

Lectures Notes on Optical Design using Zemax OpticStudio

Lecture 22 Some Non-Sequential Components

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# Content

In this chapter we will investigate Folders and some NSC Components

- Folders
- Non-sequential Sources
- Non-sequential Detectors
- Non-sequential Geometry Objects
- Polygon Objects
- Examples

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## Folders

The Folders settings are available in the Project Preferences window, which can be displayed via a button in the System section of the Setup Tab. These settings determine where OpticStudio will place or search for certain types of files.

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Başlık	Konum	Derece
Non-sequential Sources	Optic Studio	1
Exceptions and Restrict	Optic Studio	2
General Settings	Optic Studio	3
Methods of Using NSC	Optic Studio	4
Source Volume Ellipse	Optic Studio	5
Source DLL	Optic Studio	6
Source Volume Rectan	Optic Studio	7
Source EULUMDAT File	Optic Studio	8
Source Two Angle	Optic Studio	9
Zemike Surface	Optic Studio	10
Source Filament	Optic Studio	11
Source Point	Optic Studio	
Convert to NSC Group	Optic Studio	13
ZemaxSourceUnits Sou	Optic Studio	
Source Rav	Optic Studio	15
Adding New Source Tv	OpticStudio	16
Source Rectangle	Ontic Studio	17
Source Volume Cylinder	Ontic Studio	18
Polarization (System Ev	Optic Studio	19
Source Imported	Optic Studio	20
Source Imported	Optic Studio	20
Source Tube	Optic Studio	21
Source File	Optic Studio	22
Source Object	Optic Studio	23
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Non-sequential Geomet	Optic Studio	23
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Parameters Common to	OpticStudio	31
Source Diode	OpticStudio	32
Source Diffractive	OpticStudio	33
Summary of NSC Sources	OpticStudio	34
Maximum Source File R	OpticStudio	35
Object Placement	OpticStudio	36
Source IESNA File	Optic Studio	37
Placing Sources Inside	OpticStudio	38
Defining DLLs for Ray	Optic Studio	39
NSC Operands	Optic Studio	40
Non-sequential Compon	Optic Studio	41
Diffraction (object prope	Optic Studio	42
Source Gaussian	Optic Studio	43

## **Non-sequential Sources**

Sources include points, ellipses, rectangles, volumes, data files, and user defined types. Any source may be placed inside of any object, or not in any object, but not both (a source may not straddle an object boundary).

#### Next:

Summary of NSC Sources Parameters Common to All Source Objects Placing Sources Inside Objects Adding New Source Types Source Diffractive Source Diode Source DLL Source Ellipse Source EULUMDAT File Source Filament Source File Source Gaussian Source IESNA File Source Imported Source Object Source Point Source Radial Source Ray Source Rectangle Source Tube Source Two Angle Source Volume Cylinder Source Volume Ellipse

Source Volume Rectangle

Non-sequential	Detectors			<u> </u>
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NSC Operands		Optic Studio		2
Optimization Op	perands (	Optic Studio		3
Non-sequentia	Ray Tra	Optic Studio		4
Non-sequentia	Compon	OpticStudio		5
Detector Color	Object	OpticStudio		6
Object Placem	ent	Optic Studio		2
Detector Recta	angle Obj	Optic Studio		ŏ
Non-sequentia	Geomet	Optic Studio		9
Detector Surfa	re Object	Optic Studio		11
Detector Polar	Object	Optic Studio		12
Source Volume	Rectan	Optic Studio		13
Objects as Det	ectors	Optic Studio		14
Summary of NS	SC Detec	Optic Studio		15
General Setting	IS	Optic Studio		16

## **Non-sequential Detectors**

The available types of detectors in OpticStudio are described in this section.

#### Next:

Summary of NSC Detectors Detector Color Object Detector Polar Object Detector Rectangle Object Detector Surface Object Detector Volume Object Objects as Detectors

