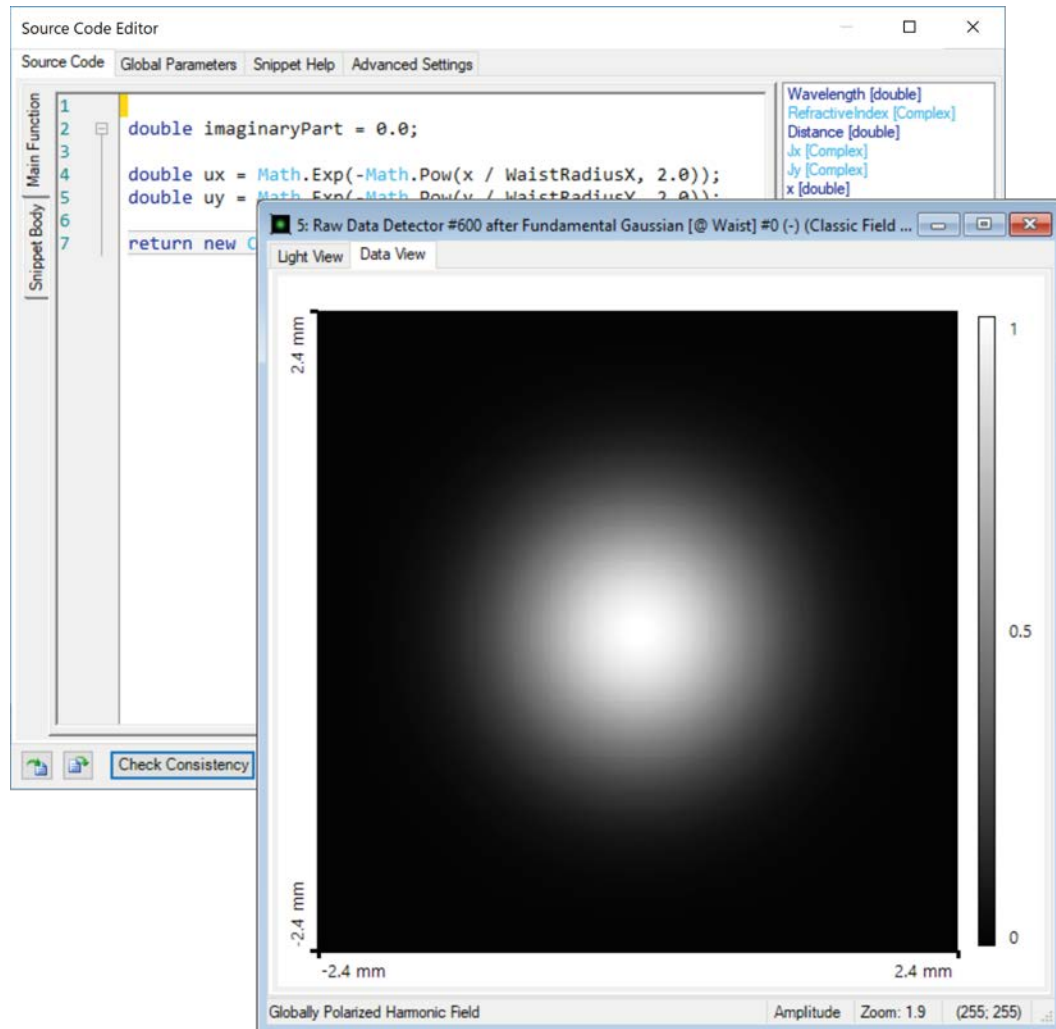


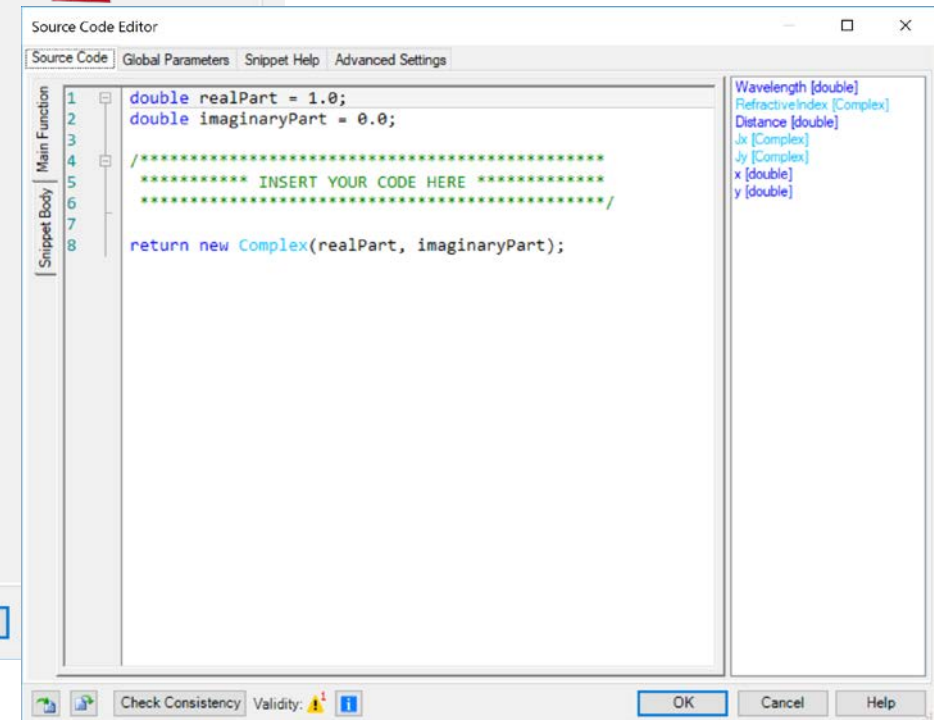
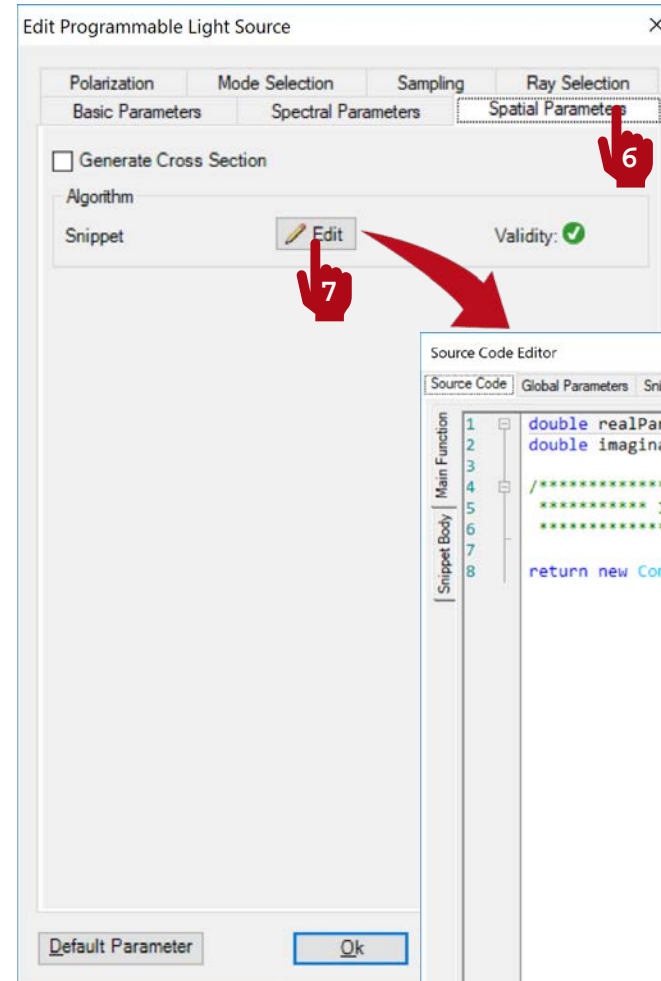
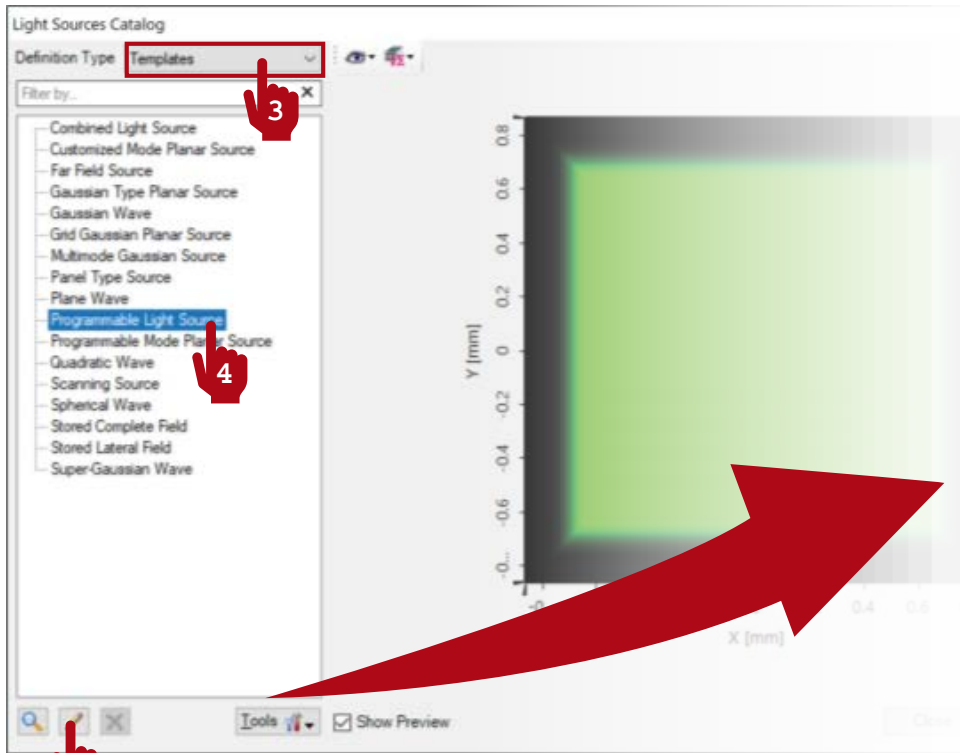
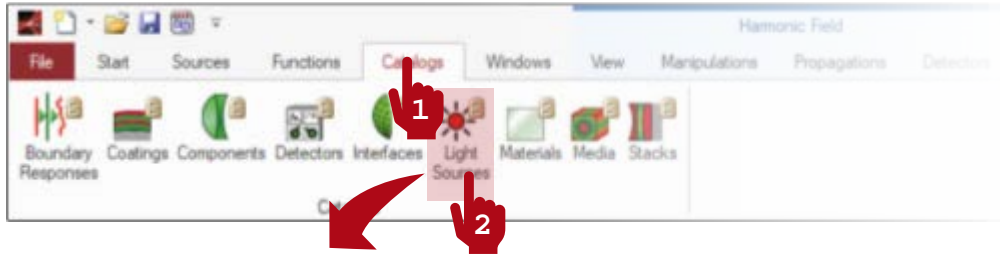
How to Work with the Programmable Light Source in VirtualLab Fusion and Example (Gaussian Beam)

Abstract



Providing maximum versatility for your optical simulations is one of our most fundamental objectives. In this document we show you how to work with the Programmable Source: a means to define the spatial dependence of a custom basic source mode which can then be used on its own, as a fully coherent, monochromatic source; or as a single mode in a more complex one (which is perhaps partially spatially coherent or polychromatic). Although the Gaussian beam is one of the source models included in VirtualLab by default, we use it here as a simple programming example.

