

Group 1 – 18.04.2024

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Lens Design I (SS' 24)
Seminar 1

Exercise 1-1: “Stair-mirror-setup” (Homework)

A system with a stair mirror pair, which decenters an incoming collimated ray bundle.

- Beam diameter = 10 mm;
- Beam decentration = 40 mm in the -Y direction;
- Beam wavelength (λ) = 632.8 nm.

After this pair of mirrors, a decentered main objective lens with focal length **f = 200 mm** made of **BK7** is located **25 mm below the optical axis** and focusses the beam.

Questions / Tasks:

- Setup the system.
- Generate layout drawings in 3D as well as “Shaded Model”.
- Check the beam cross section on the second mirror, what is the size of the pattern?
- Determine the optimal sensor plane location. Check the spot of the focused beam. Discuss the shape of this pattern.

Solution 1-1: A (Setup)

LEN5.zos - Zemax OpticStudio 22.2 - Page 2

File Setup Analyze Optimize Tolerance Libraries Part Designer Programming STAR Help

Cross-Section 3D Shaded Model Rays & Spots Aberrations Wavefront PSF MTF RMS Enclosed Energy Extended Scene Analysis Physical Optics Beam Viewer Gaussian Beams Fiber Coupling Polarization Surface Coatings System Viewers

Aperture Type: Entrance Pupil Diameter
Aperture Value: 10.0
Apodization Type: Uniform
Clear Semi-Diameter Margin Millimeters: 0.0
Clear Semi-Diameter Margin %: 0.0
Global Coordinate Reference Surface: 1
Fields Wavelengths Settings
Wavelength 1 (0.6328 μm, Weight = 1.0000)
Enable Primary Wavelength (μm): 0.6328 Weight: 1.0000 Add Wavelength Environment Polarization Advanced Ray Aiming Ray Aiming: Paraxial Use Ray Aiming Cache

Aperture [2] [1]

Surface Properties

Surface Type	Comment	Radius	Thickness	Material	Coating
0 OBJECT	Standard	Infinity	Infinity		
1 STOP	Standard	Infinity	20.000		
2 Coordinate Break		0.0000			
3	Standard	Infinity	0.0000	MIRROR	
4 Coordinate Break		-40.0000			
5 Coordinate Break		0.0000			
6 Standard		Infinity	0.0000	MIRROR	
7 Coordinate Break		40.0000			
8 Coordinate Break	Element Tilt	0.0000			
9 Standard		103.0178 X	5.0000	BK7	
10 Standard		Infinity	-5.0000 T		
11 Coordinate Break	Element Tilt return	5.0000 P			
12 Standard	Dummy	Infinity	189.5387	P	
13 IMAGE	Standard	Infinity	-		

Aperture value – 10 mm
Wavelength – 0.6328 μm

Use paraxial ray-aiming for correct rays' propagation!

For adding folding mirrors use “Add Fold Mirror” [1]
For decentering the lens use “Tilt/Decenter Elements” [2]

Solution 1-1: A-B (Setup & Layouts)

Zemax OpticStudio 22.2 Premium (2) - 26411

File Setup Analyze Optimize Tolerance Libraries Part Designer Programming STAR Help

Cross-Section 3D Viewer Shaded Model Rays & Spots Aberrations Wavefront PSF MTF RMS Enclosed Energy Extended Scene Analysis Physical Optics Beam File Viewer Gaussian Beams Fiber Coupling Polarization Surface Coatings Diffraction Efficiency Reports Universal Plot Reports Universal Plot Applications Stray Light Biconic Systems PAL/Freeform NSC Raytracing

Lens Data X Update: None

Surface 13 Properties Configuration 1/1

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia	Conic	TCE x 1E-6	Par 1(unused)	Par 2(unused)	Par 3(unused)	Par 4(unused)	Par 5(unused)	Par 6(unused)
0 OBJECT	Standard	Infinity	Infinity			0.0000	0.0000	0.0000	0.0000							
1 STOP	Standard	Infinity	20.0000			5.0000	0.0000	5.0000	0.0000							
2 Coordinate Break		0.0000				0.0000	-	-	-		0.0000	0.0000	-45.0000	0.0000	0.0000	0
3 Standard		Infinity	0.0000	MIRROR		7.0711	0.0000	7.0711	0.0000	0.0000						
4 Coordinate Break		0.0000	-40.0000			0.0000	-	-	-		0.0000	0.0000	-45.0000	P	-0.0000	0.0000
5 Coordinate Break		0.0000				0.0000	-	-	-		0.0000	0.0000	45.0000	0.0000	0.0000	0
6 Standard		Infinity	0.0000	MIRROR		7.0711	0.0000	7.0711	0.0000	0.0000						
7 Coordinate Break		40.0000				0.0000	-	-	-		0.0000	0.0000	45.0000	P	-0.0000	0.0000
8 Coordinate Break	Element Tilt	0.0000				0.0000	-	-	-		0.0000	-25.0000	0.0000	0.0000	0.0000	0
9 Standard		103.0178 X	5.0000	BK7		30.0000	0.0000	30.0000	0.0000	-						
10 Standard		Infinity	-5.0000 T			29.9452	0.0000	30.0000	0.0000	0.0000						
11 Coordinate Break	Element Tiltreturn	5.0000 P				0.0000	-	-	-		0.0000 P	25.0000 P	0.0000 P	0.0000 P	0.0000 P	1
12 Standard	Dummy	Infinity	200.0000		P	5.2056	0.0000	5.2036	0.0000	0.0000						
13 IMAGE	Standard	Infinity	-			26.3085	0.0000	26.3085	0.0000							

2: Shaded Model X 1: 3D Layout X

Use the "Element Power" solve for the Radius to get the correct curvature of the lens surface. Target f = 200 mm → Power = 0.005

EFFL: 200 WFNO: 19.112 ENPD: 10 TOTR: 245

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Solution 1-1: C (Beam cross-section)

Zemax OpticStudio 22.2 Premium (2) - 26411

File Setup Analyze Optimize Tolerance Libraries Part Designer Programming STAR Help

Cross-Section 3D Shaded Aberrations PSF MTF RMS Enclosed Energy Extended Scene Analysis Physical Optics Beam File Viewer Gaussian Beams Fiber Coupling Polarization Surface Coatings Diffraction Efficiency Reports Universal Plot Reports Universal Plot Stray Light Biocular Systems PAL/Freform Applications

System Viewers Lens Data X Update: None C Surface 6 Properties

Footprint Diagram

Footprint Diagram

Display the footprint of the beam superimposed on any surface. Used for showing the effects of vignetting and for checking surface apertures

