Practical lesson: remote operation of telescope and camera

- The Mees telescope startup/shutdown guide, found under the Mees tab on www.pas.rochester.edu/~dmw/ast244.

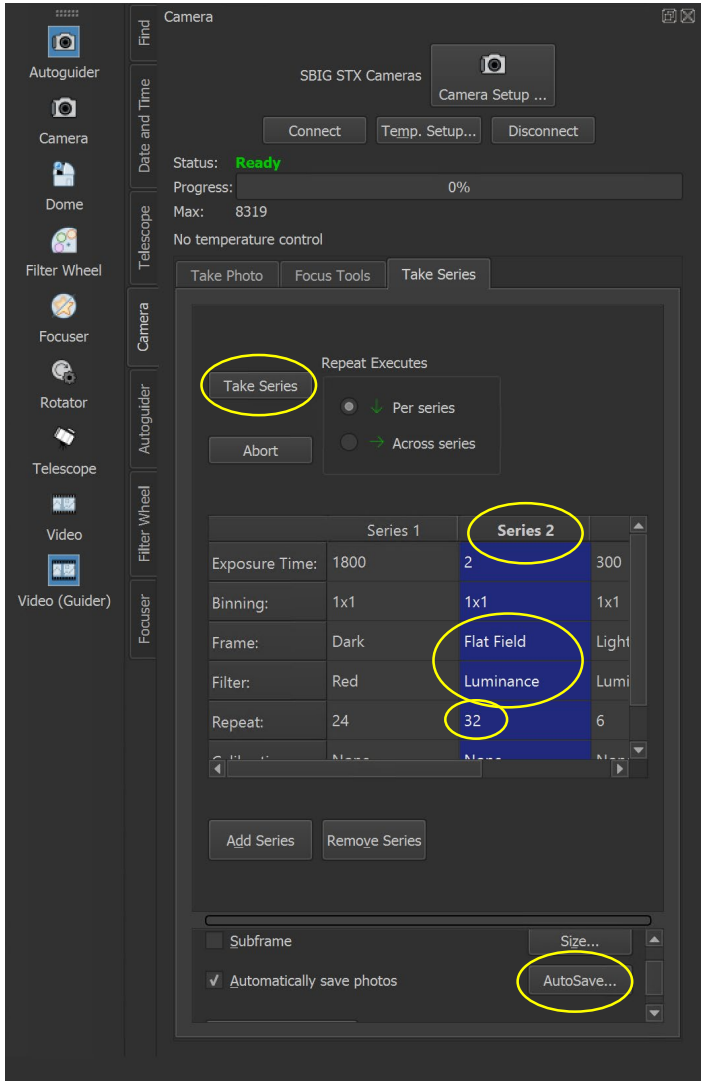
Software:

- The Sky X, or Stellarium (http://www.stellarium.org).
- Camera plugin on The Sky X, or CCDSoft v. 5.

M51, LRGB. L from Palomar (200-inch Hale telescope); color from Mees.

0. Calibration data

- Make sure you can find the dark and bias data for the camera you will use.
- Plan to take flat fields in every filter and binning you will use.
  - At least 32 frames each.
  - Exposure times such that about half-full wells are produced.
  - With the telescope-cap flatfield lamp, this takes frame times of 0.5-2 sec in the broadband filters, or 5-10 times this in the narrowband filters.



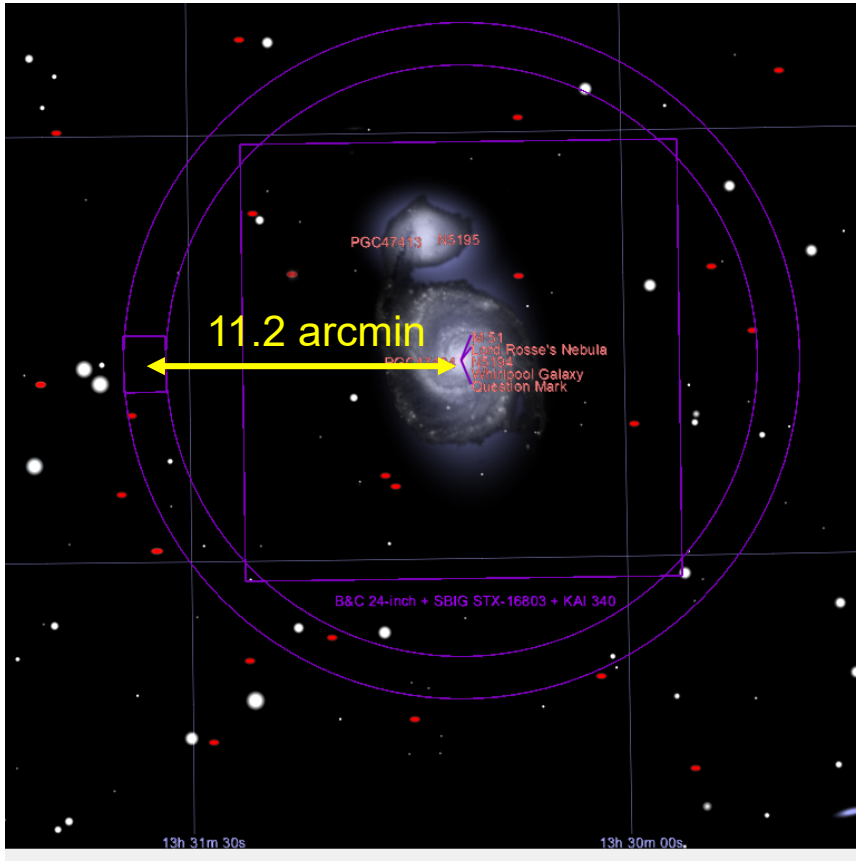
1. Select target and guide star.

