Electronic Spectrograph Number 2 (ES2)
Users' Manual
3 December 2003

The Electronic Spectrograph Number 2 (ES2) is a low- to moderate-spectral resolution spectrometer with a CCD detector. It is for use at the Cassegrain focus of the 2.1-m telescope. This manual gives an overview of the spectrograph and its associated Telescope Utility Bin (TUB) used for guiding and acquisition.

1 Description of Hardware

1.1 Specifications

- Telescope: Struve Reflector and Cassegrain Optics

Aperture	2.06m
Cass Focal Ratio	f/13.6
Focal Plane Scale	7.37 arcsec/mm (0.06 arcsec/μm at detector)
Effective Focal Length	28.0m

- Spectrograph

1. Collimator: Jaegers 6A 1506
   Material: Pyrex,Aluminized, SiO overcoated
   Figure: Spherical, 1/25 wave

Diameter	108 mm
Focal Length	1143 mm
Collimated Beam at f/13.6	84 mm
Off-Axis Angle	5.5 degrees
Camera and Collimator Reduction	8.16

2. Camera: Bowen semi-solid Schmidt Cassegrain
   Mfg. Don Loomis, Tucson Arizona
   Material: Fused Quartz
   Coating: Corrector Plate anti-reflection.
   Reflecting surface aluminum

Clear Aperture	108 mm
Focal Length	140 mm
Effective Focal Ration	f/16.7
Scale ($\perp$ to dispersion)	60 arcsec/mm
Angle between incident and dispersed chief ray	50.5 degrees

3. Front Window and Field Flattener: Fused Quartz

Concave R. of C.	86 mm
Diameter	2.5 mm
Thickness	0.185 mm

1.2 Gratings

The spectrograph can have one grating installed at a time; a range of gratings exist for this spectrograph. The desired grating(s) should be requested on your telescope "Request for Services" so that they are available at the start of a run. The gratings have blanks of dimension $110 \times 135 \times 25$mm with ruled area of 102×128mm.

Available Gratings

Grating	g/mm	Blaze Angle	Blaze Wavelengths Littrow (Å)	Blaze Wavelengths Effective (Å)	d/dx (Å/mm)	$\Delta\lambda$ (2 pix*)
1	300	2°35′	3000	2718	220	5.4
2	600	8°38′	5000	4526	114	2.8
3	600	22°02′	12500	11310	119	2.8
4	300	4°18′	5000	4521	222	5.4
5	600	13°00′	7500	6782	116	2.8
6	300	3°38′	4200	3821	221	5.4
7	600	6°54′	4000	3622	113	2.8
8	1200	13°53′	4000	3617	58	1.4
21	300	6°28′	7500	6791	225	5.4
22	600	8°38′	5000	4527	114	2.8
23	600	–	7500	–	–	2.8
24	1200	–	7500	–	–	1.4
25	1200	17°27′	5000	4520	59	1.8
26	150	3°35′	8000	7500	–	10.8
"Potters"	150	–	5000	–	–	10.8

* TI1 pixels (15 μm)

The grating angle is read off of the following tables and is set by using the protractor on the outside of the grating housing. Note that this device is crude and one can only set the wavelength approximately. Also, some of the gratings have zero point errors due to the way they are mounted in their cells. The range in wavelength is also just approximate. *Check your wavelength setup with a lamp or a star.*

300 grooves/mm, order=1

i (degrees)	Lambda (blue)	Lambda (center)	Lambda (red)
29	1352	3943	6602
30	2384	4993	7669
31	3414	6041	8734
32	4445	7087	9797
33	5474	8131	10856
34	6501	9173	11912

600 grooves/mm, order=1

i (degrees)	Lambda (blue)	Lambda (center)	Lambda (red)
30	1192	2497	3835
31	1708	3020	4367
32	2223	3544	4898
33	2737	4066	5428
34	3251	4586	5956
35	3763	5106	6482
36	4275	5623	7006
37	4785	6140	7529
38	5294	6654	8048
39	5801	7166	8566
40	6306	7676	9080
41	6810	8184	9593
42	7311	8689	10102
43	7810	9191	10608
44	8307	9691	11110
45	8801	10188	11610

1200 grooves/mm, order=1

i (degrees)	Lambda (blue)	Lambda (center)	Lambda (red)
38	2647	3327	4024
40	3153	3838	4540
42	3656	4344	5051
44	4154	4846	5555
46	4646	5341	6053
48	5134	5829	6543
50	5615	6311	7025
52	6089	6785	7499
54	6555	7250	7964
56	7014	7707	8418
58	7464	8155	8863
60	7905	8592	9297
62	8337	9019	9719
64	8758	9435	10130
66	9169	9840	10528
68	9568	10232	10914
70	9956	10613	11286

1.3 Detectors

There are two available detectors for ES2. Both of these detectors are in cryocams whose front windows represent field flatteners for the detectors.

