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NICMOSlook
An Interactive Spectrum Extraction Program for NICMOS Grism Data

Manual[1]
Version 1.1.5

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[1] An HTML version of this manual is available at
http://ecf.hq.eso.org/nicmos/nicmoslook/nicmoslook.html

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Chapter 1

Introduction

A unique capability of NICMOS is the grism mode, which permits slitless spectrometry at low resolution. Typically, a direct image is taken in conjunction with grism images for the wavelength calibration. A quick-look extraction of spectra from a large number of NICMOS grism images requires a convenient interactive tool which manipulates the pair of images and extracts spectra. NICMOSlook is an IDL program designed for that purpose at the Space Telescope – European Coordinating Facility[1].

NICMOSlook is the interactive counterpart to the Calnic C Facility[2], a program which performs the same functionality in a "pipelined" approach. The most common use of NICMOSlook will be for small amounts of data, when users prefer to have full controll of all parameters for individual spectrum extraction, or for cases which Calnic C did not extract spectra in a satisfactory way. Unlike Calnic C, NICMOSlook requires the user to determine the best way to find an object and provides a number of different ways to accomplish this. Similarly, the user decides whether a weighting appropriate for point sources or weighting by the size of the object is used for the extraction of the spectra. The actual extraction of spectra is done employing the same methods and algorithms as Calnic C. Refer to the chapter regarding Algorithms in the Calnic C manual for detailed descriptions.

A brief overview of the program's capabilities follows. A direct image and corresponding grism images can be read from FITS files and are displayed. The display options include color tables, zoom factors, and blinking. Basic image manipulation capabilities are provided. They can be used to optimize the identification of objects. Objects are identified on the direct image either by user input of coordinates via a file or with the cursor, or by applying a user defined threshold to automatically find them. The positions of the objects are used to extract spectra from a grism image of the same region. Several options for the weighting are offered. The wavelength calibration of the extracted spectra is performed using the position of the objects and parameterized dispersion relations. After extraction of the spectra, they are corrected for the wavelength dependence of the quantum efficiency of the detector. The flux scale is then computed using the standard

[1] http://ecf.hq.eso.org

[2] http://ecf.hq.eso.org/nicmos/calnicc/calnicc.html

NICMOS flux calibration data. The extracted spectra can be corrected for contamination from nearby objects. All extracted spectra are automatically searched for emission and absorption lines. In addition, the continuum emission is automatically determined. The final data products are plots on the screen, binary FITS tables and postscript files with the spectra, error estimates, object parameters derived from the direct imaging and details of the spectrum extraction process.

Chapter 2

Installing NICMOSlook

2.1 Downloading the software

The source code for NICMOSlook is available on the WWW as a GNU ZIP[1] compressed tar files. After bringing up your favorite Web browser, click on the file of choice and select a directory in which to copy it from the file selection box that appears.

2.2 Installation Procedure

The following instructions assume that a compressed tar file (`nicmoslook_`*version*`.tar.gz` where *version* is the version number) has been downloaded to a computer with a UNIX operating system running IDL. Specific UNIX commands are given for the C-shell.

Once the compressed tar file is downloaded to a local disk, the installation is as follows:

1. Create a new directory in which to install the program.
   For example, if you choose to install NICMOSlook in `/usr/local/nicmoslook`, make sure that the file system has at least 10.0 MB free space and create the directory with:
   `mkdir /usr/local/nicmoslook`.
2. Create a new environment variable called `NICMOSLOOK_BASE`.
   This variable should be set to the value of the newly created directory in the step above. For example, if you chose `/usr/local/nicmoslook` as the location for the installation, `NICMOSLOOK_BASE` should be set to that ENTIRE path name. Create the environment variable with:
   `setenv NICMOSLOOK_BASE /usr/local/nicmoslook`
   Since this variable is necessary for running and rebuilding NICMOSlook, you probably would want to include this statement to your shell's startup script (e.g. ~/.cshrc).

[1] http://ecf.hq.eso.org/nicmos/nicmoslook_latest.tar.gz

3. Create a new environment variable called `NLK_BIN`.
   This variable is necessary to rebuild the IDL NICMOSlook binary library (See section 2.4) and should be set to the `bin` subdirectory of the NICMOSlook installation:
   ```
   setenv NLK_BIN $NICMOSLOOK_BASE/bin
   ```
4. Change to the newly created NICMOSlook directory
   ```
   cd $NICMOSLOOK_BASE
   ```
   and extract the distribution. Remember that the full path name of the downloaded distribution must be supplied. For example, if you downloaded the NICMOSlook distribution tar file to the directory `/tmp` you would extract it with one of the following commands:
   ```
   zcat /tmp/nicmoslook_version.tar.gz | tar xf -
   ```
5. NICMOSlook currently comes pre-compiled to run under IDL 5.0. If you are planning to run NICMOSlook under IDL 4.0 then you will need to recompile NICMOSlook. See 2.4 for more information.

NICMOSlook is now installed on your system.

2.3 Environment Variables

In addition to the environment variables `NICMOSLOOK_BASE and NLK_BIN` which must be defined and which were discussed in section 2.2, a few additional variables can be defined: The two following variables allow the user to specify where NICMOSLOOK will look for input data files and where it will write its output files. If these are not defined, the CURRENT working directory (where NICMOSlook was started) is used as the default.

• `NLK_DATA`	Directory NICMOSlook looks for input data files
• `NLK_SPECOUT`	Default directory to write NICMOSlook output files

It is recommanded that you add the directory `NICMOSLOOK_BASE/bin` to the `PATH` environment variable so that NICMOSlook can be run from any directory. This can be best achieved by adding a line like

- setenv PATH $PATH:NICMOSLOOK_BASE/bin

to the shell startup script (e.g. ~/.cshrc).
Alternatively, The Bourne Shell (`$NICMOSLOOK_BASE`/bin/nicmoslook) which is used to startup IDL and NICMOSlook may be edited, *but this is not recommended.*
If you decide to modify the `$NICMOSLOOK_BASE/bin/nicmoslook` script , please bear the following in mind:
The following variables (which are set by the `$NICMOSLOOK_BASE`*/bin/nicmoslook shell script, MUST not be changed by the user:*

- `IDL_STARTUP` IDL startup script
- `NLK_CAL` calibration directory
- `NLK_SW` NICMOSlook software directory
- `NLK_LIB` library directory

The following variable MAY be changed provided that the `NICMOSLOOK_BASE/bin` *is in the FIRST POSITION in the path:*

- `IDL_PATH` The IDL search path

2.4 Rebuilding the IDL NICMOSlook binary Library

Any change to the IDL code of NICMOSlook requires a 'recompilation' of NICMOSlook IDL programs in order to remake `nicmoslook_binary`. This must be done while running IDL. To remake this library:

1. `cd $NICMOSLOOK_BASE/idlsrc` (Make sure that $NICMOSLOOK_BASE is set!)
2. `idl` (at the Unix prompt)
3. `@nlk.pro` (at the idl prompt)

This executes an IDL `.run` command on all the IDL program files and will `save` the results in `$NICMOSLOOK_BASE/bin/nicmoslook_binary`.

2.5 Customizing NICMOSlook

NICMOSlook is mostly controlled by its user interface. In addition, there are a number of setup files and environment variables. The setup files reside in the directory `$NICMOSLOOK_BASE/calib` and can be modified with a text editor or, with a utilities which are displayed when the user selects the either Edit Setup Params, Edit Grismspec, or Edit FITS Keywords buttons.

- `calnicc.setup` Controls behavior of NICMOSlook & Calnic C.
  Refer to section 4.1.2.
- `grismspec.dat` Defines grism characteristics.
  Read this file carefully before attempting modifications. Refer to section D.1.
- `fitskeywds.dat` Defines FITS keyword values.
  Refer to section B.2.

Chapter 3

Using NICMOSlook

3.1 Running the Program

3.1.1 Startup

Before attempting to run NICMOSlook make sure that all environment variables (section 2.2) and system config files (section 2.5) are set to desired values. There are TWO modes in which NICMOSlook can be run: from the UNIX command line and from within IDL itself. To run from the UNIX command line simply type the following at the UNIX prompt:

1. `nicmoslook`

To run NICMOSlook, from within IDL, type:

1. `idl` At the UNIX prompt
2. `nicmoslook [ spectrum [, direct]]` At the IDL prompt

The optional parameters (`spectrum` *and* `direct`*) are assumed to be grism and direct images, respectively, that have already been loaded into IDL data structures.*

The first method demonstrates how to call NICMOSlook from the command line. The shell script, `nicmoslook`, sets up additional environment variables before calling IDL. All input and output are through the user interface of NICMOSlook. The second method shows how to bring up IDL and then start nicmoslook.

When running NICMOSlook from within IDL, some care must be exercised. Advanced IDL users often have an IDL startup file referred to by the environment variable, `$IDL_STARTUP`. It is possible that some values set in this file will directly conflict with IDL variables used by NICMOSlook. Read section 2.2 carefully.

3.1.2 Input to NICMOSlook

Input to NICMOSlook is usually obtained from a dialog box on the user interface. The FITS files needed (direct and grisms image) are expected to be in the NICMOS FITS format. That is, a standard FITS file with 5 extensions containing the image data. If NICMOSlook encounters a FITS file with no extensions, it simply returns the single image as the science data and 4 images of equal size of zeroed data. Section B.1 describes this format in greater detail.

3.1.3 Output of NICMOSlook

Output from NICMOSlook consists primarily of postscript files containing a graphical representation of each object's spectrum, and a single FITS file with a FITS table extension containing the spectra information for each object detected on the images. However, additional output files can be created on the fly for convenience by selecting various buttons on the interface. For a comprehensive list of these files, please refer to section F. Any time output is directed to a file, a dialog box will prompt the user for the desired location.

- `filnm`_tab.fits :
  Contains one binary table extension for the spectrum information for each object detected. See section C for more details.

- `filnm`_*n*.ps
  Postscript file for each spectrum on the image, where *'n'* is the object number (starting with 0) as found on the image.

  where `filnm` *is the root name the user entered in the dialog box*

3.1.4 Viewing the Postscript Spectra Output

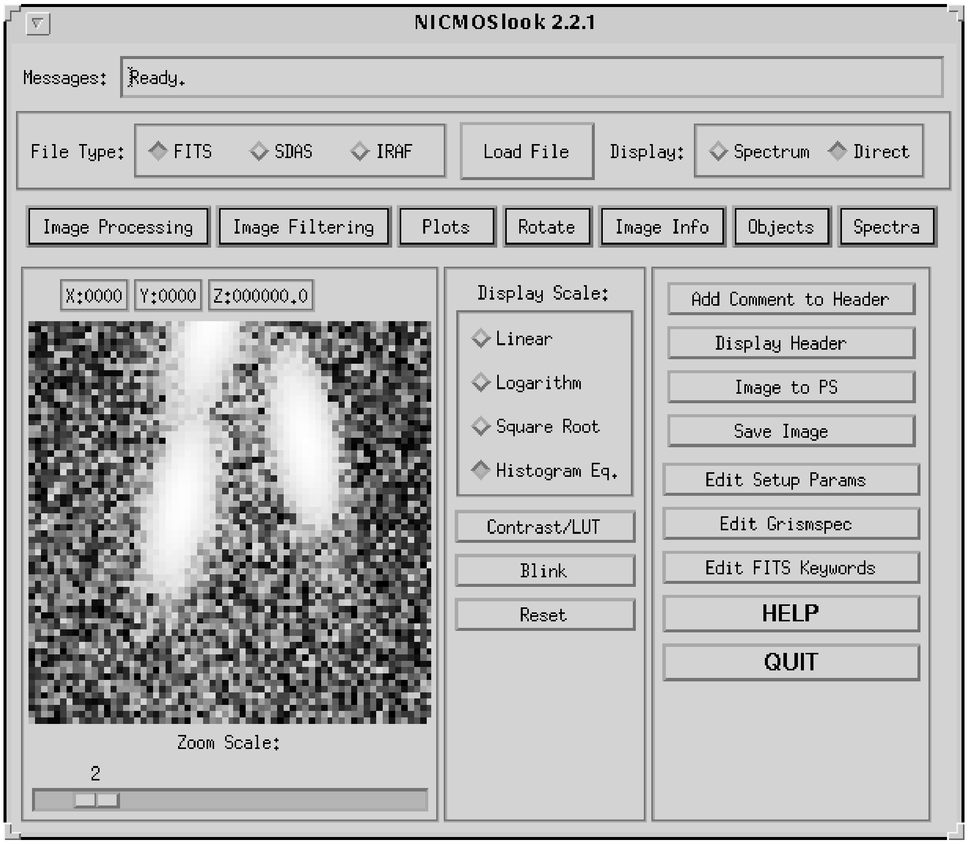
The IDL widget plots spectra in a window directly on the screen, with the option to save the plot to a Postscript file. These postscript files can be viewed with any Postscript viewer, such as `ghostview`. For example, if you direct the output to a file called `ov2_0.ps`, you would view this spectrum e.g. with `ghostview`, with:

```
ghostview ov2_0.ps
```

3.2 The User Interface

3.2.1 Startup Window

The user interface of NICMOSlook is an IDL widget. Figure 3.1 shows the user interface as it appears at the start of the program. This chapter gives a brief overview of the various buttons, switches, and pulldown menus available in NICMOSlook. Each of these items that



NICMOSlook 2.2.1

Messages: Ready.

Figure 3.1: The NICMOSlook user interface after at the start of the program.

can accept input are encased in a box. For a detailed example of the process of actually using NICMOSlook to reduce your data, refer to the NICMOSlook tutorial in chapter 5.

Starting up NICMOSlook with images already in IDL arrays: Note that image1 MUST be the spectrum, image2 the direct image (optional).

- IDL: `nicmoslook, image, header1=header1` *To load an image & header already in IDL memory:*

- IDL: `nicmoslook, image, /log` *To load an image and display it on a logarithmic scale:*

- IDL: `nicmoslook, image1, header1=header1, image2, header2=header2` *To load 2 images & headers already in IDL memory:*

If no header is given, then a minimal FITS header will be created. In this case, the user will be prompted for the grism name with a dialog box. To load an image from IRAF, FITS, or SDAS image files, call the program with no arguments. Once the widget appears select the FITS, SDAS or IRAF (depending on the type of the input file) and press the LOAD FILE button. A window will appear that prompts for the filename. FITS files are assumed to have the extension '.fits', IRAF images '.imh', and SDAS files '.hhh'. If the extension '.Z' or '.gz' is detected in the filename, the files are assumed to be compressed, and will be automatically uncompressed using the appropriate utility. There are 2 images buffers, one for the direct image, and one for the grism images. Every image is loaded into one of these buffers. Therefore, at most one direct image and one grism image can be loaded simultaneously.

