Spectroheliograph Imaging and Processing

by Wah!

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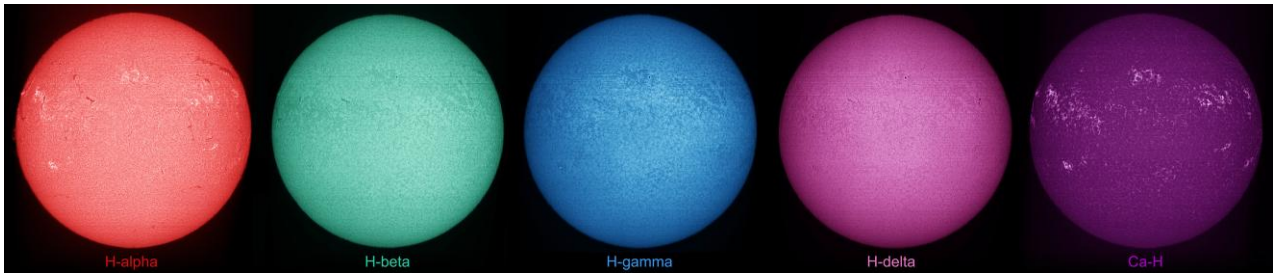


Table of Content

Imaging Procedures *(Based on using SharpCap)*

1. Setup the equipment: Do the polar alignment to your equatorial mount at good as you can. Install the spectroheliograph on the mount and make it balance.

2. Point your spectroheliograph to the sun, let the solar image project to the slit of the spectroscope. Then you should be able to see a bright colorful spectrum through the eyepiece.

3. Remove the eyepiece of your spectroscope and insert the camera into the eyepiece holder. Mono cameras are preferred. Start the capturing program such as SharpCap to preview the images.

4. Rotate the spectroscope and let the slit orientation perpendicular to the W-E movement direction of the solar image. When this task is done, the starting position will be the same as the ending position while scanning the sun from one side to the other. The spectrum will first appear then become wider, then become narrower and disappear at last.

5. Tuning the color: Adjust the angle of the grating, let your target wavelength / spectral line go to the center of your camera.

6. Change exposure time to avoid under exposure and over exposure.

7. Tune the focus of your camera holder, until the spectral lines are sharp. If there is/are lens(es) inside your spectroscope, this step must be done every time after turning the grating.

8. You may adjust the slit wide before or after step 7. If the slit is too wide, you may not be able to get any sharp spectral lines. But if the slit is too narrow, you will have long exposure time, that means the frame rate becomes lower, you'll need more time to scan the whole sun. Also, narrower the slit, the un-even brightness of the slit becomes more obvious. You need an optimized slit width for imaging. (There should be some tools to calculate the optimized slit width, but I haven't tried them yet.)

9. Rotate the camera to let spectral lines as horizontal (or vertical) as you can, this can reduce post processing work later.

10. Focusing the solar image. Although the spectral lines are sharp already, the solar image may not be sharp simultaneously. We need to adjust the focusing knob of the telescope to make the spectrum edge sharp. The best position to do focusing is let the solar center lying on the slit (widest spectrum).

11. Change the ROI in the capturing software, this can reduce the avi file size and may increase the frame rate.

12. Change the exposure again. Because most of the interesting spectral lines are quite dim, we need to increase the exposure time to let the final merged image become normal exposure. The other part of the spectrum may become over-exposed, no worry. You can also see prominence on the solar edge

13. Before avi capturing, we first need to speed up the EQ-mount and let the slit go beyond

the solar image for a little while.

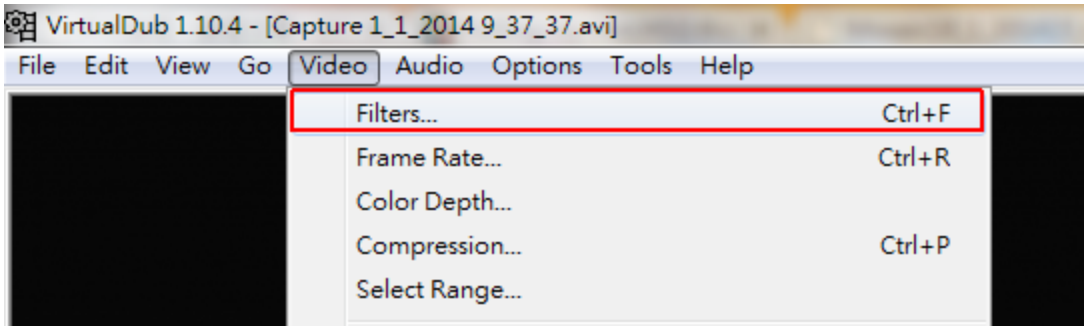
14. Then start the avi file capturing without time/frame limitation.

15. Then stop the EQ-mount or reverse tracking direction to speed up the scanning process. Let the solar image pass though the slit.

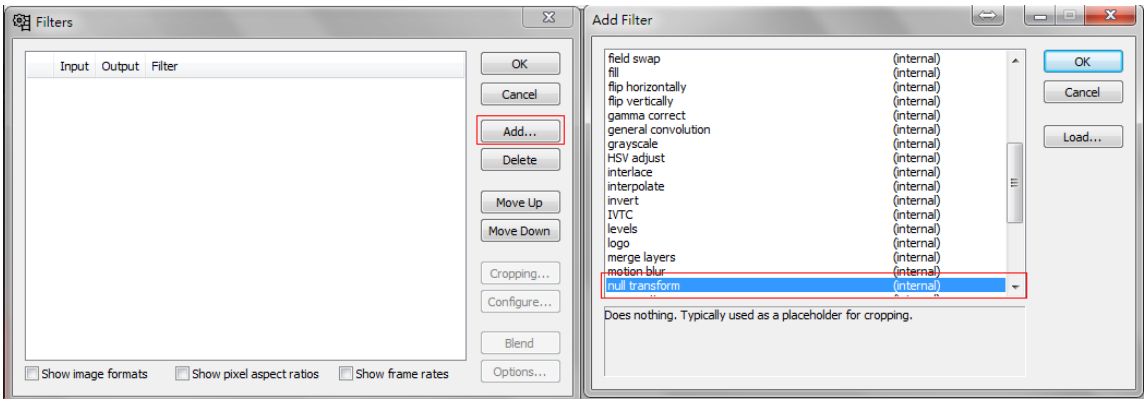
16. Stop the avi file capturing after the whole solar image has scanned pass the slit. Then you may cover the telescope objective to avoid burning the spectroscope.

VirtualDub Movie Cropping

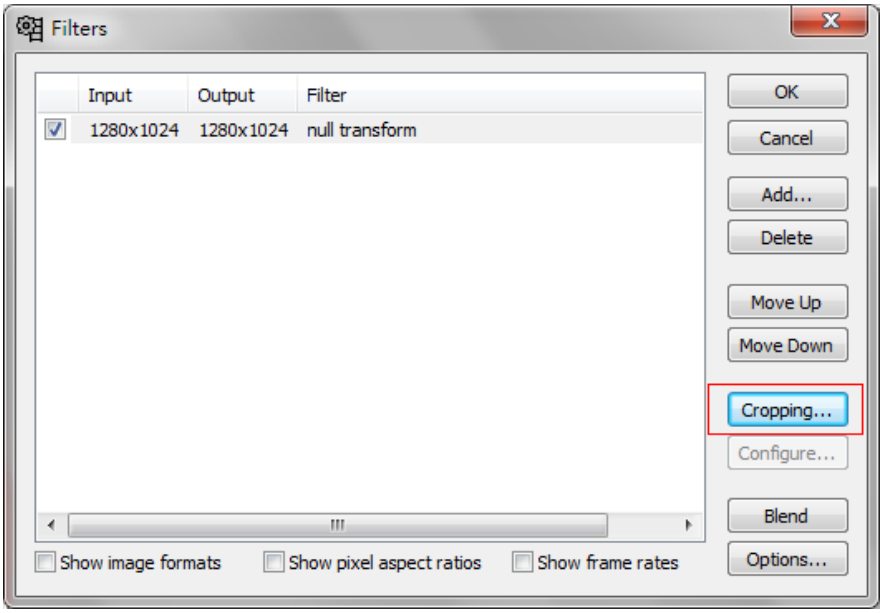
- ## Why do we need movie cropping
  1. SpecLineMerge limitation: SpecLineMerge cannot process movies from SharpCap directly because of encoding. It also cannot process high resolution movies. This is the most important reason.
  2. Reduce avi movie size: Except the target spectral line, most of the spectrum areas are over exposed, no information can be retrieved from these areas, so we can crop to remove them.
  3. Reduce the movie size can increase the processing speed.
- ## Movie cropping procedures
  1. Start VirtualDub
  2. Open the avi file (support drag & drop)



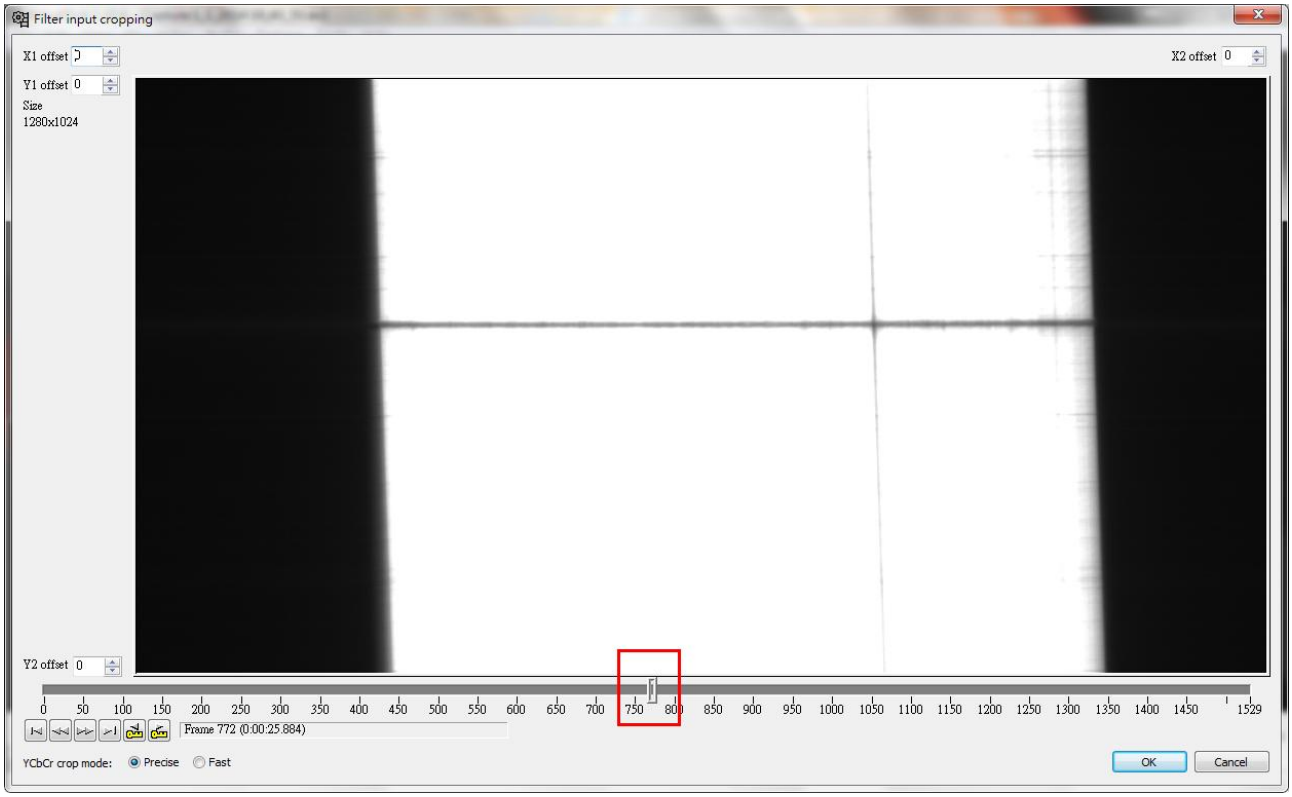
  3. Video > Filters
  4. Add > Null Transform



