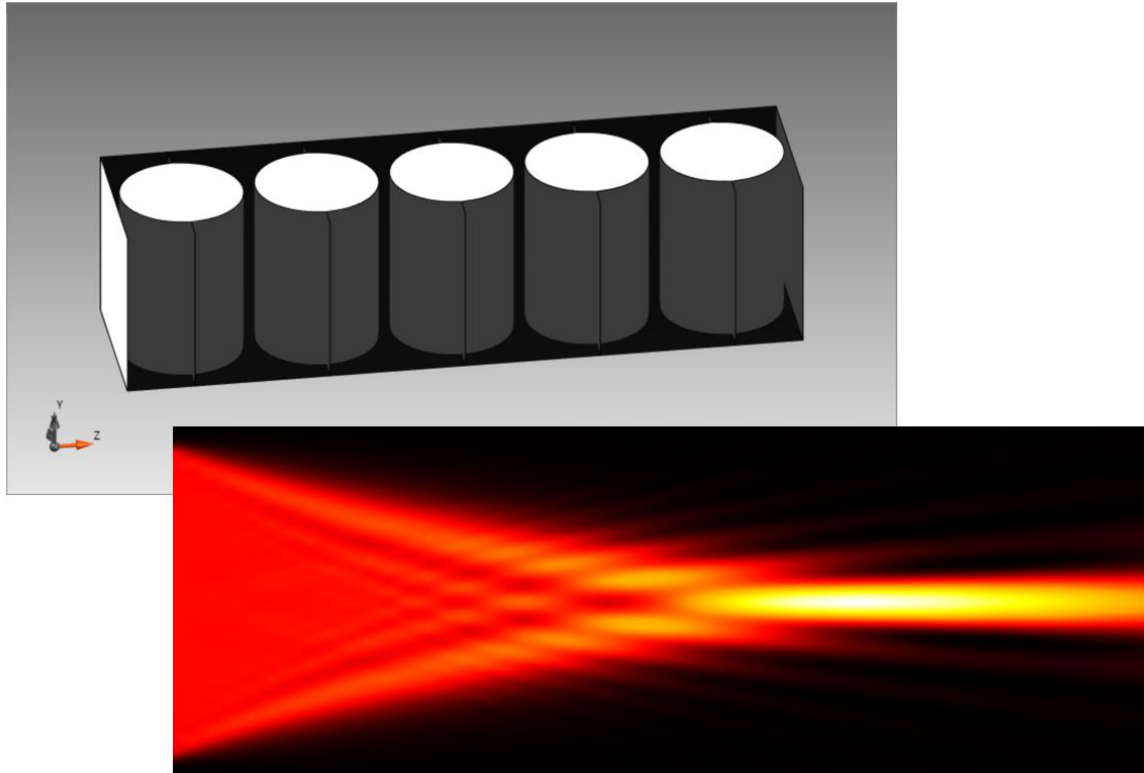


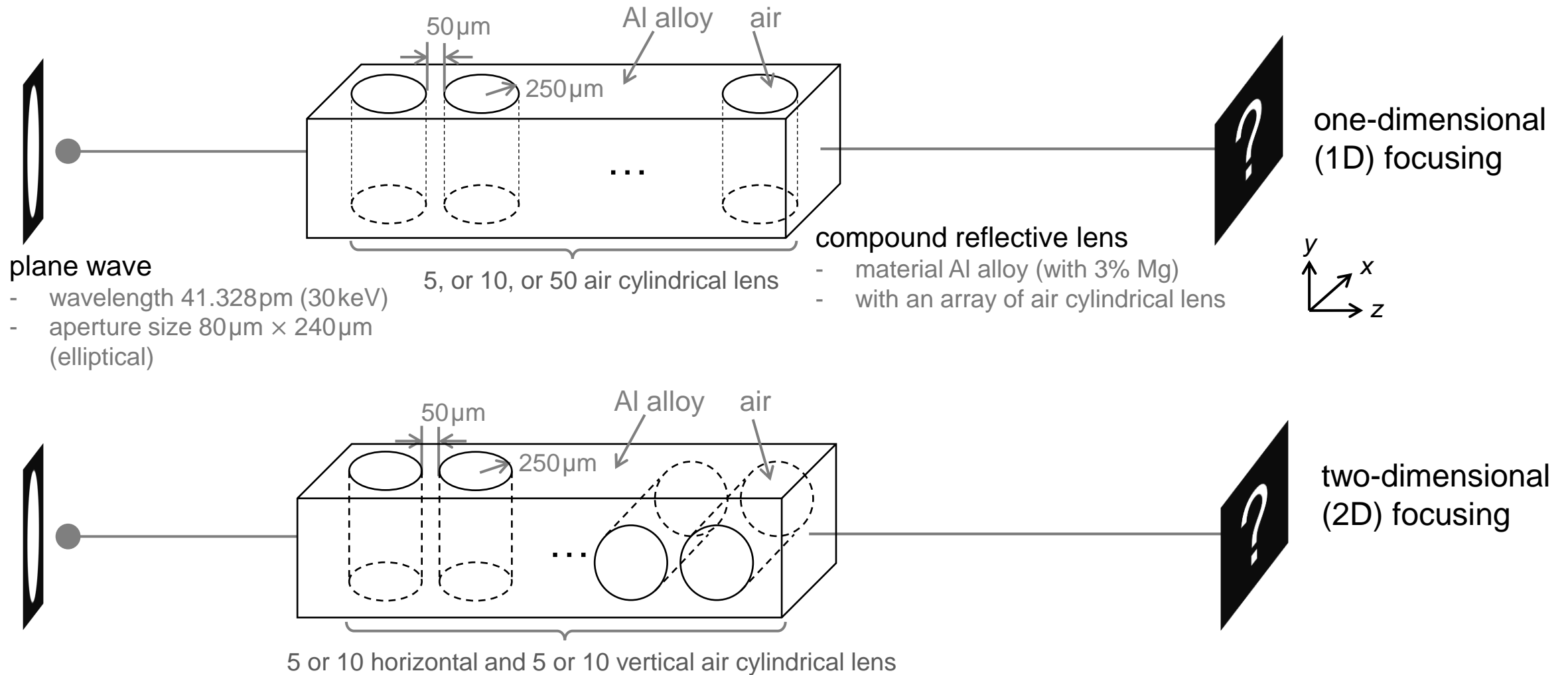
# Compound Refractive Lens for X-Ray Focusing

# Abstract



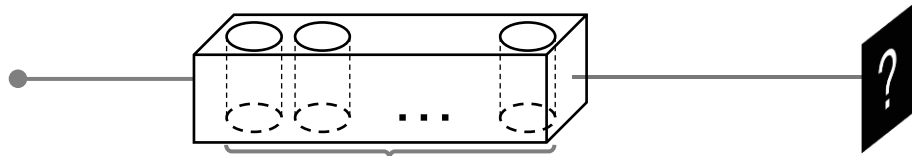
Refraction of x-rays by a single lens is usually small, but a compound lens (consisting of tens or hundreds of individual cylindrical lenses arranged in a linear array) can gradually focus x-rays one- or two-dimensionally. The focal length can be controlled by the number of the lenses, i.e., the more lenses are used, the shorter focal length is achieved. Following the paper of Snigirev *et al.* [Applied optics, 1998, 37(4): 653-662], this use case demonstrates 1D and 2D x-ray focusing by a compound refractive lens in VirtualLab Fusion.