3.2.2 Displaying the Images

When the program starts, a 512×512 separate display window with coordinate display will appear. The most recently loaded image will be displayed in this image. The input image will be resized to fit this window. The display window can be resized to any desired shape using standard window resizing techniques of the used window manager. There are a number of options to manipulate the image display.

- Changing Contrast and Colors: The image contrast can be changed through the switches labeled `Display Scale`: Linear, Logarithm, Square Root, and Histogram Eq..

- Changing Color Look-up table: The color look-up table and contrast can be changed by pressing the Contrast/LUT button. This will pop-up the standard IDL xloadct widget which presents a choice of look-up tables and display options.

- Switching Images with Toggle Buttons: Selecting the Spectrum or Direct Image toggle buttons displays the image loaded in that buffer.

- Switching Images with Blink: Selecting the Blink button pops up a window that allows the user to select the rate in which the two images currently loaded are switched, both in the zoom window and the separate image display.

- Using the Zoom Window: Clicking any mouse button once while the cursor is within the image display window causes the portion of the image centered on the cursor to be displayed in the zoom window. The zoom magnification is set through the slider bar below the zoom window.

- Resetting Images: Clicking the Reset button removes the images from the display and effectively resets the application to the initial startup state.

3.2.3 Finding Objects and Extracting Spectra

After loading both a grism image and a direct image into the tool, there are 2 main menu buttons to produce spectra:

- Objects Creates an object list from direct image or reads coordinate list from input file.

- Spectra Extracts spectra for selected objects with different weighting options.

These items are thoroughly discussed below.

- Objects The first step in the spectrum extraction procedure is to define the coordinates of the images. This is accomplished with this button. This will bring up submenus with the following options.
  - Find Objects
    - Cursor interactive input of object coordinates. Left mouse button clicks in the display window will append those coordinates to the internal object list. The last object location should be specified with a right mouse button. This terminates the 'Cursor Mode'.
    - DAOFIND find objects on the DIRECT image (independent of what is displayed.) and append them to the internal list.
    - Input File read object coordinates, sizes, angles, etc. from input file. See appendix F for a description of the format of this file.
  - Size & Orientation The extraction of spectra can be done by using weights appropriate for point sources, or by determining the weights from the size of the objects. The latter is appropriate for extended object and in this case, the size of the objects must be determined. This can be done interactively or automatically.
    - Cursor This item allows the user enter four points to mark the major and minor axis of an ellipse surrounding an object on the direct image. After selecting this menu item, click the left mouse button in the graphics window around the object in question. While this is being done, an informative window showing the actual coordinates clicked will appear. From this point on, the object is no longer considered a point source, rather an extended object.
    - Automatic automatically calculate sizes and orientation of objects selected.
    - Reset Reset sizes to zero and default type to point source.
  - Mark Objects Get a visual representation of an object's size, spectra location, or number.
    - Label objects numerically label objects on image display.
    - Spectra Location show the position of spectra to be extracted on image display.
    - Mark Sizes show the size and orientation of objects.
  - Object List Manipulate list of objects.

    - Save to File Save coordinates and sizes of objects to an ascii file. This file can be edited with any ascii editor and read back into NICMOSlook with Objects → Find Objects → Input file
    - Display List Display coordinates, sizes and orientation of objects in the object list.
    - Clear List reset internal list of object coordinates.

- Spectra This is the option which actually extracts the spectra for the objects in the current object list. Items that do not write to file will display a popup window displaying the spectrum. See section 3.4 for further information on this window.

  - Point Source Weighted Produce TinyTim weighted spectra for point sources.
  - Point Source Unweighted Produce unweighted spectra for point sources.
  - Extended Object Weighted Produce weighted spectra for extended objects.
  - Extended Object Unweighted Produce unweighted spectra for point sources.

    The above four menu items all have the following 4 menu items!

    - Specific Object Not Deblended Extract spectra of object selected by user without removing contamination from nearby objects.
    - Specific Object Deblended Extract spectra of object selected by user while attempting to remove contamination from nearby objects.
    - All To File - Not Deblended Extract spectra of all objects found on image without removing contamination from nearby objects. Write the results to a single FITS file and one postscript file for each object.
    - All To File - Deblended Extract spectra of all objects found on image while attempting to remove contamination from nearby objects. Write the results to a single FITS file and one postscript file for each object.

    When any of the above All to File ... are selected, a file selection window will appear. Enter the base name of the files that will be written. A single FITS file containing a table for each object, one Postscript file for EACH object, and a catalog file will be written to the directory and file rootname specified.

  - Strips produces several spectra by plotting the rows around a selected object and perform a wavelength calibration under the assumption that there are no distortions and rotations of the spectrum. In other words, the tool plots the appropriate sections of the rows without modifications.
  - Trace At this point, most of the parameters in the NICMOSlook calibration data base `grismspec.dat` have to be predefined (see D.1). However, the location of the spectra relative to the location of the object on the direct image can be determined automatically with this option. The object has to be defined and one of it has to be selected. THe program will then search for the position of

    the spectrum at a location close to the one specified in `grismspec.dat` for the current filter and grism. The user is presented with a plot of the y-positions of the spectrum as a function of x position. Accurate parameters are determined through a fit to this plot. The user can choose wether to update `grismspec.dat` with these parameters.

  - Extraction Images

    - Punched-out Grism Display the ”punched-out” grism image: It is often quite informative to see the pixels used for the extraction of a spectrum. This button displays in the graphics window an image whose pixels that are used are ”punched out” (ie set to the mean background pixel value of the surrounding pixels).
    - Image Background Display pixels used to calculate a background value: The graphics screen will then display an image showing which pixels were used in the calculation of a mean background value for an object.
    - Weights Display weight used in the last extraction: The graphics screen will then display an image showing the weight matrix used in the last spectra extracted

3.2.4 Supplementary Pulldown Menus

- IMAGE PROCESSING

  While NICMOSlook's main use is to extract spectra from already reduced images, a few simple image processing tools are provided so that NICMOSlook can be used as a quick-look of raw data. All tools act on the currently displayed image. All of the following procedures replace the original image in the program's buffer and update the display window.

  - Convert To Count Rate Count-rate conversion is simply dividing the image by the exposure time. The image header is searched for the keyword EXPTIME or DTIME. If not found, an error message is issued. A comment is added to the header.
  - Fix Bad Column(s) The replacement values for bad columns are linearly interpolated from the two nearest non-bad columns. A dialog box prompts the user for the coordinates of the bad columns. The image header is automatically updated.
  - Bias Subtraction Removes the 2-dimensional additive background from the image. Bias image can be loaded from the command line via the appropriate keyword or from an IRAF, FITS, or SDAS file. The bias image must be the same size as the image to be processed. The image header is automatically updated.

  - Dark Subtraction Subtracts dark count image in the same fashion as described above for bias subtraction.
  - Flat Field Compensates for the pixel-to-pixel variation in sensitivity. The image is divided by the flat. The flat field image must be normalized. If the image to be processed and the flat field image are not the same size, the task will try to register the flat by searching the image header for the starting X and Y positions (header keywords 'X0' and 'Y0'). The image header is updated.

- IMAGE FILTERING

  A number of image filtering tools are provided to help the detection of objects on the direct image. While the main application of these tools is to enhance the direct image, they can also be applied to the grism image. All tools act on the currently displayed image. They overwrite the image in the program's memory. The display window and the image header are updated.

  - Median Useful for removing cosmic ray hits.
  - Smooth Boxcar average.
  - Sobel & Roberts Edge enhancement.
  - Convolution Convolves image with a user-supplied kernel, assumed to be a FITS image. The file selection dialog box appears.

- PLOTS

  A number of tools are available to graphically investigate the images. For each of these options a pop-up widget will appear containing the requested plot. This pop-up widget contains options for rescaling the y-axis of the plot, measuring the FWHM of emission features, and writing plots to postscript. The y-axis scaling options include: 1) linear, 2) logarithmic, 3) logarithmic down to ten, and linear from ten to zero.

  - Cross Section Produces a plot of a 'slice' of an image. User must position the cursor in the display window at each end of the desired cross section. Click LEFT on the starting location and click RIGHT on the ending location. The width of the slice is one pixel.
  - Row Sum User must click LEFT on the starting and click RIGHT on ending columns. The plot is produced by direct addition.
  - Column Sum User must click LEFT on the starting and click RIGHT on ending columns. The plot is produced by direct addition.
  - Histogram Produces a histogram of the entire image.

- ROTATE

  The spectra on the grism image are assumed to have the orientation as specified in the setup file `grismspec.dat` (see appendix D.1). If for some reason the orientation of the image is different, it can be rotated into the correct orientation with this option. Another application of this option is to bring the grism image and the direct image into the same orientation if this is not the case for the input images. Note that it is the responsibility of the user to assure that the orientation of the grism image and the direct image are the same. The rotate routines act on the currently displayed image and overwrite the image in the program's memory. The display window and the image header are updated.

- IMAGE INFO

  – Statistics Computes a basic set of image statistics; mean, median, standard deviation, etc.

  – Encircled Energy Calculates the total number of counts in a user-selected region of the image. The region is defined by clicking left on the diagonal corners of an imaginary box. Coordinates of the box selected are also displayed.

  – Header Keywords Certain keywords in the FITS header are necessary for calculating various values. This item will display the values of these keywords.

3.2.5 Miscellaneous Buttons

- Adding a Comment to a FITS Header: Press the Add Comment To Header button. A dialog box will appear allowing the user to input a comment to be included in the FITS header of the image currently being displayed.

- Displaying the FITS Header of Image: Press the Display Header button. A window containing the text of the FITS header of the currently displayed object will appear.

- Writing Images to Postscript files: Press the Image to PS button. The currently displayed image will be written to a postscript file in the user's current working directory.

- Saving a Processed Image: Press the SAVE IMAGE button. A dialog box will appear allowing the user to select the name of the output file. The default selection is the input filename, if any. The output format is FITS. Note: This option only saves the currently displayed image, if you have two, then this options must selected twice.

- Editing Setup Parameters: Press the Edit Setup Params button. A screen will appear with all the setup parameters available for editing. Refer to section 4.1.2 for more information.

- Editing Grismspec File: Press the Edit Grismspec button. A screen will appear with all the grismspec values for the selected filter. Refer section D.1 for more information.

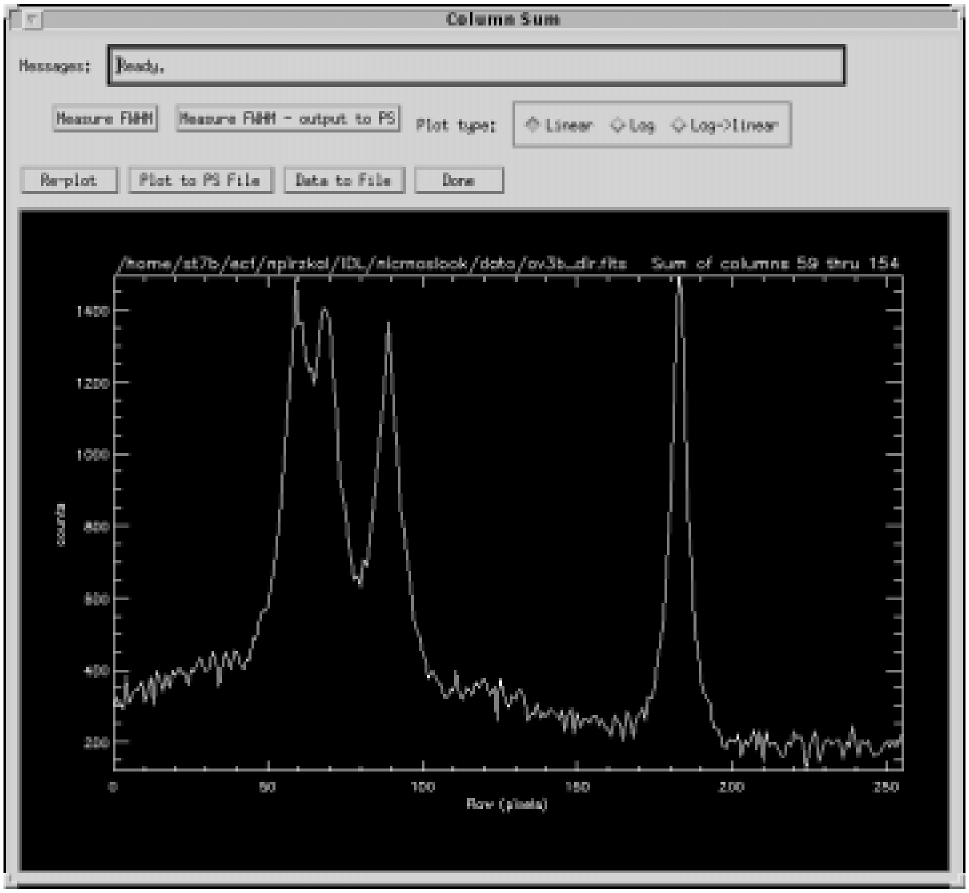
- Editing FITS Keywords: Press the Edit FITS Keywords button. A screen will appear with all the configurable FITS keyword values. Refer section B.2 for more information.

- Getting Help: Press the Help button. A window will appear with helpful information for running NICMOSlook.

- Quitting NICMOSlook: By pressing the Quit button, the NICMOSlook program is terminated.

3.2.6 Plot Popup Window

Figure 3.2 shows an example of a plot when selected with the one of the Plot menu items.



Column Sum

Messages: Ready.

Plot type: ● Linear ○ Log ○ Log->linear

/home/st7b/ecf/npirzkal/IDL/nicmoslook/data/ov3b_dir.fits Sum of columns 59 thru 154

Figure 3.2: The Popup Window

The following buttons are available on the plot window:

- Measure FWHM With this button, areas on the plot window can be selected with the mouse. Selection is terminated by using the RIGHT mouse button on the last coordinate of desired region. A gaussian is fitted to each selected region and the plot is replaced with panels containing the results. To return to the original plot, push Re-plot. See figure 3.3 for an example.

- Measure FWHM - output to PS The same procedure as above, but the output will go to a Postscript file instead of the screen.

  The plot type can be selected with one of these switches:

  - Linear
  - Log
  - Log→linear

- Replot Redisplay the plot popup window.

