

ARC Small Aperture Telescope (ARCSAT) Observing Manual

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DISCLAIMER: I have produced this observing manual as a guide and checklist for a beginner user of the ARCSAT telescope, located at Apache Point Observatory. The manual is for the use of the SurveyCam instrument. If there is a need for specific instructions for the FlareCam instrument, I will include it in later versions of this manual. It is assumed that the ARCSAT observer has some experience with remote observing and has been checked out by the 3.5m observation specialist. It is also assumed the observer understands and knows the basics of data acquisition for photometry. It is not the responsibility of the observation specialist to instruct the user during their observing run. Each observing run is unique to the scientific program, and it is the responsibility of the observer to design and execute their program in an efficient manner. Please also take special note of the **Warning!!** messages in this manual. Do not disregard them.

Please visually inspect your data throughout your observing run. Ultimately, it is your data and your science. You will get out of it what you put into it.

A big thanks to all the observation specialists who reviewed and provided suggestions to improve this document -- Russet McMillan, Jack Dembicky, Candace Gray, and Ted Rudyk. A giant thanks to our Chief Engineer, Bill Ketzeback, for spearheading this document. We all hope this manual will be useful for you.

If you have any questions or suggestions for this manual, feel free to contact me:
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ARCSAT Observing Manual

Hello Observer! You have been granted time to use the Astrophysical Research Consortium Small Aperture Telescope (ARCSAT) 0.5m at Apache Point Observatory (APO). You should have your institutional ID (AS##) and all the relevant passwords to log in to perform your remote observing. If you do not have the passwords, call your institutional scheduler first and only if you can not reach them, call APO and ask for one of the 3.5m observing specialists (“obs-specs”), and they will provide you, over the phone, your passwords. Due to security reasons, no password will be emailed to you or sent via the 3.5m TUI chat window. Please do this in advance of your observing run and not the night of your run.

The ARCSAT passwords you will need:

Action	Type of password
arc-gateway tunneling password	Per institution (changes quarterly)
Chrome ACP password	AS## password
TUI password	AS## password

You need to be able to run TUI on a Linux/Mac or Windows platform computer and you must use Chrome as your web browser for the ACP software. Make sure the computer from which you are remote observing can run all the related software and successfully connect to the APO systems well before the start of your run. If not, talk to your local IT first, and then contact the obs-specs for any additional guidance on this matter.

This manual is organized to be observer friendly and more or less goes through the steps you need to perform to get going during your run.

Before you begin:

1. Tunneling and Login

You must be able to tunnel into APO to access the telescope control software, which is behind our firewall.

A. Linux/MacOS Login

Log in via the command:

ssh -L 1234:arcusat-user.apo.nmsu.edu:80 youraccount@arc-gateway.apo.nmsu.edu

where “youraccount” is the generic institutional account name. For example, for an observer from NMSU, the account name is “nmsuobserver”. If you do not know the account name, ask the obs-spec on duty and s/he will tell you what your institutional account name is. Once you have tunneled in, open Chrome and direct the browser to (see Figure 1):

<http://localhost:1234>

Please check before your run if you can connect securely. If not, talk to your local IT support, and then consult the APO staff for additional guidance.

**** NB:** If you are physically at APO to observe, then you do not have to tunnel in. Open the Chrome browser and point it to arcusat.apo.nmsu.edu. You will get an authentication window where your Username is your institutional ID.

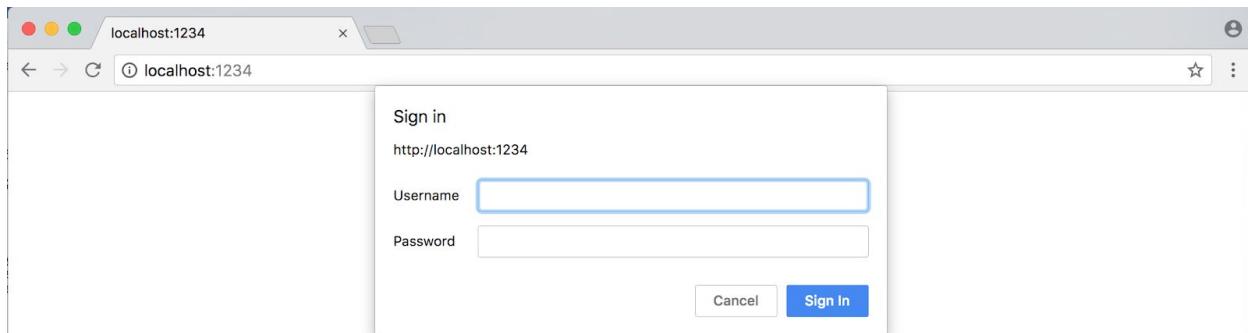


Figure 1. Login query for ACP in the Chrome browser.

B. Windows Log-in

If you are using a Windows platform, here are the instructions for login:

You must have PuTTY¹ installed on your machine and running when you log in. In the PuTTY program, under Category column, expand "Connection", then "SSH", and then "Tunnels". Source Port 1234 (the same number you use for the localhost in Chrome).

Set your destination to

arcusat-user:80

¹ <https://www.putty.org>

Check Local and Auto, but uncheck all other options. See figure 2.

Click the Add button (see figure 3)

Under Category, select "Session" (see figure 4). Enter the hostname, where "youraccount" is the institutional username:

youraccount@arc-gateway.apo.nmsu.edu

Set Port to 22.

Set Connection Type to SSH

Save Sessions Enter to something convenient, like "ARC Gateway - ARCSAT". Click SAVE!

Start a Tunnel session by clicking on the Open button. Then you can proceed with opening Chrome as in the instructions for Linux/MacOS in the previous section.

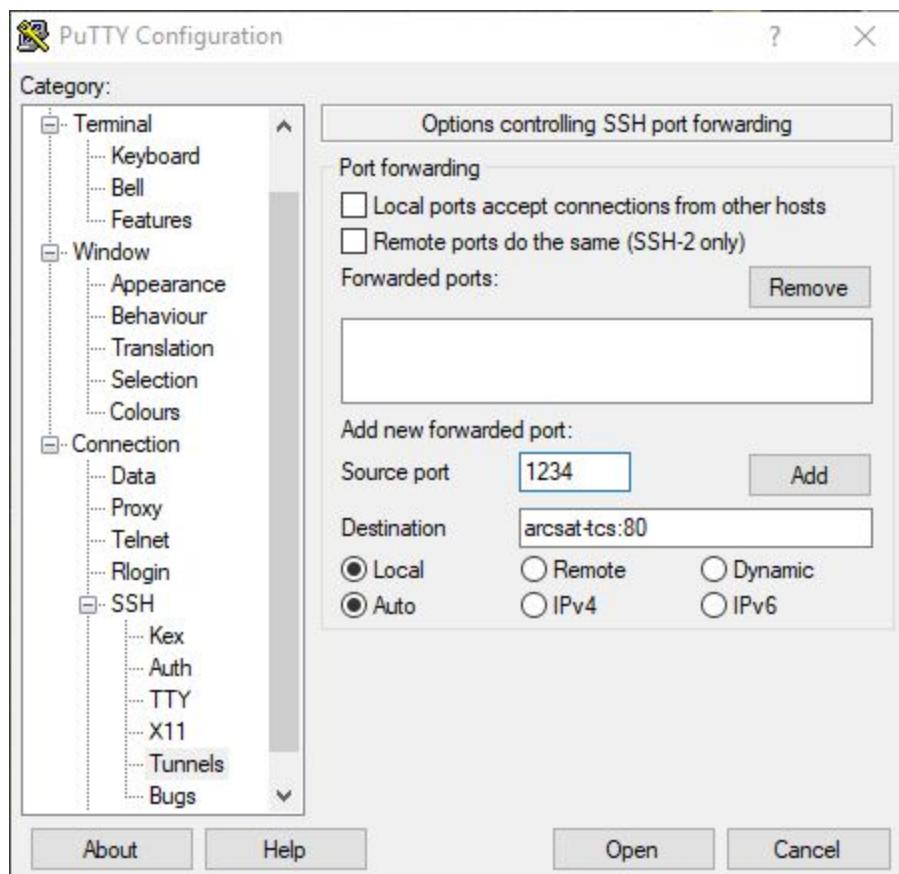


Figure 2. How to setup the SSH tunnel to the ARCSAT TCS in the Windows platform.

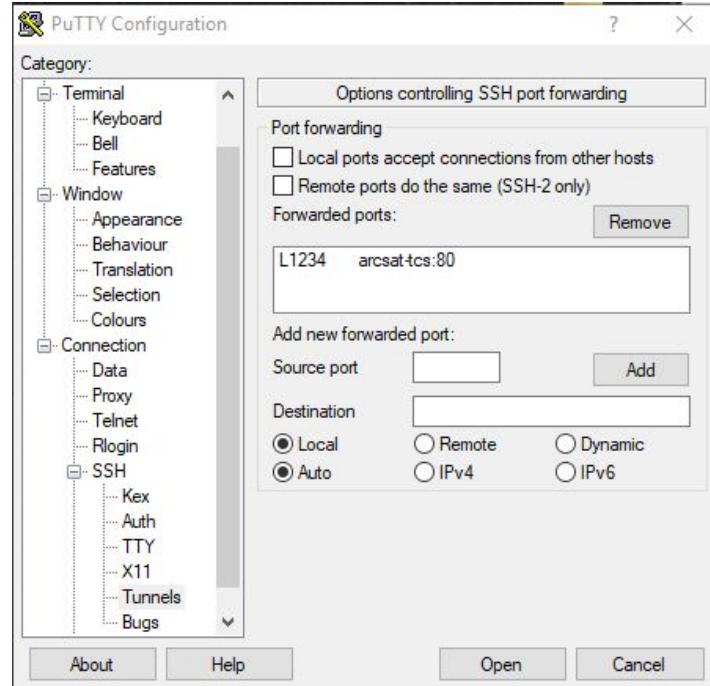


Figure 3. How to ADD the ARCSAT port in PuTTY

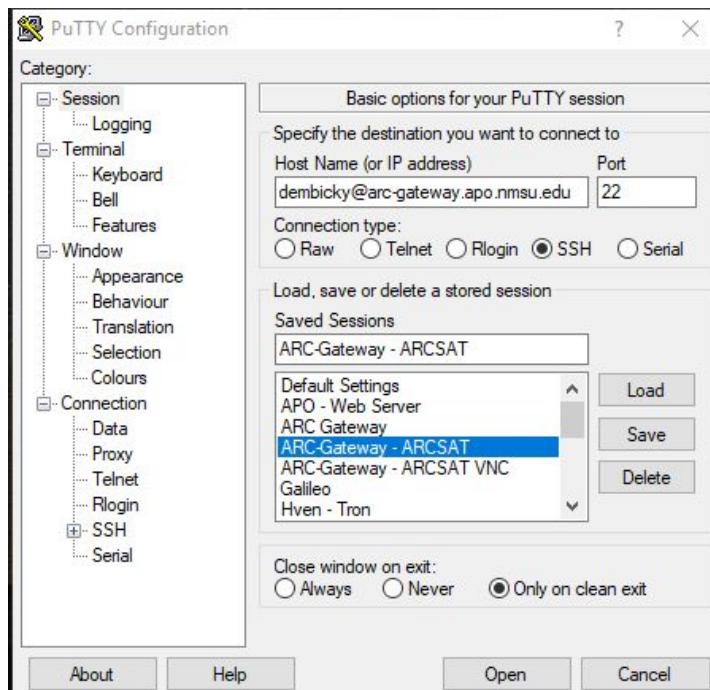


Figure 4. How to save your ARCSAT session setup in PuTTY.

