Astro Pixel Processor Quick Reference Guide

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version 0.4

Contents

1 Introduction

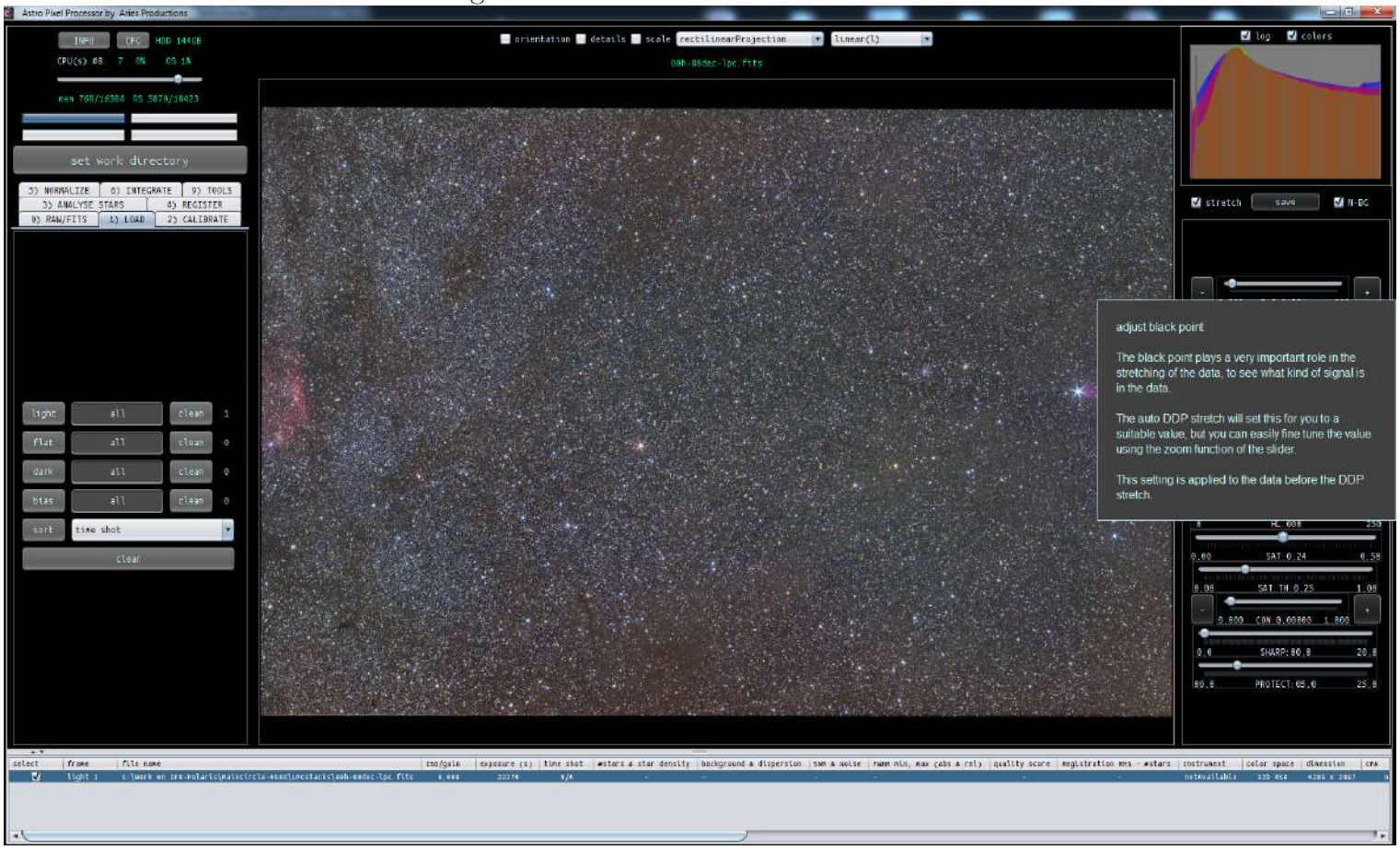
Astro Pixel Processor is a complete Deep Sky Image Processing application developed by drs. E.M.W.P. Haverkamp (Mabula). This is the quick reference guide, which will give a practical overview of all the options that Astro Pixel Processor (APP) offers for processing your data. Furthermore, depending on the situation, this guide will give recommendations on when to use which menu option. APP features among others:

- image calibration with bias, dark, flat frames and bad pixel maps
- very advanced image registration using true optical distortion correction
- very advanced image normalisation using only the data areas that exactly overlap between the reference frame and the frame that needs to be normalised
- a new innovative technique called Local Normalization Correction or LNC. This will greatly improve data normalization in the complete stack before actual data integration.
- a special and unique demosaic algorithm called: Adaptive Airy Disc that will reduce green cast in your RGB data, will improve sharpness and will make your stars rounder when compared to the well-known AHD and VNG algorithms.
- demosaic algorithms for direct processing of monochrome narrow-band data (H-alpha, SII, OIII,...) acquired with One Shot Color (color CCD/CMOS, DSLR) cameras.
- the ability to create huge mosaics automatically by solving the registration problem of all mosaic panels as one complete problem
- the ability to project your data differently than the regular rectilinear projection for huge field of views after camera calibration (focal length, principal point)
- very advanced integration/stack engine including outlier rejection filters and the ability to output rejection, weight and normalization maps.
- Multi-Band Blending to help remove stack artefacts in regular stacks or seams in a mosaic integration.
- full drizzle support including bayer drizzle. The drizzle droplet and grid enlargement can be configured. And different drizzle kernels can be used, like point, square, tophat and gauss.
- chromatic aberration correction as part of RGB data calibration using a special registration model that will correct all forms of chromatic aberration to a very high degree.

