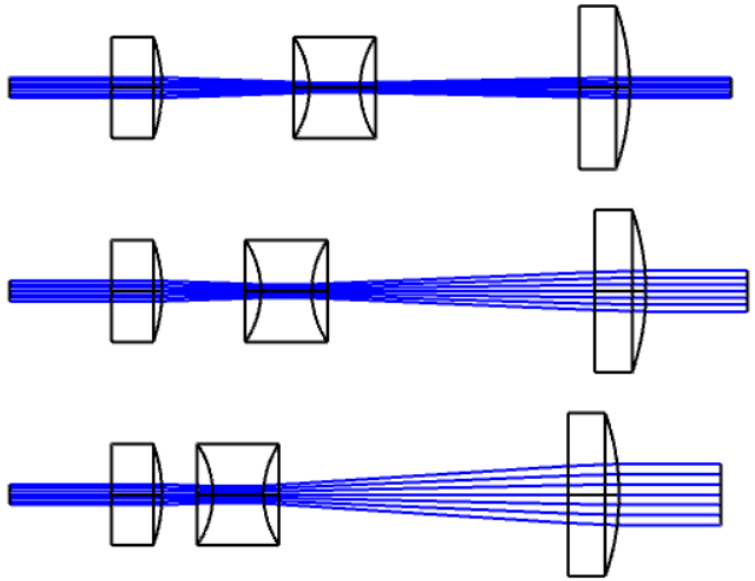
Lectures Notes on Optical Design using Zemax OpticStudio

Lecture 16

Multiple Configuration Editor



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What is Multi-Configuration System?

- Any optical system which has more than one way for the light to travel from object to image

- The Multi-Configuration Editor (MCE) is used to specify the differences between the different modes

- Any system or surface property can be “switched” via the MCE, including:
  – Aperture size, type
  – Material
  – Fields, wavelengths
  – Thickness (including object)

Some Types of MC Systems

Some applications requiring use of MCs include:

- Zoom lenses (Position of elements varies)
- Athermalized lenses (temperature and pressure varies)
- Multiple-path systems
  - Lenslet arrays
  - Interferometers
  - Beam splitters
  - etc …

MCE in Zemax

- MCE is an editor to define different types of optical configuations.

- See **Setup** tab in Zemax.

- It is mostly used to perform additional optimazations which is not possible in LDE.

- As in LDE, any value in MCE can be assigned as variable (V) and included to the optimzation calculations.

Variable Definitions

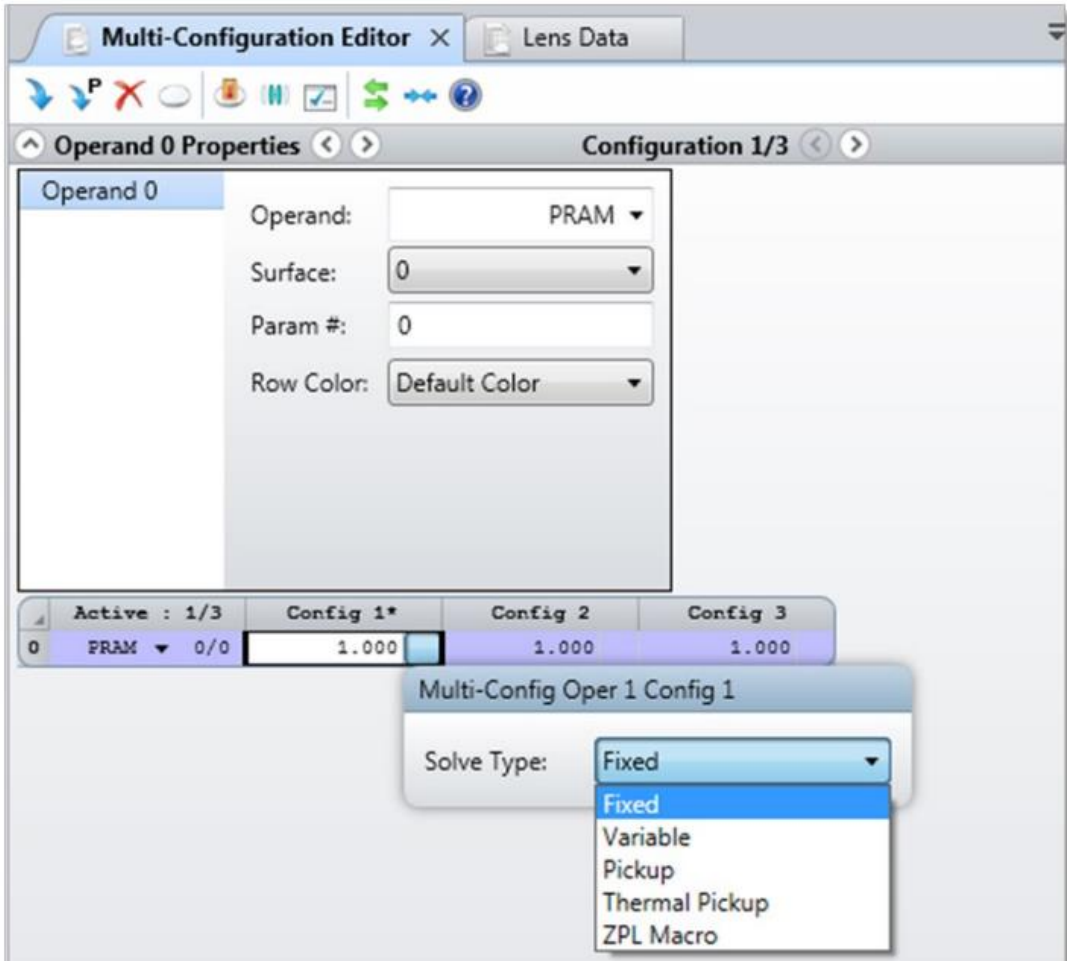
You can click on any operand to obtain list of

Solve Type’s.

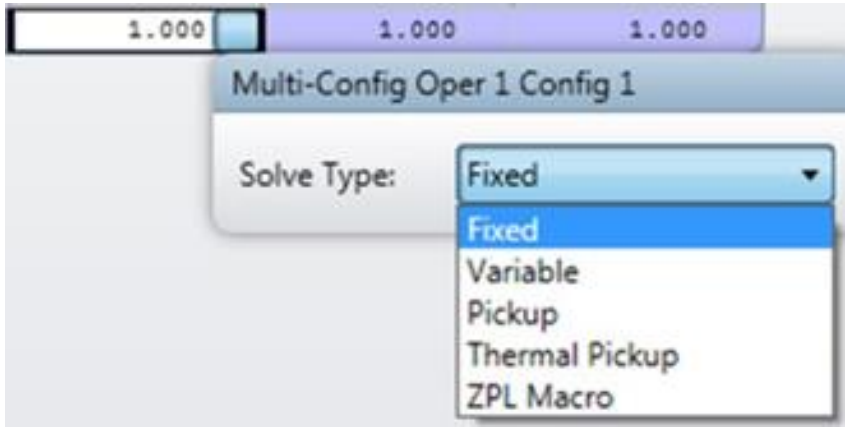
Fixed,

Variable

etc.



Variable Definitions



- **Fixed**
  used not to change a value
- **Variable**
  used for numerical operands
- **Substitute**
  used to select glasses from material catalog.
- **Pickup**
  used to get values from other cells.
- **Themal Pickup**
  used to evaluate some thermal effects on a physical parameter
- **ZPL Macro**
  used to call a ZPL macro to bring calcuations in the macro file.

Example 1: Simple Telephoto Lens Design

Design contains two lenses. ENPD=25 mm, λ = 550 nm, FOV = 5º.

