SMARTS 0.9m Telescope Observing Manual

A comprehensive manual of how to use the hardware, software, and solve common problems.

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Contents

1 Before Your Observing Run

The CTIO/SMARTS 0.9m telescope is operated by the RECONS team, currently headquartered in Atlanta. Main contacts are Todd Henry and Michele Silverstein. At CTIO, telescope operations are handled by Hernan Tirado and Manuel Hernandez. See section A.1 for contact information.

Before traveling to Chile, be sure to read the Visiting Astronomers Travel Guide.

1.1 Preparation

There are three things to do:

1. **Travel Arrangements:** Be sure to fill out the Travel Information Questionairre at least **one month** before your observing run. In the "Proposal Number" please write your NOAO or CNTAC proposal number, or simply "SMARTS" if you have purchased time.

   For assistance with travel, contact *Ximena Herreros (xherreros@ctio.noao.edu).*

2. **Instrument Setup:** Fill out the Instrument Setup Form at least **one month** before your observing run. This allows us to catch any problems, such as whether or not your requested filters are scheduled for a user at another telescope.

3. **Internet:** In order to connect to the internet in La Serena and on the mountain you must register your devices. There is wifi in the dorms and at the telescope. It is worth bringing an adapter if you need one to connect to wired internet, should something go wrong.

1.2 Transportation

Arrival in La Serena — If you arranged a taxi to pick you up at the airport in the travel questionnaire, you will see someone with a sign that says "AURA" or "CTIO" when you arrive at the La Florida Airport in La Serena. The taxi driver will take you to the AURA offices known as the Recinto where you will be staying if you arranged to spend some nights in La Serena. This is also where the carry-all picks you up to bring you to Cerro Tololo. Your cab fare will be included in your invoice at the end of your run. If no taxi driver is evident, you may need to catch your own taxi from the airport to the Recinto, and you'll need to pay in pesos, so make sure you have some.

Coming down the mountain — To return to the airport after your run, you can request a taxi from the La Serena motel using the online travel form, or just go directly to the airport from the mountain — ask the carryall driver to drop you off at the airport ("aeropuerto" in Spanish). If you have planned to stay in La Serena, the carryall driver can also take you to the AURA "Recinto" where you will be staying.

1.3 What to Expect

1.3.1 Observing

The CTIO/SMARTS 0.9m is a user-operated telescope. Although observer support may check in at the beginning/middle of the night, users will not be provided with a telescope operator. This manual is intended to provide all of the information you might need to operate the telescope and navigate your observing run. If it is your first night observing at the CTIO/SMARTS 0.9m and someone else is observing the night before you, it would be beneficial to shadow them if circumstances allow.

1.3.2 On The Mountain

Cerro Tololo Inter-American Observatory (CTIO) is in La Serena, Chile. Most observers opt to spend at least one night in La Serena before and/or after an observing run. The Travel Information Questionairre includes questions about transportation from the airport to lodging in town at the "Recinto", in addition to transportation from the Recinto to the mountain. The mountain has breakfast, lunch, and dinner prepared by chefs, in addition to night lunches. Observers stay in a building connected to this dining area and to the laundry room. While staying on the mountain, you may wish to check your room and/or bed for the occasional spider or scorpion; you will be in the desert and these things are to be expected, although the rooms are treated to try and minimize these "extra roommates". Should you have an encounter, you can report it. Although not all are fluent, many of the staff members speak English. The 0.9m is a bit further up the mountain than the lodging, and many users opt to rent a car during their stay, though there is also a walkable path up the mountain.

1.3.3 La Serena

La Serena is a growing town. You may wish to visit locations such as the beach, several miles from the Recinto, which has several restaurants, a casino, and "El Faro", an old light house that is a symbol of La Serena. A little closer, there is La Recova, a bazaar with many different souveniers, also located near several restaurants, a museum, a grocery store, and the town plaza, "Plaza de Armas".

2 Computers

2.1 Computers at the 0.9m

The main computer you will use to take data is new-ctioa4:

new-ctioa4	observer's computer with BIW/Torrent
/home	has 425 GB of disk space
/home/observer	entry directory on new-ctioa4
/home/data	where you put data

When within the CTIO system, e.g., on the mountain, you can see an archive of images taken at the 0.9m at *http://ctiop8/instruments/BIW/images/biw_images.html*

CHECK THE DISKSPACE AVAILABLE ON THE /home DISK BEFORE STARTING YOUR FIRST NIGHT BY TYPING "df -h" OR "du /home"

The 0.9m SMARTS Fellow will move previous observers' data off of the disk so that you should have plenty of space. Still, check that there is enough room to write .fits files for all the frames you anticipate you will take. Each quarter chip .fits file on the 0.9m takes up 2211840 bytes.

The new-ctioa4 computer is accessed through VNC using the windows machine. The station (monitor, mouse, keyboard) for this computer is the first one you see when you walk into the control room. If you for any reason need to reconnect to new-ctioa4, there is an icon that says "VNC???". The password is located "???" (attached to the top part of the desk/table?).

The guider computer is the one located nearest to the white TCS tower. You should never need to fiddle with the software. There are some basic guiding commands taped to the keyboard and above the monitor. There is also a guider manual located ???.

The TCS computer has two work stations: one between the guider and windows machine work stations and one upstairs in the dome.

The other computer you may use is ctio36:

ctio36	additional computer
/usr/u361/v12	home directory on ctio36
/usr/u363/v12	storage location for RECONS and SMARTS data

You can ssh to other computers on the mountain. TJH has a file of tricks called .alias where some favorite quick commands are kept. You can make your own such file and activate it by typing "source .alias" to make your commands work.

If the ctio36 machine locks up, you can try rebooting by holding the [STOP] and [a] buttons down simultaneously. Then, answer *sync* at the prompt. The root password for ctio36 is on a piece of paper in PIBOXito in case you need it to reboot.

