Modifying a Coronado PST Hα Solar Telescope

Ken Harrison
(Rev: 5e)

WARNING

Observing the Sun with any instrument can be dangerous.

If you modify your PST you will loose your warranty with Coronado/Meade.
If a proper Energy Reject Filter is securely fitted to the objective, and a blocking filter fitted at the eyepiece/ camera, the modification to the PST is 100% safe. No changes are made to the internal etalon.
You carry out these modifications at your own risk.

(It was recommended to me that I should add this statement, apparently some people (CN forum among others) think these mods should not be done –why?**)**

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Introduction

When Coronado introduced their Hα PST solar telescope in 2003, they completely changed the rules. Up until that time observing the Sun in narrowband wavelengths was really the domain of the professionals or the very gifted and well heeled amateur. The specialised optical filters required to achieve the necessary resolution (1Å or 0.1nm) are not easily manufactured and most required stabilized temperature controls to maintain the accuracy.

Observing the Sun is dangerous. The amount of light and energy collected by an average sized telescope is enormous and can instantaneously cause irreparable damage to the human eye. Energy Rejection filters (ERF) have to be used to reduce this energy to safe viewing levels and, to give acceptable images, they must be uniformly optically flat and homogenous.

How did Coronado manage then to design and build a solar telescope capable of safely observing the Sun in the narrow wave length of Hα light?

They built a small aperture telescope (40mm diameter), multi-coated the objective to reflect the majority of the incident energy added a very small (20mm) Fabry-Perot etalon filter and isolated the Hα wavelength with a narrowband blocking filter. This combination of optics was both cheap (relatively) and robust. It works very well and gave the amateur the opportunity to observe the solar disk and prominences.
http://www.uriland.it/astronomia/articles/halfa/pst_eng.html

Why modify a PST?

The answer is more resolution. If a larger aperture is used, then the resolution of surface detail and prominences is increased. An 80mm objective will collect four times more light than the basic PST at twice the resolution. This allows more surface detail to be recorded and larger, fainter prominences to be seen.

There are two modifications which can be carried out:

Stage 1 – Replace the existing objective and gold tube of the PST with a larger OTA fitted with an ERF.
Stage 2 – As above, but also remove the etalon from the PST and replace the black box with spacers and a larger blocking filter assembly.

The Basics – Inside your PST:
The PST has a 40mm f10 achromatic objective, mounted at the front of the gold tube. This tube screws onto the etalon assembly which has a -200mm Barlow lens fitted at the front, this is positioned 200mm inside the prime focus to give a parallel collimated beam through the etalon. At the rear of the etalon assembly there is a 20mm f10 "objective" which re-focuses the beam exactly 200mm behind the etalon. At the eyepiece holder there are one or two filters (depending on the age of the PST). The early PST builds (s/n prior to 100000) only had a 5mm blocking filter (BF5) and a "gold" ERF coating on the objective. These coatings deteriorated ("Rust") and were subsequently replaced with a "blue" objective.


Rusty PST objective

To assist in the energy rejection (UV-IR) a supplementary narrow band filter was added in-front of the BF5.
Inside the black box Coronado designed a penta-prism mechanism to both shorten the optical path length and provide a means of focus. This is a good idea but imperfectly executed. The penta-prism can very easily move out of alignment and cause severe astigmatism; smearing the detail in the image.

For the Stage 1 mod (retain black box) we are effectively replacing the Gold tube with a larger objective fitted with an ERF. It's as simple as that.
As the original PST was designed to work at f10, the new "donor" OTA should also be close to f10 or greater. The distance of the etalon inside the prime focus (200mm) means that the image of the sun at this point is 20mm (200/10) plus 1/100 of the OTA focal length. In the PST, this would be 20 + (400/100) = 24mm diameter. The aperture of the etalon is only 20mm which is not really large enough to give full coverage of the solar disk and the surrounding area. This gives rise to the PST "sweet spot" effect.

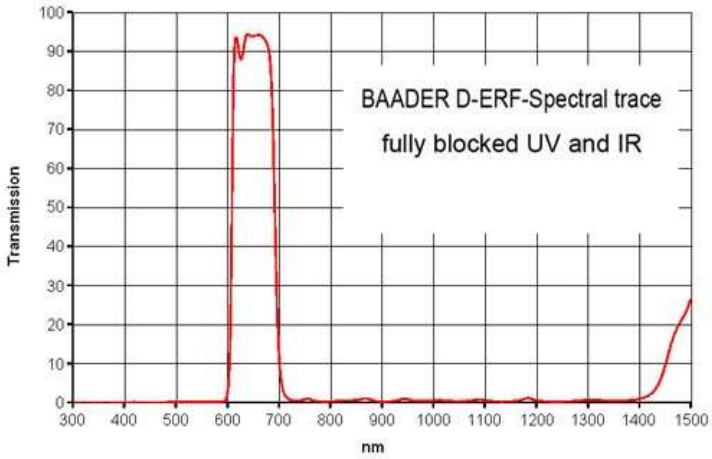
Aperture	f ratio	Focal length	Sun's diameter at etalon
80mm	f7	560mm	34.1mm
80mm	f8	640mm	31.4mm
80mm	f10	800mm	28.0mm
80mm	f12	960mm	26.3mm
80mm	f15	1200mm	25.3mm

Table 1 Solar image vs. focal ratio

(Interestingly, if you calculate the numbers, a 35mm f13 system would give an image of 20mm which would have been better suited to the PST etalon.)

Energy Rejection Filters

Energy Rejection Filters are available from a few suppliers (DayStar, Lumicon and Baader). The older traditional ERF's were red glass filters (Wratten #26 or #29); these blocked the majority of the UV, visual light and energy but still allowed the Infra Red (IR) to get through. Used in conjunction with a UV-IR cut-off filter they can still be useful. Baader's original range of "C-ERF" (C for cool) have now been replaced with an improved version "D-ERF"; these come un-mounted in diameters of 70mm, 90mm and 110mm and are 8mm thick. These filters are effectively narrow band interference H alpha filters and only allow light between 600nm and 700nm to pass, thereby removing any risk of UV exposure, and heat build up. Highly recommended.
(The filter is marked on its edge with a direct arrow indicating the surface which should face towards the Sun)



Transmission curve for the Baader D-ERF filter

Note: I found some Baader D-ERF filters were 5.6mm and others 8mm thick, this is a reply received from Baader:

> We do had the first production run with 5,6mm thickness.
> The second was 8mm thickness but not because 5,6 is to thin.
>
> We changed the thickness of all Filters to be 8mm. From 90 to 180.
> This makes the production easier.