2. Observing Support: TUI

You will have support during your observing run via the 3.5m obs-spec, who is primarily in charge of running the 3.5m ARC telescope. Please keep in mind that their FIRST PRIORITY is the 3.5m, and if they are busy, they may ask you to wait.

To communicate with the obs-spec, you will need to download and set up a piece of software called *Telescope User Interface*, or known as “TUI”. To obtain this piece of software, please go to the 3.5m website². The instructions for installation are provided on this website.

Log into TUI using your institutional ID (e.g., AS##) and the associated password. The only TUI window you will need will be the instant messenger window. To open this window, click on the drop down TUI menu “Misc”. The second option, “Message”, is the one you want. See Figure 5 for the message window example. You can close any of the 3.5m related windows that open when you log into TUI.

Warning!! You must keep the TUI message window open at all times while observing with ARCSAT. This is the primary mode of communication between the Obs-spec and ARCSAT user. If the Obs-spec needs to get your attention for some reason (ie. weather or other issue) the TUI message window is the only way for them to communicate with you.

Keep in mind that other observers on the 3.5m also use this message window, and this is **not** a private link between you and the obs-spec. Please use civil internet etiquette, otherwise, you may be banned from using ARCSAT.

² https://www.apo.nmsu.edu/35m_operations/TUI/ or https://www.apo.nmsu.edu/35m_operations/TUI-images/



Figure 5. Message window in TUI. The lower box is where you type your message. <Return> will enter your comment into the chat window.

3. Weather and Closure Information

As a remote observer, you must pay attention to the weather at APO. If you notice your stars get fuzzier, the seeing has possibly worsened. If you notice a dimming of your images, clouds may have appeared. Consult with the 3.5m obs-spec, and they can give you a quick report of the site conditions.

APO provides some resources for you about the local weather. Check both the “Current APO Weather” and “IR All-Sky Camera Image” links off of the main APO website³. Additionally, in the telescope control software, there are links to get weather information (see the next section for more details). The *Current APO Weather* page gives you the forecast for the Sacramento Mountains and nearby areas, as well as a satellite look of the Four Corners region of the American Southwest. There is a link to the *Clear Sky Clock* website as well.

The *IR All-Sky Camera* displays images of the local sky with a fisheye lens camera on site, which shows the cloud coverage (see Figure 6). In the Sacramento mountains, we experience “orographic clouds”, which are clouds that spontaneously form in the mountain ranges. These clouds are not necessarily picked up by the larger satellite view since these are microclouds forming in an isolated region. Note that the clouds you see here can be thick or thin - both look the same with the scaling we have set with this camera. Check with the on-site obs-spec about cloud conditions as well.

ARCSAT is interlocked to close with the 2.5m or 3.5m telescopes at APO. If one of these telescopes close, then that triggers the closing protocol of ARCSAT. You can see what the

³ <https://www.apo.nmsu.edu/>

current weather conditions and the telescope status on the APO Weather Status page⁴. If you notice in the operations software, ACP (described in the next section), shows that the telescope is closing, or in the APO Weather Status page that ARCSAT is "N/A", contact the 3.5m obs-spec through TUI to confirm the telescope status and closure. They will inform you of the reason why ARCSAT is closing. If you notice anything amiss or unexpected behavior with ARCSAT, notify the obs-specs through TUI. ARCSAT also has its own weather sensors and may close automatically if these sensors warrant.

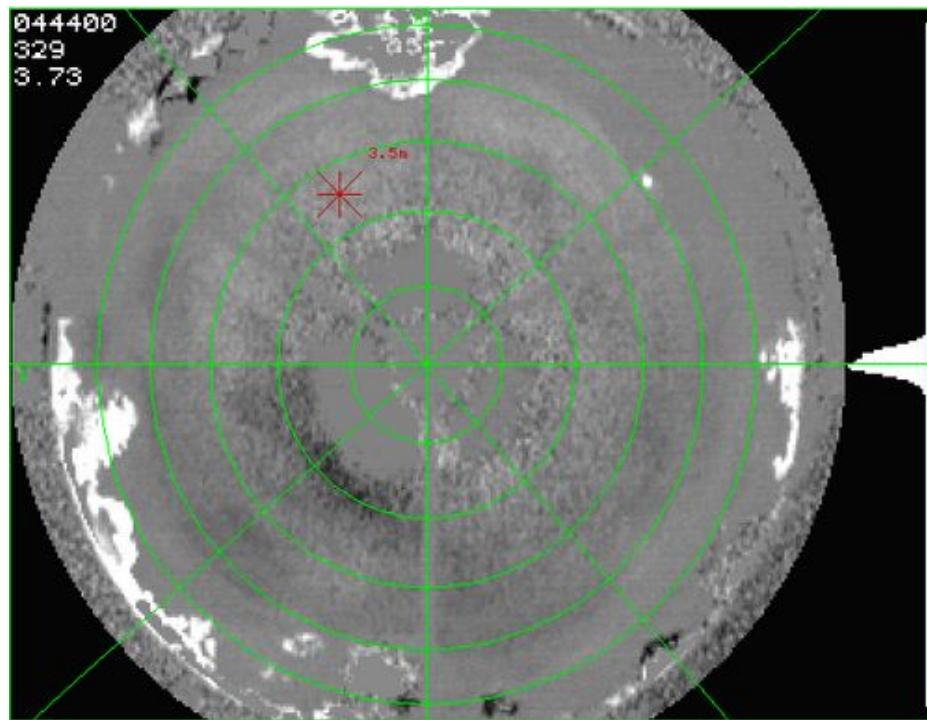
However, the obs-specs can authorize an override and allow you to continue observing -- within reason and depending on the local conditions. For example, when both the 2.5m and 3.5m telescopes are closed, you may not have remote access to the telescope shutter. In that case, the obs-specs can issue a bypass override, if they deem it is safe to operate the telescope. Another example would be if both the 2.5m and 3.5m telescope have closed in the morning, but you want to continue on to take morning twilight flats. The obs-spec will then issue the bypass to allow the user to continue using ARCSAT for the morning flat fields.

Warning!! If the ARCSAT dome closes due to weather reasons, the system will not allow the dome to be reopened for **10 minutes**, even if the bypass is being used. Please wait these 10 minutes by getting a beverage.

The 3.5m obs-spec is the **final arbiter** of opening/closing decisions, and their decision must be respected.

Check Appendix B for more weather resources to help you during your observing run.

⁴ <http://weather.apo.nmsu.edu/cgi-bin/weather.py>



IRSC image from 2018/09/11 04:44 UT, on MJD 58372



An alternate scaled view of the above timestamped image.

Figure 6. The IR All-Sky Camera fisheye image. On this night, the skies appear to be clear.

4. ACP Software

In Chrome, you should have a screen that looks like what is presented in Figure 7. Take a look at the “Recent Changes” under the welcome block. This has an updated list of changes done with the ACP software to run the ARCSAT telescope. This is shown in Figure 7b.



Figure 7. ACP login window.

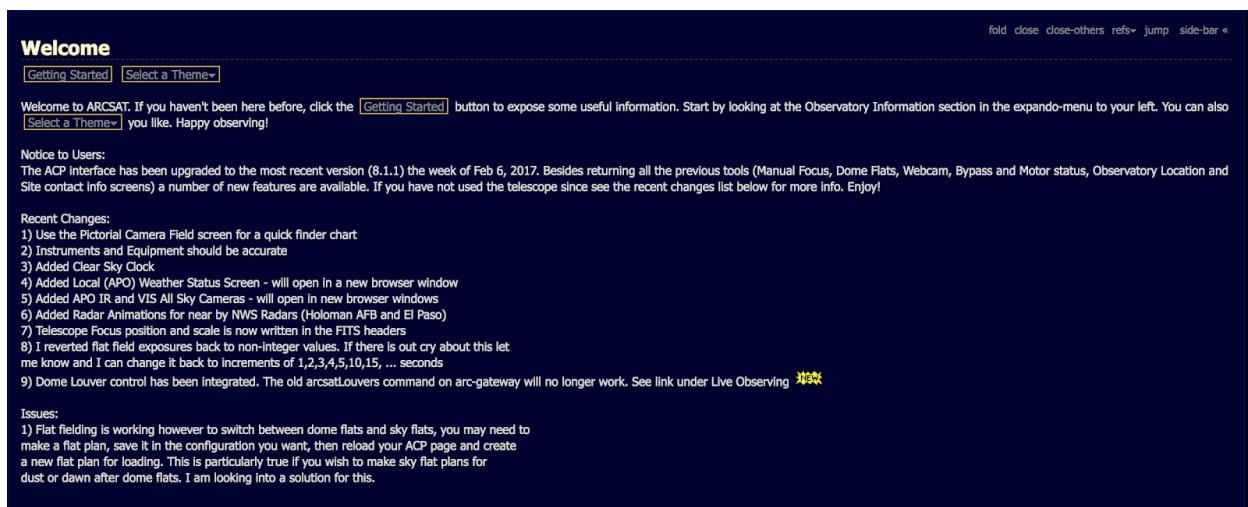


Figure 7b. ACP latest information. Read this before you begin.

Note on the left side you have drop down menus that give you a variety of tools for data acquisition, telescope and observatory information, and astronomical observing tools. One of the useful task to open before you start anything is the Dusk/Dawn information. You should be able to determine how much time you have to do your early evening calibrations and prep work. Figure 8 shows you the window block that opens when you click on the Dusk/Dawn information in the drop down menu on the left side of the ACP window.

Also under Observatory Info are links to various weather resources, as mentioned in the previous section. You can open those links to help you monitor the weather and get an idea of the site conditions.

ARCSAT

Welcome AS06

Live Observing

Scheduled

My Documents

Shared Files

Observatory Info

- System Status Display
- Pictorial Camera Field
- Instruments & Equipment
- Telescope Webcam
- Bypass Status
- Motor Status
- Observatory Location
- Clear Sky Clock
- Local Weather
- IR All Sky Camera
- VIS All Sky Camera
- Radar Animation
- Dawn-Dusk Times
- Contact Info
- RSS Events Feed

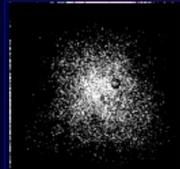
Help Resources

Toolbox

System Status

Help Hover the mouse over the links to see what they do

Observatory		Telescope		Imager		Activity		Plan	
Ready	(closed)	Stopped	Idle	Idle	FWHM	-/-	Set	-/-	
Local:	18:31:12	HA:	00:01.4	Filter	B		Target	n/a (-/-)	
UTC:	00:31:11	RA:	14:24:35.45	Binning	2:1		Repeat	-/-	
LST:	14:25:56	Dec:	74°25'34.7"	Cooler	-26°C/65%		Filter	n/a (-/-)	
Owner	Free	Az:	359.87°				Count	-/-	
Weather	9kt	Alt:	48.35°						
Shutter	Closed	Air:	1.337						
Dome	Home	Focus:	6187						



Show/Hide Run Log and Abort Control

Dawn-Dusk Times

It's 8/5/2018, 6:30:16 PM

Here are today's sunset and tomorrow's sunrise times for ARCSAT

Dusk		Dawn	
Sunset is	Sun Aug 5 19:57:19 MDT 2018	Mon Aug 6 06:19:22 MDT 2018	is Sunrise
Civil twilight ends	Sun Aug 5 20:23:55 MDT 2018	Mon Aug 6 05:52:45 MDT 2018	begins Civil twilight
Nautical twilight ends	Sun Aug 5 20:55:53 MDT 2018	Mon Aug 6 05:20:47 MDT 2018	begins Nautical twilight
Amateur twilight ends	Sun Aug 5 21:12:27 MDT 2018	Mon Aug 6 05:04:13 MDT 2018	begins Amateur twilight
Astronomical twilight ends	Sun Aug 5 21:29:32 MDT 2018	Mon Aug 6 04:47:09 MDT 2018	begins Astronomical twilight

Contributed by Dick Berg, author of the [ACP Reference Guide](#)
Computational improvements by Robert Wahlgren and Erik Young

Figure 8. On the left are the ACP drop down menus. “Observatory Info” has been opened. If you click on “Dawn-Dusk Times”, the following window block opens in your ACP session.

