Multi-Object Slit Spectroscopy with the Goodman Spectrograph

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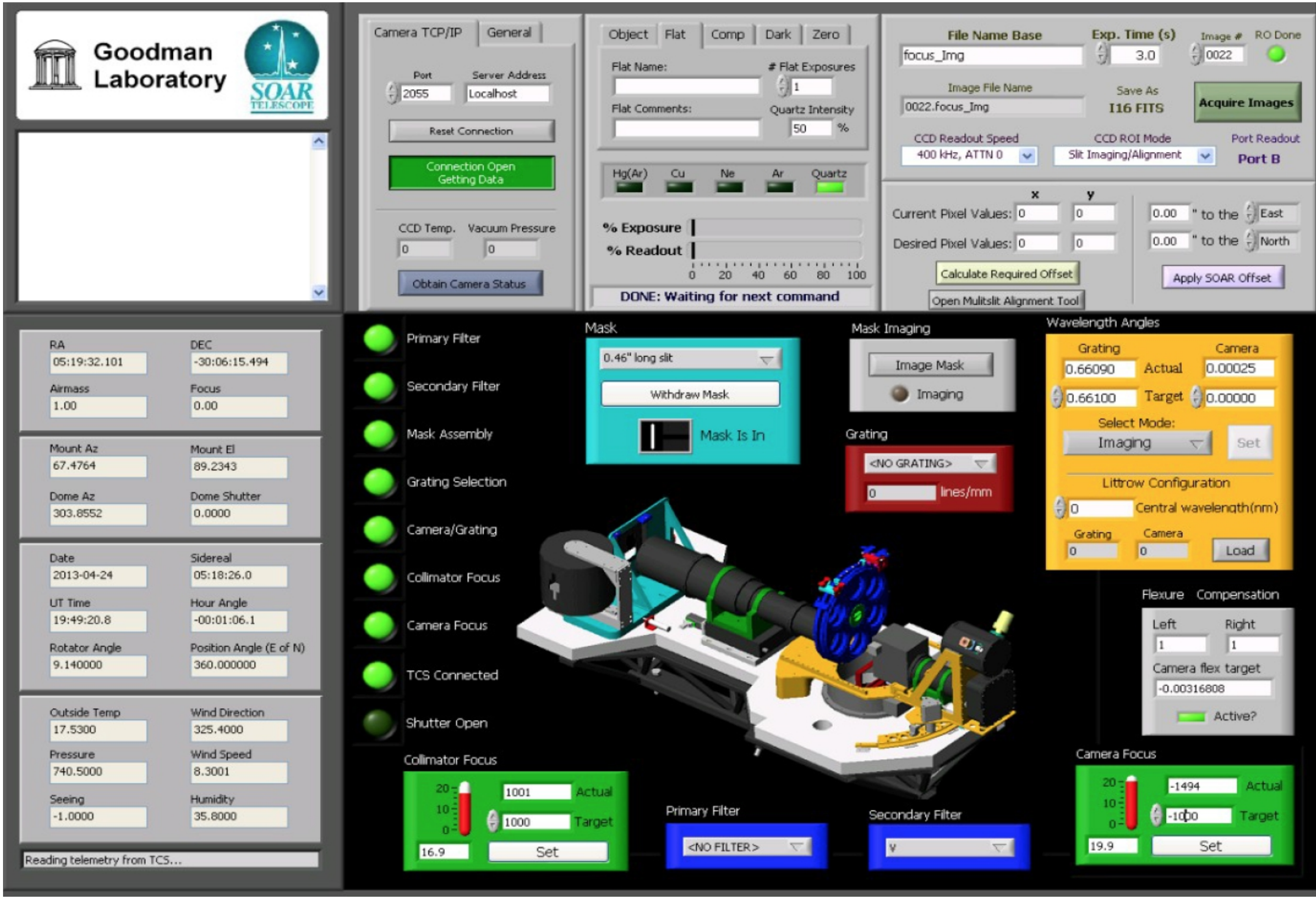
Spectroscopy:

Grating (lines/mm)	Dispersion (Å/pixel)	Coverage (Å)	Max R @ 550nm (3pix with 0.46" slit)	Blocking Filter
400	1.00	M1: 300-705 M2: 500-905	1850	– GG-455
600	0.65	UV: 301-569 Blue: 350-616 Mid: 435-702 Red: 630-893	2800	-- – GG-385 GG-495
930	0.42	M1: 300-470 M2: 385-555 M3: 470-640 M4: 555-725 M5: 640-810 M6: 725-895	4450	– – GG-385 GG-495 GG-495 OG-570
1200	0.31	M0: 302-436 M1: 350-485 M2: 420-550 M3: 490-615 M4: 555-685 M5: 625-750 M6: 695-815 M7: 765-880	5880	– – – – GG-455 GG-455 GG-495 OG-570
1800	0.19	800	9610	As needed
2100	0.15	630	11930	As needed
2400	0.12	510	14280	As needed

