LACERTA M-GEN
Stand-Alone AutoGuider
PC Win32 application

User's guide for the PC application:
LMG_SAAG_WinApp.2.10.exe

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For usage with Firmware `02.10`

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1 Required environment

To run the application You need a 32/64-bit Windows operating system. An USB to serial converter IC is placed into the Handcontroller to communicate with the PC. The driver of this IC must be installed (only once) before running the application.

1.1 Installing the FTDI D2XX driver

The latest driver program can be downloaded from the homepage of the manufacturer (FTDI) of the IC. (From here:http://www.ftdichip.com/Drivers/D2XX.htm)

Choose the latest, proper driver for Your Windows operating system (as a setup executable) and for the proper IC, which is the FT232R. The driver version **equal to or above 2.04.06** can be surely used.

After downloading the driver start it and it will install the driver if there was not before. If You are asked to restart the computer do so. This installation must be done only once for a computer, not required later. (Follow the FTDI's application note on installing the driver if having troubles!)

2 Usage of the application

The PC application does several functions for Your LACERTA M-Gen autoguider. There is a main menu window, where You can choose what to do next.

Clicking on the "About..." button, information about the PC application pop up.

The PC application's version show that highest verison number of the Firmware in the device that it can handle. There is always a new PC application for each new Firmware release. The users are advised to use the PC app. version equal to the running firmware to avoid some incompatible behaviour.

2.1 Controlling the firmware

Selected by clicking on the "Firmware control" button. A new window appears.

On the left box information or error is displayed about the autoguider's current firmware. On the right, You can select a local firmware file (on Your PC) and get it uploaded into the autoguider.

"Close" button goes back to the main menu window.

2.1.1 Reading the autoguider's current firmware

Connect HC to the PC with the USB cable, and the Camera to the HC (optional). Turn on the HC. Click on "Check versions" and after a short time version data are displayed:

```
HandController BOOT: $14
  ... firmware: $0210
Camera BOOT: $14
  … firmware: $0210
```

Note that the HC enters BOOT mode to do this query, so the running firmware is stopped. Don't use this while You are autoguiding!

BOOT version numbers identify the hardware type. This doesn't affect functionality of the firmware, except that new hardware can't run firmwares below 2.00 ($0200).
Old (type I) hardware's BOOT versions are: $12/$13 and $11.
New (type II) hardware's BOOT versions are: $14 and $14.

Fw. version numbers format is $hhll and means firmware hh.ll. The file containing this version of firmware is always named LMG_hhll.fw.

Trying to get the firmware numbers, when HC is not connected to PC or is turned off, will report an error: FTDI: device not open in Write()

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If the camera isn't connected to the HC (properly or has some error), "can't get camera boot version:..." is displayed.

2.1.2 Running the firmware

After turning on the HC the firmware is executed automatically. If You are in BOOT mode, ie. just updated the firmware, You can execute the new firmware by clicking on the "Run" button.

If it is already running, nothing will happen.

On CRC error (when the program code integrity is lost somehow), "NO FIRMWARE" is displayed on the LCD.

If the new hardware can't run an old firmware, it displays "WRONG FIRMWARE".

2.1.3 Uploading a new firmware

Connect HC to the PC with the USB cable, and the Camera to the HC. Turn on the HC, preferably in BOOT mode (ESC held down). You shouldn't be in BOOT mode, firmware could be running, the upload procedure will enter BOOT mode automatically.

1. Select the local firmware file by clicking "..." (browse) button and Open it.

   The version numbers that the file contains, are displayed below the filename selected. If this is OK, You can go on.

2. Check the appropriate boxes:
   - ✓ HandController: to upload firmware into the HC
   - ✓ Camera: to upload firmware into the Camera
   - ✓ Default var.s: to get every variable initialized in HC (restored to factory default).

   Upload firmwares separately (HC and Camera) only when You had some trouble with them. Not that mismatching firmwares will not work together. Firmwares in the same file are always matched.