The printer at the 0.9m is called np36. So, you can print a file using *lpr -Pnp36 file.ps*.

2.2 Remote Access

new-ctioa4

ssh -l observer new-ctioa4.ctio.noao.edu — use new-ctioa4 password

cd /home/data is where data are taken and stored
du -h /home/data to find out where space is being used

ctio36

ssh -l v12 ctio36.ctio.noao.edu — use v12 password

cd /u363/v12/SMARTS is where SMARTS user data is kept

3 Telescope Control

3.1 Overview

3.1.1 Limits

airmass	varies	Declination dependent (plot to be included)
wind	40 mph	might want to use wind screen at ∼20 mph
humidity	85%	
liquid nitrogen duration	12 hours	usually a fill at the beginning and end of a night is sufficient

3.1.2 Weather Conditions

Current On-Site Conditions:
- Tololo Site Environmental Webpage

To Check the Sky:
- CTIO Optical Sky Camera — No auto-refresh
- CTIO Optical Sky Camera — Internal, Auto-Refresh
- RASICAM — Infrared All-Sky Camera, Internal

To Check the Forecast and Satellites:
- CalSKY
- Intellicast Infrared Satellite Loop -OR- El Dorado Weather Infrared Satellite Loop

In the case of possible precipitation, mountain staff will usually come by to cover the telescope with a plastic tarp. Always check with and listen to the staff at the 4m.

3.2 Telescope Control

3.2.1 Manual Control — *Section in Progress*

- Slewing

  There are two telescope+dome control paddles — one located in the dome and one located in the control room. Each of these paddles controls the dome rotation (bottom of the paddle) and the telescope slew (NSEW buttons, top of the paddle).

- Focus

  Focusing the telescope is done manually using a paddle attached to a hook in the control room. The hook is attached to the top shelf of the large desk, between the TCS and windows machines. You should see a little box on the shelf displaying a number with three decimal places (the current focus value). There should be a small piece of paper also attached to the desk nearby with a general guide to focusing the telescope. One thing to remember is that when lowering the focus, one should go a few hundred down in focus before coming back up to the intended focus (ex down to 11,300 then back to the intended 11,600). This avoids slippage of the secondary. Note that the paddle has different speed options for adjusting the focus.

- Dome Control

  The two telescope+dome control paddles are for use with the dome as well. With them you can rotate the dome east or west. The paddle in the control room is often used for this purpose when the dome gets stuck and a sound like circuit breaker slamming can be heard repeatedly. Simply nudging the dome east or west will do the trick to fix this problem.

  The dome can be opened or closed with another paddle in the control room that has a little switch on the side. This switch opens and closes the dome.

- Wind Screen

  The paddle used to open and close the dome is also the paddle used to raise and lower the wind screen. There should be two green buttons on the paddle for wind screen control.

- Nuances

  1. To leave the mirror cover position, you have to manually slew west a bit using the paddle. Once you've moved the telescope to a slightly higher altitude, you should be able to use the TCS to get back to zenith.
  2. The dome azimuth and the telescope azimuth don't have to be the same on the TCS. It's the "Dome Error" you want to keep an eye on.
  3. The dome sometimes gets a bit stuck. You will hear a sound like a circuit breaker repeatedly slamming. If this happens, just use the paddle near the white electronics tower to move the dome slightly east or west (try one, and then the other if it doesn't work). This will fix the problem.

3.2.2 Telescope Control System (TCS) — *Section in Progress*

NOTE: Extensive manuals are located in the large black binder (more specifics to be included).

Basic controls are as follows: enter the coordinates of your desired target into the window. Be sure the epoch is correct. Click "apply" and make sure that your star is not at an unreasonable airmass (ex: below airmass 2.0 is definitely safe. See Section 3.1 for more specifics). The hour angle of your target should also appear. When you are confident, click slew. Note that there is a STOP button in case of emergencies, should a mistake be made. You will hear three chimes as the telescope begins to slew and three chimes again when it stops.

One of the tabs includes pre-programmed positions such as zenith, mirror cover, and flat field positions.

A list of coordinates can be entered into the TCS for use throughout the night.

3.3 Guide Camera Control

If an exposure is longer than 300 sec, find an appropriate guide star on the AUTOGUIDER. If the exposure is shorter, you typically don't need a guide star. If you are having problems with the AUTOGUIDER, you can reboot it using

login: camera2000
password: ev500gate

The autoguider controls are simple. Use the arrow keys to move the white box around a bright guide star — you can adjust how fast the box moves by changing the "Increment" value from 1 = slow to 10 = fast. Hit F9 to start guiding, and F8 to stop guiding. The 0.9m's tracking is usually perfect for exposures of 300 seconds or less. In fact, sometimes it seems 600 second exposures are BETTER WITHOUT THE GUIDER ON.

The 'Camera Head Control' window is useful for the following items. It is accessible from the CTIO PC GUIDER 5.0.1' window, under the 'Window' menu.

If the arrow keys control the mouse, click the 'snap' button.

If you cannot see stars in the autoguider, set 'Erase' to 'off'. Alternately, try LOWERING the gain on the guider camera.

Try to avoid integration times longer than 1000 ms.

3.4 Opening

3.4.1 Before Observing

More Observing Directions: A single page of fundamental instructions on how to open/close the dome, move the telescope, etc. can be found in the observing room. It should be on the shelf above the Telescope Control System monitor, but could have wandered somewhere, including into the front of the blue OBSERVING PROCEDURES binder or black "0.9m Tel. Manual" binder. In that binder, there are more directions on using the 0.9m on white pages covered with plastic in the OBSERVING section. Additional information with lots of details about operating the telescope can be found in the large black OBSERVING PROCEDURES binder.