- data interpolation algorithms for all different kinds of image transformations like Lanczos and Mitchell-Netravali algorithms
- choose different compositions for you stack before data integration. You can choose to integrate the entire field of view of all frames, or only the field of view of the reference frame, or even a crop of the reference frame.
- directly integrate using another scale, so you can directly upscale or downscale the integration result.
- a very efficient light-pollution/gradient removal tool.
- a tool to correct vignetting in your lights/stacks using Kang-Weiss models with or without a geometric factor. The geometric factor is needed for optics consisting of several optical elements.
- batch tools to rotate, resize, crop, uncrop, and even undebayer(!) your frames
- can split your RGB data into separate channels for combination with monochrome channel data.
- ability to adjust FITS meta data
- the possibility to multiply or divide your data with a certain factor or to add/remove a pedestal to/from your data
- preview filter which different automatic stretch settings, background & highlights protected saturation adjustments, contrast increase, sharpening while protecting your stars and the option to reduce the stretch in the highlights, giving tighter stars and less saturated star cores.
- using the preview filter, you can directly save all your results to FITS, TIFF or JPG formats including ICC color profiles for correct color management.
- the RGB or Luminosity histogram of your data is always visible
- tool for star color calibration
- a RGB composite tool with Luminance implementation for the creation of all kinds of composites, like LRGB, LHaRGB, or a Hubble Palette using your narrowband data (SHO).
- a selective color tool with the ability to selectively adjust the colors in your images or/and selectively boost saturation and/or luminance.
- all data processing in APP can be done on linear data. The selective color tool has no problem for instance with your linear data.

- APP will run on any 64bits operating system where the Oracle Java Runtime is available. APP is installed with the correct Java Runtime Environment (JRE), so the user doesn't need to worry about this. Currently, complete installers for Linux (DEB & RPM), Windows (.exe) en MacOS (DMG) are available.

Figure 1: Astro Pixel Processer interface



2 Hardware & Operating System requirements

2.1 minimal requirements

number of processors : 2
hdd space : 100 GB free space
memory : 4GB RAM memory
screen resolution : 1280x768
OS : 64bit OS

2.2 recommended requirements

number of processors : 4 with multi threading
hdd space : 250 GB free space
memory : 8GB RAM memory
screen resolution : 1680x1050
OS : 64bit OS

2.3 data integration and harddrive requirements

APP uses your hard disk drive (HDD) for data integration, so make sure that you have enough free HDD space. The values in Table 1 are the HDD space requirements for integration using the **normal registration mode** and **reference composition mode**, i.e. a regular integration of light frames. Try to work on the fastest hard drisk drive available in your system for optimal speed, so try to use a solid-state drive (**SSD**) if you have one. The drive on which you will work is the drive which contains your **work directory**, see section 7. APP will monitor the free HDD space and will calculate the HDD space requirement when the integration starts.

2.4 supported Operating Systems

APP currently runs on the following **64bits** Operating Systems:

- Windows, exe installer
- MacOS, dmg installer

Table 1: HDD space requirements

image type	mega pixels	# Light frames	integration type	HDD space needed
monochrome	8MP	10	regular	0.3GB
RGB	8MP	10	regular	0.9GB
monochrome	16MP	10	regular	0.6GB
RGB	16MP	10	regular	1.8GB
monochrome	16MP	100	regular	6GB
RGB	16MP	100	regular	18GB
monochrome	16MP	100	regular & MBB	9GB
RGB	16MP	100	regular & MBB	27GB
monochrome	16MP	100	regular & Bayer Drizzle	9GB
RGB	16MP	100	regular & Bayer Drizzle	27GB
monochrome	16MP	100	drizzle 2x	36GB
RGB	16MP	100	drizzle 2x	108GB
monochrome	16MP	100	drizzle 3x	81GB
RGB	16MP	100	drizzle 3x	243GB

- Linux, rpm & deb installers

APP will run on any 64bits operating system where the Oracle Java JRE is available. If you need a different installer type or want to use APP on a currently unsupported OS where the Oracle Java JRE is available, please please post you request at the forum:

https://www.astropixelprocessor.com/community/

2.5 memory configuration

You can configure APP to use a certain maximum amount of RAM using the top left CFG button.This maximum is equal to the amount of:

RAM memory in GBs - 1GB

in your system. Ideally, you want to reserve at least 1-2GBs of RAM memory for your Operating System. If you would let APP use all available RAM memory, your OS might need to start swapping at some point, which will reduce performance drastically.

