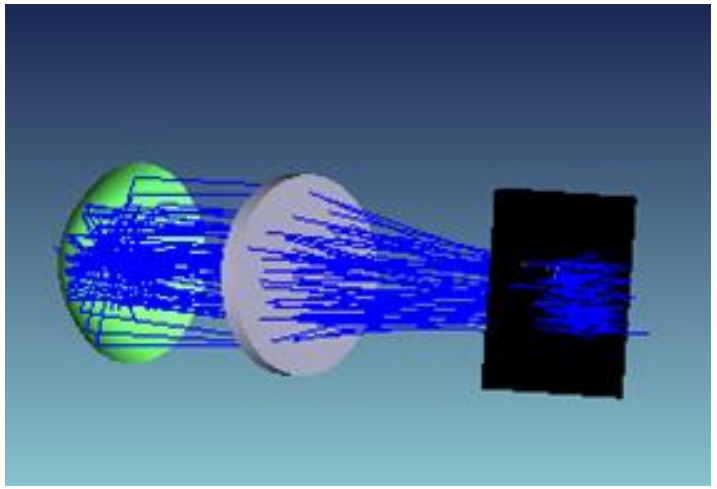
Lectures Notes on Optical Design using Zemax OpticStudio

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 imaging and afocal systems.
- Surfaces are defined in the Lens Data Editor.
- Ray can only intersect each surface once 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 reflect 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.*
- Each surface has its own local coordinate system. 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

Stray ray example

- It is primarily used for non-imaging applications such as illumination systems and/or stray-light analysis.

- Surfaces or volume objects are defined in the Non-Sequential Component Editor
- 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 global coordinate, 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 meaningful in non-sequential systems.
- The main analysis feature in non-sequential mode is the detector ray-trace, which gives spatial and angular data on incoherent or coherent rays.

Example 1: How to add standart lens

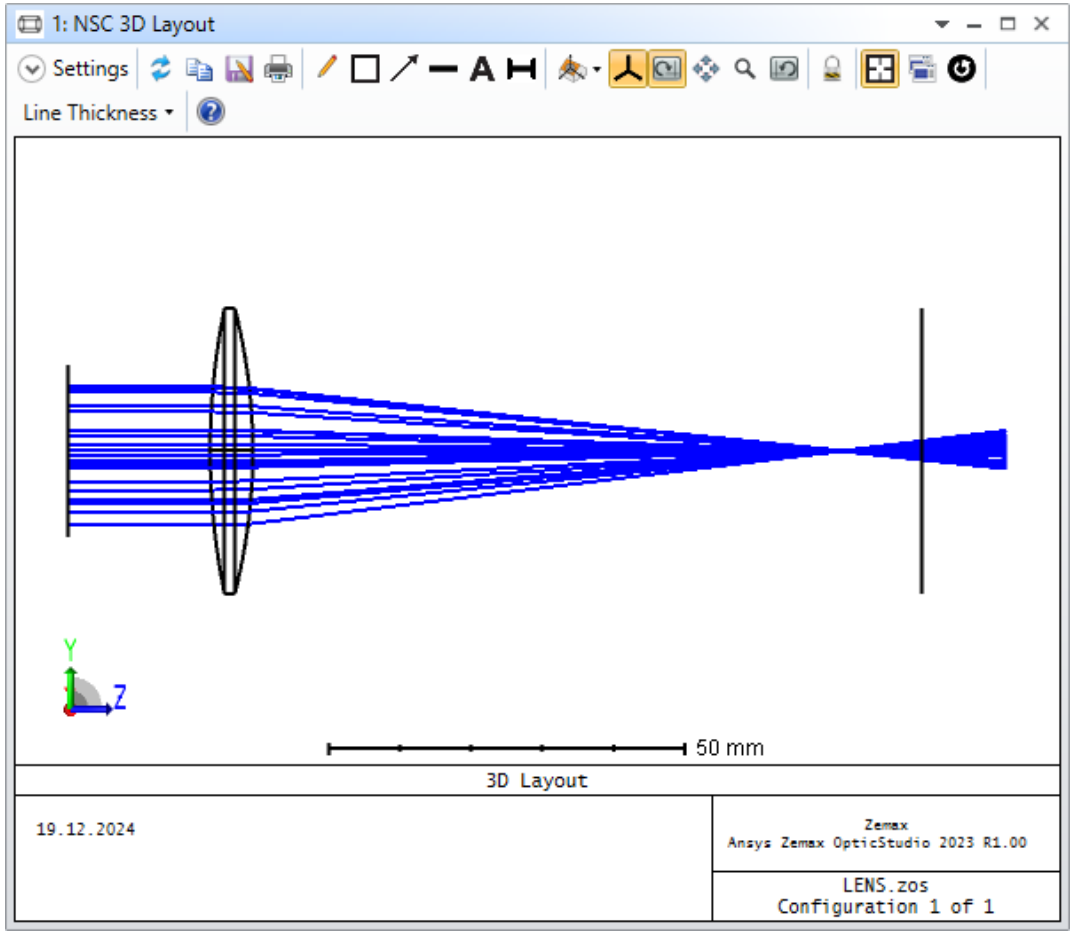
	Object Type	Comment	Ref Object	Inside Of	X Position	Y Position	Z Position	Tilt About X	Tilt About Y	Tilt About Z	Material	X Half Width	Y Half Width	# X Pixels	# Y Pixels	Data Type	Color
1	Source Ellipse		0	0	0.000	0.000	0.000	0.000	0.000	0.000	-	20	1E+05	1.000	0	0	12.000
2	Standard Lens		0	0	0.000	0.000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

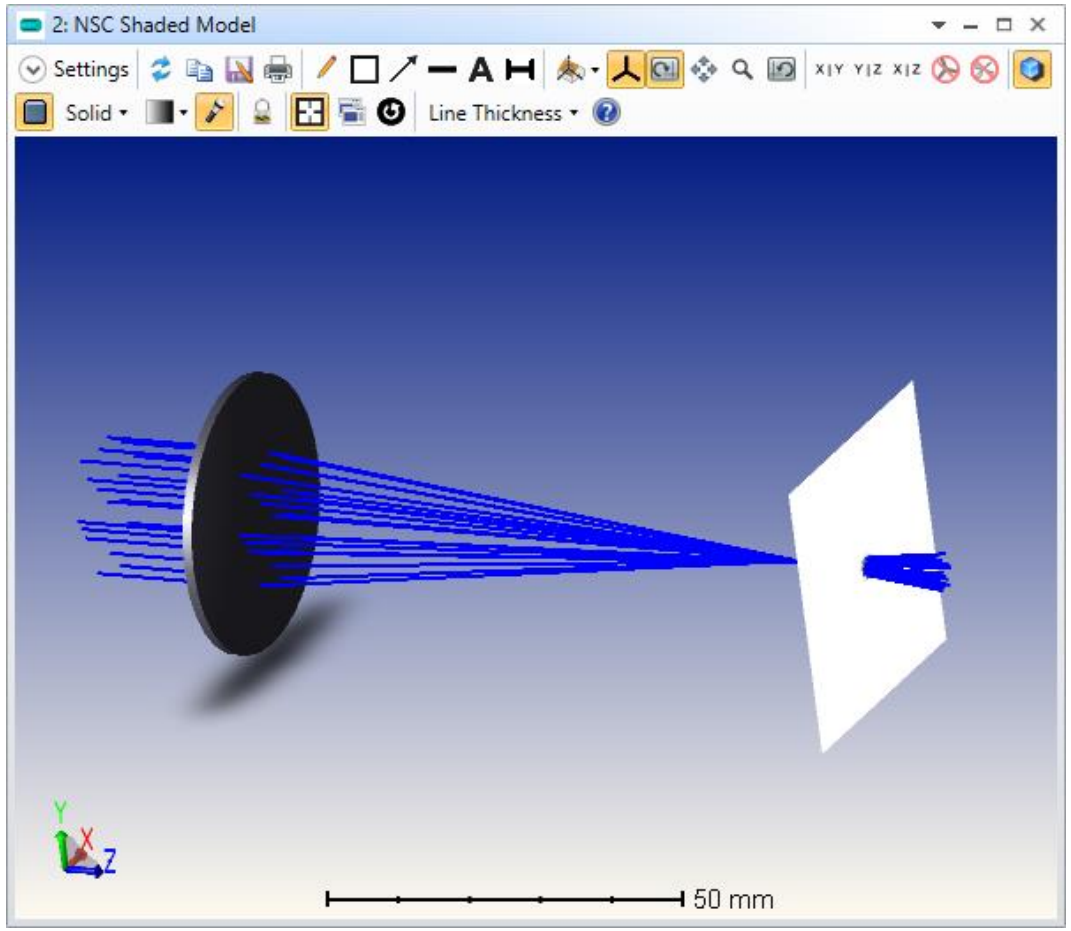
```
*** Object1
Source Ellipse
# of Layout Rays    20
# of Analysis Rays  1e5
X Half Width        12
Y Half Width        12
*** Object2
Standart Lens
Z position          20
Material            BK7
Radius1             100
Thickness           6
Clear1 = Edge1      20
Radius2            -80
Clear2 = Edge2      20
```

```
*** Object3
Detector            Rect
Z position          120
Material            Blank  (or can be ABSORB or MIRROR)
X Half Width        20
Y Half Width        20
# X Pixels         200
# Y Pixels         200
Color               3    (detector displays false color)
```

