README FILE FOR DSLR_LOGGER V3.11 (14.01.2014)

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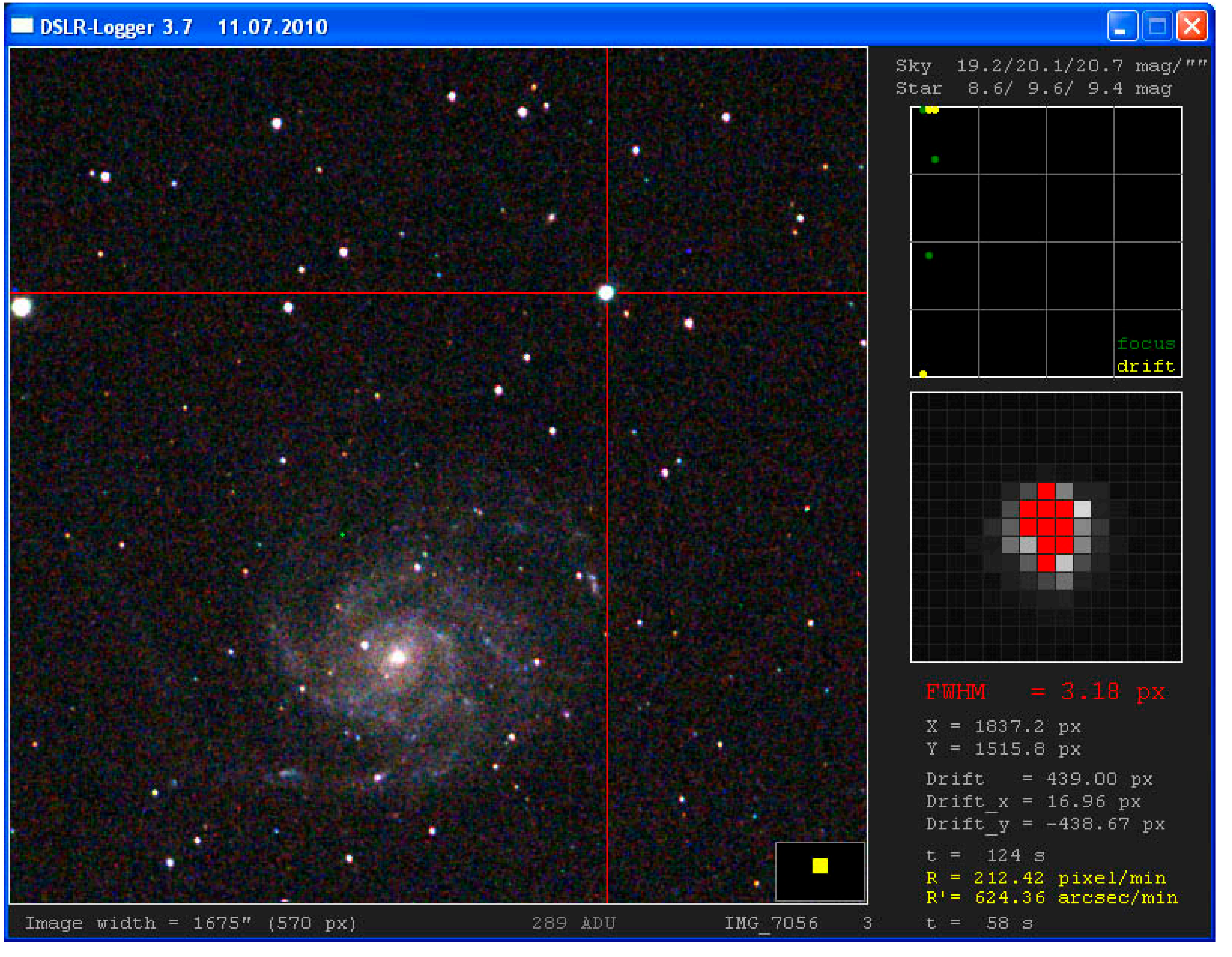


1. GENERAL

DSLR_logger is to be designed to use during a imaging session for the following tasks:

1) Immediately shows the pictures as they are captured
2) Stars can be selected to check and improve the focus (FWHM is shown)
3) Computes the magnitude of the selected star (V and color index B-V) – basic photometry
4) Computes the magnitude of the sky (in magnitude per arcsec^2)
5) Visualizes and controls the drift in x and y
6) Logs current imaging session with regard to focus (FWHM), star drift, star brightness (=clarity of sky), sky quality, Camera temperature
7) Helps to align the Astrotrac (drift align method using a star)

You need:
- This program
- A camera (I haven't checked other cameras like Nikon; maybe they work too), conected to
- A Windows notebook (Windows XP, Vista, Win 7)

<u>Note:</u>
DSLR_logger is compatible with any digital cameras and capturing software as long as the captured images are created in a folder and are of a RAW or JPG file format (the RAW file must be compatible with DCRAW). For Canon I recommend to use the Remote control software which automatically transfers the images between the DSRL and the PC via an USB-cable. The Canon software provides also an intervalometer mode which applies Bulb exposures. With newer cameras it is possible to program the exposure time to more than 30 seconds.

The current version only supports JPG/RAW images with not more than 6600x4400 pixel.
The window size is 800x600 pixel and thus suitable for the current netbooks.

<u>Important:</u>
The program runs under Windows XP, Vista, Win 7 (and maybe also other win systems). The DCRAW version does not run on Windows 7/VISTA. Please use a DCRAW version which is compatible to your windows system. You may find them in the download section of the ASTROTRAC YAHOO GROUP.

2. CONTENT

The zip file contains the following files:

DSLR_logger.exe	The main program
DSLR_logger.ini	The INI-file which contains important parameters
DSLR_logger.pas	source code (freepascal)
exiftool.exe	used by DSLR_logger to read the EXIF data. Follow the link to read more about exiftool.exe: http://www.sno.phy.queensu.ca/~phil/exiftool/ Check this site for new updates.
dcraw.exe	used by DSLR_logger to decode the camera raw-files into pgm-files (pgm=portable grey map) You can check here the latest version: http://www.insflug.org/raw/Downloads/
readme.pdf	This file
convert.exe*	Used by DSLR_logger to read JPG files. Follow the link to read more about ImageMagick: http://www.imagemagick.org/script/binary-releases.php#windows
vcomp100.dll	Used by ImageMagick

*May be provided as a separate zip file.

3. HOW TO USE DSLR_LOGGER

1) Extract the zip file into a directory. All files should be in the same directory except for the image files you want to watch. The name of the image directory should be entered into the ini-file. This directory should be identical to the destination directory of remote control software, otherwise DSLR_logger will not automatically load the new images.

2) Next you have to edit the ini-file for proper running of the main program. E.g. data of your position (latitude, longitude) and of your camera are needed (offset, maximum grey level, pixel size...)

3) Finally start the main program DSLR_logger.exe*. If you have done everything correctly you will be asked to enter the filename (only the beginning without the counting number). Press return, if the default name is okay (the default name can be changed in the ini-file). Then you will be asked to enter the number of the image file you want to start with. This allows you to log image files which are already stored earlier on the hard disk. If no image files are available on the hard disk (which would be the normal case when you haven't started tracking so far), the program waits now until the first image is captured.

* It is also possible to start DSLR_logger with a dedicated ini-file: DSLR_logger.exe [filename.ini]
This runs DSLR_logger with parameters only from the specific given ini-file [filename.ini]. This is useful if different ini-files are used (for different cameras, telescopes etc).