2.6 maximum supported image size

Depending on the amount of memory, APP is limited to certain image dimensions. See Table 2. Currently, APP has a technical limit for image size of:

Table 2: maximum image size

memory	image type	mega pixels	image dimensions
2GB	monochrome	160MP	12500 x 12500
2GB	RGB	53MP	7000 x 7000
4GB	monochrome	320MP	18000 x 18000
4GB	RGB	106MP	10000 x 10000
8GB	monochrome	640MP	25000 x 25000
8GB	RGB	214MP	14000 x14000
12GB	monochrome	960MP	31000 x 31000
12GB	RGB	322MP	18000 x 18000
16GB	monochrome	1290MP	36000 x 36000
16GB	RGB	430MP	20500 x 20500
24GB	monochrome	1940MP	44000 x 44000
24GB	RGB	645MP	25300 x 25300
32GB	monochrome	2145MP	46300 x 46300
32GB	RGB	715MP	26700 x 26700

- monochrome 2145MP or 46300x46300 pixels
- RGB 715MP or 26700x26700 pixels

which is already extremely big, but this limitation should become a thing of the past as APP develops further.

2.7 active internet connection requirement

APP needs an active internet connection to be able to activate and verify your license. This means that APP can't be started without an active internet connection. If APP is started, no online checks will be made for as long as APP is running. But, as requested by the Beta Team, I will try to remove this active internet connection requirement in the near future.

3 Camera and image support

APP currently supports the following image formats:

- FITS, read and write, 8,16,32 bits integers, 32bits floats, 64bits doubles
- Canon CR2, read (no support currently for **sRaw**, **sRaw2** formats [1].)
- Nikon NEF, read
- TIFF, read and write, 8,16,32 bits
- JPG, read and write, 8,16 bits

Unlike most other astrophotography programs, APP has no dependency on DCRAW for the interpretation of DSLR raw images. The conversion of CR2 and NEF files is completely written by Mabula himself. The implementation of other RAW image formats (Sony, Fuji, Pentax) is on the TODO list to be implemented. If you do encounter problems with your current CR2, NEF or FITS files or want to request other image formats, please share this on the Astro Pixel Processor forum at:

https://www.astropixelprocessor.com/community/

[1] The **sRaw** and **sRaw2** formats aren't supported yet in APP, because these formats don't contain linear data and are of lower resolution. The data is stored using YCbCr 4:2:2 chroma subsampling encoding. Before encoding the data, the data is transformed by your camera to one of the available non-linear colorspaces (e.g. sRGB, Adobe 1998). Linear data is essential for astronomical data calibration and processing, like data normalization and integration. If you are shooting data with your Canon DSLR, always set the data format at **RAW**, not at **sRaw** or **sRaw2**.

4 User Interface

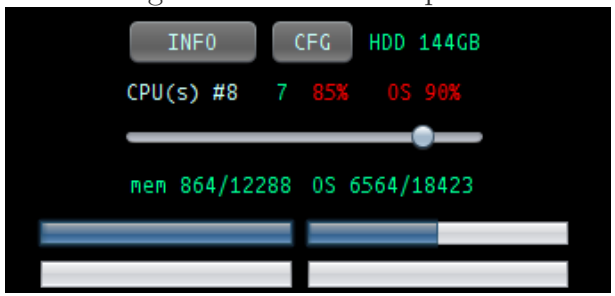
APP's user interface has the following components:

- information panel
- control panel
- image viewer panel with options
- file list panel with meta data and analytical results
- histogram panel with preview filter

4.1 information panel

The information panel (Figure 2) shows information on CPU & RAM memory usage by APP and your Operating System separately. The usage of APP is always contained in the usage of the Operating System. The amount of free HDD space on the harddisk partition which contains your **work directory** is also shown. Lastly, the panel has 2 buttons, the **INFO** & **CFG** buttons.

Figure 2: information panel



4.1.1 INFO

This will show your

- Astro Pixel Processor version
- license information

4.1.2 CFG

APP's configuration for

- the amount of RAM memory available to APP
- enable\disable Tool Tips

4.2 control panel, tabs 0) to 9)

The control panel (Figure 3) gives you complete control over APP. All data processing steps and post processing tools are available through the control panel.