- Find your target in The Sky X or Stellarium, to make sure that it will be above about 35° elevation during the time you want to observe.

- Make sure a guide star is handy. Look 11.2 arcminutes due east of the target, and note that the autoguider camera's footprint is 2 arcmin N-S and 1.5 arcmin E-W.

- Note E-W (RA) is like longitude:

$$11.2 \text{ arcmin} = (44.8 \text{ sec})/\cos\delta .$$

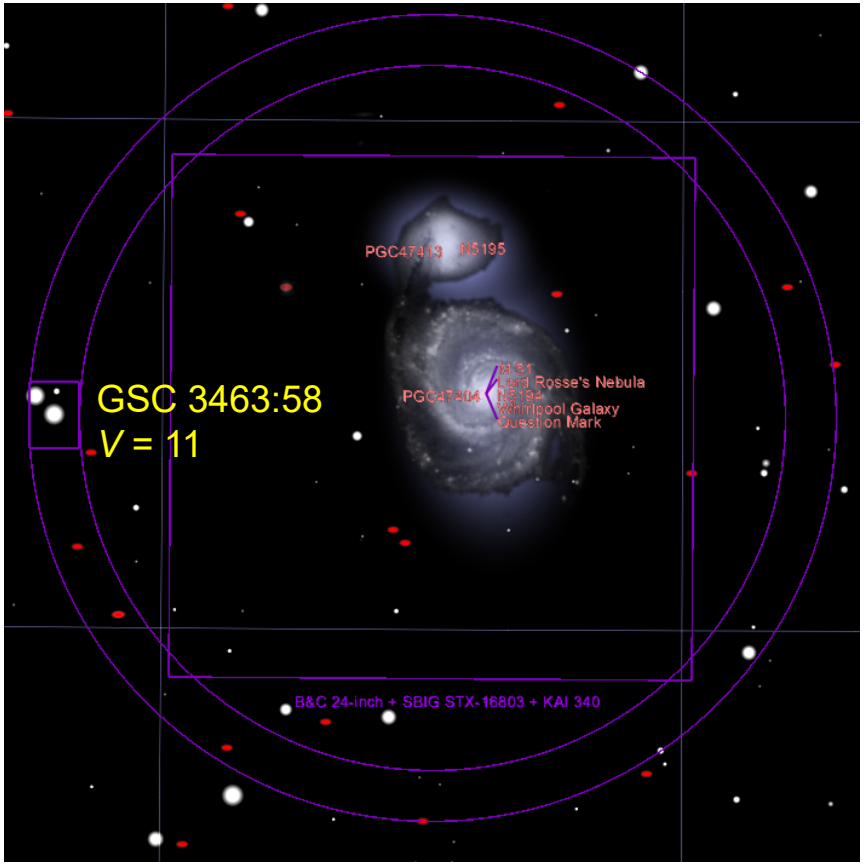


1. Select target and guide star (continued).

- You should plan to center a relatively well-isolated star in the autoguider.
- Anything brighter than 12th magnitude takes less than 10 sec of exposure for good guiding in the LRGB filters.
  For fainter:

$V = 12$	10 sec
$V = 13$	25 sec
$V = 14$	63 sec
$V = 15$	never mind;

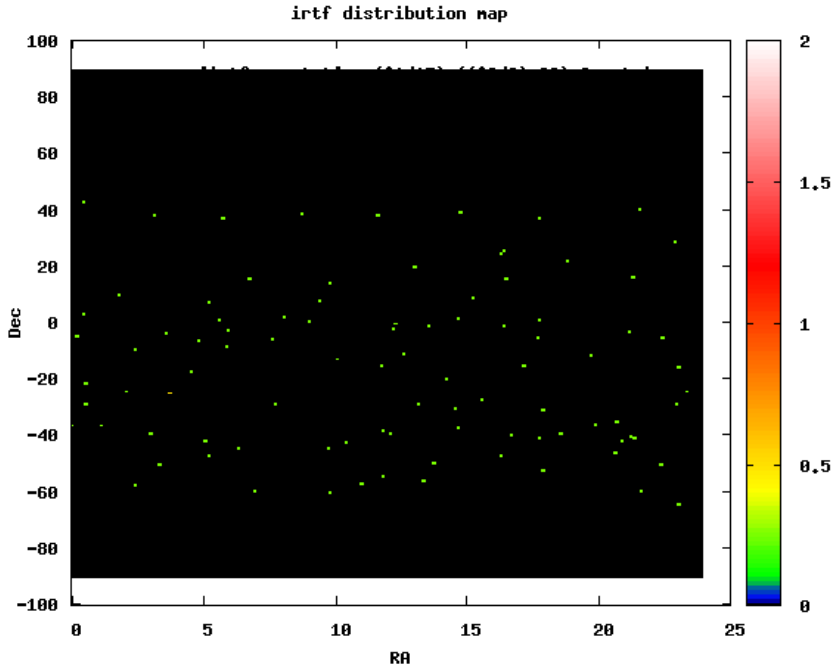
recall $(S/N)_{SL} \propto \sqrt{P_S \Delta t}$.



