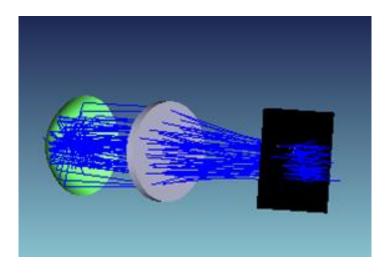


Lectures Notes on Optical Design using Zemax OpticStudio

Lecture 19 Non-Sequential Mode in Zemax 1



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### Content

- 1. Introduction
- 2. Sequential/Non-Sequential Modes
- 3. Some NSC Applications

# Introduction

There are 2 distinct ray-tracing modes in Zemax (OpticStudio)

- Sequential
- Non-sequential

In addition, a **hybrid mode** exists in which sequential and non-sequential ray-trace are used in the same system.

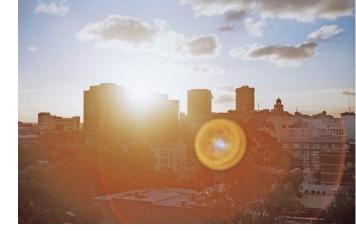
In this lecture, we will see some basic applications of Non-squential ray tracing in Zemax.

# **Sequential Mode**

- It is mainly used for designing <u>imaging and afocal systems</u>.
- Surfaces are defined in the Lens Data Editor.
- Ray can only intersect <u>each surface once</u> and has to do it in a specified -sequential- order (i.e. surface #0 then #1 ,#2 ...) and hence the name sequential ray tracing.
- Ray can only <u>reflect</u> if the surface material type is MIRROR. Partial reflections from refractive surfaces (Fresnel reflections) are accounted for to the extent of calculating the correct refracted energy, including the effects on dielectric or metallic mirrors.
- <u>Each surface has its own local coordinate system</u>. The position of each surface along the optical axis is referenced to the previous surface. In other words, the "Thickness" column in the Lens Data Editor refers to the distance from current surface and not from a global reference point.

# **Non-sequential Mode**

- It is primarily used for <u>non-imaging applications</u> such as illumination systems and/or stray-light analysis.
- Surfaces or volume objects are defined in the <u>Non-Sequential Component Editor</u>



Stray ray example

- Mechanical components may be easily imported from CAD programs, so that full Opto-Mechanical analysis may be undertaken.
- A ray can intersect the same object more than once and can intersect multiple objects in any order; hence the name non-sequential.
- Each object is referenced to a <u>global coordinate</u>, unless specified otherwise.
- Imaging-system properties such as stop location, entrance and exit pupil, field, system aperture etc. that exist in sequential systems may not be <u>meaningful</u> in non-sequential systems.
- The main analysis feature in non-sequential mode is the <u>detector ray-trace</u>, which gives spatial and angular data on incoherent or coherent rays.

## **Example 1:** How to add standart lens

|     | Object Type         | Comment | Ref Object | Inside Of | X Position | Y Position | Z Position | Tilt About X | Tilt About Y | Tilt About Z | Material | X Half Width | Y Half Width | # X Pixels | # Y Pixels | Data Type | Color   |
|-----|---------------------|---------|------------|-----------|------------|------------|------------|--------------|--------------|--------------|----------|--------------|--------------|------------|------------|-----------|---------|
| 1   | Source Ellipse 🔻    |         | 0          | 0         | 0.000      | 0.000      | 0.000      | 0.000        | 0.000        | 0.000        | -        | 20           | 1E+05        | 1.000      | 0          | 0         | 12.000  |
| 2   | Standard Lens 🔻     |         | 0          | 0         | 0.000      | 0.000      | 20.000     | 0.000        | 0.000        | 0.000        | BK7      | 100.000      | 0.000        | 20.000     | 20.000     | 6.000     | -80.000 |
| 3 D | etector Rectangle 🔻 |         | 0          | 0         | 0.000      | 0.000      | 120.000 V  | 0.000        | 0.000        | 0.000        |          | 20.000       | 20.000       | 100        | 100        | 0         | 3       |
|     |                     | 1       |            |           |            |            |            |              |              |              |          |              |              |            |            |           |         |

#### \*\*\* Object1

| Source Ellipse                |     |  |  |  |  |  |  |
|-------------------------------|-----|--|--|--|--|--|--|
| <pre># of Layout Rays</pre>   | 20  |  |  |  |  |  |  |
| <pre># of Analysis Rays</pre> | 1e5 |  |  |  |  |  |  |
| X Half Width                  | 12  |  |  |  |  |  |  |
| Y Half Width                  | 12  |  |  |  |  |  |  |
| *** Object2                   |     |  |  |  |  |  |  |
| Standart Lens                 |     |  |  |  |  |  |  |
| Z position                    | 20  |  |  |  |  |  |  |

