Goodman HTS Manual

Goodman High Throughput Spectrograph

User Manual

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The Goodman High Throughput Spectrograph has been upgraded to provide users with the choice of one of two separate cameras. One is the original UV-optimized Blue Camera, with a 4096x4096 Fairchid CCD. The new device is the Red Camera, equipped with an e2v 4096x4096 detector optimized for work at red wavelengths with negligible fringing redward of ~650nm compared to the Blue Camera. For both detectors the pixel scale is the same (0.15 arcsec per pixel). This provides a 3096 x 3096 unbinned pixels (~7.2 arcmin diameter) FOV in imaging mode and a 4096 x 1896 unbinned pixels FOV in spectroscopic mode. The long slit masks in spectroscopic mode are approximately 3.9 arcmin in length and cover ~1560 unbinned pixels, leaving enough pixels above and below the slit to obtain an estimate of the stray and scattered light.

In both cameras, the CCD is read by the Spectral Instruments controller. In the Blue Camera through 1 amplifier.

**Blue Camera:** Depending on binning and the gain setting, the CCD can be read in as little as 20 seconds (1x1 fast readout) to as long as 80 seconds (1x1 slow readout) in spectroscopic mode. Please see the table given in the Goodman Overview page for a more detailed description.

Unbinned Goodman spectra plus overscan and header information are approximately 16 Mbytes each. A typical night produces about 2-4 Gbytes of data and easily transferred over the internet. This is the preferred method of the SOAR partners. If this is unfeasible, please contact Sean Points prior to your run so that other options can be discussed.

The Goodman imaging (first) filter wheel contains space for 4 square 4x4 inch filters, plus one blank
position. The second filter wheel holds 4 inch diameter circular filters, and has 6 positions, 5 regularly equipped with the order sorting spectroscopic filters, and one open position. Filters may be up to 10mm thick. For the list of available filters look at the SOAR Filters page. Special arrangements for installing filters should be consulted well in advance of an observing run with the Instrument Scientist.

Philosophy and Structure of this Manual

This manual is intended for an observer planning to use the Goodman spectrograph. It is not intended to serve as a hardware or software reference document describing the inner workings of Goodman, although some details at that level may appear to help the observer plan observing strategies. Also, we assume that the observer is already familiar with CCD cameras, spectroscopic observations, and data reductions.

The Goodman Overview is at the front of this manual. If you've read this far, and don't plan to read any further, be sure you understand the Goodman Overview pages.

Development of the Goodman High Throughput Spectrograph is a continuing process. Throughout the lifetime of the instrument, filters will be added, old ones replaced, and software enhanced. This manual represents the status as of the date on the cover page. We expect to revise the manual occasionally to include information gained during engineering runs, as well as to reflect new filters.

Supplemental Information

A Beginner’s Guide to Using IRAF (IRAF Version 2.10), Jeannette Barnes, August 1993


Guide to the Slit Spectra Reduction Task DOSLIT, Francisco Valdes, February 1993

The Goodman Hardware

In this section you will find a description of the hardware and main components of the Goodman HTS. Click on this link for a PDF file containing photos and further notes of each mechanism.

The Blue/Red Camera Stage

Both the Blue and Red cameras are installed on an articulated stage, which is moved by a wormdriven annular stage directly encoded with a resolution of 0.6 μ-radians. To minimize flexure the camera platform rides on a concentric 400mm curved bearing rail. The platform that holds the camera optics and dewar is attached at two points to the central stage and at two points to the bearings on the curved rail. The coupling between the bearing assembly and the camera platform is through tuned
flexures that both relieve the overconstraint between the central bearing and the rail, and act as a restoring spring for two piezo-electric actuators that can move the whole platform up and down to compensate for instrument flexures. These flexures are pre-loaded with 100kg of tension, which is more than twice the total weight of the camera assemblies, to insure that the bearings on the curved rail remain on the same contact surface (the underside of the rail) during rotation of the instrument. Flexure compensation on the orthogonal axis uses the articulation motion at very low speed.

