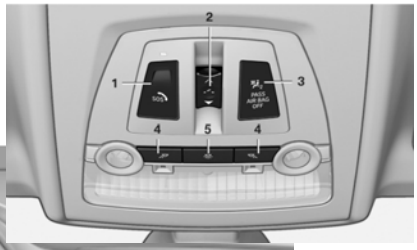
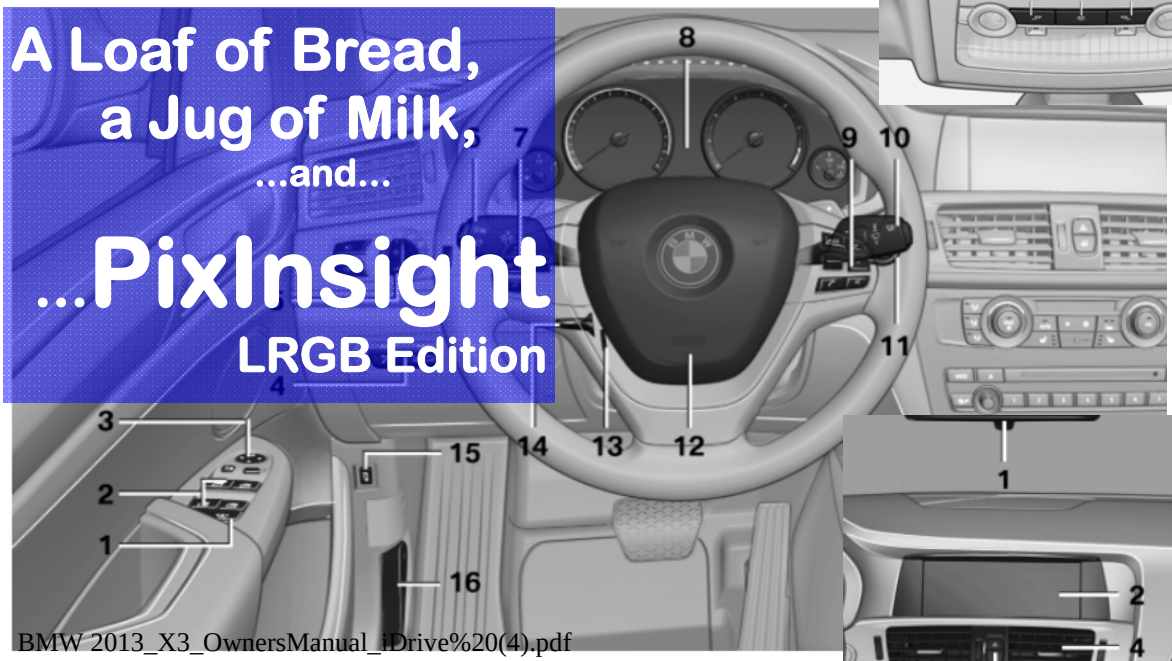
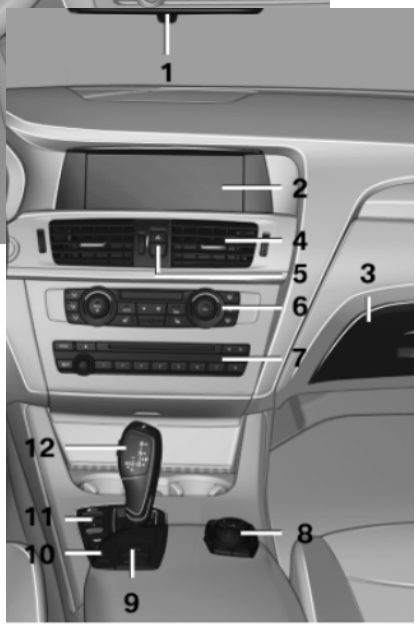
A Loaf of Bread, a Jug of Milk, ...and... ...PixInsight LRGB Edition







"Hey, Honey." It was a simple request from my lovely wife. "Why don't you jump in that new car of yours, and run down to the market and get us some bread and milk?"

She did not sense the terror that leapt in my chest.

I had just barely opened the owners manual, and there they were, page after page of pictures and instructions about which button did what, when to use it, when not to use it, how to get the most fuel efficiency out of which turbo mode, how to implement traction assist, and when, and how to change the engine torque and shift points by moving the transmission lever (item #12 in the third illustration on the fourth page of illustrations). One hundred forty pages, and that does not count separate manuals for the radio, clock, and GPS!!!

I would never figure out how to drive this car properly. Shift points? Turbo boost? My gosh, there are 25 warning light indicators on the instrument cluster. They glow in different colors to indicate different disasters. How could I ever learn?

All I wanted was to drive to the store for some bread and milk!!!!!

That was seven years and 51,820 miles ago. I learned. I survived. I even flourished.

But that same fear rushed back when first I opened PixInsight.

...All I wanted was a picture!!!

NOTE: This is the LRGB Edition. For OSC CCD or DSLR, use the OSC edition available at: http://www.alexastro.com/

Not long ago a budding young astroimager asked me to help him get started in PixInsight. During that session, I realized that quite a bit could be done in PI without knowing a lot about it. Within a few hours, this young fellow left my house with an image of M31 far better than he had produced with any other processing software—and he had been at it for several years. I resolved to put together a tutorial of what we did that day. My assumptions were:

Use Pixinsight just as it comes from the download site.
Use the processes with the biggest bang for the buck
Use the processes that could most easily be explained to a newby.
Use defaults wherever possible.

In other words, use what was in Pixinsight that could produce a photo almost automatically, without knowing much more than what processes to use.

These assumptions do not make for the best image. They do make for a pretty good one, though. I believe a good picture is *easier* to produce under these assumptions in Pixinsight than in the Deep Sky Stacker/Photoshop combination.

For this tutorial, I chose to use and explain things that were easy to explain. For instance, one can start a process many ways: The Process Explorer, the menu bar (which can be approached in several ways), the tool bar, action icons, and I don't know how many others. This tutorial always approaches from "menu bar: Process/All Processes/...(process name)." But the other approaches are actually more convenient!

I leave out many things you will eventually need to know. (See the last page here to see what this costs in quality.) You do not need them for your first image—but you will need them eventually. I have left these things out because they get in the way more than help at this stage. You will come back to them soon enough.

There are some very important processes (like star masks, morphological transform. Atrous Sharpening) that really are cool and improve the image. But they were harder to explain than we needed at this point. Once you have a handle on the system, you will learn them quickly enough.

I made some assumptions that the reader of this tutorial knows how to get around in Windows, how to select a file, how to close a window, and so forth.

This tutorial is targeted at a select audience: Those who just want to get an image for the first time. They want to drive to the store, and get a jug of milk and a loaf of bread.

If you find this tutorial too elementary for you, it is. Do not waste your time on it. If you find it helpful, enjoy it.

Before We Start

Hopefully, you have a set of LRGB, RGB, or Narrowband data.

If you took your data with a mono camera using color filters, it will work fine. A different edition, for One-Shot-Color (DSLR and OSC CCDs) is also available at my website, http://www.alexastro.com/ . (You can also use this tutorial for RGB, and even Narrowband images if you skip some parts and follow a few extra notes in others, and realize when we refer to all four channels sometimes you need to interpret for your needs.)

You should take enough light frames so that when all is said and done, and you have discarded the streaked, fogged, trailed, and so forth, you still have a dozen or so good Lights in each channel. (If you don't have a dozen, use what you have. Try to have eight or nine at least. But use what you have.) You should also take at least a dozen flats, darks, and biases. It is most convenient if you have stored them in a common folder on your hard drive, but as long as you know how to find them when you need them, you will be all right. It also helps quite a bit if your file names contain exposure, binning, and filter name—although it is not essential. And, of course, we are assuming FITS files from these cameras.

This tutorial assumes the defaults that are in PI when you first download and install the system. If you want to get back to that fresh install, simply press the Control button as you click to start Pixinsight. You will get a warning that you are tossing out any re-configuring you have done to your existing copy.

This tutorial assumes some rather simple images. I am using a big galaxy with little nebulosity. High Dynamic range images (M42) or high nebulosity images (M8) may not be as easy to process.

Do not assume that after you produced your first photo you know PixInsight. (Again, see the last page here to see that proper processing, even by me—not a very proficient processer—is better than what I describe in this tutorial.) You will be led down a very safe path, with a guide all the way. You will not take the exciting side paths that would make this a much more rewarding adventure. But, you will safely make it through. I strongly encourage you, after you have completed your journey once, to go back and explore all those other little twists and turns. That is when you will really learn the power of PixInsight.

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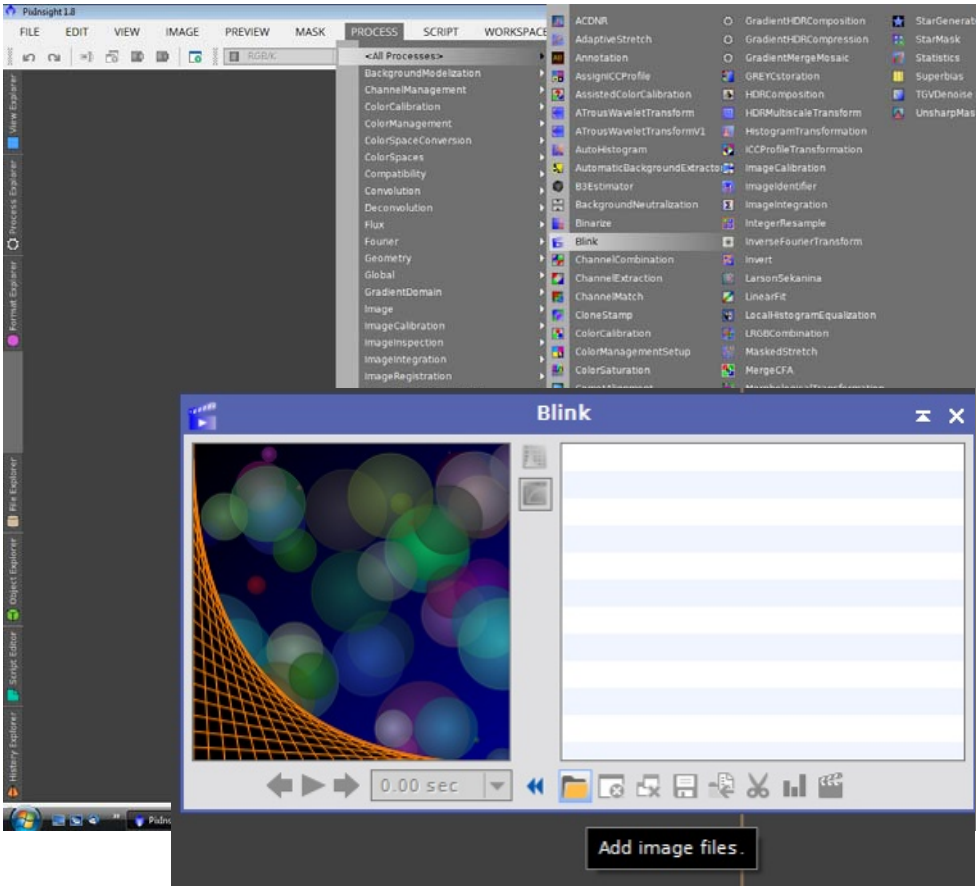
On Sunday night, October 11, 2015, I walked through the OSC version of this tutorial with the viewers of The Astro Imaging Channel. You can see a youtube version of that at: https://www.youtube.com/watch?v=hsYv2bDmGzA

I. Select the Good Shots—the Blink Process

In the course of the night, some subexposures will be good. Others will be out of focus, stuck in clouds, trailed, and such. The first step is to look at each of the subexposures, marking the good, and discarding the bad. To do that, we will use the "Blink" process.