http://www.ctio.noao.edu/soar/content/goodman-spectrograph-overview

Using Goodman: Spectrograph GUI



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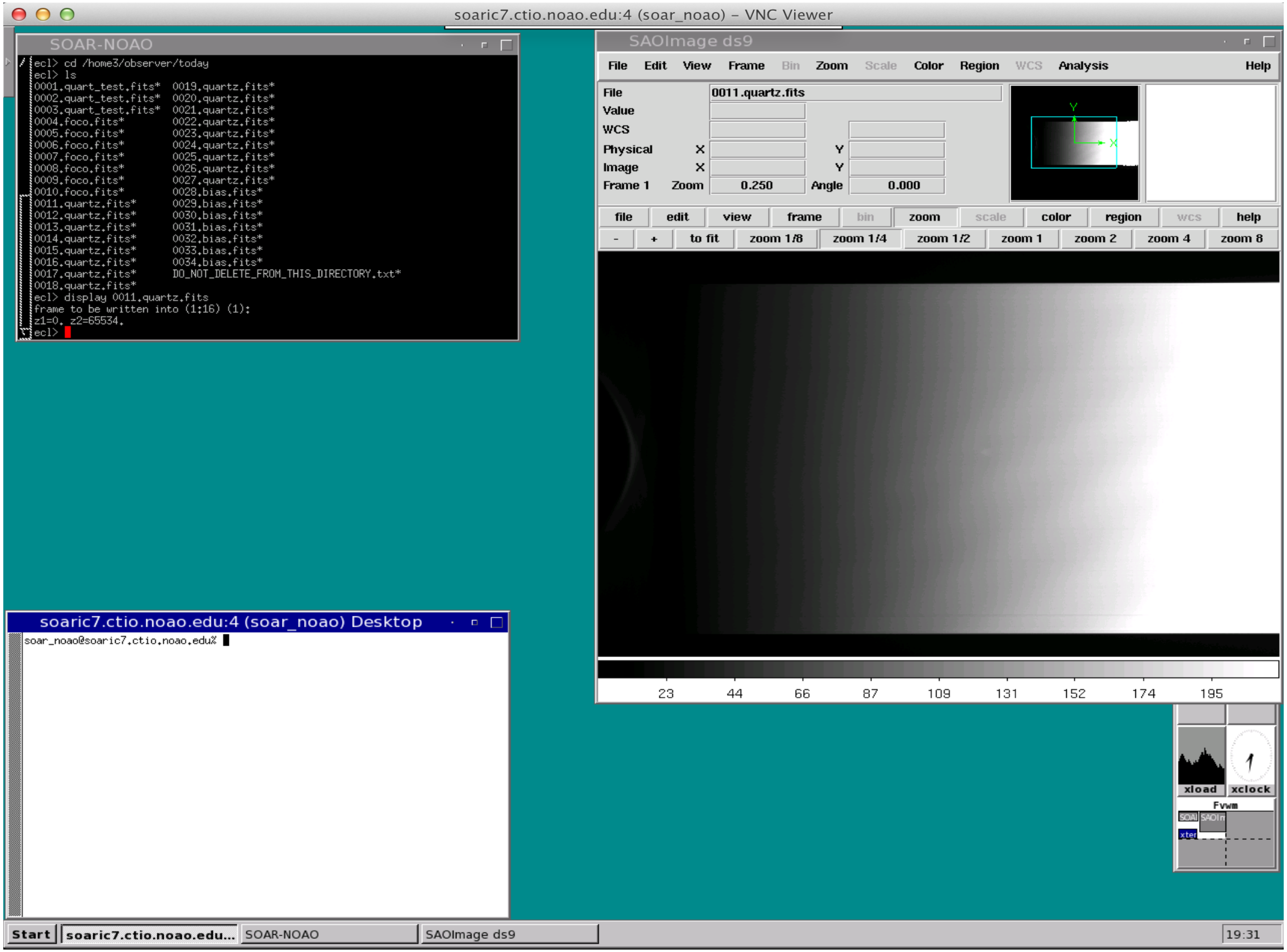
Using Goodman: Data visualization environment - IRAF -



Using Goodman: Remote Observing

Requirements (aside from familiarity with Goodman!):

• **Minimum 2 monitors** (preferably 3)

• **A good VNC connection.** This should be tested at least 1 week before your observing run. We strongly recommend the VNC Viewer client

• **Skype**

Please (re)read the Goodman Manual and documentation. We have a new SOAR website, and we are adding new and improved documentation for the observer.

