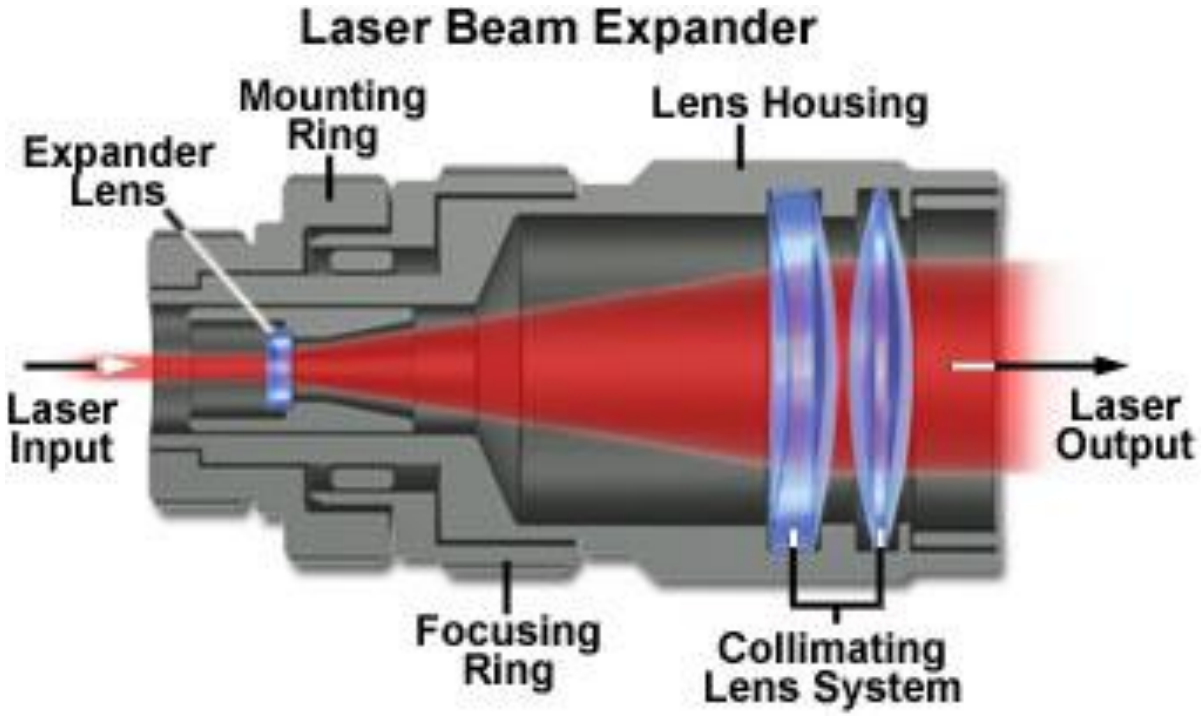
# Beam Expanders

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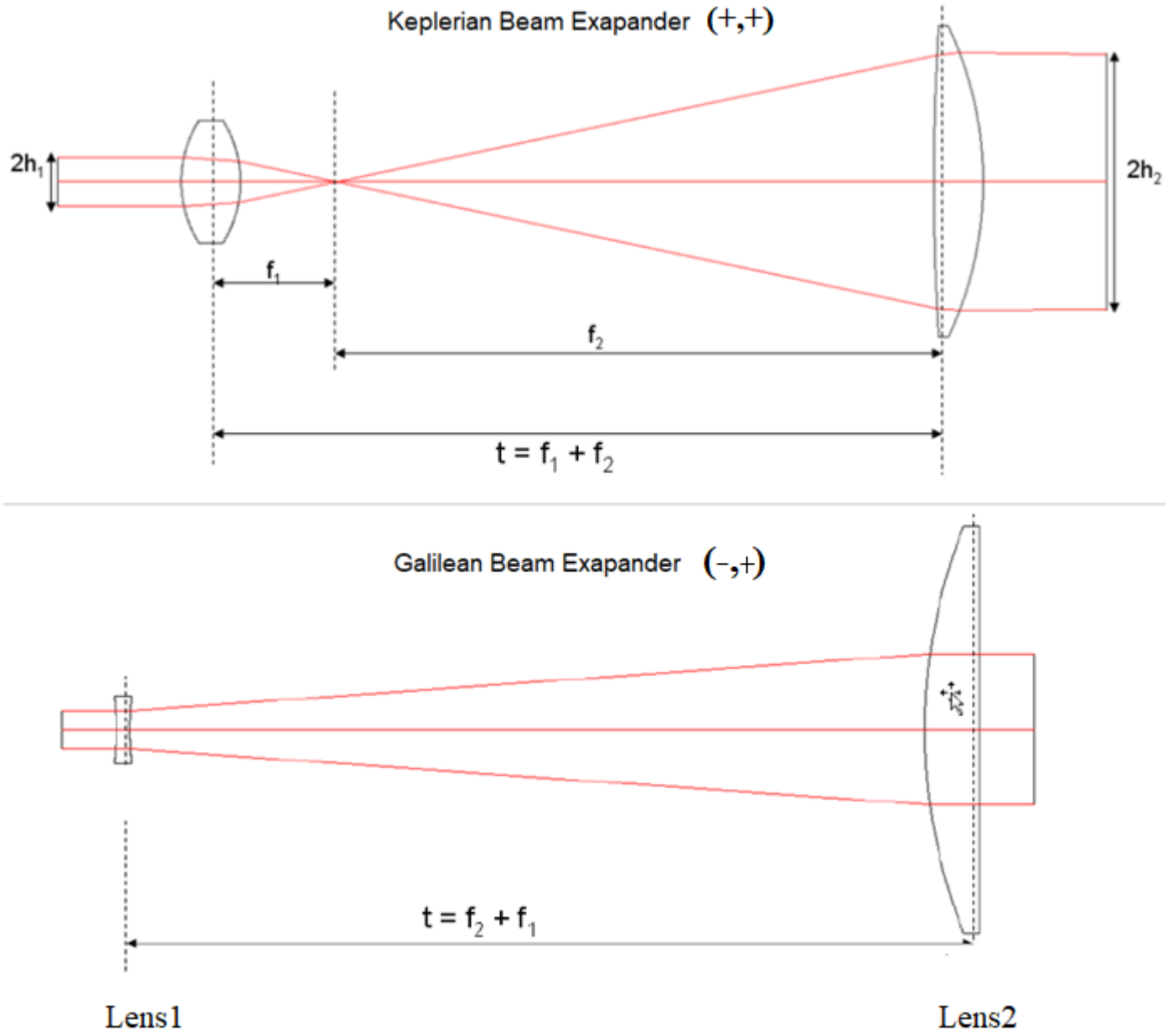
# Beam Expander

Beam exapanders are frequently used in optics lab.They are preferred in afocal apllications such as interferometer, laser scanner and collimator.

At basic level we use two lenses (PP and NP) with design parameters:

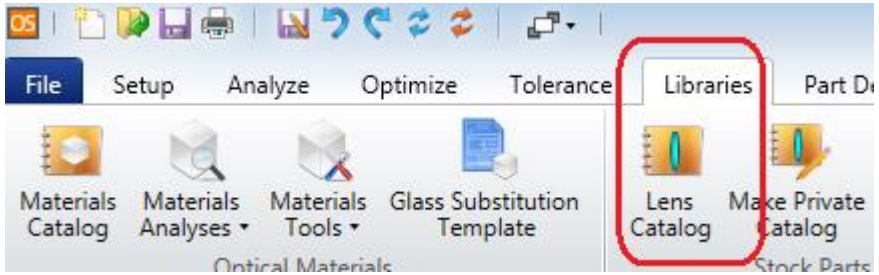
$$m = -\frac{f_2}{f_1} = \frac{h_2}{h_1} \qquad t = f_1 + f_2$$

