Using SFRplus Part 3

Imatest SFRplus results

Imatest SFRplus performs highly automated measurements of several key image quality factors using a specially-designed test chart. Unlike other modules, the user never has to manually select Regions of Interest (ROIs). Image quality factors include

- Sharpness, expressed as Spatial Frequency Response (SFR), also known as the Modulation Transfer Function (MTF),
- Noise,
- Lateral Chromatic Aberration,
- **Distortion** (with less detailed output than the Distortion module)
- **Tonal response** (again, with less detail than Stepchart; no noise statistics)
- **Color accuracy**, when used with an SFRplus that contains the optional color pattern, located above the central square.
- ISO sensitivity (Saturation-based and Standard Output Sensitivity), when incident lux is entered.

This document illustrates SFRplus results. Part 1 introduced SFRplus and explained how to obtain and photograph the chart. Part 2 showed how to run SFRplus inside Rescharts and how to save settings for automated runs.

New in Imatest 3.6 An Edge roughness plot.

New in Imatest 3.6 A Lens-style MTF plot is similar to MTF displays in the Canon, Nikon, and Zeiss websites.

New in Imatest 3.5.1 Several geometrical alignment results are displayed in the Image & geometry plot.

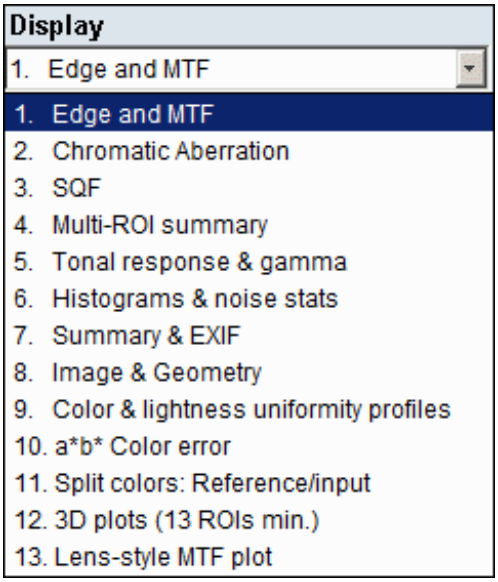
New in Imatest 3.5 ISO sensitivity is calculated when the incident lux level is entered.

New in Imatest 3.4.1 Calculations are now much faster. A Speedup checkbox has been added to the SFRplus setup window to further increase speed by eliminating some calculations that most users don't need (SQF, noise histograms, clipping check, etc.).

SFRplus results

When calculations are complete, results are displayed in the Rescharts window, which allows a number of displays to be selected. The following table shows where specific results are displayed.

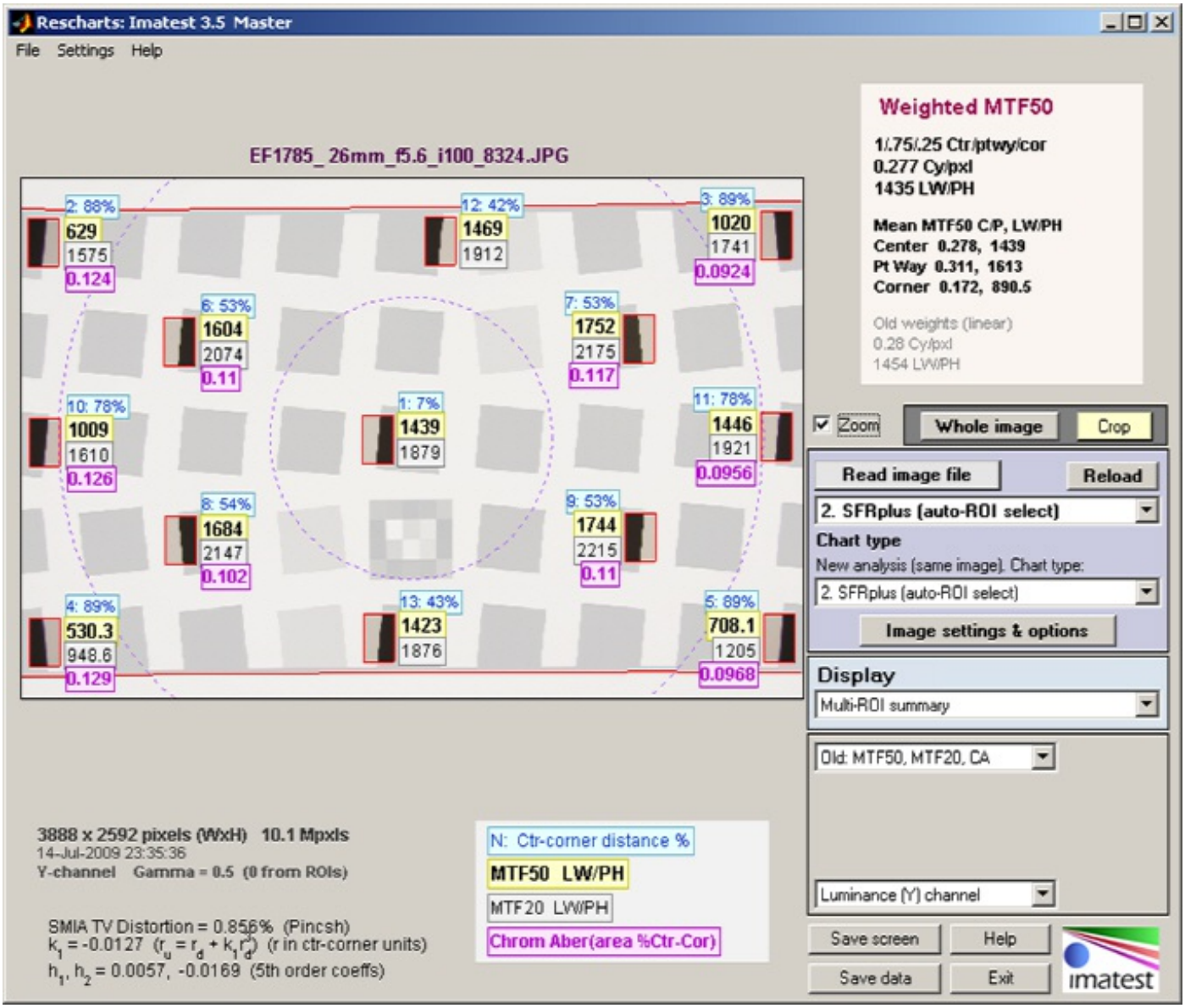
SFRplus display selections



Measurement	Display
MTF (sharpness) for individual regions	1. Edge and MTF
MTF (sharpness) for entire image	4. Multi-ROI summary 12. 3D plot 13. Lens-style MTF plot
Lateral Chromatic Aberration	2. Chromatic Aberration
Distortion, misalignment Original image showing region selection	8. Image & geometry
Tonal response & gamma	5. Tonal response & gamma
Noise	6. Histograms and noise stats
Color accuracy	10. a*b* Color error

	11. Split colors
ISO Sensitivity	5. Tonal response & gamma
Uniformity/Light falloff	9. Color & lightness uniformity profiles
EXIF data	7. Summary & EXIF data
SQF (Subjective Quality Factor)	3. SQF
Edge roughness	14. Edge roughness

Multi-ROI summary display



SFRplus results in Rescharts window: Multiple region (ROI) summary

The multi-ROI (multiple Region of Interest) summary shown in the Rescharts window (above) contains a detailed summary of SFRplus results. (The 3D plots also contain an excellent summary.) It is similar to the SFR Multiple ROI plot. The upper left contains the image in muted gray tones. The selected regions are surrounded by red rectangles and displayed with full contrast. Four results boxes are displayed next to each region. The results depend on the **Old/New** selection in the Display options area on the right. There is a legend below the image. The table below explains the contents in more detail.

	Old: MTF50, MTF20, CA	**New: MTF50, 2ndary readouts**
N: Ctr-	Region	(same)

Distortion statistics are shown in the lower left.