No shortcut key assigned

0.0000

Infinity 0.0000 MIRROR

Coordinate Break Element Tilt

103.0178 X 5.0000 BK7

Coordinate Break Element Tiltreturn

Infinity -5.0000 T

Coordinate Break Element Tiltreturn

Dummy Infinity 189.5387 P

Coordinate Break Element Tiltreturn

Infinity -

IMAGE Standard

Footprint Diagram to get the beam cross-section

Use correct surface number in settings (2nd mirror)
Set the „Ray Density“ high enough to see the full beam

Check the size of the beam

Aperture Diameter: 14.1421 % rays through = 100.00%

Footprint Diagram

12/04/2023

Surface 6:
Ray X Min = -5.0000 Ray X Max = 5.0000
Ray Y Min = -7.0711 Ray Y Max = 7.0711
Max Radius= 7.0711 Wavelength= 0.6328
Legend items refer to Field positions

Zemax OpticStudio 19.4 SP2

Configuration 1 of 1 LENS.zos

Graph Text

WFNO: 19.112 ENPD: 10 TOTR: 234.539

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Solution 1-1: D (Best sensor position)

File Setup Analyze Optimize Tolerance Libraries Part Designer Programming STAR Help

LENS.zos - Zemax OpticStudio 22.2 Premium (2) - 26411

Rays & Spots ▾

- Single Ray Trace
- Ray Aberration
- Standard Spot Diagram

Cross-Section 3D Shaded Model

Lens Data X

System Viewers

Update: None ▾

Surface 12 Properties

Surface Type	Radius	Thickness
0 OBJECT	Infinity	Infinity
1 STOP	20.000	
2 Coordinate	0.0000	
3 Coordinate	0.0000	
4 Coordinate	-40.000	
5 Vignetting Plot	0.0000	
6 Standard	0.0000	
7 Coordinate Break	40.000	
8 Coordinate Break	Element Tilt	0.000
9 Standard	103.0178 X	5.000
10 Standard	Infinity	-5.000 T
11 Coordinate Break	Element Tilt/reture	5.000 P
12 Standard	Dummy	Infinity
13 IMAGE	Infinity	189.5387

Initial sensor position (200 mm)

OBJ: 0.0000 (deg)

IMA: -0.000, -25.895 mm

Best sensor position

OBJ: 0.0000 (deg)

IMA: 0.000, -24.548 mm

Surface: IMA

Spot Diagram

12/08/2023 Units are um. Airy Radius: 14.75 um. Legend items refer to Wavelengths

RMS radius: 211.558 GED radius: 413.760 Scale bar: 1000 Reference: Centroid

Spot size

Graph Text

Surface: IMA

Spot Diagram

12/08/2023 Units are um. Airy Radius: 14.75 um. Legend items refer to Wavelengths

RMS radius: 66.548 GED radius: 125.565 Scale bar: 400 Reference: Centroid

Spot got smaller

Graph Text

Use "Quick Focus" (ctrl+shift+Q) to find the best sensor position (use centroid)

Compare Spot Size in "Standard Spot Diagram" for both positions:

200 mm and "Best position"

Exercise 1-2: “Symmetrical 4F-system”

A telecentric 4F imaging system with two identical plano-convex lenses:

- Lenses' material = BK7;
- Lenses' thickness (d) = 10 mm;
- Approximate lenses' focal length (f) = 100 mm;
- Object space NA = 0.2;
- Object diameter = 10 mm;
- Beam wavelength (λ) = 546.1 nm.

Questions / Tasks:

- a. First, for perfectly symmetrical setup, determine the layout and the spot diagram of the system.
- b. Optimize the image location. Why is the spot size improved?
- c. If the starting aperture is decreased, the system becomes more and more close to diffraction limited. What is the value of the NA to get a diffraction limited system on axis? Take in mind here, that a re-focusing might be necessary due to the lowered spherical aberrations, which depends on the aperture.

Solution 1-2: A (1st half of a setup)

LENS.zos - Zemax OpticStudio 22.2 Premium (2) - 26411

File Setup Analyze Optimize Tolerance Libraries Part Designer Programming STAR Help

Quick Focus Quick Adjust Slider Visual Optimizer Merit Function Editor Optimization Wizard Optimized! Remove All Variables Set All Radii Variable Set All Thickness Variable Global Search Hammer Current Glass Substitution Template Find Best Asphere Convert Asphere Types Stock Lens Matching Test Plate Fitting Test Plate Lists Optimization Tools

System Explorer
Update: None
Aperture
Aperture Type: Object Space NA
Aperture Value: 0.2
Apodization Type: Uniform
Clear Semi-Diameter Margin Millimeters: 0.0
Clear Semi-Diameter Margin %: 0.0
Global Coordinate Reference Surface: 3
Telecentric Object Space
Afoocal Image Space
Iterate Solves When Updating
Fast Semi-Diameters
Check GRIN Apertures

Fields
Open Field Data Editor
Settings
Field 1 (X = 0.0000, Y = 0.0000, Weight = 1.0000)
Field 2 (X = 0.0000, Y = 5.0000, Weight = 1.0000)
Add Field
Wavelengths
Settings
Wavelength 1 (0.5461 um, Weight = 1.0000)
Enable
Primary
Wavelength (um): 0.5461
Weight: 1.0000
Add Wavelength
Environment
Polarization

Lens Data X
Update: None C G + O S D P R E F
Surface 4 Properties Configuration 1/1

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia
0 OBJECT Standard		Infinity	90.0188			5.0000	0.0000	5.0000
1 Standard		Infinity	10.0000	BK7		25.4124	0.0000	25.8261
2 Standard		-51.8722 X	100.0000			25.8261	0.0000	25.8261
3 STOP Standard		Infinity	0.0000			19.6246	0.0000	19.6246
4 IMAGE Standard		Infinity	-			19.6246	0.0000	19.6246

Field Data Editor
Update: None
Field 2 Properties Configuration 1/1

Comment	X (mm)	Y (mm)	Weight
1	0.0000	0.0000	1.0000
2	0.0000	5.0000	1.0000

Field Plot
Field Type: Object Height

Field type "Object height", field points 0 and 5 mm → half of the object

1: 3D Layout X
Settings Line Thickness
Quick Adjust X
Adjust Close

Symmetrical setup is easier to build half by half. Therefore, we define the 1st lens and pre-optimize it for the best performance.

[1] Use the "Quick Adjust" tool to correct the 1st air distance. The 1st lens is a collimating lens, so the Criterion should be Angular!

Note: „Quick Adjust“ doesn't work, when the „Ray-aiming“ is on!

