An Observer's Guide for the 2.4m Hiltner Telescope

John Thorstensen, Dartmouth College

with contributions from Jules Halpern (Columbia) and Rick Pogge (OSU)

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PDF Version (88KB)

Preface

MDM Observatory's 2.4m Hiltner telescope is among largest telescopes in the world that always operates without a night assistant.

It is therefore essential that *all* observers be familiar with how it works, and attuned to their responsibiities. Each observer is responsible to the MDM observer community for the safety of the equipment, and each observer is responsible to the astronomical community for the integrity of their data. If you're attentive, thoughtful about technical matters, and patient with detail, it's not difficult to get good data at MDM and have a great time getting it, but if you gloss over the difficulties you will pay.

This document is a guide to observing with the 2.4m. It contains checklists for operating the equipment, designed to prompt experienced users who haven't observed recently, and more detailed sections intended to elucidate common procedures for novices. This document is *not* intended to replace the more detailed manual in the control room (also available in a web-based version). When in doubt, "Read The Fine Manual".

If you're preparing for your first run at MDM, you should watch the instructional videotape which I recorded back in 1996 or thereabouts. Although many of the details are out of date, it's mostly still current, and it gives a sense of the look and feel of the operation which you can't get from a verbal description. There should be a copy of the tape at each Consortium institution.

It's also a good idea to *read this document carefully*. If you understand the information discussed here and follow the procedures conscientiously, it will help you avoid many common problems and result in a happier and more productive run. I've spent *hundreds* of nights observing on the 2.4m over the years since its was built in 1985, and I've tried to construct this manual to give you the benefit of that experience. Don't just skim it.

I should be careful here to note that *novice observers must be trained at MDM in person by a qualified observer before they can observe alone*. MDM has a very small staff, and there simply are not enough people on site to train novices. Since it is hoped that novices will read this guide before their first run, I include some material aimed at them, but novices must not arrive expecting to teach themselves how to observe. Seasoned observers with extensive experience elsewhere may be able to get by on their own. However, if you are such an observer, you should be especially careful not to be overconfident - MDM has many idiosyncracies, and you ignore them at your peril. Don't forget, there's no night assistant to get you out of a jam.

Organization of this Guide

The first part of this guide is a set of terse checklists to prompt the experienced but slightly rusty observer. The second gives detailed checklsts, a version of the terse lists in which background information and reasoning is given at every step. The third is a set of remarks for the first-time observer, essentially an attempt on my part to resurrect some of the good aspects of the observing culture I grew up with. Subsequent chapters offer overviews of the important telescope systems: computers, telescope, MIS, autoguiders, and ccdcom, the latter in the context of some instrument combinations I'm familiar with.

Note that there are quite a few instrument combinations available, some of which I've never used personally. I'll try to make clear when an item or a statement refers only to a particular setup.

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Terse Checklists

Some rules ... [Detailed version.]

- Never, *never* attempt to clean any optical surface.
- Observers are not allowed to repair or modify Observatory equipment, nor to change instruments.
- Respect the telescope operating limits.
- Observatory vehicles are for official use only.
- Close curtains and dark shades at night.
- **This list is not exhaustive** (read the checklists, and use your head)!

Before the Run [Detailed version.]

- fill out Web-based observing run form (linked here).
- clear early arrival with previous observer
- generate coordinate list files if needed
- if you're inexperienced, review time-and-the-sky.
- blank data tapes (4mm DAT or 8mm Exabyte, DAT preferred).
- observatory computers run Unix and Linux, with XWindows - familiarity advisable.
- ensure ssh available on home machine.
- note that personal phone calls from the observatory must be on credit card or collect.
- if you take meals at Kitt Peak, you'll need check or credit card to settle up the charges.
- if bringing laptop, learn how to configure for fixed IP address or DHCP.

First day [Detailed version.]

- check out instrument as needed
- be sure you know the current visitor password
- copy your coordinate file(s) to hiltner
- review any local manuals
- if lightning is a possibility, review shutdown procedure
- if first-time observer, walk through procedures and learn as much as possible
- if instrument has been changed, ask staff if focus has been preset
- become aware of water and electric power conservation
- check sunset time etc. (when to open?); plan observations.
- Keep an eye on the weather, maybe check it on the web.

Opening [Detailed version.]

- (when to open?)
- *verify* safe weather conditions
  - RH <85 percent
  - mirror temperature well above dew point
  - wind <40 mph
  - no threat of precipitation
  - no dust
- *verify* that mirror support is working
- open dome
  - main shutter (punch once)
  - dropout (push and hold 'til open)
- top off instrument dewar if needed - keep an eye on the fill!
- open louvers and optionally garage door
- open instrument dark hatch
- close shades in buildings, go to dim light
- *verify* dome fully open (it can stick!)
- *verify* telescope free
  - platform all the way down
  - ladders, storage dewars, etc all cleared
- go to control room
- set dome azimuth readout to 320 degrees if needed
- enable dome control if needed (yellow button)
- in xtcs setup: clear link; set UT
- START button on black TCS control box
- silver switches on black box:
  - drives on
  - track on (*verify* telescope tracking)
  - mirror cover open
  - auto-dome on
  - dome free
  - autoguider enabled
- go out in dome and *verify* that all four mirror petals are up
- check dome lights off, control room window dark shade closed
- take sky flats?
- *verify* TV gain all the way down before powering on
- turn on guide TV monitor
- Use "Get Coords" in xtcs to find a bright star near the zenith
- slew to bright star
- if using MIS, configure so TV should see bright star:
  - retrocam OUT
  - TV selector to GUIDE (unless CCDS, which has its own slit viewer)

  - If working direct, guide probe to CENTER; if Modspec or MkIII, to SLIT
  - advance TV image tube gain SLOWLY until star is visible
  - (for important advice on the TVs, read this.)
- set TCS readout equinox ("epoch") to match the bright star (2000)
- When bright star centered, set the RA and Dec
- *verify* coordinates have set correctly.
- focus telescope as needed
- proceed!

During the Night [Detailed version.]

- keep an eye on the humidity
- step outside from time to time to monitor weather
- go into dome from time to time to check dome alignment
- some hints for efficient operation ...

Gotchas! [Detailed version.]

- Hand paddle won't respond after slew! (fix: click on STOP in xtcs).
- I've totally lost pointing! (See Instructions under *How the Telescope Works* .

Closing [Detailed version.]

- TV gain down, image tube power off, TV monitor off.
- Slew to zenith.
- reset instrument rotator to 0 degrees if needed.
- close mirror covers (do *not* move rotater with mirrorcover closed).
- set accurately to zenith; track off, drives off.
- all other switches down. Dome goes home.
- hit red STOP button on TCS black box
- dome lights on
- close instrument dark hatch
- close dome.
  - if dome did not return to contacts, hit yellow button and tweak manually.
  - dropout must close before main shutter
- top off instrument dewar - keep an eye on it as it fills!
- close louvers and garage door
- verify dome fully closed
- back up data to tape
- check air conditioner; adjust if needed
- record any messages for staff (e.g., filter changes) on whiteboard
- fill out the Observer's Nightly Report Form. Also fill out a Trouble Report Form if you encountered

any problems (even ones you fixed yourself).
- go to bed!

At the end of your run [Detailed version.]

- Plan to leave mountain as soon as practicable; keep staff informed
- Pay your meal bill (afternoon of last business day before your departure.)
- Check with staff about whether to fill dewar
- Make arrangements to get off mountain if needed
- Be sure all your data are properly backed up
- Tidy up control room; erase grease-pencil markes from TV
- Throw away food and wash your dishes
- Strip your bed; stuff used linens and towels in pillowcase and leave by linen closet
- Leave your bedroom tidy
- Check bedroom windows closed, heater off, no water leaks
- Look around to be sure you haven't forgotten anything!

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Annotated Checklists

Some rules ... [Terse version.]

Never, *never* attempt to clean any optical surface.

The telescope mirror reflects light because it has an incredibly thin and delicate coating of aluminum, which can easily be damaged by ill-advised attempts to clean it. Re-aluminizing the mirror is very expensive (around $10,000, or six months of support for a grad student), time-consuming, and not without risk -- the entire back end of the telescope must be taken off and the mirror taken up the mountain. The staff cleans the mirror periodically using specialized techniques. No matter how filthy it looks, it is strictly off-limits to observers. Lenses and filters are also not to be messed with -- their antireflection coatings can be delicate as well. Finally, diffraction gratings are *incredibly* delicate and *cannot* be cleaned -- don't even *think* about it.

Observers are not allowed to repair or modify Observatory equipment, nor to change instruments.

When trouble arises, you are allowed to turn things on and off and troubleshoot -- mindfully! -- in order to get yourself out of a jam, but you're not allowed to undertake major repairs or adjustments (e.g., don't try to swap out an electronics board unless directly told to do so by the staff, don't try to balance the telescope yourself, don't dismount the dewar and try to pump it down yourself). Instrument changes can only be done by the staff -- it's a skilled job requiring specialized tools and procedures. Use common sense!

Respect the telescope operating limits.

These are elaborated on later in this document. The purpose of the limits is to avoid damaging the telescope. Damaging the telescope is not something you want to do. The Director reserves the right to ban careless or incompetent observers from MDM. Don't be one of them.

Observatory vehicles are for official use only.

They're not for sightseeing in Tucson. Strictly business!

Close curtains and dark shades at night.

The 12-meter radio telescope just down the road uses dim red light at night to avoid disrupting our operations. Let's not give them the idea that bright white light is fine. Also, it looks terrible to see blazing white light pouring out from an observatory at night -- even if the actual impact up at the top of the mountain is minimal, it makes us look like irresponsible tenants. If it's pouring, of course, no one cares that much, but if there's a possibility that anyone is working, button up.

This list is not exhaustive (see checklists).

As an observer you have numerous other responsibilities and stipulations, most of which are pointed out in these checklists as they come up in sequence. Also, any list of rules can't cover all eventualities -- use your judgment!

Before the Run [Terse version.]

Fill out Web-based observing run form.

It is *essential* that the staff know your plans with *two weeks'* advance notice. Observers who do not fill out their observing forms run the risk of forfeiting their time!! Go to http://www.astro.lsa.umich.edu/obs/mdm/ and bring up the Observing Preparation Form. Note that there's also much useful information on this page.

Clear early arrival with previous observer.

It's a good idea to arrive the night before your observing run in order to settle in and acclimate. This is doubly so if you're a first-time observer. However, you can only do this with the knowledge *and permission* of the previous observer. Be sure to contact them well in advance to ensure it's OK. The MDM schedule is on the web. If you don't get permission you'll just have to stay downtown, perhaps at the Plaza hotel at Campbell and Speedway.

Generate coordinate list files if needed.

If you have a lot of targets, you can save considerable time at the telescope by preparing coordinate lists ahead of time. The TCS (telescope control system) expects one object per line of the form

```
my_object 18 23 23.28 -0 14 14 2000
```

where the fields are a name *without blanks*, the RA and dec in the usual sexagesimal form (hours minutes seconds and degrees minutes seconds), and the coordinate equinox (i.e., "epoch"). Note that you can't use colons to delimit the fields - they have to be blanks. Otherwise, the format is free (you don't have to get the information into specific columns). You'll be selecting objects from the list by typing their names, so you'll want to make the names simple and mnemonic (e.g., **`tausource`** rather than **`4E_0235.27389+123457-a`**).

If you're inexperienced, review time-and-the-sky.

If you're a grizzled veteran, stop reading this item. But if you haven't observed much, or someone else was calling the shots on the one trip you made, or something, better get familiar with time-and-the-sky calculations. You've probably studied this stuff in more than one astronomy class. Even so, it's amazing how little of it sticks until you use it extensively. You'll need to understand *in* *your gut* (not just your head!) the concepts of *right ascension* (Quick! Which way does it increase?), *declination*, *sidereal time*, *hour angle* (Quick! How are RA, HA, and ST related?) and *airmass*. If you're doing stellar spectroscopy you may even need to understand the *parallactic angle*.

One great way to get used to these things is to spend a couple of nights using a really old-fashioned telescope which you point using a sidereal clock. You can also play with a desktop planetarium program such as `Xephem`, or my own program `skycalc`, which is widely distributed. `Skycalc` also has a large number of features useful for real-time calculations at the telescope, so it can be worthwhile to explore its features in some detail. In early 2005 I released a GUI version that may run on a computer near you. This version is available on the observatory computers, so you can use it for on-the-spot assessments of observability.

While you're at it, be sure your targets will be observable, and that the moon isn't going to be a problem. `Skycalc` has features designed especially for this. You can anticipate and avoid many difficulties through the simple exercise of sketching a dusk-to-dawn timeline for your first night.

Blank data tapes.

This is instrument-dependent, since the MDM 8K CCD Mosaic Camera uses its own tapes; otherwise, any DAT tapes (1-4) will work fine on hiltner. If you bring a laptop with a fair amount of free hard-drive space and a working ethernet connection, you may also be able to copy the data onto its drive using `scp` or `sftp` (though I'd worry if a laptop contained the only copy). It's also possible to burn data onto a DVD, or to connect an external USB2 disk drive.

The internet from the mountain has somewhat limited bandwidth. If your images are fairly modest, you may be able to just send them home via sftp or scp, but 8k images are rather too big for this. In any case, it is a very good idea to put your precious images on some kind of medium.

Observatory computers run Unix and Linux, with Xwindows - familiarity advisable.

If your home computing environment is Unix, you'll quickly figure out the MDM environment. If you're not familiar with Unix, you should learn the rudiments - how to list directories, change directories, copy and remove files, send mail, and so on. You'll want to know the **`tar`** command for making tapes. The observatory computers interact through Xwindows, using the K window manager. Most observers won't have any particular issues with it, but if you've been in a cave for the last few decades you might want to look into it.

Ensure that ssh is available on your home machine.

If you anticipate communicating with a machine at home, you should anticipate using the **`ssh`** ("secure shell") protocol. Otherwise you'll be sending passwords in clear over the net. That means installing **`ssh`** and **`sshd`** on your home machine and ensuring that its daemon is properly started at boot time. Your home system administrator can help with this. Either ssh1 or ssh2 is acceptable.

If bringing a laptop, configure it for DHCP operation (or possibly for fixed IP address).

MDM provides network ports that can be used for laptops. There are two ways to connect your laptop: fixed IP address or DHCP. If you are configured already for the latter, you are all set -- this is the by far the simplest way to do it, it's very standard, and it's what we recommend. In the unlikely event that you really need a fixed IP address for some reason, please follow the instructions in the Guest Computer HowTo guide in the control room. (Note that on Linux machines running DHCP, you can quickly find out the IP address you've been handed by typing `/sbin/ifconfig`. So there's seldom a reason for using a fixed IP address.)

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First day [Terse version.]

Check out instrument as needed.

This is obviously instrument-dependent. Spectrographs in particular may require substantial tweaking (focusing, setting spectral ranges, etc.). If you're a first-time observer you'll want to spend some time familiarizing yourself with the equipment and the observatory.

Be sure you know the current visitor password.

The password for the visitor account changes frequently. If anything crashes you'll need it to get back up, so be certain you have the correct password.

Copy your coordinate file to hiltner.

If you have one, put your coordinate file in the home directory of visitor on hiltner. You could copy it from from your home institution using **`scp`**.

Review any local manuals.

Autoguiders in particular might use a review at this point.

Even if the weather is clear, review the emergency (lightning) shutdown procedures.

A single lightning strike can (and does) take out the observatory for many weeks. There is a procedure for shutting the equipment off when lightning threatens, and it's important that you do all the steps in order. Find the documentation and walk through it if lightning could occur. Better yet, review it with the staff to be sure you understand where all the items are.

If you are a first-time observer, walk through procedures and learn as much as possible.

You should have a qualified observer there to do this with.

If instrument has been changed, ask staff if focus has been preset

The different instruments are not par-focal. The staff can set the telescope focus to the anticipated focus for the new instrument, or you can do it yourself using the chart on the bulletin board, but it's important that you don't both do it! Note that focus values are entirely relative and that the focus can vary considerably with temperature; the aim of the focus pre-set is just to avoid being grossly out of focus, which can be confusing on the first night if the star you're trying to find is a huge donut of light.

Become aware of water and electric power conservation.

Both these utilities are extremely expensive on the mountain. Start getting in the habit of conserving them as much as possible. Shower quickly and efficiently (difficult since there's a very long run of pipe between the heater and the rooms), be especially aware of water leaks (especially things such as as running toilets!), run lights and heaters only when necessary, and so on. If you do notice a toilet running, shut off the valve beneath the tank immediately and notify the staff. Room heaters are especially power-hungry and should be used only as needed.

Check sunset time etc. (when to open?); plan observations.

The link points to instructions as to how to look up the sunset time (and much, much more) with **`skycalc`**, a program available on the Observatory computers. There's also a little treatise on how to use twilight time to best effect. Now that you're at MDM and have an idea as to what conditions might be like the coming night, it may be worth it to to firm up your target selection and set up a timeline for your nights' observations. Of course, the planning needs of different programs are different (e.g. some are very contingent on seeing, which you won't know 'til you open), and weather can always change, but it's good to have a plan.

Keep an eye on the weather, maybe check it on the web.

The link, to http://www.wrh.noaa.gov/tucson, is the best I've found for local weather. It includes a forecast specifically for the Tohono O'odham region (where Kitt Peak is).

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Opening [Terse version.]

(For advice on when to open, look here.)

Verify safe weather conditions.

- RH <85 percent
- mirror temperature well above dew point
- wind <40 mph
- no threat of precipitation
- no dust

Thanks to the efforts of Jen Marshall (OSU), there is a large monitor that displays readings from a weather station located outside the 2.4m dome. There's also a humidity sensor on the mirror air conditioning computer - the sensor readout display is a menu choice on the A/C computer, and you can get the menu by typing **`esc`** (escape). Under rare and unfavorable conditions the mirror can have ended up below the dew point - in this case you obviously can't open even if the RH is nominally OK, and you'll want to *warm up* the mirror by reversing the air conditioner (there's a menu choice); this actually works. The wind limit is pretty liberal, since a 40 mph steady wind is really howling. If the air is dusty (dust storms do occur), you must not open, even if the wind is below the limit.

I repeat here the link to the most useful local weather site I've found, which includes forecasts specifically for the Tohono O'Odham area (where we are); it's at http://www.wrh.noaa.gov/tucson/.

verify that mirror support is working.

The mirror support computer is in the left-hand computer rack. There are three numbers showing forces on the three hard points which position the mirror - they should all be within a couple pounds or better of the nominal value of 30 pounds. The telescope *should not* be moved unless the mirror support air bags are working - moving the telescope without the air bags being up can damage the mirror support system! If the air bags are deflated, the images appear grossly triangular in shape and cannot be improved by focussing. If you should see this happen, it means the airbag system has failed somehow. This doesn't happen frequently, but it's important to be able to recognize it.

open dome.

- main shutter (punch once)
- dropout (push and hold 'til open)

The dome shutter controls are on the northwest wall of the dome. In order for electrical power to get to the shutter, the electrical contact boxes mounted on the dome and the building need to be lined up. Unless the dome has been moved since it was closed, they'll be lined up. [If the shutter doesn't respond, try moving the dome slightly to get better contact on the electrical feed box. **If it still doesn't work** after several tries, **move the contacts off the electrical feed box** and use the backup cable. *Don't* plug in the backup cable with the dome near the feed box -- that can create a short!]

top off instrument dewar if needed.

This simple procedure probably causes more trouble for novice observers than any other. It's important to understand the pitfalls.

The first principle is that *dewars must be kept cold under all circumstances, and cannot be refilled if they're allowed to warm up.* Once a dewar warms up, any volatiles remaining boil off into the vacuum, and if you cool the dewar down without first pumping on it, there's a serious risk of getting gunk on the CCD. Only the staff are authorized to re-pump a dewar, it's a complicated operation which must be done correctly.

The procedure for a routine dewar fill depends on the instrument. If you're filling one of the **MDM dewars mounted in an upward-looking position** (e.g. for direct work, or the Mark III spectrograph), **be sure that the fill tube freezes into place all the way up**, that is with the metal in contact with the metal at the top of the dewar, or you'll get a false fill and likely warm the dewar up during the night. Goosing the platform up just a *little* bit after the rubber hose freezes can ensure the fill tube is touching the top of the dewar.

Assuming the fill tube is properly set, you can tell the dewar is full when it overflows. Before it actually overflows, it may spit some -- don't be fooled! When it's *really* full, the overflow is a continuous spray of drops almost like a shower.

If the storage dewars are up to pressure, it should take of order five minutes to fill an MDM dewar which has been sitting for 12 hours. If it takes a lot less than this, it's probably a bad fill, and You Will Pay. It's a good idea to just let the LN2 run for a little bit after you think the dewar is full -- nitrogen is relatively cheap compared to the expense of running the observatory and getting you there, and a warm dewar is a true show-stopper.

In the upward-looking configuration it is especially important to insert and remove the fill tube straight, without pulling or pushing sideways, as this can loosen the internal fitting which holds the LN2 and create a slow leak; your hold times will go down to a couple of hours if that happens.

Yet another caution about the dewars - *Do not start the dewar filling and forget about it,* thereby emptying the storage dewar. This is an easy mistake to make, since it's easy to wander off and get absorbed in something else during the 5-minute fill time. This error is very much to be avoided; the consequences are: (a) It wastes money, and the observatory budget is tight. (b) It forces the staff to drop whatever they're doing and refill the storage dewar. (c) If it's a weekend and you're out of nitrogen, you are probably **out of luck**. So don't be a flake, monitor your dewar fill!

Finally, a note on safety. LN2 is not particularly dangerous, but you should avoid getting any in your eyes and getting more than a few drops on your skin (if it's just a few drops it boils instantly and the vapor layer insulates you.) Be aware that LN2 in a sealed container quickly builds up lots of pressure and may cause the container to explode -- the storage dewars all have pressure release valves for this reason. These valves should be free to open. A little hissing from an LN2 dewar is normal, it's the gas escaping from inside. You *want* it to escape! Finally, in confined spaces the vapor can suffocate you -- it isn't toxic but obviously doesn't have any oxygen in it. Luckily, the domes are big enough, and the amounts of LN2 we handle are small enough, that this has never been a problem for observers.

open louvers and optionally garage door.

This and the next few items are good short tasks to do while the dewar is filling. Check the dewar frequently as you go about them.

The dome building walls have louvers that you can open to allow ambient air to circulate through the dome. You can also open the garage door by the loading dock, though doing so carries a slight risk of allowing in the local fauna (skunks have been known to wander in. No pumas so far). Allowing ambient air to flush through the dome helps the temperature equilibriate and greatly improves the seeing.

Open instrument dark hatch.

Near the top of the MIS there's a little knurled handle - pull it down to release it and flip it to its other position. This opens a dark hatch at the top of the instrument. If instead it feels like it's falling and goes "clunk" then you've closed it (the previous observer left it open by mistake!). The MDM 8K camera has its own dark slide.

Close shades in buildings, go to dim light

Keep the heavy curtains closed at night, and don't forget the shop area and living quarters. It is **very bad form** to let excessive light spill out from the living quarters -- even if the practical effect is minor, it's noticed with derision elsewhere on the mountain. Personally I also use *only incandescent* (or better yet, incandescent-matching compact fluorescent) light at night, since the bright white ceiling fluorescents are very hard on dark adaptation. It's useful to avoid frying your retinas with fluorescents since you'll want to go out and check the sky from time to time, and the fresher your eyes are, the quicker you'll dark adapt. You need to be quite well dark-adapted to see thin cloud on a dark night.

Obviously, you can "rig for silent running" whenever you want to in the sequence, as long as it's before dark.

verify dome fully open (it can stick!).

The dome has been fixed and shouldn't stick now, but you can't be too careful. In the past the the shutter has tended to stop up on various rough spots on the track, and *think* it's open. There was a particularly insidious one which leaves about 2 feet of dome in the zenith. Check carefully with a flashlight if needed to be sure the dome is open all the way. If it isn't, hit the open button again and it should continue.

Incidentally, note that the telescope beam is occulted slightly near the zenith even when the dome is fully open. See the manual for a tabulation of this zone.

verify telescope free

- platform all the way down
- ladders, storage dewars, etc all cleared

The lift platform must be all the way down, or an interlock cuts power to the telescope. When you're tired or in a hurry, it's easy to make bonehead errors like slewing the telescope with a storage dewar still attached. Just check to be sure the space around the telescope is clear of obstructions before you start.

Return to the to control room

set dome azimuth readout to 320 degrees if needed.

The dome position readout sometime loses pulses and the dome readout becomes inaccurate. If this happened the last time the telescope was used, it's likely that the dome encoder is still a little off, so you'll have to reset the dome position. At this point in the setup sequence the dome should still parked with the electric contact boxes lined up; this is azimuth 320 degrees. To reset the dome encoder, go to the **`xtcs`** window on hiltner, select **`setup`** and **`set dome azimuth`**. You set the azimuth by typing 320 and hitting carriage return.

enable dome control if needed (yellow button).

If the dome had to be manually tweaked onto the electrical contacts the last time it was closed, it was probably left in manual mode. This is controlled by a big square yellow button at the bottom of the left-hand computer rack. If this button is pressed in, the dome can be rotated by the computer (and not by hand); if it's not pressed, the dome can only be rotated by hand (using the wall-mounted box in the dome). The yellow button should light up when pressed, unless the bulb is burned out, which happens from time to time.

in xtcs setup: clear link; set UT.

Use the setup menu on **`xtcs`** for these commands. They just make sure the TCS control computer is ready to receive commands and that its clock is set correctly. Incidentally, the observatory computer clocks are set using the network time protocol (NTP). If timing is critical for your observations, there's a rack-mounted WWV clock at the 1.3m you can use to check the observatory's time.

START button on black TCS control box.

The green START button should come on and stay on when pressed. If it immediately goes out, you probably forgot to lower the platform all the way and you're being locked out.

silver switches on black box:

- drives on
- track on (*verify* telescope tracking)
- mirror cover open
- auto-dome on
- dome free
- autoguider enabled

Basically, all the silver switches should be in the up position to observe. The **`external`**

`computer` switch is obsolete and doesn't do anything.

When you flip the track switch up, you should see the RA stop changing on the TCS display, and the HA start moving. If it doesn't, there's a problem.

go out in dome and *verify* that all four mirror petals are up.

The mirror petals are driven open by a pneumatic air system. If there's a failure in that (e.g., ice in the lines) they may not come up; also, they barely clear the sky baffle so they sometimes hang on that.

Clearing a hung up mirror cover petal is an intrinsically dangerous operation, but here are the instructions if you wish to try. Alert the 1.3m observer and have them come up to watch, or at least tell them that if you don't get back to them in 10 minutes they must come up to summon aid in case you injure yourself. Using the control paddle stored on the west side of the telescope, slew the telescope way over so you can get access to the sky baffle. Get the aluminum ladder and a stick about 5 feet long (e.g., a broomstick). Get up on the ladder. *That petal is going to open explosively!!! Look out where it's going to go before you do anything!!!!* Once you're sure you won't be knocked off the ladder by the opening petal, gently push on the sky baffle to free the cover. BAM! - the cover opens *violently*. Stop shaking and climb back down. Tell the 1.3m observer that you're OK.

check dome lights off, control room window dark shade closed.

Simple stuff but forgettable.

take sky flats?

If you're working direct, and want to use the twilight sky for flatfield information, now is the time to get the flats. There's only a short time window (about 10 minutes) a little after sunset when the sky is the right brightness for this, so you have to be on the timeline.

You need at least three usable sky flats per filter, so that stars can be medianed out. Don't forget to move the telescope by a field width or so between exposures to make this possible.

Exposure times are problematical, especially since the readout time may be comparable to the timescale over which the sky changes. Note that the **`skycalc`** program is available on the observatory computers; this has a feature that computes the twilight sky brightness. [If you don't like to use the mouse, and want to save screen real estate, you can use the "classic" keyboard skycalc. You can set it to automatically update to the present time by typing **`xU`** and then a zero; then you can monitor the sky brightness with the **`=`** command.] If you write down the exposure time, filter, average counts and **`skycalc`**'s computed sky brightness, you can use the information to set the exposure time on other sky flats (in the morning, for instance). For reference, I've found with the Echelle and MDM U filter that I can start with a 2-second exposure when the sun is 3 degrees below the horizon, and skycalc reports 12.3 magnitudes above dark night sky. The U filter is the least sensitive.

verify TV gain all the way down before powering on

The MIS TVs consist of Gen-1 image tubes feeding naked, uncooled video-rate CCD cameras (the MDM 8K camera has its own guide TV). The image tubes are fed by a power supply which has a red power button on it. The image tubes have an *extremely* long RC time constant - many minutes!! - so once the gain is up, it's up. You're about to look at a bright star, and it's a good idea not to have the gain up too high. Therefore, be sure the voltage-control knob on the power supply is should be turned all the way down (left) before powering on.

turn on guide TV monitor

Use "Get Coords" in xtcs to find a bright star near the zenith

The "Nearest bright" menu choice will look up the Bright Star catalog object nearest to the telescope’s position. Since you haven’t moved yet, this will be near the zenith.

slew to the bright star

Use "Send Coords" and "Go" in xtcs to move the telescope to the star. Unless the dome just happens to be in position, you should hear the dome rumble. If you don’t, be sure the dome really is in position.

if using MIS, configure so TV should see bright star:

- Retrocam OUT
- TV selector to GUIDE (unless CCDS, which has its own slit viewer)
- If working direct, guide probe to CENTER; if Modspec or MkIII, to SLIT
- advance TV image tube gain SLOWLY until star is visible

Note that if the telescope is badly out of focus, the star image will appear donut-shaped, because of the secondary mirror obscuration. If you’re looking at the star reflected off spectrograph slit jaws, you can go ahead and do a crude focus of the telescope by eye at this point. But if you’re working direct, you’ll want to focus the telescope on the CCD first, which is a more elaborate procedure best deferred for later; see the "focus the telescope as needed" item a little farther along.

set TCS readout equinox ("epoch") to match the bright star (2000)

There’s a button in xtcs labeled "TCS Equinox" that calls up the appropriate dialog box. You send the desired value (generally 2000) by pressing "enter" on the keyboard.

When bright star centered, set the RA and Dec

This is under the "Setup" menu on xtcs. The effect of the "Set RA/Dec Encoders" command is to set the encoders to the position of the "Next Object", which is the value listed on the second line of the TCS display monitor.

verify coordinates have set correctly.

If you mess up here, you’ll lose some time fixing the problem, so before you leave the bright star you’d better be certain the coordinates did set correctly. Occasionally they don’t (usually operator error).

focus telescope as needed

This is instrument-dependent. If you’re working direct with the MIS, you’ll probably want to get to your first object and run focus frames for your filters. Then, and only then, focus the guide camera so that it is parfocal with the telescope. With the 8k, I believe the guide cameras should be permanently at the same focus as the array, but I have not used it and am not sure. If you’re looking at spectrograph slit jaws, the camera you’re using should already have been focused on the slit jaws. It suffices then to put a star near the slit jaws and focus by eye. You’ll want to use a relatively unsaturated image for this, so a bright star is probably not the best. The focus star should be near the slit jaws since the slit is inclined to the focal plane.

Telescope focus depends primarily on temperature; there's a feature on the A/C control computer which, once you set it, computes a suggested focus based on the temperature of the telescope's truss. In my experience this doesn't work perfectly but gives some idea as to which way things are going. Generally, focus numbers decrease as the telescope cools.

proceed!

Take some data! There are some remarks later in this Guide about autoguiding, and there are good manuals at the Observatory for both guiders. Read on for what to do during the night.

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During the Night [Terse version.]

keep an eye on the humidity

Episodes of high humidity can occur any time of year without warning. If you set the mirror air conditioning control computer so that the blue readout screen is on, a warning will flash if the RH rises above 85 percent. This catches the eye very effectively, provided you glance around from time to time.

step outside from time to time to monitor weather

This is always good sense, and it makes for a welcome break from the noisy control room.

go into dome from time to time to check dome alignment

As noted earlier, the dome can lose track of where it is, since the dome position system apparently picks up noise pulses from time to time. Even small inaccuracies can be a problem, since the dome slit is only a little wider than the telescope beam. The dome azimuths are marked with red reflective tape on the walls; it's a good idea to check it from time to time. I once discovered a dome problem when I saw a sawtooth light curve from the check star in a time-series photometry run - don't let it happen to you!

Some hints for efficient operation ...

Here are a few hints, some in the form of links to the relevant material; some are instrument-specific.

- Be sure to prepare pointing lists for xtcs.
- Use the GUI skycalc to help keep track of airmass, moon, etc. Your pointing list works as input for this. Instructions for running the program are here.
- Dial in your MIS guide stars with the tool provided in the GUI skycalc.
- If you do this, you may be able to use the guide stars for fast, accurate target acquisition.
- If you use the MDM cameras for direct imaging, the centermdm.py tool is much faster for field verification and centering than anything you can do by eye. It fails occasionally due to sparse fields but it is very accurate.
- The telescope encoders are good, but drift slowly with time. Update coordinates from time to time when you happen to be setting on a target not too far from zenith, but always remember that a blunder in this can get you badly lost.

- For general advice about how to approach the task of observing, see my rant later in this document, Acculturation for New Observers.

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Gotchas! [Terse version.]

Hand paddle won't work after a move ...

On occasion the telescope fails to complete a move and gets hung up, usually very close to the object you're moving to. The most obvious symptom is that the hand paddle is locked out, so it seems as if there's something wrong with the paddle. To diagnose this condition, look at the Hour Angle field of the NEXT OBJECT line near the top of the TCS monitor. When a move completes successfully, this field gets filled in with asterisks, "* * *". If you don't see this, but rather see the hour angle of the next object (which should be changing), the TCS is hung.

The fix is simple; *in the xtcs window on hiltner* , click on the red STOP virtual button. (Do *not* press the red plastic stop button on the black control panel, that will stop the drives!) This will stop the endless wait state, and give you the telescope back. Do SEND and GO again, and the move should complete.

I've totally lost pointing!

Calm down, slow down and follow the step by step instructions under *How the telescope works* .

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Closing [Terse version.]

TV gain down, image tube power off, TV monitor off.

Once you're no longer looking at the sky, turn 'em off. Leave the guider PC on.

take sky flats?

See the earlier discussion under Opening for details. If you've written down the exposure data on previous mornings and evenings, it should be possible to get a fairly good exposure the first time.

slew to zenith.

An easy way to do this enter coordinates

```
RA  = sidereal time + 1 minute
Dec = 31 57 12
Epoch = now (in decimal years)
```

into the **`xtcs`** window, and slew.

reset instrument rotator to 0 degrees if needed.

If you've rotated the instrument and it's in some funny position, you should set it back to zero, at least on your last night. Remember that the **mirror covers must be open to rotate the instrument!!**

close mirror covers (do *not* move rotator with mirror cover closed).

You should ideally be near the zenith to close the mirror covers, though in an emergency you should just go ahead. To do this, flip the silver switch on the black panel down. You'll hear the four of them crash down, hopefully in order.

set accurately to zenith; track off, drives off.

It's worthwhile to get the telescope dead straight up, since then you know exactly where it is if there's some kind of problem (e.g. a lightning shutdown). Turn off the tracking and set the hour angle to zero.

all other switches down. Dome goes home.

hit red STOP button on TCS black box.

dome lights on.

close instrument dark hatch.

close dome.

- if dome did not return to contacts, hit the yellow button and tweak manually.
- dropout must close before main shutter

Note that the main shutter takes a while to close, so you can get it started first, and then hold down the dropout close button until it slams shut. If you need it, the yellow auto-dome enable switch (discussed earlier) is in the computer room at the bottom of the left-hand rack.

If there's a problem getting power to the dome - for example, if the rotation fails and you can't get it on the contacts - there is an emergency cable which can be connected. See the full manual for details.. Note that plugging in the cable with the dome on the contacts will cause a short, so don't do that!!

top off instrument dewar

Doing this as the dome is closing is a good habit. Don't forget to mark the time on the whiteboard. See earlier cautions on filling upward-looking dewars and not filling warm dewars.

close louvers and garage door

verify dome fully closed

back up data to tape

If you lose the data, your work, and the telescope time, are gone!

The Unix **tar** command is the most reliable way of doing this. Create a subdirectory of the data you wished to back up (for example, "subdir") and in the directory above it type

```
tar cvf /dev/nst0 ./subdir
```

Observers sometimes get into trouble by leaving their tape copying to the last day. Not only does this leave you vulnerable to disk or computer failure, it can cause problems if you underestimate the time required, leading to collisions with the next observer. Back up every night, and be sure that your plans for writing tapes the last morning of the run are realistic.

check air conditioner; adjust if needed

Once the mirror petals are closed, the air conditioner will try to cool the mirror to a settable temperature, because the seeing goes bad in a hurry if the mirror is more than 1 degree C or so warmer than ambient. The mirror has a long thermal time constant (like 12 hours), and the air conditioner is not particularly effective at cooling the mirror, so if you want to adjust the temperature for the next night, better do it now.

How to decide on a temperature? The A/C control program has a feature which displays the history of the ambient temperature, the mirror temperature, and the temperature set point for the last 3 days or so. Detailed weather forecasts are available on the web; the National Weather Service Tucson office (http://www.wrh.noaa.gov/Tucson/twc.html) has a terrific site which includes very technical details of the forecast. If humidity could be an issue, you'll want to be careful not to overcool the mirror.

record any messages for staff (e.g., filter changes) on whiteboard

If you have any requests which will require timely action by the staff, please be certain to write them out legibly on the whiteboard. You cannot expect to wake up at 3 PM, saunter out of bed, and tell the staff to drop whatever they're doing and swap out all your filters. In this, and everything else, try to think ahead, both to assure that your requests can be handled and to minimize the strain on our very small staff.

Fill out the Observer's Nightly Report Form.

MDM requires that all observers fill out a brief report of the night's activities. To make this as painless as possible, a simple web form has been created that is accessed from the mountain top web server (./). Even if you did not observe, you should fill out a report saying why.

Nightly observing reports are stored on the mountaintop server, and emailed to a short list of recipients that includes the observatory directory, mountain superintendant, and the MDM consortium representatives from each member institution. Report data are used to track how much observing time is lost to weather, problems, etc., as well as to keep a permanent record of activities.

Similarly, if you encountered any problems at all, even ones you fixed yourself (i.e., not common mistakes but real problems that required you take some special action to continue working), also fill out a Trouble Report Form. There is no such thing as a "minor" trouble report. Often a big problem starts as lots of little problems or quirkly annoyances. If we can see a pattern develop in the trouble logs, we might be able to head off bigger problems later. Remember, the run you save could be your own!

Some problems occur when using the data-acquisition software or other computer systems. It will greatly help diagnosis and solution of a problem if you can include the **verbatim** text of any error messages printed when the problem occurred.

go to bed!

Your program may call for instantaneous data reduction - if so, bring a collaborator or automate it so you can get enough sleep. It’s important not to get too tired!

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At the end of your run ... [Terse version.]

Plan to depart as soon as practicable; keep staff informed

Accomodations at the Obsevatory are very limited, and the next observer should not have to work around you as they set up and settle in. Accordingly, observers are required to leave the mountain as soon as they can, ideally by the early afternoon of the day after their last run. Please keep the staff informed of your plans. If you intend to sleep for a while after your final night, be sure the staff knows when you intend to get up and leave, or they have no idea what to tell the next observer about bedroom availability and so on. The instant-departure rule can be relaxed when there is a very good reason (e.g., packing up a complicated user instrument at the end of a run), but exceptions must be cleared with all concerned!

Pay your meal bill (afternoon of last business day before your departure - you cannot pay your bill on weekends!)

If you’ve taken any meals up at the Kitt Peak cafeteria, you’re to pay for them before you leave. This is at the main office of the Admin building up top. You can dial zero on the phone to tell Joanne (usually) that you’re departing and have her make up a receipt for you.

Check with staff about whether to fill dewar.

Sometimes the staff may want the dewar to run low because it makes it more convenient for them to change the instruments.

Make arrangements to get off mountain if needed

If you’re using the Kitt Peak shuttle you’ll have to reserve a spot; the schedules are kept in the Admin building up top. MDM pays an annual fee so that observers may use the shuttle; we are not charged by the passenger, so go right ahead. MDM users may not drive Kitt Peak vehicles, so you can only use the ’U-drive’ schedule options when someone else is driving.

If you’re using an MDM vehicle to get off the mountain, you’ll have to arrange it ahead of time with the staff. Be sure to give the staff plenty of advance notice!
If you’re driving yourself off the mountain, be *very* careful in this case not to overextend yourself to the point where you’re really sleepy while driving. Falling asleep at the wheel is one of the most important causes of fatal crashes -- don’t put yourself in a position where this is a danger.

Be sure all your data are properly backed up.

Standard operating procedure is for the staff to simply wipe out your data from the observatory computers as soon as you’re gone (though if you ask real nice they can sometimes be persuaded to leave your data alone until you verify your tape is legible at home). It’s therefore a good idea to write more than one copy of your data. There are many possibilities for this -- DAT tapes, transferring the data to a laptop, writing a DVD, bringing your own USB-pluggable disk drive, etc. The observatory internet service is now fast enough that modest-size data sets (e.g., single-chip detectors) can be shipped home, but given that the phone lines can sometimes go down you shouldn't depend on this exclusively! It's a good idea to leave a backup at the observatory in case something gets wrecked on the way home.

Be sure to allow sufficient time to back up your data. You should plan any tape writing carefully so that you're finished early enough to allow the staff to start instrument changes when they arrive at 8 AM. As noted earlier, you should be backing up your data as you go along anyway.

Tidy up control room; erase grease-pencil marks from TV

Gather up all your charts, scratch paper, whatever, and leave a neat workspace for the next observer. If you've marked up the guide TV monitor with grease pencils, erase all those marks now -- they probably won't apply to the next observer. (Incidentally, you should never write anything on a *computer* monitor, and you should be sure to use easily eraseable grease pencils if you feel you must make marks on a TV monitor. I never do this anyway, since there are cursors to mark things, and yellow sticky pads too.)

Throw away uneaten food and wash your dishes

There's a tiny refrigerator and larder in the kitchenette -- space is very limited, so don't leave behind anything which could go bad. Who knows when that half-eaten sandwich was parked there, anyway? There are vermin (verpersons?) at the observatory, so you should never let dishes pile up, but if you have, better get 'em now.

Strip your bed

Stuff your used linens and towels into one of your pillowcases and leave by linen closet.

Leave your bedroom tidy

There's no chambermaid. Behave accordingly.

Be certain: bedroom windows closed, heater and lights off, no water leaks

As noted earlier, water and electrical power are extremely expensive on the mountain. No one else is going to check your room to be sure you've turned things off, so be especially careful that you do. Be absolutely sure that (a) the heater is off and (b) the toilet isn't running!

Look around to be sure you haven't forgotten anything.

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Acculturation for New Observers ...

I trained as an observer at Lick in the 1970s. At that time new observers were walked through procedures by seasoned staff observers. This certainly got the job done - we learned the equipment - but in the long run, the most important lessons we learned from this were not about which buttons to push, or how to develop plates. They were instead lessons about the experience of observing, and the attitude to bring to the telescope. As an old curmudgeon I think some of these lessons have atrophied over the intervening years, as overworked faculty pack students off to observe with minimal preparation. Here's a distillation of some of that acculturation, as refined through many hundreds of nights of observing experience since then, most of them at MDM.

- Telescope time is precious, and using a large telescope is a privilege. You should feel a strong obligation to use your time well.
- Accordingly, it's important to be efficient. This means giving some thought to your procedures. It also means having a well-thought-out and well-prepared program. I remember one famously efficient observer who was said to have spent three nights of large telescope time efficiently observing the wrong list of objects - he'd grabbed the "already observed" list instead of the "to be observed" list, and hey, galaxies all look alike!
- Be careful with the equipment. It's expensive stuff and carelessness is not an option. Leave everything in good working order. Report problems completely and carefully so that they may be fixed. Leave the control room in better order than you found it. And when conditions become dangerous to the telescope (blowing dust, too-high humidity, etc.), close immediately!
- Work very hard, but try to take care of yourself. If you get too sleep-deprived, you're liable to make really dangerous errors.
- Most primary programs require excellent conditions. What if your conditions are usable, but mediocre? What if the seeing is 2 arcsec instead of 0.7 arcsec? What if you require photometric conditions but there are high clouds? This happens a lot - have a backup program! If you can't think of one yourself, ask around your department and collaborators - someone else is sure to need something.
- You should take a workmanlike attitude toward your data. Pictures should be in focus and centered. Spectra should be in focus and properly calibrated - and they should be of the object you intended! Take a few moments to get things right.
- On the other hand, better is the enemy of good. I remember a meticulous student who hardly ever took data because the conditions were never perfect enough for his high standards - he had the most wonderful dome flats, though. I actually witnessed a memorable scene in which an instrumentally-minded investigator spent most of a beautiful night fine-tuning equipment endlessly as the stars wheeled overhead and a roomful of European collaborators flown in for the occasion became increasingly exasperated. Telescope time is precious. Use it.
- Even though you should feel a strong obligation to use the time well, you'll be more efficient in the long run if you don't hurry. Hurrying leads to really big mistakes, like that poor guy observing the wrong objects.
- Finally, have the discipline to avoid excessive distraction by the TV, the stereo, and so on. Sometimes observing gets boring and it's fine to let part of your mind do something else, but it's important to stay on task. Observing is like a dance in time, and it either happens or it's gone -- pay attention!

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Computer System Overview

This little blurb isn't complete but might help get you started. A description of the many improvements wrought by the August 2005 upgrade is given here .

There are three computers at each telescope. At the 2.4-meter telescope, these are:

hiltner:
: This is the main Observing Workstation where the observer logs in for most things. It is a fast Linux box.

agung:
: This is an identical PC running Linux configured as a Data Reduction Workstation. It is usually where any second observers will be able to login and work.

krakatoa:
: This is a Sparc 10 running Solaris configured for special data-acquisition tasks. **krakatoa** runs the MDM CCD cameras with a special interface. It is anticipated that krakatoa will be retired soon and replaced with a Linux machine, ideally in the summer of 2006.

Hiltner and **agung** run the K windowing environment, and have been set up to have a common look and feel which will be familiar to most observers. The window system has four desktops available - there's a little cartoon in one corner showing them all.

On all machines you login to a visitor account named **obs24m**. Logging onto **hiltner** as **obs24m** puts you into the directory **/lhome/obs24m**. The data all go to directories under **/data**, where the next item in the path is the machine name (e.g., hiltner or krakatoa), followed by the user name (obs24m), followed by whatever you want to put there. The **/data** directories are transparently visible to all themachines. The telescope and the MIS (Multiple Instrument System, used for everything except the MDM 8K camera) are controlled from windows on **hiltner**. There's one window called **xtcs**, which runs the telescope control system, and another called **xmis**, which runs the MIS. These controls are thoughtfully designed and should be fairly intuitive. The web-based manual has sample displays of these windows, in color.

The usual MDM CCDs (Echelle, Charlotte, Templeton, etc.) are run by a program called **ccdcom**. This has a text-based interface and runs on **krakatoa**. There's a menu choice on **hiltner** for a **ccdcom** window, which automatically logs you onto **krakatoa** and gives you an xterm with yellow letters on a black background. You now **cd** to the directory you want your data in, and type **ccdcom** to invoke the ccd control program. There's a good manual describing **ccdcom**, and a later section of this Guide gives a little advice on the program.

Note that you can run everything from **hiltner**'s terminal - just **ssh** to the other machines as you wish. It's probably a good idea to use **agung** for any heavy reduction, to keep **hiltner** free for observing.

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How the Telescope Works

The official manual contains a lot of detailed information on the workings of the telescope. Here’s a short overview which may be helpful but which is necessarily very general.

The telescope is generally configured as an f/7.5 Ritchey-Chrétien - an f/13.5 secondary is seldom used. It has an equatorial fork mount, built by DFM engineering in the early 80s. The drives are unusual in that they do not have worm gears - rather, the telescope is driven by large steel wheels with smaller driving wheels pressed up against them.

The Telescope Control System, or TCS, is a PC containing a fair amount of custom hardware. In particular, it contains counters that listen to and interpret the pulses from encoders, and boards that issue signals to the power electronics "muscle boxes". These in turn send power to the stepper motors which run almost everything. The TCS dates from 1995, when the original custom computer which came with the telescope was retired. Because of limitations of the multitasking software available for PCs at the time, the operating system of the TCS PC is OS/2, which will be unfamilar to almost everyone; luckily, observers should never have to interact with the OS.

The user interface for computer control of the telescope is through a program on hiltner called **`xtcs`**. This is fairly easy to use -- to slew, just enter the coordinates and hit ‘send’ and ‘go’. As noted earlier, this can be made more efficient by putting your target list in a file ahead of time and calling the objects by name. The **`xtcs`** window also allows users to reset the encoders, adjust track rates, and so on. It may be helpful to keep in mind that **`xtcs`** is just a user interface -- the actions are mostly occurring in the separate TCS computer. When the TCS computer program is running normally, the TCS computer’s monitor displays the status of the telescope. It’s designed to be similar to the old TCS monitor, so the comprehensive manual in the control room gives a fairly good idea of its function. I’d recommend that you peruse the monitor display carefully on your first day - you’ll be looking at it a lot, so you’ll want to understand what you’re seeing.

Under most circumstances, the telescope points to about 15 arcsec rms or better. This figure can change depending on how recently the pointing errors have been mapped and modeled; the position as displayed has been corrected using a model of the telescope errors. The position displayed is also corrected for refraction, nutation, aberration, and precession, so it should approximate the mean coordinates for the specified equinox. The model (and the corrections) are handled correctly when the coordinates are reset using a known star. The telescope readouts sometimes drift slightly in declination during the night, especially if you do a lot of long north-south slews; apparently a few pulses from the dec encoder get lost.

Note that the telescope has some pointing limits. It can’t get extremely close to the horizon, or various hard and soft limits are triggered (see the comprehensive manual for where these limits are and how to back out of them if you get into them). The RA is limited to +/-6 hours to avoid cable wrap problems. Observing under the pole is not really supported, though I hear it’s been done.

There are manual control paddles to move the telescope. These have directional buttons NSEW, and two buttons labeled SET and SLEW. The actions of these buttons are quite standard. Holding a directional button down moves the telescope very slowly in GUIDE rate (typically one or two arcsec per second of time - the guide rate can be adjusted with the **`xtcs`** window). Holding down the SET button results in a much faster rate, about 1 arcmin per second. Finally, the SLEW rate is full-speed, around 1 degree per second, used for major repositioning of the telescope. If you need to slew manually, you must keep an eye on the telescope to be sure you know what it's up to.

Restoring lost pointing. Occasionally the telescope may lose pointing entirely. Hardware failures may be responsible; more frequently, it's due to pilot error (updating pointing carelessly and then slewing away before the error is detected). There's only one way to reliably set pointing from scratch, and that's to slew to the zenith and reset the encoders. **Follow these instructions exactly and pointing will be restored.** The whole procedure takes 10-15 min at the most, if you try to improvise you'll waste much more time than that, so don't.

1. Turn off the TRACK switch (on black TCS switch panel).

2. Get a working flashlight, and go out in the dome, turning on the red dome lights as you go. There's a telescope hand paddle out in the dome, it's usually hanging near the southwest side of the polar axis. Get it.

3. Look at the telescope. Figure out which way you should move it to point at the zenith (east or west? north or south?). Then, using the paddle, manually slew the telescope to near the zenith. Keep looking at the telescope as you slew to be sure you're moving the right direction and not driving toward the horizon!!

4. Go back in the control room. If you have another observer leave them in the dome.

5. Within a few degrees of the zenith, tiltmeters mounted on the telescope will read how far off the zenith you are. The readouts are on a rack in the computer room. Move the telescope with the control room handpaddle to set the tiltmeters to exactly zero, *or to whatever the current zenith reading is*, in both axes. (If you have another observer in the dome have them alert you over the intercom if you go way off by mistake.) Note that sometimes the tiltmeters seem to drift away from the correct zenith; there will often be a handwritten note giving the tiltmeter readings for the correct zenith; if so, use those.

6. In the **`xtcs`** window, set the *TCS Equinox* to the current epoch, within half a year or so, e.g. 2006.2.

7. Find the *Sidereal Time* display on the TCS monitor. Note the time and write down the sidereal time 1 or 2 minutes in the future, to allow time for typing and so on.

8. Type the coordinates of the zenith into the appropriate fields in the **`xtcs`** window on hiltner; they are

   ```
   RA = sidereal time (the one which you just wrote down).
   Dec = 31 57 12
   Equinox = right now (decimal year)
   ```

9. SEND the coordinates to the TCS.

10. Pull down the **`setup`** menu in the **`xtcs`** window, and note the **`set RA and dec encoders`** item. Watch the sidereal time readout on the tcs. At the moment the sidereal time matches the sidereal time you've set up, let your finger off the mouse button to reset the encoders.

11. Verify that the hour angle is reading within a couple of seconds of time of zero, and that the dec is within one arcminute of 31 57 12 in the present-epoch coordinates.

12. Turn the TRACK switch back on.

13. The `xtcs` window has a button labeled `Get Coords`; click on this and select `Nearest Bright` from the pull-down menu. This will load the Yale Bright Star catalog entry nearest the zenith.

14. Slew to this bright star. Since all the bright stars are around 6th or brighter this should be a **huge** unmistakable star. (It's a common mistake to set up on the wrong star. Don't be fooled by cheap imitations, this sucker will be **bright!**) The zenith tilt meters are not necessarily accurate enough to get the star in the field of view (which for some instruments is very tiny, like 90 arcsec), so you will probably need to scan the telescope back and forth a little bit in order to find it. *Note* that the best way to pick up the bright star will be instrument-dependent, and requires a little thought on your part; here are some suggestions:

```
With the MIS: In xmis, find the pink "Preset" menu button for the guide
              probe position, and pull down "center".  This will put the
              upward-looking probe in the center of the field.  Don't
              forget to move it away when you're done, since it will
              block your science instrument there.
Retrocam:     Put in the retrocam and take a quick shot.  It's accurately
              boresighted with the telescope and shows a much bigger
              field of view than the MIS guider.
With the 8k:  Take an image (probably binned pretty heavily to minimize
              read time) and the very bright star should be obvious.
```

15. Use the directional buttons on the telescope handpaddle to put the bright star near the center of the field of view of your instrument.

16. With the telescope pointing right at the star, go to the pink "Setup" menu in xtcs and pull down the "set RA/dec encoders" item. This should reset the telescope position to that of the bright star.

17. Before moving away, make **absolutely certain** that the coordinates have set correctly on the TCS; look at the original coordinates of the star (recall it again in xtcs) and verify carefully that you have reset the coordinates correctly. Be aware of the coordinate "epoch" (more properly equinox); if the telescope "epoch" is not 2000, click on the "TCS Equinox" button in the xtcs window and adjust the telescope's display to 2000 (this affects the display, but not the actual position), and then the telescope should agree with the star's catalogued position. If you've used any offset commands in centering the star, be aware of the following insidious way to make a mistake : the **`set RA/dec encoders`** command sets the encoders to the values in the *Next Object* field. But, if you send offset commands to the TCS, this *over-writes the Next Object values*, so when you set, it will be to the wrong coordinates. The cure is to use the **`Send Coords`** button in xtcs to reset the *Next Object* field to the correct coordinates before setting the encoders. **Bottom line: don't move away until you're certain you have it right.**

18. Select another bright star nearby and slew to it to double-check. You can do this by slewing randomly by 10 degrees in any direction and doing "Nearest Bright" again.

19. Don't forget to turn off the red lights if you turned them on!

20. If you've put the MIS guide probe in the center of the field, better withdraw it to where it's not blocking the beam.

That's the procedure. I hope it's worked for you!

Here are a few more aspects of the telescope you'll want to know about:

The focus control: The telescope is focused by holding down the IN and OUT buttons on the paddle. This moves the focus rather slowly. If you also hold down the SET button, the focus moves much more quickly. The focus numbers are arbitrary and their zero point varies widely - your numbers from the last run mean nothing. Focus numbers tend to decrease as the temperature goes down.

The Instrument Rotator: There is an instrument rotator at the back of the telescope. It has its own encoder, which is not particulary reliable these days; you can set the encoder using **`xtcs`**. There are various pieces of tape marking different position angles. Note the following about the instrument rotator:

1. You *must* have the mirror covers open to rotate the instrument. The mirror covers bear upon a moving part of the instrument rotator! Metal shavings and paint flakes don't do much good for the mirror!

2. The rotator paddle is in the dome. Be sure to turn the speed all the way down before turning the rotator on or reversing direction.

3. While rotating the instrument, use a flashlight to watch carefully for any cables which might be hanging up. It's a helluva thing to have a cable catch on some critical switch or knob, pull it, and then get ripped out ... ruins your whole night.

4. To avoid problems with cable hangup, the rotator angle should be kept within +/-90 degrees.

What's the "slit angle"? : On this last, note that there's a little quantity called the "slit angle" displayed on the TCS, in the upper right-hand corner. The story behind this is as follows. If you do slit spectroscopy away from the zenith, your data suffer from atmospheric dispersion - the star is smeared into a little spectrum in a direction perpendicular to the horizon. You can capture all the wavelengths in the slit by orienting the slit perpendicular to the horizon. The position angle of an arc connecting a given point to the zenith is called the *parallactic angle*, because it's (anti)parallel to the direction of topocentric parallax displacements. Ordinarily, with the roator angle at zero the MDM spectrographs are oriented with their slits north-south, so that they're on the parallactic angle for any object crossing the meridian. Once you're far away from the meridian, you want to rotate the slit to the parallactic angle, but keep the rotator angle within +/-90 degrees. Because the slit is indifferent to 180-degree rotations, but the rotator isn't, the "slit angle" is the rotator angle which, for the present position of the telescope, will put the slit on the parallactic angle and keep the rotator within its travel. For instance, if the parallactic angle is -150 degrees, the "slit angle" will be +30 degrees. *It's important not to interpret the "slit angle" as an actual readout of the rotator position. The rotator position readout is the "Rotator Angle", displayed near the middle of the TCS monitor about 1/3 of the way from the top.*

If you intend to track an object over a large range of hour angle, you may want to check out the parallactic planner button on the GUI skycalc; it computes the optimal rotator setting over a range of time for your object and gives a graph showing how badly you do if you're off by 10 or 20 degrees on either side. This feature is only on the skycalc versions installed at MDM, not in the usual distribution. Like the guide star selector, it pops a bright blue temporary xterm window and a white-on-black pgplot Xwindow (which may cover up the xterm window); hitting ENTER in the blue xterm window makes the whole thing disappear.

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About the MIS

All the commonly used instruments *except* the MDM 8k camera are mounted on an adapter called the MIS (Multiple Instrument System). This provides a number of commonly-needed utilities. Some useful diagrams can be found in the manual.

There are three parts to the MIS. Working downward from the telescope they are

The finder unit:
: This is a gold-anodized box about two feet square and 10 inches deep. It contains a prism that can slide in and out of the beam to feed an Apogee CCD camera called *RETROCAM*, so called because it was retrofitted to the MIS by Chris Morgan of OSU. The finder unit also houses a set of *comparison lamps* - an incandescent flat bulb, and Ne, Hg, Ar, and Xe discharge lamps - for calibrating spectra. The prism that feeds the *RETROCAM* also diverts the comparison lamp light downward to the instrument, and the optics are arranged so that they provide an approximate f/7.5 beam to match the telescope. Note that you can either see comparison lamps or the sky, but not both at the same time, as they call for different positions of the RETROCAM prism.

The guider unit:
: This is about 5 inches deep; it bolts to the back of the finder unit. It has a pickoff mirror which feeds optics leading to another TV camera. The pickoff mirror can be moved around on a precision stage, which I'll call the guide probe. The TV fed from this mirror is used for offset guiding; one finds a guide star by moving the guide probe, and then starts the autoguider to keep the telescope locked in position. At one position of the stage, the TV looks into a *slit-viewing microscope*, which is mounted at the end of a push rod. If you're doing slit spectroscopy, the staff will push the slit-viewing optics into place as part of the setup procedure. If you're working direct, the slit viewing optics should be retracted. The guider TV has a fairly small field (like an arcminute) The Ohio State CCDS has its own slit-viewing arrangement.

The filter wheel:
: The filter wheel is only used for direct imaging with the MDM facility CCD cameras. There are two wheels, one of which takes 2-inch filters and the other 4-inch filters. The 2-inch filters vignette the 2048^2 SITe chip to about 1600^2. The older MDM 4-inch filter wheel hasn't seen much use lately since a far superior version built by OSU has come on-line; however, this large filter wheel is used largely (maybe exclusively) at the 1.3m.

The MIS is operated using the **xmis** program on **hiltner**. This issues commands to the MIS control computer, which is an ancient piece of equipment residing in the computer room racks. The controls are fairly straightforward to operate. There are a number of preset positions for the guide stage (slit, center, etc). You can also type in an X or Y coordinate for the guide stage and hit return to send them; an indicator blinks red while the stage is moving, then stops blinking and shows the new position when it gets there. You can also get relative steps using the "Delta X" or "Delta Y" fields. Other buttons or menus allow you to turn comparison lamps on or off, move the RETROCAM prism in or out, and so on.

There are a number of things to be aware of when using the guide probe.

1. The GUI version of *skycalc* running on agung makes it almost criminally easy to pre-select guide stars for your target, using the USNO A2.0 star catalog as a database. The full explanation is given a little later in the document. This is highly recommended, even if you're working at low latitude where guide stars are plentiful, since the software automatically excludes positions in which the guide probe might obscure the field center (see the next item on the list). Also, for some programs it's possible to use a pre-set guide star to greatly speed up field acquisition and centering.

2. It's important to note that *there's nothing to stop you from blocking the telescope beam with the guide probe*. You *must* keep the guide probe away from the ! There's a very confusing chart in the manual about this, but a rule of thumb is that if you keep the X coordinate less than a few thousand you'll be OK. If you have a cloudy night you might want to experiment by taking dome flats and moving the guide probe around until you can see it when you divide one picture by another - I've never mapped out the "safe" area myself, and someone should do it.

3. The guide probe camera needs to be focused so that when the telescope is in focus, the guide probe is also. The guide probe focus is controlled by a rocker switch on a little aluminum box a couple inches square. If you're doing spectroscopy, and guiding off the slit jaws, you focus the guide camera during spectrograph setup, by looking at the slit jaws illuminated by a flat lamp (you'll need the TV gain way down), and focusing the guide probe until the slit looks as sharp as possible. Then when you get a star on the slit jaws, you simply focus the telescope until the star looks as good as you can get it. The slit jaws are in focus in the TV, and the star is in focus in the TV, so therefore the star is in focus on the slit jaws, which is what you want. In direct work, you focus the telescope on the CCD somehow (classical step 'n shoot focus test), then find a guide star and focus the guide probe on it.

   NOTE: the focus in the slit viewing microscope is way different from the focus when the guide probe is looking up into the telescope as for offset guiding. This means that it's impractical in spectroscopy to park a star on the slit, then hunt for an offset guide star; by the time you've found a guide star and refocused the guider, the telescope has drifted enough that you can't be sure your program star is still in the slit. The OSU CCDS solves this problem by having a separate slit-viewing camera of its own, freeing the MIS guide TV for what it does best, namely offset guiding.

4. If the guide probe is driven past the end of its travel, it loses track of where it is. I've also seen it lose track when it gets *close* to the end of its travel in Y, say at 10500 or greater, but I'm not totally sure of this. In any case, it takes only a minute or so to reset the coordinates, by selecting **Origin** in **xmis**. This drives the probes back to its zero position and resets the counters.

5. The guide probe travel is larger than the unvignetted field of the telescope. You'll find that you can't see anything at Y<2000 or so, for example.

6. **Easy pre-selection of guide stars!** The GUI version of *skycalc* available on Agung contains an MDM-specific tool for selecting guide stars from the USNO A2.0 catalog. The gui has its own manual . Instructions for starting the GUI skycalc program are here. Once you have the program up, it's easy to select guide stars:
   - Enter your object's RA and dec in the main window (upper left). (If you have read in an MDM-style pointing list, this is especially painless: just double-click the name on the list, or type the name in the top entry box and hit return.)
   - If the instrument rotator isn't at zero, open the "Guide Star Config" window and enter the appropriate value.
   - Hit "Get Guide Stars". This pops a bright blue temporary Xterm window, and a big black Xwindow with a diagram of the guide field and a cursor. Click on a star near the left-hand edge of the field (for best results) and its guider XY coordinates will appear in the blue Xterm window.
   - When you're done, type "q" in the black Xwindow and the whole apparition -- Xterm and Xwindow -- will disappear.

7. **Fast target acquisition using the guide probe.** The guider XY stage is very accurate, and so is the USNO A2.0 catalog (though some stars may have moved in the 50 years since the POSS-1 on which it was based). Therefore *centering the preselected guide star in the appropriate location on the TV should put you very close to your target*, provided of course that you're setting on the right star! This can save enormous amounts of time. To develop this procedure, start with a target you can set up accurately. Select a guide star using the program (described immediately above), set up the guide probe at the XY coordinates predicted by the program, aim the telescope accurately at your target, and note where the guide star lands on the TV. If you keep the guide cursor there as you set up on new fields, and center the (correct!) guide star in the box, you should be very close. Be careful of the a HUGE GOTCHA here, explained a little farther up: *the guide probe can lose track of where it is when it is driven to Y-values greater than about 10500.* Again, as it says there, just reset the probe coordinates if that's an issue. Also, you'll want to be sure you know the rotator angle accurately [Note: A previous standalone version of the code, called gs24, proved to have a bug in it which introduced 10-20 arcsec inaccuracies. This has been fixed and the procedure described above has been field-tested with very good results; with care one can get within a few arcsec typically.]

8. It's also possible to hunt and peck for guide stars if you need to (the USNO A2.0 is no good in some crowded fields, for example). Here's how to do it. (The units used here for X-Y are the default, raw counts; you can make them arcsec or mm instead.)
   - Center up on the object
   - Be sure gain is up on the guide TV
   - set the guide probe to X = 0, Y = 2000
   - set Delta-Y to 1000
   - repeatedly hit carriage return and watch the TV to look for guide stars
   - stop when Y = 15000 or so (I think I remember the numbers, but I'm not certain).
   - At the top of the Y travel, set X = 1000 and Delta-Y = -1000, then step back down ...

   and so on, raster scanning until you have a guide star. In principle you can scan across the low Y range and up the far side of X without vignetting the chip, but this is seldom necessary. The field maps produced by the skycalc tool give an idea of the useful field.

More about the MIS TV cameras

The TV cameras currently used in the MIS are tricky devices. It’s important for many applications to understand them well.

The cameras consist of Gen I image tubes coupled to video-rate TV cameras. Since image tubes are less common than they were a while back, here is an explanation. An image is projected onto the front face of a vacuum tube, where there is a photocathode. Electrons liberated from the photocathode are accelerated greatly by a high voltage. The fields in the tube are arranged so that the electrons from a given spot on the input all land in the same spot on the other end, thus preserving the image. Where the electrons land, there is a phospher which glows when excited by these high-energy electrons. Because the incoming photon has only about 2 eV, and the electron has several keV, there’s much more energy than there was to start with, so the intensity of the image is greatly amplified.

Our image tubes are military-type units which are fed from a 6-volt power supply -- the high voltages needed to run the tube are generated internally. The voltage feeding the tubes is controlled by a power supply in the control room -- it has a knob which can feed zero to a little over 6 volts to the image tubes. The higher the voltage, the higher the voltage in the tubes, and the more the image is amplified.

There are several **important gotchas** with these image tubes:

1. The tubes discharge voltage with a *very* long time constant (like 10 minutes). Once you turn the voltage up, it is up -- unless the tube is discharged somewhat more quickly by bright light.
2. If the gain is up, bright star images completely saturate. You really can’t use them to focus or to assess the seeing. When you first set on a bright star, advance the gain *slowly* to avoid saturating it. Because of the long time constant (item 1), once the gain is too high, you can’t bring it back down!
3. The power supply is set up to "crowbar" at a little over 6 volts. If you turn up the gain beyond that, it abruptly resets to zero, and you have to turn the gain *all the way down* to get control of it again. It’s like you dropped it, and have to go down to pick it up again. Before you walk away and let the telescope autoguide while you grab lunch, be sure you haven’t let the gain drop to zero, or your guide star will -- gradually disappear!

Adding the **DTI** box to the mix adds another level of complexity, but it can be worth it because you can see much fainter. Here’s a recipe for getting the most out of the DTI while viewing the slit:

1. Retrocam OUT (so you’re looking at sky).
2. Check TV selector set to GUIDER.
3. On the DTI, set the black toggle switch to DIRECT. This passes the signal straight through.
4. Advance the image tube gain while watching the monitor. Stop when it starts getting medium-bright (but way short of white).
5. Switch the DTI to INTEGRATE.
6. Set the DTI time constant to 1/4 sec or less.
7. Spin the BLACK and WHITE knobs on the left side of the DTI (they have many turns) until the contrast looks right (greyish sky with white stars if they’re present).

8. If the image is too dim, *slowly* advance the image tube gain while watching the TV carefully.
9. When it looks optimal, increase the time constant on the DTI. Time constants up to 2 sec are useful, beyond that you're just amplifying noise.
10. Be aware that you're now looking at an integrated image, which will respond slowly.

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About the autoguiders

The autoguider programs reside in a big old Gateway 486 PC which sits on a table just inside the computer room (it had been in the control room, but it was too noisy to bear.) There are two distinct programs, namely

The "New" or "Seitzer" guider (TVGUIDER)
: This is named after Pat Seitzer, who engineered it. In this guider, the video signal comes right into the PC where it's averaged on a board. You put a little box around the guide star, adjust a few things, and start the guider. It works really well for offset guiding - there are a bunch of things you can tweak, but you generally don't have to do much. Pat has also written a very user-friendly manual, which you should read carefully before using it.

The "Old" or "DTI" guider (PCGUIDER)
: This uses the old cream-colored Digital Television Imagery ("DTI") box to integrate the signal. This integrated signal is fed into the PC, which then generates a guide signal, using a program originally written by Mark Metzger and later tweaked slightly by myself. This program does not offset guide as well as the Seitzer guider, but it has compelling advantages when you are guiding from an image reflected from the spectrograph slit. I wrote a manual for this guider which is quite complete, and it has on-screen help and default settings (**But note:** the correct guide rates are double or triple the defaults, because the defaults were tuned for the old TCS).

The Seitzer guider program works only with the integrator in the PC, and has nothing to do with the old DTI integrator. Conversely, the program that uses the old DTI integrator knows nothing about the integrator in the PC. Since the two pieces of software use different hardware, switching between the two guider programs involves plugging and unplugging cables, which must be done by the staff (hence during the day). The PC programs for the two setups have confusingly similar names (TVGUIDER = the new, Seitzer guider, while PCGUIDER = the old, DTI guider).

The Seitzer guider is much preferable for direct work -- it's simpler to use and guides better -- but the DTI guider has compelling advantages for spectroscopic work (except with CCDS which uses its own slit-viewing camera). Most importantly, *the Seitzer guider cannot display an integrated image and guide at the same time.* Furthermore, the integrated images in the Seitzer guider aren't as smooth or as deep as those in the DTI. If it's important to see and guide on faint objects on the slit jaws, the DTI rules. As noted earlier, it would be better if there were a separate camera to view the slit jaws (as in CCDS), freeing the guide probe to roam around and guide the telescope with the Seitzer guider, but that's life.

Some TIFKAM observers have noted a way in which a subtle difference between the DTI and the Seitzer guider can be important. When the DTI-based program starts guiding, it notes the position of the star in its little box, then tries to hold the telescope exactly on its initial position. The Seitzer guider, on the other hand, tries to keep the star at the exact center of the little box, even if it didn’t start out right at the center. The steps by which one moves the little box on the TV amount to a substantial fraction of an arcsecond; with a 1/2 arcsec slit, you can lose much of your flux just because of this silly digitization problem.

The DTI integrates with a "leaky memory", which gradually forgets the oldest signals; the image changes continuously, unlike the Seitzer guider, in which the new image appears abruptly. The abrupt updates can cause headaches after hours of staring.

There’s often a lot of confusion about how to set the adjustable parameters of the guiders in various situations. TVGUIDER (the Seitzer program) wakes up with good parameters for direct imaging, and the manual should be helpful for fine adjustments. PCGUIDER (the DTI) is rather more complicated. It has a menu of defaults for different setups, which should at least get the parity and rotation right. However, the default guide rates are way too small, corresponding to too-aggressive guiding. You will want to up the guide rates on PCGUIDER from the defaults to something like 7, which guides more conservatively. (The rates also depend on the guide rates set in the TCS, which control how fast the telescope moves when the button is pushed.) The refresh rate and number of frames averaged are also adjustable in PCGUIDER; I recommend setting the refresh rate to match the DTI integration time, and averaging a few frames together, because the guide signal can be glitchy.

A simple way to test any guider is to get it going on a fairly decent star and push a guide button to throw the telescope off a little bit. The error you introduce should be big enough to be obvious, but small enough so that the star stays within the guider’s field of regard, which is about the size of the little guide box on the TV. Then, watch to see if the star is guided back to the middle of the box. If it goes off the wrong way, there’s something wrong with the rotation or parity (try both axes to be certain); if the star overshoots, your guiding is too aggressive; if it doesn’t move, the guider may somehow be disabled (is the little switch on the TCS panel in the up position? The bottom of the TCS monitor has a display which reports guide pulses -- are the commands getting through?) The speed at which the telescope corrects will of course be a function of your guider parameters and the guide rates set in the TCS.

Nearly all autoguider problems are due to observer error or unfamiliarity, but occasionally something may break. It’s worth noting here that for nearly all programs, an autoguider is not essential - it’s only a convenience. Back in my day, when we walked uphill to school both ways, we guided all night by hand. A dysfunctional autoguider is a pain, but not a show-stopper. If you can’t get the damn guider to work after a reasonable effort, don’t close down -- suck it up and hand guide! There is a stereo, after all.

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Some advice about CCDCOM

The standard old MDM CCDs are run by CCDCOM. The Ohio State instruments CCDS and TIFKAM are run using an entirely separate progam called Prospero, and the MDM 8K camera uses yet another control program, on a different set of computers.

CCDCOM has its own manual, which I am not repeating here. The purpose of this chapter is to draw attention to some useful features, and a hidden gotcha or two.

One of CCDCOM's most useful commands is **`source`**, which takes as an argument the name of a file (that resides in the directory you're currently using for the data). This causes the commands stored in the named file to be executed by CCDCOM. Thus if you have a complicated set of repetitive actions, you can simply edit them into a file (called **`foo`**, let's say), and type

```
source foo
```

to execute the commands. Here are some ways you can use this to make your life much easier.

First, the readout format of the chip is set by the **`sf`** ("set format") command, which is followed by a bunch of numbers describing how the chip is to be binned and which columns and rows are to be read. If you've set up to read a subset of the chip (as for spectroscopy, say), you'll want edit up a little one-line file like

```
sf 2 2 300 400 500 600 700 32
```

or whatever the numbers are, so that if the camera has to be restarted you can quickly *and accurately* reproduce the settings. If you're off by one column, your flatfields don't work!

The **`source`** command can be very helpful in direct work, too. The read time of a big chip can be very considerable, so sometimes it's useful to read only a subarray. I like to set up files **`bigform`** and **`smallform`**, which are 2048^2 and 1024^2, so I can switch quickly. I also like to have a **`findform`**, which is the central 1024^2 binned 2x2, to give a very short read time useful for verifying the centering. You can nest **`source`** commands (a **`source`** command can occur in a file you're going to **`source`**), so I like to have a command which moves to focus mode, sets the chip format to small, changes the file prefix to something like "scratch", turns off clearing of the chip, and so on and so on, and then another command which goes back to full size, object mode, clearing the chip, and recording the data. Commands like this save a lot of time and prevent a lot of errors.

Here's another application. As a radial-velocity spectroscopist I must keep very close track of the wavelength calibration, which means taking comparison spectra before and after every sequence of exposures. The comparison lamp set at MDM is pretty poor down in the blue. There's a Hg lamp which has some very important bright lines, but there's a desert between 4358 and 5461. Xenon has some nice lines there, but the Xe lamp at MDM is extremely faint compared to the Hg. Furthermore, the Hg lamp has a long warm-up time, like 60 sec.

To get good comparison lamps every time, I combine the **`source`** mechanism with the **`tel`** command, which can command the telescope and MIS. Using a **`source`**'d file, I turn on the lamps to warm up, move the guider mirror away from the microscope to avoid frying the TV, move the Retrocam prism into the beam to reflect the comparison light down into the instrument, wait a little while with the **`tel sleep`** command, set the CCD to **`focus`** mode to get a multiple exposure, clear the chip, take a 0.1 sec exposure to get the bright Hg and Ne lamps, turn off the bright lamps, expose again for 60 sec to get the Xe, then turn off the lamps, read the chip, move the retrocam prism and pickoff mirrorback into place, and reset CCDCOM into object mode to take real data. This is error-prone, not to mention tedious, if you do it manually.

A word of warning: I've had troubles driving the 2-inch filter wheel with the CCDCOM **`tel`** mechanism. Better run it by hand with **`xmis`**. The OSU 4-inch filter wheel may work better.

You can interrupt CCD exposures by typing **`Ctrl+C`** (i.e., holding down the **`Ctrl`** and **`C`** keys simultaneously). *It is a very bad idea to type **`Ctrl+C`** while the chip is clearing or reading out* - wait until it's exposing. Once the exposure is stopped you can adjust such things as the name of the object, the exposure time, and so on. As for the exposure itself, you have three choices:

1. **`go <n>`** - continue the exposures, optionally including the number of exposures to do
2. **`rc`** - read the ccd and store the data.
3. **`cl`** - clear the chip, throw away the exposure so far.

Note the **little gotcha** in the **`go`** option: if you've started a sequence of (say) five exposures, and interrupt the second one, then typing **`go`** only starts *one* exposure, so you stop at two! To restart the sequence you'd need to type **`go 4`** to get the remaining four exposures.

When you're taking sky flats, especially, the **`istat`** command is needed. It does some quick statistics on the last image taken. With this you can see if the exposure level is correct. Ideally you want between 10K and 30K counts.

CCDCOM has an "IRAF" flag, which now defaults to "on". This writes the images (in FITS format) in such a way that IRAF properly understands them as *unsigned short integers (0 to 65535)*. This way, the digitizer uses all 16 bits without wasting a bit on the sign, since the raw numbers are all positive.

CCDCOM does not display images or do any analysis (though the **`istat`** command can be used to check mean values).

For **displaying images**, I recommend using **`ds9`** directly, that is, use the "File" menu in **`ds9`** to select your image, and *do not* use the "display" command in IRAF. The reason for avoiding the IRAF "display" command that it automatically rescales the displayed image for 8 bits of depth, thus destroying most of the information; it also destroys almost all the header information (e.g., wcs if you have it). If you display directly using **`ds9`**, you can still use the *imexamine* task (and others) in IRAF, amazingly enough.

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What time should I start?

OK, so the weather's great -- low humidity, photometrically clear, and the wind is a gentle zephyr. So you can open. But when should you plan to start observing? Here are a few remarks on that.

It obviously depends on what time it gets dark. The new GUI skycalc installed at MDM has a "Nightly Almanac" button, which pops up a window with the information you want. Instructions for how to launch the program appear immediately below. If you can do it, it's a good idea to open the dome maybe 15-20 minutes before sunset so you can have your dewar topped off and ready to go by the time the sun actually sets (that way you can enjoy the sunset and see the green flash). There are constructive uses for twilight time. If you're doing direct imaging in the optical, sky flats can start in the U band shortly after sunset, within 5 minutes or so, and the window of opportunity for well-exposed sky flats is pretty short. Bright stars can be found almost in broad daylight to verify telescope pointing. Certain kinds of spectroscopic standards can be done in quite a bright sky -- e.g. 10-th magnitude flux standards should be do-able within 20 minutes after sunset. Just be sure to keep the TV gain low when the sky is really bright!

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How do I start GUI skycalc?

The GUI skycalc, with its guide-star selector, planetarium display and so on is available only on agung, not hiltner (and at the 1.3m it's on hill, not mcgraw). You have (at least) two ways to get at it:

- On Agung's (or Hill's) console, it's installed in the launch menu (the red hat in the lower left). But -- you'll have to scoot over to agung to consult it.
- To lanch it on hiltner, click on the little terminal icon in the lower left to get a terminal. Into this terminal type the following:

  ```
  ssh agung
  skycalcdisp.py
  ```

  and it should fire right up. The "disp" means it has the planetarium display implemented; the ".py" indicates that it's in the Python language (which I believe everyone should learn, as it is more useful than, say, algebra).

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