Open the Blink Process by clicking on the main menu bar:
Process/
All Processes/
Blink

You will see the Blink Process window.

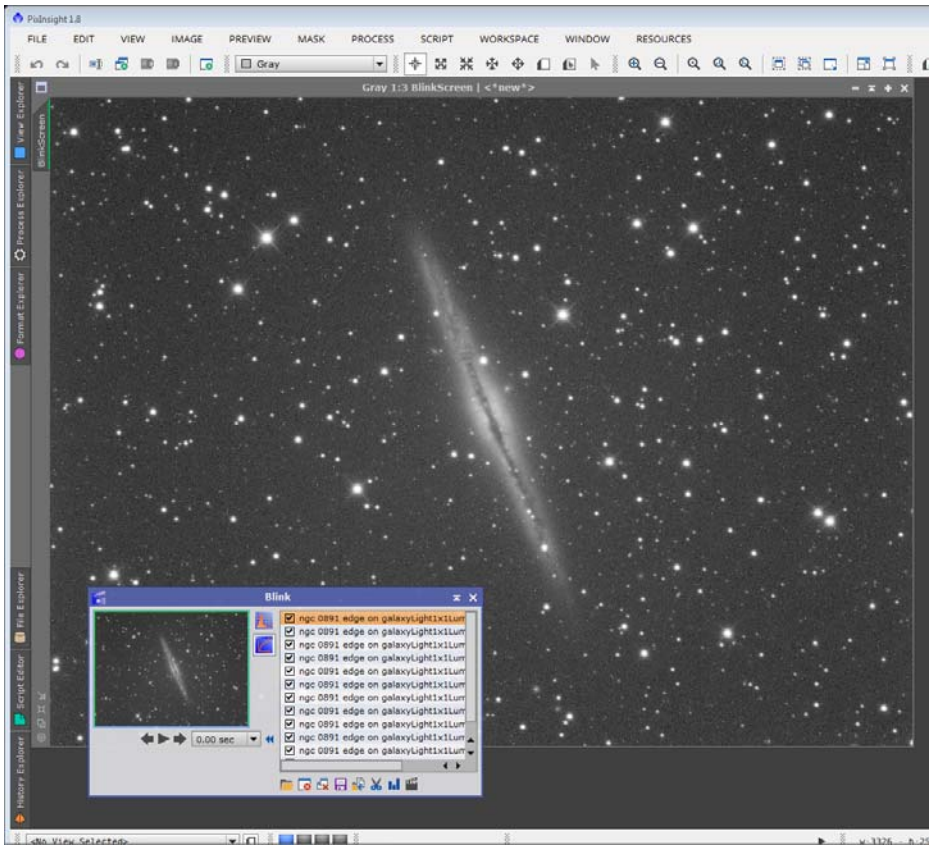
The Blink window has a set of icons at the bottom. The first we will use is the "Add Image Files" icon. It looks like a file folder, and is first on the left at the bottom.

Click on the file folder icon to add image files to the Blink window. Navigate to the folder containing your LIGHT subexposures, and select all your LUMINANCE files. (Select them as you would any windows file manager files.....click on the first, scroll down to the last, and SHIFT-Click on the last. Click the "Open" button in the lower right corner of the file selection window.) Select Green if you have no Lum, or Ha for narrowband.

Depending on the number of files, and the size and type of files, this operation could take a minute. When finished you will see one image in the main window, a smaller image in the Blink window, and a list of your files.

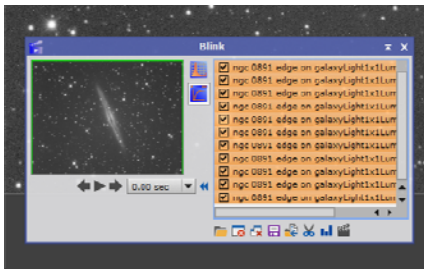
Click on the "Apply Histogram to All Files" icon. It is the orange on blue histo-

gram at the top of the column between the small image and the list of files on the Blink Window. This, as it says, modifies the screen display for all the images so that you can see them better on the screen. (It does not change the images.)



Now, click on each image in the list. If the image looks pretty good to your eyeballs, go on to the next image. If it does not look good (trailing, too fat stars, some other weirdness), click on the "Close Selected Image" icon. It is the second from the left on the bottom row, and has a white X on a red circle.

When you have been through your list, all your bad images are gone from your list. All your good images remain. Click through the list again to make sure you did a good job. If you find any bad shots remaining, close them.
Note for future reference which image looks sharpest. (It will be your "reference" image in the Pre-processing process.)



Now, you want to move all the good images from where they were to a new folder on your hard drive. To do so, select all the images (again, click on the first, and shift-click on the last). All your files should now be highlighted in orange. This means they are "Selected."

Then click on the "Move Selected Files" icon. It is the fifth icon from the left, a blue arrow pointing to a yellow folder.

When you click the Move Files Icon, you open a standard Windows file folder screen.

Navigate to where you want to save your files.

Create a “New Folder” and rename it “Selected” to hold your good files.

Click on your new folder, and choose the “Select Folder” button in the lower right corner.

Your good files will be moved to your new folder. Your bad subs will be left behind.

Remove the files in your Blink window by clicking on the “Close All Images” Icon (third from the left, across the bottom, the one with two blue and white files and a red “X.”)

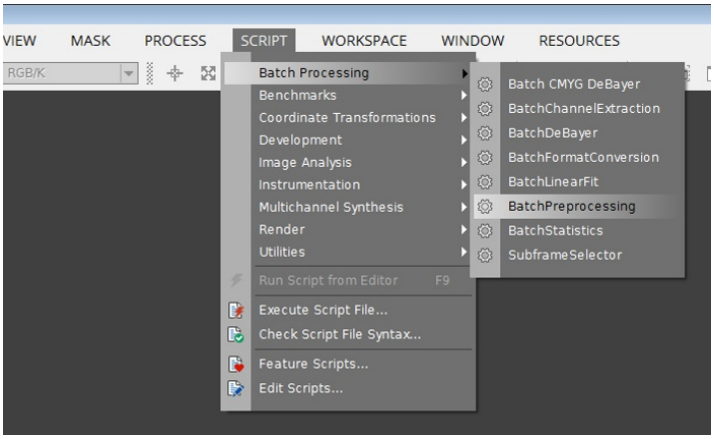
Now, do the same process for your other color filters. Do them separately, one pass for red, another for green, and a third for blue. You can go ahead and use “Selected” as your destination folder for all three. (If your filenames do not contain filter, binning and other information, you may wish to put them in separate “Selected” folders by filter.)

Notice as you go back to your original “Lights” folder to select files for any new filter, you will see the lights for the filters you have not yet inspected (no surprise), but also the files that have failed inspection!!! The failures are left behind. Don’t let these other subs confuse you as you select files for inspection.

When you are finished, go ahead and inspect your “Selected” folder. You can inspect by simply using the “File/Open” and navigating to the “Selected” folder. You should see a collection of “Good” images. Back in the original “lights” folder, you will see all the rejects, sad and lonely.

II. Calibration and Pre-Processing

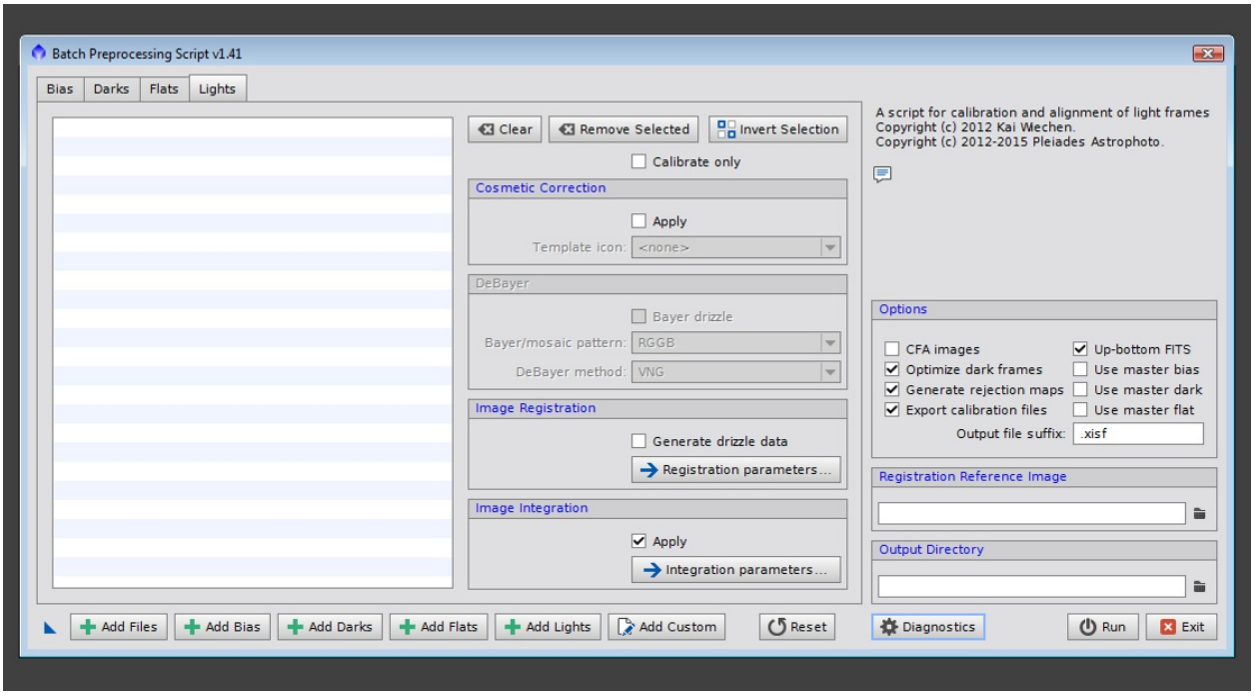
The next job is to calibrate the light frames and combine them into one master image. This is done with the Batch Pre-Processing Script.