The Camera Focus Stage

The camera optics tube rides on lead-screw driven crossed roller bearing stages. The camera stage is a custom low profile design that had to be incorporated into the articulation assembly. The camera focus stage incorporates external temperature sensors, constructed from temperature-to-voltage converters that feed built-in analog-to-digital converters in the Silvermax motors driving the stage. The optics mounts do not include passive thermal compensation, so measurements are required to correct for focus changes with temperature.
The Shutter

The clear aperture at the front of the camera is 4” and it is 2.8” at the last optic, which doubles as a dewar window. The shutter adds only ¼” to the width of the camera optics (except for a strategically positioned motor), and adds only 1” in length to the front of the camera. It consists of a friction driven curved stainless plate 0.010” thick that rides in a curved teflon track to cover the 4” entrance to the camera optics. The stepper motor can open or close the shutter in under 200 msec.

The VPH Gratings

We have available VPH gratings of 400, 600, 930, 1200, 1800, 2100 and 2400 l/mm, that have been produced in a holographic exposure facility at UNC that is currently capable of making 4” size VPH gratings. These gratings are of quality equal to or exceeding those produced by most vendors.

The Grating Rotation and Translation Stages

The grating changer can position any of three gratings at the 75 mm pupil, or lower them out of the way for imaging mode. This translation is subordinate to the grating rotation, so that the grating can be inserted and removed quickly from the pupil without resetting the angle. The rotation is driven by a Newport rotary stage at the bottom and a matching bearing at the top. This stage was retrofitted with a Silvermax motor. The stage is directly encoded with a resolution of 0.9 μ-radians, and the Silvermax motor uses feedback from this encoder for fine position control. Gratings are mounted in frames that are held by ball detents in the translation mechanism.

The Filter Wheels

The Goodman spectrograph uses two filters wheels. The first filter wheel is used mostly for imaging. It can hold up to 4 holds 4x4 inch square filters. The SOAR filter page [35] shows the list of available filters. The second filter wheel has 6 positions for 4-inch diameter circular filters. It normally holds the 5 spectroscopic order sorting filters, and an open position. Filters are placed in the collimated beam where they cause a pupil shift instead of a more irritating refocus, but this made them large, to accommodate the 75 mm pupil, and difficult to place. The wheels are suspended from a plate mounted to a cantilevered extension to the truss. The wheels are tilted enough to place any reflection ghosts the filters generate outside of the imaging field. Filters are mounted in rings that are held in the wheels using spring loaded ball detents. This allows exchange of filters without tools or fasteners that get lost or dropped in the instrument. Likewise, the wheels are held on their bearings by a hub that can be removed by hand. The wheels have teeth around their perimeter and are driven by smaller gears engaged by a spring loaded mechanism.

The Collimator

The Goodman Spectrograph collimator has a set position at this time and cannot be moved. The collimator focus value is 1000.
Slit Masks

Goodman slit masks are 3x5 arcmin on the sky. Single longslits are available in widths ranging from 0.46 to 10 arcsec. They are all roughly 3.9 arcmin long. See the Goodman longslit page for more details. Slit masks are installed on a 36 position carrousel.

Multiobject slit masks are also 3x5 arcmin on the sky. At present the mask carrousel can hold 17 MOS masks at one time, the remaining 19 positions are used by longslits, image slicers, and a few non-operative slots. Changing MOS masks is a daytime operation.

The Goodman Software

The Goodman Spectrograph Control System (GSCS) is a system of Labview programs running on a Windows machine, with which observers control the spectrograph and take data using its CCD camera. To access this software, users must use a graphical desktop sharing system to connect to the spectrograph’s control computer. We recommend using a VNC connection (see the SOAR Remote Observer's Guide), but other types of software may be used, such as Windows Remote Desktop. The following set of instructions for linking to the Goodman computer assumes that the user has established a secure VPN connection and will use a VNC or Remote Desktop session (click here to for a PDF document providing additional information on how to connect and run the Goodman GUI).

This document shows the example for the Blue Camera. For the Red Camera only the name of the computer changes (see below).

Logging on to the Data Acquisition and Data Analysis Computers

The data acquisition computers are:

- **soaric2** if using the Goodman Blue Camera
- **soaric6** if using the Goodman Red Camera.