Where to Find the Programmable Light Source: Catalog



Where to Find the Programmable Light Source: Optical Setup

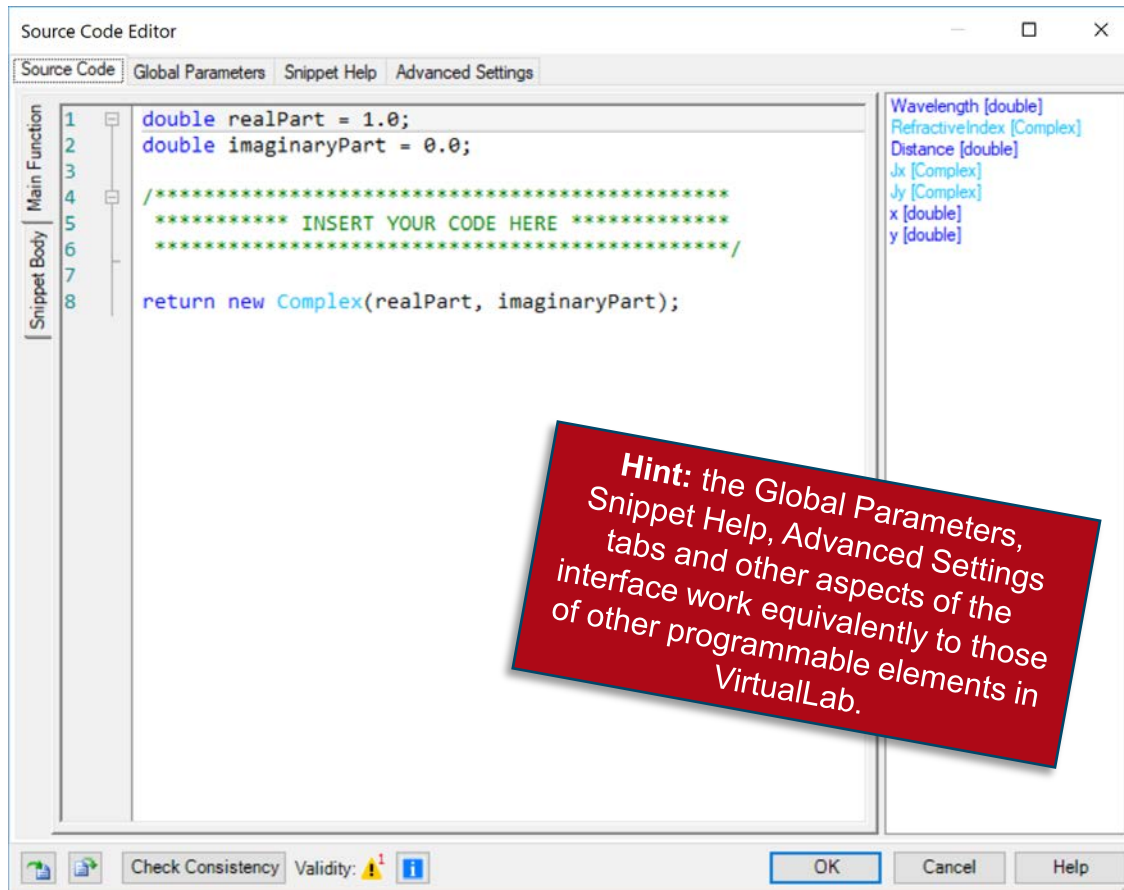
The image illustrates the steps to access the Programmable Light Source configuration in an optical setup software. It shows three main windows:

- Optical Setup View #6 (Optical Setup)*:** A tree view on the left lists various components. Under "Light Sources", "Basic Source Models", and "Programmable Light Source" is highlighted with a red hand icon labeled "1".
- Edit Programmable Light Source:** A central dialog box with tabs for "Polarization", "Mode Selection", "Sampling", "Ray Selection", "Basic Parameters", "Spectral Parameters", and "Spatial Parameters". A red hand icon labeled "2" points to the "Programmable Light Source" icon in the main workspace. A red hand icon labeled "3" points to the "Spatial Parameters" tab. A red hand icon labeled "4" points to the "Edit" button.
- Source Code Editor:** A window showing the source code for the light source. The code is as follows:

```
1 double realPart = 1.0;
2 double imaginaryPart = 0.0;
3
4 /*****
5 ***** INSERT YOUR CODE HERE *****
6 *****/
7
8 return new Complex(realPart, imaginaryPart);
```

At the bottom of the Source Code Editor, there are buttons for "Check Consistency", "Validity: 1", "OK", "Cancel", and "Help".

