

# Aber



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**Software for optical system design**

Version 1.04 [106]

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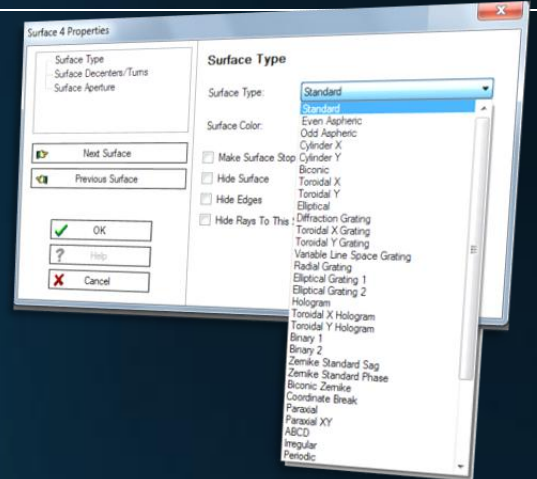
Kyiv 2011

## Program Destination:

Modeling, analysis, optimization, and tolerancing of centered, decentered, and spatial optical systems with constant and variable parameters, having refractive and/or reflective surfaces of different types.

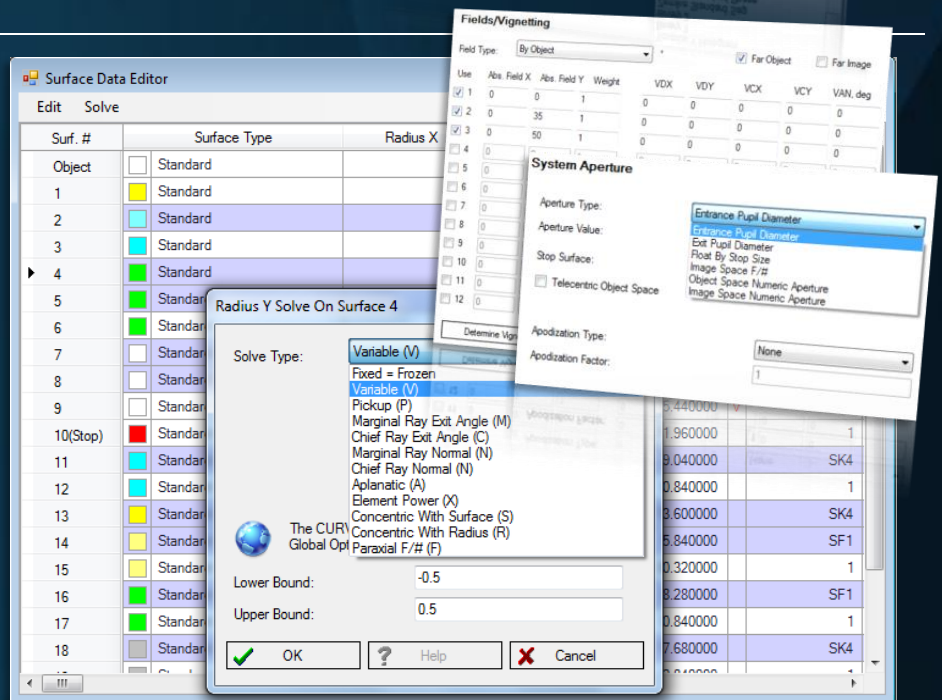
## Surface Types:

- Standard (plane, spherical, 2-nd order aspherical);
- Cylindrical;
- High-order aspherical (biconic, odd asphere, even asphere, elliptical, toroidal, Zernike, polynomial);
- Phase;
- Diffraction (straight-line ruled or radial gratings, with constant or variable grating line spacing);
- Hologram;
- Binary;
- etc. (total more than 35 types).