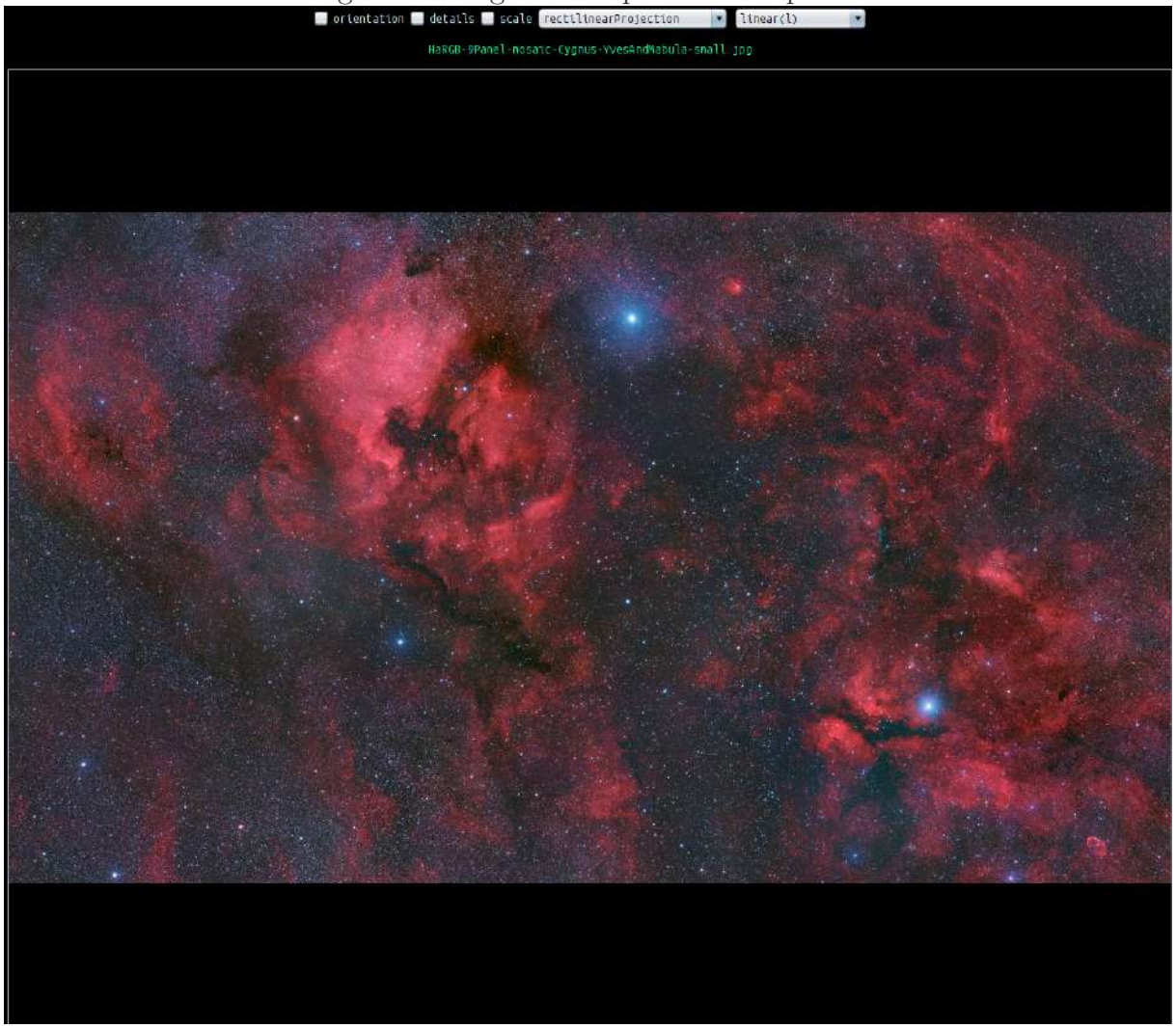
- Tab **0) RAW/FITS** is for configuration of image processing.
- Tabs **1) LOAD** to **6) INTEGRATE** are for all processing steps up to and including data integration (a.k.a stacking).
- Tab **9) TOOLS** is for post-processing of your images and contains tools for gradient/light pollution removal, background and star color calibration among others.

Figure 3: control panel

4.3 image viewer panel with options

APP is centered around the image viewer panel (Figure 4) and has extra features to study and analyse the progress of your data processing.

Figure 4: image viewer panel with options



4.3.1 zoom in/out

you can easily zoom in/out on your frames (Figure 5) using the left & right mouse button. If you click once on the left mouse button, you will zoom in with a factor of 4/3, or 133%. If you click once on the right mouse button, you will zoom out with a factor of 3/4, or 75%. You can zoom in very far to show single pixels.

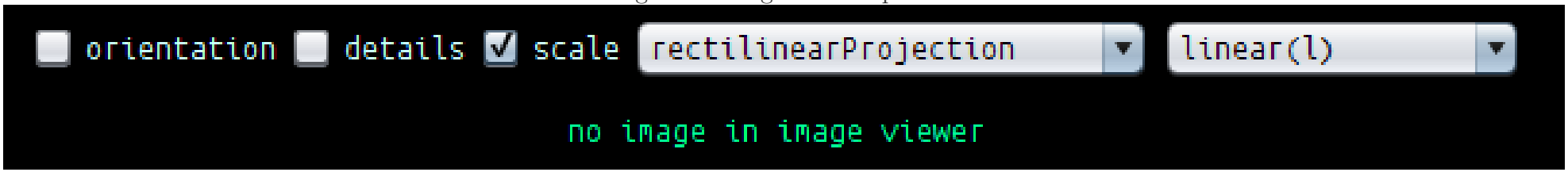
Figure 5: Left: zooming out with a couple of right mouse clicks. Right: zooming in with a couple of left mouse clicks.

4.3.2 orientation

If you select the **orientation** selectbox (Figure 6), all frames that are loaded into the image viewer will be shown with the TIFF Tag orientation applied to the frame, if this tag actually exists in the metadata of the frame. The only frame formats that could have this tag are: JPEGs, TIFFs, and the DSLR RAW image formats. The FITS format doesn't support this tag, so the orientation selectbox has no influence on FITS frames.

Please note: this setting only affects how the frame is shown in the image viewer, it does not have any influence on the actual data processing in the data processing steps from 0) RAW/FITS to 6) INTEGRATE.