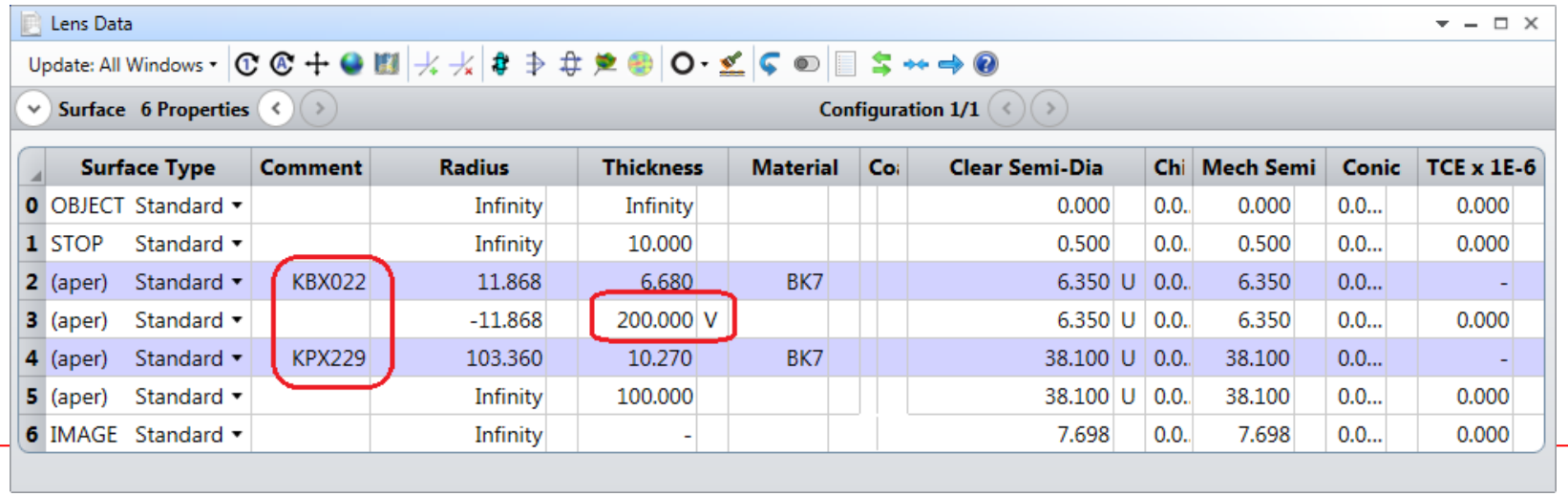
*People usually select off-the-shelf (stock) optical components to design beam expanders, since they are easy and cheaper to construct.*



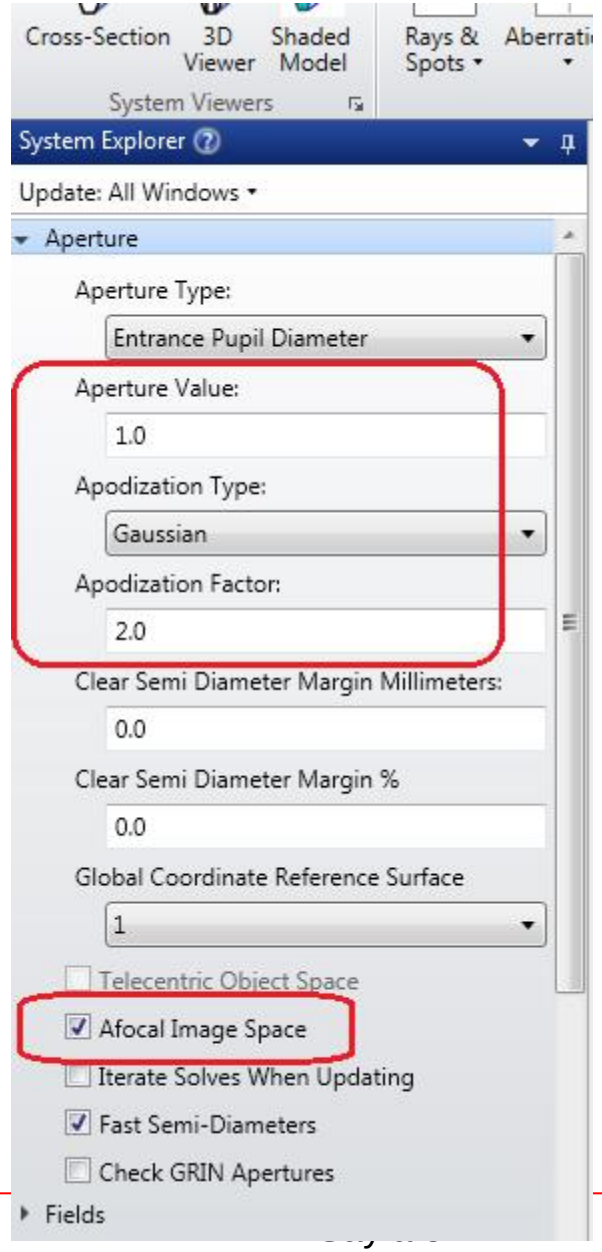
# Example: Designing Beam Expander via Lens Catalog

- In this example, we'll design a beam expander using Newport's lenses KBX022 (f=+12.66mm) ve KPX229 (f=+199.3mm) which are available in **Zemax Lens Catalog**, hence the magnification is *m* = 16x.
- We need to optimize only the distance between lenses (*t* = ?).
- Insert these lenses to LDE.
- Design parameters:
  Wavelength = 632.8 nm (HeNe)
  Gaussian beam
  ENPD = 1 mm
  Apodization factor = 2