- SMIA TV distortion is the simplest overall measure of distortion. it is positive for pincushion distortion and negative for barrel distortion.
- k_1 (the third order distortion coefficient). $r_u = r_d +$

corner distance %	number (N) and distance from the center as a percentage of center-to-corner distance		$k_1 r_d^3$ = where r_u is the undistorted radius and r_d is the distorted radius. r is normalized to the center-to-corner distance. $k_1 > 0$ for barrel distortion and $k_1 < 0$ for pincushion. • h_1 and h_2 (fifth order distortion coefficients). $r_u = r_d + h_1 r_d^3 + h_2 r_d^5$ A relatively large value of h_2 with a different sign from h_1 may indicate "wave" or "moustache" distortion, where the predominant distortion goes from barrel to pincushion (or vice-versa) as radius increases. The Distortion page has more detail. The Picture Window Pro arctangent/tangent coefficients are also calculated and included in the CSV output file.
MTF50 LW/PH or cycles/pxl	MTF50 in units specified in the MTF plots entry in Display options in the SFRplus settings and options window.	(same)	
MTF20 LW/PH or cycles/pxl	MTF20 in the same units as MTF50. May be replaced by the secondary readout in an upcoming release.	First Secondary Readout	Weighted MTF50 results are displayed on the upper-right. The default weights are 1.0 for ROIs in the central region (inside the inner dotted circle), 0.75 for the middle region (between the two dotted circles), and 0.25 for the outer region (outside the outer dotted circle). These weights can be changed in the SFRplus Settings window. The results are independent of the number of ROIs in each region.
Chrom Aberration (pxl area)	Chromatic Aberration in pixel area. % of center-to-corner distance may be an option in a future release. See Chromatic Aberration and Chromatic Aberration … plots.	Second Secondary Readout	

Plot settings area

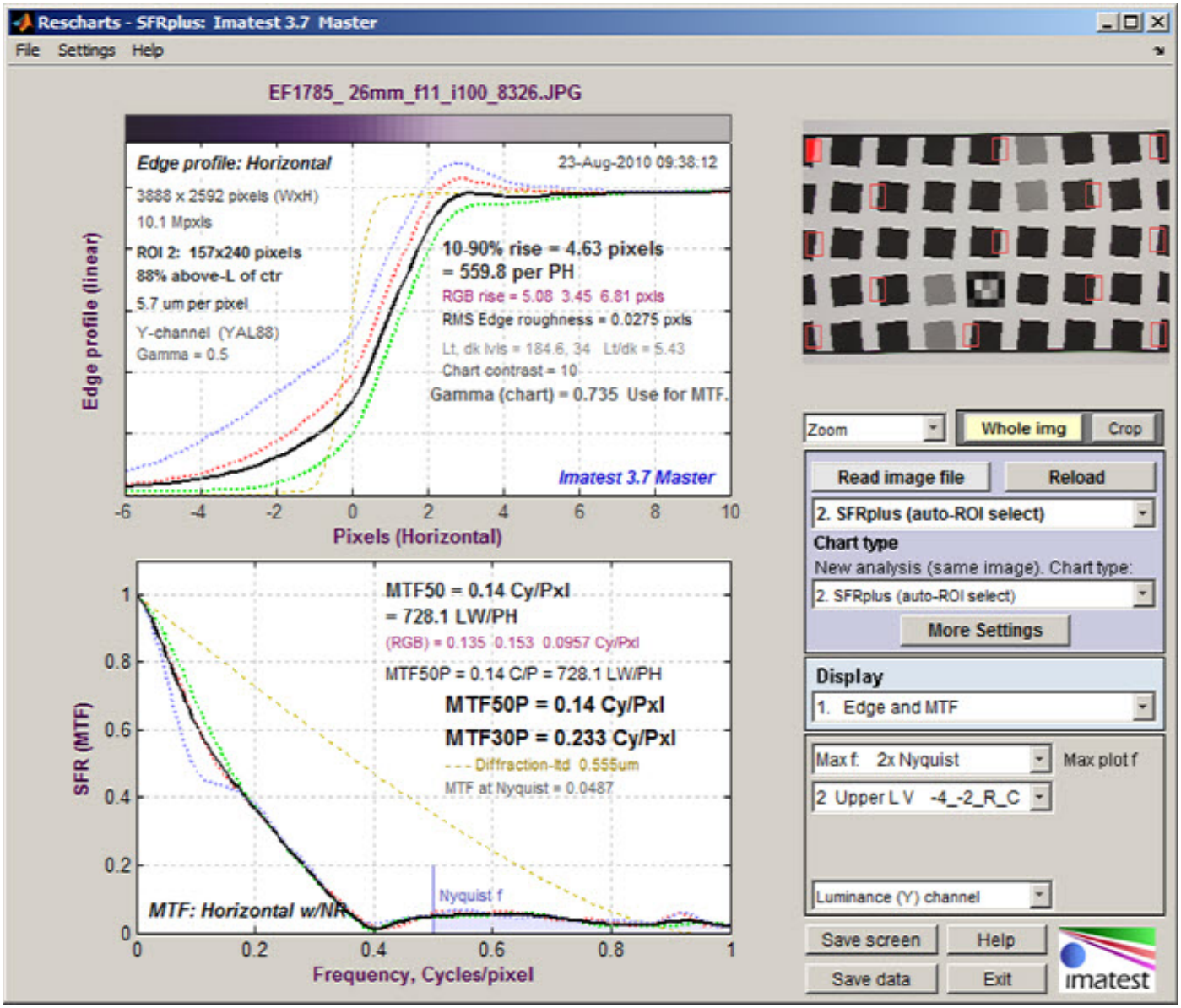
A small number of options are available in the Plot settings area, on the lower right, below the Display box (fewer than for other Rescharts modules).

All displays contain the dropdown menu for selecting the primary channel to analyze. If R, G, B, or Y (Luminance) is selected, all channels are analyzed, but the selected channel is emphasized. There is also an option to analyze any of the channels alone— useful where one of the secondary channels is dark and may cause a run to crash. Luminance (Y) is shown above. If it is changed, results are recalculated.

All displays except **Multi-ROI summary** and **Tonal response & gamma** allow you to select the ROI for viewing results.

The **Edge and MTF** display has a dropdown window for selecting the maximum MTF display frequency: 2x Nyquist (the default), Nyquist, 0.5x Nyquist, and 0.2x Nyquist.

Edge and MTF display



Edge and MTF display in Rescharts window
Diffraction-limited MTF and edge response are shown as a pale brown dotted lines

when pixel spacing (5.7um for the EOS-40D) has been entered.

This display is identical to the SFR Edge and MTF display. The edge (or line spread function) is plotted on the top and the MTF is plotted on the bottom. The edge may be displayed linearized and normalized (the default; shown), unlinearized (pixel level) and normalized, or linearized and unnormalized (good for

checking for saturation, especially in images with poor white balance). Edge display is selected by pressing .

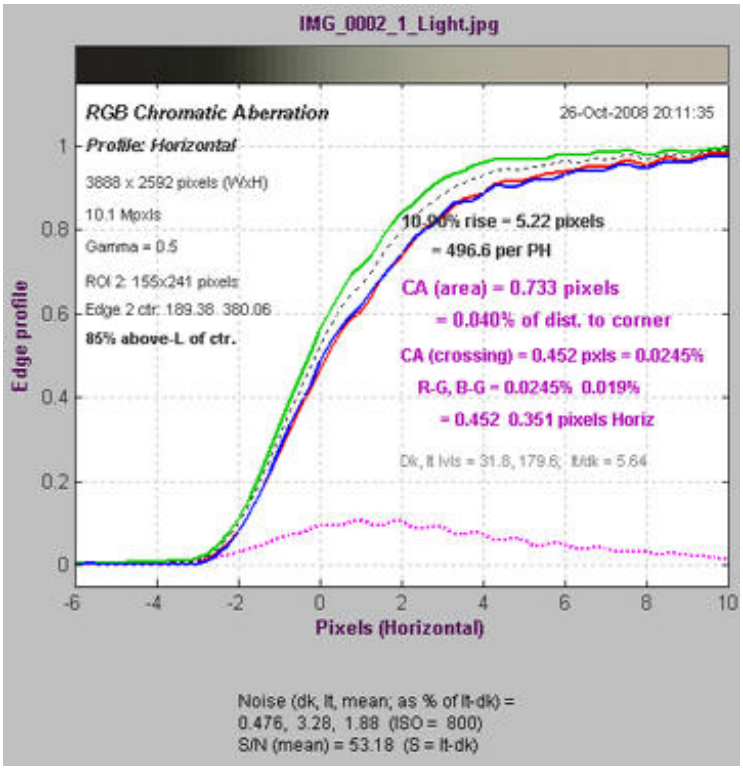
There are a number of readouts, including 10-90% rise distance, MTF50, MTF50P (the spatial frequency where MTF is 50% of the peak value, differing from MTF50 only for oversharpened pulses), the secondary readouts (MTF30 and MTF@30 lp/mm in this case), and the MTF at the Nyquist frequency (0.5 cycles/pixel). The diffraction-limited MTF curve is displayed as a pale brown dotted line.

MTF is explained in Sharpness: What is it and how is it measured? MTF curves and Image appearance contains several examples illustrating the correlation between MTF curves and perceived sharpness.

An important (and optional) readout in the upper plot is

Chromatic Aberration

Lateral Chromatic Aberration



Lateral Chromatic Aberration (**LCA**), also known as “color fringing,” is most visible on tangential boundaries near the edges of the image. Much of the plot is grayed out if the selected region (ROI) is too close to the center (less than 30% of the distance to the corner) to accurately measure CA.

The area between the highest and lowest of the edge curves (shown for the R, G, B, and Y (luminance) channels) is a perceptual measurement of LCA. It has units of pixels because the curves are normalized to an amplitude of 1 and the x-direction (normal to the edge) is in units of pixels. It is displayed as a magenta curve.

