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software solutions for the product development

Paper #009-1

LucidShape Interactive Ray Trace

Abstract

A powerful tool to investigate the behavior of reflectors and lenses is the visualization of light rays traveling through the scene. In LucidStudio one can interactively "touch" the shapes and watch ray bundles come from a source and bounce via the touch point through the whole scene until they hit an absorber or launch to infinity. Within LucidStudio's interactive ray path trace, the user can create single rays or ray bundles of various kinds. LucidShape also offers the possibility to visualize filament images in the light screen view or wavefront images in the Geo view.

The following different kinds of illustration exist:

- single ray paths or ray bundles can be displayed or frozen in the geometry view,
- filament images can be displayed or frozen in the light screen view,
- wavefront images can be enabled, disabled or frozen.

Within the appropriate dialog boxes, the user can change different ray trace properties.

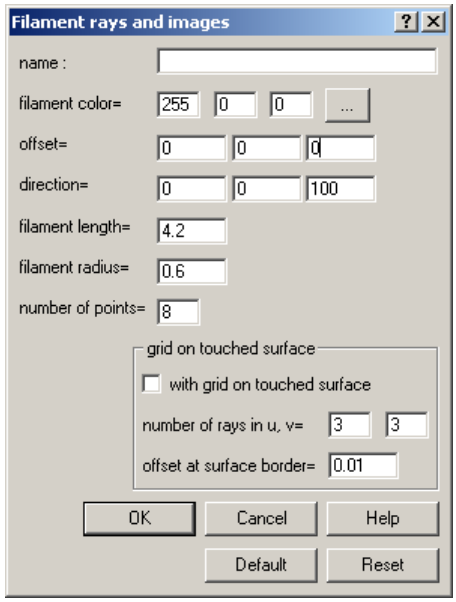
Principle and Intention

The basic concept or principle of interactive ray trace is to create a start and a touch point. The touch point is created while interactive ray trace is performed. Subsequently, the touch point can be moved over the optical device to be examined. The main purposes are to generate ray bundles and to test the behavior of optical surfaces.

The ray trace analysis and creation can be performed with different ray bundles. LucidShape interactive ray trace consists of following ray bundle types:

- Single Ray Bundles
- Cylinder Filament Bundles
- Free Surface Filament Bundles
- Cone Bundles
- Parallel Bundle
- Grid on Target Bundle
- Point Set Bundle
- Parallel on Normal Bundle
- Ray File Bundle

These ray bundles can be used to investigate lens or reflector properties for a wide range of applications. Each time a ray bundle type is chosen, a specific dialog box containing the bundle's parameters and options will be launched. Below, the "Cylinder Filament Bundle" dialog box is shown for example.



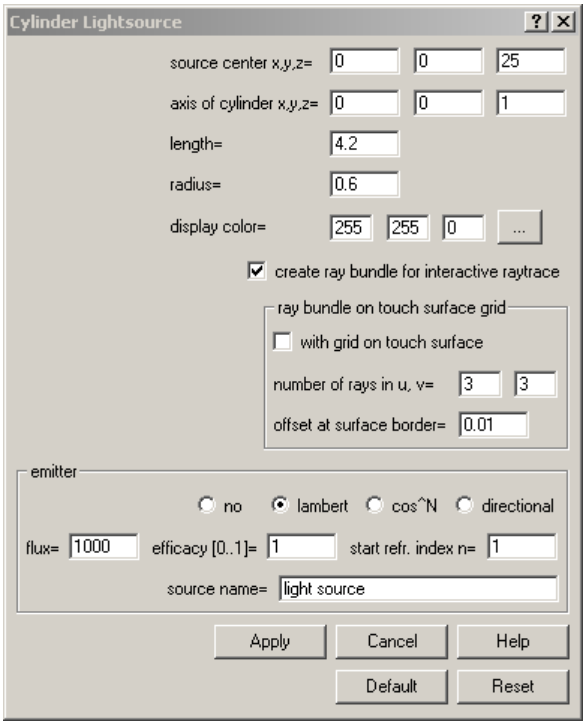
The "Cylinder Filament Bundle" dialog box

Creation of Ray Bundles

Within **Lucid**Shape there are three different ways to create ray bundles:

1. by using the "interactive ray trace" dialog box
2. by using the "create light source" dialog box
3. by using a script.