After loading the image, the following buttons are available:

F1	Opens the Help screen
F2	Shows current Logger data
F3	Shows current EXIF data
F4	Press F4 to switch between windows showing sky brightness-->star brightness--> DSLR temperature-->drift&focus data Use arrows up/down to move y axis
1-6 or Ctrl+up/down	Changes image scale (zoom)
h or Ctrl+left	Brightening the image
d or Ctrl+right	Darkening the image
r	Only the red Channel is used (color modus)
g	Only the green Channel is used (color modus)
b	Only the blue Channel is used (color modus)
w	All channels are used (color modus))
z	The selected star will be centered
s	Star align window on/off (method I or II).
m	Calculates the orientation of DSLR using current star drift (see section 5, Getting Orientation)
n	Restart logging (delete current log data)
f	Find new star
l	Saturated areas above 85% of max. grey level defined in the ini-file will be shown in red
i	Load ini-file again (useful if you have changed the ini-file)
e	Open ini-file using notepad. After saving, the ini-file is reloaded into DSLR Logger
q	Shows descriptive statistics of the background noise (mean, sd, median)
Space	Next image will be loaded if already available
backspace	Former image will be loaded
arrows	Moves the image to find a proper tracking star
+ or -	Zoom in/out polar scope window
o	Save overlay image
c	Change from B/W to Color modus and back (not working for JPG files)
Ctrl+del	Delete current image file from disk
ESC or x	Exit the program

Mouse:

The mouse can be used to

a) show the ADU value of a selected region by moving the mouse over the area,
b) select a star by left-clicking on it,
c) switch between V mag / (B-V) color index and R / V / B mag of the star/sky by clicking on the star/sky brightness display

To log and track the current imaging session with regard to focus (FWHM) and star drift, select an unsaturated star in an area with only few stars using the arrow keys (or mouse). A low image scale (key 1 or 2) helps to find an area in which the selected star is the dominant one.

4. DESCRIPTION OF THE INI-FILE:

Directory of the images	= Directory where the image files are located
Name of files (beginning)	= Default beginning name of files (useful to select files with different beginnings)
EXT	= Extension of the raw files (e.g. CRW, CR2) or jpg files (only JPG is allowed)
DCRAW	= Command lines for DCRAW (do not change it)
Your Latitude	= Your Latitude (0..90° for N and S)
Your Longitude	= Your Longitude (0..-180° for W, 0..180° for E)
Hemisphere	= The northern or southern hemisphere
Declination of star	= This is used for the drift align modus I (values -90...90°)
Hour angle of star in hh:mm	= This is used for the drift align modus I
Orientation of DSLR	= Direction of the star drift on the sensor (if driving motor is off), see ini-file
Difference to UTC	= For central European time it is: 1 for Winter time and 2 for summer time; for US (EST) it is -5
Radius of the 2nd circle	= Needed to scale the polar scope view (in arc minutes); typically 40
White balance (R, G, B)	= Default is 1. Could be used for white balance (only relevant for the color modus)
OFFSET of your camera	= Offset in ADU (ADU value when no lights falls on the sensor)
Maximum Grey value	= In bits (e.g. 14bit for newer canon models and 12 bits for older models)
Pixel size	= Pixel size in µm of your camera (e.g. 6.4 for 20D/350D, 5.7 for 1000D)
Offset for RVB bands	= Should be changed in such a way that the star magnitudes are correctly computed. E.g. Vega may be useful for calibration, since per definition it must be Vmag=0; see section 6.
Atmospheric Extinction	= Must be estimated in order to get correct sky brightness results (e.g. 0.15 very clear at high altitude, 0.25 very clear at see level, 0.35 good conditions, >=0.45 less good conditions)
Vignetting of lens	= Correction in EV of the lens used, e.g. 0 = no correction, 1 = 1EV or 50% signal fall off in the edges
RVB Correction	= Correction R(r-g), G(r-g), G(b-g), B(b-g); see section 6.
Shutter speed, Aperture, ISO, Focus length	= This is needed if the exif does not contain this information (e.g. if a telescope or manual focus lens is used)

If JPG image format is used, the values for Offset and Maximum grey value are ignored.

5. DRIFT ALIGN FEATURE

There are two ways to align the mount (method I and II).

	Method I (everywhere)	**Method II (near celestial Pole)**
General notes	A star can be chosen at will but should be sufficiently above the horizon in order to prevent diffraction errors from the atmosphere. If the declination of the star is between -20..20°, only the drift in DEC will be used. Otherwise both corrections for ALT and AZ of the mount will be calculated based on the drifts in DEC and RA. No preferred orientation of the DSLR is needed but must be known.	This method is carried out in the close vicinity of the pole (declination 85..89°, N or S), e.g. with Polaris. Both corrections for ALT and AZ of the mount will be calculated based on the drifts in DEC and RA. It is important that the DSLR is always oriented parallel to the horizon (azimuthal).
Procedure		
1. Editing INI File	Open the INI-file and enter the **Declination** and **hour angle** (not RA) of the star you want to select. The declination is positive on the northern hemisphere and negative on the southern hemisphere. Enter also the maximum **correction** to be shown in the window (= Radius of the 2nd circle) and the **hemisphere** (northern or southern). Note: About 40 arcmin is the distance of Polaris to the NCP Finally the **orientation** of the camera should be entered in the ini-file. If the star on the sensor is moving from left to right when the stepping motor is off then enter 'rightward'. If the stars are moving from right to left then enter 'leftward'. Same is true for 'upward' or 'downward'. Alternatively, the exact angle (if known) can be entered instead.	Open the INI-file and enter the maximum **correction** to be shown in the window (= Radius of the 2nd circle). Enter also the **hemisphere** (northern or southern). Note: About 40 arcmin is the distance of Polaris to the NCP. Finally, enter **'**azimuthal**'** for the **Orientation** of the DSLR.

Getting Orientation (Optional)	It is also possible to derive the exact orientation of the DSLR by assessing the current star drift. First the Astrotrac should be in the start position in which the tracking motor is off. Then take a picture of the specific region of interest and select a bright star. Now take a second picture after some seconds delay to allow the star to drift. After the second picture is loaded the same star should be selected again. Now press key ‘m’. The current drift result is calculated into an angle which represents the orientation of the DSLR. You can now press the start bottom of the Astrotrac. After this procedure the orientation of the DSLR should not be changed anymore. If you want to use the orientation from the ini file again, you have to press key ‘i’ for reloading the parameters.	Not applicable
2. Open drift align window	Press s to open the drift-align window in case it is not already open. The new window imitates roughly your polar scope view. The red line indicates the current direction of Polaris with regard to the north celestial pole. This may help to align the PS.	
3. Align Astrotrac	Approximately align the Astrotrac (e.g. using the polar scope, compass etc.)	
4. First image	Point the camera to the specified region and take an image. After loading, select a suitable bright star using the error keys. Any orientation of the DSLR is now possible as indicated in the ini file. If you want to change the orientation of the DSLR again you have to repeat the procedure as described under section 1 (key ‘m’) or you have to edit the new orientation manually in the ini-file (don’t forget to press ‘i’ afterwards).	Point the camera to e.g. Polaris. Take an image. After loading, select the star using the error keys. Be sure that the camera (i.e. x-axis of the sensor) is parallel to the horizon.
5. Wait and take next image	Wait some minutes (or shorter) and take the second image of the star. The minimum star drift should be at least several pixel/min in order to compute precise ALT/AZ corrections. This step may be repeated to have a feeling of the reproducibility of the drift.	