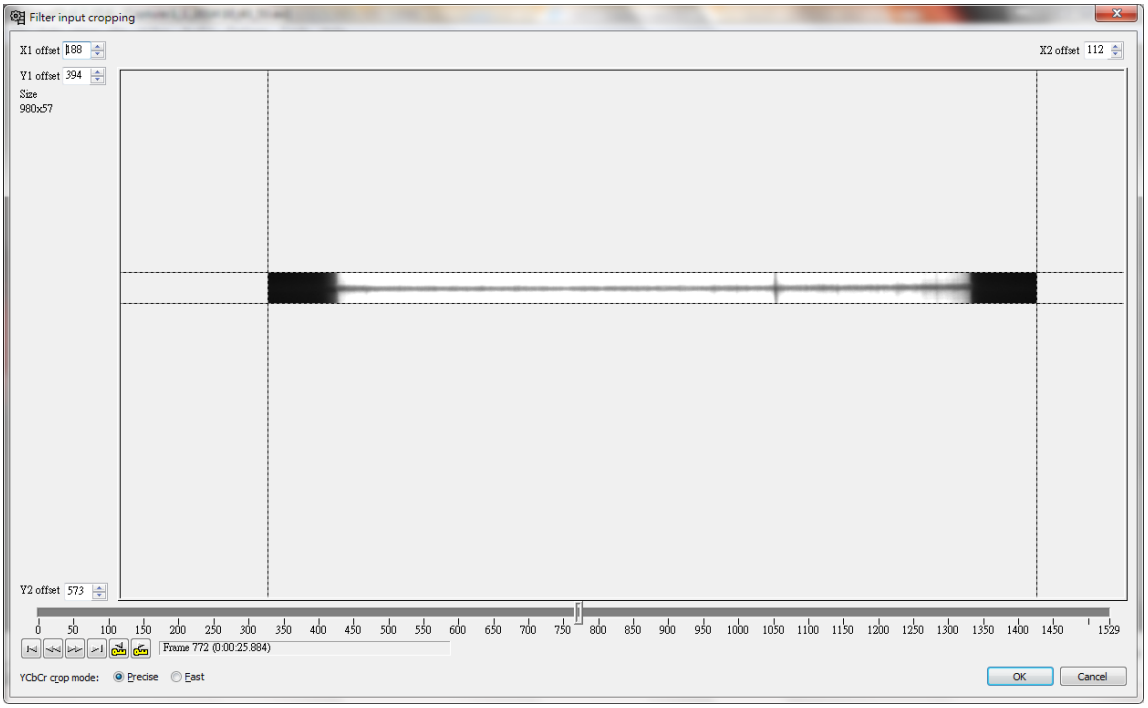
  5. Cropping



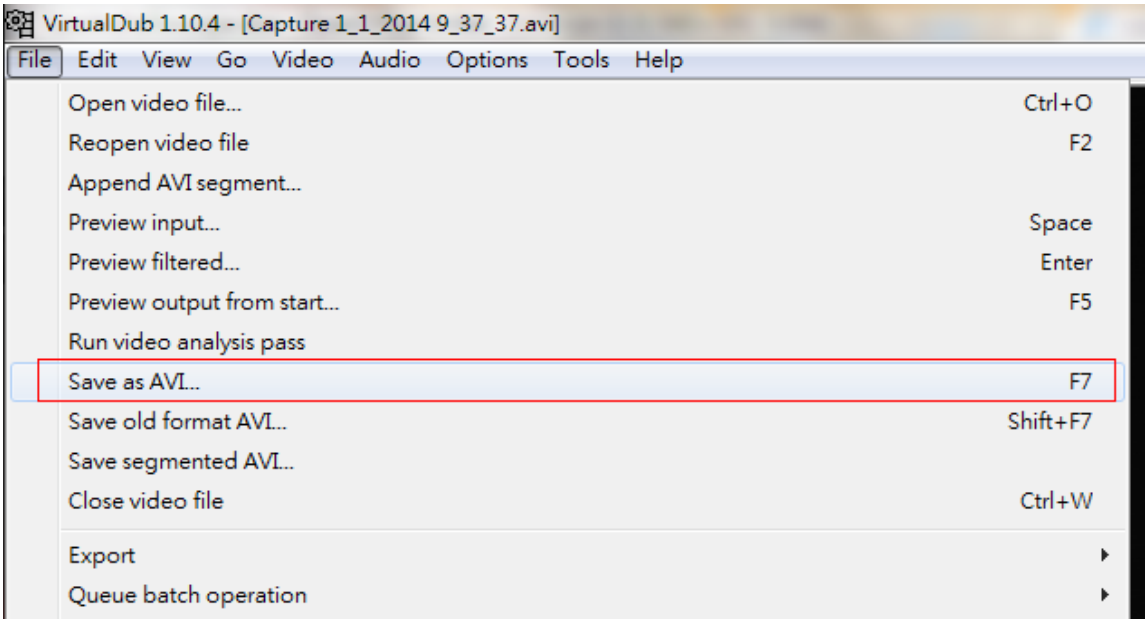
6. Drag the bottom track bar to the frame with the widest spectrum (solar diameter)



7. Adjust the crop area as below, remember to leave some sky background

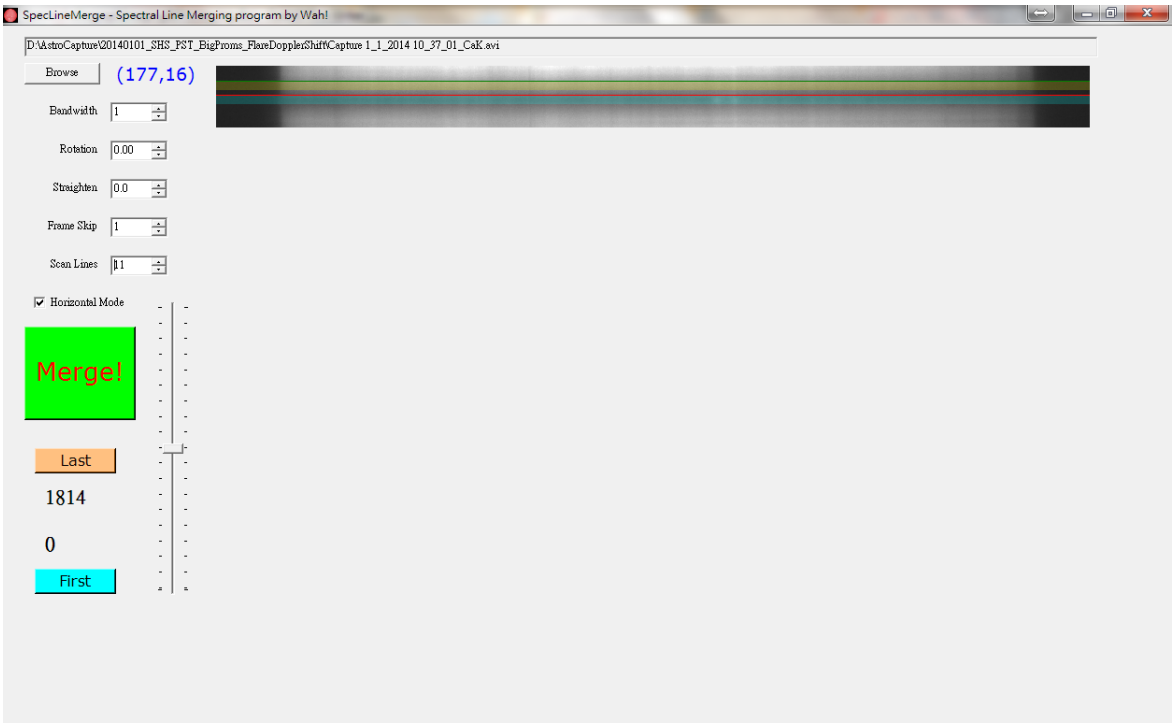


8. Click OK > OK to go back to the main screen
9. File > Save as AVI (Shortcut key **F7**)



10. Rename the AVI and click OK, then wait for the copping process finish.

Introduction of SpecLineMerge



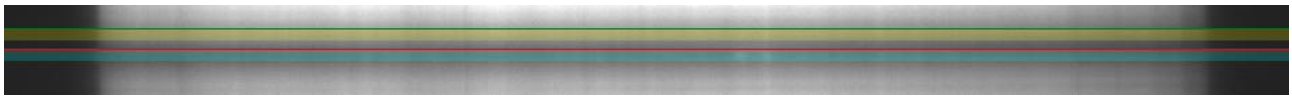
- **Interface**
  1. Browse: Select and open the Avi movie. You can also drag & drop the avi to the interface.
  2. Long vertical trackbar is the tool for you to change frame preview of the movie
  3. Area on the right is the frame preview, also where we define the spectral line that needed to be merged.
  4. First: Click the button to define current preview frame as the first frame being merged. Default 0.
  5. Last: Click the button to define current preview frame as the last frame being merged. Default the last frame.
  6. Bandwidth: Define the merging line/area width, similar to the bandwidth concept.
  7. Rotation: Adjust the tilt of the frame, useful when the original spectral lines are not absolutely horizontal / vertical.
  8. Straighten: Adjust the value to remove the “Smile” effect of the lines.
  9. Frame Skip: The number of frames to be skipped after every merging a frame. Adjust the value to avoid a very long oval shape sun. Larger the value, faster the merging speed.
  10. Scan Lines: Batch merging purpose.
  11. Horizontal Mode: If the spectral lines in your avi are in horizontal direction, you need to check this box. If not, un-check this box.
  12. Merge butto: Start merging process. When merging finished, the program will save the images to the same path as the avi movie. Auto rename with numbers to avoid duplicated names. Image format is fixed as 8bit PNG.

- ## Merging procedures

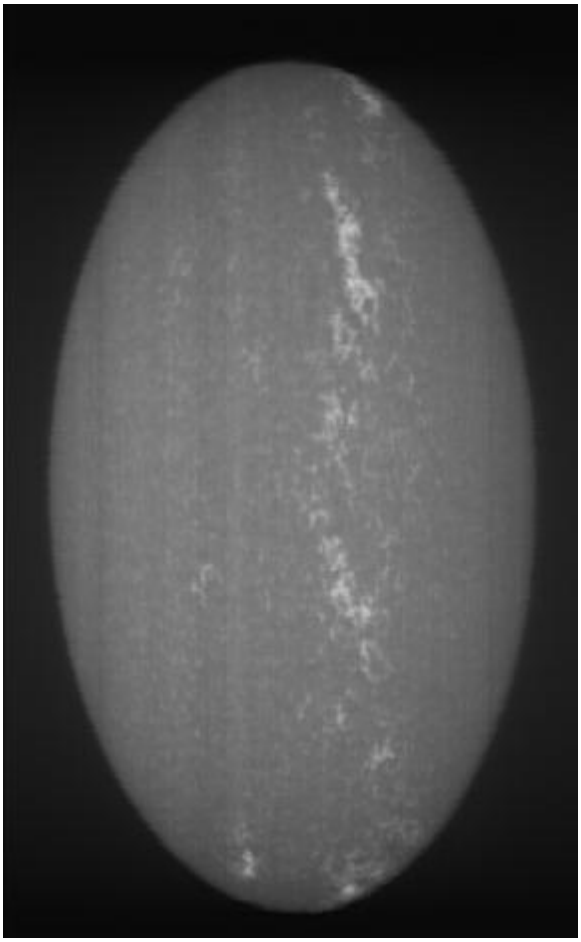
1. Open the avi file by using the “Browse” button or drag & drop.
2. Verify the horizontal/vertical mode
3. Adjust the first and the last frame if needed.
4. Left click your mouse while point to the line that you’re going to merge.

Image above: The green line will follow your mouse movement which is for preview purpose only. The red line will appear only after you left click your mouse there, which defines the line to be merged.