The data visualization computer running IRAF is **soaric7**. A number of different ways to logon to these machine exist, depending upon your preference. These methods are discussed below.

- **From Cerro Pachón:**
  - The mountain staff or your support scientist will show you the computer on which you can obtain and analyze your data. To open the Goodman user control panels:
    - Double click on the "Scroll Lock" Key
    - A window will open displaying the names of the computers to which you can connect
    - Use the "Up" and "Down" arrow keys to highlight a free machine.
    - If the Data Acquisition and Analysis windows are running, you can skip to the GUI Layout section of this manual. If these GUIs are not running, skip to the Starting and Stopping the Data Acquisition GUI and Starting and Stopping the Data Analysis GUI
sections of this Manual.

- **From the Remote Observing Center in La Serena:**
  - Log on to the observing account using the username and password provided to you by the instrument scientist (Sean Points, César Briceño, Regis Cartier or Alfredo Zenteno if your time is through NOAO or Chile, or your Brazilian Support astronomer if you are observing through Brazil time). If forgotten, these are posted on a list near the door.
  - Start the Data Acquisition GUI by typing the following command from a terminal command line on the GNU/Linux computer in the remote observing center:
    - `vncviewer -Shared soaric2.ctio.noao.edu & (Blue Camera [9])`
    - `vncviewer -Shared soaric6.ctio.noao.edu & (Red Camera [10])`
      Log on to the vncviewer with the password provided by the instrument scientist.
  - Start the Data Analysis GUI by typing the following command from a terminal command line on the GNU/Linux computer in the remote observing center:
    - `vncviewer -Shared soaric7.ctio.noao.edu:4 &`
      Log on to the vncviewer with the password provided by the instrument scientist.

- **If you are a Remote Observer:**
  - Start the VPN connection on your computer, using the username and password information provided by your Support Scientist: Sean Points or César Briceño if your time is through NOAO or Chile, your Brazilian Support astronomer if you are observing through Brazil time, or your SOAR Support person at UNC or MSU.
  - Start the Data Acquisition GUI by typing the following command from a terminal command line on the GNU/Linux computer in the remote observing center:
    - `vncviewer -Shared soaric2.ctio.noao.edu & (Blue Camera [9])`
    - `vncviewer -Shared soaric6.ctio.noao.edu & (Red Camera [10])`
      Log on to the vncviewer with the password provided by the instrument scientist. Set this GUI in one of your monitors.
  - Start the Data Analysis GUI by typing the following command from a terminal command line on the GNU/Linux computer in the remote observing center:
    - `vncviewer -Shared soaric7.ctio.noao.edu:4 &`
      Log on to the vncviewer with the password provided by the instrument scientist. Set this GUI in another of your monitors. Remember that a minimum of 2 monitors is required to carry out remote observing at SOAR, and the recommended setup is 3 monitors ([see the SOAR Remote Observer's Guide](#))

In most cases the GUIs should be started and you will be presented with a data acquisition screen and data analysis screen as shown in Figure 4.
Starting and Stopping the Data Acquisition GUI

If the data acquisition GUI has not been started, then one should see a blue screen in the soaric2 VNC window. At the bottom of the screen, you should see that the SI Image SGL D and SI Image are minimized. You may also see that the LabVIEW Transfer_To_SOARIC7 vi and the LabVIEW Goodman Spectrograph Control System vi are minimized. If these are minimized, the you just need to click on them to start the data acquisition GUI. [Click here for a PDF file with additional information on the start-up of Goodman.]

To start the data acquisition software:
Figure 5: Selecting the CCD parameters (e.g., 1x1 imaging, 2x2 imaging, 1x1 spectroscopic, 2x2 spectroscopic, etc.)
Click the **Transfer_To_SOARIC7** LabVIEW shortcut on the Desktop and start the application by clicking on the white arrow.

Open the Goodman controls by clicking on the **GSP_Main** LabView shortcut on the Desktop and start the application by clicking on the white arrow.