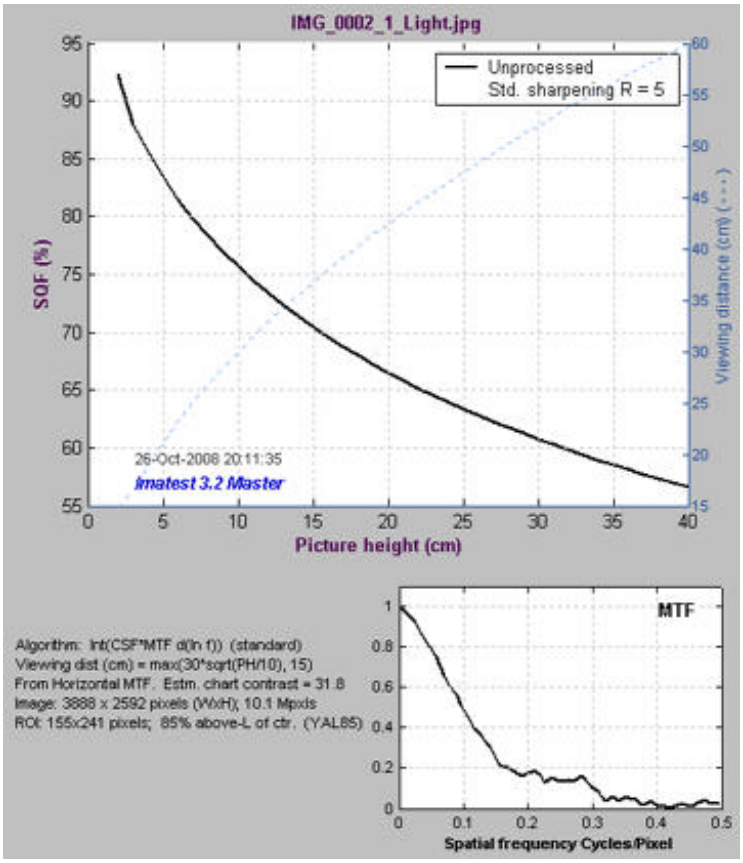
Perceptual LCA is also expressed as percentage of the distance from center to corner, which tends to be more reflective of system performance: less sensitive to location and pixel count than the pixel measurement. Values under 0.04% of the distance from the center are insignificant; LCA over 0.15% can be quite visible and serious.

Information for correction LCA (R-G and B-G crossing distances) is also given in units of % (center-to-

corner) and pixels. LCA can be corrected most effectively *before* demosaicing. Results are explained in Chromatic Aberration … plot.

SQF (Subjective Quality Factor)

SQF (Subjective Quality Factor)



SQF is a perceptual measurement of the sharpness of a display (monitor image or print). MTF, by comparison is device sharpness (not perceptual sharpness). SQF includes the effects of the human visual system's Contrast Sensitivity Function (CSF), print (or display) size, and viewing distance (which is assumed to be proportional to print height, by default).

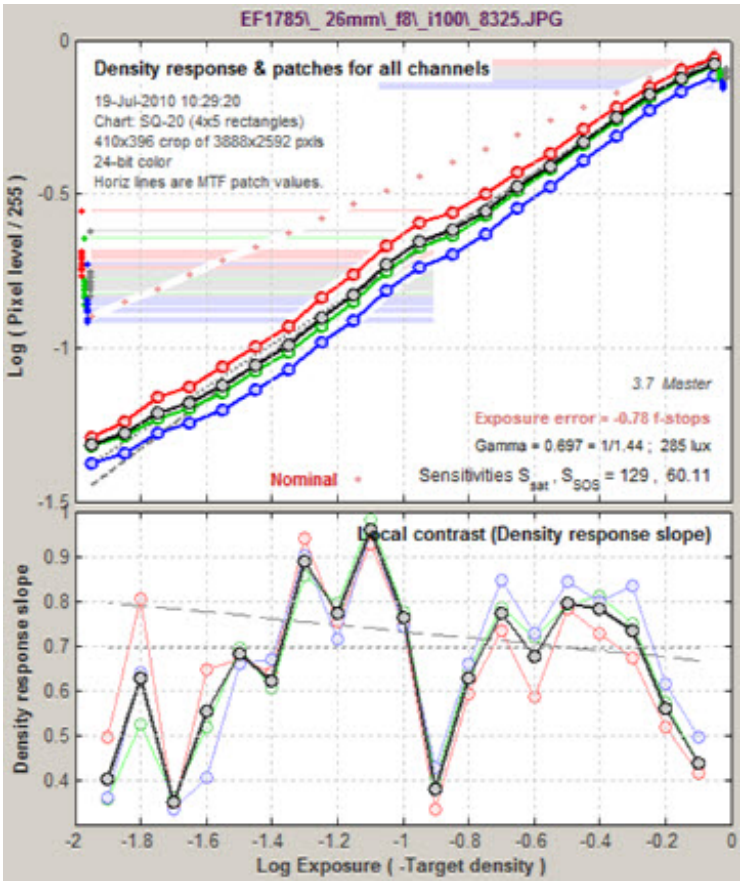
SQF is available when Speedup is unchecked in the input dialog box. See Introduction to SQF for more detail.

Tonal response & gamma

Tonal response & gamma

This display is derived from the 4x5 stepchart

pattern, located just below the center of the SFRplus test chart. It resembles the third figure in Stepchart. The upper plot shows the tonal response (also called OECF for Opto-Electronic Conversion Function) for all colors. The lower plot shows instantaneous gamma—the slope (derivative) of tonal response. The value of gamma may differ slightly from the values in the Edge response and MTF display because it's calculated differently– based on the average slope of the light to middle tone squares of the stepchart.



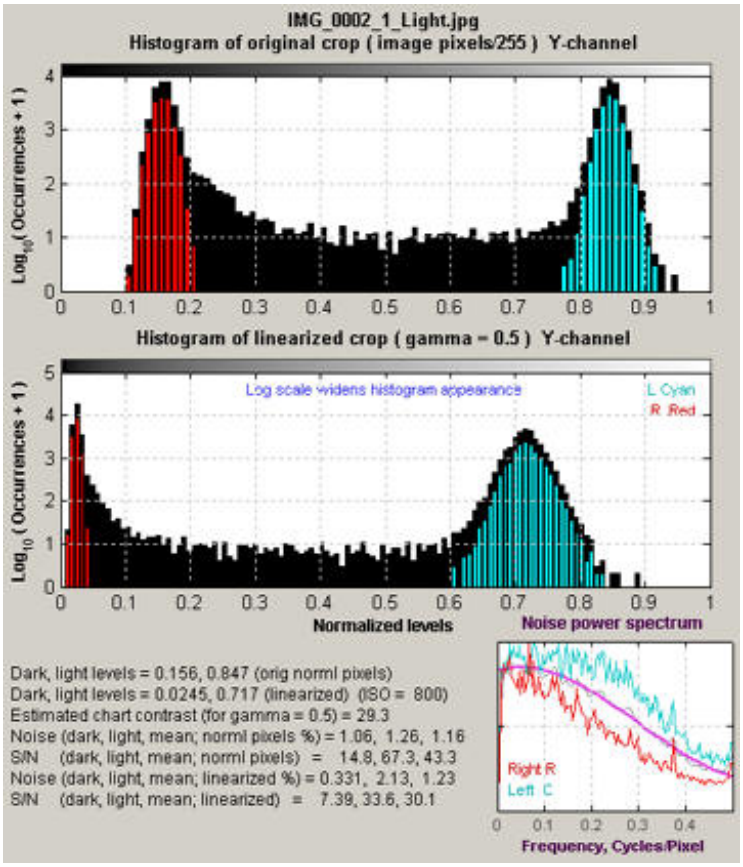
Starting with Imatest 3.7, the levels of the light and dark portions of the patches used to calculate MTF are shown as pale horizontal lines and as points on the extreme left and right of the upper plot. You can use these lines to see if the patches are within the (relatively) linear region of tonal response (they are in the example on the right). A warning message (**Warning: MTF patches may saturate**) is displayed if any of the patches are close to saturation (log(pixel level/255) > -0.01; roughly, pixel level > 249 of 255).

Histograms and noise analysis

Histograms and noise stats

Histograms and noise stats

This display, available when **Speedup** is unchecked, contains histograms of pixel levels for individual ROIs (original on top and linearized using input gamma on bottom). The black (background) histogram contains pixel levels for the entire ROI. The red histogram is for the right (dark) region, away from the transition, used in the noise statistics calculation. The cyan histogram is for the left (light) region. Sharpening may cause extra bumps to appear in the black histogram. A detailed level and noise analysis is displayed below the image.