1st lens (Edmund Optics)

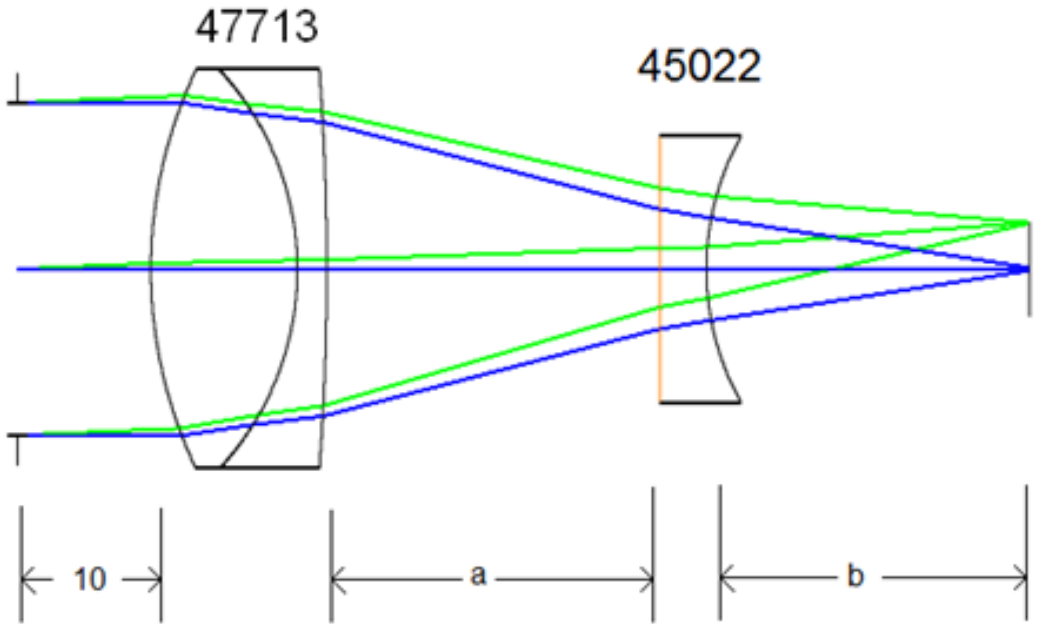
EFFL = 30 mm

Code = 47713

2nd lens (Edmund Optics)

EFFL = −40 mm

Code = 45022



We will implement a simple autofocus zoom lens system.

Thickness *a* and *b* are variable.

Given vector **a** = [25, 27, 30, 32, 35] mm.

Determine vector **b** such that the system always in focus.

- Add lenses to LDE ftom **Lens Catalog** in **Libraries Tab**.
- To reduce aberrations, reverse the surfaces of the second lens.

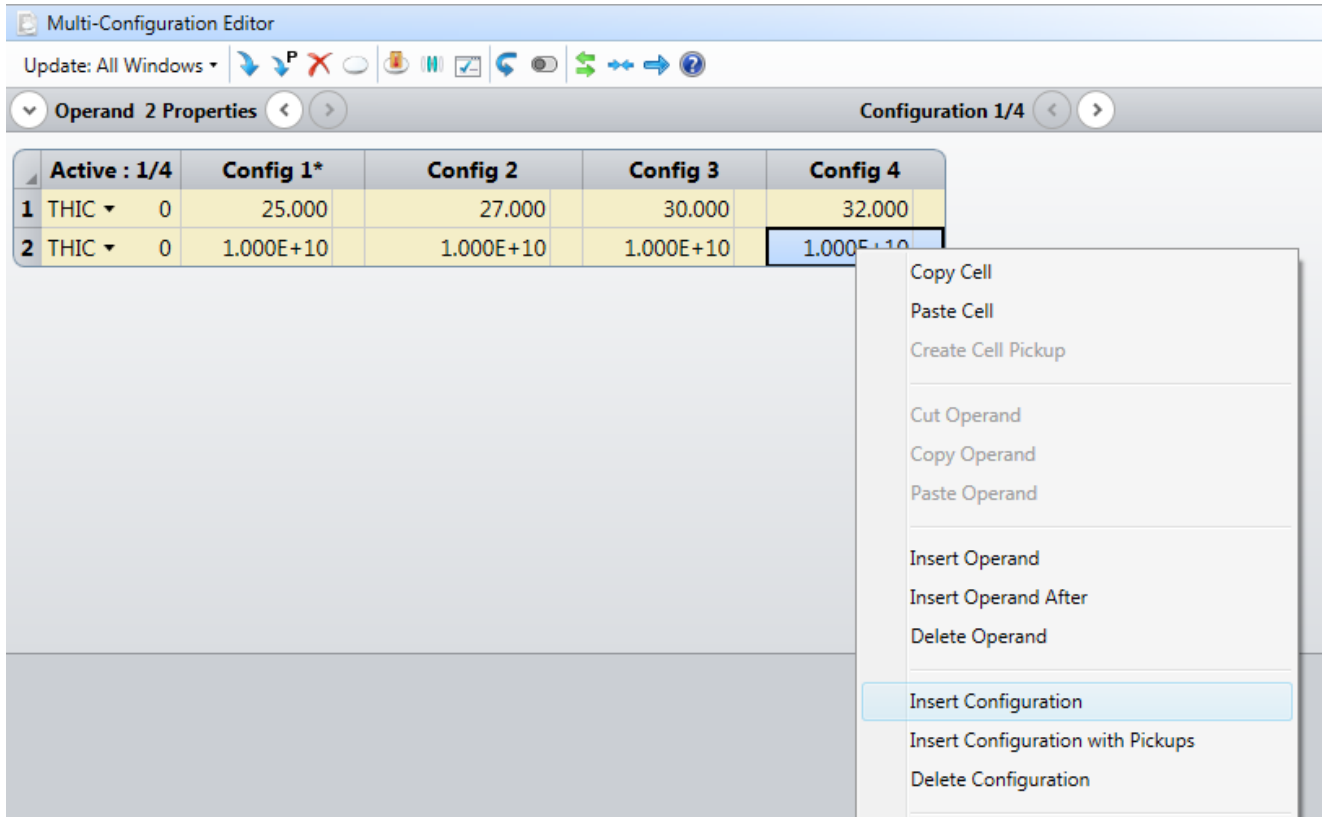
Lens Data

Update: All Windows

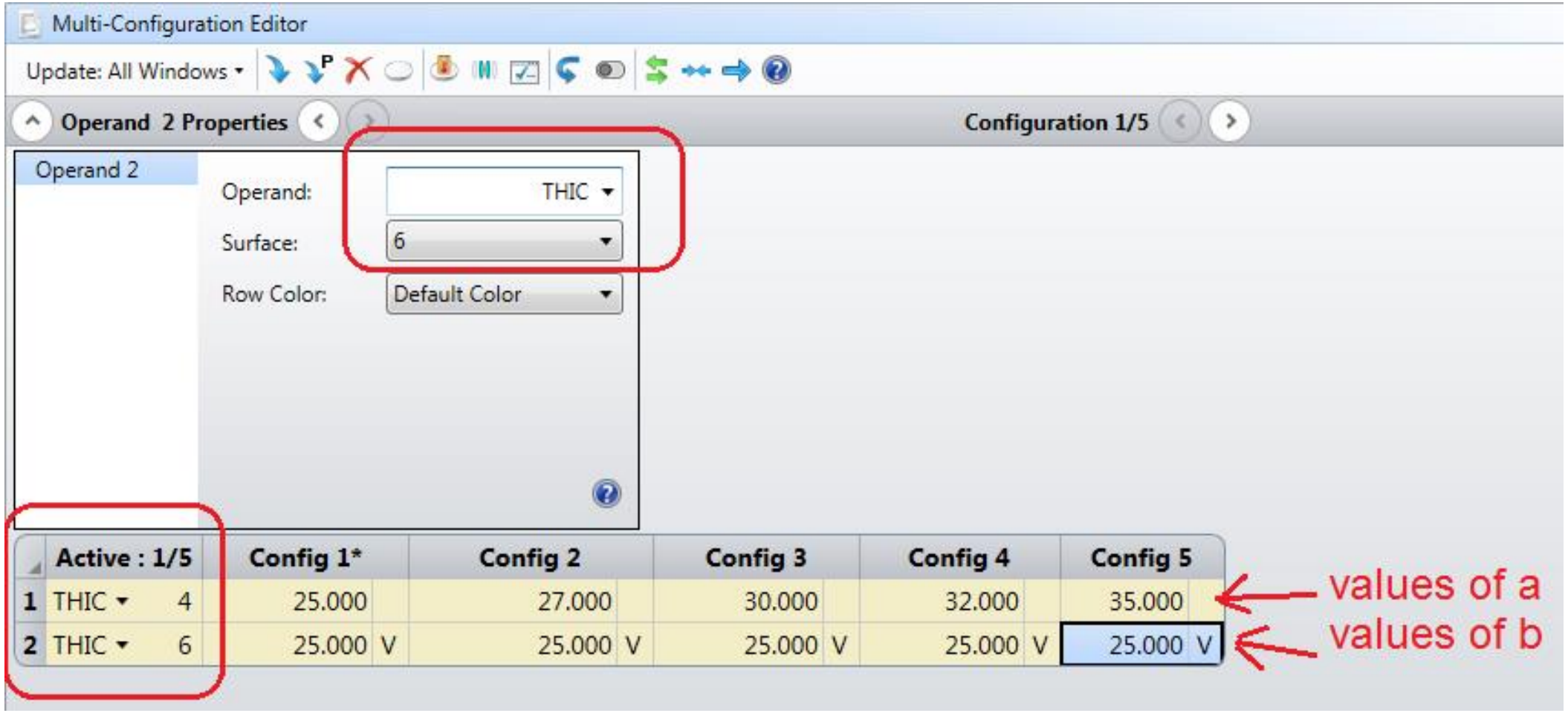
Surface 7 Properties Configuration 1/4

	Surface Type		Comment	Radius	Thickness	Material	Coating	Clear Semi-Dia	
1	STOP	Standard		Infinity	10.000			12.500	
2	(aper)	Standard	47713	34.810	11.000	N-BAF10	EO_VIS0_673	14.500	U
3	(aper)	Standard		-22.120	2.200	N-SF10		14.500	U
4	(aper)	Standard		-203.480	25.000		EO_VIS0_717	14.500	U
5	(aper)	Standard		Infinity	3.500	N-BK7		9.500	U
6	(aper)	Standard		20.670	24.221			9.500	U
7	IMAGE	Standard		Infinity	-			3.502	