Open the Batch Pre-Processing Script by clicking on the main menu bar:

Script/
Batch Processing/
Batch Pre-Processing

And up pops the BPP window:



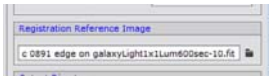
Start by populating the file windows. Notice the buttons across the bottom row. Our first (fifth from the left) is “Add Lights.” Click on it, navigate to the folder holding your good subexposures. (You labeled this folder “Selected” in the Blink section of this tutorial.) Select them all, and press “Open” in the lower right corner of the folder window. By “all” we mean all—L, R, G, and B. (If you separated your “selected” into separate folders by filter, gather them back together by using the “Add Lights” button repeatedly.)

Continue the same procedure using the Flats, Darks, and Bias buttons. All the filter

colors and binnings can be input at the same time for any exposure type (flat, dark, bias). The program will sort them according to binning and filter.

Click through the tabs at the top of the file lists (Bias, Darks, Flats, Lights) and see that the files you expect to be there are in fact there.

Now turn your attention to the “Global Options” panel at the right of the BPP Window. Uncheck CFA Images (One shot color) and those about master bias, dark, and flat. Others should be checked.

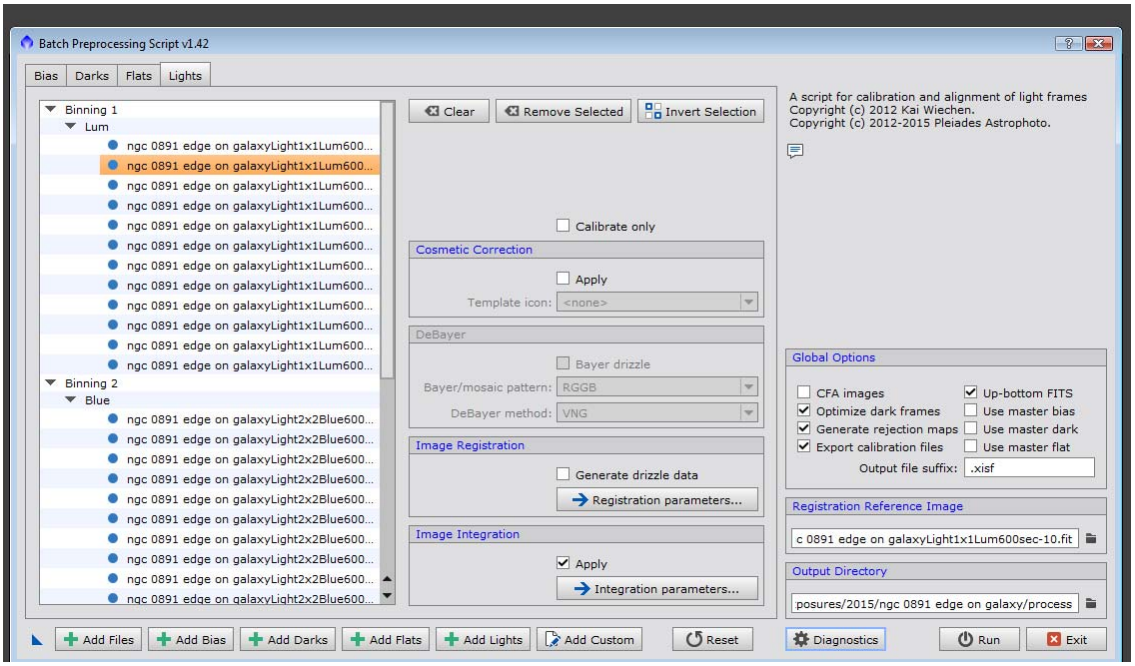


Below the Options panel, you will find an entry for Registration Reference Image. The easiest way to complete this information is to double click on one of the “Luminance” subs displayed in the File List. Choose the sharpest one you have, if you remembered form the blink process. If your subs are at different binning levels, choose one with the lowest binning (1x1 if possible).

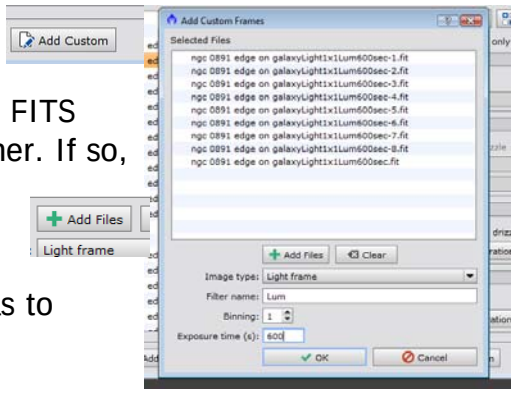
And below that, is the “Output Directory” info. This is the name of the folder where you will store files that the script develops, including your calibrated images, your master darks, flats, biases, and important integrated light files.

To select an output directory, click on the Output Directory file icon (at the end of the entry window) , navigate to where you want to store the files. Create a New Folder called “Processed.” Click on the “Processed” folder, and choose “Select Folder” from the lower right corner of the window.

Review your window and compare it to the one at the bottom of the previous page. Do you have the same boxes checked, and the same boxes empty?



Did your files go in the right places? If, for instance, the script could not identify your bias, binning, filter, or something else it needed from the FITS header, you will be missing one type of file or another. If so, use the "Add Custom" button (next to "Add Lights" on the bottom of the BPP screen.) Use the big green plus "Add Files" button to navigate to your new files, select them, and use the other input areas to specify information about the new files. Press "OK."



Click on the "Diagnostics" button at the bottom, three from the right.

The script will analyze your request and the file lists, and may give you a "Diagnostics OK" message. If it does, tell it OK, and tell the script to "Run" by pressing the second icon from the right along the bottom of the window. Then skip to the next page of the tutorial, omitting the next section (about the diagnostic report having problems).

OR.....

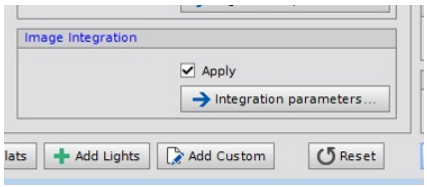
Your Diagnostics report may say you have a problem. You will not have a problem if you did everything this tutorial said to do *and had a sufficient number of files in each category*.

Let's look at some of the problems the diagnostic report could have.

You may have forgotten to identify the Registration Reference Image. Or the Output Directory. Go back and do so. These are easy to correct.

You may not have bias or flat frames. You will get a warning in the diagnostic report. If you have these files, but just forgot to enter them, do so now. If you have not yet taken calibration frames, you should do them eventually. However, you can go ahead and run the script even with these shortcomings. Your images will suffer.

Or, you may have insufficient images. This tutorial assumes you have at least a dozen of each type of image (12 Luminance, 12 red, ...12 darks, etc.). The default integration algorithm, Windsorized Sigma Clipping, needs eight subs to get reliable results. If you have fewer the script suggests you use a different rejection algorithm.



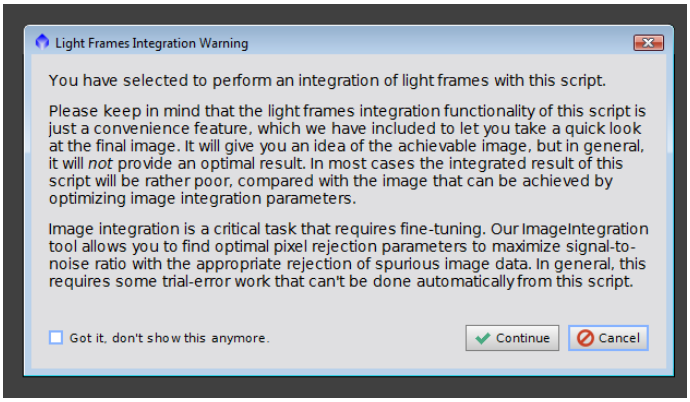
To do so, you need to change the Rejection Algorithm in the Image Integration panel/ Integration Parameters (bottom of middle column). Each type of frame (Bias, Dark, Flat, and Light) can have their own algorithm. Click on the frame type tab, and under "Integration Parameters." Choose the recommended rejection algorithm (usually Percentile Clipping for fewer than eight, etc).

Sometimes, you have sufficient L, R, G, but not B (or such). It will not be happy whether you pick Windsorized or Percentile Clipping for a “Rejection Algorithm.” If that happens, choose whatever is best for the Luminances, and ignore the error that results for the R, G, or B as a result of that choice.

The script requires that you have at least three frames before it will integrate.

You must resolve any diagnostic errors regarding not having three lights, an output folder, or registration image. Others may be ignored this time. Go ahead and push “Run.”

When you press “Run,” you will get a nasty message saying you are a lazy butt. And there is a good reason it is there: you are being a lazy butt. And the results you get from this exercise will not be as good as they should be (and as good as they ***will be*** once you learn how to use the tools available in Pixinsight). But that mean old message did not know you are a sensitive newbie and trying the hardest you can just to get something. Forget about its cruel tone, its air of superiority, its condescension, and just continue.



You are still a worthwhile human being.

Probably. I guess. I don’t actually know you.

Tell it to “Continue” and go do something else for a while (an hour sometimes!!!!). (Only real nerdy geeks try to read the Process Console as it goes by.)

When you get back, if BPP is finished, the Process Console will have disappeared and you will see the BPP screen staring at you. Exit the process, and confirm the exit.

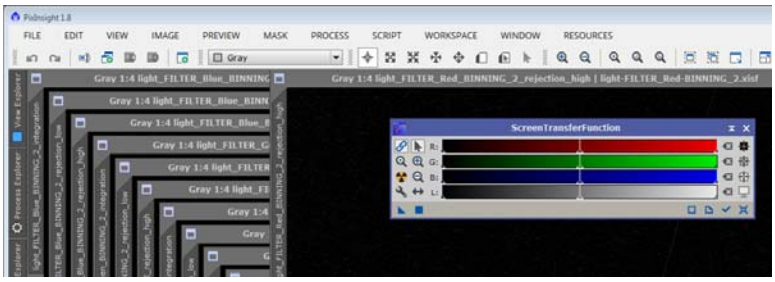
III. Cleaning the Data

The BPP process created several new files on your computer. We are interested in the Master Lights (One each for L, R, G and B). They contain the images you will work on for the rest of the tutorial.

A: Reviewing the Master Lights

On the main Menu, click File/Open, and navigate to the "Process" folder you created in the BPP section. You will notice the program has created three folders: Calibrated, Master, and Registered. Go to the Master Folder, and you will see as many as twelve new files: Bias…., Flat…, Dark…, and Light… Highlight the "Light…Lum…", and equivalent Red, Green, and Blue master lights. Click Open, and twelve images open, three for each L, R, G, and B.

All twelve images look black or very dark. To make them visible, you will use one of the most powerful of Pixinsights tricks, the Screen Transfer Function. This tool applies a temporary transformation to your data so that you can see your image.



To open the Screen Transfer function. Click on:

Process/
All Processes/
Screen Transfer Function

What you really need for now from the STF window is the "Auto Stretch" icon,  the radioactive sign. Click on one of the images (A "Rejection High" should be on top), and then click on the Auto Stretch icon. Look at the "rejections" if you like. Note how the rejected pixels stand out. Then close the rejection images by clicking the "x" in the upper right hand corner of the image pane. Inspect the "Rejection Low" images with an Autostretch if you like. There is usually less to see here. Close the file. (Rejection images are unnecessary for this tutorial, but you can learn from them when you start processing for real.)