- Plot to PS File Write the plot currently displayed to a Postscript file.

- Data to File Data currently display on the screen will be written to a data file when this button is selected.

- Done This button closes the plot popup window and returns control to the main NICMOSlook window.

Plot Popup Window: FWHM

See the above section for a description of the buttons available on this plot popup.

3.2.7 Spectrum Popup Window

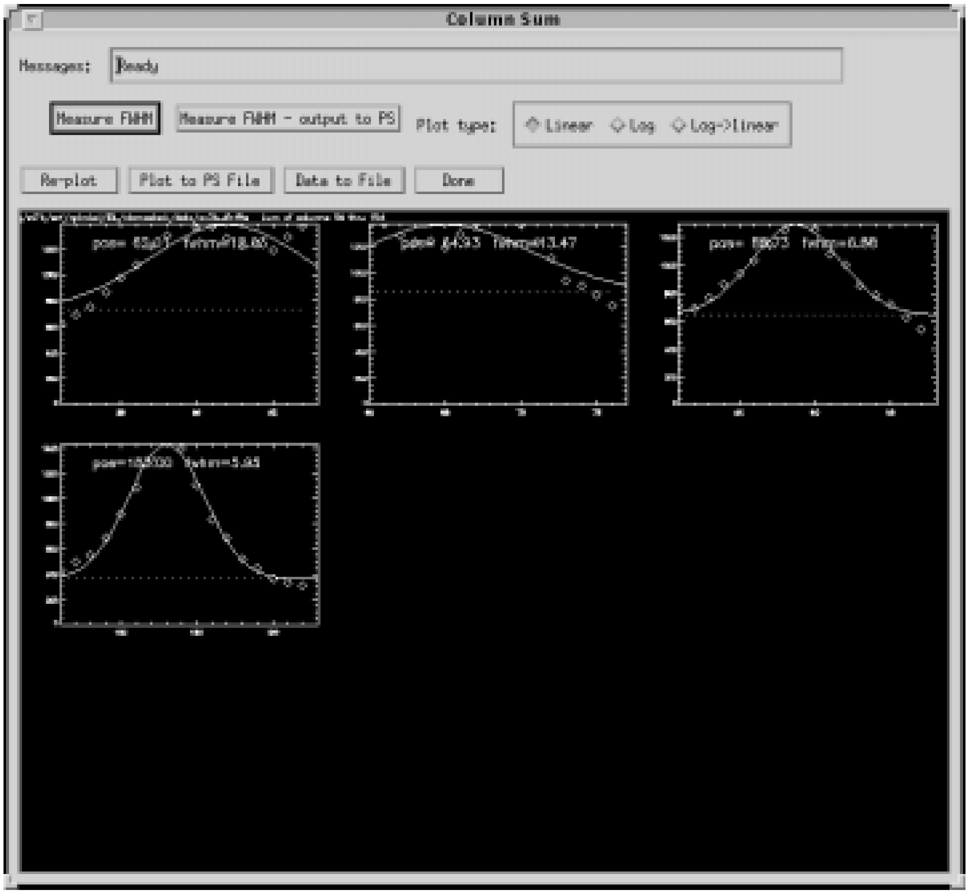
When any of the menu items selected from Spectra that do not direct output to a file are selected, a spectrum plot popup like the one in figure 3.4 will appear.

The following buttons are available on the spectrum plot window:

- Replot Redisplay the plot popup window.

- Plot to PS File Write the plot currently displayed to a Postscript file.

- Save to FITS Data currently display on the screen will be written to a data file when this button is selected.



Messages: Ready

Plot type: ◆ Linear ◇ Log ◇ Log->linear

Figure 3.3: The Plot Popup Window: FWHM

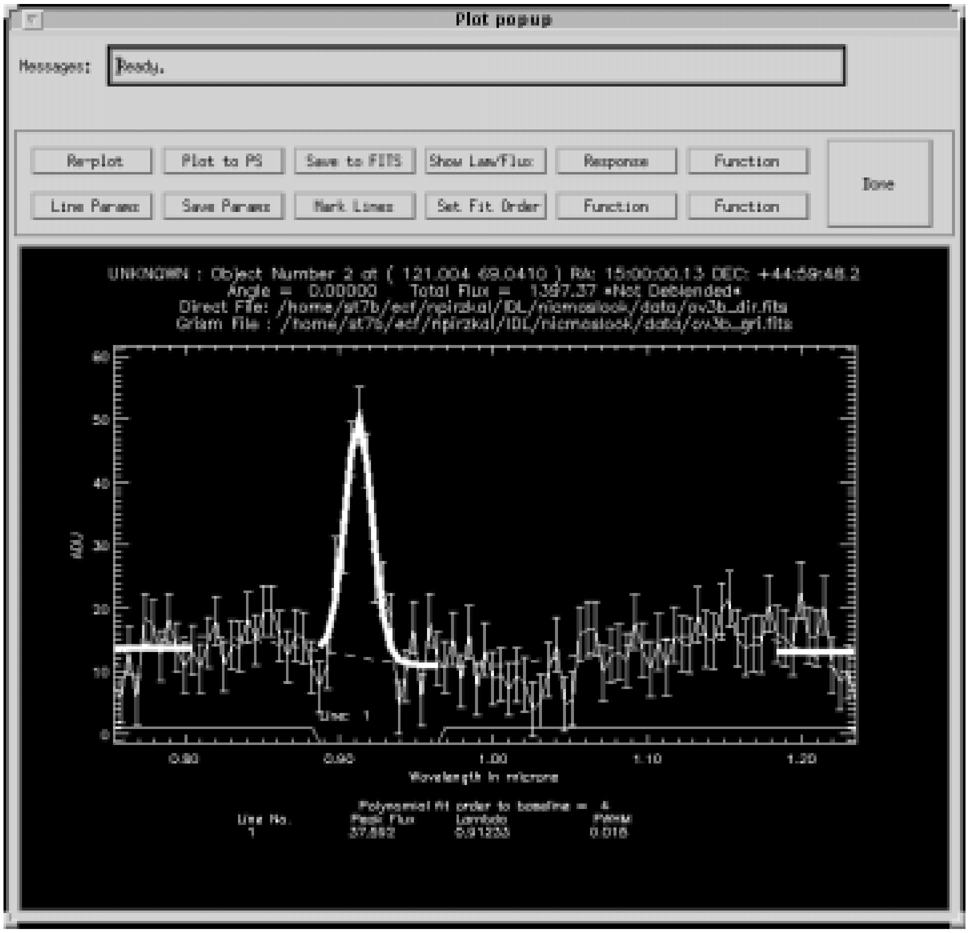
- Show Lambda/Flux Select this button and enter the plot window and click on a point. This will bring up a popup that shows the Wavelength and Flux value of the point selected.

- Response This option divides the current spectrum by a function defined through a list of wavelength - throughput pairs. The filename of this asci file is defined in `grismspec.dat`.

- Line Params Selecting this button pops up a window containing the derived line parameters from the spectra extraction process.

- Save Params Selecting this button pops up a file dialog box prompting for a file name in which to save the derived line parameters

- Mark Lines This button allows users to override line boundaries automatically determined in the spectra extraction process. After selecting the button, enter the plot and select the line boundaries with the left mouse button. The right mouse button



Messages: Ready.

```
UNKNOWN : Object Number 2 at ( 121.004 69.0410 ) RA: 15:00:00.13 DEC: +44:59:48.2
Angle =  0.00000    Total Flux =  1397.37 *Not Deblended*
Direct File: /home/st7b/ecf/npirzkal/IDL/nicmoslook/data/ov3b_dir.fits
Grism File : /home/st7b/ecf/npirzkal/IDL/nicmoslook/data/ov3b_gri.fits

Polynomial fit order to baseline =  4
Line No.       Peak Flux     Lambda          FWHM
   1           37.892        0.91233         0.016
```

Figure 3.4: The Spectrum Popup Window

is used when selecting the last point on the spectra to use. After the final point is selected, spectral line search will automatically be run.

- Set Fit Order A polynomial is automatically fit to the continuum emission of each extracted spectrum. Selecting this button pops up a window so that the fit order can be entered. This fit order will override the fit order in the setup parameter file. The spectral line search will be rerun automatically with the new value when the popup's Done button is selected.

- Response Apply a response.

- Done This button closes the spectra popup window and returns control to the main NICMOSlook window.

Chapter 4

Software Dependencies, System Requirements & Debugging

4.1 NICMOSlook

NICMOSlook is a Bourne Shell script which calls IDL. All the software is written in IDL and therefore Calnic C requires a valid IDL license. NICMOSlook has been tested so far under the Solaris operating environment.

4.1.1 Directory Structure

The directory structure contains all the necessary calibration files, fits images, etc. to run the current version of NICMOSlook. The directory structure of the NICMOSlook Software is in figure 4.1

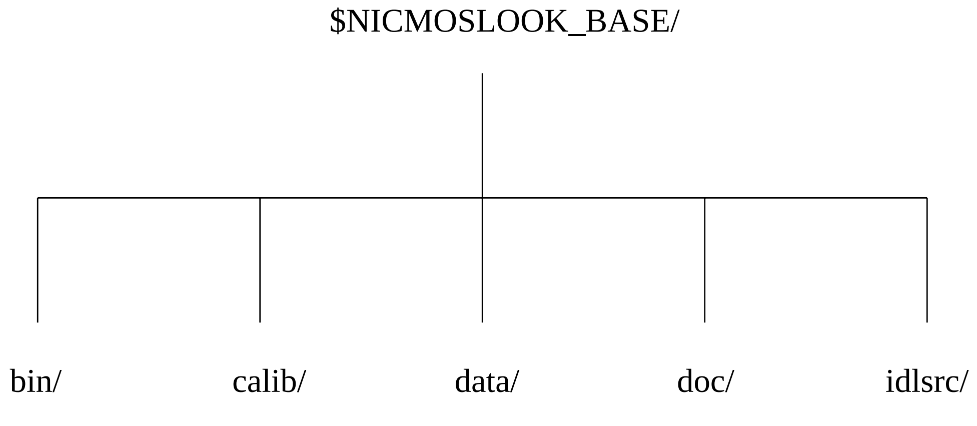


Figure 4.1: Directory Structure of NICMOSlook Software

Directory Contents:

1. `$NICMOSLOOK_BASE`/bin

nicmoslook :	The program (Bourne Shell script)	
nicmoslook_startup.pro :	IDL startup file	
nicmoslook_binary :	"Compiled" idl code	
2. $NICMOSLOOK_BASE/calib		
bck*grismX*.fits :	Image background for the different grisms	
calnicc.setup :	NICMOSLOOK/Calnic C default values	
fitskeywds.dat :	FITS keywords	
grismspec.dat :	The grism specification file	
nicmosFF.fits :	Flat Field file (this is 3 dimensional)	
*.response :	Response files for each grism	list of filter curve
*.conv :	Convolve files for each grism	PSF for each filter
weight*.fits :	Various weight files for different grisms	
3. $NICMOSLOOK_BASE/data :	One test image pair	
4. $NICMOSLOOK_BASE/doc :	Documentation directory	
nicmoslook.tex :	TeX version of NICMOSlook manual	
nicmoslook.ps :	Postscript version of NICMOSlook manual	
5. $NICMOSLOOK_BASE/idlsrc :	IDL source code for NICMOSlook	

4.1.2 NICMOSlook Setup Parameters

In the calibration subdirectory mentioned in the section above, the file `calnicc.setup` contains variety of parameters that can be set to modify the behavior of NICMOSlook. It is possible to modify these parameters while running NICMOSlook. Use the button Edit Setup Params to change the values. This will pop-up the parameter editor. All parameters are described in plain English and can be changed (see Figure 4.2). The changes take effect immediately after hitting the Save button on the editor pop-up. In addition, the values are written back to the file `$NICMOSLOOK_BASE/`calnicc.setup. See table D.2 for the default values of the parameters described below.

- `ADCGAIN`
  Analog to digital gain in electrons/ADU. This value will be used as a default IF no keyword ADCGAIN is found in the image header.

- `BADPIX_THRESH`
  Pixel coordinates that contain object information are compared with a bad pixel map. A ratio of total pixels to the number of the bad pixels is calculated and compared to this parameter. If the ratio is higher than this value, the object is removed from the object list.

- `BG_PIXELS`
  To calculate a background estimate for an object during spectral extraction, the mean value of the pixels surrounding the edge of the object is calculated. This parameter determines the width of the region used in this calculation.

- `BLEND_FACTOR`
  In the spectral line search process, 2 lines are considered to be the same line if the separation of the peaks is smaller than the sum of the line widths multiplied with this factor. In that case, the region of the two lines are joined and a new Gaussian is fitted over the entire wavelength range of the line.

- `CONT_FACTOR`
  This factor determines the region for which the average of the continuum "longwards" of the line with the longest wavelength and "shortwards" of the line with the shortest wavelength is computed. The "long" region is the peak of the line with the longest wavelength added to the σ of that line multiplied with this factor. The "short" region is the peak of the line with the shortest wavelength minus the σ of that line multiplied with this factor.

- `DAO_THRESH`
  Threshold used to find objects on the grism image outside of the regions where spectra are predicted from the objects found on the direct image. The unit of this threshold is the rms of the noise in the grism image after removing known spectra.

- `DEBLEND_ERR_MIN`
  When calculating the deblending error, this value is substituted for deblending errors that are of smaller value.

- `DET_THRESH`
  Threshold used in the spectral line search to identify lines in units of the rms of the spectrum.

- `EXTOBJ_THRESH`
  The object detection program (SExtractor) classifies all objects detected as either point source or extended object. This classification is in the form of a probability value: the closer this value is to 0.0 the more likely the object is an extended object; conversely, the closer this value is to 1.0, the more likely the object is a point source. This parameter is the "cut-off" point in which all probability values greater are regarded as point sources and all values below, extended objects. This is relevant for the weighting of the spectrum extraction.

- `FIT_ORDER1`
  A polynomial is fitted to the continuum in each spectrum. After the first fit, deviating points are removed from the fit region and the process is iterated. This parameter is the order of the polynomial for the first `N_ITERLOW` iterations (see below).

- `FIT_ORDER2`
  Polynomials are iteratively fitted to the continuum in each spectrum. After each fit, deviating points are removed from the fit region for the next iteration. This parameter is the order of the polynomial for all but the first `N_ITERLOW` iterations (see below).

- `MAXLINES`
  This parameter determines the maximum number of lines which can be detected in any spectrum.