1. Select target and guide star (continued).

- If you'll be taking scientifically-useful images, for which accurate colors are important, identify a couple of good standard stars you can observe during the night – preferably A0V stars, one 6-8 mag, one around 10 mag that's closer to your target.
- I usually use the NASA IRTF standard stars:

  http://irtfweb.ifa.hawaii.edu/~tcs3/starcat/catalogs_info/



2. Make sure the camera is connected

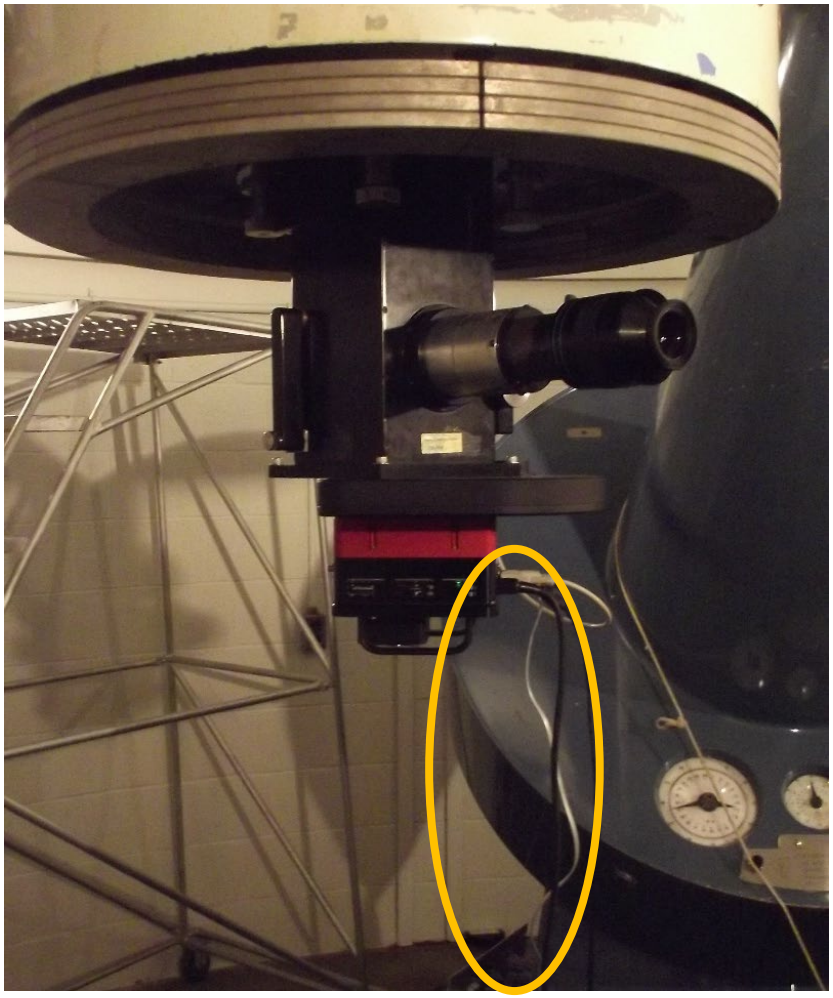
If you're at the telescope:

The cables which run from the camera to its power supply, and to the patch panel at the base of the telescope, can be found in the black valise below the workbench on the dome floor.

- ❑ Black USB 2.0 cable for CCD signal and control
- ❑ Straight-wired RJ-11 cable for autoguider signals
- ❑ Round power connector