Humidifier: It is often quite dry at CTIO, so TURN ON THE HUMIDIFIER (high setting) in the observing room. This will help prevent zaps to computers and you due to static charge.

3.4.2 Opening Procedure

1. Turn on the fans over the primary mirror using the blue dial that says POWER FANS CONTROL above the observer's computer. Turn it to the vertical mark on the dial, around 30.

2. Turn on the large fan that ventilates the dome (and open the door to upstairs). The switch for the large fan is in the electrical control box in the northeast corner of the first floor. There are pieces of tape labeled FAN to guide you.

3. Make sure the dome lights and computer screen are off, the windscreen is down, the slit is open, and the platform has been lowered.

4. To set the dome position, line up the black tape marks on the rotating and stationary parts of the dome. In the observing room, make sure the toggles for AUTO DOME and DOME TRACK are down (off). On the TCS initialize the dome by using the Telescope ... Initialization ... Dome/Other buttons. Set Dome Position to 90 and hit Apply.

5. Turn the TRACK, DRIVES, AUTO DOME, and DOME TRACK toggles up for on. The TRACK/AUX TRACK green toggle green is sometimes taped so you don't use it — it seems to be ok in either the up or down position, presumably because both the TRACK and AUX TRACK values are set to sidereal.

6. Be sure that the HALT MOTORS red button is sticking OUT for the telescope to be able to move.

7. Zero the pointing of the telescope by setting up on a bright star. You can either choose a star from the The Astronomical Almanac book in the observing room, or use the zenith file on the TCS computer. Make sure you enter the correct epoch if you use the Astronomical Almanac book. Otherwise, to get to the zenith file, click on the Shared Documents icon on the desktop, then click on the file called zenith.

   See Section 4 for Camera Control. Then, take exposures and center the star on the chip at (512,512), using "offset" as needed. Be careful to use a short exposure time; 1 second at I is usually plenty for stars brighter than magnitude ∼4.

   The default orientation on ds9 for Torrent (the new system) is North down and East left (same as it was on ARCON).

8. Initialize the telescope by using the TCS machine. Use the Telescope tab and choose Initialization. Adjust three things:

   (a) Date/Time — match it to the red digital readout on the white tower

   (b) Telescope — zero point (fixes the pointing of the telescope — be sure you are using the correct epoch!)

   (c) Dome/Other for dome alignment

   WHEN INITIALIZING THE POINTING, BE SURE THAT YOU HAVE THE CORRECT EPOCH FOR THE COORDINATES OF YOUR STAR. IF YOU DON'T, THE TELESCOPE WILL POINT INCORRECTLY.

9. To see if all is well with the telescope pointing, choose a second bright star, slew to it, and take a frame. You can skip this step if you are confident that the telescope is pointing properly.

10. Reset the Epoch readout on the TCS to 2000.0 by clicking on the Telescope tab, pulling down to Misc. and use the Display Epoch / Side of Pier tab to set to 2000.0.

11. Go to the first target star and take a test image. Inspect the result using imexam, then the following commands:

    "e" for a contour plot

    "r" for a radial plot

"s" for a surface plot

"v" twice gives you a cut across the image

"m" to get average counts in a 5×5 box

12. Focus using the Focus button on the GUI, which relocates a star image on the CCD so that you get a series of several star images at different focus values. Choose 7 integrations of 10 seconds in the filter of choice with focus increment of 30-50, depending on how well you think you know the focus already. You have to change the focus by hand, so change the focus value using the small gray metal box with the two black buttons and then hit <RETURN> to take the next exposure. V and R are expected to have the same focus at the 0.9m, while I is approximately 35 units to larger numbers.

    When you change focus from a larger value to a smaller value, remember to offset the focus about 400 units "in" (e.g. 15000) and then go "out" (e.g. 15400) to the desired focus value. This way you move the secondary mirror against gravity, and prevent backlash problems that are known to be present in the focusing mechanism.

    When displayed, the focus frame will have 7 dots/star and THE GAP WILL BE AFTER THE FIRST EXPOSURE IN THE FOCUS SEQUENCE.

    The focus is a function of temperature and telescope pointing. It is therefore best to check the focus for each target before taking observations that you plan to keep. To check the image shape, type "ql", put the cursor on a non-saturated but well-exposed single star, and type "e" — this will display a contour plot on the graphics window, look for elongations in X or Y. For astrometry, take special care to be sure that the focus is excellent — the parallax reductions are much better with round images!

    DELETE ALL FOCUS FRAMES TO MAKE DATA ORGANIZATION EASIER

3.5 Closing

3.5.1 Shut Down the Telescope

In the computer room:

1. Turn track and dome track off (TCS black box below guider) IF YOU DO NOT, THE TELESCOPE WILL CONTINUE TO MOVE WHILE YOU'RE FILLING THE DEWAR.

2. Turn off the fans over the mirror using blue dial above observer's computer.

In the hallway:

3. Turn off dome fans (in the circuit breaker box).

In the dome:

4. Slew to Zenith position (button on Windows computer).

5. Push in the two dark slides.

6. Slew to the cover position (button on Windows computer), and replace the cover.
7. Close the slit and windscreen using hand paddle.
8. Slew west using the hand paddle to get the telescope moving.
9. Slew to Zenith position (button on Windows computer).
10. Fill the dewar.
11. Make sure the platform is down.
12. Turn off master power.
13. Turn off all the lights.

In the computer room:

14. Turn off DRIVES, AUTODOME, and hit red HALT MOTORS button so that it is IN = OFF.
15. Fill out end-of-night report. http://www.ctio.noao.edu/new/Tools/Forms/EON/index.php
16. Turn off lights and monitors to save energy.

3.6 RECONS Only — End of Night

3.6.1 Check and Send Headers

If you are observing for the RECONS team, be sure to check your headers as you go or at the end of the night. If you are especially tired, do this the next day during calibrations.