All Filters either 5.6mm or 8mm are performing the same and do have the same quality.
Only 8mm is the new standard for the thickness.

Best regards,

Johannes Baader
BAADER PLANETARIUM GMBH

Adjusting the penta prism

The front face and top face of the penta prism should be square to the optical axis as viewed from the side. Open the side of the black box and use the focus knob to run the prism up to the top of the box (near the eyepiece holder). If the top surface of the prism is not parallel to the inside top edge of the box, gently twist the prism on its support pad until it aligns. This will reduce the astigmatism. A poorly adjusted prism is shown on the LH image; a better adjusted prism is shown on the RH.

Penta-prism out of alignment *Penta-prism closer to good alignment*

Focusing a PST

The final focus position in the original PST is constrained by the 200mm focal length lens behind the etalon and the limits of the penta-prism movements. This can sometimes cause problems getting the PST to focus on the camera CCD chip. (The initial PST design concept, I believe was as a purely visual instrument, hence the issues with cameras.)
A few solutions have been used.

1. Use a short nosepiece adaptor (with no retaining shoulder) on the camera, this may be just sufficient to get the CCD to the focus.
2. Remove to bottom half of the eyepiece holder and re-assemble with the BF5 top part only. This gives approx 25mm of additional space.
3. Add a small Barlow lens into the eyepiece holder to give more back focus. This is mandatory if you want to use a DSLR.
   http://sweiller.free.fr/ATM/PST-EOS.html

Improving the tuning ring

Maurice Gavin gives a good description of how and why to re-adjust the tuning ring on the PST etalon.

http://home.freeuk.com/m.gavin/pstfixx.htm

Stage 1 Modification

You need:

1. A Hα PST (obviously!)
2. A "donor" OTA. Preferably close to f10 and a large enough aperture to justify the expense and work of the conversion. In my opinion a 70mm would be the minimum; the maximum is determined by how much you are prepared to pay!
3. An ERF to suit the OTA. I recommend Baader. First class quality; they claim 1/10 wave surface accuracy. Not cheap but 100% safe and reliable. http://www.baader-planetarium.de/sektion/s37a/s37a.htm They can also supply mounting cells to suit the ERF and the OTA.
4. An adaptor to fit the PST etalon front female thread (M50 x 1) to the OTA. A 2" nosepiece adaptor specifically designed for this mod is available from Teleskop Austria. http://www.teleskop-austria.at/prod.php?tid=38&lng=slo#sonne-adap-pst

A padded vice and a couple of BOA strap wrenches
http://www.amazon.co.uk/BOA-SBOAAMZ-Standard-Strap-Wrench/dp/B00096JDKS/ref=pd_sim_diy_2

The work needed is:

- to securely fit the ERF to the OTA,
- modify the OTA to allow the etalon to sit 200mm in front of prime focus and
- remove the gold tube and fit the etalon/ black body assembly to the OTA.
-

Optical layout – Stage 1 mod

[insert diagram of etalon/ ota etc]

Mounting the ERF

The ERF can be mounted in any suitable cell which securely fits the objective of the donor scope. It's safer to remove the dew shield and fit directly to the end of the OTA. The cell should allow a slight freedom to the ERF i.e. not clamped tight either on the edges or across the face. Small cork spacers work well. If you are using a D-ERF the arrow should be orientated towards the Sun, and slightly tilted. By tilting the filter you prevent any ghost images caused by reflections between the back of the filter and the objective lens, from affecting the final images.
As the etalon is 20mm diameter, the outer edge of the etalon is only 10mm from the optical axis. Consider say a 900mm focal length objective; this would require the filter to be tilted by (10/900) mm, to move any reflections from the FOV. Applying this to a 90mm ERF, then the edge should be tilted (10/900 x 90) = 1mm. This can be achieved by using a 1mm spacer under one spot on the edge of the filter, or better by placing a 1mm spacer on the front edge and a similar 1mm spacer at 180 degrees on the rear surface. (This would mean that the filter "gap" in the retaining cell would be the thickness of the filter (8mm) plus the tilt allowance (1mm), = 9mm)

An alternative solution, would be to mount the ERF parallel in its own cell and arrange to tilt the whole cell by 1mm relative to the OTA. Large, thin section O-rings can be use to hold the ERF with minimum of stress.

(Under construction)

Finding the prime focus

To get the etalon position correct, just measure the focal length (point the OTA carefully at the sun and position a card to find the tightest focus), measure backwards 200mm and this is where the etalon must be positioned.
You can also measure the focal length very accurately by observing a star image with a Ronchi (Ron-key) grating. At precise focus the lines of the grating disappear and the FOV is an even grey.
http://www.youtube.com/watch?v=hM9zG_VNidc

Where to measure on the etalon?

The centre of the front element of the etalon is almost in line with the front edge of the knurled rubber ring. You can safely use this datum to position the etalon relative to the objective.
Likewise the rear focus of 200mm should be measured from the rear edge of the etalon body. (You can safely use 225mm from the rear edge of the knurled rubber ring)

How close is close?

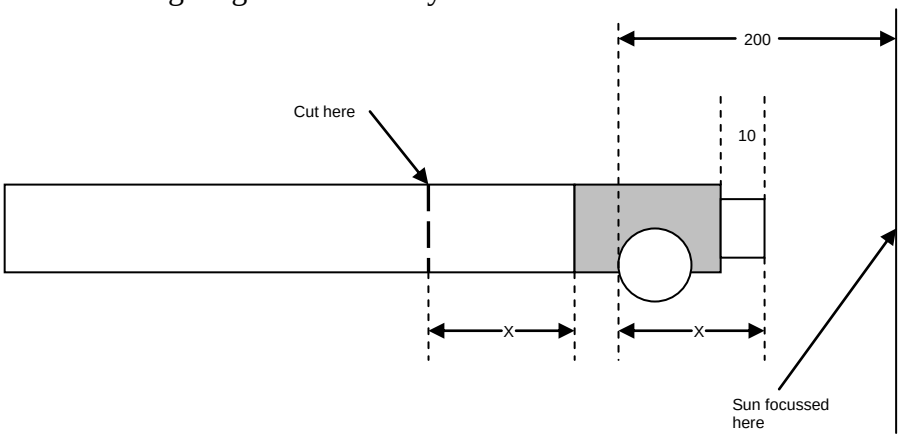
How accurate does the 200mm distance have to be for the Stage 1 modification?
Trials I've done with a 10.5mm eyepiece on the PST black box show that the etalon must be within 200mm +/- 8mm to achieve focus within the constraints of the PST focus travel.
So a tolerance of +/- 5mm should be used.

Cutting the OTA or not?

