

# An Essential Lens Design Software ELS V5.0 for Japanese MS-Windows 11

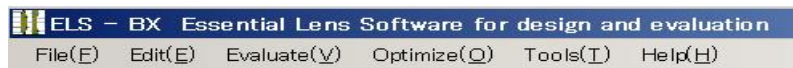
https://www.peknk.com  
ELS Lab.

## Introduction

ELS is a compact lens design software provided with essential functions for both evaluation and optimization of lens performance based on real raytrace. ELS is also provided with easy-to-use user interface with graphics to support user's working process and thinking process accompanied by complicated trial-and-error.

Optimization capabilities support DLS method (Damp Least Square method) which is traditionally used in the high-end commercial optical lens design software. Furthermore, ELS provides Global Explorer (Escape Function method) which is known as one of the practical global optimization method to escape from local solution. Separately, ELS supports Down-Hill Simplex method which is widely used in the various engineering fields.

### (Main menu and submenus)



<p>[File]</p> <ul style="list-style-type: none"> <li>New Lens...</li> <li>Open Lens...</li> <li>Save Lens</li> <li>Save Lens As...</li> <li>Set Preference...</li> <li>Calc</li> <li>NotePad</li> <li>Exit</li> </ul>	<p>[Edit]</p> <ul style="list-style-type: none"> <li>Paraxial Setup...</li> <li>Evaluation Condition...</li> <li>Drawn Rays...</li> <li>Lens Draw Option...</li> <li>Evaluation Graph Scale...</li> <li>Lens Scaling</li> <li>Glass Catalog</li> </ul>	<p>[Evaluate]</p> <ul style="list-style-type: none"> <li>List Parax.</li> <li>Third Aberration</li> <li>Single Raytrace...</li> <li>Ray Analysis</li> <li>Wavefront Map...</li> <li>Spot Diagram Analysis</li> <li>Multiple Spot Diagram...</li> <li>Point Spread Function...</li> <li>MTF</li> </ul>	<p>[Optimize]</p> <ul style="list-style-type: none"> <li>Setup Variables</li> <li>Setup Merit Function</li> <li>D.L.S.</li> <li>Global Explorer</li> <li>Simplex</li> </ul>
<p>[Tools]</p> <ul style="list-style-type: none"> <li>Surface Sag...</li> <li>Component</li> <li>Positioning</li> <li>Graphic Reports</li> </ul>	<p>[Help]</p> <ul style="list-style-type: none"> <li>ELS Help F1</li> <li>User License</li> <li>User Info.</li> <li>Release Info.</li> </ul>	<p>[ Component ]</p>	

**Lens Editor** including functional buttons and spreadsheet is used to define and edit lens parameters, and [Edit] menu functions prompt to define paraxial conditions and evaluation conditions with the associated calculations in the dialogbox form.

Cell under '\*' or 'Special' column will pop up the optional menu by right-click. Glass beginning with '\_' means user-defined glass, not quoted from manufacturer catalog.