- `MAXOBJS`
  For computing resource purposes, this number determines how many objects on an image set are to be examined.

- `MAXPIX`
  For computing resource considerations, the maximum size of input images processed by Calnic C in pixels.

- `MIN_NPOINTS`
  This parameter is the minimum number of consecutive points which deviate from the continuum fit in the spectrum which are considered as a spectral line.

- `MIN_PIX_NO`
  Minimum line width for a line to be considered as real.

- `MIN_SIGNSE`
  Detected lines whose signal-to-noise ratio is less than this value are rejected.

- `N_ITERATIONS`
  The fit to the continuum in the spectrum is discontinued after this number of iterations.

- `N_ITERLOW`
  The fit of a polynomial to the continuum in the spectrum is done in two steps. For the first iterations, a low order polynomial is fitted in order to identify strong lines. After several iterations in which deviant points are rejected and a new polynomial is fit, the order of the fit is increased. This parameter determines the number of iterations before the next higher fit order is used.

- `O_THRESH1`
  Close spectra on the grism image potentially contaminate each other. This parameter is the maximum distance of 2 spectra on the grism image for them to be considered being exactly aligned. The parameter is in units of the sum of the line widths of both spectra.

- O_THRESH2
  Close spectra on the grism image potentially contaminate each other. This parameter is the maximum distance of 2 spectra on the grism image for which a contamination is expected and Calnic C attempts to "deblend".

- O_THRESH3
  Close spectra on the grism image potentially contaminate each other. This parameter is the maximum distance of 2 spectra on the grism image for which a contamination is considered to be still possible.

- REJ_THRESH
  Currently not used.

- SZ_FACTOR
  Width of a spectrum in units of the 2nd order moment of the object on the direct image.

- DEBUG_LEVEL
  This parameter determines the verbosity of Calnic C's output messages. The higher its value, the more information is printed to the debugging output file. This parameter allows for detailed debugging messages. Refer to section 4.2 for more information.

- NOFLATFIELD
  This parameter allows users to turn off (or on) flatfielding before spectral line extraction commences.

- NOBACKGND
  This parameter allows users to turn off (or on) background subtraction before spectral line extraction commences.

4.1.3 NICMOSlook Grismspec Entries

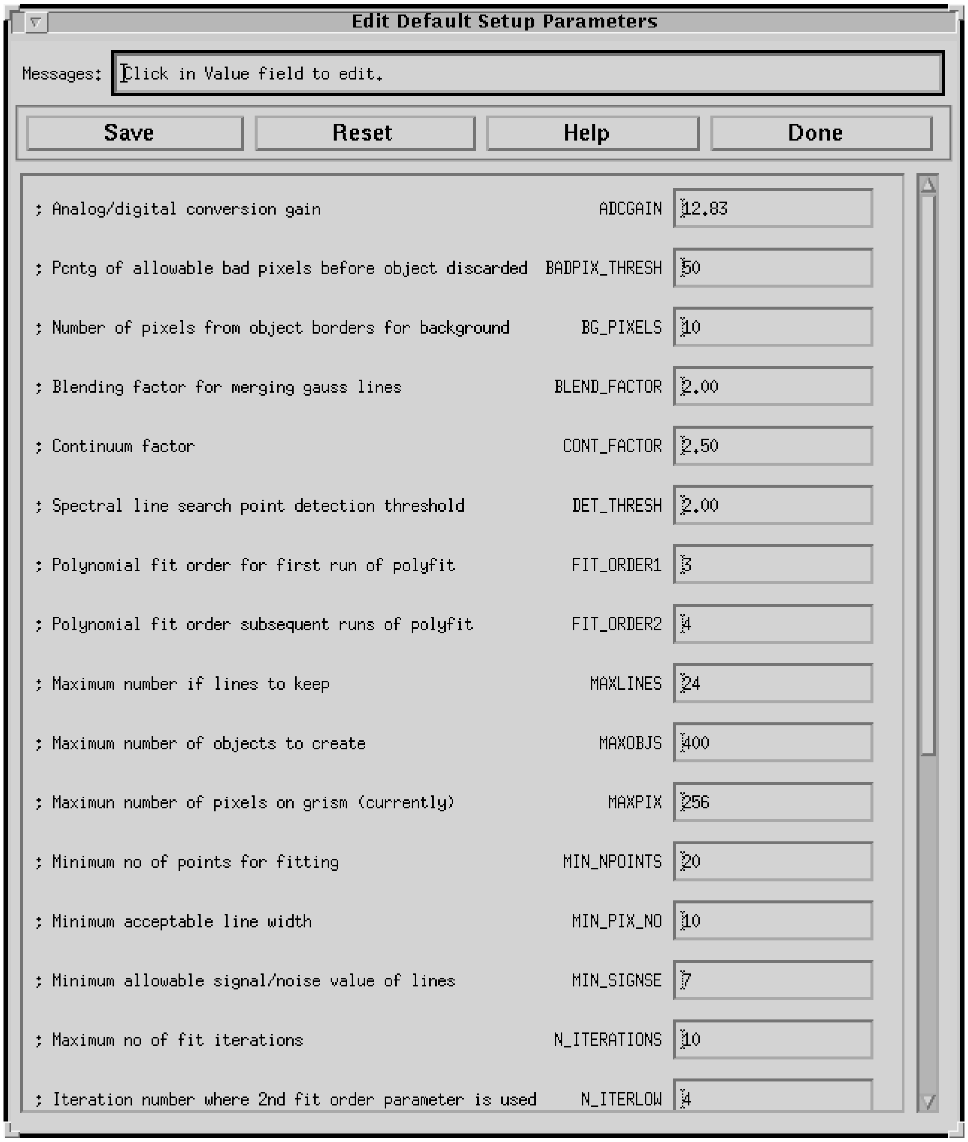
Another file in the calibration subdirectory, `grismspec.dat`, contains the filter specifications for the direct image and grism filters. It is possible to modify these parameters while running NICMOSlook. Use the button Edit Grismspec to change the values. This will pop-up the parameter editor. All parameters are described in plain English and can be changed (see Figure 4.3). The changes take effect immediately after hitting the Save button on the editor pop-up. In addition, the values are written back to the file $NICMOSLOOK_BASE/grismspec.dat. See section D.1 for more details.

4.1.4 NICMOSlook Configurable FITS Keyword Values

The file, `fitskeywds.dat`, contains entries for FITS keywords used by NICMOSlook. Since it is likely that different data sets will use different keyword values for specifying the same item of interest to NICMOSlook, flexibility is needed. For example, some FITS files might use the keyword `OPT_ELEM` to specify the optical component used for an observation. Other FITS files on the other hand, might use the keyword `FILTER` to specify the same optical component! It is possible to edit the value of the keywords used by NICMOSlook(see Figure 4.4). Use the button Edit FITS Keywords to change these values. The changes take effect immediately after hitting the Save button on the editor pop-up. See section D.3 for the default values.

4.2 Debugging

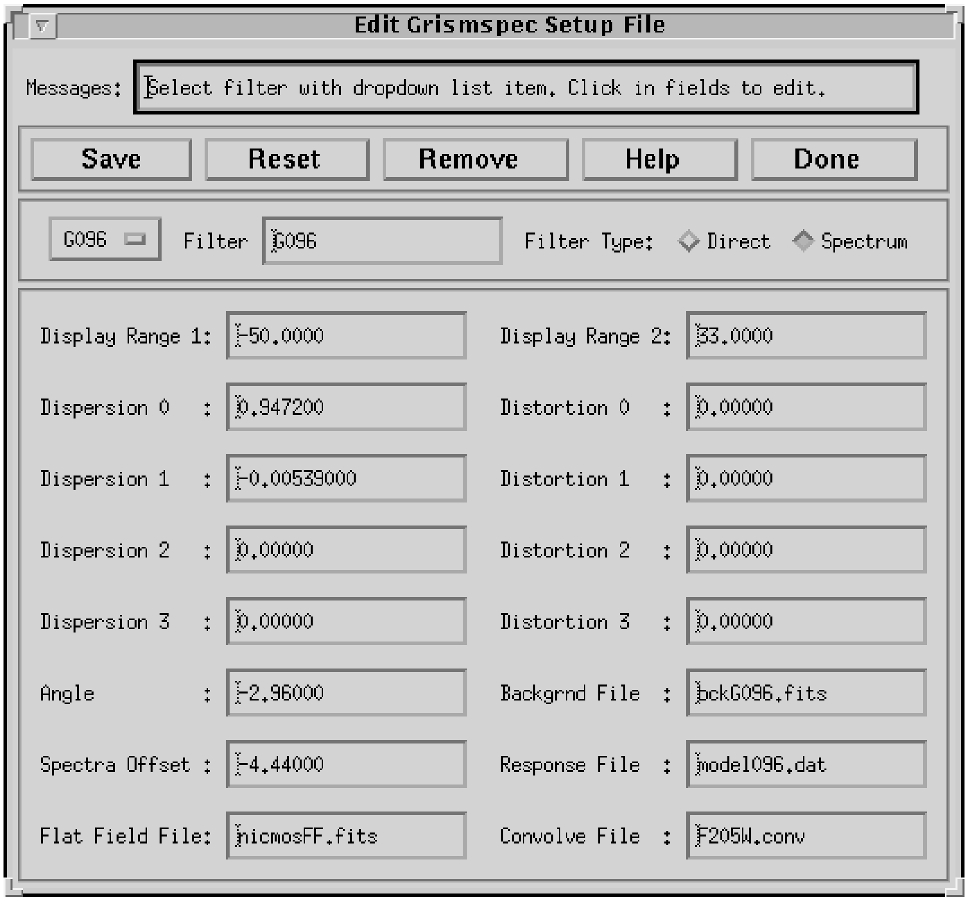
In the course of processing, NICMOSlook writes diagnostic information to the shell window from which it was started. In the unlikely event NICMOSlook does not behave in the manner expected, the parameter `DEBUG_LEVEL` can be increased from its default value. When this parameter is set higher, more detailed messages are displayed. This value can be set by selecting the Edit Setup Params button.



```
Messages: Click in Value field to edit.

; Analog/digital conversion gain                               ADCGAIN       12.83
; Pcntg of allowable bad pixels before object discarded   BADPIX_THRESH     50
; Number of pixels from object borders for background        BG_PIXELS     10
; Blending factor for merging gauss lines                   BLEND_FACTOR    2.00
; Continuum factor                                           CONT_FACTOR    2.50
; Spectral line search point detection threshold              DET_THRESH    2.00
; Polynomial fit order for first run of polyfit                FIT_ORDER1    3
; Polynomial fit order subsequent runs of polyfit              FIT_ORDER2    4
; Maximum number if lines to keep                                MAXLINES    24
; Maximum number of objects to create                             MAXOBJS    400
; Maximun number of pixels on grism (currently)                    MAXPIX    256
; Minimum no of points for fitting                            MIN_NPOINTS    20
; Minimum acceptable line width                                MIN_PIX_NO    10
; Minimum allowable signal/noise value of lines                MIN_SIGNSE    7
; Maximum no of fit iterations                               N_ITERATIONS    10
; Iteration number where 2nd fit order parameter is used     N_ITERLOW     4
```

Figure 4.2: The NICMOSlookParameter Editor.

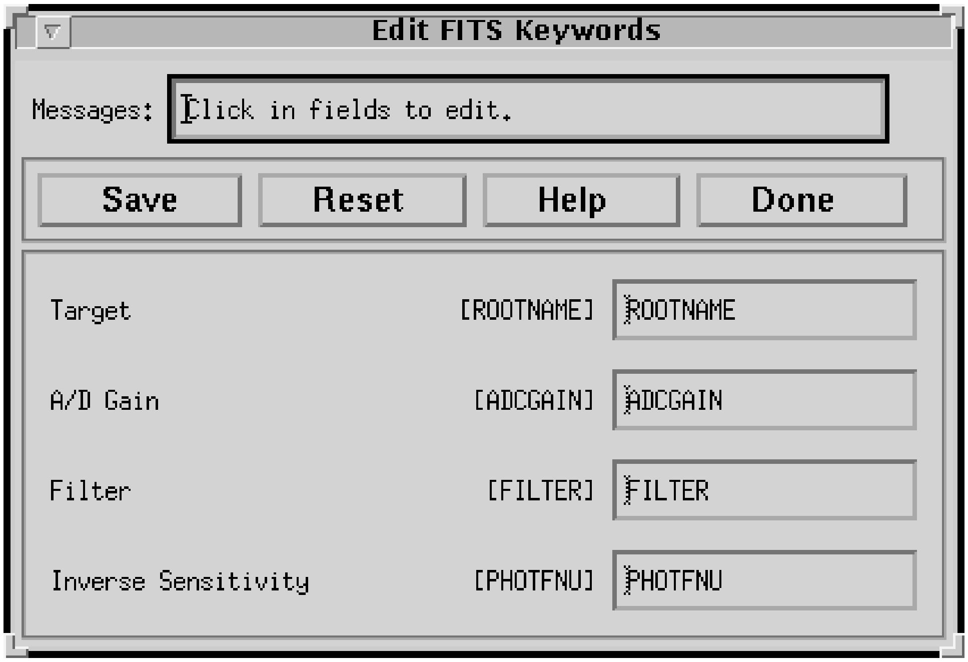


Messages: Select filter with dropdown list item. Click in fields to edit.

G096 Filter G096 Filter Type: ○ Direct ● Spectrum

Display Range 1:	-50.0000	Display Range 2:	33.0000
Dispersion 0 :	0.947200	Distortion 0 :	0.00000
Dispersion 1 :	-0.00539000	Distortion 1 :	0.00000
Dispersion 2 :	0.00000	Distortion 2 :	0.00000
Dispersion 3 :	0.00000	Distortion 3 :	0.00000
Angle :	-2.96000	Backgrnd File :	bckG096.fits
Spectra Offset :	-4.44000	Response File :	model096.dat
Flat Field File:	nicmosFF.fits	Convolve File :	F205W.conv

Figure 4.3: The NICMOSlook Grismspec Editor.



Edit FITS Keywords

Messages: Click in fields to edit.

Target	[ROOTNAME]	ROOTNAME
A/D Gain	[ADCGAIN]	ADCGAIN
Filter	[FILTER]	FILTER
Inverse Sensitivity	[PHOTFNU]	PHOTFNU

Figure 4.4: The NICMOSlook FITS Keyword Editor.

Chapter 5

Tutorial

This chapter gives you a basic guide on how to use NICMOSlook. The detailed descriptions of algorithms used can be found in the appropriate chapter of the Calnic C user's manual.