EFFL: 100 WFO: 318.069 ENPD: 4.08248e+09 TOTR: 110

Solution 1-2: A (Full setup)

LENS.zos - Zemax OpticStudio 22.2 Premium (2) - 26411

File | Setup | Analyze | Optimize | Tolerance | Libraries | Part Designer | Programming | STAR | Help

Cross-Section | 3D Viewer | Shaded Model | Rays & Spots | Aberrations | Wavefront | PSF | MTF | RMS | Enclosed Energy | Extended Scene Analysis | Physical Optics | Beam File Viewer | Gaussian Beams | Fiber Coupling | Polarization | Surface | Coatings | Diffraction Efficiency | Reports | Universal Plot | Stray Light | Biocular Systems | PAU/Freform | NSC Raytracing

Lens Data X | Surface 6 Properties X | Configuration 1/1 | 2: Spot Diagram X | 3: 3D Layout X

System Explorer

Surface 6 Properties

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Me
0 OBJECT	Standard	Infinity	90.0188			5.0000	0.0000	
1	Standard	Infinity	10.0000	BK7		23.3750	0.0000	
2	Standard	-51.8722 X	100.0000			23.9266	0.0000	
3 STOP	Standard	Infinity	0.0000			19.8655	0.0000	
4	Standard	Infinity	100.0000			19.8655	0.0000	
5	Standard P	51.8722 P	10.0000	BK7		25.5489	0.0000	
6	Standard	Infinity	90.0188 P			25.0450	0.0000	
7 IMAGE	Standard	Infinity				5.9885	0.0000	

Thickness solve on surface 6

Solve Type: Pickup
From Surface: 0
Scale Factor: 1
Offset: 0
From Column: Current

OBJ: 0.0000 mm IMA: -0.000 mm

OBJ: 5.0000 mm IMA: -4.959 mm

Add the 2nd lens symmetrically. Use "Pick-up" solve for those parameters, which are identical (or mirrored by the sign) to the 1st lens.

12/04/2023 Units are μm . Airy Radius: 1.672 μm . Legend items refer to Wavelengths

Field : 1 2

RMS radius : 322.052 417.404

GEO radius : 471.097 1302.417

Scale bar : 4000 Reference : Centroid

Zemax OpticStudio 19.4 SP2

Configuration 1 of 1 LENS.zos

Graph Text

ENPD: 4.08248e+09 TOTR: 310.019

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Solution 1-2: B (Optimization)

Solution 1-2-b.zos - Zemax OpticStudio 22.2 Premium (2) - 26411

File **Setup** **Analyze** **Optimize** **Tolerance** **Libraries** **Part Designer** **Programming** **STAR** **Help**

Quick Focus **Quick Adjust** **Slider** **Visual Optimizer** **Merit Function Editor** **Optimization Wizard** **Remove All Variables** **Set All Radii Variable** **Set All Thickness Variable** **Global Optimizers** **Hammer Current** **Glass Substitution Template** **Find Best Asphere** **Convert Asphere Types** **Stock Lens Matching** **Test Plate Fitting** **Test Plate Lists**

Lens Data X **Surface 6 Properties** **Configuration 1/1**

Surface Type	Comment	Radius	Thickness	Material
0 OBJECT	Standard	Infinity	90.0188	
1 Standard		Infinity	10.0000	BK7
2 Standard		-51.8722	X 100.0000	
3 STOP	Standard	Infinity	0.0000	
4 Standard		Infinity	100.0000	
5 Standard		51.8722	P 10.0000	BK7
6 Standard		Infinity	89.3882	V
7 IMAGE	Standard	Infinity	-	

Merit Function Editor X **Wizards and Operands** Merit Function: 0.282266344596673

Type
1 DMFS
2 BLNK * Sequential merit function: RMS spot y centroid Y Wgt = 1.0000 GQ 3 rings 6 arms
3 BLNK * No air or glass constraints.
4 BLNK * Operands for field 1.
5 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 0.3816 4.2297
6 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.1164 0.3951 7.2567
7 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 0.0246 0.0175
8 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 0.0000 0.0000
9 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.1164 0.0000 0.0000
10 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 0.0000 0.0000
11 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 -0.3816 4.2297
12 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.1164 -0.3951 7.2567
13 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 -0.0246 0.0175
14 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 -0.3816 4.2297
15 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.1164 -0.3951 7.2567
16 TRCY * 1 0... 0... 0... 0... 0... 0.0000 0.0727 -0.0246 0.0175
17 TRCY * 1 0... 0... 0... 0... 0... 2... 0.0000 0.0727 3.3736... 3.3066E-30
18 TRCY * 1 0... 0... 0... 0... 0... 5... 0.0000 0.1164 3.4934... 5.6729E-30
19 TRCY * 1 0... 0... 0... 0... 0... 7... 0.0000 0.0727 2.1719... 1.3706E-32
20 TRCY * 1 0... 0... 0... 0... 0... 0... 0.0000 0.0727 0.3816 4.2297
21 TRCY * 1 0... 0... 0... 0... 0... 0... 0.0000 0.1164 0.3951 7.2567

1: Spot Diagram 2 X **2: Spot Diagram 1 X** **3: Spot Diagram 1 X**

Spots before optimization:
 Central → RMS radius = 322 µm
 Edge → RMS radius = 417 µm

Spots after optimization:
 Central → RMS radius = 376 µm
 Edge → RMS radius = 379 µm
Balance between two fields!

Use the last air distance as Variable ("V") and optimize using "Optimization Wizard" (Image Quality → Spot)

EFFL: 1e-10 WFNO: 2.50956 ENPD: 4.08248e-09 TOTR: 309.388

Solution 1-2: B (Optimization)

Solution 1-2-b.zos - Zemax OpticStudio 22.2 Premium (2) - 26411

File Setup Analyze Optimize Tolerance Libraries Part Designer Programming STAR Help

New Open Save Save As Insert Lens File Comparator Create Archive Load Archive CAD Files Point Cloud DXF/IGES Linework Zemax Black Box Encrypted Coatings Export to Speos Lens System Convert to Project Directory Convert To NSC Group Prepare For OpticsBuilder Convert File Formats Convert Explode Exit

Lens File

Aperture Type: Object Space NA
Aperture Value: 0.018

Apodization Type: Uniform

Clear Semi-Diameter Margin Millimeters: 0.0

Clear Semi-Diameter Margin %: 0.0

Global Coordinate Reference Surface: 3

Fields Wavelengths Environment Polarization Advanced Ray Aiming Material Catalogs Title/Notes Files Units Cost Estimator

Surface 0 Properties Configuration 1/1

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia
0 OBJECT	Standard	Infinity	92.8799			5.0000
1	Standard	Infinity	10.0000	BK7		6.6206
2	Standard	-51.8722	X 100.0000			6.7339
3 STOP	Standard	Infinity	0.0000			1.8257
4	Standard	Infinity	100.0000			1.8257
5	Standard	51.8722	P 10.0000	BK7		6.9319
6	Standard	Infinity	92.8799	P		6.8104
7 IMAGE	Standard	Infinity	-			5.0688

Decreasing Object Space NA Step-by-step we reach 0.018 for the diffraction-limited system (geometrical aberrations influence image less than diffraction).

