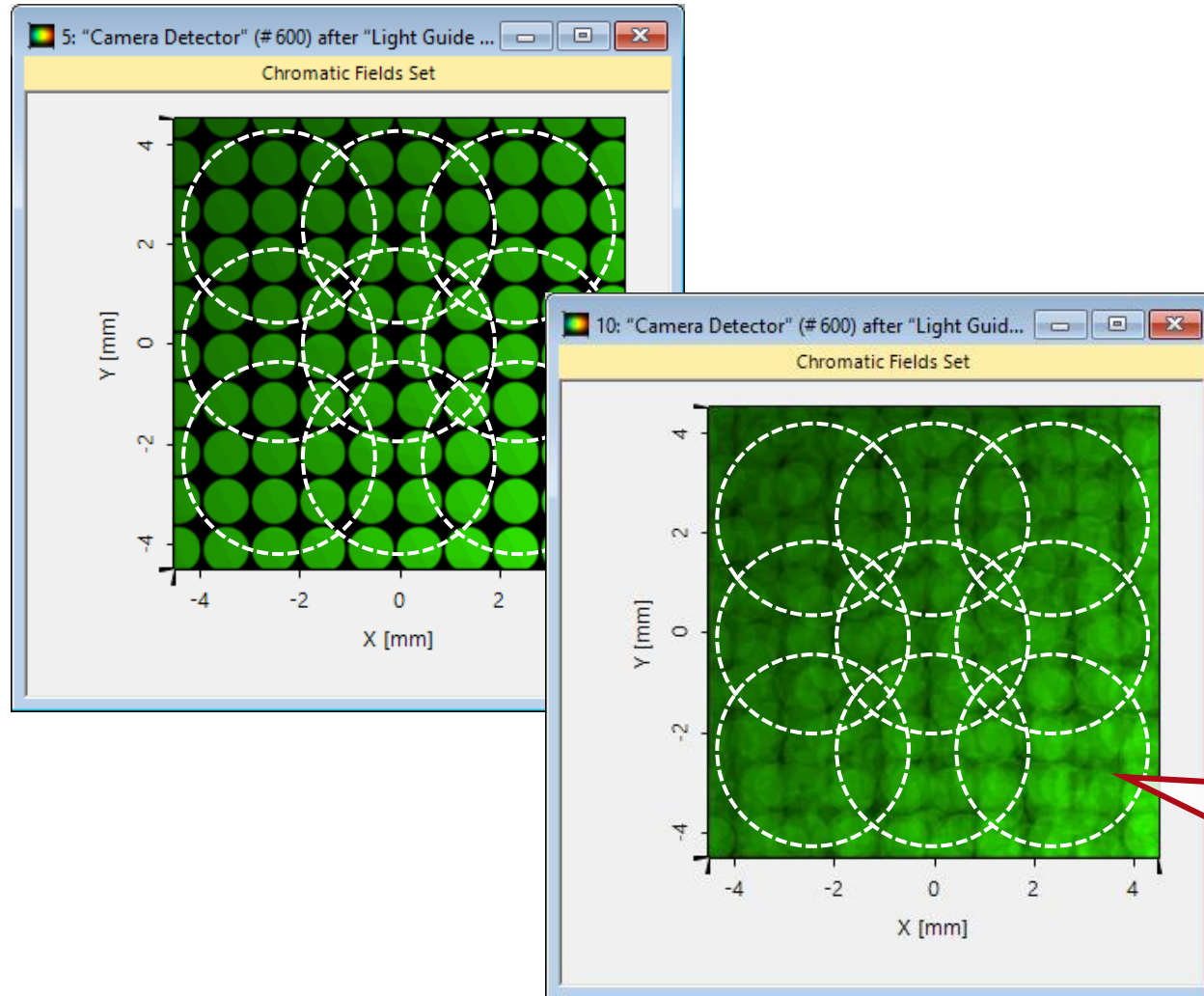


pupils with rectangular shape:



Note: The dashed circles are just for illustration of the pupils, while users will not see them in simulation.