Contact your Instrument Scientist well ahead of time! Preparing for MOS observing will require more preparation

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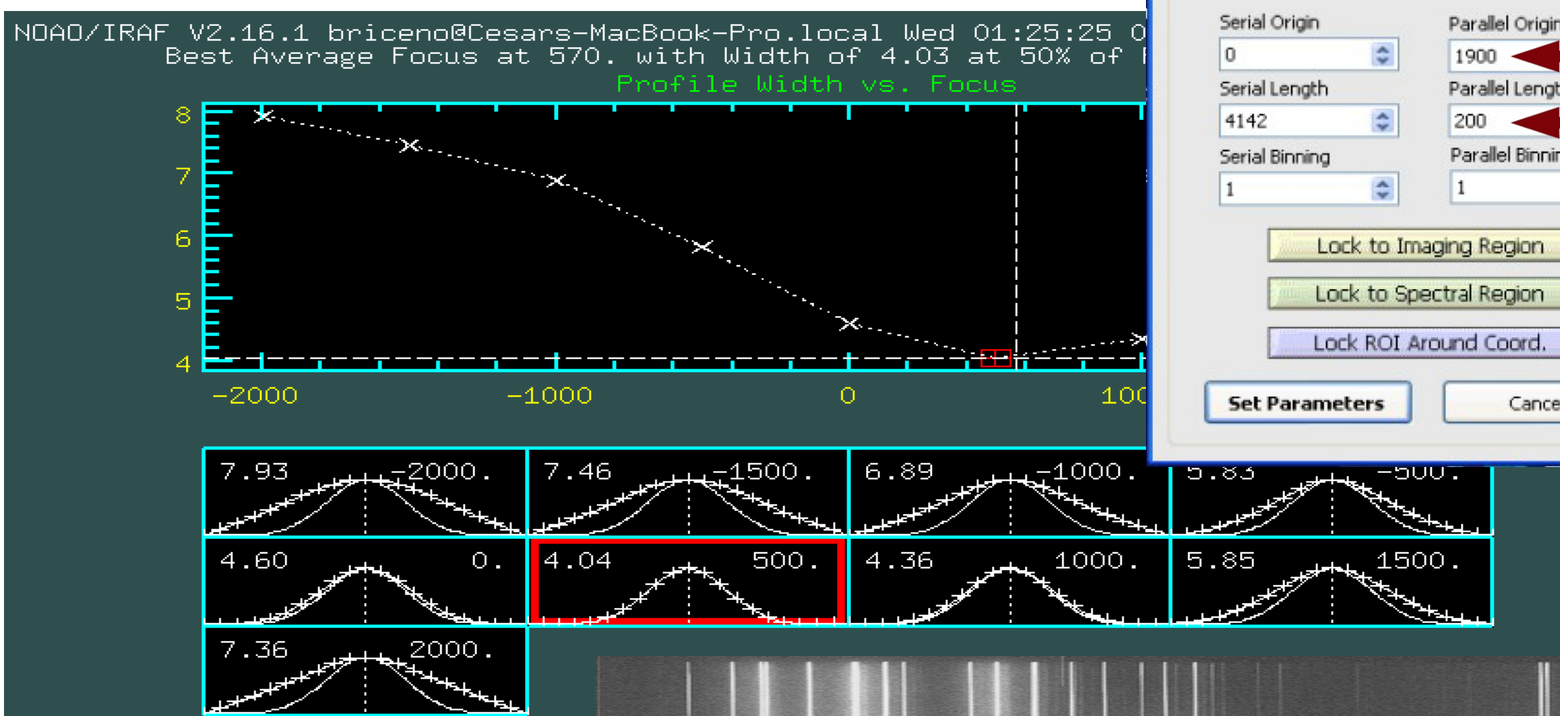
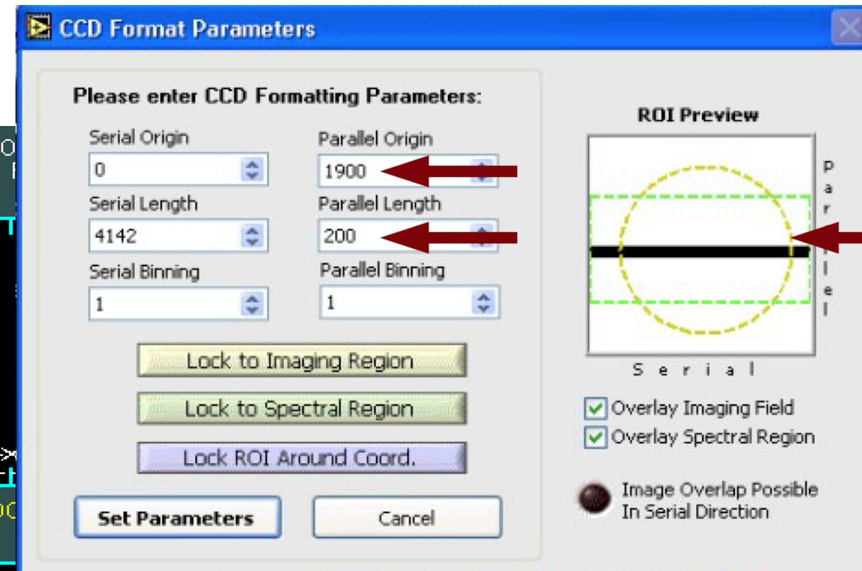
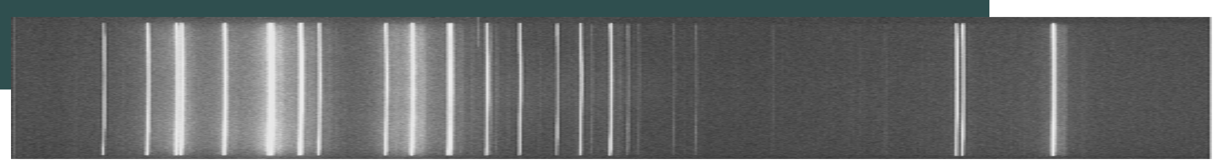
Focusing the spectrograph

-2000 to +2000 in steps of 500, Exp=1s for Hg(Ar) lamp. 400M2 + G455
Use the 400 KHz ATTN0 readout.

