DAYSTAR FILTERS
FLAT CAP

Congratulations on your purchase of a Flat Cap Gaussian diffuser for creating flat fields to correct dust spots, vignetting, and filter nonuniformity. Please read this manual before using the product.

Before using the Flat Cap, please **perform a light leak test** by setting up your normal imaging configuration including solar filter and camera. Then cover the front of your telescope with a dust cap or dark cloth. Seal any sources of light that show up on camera images.

We recommend **fixing any interference fringes** by tilting the camera off axis using our Interference Eliminator, available in T or C mount.

Next, center and focus on the Sun. **Install the Flat Cap** as the frontmost optical component, and **increase your exposure time by a factor of about 100.** Capture flat frames using your favorite capture software, then remove the Flat Cap and return the exposure time to normal.

Warnings:

The FlatCap is NOT a solar filter, and MUST be used in combination with a safe solar filter when observing the Sun.

For assistance:

Call: 1 (866) 680-6563

Email: service@daystarfilters.com

Visit: http://www.daystarfilters.com

Cautions & Warnings:

The Flat Cap is NOT a solar filter and MUST be used in combination with a safe solar filter or dedicated solar telescope. Observing the Sun through the FlatCap without a separate solar filter will result in BLINDNESS and/or severe equipment damage.

The Flat Cap must never be used in a concentrated light beam, the FlatCap must be the first component to encounter light.

The Flat Cap is not user serviceable and should never be disassembled or modified. If tears or punctures occur in the diffuser material, it should be discarded.

Solar Observing with a telescope is sensitive to certain risks.

- Caution and care of the telescope and filter is advised in assembly, use and dismantling at all times.
- Telescope owners must use caution when affixing the filter to the telescope never to point any telescope at the sun without the solar filter safely installed first.
- While observing, owners must take care and caution that all parts of the filter and telescope assembly are properly affixed and that no pieces have been opened, tampered with or removed.
- **Owners must also use caution when the telescope is being assembled and dismantled to assure the telescope is never pointing at the sun without the solar filter properly installed.**
- Responsible owners will be prudent to inform guest or novice observers of the special nature of the telescope configuration so not to imply that telescopic observing of the sun is safe without proper filtration.

Daytime Usage:

The Flat Cap is sold by the inside diameter of its cap, in millimeters. To determine which size of Flat Cap to purchase, measure the outside diameter of the frontmost component of your telescope setup. If you are using a DayStar ERF, this will be the metal cell that holds the yellow or red glass. Round up to the next nearest size, so for example if your measurement is 160mm, then order an FC170, because attempting to fit an FC160 over the 160mm telescope component could result in scratching the paint due to the tight fit.

Next please **perform a light leak test** by setting up your normal imaging configuration including solar filter and camera. Then cover the front of your telescope with a dust cap or dark cloth. Seal any sources of light that show up on camera images. Black electrical tape works well, as does a dark cloth.

Any Newton's Rings or interference fringes must be corrected by tilting your camera off axis using our interference eliminator, because fringes will not be adequately removed by flat fielding.

With your solar filter installed, center and focus the Sun normally. Install your Flat Cap, and increase your exposure time by a factor of about 100. Monitor the histogram in your capture software and adjust exposure time until the brightest areas are in the 80-90% level. If your camera has some nonlinearity at the lowest gain setting, you may need to increase gain or adjust exposure to get the brightest areas somewhat below 80%.

Next capture the flat field using your capture software. For example in SharpCap (www.sharpcap.co.uk), go to the Capture | Capture Flat… menu option. Select 10 to 50 frames. When the capture is complete you should see the image go blank gray.

Now remove the Flat Cap and return exposure time and/or gain to normal settings and enjoy your images!

Nighttime Usage:

The Flat Cap can be used for nighttime flat fields by back illuminating it with a bright object. The Moon works well, as does twilight sky. Bright lights like street lights or house lights can also be used. Very bright planets such as Venus and Jupiter may work in some scenarios.

The Flat Cap will work best with fields of view 1 degree across and smaller. For larger fields of view, it is required to use a uniform backlight instead of a point source. Twilight sky near the zenith often works, as can an illuminated wall or roof.

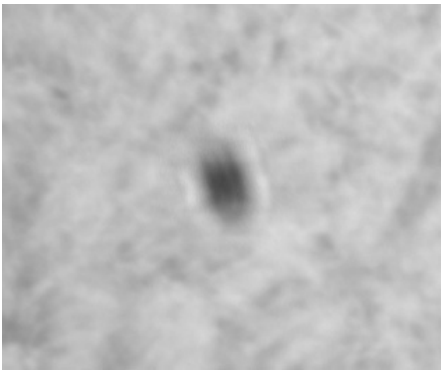
Remember to increase exposure time significantly. This may necessitate a darkframe calibration of the flat field.