6. View drift align window	The yellow arrow in the drift-align window shows you how much you have to move Polaris in your Polar scope to get the correct alignment. Don’t rotate the polar scope during this procedure. The drift align window is like an overlay image which fits into the polar scope view. If the Radius of the 2nd circle is set to 40 arcmin, this can be easily estimated as shown in the screen shoot in section 7. No arrow is shown if the calculated correction is above the second circle. Please use + or - buttons to properly change the scale of the polar scope window. The numerical correction values of DEC and AZ are also shown in arcmin. They can also be used for adjustment if Polaris is not visible in the polar scope.	
7. ALT/AZ Correction	Correct the ALT and AZ of your Astrotrac and check the position of Polaris through the PS. The new position relative to the old should be the same as proposed by DSLR_logger (yellow line).	
8. Take next image	Take an image. You might relocate and reselect Polaris on your computer screen by using the arrow keys. A light green cross is shown in the main window which indicates the new (theoretical) position of Polaris based on the ALT/AZ corrections. Ideally, after you have done the corrections according to step 6, Polaris should be close to the light green cross. At this point you can generate an overlay image by pressing key o. See LIVE VIEW below for more details.	
9. Repeat procedure	Repeat 5 to 8 unless you are happy with the drift rate.	Repeat 5 to 8 unless you are happy with the drift rate. After some time your camera will be no more parallel to the horizon. This should be checked and corrected from time to time.

OVERLAY DISPLAY FUNCTION AND REMOTE LIVE VIEW
(only Canon DSLR and EOS Utility 2.8 or higher):

After pressing o (see step 8 above), an overlay image is generated and saved into the image folder. Click on the live view button in Canons Remote control software to open the live view window. The newest version allows loading an overlay image into the live view window. Look into Canon EOS Utility documentation to find more details. The aligning star should be bright enough to be visible together with the overlay image. Now, move the star to the target (red circle) by changing ALT and Az of the mount. Once the star is in the red circle, your mount should be aligned correctly.

Pro's and Con's:

	Method I (everywhere)	Method II (near celestial Pole)
Pro's	• Applicable on the northern and southern hemisphere. The declination and the local hour angle can be chosen at will. On the celestial equator and the neighboring region only drift in DEC is used. • Aligning star can be chosen from the region of interest. Thus, misalignment due to later repositioning of the camera is unlikely (which might happen due to a flexure of the wedge/tripod) • Even applicable when celestial pole is not visible (e.g. if hidden by a building, trees etc). • No special orientation of the Camera is necessary. The actual orientation will be entered in the ini file. Unfortunately, Astrotrac has no pause feature in order to stop tracking for a while. This would help to derive the correct orientation.	• Applicable on the northern and southern hemisphere in close vicinity of the pole • On northern hemisphere Polaris is a suitable bright star which can be easily found in the camera viewer • Easy to use since your camera should be always aligned parallel to horizon (easier to check) • Declination and hour angle of the aligning star must not be known.
Con's	• Declination and hour angle of the aligning star and orientation of DSLR must be known.	• Once AT is aligned, the direction of the hour axis may change slightly when the camera is later pointed to the field of interest (which is normally not the celestial pole) due to a flexure of the wedge/tripod. • Not applicable when celestial pole is not visible (e.g. if hidden by a building, trees etc).

6. PHOTOMETRY

This is a brief description of how to calibrate the software to be able to precise measure the sky brightness as well as the star brightness for each Johnson's R, V B channel.

1	Take a defocused picture with as many stars of different colors
2	Set in the INI file all BVR offsets (correspond to B0, V0, R0 in the formulas) and corrections R(g-r), G(g-r), G(b-g), B(b-g) to zero.
3	Estimate the extinction and add this value in the ini file
4	Start DSLR-logger and click with the mouse on the mag data (top right) in order to display the values separately for the r, g and b channels
5	Now choose a non saturated star (no red areas), click on it and write down the r, g and b values given on top right.
6	Use e.g. Stellarium to get the V brightness and BV color index of the same star. Since the VR color index is only rarely published, you can use the following approximation: VR color index = BV color index * 0.6. From this you calculate for each star the following: V = V (ok, that's trivial ...) B = V + BV color index R = V – BV color index * 0.6
7	So, now we have of each star the BVR values and the rgb values of the camera. Since the BVR (Johnson) and the rgb filters of the camera, unfortunately, do not match exactly (see figures below), you now need a transformation from rgb to RVB. The coefficients of this transformation are exactly the RVB corrections R(g-r), G(g-r), G(b-g), B(b-g) to be entered in the ini-file. For that plot the difference (V-g) as a function of the difference (b-g). If the above-mentioned color filters match, all points would lie on a horizontal line, i.e. the star brightness error is independent of the color index. In fact, the filters are different and therefore the slope of the regression line will be different from zero. This slope is then the correction G(b-g). The intercept corresponds to the offset for V from the ini file. Next, plot the difference (B-b) as function of the difference (b-g) in a chart. The slope corresponds to the correction B(b-g) and the intercept corresponds to the offset for B. After all, you plot the difference (R-r) as a function of the difference (g-r) in a chart. Again, the slope corresponds to the correction R(g-r) and the intercept corresponds to the offset for R. You can set the correction factor G(g-r) to zero. That value can be determined alternatively to G(b-g) and is obtained by plotting (V-g) against the difference (g-r).
8	After you have entered all offset and correction values into the ini file you have now completed the calibration! Restart DSLR_logger and verify the brightness of the stars, whether they are correct.

The brightness data are shown in the upper right. The output format can be changed as follows by clicking with the mouse curser on it:

Output format	Star	Sky
A (Default)	V and (B-V) color index in mag	SQM* in mag/arcsec^2
B	B, V and R in mag	B, V, R in mag/arcsec^2

* The sky brightness values measured by the SQM (http://www.Unihedron.com) differ slightly from V magnitude results, since the filter curve used by Unihedron does not match the Johnson V band filter curve. To address this, the correction SQM = V + 0.25 x (B -V) – 0.15 is used.

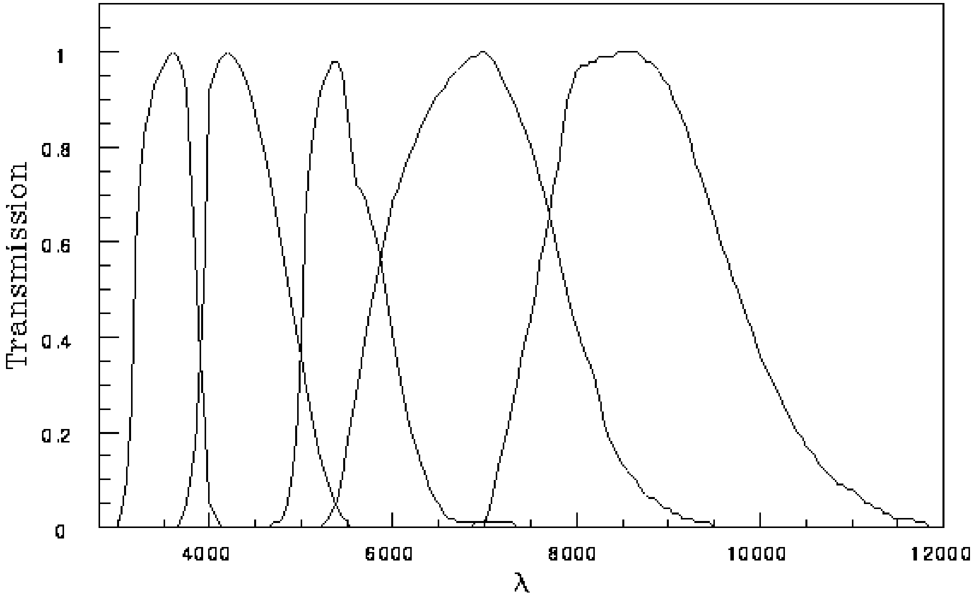
The sky brightness is always defined as "below" atmosphere. In opposite to the brightness of the stars, which is defined as ”above“ atmosphere. That is why we need the extinction of the atmosphere to be able to calculate both brightness values. A rough estimate of the transparency should go, even as the value normally lie somewhere between 0.2 and 0.5 (for reasonably clear days).

