# FlexiShaper adjustable beam shaping for laser welding

# Modelling and analysis in physical optics using ZEMAX OpticStudio software

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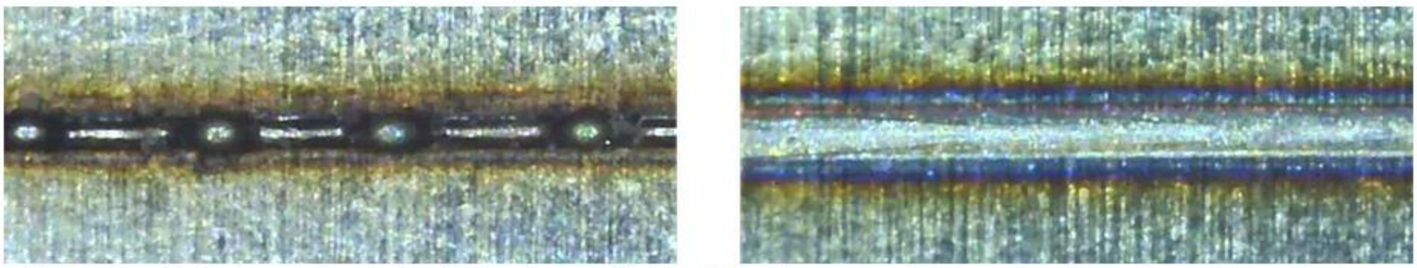
**HOLO/OR**

Keywords: Laser Welding, Adjustable beam shaping, Ring Spot shape



*Foil welding with single mode laser: Left - with Gaussian spot ; Right - with Flexishaper concentric ring and spot beam shaper. Both welds at same power and speed , courtesy of BLACKBIRD*

## Download link: FlexiShaper simulation with ideal focusing lens

## Abstract

In this simulation tutorial, we show an effective method to simulate and to analyze FlexiShaper performance using physical optics methods such as Physical Optics Propagation (POP), and Huygens PSF in ZEMAX OpticStudio software. The Huygens method works even when there are BlackBox files on the optical path.

Such a model is helpful in integrating FlexiShaper solution with laser welding setups having additional optical and mechanical subsystems such as scanners, and F-Theta lenses.

Holo/Or offers this open simulation model of the FlexiShaper for its customers as a part of technical support. Custom models are also available- just contact us.

**Background: The FlexiShaper solution**

The operating principle of FlexiShaper was introduced by HOLO/OR in a PhotonicsViews article on May 2021 https://onlinelibrary.wiley.com/doi/epdf/10.1002/phvs.202100046

*"High laser welding speed can be achieved by using a ring and central spot laser illumination profile, with an adjustable ratio of the ring energy to the spot enabling optimization of the process. We present a novel and simple diffractive-based concept to achieve such adjustable shaping for standard fiber lasers. The module is rotation-adjustable between 100% energy in the central spot to no energy in the central spot,*

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*can work with both single-mode and multimode lasers, is highly compact (less than 20mm long) and has the high LDT of passive diffractive components. This concept obviates the need for special ring-type fiber lasers, enabling simpler design of the welding laser head".*

More information about FlexiShapers including Specifications, laser welding process results, and list of Standard products are presented in the FlexisShaper product page.

Figure 1 shows the laser beam intensity distribution for different rotation adjustment positions between the FlexiShaper DOE when using a multimode input.

Figure 2 shows a typical industrial laser welding optical setup for single mode laser including FlexiShaper module and F-Theta scanner.