Spot size is smaller than Airy disc.

Note how much the system diameter has decreased.

Question: what is the remaining aberration for the outmost field?

OBJ: 0.0000 mm IMA: -0.000 mm

OBJ: 5.0000 mm IMA: -4.999 mm

Surface: IMA Spot Diagram

10/04/2023 Airy Radius: 18.51 μm Legend items refer to Wavelengths Field: 1 2 RMS radius: 13.237 17.975 GED radius: 18.043 35.731 Scale bar: 100 Reference: Centroid Configuration 1 of 1 Solution 1-2-b.zos

Graph Text Quick Adjust X

Adjust Surface: 0 Thickness Criterion: Spot Size Radial Evaluate Surface: Image

EFPL: 1e+10 WFOV: 27.7772 ENPD: 3.60058e+08 TOTR: 312.88

Exercise 1-3: “Apertures, stops and vignetting”

Load the achromat **AAP-125.0-25.4** from the lens catalogue (**CVI Melles Griot, f = 125mm**). Set the diameter of the **entrance pupil to 20 mm** and the **wavelength to 546.1 nm**. Display the wavefront of the achromat for the **field points 0°, 3° and 5°** with different stops and apertures:

- a. With the stop surface at 1st surface of the system;
- b. With the stop surface at the front focal plane (for finding the position of the focal plane, use Analysis → Rays and Spots → Cardinal Points);
- c. With adjusted entrance pupils using System Data → Fields → Settings → Set Vignetting;
- d. Insert a circular central obscuration with 6 mm radius at the 1st surface of the achromat and recalculate the wavefront with and without vignetting factors;
- e. Clear all vignetting, then calculate the ray intersection coordinates (REAY) at the last surface for the upper marginal ray and the chief ray of field 5° in the merit function editor. Interpret the result.

Solution 1-3: Loading the lens

The screenshot shows the Zemax OpticStudio 22.2 interface with the 'Libraries' tab selected. A red box highlights the 'Lens Catalog' icon in the toolbar. The 'Lens Data X' panel displays 'Surface 2 Properties' for Configuration 1/1, listing three surfaces: OBJECT, STOP, and IMAGE. A red box highlights the 'CVI MELLES GRIOT' search term in the 'Search Criteria' dropdown of the 'Lens Catalogs' dialog box. The 'Search Results' list contains numerous lens catalog entries, with 'AAP-1250-25.4 EFL= 125.00, EPD= 21.59 (7.5.2)' highlighted. The 'Load' button in the 'Lens Catalogs' dialog is also highlighted with a red box.

"Lens Catalogs" window won't close by itself once you click on "Load". You need to close it manually.

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia	Conic	TCE x 1E-6
0 OBJECT Standard		Infinity	Infinity			0.0000	0.0000	0.0000	0.0000	0.0000
1 STOP Standard		Infinity	0.0000			0.0000	0.0000	0.0000	0.0000	0.0000
2 IMAGE Standard		Infinity	-			0.0000	0.0000	0.0000	0.0000	0.0000

Lens Catalogs

Search Criteria: CVI MELLES GRIOT

Vendor(s): CVI MELLES GRIOT

Use Effective Focal Length (mm)

Min: 99 Max: 101

Use Entrance Pupil Diameter (mm)

Min: 10 Max: 10

Shape: Type

Equi- Spherical

Bi- GRIN

Plano- Aspheric

Meniscus Toroidal

Of Elements: Any

Selected 795 out of 795 files.

Catalog Report Prescription Layout

Close Load Insert

EFPL: 1e+10 WFNO: 10000 ENPD: 0 TOTR: 0

Solution 1-3: Loading the lens

The screenshot shows the Zemax OpticStudio interface with the file "TEMPSTOK.zmx" open. The main window displays the "Surface 0 Properties" table and the "Wavelength Data" editor. A red box highlights the "Aperture Type" and "Aperture Value" settings in the left sidebar. Another red box highlights the "Fields" section, specifically the "Field Data Editor" and "Wavelengths" list. A third red box highlights the "3D Layout" window showing a ray diagram of a lens system.

Surface 0 Properties

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia	Conic	TCE x 1E-6
0 OBJECT Standard	dummy	Infinity	20.0000			10.8749	0.0000	10.8749	0.0000	0.0000
1 Standard		Infinity	20.0000			12.7000	U	12.7000	0.0000	-
2 STOP (a Standard	AAP-125.0-25.4	77.2340	6.0000	N-BK7		12.7000	U	12.7000	0.0000	-
3 (aper) Standard		-52.3560	3.0000	N-SF2		12.7000	U	12.7000	0.0000	-
4 (aper) Standard		-167.1420	120.6804	M		12.7000	U	12.7000	0.0000	0.0000
5 IMAGE Standard		Infinity	-			11.0682	0.0000	11.0682	0.0000	0.0000

Wavelength Data

Wavelength (μm)	Weight	Primary	Wavelength (μm)	Weight	Primary
1	0.5461	1.0000	13	0.5500	1.0000
2	0.4861	1.0000	14	0.5500	1.0000
3	0.6563	1.0000	15	0.5500	1.0000
4	0.5500	1.0000	16	0.5500	1.0000
5	0.5500	1.0000	17	0.5500	1.0000
6	0.5500	1.0000	18	0.5500	1.0000
7	0.5500	1.0000	19	0.5500	1.0000
8	0.5500	1.0000	20	0.5500	1.0000
9	0.5500	1.0000	21	0.5500	1.0000
10	0.5500	1.0000	22	0.5500	1.0000
11	0.5500	1.0000	23	0.5500	1.0000
12	0.5500	1.0000	24	0.5500	1.0000

3D Layout

Once you loaded the lens, set the aperture, fields and wavelength as given in the task.
We recommend you putting a "dummy" surface after the object with 20 mm air distance after it – so you can better see the incoming rays

EEFL: 124.957 WFO: 6.24857 ENPD: 20 TOTR: 149.68

Solution 1-3: A (STOP at the 1st surface)

Solution 1-3.ZDA - Zemax OpticStudio 22.2 Premium (2) - 26411

Analyze tab selected.

Wavefront Map window open, showing a color-coded wavefront error across the pupil. Sampling is set to 128 x 128, Wavelength is 1, Field is 1, Show As is False Color.

Surface Properties table:

Surface Type	Comments
0 OBJECT	Standard
1	Standard
2 STOP (aper)	Standard AAP
3 (aper)	Standard
4 (aper)	Standard
5 IMAGE	Standard

Wavefront Function details:

- AAP-135_0-SF_4 Precision-grade Visible Cemented Achromat, 13/04/2023
- 0.5461 µm at 0.0000 (dela)
- Peak to Valley = 0.0360 waves, RMS = 0.0129 waves.
- Surface: Image
- Exit Pupil Diameter: 2.0253E+01 Millimeters

Configuration 1 of 1 and **Solution 1-3.ZDA** are listed at the bottom.