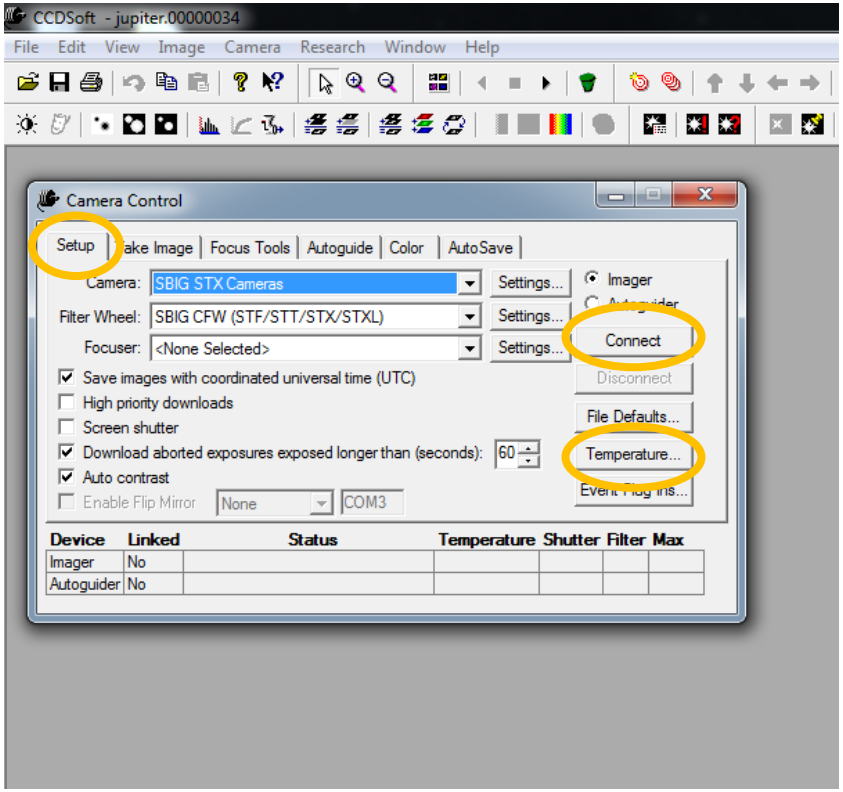
Usually we use USB port 2 and autoguider port 2.

If you're not at the telescope, remind whoever is, to check this.



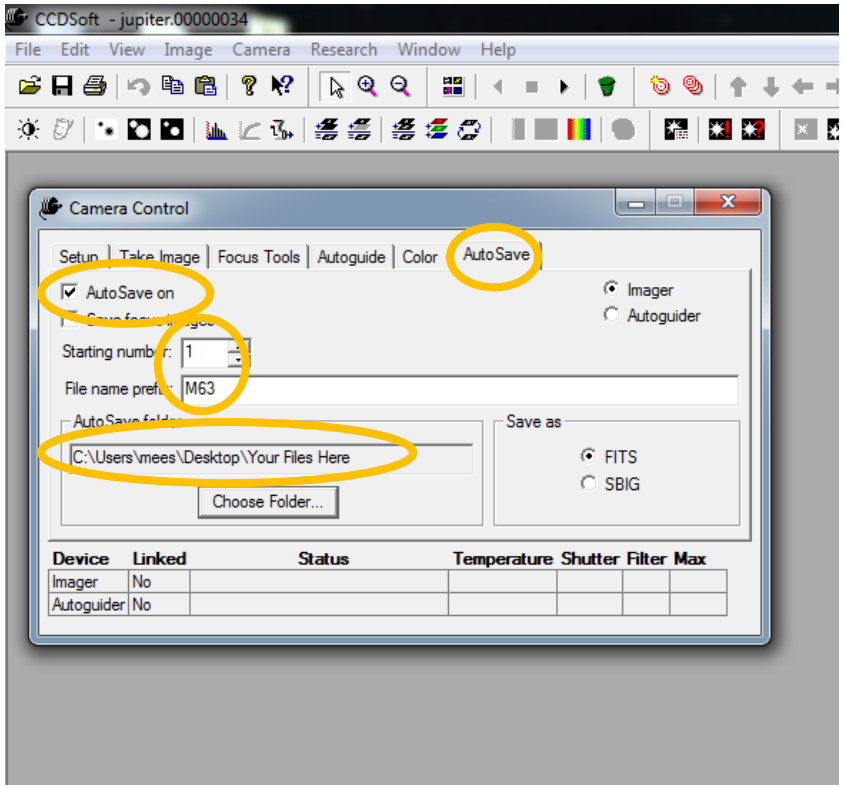
3. Connect the software to the camera, and set the focal-plane temperature.

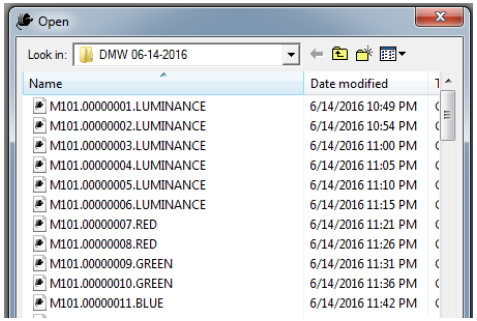
- On the TCS computer, start The Sky 10, and select Camera from the banner on the left.
- Or on the CCD camera laptop, start CCDSoft, using the desktop icon at upper left.
  - If the Camera Control (CC) window does not come up automatically, start it from the Camera menu.
- Use the Connect and Temperature (or Temp. Setup) buttons to establish communication between camera and computer, and to set the CCD temperature to *T* = -20C.