Flat Fielding Theory:

Flat fields work by capturing the undesirable effects and problems in an image. These effects can be mathematically removed from your images by dividing the image by a flat field. Darker areas of a flat field (due to dust spots, vignetting, etc) will divide the image down less, while bright areas in the flat field will divide down more, thus removing the impact of the undesirable features. This is is fundamentally different than subtracting that is used with nighttime dark frames, since things like dust spots and vignetting impact the percentage of light.

Common Image Defects:

Dust spots

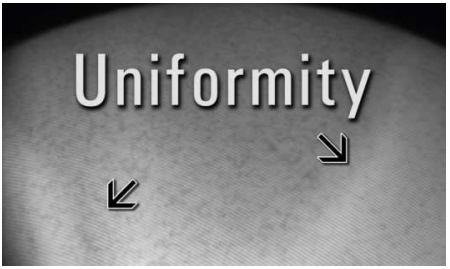


Dust spots will show up as dark circles or rings in the image. Their size depends on how far forward they are in the optical train. Small spots are typically on the camera cover window, while larger spots are probably on rear mounted solar filters, focal reducers, or diagonal mirrors. Keep your equipment sealed with caps and cases as much as possible. Dust spots can change each time your setup is reassembled, so a new flat field should be taken each time you disturb your setup.

Vignetting

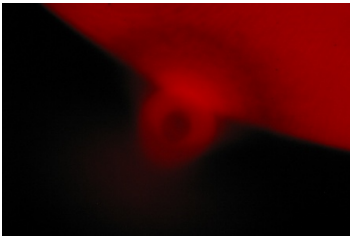
If the aperture of any part of your optical setup is smaller than the extent of your camera's image sensor, then light will be blocked, often resulting in darkened corners. Larger adapters and filters can be very expensive, so flat fields are the standard solution to this problem.

Uniformity



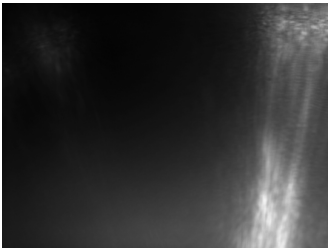
Narrowband solar filters require exceedingly precise surfaces, orders of magnitude flatter than typically used in optical instruments, so some variation in the brightness within the field of view is normal and common. A flat field does a very good job of correcting these variations.

Hot spots



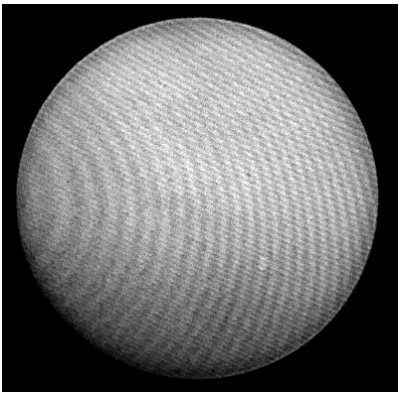
Internal reflections off non-blackened components, or poor anti-reflection coatings, or lack of baffling can cause undesirable hot spots in the images that can change as the telescope pointing relative to the center of the Sun moves. Flat fields can significantly reduce their effects, but in some cases there is no option but to replace optical components or add baffling.

Light leaks



Any gaps in the optical path can let light inside, resulting in streaks of light. Flat fields usually don't correct leaks, which is why we recommend a light leakage test before flat fielding.

Interference fringes



When the camera image sensor is too parallel to a solar filter or other planar optical window, it can set up an etalon effect which is visible in narrowband light, known as interference fringes or Newton's Rings. The standard solution is to tilt the camera off perpendicular from the optical axis, destroying the parallelism. With DayStar filters and common cameras, 2 to 5 degrees of tilt is typically used. Flat fields will not adequately correct fringes because each fringe represents a path difference of one wavelength of light, and so any change in temperature or flexure on the wavelength scale can alter fringe position or spacing. Flat fields can only correct fringes in laboratory settings where the optical components are bolted to a stiff spar or breadboard, and where ambient temperature is regulated to much less than a one degree range.

Flat Capture Methods:

The Flat Cap and plastic bag diffusers

This method works by blurring the incoming light before it enters the telescope. It works for both full disk and narrow field images. By deflecting and scattering light, or destroying the wavefront quality, a blur is achieved that removed all features on the Sun so that only telescope artifacts are visible.

Narrow field imagers can use a transparent plastic bag as long as it shows a halo around bright objects when looking through it with the eye. Full disk imagers will need a more severe blur, where no sharp features are visible when inspecting it with the eye.

Large blurs as in the Flat Cap and full disk scenarios will require a significantly longer exposure time because sunlight is blurred over such a large area. This creates sensitivity to light leaks that may not be visible in normal imaging, which is why we recommend a light leakage test before use of the Flat Cap.