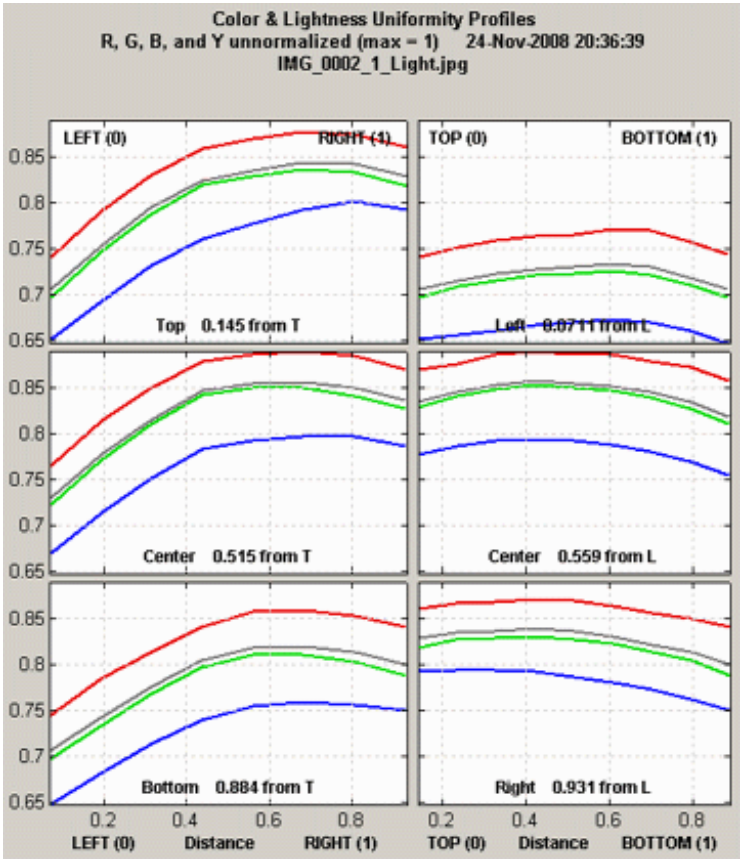


Dark, light levels	Original pixel levels normalized to 1 and linearized levels, also normalized to 1
Estimated chart contrast (for gamma = …)	The correct chart contrast must be entered in SFRplus parameters & setup window.
Noise (dark, light, mean; norml pixels %)	RMS noise expressed in pixels, normalized to 100% (for 255 in 8-bit files)
S/N (…; norml pixels)	Signal/Noise, where signal is mean pixel level of ROI at a distance from the transition.
Noise (…; linearized %)	Noise, linearized using gamma (input); normalized to 100%
S/N (…; linearized)	Signal/Noise, linearized

Noise calculations are made in portions of the ROIs (Regions of Interest) away from the transitions. They are facilitated by selecting wide ROIs. The noise spectrum on the lower right contains qualitative information about noise visibility and software noise reduction, which generally reduces high frequency noise below 0.5, typical of demosaicing alone. The region on the right is shown in **red**; left is shown in **cyan**. See also Noise.

Color & lightness uniformity profiles

Uniformity profiles



This display is similar in some respects to the profile plots in Light Falloff. It consists of profiles of the light areas (average values of rectangles between squares). Left-to-right profiles of the top, middle, and bottom of the image are shown on the left side of the display, and top-to-bottom profiles at the left, center, and right of the image are shown on the right. The following display options are available.

> *R, G, B, and Y unnormalized (max = 1)*
>
> *R, G, B, and Y normalized (max = 1)*
>
> *R, G, B, and Y unnormalized (max = 255)*
>
> *R/G (Red) and B/G (Blue) unnormalized*
>
> *R/G (Red) and B/G (Blue) normalized (max = 1)*
>
> *Delta-L* (gray), a* (R), b* (B), chroma c* (G)*

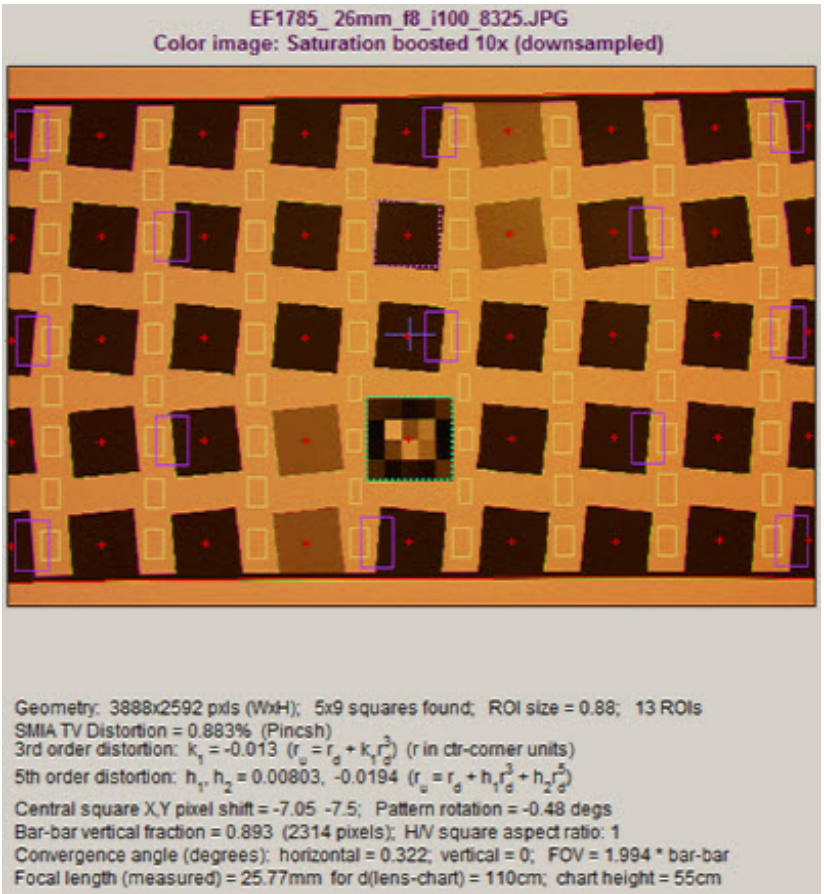
For best results with this display, you should make every effort to illuminate the target uniformly using techniques in The Imatest Test Lab. Brightness-related results (R, G, B, Y, and Delta-L*) cannot be measured as accurately as with Light Falloff, where the recommended technique calls for a clear uniform image field photographed through opal diffusing glass. But they can still be useful. The color ratios (R/G, etc.) can be especially useful for diagnosing uneven color response.

Image & Geometry

Image (shown with exaggerated saturation)

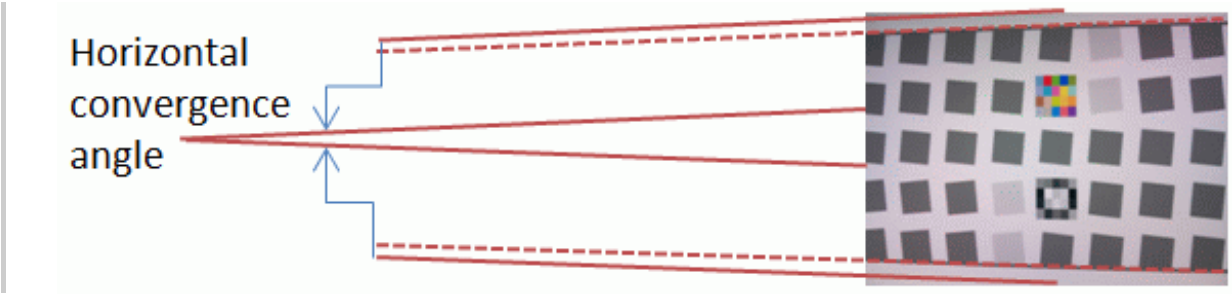
This display allows several aspects of the image to be viewed in detail. It shows the selected regions for MTF/noise analysis (violet rectangles), the yellow rectangles used for generating the uniformity profiles, and the red horizontal curves used to measure distortion). Display options include

> *(original) Color image*
>
> *Red, Green, or Blue channel*
>
> *Color image with HSV satuartion boosted 4X or 10X.*



A number of geometrical results are shown beneath the image.

- **WxH of image in pixels**; m x n squares found; ROI size (referencing input setting), number of ROIs for MTF, etc. (not for profiles).
- SMIA TV Distortion: Barrel (<0) or Pincushion (>0)
- **3rd order** distortion coefficients
- **5th order distortion coefficients**
- **x,y coordinates** of the center of the middle square relative to the image center.
- The average **rotation** of the pattern in degrees (>0 for clockwise)
- **The bar-to-bar vertical height** as a fraction of the image height and in pixels.
- **Convergence angles** (degrees). These are the result of perspective distortion, when the camera is not pointed directly at the target or is mis aligned. The horizontal convergence angle is shown below: calculated by extrapolating the horizontal bars to the top and bottom. A positive angle has a vortex to the left. In the illustration below the pairs of solid red lines at the top and bottom are parallel (to fit the image on the page).