Now, the big "reveal." You should be looking at a master "Light" file (not rejection). It will probably be very dark until you click the Auto Stretch Icon. STF puts a temporary screen stretch on the image (without changing the underlying data) so you can see what it might look like when properly stretched.

In my NGC 891, the galaxy looks pretty good. It is noisier than I would like. But, it can all be fixed. It has promise.

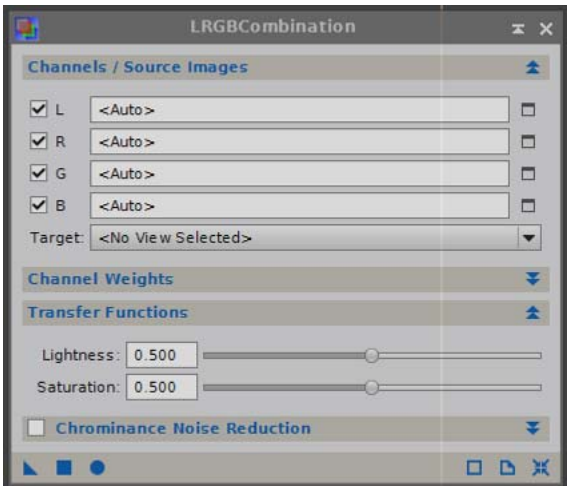
By the way, keep your STF window open for the next few steps.

Repeat the inspection you just did for Luminance on the Red, Green, and Blue files.

After closing the “Rejection” Highs, and Lows, you will have four files on your desktop, one master light for each of L, R, G, and B. (RGB only and narrowband will have three.)

Save each of these files using File/Save As (not “Save”—do not overwrite original file) and give them the names Luminance, Red, Green, and Blue. If you want to come back to start over from this point, you will use these files as your starting point (without the rejections images). Take the defaults, XISF, 32 Bits, etc.

B: “Inspection” Image



The next thing is a quick and dirty combine of these images to see how registration went, and what needs cropping.

To open the LRGB Combine Process. Click on:
Process/
All Processes/
LRGB Combination

Be sure L, R, G, and B are checked. (If you do not have Luminance, do not check L.)

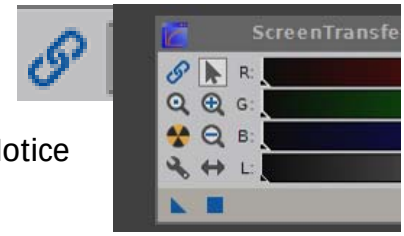
Designate which image is to be assigned to which channel by clicking on the box at the end of the file name window. A pop-up window will allow you to choose. Please ignore the word “Auto,” which implies that the program will know which is which—it is there just to tease you.

Now click the “Apply Global” icon (the blue circle, third from the left at the bottom. After a short while, a new image will show, combining all four channels. Artificially stretch it with the STF function (radioactive button). Do not worry if it is not pretty and or is all greenish or something. It is only a “rough draft” inspection.

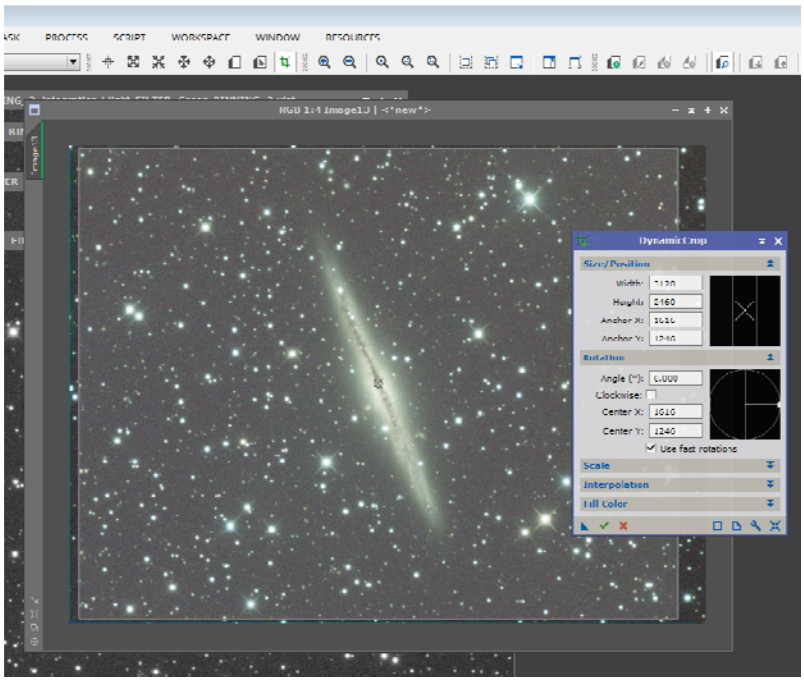
C: An Aside—Linking Color Channels

OK, you want to see it “pretty.” While there is no need to correct the color channels at this point, you may want to see your work in better color balance. Pull up the STF window as you have done before. You need a tool that has been hiding in plain sight on the STF window. Two icons above the Autostretch (radioactive) icon is the “Link

Channels" icon. It is a couple of blue chain links. Click on the links, and then on the Autostretch icon. Click again on the links, and again on the Autostretch. Flip back and forth from linked to unlinked, autostretching in each transition. Notice how your image changes general color cast. Pretty, isn't it.



D: Dynamic Crop



Now we must adjust the composition of the picture, and clean out some of the problem areas. It is good to cut out a bad gradient, or bad vignetting, annoying optical aberrations in the corners, or some distracting bright star off to one side.

To open the Dynamic Crop function. Click on:

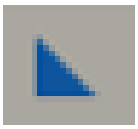
Process/
All Processes/
Dynamic Crop

You see the Dynamic Crop Window. Artificially stretch the inspection image with the STF function (radioactive button). Click-drag on your image to draw a box around the subject of your picture. Or, place a cursor on the edge of the image, dragging the edges in. Check around the edges. If you have dithered, or your images have otherwise shifted through the night on acquisition, you will find the registration process has left ragged edges. (Note the turquoise edges at left and bottom.) Crop them out. See how the shaded area marks the area that will be retained. Note the "X" marking the center of the picture has been moved to the center of the galaxy by offsetting the crop (the margin on the left is smaller than the right).

You can click drag the edges inward. You can move the whole box around by click dragging. Beware, the mouse-drawing is a little finicky. You may have to restart the tool several times before you get what you want. Experiment as needed. If you want to reset the tool, use the "Reset" icon in the lower right corner (the blue X on a blue box) or close the process and restart it.

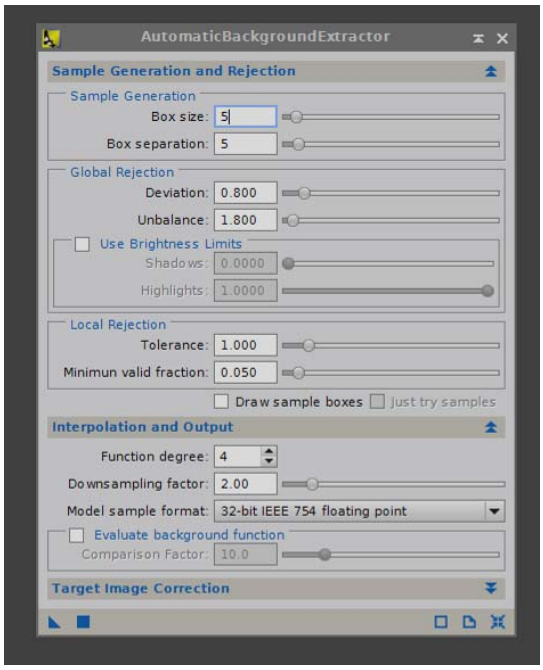
When you are satisfied, stop....It is time to meet a new friend.

Down in the lower left corner of the Dynamic Crop window is a blue triangle "New In-



stance" icon. It is actually in many process windows. In this case, it contains all the parameters you just set up for a crop of the inspection image. You want to crop your L, R, G, and B the same way you have set up for your rough draft. To do so, click-drag the triangle "new instance" icon to each of the four master lights, in succession——but not to the inspection image. (Just Click on the triangle, and while holding the mouse button down, drag it and drop (release the mouse button) on each of the pictures, L, R, G, B, one by one.) Each of them will be cropped the way you were about to crop your inspection image. You can close your inspection image (click X in upper right corner).

E. Removing Gradients: Automatic Background Extraction



Many astroimages suffer from gradients in one or several parts of the image. These are areas that are lighter or darker than they should be. They can come from vignetting (in which the corners are darker and the center brighter), incorrect flat fielding, light pollution, moonglow, and other causes.

Inspect your image (while it is stretched using the radioactive Auto-Stretch of STF), looking for brighter areas and darker areas that should not be there. If you find none, skip this section, and move on.

If, however, you have unnaturally brighter and darker areas, you need to flatten out the background. Use the Automatic Background Extractor. To get there, click on:

Process/
All Processes/
Automatic Background Extractor

So far in this tutorial we have been using defaults. But for ABE, the default for correction is "None." To change that, open a subwindow of the ABE window. To do so, click on the double down carats next to the "Target Image Correction" panel (at the bottom of the ABE window). This opens a pane where you can choose among None, Subtraction, or Division.

.....If you can see vignetting in your image (darker corners, abnormally brighter in the middle), choose Division.

.....If you have any other gradient problem, choose Subtraction.

While you are in the Image Correction Panel, click the “Normalize” box.

Click the “Apply” box (the blue square, second from the left at the bottom). After some whirring and clanging the Process Console will disappear, and you will have two new images (in addition to your original).

The first is the Background. It looks black, probably, but click on it, and then click on the Autostretch (radioactive) icon on STF. Is the pattern smooth (showing large, smooth gradations)? Does the pattern you see reflect the distortion of the background in your original? If so, you probably got a good extraction. If you see splotches, small areas of change, you probably did not.

The second new picture, says it is the “ABE” version of your original. Click on it to make it active, and Autostretch it with the STF. Is that background flat like it should be? Have the unnaturally brighter areas been brought down?

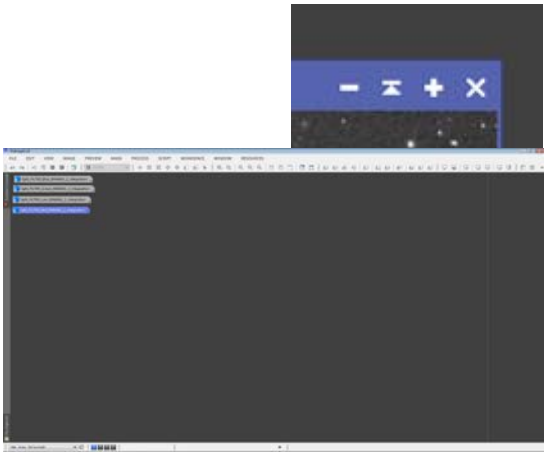
If your original was better than your new ABE version, you may want to experiment a little. Simply click on the original image, change the “division/subtraction” parameter, and try again by clicking on the “apply” square. Sometimes it helps to apply the process to the original, and then to the resulting ABE replacement. (Doing the process twice).