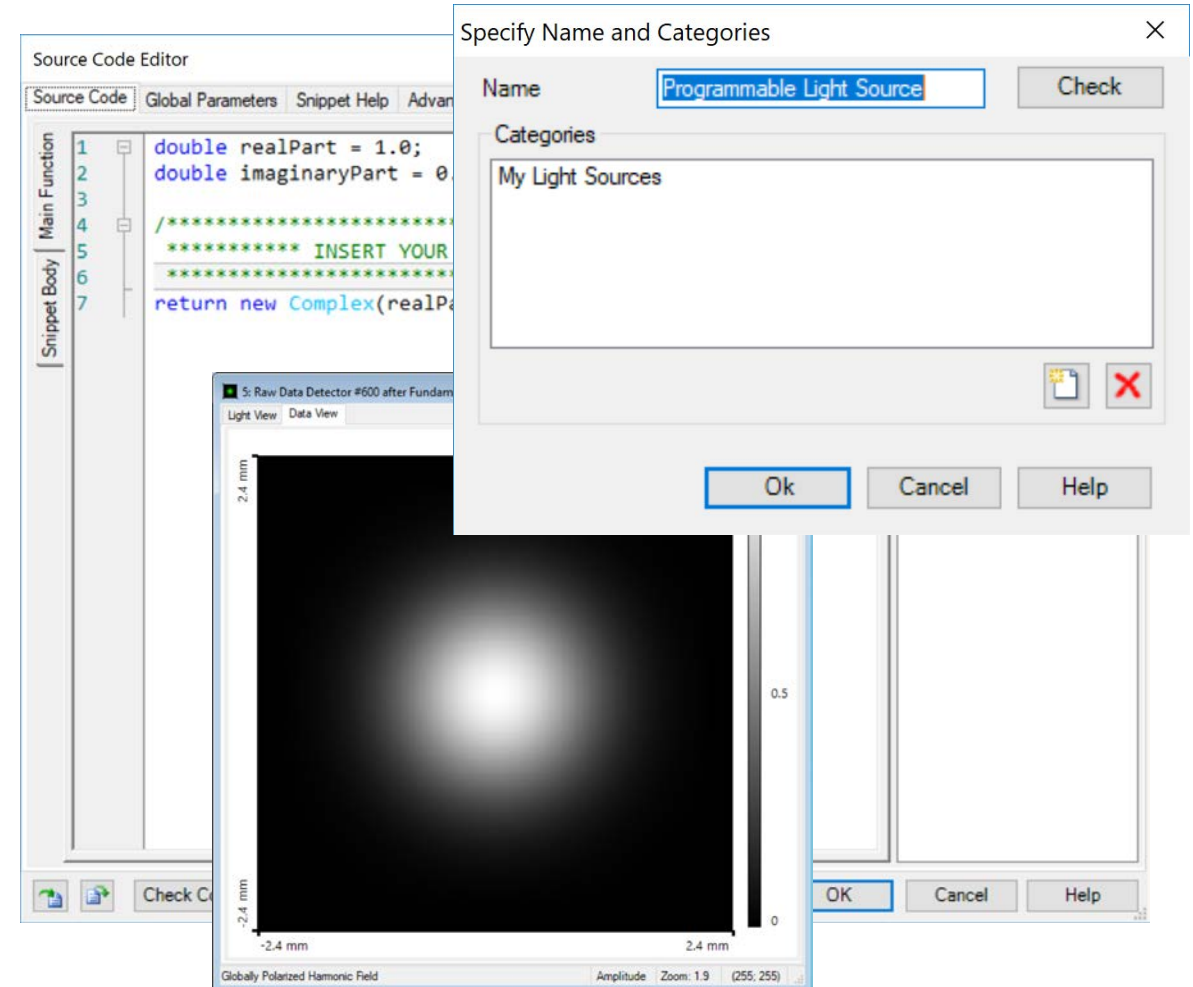
Writing the Code



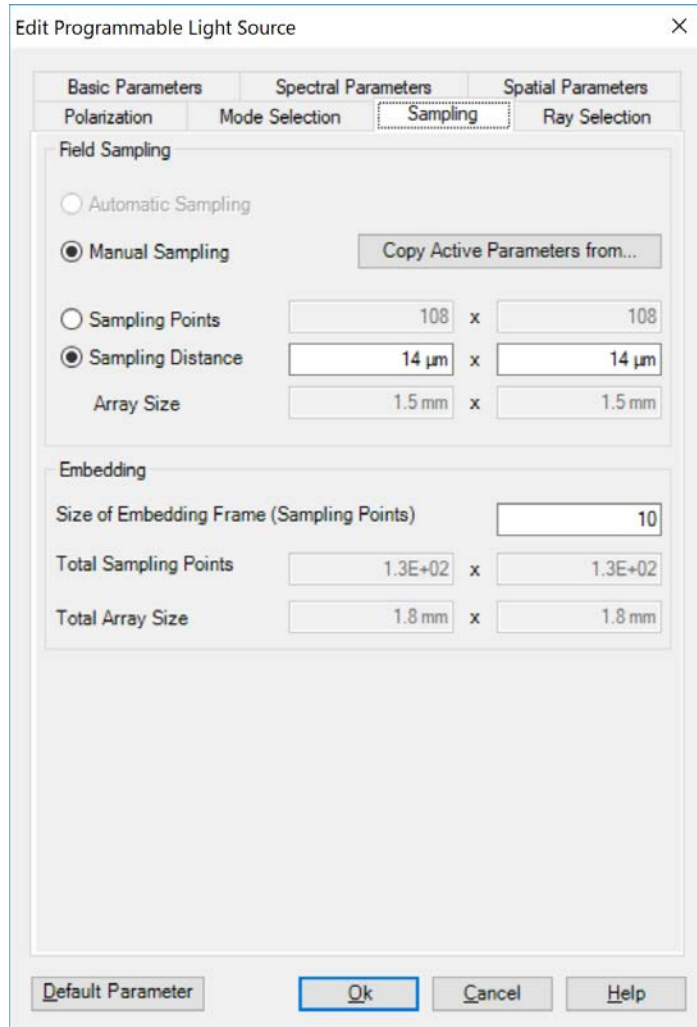
- The panel on the right shows a list of available independent parameters.
- **Wavelength** reads in the values of the wavelength or wavelengths specified in the *Spectral Parameters* tab of the configuration dialogue of the source.
- **RefractiveIndex** reads in the complex-valued refractive index of the embedding medium for the specific wavelength of the mode. The embedding medium is defined in the Basic Parameters tab.
- **Distance** reads in another parameter from the configuration dialogue, this time from the Basic Parameters tab: the Distance to Input Plane. This is an important parameter, for instance, in the case of a point source, where the source field cannot be defined exactly at the emitting point.
- **Jx** and **Jy** are the complex-valued components of the Jones polarization vector. If we represent the function which is defined in the code as $U(x, y)$, then the electric components which finally emanate from the source plane are $E_x = J_x U(x, y)$ and $E_y = J_y U(x, y)$.
- **x** and **y** represent the two-dimensional source plane; they are the coordinates spanning this plane.
- The code in the Main Function must return a **Complex** value per **x**, **y** point. All these values put together conform the function $U(x, y)$.
- Use the Snippet Body to group parts of the code in support functions.

Output

- The output is a complex-valued function which represents the spatial part of an eventual electromagnetic field component, $U(x, y)$.
- It is a conclusion of Maxwell's equations that, in a homogeneous medium, it is enough to fix two out of the six electromagnetic components, the other four follow from the equations. In VirtualLab E_x and E_y are, without loss of generality, selected to be these independent components. In the Programmable Light Source, they are fixed as $E_x = J_x U(x, y)$ and $E_y = J_y U(x, y)$.
- The output of the custom source is then an electromagnetic field whose spatial part is defined according to the code, and with a spectral composition as per the Spectral Parameters tab.
- The resulting field can be used as a standalone source in an Optical Setup, it can be saved in the catalog, or it can be employed as a basic mode in a more complex source.



Sampling



- The code defines the source field function analytically, so the accuracy of the programmed function is only limited by double precision.
- The user must ensure that the sampling of the field is fine enough to resolve the function they have implemented.
- Use the Sampling tab for this purpose.
- Please note that the sampling may depend on the actual values of the defined global parameters.