4. Decide on a file-naming convention

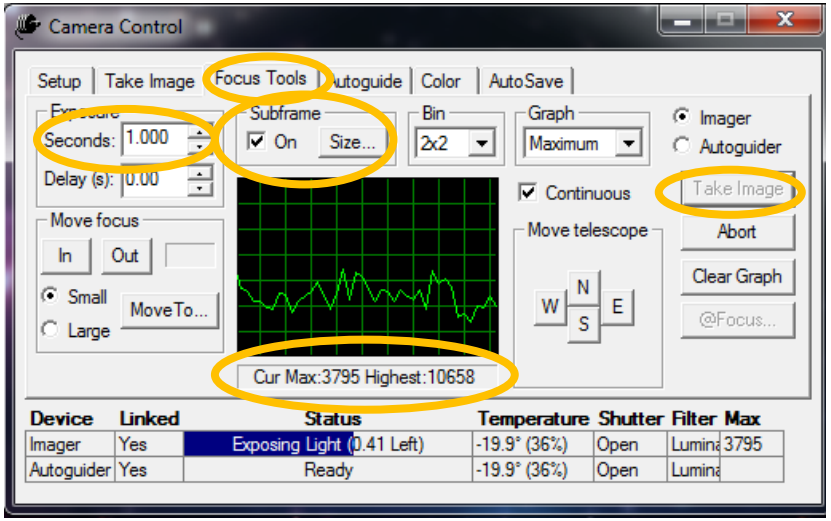
- Best to have the file name long and detailed enough to help you pick key parts of the data out of a long list.
- Use The Sky's Autosave tab to set the working directory and file-name root.
- The Color tab in CCDSoft adds useful extensions to the filenames.





5. Focus the telescope

- Point to a 4-6 magnitude star near the zenith, change the filter to L, and run the focus through a range around the last analog focus value, looking for the value which gives the smallest, brightest stellar image.
  - Easy when using TCS's focus setting tool, under Telescope > Misc > Focus.
  - Only move focus In (focus readout decreasing) to target analog-focus value.



- CC's Focus Tools can help you set up a small subframe around the star, and keep track , graphically and numerically, of its peak brightness as you move the focus around.

6. Point to your target, and acquire your guide star.

One good way to acquire the guide star:

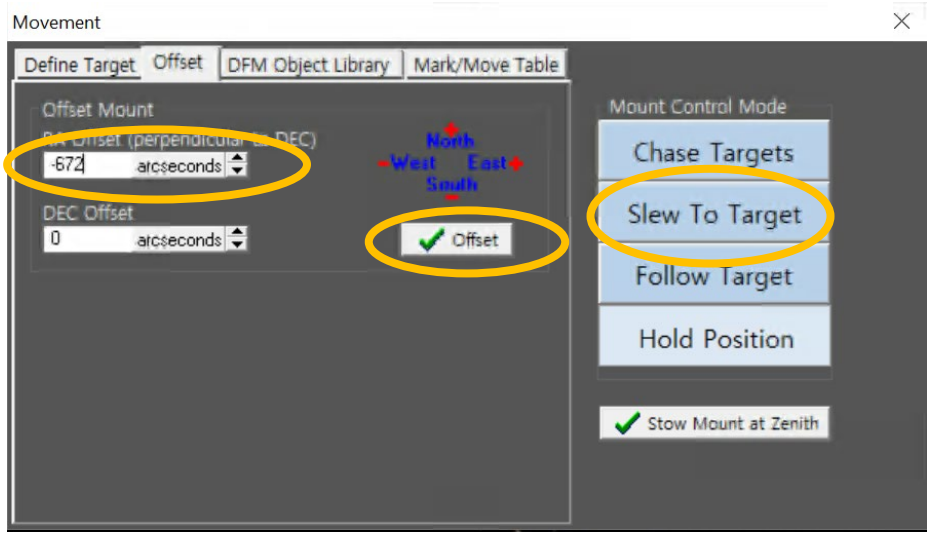
- Point the main CCD at your guide star, and take a sequence of 10-30 sec L-filter exposures while you use the paddle to center the star in the field.
- Sync the telescope coordinates on the star when centered.
- Then point to coordinates 44.8 s/cosδ west – smaller RA, either
    - by calculating the new RA and using the paddle, or