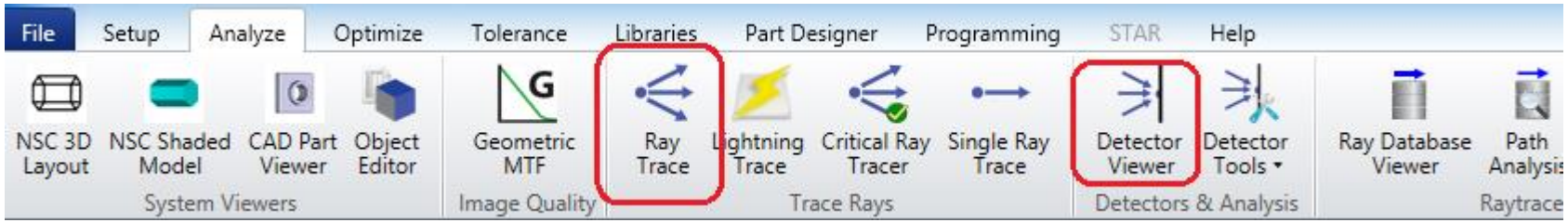
Example 1: Layout

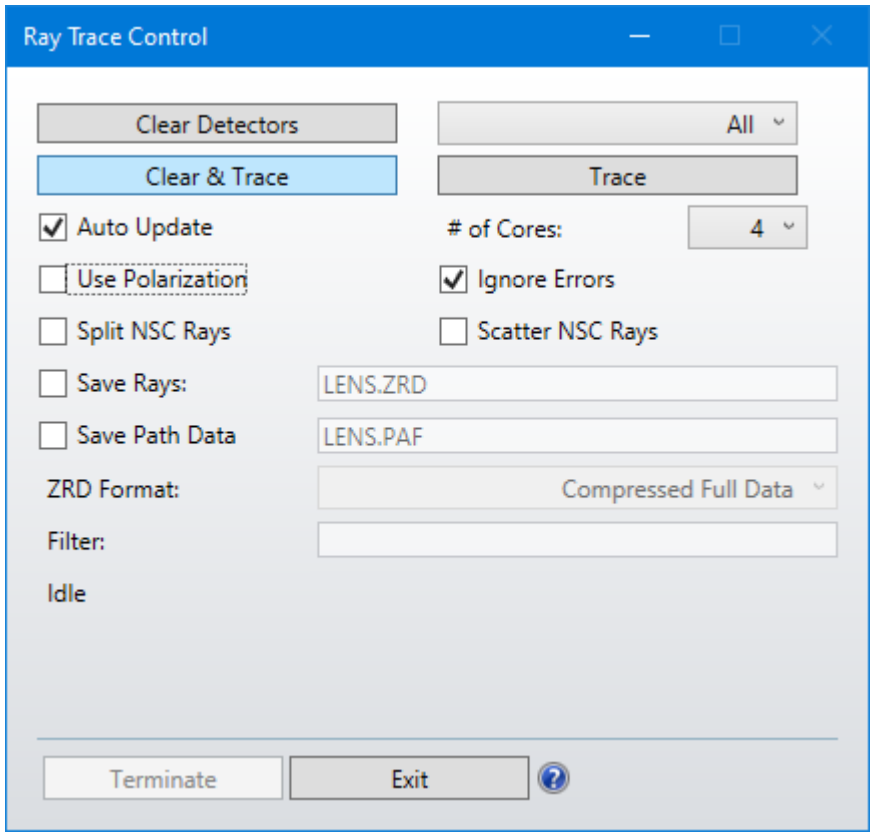
	Object Type	Comment	Ref Object	Inside Of	X Position	Y Position	Z Position	Tilt About X	Tilt About Y	Tilt About Z	Material	X Half Width	Y Half Width	# X Pixels	# Y Pixels	Data Type	Color
1	Source Ellipse		0	0	0.000	0.000	0.000	0.000	0.000	0.000	-	20	1E+05	1.000	0	0	12.000
2	Standard Lens		0	0	0.000	0.000	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