## Input Data:

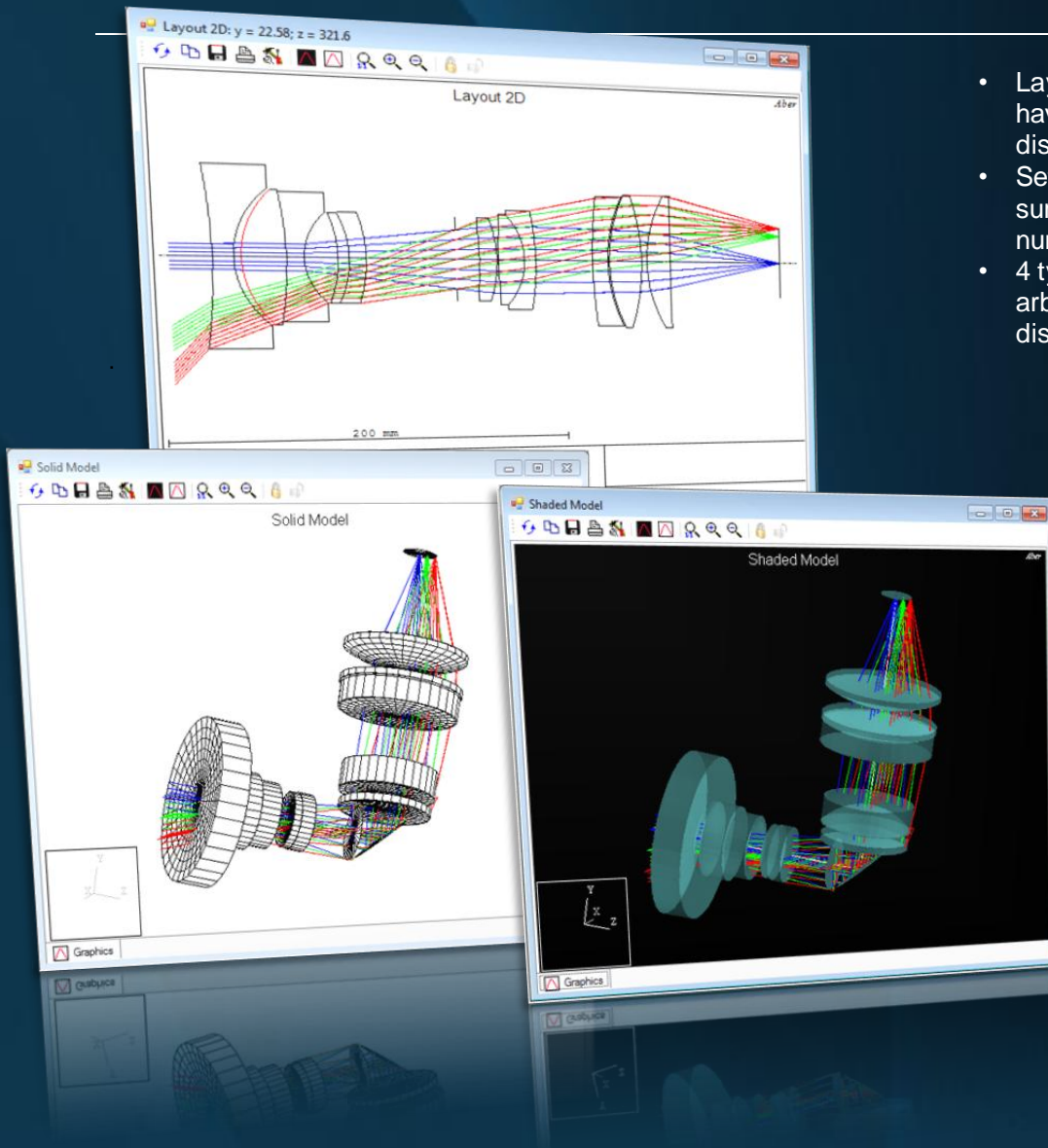
- System aperture may be set by entrance/exit pupil, aperture stop directly, object/image space numerical aperture, or focal ratio;
- Fields are set by object or image values in linear or angular units with vignetting factors;
- Surface Editor with various solves;
- Multi-Configuration Editor;
- The maximum number of wavelengths is 12.



## Paraxial Optics:

- Cardinal parameters of lens and its components (effective focal length, back focal length, etc.);
- Size and position of pupils, object, and image (classical and generalized, proposed by S. A. Rodionov);
- Angles and heights of zero rays;
- Zeidel sums and chromatic sums;
- Basic coefficients of monochromatic and chromatic aberrations, introduced by V. D. Andreeva.

## Layouts:



- Layout 2D for optical systems having an axial symmetry with displaying aspherical surfaces;
- Setting the first and last surfaces to be shown, a number of rays, etc.;
- 4 types of Layout 3D with an arbitrary spatial orientation and displaying aspherical surfaces.