Note: For accurate photometry the star should be defocused slightly to make sure that sufficient color pixels of the bayer matrix are captured. Furthermore, only standard stars with an apparent magnitude not changing over time should be selected. If only one star (e.g. Vega) is used, several images should be taken to average the results. Use only the RAW image format for photometry.

More information about this topic can be found here:

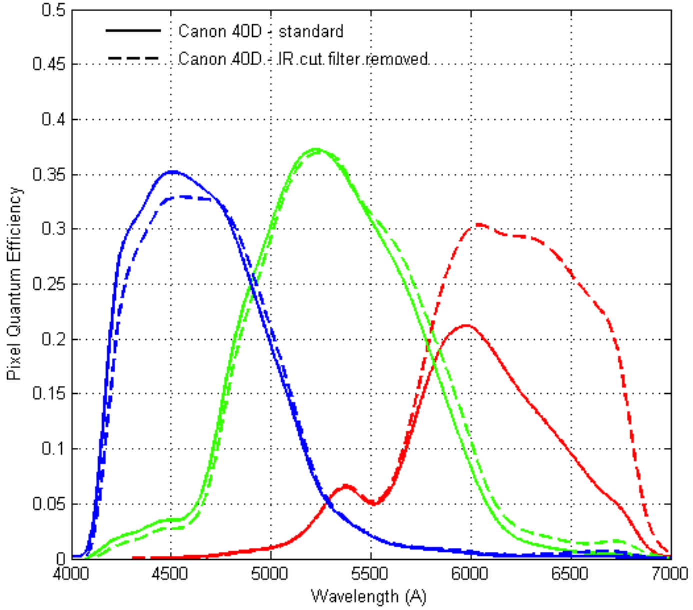
http://www.hposoft.com/EAur09/EAUR%20pdfs/DSLR.pdf
http://www.citizensky.org/book/export/html/1235

Comparison of filter curves:



Johnson UBVRI Filter system

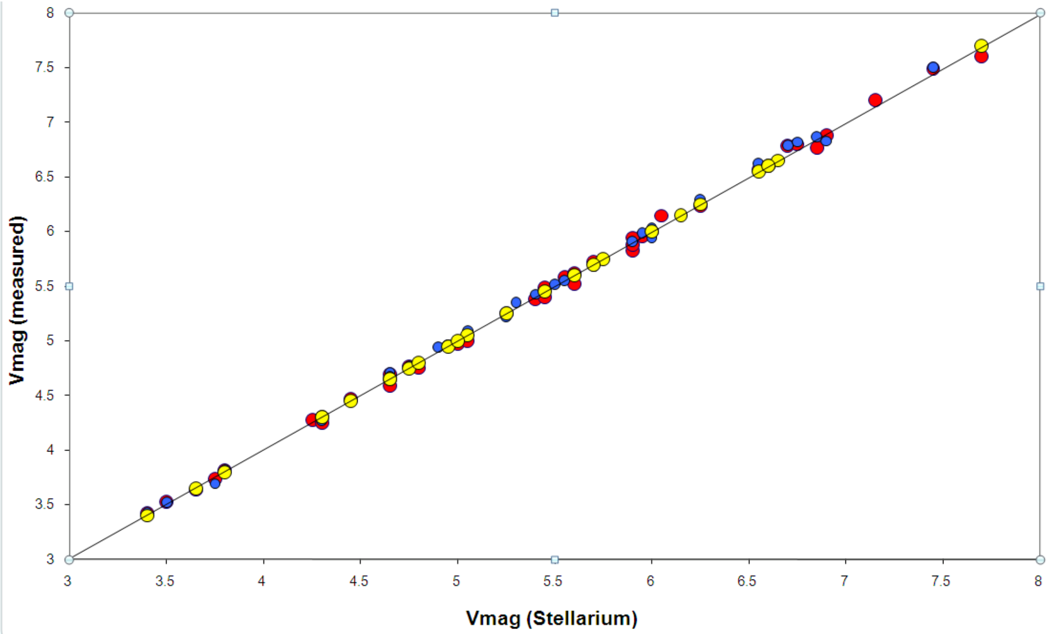
(from: http://obswww.unige.ch/gcpd/filters/fil08.html)



Canon RGB filter curve

(from: http://www.astrosurf.com/buil/50d/test.htm)

Photometric results after calibration:

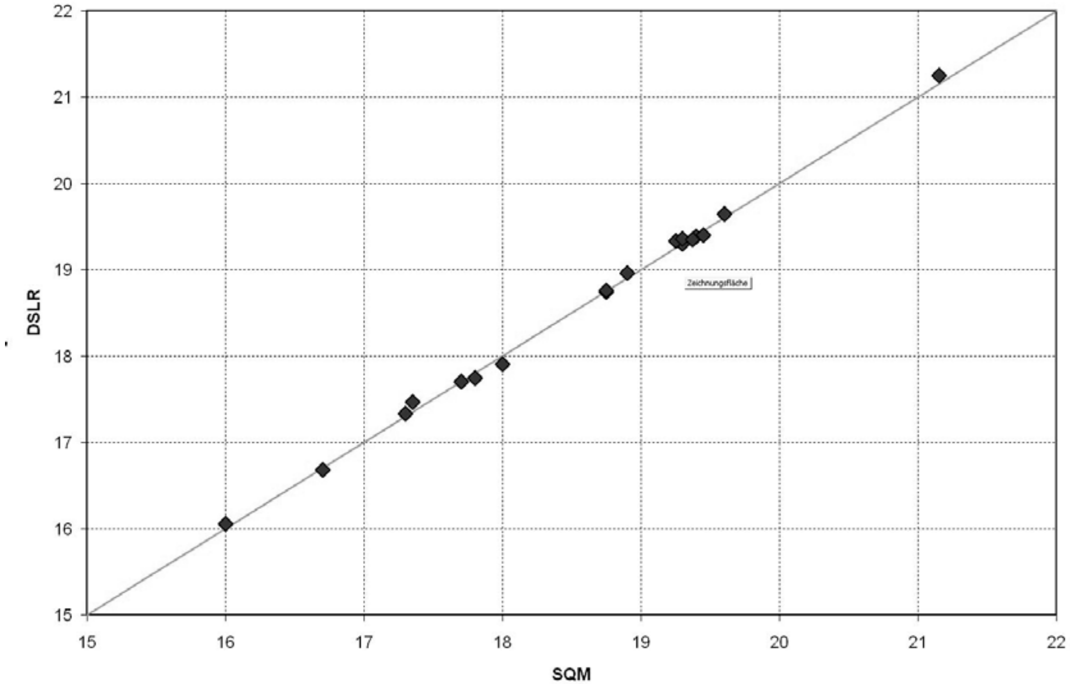


Obtained precision for two different canon models

Red: modified Canon 1000D
blue: unmodified Canon 60D
yellow: modified Canon 1000D with CLS Clip-Filter