Next check the temperature of the SurveyCam (the last item under “Imager”- 3rd column of information in “System Status”). Be sure to set it to something reasonable, depending on the season. In the summer, the cooler has to work extra hard to cool the camera and puts stress on the system. The cooler load should not be above 75%. If it is, use a warmer temperature and gradually move up to the desired temperature. It is recommended in the summer to set the camera to -20 to -25°C, and in cooler weather, -30 or -35°C is sufficient. When you set the cooler temperature, it can take about 5-10 minutes to reach the desired temperature. Please watch the temperature value in the "System Status" window. See Figure 9 for this window interface.

If you are using FlareCam, please set the cooler to -25°C for your observing run.

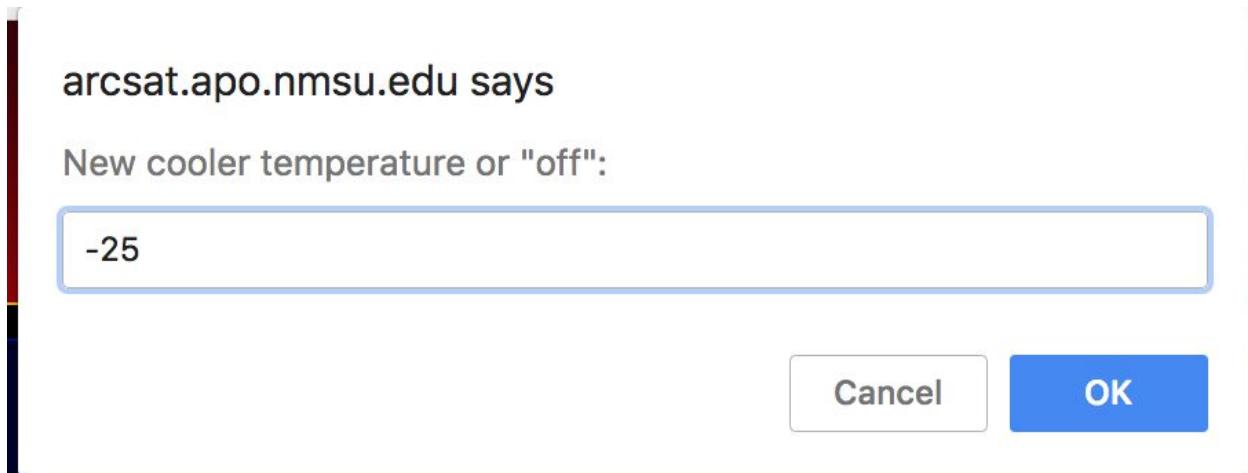


Figure 9. When you click on the "cooler", this window opens where you can input the desired camera temperature. Watch in the "System Status" window to obtain the temperature value of the camera.

Any item in the System Status window in orange is a clickable item you can activate. For example, the “Cooler”, “Shutter”, and “Dome” are all active options for you. As mentioned earlier, the Cooler controls the camera temperature, the Shutter is the dome slit (options are “open” or “close”), and Dome will allow you to put the dome to a home/stow position or have it follow the telescope (when observing).

Another function you may consider doing at this point is open the dome louvers to help thermalize the telescope to ambient temperature. If there is high wind, dust, high humidity, or blowing snow, do not open the louvers. You may have to ask the obs-specs for the local conditions. To open the louvers, click on the “Dome Louvers” under “Live Observing”, and it will open a window, as shown in Figure 10. There is a known bug in ACP that the status of the louvers in the System Status window block reports the incorrect status of the louvers. If you want to make sure, just open the “Dome Louvers” window and check the status of the louvers.



Figure 10. How to open the dome louvers and check their status.

5. Taking calibrations

If the camera is cooled to the correct temperature, you may begin taking your calibrations. If you take calibrations when the camera is too warm, you may end up seeing 2-D structures or other anomalies that the rest of your science images will not have (assuming your science images were taken at the correct cooler temperature!).

To start your bias and dark calibrations, go to the drop down menu “Live Observing” and click on “Cal Frames (Dark/Bias)”. It will open the following window (see Figure 11). For biases, set the “Duration” (or exposure time) to 0. “Count” refers to how many images you want to take. Generally, take something like 5-10 biases at the start of the night.

It is highly recommended you take dark frames since the SurveyCam is a thermoelectrically cooled camera, and it is quite sensitive to ambient temperature. Take an odd number of darks (3-5 images) and be sure to make them as long as your longest science exposure. If you are using IRAF to reduce your data, there is a feature to automatically account for exposure time scaling, so if you take a bunch of images at 5 minutes, but a handful at 10 minutes, then you must take 600 second darks to account for the accumulated thermal noise. You will then apply your 600s dark to all your science images regardless of the exposure times.

You can also require that the camera temperature be held at a specific temperature while you are taking your darks. Taking darks in variable temperatures will worsen the quality of your final reduced data.

Be sure to click the “Use” boxes to the left of each entry to activate it.

Note: The plate scale is shown for 1x1 binning.

SurveyCam: 1x1 binning has a readout time of 22 seconds.

2x2 binning has a readout time of 11 seconds

FlareCam: 1x1 binning is sub-second readout time.

2x2 binning has about 1-second readout time.

!! Be sure you set the correct binning for all your calibration and science images. If they do not match, you will have trouble reducing your data!



fold close close-others refs[▼] jump side-bar «

Calibration Frames

[Help](#)

Use this to acquire dark and bias calibration frames. To request a [bias frame](#), simply set the exposure duration to zero. The system will automatically recognize that as a request for a bias frame.

Use Count Duration Binning

<input checked="" type="checkbox"/>	10	0	2
<input checked="" type="checkbox"/>	3	900	2

[More](#)

Require cooler temp deg C

[Acquire Cal Frames](#)

Run started successfully. See [System Status](#) for ongoing info. You can close this item now.
Here is the [observing plan](#) that was just sent to ACP:

```
#chill -25
#count 10,3
#interval 0,900
#binning 2,2
#dark ; 0-exposure frames are bias frames
```

Figure 11. Calibration setup.

If you want additional calibration frames, like darks, click on the button that says “More” and enter the relevant information. Click on “Acquire Cal Frames” button, and the system will begin to take your bias and dark frames. The gray output that appears in this window block, after you start the calibrations, shows you the ACP language for a script. Confirm that it makes sense. See Appendix C for more details on ACP scripts.

Look at the running log in ACP of all your actions. To open log, under “System Status” information, there is a button that says “Show/Hide Run Log and Abort Control” (see Figure 12). Click on that and it will expand to a window with all the operational telemetry of your actions. If you don’t see the log window opening, try opening it from the “Observatory Info” drop down menu on the left hand side of ACP and clicking on “System Status Disp”.

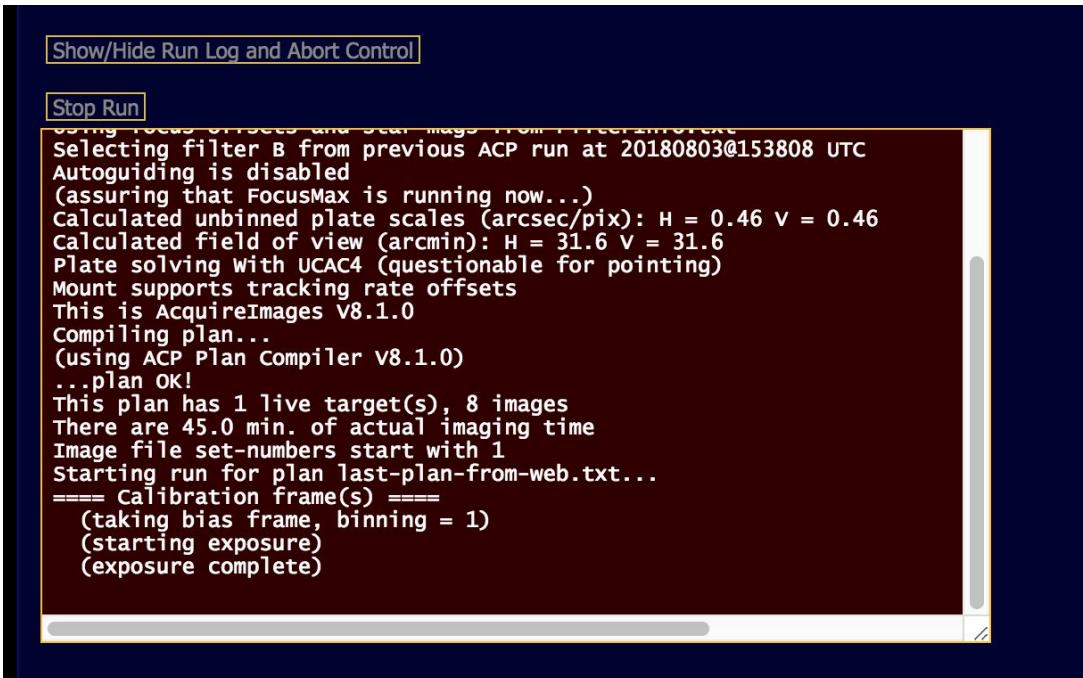


Figure 12. ACP log window with telemetry. Note the "Stop Run" button underneath the "Show/Hide Run Log and Abort Control" button. See section 8 about the "Stop Run" button action.

6. Taking flat fields

You should do your sky flats near sunset to get enough flux to get well-illuminated flat field images of blank, unfocused sky. Check the sky conditions with your obs-spec. Do not take sky flats if there are clouds of any kind - clouds are not uniform sources of light. You may want to take a set of dome flats in that case. If you want to build a robust flat field for your data reduction processing, take both sky and dome flats. Flats are good for 1-2 days after you have taken them. Dust can always move around (those out-of-focus donut shadows), so the flat field patterns can change on a nightly basis.

