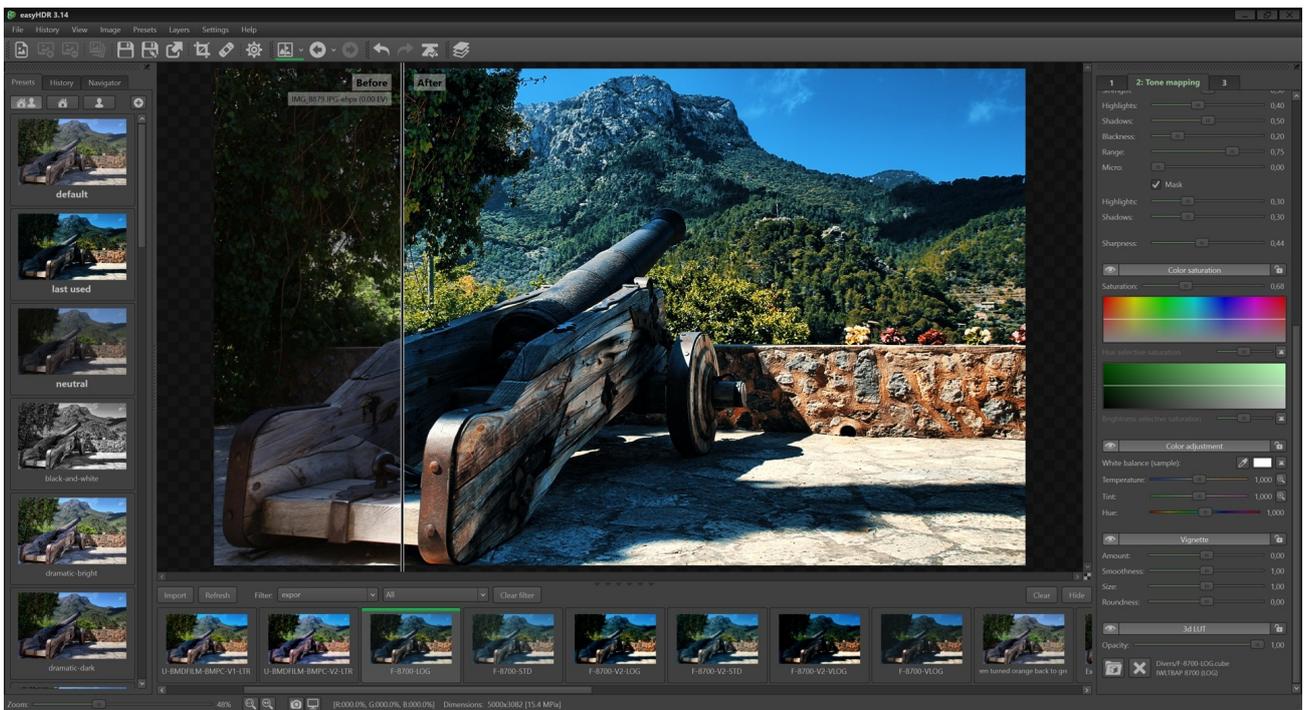


# easyHDR 3.16

## User Manual





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You can find some additional documentation and tutorials for easyHDR software on the <https://www.easyhdr.com/documentation/> website.

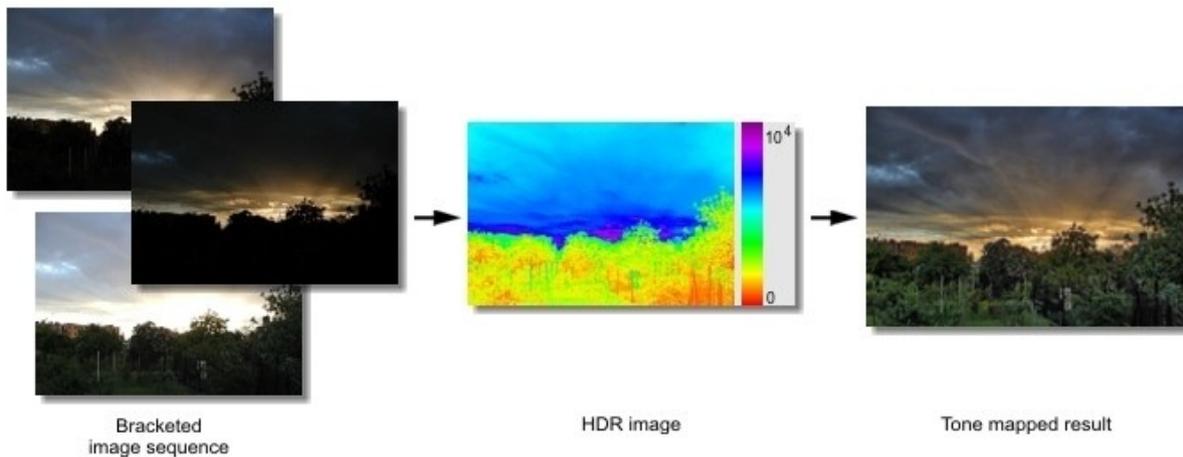
- [Tips and Tricks](#)
- [EasyHDR Adobe Lightroom Classic plug-in](#)
- [Working with layers and masks](#)
- [Lens Correction](#)
- [Ghost effect removal \(deghosting\)](#)
- [What is the Exposure Value \(EV\)?](#)
- [Astrophotography and the HDR image processing techniques.](#)
- [HDR from MARS!](#)



## 1. Introduction

EasyHDR is an image processing software that produces and tone maps High Dynamic Range (HDR) images out of photo sequences taken with a digital camera. The program works on Windows 7, 8, 10, 11 (64-bit) and on macOS 10.12 and above.

The basic idea of High Dynamic Range image processing is depicted on the graphic below.



The first step is to take a set of photographs of the same scene, at different exposure settings. EasyHDR will produce a so called HDR image (radiance map) out of these photos. The radiance map is nothing else than just an artificial photograph, but what makes it different is the dynamic range that it covers. It contains all the detail that was acquired on any photo from the set. The only problem is that it cannot be simply displayed on a computer screen as the dynamic range of this display media is relatively very low. Therefore another step has to be done – tone mapping or in other words: dynamic range compression. The tone mapping can utilize a global or local operator to achieve the compression. The global operator can give most realistic results but if the dynamic range is very high it is simply not able to give good looking output as the details and colors get washed out. Therefore the local operators are used in addition. They allow much higher level of compression, because they operate on the local level. The details in the image are amplified, while the overall dynamic range is shrunk. This gives a lot of possibilities. You can either make the result look very dramatic, or just achieve better realism by smartly using the local contrast boost.

The modern DSLR cameras are equipped with better and better CMOS or CCD sensors in sense of signal to noise ratio. In many cases just a single photo may be good enough for tone mapping. It means that it is not always necessary to take an image sequence, which may sometimes be difficult because of moving subjects or long exposure time needed. Because of that easyHDR allows you to tone map just a single photograph – JPEG or for best results: RAW.

## 2. User interface

The user interface of the easyHDR's main window consists of two base parts: workspace (1) and a three-tab panel with tools and settings (2). Additionally, when working in the tone mapping mode a third part appears (3). The panels are realizable and detachable. In order to change their width use the grip on the inner border. To detach, just catch the upper bar with mouse and move it, or alternatively click on the pin icon in the upper-right corner. Attaching back is done similarly. The position and size of the whole window and the panels is restored when program starts. It is possible to reset the panels back to their default positions by pressing *F10* key (or in main menu: *View* → *Reset window layout*).



*EasyHDR user interface.*

The top of the window is occupied by main menu (5) and the tool box (4). The latter contains some of the most important options of the main menu. Optionally, there can also be layers, crop and clone/healing toolboxes visible (7).

In the bottom, there is a status bar (6) which contains the main progress bar, zoom control for the workspace and a label showing basic information about the image – dimensions and pixel value under the mouse cursor. It also shows the last error or warning message. By clicking on it, you can see the list of all errors and warnings. It is possible to re-enable the warnings to be shown in form of dialog windows, if you previously selected not to see them again.

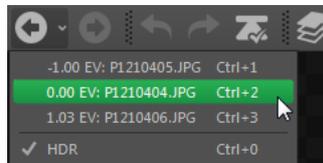
Additionally, when the color management is enabled, there are two buttons visible that allow fast access to color profile options. Hover the mouse cursor over them to see the detailed information about color profiles in use. The bottom of the workspace is also the place where The 3d LUT browser appears.



There are two options for workspace maximization. F11 key (*View → Maximize workspace*) hides the status bar, title bar and the main tool box. The “F” key (*View → Full screen*) additionally hides the left (preset) and the right (tone mapping) tabs and it also hides all the other tool boxes. The layers tool and the 3d LUT browser can be minimized to enlarge the workspace during normal operation.

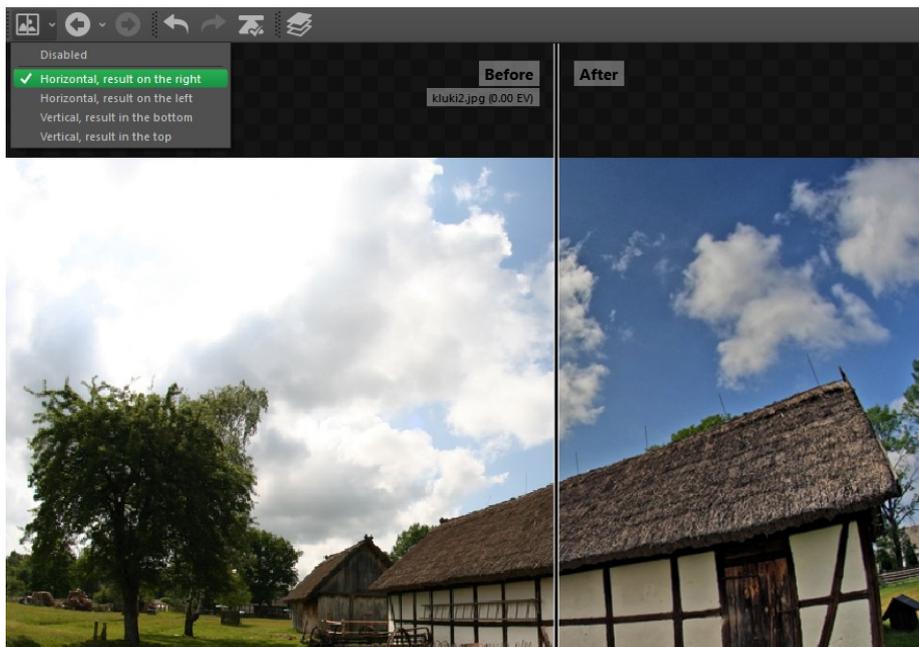
### 2.1. Workspace

In the workspace you can view the input photos, a gamma-corrected HDR intermediate image and of course the preview of tone mapping. What is visible depends on current step of operation, but it's also possible to temporarily switch to other views using “*Photo before processing*” option. It gives an easy way to compare the result with inputs. It also provides a way to examine the input images after they are preprocessed (aligned and corrected for chromatic aberration).



*Photo before processing.*

Comparing the input photos with achieved result can be even easier with the *Before/after split view* option. When enabled, the view is divided, by an interactive splitter, into before and after processing parts – horizontally or vertically.



*Before/after split view.*



The use of workspace is intuitive. Zooming can be done with mouse wheel, to pan around just press the left or right mouse button. When in cropping mode, double click inside of the crop area to accept, or away to cancel.

There is a possibility to change the background color of workspace. Just press the button in the lower, left corner.

The images are always shown at full resolution, the detail seen depends only on zoom factor. The view is anti-aliased for best viewing quality. When tone mapping, processed is only the visible part of the image, which ensures the best performance. It's possible to tune the performance of the program by toggling live anti-aliasing and live tone mapping. For these settings please see the Program Options section.

## **2.2. Main tabbed panel**

There are three tabs that correspond to three steps of processing. Switching between those tabs changes the mode of operation. The steps are the following:

1. loading, preprocessing and HDR generation,
2. tone mapping,
3. post-processing (optional).

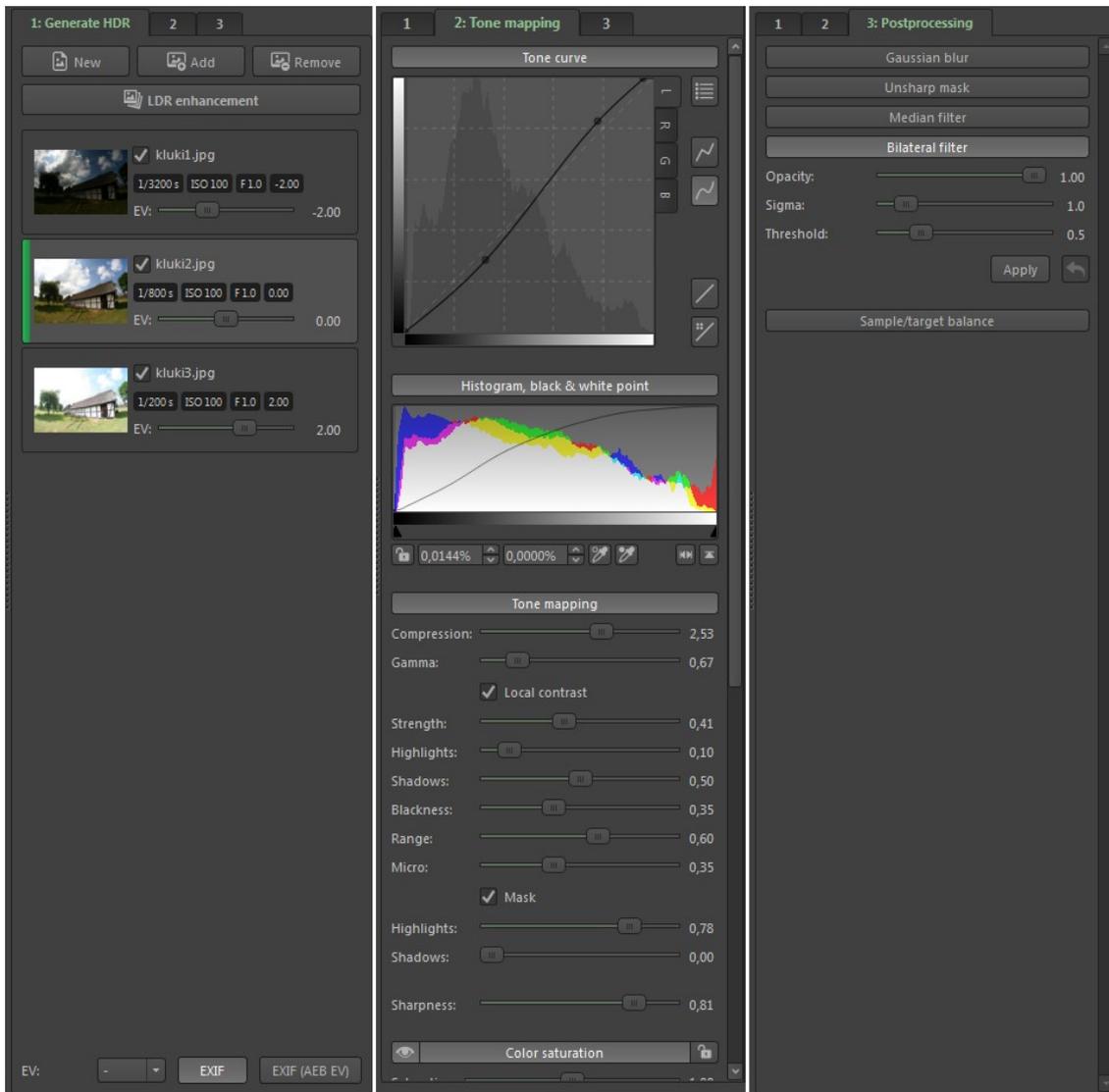
In the first step it's possible to create new project, add and remove HDR sequence photos, configure the EV values and finally, after optional preprocessing of the input photos, generate the HDR image. When HDR image is generated and some pre-calculations are made, it's possible to work at the second step – the tone mapping. At any time you can go back and regenerate HDR image with different options, or realign input photos, etc. When you are happy with the parameters you can just save the result to file, or proceed to the last step – the post-processing. In both cases the whole image is first processed at full resolution (previously only the visible area was processed). It's still possible to go back to tone mapping or even to the first step. In that case however the applied filtering is lost.

Both, the tone mapping and post-processing panels are divided into several groups which can be shown or hidden. In case of tone mapping all the settings are always used (automatically upon any change) to generate the preview image in the workspace.

Some of the groups (vignette, color adjustment and color saturation) allow disabling the effect (“eye” button). This feature is useful when comparing the impact of the effect on the currently tone mapped image. The other special button – the “padlock”, allows locking of the parameters, so that they are not loaded from presets. Additionally, when lock is enabled, the preset thumbnails are regenerated each time parameters are changed in the given group.

The post-processing concept is a bit different. Each group is a separate tool which can be used to apply changes to the current image. It means for example that when you apply Gaussian blur twice, the second iteration is done on image produced by the first iteration. Undoing is possible just one step back, but it's also possible to undo all applied post-processing. To do so, just switch back to tab 2 and again to tab 3.

For more details about each step please refer to the corresponding part of this document.



Three-step approach to HDR processing.

### 2.3. Additional tone mapping options panel

This panel appears only when you are working at the tone mapping step. It contains three tabs: **Presets**, **History** and **Navigator**.

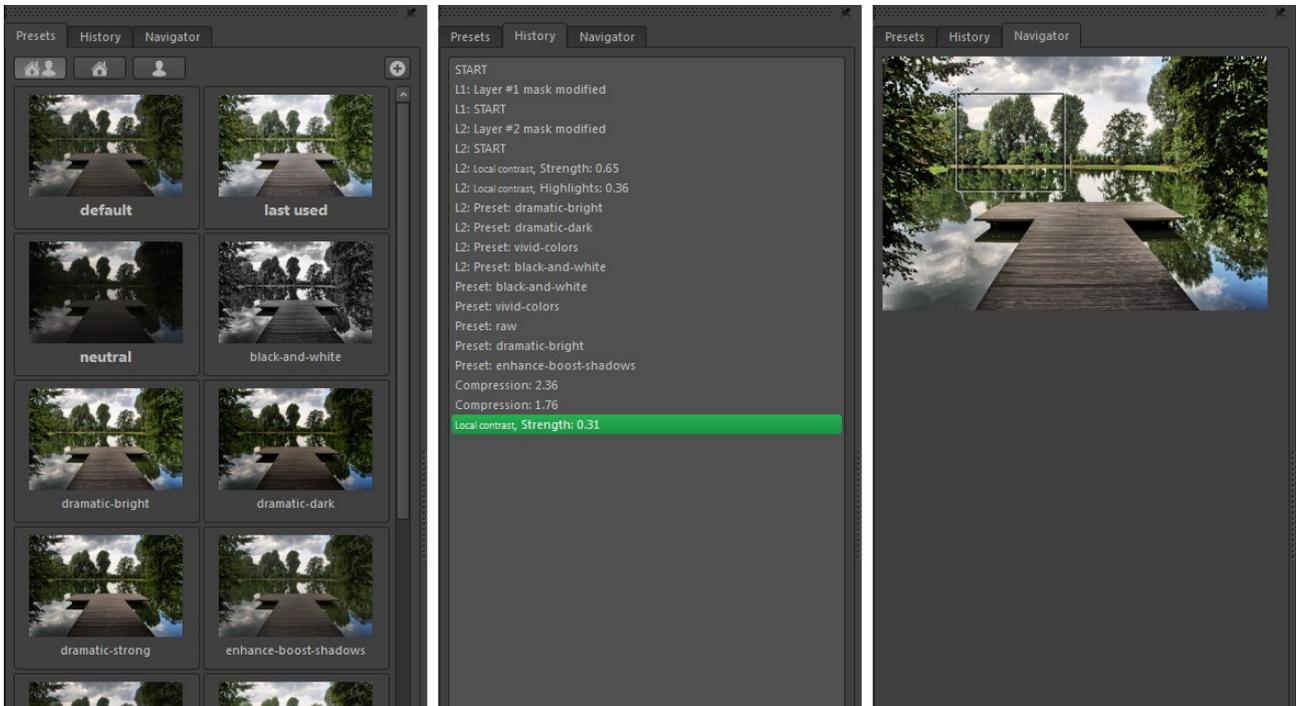
The **preset** tab allows not only simple selection of built-in presets, but also defining and using user presets. Preset selection is done by left mouse clicking on a thumbnail. You can edit the name of user presets by just clicking on it. Right click on a user preset to get more options: *delete*, *replace* and *move to group*. More information about presets can be found further in this document.

The **history** tab gives undo / redo functionality. All the tone mapping settings changes are stored here with a short, descriptive text. You can easily revert the parameter changes, while still having the ability



to change your mind. Undo and redo is also accessible with *Ctrl+Z* and *Ctrl+Y* shortcuts.

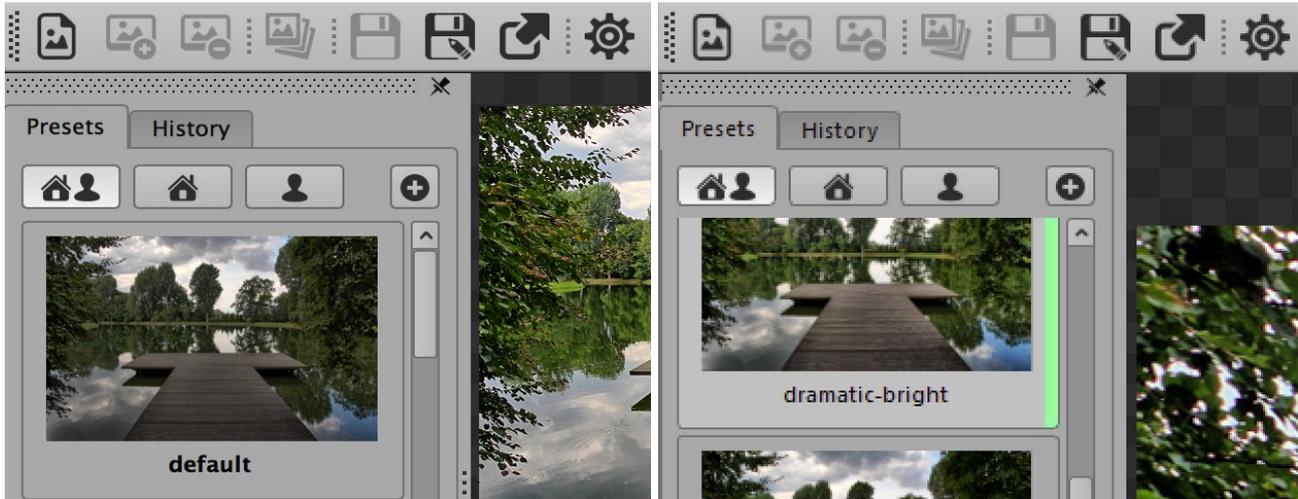
The **navigator** tab contains an interactive, tone mapped, full image, thumbnail preview. The part of the photo, currently visible in the workspace, is marked with a rectangle. The selection can be moved by dragging it with mouse, zooming is also possible with mouse wheel.



The whole panel can be resized by grabbing the edge and moving it with the mouse. In effect, it allows not only resizing the preset thumbnails, but also changing the way they are displayed – when the panel is wider, the thumbnails are organized into more columns. The maximum size of the thumbnails can be tweaked with a slider that appears on the top of the panel, when it's wide enough.

## 2.4. High DPI support

EasyHDR supports high DPI display mode (for example 4K screens). It is enabled by default when the high DPI desktop is detected. If needed, it can be forced to disabled state in the *Program Options* → *Appearance*. Please note that on high DPI screens the program has to do 4 times more calculations to provide live tone mapping preview. Therefore, it may be good to enable the live tone mapping image resampling in *Program Options* → *Performance*.

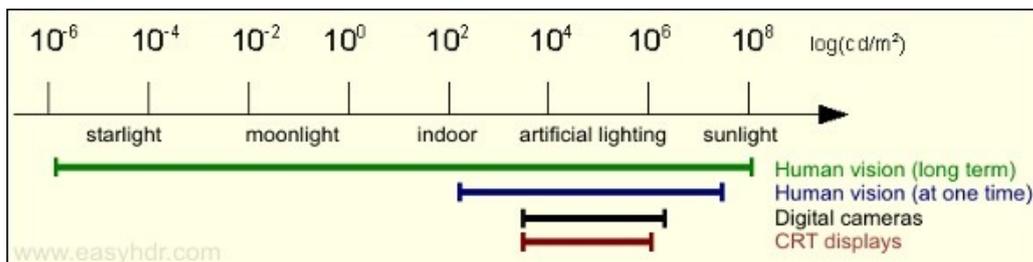


*Comparison of the display quality on a HighDPI (left) and standard (right) display. You may need to zoom in to see the difference.*

### 3. HDR radiance map generation

#### 3.1. Taking the photographs

The dynamic range (or the luminosity range) is the ratio between the brightest and the darkest part of the photographed scene. The human vision can accommodate (in long term) the dynamic range of  $10^{14} : 1$  (from starlight to bright objects in full sunlight). The light accommodation is achieved mostly by chemical means, the iris is simply not as flexible. The human eye covers the dynamic range of about  $100\,000 : 1$  at one time, just the top dynamic range of most real-world scenes. In comparison the dynamic range of typical digital cameras is about  $1000-4000 : 1$  and in case of computer displays it is even much worse. However, having the ability to cover a very wide dynamic range, the human brain is not able to distinguish small changes in brightness and also human perception is logarithmic rather than linear. Of course the digital camera and computer display design take advantage of that fact.



The camera chip (CCD or CMOS) responsivity is more or less linear. A 12-bit RAW image is converted to an 8-bit per channel photo using a compression curve stored in the camera in a Look Up Table (LUT). So the whole dynamic range that the camera can cover is compressed (fitted) into 8-bit (0..255) values.



EasyHDR allows you to create a photo that covers a much wider dynamic range than a single image taken with a typical digital camera. First of all you have to acquire enough luminosity information from the photographed scene. You can do that by taking several photographs at different exposure times so the whole dynamic range is covered. The brightest details have to be clearly visible in the shortest exposure and the darkest should be visible in the longest exposure image. It is recommended to set exposure times such that the Exposure Value (EV) step between the images is about 1 or 2 EV. In most cases 3 images will be sufficient. In order to take the image sequence automatically with your digital camera, you can use the Auto Exposure Bracketing (AEB) option.



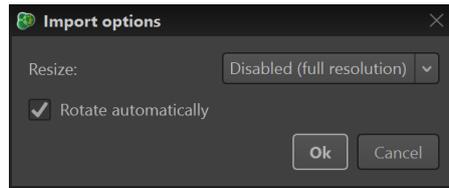
For best results, the images shouldn't be too misaligned and therefore should be taken with a camera on a tripod. However for easyHDR there is no problem if the photos were taken hand-held, because it has automatic as well as manual alignment tools built-in. Both are able to compensate even for perspective misalignment.

### 3.2. Image sequence loading

In order to load the image sequence just click *New* and multi-select all of the photo files. It is also possible to add more photos to the already loaded sequence or to remove some of them without the need to start again. If you load only one photo you will be able to enhance it with the tone mapping operators that are normally used with HDR data. This feature is called "*LDR enhancement*" and simply allows enhancing single shots – most preferably single RAW photos. EasyHDR will also load photos dragged and dropped on the main program window or photos for which the paths are provided as run-time parameters (useful for plugging easyHDR as an external editor for other image editing or management software).

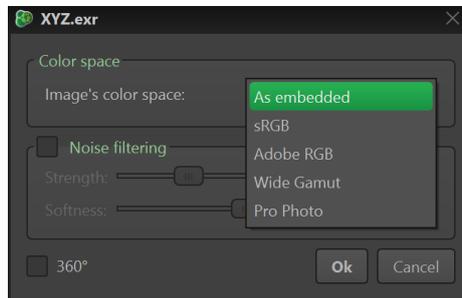
EasyHDR loads JPEG, JPEG 2000 (JP2 and J2K) photos as well as 8 and 16-bit TIFFs, PNG and HEIF. It also features a built-in RAW converter (using [LIBRAW](#) and [DCRAW](#)) that is capable of importing almost all of the RAW photo formats by all digital camera vendors. It is also possible to load FITS file format, that is most commonly used in astrophotography. EasyHDR supports additionally High Dynamic Range formats: Radiance RGBE (\*.hdr), OpenEXR (\*.exr) and 32-bit TIFF.

There is a possibility to resize photos on load (only RAWs and JPEG/JPEG2000). In order to be able to use this feature please enable first: *Settings* → *Show options when loading photos* in the main menu.



When the resizing is disabled, it is possible to load sequences of photos that slightly differ in size. The size difference allowance can be defined in the *Program Options* → *Miscellaneous*. By default the allowance is set to 0%, meaning that all input photos in the sequence have to have exactly the same dimensions.