   In normal function the best is to leave the checkboxes as they were. (Default var.s unchecked only.)

3. Click on "UPLOAD" button.

   The upload will be in progress for a minute approx. If it has ended, "Done" is displayed above the progress bar at the bottom, and the newly uploaded firmware versions are read back as done in 2.1.1.

WARNING: never plug out the USB cable or power-off the device during Firmware uploading procedure. It may (very rarely) damage the boot program that makes the upload possible and the device must be reprogrammed at factory that is not a part of the warranty.

2.2 Managing autoguider files

Selected by clicking on the "File control" button. A new window appears.
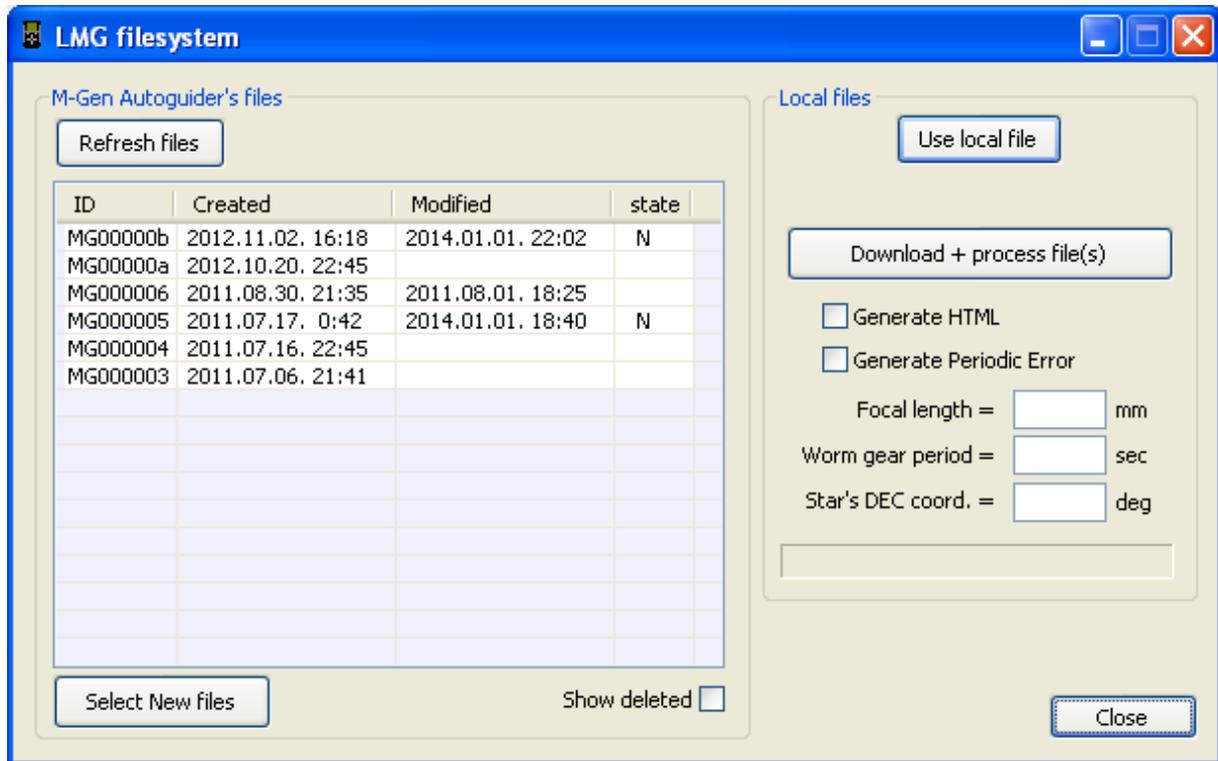
On the left side the file list is shown that are stored currently in the autoguider. If HC is not connected to PC or turned on, the list is empty and buttons in the group box don't have any effect.The PC application can't access the files in the autoguider (seen as there were no files in it) if:

- You are in the "File menu" of the autoguider;
- there is an open file in the autoguider.