Always take an odd number of flat fields (3-5 images, for example), per filter you are using. This is due to the nature of the combining algorithm (either median or average combine, in the IRAF parlance). If you are using multiple filters for your science objectives, then be sure to take flats in each filter. If you can't get all the sky flats during evening twilight, try to get them at morning twilight. Dome flats can be taken at any time (with the dome louvers and shutter closed). If you are taking dome flats while the Sun is still up, **do not open** the louvers as they will let in a large amount of sunlight. If the louvers were open for thermalization, please close the louvers for dome flats during the day.

When you are ready to take your flat fields, contact your 3.5m obs-spec with the TUI messenger window and notify them of what you are going to do. They will need to turn the

motor drives on the telescope (it has to slew to the slit or the white circle) for you to start the flat field sequence.

If you are taking **sky flats**:

Does “Live Observing” drop down menu say “Standard Sky Flats”? If not, here’s how to change it.

- Click on “Setup Flat Fields”. See Figure 13.
- Set up how many and which filters you want for your sky flats. For evening sky flats order your filters bluest to reddest. Don’t worry about exposure times. ACP will auto figure out what is the best exposure time based on the optimal 20000 flux counts.
- Save the “Use Sky Flat config” by clicking on that button.
- Save your Flat Field plan by clicking on the “Save Flat Plan” button!
- Refresh your Chrome browser. Does it say “Standard Sky Flats” under “Live Observing”?

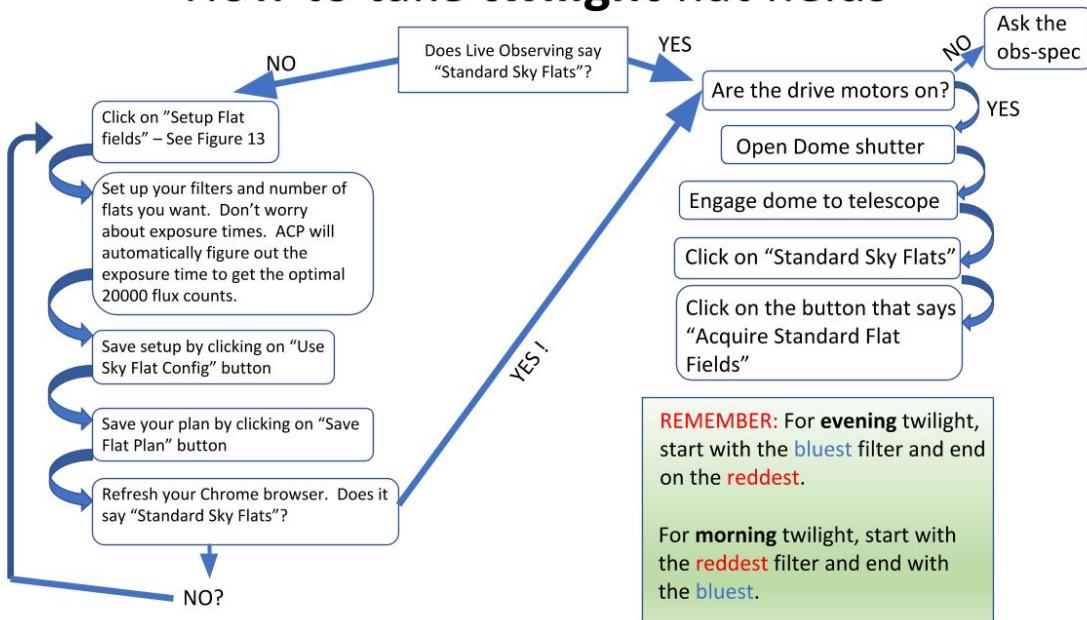
If it still does **not** show “Standard Sky Flats”:

Repeat the process, refresh Chrome, and see if the correct flavor of flat field appears listed under “Live Observing”.

If **yes**, it does show the correct flavor of flat field, then:

- Ask the obs-spec if the drive motors are on. Wait until they confirm.
- Open dome shutter.
- Engage the dome to follow the telescope.
- Click on “Standard Sky Flats”.
- Click on the button that says “Acquire Standard Flat Fields”. You are now taking your sky flats.

How to take twilight flat fields



If you are taking **dome flats**:

Does the “Live Observing” drop down menu say “Standard Screen Flats”? If not, here how to change it:

- Click on “Setup Flat Fields. See Figure 13.
- Set up how many and which filters you want for your dome flats. Don’t worry about exposure times. ACP will auto figure out the best exposure times based on the optimal 20000 flux counts.
- Save the “Use Dome Flat config” by clicking on that button.
- Save your Flat Field plan by clicking on the “Save Flat Plan” button!
- Refresh your Chrome browser. Does it say “Standard Sky Flats” under “Live Observing”?

If it still does **not** show “Standard Screen Flats”

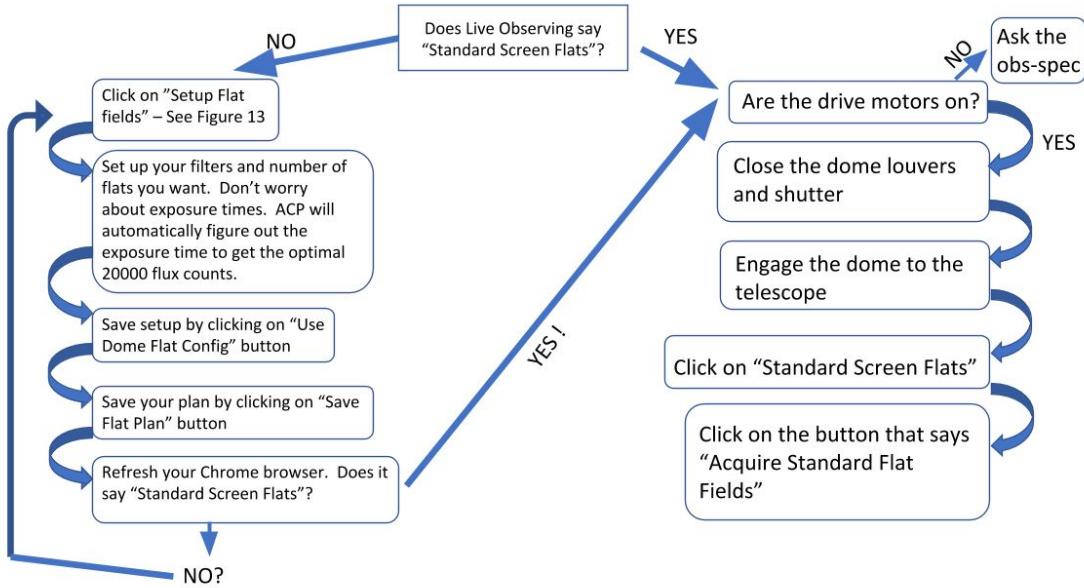
Repeat the process, refresh Chrome, and see if the correct flavor of flat field appears listed under “Live Observing”.

If **yes**, it does show the correct flavor of flat field, then:

- Ask the obs-spec to turn on drive motors. Wait until they confirm.
- Check if the dome shutter and louvers are closed.
- Engage the dome to follow the telescope.

- Click on “Standard Screen Flats”. You will get the following window (see Figure #).
- Click on the button that says “Acquire Standard Flat Fields”. You are now taking your dome flats!

How to take dome flat fields



ACP will automatically dither the telescope position for twilight sky flats. This movement will ensure any stars accidentally appearing in your flat field images will be averaged out when you combine all your flat fields. This is another reason to take an odd number of flat fields. At any other observatory, you, the observer must dither the telescope. Stars will inevitably fall in your twilight sky flats, especially if you take them past twilight and into darker skies.

FOR SANITY: Open the TelescopeWebcam Viewer. Is the telescope pointed to the correct thing? For dome flats, it should be pointing at the round, white screen (Figure 14). For sky flats, the telescope should be pointed out the slit (Figure 15). If not, consult with the 3.5m obs-spec. The telescope may be lost in space. Check the timestamp to make sure your image is recent; refresh if not, or report to the obs-spec if it's not updating.

fold close close-others refs▼ jump side-bar «

Standard Flat Fields

Acquire automatic flat fields using a previously saved standard flat plan. You can set up standard flats using the **Setup Standard Flat Fields** item.

This will start immediately and use the light panel/screen to acquire the flats. If needed, the dome/roof will be closed while this runs, and if it was open it will be re-opened afterward.

[Acquire Standard Flat Fields](#)

Setup Standard Flat Fields

Set up the standard flats to be taken when the Dusk Flats and/or Dawn Flats checkboxes are used in the **Single Object Color Series** form. The standard flats are also used by the **Standard Flat Fields** item.

Use	Count	Filter	Binning
<input checked="" type="checkbox"/>	3	B	2
<input checked="" type="checkbox"/>	3	V	2
<input checked="" type="checkbox"/>	3	I	2

[More](#)

[Save Flat Plan](#) [Use Dome Flat Config](#) [Use Sky Flat Config](#)

Figure 13. How to set up your flat field plans



Figure 14. Webcam of the telescope. The lamp is illuminating the flat field screen for dome flats. As it should be.



Figure 15. ACP webcam image of the telescope during twilight flat acquisition.

For reference, the "System Status" will tell you what kind of flat fields it will be taking (see Figure 16). Make sure the item under the fifth column, "Target" says the correct type of flat field is being acquired by ACP. If not, stop the script with the "Stop Run" button and correct your flat field set, save the plan, and refresh your Chrome browser.

The screenshot shows the ACP System Status window. On the left, there are several menu items under 'Live Observing', 'Scheduled', 'My Documents', and 'Shared Files'. The main area is titled 'System Status' and contains a 'Help' link. Below it is a table with five columns: Observatory, Telescope, Imager, Activity, and Standard Flats. The 'Imager' column is highlighted with a yellow background. The 'Activity' column shows 'Wait for Dawn'. The 'Standard Flats' column shows 'Target: Dawn Flats' and 'Repeat: 1/1'. The 'Imager' table shows the following data:

Observatory	Telescope	Imager	Activity	Standard Flats
In use	Slew 39.3°	(Short Exposures)	Wait for Dawn	Set: /
Local: 05:21:07	HA: 02:02.6	Filter: V	FWHM: 1.5	Target: Dawn Flats
UTC: 11:21:06	RA: 23:15:01.33	Binning: 1:1		Repeat: 1/1
LST: 01:17:37	Dec: 24° 33' 31.6"	Cooler: -30°C/52%		Filter: V (1/1)
Owner: AS06	Az: 260.90°			Count: 1/3
Weather: Clear 4kt	Shutter: Open			
	Dome: Slave			
	Louvers: CLOSED			

Below the table is a 'Show/Hide Run Log and Abort Control' button. The 'Standard Flat Fields' section contains a note about acquiring flat fields using a saved plan, a link to the 'Flat Analyzer' tool, and a note that the process will start immediately. It also has a 'Acquire Standard Flat Fields' button.

Figure 16. ACP System Status information as it is taking morning twilight flats. Note in the 5th column of information, ACP will always tell you what kind of flat field it is acquiring.

7. Telescope and Dome commands

In the “System Status” window, any of the orange labels are clickable. When you want to start your science and it is safe to open the dome, ask the 3.5m obs-spec if ARCSAT is ready for science observations.

Click on the item “Shutter”. It should activate and open the dome slit. When the dome slit has fully opened, the item will read “Shutter Open”. You may have already opened the shutter for twilight sky flats. When the shutter is opening, you will notice the “Status” will be flashing while the command is being executed.