5. Adjust the rotation/tilt of the spectrum if needed.
6. Adjust the straighten value to remove the “smile” if needed.
7. Adjust the frame skip value if you want.



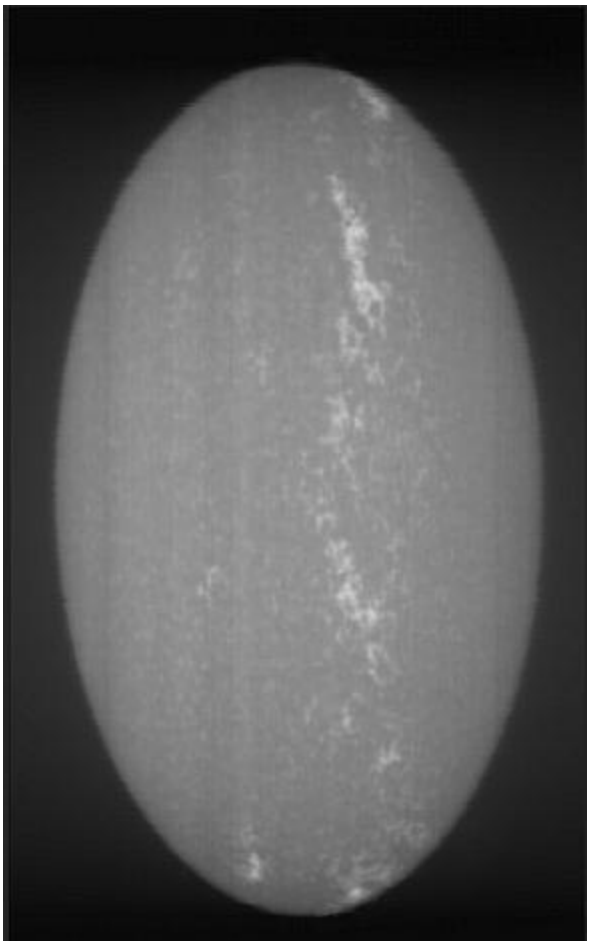
8. If you want to batch merge a range of the spectrum lines, increase the “Scan lines” value. You also need to click the red line to an upper position (more left for vertical mode). The transparent blue area is the range to be merged. Green line and yellow area is preview area that follows mouse movement.
9. Click “Merge” button to start merging.



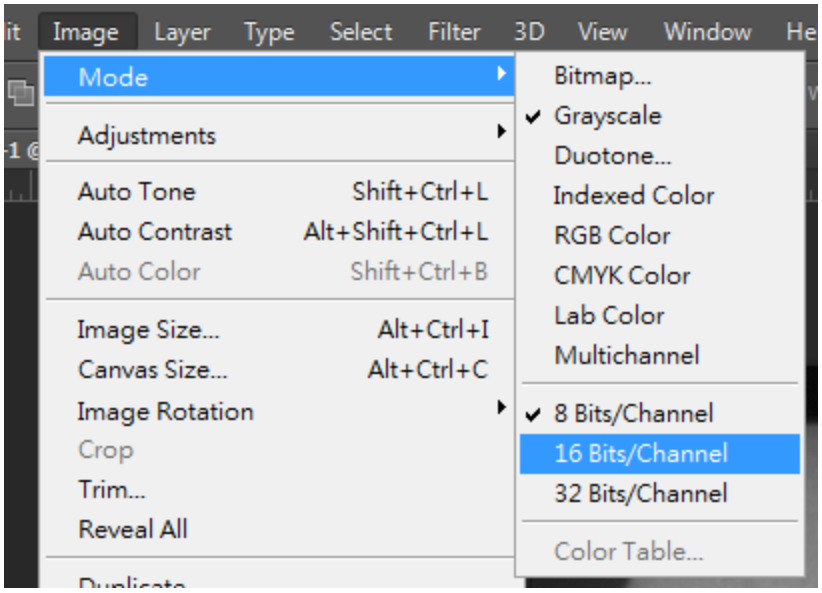
Photoshop Post Processing

- ## Purpose
  1. Flatten sky background(by subtracting FF1)
  2. Remove horizontal/vertical pattern that caused by uneven slit(by diving FF2)
  3. Make the solar disk round
  4. Let the solar disk look more natural (by multiplying FF3)
  5. Sharpening the image
  6. Increase the contrast
  7. Adding color
  8. Mosaic multiple scan images into one

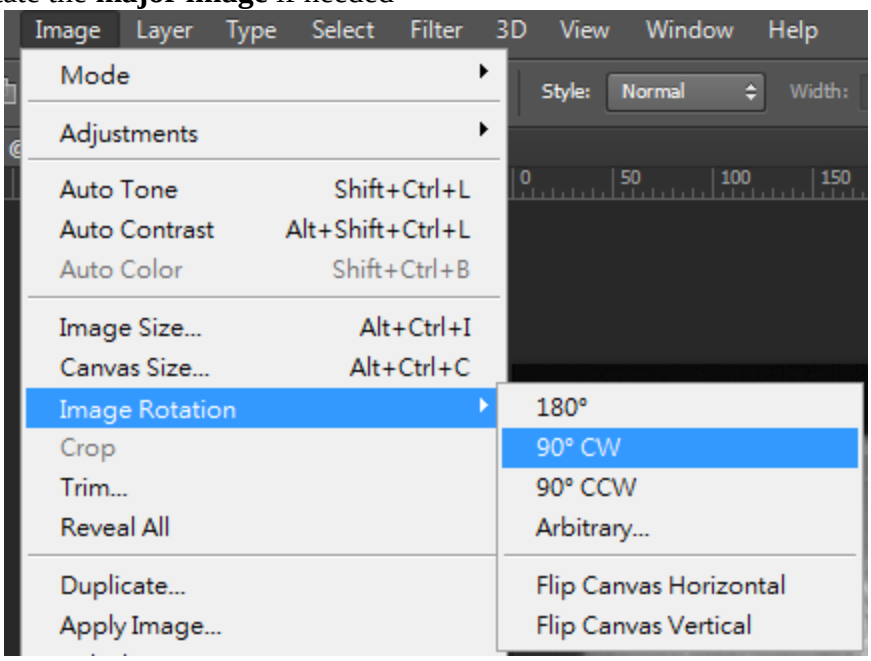
- ## Processing procedures
  1. Open the merged PNG file as your **major image**



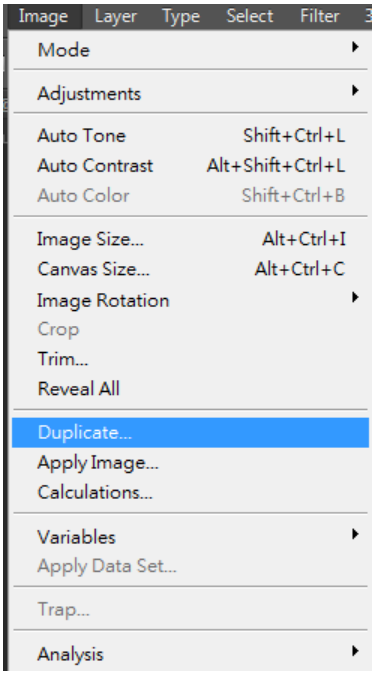
  2. Change the **major image** to 16bit mode, which hopefully can reduce signal lose during processing.



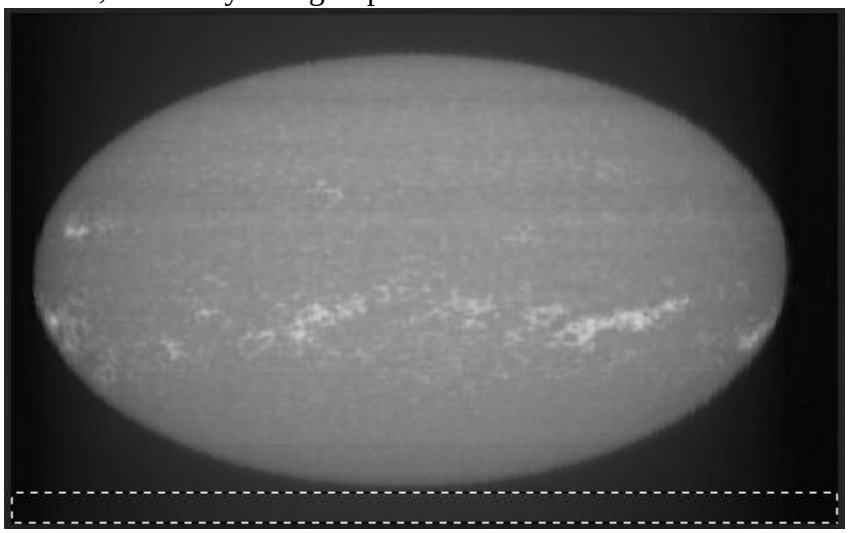
3. Rotate the **major image** if needed



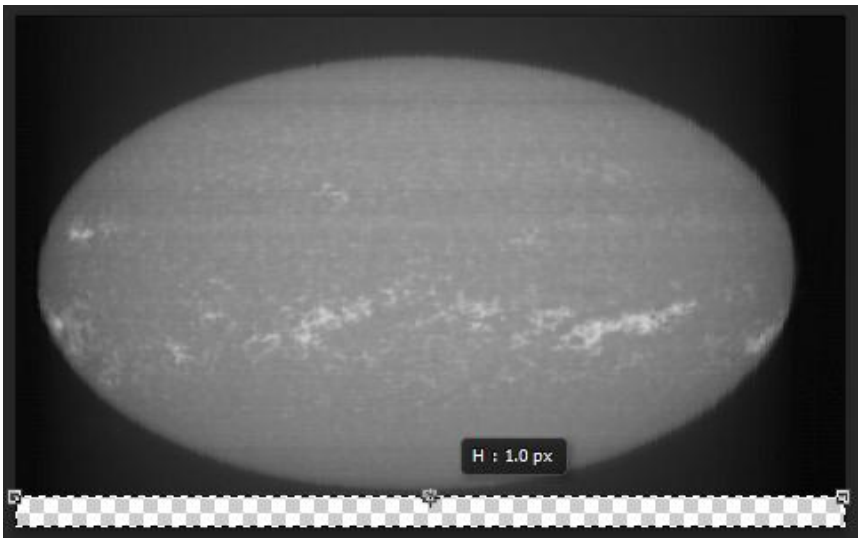
4. Duplicate the major image for **FF1** creation



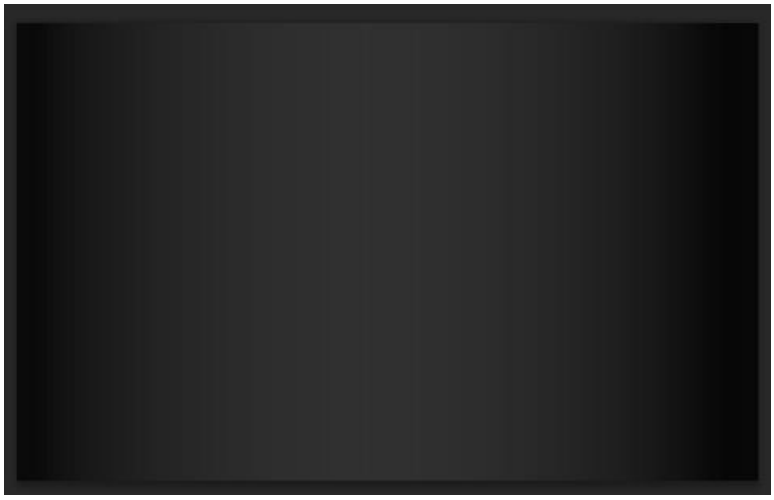
5. On **FF1**, select sky backgroup as below:



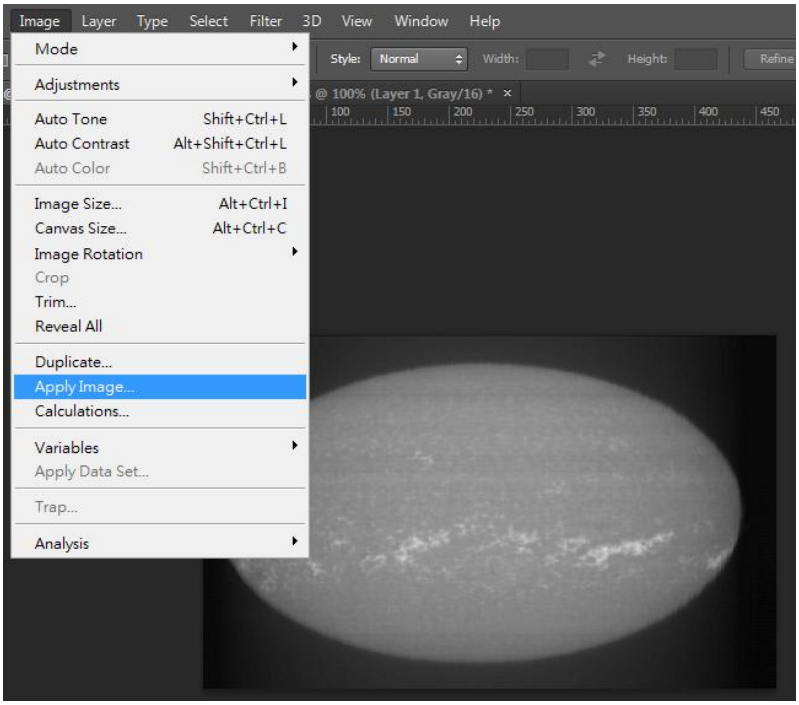
6. On **FF1,** transform select area to 1 pixel height (Ctrl+T)



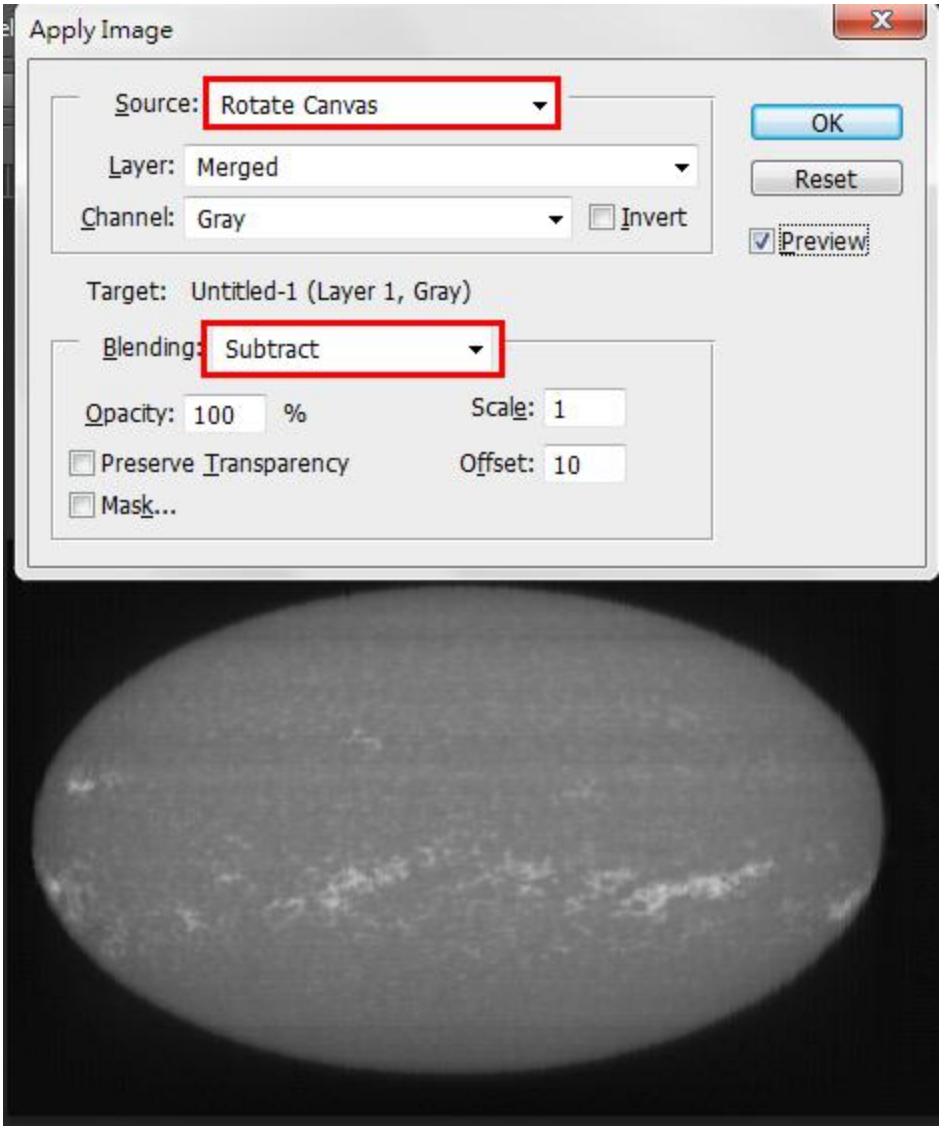
7. On **FF1**, transform the 1 pixel height area to image full height



8. Back to the **major image,** click Apply Image

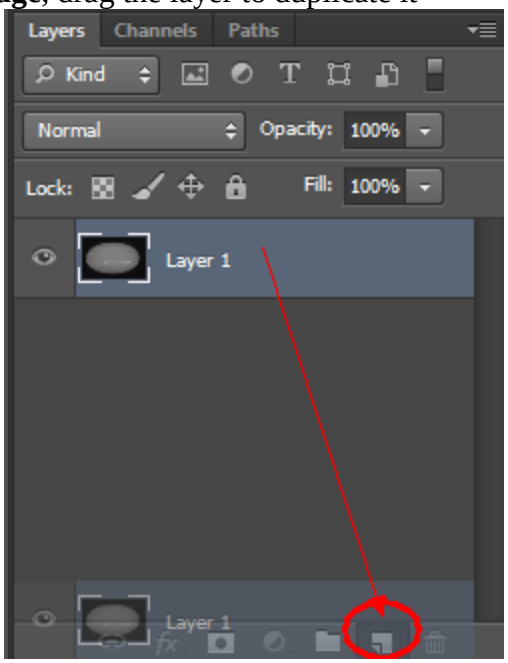


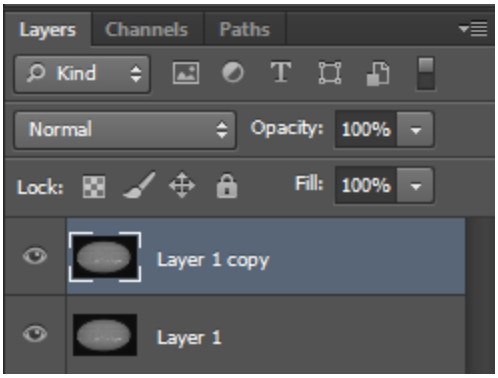
9. In the Apply Image options, choose the **FF1** and select **Subtract** method



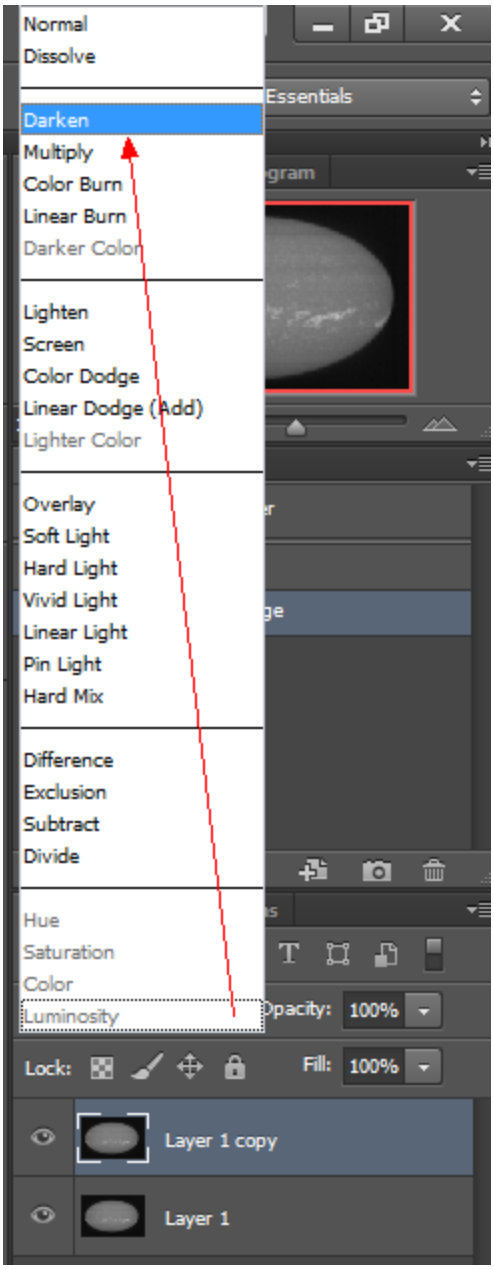
After subtracting FF1, the major image background is now even. It time for us to remove the horizontal bands caused by un-even slit. (FF1 can be closed without saving now.)

10. On the **major image**, drag the layer to duplicate it



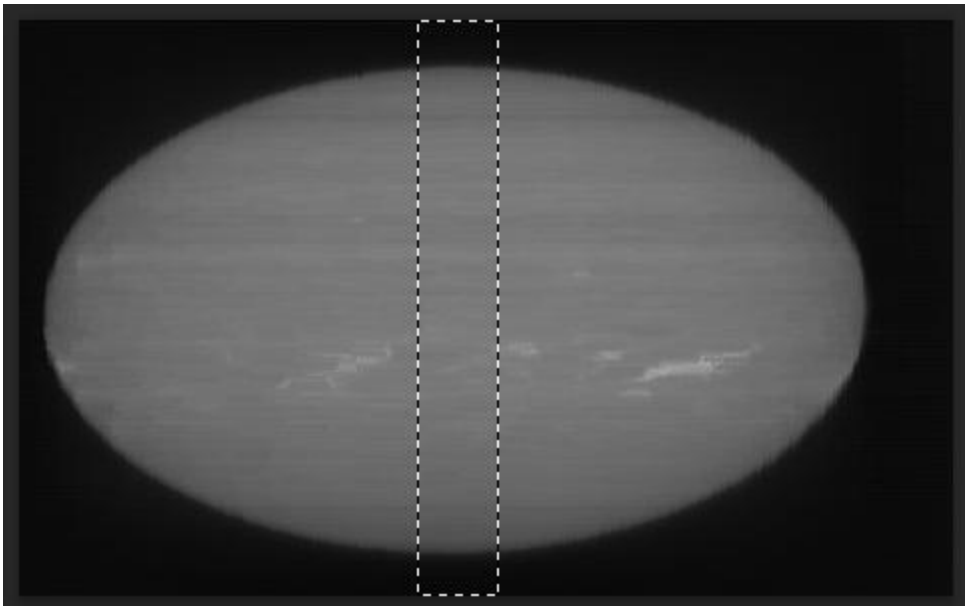


11. Then duplicate the major image to create the **FF2** (similar to step 4)
12. **On FF2,** adjust the mode from normal to darken/lighten. It depends on which wavelength is being processed, I usually prefer using Darken for CaH/CaK images, Lighten for H-a images.