If using the "Create Light Source Dialog" box, one has to enable the flag "create ray bundle for interactive ray trace".

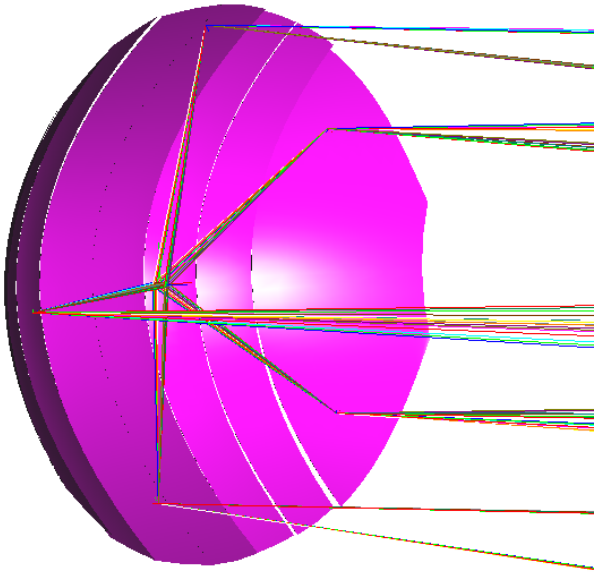


The create light source dialog box.

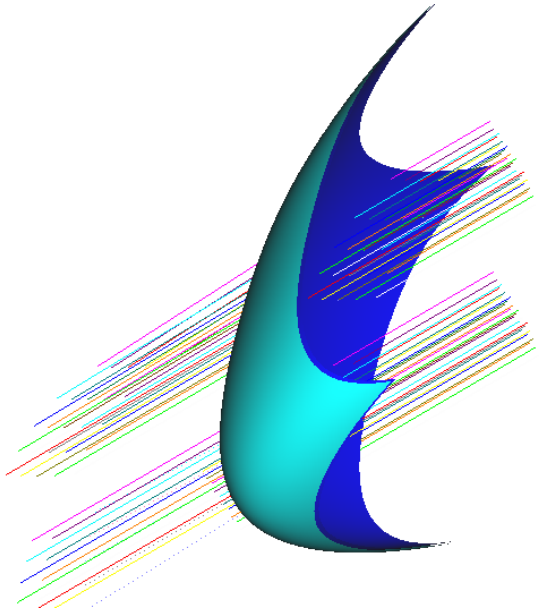
By checking the flag "with grid on touched surface", one can build a point grid over the target's surface.

Interactive Ray Trace Applications

In addition, different samples of interactive ray trace can be launched from the tasks menu item "Test Interactive Ray Trace". In each of these applications, one special ray bundle is created. By interactively touching over of the surface one can see the optical properties of individual parts of the optics.



The "Cylinder Filament" application with ray bundles

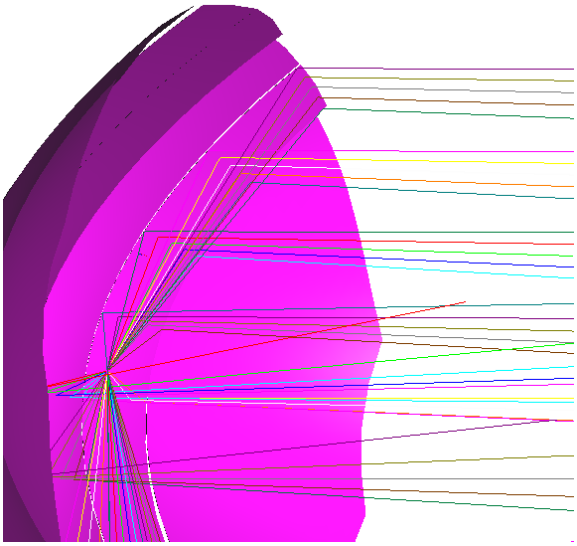


Parallel bundle with free form lens

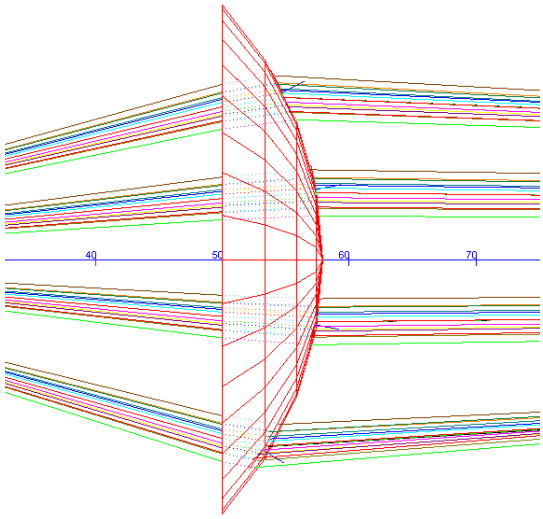
In this paper, only a few examples are described. For a more detailed discussion of the individual examples, see the Lucid Shape's application book.

Interaction

Ray paths in the 3D view and filament images in the light screen view are both displayed by pressing the CTRL-key and the left mouse button simultaneously. By holding the CTRL-key and double clicking the left mouse button, one may freeze the ray paths, the filament and the wavefront images.



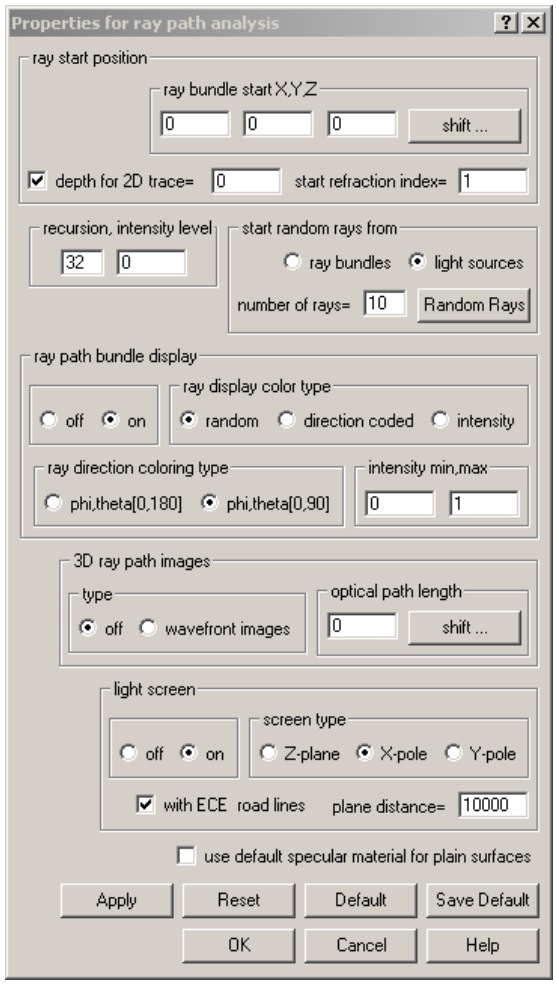
Frozen ray paths in the GEO view.



Side view of a spherical lens with ray bundles. Dots indicate that the rays are inside the medium.

Ray Analysis Properties

This dialog sets the general properties for ray path analysis and interactive ray trace. The dialog box is shown below.

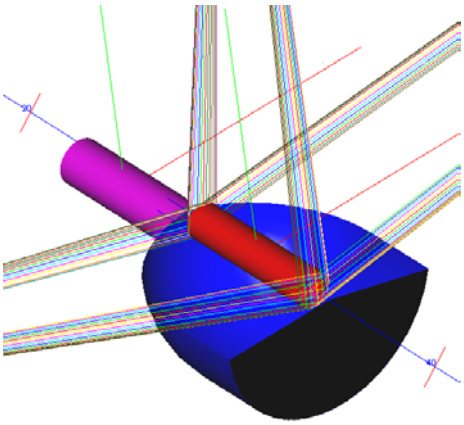


The ray analysis properties dialog box

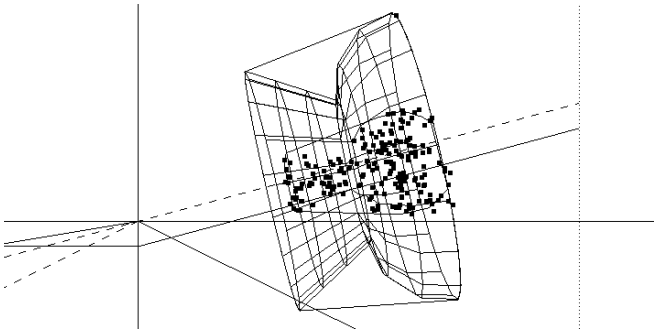
With this dialog box one can control the ray bundle properties. For instance, one can set the start position, enable or disable ray bundles, or control the display of wavefront images. In addition the screen type, either X-pole, Y-pole, or Z-plane, may be set here. The X-pole and the Y-pole view corresponds to the angular range, while the Z-plane corresponds to the plane orthogonal to the optical axis. The parallel ray bundle of course has no start position.

Ray Bundle from MF Object

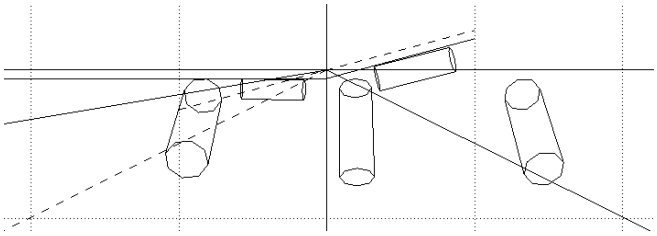
Ray bundles can be created from any free form filament light source or by using a Macro Focal (MF) object, the latter also allows the verification of MF objects. Below, one can find an example for interactive ray trace analysis with a ray bundle using a MF object. In this case, the emitter consists of an automotive H4 bulb with a shielding cup. For a detailed discussion of the MF concept, see the white paper **Lucid**Shape Macro Focal Surfaces.



H4 filament with cap along with ray bundles.



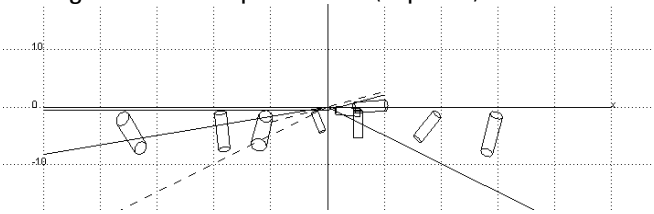
The filament image from a side emitter. The ray bundle is taken from a ray file. Within the side emitter, one can see the convex hull, which is the silhouette of the light source seen from the reflector point.



Filament images from a low beam H4 filament. One cylinder is **placed below the 15° line,** indicating **the asymmetric light distribution for an ECE low beam.** Please note **the cutoff of the cylinder images at the horizontal and the 15° cutoff line.**

Filament Images

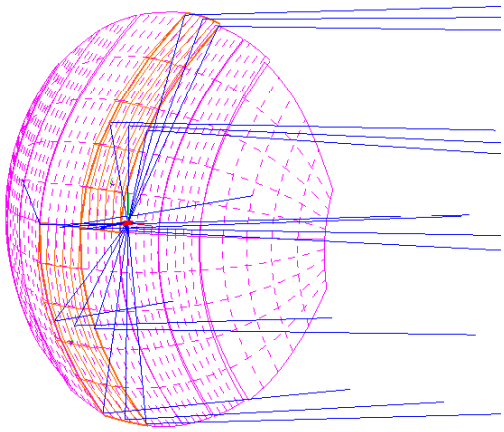
Filament images can be displayed and investigated in the light screen view. By holding the CTRL-key and double clicking the left mouse button, one may freeze the filament images. This type of presentation is a very powerful tool in order to investigate different parts of the reflector in detail. Orientation, magnification and location of the filament images in the light screen view give valuable hints to improve the reflector's optical properties. The filament images can be shown either in an angular range (X-, Y-pole) or on a plane orthogonal to the optical axis (Z-plane).



The filament images of a cylinder in the light screen view. The individual cylinder represent the filament images for different surface points of the reflector.

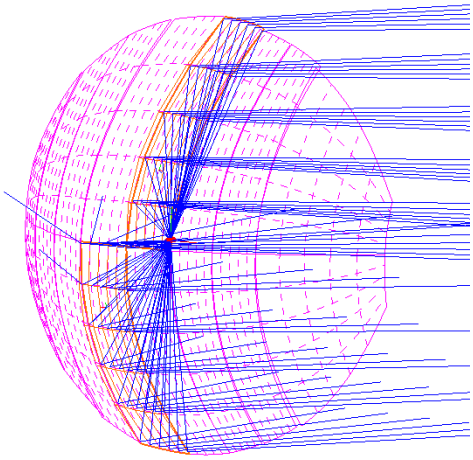
Grid on Target

LucidShape enables the creation of a point grid over a target's surface. During this process, each grid point is used as a target.



An example for grid on target

In the above example, a grid has been created for two reflector facets, one for an upper and one for a lower facet. These two facets are highlighted in red. The grid consists of 3x3 points.



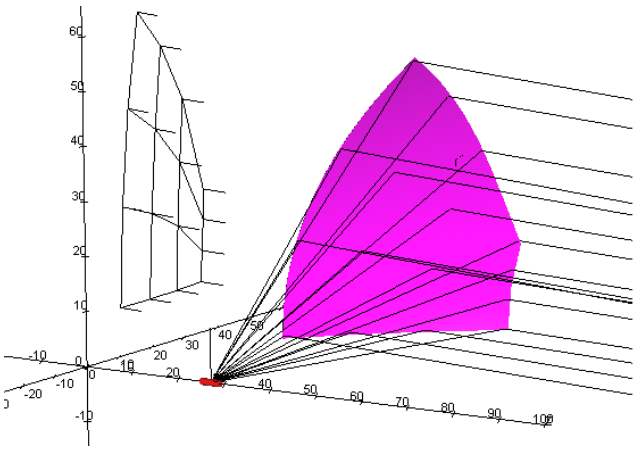
The same as above, but a grid of 6x6 points is created for each facet.

Wavefront Analysis

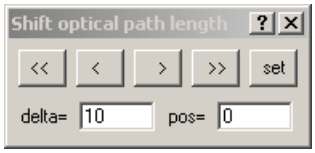
LucidShape offers the possibility to visualize and analyze wavefronts. Recall, a wavefront is an imaginary or virtual surface consisting of all points in space that a wave reaches at the same time. Wavefront analysis enables the studying of geometrical distortion of rays.

The dialog "Properties for ray path analyzing" enables or disables wavefront images. One can simply switch the type flag in the 3D ray path images between "off" and "wavefront images". Remember, this dialog can be accessed via the right mouse button or from the menu item "Options" in the Geo view.

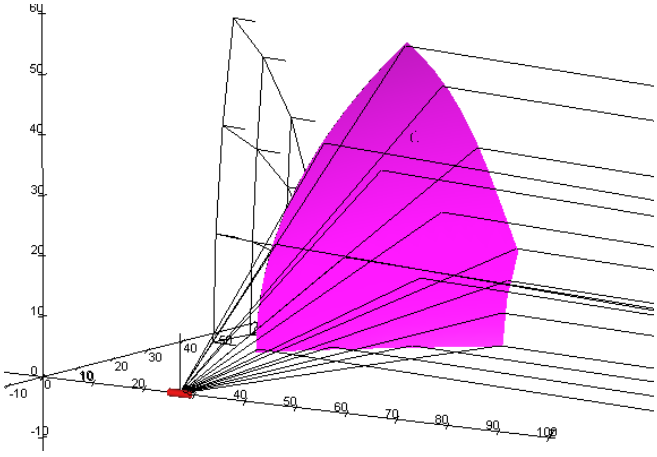
The wavefront image can be shifted with the dialog box "Shift optical path length".