Sometimes if the original focuser is removed, the etalon position can be just 50mm or so behind the end of the metal OTA tube...a suitable spacer would work. A circular wooden block with an OD to suit the tube and a 2" central hole would work. Otherwise the focuser (or a replacement 2" focuser if needs be) can be retained (will NEVER be used again!) by cutting the OTA to bring the -200mm point just behind the focuser. If you decide to shorten the OTA it's very easy and straight forward - measure the required distance and mark the OTA say 6 or eight points along the circumference. Use a strip of masking tape and wrap it around the OTA at the marks....

The tube is very thin and five minutes with a hacksaw following the edge of the masking tape will give you a clean pretty square cut. You can use the off cut to mark the position of the three 4mm holes required to re-fit the focuser.
http://www.astrotreff.de/topic.asp?TOPIC_ID=96872&whichpage=1#429282
(Half way down the page – some very good images of a cut tube exercise)

The following diagram is courtesy of Mike P.



If you use the Teleskop-Austria 2" adaptor; it's just a matter of securely screwing it onto the front of the etalon and positioning the nosepiece in the adaptor plate/ focuser.
The closer you get to the magic 200mm the better the etalon will perform. IMHO plus/ minus a couple of mm would be OK.

Final focusing is via the PST knob on the black box. That's it!

NB this Stage 1 mod will not improve the ability of the PST to focus beyond the existing eyepiece holder in the Black Box, so it can still make imaging a bit of a problem....

Removing the gold tube

Set the PST black box in a padded vice, apply the BOA Strap wrench to the gold tube. Give it a smart crack and see what moves....
It will either separate the gold tube with the etalon from the body or the gold tube only, leaving the etalon still stuck to the black body (this is the best case!)

Gold tube removed from the PST etalon

The older (gold objective) PST's seem to come apart easier than the new ones. On some of the latest PST's ALL the threaded joints (gold tube to etalon, etalon to body, and eyepiece holder to body) are smothered in Loctite. Makes it just that bit more difficult!!

Example of the Loctite on the PST joints

Getting the etalon off the gold tube without damage needs a bit of organising.

Removing the etalon from gold tube/ black box

The etalon assembly is in three main parts:

1. The main housing which has the optics and the front and rear mounting threads.
2. A rotating ring/ collar which sits under a knurled rubber band on the surface of the housing.
3. And the etalon adjusting plate which sits inside the housing and is attached to the rotating ring by a M2 x 12mm screw.

If you carefully lever up (use a small screwdriver blade) and remove the knurled rubber band you'll see a paper label which says "DO NOT REMOVE" – ignore that, and scratch it off to expose the head of the adjusting screw. Before you remove this screw make a note and mark, if need be, which hole it sits in. (You'll see in the inner plate a whole series of holes). Unless you have problems getting good Hα tuning (See "Improving the tuning ring" above) the screw should be replaced in its original hole.
After the screw is removed the outer adjusting ring can be slide off the housing.
This now leaves the housing ready to be removed from the gold tube.
The next step really needs two people and two Boa wrenches. One BOA fixed around the gold tube and the other around the etalon body. Apply as much pressure as necessary to "break" the joint and release the etalon. Keep your fingers clear of the optical surfaces.
After removal, replace the tuning collar and adjusting screw in the original hole and then add the knurled rubber ring.

With some assemblies it is possible to separate the gold tube from the etalon using rubber kitchen gloves to improve the friction grip on the tube/ etalon! (Thanks to Mike P for successfully trialling the idea!)
NB If you try and remove the etalon without first disassembling the outer adjuster ring the BOA applies all the torque to the adjuster ring which then turns, eventually jamming the M2 screw against the main housing body. The whole release torque applied is then taken by this small screw and it can be damaged (Don't ask how I know!)

Walk though of a Stage 1 modification

Based on a Meade 90mm f8.8 (fl= 800mm), T-A nosepiece and a Baader 90mm D-ERF.

Meade 90mm f8.8 donor OTA

The gold tube was removed from the PST black body as described above and the T-A nosepiece fitted. The end of the plastic focuser on the "donor" OTA was within 10mm of the required (fl-200=600mm) so it was retained.


Etalon position on donor OTA

The inside diameter of the plastic focusing tube was 50mm. A small drum sander and ten minutes work opened the bore to 2" (50.8mm). This gave a tight fit on the nosepiece. A M4 nylon screw was used to "lock" the focuser tube in place.

Focuser tube inside diameter modified to suit 2" nosepiece

The cell for the ERF was made from a Body Shop cream container (Thank's to my wife!) which exactly fitted the objective.


ERF cell using a plastic container

Using great care and a very sharp Stanley blade the base and lid were cut to give 88mm aperture holes.

ERF cell

The edges smoothed by hand sanding. (Why 88mm?? -The 88mm was the maximum size which would still allow the ERF to be held securely, and I want to use the same cell on another OTA which is 880mm focal length)

90mm Baader D-ERF filter – as received

The Baader D-ERF is clearly marked with an arrow to show the mounting direction (arrow towards the Sun). A small slip of cork about 1mm thick was glued at the edge of the aperture to tilt the ERF. The ERF was glued in place with a few dabs of hot-melt glue. The cover of the container also had a small piece of cork fitted and this was positioned 180 degrees to the first one. The cover was sealed at the edge with hot-melt glue. Some Gaffa tape was used to close and seal the edges.

The cell was a very tight fit to the objective, so no additional locking screws were added.

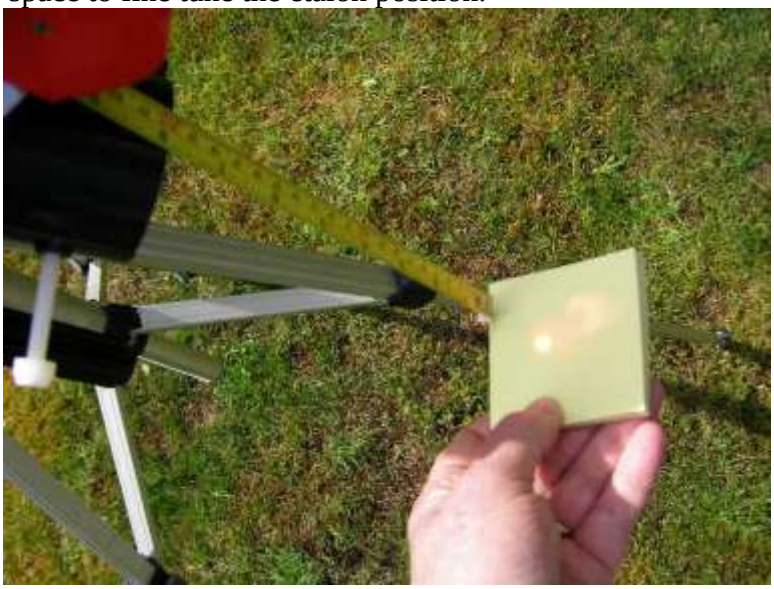
First light showed that the system would not come into focus with the black box…it appears that the etalon is too far back on the OTA (i.e. less than the 200mm inside prime focus, so the final focus is more than 200mm behind the etalon.)