Use the STF to check on your results as you go. Experiment. Do over as necessary. (See page 20, “Do Overs and Take Backs.”)”

When you are happy with the background flattening, use the best resulting image (the ABE if it was better, or the original, or whatever else you got) as your image in subsequent steps.

Repeat these steps with all of your four images so that you have background flattened L, R, G, and B images.

F: Clean up the Desktop



By now, you may have far too many images scattered across the workspace. Clean out those you do not want by clicking on the X (close icon) in the upper right of the image pane. You will no longer need the inspection image and can safely close it. You can close without saving any of the “rejection” images, and any images you have left over from the background extraction process you do not intend to use. You should have only four images remaining opened, your best (flattest, most even background) Lum, Red, Green, and Blue masters.

IV. Balancing Color Channels—Linear Fit

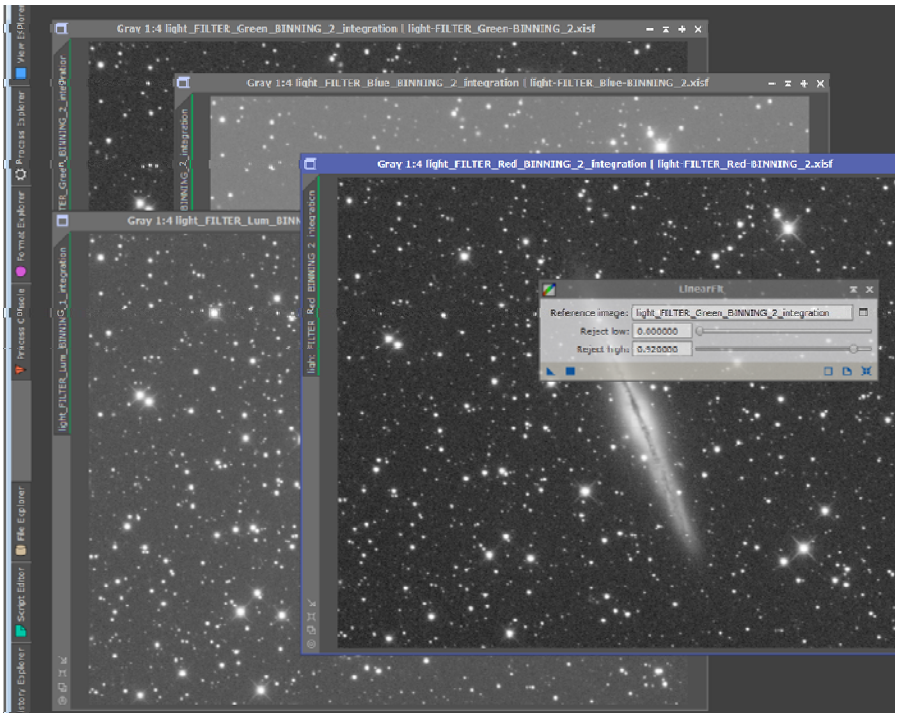
We have four monochrome images. (Three if you are only doing RGB or narrowband.) We have looked at the data, removed some gross errors through cropping, and removed the gradients. We have been watching the progress by using an artificial Automatic Screen Stretch.

Even with the nicest intensity balanced filters (designed to give equivalent exposures whether exposed through luminance, red, green, or blue), or the most careful balancing of exposure times among the filters, exposure values can vary from filter to filter. For example, the green on average is brighter than the red or blue. To overcome this, it is wise to equalize the exposures. Pixinsight can do this with a "Linear Fit." Open your four images (double click on their icons). Click on:

Process/

All Processes/

Linear Fit



In the Linear Fit window, select the Reference Image (by clicking on the box at the end of the entry line), and select your reference as Green (usually—this may change when you get experience. Choose Ha if narrowband). Then drag and drop the "New Instance Icon" to each of the other three (L, R, B) images on your desktop. Your images are all now about the same intensity as each other. This helps with color balancing. (Do not be bothered that your pictures no longer seem to look balanced. The STF used on each individual picture is based on the old data. The Linear Fit process changed the underlying data, without changing the STF. Thus, the screen transfer is no longer correct. So the image is too dark or too light. If you like, use your radioactive button on all four images, and they will once again look very similar to each other.)

V. LRGB Combination

Now, we will at last make our LRGB image.

To combine all four channels, we do the same we did for the "Inspection Image" on page 12. To open the LRGB Combine Process. Click on:

Process/
All Processes/
LRGB Combination

Be sure L, R, G, and B are checked.

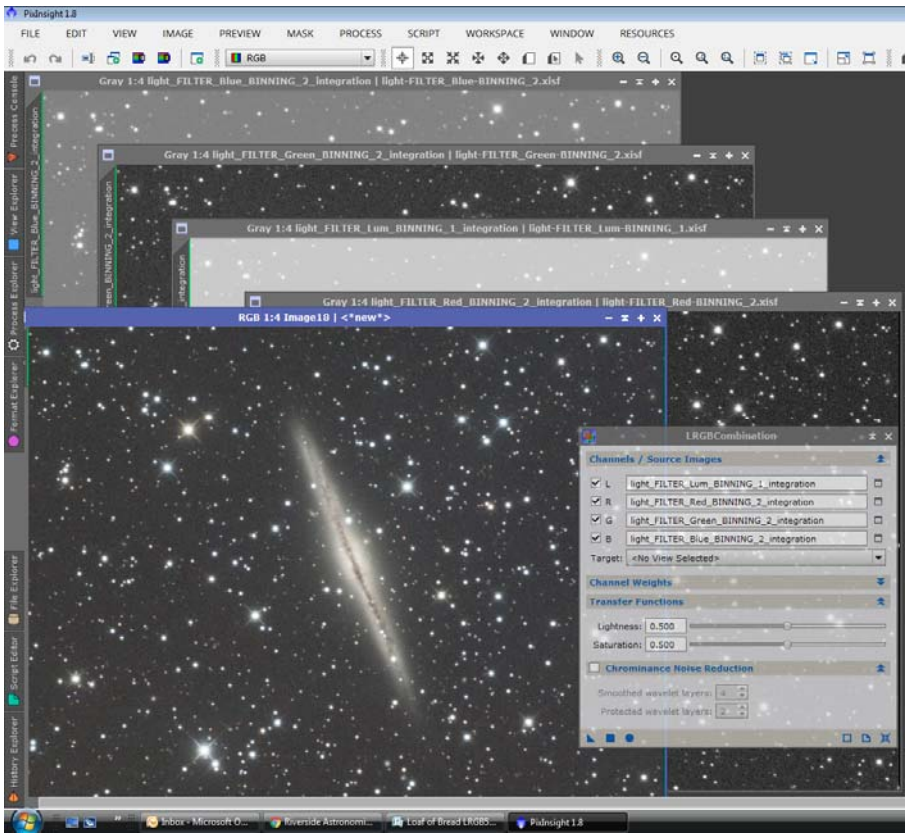
Designate which image is to be assigned to which channel (Duh, Lum to L, Red to R….). To do so click on the box at the end of the file name window. A pop-up window will allow you to choose as you did earlier.

Now click the "Apply Global" icon (the blue circle, third from the left at the bottom). After a short while, a new image will show, combining all the channels.

Artificially stretch your new image with the STF function (radioactive button).

Do not worry if it is not yet pretty.

Use File/Save As to save your LRGB Combine. Use the defaults for XISF, and so forth. You may now save and close the images of your separate channels.



NOTE TO THOSE WITHOUT LUMINANCE IMAGES:

For RGB Only: uncheck the "L."

For Narrowband: uncheck the "L" and determine which filter will be assigned to which color channel. Which goes where is a matter of taste and style, and beyond the scope of this tutorial.

For both RGB only and Narrowband, after we have created this image, we will be doing the same things as those who have full LRGB images.

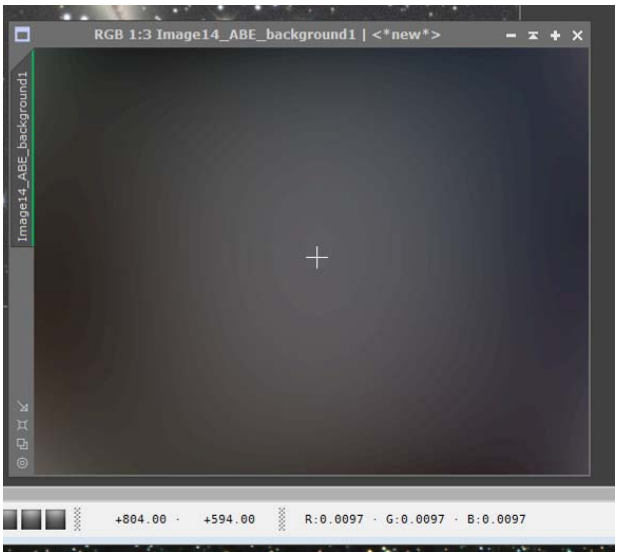
Note, narrowbanders, that your images will have "unnatural" colors in them.

VI. Processing—Cleaning the Data

We have one full color image. It is, however, dark and dreary. Press the radioactive button on your STF function, and you can see a rough draft of what you have. It brightens up, but, it may not be the right colors. And it is probably noisy. Let's fix that.

A: Automatic Background Extraction Redux

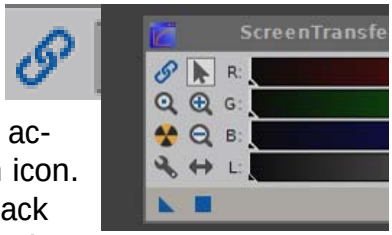
We have removed gradients (p. 14 Automatic Background Extraction) and matched their intensity (p. 16 Linear Fit). This should have done a lot to make the background nice and flat. In the combination, however, we may have picked up new irregularities in the background. You might want to RE-DO the Automatic Background Extraction (p. 14) and check out your background image, and the new resulting image to see if it helps. Do not be fooled by the screen stretch on your background, though…it can show differences which in practice may not matter much. Click the background image in various places, and if the exposure values from the brightest spot to the dimmest is not all that great, you may be able to get away with no further background extraction.



Although a STF stretch shows clear vignetting in this background, there is not really much there. The cursor shows the intensity (RGB) at 0.0097 each (Note the numbers at the bottom of the screenshot.) Move the cursor to the darkest corner, and the reading is 0.0095 for the three. Not much difference.

B: Background Neutralization

Images sometimes get color casts. The background sky should be pretty much equal in the Red, Green, and Blue channels. But say red is stronger relative to the others, the whole picture will take on a reddish cast. PixInsight has tools to take care of these problems.