Ray Trace Diagram shows light rays passing through the lens system and diverging into the exit pupil.

Text at the bottom left: AAP-125_0-254 Precision-grade Visible Cemented Achromat

Graph at the bottom left: EFL: 124.957

WFNO: 6.24857 at the bottom center

ENPD: 20 at the bottom center

TOTR: 149.68 at the bottom right

14 at the bottom right

To see the wavefront, use the “Wavefront Map” in the Analyze tab. In the settings on the appearing window use higher sampling (128 x 128) and set “Show As” to “False Color” .

Make 3 of such windows: for Field 1 (0°), Field 2 (3°) and Field 3 (5°).

Solution 1-3: A (STOP at the 1st surface)

The screenshot displays the Zemax OpticStudio 22.2 Premium software interface. The top menu bar includes File, Setup, Analyze, Optimize, Tolerance, Libraries, Part Designer, Programming, STAR, and Help. The toolbar contains various optical analysis tools like Cross-Section, 3D Viewer, Shaded Model, Rays & Spots, Aberrations, Wavefront, PSF, MTF, RMS, Enclosed Energy, Extended Scene Analysis, Physical Optics, Beam File Viewer, Gaussian Beams, Fiber Coupling, Polarization, Surface, Coatings, Diffraction Efficiency, Reports, Universal Plot, Stray Light, Biconvex Systems, PAL/Freeform, and NSC Raytracing.

The main workspace shows a lens system setup with a lens data table and a 3D raytrace visualization. The lens data table lists surfaces 0 through 5, including an OBJECT, STOP (aper), and IMAGE surface. The 3D raytrace shows light rays passing through the lenses and converging at the image plane.

Three wavefront maps are displayed in separate windows, each showing a circular pupil with a color scale from 0.0000 to 0.0360 Waves. The first map corresponds to the first window's settings (3x4, Standard, Automatic). The second map corresponds to the second window's settings (3x4, Standard, Automatic). The third map corresponds to the third window's settings (3x4, Standard, Automatic).

At the bottom, three wavefront function tables provide detailed data for each window:

Window	Wavefront Function	Zemax OpticStudio Version	Notes
1	APR-125.0-25.4 Precision-grade Visible Cemented Achromat. 13/04/2023 0.5461 um at 0.0000 (deg) Peak to valley = 0.0360 waves, RMS = 0.0129 waves. Surface: Image Exit Pupil Diameter: 2.0253E+01 Millimeters	19.4 SP2	
2	APR-125.0-25.4 Precision-grade Visible Cemented Achromat. 13/04/2023 0.5461 um at 3.0000 (deg) Peak to valley = 3.6585 waves, RMS = 0.8580 waves. Surface: Image Exit Pupil Diameter: 2.0253E+01 Millimeters	19.4 SP2	
3	APR-125.0-25.4 Precision-grade Visible Cemented Achromat. 13/04/2023 0.5461 um at 5.0000 (deg) Peak to valley = 9.9319 waves, RMS = 2.3597 waves. Surface: Image Exit Pupil Diameter: 2.0253E+01 Millimeters	19.4 SP2	

Solution 1-3: A (STOP at the 1st surface)

When the STOP is at the 1st surface (orange on the Layout), it's default STOP position of this design → all the light from all the object's field points can propagate through the system as it was intended by the design → **there is no vignetting**.

The Zemax OpticStudio interface is shown with the following components:

- Top Bar:** File, Setup, Analyze, Optimize, Tolerance, Libraries, Part Designer, Programming, STAR, Help.
- Left Sidebar:** Cross-Section, 3D Viewer, Shaded Model, Rays & Spots, Aberrations, Wavefront, PSF, MTF, RMS, Enclosed Energy, Extended Scene Analysis, Physical Optics, Beam Viewer, Gaussian Beams, Fiber Coupling, Polarization, Surface Coatings, Diffraction Efficiency, Reports, Universal Plot, Stray Light, Biocular Systems, PAL/Freeform, NSC Raytracing.
- Central Area:** A 3D Layout window showing a optical system with a lens and a stop (represented by an orange rectangle). The rays are blue and red, and the stop is highlighted in orange.
- Bottom Area:** Three Wavefront Map windows labeled 1, 2, and 3. Each map shows a circular pupil with a color scale from blue (low error) to red (high error). The color scales are:
 - Map 1: 0.0000 to 0.0360 Waves
 - Map 2: 0.000 to 3.66 Waves
 - Map 3: 0.0 to 9.9 Waves
- Bottom Left:** Wavefront Function table for Configuration 1 of 1 (TEMPSSTOP.ZMX). It includes parameters like Peak to Valley, RMS, and Exit Pupil Diameter.
- Bottom Right:** Wavefront Function table for Configuration 1 of 1 (TEMPSSTOP.ZMX).
- Bottom Footer:** Graph, Text, WFLN: 6.24857, ENPD: 20, TOTR: 149.68.

Solution 1-3: B (STOP at the focal plane)

Solution 1-3.ZDA - Zemax OpticStudio 22.2 Premium (2) - 26411

Analyze (highlighted)

Rays & Spots (highlighted)

Surface 1 Properties

Surface Type	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone
0 OBJECT	Infinity			0.0000	
1 STOP	20.0000	N-BK7			
2 (aper)	6.0000				
3 (aper)	3.0000	N-SF2			
4 (aper)					
5 IMAGE					

Cardinal Points (highlighted)

Lists for the selected range of surfaces and wavelengths the locations of the focal, principal, anti-principal, nodal, and anti-nodal planes

No shortcut key assigned

Cardinal Point Data Summary

File : C:\Users\dste\OneDrive - Fraunhofer\Seminars_assistance\2023_LD1\2023_Seminar_tasks+solutions\S1\AAP-125-0-25.4 Precision-grade Visible Cemented Achromat
Title: AAP-125-0-25.4 Precision-grade Visible Cemented Achromat
Date : 13/04/2023

Starting surface : 1
Ending surface : 5
Wavelength : 0.546100
Orientation : Y-Z
Lens units : Millimeters

Object space positions are measured with respect to surface 1.
Image space positions are measured with respect to surface 5.
The index in both the object space and image space is considered.