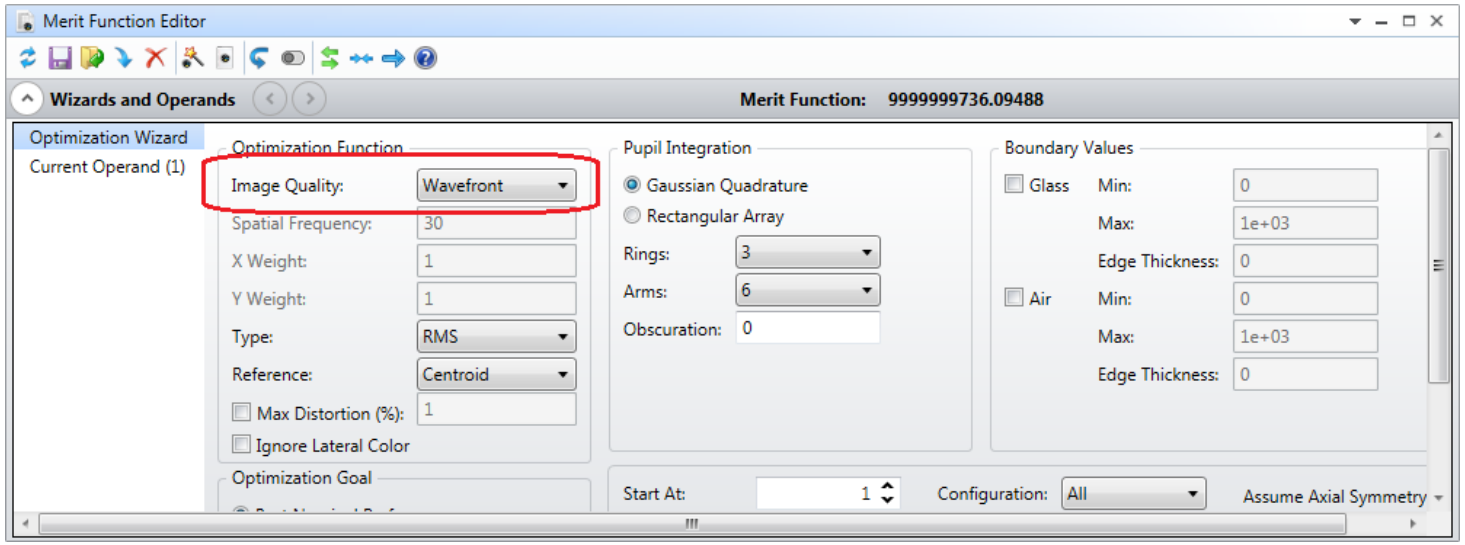


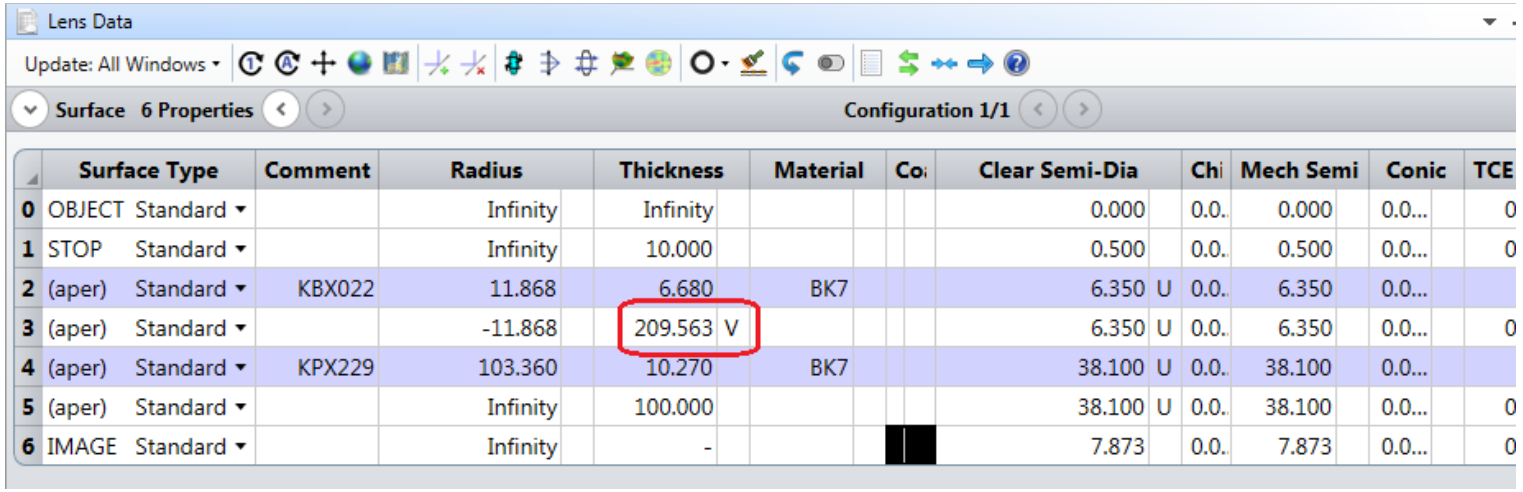




| | Surface Type | Comment | Radius | Thickness | Material | Co | Clear Semi-Dia | Chi | Mech Semi | Conic | TCE x 1E-6 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | OBJECT Standard | | Infinity | Infinity | | | 0.000 | 0.0. | 0.000 | 0.0... | 0.000 |
| 1 | STOP Standard | | Infinity | 10.000 | | | 0.500 | 0.0. | 0.500 | 0.0... | 0.000 |
| 2 | (aper) Standard | KBX022 | 11.868 | 6.680 | BK7 | | 6.350 U | 0.0. | 6.350 | 0.0... | - |
| 3 | (aper) Standard | | -11.868 | 200.000 V | | | 6.350 U | 0.0. | 6.350 | 0.0... | 0.000 |
| 4 | (aper) Standard | KPX229 | 103.360 | 10.270 | BK7 | | 38.100 U | 0.0. | 38.100 | 0.0... | - |
| 5 | (aper) Standard | | Infinity | 100.000 | | | 38.100 U | 0.0. | 38.100 | 0.0... | 0.000 |
| 6 | IMAGE Standard | | Infinity | - | | | 7.698 | 0.0. | 7.698 | 0.0... | 0.000 |



- Setup MFE as given below and click on **Apply** button.
- After optimization, it is clear that the distance betwwen lenses must be $t$ = 209.563 mm.