Main CCD

Paddle button pressed...	Star moves on image...
N	↓
W	←
E	→
S	↑

6. Point to your target, and acquire your guide star (continued).

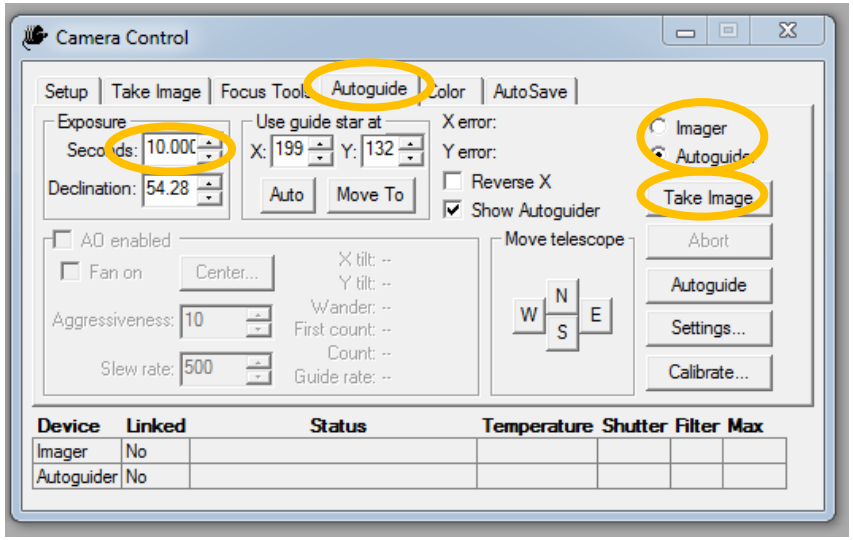
- by using TCS's Telescope > Movement > Offset/Other tools to order an 11.2 arcmin = 672 arcsec offset to the west.
- RA increases to the east, so this goes into the system as -672 arcsec.
- Offset, then Slew.



6. Point to your target, and acquire your guide star (continued)

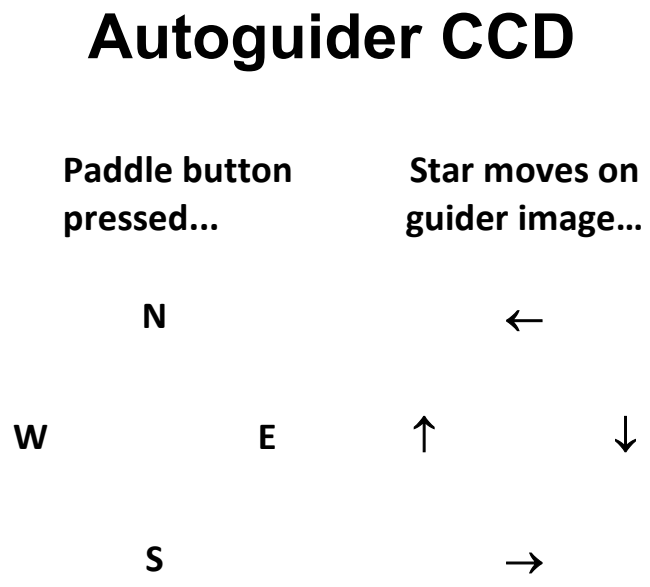
Then take images with the main CCD and the autoguider CCD, using CC's Autoguide tab, to see where target and star wound up.

- 30-60 sec in L for main CCD, if your target is a galaxy; expected exposure time on autoguider CCD, for the star. Toggle between the two with the radio button above the Take Image button.



6. Point to your target, and acquire your guide star (continued)

- Move the guide star to the center of the autoguider field, noting before you do that the stars move differently in response to the buttons for autoguider and main CCD.
    - The autoguider CCD is rotated 90 degrees, and its light goes through one more mirror reflection, relative to the main CCD.

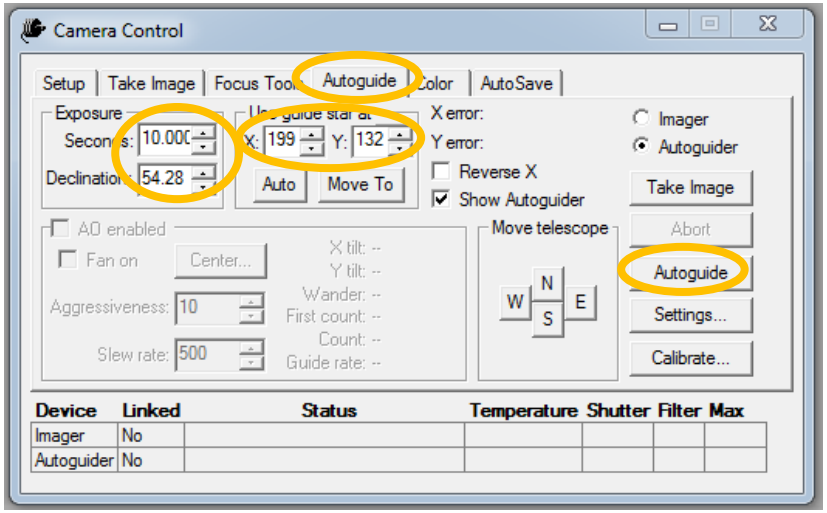


7. Autoguide

- With the Autoguide tab open and a current image of the guide star showing, click on that star *in the image*. Briefly a square surrounding that star will appear. The X and Y coordinates on the tab will now match the CCD coordinates of the star.