25mm was cut from the metal OTA tube and the focuser re-attached. (The plastic focuser tube also had to be cut back to clear an internal baffle). A strip of 25mm wide masking

tape was used as a guide and the original focus assembly used to position the new 2.5mm holes for the three self-tapping screws.

Cutting the OTA and focuser tube

With the ERF in place the Sun's image was brought to a focus on a piece of card and the distance to the end of the focuser housing double checked – it measured 215mm. This gives plenty of space to fine tune the etalon position.



Measuring the prime focus position

After placing the PST black box in position, and setting the PST focus knob to mid-travel, the nosepiece was slid in and out to bring the edge of the solar disk into focus. The distance to the etalon was re-measured and found to be VERY close to the design 200mm. With a 10.5mm eyepiece the details of the solar surface and prominence were excellent. No sweet spot, but the FOV is limited by the BF5. Not bad for two hours work!!

First light for the Stage 1 modification

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-Another Stage 1 mod:
(Based on a SW 102, Baader 90mm D-ERF)

We set it up so that the focuser is racked out 10mm to get the right spacing and still allow for some tweaking.

This meant that 60mm had to come of the OTA tube and 10mm of the focuser tube to stop it fouling on the welded internal baffles of the OTA...

Kev had bought a filter adaptor of Astroboot which was a tight fit inside the Dewshield but the hole at 89.5mm was only 0.5mm smaller than the filter... So I machined up a custom filter holder which fitted into this hole and left 85mm clear aperture and on the other side had a 90.5mm diameter by 8mm deep pocket for the 90mm Baader D-ERF

three slots allow the thread bushes to slide into the OTA which can be held in place using the shortened nylon screws and washers.. the whole cell is "tilted" to remove the reflections...

Kev's Evostar 102 Mod

We did a quick first-light and at once we found the sun proms were clearly visible without even tweaking the focus – Peter S & Kev

__oooo__

Another Stage 1 mod, based on a Skywatcher 100mm f9 donor OTA and an AE ERF. – Trevor N

Trevor's Stage 1 mod

The results (AR1084) - DMK21

The 100mm SW refractor is in fact f9. The ERF at the front is 80mm and the holder it sits in over the objective effectively reduces it to an 80mm refractor with 900mm focal length (f11 point something). I talked to several guys before going ahead with this and the general comment was you must achieve f10 or greater to get best results as the original 40mm lens on the PST is F10 itself. Some have fitted the mod to faster scopes and some problems have evidently resulted. The ERF and holder are AE components. The tube had to be cut down by 100mm to reposition the focuser. This seemed a bit dramatic but I often had problems getting enough inward focus for a focal reducer / filter wheel and camera. I reckon I should be fine with using a simple 2" extender tube to convert things back. It's certainly a vast improvement on the PST objective and I'm still getting to grips with capture and processing but I'm pleased with the results so far. –Trevor N.

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To be continued

Stage 2 Modificatiom

The Stage 2 modification, has the potential to improve the quality of the final image by removing the penta prism and adding a larger blocking filter. Removing the etalon from the black box is detailed in Stage 1 above.
This image shows the various parts. From the left; 2" nosepiece adaptor, PST etalon fitted with a M50 to SCT thread rear adaptor, SCT to 2" female adaptor, 2" to 1.25" adaptor and the BF15 blocking filter.

Stage 2 modification – components

If the etalon is positioned correctly the final focus will be 225mm behind the rubber knurled ring on the etalon. A SCT adaptor has 2" x 24tpi thread, pretty close to the M50 PST thread. A couple of wraps of Teflon tape can improve the fit.
Allow 80mm in the calculations for the overall optical length of the blocking filter diagonal.
Also consider how much back focus you'll need for the camera(s) you will use. A typical CCD needs around 12.5mm whereas a DSLR uses 55mm. The remaining gap should also contain some means of focusing; either a simple slip fit, a short Crayford focuser or a T thread helical focuser.
On another Stage 2 mod, a Revelation 10:1 SCT focuser was used behind a M50 to SCT adaptor; the BF10 filter then when straight into the focuser. This allowed all the usual eyepieces to come to a focus – great for visual, but didn't have enough back focus for a CCD (DMK21) or the DSLR. (The M50 adaptor was 30mm long, the Revelation focuser 100mm, the BF10 diagonal 80mm, giving 210mm minimum behind the rubber knurled ring) – See later for images.
The combination of an Orion (US) prime focus adaptor, 18mm wide (SCT thread to T thread) and AE helical T thread adjustable adaptor "focuser" 45-65mm wide, with a Baader # 2458125 micro focuser, 30mm wide allowed a CCD/ webcam camera to focus. - See later for images.

(to be continued)

Frequently Asked Questions

Can I use the blocking filter (BF5) from the PST in a Stage 2 mod until I find a BF10?

Yes, you can make up a 2" adaptor using an Orion prime focus adaptor and a small spacer washer.

Adapting the PST BF5 to a 2" holder

Others have managed to "screw" the PST eyepiece holder onto an old diagonal…

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If you don't fancy cutting a portion off your telescope tube to perform the simple Stage 1 PST mod, you can remove the original focuser, make or have made an adaptor that fits where the focuser was and also accepts the PST gold tube (nominally 50mm diameter), use the PST rear end as a Ha "eyepiece" and use the PST focuser as before. This of course assumes that you did not have any of the reported issues with this focuser. I have a Sky 90 modded in this way, nothing on this OTA to chop off! – Peter Drew

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I was basically wondering what to look out for when I fine tune the etalon position using the ED120 focuser. How much, and what kind of improvement shall I expect getting closer to the magic 200mm?
This question may well answer itself on first light, but I would rather spend less time faffing to get it all right if I can avoid it!- Andrew P.

If you're using the focuser on the ED120 to set the final position of the etalon, there will be no ambiguity if you are using the black box with the eyepiece/ camera on the existing PST eyepiece holder.
When you have the "black box" PST focused at its "normal" position the etalon must be correctly placed!! As simple as that.

If the focus position on the PST black box is too far out, or you find you can't get into focus, then the etalon via the 120 focuser need to be moved either in or out.