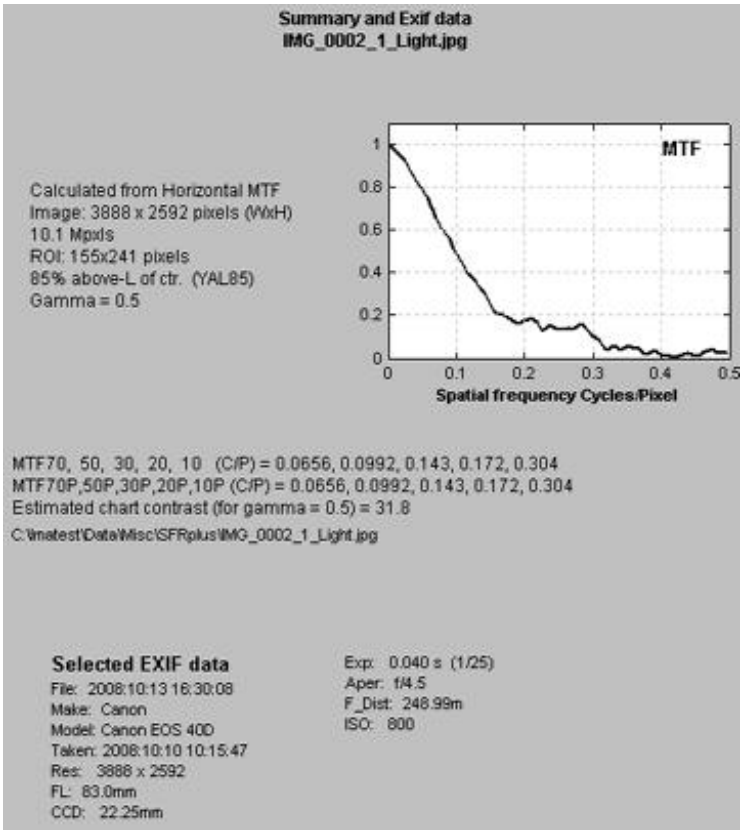
> *Perfect alignment would be x,y coordinates, rotation, and H,V convergence = 0. Marks may be added to the top and bottom white space of the SFRplus image to facilitate alignment.*

- **measured focal length of the lens** is displayed when **Bar-to-bar chart height in cm**, **Lens-to-chart distance in cm**, and **Pixel spacing (pitch)** have been been entered. It is written to the CSV output file if calculated. Equations: Magnification *M* is bar-to-bar height (on the sensor) / bar-to-bar height (on the chart). For Lens-to-chart distance f_1, lens-to-sensor distance $f_2 = f_1 M$. Using the thin lens equation, focal length $f = 1/(1/f_1 + 1/f_1)$.

Summary & EXIF data

Summary & EXIF data

This plot contains summary results for individual ROIs and EXIF data (metadata that describes camera and lens settings). When first installed, Imatest reads EXIF data from JPEG files only. Enhanced EXIF support requires a special download of ExifTool, described here.



Color analysis

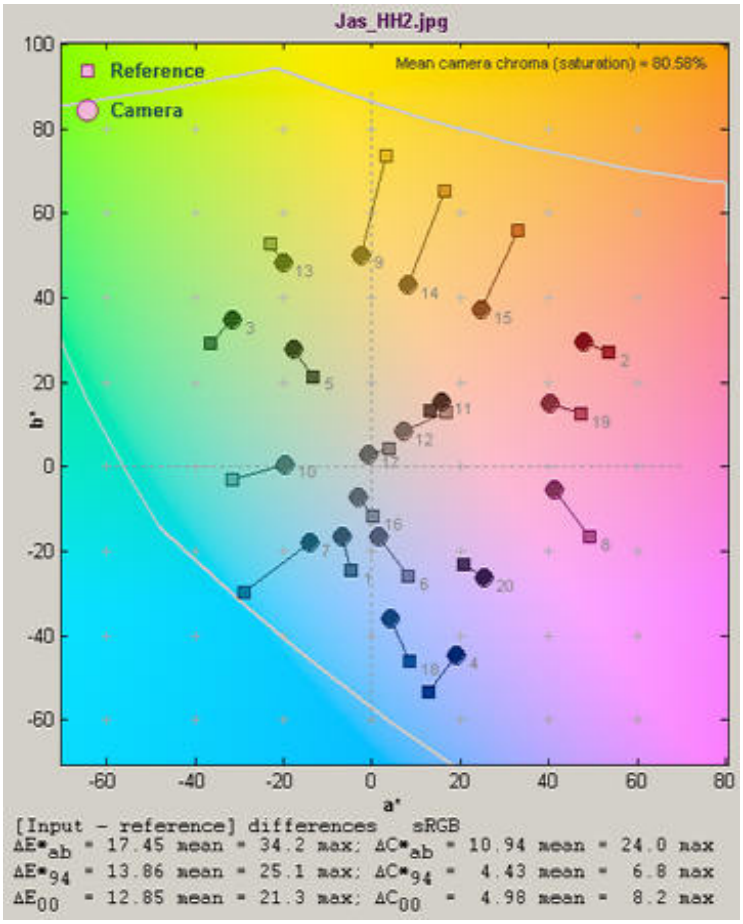
a*b* color error

Split view, showing Probe results

A color analysis is available for images that contain the optional SFRplus color pattern, which consists of 20 colors in 4 rows and 5 columns. 18 of the 20 colors are close to the colors of the industry standard 24-patch color

colors of the industry-standard 24-patch color chart. The other two are on the yellow and blue sides of neutral gray. To obtain a color analysis,

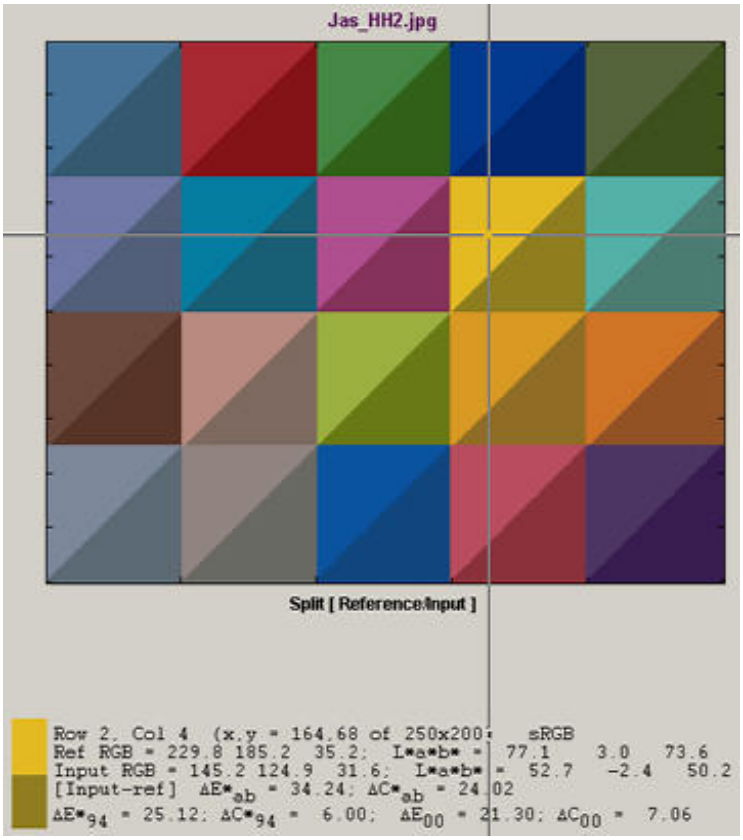
Two displays are available in the color analysis. The a*b* color error display, shown on the right, is similar to displays in Colorcheck and Multicharts. This display shows the reference (nominal) {a*,b*}values as squares and the camera (measured) values as circles. Normally the mean and maximum values of ΔE^*_{ab}, ΔC^*_{ab}, ΔE^*_{94}, ΔC^*_{94}, ΔE^*_{00} and ΔC^*_{00} are displayed



SFRplus chart with optional color pattern

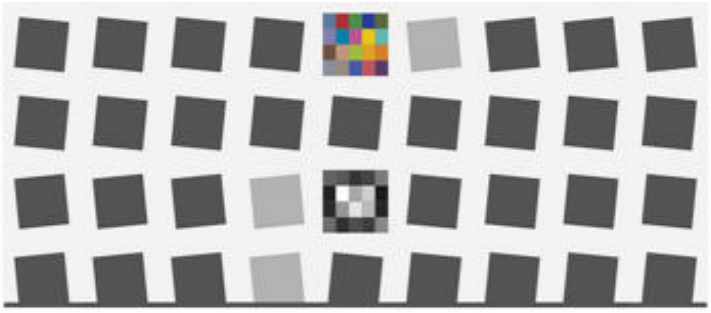
The Split (Reference/Input) display is shown on the right. The bottom shows statistics for Row 2, Column 4, obtained by clicking in the Display area on the lower right (not shown).