## Spot Diagrams:

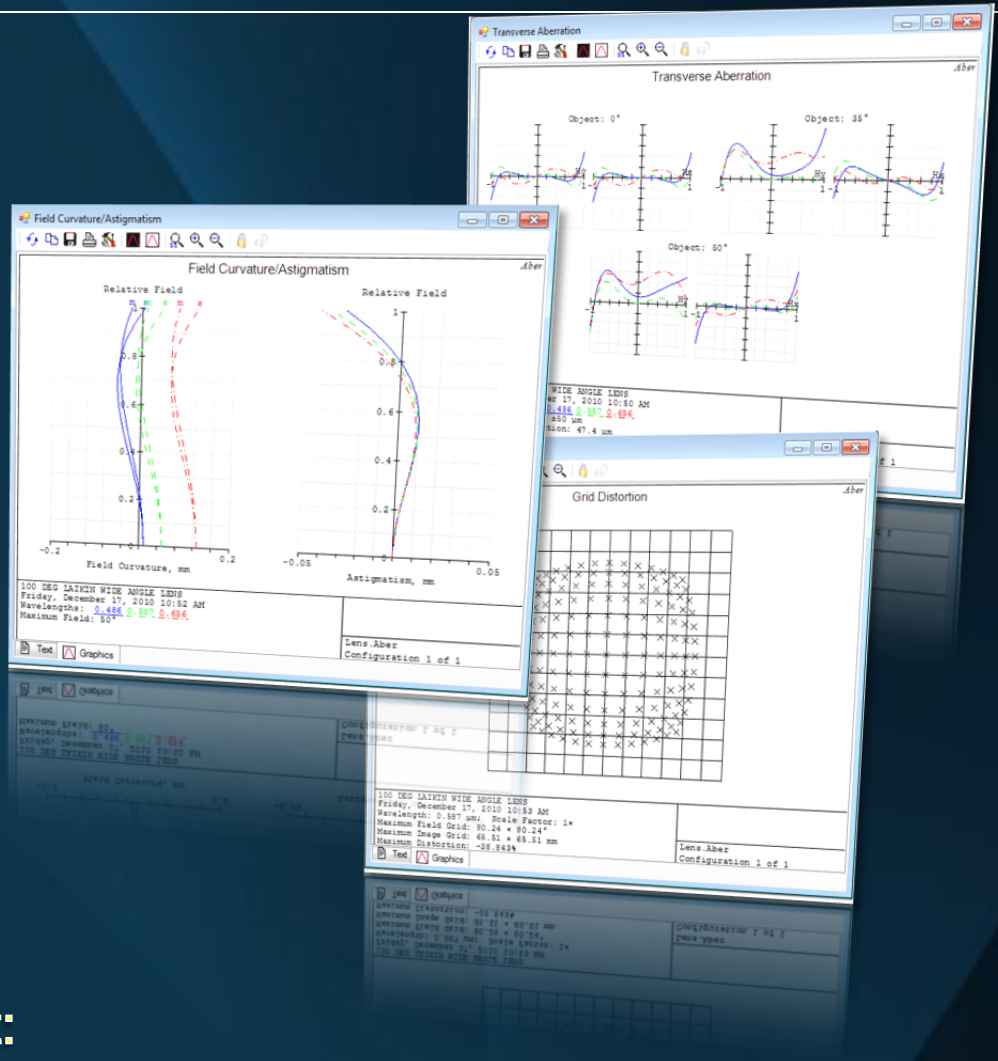


- Standard;
- Through Focus;
- Wavelength Matrix;
- Configuration Matrix;
- Full Field (all field points on a common scale).



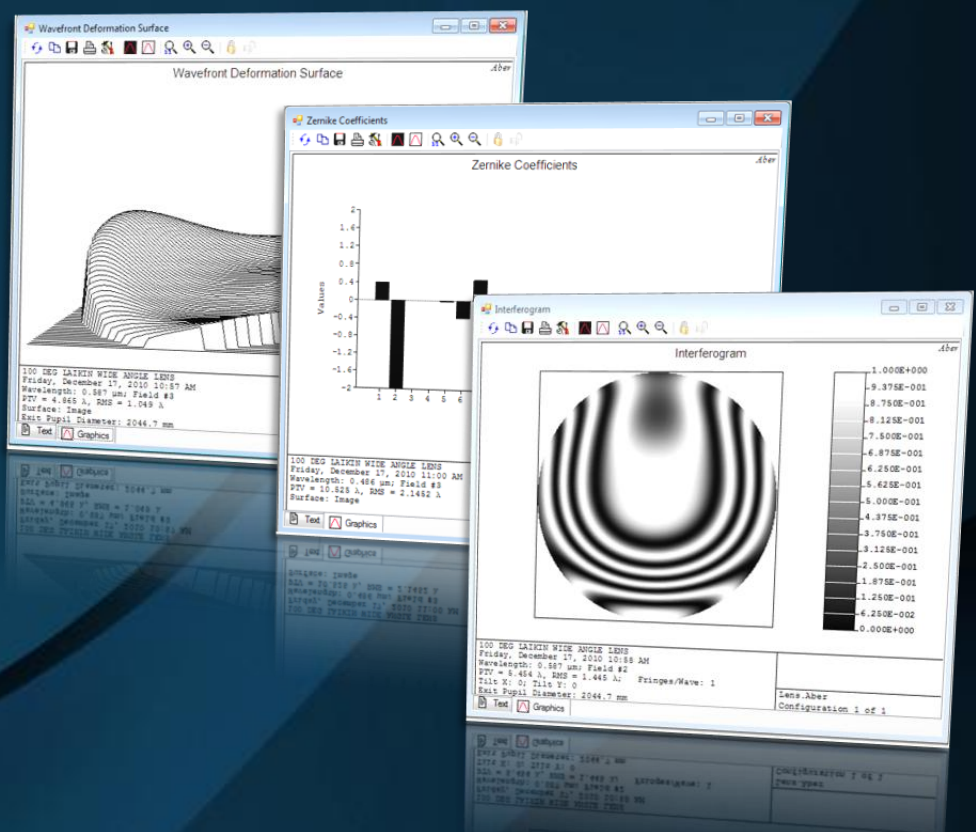
## Basic Aberrations:

- Transverse;
- Optical Path Difference;
- Spherical (Longitudinal and Transverse);
- Astigmatism;
- Field Curvature;
- Distortion (Absolute or Relative);
- Grid Distortion;
- Chromatic Focal Shift;
- Lateral Color.



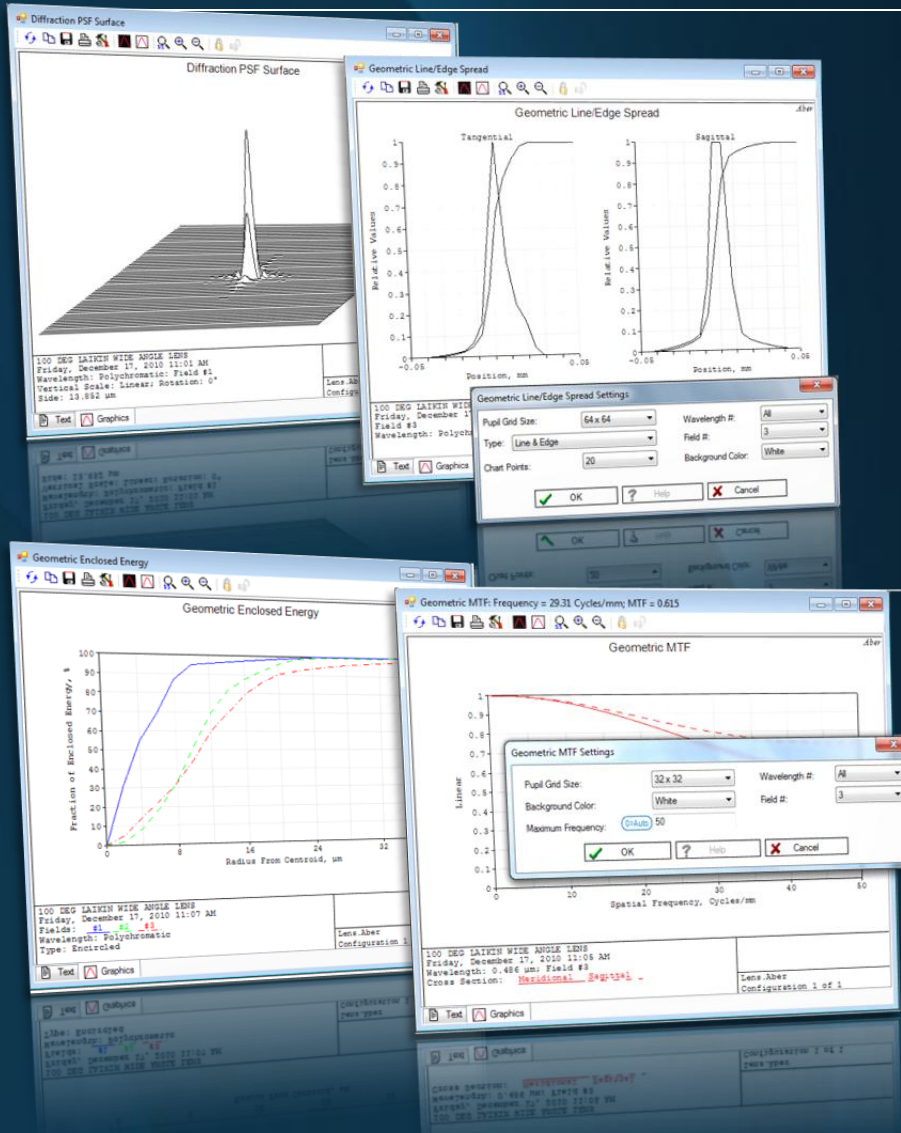
## Wavefront:

- Displayed as a 3D-surface or a color map;
- Peak-To-Valley and RMS values;
- Interferogram;
- Zernike coefficients, which approximate wavefront.