Measuring lateral Uniformity in the Eyebow



- The different positions of pupils represent a moving eye of the user of the device.
- In practical applications, the particular lightguide may be designed for a range of modes of the desired field of view (FOV), and thus an overlap of these modes on the detector.
- It depends on the actual evaluation strategy, whether the lateral uniformity should be measured per FOV mode or for all directions together.

The uniformity detector calculates the average intensity I within each pupil. Each pupil represents one position of the eyebow. The pupil grid should be arranged to cover the whole detector window but not exceed the border.

Uniformity Detector Output

The *Uniformity Detector* provides the following output:

1. intensity value within each pupil

$$I_n = \sum_{\text{region } n} \text{intensity}$$

2. minimum and maximum value

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

3. uniformity error

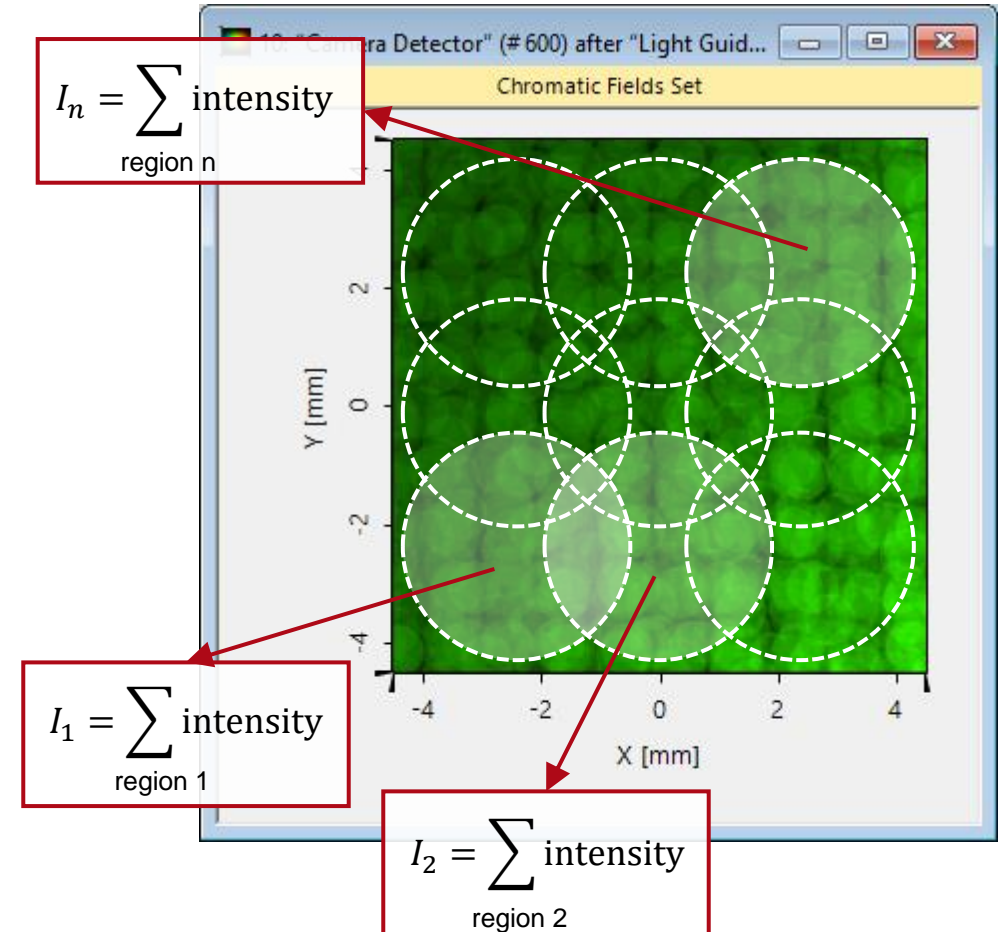
$$\delta(I) = \frac{I_{\max} - I_{\min}}{I_{\max} + I_{\min}}$$