- TI1

  This is an 800×800 pixel device manufactured by Texas Instruments. Each pixel is 15×15 microns on a side with no gaps between pixels. The projection on the sky is 0.9×0.9 arcsec (assuming a projection factor of 8.16, which changes with grating angle). This detector has the higher quantum efficiency of the two *at all wavelengths* but suffers from severe fringing in the red.

- CC1

  This is a 1024×1024 pixel device manufactured by Loral Fairchild. Each pixel is 12×12 microns on a side with no gaps between pixels. The projection on the sky is 0.72×0.72 arcsec. This detector is a "thick" chip and so suffers no fringing. This is the detector of choice in the red.

1.4 Filters

There is a filter slide which can hold 2 inch $\times$ 2 inch (or 50.8mm $\times$ 50.8mm) filters for use in order blocking. This slide can hold up to 3 filters and is located just beneath the flat plate at the top of the spectrograph/bottom of the offset guider. A variety of filters is available to the user.

Available Filters

WG360	OG590
GG375	RG610
GG435	UG5
GG475	BG12
OG495	BG25
OG550	

1.5 Telescope Utility Bin

The Telescope Utility Bin (TUB) for ES2 is the top section of the instrument. The TUB facilitates several functions of the spectrograph: 1) Acquisition and guiding using a Photometrics Star 1 CCD guide camera; 2) Calibration Lamps; 3) Slits for the spectrograph.

Hardware for the TUB exists both at the telescope and in the control room. This section of the manual describes the various parts of the hardware at a user level and does not attempt to describe detailed usage. The optical components, the calibration components and the slits reside at the telescope TUB controller.

1.5.1 Diagonal Mirror

After the light passes through the Cassegrain hole, it first encounters the diagonal mirror. This mirror is tilted at approximately a 45° angle to the sky and has a hole in its center to allow light to pass through into the spectrograph. The user may look with the guider at the solid part of the mirror in order to view the "field" (this is position 2 on the control box described below). Alternatively, the user may allow the star light to pass through the hole in the mirror and down to the spectrograph and view stars around the edge of the hole to look at an "offset" position (this is position 3). Since ES2 is a spectrograph, the user will also want to view the "slit" (this is position 1). This is done by moving the mirror out of the way and looking at the slit in reflection (there is a suitable combination of lenses and a mirror to achieve this optically.

Either position 1 or 3 must be selected for light from a star to pass down through the slit into the spectrograph. If the mirror is in position 2, then the mirror blocks the beam from the telescope. However, in order to observe the calibration sources, position 2 must be selected since the cal source light enters the spectrograph via another mirror on the back of the diagonal mirror.

1.5.2 Guide Camera

The current acquisition and guide camera is a Photometrics Star 1 CCD detector. It is run with its own control electronics and program. The camera is a remote viewer but cannot be used to autoguide (move the telescope). The Mountain Staff can instruct you in its use (or any substitute camera).

The optics for the guide camera were designed for an older, heavier camera and there was a design decision to not move the camera around to view different regions of the field. Therefore, all images ere "moved" with optics. Once the light bounces off the diagonal mirror or the slit viewer, it passes through a reimaging field lens. This light in turn passes through one of two copy lenses. The one which the user will want to use to view the slit shows the smallest amount of field at the largest magnification. When the user wants to view the field or an offset position, then they will generally want to use the lens which shows the greatest amount of sky. There are "factory pre-set" positions for all of the combinations of diagonal mirror and copy lenses but any and all of these preset positions may be overridden by the observer.