If the PC app. can access the files, the LCD displays "FILE exclusive mode". The autoguider's functions are suspended.

"Refresh files" button is to re-read the file list. On the case the PC app. couldn't access the files at the time when this window is appeared, this button can be used to retry accessing the files after You eliminated the excluding causes.

Use "Show deleted" option to display file entries that are deleted (and not overwritten yet). Data content of these files may be overwritten by other files and so be wrong! Checking/unckecking this option will refresh the available file list.

About the file list columns:

- ID: the unique identifier of the file. Downloading this will create a folder named this ID + ".dat.content" and the ID + ".dat" raw file in it.
- Created: the creation time of the file.
- Modified: time of the last opening of the file. If empty, the file was opened only once.

- state: letters about the state of the file. Meanings:

  N   - new file, not downloaded to PC yet or modified.

  X   - deleted file (entry)

2.2.1 Downloading files to PC

Select one or more (ie. Ctrl + left mouse button) files from the list. If only new or modified (so not downloaded) files are to be donwloaded, click on "Select new files" and those will be selected.

Click on "Download + process file(s)". Downloading will be started. The time it takes depends on the amount of data. The speed is about 12k bytes/sec. After each file is stored in a local file, is getting processed immediately.

The local file storing scheme is the following:
- let the file ID in this example be MG00000a
- PC app. downloads the file data into memory,
- creates a folder called MG00000a.dat.content\ in the app.'s working folder (by default where it was started),
- saves the raw data into the new folder, filename is MG00000a.dat (creates backup file if existed)
- processes the raw data file and creates some new output files in the new folder.

When downloading and processing is finished, You get back control over the window. The progress state is shown meanwhile.

2.2.2 Processing files

This is done automatically right after downloading a file to PC. "Processing" means creating some human-readable or formatted output files based on the raw data. You can read detailed desciption of these in section 3.

The file "events.csv" is always (re)created during processing. (Ld. 3.2)

The file "index.html" is created only when the "Generate HTML" checkbox is set. (See 3.3)

One or more Periodic Error file is created when "Generate Periodic Error" checkbox is on. You must enter some data about your setup to create valid measure:
- first the focal length of your telescope what was used for measuring (in millimetres);
- second the period of the used mount's worm gear;
- third the DEC coordinate of the used star, to correct RA axis. (Optional, means 0 if left empty.)

There will new 'pe?.csv' files created, where ? stands for their index. Each file contains a measure that is calculated from a data block of raw star positions. If there is less data (in time) than one gear period, no calculation is made. If there is at least 1 period of data, it is processed the following way:

o   The drift due to incorrect polar alignment is compensated by a linear function;

o RA and DEC directions are calculated using linear regression, RA will be parallel to the line fit;

o data is transformed to RA/DEC coordinate system, scaled to arcseconds, and written to file.

2.2.3 (Re-)processing a local file

Click on "Use local file". The button will remain pushed and a file open dialog appears. Choose the raw .dat file, which is now displayed and selected as the input (instead of file(s) on the autoguider).

Check and fill the edit boxes above as written in 2.2.2

Click on "Process local file above", processing will be done.

All the output files are stored in the same folder where the .dat file is.

Click on "Use local file" again to disable input as a local file.

2.3 Options of the Camera

Selected by clicking on the "Camera control" button. A new window appears. (See below at 2.3.1) The HC will display "USB Camera Control mode" if succeed.

On the left, there is the place for displaying contents representing the CCD's surface with above the currently displayed content.

By default –when the mouse cursor is not over the area- the hot pixel positions are shown that are uploaded to the Camera's hot pixel map. This is empty for first. If the cursor is over the area, it displays the last taken dark frame (1x1 binning mode), empty as well for first.

At right top the camera state is shown.