Typical parameters:

	1000Da	1000Da(CLS)	60D
R_0	2.4	1.45	1.8
V_0	3.5	2.85	3.8
B_0	3.3	2.7	3.5
Correction R(g-r)	-0.4	-0.05	-0.75
Correction G(g-r)	0	0	0
Correction G(b-g)	-0.15	-0.8	-0.2
Correction B(b-g)	0.2	1.2	0.65



Correlation of the Sky brightness between SQM (Unihedron) and DSLR result after successful calibration

Mathematical equations used in DSLR_logger:

<table>
<tr><th colspan="2">A. Details of the calculation of the sky brightness</th></tr>
<tr><td>

$$r = -2.5 * log[(Signal_{Red} - offset) * c]$$
$$g = -2.5 * log[(Signal_{Green} - offset) * c]$$
$$b = -2.5 * log[(Signal_{Blue} - offset) * c]$$

$$with \quad c = \frac{Aperture^2}{Iso * Shutter * Max_{signal} * pixel\ size^2}$$

$$R = R_0 + r + Corr_R * (g - r)$$
$$V = V_0 + g + Corr_{G1} * (g - r) + Corr_{G2} * (b - g)$$
$$B = B_0 + b + Corr_B * (b - g)$$

$$SQM = V + 0.25 * (B - V) - 0.15$$

(Empiric correction to match results of Unihedron's Sky quality meter)

</td><td>

Aperture — Aperture of the lens
Iso — Iso of the camera
Shutter — Shutter speed in seconds
pixel size — Pixel size in µm of the sensor
Max signal in ADU (typically 4095 or 16383)
Signal — Mean Signal level in ADU for each color
R_0, G_0, B_0 — Constants
$Corr_i$ — Color corrections to match astronomic RVB filter
SQM — Sky brightness result matching SQM from Unihedron

</td></tr>
<tr><th colspan="2">B. Details of the calculation of the star brightness</th></tr>
<tr><td>

$$r = -extinction - 2.5 * log[4 * Integrated\ Signal_{Red} * c * sampling^2]$$
$$g = -extinction - 2.5 * log[2 * Integrated\ Signal_{Green} * c * sampling^2]$$
$$b = -extinction - 2.5 * log[4 * Integrated\ Signal_{Blue} * c * sampling^2]$$

$$with \quad sampling = \frac{180}{\pi} * 3600 * \frac{pixelsize}{focus\ length * 1000}$$

$$R = R_0 + r + Corr_R * (g - r)$$
$$V = V_0 + g + Corr_{G1} * (g - r) + Corr_{G2} * (b - g)$$
$$B = B_0 + b + Corr_B * (b - g)$$

$$(B\text{-}V)\text{-}Colorindex = B - V$$

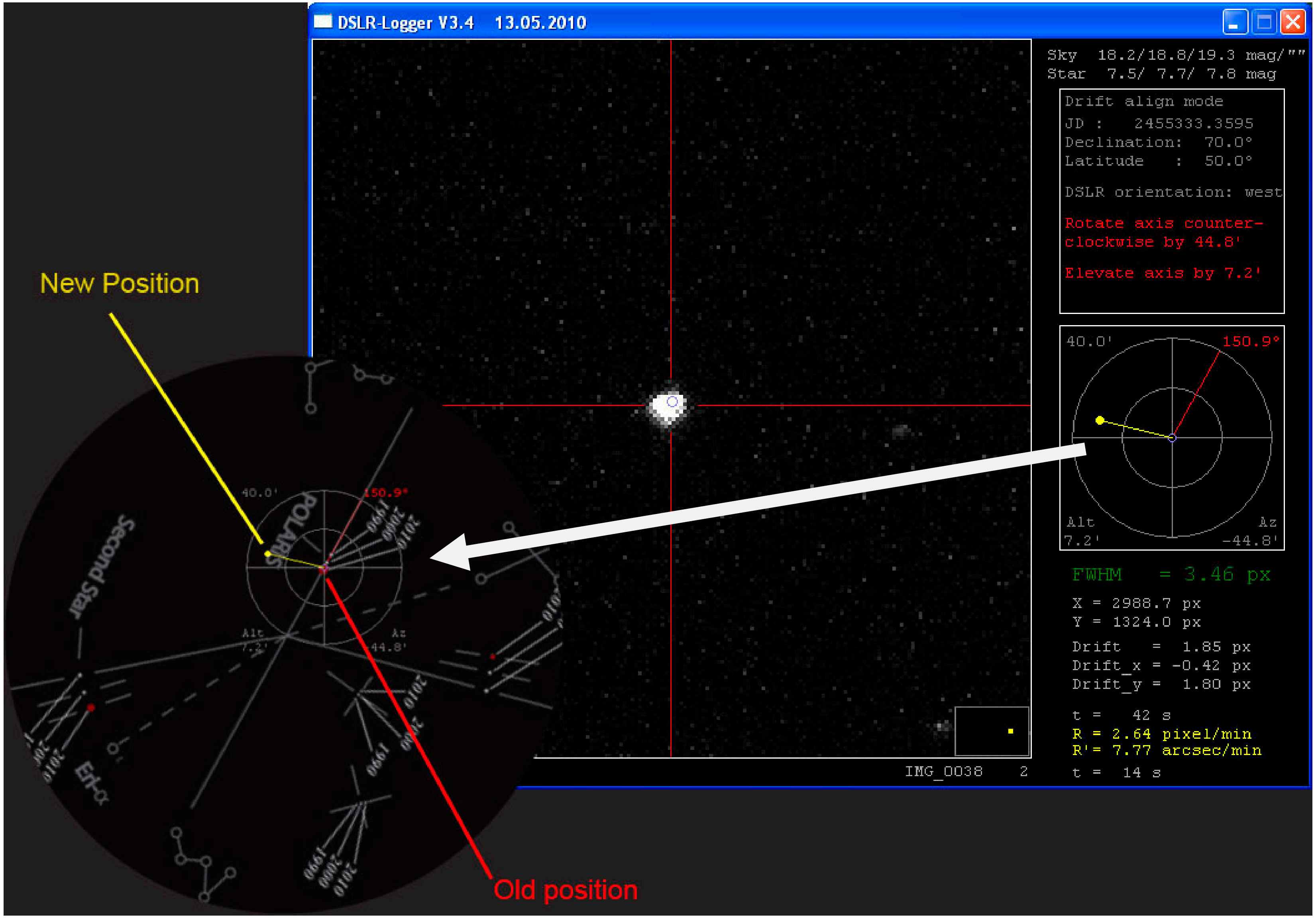
</td><td>

Sampling — Pixel size in arcseconds per pixel (depends on lens focus length)
Pixel size — in µm
focus length — in mm
Integrated Signal — Integrated signal of the selected star
Extinction — Extinction of the atmosphere