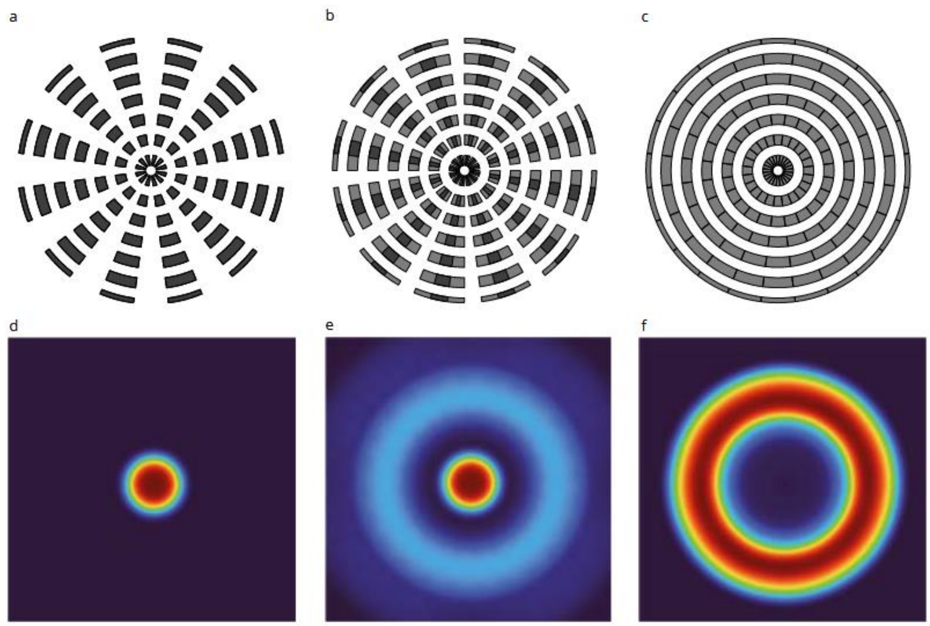


*Figure 1. Upper line shows relative rotation positions between the DOE of Flexishaper. Lower line shows the corresponding intensity distribution*

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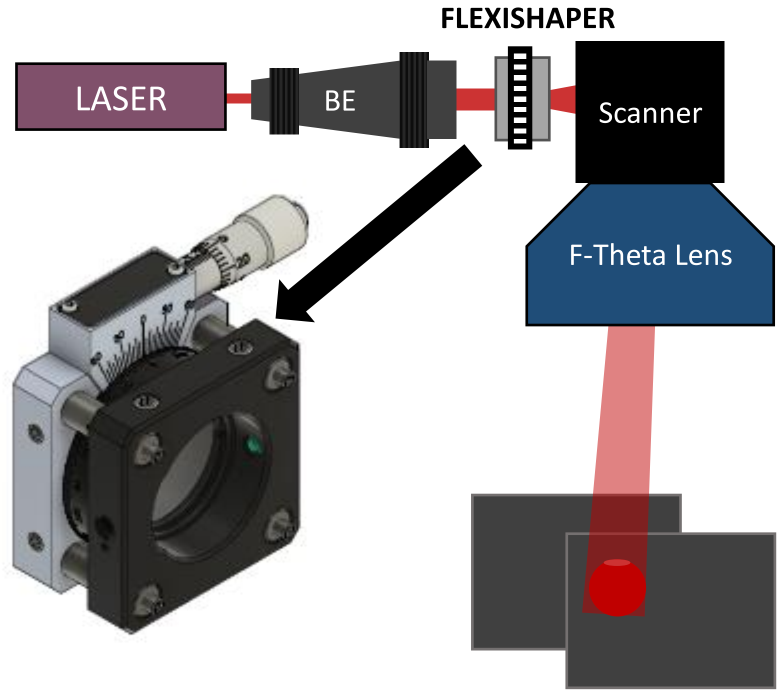


*Figure 2. Layout of a FlexiShaper module typical setup with F-Theta Scanner. Shown in the smaller picture – a FlexiShaper module integrated using standard opto-mechanics.*

## Flexishaper simulation example

As example, we choose a standard flexishpaer DOE CU-386-1-Y-A for nominal wavelength 1070 nm. It has full range of adjustability in a rotation of 15 degrees.

Simulation parameters are:

- Input beam: wavelength: 1070nm, size 5 mm, Gaussian, $M^2 = 1$.
- Spherical PLCX Fused Silica lens with EFL 300 mm
- CU386 (x2) FlexiShaper Fused Silica DOE Dia. 25.4 mm, CT 3 mm
- Ring diameter at focus (peak to peak) 600 um
- Central spot diameter at exp(-2) 82 um

Modeled system layout shown in figure 3. First two elements are FlexiShaper DOEs followed by the focusing lens.9

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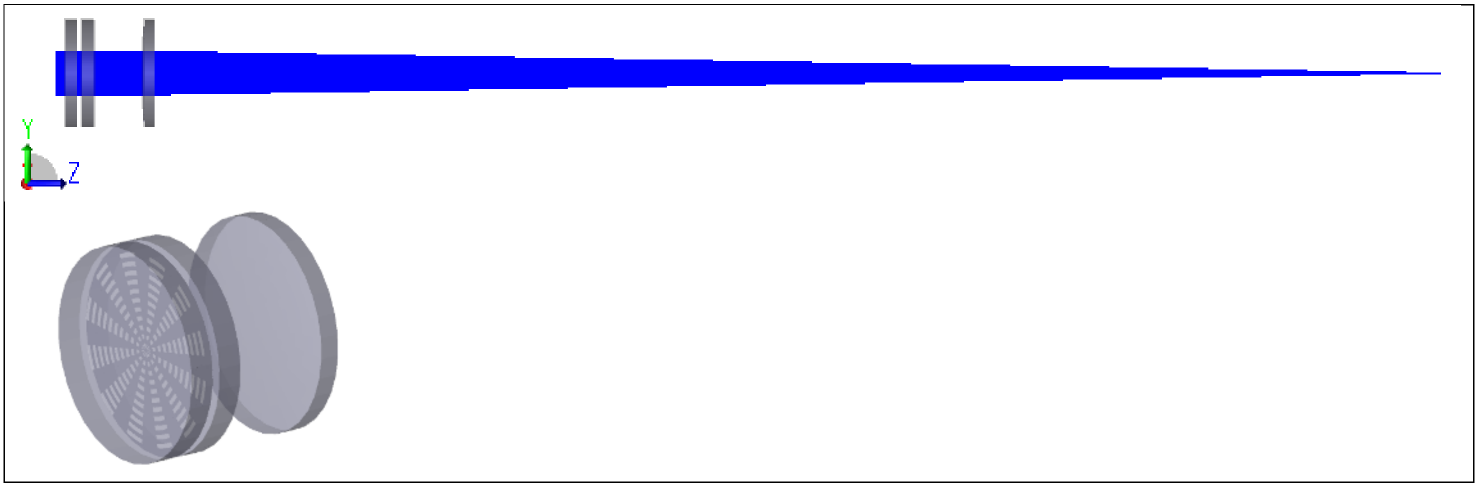