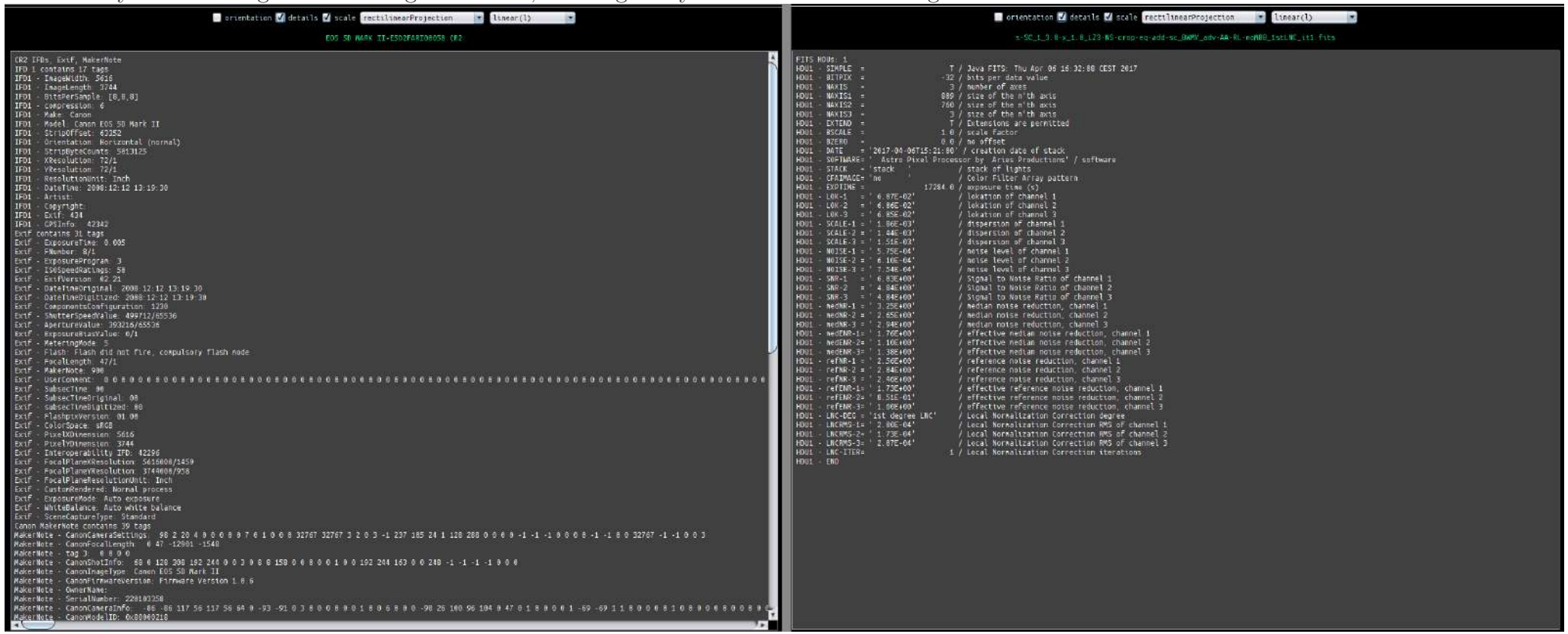
Figure 6: image viewer options.



4.3.3 details

If **details** is selected (Figure 6), the META data or Header of the frame is shown. This works for all supported image formats. You can see the complete META data of the DSLR RAW frames, like the TIFF Image File Directories (IFDs), EXIF, MakerNote and subIFDs. For FITS files you can view the complete Header of the frames showing image dimensions and possible analytical results after data Integration for example. A light integration task will analyse your integration for noise and Signal to Noise Ratio (SNR) for example (Figure 7). If you load a **star map** using the image viewer mode dropdown box, then you will see analytical results of all stars that were detected in the light frame.

Figure 7: **Left**: META data of a CR2 frame of a Canon EOS 5D Mark II showing IFDs, Exif and MakerNote data. **Right**: Header of a FITS frame that was created by APP in a light frame integration task, showing analytical results of the integration.



4.3.4 scale

With the **scale** selectbox selected (Figure 6), all frames that are loaded into the image viewer will be shown as in **scale to fit** to the image viewer panel. So the frame is shown at the maximum size, the image viewer can use to show the complete frame.

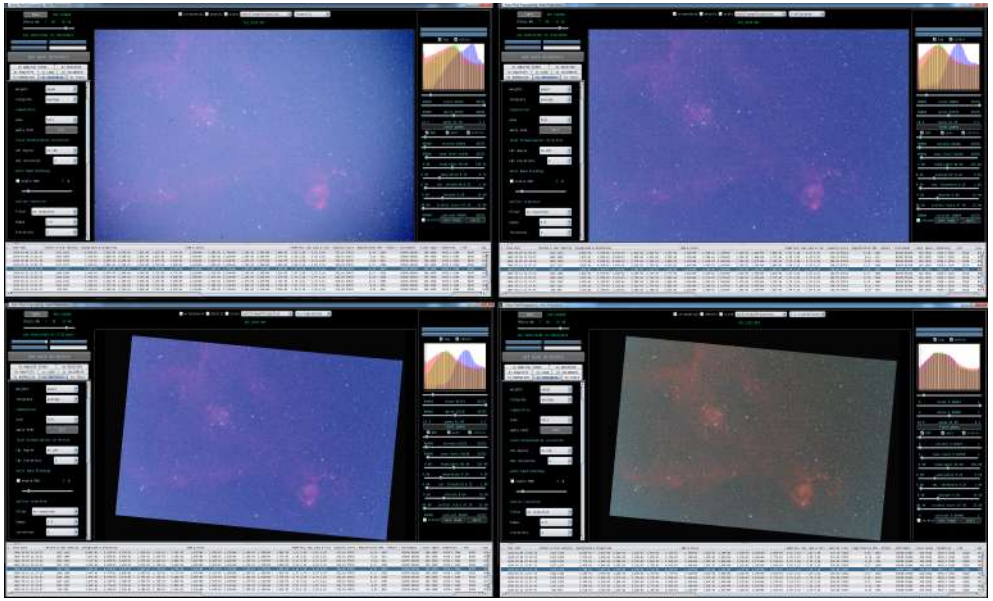
With the **scale** selectbox turned off, the frames are shown with the same zoom factor as the previous frame. Zooming can be accomplished with the left/right mouse buttons on the frame in the image viewer.