Check the camera panel. If a green button is present for "Connection Open/Getting Data" in the upper left of the GUI, Goodman "sees" the SI Image camera control software and a TCP/IP connection is available to take data. You can confirm this by clicking on the "Obtain Camera Status" button. During a normal startup of the **GSP_Main** vi the CCD Temp will read "0". If the TCP/IP connection is operating, clicking on the "Obtain Camera Status" button will show the latest temperature measurement. If Goodman is cooled, the CCD Temp should be -106.5. If the CCD Temp does not update, you will need to check the **SI Image SGL D** window and make sure that a TCP/IP connection is open.

Click on Main tab and logon;
Use the account appropriate for your observing program (i.e., BRAZIL, CHILE, MSU, NOAO, OTHER, or UNC) with the password provided by your institution.

Click the User tab, go to "Home Systems", and select "Home All". You should see the dark green lights change to yellow on the control panel as systems are being homed. Upon a successful
homing of the systems, all lights should be bright green, except the Collimator Focus which well remain a dark green. If there are any red lights, you will need to log out of GSP_Main and shutdown and cycle the power on the Goodman motor electronics.

- After the camera is homed, start the flexure correction by clicking the flexure LED. It should change from dark green to bright green.
- Select the imaging or spectroscopic mode in which you want to work.
- Select Gain and Readout Setting. These values are given in the Goodman Overview [2] and in the Goodman Cheat Sheet [3]. Usual values are 100 KHz ATTN0 with the Blue Camera, which provides gain=1.06 and readout noise= 3.72 e-, and 344KHz ATTN3 with the Red Camera, which provides gain=1.48 and read noise=3.89.
- Set up the grating and camera angles for your observations. The pre-defined modes are listed in the Goodman Overview [2].
- You are now ready to use Goodman.

If the data acquisition GUI needs to be stopped:

- Single click on the Main tab and log out.
- Click on the Main tab and Shutdown. This will move all the systems back to their "Home" positions.
- After the shutdown has finished you should ask the TelOps staff to turn off the power to the Goodman electronics box.

A more detailed explanation of the Startup and Shutdown procedures can be found in the Goodman step-by-step User's Observing Guide (PDF). [45]

Starting and Stopping the Data Analysis GUI

The Goodman data analysis VNC window (soaric7:4) has a relatively simple layout. If the IRAF data analysis windows are not open, you should see an IRAF button in the lower right corner of the VNC window. Single click on the IRAF button and an IRAF xgterm and a ds9 window will open. Load any IRAF package you may need for your observing. You will also want to make sure that you are in the correct directory to analyze your data.

> cd /home3/observer/today/

Basic GUI Layout

All observing with the Goodman Spectrograph is handled through the Data Acquisition GUI. Upon successful startup of the Goodman data acquisition GUI on soaric2, one should check that the Goodman data acquisition window looks something like that shown in Figure 4.

The Goodman observing GUI can be divided into certain distinct regions as shown in Figure 7. These include the:
Figure 7: The Goodman data acquisition GUI with regions demarcated and labeled.

- **TCS Status Region** - This region shows various telemetry data from the instrument, as well as information obtained from the Telescope Control System (TCS) and the SOAR Environmental Station. These data include the current RA and Dec of the telescope, the airmass, the sidereal time, the ISB rotator angle, etc.

- **Connection Info Region** - This region shows if the LabVIEW GSP_Main vi has a TCP/IP connection to the SI Image software. If the connection is active, then you should see a green box stating that the TCP/IP connection is open and that the SI Image software is receiving commands from the GSP_Main vi. One method of checking this connection is to click on the "Obtain Camera Status" button while you are not taking an image. This should update the "CCD Temp." and "Vacuum Pressure" fields above the camera status button. Also included in this section of the GUI is the "General" tab. If an observer selects this, they will be able to edit the "Observer" and "Proposal ID" keywords for the FITS headers.

- **Acquisition and Exposure Status Region** - This region of the GUI is complex and contains many items of which the observer should note. In this region, the observer can do the following:
Figure 8: Selecting the CCD binning and image size.
Figure 9: Selecting the Goodman readout parameters.