Programming a Gaussian Beam

The Gaussian Beam

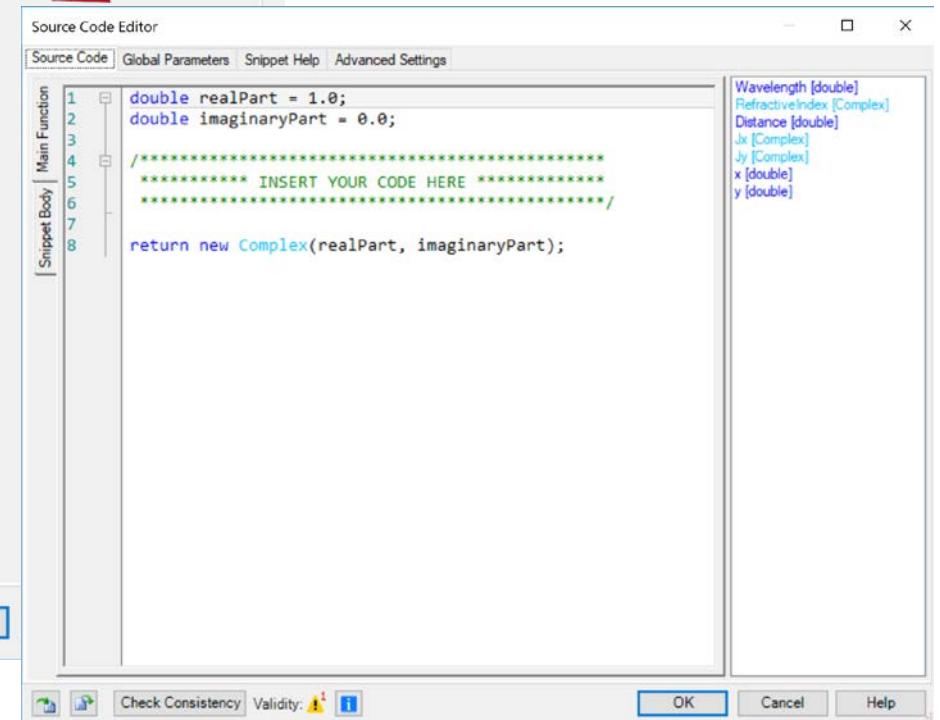
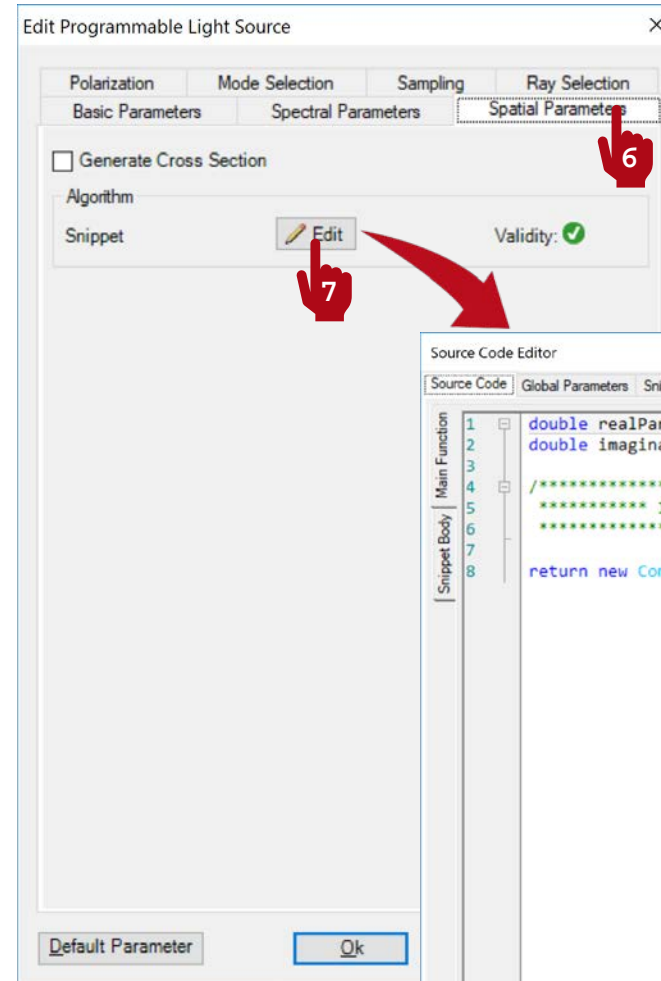
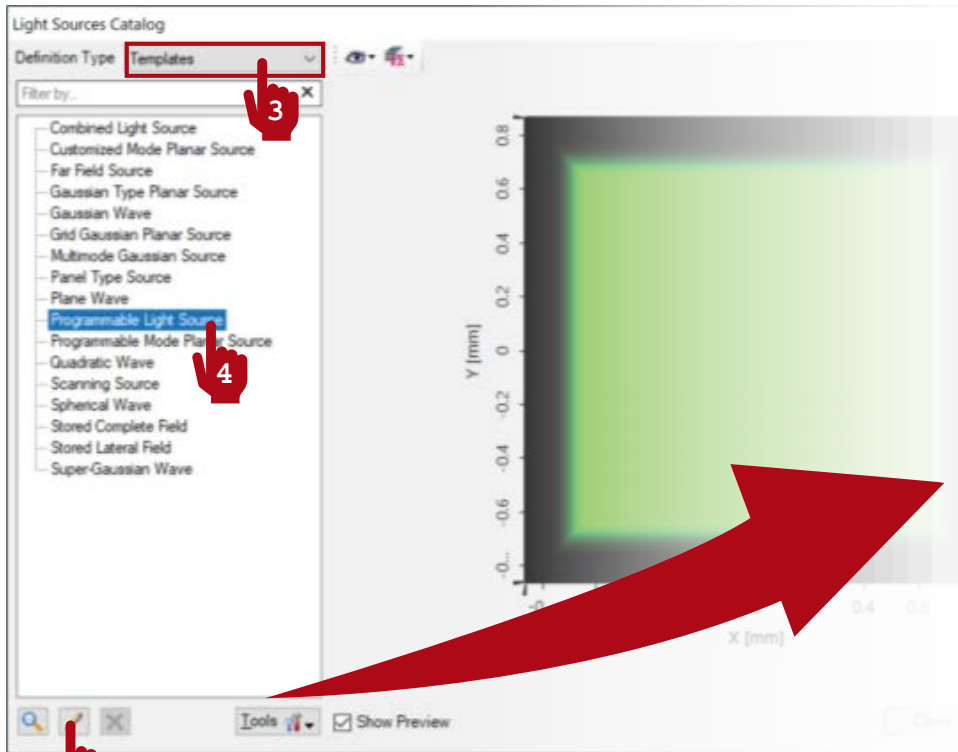
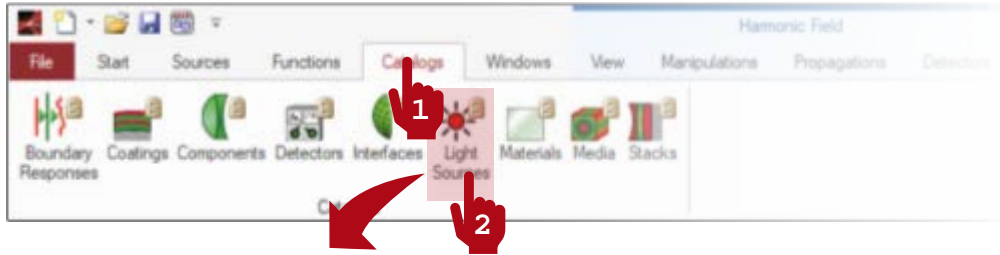
An electromagnetic field is described as a fundamental Gaussian beam when the electric component normal to the main propagation direction is given, at its waist, by a mathematical expression of the form:

$$V_\ell(x, y) \propto \exp\left(-\frac{x^2}{w_x^2}\right) \exp\left(-\frac{y^2}{w_y^2}\right) \quad (1)$$

$V_\ell(x, y) \rightarrow$ One of the six electromagnetic components, which takes a Gaussian form

$w_x, w_y \rightarrow$ Waist radius in x and y .