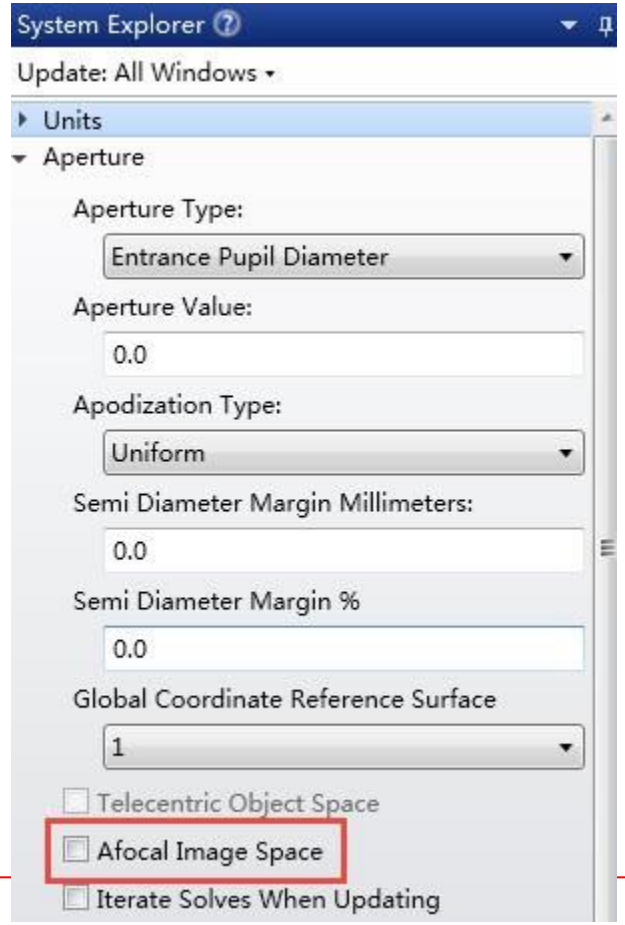



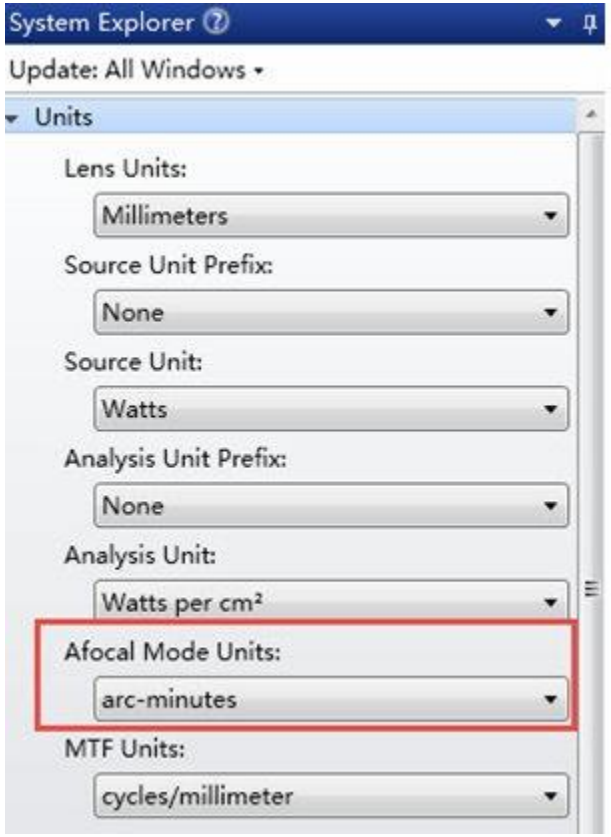

| | Surface Type | Comment | Radius | Thickness | Material | Co | Clear Semi-Dia | | Chi | Mech Semi | Conic | TCE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | OBJECT Standard | | Infinity | Infinity | | | 0.000 | | 0.0.. | 0.000 | 0.0... | 0 |
| 1 | STOP Standard | | Infinity | 10.000 | | | 0.500 | | 0.0.. | 0.500 | 0.0... | 0 |
| 2 | (aper) Standard | KBX022 | 11.868 | 6.680 | BK7 | | 6.350 | U | 0.0.. | 6.350 | 0.0... | |
| 3 | (aper) Standard | | -11.868 | 209.563 V | | | 6.350 | U | 0.0.. | 6.350 | 0.0... | 0 |