You can also read a smaller region to save time: modify the values "Parallel Origin" and "Parallel Length" to 1900 and 200, respectively will readout only a 200 pixel wide region.

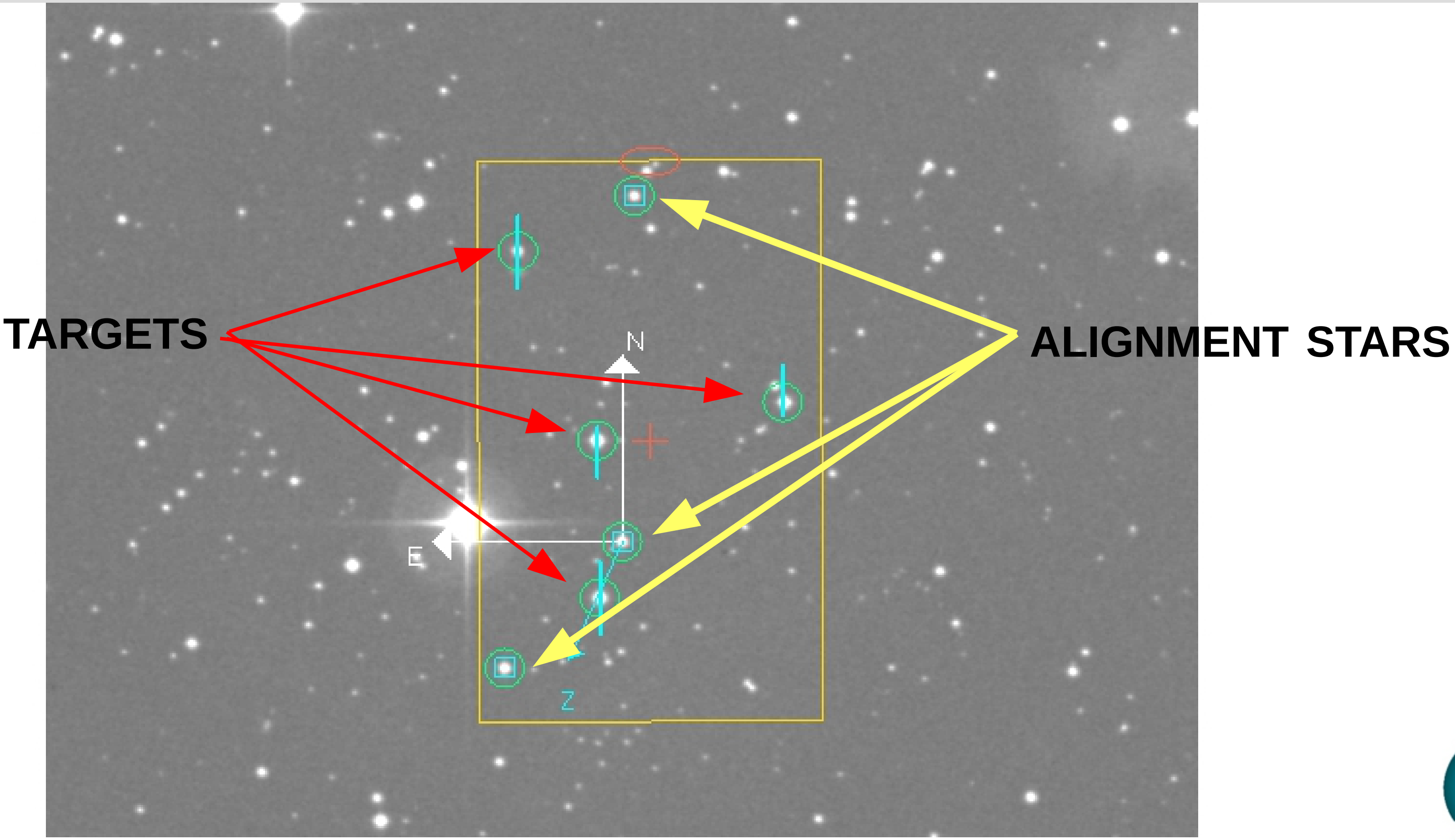






The Goodman HTS MOS mode

- **Brings multiplexing capability to Goodman over a 3x5 arcmin FOV**
- Objects should not be closer than ~5" in the spatial direction, to avoid overlap
- 3 alignment stars with V~< 15, and preferably similar magnitudes.
- Best to avoid very bright stars (V<10), so scattered light will not be an issue
- Alignment stars should form a sort of “L” pattern



Goodman MOS masks

The simple formula is: $\mathbf{D_{pixel} = -1 * 400. * (\Theta_{offset}[arcsec] / 60.)}$

where east offsets are positive and west offsets are negative.