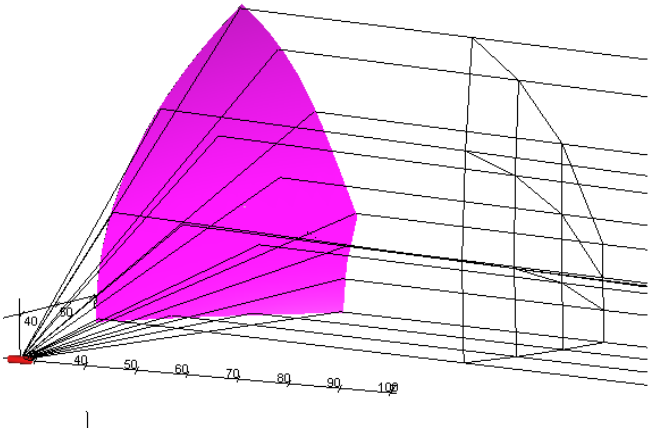
Part of a reflector in the GEO view along with light rays. The wavefront image can be seen in a 4x4 point grid in the left part.



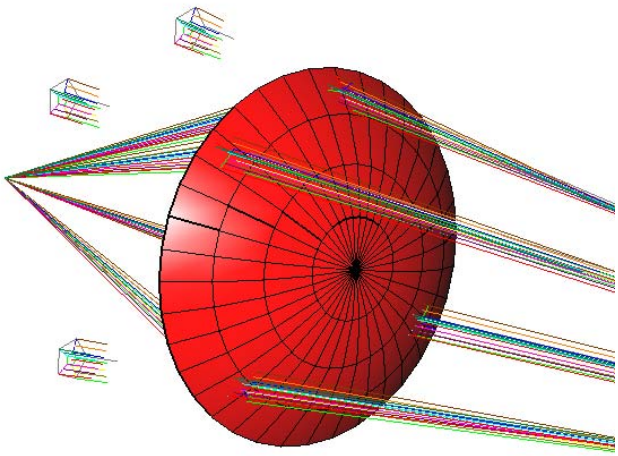
The dialog box "Shift optical path length"



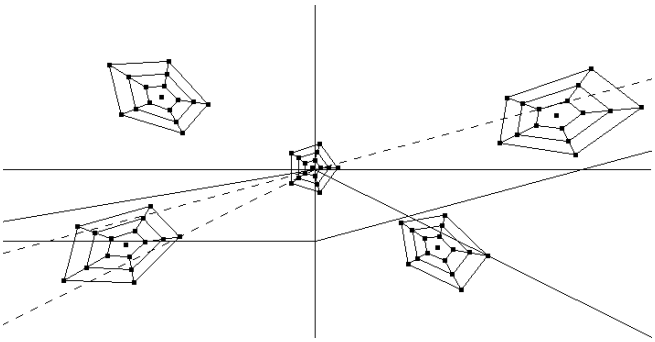
The same as before, but with a different wavefront position.



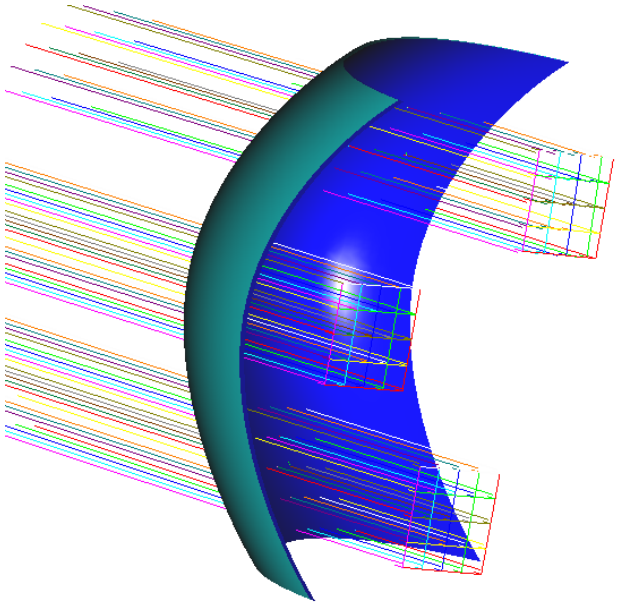
In this example, the wavefront image is shifted again and is now located in front of the reflector.



Wavefront images from a spherical lens and ray bundles.



The filament images in light screen view from the example above. The view is largely magnified in order to make the ray deviation (caused by the lens) visible.



Free form lens with parallel ray bundles and wavefront images. The regular shape of the wavefront images indicate that the ray bundles are parallel.

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