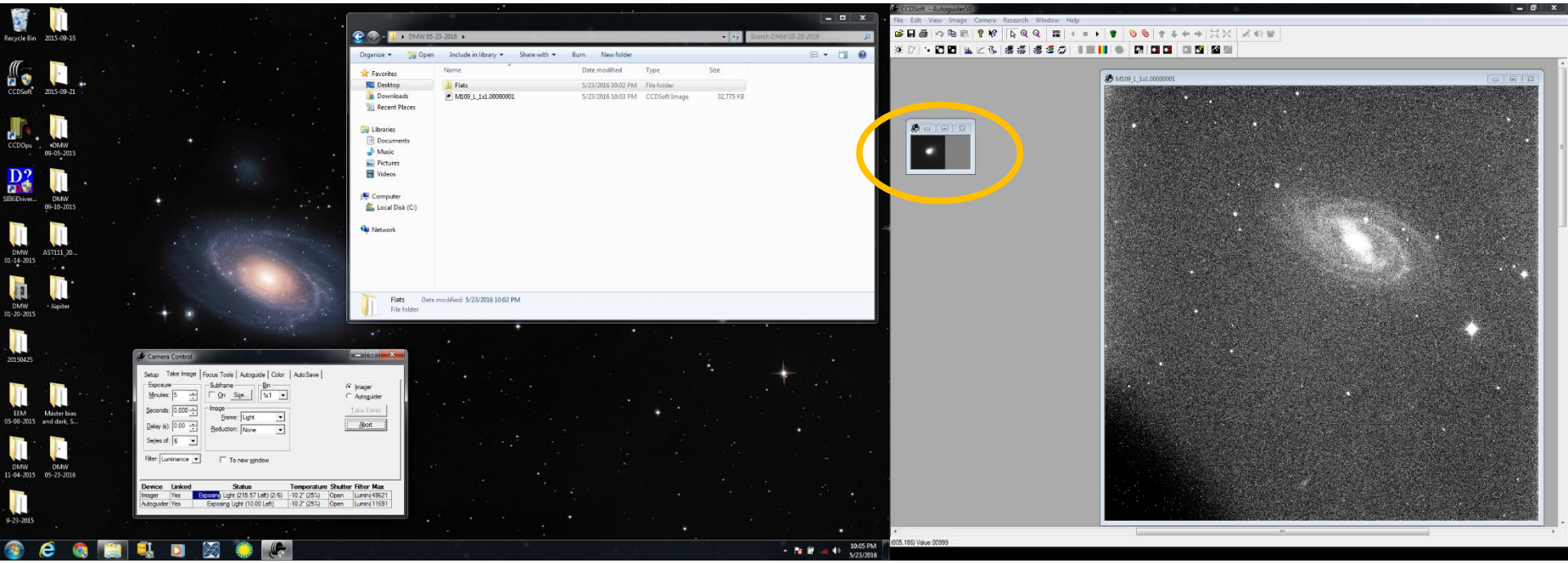
- Set the tab's Declination value equal to the guide star's declination. Check that the Exposure value will work.

- Push the Autoguide button.



7. Autoguide (continue)

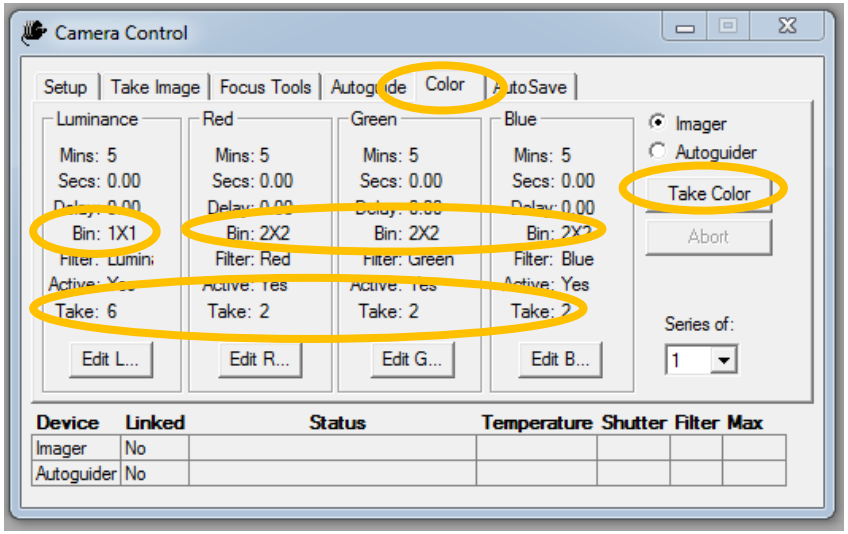
Then, every autoguider exposure time, a small image of that briefly appearing square will appear, showing the guide star and its small, corrected positions within. You are now ready to take the real data.



Happily autoguiding (and taking data)

8. Take images of your target

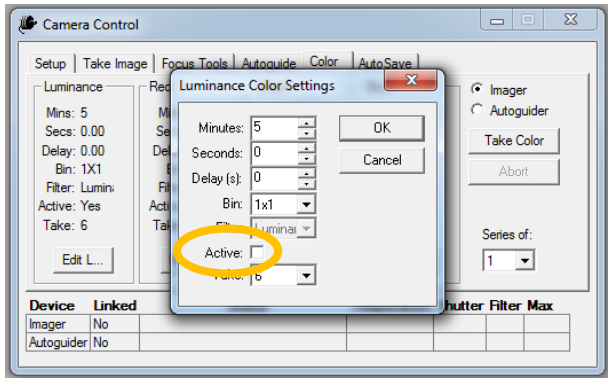
- 5 minute exposures if there will be substantial moonlight during the observations; 8-10 minute exposures otherwise.
- Use the tools in CC's Color tab to expedite the observations.
  - Or the Series tabs in The Sky X.
- For pretty pictures:
  - L in 1x1 binning, at least three times as long exposures as any of R, G and B.
  - R, G and B in 2x2 binning.
  - Sequences as long as a few hours work fine.