	Object Space	Image Space
Focal Length	-124.956616	124.956616
Focal Planes	103.394687	0.000000
Principal Planes	21.561929	-124.956616
Anti-Principal Planes	-228.351303	124.956616
Nodal Planes	21.561929	-124.956616
Anti-Nodal Planes	-228.351303	124.956616

Y-Pupil (Rel. Units)

X-Pupil (Rel. Units)

Wavefront Function

AAP-125-0-25.4 Precision-grade Visible Cemented Achromat, 13/04/2023 Zemax OpticStudio 19.4 SP2
0.5461 μm at 0.0000 (deg)
Peak to valley = 0.0360 waves, RMS = 0.0129 waves.
Surface: Image
Exit Pupil Diameter: 1.6000E+09 Millimeters

Configuration 1 of 1

Solution 1-3.ZDA

To find the focal plane use "Cardinal Points" tool in the Analyze tab.

Insert a new surface before the dummy and give it a thickness corresponding to the focal plane position you find in the Cardinal Points. Then make this new surface STOP.

Graph Text Graph

WFNO: 6.24857 ENPD: 20 TOTR: 149.68

Solution 1-3: B (STOP at the focal plane) (STOP at the focal plane)

Solution 1-3.ZDA - Zemax OpticStudio 22.2 Premium (2) - 26411

File Setup Analyze Optimize Tolerance Libraries Part Designer Programming STAR Help

Cross-Section 3D Viewer Shaded Model Rays & Spots Aberrations Wavefront PSF MTF RMS Enclosed Energy Extended Scene Analysis Physical Optics Beam Viewer Gaussian Beams Fiber Coupling Polarization Surface Coatings Diffraction Efficiency Reports Universal Plot Stray Light Biocular Systems PAU/Freeform NSC Raytracing

Lens Data X
Update: None **Surface 1 Properties** Configuration 1/1

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zor
0 OBJECT	Standard	Infinity	Infinity			10.0000	0.0000
1 STOP	New STOP	Infinity	103.3947			19.0459	0.0000
2	Standard	dummy	20.0000				
3 (aper)	Standard	AAP-125.0-25.4	77.2340	6.0000	N-BK7	12.7000 U	0.0000
4 (aper)	Standard		-52.3560	3.0000	N-SF2	12.7000 U	0.0000
5 (aper)	Standard		-167.1420	120.6804 M		12.7000 U	0.0000

4: 3D Layout X

New STOP

Some rays of non-axis fields are out of the lens system (vignetting)

1: Wavefront Map 1 X

2: Wavefront Map 2 X

3: Wavefront Map 3 X

Y-Pupil (Rel. Units) X-Pupil (Rel. Units)

Y-Pupil (Rel. Units) X-Pupil (Rel. Units)

Y-Pupil (Rel. Units) X-Pupil (Rel. Units)

Wavefront Function
AAP-125.0-25.4 Precision-grade Visible Cemented Achromat, 13/04/2023 Zemax OpticStudio 19.4 SP2
0.5461 μm at 0.0000 (deg)
Peak to valley = 0.0360 waves, RMS = 0.0129 waves.
Surface: Image
Exit Pupil Diameter: 1.6000E+09 Millimeters

Wavefront Function
AAP-125.0-25.4 Precision-grade Visible Cemented Achromat, 13/04/2023 Zemax OpticStudio 19.4 SP2
0.5461 μm at 3.0000 (deg)
Peak to valley = 3.5383 waves, RMS = 0.7663 waves.
Surface: Image
Exit Pupil Diameter: 1.6000E+09 Millimeters

Wavefront Function
AAP-125.0-25.4 Precision-grade Visible Cemented Achromat, 13/04/2023 Zemax OpticStudio 19.4 SP2
0.5461 μm at 5.0000 (deg)
Peak to valley = 9.8800 waves, RMS = 2.4731 waves.
Surface: Image
Exit Pupil Diameter: 1.6000E+09 Millimeters

Graph Text

WFNO: 6.24857 ENPD: 20 TOTR: 253.075

Solution 1-3: C (Set vignetting)

Incoming rays are re-traced only inside of the system

Click on "Set All Vignetting" in the Field Data Editor. Note the change of the wavefront shape for the non-axis fields!

The screenshot shows the Zemax OpticStudio 22.2 Premium software interface. The top menu bar includes File, Setup, Analyze, Optimize, Tolerance, Help, and various toolbars for System Explorer, Project Preferences, Scale Lens, and Mode. The main window displays a ray trace diagram with a red box highlighting the text "Incoming rays are re-traced only inside of the system". Below the ray trace are three wavefront maps labeled 1, 2, and 3, each showing a circular pattern with a color scale from blue (0.000 Waves) to red (e.g., 3.90 Waves). The bottom section shows wavefront function tables for each map.

Comment	X Angle (°)	Y Angle (°)	Weight	VDX	VDY	VCX	VCY	TAN
1	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	3.0000	1.0000	0.0000	-0.1911	0.0145	0.1911	0.0000
3	0.0000	5.0000	1.0000	0.0000	-0.4135	0.0819	0.4136	0.0000

Wavefront Function
AAP-125-O-25-4 Precision-grade Visible Cemented Achromat, 14/04/2023 Peak to valley = 0.0360 waves, RMS = 0.0129 waves. Surface: Image Exit Pupil Diameter: 1.6000E+09 Millimeters

Wavefront Function
AAP-125-O-25-4 Precision-grade Visible Cemented Achromat, 14/04/2023 Peak to valley = 2.29 waves, RMS = 0.5814 waves. Surface: Image Exit Pupil Diameter: 1.6000E+09 Millimeters

Wavefront Function
AAP-125-O-25-4 Precision-grade Visible Cemented Achromat, 14/04/2023 Peak to valley = 3.90 waves, RMS = 1.0595 waves. Surface: Image Exit Pupil Diameter: 1.6000E+09 Millimeters

Solution 1-3: C (Set vignetting)

-- What does it do?

"Set vignetting" recomputes the vignetting factors for each field based upon the current lens data.

Vignetting factors (VDX, VDY → pupil decentration factors; and VCX, VCY → pupil compression factors) are coefficients which describe the apparent entrance pupil size and location for different field positions.

These vignetting factors should be left at zero if there is no vignetting in the system. The set vignetting algorithm estimates the vignetting decenter and compression factors so that the four marginal rays in the top, bottom, left, and right edges of the pupil pass within the apertures of each surface in the system.

In other words, "Set Vignetting" re-shapes the entrance pupil in such a way, that **it would pass through the optical system entirely. Only the primary wavelength is used.**

The screenshot shows the Zemax OpticStudio software interface. The top menu bar includes File, Setup, Analyze, Optimize, Tolerance, Help, and various tool buttons. The main window displays the 'Field Data Editor' tab, showing 'Field 2 Properties' for Configuration 1/1. A table lists four rows of data with columns for Comment, X Angle (°), Y Angle (°), Weight, and four vignetting factors (VDX, VDY, VCX, VCY). The VDX, VDY, VCX, and VCY columns are highlighted with a red border. Below the table are two wavefront maps labeled '1: Wavefront Map 1 X' and '2: Wavefront Map 2 X'. Each map shows a circular pupil with a color scale from blue (0.0000 Waves) to red (e.g., 0.69 Waves for Map 2). At the bottom, three tables provide detailed wavefront function data for each map.