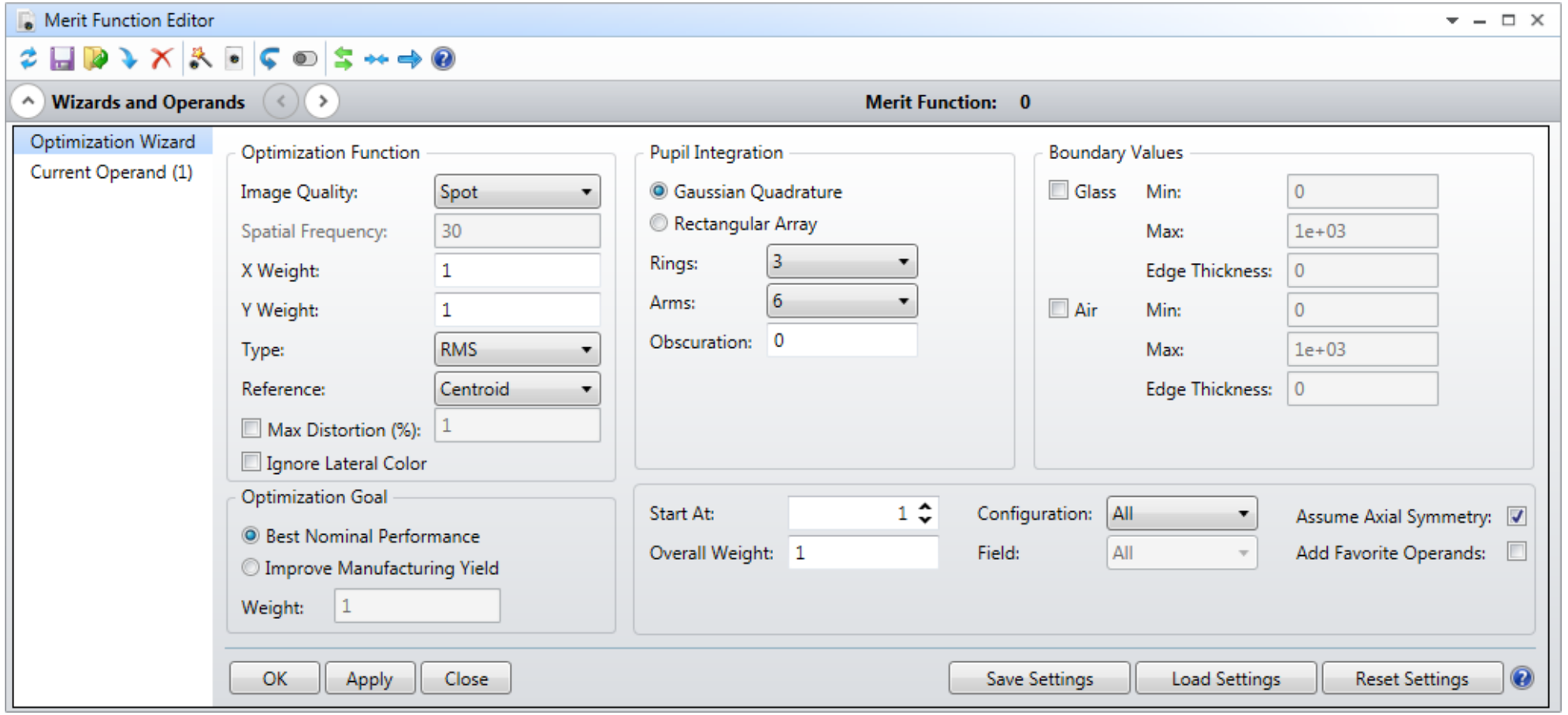
- Open **MCE** from **Setup** Tab. Add **2 rows** and **5 columns**. Each row is an operand and each column is a configuation.
- To determine thicknesses, write **THIC** operand to all rows in the first column.



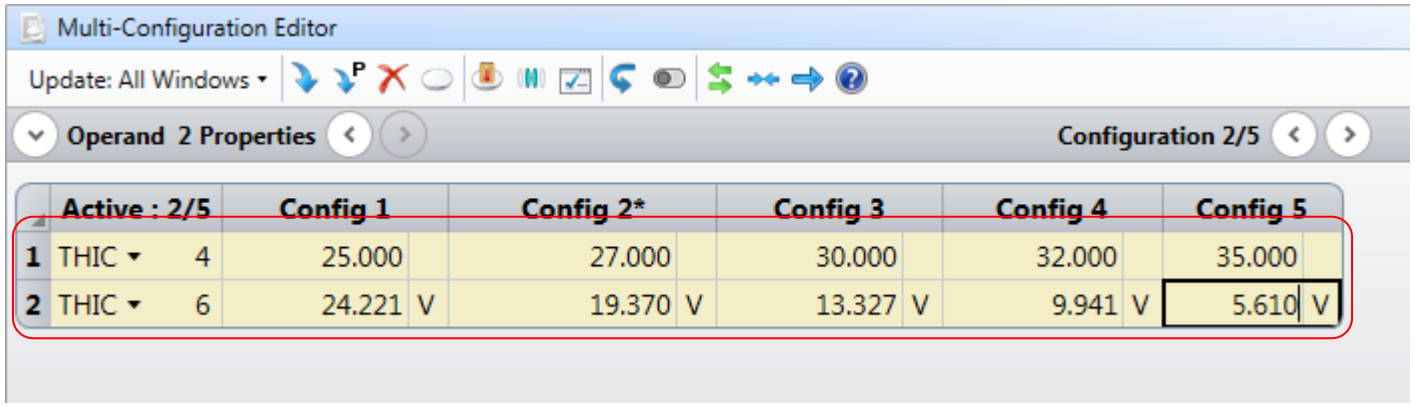
Final MCE table will look like:



Setup **MFE** as below. Click on OK. After optimization, the system will be in focus for each configuration automatically.

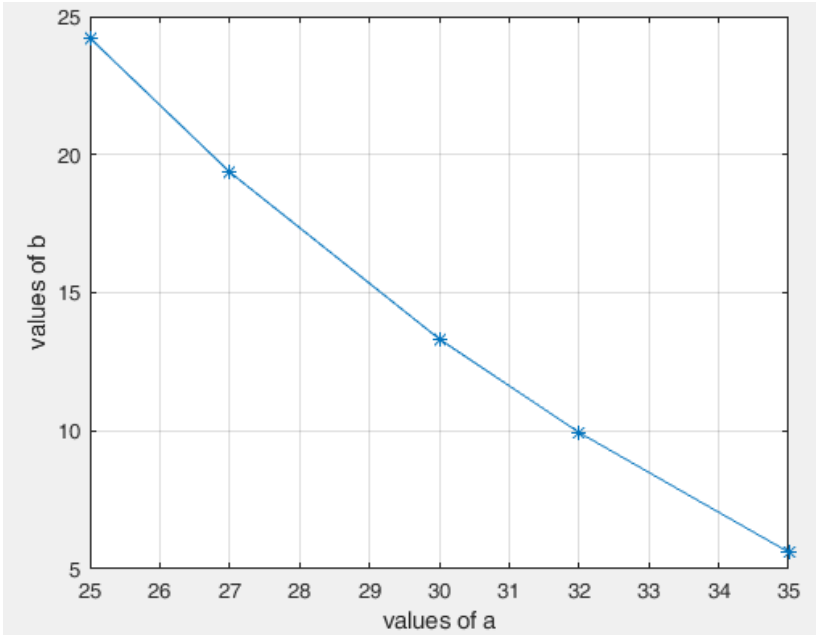


At the end of optimzation, values of **b** are computed by Zemax as follows:



Active : 2/5		Config 1	Config 2*	Config 3	Config 4	Config 5
1 THIC	4	25.000	27.000	30.000	32.000	35.000
2 THIC	6	24.221 V	19.370 V	13.327 V	9.941 V	5.610 V

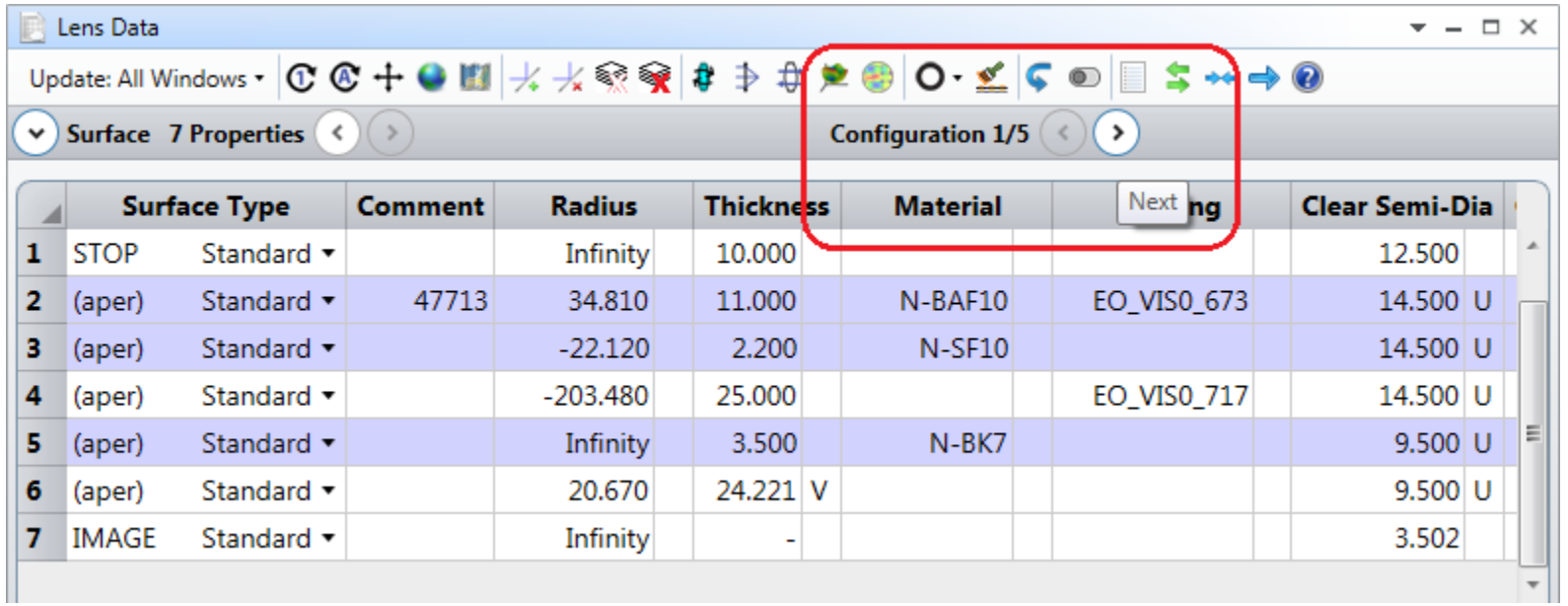
a	b	EFFL
25	24.221	80.88
27	19.370	74.80
30	13.327	67.23
32	9.941	62.98
35	5.610	57.52



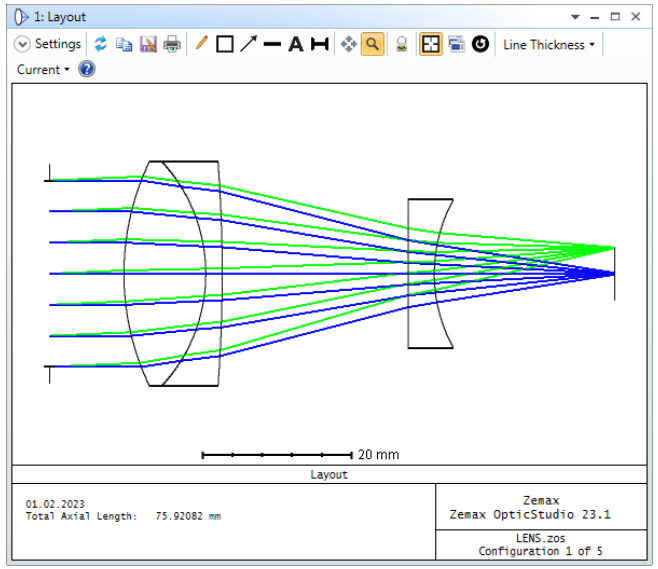
Switching between confiuguations

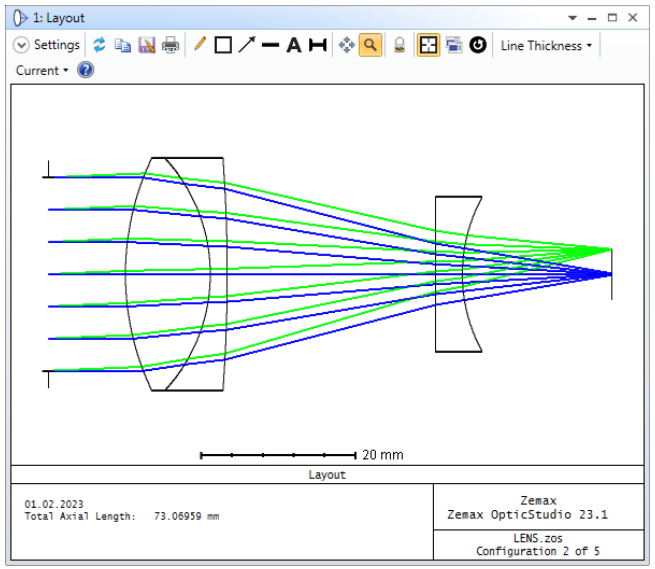
There are two ways.

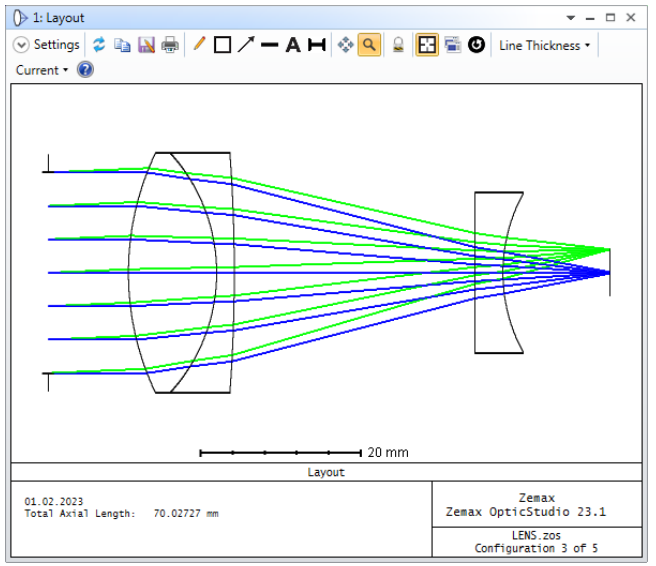
- Click on **Configuration** buttons (forward/backward) in LDE.
- Use **CTRL +A** key combination.

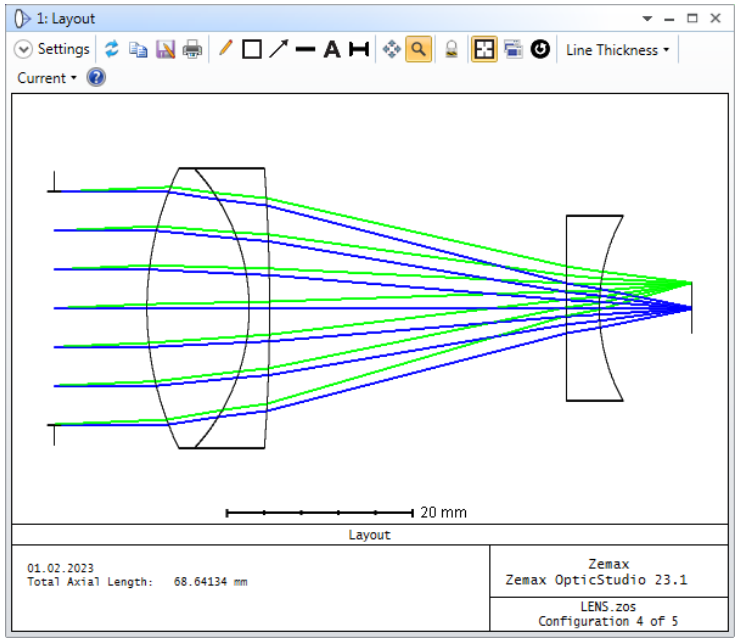


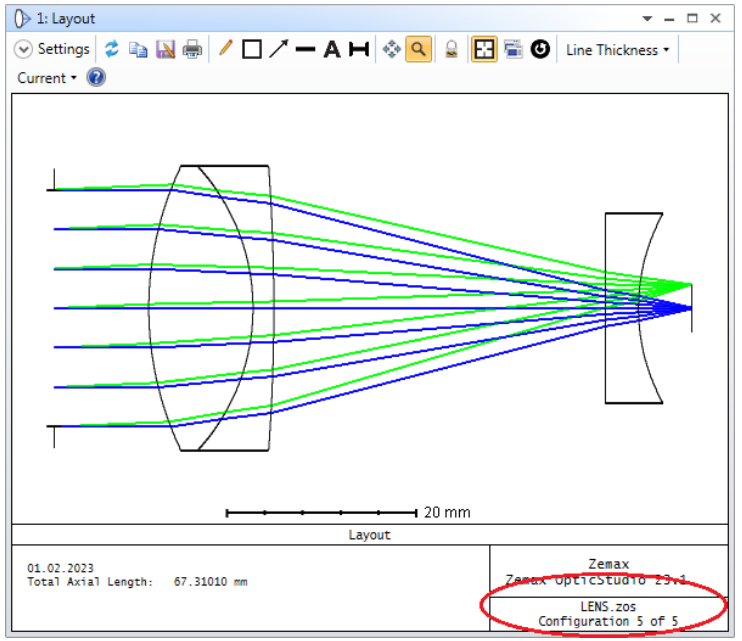
	Surface Type		Comment	Radius	Thickness		Material		Clear Semi-Dia	
1	STOP	Standard		Infinity	10.000				12.500	
2	(aper)	Standard	47713	34.810	11.000		N-BAF10	EO_VIS0_673	14.500	U
3	(aper)	Standard		-22.120	2.200		N-SF10		14.500	U
4	(aper)	Standard		-203.480	25.000			EO_VIS0_717	14.500	U
5	(aper)	Standard		Infinity	3.500		N-BK7		9.500	U
6	(aper)	Standard		20.670	24.221	V			9.500	U
7	IMAGE	Standard		Infinity	-				3.502	


1: Layout
Settings
Line Thickness
Current
20 mm
Layout
01.02.2023
Total Axial Length: 75.92082 mm
Zemax
Zemax OpticStudio 23.1
LENS.zos
Configuration 1 of 5


1: Layout
Settings
Line Thickness
Current
20 mm
Layout
01.02.2023
Total Axial Length: 73.06959 mm
Zemax
Zemax OpticStudio 23.1
LENS.zos
Configuration 2 of 5


1: Layout
Settings
Line Thickness
Current
20 mm
Layout
01.02.2023
Total Axial Length: 70.02727 mm
Zemax
Zemax OpticStudio 23.1
LENS.zos
Configuration 3 of 5


1: Layout
Settings
Line Thickness
Current
20 mm
Layout
01.02.2023
Total Axial Length: 68.64134 mm
Zemax
Zemax OpticStudio 23.1
LENS.zos
Configuration 4 of 5


1: Layout
Settings
Line Thickness
Current
20 mm
Layout
01.02.2023
Total Axial Length: 67.31010 mm
Zemax
LENS.zos
Configuration 5 of 5

Zoom value

In auto focus (or manual focus) zoom system, the ratio

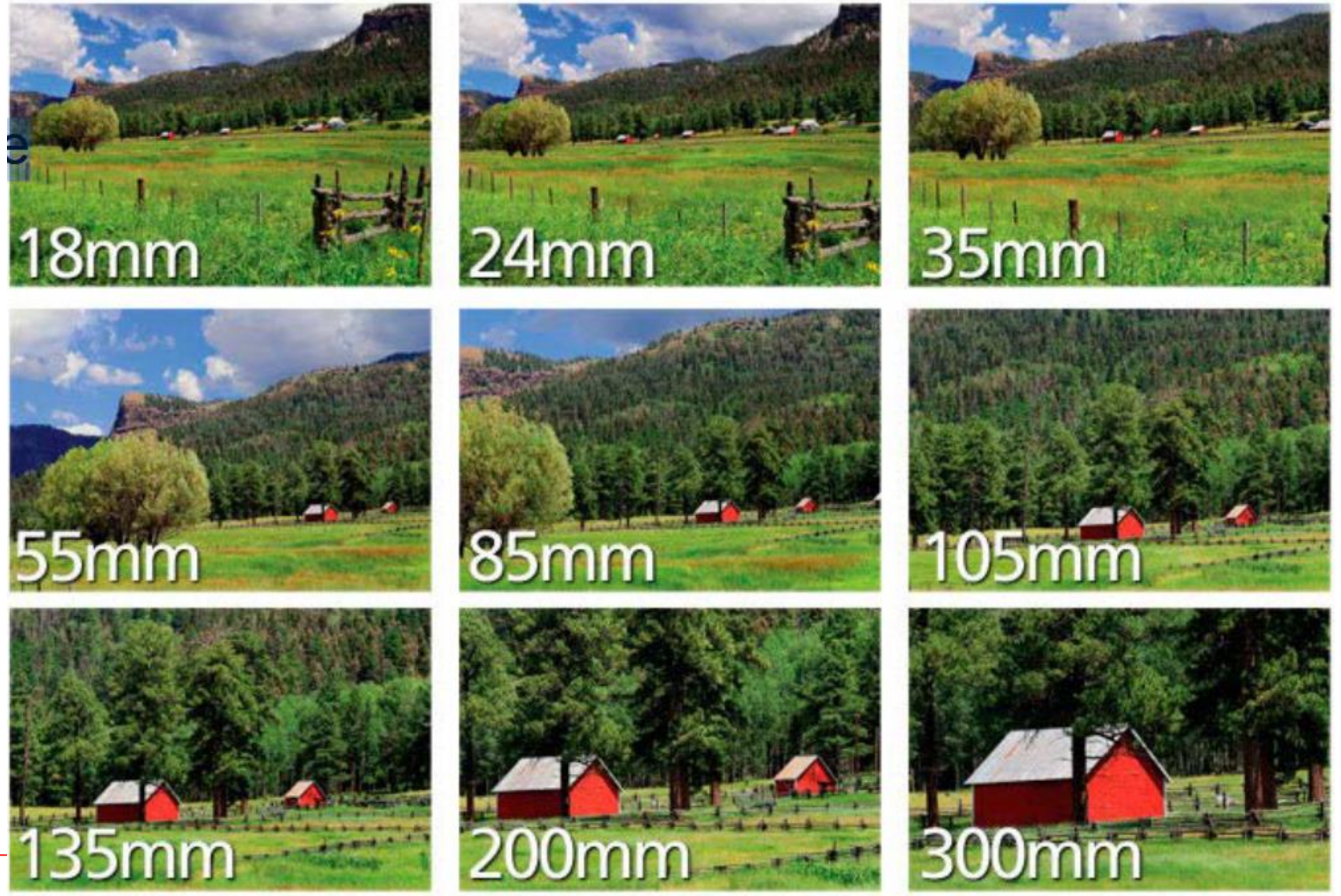
$$M = F_{max} / F_{min}$$

defines the maximum zoom value. In this example

$$M = 80.88 / 57.52 = 1.4$$

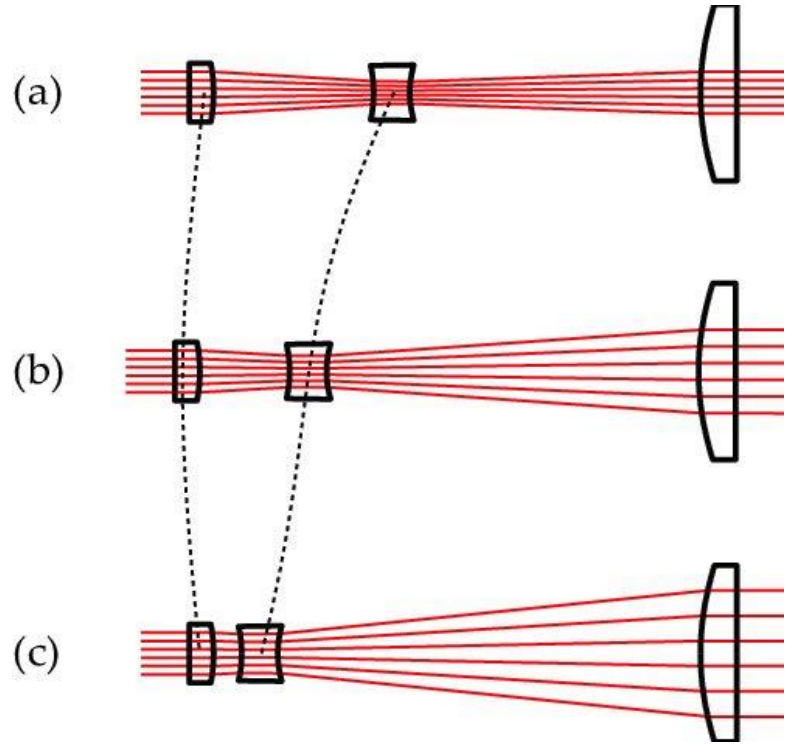
Hence, we have **1.4x** zoom system.

Images from varifocal zoom system



Example 2: Simple Zoom Beam Expander

In some laser applications, we require a specific zoom beam expander (ZBE). In this case, we need at least three (fixed focal length) lenses. Two of them has to be moveable. An example ZBE with PNP stucture is shown below where first and second lenses are moving while third one is fixed.



M = 1x => EXPD/ENPD = 1

M = 2x => EXPD/ENPD = 2

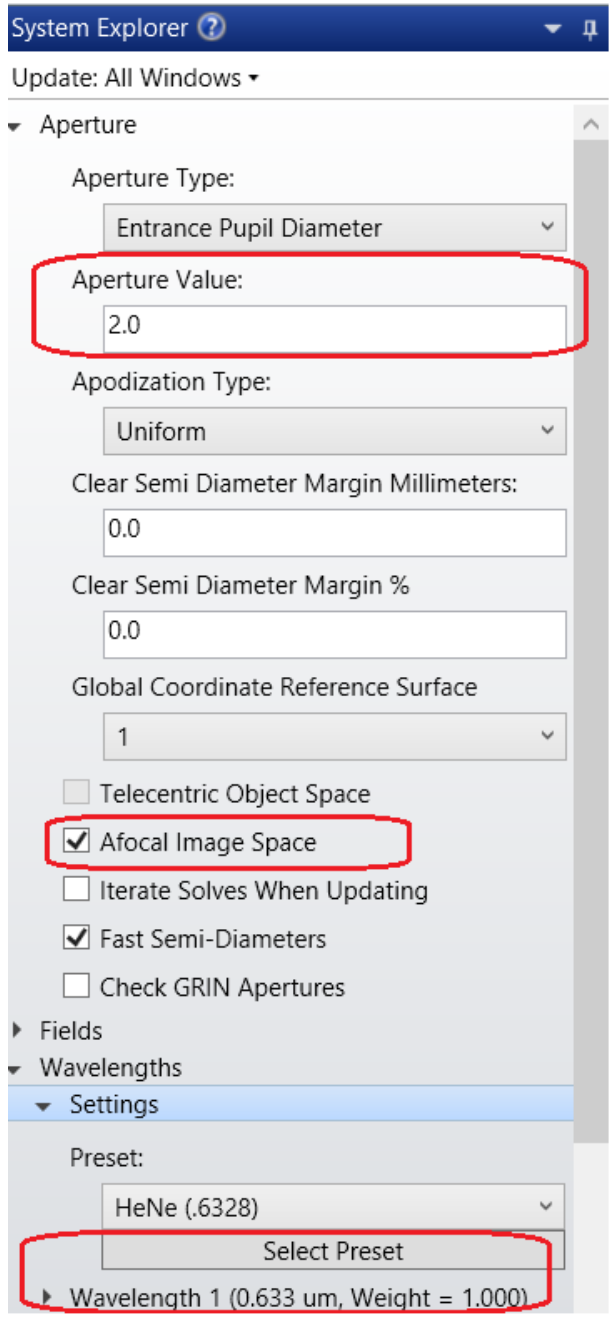
M = 3x => EXPD/ENPD = 3

In this example we will design a 3x ZBE for laser application.

Setup is as follows:

ENPD = 2 mm
Wavelength = 0.6328 (HeNe)
Afocal image space

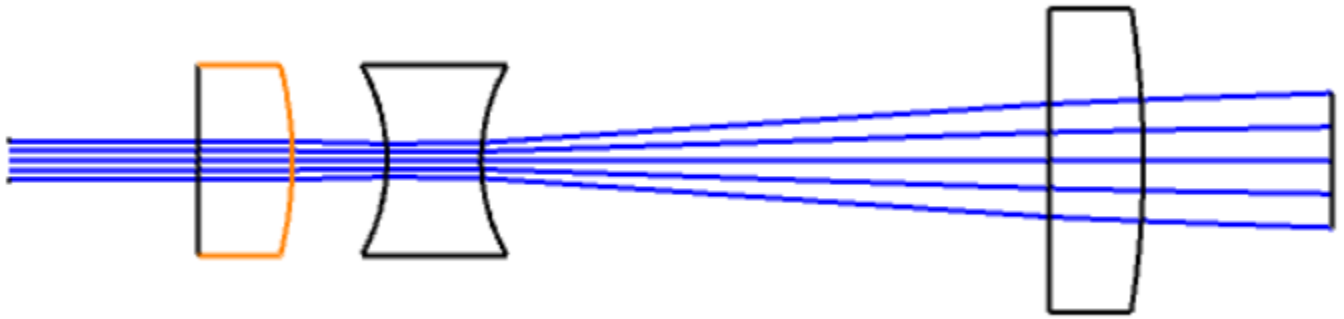
EXPD = 2, 4, 6 (will be calculated)



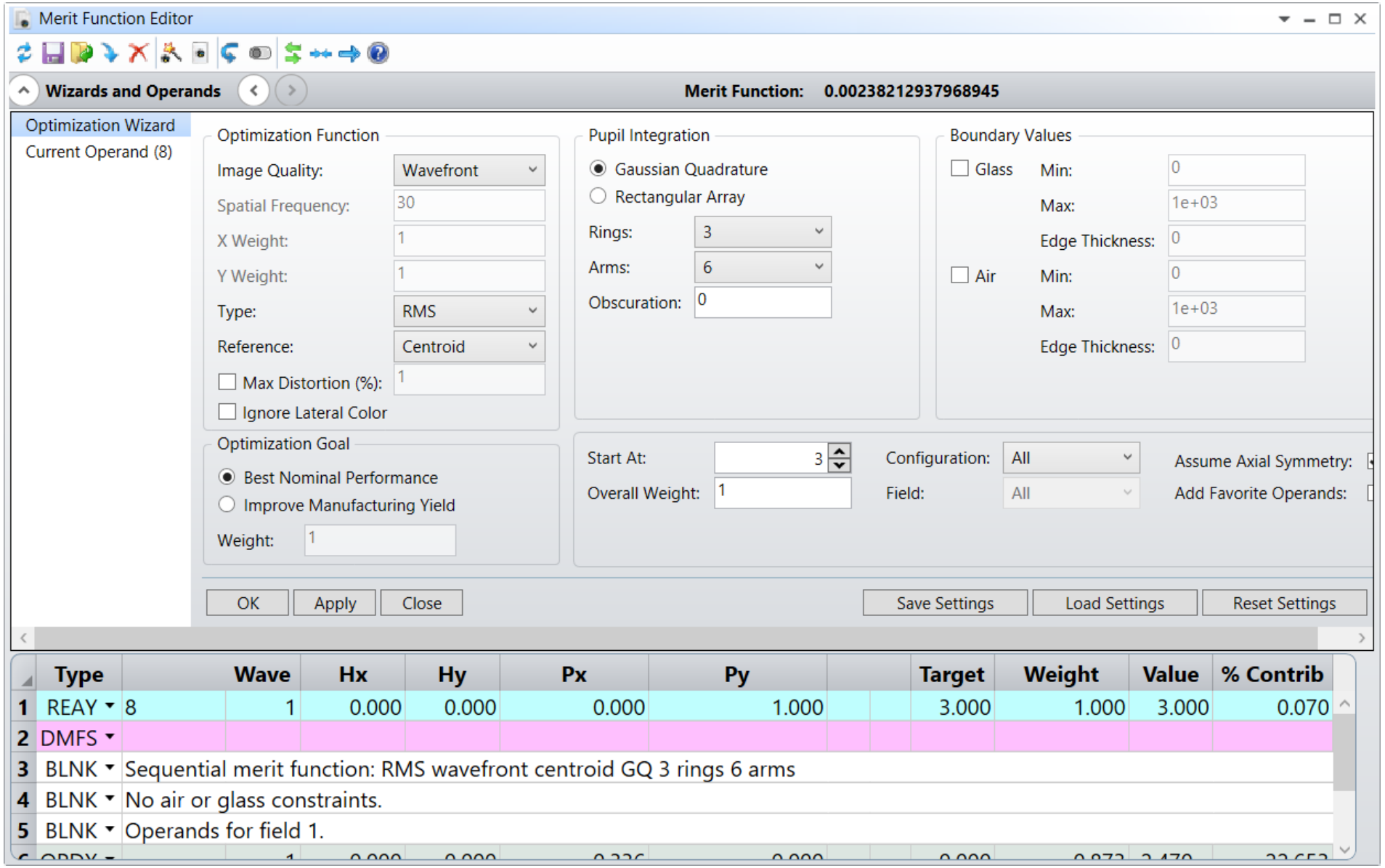
Initial LDE and Layout are as follows:

Pickup on Surface 5 is selected such that Radius5 = -Radius4

	Surface Type		Comm	Radius		Thickness	Material	Clear Semi-Dia	
0	OBJECT	Standard		Infinity		Infinity		0.000	
1	STOP	Standard		Infinity		10.000		1.000	
2	(aper)	Standard		Infinity		5.000	N-BK7	5.000	U
3	(aper)	Standard		-20.000	V	5.000		5.000	U
4	(aper)	Standard		-10.000	V	5.000	N-BK7	5.000	U
5	(aper)	Standard		10.000	P	30.000		5.000	U
6	(aper)	Standard		Infinity		5.000	N-BK7	8.000	U
7	(aper)	Standard		-50.000	V	10.000		8.000	U
8	IMAGE	Standard		Infinity		-		3.559	

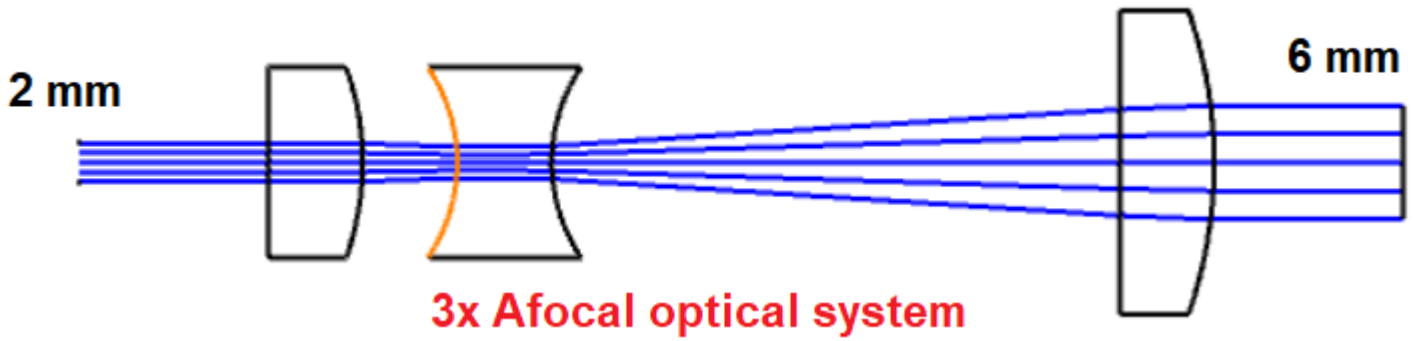


We will optimize the variables so that the magnification is 3x.

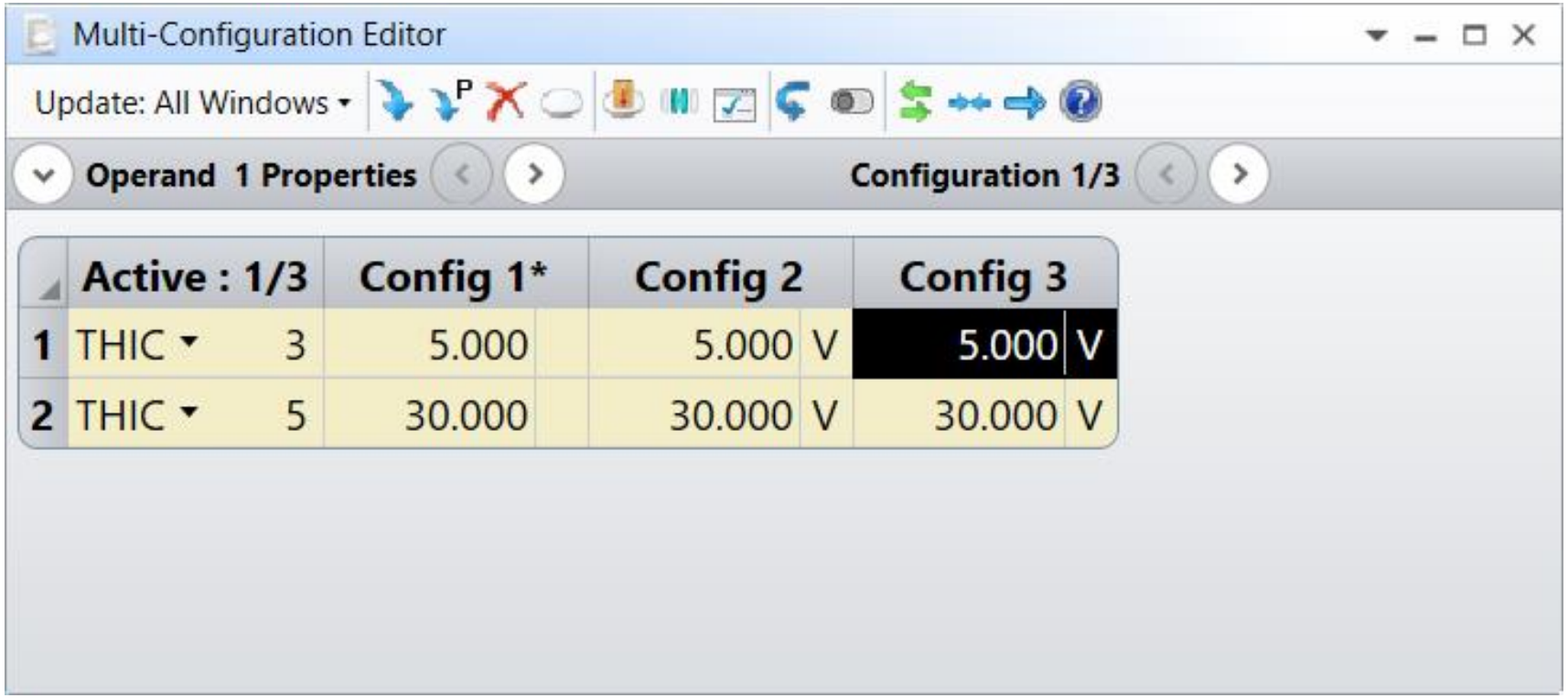


After optimization we have new radius of curvatures

	Surface Type		Comment	Radius		Thickness	Material	Clear Semi-Dia	
0	OBJECT	Standard		Infinity		Infinity		0.000	
1	STOP	Standard		Infinity		10.000		1.000	
2	(aper)	Standard		Infinity		5.000	N-BK7	5.000	U
3	(aper)	Standard		-14.824	V	5.000		5.000	U
4	(aper)	Standard		-8.885	V	5.000	N-BK7	5.000	U
5	(aper)	Standard		8.885	P	30.000		5.000	U
6	(aper)	Standard		Infinity		5.000	N-BK7	8.000	U
7	(aper)	Standard		-24.204	V	10.000		8.000	U
8	IMAGE	Standard		Infinity		-		3.000	



Now remove all variable symbols and setup MCE as follows:



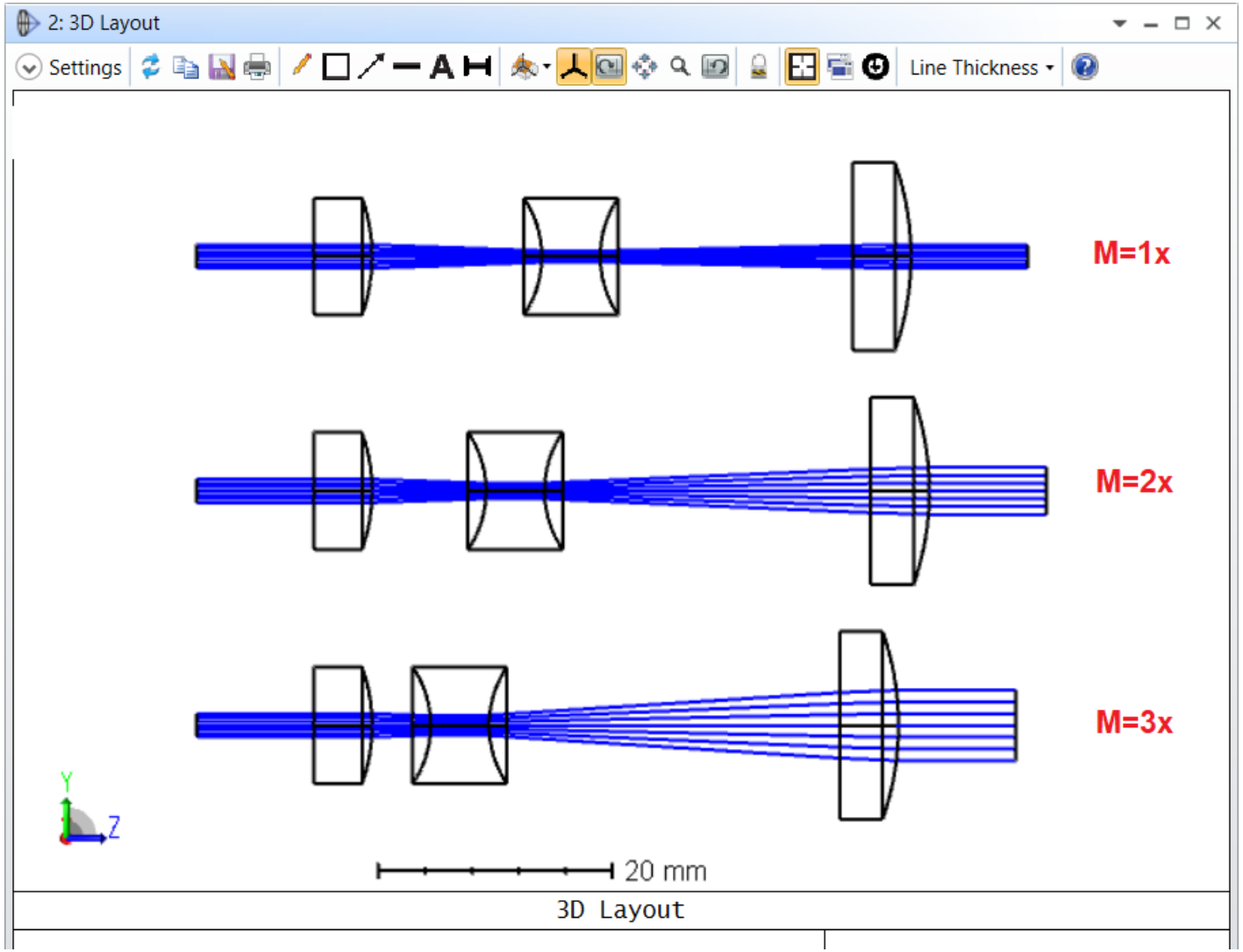
Again, setup MFE as follows and click on optimize.

Merit Function Editor

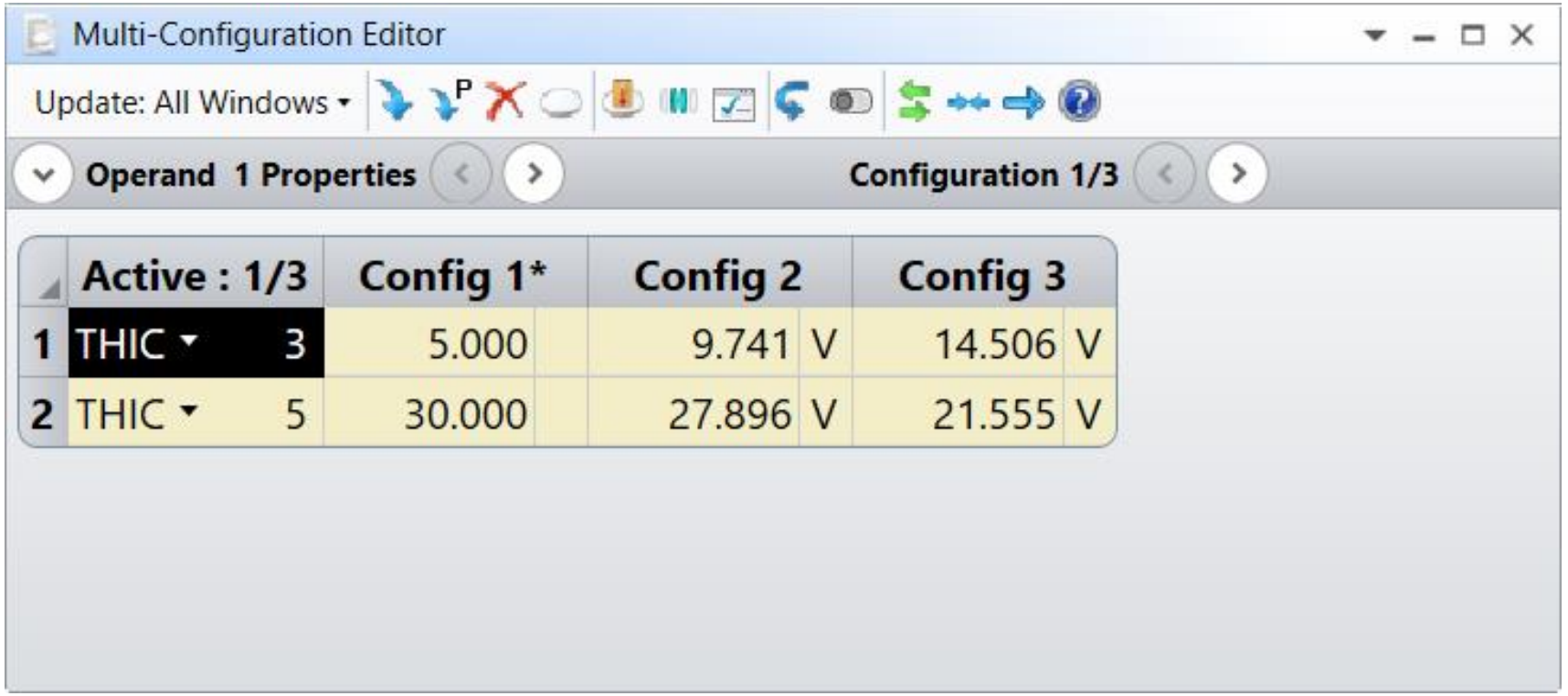
Wizards and Operands Merit Function: 0.0026000066845638

	Type	Cfg#										
1	CONF	1										
2	DMFS											
3	CONF	1										
4	REAY	8	1	0.000	0.000	0.000	1.000		3.000	1.000	3.000	0.023
5	OPDX		1	0.000	0.000	0.336	0.000		0.000	0.873	2.470...	7.555
6	OPDX		1	0.000	0.000	0.707	0.000		0.000	1.396	-3.05...	18.513
7	OPDX		1	0.000	0.000	0.942	0.000		0.000	0.873	2.421...	7.258
8	CONF	2										
9	REAY	8	1	0.000	0.000	0.000	1.000		2.000	1.000	3.000	0.023
10	OPDX		1	0.000	0.000	0.336	0.000		0.000	0.873	2.470...	7.555
11	OPDX		1	0.000	0.000	0.707	0.000		0.000	1.396	-3.05...	18.513
12	OPDX		1	0.000	0.000	0.942	0.000		0.000	0.873	2.421...	7.258
13	CONF	3										
14	REAY	8	1	0.000	0.000	0.000	1.000		1.000	1.000	3.000	0.023
15	OPDX		1	0.000	0.000	0.336	0.000		0.000	0.873	2.470...	7.555
16	OPDX		1	0.000	0.000	0.707	0.000		0.000	1.396	-3.05...	18.513
17	OPDX		1	0.000	0.000	0.942	0.000		0.000	0.873	2.421...	7.258

Optimization will be performed for all three configurations.



Final evaluated thicknesses in MCE are as follows:



	Active : 1/3	Config 1*	Config 2	Config 3
1	THIC 3	5.000	9.741 V	14.506 V
2	THIC 5	30.000	27.896 V	21.555 V