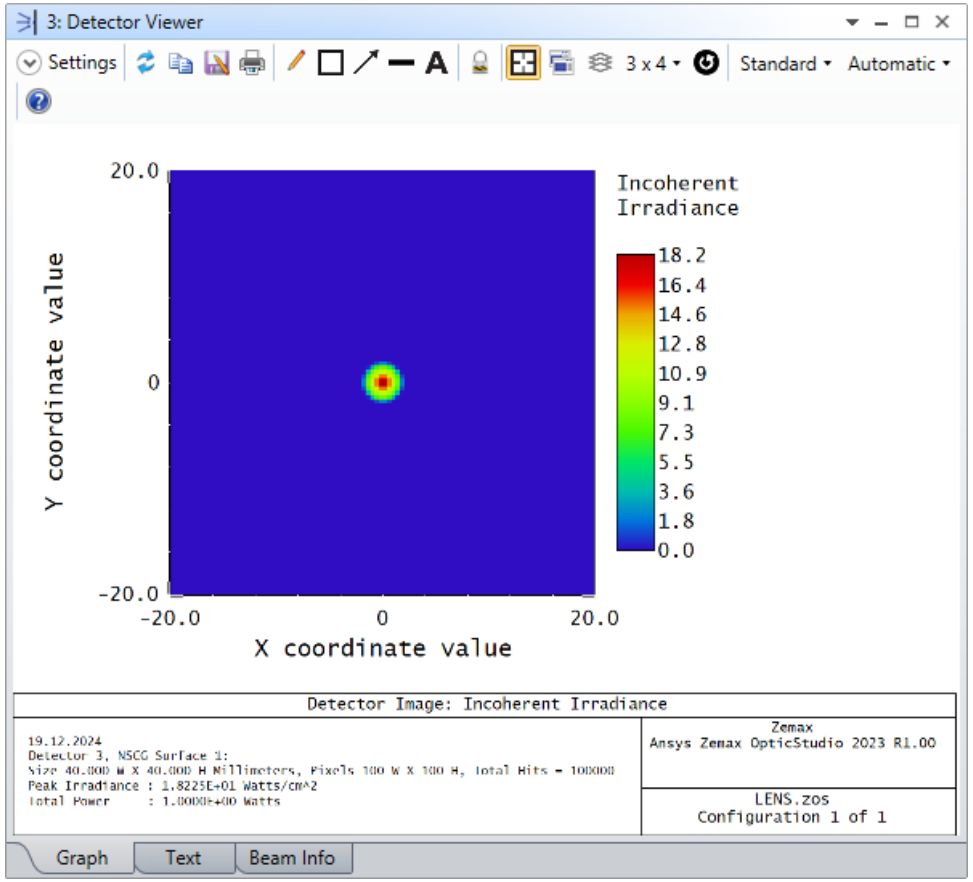




Example 1: Ray Tracing







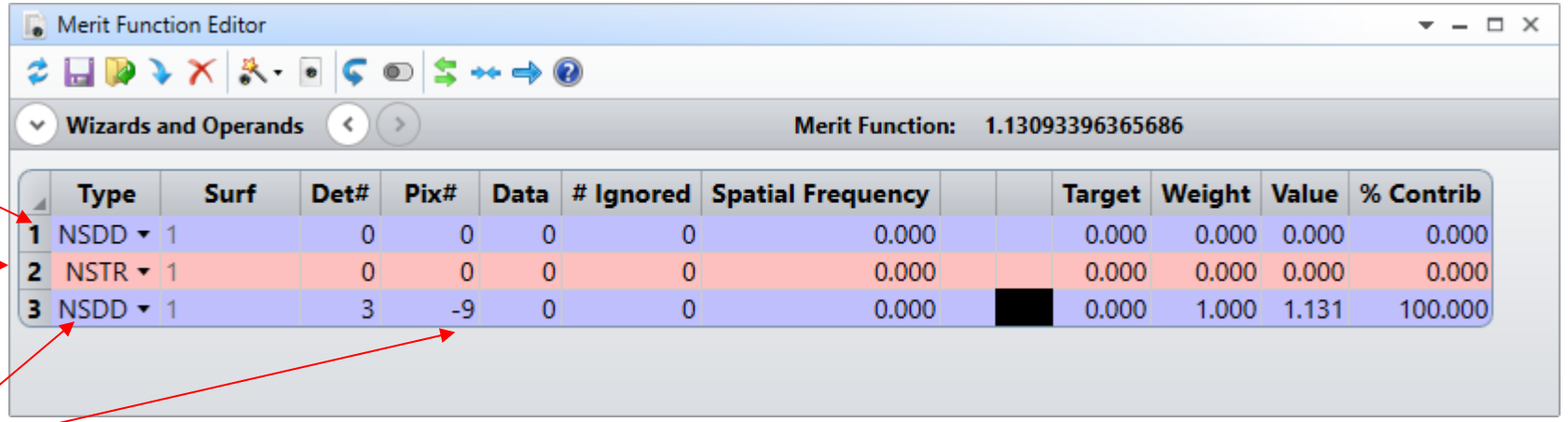
Example 1: Optimization

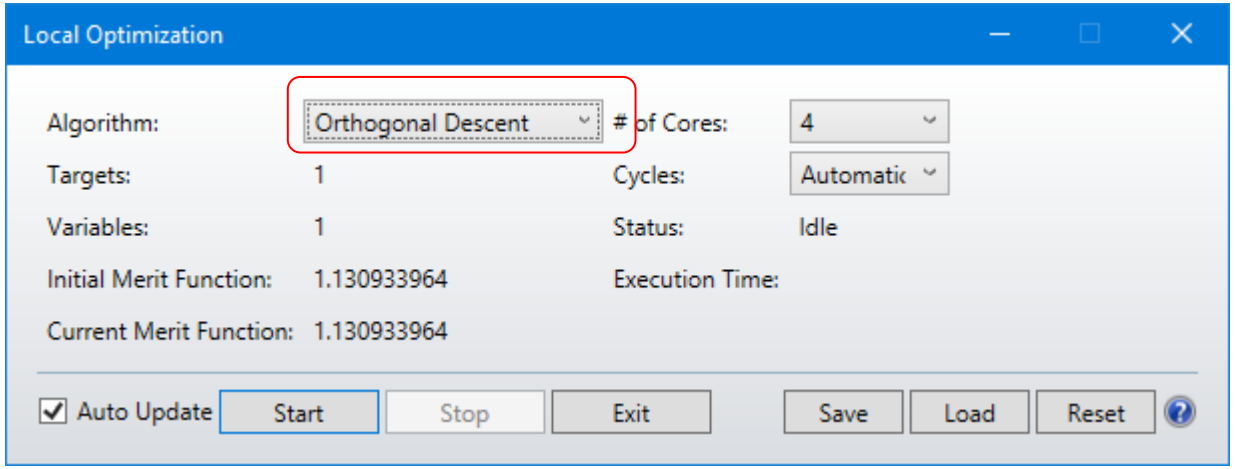
The aim is to put detector at a location where we have minimum rms spot size