Comment	X Angle (°)	Y Angle (°)	Weight	VDX	VDY	VCX	VCY
1	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	3.0000	1.0000	0.0000	-0.1911	0.0145	0.1911
3	0.0000	5.0000	1.0000	0.0000	-0.4135	0.0819	0.4136

APR-125-O-25.4 Precision-grade Visible Cemented Achromat, 14/04/2023	Zemax OpticStudio 19.4 SP2
0.5461 μm at 0.0000 (deg)	
Peak to valley = 0.0360 waves, RMS = 0.0129 waves.	
Surface: Image	
Exit Pupil Diameter: 1.6000E+09 Millimeters	
Configuration 1 of 1	
Solution 1-3-b.ZMX	

APR-125-O-25.4 Precision-grade Visible Cemented Achromat, 14/04/2023	Zemax OpticStudio 19.4 SP2
0.5461 μm at 3.0000 (deg)	
Peak to valley = 2.2892 waves, RMS = 0.5814 waves.	
Surface: Image	
Exit Pupil Diameter: 1.6000E+09 Millimeters	
Configuration 1 of 1	
Solution 1-3-b.ZMX	

APR-125-O-25.4 Precision-grade Visible Cemented Achromat, 14/04/2023	Zemax OpticStudio 19.4 SP2
0.5461 μm at 5.0000 (deg)	
Peak to valley = 3.0026 waves, RMS = 1.0595 waves.	
Surface: Image	
Exit Pupil Diameter: 1.6000E+09 Millimeters	
Configuration 1 of 1	
Solution 1-3-b.ZMX	

Graph Text

EFPL: 124.957 WFOV: 6.24857 ENPD: 20 TOTR: 253.075

Solution 1-3: C (Set vignetting)

-- Why is that important?

"Set vignetting" doesn't change the properties of the real object, i.e., if you want to design a system, which would image an apple, and you notice that you have some rays truncated by the system (as on slide 18) it means, that the edges of your image of this apple would have much less light (would be dimmed) than in the center (in some cases it can be even cut-out → completely no light).

Now, if you set vignetting it doesn't mean, that the whole apple will be imaged brightly by the system.

It rather means, that the further design & optimization will be focused only on the part of the image, which is built by the rays, which are not truncated by the system.

If there are truncated rays, but you don't set vignetting, then the further optimization will consider those rays, which are out of the system → inefficient calculation.

If you set vignetting, the optimization will consider only the rays, which pass through the system.

The screenshot shows the Zemax OpticStudio interface with the following details:

- Top Bar:** File, Setup, Analyze, Optimize, Tolerance, Help.
- Mode Selection:** Sequential (highlighted in yellow), Non-Sequential, Lens Data.
- Toolbars:** System Explorer, Project Preferences, Scale Lens, Mode, Field Data Editor, Lens Data.
- Field 2 Properties:** Configuration 1/1, showing a table of ray parameters (X Angle, Y Angle, Weight, VDX, VDY, VCX, VCY) for rays 1, 2, and 3.
- Wavefront Maps:** Three plots showing wavefront aberration across the pupil. Map 1 shows the full circular pupil with a color scale from 0.0000 to 0.0360 Waves. Map 2 shows a semi-circular pupil with a color scale from 0.00 to 0.0360 Waves. Map 3 shows a semi-circular pupil with a color scale from 0.00 to 0.00 Waves.
- Bottom Status Bars:** Graph, Text, WFOV: 6.24857, ENPD: 20, TOTR: 253.075.
- Bottom Tables:** Wavefront Function tables for Configuration 1 of 1, Solution 1-3-b.ZMX.

Solution 1-3: D (Obscuration)

Remove vignetting with "Clear All Vignetting" and put a circular obscuration with 6 mm radius at the 1st surface of the system.

Now even more rays are blocked.

Do the same with “Set All Vignetting” and compare the wavefront images of two cases.

Remove vignetting with "Clear All Vignetting" and put a circular obscuration with 6 mm radius at the 1st surface of the system.

Now even more rays are blocked.

Do the same with "Set All Vignetting" and compare the wavefront images of two cases.

The screenshot shows the Zemax OpticStudio software interface. The top menu bar includes File, Setup, Analyze, Optimize, Tolerance, Libraries, Part Designer, Programming, STAR, and Help. Below the menu is a toolbar with various icons for file operations like New, Open, Save, Insert, etc. A System Explorer window is visible on the left. The main workspace displays a lens system diagram with multiple lenses and a wavefront map. A table of lens parameters is shown, with the aperture settings highlighted. A color scale for the wavefront map ranges from 0.00 to 8.12 waves. The bottom status bar provides wavefront function details and file paths.

Comment	X Angle (°)	Y Angle (°)	Weight	VDX	VDY	VCX	VCY	TAN
1	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	3.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	5.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Surface Type	Comment	Radius	Thickness	Material	Coating	Semi-Diameter	Chip Zone	Mech Semi-Dia	Conn	TCE x 1E-6
0 OBJECT	Standard	Infinity	Infinity			Infinity	0.0000	Infinity	0.0000	0.0000
1 STOP	Standard	New STOP	103.3947			10.0000	0.0000	10.0000	0.0000	0.0000
2	Standard	dummy	20.0000			19.0459	0.0000	19.0459	0.0000	0.0000
3 (aper)	Standard	AAP-125.0-25.4	77.2340	6.0000	N-BK7	12.7000 U	0.0000	12.7000	0.0000	-
4 (aper)	Standard		-52.3560	3.0000	N-SF2	12.7000 U	0.0000	12.7000	0.0000	-
5 (aper)	Standard		-167.1420	120.6804 M		12.7000 U	0.0000	12.7000	0.0000	0.0000
6 IMAGE	Standard		Infinity	-		10.9188	0.0000	10.9188	0.0000	0.0000