Next, click on “Dome”. This will connect the dome movements with the telescope, or “engage the dome to the telescope”. This item should read “Dome Engaged”.

For better thermalization of the dome, you may want to open the wall louvers. To do this, click on “Dome Louvers” under “Live Observing”. Figure 10 shows you what that window looks like. Be sure to activate the refresh because it does take some time to execute the command. Check the “STATUS” for the louvers to be either “OPEN” or “CLOSED”. In the System Status window block, sometimes, but not always, the Louvers status reports incorrectly. If you are not sure, just check with the “Dome Louvers” window block and ask the 3.5m obs-spec if the louvers are indeed open/closed. You can also check the status of the louvers on the APO Weather Status⁵ page, which reports the louver status correctly.

Warning!! if you are taking dome flats during the day, keep the louvers closed!

⁵ <http://weather.apo.nmsu.edu/cgi-bin/weather.py>

For the telescope, keep in mind the lowest observing limit is 27 degrees above horizon or an airmass of 2.2. At an airmass of 2.1, you might experience some eclipsing due to the shutter door being in the way. Don't try to chase your target as it is setting! Please try to observe your targets above this limit (airmass between 1.0 and 2.0). ACP will automatically abort any exposure once the telescope reaches an airmass of 2.2.

8. Science observations

Depending on your science objectives, you will want to start sometime between nautical (12 degree) and astronomical (18 degree) twilight. Check the Dawn/Dusk astronomer tool under Observatory Info in ACP. **Warning!! ACP will not let you start science observations until after nautical twilight, even in bypass mode.**

A. Pointing and Focusing

Warning!! Do this on the first night of your run or if the ARCSAT computers crash during your run. It is your sanity check that the telescope is pointing at your targets.

First, you must check if your pointing is good. The obs-spec may help you with this task if they are not busy. If they are busy, point the telescope to a 4th-5th magnitude star (use Hoffleit's Bright Star Catalog) or an obvious object, like a globular cluster or nebula in the Messier catalog. Take a 3-5 second exposure using the single image tool in Live Observing, and see if the object appears near the center of the thumbnail image in the "System Status" block. Don't pick a very bright star, like Sirius, or you run the risk of burning it into the CCD chip and then you will have to deal with the persistence of that image for a while. You may also consider using a narrow band filter, like H_alpha, to do this to further protect the CCD chip.

Alternatively, if you have a finding chart (from SIMBAD's Aladin feature), slew to your field. Watch the status output log and look for failures with the ACP PLATE SOLVE routine. If the PLATE SOLVE routine fails, let the obs-spec know, and they can check if the pointing is really off.

In the case of a system crash, if you have kept track of your target's hour angle and declination, let the obs-spec know. Recovery from a crash may be quicker if you have this information.

Focusing can be an automated process and is an option when taking data in either single object or multi-object mode. When you set the autofocus on, the whole procedure will take between 1-3 minutes. The telescope will slew to a nearby 6th magnitude star and perform a focusing routine, calculating the half-flux diameter (HFD). Once ACP has determined the best focus value, it will slew back to your target field, recheck the pointing, and will then be ready to take science images. Always **examine the final image**, in case the autofocus routine fails for some reason, as it does happen.

If you opt to do Manual Focusing (an option under “Live Observing”), you can input how many focus steps to fine tune the current focus value. The focus value can be found in the System Status window block, under Telescope. With manual focusing, you can either use an absolute step number or apply an offset in step units. Try to keep your stars point-like and less like oblong blobs.

- If you see the out-of-focus star is a horizontal blob, try bumping the focus up 2-5 steps.
- If you see the out-of-focus star is a vertical blob, try bumping the focus down by 2-5 steps.
- Again, [examine the final image](#).

As a final note on focusing, you can use autofocus to get you close to the best focus, and then you can switch to manual focus to tweak it up. Depending on the nature of your observations, all of these methods should help and keep the telescope focused for your data.

B. Guiding

Guiding is still in the beta test stage and we are still working some of the bugs of the system. Consider guiding currently as Shared Risk, but available for you to try. It is relatively easy for the observing specialists to turn it on/off if problems arise.

First request

C. Single exposure of one target

Under “Live Observing”, click on “Single Image” (see Figure 17). Input your J2000.0 coordinates into the appropriate boxes. Be sure to give your target name something easy to remember and type (it will form the name of the filename, so avoid spaces). Enter your exposure time in seconds, select your filter, and finally, select your binning. If you want to automatically refocus your field, click on the Autofocus option. It will take a few minutes to find the optimal focus before the exposure begins. If you are in a time crunch, you can turn off the Autofocus function, however, you may want to check your focus periodically through the night, especially under variable weather. Focus should remain good (if the skies are stable) for up to 1-1.5 hours.

Once everything is set up, click on the “Acquire Image” button. Watch the log window to make sure the focus is happening (if autofocus is selected), and especially watch the log for any problem. The log will list what error occurred. You may want to report what errors you get throughout the night in the night log and possibly to the obs-spec.

Target Name:	CVn-I	Get Coordinates or Ephemeris
Right Asc. (hrs):		Deep Sky Catalog Search
Declination (deg):		<i>(coordinates in J2000)</i>
Duration (sec):		Filter: halpha Binning: 1
<input type="checkbox"/> Auto focus before imaging <input type="checkbox"/> Auto calibrate		
<input type="button" value="Acquire Image"/>		

Figure 17. Input window block for Single Object Observing. Add in the J2000.0 coordinates in RA and DEC fields, and your desired exposure time under "Duration". Remember to use the correct filter and bin size before executing. Be sure to activate the Auto Focus. Use Auto Calibrate at your own risk (performs bias and dark subtraction automatically).

D. Single object imaging: Color Series

This option allows you to observe one target, but in multiple filters. Figure 18 shows you an example of multi-filter observing of a single target. Enter the J2000.0 equatorial coordinates. Count refers to how many exposures in each filter you want. Duration is the exposure time in seconds. You can also activate the autofocus, either at the start of the image or over a periodic timed interval. If you have a larger target that does not fit in the FOV, you may want to move the telescope around, or "dither". You can set the dither amount under this window block (see Figure 18). A note on 'dithering': ACP randomly moves the telescope around within a specified number of pixels and direction while dithering. See appendix E '#DITHER' for more details.

I do not recommend taking dome flats at this point, so DO NOT click on "Standard screen flats (at end)". It will just take away from your science time. Flat fields are generally taken at the beginning or end of the night. The sensitivity of the chip should not vary throughout the night. In Figure 18, I've queued up 1 image in Johnson B for 900s, bin 2x2, 2 images in Johnson V for 900s, bin 2x2, and 1 image in Johnson-Cousins I for 600s, bin 2x2.

Target Name:	CVn-I	Get Coordinates or Ephemeris																														
Right Asc. (hrs):		Deep Sky Catalog Search																														
Declination (deg):		(coordinates in J2000)																														
<table border="1"> <thead> <tr> <th>Use</th> <th>Count</th> <th>Filter</th> <th>Duration</th> <th>Binning</th> <th></th> </tr> </thead> <tbody> <tr> <td><input checked="" type="checkbox"/></td> <td>1</td> <td>B</td> <td>900</td> <td>2</td> <td><input type="checkbox"/> Auto focus at start <input type="checkbox"/> Auto calibrate</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td>2</td> <td>V</td> <td>900</td> <td>2</td> <td><input type="checkbox"/> Periodic auto focus every 30 minutes</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td>1</td> <td>I</td> <td>600</td> <td>2</td> <td>Dithering: 0.0 (pixels rms i -1.0 for auto)</td> </tr> <tr> <td><input checked="" type="checkbox"/></td> <td></td> <td>halpha</td> <td></td> <td>2</td> <td><input type="checkbox"/> Standard screen flats (at end)</td> </tr> </tbody> </table>			Use	Count	Filter	Duration	Binning		<input checked="" type="checkbox"/>	1	B	900	2	<input type="checkbox"/> Auto focus at start <input type="checkbox"/> Auto calibrate	<input checked="" type="checkbox"/>	2	V	900	2	<input type="checkbox"/> Periodic auto focus every 30 minutes	<input checked="" type="checkbox"/>	1	I	600	2	Dithering: 0.0 (pixels rms i -1.0 for auto)	<input checked="" type="checkbox"/>		halpha		2	<input type="checkbox"/> Standard screen flats (at end)
Use	Count	Filter	Duration	Binning																												
<input checked="" type="checkbox"/>	1	B	900	2	<input type="checkbox"/> Auto focus at start <input type="checkbox"/> Auto calibrate																											
<input checked="" type="checkbox"/>	2	V	900	2	<input type="checkbox"/> Periodic auto focus every 30 minutes																											
<input checked="" type="checkbox"/>	1	I	600	2	Dithering: 0.0 (pixels rms i -1.0 for auto)																											
<input checked="" type="checkbox"/>		halpha		2	<input type="checkbox"/> Standard screen flats (at end)																											
More																																
Acquire Images																																

Figure 18. Input window block for color-series set of observations for one target.

An example of the output ACP gives you after clicking on the "Acquire Images" button is provided in Figure 19.

```

;
; Single target color series plan by AS06, created Tue, 7 Aug 2018 07:33:01 UTC
;
#autofocus
#afinterval 30
#count 1,1,1
#interval 900,900,600
#binning 2,2,2
#filter B,V,I
Laevens3      21.115083333333334      14.98

```

Figure 19. Output for doing a Color-Series on a single target.

E. Multiple targets -- scripting and batch mode options

If you have multiple targets or performing time-series photometry, scripting may be an option for you. Running the script inside of ACP allows you to automate your observing. This is an advanced feature for an experienced observer. You will still have to look at your images to make sure your script is executing your observations correctly. If not, you can stop the script by clicking on the “Stop run” button under the “System Status” window block.

You can write your own script and upload it to ACP.

To write a script, open a text file in your favorite editor. All ACP commands begin with a “#”. At the very least, you must tell ACP:

- The number of exposures you want
- Exposure time
- Binning
- Name of the target and its J2000.0 equatorial coordinates
- Autofocus (optional)
- Plate solving (optional)
- Pointing correction (optional)

!! Important: do not skip this step if you are using Multi-object mode: To check if your script will run correctly in ACP, click on “Obs. Plan Checker” under “Live Observing”. This will open the script from your computer and check the ACP syntax. If it is correct, ACP will tell you that the “Plan is OK!”. If not, you will need to edit your script to the correct ACP syntax.

Once you have confirmed that your script will run with the Plan Checker, you must upload it to the ACP system at APO. To do this, open the drop down menu for “My Documents”. Click on “Observing Plans”. There may be a bit of a delay, so be patient. It will recommend you to upload the scripts via FTP, and that is one option to do the upload.

Another way to upload your script is to click on the “Choose File” and select your script. Then click on the “Upload” button to register it among all the archived plans. At the bottom of this window block, there is a “Refresh” button. Click on it and check if your script has uploaded. Periodically, scripts will be culled from this archive, or you can simply remove it yourself at the end of the run. To remove your scripts from the archive, go to Shared File in ACP and navigate to the proper subdirectory. Delete your scripts/plans that you are not using.

Once your script has registered in the archive, click “Multiple Objects (Plan)” under “Live Observing”. Figure 20 shows you what that window block looks like. Select your script from the archive and then click on the “Acquire Images” button. Check the log window under “System Status” to see the execution of your script.