Clear detector

Start ray tracing

Obtain minimum spot size

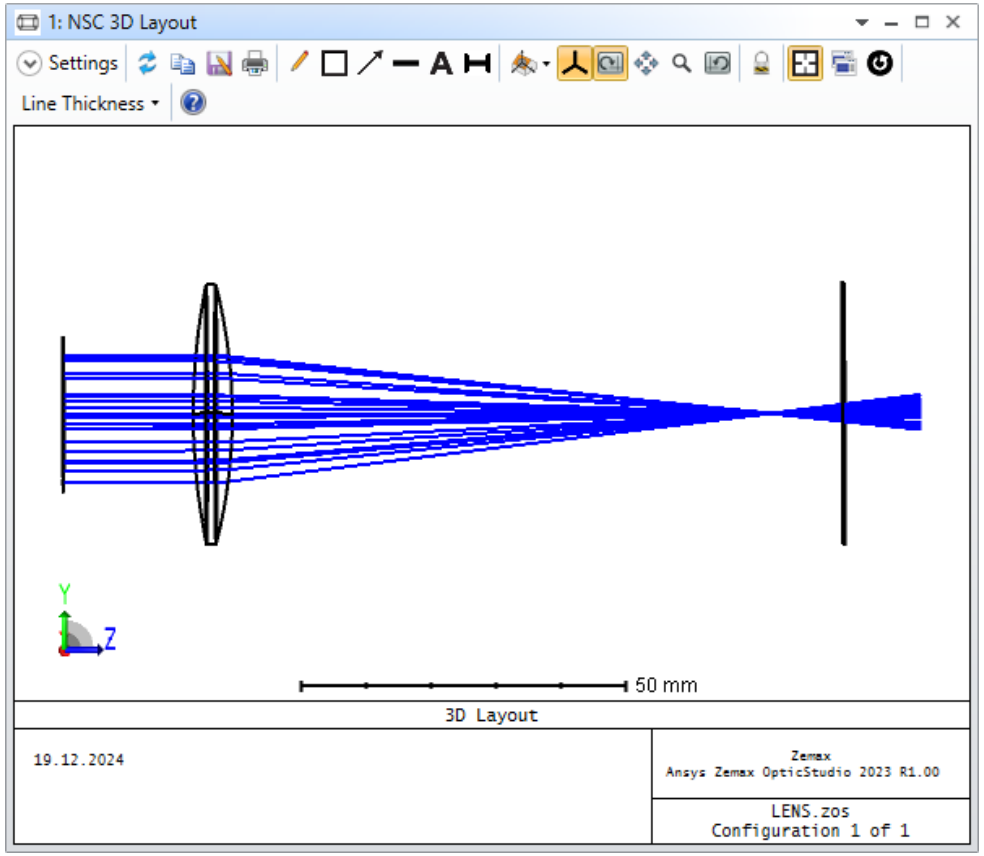




Example 1: Results

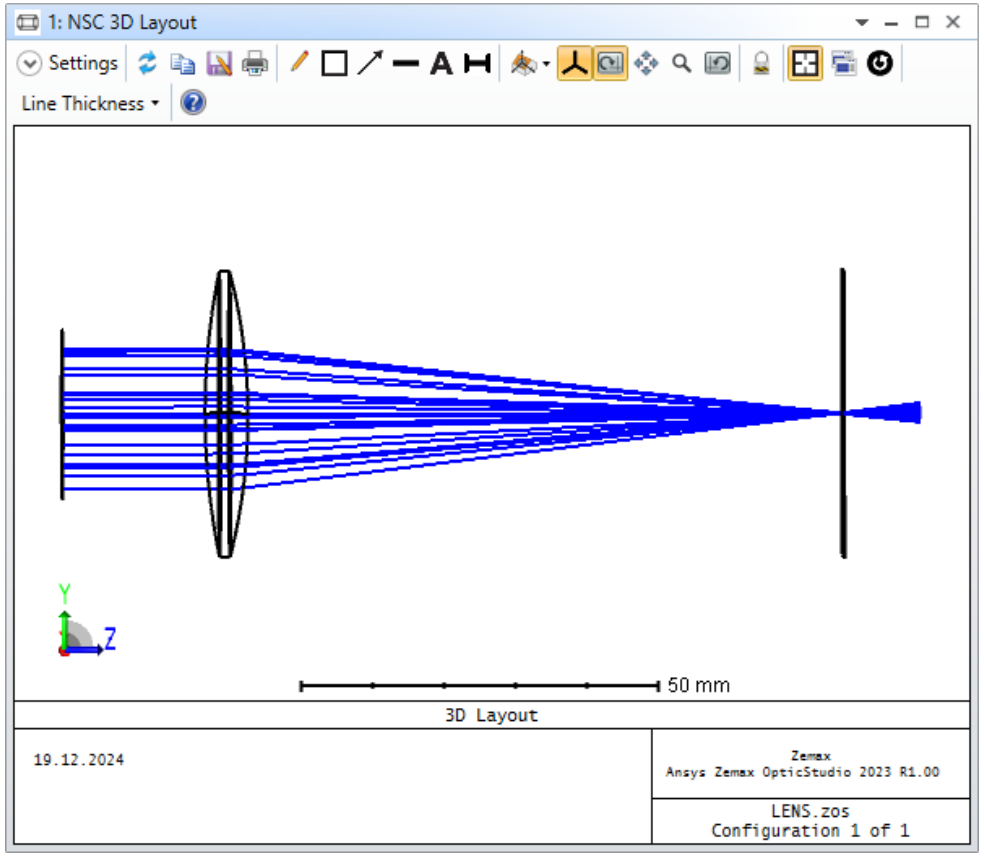
Z Position of detector = 120 mm

Before optimization



Z Position of detector = 108. 7 mm

After optimization

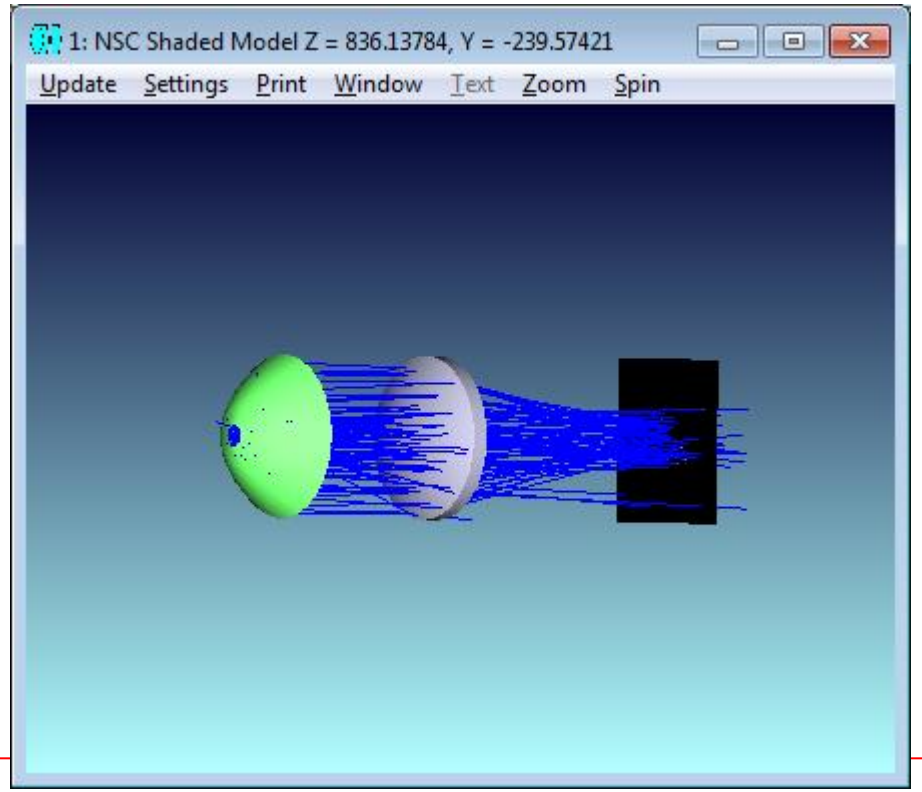


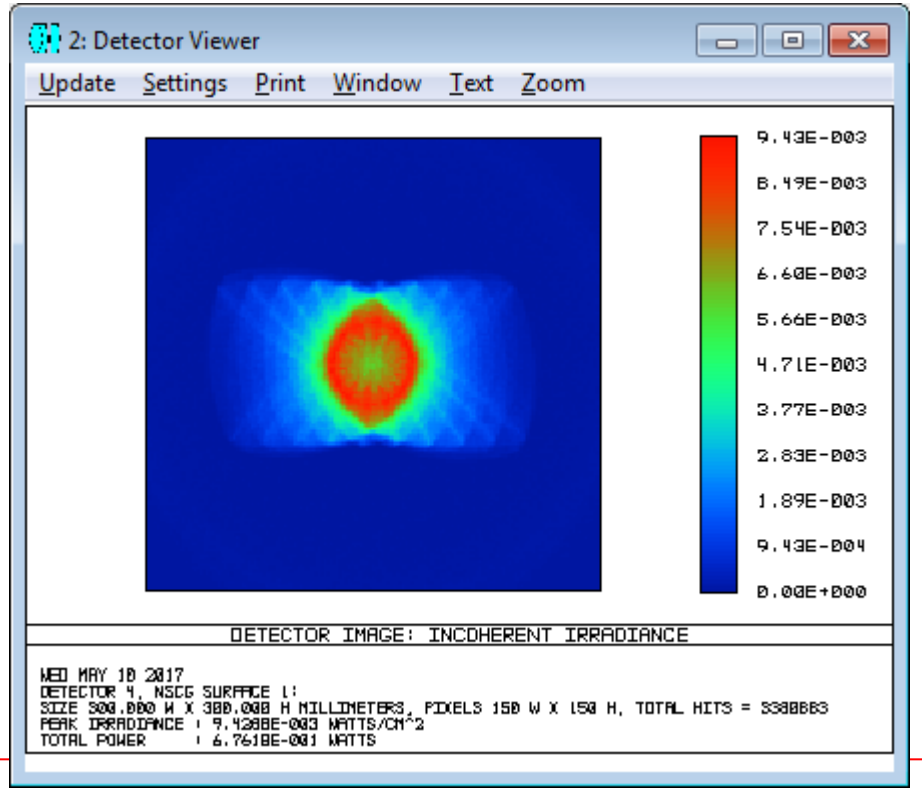
Example 2: Mirror-Lens-Detector

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:





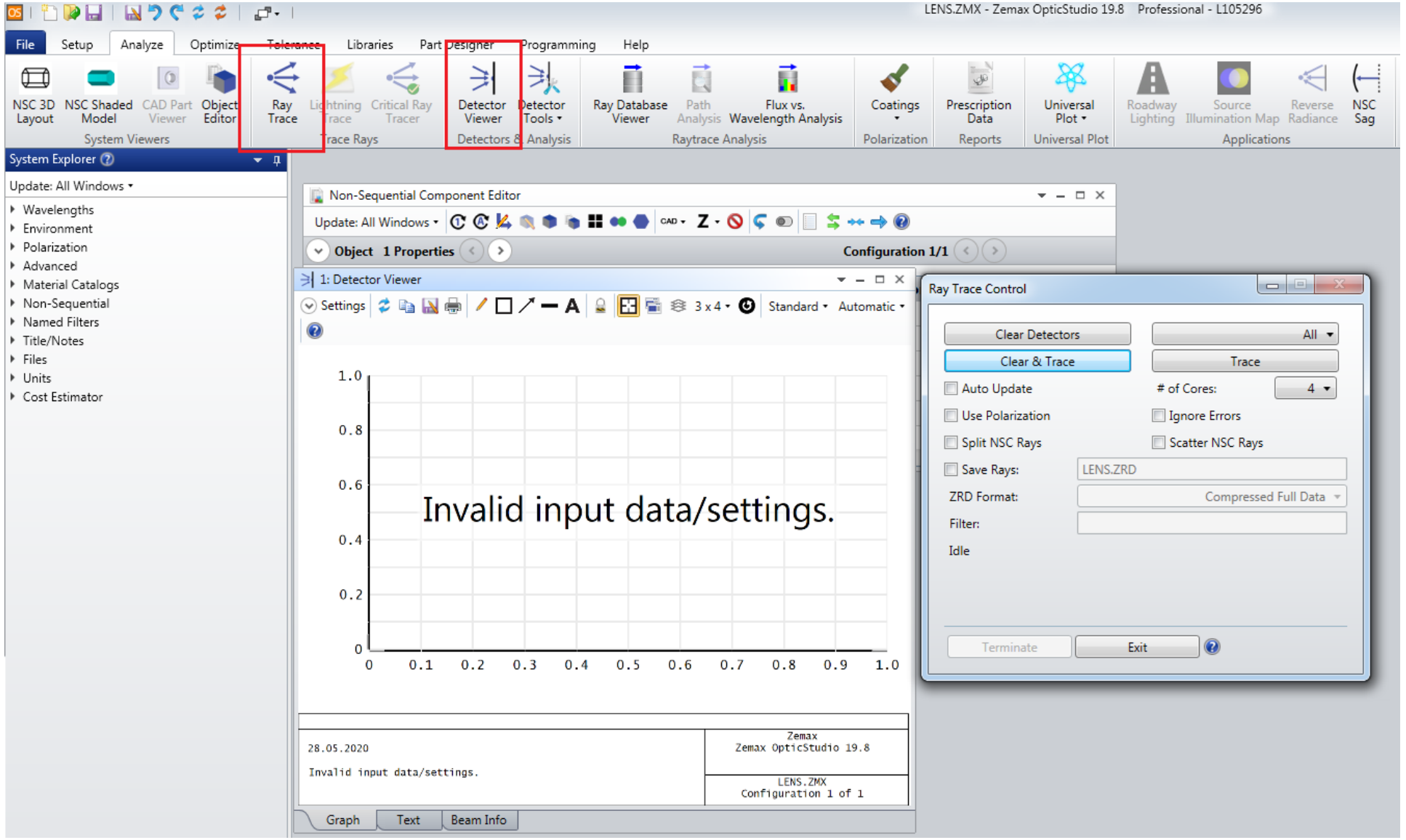
```
*** Object1
Standart Surface
Material          Mirror
Radius            100
Conic             -1 (parabola)
Max Aper          150
Min Aper          20 (center hole in the reflector)

*** Object2
Source Filament
Z position        50 (focus of the parabolic reflector)
# Layout Rays     20
# Analysis Rays   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
```

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

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



ZEMAX-EE - 19052 - C:\Users\Ahmet Bingul\Desktop\ZEMAX\NonSequential\ns1.ZMX

File Editors System Analysis Tools Reports Macros Extensions Window Help

New Ope Sav Sas Upd Upa Gen Wav Chk L3n LSn Obv Dcl Dvr Rdb Gla ABg Pre

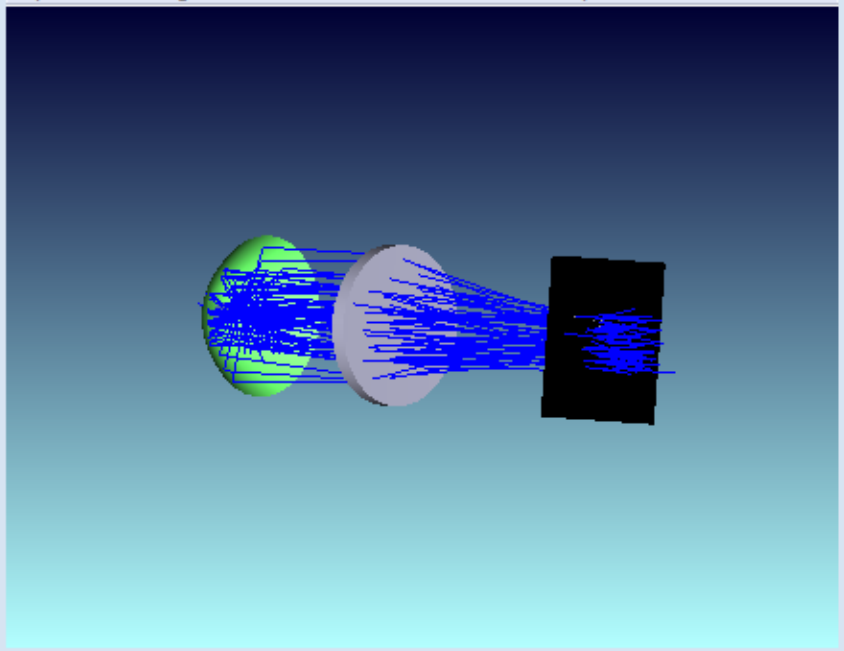
Non-Sequential Component Editor

Edit Solves Errors Detectors Database Tools View Help

	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	5000000	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	-				

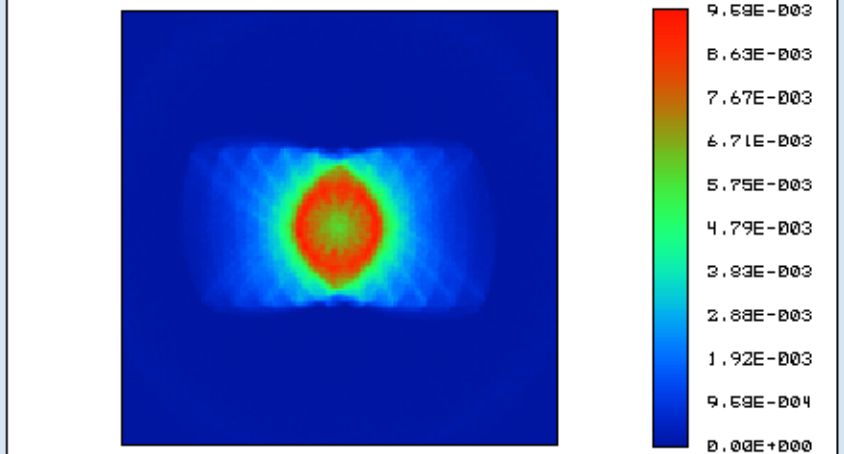
1: NSC Shaded Model

Update Settings Print Window Text Zoom Spin



2: Detector Viewer

Update Settings Print Window Text Zoom

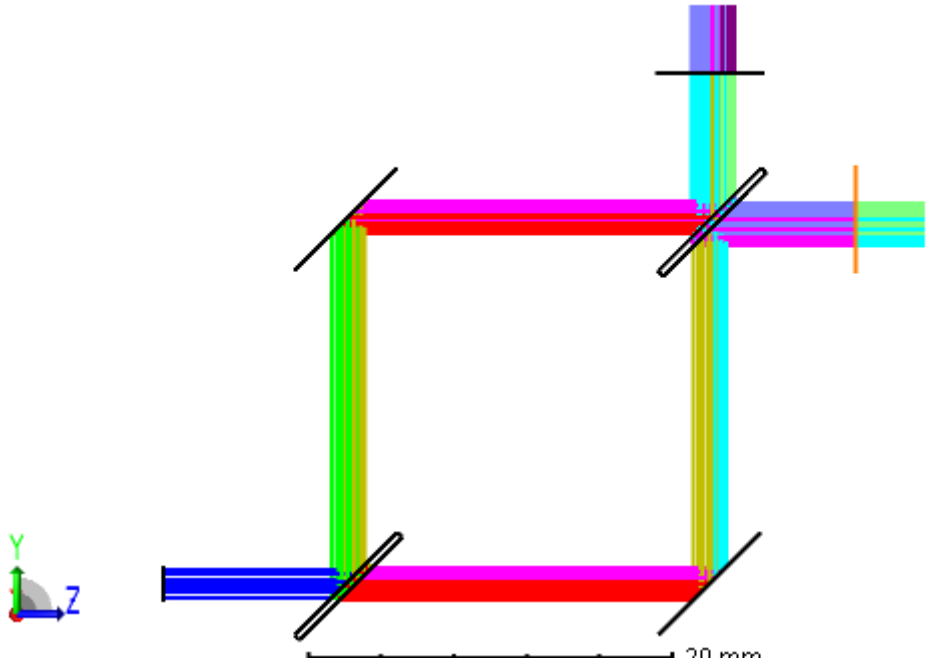


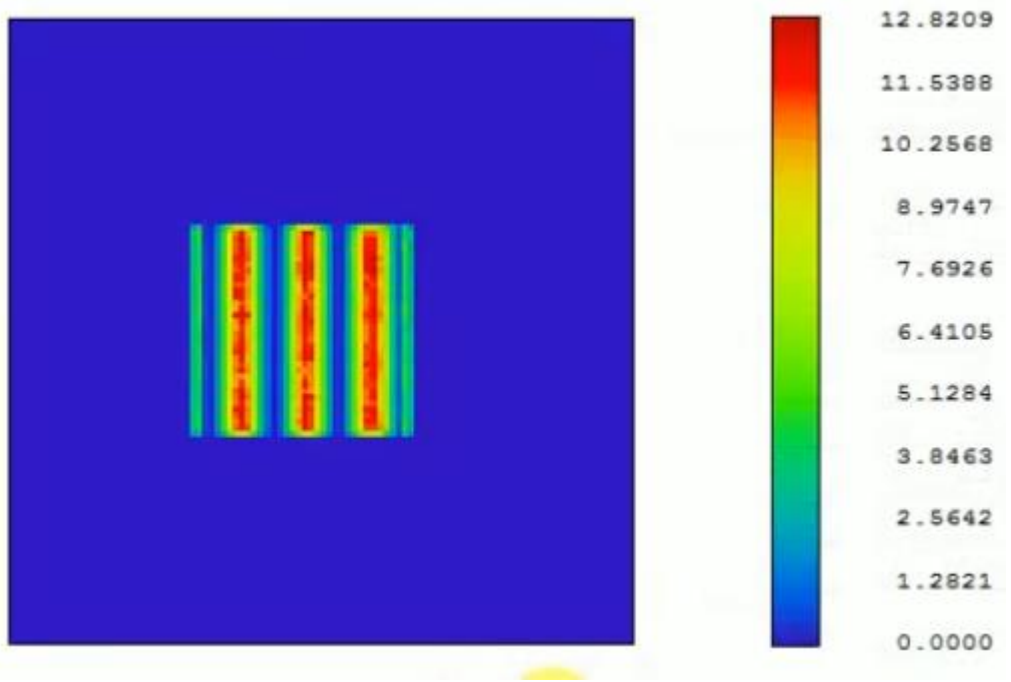
DETECTOR IMAGE: INCOHERENT IRRADIANCE

WED MAY 10 2017
DETECTOR 4, NSCG SURFACE 1:
SIZE 300.000 W X 300.000 H MILLIMETERS, PIXELS 150 W X 150 H, TOTAL HITS = 5379270
PEAK IRRADIANCE : 9.5842E-003 WATTS/CM^2
TOTAL POWER : 6.7696E-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