Once the D_{pixel} is calculated, one can find the D_{lambda} by multiplying by the dispersion for the grating in use.

400l/mm: ± 400A
600l/mm: ± 260A
930l/mm: ± 170A
1200l/mm: ± 125A
2100l/mm: ± 75A

Observing with the Goodman MOS mode: practical considerations

The **overhead** is **~12 min per MOS field**, from the moment the Telescope Operator has centered the target and acquired a guide star, to the start of the science integration

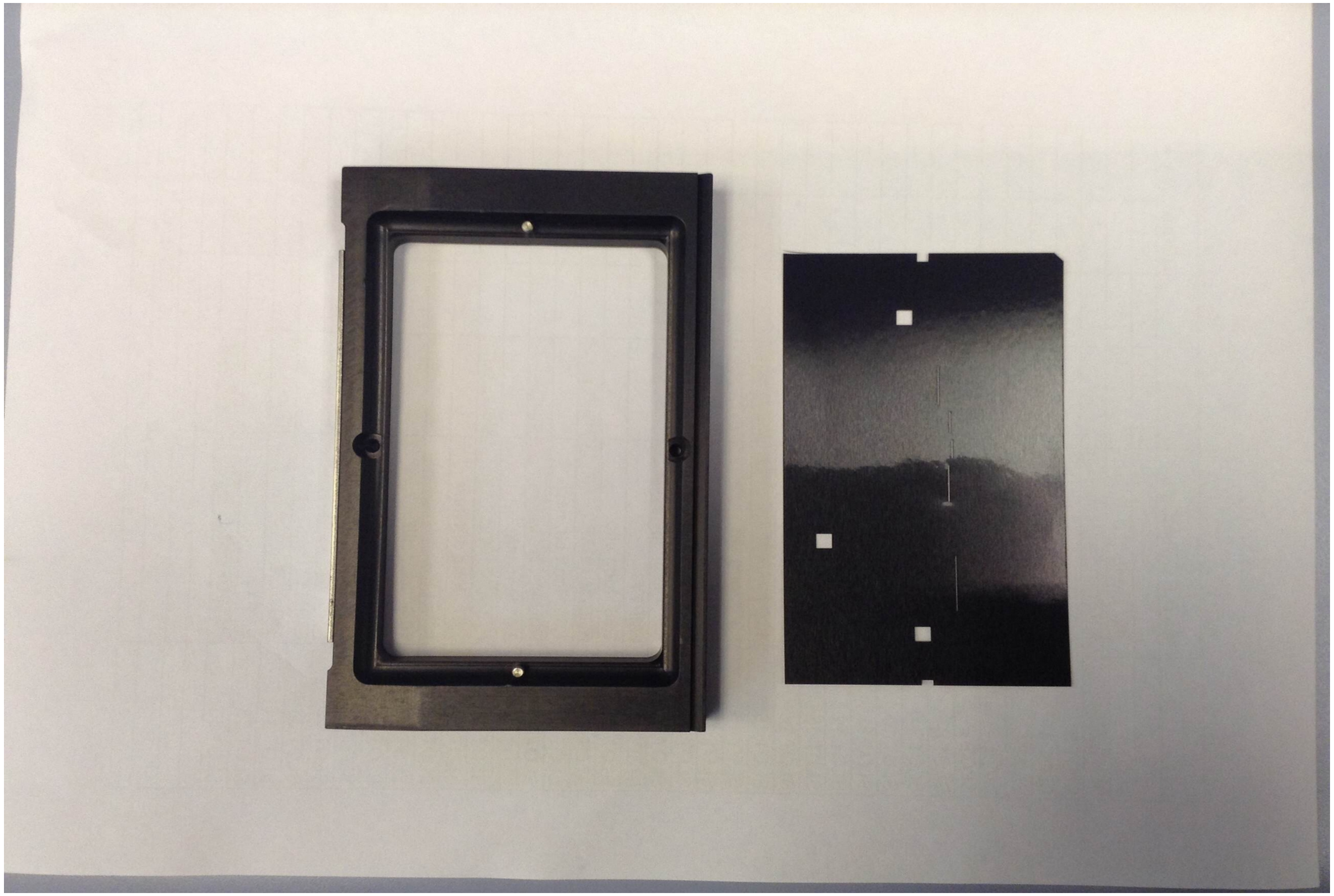
→ **MOS observations are most efficient when observing >~several objects with moderate/long integrations**

This includes time spent for initial field acquisition (1st image), imaging the mask (2nd image), operating the MOS Alignment module to calculate offsets/rotation and applying these, taking 3rd image of the mask on the field to verify alignment.