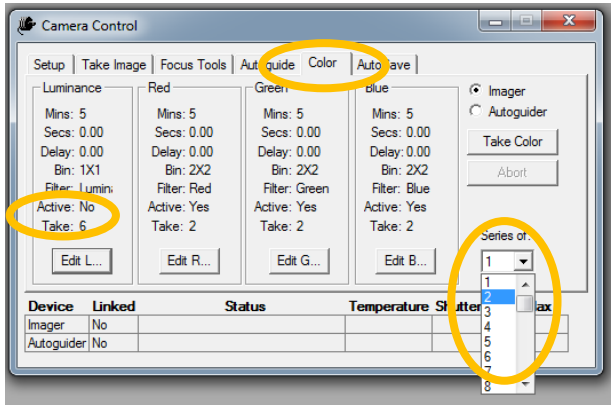


A one-hour pretty-pictures color series.

8. Take images of your target (continued)

- For scientifically-useful (color calibrated) observations:
  - More time into RGB.
  - Use 2x2 binning or more, unless the seeing is *really* good.
  - Every hour or so, take a set of much shorter-exposure RGB images of the standard stars.



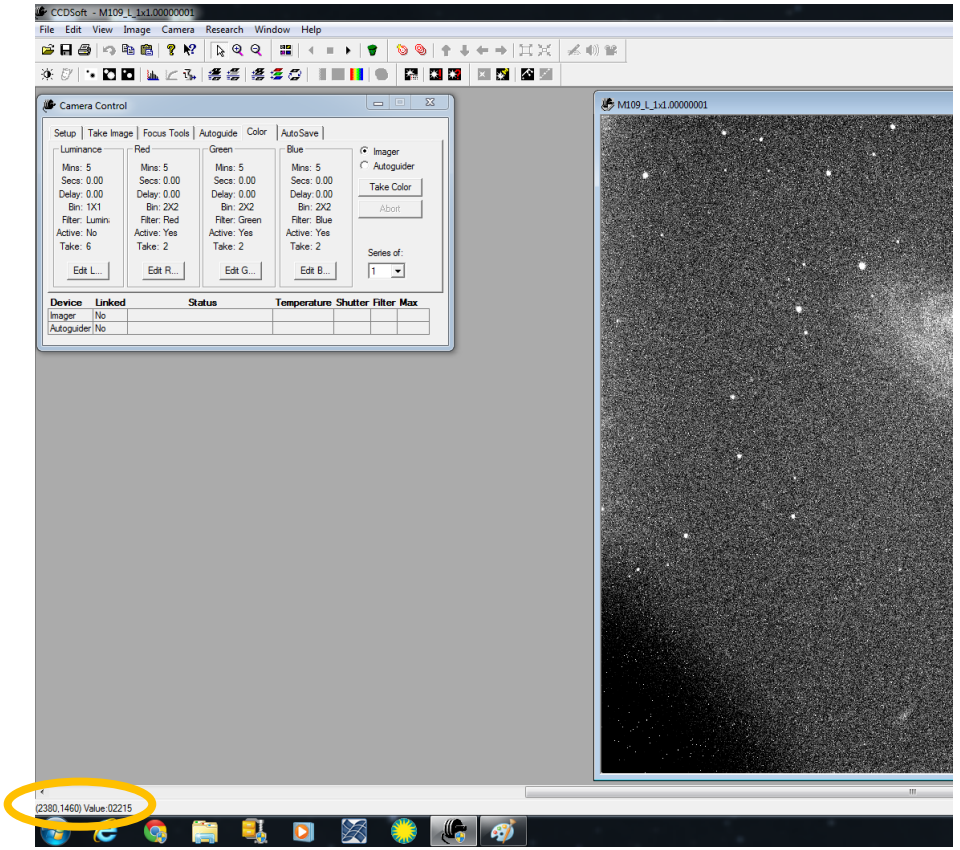


8. Take images of your target (continued)

- Either way, monitor the guiding and be prepared to repeat steps 7 and 8 if guiding is lost. It has been working very smoothly of late, though.

- Watch your images come in too. Keep familiar with signal levels, to make sure you're still happy with exposure times.

  - Saturation occurs at DN = 65535; don't let signal exceed about 50000 for any object you care about.



9. Save your data

- Leave copies in the directories you created in the beginning, but…
- Take copies of everything with you on a memory stick.
- Or upload it all to the Wiki.
- Take good enough notes to be able to decode your filenames later – though the file headers contain most of the important information.