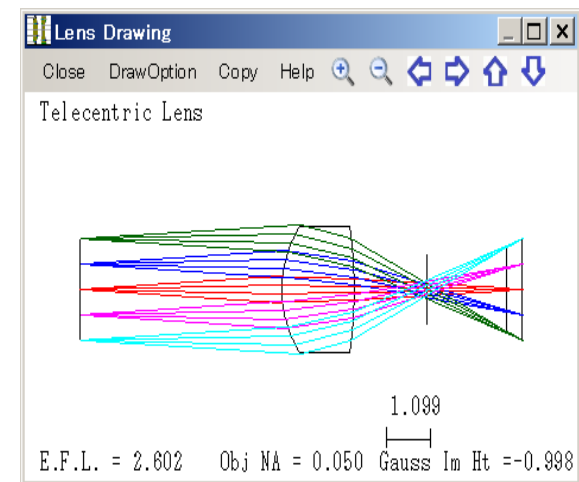
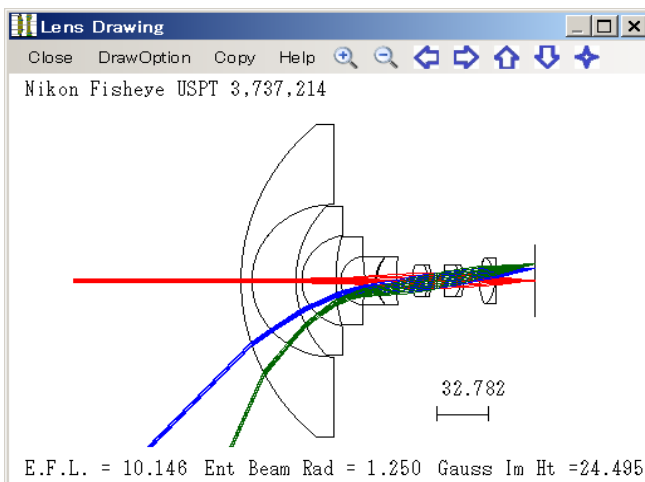
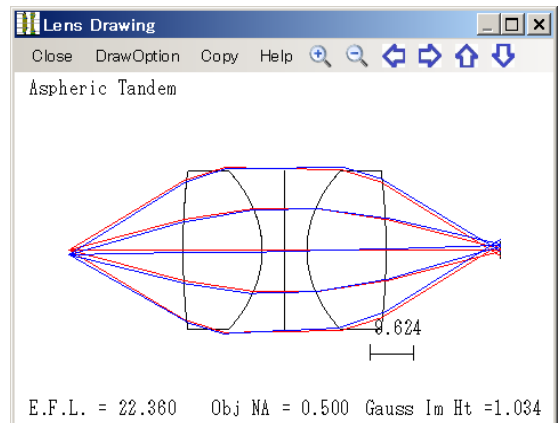
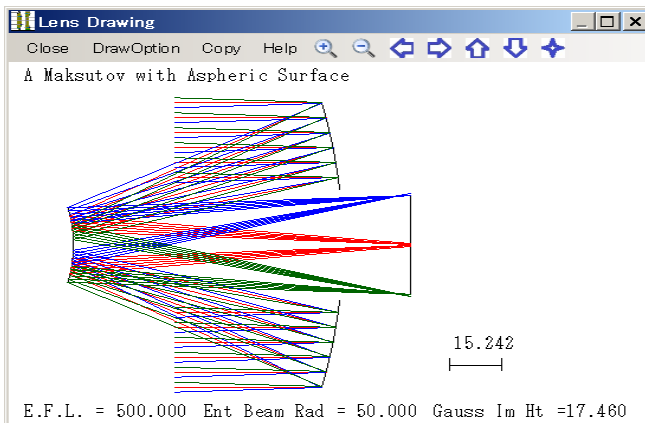
Srf No.	Radius	*	Thickness	*	Glass	*	Aperture	*	Special
OBJ00	0.000000		25.460000		AIR		1.000000	A	
▶ 01	140.000000	V	17.660000	V	N-BK7		17.000000	U	
02	-21.000000	V	5.000000	V	AIR		17.000000	U	AS
STP03	0.000000		5.000000	P	AIR		17.000000	U	
04	21.000000	P	17.660000	P	N-BK7	P	17.000000	U	AS
05	-140.000000	P	25.460000		AIR		17.000000	U	
IMG06	0.000000		0.000000		AIR		1.828017	A	

### (Spread Sheet)

- On the spread sheet, lens surfaces are sequentially numbered from "Object" surface to "Image" surface beginning with 0 for "Object" surface. Each row of lens spreadsheet accepts the parameters of each lens surface including surface shape, thickness, space medium, surface aperture etc.
- Focused cell is recognized by inversion display of fore color and backcolor of the cell and moved by TAB-key, Shift+TAB-key, Cell-Click or Arrow-keys.
- Optional data are "Solve", "Pickup", "Check Aperture", or "Special data", are specified by each cell in the column marked by "\*" or "Special".
- "Special data" includes two-type data of "Aspheric" and "Obstruct".

### (Function Button)

- [Ins], [Del], [Copy], [Cut], [Paste] on the 1st line of Lens Editor indicates the manipulation for the selected surfaces of lens spreadsheet.
- The Manufacturer's glass name is available for the entry to Glass column. Available manufacturers are **Schott, Hoya, Ohara, Hikari, Sumita**. The glasses not included in these manufacturer's catalog can be used as **User glass**.
- [List Lens], [List Parax.], and [Draw Lens] buttons displays the lens parameters, paraxial performance, and the graphical profile of the current lens on the spreadsheet respectively.

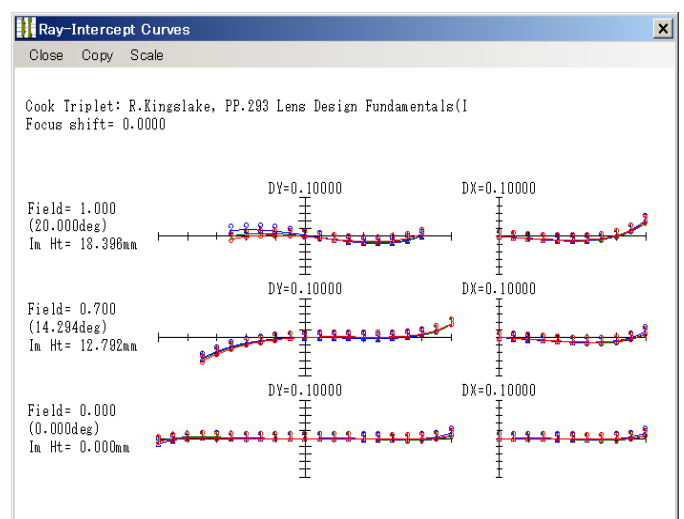
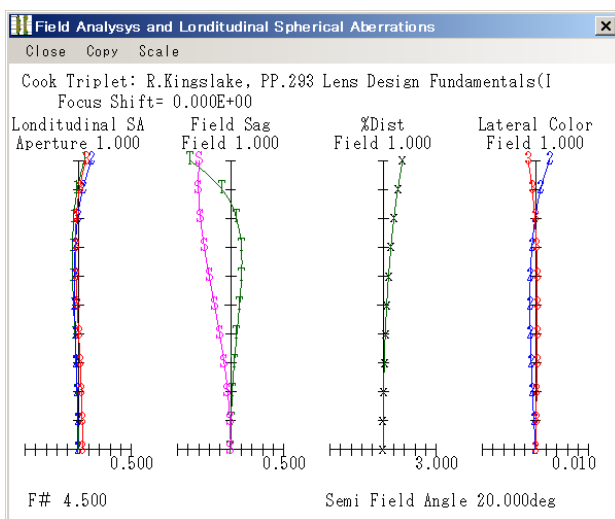


**[Edit]** menu includes submenus for working with Lens Editor.

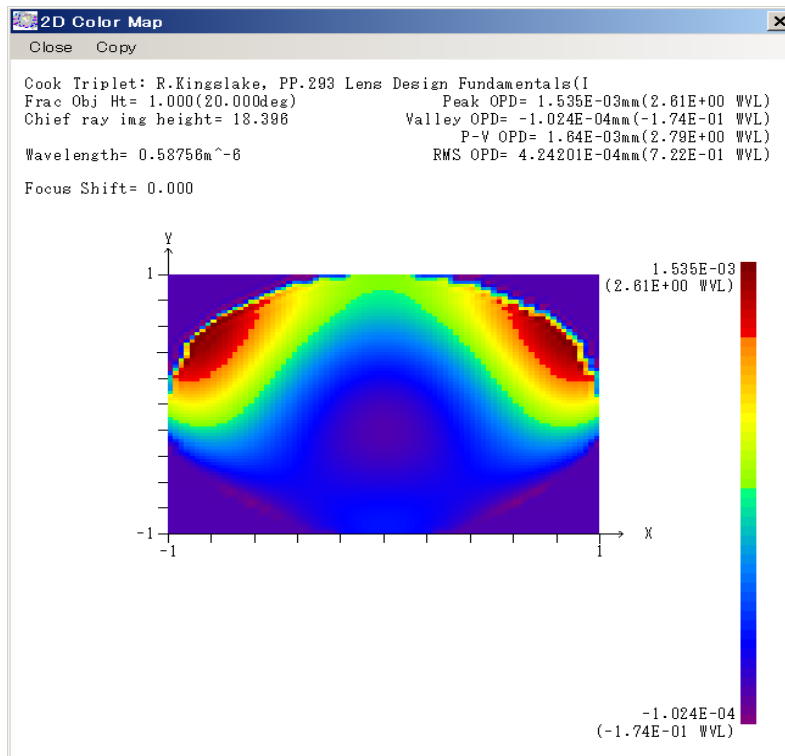
- **[Paraxial Setup]** setup the four types of paraxial properties, (System Aperture), (Field View), (STOP position), (System Conjugate).
- **[Drawn Rays]** specifies the rays drawn with the lens profile in Lens Drawing window.
- **[Evaluation Condition]** specifies the condition for calculating lens performance; (Wavelengths and the relative weight of each wavelength), (Ray Aiming Mode for entrance ray, which is Standard or Wide Angle), (Reference Sphere Position), (Ray Mapping for Standard Ray Aiming Mode).

**[Evaluate]** menu is used to evaluate the lens properties or performance.

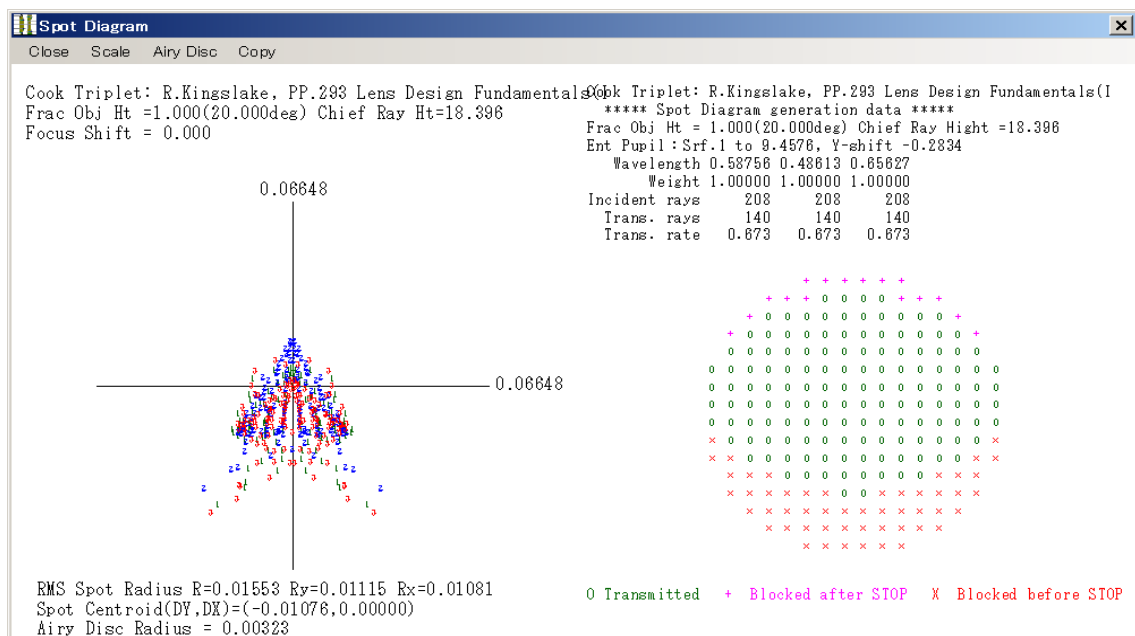
- **[List Parax.]** lists paraxial properties, which are EFL, focal distance, principal points, etc., additionally shows the information for paraxial raytrace at each surface.
- **[Third Aberration]** shows the 3rd order aberration coefficients at each surface and the total.
- **[Single Raytrace]** trace a single ray which emanate from an object point and enter the specified incident coordinate of lens system. The output shows the information of the incident point and angle etc. at each surface.
- **[Ray Amnalysis]** has 3 submenus.
  - **[Ray Fan Numeric Analysis]** trace the Y-Fan rays and X-Fan rays for a single field point and generates the differences in numerics between each fan ray and the chief ray at image surface.
  - **[Ray Fan Graphic Analysis]** trace the Y-Fan rays and X-Fan rays for multiple field points and generates the differences in graphics between each fan ray and the chief ray at image surface.
  - **[Field Analysis]** generates the chief ray information at image surface for multiple object points in numerics or graphics. The output of chief ray information include Y-field sag, X-field sag, %distortion, lateral color difference. Additionally, for the axial object point, longitudinal SA is displayed.



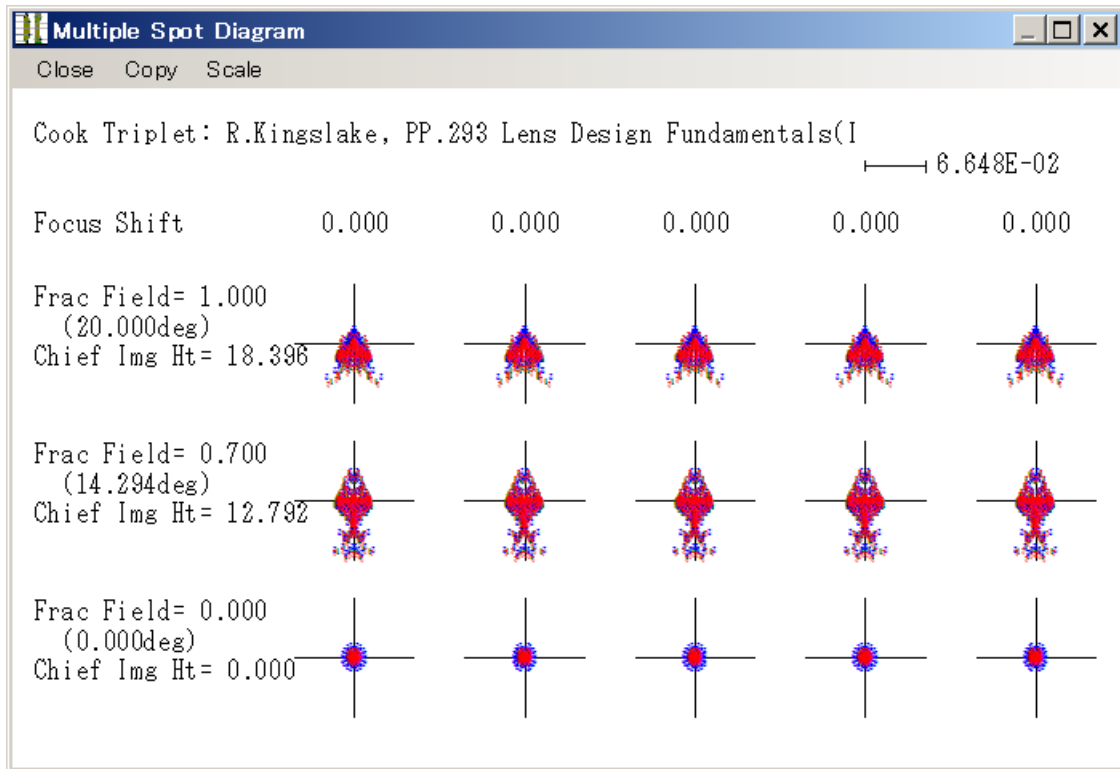
- **[Wavefront Map]** generates wavefront map of the rays which emanate from an object point and enter the specified aperture grid. The output is displayed in 2D or 3D graphics.



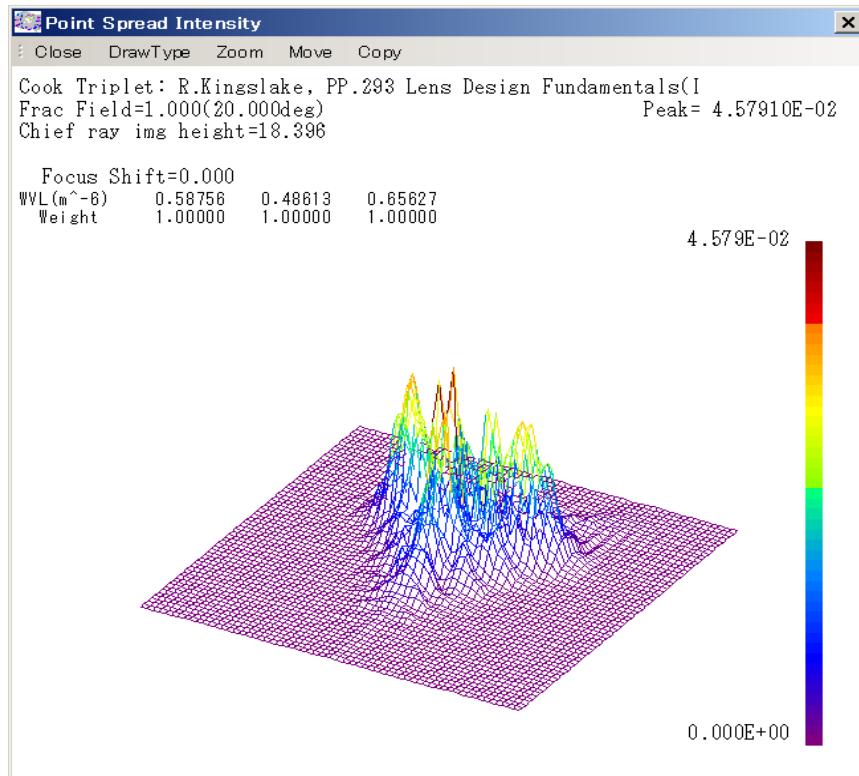
- **[Spot Diagram Analysis]** generates spot diagram of the rays which emanate from an object point and enter the specified aperture grid. Additionally, it generates the aperture grid map which shows the transmitted rays and intercepted rays in graphics.



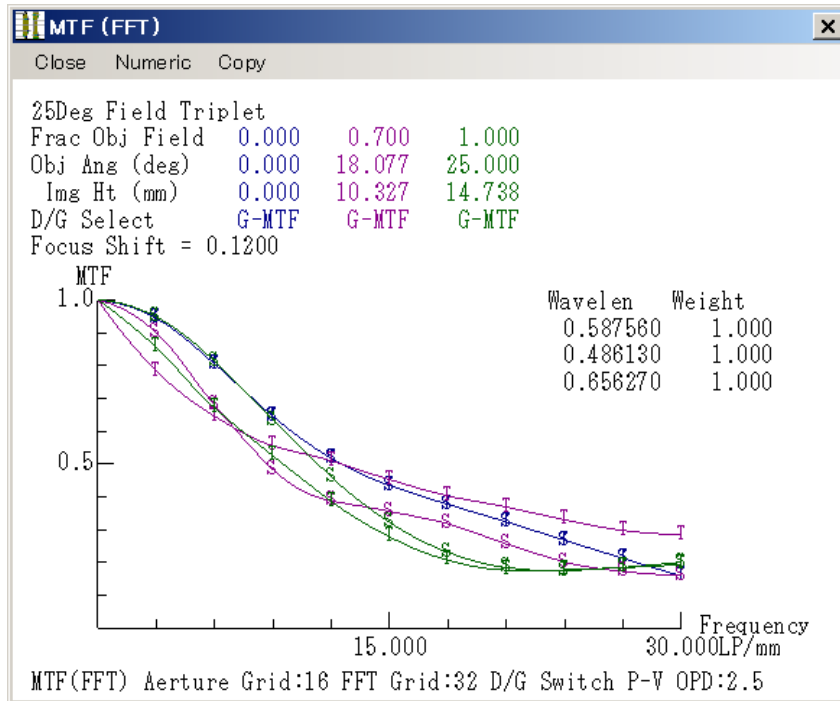
- **[Multiple Spot Diagram]** generates spot diagram for multiple object points with the changes of focus shift.



- **[Point Spread Function]** generates PSF (point spread function) for the rays which emanate from an object point. The output is displayed in 2D or 3D graphics.



- **[MTF]** generates MTF (Modulation Transfer Function) values for the multiple object points. The output is displayed in numerics or graphics. Diffraction MTF and Geometric MTF are exchanged the indicated switchover value of Peak-Valley OPD.



**[Optimize]** menu is used to improve the lens performance by changing the lens parameters (surface curvatures, thickness etc) which are called variables. Lens performance is expressed in the figure of "merit function" or "error function" which consist of ray errors and lens property errors as shown below. That is, optimization is to explore a set of variables so that figure of merit function (Fmt) is minimize mathematically.

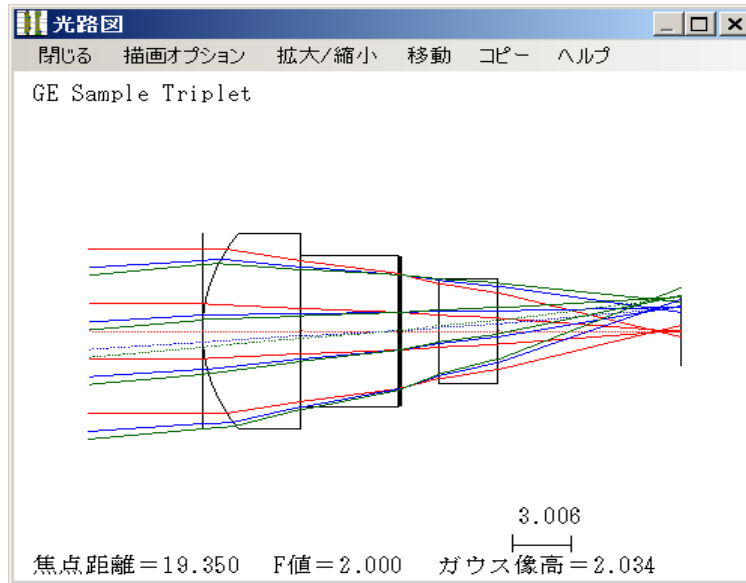
$$\phi = \sqrt{\frac{1}{m} \sum_{i=1}^m w_i (f_i(x_j) - f_i^T)^2}$$

- $x_j$  Lens parameter as variable(surface cyrvature, thickness etc.)
- $f_i(x_j)$  Evaluated element to express lens performance or property
- $f_i^T$  Target value for evaluated element
- $w_i$  Weight for evaluated element

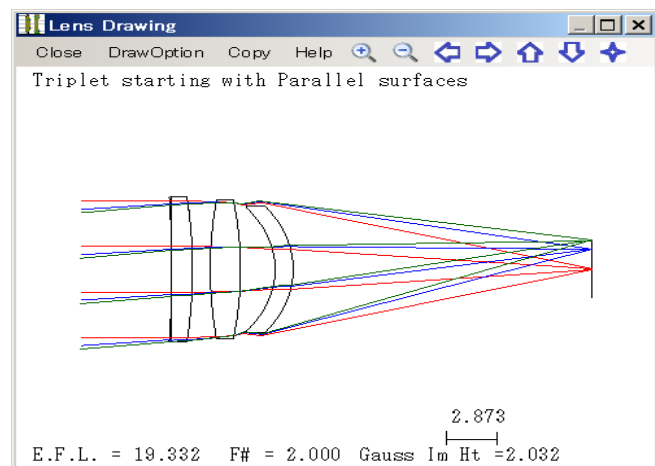
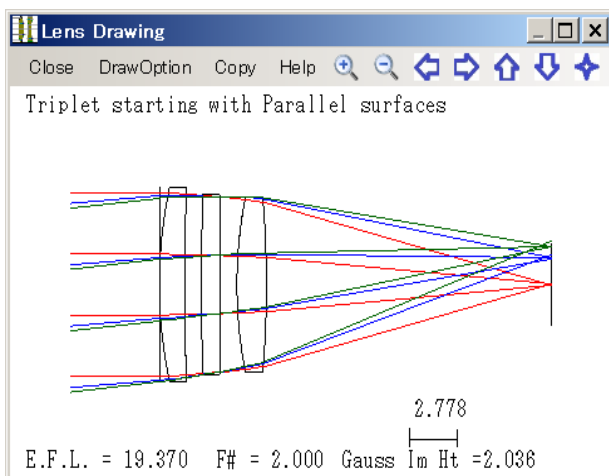
- **[Setup Variables]** setups the lens parameters with the boundary conditions as variable for optimization.
- **[Setup Vignetting]** setups the vignetting factor to compress the ray coordinates for system aperture.
- **[Setup Merit Function]** setups evaluated elements with the target values for optimization.
- **[Damped Least Square (DLS)]** launches **DLS (Damped Least Square)** optimization invented by Levenberg-Marquardt.
- **[Global Explorer (GE-DLS)]** launches DLS optimization with "**Escape Function**" to explore the global solution better than DLS local solution. This method is named "Global Explorer (GE)" by the inventor M.Isshiki.
- **[NM-Simplex (NMS)]** launches **Down-Hill Simplex** optimization by Nelder-Mead.

(Optimization Sample)

Initial lens before optimization



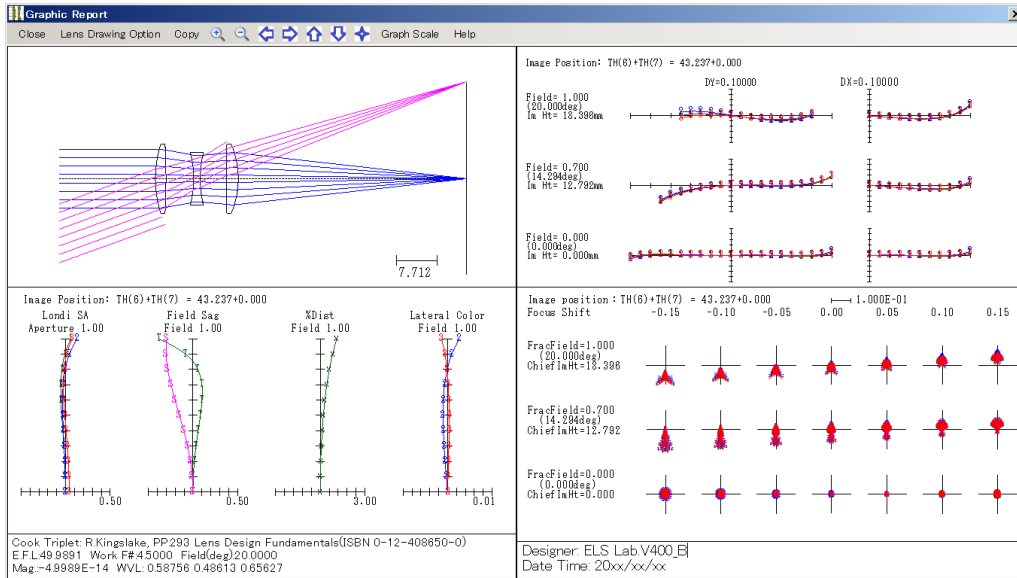
Samples after optimization



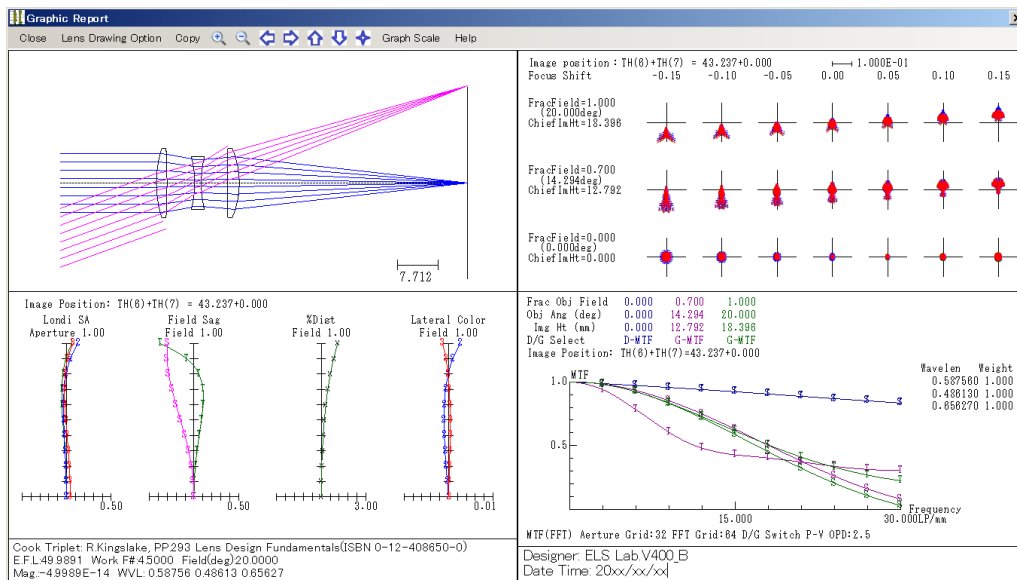
**[Tools]** menu is used to analyze the components of lens system and manipulate

- **[Surface Sag]** generates sag values for the indicated y-height.
- **[Component]** menu is used to see the paraxial properties of the indicated lens component. Submenus **[Indicate Magnification]**, **[Indicate Objective Distance]**, **[Indicate Image distance]**, **[Every lens unit]** shows a dialogbox to analyze the paraxial property for each designated condition of lens component respectively
- **[Positioning]** menu fix the position of indicated lens component to produce the indicated finite conjugate for the infinite conjugate lens. Submenus **[Whole Lens Move]**, **[Front Lens Move]**, **[Inner Lens Move]** shows a dialogbox to fix the **position movement for finite conjugate** of the specified lens component
- **[Graphic Reports]** display the report graphics of the lens profile and different type combination of the evaluation graphics.

(Output sample of Type-A(Add FAN/SPD))



(Output sample of Type-B(Add SPD/MTF))



(Output sample of Type-C(Add FAN/MTF))