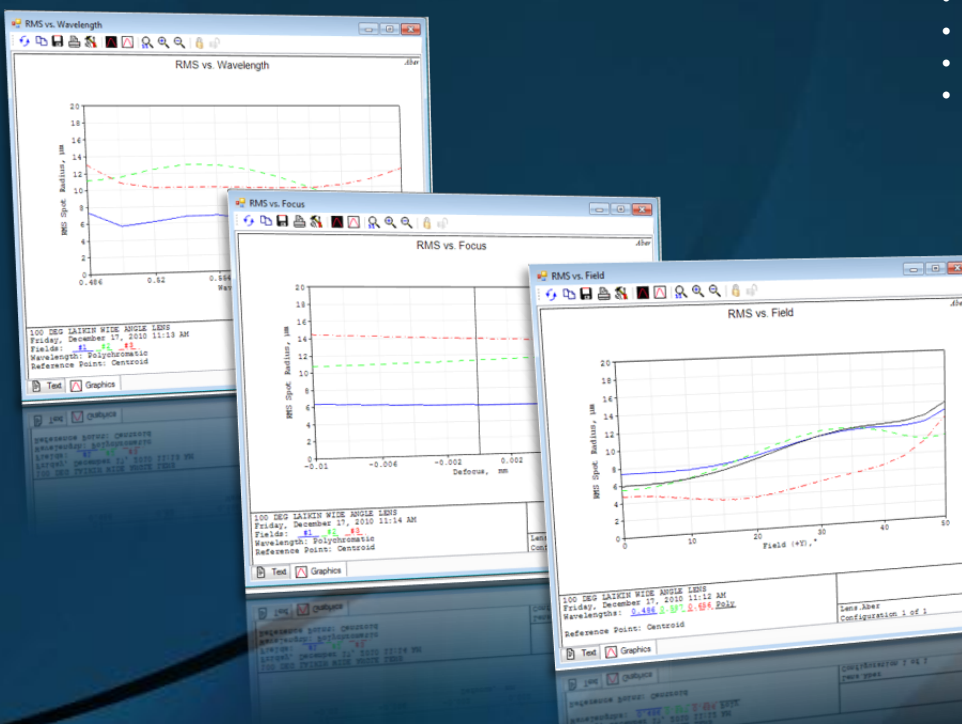
## Image Quality:

- PSF (surface and cross section);
- MTF (surface and charts for meridional and sagittal cross sections);
- Enclosed Energy (encircled or ensquared);
- Line and Edge Spread Functions (for meridional and sagittal cross sections);
- In geometrical or diffraction approximation.