Where to Find the Programmable Light Source: Catalog



Where to Find the Programmable Light Source: Optical Setup

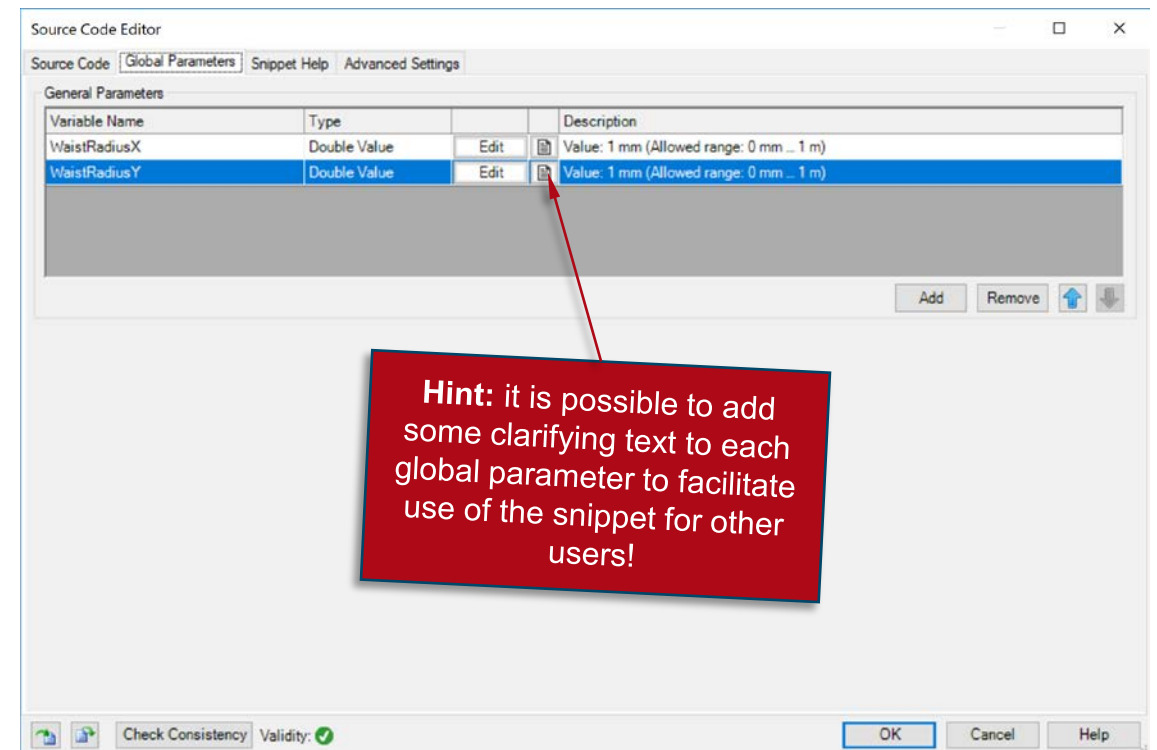
The image illustrates the steps to access the Programmable Light Source configuration in the software. It shows three main windows:

- Optical Setup View #6 (Optical Setup)*:** A tree view on the left lists various components. Under "Light Sources", "Basic Source Models", and "Programmable Light Source" is highlighted with a red hand icon labeled "1".
- Edit Programmable Light Source:** A central dialog box with tabs for "Polarization", "Mode Selection", "Sampling", and "Ray Selection". The "Spatial Parameters" tab is selected, indicated by a red hand icon labeled "3". An "Edit" button is highlighted with a red hand icon labeled "4".
- Source Code Editor:** A window showing the source code for the light source. The code includes variables for Wavelength, Refractive Index, Distance, Jx, Jy, x, and y, and a main function that returns a new Complex object. A red arrow points from the "Edit" button in the dialog to this window.