1. **CHECK** — Headers can be checked by typing ***imhead *fits*** in the iraf terminal and comparing the resulting printout to what you've written in the log book.

   Alternatively you can type ***hselect *fits '$I, object' yes*** to display the same information.

   Also be sure to check that the file number is correct. For example, you may have in the log book that a certain star is image 110, but the filename is f111.fits for some reason.

2. **FIX** — If you find a mistake in one of your headers, change it by typing ***hedit*** filename ***object*** and following the steps to correct the header.

   To change the name of a file, simply type in the iraf window ***mv*** **filename newfilename** OR ***imrename*** **filename newfilename**. BE CAREFUL NOT TO ACCIDENTALLY OVERWRITE ANOTHER FILE. Although the data are automatically backed up by NOAO, it can be a pain to recover.

   See another method below for the case where many filenames need to be changed.

3. **FORMAT FOR ARCHIVING** — If your fits files are not already in the format YYYYMMDD.09.###.fits (perhaps they are in the format f###.fits), then they will need to be renamed. The easiest way to do this is with the imrename command in iraf:

   Create list of current (old) filenames:

   *ls *fits >> old*

   Open textfile of names:

   emacs old &

   Your 'old' file will look something like:

   f001.fits

   f002.fits

   f003.fits

   f004.fits

   f005.fits

   and so on with all your fits file names.

   In emacs, change each *f* to *YYYYMMDD.09.* for each file.

   Method #1:

   - Highlight everything with the mouse.
   - Press Esc-x
   - At the bottom of the emacs window, you should be able to type in a little terminal. Type *replace-string* and press enter
   - Type *f* and press enter
   - Type *YYYYMMDD.09.* and press enter
   - Save the file as 'new' by hitting Ctrl-x Ctrl-w, typing *new*, and pressing enter.
   - Exit by typing Ctrl-x Ctrl-c

   Method #2:

   - Highlight only the *f* at the beginning
   - Press Esc-x
   - At the bottom of the emacs window, you should be able to type in a little terminal. Type *string-rectangle* and press enter
   - Type *YYYYMMDD.09.* and press enter, where YYYYMMDD is the date of the observations (ex 20170807 for a night that started on August 7th, 2017).
   - Save the file as 'new' by hitting Ctrl-x Ctrl-w, typing *new*, and pressing enter.
   - Exit by typing Ctrl-x Ctrl-c

   In addition to your *old* file, you should now have a file called *new* with a list of new names, that looks like:

   YYYYMMDD.09.001.fits

YYYYMMDD.09.002.fits

YYYYMMDD.09.003.fits

YYYYMMDD.09.004.fits

YYYYMMDD.09.005.fits

and so on.

Be sure that you have the same number of rows in both the *old* and *new* files, and that the numbers at the end match up (ex: f001.fits is in the same row in *old* as YYYYMMDD.09.001.fits is in *new*). If you are unsure you have done this right, you can make a backup folder with a copy of all your fits files.

When you are confident your *old* and *new* files are good, and once you've made your backup if you've decided to do so, change the names of all your fits files in the iraf terminal by typing ***imrename @old @new***.

4. **GENERATE AND SEND HEADERS** — Once all your files are of the format YYYYMMDD.09.###.fits and your headers have been checked, you are ready to generate and send out the header files. Do this in the iraf terminal by typing ***finishctiopi*** and entering the appropriate values.

   Once you have done these 4 things, you will be ready to move the data to the ctio36 computer as described below. The SMARTS Fellow is responsible for transferring the data to ctio36 and back to Atlanta, so you do not *have* to, but you can.

3.6.2 Move Files to ctio36

Because the SMARTS Fellow will do this anyway, it's not necessary for the observer on the mountain to do this. However, if you do, the SMARTS Fellow might be appreciative.

1. Pull up a terminal window in the ctio36 machine and make directories for your observing nights.

Non-RECONS Team Observers	*RECONS Team Observers*
cd /u363/v12/SMARTS *mkdir YYYYMMDD* (ex: *mkdir 20170807*)	*cd /u363/v12/ctiopi* *mkdir YYYYMMDD* (ex: *mkdir 20170807*)

2. Back on new-ctioa4, move files to the ctio36 machine, using sftp:

Non-RECONS Team Observers	*RECONS Team Observers*
sftp v12@ctio36 enter password *cd /u363/v12/SMARTS/YYYYMMDD* *mput* files	*sftp v12@ctio36* enter password *cd /u363/v12/ctiopi/YYYYMMDD* *mput *.fits* *mput *head**

   Alternatively you can use rsync:

Non-RECONS Team Observers
On new-ctioa4, cd to data directory *rsync -avz* files *v12@ctio36.ctio.noao.edu:/u363/v12/SMARTS/YYYYMMDD* enter password
RECONS Team Observers
On new-ctioa4, cd to data directory *rsync -avz *fits v12@ctio36.ctio.noao.edu:/u363/v12/ctiopi/YYYYMMDD* enter password *rsync -avz *head* v12@ctio36.ctio.noao.edu:/u363/v12/ctiopi/YYYYMMDD* enter password

3. Don't delete the files from new-ctioa4 (where you took the data) until you've confirmed that all files are on ctio36 (typing *ls -lt * | wc* in each directory will report the number of files), and even better, copied to your home institution (for RECONS folks, back in Atlanta).

4. If you wish to rsync files to Atlanta yourself (not recommended):

   open up a terminal on ctio36 and cd to the night to move
   cd /u363/v12/ctiopi/YYYYMMDD
   type the following:
   rsync -avz YYYY yourname@astro.gsu.edu:/nfs/recons2/incoming.0.9m/YYYYMMDD*

   This will only work if you have permission to write there as a member of the RECONS group. It is also prone to hanging, so if no file has transferred for a while, <CTRL> c and retry the command. It will pick up where it left off. You will probably want to go to bed rather than wait for it to finish. Note that if you do this, RECONS people will not be able to restart it for you. When you are done, make sure all the files made it to Atlanta successfully.