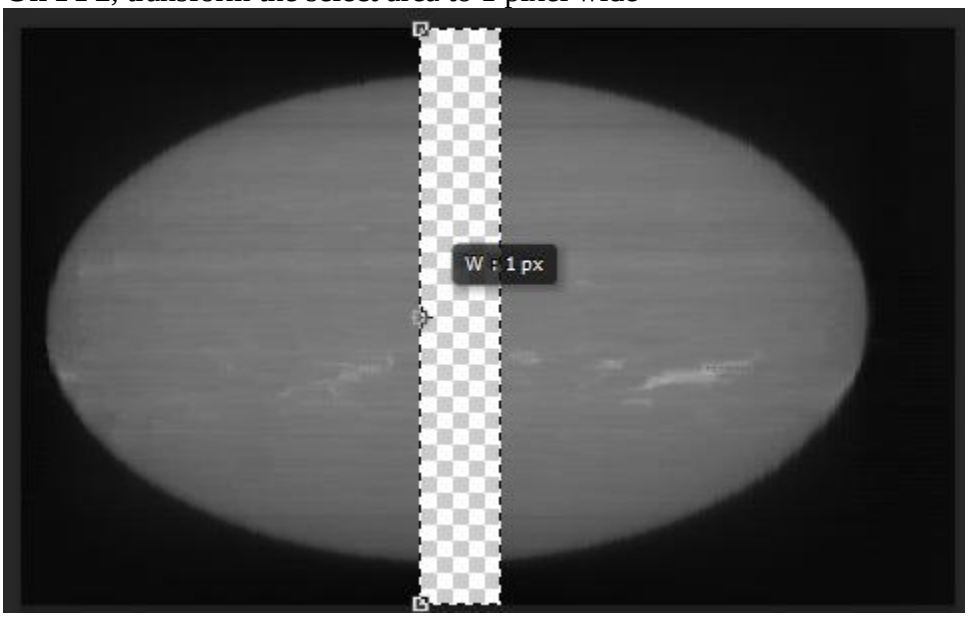


13. **On FF2,** move upper layer horizontally only, this can remove the bright active regions effectively. Repeat copying and moving the layers can finally remove all unwanted features from the flat field.

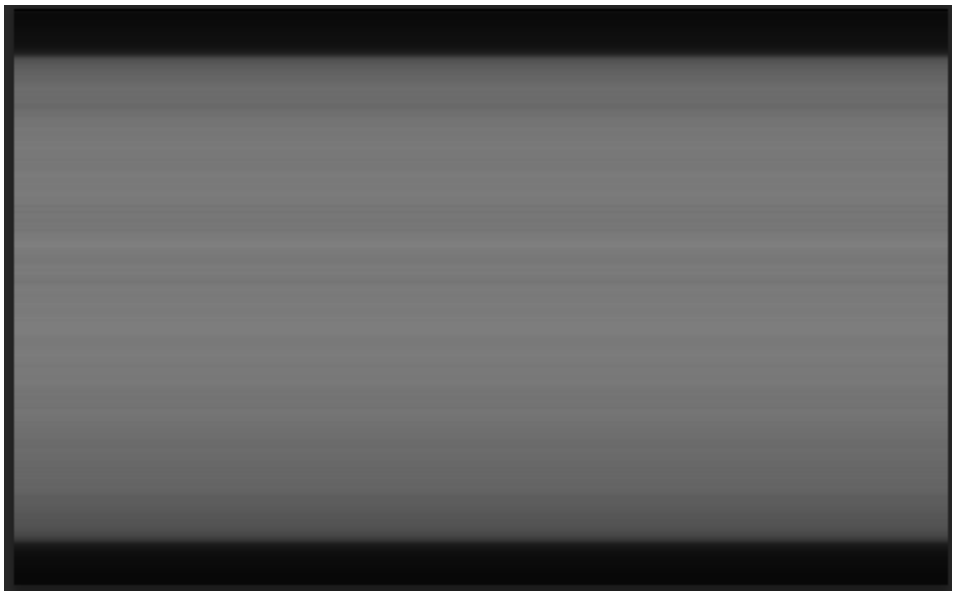
14. On FF2, choose the highest and most even region:



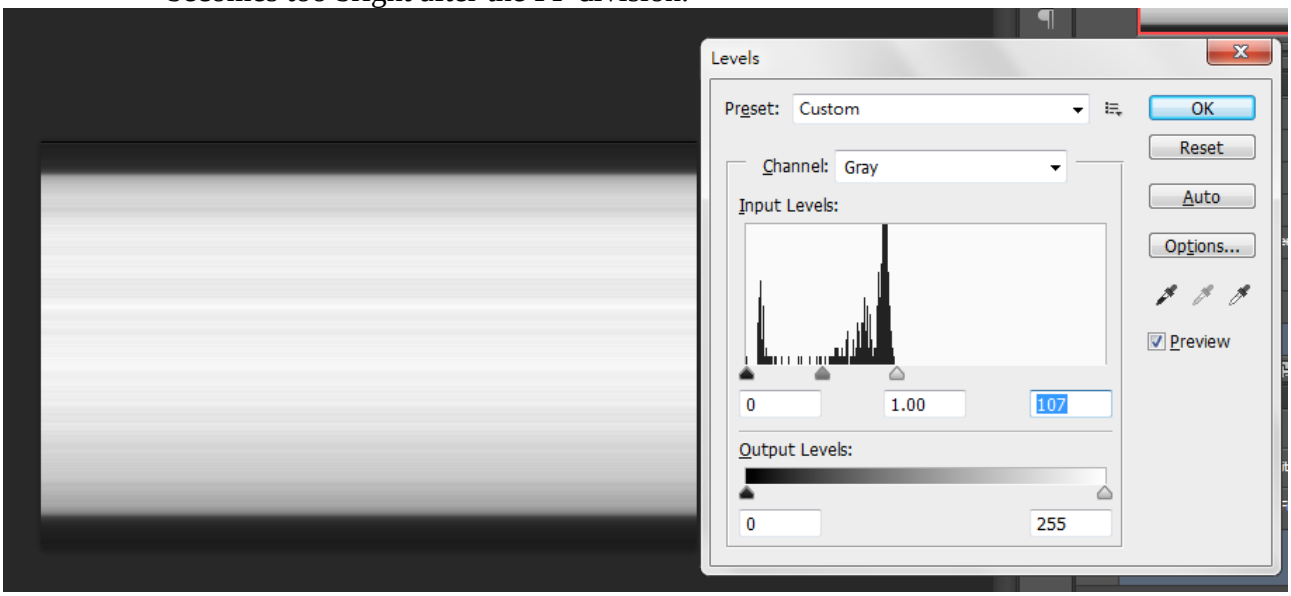
15. On FF2, transform the select area to 1 pixel wide



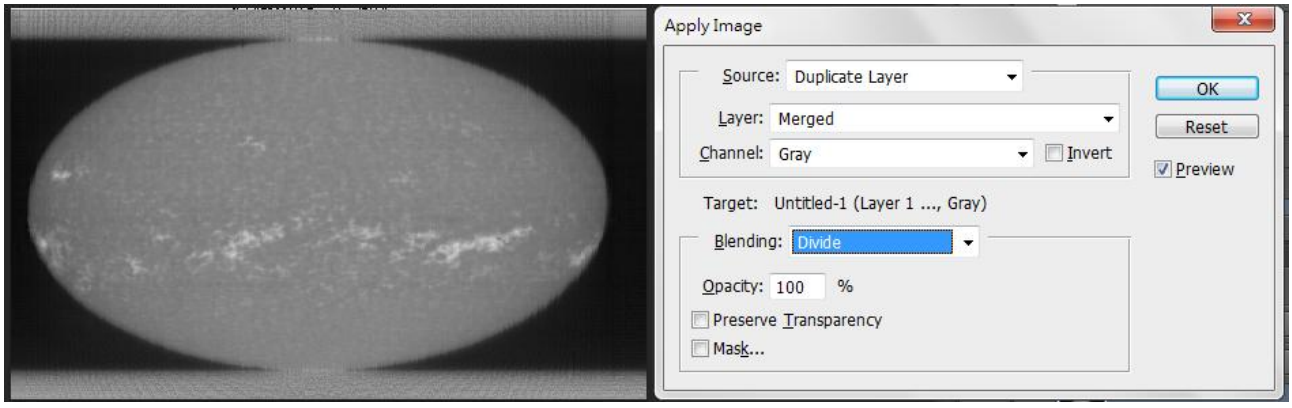
16. **On FF2**, transform 1 pixel wide area to full picture width



17. Adjust **FF2** Level, that the bright pixels becomes value 255, this is to avoid final image becomes too bright after the FF division:

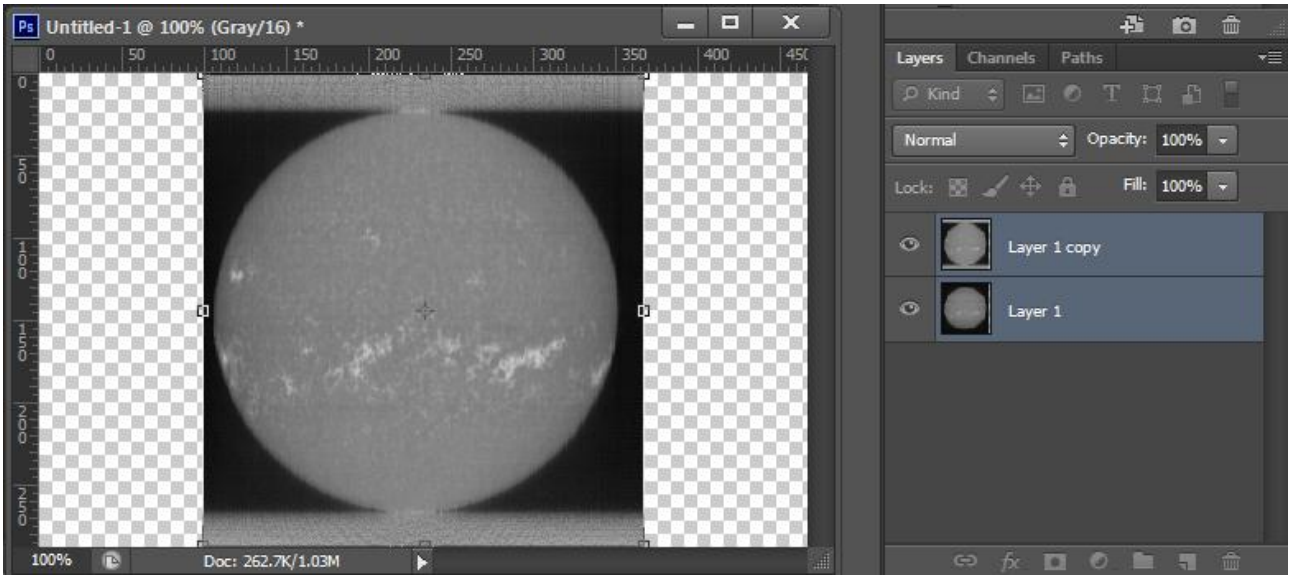


18. Back to the **major image**, Apply Image, choose FF2 and blending with Divide:

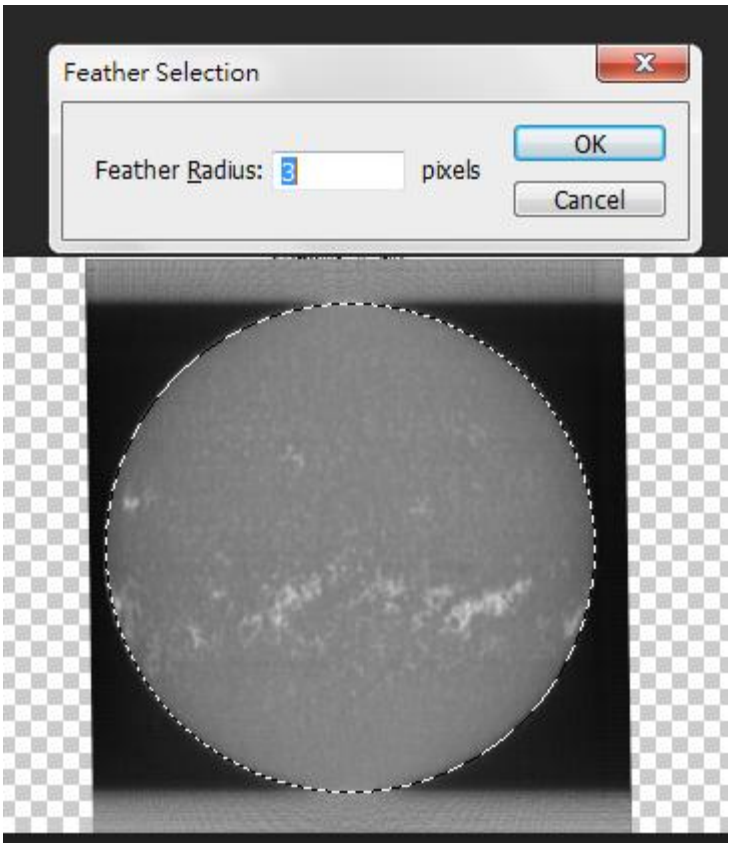


The horizontal bands are now be removed, FF2 can now be closed without saving.