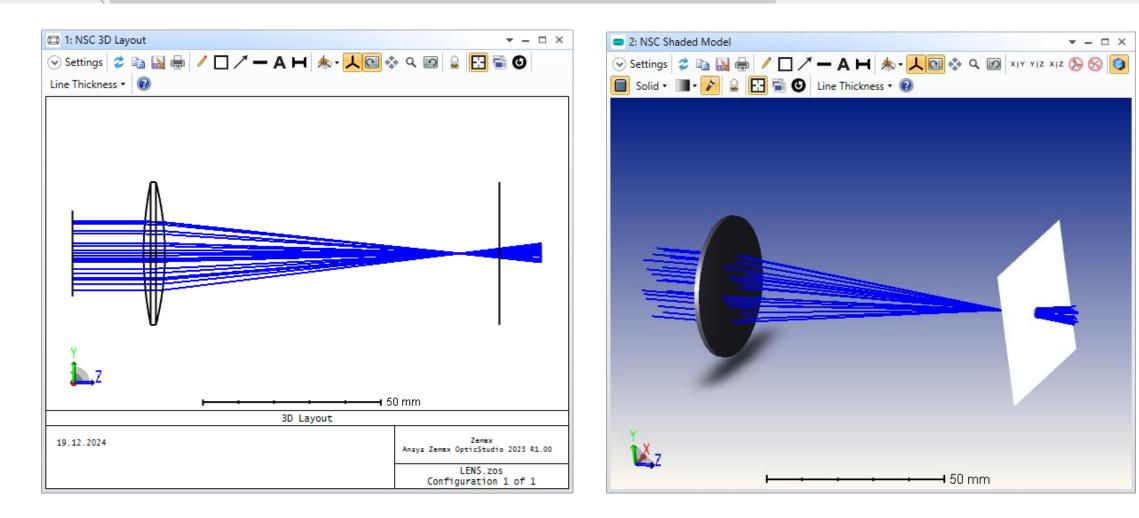
| —              |     |
|----------------|-----|
| Material       | BK7 |
| Radius1        | 100 |
| Thickness      | 6   |
| Clear1 = Edge1 | 20  |
| Radius2        | -80 |
| Clear2 = Edge2 | 20  |
|                |     |

#### \*\*\* Object3

| Detector          | Rect                               |
|-------------------|------------------------------------|
| Z position        | 120                                |
| Material          | Blank (or can be ABSORB or MIRROR) |
| X Half Width      | 20                                 |
| Y Half Width      | 20                                 |
| <b>#</b> X Pixels | 200                                |
| <b>#</b> Y Pixels | 200                                |
| Color             | 3 (detector displays false color)  |
|                   |                                    |

### **Example 1:** Layout

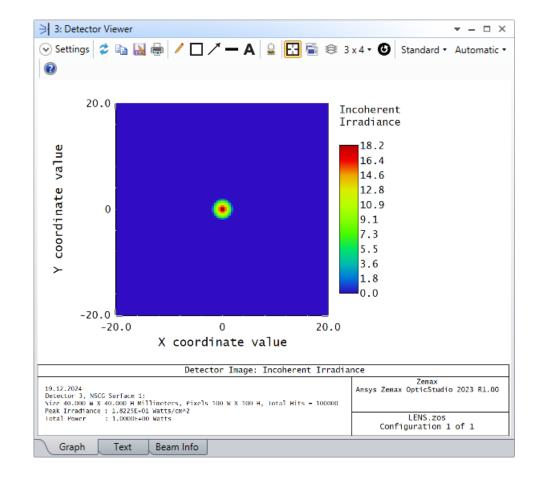
|   | Object Type          | Comment | Ref Object | Inside Of | X Position | Y Position | Z Position | Tilt About X | Tilt About Y | Tilt About Z | Material | X Half Width | Y Half Width | # X Pixels | # Y Pixels | Data Type | Color   |
|---|----------------------|---------|------------|-----------|------------|------------|------------|--------------|--------------|--------------|----------|--------------|--------------|------------|------------|-----------|---------|
| 1 | Source Ellipse 🔻     |         | 0          | 0         | 0.000      | 0.000      | 0.000      | 0.000        | 0.000        | 0.000        | -        | 20           | 1E+05        | 1.000      | 0          | 0         | 12.000  |
| 2 | Standard Lens •      |         | 0          | 0         | 0.000      | 0.000      | 20.000     | 0.000        | 0.000        | 0.000        | BK7      | 100.000      | 0.000        | 20.000     | 20.000     | 6.000     | -80.000 |
| 3 | Detector Rectangle 🔹 |         | 0          | 0         | 0.000      | 0.000      | 120.000 V  | 0.000        | 0.000        | 0.000        |          | 20.000       | 20.000       | 100        | 100        | 0         | 3       |
|   |                      | 1       |            |           |            |            |            |              |              |              |          |              |              |            |            |           |         |



# **Example 1:** Ray Tracing



| Ray Trace Control |         |         | —            |              |     |
|-------------------|---------|---------|--------------|--------------|-----|
| Clear Detectors   |         |         |              | All ~        |     |
| Clear & Trace     |         |         | Trace        |              |     |
| ✓ Auto Update     |         | # of Co | res:         | 4            | ~   |
| Use Polarization  |         | 🗸 Igno  | re Errors    |              |     |
| Split NSC Rays    |         | Scat    | ter NSC Rays |              |     |
| Save Rays:        | LENS.ZR | )       |              |              |     |
| Save Path Data    | LENS.PA | -       |              |              |     |
| ZRD Format:       |         |         | Compresse    | ed Full Data | a ~ |
| Filter:           |         |         |              |              |     |
| ldle              |         |         |              |              |     |
|                   |         |         |              |              |     |
|                   |         |         |              |              |     |
| Terminate         | Exi     | it      | ] 🕡          |              |     |