4. arithmetic mean

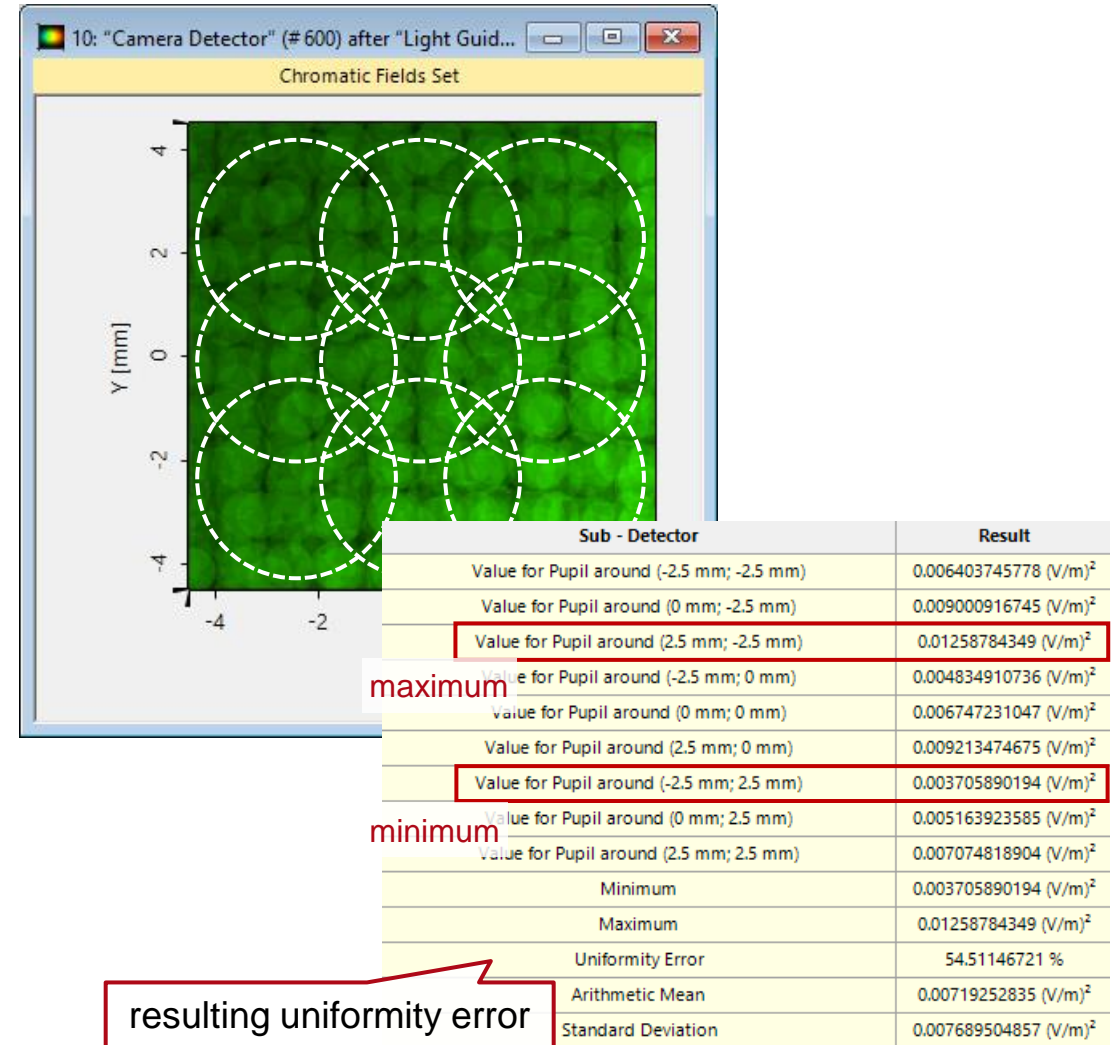
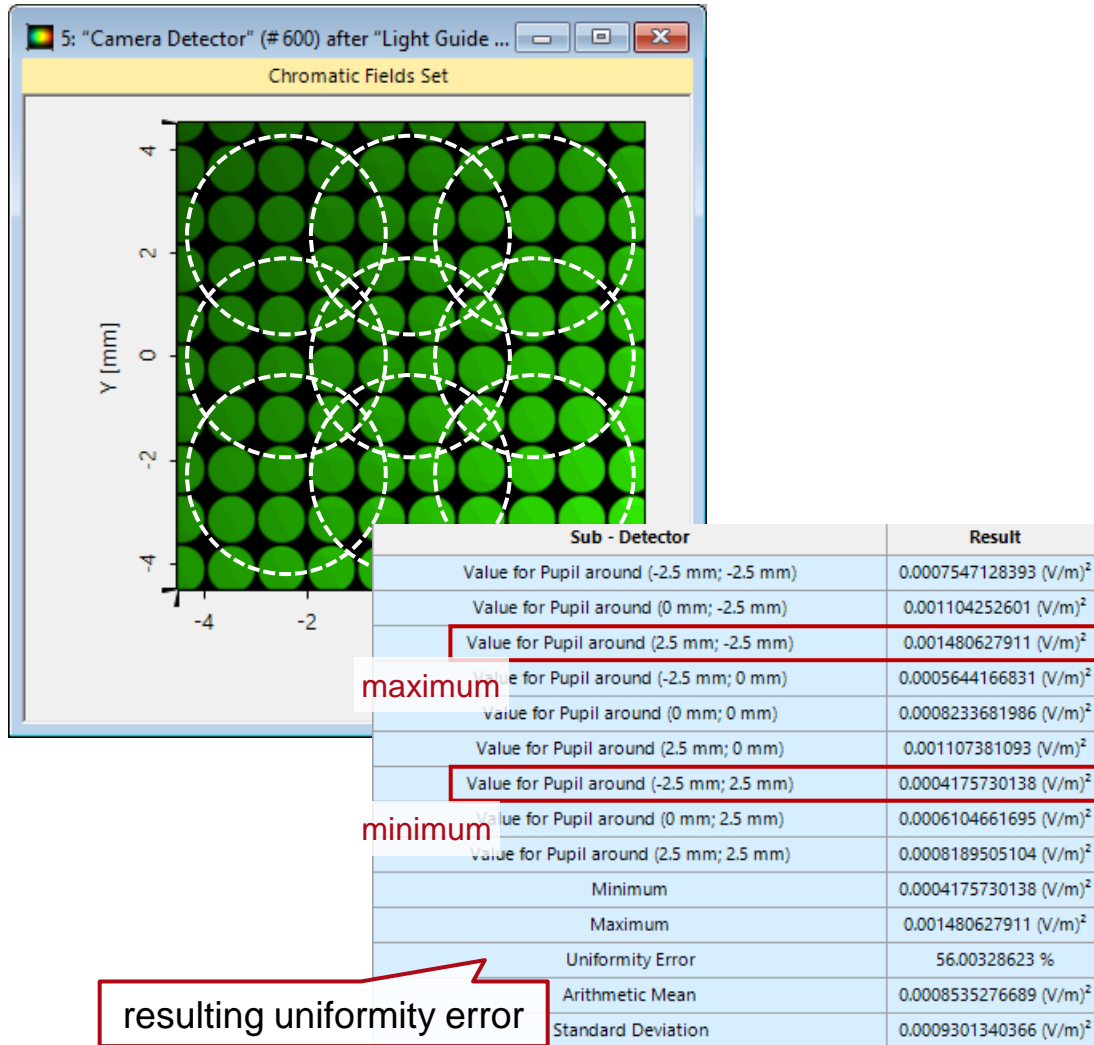
$$\langle I \rangle = \frac{1}{n} \sum_{i=1}^n I_i$$

5. standard deviation

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



Examples of Uniformity Detector Output



Document Information

title	Uniformity Detector for Lightguide Systems
document code	LIG.0012
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software version	2021.1 (Build 1.180)
category	Feature Use Case
further reading	<ul style="list-style-type: none">- <u>Complex Lightguide System with a 2D Eye Pupil Expansion and Human Eye Model</u>- <u>Construction of a Light Guide</u>- <u>Modeling of a “HoloLens 1”-Type Layout with Light Guide Component</u>- <u>Light Guide Layout Design Tool</u>- <u>k-Domain Layout Visualization</u>- <u>Simulation of Lightguide with 1D-1D Pupil Expander and Real Gratings</u>