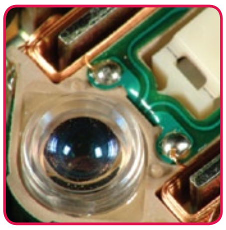
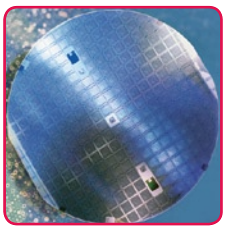
Characterization of a Portable Telephone's Camera Module

Market demand for smaller, better performing devices is motivating mobile phone and digital camera developers and integrators to find new solutions that respond to consumer expectations. Conceiving more compact devices means that the optical systems at the heart of their imaging systems must equally become smaller and smaller all the while with increasingly wide numerical apertures. Add to this that CCD resolution is increasing almost exponentially which makes the intrinsic quality of the optical system all that more important for producing high-quality images. Although several manufacturers offer systems to characterize these types of objectives, we don't know of any one system that incorporates all the functionalities of the SL-Sys neo™.





Imagine Optic™
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Introduction

The SL-Sys neo, developed by Imagine Optic, enables you to characterize objectives from 1.5 to 12 mm in diameter, regardless of their numerical aperture (NA). At the heart of the device is a HASO™3 (32 or 76) Shack-Hartmann wavefront sensor incorporated into an ingenious, patented optical system. Parameters are easily defined via the SL-Sys neo's unique software interface which then automatically drives the measurement and characterization processes including:

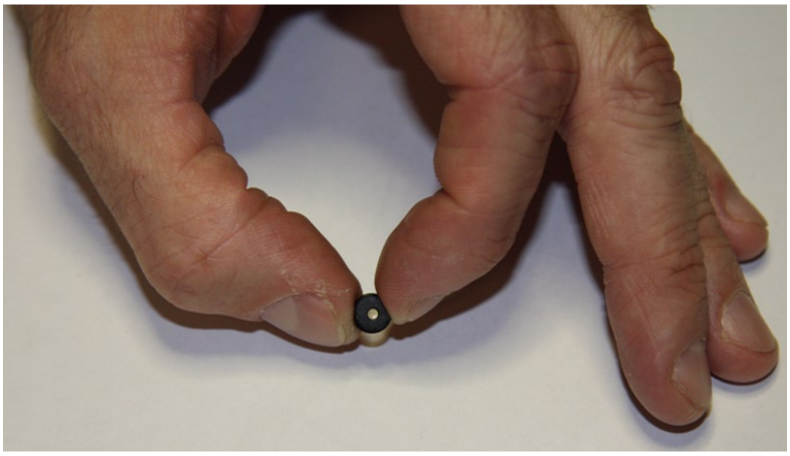
- Wavefront (WF) aberrations on-axis as well as for up to 8 points in the field (fully customizable in any direction within ±45°);
- Modulation Transfer Function (MTF) on-axis as well as for up to 8 points in the field (fully customizable in any direction within ±45°) as well as the through-focus MTF;
- Effective Focal Length (EFL) and Front Focal Length (FFL, sometimes referred to as Front Focal Distance (FFD));
- Distortion, field curvature and vignetting;
- Comparative chromatism at 532 (green) and 635 (red) nm.

By combining numerous precision diagnostics with a highly flexible software interface that allows users to select individual parameters, the SL-Sys neo is an indispensible tool for industrial R&D services.