Before you begin, you should make sure that IDL is installed with the correct licenses on your machine. Then ollow the instructions in section 2.2 to install the latest version of NICMOSlook.

After the installation process is complete, you are ready to run NICMOSlook by simply typing `nicmoslook` at the UNIX command line. Refer to section 3.1 for a alternative methods of starting NICMOSlook.

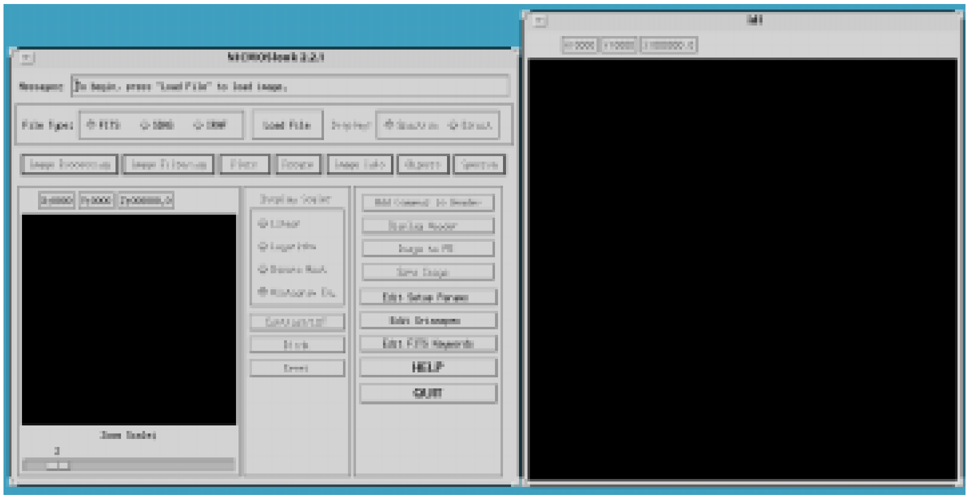
In this tutorial, all commands you type in from your keyboard are `type-writer font`, and commands you click on your screen are encased by boxes.

This command will automatically start IDL and two windows will appear: one is the main NICMOSlook window which contains all of the data processing tasks; the other window is an IDL image display window. See Figure 5.1. All the functional buttons in the main NICMOSlook window can be activated by pressing the left button on your mouse unless stated otherwise. Before you start using various functions, read the help file by pressing the button $\boxed{\text{Help}}$ on the main NICMOSlook window. This file contains detailed description of every task in NICMOSlook. To close the windows, press $\boxed{\text{Done}}$

5.1 Image Display

To start the data processing, press $\boxed{\text{Load}}$ in the main NICMOSlook window. A separate small window will appear with directory names and the files in each of the directories. See Figure 5.2. Select the correct directory and the image file which you want to load into NICMOSlook. For example, you can click on subdirectories $\boxed{\text{data}}$, a file `obj10_dir.fits`, then click $\boxed{\text{ Ok }}$. This will load the FITS format image obj10_dir.fits into the IDL image display window.

In order to produce a quick spectrum extraction of a grism spectrum, you need to load both a grism spectrum and the corresponding direct image into NICMOSlook. This is because the direct image provides the information about the locations of your objects on the NICMOS detector, and NICMOSlook needs to know the precise positions of your objects before starting tracing and extracting the corresponding grism spectra.



Message: To begin, press "Load File" to load image.

Figure 5.1: The NICMOSlook main window when you first start up nicmoslook.

You can load your direct image and grism spectrum in any order you want. NICMOSlook recognizes your image file from its FITS header. If it is a direct image, NICMOSlook puts it in the direct image buffer; if it is a grism spectrum, NICMOSlook puts it in the spectrum buffer. It should be pointed out that each of these buffers can hold only one image file at a time. If you do any processing to the image, it overwrites the original image in that buffer. If you need the original image, you have to reload the image from the disk again. If you want to save what you have done, you have to press Save Image in the main NICMOSlook window.

After you have loaded both the direct image and the grism spectrum, you can click the exclusive menu button labelled `Display` (on the main NICMOSlook window) to choose which image you wish to display in the main IDL image window. Select Spectrum to display the grism image, or Direct image to display the direct image.

If you wish to examine your image in detail, put the cursor at the position you want in the big IDL image display window, then click the left mouse button. A section of your image centered around the cursor position will appear in the small image display window in the main NICMOSlook window. You can then control the image expansion from this small window.

You can also examine your file header by pressing Display Header in the main NICMOSlook window. Again a separate window appears to show you the fits file header. To add any comments to the file header, you can press Add Comment to Header button, then a separate window will appear which says: Enter comment to be added to header. After you are done, press Done. You can check your newly added comment by using Display Header.

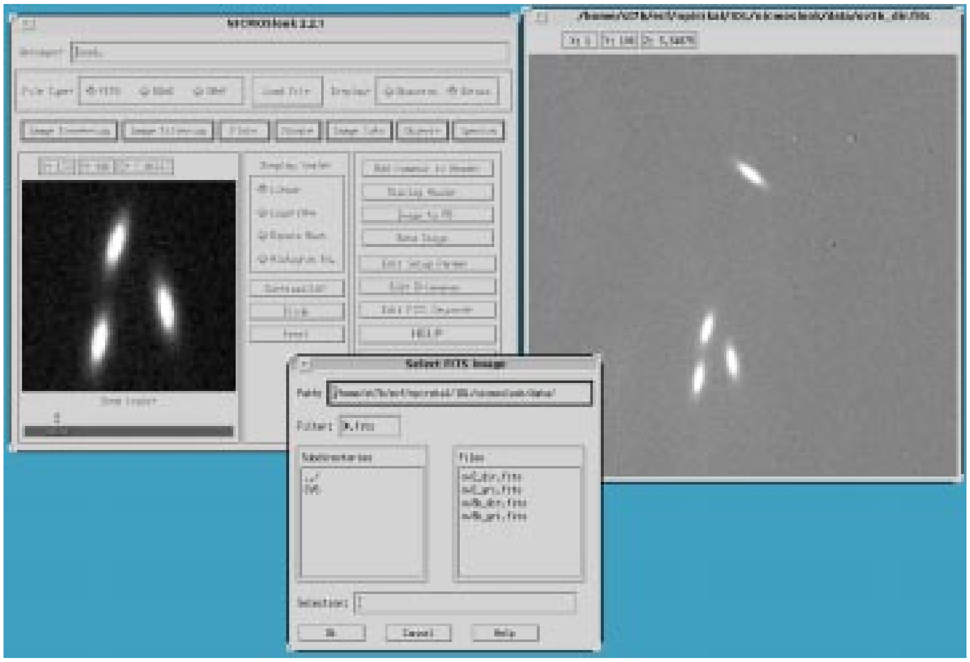


Figure 5.2: The window configuration when you start loading images to NICMOSlook.

Using Edit Setup Params, you can change some of the parameters used for the spectrum extraction. For example, if you click in the field ADCGAIN, you can put in the appropriate gain factor, then press Save Changes & Quit. This not only changes the values for the current session, but also saves the values in the `calnicc.setup` file. When you start a new session of NICMOSlook, these newly saved setup parameter values will be the default. Of course you could change the setup parameters in the file `calnicc.setup` in the `$NICMOSLOOK_BASE/`calib directory.

By pressing Contrast/LUT you can adjust the color table. Also in Display Scale, you can choose one of the options for your image display.

5.2 Image Processing

If you press the button Image Processing, you will see a menu appearing with listed functions NICMOSlook has. For example, if you want to do bias subtraction, you can press Image Processing→Bias Subtraction, then a separate window will appear which ask you to select the bias image for the processing. Notice at the top of the main NICMOSlook window, there is a small message field which always contains information about what is happening. It is useful for users to keep an eye on that window. Other functions within "Image Processing" are dark counts subtraction, flat fielding, count rate conversion, overscan subtraction and fixing bad pixels. By pressing Blink you can blink the direct image against the grism spectrum image. Also other functions such as Image Filtering and Rotate can be used to smooth and rotate your images. Plots can be used to make a plot of either several raws or columns or even a section of your image. This function is very useful when you want to see if the objects in your image are point sources or extended, see details in next section.

To check the statistics of the displayed image, you can press the button in the main window Image Info → Statistics.

5.3 Finding Objects and Determining Sizes

Before you start the spectrum extraction, you need to assign the sizes to the objects you are interested in. The reason is that the spectrum extraction algorithm was designed to give different weights depending on the sizes of the objects, and more importantly, the way of calculating the weights is different for point sources and for extended galaxies. Thus, you need to decide, first, if your objects are extended or point sources; second, the sizes of your objects. The actual procedure is as follows:

You should first define your object positions on the direct image. If you press Objects, a small menu pops up, which lists several functions. Among these functions, Find Objects gives several options. For example, "Cursor" means you could define your object positions directly by clicking on your grism spectrum image `IF` you know beforehand the exact positions of your objects on NICMOS detectors. Similarly, function "Input file" can also provide a list of positions for extracting the grism spectra of your objects without any direct image of your objects. See Figure 5.3 which shows that you could use input file object5.dat pre-defined the object positions.

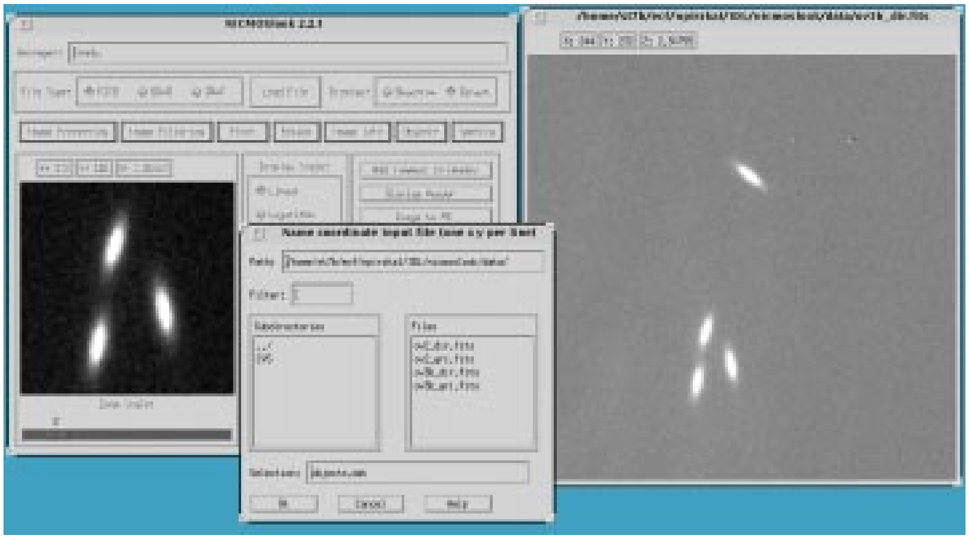


Figure 5.3: This shows you can select the object positions from an input file.

If you click on Objects → Find Objects → DAOFIND, you will get a separate window which requires three user adjustable parameters — `threshold` used for the object detection, `minimum and maximum sharpness`. See Figure 5.4. Very large minimum and maximum sharpness values will allow you to only pick up point like sources, for instance, minimum sharpness of 0.8 and maximum sharpness of 100 will allow you to ignore most of the extended galaxies in the test image obj10_dir.fits. Similarly, if you set small values of minimum and maximum sharpness, for example, minimum sharpness of 0.2 and maximum sharpness of 1.0 will allow you to only pick up extended galaxies and no point sources in the test image obj10_dir.fits. Of course the actual values of sharpness may be different from the above numbers for your real data images. The appropriate values should be tested with your actual data. To ignore any previous object findings, you can press $\boxed{\text{Objects}}$→$\boxed{\text{Object List}}$→$\boxed{\text{Clear List}}$ to empty the object file. This will actually empty the file from the computer memory. $\boxed{\text{Objects}}$→$\boxed{\text{Mark Objects}}$→$\boxed{\text{Label}}$ will allow to label the objects you have found on the image display window.

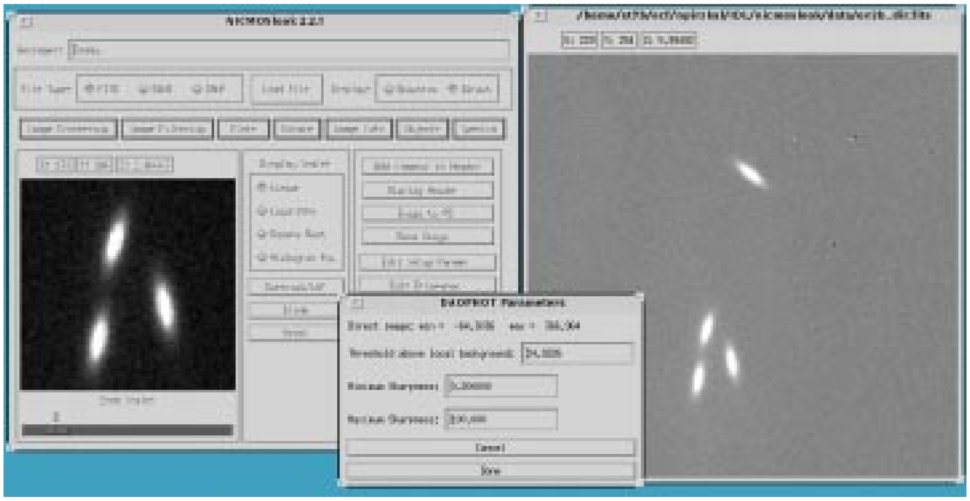


Figure 5.4: What you should get when you use DAOFIND to search for objects.

After you have selected your objects, either point or extended sources, you have to assign the size values to them. Remember that by default, objects found with DAOFIND are considered as point sources. There are several ways to do this. $\boxed{\text{Objects}}$→$\boxed{\text{Size \& Orientation}}$ gives three options. One is to use CURSOR. When you click on $\boxed{\text{Cursor}}$ and click on your object, you will have another window which asks you to click on the major and minor axes of your extended object. After you click at the appropriate places, the (x, y) positions of the major and minor axes will be shown in this window too. This option is sometimes not easy to use when your galaxy is small on the NICMOS detector. As described before, $\boxed{\text{Plots}}$ can be useful in this situation since it can give you some ideas of Full Width Half Maximum (FWHM) of the cross-section of your object. By pressing $\boxed{\text{Plots}}$→$\boxed{\text{Rows}}$, you have a message in the main NICMOSlook window saying "Position cursor on first and last raw to sum & click left". After you do that, you will have a separate plot window showing the cross-section. In this window, you can click on $\boxed{\text{Measure FWHM}}$ to roughly measure the object size. See Figure 5.5.