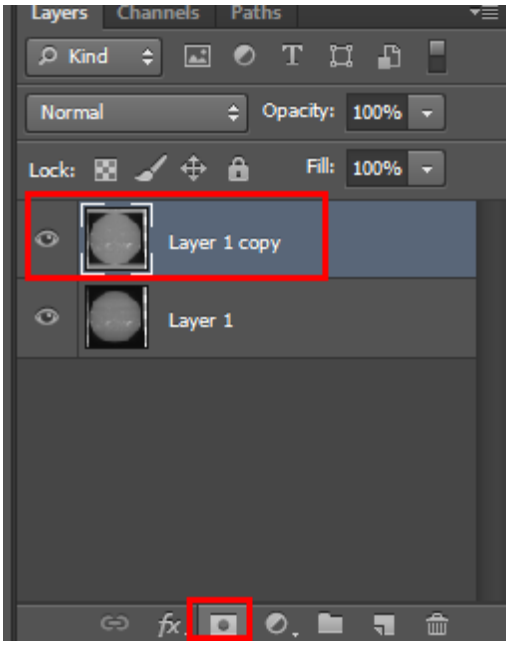
19. On major image, select both layers, transform and slew to make the sun round:

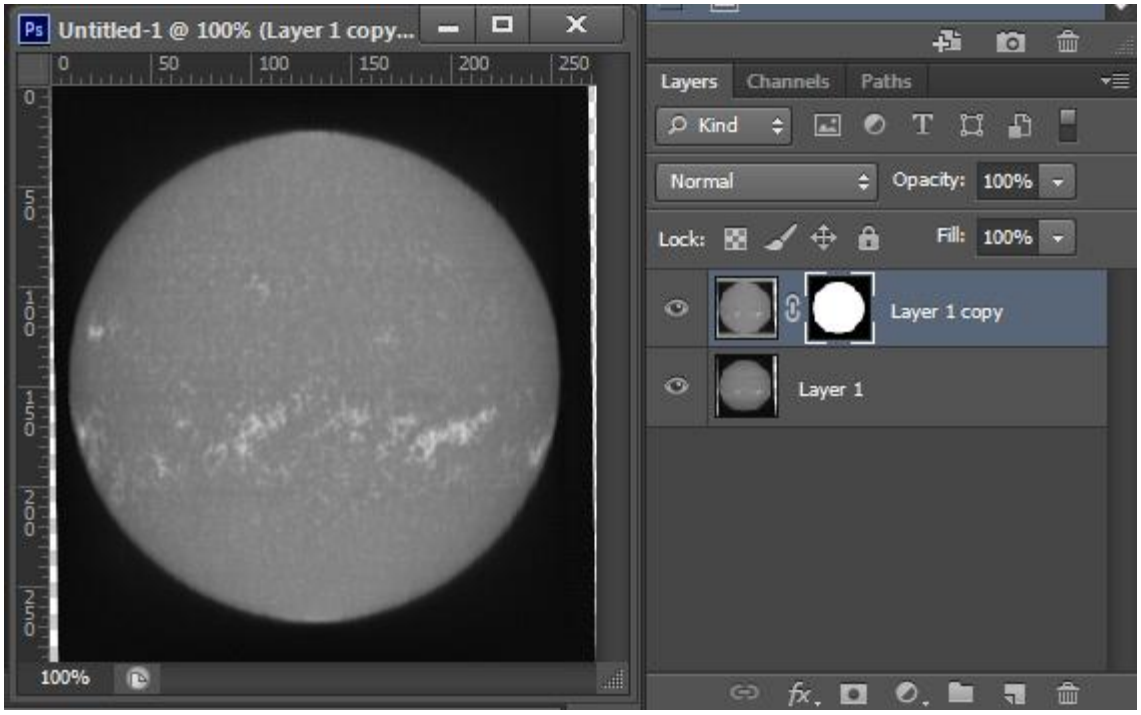


20. On major image, select a circle area with feather edge that just fit on the solar edge:



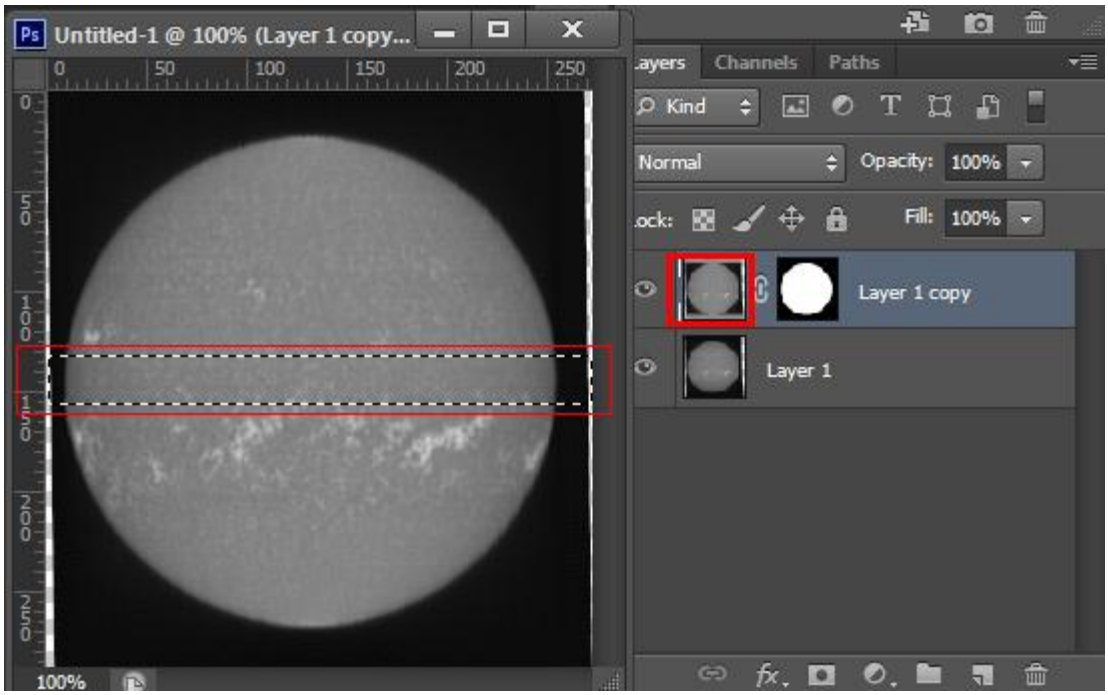
21. **On major image**, select the upper layer, click the create layer mask button.



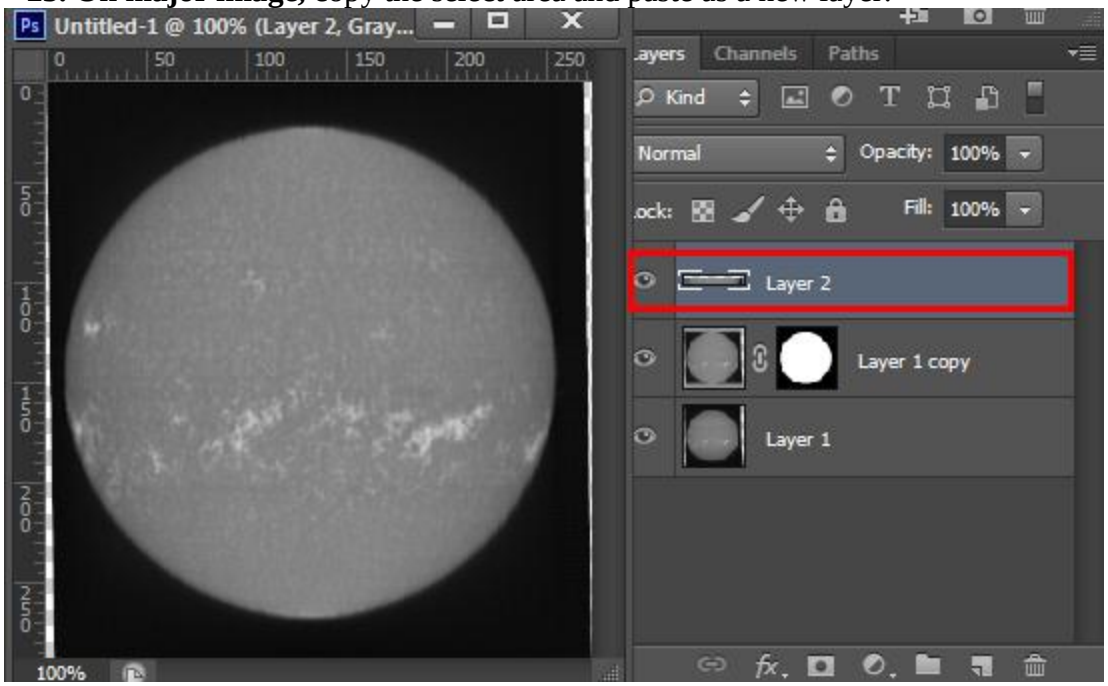


Now the solar disk is after FF2 processing and background is without FF2 processing. It's time to deal with the vertical brightness un-natural problem. Let's make a FF3.

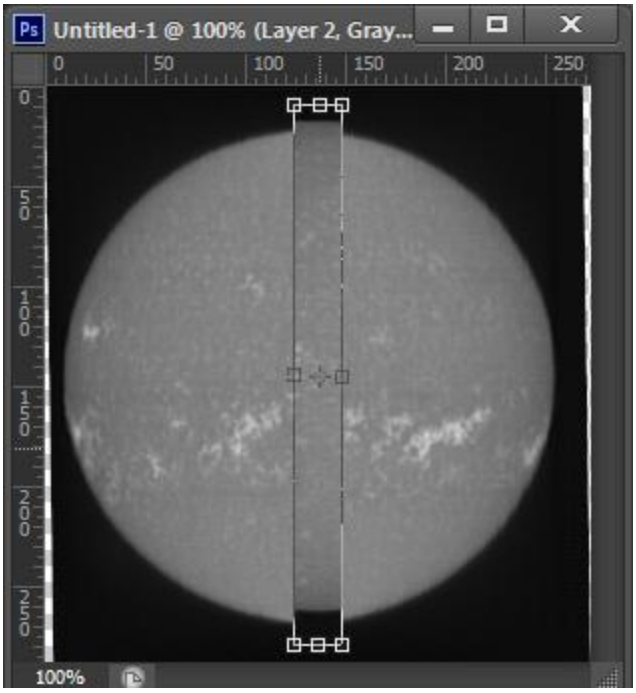
22. **On major image,** select upper layer image (don't select the layer mask), select a horizontal area that go through the center of the solar disk:



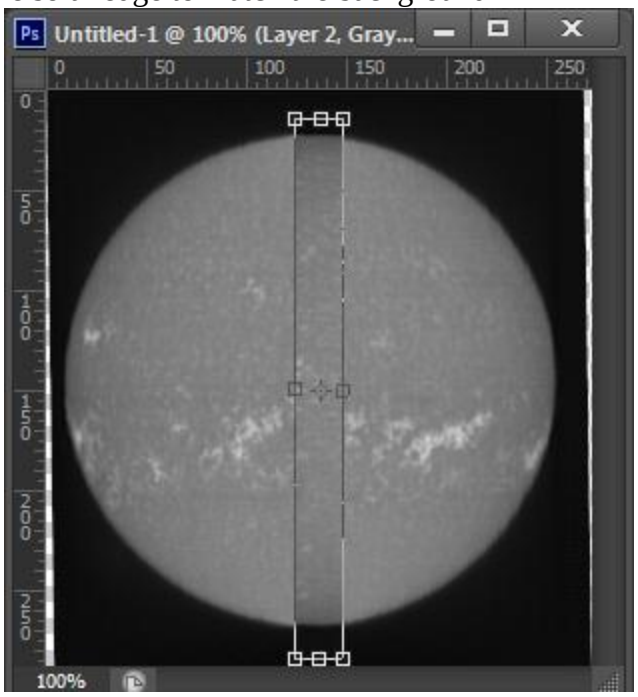
23. On major image, copy the select area and paste as a new layer:



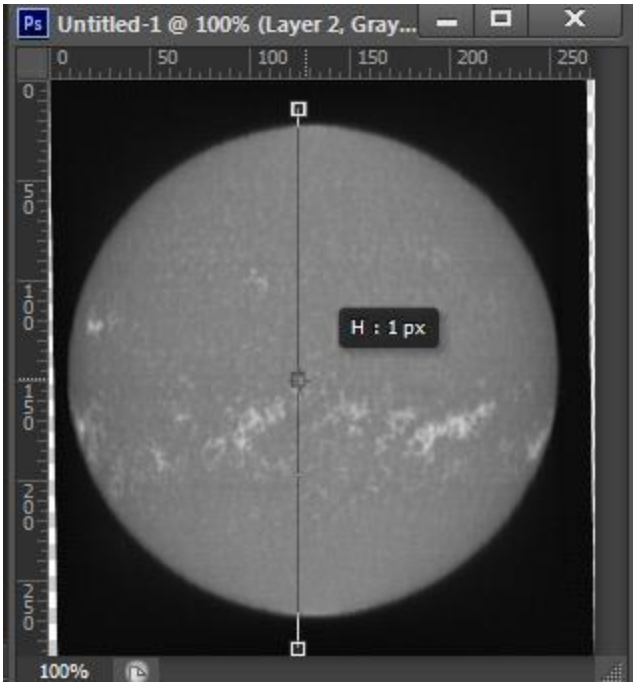
24. Rotates the new layer 90 degrees



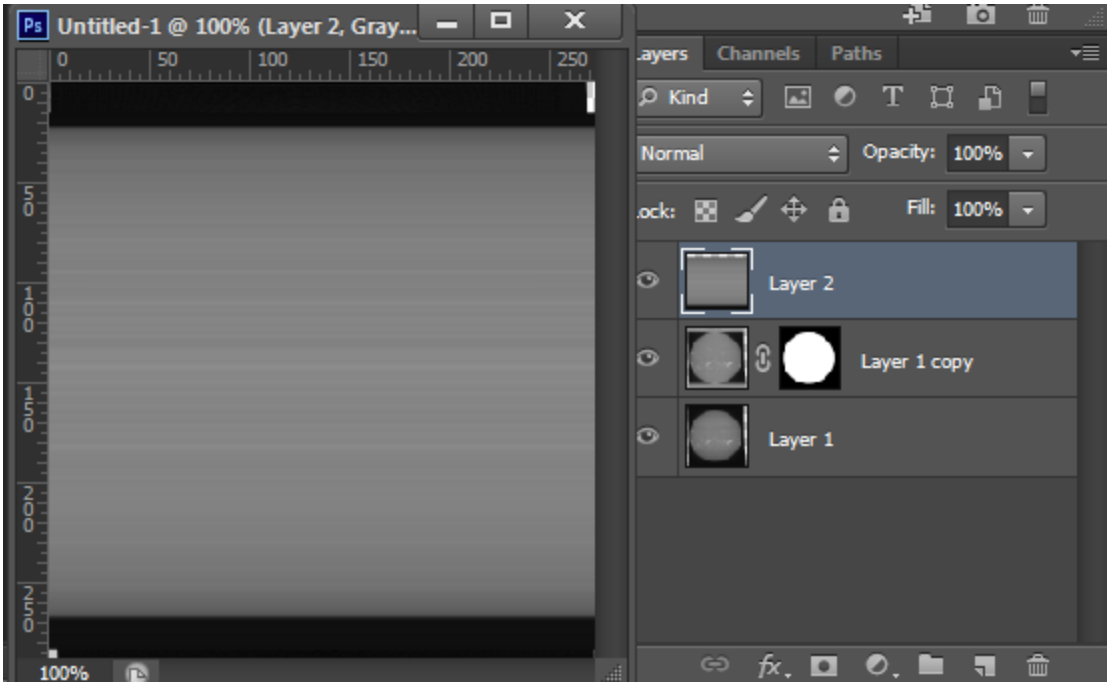
25. Then align the solar edge to match the background