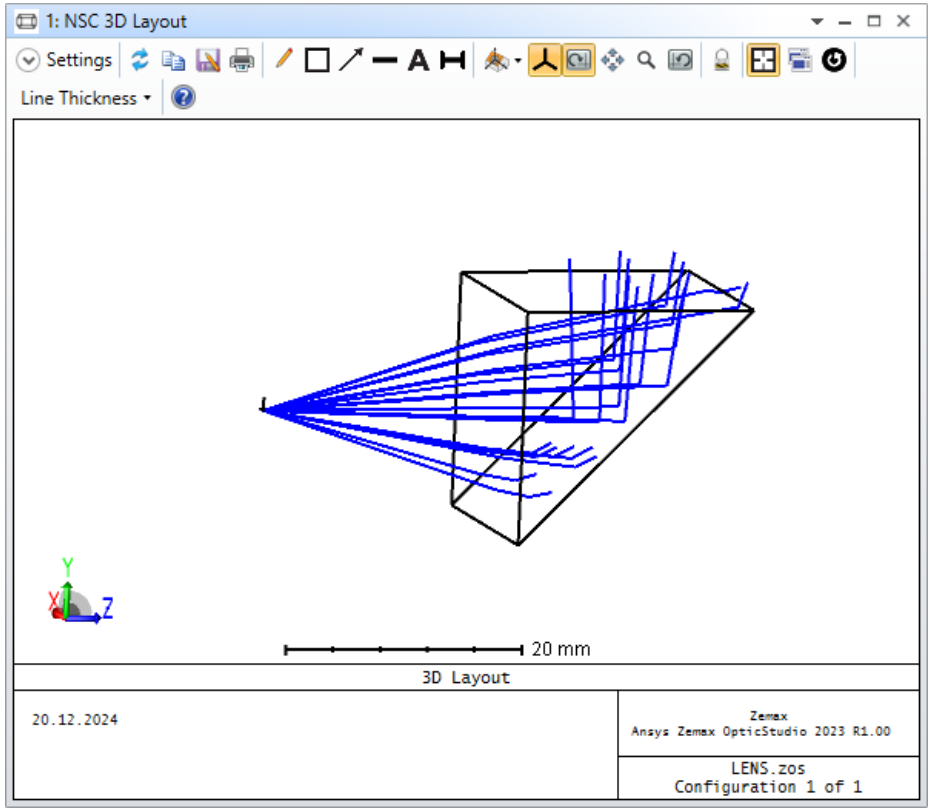
Non-Sequential Component Editor

Update: All Windows

Object 1 Properties

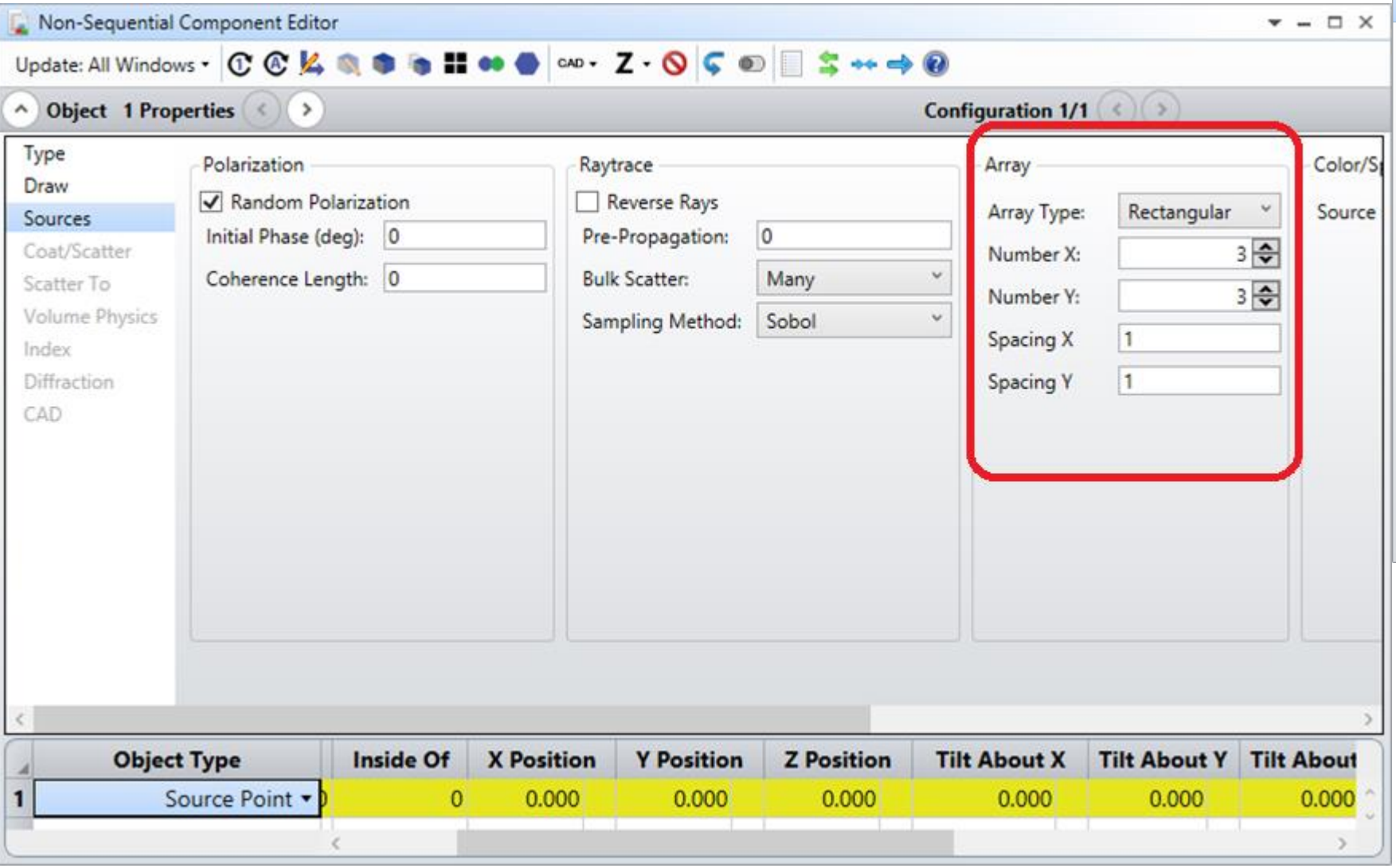
Configuration 1/1

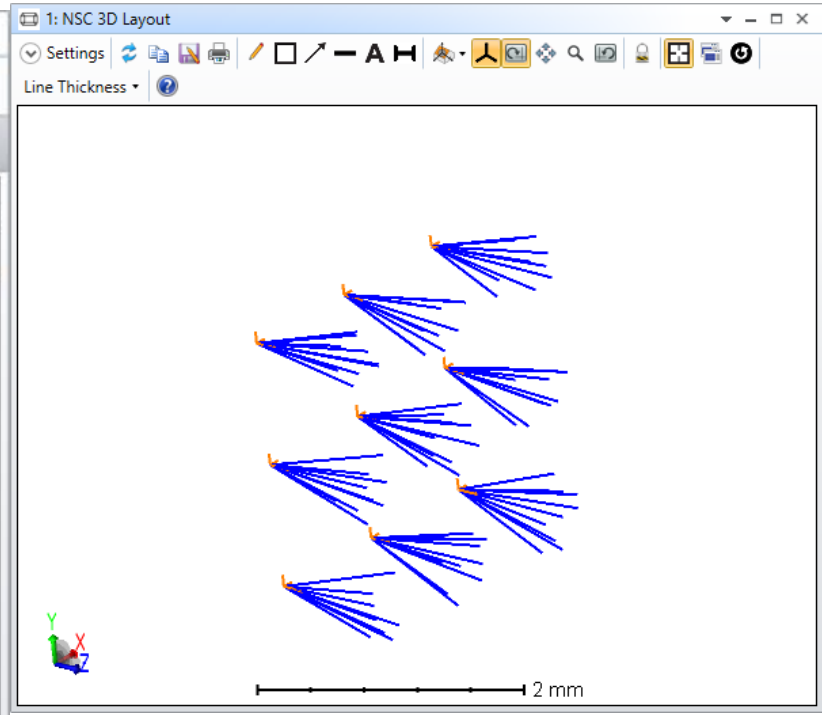
	Object Type	Comment	Ref Object	Inside Of	X Position	Y Position	Z Position	Tilt About X	Tilt About Y	Tilt About Z	Material	# Layout Rays	# Analysis Rays	Power(Watts)	Wavenumber	Color #	Cone Angle
1	Source Point		0	0	0.000	0.000	0.000	0.000	0.000	0.000	-	20	1E+05	1.000	0	0	20.000
2	Polygon Object	Prism45.POB	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 20º.





Example 5: Gaussian Beam Source

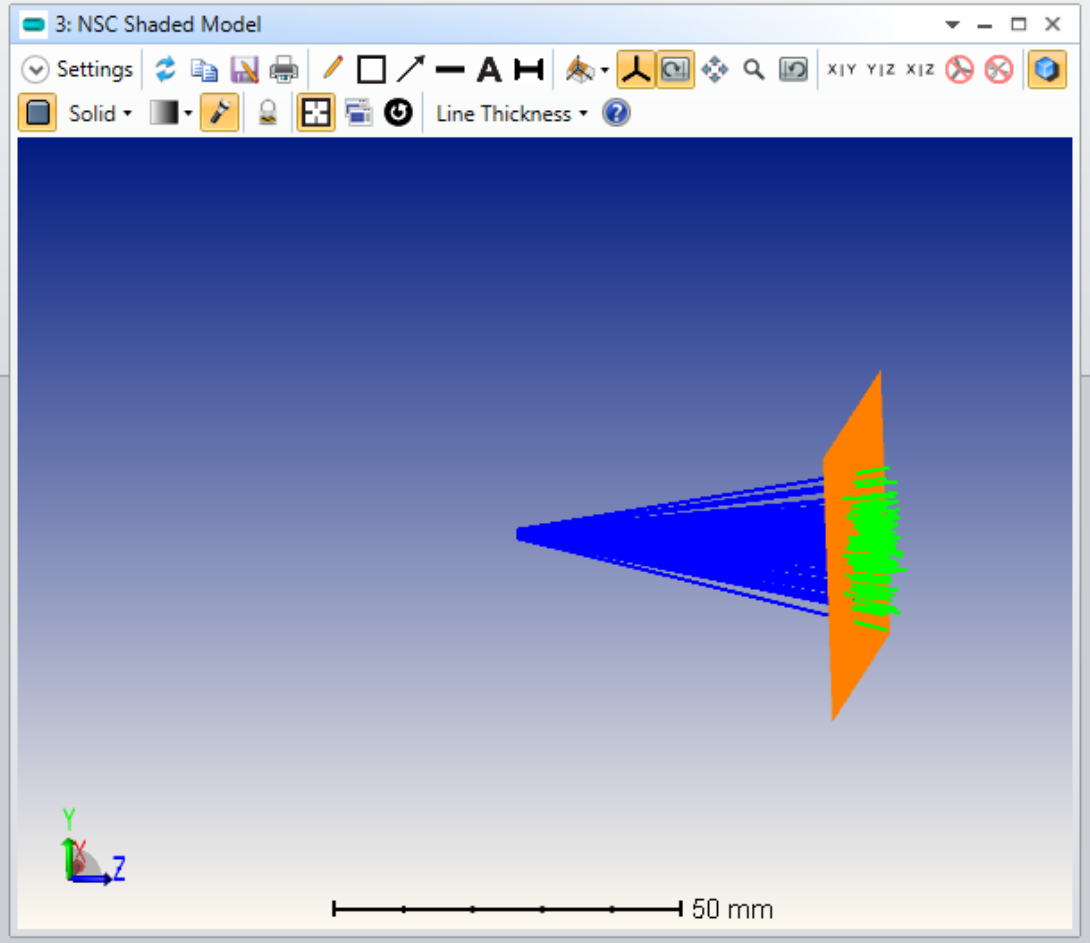
Non-Sequential Component Editor

Update: All Windows

Object 2 Properties

Configuration 1/1

	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
1	Source Gaussian		0	0	0.000	0.000	0.000	0.000	0.000	0.000	-	100	1E+05	1.000	0
2	Detector Rectangle		0	0	0.000	0.000	50.000	0.000	0.000	0.000		20.000	20.000	100	100