2.3.1 Displaying the current hot pixel map

To check the current hot pixel map of the Camera, click on "Read current" button. After downloading the map, they are shown as simple dots.
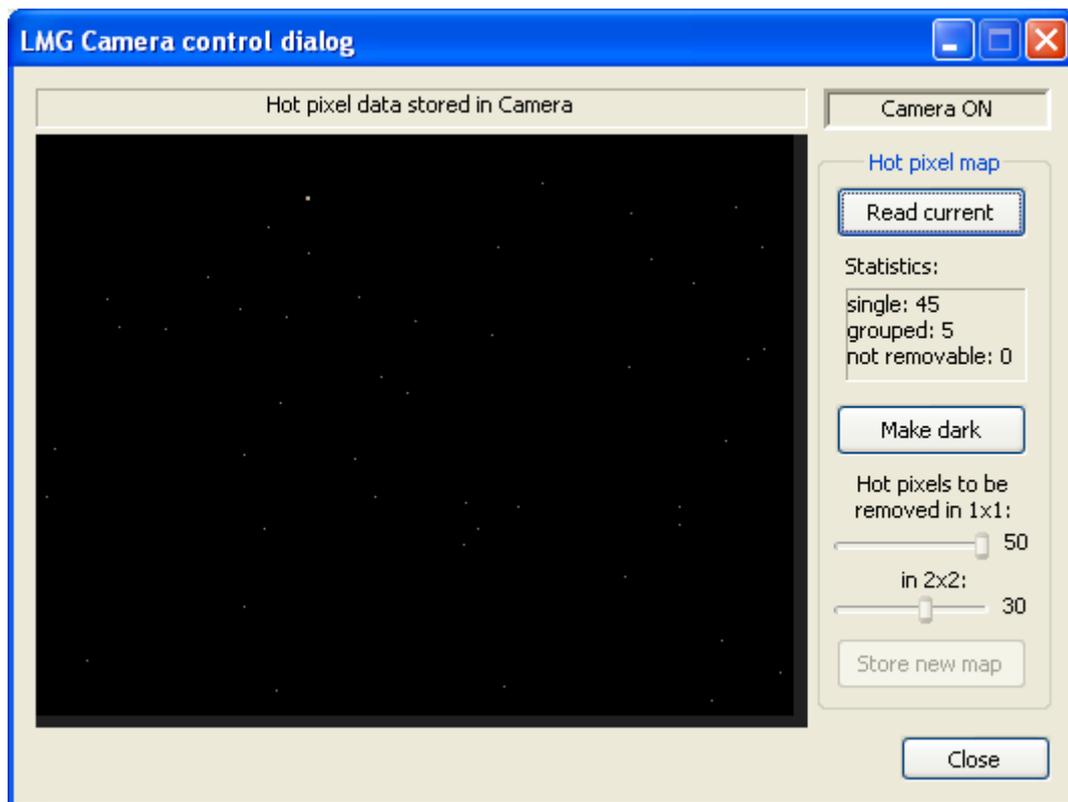
"Statistics" gives some info about the amount of different hot pixel types. Single hot pixels are surrounded with normal (non-hot) pixels. A grouped hot pixel is such that it has at least one neighbouring hot pixel. These could be cosmetized as well but with less efficiency, since there are less surrounding good pixel information. Not removable hot pixels are totally surrounded by another hots, these are very rare and won't be cosmetized at taking frames.

2.3.2 Creating a hot pixel map

To create a new hot pixel map the program needs a good dark frame taken. Click on "Make dark".

In the appearing dialog, enter the number of dark frames to be taken. The more single dark frames are taken, the more precise the resulting dark will be. (It is required because of cosmic ray impacts or such instable hot pixels that may get normal for a short time.) The single darks are then stacked together with the Artificial Scepticism Stacking method.

Ensure that the CCD is not lit even a little bit. The exposures are 4 seconds long and taken at high gain (sensitivity).