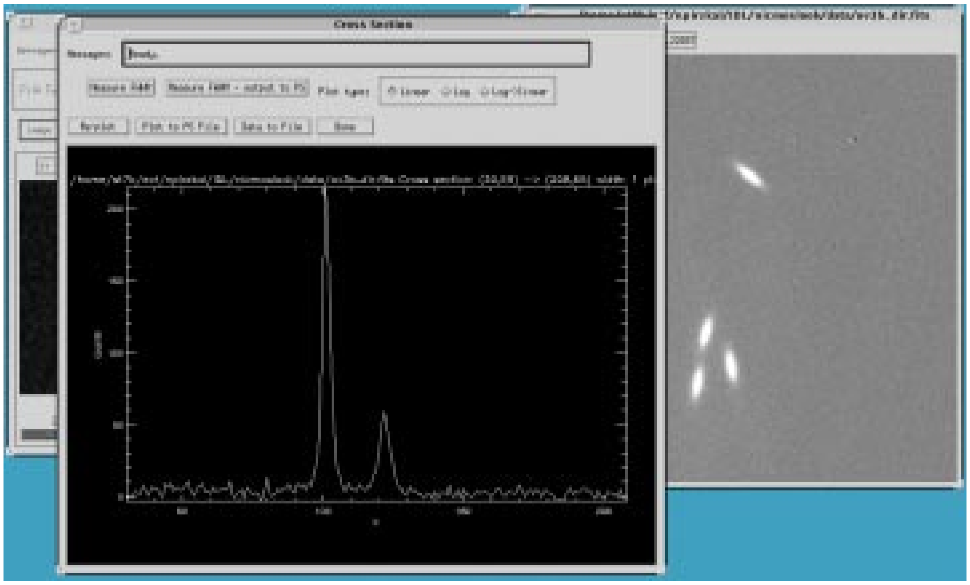


Figure 5.5: This shows that you can measure the approximate sizes of your objects with option Plots.

The second option is Objects→Size & Orientation→Automatic. A separate IDL window appears to ask you which object to determine the size, you can enter the ID number found by Objects→Find Objects→DAOFIND, or click on All. Then pressing Done will give you the automatically calculated sizes. For the detailed algorithm for calculating the sizes of extended sources, you can consult the Calnic C user's manual.

After the object sizes are determined, you can visually exam the result by pressing Objects→Mark Objects→Mark Sizes, which draws the ellipses indicating both sizes and orientations of the galaxies in your image. See Figure 5.6. Finally, for some wrongly identified extended sources, you can manually reset their status to point sources by pressing Reset, and click Direct in the exclusive menu button labelled `Display` and then on either Label or Mark Sizes under the menus Objects→Mark Objects a fresh view of the marked image will be displayed.

5.4 Extracting Spectra

Clicking Spectrum in the exclusive menu button labelled `Display` on the main NICMOSlook window will load your spectrum from the spectrum buffer to the IDL image display window.

Before extracting any spectrum, you can use Objects→Mark Objects→Spectra Location to mark the spectral centroids on the grism image. See Figure 5.7. You can see the objects being marked on the IDL image display window, extended sources with rectangular boxes and point sources with lines through the centroids.

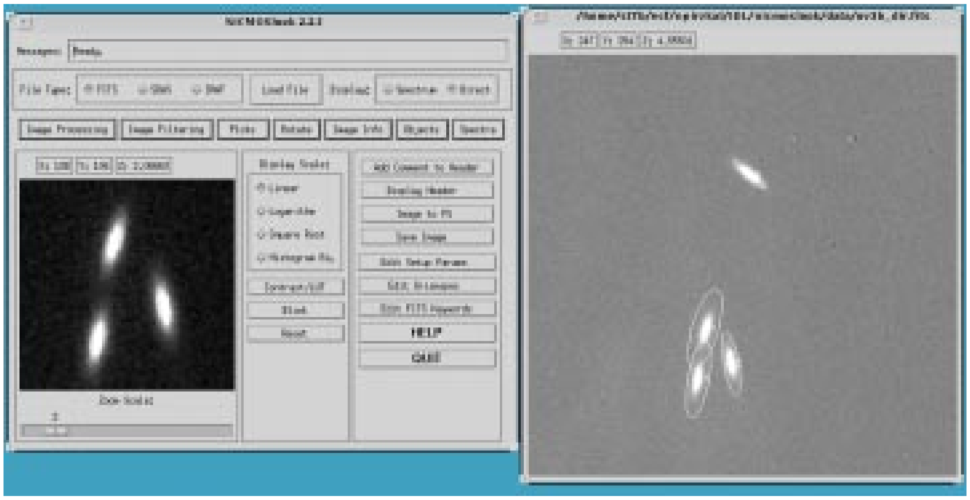


Figure 5.6: This shows what it should look like when you mark your objects with sizes and object IDs on the direct image.

Spectra in the main NICMOSlook window contains several ways of extracting spectra. Each extraction can be weighted or unweighted according to the locations of pixels, and also you can choose to deblend the spectra if your objects are too close to each other. Be careful that if you choose point source options to extract the spectra, then the object will be treated as a point source `even if` it was classified as an extended source before. These options over-write the previous classification. However, if you choose options for extended sources, objects classified as point sources will still be treated properly with point source weighting algorithm.

There are several options for extracting a spectrum. For example, you can press Spectra → Extended Object Weighted → Specific Object Deblended, a separate idl window will pop up which ask you specify the object ID number. By pressing done, you will have another plot window showing you the extracted spectrum. From this plot window, you can also plot the spectrum in linear scale, or in logarithmic scale or in log-linear scale (see the help manual for the detailed explanation). You can also save the spectrum in either PostScript or ASCII format. Then you press Done.

To extract the spectra and dump resulting pairs to files, press Spectra → Extended Object Weighted → All to File −− Deblended, a window will pop up and prompt for the output file name where the extracted spectra are stored. By pressing Spectra → Strips, in a separate plot window nine spectra are shown, each of which represents one pixel row of the 2-D grism spectrum.

5.5 Examining Your Spectra

After you have extracted your object spectrum, you can use several functions to obtain the detailed astrophysical information. For example, if you use option

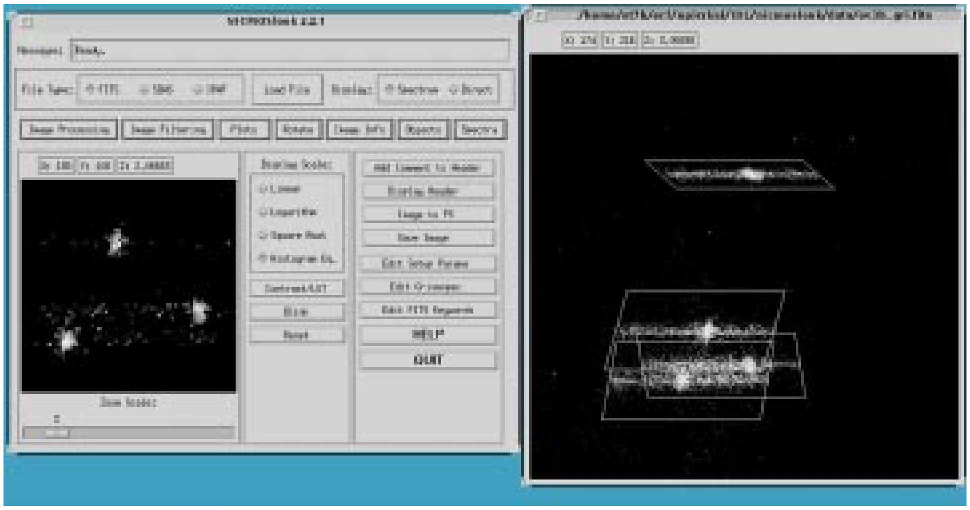


Figure 5.7: This shows what it should look like when you mark your objects with sizes and object IDs on the grism image.

Spectra →Extended Object Weighted →Specific Object Deblended and specify object 3, for instance, you would get another plot window showing you the spectrum, as shown by Figure 5.8. Within this spectrum plot window, you have several options to measure the spectral features. Re-plot will allow you to clear and re-plot the spectrum. Plot to PS File will save the displayed spectrum to a postscript file in your chosen directory. The same is for option Data to FITS File, except the data format is in FITS. Pressing Show Lambda/Flux, you will see a message in the small message window within the spectrum plot window saying "Click mouse button at plot location". For example, if you click on the line feature shown in Figure 5.8, another small window will pop up showing the wavelength and flux of the *location you just clicked*. Notice that wavelength is in units of micron and flux in milli-Jansky. This function allows you to do interactive measurements. Show Line Params gives you the parameters determined for the significant spectral lines, i.e, Line number ID, peak flux in the line, the central wavelength, FWHM, signal-to-noise ratio (S/N), χ^2 of the Gaussian fit to the line and its integrated line flux. Also you can save the above parameters in a ascii file with Save Line Params. Mark Lines enables you to select the lines you think are missed by the automatic line detection. You can click at the left and the right side of the continuum for each line feature you want to select. The last location should be identified with the `RIGHT` mouse button. This is NICMOSlook's signal to immediately display the new spectrum using the newly delimited lines. With Set Fit Order, you can choose the order for the polynomial fitting of the continuum. After you are happy with all the spectral line measurements, click on Done to go back to the next line.

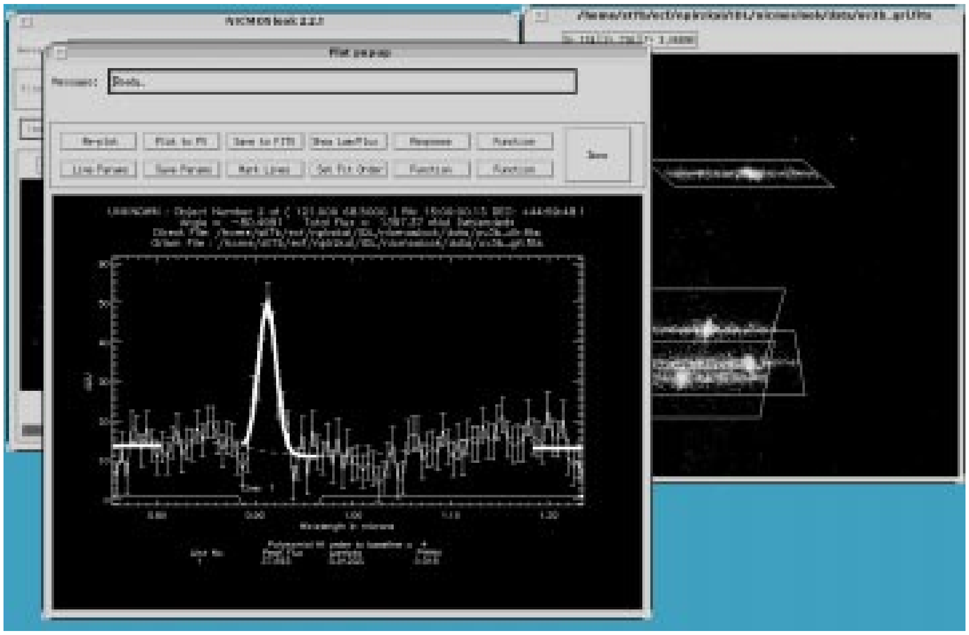


Figure 5.8: This is what you would get when the extracted spectrum for a specific object is displayed. You can obtain detailed spectral parameters from the line plot window.

Chapter 6

Acknowledgments

A number of people contributed to the development of NICMOSlook. The user interface is based on the IDL widget stislook which was written by Terry Beck. He kindly made it available to us before its release. Rudolf Albrecht supported the development starting from the first concepts through its final implementation. Lin Yan computed the background image. Richard Hook computed the PSFs used for the weighting of the extraction. Hans-Martin Adorf helped with release 1.2 of NICMOSlook. Jeremy Walsh graciously took time to proofread this manual. The algorithms employed in NICMOSlook were repeatedly discussed with Rodger Thompson, Betty Stobie and Dave Axon. Their input and suggestions were invaluable.

Appendix A

NICMOSlook Utilities

A.1 Test Image Generator

In the process of developing NICMOSlookit became clear that it would be necessary to have some test data for debugging the system. An IDL widget program was developed solely for the purpose of defining test cases that would adequately exercise all the functionality of NICMOSlook. This program will soon be available for public use. Figure A.1 shows the test image generator program.

A.1.1 Installation

To download and run this program:

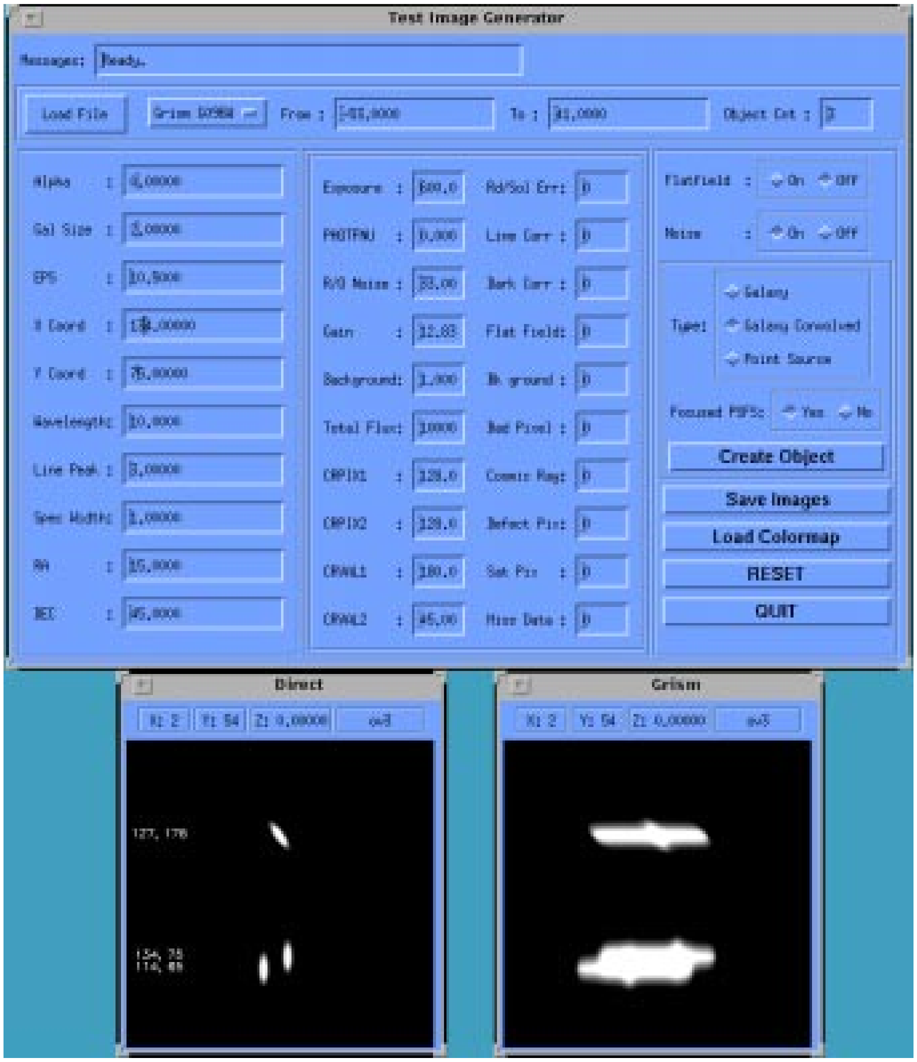
- Create a directory called `testim`; change to this directory.
- Download `testim_0.0.tar.gz` from the NICMOS Web page to the directory created above.
- Type: `zcat testim_0.0.tar.gz | tar xvf -` Unpack the source

A.1.2 Running the Test Image Generator

- Type: `source testim.setup` Set the environment
- Type: `idl`

To Create an Object:

- Set the parameter values (refer to section A.1.3)
- Select object type
- Click in either of the two image windows at the center point of the object



Test Image Generator

Messages: Ready.