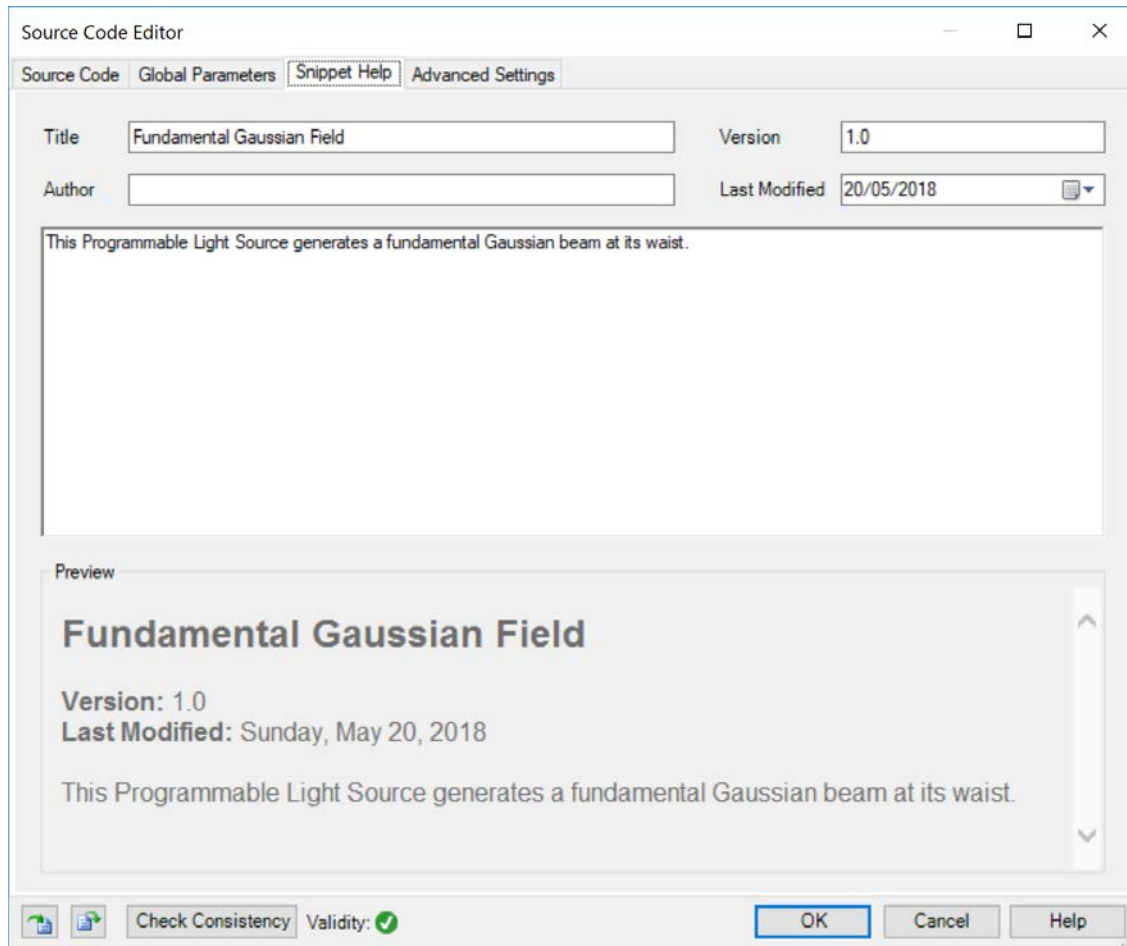
Red hand icons and arrows indicate the sequence of actions: 1. Selecting the Programmable Light Source in the tree view; 2. Clicking the "Edit" button in the dialog; 3. Selecting the "Spatial Parameters" tab; 4. Clicking the "Edit" button in the dialog to open the source code editor.

Programmable Light Source: Global Parameters

- Once you have triggered open the Edit dialogue, go to the Global Parameters Tab.
- There, Add and Edit two global parameters:
 - `double` `WaistRadiusX` = 1 mm (0 mm, 1 m): the radius of the Gaussian beam, in x direction, at the waist.
 - `double` `WaistRadiusY` = 1 mm (0 mm, 1 m): the radius of the Gaussian beam, in y direction, at the waist.



Programmable Light Source: Snippet Help



- **Optional:** you can use the Snippet Help to write instructions, clarifications, and some metadata associated to your snippet.
- This option is very helpful to keep track of your progress with a programmable element.
- It is especially useful when the programmable element is later disseminated to be handled by other users!

Programmable Light Source: Snippet Help

The image shows a software interface with a 'Source Code Editor' window and an open 'Snippet Help' dialog. The editor window has tabs for 'Source Code', 'Global Parameters', 'Snippet Help', and 'Advanced Settings'. The 'Snippet Help' tab is active, displaying the following information:

Fundamental Gaussian Field

Version: 1.0
Last Modified: Sunday, May 20, 2018

This Programmable Light Source generates a fundamental Gaussian beam at its waist.

PARAMETER	DESCRIPTION
WaistRadiusX	Waist radius along x axis.
WaistRadiusY	Waist radius along y axis.

At the bottom of the editor window, there is a 'Check Consistency' button and a 'Validity: ✓' indicator. A red hand icon is pointing to a 'Help' button in the bottom right corner of the editor window, with a red arrow pointing from this button to the 'Snippet Help' dialog window.

Programmable Light Source: Writing the Code

Source Code Editor

Source Code Global Parameters Snippet Help Advanced Settings

1 `double realPart = 1.0;`
2 `double imaginaryPart = 0.0;`
3
4 `double ux = Math.Exp(-Math.Pow(x / WaistRadiusX, 2.0));`
5 `double uy = Math.Exp(-Math.Pow(y / WaistRadiusY, 2.0));`
6
7 `realPart = ux * uy;`
8
9 `return new Complex(realPart, imaginaryPart);`

Wavelength [double]
RefractiveIndex [Complex]
Distance [double]
Jx [Complex]
Jy [Complex]
x [double]
y [double]
WaistRadiusX [double]
WaistRadiusY [double]

Eq. (2)

Declaration of output variable given by default

Default global parameters/variables

Global parameters defined by user in Global Parameters tab

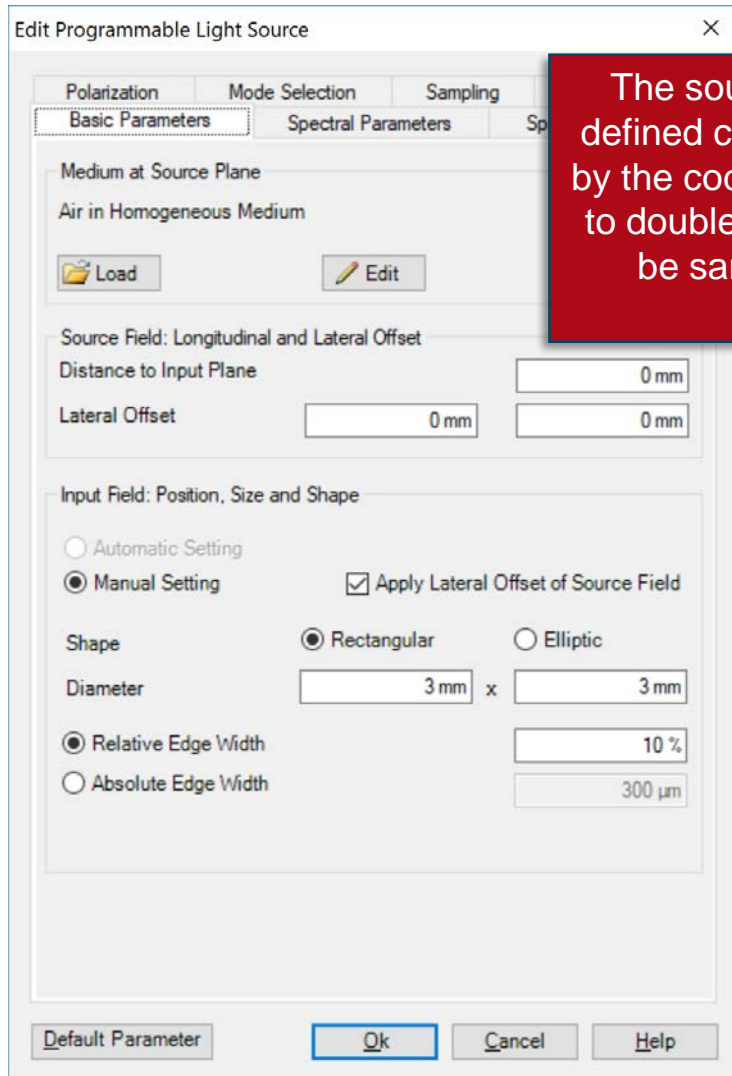
Are there errors in your code?