Click on "Take dark frame" to start the process, while You can see this progress indicator.
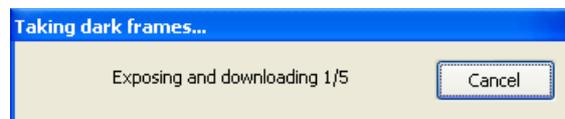
After finishing, the resulting dark frame can be seen (mouse over the area).
"Cancel" stops taking more darks and the procedure will be broken.
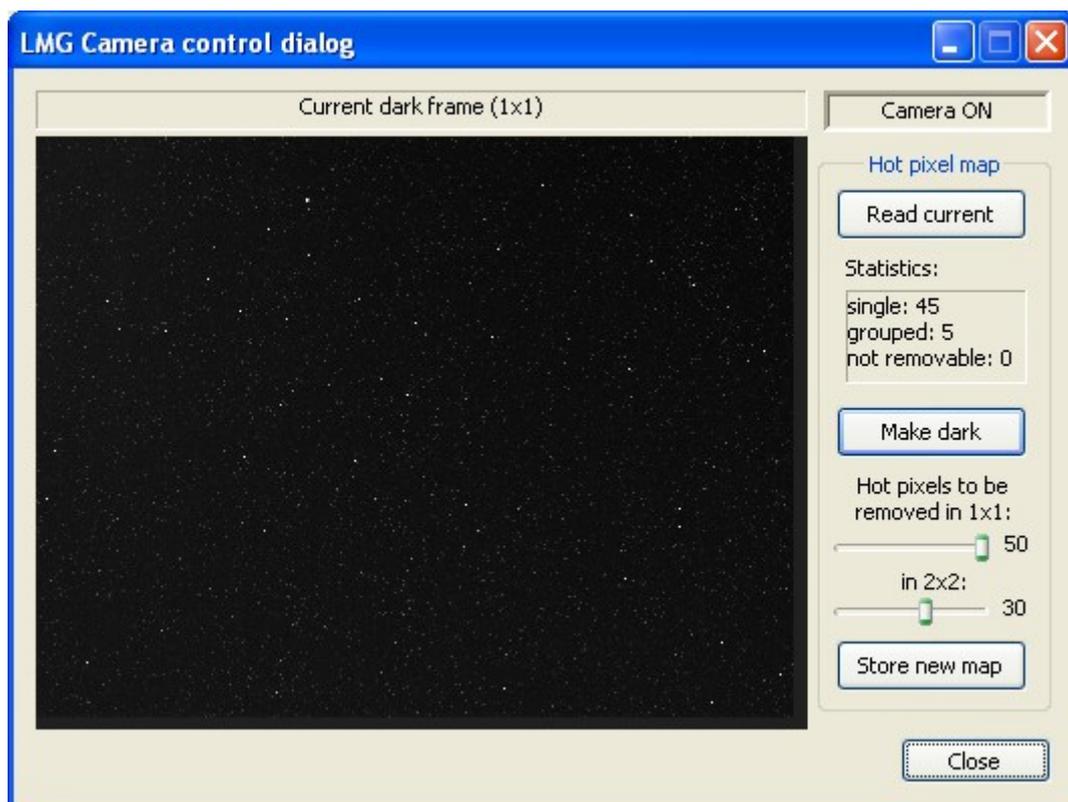
The displayed image is reduced in size by a factor of two, so each pixel shows the maximum of a 2×2 pixel block of the CCD. That's why You can see a lot of gray ("warm") pixels besides the hots. Maximum must be shown to see every single hot pixel left (not cosmetized yet).

The image above is from a development piece of the MGen camera. In room temperature, warmed up well. You can ignore the bunch of medium gray pixels, these are quite invisible 'outside' the night. Our goal is to remove the white ones, those are the hots.

There are two hot pixel maps in the Camera, one for 1×1 and one for 2×2 bininng mode. The two sliders on the right are to set the amount of the hottest pixels to be cosmetized. While You are moving the slider, the cosmetized dark frame can be seen on the left. Set both values so that no more hot pixels can be seen.

On 2×2 mode, the dark frame seems to be less noisy. This is due to the fact that a single hot or warm pixel is only ¼ part of a binned pixel. This mode requires less pixels to be cosmetized. It's Your choice.