Nominal Mirror/Lens Combinations

Knob Position	Mirror Position	Copy Lens Position	FOV
1	Slit	Slit - most magnified	100×60arcsec
2	Field	Field - least magnified	8×4.5 arcmin
3	Offset (hole)	Field - least magnified	8×4.5 arcmin

The guide camera is a broadband detector whose peak response depends on the spectral type of the object. If the star is too bright for the shortest integration times, or if you want to use a filter to guide at a wavelength similar to your observations, you may put a filter into the beam from the diagonal mirror to the guider (it will not be in the beam to the spectrograph). There is a *manual* filter slide for this purpose which can hold up to five filters. Standing at the Remote Control Panel on the instrument at the telescope facing the panel, the filter slide is on the left-hand side of the instrument at the end nearest the TV. There is a knob which chooses between filter positions and four screws which release the filter holder. To insert a filter, remove the screws and pull out the filter slide. Insert any 2 inch filter into the slide and replace the slide in the TUB. Filter position is chosen manually by pulling or pushing the slide knob.

1.5.3 Slit Wheel

Rather than have a continuously adjustable slit/decker combination as at other spectrographs, the TUB contains a slit wheel with 12 discrete positions. The user changes slit width by turning a knob on one of the control boxes (described below). The length of the slits is fixed and is nominally 120 arcsec long. All of the slits are aligned with one another so that they are imaged on the same part of the CCD detector.

Slit Position	Slit Width	Slit Position	Slit Width
1	large hole	7	3.1 arcsec
2	pin hole	8	4.1 arcsec
3	0.65 arcsec	9	5.1 arcsec
4	1.1 arcsec	10	7.1 arcsec
5	1.6 arcsec	11	9.1 arcsec
6	2.1 arcsec	12	12.1 arcsec

1.5.4 Calibration Lamps

The calibration lamps reside in the TUB. There is an argon penlight lamp (cal source 1), a neon penlight lamp (cal source 2), and a quartz incandescent lamp (cal source 3) (a Hg lamp may be substituted for either the argon or neon lamp by a member of the mountain staff). These lamps are selectable with switches on the control panels. Note that there is an interlock for these lamps such that the lamps may not be turned on in a situation where their light might enter the guide camera. Thus, the diagonal mirror must be in position 2 (the "field" position) before the lamps are turned on. The calibration sources are actually reflected off of a mirror on the back of the diagonal mirror in order to have their light reach the spectrograph. The two arc lamps may be fired individually or together. Users should use "dome flats" instead of the internal incandescent lamp for the highest quality flat fields.

The intensity of the calibration lamps is fixed. Thus, they may be too bright for observing in some situations. There are a set of wire mesh attenuators ("neutral density") to cut down the amount of light reaching the spectrograph. These filters are selectable with a knob on the control box. Position 1 has the maximum attenuation, position 2 has less attenuation and position 3 has the minimum attenuation. Positions 4 and 5 are clear (no attenuation).

1.5.5 Remote Control Panel (on TUB)

The Remote Control Panel (RCP) is the part of the TUB attached to the top of the spectrograph; it has all of the switches and knobs. It is the primary control panel and the panel in the control room (see below) is slaved to it. Most of the switches on the RCP are "momentary" switches, which means that the user holds them down momentarily and then releases them to select a function. The next time they are held down, they reverse the action for most switches. Switches exist to turn the calibration sources on and off, move the copy lenses, set the positions of the copy lens stages, clear the offset position, select observing station, etc. In addition, some functions are chosen with a knob. Such functions are slit position, diagonal mirror position or neutral density for the calibration sources.

1.5.6 Instrument Control Panel (In Control Room)

The Instrument Control Panel (ICP) is the slave of the RCP and presents all of the same functionality to the user. It also consists of a series of knobs and switches in a one-to-one correspondence with the RCP. However, the two control boxes *do not* have their switches and knobs in the same locations on the boxes. Control is switched between the ICP and the RCP by means of a momentary switch in the upper left-hand side of either box. A light near the switch indicates which box has control. Pressing the switch transfers control from the box with control (light lit) to the other box. Thus, if the ICP has control and the user is on the platform and wants control, simply pressing the switch on the RCP will grab control without the observer having to go back to the control room. Similarly, the user can give control to the ICP from the RCP.

Since the ICP is a slaved box, it is much slower to respond to switches than the RCP. When you push down a switch, it will flash the appropriate led to acknowledge the command. At this point you may release the switch. The move is complete when the led lights solidly. Also, note that the display for the copy lens position updates slowly on the ICP and so appears jerky.

2 Setup and Operation

2.1 Installation of a Grating

Generally, the gratings will be installed by the mountain staff into the spectrograph. They will install whichever grating is requested in the "Request for Services". In this section, the procedure for installing a grating is described, but the user should not have to install the gratings.