Tell the TO the PA you used to design your mask. Since you will likely have to adjust the PA, ask the TO not to find the guide star until after the PA has been adjusted

Goodman MOS masks

Goodman MOS masks are designed with the Slit Designer software, developed at UNC. Presently they are cut on carbon fiber sheets, on the same laser cutting machine used for GMOS @Gemini South.



Goodman MOS masks

Because the individual slits may be located at differing locations in the dispersion direction, the central wavelength shifts as a function of position of each slit.

In the dispersion direction, the Goodman masks are 3'' wide (1200 pix). The central slit position is at pixel x=600. Slits to the left of the central slit will see the center wavelength of the spectrum shift toward the blue. Slits to the right of the central position will see the central wavelength shift to the red. If the slits are oriented NS and East is left and West is right, then for slits located 1 arcmin east and west of the central position (1 arcmin = 60 arcsec = 400 pixel at a scale 0.15 arcsec/pixel) spectra are shifted to the blue and to the red by 400 pixels respectively.

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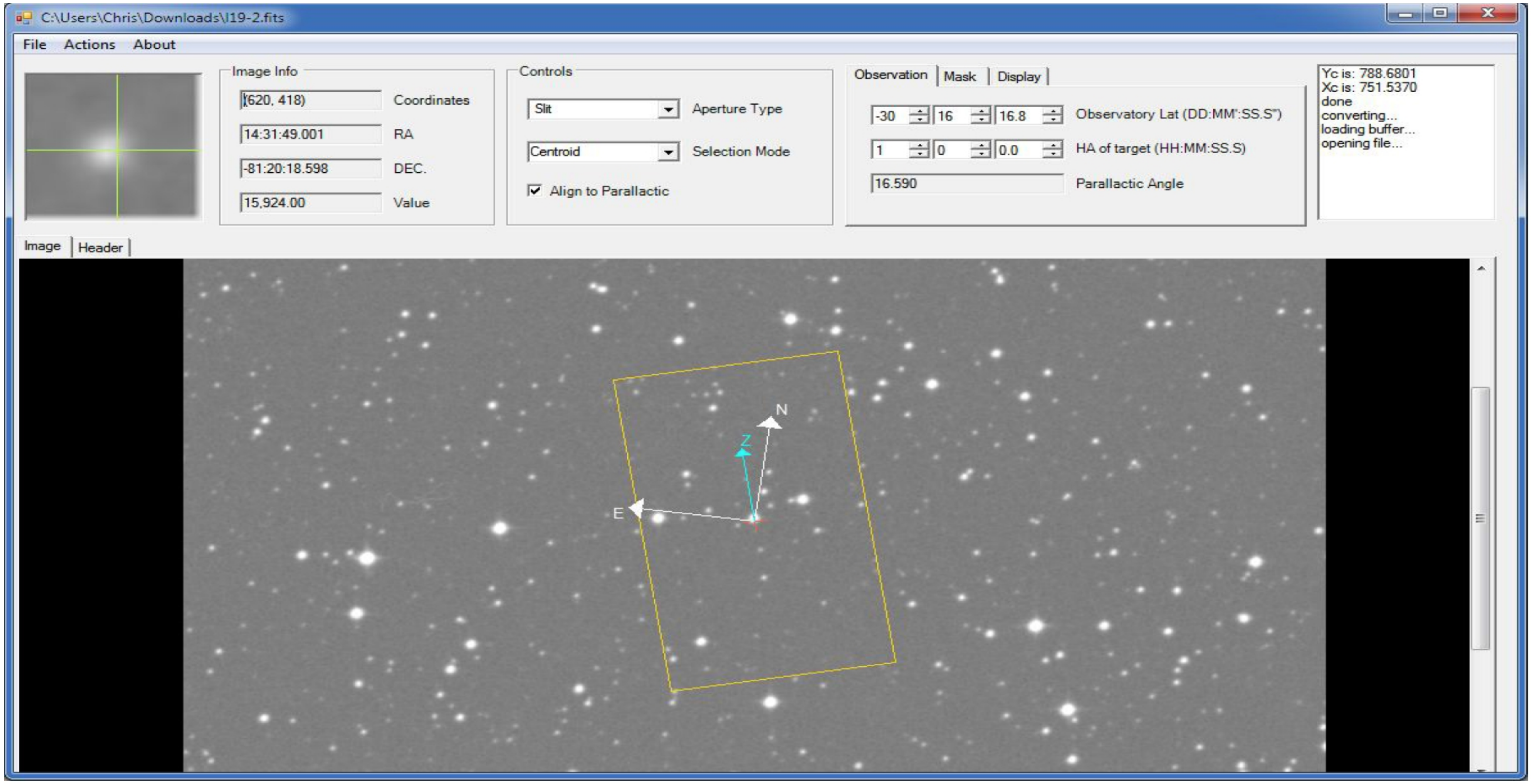
1) Preparing your MOS mask with SlitDesigner

• FITS file with image of your field: DSS or Goodman pre-image. Should have a suitable WCS
• If using DSS be aware of proper motion!
• Need Windows to run the *Slit Designer* software; we have tested it on **Windows 7** (32, 64-bit)....**a MacOS X version is in the works**



Upcoming features in Slitmask Designer

1) Port to Mac OS X
2) When loading saved masks, read and preserve HA, PA, slit length, type and width.