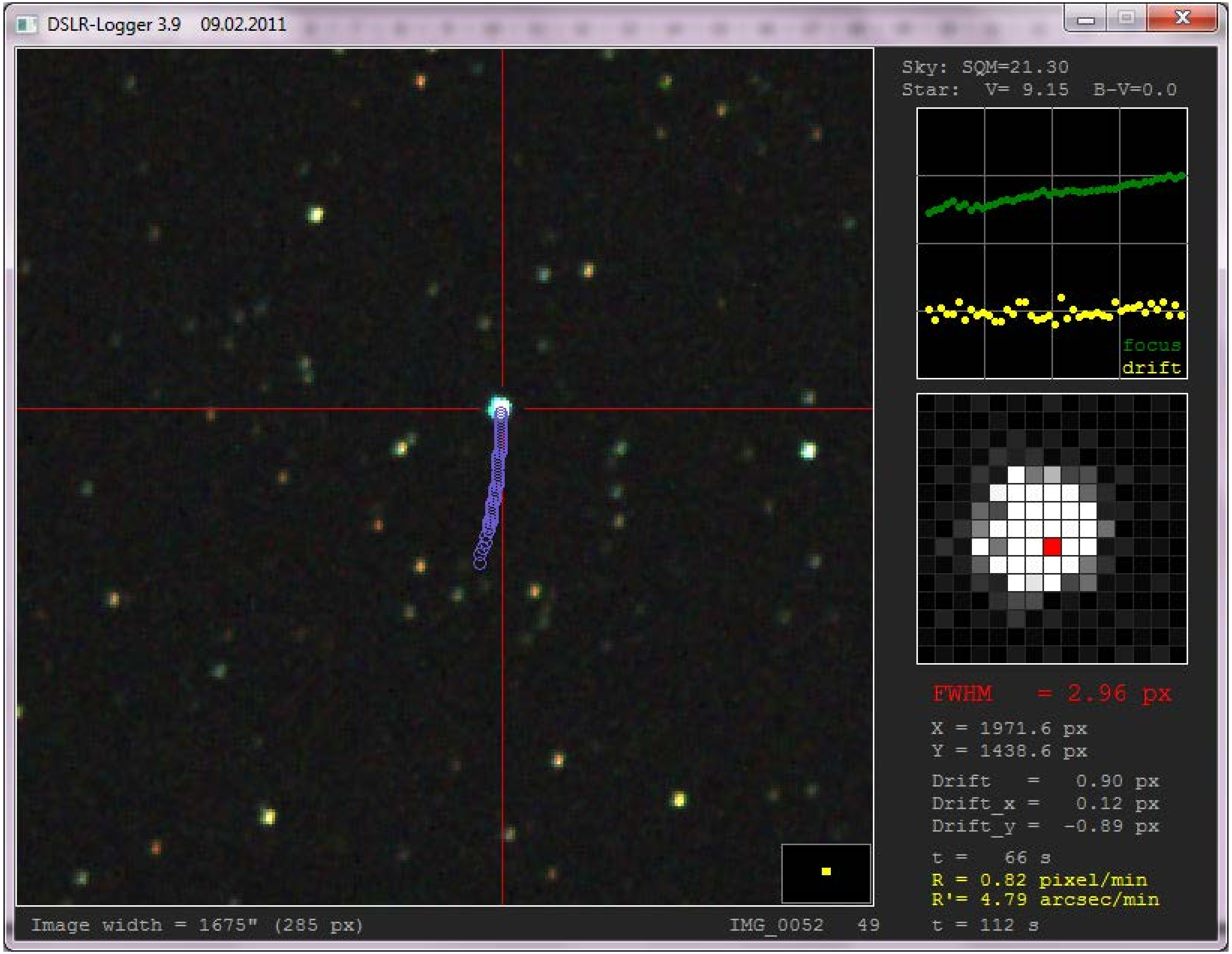
</td></tr>
</table>

7. SCREEN SHOTS

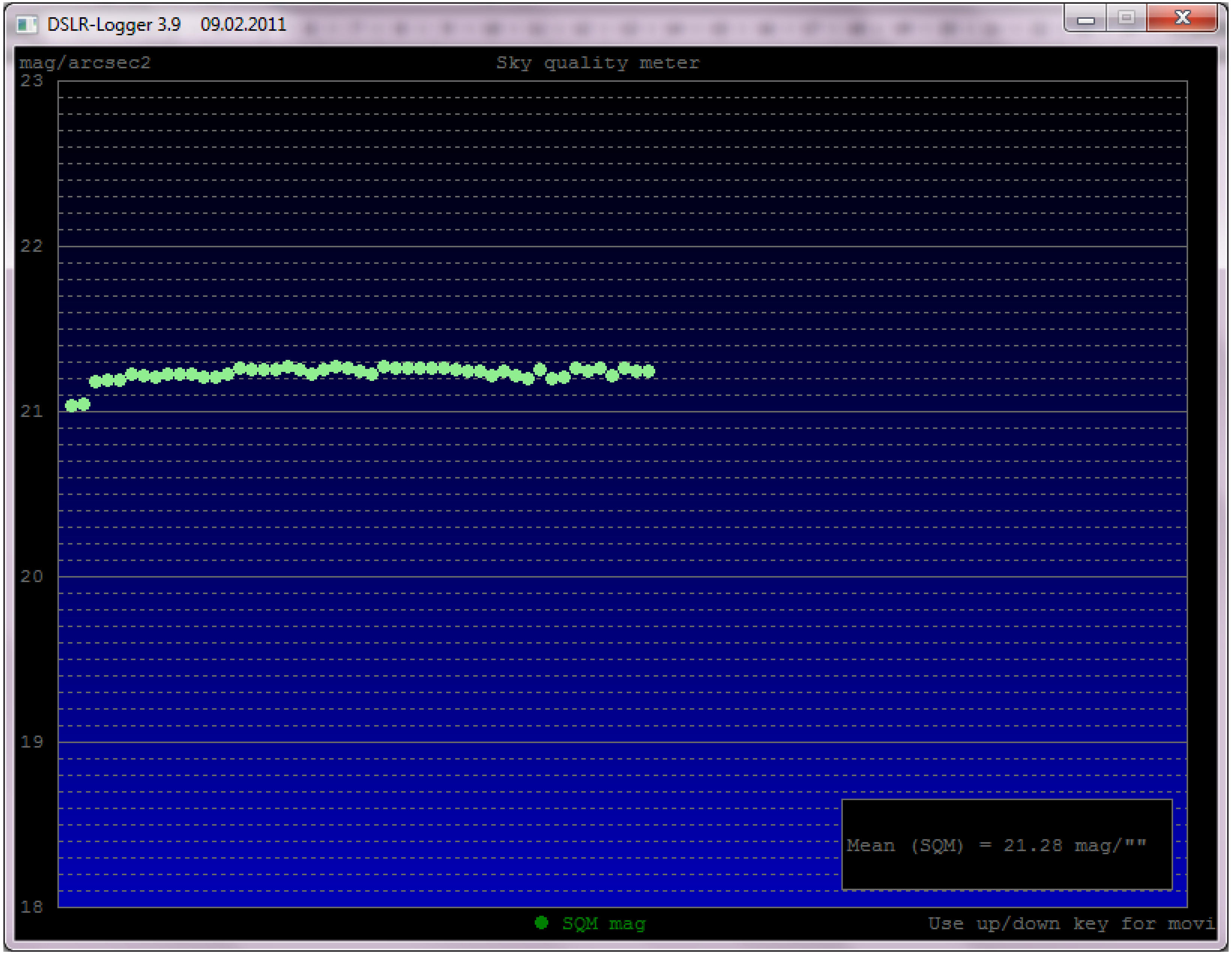
Step 6 during alignment: Correct the ALT and AZ of your Astrotrac and check the position of Polaris through the PS. The new position relative to the old should be the same as proposed by DSLR_logger (yellow line).