## RMS:

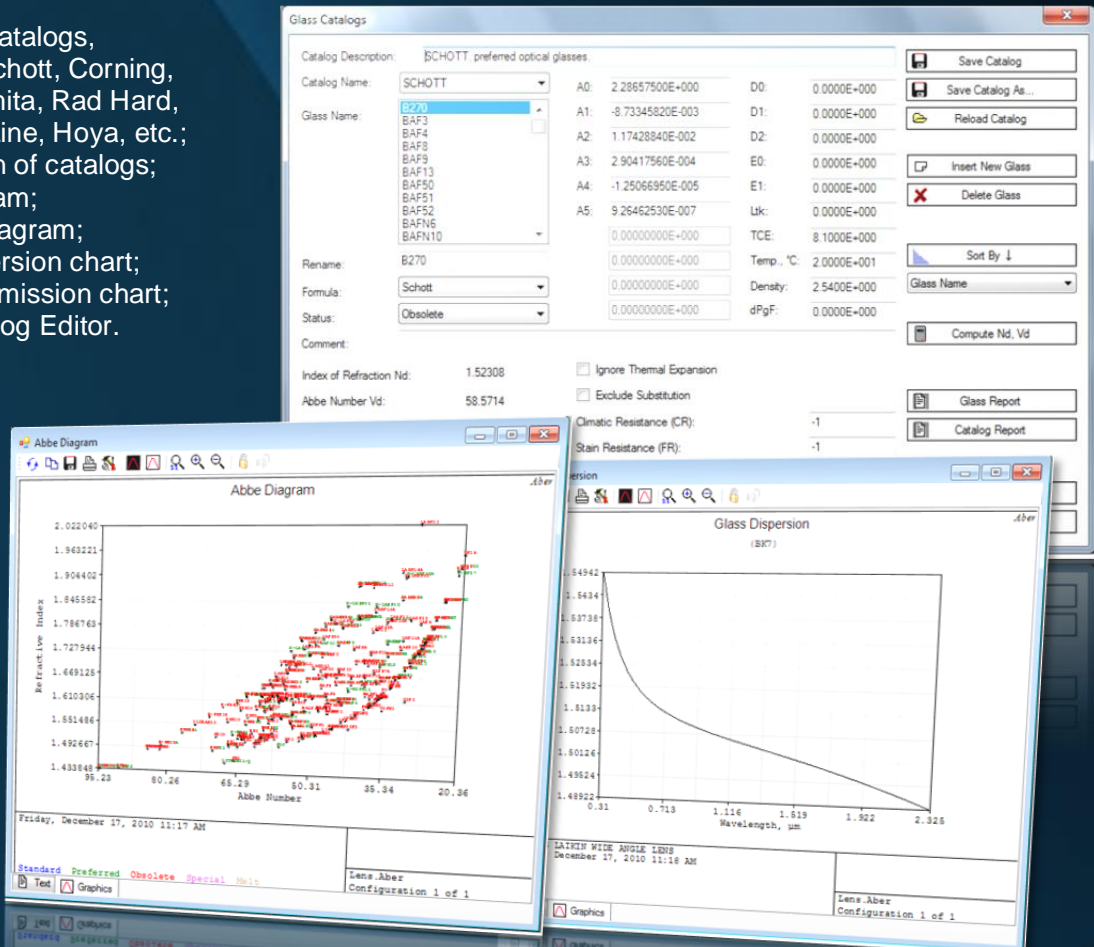
- RMS vs Field;
- RMS vs Focus;
- RMS vs Wavelength;
- For wavefront error, spot radius, spot X size, spot Y size, Strehl ratio.





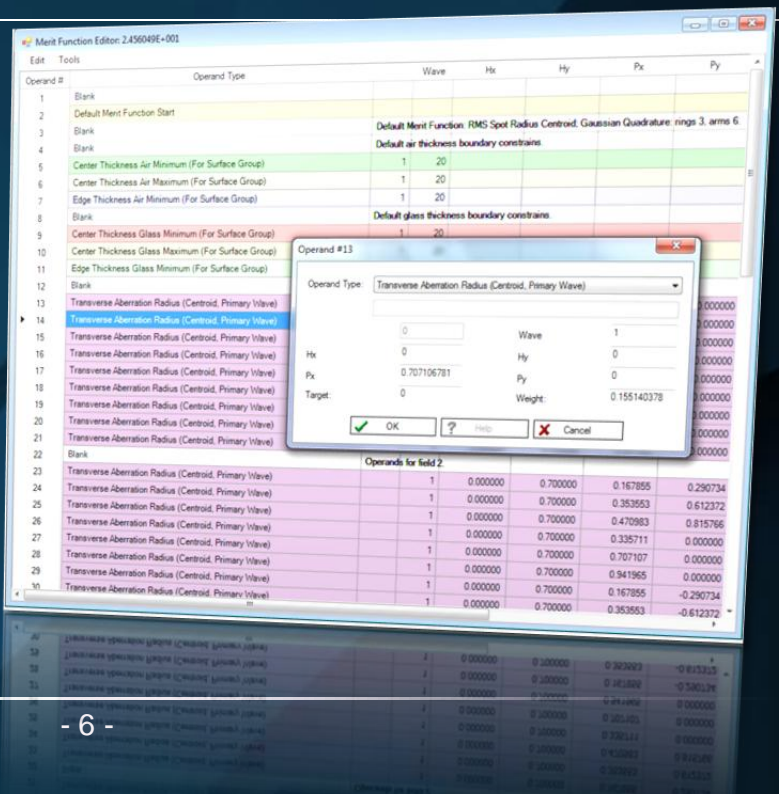
## Glass Catalogs:

- 25+ glass catalogs, including Schott, Corning, Ohara, Sumita, Rad Hard, Infrared, I-Line, Hoya, etc.;
- Comparison of catalogs;
- Abbe diagram;
- Athermal diagram;
- Glass dispersion chart;
- Glass transmission chart;
- Glass Catalog Editor.



## Optimization:

- Local and global optimization with constraints;
- Optimization variables: surface radii, axial thicknesses, conic coefficients, decenters, tilts, specific surface data;
- Merit function operands: various aberrations, lens parameters, constraints on prescription data, etc.;
- Merit Function Editor. A total number of possible operands exceeds 70;
- Default merit functions.



## Tolerances:

Tolerance operands include surface radii (in mm or fringes); axial thicknesses; conic coefficients; refraction indices of mediums; Abbe numbers of mediums; surface irregularities; extra (specific) data of surfaces; multi-configuration operands; decenters and turns of surfaces; decenters and turns of optical components. Incorporated tolerancing algorithms are based on computing real rays. An arbitrary number of different compensators is supported.

**Tolerancing**

**SENSITIVITY ANALYSIS:**

Mode: Sensitivity Analysis

Operand and Compensator Descriptions:

Type	Int1	Int2	Int3	Value	Criteria	Change	Value	Criteria	Change
Tolerance On Radius Y	2			-0.20000000	0.00147916	-0.00000028	0.20000000	0.00147973	0.00000029
Compensator: Thickness				62.44168361			62.44358239		
Tolerance On Radius Y	3			-0.20000000	0.00185375	0.00037431	0.20000000	0.00178021	0.00030077
Compensator: Thickness				62.46309527			62.42300052		
Tolerance On Radius Y	4			-0.20000000	0.00175623	0.00027679	0.20000000	0.00179292	0.00031348
Compensator: Thickness				62.42300084			62.46309326		
Tolerance On Radius Y	5			-0.20000000	0.00147965	0.00000021	0.20000000	0.00147923	-0.00000021
Compensator: Thickness				62.44913877			62.444212521		
Tolerance On Radius Y	6			-0.20000000	0.00270914	0.00122970	0.20000000	0.00262012	0.00114069
Compensator: Thickness				62.46315661			62.42293998		
Tolerance On Radius Y	7			-0.20000000	0.00155463	0.00007519	0.20000000	0.00151150	0.00003206
Compensator: Thickness				62.42302363			62.46306579		
Tolerance On Abbe Number	18			-0.58629829	0.00147619	-0.00000325	0.58629829	0.00148443	0.00000500
Compensator: Thickness				62.44185628			62.44339328		
Tolerance On Abbe Number	20			-0.58629829	0.00147662	-0.00000282	0.58629829	0.00148333	0.00000390
Compensator: Thickness				62.44201317			62.44323952		

**Worst Offenders:**

Type	Int1	Int2	Int3	Value	Criteria	Change
Tolerance On Surface Tilt Y In Deg	17			-0.20000000	0.02800763	2.6628E-002
Tolerance On Surface Tilt Y In Deg	17			0.20000000	0.02796113	2.6492E-002
Tolerance On Surface Tilt Y In Deg	15			0.20000000	0.02770999	2.6231E-002
Tolerance On Surface Tilt Y In Deg	15			-0.20000000	0.02770962	2.6224E-002
Tolerance On Surface Tilt Y In Deg	16			0.20000000	0.02670997	2.5231E-002
Tolerance On Surface Tilt Y In Deg	16			-0.20000000	0.02669879	2.5219E-002
Tolerance On Surface Tilt Y In Deg	18			-0.20000000	0.02403689	2.2584E-002
Tolerance On Surface Tilt Y In Deg	18			0.20000000	0.02403461	2.2555E-002
Tolerance On Element Decenter X	18	19		-0.20000000	0.02368609	2.207E-002
Tolerance On Element Decenter X	18	19		0.20000000	0.02366692	2.2187E-002

**Estimated Performance Changes based upon Root-Sum-Square Method:**

Nominal: 0.0014794

Estimated Change: 0.1015649

Estimated Value: 0.1030344

**Compensator Statistics:**

Compensator: Thickness, Surf 21:

Nominal: 62.4426925

Minimum: 62.4220050

Maximum: 62.4640552

Mean: 62.4425764

Std. Dev.: 0.0125453

**Tolerancing**

Mode: Sensitivity Analysis

Criterion: RMS Spot Radius

Nominal: 0.014223

Update

Sampling: 3

Fields: Y-Symmetric

Config #: All

Statistical Distribution: Normal

Number Of Worst Offenders: 10

Number Of Opt. Cycles: Automatic

Total Monte Carlo Runs: 20

Max Number Of Lens Files To Be Saved: 0

Force Ray Aiming On: ☐

Separate Fields/Configurations: ☐

Show Operand Descriptions: ☒

Show Compensator Descriptions: ☒

Show Worst Offenders: ☒

Use Paraxial Focus Compensator Only: ☒

Status: Idle

Run Terminate Help Cancel

Tolerance criteria:

- RMS Spot Radius;
- RMS Spot X;
- RMS Spot Y;
- RMS Wavefront;
- Boresight Error;
- User's Merit Function.