Demonstration of the SL-Sys neo's functionalities

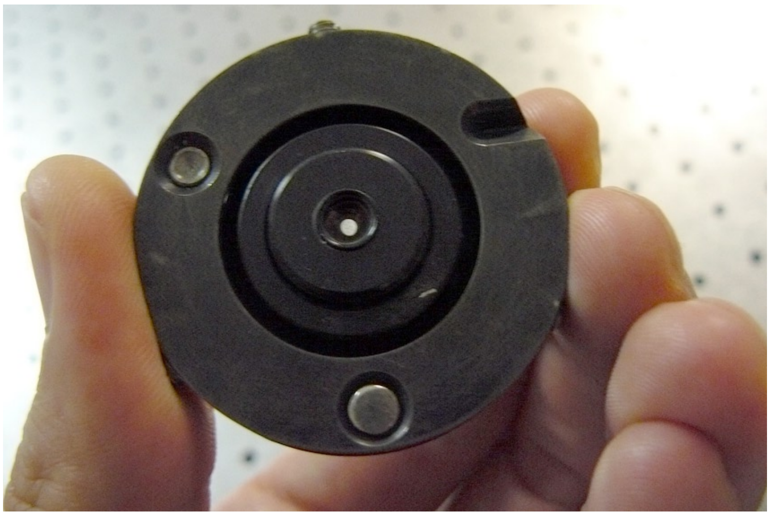
To demonstrate how the SL-Sys neo fully characterizes a camera objective developed for integration into a mobile telephone, we chose an assembly with the following characteristics (shown right):

- Diameter (objective): 1.5mm
- Diameter (image plane on CCD): 3.5mm
- Effective Focal Length (EFL): 5.7mm

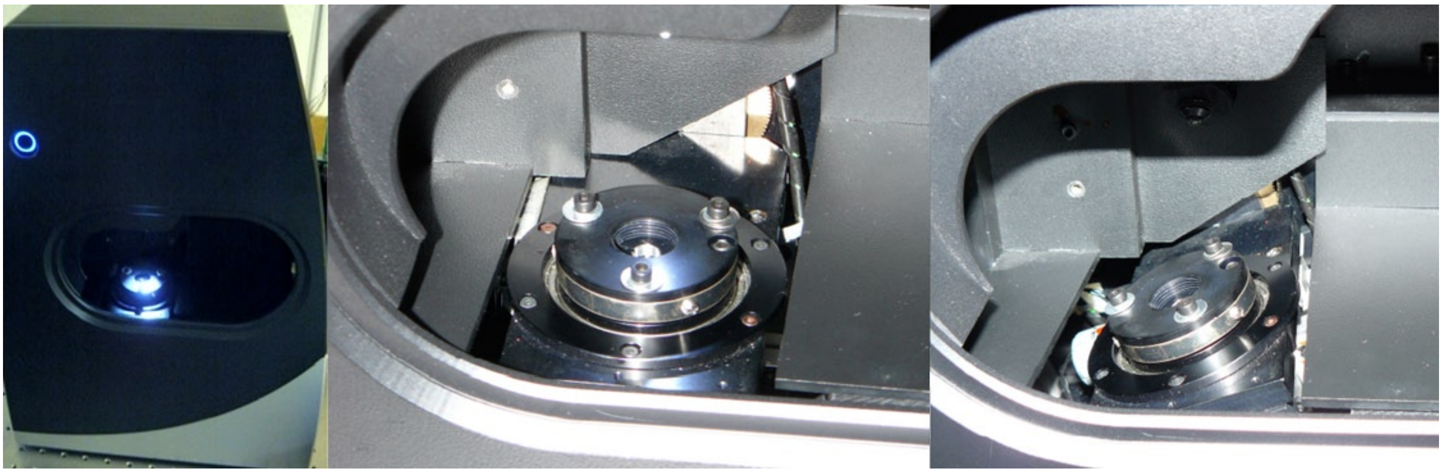


Mounting the objective

The objective to be characterized is placed in a dedicated mounting stage (shown below):



The mounted objective is then secured on the SL-Sys neo's rotation stages (shown below) that will enable its on and off-axis characterization.