3.7 Troubleshooting — Telescope

CONTACTS — Hernan Tirado, Manuel Hernandez, 4m telescope (see Section A.1)

IF YOU LOSE POINTING ... you have various options ...

(a) Make sure you are entering the correct epoch for the coordinates into the TCS for your bright star during pointing. If you are using the Almanac, use 2016.5 (or whatever) instead of 2000.0.

(b) Use the plumb-line that is hanging on the side of the telescope tube. Once vertical, type in the RA = Sidereal Time and DEC = -30d 10m 09s.

(c) Point the telescope at a bright star and center it on the finder scope, then on the CCD. Use Sirius, Betelgeuse, alpha Cen, Antares, alpha Crux, etc. They are all the alpha stars in their constellations and mag 1 or brighter. You can't miss them in the sky (even through the slit) and they are easy to find in the book. At least one is always up. What you do is lie on the floor below the telescope and eyeball the star along the finder scope. You

can usually get close enough that way to see a glint in the finder so you know which way to paddle around to find the star. Once you get the star centered in the finder scope, you can usually get it on the chip (unless someone has really screwed up the finder scope). Then, offset to center and type in the coords into the TCS.

IF YOU HEAR A SOUND LIKE A CIRCUIT BREAKER SLAMMING

This is the auto-dome controller not quite moving the dome. It happens most often when pointing near the horizon, or while the telescope is parked. Move the dome manually with the dome L/R controls on the telescope control hand paddle (in either the dome or the telescope control room) so the dome error is reduced. Dome error is displayed on the TCS monitor.

IF THE DOME STOPS MOVING

If the dome stops rotating, (1) use the hand paddle to figure out which way the dome is trying to spin (it will stop moving when you hit the button for the OTHER direction), (2) stop dome tracking, then (3) use the hand paddle to spin it the other way.

IF THE DOME WON'T CLOSE

The most likely cause is that the toggle on the handpaddle up in the dome has been left in the "OPEN" position. Move it to the neutral position and the dome will likely close.

IF THE FOCUS STOPS WORKING

If you can't get the focus mechanism to change numbers, it is likely stuck. If it is, you should not hear any sound when pressing the buttons. You can sometimes unstick the focus mechanism by moving the telescope away from your current position to change the weight-bearing vectors on the secondary. Slew away, then slew back and see if it starts working.

IF YOU RUN OUT OF LIQUID NITROGEN

Full tanks can be found on the bottom floor of the 1.5m dome. Grab one and head back to the 0.9m to fill the dewar.

IF YOU HAVE TRACKING ISSUES

If you are having what looks like streaking in the E-W direction, make sure auxiliary tracking set to "off". You can also check TCS software for tracking rate — it should read 15.041.

4 Camera Control

4.1 Overview

In May 2016 a new instrument controller called Torrent was installed at the 0.9m, replacing the honorable and venerable ARCON. The new system is called BIW, for Best Imager in the World, very appropriate for the instrument available at The Best Telescope in the World (TBTW).

There are four icons on the desktop for BIW:

start BIW	makes BIW go and opens BIW GUI
shutdown BIW	stops BIW, kills running processes, and closes BIW GUI
irafacq	creates an IRAF window for acquisition
irafred	creates an IRAF window for reduction

Information about BIW that you need to know:

THE GOOD:

1. You can use the GUI to take data instead of typing on a command line. You can also still take data much like you did with ARCON by typing commands directly into a command line. Many, but not all of the previous ARCON commands work.

2. The well-depth is 60000 AU and the CCD is linear to 0.5% (!) all the way to 60000 ADU, where the wells saturate.

3. Correct TCS (Telescope Control System) information is transferred to the headers.

4. Offsets are sent directly to the TCS, so when using the offset command, be careful to set pointing X,Y coordinates correctly, and then sit back and enjoy NOT having to do offsets manually.

5. Frames are written in .fits format rather than the old .imh and .pix files.

6. The upgrade from the Sun computer to a more modern Windows machine has had two positive benefits: (1) more memory on the acquisition machine and (2) higher overall processing speed, which makes up in part for slower readout time described below

THE BAD:

6. readout times are slower than with ARCON — 66 sec vs 45 sec for quarter chip, single amp

7. readout noise is now 8-10 e- instead of 2-3 e-

8. there is only one gain setting = 3 e-/ADU

9. stars with 20000 counts or more have trails at the 1% level to the west due to readout

4.2 Connecting

The camera control software is on new-ctioa4, which is accessed via vnc viewer on the windows machine. It is likely that the vnc viewer will already be set up for you.

4.2.1 BIW Startup

1. To start BIW, click on the start BIW icon that looks like a small camera.

   Many windows come and go upon starting, and four will remain:

OPTGUI	your control panel to take observations
PanVIEW	a running dialog of what's happening
SAOImage	a window to look at your data
IRAF Window	where you work with your data using IRAF
ENV	you can minimize this one to get it off the desktop (but don't shut it down)

2. Click on the irafacq icon to get an IRAF window that displays the image just taken.

3. Better yet, click on the irafred icon to get an IRAF window that gives you a red command line box for IRAF and an SAOImage window to evaluate the image.

   If for some reason you need to use BIW from the ctio36 machine:

   (a) login to ctio36 machine with v12 and the usual password.

   (b) Click on lower left blue button with f, slide to System Tools, then Terminal (the one with the yellow background when it comes up), and you should get a window.