Depending on the final f ratio, and focal length of the "donor" OTA, the "sweet spot" will vary. If the ERF is not tilted enough you'll have a background glow.
All these things you'll sort out in the first five minutes!
Remember the PST tuning ring is VERY sensitive, it doesn't take much to move between a detailed surface view and prominences; or going from a good image to a poor image.....
Getting accurate focussing for good imaging, may take a little longer.

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I duuno what I've done but I thought I'd use my eyes instead of the camera. Looking through the EP and getting a really nice sharp focus I saw a hell of a ghost disk which moved left to right when I rotated the etalon! Wonder if that's the SCT focuser?

I've also remounted the D-ERF so its off set by about 1mm

So all I had in the was the SCT focuser 2 - 1.25 adaptor BF5.
The ghost image is caused by a combination of the ERF and the inner workings of the etalon.
Get at position on the tuner where the ghost image is visible and remove/ add the spacers at the ERF... my guess is that nothing will change... that just verifies that the plates in the etalon are causing the problem.
Or
The etalon tuning needs to be "re-set" using the small screw/ next hole routine....

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I've got a really nice 10:1 focuser for my Meade SCT. I've wrapped some ptfe tape around the etalon and the focuser fits nicely and hand tightens. The distance from the etalon to the edge of the draw tube runs from 85 to 125mm. If you say the diagonal adds

80mm that should give 165 - 205mm. Allowing for the distance for the BF5/Camera of about 35mm might work?

Image attached.

Stage 2 Modification

The arithmetic is OK, but if you're reusing the BF5 housing and a DMK then I don't think you have 55mm backfocus there...the DMK is about 12mm behind the front surface and BF5 adaptor is ?? 35mm?? that gives 47mm???
OK what about putting a 2" to 1.25" reducer in the SCT adaptor, then using a 1.25" diagonal, then the BF5+DMK?? You might still need a spacer either before or after the diagonal but once you find the focus you can reverse engineer the bits.

(I think the 2" diagonal is worth about 110mm back focus)

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What I found was the distance from the flat of the etalon to edge of the SCT adaptor was 21mm the 50mm tube brought that out to a total of 85mm from the etalon. I guestimated the distance from the front of the BF5 to the CCD sensor was about 55mm and a Barlow tube less the lens added another 55mm. So drawing the fittings apart got a focus of sorts on to the camera. Not good!

How I wish I could get something approaching a proper tube extension and some form of focuser on the back of that! I then tried using a 2" diagonal and a 50mm tube and it was just, and I mean just, not enough in focus, really aggravating.

After a lot of fiddling about I got the camera just close but the sweet spot was terrible. I

just got some really low contrast surface detail on the camera but nothing on visual it was just too bright an image.

If the etalon is close to the 200mm inside prime focus, leave it there... don't get tempted to readjust it. What ever the issue is, it's not the positioning of the etalon.
Ok if you managed to see a prom with an eyepiece, then again, you're not to far away.
The back focus is definately 200mm!!
There's a lot of Ha light coming through the 80mm ERF, so the exposures WILL be pretty short.
The tuning of the etalon is very sensitive.....i
keep trying.... if you find that you can focus on proms but not on the surface then the tuning is wrong, not the focus! If it doesn't come good check out the tuning ring "adjustment" - remember that "do not remove sticker".....
Are you getting any signs of "sweet spot" bright patch or is the FOV pretty even??

__oooo__

Sorry to be a pain but I'm having the devil's own job in getting the focus on to the DMK. I managed it briefly with a cheapo EP and got a prom but I couldn't get any surface detail at all by adjusting the etalon either. I've tried my hardest to get the 200mm in focus on the etalon as we talked about the other day and have the 7-8 mm dia. or so spot as sharp and as small as I can.

As much as I try to get the CCD either side of 200mm it won't focus.
I've tried using a 50mm tube extender in the SCT adaptor with a 1.25 diagonal, a bit of barlow tube less the lens to get the BF5 at about 180mm or so so that allows the ccd to go through either side of 200mm.

with all that weight I'm worried about flexing

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I'm still puzzled by the question of focal ratios suitable for stage 1 PST mods. I've been experimenting along these lines for a while now, I have a 145mm ERF which gives me the opportunity to try out a range of apertures. So far, I've tried a 6" f8 Skywatcher stopped to 125mm, a 102 Vixen Flourite at 100mm, a Sky 90 at 80mm, a 100ED at 80mm and recently the "popular" Vixen A80M at 80mm. All have given much better performance than the standard PST and some of the best views have been with the Sky 90 which is at odds with the logical f10 optimal focal ratio. What I have noticed, is that as the focal length goes up, the small 5mm blocking filter vignettes the field so that only a portion of the Solar disc can be seen. This can be mitigated by raising the eyepiece with an adaptor or using binoviewers although I'm not sure if this results in the blocking filter vignetting the objective aperture. Based on my experiences, I would advise a would-be modder to have a go with what they've got to hand within reason, it at least should provide an improvement over the original. - Peter Drew

Broadband filter deterioration

I've seen that deterioration before!!

Coronado/ Meade say their coating problems only affected a limited run of the early PST's objectives and said that the secondary filter was "unaffected" - absolute BS. Dump it - you'll NEVER use it again!! Even if you go back to the "black box" arrangement it can safely be left out (just unscrew the holding ring) and the BF5 re-fitted etc.

[Addition – This broadband filter besides reducing the UV-IR acts also as a ND filter (due to the low transmission efficiency of the filter at Ha). For visual it may be necessary to add a ND1 or ND2 (moon filter) between the etalon and the BF to reduce the glare.]

Deterioration of the broadband filter in the PST BF5

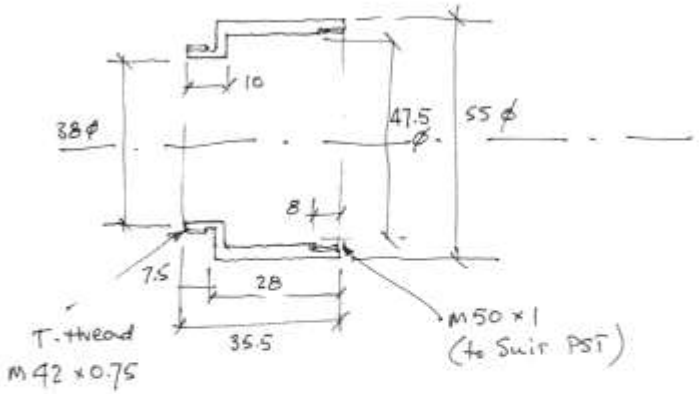
All I've got to do now is work out how to focus the BF5 and get the 200mm distance from the ealon to the sensor on the DMK31