# Modeling Task



system parameters from Snigirev A, et al. Applied optics, 1998, 37(4): 653-662

# System Building Blocks – Components

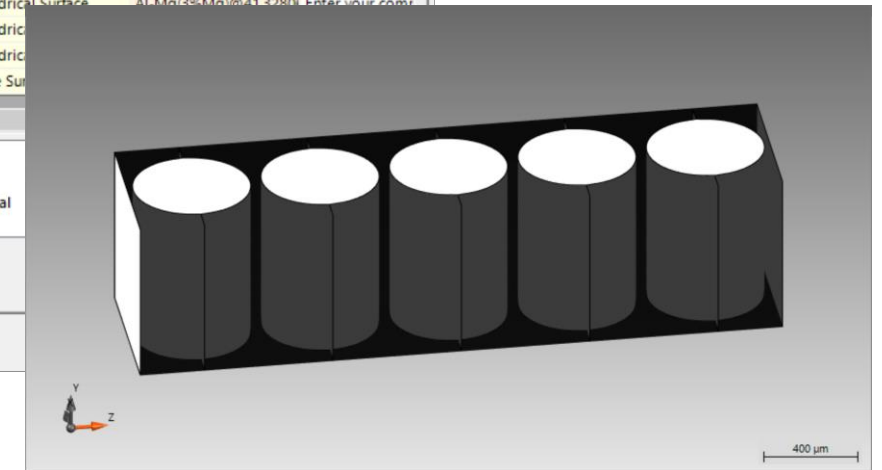


- The *Lens System Component* allows the definition of multiple surfaces and the media in between according to the user specifications. By setting two cylindrical surfaces with contrary sign on the *Radius of Curvature* it is possible to generate the cylindrical lenses used in this kind of component.
- This lens modeling is not apt for illumination of the full curvature (including the area where the surface becomes flat). But this is no limitation for this simulation at all, as only a small part of the lens curvature is illuminated.

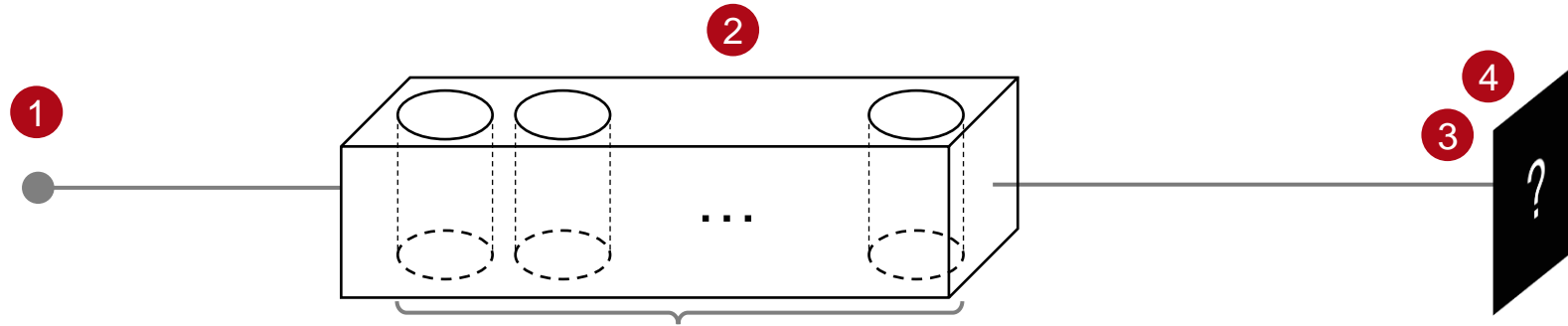
The screenshot shows the 'Edit Lens System Component' software interface. It features a table of lens parameters and a 3D model of the lens system.

Index	Distance	Position	Type	Homogeneous Medium	Comment
1	0 mm	0 mm	Plane Surface	Al-Mg(3%Mg)@41,3280	Enter your com
2	25 $\mu$ m	25 $\mu$ m	Cylindrical Surface	Air (X-ray spectral regio	Enter your com
3	500 $\mu$ m	525 $\mu$ m	Cylindrical Surface	Al-Mg(3%Mg)@41,3280	Enter your com
4	50 $\mu$ m	575 $\mu$ m	Cylindrical Surface	Air (X-ray spectral regio	Enter your com
5	500 $\mu$ m	1.075 mm	Cylindrical Surface	Al-Mg(3%Mg)@41,3280	Enter your com
6	50 $\mu$ m	1.125 mm	Cylindrical Surface	Air (X-ray spectral regio	Enter your com
7	500 $\mu$ m	1.625 mm	Cylindrical Surface	Al-Mg(3%Mg)@41,3280	Enter your com
8	50 $\mu$ m	1.675 mm	Cylindrical Surface	Air (X-ray spectral regio	Enter your com
9	500 $\mu$ m	2.175 mm	Cylindrical Surface	Al-Mg(3%Mg)@41,3280	Enter your com
10	50 $\mu$ m	2.225 mm	Cylindrical Surface	Air (X-ray spectral regio	Enter your com
11	500 $\mu$ m	2.725 mm	Cylindrical Surface	Al-Mg(3%Mg)@41,3280	Enter your com
12	25 $\mu$ m	2.75 mm	Plane Surface	Al-Mg(3%Mg)@41,3280	Enter your com

The interface also includes a 3D model of the lens system, a toolbar with icons for 'Plane', 'Conical', and 'Cylindrical' surfaces, and a 'Tools' button. A 'Validity' indicator is shown at the bottom left.