The Focus Blur

This method works best with high power views that completely fill the frame of the camera. Center and focus on the Sun with your normal solar imaging setup. If there is an active region or filament, find a more bland area near the center. Then rack focus out significantly until all surface features blur out. The disadvantage to this method is that since the optical configuration changes, dust spots and other effects might change in size, causing poor flats.

The Boogie

This method only works with high power views that completely fill the frame of the camera. Center and focus on the Sun with your normal solar imaging setup. If there is an active region or filament, find a more bland area near the center. Then start continuous image capture and slowly slew your telescope around to blur out details from features on the Sun. By averaging enough frames, solar features will average out, leaving just the correctable effects of the imaging setup visible.

About Seeing Limitations and Resolution:

Solar observing seeing conditions vary greatly from nighttime conditions. During the daytime, radiant heating from the sun affects seeing significantly. Characterized by turbulence or shimmering as seen over a hot street, seeing can cause significant impact on quality of solar observations.

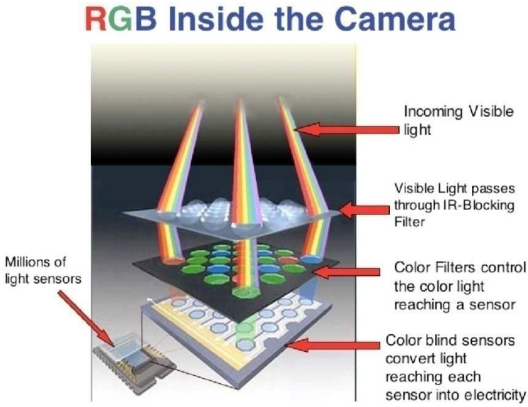
- Bad seeing is caused by air of different temperatures mixing. This typically happens within the lowest 10 feet of air. It occurs most often over pavement, dark objects, rooftops and sometimes trees.
- High cirrus clouds or “scuzz” will cause scattering of sunlight in the high atmosphere which often makes for bad viewing conditions. A classic sign of high cirrus clouds is the inability to achieve focus, or the need to “chase focus”, or a lack of contrast.

- A jet-stream moving overhead can also hurt seeing conditions even on a clear day.

DayStar Filters are high power viewing platforms and this high resolution can be susceptible to seeing issues. Solar Observers using high powered, high resolution telescopes and DayStar filters should heed daytime seeing. While many of these conditions are beyond our control, observing in an area with ideal conditions, without pavement in the direction of viewing, and on days with no high cirrus will offer best results. Grass is the best environment for daytime seeing stability.

Each observing location offers different behavior for daytime seeing cells at different times of the day, as the air through which one views changes with movement of the sun. Some locations benefit from best seeing in the morning, while many have best seeing in the afternoon. Because most heat variation between air and ground surfaces occurs within the first 10 feet above the ground, often a high observing platform will offer superior seeing. This might include a second story deck which overlooks grass.

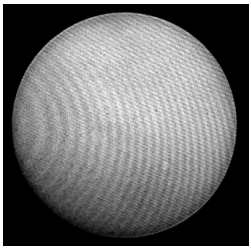
Solar Imaging Tips:



Daystar recommends MONOCHROME CCD imaging whenever possible for best results. The recent availability of CCD cameras and DSLR cameras has offered a simple opportunity for solar observers to image the Sun in Hydrogen Alpha with a Digital SLR camera. Please be advised, however, that due to the nature of monochromatic light and its effects on a CCD camera, certain negative effects are likely to occur.

The DSLR imager must be aware that most camera manufacturers (Canon and Nikon) use an IR blocking filter which greatly reduces the transmission of Hydrogen Alpha light. DSLR cameras without this IR blocking filter will have better sensitivity imaging in Hydrogen Alpha.

The imager should also appreciate that even after considering IR blocking filters, that the COLOR CCD chip is constructed in a way that only 1 in 4 pixels detect red light. The other 3 sensors only detect blue and green because the pixels are actually permanently covered with a colored dye for each corresponding color. So a color CCD chip (in a DSLR or a CCD camera) will only offer 1/4 the sensitivity and 1/2 the resolution of a monochrome chip.



Another effect present in CCD imaging of monochrome light of Hydrogen Alpha is the interference pattern - or Newton's Rings. The effect is similar to interference testing of an optical surface between two flat surfaces. The sensor and cover slip cause a small interferometer inside the camera and cause a Newton's Ring moire' pattern. The CCD chip must be tilted to a minor degree to prevent this pattern. Recent advances in aftermarket adapters offer a simplified solution for the issue. This effect is a concern for both color and monochrome sensors.

An optional accessory is available from DayStar (MG-0408) which can be used between the DSLR and Quark to adjust the light angle and extinct the interference pattern.