4.3.5 image viewer modes

With the image viewer mode dropdownbox, (extreme right in Figure 6), you can visualize your light frames in different modes. (Figure 8)

- **image** shows the non-linear color space (sRGB, Adobe 1998) interpretation of your raw data. Only applicable to DSLR RAW data.
- **linear(l)** shows the raw data contained in your frame (if the frame wasn't stretched earlier by another application).
- **l-calibrated** shows the linear and calibrated data for light frames if there are master calibration frames loaded, otherwise, the frame is shown linearly.
- **l-c-registered** shows the linear, calibrated and registered light frame, if registration was performed.
- **l-c-r-normalised** shows the linear, calibrated, registered and normalized light frame, if normalization was performed.
- **star map** shows where APP detects stars in the light frame with the current settings in 3) ANALYSE STARS. Also shows information on the star shape and size of the stars in the light frame. (Figure 9)

Figure 8: 4 images modes of light frame with an exposure of the Heart Nebula **Top Left**: linear(l) **Top Right**: l-calibrated **Bottom Left**: l-c-registered **Bottom Right**: l-c-r-normalised



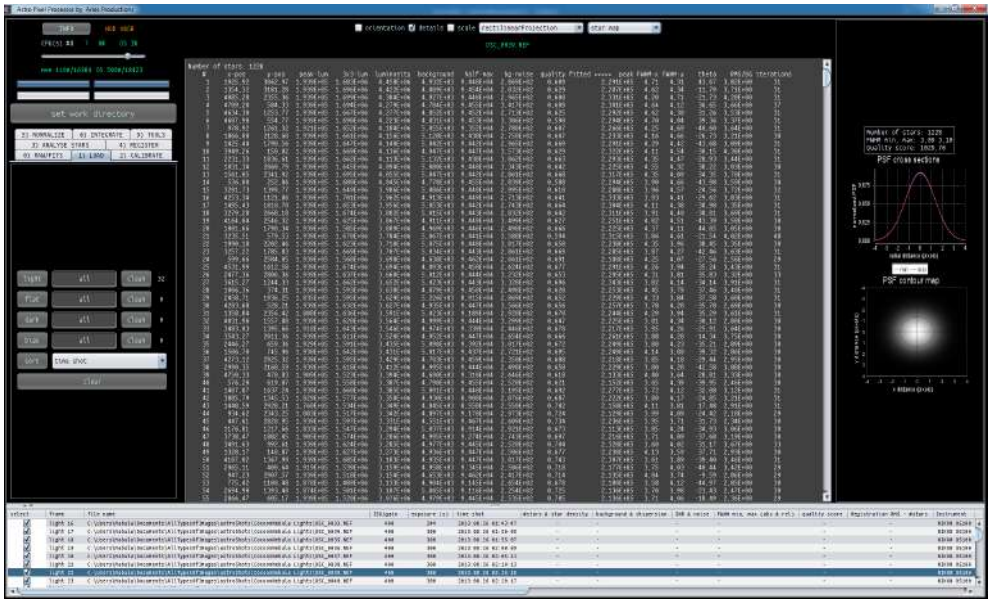
4.3.6 image viewer projection modes

With the image viewer projection mode dropdownbox, (second to the right in Figure 6), you can visualize your light frames in different projection modes if you have registered your frames with the **calibrated projective registration mode**.

4.4 file list panel with meta data and analytical results

4.5 histogram panel with preview filter

Figure 9: star map image viewer mode with the details selectbox turned on. You see extensive analytical results per star of the star analysis of your frame. To the right of the image viewer you see: **bottom**: a contour map of the average star shape in the frame. **top**: 2D cross sections of the average star profile for the calculated maximum and minimum Full Width Half Maximum (FWHM). A nice round star profile shape has identical cross sections for maximum and minimum FWHM of the star profile.



5 Workflow principle

APP has a built-in automatic workflow which will ensure the user that the processing steps up until and including integration (stacking) are done in the right order. The user can choose to do each step from calibration (2) CALIBRATE) to integration (6)INTEGRATE) and verify each step using the image viewer and the analytical results in the file list panel. You'll have the option to save intermediate results like, calibrated lights, registered lights or even normalized lights.
Or, after loading all of your frames (lights and calibration frames), you can set all settings, according to your wishes, in the tabs in the control panel from 2) to 6) and immediately click on the **integrate** button in tab 6). APP will automatically perform steps 2) to 6) in that case. It will also automatically choose a reference frame for registration. You can interrupt APP at any time if you want. Or just wait for the integration result.

6 Debayering Color Filter Array (CFA) data

APP takes complete control over the moment that your CFA data needs to be debayered. Calibration of your CFA lights and the creation of the master frames are all done using only the CFA pixels, so the master frames are CFA data as well with the same CFA pattern as your lights. (Except for the Bad Pixel Map, since this is just a map of bad pixels on your sensor, the CFA pattern is irrelevant for the Bad Pixel Map.) No debayering is done before or while calibrating your lights. This ensures that only the raw sensor data is properly calibrated and that there is no unwanted noise from debayering before calibration. In a nutshell, APP will give you the assurance that debayering is done at the right moment while processing so you don't even have to think about it.