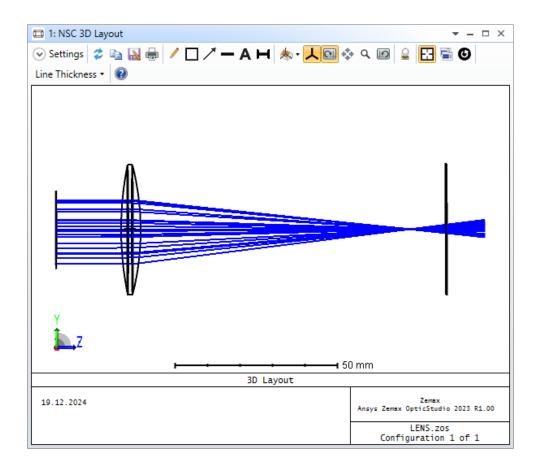
## **Example 1: Optimization**

The aim is to put detector at a location where we have minimum rms spot size

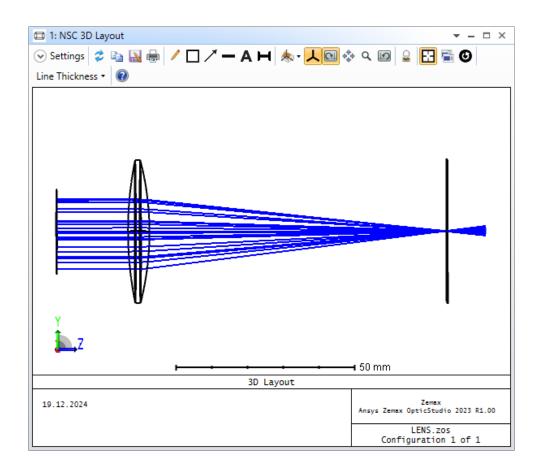
| Clear detector           | 🐻 Merit Function Editor 🗢 – 🗆 🗙                                                                                                               |                                                        |             |          |                  |      |                                                    |                            |       |        |             |       |           |
|--------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------|-------------|----------|------------------|------|----------------------------------------------------|----------------------------|-------|--------|-------------|-------|-----------|
| Clear delector           | $\Rightarrow \square \bigcirc \mathbin{\blacktriangleright} \times \times   \And \bullet \odot   \Leftrightarrow \bullet \Rightarrow \oslash$ |                                                        |             |          |                  |      |                                                    |                            |       |        |             |       |           |
|                          | $\odot$                                                                                                                                       | Wizards and Operands () Merit Function: 1.130933963650 |             |          |                  |      |                                                    |                            |       |        | 5 <b>86</b> |       |           |
|                          |                                                                                                                                               | Туре                                                   | Surf        | Det#     | Pix#             | Data | # Ignored                                          | Spatial Frequency          |       | Target | Weight      | Value | % Contrib |
|                          | 1                                                                                                                                             | NSDD - 1                                               | l           | 0        | 0                | 0    | 0                                                  | 0.000                      |       | 0.000  | 0.000       | 0.000 | 0.000     |
| Start ray tracing        | 2                                                                                                                                             | NSTR - 1                                               | 1           | 0        | 0                | 0    | 0                                                  | 0.000                      |       | 0.000  | 0.000       | 0.000 | 0.000     |
|                          | 3                                                                                                                                             | NSDD 🔻 1                                               | l           | 3        | -9               | 0    | 0                                                  | 0.000                      |       | 0.000  | 1.000       | 1.131 | 100.000   |
| Obtain minimum spot size |                                                                                                                                               |                                                        |             |          |                  |      |                                                    |                            |       |        |             |       |           |
|                          | Loc                                                                                                                                           | cal Optimiza                                           | tion        |          |                  |      |                                                    | —                          |       | ×      |             |       |           |
|                          | T<br>V                                                                                                                                        | Algorithm:<br>Fargets:<br>/ariables:<br>nitial Merit F |             |          | nal Desce<br>964 |      | # of Cores:<br>Cycles:<br>Status:<br>Execution Tin | 4 ~<br>Automatic ~<br>Idle |       |        |             |       |           |
|                          | c                                                                                                                                             | Current Meri                                           | t Function: | 1.130933 | 964              |      |                                                    |                            |       |        |             |       |           |
|                          |                                                                                                                                               | Auto Upd                                               | ate Star    | rt       | Stop             |      | Exit                                               | Save Load                  | Reset | t 🕜    |             |       |           |

### **Example 1: Results**

### Z Position of detector = 120 mm Before optimization



Z Position of detector = 108. 7 mm After optimization

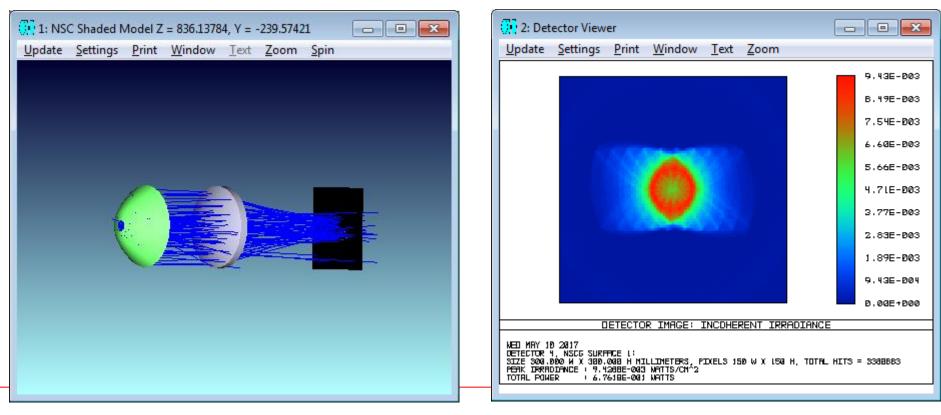


### **Example 2:** Mirror-Lens-Detector

We will make a non-sequential system with

- > a filament source
- > a parabolic reflector
- > a plano-convex lens
- > a rectangular detector

as shown in the layout below:



#### \*\*\* Object1

Standart Surface

| Material | Mirror                            |  |  |  |  |  |  |  |
|----------|-----------------------------------|--|--|--|--|--|--|--|
| Radius   | 100                               |  |  |  |  |  |  |  |
| Conic    | -1 (parabola)                     |  |  |  |  |  |  |  |
| Max Aper | 150                               |  |  |  |  |  |  |  |
| Min Aper | 20 (center hole in the reflector) |  |  |  |  |  |  |  |

### \*\*\* Object2

| Source Filament        |                                       |
|------------------------|---------------------------------------|
| Z position             | 50 (focus of the parabolic reflector) |
| <b>#</b> Layout Rays   | 20                                    |
| <b># Analysis Rays</b> | 5e6                                   |
| Length                 | 20                                    |
| Radius                 | 5                                     |
| Turns                  | 10                                    |
| Tilt about Y           | 90 (deg)                              |
| X position             | -10 (mm)                              |

#### \*\*\* Object4

Standard Lens

| Ref Object | 3 (before detector) |
|------------|---------------------|
| Z Position | 200                 |
| Material   | N-BK7               |
| Radius 1   | 300                 |
| Clear 1    | 150                 |
| Edge 1     | 150                 |
| Thickness  | 70                  |
| Clear 2    | 150                 |
| Edge 2     | 150 n               |

#### \*\*\* Object5 Detector Rect Z position 1000 **Blank** (or can be ABSORB or MIRROR) Material X Half Width 150 Y Half Width 150 # X Pixels 150 # Y Pixels 150 (detector displays inverse greyscale) Color 1

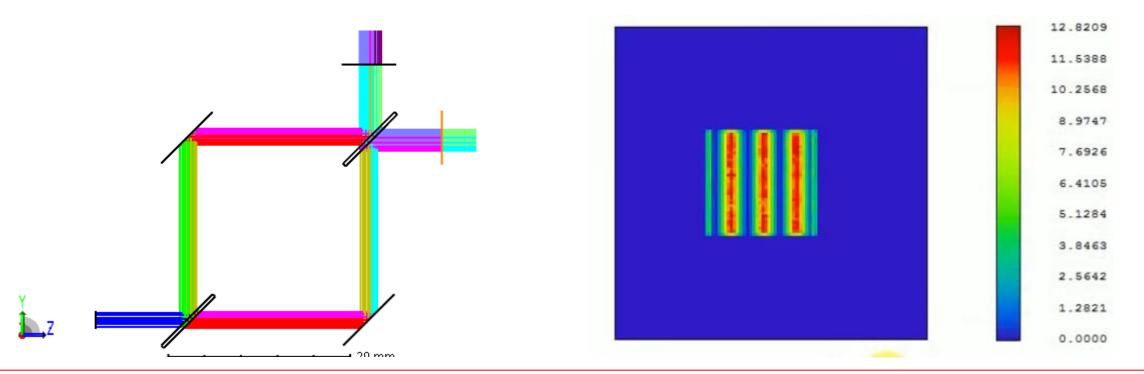
### In the analysis you should use **Detector Viewer** and **Ray Trace** buttons.

| ◙   ੈ ) 🖗 🖬   🔜 🤊 🤻 🗢 🗗 🗗                                                                                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | LENS.ZMX - Zemax OpticStudio 19.8 Professio                                                                   | onal - L105296                                                      |
|--------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------|
| NSC 3D NSC Shaded CAD Part Object Ra                                                                         | ay Lichtning Critical Ray Detector Detector Tools Ray Database Par<br>Trace Tracer Tools Detector Tools Ray Database Par<br>Trace Rays Detectors & Analysis Raytr                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | ilysis Wavelength Analysis  → Data Plot → Lighting race Analysis Polarization Reports Universal Plot  → - □ × | Source Reverse NSC<br>Illumination Map Radiance Sag<br>Applications |
| Environment                                                                                                  | Update: All Windows 🗸 🕐 🚱 🔽 🌑 🕒 🖬 🕶 🌑 🗚 🗸                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |                                                                                                               |                                                                     |
| <ul> <li>Polarization</li> <li>Advanced</li> <li>Material Catalogs</li> <li>Non-Sequential</li> </ul>        | ✓ Object 1 Properties       ✓         > 1: Detector Viewer         ✓ Settings       ✓         ▲       ▲         ▲       ▲         ▲       ▲         ●       ▲         ●       ▲         ●       ▲         ●       ▲         ●       ▲         ●       ▲         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ●         ●       ● <td>Configuration 1/1</td> <td></td> | Configuration 1/1                                                                                             |                                                                     |
| <ul> <li>Named Filters</li> <li>Title/Notes</li> <li>Files</li> <li>Units</li> <li>Cost Estimator</li> </ul> | Invalid input data/                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | Clear Detectors Clear & Trace Auto Update # of t Use Polarization Igr Split NSC Rays Sca Save Rays: LENS.ZRD  | All  Trace Cores: 4  Cores: 4  Compressed Full Data                 |
|                                                                                                              | 0 0.1 0.2 0.3 0.4 0.5 0.6<br>28.05.2020<br>Invalid input data/settings.<br>Graph Text Beam Info                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  | 0.7 0.8 0.9 1.0                                                                                               |                                                                     |

