

Rectangular Lenslet Array

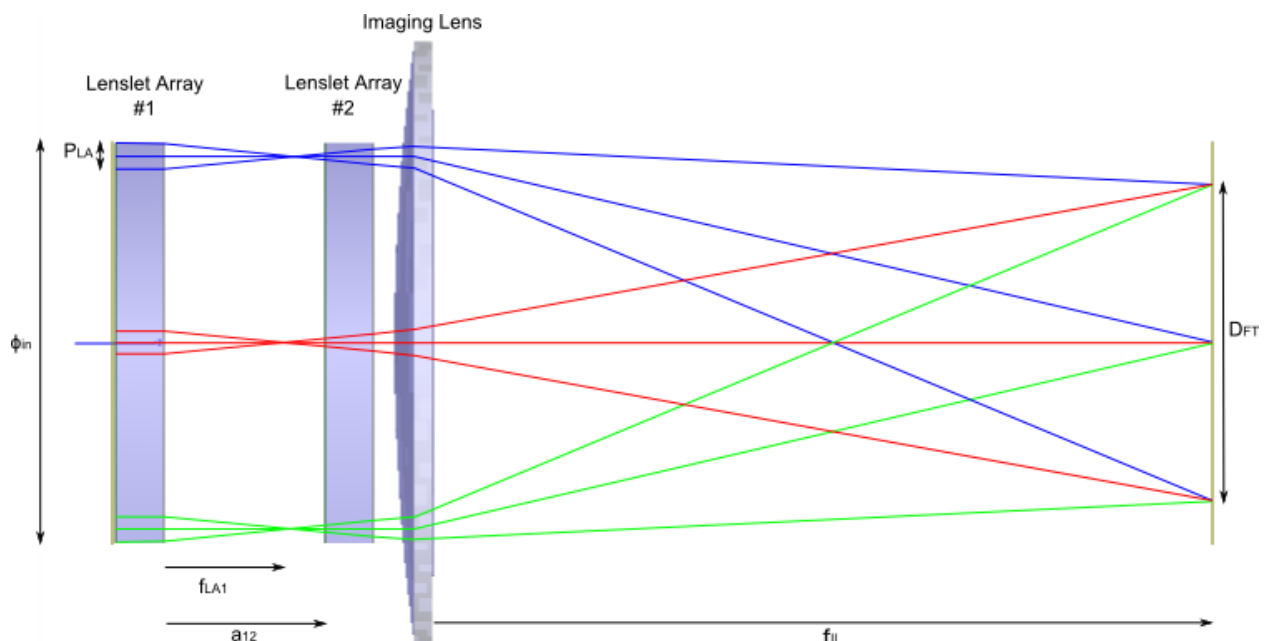
INTRODUCTION

Lenslet arrays are used in a variety of applications that include beam homogenization. This knowledge base article demonstrates the setup of an imaging lenslet array for creating uniform incoherent illumination on a detector. The input beam has a gaussian profile with half width equal to the lenslet array size and it is shown that this power profile is washed out by the lenslet array.

The example file and discussion follow from the technical note on the subject provided by Suss Micro-optics, which can be found [here](#). The reader is encouraged to review their documentation and catalog for further information.

SYSTEM LAYOUT

The simple example system consists of a monochromatic input source with a spatial gaussian power apodization ($1/e^2 = 5 \text{ mm}$) and 0.6 degree half angle divergence, two identical 33 x 33 element lenslet arrays (10 mm aperture) with lenslet focal length 4.80 mm and pitch 0.3 mm, an imaging lens with focal length 100 mm, and a detector plane located at the back focal plane of the imaging lens.



In the imaging configuration shown here, $f_{LA1} < a_{12} < f_{LA1} + f_{LA2}$. The diameter of the illumination area at the detector plane is given by:

$$D_{FT} = P_{LA1} \left[\frac{f_{FL}}{f_{LA1} * f_{LA2}} \right] [f_{LA1} + f_{LA2} - a_{12}]$$

The divergence half angle at the illumination plane is given by:

$$\tan(\theta) = \frac{\phi_{in} + D_{FT} - 2P_{LA}}{2f_{FL}} \text{ for } D_{FT} > P_{LA}$$