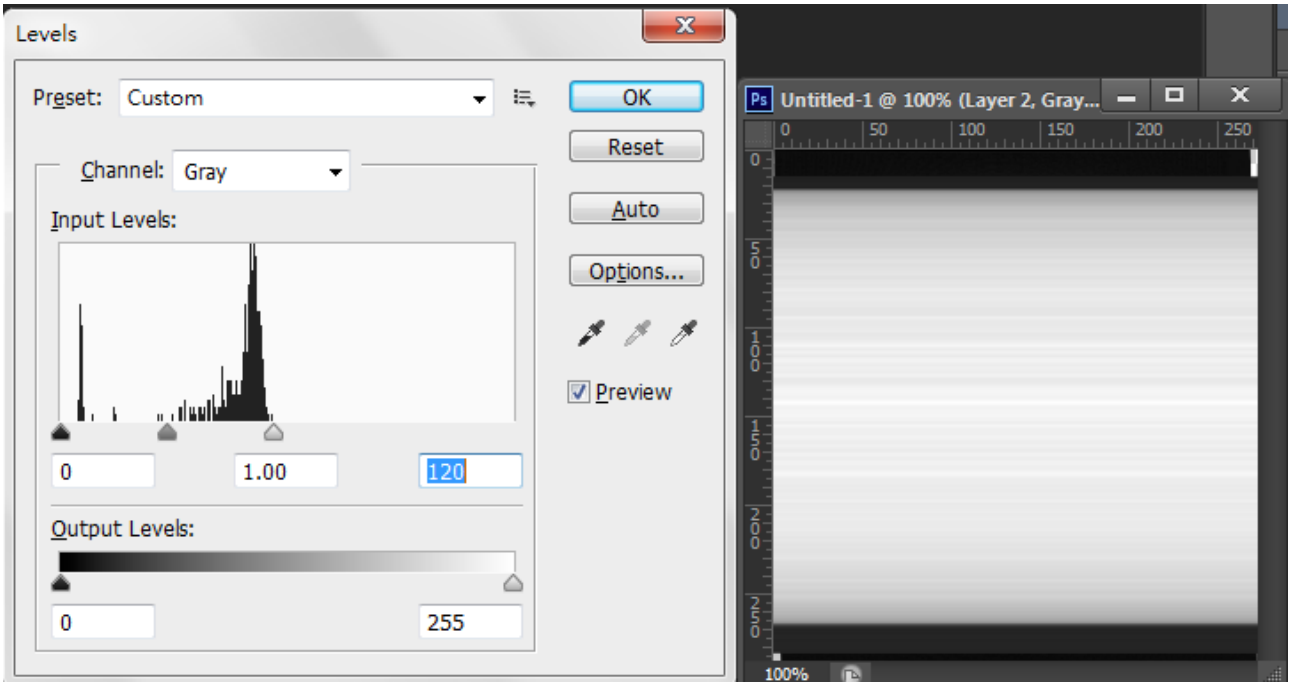
26. Transform to 1 pixel width



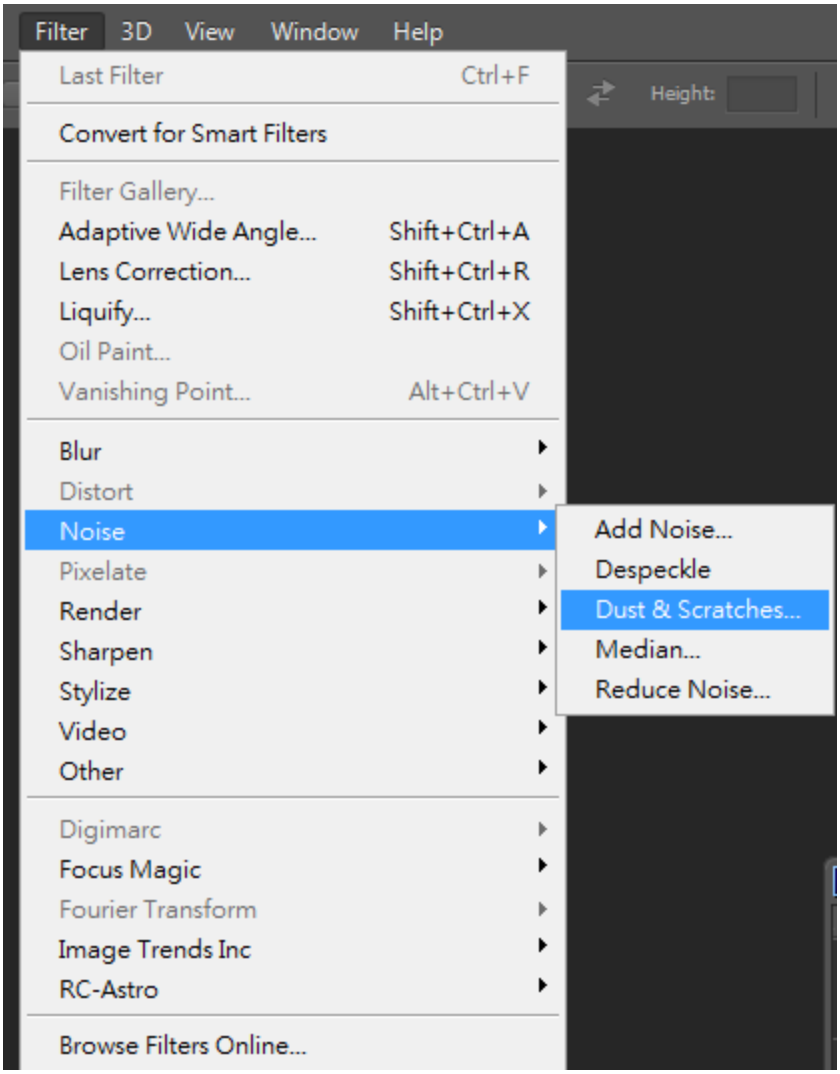
27. Then transform to full width

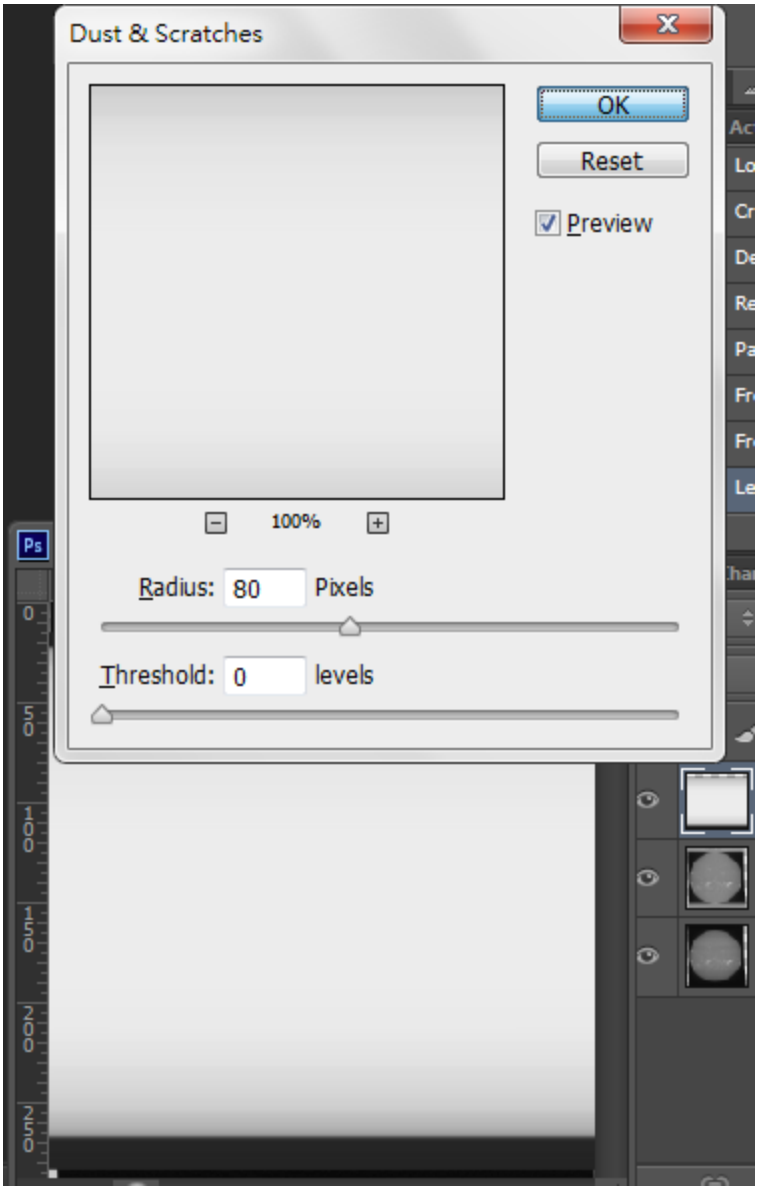


28. Adjust the level to let brightest pixels at value around 255

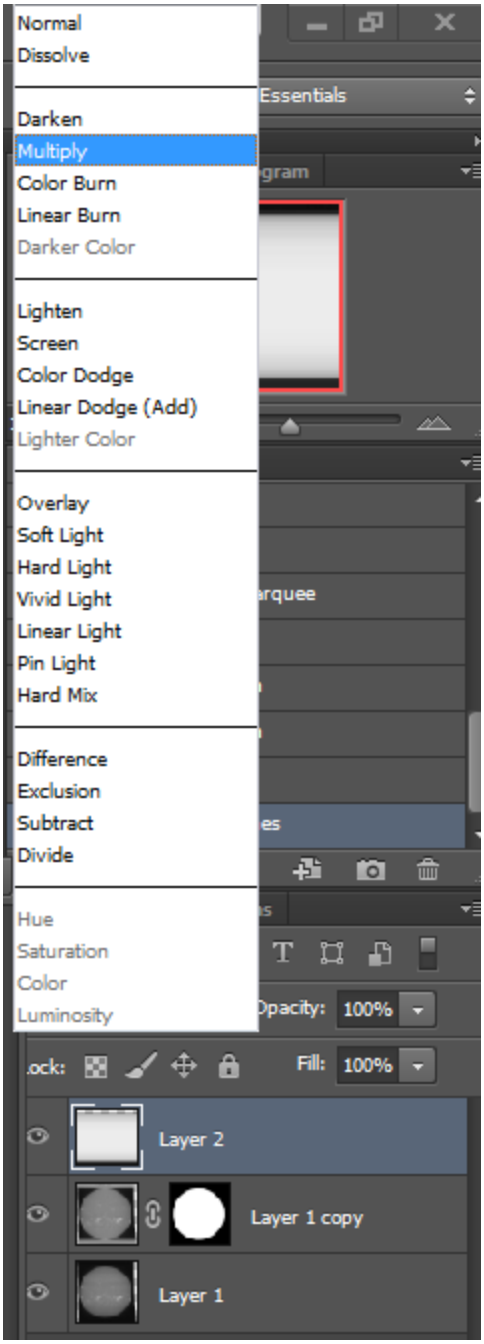


29. Then use Dust & Scratches filter to smoothen it

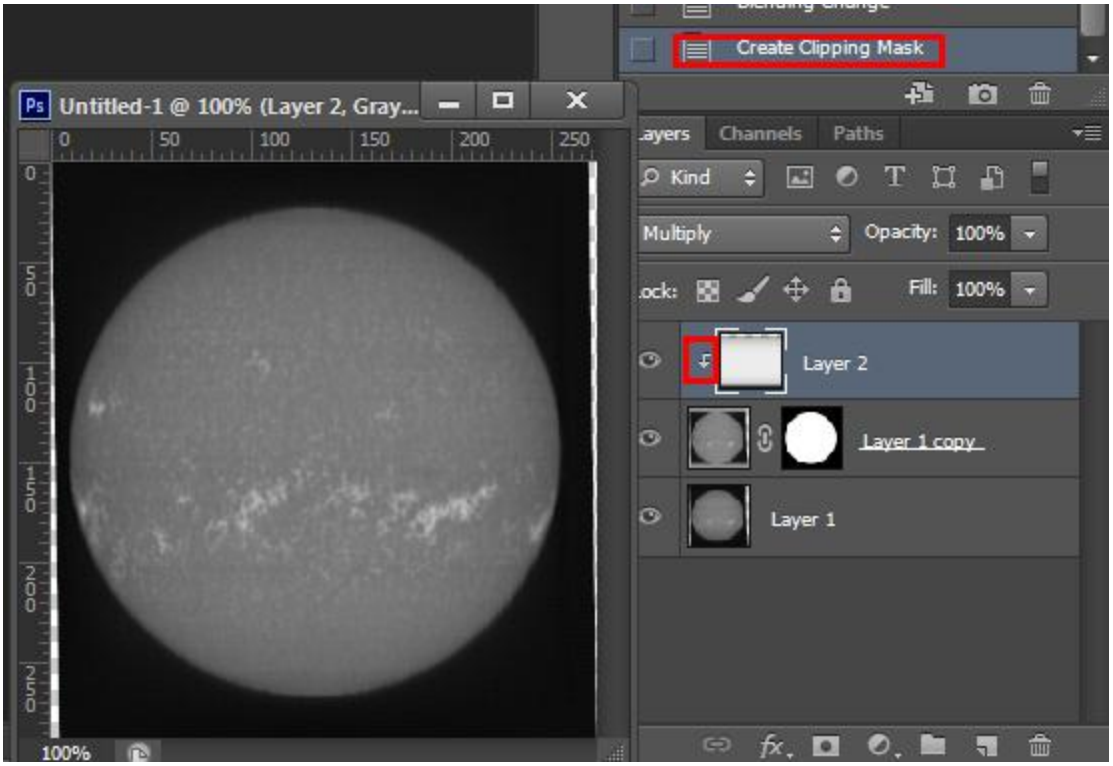




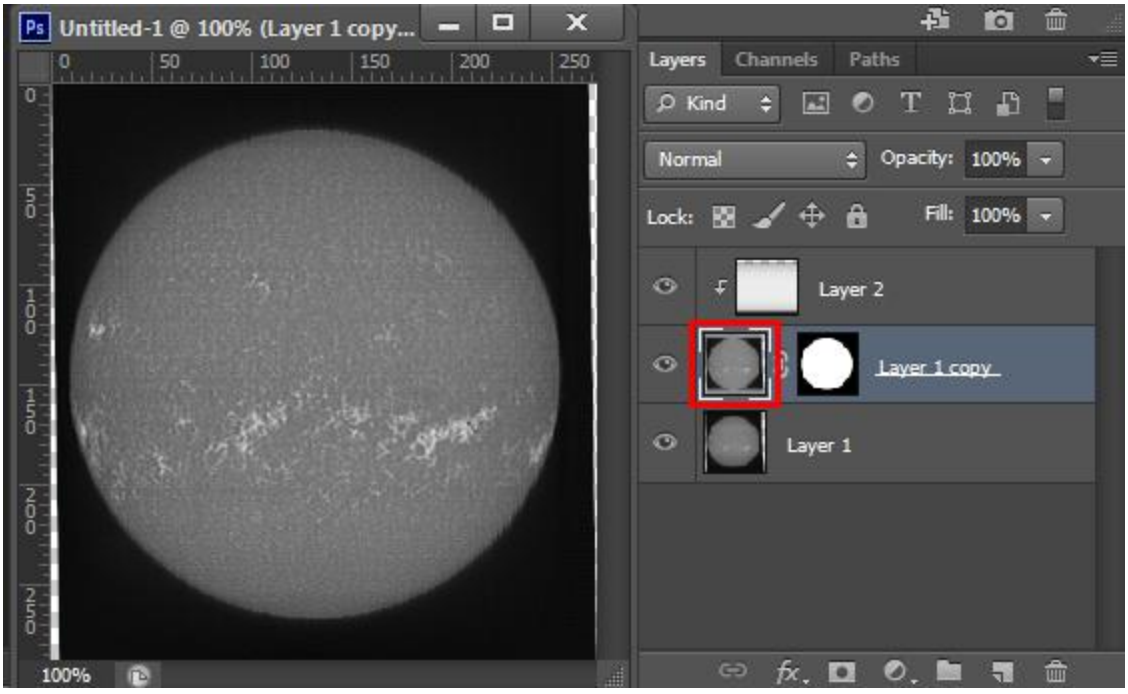
30. The FF3 creation is finished, adjust the layer properties to **Multiply**



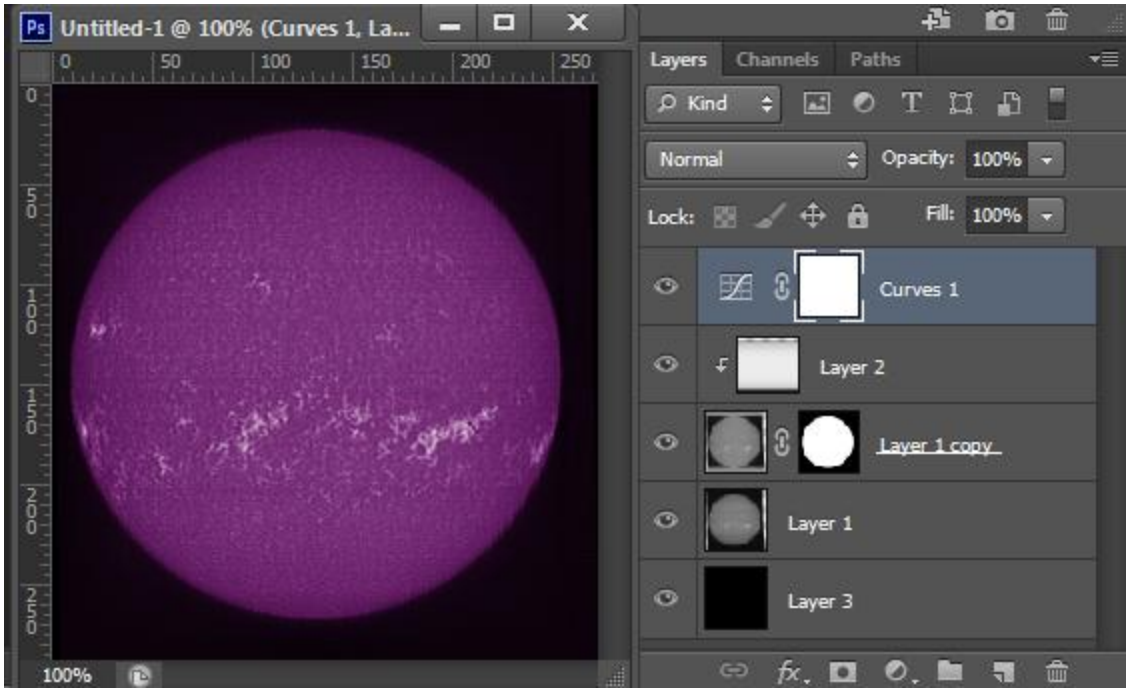
31. Right click the **FF3** layer and choose Create Clipping Mask.



32. Choose the solar disk layer (don't select its layer mask), do some contrast adjustment and sharpening



33. Fill the empty background to black with a new bottom layer, then add color with new top curve layer, the processing is now finished, FINALLY.



Repeat the above procedures, and with some more complex fine-tune processing, we mosaic several scanned images into one solar disk, similar the one below: