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 — ¡Bienvenidos a Chile!

The CTIO/SMARTS 0.9m telescope is operated by the RECONS team, currently headquartered in Atlanta. The main contacts are Todd Henry and Eliot Vrijmoet. 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].**

1.1 Preparation

There are three things to do:

1. **Travel Arrangements:** Be sure to fill out the Travel Information Questionnaire[2] at least **one month** before your observing run. In the "Proposal Number" field 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[3] at least **one month** before your observing run. This allows us to catch any problems, such as whether or not your requested filters are already 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[4]. 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; this is where you will be staying if you arranged through CTIO 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. You can change currency at the Santiago airport (but probably not at the La Serena airport) at an AFEX window, or later at an ATM outside the airport.

Coming down the mountain — To return to the airport after your observing run, you can request a taxi from the Recinto in La Serena 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

[1] http://www.ctio.noao.edu/noao/content/Visiting-Astronomers-Travel-Guide
[2] http://www.ctio.noao.edu/noao/content/Travel-Information-Questionnaire
[3] http://www.ctio.noao.edu/noao/eform/submit/vistor-support-questionaire
[4] http://www.ctio.noao.edu/sys/dhcpform.php

("aeropuerto" in Spanish). If you have planned to stay at the Recinto in La Serena after your run, the carryall driver can also take you there.

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 with you 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 Questionaire[5] includes questions about transportation from the airport to lodging in town at the Recinto (AURA offices), 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."

[5] http://www.ctio.noao.edu/noao/content/Travel-Information-Questionnaire

2 Essential Telescope Information — Never Forget These Things!

2.1 Telescope/Facility Limits

airmass	varies	Depends on declination (See Section A.2).
wind	40 mph	Use wind screen at ∼20 mph.
humidity	85%	
liquid nitrogen duration	12 hours	Filling at the beginning and end of the night is usually sufficient.

2.2 Weather Conditions

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.

To check CTIO's current humidity, temperature, wind, and more:

- CTIO Site Environmental Conditions (auto-refreshes)

  https://noirlab.edu/science/observing-noirlab/weather-webcams/cerro-tololo/environmental-conditions

To check the sky:

- CTIO Optical Sky Camera (does not auto-refresh)

  https://www.ctio.noirlab.edu/~seecam/CTIO_webcam.jpg

- Cameras for all NOIRLab facilities, including CTIO:

  https://noirlab.edu/science/observing-noirlab/weather-webcams

(the following "internal" links are accessible only from within CTIO)

- CTIO Optical Sky Camera (internal; does auto-refresh)

  http://139.229.13.119

- RASICAM — Infrared All-Sky Camera (internal)

  http://rasicam.ctio.noao.edu

To check the weather forecast:

- `yr.no` forecast (Norwegian Meteorological Institute)

  https://www.yr.no/en/forecast/daily-table/2-3895825/

- Satellite loop from NOAA

  https://www.star.nesdis.noaa.gov/GOES/sector_band.php?sat=G16&sector=ssa&band=GEOCOLOR&length=12

- Intellicast Infrared Satellite Loop

  http://www.intellicast.com/global/satellite/infrared.aspx?region=hisasat&animate=true

- El Dorado Weather Infrared Satellite Loop

  www.eldoradocountyweather.com/satellite/misc/s.america-ir-sat.html

2.3 Additional Useful Observing Links

- Sunrise and sunset times for Cerro Tololo:

  https://www.timeanddate.com/sun/chile/la-serena

- Moon location and phase:

  http://neoprogrammics.com/moon/DE405_Lunar_Ephemeris_Calculator.php

- Sun location (RA/DEC):

  https://theskylive.com/sun-info

- Sidereal clock (use longitude = 70 deg West):

  http://www.jgiesen.de/astro/astroJS/siderealClock/

2.4 Using this Manual

For observers more experienced with the CTIO 0.9m, quick summary instructions are given in boxes marked with arrows. More detailed instructions appear below each of these summaries. For example:

⟶ Quick summary instructions will be in a box like this...

...And more detailed descriptions of those instructions will appear below in normal text, like this.

3 Setting Up at the Telescope

3.1 Computers Overview

The main computer you will use to take data is <u>ctimac5</u>. This computer is a Linux machine lying on its side in the cooled computer room. It is labeled 0.9 TORRENT ACQ PC. It should be running VNC and connected to ctimac5 automatically.

ctimac5	observer computer with BIW/Torrent
/home	has 425 GB of disk space
/home/observer	entry directory on ctimac5
/home/data	where you put the folder for your data

⟶ The password for ctimac5 is *observer_opr* (and is also written on the shelf above the monitor). If the keyboard resets, the underscore is on the *?* (question mark) key.

If the VNC is not running, click on the VNC icon on the Mac dock at the bottom of the screen. Then click on the new-ctio4:1 icon.

The **Telescope Control System (TCS)** is accessed via the computer on the desk to the left of the ctimac5 monitor. You can also access this system from the computer on the desk on the platform inside the dome.

The **guider computer** is to the left of the TCS. Basic commands for this system are on a paper taped to the shelf above the monitor.

The other computer you may use is ctio36.

ctio36	additional computer for observing
/usr/u361/v12	home directory on ctio36
/usr/u363/v12	where RECONS and SMARTS data are stored

⟶ The login information for ctio36 is on a paper attached to the wall behind that computer's monitor.

If the ctio36 machine locks up, you can try rebooting it with ALT-X, CTRL-ALT-DEL, or by pressing the reset button on its computer tower. Then, answer *sync* at the prompt.

You can ssh to other computers on the mountain. TJH has a file of tricks called .alias where some favorite quick commands are kept, located on ctio36 at */u361/v12/.alias*. You can make your own such file and activate it by typing *source .alias* to make your commands work.

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

When within the CTIO system, e.g., on the mountain, you can see an archive of images taken at the 0.9m at *http://cagvm2.ctio.noao.edu/www/instruments/BIW/images/biw_images.html*

⟶ **CHECK THE DISK SPACE 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 from the 0.9m takes 2211840 bytes.

3.2 Camera and BIW Introduction

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 six icons on the desktop, four of which are 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 (with a red background) for reduction

The other two are "xterm" and "Trash".

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 60,000 ADU and the CCD is linear to 0.5% (!) all the way to 60,000 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:

7. Readout times are slower than with ARCON — 66 sec vs 45 sec for quarter chip, single amp
8. Readout noise is now 8-10 e^- instead of 2-3 e^-
9. There is only one gain setting: 3 e^-/ADU
10. Stars with 20,000 counts or more have trails at the 1% level to the west due to readout.

3.3 Connecting and Starting BIW

The camera control software is on ctimac5, which is accessed via VNC viewer to the Linux machine in the computer room (see Section 3.1). It is likely that the VNC viewer will already be set up for you.

⟶ Start up BIW and irafred on ctimac5, if they are not started already.

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

   Many windows come and go upon starting, but ultimately five will remain:

OPTGUI	your control panel to take observations
PanVIEW	a running dialog of what's happening
SAOImage (ds9)	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)

If you plan to use SAOImage ds9 with irafred (described below), you must first close the ds9 window opened by BIW here.

⟶ If you need login information for BIW, check the laminated page located on the wall to the right of the ctimac5 monitor (the page is titled "Rebooting BIW").

If VNC locks up or the observing software crashes, follow the procedure outlined in Section A.5.

⟶ $\boxed{\text{If this is a new IRAF session, enter } \textit{ctiopi} \text{ in the red IRAF window.}}$

2. Click on the irafred icon to get both a red command line window for IRAF and an SAOImage ds9 window to evaluate the image. Enter *ctiopi* into the red IRAF window to load the relevant observing commands.

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

   (a) Log in 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 × 1050
   (d) Then in the terminal window, type
   vncviewer ctimac5:1
   password = *vnc4observer*

3. If there is a problem using the red IRAF window, the irafacq icon on the desktop also launches IRAF and SAOImage ds9 together.

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

⟶ $\boxed{\text{Set up your directory and enter its path into the GUI.}}$

4. Set up the directories for this observing run (if not already done so) and for tonight's observing.

   - Create a directory under */home/data* titled *yourname*
   - Within the *yourname* directory, create a directory called something like "n1" for night 1 and cd to it so that you now have */home/data/yourname/n1* as your working directory.
   - in the GUI, enter */home/data/yourname/n1* in the **Path** field.

5. Adjust SAOImage ds9 for optimal frame viewing (Todd-ify it).

   - Under *View*, remove everything.
   - Add back Information Panel, Magnifier, Filename, Object, Frame Information, and Physical.
   - Under *Zoom*, select "Zoom to Fit Frame."

3.4 Take Calibrations and Begin Opening Procedure

It is recommended to take a set of calibration frames (zeros and dome flats) each afternoon prior to observing. Be aware that a full set of calibrations may take several hours, depending on your readout/chip specifications and how many biases and flats you need. For example, typical RECONS calibrations of 50 frames (17 biases + 33 dome flats) in quarter-chip, single-amplifier mode take roughly two hours.

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).**

⟶ Set up the GUI for tonight's observing run.

1. Set **Observer** = YOU! and **Proposal** = SMARTS

   (RECONS team: set Proposal = RECONS)

2. Verify that **Path** = */home/data/yourname/n1*

3. Set **Basename** = f

4. Click **Geometry** to set the readout specifications. A pop-up window will appear. For quarter-chip, single-amplifier readout, use the following settings:

   Amplifier = upperleft (Click APPLY after selecting this)

   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

   RECONS only: Only one set of calibration frames is taken each night, in 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.

⟶ Take a test bias frame.

5. For taking a test frame, set **Observation Type** = Zero (leave **Comments** blank).

6. Click the grey **TEST** button to get a test bias frame and check the counts with *imstat* in IRAF. You should get around 1260 counts (checked February 2019).

⟶ Verify that the computer beep is working.

7. Take a test frame and check that the computer beeps audibly when the frame is done reading out. Adjust the Mac's volume if necessary.

8. Locate the *Quick Open Guide*, a single page of fundamental instructions on how to open/close the dome, move the telescope, etc. It should be in the control room on the shelf above the Telescope Control System monitor, but could have wandered somewhere, including into the front of the blue OBSERVING PROCEDURES binder. In that binder, as well as in the black "0.9m Tel. Manual" binder, there is a lot more

information about the 0.9m.

⟶ Go through steps #1-#7 of the **Quick Open Guide**.

9. Push the red **HALT MOTORS** button so that it is in the out position (it should light up, but sometimes the bulb fades).
   Located on the lower half (black part) of the tall white tower.

10. Turn on (flip up) the **DRIVES** toggle lever, but leave all of the others off/down (TRACK, AUTO DOME, EXTERNAL COMPUTER, DOME TRACK).
    Located to the left of HALT MOTORS, on the lower half (black part) of the tall white tower.

11. In the control room, turn on the **DOME FLAT LAMPS** using the toggle. Check that all three LEDs next to the switch turn on, indicating that all three lamps are working.
    Located under the time readout at the top of the tall white tower.

12. Go upstairs into the dome, pull out the dark slides, check that all three flat field lamps are on, and make sure the mirror cover is off the telescope.
    - Dark slides: *located above the gold dewar, identifiable by their copper-colored ends.* Pull on these endpieces to open the slides.
    - Flat field lamps: *located at the far end of the telescope tube, arranged symmetrically around the circular opening.*
    - Mirror cover: *placed on the end of the telescope when it's on, or stowed in a hemisphere-shaped holder to the left of the the LN_2 table on the platform.*

13. Check that the telescope is pointed at the white spot in the dome.

    If the telescope is not pointed toward the white spot, go back to the control room and verify that the green MASTER POWER button is on (Step 19).

    The telescope can be slewed to the white spot via the TCS software: in the Movement window, Offset/Zenith tab, under Set Punto Blanco/Flat Field, click Apply, and then click Start Slew. You can access the TCS software in the dome using the monitor up there, or back in the control room.

⟶ Take a test flat image to verify the counts.

14. Back in the control room, on BIW, set **Observation Type** to **Dflat** and set **Filters** to **cb** and **ov**. Take test frame (about 30 sec is enough integration time), note mean counts with *imstat* in IRAF, and subtract the bias level to get the counts to check.

⟶ **MAKE SURE** to set the first **Filters** field to **cb** (color balance) to balance the quartz lamp emission to sky color! If you omit this step, then your counts will be too high.

    Ultimately, we want the mean counts for each flat frame to be ~30,000, so scale up the test frame counts (i.e., the result after subtracting the bias counts from the mean counts) to ~30,000 to determine the needed exposure time.

    For example, if for a 30-second test exposure we got 9200 counts and the bias is 1200, then for a 120-second exposure we will have $(9200 - 1200) \times 120/30 = 32{,}000$ counts—right on target.

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! For a while, 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

⟶ On your first night, verify that the filters are in the correct configuration.

15. The filter wheel that holds the Johnson/Kron-Cousins filters should be in the following configuration for the 8 available slots:

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

The filter wheel that holds the SDSS filters should be in the following configuration for the 5 available slots:

	slot1	slot2	slot3	slot4	slot5
name	u	g	r	i	z
filter	u	g	r	i	z

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:

(a) Use the test filter frame from Step 14 above to get baseline counts for oV filter to which you can compare other filters.

⟶ Again, **MAKE SURE** to set the first **Filters** field to **cb** (color balance)!

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

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

THE RATIOS MATTER MUCH MORE THAN THE NUMBER OF COUNTS. The counts here were obtained (after subtracting the bias counts) from 30-second exposures on 2016.1128.

⟶ Take calibration frames (zeros and dflats) — Step #7 of the Quick Open Guide.
DON'T FORGET TO SET **Image Number** TO 1 BEFORE CALIBRATIONS!

16. To take the full set of calibrations, including biases and flats, click the grey **flats** button in the lower left of the BIW GUI. That gives you a new window called FLATS.
    For a standard set of RECONS calibration frames, enter the script */home/observer/scripts/ctiopi.calibrations* in the **Path** box at the top of the FLATS window and press **Load** (or else it won't load). For the typical RECONS observations, a full set of calibrations consists of:

    - 17 zero frames (bias frames) for 0 seconds
    - 11 V flats, 11 R flats, 11 I flats (dome flats) for 120 seconds each

    In the main BIW GUI, make sure you have the **Basename** set to "f" and **Image Number** set where you want it (typically 1), then in the FLATS window 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 30,000 counts in each filter (a range from 20,000 to 40,000 counts is acceptable). Integrations of about 120 sec are usually fine, giving about 30,000 counts in the flats (highest in V, lowest in I).

YOU WILL LIKELY GO TO DINNER AT THIS POINT

17. When the flats are completed, check that they have enough counts. In IRAF, enter *imstat f** to get the average counts in a frame to see if everything is ok.

    - For zeros, you should get $\sim$ 1260 counts (as of 2019.0201).
    - For dome flats, you should get 20,000 to 40,000 counts. Highest in V, lowest in I.
    - Your flats counts should not vary by more than $\sim$3,000 from night to night.

    If the counts are too low, then you need to increase the exposure time. Integration times of 120 seconds are usually about right.

    Inspect frames visually by entering *imexam f001.fits* (for a frame named *f001.fits*) or *quicklook* or *ql* in IRAF. More useful IRAF commands are found in Section A.10.2 of this manual.

18. Check the frame size with *imhead* in IRAF. 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.

3.5 Completing the Opening Procedure

⟶ Complete the rest of the **Quick Open Guide** steps (#8-#17).

19. In the control room, turn off the flat field lamps using the toggle switch and turn on the master power using the big green button. *The master power switch is located about halfway down the tall white tower. There is also one you can use inside the dome.*

20. Open the dome and put down the dome wind screen. Both the dome and the wind screen controls are on the same paddle:
– The silver toggle switch on the side opens and closes the dome.
– The green buttons on top open and close the wind screen.

21. Fill the liquid nitrogen dewar using the LN_2 tank on the platform. On a table on the platform there are gloves and a plastic mask that you should use for safety.

    There is a tablet at the observer's station in the control room displaying the dewar temperature and pressure. You want to see CCDTEMP at ∼163 K and DEWPRESS ∼7E-04. If these values change or if they become highlighted in orange or red, go fill the dewar with LN_2 **FAST**!

22. Before leaving the dome, verify that the dome flat lights are off, the computer monitor (on the desk on the platform) is off, and the platform has been lowered.

23. Turn on the big fan downstairs via the circuit breaker. Open the door to the stairwell all the way, so the dome is well ventilated.
The big fan switch is located on the northeast wall in the big open area behind the bathroom, ground floor. There are pieces of tape labeled "FAN" to guide you.

24. In the control room, turn on the mirror fans using the big blue dial. The "on" and "off" positions are marked on the dial with permanent marker.
Located on the shelf along the east wall, directly above the ctimac5 monitor.

25. Turn on the **AUTO DOME**, **DOME TRACK**, and **TRACK** switches. The TRACK/AUX TRACK toggle 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.
Located on the lower half (black part) of the tall white tower.

4 Science Observing

4.1 Begin Observing

⟶ Zero the pointing of the telescope by setting up on a bright star.

1. Choose a bright star from the The Astronomical Almanac book in the observing room, or use the zenith file on the TCS computer. Take careful note of the epoch if you use the Astronomical Almanac book, because when slewing you need to enter this correctly. Otherwise, to get to the zenith file, click on the Shared Documents icon on the desktop, then click on the file called zenith.

Slewing to your target: Enter the coordinates of your desired target into the TCS window, Movement tab. Be sure the Slew Epoch is correct for the coordinates you're using. Click "Apply" and make sure that your star is not at an unreasonable airmass (for example, less than airmass 2.0 is definitely safe. See Section A.2, "Hour Angle and Airmass Limits," for more specifics). The hour angle of your target should also appear. When you are confident, click Start 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.

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

Then, take test exposures and center the star on the chip at (512,512) using *offset* in IRAF. **Be careful to use a short exposure time**; 1.0 second at I is usually plenty for stars brighter than magnitude ∼4.

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

⟶ Initialize the TCS date/time/epoch.

2. Initialize the telescope using the TCS machine. Open the Telescope menu (next to "File") and choose Initialization. Adjust three things:

   - Date/Time — match it to the red digital readout on the white TCS tower.
   - Telescope — ZPOINT — enter the exact coordinates of the bright star you are currently pointing to. **Be sure you are using the correct epoch!**
   - 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.

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

4. 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.

   Now you're ready to start taking science data!

4.2 Taking Data

Before doing anything, make sure **Observation Type** is set to **Object** and the first **Filters** field is set to **dia**!

⟶ Choose an object and slew to it.

5. If you haven't already, choose your first science target! It is wise to come prepared with a list of targets organized by RA, so you can make better decisions on-the-fly about where to point and what to look at.

- RA near sidereal time (**ST** on TCS readout) is ideal for astrometry.
- Save bright targets for bad seeing and cloudy hours.

6. Enter the object's coordinates into the TCS Movement window.
   Press Apply, then Start Slew.

$\longrightarrow$ Take a test frame, enter the *offset*, and use it to estimate the exposure time for the upcoming science frames. Make sure the first **Filters** field is set to **dia**.

7. Take a test frame to check positioning and estimate exposure time.
   - Set **Observation Title** = test, and **ExpTime** = 10.0
   - Make sure the **Filters** fields are set to (1) **dia** and (2) the VRI filter specified on the setup page.
   - When everything is set up, press the grey **TEST** button.

8. When the test frame is done reading out, use it to offset the pointing to match the setup page field. Enter *offset* into IRAF and follow the prompts.
   If at any point you make a mistake, enter CTRL-c to abort the offset process.
   - After the first prompt (regarding the display frame), place the mouse cursor over the image and press *q* to continue (it begins by starting up imexam — *q* exits that so you can move on).
   - For the x and y coordinates requested by the prompt, enter the coordinates given for the pointing star on the setup page.
   - Older setup pages may need an additional pointing adjustment to match the field. We have found that moving the telescope ∼8 arcseconds west is generally a good correction.

9. Check the focus in the test frame and adjust it if needed.

$\longrightarrow$ Take your science frames!
Don't forget to first verify the filters, observation title, and exposure time.

- Use the peak counts for the "sets exposure" star (usually marked with a square on the setup page) to estimate the proper exposure time.
  For example, if your 10-second test integration produced 3,000 counts, to get 50,000 counts you need to integrate for $50{,}000 \div 3{,}000 \approx 17$ times longer, or 170 seconds.

10. Enter the target name and VRI filter in the **Observation Title** field using the appropriate format.

11. Press the red **Start** button to begin exposing.

12. When the image is done reading out, the computer will beep 6 times. Check it in case any offset or exposure adjustments are needed before taking more science frames.

- View the image with *ql* in IRAF, and use *e* to check the focus and *r* to check the peak counts and seeing for exposure-setting star.
- Display the test frame and check that all the reference stars are in frame and not on the bad columns.
- Adjust the exposure time if the peak counts are greater than 60,000 or lower than ∼40,000.

13. Press the red **Start** button to begin the next science exposure. After each readout, **check the frame** with IRAF (as in Step 12 above) in case the focus or exposure time needs adjusting to account for seeing changes or clouds.

4.3 Focusing

Focusing automatically: Use 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.

Focusing manually: Use the 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 new-ctioa4 monitors. You should see a little box on the shelf displaying a number (in green) with three decimal places — this number is the current focus value. To the right of this box, attached to the shelf above the new-ctioa4 monitor, there should be a small laminated paper with a general guide to focusing the telescope.

When you change focus from a larger value to a smaller value, remember to offset the focus about 400 units "in" (down, e.g. to 15,000) and then go "out" (up, e.g. 15,400) to the desired focus value. This way you move the secondary mirror against gravity, and prevent slippage of the secondary. Note that the paddle has different speed options for adjusting the focus.

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, enter *ql* in IRAF, 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.

4.4 Guiding

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.

4.5 Miscellaneous Telescope Notes

- There are two telescope+dome control paddles — one located in the dome and one in the control room. With them you can manually rotate the dome east or west (bottom of the paddle) and slew the telescope (NSEW buttons, top of the paddle). Manually rotating the dome via the control room paddle is recommended when the dome gets stuck (see Section A.4).

- 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.

- The dome azimuth and the telescope azimuth don't have to be the same on the TCS. The "Dome Error" is what you want to keep an eye on.

5 Ending the Night

5.1 Shut Down the Telescope

⟶ Complete all the steps of the **Quick Close Guide**.

In the computer room:

1. Turn off the **TRACK** and **DOME TRACK** toggle switches.
   Located in the bottom (black part) of the white TCS tower.
   IF YOU DO NOT DO THIS, THE TELESCOPE WILL CONTINUE TO MOVE WHILE YOU'RE FILLING THE DEWAR.

2. Turn off the **mirror fans** using the blue dial above observer's computer. The "on" and "off" positions should be marked on the dial with permanent marker or tape.
   Located on the shelf along the east wall, directly above the new-citioa4 computer.

In the hallway:

3. Turn off the big **dome fans** using the switch.
   Located in the circuit breaker box in the area behind the bathroom.

In the dome:

4. Slew to Zenith position using the button in the Movement window of the TCS (on the dome computer).

5. Push in the two dark slides.

6. Slew to the cover position using the button in the TCS Movement window (dome computer), and replace the mirror cover. Be careful not to bump any of the dome flat lamps on the edge of the telescope.

7. Close the slit and windscreen using the hand paddle.

8. Slew west using the hand paddle to get the telescope moving. To an hour angle of $\sim$4 hours is usually sufficient.

9. Slew again to Zenith position using the button on the TCS Movement window (dome computer).

10. Fill the liquid nitrogen dewar.

11. Make sure the platform is down.

12. Turn off master power using the big red button.

13. Turn off all the lights as you leave.

In the computer room:

14. Turn off **DRIVES**, **AUTODOME**, and press the red **HALT MOTORS** button so that it is IN (OFF).

→ $\boxed{\text{Fill out the end-of-night report.}}$

15. Fill out the end-of-night report so everyone knows how the night went. This is your chance to mention any issues you had with the telescope or facilities, so members of the support staff can address them ASAP. This includes small things in addition to big things, like if the printer is out of paper, or a door needs repairing, or the LN_2 tanks are empty. The report form can be accessed at:

    http://www.ctio.noirlab.edu/new/Tools/Forms/EON/Form.php?telescope=0.9-m

16. Finally, when you leave please turn off lights and monitors to save energy.

6 End of Run

6.1 Before Leaving the Telescope

6.1.1 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 A.8.2. 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.

6.1.2 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: http://www.ctio.noirlab.edu/new/Tools/Forms/EOR/

6.2 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 — Getting Help

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	Eliot Halley Vrijmoet scheduling, troubleshooting, data management *vrijmoet[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 Hour Angle and Airmass Limits

These limits are imposed by the TCS, and indicate the hour angles corresponding to 3.8 airmasses. That limits is mostly likely based on the physical limits of the mount and the objects on the platform in the dome. They do not take into account visibility issues due to the other domes nearby!

When conducting physical tests on 2018.1010, it was noted that the telescope made some unusual sounds and seemed strained at two points: HA 11:07 W at DEC −80°, and HA 5:25 E at DEC −40°. For this reason, **we discourage slewing past HA 5:20** in either direction, at any declination.

Declination (°)	TCS HA limit E/W (hours)
+30	3:08
+25	3:33
+20	3:53
+15	4:08
+10	4:25
+05	4:38
00	4:50
−05	5:02
−10	5:14
−15	5:25
−20	5:36
−25	5:48
−30	6:00
−35	6:10
−40	6:22
−45	6:37
−50	6:53
−55	7:11
−60	7:35
−65	8:10
−70	9:05
−75	11:59
−80	11:59

A.3 Readout Times and Bias for Geometry Configurations

Tests conducted on 2018.1011 gave the following results for readout times and bias levels using the quarter chip and full chip configurations. For each configuration, we took at least 11 bias frames and averaged the readout times and bias levels. Readout times were very consistent, varying by only tens of milliseconds from frame to frame for each setup.

Quarter chip readout:

	Readout time (sec)	Bias level
UL	66	1250
UR	67.07	1217
LL	67.19	847
LR	67.08	397
Upper	29.85	1210 (L), 1182 (R)
Lower	29.85	807 (L), 479 (R)
Quad	14.93	1346 (UL), 1218 (UR), 807 (LL), 403 (LR)

Full chip readout:

	Readout time (sec)	Bias level
UL	160.66	1304
UR	160.65	1208
LL	160.06	794
LR	160.65	416
Upper	85.33	1213 (L), 1225 (R)
Lower	85.33	751 (L), 484 (R)
Quad	42.73	1352 (UL), 1353 (UR), 848 (LL), 440 (LR)

A.4 Troubleshooting the Telescope

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

If you lose pointing, you have various options:

- Make sure you are entering the correct epoch for the coordinates into the TCS for your bright star during pointing. If you are using a star from the Almanac, use the epoch specified in there (e.g., 2017.5) instead of 2000.0.
- Manually point the telescope at zenith. To confirm that you have pointed it perfectly vertically, use the plumb-line that is hanging on the side of the telescope tube. Once the telescope is precisely vertical, type in the current sidereal time for the RA and −30d 10m 09s for the DEC.
- 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 open shutter), they are easy to find in the book, and at least one is always up.

  If you have trouble getting the star in the finder scope, try lying on the floor below the telescope and eyeballing 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. Turn on the crosshairs for the finder scope to help you center the star there (don't forget to turn it off afterward). 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 the coordinates 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. A small manual bump or two east or west is usually sufficient.

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 hand paddle 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 (next to the very large LN2 tank). Grab one and head back to the 0.9m to fill the dewar. Sometimes broken tanks are left in that area as well, so please check new tanks carefully to be sure they are not marked "DO NOT USE" or "NO USAR."

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" and check TCS software for tracking rate — it should be 15.041.

To move the telescope out of the mirror cover position:

Mirror cover position is past the usual HA limits, so to get out of it you need to manually slew west a bit using the paddle. Once you've moved the telescope to a slightly higher altitude (to HA of ∼4:00), you should be able to use the TCS to get back to zenith.

A.5 Troubleshooting the Camera/BIW

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

If you lose the IRAF window:

- Click on the irafacq or irafred icons on the desktop to open a new one.

If you lose the SAOImage ds9 window:

- Option 1: click on GUI button Display and click Start Display (you may need to close and reopen the IRAF window).
- Option 2: type *!ds9 &* in an IRAF window.

If the observing software crashes, it could be for several reasons. Here is a three-part procedure for getting things working again:

1. Reboot BIW, the instrument control software:
   (a) Click on icon "shutdown BIW"
   (b) Click on icon "start BIW" ... reset chip, Observer, etc.
   (c) Sometimes you may need to do this more than once.

   ... IF THAT DOESN'T WORK ...

2. Reboot Torrent, the controller that connects the software and CCD:
   (a) Click on icon "shutdown BIW"
   (b) Push the small clear/gray button on the Torrent controller — the controller is the silver metal box attached to the gold dewar that contains the CCD.
   (c) Listen carefully ... 1 click OFF ... 2 clicks ON. You should see two red lights turn on.

   (d) Reboot BIW software, as above.

   ... IF THAT DOESN'T WORK ...

3. Reboot the BIW computer:
   (a) Click on icon "shutdown BIW"
   (b) Go into computer room and open door on horizontal machine with label 0.9 TORRENT ACQ PC
   (c) Open door by twisting knob
   (d) Hit power button to turn OFF ... wait until the cursor on ctimac5 is a spinning wheel and a message appears saying, "Attempting to reconnect to VNC server"
   (e) Hit power button to turn ON
   (f) Wait a few minutes (not fast!) for ctimac5 to come up ***
   (g) Go upstairs and hit gray/clear button on Torrent controller
   (h) Reboot BIW software, as above
   *** At step (f) you may need to close down the large window on ctimac5 desktop. If you do close that window, then:
      - Find Applications folder on iMac (likely already open).
      - Click on VNC icon ... be patient, then a large blue window should appear, followed by an image of a galaxy.
      - Fill the screen by stretching the window from corners, not sides.

A.6 Remote Access to the 0.9m Computers

ctimac5

ssh -l observer new-ctioa4.ctio.noao.edu — use ctimac5 password

cd /home/data — 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 — where SMARTS user data is kept

A.7 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'

A.8 RECONS Only — End of Night Procedure

A.8.1 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.

Check headers by making sure the object name, filter, and notes (if any) of each frame match what you have written in the log book. Enter one of these commands into IRAF to prints the headers:

imhead

OR

*hselect *fits '$I, object' yes*

If you find a mistake in one of your headers, change it by entering *hedit filename title* and following the steps to correct the header.

Additionally, be sure to check that the file numbers are consistent with the log book. 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.

If you need to change the name of a file, enter 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.

To generate and send the header files, in the IRAF window enter *finishctiopi* and follow the prompts. This script does the following:

- Changes the file names to match the usual RECONS convention: YYYYMMDD.09.###.fits
- Generates files with the headers from all the frames, and e-mails copies of these files to a list of specific people.
- Copies the contents of that night's directory to ctio36, under */u363/v12/ctiopi/YYYYMMDD/*.

⟶ **DO NOT** run this script more than once in the same folder! Doing so will delete the data.

The SMARTS Fellow is responsible for transferring the data from ctio36 to Atlanta, so you do not *have* to, but you can.

A.8.2 Moving Files to ctio36 Manually

The *finishctiopi* script should move the files to ctio36 automatically, but sometimes that process fails and you or the SMARTS Fellow will need to move the files manually using these instructions.

1. Pull up a terminal window in the ctio36 machine and make directories for your observing nights. Enter:
   cd /u363/v12/ctiopi
   mkdir YYYYMMDD
   (for example, *mkdir 20180701*

2. Back on ctimac5, move files to the ctio36 machine using sftp:

   !sftp v12@ctio36
   enter password
   cd /u363/v12/ctiopi/YYYYMMDD
   *mput *head**
   *mput *.fits*

   Alternatively, you can use rsync. On ctimac5, 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 ctimac5 (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.

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.

A.9 RECONS Only – Making New Setup Pages

For each pi star you set up, make a page that shows the field and marks the reference stars. These pages go in the binders in the PIBOX.

1. Make sure the .fits frames from the night with the new setup(s) are already on ctio36. The directory for RECONS data there is at */u363/v12/ctiopi/* and the night's data are in a folder there named by that date: YYYYMMDD.

2. On ctio36, open a terminal window via the Fedora icon (blue button f) and select ... System Tools ... Terminal

3. Type *xg* (not *xgterm*) to open an xgterm window.

4. Type *ctiocl* to start an IRAF session that includes all of the ctiopi packages. Note: there is no need to open a ds9 window — the script will do that for you and size it just right.

5. cd to the directory that has the night with the data you want to use for the new setup, e.g. */u363/v12/ctiopi/20100303* in your iraf window. Using the logbook, select a frame that you would like to use as the setup frame for a given object (perhaps the one that was best exposed or had better seeing — typically the one whose representative exposure times and seeing you plan to quote).

6. Type *setpoint* in the IRAF window. This will launch a ds9 window (you can move it if need be but don't resize it). If you cannot see the entire field in the ds9 display, it means the screen resolution is not set properly. You will have to reset the screen resolution — go to the Fedora icon (blue button F) and select ... System ... Preferences ... NVIDIA X Server Settings. In there, select "X Server Display Configuration" on the left-hand side. On the right hand side, you'll see a drop-down menu next to "Resolution." Select 1400×1050 and click "Apply" and "Quit." This should stick as long as you don't log out of the machine.

7. The script will prompt you for a number of different pieces, outlined here:

   (a) "Choose the setup frame ..." — this is the .fits file you have chosen to use as a setup.

   (b) "Evaluate possible reference stars ..." — this executes *imexam* so you can cycle through all possible reference stars by using routine commands (e.g., r for radial plot, e for contour plot). At this stage, you'll want to make a mental note of the exposure setter if not the PI star. You can make a printout of the field to mark up as you draft the field.

   (c) When you know which stars you want, type q to quit.

   (d) "Tag reference stars ..." — here you will tag the reference stars that you selected using the space bar — TAG THE PI STAR(S) LAST. It's good to tag the exposure setting star (if not the PI star) first so you don't forget. When done tagging, type <CTRL>-z to exit.

   (e) "Enter size of circular star marker ..." — use option 2 as a default. Only in the cases where there are a number of reference stars (or more importantly, the PI star very near reference stars) would you select option 1. Option 3 produces obnoxiously large circles, so I don't imagine it will be necessary (but a "feature" nonetheless). If you don't like option 2, don't worry, you will immediately have the option to change your mind (just type y when prompted for "Do you want to change ..."). When you are happy with the apertures, type n after that prompt to continue.

   (f) "How many resolved pi stars ..." — in most cases, this will be 1. For multiple systems (that are resolved, i.e., each received an aperture), enter the number of apertures assigned. If more than 1, read below. Otherwise proceed to the next step.

      i. If your system has two components, each with an aperture in your field, select 2.
      "Enter number corresponding to primary ..." — select the aperture number that belongs to your primary component(s).
      "Enter label of primary ..." — enter the label you want, i.e., A, AC, etc.

"Enter number corresponding to secondary ..." — select the aperture number that belongs to your secondary component(s).
"Enter label of secondary ..." — enter the label you want, i.e., B, BC, etc.

ii. "X position of PI component labels" — this is the pixel offset for the A, B, AC, BC label with respect to the center of the aperture you tagged. You can change the offset after looking at a draft that will appear. "Y position of PI...", same thing as above. For example, if you enter "18" and "18" for X and Y, respectively, your labels will be diagonally up and to the right of the stars. Find a position where the labels do not interfere with other reference stars (don't worry about the aperture numbers, they are not printed out in the final setup, they're just there to identify important stars). When you're happy with the placement of the labels, type *n* to continue.

(g) "Enter number of exposure ..." — here you enter the aperture number of the star that sets the exposure (typically, either the value of the PI star or number 1, if you tagged the exposure star first.

(h) "Enter number of star for pointing ..." — because we are no longer using the PI star (which almost always has a proper motion) as our pointing reference, we need to select a reference star to act as our pointing reference. It is best to pick a star near the center (and near the PI star) so that it shows up when you first point the telescope at the field. It also helps to choose a star for which the label for the (X,Y) position fit cleanly without covering other reference stars or landing on the bad column. This will become instinct after the first few setups so don't worry if you don't get it right the first time (unfortunately for this step, if you select a bad star, you will have to start from the top).

(i) "Enter X pixel coordinate..." — drag the cursor over the center of your pointing reference star and take the X (and Y) value from the ds9 window (at the top, labeled "Image"). Enter the X value, then press Enter. Do the same for the Y pixel value when prompted.

(j) "X position of pointing star label..." — again here, as with the labels for a multiple system, there is a lot of flexibility as to where you can place the actual label in the image. Just as a reference, the following values work great for the four cardinal positions around the aperture center (assuming both x and y are pixels numbered in the 100s, e.g., not "37"). Again, if you don't like the position, there is the option to change it as many times as you like. When you are happy with the label's position, type *n*.

Position	X	Y
Above	-55	20
Below	-55	-32
Right	18	-7
Left	-125	-7

(k) Now the ds9 window will close and you'll be prompted for details that will be printed on the page outside of the setup image. These are outlined below.

i. "Enter star/system..." — enter the star name, as it appears on the observing list.

ii. "Enter accurate J2000.0 coordinates..." — as mentioned above, this should be accurate, proper motion adjusted, coordinate — NOT the ones from the TCS that you have written down in the logbook.

iii. "In which filter..." — enter the filter used for the setup (capital letter).

iv. "What is the exposure time..." — enter a representative exposure time (only numbers, don't type "seconds").

v. "What is the seeing..." — enter a representative seeing (again, only numbers, no arcsecond symbols).

vi. "Enter any short notes..." — this is useful for setups that require, for example, only "3 Frames at 600 sec." Also, if the exposure setter does not reach ~50K counts(i.e., very faint targets), it is helpful to state what the peak counts one can expect are. This can be done by typing, for example, "PI star counts $\\sim$50K" without the quotes. You need two backslashes for the ~ character to work because bash script uses one backslash as a special character. If you have no notes, just hit enter.

8. You should now have a pair of files in the directory called *"starname".point.ps* and *"starname".ps*. The important file is the .point.ps file (the other one is just the marked up image). Print out each of the .point.ps files to be filed into the setup binders, using the command *lpr -Pnp36 filename.point.ps*.

9. The setup files are being stored on the ctio36 machine at */u363/v12/ctiopi/Setups.lastATLmove.YYYY.MMDD*, where the date indicates the last time setups were moved back to ATL. There is another staging directory at */u363/v12/ctiopi/Setups* — these should eventually be moved back to ATL, then shifted over to */u363/v12/ctiopi/Setups.lastATLmove.YYYY.MMDD*.

   Type *mv *.point.ps /u363/v12/ctiopi/Setups/* to transfer your new setups to the staging directory. The rest of the .ps files and the tempfile can be deleted. All that should be left in the data directory are the fits files, ready to be ftp'd to Atlanta. When all of your setup .point.ps files are in the Setups directory, it is a good idea to ftp those back to Atlanta. This can be done in the terminal window via

   *rsync -avz *.ps yourname@joy.astro.gsu.edu:/nfs/recons2/setups.dir/*

10. At the end of the run, be sure that you have put one copy of the setup in the binders and bring one copy back to Atlanta.

A.10 Software Commands and Details

A.10.1 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 (**Path** = */home/data/yourname/n1*), the file name (**Basename** = f), and file number (**Image Number** = 1). The Image Number will index as you take frames and increment on its own with each new frame.
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 2048 × 2046 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

A.10.2 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 images 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 new-ctioa4 machine.

flpr — resets window commands after aborting or stopping.
Type it three times to be sure.

hedit — is useful if you misname the file or want to add comments — 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. After entering *imexamine*, a cursor appears on the image in the imtool box. There are a number of useful commands you can give by pressing single letter with the cursor over the displayed image: *e* contour plot, to see if the focus is ok *r* radial profile plot, to see if a star is saturated (60,000 counts) or has enough counts, and to check the FWHM/seeing *s* surface plot, similar to radial plot but in 3D *v* press twice, at different mouse positions, to get a 2D cut of the image between those points *m* average counts in a 5×5 box and sky noise estimate *a* readout of the peak value **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)

A.10.3 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

A.10.4 Directories and Filenames

The general location for data is */home/data*.
The location for your data is */home/data/yourname*, with your name (typically last name) in place of *yourname*.

Under your data directory, keep a different directory for each night you observe. Use a consistent naming scheme, e.g., *n1* for night 1, *n2* for night 2, etc.

mkdir n1	creates directory *n1*
cd n1	moves into directory *n1* — do this to take data for this night.

Files will have names corresponding to what is in the Basename box on the GUI; RECONS uses “f” for their frames. You can also set the frame number in the Image Number box. Numbers will be appended automatically with each exposure, so that the first frame will be f001.fits, the second will be f002.fits, etc.

A.10.5 Observing Scripts

When in IRAF, enter *ctiopi* to load the observing scripts. These are a set of very slick scripts that will allow you to do cool things — see the IRAF COMMANDS section above.