Exposure time:

Imaging solar vs. nighttime astrophotography is very different. Dark sky imaging requires long exposure times to capture enough light. Solar imaging offers ample light, so exposures should be very short. Plus, fluctuations in seeing dictate that short <1/10 second frame rates will be better, as seeing cells move quickly to distort the image and can come and go during a long exposure.

- Short exposure webcam imagers are better than long exposure CCD cameras when imaging the sun.
- Because the sun has a range of brightnesses, automatic exposure doesn't work well. A software interface that allows the user to control the exposure settings manually is very important.

Exposures for prominences taken through a DayStar with a webcam style camera might be about 1/15 – 1/100th of a second. Exposures for surface detail would be even shorter exposure with about 1/300 to 1/500th of a second.

Bit depth:

Solar activity encompasses a wide dynamic brightness range from bright solar flares to faint eruptive or floating prominences quite a distance from the solar limb. In order to capture all these features, we recommend the use of 12 bit or 16 bit cameras. Normal 8 bit cameras can be used, but will typically only be able to image either the surface or prominences, necessitating multiple bracketed exposures and subsequent recombination in a computer. 12 bit or 16 bit cameras enable capturing these features in the same exposure, simplifying the image processing.

Focal reducers:

Because of the long effective focal length at the output of the Quark, the image scale will be quite large and small (1/2" or below) image sensors will only capture a fraction of the whole solar disk in one frame. Large pixel sizes (9 microns and above) will enable a larger field of view.

Alternatively, a focal reducer can be employed between the Quark and the camera. Simple 1.25" screw in focal reducers can be attached to the camera nosepiece to allow a wider field of view with small (1/2", 1/3", ¼") sensor cameras. More distance between the focal reducer and camera surface will result in more focal reduction and larger field of view.

Troubleshooting:

Image goes completely dark:

Increase your exposure time by a factor of 100.

Still getting regular lines:

Interference fringes / Newton's Rings must be corrected by tilting your camera off perpendicular from the optical axis by 2 to 5 degrees. Use our Intereference Eliminator, available in T or C mount.

Poor flat quality:

Perform a light leakage test (described elsewhere in this manual) and correct any stray light.

Take flat field while pointing at the exact center of the Sun.

Inspect optical train for hot spots created by reflections off internal surfaces.

Ensure you are using your software's flat field (division) function, not the darkframe (subtraction) function.

Specifications:

Construction:	Spun Aluminum ring with polymer diffuser
Intensity distribution:	Gaussian
Divergence angle:	4 degrees FWHM
Exposure time adjustment factor:	100x longer
Maximum field of view:	1 degree with Sun backlight Appx 10 degrees with twilight
Wavelength transmission range:	350-800nm
Operating temperature:	-10 to 100℃ (14-212℉)

Standard apertures in 10mm increments
Custom apertures up to 0.6m (24 inches)

Made in USA

Warranty:

Warrantor: DayStar Filters LLC
Elements of Warranty: DayStar warrants, for one year of the original retail purchase owner, this Product to be free from defects in materials and workmanship with only the limitations or exclusions set out below.
Warranty Duration: This warranty to the original user shall last for one year of the original user. The warranty is invalid if the Product is (A) damaged or not maintained as detailed in Operating and Maintenance Manual (B) modified, altered, or used as part of any conversion kits, subassemblies, or any configurations not sold by DayStar, or (C) serviced or repaired by someone other than the DayStar Filters Service Center for a defect or malfunction covered by this warranty. This warrantee includes shipping to and from any point inside the United States. Insurance upon that shipping and/or international shipping and/or any customs and/or import duties attached are the sole responsibility of the owner.
Statement of Remedy: In the event that the product does not conform to this warranty at any time while this warranty is in effect, warrantor will repair the defect and return it to you without charge for parts, service or any cost incurred by the warrantor in connection with the performance of this warranty. THE ONE YEAR WARRANTY SET FORTH ABOVE IS THE SOLE AND ENTIRE WARRANTY PERTAINING TO THE PRODUCT AND IS IN LIEU OF AND EXCLUDES ALL OTHER WARRANTIES OF ANY NATURE WHATSOEVER, WHETHER EXPRESS, IMPLIED OR ARISING BY OPERATION OF LAW, INCLUDING BUT NOT LIMITED TO ANY IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE. THIS WARRANTY DOES NOT COVER OR PROVIDE FOR THE REIMBURSEMENT OR PAYMENT OF INCIDENTAL OR CONSEQUENTIAL DAMAGES.
Procedure for obtaining performance of warranty: Upon discovery of flaw, we require that the user communicate by telephone and/or email to the DayStar Service department to report the failure of equipment. Should technical support be unable to resolve the conflicts of the product, it should be packaged in its original packaging and returned with evidence of original purchase and note describing defect to include owner contact information. The product should be shipped freight pre-paid by traceable means or delivered to warrantor at:

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