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Başlık	Konum	Derece	$\wedge$		
Non-sequential Geom	OpticStudi	1			
Slide (non-sequential	OpticStudi	2			
Binary 1 (non-sequent	OpticStudi	3			
Binary 2 (non-sequent	OpticStudi	4			
Foroidal Hologram (no	OpticStudi	5			
Sphere (non-sequenti	OpticStudi	6			
Diffraction Grating (no	OpticStudi	7			
lones Matrix (non-seq	OpticStudi	8			
Array (non-sequential	OpticStudi	9			
Cylinder 2 Volume	OpticStudi	10			
Tabulated Fresnel Ra	OpticStudi	11			
ReverseRadiance Ta	OpticStudi	12			
Annulus	OpticStudi	13			
Biconic Zemike Surfa	OpticStudi	14			
Hologram Surface	OpticStudi	15			
Annular Aspheric Lens	OpticStudi	16			
Zemike Surface	OpticStudi	17			
Grid Sag Lens 2	OpticStudi	18			
Cone	OpticStudi	19			
CAD Assembly: Autod	OpticStudi	20			
Paraxial Lens	OpticStudi	21			
Aspheric Surface 2	OpticStudi	22			
Nolter Surface	OpticStudi	23			
Grid Sag Lens	OpticStudi	24			
Binary 2A	OpticStudi	25			
Boolean Native	OpticStudi	26			
Forus Volume	OpticStudi	27			
Hologram Lens	OpticStudi	28			
Biconic Surface	OpticStudi	29			
Rectangular Roof	OpticStudi	30			
Triangular Comer	OpticStudi	31			
Standard Surface	OpticStudi	32			
Tabulated Faceted T	OpticStudi	33			
Aspheric Surface	OpticStudi	34			
Fresnel 1	OpticStudi	35			
enslet Array 2	OpticStudi	36			
Toroidal Surface	OpticStudi	37	v		

Onceki sonuçlarda ara Benzer sözcükleri eşleştir Yalnızca başlıklarda ara The Setup Tab > Editors Group (Setup Tab) > Non-sequential Component Editor > Non-sequential Geometry Objects

## **Non-sequential Geometry Objects**

OpticStudio NSC object types include ellipses, triangles, rectangles, spheres, cylinders, and other basic shapes. Complex objects such as arbitrary prisms, aspheric lenses, torics, toruses, and other optical components are also available. The reflective, refractive, and absorptive properties of these objects are determined by the material assigned to the objects.

For details on reflective, refractive, and absorptive properties, see the sections called "Using Material Catalogs" and "Polarization (system explorer)".

Each NSC object type is described in the following summary table, and in greater detail in the following sections. Note these basic objects may be combined to form more complex objects. See the "Object Placement" section of the "Non-sequential Overview" for information on placing objects inside or adjacent to one another.

For information on sources and detectors, please see the sections "Non-sequential Sources" and "Non-sequential Detectors".

If an object type is required that is not listed, please email technical support to suggest the new object type be added to OpticStudio.

#### Next:

Summary of NSC Objects Annular Aspheric Lens Annular Axial Lens Annular Volume Annulus Array (non-sequential geometry objects) Array Ring Aspheric Surface Aspheric Surface 2 Axicon Surface Biconic Lens

A <u>r</u> anacak si	özcükleri yazı	n:
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Polygon	Objecte
	Objects

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	Konulan	Listele		<u>G</u> örüntü	le
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Başlık		Konum		Derece	Γ
Polygon Object	t	OpticStudi		1	
SETNSCPROF	PERTY	OpticStudi		2	
Summary of NS	SC Obj	OpticStudi		3	
Combine Object	ts	OpticStudi		4	
User Defined C	)bject	OpticStudi		5	
CAD Part: STL		OpticStudi		6	
Create Polygor	n Object	OpticStudi		7	
Objects as Det	ectors	OpticStudi		8	
Non-sequentia	Geom	OpticStudi		9	
Tutorial 1: 7-Ce	ell Clust	OpticStudi		10	
Refraction and	Reflec	OpticStudi		11	
User Defined A	pertur	OpticStudi		12	
General Setting	js	OpticStudi		13	
Convert to Proj	ect Dir	OpticStudi		14	
Object Creation	n Com	OpticStudi		15	
NSC Editor To	olbar	OpticStudi		16	
Detector Surfa	ce Obj	OpticStudi		17	
Objects		OpticStudi		18	
Polygon		OpticStudi		19	
Edit Object Da	ta File	OpticStudi		20	
Pyramid (object	ts)	OpticStudi		21	
Paraxial Lens		OpticStudi		22	
OpticStudio File	e Type	OpticStudi		23	
Faceted Surface	e	OpticStudi		24	
Adding New So	ource	OpticStudi		25	
Lens		OpticStudi		26	
Aperture (surfa	ce pro	OpticStudi		27	



**-** +



The polygon object is a very general user-defined object. It can be used to define an open polygon surface or a closed polygon volume with some portions reflective and others refractive or absorptive. The Polygon Object is based on a collection of 3D triangles whose vertices are placed in a file with the POB extension. See the "Defining Polygon Objects" for more details. Any Polygon Object may be used as a detector as described in "Objects as detectors".

Önceki sonuçlarda ara
 Benzer sözcükleri eşleştir

# **Example 22.1: Source Point and a Prism**

	Non-Sequential Compone	nt Editor															▼ = □ >	¢
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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	1
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	-							J



## **Array of point sources**

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

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# **Example 22.2: Source Gaussian (Beam)**

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# **Source File**

- The Source File is a source whose ray coordinates, cosines, and intensity are defined in a user supplied file.
- The file extension may be either DAT or SDF and the file must be placed in the <data>\Objects\Sources\Source Files folder (see "Folders").
- The file format may be either **text** or **binary**, both formats are in Help File.

We will see both formats.

# **Example 22.3:** How to use LED (a binary source file)

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 as a point source in eulumdat file which is used for a quick analysis.
- The ray file 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:

Put Geometry files (igs or step) in
C:\<ZEMAX>\Objects\CAD Files

Put Spectrum files must be in

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

Put Ray files in

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

# **Example 22.4: Simple LED Collimator**

We will use the LED (SFH4718A) placed at (0,0,0), a collimating plano-convex lens and a detector. In the lecture, I will show you both rectangular and polar detectors.

Standard Lens Z pos = 4 mm (can be variable) Clear1=Edge1=Clear2=Edge2 = 6 mm Thickness = 6 mm Radius2 = -6 mm Conic2 = 0 mm  $\frac{\text{Detector}}{\text{Z pos} = 100 \text{ mm}}$ X-Y Half Width = 100 mm X-Y Pixel # = 100

	Object Type		Comn	nent	Re	ef lr	nsi X Positi	ion	Y Position	n Z Posi	tion Tilt	About X	Tilt About Y	Tilt Abou	ıt Z	Materi	al	Radius 1	Co	nic 1	Clear 1	Edge 1	
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3	Standard Lens 🔻					0	0 0.000	)	0.000	4.00	00	0.000	0.000	0.00	0 1	РММА		0.000		0.000	6.000	6.000	
4	Detector Rectangle 🔻					0	0 0.000	)	0.000	100.00	00	0.000	0.000	0.00	0			100.000	1	00.000	100	100	
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## Without collimating lens



## With collimating lens



## **Universal Plot**

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## Polar detector



# **Example 22.5: Text Source File**

The text Source File consists of a single line of header data with just two integer numbers of the form:

number\_of\_rays dimension\_flag

The remaining lines in the file are of the format:

x y z l m n intensity wavelength

#### Example source file:

54							
2.53	7.53	12.98	0.59	0.49	0.63	1.0	0.444
2.50	7.77	17.36	-0.45	0.67	0.64	1.0	0.425
2.31	9.65	52.21	0.12	-0.70	0.69	1.0	0.407
2.34	9.41	47.81	0.47	-0.53	0.69	1.0	0.539
2.32	9.54	50.11	0.56	0.52	0.63	1.0	0.500

#### where

number_of_rays	is the total number of rays in the file.
dimension_flag	is 0 for meters, 1 for inches,
	2 for cm, 3 for feet, and 4 for mm.
x y z	are initial coordinates of the ray.
lmn	are direction cosines (unit vector) of the ray.
intensity	is the intensity of the ray in the range [0,1].
wavelength	is the wavelenth of the ray in micrometers.

See also course web page for Gaussian, Lambertian and Cherencov source file generators written in matlab.

# **Example 25.6: Beam Expander Performance**

## See Chapter 7 before this example.

In Sequential mode, select two lenses from Edmund Optics stock.

#45-008: EPD = 6 mm & EFL = −12 mm.

#45-127: EPD = 25 mm & EFL = +60 mm

 $\lambda = 633 \text{ nm}$ 

Input beam size is 2 mm.

Input beam size is 10 mm.

Optimize system to obtain 5x beam expander.



📄 Lens Data										•	- 🗆 ×
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Surface 6	Properties 🔇	>				Configuration 1/1	$\langle \rangle$				
Sur	face Type	Comment	Radius	Thickness	Material	Clear Semi-Dia	Chip Zone	Mech Semi-Dia	Conic	Coating	TCE x 1
0 OBJECT	Standard 🔻		Infinity	Infinity		0.000	0.000	0.000	0.000		0.00
1 STOP	Standard 🔻		Infinity	10.000		1.000	0.000	1.000	0.000		0.00
2 (aper)	Standard 🔻	45008	Infinity	1.500	N-BK7	2.700 U	0.300	3.000	0.000		
3 (aper)	Standard 🔻		6.200	45.014 V		2.700 U	0.300	3.000	0.000		0.00
4 (aper)	Standard 🔻	45127	Infinity	4.700	N-BK7	12.000 U	0.500	12.500	0.000		
5 (aper)	Standard 🔻		-31.010	20.000		12.000 U	0.500	12.500	0.000		0.00
6 IMAGE	Standard 🔻		Infinity	-		5.061	0.000	5.061	0.000		0.00
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## Now, convert Sequential objects to NSC Group

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		L	ens File			s	Arc	hive			Export				-	Conve	ert		Explode
System	Explorer	0			-	<b>4</b>	Lens Data	()								Convert To	NSC Group		
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#### Non-Sequential Component Editor

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✓ Object 5 Properties (<) >

Configuration

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2	Annulus 🔻	aperture 1	0	0	0.000	0.000	0.000	0.000	0.000	0.000	ABS	
3	Standard Lens 🔻	surfaces 2-3	0	0	0.000	0.000	10.000	0.000	0.000	0.000	N-BK7	
4	Standard Lens 🔻	surfaces 4-5	0	0	0.000	0.000	56.514	0.000	0.000	0.000	N-BK7	
5	Null Object 🔻	Image Plane	0	0	0.000	0.000	81.214	0.000	0.000	0.000	-	
6	Detector Rectangle 🔻	Field 1	5	0	0.000	0.000	0.000	0.000	0.000	0.000		
		<										



## Then,

- Delete Annulus (this was aperture stop in sequential mode)
- Add Rectangular Volume to define a beam splitter
- Rotate and displace detector.

	Non-Sequential Componen	t Editor																	- □ ×
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	Object Type	Comment	Ref Object	Inside Of	X Position	Y Position	Z Position	Tilt About X	Tilt About Y	Tilt About Z	Material	X1 Half Width	Y1 Half Width	Z Length	X2 Half Width	Y2 Half Width	Front X Angle	Front Y Angle	Rear X Angle
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2	Standard Lens 🕶	Lens1	0	) 0	0.000	0.000	10.000	0.000	0.000	0.000	N-BK7	-0.000	0.000	3.000	3.000	1.500	6.200	0.000	3.000
3	Standard Lens 🔻	Lens2	0	) 0	0.000	0.000	57.000	0.000	0.000	0.000	N-BK7	-0.000	0.000	12.500	12.500	4.700	-31.010	0.000	12.500
4	Rectangular Volume 🔻	Beam splitter	0	) 0	0.000	0.000	100.000	45.000	0.000	0.000	N-BK7	15.000	15.000	2.000	15.000	15.000	0.000	0.000	1.000E-02
5	Detector Rectangle 🕶	Detector	0	) 0	0.000	30.000	100.000	90.000	0.000	0.000		10.000	10.000	100	100	0	0	0	0
C		<																	>



After ray tracing, Show Data as Coherent Irradiance in Detector Viewer



## Z position of Lens2 is 56.514 mm



By changing Z position of Lens2 you can tilt the interferance pattern on the detector!



Z position of Lens2 is **56.000** mm

## Z position of Lens2 is 57.000 mm



# **Powell Lens**

Powell Lens

Powell Lenses, also known as laser line generating lenses, create straight and uniform laser lines by fanning out collimated beams in one dimension.



See also: https://www.thorlabs.com/newgrouppage9.cfm?objectgroup\_id=13875

# Example 22.7: LGL130 Powell lens from Thorlabs

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	Object Type	)f	X Position	Y Position	Z Position	Tilt About X	Tilt About Y	Tilt About Z	Material	# Layout Rays	# Analysis Rays	Power(Watts)	Wavenumber	Color #	Beam Size	Position	
1	Source Gaussian 🔻	0	0.000	0.000	0.000	0.000	0.000	0.000	-	50	1E+04	1.000	0	0	0.500	0.000	
2	CAD Part: STEP/IGES/SAT 🔻	0	0.000	0.000	15.000	0.000	0.000	90.000	BK7	1.000	1	5	5	5			
3	Detector Rectangle 🔻	0	0.000	0.000	120.000	0.000	0.000	0.000		30.000	30.000	100	100	0	0	0	
		<															$\rightarrow$
							1										
	15 mm		120	mm											a second		



# **Off-Axis Mirrors (OAP)**

The off-axis parabolic mirror is an important design form in the optics industry.

Parabolic mirrors have the ability to focus collimated light without introducing spherical aberration.

OAP mirror is simply a side section of a parent parabolic mirror. Collimated light that is incident to an OAP mirror is focused to a point. However, unlike a centered parabolic mirror, an OAP mirror has an advantage in that it allows more interactive space around the focal point without disrupting the beam.



## **Commertial Products:**

Edmund Optics

https://www.edmundoptics.com/f/aluminum-off-axis-parabolic-mirrors/39488

Thorlabs

https://www.thorlabs.com/navigation.cfm?guide\_id=15

If the obstruction caused by the image receiver is undesirable, an off-axis parabola may be used The only practical way to construct such a mirror is to make a large on-axis mirror and cut as many off-axis mirrors from it as are needed. Such mirrors are used in mirror monochromators and as Schlieren mirrors for wind tunnel applications.



Cutting three off-axis parabolic mirrors from one large paraboloid.

# Example 22.8: Modeling an off-axis parabolic mirror

This example is extracted from Zemax Knowledgebase

# Design specifications: ENPD = 100 mm EFFL = 1000 mm Off-axis distance = 150 mm Component physical diameter = 203 mm

We will model a commercially-available off-axis parabolic mirror.

The goal of this example is to be able to tilt the mirror about the X axis at any point along the optical axis (Z axis). Back surface of the substrate is perpendicular to the optical axis.

## We will start a new **Sequential Mode** session:

80	Lens Data		2	141 C 1 140 11		And Distance Inc.			
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0	OBJECT S	Standard 🔻	Infinity	Infinity			0.0		0.0
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Surface 2 Pro	operties 🔇 🔊	Configuration	on 1/2 🔇 📎
Type Draw	o This Surface:	Draw Edges	As: Squared To Next Surface 🔻
Aperture Scattering Tilt/Decenter	<ul> <li>This Surface:</li> <li>v This Surface:</li> </ul>	Mirror Subst	rate: Flat • 40

## Add off-axis distance which is 150 mm

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Surface 2 Prope	erties 🔇 🔊		Config	juration 1/2 🔇	>
Type Draw	Before Surfac	e		After Surface:	Reverse This Surface
Aperture	Order:	Decenter,Tilt	•		
Scattering	Decenter X:	0			
Tilt/Decenter Physical Optics Coating Import	Decenter Y:	-150			
	Tilt X:	0			
	Tilt Y:	0			
	Tilt Z:	0			

Specify the physical diameter of the mirror as 203 mm.

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Scattering				Aperture X-Decenter:	0
Physical Optics				Aperture Y-Decenter:	150

Final form of the design.



We can convert design (mirror) to a CAD object to be used as non-sequentail component, by using **CAD Files** button in file menu. Save as **my-off-axis-mirror.stp** 

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## Now, you can switch to Non-squential mode. Add source ellipse, off-axis mirror and a detector.



# Monochromator

Wikipedia says:

A monochromator is an optical device that transmits a mechanically selectable narrow band of wavelengths of light chosen from a wider range of wavelengths available at the input.

In the common Czerny–Turner design, the broad-band illumination source (A) is aimed at an entrance slit (B). The amount of light energy available for use depends on the intensity of the source in the space defined by the slit (width × height) and the acceptance angle of the optical system. The slit is placed at the effective focus of a curved mirror (the collimator, C) so that the light from the slit reflected from the mirror is collimated (focused at infinity). The collimated light is diffracted from the grating (D) and then is collected by another mirror (E), which refocuses the light, now dispersed, on the exit slit (F). In a prism monochromator, a reflective Littrow prism takes the place of the diffraction grating, in which case the light is refracted by the prism.



## Monochromator



# **Exercise 1**

Consider OSRAM Metal Can TO38, PLT3 520D Laser at 633 nm, plano-convex lens from Edmund optics, and the LGL130 Powell lens. The lens will be used to collimate the laser beam, while an annulus will filter out (kill) larger-angle rays from the source. Implement the following design in Zemax



# **Exercise 2**

Implement Czerny–Turner design in Zemax.



For simplicity, you can put

- Point Source at point B (and set wavelength to Phtotopic Bright)
- Annulus at point F with a small diameter (to simulate slit)
- Detector Color at point G

Then, you can play with angular position of the reflecting grating to select desired wavelength at the output slit.

# **Exercise 3**

Try to simulate a 8x beam expander similar to Exercise 25.6.

Use suitable lenses from Edmund catalog

Light source is a Gaussian beam with  $\lambda = 1064$  nm, beam size 2 mm and position 100 mm.

- In squential mode, define source using Object Cone Angle.
- Then, collimate the light with a plano convex lens.
- Then, use two more lenses to expand beam size to about 16 mm.
- In Nonsquential mode, Investigate the performance of the beam exapander on the detector.