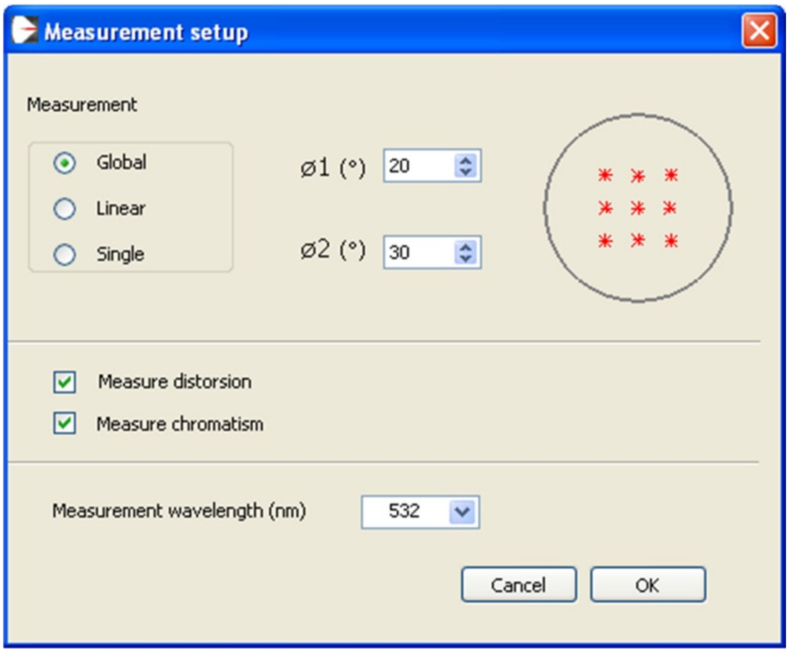


Configuring the characterization

Characterization parameters are quickly defined via the simple interface featured below.

In this dialogue box, the user is presented with 3 operating modes:

- Single – Instructs the SL-Sys neo to characterize the objective for one single point in the field.
- Linear – Enables the user to select 8 points, in addition to the on-axis (center) point, at ±45° in the field to measure.
- Global – Allows the user to select a combination of 8 measurement points with different orientations, in addition to the on-axis (center) point.



Once the operating mode is selected, the user can choose to add two additional measurement options including:

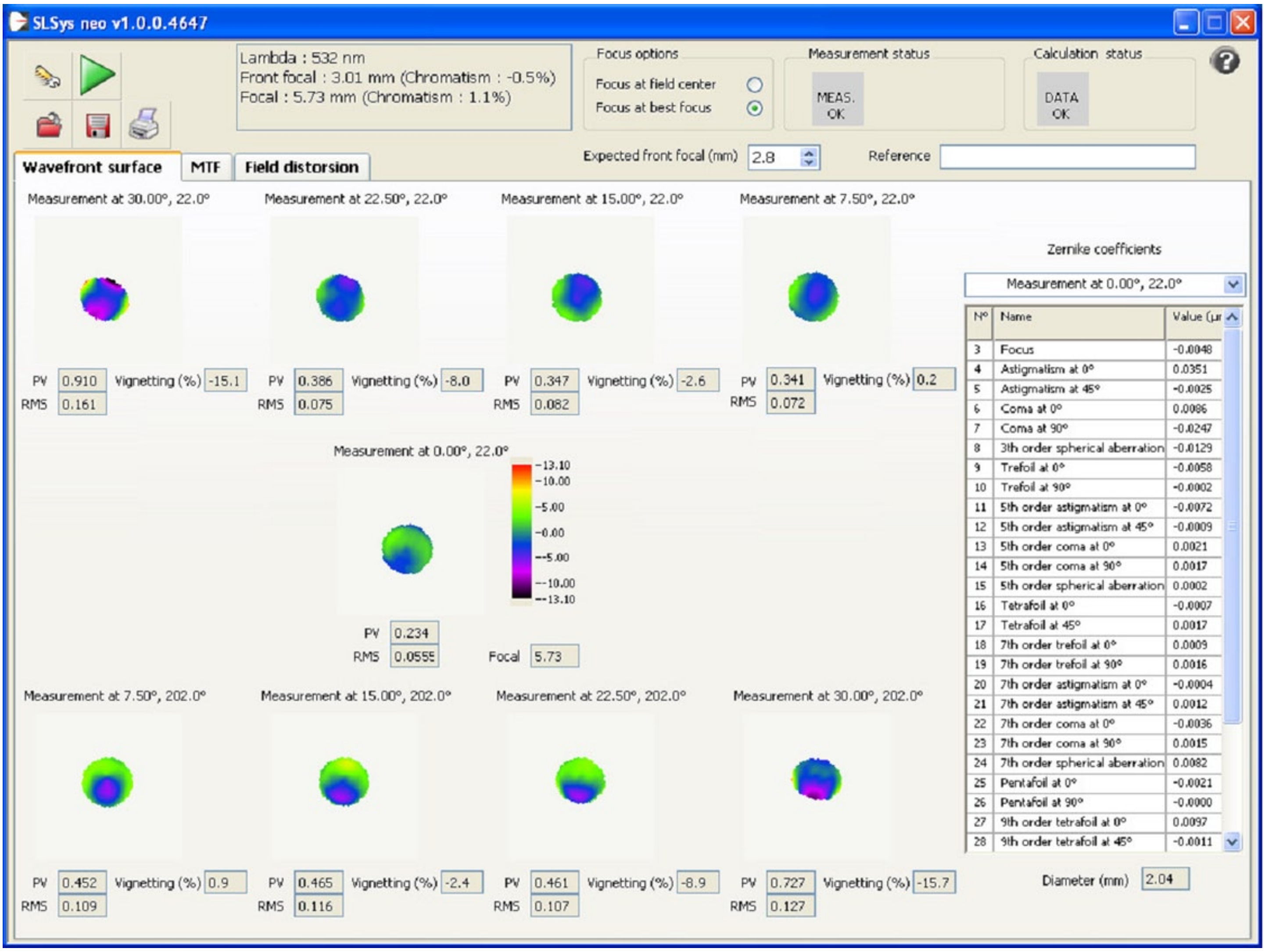
- Distortion – For each angle in the field, the EFL is measured and compared to the on-axis EFL (this option is only available in the Linear and Global operating modes).

- Chromatism – The SL-Sys neo is delivered with two sources, one functioning at 532 nm (green and the other at 635nm (red) and users can choose to characterize with either one, or both, of them. The comparison of the EFL measured by the two sources provides information on the objective's chromatism.

Characterizing the objective

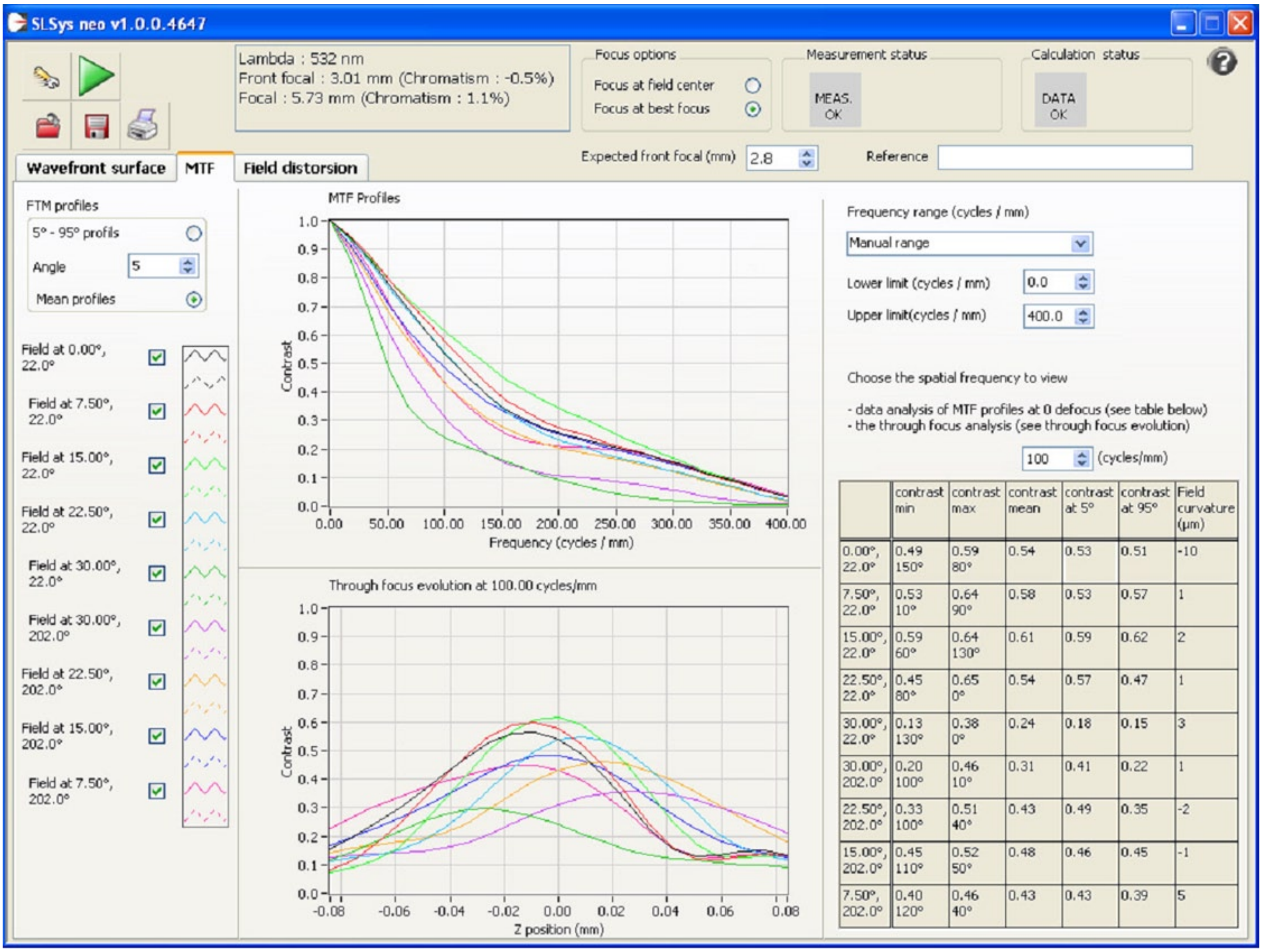
The results presented here correspond to a Linear Mode characterization of the objective described earlier.