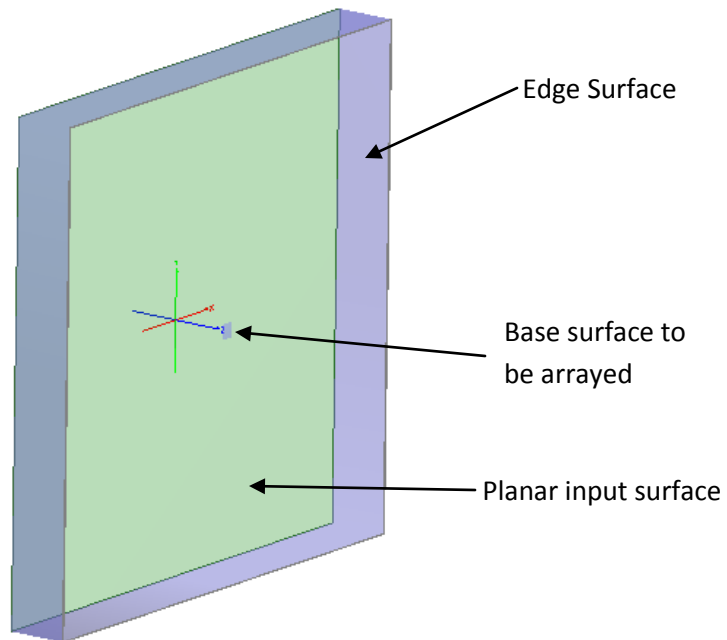
For the specified lenslet arrays and imaging lens in the example FRED file, this configuration should give:

$$D_{FT} = 6.07 \text{ mm}$$

$$\theta \approx 4.4^\circ$$

LENSLET CONSTRUCTION

The construction of the lenslet consists of an input plane, the base surface which will be arrayed, and an outer edge surface which closes the lenslet array volume. These components are shown below:

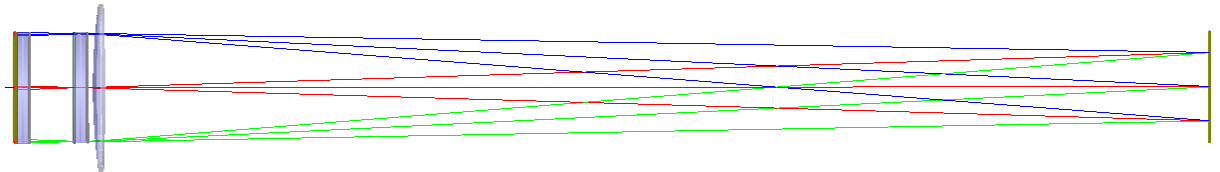


The following steps can be taken to create the geometry for the lenslet array.