   (c) If needed, reset the screen resolution by typing "nvidia-settings"
   click X Server Display Configuration
   click Resolution 1400 X 1050

   (d) Then in the terminal window, type vncviewer new-ctioa4:1
   password = vnc4observer

DO NOT GO TO THE LOWER LEFT CORNER OF THE INTERFACE WINDOW (the multi-color icon that brings up K Menu) AND LOG OUT!

4.3 Before Observing

4.3.1 Setup

Setting the directory

- create directory under /home/data titled YOURNAME
- create subdirectory called something like"n1" for night 1 and cd to it so that you now have /home/data/YOURNAME/n1 as your working directory
- enter /home/data/YOURNAME/n1 as the directory in the GUI

4.3.2 RECONS Calibrations

Only one set of calibration frames is taken each night. The set of calibration frames should be for either the full-chip or quarter-chip mode, BUT NOT BOTH, because it takes several hours per set. Science images may still be taken in both setups during one night, but calibration frames from a different night will be used during data reduction.

For both the full-chip and quarter-chip setups, bias frames (called "zero" in the GUI and headers) and VRI dome flats should be done. You should take 17 zero frames, 11 V dome flats, 11 R dome flats, and 11 I dome flats. This makes a total of 50 calibration frames. Before taking any type of calibration frame, it is best to take a test frame to see if everything

is working as expected. You can use the gray "TEST" button to take a test frame but not save it (and not increment the frame number).

1. Set Observer = YOU! and Proposal = RECONS.
2. Set Path /home/data/YOURNAME/n1 (typically).
3. Set Basename = f.
4. Click Observation Type = Zero and Comments = zero
5. Click Geometry and set the following:

   Amplifier = upperleft (AMPLIST = 21 in header)

   Binning X = 1 and Y = 1

   click on predefined ... Select ... Quarter ... the boxes show:

   X start = 513 Y start = 513
   X box size = 1024 Y box size = 1024
6. Click TEST to get a test bias frame and check the counts with imstat. You should get around 1286 counts.
7. You want to get the beep working so that you are notified when the frame is done reading out. Connect audio jack cables (3 prongs on one end, 2 on the other) between the old Aiwa stereo output in the back (2 inputs) and the right 2 inputs on the back of the Torrent Trendsonic computer (right behind the observer's monitor). Note that the pins are different sizes, so there's only one way to do it. Set the Aiwa stereo to VIDEO/AUX and turn the volume up. You should now hear the beep.
8. In the control room, turn on the flatfield lamps using the toggle on just under the red time readout on the tall white tower.
9. Push the green button on the MASTER POWER switch. You can also do this from the dome.
10. Push the red HALT MOTORS button so that it is in the out position (it should light up, but sometimes the bulb fades).
11. Turn on — flip up — the DRIVES toggle lever, but leave all of the others off (TRACK, AUTO DOME, EXTERNAL COMPUTER, DOME TRACK) except DRIVES, which you flip up to turn them on.
12. Go upstairs, pull out the dark slides, check that all three flatfield lamps are on, make sure the mirror cover is off the telescope, and check that the telescope is pointed at the white spot. If the telescope is not pointed toward the white spot, back in the control room you can do it by turning on the power to the telescope via the TCS in the large white rack of computer equipment:

13. Point the telescope to the white spot using the Offset/Zenith tab on the Movement panel on the TCS screen. Choose Set Punto Blanco/Flat Field and click Start Slew. You can do this in the dome using the monitor up there, or back in the control room.

    Begin Interlude about V Filters

    As of August 2009, we again use the oV = old V = Tek#2 V filter, which has a several millimeter sized crack in one corner. WE MUST USE THIS FILTER FOR GOOD ASTROMETRY! We had switched to the nV = new V = Tek#1 V = replacement V filter. There is a tiny one millimeter crack in the very corner of this backup V filter. The nV filter is the standard one used for SMARTS programs because most people (a) don't care which V filter is used and (b) we don't know for sure if the crack in the corner of the oV filter affects FULL CHIP observations, which most people do. So, both filters are in the UBVRI wheel.

    End Interlude about V Filters

14. The filter wheel that holds the UBnVRIoV filters should be in the following configuration for the 8 available slots:

	slot1	slot2	slot3	slot4	slot5	slot6	slot7	slot8
named	u	b	nv	r	i	ov	-	-
filter	U	B	nV	R	I	oV	-	-
			Tek1	Tek2	Tek2	Tek2		

    On your first night, or when BIW loses track of filter positions, carefully check that the filters are the correct ones and are in the slots that BIW is telling you. Do this by spinning through the filters.

15. Back in the control room, on BIW set the filters to cb and ov to start. Take test frame (about 30 sec is enough integration time), note mean counts with imstat, subtract the bias level, and get baseline counts for ov filter to which you will compare other filters.

    USE THE COLOR BALANCE FILTER "cb" IN FILTER WHEEL #1 TO BALANCE THE QUARTZ LAMP EMISSION TO SKY COLOR

16. Take a test frame in each filter and calculate the counts after subtracting the bias level. You should get the following count ratios:

    FOR 30 SEC ON 2016.1128, THE FOLLOWING WERE THE COUNTS (AFTER SUBTRACTING THE BIAS COUNTS) THE RATIOS MATTER MUCH MORE THAN THE NUMBER OF COUNTS

U	172	2.3 %
B	3955	53.3 %
nV	7241	97.6 %
R	6869	92.6 %
I	5946	80.1 %
oV	7421	100.0 %

17. To take the full set of calibrations, including biases and flats, click gray "flats" button in the lower left of the GUI. That gives you a new window called FLATS. For a standard set of CTIOPI calibration frames, Load the script "*/home/observer/scripts/ctiopi.calibrations*" in the Path box at the top of the FLATS window. Make sure you have the Basename

set to "f" and Image Number set where you want it (typically 1), then hit the"GO" button.