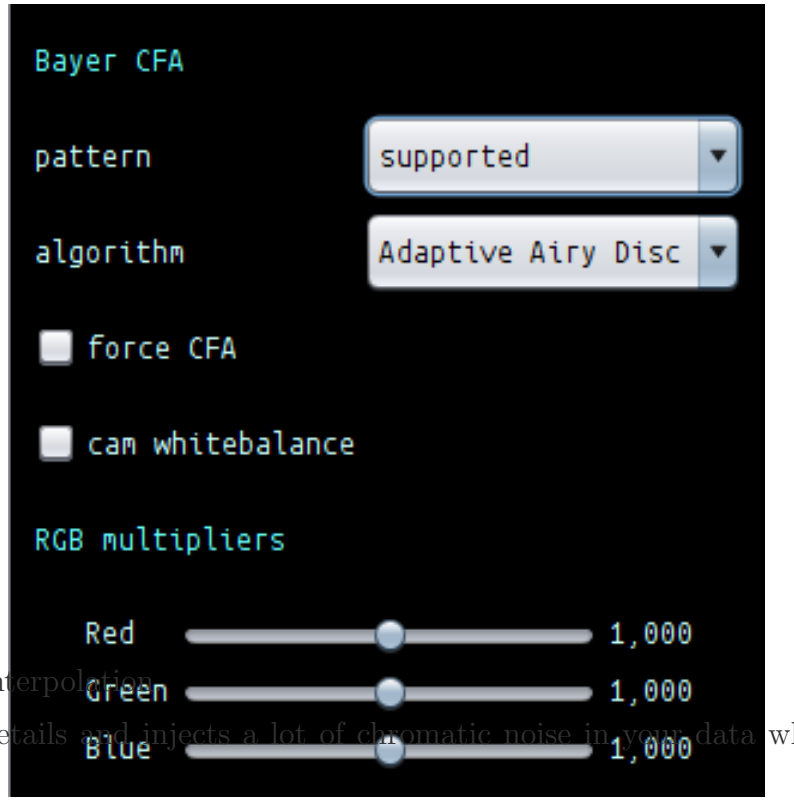
7 Work Directory

The first thing to do is to set your work directory. This directory is used to save temporary files, while performing data integration, and integration and post-processing results. The HDD number in the **information panel** (Figure 2) will indicate how much free space you have on the harddisk partition that contains your work directory. Make sure that you have enough room on the disk to be able to save the results and temporary integration files.

8 0) RAW/FITS

The RAW/FITS tab (Figure 10) is a configuration tab for the processing of your frames.

Figure 10: tab **0) RAW/FITS**



- **Bayer CFA pattern** Choose the bayer pattern of your sensor for correct debayering of your **Color Filter Array**, or **CFA**, data
  - **supported** For DLSR images, the correct pattern is automatically chosen. For FITS images, this depends on an appropriate FITS keyword in the fits header. If the keyword is missing, APP will use the default setting of **RGGB**.
  - **RGGB**, **GBRG**, **BGGR**, **GRBG** Choose any of these four patterns if the **supported** setting isn't correct. You can check the difference by setting a different pattern and then reloading the image with the image viewer mode options. Just reselect the **linear(l)** mode for example.
- **Bayer CFA algorithm** Choose the debayer algorithm. These algorithms have a big influence on your data which will translate into the quality of your integration results. For RGB data, the **Adaptive Airy Disc (AAD)** algorithm is highly recommended. If you have used a narrowband filter with your One Shot Colour (OSC) camera, choose the appropriate algorithm for the filter that was used.
  - **no interpolation** This will show you the monochrome raw CFA data without interpolation.
  - **Bilinear** This is the most simple debayer algorithm. It gives artefacts, blurs details and injects a lot of chromatic noise in your data when compared to the other options.
  - **Adaptive Edge** This is an advanced debayer algorithm for processing of normal photography images. It gives the least artefacts along lines in your images, since it adapts to contrast edges.
  - **Adaptive Airy Disc** This is a very advanced debayer algorithm for processing of astrophotography images and therefor the default algorithm in APP. This algorithm is developed by Mabula, especially for astrophotography. It performs better than any other algorithm (like AHD, VNG). It gives the best resolution, least artefacts, least chromatic noise and the best colors, especially after background and star color calibration of your integration result.

  - **Super Pixel** This modus will not debayer your data, instead, each 2x2 CFA block on your sensor will be replaced by a 1x1 block. The R,G,B values will be the values that were recorded by your sensor in the original 2x2 block. For green, this will be the average of the 2 green cfa pixels. Super Pixel modus will downscale your data by a factor of 2, so only use this setting if you have a clear reason to start with downscaling your data. A reason could be to make a downscaled integration as a preview of your data. Please realise, that the super pixel modus will have a big degrading effect on the registration quality of your results, since star lokation calculations will have much bigger uncertainty. Super Pixel modus immediately throws away valuable information.
  - **Hydrogen Alpha**, **Beta**, **Sulfur II**, **Oxygen III**, **Nitrogen II** You can directly debayer narrowband data, shot with your One Shot Colour (OSC) camera. If you choose any of these algorithms, you will directly have the monochrome narrowband exposure. There is no need to seperate the channels first. This method is superior to any other workflow used in processing narrowband data shot with an OSC camera. It preserves resolution, which also has the benefit that registration will not suffer. In other workflows, the integration result usually is upscaled again by using drizzle integration which will inject a lot of noise.