When the Color Management is enabled, the color space definition of the loaded photos is read from their EXIF (all photos must be within the same color space). If the image is in certain color space (other than sRGB), but it is not defined in EXIF, you can select that from the input color space list (see chapter 9). In case of OpenEXR and RadianceRGBE formats, the space of the loaded image can be also selected prior to loading (those formats may contain the space primaries as they do not have EXIF).



The RAWs, as the name suggest, are raw, not developed images. The output color space (result of the development) can be selected in the RAW load dialog, sRGB is the default.

### 3.2.1. Loading RAW photos

EasyHDR, for RAW decoding, uses DCRAW or its compatible successor – LibRAW. By default LibRAW is selected, however it is possible to switch back to DCRAW by selecting it in the *Program Options* → *Miscellaneous*. It is also possible to select there the demosaicing algorithm. By default the best one is used – DCB.

EasyHDR provides a graphical interface to LibRAW/DCRAW in a form of a dialog window displayed when a RAW image is being loaded.

You can select the target **color space** for the decoded image. The standard one is *sRGB*, but with *ProPhoto* you will have a wider color gamut, which will help, while tone mapping, preserve details in the most color-saturated areas. Please note that easyHDR's color management module will make pixels in any color space to be displayed correctly in the workspace. EasyHDR will also embed the image's color space definition into the output image file, so other applications can properly decode it. If you want the final result to be used by a non-color space aware media, you should select automatic conversion to *sRGB* when the result is saved.

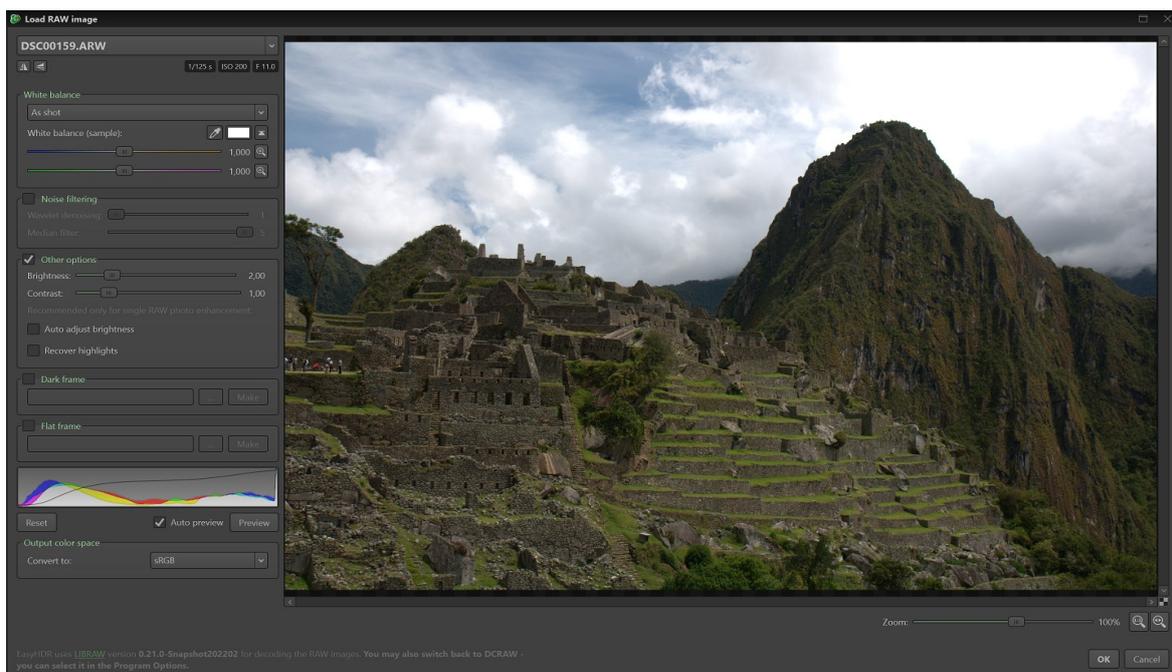


The **white balance** correction at the RAW decoding step is the best way to achieve greatest possible color correction quality. It is because the operation is done on raw data. By default, the coefficients measured by the camera, at the time of taking the photograph are used (“*as shot*”). You can also use automatic balancing method (will not work well in all possibilities, because it assumes the image as a whole is neutral), or manually select the neutral point (the area that should be gray on the developed image). The neutral point selection can be done either for the decoding step (“*LibRAW selection*” mode), or as a post-development tuning when “*as shot*” mode is selected. Then you can also manually control the **Temperature** and **Tint**.

In case of noise filtering, it's worth mentioning that the “**Median filter**” is useful for removing hot pixels, while the “**Wavelet filter**” smooths random noise. Noise filtering is worth to be done when loading a single or just a couple of RAWs for merging to HDR. When loading big number of lower quality RAWs for stacking (astrophotography) the noise filtering should rather be off or kept low (wavelet) in order to preserve the details hidden in noise that will eventually pop after stacking.

The “**Other options**” group contains two parameters that shouldn't be used when processing HDR sequences, but are great when working with single RAW photos. The “**Recover highlights**” option allows getting more detail in the overexposed areas, but at the same time it may cause some color shift there. “**Auto adjust brightness**” boosts underexposed photos. The other two parameters: “**Brightness**” and “**Contrast**” allow fully manual correction to adjust the image, before it is touched by the tone mapping algorithm.

If any further color correction is necessary or you want to remove some more noise, easyHDR allows these at later steps as well – advanced color adjustment is possible at the tone mapping level, while more noise filtering can be done at the pre-processing step (in the *HDR generation / LDR enhancement* window).



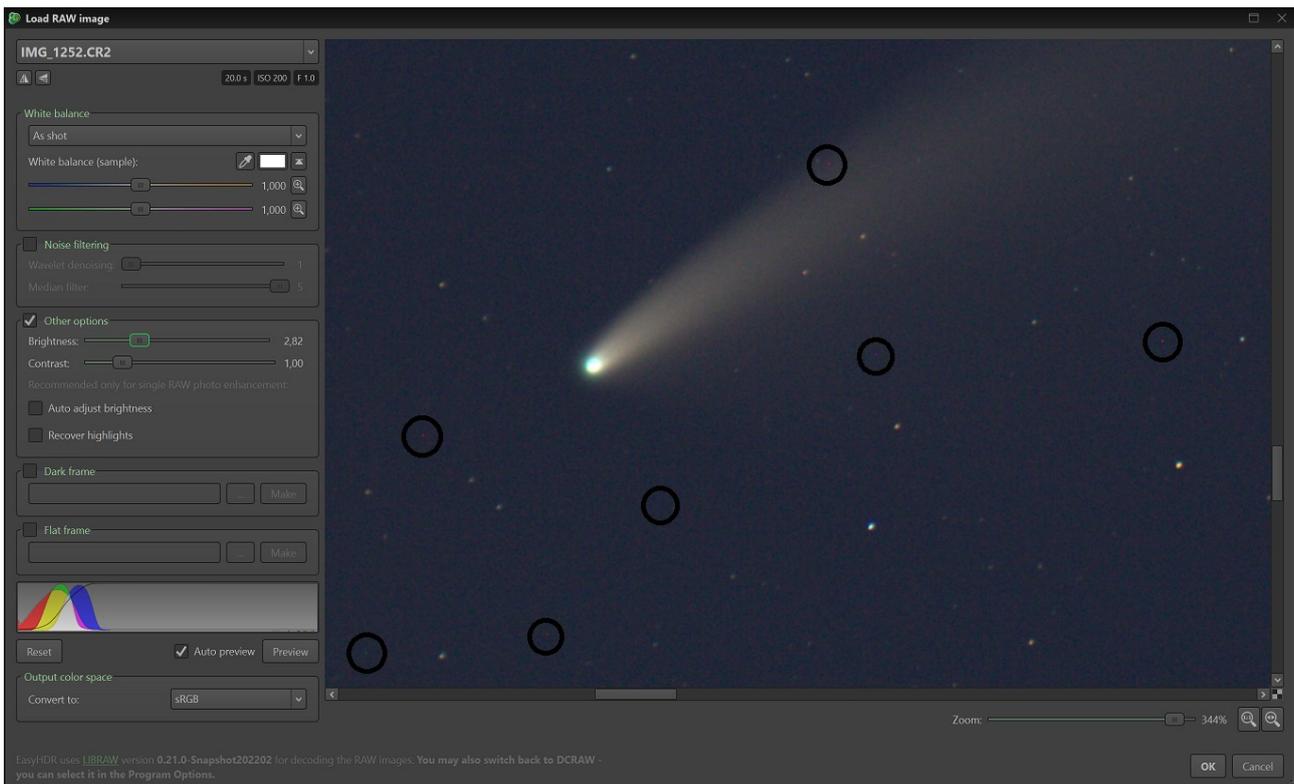
RAW image loading.



The “**Dark frame**” is an advanced option for processing of long exposure photos (useful especially in astrophotography, but not solely). It allows removal of hot pixels – damaged pixels on the sensor, which appear as blue, red or green points of various intensity on long exposure (or higher ISO) photographs. They appear sooner at higher ambient temperatures.

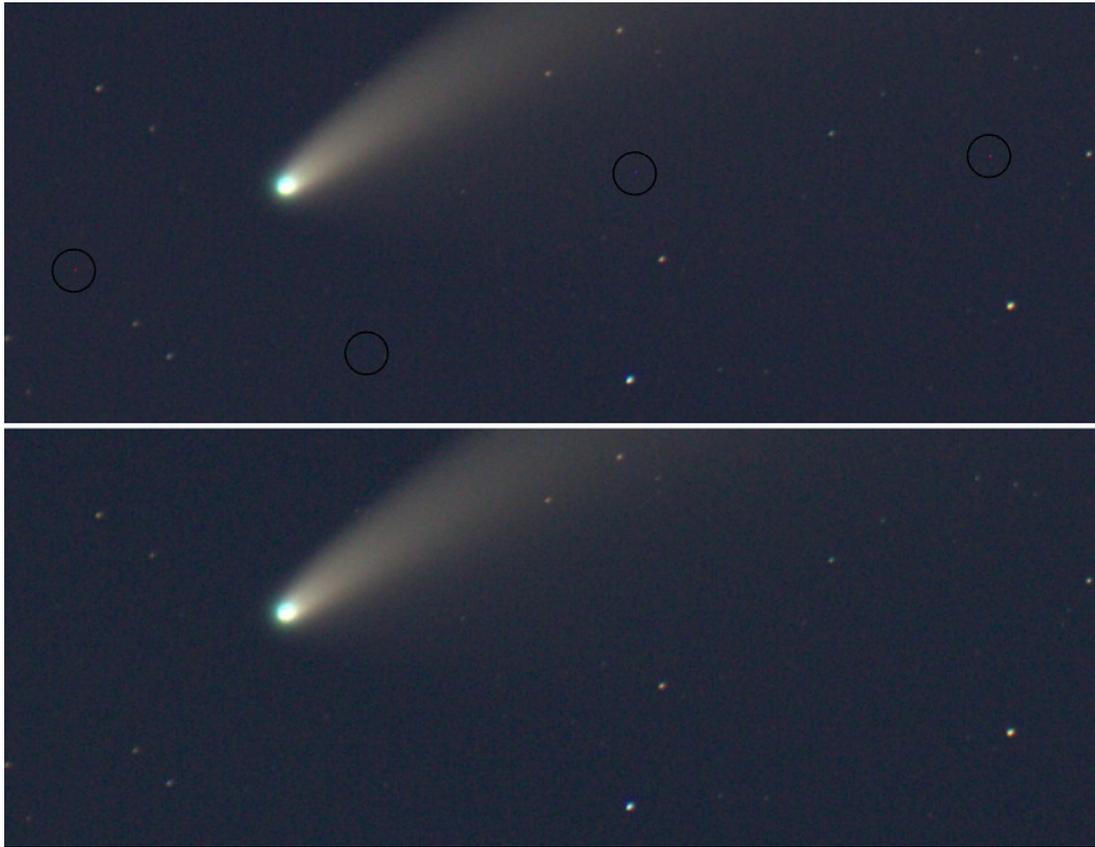
The “**Flat frame**” is another advanced option, which allows calibrating the image in terms of removing uneven exposure of the frame caused by optical system vignetting as well as dust grains. If you use this feature, please do not enable vignette correction in the “Lens correction” tool at later step.

The near perfect hot pixel removal and flat field correction can be achieved only on raw images. For example, if a long-exposed image with hot pixels is converted to JPEG (including when it’s done internally by the camera), the hot pixels are spread over larger area due to the demosaicing process and also the JPEG compression causes its own artifacts. Such altered hot pixels are much harder to remove and attempting to wipe them will surely cause other image details to be affected.



*A zoom in on a 20-sec exposure taken at low ISO, but at high ambient temperature with with Canon 650D. Some most notable hot pixels are marked with black circles.*

Some cameras offer an option to automatically remove hot pixels and long exposure noise. They do it by catching the exposure twice – once with the sensor open to light and once when the sensor is covered, so it acquires only its own noise. That approach has certain advantages – each photo is corrected with updated dark frame (the thermal noise level varies over time) and the camera can immediately save also corrected JPEGs. The drawback is that every long exposure needs to be followed by another, with the same settings, so the “exposure time” is doubled.

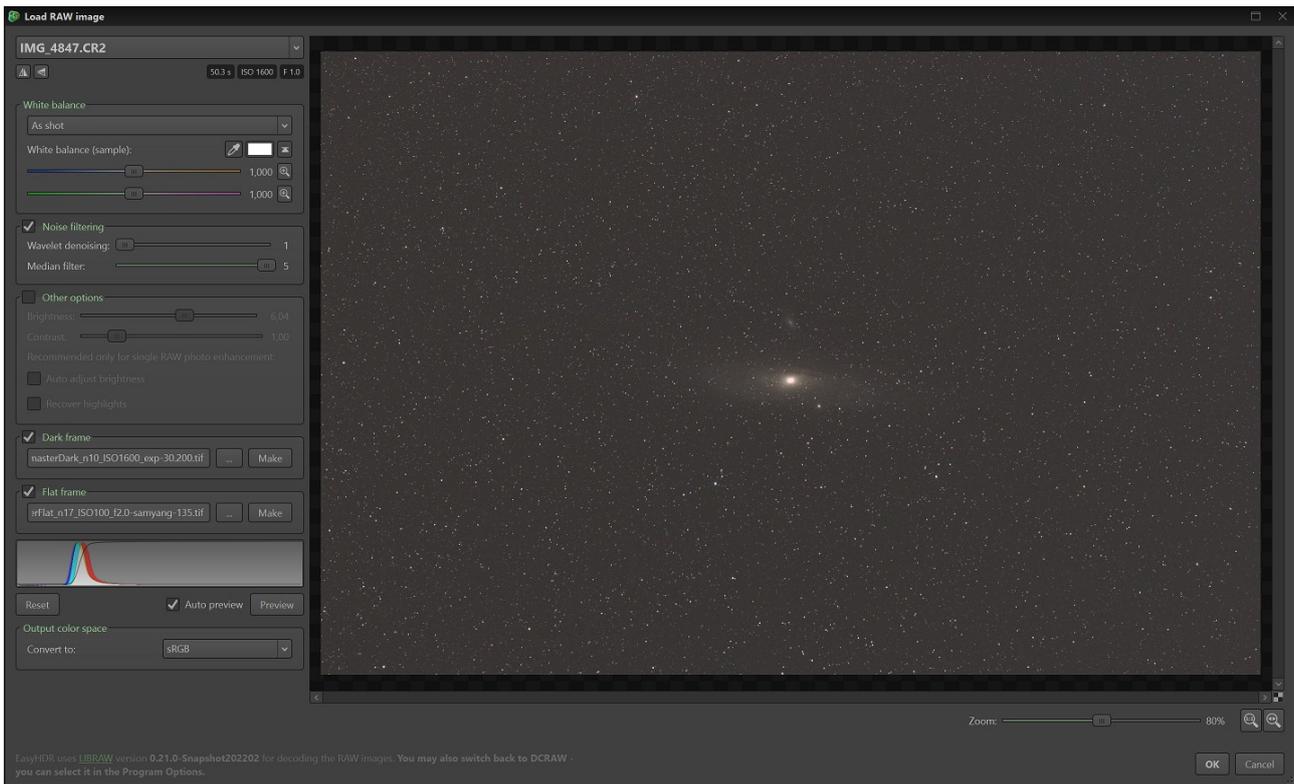


*Before and after dark frame subtraction.*

When the camera is warmed up (its temperature is stabilized) and held in stable conditions, the thermal noise level is quite stable as well (although there is the random component as well). The hot pixels are stationary by definition and new ones appear very rarely. That allows simplifying the process, by taking the dark frame image (same exposure with lens covered with lens cap) once every several exposures. It saves time, but then you need to subtract the dark frame from images in software.

The existence of hot pixels spoils the photo, but if multiple, software-aligned, photos are merged together, the hot pixels will appear as streaks of dots on the result (due to the alignment). Such streaks are much more easily noticeable. It's worth noting that applying the median filter is also a good way of coping with salt & pepper like noise.

For more information on dark and flat frames please go to paragraph: 3.2.3.



*Dark and flat frame removal enabled using easyHDR-made master calibration frames.*

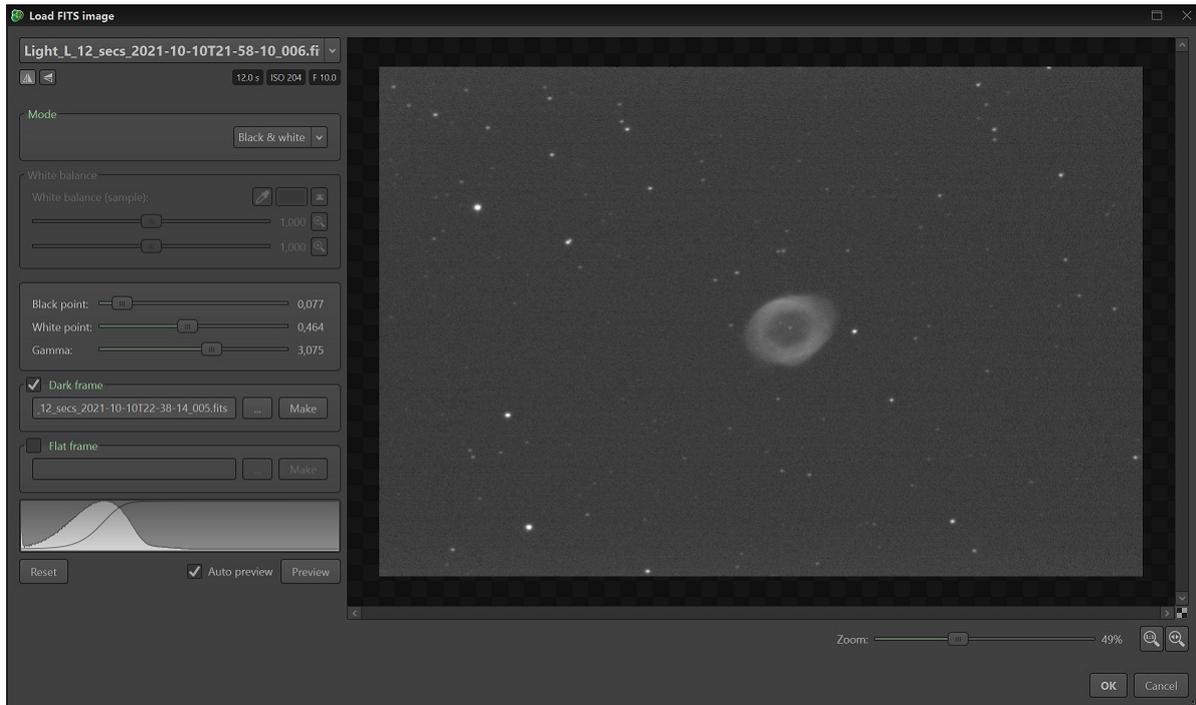
If the imported RAW images look strange (completely bad colors etc.), it may mean that the DCRAW or LIBRAW version used by easyHDR does not support your camera. Please make sure that you use the current easyHDR version, if so please contact [easyHDR support](#).

### 3.2.2. Loading FITS photos

The FITS format import dialog is very similar to the one for RAWs. However, it does not allow noise filtering of individual images. It also offers slightly different approach to contrast and brightness, where the black and white points are set individually.

You should keep the same contrast and gamma settings when loading multiple photos.

Both grayscale and color FITS are handled. The RAW color FITS (Bayer pattern) are not yet supported by easyHDR.

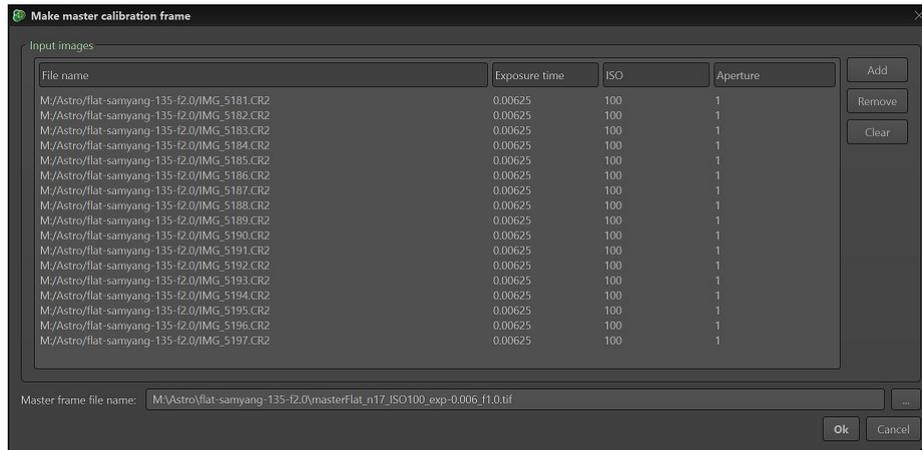


*FITS load dialog.*

### 3.2.3. RAW and FITS calibration frames

Correction with a single dark and flat frame is possible, but due to random thermal noise on these images, it will increase the noise level of the light image itself (the “light image” is the actual photograph of the subject). It’s therefore a good idea to prepare so called master dark and flat frames, which are stacks of multiple calibration images (10-20 should be sufficient).

The master frame can be created either by clicking the “Make” button next to path of the dark or flat frame in either RAW or FITS import dialog while importing the light images. It can also be made earlier by running the tool from “File→Make master calibration frame”. It’s enough to make the master frames just once. When re-using the same calibration frames, instead of using the creation tool please just provide the path to the master calibration frame that has already been created and stored in TIFF format. For tidiness you should keep the separate frame sets in separate folders.



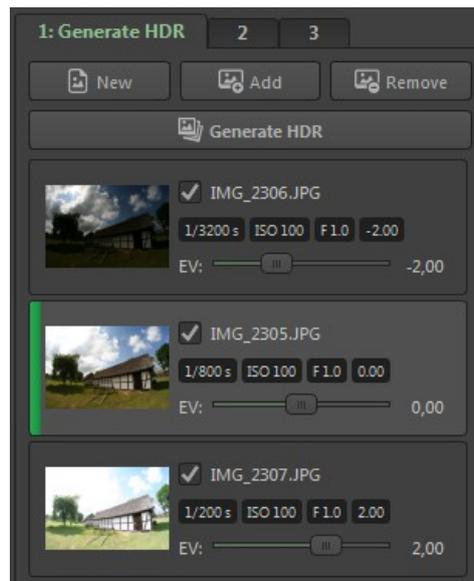
The master calibration frame creation tool with a set of RAW flats loaded and output file name auto assigned.

The dark frames are exactly the same exposures as the light images (the same exposure time and ISO), but with the lens cap blocking the light (that also means the lens can be removed and the camera's sensor just needs to be closed to light).

The flat frames, on the other hand, need to be taken with exactly the same optical system as the light images. The aperture must not be changed, nor the focus. You should also ensure not to clear the sensor or let it get dusted, because the flat will not match the light image. To reduce the noise, you should use low ISO and short exposure settings, meaning that the photographed flat object needs to be bright. You should photograph something neutral in color and evenly illuminated, ensuring its out of focus – like a computer or tablet screen held very close to the lens, displaying a white picture. The exposure parameters should be selected in a way that the histogram is spanning around the two-thirds of the scale. Taking good flat frames is sometimes not an easy task.

### 3.3. HDR generation

After loading the photo sequence, a “Generate HDR” window with processing options appears automatically. If the EXIF data of the photos is correct and the calculated EVs (Exposure Values) for the photos are good, you are just a click away from generating a HDR image. Otherwise you can go back by closing the dialog and edit the EV values manually, or select one of the auto EV options in the bottom of the „Generate HDR” tab. The EVs are vital for correct HDR generation. They are most important for ghost removal, but auto alignment also requires them to be more or less correct. If you are going to process just one photo (LDR enhancement), you don't have to worry about EV at all. Those values are needed just for proper image calibration.



Setting the EV values for a 3-photo HDR photo sequence.  
The photos are automatically sorted by the EV values, from smallest to highest.

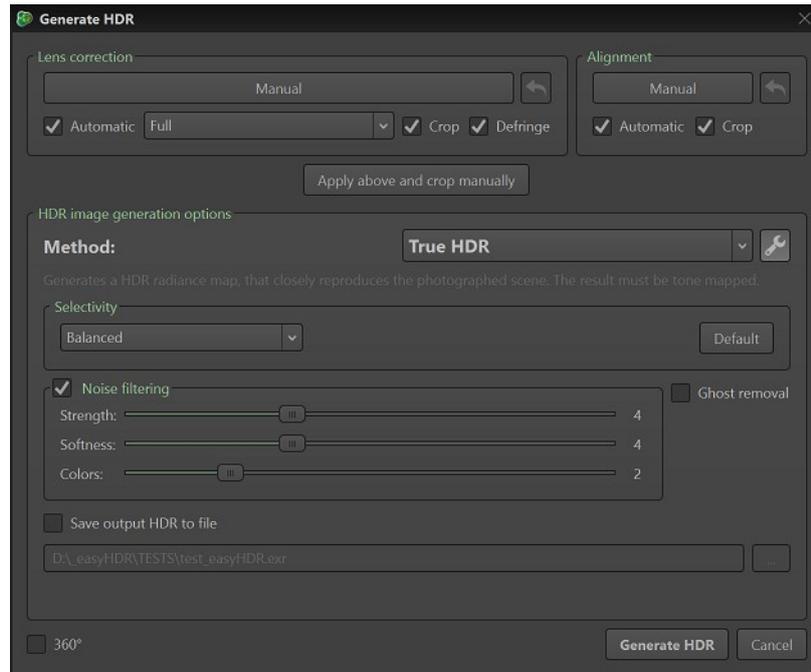
In the bottom of the „Generate HDR” tab you can find several options for automatic EV setup. EasyHDR selects by itself the option that seems the best. The options are (from left to the right):

- *EXIF*: available when the EXIF headers contain valid data. When selected, the EVs are calculated based on exposure time, ISO and the f-number.
- *EXIF (AEB EV)*: available when there are EV bias values stored in EXIF (when photos are taken with a camera in Auto Exposure Bracketing mode). When selected, the EV are not calculated, but taken directly from EV bias fields in EXIF.
- *Automatic (robot arm icon)*: easyHDR calculates the EV values automatically by comparing the loaded photos.
- *Manual EV spacing*: when a value is selected from the drop down menu, the photos are sorted from darkest to the brightest and are assigned with EV values accordingly to selected spacing.



When AEB sequence of photos is taken, some cameras, sometimes store slightly wrong values of exposure parameters. In such a case easyHDR may warn and automatically select the *EXIF (AEB EV)* option. If you developed a single RAW image several times to produce two or more differently “exposed” images, the third party software might have transferred the same EXIF data to all output images. In such a case you should either manually set the EVs, or select the *Automatic* option. When no EXIF is available, easyHDR attempts to calculate the EV values automatically.

You can experiment with HDR generation by disabling some of the already loaded input photos from being used for the HDR. There is no need to remove the photos, just uncheck the checkbox next to the name of the photo.



HDR generation options.

The HDR generation step can be divided into two stages:

1. **Preprocessing.** It includes lens correction and image alignment. By using the “*Apply above and crop manually*” button, you can let easyHDR do the preprocessing and it will break, allowing you to crop the image. Once you are finished, the “*Generate HDR*” window is shown again.
2. **The actual HDR radiance map generation.** It can be done using three available methods – *True HDR*, *Smart Merge* and *Stack*. Each of them has various additional options and features. The HDR image generation is followed by noise filtering, so the already filtered image is used for tone mapping.

### 3.3.1. Preprocessing

Before generating the HDR image it is possible to preprocess the input photographs. The available options are: lens correction and image alignment. After preprocessing, and closing the HDR generation window, it is possible to view the modified photos in the main program window by using the “*Photo before processing*” option and also to save them with: “*File → Save preprocessed input photos*”. Both transformations can be undone, allowing re-processing without the need to reload the photos.



### **3.3.1.1. Lens correction**

The camera lenses are not perfect (especially those cheaper). They have many optical defects, among which there are three most notable, that fortunately can be fixed with easyHDR. The Lens Correction tool allows fixing distortion, vignetting and chromatic aberration. It can be used right after the photos have been loaded, but before they are aligned or used for generating a HDR image.

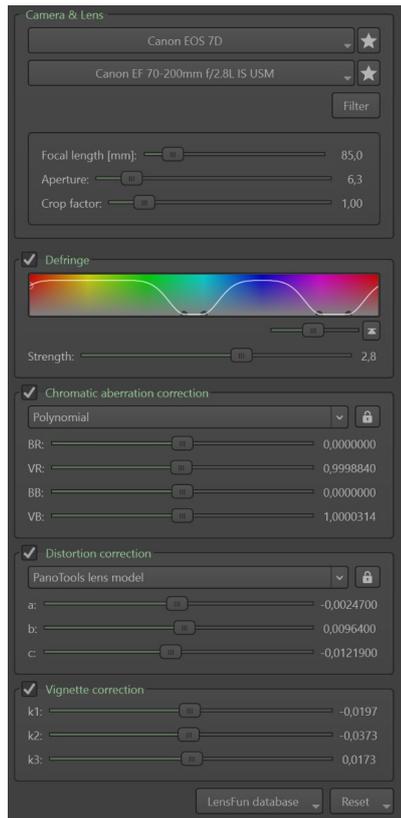
**Lens distortion** occurs when a lens is not projecting the light properly, by producing bent lines on the camera's sensor from straight lines in the photographed scene. The defect is stronger in zoom lenses and it varies with focal length. The fish eye lenses, because of their very short focal length, characterize with very strong distortion. This however shouldn't be considered purely as a defect, because this is how the fish eye lenses work. With easyHDR it is still possible to straighten photos taken with such lenses (using the crop/rotate/perspective/distortion tool), but it may make little sense to do it fully, because it may require strong cropping, or will introduce severe stretching of objects closer to photo's edges.

**Chromatic aberration (CA)** occurs when the lens does not focus all light wavelengths in one point, because of different refractive index for different wavelengths, in different parts of the lens. In the photo it appears as red-magenta and green-cyan "fringes" around dark-bright boundaries. This effect gets stronger towards the borders of the photo and typically is the lowest (or does not exist at all) in the center of the image. Cheaper lenses, especially the zoom lenses, have stronger chromatic aberration. As it is with distortion, chromatic aberration also varies with focal length in case of zoom lenses.

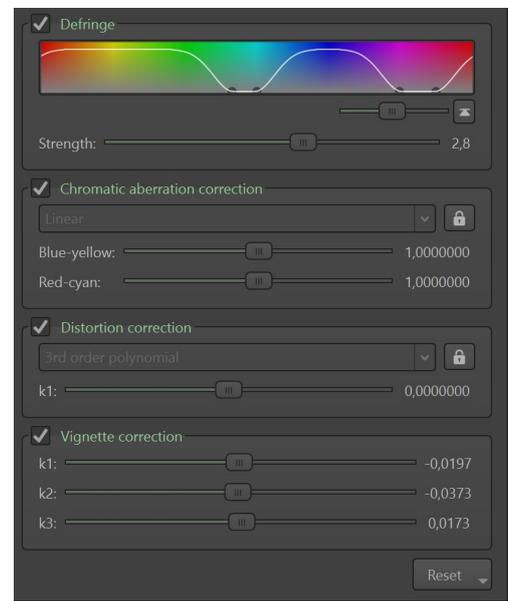
**Vignetting** is caused by the lens not evenly distributing light over the image sensor and also due to different angles of rays falling on pixels in different areas of the sensor. Compact cameras, with non-replaceable lenses do the vignetting correction by themselves, because they know the characteristics, but DSLR cameras not necessarily (especially if lens is not made by the camera's manufacturer).

The distortion and chromatic aberration vary with the focal length of the lens (if it's a zoom lens), but the vignetting varies also with aperture. Therefore if your HDR sequence of photos was taken with varying aperture, each of the photos will be corrected with the same CA and distortion parameters, but with different vignetting coefficients.

When you store your photos in RAW format, they are not corrected for distortion, CA and vignetting. Your camera may not do it either (or apply just partially) even when saving JPEGs. Fortunately the corrections can be done in software and easyHDR is one of the options.



Camera and lens were detected and found in the database.  
The tool is in the Advanced mode.



Camera and lens not detected, tool in simple,  
manual mode.

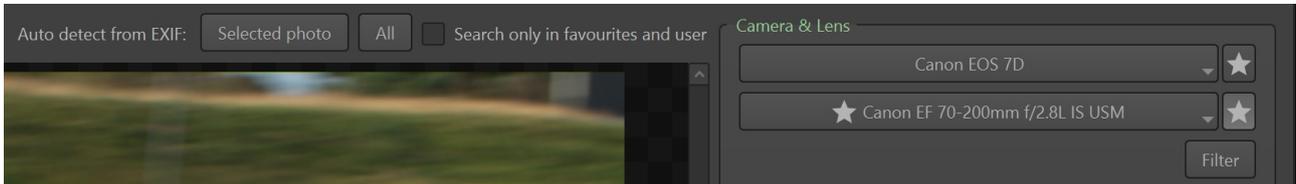
The easyHDR's Lens Correction tool uses the [LensFun](https://www.easyhdr.com/) database of cameras and lenses in order to apply correction parameters automatically for the detected camera-lens pair. If the required information is not found in photo's EXIF meta-data, or the particular hardware is not found in the database, the user can still set the values manually, or select the similar camera or lens from the list of available models. Of course it is also possible to tweak the parameters if those from the database don't give perfect results. There are several numeric lens models available. For manual editing it's much easier to use those with less parameters:

1. Chromatic aberration correction
  - **linear**, two parameters, easy to set manually
  - **polynomial**, four parameters
2. Distortion correction
  - **PanoTools lens model**, three parameters
  - **3<sup>rd</sup> order polynomial**, one parameter, very easy to set manually
  - **5<sup>th</sup> order polynomial**, two parameters
3. Vignetting
  - **“pa” model**, three parameters



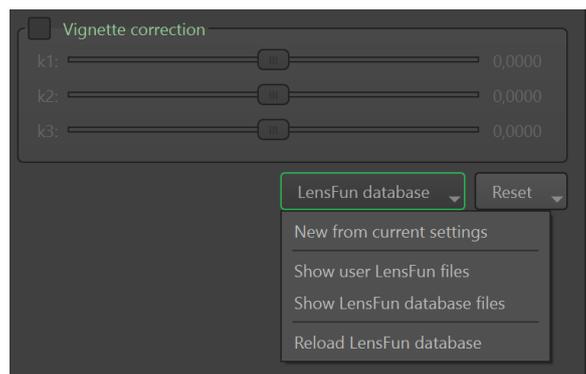
The CA and distortion parameters are locked by default and the same are used for all of the sequence photos. To force different parameters (normally not needed!), please just unlock the padlock buttons. By definition, vignetting parameters are separate for each of the inputs.

To help easyHDR auto find the right equipment, you can mark the owned models as favorites – they will get better score. They are also marked with star icons and are easier to find in the drop down lists.



When the “**Search only in favorites and user**” is checked, the auto detection (“automatic” lens correction option in the HDR generation window) is done only within the models marked as favorite and those created by the user.

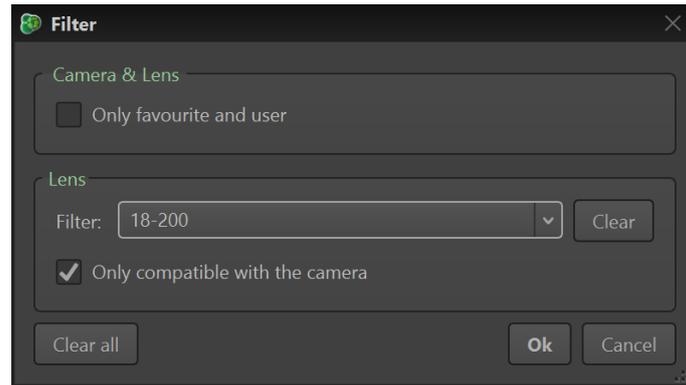
If LensFun does not come with definitions for your camera and lens, you can also create the entries manually. Find a similar camera and lens and tweak the parameters, then create a new entry, using the “*LensFun database → New from current settings*” option. More advanced approach is to manually edit the LensFun XML files – in such a case it is better to keep the own-created files in the “*User LensFun folder*”, so they won’t be lost when easyHDR is updated. After editing the files manually, please click the “*Reload LensFun database*” menu item.



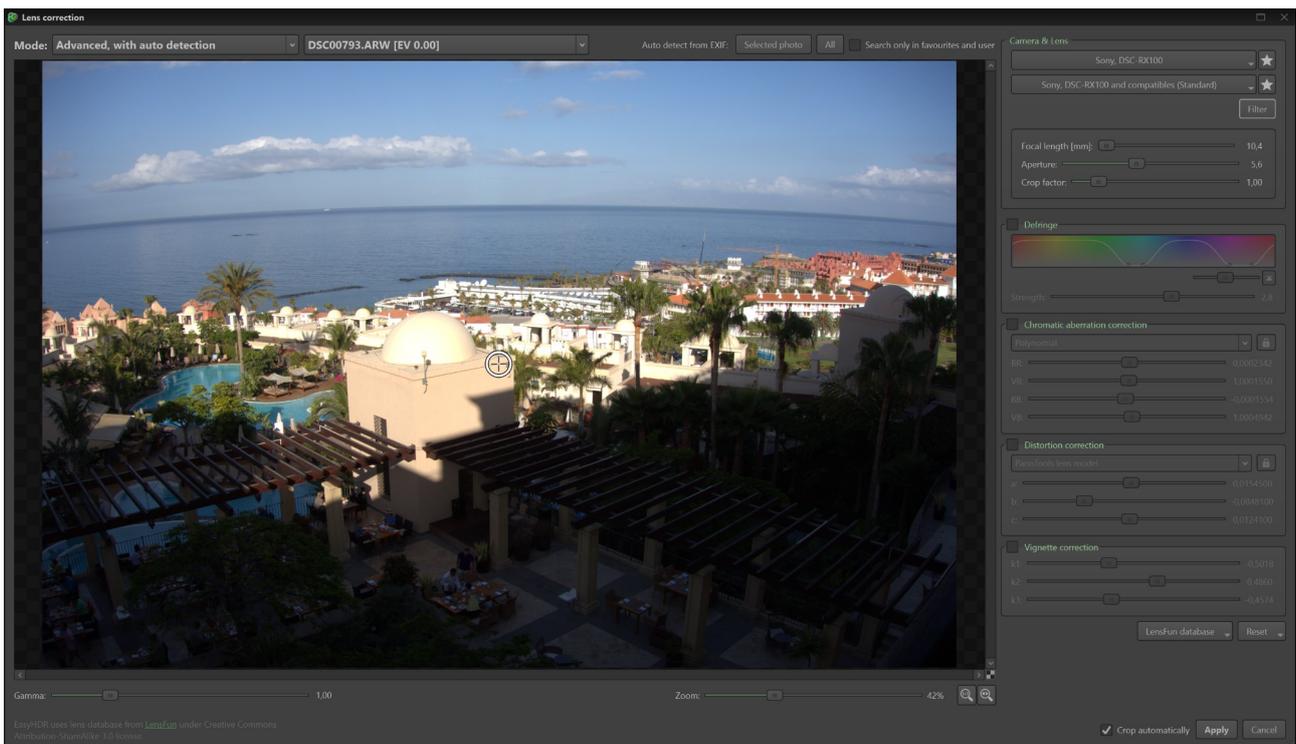
Each user-created camera and lens pair is stored under a different file name. An already existing definition is updated with new parameters, but if other aperture and focal length are defined, new entries for those settings are appended. It is therefore possible to create definitions for the zoom lenses.

You can preview any of the input photos by selecting it from the drop down list in the top of the window. The drop down also shows a tool tip with EXIF information for the selected photo.

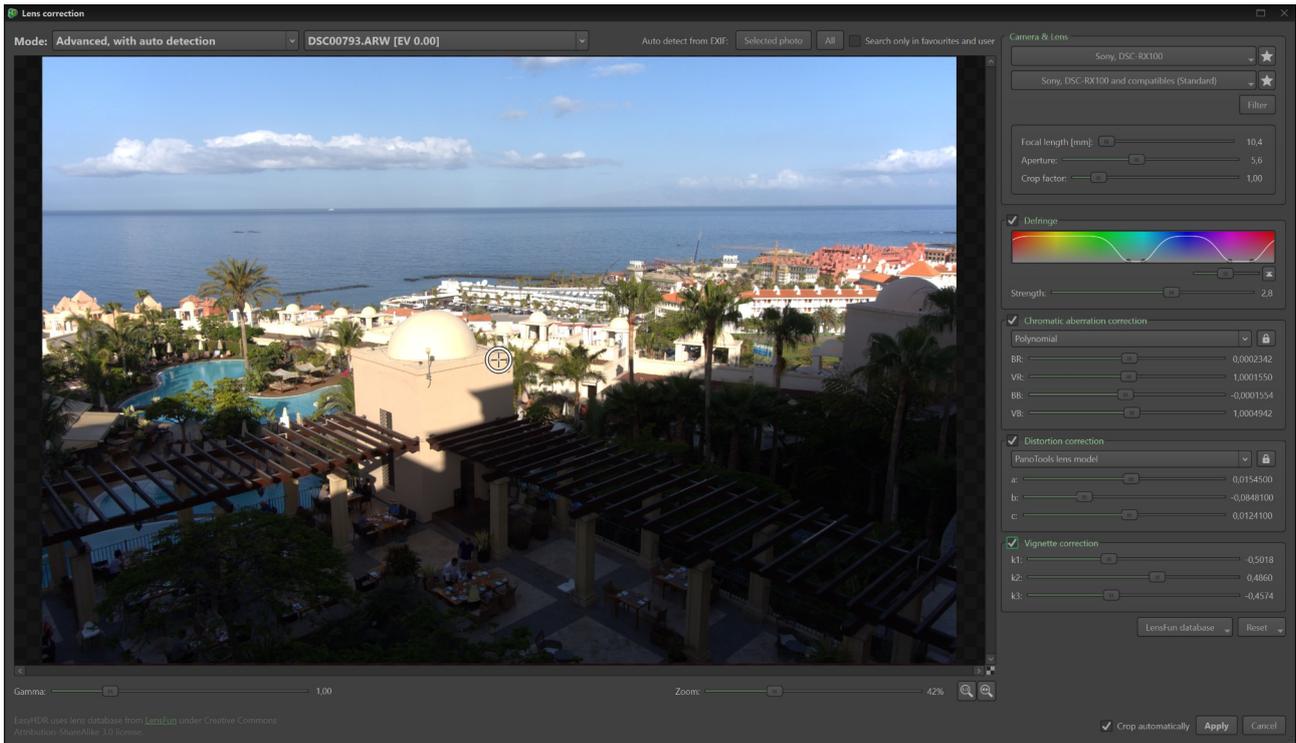
When manually selecting cameras and lenses from the lists, you may find the filter option handy. It allows limiting to just favorites and user-created models and, in case of lenses, it allows filtering out all incompatible (with different mounts) and allows showing only those that fit a search string. You may typically filter a certain focal length or the manufacturer’s name.



**Defringe** is a separate operation, that does not rely on the data from the LensFun database. It's job is to remove chromatic aberration fringes (red-magenta and green-cyan) around high contrast edges. Those fringes may not necessarily be removable by the chromatic aberration correction feature, or the LensFun database may not have the required parameters for the certain lens. For defringe, you can control the strength and also the hue selectivity. The default hue suppress curve should work fine in most of the cases, but sometimes some more attenuation of a bit more reddish, violet or blueish colors may be needed to even better reduce the fringes. When the curve is straight in the top of the hue palette, no color attenuation is done. Pushing the curve to the bottom, means attenuating the particular hue range. Please watch out not to desaturate the pixels near the fringes too much, while tweaking the curve.



*Photo before lens correction.*



*Photo after lens correction – parameters taken automatically from the database. At this scale the most notable is the distortion correction.*



*Zoom at photo before chromatic aberration correction.*



*Zoom at photo after chromatic aberration correction.*



*A zoomed in crop, close to the edge of a different photo taken with an 18-200mm ultra zoom lens still shows strong CA, even though CA correction using the LensFun coefficients was applied.*



*Defringing was applied to get rid of the red and green fringes that are most notable on the high contrast edges.*

**Note:** The Generate HDR window offers a possibility to use automatic lens correction. Before using this feature please check, using the manual option, whether the camera and lens are properly detected and that the correction parameters are good. It needs to be done only once for particular camera and lens pair. There is no need to do that for all photos that you process.

**Note:** Please make sure that lens correction is applied to a photo only once. For example if you load to easyHDR JPEGs or TIFFs previously developed from RAW using other software, the photo might have already been corrected. Also, some cameras may apply chromatic aberration correction automatically.

**Note:** Defringing is a separate procedure. It may be applied in combination with lens correction, or alone. It does not use parameters from the LensFun database.

EasyHDR remembers the last used Lens correction mode (whether it's enabled and whether it's full or limited to just distortion, vignetting or CA correction). It stores that information for each camera/lens/file format combination.

As mentioned before, the most challenging is correction of fisheye lenses. First of all it must be noted that such correction may not be needed, or even anticipated in most cases, however in some it might be possible and might give good results. In the sample below the trick was to move the center point (drag with mouse) to the bottom-center of the image and set just one distortion parameter using the simplest, 3<sup>rd</sup> degree polynomial model. You can also do it with the crop/rotate/distortion/perspective tool available from the main window.

The noise filtering available in the "HDR Generation" window allows further fringe reduction. It is achieved with the "Colors" parameter, which controls strength of color noise smoothing. The thin fringes are within thresholds.



*Photo taken with an 8 mm fisheye lens – no correction applied.*



*Center point moved to the bottom and the distortion parameter tweaked manually in a way to make the horizon straight. The photo still requires some rotation, which can be done later (see “Image” in the main menu).*



### 3.3.1.2. Alignment

In order to get the best, sharp and fine detailed results, the photo sequence used to generate the HDR radiance map should be taken with a camera on a tripod. Of course it is not always possible. Even the fastest cameras, with exposure bracketing option enabled, still need quite much time to take the full sequence. The slightest move of a hand during that process can cause the acquired photos to be misaligned in respect to each other, which results in artifacts on a generated HDR image. The weirdest artifacts may appear on a HDR created with “True-HDR” method. They are caused by invalid pixel luminosity – i.e. an area that should be darker on a shorter exposure is in fact brighter, which confuses the algorithm.

#### Manual alignment

EasyHDR has a built-in manual alignment tool that can be used to align the photos if it's needed. The tool uses planar stretching method that is controlled (by the user) by manual placement of up to 4 pins for image pairs. One of the images, preselected by the user, is called “base”. All other photos (“to align”) are aligned to the “base”. The user has to set the pins for each pair of the photos.



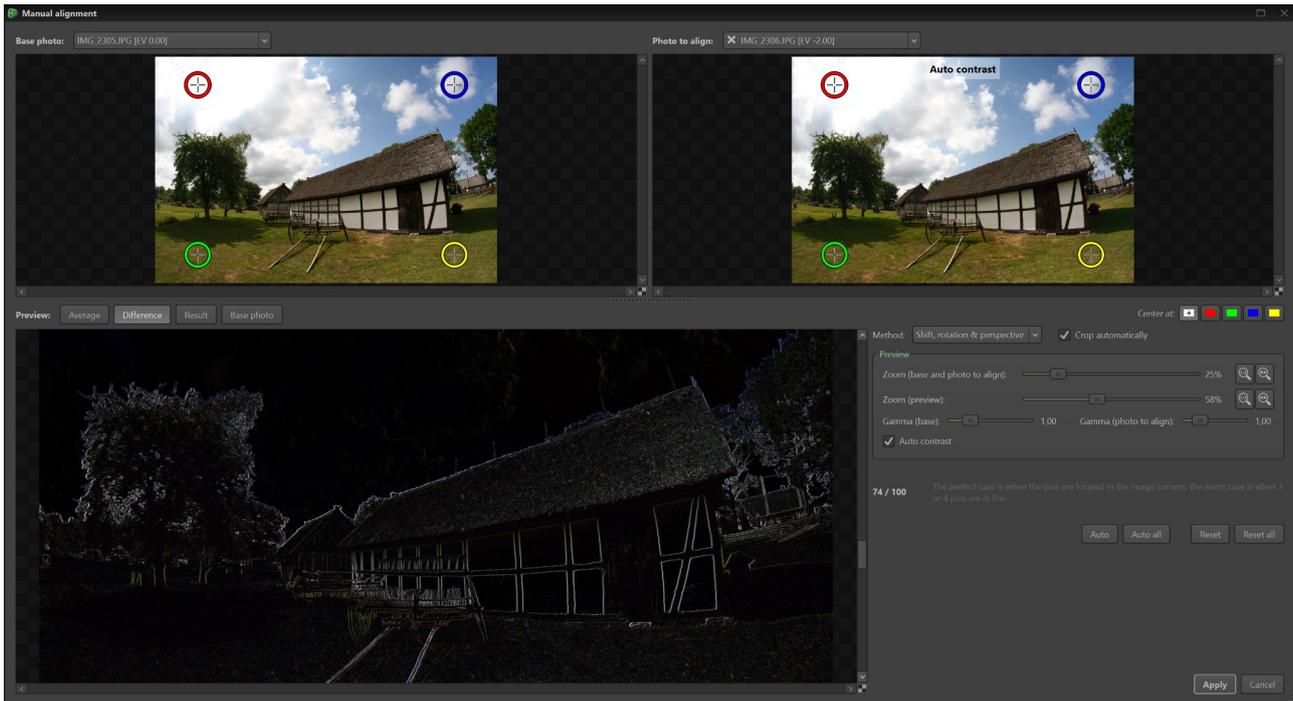
*Crop of a tone mapped HDR blended from misaligned photos.*



*After manual alignment.*

Below is described the procedure that leads to generation of a HDR radiance map from a misaligned sequence of photographs is described:

- Load a sequence of photos into the program and click “Manual alignment” button in the “HDR generation” window.
- Choose the base photo to which the remaining images shall be aligned. The base photo appears in the top, left box. By default the middle exposed photo is automatically selected.
- Decide on the method of transformation (of course you can do it later as well, but please note that the method is common for all photos that are transformed). Compensation for shift requires setting of one pin pair. Shift and rotation needs 2 pin pairs. Perspective matching is achieved by setting all the available, 4 pin pairs.



*Photo to be aligned is loaded into the top-right box. The preview style was selected as “difference” to better show the misalignment. Auto contrast ensures good calibration of both photos' brightness, so it's easier to compare them.*

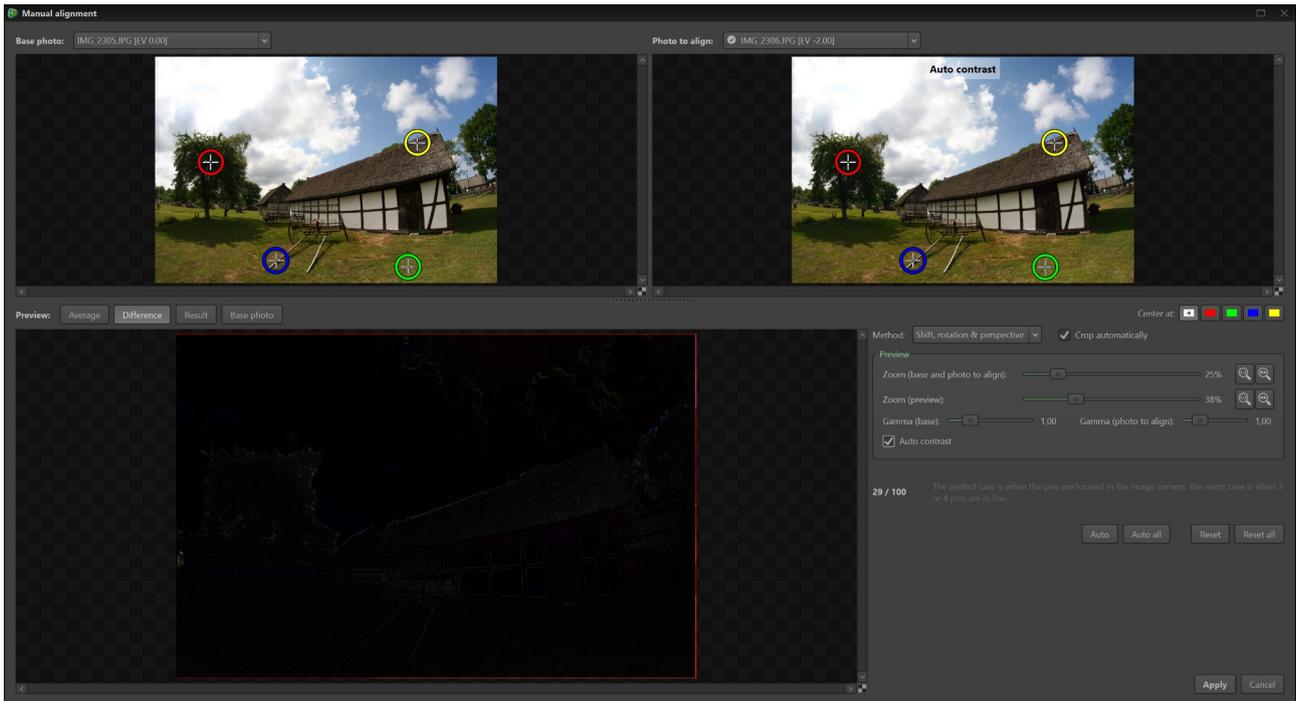
- Open one of the remaining photographs in the top, right box. This is the photo that will be transformed by the program in order to be aligned to the base image.
- Set the pins, on the two loaded images (base and “photo to align”), so they point exactly at the same object details of the photographed scene. It is a good practice to initially place the pins close to the chosen scene features while the zoom is set to a small value and later fine tune the placement at higher zoom. The pin centering option (see picture below) is useful while fine tuning the positions. The view is automatically centered at the selected pin pair.



The keyboard arrows can be used to fine tune the pin positions. Just double-click on the chosen pin to enter the keyboard mode. While the right *Shift* key is held, the pin jumps several times faster. In order to exit the keyboard mode, press *Enter*, *Space*, *Esc* or double click on the image away from a pin.

**Please note that the image is correctly transformed only after all the required pin pairs are properly placed. You can disregard what is shown in the preview box until the last pin is set and then use the preview while fine tuning.**

- Repeat the operation described in the previous two points on every photo, that shall be aligned to the base. Note that it is possible to set different pin positions for each image pair.
- Click on the “Apply” button. The photos will be aligned and in the next step you will finally be able to generate the HDR radiance map.

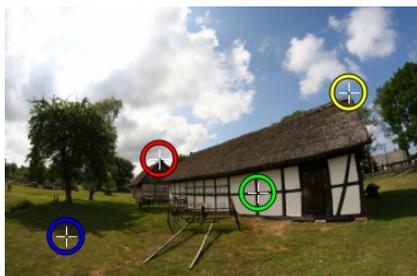


Four pins point at exactly the same picture features. The pins are set with sub-pixel accuracy.

The “auto contrast” option calibrates the brightness of both photos currently being aligned so they are easier to compare. Perfectly aligned photos, perfectly calibrated should produce a black “Difference” preview image. In case of slight misalignment the “Difference” view shows bright borders around edges.

The manual alignment tool can be used in a semi-manual way. Right after the window appears it is possible to use the “Auto all” button to allow easyHDR place the pins automatically. The user can check whether the automatic algorithm succeeded and if it's necessary, correct the pin positions before applying the alignment. The “Auto” button, on the other hand, causes automatic pin placement for just the currently selected image pair.

When compensating for more than just the shift please note that the pins should be well spread over the photograph. The best case is when they are located near the corners. Placing them too close to each other or setting 3 or 4 of them in one line will result in big alignment errors and therefore should be avoided. A score value (0 to 100) is calculated by the program to help you set the pins correctly.



Bad spread of the pins. Pins are almost in one line. Score = 14/100



Bad spread of the pins. Pins are too close to each other. Score = 13/100



Good spread of the pins. Score = 61/100



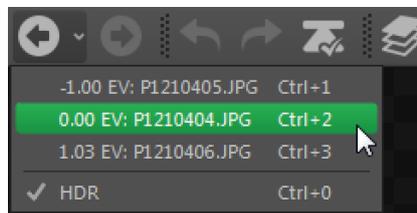
In a HDR image sequence it might be hard to find the same details in both pictures (base and “photo to align”) due to the difference in brightness. If the detail is not overexposed, but rather underexposed in the darker of the photos, you may manually alter gamma setting for the particular image, in order to brighten (or darken) it. “Auto contrast” option may also be useful. It automatically enhances contrast (not gamma) in the darker of the photos, to match it to the brighter one.

Automatic cropping option can be used to cut off the parts of the images that are invalid in one or more of the aligned photos. Such invalid parts have bad influence on the tone mapping process when local operator is used.

### Automatic alignment

The automatic alignment feature is a convenient way to align photos without any user intervention. It always tries to compensate for shift, rotation, scale and perspective.

*Tip: you can check whether the alignment succeeded before generating the HDR image (which is time consuming). To do so just close the HDR generation window and use the “Photo before processing” option.*

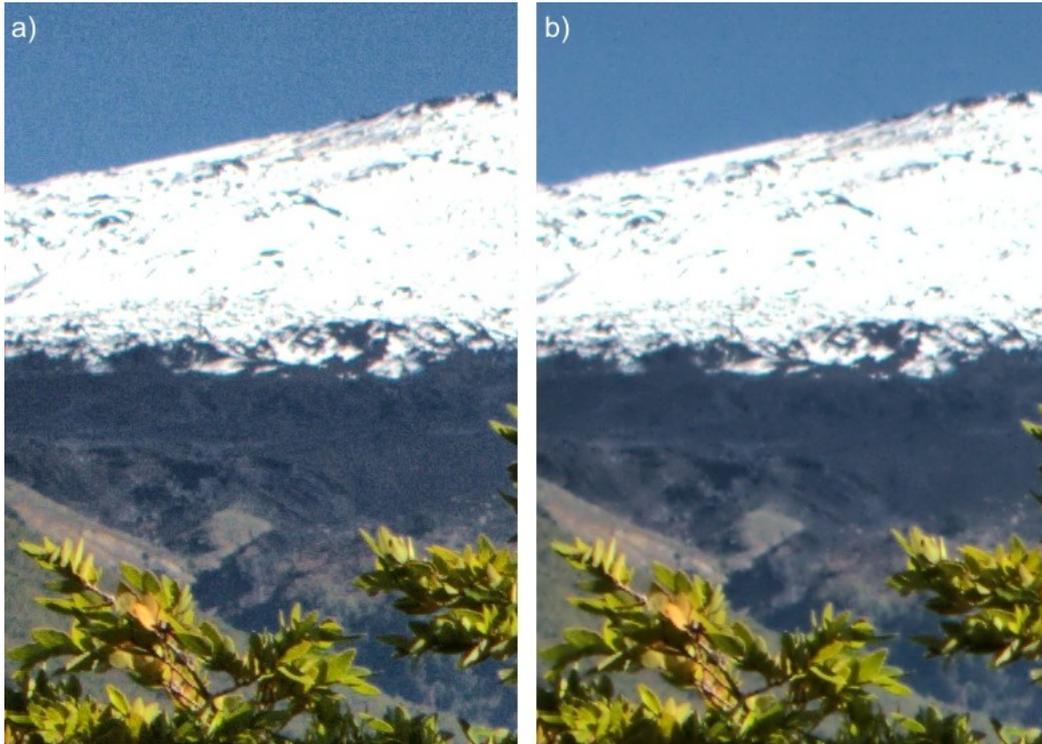


### 3.3.2. HDR image generation options

The HDR generation step is the moment when the preprocessed, input sequence of photos is finally merged, in order to form a single image – the HDR radiance map. It is possible to choose one out of three methods for HDR generation: *True-HDR, Smart Merge & Image Stacking*.

EasyHDR allows also tone mapping of a single LDR photo (i.e. a single RAW or JPEG). In such a case, a HDR radiance map is not generated of course. Instead, the input image is prepared for being tone mapped. In easyHDR it is called “LDR enhancement”.

The common post HDR generation / LDR enhancement option is *noise filtering*. This feature reduces the noise level in the already generated HDR image, before it undergoes tone mapping. This approach ensures that the noise itself is not strengthened so much by the *Local Contrast* tone mapping operator. It allows relatively stronger local contrast boost, while preserving good signal-to-noise ratio in the final photograph.



*Single RAW image tone mapped with high strength of Local Contrast operator. Without applying noise filtering before the tone mapping (left hand picture) the noise level is very high. If the noise filtering is applied, the image is smooth while the fine details are preserved. In this example the noise filtering strength was set at: 6 and softness was 3.*

When processing an image which is an already assembled, 360° panorama, the “360°” option should be checked. In this case the tone mapping will be done as if the left and right border were connected with each other. Otherwise they wouldn't match when virtual tour was made with the processed image.

### 3.3.2.1. True HDR

The *True HDR* method generates a radiance map that closely represents the real light radiance that was focused by the lens on the image sensor when the scene was photographed. This method requires proper Exposure Values set for the particular photos in the sequence.

When the HDR generation window is opened the program reads the appropriate exposure time, ISO and f-number values from JPEG, TIFF or RAW EXIF headers and utilizes them to calculate the true EV (Exposure Value). If there is no EXIF data embedded in the files, the photos are sorted from the darkest to the brightest and the Exposure Values are set up to meet the spacing requirement. You can also edit each of the EV independently. Note that these values are critical in HDR calculation process, especially when you want to receive a realistic result. [Learn more about the Exposure Value.](#)

There are a couple of options available only for this algorithm:



- **Selectivity:** Controls what parts of the input photos and with what weight are taken into consideration during the HDR image creation process. The “*none*” setting means that the importance of all pixels is equal. The “*balanced*” setting means smaller weight for under- and over-exposures (weight gets smaller symmetrically towards black and white). “*Cut off over and under exposures*” disregards just the worst pixels, while “*get best exposed*” favors brighter pixels, where signal to noise ratio is higher, rather than darker pixels.
- **Reject brightest and reject darkest:** defines how many brightest and darkest pixels from the entire HDR sequence shall be rejected. It is useful only when averaging/merging equally exposed photos, when there are many of them, so typically for astrophotography stacking. It allows rejecting pixels with satellite tracks, allowing to use the spoiled photos within the stack.
- **Ghost removal:** See below.
- **Saving the HDR image:** Check this option and choose the directory, the file name and format (Radiance RGBE, OpenEXR or 32-bit floating point TIFF). Saving the HDR image (radiance map) is possible only at this step.

### Ghost removal

When the photos are well aligned some of the objects within the photographed scene may still not match. These objects appear as ghosts in the final HDR image, because they are not in the same position in all of the photos in a HDR sequence. In the “ghosted” area the input data for HDR image calculation is improper and therefore has to be somehow fixed, otherwise ugly artifacts appear on the final image.



*A sample sequence of two differently exposed photos, where some subjects moved while the photos were taken.*

Most common ghost sources are:

- moving people, cars, etc.,
- leaves or branches moving in the wind,
- fast moving clouds, smoke,
- ripples and waves on water,
- bad photo alignment,

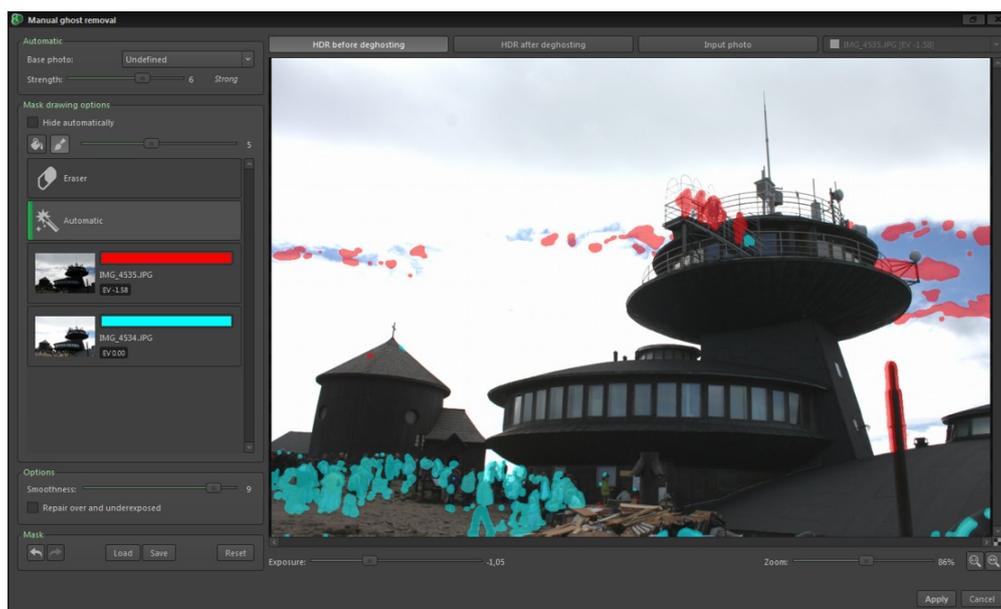


- misalignment that cannot be removed by aligning the photos – i.e. due to parallax.

Normally it should be avoided to take HDR sequences of scenes where ghosts might appear, but it would severely limit usability of HDR techniques. Ghost removal tool in easyHDR allows to create HDR photos even if some of the image area is ghosted. There is a manual as well as automatic ghost removal possibility.

When the “Generate HDR” button is hit and the ghost removal option is checked, easyHDR shows the ghost removal tool window. Of course, if the automatic alignment was also selected, it is done first, so it may take a while before the de-ghost tool is shown.

EasyHDR automatically attempts to find ghosts and if detected, they are immediately marked on the de-ghost preview.



*Ghost removal tool – ghosts detected automatically.*

Each mask color corresponds to the input image used for patching the painted area. The patching image is carefully calibrated by easyHDR to match it best to the rest of the HDR. The areas not painted with mask are created out of all input images.

The user is supposed to visually check the automatically created mask and if it's needed to modify it. Helpful are three view modes:

- HDR before de-ghosting,
- HDR after applied de-ghosting – the current mask is used,
- Input photo – selected from a drop down menu.

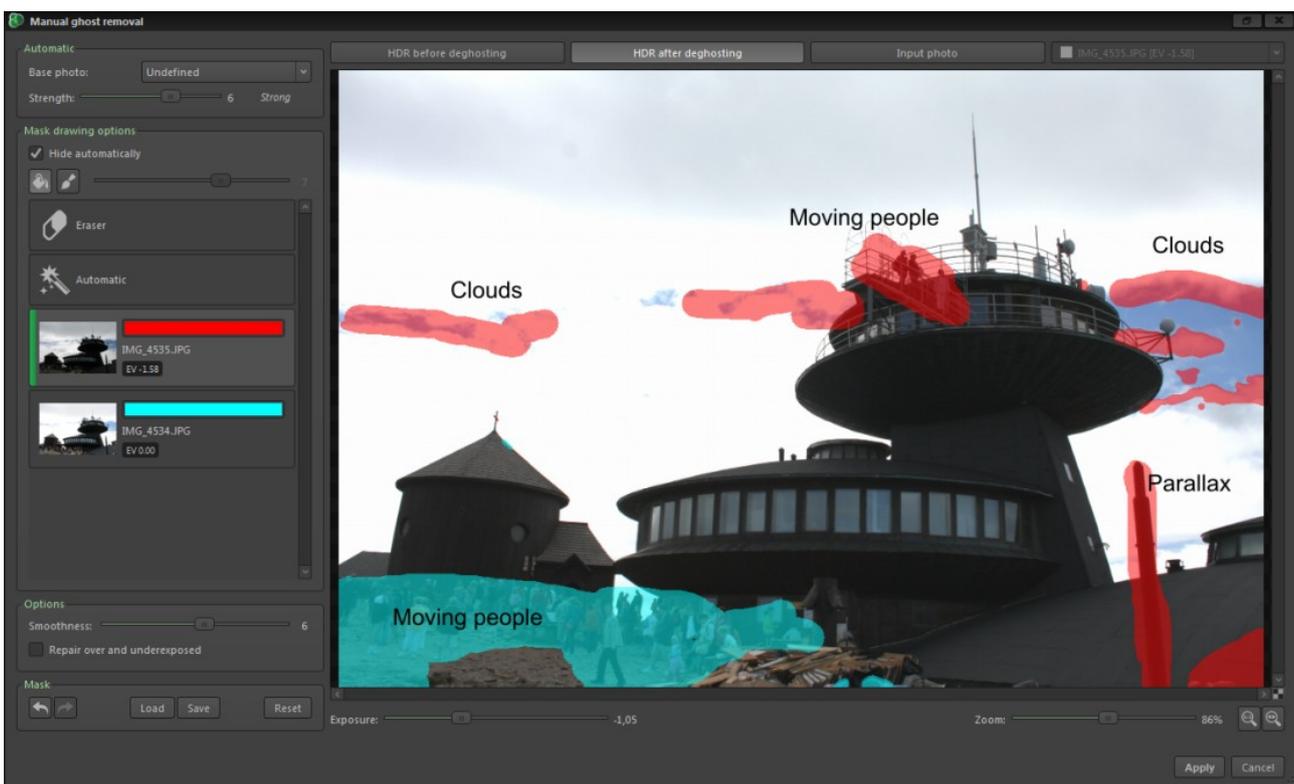
The first two are just roughly, gamma-corrected HDR images. The view can be made brighter or darker (to show various areas – shadows and over-exposures) by changing the “**Exposure**” value. This parameter affects only the preview!

When the “**Hide automatically**” option is selected, the mask is shown only if the mouse cursor hovers

over the preview.

If the automatic ghost detection did not work good enough it is possible to change the detection threshold by tweaking the **“Strength”** parameter. The mask is auto regenerated. For the painted mask, it is also possible to select the **“Base photo”** - it's a key frame used for the entire photo to patch all the marked ghosts. Selecting **“Undefined”** base photo allows easyHDR to auto-assign various inputs for patching the ghosts.

The user can also paint the mask manually. The mask painting tool is either a brush of various sizes or a flood-fill tool. The user can explicitly select which input photo to use for the particular mask that is being painted. It is also possible to leave the decision to the program and use the **“Automatic”** mask type (default). Mask type: **“Eraser”** is of course for clearing already painted masks. Eraser is also enabled when painting with **Ctrl** key pressed. The flood-fill tool can be used to change the particular mask's target image, or to completely erase the selected, individual masked area. It cannot flood-fill a not masked part of the photo.



*Manually edited mask - red for -1,58 EV photo (currently selected mask type) and cyan for the other, 0 EV photo. Longer exposure (cyan) is taken for the shadowed area, while the shorter exposure (red) is for the highlights.*

As it was already mentioned before, the masked area is no longer a real HDR. It's just a well calibrated patch of a single input photo. It means that the best results can be achieved when the ghosts are relatively small and when the image that is selected for patching is well exposed (in the masked area). Underexposed patch means high level of noise and possibly some brightness mismatch. In case of overexposed patch the area will be overexposed in the final HDR image and additionally it will not match in brightness. The overexposed and underexposed areas are repaired (filled with best exposed pixels, however not coming from the patch image) when **“Repair over and underexposed”** option is

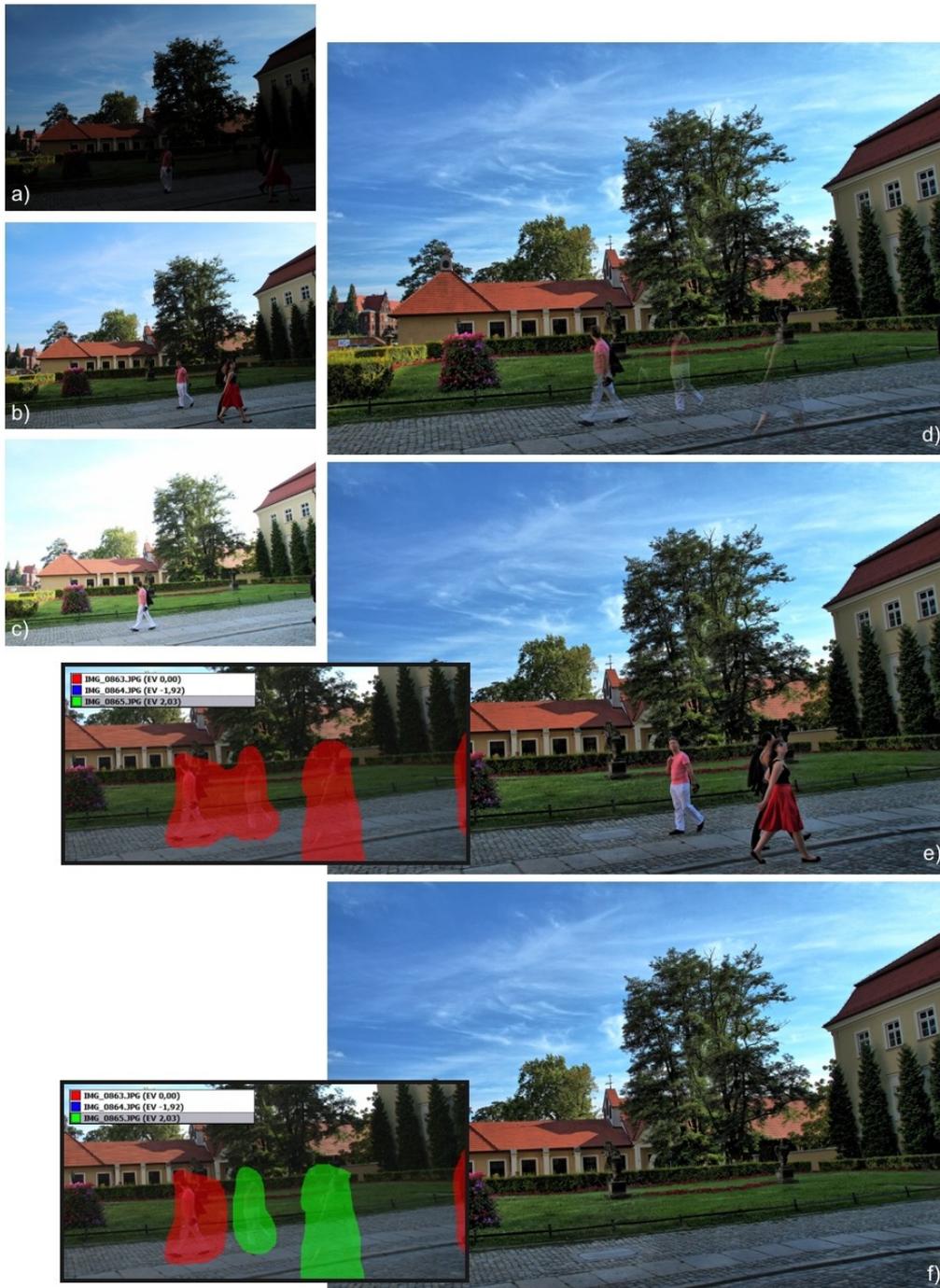


checked. The “*Smoothness*” parameter controls the softness of the patch edges – smoother are better blended and therefore less visible, but the patched areas are extended.



*Tone mapped HDR image before (a) and after (b) manual ghost removal.*

The ghost removal tool can be used to repair ghosted areas in your HDR photo, but because it is possible to select which photo should be used for patching, there is yet another and very interesting possibility. For example, it can be used to completely remove moving people or cars from a photograph. It's just a matter of taking photos correctly. The ghost can be removed completely only if the affected area is well exposed and without the moving object itself at least in one of the photos in a sequence (see the example above).



*a), b) and c) Input photos (-2, 0 and +2 EV) – differently exposed, people moved while the sequence was taken, d) tone mapped HDR – no ghost removal, e) ghosts removed, but in a way to leave the people as in the 0 EV shot (see the red mask), f) the ghosted areas were patched in a way to completely remove the people (red mask replaces ghosts with part of a 0 EV photo, while the green mask patches the area with +2 EV photo).*



### 3.3.2.2. Smart Merge

This method doesn't generate a real HDR radiance map. Instead, the input photographs are merged together by taking the best exposed details with higher weight. The over and under exposed areas are rejected. Ghost removal is not available here because the photos are not calibrated as it is done for the True-HDR method.

The user can control the strength of Smart Merge's selectivity. In most cases the low values (0 – 2) are just perfect. In case of some photo sequences stronger effect may give some further dynamic range compression, but sometimes it may cause unnatural look.

The result of the merge may look very natural when only slight local contrast enhancement is used. Of course stronger tone mapping may also be applied in order to get more dramatic look.



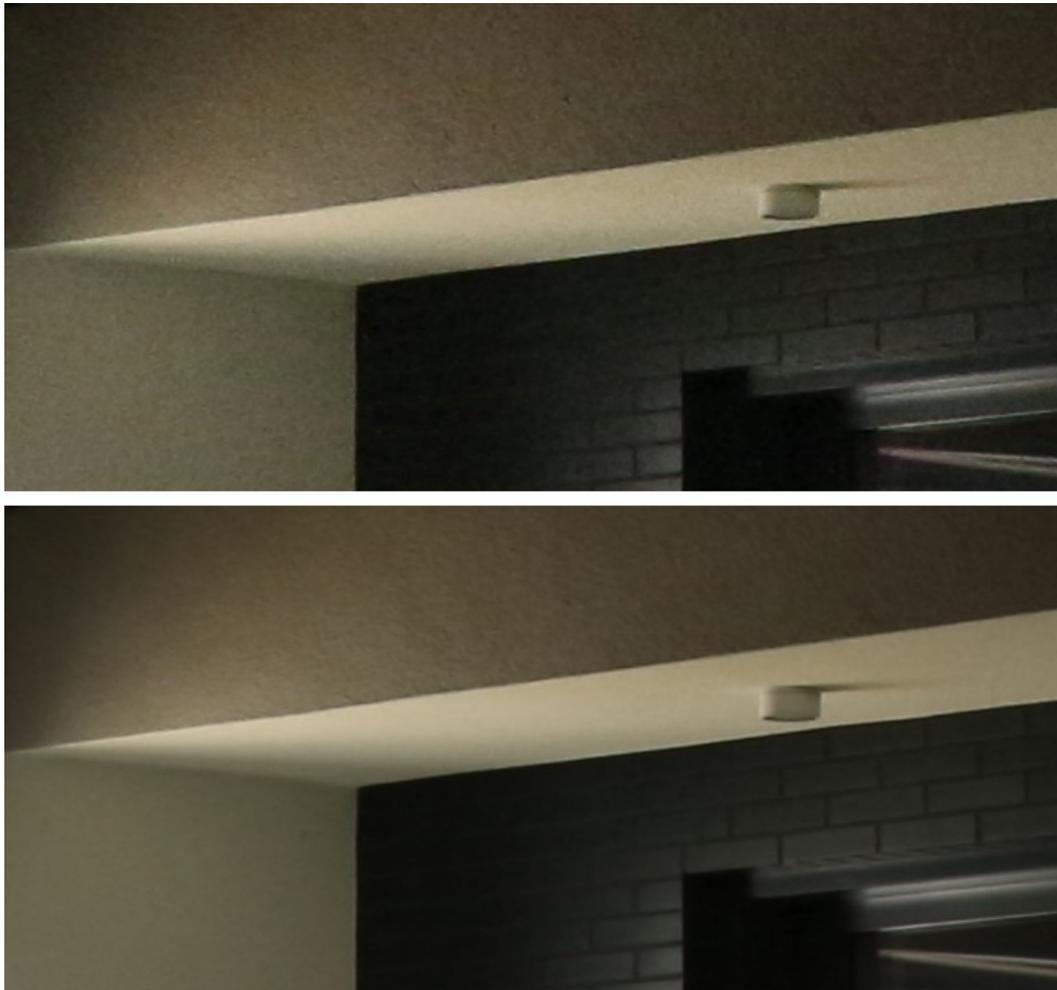
*a), b) and c) Differently exposed photos (photo sequence loaded to easyHDR),  
d) Result after Smart Merge, strength = 1, e) Result after Smart Merge, strength = 5  
(both results processed with default tone mapping settings).*

### 3.3.2.3. Image Stacking

Stacking is a method of blending photos by simply taking the average of the input images. The luminance value for each pixel is a sum of the true signal and of course the noise. If the photographed scene is static, the signal acquired for each pixel is constant for each photo taken at the same exposure settings, while the noise is random. The average of the noise aims for a constant bias and thus is easy to



subtract by a slight contrast boost. In other words by taking an average of photos the signal to noise ratio (SNR) is increased. Also the dynamic range is expanded given the image quality improvement for the darkest areas.



*Top – part of a photo taken with Canon 650D at ISO1600 and exposure time 1 sec.*

*Bottom – stack of 11 different exposures, taken with exactly the same camera settings, no other processing was applied.*

You can also try to stack differently exposed photos instead of generating a HDR image. The result will be characterized by improved dynamic range, but cannot be called a High Dynamic Range radiance map, because the input photos are not calibrated and the luminance scale is untrue. Nevertheless the result may be pleasing in some cases.

**Note: Stacking is equivalent to merging equally exposed photos with the “True HDR” method, with “none” selectivity option selected.**



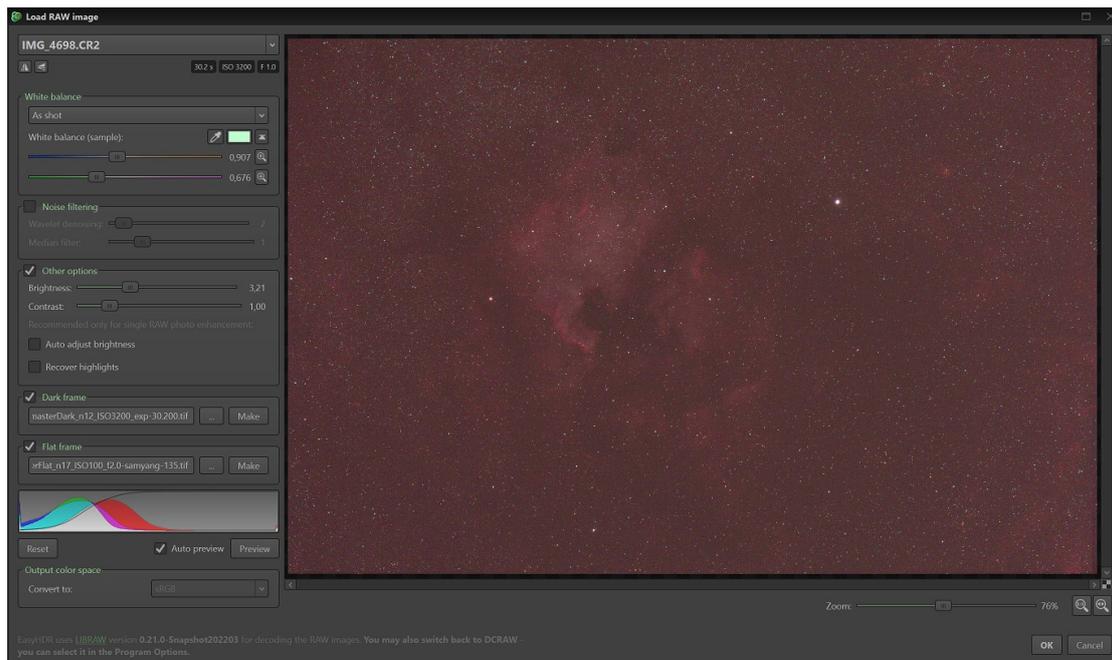
### 3.3.3. Astrophotography stacking

Processing of astronomy images (deep sky astrophotography) differs a bit from typical terrestrial, daylight photography. The main difference is the very low light that is being captured. It makes the effort very challenging. First of all the right equipment is needed – a tracker to guide the star movement and a camera and lens able to capture enough light in reasonable time, with low enough noise, not mentioning good atmospheric conditions, including low light pollution.

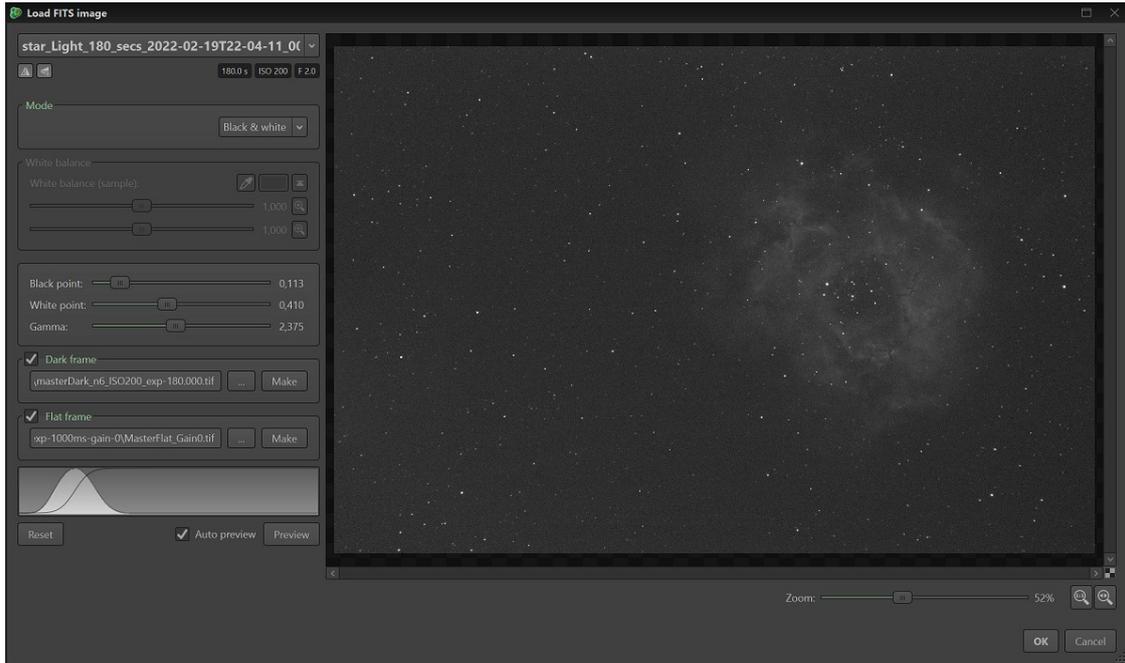
Normal DSLR cameras need to be specially modified for astrophotography, by removing their built-in IR filter. To fight with light pollution (if traveling to dark places is not always an option) it is possible to use specialized filters – either those that can cut parts of the spectrum typical for light pollution (i.e. UHC filter), or narrow band filters – like Ha, OIII, etc.

Instead of taking a single, very long exposure, it's way better to take multiple images (the more the better – easyHDR has limits though, it can handle up to 200 photos). The exposure settings – time and ISO/gain, should be selected carefully not to exceed the limits of the tracker and the camera. Those multiple images can be stacked together (averaged) in order to bring out much more detail.

Some noise is residual and the vignetting of the optical system (and dust grains on the image sensor) do cause the field to be unevenly exposed. The photos should be therefore calibrated by removing the dark and flat fields. EasyHDR can do both of that for RAW and for FITS images. It can also create master (stacked) calibration frames. For more information please go to the paragraph: 3.2.3.



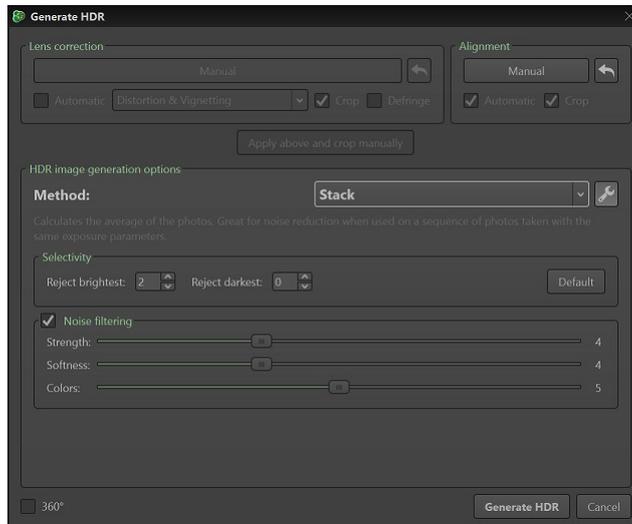
*RAW import dialog – corrected white balance & brightness, also the dark and flat frames are used for image calibration. Astro-modified Canon 650D, Samyang 135mm f2 lens and UHC filter (therefore the remaining magenta-cyan color tone) – rural sky.*



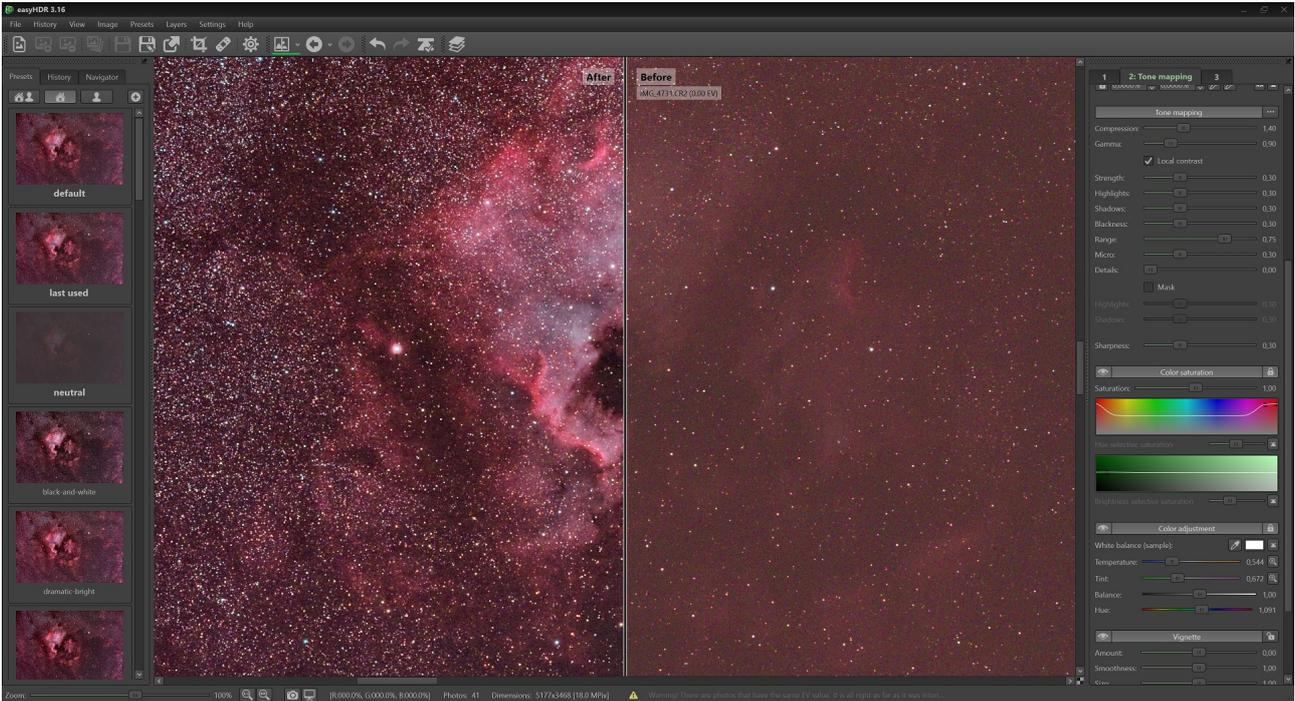
*FITS import dialog – corrected contrast and gamma, also the dark and flat frames are used for image calibration. Rosette nebula taken with black and white ZWO ASI 178MM, Samyang 135mm f2 at f4 and a Ha filter – city sky.*

When loading RAWs please do rather not use the noise filtering in the import dialog, or use just the median filter. Smothering too much there would cause the fine details to be lost.

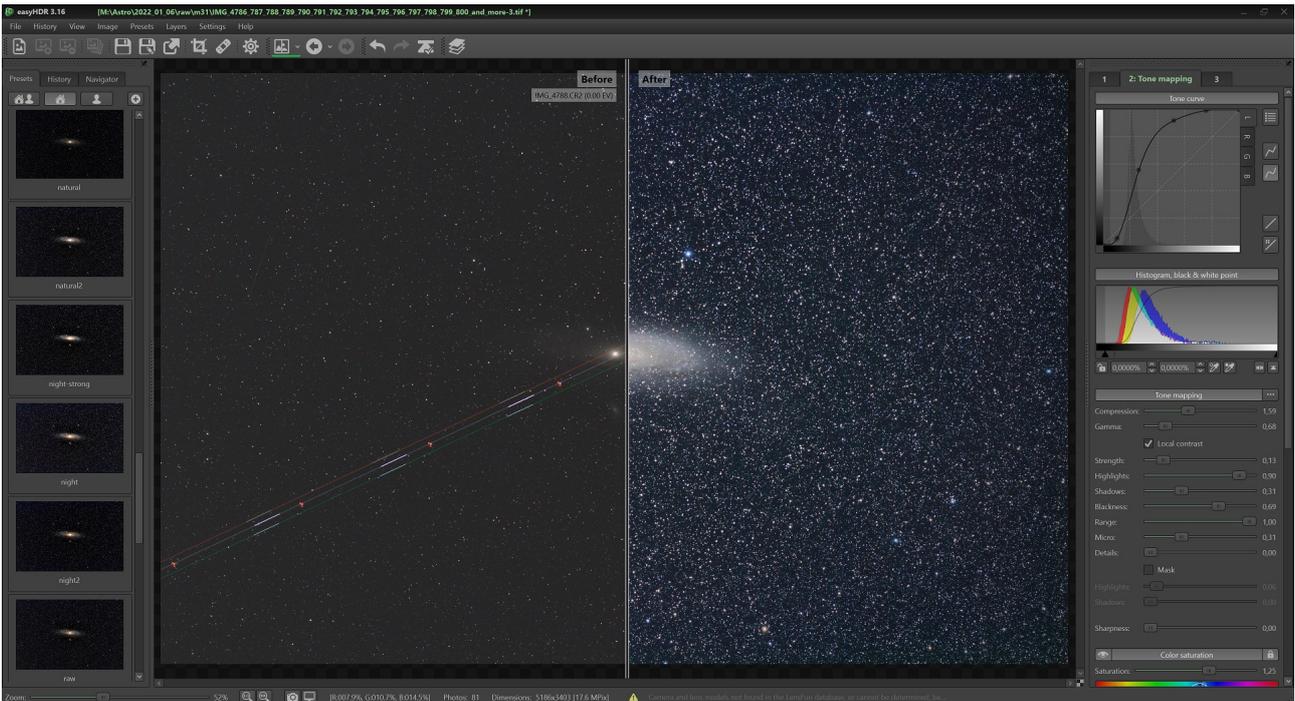
If some of your photos are spoiled by satellites or planes, use the “*Reject brightest*” option. It will let you use those photos in the stack.



*Typical settings for astrophotography stacking for RAWs. Please note the “*Reject brightest*”. EasyHDR also does auto alignment of deep sky photos.*



Comparison of a single, developed RAW image taken with astro-modified Canon 650D and Samyang 135mm f2 lens at 30 sec of exposure and ISO 3200 with a result of stacking and tone mapping of 41 such photos. The exposures should have actually be a bit longer, at lower ISO and there should have been at least 100 of them (alternatively, a better camera and lens could be used...).



Multiple input images were spoiled by either satellites or even a plane flying directly through the center of the view – here the frame with plane is shown for comparison. EasyHDR could still use those frames within the stack, by using the brightest pixels rejection.



## 4. Tone mapping

When the HDR radiance map is generated, the next step is to tone map it, so it can be displayed on the computer screen, saved in a typical image format or printed. Thanks to tone mapping the dynamic range of the photographed scene is preserved and fitted into the capabilities of display media (or storage formats). The resulting photo is in fact LDR (Low Dynamic Range), but it contains details present in the whole dynamic range of the photographed scene. Therefore it is wrong to call the result a HDR or either LDR image. It should be called a **tone mapped HDR radiance map**. Tone mapping does not only apply to the processing of HDR images. A digital camera applies tone mapping (with a global operator – in this case a simple curve compression) in order to fit the acquired (i.e.) 12-bit image pixel data into 8-bit per pixel (per channel) picture format.

When the HDR image is generated in easyHDR the preview size is automatically adjusted so the previewing process does not take too much time. After finding the best tone mapping settings just click the “Process all” button.

EasyHDR allows you to save and load tone mapping settings. It also has a preset selection feature, which allows faster access to most commonly used settings. To find out more about settings and presets please go to paragraph 9.

### 4.1. Global vs. local operator

There are 3 operator functions from which to choose. If the “Local contrast” and “Mask” checkboxes are unchecked only the global operator is being applied. By checking the aforementioned options the 2 available local operators can be enabled.

The global operator works the same for all pixels in the processed image, regardless on their position. The result for each pixel is computed by using only the operator parameters set by the user and the pixel's value. This ensures that there will be no brightness inversions in the output photo, leaving it as natural as it is possible, while fitting the selected scene dynamic range into the display media capabilities. No brightness inversions mean that the areas that were brighter than others in the real, photographed scene, will remain brighter. This limitation makes it very difficult to compress the entire dynamic range, without washing out colors or losing local contrast.

The local operator, on the other hand, is spatially variable. The local parameters are computed for each pixel independently while taking its neighboring pixels into account. Therefore the local operator is capable of greater contrast reduction on wide scale, at the same time preserving local contrasts (details) and colors. When the effect is too strong, however, the photo may become unnatural. It may sometimes be anticipated – to achieve a dramatic result, but also sometimes an unwanted “halo effect” can show up.

The local operator works similarly to local, chemical adaptation in the human eye, which is one of the factors that make the human vision capable of sensing very wide dynamic range. Note that in classical digital photography only the global operators are used (i.e. gamma pre-processing inside a digital camera).



The parameters for the global operator in easyHDR are:

- Compression,
- Gamma,
- Contrast (histogram clipping),
- Color adjustment and color saturation (hue, white balance and selective saturation),
- Tone curve (L, R, G and B channels).
- 3d LUT color grading.

for the "Local Contrast":

- Strength,
- Highlights,
- Shadows,
- Blackness,
- Range,
- Micro,
- Details

and for the "Mask" local operator:

- Highlights,
- Shadows.

## **4.2. Global Operator: Compression, Gamma & Saturation**

**Gamma** curve adjust is a function available in most image editing software. It brightens or darkens the photo, but at the same time it does not cause any image data to be lost, by clipping the pixel values to black or white. It applies a non-linear (gamma curve) transformation that compresses the whole dynamic range of the processed photo. When the value is higher than 1.00 the pixel luminance in shadows is amplified more than in the bright areas, therefore the compression is achieved. Setting the values below 1.00 makes the photo darker and also the contrast gets stronger.

The “**Compression**” function applies a similar non-linear transformation as gamma adjust. However as opposed to the gamma function, it preserves and even increases the color saturation. See the example below.

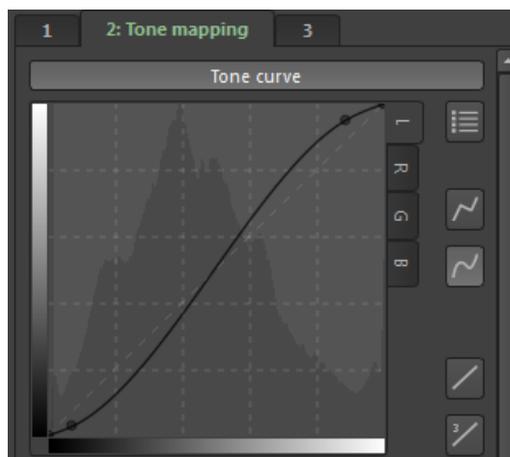
Both parameters should be used together in order to get best results. In example, if the photo gets too bright after the “**Compression**” is increased, it can be darkened with the “**gamma**” setting.



a) Photo tone mapped with default settings (Gamma = 1.00, Compression = 1.00), b) Gamma = 1.80, c) Compression = 2.20, d) Gamma = 0.80, Compression = 2.20.

### 4.3. Global Operator: Tone curve

Tone curve adjust is a powerful, but simple in use tool that is implemented in almost every image editing software. It offers much more flexibility than the gamma setting described above. The user manually shapes, using special knee points, the curve that is used to compress the dynamic range of the photo. The points can be created by simply clicking in the curve area with the left mouse button. Knee point removal is done by pressing the right mouse button while the cursor hovers over the selected point.





The curve tool that is implemented in easyHDR operates on HDR rather than LDR (Low Dynamic Range) image data, as it is done in typical photo editing software. Because of that, operations can have different, much better effects, i.e. brightening shadows does not necessarily mean boosting noise level (of course there must be enough shadow information in the HDR composite).

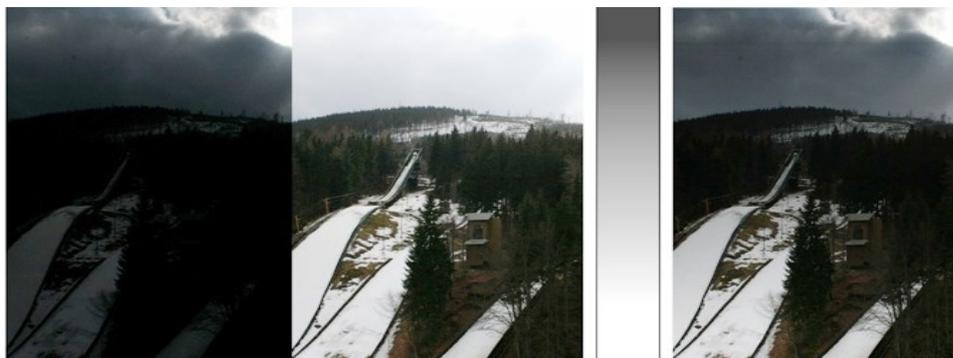
The curve tool does not make any changes to the output image when it is in the reset position (straight line). It gives enough flexibility when there are 2 or 3 knee points.

EasyHDR allows editing curve either for pixel luminance or for each (red, green and blue) channels separately. There is a set of several ready to use presets that can be the starting points to further curve shaping – to access them just press the “star” button.

#### 4.4. Local Operator: Mask

The "Mask" operator works similarly to a gray filter mounted in front of CCD or CMOS device during the exposure. The light coming from the photographed scene is focused on the surface of the imaging sensor, but the filter attenuates it in certain regions more than in the other. The idea is similar to using a gradient, gray filter mounted in front of the camera lens.

In case of HDR image processing, the High Dynamic Range radiance map that is recovered from a sequence of photos is the estimated irradiation of the surface of the imaging sensor during the exposure. EasyHDR calculates the complex gray filter mask based on the input HDR image and applies the attenuation. The brighter, large-scale areas are attenuated stronger, than the shadows. Since the mask does not affect the small-scale luminance variations, the local contrasts (details) are preserved – they are not flattened.



*A linear gradient gray filter may be enough in case of the simple scene as shown here. The two photos on the left are real single shots of the same scene taken with different exposure times. On the right side there is a simulated view as if the photo was taken with a gradient, gray filter.*

The strength of the mask operator is controlled with the "**Highlights**" and "**Shadows**" parameters, selectively for the bright and dark parts of the image. Higher values for highlights mean stronger attenuation of the bright areas (they get darker). Higher values for shadows mean that the darker areas are more strongly intensified (get brighter).



In case of both photos:  $\gamma = 1.00$ ,  $\text{compression} = 1.80$ .  
a)  $\text{Highlights} = 0.00$ ,  $\text{Shadows} = 0.00$ , b)  $\text{Highlights} = 0.40$ ,  $\text{Shadows} = 0.40$ .

#### 4.5. Local Operator: Local Contrast

This operator compresses the global dynamic range of the photograph while enhancing the details at local level. It gives a lot of possibilities ranging from just slight improvement of contrasts (to give better realism) up to achieving very dramatic results. The “local contrast” operator is very sensitive, so when used with strong settings it may amplify noise, especially if the input images are of low quality (i.e. taken with high ISO, with a poor digital camera, or saved with high JPEG compression settings). In case of processing HDR image sequences please keep in mind that the noise level might be lower if the HDR sequence of images covers the entire dynamic range of the scene – so if there are no parts of the scene that are not properly exposed in any of the photos. Noise reduction is also achieved by using “normal” selectivity in case of the *True-HDR* method. Even lower noise level should be possible when using the *Smart Merge* method.



a) No local contrast applied, b) Local contrast applied  
By using the “local contrast” operator we achieve greater compression of the dynamic range of the photograph, while the details are not only preserved... they are enhanced.

The “Local Contrast” operator is controlled by a number of parameters. The “**Strength**” defines the power of dynamic range compression and local contrast boost. The “**Range**” controls the extent of the local detail sensing. The higher is the value the bigger areas of the photo are being treated as “local”.



There is also a pair of parameters that control the brightness- and darkness- sensing thresholds of the operator. The **“Highlights”** setting defines how strong should be the contrast enhancement in the brightest parts of the photograph. At the same time it little affects the darkest parts. The **“Shadows”** on the other hand controls the level of dynamic range reduction in the dark areas.



a) Strength = 0,50, highlights = 0,00, shadows = 0,30, b) Strength = 0,50, highlights = 0,60, shadows = 0,10. By increasing the **“highlights”** parameter the clouds (which are the brightest in this photo) get more dramatic, while by decreasing the **“shadows”** setting the darkest areas are more strongly amplified.

If the signal to noise ratio in the darkest parts of the photograph (i.e. deep shadows or dark, night sky) is too small, then it might be desirable not to enhance those parts so much because otherwise the noise level would be unacceptable. Not enhancing the shadows too strongly could also preserve the feel of realism. In order to achieve that please try increasing the **“Shadows”** value as well as **“Blackness”**, which controls the threshold of shadow deepness.



a) Blackness = 0,30, b) Blackness = 0,60.

Another parameter, **“Micro”**, controls strength of the smallest details enhancement. Similar parameter - **“Details”**, on the other hand, enhances the smallest details much more selectively, not boosting noise on plain surfaces (like blue sky), but doing contrast boost just around most distinct edges. It also does not introduce a halo effect. The **“Details”** works best in combination with high **“Range”** values.

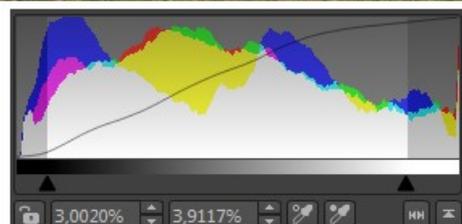
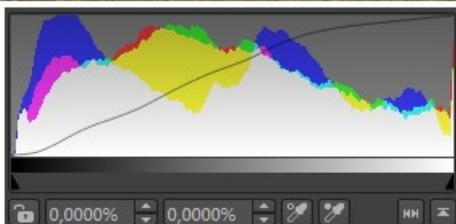
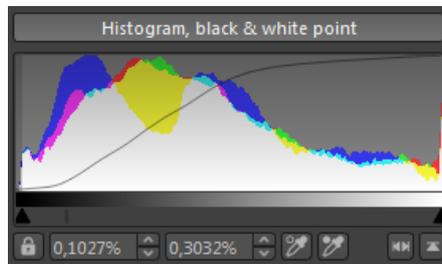
By using the **“Mask”** operator in combination with the **“Local contrast”** it is possible to further boost brightness in the shadows and to attenuate the brightest parts of the image, while not bringing up noise so much as it could be happening with the **“local contrast”** alone .



#### 4.6. Black & white clip (contrast)

The human eye is not able to "see" the whole dynamic range of every scene, so if you want to achieve a natural effect it is sometimes good to clip some shadows to black and some bright areas to white. By losing some information in those areas you get better a looking, more natural image with better contrast. By default 0.1% of the darkest pixels are cut to black and the 0.2% of the brightest are clipped to white. This makes the result look much more natural and not washed out, while sacrificing only a small fraction of the dynamic range.

To set the clipping points just move the markers over the histogram or manually set the desired cut-off pixel percentage, for black and white separately. There is also a possibility to set the clipping points by sampling the image with eyedropper tools. In order to use the eyedroppers click on the appropriate icon and then select the desired point on the image. Using left mouse button selects the point from the currently viewed result image, while using the right mouse button chooses the point from the input HDR image.

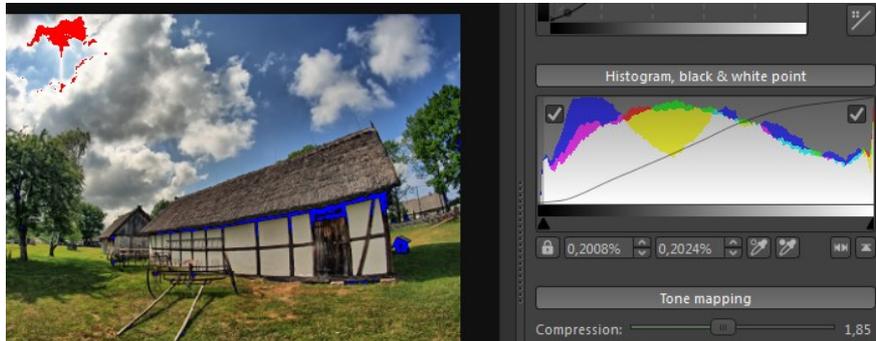


*Example of the histogram clipping. The entire available dynamic range is preserved in the photo a), while in case of photo b) the 4,7% of darkest pixels are clipped to black and 1,8% of the brightest pixels are clipped to white. This means that there is a loss in dynamic range, but at the same time the photo has higher contrast.*



If the padlock icon is “locked”, the clipping is done automatically to the preset percentage values when other tone mapping parameters are changed. When it is in the “unlocked” position, the markers always stay in the same place, but you can still move them manually.

When mouse cursor hovers above the histogram, two checkboxes are shown. When checked, the under and/or overexposed areas are marked on the preview image with blue and red color.



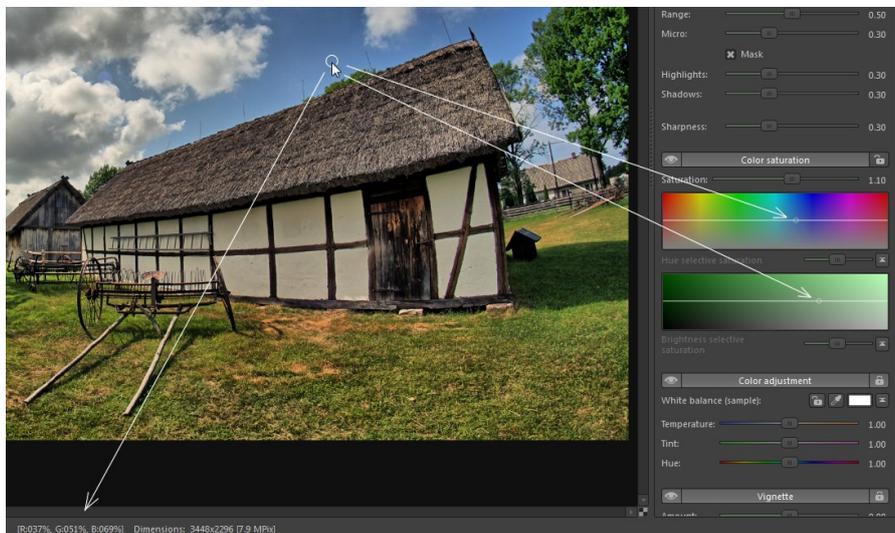
Marking the under and overexposed areas.

Click on the histogram to toggle the mode – right mouse button switches between RGB and Luminance mode, while the left mouse button selects linear or logarithmic Y-axis.

#### 4.7. Color saturation

EasyHDR allows advanced control over color saturation. There is not only global saturation setting, but there are also two selective tools:

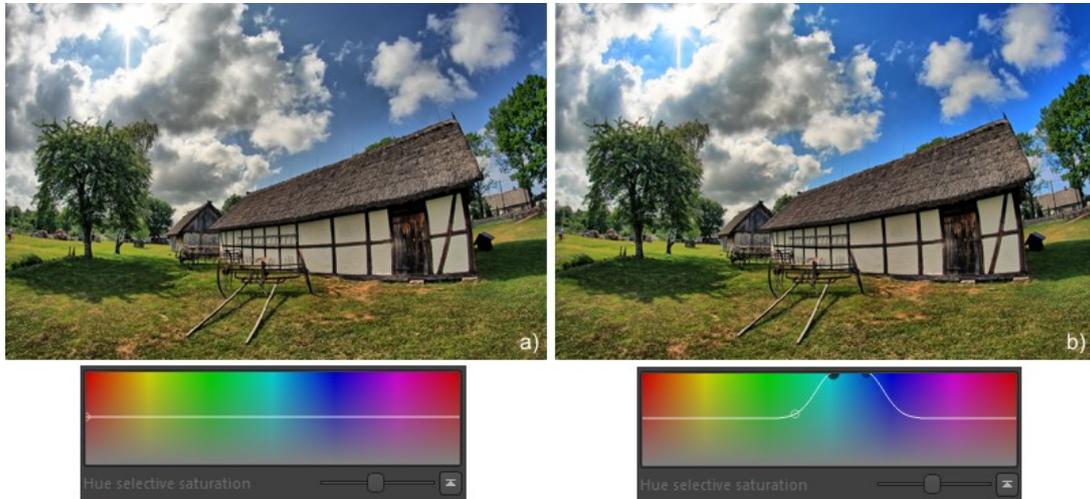
- saturation selective by brightness,
- saturation selective by hue.



The small circles mark the currently pointed pixel on the brightness and the hue axes. The status bar shows the pixel value under the cursor.



The horizontal axes have the meaning of brightness and hue respectively. When the curve is in the middle of the gradient field (as depicted above), the saturation is not altered. Moving the curve up means boosting saturation for the selected types of pixels, while lowering the curve means selective decrease of saturation.



a) Saturation settings at reset position, b) Increased saturation for the blue color.

The user has control over the shape of the curve by the mean of control points. Each of them defines a separate Gaussian function for which it is possible to set sigma (smoothness) parameter. If the separate curves are close enough to each other, they are glued together, so it is possible to draw straight lines. In order to add a new control point just click with the left mouse button on the tool. To remove a point use the right mouse button.

One of the more advanced possibilities that the selective saturation gives is leaving just a single color tone and making the rest of the photograph black and white.



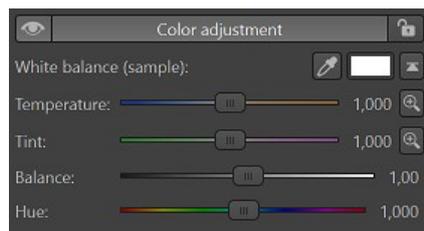
Saturation has been reduced to zero for all colors apart from red and violet.



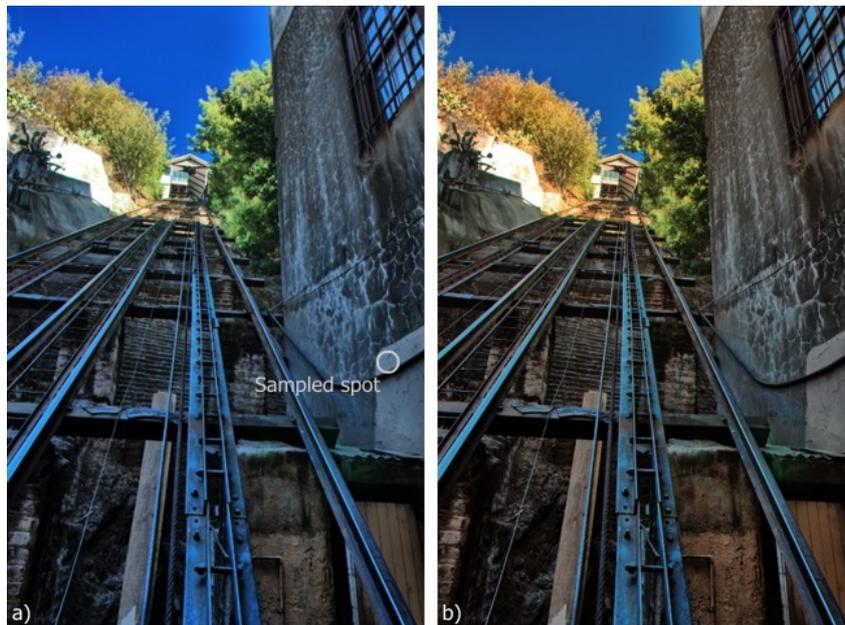
### 4.8. Color adjustment

The camera not always uses the perfect white balance settings when the photos are taken. EasyHDR allows you to fix the color tone at the tone mapping step. Two settings fulfill this task: “**Temperature**” and “**Tint**”. The first controls the blue-orange tone, while the second of them allows green-magenta balance. The sliders offer fine-tuning mode, which can be enabled by clicking the zoom buttons next to them.

Sometimes the shadows and highlights require slightly different temperature and tint correction. The “**Balance**” slider allows to tune the selectivity.



If there is a spot on the photo that should be neutral, you can sample it with the eyedropper tool. EasyHDR will set the temperature and tint to fulfill the requirement.



a) Tone mapped HDR created out of 5 photos that had some bluish tint due to bad white balancing done by the camera, b) white balance corrected automatically by sampling the marked spot.

The “**Hue**” setting, when used very delicately, can help with achieving best color temperature correction. When tweaked more strongly it creates unreal effects by shifting the colors. That may be useful if you want to achieve special coloring effects.



#### 4.9. Vignette

Vignette tool can be used either to further reduce vignetting caused by camera lens (although it's better to do it using the Lens Correction tool), or to apply a creative vignetting effect. There are a couple of parameters that give very wide range of possibilities:

- **Amount** – positive values mean dark vignetting, while negative cause brightening of the edges. By setting the negative values, the user is able to compensate for dark edges caused by the camera lens.
- **Smoothness** – the higher the value the smoother is the edge of the vignette.
- **Size** – distance from the middle point, to the edge of the vignette.
- **Roundness** – controls the shape. Value -1 means that the vignette is a rectangle with the aspect ratio of the image, with the corners rounded a bit; 0 is an ellipse with aspect ratio of the image and +1 is a circle. When you are fixing the vignetting caused by the lens, you should set roundness to 1.



a) No vignette applied, b) Vignette applied (Amount = 2, Smoothness = 1, Size = 0.75, Roundness = -0.75).

#### 4.10. 3d LUT – color grading

Apart from the described before, standard color grading tools – like the RGBL tone curves, saturation, hue, temperature and tint, easyHDR allows applying also predefined 3-dimensional color Look-Up Tables (3d LUTs). The 3d LUT is a table that maps RGB colors (triples of R, G and B values) into other RGB colors, allowing totally arbitrary change of color hue, tone, saturation, brightness, etc. The color transformation depends only on input pixel's RGB value and does not vary spatially.

The table cannot just map any possible combination of R, G and B values, especially for 16- or even higher bit-depth of pixel values, because such a table would have to take a lot of memory. The colors not defined in the table are therefore interpolated, but the LUTs are typically created in a way that allows good interpolation results.



### 4.10.1 Importing 3d LUT files

EasyHDR is not an editor nor creator of 3d LUT files, it can only import and use such files (in the \*.cube format). Those files can be created with specialized software, or purchased from third parties. There are also many freeware 3d LUTs available for download on the Internet.

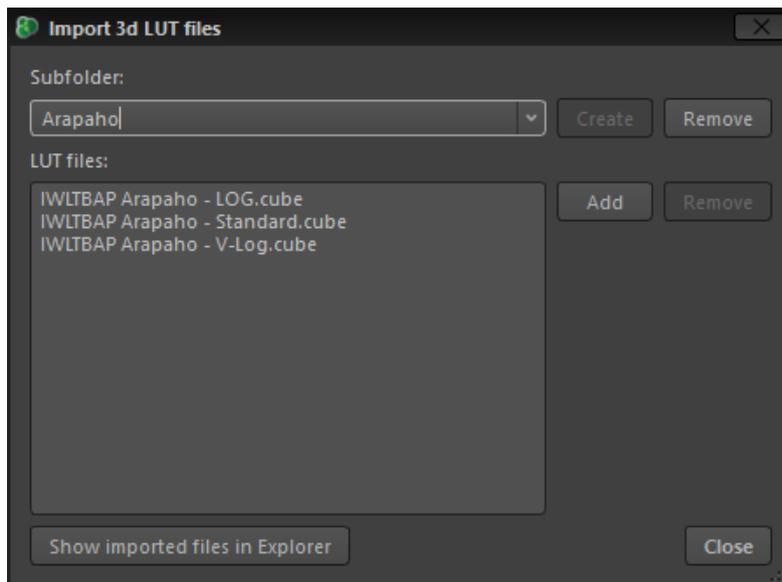
EasyHDR recognizes files that are copied to a special location:

- Windows: `C:\Users\[name]\easyHDR 3\3dLUT-imports\`,
- macOS: `/Users/[name]/Documents/easyHDR3/3dLUT-imports/`.

The files can be grouped in subfolders (one level of depth).

In order to import the cube files you can just copy them manually to the above mentioned folder, placing them in different subfolders or in the main directory. Alternatively you can use the “Import” dialog (“Import” button in the 3d LUT selector toolbox).

The dialog allows creating and removing the subfolders as well as copying the cube files into the selected subfolder, or removing the selected files. In order to create a group just type its name in the “Subfolder” line edit and click “Create”. The already existing subfolders can be selected from the drop down menu. The LUT files that exist in the selected subfolder are shown on the list. New files can be added or the selected files can be removed.



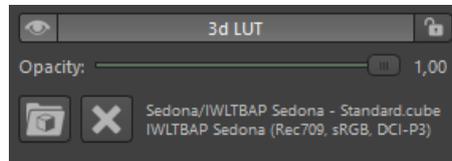
*3d LUT file import dialog.*

### 4.10.2 Applying 3d LUTs

In order to apply a 3d LUT, the file has to be loaded. To do it, click on the leftmost button. The LUT selector tool box will appear in the bottom of the workspace.

The LUT can be cleared by hitting the “X” button. It is also possible to apply the LUT with smaller strength by controlling the opacity.

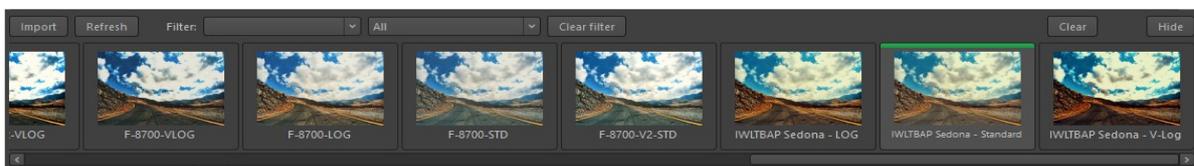
**The LUT selection is stored in easyHDR presets. However, such a preset will work only if the LUT file is present within the imports. That applies also to the project files – they do not contain the LUT itself.**



*The 3d LUT group in the tone mapping tab.*

The LUT selector tool box shows thumbnails with the 3d LUTs applied. They are generated when the selector is shown. If the base image changes significantly, when the tone mapping parameters are altered, you may hit the “Refresh” button to re-generate the thumbnails.

To make searching simpler, it is possible to filter the shown thumbnails by typing part of the file name, or by selecting a group (subfolder).



*The LUT selector tool box.*



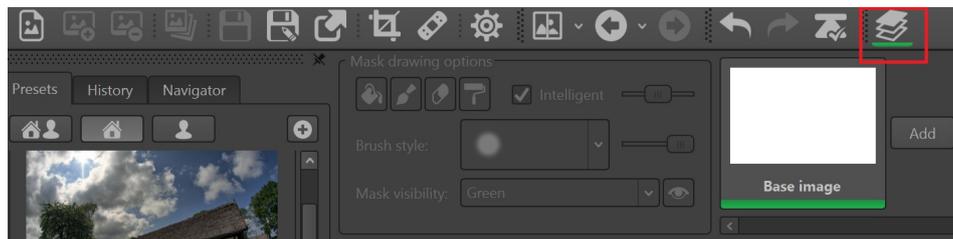
*The main window with the LUT selector bar shown. A selected LUT is applied.*



## 5. Layers

The normal approach is to process the whole photograph with single, user selected tone mapping settings. Sometimes however you may want to process some parts differently – i.e. get more dramatic sky, or make one shadow brighter, or even to change color of something, while not altering the rest. In order to do so, you can process the photo several times (with different tone mapping settings) and later blend those results with Photoshop or GIMP, masking the regions manually. EasyHDR brings layers feature to give exactly this functionality, but with something more – live preview and possibility to set tone mapping settings individually for each layer at any step of processing.

When a new project is started the layers are always disabled and the program allows processing the whole image with just one set of tone mapping settings. In order to enable the layers, easyHDR must be already in the tone mapping mode. Go to the main menu → *Layers* → *Enable layers*, or press the "Layers" button in the tool box.



*Layers enabled.*

You can easily turn off the layers mode by selecting *Layers* → *Disable layers*, or pressing the tool box icon again. The layers themselves are not removed and the settings are not lost, they are just not applied to the final result nor the preview.

### 5.1. Managing layers

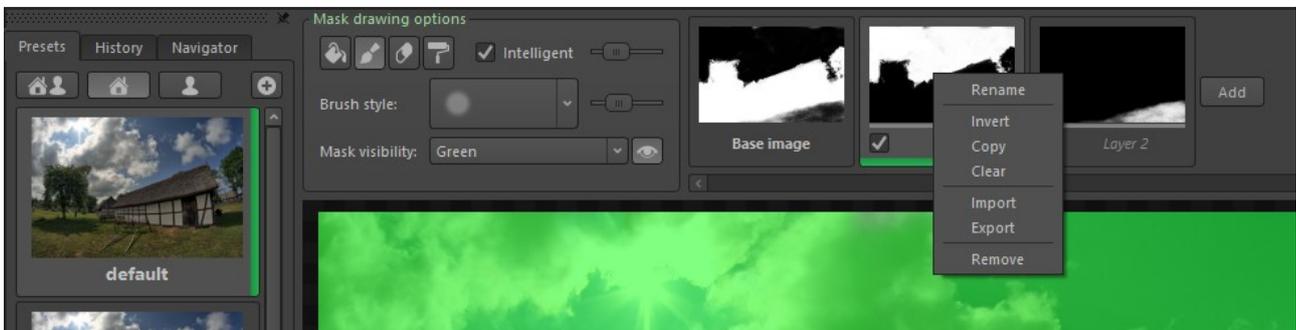
Initially, there are no layers. Just the "Base image" item is selectable. To create one, click the "Add" button. The selection is immediately switched to that new layer item, which means that you can already paint the mask on the image and that all the tone mapping settings visible in the right panel are relevant to that layer. When a new layer is created, the current tone mapping settings are copied and applied to it. There can be up to 9 layers, but please note that more of them mean more memory usage and longer processing time.

The layer's global opacity is user-definable. In order to change it, hover with mouse over the thumbnail – a slider is shown. When the mouse cursor is away from the item, the opacity value is depicted with a thin bar just below the thumbnail.



Layer opacity

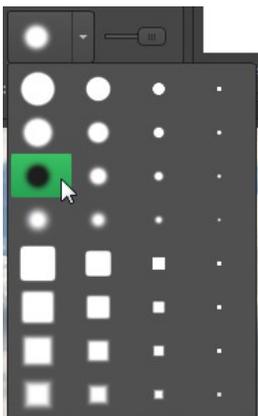
Each layer can be individually enabled or disabled (see the check box next to the layers name). It allows easy comparison of the result with and without the layer applied. If you feel it is helpful, the layer's name can be changed. Just click on the name to edit it. More options are available in the item's context menu. It is possible to invert the mask, clear it, or delete the selected layer. It is also allowed to export and import the mask (in PNG file format), so that it can be edited using an external application, or stored for later use.



Layer item context menu.

Switching between the active layers and the base image is done by just selecting the items.

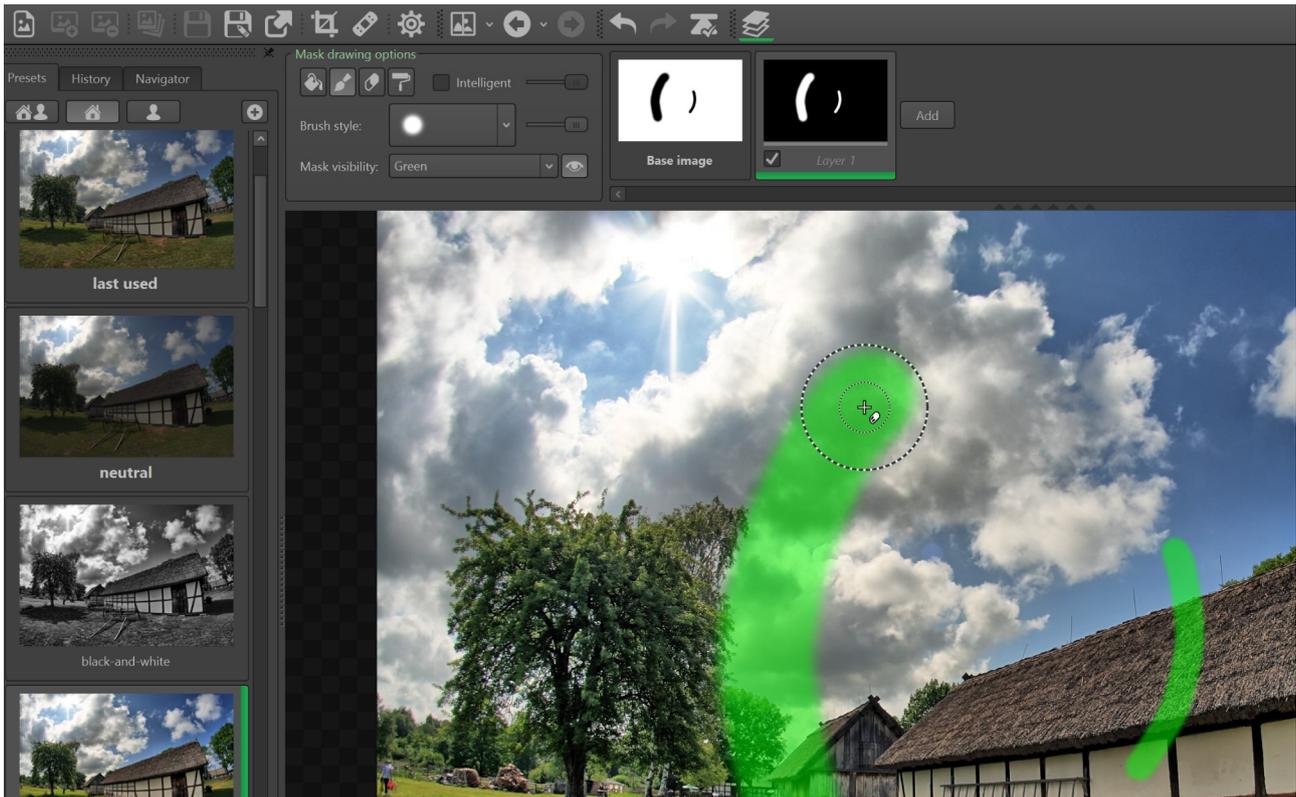
## 5.2. Painting the mask



When any layer (other than the base) item is selected, the mask can be painted on it. It can be done with either brush, paint bucket or interactive gradient tool. There is also a separate eraser brush. Erasing can also be achieved with the brush itself or with the paint bucket – the *Ctrl/Cmd* key must be held.

When the brush or the eraser brush is selected, you can choose its style. The brush size changes automatically with image zoom factor, but there are also 4 different default size classes.

The slider next to the brush style drop down menu allows setting opacity of the brush stroke.



*In case of both brush strokes the same brush style was used, but they were done at two different image zoom factors. The stroke to the left was painted at 10% zoom, while the one in the right when the zoom was 30%.*

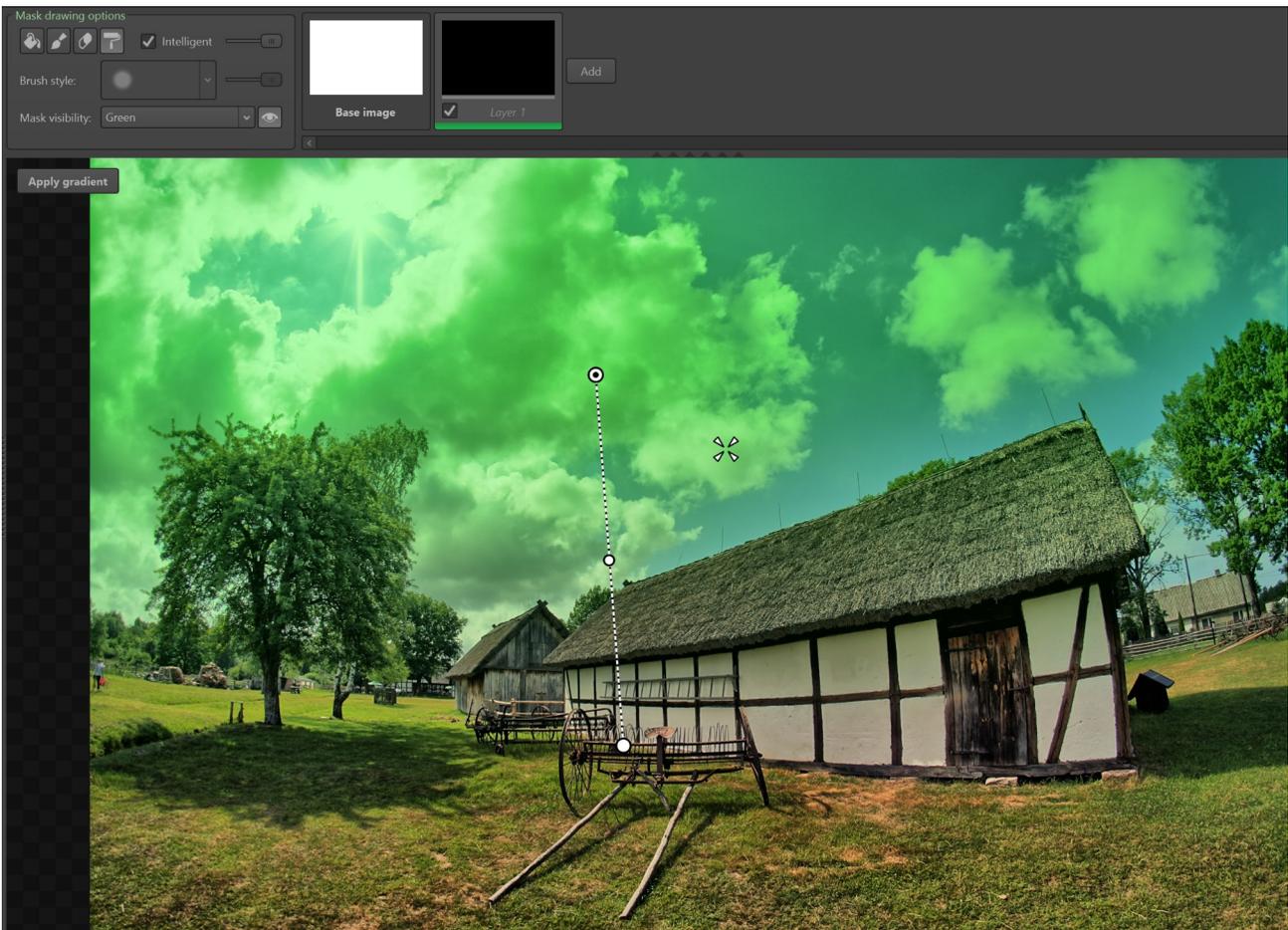


*Mask painted with the intelligent brush. The painting was started in the spot marked with the cursor.*



There is a special mode of painting available. When the "Intelligent" option is selected, the opacity of the brush depends on pixel values of the HDR image. The opacity is higher if the pixels under the brush are more similar to values sampled when mouse button was clicked (the sampling point is marked with a cross). It means that with long strokes you can limit to covering similar areas like for example the sky. The slider next to the "Intelligent" option allows control over the threshold of similarity. The intelligent painting mode is also available with the paint bucket tool (and actually only then usage of this tool really makes sense). It works also with the eraser.

The interactive gradient tool gives a possibility to paint image-wide areas with a smooth gradient. The starting and ending points are set with a mouse on the image. There is also a possibility to modify the gradient's middle point with the third pin. When the "Intelligent" mode is used, you can also move the sampling point (marked with a cross). In order to apply the gradient just press *Enter*, or click the button that appears in the top left corner of the workspace. For cancellation, hit *Esc*, or change the painting mode. The *Space* key can be used to invert the gradient.



*Gradient tool used to select the clouds, intelligent mode is enabled.*

By default, the mask is visible as a green area over the background image, with 50% opacity. The green color may sometimes be an obstacle, so there is a possibility to switch it to red, or blue. There is also an option to show just the mask as a black and white image. The mask may finally be also made invisible, which allows live preview while painting. The mask is automatically made invisible, when mouse cursor hovers over the preset/history panel or the tone mapping panel.



### 5.3. Tone mapping settings

The tone mapping settings visible in the panel on the right hand side are switched accordingly to selected layer item. Any change is applied to the selected layer only. When a preset is selected, it is also applied to the currently selected layer. The only exception is vignette. For all the layers the vignette settings are assumed the same as for the base image.

Any change of the tone mapping settings for each layer is stored on the history list. The changes concerning layers are marked with "L[n]", where "[n]" is the layer number. When a new layer is created, a "L[n]: START" record is added and it holds the initial settings. When a layer is deleted, the history entries for it are removed.



*Example - the layer's mask was painted using the intelligent brush to cover just the sky. Then the layer's settings were changed to make the sky more dramatic and desaturated.*

### 6. Image transformations

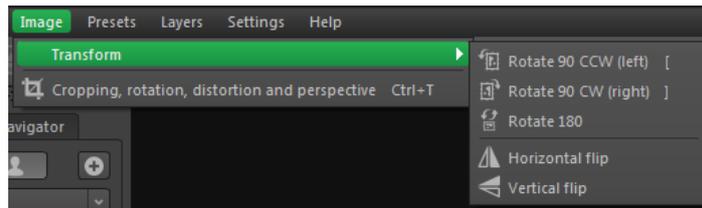
The image transformations (main menu: *Image*) can be done at any step – right after photos are loaded, during tone mapping or post-processing. It is possible to rotate the photo by 90° left, or right, rotate by 180° and flip it horizontally and vertically. There is also a combined, interactive crop, rotate, distortion and perspective function. Rotation lets you fix tilted photos, distortion allows straightening lines that should be straight and perspective gives even more freedom to visually correct composition, (i.e. in case of architectural photography).

When in cropping mode, an additional bar with options is shown. You can find there crop area size with a possibility to block the aspect ratio, rotation angle, distortion and perspective factors. Those values may be edited there, but they can also be set interactively on the image itself:



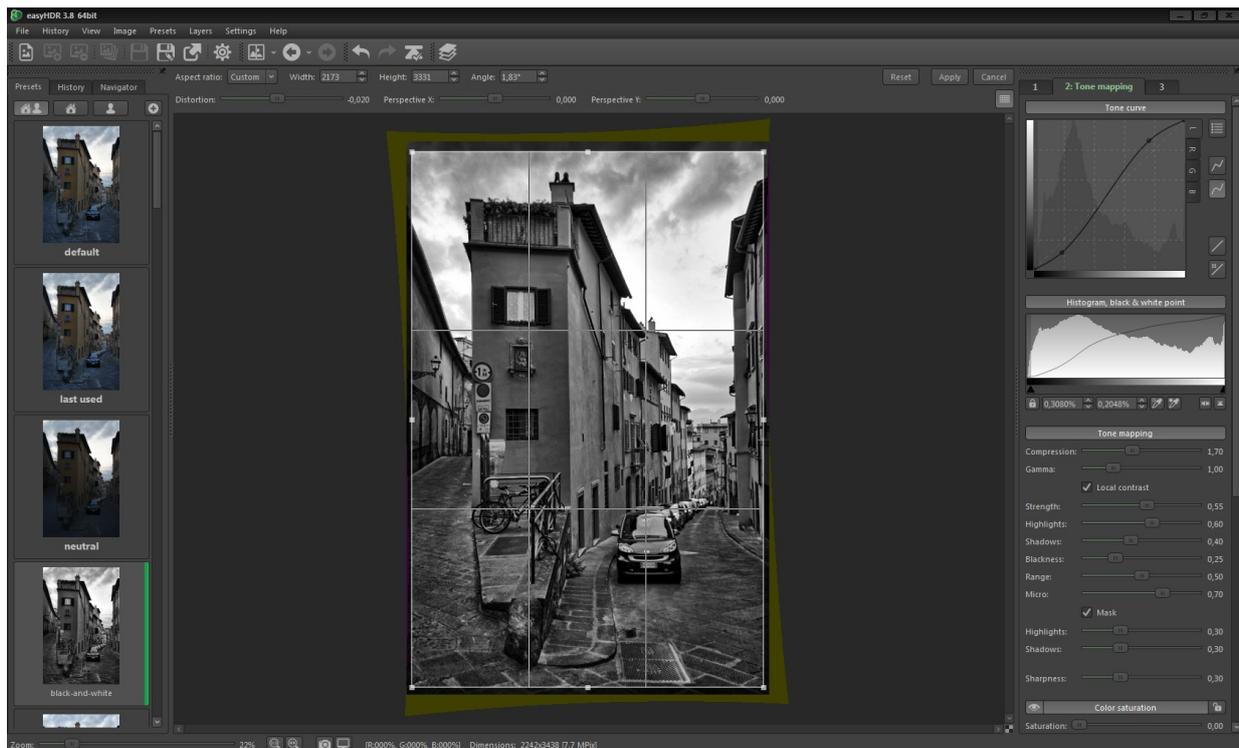
- hold down *Shift* key and drag the image with mouse to set the rotation,
- hold down *Ctrl/Cmd* key and drag the image with mouse to tweak distortion,
- hold down *Alt* key and drag the image with mouse to set horizontal and vertical perspective.

The crop area can be resized by grabbing and moving markers on its edges and corners. To move it, just drag it with mouse. A click away from the crop area starts new selection and a double click away (or *Esc* key) abandons the cropping mode without applying any changes. To accept transformation click the *Apply* button or double click inside of the crop area.



*Image transformation options.*

**Note: it is not possible to undo the cropping and free transformation. Please also note, that applying it several times causes degradation of image details. It's because of anti-aliasing filtering applied.**

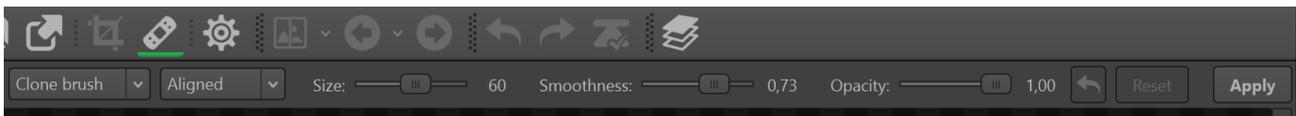


*Photo corrected for distortion, perspective and rotation.*



## 7. Clone/healing tool

Whenever any small object spoils the photograph (like people standing in the distance, in a landscape shot, or there is a dust particle on a sensor right in the middle of the clear blue sky), the clone/healing tool can be used to remove it. The tool is a standard option in the typical photo editors, but having it available at tone mapping stage in HDR processing software allows you to skip further post processing and achieve perfect results using easyHDR alone. Also, not being distracted by the existence of the rogue dust particles, you can find better tone mapping settings.



*The clone/healing tool options.*

The tool, as the name suggests, offers two options:

- **Clone brush** – copies the pixels directly from a different location,
- **Healing brush** – copies pixels from a different location, but at the same time applies color and tone matching, in order to better fit the surroundings.

In order to start painting, you first need to mark the source position. You can do it by just clicking mouse button with *Ctrl/Cmd* key pressed. Then, simply start the stroke over the object to erase.

For both of the brushes it is possible to define the method of alignment:

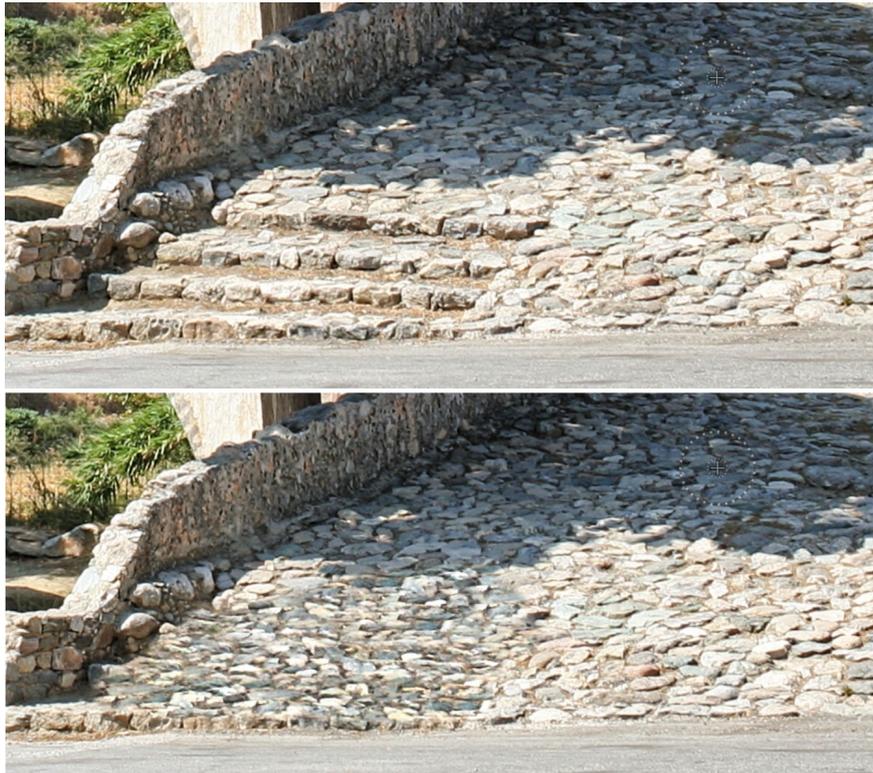
- *Not aligned* – the source position is reset to the initial location, when each stroke begins,
- *Aligned* – the source is always equally separated from the destination, as it was when the first stroke was started,
- *Fixed* – the source is stationary.

The base size of the brush, along with the smoothness and opacity can be controlled with sliders. The size of the brush, as visible on the screen, stays the same while you zoom the image in and out, which means it varies in respect to the image's dimensions.

The **clone brush** makes direct copying of the pixels, which requires the source and the destination to be matched in terms of brightness and color, otherwise the patch will be clearly distinguishable. In most cases it can be achieved by copying some nearby area, but this can cause visible artifacts like doubled patterns (i.e. two or more same pebbles lying on the ground). Human brain easily detects such unusual errors, therefore you need to try copying from various nearby areas.

The **healing brush** shouldn't be used to copy and fix areas with large variations of brightness or colors, like around distinct edges. However, it allows copying areas that look similarly and the object to remove is relatively small as compared with the brush size. For example, you can copy the ground pattern from a shadow and fix something in the sunlit part, or remove a small dust particle from the sky using a larger brush.

When the object to erase is large and/or very different from the surroundings, you may try to roughly "fix" it first with the clone brush, in order to flatten the area's look. Then, do the final touches with the healing brush, by copying patterns from various parts of the photo.



*The stairs have been removed with the healing brush, with the stones taken from the shadow.*



*The clone brush is not able to do anything good here with the source pixels taken from the shadow.*



*The clone tool is just the right choice when removing this road sign.*



*Before repair.*



*After repair – removed: person, cable, road sign, bench, fences and the energy pole.*



The clone/healing tool can be used only at the tone mapping stage. When it's enabled, changing the tone mapping parameters is disabled. It's also not possible to draw layer masks, or do image transformations. Every stroke can be undone by pressing the *Undo* button, or by pressing *Ctrl+Z*. The *Reset* option undoes all the strokes made since the tool was enabled. When the tool is turned off, all the changes are also lost. Pressing *Apply* means accepting the changes, clearing up the undo queue and closing the tool. Should you need to start again, just go back to the *HDR generation* and start over without the need of reloading (incl. lens correcting and aligning) the source photos.

## 8. Post processing

If you are finished with tone mapping, you may do some post processing to the output image before you save it. You can use 4 filters: Gaussian blur, sharpen, median and bilateral filter. EasyHDR allows also manipulation of color tones.

After filtering is applied, it is possible to undo (in all cases excluding cropping). If you want to reset all applied post processing you can simply go back to tone mapping step and reprocess the whole image.

### 8.1. Gaussian blur (smoothing)

You can use Gaussian blur filter to introduce some neat smoothing effect to your photo. The higher the "**Sigma**" value the more blurred is the result. Use the "**Opacity**" setting to mix the blurred result with the input.



a) Input photo: 8MPix, b) Sigma = 6.0, opacity = 100%, c) Sigma = 6.0, opacity = 50%.



### 8.2. Unsharp mask (sharpening)

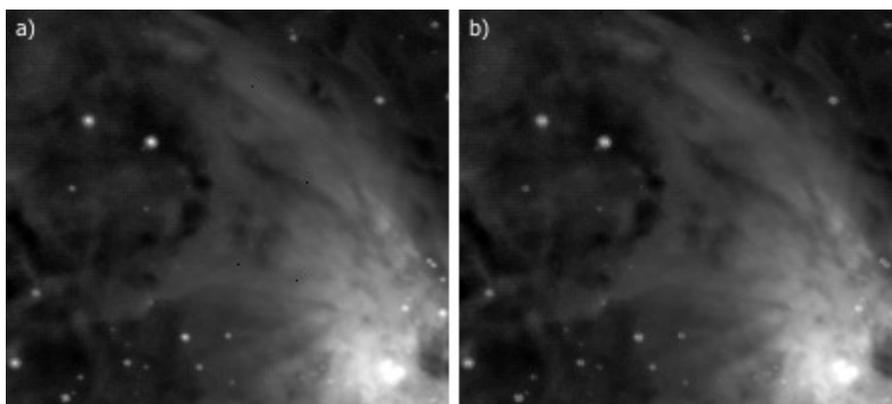
The sharpening tool is a must in every image editing software. EasyHDR allows sharpening at the tone mapping level, but also in the post processing step. You can change three parameters: "**Sigma**" – extent; "**Amount**" – strength of the effect; "**Threshold**" – cutoff level.



a) Input photo, b) Sigma = 1.0, amount = 100%, threshold = 0.00,  
c) Sigma = 3.0, amount = 100%, threshold = 0.05.

### 8.3. Median filter (noise reduction)

If you want to remove salt & pepper noise like hot pixels and you don't have a dark frame, this filter will be just what you need. It scans the masked neighborhood of each pixel and exchanges the luminance of the pixel with the computed, median (most probable) value. You can set the matching threshold, so only pixels that are significantly different than their neighbors are affected. It causes the noise to be wiped out while the other areas of the photo are left unchanged.



a) Input photo – Orion nebula, b) some dark bad pixels are easily removed with the median filter.  
Threshold: 0.12, horizontal bar – 5 pixels.



#### 8.4. Bilateral filter (noise reduction)

The bilateral filter is a great noise removal tool that blurs noise while preserving edges. The example below shows how the filter works. The low-scale areas similar in luminance are blurred, while the significant edges are not affected.

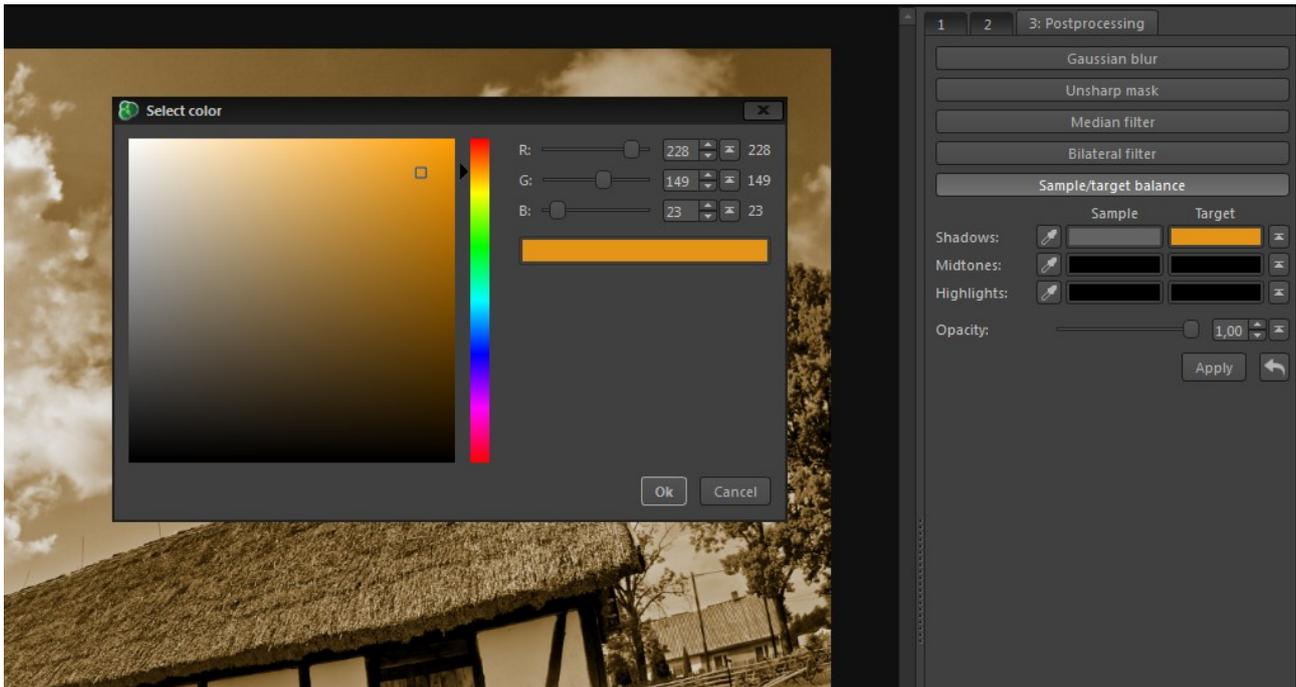
Apart from "Opacity", the user can control "Sigma" – extent of blurring and "Threshold" – edge detection level.



a) Input photo, b) Sigma = 2.0, opacity = 100%, threshold = 0.5,  
c) Sigma = 4.0, opacity = 100%, threshold = 1.0.

#### 8.5. Sample/target balance

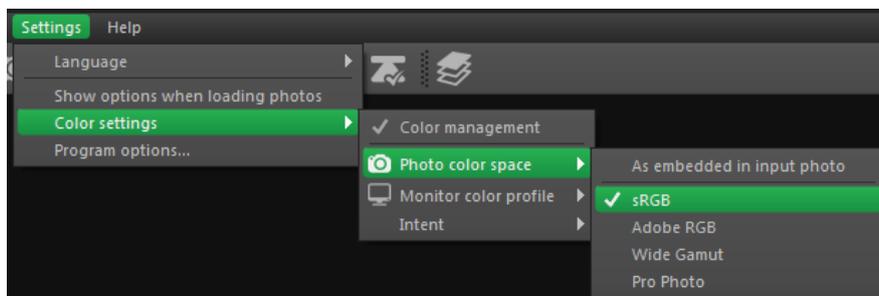
This tool allows to change sampled color tones into target colors (set by the user). For greater flexibility you can apply changes to shadows, highlights or middle tones separately. Additionally you can limit the strength of the color transformation by lowering the "Opacity".



You can set the target color by clicking the left mouse button on the appropriate field. Click on the sample to reset the target color. If the target color is the same as sample the tool has no effect.

## 9. Color management

EasyHDR can properly work with color managed photos and monitor profiles. The Color Management is disabled by default (when the program is installed), but can be enabled by checking the option in the main menu: Color Settings → Color Management.



*Color Management options – in the main menu as well as the status bar.*

The photograph's color space is extracted automatically from the JPEG or TIFF input once the image file is loaded. In case of RAWs, RadianceRGBE and OpenEXR the color space is user-defined at loading. If the color space definition is not embedded it is always possible to manually select the space



from a list (sRGB, AdobeRGB, WideGamut or ProPhoto). The monitor color profile can be selected from one of standard profiles (sRGB, AdobeRGB, AppleRGB, ColorMatch, or DCI-P3) or loaded from an ICC or ICM file.

The color transform function that is calculated basing on the input and output profiles is used to properly display the image colors in the program's preview window. The color space of the output photo is not changed and is the same as it is in case of the inputs. The color space definition is just rewritten to the output photo, so other color management aware software can display it properly.

Raw photos, by definition, do not have any color space. When they are loaded, the image data is decoded into a user-defined RGB color space.

EasyHDR can work only with RGB color spaces. Other, like for example: CMYK are not possible to use. Note that all input photos (that are used to create one HDR image) have to be in the same color space, otherwise easyHDR will deny to load them.

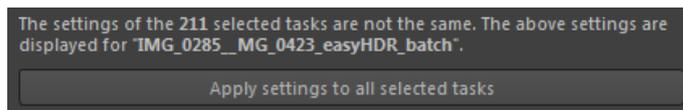
For best quality process only 16-bit, color managed TIFFs.

## 10. Batch processing

If you want to process many image sequences, especially if the photos are very big, you'll appreciate the advantages of batch processing. The idea is to create a list of many tasks to be done by easyHDR and then let the program do the whole job without user interaction. Below you can see the batch processing window (click *File* → *Batch processing*).

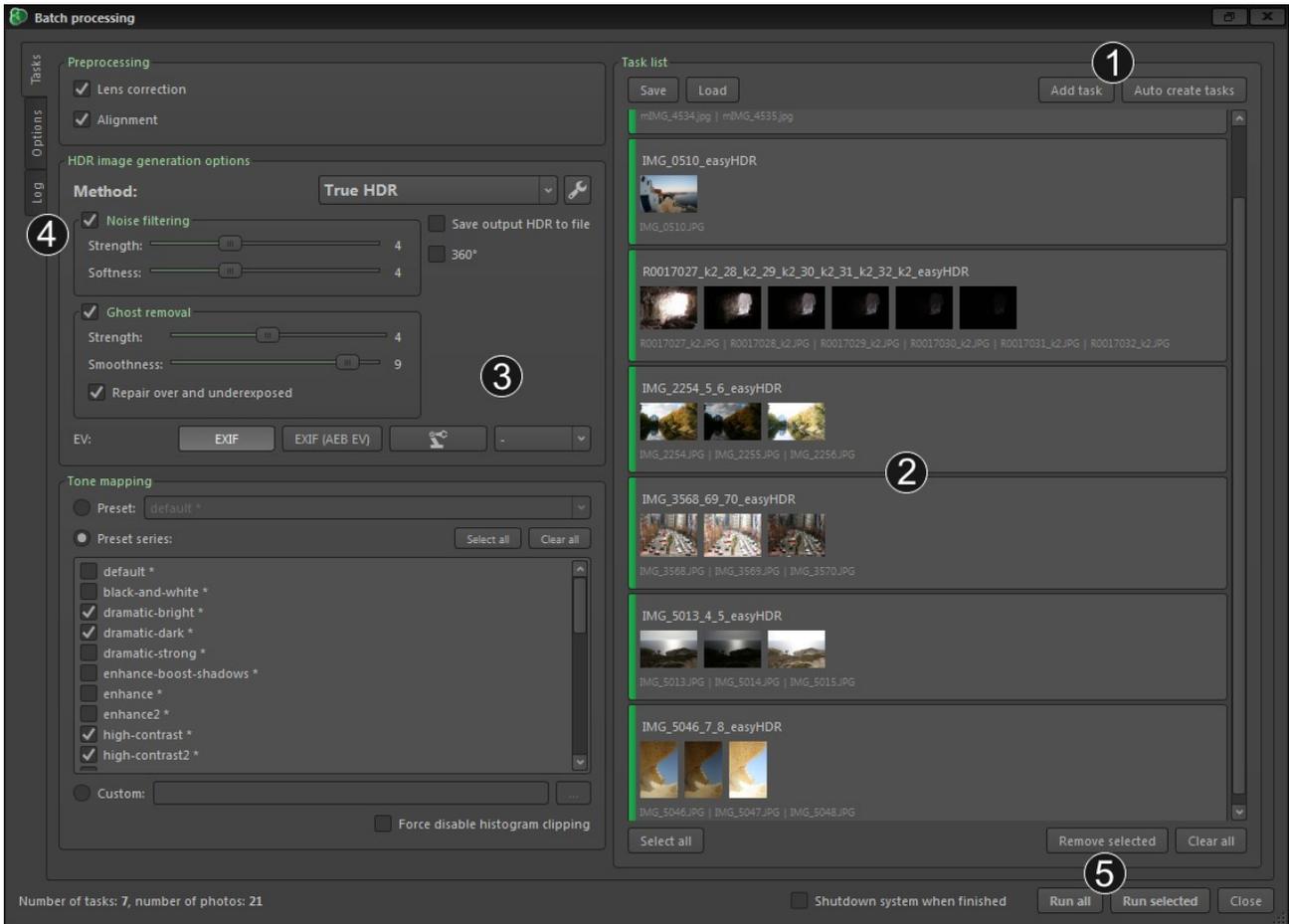
The first step is to create a list of tasks (1). To do so use “Auto create tasks” option to make tasks automatically out of files from within a defined directory. There is also a possibility to add a single task by directly pointing a HDR image sequence (or a single image for LDR enhancement).

The tasks (2) are displayed in a scroll box. Each of them is a separate processing job for easyHDR and has own settings associated (3). Every task has a name that is used as the output file name. The input photos' names are also displayed along with the thumbnails. To change the task name simply click on it. The settings are displayed for all selected tasks. If at least one of them has different settings, a warning message is shown:

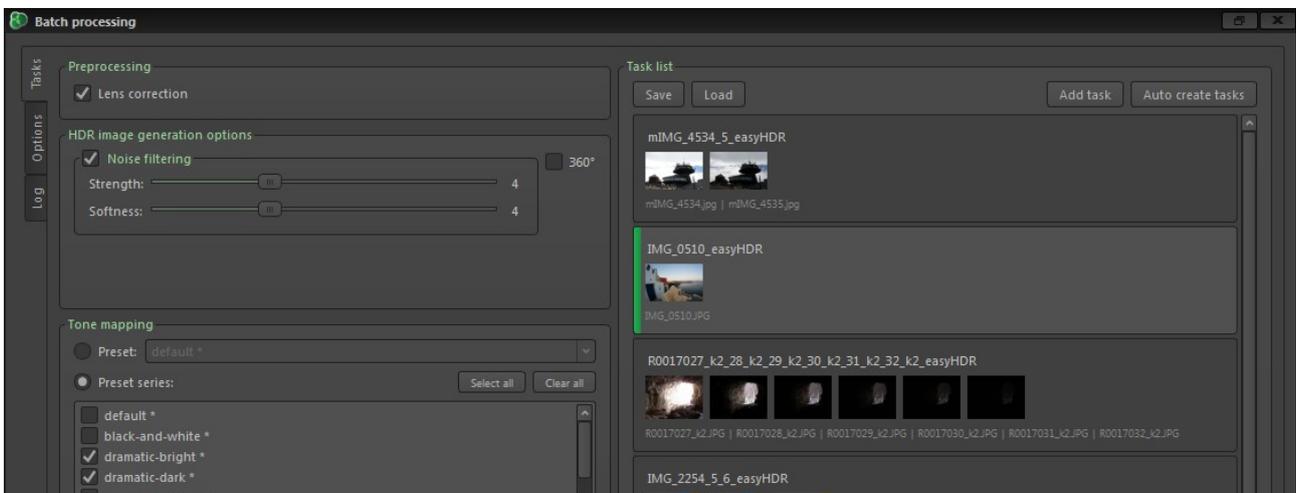


You can apply then the currently visible settings to all selected tasks.

*If there are various types of tasks selected at once (both HDR sequences and single photos) always the settings for HDR processing are displayed. Of course some of the options are not valid for single-photo tasks in this case. If tasks consisting of only single photos are selected, then appropriate set of parameters is visible, as depicted in the picture below.*



*The main batch processing configuration window.*



*Settings for single-photo tasks.*

There are three possible options for tone mapping settings usage. You can select any settings file (\*.ehsx) from your hard drive, you can choose a single preset from drop down list, or finally, you can

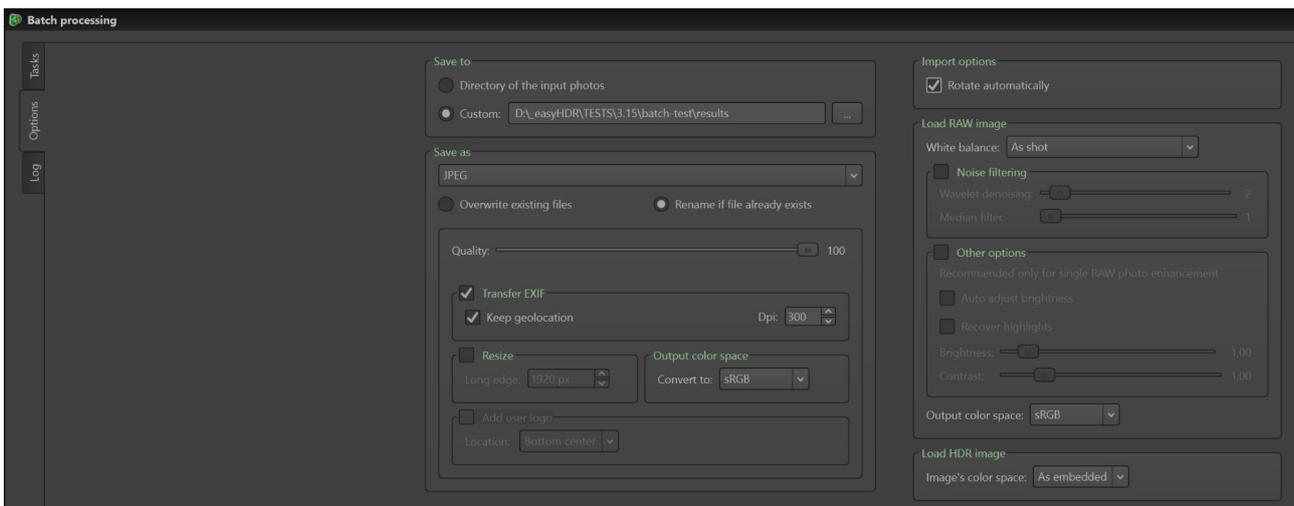


select a set of available presets. In the latter case, tasks are processed several times, for each selected settings. The preset name is appended to the output file name. This option is perfect if you want to compare results achieved with several settings and just choose those which you prefer.

The task list can be saved and loaded later. There is an option to process only tasks that were not completed previously, so it's possible to continue the once stopped job, even after system restart. It's just important not to change the input photos location on the disk and not to delete or remove the already done results.

If the automatic task creator failed to combine some of the photos into tasks correctly, you may fix it manually. Each multi-image task can be split into single-image tasks. Any set of selected tasks can be combined together. These options are available in task's context menu (right click).

Configuration common for the whole batch job is available after switching to the “Options” tab (4).



*Options common to the whole batch job.*

The options are:

- Color space for the imported RAW and HDR images,
- More LibRAW/DCRAW options for RAW import: white balance, noise filtering and highlights recovery,
- Destination folder – by default each task is saved in the same folder as the input photos, but it can be a different, user specified location,
- Result file format – TIFF, JPEG/JPEG2000. Optionally, also the easyHDR project can be stored in EHPX format. It is also possible to turn off the tone mapping here, allowing to generate and store just the HDR radiance maps in \*.hdr or \*.exr formats (see in HDR generation options).

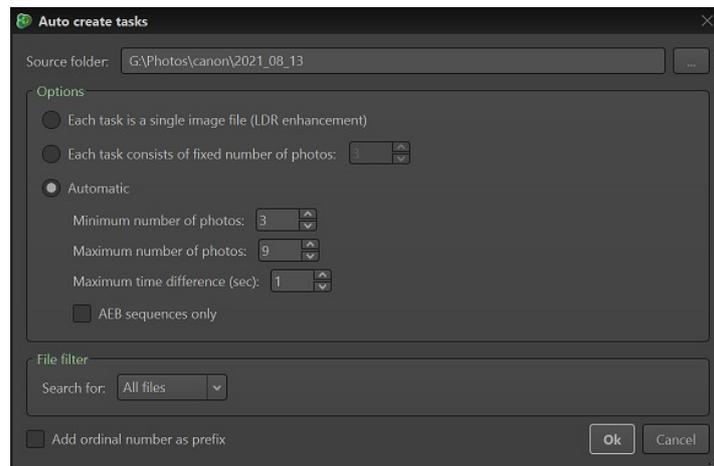
When everything is ready, you can finally start the batch job. It's possible to run all the tasks, or just those selected. There is also an option to shutdown the system on completion. **When you use it, please make sure that all of your open documents are saved, or better, that all other applications are closed. This will prevent data loss.**



### 10.1. Automatic task list creation

The power of batch processing is handling tens or hundreds of tasks. It wouldn't make much sense if tasks had to be created manually one by one. EasyHDR is able to create the task list automatically.

It is possible to add tasks built out of files from within a single directory. The current list is appended, not cleared first, so this feature can be used several times for different inputs. By default a fully automatic method of HDR image sequence detection is in effect. In this mode, the EXIF headers of all the image files found in the defined directory are examined by easyHDR. The photos that were taken within a very short period of time are assumed to be in a single HDR sequence. If you always take your HDR sequences using AEB mode in your camera, you should also select “AEB sequences only” option. It raises the accuracy because photos taken in *continuous shooting* mode (but not AEB) or those taken fast one after another are not merged together into single tasks.

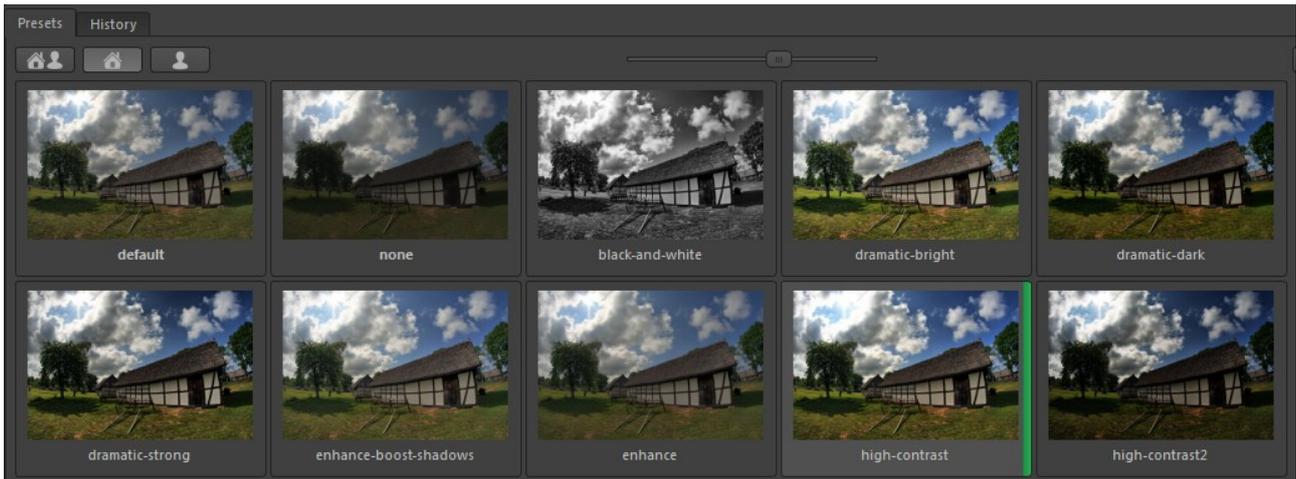


Automatic task creation options.

Another method assumes a fixed amount of photos in each HDR sequence, in the source folder. There is also a simple mode useful when you want to process single photos only (LDR enhancement). Each task consists then out of a single photo.

## 11. Tone mapping settings management, presets

EasyHDR allows you to save the tone mapping settings to files and to import those settings later. The most commonly used settings can be put into a special pool of presets. When the program is installed, a couple of built-in presets are already there – i.e. “*dramatic-bright*” or “*natural*”.



By grabbing and moving the edge of the panel you are able to resize the thumbnails. Additionally, when the panel gets wider, the view changes and the presets are displayed in more columns.

In order to add a new, user preset (based on the currently selected tone mapping settings) you can use the “plus” button in the top-right corner of the panel. You can rename user presets by simply clicking on the names. To replace a preset with current settings or delete it, just click right mouse button on the thumbnail to open a pop-up menu with options.

The presets are just ordinary easyHDR settings files (\*.ehsx). What makes them different is the place where they are stored:

- Win XP: *C:\Documents and Settings\[name]\easyHDR 3\presets\*,
- Windows: *C:\Users\[name]\easyHDR 3\presets\*,
- macOS: */Users/[name]/Documents/easyHDR3/presets.*

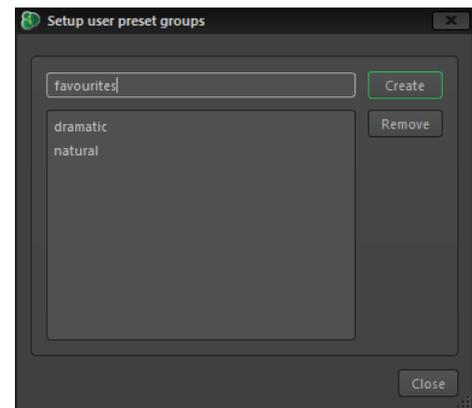
The built-in presets are in the easyHDR application folder:

- Windows: *C:\Program Files\easyHDR 3\built-in presets,*
- macOS: symbolic link - */Users/[name]/Documents/easyHDR3/built-in presets.*

The user presets can be grouped into user-defined folders. Group selection is possible only when user presets are filtered (third button from the left). To move an existing preset from one group to another just right click on it and choose the target.

Management is done with: *Settings* → *Setup user preset groups*. Using the dialog, you can create or remove the groups. Renaming is possible after double clicking on an existing group name. When removing a group that contains presets you can choose either to delete, or to keep them as “not grouped”.

The user groups are just sub-folders in the *easyHDR 3/presets* location on your hard disk, which means it's very easy





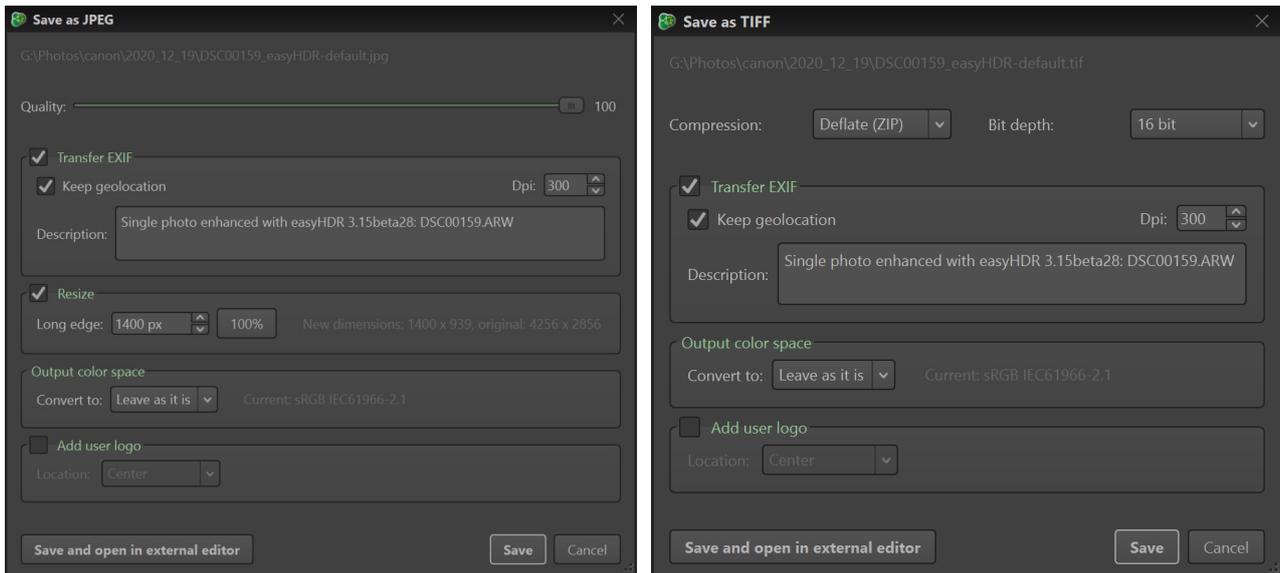
to manage all the user presets manually using Explorer (Windows) or Finder (Mac). Please note however, that after manipulating files and folders there, you have to restart easyHDR, so it can refresh it's own lists. The simplicity of user preset handling adds another advantage - you can easily back up or move your presets from one PC to another, or even share them with other people.

## 12. Saving the result

EasyHDR can save the results in TIFF, JPEG and JPEG 2000 image formats. It is also possible to save the generated HDR radiance map as Radiance RGBE (\*.hdr) or OpenEXR (\*.exr). However it is only allowed in the "HDR generation" window, for the *True-HDR* method.

The difference between TIFF and JPEG format is that the first of them is loss-less (even if the data is compressed). It means that absolutely no detail is lost when the file is saved. The *LZW* compression works well with 8-bit TIFFs, but for 16-bit data the *Deflate* method produces, in most cases, smaller files. For best quality you should save in 16-bit TIFF format, especially if you want to do further post processing with other photo editing tools.

The less popular format, JPEG 2000 (JP2), allows both lossy and lossless compression of 8 and 16 bit data. The lossless compression is done when the quality is set to 100.



When saving in JPEG format it is additionally possible to resize the photo. You can define the longer edge of the photo in pixels.

EasyHDR is capable of transferring EXIF headers to the output photographs. It uses an external *Exiftool* software to achieve this goal. *Exiftool* is capable of transferring full EXIF data from and to all image formats including RAW photos. If your camera stores location information, but you want to remove it from the particular photograph, you may easily do so by un-checking the "Keep geolocation" box. It's perfect option if you want to share the photos on the Internet, but you don't want to show



everybody the exact location where they were taken (eg. in your backyard).

When color management is enabled, it is possible to convert the color space of the photo to sRGB. It is useful if photos in other color space were processed and you want the results to be displayed correctly by programs that do not support color management, also when you want to publish them on a web page.

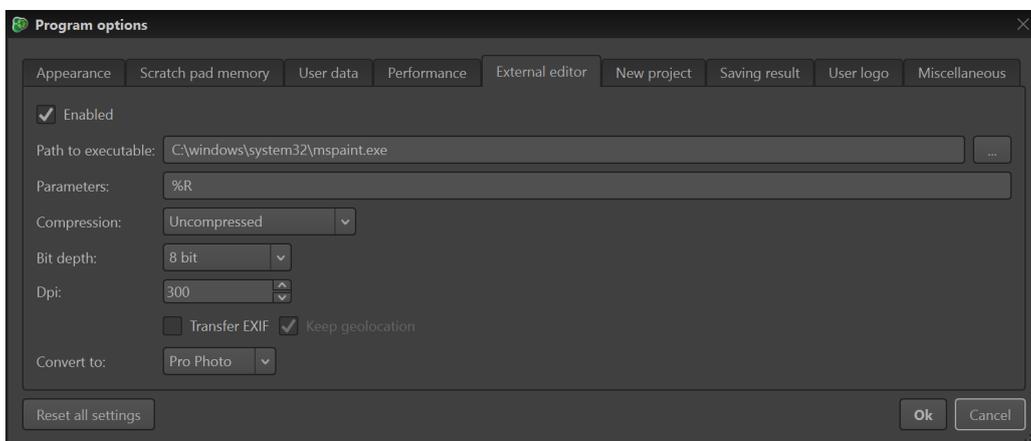
The DPI value definition is for user's convenience. It does not influence the pixel dimensions, or amount of detail. It is just a value that in addition to pixel dimensions defines the physical dimensions of the photo. It is useful to set it to a value that you normally use when preparing for printing, because then you can more easily edit the physical dimensions of the photo when post-processing in an external application. The most commonly used value is 300, it ensures very good print quality (invisible pixelization).

$$Physical\ dimension\ [mm] = \frac{Pixel\ dimension}{DPI} \cdot 25.4$$
$$Pixel\ dimension = \frac{Physical\ dimension\ [mm] \cdot DPI}{25.4}$$

In case of DPI resolution = 300, the pixel dimensions for a 15x10 cm print are: 1772 x 1181 (just 2 megapixels). An 18 megapixel photo can be printed on a ca. 44 x 29 cm paper.

### 12.1. Exporting to external editor

If you want to do further processing on the photo generated with easyHDR you can use the export to external editor option instead of saving to file and manually opening it with the other software. Before this option can be used it must be configured in the Program Options. You have to provide a path to executable of the third party software you want to use.



*Configuration of the external editor.*

Export to external editor allows transfer of 8 or 16 bit pixel format. It is user selectable, because not all image editing software support 16 bit photos. It is also possible to select whether conversion to sRGB is needed, or the color space should remain the same.



### 13. Saving and restoring projects

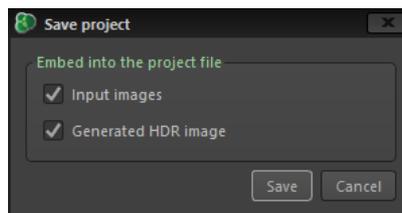
EasyHDR provides a way to save and restore your work. The project file can be saved and loaded using actions from the “File” menu. The project contains the following items:

- Preprocessed input images (aligned and with Chromatic Aberration corrected), along with full EXIF data, color profiles and EV values,
- HDR generation settings,
- Ghost removal mask (if set),
- Generated HDR image (optionally),
- Layer masks,
- Tone mapping settings for each layer.

When the project file is loaded, the photo can not only be tone mapped again, but also the HDR image may be regenerated, with different settings and different ghost mask.

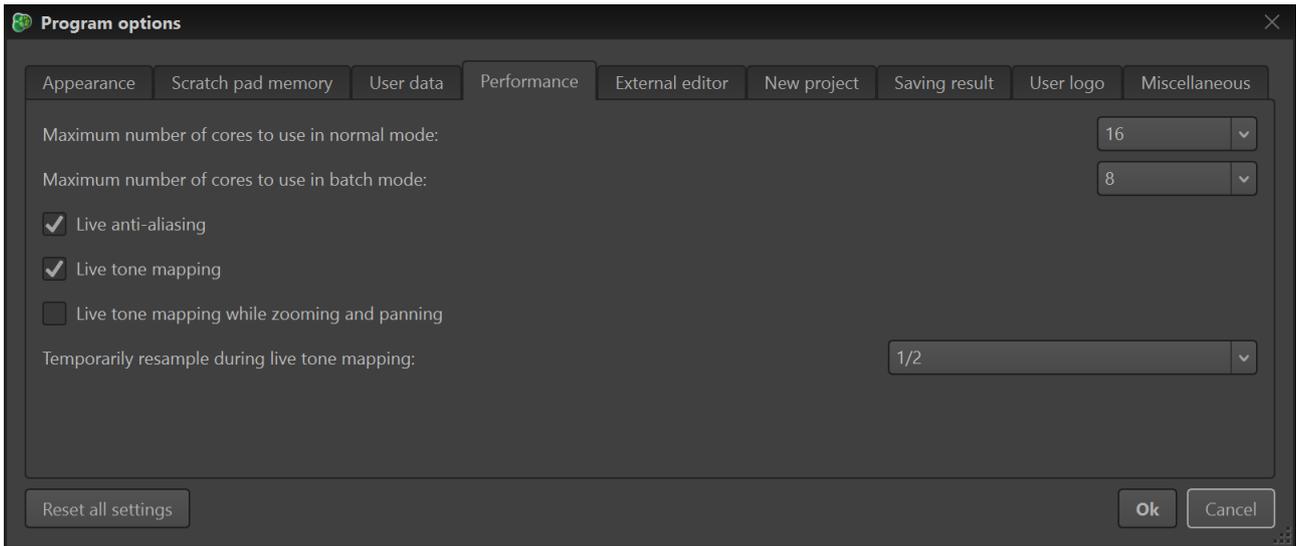
The project file can be very big, especially when the HDR image is embedded. Putting HDR image data into the file makes sense only if you rather do not plan to regenerate HDR and at the same time want to load the file a bit faster.

When the HDR data is embedded in the project file, it is optionally possible not to embed the input photos. It allows significant project file size reduction, but makes it impossible to fully reedit the photo when the project is loaded (ghost removal, lens correction, alignment and HDR generation are not available). It is only possible to modify the tone mapping.



### 14. Program options

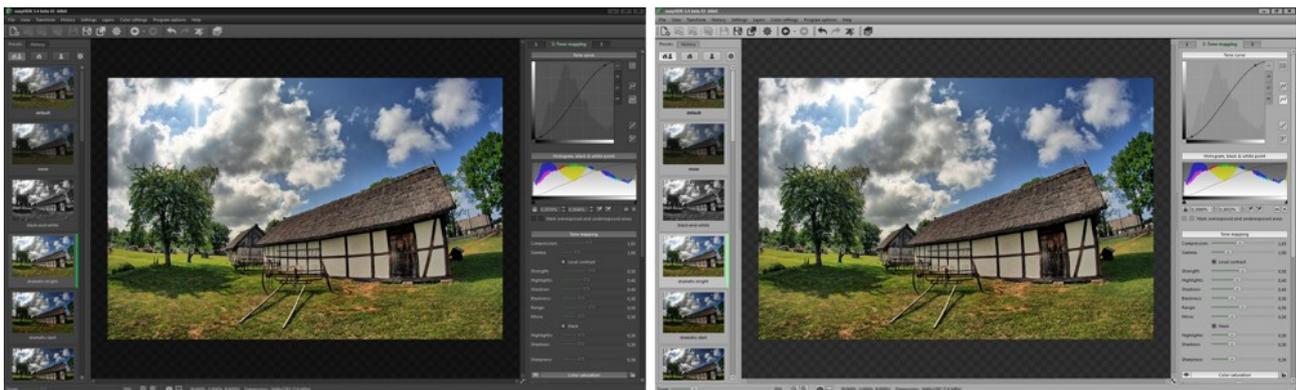
Most of the program settings are saved automatically when the program is closed (eg. image saving options). There are several options however that are set manually. In order to modify these settings click *Settings* → *Program options*.



*Program Options window.*

## Appearance

By default, easyHDR has a dark gray skin. You can change it here to light gray one. Another two options (“scale” and “pixel ratio”) allow scaling of all program fonts, buttons and windows. Normally the program takes the system's DPI setting to scale itself, but with the options here you can override the system's values.



*Dark and bright skins.*

The “High DPI” option is available only if your desktop supports it (4K screens). When enabled, easyHDR works in full resolution mode, which means that all the icons, fonts, tools and workspaces look much sharper. There is one disadvantage however. The program has to do 4 times more calculations to show the live tone mapping preview. If it causes inconvenience, please enable the live preview resampling (it can be found in the *Performance* tab).

Any change of the appearance settings requires easyHDR to be restarted.



## Scratch pad memory

You can choose here which hard drive (or directory) should be used by easyHDR to store temporary data. The option is set to system temporary directory by default. This setting should be modified only if you have little free space on the hard drive where the operating system is installed. The necessary free space for the program to work properly depends on how big images you want to load into the program and how many of them are in sequences you blend into HDR. The data is dumped to the disk only if it cannot be stored in memory. It's good to have at least 1 GB of free space.

## User data

This option allows you to change the user folder location, if for any reason the standard location is not welcome. One case may be macOS folder access restrictions – you may not want to grant easyHDR access rights to the User Documents location.

## Performance

EasyHDR is capable of using several CPU cores, if they are available. By doing parallel processing the performance of the program is greatly improved. It is possible to select the maximal number of cores used by the program in normal or in the batch mode separately. Note that when the maximal number of cores to be used is the same as available number of cores, easyHDR will claim 100% of CPU time during some operations. That means that other processes running on your system will work much slower during that period of time.

There are also other performance settings. When *live anti-aliasing* is enabled the photos are anti-aliased while zooming and panning, otherwise a rough image is displayed and after some timeout an anti-aliased view appears. The *live tone mapping* mode means that the tone mapping preview is generated at the same time as the settings change, otherwise a timeout must pass before the view is refreshed. *Live tone mapping while zooming and panning* does not require any further explanation.

There is also a special option that allows live tone mapping of a re-sampled image preview instead of full resolution one. The full resolution image is calculated after a short timeout passes. This feature may be really useful on slow computers, or when the screen resolution is very high – then the preview area that needs to be reprocessed live is large and requires more processing time (especially when working on a high DPI screen).

## External editor

See the “Exporting to external editor” section in this document.

## New project

- *Auto generate HDR / preprocess for LDR enhancement*

If you repeatedly use the same HDR generation settings, you may enable automatic HDR generation (or preprocessing for LDR) that will be done immediately after photos are loaded. Optionally, you can also select to automatically apply ghost removal. The option may be limited to easyHDR operation as the Lightroom’s plug-in.



- *Reset color adjustment settings for new project*

When enabled, the Color Adjustment settings (temperature and tint) are reset for new projects.

- *Automatically show file open dialog when starting new project*

It is enabled by default. Disabling it is useful when you want to load photos mostly by dropping them on the workspace instead of using the “New” or “Add” buttons.

### Saving result

Here it is possible to define the default output file name. It is set up in a form of expression with tags (see the tooltip for the line entry to see the details):

- %F – is a list of file names separated with “\_” characters,
- %C – common part of the input file names,
- %L – list of uncommon parts of the input file names, separated with “\_” characters,
- %0 – middle exposed (0 EV) photo file name,
- %N – number of input photos,
- %E – input file extension (format),
- %P – name, preceded with “-” character, of the current preset in use (if it was not edited by changing any of the tone mapping settings).

The %C+%L or %F alone is required to be part of the expression. By default, the expression is:  
*%C%L\_easyHDR%P,*

For example, when the input photo file names are: IMG1234.jpg, IMG1235.jpg and IMG1236.jpg, and the “natural” preset is used, the default expression results in the following suggested file name:

*IMG1234\_5\_6\_easyHDR-natural.*

In this tab, you can also choose whether the output folder shall be the same as the folder of the source photos, or shall it be as the last that was used for saving.

Another option lets you decide whether you want the exposure time values be removed from EXIF in case of HDR images. Normally the exposure time makes no sense in case of a HDR, but you can have the value taken from the 0 EV photo, when the removal option is turned off.

It is also possible to define the default HDR image format: *Radiance RGBE, OpenEXR or 32-bit TIFF*. This setting is used in the HDR generation window and in the batch processing to define the (optional) HDR image output format. The “Normalize” checkbox enables normalization (scaling pixel values down to 0..1 range) of the HDR data for the file – needed by some third party software.

Finally, you can define the default description added to the EXIF of the result image (can be edited on saving) and the “Artist” field in EXIF (leave it blank to preserve the value already existing in the input images).

Other result saving parameters are stored automatically when the program is closed (i.e. the last used file format, JPEG quality or TIFF compression).



## User logo

You can define here your logo/watermark/signature image (in PNG format) that may be added to the result photos. You will be able to enable or disable the logo and define its location each time the result is saved. The margin and logo scaling need however to be set in the Program Options.

## Miscellaneous

Some other options are available here:

- *Raw decoder*  
Choose between DCRAW and LibRAW (default).
- *Raw demosaic interpolation algorithm*  
Selects the algorithm used by DCRAW/LibRAW to demosaic the Bayer pattern. The best one (and most time consuming) is DCB – it reduces the color moire and aliasing effects the most. It is also the default one.
- *Allow input photos to differ in size*  
Percentage-defined allowance of size difference between the photos in a single HDR sequence. When set to 0% (default) the input HDR sequence photos must have exactly the same pixel dimensions. If you want to load photos that are slightly and differently cropped due to some external preprocessing, please define the allowance.
- *Detect panorama by aspect ratio and set suitable HDR generation settings*  
When checked and when a photo with aspect ratio 2:1 is loaded, easyHDR shows a question dialog asking whether to override some of the last used HDR generation settings with options suitable for panorama processing – it enables the 360° option and turns off the lens correction.
- *Require Ctrl/Cmd key pressed to zoom with mouse wheel*  
By default this option is turned off. In this case zooming the image can be done with mouse wheel. When it's on, mouse wheel is used to scroll the image (up/down and left/right), zooming requires *Ctrl* (Windows), or *Cmd* (Mac OS) key to be held.
- *Use system native open/save file dialogs*  
When selected (default), the file dialogs shown by easyHDR are standard system file browsers. Turning off this function makes the Qt framework's dialogs to be shown instead. The latter do not show thumbnails. This option is supposed to be changed only if there are problems with the native dialogs.

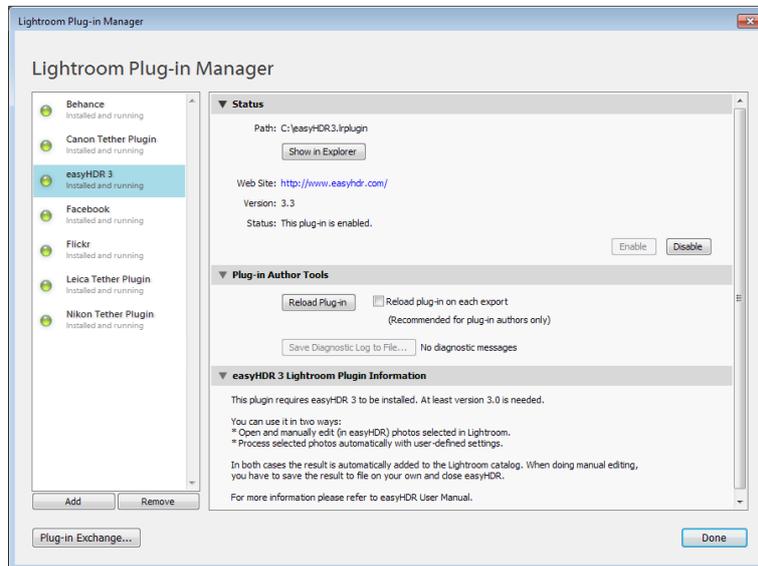
## 15. Adobe Lightroom plug-in

The plug-in allows exporting photos from Adobe Lightroom (version 3 and higher) to easyHDR. After processing, the results are automatically imported into the Lightroom Catalog.



### 15.1. Installation and setup

Install easyHDR 3 demo if you want to try, or the full version if you are a registered user. During installation on Windows please make sure that Lightroom plug-in option is selected. It is by default if Lightroom is detected in the system. When easyHDR is installed on Mac OS, the plug-in is installed automatically – if Lightroom is already installed.



*Lightroom plug-in Manager*

The plug-in files are installed in: *C:\Users\[name]\AppData\Roaming\Adobe\Lightroom\Modules\* on Windows, or in */Users/[name]/Library/Application Support/Adobe/Lightroom/Modules,* or */Library/Application Support/Adobe/Lightroom/Modules* on macOS. It automatically becomes available to Lightroom, you may just need to enable it in the "Plug-in manager".

### 15.2. Plug-in usage

In Lightroom, select photos you want to process with the plug-in. Then go to *File → Export* and choose "Export to": "easyHDR 3". An export options panel will show up. Depending on the mode you want to use, you should select a single image, several photos supposed to be merged to HDR, or a set of photos you want to process separately.

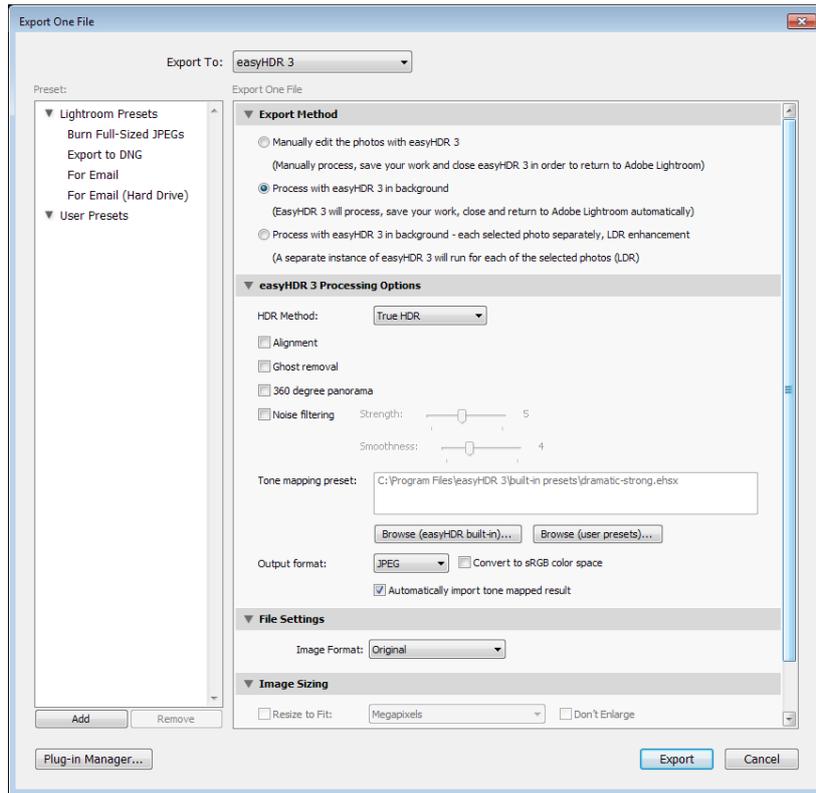
The plug-in's export options are divided into several groups:

1. *Export Method:* Selection of the mode of operation for the plug-in:
  - *Manually edit the photos with easyHDR 3* – the selected photo or a sequence of photos (to be merged to HDR) is loaded into easyHDR. You are responsible for processing and



saving the result manually. Once you save the processed image, just exit easyHDR. The image is automatically imported to the Lightroom catalog.

- *Process with easyHDR 3 in background* – the selected photo or a sequence of photos (to be merged to HDR) is loaded into easyHDR, automatically processed using the provided settings, saved and finally is imported into the Lightroom catalog. EasyHDR program window is visible during the process but cannot be used by the user.
  - *Process with easyHDR 3 in background, each selected photo separately* – each of the photos selected in Lightroom is loaded into easyHDR separately, one by one. No HDR image is generated – each photo is processed as LDR. All generated results are imported into Lightroom catalog.
2. *EasyHDR 3 Processing Options* – here you are supposed to define the settings for easyHDR, like image alignment, ghost removal, noise filtering, tone mapping preset and the output file format.
  3. *File Settings* – This is a standard Lightroom panel. It allows defining the exported image format (the format of the image that is loaded by easyHDR, not the format of the result!). If you choose “Original”, the exported photos are not altered before they are loaded into easyHDR, otherwise they are re-formatted using the provided settings. Only TIFF format is allowed here because it makes no sense to lose quality while converting to JPEG. The common cases when you want to change the exported image format are:
    - You want to process RAW images, but you want Lightroom to do RAW conversion instead of leaving it to easyHDR.
    - You want to resize the image before exporting it to easyHDR (see point 4).
    - You want to remove some metadata from the exported images before they are exported (see point 5).
    - You want to change (or set, in case of RAWs) the color space before the photos are loaded by easyHDR.
    - EasyHDR does not support the image format you want to export.
  4. *Image Sizing* – It's available only if format conversion to TIFF is selected. It allows resizing of the images before they are exported to easyHDR.
  5. *Metadata* – It's available only if format conversion to TIFF is selected. It allows removal of some EXIF headers – like location information etc. before the images are exported to easyHDR.



Export options dialog.

It's very useful to create own Lightroom presets, based on defined export settings. You have then very easy access to the most commonly used setups. There are two such presets installed along with the plug-in. They are available by right-clicking on the image and selecting "Export" from the popup menu, or from *File* → *Export with preset*.