*Figure 3.Simulated system layout of FlexiShaper with zoom on optical elements.*

To Simulate a FlexiShaper in ZEMAX we used a hybrid model combining sequential and non-sequential modes. Binary DOE are modeled as POB (Polygon Objects) and defined in non-sequential editor. Sequential mode is used for coherent waves analysis, which is not available in non-sequential.

First, we start by defining the standard properties of Gaussian beam size (5mm) and wavelength (1070nm).

Following this, in surface 2 we define a non-Sequential component and after that place a standard spherical lens. Lens Data editor of sequential mode shown in figure 4. Additional parameter to care about is exit location of the Non-Sequential component.

Lens Data × | Non-Sequential Component Editor: Component Group on Surface 2 Config 4/4

Update: All Windows ▾

Surface 0 Properties

| | Surface Type | Comment | Radius | | Thickness | | Material | | Coating | | Clear Semi-Dia | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | Standard | | Infinity | | Infinity | | | | | | 0.000 | |
| 1 | Standard | | Infinity | | 2.000 | | | | | | 5.000 | |
| 2 | Non-Sequential Component | flexiShaper | Infinity | | - | | | | | | 5.000 | |
| 3 | Standard | | Infinity | | 10.000 | | | | | | 12.700 | U |
| 4 | Standard | | 135.000 | | 3.000 | | F_SILICA | | | | 12.700 | U |
| 5 | Standard | | Infinity | | 300.000 | | | | | | 12.700 | U |
| 6 | Standard | | Infinity | | - | | | | | | 0.032 | |

*Figure 4 Print screen of sequential mode Lens Data Editor*

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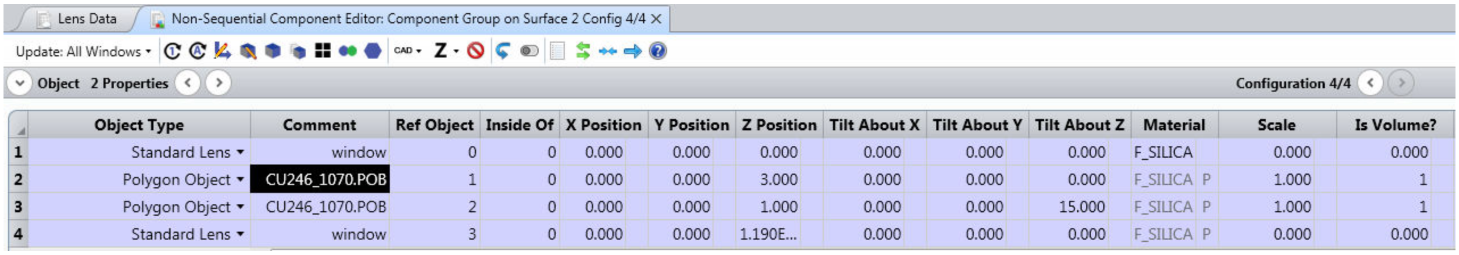
In the Non-Sequential data editor (see figure 5) we define the FlexiShaper. The FlexiShaper consists of two identical DOEs, manufactured on windows with diameter 25.4 mm and central thickness 3 mm made of Fused Silica. Windows are defined by a standard lens object with infinity radius. A Binary (two levels) diffractive pattern is created using polygons and saved as POB file in the dedicated ZEMAX folder for polygon objects.