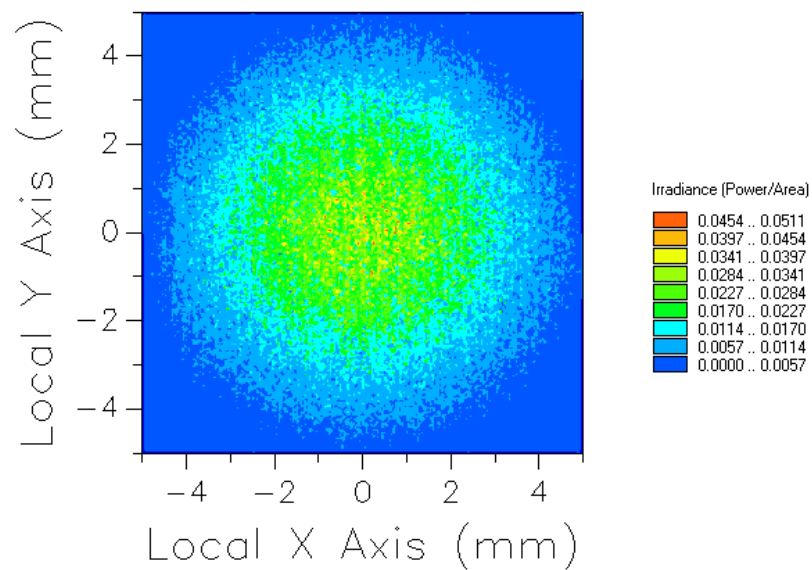
1. Create a subassembly to hold the components of the lenslet array (Menu > Create > New Subassembly).
2. Create an input plane whose half widths correspond to the arrayed lenslets. In this example, the lenslet pitch is 0.3 mm, the number of lenslets is 33 x 33, and so the plane half width is $16 \times 0.3 + 0.15 = 4.95$ mm. FRED's element primitive construct is used to define the plane (Menu > Create > New Element Primitive > Plane).
3. Create a custom element node which will contain the base surface (Menu > Create > New Custom Element). This custom element node will be arrayed to form the exit surface of the lenslet.
 - a. Create a new surface as a child of the custom element node in step 3 (Menu > Create > New Surface). In this case, the surface is specified by $R = -2.2$ with $\text{conic} = -1$. On the Aperture tab of the surface, the trimming volume outer boundary X and Y dimensions should be set to half the array pitch (0.15 mm). The Z-depth should be minimized to be the smallest size that contains the surface (TIP: Use the scripting language's Sag function to find the necessary Z-depth for the semi-aperture).
 - b. Array the custom element created in step 3 which contains the base surface (Right mouse click on the custom element node and select "Edit/View Array Parameters"). In this example, the array is defined in the X and Y directions with spacing equal to the lenslet pitch in each direction. For a 33 x 33 lenslet array, the minimum and maximum cell values go from -16 to +16 in each direction.
4. Add another custom element to the subassembly node which will contain the edge surface created by extruding a closed curve along the Z-axis.
 - a. Add a curve to the custom element node (Menu > Create > New Curve) and set its type to "Segmented". Right mouse click in the spreadsheet area for the points specification and choose "Generate Points" to open a utility that can be used to quickly specify a closed segmented curve. In this example, the aperture shape is square with semi aperture 4.95 mm. In the Segmented Curve Generation dialog we can then choose the following settings:
 - i. # points around generating curve = 4
 - ii. X semi-width = Y semi-width = 4.95
 - iii. Orientation = Top edge parallel to X axis
 - iv. Type = circumscribe
 - b. Add a surface to the custom element and set its type to "Tabulated Cylinder". The Directrix curve should be the closed curve from 4a, and its Z-direction should be set to thickness of the lenslet array ($Z = 1.2$). On the Aperture tab of the surface dialog set its x and y trimming volume outer boundaries to be larger than the aperture of the lenslet array (i.e. 4.96). The z trimming volume should again be large enough to contain the extruded surface.

SIMULATION RESULTS

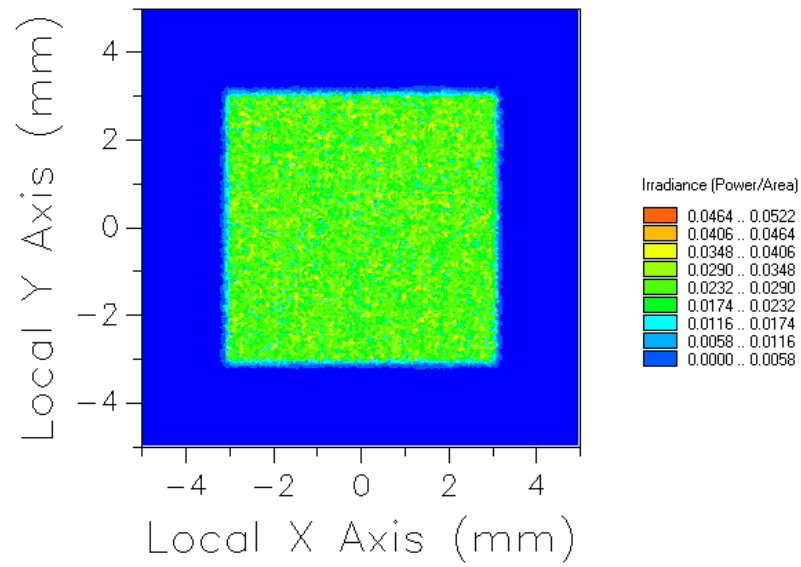
The three ray bundles shown in the system layout schematic can be simulated in the attached FRED example file by toggling the sources "InputSource 1", "InputSource 2" and "InputSource 3" traceable using the right mouse click menu option. Source "FullAperture" should be made untraceable. The resulting raytrace is shown below.



When the source "FullAperture" is traceable, its irradiance profile is a gaussian with a half width of 5 mm as shown below.



The final distribution at the illumination plane is shown below.



The intensity profile at the illumination plane is shown below.