Alternately, you can write your own script and put it in /home/observer/scripts, or edit the parameters manually to get what you want. Three important things to know if you do that:

- click the"modify" button to make your changes stick
- highlight the first line in your sequence before starting, or the sequence will start with the last line you modified
- click the"GO" button to run the script

For dome flats choose an exposure time that gives about 30000 counts in each filter (a range from 20000 to 40000 counts is acceptable). Integrations of about 120 sec are usually fine, giving about 30000 counts in the flats (highest in V, lowest in I).

YOU WILL LIKELY GO TO DINNER AT THIS POINT

18. Turn the flatfield lamps off when the flats are done and checked.

19. Once you have frames,"imstat f*" to get the average counts in a frame to see if everything is ok. You should get about 1286 counts for zeros and 20-30K for VRI flats.

    "qlook" ("ql" will suffice) to inspect the frame. Use IRAF commands in imexam to check the image:

    "e" for a contour plot

    "r" for a radial plot

    "s" for a surface plot

    "v" twice gives you a cut across the image

    "m" to get average counts in a 5×5 box

    FOR ZEROS, YOU SHOULD GET ∼1286 COUNTS (as of 2016.1128).

    FOR DOME FLATS, YOU SHOULD GET 20000-40000 COUNTS

    HIGHEST IN V, LOWEST IN I

    120 SECOND INTEGRATIONS ARE USUALLY ABOUT RIGHT

20. "imhead" to check the frame size — you should end up with a file size of [1074,1024] for 1,099,776 total pixels. Note that via ARCON, the size was [1098,1024] starting 2013.0401 or (usually) [1118,1024] before 2013. We don't understand why this changed. It doesn't affect reductions as the differences seem to have to do with the location of the bias columns.

4.4 Camera Control

4.4.1 BIW Main GUI

There are four panels in the GUI for BIW/Torrent:

1. Upper left gray panel has various diagnostics, including the CCD temperature (∼165K), other temperatures, and Telescope Control System (TCS) information. This is also where you enter your name and the proposal (RECONS for us).

2. Upper right tan panel shows what the CCD is doing. You will stare at this a lot.

3. Middle right gray-blue panel is where you enter the path for your data = /home/data/n1, the file name = f, and number = 1. The Image Number will index as you take frames.

4. Lower blue panel is where you control the exposure you want to make. NOTE: When changing the number of exposures or the exposure time, hit <RETURN> to make it stick.

The various buttons, pulldowns, and boxes to fill are described here, listed in alphabetical order:

Basename	extension for filename (RECONS uses "f")
Display	use to reinitialize SAOImage window if it hangs
EXIT	get out of BIW smoothly
Exp Time	if you need to change the integration time, just type in the new number and return
Filters	choose your two filters. Filter assignments can be found in the file: /home/observer/apps/BIW/config/DEV_FILCT09M_filters.list
flats	is used to queue a set of observations, typically calibrations. You can make your own specific script in the /home/observer/scripts directory. RECONS uses /home/observer/scripts/ctiopi.calibrations
Focus	is used to focus the telescope. Enter the exposure time, number of exposures, and the focus value for the first image. The charge is transferred along the CCD so that you get several star images in a line to inspect for focus. You adjust the focus manually between each exposure and hit <RETURN> when you are ready for the next one. The file is written to disk in your data directory. Delete the file and reset the counter when you are done if you don't want to keep the focus frame. NOTE: The gap is after the FIRST exposure.
Geometry	allows you to set the detector how you want it, including amplifiers you want to use (4 is fastest, 2 is medium, 1 is slowest), binning, and the Region Of Interest (ROI), you want. The ROI is typically Full for most observers who want the 2048X2046 full chip. RECONS uses Quarter mode, so the setup looks like:

Amplifier = upperleft (AMPLIST = 21 in header)
Binning X = 1 and Y = 1
click on predefined ... Select ... Quarter
the boxes should then show:
X start = 513 Y start = 513
X box size = 1024 Y box size = 1024

Image Number	number of the file
Observation Title	what you want to call the image
Observation Type	choose Object, Zero, Dark, Dflat, Sflat
obslist	can be used to input a list of objects
Path	where data will be written, typically /home/data/n#
Pause	pause the exposure (dark time clock continues)
Resume	appears when Pause(d) to resume the exposure
Scripts	can be used to run scripts (not tested, DEC 2016)
Start	take the image or sequence
Stop	stop single exposure AND the entire sequence last image will be written to disk

4.4.2 IRAF Commands

A fairly comprehensive list of commands you can use for observing is given here. If you don't want to use the GUI, you can still do lots of things in an IRAF window, much as you did with ARCON, such as:

<CTRL> d		to save any parameter changes in IRAF
:q		to save any parameter changes in IRAF
ctiopi	*	loads useful scripts for CTIOPI, including

finishctiopi
offset
qlook

display		is the command that puts the image in the SAOImage box. It is best to [epar display] and make sure that the parameter "fill" is set to "yes" so that the image fills the box. There are a million subtleties to [display] that you can pretty much ignore for data-taking purposes. Note that in the login.cl it should say "set stdimage=imt800" to display correctly "set stdimage=imt2048" try if weird things happen
doobs		is used to set up a series of observations and is very useful for flats (take 11 exposures each in the filter sequence "v,r,i").
epar		is the command you type to get inside each package to change parameters. You keep the changes and exit the package by typing <CTRL> d.
finishctiopi	*	when observing for CTIOPI, makes .fits files, creates header files, and emails them. The script is located at /home/observer/ctiopi on the newctioa4 machine.
flpr		resets window commands after aborting or stopping. Type it three times to be sure.
hedit		is useful if you misname the file — use it to change the title to one of the following formats: STAR0088 at R for pi STAR0088 at R for phot STAR0088 at R for pi and phot STAR0088 at R — clouds STAR0088 at R — bad STAR0088 at R — sat
hselect		used to example keywords in IRAF headers, very useful
imarith		is used to add/subtract/multiply/divide images, i.e. basic arithmetic.