3) When reloading saved masks, turn off centroiding if selected and leave display slit locations as in file.
4) Upload target lists from text files.
5) Implement csv format target list, check which targets are on the current image, and mark those as selected. Offer user the choice to either centroid or not upon loading.
6) Add dotted outline of clear aperture of mask to rectangular representation
7) Try to add contrast, brightness, stretch functionality.
8) Show cut off corner on displayed mask to match fabricated assembly
9) Circles around targets should be a fixed size in arcsec, not in pixels.

Possible New functions

1) Manual repositioning of slitlets.
2) Allow positioning of slitlet at mask center (where directional are now).
3) Allow fine positioning of cursor with arrow keys or other keystrokes.
4) In addition to setting PA to parallactic angle, allow setting PA to a specified number that is entered in a box.

2) Submitting your MOS masks and checking them prior to your run

Masks should be sent at least 1 month in advance of the observations, to: goodman_mos@ctio.noao.edu.

Masks not sent by the 1 month deadline, are not guaranteed to be cut and installed in time for your run.

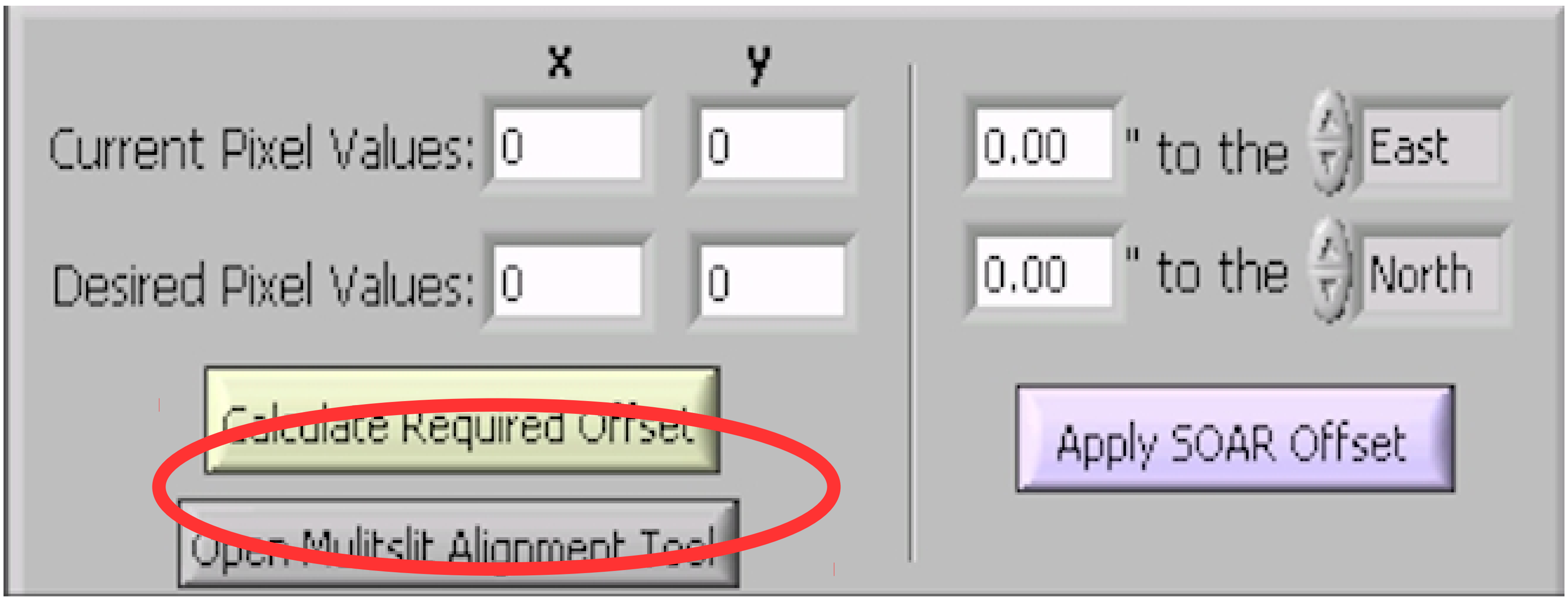
You should send the following files:

- The **FITS file of your mask field**, either from the DSS or a Goodman pre-image.

- The **.msk, .emf and G-code files produced by the Goodman MOS design software** (note that the G-code files will have no extension, but will be recognized as text files in Windows).

- **A screenshot (jpg, png or gif file) of your final mask** as seen in the Sli tDesigner software, i.e., showing your field with the mask, slits and alignment slots on it.