Example scripts are provided in the Appendix C to help you construct your script.



Figure 20. Multi-object observing window. Select your script from the list under "Select the observing plan to run:". To execute, click on the "Acquire Images" button.

F. Aborting an image or script

If you need to abort an exposure, click on the “Stop Run” button, found just below the System Status window and after opening the Run Log (see section 5, Figure 12). If you stop a run, a message will appear that the run will end as soon as it is able, and then a window will appear notifying you that the run has been aborted. Close that window to get back into the ACP interface.

9. End of Night Tasks

As the night comes to a close, keep a careful eye on the sky levels. After about 6 degree morning twilight, you may want to consider taking morning twilight sky flats, if you are using them in your data reduction. Remember, for the morning twilight flats, you want to go from reddest to bluest to help minimize the amount of time collecting sufficient photons for your morning sky flats. As with the evening sky flats, the procedure is the same, but the **filters are in reverse order**. See flowchart for twilight flats or Section 6.

If you did not have time at the start of the night to take all the calibrations you wanted, you can take them now at the end of the night. If you are taking biases and darks, let the obs-spec know that is what you are doing. They will need to know what you are doing as they must ensure the telescope will be closed up in a timely manner before sunrise.

A. Night Log

You must fill out the night log. You can obtain the template from the ARCSAT web pages under “Observing Aids”⁶. Under the Activity log section, list any problems you

⁶ <http://www.apo.nmsu.edu/Telescopes/ARCSAT/ObservingAids/index.html>

encountered with as much detail as you can. Copy into this window any error messages from the log window and a time-stamp, if you can get it. The more complete the description of the problem, the more helpful it will be for the APO staff. Just saying the "telescope broke" is NOT helpful.

For the focus session, copy from the generated log files all the relevant information regarding focus.

For the weather session, there is an online tool that will allow you to fill in, by the hour, the weather conditions you encountered during your run.

Don't forget to mail the night log out to the 0.5m mailing list. An example night log is in Appendix D.

B. Closing the telescope

Once you are done observing, please close and park the dome. Do not leave Chrome until this is done as the obs spec will be attending to closure of the 3.5m telescope during this time. Please close the dome shutter by clicking on "Shutter" in the "System Status" window block. Next, click on "Dome" to home it and to disconnect from following the telescope. Next, close the dome louvers (see Figure 21). Ask the obs-spec to visually check that the dome has indeed closed properly or open the dome webcam feature and check for yourself. If you have problems closing, the obs-spec can help you with closing the dome. Be advised that ARCSAT will automatically close at sunrise. If this happens, please ask the obs-spec to visually check that the dome has closed. Use the dome webcam to ensure that the louvers and the shutter are closed -- you should not see any light inside the dome. Tell the obs-spec that you are logging off so that they know to check that the ARCSAT dome, louvers are closed, and that the drive motors are off. To log out of ACP, close your Chrome window.



Figure 21. At the end of the night be sure you have closed the dome louvers! Check by opening this window under "Live Observing".

C. Transfer your data

To copy over any data from APO to your machine, you can tunnel to APO data server and download your data. You will need your institutional username and password. Keep in mind these passwords are changed every quarter. If you don't know what it is, speak to your institutional scheduler first before calling APO and they will tell you over the phone what the password is. Due to security reasons, these passwords will not be sent to you via email.

First, ssh into `arc-gateway.apo.nmsu.edu` using your institutional account name. For example, an NMSU observer will use "nmsuobserver" as their account name.

Go to the `/export/arcasat/AS##` directory. Look for your observing date and cd into that. Note that the date for ARCSAT data directories is start of night (same as the schedule date). Are the files listed there your data?

Once you know the path to your directory on arc-gateway, you can scp your data over to your machine with the following command:

```
scp youraccount@arc-gateway.nmsu.edu:/export/arcasat/AS##/your_obs_date/*.* ./
```

Once all your data and auxiliary files (such as the ACP logs) have been copied over to you, close your tunneling connection to APO.

Alternatively, you can download your data through ACP itself. Expand the "My Documents" dropdown menu and select "Acquired Images". In the new window block that opens, select the "Date of Interest" and "Explore". You should see all the images taken under your id (AS##). Click on the FITS file and it will auto-download to your machine. When the download is complete, the download progress wheel at the bottom of the screen will change to a check mark and return to the list of FITS filenames. If you are experiencing a long download time, connect to a hardline rather than using wireless.

10. Troubleshooting Tips

- If you are unsure if your ACP screen is active, refresh your Chrome window. If you have lost your connection, your ACP interface will not appear. Restart your tunneling and open up ACP in Chrome again. Let the 3.5m obs-spec know you may have connectivity issues.
- Check your twilight sky flats. If the exposure time is too short, you will see the shutter of the camera in the flat field. See Figure 22. To remedy this, you may want to wait for a slightly darker sky to attempt a twilight flat in the bluer filters. This will help prevent the

shutter pattern from appearing in your flat fields.

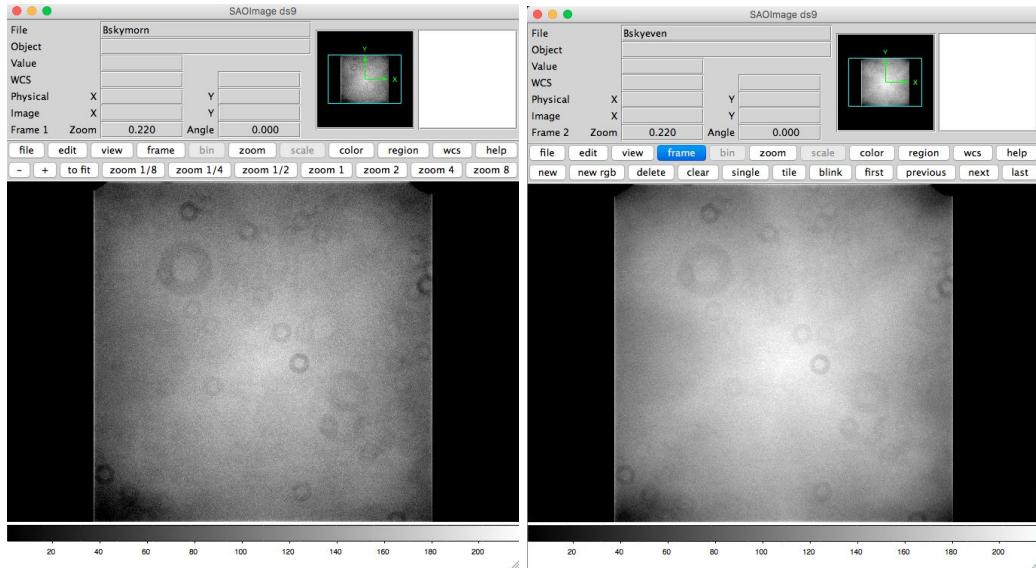


Figure 22. The left figure is a twilight flat taken during the morning with 4-5 second exposures. The right figure is of a twilight flat taken during the evening with 1 second exposure (note the starfish pattern - that is the camera shutter).

- A relatively common problem is slow data transfer - a problem if observers are trying to check their data in real time. Often they can work around it by using the FTP interface inside ACP/Chrome instead of waiting for images to appear on disk.
- Clear Browsing Data tip: In Chrome, you should "Clear Browsing Data", especially if you reconnecting to ACP after a reboot. Chrome caches your previous data and will try to load previous information rather than the updated ones. If you ACP information looks wrong, especially if everything looks the same before the ACP reboot, try clearing your Chrome. See Figure 23 to see where this is done.

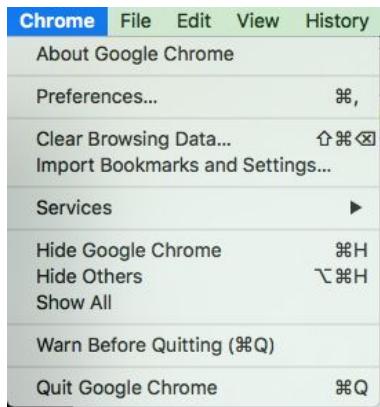


Figure 23. On a Mac, "Clear Browsing Data" is under the Chrome drop down menu. If something looks funny on your ACP interface, try this option.

Engineering

Bill and Jack's section.

APPENDIX

APPENDIX A. OBSERVER'S CHECKLIST

Observing Checklist

- Tunnel to APO. Log into ACP. Open weather web sites.
- Set camera cooler temperature unless it is already at the right temp. Open dome louvers to help thermalize and ventilate the telescope.
- Take bias and dark calibration frames before sunset. Look at these data.
- Take dome flats, if using. Let the 3.5m obs-spec know you need the motors to be turned on so you can position the telescope to the white spot in the dome. Close the dome louvers before taking dome flats, and open them up again when done with dome flats.
- If you are taking twilight sky flats, just before sunset, ask the 3.5m obs-spec to turn on the motors so that you may move the telescope to zenith. Open the shutter and engage the dome. Take evening twilight sky flats after sunset with filters in order of bluest to reddest.
- If you did NOT take sky flats, open the dome shutter. Engage the dome to the telescope.
- Go to a bright star and check the telescope pointing. Is your star in the center of the thumbnail images in ACP? Adjust focus with autofocus feature.
- Ask for the guider to be turned on, if using.
- Single target observing - enter object name, coordinates, filter, binning, and exposure time. Look at your data.
- Multi-object observing - write your own scripts, upload to ACP, and run the scripts. Look at your data.
- (Optional) Take morning twilight sky flats. Do these in order of the reddest to the bluest filters.
- Close the dome shutter, home the dome, and close the louvers.
- Set camera cooler to something slightly warmer, like -10°C.
- Log out of ACP and TUI
- Copy over your data from APO. Begin your data reduction and analysis. Publish.

APPENDIX B. WEATHER RESOURCES

Use your favorite weather websites to help you monitor the weather at Apache Point Observatory, located in Southeastern New Mexico in the Sacramento Mountains. Here are some quick links that the observing staff uses:

Current APO weather (words and graphs): <http://weather.apo.nmsu.edu/>

IR All-Sky Cloud camera: <http://irsc.apo.nmsu.edu/>

APO weather status (tables of numbers): <http://weather.apo.nmsu.edu/cgi-bin/weather.py>

National Weather Service: <https://www.weather.gov/>

Clear Sky Clock (set to APO) : <http://www.cleardarksky.com/c/ApachePtNMkey.html>

APPENDIX C. ACP SCRIPT EXAMPLES

In all cases of ACP scripts, you MUST add a TAB in between the name of the target and each coordinate. If you put blank spaces, the Plan Checker in ACP will fail and tell you that your target does not exist in any catalog.

This script allows you to take different length exposure (keyword: interval) of one target. You can also control the number of images you want (keyword: count).

```
#count 5
#interval 300
#binning 2
#filter V
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

```
#count 1
#interval 600
#binning 2
#filter V
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

```
#count 1
#interval 900
#binning 2
#filter V
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

This script allows you to change filters (keyword:filter) and change the exposure times (keyword:interval).