Load File | Grism G096 | From : -55.0000 | To : 55.0000 | Object Cnt : 3

Alpha : 0.00000
Gal Size : 2.00000
EPS : 10.5000
X Coord : 130.00000
Y Coord : 75.00000
Wavelength: 10.0000
Line Peak : 3.00000
Spec Width: 1.00000
RA : 15.0000
DEC : 45.0000

Exposure : 600.0
PHOTFNU : 0.000
R/O Noise : 33.00
Gain : 12.03
Background: 1.000
Total Flux: 10000
CRPIX1 : 128.0
CRPIX2 : 128.0
CRVAL1 : 180.0
CRVAL2 : 45.00

Rd/Sol Err: 0
Line Corr : 0
Dark Corr : 0
Flat Field: 0
Bk ground : 0
Bad Pixel : 0
Cosmic Ray: 0
Defect Pix: 0
Sat Pix : 0
Miss Data : 0

Flatfield : ○ On ○ Off
Noise : ○ On ○ Off
Type: ○ Galaxy ○ Galaxy Convolved ○ Point Source
Focused PSFS: ○ Yes ○ No

Direct

X: 2 | Y: 54 | Z: 0.00000 | ox3

Grism

X: 2 | Y: 54 | Z: 0.00000 | ox3

Figure A.1: NICMOSlooktest image generator.

- Press $\boxed{\text{Create Object}}$

Press $\boxed{\text{Save}}$ to create a NICMOS FITS file data pair. A file name dialog box will prompt the user for an the output filename. The grism image will be written to a file that has the selected filename plus '_gri' appended before the '.fits' extension. Similarly, the direct image will be written to the filename with '_dir' appended. Both files are written to the `fits` subdirectory that is located in the install directory created in the first step.

A.1.3 Parameter Settings

In order to facilitate the testing of the many features of NICMOSlookmaximum flexibility was a priority in the design of the test image generator. Using the input fields supplied, one is able to generate galaxies and point sources with varying sizes, inclinations, central wavelengths, etc. Also, by setting bad pixels, random noise, and the like, the FITS file that is written will contain the NICMOS FITS file format with this data in the extensions. Below is a comprehensive list of all the input fields for the test image generator:

The following items relate to the object's size, location, and other characteristics:

- `Alpha`
  Sets the angle (in degrees) of an extended object.

- `Gal Size`
  The surface luminosity profile is defined as being $\propto e^{x/\texttt{GalSize}}$, where x is the distance of a point from the center of the galaxy in pixels.

- `EPS`
  Ellipticity of galaxy disk.

- `X Coord`
  This is the x-coordinate of the center of the object to be created in pixels. It can be set either by typing in the number or by clicking at a position on the image display.

- `Y Coord`
  This is the y-coordinate of the center of the object to be created in pixels. It can be set either by typing in the number or by clicking at a position on the image display.

- `Wavelength`
  The of the central wavelength of a spectral line relative to the center of the spectrum in pixels.

- `Spec Width`
  The line width of the spectral line in pixels.

- `RA`
  The right ascension of the reference point within the image. This information is used to create a WCS.

- `DEC`
  The declination of the reference point within the image. This information is used to create a WCS.

  The following items are concerned with the image characteristics and the FITS data file output:

- `Exposure`
  The exposure time.

- `PHOTFNU`
  The flux scale of the image in $JY * sec/DN$

- `R/D Noise`
  The readout noise in electrons.

- `Gain`
  The gain of the detector.

- `Background`
  The value of the background level in DN.

- `Total Flux`
  The total flux in the created object in DN.

- `CRPIX1`
  The pixel coordinate of the reference point within the image. This information is used to create a WCS.

- `CRPIX2`
  The pixel coordinate of the reference point within the image. This information is used to create a WCS.

- `CRVAL1`
  not used.

- `CRVAL2`
  not used.

  The following are parameters to set flags in the mask plane of the image. They are currently not used.

- `Rd/Sol Err`

- `Line Corr`

- `Dark Corr`

- `Flat Field`

- `Bk Ground`

- `Bad Pixel`

- `Cosmic Ray`

- `Defect Pix`

- `Sat Pix`

- `Miss Data`

A.2 Additional Utilities

Code for utilities for the generation of test and calibration data is in the ECF IDL directory: `//home/ns3c/idl/ecf`

A.2.1 Point Spread Function Generator

For PSFS creation, TinyTim must be used. See TinyTim documentation for further details.

TinyTim is an interactive program that has two steps. The first step (tiny1) generates a parameter file for the second step. Using `tiny1` to generate these parameter files is very tedious and time consuming. An IDL program is available to create these parameter files for each grism. To use the program:

1. Start IDL
2. psfs *grismid* Where *grismid* is the name of the grism.
3. exit idl

The next step in PSFS creation is now ready to begin. The following commands are for the UNIX c-shell.

```
prompt¿ foreach i (‘ls *.pf‘)
foreach? tiny1 $i < $i
foreach? end
```

The above command takes each input file, as input to tiny1 and writes the output to the same file (thus overwriting it; which is OK because it is not needed at this point).

The following command takes the output from tiny1 and uses it for tiny2.

```
prompt¿ foreach i (‘ls *.pf‘)
foreach? tiny2 $i
foreach? end
```

`tiny2` writes a FITS file for each run. These files must be placed in a single FITS file for use by the Test Image Generator. A second IDL utility has been written for this purpose.

1. Start IDL
2. `mkf` *grismid* Where *grismid* is the name of the grism.
3. exit idl

Look at the code files: `psfs.pro` and `mkf.pro`, directly to see what they expect and where output files are written. These steps are meant as an aid and therefore, are not particularly flexible.

A.2.2 Flatfield "Cube" Generator

CalnicC and NICMOSlook expect a FITS file containing 3-dimensional flat field data. Once the 18 flat field fits files are assembled in a directory, IDL may be run to create the 3-dimensional FITS file.

1. Start IDL
2. `mkcube`
3. exit idl

Look at the code file, `mkcube.pro`, to see what is expected and where the output file is written.

A.2.3 Reading FITS Tables Into IRAF

It is possible to read the output FITS binary tables into an IRAF `onedspec` format with `spec_tab2im.cl`.

Within IRAF, spec_tab2im should be defined as a task by typeing

```
task spec_tab2im = spec_tab2im.cl
```

Subsequently, NICMOS FITS spectra can be converted to IRAF images by typeing

```
task spec_tab2im *.fits
```

Appendix B

FITS Input File Format

B.1 NICMOS Input FITS File Description

The FITS format is used for storing NICMOS science and calibrator reference data. Multiple images are stored in a single file using FITS Image extensions. The layout of the FITS input data files that NICMOSlook expects is:

- Primary FITS header
- Header for Science Data
- Image for Science Data
- Header for Error plane
- Image for Error plane
- Header for Quality flags
- Image for Quality flags
- Header for Sampling
- Image for Sampling
- Header for Integration time
- Image for Integration time

B.2 NICMOS FITS Header Keyword Requirements

FITS Keyword Requirements

Name	Description
	The following keywords are REQUIRED for NICMOSlookto run.
EXTEND	States file may contain extensions
NEXTEND	Number of extensions should be 5 for NICMOS data files
XTENSION	For the 5 extensions this should be 'IMAGE'
EXTNAME	Actual data stored in current extension (SCI/ERR/etc)
EXTVER	Extension version (not used currently but should be 1)
ROOTNAME	Rootname of observation set. Used for output file names
FILTER	Name of the filter/grism used in observation
	The following keywords are not required but some functionality depends on them.
ADCGAIN	Analog/digital conversion gain
BACKEST1	Background estimate 1
BACKEST2	Background estimate 2
BACKEST3	Background estimate 3
CRPIX1	x-coordinate of reference pixel
CRPIX2	y-coordinate of reference pixel
CRVAL1	First axis value at reference pixel
CRVAL2	Second axis value at reference pixel
CTYPE1	The coordinate type for the first axis
CTYPE2	The coordinate type for the second axis
CD1_1	Partial of first axis coordinate w.r.t. x
CD1_2	Partial of first axis coordinate w.r.t. y
CD2_1	Partial of second axis coordinate w.r.t. x
CD2_2	Partial of second axis coordinate w.r.t. y
EXPTIME	Commanded exposure duration
PHOTFNU	Inverse sensitivity (JY*sec/DN)

Appendix C

FITS Output File

C.1 FITS File Description

When any of the submenus that direct all output to a file is chosen under Spectra a single FITS file is created. The first entry in this file is an extensive primary FITS header that contains general information of the observation as well as setup information for the series of binary table extensions that follow the header. Table C.3 gives a detailed description of this primary header.

C.1.1 FITS Binary Table Description

Following the primary FITS header in the NICMOSlook FITS output file are the binary tables which contain information for each object detected on the image pair. *One binary table is written out for each object detected on the image pair.* Preceding each table, is an extensive FITS header describing the object whose spectra information is contained in the table. The binary table consists of five columns which contain an object's, flux (in mJy), wavelength (in microns), statistical errors, deblending errors, and total errors. The error vectors contain values for each flux/wavelength pair for the entire spectrum. An example of a FITS table header is in table C.3

C.2 FITS Primary Header Example

Name	Description
SIMPLE = T	Written by IDL: 26-Mar-1997 11:21:10.00
BITPIX = 8	
NAXIS = 0	
EXTEND = T	Binary Table follows
ADCGAIN = 10.0000	analog-digital conversion gain
DROOTNM = 10.0000	analog-digital conversion gain
	Direct image header information
DROOTNAM= 'N33L0101T'	rootname of the observation set
DPARALEL= 'NO '	indicates if observa taken in parallel
DTARGNAM= 'OBJECT1 '	proposers target name
DRA_TARG= 15.0000	right ascension of the target(deg) (J2000)
DDEC_TAR= 45.0000	declination of the target (deg) (J2000)
DCAMERA = 1	Camera in use (1, 2, or 3)
DAPETURE= 'NIC1 '	aperture in use
DOBSMODE= 'ACCUM '	array readout mode
DFILTER = 'F205W '	filter wheel element in beam during obs
DBAKEST1= 1.00000	background estimate number 1
DBAKEST2= 0.50000000	background estimate number 2
DBAKEST3= 1.50000	background estimate number 3
DPHOTMOD= 'NICMOS,1,F205W,DN'	photometry mode
DPHOTFLA= 8.9776100e-19	inverse sensitivity
DPHOTFNU= 1.00000	inverse sensitivity (JY*sec, DN)
DPHOTZPT= -21.100000	ST magnitude system zero point
DPHOTPLA= 11292.4	Pivot wavelength of the photmode
DPHOTBW = 1653.64	RMS bandwidth of the photmode
DPOHTPDG= 'GROUND '	photometric calibration tabl pedigree
DBAKPDGR= '- '	background model parameters table pedigree

FITS Primary Header Example: continued

Name	Description
	Grism image header information
ROOTNAME= 'N33L0101T'	rootname of the observation set
PARALELL= 'NO '	indicates if observa taken in parallel
PROPOSI = 'UNKNOWN '	Unable to determine from GRISM image
PEP_EXPO= '- '	PEP exposure identifier including sequence
LINENUM = '- '	PEP proposal line number
PR_INV_L= '- '	last name of principal investigator
PR_INV_F= '- '	first name of principal investigator
PR_INV_M= '- '	middle initial of principal investigator
ORIENTAT= 0.00000	position angle of imag y axis (deg. e of n)
SUNANGLE= 0.00000	angle between sun and V1 axis
MOONANGL= 0.00000	angle between moon and V1 axis
SUN_ALT = 0.00000	altitude of the sun above Earths limb
FGSLOCK = 'FINE '	commanded FGS lock
DATE-OBS= 'now '	UT date of start of observation
TIME-OBS= 'now '	UT time of start of observation
EXPSTART= 0.00000	exposure start time (Modified Julian Date)
EXPEND = 0.00000	exposure end time (Modified Julian Date)
EXPTIME = 600.000	commanded exposure duration
EXPFLAG = 'NORMAL '	Exposure interruption indicator
CAMERA = 1	Camera in use (1, 2, or 3)
APERTURE= 'NIC1 '	aperture in use
OBSMODE = 'ACCUM '	array readout mode
BACKEST1= 1.00000	background estimate number 1
BACKEST2= 0.50000000	background estimate number 2
BACKEST3= 1.50000	background estimate number 3
FILTER = 'F205W '	filter wheel element in beam during obs
PHOTMODE= 'NICMOS,1,F205W,DN'	photometry mode
PHOTFLAM= 8.9776100e-19	inverse sensitivity
PHOTFNU = 1.00000	inverse sensitivity (JY*sec, DN)
PHOTZPT = -21.100000	ST magnitude system zero point
PHOTPLAM= 11292.4	pivot wavelength of the photmode
PHOTBW = 1653.64	RMS bndwid of the photmode
PHOTPDGR= 'GROUND '	photometric calibration tabl pedigree
BACKPDGR= '- '	background model parameters table pedigree
NEXTEND = 6	Number of table extensions
END	