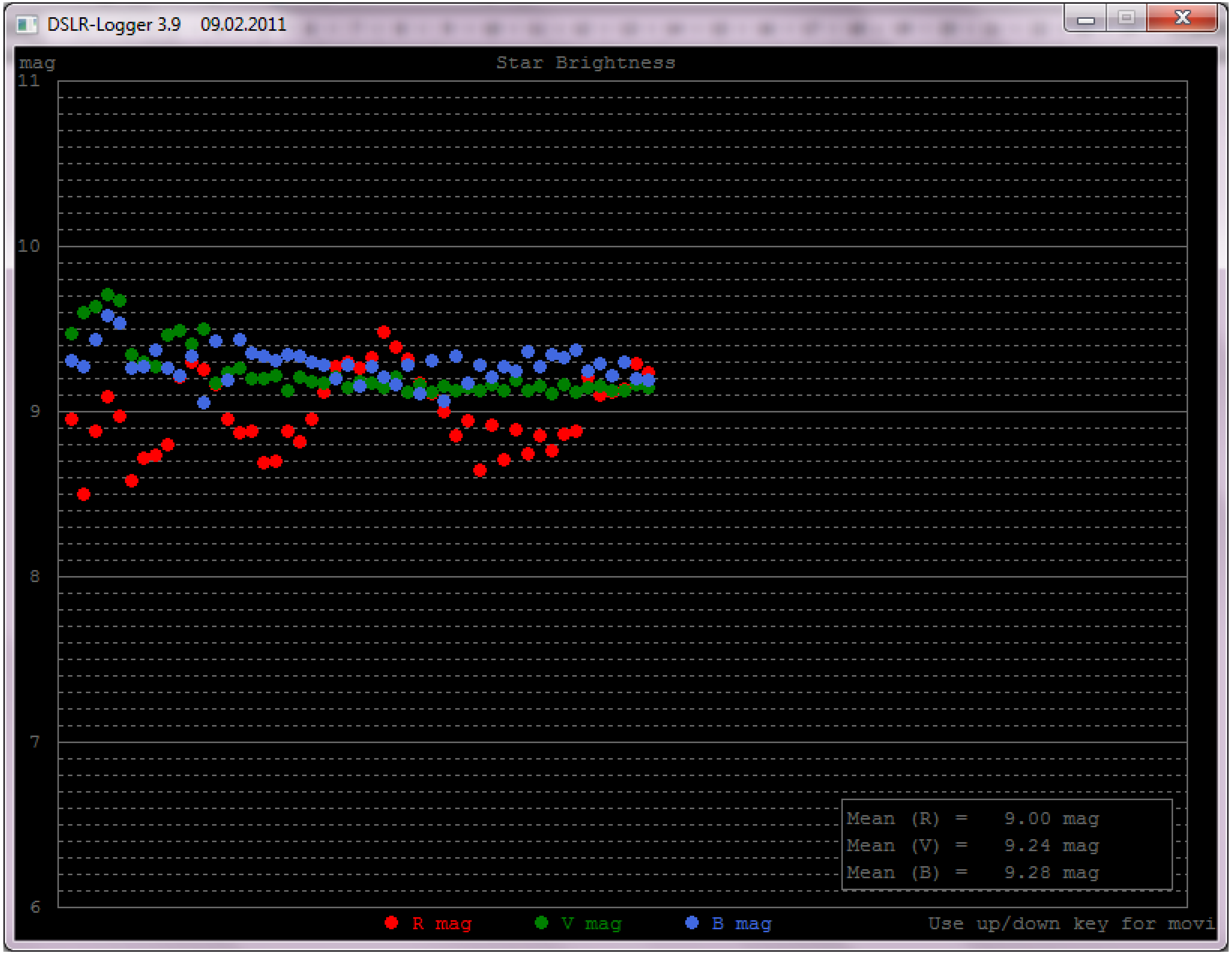
The star drift is shown as blue circles. The trend of the focus (FWHM) as well as the drift is shown in the upper right window. In this case, the focus clearly got worse.



The ‘Sky quality meter’ window plots the brightness of sky during the session (to open press F4). The unit is vmag and should correlate to the result of the SQM from Unihedron. In this case, no trend is visible. Use arrows up/down to move y axis