__oooo__

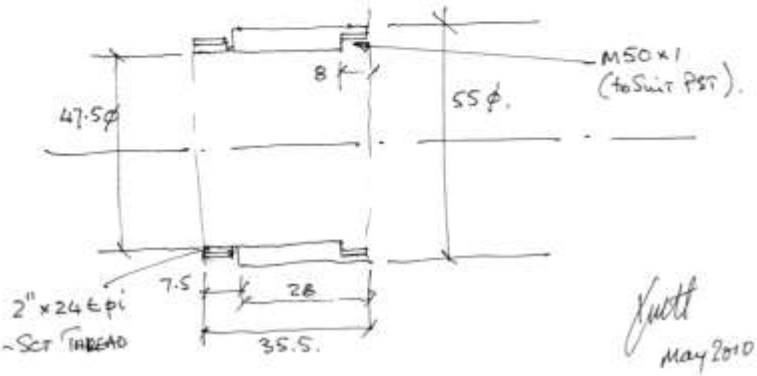
Can I make an adaptor for the rear of the etalon to fit an SCT focuser? What about T thread extensions?

PST - REAR ETALON ADAPTORS

(1) M50 to T thread



(2) M50 to SCT thread



Stage 2 Modification

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….sounds like the setup is almost there, curious on the TH ERF though...hopefully it's as flat as the Baader. I tried a few ERF options, and stuck with the Baader as the others produced blurred images due to lack of flatness in the glass.

What is the focal length on the skywatcher btw? was it F11 to start with?

My setup is

Baader C-ERF in Ambermile Filter cell
Vixen A80M with 100mm lopped off (bit more than needed, but hey ho)
PST adapter front (Ambermile)
PST Etalon (0.7A side by side comparison with SV50)
PST adapter rear (Astro Engineering SCT adapter)
2" to 1.25" extension tube (Ambermile)
Coronado BF10 (no rust)
Lumenera Skynyx 2-0m camera, usually with a Televue 2.5X powermate (for F25) and 2X Celesttron barlow lens (for F50) attached

Images...all over the web :-) – Nick Howse

__oooo__

Some notes on the PST etalon construction

I've been waiting to get in to solar work for a while and have been using White light filters up to now but have just managed to get hold of a broken PST from Dave. From what I can see the PST Etalon is a parallel airspaced unit. If I understand the system correctly the PST Etalon should be a fixed unit of two plates with the semi mirrored surfaces on the inside edges and the plates fixed together to give the cavity. The tuning on the PST is done by compression tilting. The Etalon is mounted on a piece of sponge rubber and as the upper mount is compressed down the etalon tilts on the sponge. (I may be wrong here) From what I can see the two etalon plates have separated and the top plate rotates with the upper compression ring. The air space seems to be formed on the Etalon by three glass raised edges on the plates one on the top plat and two on the bottom plate. Should these plates be fixed(which is what I think they should).
I had it apart last night, as I have nothing to loose, and the spacers seem to be just raised glass lugs. There are three in total. Two on one plate and one on the other. There are pencil marks on the glass sides but it is a little confusing as the top plate has one mark and the bottom plate has four !!!! If the plates are to be parallel then the spacers should be equal distance apart around the rim of the plates. The problem here is ,is that if this is done none of the pencil marks line up. I have tried it as equal spaced spacers and although it is better their is little filtering. I will try again tonight if I get time. When it is apart I will try and get some photo's for you. If the tilt is a few nanometers then I'm not sure how the sponge mount works as it is possible to move the whole assembly about 3 mm as it is compressed. The only thing I can think off is that the sponge is only a buffer and it is relying on the glass distortion to give the tilt.

Well I've got stripping the whole PST down to a fine art now. I've done it 5 times tonight !!!!

I've taken a few photo's to show you what I have found. Excuse the quality I was in a little hurry before the sun went down.

Now from what I have found is that the Etalon has no spacers, what I thought was spacers was actually super glue which came off easily with a little nudge. You can see a bit on the Etalon picture on the rim of the glass as a small circle. I reassembled the Etalon with no spacer just using the glass super glue as the spacer.(the glass glue cures with UV light in about ten seconds). I then reassembled it and tested it on the sun. Result was no filtering just an orange disc. So I disassembled it and placed a tissue paper spacer in between and glued again and then pulled out the paper. Reassembled and tested this time I had multi discs approx 15 - 20 getting fainter. Still no filtering. Tried again with 2 layers and then 3 layers of tissue as a spacer. Each time the multi discs got fewer and wider apart. With 3 layers as a spacer I have 4 discs. I've now gone for 4 layers but the sun went in so will need to play again tomorrow.

I've included a photo of the inners of the Etalon carrier which shows the Deep Blue filter in the base of it. The Prism seems not to have silvering on it but I may be wrong here as I have only had that apart once !!! i.e. the side plate off.

To remove the etalon securing compression ring (with the two holes in) first remove the rubber ring on the tuning ring and you will see a screw in the ring. Remove that screw and the tuning ring will come off. With the ring off the Compression plate will just unscrew leaving the Glass etalon in the housing.

Stripped down PST etalon assembly

PST etalon

To remove the etalon securing compression ring (with the two holes in) first remove the rubber ring on the tuning ring and you will see a screw in the ring. Remove that screw and the tuning ring will come off. With the ring off the Compression plate will just unscrew leaving the Glass etalon in the housing.
The front lens is removed without affecting the etalon. It can be removed in its holder or it can be removed from the holder in situ either way it does not move the etalon. The front lens is the second from the left in the photo and I remove it in its holder.

I don't know about the rear lens/filter as I can't get the Etalon housing out of the main body. Looking at it I think it must be removed from the rear of the etalon body as there are no threads on the inside at the rear.
The latest is that I managed to get the Etalon main housing out of the Prism block and there is no filter on that rear lens it is just the way it looks when all together. so there is jst a positive lens. Still no luck on the spacing of the etalon though.
I've tried and tried to get the distance and parallel plates correct and so far have not succeeded. It looks like I'm going to have to buy a new one !!! I had intended to use the Etalon in a conversion but looks like it may be easier to just buy the bits. – Peter N

__oooo__

Set up the PST etalon in front of the 600lpm spectroscope, only visual; will get a couple of photos when I get back.
Interesting.....
The solar spectrum is still very visible from the Blue through to the far Red.
There are prominent "dark lines" (very much like your typical absorption lines but much wider) spread across the spectra. These show the resonance peaks. The "resonance bands" if I can call them that are far more obvious in the red than the blue (the effect of shorter wavelengths?)

Summary: The spectrum is still very bright, much more total light getting through than I imagined! Need to do the same observation with the ERF in place.