The 2×2 dark is also more luminous. This is because the binned pixel is 4 times sensible to the light and any signals. You can see some glowing on the upper left part, this is the "footprint" of the CCD output amplifier circuit, it's normal.
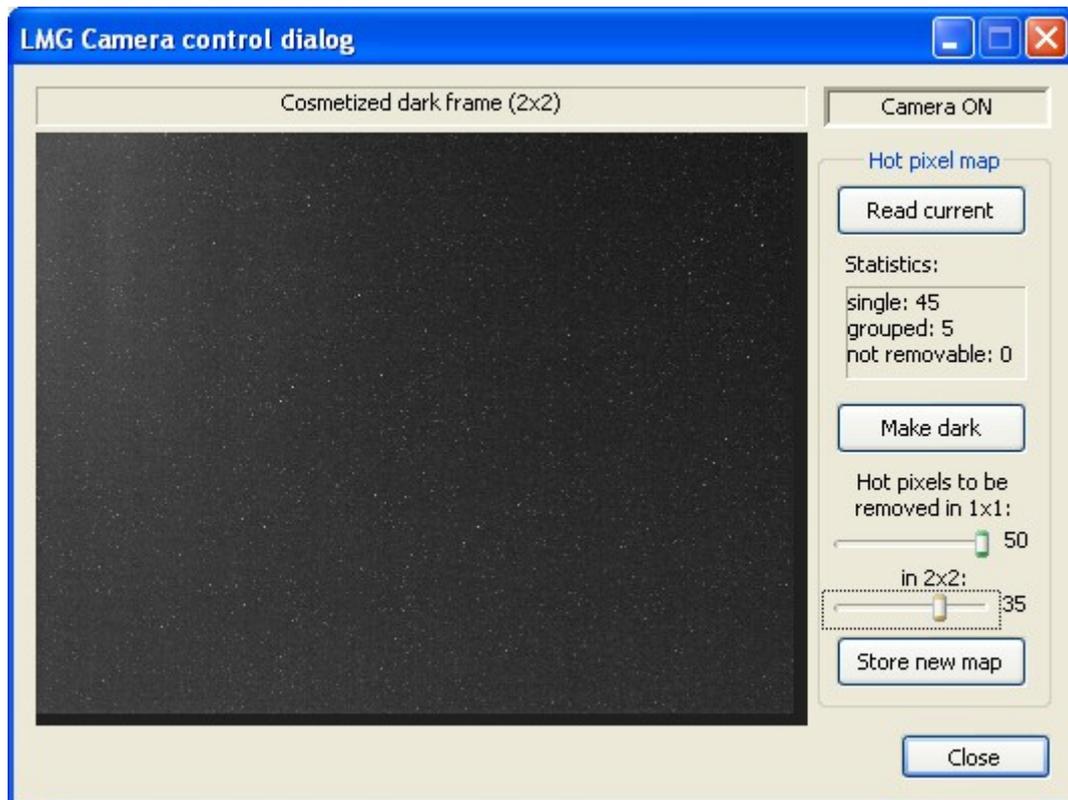
If You have set the amount of hot pixels (= pixels considered as hots), click on "Store new map" and these will be uploaded into the Camera. From now the Camera will cosmetize these pixels in 1×1 and 2×2 modes while taking guiding frames or searching stars. Note that hot pixels are not removed in LiveView mode.

The Camera will not lose the hot pixel map at power-off or at firmware update, since it is stored in a separate non-volatile memory. To disable hot pixel cosmetics, set and upload 0 hots for each binning modes.

2.4 Remote control of M-Gen through USB

There is a possibility to remote control the HandController using this Application. "Virtual M-Gen UI" button provides a virtual User Interface window for You. This can be used anytime, except when the M-Gen is in update (BOOT) mode.