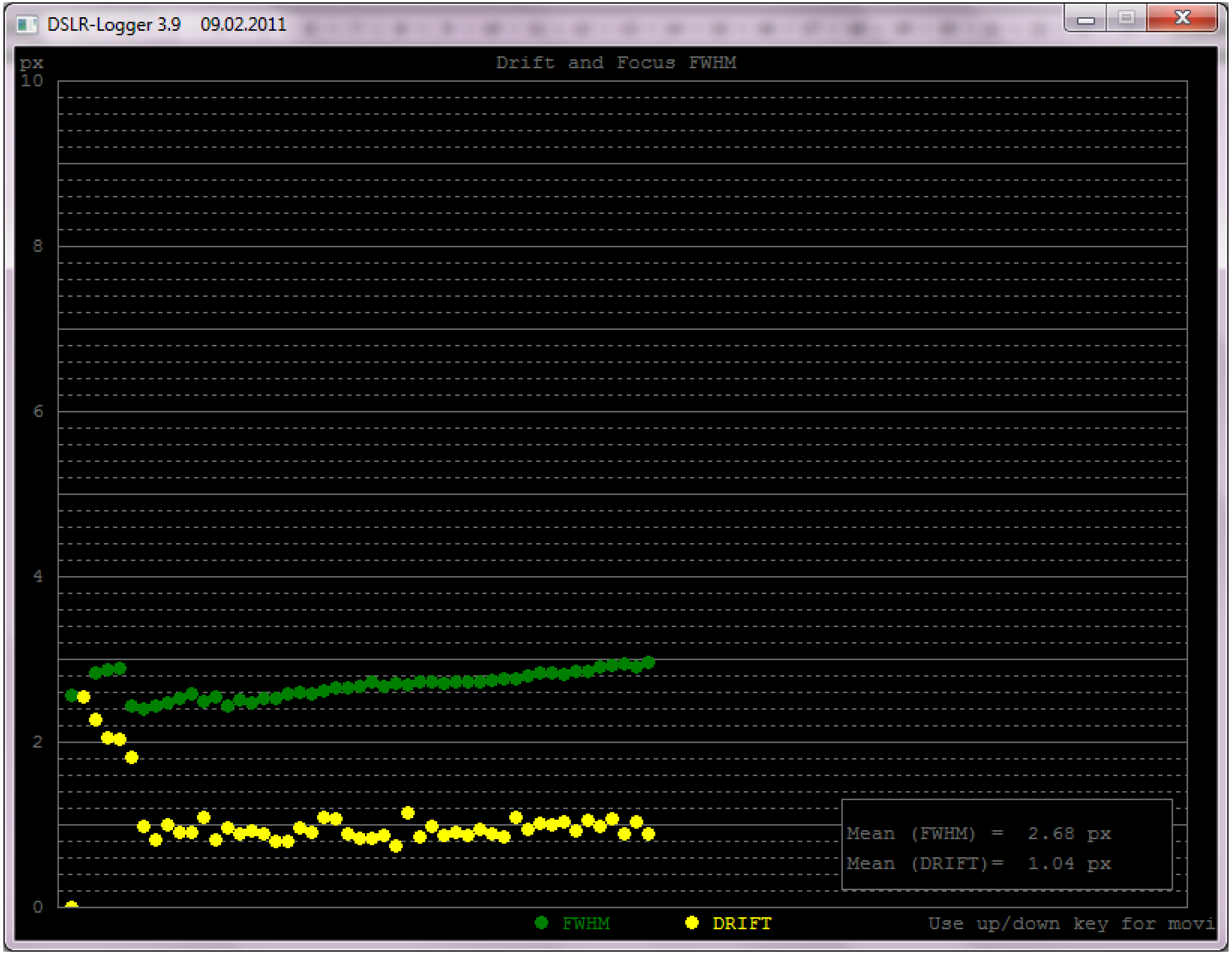


If F4 is pressed twice, the brightness of the tracking star is plotted. The result is shown in Rmag, Vmag and Bmag. For correct results, a calibration using your specific camera is necessary (same is true for Sky brightness). Use arrows up/down to move y axis



If F4 is pressed three times, the camera temperature is plotted. Not all cameras are providing this feature. This window is only shown if the camera supports that. The data may be useful to select proper dark frames. Use arrows up/down to move y axis

If F4 is pressed four times, the focus and drift result is plotted. This window is identical with that shown in the main window.



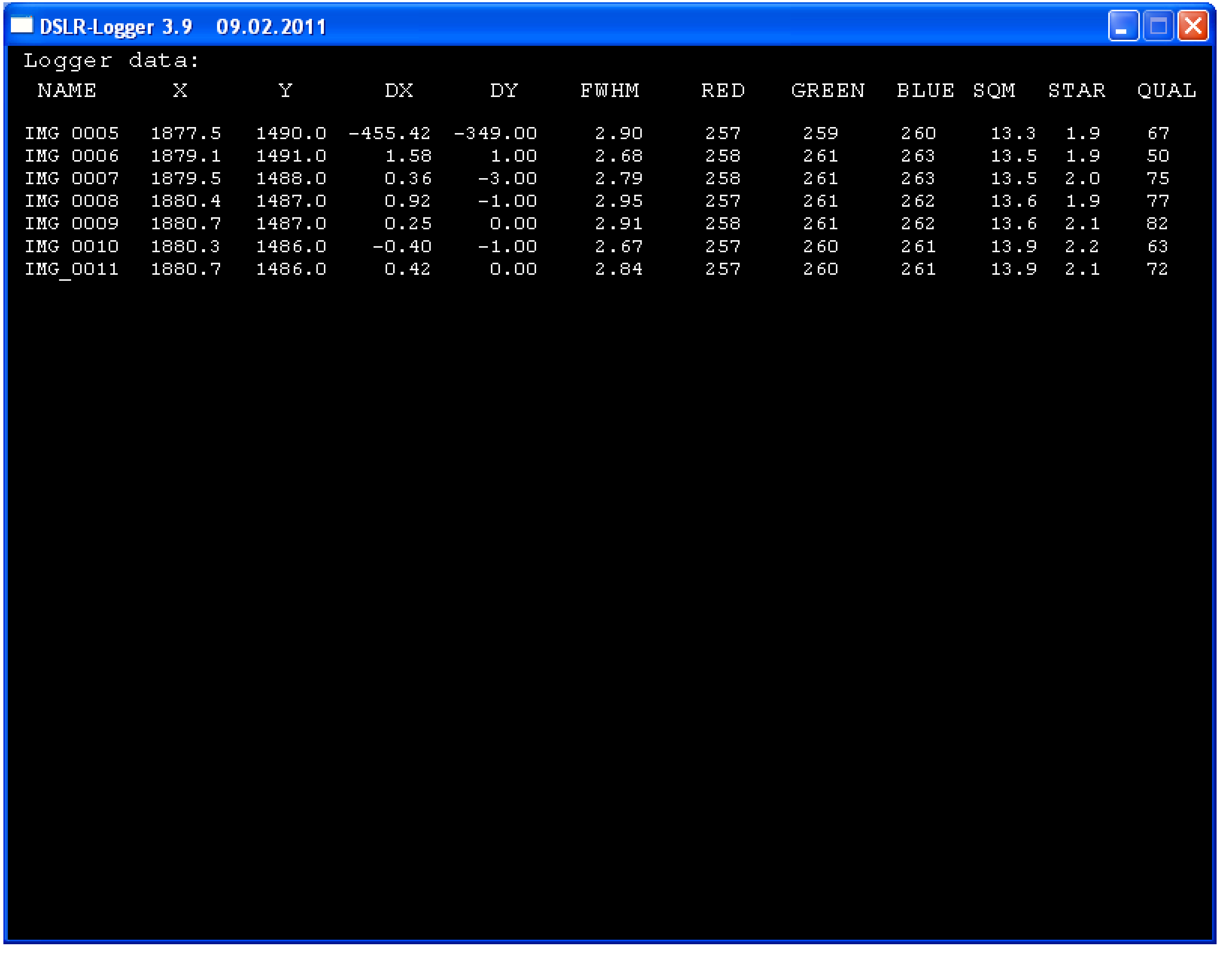
By pressing F3, the EXIF data of the current image are shown.

DSLR-Logger 3.9 09.02.2011

EXIF-Data:

File Name	: IMG_0052.cr2
Camera Model Name	: Canon EOS 1000D
Date/Time Original	: 2011:01:29 23:27:23
Shooting Mode	: Bulb
Shutter Speed	: 60
Aperture	: 2.8
Metering Mode	: Evaluative
Exposure Compensation	: 0
ISO	: 400
Lens	: 200.0 mm
Focal Length	: 200.0 mm
Image Size	: 3888x2592
Quality	: RAW
Flash	: Off, Did not fire
White Balance	: Auto
Focus Mode	: Manual Focus (3)
Contrast	: Normal
Sharpness	: 3
Saturation	: Normal
Color Tone	: Normal
File Size	: 8.6 MB
File Number	: 100-3326
Drive Mode	: Single-frame shooting
Owner Name	:
Camera Body No.	: 0680229556
Camera Temperature	: 1 C

By pressing F2, the logging data of the current session are shown.



Logger data:

NAME	X	Y	DX	DY	FWHM	RED	GREEN	BLUE	SQM	STAR	QUAL
IMG 0005	1877.5	1490.0	-455.42	-349.00	2.90	257	259	260	13.3	1.9	67
IMG 0006	1879.1	1491.0	1.58	1.00	2.68	258	261	263	13.5	1.9	50
IMG 0007	1879.5	1488.0	0.36	-3.00	2.79	258	261	263	13.5	2.0	75
IMG 0008	1880.4	1487.0	0.92	-1.00	2.95	257	261	262	13.6	1.9	77
IMG 0009	1880.7	1487.0	0.25	0.00	2.91	258	261	262	13.6	2.1	82
IMG 0010	1880.3	1486.0	-0.40	-1.00	2.67	257	260	261	13.9	2.2	63
IMG_0011	1880.7	1486.0	0.42	0.00	2.84	257	260	261	13.9	2.1	72