The gratings are permanently mounted into cells with removable covers for protection of the reflecting surface. To install or remove a grating, loosen the screws on the ring to which the protractor is attached. Remove the ring. Grasp the handle in the center of the grating housing and slide the grating and housing out of the instrument. *Beware that the combination of housing and grating is somewhat heavy. Do not drop it!* Place the housing on a flat surface on the handle side of the housing. At this point, be sure to place the protective cover on the grating. Then the grating can be removed or installed with two screws which attach a bar on what will now be the top of the housing. Only 1 screw need be removed and the other loosened and the bar will swing out of the way. Once the bar is out of the way, gently slide the grating and cell out of the housing. Put the grating away. Another grating may now be installed in the housing and its cover has been removed. Slide the housing back into the instrument and replace the ring that holds it into place.

The grating angle can be set by using the tables above to determine the angle. To change angles, the screws holding the ring with the protractor just need to be loosened. The ring should not be removed. Then, grasping the handle, the grating can be rotated to a new angle. Be sure to tighten the screws holding the ring. The exact wavelength coverage should be checked with a lamp or star spectrum after final tightening of the ring.

2.2 Installation of Filters

To install a filter into the slide, loosen the two screws which hold the filter slide in place. Remove the complete filter slide from the instrument. Filters are held in the slide with metal rings. Be careful not to scratch the filters when removing the rings. Which position is in the beam is selected manually by pulling the filter slide knob out or pushing it in.

2.3 Focusing the Spectrograph

The spectrograph is focused by moving the collimator position up or down. To do this, there is a knob on the bottom of the collimator. It is set inside a metal collar to try to protect it (but please do not run the platform into the knob). Typically, arc lamps are observed at different settings of the collimator focus until the narrowest lines are observed. Start focusing with steps around 500–1000 units. These observations are generally obtained with a narrow slit so that blending is not as much of an issue.

2.4 Telescope Utility Bin

2.4.1 Start-up

The various processes of the TUB are controlled by a series of microprocessors which should have their programs resident in them when the observer starts. If there appears to be no software running in the TUB, contact the Mountain Staff. They will generally power up the system and run a complete test before the user begins.

To start the TUB, turn on the power to the ICP and RCP with the power switch on each of the boxes. When the RCP power is turned on, the instrument will go through its normal start-up process. Note that the ICP is not needed to run through the start-up process but that the RCP is *always* needed. Control of the TUB resides with the RCP on power up. Note also that if the power is already turned on on the RCP and you want to restart things, you must turn off the RCP power and wait a few seconds before powering it on again.

When the user powers on the TUB RCP, the program will check the actual positions of the diagonal mirror and copy lens and the neutral density position. These positions are compared with the positions of the knobs. First, the slit wheel is homed against the limit switch (a relatively slow process) and then the slit is moved to the position set on the knob. If the positions of the diagonal mirror and the lamp neutral density match the knobs, then the station select light on the RCP will light. If, however, the hardware is in a different position than the knobs are set at (if the knobs have been turned with the power off), the position lights for the diagonal mirror and/or the neutral density will flash until the user changes the knob setting to match the hardware position. Once the settings and the hardware match, the station select led will light.

The instrument has some "factory preset" positions for the diagonal mirror and copy lens combinations. The meaning of these positions and how to change them will be described below under "normal operation". However, since the user may change these values, a normal power-up sequence will use the *user selected* values for these positions rather than the factory presets unless the user goes through a full "reboot". The reason for this is so that a user's positions are not lost in a power failure. Note that, unless a full reboot is performed at the start of a run, the user will get the positions set by a previous observer. To perform a full reboot, the user needs to hold down the station select button on the RCP at the time the power on the RCP is being turned on and keep holding down the station select button until the station seclect led comes on solidly. This restores the factor preset positions as the default. In addition, it homes the slit and sets it to the position on the knob, homes the mirrors and copy lens and leaves them in position 2 (field), and sets the neutral density slide to position 5 (clear).

It should be noted that the motors are quite "musical" when they run. In addition, some of the functions require more steps than there are bits in the instruction, so the motor may have to ramp up and run a distance then ramp down more than once in order to move one of the functions from one place to another. For example, the slit will almost always need more than one instruction since the slit wheel needs 144000 half steps to complete a revolution. Thus, if you are near the instrument and hear the motors stop making noise, you might not be in position since the microprocessor might have to issue another command. *The only way to be sure that you are in position for the slits, mirrors, etc. is to look at the leds on the RCP or ICP.* They will light when a move has completed.