| ZEMAX-EE - 19052 - C:\Users\Ahmet Bingul\Desktop\ZEMAX\NonSequential\ns1.ZMX                                                                                                                                        |                                          |          |                                             |                         |            |            |  |  |  |  |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------|----------|---------------------------------------------|-------------------------|------------|------------|--|--|--|--|
| <u>F</u> ile <u>E</u> ditors <u>S</u> ystem <u>A</u> nalysis <u>T</u> ools <u>R</u> eports <u>M</u> acros E <u>x</u> tensions <u>W</u> indow <u>H</u> elp                                                           |                                          |          |                                             |                         |            |            |  |  |  |  |
| New       Ope       Sav       Upd       Upd       Gen       Wav       Chk       L3n       LSn       Obv       Dcl       Dvr       Rdb       Gla       ABg       Pre                                                 |                                          |          |                                             |                         |            |            |  |  |  |  |
| Non-Sequential Component Editor                                                                                                                                                                                     |                                          |          |                                             |                         |            |            |  |  |  |  |
| <u>E</u> dit <u>S</u> olves <u>E</u> rrors <u>D</u> etectors <u>D</u> atabase <u>T</u> ools <u>V</u> iew <u>H</u> elp                                                                                               |                                          |          |                                             |                         |            |            |  |  |  |  |
| Object Type                                                                                                                                                                                                         | Tilt About Z                             | Material | X Half Width                                | Y Half Width            | # X Pixels | # Y Pixels |  |  |  |  |
| 1 Standard                                                                                                                                                                                                          | 0.000                                    | MIRROR   | 100.000                                     | -1.000                  | 150.000    | 20.000     |  |  |  |  |
| 2 Source Fi                                                                                                                                                                                                         | 0.000                                    | -        | 100                                         | 500000                  | 1.000      | 0          |  |  |  |  |
| 3 Standard                                                                                                                                                                                                          | 0.000                                    | N-BK7    | 300.000                                     | 0.000                   | 150.000    | 150.000    |  |  |  |  |
| 4 Detector                                                                                                                                                                                                          | 0.000                                    |          | 150.000                                     | 150.000                 | 150        | 150        |  |  |  |  |
| 5 Null Object                                                                                                                                                                                                       | 0.000                                    | -        |                                             |                         |            |            |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         |            |            |  |  |  |  |
| •                                                                                                                                                                                                                   |                                          |          |                                             |                         |            |            |  |  |  |  |
| 1: NSC Shaded Model                                                                                                                                                                                                 |                                          |          | 2: Detector Viewer                          |                         |            | x          |  |  |  |  |
| Update Settings Print                                                                                                                                                                                               | <u>W</u> indow <u>T</u> ext <u>Z</u> oom | Spin     |                                             |                         |            |            |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         | 9.595-00   | 13         |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          | B.63E-003                                   |                         |            |            |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             | 7.67E-D03               |            |            |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         | 6.71E-00   |            |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         | 5.755-00   | 3          |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             | 63                      | 4.79E-D0   | 13         |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             | - <b>V</b>              | 3.83E-D0   | 13         |  |  |  |  |
| Sale of the second                                                                                                                                                                                                  |                                          |          |                                             | 0.000 - 40/0/07         | 2,885-00   | 13         |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         | 1.92E-00   | 13         |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         | 9.585-00   | 54         |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         | D.00E+D0   | 00         |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             | ECTOR IMAGE: INCOHERENT | IRRADIANCE |            |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          | MED MRY 10 2017<br>DETECTOR 4. NSCG SURFICE | E L:                    |            |            |  |  |  |  |
| WED MRY 10 2017<br>DETECTOR Y, NSCG SURFACE L:<br>SIZE S00.000 W X 300.000 H MILLDMETERS, PIXELS 150 W X 150 H, TOTAL HITS = 3379270<br>PERK DERRODANCE Y 9.5992E-003 WATTS/CM^2<br>TOTAL POWER Y 6.7996E-001 WATTS |                                          |          |                                             |                         |            |            |  |  |  |  |
|                                                                                                                                                                                                                     |                                          |          |                                             |                         |            |            |  |  |  |  |