Figure 10: (a) Taking an internal calibration quartz spectrum. In this image the internal quartz lamp is off. (b) Taking an internal lamp quartz spectrum. The quartz lamp has been turned on at the 70% level.
○ Change the OBSTYPE (OBJECT, FLAT, COMP, DARK, or ZERO) of the image by clicking on the appropriate tab.
○ Edit the "Object Name" for the FITS headers.
○ Set the number of exposures for each OBSTYPE.
○ Set the base name of the FITS file.
○ Set the exposure time.
○ Select the CCD binning and image size. The default 1x1 imaging mode has an image size of 3096x3096 pixels. The default 1x1 spectroscopic mode has an image size of 4142x1896 pixels. Please note that no overscan region is written for imaging mode. The overscan region is only read if the serial dimension is greater than 4096 pixels.
○ Select the CCD readout speed, gain and readnoise parameters.
○ Turn on/off calibration lamps (HgAr, CuHeAr, Ne, Ar, Quartz). For example, select the "Flat" tab in the "Acquisition and Exposure Status" region of the GUI (see Figure 10). All of the calibration lamp LEDs should be dark green (Figure 10a). If you are using the internal quartz lamp, select the desired intensity value and then click the dark green box beneath the "Quartz" label. The dark green box should now be bright green (Figure 10b). You should always check with the telescope operators that the calibration lamp has been turned on.
○ Make a telescope offset.
○ View the exposure time and readout status.

All of these features will be discussed in more detail in the Observing with Goodman [46] section of this manual.

- **Instrument Status Region** - This region of the GUI is equal in its complexity as the Acquisition and Exposure Status Region. In this section, the observer controls the physical setup of the spectrograph. In this region, the observer can do the following:
Figure 11: Changing the primary filter.
Figure 12: Changing the secondary filter.
Figure 13: Selecting the slit mask assembly.
Figure 14: Selecting the grating.
Figure 15: Selecting the camera and grating angles (Wavelength Assembly).
Check on the status of the motor sub-systems. This is indicated by the vertical column of round lights (LEDs) on the left of the display. If the lights are bright green, it signifies that the sub-systems are homed and/or in their proper positions as determined by the sub-displays in this region. If the lights are dark green, it indicates that the sub-system has not been homed. At present, only the status light for the Collimator Focus should be dark green (see below). If the status light is yellow, it signifies that the sub-system is moving from one state to another. For example, if you change the Slit Mask from the 0.46" slit to the 1.03" slit, the light to the left of "Mask Assembly" will change from bright green to yellow and then back to bright green during the exchange of slit masks. If a motor light should be red, it indicates that an error has occurred and that the observer needs to shutdown the Data Acquisition GUI and restarted after the power to the instrument electronics box has been cycled.

Change the "Primary Filter". The Goodman filter wheels can hold 5 +1 (empty) 4" diameter filters. We have placed UBVR filters on the Kron-Cousins system in the primary filter wheel on Goodman (see Figure 11).

Change the "Secondary Filter". The Goodman filter wheels can hold 5 + 1 (empty) 4" diameter filters. We have placed GG-385, GG-455, GG-495, and OG-570 order blocking filters.
in the secondary filter wheel.

- Change the "Slit Mask". An observer can change the Slit Mask from that which is currently in place by clicking on the upper-most button under the "Mask" section of the GUI and select a different slit mask (see Figure 13). After a successful startup of the GUI no slit mask will be in place. The observer should then choose from among our current long-slit masks as given in the Goodman Overview [2].

- Change the "Grating". An observer can choose from no grating, to any of the maximum of three gratings that can be installed at a given time, e.g., the 400l/mm, 600l/mm, or 1200l/mm by clicking on the grating selection button. For the updated list of available gratings see the Goodman Overview page [2].

- Select the "Camera and Grating" angles for the observations. This feature allows the observer to select among the various predetermined spectroscopic modes of the instrument (see Figure 15). These modes are listed in the Goodman Overview [2] section of this manual. We provide examples of HgAr and CuHeAr spectra in the Comparison Lamp [47] section of the Goodman documentation.

- The "Camera Focus" depends upon the observing setup that the observer chooses. The TelOps staff have a list of the most recent camera foci that have been determined during an engineering run. If in doubt, the observer should determine the best camera foci for their run during afternoon calibrations. More information on determining the camera focus is given in the User's Guide to Observing with Goodman. [24]