The display here is exactly the same as on the HC's LCD display.
The buttons are replaced by the PC's keyboard with the following mapping:

M-Gen	PC
ESC	Escape
SET	Enter
▲	↑
▼	↓
◄	←
►	→
(long ESC)	Backspace

(long pressed ESC is used to toggle directly between the AutoExposure and Guiding screens)

It is planned for future firmwares to display the LED indicator states on this virtual UI window as well.

2.5 Miscellaneous

There are one or two direct signalling possibilities for the M-Gen:

Power ON: This sets the ESC button signalled for a short time and so can be used to turn on the HC remotely. Works only if the HC is not already turned on.

NOTE: this feature requires appropriate hardware and it is not included in old M-Gens. (These have HC boot ID of $12 or $13.) Later M-Gens support the power-on.

RESET: Does a hardware reset to the HC. Use this only in an emergency case! Old M-Gens could be turned on this way, but take care that the HC is not working already in any mode.

3   File data content and outputs

When You download a file from the device, a new directory is created with the name of the file's ID („`MG`" followed with the file's unique ID, a 6-character hexadecimal number) plus „`.content`". The directory will be created into the application's working directory.

File types that are created anyway at download time:

- The RAW data stored in the device.
- A RAW (but „human readable") text format output that contains all the data items in a formatted mode. This is a CSV file that can be parsed as a single text file or opened by Microsoft Excel.

File types that are created optionally:

- A well formatted HTML output file. This is a visual representation of the data stored with diagrams, separated into different parts.
- Periodic Error files, based on stored raw star position data blocks.

3.1   The RAW data file

The filename is the same as the directory's but without the „`.content`". This file would be used for re-interpreting the old data files with the later PC application versions that might generate more complex data sets or more (bugfixed) diagrams etc.

3.2 CSV format raw text file

The filename is always „`events.csv`". This is a text file, may be interpreted by a user program if some wants to. Microsoft Excell also opens it. Each line is splitted into columns by the semicolon (;) character. Excell splits the line data into its columns by this.

This file holds „events" that have occured in the device. Most of them have timestamp to be able to fully recover the operation of the device. Each line in this file holds one event's data. The first 3 columns is always the same as the header (very first row) says:

Date	Time	event

Date   `yy.mm.dd.` format (<u>y</u>ear, <u>m</u>onth, <u>d</u>ay). Year is the last 2 digits of 20xx.
Time   Seconds elapsed since the last midnight in 0.1 sec. resolution.
event   The type of the stored event or data. This indicates how to interpret the following columns' data as described below.

Note: the date and time value is always that You have set up in the device. It's Your responsibility to enter the proper date and time before You open or create a file by the device.

The Firmware ver. 02.10 generates the following events (formatted lines):

- **`<OPEN>`**
  The file has been (re)opened. The version number is written in the next column as „`file has been opened by FW version 02.10`".

- **`<EOF>`**
  Indicates End Of File. Must be only at the last row of the file. The next column of this event gives information about the file-end:
  „`End Of File (msg = '…')`", where '…' stands for the cause of it. If empty, the file was closed normally and could be re-opened later. If there is an error message, the file is broken (wasn't closed normally, the data stream is broken) and can't be re-opened.

- **`AE change`**
  AutoExposure has changed its state and the output signals.

  The next column shows the new state, which can be:
  - IDLE   - the AE is idle
  - WAIT   - wait state („`w`" shown in its screen)
  - ML   - mirror lockup state („`m`" shown in its screen)
  - EXP   - exposure state („`e`" shown in its screen)

  The 2nd following column shows the new AE output signals (the physical output on the stereo jack connector). Can be:
  - *empty*   - neither signal is active
  - FOC   - focus signal is active only (middle pin pulled down)

- o EXP   - exposure signal is active only (inside pin pulled down)
- o FOC+EXP   - both signals are active

- **drift**

  A new guiding star position is read from the Camera (during autoguiding). The „drift" is the offset to the guiding center where the star should be held at.