2.4.2 Normal Operation

Once the instrument is powered on, normal operations may begin. First, the user must decide whether they want to run with the RCP or the ICP. All of the functions of the two panels are the same, so this is a function of where the user wants to be and what they want to do. Look at the upper left-hand corner of whichever panel you choose. If the light is on for station select, then the control panel you are at is the working control panel. If the light is not lit, then hold down the station select button for ~ 1sec and release. After a short period of time, the station select light should come on, indicating that the control panel you are at is operational. The switch settings on the currently active panel will then be checked to be sure that the hardware and the settings match. If they do not match, the hardware will be moved to match the settings on the currently active panel. Once the station select led is lit, you may now use the panel to change instrument settings.

The user starts out with the factory preset positions. They may want to perform the following sequence for defining their own settings. First, point to a star and select position 2 (field). Move the telescope to more or less center the star. Next select position 1 (slit). Center the star on the slit. If you can not see a star, you will have to search around by moving the lens. Push the switches on the control panel for the X or Y copy lens stage. If you had to search around a lot or if you just want the star in a different place on the TV while on the slit, then center things the way you want and hold down the "X,Y set" button until the station select light blinks. You have now overridden the factor preset slit position with your own choice.

Once you have set the slit position, return to position 2 (field). Is the star somewhere in the field and at a position you like? If so, then mark its position on the TV screen with a grease pencil. Then, whenever you acquire a new object, place the mirror in position 2, center the star on your mark and select position 1. The star will then be on the slit at the place you desire.

Instead, if the star is not in the field, or on a good spot when you move back to the field, move the X stage until the image is where you want it and mark that spot with the grease pencil. There is no Y stage motion when using the copy lens with the least magnification (normal field position lens). Set the position of the stage in memory by using the "X,Y set" button, as with the slit. You have now changed the factory preset position to your own position.

If you want to offset guide, place the star on the slit and get everything where you want it. Then, select position 3 (offset). If you still have the factory preset for position 3, the TV should be looking at the hole in the mirror with stars or sky around the edge. If you have changed the offset position, then it will return to the last offset position. You may clear an offset position and return to the position 2 (field) X,Y position at any time by depressing the "Offset Clear" button and holding it until the station select light blinks. Scan around with the X (or Y if you are using the maximum magnification lens) stage buttons until you find an offset star. Set the offset position with the "X,Y set" button.

Once your positions are set, you should not have to change positions 1 or 2 during a night. However, you may want to change position 3 for each object if you are offset guiding. Once the positions are set, you should be able to switch between the positions by just turning the knob and the star should return to your marked positions. Remember, you are changing the position of the copy lens as well as the diagonal mirror and the two are slaved to one another.

The switches which move the X and Y stages of the copy lens control the speed of the move by the length of time which you hold down the switch. A quick flick of the switch will single step the stage. If you hold down the switch, the stage will start out moving slowly and will accelerate up to full speed if you continue to hold down the switch.

The position of the X and Y stages of the copy lens are displayed on both the RCP and ICP. The displays are in arbitrary steps. *Note that the RCP and ICP readouts will display different values!* There is a switch on the RCP which will turn off the display and leds so that it does not glow in the dome. If the display is not lit, check the status of this switch. Note also that the numbers on the display are not really meaningful nor necessarily reproducible!

3 Software

The detector for ES2 is run using the IRAF package icex. Included here are examples of the four parameters files necessary to run the instrument.

In these examples, it is assumed that the user is using the TI1 detector and is binning by a factor of two in the spatial direction.

The DETPARS file

```
    (firstcol = 1)             First column of data (device coordinates)
     (lastcol = 800)           Last column of data (device coordinates)
    (firstrow = 1)             First row of data (device coordinates)
     (lastrow = 800)           Last row of data (device coordinates)
      (colbin = 2)             Column binning factor
      (rowbin = 1)             Row binning factor
    (preflash = 0)             Preflash time in seconds
        (gain = 0)             Instrumental gain setting (0 for default)
     (detinfo = "")            Optional image header info about detector
      (detcap = "runlib$detcap") Detector capabilities file
     (detname = "ti1")         Detector name
      (detpix = "u")           Data type of detector pix (u=16-bit l=18-bit)
  (integrator = "1")           Detector integrator (1=slow 2=medium 3=fast)
   (amplifier = "1")           Detector amplifier
     (nframes = "")            IRDetector sum/average nframes
       (angle = 0)             Detector angle from nominal
     (regions = "")            Selected regions of the detector to readout
       (debug = no)            Debug the detector interface
        (mode = "ql")
```

For OBSPARS, parameters such as “exposuretime”, ”imagetype”, and ”objecttitle” will be filled in by whatever observe task the user is using. The filename is constructed of a concatenation of the “rootname” and “sequence”. The sequence number updates automatically with each image. The user may want to add things to parameters such as “observers”, “comments”, etc. “Command” is the command for post-processing. In this example, the data will be displayed at the end of the readout to buffer 1 of the image tool.