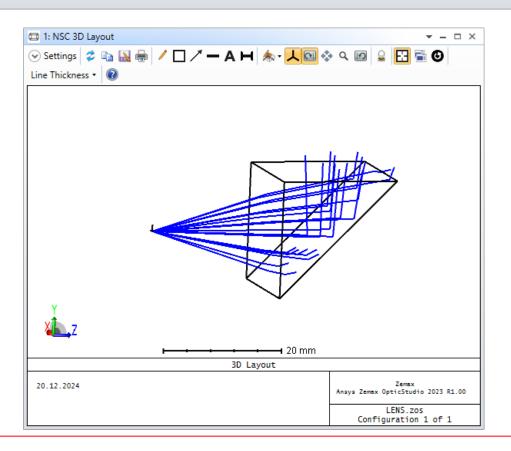
## **Example 3: Simple Interferometer**

|   | Object Type          | Comment      | Ref Object | Inside Of | X Position | Y Position | Z Position | Tilt About X | Tilt About Y | Tilt About Z | Material | X Half Width | Y Half Width |
|---|----------------------|--------------|------------|-----------|------------|------------|------------|--------------|--------------|--------------|----------|--------------|--------------|
| 1 | Source Rectangle 🔻   |              | 0          | 0         | 0.000      | 0.000      | 0.000      | 0.000        | 0.000        | 0.000        | -        | 10           | 1E+05        |
| 2 | Polygon Object 🔻     | splitter.POB | 0          | 0         | 0.000      | 0.000      | 10.000     | 45.000       | 0.000        | 0.000        | BK7      | 4.000        | 1            |
| 3 | Polygon Object 🔻     | splitter.POB | 0          | 0         | 0.000      | 20.000     | 30.000     | 45.000       | 0.000        | 0.000        | BK7      | 4.000        | 1            |
| 4 | Rectangle 🔻          |              | 0          | 0         | 0.000      | 20.000     | 10.000     | 45.000       | 0.000        | 0.000        | MIRROR   | 4.000        | 4.000        |
| 5 | Rectangle 🔻          |              | 0          | 0         | 0.000      | 0.000      | 30.000     | 45.000       | 0.000        | 0.000        | MIRROR   | 4.000        | 4.000        |
| 6 | Detector Rectangle 🔻 |              | 0          | 0         | 0.000      | 20.000     | 38.000     | 0.000        | 0.000        | 0.000        |          | 3.000        | 3.000        |
| 7 | Detector Rectangle 🔻 |              | 0          | 0         | 0.000      | 28.000     | 30.000     | 90.000       | 0.000        | 0.000        |          | 3.000        | 3.000        |



### **Example 4: A Point Source and a Prizm**

| 🗋 Ne  | Non-Sequential Component Editor           |             |            |             |            |            |            |              |              |              |          |               |                 |              |            |         |            |  |
|-------|-------------------------------------------|-------------|------------|-------------|------------|------------|------------|--------------|--------------|--------------|----------|---------------|-----------------|--------------|------------|---------|------------|--|
| Upda  | ate: All Windows - 🛈 🕻                    | ® 📙 🔍 🗣 🕯   |            | cad • Z • ( | S < 🔊 🛛    | \$ ++ =>   | 0          |              |              |              |          |               |                 |              |            |         |            |  |
| (v) ( | Object 1 Properties     Configuration 1/1 |             |            |             |            |            |            |              |              |              |          |               |                 |              |            |         |            |  |
|       |                                           |             |            |             |            |            |            |              |              |              |          |               |                 |              |            |         |            |  |
|       | Object Type                               | Comment     | Ref Object | Inside Of   | X Position | Y Position | Z Position | Tilt About X | Tilt About Y | Tilt About Z | Material | # Layout Rays | # Analysis Rays | Power(Watts) | Wavenumber | Color # | Cone Angle |  |
| 1     | Source Point 🔻                            |             | 0          | 0           | 0.000      | 0.000      | 0.000      | 0.000        | 0.000        | 0.000        | -        | 20            | 1E+05           | 1.000        | 0          | 0       | 20.000     |  |
| 2     | Polygon Object 🔻                          | Prism45.POB | 0          | 0           | 0.000      | 0.000      | 20.000     | 0.000        | 0.000        | 0.000        | BK7      | 10.000        | 1               |              |            |         |            |  |
| 3     | Null Object 🔻                             |             | 0          | 0           | 0.000      | 0.000      | 0.000      | 0.000        | 0.000        | 0.000        | -        |               |                 |              |            |         |            |  |
|       |                                           |             |            |             |            |            |            |              |              |              |          |               |                 |              |            |         |            |  |



### **Array of point sources**

Consider we have a point source with cone angle 20°.

|                                                                                                        | Component Editor                                                             |                |            | - 0 -                                                                  |                    |                                                                          |              | ▼ - □ X           | □ 1: NSC 3D Layout       - □ ×         ○ Settings       2 □ ▲ |
|--------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------|----------------|------------|------------------------------------------------------------------------|--------------------|--------------------------------------------------------------------------|--------------|-------------------|---------------------------------------------------------------|
| Object 1 Prop                                                                                          | ws • 🕜 🕲 🔽 🧠 🕅                                                               | <b>9</b> (9 II | CAD +      | Z • 🛇 🖕 👳                                                              | ♪  ] <b>३ •• व</b> | Configuration 1/1                                                        |              |                   | Line Thickness •                                              |
| Type<br>Draw<br>Sources<br>Coat/Scatter<br>Scatter To<br>Volume Physics<br>Index<br>Diffraction<br>CAD | Polarization<br>Random Polariza<br>Initial Phase (deg):<br>Coherence Length: | 0              | Pre<br>Bul | trace<br>Reverse Rays<br>-Propagation:<br>k Scatter:<br>npling Method: | 0<br>Many<br>Sobol | Array<br>Array Type:<br>Number X:<br>Number Y:<br>Spacing X<br>Spacing Y |              | Color/S<br>Source |                                                               |
| < Object                                                                                               | t Type In                                                                    | side Of        | X Position | Y Position                                                             | Z Position         | Tilt About X                                                             | Tilt About Y | Tilt About        |                                                               |
| 1 s                                                                                                    | iource Point 🔻 )                                                             | 0              | 0.000      | 0.000                                                                  | 0.000              | 0.000                                                                    | 0.000        | 0.000 (           |                                                               |

# **Example 5:** Gaussian Beam Source

| Object 2 Properties  | <>> |            |           |            |            |            |              |              |              | Config | uration 1/1 🔇 | >            |            |            |
|----------------------|-----|------------|-----------|------------|------------|------------|--------------|--------------|--------------|--------|---------------|--------------|------------|------------|
| Object Type          |     | Ref Object | Inside Of | X Position | V Position | 7 Position | Tilt About X | Tilt About V | Tilt About 7 |        | X Half Width  | Y Half Width | # X Pixels | # Y Pixels |
| Source Gaussian •    |     | 0          | 0         |            | 0.000      | 0.000      | 0.000        | 0.000        | 0.000        | -      | 100           | 1E+05        | 1.000      | 0          |
| Detector Rectangle • |     | 0          | 0         |            | 0.000      | 50.000     | 0.000        | 0.000        | 0.000        |        | 20.000        | 20.000       | 100        | 100        |
|                      | <   |            |           |            |            |            |              |              |              |        |               |              |            |            |
| 3: NSC Shaded Mode   | 1   |            |           |            |            | ▼ - □ >    | c            |              |              |        |               |              |            |            |
| Solid 🔻 🔳            |     |            |           |            |            |            |              |              |              |        |               |              |            |            |

### **Example 6:** How to use LED

LED manufacturers (such as Osram Opto Semiconductors) distribute comprehensive ray-tracing data files to be used in optical simulations such as

eulumdat file, ray file and spectrum file.

- In principle, LED is considered to be a point source in eulumdat file which is used for a quick analysis.
- whereas, the ray le represents actual spatial and angular distribution of rays originating from the outer surface of LED. Therefore, ray files can be used in more realistic simulations.
- The spectral distribution of LED (wavelengths emitted and corresponding weights) are stored in spectrum files.

Two types (White and IR) of LED provided by Osram Company will be presented. [If possible, show ray files and eulumdat files]

Examples:

- **LUW H9GP** a white LED having color temperature of 6500 K.
- SFH 4718A which is an IR LED whose peak irradiance is at 850 nm

After downloading LED's simulation files, you should copy and paste files to the related folders:

```
Geometry files (IGS or STEP) goes to:
C:\<ZEMAX>\Objects\CAD Files
```

Spectrum files goes to:

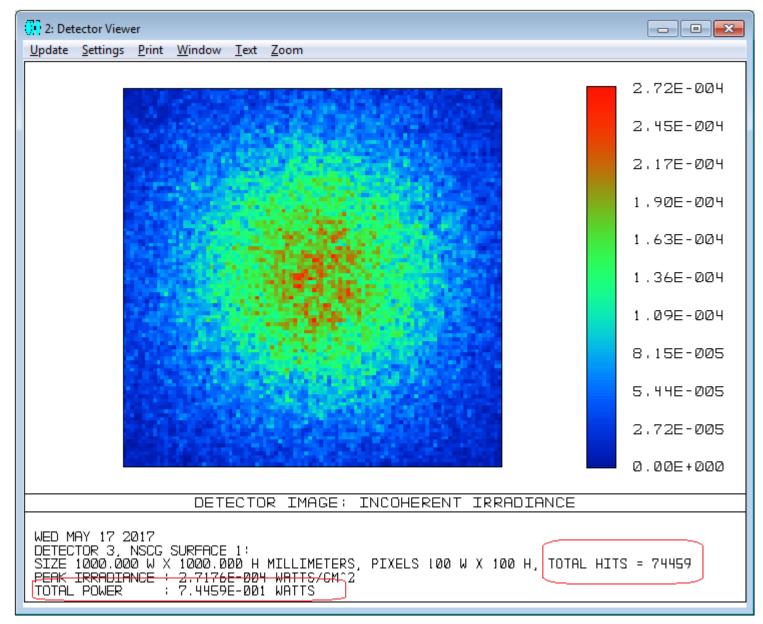
```
C:\<ZEMAX>\Objects\Sources\Spectrum Files
```

Ray files goes to C:\<ZEMAX>\Objects\Sources\Source Files

### Then, add a **rectangular** or **polar** detector

| ZEMAX-EE - 19052 - C:\Use                           |                     |                                           |                                                                               |                                                                              |                             |              |              |            |
|-----------------------------------------------------|---------------------|-------------------------------------------|-------------------------------------------------------------------------------|------------------------------------------------------------------------------|-----------------------------|--------------|--------------|------------|
|                                                     |                     | acros E <u>x</u> tensions <u>W</u> indo   |                                                                               |                                                                              |                             |              |              |            |
|                                                     | d Upa Gen Wav Chk   | L3n LSn Obv                               | Dcl Dvr Rdb Gla                                                               | ABg Pre                                                                      |                             |              |              |            |
| 💮 Non-Sequential Compo                              | nent Editor         |                                           |                                                                               |                                                                              |                             |              |              |            |
| <u>Edit</u> <u>Solves</u> <u>Errors</u> <u>D</u> et |                     |                                           | 1                                                                             | 1 1                                                                          |                             | Γ            | T            | 1          |
| Object Type                                         | Z Position          | Tilt About X                              | Tilt About Y                                                                  | Tilt About Z                                                                 | Material                    | X Half Width | Y Half Width | # X Pixels |
| 1 Source File                                       | 0.000               | 0.000                                     | 0.000                                                                         | 0.000                                                                        | -                           | 1000         | 100000       | 1.000      |
| 2 Imported                                          | 0.000               | 0.000                                     | 0.000                                                                         | 0.000                                                                        |                             | 1.000        | L            | 5          |
| 3 Detector                                          | 500.000             | 0.000                                     | 0.000                                                                         | 0.000                                                                        |                             | 500.000      | 500.000      | 100        |
| 4 Null Object                                       | 0.000               | 0.000                                     | 0.000                                                                         | 0.000                                                                        | -                           |              |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              |                             |              |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              |                             |              |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              |                             |              |              |            |
| 1: NSC Shaded Model                                 |                     |                                           | 🛛 🛛 🙀 2: Detector Viewer                                                      |                                                                              |                             | 83           |              |            |
| Update Settings Print                               | Window Text Zoom    | Spin                                      | Update Settings P                                                             | Print Window Text Zoo                                                        | m                           | -            |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | 2.72E-D                     | 04           |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | 2.45E-0                     | оч           |              |            |
|                                                     | The still be fritte |                                           |                                                                               | 他的王子是他们                                                                      | 2.17E-Ø                     | 04           |              |            |
|                                                     |                     |                                           |                                                                               | -1.15E                                                                       | 1.90E-D                     | 04           |              |            |
|                                                     |                     |                                           |                                                                               | - Bartes                                                                     | 1.63E-D                     | 04           |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | 1.36E-D                     | 04           |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | 1.09E-D                     | 04           |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | B.15E-D                     | 05           |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | 5.44E-Ø                     | 05           |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | 2.72E-0                     | 05           |              |            |
|                                                     |                     |                                           |                                                                               |                                                                              | D.00E+D                     | 00           |              |            |
|                                                     | V Welde             | A. C. |                                                                               | ECTOR IMAGE: INCOHERENT                                                      | IRRADIANCE                  |              |              |            |
|                                                     |                     |                                           | THU MAY 11 2017<br>DETECTOR 3, NSCG SURPHC                                    | EL                                                                           |                             |              |              |            |
|                                                     |                     |                                           | SIZE LOGB. DOG N × 1000.0<br>PEAK DRRADIANCE + 2.7170<br>TOTEL POLICE + 2.400 | E L:<br>BOD H MILLIMETERS, PIXELS LOO W<br>GE-004 WATTS/CH^2<br>PE-001 WATTS | X 180 H, TOTAL HETS = 74459 |              |              |            |
|                                                     |                     |                                           | TOTAL POMER 17.446                                                            | TE-981 M110                                                                  |                             |              |              |            |

### The detector



## **Example 7: Simple LED Collimator**

|     | Object Type         | Comme   | Ref Object | Inside Of | X Position | Y Position | Z Position | Tilt About X | Tilt About Y | Tilt About Z | Material | X Half Width | Y Half Width | # X Pixels | # Y Pixels | Data Type | Color     | Smoothing    |
|-----|---------------------|---------|------------|-----------|------------|------------|------------|--------------|--------------|--------------|----------|--------------|--------------|------------|------------|-----------|-----------|--------------|
| 1   | Source File 🔻       | rayfile | 0          | 0         | 0.000      | 0.500      | 0.000      | 0.000        | 0.000        | 0.000        | -        | 50           | 1E+05        | 1.000      | 0          | 0         | 0         | 3.257E-03    |
| 2   | Standard Lens 🔻     |         | 0          | 0         | 0.000      | 0.000      | 5.000      | 0.000        | 0.000        | 0.000        | PMMA     | 50.000 V     | 8.273E-05 V  | 10.000     | 10.000     | 10.000    | -10.242 V | -1.287E-05 V |
| 3 D | etector Rectangle 🔻 |         | 0          | 0         | 0.000      | 0.000      | 100.000    | 0.000        | 0.000        | 0.000        |          | 100.000      | 100.000      | 100        | 100        | 0         | 0         | 0            |

|   | Туре   | Surf | Det# | Pix# | Data | # Ignored | <b>Spatial Frequency</b> | Target | Weight | Value | % Contrib |
|---|--------|------|------|------|------|-----------|--------------------------|--------|--------|-------|-----------|
| 1 | DMFS - |      |      |      |      |           |                          |        |        |       |           |
| 2 | NSDD 🔻 | 1    | 0    | 0    | 0    | 0         | 0.000                    | 0.000  | 0.000  | 0.000 | 0.000     |
| 3 | NSTR 🔻 | 1    | 0    | 0    | 0    | 0         | 0.000                    | 0.000  | 0.000  | 0.000 | 0.000     |
| 4 | NSDD 🔻 | 1    | 3    | 0    | 0    | 0         | 0.000                    | 1.000  | 1.000  | 0.701 | 100.000   |