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

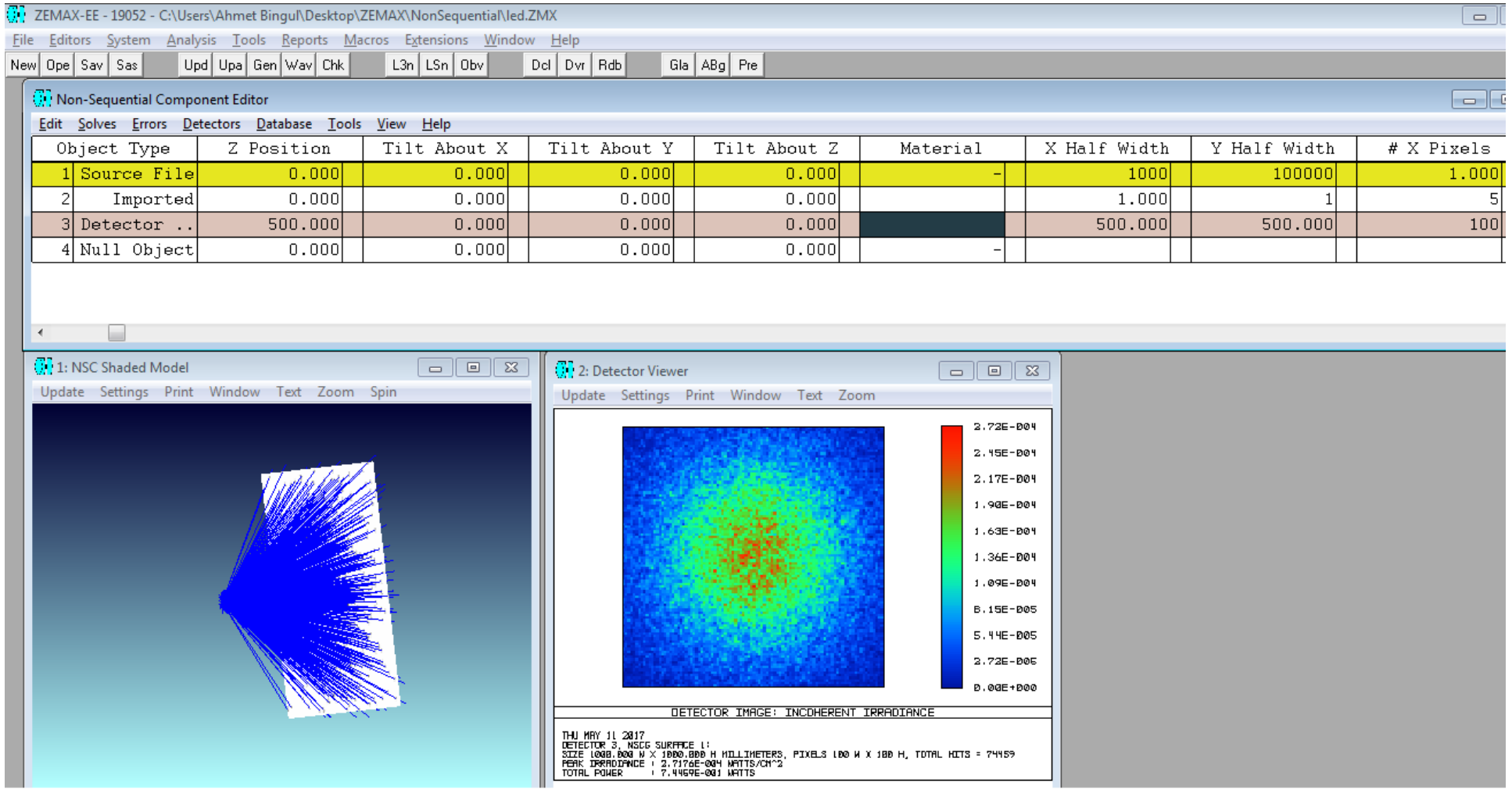
Spectrum files goes to:

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

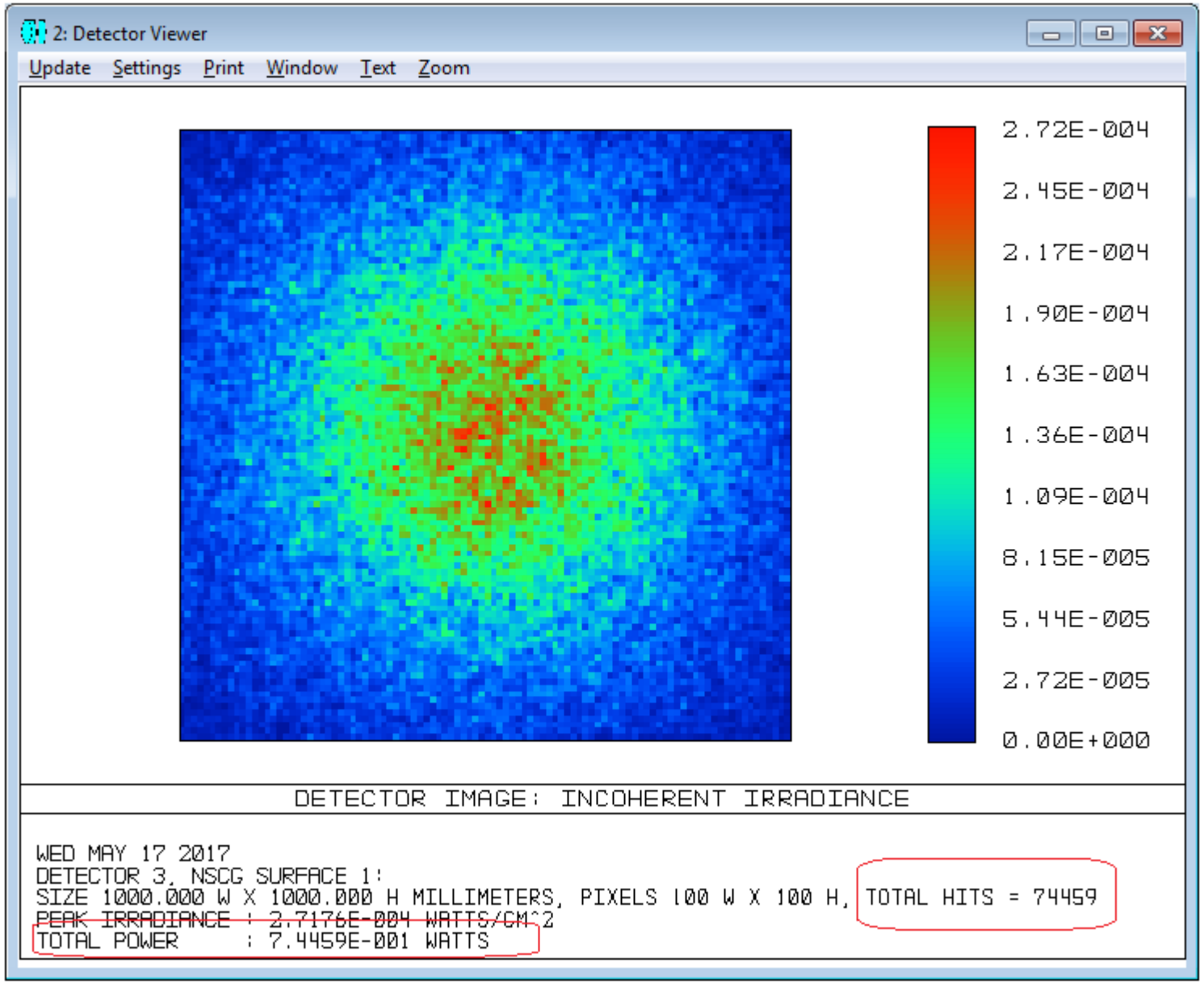
Ray files goes to

C:\<ZEMAX>\Objects\Sources\Source Files

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



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	Detector Rectangle		0	0	0.000	0.000	100.000	0.000	0.000	0.000		100.000	100.000	100	100	0	0	0

	Type	Surf	Det#	Pix#	Data	# Ignored	Spatial Frequency		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