The OBSPARS file

```
 exposuretime =                Exposure time (seconds)
    imagetype =                Image type
  objecttitle =                Object title
       nfexpo = 7              Number of focus exposures
       shtype = "detector"     Shift type
      focmode = "manual"       Focus mode
       fstart =                Starting focus value
       fdelta = ""             Focus increment
      nrvrows = 25             Number of rows to reverse shift
    (rootname = "es2")         Image root name
```

```
   (sequence = 5907)           Sequence number
  (setfilters = no)            Query and set filters?
    (setfocus = no)            Query and set focus?
 (setscanrows = no)            Query and set nscanrows? (short scan mode)
     (filtype = "telescope")   Type of filters to use
     (foctype = "telescope")   Type of focus to use
     (pixtype = "u")           Data type of IRAF pixels
   (observers = "")            Observers
    (comments = "")            Comments
     (comfile = "")            Observer header comments file
     (obsinfo = "")            Optional observing information for image header
 (observatory = "MCDONALD")    Observatory name
     (command = "display %s 1") Postprocessing command
 (preallocate = 60)            Preallocate image (0=no 1=yes N=if exptime > N)
   (preprefix = "imdir$_")     Preallocate image prefix
    (longexpo = 300.)          Long exposure time (seconds)
     (verbose = yes)           Type out image name?
       (debug = no)
        (mode = "ql")
```

For INSTRPARS, the user must set "instrname" to "es2".

The INSTRPARS file

```
(instrfilters = "")            filter bolt positions
    (aperture = "")            aperture
      (tvfilt = "")            tv filter
    (complamp = "")            comparison lamp
    (probepos = "")            probe position file
   (disperser = "")            disperser
     (tiltpos = "")            tilt position
       (order = "")            spectral order (0 = most efficient)
      (decker = "")            decker
  (instrfocus = "")            instrument focus
    (posangle = "")            position angle
    (dispaxis = "")            dispersion axis
         (fts = "")            filter translation
    (filtoffs = "")            filter offset values
         (gts = "")            grism translation
(slitunitoffs = "")            slit unit focus offset values
   (polarizer = "")            polarizer angle in degrees
   (instrinfo = "")            Optional image header info about instrument
    (instrcap = "runlib$instrcap") Instrument capabilities file
   (instrname = "es2")         Instrument name
       (debug = no)            Debug the instrument interface
        (mode = "ql")
```

Most of the parameters in the TELPARS file are filled in automatically when an observe task is executed. The user must set the "telname" to "mcd82x".

The TELPARS file

```
     (dateobs = "")             date (dd/mm/yy) of observation
          (ut = "")             universal time (hh:mm:ss)
          (st = "")             sidereal time (hh:mm:ss)
          (ra = "")             right ascension (hh:mm:ss)
         (dec = "")             declination (dd:mm:ss)
       (epoch = "")             epoch of ra and dec
          (ha = "")             hour angle (hh:mm:ss)
          (zd = "")             zenith distance (dd:mm:ss)
     (airmass = "")             airmass
    (telfocus = "")             telescope focus
  (telfilters = "")             filter bolt positions
    (rotangle = "")             rotation angle
    (pressure = "")             barometer
     (teltemp = "")             telescope temperature
   (windspeed = "")             wind speed
(winddirectio = "")             wind direction
    (humidity = "")             humidity
      (seeing = "")             seeing
    (pointsrc = "")             point source info
    (pointdir = "")             optional point source directory info
   (pointtype = "mean")         point type header info
    (aperture = 2.1)            telescope aperture size (m)
  (focalratio = 13.5)           telescope focal ratio
      (tcscmd = "")             TCS motion command
     (telinfo = "")             Optional image header info about telescope
      (telcap = "runlib$telcap") Telescope capabilities file
     (telname = "mcd82x")       Telescope name
       (debug = no)             Debug the telescope interface
        (mode = "ql")
```