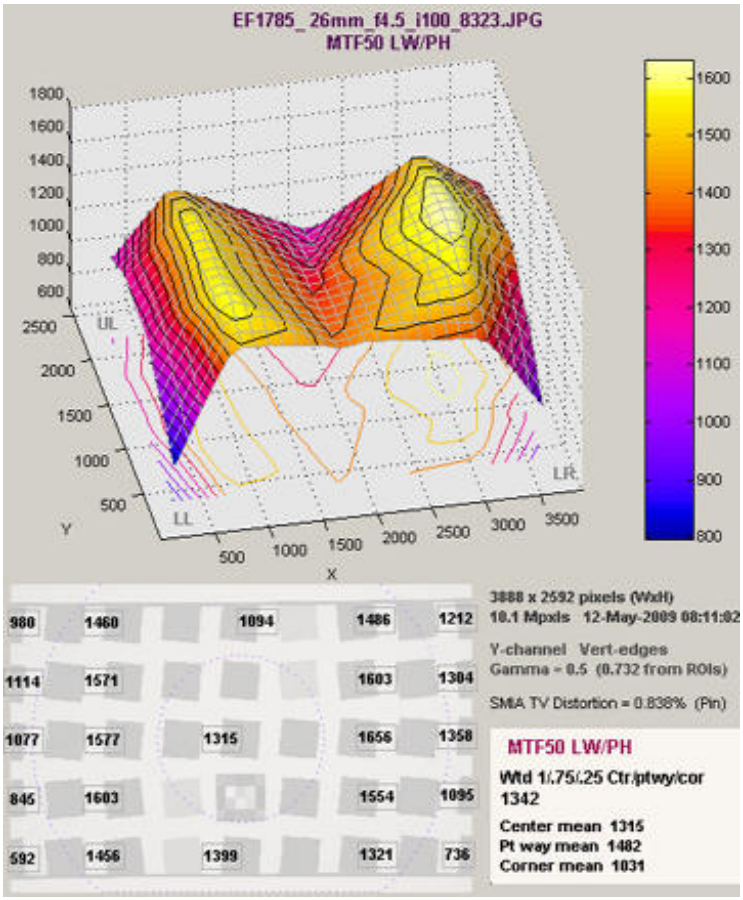
To turn off the probe, click outside the image (in the current version, you need to ckickon the text below the image. This should be fixed in a future version.) When the Probe is off the mean and maximum values of ΔE^*_{ab}, ΔC^*_{ab}, ΔE^*_{94}, ΔC^*_{94}, ΔE^*_{00} and ΔC^*_{00} are displayed.



3D Plots

MTF50 3D plot





1. MTF50

1. MTF50
2. MTF @ .25 Cy/pxl =
3. MTF @ .125 Cy/pxl =
4. MTF30
5. MTF20
6. MTF50P
7. R1090 pixels
8. R1090 /PH
9. Peak MTF
10. LSF PW50
11. Chrom Aberr Area %
12. CA Area pixels
13. CA Crossing %
14. CA R-G pixels
15. CA B-G pixels

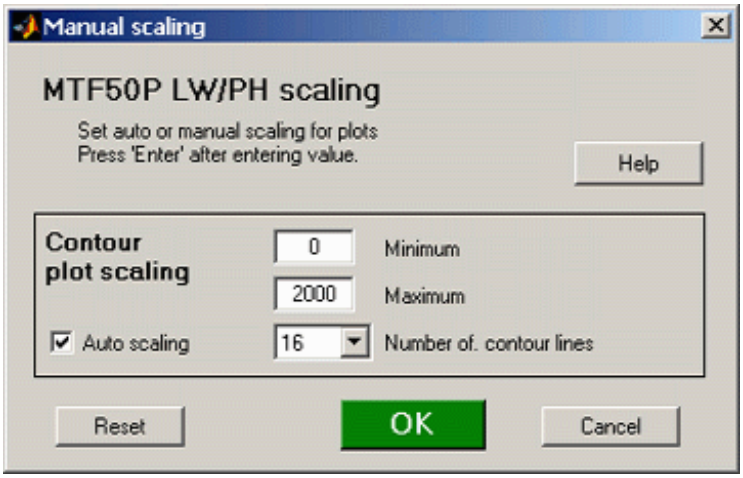
Plot options (Master)

Pscolor shaded, image & text

Pseudocolor, image & text
Pscolor shaded, image & text
Contours, image & text
Pseudocolor only
Pscolor shaded only
Contours only

Display options

Scaling window

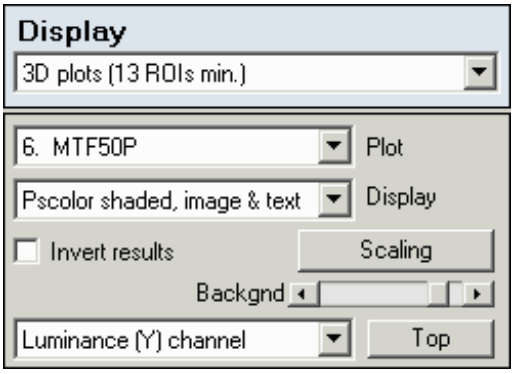


Displays results as three-dimensional pseudocolor images. The parameter to be displayed is selected by **Plot** options, shown on the right. (Only MTF50, automatically scaled, can be displayed in Imatest Studio) The display can be rotated for enhanced visualization. Region selection should include at least 13 regions.

A 5x5 ROI grid (23 regions) was chosen for the analysis on the right. The largest selection that avoids the low contrast edges, which tend to have lower MTFs in typical consumer/DSLR cameras with nonlinear signal processing, is **13. All sqs, inner & bdry except low contrast**. Single-contrast charts (without the low contrast regions) work well for 3D plots (for example, in equipment reviews). The rather strangely shaped surface (center has lower MTF than part way region) may be the result of autofocus issues and/or curvature of field.

Several **Display** options are available. The Pseudocolor shaded plot with image and text shown on the right is the most generally useful. Other options include no shading, colored contour lines-only, and 3D plots only (displayed larger, but without the summary image and text shown below the 3D plot).

Display area. Details on right



The Z-axis of the image (which contains the results) can be inverted to reveal detail obscured in a normal display. The background color can be varied from white to black using the Backgnd slider. The default is light gray (0.9).

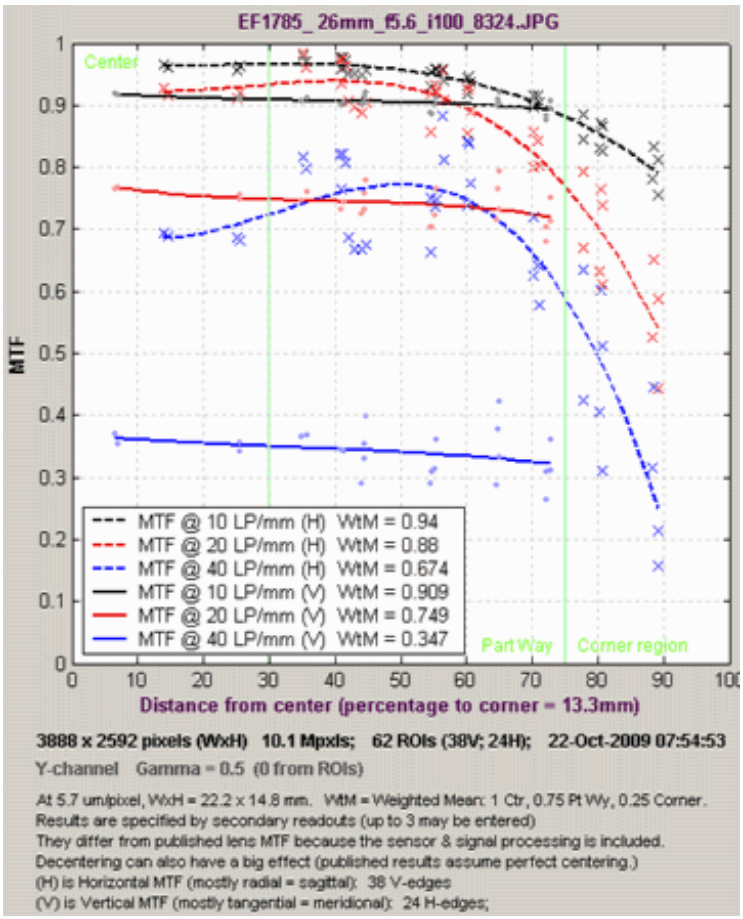
Manual or automatic scaling may be selected in Master using the button. Automatic is the default. When is pressed, the Manual scaling window, shown on the right, lets you set the scaling for the parameter selected in the Plot menu (MTF50P in this case). Minimum and Maximum only apply for manual scaling, i.e., when Auto scaling is unchecked. 6, 11, 16, 21, or 26 contour lines may be selected.

The button sets a top (pseudo-2D) view. It toggles between and . You can rotate the image starting from either setting.

Several 3D plots can be displayed in **SFRplus auto** by making appropriate selections in the button in the SFRplus settings window.

Lens-style MTF plot

Lens-style MTF plot



(Introduced in Imatest 3.6) Produces results similar to the MTF plots in the Canon (explanation), Nikon (explanation), and Zeiss websites. Up to three plot parameters may be selected with the Secondary readout. Typical choices are MTF at 10, 20, and 40 lp/mm (used by Zeiss) or 10 and 30 lp/mm (used by Canon and Nikon). Pixel spacing (um/pixel, etc.) must entered to obtain lp/mm spatial frequencies.

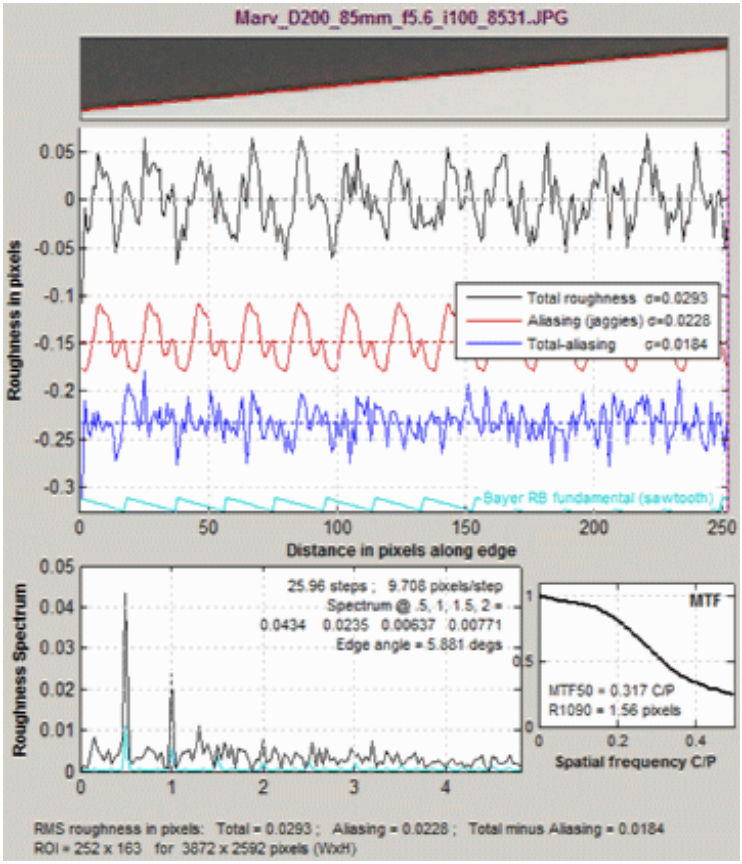
A minimum of 13 regions is required, though more are better. Recommended region selections are **10. All squares, inner & boundary edges (best 3D map)** (for single-tone charts) or **13. All squares, inner & bdry except low contrast (good 3D map)** (for two-tone charts). **V&H edges (both)** should be selected.

Though these plots are similar to the website plots, there are several significant differences.

- Imatest calculates he system MTF, including the sensor and signal-processing. The websites display the optically-measured MTF for the lens-only. Imatest results are comparable, but never *identical*, to the published lens curves.
- The horizontal (H) MTF curves, derived from vertical edges, are mostly radial (sagittal) near the sides of the image (at large distances from the center). The SFRplus chart was designed for this purpose.
- The Vertical (V) MTF curves, derived from horizontal edges, are mostly tangential (meridional) near the sides.
- The published curves assume perfect centering. Some manufacturers, like Canon, obtain their results from design calculations, not from measured test results (no centering issues— or perhaps they use "cherry-picked" lenses!). Real lenses almost always exhibit some decentering, primarily due to manufacturing variability, which is more visible in other displays, particularly the 3D plots. In the lens-style MTF plot, decentering shows up as a spread in the individual readings (x for Horizontal MTF from vertical edges, • for Vertical MTF from horizontal edges).

The curves are calculated using third-order polynomial regression. With higher-order regression, scatter due to lens decentering often caused the curves to display serious irregularities.

Edge roughness plot



Edge roughness plot

(Introduced in Imatest 3.7) Analyzes edge roughness, which has two components:

- **Random** (aperiodic), caused by noise.
- **Periodic** (also called "jaggies" for jagged edges), caused by aliasing (signal response above the Nyquist frequency). Affected by the demosaicing algorithm.

The periodic noise has peak spectral response at spatial frequencies corresponding to one or two pixels *perpendicular* to the edge, where one pixel corresponds to the green channel and two pixels corresponds to the red and blue channels of Bayer color filter arrays. In the Roughness Spectrum (lower) plot these frequencies are 1 and 0.5, respectively. The response peaks at these frequencies are fairly typical.

The periodic noise is calculated by transforming the frequency components at $f = 0.5$ through 2.5 in steps of 0.5 (i.e., the aliasing fundamentals and the first few harmonics) back into spatial domain. The aperiodic noise is calculated by subtracting the periodic noise from the total noise.

Three RMS (σ = standard deviation) roughness values are reported: Total, aliasing (jaggies), and Total-aliasing (aperiodic).

The interpretation of edge roughness results is somewhat challenging because it's a new measurement and there isn't a lot of data for comparison. While the pattern on the right is fairly typical (and expected), we've seen many spectra that don't resemble it at all. In general noise, peaks are weak (or nonexistent) for blurred edges. Although we hope this calculation will enable us to distinguish excellent and mediocre demosaicing algorithms, we're not there yet.

SFRplus summary

- SFRplus analyzes images of the SFRplus test chart, framed so that there is white space above and below the horizontal bars in the chart, i.e., the bars must not run off the top or bottom of the image. They may, however, run off the sides of the image. The white space should be between 0.5% and 25% of the image height. There should be few or no interfering patterns (bars, etc.) outside the image of the chart itself.
- Lighting should be even and glare-free. Lighting and alignment recommendations are given in Building a test lab.
- The first time SFRplus is run, it should be run through Rescharts. This allows
    - parameters to be adjusted and saved for later use in the automatic version of SFRplus, which is opened with the button in the Imatest main window.
    - results (listed above) to be examined interactively in the Rescharts window.

Result file names— The roots of the file names are the same as the image file name. The channel (Y, R, G, or B) is included in the file name. If a Region of Interest has been selected from a complete digital camera image, information about the location of the ROI is included in the file name following the channel. For example, if the center of the ROI is above-right of the image, 20% of the distance from the center to the corner, the characters AR20 are included in the file name.

Output files for *filename.jpg* (Y-channel)

(default location: subfolder Results)

Excel .CSV (ASCII text files that can be opened in Excel)	
SFR_cypx.csv	(Database file for appending results: name does not change). Displays 10-90% rise in pixels and MTF in cycles/pixel (C/P).
SFR_lwph.csv	(Database file for appending results: name does not change). Displays 10-90% rise in number/Picture Height (/PH) and MTF in Line Widths per Picture Height (LW/PH).
*filename*_YA17_MTF.csv or *filename*_*nn*_MTF.csv	Excel .CSV file of MTF results for this region (designated by location (YA17) or sequence (*nn* = 01,…). All channels (R, G, B, and Y (luminance)) are displayed.
*filename*_Y_multi.csv	Excel .CSV file of summary results for a multiple ROI run.

*filename*_Y_sfrbatch.csv	Excel .CSF file combining the results of batch runs (one or more files) with multiple ROIs. Only for automatic SFRplus (not Rescharts). Used as input to Batchview.

Excel .CSV (Comma-Separated Variables) and XML output

Imatest SFR creates or updates output files for use with Microsoft Excel. The files are in CSV (Comma-Separated Variable) format, and are written to the Results subfolder by default. .CSV files are ASCII text files that look pretty ugly when viewed in a text editor:

File ,Date/time ,PH,Ch,H/V,10-90U,10-90C,Over-,Over-
,MTF50U,MTF50C,MTF,Camera,Lens,FL,f-stop,Loc,Misc.

,,,,,/PH,/PH,shoot%,sharp%,LW/PH,LW/PH,Nyq,,,(mm),,,settings

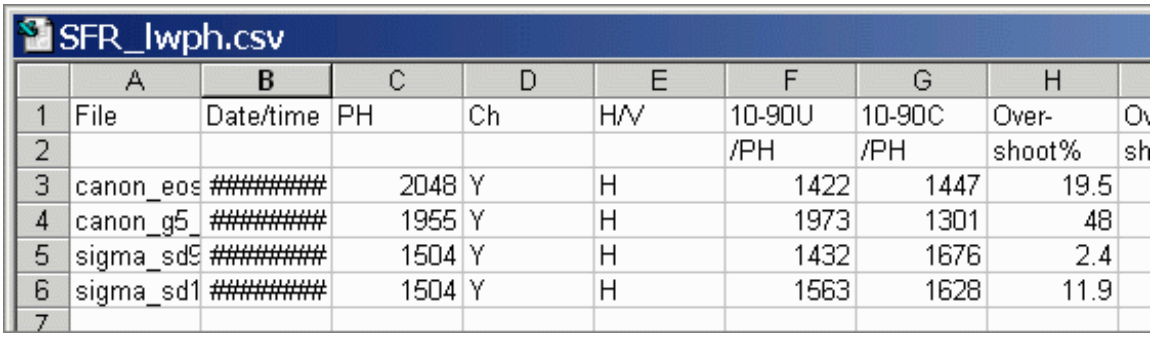
canon_eos10d_sfr.jpg,2004-03-19 22:21:34, 2048,Y,H, 1422, 1447, 19.5, -0.7, 1334,
1340,0.154,,,,,

canon_g5_sfr.jpg,2004-03-19 22:24:30, 1955,Y,H, 1973, 1301, 48.0, 21.3, 1488,
1359,0.268,Canon G5,—,14,5.6,ctr,

sigma_sd9_sfr.jpg,2004-03-19 22:27:55, 1504,Y,H, 1432, 1676, 2.4, -7.7, 1479, 1479,0.494,,,,,

sigma_sd10_sfr.jpg,2004-03-19 22:28:32, 1504,Y,H, 1563, 1628, 11.9, -2.0, 1586,
1587,0.554,,,,,

But they look fine when opened in Excel.



	A	B	C	D	E	F	G	H	
1	File	Date/time	PH	Ch	H/V	10-90U	10-90C	Over-	Ov
2						/PH	/PH	shoot%	sh
3	canon_eos	#########	2048	Y	H	1422	1447	19.5	
4	canon_g5_	#########	1955	Y	H	1973	1301	48	
5	sigma_sd9	#########	1504	Y	H	1432	1676	2.4	
6	sigma_sd1	#########	1504	Y	H	1563	1628	11.9	
7									

.CSV files can be edited with standard text editors, but it makes more sense to edit them in Excel, where columns as well as rows can be selected, moved, and/or deleted. Some fields are truncated in the above display, and Date/time is displayed as a sequence of pound signs (#####…).

The format can be changed by dragging the boundaries between cells on the header row (A, B, C, …) and by selecting the first two rows and setting the text to **Bold**. This makes the output look better. The modified file can be saved with formatting as an Excel Worksheet (XLS) file. This, of course, is just the beginning.

SFR_lwph.xls

	A	B	C	D	E	F	G	H	I	J
1	File	Date/time	PH	Ch	H/V	10-90U	10-90C	Over-	Over-	MTF
2						/PH	/PH	shoot%	sharp%	LW/
3	canon_eos10d_sfr.jp	3/19/2004 22:21	2048	Y	H	1422	1447	19.5	-0.7	1
4	canon_g5_sfr.jpg	3/19/2004 22:24	1955	Y	H	1973	1301	48	21.3	1
5	sigma_sd9_sfr.jpg	3/19/2004 22:27	1504	Y	H	1432	1676	2.4	-7.7	1
6	sigma_sd10_sfr.jpg	3/19/2004 22:28	1504	Y	H	1563	1628	11.9	-2	1
7										

It's easy to customize the Excel spreadsheet to your liking. For example, suppose you want to make a concise chart. You can delete Date/time (Row B; useful when you're testing but not so interesting later) and Channel (all Y = luminance). You can add a blank line under the title, then you can select the data (rows A4 through J7 in the image below) and sort on any value you choose. Corrected MTF50 (column I) has been sorted in descending order. Modified worksheets should be saved in XLS format, which maintains formatting.

SFR_lwph_mod.xls

	A	B	C	D	E	F	G	H	I	J
1	File	PH	H/V	10-90U	10-90C	Over-	Over-	MTF50U	MTF50C	MTF
2				/PH	/PH	shoot%	sharp%	LW/PH	LW/PH	Nyq
3										
4	sigma_sd10_sfr.jpg	1504	H	1563	1628	11.9	-2	1586	1587	0.554
5	sigma_sd9_sfr.jpg	1504	H	1432	1676	2.4	-7.7	1479	1479	0.494
6	canon_g5_sfr.jpg	1955	H	1973	1301	48	21.3	1488	1359	0.268
7	canon_eos10d_sfr.jp	2048	H	1422	1447	19.5	-0.7	1334	1340	0.154
8										

There are no limits. With moderate skill you can plot columns of results. I've said enough. (*I'm not an Excel expert!*)

Summary .CSV and XML files for MTF and other data

An optional .CSV (comma-separated variable) output file contains results for MTF and other data. Its name is [*root name*]_[*channel location*]_MTF.csv, where channel is (R, G, B, or Y) and the location BL75 means below-left, 75% of the distance to the corner (from the center). An example is Canon_17-40_24_f4_C1_1408_YBL75_MTF.csv. Excerpts are shown below, opened in Excel.

Module	SFR						
File	Canon_17-40_24_f4_C1_1408.jpg						
Run date	5/10/2005 11:49						
Cy/mm	LW/PH	MTF(ncha	MTF(corr)	MTF(R)	MTF(G)	MTF(B)	MTF(Y)
0	0	1	1	1	1	1	1
1.2066	36.64	1.0145	1.0166	1.014	1.0152	1.0127	1.0145
2.4131	73.29	1.0063	1.0146	1.0048	1.0077	1.006	1.0063
...							
133.9286	4067.36	0.0538	0.0539	0.0614	0.0556	0.0552	0.0538
135.1351	4104	0.0593	0.0593	0.0703	0.0567	0.0643	0.0593
x (pixels)	R Edge	G Edge	B Edge	Y Edge	CA (max Delta)		
-6	0.001	0.001	0.001	0.001	0.001		
...	...	...	...	...	...		
-0.25	0.317	0.405	0.291	0.365	0.113		
0	0.406	0.502	0.383	0.459	0.119		
0.25	0.506	0.609	0.487	0.563	0.121		
...	...	...	...	...	...		
10	1.012	1.012	1.01	1.012	0.002		
Profile	Horizontal						
Image WxH & Mpxls	3076	2052	6.31				
ROI	75% below-L of ctr.						
...	...						
Exif data							
File: 2004:06:25 12:20:30							
...							

A portion of the summary CSV file, opened in Excel

The format is as follows:

Line 1	Imatest, release (1.n.x), version (Light, Pro, Eval), module (SFR, SFR multi-ROI, Colorcheck, Stepchart, etc.).
File	File name (title).
Run date	mm/dd/yyyy hh:mm of run.
(blank line)	
Tables	Separated by blank lines if more than one. Two tables are produced.
	The first table contains MTF. The columns are Spatial frequency in Cy/mm, LW/PH, MTF (selected channel), MTF (Red), MTF (Green), MTF (Blue), MTF (Luminance = Y). (…) represent rows omitted for brevity.
	The second table contains the edge. Columns are x (location in

	pixels), Red edge, Green edge, Blue edge, Luminance (Y) edge, and Chromatic Aberration (the difference between the maximum and minimum).
(blank line)	
Additional data	The first entry is the name of the data; the second (and additional) entries contain the value. Names are generally self-explanatory (similar to the figures).
(blank line)	
EXIF data	Displayed if available. **EXIF data** is image file metadata that contains important camera, lens, and exposure settings. By default, Imatest uses a small program, jhead.exe, which works only with JPEG files, to read EXIF data. To read detailed EXIF data from all image file formats, we recommend downloading, installing, and selecting Phil Harvey's ExifTool, as described here.

This format is similar for all modules. Data is largely self-explanatory. Enhancements to .CSV files will be listed in the Change Log.

The optional XML output file contains results similar to the .CSV file. Its contents are largely self-explanatory. It is stored in [*root name*].xml. XML output will be used for extensions to Imatest, such as databases, to be written by Imatest and third parties. Contact us if you have questions or suggestions.

An optional .CSV file is also produced for multiple ROI runs. Its name is [*root name*]_multi.csv.

Links

How to Read MTF Curves by H. H. Nasse of Carl Zeiss. Excellent, thorough introduction. 33 pages long; requires patience. Has a lot of detail on the MTF curves similar to the Lens-style MTF curve in SFRplus. Even more detail in Part II. Their (optical) MTF Tester K8 is of some interest.

Understanding MTF from Luminous Landscape.com has a much shorter introduction.

Understanding image sharpness and MTF A multi-part series by the author of Imatest, mostly written prior to Imatest's founding. Moderately technical.

Bob Atkins has an excellent introduction to MTF and SQF. SQF (subjective quality factor) is a measure of perceived print sharpness that incorporates the contrast sensitivity function (CSF) of the human eye. It will be added to Imatest Master in late October 2006.

Optikos makes instruments for measuring lens MTF. Their 64 page PDF document, How to Measure

MTF and other Properties of Lenses, is of particular interest.