Tolerance modes:

- Direct Sensitivity Analysis;
- Inverse Sensitivity Analysis;
- Monte Carlo Analysis.

## Tools:

**Test Plate Fitting**

File Name: APPLIED.TPD

Fitting Method: Try All Methods

Number Of Opt. Cycles: Automatic

Number Of Plates: 704

Number Of Radii: 0

Initial MF: 2.680

Current MF: 2.680

Status: Idle

Run Help Terminate Exit

**Add Fold Mirror**

Fold Surface: 21

Tilt Type: Tilt About X

Reflect Angle, Degrees: 90

OK Help Cancel

**Decenter/Tilt Elements**

First Surface: 1

Last Surface: 21

Decenter X: 0

Decenter Y: 0

Tilt About X: 0

Tilt About Y: 0

Tilt About Z: 0

Order: Decenters, Turns

OK Help Cancel

- Automatic test plate fitting (4 methods);
- Automatic best aspheric surface search;
- Quick focus;
- Quick adjust (by arbitrary parameter);
- Reverse elements/system;
- Add/delete fold mirrors;
- Decenters and turns of elements;
- Scale the lens;
- Make given focal length;
- Slider.

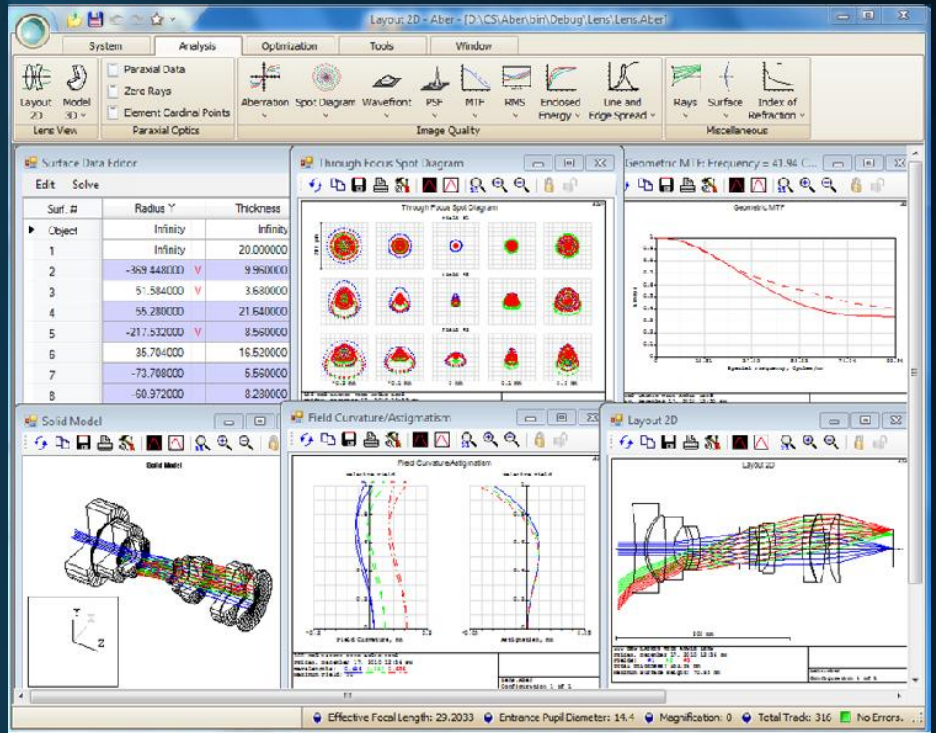


## Program Implementation:

- Microsoft Visual C# from Microsoft Visual Studio 2010;



- To display 3D graphics, Microsoft DirectX and SlimDX are used;
- Multi-window interface;
- Ribbon support;
- Undo/Redo functionality;
- Results are presented as graphics and/or text reports;
- The interface is implemented in three languages: English, Ukrainian, and Russian.



## Sample (Spectrometer):

An optical system of a spectrometer shown below contains a slit aperture diaphragm, one diffraction grating, and two tilted mirrors.