MOS mode:
Centering/aligning your mask



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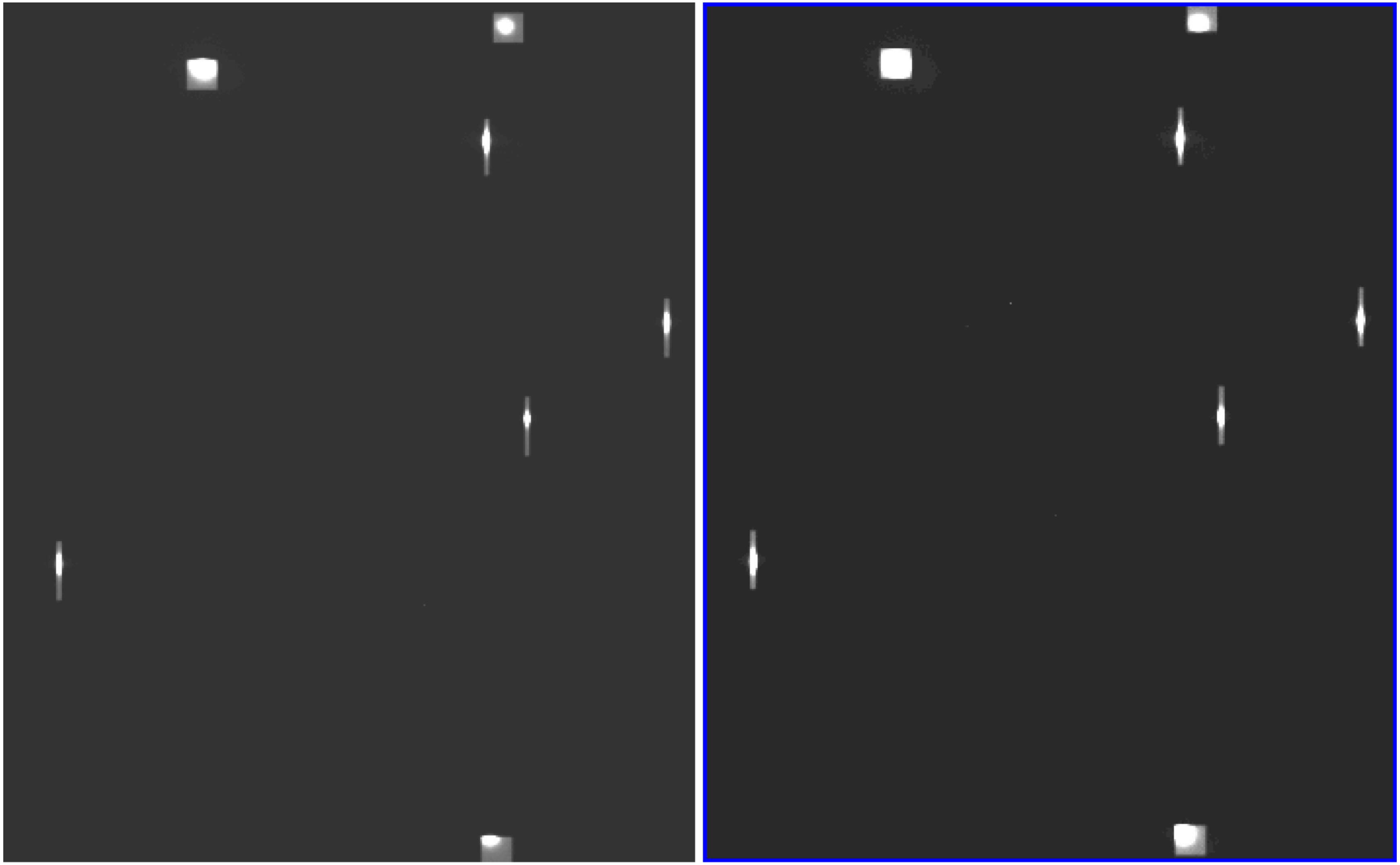

Which MOS system to use at NOAO-S?

- **Using either system requires advance preparation of masks**

- **Goodman MOS on SOAR:**
  - **Instrument is always on the telescope!**
  - Optimized for best performance in the blue-UV, but with new "Red" camera, will provide much better results out to ~900nm
  - Better image quality than Blanco → take advantage of nights with very good seeing (e.g., two masks of same field: one with narrower slits, other with wider slits)

- **COSMOS on the Blanco 4m:**
  - Larger FOV
  - Better performance (at present) in the red end
  - Only available during f/8 time (which is relatively little, since DeCam is taking up most of the time for the next few years)

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Documentation

Goodman SOAR webpage
http://www.ctio.noao.edu/soar/content/goodman-high-throughput-spectrograph

Summary of Goodman
http://www.ctio.noao.edu/soar/content/goodman-spectrograph-overview

Goodman webpage at UNC
http://www.goodman-spectrograph.org/

Luciano Fraga's excellent tutorial:
http://www.lna.br/obsresoar/Apresentacao/goodman2013.pdf

You can download the *current* MOS documentation at the SOAR Goodman web page:
http://www.ctio.noao.edu/soar/content/goodman-high-throughput-spectrograph

MOS documentation is currently evolving!....ask us for the latest version or download it from the ftp site above