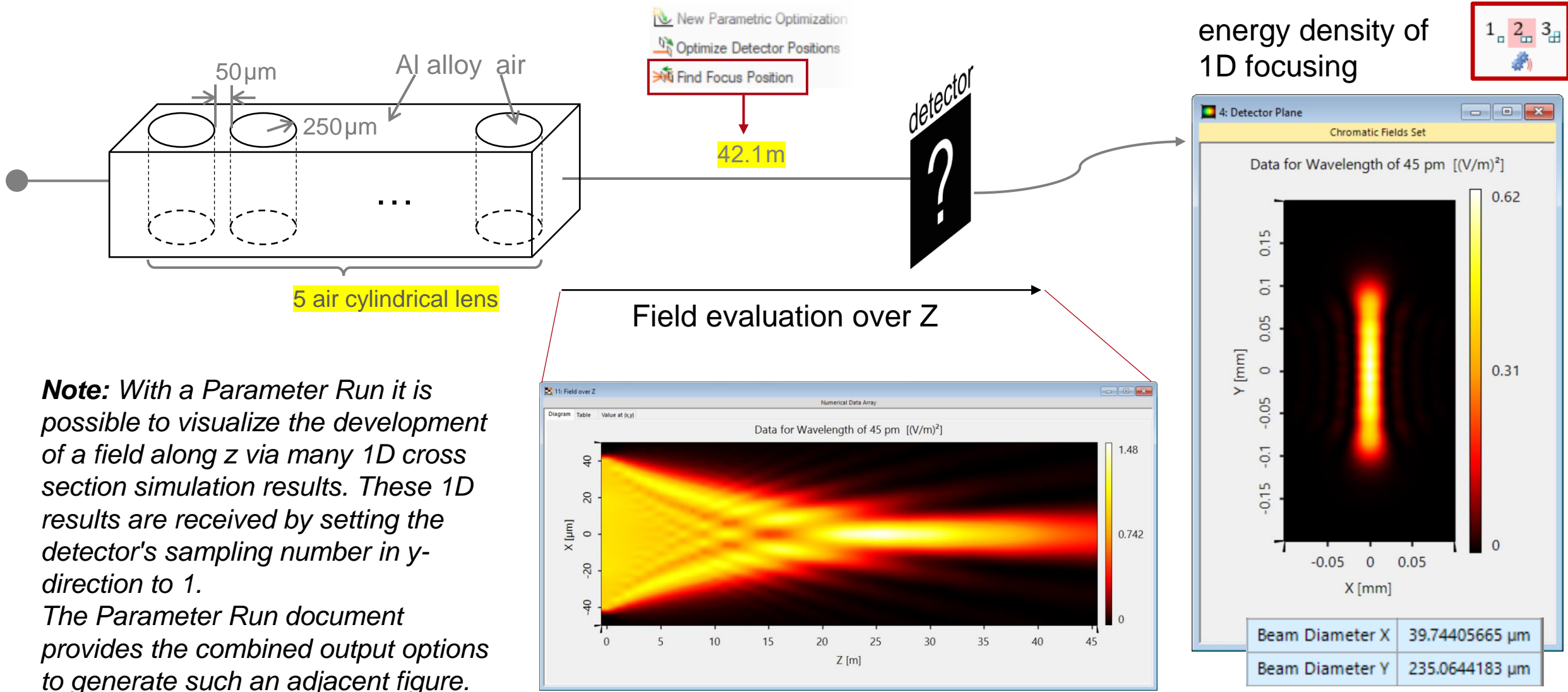
# Summary – Components...



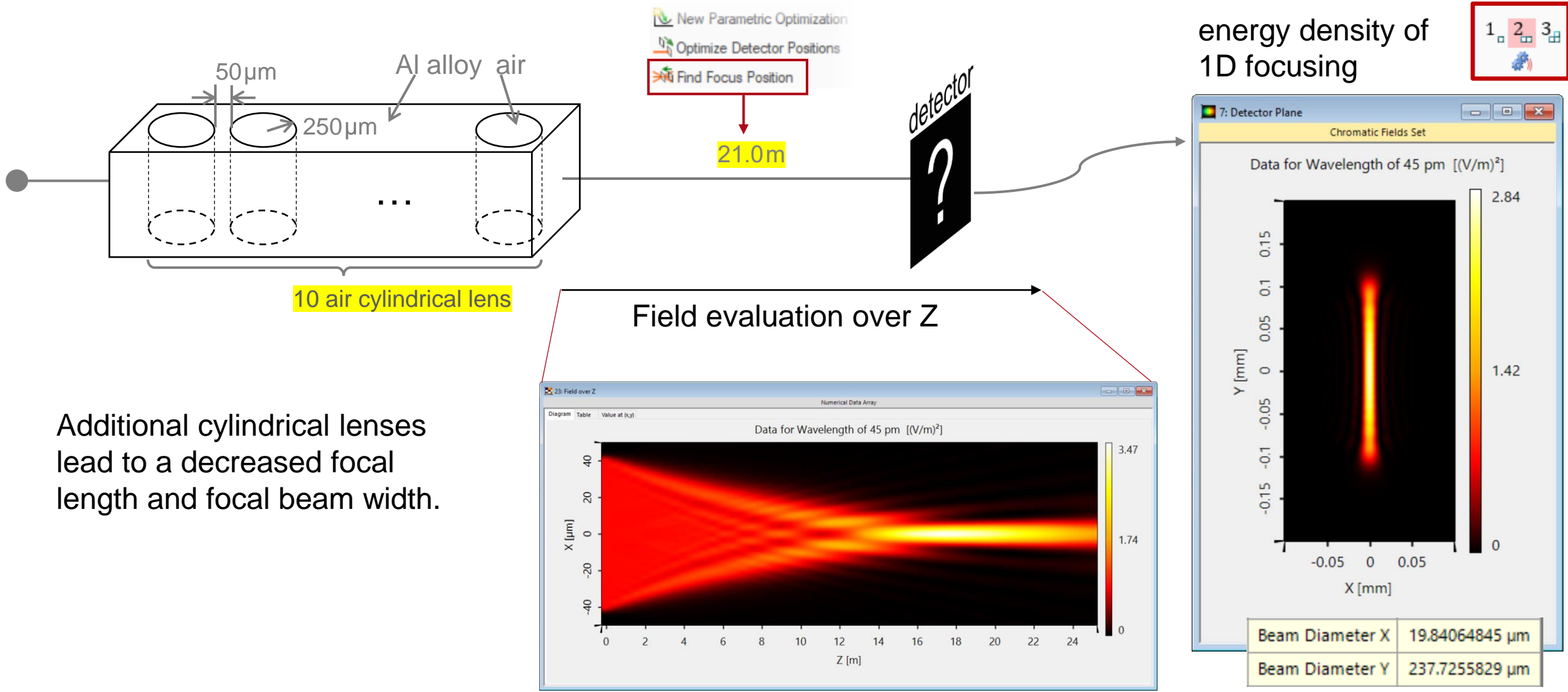
... of Optical System	... in VirtualLab Fusion	Model/Solver
1. Source	<i>Plane Wave Source</i>	Truncated Ideal Plane Wave
2. Compound lens	<i>Lens System Component</i>	Local Plane Interface Approximation (LPIA)
3. Detector	<i>Spot Size Detector</i>	Second-Momentum theory
4. Detector	<i>Camera Detector</i>	Energy density

# Simulation Results

# 1D-Simulation: 5 Cylindrical Lens

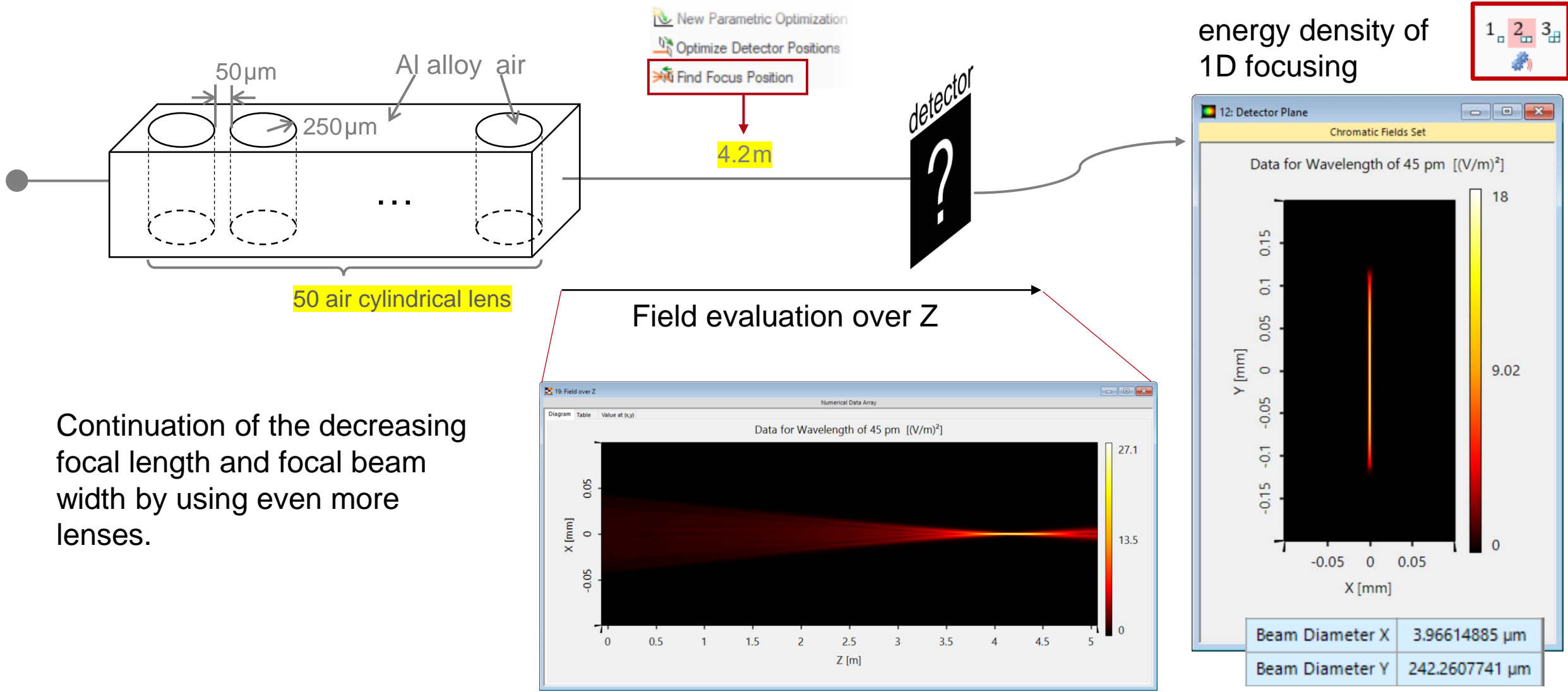


# 1D-Simulation: 10 Cylindrical Lens



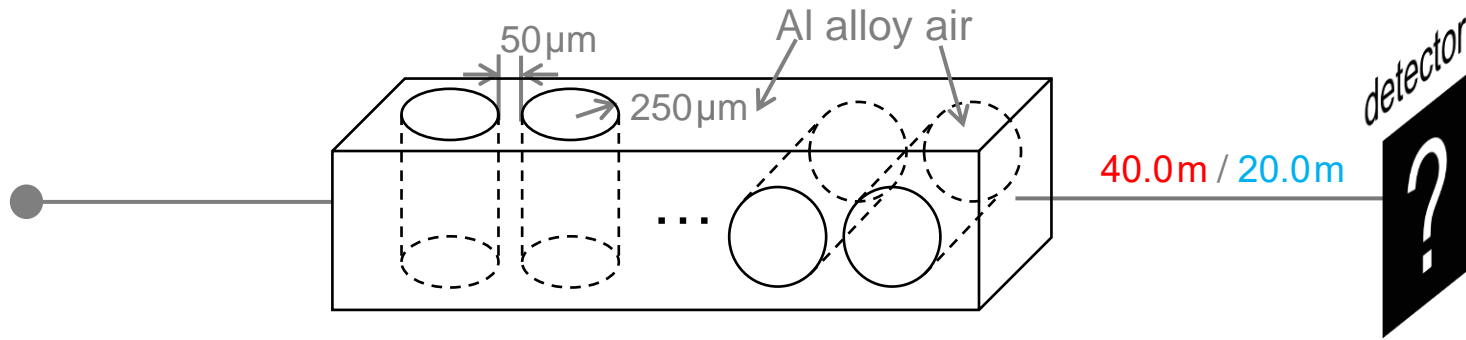


# 1D-Simulation: 50 Cylindrical Lens

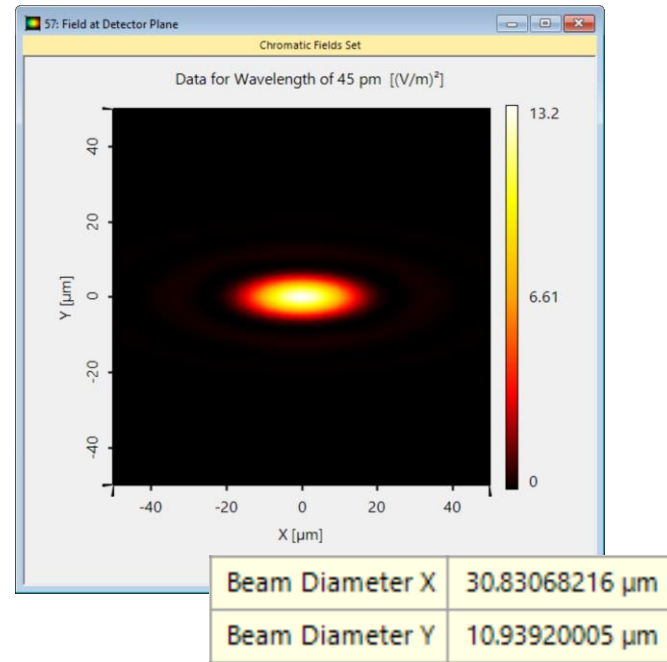


Continuation of the decreasing focal length and focal beam width by using even more lenses.

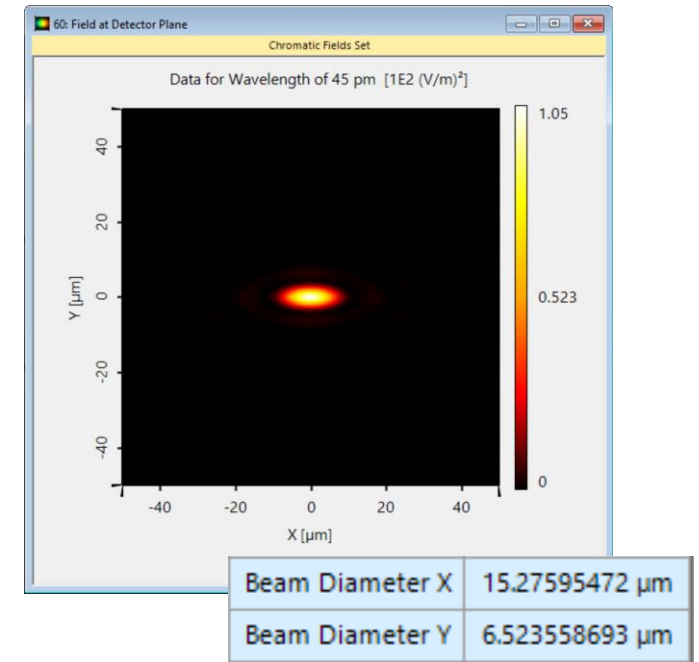
# 2D-Simulation: 5 Cylindrical Lens



- To focus the x-ray beam in both x- and y-direction the compound lens can be build up by an horizontally (H) and vertically oriented cylindrical lenses.
- Here we simulated an equal number of both types.

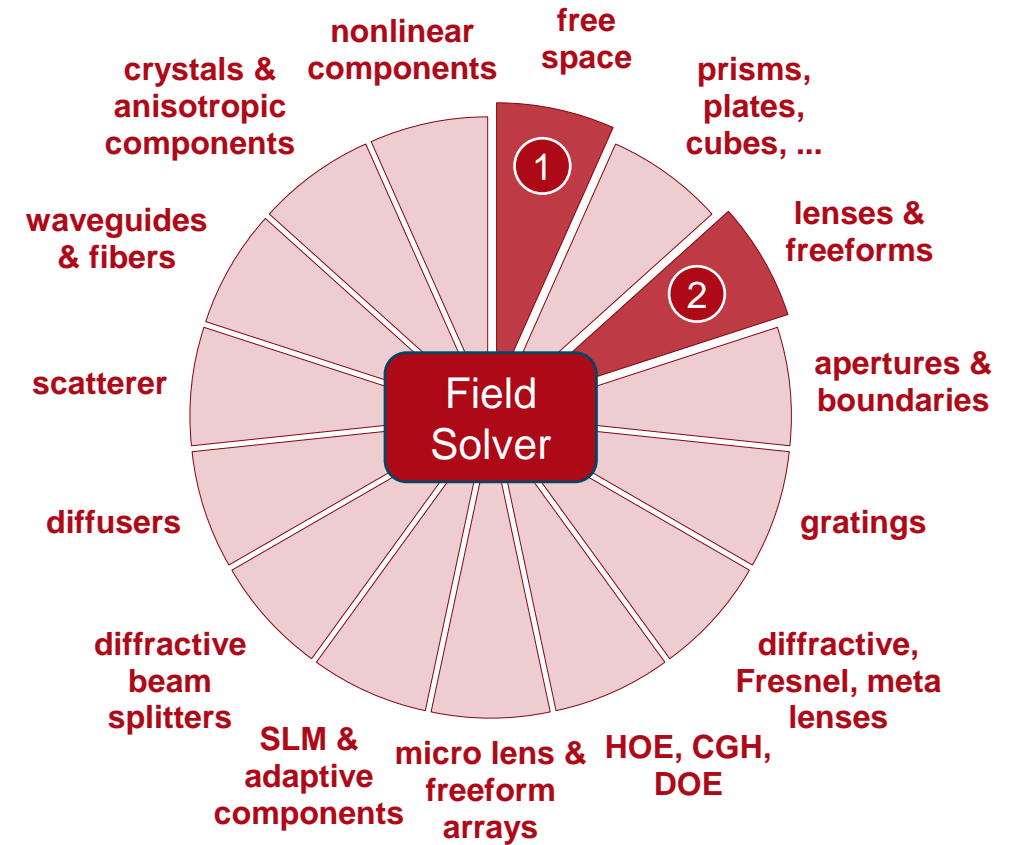
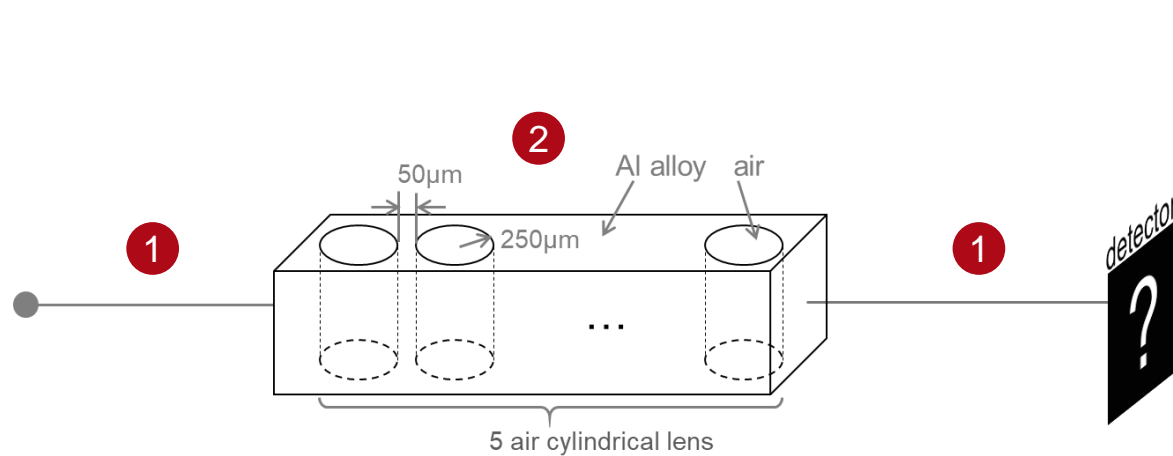


5 (H) and 5 (V) air cylindrical lens



10 (H) and 10 (V) air cylindrical lens

# VirtualLab Fusion Technologies



# Document Information

title	Compound Refractive Lens for X-Ray Focusing
document code	XRAY.0004
version	1.0
edition	VirtualLab Fusion Basic
software version	2021.1 (Build 1.180)
category	Application Use Case
further reading	<ul style="list-style-type: none"><li>- <a href="#">Single Grating Interferometer for X-Ray Imaging</a></li><li>- <a href="#">Grazing-Incidence Focusing Mirrors for X-Ray Beams</a></li></ul>