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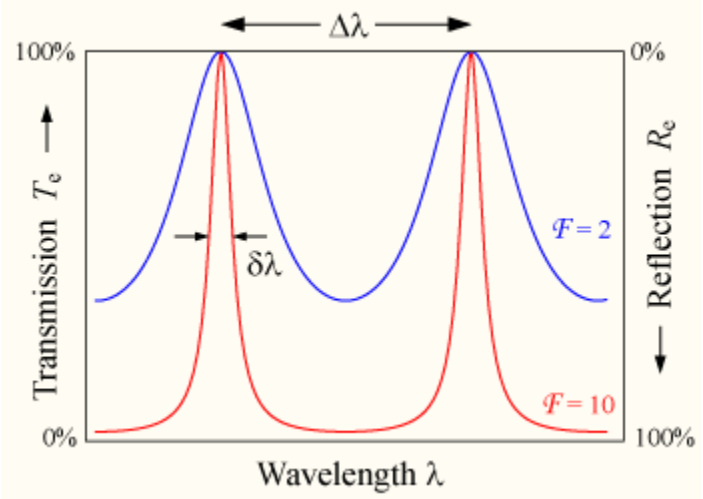
I was thinking on the best way to explain this. As the reflectivity falls off as we get away from the reflective coatings design wavelength we will see the finesse drop. This not only widens the bandpass of the higher orders it raises the amount of out of band light so the etalon passes a much larger percentage of light overall as we go from the design wavelength.

This diagram is not really correct, the peaks would start to fall from 100% as the bandpass widened and the "floor noise" was raised.-Colin K



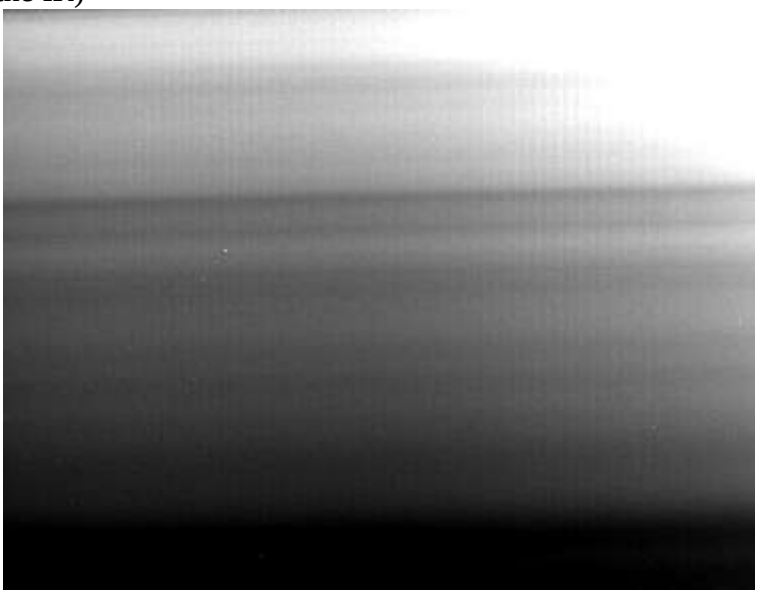
Fabry-Perot etalon resonance pattern

I just got the bright idea to take out the two EP filters in my blue objective PST and test them with a cheap spectroscope. The larger one that is hidden passes a much wider band of red than the little back one. It is likely taking the brunt of the energy trying to get more life from the trim filter. The out of band blocking was very good in the pre-filter. - Colin K

__oooo__

At Colin's suggestion I set up the spectroscope with the MX7c against a 100W lamp. Needed a wide slit, about 30microns and a 6 sec exposure.
Some interesting results:
1. The PST etalon has NO built in ERF; the resonance bands are seen all along the spectrum from the far red down to the violet. Much brighter image!
2. The SM40... well, well, well, it definately has a built-in ERF! The image is extremely faint to the eye. The broadband effect is much "tighter" than the Wratten #25 or the Baader C-ERF, certainly centred on the Ha. (Can't get up into the IR with the camera/ lens combination)
The resonance bands look identical to those of the PST but obviously much fainter and only visible in the red.
3. With the C-ERF, the red/orange side of the spectrum looks VERY similar to the cut-

off in the Wratten#25, and as seen before the red "drops" off just beyond the Ha. I'd have to agree with the curves published elsewhere; the visible bandwidth is from 600 to 700nm (can't measure the IR)



Resonance bands from the PST etalon (vertical stripes)

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1) The achromat has to be f/10 or less (f/11 and so on). The particular SW909 unit I use has f/10 on the label but probably in the real world it's close to f/9-f/9.5 because I loose contrast on the disk detail at full aperture. I am stopping it down to something like D=60mm to get the full contrast on disk. Try to find some other f/10 achromat to base your heliograph on. Probably TAL-100R is a good choice. No need for APOs as you're shooting in monochromatic light, so a standard Fraunhofer doublet does the job really well. Just try to make sure it does not have lots of spherical aberration. An f/5 unit with a telecentric barlow such as TeleVue Powermate or Baader Telecentric Barlow before the etalon will do the job as well, just make sure not to use standard barlow lenses. f/10 light beam shall hit the etalon.

2) PST has 50mm threads. I have asked a craftman to do custom 50mm-to-1.25" and vice versa adapters to plug it into the focuser. You may want to go the 2" path as 1.25" results in some vignetting.

3) After the etalon, I have a barlow lens screwed into the diagonal nosepiece, then a part of standard chinese star diagonal and the trimming/blocking filters from PST screwed into that diagonal instead of it's standard 1.25" nosepiece. Barlow lens is required because I can't reach focus with the diagonal. Diagonal is required because of custom trimming filter thread that fits that diagonal only and can not be inserted into the 1.25" nosepiece. I will replace this three components monster unit with a 2A 1.25" Baader Protuberanzfilter and 70A (7nm) standard H-alpha deep sky Baader filter. This will allow me to reach focus, use less magnifications, etc. I will probably make up a web page with whole unit once it's done.
4) I am not using C-ERF filter. Nothing is wrong with my camera or etalon so far.

Etalon is made from quartz so there's no harm for it, however I admit it can degrade with time as microwaves are passing through, so I just ordered a Baader C-ERF filter and will be installing it soon. But you can start with no C-ERF in place. Possibly my images are degraded also as without C-ERF I let the heat into the tube, not a good idea.