| 4 | (aper) Standard | KPX229 | 103.360 | 10.270 | BK7 | | 38.100 | U | 0.0.. | 38.100 | 0.0... | |
| 5 | (aper) Standard | | Infinity | 100.000 | | | 38.100 | U | 0.0.. | 38.100 | 0.0... | 0 |
| 6 | IMAGE Standard | | Infinity | - | | | 7.873 | | 0.0.. | 7.873 | 0.0... | 0 |

# Example: Designing Beam Expander without Lens Catalog

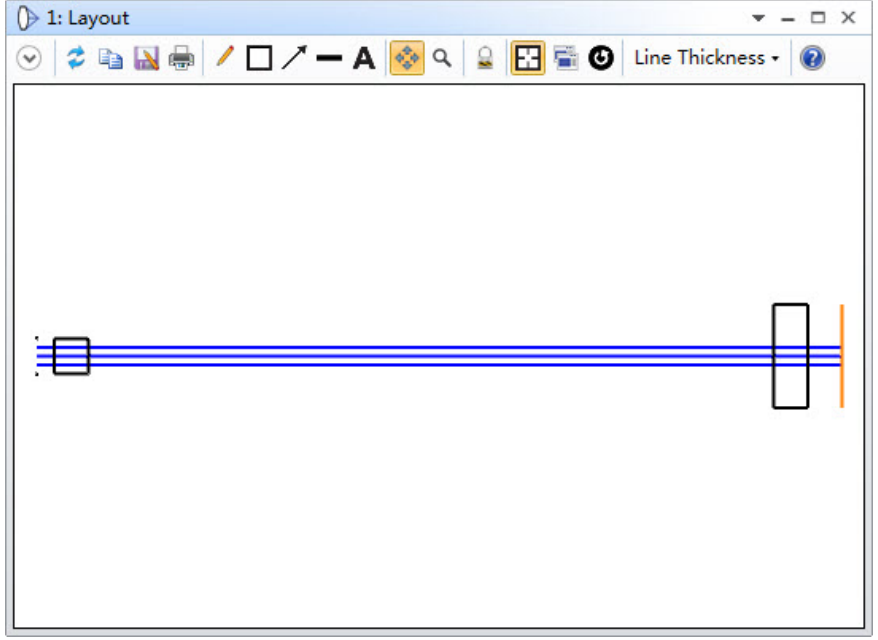
Beam expanders are afocal systems. Afocal systems don't have an effective focal length and thus provide no net convergence or divergence of the incident light beam.

To enable Afocal Image Space in Zemax, navigate to the System Explorer...Units and check the setting.



This is intended to be a 5x beam expander, working at the red He-Ne line, and to have minimum RMS wavefront error.
In the starting design there is no power in the optics and therefore no beam expansion.
Let EnP = 5 mm



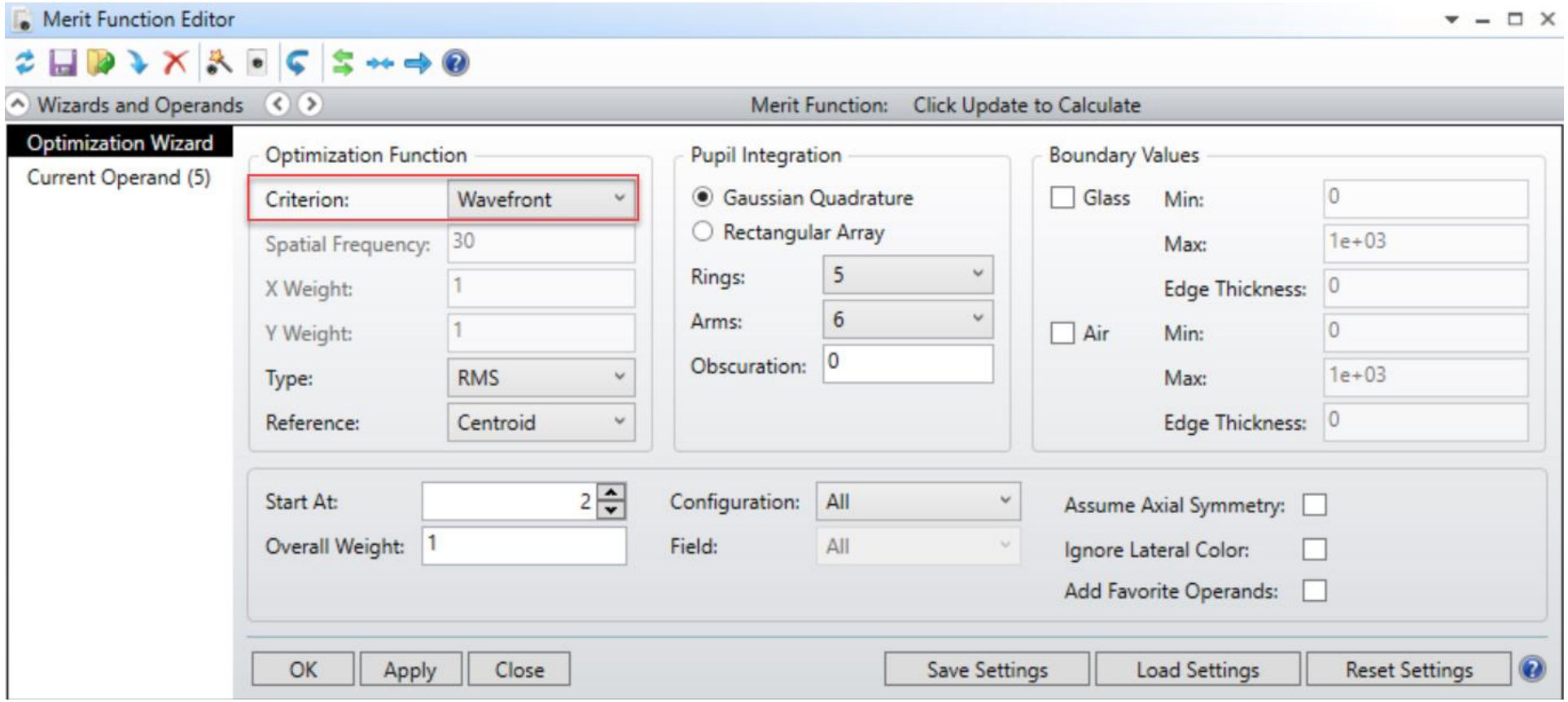

Lens Data

Update: All Windows

Surface 6 Properties  Configuration 1/1

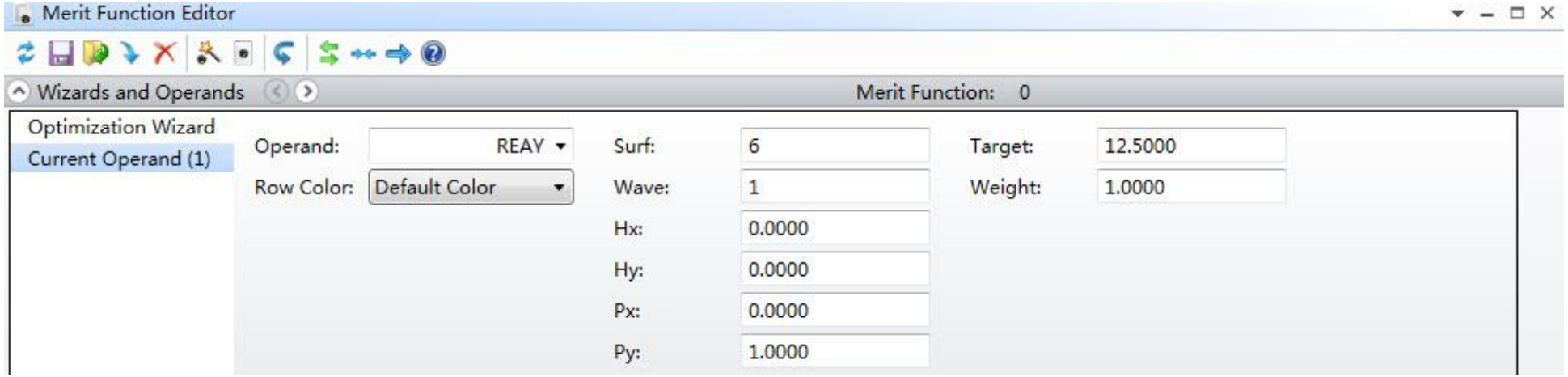
| | Surf:Type | | Comment | Radius | | Thickness | Material | Coating | Semi-Diameter | |
|---|---|---|---|---|---|---|---|---|---|---|
| 0 | OBJECT | Standard | | Infinity | | Infinity | | | 0.0000 | |
| 1 | STOP | Standard | input beam | Infinity | | 5.0000 | | | 5.0000 | U |
| 2 | (aper) | Standard | expander | Infinity | V | 10.0000 | N-BK7 | | 5.0000 | U |
| 3 | (aper) | Standard | | Infinity | V | 200.0000 | | | 5.0000 | U |
| 4 | (aper) | Standard | collimator | Infinity | V | 10.0000 | N-BK7 | | 15.0000 | U |
| 5 | (aper) | Standard | | Infinity | V | 10.0000 | | | 15.0000 | U |
| 6 | IMAGE | Standard | output beam | Infinity | | - | | | 15.0000 | U |

