
4k CCD Observers Software

Observers' manual for BOAO 4k CCD camera system

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KASI • Optical Astronomy Division • Fri. Oct. 28. 2011



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Introduction

Director and Detcom

This is a users' manual for the observation software of the new 4k CCD camera at Bohyunsan Optical Astronomy Observatory (BOAO) . The software runs in the Linux operating system, and is Detcom V3.57 with Director V5.05 as a wrapper. The two softwares are developed at the Canada-France-Hawaii Telescope (CFHT). Since they are used for all CCD cameras at CFHT, users who have experiences to observe at CFHT will not feel it hard to use them.

1. Director

Director is a text-based window manager program that is designed to run Detcom. The Director window is always running at the console of the observers' computer. Most of the command can be run in this window. The window is divided into two parts: observers can type commands and see results at the upper part, and the current status of the CCD camera is displayed in lower part. Just above the command input line, a blue text line shows the name of the next image file, size of the image, type of the observation, and exposure time. Some important information at the lower window includes the name of the downloaded control software and the current value of various bias voltages. The Director window does not support scrolling with mouse, so observers should use PgUP/PgDown key for scrolling. There may be another Director window running on remote computer just for monitoring what is going on with the CCD camera. This is feature is useful for real-time maintenance. When this clone Director is running, the observer using main Director can chat with the user running clone Director.

2. Detcom

Detcom is main program that actually control the CCD camera for observation. The observer can perform observation by running various single Detcom commands sequentially, or by writing and running his/her own scripts composed of a series of commands. The latter is useful for automatic observation. Since the observing environments at BOAO are different from that at CFHT, some features like controlling

cryogenic temperature of the camera and moving filters are added as an external program for the Detcom. Since Detcom is command line interface, observers who want to have a look on the observed image should use image display program such as ds9. IRAF and Vista is also installed so that observers can do a simple and easy inspection of the images. We do not recommend the observer to use IRAF for a thorough reduction and analysis of the images since this computer is mainly for controlling CCD camera.

Preparation for Observation

what you need to prepare before doing observation

The observer must decide the format of CCD, directory to store the image files, file name prefix, numbering of the image files before doing real observation.

1. Choosing CCD format

There are three read out modes for 4k CCD camera whose CCD chip is e2v CCD231-84 where the number of output amplifiers are at four corners. The four output amplifiers are named as E, F, G, and H from lower left corner to clock-wise direction. The best amplifier is E where the readout noise is smallest. So we use E when reading out the CCD with one amplifier. The CCD also can be read by using two amplifiers and all four amplifiers. The time for reading out the CCD is approximately 166 seconds for single amp, 85 seconds for two amps, and 43 seconds for four amps. It takes about 2 seconds to flush the CCD.

The program to choose read out mode of the CCD must be run in ordinary terminal other than the Director window. The observer can invoke a new terminal by pressing left mouse button or click on terminal icon at the bottom of the screen. The program for each read out mode is as the following.

For one output amp

```
[fourk@fourk:~/] Config_AmpSINGLE E ↵
```

For two output amps

```
[fourk@fourk:~/] Config_AmpEF ↵
```

-we only use EF when using two output amps.

For four output amps

```
[fourk@fourk:~/] Config_AmpALL ↵
```

2. Choosing FITS file format for multiple amps

When using more than one amp, the image from each amp are stored in separate FITS file. The files can be stored as a number of simple FITS file or stored as one multiple

extension FITS file (MEFITS). The observer can select the format of the file by running the following command.

Choose multiple extension FITS file

```
> mef on ↵
```

Choose simple FITS file

```
> mef off ↵
```

3. Checking status of the CCD

Normally the CCD must be ready for observation when the observer arrives at the observing room. However, if the observer wants to be sure, he/she can force the CCD camera boot again by running the following command, download proper code into the controller and re-engage high voltages.

```
> boot -force <Enter>
```

4. Setting the name of the observer

If the observer want to add his/her name on the FITS image header, use this command.

For example, if the observer's name is Yuna Kim,

```
> header observer Yuna Kim <Enter>
```

5. Setting file name prefix and directory for storage

Create a directory to save the observed images and change working directory there.

This movement must be done at the Director window. All subsequently created image files will be saved in this directory. The example shows how to do that where the command prompts at ordinary terminal (“[...]”) and Director window (“>”) are differently shown.

```
[fourk@fourk:~/] mkdir yuna ↵
```

```
> cd yuna
```

The observer can determine file name prefix as the following.

```
> filename yuna???.fits ↵
```

In the above example, “???” will be replaced with sequential number and the trailing “\$” will be replaced with one character according to the type of the exposure. For

example, if the first image is a bias, then the image file will be “yuna001b.fits”. The number will start from 1. The type of exposure will be “b” for bias, “f” for flat, “d” for dark, “c” for comparison source, “o” for object. so that the observer can easily distinguish different type of images just by the file names only. The number of question marks will determine the largest number possible so use as many question marks to accommodate large number of images in a certain observation such as time series.

If the observer chooses multiple amps read out and file storage as simple FITS file, the image files created will be stored in a sub-directory and the file name has additional extension describing the name of the output amp of that file. For example, if the observer chooses two amps read out, then a new sub-directory names “yuna001b” will be created. In the “yuna001b”, two files will be stored which are “yuna001b00.fits” and “yuna001b01.fits”. Here the extension “00” is for E amp, and “01” is for F amp. If all four amps are used, the number will be 00-01-02-03 for E-F-G-H. The observers are recommended to create their own directory to save their observed images.