C.3 FITS Table Header Example

Name	Description
XTENSION= ’BINTABLE’	/ Written by IDL:23-Oct-1996 16:57:25.00
BITPIX= 8	/
NAXIS = 2	/ Binary table
NAXIS1 = 20	/ Number of bytes per row
NAXIS2 = 95	/ Number of rows
PCOUNT = 0	/ Random parameter count
GCOUNT = 1	/ Group count
TFIELDS = 5	/ Number of columns
EXTNAME = ’0 ’	/ Object number
TFORM1 = ’95r ’	/ Length and type of column
TTYPE1 = ’Lambda ’	/ Label for column
TDIM1 = ’(95) ’	/ Array dimension for column
TFORM2 = ’95r ’	/ Length and type of column
TTYPE2 = ’Flux ’	/ Label for column
TDIM2 = ’(95) ’	/ Array dimension for column
TFORM3 = ’95r ’	/ Length and type of column
TTYPE3 = ’Stat Err’	/ Label for column
TDIM3 = ’(95) ’	/ Array dimension for column
TFORM4 = ’95r ’	/ Length and type of column
TTYPE4 = ’Debl Err’	/ Label for column
TDIM4 = ’(95) ’	/ Array dimension for column
TFORM5 = ’95r ’	/ Length and type of column
TTYPE5 = ’Tot Err ’	/ Label for column
TDIM5 = ’(95) ’	/ Array dimension for column
	Sextractor Object Information
CLASS = 0.0140434	/ Object type (galaxy or star)
A_OBJ = 0.00000	/ Major axis of object
B_OBJ = 0.00000	/ Minor axis of object
XCOORD= 122.913	/ x-coord of object in pixel
COORD= 122.835	/ y-coord of object in pixel
RA_OBJ= 0.00000	/ Right ascension of object (deg) (J2000)
DEC_OBJ = 0.00000	/ Declination of object (deg) (J2000)
	Spectral Line Extraction
LINEPK1 = 3495.08	/ Line peak
LINELAM1= 1.58542	/ Central wavelength
LINEWID1= 0.319452	/ Width of line
LINESN1 = 17.7016	/ Signal to noise
CHI2_1 = 0.0376511	/ Chi-square
ILF_1 = 0.0011627	/ Integrated Line Flux

FITS Table Header Example: continued

Name	Description
LINEPK2 = 4402.01	/ Line peak
LINELAM2= 1.35420	/ Central wavelength
LINEWID2= 0.927476	/ Width of line
LINESN2 = 22.2950	/ Signal to noise
CHI2_2 = 0.0376511	/ Chi-square
ILF_2 = 0.0011627	/ Integrated Line Flux
LINEPK3 = 4402.57	/ Line peak
LINELAM3= 1.53262	/ Central wavelength
LINEWID3= -0.941618	/ Width of line
LINESN3 = 22.2978	/ Signal to noise
CHI2_3 = 0.0376511	/ Chi-square
ILF_3 = 0.0011627	/ Integrated Line Flux
LINEPK4 = 3568.77	/ Line peak
LINELAM4= 1.99225	/ Central wavelength
LINEWID4= -0.164191	/ Width of line
LINESN4 = 18.0749	/ Signal to noise
CHI2_4 = 0.0376511	/ Chi-square
ILF_4 = 0.0011627	/ Integrated Line Flux
LINEPK5 = 3966.44	/ Line peak
LINELAM5= 2.38475	/ Central wavelength
LINEWID5= -0.681985	/ Width of line
LINESN5 = 20.0889	/ Signal to noise
CHI2_5 = 0.0376511	/ Chi-square
ILF_5 = 0.0011627	/ Integrated Line Flux
NLINES= 6	/ Actual # of lines
CONSHORT= 0.00000	/ Continuum lambda ¡ first line
CONLONG = 0.00000	/ Continuum lambda ¿ last line
RMSFIT = 0.000294	/ RMS of last fit
FORDER = 4	/ Order of last fit
MAG_BEST= -15.3115	/ Best magnitude estimate
MAG_ERR = 0.00190733	/ Error in magnitude estimate
BAKUSED = 1.00000	/ Background estimate used
BACKFIL = 'bckG206W.fits'	/ Background file used
END	/ That is all

Appendix D

Setup

D.1 Grism Specification File

D.1.1 Contents

The grism specification file, `grismspec.dat`, defines the filters and grisms NICMOSlook recognizes and the parameters NICMOSlook assumes for each of them. It is found in the `$NICMOSLOOK_BASE/calib` directory.

The file is read by NICMOSlookand specifies a keyword to read the name of the filter or grism. For each recognized name, it list then:

1. whether the image is a direct image or a grism image
2. in case of a grism image
   - the position of the spectrum in dispersion direction
   - the dispersion relation of the grism
   - the distortion of the spectra
   - the offset of the spectrum relative to the direct image
   - a 3d flatfield (FITS) file to be used for flatfield correction
   - a file which defines the convolution kernel for object detection
   - a FITS file containing image background data
   - a file which defines the filter response curve
3. the FITS file with the appropriate PSF for the direct image or grism used to identify objects.

D.1.2 Format

Parameters in `grismspec.dat` are listed one entry (filter or grism) per line. They are written format free and have to be given in the right order. Comment lines can be placed at any place in the file; they are recognized by a “;” in the first column.

Each entry must start with the keyword in the image header which is used to identify the image. Next, the value for this keyword and the corresponding image type is given (d= direct image, s= spectrum).

The subsequent information in an entry depends on whether the entry refers to a direct image or a grism image.

Direct Image

For a direct image, the only additional information listed is the name of the FITS file with a PSF used to search for objects on the image. The location of the corresponding FITS file has to be the same directory directory as `grismspec.dat`

Grism Image

For a grism image, the three numbers following the image type define the dispersion relation, parameterized with four parameters $a0$, $a1$, $a2$, and $a3$. They are used to compute the wavelength λ in microns via

$$\lambda = a0 + a1 \cdot x + a2 \cdot x^2 + a3 \cdot x^3 \tag{D.1}$$

where x is the x-position in pixels relative to the center of the direct image.

Subsequently, four parameters for the the image distortion (in y direction) $b0$, $b1$, $b2$, and $b3$ are listed. They parameterize the distortion as:

$$\delta = b0 + b1 \cdot r + b2 \cdot r^2 + b3 \cdot r^3 \tag{D.2}$$

where

$$r = \sqrt{(x^2 + y^2)} \tag{D.3}$$

is the radius position in pixels and δ is the y-deviation in pixels of the spectrum from a horizontal line.

The next parameter is the angle θ which specifies a possible small global rotation of the spectrum relative to an exact alignment along a row. The angle is measured counterclockwise in units of degrees.

Following the angle is the spectra offset field. This is the number of pixels in the y direction that the grism image is offset from the direct image.

The next column specifies the name of the flatfield file to be used for extraction of the spectra.

The next column lists the name of the fits file with a PSF used to search for objects on an image.

The file containing the background estimage is listed next, followed by the a file containing the response specifications for the grims.

Refer directly to `$NICMOSLOOK_BASE/calib/grismspec.dat` for examples.

D.2 Tunable Parameters

Tunable Parameters (default values)

ADCGAIN 12.83	; Analog/digital conversion gain
BADPIX_THRESH 50.0	; Percent of allowable bad pixels before object discarded
BG_PIXELS 2	; Width of region for background estimate in pixels
BLEND_FACTOR 2	; Blending factor for merging gauss lines
CONT_FACTOR 2.5	; Continuum factor
DAO_THRESH 2	; Brightness threshold for daofind
DEBLEND_ERR_MIN 0.1	; Deblending error minimum
DET_THRESH 2	; Spectral line search point detection threshold
EXTOBJ_THRESH 0.3	; 0.0 = extended object, 1.0 = star
FIT_ORDER1 3	; Polynomial fit order for first run of polyfit
FIT_ORDER2 4	; Polynomial fit order subsequent runs of polyfit
MAXLINES 24	; Maximum number of lines to keep
MAXOBJS 400	; Maximum number of objects to create for sextractor
MAXPIX 256	; Maximum number of pixels on grism (per dimension)
MIN_NPOINTS 20	; Minimum number of points for fitting
MIN_PIX_NO 10	; Minimum acceptable line width
MIN_SIGNSE 7	; Minimum allowable signal/noise value of lines
N_ITERATIONS 10	; Maximum number of fit iterations
N_ITERLOW 4	; Iteration number where 2nd fit order param is used
O_THRESH1 0.05	; First overlap threshold for deblending
O_THRESH2 2.0	; Second overlap threshold for deblending
O_THRESH3 3.0	; Third overlap threshold for deblending
REJ_THRESH 3	; Object rejection threshold
SZ_FACTOR 2	; 2nd order mom factor of extended obj from sextractor
DEBUG_LEVEL 101	; Debugging level
NOFLATFIELD 1	; Turn off/on (1/0) flatfielding
NOBACKGND 1	; Turn off/on (1/0) background subtraction

D.3 Configuring FITS Keywords

FITS Keywords (default values)

Target	TARGNAME	Target of observation
A/D Gain	ADCGAIN	Analog to Digital conversion gain
Filter	FILTER	Filter used in ovservation
Inverse Sensitivity	PHOTFNU	Unit Conversion (ADU -¿ mJy)

Appendix E

List of all input files

Name	Description
grismspec.dat	Descriptions of all available grisms and filters
bckG096W.fits	Background estimates for grism J
bckG141W.fits	Background estimates for grism H
bckG206W.fits	Background estimates for grism K
calnicc.setup	Tunable parameters for Calnic C
default.conv	Convolution file for SExtractor
default.nnw	Neural network weights file for SExtractor
default.param	List of SExtractor parameters to return
default.sex	Tunable parameters to modify SExtractor behavior
calnicc_tmp.cat	SExtractor output file (not used by Calnic C)
nicmosFF.fits	Flat field image for each wavelength of grism (cube)
weight_G096W.fits	Weight file for grism J (weighted)
weight_G096W_unweighted.fits	Weight file for grism J (unweighted)
weight_G141W.fits	Weight file for grism H (weighted)
weight_G141W_unweighted.fits	Weight file for grism H (unweighted)
weight_G206W.fits	Weight file for grism K (weighted)
weight_G206W_unweighted.fits	Weight file for grism K (unweighted)
flat.fits	For flat subtraction
dark.fits	For dark subtraction
bias.fits	For bias subtraction
G096.response	For response
G096W.response	For response
G141.response	For response
G141W.response	For response
G206.response	For response
G206W.response	For response
fitskeywds.dat	FITS keyword configuration file
F090M.conv	Convolution files used by SExtractor for each filter
F095N.conv	
F097N.conv	
F108N.conv	
F110M.conv	
F110W.conv	
F113N.conv	

Input files to Calnic C: continued

F140W.conv	Continuation of convolution files for each filter
F145M.conv	
F150W.conv	
F160W.conv	
F164N.conv	
F165M.conv	
F166N.conv	
F170M.conv	
F171M.conv	
F175W.conv	
F180M.conv	
F187N.conv	
F187W.conv	
F190N.conv	
F196N.conv	
F200N.conv	
F204M.conv	
F205W.conv	
F207M.conv	
F212N.conv	
F215N.conv	
F216N.conv	
F222M.conv	
F237M.conv	

Appendix F

Output Files of NICMOSlook

F.1 Object List

NICMOSlook creates an internal object list for each object detected or otherwise identified on the loaded images. This list contains information regarding the location, size (major, and minor moments along the axis), and the angle of the object's orientation. It is often convenient to save these values to a data file so, for example, that other images can be loaded without destroying current information. At a later time, the object list can be loaded back in and processing can be resumed where left off. To save the current object list, select the Save to File menu item under the Objects → Object List menus. Below is an example output file of the an output file created in this manner:

x Coord	y Coord	Maj Mom	Min Mom	Angle
15.0005	62.9947	0.00000	0.00000	-90.0000
157.000	65.0026	1.38696	0.489883	0.306816
82.9863	67.0088	2.87775	0.747376	-53.1466

To read the file back into memory, one would use the Input File menu item under the Objects → Find Objects menus.

F.2 Derived Line Parameters

By Selecting the Save Line Params button on a spectra's Plot Popup, one can save the derived line parameters to a data file. Below is an example of a file created by choosing this button:

Polynomial fit order used: 4

Line No.	Peak Flux	Lambda	FWHM	S/N	CHI2	ILF
1	0.03	1.01	0.025	20.297	32.78	6.8508E-04
2	0.12	0.08	0.020	18.302	30.92	5.5243E-04
3	0.09	0.95	0.001	15.122	28.16	4.8173E-04

F.3 Catalogue Output

The following shows an example of a human readable catalogue entry.

```
Object Number 0 from observation file ../data/direct.fits
RA = 0.00000 DEC = 0.00365056
Output FITS file: N33L0101T_0.fits
Object Type Probability (1.0 = star; 0.0 = extended object): 0.0140434
Object size (2nd order moments along axes): 13.8394 7.73015
Object angle along major axis:): 43.0521
Total flux of spectrum: 38295.5
Number of lines: 7
Order of last curve fit: 4

5 Most significant lines:
Flux      Wavelength   FWHM        S/N       CHI2     ILF
957.141     1.15657    0.0403234   147.223   596.2    41.1161
758.077     1.64862    0.0103599   11.1825   314.4    22.704
458.424     1.94372    0.0264251   10.5146   154.2    28.51
534.383     2.05612    0.0505358   16.7858   774.5    33.45
655.240     2.28973    0.1081202   30.5714   594.3    12.17

RMS of last polynomial fit : 71.2457
Continuum (long) : 593.520
Continuum (short): 252.996
```

Below is an example of a log file entry.

```
Date Run : Fri Sep 27 10:53:43 1996
Direct image : ./data/direct.fits
Grism image : ./data/spec.fits

Objects Found : 3
Number of extended objects : 2
Number of point Sources : 1
Spectra Extracted : 3
Spectra with no lines : 0
Spectra with 1 lines : 1
Spectra with 2 lines : 2
Spectra with more than 2 lines: 0

Warnings: none
Errors : none
```

Appendix G

Sample Data Files

The directory `$NICMOSLOOK_BASE/data` contains two direct/grism pairs of sample data files called:

```
ov2_dir.fits
ov2_gri.fits
ov3b_dir.fits
ov3b_gri.fits
```