So far that's it. Really simple but the unit is much more powerful than standard PST. You can also check www.astropixel.org (check PST modification page) Sebastian uses a Takahashi f/5 apochromat with 2x telecentric lens, then etalon and Coronado's BF10 blocking filter diagonal, C-ERF in place. His shots are the best I've ever seen with a modified PST thing. But I am pretty sure apochrmat isn't required to produce good shots.- Maxim Usatov

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The daystar ERFs are normally Wratten #25 filters as I understand – Michael o'C

__oooo__

I worry more about coatings getting damaged on the objective and in the blocking filters. Removing energy as early as possible from the system is the safest way to look at it. The blue objective PSTs use IR/UV after the etalon and I don't see that as a problem. However if we increase the aperture from 40mm to 80mm then we have increased the energy by 4 and the little PST UV/IR blocker is likely going to fail over time. I have not seen any blocking filters fail by allowing more energy in, I have found they simply degrade the image. - Colin K

(To be continued)

Other Successful Mods

Here's a mod based on a 90mm Surplus Shed objective, a square wooden tube (MDF), and the Revelation SCT focuser.

PST etalon, 50mm to SCT adaptor and SCT Crayford focuser

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Nick Howse:

Baader C-ERF in Ambermile Filter cell
PST adapter front (Ambermile)
PST Etalon (0.7A side by side comparison with SV50)
PST adapter rear (Astro Engineering SCT adapter)
2" to 1.25" extension tube (Ambermile)

Coronado BF10 (no rust)

Nick's original Stage 2 modification

<u>90mm Double stacked modification</u>

Well, just finalising the optical train and laser aligning. A bit disappointed to find that the Meade diagonals are NOT set exactly at 90 deg; just a bit more fiddling!!
Proof of concept prototype should be finished tomorrow (just in time for the rain to stop!)
The attached photo shows the ED90 square tube with the two 2" diagonals feeding up to a 2" Barlow then into the PST fitted with the SM40, Revelation focuser and BF5 at the end.
By bending the optics back on themselves, you get quite a compact design only 590mm long.

PST/ SM40 double stack on a 90mm collimated system. T-H ERF.

(The final configuration shown used 50/50 mirrors to replace the diagonals and did not use the ERF)

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I promised I'd get some pictures of my solar mod as soon as the clouds cleared for any reasonable duration. That took 10 days!

So this is my 90mm/110mm PST mod. The arrangement is thus:

(90mm aperture mask for f/10)
110mm Baader C-ERF in custom cell (106mm, f/8.5 without mask)
ED120 objective
ED120 tube, shortened by 90mm
Skywatcher dual speed focuser (to tune etalon position)
AOK PST etalon to 2" nosepiece adaptor
PST etalon (~0.75A)
SCT dual speed focuser (to focus)
(extension tube required if using an eyepiece)
Coronado 10mm Blocking filter
Eyepiece/camera

Andrew's Stage 2 Modification

I still have to work through some issues: the BF-10 may be faulty, and I have an annular sweet spot - not circular as I expected. However, the system definitely works, very well. I haven't noticed a huge difference between f/8.5 and f/10, but I will keep on looking! - Andrew P

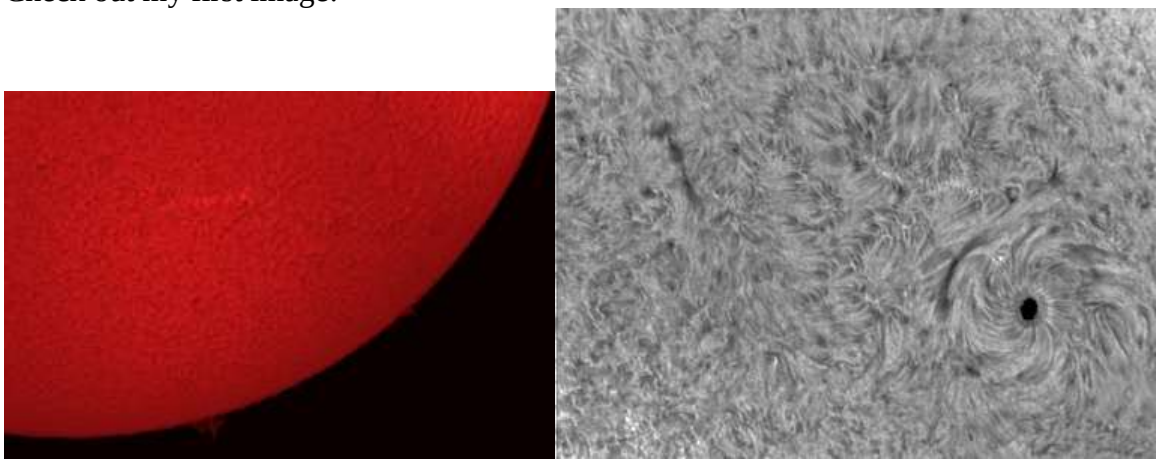
[Addition- Re-tuning the etalon removed the sweet ring]

OMG!! If you're in two minds about doing the PST mod, one mind has to go!

I got things sorted today - the tuning is key. I put the Revelation binoviewers in at 180x using 15mm eyepieces and a barlow element. I found the views were best without the aperture mask - 106mm, f/8.5. It was so relaxing with the binoviewers and I saw quite a bit more than without, but even without - just amazing to mosy across the disc, taking in the various filaments etc., that don't show up under lower magnification.

The cherry on the cake is being able to chuck anything at the system and it'll focus it, and do it well. - Andrew P

Check out my first image:



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Stage 2 Mod using a Meade 90mm f8.8 “donor”:

Stage 2 mod: Meade 90mm –note solar finder

The Revelation focuser allow great visual results, but not enough back-focus for the CCD camera.

Revelation SCT focuser

AE variable T thread "focuser"

The AE variable T adaptor allowed the CCD (DMK21) to come to focus.

[To be continued]

Links to other successful mods

http://www.dd1us.de/Downloads/Modification%20of%20a%20Coronado%20PST%200v6.pdf
https://www.denkmeier.com/index.cfm?fuseaction=product.display&Product_ID=99&CFID=24989872&CFTOKEN=47380185
http://www.robertarnold.co.uk/photographs/astro/Solar/CERFequipment.htm
http://www.lightfrominfinity.org/PST/PST.htm
http://www.astropixel.org/astropixel_modif_pst.htm
http://www.astrode.de/pstumbau.htm
http://www.8ung.at/komet/pstumb/pstumbau.html

Other handy sites
http://translate.google.com/translate?u=www.sonnen-filter.de%2F&hl=en&ie=UTF8&sl=de&tl=en
http://www.designerinlight.com/solar/EtalonArticlePt1.pdf
http://www.solarlive.nu/?page_id=281
http://www.pulsar-optical.co.uk/prod/cool%20erf%20filter%20in%20screw%20mount%20for%20Z80%20clones/ERF.html