Before we look at Background Neutralization, let us again use the "Link Channels" icon. You met it on page 12—"C: An Aside—Linking Color Channels." Make sure your image is active, and click on the blue links, and then on the Autostretch icon. Click again on the links, and again on the Autostretch. Flip back and forth from linked to unlinked, autostretching in each transition. If your image does not change color casts, you can skip Background Neutralization and jump to **C. Color Calibration**, below. If it changes the general color, how-

ever, click on:
Process/
All Processes/
Background Neutralization.

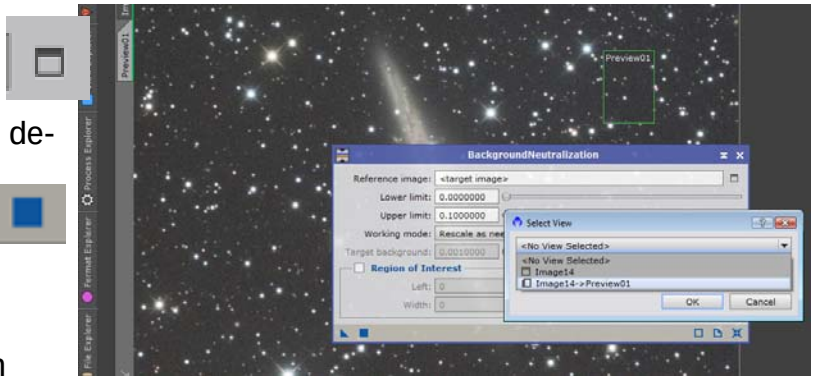
The tool uses a reference image that shows the typical background sky. It computes the relative weights of the channels, and then mathematically corrects those values, so the typical background sky is neutral—all three colors at about the same strength.

You don't absolutely need to define the background sky for the image. You can consider the whole image as the reference by taking the default "Target Image."

But you should create a preview if you have a good bit of nebulosity, and relatively little background sky. It is easy to define a reference image, and a skill you should learn. (You will need it in the next step!!!)

Creating a Preview Image: Click on your target image to make it active. Press Alt-N (hold the "Alt" key down while you press "N" once. Release both keys). On the image, click-drag to create a box covering a good sample of background sky. Try not to include any nebulosity, and relatively few stars if possible. Release the mouse button, and you have your first preview. (If you mess up, and get too small a sample, or cover too much nebulosity, just try again. You can delete any bad previews by right-clicking their tab on the side, and using the "delete" option.)

Now, look to the Background Neutralization window. Under "Reference Image" either take the default "Target Image," or, preferably "...Preview01." Choose by clicking the file icon at the end of the reference image window.



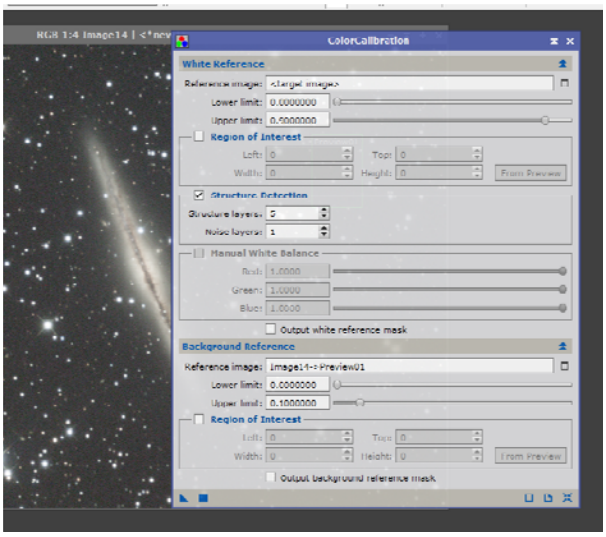
Leave the other inputs at their defaults for now. Apply the process by clicking the blue "Apply" square on the bottom left.

When the process finishes, run that experiment with STF autostretch again, linking and unlinking the channels (blue links) as you autostretch your images. Hopefully, this time, you should not observe large color shifts.

C: Color Calibration

So, the background has been neutralized, and with it the other objects of interest. But are they the right colors? PixInsight provides the Color Calibration Process. To call it up, click on:

Process/
All Processes/
Color Calibration



You can re-use the background reference preview you created for Background Neutralization. Under “Background Reference” in the bottom third of the window, click on the file icon at the end of “Reference Image” and choose that preview.

Make sure Structure Detection is checked, and the 5 and 1 are entered in layers under “Structure Detection” as shown at right.

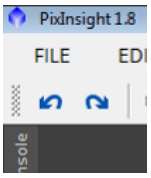
Accept all the other defaults (including target image as the white “Reference Image” at the top) and apply the process by clicking on the blue “apply” box at the bottom as you have done with other processes.

Click your STF radioactive button to see how far you have come.

D: Save/Close/Cleanup

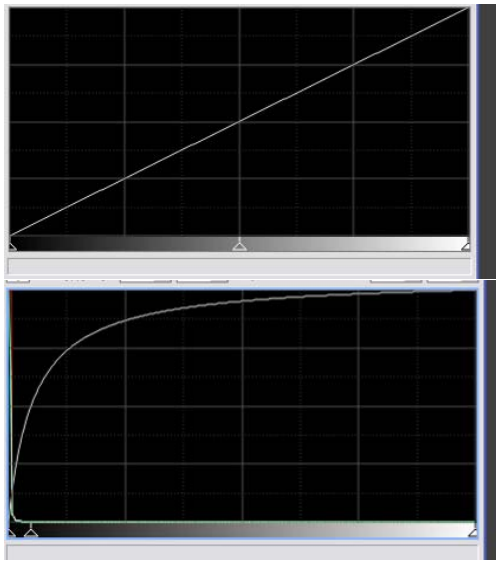
Save your color image, just in case something happens. From the main menu bar, call File/Save, and take the defaults to save an XISF file under the name RGB. Your desktop should show one open file.

Do-Overs and Take Backs and Experiments



Ever wish you could go back and re-do something? Fix some of the big mistakes you have made in your life? (I mean, did you *really* say *that* to her? at the *Prom*?) At least Pixinxight processes are reversible. In the upper left hand corner of the PI screen, you will find two curvy arrows. Click on the Undo (backwards) arrow, and you can undo what you just did. Click again on that arrow, and it takes you further back. Click on the Re-Do arrow, and you come forward again. These arrows are nice if you want to undo something. They are also useful to show the effect of a process. Do the process. Undo it. Redo it, Undo it, Redo it, etc. while looking at the effects it has on the image.

VII. Processing—Going Non-Linear



So far we have been working with “Linear” data, like the graph at the top. Every value has a direct correspondence, 1:1 (or some other number, depending on the gain of your chip), between the number of photons that struck the pixel, and the displayed brightness. For every increase in input, there is a corresponding—straight line—increase in output. Your “input:output” ratio is 1:1.

Without the STF, you see a largely black image, with a few spots of lighter stuff. If you hit the radioactive button, though, you get that artificial stretch such that the darker areas are very much brightened while the already bright areas are not brightened so much. That graph would look like the second. The input:output graph is no longer 1:1, but depends on how bright the pixel was in the first place.

A: Stretching the Data/Histogram Transformation

After stretching, one sees lots of change between the dim levels, but not so much in the brighter ranges. All this time, the Autostretch function has been doing this to the screen display—brightening the dimmest data while keeping the brightest data close to its original values. This brings out the dim stuff, while preventing any blown out bright spots. But the original data is not changed.

We must now “stretch” the data itself so that the Autostretch becomes permanent.

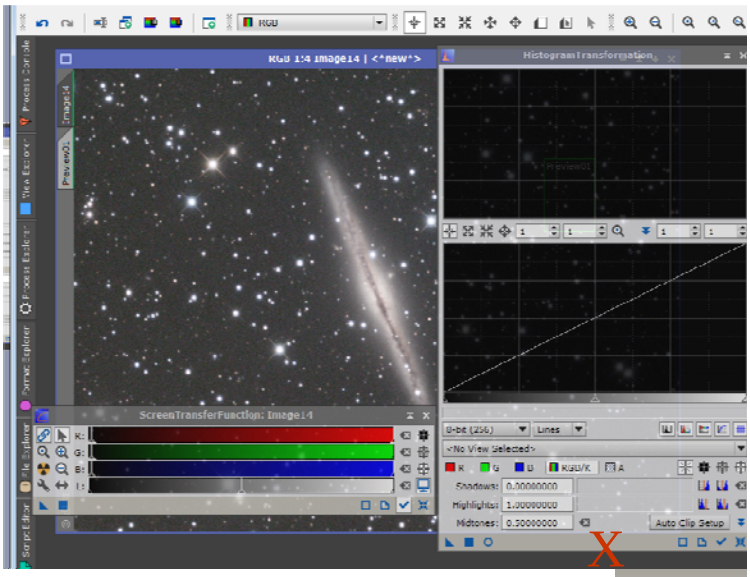
The simplest way to do this is to use the STF Autostretch function as our guide to a Histogram Transformation.

The Screen Transfer Function should already be open. To open the Histogram Transformation Process click on:

Process/
All Processes/
Histogram Transformation

Here you see our old friend, the Screen Transfer Function window, and our new acquaintance, the Histogram Transformation Window.

We will use the “new instance” icon (blue triangle on the STF window) to make our histogram transformation.



Start the transformation by computing a good curve. Do this by “autostretching” the image as you have so many times before—press the “Autostretch” radioactive icon in STF. That little triangle (new instance icon) is now holding all the information and parameters that the Screen Transfer Function has computed for the image autostretch. Transfer all of that to the Histogram Transformation window by click-dragging the blue triangle from the Screen Transfer Window to the bottom line of the Histogram Transformation window. Make it land between the open circle and the open square, right in the middle there. (X marks the spot!) Notice how the curve in the Histogram process window changes.