5. Filters

5.1 Filter configuration file

The observer will hope to check whether the filters needed are correctly installed. The names and sequence of the current filters are stored in the configuration file.

```
[fourk@fourk:~/] cd .director/bin ↵
```

```
[fourk@fourk: ~/.director/bin] cat filter.conf ↵
```

```
1 : U
2 : B
3 : V
4 : R
5 : I
6 : Ha
```

5.2 Initialization of the filter

There are six filter positions in the filter box. The command to initialize the position of the filter wheel is as the following.

```
> home ↵
```

It takes about 15 seconds for turning the filter wheel complete circle and about 5 seconds to move from one position to next position. It moves only one direction for accurate positioning..

Observation

How to observe

Now it is time to do real observation. Detcom saves all the image files after exposure to prevent unexpected loss of the image by mistake. The exposure is taken place by invoking “go” command after setting various parameters for observation. Actually Detcom does not allow the observer running commands other than “go”, “clean”, and “expose” that are all needed for observation.

1. Setting image format

Decision whether to use all or part of the CCD area, whether to bin the CCD as 2x2 or 3x3 is done by raster command.

```
> raster full ↵
```

Read whole CCD as 1x1 (unbinned) format

```
> raster full [bin2 | bin4 | bin8] ↵
```

Read the whole region, with binning factor of 2x2, 4x4, or 8x8.

```
> raster center <xs> <ys> [<xb> <yb>] ↵
```

Read sub-image centered at the original center of the CCD x_s , and y_s is the size of the active box, and optional arguments x_b and y_b is binning factor. If no x_b and y_b is given, the image will be unbinned.

```
> raster <xc> <yc> <xs> <ys> [<xb> <yb>] ↵
```

The same as the previous example with different center coordinates given by x_c and y_c .

The physical dimension of the 4k CCD is 4096x4112, but there are 50 pixel wide prescan region at each readout amp, so when the CCD is fully read out the dimension is 4196x4112. We add 32 logical overscan pixels horizontally that makes the dimension of 1x1 full range image to be 4228x4112. The 32 logical overscan pixels is

added to every sub-image, too. The size of overscan varies proportionally with different binning factors.

2. Setting exposure type

The `etype` command sets the type of exposure.

- > `etype bias ↵` : set the exposure to be bias (zero)
- > `etype dark ↵` : for dark image
- > `etype flat ↵` : for flat image
- > `etype comparison ↵` : for comparison source image
- > `etype object ↵` : for object image

The type of the exposure determines file name extension and is also recorded into the image header. For types of bias and dark, shutter will not be opened and in the case of bias image, the exposure time will be ignored.

3. Setting the name of the object

The command “`header`” modifies FITS image header. In this case, use the command as the following to set the name of the object.

- > `header object NGC 7814 ↵`

The image header keyword “`object`” will have the name of the object, here “`NGC 7814`”.

4. Setting the exposure time

The `etime` command sets the exposure time.

- > `etime 10 ↵` : 10 seconds
- > `etime 60: ↵` : 60 minutes
- > `etime 1:30 ↵` : 1 minute and 30 seconds = 90 seconds
- > `etime 0.3 ↵` : 0.3 seconds

The exposure time can be 1 ms (0.001 seconds) at minimum and 3 hours (180 minutes) at maximum. The shutter is two blades Bonn type shutter which accurately opens and closes to accommodate as short exposure as possible.

5. Setting Filter

The filter command moves filter.

```
> filter U ↵ : use U filter
```

Filter wheel moves immediately with this command. The name of the filter is recorded at FITS image header keyword “filter”.

6. Image Acquisition

So far, the commands except “filter” do not perform any action. They are just commands to prepare for real image acquisition. In order to acquire real image, the observer must run “go” command.

```
> go [n] ↵
```

The optional argument “n” is the number of repetition.

When invoked, “go” reads temperature of the CCD first, and then reads the TCS information from the TCS computer over network, performs “clean” command to flush the CCD, performs “expose” command to do exposure, reads out image from the CCD, and saves the image as disk file(s). If optional repetition number “n” is specified, the same sequence repeats “n” times.

The observer can stop repetitive exposures in two ways.

```
> go [n] ↵
```

```
> quit ↵ : Stop the repetition after finishing the  
           current exposure
```

```
> abort ↵ : Stop the exposure at once
```

These commands can not be used when the CCD is being read out.

7. Focus adjustment

A special exposure sequence for telescope focus adjustment is prepared. In this mode, the CCD is not read out after intermediate exposure. Instead, the CCD is read out after a sequence of exposures taken with various telescope focus.

Focus adjustment mode

```
> etype focus ↵
```

In this special mode, the exposure type is set to “x” so the image file has “x” for etype.

Preparation

> etime <nnn> ↵ : Set the exposure type as usual

> filter <filter name> ↵ : Set filter as usual

First exposure

> go ↵

- The first exposure is the same as ordinary “go”, in which “clean” will be done before exposure, except that the CCD is not read out.

Intermediate exposures

> go ↵

- From second exposure, the “go” will not do “clean”, thus preserves the previous image on the CCD, and does not read out. As many “go”‘s can be run as needed.

Last exposure

> go -r ↵

- This is the last exposure in the focus adjustment mode. “go -r” will perform exposure without cleaning the CCD and then read out the CCD.

Finish focus adjustment mode

> etype object ↵ : Choose different etype other than
‘focus’