Then open the Merit Function via Optimize...Merit Function Editor and select Optimization Wizard from the settings.

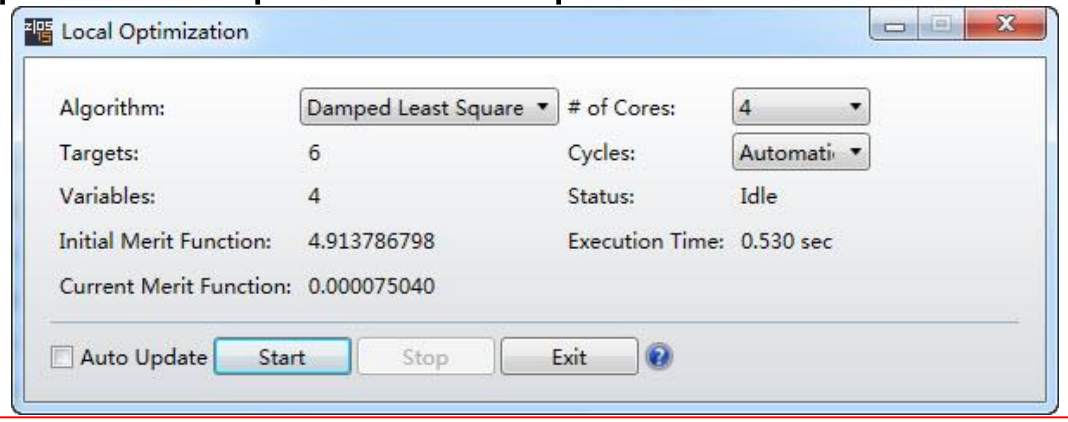



*Note that we can build a default Merit Function to minimize wavefront error, spot radius (and X, Y individually) or angular error as a radius or as x and y separately. In this case, we will choose Wavefront, and use 5 rings in the Gaussian Quadrature algorithm because we want a well-corrected system.*

The only extra information OpticStudio needs is the size of the output beam. The input beam is 5 mm, and the magnification is 5x, so the output beam should have a diameter of 25 mm. Insert a new operand before the DMFS statement in the merit function, and enter the REAY operand as follows:




This requires the real ray y-coordinate on surface 6 (the image surface) to have a height of 12.5 mm. Then click Optimize...Optimize! and press the Start button.



OpticStudio quickly optimizes the afocal system.