| | Object Type | Comment | Ref Object | Inside Of | X Position | Y Position | Z Position | Tilt About X | Tilt About Y | Tilt About Z | Material | Scale | Is Volume? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Standard Lens | window | 0 | 0 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | F_SILICA | 0.000 | 0.000 |
| 2 | Polygon Object | CU246_1070.POB | 1 | 0 | 0.000 | 0.000 | 3.000 | 0.000 | 0.000 | 0.000 | F_SILICA P | 1.000 | 1 |
| 3 | Polygon Object | CU246_1070.POB | 2 | 0 | 0.000 | 0.000 | 1.000 | 0.000 | 0.000 | 15.000 | F_SILICA P | 1.000 | 1 |
| 4 | Standard Lens | window | 3 | 0 | 0.000 | 0.000 | 1.190E... | 0.000 | 0.000 | 0.000 | F_SILICA P | 0.000 | 0.000 |

*Figure 5 Print screen of Non-Sequential Component Editor*

The ratio between power in the ring and the spot can be controlled manually by manipulating the Tilt About Z value in object 3 on NSC Editor or by defining a Multi-Configuration Editor as demonstrated in Figure 6.

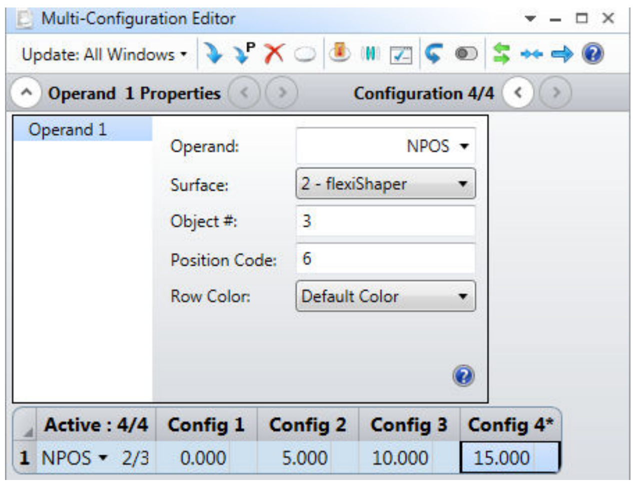



*Figure 6. Print screen of Multi-Configurarion Editor with parameter of Tilt About Z (rotation) to control Ring Spot power relation*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## 2.Analysis

Performance analysis can be performed by different methods that includes coherent properties of the laser. We used POP and Huygens PSF methods. Huygens PSF is a more universal method that will work even with BlackBoxes on optical path for example with F-Theta scanner setup. Geometrical rays tracing does not work. In figure 7 we show the intensity distribution in different adjustment positions.

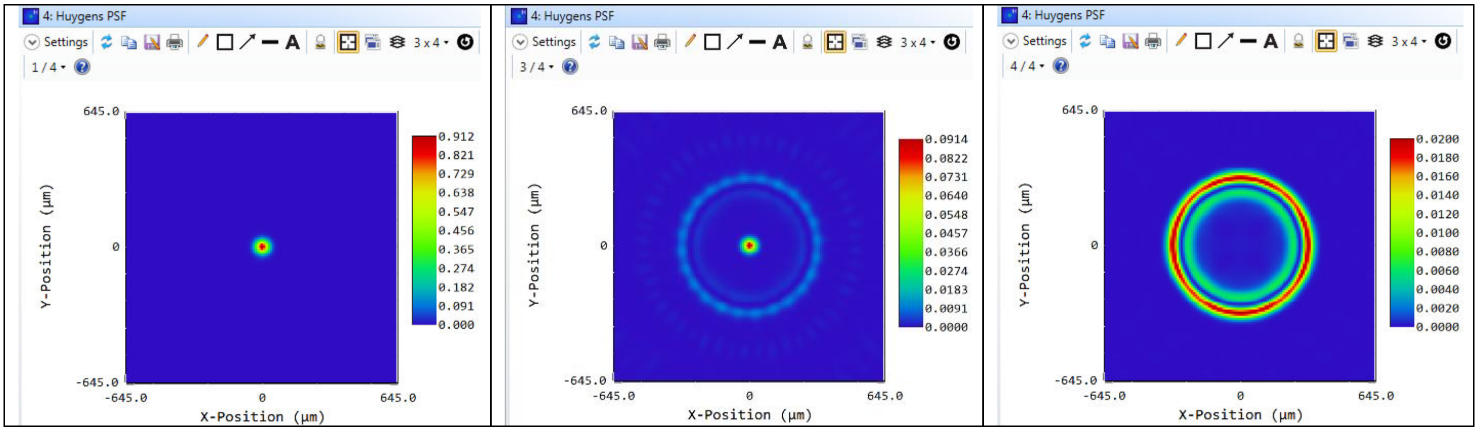


*Figure 7. Intensity distribution for different adjustment positions shows variation between ring and spot power for laser welding.*

## 3.Summary

Holo/Or has developed an effective simulation tool for a FlexiShaper system. You are welcome to contact us for more details, help in design, and an offer for the various DOE components for your laser welding application.