  The next two following column contains the RA and DEC drift values measured in pixel units as fractional numbers. (The drift is scaled to the CCD's horizontal pixel size which is 4.85µm because the pixel aspect ratio is not exactly 1:1).

  The next two columns may be empty or store a fractional number (for RA and for DEC). An empty column means that no new autoguiding signal were calculated (and put out), in this case the device only accumulated the new position. This happens only if the „Num" of an axis' guiding parameters is set more than one.
  If there is a value, it means the calculated correction signal length (in seconds) put out to the ST-4 compatible output. (Note that this is the <u>calculated</u> value, a new signal that happens before the previous signal elapsed will „overwrite" it.) A zero value means that the autoguider signals are set to be inactive on that axis. The sign of the value shows the direction of the new correction signal.

  This event is only stored when the autoguiding is working (has been started), there is a new guiding star position and the AutoExposure process is in the exposure state.

- **position**

  The next two following column contains the star's X and Y raw position of center. It is generated when You were saving positions with inactive autoguiding. Note that these X-Y coordinates are the raw CCD coordinates, what means the following:

  - ➢ The Y coordinate must be multiplied with $4.65/4.85 = 0.9588$ (= CCD pixel aspect ratio) to have coordinates for a virtual square-pixel CCD.

  - ➢ For binned modes, the position is given in binned pixel units. The CCD pixel aspect ratio (above) must be applied as well.

- **NOP**

  No OPeration. Used to separate such data blocks like the 'position' above. There are no following columns.

- **Variable**

  Stores the current value of some variable. The next column contains the variable's identifier (name) and the 2nd next column it's value, which's format depends on the variable. The followings are stored in this version:

Name	Value	Description
gain	2…9	Camera gain
expo	50…4000 (ms)	Camera expo.time

thr.	1…99 (%)	threshold
RA	*	RA settings
DEC	*	DEC settings

* = new variable+value column pairs come as they can be seen at the RA/DEC settings page (guiding screen, page 3 and 4).

- **ERROR:** …

  If the event starts with this string („ERROR:") an unknown-type event is found in the data stream or is some error in it. Always use the same (or a later) version of PC Application as the firmware that stored data into the file in the device to avoid such cases!

3.3 HTML formatted output

There is an embedded parser in the PC Application that interprets the stored events and visualizes them.

The HTML is splitted into several sections, separated with horizontal lines. Currently only one type of section is available, the „Guided exposure".

Guided exposure #n:

This is data and diagrams of one exposure that were done during an active autoguiding. The number of it (#n) is counted by the parser.

The date of starting the exposure can be seen next to the section name.

The „AutoExposure info" table shows the starting, ending time of the guided exposure along with the time spent in non-idle state(s) between them. All the values are meant in seconds with 0.1 step.

The „Point spread" diagram shows all the guiding star positions got from the Camera. The center of the diagram is the guiding center (where the star should be held). The background grid has one pixel width resolution to show the effective spreading of the position.

Next to this there is some information about the guiding positions and actions: how many positions were read from the Camera during the exposure, how many frames per second was the actual frame rate (in average), and how many times were a new non-zero length correction signal sent to the axes.

The „Guide star drifts" diagram is the same as the „Point spread" but the two axes (RA (top), DEC (bottom)) separately as a function of the time (horizontal axis). Some statistical data is shown for the data sets like mean and standard deviation. The full std. deviation interval is drawn right to the diagrams.

The „Approx. tracking error of the mount" is what its name suggests. The effective autoguider correction signals are used to reproduce the tracking error of the mount and/or the effect of the polar misalignment. The diagrams' scaling is given. The unit is seconds, because it is independent of any of the used parameter settings, depends only on Your mount's actual correction speed.

Note that high backlash on an axis (typically on DEC) could confuse the approximated „tracking error".

Beware of accepting the diagrams content, it assumes the the mount is ideal, reacts well to the shortest (32 ms) correction signal. If it's not the case, the diagram accumulates (integrates) much not reacted short signals and it could show much larger tracking error than the mount had for real.