```
#count 1
#interval 600
#binning 2
#filter I
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

```
#count 1
#interval 900
#binning 2
#filter V
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

```
#count 1
#interval 900
#binning 2
#filter B
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

This script allows you to change targets:

```
#count 1
#interval 900
#binning 2
#filter V
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

```
#count 1
#interval 900
#binning 2
#filter B
#autofocus
Laevens3    21:06:54.3    +14:58:48
```

```
#count 1
#interval 180
#binning 2
#filter V
#autofocus
SA113 21:41:28 +00:40:15
```

```
#count 1
#interval 180
#binning 2
#filter B
#autofocus
SA113 21:41:28 +00:40:15
```

```
#count 1
#interval 120
#binning 2
#filter I
#autofocus
SA113 21:41:28 +00:40:15
```

Putting it all together, this script allows you to use multiple filters, binning and intervals (keyword:filter) and change the exposure times (keyword:interval).

```
#count 2, 1, 2
#interval 180, 360, 90
#binning 2, 2, 2
#filter V, B, I
#autofocus
SA113 21:41:28 +00:40:15
```

APPENDIX D. Example Night Log

Apache Point Observatory
0.5m Telescope Night Log
Sunday August 5, 2018

Astronomer: Karen Kinemuchi

Program ID: AS06

UTC Start time: 01:00 UTC End time: 11:50

Instrument: surveycam

----- Activity Log -----

Observer(s): Karen Kinemuchi

A mostly good night with rain at the beginning and some clouds towards the end of the night. Photometric skies for about an hour. A couple of problems cropped up. They were cleared up by waiting and restarting exposures. We did one reboot of the computer system when "out of space" error appeared and killed the exposure.

Took 900s exposures and the thumbnail images looked good. Will reduce the data later today to check stellar profiles.

Error messages from the log:

01:04:50 Source: MaxIm DL 6

01:04:50 Message: ImageArray error while transferring image

Could not invoke 'ImageArray'

Reason: Not enough storage is available to complete this operation.

--> reboot seemed to have worked.

04:59:19 **Script Error (Tracking has been stopped)**

04:59:19 Source: MaxIm.CCDCamera

04:59:19 Message: **Exposure timed out waiting for ImageReady.

04:59:19 Location: line 1530 column 33.

--> not sure what happened here. Restarted the exposure and the error disappeared.

----- Focus Log -----

Telescope Air

Time Focus RA DEC AM Temp filt FWHM

20180806@040242.log:04:12:53 Image FWHM is 3.6 arcsec (3.85 pixels)
20180806@054215.log:05:58:19 Image FWHM is 3.9 arcsec (4.16 pixels)
20180806@054215.log:06:19:07 Image FWHM is 3.3 arcsec (3.51 pixels)
20180806@062537.log:06:37:02 Image FWHM is 2.8 arcsec (2.98 pixels)
20180806@062537.log:06:42:36 Image FWHM is 2.7 arcsec (2.97 pixels)
20180806@062537.log:06:42:36 (avg FWHM = 2.75 arcsec)
20180806@062537.log:06:48:10 Image FWHM is 2.8 arcsec (2.98 pixels)
20180806@062537.log:06:48:10 (avg FWHM = 2.75 arcsec)
20180806@062537.log:06:53:45 Image FWHM is 2.9 arcsec (3.19 pixels)
20180806@062537.log:06:53:45 (avg FWHM = 2.80 arcsec)
20180806@062537.log:06:59:21 Image FWHM is 2.9 arcsec (3.16 pixels)
20180806@062537.log:06:59:21 (avg FWHM = 2.85 arcsec)
20180806@062537.log:07:14:22 Image FWHM is 2.5 arcsec (2.75 pixels)
20180806@062537.log:07:34:35 Image FWHM is 2.8 arcsec (2.98 pixels)
20180806@073512.log:07:45:35 Image FWHM is 2.5 arcsec (2.74 pixels)
20180806@073512.log:07:51:16 Image FWHM is 2.5 arcsec (2.68 pixels)
20180806@073512.log:07:51:16 (avg FWHM = 2.52 arcsec)
20180806@073512.log:07:56:54 Image FWHM is 2.4 arcsec (2.63 pixels)
20180806@073512.log:07:56:54 (avg FWHM = 2.50 arcsec)
20180806@073512.log:08:02:36 Image FWHM is 2.5 arcsec (2.65 pixels)
20180806@073512.log:08:02:36 (avg FWHM = 2.48 arcsec)
20180806@073512.log:08:08:09 Image FWHM is 2.3 arcsec (2.45 pixels)
20180806@073512.log:08:08:09 (avg FWHM = 2.41 arcsec)
20180806@073512.log:08:23:29 Image FWHM is 2.8 arcsec (2.98 pixels)
20180806@073512.log:08:43:51 Image FWHM is 2.8 arcsec (2.99 pixels)
20180806@084619.log:08:56:58 Image FWHM is 2.2 arcsec (2.39 pixels)
20180806@084619.log:09:02:38 Image FWHM is 2.2 arcsec (2.40 pixels)
20180806@084619.log:09:02:38 (avg FWHM = 2.21 arcsec)
20180806@084619.log:09:08:22 Image FWHM is 2.4 arcsec (2.62 pixels)
20180806@084619.log:09:08:22 (avg FWHM = 2.27 arcsec)
20180806@084619.log:09:14:04 Image FWHM is 2.4 arcsec (2.56 pixels)
20180806@084619.log:09:14:04 (avg FWHM = 2.31 arcsec)
20180806@084619.log:09:19:45 Image FWHM is 2.3 arcsec (2.46 pixels)
20180806@084619.log:09:19:45 (avg FWHM = 2.33 arcsec)
20180806@084619.log:09:43:45 Image FWHM is 3.1 arcsec (3.37 pixels)

20180806@084619.log:09:43:45 (avg FWHM = 2.55 arcsec)

20180806@101015.log:10:28:01 Image FWHM is 2.4 arcsec (2.55 pixels)

----- WEATHER LOG -----

Time	Wind			Precip.or			
	Temp F	Dewp F	MPH	Direction	Dust	Sky	Conditions
16:00	70	45	4	218 (SW)	634	ptly cldy	none
17:00	70	45	2	123 (ESE)	606	ptly cldy	none
18:00	69	45	5	125 (SE)	587	ptly cldy	lt rain
19:00	67	45	7	94 (E)	588	mstly cldy	rain
20:00	64	46	14	100 (E)	1183	ptly cldy	none
21:00	62	45	20	79 (E)	1477	mstly clr	none
22:00	60	45	17	79 (E)	1783	mstly clr	none
23:00	59	44	15	84 (E)	2704	mstly clr	none
00:00	57	43	15	77 (ENE)	2693	mstly clr	none
01:00	58	43	12	69 (ENE)	2609	mstly clr	none
02:00	60	44	3	12 (NNE)	1842	clear	none
03:00	63	44	2	303 (WNW)	1539	mstly clr	none
04:00	62	44	6	3 (N)	1491	ptly cldy	none
05:00	61	44	4	353 (N)	1463	ptly cldy	none
06:00	61	43	3	339 (NNW)	1507	mstly clr	none

APPENDIX E. ACP COMMANDS GLOSSARY

Command definitions taken from ACP manual.

- **#REPEAT** - Tells script to take the given number of filter groups of the next target or dark/bias frame (#DARK) in a row. #REPEAT may be combined with #SETS. For example: #REPEAT 5
- **#CALIBRATE**-Forces calibration of the images for this target, even if ACP's auto-calibration preference is turned off (it is redundant if ACP's auto-calibration is turned on). This will not cause calibration of pointing exposures, only the final images.
- **#STACK** - Combines repeated images within one filter group without aligning into a single image. Individual images used in the stack are preserved. File names will have - STACK in place of the repeat number. This is most useful when doing orbital tracking. See #TRACKON. The stacked image is saved in IEEE floating-point FITS format to preserve the dynamic range.
- **#STACKALIGN** - Combines repeated images within one filter group and aligns images into a single image. Individual images used in the stack are preserved. File names will have STACK in place of the repeat number. Use this for all stare-mode image sets. The stacked image is saved in IEEE floating-point FITS format to preserve the dynamic range.
- **#AUTOFOCUS** - Automatically refocus the optical system before each filter group in the filter group for this target. In order to preserve compatibility with the old target-per-filter plan format, this is modified if there is only one filter group. In this case, the autofocus is done once for the target, even if #repeat is greater than one. This requires that FocusMax 3.4.1 or later be installed and autofocus be enabled in ACP's preferences.
- **#POINTING** - Schedule a pointing update prior to the target. This will work even if auto-center is disabled in Preferences. Thus, you can use #POINTING as a means to manually control when pointing updates occur in a plan.
- **#NOPOINTING** - Prevent the pointing update prior to the target. Harmless if auto-center is disabled in Preferences. **!!IMPORTANT!! Invoking NOPOINTING or NOSOLVE**

disables plate solving and prevents WCS information from being writing to the FITS headers.

- **#NOSOLVE**-Prevent final/data image plate solving for all of the images of the current target. Harmless if final/data image solving is disabled in Preferences.
!!IMPORTANT!! Invoking NOPOINTING or NOSOLVE disables plate solving and prevents WCS information from being writing to the FITS headers.
- **#WAITFOR** - Pause for the given number of seconds before processing the next target.
For example: #WAITFOR 30
- **#WAITUNTIL** - Pause during a specific set (see #SETS) until the given UTC date/time or (only) time. The first parameter is the set number for the pause, the second is the date/time at which to resume. The set number may range from 0 through the number of sets given by the #SETS directive. If there is no #SETS directive on the plan, the set number must be 1. If the set number is 0, it means "wait on all sets". This is useful, when only a time is given, for plans that are stopped before completion then resumed on subsequent nights. If a complete date/time is given, and has passed, the directive is ignored. If only a time is given, it will wait for up to 12 hours. If the time is less than 12 hours in the past, it will not wait. The idea is that the time is relative to that observing night, and may be re-used on the next night. See the note below. For example:

#WAITUNTIL 1, 21-Apr-2011 08:02:00

Wait until 08:02 UTC only if set #1 and only if 21-Apr-2011

- **#WAITINLIMITS** - Pause until the target is within the observatory limits: minimum elevation, horizon, and any tilt-up limit. If target will never meet the criteria, it is immediately skipped. A maximum time to wait (minutes) must be included. For example:

#WAITINLIMITS 60

This will wait for the target to rise above the observatory limits for up to 60 minutes.

- **#WAITZENDIST** - Pause until the target is within the given zenith distance (deg) for up to the given time (min). If the target will never get within the given zenith distance, or won't get there within the time limit, it is skipped. A maximum time to wait (minutes) must be included. For example:

#WAITZENDIST 40, 30

This will wait until the target is within 40 degrees of the zenith for up to 30 minutes.

- #WAITAIRMASS - Pause until the target is at or below the given air mass. If the target will never get within the given air mass, or won't get there within the time limit, it is skipped. A maximum time to wait (minutes) must be included. For example:

```
#WAITAIRMASS 2.5, 30
```

This will wait until the target is at or below 2.5 air masses for up to 30 minutes.

- #TAG - Adds a named tag to the target. This directive does not affect the image acquisition process; it simply attaches the tag name and value to the target. You can specify as many of these as you want (each with different names) for any target. The tag name(s) and value(s) will be echoed to the run log, but this is most useful when you have custom actions defined for TargetStart and TargetEnd. These custom actions are passed a Target object as a parameter. Within the custom action, you can refer to tags by their name (as you defined them) with the syntax Target.Tags.name. Thus, you can use tags to alter the action of TargetStart and TargetEnd based on the tags' value(s). This is an expert feature and allows powerful custom logic to be implemented. The syntax is #TAG name=value. There must be an '=' in the #TAG directive. For example:

```
#TAG type=reference star
```

This will attach a tag "type" with the value "reference star" to the target.

- #COUNT - Used only when specifying a filter group. For example: #Count 5,10,5,15
- #INTERVAL - Set the final target exposure interval(s) for subsequent targets (sec.). For example: #INTERVAL 31.5 #INTERVAL 180,240,180,180
- #FILTER - Set the filter(s) for subsequent targets. If the filter name is not recognized, an error is logged at plan start, and the plan will not run. For example:

```
#FILTER Blue
```

```
#FILTER Red,Clear,Green,Blue
```
- #BINNING - Sets the binning factor(s) for subsequent targets. Note that some detectors don't support arbitrary binning values. Consult the documentation for your detector for specifics. Note: for auto-calibration, of the binned size must be available in MaxIm's calibration groups. For example: #BINNING 4 #BINNING 2,1,2,2
- #SUBFRAME - Sets the fraction of the chip to be used for subsequent images. Legal values are 0.1 to 1.0 (full frame). For example, if the chip is 1K by 1K (1024 by 1024), a SUBFRAME of 0.5 will result in using the center 512 by 512 pixels of the chip. For example: #SUBFRAME 0.5

- **#DITHER** - Offset each image in a repeat-set by some small amount away from the original target location. Works for both guided and unguided images. If no parameter is given, ACP uses a value of 5 main imager pixels for dithering (see below). Normally, this value will be appropriate for achieving the noise reduction effect of dithering. Dithering is done by generating **two uniform random numbers** ranging from minus to plus the "amount". One is applied in the X direction, the other in the Y direction. Note that you must supply a value for the guider's plate scale in order for ACP to calculate main imager pixels for guided dithering. If you fail to do this, a warning message will appear in your run log and dithering will be in guider pixels.

If given, the parameter specifies the maximum amount in each axis of this offset in fractional pixels. A parameter value of 0 disables dithering. The random offsets are applied independently in X and Y and are always relative to the initial position. For example: #DITHER ; Automatic dithering

```
#DITHER 3.0 ; 3 pixels dither on the image
#DITHER 0 ; Disable dithering
```

- **#DIR** - Temporarily change the directory into which all subsequent images are to be stored. This can be a relative or full (with a drive letter) directory path, with multiple levels. If relative, the folder is relative to the default image folder as configured in the Local User tab of ACP Preferences (or for web users, their images folder). The folder, including all intermediate levels, is created if needed. For example:

```
#DIR C:\Special\Comet Search\28-Sep-2003 (absolute)
#DIR Photometric Standards\Landolt (relative)
```

If no folder name is given, this will switch back to the default image folder as configured in the Local User tab of ACP Preferences (or for web users, their images folder) plus the usual date-based subfolder. For example: #DIR ; Restore default image folder

- **#TRACKON** - Initiates orbital tracking of solar system bodies. This remains in effect until cancelled by #TRACKOFF. Orbital tracking will not be done except for solar system bodies, so non-solar-system targets may be intermixed without harm. Autoguiding will not be done if orbital tracking is active. Note that orbital tracking requires orbital elements as the target specification (major planet targets will also be tracked).
- **#TRACKOFF** - Cancels orbital tracking. This remains in effect until re-enabled with #TRACKON.

- **#READOUTMODE** - Selects the imager's readout mode for the current target and all subsequent targets. The imager must support readout modes, and the name you give must be supported by your imager. You can see which readout modes (if any) are supported by looking on the MaxIm DL CCD control window's "Expose" tab. Pointing exposures will always use Fast or Normal, so this will not impact pointing update times. For example: `#READOUTMODE 8 MPPS (RBI Flood)`
- **#DEFOCUS** - Moves the focuser the given number of integer steps away from proper focus just before acquiring each subsequent image. The focus position is restored immediately after acquiring the image, but this directive does carry from target to target, so unless changed, the focus will be moved away from proper focus before each subsequent image. This does not affect pointing images. For example: `#DEFOCUS -150`
- **#SETS** - Repeat the entire plan a given number of times. The images are acquired in round-robin order. This directive may appear anywhere in the plan. If it appears more than once, the last value is used for the plan. The default is a single set. For example: `#SETS 3`
- **#AFINTERVAL** - Turns on periodic autofocus and forces an autofocus at the start (or resumption) of the plan. The interval is given in minutes. If an **#AUTOFOCUS** directive is seen, it overrides a scheduled autofocus, and the time to the next autofocus is reset to the interval. This directive may appear anywhere in the plan, and the value given in the last appearance will be used for the entire plan. For example, to start the plan with an autofocus, then do an autofocus every 30 minutes: `#AFINTERVAL 30`
- **#ALWAYSSOLVE** - Normally, when ACP fails to solve a final/data image in a series (the same target/filter/etc.), it will not try to solve again for that series. This prevents wasting time waiting for plate solves that will probably fail (again). If you want to override this behavior and force ACP to attempt solving every final/data image, include this directive anywhere in your plan.
- **#DUSKFLATS** - The plan starts by acquiring a series of automatic sky flats at dusk via the AutoFlat.vbs script (which is run under control of AcquireImages.js). See **#DAWNFLATS** below, and Using Automatic Sky Flats. If no argument is supplied, there must be a default flat plan named defaultduskflat.txt or just defaultflat.txt in the Local User's default plans folder or AcquireImages will not try to start AutoFlat. This avoids AutoFlat stalling waiting for flat plan input. If an argument is supplied it can be either a full path to a flat plan, or just a flat plan file name. If just the flat plan file name is given,

it is assumed to be in your default Plans folder. For example:

```
#DUSKFLATS
```

Need standard flat plan defaultflat.txt in user's default plans folder

```
#DUSKFLATS 20060122-dusk-flats.txt
```

(In user's default plans folder #DUSKFLATSC:\MasterCalibration\LRGB-Standard-Flats.txt)

- **#MISSETTIME** - The minimum amount of time that a set is allowed to take. This can be used to limit the number of sets per unit time. For example: #MINSETTIME 00:05 will tell ACP to wait until at least 5 minutes has elapsed before starting the next set.
- **#QUITAT** - Set a "quitting time" at which the plan will stop acquiring images. The quitting date/time is in UTC, and is interpreted the same as for #WAITUNTIL. If you specify #DAWNFLATS, #CHAIN, or #CHAINSCRIPT, these actions will still occur after the plan ends. For example: #QUITAT 7/1/01 08:22

If the plan completes before the quit date/time is reached, it ends as usual. If only a time is given, it will always wait until the given time, even if it was just passed (it will wait till it is that time again).

- **#SHUTDOWNAT** - Same as #QUITAT, except the scope is parked and the camera is shut down at the quitting time, or at normal exit. The shutdown time is in UTC, and is interpreted the same as for #WAITUNTIL. For example:

```
#SHUTDOWNAT 7/1/06 08:22
```

If the plan completes before the shutdown date/time is reached, it acts as though a #SHUT- DOWN directive was given instead. If only a time is given, it will always wait until the given time, even if it was just passed.

- **#SHUTDOWN** - At the end of the run, parks the scope and shuts down the camera and cooler. If dome control is active, and if the "Automatically park or home and close AFTER the scope is parked" option is set, then the dome will be parked or homed and the shutter or roll-off roof will be closed. This may be used with #DAWNFLATS, and shutdown will occur after dawn flats have been taken.
- **#STARTSETNUM** - The starting set number used in naming image files. Do not include this in your plans, it is automatically inserted in all plans by AcquireImages.js. Each time the plan runs to completion, this number is incremented by the number of sets specified in #SETS or by 1. Its main use is to prevent overwriting of images when the same plan is run multiple times. For example: #STARTSETNUM 6

- **#COMPLETIONSTATE** - The number of sets, targets in the current set, repeats in the current target, filter groups in the current repeat, and images in the current filter group, that have been completed. Do not include this in your plans, it is automatically inserted in all plans by AcquireImages.js each time a target is completed, then removed if and when the plan runs to completion (at which time #STARTSETNUM is adjusted as described above). Its main use is to allow an interrupted plan to resume at the point where the interruption occurred. For example: #COMPLETIONSTATE 2,4,1,3,1
- **#DARK** - Acquire a dark or bias frame using the current target exposure interval. If you set #INTERVAL to 0 before using #DARK, ACP will acquire a bias frame, and the file naming will be adjusted. It is recommended, however, to use the #BIAS directive described below. You can use the #REPEAT directive to acquire multiple darks or biases. Multiple darks/biases will be sequence numbered as well as carrying the current #SET number, similar to file naming for light images (except no filter name is included of course).
- **#BIAS** - Acquire a bias frame using the current target exposure interval. You can use the #REPEAT directive to acquire multiple biases. Multiple biases will be sequence numbered as well as carrying the current #SET number, similar to file naming for light images (except no filter name is included of course).
- **#MANUAL** - Acquire an image at the current telescope location. No pointing updates or slews will be done. This is actually a type of target, so don't include a target line. Include an object name. For example: #MANUAL MyImage

If you don't include an object name, the current date/Time will be used. For example: #MANUAL

- **#CHILL** - If needed, turns on the imager's cooler and waits for 5 seconds. In any case, the imager's temperature setpoint is changed to the given temperature (deg. C). After the change, #chill waits for up to 15 minutes for the cooler to reach a temperature within the given tolerance (or 2 degrees, default) of the setpoint. This is actually a type of target, so you can wait before it, have the imager cooled, then wait again so that imaging starts later. If the cooler does not reach the given temperature and tolerance, the plan fails with an error. For example: #CHILL -35.0 #CHILL -32.5, 0.2
- **#DOMEOPEN** - Opens the shutter or roll-off roof, and waits until the shutter or roof is actually open. Will un-home or un-park the dome if needed. Effective only during the

first or only set-loop of the plan. This is actually a type of target, so you can wait before it, have the shutter or roof opened, then wait again so that imaging starts later.

- **#DOMECLOSE** - Closes the shutter or roll-off roof, and waits until the shutter or roof is actually closed. Effective only during the last or only set-loop of the plan.
- **#DAWNFLATS** - When encountered during the last (or only) set, immediately stops reading image acquisition lines from the current observing plan file, terminates AcquireImages.js, and starts ACP's automatic sky-flat script AutoFlat.vbs. If AcquireImages fails or is aborted, the auto-flats will not occur. See **#DUSKFLATS** above, and Using Automatic Sky Flats. If no argument is supplied, there must be a default flat plan named defaultdawnflat.txt or just defaultflat.txt in the Local User's default plans folder or AcquireImages will not try to start AutoFlat. This avoids AutoFlat stalling waiting for flat plan input. If an argument is supplied it can be either a full path to a flat plan, or just a flat plan file name. If just the flat plan file name is given, it is assumed to be in your default Plans folder. For example:

```
#DAWNFLATS
```

Need standard flat plan defaultflat.txt in user's default plans folder

```
#DAWNFLATS 20060122-dawn-flats.txt
```

In user's default plans folder #DAWNFLATS C:\MasterCalibration\LRGB-Standard-Flats.txt