The first diagnostic results shown, in the screen capture below in the tab "Wavefront surface," are a series of 9 wavefront measurements that includes the residual wavefront Root Mean Square (RMS) and Peak-to-Valley (PV) as well as information on vignetting, or diminution of the pupil diameter in the field (clearly visible for the two extreme wavefronts in image 5) for all the measured points in the field. If distortion measurement has been selected, information on distortion is displayed next to each wavefront map. Finally, the values of the Zernike coefficients for each measured wavefront are directly accessible to the right of the screen. The ensemble of the characterization data can be easily exported in text or .has (HASO proprietary file) formats.



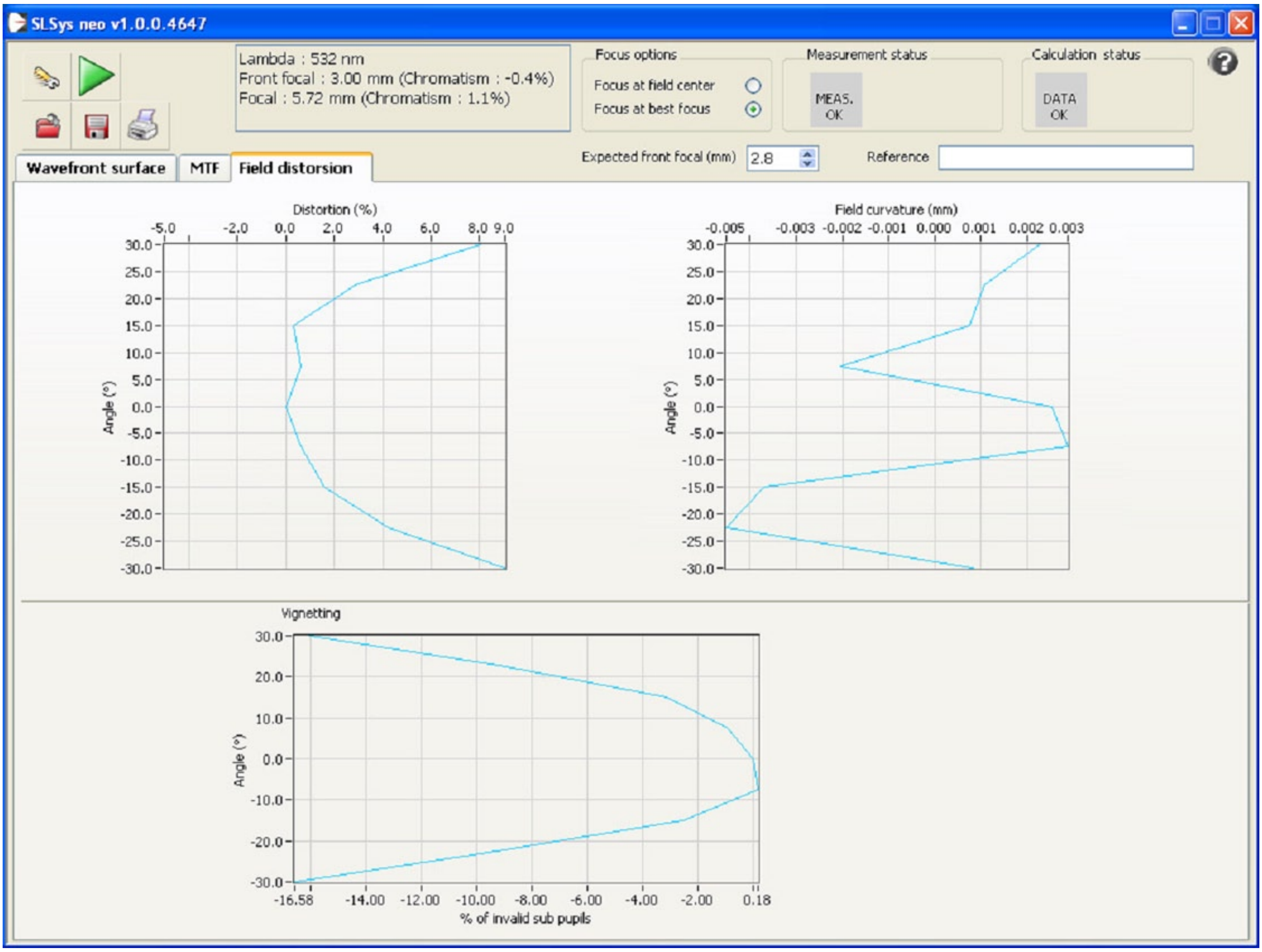
The second diagnostic results shown in the image on the following page under the tab "MTF" equally displays the measurements for the 9 measured points in the field, and the ensemble of the MTF measurements are shown in the upper zone of the window. It is worth noting that, in contrast to typical MTF measurement systems where the MTF is only measured on 2 slits at 90° (sagittal and tangential), the SL-Sys neo can calculate the MTF in any two orthogonal directions for each measured point in the field. The software equally proposes the option to average the MTF in all directions in order to calculate an average residual MTF.

The central portion of the window in displays a presentation of the chosen MTF's evolution relative to z-axis. The graph displays the through-focus MTF and enables users to determine the optimal z-axis position for the CCD.



The last tab in the screen capture on the following page, labeled "Field distortion," displays a series of graphs that indicate:

- Distortion – This indicates the EFL's evolution (increase or decrease) as a function of the field angle. The direct effect of the distortion is a deformation (barrel or pincushion) of the image at the outer extremities.
- Field curvature – This measurement relates to the evolution in the field of the focal point location along the z-axis. Objectives with a strong field curvature will display a slightly spherical, uneven, focal plane. Once the CCD is positioned at the ideal focal plane (best focus on-axis, for example), the effects of the field curvature result in a crisp central image whereas the outer extremities will appear blurred. Note that, in the characterization of the above mentioned objective, the field curvature ranges between -5 and 3µm. Given the display scale, the measurement noise if detectable but the real effect remains negligible.
- Vignetting – This curve represents the reduction in the effective pupil size when the field angle increases.



Conclusions

As demonstrated above, the SL-Sys neo was able to completely and precisely characterize an objective designed for a mobile telephone in less than 1 minute. The extensive data, displayed in a user-friendly and ergonomic interface enables users to make fast use of the information. From calculating the best position for the CCD on the z-axis to determining whether or not the objective's design meets the prescribed specifications as calculated in optical design software, the SL-Sys neo provides all the information users need to quickly make important decisions on quality vs. cost.