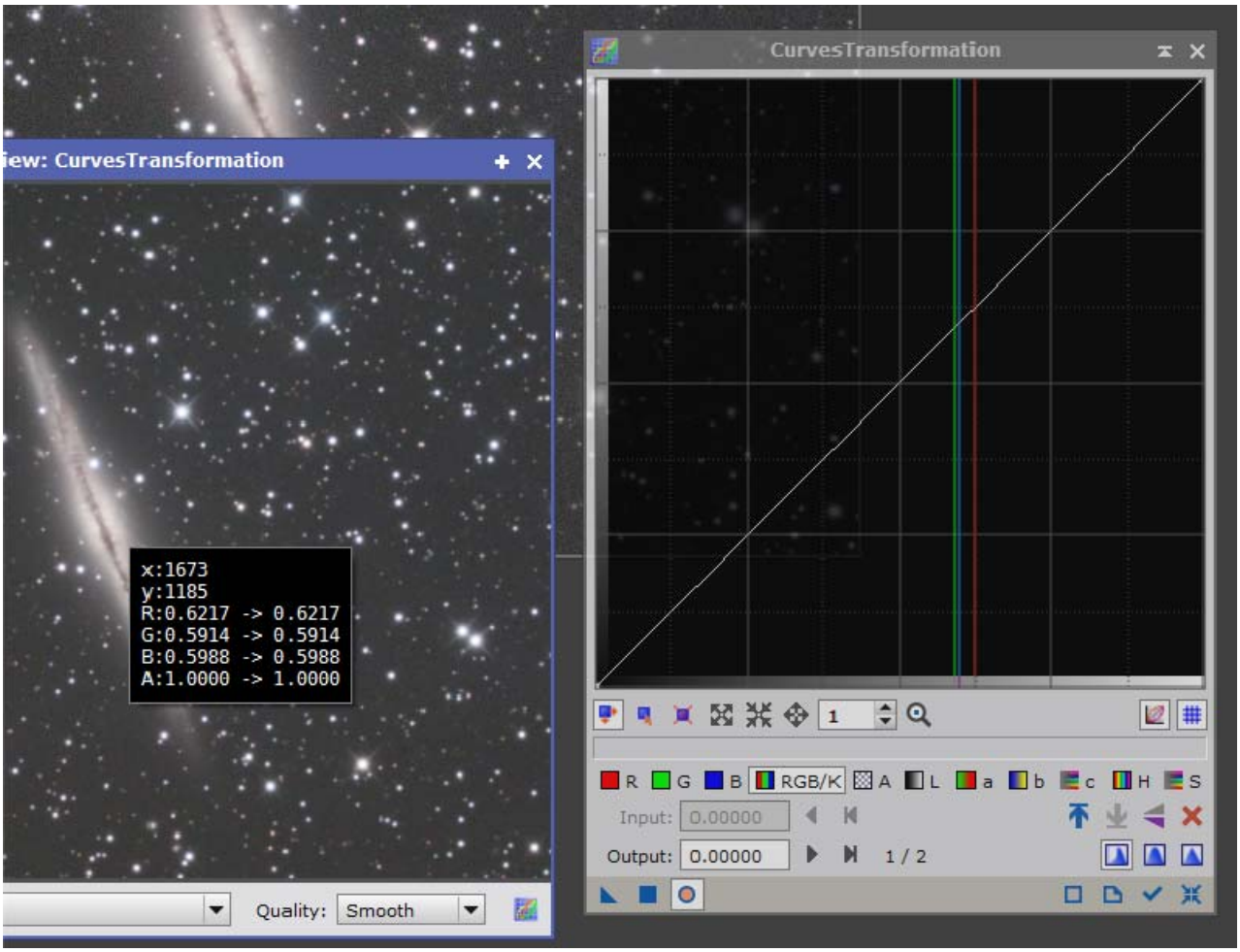
Now, apply the HT process by clicking on the “Apply” blue square icon near the lower left corner of the HT window.

After the Process Console does its thing, the image turns white!!!! Or so. Not to worry. The image data has changed, but the Screen Transfer Function is still applying its Autostretch based on what it thought the data was. “Reset” (blue X in lower right corner of STF) the Screen Transfer Function. Your image returns to actual data.

Click Autostretch radioactive again, and there may be a slight appearance change. Reset, and the change will reverse. Earlier when you tried the same thing, the image shifted from mostly black (Linear) to pleasant brightness (Artificially Stretched) and back again. Now, it is shifting ever so slightly, perhaps, but staying generally “Stretched.” Your underlying data is now “stretched,” and no longer “linear.”

The really cool thing about all this——you already probably have a better picture here *automatically* than anything you got after a lot of *thoughtful (and perhaps frustrating) manipulation* in some other image processing programs!!!

Incidentally, you probably will no longer need the STF process, and can bid it adieu.



B: Curves

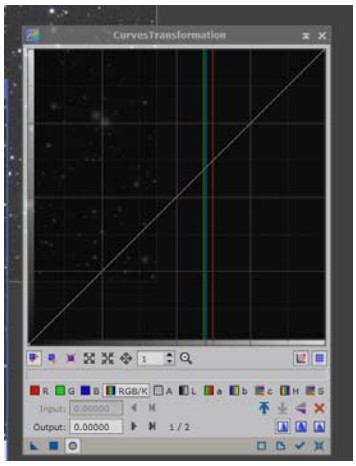
You may, or may not be satisfied with the automatic stretching done by the Screen Transfer Function. To increase the stretch a bit, you can turn to the Curves process. To call up the Curves Process, click on:

Process/
All Processes/
Curves Transformation

This process should be quite familiar to anybody who has used Curves in Photoshop or other image processing programs. Remember in the discussion of Histogram Transformation, we saw how changing the shape of the input-output curve enabled us to brighten dark areas while not blowing out light areas. This was a “curves” function that changed the Histogram. The curves process, however, allows more varied curves.

Above right is a sample curves window. I have clicked on the center of the galaxy. This put a cross hair on where I had my cursor, and brought up an information window, telling me the bull’s-eye was on a point at 1673 in x coordinate, 1105 in y, and the color

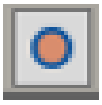
values for that pixel (R=0-.6217, G=0.5914, and B= 0.5988). It also illustrated (with the vertical colored lines in the curve graph) just where that point fell along my input-output curve.



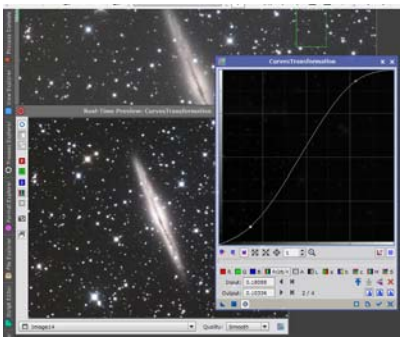
The autostretch function you applied in Histogram Transformation already took its best shot at assigning the proper curve. This is not the place for an extended discussion of how to use curves. But if you are familiar with them in the first place, you can use them to tweak the curves assigned in the Histogram Transformation.

Start by telling the process that you want to "Track View." The Track View icon is the little blue checkmark, second from the right at the bottom of the window. When you are tracking the view, the window will provide you a histogram of the data.

Then, start a "Real Time Preview" of your image. The Real Time Preview icon is the blue open circle (it turns pink some times), third in from the left end at the bottom. Up pops a low resolution duplicate of your image. As you change the curves, it will reflect your changes (but your changes will not change the original image until you apply the changes). If the little circle turns pink, press it twice to update your real time preview.



Now, experiment. Decide which area you want darkened, or lightened in relation to the rest of the image. To determine the brightness level of a pixel or area, click on it in your picture. Note that in the curves process box a vertical line indicates the brightness level of where you are clicking. Click on that part of the curves line drag downward to darken, and upward to lighten.



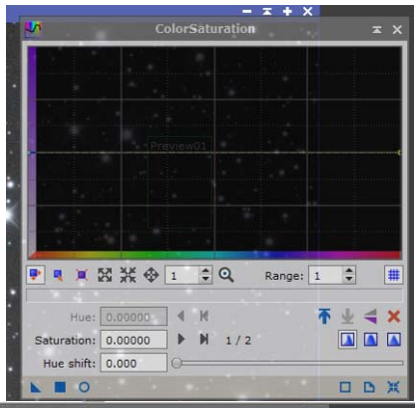
A simple "S" curve (the brights pulled up, and the darks pulled down) produces more contrast in this image, for instance. Compare the Real Time Preview with the original underneath.

You can reset to start over by clicking the "Reset" blue X in the far right at the bottom.

When you are finished, click the "Apply" blue square at the left bottom. Note that your Real Time Preview will stay active, and since it is applying the new curve to the new data, it will be doubly done—and probably ugly. To reset the Real Time Preview, reset the curves function (with the reset blue X in the lower right hand corner of the Curves Transformation window). If you are happy with the real image cancel out of the real time preview (by the X in the upper right). Once you are satisfied with the curves operation, you do not need the Real Time Preview.

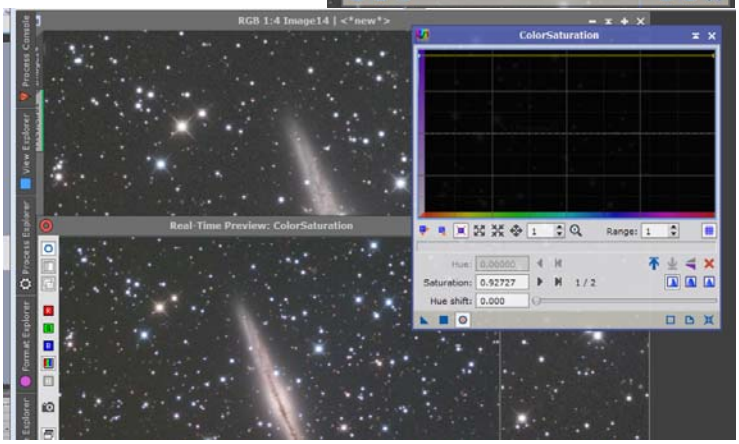
You should be staring at a stretched, fairly contrasty full color image.

C: Saturation



Increasing saturation deepens the colors in an image. This can be overdone. But when it is needed, it does help the image.

To call up the Color Saturation process, click on:
Process/
All Processes/
Color Saturation



Start a real time preview (open circle, third from left on bottom) just as you did with the Curves window.

There is a yellow line running horizontally across the middle of the graph. To saturate all colors evenly, click drag the anchor point on one end or the other of the yellow line upwards. Above you see the line "before." At right, is "after" the drag. Note the thin yellow line is now at the top of the graph window. Note above how the colors in the preview (left) are deeper than the original.

Note that if you do not grab the anchor point at the very end of the horizontal bar, you will pull one color without the others. Reset (blue "X") and try again.

To increase or decrease one part of the spectrum more than another, use the "hue shift" slider to move the color you want to work with to the middle of the horizontal axis. Then, above that color, push the curve up or down—-(but no beginning, and few advanced, astroimagers ever push a saturation curve down. (That is a joke. Do not take it seriously.)).

If you run out of travel in the curve (it is pushed all the way up), you can change the zoom on the graph and the range (power) of the process by experimenting with the numbers in the boxes just below the graph.

You can add control points (click or click-drag on the line) in various places to aid alterations. And, of course, there is a "reset X" there when you want to start over.

Click the blue “apply” button to make your saturation changes permanent.