imexamine	is very useful when taking data. Type [imexamine] to get a cursor on the image in the imtool box. Type "r" to get a radial profile to see if a star is saturated (60,000 counts) or has enough counts, and to check the FWHM/seeing. Type "e" to get a contour plot to see if the focus is ok. Type "a" to get a readout of the peak value. Type "m" to get counts in a 5x5 box to get a sky noise estimate. Type "v" twice to get a plot along a vector where you mark the two ends. Type "s" to get a surface plot. NOTE THAT YOU MUST HAVE A SQUARE BOX FOR THE IMEXAMINE WINDOW TO LOOK AT THE SHAPE OF THE IMAGE — A RECTANGULAR BOX WILL FLATTEN THE IMAGE AND MAKE IT LOOK IN FOCUS WHEN IT IS NOT!!!
imhead	typed alone, this will give you short header names for each file taken and show them on the screen. Typed as "imhead f* ¿ look" will make a file called look that lists all of the frames taken. If you [epar imhead] you can change "longhead" to "yes", <CTRL> d out of it, and then get all the details of the observation. Type "imhead f001 long+" to see the full header of a single file.
zero	takes a bias frame with exposure of zero seconds

* — *CTIOPI scripts that are now found in /home/observer/ctiopi*

Obsolete IRAF Commands

x	lpar telpars	telescope parameters, e.g. focus
x	lpar detpars	detector setup parameters, e.g. pixels used, gain
x	lpar instrpars	instrument parameters, e.g. current filter positions
x	lpar wheel1	assignments for filters in wheel 1 (epar to edit)
x	lpar wheel2	assignments for filters in wheel 2 (epar to edit)

4.4.3 Terminal Window Commands

flt init	initializes both filter wheels to slot 8 in wheel1 and 5 in wheel2
tcs info	shows information about where the telescope is pointed and more

4.4.4 Directories and Filenames

The location for data is /home/data

Create a directory for your first night, e.g. "mkdir n1". To move into the desired directory to take data or the night, type "cd n1".

Type "ctiopi" to load a set of very slick scripts that will allow you to do cool things — see the IRAF COMMANDS section above.

4.4.5 Observing Scripts

IN IRAF WINDOWS, TYPE "ctiopi" TO LOAD THE OBSERVING SCRIPTS

Files will have names corresponding to what is in the Basename box on the GUI, "f" for RECONS. You can also set the frame number in the "Image Number" box. Numbers will be appended during the night, so that the first frame will be f001.fits, the second will be f002.fits, etc.

4.5 Camera Properties — *Section in Progress*

5 End of Run

5.1 Before Leaving the Telescope

5.1.1 Getting Your Data

Before leaving the mountain, it is good to back up your data on the ctio36 computer. For directions on how to do that, see 3.6.2. If you do not do this on your own, the SMARTS Graduate Fellow will do it for you after your run. However, you may still want to do this yourself: in some ways it is easier to get your data from the ctio36 machine. Although it is becoming old school, the ctio36 machine has a DVD writer that can be used if you bring a DVD. You can also plug in a flash drive or rsync or ssh the data to your home machine.

It is important to get a copy of your data before you leave the mountain, because external access to the network is limited.

If you find you need a copy of your data after you've left the mountain, you can contact the current SMARTS Graduate Fellow, who will be able to help.

5.1.2 Cleaning Up

- Be sure to label any food left in the fridge with the date you bought/opened it. Throw out any food that is expired.
- Make sure the heater and lights are off.
- Be sure to complete the End-of-Run Report.

5.2 Leaving the Mountain

Report to the round office building to pay bills and return your key. This is also where you will catch the carry-all back to La Serena. Be sure to show up for the carry-all *ON TIME*. If you are planning to catch a flight right after you leave the mountain (rather than staying in La Serena for the night), you can tell the driver to take you to the airport ("aeropuerto" in Spanish) instead of back to the AURA Recinto. Otherwise, be sure to request a taxi from the Recinto to the airport in the travel form.

Safe travels!

A Appendices

A.1 Resources

A.1.1 Help on the Mountain

Observer Support	dial 421/422
4m	dial 400/401/402
Electronics Support	dial 412/417
Medical Center	dial 430

A.1.2 SMARTS 0.9m Contacts and Information

SMARTS 0.9m Web Page	http://www.astro.gsu.edu/∼thenry/SMARTS/index.htm
SMARTS 0.9m Director	Dr. Todd J. Henry scheduling, troubleshooting, financial management *thenry[at]astro[dot]gsu[dot]edu*
SMARTS Graduate Fellow	Michele L. Silverstein scheduling, troubleshooting, data management *silverstein[at]astro[dot]gsu[dot]edu*
CTIO Travel Specialist	Ximena Herreros all travel related questions *xherreros[at]ctio[dot]noao[dot]edu*

A.1.3 Radio

As of DEC 2016, good radio stations (at least by TJH's standards) include 88.9, 100.9, 101.5 and 102.1. The second one has been known to play the Pet Shop Boys, so listen at your own risk.

A.2 Non-Sidereal Tracking — For Solar System Objects

Non-sidereal tracking is a three-step process.

1. Confirm whether you have the non-sidereal tracking rate, or the CORRECTION to sidereal tracking rate.

2. The tracking rates are controlled on the DFM control window (Windows computer) under the Telescope → Rates menu option. The entire non-sidereal rate should be entered in the bottom set of boxes, not just the correction. Hit apply.

   For reference, the *sidereal* tracking rate is 15.0411 arcsec/sec (RA) and 0 arcsec/sec (DEC)

3. On the black TCS control box, flip the green tracking switch to 'Aux Track'