Compound Refractive Lens for X-Ray Focusing
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

plane wave
- wavelength 41.328 pm (30 keV)
- aperture size 80 µm × 240 µm (elliptical)

compound reflective lens
- material Al alloy (with 3% Mg)
- with an array of air cylindrical lens

50 µm
250 µm

5, or 10, or 50 air cylindrical lens

one-dimensional (1D) focusing

Al alloy
air

50 µm
250 µm

5 or 10 horizontal and 5 or 10 vertical air cylindrical lens

two-dimensional (2D) focusing

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.
Summary – Components…

<table>
<thead>
<tr>
<th>… of Optical System</th>
<th>… in VirtualLab Fusion</th>
<th>Model/Solver</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Source</td>
<td>Plane Wave Source</td>
<td>Truncated Ideal Plane Wave</td>
</tr>
<tr>
<td>2. Compound lens</td>
<td>Lens System Component</td>
<td>Local Plane Interface Approximation (LPIA)</td>
</tr>
<tr>
<td>3. Detector</td>
<td>Spot Size Detector</td>
<td>Second-Momentum theory</td>
</tr>
<tr>
<td>4. Detector</td>
<td>Camera Detector</td>
<td>Energy density</td>
</tr>
</tbody>
</table>
Simulation Results
Note: With a Parameter Run it is possible to visualize the development of a field along z via many 1D cross section simulation results. These 1D results are received by setting the detector's sampling number in y-direction to 1. The Parameter Run document provides the combined output options to generate such an adjacent figure.
1D-Simulation: 10 Cylindrical Lens

Additional cylindrical lenses lead to a decreased focal length and focal beam width.

Field evaluation over Z

Energy density of 1D focusing
1D-Simulation: 50 Cylindrical Lens

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

- Prisms, plates, cubes, ...
- Lenses & freeforms
- Apertures & boundaries
- Gratings
- Diffractive, Fresnel, meta lenses
- HOE, CGH, DOE
- Micro lens & freeform arrays
- SLM & adaptive components
- Diffractive beam splitters
- Scatterer
- Diffusers
- Waveguides & fibers
- Nonlinear components
- Free space
- Crystals & anisotropic components
- 5 air cylindrical lens
- 50 µm
- 250 µm
- Al alloy
- Air

Field Solver
<table>
<thead>
<tr>
<th>title</th>
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<tbody>
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| further reading      | - [Single Grating Interferometer for X-Ray Imaging](#)  
|                      | - [Grazing-Incidence Focusing Mirrors for X-Ray Beams](#) |