D: Noise Reduction

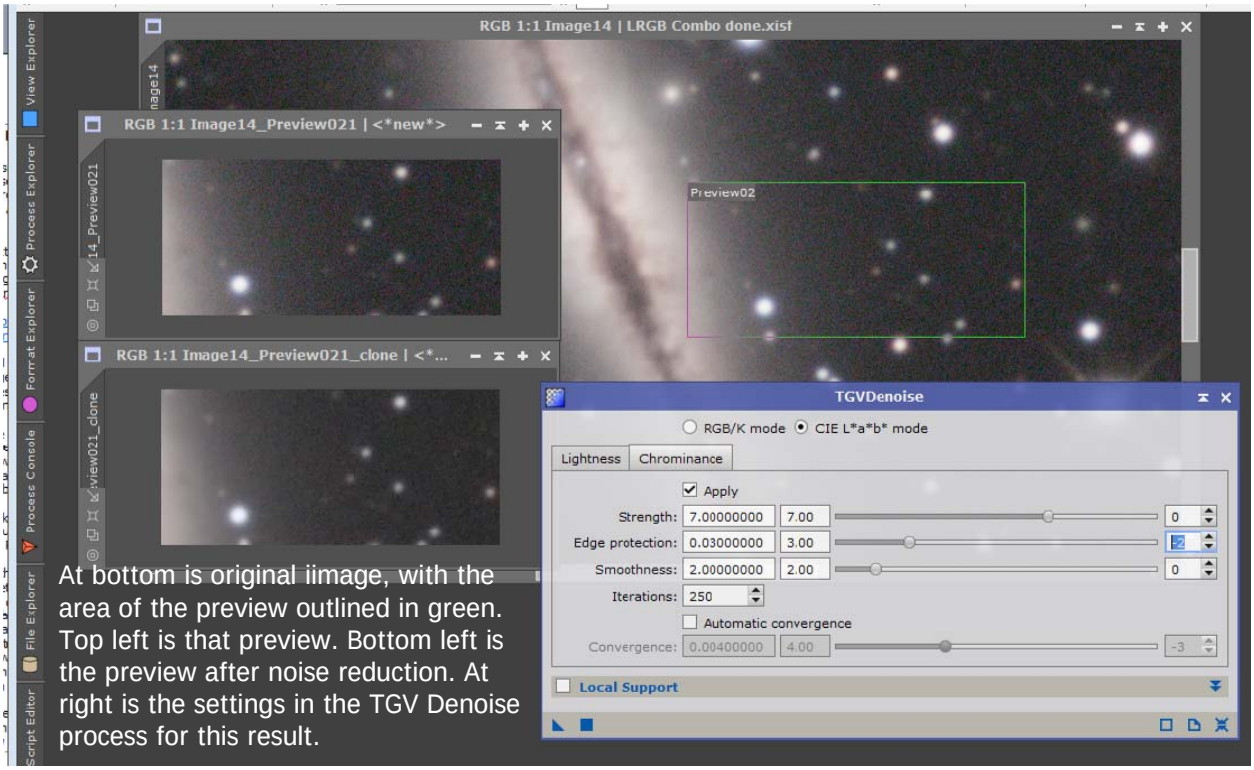
Noise can be a challenge in any astronomical image. Pixinsight offers a number of noise reduction processes. The most popular is TGV Denoise. To start it, click on:

Process/
All Processes/
TGV Denoise

Getting the settings right can be a challenge—maybe more than you need if all you want is a loaf of bread and a jug of milk. If so, skip this denoising stuff for now. Your image is probably already pretty good. But if you want to explore before you go, visit Harry’s Astroshed:

http://www.harrysastroshed.com/pixinsight/pixinsight%20video%20html/pixinsighthomeinter.html

and follow the TGV Denoise tutorial. Harry uses a mask. A little later he works with his edge protection to really bring out some faint detail. And he is working in Luminance. These are the things that improve your eventual product, but may be more confusing than you need right now. *But, appreciate Harry’s willingness to experiment.* That is what you need to get the parameters right.



At bottom is original iimage, with the area of the preview outlined in green. Top left is that preview. Bottom left is the preview after noise reduction. At right is the settings in the TGV Denoise process for this result.

The process starts with a small preview because getting the settings right takes some experimentation, and this is processor intensive (slow!!!). Create a new preview with an Alt-N just like you did back on page 19. But this time you want a small area featuring some background sky and some nebulosity where you might have noise problems.

Click and drag your preview out from the main image window. This creates a clone. (You can create a clone of any image simply by dragging its tab into a blank area on the PI workspace.) I like to make several clones to run several experiments.

In the TGV Denoise window, click on the CIE L*a*b since you are working in a stretched color image, and click on the Chrominance tab. Reset the "Iterations" from the default 100 to 250. Click on one of your preview clones, and just for kicks, try the defaults by clicking the "execute" square. Did the noise go away without hurting your detail? Then you are magic. If it did not, try first raising the exponent on "edge protection" (from –3 default to –2), and run the experiment again on a different preview clone. Which one looks better? Continue to experiment until you get what you want. Go ahead and try the other settings in your experimentation, but edge protection is the most important.

When you have a setting that makes you happy, click on the full size LRGB image you want to work on, and execute the process with those settings. (To execute, use the square blue "Execute" box.) Sit back. It may take a few minutes.

Remember, you can use the undo arrows if it does not do what you want.

E: Save/Close/Cleanup

Much more can be done to optimize your image all along the way, and from this point on even.

But, all we want right now is a loaf of bread and a jug of milk.

Save your work. From the main menu bar, call File/Save As (make sure you go to Save As, not just Save—you do not want to overwrite the original data and previous work in case you want to go through these later stages again), give it a new name to indicate it is finished, and take the defaults to save an XISF file.

VIII. Finishing Touches

Your photo is essentially done. Certainly as you become more proficient in Pixinsight, you will find other tools that you can apply to make it even better.

We will leave that to your later experimentation, but for now, we should save things, and perhaps ready them for posting to your envious friends.

A: Save Originals

If you have not yet, save your picture off to your hard drive. Generally, click on File/ Save As/, navigate to where you want to store the image, and give it a new name. (Do not save under the original name. That file contains the original data. You may want to return to them some day when you learn what you are doing.)

Save as an 32 bit XISF file, taking the defaults all the way. This gives you your highest fidelity.

Then File/Save As again. This time, save as a TIFF, and when the parameter window comes up, tell it 16 bit unsigned integer. This file can be used in other image processing programs that cannot use the XISF foromat.

You will get warnings that a TIFF file does not do all that PixInsight's own XISF file format wants you to do. That's okay. For your purposes, having that additional TIFF file may be an advantage.

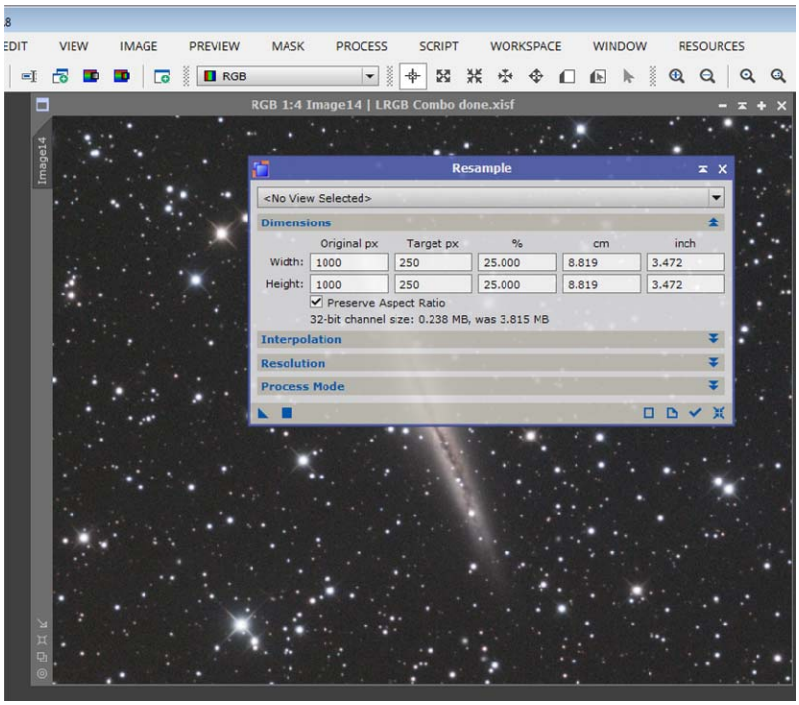
B: Save for Web

Now, to get it ready to post on Cloudy Nights and in other places that cannot handle large file sizes, you may want to reduce the file size. Do this by resampling the image and saving as a jpeg.

To start, click on:
Process/
All Processes/
Resample

You will want to cut your image to about 25% of its original size to post on many forums, and to send to your girlfriend or boyfriend on the phone. To do so, make sure "Preserve aspect ratio" is checked, and enter a 25 in the % column (third one over) press "enter," and the image will shrink. If 25% is too small, try 50 or whatever else

you think appropriate.



Now, do a Save As, giving it a new name, and specifying ".jpg" as file type. Be sure not to use a standard "save," so that you do not overwrite your full size file. You will need to specify the quality of your jpg. Don't be put off by the warnings PI gives you about loss of quality. That is inherent in saving for the web.

(If you wish to continue working on your file, do not, generally, work on the JPG so much as go back to the original LRGB to do alterations.....but, hey, really, you got your jug of milk, and your loaf of bread, and I'm gonna stop telling you how to run your life.)

Final Words

If your data was at all decent, you should have something that will wow your significant other, amaze your boy scout troop, and put you in line for a promotion from your boss (Until she saw that galaxy photo, she really did not realize you had a talent!). (And on a phone display, it will look even better than on a computer monitor!!!)

Of course, you will not stand a chance with the dudes on AstroBin or Cloudy Night CCD Forum. But, hey——-you are a proud beginner.

Seriously, amateur astroimagers will be able to pixel-peep your image to death. Do not worry about that.

Think instead about what you have learned by doing:

- Processes and Scripts
- Inputting parameters,
- Real Time Preview screen,
- Preview,
- Common icons to apply, reset, or undo a process used throughout PixInsight,
- New instance icons…,

The list goes on.

You have no idea how much you do not know:

- How to use the Process Explorer (Nobody goes to “Processes/All Processes/?????” to start a process…..it was just the easiest way to explain how to start a process.)
- How to optimize the calibration routines, integration parameters, and a whole lot more to get the most out of your data.
- How to sharpen, to shrink stars, to increase contrast in the nebulae.
- Masks——OMG, you don’t know Masks!!!!
- The icons in the toolbar. My gosh—so many things are up there that you do not know about yet!!!!

I won’t go on. But look to the last page here to see the difference between this nearly automatic processing and thoughtful work done in PI. And I am not that good at it yet.

The point is, what was once an impenetrable mass of buttons, switches, dials, and gobble-de-gook has produced a pretty darn good picture.

You have justified its purchase price. Go get your bread and milk.

You have a nodding acquaintance of things *PixInsightish*, and can take it from here.

Tutorial Ver 1.02 January 25, 2015
This tutorial uses PixInsight 01.08.04.1195
The Lights of NGC 891 were acquired at GMARS, Landers, California (see rivastro.org) in November, 2015, with a TPO 12 inc RC/flattener, on an AP1200, using SGP and PhD2 Guiding. The camera was a QSI 583. Exposures 600 sec L at 1x1. RGB at 2x2

The same data—NGC 891—processed by the author (who is not particularly adept in image processing). Above, according to this tutorial. Below with a little more thoughtful PI processing. Imagine what I will be able to do if I ever get good.