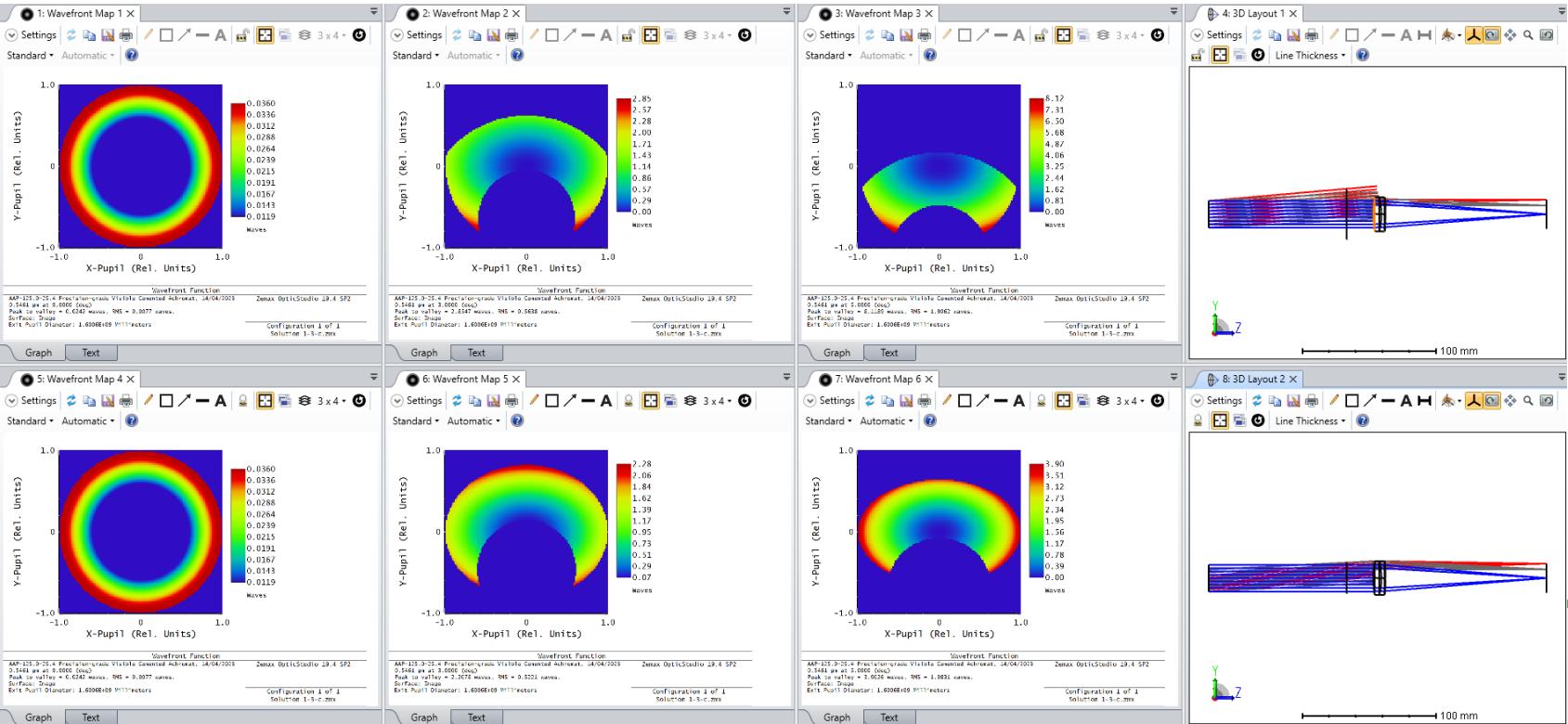
Wavefront Function
125.0-25.4 Precision-grade Visible Cemented Achromat, 14/04/2023
0.1 micrometers = 3.0000 Edges from center to valley = 8.1189 waves, RMS = 1.9062 waves.
Surface: Image
Exit Pupil Diameter: 1.6000E+09 Millimeters
Configuration 1 of 1
Solution 1-3-c.zmx

Graph Text

Solution 1-3: D (Obscuration → Result)

Top images → Without "Set Vignetting"

Bottom images → With "Set Vignetting"



Solution 1-3: E (Ray coordinates)

Zemax OpticStudio 22.2 Premium - 26411

Optimize (highlighted)

Merit Function Editor

Lens Data X

Surface 2 Properties

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia
0 OBJECT	Standard	Infinity	Infinity			Infinity	0.0000	Infinity
1 STOP	Standard	New STOP	Infinity	103.3947		10.0000	0.0000	10.0000
2	Standard	dummy	Infinity	20.0000		19.0459	0.0000	19.0459
3 (aper)	Standard	AAP-125.0-25.4	77.2340	6.0000	N-BK7	12.7000 U	0.0000	12.7000
4 (aper)	Standard		-52.3560	3.0000	N-SF2	12.7000 U	0.0000	12.7000
5 (aper)	Standard		-167.1420	120.6804 M		12.7000 U	0.0000	12.7000
6 IMAGE	Standard	Infinity	-			10.9188	0.0000	10.9188

Field Data Editor X

Field 2 Properties

Comment	X Angle (°)	Y Angle (°)	Weight	VDX	VDY	VCX	VCY	TAN
1	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	3.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
3	0.0000	5.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Merit Function Editor X

Wizards and Operands

Calculation without "Set Vignetting":

Is there something worth to note on the value of the rays' coordinates?

Ray height is ~21 mm

20 mm

WFNO: 6.24857 ENPD: 20 TOTR: 253.075

Solution 1-3: E (Ray coordinates)

Lens Data X

Surface Type	Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	Chip Zone	Mech Semi-Dia
0 OBJECT	Standard	Infinity	Infinity			Infinity	0.0000	Infinity
1 STOP	Standard	New STOP	Infinity	103.3947		10.0000	0.0000	10.0000
2	Standard	dummy	Infinity	20.0000		11.6733	0.0000	11.6733
3 (aper)	Standard	AAP-125.0-25.4	77.2340	6.0000	N-BK7	12.7000 U	0.0000	12.7000
4 (aper)	Standard		-52.3560	3.0000	N-SF2	12.7000 U	0.0000	12.7000
5 (aper)	Standard		-167.1420	120.6804 M		12.7000 U	0.0000	12.7000
6 IMAGE	Standard	Infinity	-			10.9188	0.0000	10.9188

Field Data Editor X

Comment	X Angle (°)	Y Angle (°)	Weight	VDX	VDY	VCX	VCY	TAN
1	0.0000	0.0000	1.0000	0.0000	0.0000	0.0000	0.0000	0.0000
2	0.0000	3.0000	1.0000	0.0000	-0.1873	0.0136	0.1873	0.0000
3	0.0000	5.0000	1.0000	0.0000	-0.4135	0.0819	0.4136	0.0000

Wizards and Operands

Type	Comment
1 BLNK	
2 REAY	5 1 0.0000 1.0000 0.0000 1.0000 0.0000 0.0000 12.6996 0.0000
3 REAY	5 1 0.0000 1.0000 0.0000 0.0000 0.0000 0.0000 6.9492 0.0000
4 BLNK	
5 BLNK	

1: 3D Layout X

Ray height is ~12 mm

Calculation with "Set Vignetting":

What has changed? Why?

Hint – the answer was given in the previous slides of this exercise.

20 mm

WFNO: 6.24857 ENPD: 20 TOTR: 253.075



Thank you for attention!
End of Seminar 1