- **force CFA** Enable this if the frames are monochrome CFA frames and APP doesn't detect this should be interpreted as such.
- **camera White Balance** Enable this to use the camera White Balance of DSLR RAW images.
- **RGB multipliers** Adjust the RGB multipliers if you want to set your own White Balance for instance. This works on all currently supported data formats.

9 1) LOAD

This tab (Figure 11) is used to load, select and deselect all of your frames for processsing up until data integration (tab 6)INTEGRATE). All loaded frames will show in the bottom file list panel.

Figure 11: tab **1) LOAD**

- **light** add light frames. If you load a previously created stack with this button, it will be used as a light frame.
- **flat** add flat frames.
- **dark** add dark frames.
- **bias** add bias frames.
- **all\none** to the right of the **light, flat, dark & bias** buttons, there are switchboxes which you can use to select/deselect all frames of that type.
- **clean** to the right of the **all\none** switchboxes, there are **clean** buttons to remove all deselected frames of that type.
- **number of frames per type** to the right of the **clean** buttons, a number is shown, which indicates the number of loaded and selected lights for that frame type.
- **sort** use this button to sort the frames per type using the criterium in the dropdownbox to the right of this button. You can sort on
  - **file name** sort your frames alphabetically by file name
  - **ISO\gain** sort your frames on the ISO or gain value if available
  - **exposure** sort your frames on the exposure length of your frames.
  - **time shot** default setting, it will sort your frames chronologically.
- **clear** clears the frame list window, memory and the image viewer.

All master calibration frames (**MasterBias**, **MasterDark**, **MasterFlat** & **BadPixelMap**) can be loaded with any of the **light, flat, dark or bias** buttons. APP will recognize that these are Master frames and will use them as such.

10 2) CALIBRATE

11 3) ANALYSE STARS

12 4) REGISTER

13 5) NORMALIZE

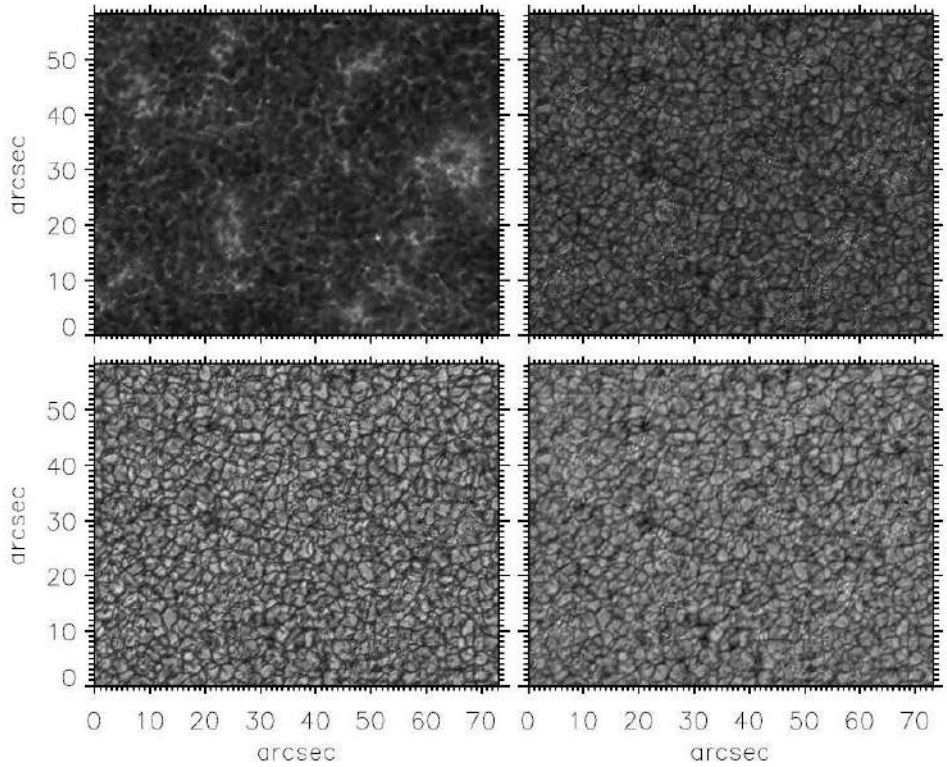
14 6) INTEGRATE

15 9) TOOLS

16 About Mabula Haverkamp

Mabula is the main developer of Astro Pixel Processor. He has a drs. degree in Astrophysics from the University of Utrecht, The Netherlands (2004). His master research project was done under the supervision of prof. dr. R.J. Rutten, dr. P. Sütterlin, dr. K. Tziotziou en dr. A.G. de Wijn.

Solar magnetic fluxtubes diagnosed from isolated internetwork bright points - An analysis of Dutch Open Telescope observations



Astronomy & Astrophysics, AA 441, 1183-1190 (2005) DOT tomography of the solar atmosphere. IV. Magnetic patches in internetwork areas

prof. dr. R.J. Rutten, dr. P. Sütterlin, dr. A.G. de Wijn, drs. E.M.W.P. Haverkamp