Export Snippet to save your work!

Check Consistency Validity:

OK Cancel Help

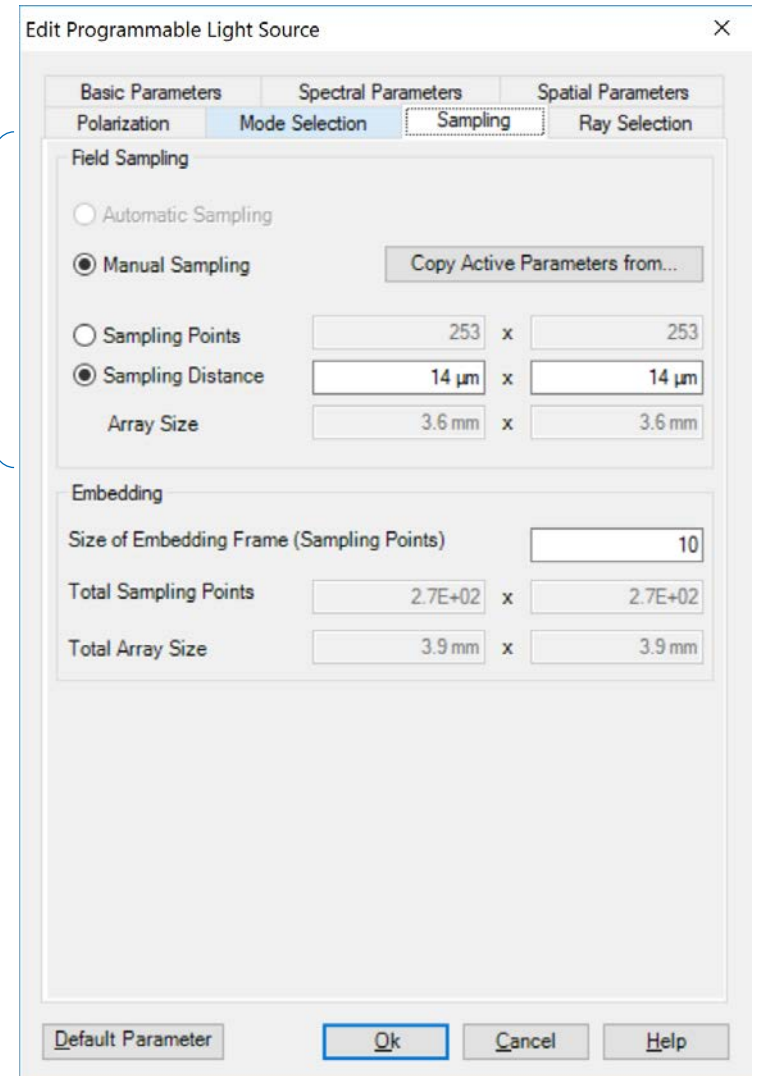
Programmable Light Source: Adjusting Sampling and Window



The source field function is defined completely analytically by the code—full accuracy (up to double precision)—and can be sampled as finely as required!

It is up to the user to define a suitable area of definition in the x, y plane for their custom source in the Basic Parameters tab

It is up to the user to define a suitable sampling distance for their custom source in the Sampling tab



Programmable Light Source: Using Your Snippet

The image shows a software interface for editing a light source snippet. The main window is titled "Edit Programmable Light Source" and has several tabs: "Polarization", "Mode Selection", "Sampling", "Ray Selection", "Basic Parameters", "Spectral Parameters", and "Spatial Parameters". The "Spectral Parameters" tab is currently selected. Below the tabs, there is a checkbox for "Generate Cross Section" and a section for "Algorithm" containing a "Snippet" field with an "Edit" button and a "Validity" indicator (a green checkmark). Below this is a "Parameters" section with two input fields: "WaistRadiusX" and "WaistRadiusY", both set to "1 mm". At the bottom of the dialog are buttons for "Default Parameter", "Ok", "Cancel", and "Help".

Annotations and arrows point to various parts of the interface:

- A blue arrow points from the text "Configure the spectral make-up of the source independently in the Spectral Parameters tab" to the "Spectral Parameters" tab.
- A blue arrow points from the text "Modify your snippet by clicking on Edit" to the "Edit" button.
- A blue arrow points from the text "You can modify the value of the global parameters you defined here" to the "WaistRadiusX" and "WaistRadiusY" input fields.
- A red arrow points from the "Ok" button to a window titled "17: Camera Detector #600 after Fundamental Gaussian beam at waist (custom) #0 (-) ...". This window displays a "Chromatic Fields Set" plot with a green Gaussian beam centered at the origin of an X-Y coordinate system (both axes ranging from -3 to 3 mm).
- A red arrow points from the "Help" button in the dialog to a "Snippet Help" window. This window contains the following information:
Fundamental Gaussian Field
Version: 1.0
Last Modified: Sunday, May 20, 2018
This Programmable Light Source generates a fundamental Gaussian beam at its waist.

PARAMETER	DESCRIPTION
WaistRadiusX	Waist radius along x axis.
WaistRadiusY	Waist radius along y axis.

Test the Code!

Main Function (Height Profile)

```
double realPart = 1.0;
double imaginaryPart = 0.0;

double ux = Math.Exp(-Math.Pow(x / WaistRadiusX, 2.0));
double uy = Math.Exp(-Math.Pow(y / WaistRadiusY, 2.0));

realPart = ux * uy;

return new Complex(realPart, imaginaryPart);
```

Document Information

title	How to Work with the Programmable Light Source in VirtualLab Fusion and Example (Gaussian Beam)
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toolbox(es)	Starter Toolbox
VL version used for simulations	7.4.0.49
category	Feature Use Case
further reading	<ul style="list-style-type: none">- Customizable Help for Programmable Elements- Programmable Light Source, Function, Interface and Medium- Programming Radially & Azimuthally Polarized Sources